New Results on GEM - MediPix2 setup and plans

A. Bamberger

Institute of Physics, Albert-Ludwigs-Universität

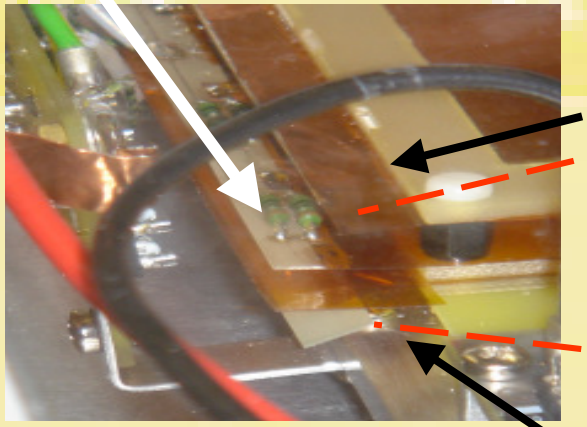
JRA2 Kickoff, 15.2.2006, DESY

Overview

- Tripple GEM setup
- Readout with pads and MediPix2 Chip
- Calibration with Fe55
- Min. ionizing electrons (β´s from Ru106)
- Position resolution of clusters from tracks
- Plans for the next future

Triple GEM setup

resistors for protection



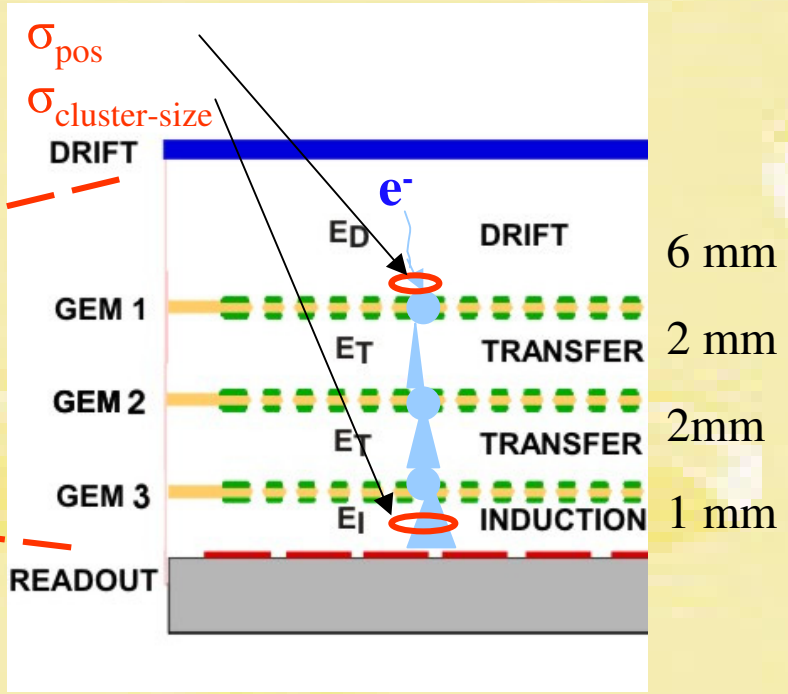
drif t elektrode

GEM 1

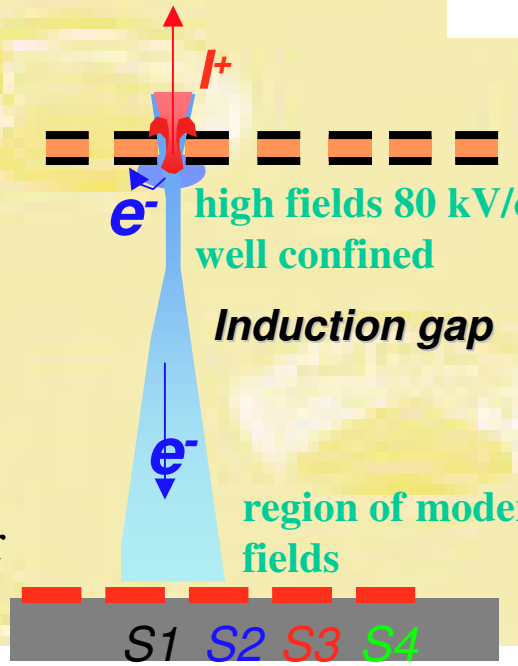
GEM 2

GEM 3

readout elektrode



- gas amplification up to 10^5 easily achievable with Ar/CO_2 ratio 70/30
- sufficient for min. ionizing particles
- minimized positive ion feedback
- small rate of discharges for highly ionizing particles



potentials/fields:

E_D= 1.1 kV/cm

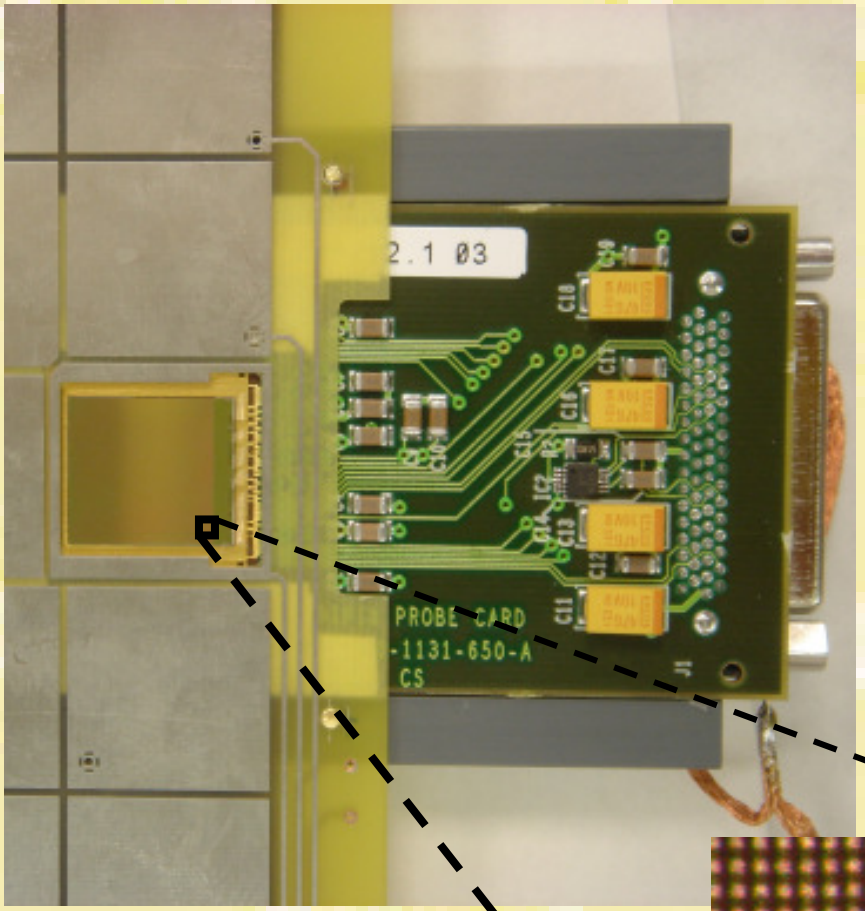
ΔV_{GEM}= 404 V

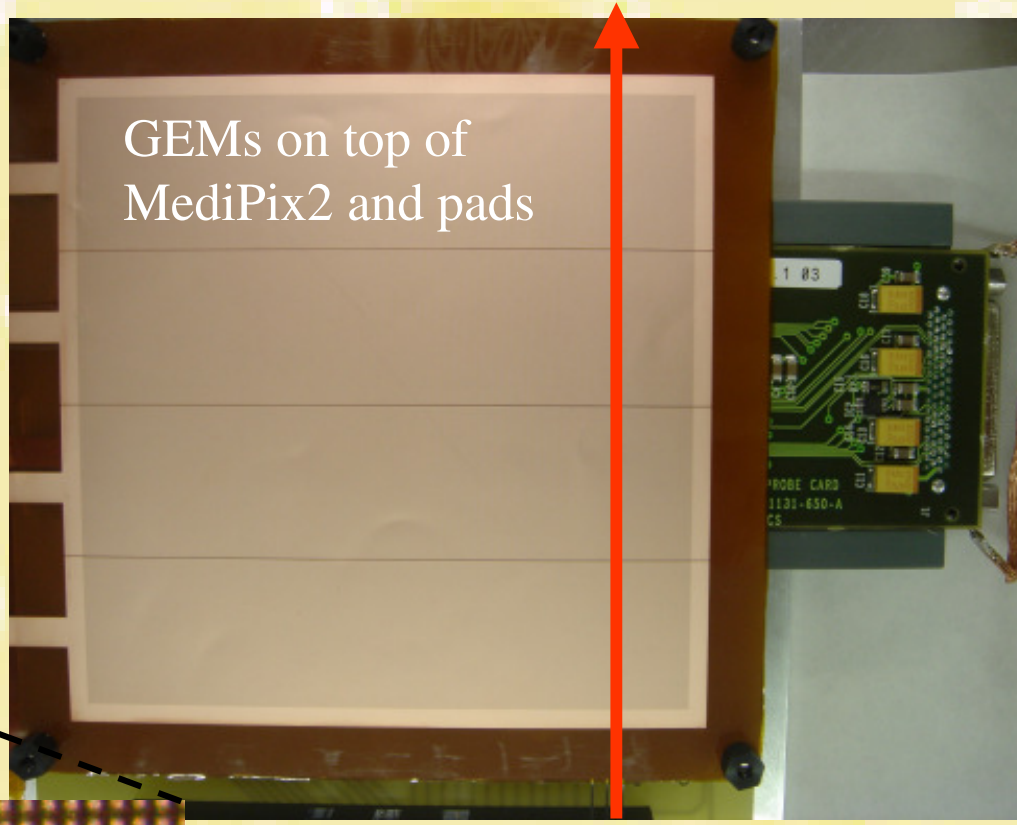
E_T = 3.2 kV/cm

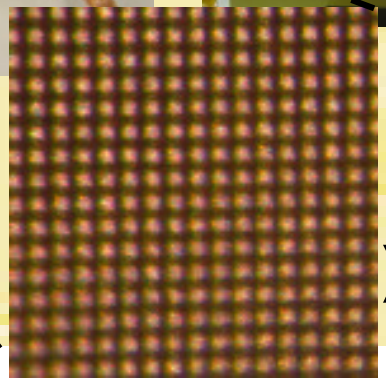
E_I = 4.2 kV/cm

Inserting MediPix2 into the GEM stack

in total 25 square pads of 2x2 cm^2 with readout electronic (L3 μ amplifiers)







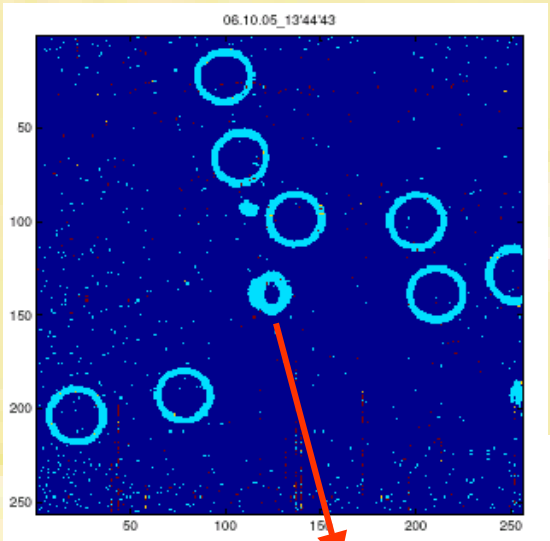
55 μm

β^- source ^{106}Ru, 3.5 MeV from daughter Rh106 crosses 4 pads with MediPix2 in between

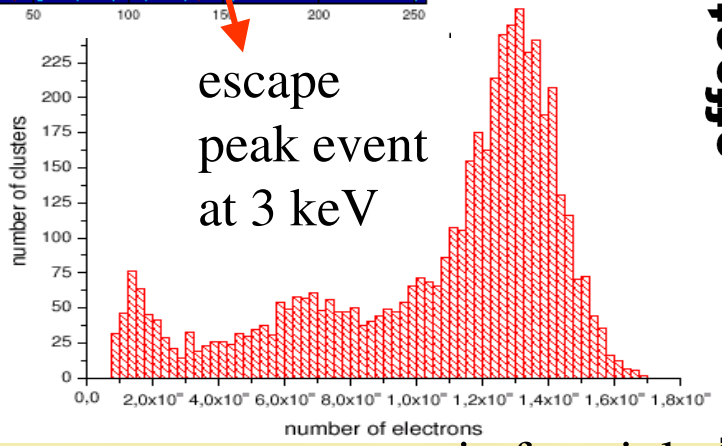
Muros2 triggered readout

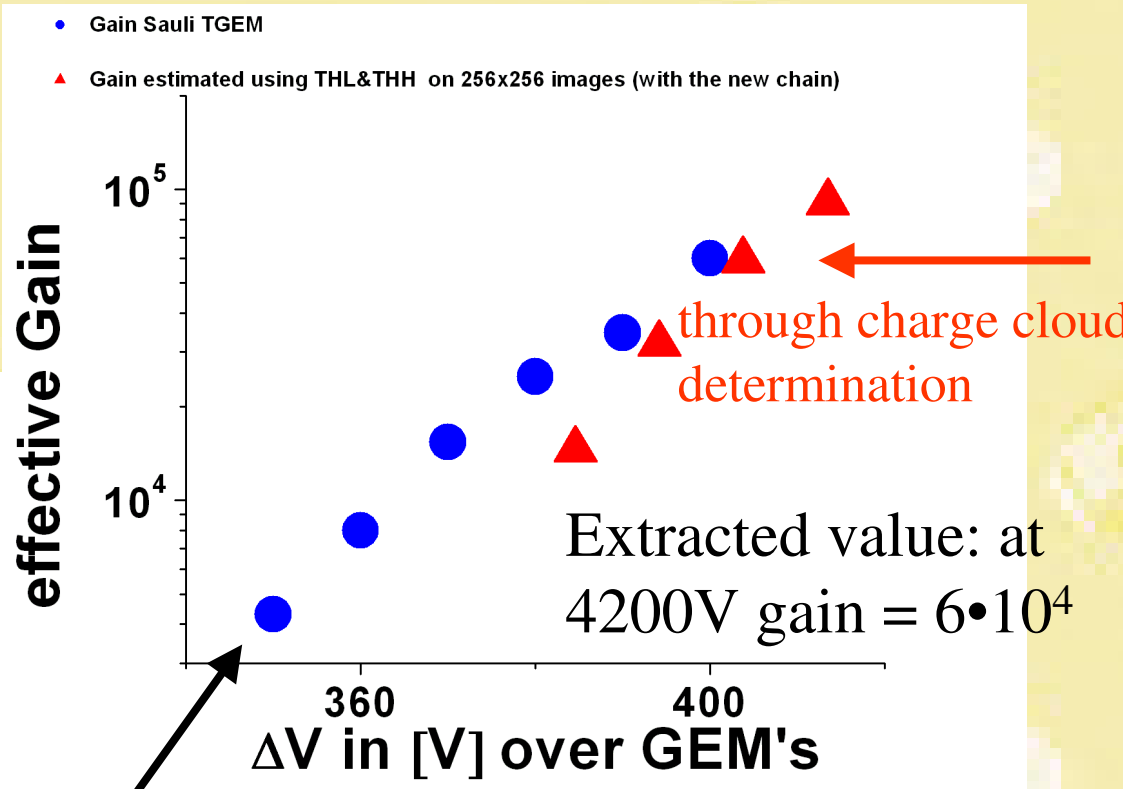
Gain determination for 3GEM-MediPix using ^{55}Fe ring-shaped events

^{55}Fe quanta of 5.9 keV delivers ~220 electrons in the gas



escape peak event at 3 keV





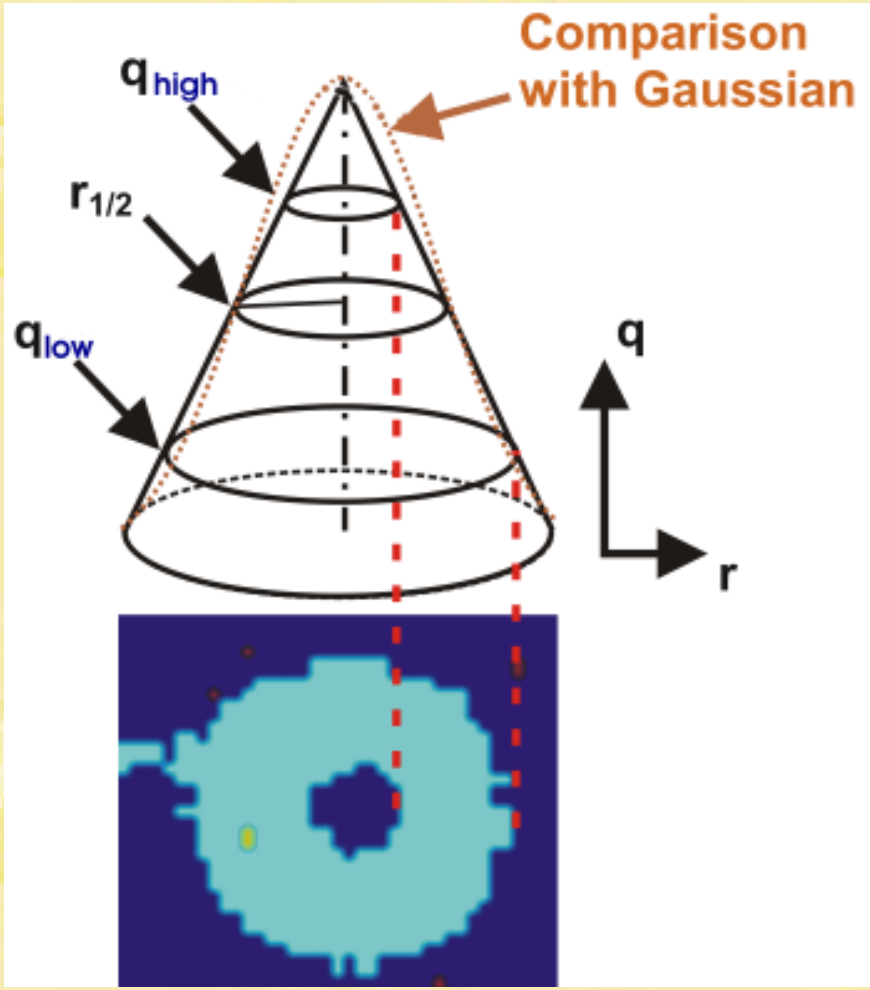
gain for triple GEM from F. Sauli matches our setup concerning induction and transfer fields

Principle of charge cloud determination

Data evaluation by MATHLAB (essentially regionprops)

- the shape of cloud assumed to be triangular (other shapes like Gaussian also possible)
- nearly circular „donuts“ (eccentricity cut)
- the values $q_{low}(r_{low})$ and $q_{high}(r_{high})$ are taken for a straight line resulting in (q_{max} , r=0) and (q=0, r_{max})

10^4 e -> $q_{high} > q_{low}$>960 e^-



- **Total charge**

$$Q=1/3\ (\pi\ r_{max}^{2})\ q_{max}$$

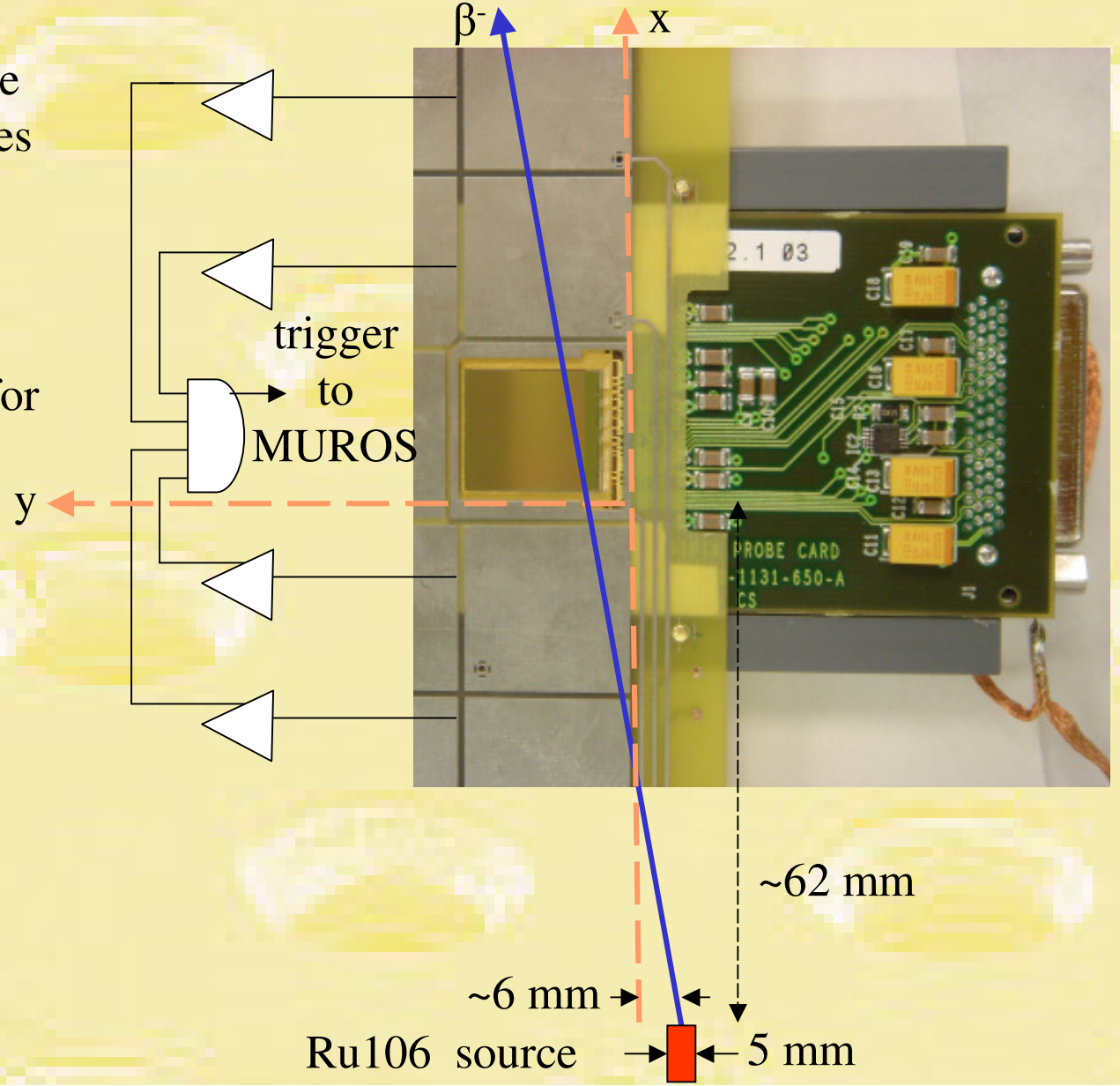
- **Half Width Half Max**

$$HWHM = r_{½} \sim \sigma_{gauss}$$

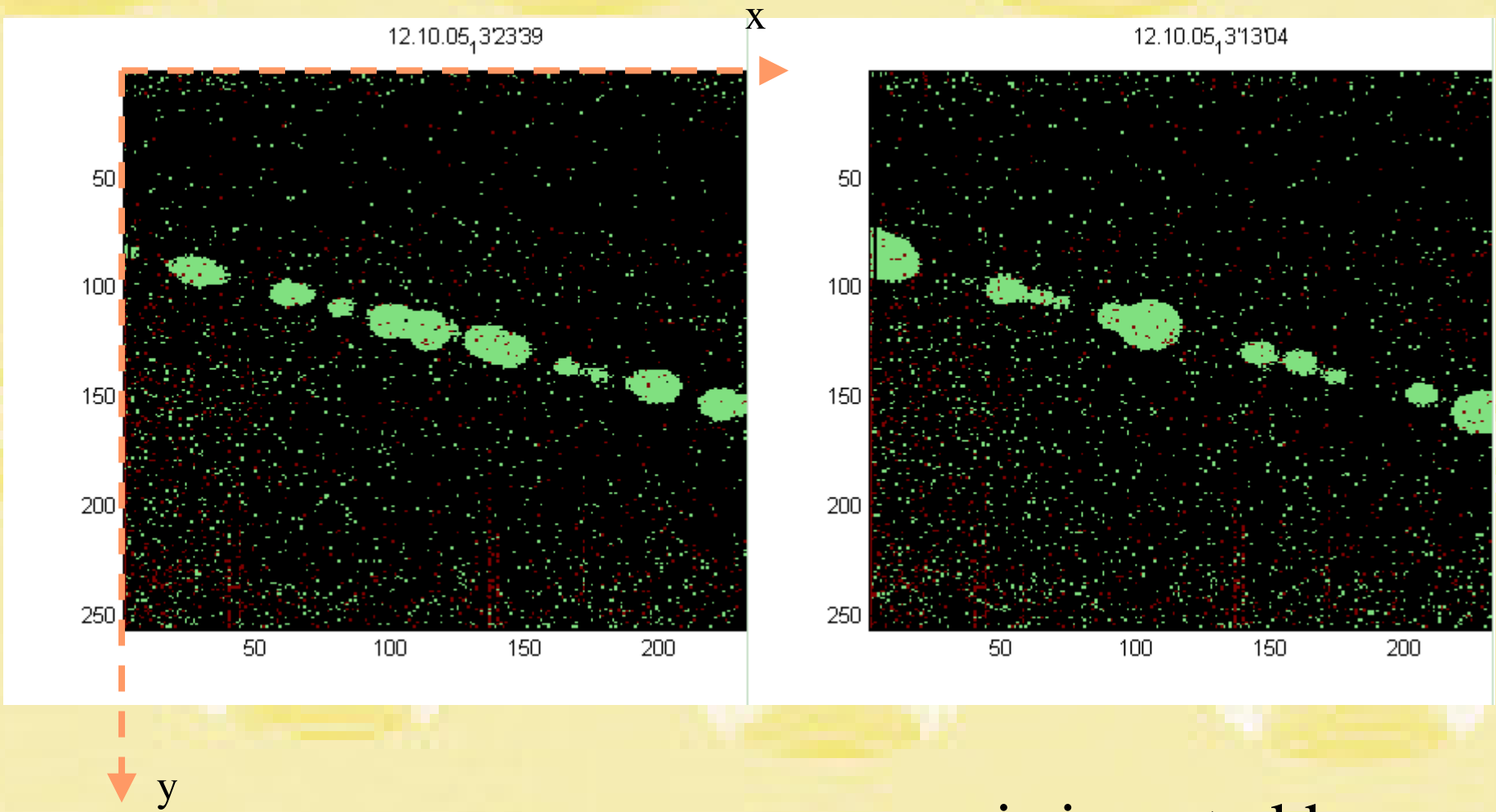
Coincidence requirement for β⁻'s

- Source positioned outside the frames near the frames
- coincidence with 4 pads across the GEM
- rate about 1/10 cps
- coordinate system used for the reconstruction

- Running condition:
  HV 4200 V, gain $6 \cdot 10^4$



Some β - events



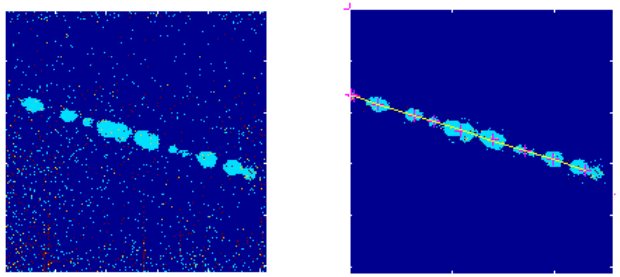
- y – axis inverted here

Charge position determination and track fitting

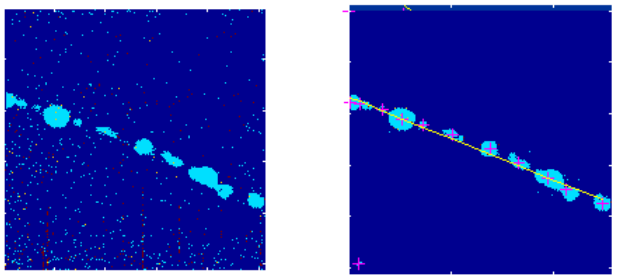
- for position determination of the cluster the lower threshold THL is set near 960e^-
- fired pixel with contiguous areas are searched for
- Minimum cluster size > 4 pixels
- clusters are identified through content, centroid and excentricity (<0.4)
- concatenation for common clusters of a track is done by their closest distance (< 50 pixels in x)
- straight line fit on the identified centroids is done without weights
- minimum number of clusters/track 6

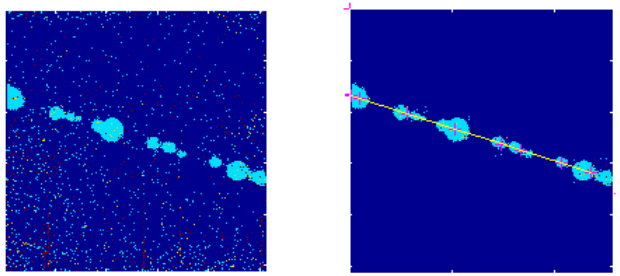
Some exemplary events with fits

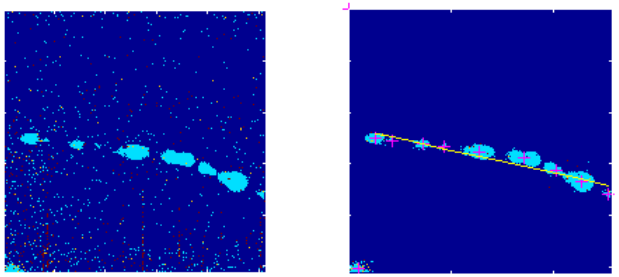
< 25μm



> 200μm,
multiple scatterer





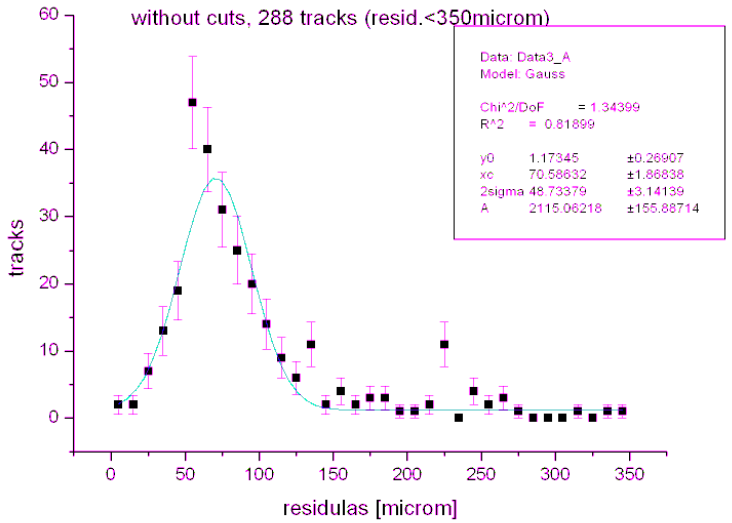


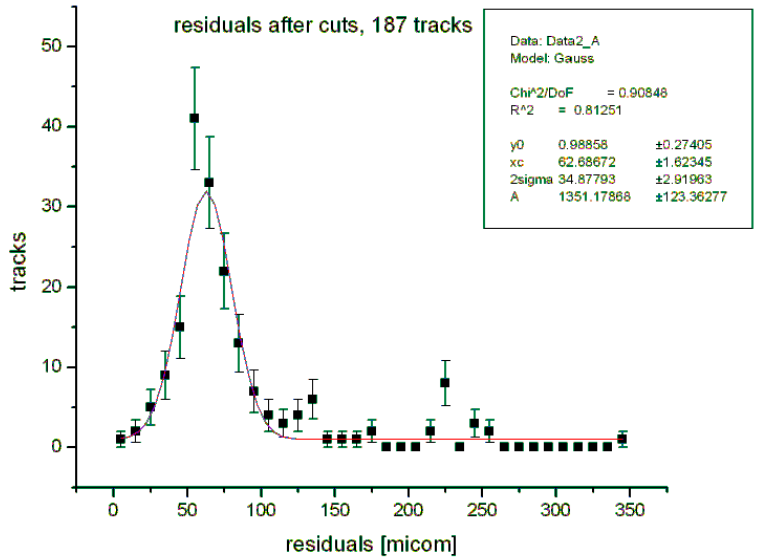
Results for the residuals of the fit

- residuals of all cluster centers are taken and averaged: $\sqrt{\chi^2 / dof}$ (removal of one cluster adds about few µm using geometric mean)
- average number of clusters/track 8.1 (accepted clusters/track: >5)
- total number of tracks 358
  - fiducial volume cuts: 293
  - track multiplcity cut (tot. # cl./ev. <23): 247
  - residuals <350µm: 210
  - tot. (#clust/ev.)/(#clust/track) < 3: 187

peak of residuals at 63 ± 1.6 µm

st. dev. of peak distr. 17.4 ± 1.5 µm





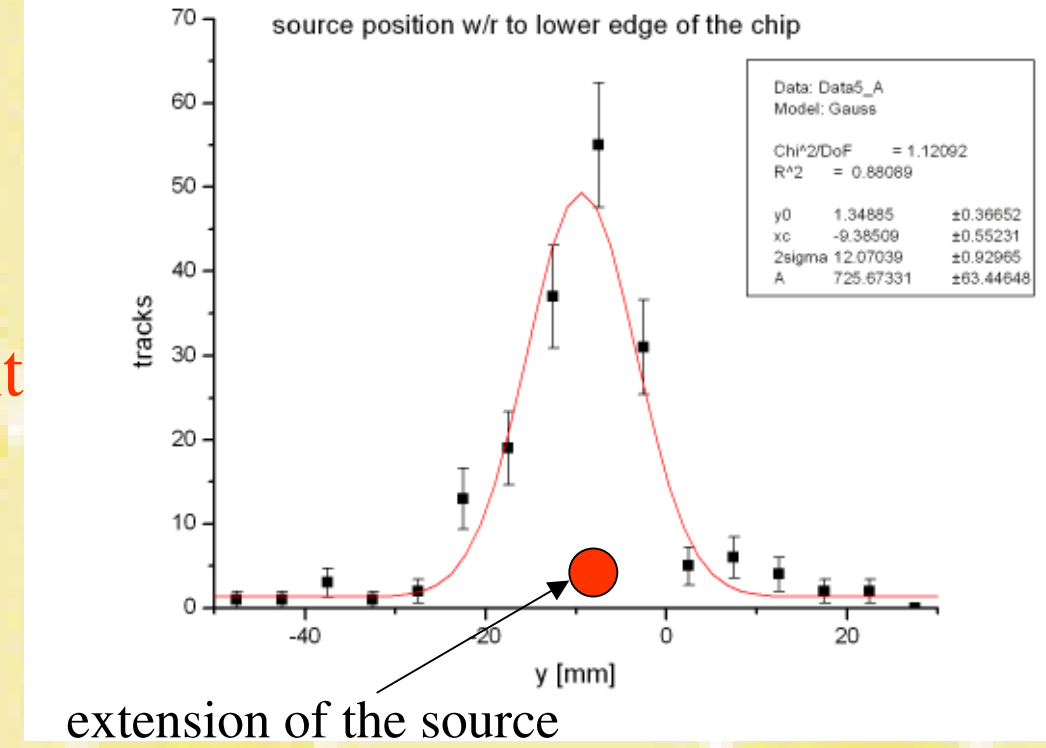
Projection of tracks back to the source

- indicates blurred image of the source due to multiple coulomb scattering
- estimated displacement for electron of ~1.5 MeV in A/CO_2: 4.6 mm

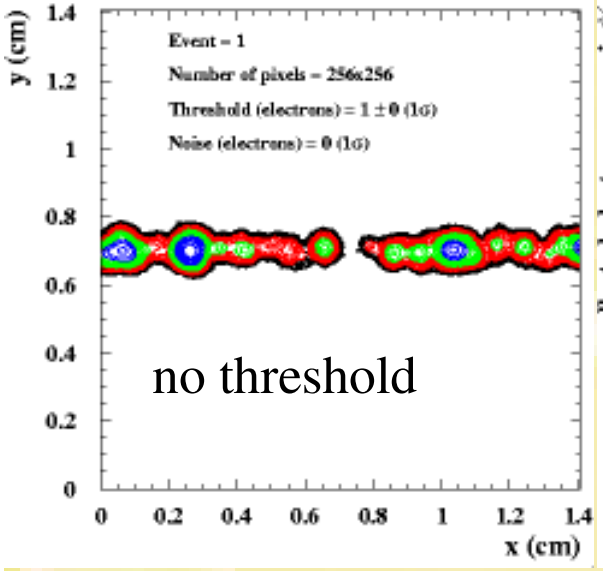
  to be compared with 6.0 mm from the plot

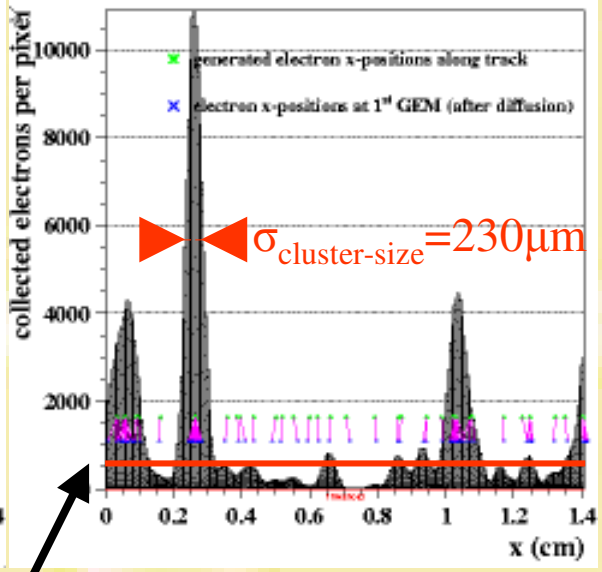
multiple scattering is present

An improvement of result of 63 µm for the residuals for electron in the GeV range may be expected. Simulations?



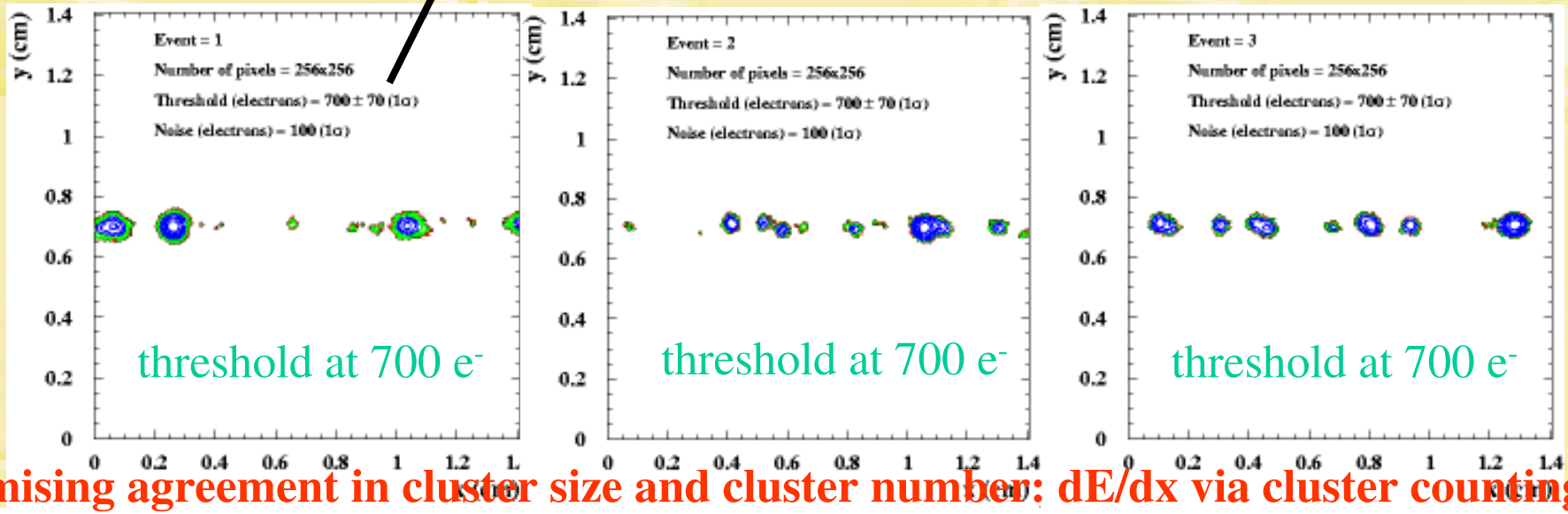
Comparison with simulation (Michael Hauschild CERN)





- MAGBOLTZ and HEED used
- input parameters (geometry, gas mixture, field, threshold in number of electrons) as the Freiburg experiment
- effective gain as measured in this setup as input
- no multiple scattering included (!)
- matches our measured ionisation energy loss: 45 e⁻

some events



promising agreement in cluster size and cluster number: dE/dx via cluster counting

Summary

- A GEM – MediPix2 chip setup successfully operated at a gain of ~6 10^4. It should be noted that this is not limited in principle: Tests indicate that higher gains are achievable.
- The calibration of low and high thresholds allow sensitivity down to 960 e^- and charge reconstruction
- Determination of the gain/primary electrons through ^{55}Fe
- Investigation the use of low/high threshold for tracks is continuing
- The MediPix2 readout allows cluster position resolution within 63µm with a small dispersion of 17.4 µm.

Plans

Near future plans:

- Compactification of setup with ≤1mm gap between the GEMs in order to decrease transverse diffusion in the stack
- Reproducing results with 2nd MediPix-Chip (no loss sofar !)
- Postprocessing of chip with increased size of pad at same sensitivity => lowering the effective threshold (55x55 , 110x110, 220x220 μm^2,…)
- Test beam runs at DESY with GeV-electrons

Medium term future:

- Study of faster gases
- Prototype TPC readout with Time-Pix and Time over Threshold feature for „3-dim“ track reconstruction
- End plate for prototype, TimePix integrated into pad readout or stand alone endplate