# Research and Development on ECR Ion Sources

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## Upgrade of the HLI microwave system

In the last years several experiments using the technique of frequency tuning were carried out at the ECR injector test setup (EIS) of GSI in order to investigate the influence on the performance of the CAPRICE-type ECR Ion Source (ECRIS) in terms of enhanced ion currents of high charge states [1] [2]. It was demonstrated that this technique allows increasing the ion current extracted from an ECRIS both for gaseous and for metallic elements [3].

In order to use this technique for the routine operation of the ECRIS installed at the high charge state injector (HLI) of GSI, the microwave injection system has been modified. Figure 1 shows a schematic view of the upgraded microwave system. A signal generator provides the microwave signal to be amplified by two traveling-wave tube amplifiers (TWTAs). Each of them provides up to 650 W in the frequency range 12.75-14.5 GHz. When the required power is higher than 650 W, i.e. for Ca or Ti beam production, the power of the two amplifiers is summed up through a WR62 waveguide power combiner. The system is integrated into the existing waveguide system with a WR62 mechanical switch. With this versatile setup the microwave input can be switched from the waveguide line connected to the klystron to the one where the upgraded system including the TWTAs is installed. Two directional couplers are inserted between the switch and the ion source. Microwave power probes are connected to each directional coupler to measure the forward power and the reflected power to and from the ECRIS. The knowledge of the reflection coefficient is beneficial to optimize the microwave coupling to the plasma which is a fundamental condition for a good performance and stable operation of the ECRIS [1].

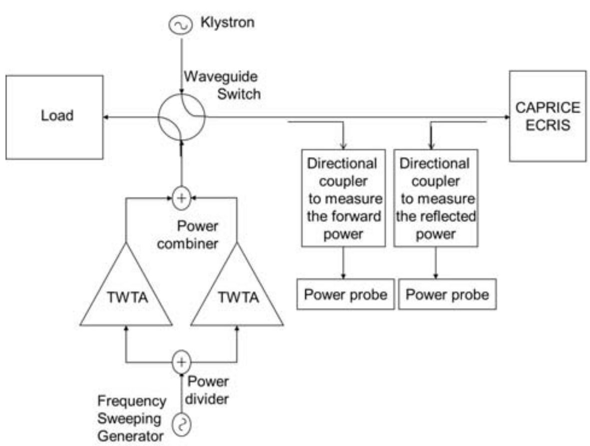


Figure 1: Block diagram of the upgraded microwave system of the HLI

## X-ray spectroscopy

In the framework of the ENSAR-ARES collaboration (supported by the European Union Seventh Framework Programme FP7/2007-2013 under EU grant agreement n ° 262010) various experiments have been carried out on the investigation of X-ray emission from the CAPRICE ECRIS. The measurements were performed at the EIS test setup by using two different detectors. A Silicon drift detector (2-30 keV) has been mounted at the extraction electrode, and a high purity Ge detector (30-500 keV) has been placed behind the analyzing dipole magnet in 0 ° direction, respectively. The experiments were performed at different settings of the confining magnetic field and at different microwave frequencies to characterize the electron energy distribution and to investigate correlations with the charge state distribution (CSD) of the extracted ion beam. Results show that the tuning of the heating frequency considerably affects the plasma density. Details are reported in [4].

## Beam profile measurements

Ion beams extracted from an ECRIS are in most cases characterized by an internal structure with inhomogeneous current density distribution. Viewing targets (VT) can be used to obtain a qualitative 2D image of the beam profile [5]. For quantitative measurement of spatially resolved 2D current density distributions a multiple Faraday cup array (FCA) is a versatile tool [6]. An in-situ comparison of VT and FCA performed at the EIS test setup in cooperation with L. Panitzsch (Institute for Experimental and Applied Physics, University of Kiel, Germany) could confirm good agreement. A detailed analysis of the data is in progress.

## References

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