RIKEN 160 CM CYCLOTRON

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Abstract

RIKEN 160 cm cyclotron was constructed in 1966 and since that time it has been operated and served for studying in many fields of research. This paper describes a present status of this cyclotron and some researches studyed in this cyclotron recently.

Cyclotron

The RIKEN 160 cm cyclotron is of a weak focusing type. In this cyclotron the operation ranges of electro-magnet and radio frequency system are 0.5 to 2.0 Wb/m^2 and 5.0 to 12.0 MHz, respectively, and various particles of different mass to charge ratios from proton to $^{20}Ne^{5+}$ ion can be accelerated with variable energy.[1)]

It's project was authorized in 1962. The first beam was accelerated in October 1966 and research program started in February 1967. Since that time it has been operated on 4000 to 5000 hours in a year and has been used for the studies in many fields of research. The plane view of the 160 cm cyclotron is shown in Fig. 1. In Tables 1 and 2 the cyclotron characteristics, and kinds of ions being accelerated at present are shown, respectively.

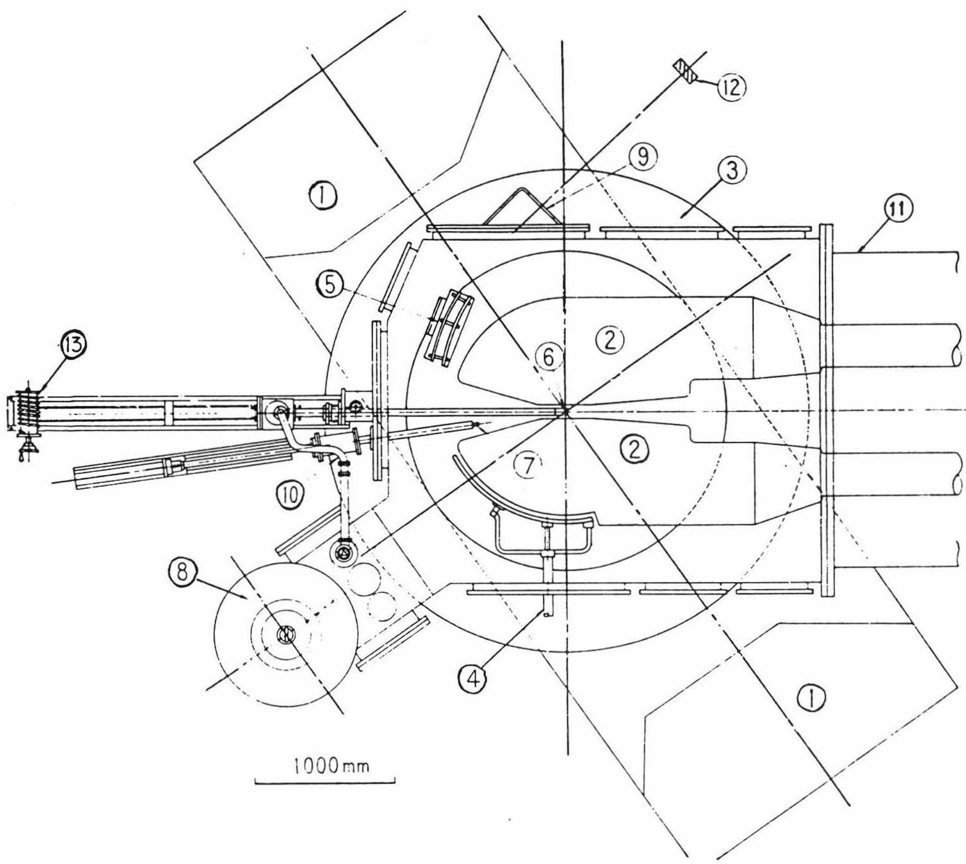


Fig.1 The schematic view of the accelerating chamber arrangement.
1. Side yoke 2. Dees 3. Coil tank 4. *RF*-deflector 5. Beam focusing magnetic channel 6. Ion source 7. Beam probe 8. 32″ oil diffusion pump 9. Beam exit flange 10. Exhaust pipe for ion source 11. Oscillator tank 12. Gate drop probe 13. Winch

Table 1. Cyclotron characteristics.

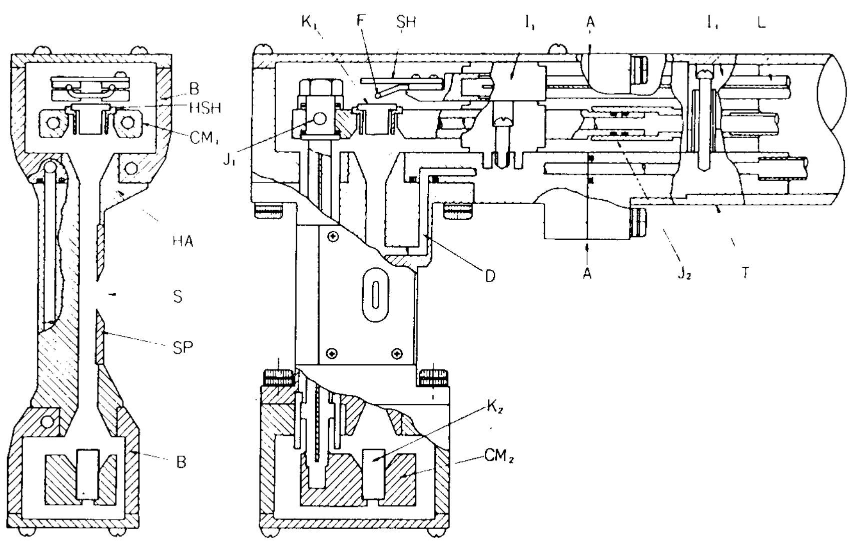
Acceleration system	
Number of dees	2
Dee width	180 deg.
Beam aperture	5 cm
Radio frequency	6 to 12.5 MHz
Tuned by	Movable short plus movable panels
Gain max.	400 kV/turn
Dee-gnd. max.	100 kV
RF power input max.	150 kW
Magnet	
Type of magnet	Weak focusing type
Pole tip dia.	162 cm
Extraction radius	73 cm
Gap between pole tips	26 cm
Field at max. excitation	2.0 Wb/m^2
Circular triming coils	4 pairs
Weights Fe (Cu)	310 (20) tons
Magnet excitation	6 x 10^5 amp-turns
Power max.	400 kW
Ion source	
For light ions (H,He)	Livingston type
For heavy ions (Gas)	Electron bombarded hot cathode PIG type
For heavy ions (Solid)	Same with sputtering electrode

Table 2. Particles, energy ranges and particle yields.

Particle	Energy(MeV)	Extracted beam current (μA)
p	5-17	30
d	8-26	30
$^3He^{++}$	12-50	30
$^4He^{++}$	16-52	30
$^6Li^{2+}$	25-48	0.2
$^7Li^{2+}$	29-48	2.0
$^7Li^{3+}$	29-75	0.05
$^9Be^{3+}$	45	0.8
$^{10}B^{3+}$	60	0.3
$^{11}B^{3+}$	66	1.3
$^{12}C^{4+}$	55-100	3.0
$^{14}N^{4+}$	65-100	3.0
$^{14}N^{5+}$	60-125	1.0(3.0)$^{a)}$
$^{16}O^{5+}$	65-125	1.0(3.0)$^{a)}$
$^{19}F^{5+}$	80-130	0.3
$^{19}F^{6+}$	80-150	0.1
$^{20}Ne^{6+}$	82-160	0.3$^{a)}$

a) Pulsed operation.

In this cyclotron two types of ion source are used, one is the Livingston type for light ions, and another is an electron bombarded hot cathode PIG source[2] for multiply-charged heavy ions. Fig. 2 shows a cross-sectional view of the heavy ion source. This source is supported by a single supporting tube(T) and the head part of the source can be removed from the supporting stem at a position indicated by A in Fig. 2. When the life time of the source is over, the head part is taken away and new one is attached in several minutes.



K_1: hot cathode (W or Ta)
K_2: reflector (W)
F: filament (W)
SH: electron shield (Mo)
CM_1, CM_2: cathode mount (copper, water-cooled)
HSH: cathode heat shield (W)
SP: slit plate (Mo)
J_1, J_2: cooling channel joint
I_1, I_2, I_3: insulator (ceramic)
D: distribution plenum
S: source aperture
L: leading tube
T: suporting tube (stainless steel)
B: anode box (copper)
HA: hot anode (copper)

Fig.2 Cross-sectional view of the source.

Applications

Recently, ion beams accelerated in the 160 cm cyclotron are used for several fields of research described below.

1) Nuclear reactions and structures
2) Radiochemical analysis of ^{16}O, ^{14}N and ^{12}C in Si crystal and GaAs.(related paper J4)
3) Cell death and DNA lesion caused by accelerated charged particles(related paper L43)
4) Proton irradiation effects on organic polymers (related paper L38)
5) Testing of radiation damage of fusion reactor materials
6) Effects of the fast neutron irradiation on cable materials
7) Study of radiation damage of some devices used in the satellite
8) Testing of single event upset by heavy ion irradiation
9) Production of fast switching power thyristars by proton irradiation

Researches 2), 3) and 4) are reported in this proceeding, and we describe briefly two researches 6) and 7) by way of example in this paper. Fig. 3 shows a schematic of irradiation system to study effects of the fast neutron irradiation on cable materials.[3] Fast neutrons were generated by bombarding the thick ^{9}Be target with 20 MeV deuteron beams having an aperture of 20 mm square. The test results of the characteristics changes for test specimens of a cable material, cross-linked polyethylene (XLPE) due to fast neutron and γ-ray irradiation using Co-60 are shown in Fig. 4.a and b, where the solid line shows the fast neutron irradiation effects and the broken line shows those γ-ray irradiation.

Comparison of high energy proton radiation damages on AlGaAs/GaAs and Si solar cells [4] was studied. Fig. 5 shows a schematic cross section of the AlGaAs/GaAs solar cells, and Fig. 6 shows remaining power P/Po of the AlGaAs/GaAs solar cells and Si solar cells after 5, 10, 15 and 52 MeV proton irradiation.

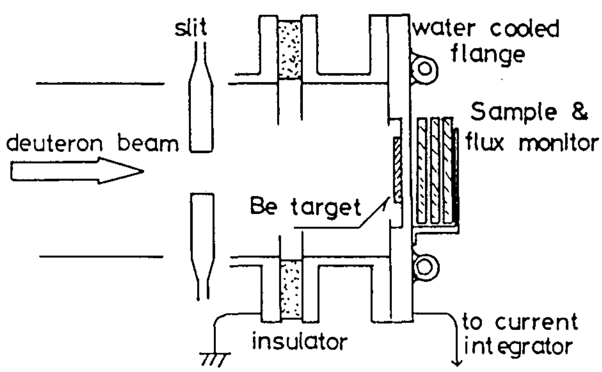


Fig.3 Schematic of irradiation system

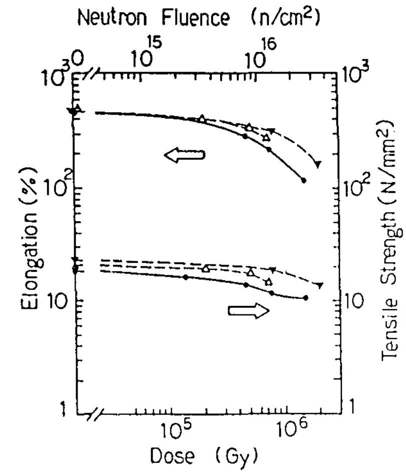


Fig.4a Mechanical characteristics changes of XLPE

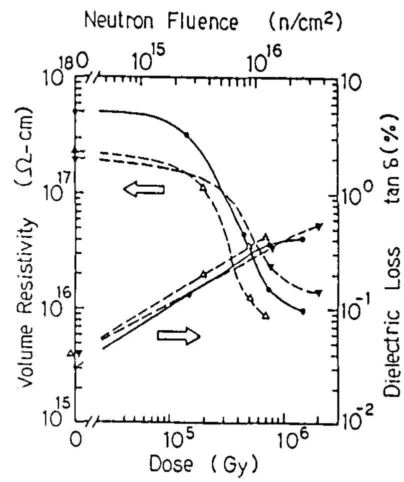


Fig.4b Electrical characteristics changes of XLPE

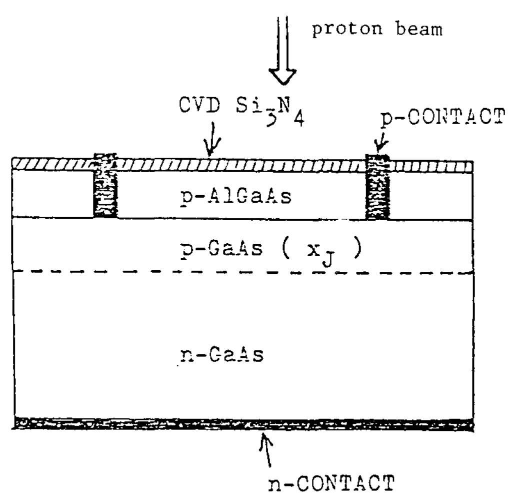


Fig. 5 Schematic cross section of the AlGaAs/GaAs solar cells.

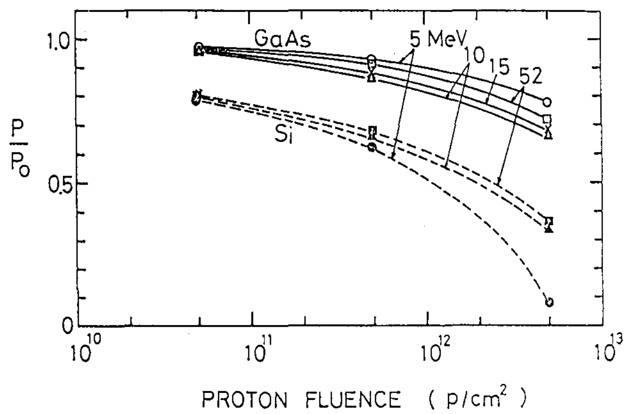


Fig. 6. Remaining power P/Po of the AlGaAs/GaAs solar cells and Si solar cells after 5, 10, 15 and 52 MeV proton irradiation.

References

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