MICROWAVE FREQUENCY DEPENDENCE OF THE PROPERTIES OF THE ION BEAM EXTRACTED FROM A CAPRICE TYPE ECRIS

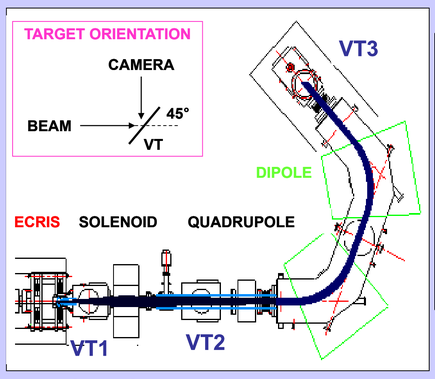
F. Maimone[1,2], K. Tinschert[1], P. Spädtke[1], J.Mäder[1], J. Roßbach[1], R. Lang[1], L. Celona[3]

[1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstr. 1, 64291 Darmstadt, Germany
[2] Università degli Studi di Catania, D.M.F.C.I., Viale A. Doria 6, 95125 Catania, Italy
[3] INFN-LNS, Via S.Sofia 62, 95123. Catania, Italy

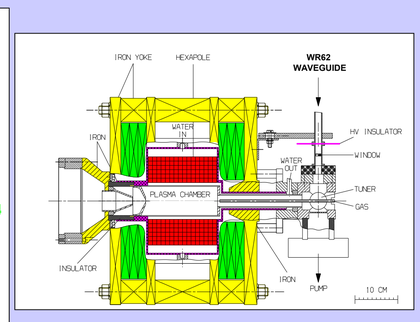
XIXth International Workshop on ECR Ion Sources
ECRIS 2010
LPSC Grenoble, France, August 23 – 26, 2010

EXPERIMENTAL SET-UP

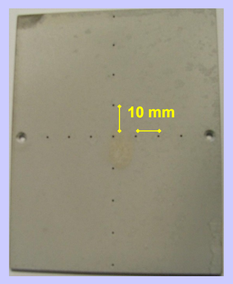
- 1.2 T maximum radial magnetic field
- Plasma chamber dimensions: 179 mm of length and 64 mm of diameter
- 100 W RF power provided by a TWTA (Traveling Wave Tube Amplifier) driven by one signal generator (two for the double frequency experiment) sweeping in the frequency range of 12.5÷16.5 GHz (steps 200 kHz with a dwell time of 20 ms for each step)
- Argon with Helium as mixing gas
- Extraction voltage set to 15 kV and -2 kV screening voltage
- Two directional couplers of high directivity measure the forward and the reflected microwave power
- Viewing targets (coated with KBr) monitor the beam shape evolution after the extraction (VT1), after the focusing solenoid (VT2) and the selected charge states beam (VT3)



EIS TESTBENCH BEAM LINE WITH TARGETS POSITIONS

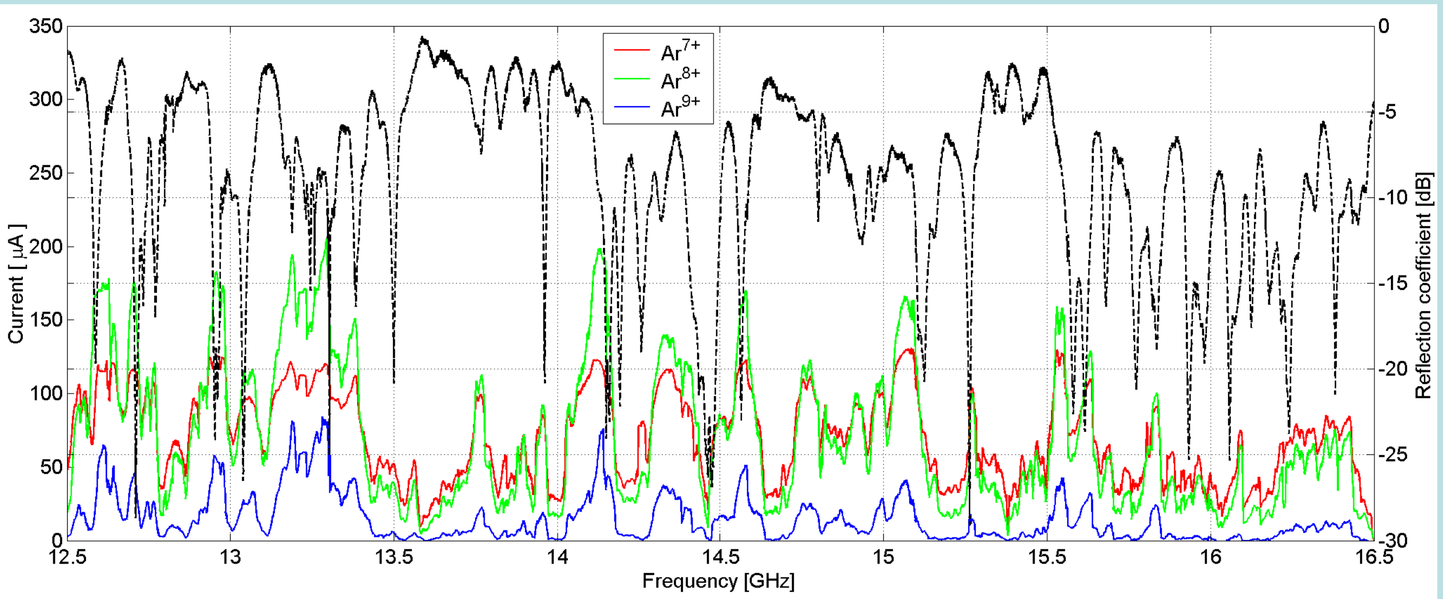


CAPRICE ECRIS



VIEWING TARGET

SINGLE FREQUENCY SWEEPING

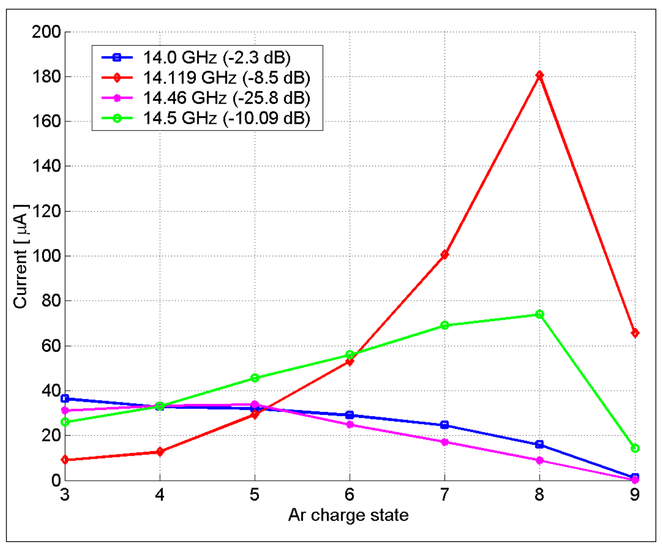


Reflection coefficient and current evolution vs. microwave frequency (the coloured solid lines refer to the left scale while the dashed black line is the reflection coefficient referring to the right scale)

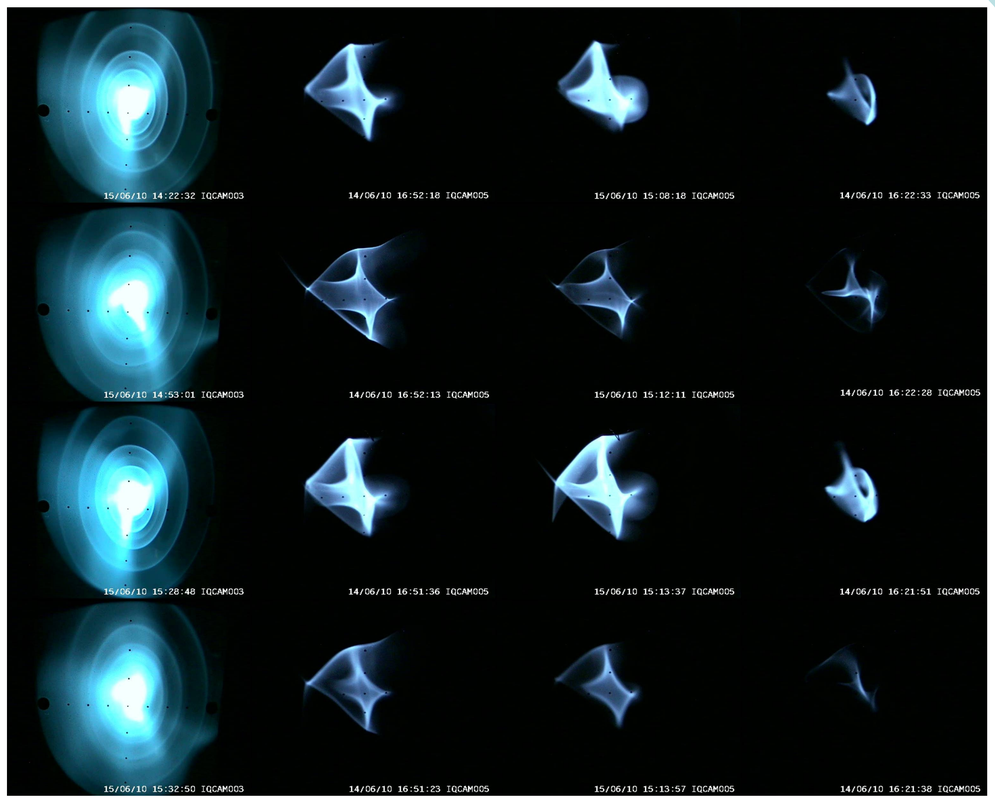
- Unchanged source parameters during the measurement sessions and reproducible experimental results.
- The matching impedance between the cavity filled by the plasma and the electromagnetic wave clearly depends on the frequency.
- The peaks of the reflection coefficient and the current amplitude are strongly correlated.
- The current amplitude affected by the choice of the operative frequency, i.e. the Ar^{8+} current ranges from a few μA up to 200 μA.
- Same evolution of the Ar^{7+} and Ar^{8+} currents with different amplitudes in the peak positions and in the minima points.
- In the range 15.64-16.5 GHz the currents of the higher charge states, i.e. Ar^{9+}, tend to lower values.
- The drain current evolution follows the trend of the three charge states.

ARGON CHARGE STATES DISTRIBUTION

- 14.5 GHz is the normal operation frequency of the CAPRICE ECRIS.
- 14.46 GHz and 14.119 GHz are the frequencies where the respective minimum and maximum Ar^{8+} current were measured in the 14-15 GHz frequency range.
- At 14.0 GHz and at 14.46 GHz similar charge state distributions were obtained with different reflection coefficients (indicated in the legend of the figure).



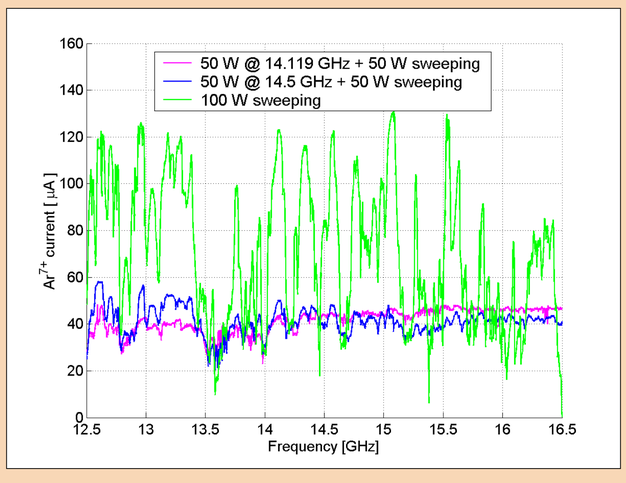
- For the frequencies where the higher charge states are favoured the current of lower charge states is decreasing and vice versa.
- The frequency tuning is more affecting the higher charge states.
- At 14.119 GHz the current enhancement respect to the normal operation frequency is 240% for the Ar^{8+} and 450% for the Ar^{9+}.

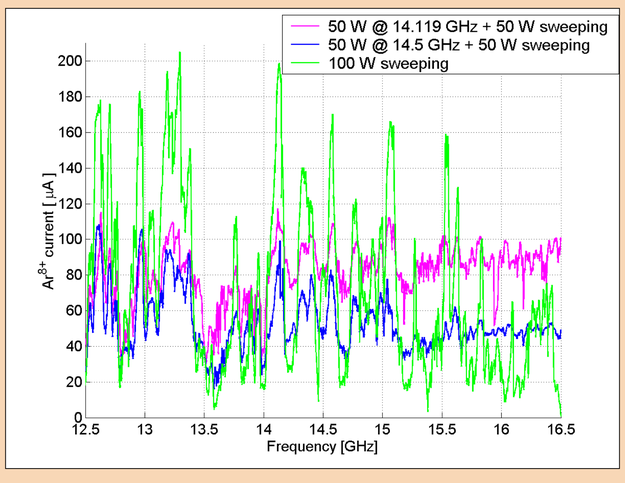


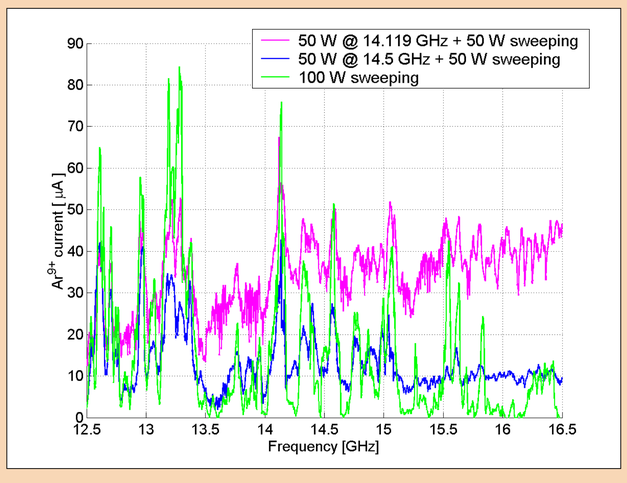
Argon beam viewed at the targets located after the focusing solenoid (first column) and after the dipole for the Ar^{7+}, the Ar^{8+} and the Ar^{9+} respectively

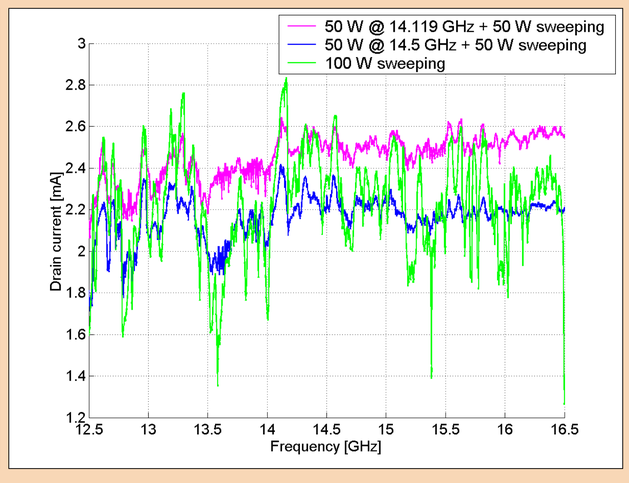
DOUBLE FREQUENCY HEATING

- Two sweeping microwave generators, providing the same power, have been used to drive the TWTA in order to feed the plasma of the CAPRICE ECRIS with two electromagnetic waves (50 W power for each wave).
- One frequency was fixed while the second one was sweeping in the 12.5÷16.5 GHz frequency range.
- Two fixed frequencies were chosen: 14.5 GHz (normal operation of the source) and 14.119 GHz (enhances the current of the higher charge states).









The choice of the fixed frequency allows to enhance the higher charge states current. With two frequencies the current peaks are lifted, the frequencies where they occur remain the same, the mean current remains high (almost constant for the Ar^{7+}) while the higher charge states tend to higher currents when increasing the frequency.