IMPROVING THE RELIABILITY OF IPM*

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Abstract

IPMs measure in a non-destructive way the profile of ion beams independent whether the beam is bunched or not. Our application is the heavy ion synchrotron SIS, which can accelerate ions with a large variety of different masses and charges. The IPM is used to obtain information about the beam matching, the electron cooling and to support for any kind of machine experiments. To ensure reliable function and to increase the data accuracy we executed some important mechanical improvements. The resistive E-field plates were replaced by discrete electrodes. We designed a new MCP-Phosphor-screen assembly of rectangular shape and large active area and in addition a module with a filament mounted in meander shape to monitor the degradation of the MCPs. The whole device was planned with respect of high field uniformity and small mechanical dimensions at a large clearance for the beam.

INTRODUCTION

Ionization Profile Monitors (IPM) are used in synchrotrons and storage rings to measure the beam profile. The IPM at the GSI heavy ion synchrotron (SIS) measures every 10ms a full beam profile, horizontal and vertical. At the end of the cycle the data are automatically analysed and the users can view the beams evolution of the whole synchrotron cycle. The beam profile and the beam position provide information about the injection matching and the accelerator setting and adaption. The beamwidth shows the effects of electron cooling and of multiple injections, it also gives a hint of beamlosses during the cycle. The benefit of these measurements is connected to the reliability and long term stability of the IPM and the trustiness of the obtained data. The environmental conditions for IPMs are usually vacuum bakeout and long maintenance intervals. Once installed or modified the IPM is not accessible for a long time, often for several years. These conditions make it necessary to restrict the number of functional parts and to control most parameters from outside the vacuum. The device has to be achieved in a way that it withstands all possible burdens during long term operation. The quality and the long term stability of the electrical field (E-field) that accelerates the ionized particles perpendicular to the beam is most important for a true image of the beam. A rectangular (Multi-Channel-Plate) MCP-Phosphor screen assembly fits best the needs of an IPM. These devices are only in concentric form commercially available. We developed a rectangular device with an active area of 100mm by 22mm. The IPM is designed to have the freedom of detecting residual gas ions and electrons. When detecting residual gas electrons the residual gas ions will produce secondary electrons at the bottom of the E-field box. The resulting signal complicates automatic analysis of the data. Therefor a secondary electron suppression is needed. The amplification of MCPs degrades during operation. Partially the areas of the MCP degrade at most where the density of impacts by residual gas particles is biggest. The degradation must be observed careful to obtain a beam profile correction function. A filament can be used both as secondary electron suppression and to generate a test signal for the MCPs.

ELECTRICAL FIELD BOX

The original E-field design of the IPM was based on resistive side electrodes made of glass coated with germanium [1]. Cracks in the germanium layer occurred probably because of the rough environmental conditions like big temperature changes during multiple vacuum bakeout and the different thermal coefficients of the glass sheet and the coating. The cracks prevented a constant conductivity of the resistive layer. By time the potential difference was equalized by sparks and thus the beamprofiles were strongly deformed. That made it nearly impossible to analyse the IPM data automatically.

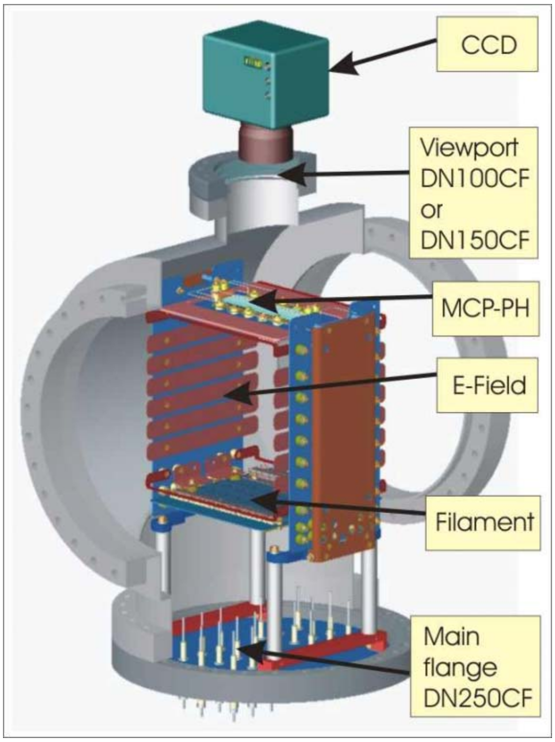

Fig. 1: E-field box vertical side electrodes, double layer filament, corrector electrodes, rectangular MCP-Phosphor assembly.

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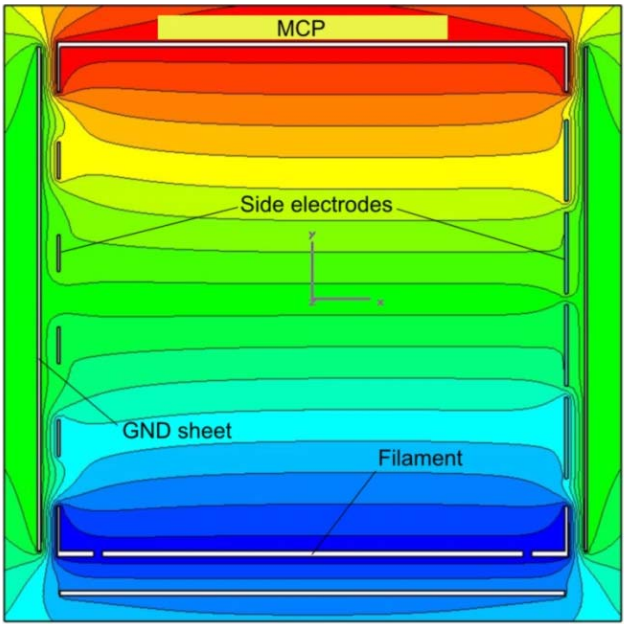

Figure 2: Four discrete side electrodes per side. Left hand side: large gaps between the electrodes, right hand side: small gaps. The y-coordinates of the electrodes are equal also the potentials.

Resistive electrodes are active parts of the E-field contrary to discrete electrodes. We designed and installed an E-field box that uses discrete side electrodes, Fig.1. The potential of each pair of side electrodes can be changed from outside the vacuum. The special alignment of the side electrodes increases the field uniformity if the gaps between the electrodes are small and it reduces the consumption of mechanical space. If the gaps are large the non-uniformity increases, Fig.2. The clearance of the E-field box is about 175mm in square.

The side electrodes increase the field uniformity perpendicular to the beam direction. To increase the longitudinal field uniformity corrector electrodes were

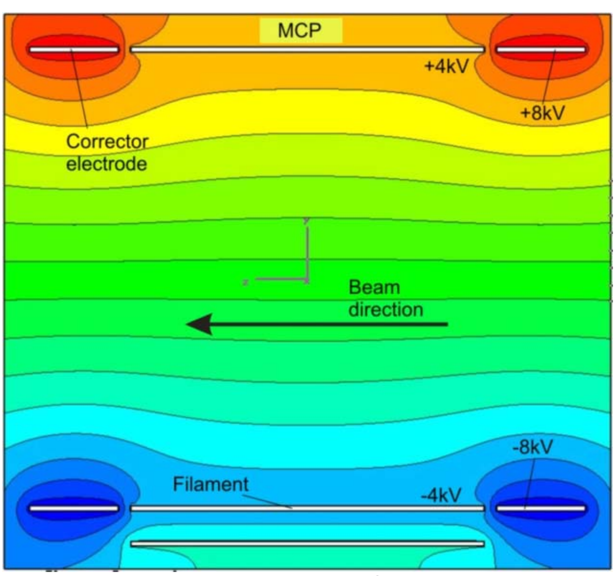

Figure 3: Longitudinal E-Field uniformity increased by corrector electrodes.

applied at the beams entrance and exit of the E-field box, see Fig. 3. The field uniformity is improved significant when the absolute potentials of the correctors are bigger than the absolute potentials of the corresponding top or bottom plate. The relation of the potentials between the corrector and the corresponding electrode depends on the E-field box dimensions.

The fixations of all the electrodes were achieved with standard insulators which are made of glass ceramics due to the UHV conditions.

SHIELDING

The IPM can measure the horizontal and vertical beam profile simultaneously. In this case the main E-field vectors of the horizontal and the vertical IPM are torn by 90°. To avoid mutual disturbances a shielding is foreseen located between the two IPMs, see Fig.4. The shielding is achieved as a ring at ground potential. This configuration allows also a kick compensation whereby one IPM measures while the second one compensates the kick.

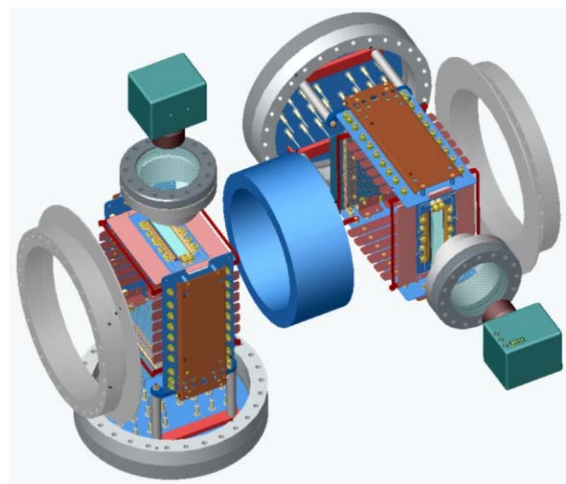

Figure 4: Horizontal and vertical IPM, separated by shielding.

RECTANGULAR MCP-PHOSPHOR ASSEMBLY

The ion beam width in the heavy ion synchrotron is sometimes bigger than 20mm. Additionally the beamposition can be shifted by about 20mm. To detect the ion beam at these conditions we choose MCPs of 100mm by 30mm. The rectangular shape exploits best the conditions of the electrical field. The MCPs are in Chevron configuration with a gap of 0.1mm. The gap between the MCP and Phosphor screen will be about 0.8mm and the potential will be in the range of 6.3kV/mm. The MCPs and the Phosphor screen are not mechanically connected like in commercially available devices. The MCPs are arranged in sandwich style. Two flat springs along the long edges press the MCP Chevron configuration onto the base sheet. The springs are insulated of the base sheet. The electrical power is supplied by the springs to the MCPs. The gap between the MCPs is created by two 2mm wide and 0.1mm thick metal strips. The strips have also electrical connections to

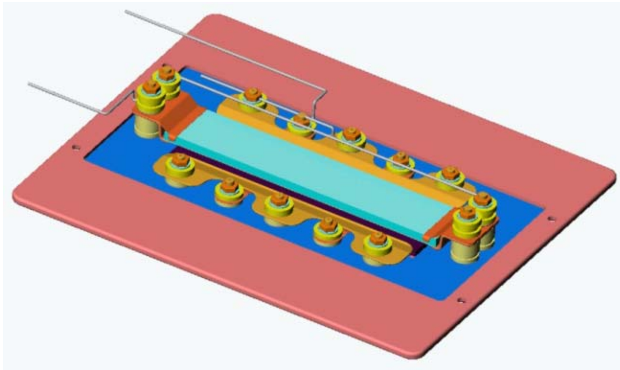

Figure 5: Rectangular MCP–Phosphor assembly. The visible image is 100mm by 22mm.

control the voltage between the MCPs, see Fig 5.
The Phosphor screen is fixed at his short edges on the base sheet and it is lifted 0.8mm above the MCPs. Due to the UHV conditions and no mechanical connection between MCP and Phosphor screen the potential difference of 5kV is not critical. First high voltage tests showed the applicability of this design. The electrical power is supplied by the mechanical fixations. The module provides a detectable image to the CCD of 100mm by 22mm.

FILAMENT MODULE

The tungsten filament is achieved in meander shape to cover the whole MCP, see Fig.6. The center to center spacing of two turns is of about 3mm while the wire diameter is 0.1mm. Each end of the filament is individual connected to an electrical vacuum feed through. To suppress the secondary electrons a proper potential is applied to the filament while the potential of the base sheet is more positiv. To test the MCPs degradation the filament can be used to emit electrons, which are accelerated towards the MCP. On the phosphor screen an image is generated representing the shape of the filament [3]. This can be done by times to keep the correction function up to date. To verify the uniform electron emission a second filament layer of similar function and style is installed. First tests show the feasibility of this technique. The filament was heated for 2 days in intervals of 1hour and there was no measurable change in the resistance. To obtain an uniform electron emission wires free of tinder are required. To compensate the extension

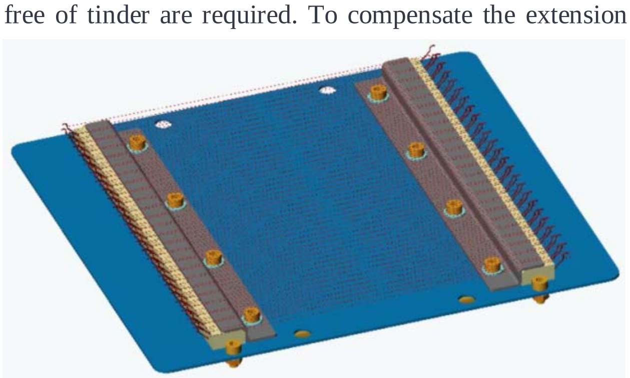

Figure 6: Filament module, the center to center spacing of two wires is 3mm.

of the heated filament every meander turn should be streched by a separate spring. The springs diameter is 0.4mm. A special mounting tool was developed to ensure the accurate assembling and tension of the wires.

Reducing The MCP Degradation

In a Chevron configuration the second MCP degrades usually at first moreover only the rearmost part of the MCP channels [2]. The MCPs degradation can be reduced dramatically when the high voltage is applied only during the measurement. The heavy ion synchrotron of the GSI can control 16 virtual accelerators with different settings for different masses and charges at time. Ions of different masses and charges from several sources can be accelerated alternately. The IPM is used at a time only for one ion mass and charge due to the exact setting of the MCP amplification. Nevertheless the MCPs are reached permanently by residual gas ions of all virtual accelerators. To take care of the MCP it is sufficient to reduce the MCP voltage for a few hundreds of volts outside the measurement. A high voltage relay that bridges a resistor is one possible solution. It can be controlled automatically by timing events of the accelerator. A control mechanism by software is also applied to switch off the MCP amplification completely after a certain time of inactivity.

CONCLUSION

The IPM in the SIS is used more and more for operating purposes. It is permanently improved and upgraded to satisfy the need of reliable data during common operating and at special machine experiments. To ensure an effective and profitable usage of accelerators it is important to make beam instrumentations reliable, long term stable and permanent available.

REFERENCES

[1] T.Giacomini , “Development Of A Residual Gas Profile Monitor With High Resolution And Fast Readout”, BIW 2004, Knoxville, USA.

[2] V.Kamerdzhiev, “Ionization Beam Profile Monitor At The Cooler Synchrotron COSY-Juelich”, DIPAC 2003, Mainz, Germany.

[3] G.Ferioli, “Sensitivity Studies With The SPS Rest Gas Profile Monitor”, DIPAC 2001, Grenoble, France.