Space charge investigation for low energy ion beams with a 4-grid analyzer

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4-grid Analyzer

The 4-grid Analyzer, or Retarding Potential Analyzer (RPA) is dedicated to space charge compensation measurements of ion beams by analyzing the energy distribution of secondary ions accelerated by the beam potential. The RPA consists of four grids, as shown in Figure 1. Grid one is on ground potential to shield the ion beam. Grid two repels electrons coming from the beam tube. The voltage on grid 3 is retarding and can be varied from negative to positive electric potential to filter secondary ions produced during interaction between primary ions and residual gas in the beam. The fourth grid repels electrons produced in the Faraday cup at the end of the RPA. For capturing the signal a current to voltage transformer (I-U transformer) with a high signal acceptance is used.

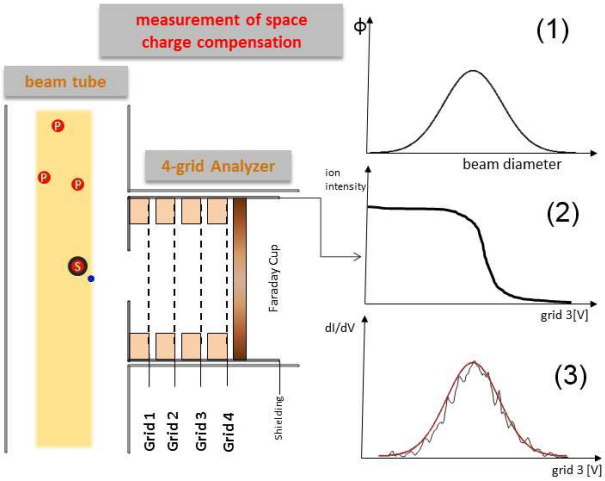

Figure 1: Schematic view of the 4- grid analyzer, data acquisition and analysis.

Secondary ions fully pass the third grid up to a certain potential which leads to a decrease of the Faraday cup signal. (1) shows an example for the ion beam potential as a function of the ion beam diameter. (2) shows the signal captured by the Faraday cup and (3) the estimated ion beam potential received from the measurement by derivation of signal (2). The uncompensated beam potential $\Delta\Phi_{uncomp}$ is calculated using

$$\Delta\Phi_{uncomp} = \frac{I}{4\pi \cdot \epsilon_0 \cdot v_{ion}} \qquad (1)$$

Experimental Results

Measurements are performed at the high current test bench and at the high current test injector under variable conditions. First measurements are performed with a high current ion source (MUCIS), single hole extraction system with He and Ar gas. An example for the results is shown in Figure 2.

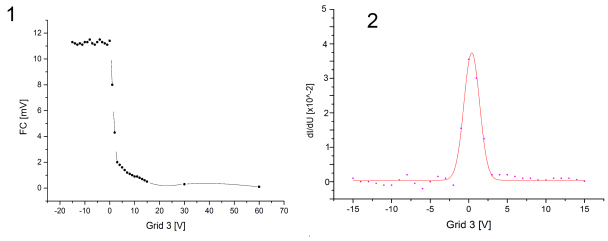

Figure 2: (1) Measurement at high current test bench $U_{Extr} = 20kV$,$I_{FC} = 7mA$; (2) Results via derivation

Above a voltage of $\Delta\Phi_{uncomp} = 122V$. This results in a space charge compensation of the ion beam of apparently 98%.

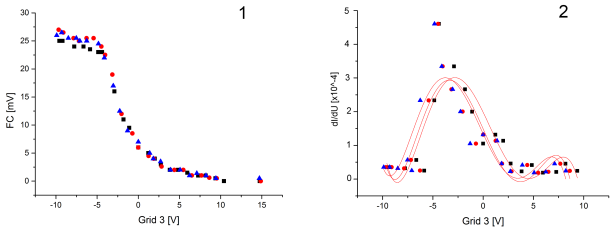

Figure 3: (1)Measurements at HOSTI test injector; $U_{Extr} = 110kV$,$I_{FC} = 10mA$ (2) Results via derivation

At HOSTI the RPA is installed behind a superconducting solenoid to analyze focused ion beams. Potentially inside the solenoid the beam compensation can partly be destroid. In Figure 3 space charge compensation varies round 97% based on $\Delta\Phi_{uncomp} = 23.7V$.

Outlook

It is planned to check on the time dependency of space charge compensation in a pulsed ion beam at HOSTI test bench. Various ion source types with different extraction systems for high current injection will be used to compare light and heavy ion operation as well as metal operation.

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