Welcome Ladies and Gentleman to this presentation.

My name is Heiko Breede and I work in the detector laboratory in DESY Zeuthen site.

Today I want to inform you about my new compact Design of a three-dimensional Ionization Profile Monitor.

The design is superior to older versions of residual gas monitors.

The Design is optimized for better accuracy of measurements, more friendly to use and easier to maintain.
In the beginning, I would like to present you my structure.

At first I will explain you the function principle of the device for understanding how the monitor functions.

Afterwards I will tell you the final features of the device and how a better accuracy can be achieved.

Then I will talk about the special chosen parts in order to reach a better accuracy and a short measurement period.

Last, but not least I will talk about how a precise user-friendly handling and assembling will be reached.

In addition, I will explain in more details how the final features will be reached with additional special solutions.

Finally I will summarize the main points and inform you about the status of February 2016.
The beam is located in the vacuum. A certain amount of residual gases still remain. If the beam hits a residual gas atom, it will become ionized and electrons and ions will be created.

By means of a homogeneous electric field, the ions can be accelerated in a rectangular way towards a micro-channel-plate. Here, the impacting particles create an avalanche of secondary electrons in the micro tubes of the MCP. They are visualized on the phosphor-screen.

This results in an image of the intensity-dependent beam profile.

By alternating the electric field, the horizontal and vertical beam profile could be measured in one device.

The Potential cage is almost completely close to ensure an optimal homogenous electric field.

The Cage consists of plates, pads and grids. The pads are needed to alternate the homogenous field. The Ions travel to the MCP through a grid in the cage in front of the MCP. The potentials and the cage-design are optimized by an FEM-Analysis.
All the features will be explained later in more details.

The lengths of the IPM in beam direction is about 200 mm because of the unification of horizontal and vertical measurement in one device. The IPM can reach an accuracy of the beam position of ±50 μm because of the nearly optimal homogenous electric field. A higher accuracy of ±8 μm will be reached with software interpolation.

The horizontal and vertical measurement period is about 1 ms. The ion travel time to the MCP and the voltage rise time are in the area of μ and ns. The limitation factor of the measurement period is the camera shutter time. The Shutter time is about 99,5 % of the whole measurement period. That means optimal optics are needed. The time resolution of individual trains of XFEL or FLASH is possible by triggering on the beam-frequency. Individual trains can be measured horizontal or vertical. The individual train pulse duration is too short to make a horizontal and a vertical measurement.

In addition, we will have a self-regulation system for different beam wavelengths and intensities. Finally we will have just one control-computer for observation.
2. Final Features – Position Interpolation

\[ N^{2+} \text{ particle trajectory in the EF & E-streamline} \]

- Starting points: \( x = \pm \frac{5}{\sqrt{2}} \text{ mm} \); \( y = \frac{5}{\sqrt{2}} \text{ mm} \)

![Diagram showing particle trajectories with y-offset and accuracy calculation](image)

The figure shows the trajectory of two ionized Nitrogen particles from the point of ionization until passing the potential grid in front of the MCP. The starting points of both are 5 mm away from the device-center. One is nearer and the other is farther to the MCP. The electric field strengths-streamline is shown as well. A Streamline is the sequence of the vectors of the electric field strengths starting from the starting points. The ions follow not exactly the streamline, because they have a inertia and a charge. The final offset is the drift of the particle regarding to the y-axis.

This will be used for y-position measurement. By subtract the arithmetic means from the measured y-position, the remaining inhomogeneity of the electric field could be add out. With willful neglect of the x-starting-point the position could have a theoretical accuracy of \( \pm 8 \mu \text{m} \). The exact x-position is unknown in this measurement because the x-position can change until the y-measurement.

Because of other unknown influences, the accuracy probably will not reach the elaborated value. However, in each case the accuracy will be improved by this interpolation.
The animation shows the trajectory of the ions relating to the beam direction (z-axis).

One fish figures an ionized ion.

The shown z-axis offset is not so important for the position interpolation, but shows clearly the offset because of a inhomogeneous electric field.

The hole for the beam guidance leads to a drift of the particles towards outside the device.

A nearer position to the hole leads to a higher drift and finally to leaving the cage.
Now, I would like to present you a selection of special chosen parts in order to reach a high resolution and a short measurement period.

The selected MCP-Assembly has the smallest available channel diameters and a screen, which has a very short afterglow time. This leads to less noise in beam pictures. Noise is the result of spontaneous ionization in the beam pipe. Therefore, we have a better resolution for the numerous small channels.

The selected phosphorscreen emits a blue light, which is different from other types. The selected optics and the camera have a high transmission and sensitivity to this wavelength spectrum. 48% of the emitted signal can be seen on beam’s pictures. This is very important in order to reach very short shutter durations. The shutter duration has the biggest influence on the measurement period, as I explained before.

Finally, we can use a cheap low voltage electrical feedthrough and can switch the potentials faster.

The Acceleration voltage of the particles is lower than 1.000 V.
4. Precise User-Friendly Handling & Assembling

- CAD modeling of all wires & connectors
  - Short ways for short signal transit time

- UHV heat shrink tube
  - Easy wiring & low risk of short circuits

- Shielded cables for power supply
  - No additionally compensation of stray capacitances on place of installation

- One control computer for easy usage
  - No different systems with different panels for just doing one thing

Now I will explain you the special procedures in order to reach a precise and user-friendly assembling and handling.

All wires, connectors and plugs were modelled in CAD in order to reach short wires and a short signal transit time. Furthermore, the chamber has a size, which is small as possible and there is no collision or short circuit risk with other parts.

In order to reach the highest comfort and safer, heat shrink tubes are used.

The DESY department FS-BT verified the shrink tube for usage in the UHV.

For a fast installation and commissioning, shielded wires are used.

The power supply has to be compensated of stray capacitances after the connection with the device was accomplished. Stray capacitances lead to a longer potential rise time. Shifted wires lead to different capacitances, because of the different electromagnetic field strengths. The shielded wires bring us a defined state and wire shifting doesn’t matter.

Finally the usage of just one control computer makes the device user-friendly. We don’t have different systems, panels or interfaces, which should be hand operated separately for just one small change. The computer is the signal and graphical user, which interface all actions.
The beam has different ionization rates, depending on the wavelengths spectrum and the beam intensity. The value of the ions which arrive on the MCP is different, depending on the beam characteristic. The number of particles, which arrive on the screen is shown as the current, which is indicated from the power supply. By variation of the voltage of the MCP, the current operating point will be adjusted.

The set point of the regulation system is the MCP-Current and the actuating variable is the MCP-Voltage. So the MCP-Gain will be adjusted automatically, depending on the beam characteristic. The current regulation is an implemented function in the LabView interface of the power supply.

In addition, we can reach a time resolution of 0.5 ms of individual beam trains by triggering the camera shutter on the beam train period. The arrival of the train will be provided from the beam operation team. The alternating of the electric field and the camera shutter will follow the external trigger signal. The electric field is ready and the camera shutter is opened, when the particles reach the MCP.

Finally, a macro objective and an adjustable camera mount bring us the imaging of the interesting area of the phosphorscreen on the nearly completed camera sensor. So we have the best possible resolution and a high accuracy.
We are nearly at the end of my presentation.

I presented the features which the device will have and how they are realized.

Finally the accuracy of the beam position can be $\pm 8\,\mu m$ by software interpolation.

This is possible because of the known trajectory of the ionized particles.

Moreover, we have a time resolution of individual beam trains.

The optical elements are optimized with respect to emission, transmission, sensitivity and resolution.

The chosen MCP-Assembly has easy changeable MCP’S and a screen which provides a picture with a low noise.

A control-system adjusts the MCP-Gain in order to show independently the beam from the wavelength and the intensity.

All needed hardware components are in House and ready for commissioning.

Actually, in February 2016, we assemble, wiring the device and preparing test beam measurements. The next steps are a beam test and developing the control system & the user interface.
Thank you for your attention.

I hope I was able to provide a good overview of my new compact Ionization profile monitor.

If you have any questions you could write me an e-mail. Also you can call me.

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