ORNL-2644
Particle Accelerators and
High-Voltage Machines

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CYCLOTRONS AND HIGH-ENERGY ACCELERATORS - 1958

F. T. Howard

OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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F. T. Howard

Electronuclear Research Division

November 17, 1958

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Post Office Box X
Oak Ridge, Tennessee

Forward

For a number of years an information file on cyclotrons has been maintained here at the Laboratory. Data sheets were first prepared for fixed-frequency (FF) and frequency-modulated (FM) cyclotrons. More recently data sheets for other high-energy accelerators were added. Since last May an attempt has been made to obtain recent verified data for all cyclotrons and other high-energy machines. Questionnaires were sent to all laboratories for which we had addresses. The response has been uniformly good, except for some delay in returns from the countries of eastern Europe. It is to be hoped that in any future edition more detailed and reliable data may be available for these installations.

Data supplied in the questionnaires were edited only enough to provide some unformity in terminology and thus to avoid possible misinterpretations. Some of the terms and abbreviations used are defined on page 2. In a few cases additional information was obtained from published sources. Where the questionnaire was not returned by publication time, data accumulated from journals, press releases, and personal communications are given. The writer takes no responsibility for these unverified data; the status of the machine may have changed, and in some cases the present location or even existence of the machine may be in error.

We will continue to attempt to maintain up-to-date files on the many medium and high-energy accelerators. We would appreciate any additional information (or corrections) on existing accelerators and any data on new installations or on machines which may have been omitted. If, at a later date, it appears desirable a new edition of the Directory will be prepared.

Acknowledgements

The more inclusive but somewhat less detailed tabulations of accelerators prepared at Brookhaven[(1)] and at Berkeley[(2-5)] have been very helpful.

Members of the staff of the Electronuclear Research Division, particularly B. L. Cohen and A. Zucker, gave valuable assistance in the preparation of the questionnaire forms.

The writer is especially indebted to the many busy people at the various laboratories who have taken time to provide the data requested in the questionnaires.

The writer is also indebted to R. S. Livingston for suggestions and encouragement.

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1. E. Thomas, P. Mittelman, and H. H. Goldsmith, Particle Accelerators; Bibliography and List of High-Energy Installations, BNL-L-101 and AECU-31 (July 1, 1948).

2. Bonnie E. Cushman, Bibliography of Particle Accelerators July 1948 to December 1950, UCRL-1238 (March 1951).

3. Sergey Shewchuck, Bibliography of Particle Accelerators January to December 1951, UCRL-1951 (September 1952).

4. F. E. Frost and J. M. Putnam, Particle Accelerators, I. Bibliography. II. List of High-Energy Installations, UCRL-2672 (November 16, 1954).

5. Gerald A. Behman, Particle Accelerators, I. Bibliography, II. List of Accelerator Installations, UCRL-8050 (January 1, 1958). (Note in proof: This list was published in the October 1958 issue of Nuclear Instruments.)

TABLE OF CONTENTS

SUMMARY

In all, 140 cyclotrons and other high-energy accelerators are reported. Verified data are provided for 108 of these; the amount of data available for the remainder varies. The vigor with which nuclear studies are being pursued is indicated by the large number of machines (50) now under construction, being designed, or subject to serious study.

Summary Table

	Built	Constr.	Design	Study	Total
FFC	56	11	5	4	76
FMC	18	0	0	0	18
PS	5	10	0	2	17
ES	2	7	2	0	11
Linac-e	1	1	1	1	4
Linac-p	5	4	1	0	10
Linac-h	3	1	0	0	4
Totals	90	34	9	7	140

An examination of the entries for these new machines suggests the ingenuity with which concepts of cyclic magnetic field configurations are being applied to accelerator design. In the low-medium energy range the FF cyclotron is being provided with an azimuthally varying magnetic field and a choice of frequencies for the acceleration of several ions to various energies and for operation at relativistic energies. The alternating gradient principle is being used to markedly increase the energy of both proton and electron synchrotrons. Apparently no new FM cyclotrons are being developed.

Interpretation of Tables

Column 1. Types of Machines

FFC	-	fixed-frequency cyclotrons, all
FMC	-	frequency-modulated cyclotrons, all
PS	-	proton synchrotrons, all
ES	-	electron synchrotrons, E $\gtrsim$ 0.5 Gev
Linac	-	linear accelerators for electrons, E $\gtrsim$ 0.5 Gev for protons, E $\gtrsim$ 10 Mev for heavy ions, E $\gtrsim$ 100 Mev

Column 2. Dimensions

FFC and FMC	-	diameter of pole tip
PS and ES	-	radius of orbit
Linac	-	length of tank (s)

Columns 3 and 4. Energy and Particle

The apparent basic design energy for the given particle is listed; other energies and particles often possible, see data sheets. Usual symbols for protons, deuterons, and electrons; h for heavy ions.

Column 5. Status

built	-	machine has produced accelerated particles
constr.	-	machine is in construction stage
design	-	engineering design is being prepared
study	-	preliminary study is being made of design feasibility and requirements

Symbols used

ag	-	alternating gradient
cg	-	constant gradient
avf	-	azimuthally varying field
h	-	heavy ions
*	-	variable energy
**	-	data not verified. No data sheet was received for this machine. The data given were obtained from journals articles, press releases, and personal communications.

In conformity with international usage the following prefixes are used:

G	-	giga-	10^9
M	-	mega-	10^6
k	-	kilo-	10^3
m	-	milli-	10^{-3}
μ	-	micro-	10^{-6}
n	-	nano-	10^{-9}
p	-	pico-	10^{-12}

In all cases, the period (.) is used for the decimal and the comma (,) to set off large numbers.

GENERAL DIRECTORY

See page 2 for key to tables

					(Page)
POLAND					
Institute of Nuclear Research, Cracow					
FFC	50-cm	--	-	built**	57
FFC	120-cm	12.5-Mev	d	built**	59
Central Polish Nuc. Res. Inst., Warsaw					
Linac	--	10-Mev	p	built**	281
RUMANIA					
______________, Bucharest					
FFC	120-cm	12.5-Mev	d	constr.**	61
SWEDEN					
University of Lund, Lund					
ES_{ag}	3.65-m	1.2-Gev	e	constr.	255
Nobel Institute of Physics, Stockholm					
FFC	80-cm	7-Mev	d	built	63
FFC	225-cm	22-Mev	d (h)	built	65
Gustaf Werner Institute, Uppsala					
FMC	230-cm	200-Mev	p	built	185
SWITZERLAND					
Federal Institute of Technology, Zurich					
FF	33-in.	14-Mev	d	built	67
FF_{avf}	300-cm	>100-Mev*	h	study	69
UNION OF SOUTH AFRICA					
Council for Sci. and Ind. Res., Pretoria					
FFC	45-in.	16-Mev	d	built	71

USSR

(Page)

Joint Nuclear Research Institute, Dubna

FFC	300-cm	>100 Mev	h	constr.**	73
FMC	6-m	680-Mev	p	built**	187
PS	28-m	10-Gev	p	built**	219

Ukranian Technical Institute, Kharkov

Linac	12.4-m	21-Mev	p	built**	283
Linac	--	1-Gev	e	design**	273
Linac	--	>100-Mev	h	built**	303

Ukranian Physical Institute, Kiev

FFC	--	14-Mev	d	built**	75

Leningrad University, Leningrad

FFC	76-cm	4-Mev	d	built**	77
FFC	120-cm	12.5-Mev	d	constr.**	79

Physical-Technical Institute, Leningrad

FFC	120-cm	25-Mev	h	built**	81

Radium Institute, Leningrad

FFC	35-cm	2-Mev	d	built**	83

Res. Inst. of Electro-physical Instruments, Leningrad

PS_{ag}	5-m	650-Mev	p	constr.**	221
PS_{ag}	167-m	50-Gev	p	constr.**	223

Atomic Energy Institute, Moscow

FFC	150-cm	22-Mev	d (h)	built**	85
ES	34-cm	1-Gev	e	design**	257

Lebedov Institute, Moscow

ES	--	0.6-Gev	e	constr.**	259

UNITED STATES (Continued)

UNITED STATES (Continued)

FIXED-FREQUENCY CYCLOTRONS

					(Page)
Australia	31-in.	8-Mev	p	built	19
	40-in.	11-Mev	p	built	21
Belgium	102-cm	13-Mev	d	built	23
Bulgaria	120-cm	12.5-Mev	d	constr.**	25
China	120-cm	12.5-Mev	d	built**	27
Czechoslovakia	120-cm	12.5-Mev	d	built**	29
Denmark	90-cm	12-Mev	d	built	31
France					
Saclay	180-cm	22-Mev	d (h)	built	33
Orsay	36-in.	7-Mev	d	built	35
Orsay	200-cm	20-Mev*	d	constr.**	37
Germany (E)	120-cm	12.5-Mev	d	built	39
Germany (W)	101-cm	13-Mev	d	built	41
Israel	--	2-Mev	p	constr.**	43
Japan					
Kyoto	105-cm	15-Mev	d	built	45
Osaka	44-in.	12-Mev	d	built	47
Tokyo	160-cm	21-Mev*	d	built	49
Tokyo	25-in.	4-Mev	d	built	51
Tokyo	16-in.	2-Mev*	d	built	53
Netherlands	85-cm	12-Mev	p	built	55
Poland	50-cm	--	-	built**	57
	120-cm	12.5-Mev	d	built**	59
Rumania	120-cm	12.5-Mev	d	constr.**	61
Sweden	80-cm	7-Mev	d	built	63
	225-cm	22-Mev	d (h)	built	65
Switzerland	33-in.	14-Mev	d	built	67
	300-cm	>100-Mev*	h	study	69
Union of S. Africa	45-in.	16-Mev	d	built	71

See page 2 for key to tables

F-F Cyclotrons (Cont.)

					(Page)
USSR					
Dubna	300-cm	100-Mev	h	constr.**	73
Kiev	--	14-Mev	d	built**	75
Leningrad	76-cm	4-Mev	d	built**	77
Leningrad	120-cm	12.5-Mev	d	constr.**	79
Leningrad	120-cm	25-Mev	h	built**	81
Leningrad	35-cm	2-Mev	d	built**	83
Moscow	150-cm	22-Mev	d(h)	built**	85
Moscow	120-cm	14-Mev	d	built**	87
United Kingdom					
Birmingham	40-in.	12-Mev	d	constr.	89
Birmingham	62-in.	20-Mev	d(h)	built	91
Liverpool	36-in.	9-Mev	d	built	93
London	50-in.	15-Mev	d	built	95
United States					
Argonne	62-in.	22-Mev	d	built	97
Brookhaven	18-in.	3-Mev	p	built	99
	62-in.	20-Mev	d	built	101
UCRL	72-in.	24-Mev	d(h)	built	103
	88-in.	115-Mev*	p(h)	design	105
UCRL/L	90-in.	15-Mev*	p	built	107
UCLA	44-in.	50-Mev*	p	constr.	109
Carnegie	60-in.	16-Mev	d	built	111
Colorado	52-in.	30-Mev	p	constr.	113
Columbia	36-in.	15-Mev*	p	built	115
Florida	120-in.	400-Mev	p	study	117
Howard	16-in.	4-Mev	p	constr.	119
Illinois	44-in.	14-Mev*	p	constr.	123
Indiana	45-in.	12-Mev	d	built	125
Los Alamos	42-in.	16-Mev*	d	built	127
MIT	43-in.	16-Mev	d	built	129

F-F Cyclotrons (Cont.)

					(Page)
United States (Continued)					
Michigan	42-in.	10-Mev	d	built	131
	64-in.	40-Mev*	p (h)	design	133
	83-in.	40-Mev*	d	design	135
NASA	60-in.	20-Mev	d	built	137
NRDL	70-in.	70-Mev*	p	study	139
ORNL	44-in.	5-Mev	p	built	141
	63-in.	27-Mev	N^{3+}	built	143
	86-in.	25-Mev	p	built	145
	76-in.	75-Mev*	p (h)	design	147
	17-ft	850-Mev	p	study	149
Ohio	47-in.	12-Mev	d	built	151
Oregon	37-in.	7.5-Mev	d	built	153
Pittsburgh	47-in.	20-Mev	d	built	155
Purdue	37-in.	10-Mev	d	built	157
Rochester	26-in.	8-Mev*	p	built	159
Stanford	27-in.	3-Mev	d	built	161
Washington, U. of	60-in.	22-Mev	d	built	163
Washington U.	45-in.	10-Mev	d	built	165
Yale	28-in.	4-Mev	d	built	167
Yugoslavia	56-in.	16-Mev*	d	built	169

The AVF Cyclotrons

The successful operation of electron models demonstrates that the use of an azimuthally varying field in a cyclotron makes it possible to provide focusing forces and at the same time to increase the average magnetic field to maintain isochronism at relativistic energies. "Thomas shims" are now used in several installations to improve the beam. The lively interest in fully isochronous machines is indicated by the tabulation on the following page. Here, FF cyclotrons of the AVF type are regrouped for convenient reference. Since some of these machines are still in early stages of development the data is somewhat incomplete.

THE AZIMUTHALLY-VARYING-FIELD CYCLOTRONS

	Energy (Mev)	Particle	ΔH(%)	Sectors	Spiral	Sector Coils	Status	Page
Austria								
Vienna	-	-	-	-	-	-	study	**
Canada								
U. of Manitoba	(similar to UCLA)		-	-	-	-	study	
France								
Saclay	22	d	-2%	-	-	-	tests	33
Netherlands								
Delft	12	p	inc.	4	no	no	built	55
Switzerland								
Zurich	100	N	inc.	4	yes		design	69
USSR								
Dubna	-	-	-	-	-	-	constr.	**
United Kingdom								
Birmingham	12*	d	+0.85%	3	yes	yes	constr.	89
United States								
UCRL	115*	p (h)	+3%	4	yes		design	105
UCLA	50*	p	+5.5%	4	yes		constr.	109
Colorado	30	p (h)	+3.5%	4	yes		constr.	113
Florida	400	p	+40%	6	yes		study	117
Illinois	14*	p, d, (h)	+1.7%	4	yes		constr.	123
Los Alamos	16*	d	dec.	3	no	no	built	127
MIT	16	d	-2.5%	3	no	no	built	129
Mich. S.U.	40*	p (h)	+4%				design	133
U. of Mich.	40*	d		4	yes		study	135
NRDL	70	p	+8%	4	yes		study	139
ORNL	75*	p (h)	+8%	3	yes	yes	design	147
ORNL	850	p	+90%	8	yes	yes	study	149

See page 2 for key to tables.

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: ANU 30-Inch Cyclotron

Institution: Australian National Laboratory

Address: Box 4, G.P.O., Canberra, A.C.T. Australia

Person in charge: Prof. M. L. Oliphant

Person supplying data: W. I. B. Smith   Date: May 1958

Present Fields of Research	% of Time
Cyclotron operation and beam improvement	60
Nuclear reactions	40

History and Status

Design study	April 1953
Model tests	
Engineering design	
Construction started	May 1953
Completion date	First beam Sept 1955
Scheduled operation	80 hrs/wk (when on reaction studies)
Magnet cost	
Total cost	$50,000 (approx.)

Design Specifications

Magnet

Core dia.	____ cm, 35 in.
Pole tip dia.	____ cm, 31 in.
Beam radius, max	____ cm, 12.6 in.
Field gap, center	____ cm, 5.5 in.
Field, max	12.6 k-gauss
Field drop-off	2 %
Weight, Fe	31 ; Al ____ tons
Winding	aluminum
Cooling	water
Dee dia.	____ cm, 29 in.
Dee aperture	____ cm, 3 1/4 in.
Dee-to-dee gap	____ cm, 1 in.
Beam extraction, type	d-c def. + mag. shims
Ion source, type	hooded arc, tungsten filament

Design energy and particle

8 Mev protons

____ Mev

____ Mev

____ Mev

R-F frequency	19.6 Mc/s
Oscillator type	self-ex., gnd-cath
Oscillator tube	3Q 260E (S.T.C.)
Osc. input, max	(available) 100 kw
Osc. output, max	50 kw
Pre-exciter	yes (booster)
Dee bias, d-c max	none v
Dee-to-~~dee~~ gnd, max	(one dee) 80 kv
Shielding	20 in. concrete top and sides + local borated paraffin

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.55				
Frequency, Mc/sec	19.6				
Mag. field, k-gauss	12.6				
Dee-to-dee, kv	80				
Internal Beam, Stable, μa	3,000				
Peak, μa	r-f power limited				
Energy spread, %					
External Beam, Stable, μa	10				
Peak, μa	10				
Energy spread, %	0.5				

Present operating conditions for beam on nuclear reactions. Maximum extracted beam at present is 250 μa with 300 μa circulating beam. (limited by heat dissipation on spider plate).

Beam "piped" 12 ft to external target. Beam analyzing magnet used? None used But quadropole focusing magnet used.

Unusual Features

Electric focusing with carbon grids on the dees successful on first four revolutions.

Beam defining slits used on 1, 2, and 3rd revolutions to define center of beam rotation; 3rd turn slit is 1/2 mm wide.

100% extraction efficiency with low beams, requires better than 1/2% stabilization of dee volts.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Melborne University Variable Energy Cyclotron (MUVEC)

Institution: Physics Dept., University of Melbourne

Address: Carlton, N.3, Victoria, Australia

Person in charge: Professor Sir Leslie Martin

Person supplying data: Dr. D. E. Caro   Date: May 1958

Present Fields of Research	% of Time

History and Status

Design study	June '53 to Jan '54
Model tests	
Engineering design	
Construction started	Jan '54
Completion date	(First beam) Jan. 1957
Scheduled operation	hrs/wk
Magnet cost	£A7000
Total cost	£A35,000

Design Specifications

Magnet

Core dia.	cm, 40 in.
Pole tip dia.	cm, 39 1/2 in.
Beam radius, max	cm, 14.4 in.
Field gap, center	cm, 6 in.
Field, max	14 k-gauss
Field drop-off	1.8 %
Weight, Fe 42 ; Al 3	tons
Winding	1 1/2" x 1" 0.4" dia hole
Cooling	degassed water
Dee dia.	cm, 16 in.
Dee aperture	cm, 2 in.
Dee-to-dee gap	one dee cm, in.
Beam extraction, type	d-c def
Ion source, type	hooded arc

Design energy and particle

11 Mev protons

Mev

Mev

Mev

R-F frequency	19.9 Mc/s
Oscillator type	power amp, gnd-cath
P.A. Oscillator tube	STC 3Q/261E
Osc. input, max	70 kw
Osc. output, max	50 kw
Pre-exciter	no
Dee bias, d-c max	none v
Dee-to-dee, max	120 kv
Shielding	2.5 ft brick and sand, 1.5 ft water

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	10.8				
Frequency, Mc/sec	19.9				
Mag. field, k-gauss	13				
Dee-to-dee, kv	100				
Internal Beam, Stable, μa	750				
Peak, μa	1000				
Energy spread, %					
External Beam, Stable, μa	30*				
Peak, μa	50*				
Energy spread, %					

* Preliminary figures near machine. Extraction tests in progress.

Beam "piped" 32 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Published Articles Describing Machine

D.E. Care, L.H. Martin, and J. L. Rouse, "A Variable Energy Cyclotron," Australian Journal of Physics, 8, 306 (1955).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Cyclotron du Centre de Louvain

Institution: Centre de Physique Nucléaire de l'Université de Louvain

Address: Avenue Cardinal Mercier, Louvain, Belgique

Person in charge: Robert Keppenne

Person supplying data: Robert Keppenne   Date: June 1958

Present Fields of Research	% of Time
Isotope production	70
Neutron work	30

History and Status

Design study:

Model tests:

Engineering design:

Construction started: 1949

Completion date: ✓

Scheduled operation: 25 hrs/wk

Magnet cost:

Total cost:

Design Specifications

Magnet

Core dia.: 107.5 cm, ____ in.

Pole tip dia.: 101.5 cm, ____ in.

Beam radius, max: 41 cm, ____ in.

Field gap, center: 15 cm, ____ in.
+ two shimming gaps of 0.8 mm each

Field, max: 18.1 k-gauss

Field drop-off: 2.5 %

Weight, Fe 60 ; Cu ____ tons

Winding: copper

Cooling: air cooled

Dee dia.: 86.6 cm, ____ in.

Dee aperture: 5.3 cm, ____ in.

Dee-to-dee gap: 5 cm, ____ in.

Beam extraction, type: electrost. def.

Ion source, type: hot cathode arc discharge type

Design energy and particle

12.7 Mev deuterons

____ Mev

____ Mev

____ Mev

R-F frequency: 13.6 Mc/s

Oscillator type: power amp. driven by an oscillator

P.A. ~~Oscillator~~ tube: two 5770

P.A. ~~Osc.~~ input, max: 40 kw

Osc. output, max: ____ kw

Pre-exciter: 15-kw radio telegraph transmitter: Press Wireless Inc.

Dee bias, d-c max: ____ v

Dee-to-dee, max: ____ kv

Shielding: 50 cm ord. con. on three. 100 cm con. and 100 cm water on fourth.

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		12.71			
Frequency, Mc/sec		13,55			
Mag. field, k-gauss	(center)	18.1			
Dee-to-dee, kv					
Internal Beam, Stable, μa		300			
Peak, μa		400			
Energy spread, %					
External Beam, Stable, μa		none			
Peak, μa					
Energy spread, %					

Beam "piped" ______ ft to external target. Beam analyzing magnet used? __________

Unusual Features

Published Articles Describing Machine

1. Y. Hecq and L. Gillon, "Stabilisation du champ magnetique de l'electric aimant du cyclotron de Louvain par amplidyne," Annales de la Societe Scientifigue de Bruxelles, December 15, 1951.

2. L. Gillon et Y. Hecq, "Controle des thyratrons de l'alimentation en courant continu de l'amplification 100 kw du cyclotron," Annales de la Societe scientifique de Bruxelles, December 21, 1953.

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution ______

Address Sofia, Bulgaria

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	✓
		Completion date	
		Scheduled operation	hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia. ______ cm, ______ in.

Pole tip dia. 120 cm, ______ in.

Beam radius, max ______ cm, ______ in.

Field gap, center ______ cm, ______ in.

Field, max 14 k-gauss

Field drop-off ______ %

Weight, Fe 120 ; Al Cu ______ tons

Winding ______

Cooling ______

Dee dia. ______ cm, ______ in.

Dee aperture ______ cm, ______ in.

Dee-to-dee gap ______ cm, ______ in.

Beam extraction, type ______

Ion source, type ______

Design energy and particle

12.5 Mev deuterons

25 Mev alphas

______ Mev ______

______ Mev ______

R-F frequency ______ Mc/s

Oscillator type ______

Oscillator tube ______

Osc. input, max ______ kw

Osc. output, max 120 kw

Pre-exciter ______

Dee bias, d-c max ______ v

Dee-to-dee, max ______ kv

Shielding ______

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ________ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

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Published Articles Describing Machine

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X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution Institute of Atomic Energy

Address Peiping, China

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	1958
		Scheduled operation	______ hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia.	______ cm, ______ in.
Pole tip dia.	120 cm, ______ in.
Beam radius, max	______ cm, ______ in.
Field gap, center	______ cm, ______ in.
Field, max	14 k-gauss
Field drop-off	______ %
Weight, Fe 120 ; Al/Cu	______ tons
Winding	
Cooling	
Dee dia.	______ cm, ______ in.
Dee aperture	______ cm, ______ in.
Dee-to-dee gap	______ cm, ______ in.
Beam extraction, type	
Ion source, type	

Design energy and particle

12.5 Mev deuterons

25 Mev alphas

______ Mev ______

______ Mev ______

R-F frequency	______ Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	______ kw
Osc. output, max	120 kw
Pre-exciter	
Dee bias, d-c max	______ v
Dee-to-dee, max	______ kv
Shielding	

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution Institute of Nuclear Physics Research

Address Husinez-Rez, Prague, Czechoslovakia

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	1958
		Scheduled operation	hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia.	cm,	in.
Pole tip dia.	120 cm,	in.
Beam radius, max	cm,	in.
Field gap, center	cm,	in.
Field, max	14 k-gauss	
Field drop-off	%	
Weight, Fe 120 ; Al / Cu	tons	
Winding		
Cooling		
Dee dia.	cm,	in.
Dee aperture	cm,	in.
Dee-to-dee gap	cm,	in.
Beam extraction, type		
Ion source, type		

Design energy and particle

12.5	Mev	deuterons
25	Mev	alphas
	Mev	
	Mev	

R-F frequency	Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	kw
Osc. output, max	120 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	kv
Shielding	

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine ______

Institution Institute for Theoretical Physics, University of Copenhagen, Denmark

Address Blegdamsvej 17, Ø.

Person in charge Dr. N. O. Lassen

Person supplying data cand. mag. N. Roy Poulsen Date June 1958

Present Fields of Research	% of Time
Scattering experiments	90
Isotope production	10

History and Status

Design study ______

Model tests ______

Engineering design ______

Construction started ______

Completion date ______

Scheduled operation ______ hrs/wk

Magnet cost ______

Total cost ______

Design Specifications

Magnet

Core dia.	120 cm,	47 in.
Pole tip dia.	90 cm,	35 in.
Beam radius, max	40 cm,	16 in.
Field gap, center	11 cm,	4.3 in.
Field, max	17.5 k-gauss	
Field drop-off	1.75 %	
Weight, Fe 35 ;	Cu 2.5 tons	
Winding	solid strip 3x0.3 cm	
Cooling	oil bath	
Dee dia.	42.5 cm,	17 in.
Dee aperture	5 - 7 cm,	2-2.8 in.
Dee-to-dee gap	5 cm,	2 in.
Beam extraction, type	electrostatic	
Ion source, type	capillary hooded arc (spec.)	

Design energy and particle

6 Mev	protons (H_2)
12 Mev	deuterons
24 Mev	alphas
____ Mev	

R-F frequency	13 Mc/s
Oscillator type	push-pull, self-ex.
Oscillator tube	two Maclett 880
Osc. input, max	30 kw
Osc. output, max	____ kw
Pre-exciter	no
Dee bias, d-c max	6000 v
Dee-to-dee, max	200 kv
Shielding	boron-loaded concrete 4 - 7 ft

over

X-882A

ACTUAL PERFORMANCE DATA

	Protons(H_2)	Deuterons	Alphas		
Energy, Mev	5.3	10.5	21		
Frequency, Mc/sec	13	13	13		
Mag. field, k-gauss	17.5	17.5	17.5		
Dee-to-dee, kv	150	150	150		
Internal Beam, Stable, μa	200	100	50		
Peak, μa	300	150	75		
Energy spread, %					
External Beam, Stable, μa	4* 0.2**	2* 0.1**	2* 0.1**		
Peak, μa					
Energy spread, %	<1 <0.5	<1 <0.5	<1 <0.5		

*9 ft from cyclotron, after focusing magnets. **at 33 ft, after analyzing magnet

Beam "piped" 33 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Ion source through hole in magnet yoke

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Cyclotron de Saclay

Institution: Centre d'Etudes Nucléaires

Address: B.P. No. 2 Gif sur Yvette (Seine et Oise) France

Person in charge: André Bariaud et Jacques Thirion

Person supplying data: ______ Date: November 1958

Present Fields of Research	% of Time
Scattering experiments	80
Nuclear reactions	20

History and Status

Design study	1947
Model tests	
Engineering design	
Construction started	1948
Completion date	1953
Scheduled operation	90 hrs/wk
Magnet cost	60 million francs
Total cost	300 million francs

Design Specifications

Magnet

Core dia.	______ cm, ______ in.
Pole tip dia.	______ cm, 70 in.
Beam radius, max	______ cm, 27 in.
Field gap, center	______ cm, 11.8 in.
Field, max	18 k-gauss
Field drop-off	2 %
Weight, Fe	252 ; Cu 18 tons
Winding	hollow copper bar
Cooling	deionized water
Dee dia.	______ cm, 60 in.
Dee aperture	______ cm, 6.7 in.
Dee-to-dee gap	______ cm, 3.1 in.
Beam extraction, type	d-c deflector
Ion source, type	Oak Ridge

Design energy and particle

11 Mev	protons
22 Mev	deuterons
44 Mev	alphas
______ Mev	

R-F frequency	10.6 Mc/s
Oscillator type	self-ex., gnd-g
Oscillator tube	one LCT 3067 B
Osc. input, max	80 kw
Osc. output, max	60 kw
Pre-exciter	yes
Dee bias, d-c max	no v
Dee-to-dee, max	180 kv
Shielding	underground, 6 ft concrete

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	11		44		
Frequency, Mc/sec	10.5		10.5		
Mag. field, k-gauss	13.75		13.75		
Dee-to-dee, kv	180		180		
Internal Beam, Stable, μa	100		50		
Peak, μa	500		200		
Energy spread, %					
External Beam, Stable, μa	10		1		
Peak, μa					
Energy spread, %					

Beam "piped" 30 ft to external target. Beam analyzing magnet used? 2 focusing and analyzing magnets + one 60° analyzing magnet

Unusual Features

Azimuthally varying field; correcting coils inside the chamber.

Published Articles Describing Machine

1. Pierre Debraine, "Le cyclotron du C.E.A. à Saclay", Onde électrique T XXXV, No. 344, p1048 (Nov. 1955).

2. Andre Bariaud, "Les circuits HF du cyclotron", Onde electriqe T XXXV, No. 344, p1052 (Nov. 1955).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Cyclotron

Institution: Collège de France

Address: Laboratoire de Physique Nucléaire à Orsay (Seine et Oise)

Person in charge: Dr P. Savel

Person supplying data: Cabrespine — Date: June 1958

Present Fields of Research	% of Time
Isotope production	10
Nuclear reactions	90

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1937
Completion date	1939
Scheduled operation	40 hrs/wk
Magnet cost	
Total cost	1,500,000 francs (1937)

Design Specifications

Magnet

Core dia.	cm, 35.5 in.
Pole tip dia.	cm, 35.5 in.
Beam radius, max	cm, 14 in.
Field gap, center	cm, 4.5 in.
Field, max	17 k-gauss
Field drop-off	2 %
Weight, Fe ; Cu	tons
Winding	copper
Cooling	ordinary water
Dee dia.	cm, 29.5 in.
Dee aperture	cm, 2 in.
Dee-to-dee gap	cm, 1.6 in.
Beam extraction, type	electric deflector
Ion source, type	r-f heated filament

Design energy and particle

6.7 Mev	deuterons
12 Mev	alphas
Mev	
Mev	

R-F frequency	11.5 Mc/s
Oscillator type	auto-oscillator amp.
Oscillator tube	two 100 TH CFTH
Osc. input, max	22 kw
Osc. output, max	kw
Pre-exciter	no
Dee bias, d-c max	none v
Dee-to-dee, max	40 kv
Shielding	1 m concrete all sides and top

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		6.7	12		
Frequency, Mc/sec		11.5	11.5		
Mag. field, k-gauss		15	15		
Dee-to-dee, kv		40	40		
Internal Beam, Stable, μa		200			
Peak, μa					
Energy spread, %					
External Beam, Stable, μa		10	0.1		
Peak, μa		20	1		
Energy spread, %		10	4		

Beam "piped" _______ ft to external target. Beam analyzing magnet used? 2 focusing electrical + 1 analyser

Unusual Features

Published Articles Describing Machine

1. P. Debraine, "Le Cyclotron," Atomas (Février 1947)

2. A. Bariaud, "Le Cyclotron," Edition de la Revue d'Optique (1950)

3. M. Vivargent, Focalisation det analyse du faisceau du Cyclotron du College de France Thèse, Paris (1956)

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine: Variable Energy Cyclotron

Institution: Laboratorie de Physique Nucleaires

Address: Orsay, Seine-et-Oise, France

Person in charge: ___

Person supplying data: (various sources) Date: ___

Present Fields of Research	% of Time

History and Status

Design study ___

Model tests ___

Engineering design ___

Construction started ✓

Completion date ___

Scheduled operation ___ hrs/wk

Magnet cost ___

Total cost ___

Design Specifications

Magnet

Core dia. 200 cm, ___ in.

Pole tip dia. ___ cm, ___ in.

Beam radius, max ___ cm, ___ in.

Field gap, center ___ cm, ___ in.

Field, max ___ k-gauss

Field drop-off ___ %

Weight, Fe ___ ; Al Cu ___ tons

Winding ___

Cooling ___

Dee dia. ___ cm, ___ in.

Dee aperture ___ cm, ___ in.

Dee-to-dee gap ___ cm, ___ in.

Beam extraction, type ___

Ion source, type ___

Design energy and particle

20 Mev* deuterons

___ Mev ___

___ Mev ___

___ Mev ___

R-F frequency ___ Mc/s

Oscillator type ___

Oscillator tube ___

Osc. input, max ___ kw

Osc. output, max ___ kw

Pre-exciter ___

Dee bias, d-c max ___ v

Dee-to-dee, max ___ kv

Shielding ___

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine Festfrequenz-Zykotron, Type U-120-1

Institution Zentralinstitut für Kernphysik, Rossendorf bei Dresden

Address Dresden-Bad Weisser-Hirsch, Postschliessfach 19

Person in charge Prof. Dr. phil. habil. Josef P. Schintlmeister

Person supplying data ______ Date October 1958

Present Fields of Research	% of Time
Nuclear physics	100

History and Status

Design study	
Model tests	developed in USSR
Engineering design	
Construction started	
Completion date	August 1958
Scheduled operation	at present 35 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	144 cm, ___ in.
Pole tip dia.	120 cm, ___ in.
Beam radius, max	52.5 cm, ___ in.
Field gap, center	17.0 cm, ___ in.
Field, max	17 k-gauss
Field drop-off	2.4 %
Weight, Fe	105 ; Cu 15 tons
Winding	2 x 336
Cooling	distilled water
Dee dia.	60.8 cm, ___ in.
Dee aperture	2.5 x 1.0 cm, ___ in.
Dee-to-dee gap	2.5 cm, ___ in.
Beam extraction, type	electrostatic
Ion source, type	capillary arc

Design energy and particle

12.5 Mev	deuterons
25 Mev	alphas
___ Mev	
___ Mev	

R-F frequency	___ Mc/s
Oscillator type	GU-120, 5-stage push-pull
Oscillator tube	5th stage, two, GU-23-A
Osc. input, max	___ kw
Osc. output, max	150 kw
Pre-exciter	external and self-excited
Dee bias, d-c max	0 v
Dee-to-dee, max	110 const., 160 pulsed kv
Shielding	concrete, 2.5 m

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas	H_2^+	
Energy, Mev				13.5	
Frequency, Mc/sec				11.086	
Mag. field, k-gauss				14 700	
Dee-to-dee, kv				120	
Internal Beam, Stable, μa				1000 ave. in pulsed operation	
Peak, μa				2250 pulsed operation	
Energy spread, %					
External Beam, Stable, μa				35% of average	
Peak, μa				51% of peak internal beam	
Energy spread, %					

Beam "piped" 10.1m ~~ft~~ to external target. Beam analyzing magnet used? Yes

Unusual Features

The cyclotron is largely automatic; 33 electric servomotors are used for remote control.

Published Articles Describing Machine

J. Schintlmeister, "Über das Zyklotron des Zentralinstitutes für Kernphysik und die Forschungsvorhaben" im Bereich "Physik der Atomkerne" in der Broschüre: Das Zentralinstitut für Kernphysik am Beginn seiner Arbeit, herausgegeben von H. Barwich. Akademie-Verlag Berlin, 1958.

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Heidelberg Cyclotron

Institution: Max Planck Institut für medizinische Forschung

Address: Heidelberg Jahnstr. 29

Person in charge: Dr. U. Schmidt-Rohr

Person supplying data: U. Schmedit-Rohr   Date: June 1958

Present Fields of Research	% of Time
Isotope production	20
Nuclear reactions	40
Short-life activities (β - recoil exp., mirror nuclei)	40

History and Status

Design study: ____

Model tests: ____

Engineering design: ____

Construction started: first 1938; second 1952

Completion date: first 1944; second Sept 1956

Scheduled operation: 40 hrs/wk (80 after October)

Magnet cost: ____

Total cost: 1.5×10^6 DM

Design Specifications

Magnet

Core dia.: 128 cm, ____ in.

Pole tip dia.: 101 cm, ____ in.

Beam radius, max: 43 cm, ____ in.

Field gap, center: 27 cm, ____ in.

Field, max: 17 k-gauss

Field drop-off: 1.5 %

Weight, Fe: 80 ; ____ tons

Winding: rectangular tube

Cooling: distilled water

Dee dia.: 90 cm, ____ in.

Dee aperture: 6.0 cm, ____ in.

Dee-to-dee gap: 4 cm, ____ in.

Beam extraction, type: d-c deflector

Ion source, type: hooded capillary arc or PIG type

Design energy and particle

13 Mev deuterons

26 Mev alphas

____ Mev ____

____ Mev ____

R-F frequency: 12.8 Mc/s

Oscillator type: neutralized

Oscillator tube: two TW 25

Osc. input, max: ____ kw

Osc. output, max: 80 kw

Pre-exciter: yes

Dee bias, d-c max: 2000 available v

Dee-to-dee, max: 100 kv

Shielding: 1 m water; 0.5 m concrete

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		13	26		
Frequency, Mc/sec		12.8			
Mag. field, k-gauss		17			
Dee-to-dee, kv		100			
Internal Beam, Stable, μa		300	10		
Peak, μa		500			
Energy spread, %		< 2%			
External Beam, Stable, μa	6 m	0.5*			
Peak, μa		> 1			
Energy spread, %					

* 6 m from cyclotron, beam 4 mm diameter

Beam "piped" 20 ft to external target. Beam analyzing magnet used? under construction

Unusual Features

One-dee system, admits experiments inside the chamber. Deflector independent from dee adjustable; water-cooled tubes for deflector septum. Alternating-gradient focusing magnet channel.

Published Articles Describing Machine

R. Bock, A. Doehring, J. Janecke, O. Knecht, L. Koester, H. Maier-Leibnitz, Ch. Schmelzer, U. Schmidt-Rohr, "Ein Festfrequenz-Zyklotron mit einem Dee," Z.f. angew. Phys. 10.49. (1958).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution ______ Hebrew University

Address ______ Jerusalem, Israel

Person in charge ______

Person supplying data ______ Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	✓
		Completion date	
		Scheduled operation	hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia. ______ cm, ______ in.

Pole tip dia. ______ cm, ______ in.

Beam radius, max ______ cm, ______ in.

Field gap, center ______ cm, ______ in.

Field, max ______ k-gauss

Field drop-off ______ %

Weight, Fe ______ ; Al / Cu ______ tons

Winding ______

Cooling ______

Dee dia. ______ cm, ______ in.

Dee aperture ______ cm, ______ in.

Dee-to-dee gap ______ cm, ______ in.

Beam extraction, type ______

Ion source, type ______

Design energy and particle

2 Mev protons

______ Mev ______

______ Mev ______

______ Mev ______

R-F frequency ______ Mc/s

Oscillator type ______

Oscillator tube ______

Osc. input, max ______ kw

Osc. output, max ______ kw

Pre-exciter ______

Dee bias, d-c max ______ v

Dee-to-dee, max ______ kv

Shielding ______

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine Kyoto Cyclotron

Institution Institute for Chemical Research, University of Kyoto

Address Sakyo-ku, Kyoto, Japan

Person in charge Prof. Kiichi Kimura

Person supplying data Dr. R. Ishiwari and Dr. S. Yamashita Date June 1958

Present Fields of Research	% of Time
Isotope production	10
Nuclear reactions and structure	83
Biological experiment	7

History and Status

Design study	
Model tests	
Engineering design	
Construction started	April 1952
Completion date	January 1956
Scheduled operation	30 hrs/wk
Magnet cost	¥ 19,300,000
Total cost	¥ 87,000,000

Design Specifications

Magnet

Core dia.	126 cm,	in.
Pole tip dia.	105 cm,	in.
Beam radius, max	47.0 cm,	in.
Field gap, center	13.4 cm,	in.
Field, max	17.5 k-gauss	
Field drop-off	2.65 %	
Weight, Fe	71.3 ; Cu 8.5 tons	
Winding	30 x 2.5mm strip	
Cooling	oil bath	

Dee dia.	102.4 cm,	in.
Dee aperture	4.8 cm,	in.
Dee-to-dee gap	4.0 cm; 2.6 cm between feelers cm,	in.
Beam extraction, type	electrostatic def.	
Ion source, type	hooded arc	

Design energy and particle

7.6 Mev	protons
15.2 Mev	deuterons
30 Mev	alphas
Mev	

R-F frequency	13.1 Mc/s
Oscillator type	self-ex., grd-g
Oscillator tube	two, RCA 5671
Osc. input, max	150 kw
Osc. output, max	100 kw
Pre-exciter	no
Dee bias, d-c max	-300 v
Dee-to-dee, max	150 kv
Shielding	170 cm concrete, all sides and top

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.6	15.2	30		
Frequency, Mc/sec	13.1	13.1	13.1		
Mag. field, k-gauss	17.5	17.5	17.5		
Dee-to-dee, kv	120	120	120		
Internal Beam, Stable, μa	200	200	40		
Peak, μa	350	350	50		
Energy spread, %					
External Beam, Stable, μa	40*	40*	5*		
Peak, μa					
Energy spread, %					

* Near cyclotron

Beam "piped" 30 ft to external target. Beam analyzing magnet used? Yes

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The Osaka University 44-Inch Cyclotron

Institution: Faculty of Science, Osaka University

Address: Nakanoshima, Osaka, Japan

Person in charge: Dr. Tetsuo Wakatsuki

Person supplying data: Tetsuo Wakatsuki   Date: June 1958

Present Fields of Research	% of Time
Isotope production	25
Nuclear reactions and structures	75

History and Status

Design study:

Model tests:

Engineering design:

Construction started: July 1952

Completion date: July 1954

Scheduled operation: 40 hrs/wk

Magnet cost:

Total cost: $100,000

Design Specifications

Magnet

Core dia.: 44-48 taper cm, in.

Pole tip dia.: cm, 44 in.

Beam radius, max: 50 cm, in.

Field gap, center: 14 cm, in.

Field, max: 15.5 k-gauss

Field drop-off: 1.5 %

Weight, Fe 45 ; Cu 8 tons

Winding: solid strip

Cooling: oil bath

Dee dia.: cm, 21 in.

Dee aperture: cm, 1 in.

Dee-to-dee gap: cm, 2 in.

Beam extraction, type: d-c def., mag. channel

Ion source, type: Oak Ridge

Design energy and particle

12 Mev deuterons

Mev

Mev

Mev

R-F frequency: 10.6 Mc/s

Oscillator type: self-ex., gnd-g

Oscillator tube: two SN167 demountable

Osc. input, max: 60 kw

Osc. output, max: 45 kw

Pre-exciter: Berkeley-type booster

Dee bias, d-c max: none v

Dee-to-dee, max: 80 kv

Shielding: concrete wall 1.3 m and earth wall 3m; + concrete blocks

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	5.7	11.5	22.0		
Frequency, Mc/sec	10.6	10.6	10.6		
Mag. field, k-gauss	14	14	14		
Dee-to-dee, kv	80	80	80		
Internal Beam, Stable, μa	30	60	6		
Peak, μa	50	100	10		
Energy spread, %					
External Beam, Stable, μa	5 (0.1*)	10	1		
Peak, μa	8	15	2		
Energy spread, %					

*Beam "piped" 20 ft to external target. Beam analyzing magnet used? yes
Slit width 7 mm

Unusual Features

Built-in demountable oscillator tube.

Published Articles Describing Machine

Annual Report of Scientific Works, Faculty of Science, Osaka University; Vol. 3, 1-24 (1955).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine The UTINS 63-Inch Cyclotron

Institution Institute for Nuclear Study

Address Tanashi-Machi, Tokyo, Japan

Person in charge Dr. Seishi Kikuchi

Person supplying data Seishi Kikuchi Date May 1958

Present Fields of Research	% of Time
Isotope production	30
Nuclear reaction and structure	70
"on beam" 50 hrs/wk	

History and Status

Design study

Model tests

Engineering design

Construction started April 1954

Completion date (first beam) Sept 1957

Scheduled operation 85 hrs/wk

Magnet cost $220,000

Total cost $650,000

Design Specifications

Magnet

Core dia. 212 cm, ___ in.

Pole tip dia. 160 cm, (63.0) in.

Beam radius, max 72 cm, ___ in.

Field gap, center 25 cm, ___ in.

Field, max 13.3 k-gauss

Field drop-off 2 %

Weight, Fe 243 ; 21.8 tons

Winding solid strip 2x32 and 2.2x28 mm

Cooling oil bath

Dee dia. 80 cm, ___ in.

Dee aperture 7 cm, ___ in.

Dee-to-dee gap 10 cm, ___ in.

Beam extraction, type r-f def. mag. channel

Ion source, type Oak Ridge

Design energy and particle

7.5-15 Mev protons

15-21 Mev deuterons

30-42 Mev alphas

___ Mev

R-F frequency 84 - 12.1 Mc/s

Oscillator type self-ex., gnd-g

Oscillator tube two, 9T-71

Osc. input, max 220 kw

Osc. output, max 120 kw

Pre-exciter no

Dee bias, d-c max -2000 v

Dee-to-dee, max 260 kv

Shielding concrete, 150 cm sides and 96 cm top

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.5 ~ 15	15 ~ 42	30 ~ 42		
Frequency, Mc/sec	8.4 ~ 12.1	8.4 ~ 10	8.4 ~ 10		
Mag. field, k-gauss	5.5 ~ 7.9	11. ~ 13.	11 ~ 13		
Dee-to-dee, kv	64 ~ 140	120 ~ 190	120 ~ 190		
Internal Beam, Stable, μa	600	600	50		
Peak, μa	1000				
Energy spread, %					
External Beam, Stable, μa	80*, 0.3**	80*, 0.3**	10*, 0.05**		
Peak, μa	120, 0.5				
Energy spread, %					

* About 10 cm from def. exit. ** At 27 ft, after 5-mm dia collimating slits.

Beam "piped" 27 ft to external target. Beam analyzing magnet used? ~~under preparation~~ tion

Unusual Features

Variable energy; the length of dee stem is variable by adjusting the position of the shorting bar. Relative radial distribution of magnetic field is almost constant for the wide range of magnetic field strength between 5000 and 14000 gauss (see Ref. 1). By exchanging r-f system, and raising the magnetic field to 16000 gauss, the machine can be used as an f-m cyclotron for 60-Mev protons.

Published Articles Describing Machine

1. H. Kumagai et al, "Reports on the Wide Range Magnet for 160-cm Synchrocyclotron," INSJ-2, (June 13, 1957).
2. Full report is under preparation.

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The Scientific Research Institute 26-Inch Cyclotron

Institution: Scientific Research Institute

Address: 31, Kamifujimae-cho, Bunkyo-ku, Tokyo, Japan

Person in charge: Dr. Fumio Yamasaki

Person supplying data: F. Yamasaki   Date: May 1958

Present Fields of Research	% of Time
Isotope production	20
Nuclear reaction and structure	50
Radiochemical exp. (as neutron source)	30
"On Beam" 30 hrs/wk	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	Sept 1951
Completion date	Dec 1952
Scheduled operation	40 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, 26 in.
Pole tip dia.	___ cm, 25 in.
Beam radius, max	___ cm, 10.7 in.
Field gap, center	___ cm, 3.44 in.
Field, max	15.8 k-gauss (at exit slit)
Field drop-off	3 %
Weight, Fe	18 ; Cu 4 tons
Winding	0.43 x 0.16 in.
Cooling	circulated oil bath
Dee dia.	___ cm, 22 in.
Dee aperture	___ cm, 1.7 in.
Dee-to-dee gap	___ cm, 1.54 in.
Beam extraction, type	d-c def.
Ion source, type	low voltage arc

Design energy and particle

4.3 Mev deuterons

___ Mev ___

___ Mev ___

___ Mev ___

R-F frequency	11.4 Mc/s
Oscillator type	self-ex.
Oscillator tube	SN 167H x 2
Osc. input, max	24 kw
Osc. output, max	12 kw
Pre-exciter	no
Dee bias, d-c max	none v
Dee-to-dee, max	30 kv
Shielding	4-ft concrete, all sides

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		4			
Frequency, Mc/sec		11.4			
Mag. field, k-gauss		15			
Dee-to-dee, kv		27			
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa		30			
Peak, μa		50			
Energy spread, %		5			

Beam "piped" ________ ft to external target. Beam analyzing magnet used? no

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The Variable Energy 16-Inch Cyclotron

Institution: The Institute for Solid State Physics

Address: Komaba, Meguro, Tokyo, Japan

Person in charge: Kazuo Ôno

Person supplying data: Kazuo Ôno   Date: May 1958

Present Fields of Research	% of Time
Nuclear reactions	75
Isotope production	10
Radiation damage	15
"on beam" 30 hrs/wk	

History and Status	
Design study	
Model tests	
Engineering design	
Construction started	April 1953
Completion date	(First beam) June 1955
Scheduled operation	hrs/wk
Magnet cost	
Total cost	$40,000

Design Specifications

Magnet

Core dia.	cm,	20 in.
Pole tip dia.	cm,	16 in.
Beam radius, max	cm,	6.4 in.
Field gap, center	cm,	2 in.
Field, max	18.5 k-gauss	
Field drop-off	2.5 %	
Weight, Fe	6 ; Cu 1 tons	
Winding	solid strip, 18x2mm	
Cooling	water cooling	
Dee dia.	cm,	13.6 in.
Dee aperture	cm,	0.8 in.
Dee-to-dee gap	cm,	0.8 in.
Beam extraction, type	inner deflector	
Ion source, type	hooded low voltage	

Design energy and particle

1 - 2 Mev	deuterons
2 - 4 Mev	alphas
2 - 4 Mev	protons
Mev	

R-F frequency	11 - 14 Mc/s
Oscillator type	self-ex., gnd-g
Oscillator tube	one 8T11R
Osc. input, max	10 kw
Osc. output, max	6 kw
Pre-exciter	no
Dee bias, d-c max	none v
Dee-to-dee, max	18 kv
Shielding	2-ft concrete or water-tank, all sides

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		1.2 - 2.0	2.5 - 4.0		
Frequency, Mc/sec		11 - 14	11 - 14		
Mag. field, k-gauss		14 - 19	14 - 19		
Dee-to-dee, kv		10 - 18	10 - 18		
Internal Beam, Stable, μa		100	10		
Peak, μa		250			
Energy spread, %					
External Beam, Stable, μa		25* 0.1**	0.05** 0.01**		
Peak, μa		45 0.5	0.1		
Energy spread, %		0.3	1 0.3		

* Intermediate position. ** At 16 ft from cyclotron.

Beam "piped" 16 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Approximately constant distribution of magnetic induction B in the pole by special design of pole shape. Magnetic field variable, by only changing the coil current, from 14 to 18 kg with 1 to 2.5% field drop-off at the exit (r = 16cm). Frequency variable oscillator, 11 ~ 14 Mc/s for deuteron and 22 ~ 28 Mc/s for proton. Single dee.

Published Articles Describing Machine

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine 12-Mev Radial-Sector Fixed-Frequency Proton Cyclotron

Institution Technical University - Accelerator Division

Address Kanaaburg 2, Delft, Netherlands

Person in charge Prof. Dr. F. A. Heyn

Person supplying data F. A. Heyn Date July 1958

Present Fields of Research	% of Time
Machine itself being studied	100

History and Status

Design study ____

Model tests ____

Engineering design ____

Construction started 1956

Completion date (internal beam) Jan. 1958

Scheduled operation ____ hrs/wk

Magnet cost ____

Total cost ____

Design Specifications

Magnet

Core dia. 85 cm, ____ in.

Pole tip dia. 85 cm, ____ in.

Beam radius, max 36 cm, ____ in.

Field gap, center 12 cm, ____ in.

Field, ~~max~~ center 14 k-gauss

Field ~~drop-off~~ increases ____ % at r_{max} H = 10.8 to 18.5 kgauss

Weight, Fe ____; Al ____ tons

Winding hollow aluminum, 2 x 2 cm

Cooling water

Dee dia. ____ cm, ____ in.

Dee aperture ____ cm, ____ in.

Dee-to-dee gap one dee ____ cm, ____ in.

Beam extraction, type ____

Ion source, type ____

Design energy and particle

12 Mev protons

____ Mev ____

____ Mev ____

____ Mev ____

R-F frequency 21.5 Mc/s

Oscillator type self-ex., gnd-g

Oscillator tube one - 20 kw

Osc. input, max ____ kw

Osc. output, max ____ kw

Pre-exciter no

Dee bias, d-c max 500 v

Dee-to-dee, max 25 kv

Shielding ____

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	12				
Frequency, Mc/sec	21.5				
Mag. field, k-gauss (center)	14				
Dee-to-dee, kv	20-25				
Internal Beam, Stable, μa	25*				
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

*Held low because of inadequate shielding

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Radial-sector "isochronous" cyclotron. Fixed frequency - only 25 kw on single dee. High frequency oscillator at atmospheric pressure.

Published Articles Describing Machine

F. A. Heyn and Kloc Kong Tat, Rev. Sci. Instr. (July 1958)

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ____

Institution Institute of Nuclear Research

Address Cracow, Poland

Person in charge ____

Person supplying data (various sources) Date ____

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	in operation
		Scheduled operation	____ hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia. 50 cm, ____ in.

Pole tip dia. ____ cm, ____ in.

Beam radius, max ____ cm, ____ in.

Field gap, center ____ cm, ____ in.

Field, max ____ k-gauss

Field drop-off ____ %

Weight, Fe ____ ; Al Cu ____ tons

Winding ____

Cooling ____

Dee dia. ____ cm, ____ in.

Dee aperture ____ cm, ____ in.

Dee-to-dee gap ____ cm, ____ in.

Beam extraction, type ____

Ion source, type ____

Design energy and particle

____ Mev ____

____ Mev ____

____ Mev ____

____ Mev ____

R-F frequency ____ Mc/s

Oscillator type ____

Oscillator tube ____

Osc. input, max ____ kw

Osc. output, max ____ kw

Pre-exciter ____

Dee bias, d-c max ____ v

Dee-to-dee, max ____ kv

Shielding ____

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution Institute of Nuclear Research

Address Cracow, Poland

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	1958
		Scheduled operation	______ hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia.	______ cm,	______ in.
Pole tip dia.	120 cm,	______ in.
Beam radius, max	______ cm,	______ in.
Field gap, center	______ cm,	______ in.
Field, max	14 k-gauss	
Field drop-off	______ %	
Weight, Fe 120; Al/Cu ______ tons		
Winding		
Cooling		

Dee dia.	______ cm,	______ in.
Dee aperture	______ cm,	______ in.
Dee-to-dee gap	______ cm,	______ in.
Beam extraction, type		
Ion source, type		

Design energy and particle

12.5 Mev	deuterons
25 Mev	alphas
______ Mev	
______ Mev	

R-F frequency	______ Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	______ kw
Osc. output, max	120 kw
Pre-exciter	
Dee bias, d-c max	______ v
Dee-to-dee, max	______ kv
Shielding	concrete

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

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Published Articles Describing Machine

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X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution ______

Address Bucharest, Rumania

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	✓
		Completion date	
		Scheduled operation	hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia.	cm,	in.
Pole tip dia.	120 cm,	in.
Beam radius, max	cm,	in.
Field gap, center	cm,	in.
Field, max	14 k-gauss	
Field drop-off	%	
Weight, Fe 120 ; Al Cu	tons	
Winding		
Cooling		
Dee dia.	cm,	in.
Dee aperture	cm,	in.
Dee-to-dee gap	cm,	in.
Beam extraction, type		
Ion source, type		

Design energy and particle

12.5	Mev	deuterons
25	Mev	alphas
	Mev	
	Mev	

R-F frequency	Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	kw
Osc. output, max	120 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	kv
Shielding	

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ________ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: 80-cm Cyclotron

Institution: Nobel Institute of Physics

Address: Stockholm 50, Sweden

Person in charge: Dr. K. G. Malmfors

Person supplying data: K. G. Malmfors   Date: May 1958

Present Fields of Research	% of Time
Isotope production	20
Neutron work	80

History and Status

Design study	
Model tests	
Engineering design	
Construction started	First 1937 Second 1953
Completion date	First 1939 Second 1954
Scheduled operation	hrs/wk
Magnet cost	
Total cost	$50,000

Design Specifications

Magnet

Core dia.	cm, 32 in.
Pole tip dia.	cm, 32 in.
Beam radius, max	cm, 28 in.
Field gap, center	cm, 5 in.
Field, max	15 k-gauss
Field drop-off	2 %
Weight, Fe 15 ; Cu 2 tons	
Winding	square tube
Cooling	water
Dee dia.	cm, 20 in.
Dee aperture	cm, 2.5 in.
Dee-to-dee gap	cm, 2 in.
Beam extraction, type	int. el. stat. def.
Ion source, type	arc

Design energy and particle

3.5 Mev	protons
7 Mev	deuterons
14 Mev	alphas
Mev	

R-F frequency	12.2 Mc/s
Oscillator type	push-pull
Oscillator tube	two, Phillips TAW 12/10
Osc. input, max	40 kw
Osc. output, max	20 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	80 kv
Shielding	3 ft concrete

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	3.5	7.0	14.0		
Frequency, Mc/sec	12.2	12.2	12.2		
Mag. field, k-gauss	15	15	15		
Dee-to-dee, kv	80	80	80		
Internal Beam, Stable, μa	500	500			
Peak, μa		1000			
Energy spread, %					
External Beam, Stable, μa	5-10				
Peak, μa		30			
Energy spread, %	1	1			

Beam "piped" 18 ft to external target. Beam analyzing magnet used? under installation

Unusual Features

Published Articles Describing Machine

K. G. Malmfors, J. Kjellman, and A. Nilsson, Nucl. Instr. 1, 186 (1957).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The Stockholm 225-cm Cyclotron

Institution: Nobel Institute of Physics

Address: Stockholm 50, Sweden

Person in charge: Dr. Hugo Atterling

Person supplying data: Hugo Atterling   Date: Sept 1958

Present Fields of Research	% of Time
Isotope production by means means of light ions, mainly deuterons (mostly for beta-spectroscopy).	20-25% of total time (in 1957)
Accelerator of heavy ions/ production of alpha-emitters (transuranic and others), fission and other experiments.	

History and Status	
Design study	1946
Model tests (r-f)	1946
Engineering design	began 1946
Construction started	1946
Completion date	(first beam at full radius) 1951
Scheduled operation	~ 40 hrs/wk
Magnet cost	~$160,000
Total cost	~$500,000 (excluding building), rough estimate

Design Specifications

Magnet

Core dia.	232 cm, ___ in.
Mag pole face dia.	225
Pole tip dia.	211 cm, ___ in.
Internal target	94
Beam radius, max, def	90 cm, ___ in.
In vacuum	32.8
Field gap, center	34.8 cm, ___ in.
Field, max	20 k-gauss
Field drop-off	~ 2 % at 11 kg
Weight, Fe	370 ; Cu 27 tons
Winding	28 x 25-mm bar; 11-mm hole
Cooling	water
Dee dia.	190 cm, ___ in.
Dee aperture	at center 12 cm, ___ in.
Dee-to-dee gap	12 cm, ___ in.
Beam extraction, type	d-c def.
Ion source, type	mod. open arc

Design energy and particle

25 Mev deuterons

(subsequently reduced to 22 Mev)

R-F frequency	___ Mc/s
Oscillator type	self-ex., gnd-g
Oscillator tube	one, Standard-3Q/331 E
Osc. input, max	~ 300 kw
Osc. output, max	~ 180 kw
Pre-exciter	no
Dee bias, d-c max	-700 v
Dee-to-dee, max	~ 200 kv
Shielding	underground, 2 m water on top

over please

X-882A

ACTUAL PERFORMANCE DATA as of March 1958

(Machine down for remodeling until early 1959)

	Protons	Deuterons	Alphas	C^{4+}	N^{6+} to Ne^{6+}
Energy, Mev	11	22	44	11/nuc. max.	11/nuc. max.
Frequency, Mc/sec	8.1	8.1	8.1	8.1	8.1
Mag. field, k-gauss	5.3	10.7	10.7	~16	up to 19.8
Dee-to-dee, kv		150		~ 200	~ 200
Internal Beam, Stable, μa					
Peak, μa	not maximized				
Energy spread, %				discrete high-energy peak	continuous spectrum
External Beam, Stable, μa	deflector being installed				
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

Insulated dee-stems, short-circuited to ground for r-f by condensers.

A variety of heavy ions can be accelerated without changing the frequency (max. m/e ~3.7).

Typical "meter currents" for heavy ions at max. dee-volts.

$^{12}C^{4+}$ ≤ 1.0 μa at > 100 Mev

$^{14}N^{6+}$ ≤ 0.1 μa at > 100 Mev

$^{16}O^{6+}$ ≤ 0.1 μa at > 80 Mev

$^{20}Ne^{6+}$ ≤ 0.05 μa at > 130 Mev

$^{22}Ne^{6+}$ ≤ 0.02 μa at > 140 Mev

Published Articles Describing Machine

1. H. Atterling, "Design of Acceleration Chamber and Dees for the 225-cm Cyclotron at the Nobel Institute for Physics, Stockholm," Ark. f. Fysik, 2, 559 (1951).

2. H. Atterling and G. Lindstrom, "Notes on the 225-cm Cyclotron at the Nobel Institute for Physics, Stockholm," Ark. f. Fysik, 4, 559 (1952).

3. H. Atterling and G. Lindstrom, "A Fixed-Frequency Cyclotron with 225 cm Pole Diameter," Nature, 169, 432 (1952).

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine ETH Cyclotron

Institution Federal Institute of Technology, Physics Dept.

Address Gloriastr. 35, Zürich 6, Switzerland

Person in charge Prof. P. E. Marmier

Person supplying data P. E. Marmier Date June 1958

Present Fields of Research	% of Time
Isotope production	10
Biological exp.	5
Coulomb excitation	25
Scattering exp.	25
γ-Spectroscopy	25
Miscellaneous	10

History and Status	
Design study	
Model tests	
Engineering design	1940
Construction started	1941
Completion date	1944
Scheduled operation	50 hrs/wk
Magnet cost	
Total cost	approx. $100,000

Design Specifications

Magnet

Core dia.	___ cm,	___ in.
Pole tip dia.	___ cm,	33 in.
Beam radius, max	___ cm,	15 in.
Field gap, center	___ cm,	8 in.
Field, max	19.8 k-gauss	
Field drop-off	2 %	
Weight, Fe 60 ;	Al Cu ___ tons	
Winding	copper	
Cooling	water	
Dee dia.	___ cm,	31 in.
Dee aperture	___ cm,	1.8 in.
Dee-to-dee gap	___ cm,	8 in.
Beam extraction, type	electrostatic	
Ion source, type	W-fil, 800 v	

Design energy and particle

7.2 Mev	protons
14 Mev	deuterons
28 Mev	alphas
___ Mev	

R-F frequency	13 - 16.6 Mc/s
Oscillator type	Xtal controlled
Oscillator tube	two, Brown-Broveri
Osc. input, max	80 kw
Osc. output, max	50 kw
Pre-exciter	5 stages, push-pull 833A
Dee bias, d-c max	none v
Dee-to-dee, max	70 kv
Shielding	1 m water, top none, 2-m concrete lab. wall

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.2	8.7	17.4		
Frequency, Mc/sec	16.6	13.0	13.0		
Mag. field, k-gauss	10.9	17	17		
Dee-to-dee, kv	55	55	55		
Internal Beam, Stable, μa	150	150	20		
Peak, μa	200	200	25		
Energy spread, %	5				
External Beam, Stable, μa	30	25			
Peak, μa	30	25			
Energy spread, %	3	3			

Beam "piped" 20 ft to external target. Beam analyzing magnet used? no

quadrupole focusing

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: ETH 300-cm Cyclotron Project

Institution: Swiss Federal Institute of Technology

Address: Zürich, Switzerland

Person in charge: P. Stähelin

Person supplying data: P. Stähelin   Date: October 1958

Present Fields of Research	% of Time

History and Status

Design study	Jan 1958
Model tests	to start Jan 1959
Engineering design	to start July 1959
Construction started	
Completion date	
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	300 cm, ___ in.
Pole tip dia.	300 cm, ___ in.
Beam radius, max	121 cm, ___ in.
Field gap, ~~center~~ min	36 cm, ___ in.
Field, ~~max~~ center	16 k-gauss
Field drop-off	(spiral ridges) %
Weight, Fe 625 ; Cu 47 tons	
Winding	tubing
Cooling	water
Dee dia.	250 cm, ___ in.
Dee aperture	10 cm, ___ in.
Dee-to-dee gap	___ cm, ___ in.
Beam extraction, type	electrostatic
Ion source, type	Oak Ridge

Design energy and particle

110 Mev	N^{3+}
200 Mev	N^{4+}
44 Mev	He^{+}
22 Mev	1/2 D_2^+

R-F frequency	Mc/s
Oscillator type	Brown Boveri SK51B3
Oscillator tube	B7 S 50
Osc. input, max	kw
Osc. output, max	300 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	~ 400 kv
Shielding	concrete, 165 cm

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Four-sector, spiral-ridged, pole tips with the magnet gap 45 ± 9 cm and with a max spiral of 50 degrees.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The CSIR 44.5-Inch Cyclotron

Institution: Nuclear Physics Division, Council for Scientific and Industrial Research

Address: P. O. Box 395, Pretoria, South Africa

Person in charge: Dr. S. J. duToit

Person supplying data: S. J. duToit — Date: August 1958

Present Fields of Research	% of Time
Isotope production for nuclear spectroscopy	50
Beam extraction work	50

History and Status

Design study	1950 - 1952
Model tests	
Engineering design	1951 - 1953
Construction started	August 1953
Completion date	January 1958
Scheduled operation	20 hrs/wk
Magnet cost	£25,000
Total cost	£100,000

Design Specifications

Magnet

Core dia.	___ cm, 55 in.
Pole tip dia.	___ cm, 44.5 in.
Beam radius, max	45 cm, ___ in.
Field gap, center	___ cm, 5 in.
Field, max	17.5 k-gauss
Field drop-off	0.7 %
Weight, Fe 73.8 ; Al 5.4 tons	
Winding	hollow core 22x28 mm
Cooling	distilled water
Dee dia.	105 cm, ___ in.
Dee aperture	5 cm, ___ in.
Dee-to-dee gap	6 cm, ___ in.
Beam extraction, type	not yet installed
Ion source, type	open, spare filament

Design energy and particle

16 Mev deuterons

___ Mev ___

___ Mev ___

___ Mev ___

R-F frequency	13.25 Mc/s
Oscillator type	self-ex., gnd-g TP, TG
Oscillator tube	two, Machlett ML 5658
Osc. input, max	13 kw
Osc. output, max	6.5 kw
Pre-exciter	1-kw input tickler oscillator 6.5 Mc/s
Dee bias, d-c max	none v
Dee-to-dee, max	110 kv
Shielding	4 m earth and concrete

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.5	15	32		
Frequency, Mc/sec		13.25			
Mag. field, k-gauss		17.5			
Dee-to-dee, kv		110			
Internal Beam, Stable, μa		200			
Peak, μa		230			
Energy spread, %		not yet measured			
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? not yet

Unusual Features

Dee lines at angle of 20 deg to each other. Single diffusion pump, between dee lines. Dees removable through dee-stem housings. Ion source with spare filament (at other end).

Published Articles Describing Machine

The Cyclotron of the National Physical Research Laboratory, Report No. 1, C.S.I.R. Pretoria (April 1958).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine: Heavy-Ion Cyclotron

Institution: Joint Nuclear Research Institute - Nuclear Reactions Laboratory

Address: Dubna, USSR

Person in charge: G. Flerov

Person supplying data: (various sources) Date: ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	1958
		Completion date	
		Scheduled operation	______ hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia. ______ cm, ______ in.

Pole tip dia. 300 cm, ______ in.

Beam radius, max ______ cm, ______ in.

Field gap, center ______ cm, ______ in.

Field, max ______ k-gauss

Field drop-off ______ %

Weight, Fe ______ ; Al Cu ______ tons

Winding ______

Cooling ______

Dee dia. ______ cm, ______ in.

Dee aperture ______ cm, ______ in.

Dee-to-dee gap ______ cm, ______ in.

Beam extraction, type ______

Ion source, type ______

Design energy and particle

8-10 Mev/nuc Heavy ions

______ Mev ______

______ Mev ______

______ Mev ______

R-F frequency ______ Mc/s

Oscillator type ______

Oscillator tube ______

Osc. input, max ______ kw

Osc. output, max ______ kw

Pre-exciter ______

Dee bias, d-c max ______ v

Dee-to-dee, max ______ kv

Shielding ______

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

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Published Articles Describing Machine

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X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ____

Institution Ukranian Physical Institute

Address Kiev, USSR

Person in charge Nemetz

Person supplying data (various sources) Date ____

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	before 1956
		Scheduled operation	____ hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia. ____ cm, ____ in.

Pole tip dia. ____ cm, ____ in.

Beam radius, max ____ cm, ____ in.

Field gap, center ____ cm, ____ in.

Field, max ____ k-gauss

Field drop-off ____ %

Weight, Fe ____ ; Al Cu ____ tons

Winding ____

Cooling ____

Dee dia. ____ cm, ____ in.

Dee aperture ____ cm, ____ in.

Dee-to-dee gap ____ cm, ____ in.

Beam extraction, type ____

Ion source, type ____

Design energy and particle

13.5 Mev deuterons

____ Mev ____

____ Mev ____

____ Mev ____

R-F frequency ____ Mc/s

Oscillator type ____

Oscillator tube ____

Osc. input, max ____ kw

Osc. output, max ____ kw

Pre-exciter ____

Dee bias, d-c max ____ v

Dee-to-dee, max ____ kv

Shielding ____

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution Leningrad University

Address Leningrad, USSR

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time
Gamma spectra	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1949
Scheduled operation	___ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, ___ in.
Pole tip dia.	76 cm, ___ in.
Beam radius, max	___ cm, ___ in.
Field gap, center	___ cm, ___ in.
Field, max	___ k-gauss
Field drop-off	___ %
Weight, Fe	30 ; Al Cu ___ tons
Winding	
Cooling	
Dee dia.	___ cm, ___ in.
Dee aperture	___ cm, ___ in.
Dee-to-dee gap	___ cm, ___ in.
Beam extraction, type	
Ion source, type	

Design energy and particle

4 Mev deuterons

___ Mev ___

___ Mev ___

___ Mev ___

R-F frequency	___ Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	___ kw
Osc. output, max	___ kw
Pre-exciter	
Dee bias, d-c max	___ v
Dee-to-dee, max	___ kv
Shielding	

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine

Institution Leningrad University

Address Leningrad, USSR

Person in charge

Person supplying data (various sources) Date

Present Fields of Research	% of Time

History and Status	
Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1958
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	cm,	in.
Pole tip dia.	120 cm,	in.
Beam radius, max	cm,	in.
Field gap, center	cm,	in.
Field, max	14 k-gauss	
Field drop-off	%	
Weight, Fe	120 ; Al / Cu	tons
Winding		
Cooling		
Dee dia.	cm,	in.
Dee aperture	cm,	in.
Dee-to-dee gap	cm,	in.
Beam extraction, type		
Ion source, type		

Design energy and particle

12.5 Mev	deuterons
25 Mev	alphas
Mev	
Mev	

R-F frequency	Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	kw
Osc. output, max	120 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	kv
Shielding	

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution Physical-Technical Institute

Address Leningrad, USSR

Person in charge Grinberg

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
Heavy-ion reactions		Design study	
Coulomb excitation		Model tests	
		Engineering design	
		Construction started	
		Completion date	before 1957
		Scheduled operation	96 hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

Core dia. ______ cm, ______ in.

Pole tip dia. 120 cm, ______ in.

Beam radius, max ______ cm, ______ in.

Field gap, center ______ cm, ______ in.

Field, max ______ k-gauss

Field drop-off ______ %

Weight, Fe ______ ; Al Cu ______ tons

Winding ______

Cooling ______

Dee dia. ______ cm, ______ in.

Dee aperture ______ cm, ______ in.

Dee-to-dee gap ______ cm, ______ in.

Beam extraction, type ______

Ion source, type ______

Design energy and particle

25 Mev N^{3+}

13.6 Mev alphas

______ Mev ______

______ Mev ______

R-F frequency ______ Mc/s

Oscillator type ______

Oscillator tube ______

Osc. input, max ______ kw

Osc. output, max ______ kw

Pre-exciter ______

Dee bias, d-c max ______ v

Dee-to-dee, max ______ kv

Shielding ______

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas	N^{3+}	
Energy, Mev			13.6	25	
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa				0.5	
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ____

Institution Radium Institute

Address Leningrad, USSR

Person in charge ____

Person supplying data (various sources) Date ____

Present Fields of Research	% of Time

History and Status	
Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1937
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	cm,	in.
Pole tip dia.	35 cm,	in.
Beam radius, max	cm,	in.
Field gap, center	cm,	in.
Field, max	k-gauss	
Field drop-off	%	
Weight, Fe ____ ; Al/Cu	tons	
Winding		
Cooling		
Dee dia.	cm,	in.
Dee aperture	cm,	in.
Dee-to-dee gap	cm,	in.
Beam extraction, type		
Ion source, type		

Design energy and particle

2	Mev	deuterons
	Mev	
	Mev	
	Mev	

R-F frequency	Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	kw
Osc. output, max	kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	kv
Shielding	

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

Reported to be the first cyclotron built in Europe, 1937.

Median plane of magnetic field is vertical.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine: Moscow 60-Inch Cyclotron

Institution: Atomic Energy Institute

Address: Moscow, USSR

Person in charge: Kirchatov

Person supplying data: (various sources) Date:

Present Fields of Research	% of Time
Light-particle physics	
Heavy-particle physics	
Nuclear chemistry	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1945
Completion date	1949
Scheduled operation	168 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	cm, in.
Pole tip dia.	cm, 59 in.
Beam radius, max	cm, 26.6 in.
Field gap, center	cm, 7 in.
Field, max	13.6 k-gauss
Field drop-off	1.7 %
Weight, Fe	330 ; Al Cu tons
Winding	
Cooling	air
Dee dia.	cm, in.
Dee aperture	cm, in.
Dee-to-dee gap	cm, in.
Beam extraction, type	
Ion source, type	slit

Design energy and particle

22 Mev	deuterons
100 Mev	heavy ions
Mev	
Mev	

R-F frequency	Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	kw
Osc. output, max	130 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	160 kv
Shielding	water, 1 m

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas	C, N, O	
Energy, Mev	12			~100	
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa	1000			5	
Peak, μa					
Energy spread, %					
External Beam, Stable, μa	250* 40**	200* 30**			
Peak, μa					
Energy spread, %					

* Intermediate position; **At 40-ft position

Beam "piped" 40 ft to external target. Beam analyzing magnet used? ________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

** data not verified

Name of machine ______

Institution Thermotechnical Institute

Address Moscow, USSR

Person in charge Nikitin

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time
Neutron time of flight	
Neutron multiplication	
Polarization	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1949
Scheduled operation	90 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, ___ in.
Pole tip dia.	120 cm, ___ in.
Beam radius, max	___ cm, ___ in.
Field gap, center	___ cm, ___ in.
Field, max	___ k-gauss
Field drop-off	___ %
Weight, Fe ___ ; Al/Cu ___ tons	
Winding	
Cooling	
Dee dia.	___ cm, ___ in.
Dee aperture	___ cm, ___ in.
Dee-to-dee gap	___ cm, ___ in.
Beam extraction, type	
Ion source, type	

Design energy and particle

14 Mev deuterons

___ Mev ___

___ Mev ___

___ Mev ___

R-F frequency	___ Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	___ kw
Osc. output, max	___ kw
Pre-exciter	
Dee bias, d-c max	___ v
Dee-to-dee, max	150 kv
Shielding	water + boric acid, 1 m

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ________ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

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Published Articles Describing Machine

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X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Radial Ridge Cyclotron

Institution: Birmingham University, Department of Physics

Address: Birmingham, England

Person in charge: Profs. P. B. Moon and W. E. Burcham

Person supplying data: W. B. Powell — Date: October 1958

Present Fields of Research	% of Time
Being converted	

History and Status

Design study	June 1957
Model tests	none
Engineering design	Oct. 1957
Construction started	April 1958
Completion date	(April 1960)
Scheduled operation	______ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	____ cm, 43.5 in.
Pole tip dia.	____ cm, 40 in.
Beam radius, max	____ cm, 18 in.
Field gap, center	3.25 and 4.25 in.
Field, ~~max~~ ave	16 k-gauss
Field ~~drop-off~~ rise	0.85 %
Weight, Fe 40 ; Cu 8 tons	
Winding	strip, 1 x 0.2 in.
Cooling	water-cooled rubber bags

Dee dia.	____ cm, 41 in.
Dee aperture	____ cm, 1.25 in.
Dee~~-to-dee gap~~ single dee	____ cm, ____ in.
Beam extraction, type	d-c deflector
Ion source, type	hooded carbon arc

Design energy and particle

12 Mev	deuterons
____ Mev	
____ Mev	
____ Mev	

R-F frequency	______ Mc/s
Oscillator type	TP, TG
Oscillator tube	BW 1121 (Eng. Elect.)
Osc. input, max	58 kw
Osc. output, max	45 kw
Pre-exciter	
Dee bias, d-c max	800 v
Dee-to-~~dee~~ gnd, max	35 kv
Shielding	concrete, 4 ft

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

The machine is a conversion of the Cambridge (Cavendish) 37-Inch Cyclotron. It has three flat sectors with 3.25-in. between hills and 4.24-in. between valleys. The stem to the single 180-deg dee is brought out to air via insulators.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The Nuffield Cyclotron

Institution: University of Birmingham, England

Address: Edgbaston, Birmingham, England

Person in charge: Prof. W. E. Burcham

Person supplying data: W. E. Burcham Date: October 1958

Present Fields of Research	% of Time
Nuclear reaction of H^1, H^2, He^3, He^4	50
Heavy-ion reactions	
Biological tracer studies with F^{18}	25
Isotope production	25

History and Status	
Design study	
Model tests	
Engineering design	
Construction started	1938
Completion date	1949
Scheduled operation	70 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	cm, 75 in.
Pole tip dia.	cm, 61.5 in.
Beam radius, max	cm, 27 in.
Field gap, center	cm, 10 in.
Field, max	18 k-gauss
Field drop-off	2 %
Weight, Fe	250 ; Cu 40 tons
Winding	strip
Cooling	air
Dee dia.	cm, 28.5 in.
Dee aperture	cm, 5 to 3 in.
Dee-to-dee gap	cm, 3 in.
Beam extraction, type	electrostatic
Ion source, type	hooded arc

Design energy and particle

10 Mev	protons
20 Mev	deuterons
40 Mev	alphas
10/mc Mev	heavy ions

R-F frequency	Mc/s
Oscillator type	gnd-g
Oscillator tube	laboratory-made
Osc. input, max	150 kw
Osc. output, max	100 kw
Pre-exciter	M.O. - amp.-driven
Dee bias, d-c max	v
Dee-to-dee, max	200 kv
Shielding	concrete and water

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas	He^3	Heavy Ions
Energy, Mev	10	20	40	30	10/nuc
Frequency, Mc/sec	10.2	10.2	10.2	10.2	10.2
Mag. field, k-gauss	6.75*	13.5	13.5	10.1*	various
Dee-to-dee, kv	170	170	170	170	170
Internal Beam, Stable, μa	500	300	50	15	
Peak, μa	800	200	100		
Energy spread, %					
External Beam, Stable, μa	80	50	6	3	
Peak, μa		100	20		
Energy spread, %		3	4	3	

Beam "piped" 15 ft to external target. Beam analyzing magnet used? yes

Unusual Features

*Concentric pole face windings used to correct field shape at these lower values; effective change of 1% obtained.

Published Articles Describing Machine

1. J. H. Fremlin and J. S. Gooden, "Cyclic Accelerators," Rep Prog. Phys. 13, 295 (1950).

2. "The University of Birmingham Cyclotron," Nature 169, 476 (1952).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Liverpool 37-Inch Cyclotron

Institution: Nuclear Physics Research Laboratory, Univ. of Liverpool

Address: Mount Pleasant, Liverpool 3

Person in charge: Professor H. W. B. Skinner

Person supplying data: M. J. Moore — Date: June 1958

Present Fields of Research	% of Time
Nuclear reactions	100

History and Status

Design study	1936
Model tests	
Engineering design	
Construction started	August 1937
Completion date	June 1939
Scheduled operation	40 hrs/wk
Magnet cost	
Total cost	£ 8,000

Design Specifications

Magnet

Core dia.	106.5 cm, 43.5 in.
Pole tip dia.	88.2 cm, 36 in.
Beam radius, max	37.5 cm, 15 in.
Field gap, center	19.6 cm, 8 in.
Field, max	18.5 k-gauss
Field drop-off	2.5 %
Weight, Fe 46 ; Cu 7.5 tons	
Winding	copper
Cooling	water
Dee dia.	33 cm, 13.5 in.
Dee aperture	4.9 cm, 2 in.
Dee-to-dee gap	3.7 cm, 1.5 in.
Beam extraction, type	electrostatic plate
Ion source, type	hot cathode

Design energy and particle

9 Mev deuterons

Mev

Mev

Mev

R-F frequency	12.5 Mc/s
Oscillator type	M. O. excited Class C push-pull
Oscillator tube	S. T. C. 3 Q/221E
Osc. input, max	1 kw
Osc. output, max	20 kw
Pre-exciter	yes
Dee bias, d-c max	none v
Dee-to-dee, max	60 kv
Shielding	4 ft concrete to front

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		9.0			
Frequency, Mc/sec		12.5			
Mag. field, k-gauss		16.8			
Dee-to-dee, kv		60			
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa		40			
Peak, μa		100			
Energy spread, %		1.5*			

* Full width of distribution curve at one-half max ht. after analysing magnet.

Beam "piped" 10 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: MRC Cyclotron

Institution: Medical Research Council, Radiotherapeutic Research Unit

Address: Hammersmith Hospital, Ducane Road, London W 12, England

Person in charge: D. D. Vonberg

Person supplying data: D. D. Vonberg   Date: July 1958

Present Fields of Research	% of Time
Production of Isotopes	
1/2 life < 30 min	25
1/2 life > 30 min	50
Neutron beam measurements for Therapy (temp. suspended)	
Eng. development	25

History and Status	
Design study	Jan. 1950
Model tests	Jan. 1950
Engineering design	Jan. 1950
Construction started	1951
Completion date	July 1955
Scheduled operation	40 hrs/wk
Magnet cost	£ 40,000
Total cost	£ 150,000

Design Specifications

Magnet

Core dia.	___ cm, 57 in.
Pole tip dia.	___ cm, 50 in.
Beam radius, max	___ cm, 21 1/2 in.
Field gap, center	___ cm, 6 in.
Field, max	15 k-gauss
Field drop-off	3 1/2 %
Weight, Fe	111; Al 11 tons
Winding	aluminum
Cooling	water
Dee dia.	___ cm, 50 in.
Dee aperture	___ cm, 2 1/4 in.
Dee-to-dee gap	___ cm, 2 1/4 in.
Beam extraction, type	d-c deflector
Ion source, type	Oak Ridge carbon chimney

Design energy and particle

15 Mev	deuterons
30 Mev	alpha particles
7.5 Mev	protons
Mev	

R-F frequency	11.3 Mc/s
Oscillator type	crystal controlled
Oscillator tube	driver neutralized power amplifier
Osc. input, max	100 kw
Osc. output, max	75 kw
Pre-exciter	no
Dee bias, d-c max	none v
Dee-to-dee, max	120 kv
Shielding	6 ft concrete, with 10 ft lab wall

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.5	15	30		
Frequency, Mc/sec	11.3	11.3	11.3		
Mag. field, k-gauss	14.8	14.8	14.8		
Dee-to-dee, kv	120	120	120		
Internal Beam, Stable, μa		500	500		
Peak, μa		1000	1000		
Energy spread, %					
External Beam, Stable, μa		50	50		
Peak, μa		100	100		
Energy spread, %					

Beam "piped" 8 ft to external target. Beam analyzing magnet used? quadrupole focusing magnet on test

Unusual Features

Carbon aperture 5/16 in. sq after one turn to limit dissipation on dees. Closed circuit television viewing of carbon aperture, ion source chimney, and target.

Published Articles Describing Machine

"A Cyclotron for Medical Research," Institution of Electrical Engineers Proceedings 104, Part B, No. 17 (Sept. 1957).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: ANL 60-Inch Cyclotron

Institution: Argonne National Laboratory

Address: P. O. Box 299, Lemont, Illinois

Person in charge: W. J. Ramler - G. W. Parker

Person supplying data: W. J. Ramler   Date: June 1958

Present Fields of Research	% of Time
Physics Div. (scattering)	25
Chemistry Div. and participating institutions	75
(a) Nuclear activator studies	
(b) Solid state physics	
(c) Radiation chemistry	
(d) Fission studies	
(e) Isotope production	

History and Status

Design study	
Model tests	
Engineering design	
Design and Construction started	June 1949
Completion date	June 1952
Scheduled operation	60-80 hrs/wk
Magnet cost	
Total cost	$950,000 cyclotron $840,000 bldg. and facilities

Design Specifications

Magnet

Core dia.	___ cm, 74-3/8 in.
Pole tip dia.	___ cm, 62 in.
Beam radius, max	___ cm, 26 / 22 in.
Field gap, center	___ cm, 14 in.
Field, max	14.9 k-gauss
Field drop-off	2.9 %
Weight, Fe	265 ; Al 26 tons
Winding	aluminum
Cooling	demineralized water
Dee dia.	___ cm, 29-1/4 in.
Dee aperture	___ cm, 2-1/2 in.
Dee-to-dee gap	___ cm, 4 in.
Beam extraction, type	d-c deflector
Ion source, type	hooded, arc, d-c filament

Design energy and particle

21.6 Mev	deuterons
43.2 Mev	alphas
10.8 Mev	protons (H_2)
___ Mev	

R-F frequency	11.2 Mc/s
Oscillator type	push-pull, + TP, amp. push-pull gnd-g
Oscillator tube	ML 356
Amplifier tube	ML 5681
Osc. Amp input, max	200 kw
Operating Input / Osc. output, max	70-100 kw
Pre-exciter	
Dee bias, d-c max	none v
Dee-to-dee, max	310 kv
Shielding	150-lb concrete, 7-ft walls, 4-ft roof

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	10.8	21.6	43.2		
Frequency, Mc/sec		11,200			
Mag. field, k-gauss	14.9	14.9	14.9		
Dee-to-dee, kv	240-260	240-260	240-260		
Internal Beam, Stable, μa	350	700	350		
Peak, μa	Not Maximized				
Energy spread, %	Not Measured				
External Beam, Stable, μa	100-125	225	100-125		
Peak, μa	Not Maximized	330	180		
Energy spread, %	1	1	1		

Beam "piped" 40 ft to external target. Beam analyzing magnet used? no

Unusual Features

Focused external beams can be used either in the vault or in experimental tunnel. About 20% of the total deflected beam can be focused. Helium ion beams of 8 μa, 50 μa total deflected, have been focused through an aperature of 1 x 2 mm. In October, 1958 a multiple beam port system will be installed. At this time, a squeezing coil will be installed to facilitate the focusing of about 50% of the deflected beam.

Published Articles Describing Machine

A report will be ready for circulation about September 1958.

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: BNL 18-Inch Cyclotron

Institution: Brookhaven National Laboratory

Address: Upton, New York

Person in charge: G. N. Glasoe

Person supplying data: G. N. Glasoe   Date: July 1958

Present Fields of Research	% of Time
Elastic and inelastic scattering of neutrons	75
Study of (p,n) reactions	25

History and Status

Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1952-53
Scheduled operation	35-40 hrs/wk
Magnet cost	
Total cost	$110,000

Design Specifications

Magnet

Core dia.	__ cm, 18 in.
Pole tip dia.	__ cm, 18 in.
Beam radius, max	__ cm, 7.5 in.
Field gap, center	__ cm, 3 in.
Field, max	14 k-gauss
Field drop-off	3 %
Weight, Fe 6 ; Cu 4 tons	
Winding	3/4" x 1/16" strip
Cooling	
Dee dia.	__ cm, 17 in.
Dee aperture	__ cm, 1 3/4 in.
Dee-to-dee gap	__ cm, 1 1/2 in.
Beam extraction, type	DC deflector
Ion source, type	hot cathode, copper arc house

Design energy and particle

3 Mev protons

2 Mev deuterons

__ Mev

__ Mev

R-F frequency	20 Mc/s
Oscillator type	self-ex.
Oscillator tube	5771
Osc. input, max	35 kw
Osc. output, max	20 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	60 kv
Shielding	concrete

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	3				
Frequency, Mc/sec	20				
Mag. field, k-gauss	13.1				
Dee-to-dee, kv	60				
Internal Beam, Stable, μa	1000-2000				
Peak, μa					
Energy spread, %					
External Beam, Stable, μa	800 μa 100 μa focused on target 15 ft from machine				
Peak, μa					
Energy spread, %	1				

Beam "piped" 15 ft to external target. Beam analyzing magnet used? no

Unusual Features

The phase bunching of the protons is utilized to produce short pulses of neutrons; pulse at target is ~1.5 ns duration. The pulsed character of the beam, together with fast time-to-pulse-height converter, make it possible to do nanosecond timing with neutrons in Mev range and to use multi-channel analyzer to display neutron spectra in inelastic scatering or in (p,n) reactions.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: BNL 60-Inch Cyclotron

Institution: Brookhaven National Laboratory

Address: Upton, Long Island, New York

Person in charge: C. P. Baker

Person supplying data: C. P. Baker — Date: October 1958

Present Fields of Research	% of Time
Nuclear reactions	32
Radiochemistry	15
Decay scheme and β spectra	20
Radiation chemistry	10
Nuclear moments	18
Medicine and biology	5

History and Status

Design study	
Model tests	
Engineering design	
Construction started	October 1948
Completion date	April 1951
Scheduled operation	56.5 hrs/wk
Magnet cost	
Total cost	~ $950,000

Design Specifications

Magnet

Core dia.	cm, 72 in.
Pole tip dia.	cm, 62 in.
Beam radius, max	cm, 25.5 in.
Field gap, center	cm, 10 in.
Field, max	15 k-gauss
Field drop-off	1 %
Weight, Fe	240; Al tons
Winding	bar 2 3/4 x 1/2 in. Al strap
Cooling	water
Dee dia.	cm, in.
Dee aperture	cm, 4 in.
Dee-to-dee gap	cm, 3 in.
Beam extraction, type	internal deflector
Ion source, type	arc (hot cathode)

Design energy and particle

20 Mev	deuterons
Mev	
Mev	
Mev	

R-F frequency	11 Mc/s
Oscillator type	MOPA
Oscillator tube	osc. 2-5771; amp. 6-5658
Osc. input, max	150 kw
Osc. output, max	not measured kw
Pre-exciter	master oscillator
Dee bias, d-c max	none v
Dee-to-dee, max	200 kv
Shielding	loaded concrete 4 to 5 ft

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	10.5	21	42		
Frequency, Mc/sec	11.05	11.05	11.05		
Mag. field, k-gauss	15	15	15		
Dee-to-dee, kv	~200	~200	~200		
Internal Beam, Stable, μa	300	300	300	self imposed limit,	
Peak, μa	300	300	200	could be increased	
Energy spread, %	not measured				
External Beam, Stable, μa	50	50	30		
Peak, μa	50	50	50	self imposed limit, could be increased	
Energy spread, %	1	1	1		

Beam "piped" 30 ft to external target. Beam analyzing magnet used? no

Unusual Features

Under pulsed conditions, 1 ma peak deuteron current for 0.6 μs pulse. The phase-focused beam-bunches of ~ 4 ns duration and 10 ma peak can be isolated and used at a low repetition rate by pulsing both the arc and the deflector.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Crocker Laboratory 60-Inch Cyclotron

Institution: University of California

Address: Berkeley 4, California

Person in charge: William B. Jones

Person supplying data: William B. Jones   Date: May 1958

Present Fields of Research	% of Time	History and Status	
Isotope production	5.52	Design study	
Biological exp.	5.52	Model tests	
Scattering exp.	38.67	Engineering design	
Cross section work	33.15	Construction started	1937
Neutron work	6.08	Completion date	1939
(Other)	11.05	Scheduled operation	90 hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet		Design energy and particle	
Core dia.	___ cm, 72 in.	12 Mev	protons
Pole tip dia.	___ cm, 72 in.	24 Mev	deuterons
Beam radius, max	___ cm, 25 1/2 in.	48 Mev	alphas
Field gap, center	___ cm, 9 3/4 in.	equiv. Mev	heavy ions
Field, max	19.7 k-gauss	R-F frequency	12 Mc/s
Field drop-off	at max 5 %	Oscillator type	self-ex., gnd-g
Weight, Fe 196 ; Cu 25 tons		Oscillator tube	continuously pumped
Winding	copper	Osc. input, max	___ kw
Cooling	oil	Osc. output, max	250 kw
Dee dia.	___ cm, 26 1/2 in.	Pre-exciter	no
Dee aperture	___ cm, 2 3/4 in.	Dee bias, d-c max	none v
Dee-to-dee gap	___ cm, 3 in.	Dee-to-dee, max	200 kv
Beam extraction, type	d-c and r-f defl.	Shielding	5 ft water
Ion source, type	capillary		

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas	$^6C^{12}$	$^6O^{16}$
Energy, Mev	12	24	48	144	152
Frequency, Mc/sec	12	12	12	12	10.7
Mag. field, k-gauss	16.15	16.15	16.15	16.15	19.1
Dee-to-dee, kv	160	160	160	160	160
Internal Beam, Stable, μa					
Peak, μa				0.2	0.1
Energy spread, %					
External Beam, Stable, μa	50-60	90	50-60		
Peak, μa	110	125	100	0.0002	
Energy spread, %	< 1	1	1		

Beam "piped" 24 ft to external target. Beam analyzing magnet used? Beam steered but not analyzed

Unusual Features

Remodeled four times in 16 years for maximum flexibility in energy and ions accelerated. Presently equipped with external frequency shifter for range of 10.7 to 12.3 Mc/s. Continuous range from 11.9 to 12.3 Mc/s.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine ______

Institution: University of California Radiation Laboratory

Address: Berkeley, California

Person in charge: Prof. G. T. Seaborg

Person supplying data: Elmer L. Kelly Date: June 1958

Present Fields of Research	% of Time
Being designed	

History and Status

Design study	in progress
Model tests	July 1958
Engineering design	in progress
Construction started	
Completion date	July 1961
Scheduled operation	______ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	______ cm, 88 in.
Pole tip dia.	______ cm, 88 in.
Beam radius, max	______ cm, 37 in.
Field gap, ~~center~~	7" min 11" max in.
Field, ~~max~~ ave	17 k-gauss
Field ~~drop-off~~ increase	3 %
Weight, Fe	258; Cu 9.6 tons
Winding	hollow copper
Cooling	water
Dee dia.	______ cm, 40 in.
Dee aperture	______ cm, 2 in.
Dee-to-dee gap	______ cm, 4 in.
Beam extraction, type	
Ion source, type	

Design energy and particle

15 - 60 Mev	deuterons
7 1/2-115 Mev	protons +
30 - 120 Mev	alphas
equiv. Mev	heavy ions

R-F frequency	6 - 23 Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	______ kw
Osc. output, max	______ kw
Pre-exciter	
Dee bias, d-c max	______ v
Dee-to-dee, max	______ kv
Shielding	8 ft concrete

+ F-M operation for highest proton

over please

X-882A

~~ACTUAL PERFORMANCE DATA~~
PERFORMANCE GOALS

	Protons	Deuterons	Alphas		
Energy, Mev	7 1/2 - 115	15 - 60	30 - 120		
Frequency, Mc/sec	6 - 23	6 - 13	6 - 13		
Mag. field, k-gauss	8 - 17	8 - 17	8 - 17		
Dee-to-dee, kv	150	150	150		
Internal Beam, Stable, μa		1000			
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ________ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Variable energy, spiral ridge (probably 4 sectors). Constant frequency with 2:1 frequency range. The high energy protons would be achieved by an f-m, r-f mode of operation. Hope for beam extraction by radial resonance induced by magnetic bumps.

Published Articles Describing Machine

UCID-98

UCID-133

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: UCRL Livermore 90-Inch Cyclotron

Institution: University of California Radiation Laboratory

Address: Livermore, California

Person in charge: Dr. Jack M. Peterson

Person supplying data: L. M. Erickson — Date: June 1958

Present Fields of Research	% of Time
Isotope production	5
Scattering experiment	10
Neutron experiment	80
Development	5
"Beam on time" 80 hr/wk	

History and Status	
Design study	1952
Model tests	1953-1954
Engineering design	1953
Construction started	November 1953
Completion date	February 1955
Scheduled operation	80 hrs/wk
Magnet cost	$250,000
Total cost	$1,000,000

Design Specifications

Magnet

Core dia.	268 cm,	105 in.
Pole tip dia.	228 cm,	90 in.
Beam radius, max	89 cm,	35 in.
Field gap, center	305 cm,	12 in.
Field, max	9 k-gauss	
Field drop-off	1 %	
Weight, Fe	320; Cu	11 tons
Winding	copper	
Cooling	oil-cooled	
Dee dia.	198 cm,	78 in.
Dee aperture	6.35 cm,	2.5 in.
Dee-to-dee gap	one dee cm,	in.
Beam extraction, type	electrostatic	
Ion source, type	ORNL	

Design energy and particle

2.6-14.6 Mev	protons
5.2-18.3 Mev	deuterons
10.3-36 Mev	alphas
7.7-12.3 Mev	tritons

R-F frequency	4-6 Mc/s
Oscillator type	driven
Oscillator tube	one RCA A-2332
Osc. input, max	490 kw
Osc. output, max	300 kw
Pre-exciter	2 E26 4-400 6166
Dee bias, d-c max	none v
Dee-to-dee, max	170 kv
Shielding	concrete, 5ft sides, 2 ft top

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons		Deuterons		Alphas			
	Low	High	Low	High	Low	High		
Energy, Mev	2.79	5.36	5.17	11.77	13.29	23.4		
Frequency, Mc/sec	4.11	5.76	4.0	6.035	4.55	6.035		
Mag. field, k-gauss	2.7	4.0	5.3	8	6.2	8		
Dee-to-dee, kv	38	105	40	145	65	150		
Internal Beam, Stable, μa	100	200	100	350	50	100		
Peak, μa								
Energy spread, %								
External Beam, Stable, μa	5	15	7	26	2.5	6		
Peak, μa								
Energy spread, %								

Beam "piped" 30 ft to external target. Beam analyzing magnet used? not yet

Unusual Features

Median plane is vertical, dees suspended. Cam-shaped pole pieces for more efficient beam extraction. Magnetic field continuously variable 2-9 kg., oscillator variable from 4 to 9.5 Mc/s in 55-kc steps by selecting proper crystals. This permits beam energy to be varied in small steps, and provides the following outputs: protons 3-14 Mev, deuterons 5-12 Mev, alphas 10-23 Mev, and about 7.5 Mev tritons (when equipment for tritium is installed). Beam sweeper being installed for time-of-flight work to give target bursts at $f_o/4$.

Published Articles Describing Machine

UCRL Report No. 2620

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The UCLA 50-Mev Cyclotron

Institution: University of California, Los Angeles

Address: Los Angeles 24, California

Person in charge: Prof. J. Reginald Richardson

Person supplying data: J. R. Richardson   Date: May 1958

Present Fields of Research	% of Time	History and Status	
Being designed; our old		ReDesign study (as FF)	Fall 1957
21-Mev proton F-M		Model tests	
machine is still operating		Engineering ~~design~~ redesign	Spring 1958
30 hr/wk		Construction started	1954 as FM
		Completion date, as	FF 1959
		Scheduled operation	hrs/wk
		Magnet cost	$25,000
		Total cost	$60,000 exclusive of control desk

Design Specifications

Magnet

Core dia.	cm,	50 in.
Pole tip dia.	cm,	44 in.
Beam radius, max	cm,	21 in.
Field gap, center	cm,	6 in.
Field, max, on hills	26 k-gauss	
Field ~~drop-off~~ increase	5.5 %	
Weight, Fe	40; Cu. 3.5 tons	
Winding	1-in. hollow	
Cooling	water	
Dee dia.	cm,	1 1/2 in.
Dee aperture	cm,	in.
Dee-to-dee gap	cm,	in.
Beam extraction, type		
Ion source, type		

Design energy and particle

25-50 Mev	protons
Mev	
Mev	
Mev	

R-F frequency	Mc/s
Oscillator type	under development
Oscillator tube	
Osc. input, max	kw
Osc. output, max	kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	kv
Shielding	2 ft iron all around

over please

X-882A

~~ACTUAL PERFORMANCE DATA~~

PERFORMANCE GOALS

	Protons	Deuterons	Alphas		
Energy, Mev	50				
Frequency, Mc/sec					
Mag. field, k-gauss (Ave)	20				
Dee-to-dee, kv					
Internal Beam, Stable, μa	100				
Peak, μa					
Energy spread, %					
External Beam, Stable, μa	10				
Peak, μa					
Energy spread, %					

Beam "piped" ______ ft to external target. Beam analyzing magnet used? will be

Unusual Features

Thomas field to half radius then spiral ridge to exit. Two 45-deg dees, in valleys. Magnetic gap at hills 1.5 in.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Dept. of Terrestrial Magnetism 60-Inch Cyclotron

Institution: Carnegie Institution of Wash., Dept. of Terrestrial Magnetism

Address: 5241 Broad Branch Road, N. W., Washington 15, D. C.

Person in charge: Dr. N. P. Heydenburg

Person supplying data: N. P. Heydenburg — Date: October 1958

Present Fields of Research	% of Time
occasional runs	
β-ray spectroscopy studies	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1940
Completion date	1944
Scheduled operation	20-30 hr/mo ~~hrs/wk~~
Magnet cost	
Total cost	$250,000

Design Specifications

Magnet

Core dia.	cm	60 in.
Pole tip dia.	cm	60 in.
Beam radius, max	cm	25 in.
Field gap, center	cm	12 in.
Field, max	16 k-gauss	
Field drop-off	2.0 %	
Weight, Fe 200; Cu 50 tons		
Winding	copper	
Cooling	water	

Dee dia.	cm	55 in.
Dee aperture	cm	6 in.
Dee-to-dee gap	cm	3 in.
Beam extraction, type		
Ion source, type	hooded arc	

Design energy and particle

8 Mev	protons
16 Mev	deuterons
32 Mev	alphas
Mev	

R-F frequency	Mc/s
Oscillator type	power amp
Oscillator tube	two, 893 A
Osc. input, max	75 kw
Osc. output, max	kw
Pre-exciter	yes
Dee bias, d-c max	none v
Dee-to-dee, max	300 kv
Shielding	earth and masonry

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.5	15	30		
Frequency, Mc/sec	10.6	10.6	10.6		
Mag. field, k-gauss	15.6	15.6	15.6		
Dee-to-dee, kv	300	300	300		
Internal Beam, Stable, μa	120	130	40		
Peak, μa		150	45		
Energy spread, %					
External Beam, Stable, μa	10	12	0.6		
Peak, μa	14	15	1.0		
Energy spread, %	2	2	2		

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: University of Colorado 52-Inch Cyclotron

Institution: University of Colorado

Address: Boulder, Colorado

Person in charge: D. A. Lind

Person supplying data: W. R. Smythe   Date: May 1958

Present Fields of Research	% of Time
Being designed	

History and Status

Design study	1957
Model tests	1957-1958
Engineering design	1958
Construction started	1958
Completion date	Early 1961
Scheduled operation	hrs/wk
Magnet cost, est.	[illegible]
Total cost	$750,000

Design Specifications

Magnet

Core dia.	cm, 59 in.
Pole tip dia.	cm, 52 in.
Beam radius, max	cm, 22 in.
Field gap, center	cm, 7 1/2 in.
Field, max ave.	15 k-gauss
Field ~~drop-off~~ rise	3.5 %
Field flutter	25
Weight, Fe 85; Cu 8.8	tons
Winding	copper
Cooling	water
Dee dia.	cm, 24 in.
Dee aperture	cm, 1 1/2 in.
Dee-to-dee gap	cm, 1 in.
Beam extraction, type	regenerator and electrostatic
Ion source, type	hooded

Design energy and particle

30 Mev	protons
20 Mev	deuterons
40 Mev	alphas
Mev	

R-F frequency	7 - 23 Mc/s
Oscillator type	master osc.
Oscillator tube	power amplifier
Final amp. ~~Osc.~~ input, max	115 kw
Final amp. ~~Osc.~~ output, max	80 kw
Pre-exciter	
Dee bias, d-c max	none v
Dee-to-~~dee~~ gnd, max (one dee)	75 kv
Shielding	7 ft concrete

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" 30 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Alternating-gradient magnetic field with 4-fold symmetry incorporating Thomas or spiral shims (max. spiral angle, 45°)

Published Articles Describing Machine

1. Proposal to Establish a Laboratory for Nuclear Physics Research, University of Colorado (Feb. 1957).
2. Supplemental Proposal, University of Colorado (Oct. 1957).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Columbia University 36-Inch Cyclotron

Institution: Columbia University, Pupin Cyclotron Laboratory

Address: New York 27, N. Y.

Person in charge: Lawrence Feldman

Person supplying data: L. Feldman Date: October 1958

Present Fields of Research	% of Time
none. cyclotron is being modified to accelerate protons, with an externally deflected beam	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1936
Completion date	remodeled 1939-40
Scheduled operation	hrs/wk
Magnet cost	
Total cost	about $28,000 (1937) exclusive of scientific staff salaries

Design Specifications

Magnet

Core dia.	cm, 44 in.
Pole tip dia.	cm, 36 in.
Beam radius, max	cm, 15.25 in.
Field gap, center	cm, 5.875 in.
Field, max	17.5 k-gauss
Field drop-off, to deflector	1 %
Weight, Fe ; Al Cu	tons
Winding	copper strip
Cooling	water
Dee dia.	cm, 33 in.
Dee aperture	cm, 1.5 in.
Dee-to-dee gap	cm, 1.75 in.
Beam extraction, type	electrostatic deflector external to dees
Ion source, type	Oak Ridge

Design energy and particle

8 to 15 Mev	protons
11 Mev	deuterons
Mev	
Mev	

R-F frequency	Mc/s
Oscillator type	MOPA driven system osc and amp each push-pull amp. gnd-g.
Oscillator tube,	osc. 2-1500T, amp. 2-9C01
Osc. input, max	50 kw
Osc. output, max	30 kw
Pre-exciter	none
Dee bias, d-c max	none v
Dee-to-dee, max	90 kv
Shielding	water, 4-ft

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	13	8			
Frequency, Mc/sec	20	13			
Mag. field, k-gauss	13,000	16,800			
Dee-to-dee, kv	200	200			
Internal Beam, Stable, μa	200	200			
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

This cyclotron was formerly a deuteron machine and used almost exclusively for neutron research. It is being modified to accelerate protons, with an externally deflected beam. It has an adjustable frequency r-f system to produce protons variable in energy from 8 to 15 Mev.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine University of Florida Spiral Ridge Cyclotron

Institution University of Florida

Address Gainesville, Florida

Person in charge D. L. Lafferty

Person supplying data D. L. Lafferty Date October 1958

Present Fields of Research	% of Time

History and Status

Design study June 1958

Model tests 2-ft model under construction

Engineering design preliminary design in progress

Construction started ____

Completion date ____

Scheduled operation ____ hrs/wk

Magnet cost ____

Total cost est. $5,000,000

Design Specifications

Magnet

Core dia. ____ cm, ____ in.

Pole tip dia. ____ cm, ____ in.

Beam radius, max ____ cm, 120 in.*

Field gap, center ____ cm, 8 in.*

" " perimeter 6 in.*

Mean Field, max 10 k-gauss*

Mean Field, at center ~7 k-gauss

Weight, Fe ____ ; Al Cu ____ tons

Winding ____

Cooling ____

Dee dia. ____ cm, ____ in.

Dee aperture ____ cm, ____ in.

Dee-to-dee gap ____ cm, ____ in.

Beam extraction, type possibly 3/2 resonance

Ion source, type ____

Design energy and particle

400 Mev protons

____ Mev ____

____ Mev ____

____ Mev ____

R-F frequency ____ Mc/s

Oscillator type ____

Oscillator tube ____

Osc. input, max ____ kw

Osc. output, max ____ kw

Pre-exciter ____

Dee bias, d-c max ____ v

Dee-to-dee, max ____ kv

Shielding ____

*Preliminary conservative figures, will be modified on basis of magnet model studies.

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ________ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

The projected design incorporates 6 spiral ridges, shaped to give the desired axial focusing, while providing the radially increasing mean magnetic field required for fixed frequency operation, and leaving an almost constant gap. As an alternative to the low-field design described above, a high-field machine is under consideration. This would involve a very small magnet gap, with accelerating electrodes placed in three of the valleys. The design is in its preliminary stages, and more realistic figures must await the magnet model and associated orbit studies now being undertaken. Shielding considerations may be decisive in influencing the final beam current.

Published Articles Describing Machine

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FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Howard College Cyclotron

Institution: Howard College

Address: Birmingham 9, Alabama

Person in charge: W. H. Bancroft, Jr.

Person supplying data: W. H. Bancroft, Jr. Date: June 1958

Present Fields of Research	% of Time
Under construction	

History and Status

Design study: About 1948

Model tests:

Engineering design:

Construction started: 1948

Completion date:

Scheduled operation: ______ hrs/wk

Magnet cost:

Total cost, est.: $120,000 (most materials have been donated by local industry)

Design Specifications

Magnet

Core dia. ______ cm, 16 in.

Pole tip dia. ______ cm, 16 in.

Beam radius, max ______ cm, 10 (est) in.

Field gap, center ______ cm, 4 in.

Field, max 15-16 k-gauss

Field drop-off (est) 2 %

Weight, Fe 10 ; Cu 2 tons

Winding 1/4 in. solid square

Cooling air

Dee dia. 21 cm, 21 in.

Dee aperture ______ cm, 1 7/16 in.

Dee-to-dee gap ______ cm, 1 5/16 in.

Beam extraction, type internal (considering change to r-f def.)

Ion source, type Oak Ridge

Design energy and particle

4 Mev proton

______ Mev

______ Mev

______ Mev

R-F frequency ______ Mc/s

Oscillator type TP with buffer and amp. stages

Oscillator tube 4- 304TL

Osc. input, max 5.2 kw

Osc. output, max 3 kw

Pre-exciter

Dee bias, d-c max ______ v

Dee-to-dee, max 50 kv

Shielding Iron ore blocks

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

Air-cooled coils. Iron ore blocks for shielding.

Published Articles Describing Machine

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(pages 121-2 omitted)

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: University of Illinois Variable-Energy Cyclotron

Institution: University of Illinois, Physics Department

Address: Urbana, Illinois

Person in charge: Dr. James S. Allen

Person supplying data: James S. Allen   Date: June 1958

Present Fields of Research	% of Time
Isotope production	5
Nuclear physics	70
Solid state physics	25

History and Status

Design study	
Model tests	1956 - 57
Engineering design	1956 - 58
Construction started	1956
Completion date	September 1958
Scheduled operation	60 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, 50 in.
Pole tip dia.	___ cm, 43 1/2 in.
Beam radius, max	___ cm, 18 1/2 in.
Field gap, center	15.2 cm, 6 in.
Field, max	17; min 5 k-gauss
Field ~~drop-off~~ rise	0 to 1.7 %
Weight, Fe	60; Cu 10 tons
Winding	solid strip
Cooling	water

Dee dia.	___ cm, 42 in.
Dee aperture	___ cm, 1.87 in.
Dee-to-dee gap	one dee ___ cm, ___ in.
Beam extraction, type	elec. deflector
Ion source, type	Oak Ridge

Design energy and particle

3.7 to 14 Mev	protons
7 to 14 Mev	deuterons
15 to 28 Mev	alphas
11 to 36 Mev	He^{3++}

R-F frequency	___ Mc/s
Oscillator type	self-ex., Colpitts
Oscillator tube	Machlett 5681
Osc. input, max	100 kw
Osc. output, max	75 kw
Pre-exciter	
Dee bias, d-c max	none v
Dee-to-dee, max	75 kv
Shielding	4 ft water with borax sides and top

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Machine employs strong focusing provided by spiral iron shims on both pole faces. Shims are 7/8 inch thick. The av shape of the mean field may be adjusted by means of 4 sets of coils located within the vacuum chamber.

Published Articles Describing Machine

1. P. Stahelin, "The Radial Stability of Orbits in a Spiral Ridge Cyclotron," Technical Report No. 1, U. of Ill. Cyc. Lab.

2. V. Bluemal, J. B. Carroll and P. Stahelin, "Investigation of the Field Modulation Produced by Flat Spiral Shims in a Cyclotron Magnet," Technical Report No. 2, U. of Ill. Cycl. Lab.

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FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Indiana University 45-Inch Cyclotron

Institution: Indiana University

Address: Bloomington, Indiana

Person in charge: Dr. M. B. Sampson

Person supplying data: ________ Date: May 1958

Present Fields of Research	% of Time
Isotope production	10
Nuclear reactions and scattering	90

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1939
Completion date	1941
Scheduled operation	30 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

	cm	in.
Core dia.		54
Pole tip dia.		45
Beam radius, max		20
Field gap, center		5

Field, max: 16 k-gauss

Field drop-off: 2 %

Weight, Fe 77 ; Cu 10 tons

Winding: solid strip 3/16"x 1 1/2"

Cooling: water coils

	cm	in.
Dee dia.		20.5
Dee aperture		2 1/2
Dee-to-dee gap		2

Beam extraction, type: ext. deflector

Ion source, type: hooded-cone, molybdenum

Design energy and particle

Mev	Particle
11 1/2	deuterons
23	alphas

R-F frequency: 10.4 Mc/s

Oscillator type: self ex., push-pull, gnd-p

Oscillator tube: two - (demountable)

Osc. input, max: 60 kw

Osc. output, max: 30 kw

Pre-exciter: none

Dee bias, d-c max: none v

Dee-to-dee, max: 100 kv

Shielding: 5 ft water and 2 ft concrete sides; 3 ft water top

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		11.4	22.8		
Frequency, Mc/sec		10.4			
Mag. field, k-gauss		14.6			
Dee-to-dee, kv		100			
Internal Beam, Stable, μa		500			
Peak, μa					
Energy spread, %					
External Beam, Stable, μa		150	75 - 100		
Peak, μa		225	110		
Energy spread, %		1	1		

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

Published Articles Describing Machine

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FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Los Alamos Variable Energy Cyclotron

Institution: Los Alamos Scientific Laboratory

Address: Los Alamos, New Mexico

Person in charge: Robert Leachman

Person supplying data: Keith Boyer   Date: November 1958

Present Fields of Research	% of Time
Precision cross sections for nuclear reactions and scattering	
Polarization studies	
Stripping and pickup reactions	
Neutron reactions	
He^3 reactions and scattering	

History and Status	
Design study	1952-1954
Model tests	none
Engineering design	1952
Construction started	Jan 1954
Completion date	Dec 1954
Scheduled operation	112 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, 45.6 in.
Pole tip dia.	___ cm, 42 in.
Beam radius, max	___ cm, 19 in.
Field gap, center	___ cm, 4.5 in.
Field, max	18.5 k-gauss
Field drop-off	variable %
Weight, Fe	70; Al Cu ___ tons
Winding	copper
Cooling	water
Dee dia.	___ cm, 40 in.
Dee aperture	___ cm, 1.9 in.
Dee-to-dee gap	___ cm, 1.5 in.
Beam extraction, type	d-c def., r-f shielded
Ion source, type	similar to Oak Ridge

Design energy and particle

6-16 Mev	deuterons
3-9 Mev	protons
12 Mev	tritons
9-27 Mev	He^3
12-32	alphas

R-F frequency	8.3 to 13.9 Mc/s
Oscillator type	self-ex., TP, TG
Oscillator tube	two, 880
Osc. input, max	100 kw
Osc. output, max	70 kw
Pre-exciter	booster through multipactor region
Dee bias, d-c max	none v
Dee-to-dee, max	none kv
Shielding	concrete, 4 to 6 ft

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas	He^3	
Energy, Mev	3 to 9	6 to 16	12 to 30	12 - 27	
Frequency, Mc/sec	8.3 to 13.9				
Mag. field, k-gauss	0 to 18				
Dee-to-dee, kv	140				
Internal Beam, Stable, ~~μa~~	2.5 ma	2 ma	1 ma	1 ma	
Peak, ~~μa~~	5 ma	2.25 ma	2 ma	2 ma	
Energy spread, %					
External Beam, Stable, μa	50	50	50	50	
Peak, μa	120	100	65	75	
Energy spread, %					

Beam "piped" 20 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Modified Thomas field, three-fold symetry for axial focusing. Variable drop-off by use of Rose shims. Dees cut back 20 deg on each edge. Frequency varied by moving shorting nodes. Oscillator frequency and dee-voltage balance regulated by servo-driven capacitors. He^3 purifying and recirculation system.

Published Articles Describing Machine

none

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FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Markle Cyclotron

Institution: Massachusetts Institute of Technology

Address: 77 Mass. Avenue, Cambridge 39, Massachusetts

Person in charge: Dr. N. S. Wall

Person supplying data: Mr. E. F. White   Date: May 1958

Present Fields of Research	% of Time
Isotope production	20
Nuclear reactions and structure	80
"on beam" 60 hr/wk	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1938
Completion date	(first beam) 1940
Scheduled operation	125 hrs/wk
Magnet cost	
Total cost	$100,000

Design Specifications

Magnet

Core dia.	cm,	52 in.
Pole tip dia.	cm,	42.5 in.
Beam radius, max	cm,	19 in.
Field gap, center	cm,	5.5 in.
Field, max	17.4 k-gauss	
Field drop-off	2.5 %	
Weight, Fe total 96; Al Cu	tons	
Winding	copper	
Cooling	water	
Dee dia.	cm,	40 in.
Dee aperture	cm,	2 in.
Dee-to-dee gap	cm,	2 in.
Beam extraction, type	inter. d-c defl.	
Ion source, type	conventional capillary arc	

Design energy and particle

16 Mev deuterons

Mev

Mev

Mev

R-F frequency	13.1 Mc/s
Oscillator type	self-ex., gnd-p
Oscillator tube	two, 880s pp
Osc. input, max	100 kw
Osc. output, max	70 kw
Pre-exciter	none
Dee bias, d-c max	none v
Dee-to-dee, max	125 kv
Shielding	concrete, 4 ft walls 3ft ceiling

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ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7.55	15.1	30.5		
Frequency, Mc/sec	13.1	13.1	13.1		
Mag. field, k-gauss	17.4	17.4	17.4		
Dee-to-dee, kv	100	120	100		
Internal Beam, Stable, μa		200	80		
Peak, μa		Thermal limit	150		
Energy spread, %					
External Beam, Stable, μa	50* 0.5**	60* 1**	15* 0.1**		
Peak, μa	70 2	110 2	30 0.5		
Energy spread, %	< 1	< 1	< 1		

*Intermediate target **Scattering chamber

Beam "piped" 18 ft to external target. Beam analyzing magnet used? no

Unusual Features

Axial focusing by 3 - 1/8-in. - 60-deg alternate wedge shims, top and bottom. Time spread of beam bursts measured to be about 3 x 10^{-9} sec. High ratio operating time over servicing time.

Published Articles Describing Machine

Journal of Applied Physics, 15, 2 and 128 (1944).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: University of Michigan 42-Inch Cyclotron

Institution: University of Michigan

Address: Ann Arbor, Michigan

Person in charge: W. C. Parkinson

Person supplying data: W. C. Parkinson Date: July 1958

Present Fields of Research	% of Time
Nuclear spectroscopy	99
Service bombardments	1

History and Status

Design study	
Model tests	
Engineering design	
Construction ~~started~~	1936
Remodeled ~~Completion date~~	1950
Scheduled operation	80 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	cm, 50 in.
Pole tip dia.	cm, 42 in.
Beam radius, max	43 cm, in.
Field gap, center	cm, 6 in.
Field, max	15 k-gauss
Field drop-off	1 %
Weight, Fe 75 ; Cu 12 tons	
Winding	copper
Cooling	water
Dee dia.	96 cm, in.
Dee aperture	cm, 2 1/2 in.
Dee-to-dee gap	cm, 1 in.
Beam extraction, type	d-c deflector
Ion source, type	arc

Design energy and particle

5 Mev	protons (H_2)
10 Mev	deuterons
20 Mev	alphas
Mev	

R-F frequency	10.2 Mc/s
Oscillator type	TG, TP push-pull
Oscillator tube	F 124 A
Osc. input, max	75 kw
Osc. output, max	60 kw
Pre-exciter	none
Dee bias, d-c max	none v
Dee-to-dee, max	50 kv
Shielding	water and concrete

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	3.9	7.8	15.6		
Frequency, Mc/sec	10.2	10.2	10.2		
Mag. field, k-gauss	6.2	12.5	12.5		
Dee-to-dee, kv	40	40	40		
Internal Beam, Stable, μa	1000	800	50 (?)		
Peak, μa	>1000	>1000			
Energy spread, %	not known				
External Beam, Stable, μa	>300	> 200	?		
Peak, μa	>300	> 200	?		
Energy spread, %	?	~5%	5%		

Beam "piped" 15 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Published Articles Describing Machine

1. Rev. Sci. Inst., 27, 516 (1956).
2. Rev. Sci. Inst., 24, 42 (1953).

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FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Michigan State University 64-Inch Cyclotron

Institution: Michigan State University

Address: Department of Physics and Astronomy, East Lansing, Michigan

Person in charge: H. G. Blosser

Person supplying data: H. G. Blosser   Date: June 1958

Present Fields of Research	% of Time

History and Status

Design study	Began June 1957
Model tests	Began June 1958
Engineering design	
Construction started	Expected June 1959
Completion date	Expected June 1961
Scheduled operation	hrs/wk
Magnet cost	
Total cost	$\$1.5 \times 10^6$

Design Specifications

Magnet

Core dia.	cm,	64 in.
Pole tip dia.	cm,	64 in.
Beam radius, max	cm,	58 in.
Field gap, center	cm,	6 in.
Field, max	17 k-gauss	
Field ~~drop-off~~ increase	4 %	
Weight, Fe ~75; Al / Cu	tons	
Winding		
Cooling		

Dee dia.	cm,	62 in.
Dee aperture	cm,	2 in.
Dee-to-dee gap	cm,	in.
Beam extraction, type	regenerative	
Ion source, type		

Design energy and particle

40	Mev	protons
45	Mev	N^{4+}
	Mev	
	Mev	

R-F frequency	Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	kw
Osc. output, max	kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	kv
Shielding	

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ______ ft to external target. Beam analyzing magnet used? ______________

Unusual Features

AVF variable field magnet. Variable energy.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: 86-Inch Spiral-Pole Cyclotron

Institution: University of Michigan

Address: Ann Arbor, Michigan

Person in charge: Prof. W. C. Parkinson

Person supplying data: W. C. Parkinson   Date: June 1958

Present Fields of Research	% of Time

History and Status

Design study	1957
Model tests	1958
Engineering design	
Construction started	
Completion date	
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	cm, 83 in.
Pole tip dia.	cm, 83 in.
Beam radius, max	cm, in.
Field gap, center	cm, in.
Field, max	k-gauss
Field drop-off	%
Weight, Fe	342 ; Al tons
Winding	hollow bar
Cooling	water
Dee dia.	cm, in.
Dee aperture	cm, in.
Dee-to-dee gap	cm, in.
Beam extraction, type	
Ion source, type	

Design energy and particle

15-40 Mev	deuteron
Mev	
Mev	
Mev	

R-F frequency	Mc/s
Oscillator type	TG, TP, self-ex.
Oscillator tube	two, F-124A
Osc. input, max	kw
Osc. output, max	150 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	100 kv
Shielding	

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ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Four-sector, spiral, AVF magnet. Variable energy.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine NASA 60-Inch Cyclotron

Institution Lewis Research Center (Nat'l. Aero. and Space Adm.)

Address 21000 Brookpark Road, Cleveland 35, Ohio

Person in charge Jack Aron

Person supplying data James W. Blue Date October 1958

Present Fields of Research	% of Time
Nuclear	60
Solid state	20
Miscellaneous	20

History and Status

Design study	
Model tests	
Engineering design	
Construction started	March 1948
Completion date	July 1956
Scheduled operation	20 hrs/wk
Magnet cost	
Total cost	$1,000,000

Design Specifications

Magnet

Core dia.	cm,	72 in.
Pole tip dia.	cm,	60 in.
Beam radius, max	cm,	26 in.
Field gap, center	cm,	12 in.
Field, max	17 k-gauss	
Field drop-off at 26" R with 14,600 Gauss	1.7 %	
Weight, Fe 225 ; Cu 26 tons		
Winding	copper	
Cooling	water	
Dee dia.	not circular cm,	in.
Dee aperture	cm,	4.37 in.
Dee-to-dee gap	cm,	4-3 in.
Beam extraction, type	electrostatic	
Ion source, type	Berkeley	

Design energy and particle

20	Mev	deuterons
40	Mev	alphas
10	Mev	protons
	Mev	

R-F frequency	Mc/s
Oscillator type	self-ex., gnd-g
Oscillator tube	four, 9C21
Osc. input, max	612 kw
Osc. output, max	400 kw
Pre-exciter	yes
Dee bias, d-c max	none v
Dee-to-dee, max	400 kv
Shielding	concrete 13 in., earth, 4 ft

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	10.5	21.5	43		
Frequency, Mc/sec	11.0	11.0	11.0		
Mag. field, k-gauss		14.6			
Dee-to-dee, kv	180 kv	220 kv	180 kv		
Internal Beam, Stable, μa	not measured	300	100		
Peak, μa		500			
Energy spread, %	never	measured			
External Beam, Stable, μa	*80 **0.1	*120 **1	*50 **0.1		
Peak, μa	2	180 7	2		
Energy spread, %		0.7			

* intermediate position; ** 38 ft from cyclotron

Beam "piped" 38 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Toluene-cooled deflector. Remote positioning of dees. Three-dimensional positioning of ion source. Pulsed pre-exciter with high peak power.

Published Articles Describing Machine

* at cyclotron target chamber
** in "Beam" room - 38 feet from target chamber

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: NRDL Cyclotron

Institution: U. S. Naval Radiological Defense Laboratory

Address: San Francisco 24, California

Person in charge: Dr. H. A. Howe

Person supplying data: H. A. Howe   Date: October 1958

Present Fields of Research	% of Time

History and Status

Design study	
Model tests	
Engineering design	(Jan. 1960)
Construction started	(Jan. 1960)
Completion date	(1962)
Scheduled operation	hrs/wk
Magnet cost	$345,500
Total cost	$1,515,000

Design Specifications

Magnet

Core dia.	cm, 70 in.
Pole tip dia.	cm, in.
Beam radius, max	cm, ~30 in.
Field gap, center	cm, ~5 in.
Field, max	$\bar{B}$ = 17 k-gauss
Field ~~drop-off~~ increase	8 %
Weight, Fe ; Al / Cu	tons
Winding	hollow copper
Cooling	water

Dee dia.	cm, in.
Dee aperture	cm, in.
Dee-to-dee gap	cm, in.
Beam extraction, type	magnetic regenerative
Ion source, type	

Design energy and particle

70 Mev	protons
35 Mev	deuterons
70 Mev	alphas
Mev	

R-F frequency	Mc/s
Oscillator type	
Oscillator tube	
Osc. input, max	kw
Osc. output, max	kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	100 kv
Shielding	5 ft concrete

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

A strong focusing cyclotron of the spiral ridge type.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: ORNL 44-Inch Cyclotron

Institution: Oak Ridge National Laboratory

Address: Oak Ridge, Tennessee

Person in charge: Dr. R. S. Livingston

Person supplying data: R. J. Jones — Date: October 1958

Present Fields of Research	% of Time
Cyclotron development	100

History and Status

Design study	1952
Model tests	
Engineering design	
Construction started	
Completion date	1955
Scheduled operation	ad lib hrs/wk
Magnet cost	*
Total cost	$100,000*

Design Specifications

Magnet

Core dia.	cm, * in.
Pole tip dia.	cm, 44 in.
Beam radius, max	cm, 20 in.
Field gap, center	cm, in.
Field, max	6.3 k-gauss
Field drop-off	2 %
Weight, Fe	* ; Al Cu tons
Winding	copper strip
Cooling	circ. oil bath
Dee dia.	cm, 44 in.
Dee aperture	cm, 7.5 in.
Dee-to-dee gap	cm, 13.5 in.
Beam extraction, type	
Ion source, type	

Design energy and particle

5 Mev protons

Mev

Mev

Mev

R-F frequency	9.67 Mc/s
Oscillator type	gnd-g
Oscillator tube	F-134
Osc. input, max	450 kw
Osc. output, max	kw
Pre-exciter	none
Dee bias, d-c max	-2000 v
Dee-to-dee, max	2000 kv
Shielding	extension area only

*One gap in an irregular-shaped calutron magnet array is used.

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	5				
Frequency, Mc/sec	9.67				
Mag. field, k-gauss	6.34				
Dee-to-dee, kv	160				
Internal Beam, Stable, μa	≤ 1000*				
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

*Very large currents available, limited because of radiation hazards.

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Designed for very large proton currents at from 1 to 5 Mev. The median plane of the magnetic field is vertical, with the dees one above the other. Dee stems are included in the vacuum chamber.

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The ORNL 63-Inch Cyclotron

Institution: Oak Ridge National Laboratory

Address: Oak Ridge, Tennessee

Person in charge: Dr. Robert S. Livingston

Person supplying data: Dr. A. Zucker   Date: June 1958

Present Fields of Research	% of Time
Nuclear reactions	50
Scattering experiments	40
Cross sections	10

History and Status

Design study	
Model tests	
Engineering design	
Construction started	May 1951
Completion date	May 1952 (1st beam)
Scheduled operation	56 hrs/wk
Magnet cost	*
Total cost	*

Design Specifications

Magnet

Core dia.	___ cm, * in.
Pole tip dia.	___ cm, 63 in.
Beam radius, max	___ cm, 25.3 in.
Field gap, center	___ cm, 6 in.
Field, max	15.5 k-gauss
Field drop-off	2 %
Weight, Fe	* ; Cu ___ tons
Winding	solid copper strip
Cooling	circ. oil bath
Dee dia.	___ cm, 25.5 in.
Dee aperture	___ cm, 3.5 in.
Dee-to-dee gap	___ cm, 2 in.
Beam extraction, type	d-c defl.
Ion source, type	Oak Ridge**

Design energy and particle

27 Mev N^{+++}

___ Mev

___ Mev

___ Mev

R-F frequency	4.9 Mc/s
Oscillator type	self-ex., gnd-g
Oscillator tube	one, RCA-5770
Osc. input, max	35 kw
Osc. output, max	___ kw
Pre-exciter	no
Dee bias, d-c max	-1000 v
Dee-to-dee, max	90 kv
Shielding	none, exclusion area

* Much old calutron equipment modified and used.

** See Ref. 2.

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas	N^{+++}	
Energy, Mev				27	
Frequency, Mc/sec				4.9	
Mag. field, k-gauss				15	
Dee-to-dee, kv				75	
Internal Beam, Stable, μa				100	
Peak, μa				100	
Energy spread, %				20	
External Beam, Stable, μa				2	
Peak, μa				2	
Energy spread, %				2	

Beam "piped" _______ ft to external target. Beam analyzing magnet used? _______________

Unusual Features

High intensity ion sources (see Ref. 2). Designed to accelerate triply ionized nitrogen ions from the ion source.

Published Articles Describing Machine

1. R. S. Livingston, "Acceleration of Partially Stripped Heavy Ions," Nature 173, 54 (Jan. 9, 1954).

2. R. J. Jones and A. Zucker, "Two Ion Sources for the Production of Multiply Charged Nitrogen Ions," Rev. Sci. Instr. 25, 562 (1954).

3. Reynolds, Scott, and Zucker, "Nuclear Reactions with Energetic Nitrogen Ions," Proc. Nat. Acad. Sci. 39, 975 (1953).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The ORNL 86-Inch Cyclotron

Institution: Oak Ridge National Laboratory

Address: Oak Ridge, Tennessee

Person in charge: Dr. Robert S. Livingston

Person supplying data: Mr. M. B. Marshall Date: May 1958

Present Fields of Research	% of Time
Isotope production	30
Nuclear reactions and structure	70
"on beam" 44 hrs/wk	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	Sept 1949
Completion date	(first beam) Nov 1950
Scheduled operation	80 hrs/wk
Magnet cost	
Total cost	$700,000 (plus existing equipment)

Design Specifications

Magnet

	cm	in.
Core dia.		86
Pole tip dia.		86
Beam radius, max		33
Field gap, center		17.5

Field, max: 9 k-gauss

Field drop-off: 1.75 %

Weight, Fe 350; Cu 44 tons

Winding: solid strip, 3 x 0.4 in.

Cooling: circ. oil bath

	cm	in.
Dee dia.		70
Dee aperture		6
Dee-to-dee gap		4

Beam extraction, type: r-f def, mag channel

Ion source, type: Oak Ridge*

Design energy and particle: 25 Mev protons

R-F frequency: 13.4 Mc/s

Oscillator type: self-ex., gnd-g

Oscillator tube: one, Federal-134

Osc. input, max: 400 kw

Osc. output, max: 250 kw

Pre-exciter: no

Dee bias, d-c max: -1000 v

Dee-to-dee, max: 500 kv

Shielding: 5-ft concrete, all sides and top

*See Reference 2

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ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	. 22				
Frequency, Mc/sec	13.4				
Mag. field, k-gauss	8800				
Dee-to-dee, kv	400				
Internal Beam, Stable, μa	2000				
Peak, μa	3000				
Energy spread, %	3	(full width at	1/2 max)		
External Beam, Stable, μa	40* 0.1**				
Peak, μa	180 10				
Energy spread, %	3 0.5				

*At intermediate target, **At 40-ft position

Beam "piped" 40 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Median plane of magnetic field is vertical; dees suspended. High dee-to-dee voltage. U-shaped magnet yoke. Large beam currents at high energy. Water-cooled tubes for deflector septum; beam deflected by r-f and passes through electromagnetically-neutralized channel.

Published Articles Describing Machine

1. R. S. Livingston, "The Oak Ridge 86-Inch Cyclotron," Nature **170**, 221 (Aug. 9, 1952).

2. R. S. Livingston and R. J. Jones, "High Intensity Ion Source for Cyclotrons," Rev. Sci. Instr. **25**, 552 (June, 1954).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Oak Ridge Relativistic Isochronous Cyclotron

Institution: Oak Ridge National Laboratory

Address: Oak Ridge, Tennessee

Person in charge: Dr. R. S. Livingston

Person supplying data: ____________ Date: October 1958

Present Fields of Research	% of Time

History and Status

Design study	1957
Model tests	1958
Engineering design	1958
Construction ~~started~~ to start	Spring 1959
Completion date	1960
Scheduled operation	______ hrs/wk
Magnet cost	~ $185,000
Total cost + bldg. + facilities	$\$3 \times 10^6$

Design Specifications

Magnet: AVF (azimuthally varying field)

Core dia.	____ cm,	76 in.
Pole tip dia.	____ cm,	76 in.
Beam radius, max	____ cm,	31.5 in.
Field gap, center	____ cm,	7.5 in.
Field, ~~max~~ ave	1.8 - 17 k-gauss	
Field ~~drop-off~~ rise	8 %	
Weight, Fe 200 ; Al 9 tons		
Winding	bar 1.13-in. sq., 0.75-in. hole	
Cooling	water	
Dee dia.	____ cm,	35.5 in.
Dee aperture	____ cm,	1.87 in.
Dee-to-dee gap	____ cm,	2 in.
Beam extraction, type	regenerative	
Ion source, type	Oak Ridge	

Design energy and particle

Energy		Particle
1-75	Mev	protons
4-100	Mev	N^{4+}
> 100	Mev	heavy ions
____	Mev	____

R-F frequency	7.5 to 22.5 Mc/s
Orbit frequency	1.5 to 22.5
Oscillator type	
Oscillator tube	RCA 6949
Osc. input, max	700 kw
Osc. output, max	500 kw
Pre-exciter	no
Dee bias, d-c max	-1000 v
Dee-to-dee, max	200 kv
Shielding	concrete, 7 to 8 ft

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

Three-sector AVF magnet, with small spiral effect; magnet gap 28.5 in. in valleys; sector coils in valleys to control field configuration. R-f to be used first, third, and fifth harmonics of orbit frequency. Designed for 75-kw maximum beam power. Multiply-charged ions originate in ion source. Feasibility of AVF system proven with 190-kev electrons in Cyclotron Analogue I, see Ref. 1.

Published Articles Describing Machine

1. H. G. Blosser et al, "Four-Sector Azimuthally Varying Field Cyclotron," Rev. Sci. Instr. 29, 819-834 (October 1958).

2. R. S. Livingston and F. T. Howard (eds), The Oak Ridge Relativistic Isochronous Cyclotron, ORNL Report-2648 (1958).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Southern Regional Accelerator (Injector)

Institution: Oak Ridge National Laboratory

Address: Oak Ridge, Tennessee

Person in charge: Dr. R. S. Livingston

Person supplying data: ______ Date: October 1958

Present Fields of Research	% of Time
At present design studies	
and model tests only.	
To be proposed as injector	
for 12-Gev proton synchrotron	

History and Status	
Design study	began 1957
Model tests	began 1957
Engineering design	
Construction started	
Completion date	
Scheduled operation	______ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet AVF (azimuthally varying field)

Core dia. 8-sector magnet cm, ______ in.

Pole tip dia. ______ cm, ______ in.

Beam radius, max ______ cm, 17.1 ft

Field gap, center ______ cm, ______ in.

Field, max 22 k-gauss

ave Field ~~drop-off~~ increases 5.4 to 10.6 k-gauss

Weight, Fe 2600 ; Cu 150 tons

Winding ______

Cooling ______

Dee dia. ______ cm, ______ in.

Dee aperture ______ cm, ______ in.

Dee-to-dee gap ______ cm, ______ in.

Beam extraction, type ______

Ion source, type ______

Design energy and particle

850 Mev protons

______ Mev ______

______ Mev ______

______ Mev ______

R-F frequency ______ Mc/s

Oscillator type four cavities

Oscillator tube ______

Osc. input, max 1000 kw

Osc. output, max ______ kw

Pre-exciter ______

Dee bias, d-c max ______ v

Energy gain ~~Dee-to-dee~~, max 1 Mev/turn

Shielding ______

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ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ________ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

High energy and current at fixed frequency. Eight-sector magnet, spiraled, with sector windings. Feasibility of AVF system proven up to 190-kev electrons in Cyclotron Analogue I, see Ref. 1. Cyclotron Analogue II being constructed for electrons to 500 kev.

Published Articles Describing Machine

1. H. G. Blosser, et al, "Four-Sector Azimuthally-Varying-Field Cyclotron," Rev. Sci. Instr., 29, 819 (October 1958).
2. R. S. Livingston, "Trends in Cyclotron Design," Ind. and Eng. Chem., 48, 1231 (August 1956).

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FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The Ohio State University 42-Inch Cyclotron

Institution: The Ohio State University

Address: Columbus 10, Ohio

Person in charge: Prof. H. J. Hausman

Person supplying data: H. J. Hausman Date: June 1958

Present Fields of Research	% of Time
Nuclear reactions	90
Isotope production	10

History and Status

Design study	1937
Model tests	
Engineering design	
Construction ~~started~~	1940
Remodeled ~~Completion date~~	1954
Scheduled operation	30 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	cm, 50 in.
Pole tip dia.	cm, 47 in.
Beam radius, max	cm, 21 in.
Field gap, center	cm, 10 in.
Field, max	15 k-gauss
Field drop-off	approx. 3 %
Weight, Fe	80 ; Cu 10 tons
Winding	tubing
Cooling	water
Dee dia.	cm, 42 in.
Dee aperture	cm, 1 in.
Dee-to-dee gap	cm, 1 1/2 in.
Beam extraction, type	electrostatic
Ion source, type	arc

Design energy and particle

6.2 Mev	protons
12.4 Mev	deuterons
24.0 Mev	alphas
Mev	

R-F frequency	11.2 Mc/s
Oscillator type	TP, TG
Oscillator tube	Amperex 859
Osc. input, max	50 kw
Osc. output, max	35 kw
Pre-exciter	
Dee bias, d-c max	v
Dee-to-dee, max	120 kv
Shielding	

over please

ACTUAL PERFORMANCE DATA

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	Protons H_2	Deuterons	Alphas		
Energy, Mev	6.2	12.4	24		
Frequency, Mc/sec	11.2	11.2	11.2		
Mag. field, k-gauss	7.2	14.4	14.4		
Dee-to-dee, kv	100	100	100		
Internal Beam, Stable, μa	150-200	150-200	100		
Peak, μa	250	250			
Energy spread, %					
External Beam, Stable, μa	50* 0.5**	50* +	+		
Peak, μa	75 2.0				
Energy spread, %	0.5				

* Intermediate position, ** At 16-ft position

Beam "piped" 16 ft to external target. Beam analyzing magnet used? yes

Unusual Features

External beam analyzing system consists of a pair of quadrupole focusing magnets, 15-deg sector-type beam-bending magnet, and 7000 lb double-focusing sector-type reaction particle analyzing magnet.

Published Articles Describing Machine

1. Progress Report, U.S.A.E.C., Contract AT(11-1)-158 (1953)

2. Progress Report, U.S.A.E.C., Contract AT(11-1)-503 (1957)

+ Ion source and dee for d and α under construction

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: 37-Inch Cyclotron

Institution: Oregon State College

Address: Corvallis, Oregon

Person in charge: E. A. Yunker

Person supplying data: E. A. Yunker Date: May 1958

Present Fields of Research	% of Time
Testing and instrumentation	100

History and Status

Design study	
Model tests	
Engineering design	
Construction started	
Completion date	May 1957
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

	cm	in.
Core dia.		45
Pole tip dia.		37
Beam radius, max		16
Field gap, center		9.5

Field, max: 14 k-gauss

Field drop-off: ____ %

Weight, Fe 50 ; Cu 5.5 tons

Winding: copper

Cooling: air

	cm	in.
Dee dia.		32
Dee aperture		4
Dee-to-dee gap		1.75

Beam extraction, type: none

Ion source, type: hot filament

Design energy and particle

Mev	Particle
7.5	deuterons
15	protons

R-F frequency: ____ Mc/s

Oscillator type: self-ex.

Oscillator tube: RCA 5770

Osc. input, max: 30 kw

Osc. output, max: ____ kw

Pre-exciter: ____

Dee bias, d-c max: ____ v

Dee-to-dee, max: 140 kv

Shielding: concrete

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" _______ ft to external target. Beam analyzing magnet used? ________________

Unusual Features

___

___

___

___

___

___

___

Published Articles Describing Machine

___

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___

___

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: University of Pittsburgh Cyclotron

Institution: University of Pittsburgh

Address: Pittsburgh 13, Pennsylvania

Person in charge: Dr. A. J. Allen

Person supplying data: A. J. Allen   Date: June 1958

Present Fields of Research	% of Time
Isotope production	
Biological experiments	
Scattering experiments	
Cross section work	
Neutron work	
Radiation damage	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1945
Completion date	1946
Scheduled operation	70 hrs/wk
Magnet cost	
Total cost	$200,000

Design Specifications

Magnet

Core dia.	__ cm, 55 in.
Pole tip dia.	__ cm, 47 in.
Beam radius, max	__ cm, 21 1/4 in.
Field gap, center	__ cm, 4 1/4 in.
Field, max	18 k-gauss
Field drop-off	__ %
Weight, Fe __ ; Al Cu __ tons	
Winding	copper strip
Cooling	oil
Dee dia.	__ cm, 23 in.
Dee aperture	__ cm, __ in.
Dee-to-dee gap	__ cm, 1 1/2 in.
Beam extraction, type	
Ion source, type	capillary arc

Design energy and particle

10 Mev	protons
20 Mev	deuterons
40 Mev	alphas
__ Mev	

R-F frequency	11.8 Mc/s
Oscillator type	push pull
Oscillator tube	two 880's W
Osc. input, max	70 kw
Osc. output, max	50 kw
Pre-exciter	none
Dee bias, d-c max	self bias v
Dee-to-dee, max	200 kv
Shielding	water and earth

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	8	16	32		
Frequency, Mc/sec	11.8	11.8	11.8		
Mag. field, k-gauss	8 or 16	16	16		
Dee-to-dee, kv	200	200	200		
Internal Beam, Stable, μa	200	300	40		
Peak, μa	250	350	50		
Energy spread, %	1	1	1		
External Beam, Stable, μa	40	50	10		
Peak, μa					
Energy spread, %		0.5			

Beam "piped" 45 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Small magnet gap and small dee thickness gives high energy with low oscillator and magnet power. Push-pull oscillator of simple design.

Published Articles Describing Machine

R. S. Bender, E. M. Reilley, A. J. Allen, R. Ely, J. S. Arthur, and J. Hausman, "The University of Pittsburgh Scattering Project," Rev. Sci. Instr. 23, 10, 542 (October 1952).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Purdue Cyclotron

Institution: Purdue University

Address: Lafayette, Indiana

Person in charge: Prof. D. J. Tendam

Person supplying data: D. J. Tendam   Date: June 1958

Present Fields of Research	% of Time
Nuclear reactions	40
Isotope production for nuclear spectroscopy	20
Radiation damage	40

History and Status

Design study:

Model tests:

Engineering design:

Construction started: 1936

Completion date: August 1938

Scheduled operation: 60 hrs/wk

Magnet cost:

Total cost: $100,000 (no labor costs included)

Design Specifications

Magnet

Core dia.: ___ cm, 40 in.

Pole tip dia.: ___ cm, 36.5 in.

Beam radius, max: ___ cm, 16 in.

Field gap, center: ___ cm, 5.5 in.

Field, max: 16.3 k-gauss

Field drop-off: 2.5 %

Weight, Fe 40; Cu 3 tons

Winding: copper tubing

Cooling: distilled water

Dee dia.: ___ cm, 32 in.

Dee aperture: ___ cm, 2 in.

Dee-to-dee gap: ___ cm, 1.25 in.

Beam extraction, type: electrostatic deflector

Ion source, type: capillary arc

Design energy and particle

10 Mev deuterons

20 Mev alphas

___ Mev

___ Mev

R-F frequency: 12.4 Mc/s

Oscillator type: TP, TG

Oscillator tube: 2, Machlette 5658

Osc. input, max: 40 kw

Osc. output, max: ___ kw

Pre-exciter: no

Dee bias, d-c max: ___ v

Dee-to-dee, max: 80 kv

Shielding: 3 ft water, all sides and top

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		9.6	19.3		
Frequency, Mc/sec		12.4	12.4		
Mag. field, k-gauss		16.2	16.2		
Dee-to-dee, kv		80	80		
Internal Beam, Stable, μa		200	80		
Peak, μa		240	100		
Energy spread, %		3	3		
External Beam, Stable, μa		25* 0.3**	8* 0.15**		
Peak, μa		30 0.3	10 0.15		
Energy spread, %		3 0.1	3 0.1		

*Intermediate target position **At 23-ft position.

Beam "piped" 23 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Published Articles Describing Machine

W. J. Henderson, L. D. P. King, J. R. Risser, H. J. Yearian, and J. D. Howe, "The Purdue Cyclotron," J. Frank. Inst. 228, 563 (1939).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Variable Energy Cyclotron

Institution: University of Rochester

Address: Rochester, New York

Person in charge: Prof. H. W. Fulbright

Person supplying data: H. W. Fulbright   Date: July 1958

Present Fields of Research	% of Time
Nuclear reactions and	
spectroscopy	100

History and Status

Design study	
Model tests	
Engineering design	
Construction ~~started~~	1934 (4 Mev)
Rebuilt ~~Completion date~~	1954
Scheduled operation	50 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, 26.4 in.
Pole tip dia.	___ cm, 26.4 in.
Beam radius, max	___ cm, 11.75 in.
Field gap, center	___ cm, 3.4 in.
Field, max	14.5 k-gauss
Field drop-off	3.4 %
Weight, Fe ___ ; Al Cu ___ tons	
Winding	copper strip
Cooling	water
Dee dia.	___ cm, 26 in.
Dee aperture	___ cm, 2 in.
Dee-to-gnd ~~dee~~ gap	___ cm, 1 in.
Beam extraction, type	hooded arc
Ion source, type	

Design energy and particle

8 Mev	protons
4.25 Mev	deuterons
8.5 Mev	alphas
Mev	

R-F frequency	9 - 22 Mc/s
Oscillator type	gnd-p
Oscillator tube	one, 5771
Osc. input, max	40 kw
Osc. output, max	25 kw
Pre-exciter	
Dee bias, d-c max	___ v
Dee-to-gnd ~~dee~~, max	40 kv
Shielding	3 ft limonite concrete

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	7	4.25	8.5		
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa	100	100	small		
Peak, μa	100	100			
Energy spread, %					
External Beam, Stable, μa	20* 0.3**				
Peak, μa	40				
Energy spread, %	0.2				

*Intermediate position **At 20-ft position.

Beam "piped" 20 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Easily varied energy. Single dee. Highly resolved external beam.

Published Articles Describing Machine

NYO-6541 (AEC report).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Stanford 27-Inch Cyclotron

Institution: Stanford University, Physics Department

Address: Stanford, California

Person in charge: Prof. W. E. Meyerhof

Person supplying data: W. E. Meyerhof   Date: July 1958

Present Fields of Research	% of Time
Gamma-ray studies	
Isotope production	(rarely)

History and Status

Design study	1939-40
Model tests	
Engineering design	1939-40
Construction started	1940
Completion date	July 1941
Scheduled operation	20 hrs/wk
Magnet cost	
Total cost	$5000 initial $5000 improvements

Design Specifications

Magnet

Core dia.	___ cm, 27 in.
Pole tip dia.	___ cm, 27 in.
Beam radius, max	___ cm, 11.25 in.
Field gap, center	___ cm, 3.5 in.
Field, max	12.5 k-gauss
Field drop-off	___ %
Weight, Fe	10 ; Cu 1.5 tons
Winding	copper
Cooling	air
Dee dia.	___ cm, 23 in.
Dee aperture	___ cm, 1.06 in.
Dee-to-dee gap	___ cm, 1 in.
Beam extraction, type	
Ion source, type	hooded arc

Design energy and particle

3 Mev	deuterons
___ Mev	
___ Mev	
___ Mev	

R-F frequency	___ Mc/s
Oscillator type	TG, TP
Oscillator tube	one, RCA 899A
Osc. amplifier input, max	12 kw
Osc. output, max	___ kw
Pre-exciter	yes
Dee bias, d-c max	none v
Dee-to-dee, max	20 kv
Shielding	water, 4 ft

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev		3			
Frequency, Mc/sec		9.4			
Mag. field, k-gauss		12.3			
Dee-to-dee, kv		20			
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa		2			
Peak, μa		4			
Energy spread, %		few			

Beam "piped" 4 ft to external target. Beam analyzing magnet used? ________

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: The University of Washington 60-Inch Cyclotron

Institution: The University of Washington

Address: Seattle 5, Washington

Person in charge: Ted J. Morgan

Person supplying data: Ted J. Morgan Date: July 1958

Present Fields of Research	% of Time	History and Status	
Isotope production	1	Design study	
Nuclear fission	5	Model tests	
Range-energy relations	15	Engineering design	
Nuclear reactions and		Construction started	Spring 1948
scattering	79	Completion date	October 1952
		Scheduled operation	119 hrs/wk
		Magnet cost	
		Total cost	$900,000

Design Specifications

Magnet

Core dia.	cm, 72 in.
Pole tip dia.	cm, 60 in.
Beam radius, max	cm, 25.5 in.
Field gap, center	cm, 10 in.
Field, max	19 k-gauss
Field drop-off	2 %
Weight, Fe	200 ; Cu 18 tons
Winding	copper
Cooling	oil
Dee dia.	cm, 53 in.
Dee aperture	cm, 2-4 in.
Dee-to-dee gap	cm, 3.5 in.
Beam extraction, type	r-f + d-c defl.
Ion source, type	graphite enclosed, with virtual cathode

Design energy and particle

11 Mev	protons
22 Mev	deuterons
44 Mev	alphas
Mev	

R-F frequency	11.6 Mc/s
Oscillator type	self-ex., gnd-g
Oscillator tube	one, Machlett ML 5681
Osc. input, max	150 kw
Osc. output, max	100 kw
Pre-exciter	yes
Dee bias, d-c max	none v
Dee-to-dee, max	250 kv
Shielding	sides 10 ft earth or 4 ft concrete; top 1 ft concrete and 3 ft water

over please

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	10.5	21	42		
Frequency, Mc/sec	11.6	11.6	11.6		
Mag. field, k-gauss	15	15	15		
Dee-to-dee, kv	200-250	200-250	200-250		
Internal Beam, Stable, μa	1000	500	?		
Peak, μa	?	?	?		
Energy spread, %					
External Beam, Stable, μa	300	150	90		
Peak, μa	500	260	110		
Energy spread, %	1	1	1*		

* Width at half maximum

Beam "piped" 50 ft to external target. Beam analyzing magnet used? yes

Unusual Features

See Ref. 1 below

Published Articles Describing Machine

1. F. H. Schmidt, G. W. Farwell, J. E. Henderson, T. J. Morgan, and J. L. Streib, "The University of Washington Sixty-Inch Cyclotron," Rev. Sci. Instr. 25, No. 5, 499-510 (May, 1954).

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Washington University Cyclotron

Institution: Washington University

Address: St. Louis 5, Missouri

Person in charge: J. B. Reynolds

Person supplying data: J. B. Reynolds   Date: June 1958

Present Fields of Research	% of Time
Nuclear reactions	65
Isotope production and misc.	35
"beam on" target 84 hr/wk	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	Early 1940
Completion date	Nov 1941
Scheduled operation	100 hrs/wk
Magnet cost	
Total cost	original: $125,000 present plant: $750,000

Design Specifications

Magnet

Core dia.	___ cm, 54 in.
Pole tip dia.	___ cm, 45 in.
Beam radius, max	___ cm, 19 1/4 in.
Field gap, center	___ cm, 7 1/2 in.
Field, max	14.3 k-gauss
Field drop-off	3.1 %
Weight, Fe	70 ; Cu 12 tons
Winding	copper
Cooling	oil
Dee dia.	___ cm, 39 1/2 in.
Dee aperture	___ cm, 3 1/4 in.
Dee-to-dee gap	___ cm, 2 in.
Beam extraction, type	d-c defl.
Ion source, type	hooded capillary

Design energy and particle

5 Mev	protons
10 Mev	deuterons
20 Mev	alphas
___ Mev	

R-F frequency	10.8 Mc/s
Oscillator type	TP, TG
Oscillator tube	2 homemade, demountable
Osc. input, max	107 kw
Osc. output, max	70 kw
Pre-exciter	none
Dee bias, d-c max	none v
Dee-to-dee, max	130 kv
Shielding	underground

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	5.1	10.2	20.4		
Frequency, Mc/sec	10.8	10.8	10.8		
Mag. field, k-gauss	7.15	14.3	14.3		
Dee-to-dee, kv	100	100	100		
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa	300	300	15		
Peak, μa		480	40		
Energy spread, %					

Beam "piped" 20 ft to external target. Beam analyzing magnet used? no

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine: Yale 28-Inch Cyclotron

Institution: Yale University

Address: Sloane Physics Laboratory, New Haven, Connecticut

Person in charge: F. E. Steigert

Person supplying data: F. E. Steigert — Date: June 1958

Present Fields of Research	% of Time
Biophysics	20
Scattering experiments	5
Nuclear reactions	75

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1936
Completion date	1938
Scheduled operation	72 hrs/wk
Magnet cost	
Total cost	$10,000

Design Specifications

Magnet

Core dia.	cm, 28 in.
Pole tip dia.	cm, 28 in.
Beam radius, max	cm, 12 1/2 in.
Field gap, center	cm, 6 in.
Field, max	k-gauss
Field drop-off	16 %
Weight, Fe 17; Cu 3	tons
Winding	copper strip
Cooling	air
Dee dia.	cm, 25 in.
Dee aperture	cm, 1 3/4-1 1/4 in.
Dee-to-dee gap	cm, 1 in.
Beam extraction, type	external deflector
Ion source, type	hooded arc

Design energy and particle

8	Mev	alphas
4	Mev	deuterons
2	Mev	protons (H_2)
	Mev	

R-F frequency	10.6 Mc/s
Oscillator type	push-pull, ext. driven
Oscillator tube	5666
Osc. input, max	28 kw
Osc. output, max	24 kw
Pre-exciter	4-kw 833 stage
Dee bias, d-c max	none v
Dee-to-dee, max	90 kv
Shielding	16-in. concrete

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev	seldom used	4.1	8.2		
Frequency, Mc/sec		10.56	10.56		
Mag. field, k-gauss		14	14		
Dee-to-dee, kv		90	90		
Internal Beam, Stable, μa		2	300	(at 10-in. radius)	
Peak, μa					
Energy spread, %					
External Beam, Stable, μa		40	20		
Peak, μa		10	2		
Energy spread, %		5	5		

Beam "piped" 15 ft to external target. Beam analyzing magnet used? yes

Unusual Features

Published Articles Describing Machine

X-882

FIXED-FREQUENCY CYCLOTRON DATA SHEET

Name of machine ______

Institution: Institut Ruder Bošhović

Address: Bijenička 56, Zagreb, Yugoslavia

Person in charge: Marcel Lažanski

Person supplying data: Marcel Lažanski Date: October 1958

Future ~~Present~~ Fields of Research	% of Time
Nuclear reactions and structure	50
Isotope production	50

History and Status

Design study	1953
Model tests	none
Engineering design	Jan 1958
Construction started	under way
Completion date	
Scheduled operation	______ hrs/wk
Magnet cost	$30,000
Total cost	$300,000 (including building)

Design Specifications

Magnet

Core dia.	140 cm, ______ in.
Pole tip dia.	140 cm, ______ in.
Beam radius, max	59.5 cm, ______ in.
Field gap, center	20 cm, ______ in.
Field, max	18 k-gauss
Field drop-off	1.5 %
Weight, Fe	60 ; Cu 10 tons
Winding	solid strip, 5.6 x 0.34 cm
Cooling	water tube pancakes
Dee dia.	125 cm, ______ in.
Dee aperture	9.6 cm, ______ in.
Dee-to-dee gap	8 cm, ______ in.
Beam extraction, type	d-c deflector
Ion source, type	similar to Oak Ridge

Design energy and particle

16* Mev deuterons

______ Mev ______

______ Mev ______

______ Mev ______

R-F frequency	variable Mc/s
Oscillator type	self-ex., gnd-g
Oscillator tube	home made, 100 kw
Osc. input, max	120 kw
Osc. output, max	80 kw
Pre-exciter	10 kw
Dee bias, d-c max	no v
Dee-to-dee, max	160 kv
Shielding	underground except front, 2 m concrete

over please

X-882A

ACTUAL PERFORMANCE DATA

	Protons	Deuterons	Alphas		
Energy, Mev					
Frequency, Mc/sec					
Mag. field, k-gauss					
Dee-to-dee, kv					
Internal Beam, Stable, μa					
Peak, μa					
Energy spread, %					
External Beam, Stable, μa					
Peak, μa					
Energy spread, %					

Beam "piped" ________ ft to external target. Beam analyzing magnet used? under construction

Unusual Features

Shorting bar movable over a range of 140 cm (to permit variable energy).

Published Articles Describing Machine

FREQUENCY-MODULATED CYCLOTRONS

See page 2 for key to tables

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: The Buenos Aires 71-inch synchrocyclotron

Institution: Comisión Nacional de la Energía Atómica

Address: Avenida Libertador General San Martín 8250, Buenos Aires

Person in charge: Dr. Santos Mayo

Person supply data: Dr. Santos Mayo   Date: April 1956

Present Fields of Research	% of Time
Nuclear chemistry	60
Nuclear spectroscopy	38
Biological	1
Isotopic production	1

History and Status	
Design study	(at Amsterdam)
Model tests	
Engineering design	
Construction started	1952
Completion date	November 1954
Scheduled operation	20 hrs/wk
Magnet cost	600,000 florins
Total cost	3,000,000 florins

Design Specifications

Magnet

Core dia.	cm, 71 in.
Pole tip dia.	cm, 71 in.
Beam radius, max	cm, 31.4 in.
Field gap, center	cm, 14 in.
Field, center	14.56 k-gauss
Field, where n = 0.2	14.15 k-gauss
Radius, where n = 0.2	cm, 31.8 in.
Power	240 kw
Weight, Fe 180 ; Al 9	tons
Winding	aluminum
Cooling	water
Dee aperture	cm, 7.5 in.
Dee bias, d-c max	-500 v
Beam extraction, type	regenerative*
Ion source, type	arc or filament

* Under development

Design energy and particle

30 Mev deuterons

Mev

Oscillator type	self-ex., gnd-g
Pre-exciter	none
Oscillator tube	one, TAW-12/20 Philips
Osc. d-c input, max	24 kw
Osc. r-f output, max	kw
Frequency range	10.46 to 10.88 Mc/s
Modulation method	rotating capacitor
Repetition rate	1950 pulses/sec
Acceptance time	7 r-f deg
Dee-to-ground	17 kv, peak
Shielding	concrete 31.5 in., + water 31.5 in.

ACTUAL PERFORMANCE DATA

174

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev		30	56	
Frequency range, Mc/sec		10.5	10.5	
Mag. field, k-gauss		14.56	14.56	
Dee-to-ground, peak, kv		±17		
Duty cycle, %		4, modulation		
Internal Beam, stable Time averaged, μa		13 13	0.5 0.5	
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p				
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

____

____

____

____

Published Articles Describing Machine

1. F.A. Heyn, Philips Technical Review 12, No. 9, 241 (1951).
2. F.A. Heyn, Philips Technical Review 12, No. 9, 247 (1951).
3. F.A. Heyn, Philips Technical Review 12, No. 12, 349 (1951).
4. F.A. Heyn and J.J. Burgerjon, Philips Technical Review 14, No. 9, 263 (1953).

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: McGill Synchro-Cyclotron

Institution: McGill University, Radiation Laboratory

Address: Montreal 2, Canada

Person in charge: Prof. J. S. Foster

Person supply data: J. S. Foster   Date: May 1958

Present Fields of Research	% of Time
New isotopes and their properties	

History and Status

Design study	oscillator only
Model tests	none
Engineering design	no drawings
Construction started	1946
Completion date	1949
Scheduled operation	ad lib hrs/wk
Magnet cost	$55,000
Total cost	not over $200,000

Design Specifications

Magnet

Core dia.	cm, 82 in.
Pole tip dia.	cm, 82 in.
Beam radius, max	cm, 36 in.
Field gap, center	cm, 7.5 in.
Field, center	16.3 k-gauss
Field, where n = 0.2	15.7 k-gauss
Radius, where n = 0.2	cm, 36.25 in.
Power	200 kw
Weight, Fe ;	Al tons
Winding	hollow Al bar
Cooling	water
Dee aperture	cm, 3.5 in.
Dee bias, d-c max	-2500 v
Beam extraction, type	scatterer
Ion source, type	cold cathode

Design energy and particle

100 Mev proton

Mev

Oscillator type	gnd-g
Pre-exciter	none
Oscillator tube	one, 880
Osc. d-c input, max	kw
Osc. r-f output, max	available 30 kw
Frequency range	25 to 20.6 Mc/s
Modulation method	rotating condenser
Repetition rate	400 pulses/sec
Acceptance time	~ 18° r-f deg
Dee-to-ground	14 kv, peak
Shielding	12 ft underground

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	~100			
Frequency range, Mc/sec	25 - 20.6			
Mag. field, k-gauss	16			
Dee-to-ground, peak, kv	14			
Duty cycle, %	15			
Internal Beam, stable Time averaged, μa	1.25			
Energy spread, %				

External Beams, Scattered

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p			90	4 Mev
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" ~25 ft to target. Beam analyzing magnet used? yes

Unusual Features of Installation

Low cost. Water cooled through hollow aluminum bar. Condenser on hollow, water-cooled, ceramic axle. Top and bottom of vacuum chamber welded to pole pieces. Pole-pieces built up from 9-in. slabs welded and then machined.

Published Articles Describing Machine

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: 600 Mev Synchrocyclotron

Institution: CERN (European Organization for Nuclear Research)

Address: Genève 23 (Meyrin), Genève, Switzerland

Person in charge: Prof. Dr. W. Gentner

Person supply data: B. Hedin, member AIEE   Date: May 1958

Present Fields of Research	% of Time
Nuclear physics	100

History and Status

Design study	July 1952
Model tests	July 1952
Engineering design	July 1952
Construction started	October 1954
Completion date	August 1957
Scheduled operation	75 hrs/wk
Magnet cost	6,100,000 Swiss francs
Total cost	10,300,000 Swiss francs (excl. building)

Design Specifications

Magnet

Core dia.	500 cm, 197 in.
Pole tip dia.	500 cm, 197 in.
Beam radius, max	228 cm, 90 in.
Field gap, center	cm, 17.5 in.
Field, center	18.86 k-gauss
Field, where n = 0.2	17.89 k-gauss
Radius, where n = 0.2	227.3 cm, 89.5 in.
Power	680 kw
Weight, Fe	2500; Al 60 tons
Winding	38x50 mm bar; 20 mm hole
Cooling	water
Dee aperture	12 cm, 4.7 in.
Dee bias, d-c max	2000 v
Beam extraction, type	Le Couteur
Ion source, type	Penning

Design energy and particle

600 Mev protons

Mev

Oscillator type	modified Hartley
Pre-exciter	
Oscillator tube	TBW 12/100
Osc. d-c input, max	12 kw
Osc. r-f output, max	7.7 kw
Frequency range	28.75 to 16.4 Mc/s
Modulation method	tuning fork
Repetition rate	55 pulses/sec
Acceptance time	r-f deg
Dee-to-ground	24 - 8 kv, peak
Shielding	heavy concrete 13 ft, lab. wall 19 ft

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	600			
Frequency range, Mc/sec	16.4			
Mag. field, k-gauss	17.89			
Dee-to-ground, peak, kv	24			
Duty cycle, %	60			
Internal Beam, stable Time averaged, μa	0.1			
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	5×10^8	30	595	Less than ± 1 Mev
n				
$\pi+$				
$\pi-$	5000	40	250	5%
	7600	50	150	5%

Ext. beam "piped" 60 ft to target. Beam analyzing magnet used? only for π^+ and π^-

Unusual Features of Installation

Pion magnet with adjustable edges close to cyclotron can give a pion beam of any desired energy (up to over 300 Mev) through a fixed pipe in shielding wall.

Published Articles Describing Machine

1. Hedin, B., "Design of CERN Synchro-cyclotron Magnet," CERN-55-3 (Jan 1955).

2. Debrain P. Lazanski M. and Boyadjian G., "The CERN Synchro-cyclotron Control System," CERN-56-1, (Jan 1956).

3. Krienen F., "Modulator, CERN Synchro-cyclotron," CERN-58-8 (April 1958).

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: Synchro-cyclotron de 150 Mev

Institution: Faculte des Sciences de Paris

Address: Laboratoire de Physique Nucléaire - B.P. No. 1 - Orsay (S. et O.)

Person in charge: Professor Joliot

Person supply data: C. Bergamaschi Date: June 1958

Present Fields of Research	% of Time

History and Status

Design study: Societe Philips (Hollande)

Model tests: ______

Engineering design: Phillips

Construction started: January 1957

Completion date: June 1958

Scheduled operation: ______ hrs/wk

Magnet cost: 500,000,000 francs

Total cost: ______

Design Specifications

Magnet

Core dia.: 280 cm, ______ in.

Pole tip dia.: 280 cm, ______ in.

Beam radius, max: 123 cm, ______ in.

Field gap, center: 39 cm, ______ in.

Field, center: 16.24 k-gauss

Field, where n = 0.2: 15.4 k-gauss

Radius, where n = 0.2: 123 cm, ______ in.

Power: 400 kw

Weight, Fe 650; Al 9 tons

Winding: Al 24x24-mm bar; 13-mm hole

Cooling: water

Dee aperture: 20 - 8.5 cm, ______ in.

Dee bias, d-c max: ______ v

Beam extraction, type: regenerative

Ion source, type: W-filament arc

Design energy and particle

155 Mev protons

80 Mev deuterons

Oscillator type: ______

Pre-exciter: ______

Oscillator tube: Philips TAW 12/35

Osc. d-c input, max: 50 kw

Osc. r-f output, max: ______ kw

Frequency range: 25.2 to 20.2 Mc/s

Modulation method: rotating condenser

Repetition rate: 500 pulses/sec

Acceptance time: ______ r-f deg

Dee-to-ground: 25 max kv, peak

Shielding: concrete

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	155	80	160	
Frequency range, Mc/sec	25.2-20.2	12.5-11	16.2-6	
Mag. field, k-gauss	16.26	16.26	16.26	
Dee-to-ground, peak, kv	25			
Duty cycle, %				
Internal Beam, stable Time averaged, μa	~2			
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p				
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" ________ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

____

____

____

____

Published Articles Describing Machine

____

____

____

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(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: Synchrocyclotron Bonn

Institution: Institut für Kernphysik, Universität Bonn

Address: Nussallee 8, Bonn, Germany

Person in charge: Prof. W. Reizler

Person supply data: W. Reizler — Date: Nov 1958

Present Fields of Research	~ % of Time
Production of radioisotopes	50
Radiation effects on cyrstals	20
Scattering experiments	20
Nuclear reaction mechanisms	10

History and Status	
Design study	1953
Model tests	1954
Engineering design	1954
Construction started	1954
Completion date	May 1958
Scheduled operation	varies hrs/wk
Magnet cost	620,000 DM
Total cost	1,500,000 DM

Design Specifications

Magnet

Core dia.	190 cm, ___ in.
Pole tip dia.	186.5 cm, ___ in.
Beam radius, max	84 cm, ___ in.
Field gap, center	29.7 cm, ___ in.
Field, center	14.5 k-gauss
Field, where n = 0.2	14.1 k-gauss
Gap, where n = 0.2	24.4 cm
Radius, where n = 0.2	84.5 cm, ___ in.
Power	70 kw
Weight, Fe	220; Cu 24 tons
Winding	copper
Cooling	dis. water
Dee aperture	10 cm, ___ in.
Dee bias, d-c max	0 - 1300 v
Beam extraction, type	
Ion source, type	low voltage arc

Design energy and particle

35 Mev deuterons

70 Mev alphas

Oscillator type	self-ex., gnd-g
Pre-exciter	
Oscillator tube	RS 533
Osc. d-c input, max	25 kw
Osc. r-f output, max	10 kw
Frequency range	10.7 to 11.2 Mc/s
Modulation method	ferroelectric condenser
Repetition rate	1800 pulses/sec
Acceptance time	___ r-f deg
Dee-to-ground	10 kv, peak
Shielding	concrete, 2 m

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev		35	70	
Frequency range, Mc/sec		10.7-11.2	10.7-11.2	
Mag. field, k-gauss		14.5	14.5	
Dee-to-ground, peak, kv		10	10	
Duty cycle, %				
Internal Beam, stable Time averaged, μa		4	0.1	
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p				
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Ferroelectric modulation

Published Articles Describing Machine

none

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: Philips' Synchrocyclotron

Institution: Institute for Nuclear Research

Address: Oosterringdijk 18, Amsterdam-O., Netherlands

Person in charge: Dr. K. van Duuren

Person supply data: Dr. K. van Duuren   Date: May 1958

Present Fields of Research	% of Time
Commercial radioisotope production	30
Irradiation for sci. res.	30
Beam extraction exp.	40
On beam 55 hr/wk	

History and Status

Design study	started 1942
Model tests	
Engineering design	
Construction started	1946
Completion date	August 1949
Scheduled operation	70 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	130 cm, ___ in.
Pole tip dia.	180 cm, ___ in.
Beam radius, max	79.5 cm, ___ in.
Field gap, center	32 cm, ___ in.
Field, center	13.72 k-gauss
Field, where n = 0.2	13.34 k-gauss
Radius, where n = 0.2	79.5 cm, ___ in.
Power	90 kw
Weight, Fe	170 ; Cu 30 tons
Winding	solid strip
Cooling	oil
Dee aperture	18.2-15.7 cm, ___ in.
Dee bias, d-c max	-500 v
Beam extraction, type	magnetic, near completion
Ion source, type	d-c arc with filament

Design energy and particle

28 Mev deuterons

56 Mev alphas

Oscillator type	self-ex., gnd-g
Pre-exciter	no
Oscillator tube	two TAW 12/20 Philips
Osc. d-c input, max	25 kw
Osc. r-f output, max	8 kw
Frequency range	10.05 to 10.43 Mc/s
Modulation method	rotating condenser
Repetition rate	1960 pulses/sec
Acceptance time	unknown r-f deg
Dee-to-ground	25 kv, peak
Shielding	1 m concrete

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev		265	53	
Frequency range, Mc/sec		0.380	0.380	
Mag. field, k-gauss		13.72	13.72	
Dee-to-ground, peak, kv		25	25	
Duty cycle, %		7		
Internal Beam, stable Time averaged, μa		30	1.5	
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p				
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Special design ion source; high dee voltage; high value duty cycle; high output current; special design modulator motor.

Published Articles Describing Machine

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: Uppsala Synchrocyclotron

Institution: The Gustaf Werner Institute for Nuclear Chemistry

Address: University of Uppsala

Person in charge: Prof. The Svedberg

Person supply data: Dr. Helge Tyrén and Mr. A. Svanheden — Date: May 1958

Present Fields of Research	% of Time
High energy physics	60
Nuclear spectroscopy	10
Nuclear chemistry	10
Radiation biology	20

History and Status

Design study	1946
Model tests	1947
Engineering design	1946
Construction started	1947
Completion date	(First beam) Dec 1951
Scheduled operation	115 hrs/wk
Magnet cost	$150,000
Total cost	$1,000,000

Design Specifications

Magnet

Core dia.	280 cm, 110 in.
Pole tip dia.	230 cm, 90.5 in.
Beam radius, max	102 cm, 40.1 in.
Field gap, center	25 cm, 9.8 in.
Field, center	21.54 k-gauss
Field, where n = 0.2	20.58 k-gauss
Radius, where n = 0.2	102 cm, 40.1 in.
Power	440 kw
Weight, Fe 600 ; Cu 50 tons	
Winding	copper
Cooling	water
Dee aperture	8 cm, 3.1 in.
Dee bias, d-c max	1000 v
Beam extraction, type	nonlin. regen.
Ion source, type	pulsed arc

Design energy and particle

200 Mev protons

Mev

Oscillator type	gnd-g
Pre-exciter	no
Oscillator tube	Philips TBW 12/25
Osc. d-c input, max	25 kw
Osc. r-f output, max	kw
Frequency range	25.5 to 33.3 Mc/s
Modulation method	rot. condenser
Repetition rate	240 pulses/sec
Acceptance time	3-4 r-f deg
Dee-to-ground	≤10 kv, peak
Shielding	underground + iron-ore concrete

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	192			
Frequency range, Mc/sec	26.0 - 32.8			
Mag. field, k-gauss	21.54			
Dee-to-ground, peak, kv	≤ 10			
Duty cycle, %	≈ 4			
Internal Beam, stable Time averaged, μa	1			
Energy spread, %	17			

External Beams

Particle	Flux (part./ -sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	$\leq 5 \times 10^{10}$	≥ 0.1	185	$\Delta E_{1/2} \leq 1$ Mev
n	2×10^5	20	186	$\Delta E_{1/2} \approx 15$ Mev
$\pi+$				
$\pi-$				

Ext. beam "piped" 53 ft to target. Beam analyzing magnet used? no

Unusual Features of Installation

Frequency modulation condenser rotating in air.

Published Articles Describing Machine

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

** data not verified

Name of machine: 6-Meter Phasotron

Institution: Joint Nuclear Research Institute - Nuclear Problems Laboratory

Address: Dubna, USSR

Person in charge: V. Dzhelepov

Person supply data: (various sources) Date: ______

Present Fields of Research	% of Time
Elastic scattering p and n	
Pion formation	
Pion interactions	

History and Status	
Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1949; 1953
Scheduled operation	110 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	600 cm, ____ in.
Pole tip dia.	____ cm, ____ in.
Beam radius, max	____ cm, ____ in.
Field gap, center	60 cm, ____ in.
Field, center	16.8 k-gauss
Field, where n = 0.2	____ k-gauss
Radius, where n = 0.2	____ cm, ____ in.
Power	1000 kw
Weight, Fe	7200; Cu 700 tons
Winding	copper bar
Cooling	air
Dee aperture	____ cm, ____ in.
Dee bias, d-c max	____ v
Beam extraction, type	
Ion source, type	hot cathode

Design energy and particle

680 Mev	protons
____ Mev	
Oscillator type	gnd-g
Pre-exciter	
Oscillator tube	two, Gu-12A
Osc. d-c input, ~~max~~ ave	50 kw
Osc. r-f output, max	____ kw
Frequency range	26 to 13 Mc/s
Modulation method	rotating condenser
Repetition rate	80 pulses/sec
Acceptance time	____ r-f deg
Dee-to-ground	15 kv, peak
Shielding	concrete, 6 m; near beam 6 m of iron

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	680			
Frequency range, Mc/sec				
Mag. field, k-gauss				
Dee-to-ground, peak, kv				
Duty cycle, %				
Internal Beam, stable Time averaged, μa	0.1 - 0.2			
Energy spread, %				

External Beams

Particle	Flux ~~(part./cm²-sec)~~	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	0.015 μa			
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Published Articles Describing Machine

CERN Symposium 1956, p. 148.

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: 110-Inch Synchrocyclotron

Institution: Atomic Energy Research Establishment

Address: Harwell, Berkshire, England

Person in charge: Mr. B. Rose

Person supply data: B. Rose — Date: May 1958

Present Fields of Research	% of Time	History and Status	
Nucleus-nucleus scattering	52	Design study	
Nucleon-nucleus scattering	40	Model tests	
Radiochemistry	3	Engineering design	Jan 1946
Isotope production	1	Construction started	Dec 1946
Miscellaneous	4	Completion date	Dec 1949
		Scheduled operation	80 hrs/wk
		Magnet cost	~£ 90,000
		Total cost	~£250,000

Design Specifications

Magnet

- Core dia.: ____ cm, 110 in.
- Pole tip dia.: ____ cm, 110 in.
- Beam radius, max: ____ cm, 50.4 in.
- Field gap, center: ____ cm, 12 in.
- Field, center: 16.2 k-gauss
- Field, where n = 0.2: 15.5 k-gauss
- Radius, where n = 0.2: ____ cm, 50.4 in.
- Power: 300 kw
- Weight, Fe 670; Cu 70 tons
- Winding: copper strip
- Cooling: oil

Dee aperture: ____ cm, 4 in.

Dee bias, d-c max: 1200 v

Beam extraction, type: scatter., mag. channel

Ion source, type: d-c filament arc

Design energy and particle

175 Mev protons

____ Mev ____

Oscillator type: gnd-g triode

Pre-exciter: none

Oscillator tube: one, GEC CAT-17

Osc. d-c input, max: 21 kw

Osc. r-f output, max: ____ kw

Frequency range: 26.3 to 18.9 Mc/s

Modulation method: rotat. vac. condenser

Repetition rate: 180 pulses/sec

Acceptance time: ____ r-f deg

Dee-to-ground: 10 kv, peak

Shielding: underground, 6 ft concrete roof

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	175			
Frequency range, Mc/sec	26.0-20.3			
Mag. field, k-gauss	16.2			
Dee-to-ground, peak, kv	10			
Duty cycle, %	~ 5			
Internal Beam, stable Time averaged, μa	~ 2			
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	~~Energy Spread~~ piped
p	1.5×10^6	0.5	140 ± 2	23 ft
p	3×10^6	4	140 ± 3	48 ft
n	10^4	as required	> 100	up to 75 ft

Ext. beam "piped" ________ ft to target. Beam ~~analyzing magnet used~~ focusing magnets? quadrupole

Unusual Features of Installation

Underground installation. Pulsed internal beam for fast neutron time-of-flight, 15-120 Mev.

Published Articles Describing Machine

1. Pickavance, Adams, and Snowden, Nature, 165, 90 (1950).

2. Pickavance and Cassels, Nature, 169, 520 (1952).

3. J. P. Scanlon et al, Rev. Sci. Inst., 28, 749 (1957).

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: Liverpool 156-Inch Synchrocyclotron

Institution: Nuclear Physics Research Laboratory, University of Liverpool

Address: Mount Pleasant, Liverpool 3

Person in charge: Professor H. W. B. Skinner

Person supply data: M. J. Moore   Date: June 1958

Present Fields of Research	% of Time
Pion physics	80
Proton and neutron reactions	15
Isotope production	3
Bubble chamber	2
"On beam" yearly average	77 hr/wk

History and Status	
Design study	1947 - 1950
Model tests	r-f only 1948-1950
Engineering design	1947-1952
Construction started	1951
Completion date	1954
Scheduled operation	84 hrs/wk
Magnet cost	£ 215,000
Total cost	£ 473,000

Design Specifications

Magnet

Core dia.	381 cm, 156 in.
Pole tip dia.	381 cm, 156 in.
Beam radius, max	176 cm, 71.9 in.
Field gap, center	36 cm, 41.1 in.
Field, center	18.9 k-gauss
Field, where n = 0.2	17.9 k-gauss
Radius, where n = 0.2	176 cm, 71.9 in.
Power	800 kw
Weight, Fe	1640; Al 60 tons
Winding	aluminum
Cooling	treated water
Dee aperture	9.6 cm, 4 in.
Dee bias, d-c max	-1,800 v
Beam extraction, type	peeler regenerator
Ion source, type	hot-cathode; (cold-cathode Sept 1958)

Design energy and particle

400 Mev	protons
Mev	
Oscillator type	self-ex. 3/4 wave Mackenzie
Pre-exciter	none
Oscillator tube	M.O.V. E.1872 gnd-g triode
Osc. d-c input, max	2.9 kw
Osc. r-f output, max	not known kw
Frequency range	28.2 to 18.9 Mc/s
Modulation method	rotating condenser
Repetition rate	110 pulses/sec
Acceptance time	50 μs r-f deg
Dee-to-ground	7 kv, peak
Shielding	sides 6 ft concrete + 12 ft rock; front 12 ft loaded concrete; top 6 ft concrete

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	381			
Frequency range, Mc/sec	29.2 - 18.9			
Mag. field, k-gauss	18.9 - 17.5			
Dee-to-ground, peak, kv	7			
Duty cycle, %	3			
Internal Beam, stable Time averaged, μa	1.0			
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	3×10^{10}	2.5	581	± 2
n	1.5×10^5	4	350	
$\pi+$	10^3/sec	20	100	± 5
$\pi-$	3.5×10^3	20	100	± 5

Ext. beam "piped" 40 ft to target. Beam analyzing magnet used? yes

Unusual Features of Installation

First machine to use peeler regenerator beam extraction successfully, to use aluminum magnet conductor, to use strong focusing or external pion beams.

Published Articles Describing Machine

Moore, M. J., Nature 175, 1012 (1955).

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine 184-Inch Cyclotron

Institution Radiation Laboratory, University of California, Berkeley

Address Berkeley, California

Person in charge R. L. Thornton

Person supply data J. T. Vale Date Nov. 1958

Present Fields of Research	% of Time
Nuclear physics	86
Nuclear chemistry	2
Medical	12

History and Status

Design study	1940
Model tests	
Engineering design	
Construction started	1940 ; 1955
Completion date	1946 ; 1957
Scheduled operation	119 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, 184 in.
Pole tip dia.	___ cm, 188.75 in.
Beam radius, max	___ cm, 82 in.
Field gap, center	___ cm, 14 in.
Field, center	23.3 k-gauss
Field, where n = 0.2	22.275 k-gauss
Radius, where n = 0.2	___ cm, 82.2 in.
Power	old coils 900 aux coils 1600 kw
Weight, Fe	4000 ; Cu old coils 300 tons aux coils 40 tons
Winding	old coils 1/4 x 4 in. solid Cu aux coils hollow Cu 1 3/16 x 1 1/16
Cooling	old coils - oil aux coils - water
Dee aperture	12.3 cm, 4 3/16 in.
Dee bias, d-c max	2000 v
Beam extraction, type	regenerator channel
Ion source, type	conventional

Design energy and particle

730 Mev	protons
460 Mev	deuterons

Oscillator type	self-ex., gnd-g
Pre-exciter	none
Oscillator tube	Machlett ML 5681
Osc. d-c input,	operating cond. 10 kw
Osc. r-f output,	operating cond. 5 kw
Frequency range	36 to 13 Mc/s
Modulation method	vibrating reed capacitor
Repetition rate	64 pulses/sec
Acceptance time	___ r-f deg
Dee-to-ground	10 kv, peak
Shielding	15 ft concrete sides 4 ft concrete top

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	730	460	910	
Frequency range, Mc/sec	36 - 18	18 - 13.5	18 - 13.5	
Mag. field, k-gauss				
Dee-to-ground, peak, kv	9	6	6	
Duty cycle, %	38	28	28	
Internal Beam, stable Time averaged, μa	~1	~1	~0.25	
Energy spread,	55 Mev			

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	2×10^{10}	25	743	14 Mev
n	Hess-Patterson	Determined by collimator		
$\pi+$	100 10	100 100	100 250	10 20
$\pi-$	500 100	100 100	100 300	10 30

Ext. beam "piped" 35 ft to target. Beam analyzing magnet used? Yes

Unusual Features of Installation

Vibrating reeds used for variable capacitor.

Published Articles Describing Machine

R. L. Thornton, "Frequency Modulation and Radiofrequency System for the Modified Berkeley Cyclotron." CERN Symposium 1956, p 413

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(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: UCLA 41-Inch Cyclotron

Institution: University of California, Physics Department

Address: Los Angeles 24, California

Person in charge: Prof. J. Reginald Richardson

Person supply data: B. T. Wright — Date: June 1958

Present Fields of Research	% of Time
Cross sections	20
Particle scattering	20
Radioisotope production	40
Miscellaneous	20

History and Status	
Design study	*
Model tests	*
Engineering design	
Construction started	
Completion date	
Scheduled operation	30 hrs/wk
Magnet cost	*
Total cost	

Design Specifications

Magnet	
Core dia.	___ cm, 41 in.
Pole tip dia.	___ cm, 41 in.
Beam radius, max	___ cm, 18 in.
Field gap, center	___ cm, 4.5 in.
Field, center	16.6 k-gauss
Field, where n = 0.2	15 k-gauss
Radius, where n = 0.2	___ cm, 18.2 in.
Power	60 kw
Weight, Fe 80; Cu ___ tons	
Winding	copper
Cooling	oil
Dee aperture	___ cm, 1.5 in.
Dee bias, d-c max	1200 v
Beam extraction, type	d-c deflector
Ion source, type	open d-c arc

Design energy and particle	
21 Mev	protons
___ Mev	
Oscillator type	self-ex, gnd-g
Pre-exciter	none
Oscillator tube	one, Eimac 3W5000A3
Osc. d-c input, max	10 kw
Osc. r-f output, max	6 kw
Frequency range	22 to 25.6 Mc/s
Modulation method	rotating condenser
Repetition rate	1000 pulses/sec
Acceptance time	___ r-f deg
Dee-to-ground	9 kv, peak
Shielding	water wall + exclusion

* Old magnet, old Berkeley 37-inch first used 1933, many modifications.

over, please

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	20.3			
Frequency range, Mc/sec	22-25.6			
Mag. field, k-gauss	16.6			
Dee-to-ground, peak, kv	9			
Duty cycle, %	4			
Internal Beam, stable Time averaged, μa	0.6			
Energy spread, %	3			

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	6×10^{10}	1	20	0.1 Mev
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

First F-M cyclotron. Uses electrostatic deflector.

Published Articles Describing Machine

J. R. Richardson et al, "Development of the Frequency-Modulated Cyclotron", Phys. Rev. 73, 424 (1948). (describes earlier version of present machine).

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(Rev. 9-58)

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FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: CIT 440-Mev Synchro-cyclotron

Institution: Carnegie Institute of Technology

Address: Pittsburgh 13, Pennsylvania

Person in charge: Dr. R. B. Sutton

Person supply data: R. E. Summars and J. A. Thompson   Date: June 1958

Present Fields of Research	% of Time
Nuclear and meson work	90
Radiation damage	5
Spallation chemistry	5

History and Status

Design study	1946
Model tests	1946-7
Engineering design	1946-7
Construction started	1948
Completion date	May 1952
Scheduled operation	120 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Core dia.	___ cm, 163.4 in.
Pole tip dia.	___ cm, 141 in.
Beam radius, max	___ cm, 68.4 in.
Field gap, center	___ cm, 156.2 in.
Field, center	20.5 k-gauss
Field, where n = 0.2	19.6 k-gauss
Radius, where n = 0.2	___ cm, 68.4 in.
Power, max	430 kw
Weight, Fe	1460; Cu. 138 tons
Winding	copper
Cooling	oil
Dee aperture	___ cm, 4 in.
Dee bias, d-c max	2000 v
Beam extraction, type	* (over)
Ion source, type	hot cathode

Design energy and particle

440 Mev proton

___ Mev ___

Oscillator type	Hartley 3/4 wave self-ex.
Pre-exciter	none
Oscillator tube	two 880
Osc. d-c input, max	60 kw
Osc. r-f output, max	35 kw
Frequency range	31.5 to 19.8 Mc/s
Modulation method	rotary capacitor
Repetition rate	180 - 200 pulses/sec
Acceptance time	30 μs r-f deg
Dee-to-ground	15 kv, peak
Shielding	Magnetic cement + 60% steel scrap - 12 ft min; roof - 5 ft, reg concrete

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	440			
Frequency range, Mc/sec	30.5 - 19.8			
Mag. field, k-gauss	20.5			
Dee-to-ground, peak, kv	15			
Duty cycle, %	45			
Internal Beam, stable Time averaged, μa	1			
Energy spread, % max	5			

External Beams

Particle	Flux (part./cm²-sec)	Beam Area (cm²)	Energy (Mev)	Energy Spread
p	2×10^7	25	448	2%
n	2×10^5	12	> 365	2%
$\pi+$	25 ave	15	75 - 170	3%
$\pi-$	300 ave	15	75 - 220	3%

Ext. beam "piped" 25 ft to target. Beam analyzing magnet used? yes

Unusual Features of Installation

* A few percent of the beam is accelerated until it reaches a radius of about 70 inches (n = 1), where it has sufficient energy to spiral out. There are also two p-scattering targets for polarized protons.

Published Articles Describing Machine

NYO-780

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(Rev. 9-58)

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FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: 170" Synchrocyclotron

Institution: Enrico Fermi Institute for Nuclear Studies, University of Chicago

Address: 5630 South Ellis, Chicago, Illinois

Person in charge: H. L. Anderson

Person supply data: H. L. Anderson   Date: May 1958

Present Fields of Research	% of Time
Pion physics	60
p-p and np scattering and polarization	20
Radiochemistry and high-energy interactions	20

History and Status	
Design study	1947
Model tests	1947
Engineering design	1947
Construction started	1947
Completion date	1951
Scheduled operation	144 hrs/wk
Magnet cost	$\$0.6 \times 10^6$
Total cost	$\$2.5 \times 10^6$

Design Specifications

Magnet

Core dia.	___ cm, 170 in.
Pole tip dia.	___ cm, 170 in.
Beam radius, max	___ cm, ___ in.
Field gap, center	___ cm, 18 in.
Field, center	18.6 k-gauss
Field, where n = 0.2	17.6 k-gauss
Radius, where n = 0.2	___ cm, 76.5 in.
Power	700 kw
Weight, Fe 2200; Cu ___	tons
Winding	copper
Cooling	water
Dee aperture	___ cm, 4.5 in.
Dee bias, d-c max	-2300 v
Beam extraction, type	peeler regenerator
Ion source, type	d-c hot-cathode

Design energy and particle

460 Mev protons

___ Mev ___

Oscillator type	(see ref. 1)
Pre-exciter	none
Oscillator tube	RCA-5770
Osc. d-c input, max	140 kw
Osc. r-f output, max	___ kw
Frequency range	28.5 to 11.3 Mc/s
Modulation method	rotating condenser
Repetition rate	60 pulses/sec
Acceptance time	___ r-f deg
Dee-to-ground	30 kv, peak
Shielding	10 ft steel-punching-loaded concrete

over, please

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ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	456			
Frequency range, Mc/sec	29 - 17.4			
Mag. field, k-gauss	18			
Dee-to-ground, peak, kv	[illegible]			
Duty cycle, %	50			
Internal Beam, stable Time averaged, μa	1			
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	2×10^{10}	0.5	440	$\leq$ 2 Mev
n	$\sim 10^6$ not used recently			
$\pi+$	50 - 1000*	50	20 - 240	
$\pi-$	50 - 1000*	50	20 - 240	
	*energy dependent			

Ext. beam "piped" 30 ft to target. Beam analyzing magnet used? strong-focus magnet

Unusual Features of Installation

Rotating shield in partition wall. Regenerative method of proton beam extraction.

Published Articles Describing Machine

1. K. R. Mackenzie, Phys. Rev., 74, 104 (1948).

2. H. L. Anderson et al, Rev. Sci. Inst., 23, 707 (1952).

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: The Nevis Cyclotron

Institution: Columbia University

Address: Box 137, Irvington-on-Hudson, New York

Person in charge: Prof. James Rainwater

Person supply data: Dr. Warren F. Goodell, Jr. Date: May 1958

Present Fields of Research	% of Time
Meson cross sections	
Mu meson parity, g, μ	80
Scattering	
Slow neutron velocity	
spectrometer	20

History and Status	
Design study	1946
Model tests	1947
Engineering design	1947
Construction started	1947
Completion date	1950
Scheduled operation	120 hrs/wk
Magnet cost	$600,000
Total cost	$3,000,000

Design Specifications

Magnet

Core dia.	___ cm, 170 in.
Pole tip dia.	___ cm, 164 in.
Beam radius, max	___ cm, 74 in.
Field gap, center	___ cm, 18 in.
Field, center	18 k-gauss
Field, where n = 0.2	17 k-gauss
Radius, where n = 0.2	___ cm, 74 in.
Power	550 kw
Weight, Fe	2000; Cu 200 tons
Winding	copper
Cooling	oil
Dee aperture	___ cm, 5 in.
Dee bias, d-c max	5400 v
Beam extraction, type	none
Ion source, type	cold cathode

Design energy and particle

350 Mev	protons
___ Mev	
Oscillator type	self-ex., gnd-g
Pre-exciter	
Oscillator tube	two, 5658
Osc. d-c input, max	25 kw
Osc. r-f output, max	___ kw
Frequency range	29 to 17 Mc/s
Modulation method	rotating condenser
Repetition rate	60 pulses/sec
Acceptance time	___ r-f deg
Dee-to-ground	10 kv, peak
Shielding	6 ft concrete + 2 ft pig iron; 8 ft iron forward

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	380-400			
Frequency range, Mc/sec	29-17			
Mag. field, k-gauss	18			
Dee-to-ground, peak, kv	~ 10			
Duty cycle, %	~ 5			
Internal Beam, stable Time averaged, μa	~ 1			
Energy spread, %				

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p				
n			slow	0.1 - 1000 ev
$\pi+$	100	300	40 - 80	
$\pi-$	200	300	40 - 180	

Ext. beam "piped" 15 ft to target. Beam analyzing magnet used? yes

Unusual Features of Installation

Rotating condenser across lip of dees. Magnet powered by mechanical rectifier.

Published Articles Describing Machine

A-875
(Rev. 9-58)

2-03

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: Harvard 95-Inch Cyclotron

Institution: Harvard University

Address: Cambridge, Massachusetts

Person in charge: Dr. W. M. Preston

Person supply data: A. M. Koehler   Date: May 1958

Present Fields of Research	% of Time
Scattering of protons, both	
polarized and unpolarized	

History and Status

Design study	Jan 1946
Model tests	
Engineering design	
Construction started	August 1946
Completion date	June 1949
Scheduled operation	120 hrs/wk
Magnet cost	
Total cost	approx $1 million

Design Specifications

Magnet

Core dia.	___ cm, 112 in.
Pole tip dia.	___ cm, 95 in.
Beam radius, max	___ cm, ___ in.
Field gap, center	___ cm, 11.7 in.
Field, center	19 k-gauss
Field, where n = 0.2	18.1 k-gauss
Radius, where n = 0.2	___ cm, 42 in.
Power	160 kw
Weight, Fe 641 ; Cu 74	tons
Winding	copper
Cooling	water
Dee aperture	___ cm, 2 in.
Dee bias, d-c max	2000 v
Beam extraction, type	scatterer or regenerator, and channel
Ion source, type	hot-filament pulsed arc

Design energy and particle

168 Mev protons

___ Mev ___

Oscillator type	self-ex., gnd-g
Pre-exciter	none
Oscillator tube	one 9D21
Osc. d-c input, max	~10 kw
Osc. r-f output, max	___ kw
Frequency range	26 to 30 Mc/s
Modulation method	rotating condenser
Repetition rate	0-280 pulses/sec
Acceptance time	___ r-f deg
Dee-to-ground	10 kv, peak
Shielding	3 to 8 ft concrete

over, please

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	158			
Frequency range, Mc/sec				
Mag. field, k-gauss	19			
Dee-to-ground, peak, kv	10			
Duty cycle, %				
Internal Beam, stable Time averaged, μa	0.2			
Energy spread, %	~ 10			

External Beams

Particle	Flux	Beam Area (cm^2)	Energy (Mev)	Energy Spread
unpolarized protons	5×10^{10}/sec	7	158	2 Mev
polarized protons	1×10^{7}/sec	15	150	3 Mev
$\pi+$				
$\pi-$				

Ext. beam "piped" 25 ft to target. Beam analyzing magnet used? yes

Unusual Features of Installation

Magnetic regenerative action used to deflect internal beam into magnetic channel, c.f. Rev. Sci. Inst. 27, 5 (1956).

Published Articles Describing Machine

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: Princeton F-M Cyclotron

Institution: Princeton University

Address: Princeton, New Jersey

Person in charge: Milton G. White

Person supply data: R. Sherr and Glen Schrank   Date: June 1958

Present Fields of Research	% of Time
Nuclear reactions	95
Radioactivity	5

History and Status

Design study	Feb 1950
Model tests	
Engineering design	
Construction started	May 1950
Completion date	Jan 1951
Scheduled operation	~ 100 hrs/wk
Magnet cost	$18,000 (coils)
Total cost	$180,000

Design Specifications

Magnet

Core dia.	cm, 40 in.
Pole tip dia.	cm, 35 in.
Beam radius, max	cm, 14.1 in.
Field gap, center	cm, 3.5 in.
Field, center	12 k-gauss
Field, where n = 0.2	13.5 k-gauss
Radius, where n = 0.2	cm, 14.1 in.
Power	20 kw
Weight, Fe	40; Cu 8 tons
Winding	copper strap
Cooling	water
Dee aperture	cm, 1.25 in.
Dee bias, d-c max	none v
Beam extraction, type	elect. radial def.
Ion source, type	hot filament

Design energy and particle

20 Mev protons

Mev

Oscillator type	self-ex., gnd-g
Pre-exciter	none
Oscillator tube	two, 4 x 2500 A3
Osc. d-c input, max	6 kw
Osc. r-f output, max	kw
Frequency range	25 to 28 Mc/s
Modulation method	rotating condenser
Repetition rate	2000 pulses/sec
Acceptance time	r-f deg
Dee-to-ground	7 kv, peak
Shielding	3 ft heavy concrete, all sides and top

over, please

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	19.6			
Frequency range, Mc/sec	28 - 25			
Mag. field, k-gauss	19			
Dee-to-ground, peak, kv	7			
Duty cycle, %	3 - 5			
Internal Beam, stable Time averaged, μa	1 - 1.5			
Energy spread, %	0.5			

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p	2×10^{11}	0.3 cm^2	19.6	± 1/2
n				
$\pi+$				
$\pi-$				

Ext. beam "piped" 30 ft to target. Beam ~~analyzing~~ focusing magnet used? quadrupole

Unusual Features of Installation

Energy centroid stablized to ±0.1% or better.

Published Articles Describing Machine

1. G. Schrank, "An Energy Control for External Beams," Rev. Sci. Inst. 26, 677 (1955).

X-875
(Rev. 9-58)

FREQUENCY-MODULATED CYCLOTRON DATA SHEET

Name of machine: 130-Inch Synchrocyclotron

Institution: University of Rochester

Address: Rochester, New York

Person in charge: Committee

Person supply data: S. W. Barnes, E. Hafner, W. Coombs   Date: June 1958

Present Fields of Research	% of Time
Meson scattering	
Nucleon scattering	
Nuclear polarization	

History and Status	
Design study	July 1946
Model tests	1946
Engineering design	1946-1947
Construction started	July 1946
Completion date	1948
Scheduled operation	104 hrs/wk
Magnet cost	$300,000
Total cost	$1,362,000

Design Specifications

Magnet

Core dia.	___ cm, 130 in.
Pole tip dia.	___ cm, 130 in.
Beam radius, max	___ cm, 59 1/4 in.
Field gap, center	___ cm, 13.6 in.
Field, center	16.9 k-gauss
Field, where n = 0.2	16.33 k-gauss
Radius, where n = 0.2	___ cm, 58.35 in.
Power	160 kw
Weight, Fe 1000; Al 80	tons
Winding	aluminum
Cooling	water
Dee aperture	___ cm, 3 in.
Dee bias, d-c max	___ v
Beam extraction, type	
Ion source, type	cold cathode

Design energy and particle	240 Mev protons
	___ Mev ___
Oscillator type	self-ex. gnd-g
Pre-exciter	no
Oscillator tube	four, 5771's
Osc. d-c input, max	25 kw
Osc. r-f output, max	___ kw
Frequency range	19.5 to 26.3 Mc/s
Modulation method	rotating condenser
Repetition rate	100 to 300 pulses/sec
Acceptance time	___ r-f deg
Dee-to-ground	~10 kv, peak
Shielding	3 ft concrete on top and back; 3 ft copper on front

X-875A

ACTUAL PERFORMANCE DATA

Internal Beams

	Protons	Deuterons	Alphas	
Energy, Mev	240			
Frequency range, Mc/sec	26.3 - 19.5			
Mag. field, k-gauss	16.8			
Dee-to-ground, peak, kv	~10			
Duty cycle, %	~2			
Internal Beam, stable Time averaged, μa				
Energy spread, %	7.5 to 5			

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
p(blow-up)	10^7	10	245	< 3 Mev
n	10^6		peak at 185	20 Mev
$\pi+$	600	10	25-45	1-2 Mev
$\pi-$	200	10	25-45	1-2 Mev
p (scatt)	10^6	25	210	~5 Mev
(scatt) p regen.	10^6	25	225	< 2 Mev

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? 30-deg-wedge

Unusual Features of Installation

Published Articles Describing Machine

none, Final Report to O.N.R. on construction, 1949 (unpublished).

PROTON SYNCHROTRONS

+ For convenience, the proposed MURA accelerator is listed here because it resembles the alternating-gradient synchrotrons in some ways. It might also be described as a special type of frequency-modulated cyclotron with a 66-fold azimuthally varying magnetic field and 50-Mev injection.

See page 2 for key to tables

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SYNCHROTRON DATA SHEET

Name of machine: ANU 10-Gev Proton Synchrotron

Institution: Australian National University

Address: Box 4, G.P.O. Canberra, A.C.T. Australia

Person in charge: Professor M. L. Oliphant

Person supplying data: Mr. J. W. Blamey — Date: June 1958

Present Fields of Research	% of Time	History and Status	
		Design study	1953
		Model tests	
		Engineering design	
		Construction started	
		Completion date	
		Scheduled operation	hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet		Design Goals	
Focusing, type	weak, c-g	Particle accelerated	protons
Focusing, order		Energy	10.6 Gev
Field index, n =	-0.55	Pulse rate	1 per 10 min
Orbit radius	4.8 m, ___ ft	Output	___ part/pulse
Mean radius	6.4 m, ___ ft	**Injector System**	
Sectors, number	4	Type	cyclotron
Field, at inj.	850 gauss	Energy	8 Mev
Field, max	80 k-gauss	Injector output	1 ma
Power input, max	500,000 kw	Injection period	30 turns
Storage system	homopolar generator	Inflector type	electrostatic
Rise time	0.7 sec	**Acceleration System**	
Weight, Fe	O ; Cu 80 tons	Frequency	1 to 7.5 Mc/s
Aperture, width	22 cm, ___ in.	Accel. cavities	1
Aperture, height	22 cm, ___ in.	Harmonic number	1
Shielding		Orbit freq. final	7.5 Mc/s
		Gain, ave	in early stages 4 kev/turn
		Input to RF, max	60 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ____________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Air-cored orbital magnet with homopolar generator as power supply.

Published Articles Describing Machine

J. W. Blamey, "The Orbital Magnet and Power Supply of the 10-Gev Proton Synchrotron at the Australian National University," CERN Symposium on High Energy Particles Accelerators, 1, 344 (1956).

X-1069

SYNCHROTRON DATA SHEET

Name of machine: CERN 25-Gev Proton Synchrotron

Institution: European Organization for Nuclear Research (CERN)

Address: Meyrin, Geneva-23, Switzerland

Person in charge: J. B. Adams, Director PS Division, CERN

Person supplying data: M. G. N. Hine   Date: June 1958

Present Fields of Research	% of Time

History and Status

Design study	1953-1954
Model tests	1954-1957
Engineering design	1955-1958
Construction started	1956
Completion date	1960
Scheduled operation	___ hrs/wk
Magnet cost	Sw. Fr. 10,000,000
Total cost	Sw. Fr. 100,000,000 incl. buildings and general expenses

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	
Field index, n =	288.4
Orbit radius	70.08 m, ___ ft
Mean radius	100.00 m, ___ ft
Sectors, number	100
Field, at inj.	147 gauss
Field, max	12-14 k-gauss
Power input, max	27-32,000 kw
Storage system	flywheel
Rise time	1.0 sec
Weight, Fe	3,400; Al 130 tons
Aperture, width	14 cm, ___ in.
Aperture, height	7 cm, ___ in.
Shielding	5.5 m baryte concrete

Design Goals

Particle accelerated	protons
Energy	25-28 Gev
Pulse rate	1 per 3 to 5 sec
Output	5×10^9 part/pulse

Injector System

Type	linac
Energy	50 Mev
Injector output	1 ma
Injection period	1 turns
Inflector type	pulsed electric

Acceleration System

Frequency	3 to 10 Mc/s
Accel. cavities	16
Harmonic number	20
Orbit freq. final	1/2 Mc/s
Gain, ave	54 kev/turn
Input to RF, max	16 x 6 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ________ Gev Energy spread ________

Beam current ________ part/pulse Pulse rate ________

Beam current ________ part/sec ________ ________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ________

Unusual Features of Installation

Published Articles Describing Machine

1. Lectures on Theory and Design of A-G Proton Synchrotron, CERN (1953).
2. CERN Symposium Proceedings, Vol. 1 (1956).

X-1069

SYNCHROTRON DATA SHEET

Name of machine: Synchrotron à protons "SATURNE"

Institution: Commissariat à l'Energie Atomique

Address: CEN Saclay - B.P. No. 2 - Gif-sur-Yvette (Seine and Oise)

Person in charge: R. Maillet - S. D. Winter

Person supplying data: S. D. Winter — Date: Nov. 1958

Present Fields of Research	% of Time

History and Status

Design study	began 1953
Model tests	began 1954
Engineering design	began 1954
Construction started	1955
Completion date	August 1958
Scheduled operation	80 hrs/wk
Magnet cost	$\sim 400 \times 10^6$ francs
Total cost	$\sim 6 \times 10^9$ francs

Design Specifications

Magnet

Focusing, type	weak, c-g
Focusing, order	
Field index, n =	0.6
Orbit radius	8.42 m, ____ ft
Mean radius	$\sim$ 11 m, ____ ft
Sectors, number	4, and 284 blocks
Field, at inj.	326 gauss
Field, max	15 k-gauss
Power input, max	24,000 kva ~~kw~~
Storage system	flywheel
Rise time	0.8 sec
Weight, Fe 1080 ; Cu 55 tons	
Aperture, width between pole tips	52.75 cm, ____ in.
Aperture, height between pole pieces	17.54 cm, ____ in.
Shielding	concrete

Design Goals

Particle accelerated	protons
Energy	$\geq$ 2.5 Gev
Pulse ~~rate~~ duration	3.2 sec
Output	10^{10} part/pulse
Output after changes in injector	10^{11}

Injector System

Type	electrostatic generator
Energy	3.6 Mev
Injector output	protons 1.5 ma
Injection period	____ turns
Inflector type	electrostatic

Acceleration System

Frequency	0.78 to 8.41 Mc/s
Accel. cavities	1
Harmonic number	2
Orbit freq. final	4.2 Mc/s
Gain, ave	1.16 kev/turn
Input to RF, max	15 kw

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy 3 Gev Energy spread

Beam current 5×10^8 part/pulse Pulse rate

Beam current part/sec

External Beams expected 1959

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ft to target. Beam analyzing magnet used?

Unusual Features of Installation

Separated pole pieces. Achromatic and afocal injection optics. Vacuum chamber (construction). RF tuning system (oscillating condenser + ferrites).

Published Articles Describing Machine

H. Bruck and R. Levy-Mandel, Nuovo Cimento (10), 2, Supp. 1, p423 (1955). (obsolete)

Internal reports.

X-1069

SYNCHROTRON DATA SHEET

Name of machine: Delft Proton Synchrotron

Institution: Technical University - Accelerator Division

Address: Kanaabweg 2, Delft, Netherlands

Person in charge: Prof. Dr. F. A. Heyn

Person supplying data: F. A. Heyn   Date: July 1958

Present Fields of Research	% of Time

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1956
Completion date	January 1959
Scheduled operation	______ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	edge
Focusing, order	
Field index, n =	0
Orbit radius	3.25 m, ______ ft
Mean radius	______ m, ______ ft
Sectors, number	4
Field, at inj.	______ gauss
Field, max	17.5 k-gauss
Power input, max	3000 kva
Storage system	none
Rise time	0.8 sec
Weight, Fe ______ ; Al/Cu	______ tons
Aperture, width	25 cm, ______ in.
Aperture, height	10 cm, ______ in.
Shielding	

Design Goals

Particle accelerated	protons
Energy	1 Gev
Pulse rate	1 per 2 sec
Output	______ part/pulse

Injector System

Type	cyclotron
Energy	~ 10 Mev
Injector output	______ ma
Injection period	______ turns
Inflector type	electrostatic

Acceleration System

Frequency	______ to ______ Mc/s
Accel. cavities	ferrite transformer
Harmonic number	1 st
Orbit freq. final	______ Mc/s
Gain, ave	______ kev/turn
Input to RF, max	______ kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev   Energy spread ____________

Beam current ____________ part/pulse   Pulse rate ____________

Beam current ____________ part/sec   ____________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ________

Unusual Features of Installation

Magnetic field is radially constant. Axial focusing by "edge focusing" at edges of the four sectors. Faces of sectors are at 19-deg angle to radius.

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET

** data not verified

Name of machine: 10-Gev Synchrophasotron

Institution: Joint Nuclear Research Institute - High Energy Laboratory

Address: Dubna, USSR

Person in charge: V. Veksler.

Person supplying data: (various sources) Date: ____

Present Fields of Research	% of Time

History and Status

Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1957
Scheduled operation	____ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	weak, c-g
Focusing, order	
Field index, n =	0.70
Orbit radius	28 m, ____ ft
Mean radius	30.5 m, ____ ft
Sectors, number	48
Field, at inj.	150 gauss
Field, max	13 k-gauss
Power input, max	140,000 kw
Storage system	flywheels
Rise time	3.3 sec
Weight, Fe 35 000 ; Cu 2700 tons	
Aperture, width	150 cm, ____ in.
Aperture, height	40 cm, ____ in.
Shielding	

Design Goals

Particle accelerated	protons
Energy	10 Gev
Pulse rate	5/min
Output	10^9 - 10^{10} part/pulse

Injector System

Type	linac
Energy	9 Mev
Injector output	10 ma
Injection period	____ turns
Inflector type	

Acceleration System

Frequency	0.19 to 1.45 Mc/s
Accel. cavities	2
Harmonic number	1
Orbit freq. final	____ Mc/s
Gain, ave	2.2 kev/turn
Input to RF, max	____ kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ______________ Gev   Energy spread ______________

Beam current ______________ part/pulse   Pulse rate ______________

Beam current ______________ part/sec   ______________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Published Articles Describing Machine

CERN Symposium 1956, p339, 378, 382, 385, and 429.

X-1069

SYNCHROTRON DATA SHEET

** data not verified

Name of machine: Model Synchrophasotron (model for 7 Gev)

Institution: Research Institute of Electro-physical Instruments

Address: Leningrad, USSR

Person in charge:

Person supplying data: (various sources) Date:

Present Fields of Research	% of Time

History and Status

Design study	
Model tests	
Engineering design	
Construction started	
Completion date	1958 ?
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	
Field index, n =	27.5 - 28.5
Orbit radius	5 m, ft
Mean radius	m, ft
Sectors, number	34
Field, at inj.	274 gauss
Field, max	5 (10) k-gauss
Power input, max	kw
Storage system	
Rise time	<1 sec
Weight, Fe ; Al/Cu	tons
Aperture, width	13.9 cm, in.
Aperture, height	7.8 cm, in.
Shielding	

Design Goals

Particle accelerated	protons
Energy	200 (650) ~~Gev~~ Mev
Pulse rate	4/min
Output	part/pulse

Injector System

Type	
Energy	Mev
Injector output	ma
Injection period	turns
Inflector type	

Acceleration System

Frequency	to Mc/s
Accel. cavities	
Harmonic number	
Orbit freq. final	Mc/s
Gain, ave	0.106 kev/turn
Input to RF, max	kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ______________ Gev Energy spread ______________

Beam current ______________ part/pulse Pulse rate ______________

Beam current ______________ part/sec ______________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Published Articles Describing Machine

CERN Symposium 1956, p387

X-1069

SYNCHROTRON DATA SHEET

** data not verified

Name of machine 50-Gev Synchrophasotron

Institution Research Institute for Electro-Physical Equipment

Address Leningrad, USSR

Person in charge

Person supplying data (various sources) Date

Present Fields of Research	% of Time

History and Status

Design study	1956
Model tests	1956
Engineering design	
Construction started	1957
Completion date	(1961)
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	
Field index, n =	410
Orbit radius	167 m, ___ ft
Mean radius	___ m, ___ ft
Sectors, number	120
Field, at inj.	90 gauss
Field, max	12 k-gauss
Power input, max	100,000 kw
Storage system	flywheels
Rise time	3.8 sec
Weight, Fe 22000 ; Al Cu	___ tons
Aperture, width	20 cm, ___ in.
Aperture, height	12 cm, ___ in.
Shielding	

Design Goals

Particle accelerated	protons
Energy	50 Gev
Pulse rate	6/min
Output	___ part/pulse

Injector System

Type	linac
Energy	100 Mev
Injector output	___ ma
Injection period	___ turns
Inflector type	

Acceleration System

Frequency	2.6 to 6.1 Mc/s
Accel. cavities	ferrite transformers
Harmonic number	(rf = 30 x orb. freq.)
Orbit freq. final	___ Mc/s
Gain, ave	100 kev/turn
Input to RF, max	___ kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Published Articles Describing Machine

CERN Symposium 1956, p122.

X-1069

SYNCHROTRON DATA SHEET ** data not verified

Name of machine: 7-Gev Synchrophasotron (Model for 50 Gev)

Institution: Thermotechnical Institute

Address: Moscow, USSR

Person in charge: Vladimirski

Person supplying data: (various sources) Date: ___

Present Fields of Research	% of Time

History and Status

- Design study: 1956
- Model tests: 1956
- Engineering design: ___
- Construction ~~started~~ underway: 1957
- Completion date: (1959?)
- Scheduled operation: ___ hrs/wk
- Magnet cost: ___
- Total cost: ___

Design Specifications

Magnet

- Focusing, type: strong, a-g
- Focusing, order: ___
- Field index, n = ___
- Orbit radius: 40 m, ___ ft
- Mean radius: ___ m, ___ ft
- Sectors, number: 98 c and 12 x
- Field, at inj.: 90 gauss
- Field, max: 9.5 k-gauss
- Power input, max: ___ kw
- Storage system: ___
- Rise time: 1.5 sec
- Weight, Fe 2700; Al ___ Cu tons
- Aperture, width: 11 cm, ___ in.
- Aperture, height: 8 cm, ___ in.
- Shielding: ___

Design Goals

- Particle accelerated: protons
- Energy: 7 Gev
- Pulse rate: 12/min
- Output: ___ part/pulse

Injector System

- Type: linac
- Energy: 20 Mev
- Injector output: ___ ma
- Injection period: ___ turns
- Inflector type: ___

Acceleration System

- Frequency: 0.65 to 8.5 Mc/s
- ~~Accel. cavities~~ Drift tubes: 11
- Harmonic number: 7
- Orbit freq. final: ___ Mc/s
- Gain, ave: 4.35 kev/turn
- Input to RF, max: 500 kw

over please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy __________ Gev Energy spread __________

Beam current __________ part/pulse Pulse rate __________

Beam current __________ part/sec __________ __________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ________

Unusual Features of Installation

Published Articles Describing Machine

CERN Symposium 1956, p118.

X-1069

SYNCHROTRON DATA SHEET** data not verified

Name of machine: The Birmingham Proton Synchrotron

Institution: University of Birmingham

Address: Birmingham 15, England

Person in charge: Dr. J. L. Symonds and Dr. P. D. Whitaker

Person supplying data: (various sources) Date: ________

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	began 1946
		Construction started	Dec 1947
		Completion date	July 1953
		Scheduled operation	40 hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet		Design Goals	
Focusing, type	weak, c-g	Particle accelerated	protons
Focusing, order		Energy	1 Gev
Field index, n =		Pulse rate	5/min
Orbit radius	5 m, ____ ft	Output	10^{10} part/pulse
Mean radius	____ m, 16.5 ft	**Injector System**	
Sectors, number		Type	Cockcroft-Walton
Field, at inj.	200 gauss	Energy	500 kev
Field, max	____ k-gauss	Injector output	200 μa
Power input, max	____ kw	Injection period	____ turns
Storage system		Inflector type	
Rise time	____ sec	**Acceleration System**	
Weight, Fe ____; Al/Cu ____ tons		Frequency	0.3 to 9.6 Mc/s
Aperture, width	____ cm, ____ in.	Accel. cavities	ferrite loaded
Aperture, height	____ cm, ____ in.	Harmonic number	
Shielding	concrete, 2m pyrite-loaded on lab. side	Orbit freq. final	____ Mc/s
		Gain, ave	____ kev/turn
		Input to RF, max	60 kw

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____1____ Gev Energy spread ________

Beam current ____10^{10}____ part/pulse Pulse rate ________

Beam current ________ part/sec ________ ________

External Beams

Particle	Flux (part./cm^2-[redacted])	Beam Area (cm^2)	Energy (Mev)	Energy Spread
	5×10^3/pulse			

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ________

Unusual Features of Installation

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET

Name of machine: 7-Gev Proton Synchrotron

Institution: Rutherford High Energy Laboratory, National Institute for Research in Nuclear Science

Address: Harwell, Berkshire, England

Person in charge: Dr. T. G. Pickavance

Person supplying data: T. G. Pickavance   Date: May 1958

Present Fields of Research	% of Time
Under construction	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	July 1957
Completion date	Dec 1961
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	weak, c-g
Focusing, order	
Field index, n =	0.6
Orbit radius	18.78 m, ft
Mean radius	23.63 m, ft
Sectors, number	8
Field, at inj.	299 gauss
Field, max	14 k-gauss
Power input, max	8,400 kw
Storage system	flywheels
Rise time	0.7 sec
Weight, Fe	7,000 ; Cu 250 tons
Aperture, width	cm, 36 in.
Aperture, height	cm, 9 in.
Shielding	concrete and earth

Design Goals

Particle accelerated	protons
Energy	7.0 Gev
Pulse rate	25-30 per min
Output	10^{12} part/pulse

Injector System

Type	linac
Energy	15 Mev
Injector output	5 ma
Injection period	300 turns*
Inflector type	electrostatic

Acceleration System

Frequency	1.4 to 8.02 Mc/s
Accel. cavities	1 double
Harmonic number	4
Orbit freq. final	2.01 Mc/s
Gain, ave	7 kev/turn
Input to RF, max	80 kw

* non-linear rise of field

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ______ Gev Energy spread ______

Beam current ______ part/pulse Pulse rate ______

Beam current ______ part/sec ______ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ______ ft to target. Beam analyzing magnet used? ______

Unusual Features of Installation

Overhead shielding by 6.5 ft of concrete + 20 ft earth, over synchrotron. Experimental area with light roof, separated from machine by 30-ft concrete wall. Probable use of epony-resin glass laminates for vacuum vessel. "Crenillated" pole pieces for magnetic field compensation at high fields.

Published Articles Describing Machine

J. J. Wilkins and A. L. Egginton, "Some Parameters of the Gev Proton Synchrotron Magnet," AERE GP/R 2181.

X-1069

SYNCHROTRON DATA SHEET

Name of machine: ZGS (Zero Gradient Synchrotron)

Institution: Argonne National Laboratory

Address: Lemont, Illinois

Person in charge: J. J. Livingood

Person supplying data: John J. Livingood   Date: June 1958

Present Fields of Research	% of Time

History and Status

Design study	Feb 1956 - present
Model tests	Aug 1956 - present
Engineering design	Approx 1957
Construction started	Summer 1958
Completion date	1962
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	edge
Focusing, order	weak
Field index, n =	zero
Orbit radius	m, 71 ft
Mean radius	m, 87 ft
Sectors, number	8
Field, at inj.	477 gauss
Field, max	21.5 k-gauss
Power input, max	~100,000 kw
Storage system	flywheel
Rise time	one sec
Weight, Fe	4000; Cu 65 tons
Aperture, width	cm, 32 in.
Aperture, height	cm, 5 1/4 in.
Shielding	earth, 20 ft above, 100 ft sides

Design Goals

Particle accelerated	protons
Energy	12.5 Gev
Pulse rate	1 per 4 sec
Output	$\sim 10^{12}$ part/pulse

Injector System

Type	linac
Energy	50 Mev
Injector output	~5 ma
Injection period	68 turns
Inflector type	magnetic

Acceleration System

Frequency	4.2 to 14 Mc/s
Accel. cavities	two
Harmonic number	8
Orbit freq. final	1.745 Mc/s
Gain, ave	7.32 kev/turn
Input to RF, max	80 - 100 kw

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ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ______________ Gev   Energy spread ______________

Beam current ______________ part/pulse   Pulse rate ______________

Beam current ______________ part/sec   ______________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? __________

Unusual Features of Installation

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET

Name of machine: Cosmotron

Institution: Brookhaven National Laboratory

Address: Upton, New York

Person in charge: George B. Collins

Person supplying data: William H. Moore

Date: October 1958

Present Fields of Research	% of Time
Strange particles	75
Pions	25

History and Status

Design study	1947 - 1949
Model tests	1948 - 1950
Engineering design	1949 - 1951
Construction started	1949
Completion date	1952
Scheduled operation	100 hrs/wk
Magnet cost	$750,000
Total cost	$7,000,000

Design Specifications

Magnet

Focusing, type	weak, c-g
Focusing, order	
Field index, n =	0.6
Orbit radius	___ m, 30 ft
Mean radius	___ m, 30 ft
Sectors, number	4
Field, at inj.	290 gauss
Field, max	13.8 k-gauss
Power input, max	26,000 kw
Storage system	40-ton flywheel
Rise time	1.0 sec
Weight, Fe	2000; Cu 70 tons
Aperture, width	___ cm, 28 in.
Aperture, height	___ cm, 6 in.
Shielding	concrete

Design Goals

Particle accelerated	protons
Energy	3.0 Gev
Pulse rate	12 per min
Output	10^{10} - 10^{11} part/pulse

Injector System

Type	Van de Graaff
Energy	3.6 Mev
Injector output	3 ma
Injection period	60 μs turns
Inflector type	electrostatic

Acceleration System

Frequency	0.33 to 4.18 Mc/s
Accel. cavities	1
Harmonic number	1 st
Orbit freq. final	4.18 Mc/s
Gain, ave	1000 kev/turn
Input to RF, max	50 kw

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ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy 2.96 Gev   Energy spread 2%

Beam current 10^{10}-10^{11} protons/pulse   Pulse rate

Beam current 1/5 x (10^{10} to 10^{11}) part/sec

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
protons	4 x 10^{10}	20	2000 - 2960	2%

Ext. beam "piped" 50-100 ft to target. Beam analyzing magnet used? yes

Unusual Features of Installation

Hollow-core magnet coils. Ferrite accelerating core. Extraction of large fraction of internal beam.

Published Articles Describing Machine

(Detailed 140-page report) Rev. Sci. Instr., 24, No. 9 (September 1953).

X-1069

SYNCHROTRON DATA SHEET

Name of machine: Brookhaven Alternating Gradient Synchrotron

Institution: Brookhaven National Laboratory

Address: Upton, Long Island, New York

Person in charge: Dr. G. K. Green and Dr. J. P. Blewett

Person supplying data: Dr. G. K. Green   Date: May 1958

Present Fields of Research	% of Time

History and Status	
Design study	
Model tests	electron analogue
Engineering design	
Construction started	1955
Completion date	1960
Scheduled operation	______ hrs/wk
Magnet cost	$5 million
Total cost	$29 million

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	
Field index, n =	359
Orbit radius	______ m, 421.45 ft
~~Mean~~ Magnet radius	______ m, 280 ft
Sectors, number	240
Field, at inj.	120 gauss
Field, max	13 k-gauss
Power input, max	______ kw
Storage system	
Rise time	one sec
Weight, Fe	4,000 ; Cu 400 tons
Aperture, width	______ cm, 6 in.
Aperture, height	______ cm, 2 5/8 in.
Shielding	earth and concrete

Design Goals

Particle accelerated	protons
Energy	30 Gev
Pulse rate	3 per min
Output	______ part/pulse

Injector System

Type	linac
Energy	50 Mev
Injector output	______ ma
Injection period	one turns
Inflector type	electrostatic

Acceleration System

Frequency	1.5 to 4.5 Mc/s
Accel. cavities	24
Harmonic number	12
Orbit freq. final	______ Mc/s
Gain, ave	8.0 kev/turn
Input to RF, max	______ kw

over, please

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ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ____________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

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Published Articles Describing Machine

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X-1069

SYNCHROTRON DATA SHEET

Name of machine: Bevatron

Institution: University of California Radiation Laboratory

Address: Berkeley, California

Person in charge: Dr. Edward J. Lofgren

Person supplying data: Walter Hartsough Date: Sept 1958

Present Fields of Research	% of Time
Particle physics research	95
Chemistry	2 1/2
Machine development	2 1/2

History and Status

Design study	1946
Model tests	1948
Engineering design	April 1948
Construction started	Sept 1949
Completion date	Feb 1954
Scheduled operation	160 hrs/wk
Magnet cost	$5,193,000
Total cost	$9,700,000

Design Specifications

Magnet

Focusing, type	weak, c-g
Focusing, order	
Field index, n =	0.6
Orbit radius	___ m, 50 ft
Mean radius	___ m, 63 ft
Sectors, number	144
Field, at inj.	299 gauss
Field, max	16 k-gauss
Power input, max	100,000 kw
Storage system	flywheel
Rise time	1.85 sec
Weight, Fe 9700 ; Cu 347 tons	
Aperture, width, Net	112 cm, 44 in.
Aperture, height, Net	25 cm, 10 in.
Shielding	5 - 10 ft concrete

Design Goals

Particle accelerated	proton
Energy	6.2 Gev
Pulse rate	11/m
Output	___ part/pulse

Injector System

Type	linac
Energy	9.9 Mev
Injector output	0.45 ma
Injection period	100 turns
Inflector type	electrostatic

Acceleration System

Frequency	0.36 to 2.46 Mc/s
Accel. cavities	one
Harmonic number	1
Orbit freq. final	2.46 Mc/s
Gain, ave	1.5 kev/turn
Input to RF, max	25 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy 6.2 Gev   Energy spread max 10 Mev

Beam current $1/6 \times 10^{11}$ part/pulse   Pulse rate ______

Beam current ______ part/sec

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
	No External Primary Beam			

Ext. beam "piped" ______ ft to target. Beam analyzing magnet used? ______

Unusual Features of Installation

Published Articles Describing Machine

1. W. M. Brobeck, "Design and Construction of the Bevatron," UCRL-3912 (Sept. 1957).
2. E. J. Lofgren, "Bevatron Operational Experiences," CERN Symposium, p496 (1956).
3. B. Cork, "The Bevatron 9.9-Mev Proton Linear Accelerator," UCRL-2385, (July 1954).

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SYNCHROTRON DATA SHEET

Name of machine: MURA 15 Bev Two-Way Accelerator

Institution: Midwestern Universities Research Association

Address: 2203 University Avenue, Madison, Wisconsin

Person in charge: Keith R. Symon

Person supplying data: Francis T. Cole　　Date: Nov 1958

Present Fields of Research	% of Time

History and Status

Design study: Nov 1957 - present

Model tests: 40-Mev electron model under construction

Engineering design:

Construction started:

Completion date:

Scheduled operation: ______ hrs/wk

Magnet cost:

Total cost:

Design Specifications

Magnet (FF here = fixed-field)

Focusing, type: FFAG radial sector

Focusing, order: fodo fodo

Field index, $k = \frac{r}{B}\frac{\partial B}{\partial r}$ = 212

Orbit radius: 33 m, 108.3 ft

Mean radius: 180 m, 590.6 ft

Sectors, number: 66

Field, at inj.: 300 gauss

Field, max: 18 k-gauss

Power input, max: 60,000 kw

Storage system: not applicable

Rise time: not applicable sec

Weight, Fe 62,500 ; 3,000 tons

Aperture, width: 490 cm, 192.9 in.

Aperture, height: 15 cm, 59.1 in.

Shielding: Underground with 20 ft earth cover

Design Goals

Particle accelerated: protons

Energy: 15 (540) Gev

Pulse rate:

Output: ______ part/pulse

Injector System

Type: linac

Energy: 50 Mev

Injector output: 5 ma

Injection period: 100 turns

Inflector type: programmed magnetic bump

Acceleration System 0.934 to 2.7 (stacking)

Frequency: 2.7 to 2.91 Mc/s

Accel. cavities: 11

Harmonic number: 11

Orbit freq. final: 0.625 Mc/s

Gain, ave: 170 kev/turn

Input to RF, max: 4,000 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev   Energy spread ____________

Beam current ____________ part/pulse   Pulse rate ____________

Beam current ____________ part/sec   ____________ ____________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

(The fixed magnetic field increases by a factor of 40 or 50 over the radial aperture of 490 cm. The field is reversed in each half-sector; thus, on any circle averaged over azimuth the field is zero. Oscillations of equilibrium orbit about the circle result in net orbit-bending field for ions in either direction. R-f programed for initial pulsing at 10/sec, stacking at 1.4 Gev, and final pulsing at 1/sec. Two 15-Gev beams colliding provides 540-Gev equivalent energy. . . Abstracted from Proposal by F. T. Howard).

Published Articles Describing Machine

The electron model is described in MURA Reports 373 and 375.

The MURA proposal document, March 14, 1958, is not numbered.

X-1069

SYNCHROTRON DATA SHEET

Name of machine: Southern Regional Accelerator

Institution: Oak Ridge National Laboratory

Address: Oak Ridge, Tennessee

Person in charge: Drs. R. S. Livingston and T. A. Welton

Person supplying data: ______ Date: October 1958

Present Fields of Research	% of Time
At present, design study	
and model tests only.	

History and Status

Design study	began 1957
Model tests	began 1957
Engineering design	
Construction started	
Completion date	
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	
Field index, n =	270
Orbit radius	___ m, 142 ft
Mean radius	___ m, 213 ft
Sectors, number	32
Field, at inj.	1.2 gauss
Field, max	10 k-gauss
Power input, ave ~~max~~	700 kw
Storage system	condenser-choke
Rise time	1/120 sec
Weight, Fe	1200; Cu 180 tons
Aperture, width	13 cm, ___ in.
Aperture, height	6 cm, ___ in.
Shielding	
Vacuum chamber	oval, 2.5x6.5 in.

Design Goals

Particle accelerated	protons
Energy	12 Gev
Pulse rate	60/sec
Output	20 μa ~~part/pulse~~

Injector System

Type	AVF fixed-frequency cyclotron
Energy	850 Mev
Injector output, pulses	5 ma
Injection period	40 turns
Inflector type	resonant

Acceleration System

Frequency	98 to 115 Mc/s
Accel. cavities	16
Harmonic number	157
Orbit freq. final	0.732 Mc/s
Gain, ~~ave~~ max	4 Mev ~~kev~~/turn
Input to RF, max	~ 1000 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Use of high-energy AVF cyclotron as injector. Large proton output at 12 Gev.

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET

Name of machine: 3-Bev High Intensity Proton Synchrotron

Institution: Princeton University and University of Pennsylvania

Address: James Forrestal Research Center, Princeton, New Jersey

Person in charge: Prof. Milton G. White

Person supplying data: F. C. Shoemaker

Date: May 1958

Present Fields of Research	% of Time

History and Status

Design study	1954-1956
Model tests	1956-1958
Engineering design	1957
Construction started	July 1958
Completion date	January 1960
Scheduled operation	hrs/wk
Magnet cost	$2,000,000
Total cost	$9,000,000

Design Specifications

Magnet

Focusing, type	weak, c-g
Focusing, order	
Field index, n =	0.6
Orbit radius	30 m, ft
Mean radius	40 m, ft
Sectors, number	16
Field, at inj.	270 gauss
Field, max	13.8 k-gauss
Power input, max	3,000 kw
Storage system	capacitors and choke
Rise time	25×10^{-3} sec
Weight, Fe	400; Cu 25 tons
Aperture, width	cm, 7 in.
Aperture, height	cm, 2 3/4 in.
Shielding	240-in concrete, 15 ft

Design Goals

Particle accelerated	protons
Energy	3.0 Gev
Pulse rate	20 per sec
Output	1.5×10^{11} part/pulse

Injector System

Type	Van de Graaff
Energy	3.0 Mev
Injector output	5 ma
Injection period	9 turns
Inflector type	electrostatic

Acceleration System

Frequency	2.5 to 30 Mc/s
Accel. cavities	4, double
Harmonic number	8
Orbit freq. final	3.75 Mc/s
Gain, ave max	62 kev/turn
Input to RF, max	300 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ______ Gev Energy spread ______

Beam current ______ part/pulse Pulse rate ______

Beam current ______ part/sec ______ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ______ ft to target. Beam analyzing magnet used? ______

Unusual Features of Installation

High pulse rate, 20 pulses per sec. High duty cycle - 10% for 10% energy spread, 5% for 2 1/2% energy spread. Completely shielded machine.

Published Articles Describing Machine

M. G. White, F. C. Shoemaker and G. K. O'Neill, "A 3-Bev High Intensity Proton Synchrotron," Proceedings of the CERN Symposium, Vol. 1, (1956).

ELECTRON SYNCHROTRONS

$E \geqq 0.5$ Gev

See page 2 for key to tables

X-1069

SYNCHROTRON DATA SHEET

Name of machine: 500-Mev Elektronen-Synchrotron

Institution: Physikalisches Institut der Universität Bonn

Address: Bonn, Germany Nussallee 6

Person in charge: Prof. Dr. W. Paul

Person supplying data: Dr. H. Ehrenberg Date ______

Present Fields of Research	% of Time
Testing of machine	
operation and performance	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1954
Completion date	1958
Scheduled operation	______ hrs/wk
Magnet cost	500,000 DM
Total cost	1300,000 DM

Design Specifications

Magnet

Focusing, type	strong a-g
Focusing, order	
Field index, n =	17
Orbit radius	1.70 m, ______ ft
Mean radius	2.63 m, ______ ft
Sectors, number	9
Field, at inj.	69 gauss
Field, max	10 k-gauss
Power input, max	75 kw
Storage system	condensers
Rise time	8.5 msec
Weight, Fe	12; Cu 4.8 tons
Aperture, width	______ cm, ______ in.
Aperture, height	______ cm, ______ in.
Shielding	

Design Goals

Particle accelerated	electrons
Energy	0.5 Gev
Pulse rate	50 per sec
Output	______ part/pulse

Injector System

Type	van de Graaff
Energy	3 Mev
Injector output	100 ma
Injection period	30 turns
Inflector type	electrostatic

Acceleration System

Frequency	161.45 to 163.08 Mc/s
Accel. cavities	6
Harmonic number	9
Orbit freq. final	18.12 Mc/s
Gain, ave	4 kev/turn
Input to RF, max	2 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________________ Gev Energy spread ____________________

Beam current ____________________ part/pulse Pulse rate ____________________

Beam current ____________________ part/sec ____________________ __________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

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Published Articles Describing Machine

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X-1069

SYNCHROTRON DATA SHEET

Name of machine: Deutsches Elektronen-Synchrotron (DESY)

Institution: Deutsches Elektronen-Synchrotron

Address: Hamburg-Bahrenfeld, Luruper Chaussee 149

Person in charge: Prof. Dr. W. Jentschke

Person supplying data: Dr. H. O. Wuster — Date: November 1958

Present Fields of Research	% of Time

History and Status

Design study	May 1957
Model tests	
Engineering design	
Construction started	
Completion date	
Scheduled operation	hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	AG
Focusing, order	FODO
Field index, n =	70.261
Orbit radius	31.70 m, ____ ft
Mean radius	50.42 m, ____ ft
Sectors, number	48
Field, at inj.	42 gauss
Field, max	7.89 k-gauss
Power input, max	1800 kw
Storage system	resonant circuit
Rise time	8 m sec
Weight, Fe	600; Cu 80 tons
Aperture, width	p.t.o. ____ cm, ____ in.
Aperture, height	p.t.o. ____ cm, ____ in.
Shielding	direct 10 m earth equiv. roof 2.50 m earth equiv.

Design Goals

Particle accelerated	electron
Energy	7.5 Gev
Pulse rate	50/sec
Output	10^{11} part/pulse

Injector System

Type	linear accelerator
Energy	40 Mev
Injector output	125 ma
Injection period	1 turns
Inflector type	electrostatic

Acceleration System

Frequency	499.67 to -- Mc/s
Accel. cavities	16
Harmonic number	528
Orbit freq. final	0.946 Mc/s
Gain, ave	1000 kev/turn
Input to RF, max	400 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ______________ Gev Energy spread ______________

Beam current ______________ part/pulse Pulse rate ______________

Beam current ______________ part/sec ______________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Different apertures in F and D - sectors

In radial focusing sectors: aperture width 14.4 cm, height 4.8 cm

In radial defocusing sectors: aperture width 8.4 cm, height 8.0 cm

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET

Name of machine: The INFN 1-Gev Electron Synchrotron

Institution: Institute Nagionale di Fisica Nucleare

Address: Casella Postale no 15 - Frascati (Roma)

Person in charge: Prof. Giorgio Salvini

Person supplying data: ______ Date: June 1958

Present Fields of Research	% of Time

History and Status

Design study	1954-1955
Model tests	1955-1956
Engineering design	1955-1956
Construction started	January 1956
Completion date	January 1959
Scheduled operation	______ hrs/wk
Magnet cost	Lira 200,000,000 (~$350,000)
Total cost	~$1,500,000

Design Specifications

Magnet

Focusing, type	weak
Focusing, order	first
Field index, n =	0.61
Orbit radius	3.60 m, ______ ft
Mean radius	4.37 m, ______ ft
Sectors, number	4
Field, at inj.	22.7 gauss
Field, max	9.26 (11) k-gauss
Power input, max	825 kw
Storage system	capacitors
Rise time	$\sim 25 \times 10^{-3}$ sec
Weight, Fe	~95; Cu ~8 tons
Aperture, width	22.7 cm, ______ in.
Aperture, height	8.6 cm, ______ in.
Shielding	concrete and iron

Design Goals

Particle accelerated	electrons
Energy	1 (1.2) Gev
Pulse rate	20 per sec
Output	______ part/pulse

Injector System

Type	Cockcroft - Walton
Energy (kinetic)	2 Mev
Injector output	200 ma
Injection period	~10 - 20 turns
Inflector type	electrostatic

Acceleration System

Frequency	42.6 to 43.7 Mc/s
Accel. cavities	2
Harmonic number	4
Orbit freq. final	10.9 Mc/s
Gain, ave	~4.5 kev/turn
Input to RF, max	30 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ________________ Gev Energy spread ________________

Beam current ________________ part/pulse Pulse rate ________________

Beam current ________________ part/sec ________________ ________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ________

Unusual Features of Installation

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Published Articles Describing Machine

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X-1069

SYNCHROTRON DATA SHEET

Name of machine: The INS 1-Bev Electron Synchrotron

Institution: Institute for Nuclear Study, University of Tokyo

Address: Tanashi-machi, Kitatama-gun, Tokyo, Japan

Person in charge: Dr. Hiroo Kumagai

Person supplying data: Dr. Hiroo Kumagai   Date: May 1958

Present Fields of Research	% of Time

History and Status

Design study	1955
Model tests	1956
Engineering design	1956
Construction started	April 1957
Completion date	March 1960
Scheduled operation	hrs/wk
Magnet cost	\$300,000
Total cost	\$640,000

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	(1/2F)(D)(1/2F)
Field index, n =	15
Orbit radius	4 m, ___ ft
Mean radius	~5.5 m, ___ ft
Sectors, number	8
Field, at inj.	~54 -gauss
Field, max	6.25(10.8) k-gauss
Power input, max	140(210) kw
Storage system	condensers
Rise time	8.4×10^5 gauss/sec
Weight, Fe	53 ; Cu 7.9 tons
Aperture, width	~15 cm, ___ in.
Aperture, height	5.4 cm, ___ in.
Shielding	concrete

Design Goals

Particle accelerated	electrons
Energy	0.75 (~1.3) Gev
Pulse rate	21.5 ± 2 per sec
Output	3×10^{10} part/pulse

Injector System

Type	linac
Energy	6 Mev
Injector output	(peak) > 50 ma
Injection period	one or more turns
Inflector type	electrostatic

Acceleration System

Frequency	___ to 138.1 Mc/s
Accel. cavities	one
Harmonic number	16
Orbit freq. final	8.6 Mc/s
Gain, ave	7 (6) kev/turn
Input to RF, max	5 (50) kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ____________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Present final energy is 0.75 Gev, with a-c current only. In the future, energy will be raised up to ~1.3 Gev by adding d-c bias current. Parenthesized values in the front page refer to this energy.

Published Articles Describing Machine

H. Kumagai, "Design Study for the INS 1-Bev Electron Synchrotron by the High Energy Division," INSJ-1 (TH-15) (June 13, 1957) (INSJF Journal of Institute for Nuclear Study, University of Tokyo)

X-1069

SYNCHROTRON DATA SHEET

Name of machine

Institution Department of Physics, University of Lund

Address Lund, Sweden

Person in charge Prof. S. V. Friesen and Dr. S. A. E. Johansson*

Person supplying data S. V. Friesen Date May 1958

Present Fields of Research	% of Time	History and Status	
		Design study	1954
		Model tests	1954-56
* The machine is being built		Engineering design	1957
by Dr. Olle Werholm at the		Construction started	
Electronics Dept. of the		Completion date	
Royal Institute of Technology,		Scheduled operation	hrs/wk
Stockholm.		Magnet cost	
		Total cost	

Design Specifications

Magnet		Design Goals	
Focusing, type	strong, a-g	Particle accelerated	electrons
Focusing, order		Energy	1.2 Gev
Field index, n =	11.2	Pulse rate	12.5
Orbit radius	3.65 m, ___ ft	Output	___ part/pulse
Mean radius	5.30 m, ___ ft	Injector System	
Sectors, number	16	Type	microtron
Field, at inj.	55 gauss	Energy	5.6 Mev
Field, max	11 k-gauss	Injector output	50 ma
Power input, max	200 kw	Injection period	___ turns
Storage system	condensers	Inflector type	electric
Rise time	___ sec	Acceleration System	
Weight, Fe 32 ;	Cu 6.5 tons	Frequency	402 to ___ Mc/s
Aperture, width	6.0 cm, ___ in.	Accel. cavities	1
Aperture, height	3.6 cm, ___ in.	Harmonic number	45
Shielding		Orbit freq. final	8.9 Mc/s
		Gain, ave	___ kev/turn
		Input to RF, max	5-10 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev   Energy spread ____________

Beam current ____________ part/pulse   Pulse rate ____________

Beam current ____________ part/sec   ____________ ____________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

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Published Articles Describing Machine

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X-1069

SYNCHROTRON DATA SHEET ** data not verified

Name of machine ______

Institution Atomic Energy Institute

Address Moscow, USSR

Person in charge Budker

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	air-cored, 1957
		Engineering design	
		Construction started	
		Completion date	
		Scheduled operation	______ hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet		Design Goals	
Focusing, type		Particle accelerated	electrons
Focusing, order		Energy	1 Gev
Field index, n =		Pulse rate	
Orbit radius	0.34 m, ______ ft	Output	______ part/pulse
Mean radius	______ m, ______ ft	Injector System	
Sectors, number		Type	
Field, at inj.	______ k-gauss	Energy	______ Mev
Field, max	100 k-gauss	Injector output	______ ma
Power input, max	______ kw	Injection period	______ turns
Storage system		Inflector type	
Rise time	______ sec	Acceleration System	
Weight, Fe ______ ;	Al/Cu ______ tons	Frequency	______ to ______ Mc/s
Aperture, width	______ cm, ______ in.	Accel. cavities	
Aperture, height	______ cm, ______ in.	Harmonic number	
Shielding		Orbit freq. final	______ Mc/s
		Gain, ave	______ kev/turn
		Input to RF, max	______ kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Guide field between inner and outer coaxial lines produced by large pulsed currents ($\sim 10^6$ amp).

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET ** data not verified

Name of machine ______

Institution Lebedev Institute

Address Moscow, USSR

Person in charge Veksler

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	1956
		Completion date	
		Scheduled operation	______ hrs/wk
		Magnet cost	
		Total cost	

Design Specifications

Magnet

- Focusing, type ______
- Focusing, order ______
- Field index, n = ______
- Orbit radius ______ m, ______ ft
- Mean radius ______ m, ______ ft
- Sectors, number ______
- Field, at inj. ______ k-gauss
- Field, max ______ k-gauss
- Power input, max ______ kw
- Storage system ______
- Rise time ______ sec
- Weight, Fe ______ ; Al Cu ______ tons

Aperture, width ______ cm, ______ in.

Aperture, height ______ cm, ______ in.

Shielding ______

Design Goals

- Particle accelerated electrons
- Energy 0.6 Gev
- Pulse rate ______
- Output ______ part/pulse

Injector System

- Type ______
- Energy ______ Mev
- Injector output ______ ma
- Injection period ______ turns
- Inflector type ______

Acceleration System

- Frequency ______ to ______ Mc/s
- Accel. cavities ______
- Harmonic number ______
- Orbit freq. final ______ Mc/s
- Gain, ave ______ kev/turn
- Input to RF, max ______ kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ____________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Conversion of 180-Mev model of 10-Gev synchrophasotron.

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET ** data not verified

Name of machine ____________________

Institution (not clear)

Address USSR

Person in charge Terasov

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time

History and Status

Design study	1957
Model tests	1957
Engineering design	
Construction started	
Completion date	
Scheduled operation	______ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	
Field index, n =	
Orbit radius	______ m, ______ ft
Mean radius	______ m, ______ ft
Sectors, number	
Field, at inj.	______ k-gauss
Field, max	______ k-gauss
Power input, max	______ kw
Storage system	
Rise time	______ sec
Weight, Fe ______ ; Al Cu	______ tons
Aperture, width	______ cm, ______ in.
Aperture, height	______ cm, ______ in.
Shielding	

Design Goals

Particle accelerated	electrons
Energy	4 Gev
Pulse rate	
Output	______ part/pulse

Injector System

Type	
Energy	______ Mev
Injector output	______ ma
Injection period	______ turns
Inflector type	

Acceleration System

Frequency	______ to ______ Mc/s
Accel. cavities	
Harmonic number	
Orbit freq. final	______ Mc/s
Gain, ave	______ kev/turn
Input to RF, max	______ kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev   Energy spread ____________

Beam current ____________ part/pulse   Pulse rate ____________

Beam current ____________ part/sec   ____________ ______

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

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Published Articles Describing Machine

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X-1069

SYNCHROTRON DATA SHEET

Name of machine: CalTech Synchrotron

Institution: California Institute of Technology

Address: Pasadena, California

Person in charge: Robert F. Bacher

Person supplying data: Robert L. Walker — Date: Nov. 1958

Present Fields of Research	% of Time
Photoproduction of single pions	40
Photoproduction of multiple pions	25
Photoproduction of $K^+ + \Lambda^o$	30
Other	10

History and Status — Phase I (500 Mev) Phase II (1200 Mev)

Design study	(I) Sept 1949
Model tests	
Engineering design	
Construction started	
Completion date	(II) Sept 1956
Scheduled operation	100 hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	weak, cg
Focusing, order	
Field index, n =	0.60
Orbit radius	148 in. ~~m~~, ___ ft
Mean radius	___ m, ___ ft
Sectors, number	4
Field, at inj.	13 k-gauss
Field, max	13.4 k-gauss
Power input, max	8500 kw
Storage system	flywheel
Rise time	0.25 sec
Weight, Fe ___ ; Al Cu ___ tons	
Aperture, width	___ cm, 10 in.
Aperture, height	___ cm, 3 in.
Shielding	4-in. lead in median plane only. External shielding: 3 feet concrete wall. No roof.

Design Goals

Particle accelerated	electrons
Energy	1.4 Gev
Pulse rate	1/sec
Output	$10^{10} - 10^{11}$ part/pulse

Injector System

Type	pulse transformer
Energy	1.0 Mev
Injector output	60 ma
Injection period	~ 4 turns
Inflector type	90-deg electrostatic

Acceleration System

Frequency	37.6 to 40 Mc/s
Accel. cavities	1 FM, 1 high power
Harmonic number	4
Orbit freq. final	10 Mc/s
Gain, ave	0.6 kev/turn
Input to RF, max	40 kw

Main rf requirement is to supply radiation losses.
100 kv rf needed at 1100 Mev

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy 1.2 Gev Energy spread << 1 percent

Beam current ________ part/pulse Pulse rate ________

Beam current 1×10^{10} part/sec

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
x-rays	5×10^6 equivalent quanta	35 cm^2	$\leq$ 1100	bremsstrahlung spectrum

Ext. beam "piped" 15-40 ft to target. Beam analyzing magnet used? No

Unusual Features of Installation

Built from 1/4-scale Bevatron.

Published Articles Describing Machine

X-1069

SYNCHROTRON DATA SHEET

Name of machine: The Cornell 1.5-Bev Electron Synchrotron

Institution: Laboratory of Nuclear Studies, Cornell University

Address: Ithaca, New York

Person in charge: Prof. Robert R. Wilson

Person supplying data: Robert R. Wilson Date: May 1958

Present Fields of Research	% of Time
Strange particle	
Photo production	35
High-energy electronic processes	20
High-energy nuclear physics	10

History and Status	
Design study	August 1952
Model tests	September 1952
Engineering design	October 1952
Construction started	January 1953
Completion date	
Scheduled operation	40 hrs/wk
Magnet cost	~ $100,000
Total cost	~ $500,000

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	N = 15
Field index, n =	+14.75, -16.25
Orbit radius	m, 12.5 ft
Mean radius	m, 12.5 ft
Sectors, number	16
Field, at inj.	20 gauss
Field, max	13.5 k-gauss
Power input, max	250 kw
Storage system	
Rise time	1/100 i.e. 30 cycle sec
Weight, Fe	20 ; Cu 0.5 tons
Aperture, width	7 cm, 3 in.
Aperture, height	2.5 cm, 1 in.
Shielding	loaded concrete

Design Goals

Particle accelerated	electrons
Energy	1.5 Gev
Pulse rate	30
Output	10^9 part/pulse

Injector System

Type	Van de Graaff
Energy	2 Mev
Injector output	50 ma
Injection period	2 - 10 turns
Inflector type	electrostatic

Acceleration System

Frequency	85 to 87 Mc/s
Accel. cavities	
Harmonic number	8
Orbit freq. final	11 Mc/s
Gain, ave	10 to 120 kev/turn
Input to RF, max	20 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy 1.5 Gev Energy spread <0.1%

Beam current 10^9 elect/pulse part/pulse Pulse rate

Beam current part/sec

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread
photons	10^{11} "Q"/min	~1 milliradian	0.15 Gev	bremsstrahlung

Ext. beam "piped" ______ ft to target. Beam analyzing magnet used? ______

Unusual Features of Installation

Published Articles Describing Machine

Cornell Report, available on request.

X-1069

SYNCHROTRON DATA SHEET

Name of machine: Cambridge Electron Accelerator

Institution: Massachusetts Institute of Technology and Harvard University

Address: 42 Oxford Street, Harvard University, Cambridge 38, Mass.

Person in charge: Prof. M. Stanley Livingston

Person supplying data: M. Stanley Livingston   Date: May 1958

Present Fields of Research	% of Time

History and Status

Design study	April 1956
Model tests	1956-1957
Engineering design	1957-1958
Construction started	1957
Completion date	January 1960
Scheduled operation	______ hrs/wk
Magnet cost	
Total cost	

Design Specifications

Magnet

Focusing, type	strong, a-g
Focusing, order	FODDOF
Field index, n =	90
Orbit radius	______ m, 85.8 ft
Mean radius	______ m, 118.3 ft
Sectors, number	48
Field, at inj.	25 gauss
Field, max	8 k-gauss
Power input, max	1,200 kw
Storage system	capacitors and choke
Rise time	1/120 sec
Weight, Fe 350 ; Cu 55 tons	
Aperture, width	______ cm, 6.0 in.
Aperture, height	______ cm, 1.5 in.
Shielding	underground

Design Goals

Particle accelerated	electrons
Energy	6.0 Gev
Pulse rate	60/sec
Output	1×10^{11} part/pulse

Injector System

Type	electron linac
Energy	20 Mev
Injector output	250 ma
Injection period	1 turns
Inflector type	electric-pulsed

Acceleration System

Frequency	475.83 to ______ Mc/s
Accel. cavities	32
Harmonic number	360
Orbit freq. final	1.32 Mc/s
Gain, peak	4,500 kev/turn
Input to RF, max	350 kw

over, please

X-1069A

ACTUAL PERFORMANCE DATA

Internal Beam

Maximum energy ____________ Gev Energy spread ____________

Beam current ____________ part/pulse Pulse rate ____________

Beam current ____________ part/sec ____________ ____________

External Beams

Particle	Flux (part./cm^2-sec)	Beam Area (cm^2)	Energy (Mev)	Energy Spread

Ext. beam "piped" ________ ft to target. Beam analyzing magnet used? ____________

Unusual Features of Installation

Published Articles Describing Machine

ELECTRON LINEAR ACCELERATORS

E $\geq$ 0.5 Gev

See page 2 for key to tables

X-1070
(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: Accelerator Lineaire D'Orsay

Institution: Laboratoire Des Hautes Energies et de Physique Des Solides

Address: Boite Postale No. 2 - Orsay (S. and Oise) France

Person in charge: H. Halban - J. L. Delcroix

Person supplying data: J. L. Delcroix Date: October 1958

Future ~~Present~~ Fields of Research	% of Time
Electron scattering,	
elastic and inelastic studies;	
Photo effect; Study of	
polarization phenomenon	
~~photo-mesons near threshold;~~	
Nuclear-photo effect; and	
Electrode disinegration.	

History and Status

Design study	1955-56
Model tests	1956-57
Engineering design	1956-57
Construction started	1956
Completion date	1960
Scheduled operation	100 hrs/wk
Total cost	I. 5 x 10^9 francs

Design Specifications

Injector System

Type	electron gun
Energy	40 kev
Output	peak 100 ma at the output of the buncher with energy = 2.3 Mev

RF System

Frequency	2997.92 Mc/sec
Field mode	T M O I
RF power, peak	320 kw
Power units	16 klystrons
Equilib. phase	by 16 phasing networks
RF pulse duration	2 μsec
Ions focused by	grid wires, at 12 m
Multipactoring overcome by	the high value of the electric field (100 < E < 150 kv/cm

Beam Characteristics

Particle accelerated	electrons
Energy	1 Gev
Energy spread	50% of current in 10% energy
Output, ave	1 μa
Beam pulse	0.1-1 μsec
Beam diameter	1 cm

Mechanical Details

Tank length	
Tank diameter	
Drift tubes, number	
Length 1st tube	
Dia. 1st tube	
Length 1st gap	
Length last tube	
Dia. last tube	
Length last gap	

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Intermediate stations at 250, 500, and 750 Mev

Section length 6.1 m (61.2 Mev/section at 1 pA)

Guide diameter 79.98 < 2b < 82.12 mm

Iris diameter 18 < 2a < 27 mm

Cavity length 2.5 cm C = $\lambda 9/4$

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

** data not verified

Name of machine ______

Institution Ukranian Technical Institute

Address Kharkov, USSR

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time

History and Status

Design study	1956
Model tests	1956
Engineering design	
Construction started	
Completion date	
Scheduled operation	hrs/wk
Total cost	

Design Specifications

Injector System

Type	
Energy	kev
Output	ma

RF System

Frequency	Mc/sec
Field mode	
RF power	kw
Power units	
Equilib. phase	
RF pulse duration	μsec
Ions focused by	
Multipactoring overcome by	

Beam Characteristics

Particle accelerated	electron
Energy	1 Gev
Energy spread	
Output, ave	μa
Beam pulse	μsec
Beam diameter	

Mechanical Details

Tank length	
Tank diameter	
Drift tubes, number	
Length 1st tube	
Dia. 1st tube	
Length 1st gap	
Length last tube	
Dia. last tube	
Length last gap	

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: Mark III Electron Linear Accelerator

Institution: High-Energy Physics Laboratory, Stanford Laboratory

Address: Stanford, California

Person in charge: W. K. H. Panofsky

Person supplying data: R. B. Neal — Date: May 1958

Present Fields of Research	% of Time
Electron scattering	40
Meson production	40
High-energy electro-dynamics	20

History and Status

Design study	1946-7
Model tests	1947-9
Engineering design	1948-9
Construction started	Winter 1949
Completion date	Spring 1952
Scheduled operation	90-110 hrs/wk
Total cost	$\$ 3 \times 10^6$

Design Specifications

Injector System

Type	pulsed
Energy	80 kev
Output	250 ma

RF System

Frequency	2856 Mc/sec
Field mode	$\pi/2$
RF power	300,000 (peak) kw
Power units	21 klystrons
Equilib. phase	wave crest
RF pulse duration	2 μsec
~~Ions~~ Electrons focused by	relativity
Multipactoring overcome by	

Beam Characteristics

Particle accelerated	electrons
Energy	700 Mev
Energy spread	3%
Output, ave	1 μa
Beam pulse	1 μsec
Beam diameter	0.5 cm

Mechanical Details

~~Tank~~ Accelerator length	220 ft*
~~Tank~~ Accelerator diameter	3.247 in. ID
Drift tubes, number	
Length 1st tube	
Dia. 1st tube	
Length 1st gap	
Length last tube	
Dia. last tube	
Length last gap	

* Will be extended to 300 ft and ~1 Gev.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Three beams in final target area, two with achromatic translation. Two beams at intermediate energies.

Published Articles Describing Machine

Chodorow, Ginzton, Hansen, Kyhl, Neal and Panofsky, Rev. Sci. Instr., 26, 134 (1955).

X-1070
(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: "M" Electron Linear Accelerator

Institution: Stanford University

Address: Stanford, California

Person in charge: E. L. Ginzton

Person supplying data: W. K. H. Panofsky   Date: May 1958

Present Fields of Research	% of Time	History and Status	
		Design study	1956-57
		Model tests	
		Engineering design	
		Construction started	
		Completion date	
		Scheduled operation	hrs/wk
		Total cost	

Design Specifications

Injector System		Beam Characteristics	
Type	electron gun	Particle accelerated	electrons
Energy	100 kev	Energy (max)	45 Gev
Output	1000 ma	Energy spread	∼2 %
		Output, ave	3 μa
RF System		Beam pulse	2 μsec
Frequency	2856 Mc/sec	Beam diameter	1/8 in.
Field mode	π/2	**Mechanical Details**	
RF power	20,000,000 kw	Accelerator ~~Tank~~ length	10,000 ft
Power units	klystrons	Accelerator ~~Tank~~ diameter	4 in. OD
Equilib. phase	wave crest	Drift tubes, number	
Electrons ~~RF~~ pulse duration	2 μsec	Length 1st tube	
Ions focused by	relativity	Dia. 1st tube	
Multipactoring overcome by		Length 1st gap	
		Length last tube	
		Dia. last tube	
		Length last gap	

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

PROTON LINEAR ACCELERATORS

E ≥ 10 Mev

See page 2 for key to tables.

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

** data not verified

Name of machine ____

Institution Central Polish Nuclear Research Institute

Address Swierk, Warsaw, Poland

Person in charge Andrezej Soltan

Person supplying data (various sources) Date ____

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	in operation
		Scheduled operation	hrs/wk
		Total cost	

Design Specifications

Injector System		Beam Characteristics	
Type		Particle accelerated	protons
Energy	kev	Energy	10 Mev
Output	ma	Energy spread	
		Output, ave	μa
RF System		Beam pulse	μsec
Frequency	Mc/sec	Beam diameter	
Field mode		Mechanical Details	
RF power	kw	Tank length	
Power units		Tank diameter	
Equilib. phase		Drift tubes, number	
RF pulse duration	μsec	Length 1st tube	
Ions focused by		Dia. 1st tube	
Multipactoring overcome by		Length 1st gap	
		Length last tube	
		Dia. last tube	
		Length last gap	

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

** data not verified

Name of machine ____

Institution: Ukranian Technical Institute

Address: Kharkov, USSR

Person in charge: Fainberg

Person supplying data: (various sources) Date ____

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	1950
		Scheduled operation	hrs/wk
		Total cost	

Design Specifications

Injector System

Type	Van de Graaff	
Energy	1700	kev
Output		ma

RF System

Frequency		Mc/sec
Field mode		
RF power		kw
Power units		
Equilib. phase		
RF pulse duration	250	μsec
Ions focused by		
Multipactoring overcome by		

Beam Characteristics

Particle accelerated	protons	
Energy	21 Mev	
Energy spread		
Output, ave		μa
Beam pulse	4/sec	
Beam diameter		

Mechanical Details

Tank length	12.4 m
Tank diameter	
Drift tubes, number	
Length 1st tube	
Dia. 1st tube	
Length 1st gap	
Length last tube	
Dia. last tube	
Length last gap	

over, please

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ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET ** data not verified

Name of machine (Injector for 7-Gev Synchrophasotron)

Institution Thermotechnical Institute

Address Moscow, USSR

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	1957
		Completion date	
		Scheduled operation	hrs/wk
		Total cost	

Design Specifications

Injector System		Beam Characteristics	
Type		Particle accelerated	protons
Energy	kev	Energy	20 Mev
Output	ma	Energy spread	
		Output, ave	μa
RF System		Beam pulse	μsec
Frequency	Mc/sec	Beam diameter	
Field mode		**Mechanical Details**	
RF power	kw	Tank length	
Power units		Tank diameter	
Equilib. phase		Drift tubes, number	
RF pulse duration	μsec	Length 1st tube	
Ions focused by		Dia. 1st tube	
Multipactoring overcome by		Length 1st gap	
		Length last tube	
		Dia. last tube	
		Length last gap	

over, please

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ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

** data not verified

Name of machine ______

Institution Moscow Physical Institute

Address Moscow, USSR

Person in charge Kurchatov

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time

History and Status

Design study	
Model tests	
Engineering design	
Construction started	
Completion date	before 1957
Scheduled operation	hrs/wk
Total cost	

Design Specifications

Injector System

Type	
Energy	kev
Output	ma

RF System

Frequency	Mc/sec
Field mode	
RF power	kw
Power units	
Equilib. phase	
RF pulse duration	μsec
Ions focused by	
Multipactoring overcome by	

Beam Characteristics

Particle accelerated	protons
Energy	40 Mev
Energy spread	
Output, ave	μa
Beam pulse	μsec
Beam diameter	

Mechanical Details

Tank length	
Tank diameter	
Drift tubes, number	
Length 1st tube	
Dia. 1st tube	
Length 1st gap	
Length last tube	
Dia. last tube	
Length last gap	

over, please

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ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

X-1070
(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

** data not verified

Name of machine: 50-Mev Proton Linac

Institution: Rutherford High Energy Laboratory, NIRNS

Address: Harwell, Berkshire, England

Person in charge: Dr. Godrey Stafford

Person supplying data: (various sources) Date: ______

Present Fields of Research	% of Time

History and Status

Design study	
Model tests	
Engineering design	
Construction started	1957
Completion date	Early 1959
Scheduled operation	hrs/wk
Total cost	

Design Specifications

Injector System

Type	Cockcroft-Walton
Energy	500 kev
Output	ma

RF System

Frequency	202.5 Mc/sec
Field mode	
RF power	4000 kw
Power units	
Equilib. phase	
RF pulse duration	400 μsec
Ions focused by	grids + quad. lenses
Multipactoring overcome by	

Beam Characteristics

Particle accelerated	protons
Energy	50 Mev
Energy spread	
Output, ave	μa
Beam pulse rate	50/sec ~~μsec~~
Beam diameter	

Mechanical Details

Tank ~~length~~	3 tanks; 10, 20, and 20 Mev
Tank diameter	
Drift tubes, number	
Length 1st tube	
Dia. 1st tube	
Length 1st gap	
Length last tube	
Dia. last tube	
Length last gap	

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: Injector for the 12.5-Bev Synchrotron (ZGS)

Institution: Argonne National Laboratory

Address: Lemont, Illinois

Person in charge: R. Perry, P. Livdahl

Person supplying data: J. J. Livingood | Date: May 1958

Present Fields of Research	% of Time

History and Status

Design study	(at BNL)
Model tests	July 1958
Engineering design	Summer 1958
Construction started	
Completion date	January 1961
Scheduled operation	hrs/wk
Total cost	

Design Specifications

Injector System

Type	Cockcroft-Walton
Energy	750 kev
Output	50 ma

RF System

Frequency	200 Mc/sec
Field mode	TM 010
RF power	2500 kw
Power units	1 or 2
Equilib. phase	-26% (from peak)
RF pulse duration	500 μsec
Ions focused by	d-c quadrupoles
Multipactoring overcome by	fast r-f rise

Beam Characteristics

Particle accelerated	protons
Energy	50 Mev
Energy spread	± 75 kev
Output, ave	5000 μa
Beam pulse	250 μsec
Beam diameter	1 in.

Mechanical Details

Tank length	110 ft
Tank diameter	39 in.
Drift tubes, number	124
Length 1st tube	0.915 in.
Dia. 1st tube	8.16 in. OD; 0.5 in. ID
Length 1st gap	0.546 in.
Length last tube	13.961 in.
Dia. last tube	5.80 in. OD; 1.25 in. ID
Length last gap	4.637 in.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: Brookhaven AGS Injector

Institution: Brookhaven National Laboratory

Address: Upton, Long Island, New York

Person in charge: John P. Blewett

Person supplying data: John P. Blewett   Date: May 1958

Present Fields of Research	% of Time
Construction not completed	

History and Status

Design study	
Model tests	
Engineering design	
Construction started	yes
Completion date	1959
Scheduled operation	to be 120 hrs/wk
Total cost	~ $2,000,000

Design Specifications

Injector System

Type	cascade transformer
Energy	750 kev
Output	1 to 20 or more ma

RF System

Frequency	200 Mc/sec
Field mode	TM 010
RF power	2500 kw
Power units	triodes (TH-470)
Equilib. phase	-26 deg
RF pulse duration	200 μsec
Ions focused by	quadrupole magnets
Multipactoring overcome by	drift tube shape

Beam Characteristics

Particle accelerated	protons
Energy	50 Mev
Energy spread	±0.5%
Output, ave	> 1000 μa
Beam pulse	10 μsec
Beam diameter	~1 in.

Mechanical Details

Tank length	110 ft
Tank diameter	3 ft
Drift tubes, number	124
Length 1st tube	1.931 in.
Dia. 1st tube	8 in.
Length 1st gap	0.546 in.
Length last tube	13.961 in.
Dia. last tube	6 in.
Length last gap	4.637 in.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

J. P. Blewett, "Linear Accelerator Injectors for Proton Synchrotrons," CERN Symposium, Vol. 1, 159 (1956).

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LINEAR ACCELERATOR DATA SHEET

Name of machine: Bevatron 10 Mev Injector

Institution: University of California Radiation Laboratory

Address: Berkeley 4, California

Person in charge: Prof. Edward J. Lofgren

Person supplying data: Bruce Cork Date: May 1958

Present Fields of Research	% of Time
Injector for Bevatron	100

History and Status

Design study	1950
Model tests	1950
Engineering design	1951
Construction started	1952
Completion date	November 1953
Scheduled operation	160 hrs/wk
Total cost	$400,000

Design Specifications

Injector System

Type	Cockroft-Walton
Energy	480 kev
Output	total 10, protons 5 ma

RF System

Frequency	202.5 Mc/sec
Field mode	0, 1, 0
RF power	500 kw
Power units	Eimac 3W 10,000
Equilib. phase	25 deg
RF pulse duration	600 μsec
Ions focused by	grids
Multipactoring overcome by	clean system

Beam Characteristics

Particle accelerated	protons
Energy	9.9 Mev
Energy spread	±30 kev
Output, ave	330 μa
Beam pulse	500 μsec
Beam diameter	1/4 in.

Mechanical Details

Tank length	20 ft
Tank diameter	42-in. cavity
Drift tubes, number	42 + two 1/2
Length 1st tube	1.5 in.
Dia. 1st tube	5.5 in.
Length 1st gap	1/2 in.
Length last tube	4.6 in.
Dia. last tube	3.8 in.
Length last gap	1.7 in.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

High reliability and ease of maintenance for long periods. Can be developed to give higher currents.

Published Articles Describing Machine

Bruce Cork, "Proton Linear Accelerator for the Bevatron," Rev. Sci. Instr., 26, 210 (February 1955).

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: 32-Mev Linac

Institution: University of Southern California

Address: Los Angeles 7, California

Person in charge: Prof. G. L. Weissler

Person supplying data: Prof. Charles Wadell   Date: October 1958

Present Fields of Research	% of Time

History and Status

Design study	1945
Model tests	1945
Engineering design	
ReConstruction started	July 1958
Completion date	Summer 1959
Scheduled operation	hrs/wk
Total cost	original, at Berkeley ~\$2,000,000 + reinstallation cost \$500,000

Design Specifications

Injector System

Type	Van de Graaff
Energy	4 Mev
Output	1.5 ma

RF System

Frequency	202.55 Mc/sec
Field mode	TM 010
RF power, at 15 pps	20 kw
Power units	10
Equilib. phase	~36 deg
RF pulse duration	600 μsec
Ions focused by	grids
Multipactoring overcome by	pre-exciters coupled at high-energy end of cavity

Beam Characteristics

Particle accelerated	protons
Energy	31.5 Mev
Energy spread	est < 1%
Output, ave, at 15 pps	0.2 μa
Beam pulse	400 μsec
Beam diameter	1 cm, divergence 10^{-3} radians

Mechanical Details

Tank length inside	40.5 ft
Tank diameter inside	48 in.
Drift tubes, number	46
Length 1st tube	4.373 in.
Dia. 1st tube	4.750 in.
Length 1st gap	1.200 in.
Length last tube	10.933 in.
Dia. last tube	2.760 in.
Length last gap	3.476 in.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

The machine, originally at Berkeley, is being reinstalled at Los Angeles.

Published Articles Describing Machine

1. L. W. Alvarez et al, UCRL-236/AECU 120 (1948).

2. L. W. Alvarez et al, Rev. Sci. Instr., 26, 111 (1955).

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: Proton Linear Accelerator

Institution: University of Minnesota, School of Physics

Address: Minneapolis 14, Minnesota

Person in charge: J. H. Williams

Person supplying data: N. M. Hintz   Date: June 1958

Present Fields of Research	% of Time
Nuclear scattering and reactions	100

History and Status

Design study	1950
Model tests	1950-51
Engineering design	1950-51
Construction started	1951
Completion date	10 Mev - early 1954 68 Mev - late 1955
Scheduled operation	96 hrs/wk
Total cost	$\$1.25 \times 10^6$

Design Specifications

Injector System

Type	60 Xformer
Energy	500 kev
Output	peak 3 ma

RF System

Frequency	202.55 Mc/sec
Field mode	TM
RF power	600-2200-3200 kw
Power units	Resnatron amplifiers
Equilib. phase	70 deg
RF pulse duration	300 μsec
Ions focused by	grids
Multipactoring overcome by	fast r-f buildup

Beam Characteristics

Particle accelerated	protons
Energy	9.99; 39.95; 68 Mev
Energy spread	±0.07; 0.20; 0.60 Mev
Output, ave	0.2; 0.04; 0.02 μa
Beam pulse	150 μsec
Beam diameter	0.5; 1.0; 1.7 cm

Mechanical Details

Tank length	18; 40; 40 ft
Tank diameter	55; 60; 52 in.
Drift tubes, number	42; 38; 25
Length 1st tube	1.45; 6.29; 12.35 in.
Dia. 1st tube	5.52; 6.57; 5.64 in.
Length 1st gap	0.38; 2.12; 4.14 in.
Length last tube	6.29; 12.35; 15.79 in.
Dia. last tube	2.42; 2.54; 3.90 in.
Length last gap	2.10; 4.09; 5.24 in.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Beam exit ports at 10, 40, and 68 Mev. Continuously variable energy - 68 Mev to 40 Mev.

Published Articles Describing Machine

E. A. Day, R. P. Featherstone, L. H. Johnston, E. E. Lampi, E. B. Tucker, and J. H. Williams, "The Minnesota 10, 40 and 68 Mev Proton Linear Accelerator," Rev. Sci. Inst. 29, 457 (June 1958).

HEAVY-ION LINEAR ACCELERATORS

See page 2 for key to tables

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET ** data not verified

Name of machine ______

Institution Ukranian Technical Institute

Address Kharkov, USSR

Person in charge ______

Person supplying data (various sources) Date ______

Present Fields of Research	% of Time	History and Status	
		Design study	
		Model tests	
		Engineering design	
		Construction started	
		Completion date	before 1957
		Scheduled operation	hrs/wk
		Total cost	

Design Specifications

Injector System		Beam Characteristics	
Type		Particle accelerated	heavy ions
Energy	kev	Energy	9 Mev/nucleon
Output	ma	Energy spread	
		Output, ave	μa
RF System		Beam pulse	μsec
Frequency	150 Mc/sec	Beam diameter	
Field mode		**Mechanical Details**	
RF power	kw	Tank length	
Power units		Tank diameter	
Equilib. phase		Drift tubes, number	
RF pulse duration	μsec	Length 1st tube	
Ions focused by		Dia. 1st tube	
Multipactoring overcome by		Length 1st gap	
		Length last tube	
		Dia. last tube	
		Length last gap	

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

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(Rev. 9-58)

LINEAR ACCELERATOR DATA SHEET

Name of machine: Heavy Ion Linear Accelerator (First Section)*

Institution: Physics Department, University of Manchester

Address: Oxford Road, Manchester 13, England

Person in charge: Professor S. Devons

Person supplying data: G. Nassibian — Date: October 1958

Present Fields of Research	% of Time

History and Status

Design study	1957
Model tests	1957
Engineering design	1957
Construction started	December 1957
Completion date	Spring 1959
Scheduled operation	hrs/wk
Total cost	

Design Specifications

Injector System

Type	Cockcroft-Walton
Energy	200 kv
Output	≥ 5 ma
	pulsed, dependent on ion selected

RF System

Frequency	25 Mc/sec
Field mode	Sloan and Lawrence
RF power	500 kw
Power units	conventional
Equilib. phase	30 deg
RF pulse duration	500 - 3,000 μsec
Ions focused by	grids
Multipactoring overcome by	

Beam Characteristics

Particle accelerated	heavy ions, $e/m > 1/8$
Energy	$\sim$ 1 Mev/nucleon
Energy spread	
Output, ave	μa
Beam pulse	μsec
Beam diameter	

Mechanical Details

Tank length	25 ft
Tank diameter	U-shaped, 3x3 ft
Drift tubes, number	40
Length 1st tube	1.1 in.
Dia. 1st tube	3 in.
Length 1st gap	0.6 in.
Length last tube	6.4 in.
Dia. last tube	4.5 in.
Length last gap	5.5 in.

* Turn page for second section

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LINEAR ACCELERATOR DATA SHEET

Name of machine: Heavy Ion Linear Accelerator (Second Section)

Institution: Physical Department, University of Manchester

Address: Oxford Road, Manchester, 13, England

Person in charge: Professor S. Devons

Person supplying data: G. Nassibian   Date: October 1958

Present Fields of Research	% of Time

History and Status

Design study	underway
Model tests	
Engineering design	underway
Construction started	to start Spring 1959
Completion date	1961
Scheduled operation	hrs/wk
Total cost	

Design Specifications

Injector System

Type	linac
Energy	(first section) kev
Output	ma

RF System

Frequency	70-75 Mc/sec
Field mode	Alvarez TM 010
RF power	3,000 kw
Power units	
Equilib. phase	~ 30 deg
RF pulse duration	~ 3,000 μsec
Ions focused by	quadrupole magnets
Multipactoring overcome by	

Beam Characteristics

Particle accelerated	heavy ions, e/m > 0.22
Energy	about 9-10 Mev/nuc
Energy spread	
Output, ave	μa
Beam pulse	~ 2,000 μsec
Beam diameter	

Mechanical Details

Tank length	tank, each ~ 45 ft
Tank diameter	~ 9 ft
Drift tubes, number	~ 75
Length 1st tube	
Dia. 1st tube	
Length 1st gap	
Length last tube	
Dia. last tube	
Length last gap	

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LINEAR ACCELERATOR DATA SHEET

Name of machine: Heavy Ion Linear Accelerator

Institution: University of California Radiation Laboratory

Address: Berkeley 4, California

Person in charge: C. M. Van Atta

Person supplying data: E. L. Hubbard — Date: May 1958

Present Fields of Research	% of Time
Production of new heavy elements	39
Coulomb excitation	18
Other nuclear chemistry	22
Other nuclear physics	12
Medical physics	

History and Status

Design study	1954
Model tests	
Engineering design	1954-56
Construction started	April 1955
Completion date	April 1957
Scheduled operation	72 hrs/wk
Total cost	$1,700,000

Design Specifications

Injector System

Type	Cockcroft-Walton
Energy	500 max kv
Output ave	0.006 ma

RF System

Frequency	70 Mc/sec
Field mode	TM 010
RF power, pk	3000 kw
Power units	4
Equilib. phase	pre-20 deg; post-26 deg
RF pulse duration	3000 μsec
Ions focused by	pre-grids; post-a-g mag
Multipactoring overcome by	

Beam Characteristics

Particle accelerated	C	N	O	Ne
Energy	120	140	160	200 Mev
Energy spread	2%			
Output, ave	0.2 μa			
Beam pulse	2000 μsec			
Beam diameter	1/2 in.			

Mechanical Details

	pre	post
Tank length	15	90 ft
Tank diameter	124	108 in.
Drift tubes, number	87	67
Length 1st tube	1.67	5.95 in.
Dia. 1st tube	9.96	19.8 in.
Length 1st gap	0.53	1.93 in.
Length last tube	5.59	16.40 in.
Dia. last tube	8.88	19.8 in.
Length last gap	1.97	8.26 in.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

The linac is divided into two tanks. In between the tanks electrons are stripped off the ions to shorten the length of the following tank. The tank on the input side of the stripper is called the pre-stripper, that on the output side is called the post-stripper. They are designated pre and post, respectively, on other side of paper.

Published Articles Describing Machine

1. L. Smith and R. L. Gluckstern, "Focusing in Ion Linear Accelerators," Rev. Sci. Inst. 26, 220 (1955).

2. C. E. Anderson and K. W. Ehlers, "Ion Source for the Production of Multiply Charged Ions," Rev. Sci. Inst. 27, 809 (1956).

3. R. Beringer and W. Rall, "Mercury Jet Target and Stripper," Rev. Sci. Inst. 28, 77 (1957)

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LINEAR ACCELERATOR DATA SHEET

Name of machine: Heavy Ion Accelerator

Institution: Yale University

Address: New Haven, Connecticut

Person in charge: Prof. Robert Beringer

Person supplying data: Prof. Robert Beringer Date: May 1958

Present Fields of Research	% of Time
Nuclear reactions	90
Nuclear chemistry	10

History and Status	
Design study	1954-55
Model tests	1954-55
Engineering design	1954-55
Construction started	September 1955
Completion date	March 1958
Scheduled operation	40 hrs/wk
Total cost	$1,6000,000

Design Specifications

Injector System

Type	Cockroft-Walton
Energy	up to 600 kev
Output	(pulsed) 1 ma

RF System

Frequency	70 Mc/sec
Field mode	TM 010
RF power	3000 kw
Power units	four, RCA 2332
Equilib. phase	unknown
RF pulse duration	3000 μsec
Ions focused by	grids and quadrupoles
Multipactoring overcome by	blood, sweat, and tears

Beam Characteristics

Particle accelerated	He - A
Energy	10 Mev/nuc
Energy spread	unknown
Output, ave	< 0.1 μa
Beam pulse	2000 μsec
Beam diameter	variable

Mechanical Details

Tank length	15 and 90 ft
Tank diameter	11 and 10 ft
Drift tubes, number	36 and 67
Length 1st tube	~1 in.
Dia. 1st tube	~10 in.
Length 1st gap	~5/8 in.
Length last tube	~2 ft
Dia. last tube	~20 in.
Length last gap	~8 in.

over, please

X-1070A

ACTUAL PERFORMANCE DATA

Particle	Current	Energy	Energy Spread

Unusual Features of Installation

Published Articles Describing Machine

ORNL-2644
Particle Accelerators and
High-Voltage Machines
TID-4500 (14th ed.)

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