Study on the Extraction of an 18MeV High-intensity Cyclotron for BNCT

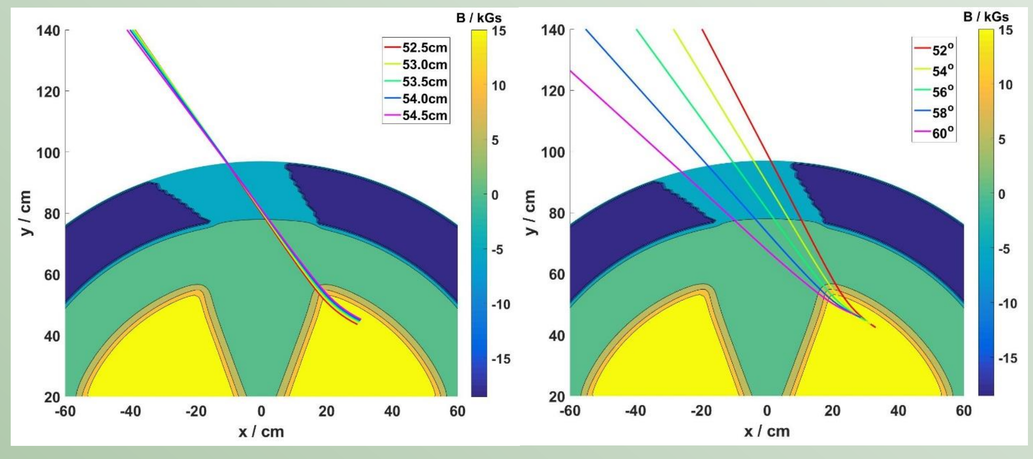
Luyu Ji, Shizhong An, Tianjian Bian, Fengping Guan, Sumin Wei, Jiansheng Xing

China Institute of Atomic Energy，Beijing，102413

ABSTRACT

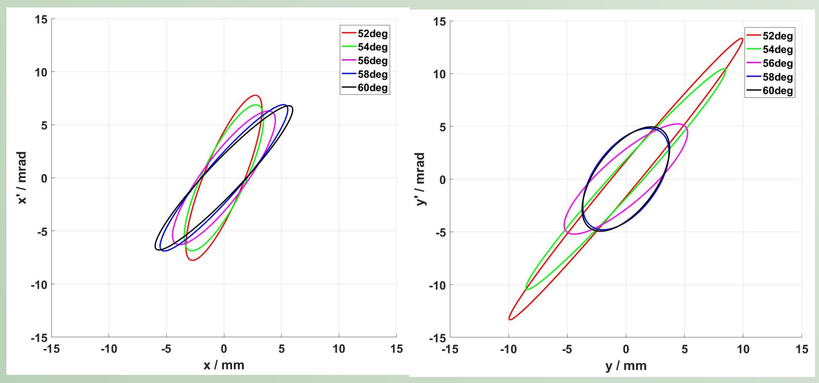
An 18 MeV, 1 mA H^- compact cyclotron is under design at China Institute of Atomic Energy (CIAE). The proton beam bombards a beryllium target, producing high-flux neutron beam for Boron Neutron Capture Therapy (BNCT). Stripping extraction is adopted in this cyclotron. The position of the stripping point affects the trajectory and beam quality of the extracted beam. In this paper, we use particle tracking methods to simulate the beam trajectory and emittance with different positions and tilt angles of stripping foil, and adopt the extraction point whose radius is 53.6 cm, azimuth is 57° and tilt angle is 15° .

The position of stripping foil



Compared with the radius of stripping foil, the azimuth has a greater impact on the trajectory. The azimuth should be within 52° -60° to make the beam pass through the valley of yoke.

Beam focusing



$$n = -\frac{r}{B}\frac{dB}{dr}$$

$$\nu_r = \sqrt{1-n}$$

$$\nu_z = \sqrt{n}$$

The beam trajectories with the different azimuths of stripping foil are quite different, resulting in different magnetic fields. The closer the stripping foil is to the center of the magnetic pole, the closer the beam trajectory is to the inside of the magnetic pole. The radial focusing will be stronger and the axial focusing will be weaker.

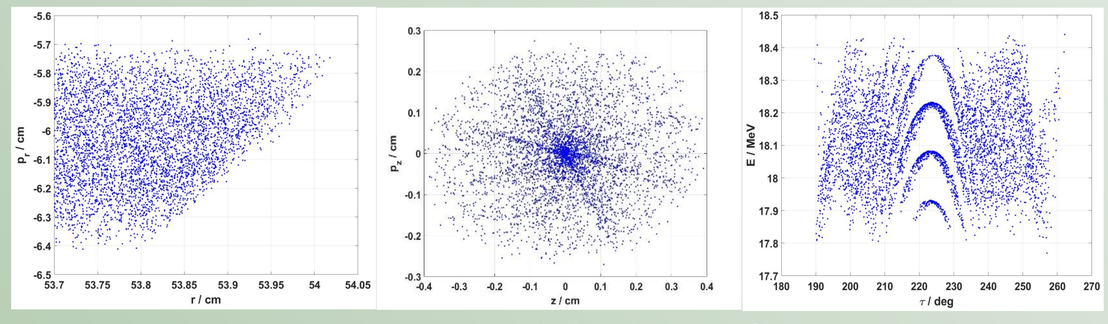
When there is an angle α between the stripping and the particle direction, the angle of particles passing through the stripping foil will be changed:

$$\begin{cases} \Delta x' = \dfrac{2\tan\alpha}{\rho}x \\ \Delta y' = 0 \end{cases}$$

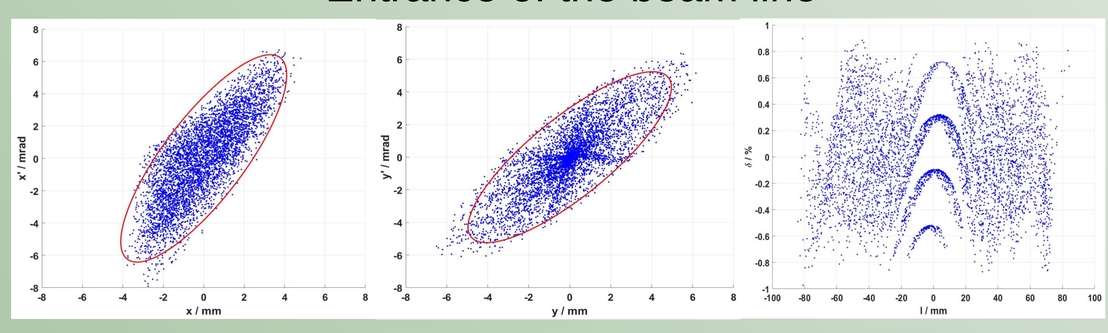
When there is an angle between the normal of the stripping foil and the direction of particle movement, focusing or defocusing will occur in the horizontal direction, which is similar to the inlet and outlet angles of the dipole.

Muti-particle tracking

On the Stripping Foil



Entrance of the beam line



The multi-particle tracking method is used to simulate the parameters of the extracted beam. The size of stripping foil depends on the beam envelope (3.2mm×8.0mm). The distribution at the entrance of beam line is used to design the beam line as a initial condition.

Result

The azimuth of the stripping foil is 57° , and the radius is 53.6 cm. The tilt angle is 15° . The horizontal envelope of the extracted beam at the entrance of beam line is 3.81mm, and the vertical envelope is 4.82mm.

Parameter	Value
ε_x/π-mm-mrad	13.49
x/mm	4.81
x'/mrad	7.04
α_x	-2.30
β_x/mm·mrad^{-1}	1.71
γ_x/mm^{-1}·mrad	3.68
ε_y/π-mm-mrad	15.00
y/mm	3.82
y'/mrad	4.52
α_x	-0.57
β_y/mm·mrad^{-1}	0.97
γ_y/mm^{-1}·mrad	1.36
l/mm	99.99
δ/%	0.87