Preliminary design and simulation results of Ne^+ beam source

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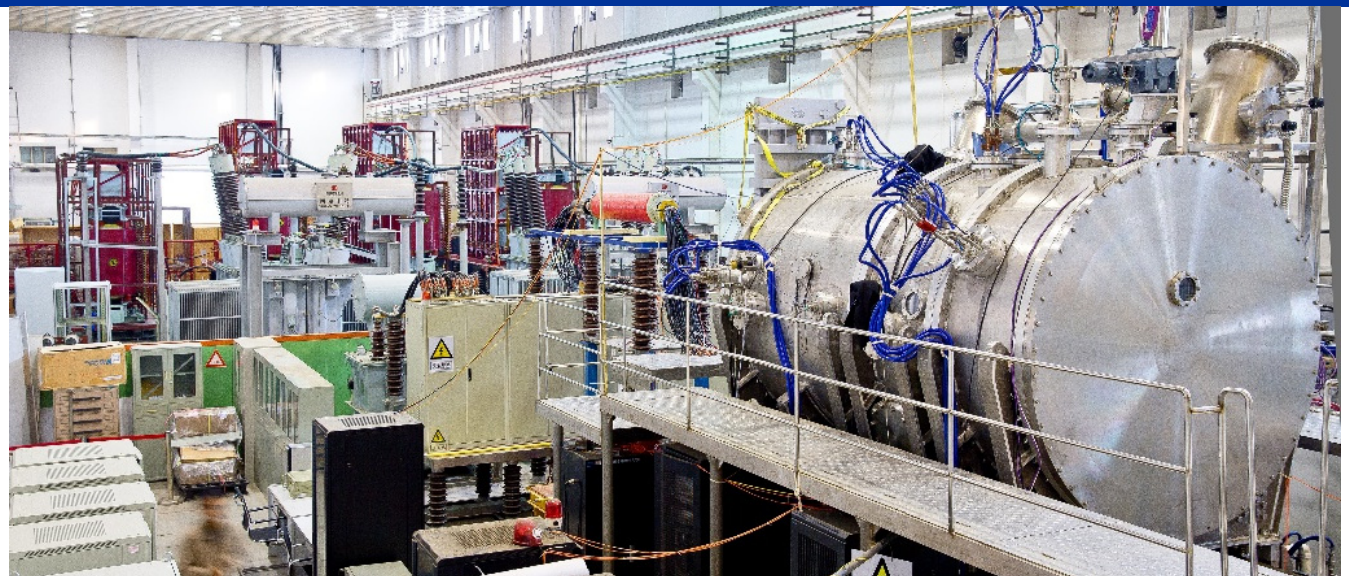


Outline

- Introduction
- Design of Ne^+ beam source
- Preliminary results of beam performance
- Summary

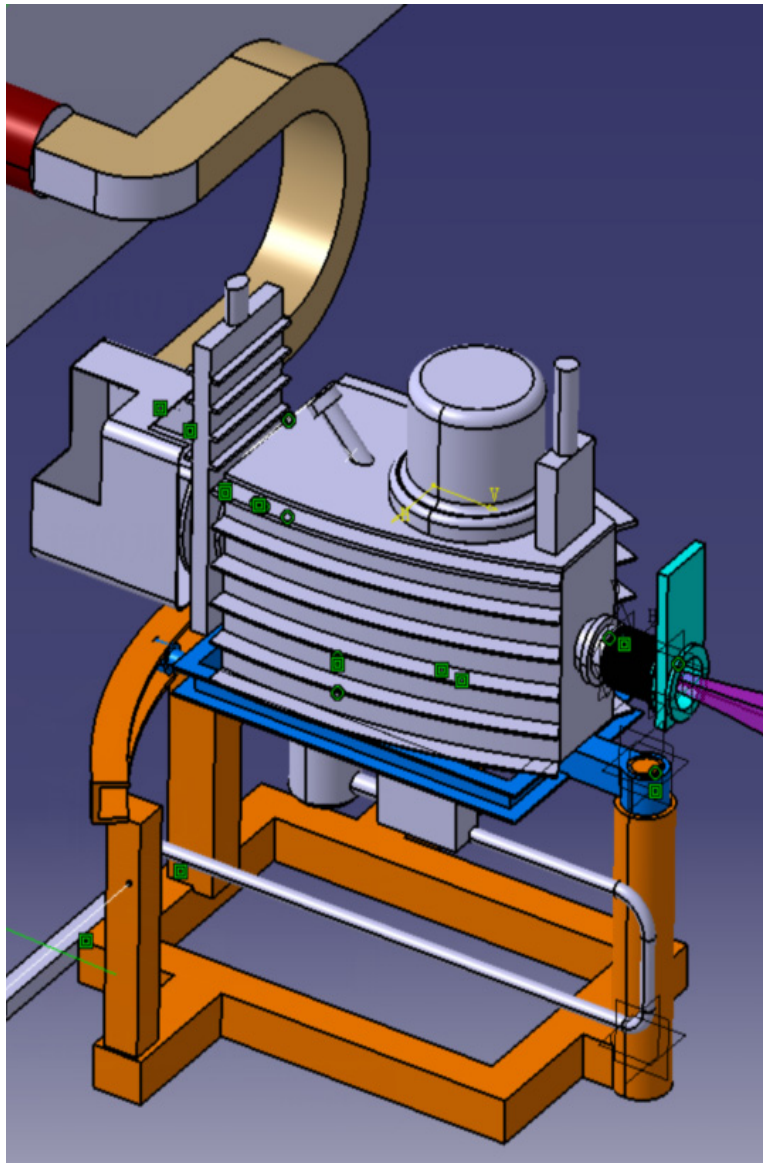
Ion beam system for basic physical research

- An ion beam system (IBS) was designed to supply fast ions for basic physical research in the Institute of Plasma Physics, Chinese Academy of Science (ASIPP).
- The required beam power is 50kW with beam size of 25 cm × 25 cm in 2 seconds, and the beam energy can be changed from 10 keV to 20 keV. The beam divergence angle should no more than 5 degree.
- The ion beam system was designed with a Ne^{+} beam source and a short beam transmission line.

Design of Ion beam system

- Beam species: Ne^+
- Beam energy: 10-20 keV
- Beam power: 50 kW
- Beam cross-section: 25 cm×25 cm
- Beam duration: 2s

- Ion source
- Vacuum vessel
- Calorimeter
- Power supply system
- Water cooling system
- Control system
- Pumping system



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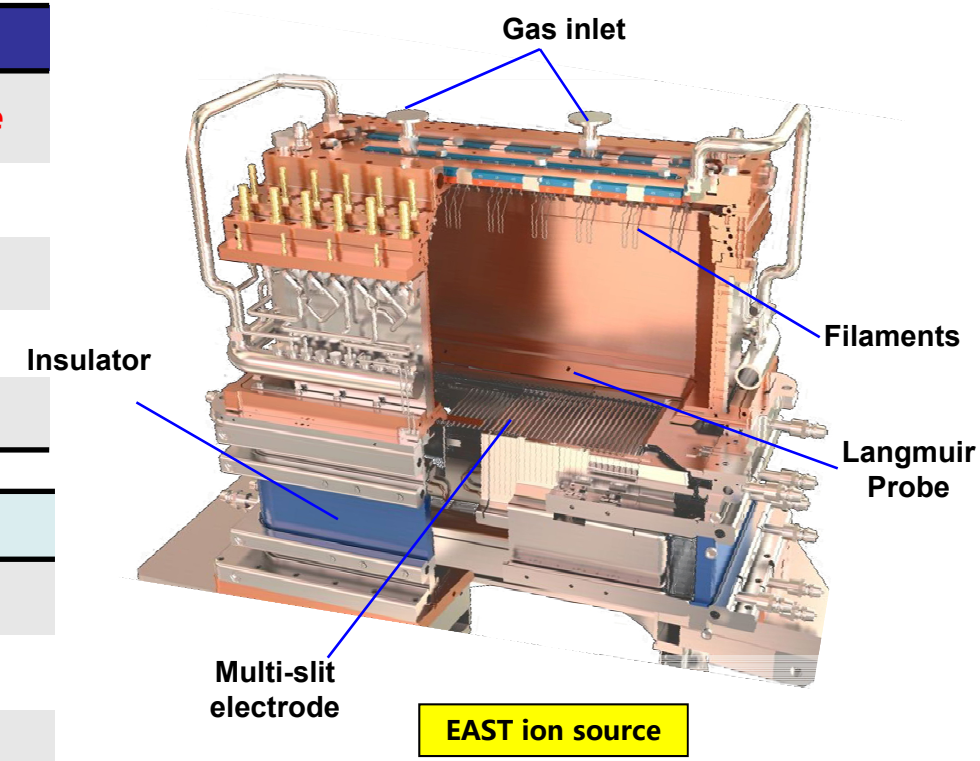
The ion source on EAST-NBI

- EAST-NBI ion source：50-80keV，2-4MW， 10-100s
- The design of Ne^+ beam source was based on the R&D experiences of EAST-NBI ion source

Plasma generator	
Plasma production	**Filament (32) arc discharge**
Plasma confinement	**Axial** multi-cusp
Inner dimensions	65(L) x 26(W) x 30(D) cm^3
Atomic species ratio	~80%
Discharge time	>100s with **arc regulation**

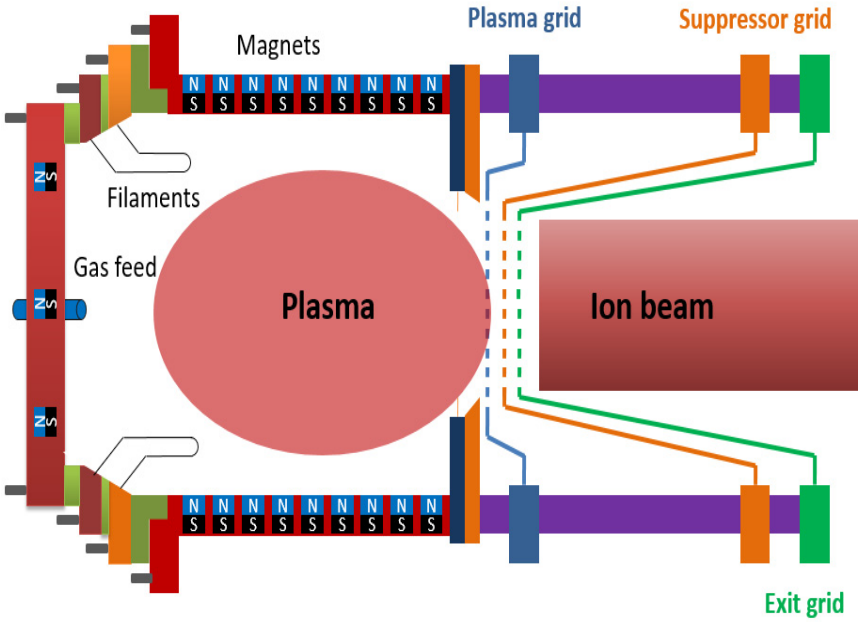
Accelerator	
Extraction area	12 x 48 cm^2, 4 segments
Beam transparence	~60%
Electrode system	**4 multi-slit grid**, Ext.-Acc.-Dec. stage
Beam div.	0.6° (X) , 1.2° (Y)



Design of Ne^+ beam source

Hot cathode plasma generator and three electrodes accelerator

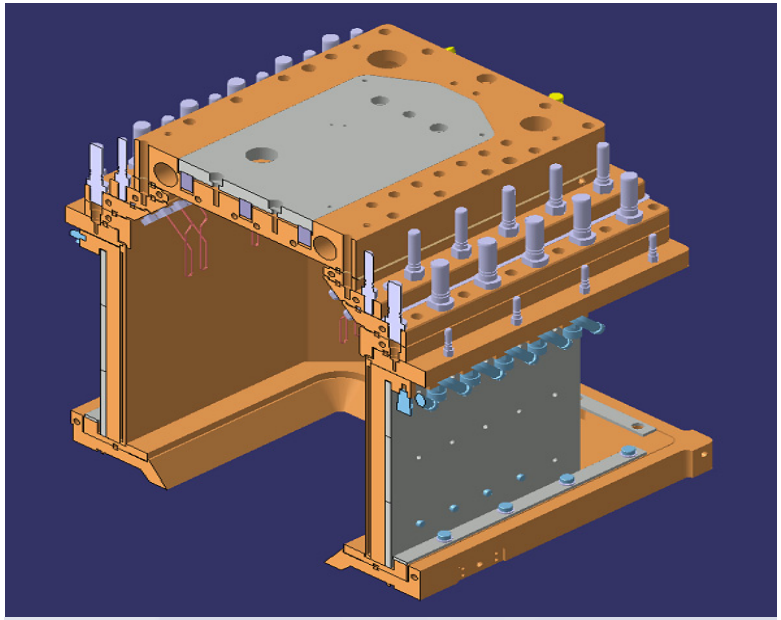
- Beam energy：10-20 keV
- Ion beam power：> 50 kW
- Beam duration：：≤ 2 s
- Beam size：25 cm×25 cm
- Plasma source type：hot cathode
- Accelerator type: slot (Acc.-Dec.)
- Maximum divergence angle：5°

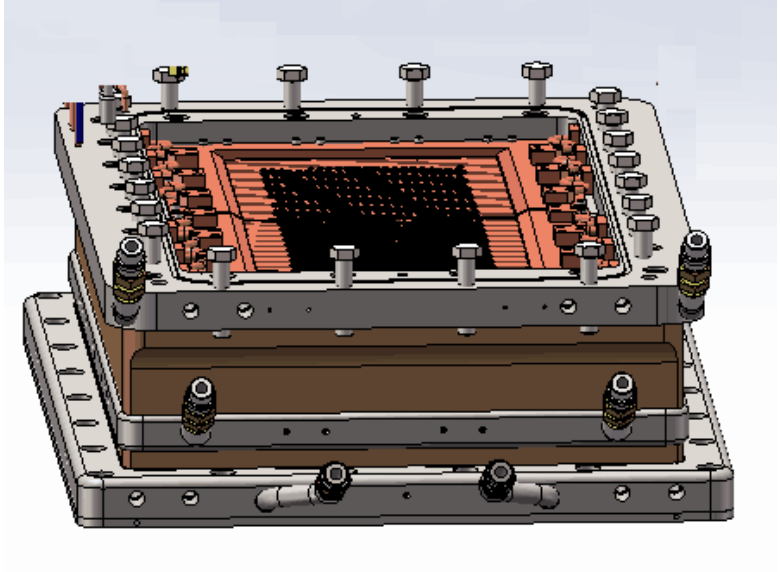


Detail design of ion beam source

- Bucket source with 40cm×40cm
- 16 hot cathode (tungsten,1.5mm in diameter and 160mm long)
- Multi-cusp by permanent magnets

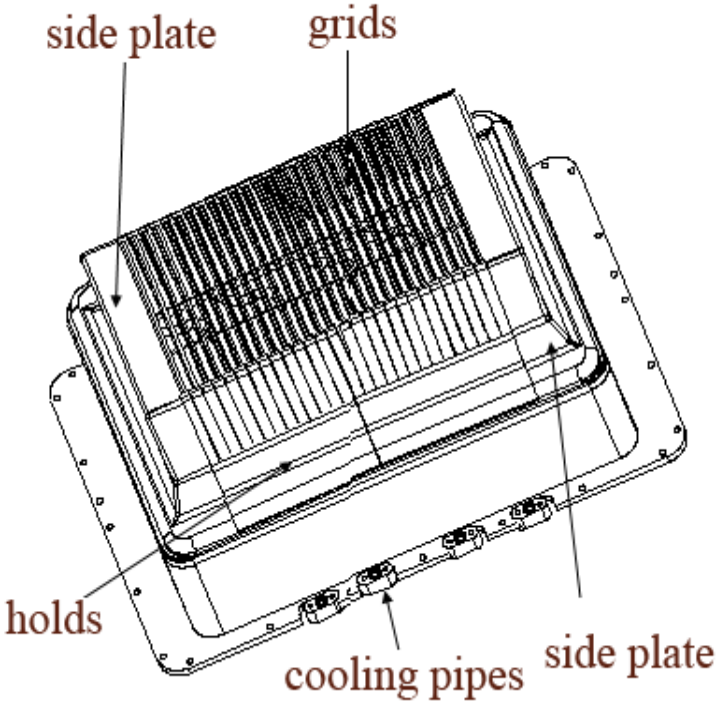
- Three stage (acc-dec) system
- Multi-slit accelerator
- Two pieces of grids (each 14 slits)
- Beam divergence angle: less than 5 degree
- Extraction area: 25 cm ×25 cm

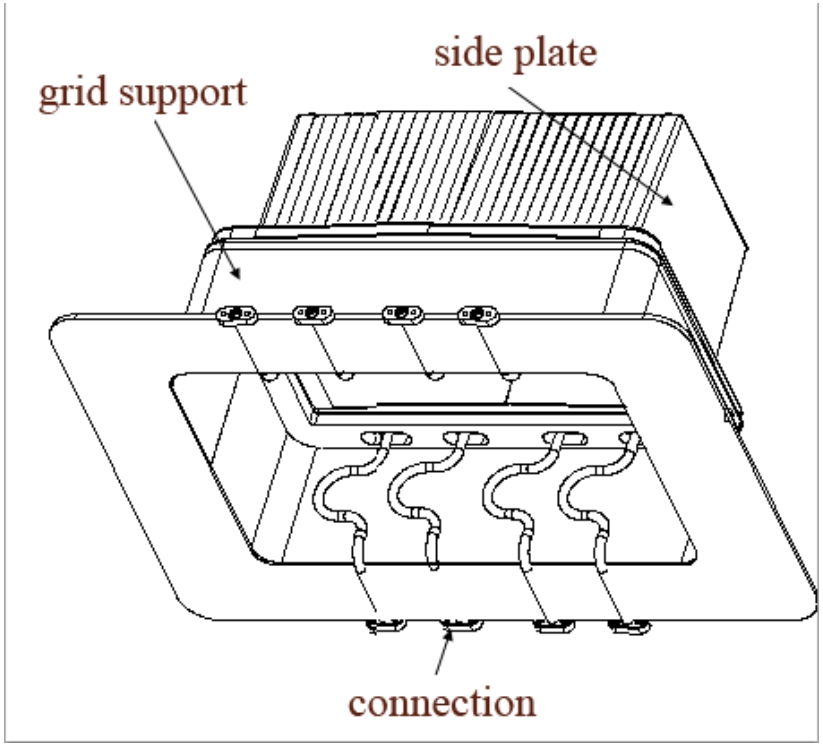




Design of accelerator

- The accelerator contains grids, holds, gird support, side plate, water cooling pipes
- Cooling water goes through the inner pipes of each grids





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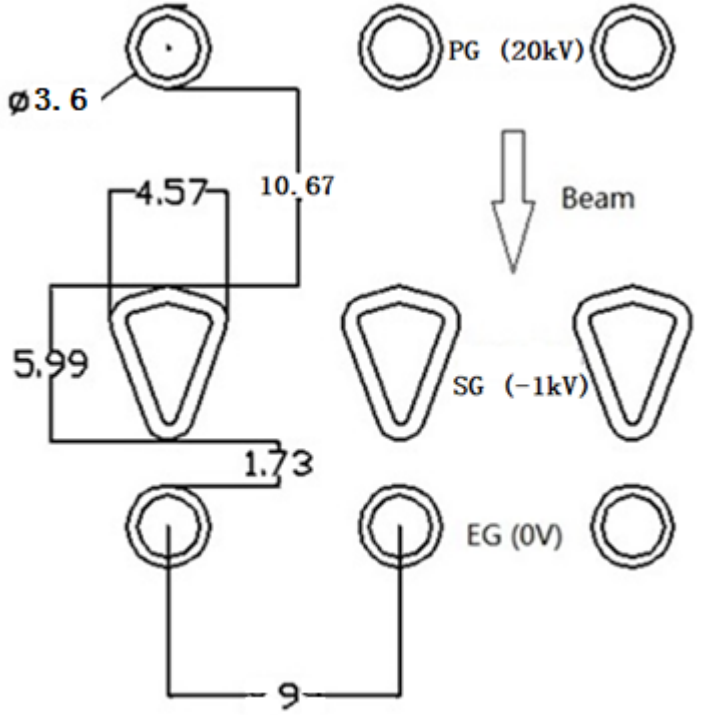
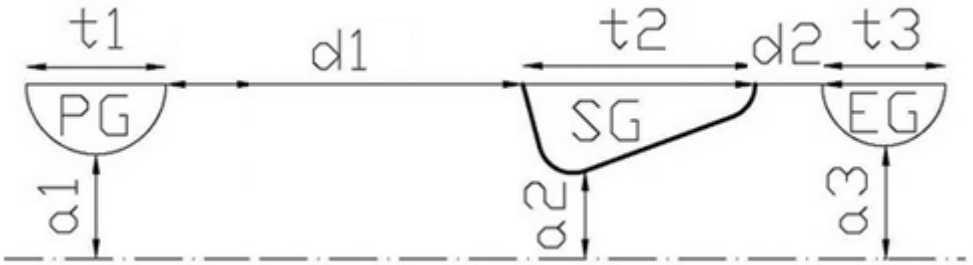
Layout of accelerator grids

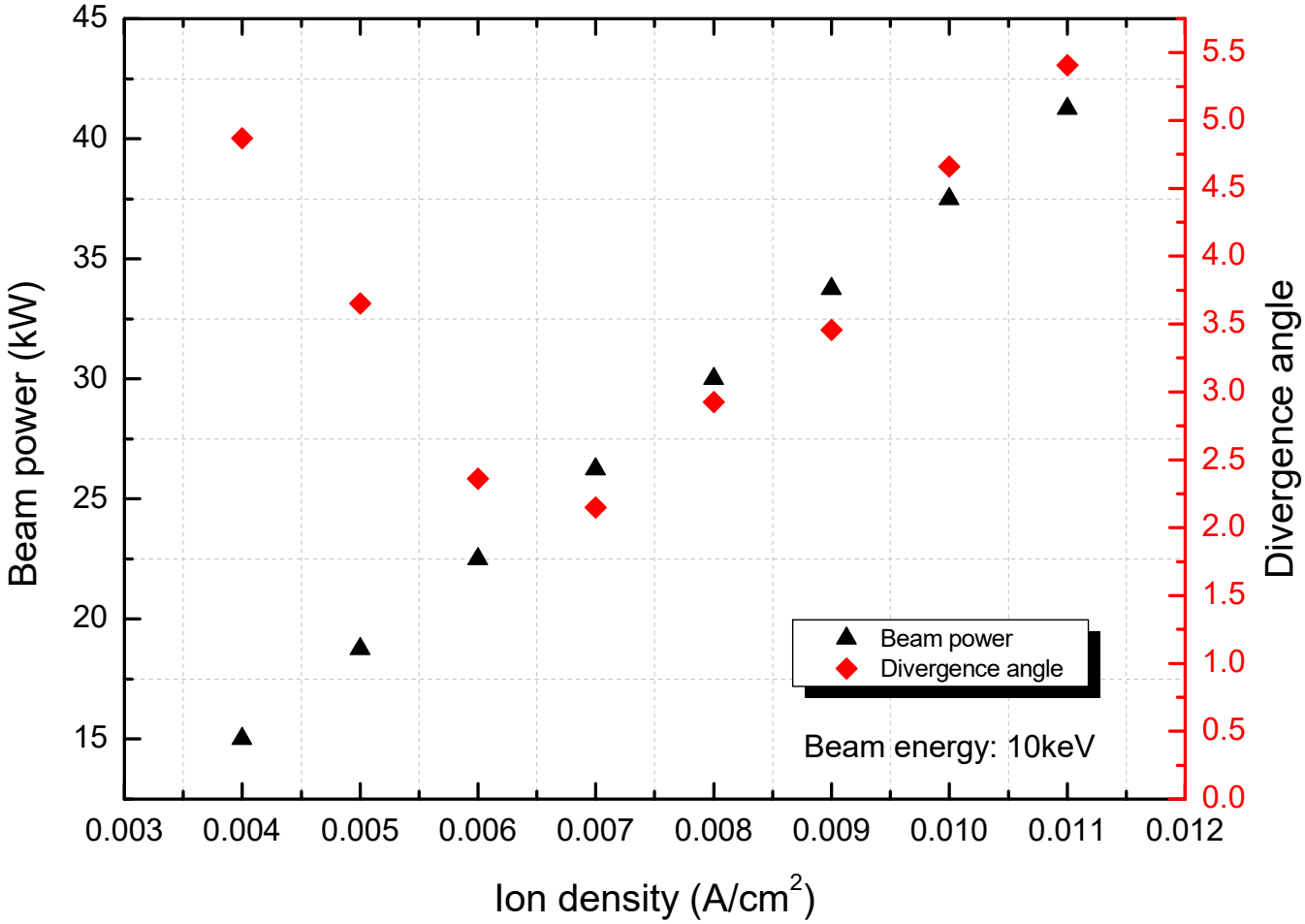
- PG and EG are circular shape
- SG is water-drop shape
- Length of grids is 35 cm
- Diameter of grids is 3.6 mm
- Distance between two grids is 5.4 mm
- The beam divergence angle was simulated



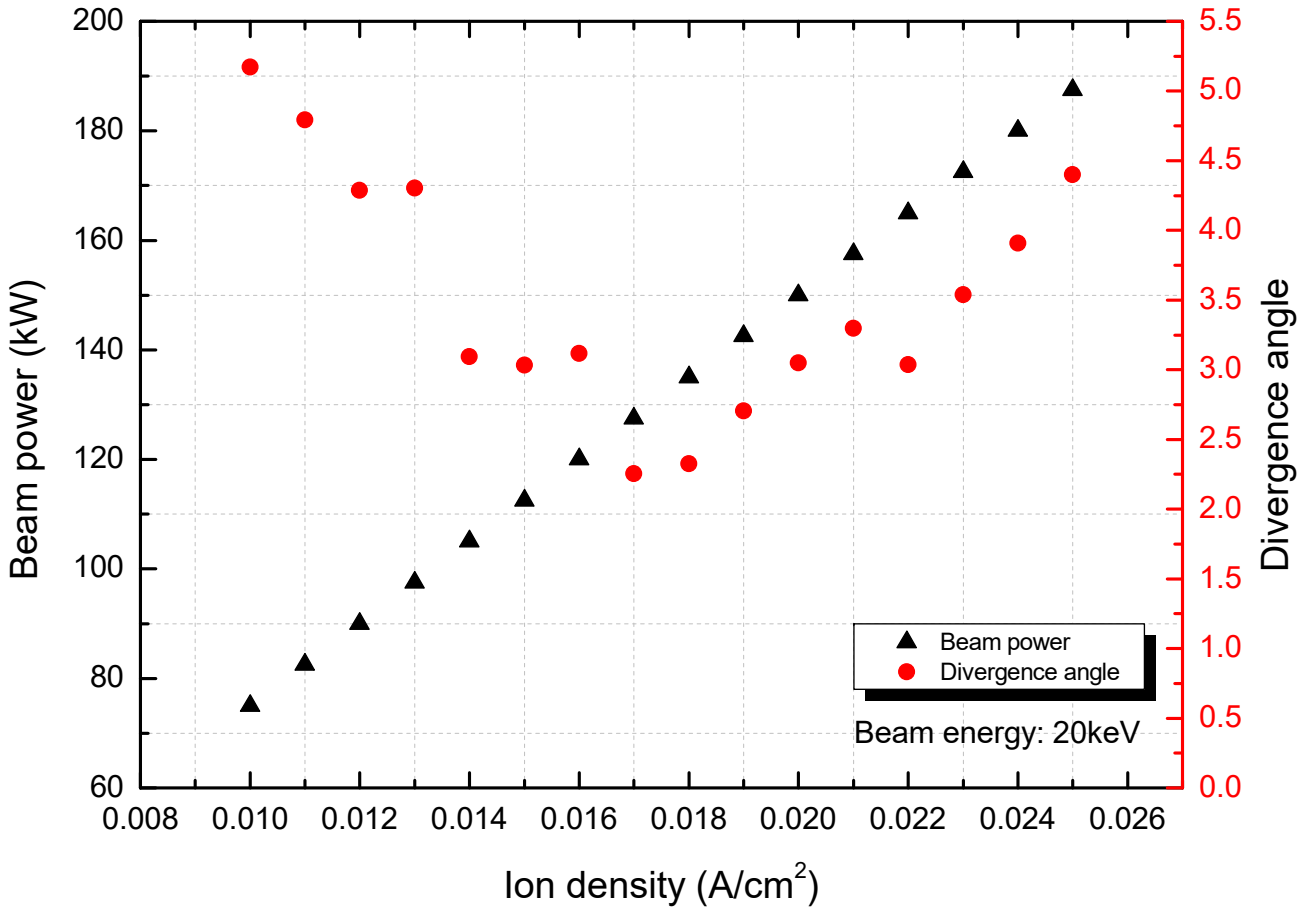


The schematic map of accelerator

Beam power and divergence angle (10keV)

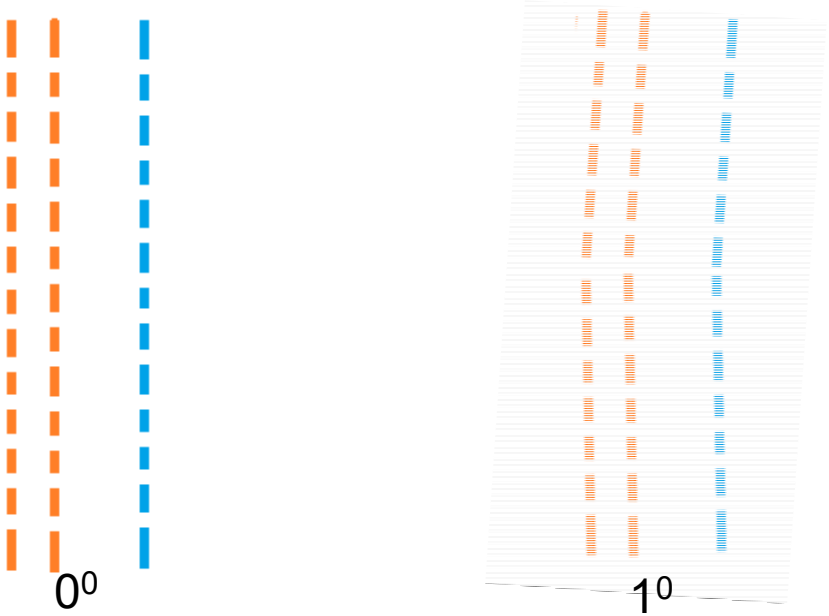


Beam power and divergence angle (20keV)

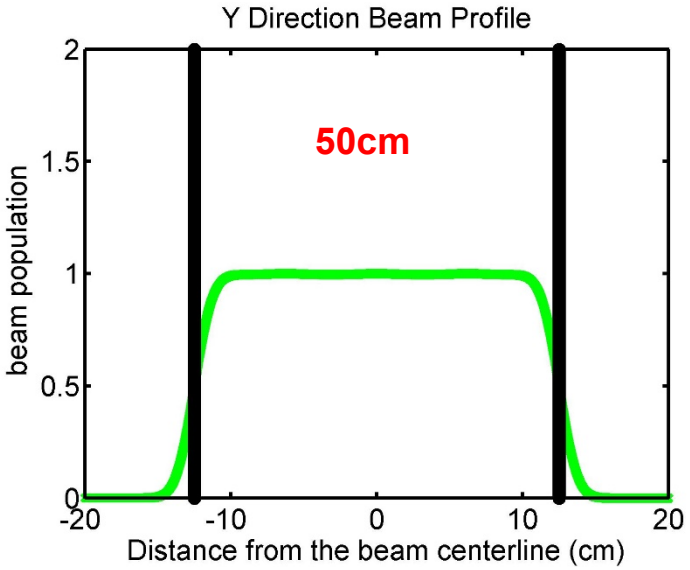


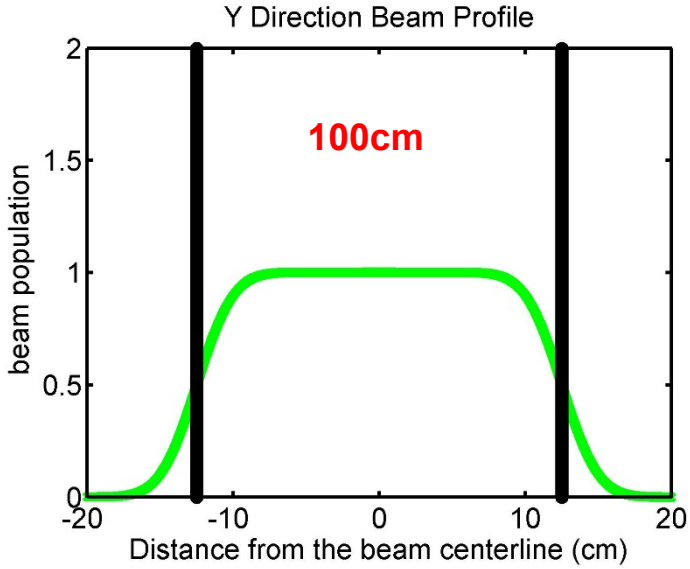
Beam transmission consideration

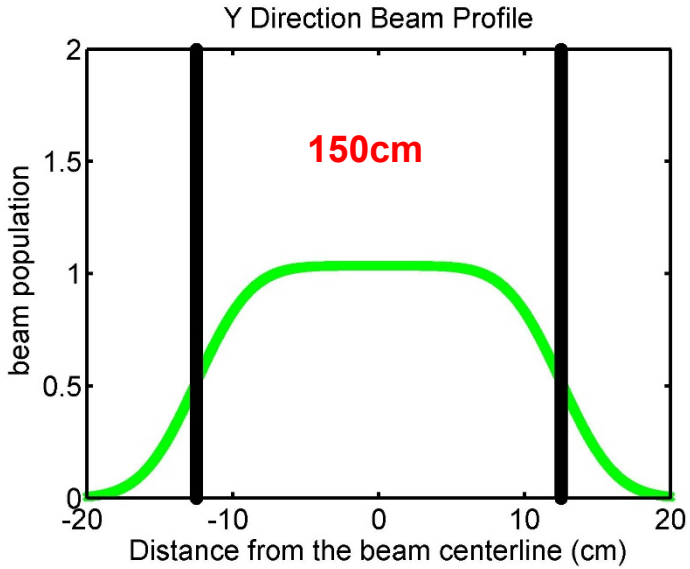
- The vacuum chamber is designed 1.5 m and the beam will transmitted about 1.8 m into the plasma
- The beam profile was simulated with minimum divergence angle(2.25 degree)
- Two segments of grids was installed with different angle

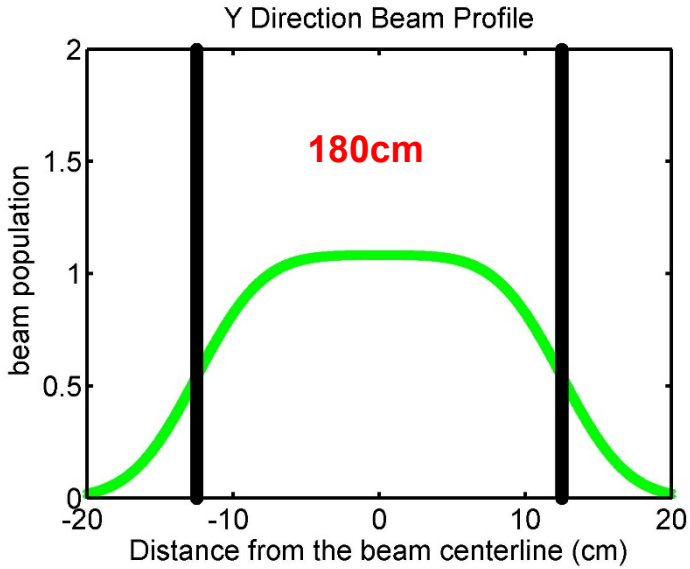


Beam profile with beam path(0^0)

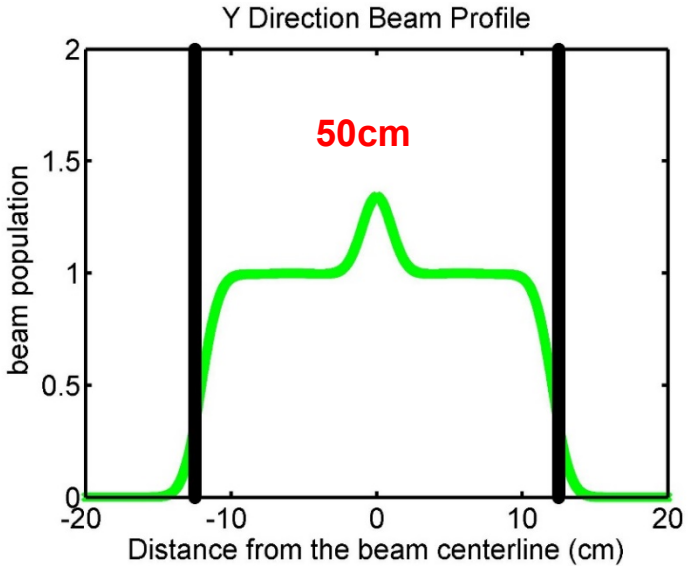


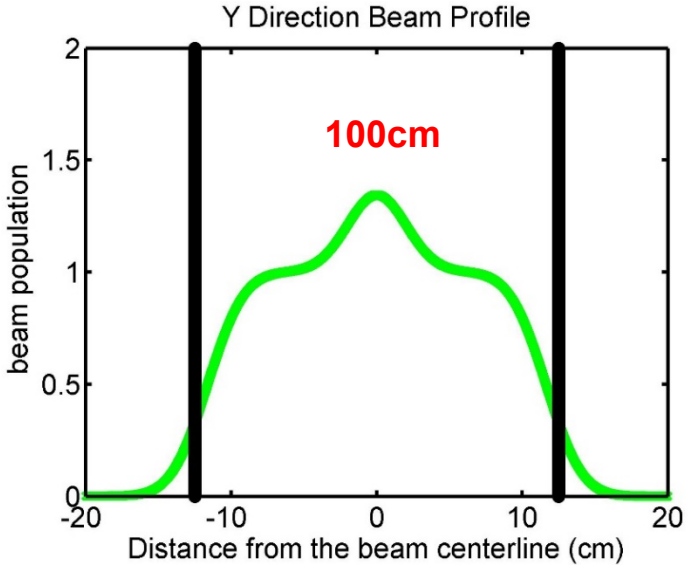


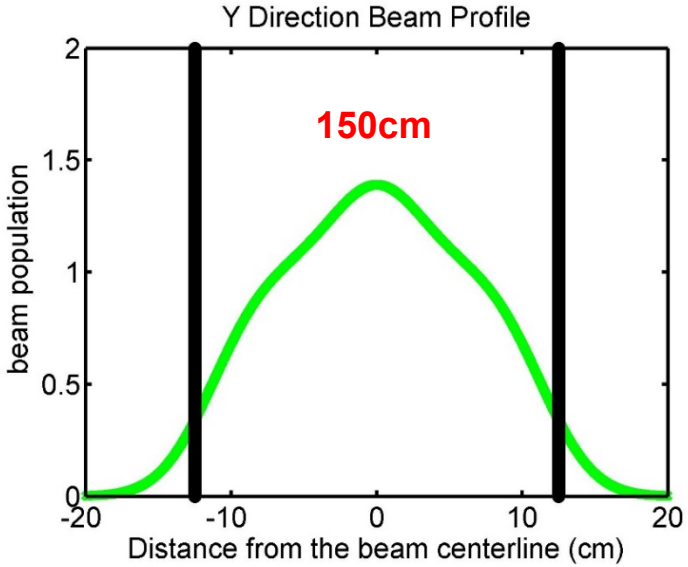


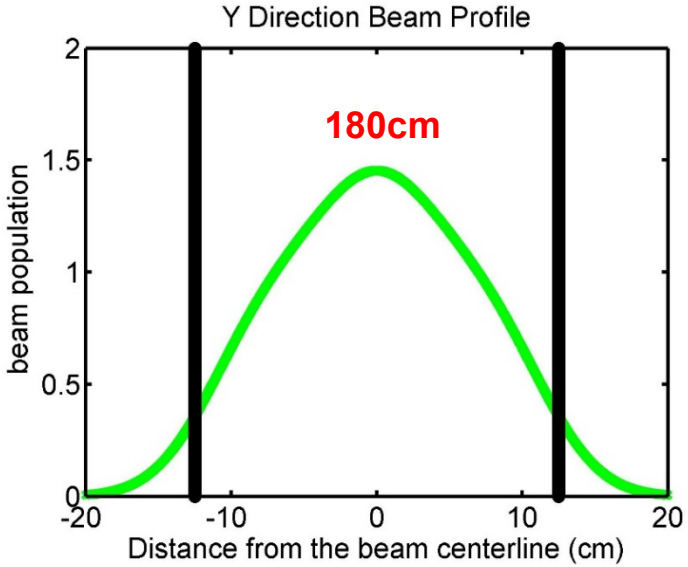


Beam profile with beam path (1^0)



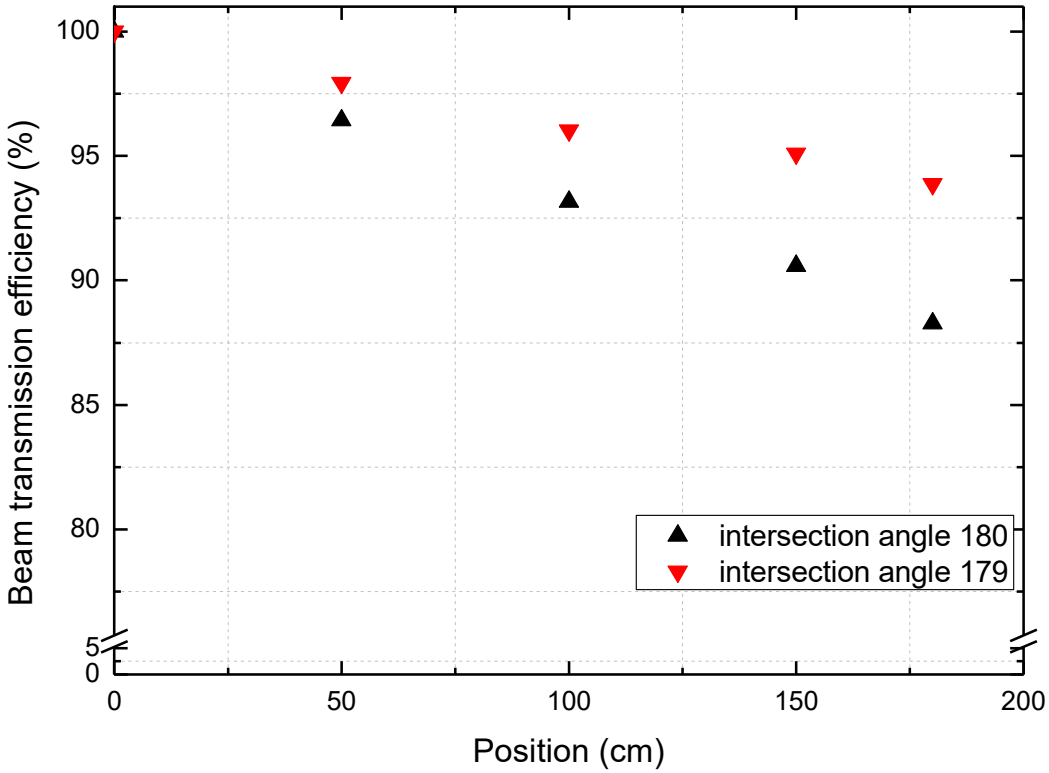






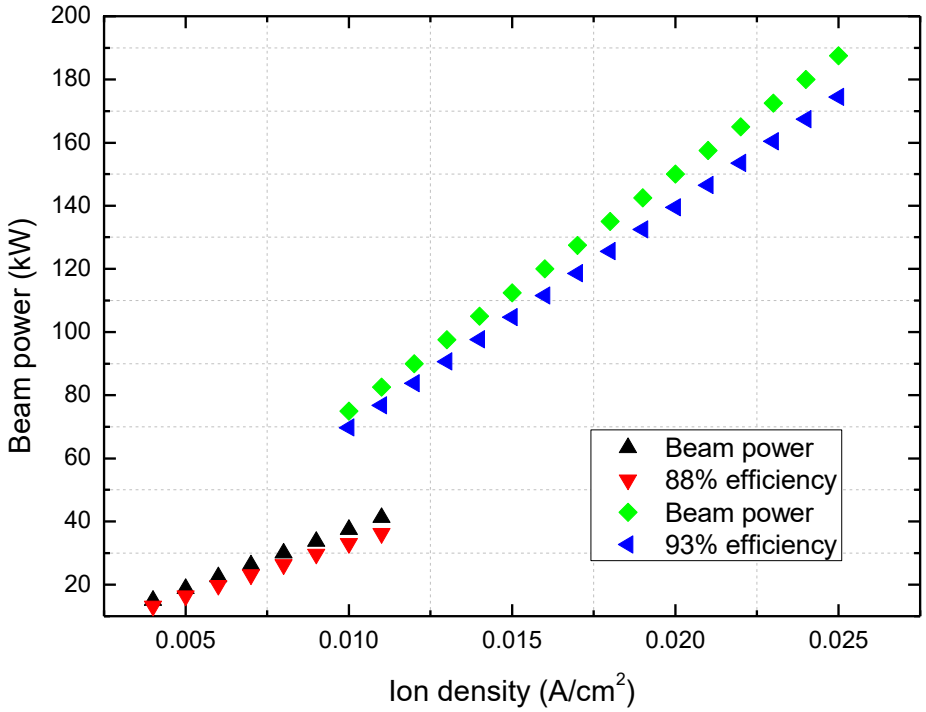
Beam profile and transmission efficiency

- The Bean profile is much smooth with flat accelerator grids
- The beam will overlap when two pieces of grids has angle of 1^0 and like Gaussian distribution
- The beam transmission efficiency with flat grids is about 88% and about 5% lower than the grids with 1^0 angle

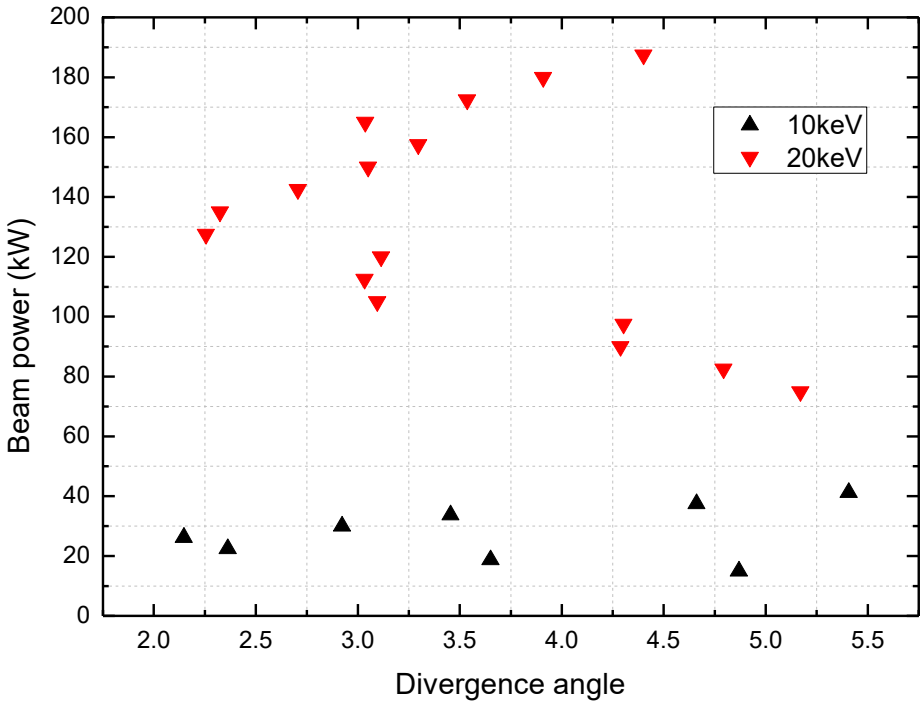


Beam power with different beam energy

- Beam power increased from 28kW to 130kW when beam energy change from 10keV to 20keV with optimum divergence angle



Beam power with different beam energy



Beam Power VS divergence angle

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- The Ne^+ source was designed to supply fast ions
- When beam energy is 10 keV, the max. beam power of 40 kW can be extracted when the divergence angle less than 5 degree (28 kW with min. divergence angle of 2.2 degree)
- When the beam energy is 20 keV, the max. beam power of 180 kW can be extracted when divergence angle less than 5 degree (130 kW with min. beam divergence angle of 2.2 degree)
- The results shown that, the max. beam power can not achieve 50 kW with beam energy of 10 kW, but the beam power can achieve 130 kW with beam energy of 20 keV

Thanks for your attention !