THE INR 30 Mev(p) CYCLOTRON

Yao Chongjue, Chang Hongjun
Institute of Nuclear Research, Academia Sinica, Shanghai, China

Summary

The INR 120cm cyclotron was converted into a 30 Mev(p) sector focused cyclotron in 1983. It has been put into operation for two years. About 16 researches and 36 changes of energy or particle have been performed. Accelerator performance and operation are briefly summarized. Some developments are also included.

Description of the cyclotron

The INR 120cm cyclotron is a classical 6.8 Mev(p) cyclotron built in 1964. In order to broaden the field of research, in 1978, we started to convert the machine into a sector focused cyclotron with energy of 30 Mev(p). This project lasted four years for design and engineering preparation, one and a half years shut down for installation and beam tuning. It was completed in December 1983 according to schedule.

After completion of acceptance test, the cyclotron has been under routine operation since summer 1984. The reports on design, construction, installation and tuning have been given elsewhere.[1), 2), 3), 4)] we will give here only the maim technical measures and parameters.

The main measures to remodel this machine are

—— Replacing the 120cm conic pole with cyclindrical one's of 144cm diameter providing 3 sectors, 9 pairs of trimcoils and 3 pairs of valley coils in each valley.

—— Using a single 180° Dee cantilevered from two stems instead of two 180° Dees and developing a balum unit (a device which transforms a balanced impedance to unbalanced one's) for transmition RF power from final power amplifier stage to the single Dee.

—— Using two sets of electrostatic deflector, following that, providing a focusing magnetic channel, a magnetic weakening channel and a steering magnet.

The maim parameters are listed in Table 1.

Table 1: Maim parameters of the cyclotron

Energy	
p	10-30 Mev & (5-8 Mev)
d	10-16 Mev
α	20-32 Mev
Magnet pole diameter	1386mm
Sectors	3
Spiral angle	45° Max
Gap on hill	146mm
Gap in valley	224mm
Frequency range	10.5-21.5 MHz
Dee	180° x1
Dee height	48mm
Beam aperture	30mm
Dee ground clearance	34.5mm
Extraction	2 sets of electroctatic deflector

Cyclotron performance & operation

Particles and energies accelerated in 1984-1985 are listed in Table 2.

Table 2. Particles and energies accelerated in 1984-1985

Particle	Energy(Mev)
p	11,15,17,20,25,30
d	16,20
α	32,40
$^{2}_{H}1$	4.1
$^{12}_{C}3$	53
$^{14}_{N}3$	25
$^{16}_{O}4$	40
$^{20}_{Ne}4$	29

The heavy ions produced from existing hot filament ion source gave only a few naoampers were mainly used for trial test of inadiation of solids.

Research work is presently being concentrated in the fields of nuclear physics and applied science. About 16 experiments were performed from the middle of 1984 to 1985. The experiments are as follows:

1) Experiments of nuclear researches of 16.7 Mev(p,p), 28.9 Mev ^{56}Fe(p,n), 16 Mev d+ ^{10}B, 16 Mev d + d.

2) Production of radionuclides of ^{201}Tl, ^{203}Pb, ^{111}In.

3) Trace analysis by charged particle activation.

About 36 changes of particles type on energy were practiced in satisfy the requirements of these experiments and the developed studies. Oparational time distribution to the experiments are shown in Table 3.

Table 3. Time distribution of cyclotron

Total time	1520 H
Nuclear physics	700 H
RI production	670 H
Development	150 H

The performance of the machine has been improved. Several acceleration test have performed to determine the optinum acceleration parameters. The beam current of α particle have increased more than ten microamperes in the straight line target and α particle energy has increased up to 40 Mev. During this period, the machine was steadily operated with much less difficulty than we had anticipated. Also there was no distinct mechanical deformation in the trim coil cover plate and Dee structures.

The problems we had like leakage and unreliable power supplies were within the tolerable limits. Failures related to the RF, power supplies and deflector are as follows:

1) The coupling capacity bellows was break down by RF sparking at one time.

2) Unreliable power supplies were accused only a few times mainly caused by poor quality of some parts such as transistor and resistance.

3) The tantalum septum of the first set deflector were slightly melted by beam current.

Recent developments

Some developments were carried out on the cyclotron. There are mainly as follows:

The non-intercepting type beam phase probe has been developed to measure the phase of beam.

The automatic frequency control and Dee voltage stabilizer have been added to existing RF control system. The performance of the system is based on the comparision of the phase of Dee vollage and RF voltage of the final stage of amplifier. These system maintain the accelerating voltage within stability better than 5×10^{-3}.

The tantalum septum of the first set deflector has been replaced with a graphite one's. After replacing, it operated rather satisfactory.

Morever an intensive α ion source has been developed. The yields of α particle has nearly increased by 100%.

Future development

There are still a lot of work to improve the cyclotron performance. The major subjects concerned are:

—— Developing a digital control system to set parameters of the cyclotron, then using phase probe signal to isochronize the cyclotron for a variety of particles and energies.

—— Installing beam phase slit to improve energy resolution.

—— Setting up of the beam transport system to the new experiment room.

—— Developing light heavy ions.

References

1. Chang Hongjun et al., Japan-China joint symposium on accelerators for Nuclear Science and their applications ATAM. 8-11 Sep. (1980) 101.

2. Chang Hongjun et al., Ninth International Conference on cyclotron and their applications Sep. 7-10th, (1981) 62.

3. Chang Hongjun et al., China-Japan joint symposium on accelerators for Nuclear Science and their applications Lanzhou, 11-13 Oct. (1983) 37.

4. Chang Hongjun et al., Tenth International Conference on cyclotrons and their applications April 30-May 3, (1984) 449.