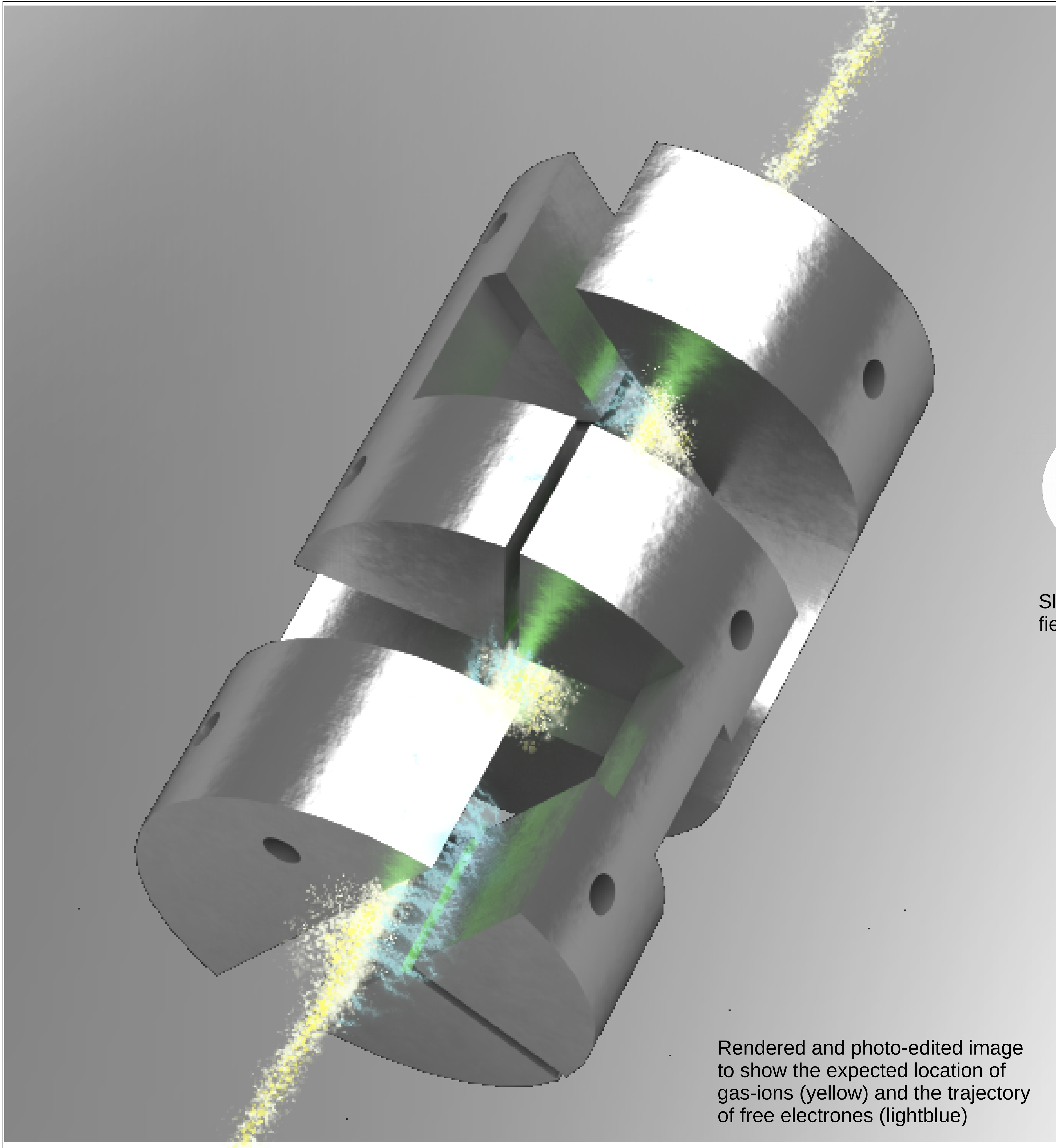
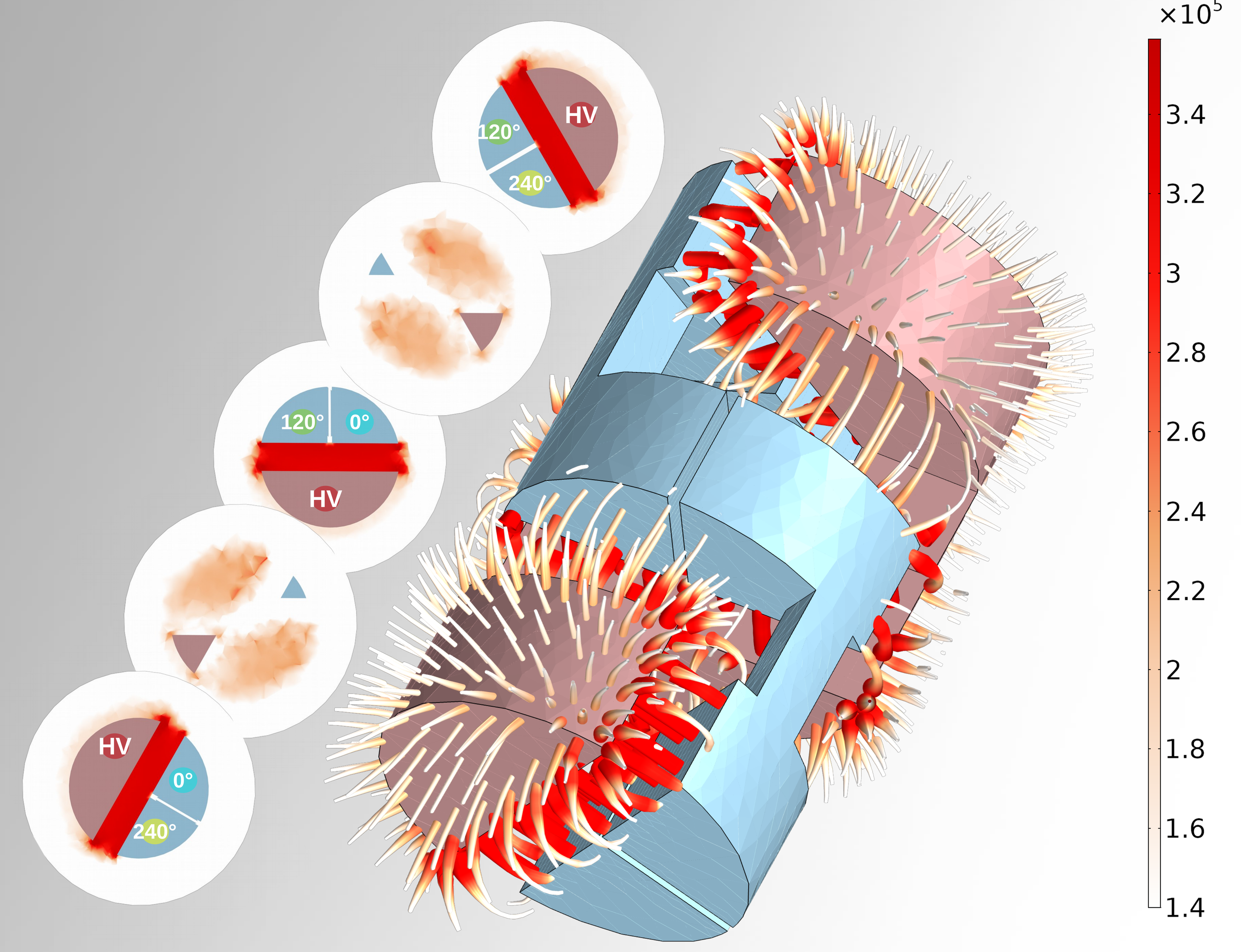
A new three-signal 2d-beam-position-monitor based on a segmented Ionization Chamber

Marcel Görlitz[1], Wolfgang Caliebe[1]
[1] Deutsches Elektronen-Synchrotron DESY, Germany;

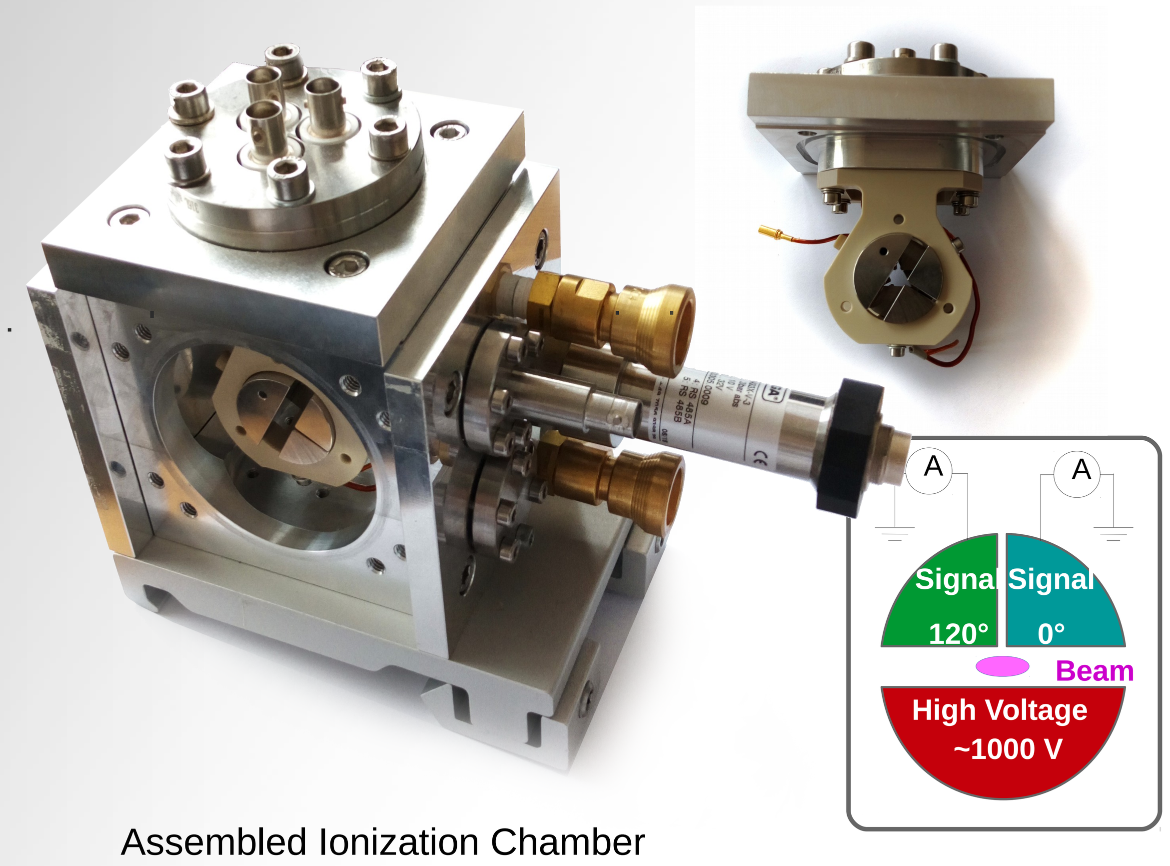


Rendered and photo-edited image to show the expected location of gas-ions (yellow) and the trajectory of free electrones (lightblue)



Slices of electric field strength [V /m]

electric field lines [V / m] Comsol-Simulation



Assembled Ionization Chamber

DESIGN

The new design of the beam position monitor (BPM) uses three signals. The high voltage electrode is a single part with 3 flat surfaces in the angles 0°, 120° and 240°. The measuring part consists of 4 parts: two small electrodes on the front and back, which are connected to the same signal wire, and two bigger measuring electrodes, which are each connected to a single signal wire. The measuring areas have a rotational symmetry of 120°. The gaps between the electrodes are 6 mm. The chamber can be filled with Nitrogen for application at low energies or Krypton at high x-ray energies.

SIGNAL DEPENDANCY

The signal of the 2d-Position can be calculated by the formula:

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} c_{x0} & c_{x1} & c_{x2} & c_{x3} \\ c_{y0} & c_{y1} & c_{y2} & c_{y3} \end{bmatrix} \cdot \begin{bmatrix} 1 \\ u \\ v \\ w \end{bmatrix} \quad (1a)$$

$$u = \frac{I_A}{I_A+I_B+I_C} \quad v = \frac{I_B}{I_A+I_B+I_C} \quad w = \frac{I_C}{I_A+I_B+I_C} \quad (1b)$$

The Intensities I_A, I_B, I_c are the measured raw signals of the current amplifier. The factors $c_{\#\#}$ are the calibration factors. Typical values are:

c_{x0}	-0.18	c_{y0}	-0.17
c_{x1}	-2.73	c_{y1}	-5.89
c_{x2}	5.07	c_{y2}	-0.09
c_{x3}	-2.52	c_{y3}	5.81

CALIBRATION

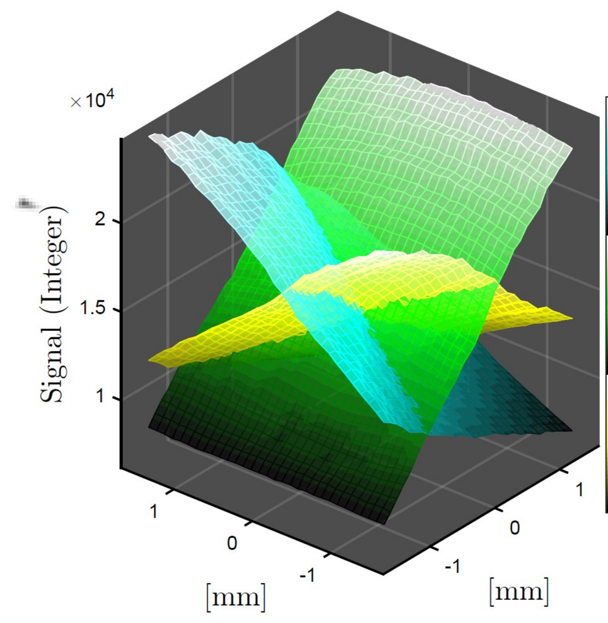
Calibration factors $c_{\#\#}$ can be found by solving an inverse problem using linear regression.
Calculation and application will be shown in detail in the paper. Therefore two procedures are compared: Moore-Penrose-Pseudoinverse and Simplex-Algorithm. Both variants take into account weightening factors. For the calculation of the factors a 2D-Gauss-function has been used. Whereas residual errors outside the center count in less than points in the center. For the calibration several points/ tuples <u_i, v_i, w_i, x_i, y_i, p_i> are needed. They include values of the raw mearement, the real position and a weightening factor.

RESULT

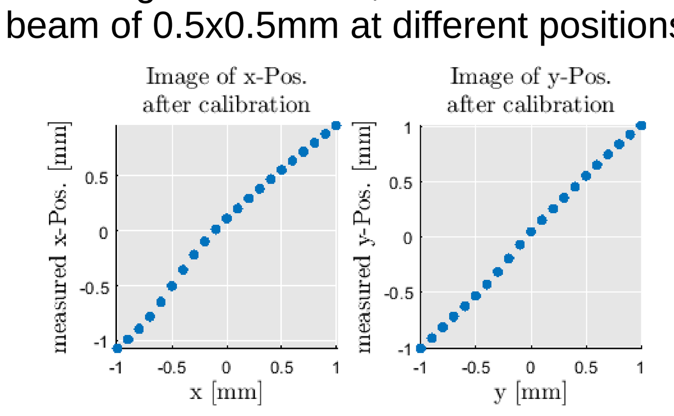
The accuracy looks reasonable. Values show a strictly monoton behaviour in both directions. For this reason the chamber can be used for position control in further steps. Moreover, the chamber can find application at beamlines, where BPM diffraction peaks have to be avoided or absorption-behaviour need to be changed easily.

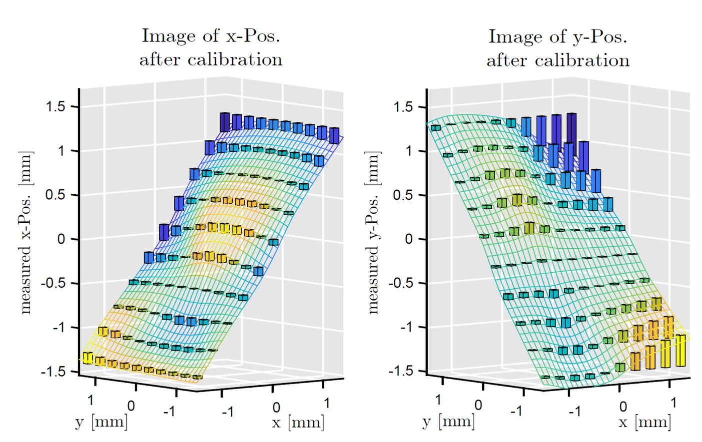
Acknowledge

Special acknowledge goes to the DESY-workshop and the CNC preparation group as well as to the P64 staff: Akhil Tayal, Aleksandr Kalinko, Maria Naumova



Raw signals, measurement at 20 keV; ionized gas: 100% N_2, beam of 0.5x0.5mm at different positions





Position after calibration; bar/color: difference between measurement and calibration
In an area of 1x1mm²: Calibration-Accurancy: 0.15mm, Sensitivity to position changes in all area