

**ENTRY NO. FM-8**

NAME OF MACHINE ..... 160 MeV Synchrocyclotron ..... DATE ..... 27 August, 1981 .....  
 INSTITUTION ..... Harvard Cyclotron Laboratory, Harvard University .....  
 ADDRESS ..... 44 Oxford St., Cambridge, MA ..... 02138, U.S.A. ....  
 TEL (617) 495-2885 ..... TELEX .....  
 IN CHARGE ..... A.M. Koehler ..... REPORTED BY ..... A.M. Koehler .....

**HISTORY AND STATUS**

DESIGN, date ..... Model tests .....  
 ENG DESIGN, date .....  
 CONSTRUCTION, date ..... 1946 .....  
 FIRST BEAM, date (or goal) ..... 1949 .....  
 MAJOR ALTERATIONS ..... increased energy and external beam, 1957 .....  
 COST, ACCELERATOR ..... \$1,000,000 .....  
 COST, FACILITY, total ..... \$1,700,000 .....  
 FUNDED BY ..... Office of Naval Research, 1946-67 .....

**ACCELERATOR STAFF, OPERATION AND DEVELOPMENT**

SCIENTISTS ..... 2.5 ..... ENGINEERS ..... 1.5 .....  
 TECHNICIANS ..... 4 ..... CRAFTS ..... 1.5 .....  
 GRAD STUDENTS involved during year ..... 1 .....  
 OPERATED BY ..... X ..... Research staff or ..... X ..... Operators  
 OPERATION ..... 45 hr/week hr/wk. On target ..... hr/wk  
 TIME DISTR. in house ..... 5 ..... % Outside ..... 95 ..... %  
 BUDGET, op & dev ..... \$310,000 .....  
 FUNDED BY ..... User's fees .....

**RESEARCH STAFF, not included above**

USERS, in house ..... c. 1 ..... outside ..... c. 12 .....  
 GRAD STUDENTS involved during year ..... 1 .....  
 RESEARCH BUDGET, in house ..... \$140,000 .....  
 FUNDED BY ..... National Cancer Institute .....

**MAGNET**

POLE FACE, diameter (compact) ..... 241 ..... cm, R extraction ..... 105 ..... cm  
 R injection ..... cm  
 GAP, min ..... 29.6 ..... cm, Field ..... 19.0 ..... kG }  
 min ..... 30.5 ..... cm, Field ..... 18.3 ..... kG } at ..... 600,000 .....  
 AVERAGE FIELD at R ext ..... 18.1 ..... kG } Ampere turns  
 B max/ < B > .....  
 NUMBER OF SECTORS { compact ..... } Spiral, max ..... deg  
 { separated ..... }  
 SECTOR ANGLE (SSC) ..... deg  
 TRIMMING COILS .....

CONDUCTOR, material and type ..... copper strip .....  
 STORED ENERGY (cryogenic) ..... MJ  
 POWER: main coils ..... 160 ..... max, kW; current stability 0.1% .....  
 trimming coils ..... max, kW; current stability .....  
 WEIGHT: Fe ..... 641 ..... tons; coils ..... 74 ..... tons  
 COOLING system ..... closed loop water .....  
 ION ENERGY (bending limit) E/A = ..... q/a<sup>2</sup> MEV/amu  
 (focusing limit) E/A = ..... q/a MEV/amu

**ACCELERATION SYSTEM**

DEES, number ..... 1 .....; angle ..... 180 ..... deg  
 BEAM APERTURE ..... 6 ..... cm; DC Bias ..... -2 ..... kV  
 TUNED by, coarse ..... fine .....  
 RF ..... to ..... mHz, stable ± .....  
 Orb F ..... to ..... mHz  
 HARMONICS, RF/Orb F, used .....  
 DEE-Gnd, max ..... kV, min gap ..... cm  
 STABILITY, (pk-pk noise)/(pk RF volt) .....  
 ENERGY GAIN, max ..... kV/turn  
 RF PHASE, stable to ± ..... deg  
 RF POWER input, max ..... kW  
 FREQUENCY MODULATION, rate ..... 0. to 250 ..... /s  
 modulator, type ..... rotating capacitor .....  
 beam pulse, width ..... 200 sec. typ. ....

**VACUUM SYSTEM**

OPERATING PRESSURE ..... -6,000,000 ..... Torr or mbar  
 PUMPS, No. Type. Size ..... 4 NRC 6" oil .....

**ION SOURCES**

**INJECTION SYSTEM**

..... hot filament, pulsed arc "volcano" .....

**EXTRACTION SYSTEM**

..... passive regenerator and channel .....

**FACILITIES FOR RESEARCH**

SHIELDED AREA, fixed ..... m<sup>2</sup>; movable ..... m<sup>2</sup>  
 TARGET STATIONS ..... in .....  
 STATIONS served at same time, max .....  
 MAG SPECTROGRAPH, type .....  
 COMPUTER model .....  
 OTHER FACILITIES .....

**CHARACTERISTIC BEAMS**

PARTICLE	ENERGY (MeV)		CURRENT (pμA)	
	Goal	Achieved	Internal	External
proton		160	1.1 A	0.021 A
SECONDARY			(part/s)	

**BEAM PROPERTIES**

	MEASURED		CONDITIONS	
PULSE WIDTH	60 RF deg		pμ A of	MeV ions
PHASE EXC. max	RF deg		pμ A of	MeV ions
EXTRACT eff	5.1 %		pμ A of	MeV ions
RESOL ΔE/E	1.5 %		pμ A of	MeV ions
EMITTANCE (π mm. mrad)	{ axial } { rad }		pμ A of	MeV

**OPERATING PROGRAMS, time distribution**

BASIC NUCLEAR PHYSICS ..... 2% ..... SOLID STATES PHYSICS ..... 0% .....  
 BIOMEDICAL APPLICAT ..... 95% ..... ISOTOPE PRODUCTIONS ..... 2% .....  
 radiation damage, 1% .....

**REFERENCES/NOTES**

Self-supporting operation at \$2400 per 24 hours day 1981-82. Primarily used for proton beam therapy; 1700 patients so far, 170 per year. Third treatment area now underconstruction.

**PLAN VIEW OF FACILITY, COMMENTS, ETC.**