Status of the NEOMAFIOS at RCNP

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The NEOMAFIOS was assembled and Li^{2+} beam was analyzed with intensity of 16 μA by using of LiF rod with He support gas. The NEOMAFIOS was installed on the shielding roof of AVF cyclotron and new axial injection system were constructed in one year. The design and the preliminary results are described.

1 Introduction

A new high intensity polarized proton and deuteron ion source, a new axial injection system and injection beam line for polarized ion source and NEOMAFIOS were installed in August 1994. In order to get high quality injection beam for the ring cyclotron, phase space volume of the injection beam is limited by various slits between the ion source and the ring cyclotron. The beam intensity reduction about 10^{-2} with these slits is very serious for polarized beam and heavy ion beam. The beam intensity upgrade project had been done in 1994. In this project, we construct the new axial injection system[1] and the two type of the external ion source. The one is HIPIS (High Intensity Polarized Ion Source)[2] and the other is NEOMAFIOS[3].

2.New axial injection system

The polarized protons and deuterons have been injected into the AVF cyclotron. On the other hand, unpolarized ions including light heavy ions have been produced by an internal ion source. When ions are injected with a mirror system, some structures in the central region of the cyclotron have to be changed from those used for the internal source. In the new system, both polarized ions from HIPIS and unpolarized ions produced with a ECR ion source, NEOMAFIOS, are injected through the common vertical injection line and the common inflection system. The axial injection system for AVF cyclotron was installed last August. Old axial injection line with electostatic quadrupole lenses was replaced by new system with Glaser lenses, sawtooth buncher and spiral inflector to get a high-transmission and stable operation. The Glaser lenses's acceptance is four times largger than elecrostatic quadrupole lenses. The obtained injection efficiency for 65MeV proton is 14%.

3.NEOMAFIOS

NEOMAFIOS is the ECR ion source of 10GHz RF frequency for non-polarized light and medium ion. This ion source is used a permanent magnet (Fe-Nd-B) as a mirror magnet instead of solenoidal coil and was developed at CEA(Centre d'Etudes Nucle'aires de Grenoble, France). Main parameters of NEOMAFIOS is shown in Table 1. Drawing of NEOMAFIOS is shown in Fig.1

Magnetic confinement	Mirror + hexapole field
RF frequency	10GHz
Chamber diameter	67mm
Chamber length	170mm
Evacuating pump	520 l/sec TMP

Table 1 Main parameters of the NEOMAFIOS

The extraction voltage is varied from 5 to 20 KV according to the injection condition to the AVF cyclotron.

The einzel lens is set up 20cm downstream of NEOMAFIOS. On the first trial, to increase the voltage, the beam intensity decreased. On this case, electric potential of einzel lens was positive voltage, however good focusing can not obtain. Very strong electric charge effect by the penning discharge due to the effect of leak magnetic field and positive electric potential disturb the electric potential. To change the polarity of einzel lens electric potential from plus to minus, we get very good focus and 1.2 times more intensity beam.

The energy distribution of X-rays from NEOMAFIOS were measured to check the radiation hazardd with a Ge-detector. A typical energy spectrum is shown in Fig.2.

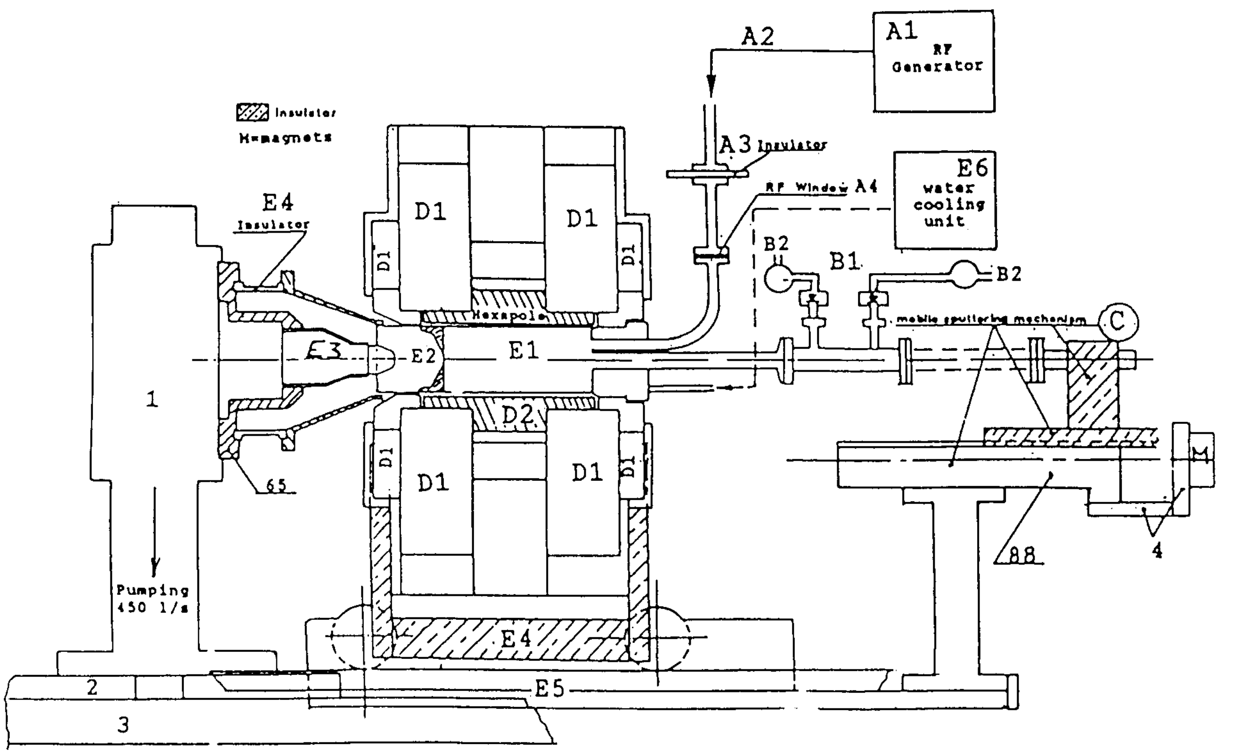

Fig.1 Drawing of NEOMAFIOS

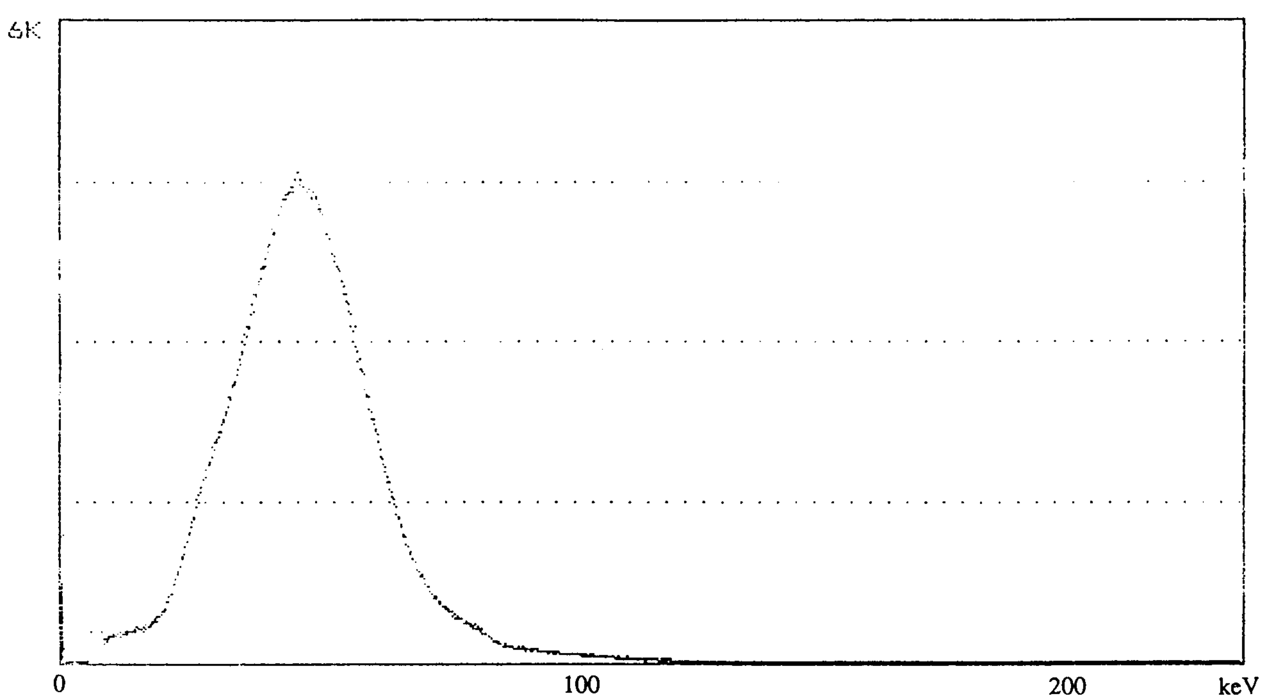

Fig.2. A typical energy spectrum of the x-ray from the NEOMAFIOS

The end point of energy is 120keV.

Typical vacuum status is 3×10^{-7} Torr at extraction region. The operating RF power was typically 650W and the drain current was usually between 1mA and 3mA.

The source has been operated with gaseous element. The ions of H and He were used as self-support gas. For ^{14}N and ^{16}O ions were used He support gas. For ^{20}Ne and ^{40}Ar ions are used N_2 support gas.

On the other hand, Li ions were produced by using LiF rod and He support gas. The size of this rod was 5mm$\times$5mm$\times$50mm and moving 0.3 mm/h to direction to the central region. The Ta sheet was prevented for damage of inner chamber.

Typical intensity of ion and charge state was shown in Table.2 and Fig.3.

CS	^{1}H	^{4}He	^{7}Li	^{14}N	^{16}O	^{20}Ne	^{40}Ar
1+	500	1100	10			29	
2+		580	16			100	34
3+			2			145	50
4+				110	180	96	51
5+				65	85		
6+				6	35	16	47
7+					2	4	35
8+							35
9+							8

Table.2 Intensity of ion and charge state(eμA)

4.External ion source

The external ion source have some merit in comparison with internal ion source. The one is maintenance. It dose not need exchange of filament. The other is productivity of the multi charge state.

The ion source was installed on the shielding roof of AVF cyclotron.

The ions produced gaseous element was accelerated by AVF cyclotron on February. The Li ions was accelerated by AVF cyclotron on March. Typical accelation condition was shown in Table.3.

ion	extraction voltage(kV)	AVF cyclotron energy(MeV)	bean current at AVF cyclotron exit(eμ A)
d	12	43.5	9
$^{3}He^{1+}$	9	32	4
$^{3}He^{2+}$	11	92.6	7.4
$^{4}He^{2+}$	15	120	3.2
$^{6}Li^{2+}$	7.2	64	0.042
$^{6}Li^{3+}$	9.4	131.1	0.088
$^{7}Li^{3+}$	8.1	114.0	0.242
$^{14}N^{4+}$	9.1	130.3	4.4
$^{14}N^{5+}$	11.5	210	2.3

Table.3 acceleration condition

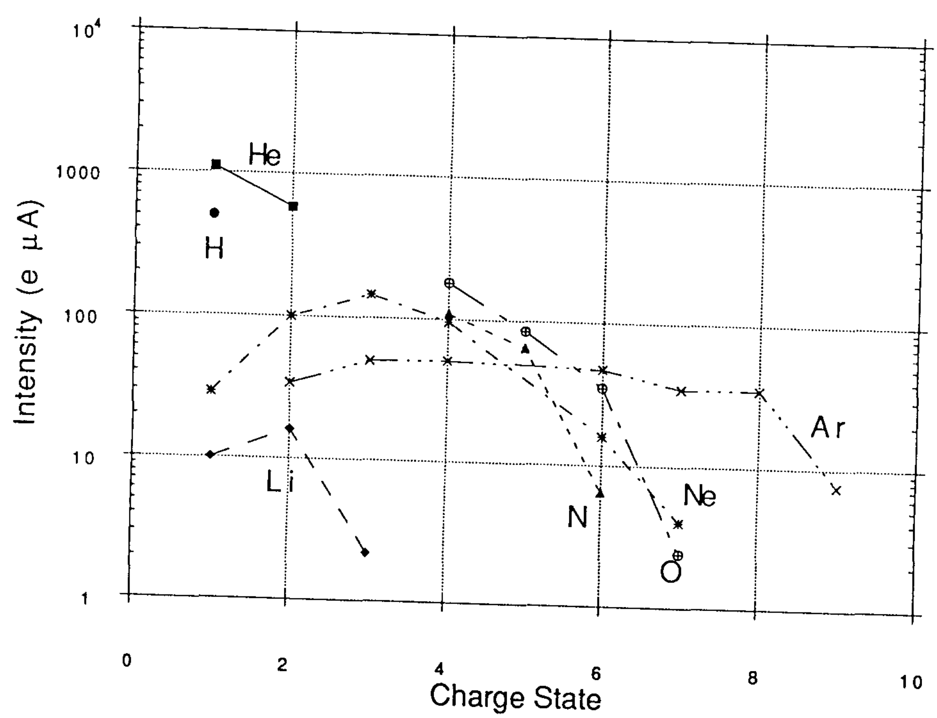

Fig.3 Intensity of ion and charge state(eμA)

5.Summary

The NEOMAFIOS has successfully operated as external ion source on RCNP. The operation of the injection system for RCNP AVF cyclotron has been successfully performed. The beam intensity for ions up to nitrogen is resonably sufficient to accelearate them with the injector AVF cyclotron.

References

[1] H.Hatanaka et al.,RCNP Annual Report (1993) p.200
[2] H.Hatanaka et al.,RCNP Annual Report (1993) p.194
[3] R.Geller ,Annu.Rev.Nucl.Part.Sci. (1990) p.15