PERMANENT MAGNET ECRIS FOR THE KEK DIGITAL ACCELERATOR

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KEK-DA Including ECRIS and Low Energy Beam Transport Line

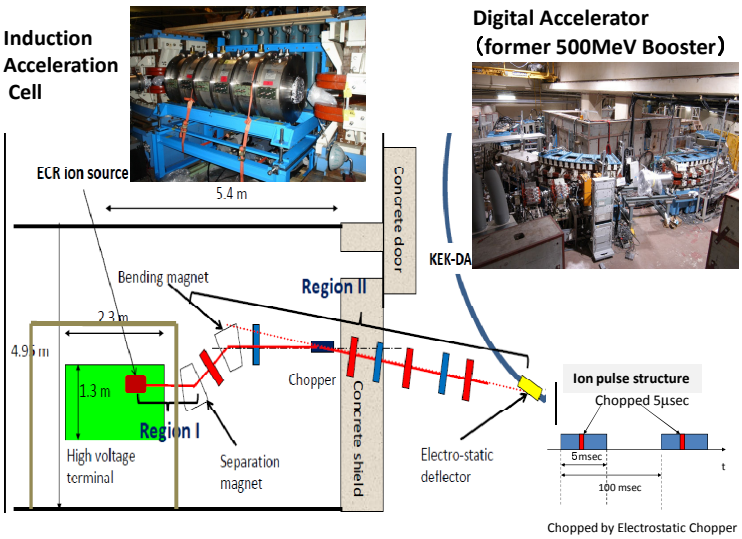

Figure 1: Overview of KEK DA, ion source and low energy beam transport

ECRIS Devices and Parameters

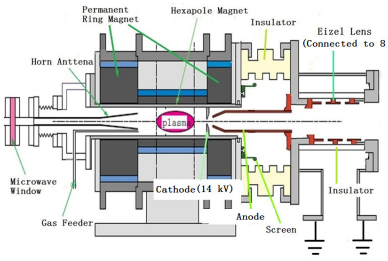

Figure 2: Schematic overview of the X-band ECR for The KEK-DA

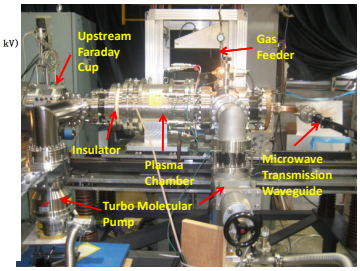

Figure 3: Photograph of the ECRIS at test bench

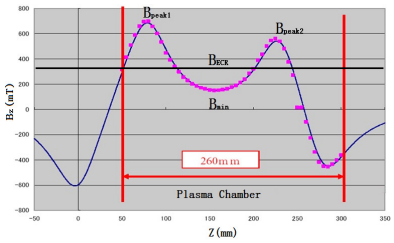

Figure 4: Field distribution through the ECRIS. B_{peak1}=7 kG, , B_{peak2}=5.6 kG, , B_{min}=1.7 kG and B_{ECR}=3.3kG, B_{radial}=5 kG

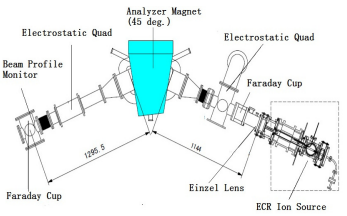

Figure 5: Schematic overview of test bench

Test Bench Measurement Results

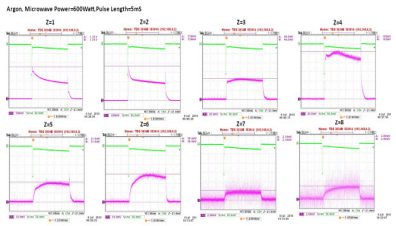

Figure 6: Waveform of ion current, upper green trace is the reflection of microwave power (Argon)

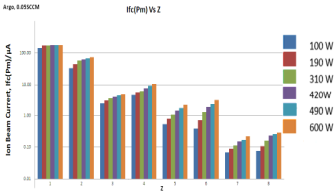

Figure 7: Ion current of an individual charge state for various microwave power (Argon)

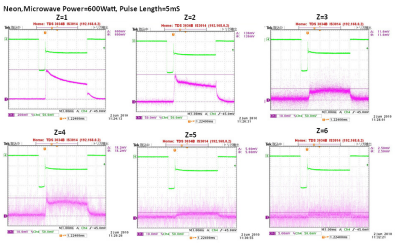

Figure 8: Waveform of ion current, upper green trace is the reflection of microwave power (Neon)

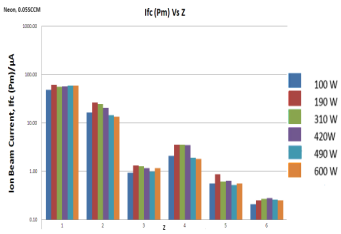

Figure 9: Ion current of an individual charge state for various microwave power (Neon)

High Voltage Terminal

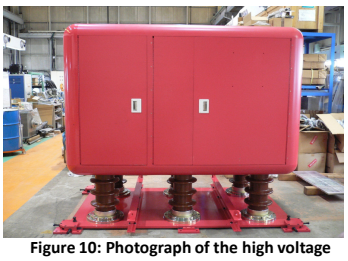

Figure 10: Photograph of the high voltage terminal box

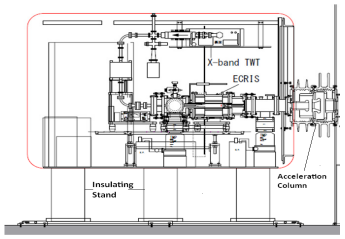

Figure 11: High voltage terminal

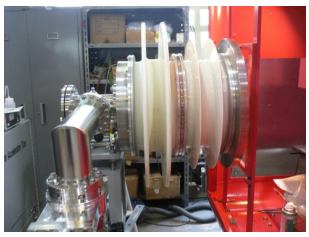

Figure 12: 185 kV acceleration column

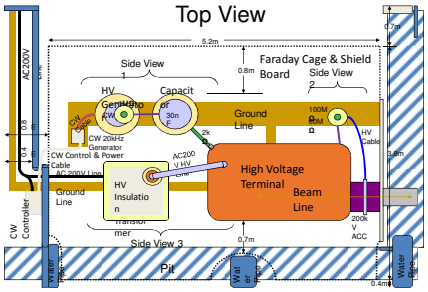

Figure 13: Layout of high voltage terminal setup

Anode , Cathode and Einzel Lens

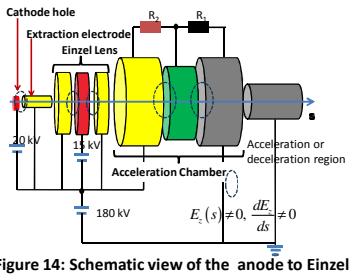

Figure 14: Schematic view of the anode to Einzel lens

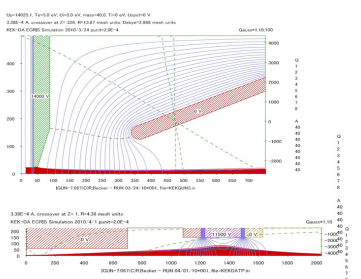

Figure 15: Beam envelope from anode to cathode and from cathode to Einzel lens

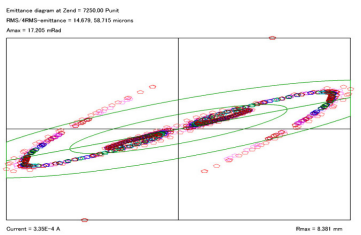

Figure 16: Phase space plot by IGUN Simulator

- IGUN simulator is used to simulate the beam dynamics.
- Beam emittance and phase space plot are generated from IGUN output.
- The experimental result is in good agreement with the total estimation ion current from IGUN simulation based on the Langmuir-Child law.

Discussions and Summary

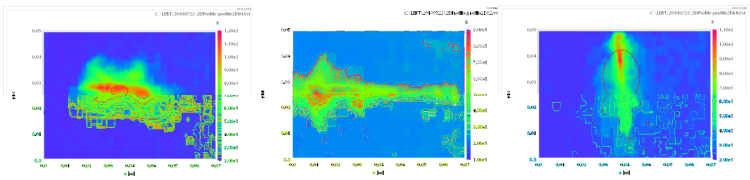

Figure 17: X-Y plane beam profile analysis results for various cases

DISCUSSIONS

- Achieved highest charge states for Oxygen, Neon and Argon were 6, 6 and 8.
- The ionization energy (ΔE) of $Ar^{7+\rightarrow 8+}$ is 143.5 eV, $Ar^{8+\rightarrow 9+}$ is 422.4 eV and $Ne^{5+\rightarrow 6+}$ is 157.9 eV, $Ne^{6+\rightarrow 7+}$ is 207.3 eV and $O^{5+\rightarrow 6+}$ is 138.1 eV, $O^{6+\rightarrow 7+}$ is 739.3 eV might lead to the achieved charge state for the present ECRIS.
- To obtain higher charge state ions, the electron energy must be sufficiently higher than the required ionization energy for a desired charge state.
- Ion beam profile measurements are consistent with the predicted results.

SUMMARY

- The present ECRIS can deliver low charge-state ions current with sufficient intensity.
- The ion intensity of higher charge state is not sufficient enough.
- The low B_r may attribute to the low intensity of higher charge state.
- For further improvement, installation of a thinner hexapole is undergoing in our present ECRIS.