

IONIZATION PROFILE MONITOR TO DETERMINE SPATIAL AND ANGULAR STABILITY OF FEL RADIATION OF FLASH

M. Sachwitz, A.Hofmann, S. Pauliuk, DESY, Zeuthen Side, Germany

K. Tiedtke and H. Wabnitz, DESY, Hamburg Side, Germany

Abstract

The design and implementation of an Ionisation Profile Monitor (IPM) for the Free Electron Laser at Hamburg (FLASH) is shown. The monitor determines the relative position and the profile of the FEL beam with the spatial resolution of 50 μm . In our paper we present first results taken at FLASH.

INTRODUCTION

The Free Electron Laser (FEL) in Hamburg (FLASH) facility at the Deutsches Elektronen Synchrotron DESY is a linear accelerator operated in superconducting technology producing soft X-ray laser light from 6nm to 30nm. The light is created by Self Amplified Spontaneous Emission (SASE).

To improve the operation stability of FLASH monitoring of the beam parameters like position and beam profile are required. Our contribution to the photonbeam diagnostics is the development of a specific Ionization Profile Monitor (IPM) [1].

The functional principle of the IPM is based on the detection of ions generated by interactions of the photon beam with the residual gas in the photon beam line [2]. The monitor consists of a cylindrical vacuum chamber,

two beam pipes and a micro-channel plate, and a repeller plate at the opposite side. The ions created by the FEL beam drift in a homogenous electrical field towards a micro-channel plate (MCP), which produces an image of the beam profile on an attached phosphor screen. A CCD camera in combination with a computer is used for the evaluation. This indirect detection scheme operates over a wide dynamic range and allows the detection of the centre of gravity and the shape of the photon beam without affecting the FEL beam.

DESIGN AND OPERATION OF THE IPM

The IPM consists of an electrode and a high spatial resolution detector (MCP), with a diameter of 25mm and a spatial resolution of 6 μm (Figure 1).

The distance between the repeller plate and MCP are 76.7mm. Both components have a definite potential. The maximal value of the electrical field is 60V/mm. To provide a uniform field, additional electrodes are installed. Figure 2 shows the field configuration as computed with the program package CST Particle Studio Suite 2006 [3].

The field is almost homogenous except at the outer edges of the MCP.

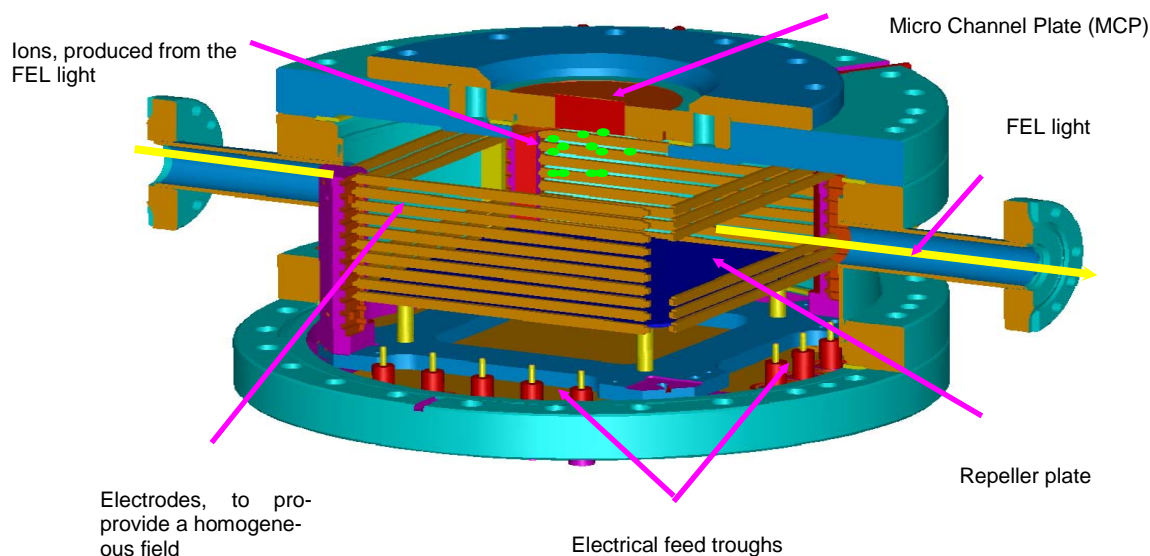


Figure 1: Design of the IPM. Field electrodes are realized by bars.

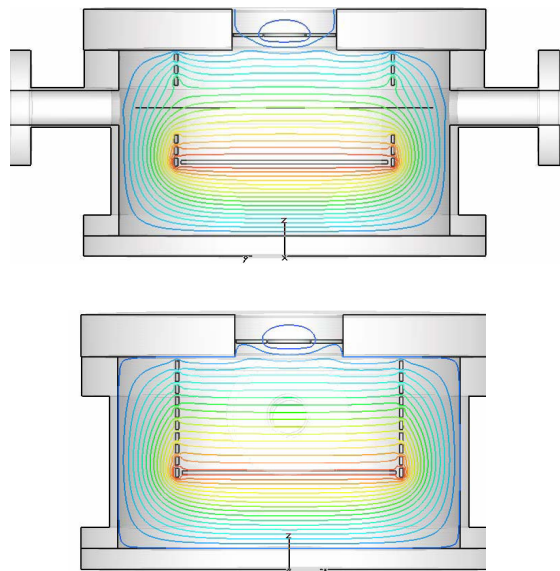


Figure 2: Calculation of the electrical field, side view (above) and front view (below).

To achieve an optimal signal during the experimental campaign a small amount of Xenon has been added locally thus the pressure is increased to about $5 \cdot 10^{-6}$ mbar. The gas inside the beam tube is ionized by the FEL light. The created ions are accelerated in the homogeneous electrical field toward the micro-channel plate (Figure 1 and 2).

The micro-channel plate (MCP) is an image intensifier with a distortion-free image conversion with high gain

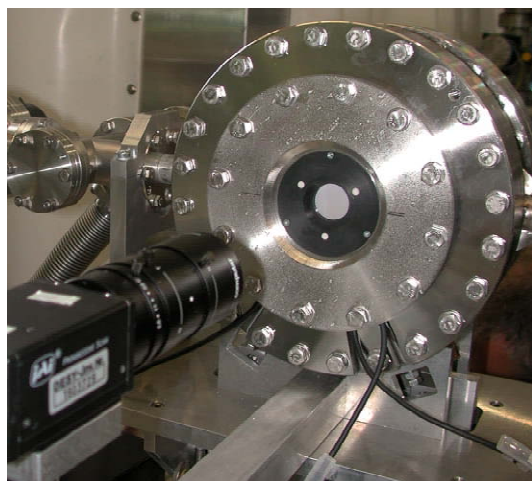


Figure 3: The IPM in a test setup at FLASH. A CCD camera (resolution $9.9\mu\text{m}$) records the image.

and high resolution. The electrons produced escape from the photocathode and are strongly accelerated by a high potential electrical field. They strike the phosphor screen and stimulate fluorescence [4]. The image recorded by a CCD camera is transferred to a computer for further evaluation (Figure 3).

FIRST TEST OF THE IPM AT FLASH

First measurements of the IPM were performed at FLASH, operating at a wavelength of $\sim 13\text{nm}$. In order to ensure well defined beam conditions, a collimator with an inner diameter of 1mm was positioned inside the beam tube.

Figure 4 shows the image of the beam on the screen and the profile of the collimated laser beam in pixel.

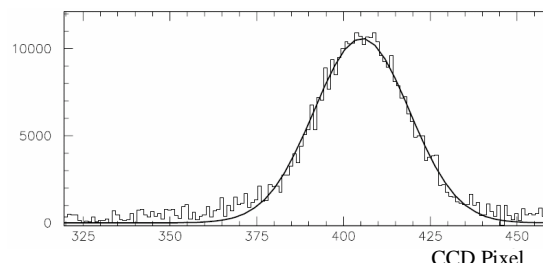
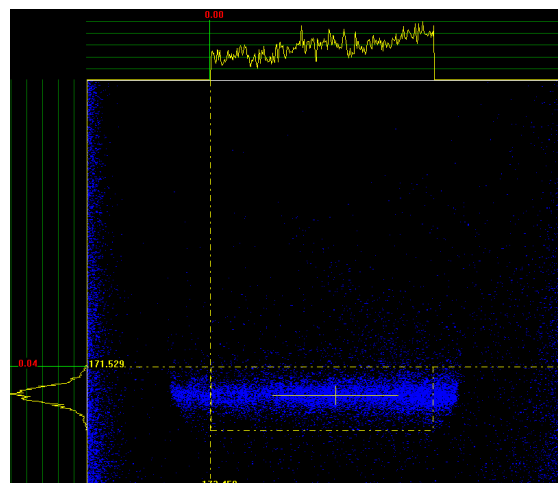


Figure 4: The laser beam profile on the monitor and in CCD pixel.

The IPM was supported on a lifting table enabling the simulation of different beam positions. The relative displacement was measured by a Linear Variable Differential Transformer (LVDT) consisting of an analogue gauging probe with a precision linear bearing. The sensor has an accuracy of $1\mu\text{m}$ [5]. The result of the position measurement is presented in Figure 5.

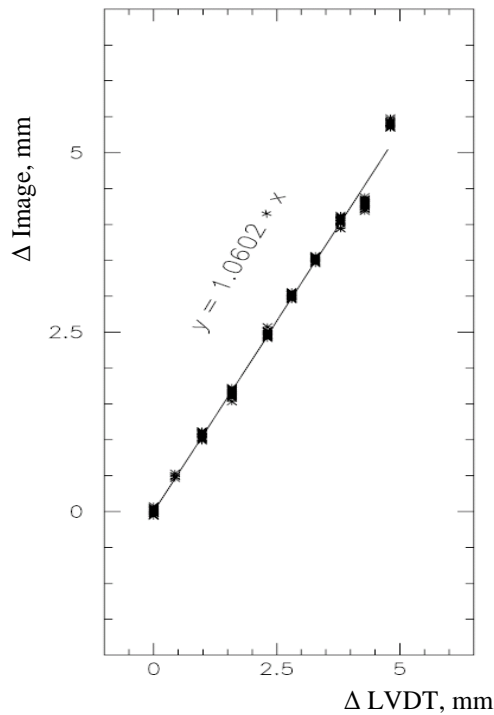


Figure 5: Relationship between real beam position (LVDT) and measured beam position (Δ Image).

It shows the expected linear relationship between the real and the measured beam position with a slope of 45° . The linear behaviour of the IPM measurements is an indication for a homogenous electrical field distribution inside the IPM. These measurements are in excellent agreement with simulations, which have been performed with the programme, CST Particle Studio Suite 2006, see also Figure 2. The last two points of the measurement deviate from the fitted line. Here, the beam approaches the outer region where the electrical field is no longer uniform and thus, these points are neglected. As a result of the test measurements at FLASH one determines a value of about $50\mu\text{m}$ for the spatial resolution (see figure 6).

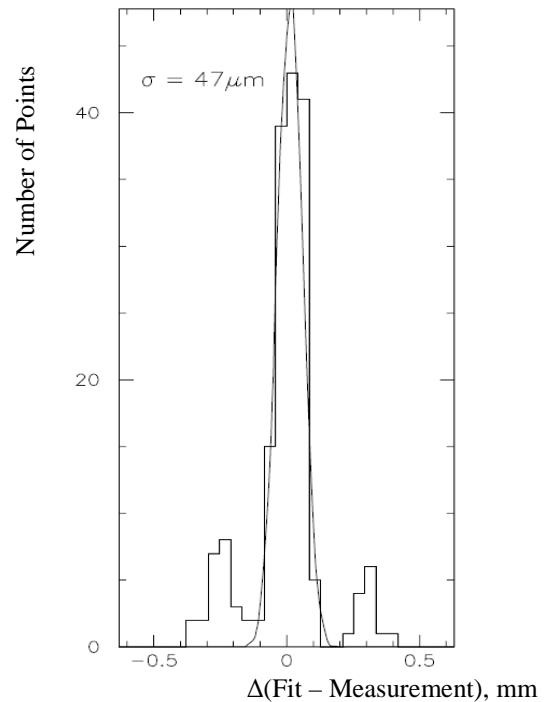


Figure 6: Spatial Resolution of the IPM.

REFERENCES

- [1] A. Hofmann, Diploma Thesis, Dresden, 2006.
- [2] K. Wittenburg, DESY "Experience with the Residual Gas Ionization Beam Profile Monitors at the DESY Proton Accelerators", 3rd European Particle Accelerator Conference, 1992, Berlin, Germany and DESY HERA 92-12.
- [3] CST - Computer Simulation Technology <http://www.cst.com>.
- [4] Data sheet Proxitronic for an OD2561Z-V MCP <http://www.proxitronic.com>.
- [5] User and installation manual solartron metrology <http://www.solartronmetrology.com>.