BEAM PROFILE MEASUREMENTS WITH A SLIT-FARADAY CUP AND A WIRE SCANNER FOR A NEWLY DEVELOPED 18 GHZ SUPERCONDUCTING ECR ION SOURCE AND ITS LEBT

H.J. You, *S.O. Jang*, *W. I. Choo*

Plasma Technology **R**esearch **C**enter, **N**ational **F**usion **R**esearch **I**nstitute, Gunsan, South Korea

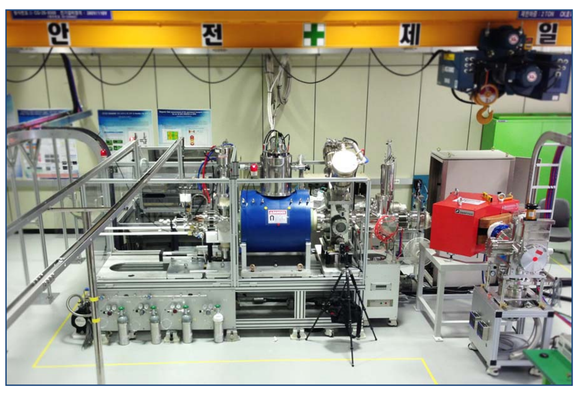
Abstract

In this presentation we show results of beam profile measurements by a slit-Faraday cup and a wire scanner. Argon 8+ beams were generated in a new liquid helium-free superconducting electron cyclotron resonance ion source (ECRIS). The ECRIS, named SMASHI, was successfully developed at the National Fusion Research Institute in 2014, and in the future it will be dedicated for highly charged ions matter interaction research facility (HIMIRF). Before designing HIMIRF terminals after low energy beam transport (LEBT), it is necessary to characterize the beam properties of the source and its LEBT line. The beam profile measurements have been done after an analyzing dipole magnet (DM). The slit-Faraday cup and the wire scanner were installed at 25 cm and 120 cm from the exit flange of the DM, respectively. Between the two diagnostics an Einzel lens was positioned to control the focusing of diverged beams. Here, with the measurements we checked the present beam alignments in the LEBT, and studied the dependence of beam profile variation on the operations of beam optics such as steering magnets and Einzel lens.

SMASHI (NFRI 18 GHz superconducting ECR ion source) & HIMIRF

» Main Features of SMASHI (Superconducting Multi-Application Source of Highly-charged Ions)

1) 2.1 T (B_{inj}), 1.5 T (B_{ext}), 0.4-0.6 T (B_{min})
   →"Liquid He-free" superconducting magnet & its flexible tuning
2) 1.3 T of high radial field (permanent magnet hexapole)
3) 18 GHz & Two frequency heating (18, 18±Δ GHz)
   Max. TWT power=1250 W
4) High power-capable Al/S.S. plasma chamber (Ø82×410 mm=2.2 liter)
5) Movable extraction-einzel lens system for low beam emittances
   Max. extraction voltage(V_{ext})=30 kV, Mas. Einzel lens voltage=-30 kV
6) Capability to generate diverse ion elements from gas to metal
7) Two diagnostic ports for diagnosing the extraction region of plasma



» Purposes of SMASHI & HIMIRF

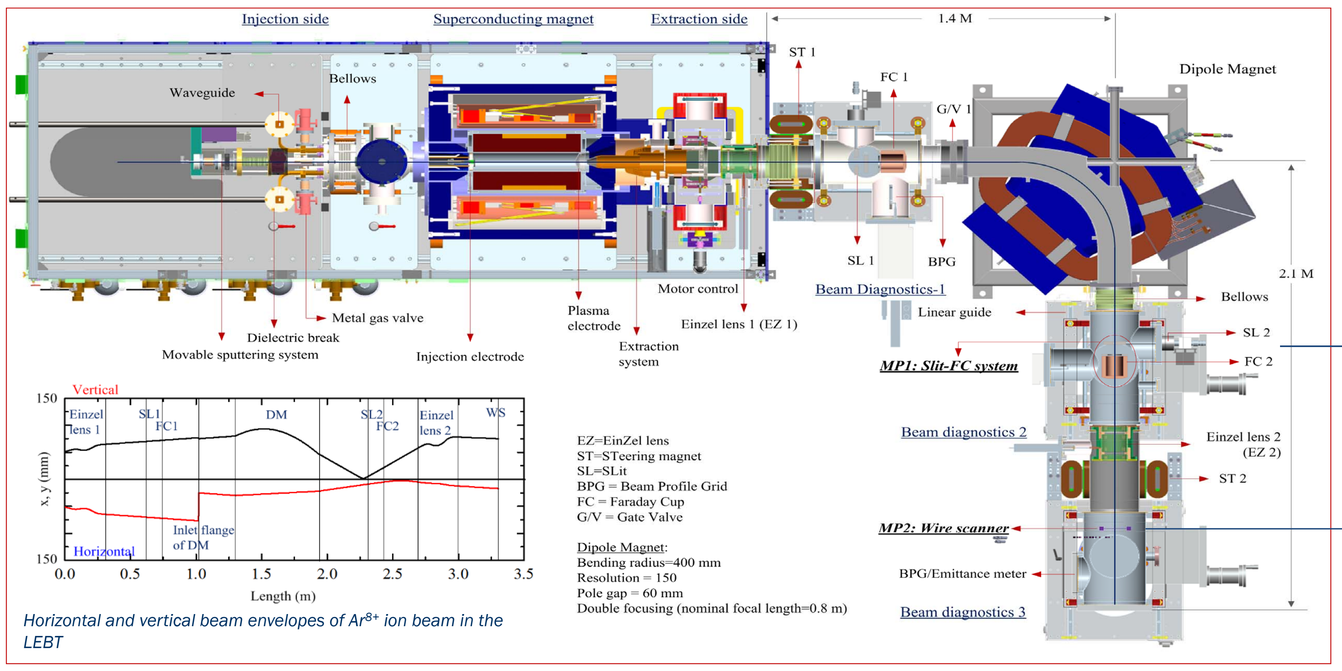
Development of Advanced high-performance ECR ion source

1) Development of compact high-performance ECR ion sources for heavy ion therapy and material(surface) interaction
2) Studies on ECRIS Plasma

Highly-charged Ion Matter Interaction by using well-defined ion beams

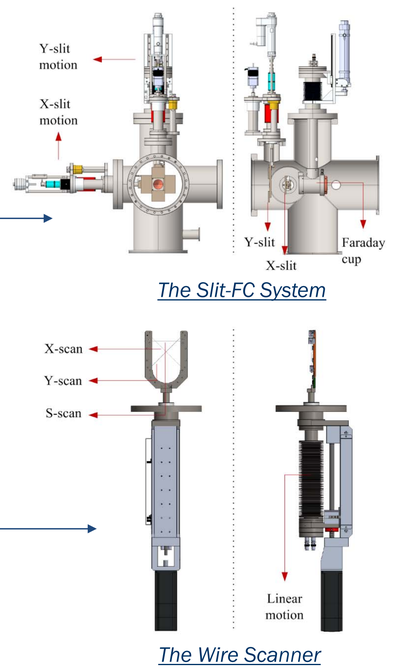
1) Investigation of various highly-charged ion-surface interactions
2) Ion beam studies & material analysis
3) Highly-charged ion micro-beam irradiation of living cells

» SMASHI & its LEBT



Horizontal and vertical beam envelopes of Ar^{8+} ion beam in the LEBT

» Beam Instrumentation for Beam Profile Measurement



For BPM, the x and y slit in the slit-FC system are designed to be independently movable from -25 to 25 mm. Also the gap widths(d's) of the slits are remotely controllable from 0 to 50 mm. When the slit-FC system works for BPM, the gap width of a moving slit is normally set to 2.5 mm, and the other one is set to 50 mm. In other words, when horizontal(x) beam profile is measured, x slit of d=2.5 mm is moved from x=-25 to 25 mm while y slit is fixed at y=0 with its gap width set to 50 mm. The FC is comprise of an isolated metal cup and a high voltage suppression ring close to the entrance of the cup. The cup is Ø50 mm in diameter and 80 mm in length, and the suppression ring can be biased up to -1 kV.

The wire scanner (WS), shown Fig. 5(b), is a fork type scanner. The WS is inserted into the beamline by an angle of 45 degree. The WS is composed of three wires mounted in horizontal(x), vertical(y), and diagonal(s) directions, so that three directions of profiles can be simultaneously measured by one passage. The scanning length of the WS was designed to be 165 mm; The measurement ranges of x, y, and s direction become 50(-25 to 25 mm), 50(-25 to 25 mm), 95 mm(-42.5 to 42.5 mm), respectively.

Initial Results of Beam Charge Spectra, their Intensities & Beam Profiles

» Preliminary Results of beam charge spectra from SMASHI (B_{inj}=1.7 T, Max. TWT power=600/900 W)

Beam charge spectra of ^{4}He, ^{16}O, ^{40}Ar, ^{132}Xe ion beams

Operation conditions

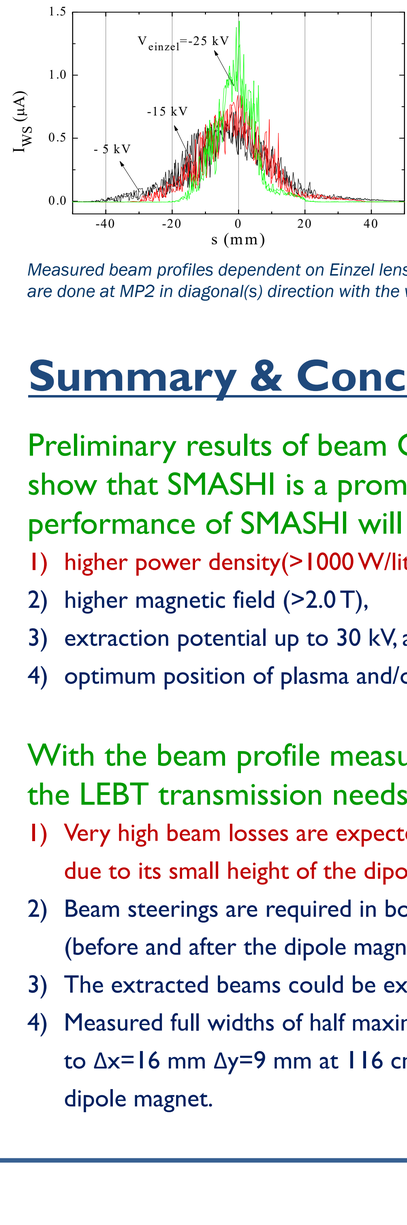
- Max. TWT Power = 600 W[1] + 300 W[2]
  Input power was limited to ~900 W due to high X-ray dose rate(>0.5 μSv/h) at operator position
- B_{inj}=1.7 T (80 %), B_{ext}=1.3 T, B_{min}=0.5 T
- Extraction voltage ≤ 20 kV, ∅8 mm aperture
- Biased disk voltage = -200~600 V
- Stainless steel plasma chamber & No gas mixing

Charge	^{4}He	^{32}O	^{40}Ar	^{132}Xe
1+	910			
2+	**900***			
3+				
4+				
5+		184		
6+		**202***		
7+		43	105	
8+		4.3	**200***	
9+			138	
10+			75	
11+			31	
12+			9.4	
13+			2	
19+				25
20+				**23***
21+				22

※ **Results of 600 W operations are in blue**, and **those of 900 W operations are in red**. Optimized charge is indicated by asterisk(*).

» Beam Profile Measurements of Ar^{8+} by the Slit-FC & the Wire Scanner

Horizontal (x) and vertical (y) beam profiles measured by (a) the Slit-FC system at MP1 and (b)-(d) the wire scanner at MP2: (b) not steered, (c) x-steered by ST1 (0.24 A), (d) y-steered by ST2 (1.2 A)



Measured beam profiles dependent on Einzel lens potential (V_{einzel}). The measurements are done at MP2 in diagonal(s) direction with the wire scanner

Summary & Conclusion

Preliminary results of beam CSD & their intensities show that SMASHI is a promising source and its performance of SMASHI will be enhanced by applying

1) higher power density(>1000 W/liter),
2) higher magnetic field (>2.0 T),
3) extraction potential up to 30 kV, and
4) optimum position of plasma and/or injection electrode

With the beam profile measurements, we found that the LEBT transmission needs to be improved:

1) Very high beam losses are expected in front of the dipole magnet due to its small height of the dipole inlet.
2) Beam steerings are required in both side of the dipole magnet (before and after the dipole magnet).
3) The extracted beams could be experiencing a rotation.
4) Measured full widths of half maximum of Ar8+ beam are estimated to Δx=16 mm Δy=9 mm at 116 cm from the exit flange of the dipole magnet.

(E) hjyou@nfri.re.kr (T) +82.10. 3327.7615