SPATIAL RESOLUTION TEST OF A BPMS FOR DESIREE BEAM LINE DIAGNOSTICS*

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Abstract

A beam profile monitoring system (BPMS) to cover the wide range of beam intensities and energy was built for the DESIREE (Double ElectroStatic Ion Ring ExpEriment) beam line diagnostics. The spatial resolution of the system was tested for a H_2^+ beam of energy 3.5, 5, 10, and 20 keV, respectively, and was found to be around 2 mm. For the lowest energies, a substantial steering effect on the ion beam before hitting the Al foil was observed and found to be in agreement with calculations with SIMION.

INTRODUCTION

Single electrostatic ion storage rings have attracted considerable attention in recent years in atomic and molecular physics because of several advantages over magnetic storage rings [1-2]. Motivated by the success of electrostatic ion storage rings and the possibility of performing merged-beams experiments with positive and negative ions, DESIREE as shown in Fig. 1 has been under construction at Stockholm University and will soon be ready for the experiments [3].

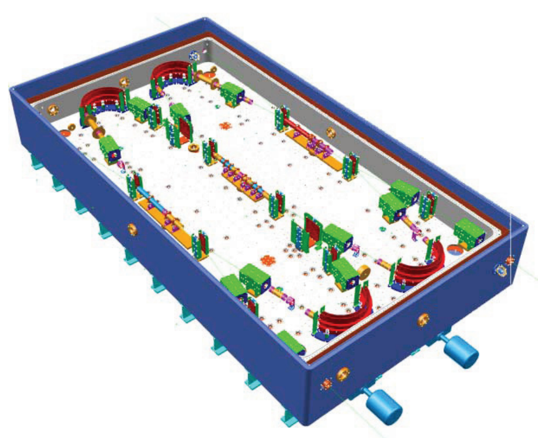

Figure 1: Schematic layout of DESIREE. It consists of two rings of same circumference, 9.2 m, and a common straight section of length 1 m for the merged-beams experiments with ions of opposite charges.

A BPMS based on the observation of low energy secondary electrons (SE) generated by a beam striking a metallic foil was recently developed by Kruglov and coworkers [4]. Inspired by its simplicity and applicability, a similar BPMS to cover the wide range of beam intensities and energies was built at Stockholm University for the DESIREE beam line diagnostics. To test the spatial resolution of the BPMS, a beam collimator containing a set of circular holes of different diameters and separation between them was built [5], and tested with proton and H_2^+ beams. The resolution was found to be around 2 mm.

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EXPERIMENTAL SET-UP

The BPMS consists of an aluminum (Al) foil, a grid placed in front of Al, a microchannel plate (MCP), a fluorescent screen (F.S.), a PC, and a CCD camera. For the present measurements three holes of diameter 1 mm and separated by a distances 2 and 4 mm, respectively, and H_2^+ beams of energy 3.5, 5, 10, and 20 keV were used. The schematic diagram of the experimental set-up is shown in Fig. 2. The collimator creates well separated (distinguishable) narrow beams of approximately same intensity. The collimator and the Al foil attached with the grid can be inserted and taken out of the beam path by a pneumatic feed-through. The beams from the CRYRING source passes through the collimator, strikes the Al foil, and knocks out low energy (~10 eV) secondary electrons (SE). These electrons are accelerated by a homogeneous electric field applied between the Al foil and the grid, kept at negative (V_{acc}) and ground potentials, respectively. The accelerated electrons from the grid then travel the field free region to the MCP where they get amplified. The cascade of electrons after leaving from the back of the MCP hits the F.S. and produces flashes of light, which, are captured by a CCD camera. This camera is connected to a PC for further storage and analysis of the recorded light intensities.

RESULTS AND DISCUSSION

The CCD images of the light produced in the F.S. after the beam passing through the collimator and striking the Al plate are shown in Fig. 3 for a 3.5 keV H_2^+ beam. Two beam spots of diameter 1 mm each and separated by 2 mm are clearly seen, suggesting a spatial resolution of 2 mm of the system. Moreover, for a beam energy of 3.5 keV it was observed that the images of the circular holes shift with the F.S. voltages for fixed MCP and Al plate voltages. The upper spots in the three images in Fig. 3 show the beam spots produced by the ions and the shift in position for different voltages on the F.S. is evident. The lower spots in the images are unaffected by the detector voltages and, furthermore, also by any changes in the focussing elements in the beamline before the detector. We have thus concluded that these spots are caused by

Bremsstralung photons that have been created when the beam passes through the narrow channel of the RFQ. During these tests, no voltage was applied to the RFQ, which thus acted as a long (~1 m) and narrow (Φ≤10 mm) non-focussing channel and a rather large part of the ion beam therefore must have hit the copper rods inside the RFQ. While these spots can be troublesome by causing a background to the ion spots, in this experiment they also were an advantage, since they constituted a fixed position reference on the screen. Calculations with SIMION [6] were performed to check the steering effect of low-energy beams. Results from these calculations are presented in Fig 4 for two sets of typical voltages. As can be seen, the displacement of the beam obtained in these simulations is in decent agreement with our measured results. Some attempts were also made to study the effect of changing the MCP voltage. Since the MCP is closer to the beam, this voltage should have a larger effect on the trajectories. However, since the gain of the MCP depends very strongly on this voltage, it was difficult to make large enough changes to be able to clearly register a change in the position of the beam spots without loosing the intensity too much. A more successful search for this effect could possibly be made, if one would be able to change the beam current to a larger extent than was possible in the present experiment.

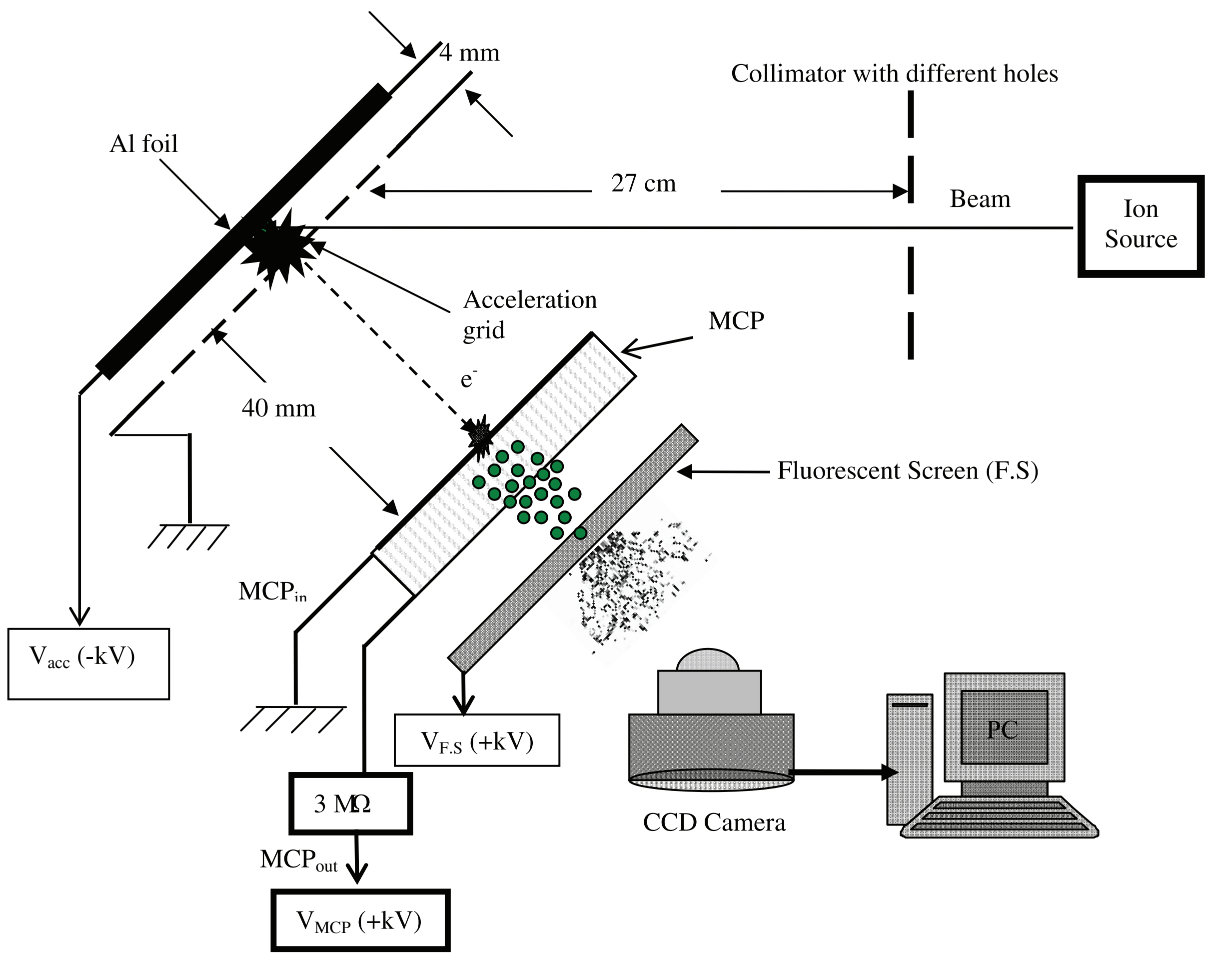
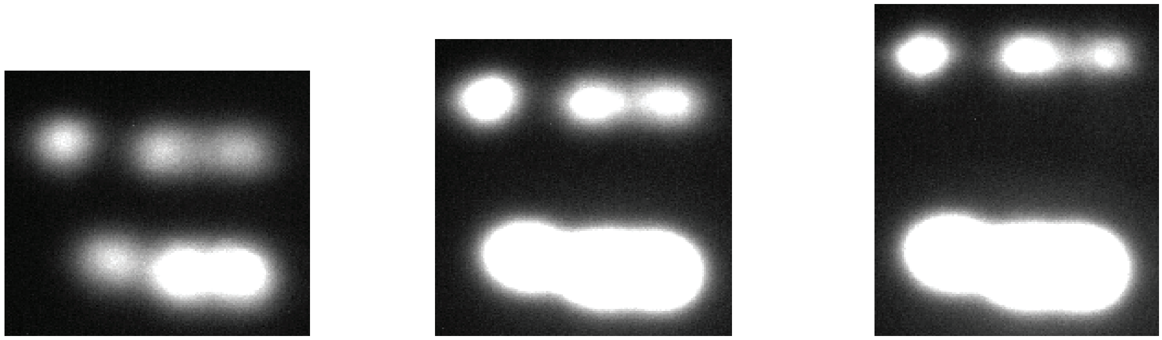


Figure 2: Schematic diagram of the experimental set-up.



F.S. = 2954 V F.S. = 4000 V F.S. = 4947 V

Figure 3: CCD images (upper spots) of the light produced in the F.S. by 3.5 keV H2+ beam for different $V_{F.S.}$ at fixed MCP (1326 V) and Al plate (-6.4 kV) voltage. Two beam spots of diameter 1 mm each and separated by 2 mm can be clearly seen, suggesting a spatial resolution of 2 mm of the system. The diffused lower spots are due to the Bremsstralung photons that are created when the beam passes through the narrow channel of the RFQ. The upper spots shift with the F.S. voltages.

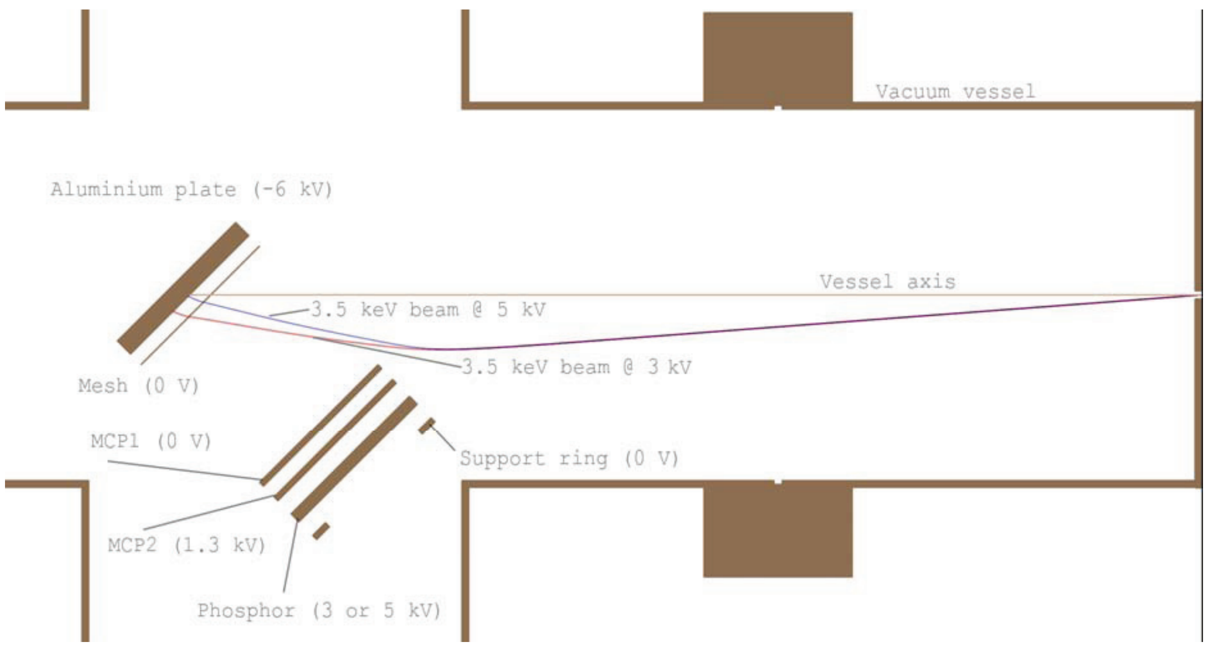


Figure 4. SIMION Calculations for the 3.5 keV H_2^+ beams for different F.S. voltages.

CONCLUSIONS

In summary, a beam profile monitoring system was built. The spatial resolution of the system was tested using a collimator and an H_2^+ beam of different energies. A resolution of 2 mm was achieved for all the energies. For low-energy beams, the images were found to shift with fluorescent screen voltages. It was noted that, in spite if this shift, the detector can be used for ion beams with an energy as low as 3.5 keV. Probably it could also be used at somewhat lower energies, but, as is seen in the simulations, the distortion of the beam trajectories will be increasingly severe. Possibly a modified version of the detector could be constructed, in which metal shields would be incorporated to shield the beam from the electrical fields of the MCP and the fluorescent screen. However, such a design would require more detailed simulations as well as further systematic investigations.

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[6] SIMION 8.0.