

BEAM EXTRACTION SYSTEM FROM DC60 CYCLOTRON

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Abstract

The results of numerical simulation of the heavy ions beam extraction system ($A/Z=6\div 12$, $W=0.35\div 1.77$ MeV/amu) from the DC60 cyclotron are presented. The parameters of the extraction system elements (electrostatic deflector and focusing magnetic channel) and diagnostic elements are chosen. The experimental extraction efficiency of $^{14}\text{N}^{2+}$ and $^{84}\text{Kr}^{12+}$ beams is equal to 60÷65% with intensity $1.5\div 2.5 \mu\text{A}$.

INTRODUCTION

The DC60 is a sector cyclotron with variation of the magnetic field level at range $B_0=1.25\div 1.65$ T. The energy range of the accelerated and extracted ion beams W is continued with interval $0.35\div 1.77$ MeV/amu for ratio of the ion mass (A) to ion charge (Z) $A/Z=6\div 12$. The main parameters of DC60 cyclotron are given in Table 1.

Table 1. Main parameters of the DC60 cyclotron

Pole diameter [mm]	1620
Number of the sectors	4
Azimuthal width of sector [deg]	52
Valley gap [mm]	176
Sector gap [mm]	33
B_0 [T]	1.25÷1.65
Number of dee	2
Azimuthal width of dee [deg]	35
Udee [kV]	50
Frot [MHz]	1.83÷4.35
q	4, 6
Frf [MHz]	11.0÷17.4
A/Z	6÷12
W [MeV/amu]	0.35÷1.77

For beams extraction from the cyclotron is used the electrostatic deflector. The extraction system of the DC60 cyclotron consist a next elements:

1. Electrostatic deflector (ESD);
2. Focusing magnetic channel (MC);
3. Elements of diagnostic
 - a) Extraction probe;
 - b) profilometer.

NUMERICAL SIMULATION OF THE BEAM EXTRACTION

For numerical simulation the 5 test ions in accordance with working diagram are used. The parameters of there ions are given in Table 2.

Table 2. Parameters of the test ions

N	A/Z	W [MeV/amu]	Udef [kV]	B_0 [T]
1	6	1.07	30.8	1.25
2	10	0.38	18.6	1.25
3	8	0.79	29.4	1.45
4	6	1.77	51.9	1.65
5	12	0.46	25.6	1.65

The extracted trajectory is shown in Figure 1. The average radius of the maximal accelerated orbit is equal ≈ 70 cm (Figure 2).

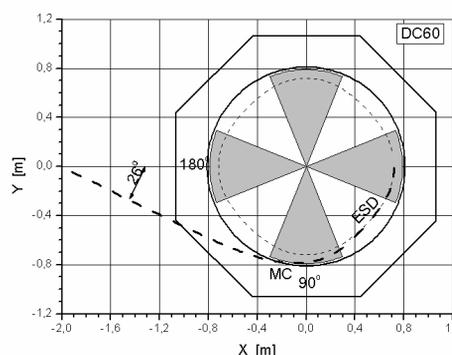


Figure 1. Trajectory of the test ion ($A/Z=8$, $B_0=1.45\text{T}$) extracted from DC60 cyclotron

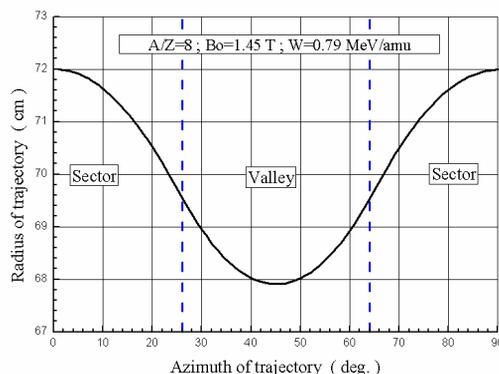


Figure 2. The maximal accelerated orbit for test ion

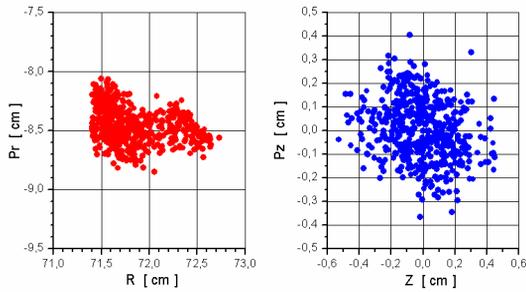


Figure 3. The horizontal and vertical beam emittances at the deflector entrance ($A/Z=8$, $B_0=1.45$ T)

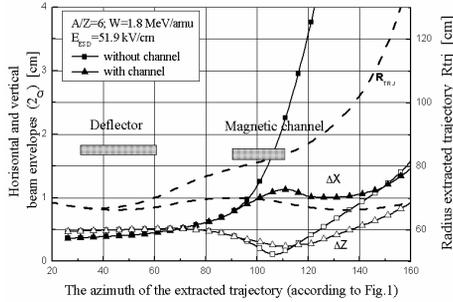


Figure 4. The horizontal and vertical beam envelopes

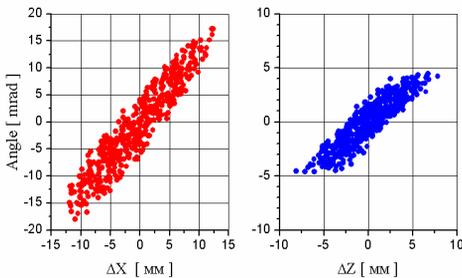


Figure 5. The horizontal and vertical emittances of the extracted beam ($A/Z=8$, $B_0=1.45$ T)

ELECTROSTATIC DEFLECTOR

The main parameters of the electrostatic deflector are given in Table 3. The electrostatic deflector is shown in Figure 6.

Table 3. Parameters of the electrostatic deflector

Azimuthal position [deg]	84÷112
Max. voltage [kV]	65
Length of the “potential” plate [mm]	400
Length of the “septum” plate [mm]	440
Thickness of the “septum” plate [mm]	0.3÷1.0
Curvature of the plate [mm]	1800
Gap between plates [mm]	10
Displace of the deflector edges [mm]	± 15
Material of the “potential” plate	Ti
Material of the “septum” plate	Mo

FOCUSING MAGNETIC CHANNEL

The main parameters of the magnetic channel are given in Table 4. The magnetic channel is shown in Figure 7.

Table 4. Parameters of the magnetic channel

Azimuthal position [deg]	84 ÷ 112
Length of the channel [mm]	≈400
Curvature of the plate [mm]	≈ 860
Aperture [mm] horizontal	25
vertical	15
Displace of the edges [mm]	± 15
Focusing gradient of the magnetic field [T/m]	35÷40

THE ELEMENTS OF DIAGNOSTIC

The extraction probe is placed between electrostatic deflector and magnetic channel. It has 10 lamels with thickness 5 mm for measurement of the beam intensity and horizontal distribution. The extraction probe is shown in Figure 8.

The profilometer is placed at the vacuum chamber exit. It has 15 vertical and 15 horizontal wires with step 5 mm and is used for measurement of the beam intensity, horizontal and vertical distribution. The profilometer is shown in Figure 9.



Figure 6. Electrostatic deflector



Figure 7 Magnetic channel

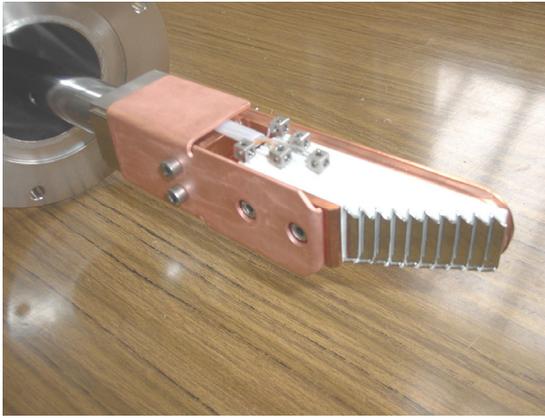


Figure 8. Extraction probe

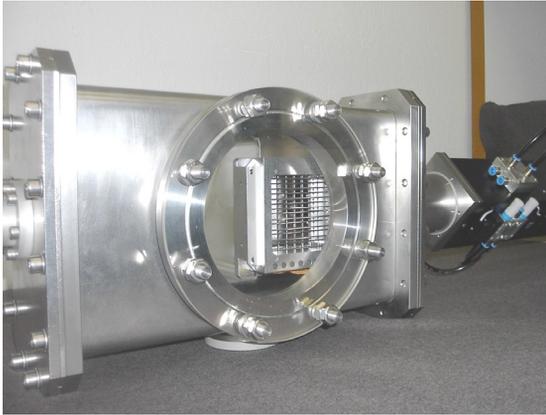


Figure 9. Extraction chamber with profilometer

EXPERIMENTAL RESULTS

The first extracted beams was obtained at December 2006. The parameters of the first extracted beams are given in Table 5.

Table 5. Parameters of the extracted beams

Ion	$^{84}\text{Kr}^{12+}$	$^{14}\text{N}^{2+}$
A/Z	7	7
Bo [T]	1.42	1.64
Rfr [MHz]	12.67	14.4
Buncher	Yes	No
Accelerated beam currency [μA]	2.5	1.46
Extracted beam currency [μA]	1.65	0.9
Extraction efficiency [%]	66	61.6

CONCLUSION

Extraction of the heavy ion beams from DC60 cyclotron is realized. The extraction efficiency is is equal to 60÷65% with intensity 1.5÷2.5 μA .

REFERENCES

- [1] B.N. Gikal et al., "Project of the DC-60 cyclotron with smoothly ion energy variation for research center at L.N. Gumilev EuroAsian State University in Astana (Kazakhstan)", Cyclotrons and their applications, 2004, pp.205-207.