3GEM-MediPix2: 5GeV at DESY

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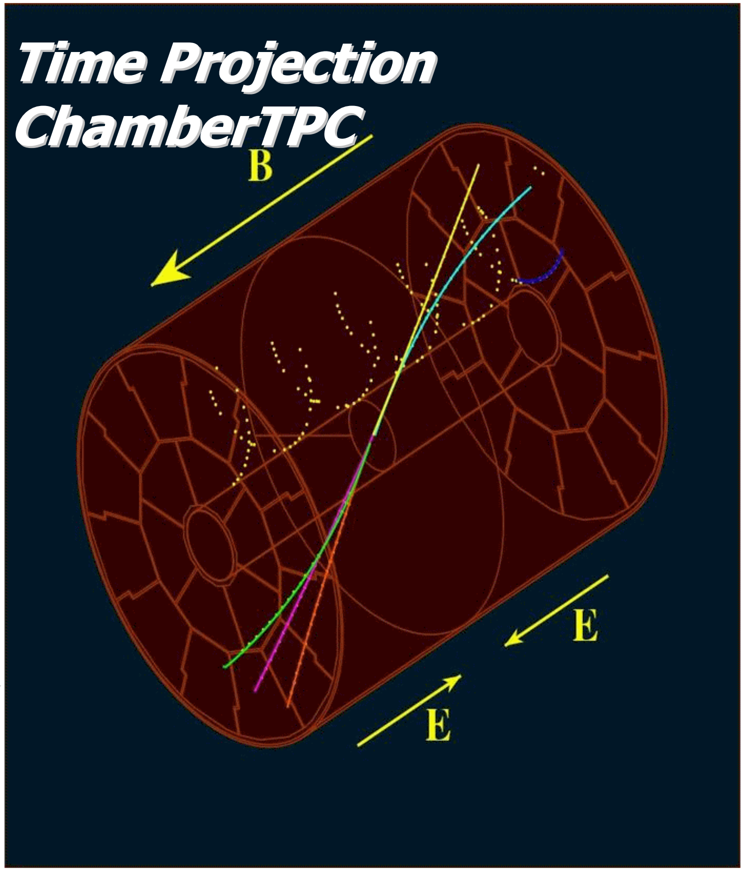
Overview

- **Gas amplification and *GEMs***
- **State of the art readout with *Medipix2***
- **Freiburg setup**
- **Measurements with 2MeV e^-**
- **Integration in test beam**
- **Measurements with *5GeV e^-***
- **Summary and Outlook**



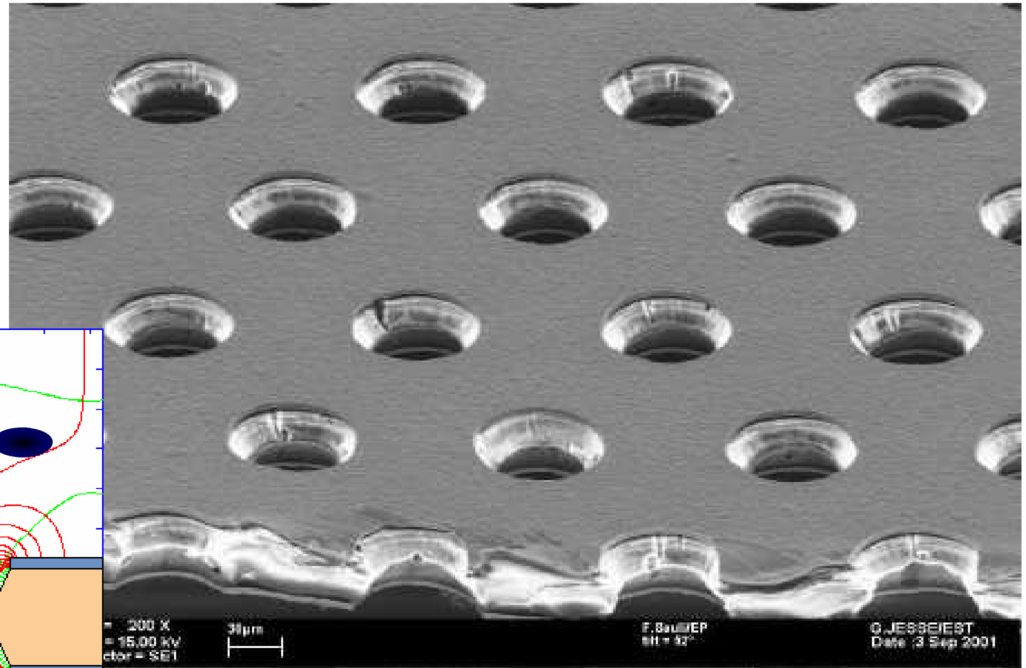
Thin, metal coated polymer foil. Very high density of chemical pierced holes

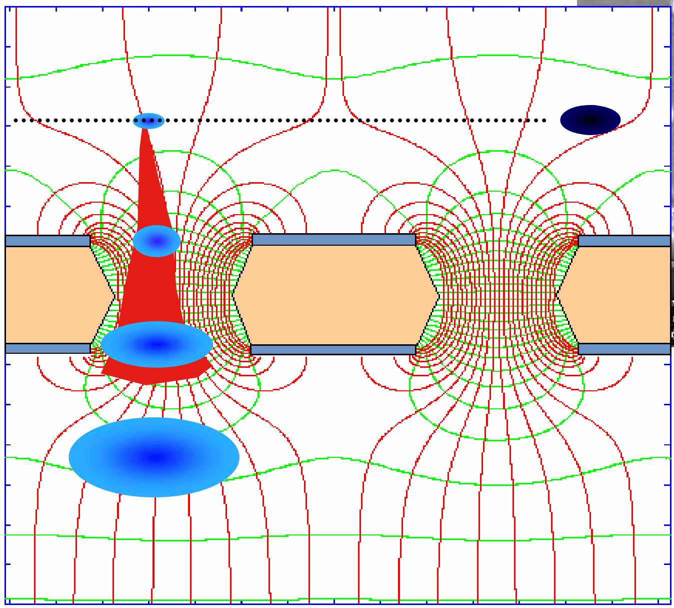
F. Sauli, Nucl. Instrum. Methods A386(1997)531
F. Sauli, http://www.cern.ch/GDD

GEM - Gas Electron Multiplier

Typical look:

- ***2 layers Cu*** **each 5µm thick, separated from each other by 50µm *Kapton*.**
- **Conical etched *holes* largest *Ø70µm, distance of holes 140µm*.**





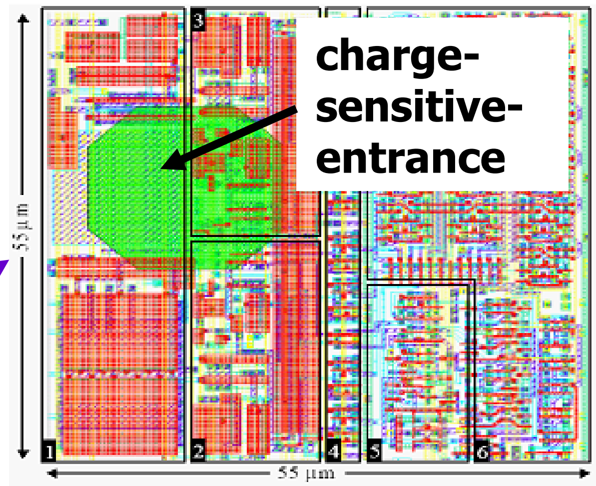
Advantages of Triple-GEM-setup

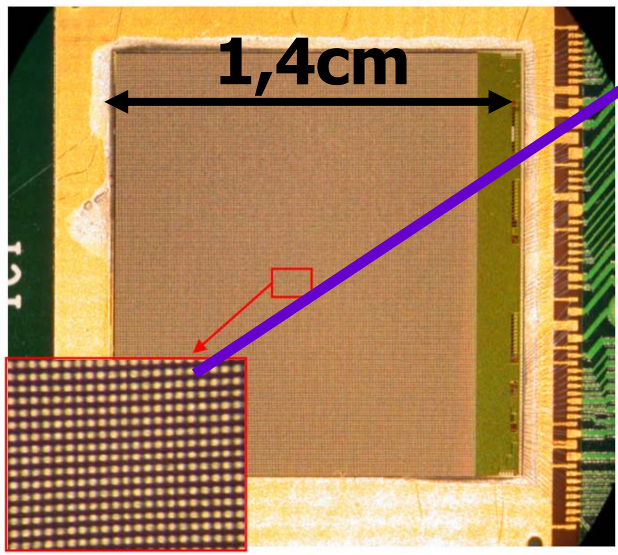
- ***Gas gain up tp 10^5*** **in $ArCO_2$ easily achievable**
- ***Minimizing the backdrift of positive ions into the drift volume ($\mathcal{O}(10^{-2})$)***
- ***Encapsulated region of amplification***

MediPix2

X. Llopart, IEEE Trans. Nucl. Sci., vol. 49, NO. 5

- ***Pixel size 55µm, arranged in a 256x256 Matrix***
- **dimensions of the *sensitive area*: *1,4x1,4cm^2***
- ***Clock up to 100MHz* → allows readout of the chip within *9ms in seriell* and ≈250µs in parallel mode**





- ***Bipolar, charge sensitive entrance with pre-amplifier***
- ***discriminator logic* for setting a lower and higher threshold *(THLow/THHigh)***
- **Roughly 150e$^-$ RMS noise per pixel.**
- ***According to our calibration we operate with a lower threshold of ≈ 990e$^-$***
- **For attaining additional *information on drift time* and duration of the pulse above THL, the *TimePix* was recently developed at CERN → *see talk of X. Llopart***

Setup

schematic view of the stack from the side

windows are made of *0.5mm thick* Plexiglas

$\sigma_{position}$

$\sigma_{cluster-size}$

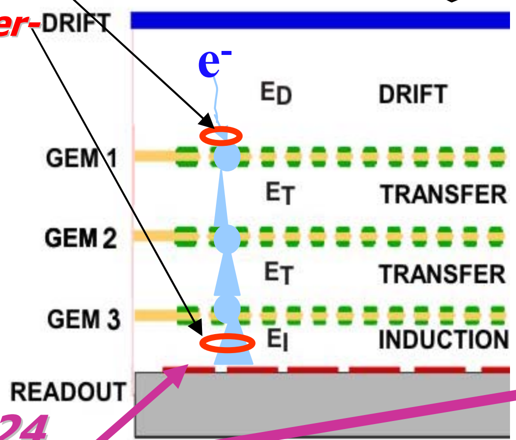
Potentials and fields:

E_D= 1.1 kV/cm

ΔV_{GEM}= 404 V

E_T = 3.2 kV/cm

E_I = 4.2 kV/cm

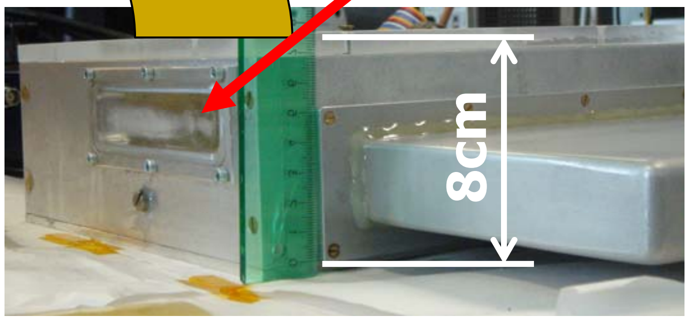


6mm

2mm (1mm)

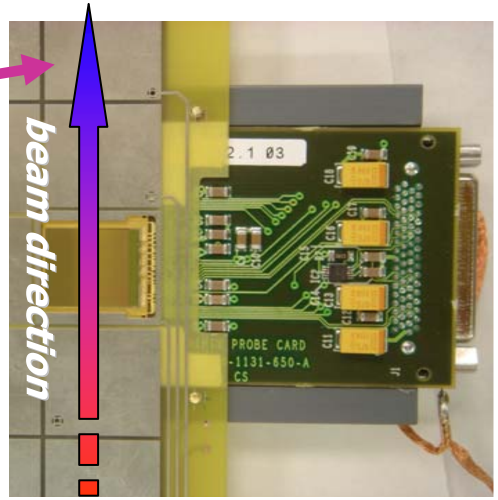
2mm (1mm)

1mm



In total *24 2cm x 2cm wide pads* are connected with *L3-μ-amplifiers*

placment of the MediPix2

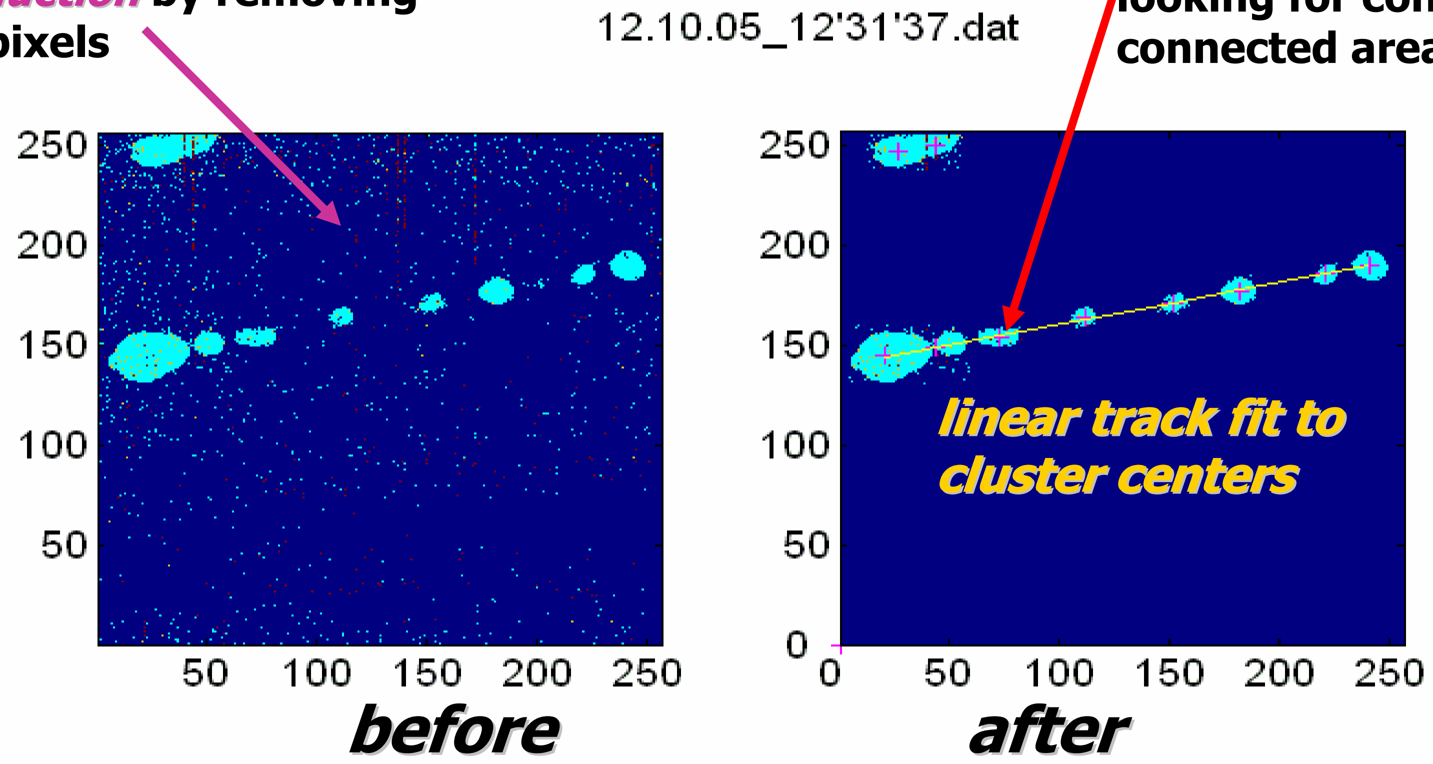


For the first time we are using the *hardware shutter* option coming along with the *MUROS 2.1* readout system. Hence a fast trigger allows control of the MediPix2 exposure.

Typical ^{106}Ru-event

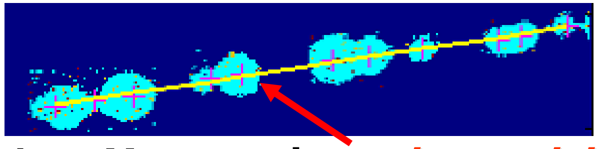
Noise reduction **by removing isolated pixels**

Clusterfinding **by looking for contigous connected areas**

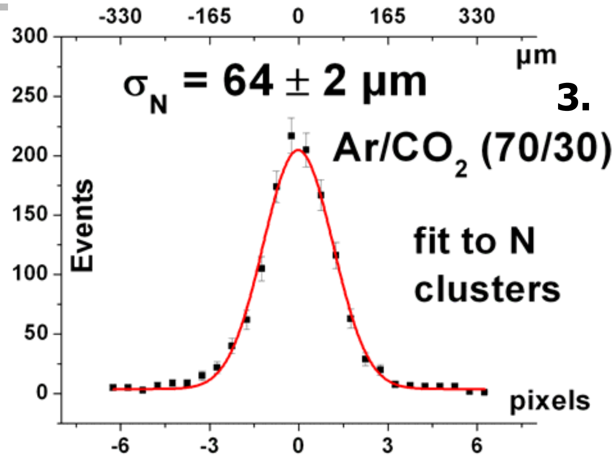


Processing with Matlab

Point resolution, the 2MeV case

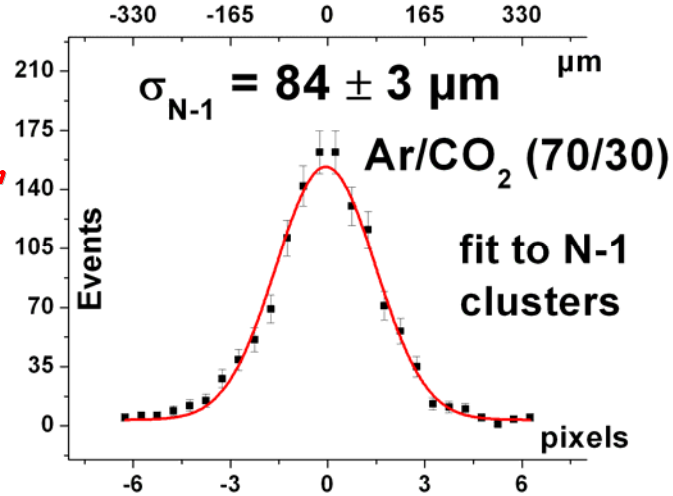


1. Measure the ***orthogonal distance*** between all clusters and the fit with ***N-clusters***
2. Afterwards ***omit*** one cluster. Now make a fit with ***N-1*** clusters and record the ***displacement to the exempted cluster***. Repeat this for all possible permutations.



3. Plot the ***distribution of the deviations***. And estimate the sigma of the fit for the ***N-cluster*** case σ_N and also for ***N-1*** σ_N

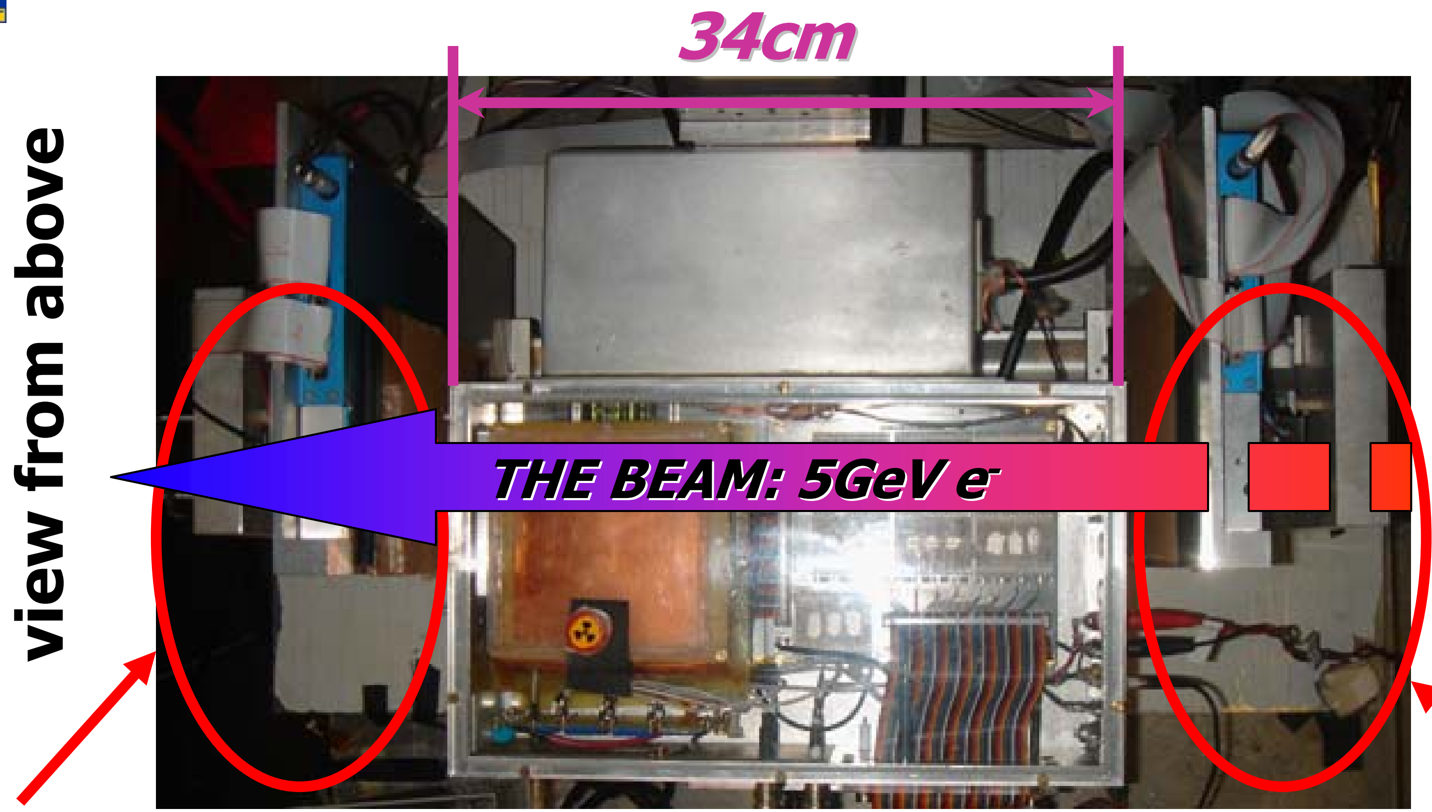
4. Take the ***geometric mean*** σ_{mean} σ_N of σ_{N-1} and $\sigma_N \Rightarrow$ ***unbiased estimator***



	Ar/CO$_2$	He/CO$_2$
σ_{mean}	*73 ± 3 µm*	*65 ± 3 µm*
$\sigma^{corrected}_{mean}$ *	*≈ 54 µm*	*≈ 61µm*

*Geometric mean σ_{mean} corrected for the contribution due to multiple scattering, which is in Ar/CO$_2$: ~49µm and in respectively He/CO$_2$: ~23µm)

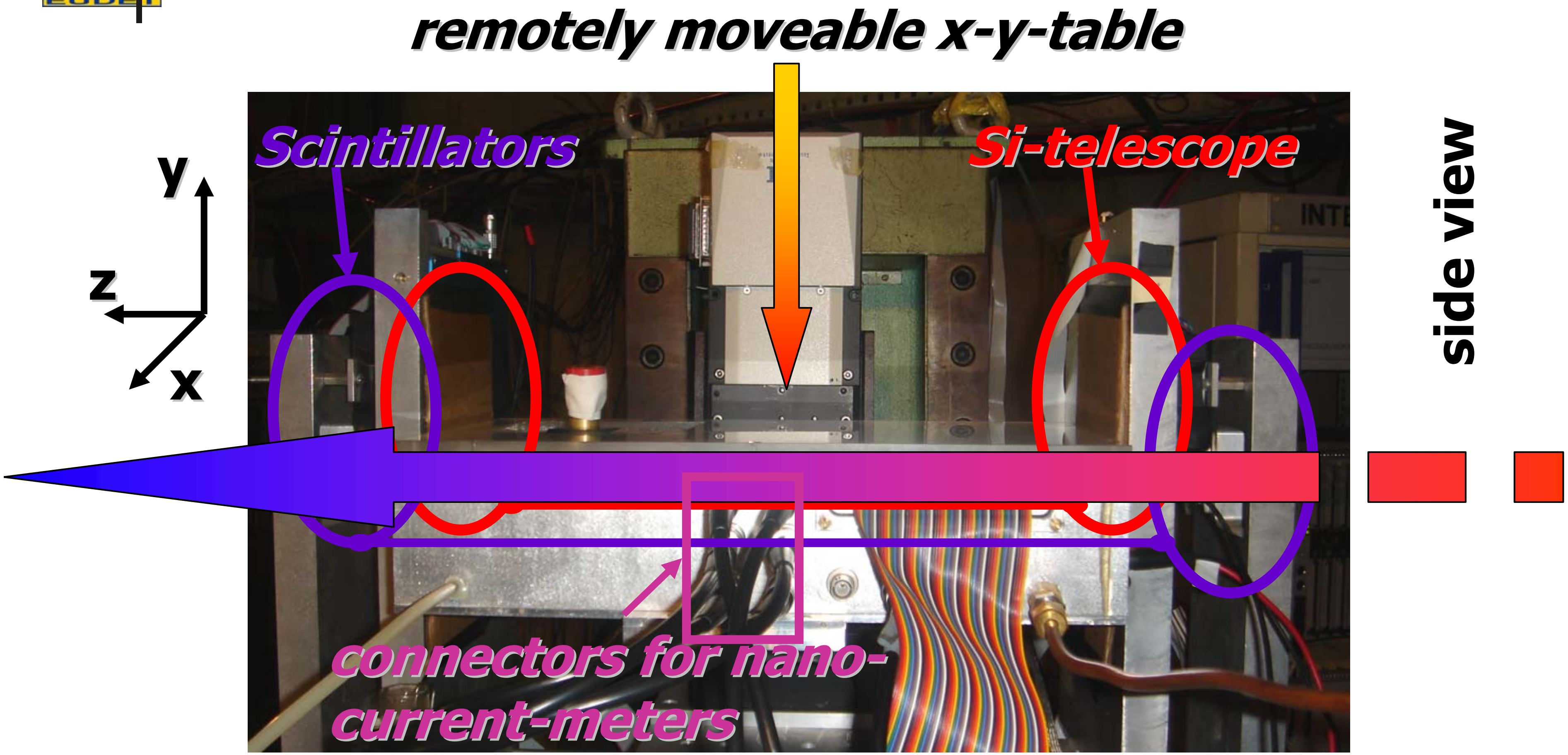
Integration into beam (1)



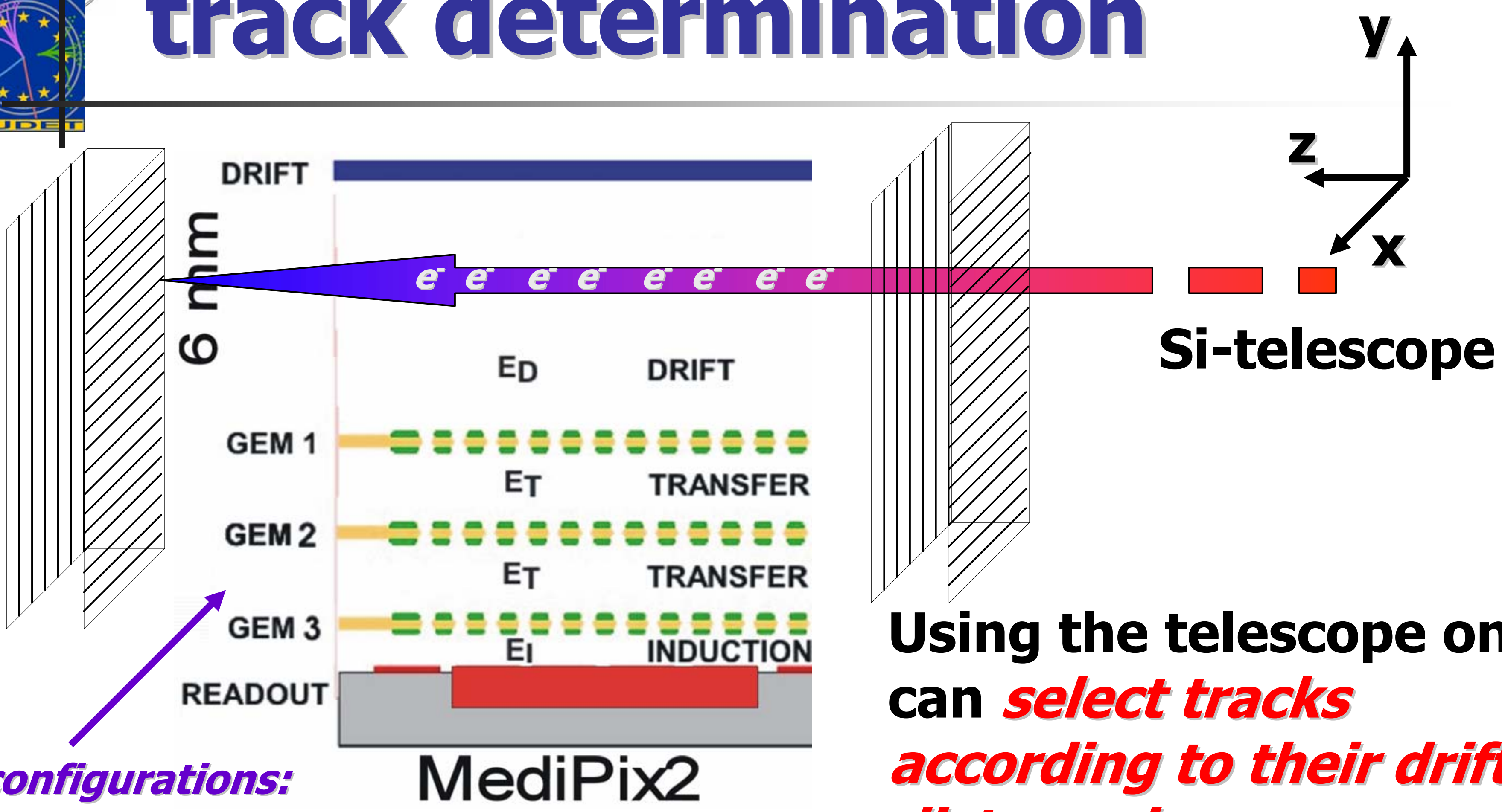
Special thanks to Uli Kötz et al. for permitting us to use the Si telescope

scintillators for fast trigger and Si-stripe-telescope on each side

Integration into beam (2)



Si-Telescope for external track determination



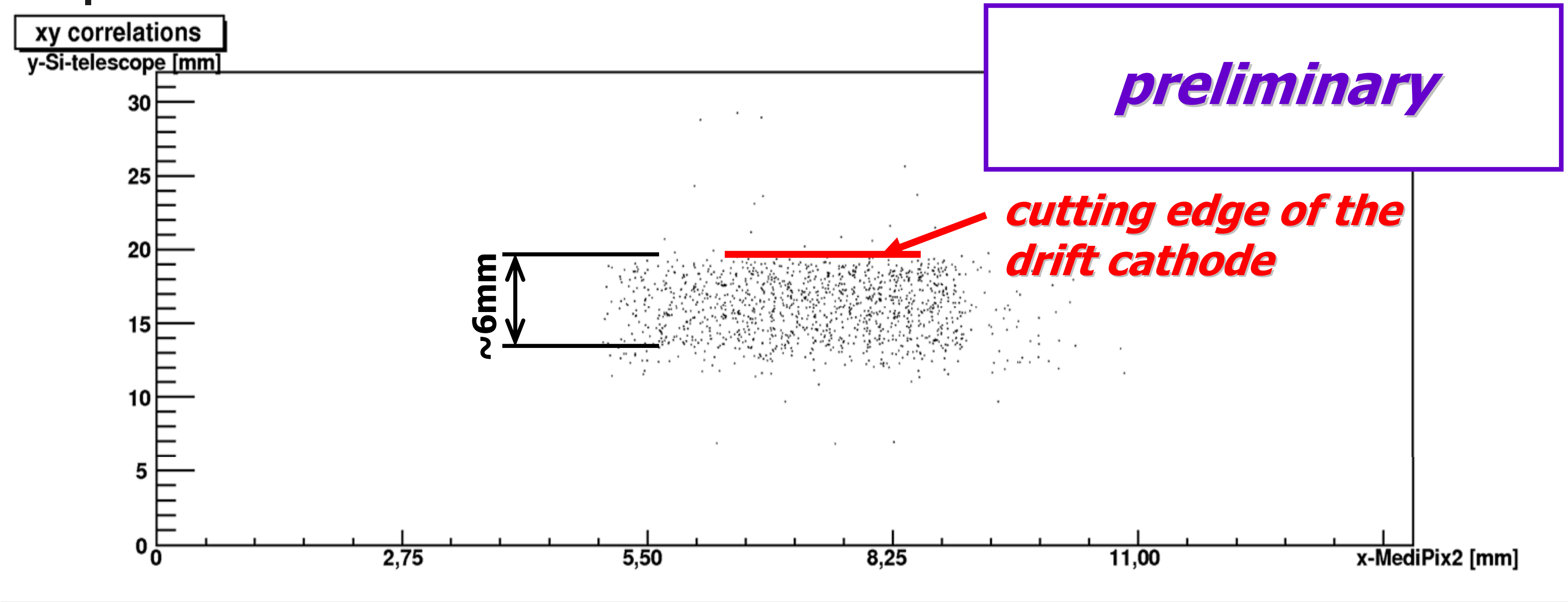
Using the telescope one can ***select tracks according to their drift distance in y.***

2 configurations:

2mm transfer gap and 1mm induction gap (2-2-1)

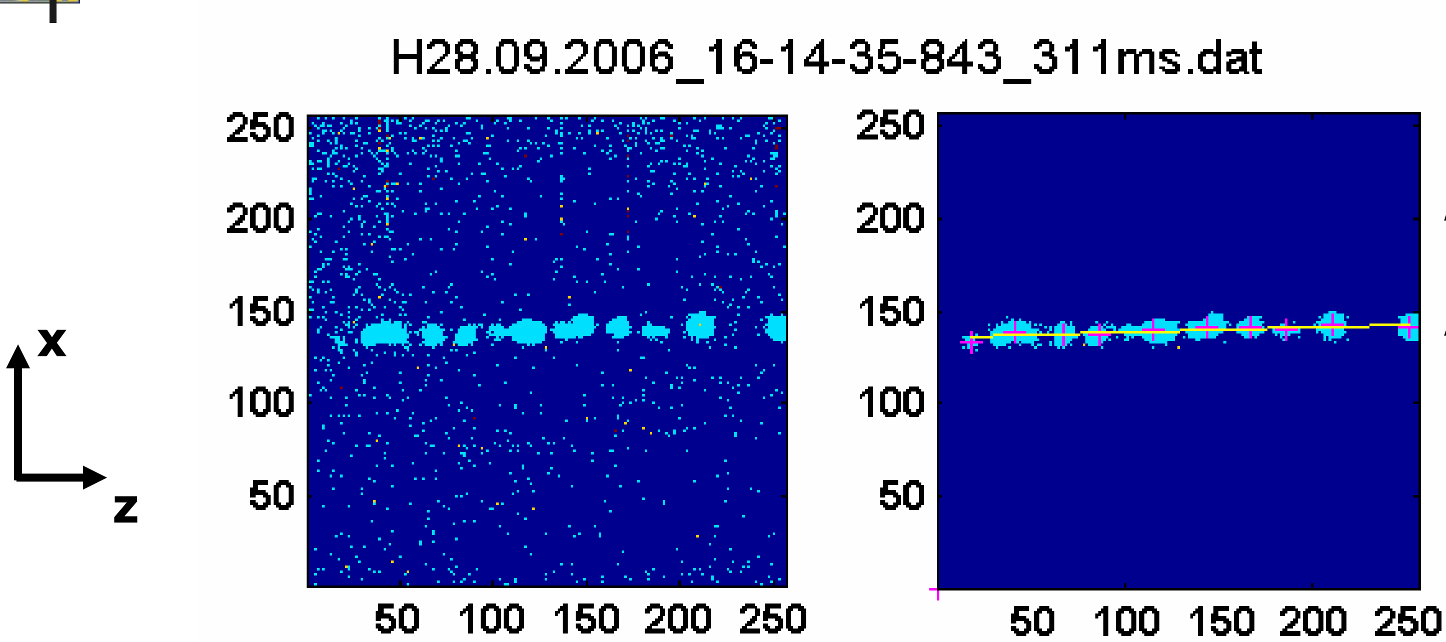
1mm transfer gap and 1mm induction gap (1-1-1)

Combination of MediPix2 and Si-telescope data



Correlating the data acquisition of the beam telescope (y-axis) and our setup (x-axis) allows *determination* of the *resolution as function of drift distance*

Typical event at DESY



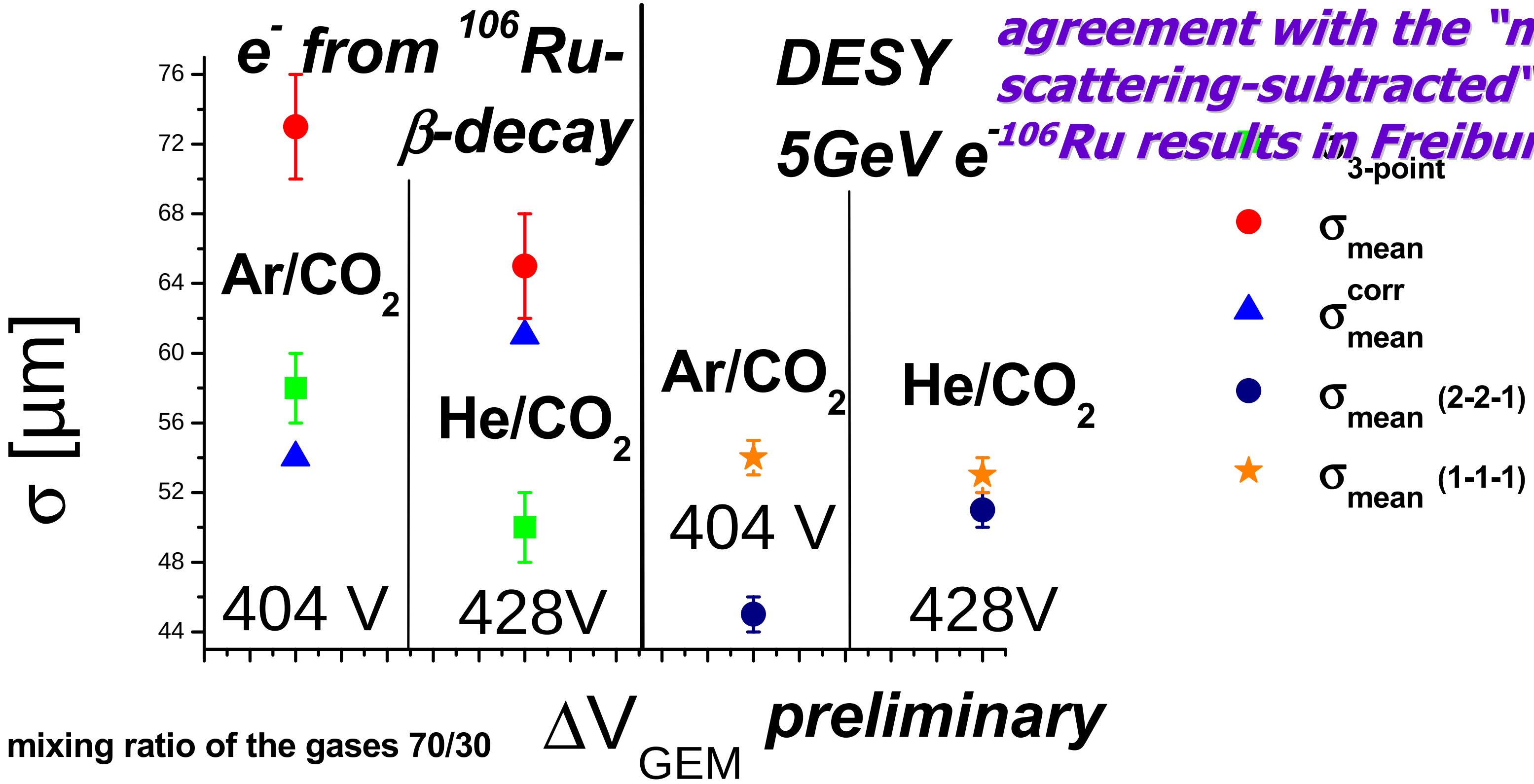
ArCO2,

ΔV_{GEM}=404V

Tracks are almost perfectly straight. Contribution of *multiple scattering is negligible* at 5GeV. The whole setup has been tuned to *minimize the material budget* with respect to the beam.

Point resolution for ^{106}Ru-electrons and 5GeV e^-

The measured resolution in the beam is in good agreement with the "muliple-scattering-subtracted" 2MeV-^{106}Ru results in Freiburg.



mixing ratio of the gases 70/30

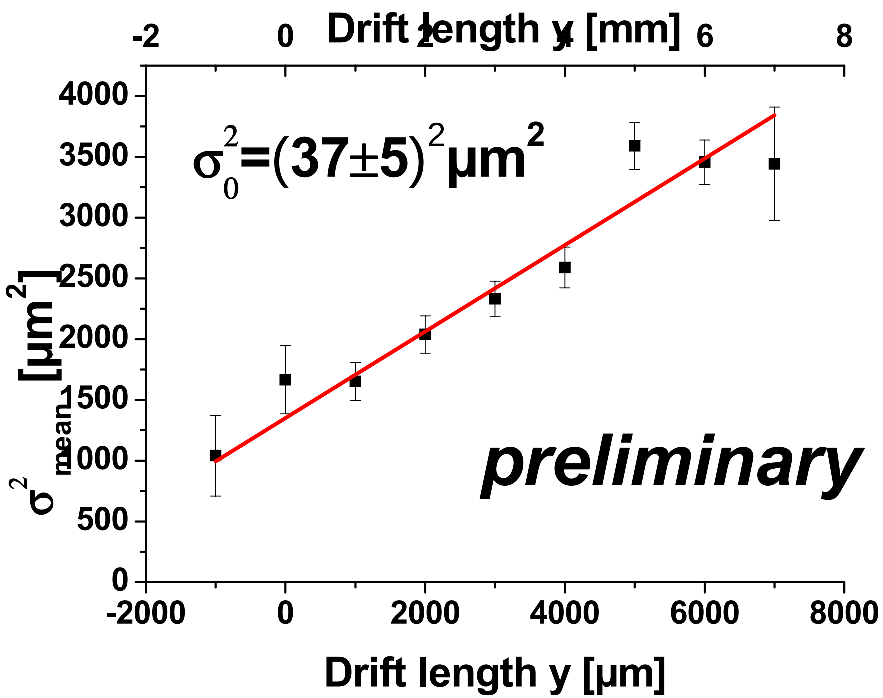
Dependence of point resolution from drift length

$$\sigma_{mean}^2 = \sigma_0^2 + \frac{D_t^2 \cdot y}{n_{cl}^{el}}$$

- **σ_{mean}: variance of the mean position of ionization cluster centers**
- **D_t: transverse diffusion coefficient**
- **n_{cl}^{el} : number of primary electrons per cluster**
- **y: drift length**

- ***σ_0: intrinsic resolution (GEM term).*** **Loosely spoken "The resolution which can be achieved when the electron grazes just above the surface of the uppermost GEM."**

Drift-distance-scan using the Si-telescope (1)



$ArCO_2$

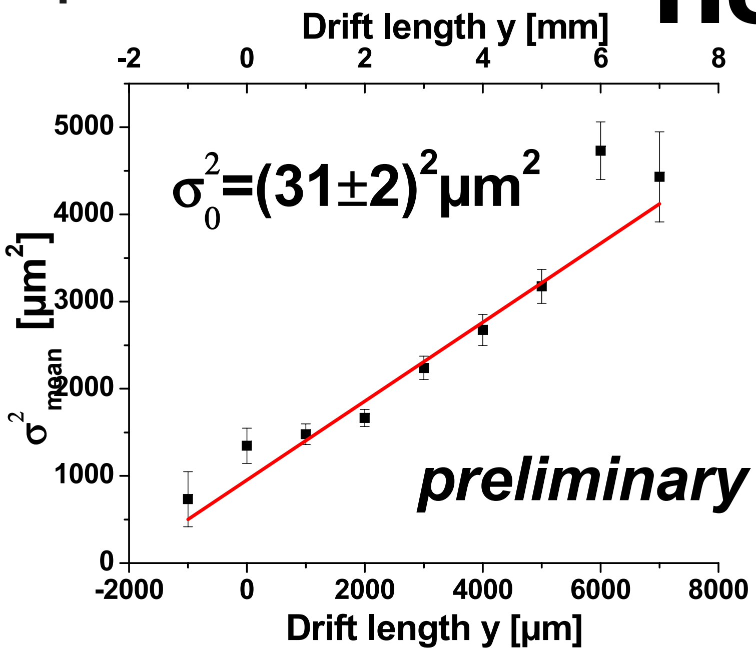
2mm transfer gap

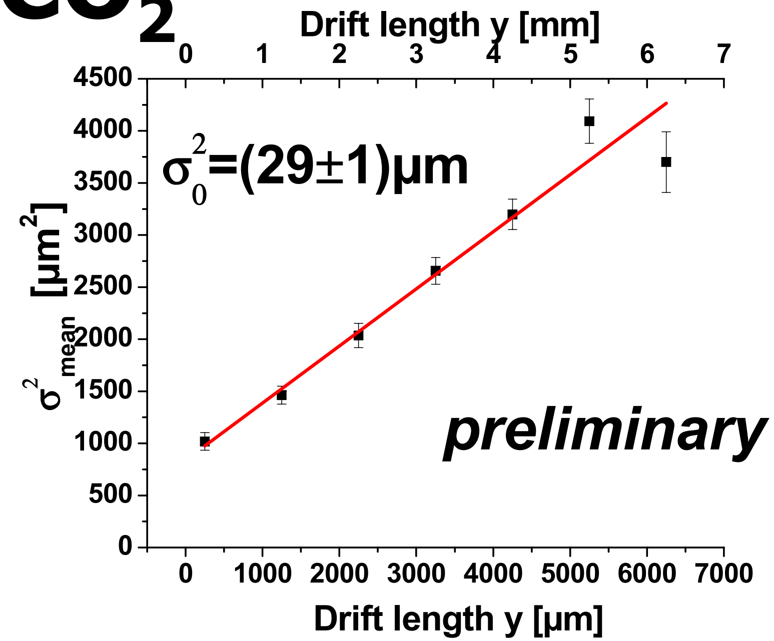
1mm induction gap

After adjusting the telescope coordinates and the drift space one can plot the *resolution as function* of the drift length

Drift-distance-scan using the Si-telescope (2)

$HeCO_2$

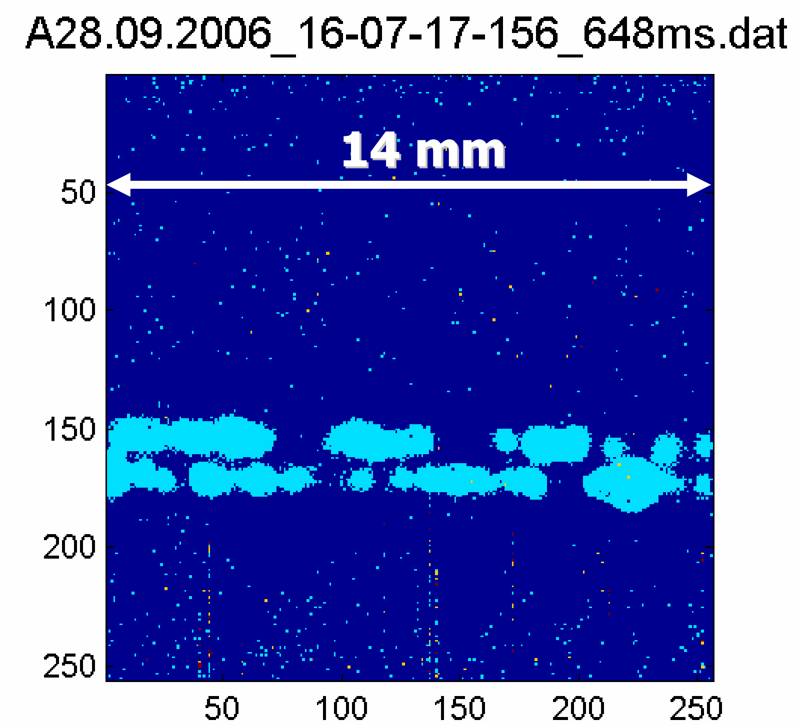


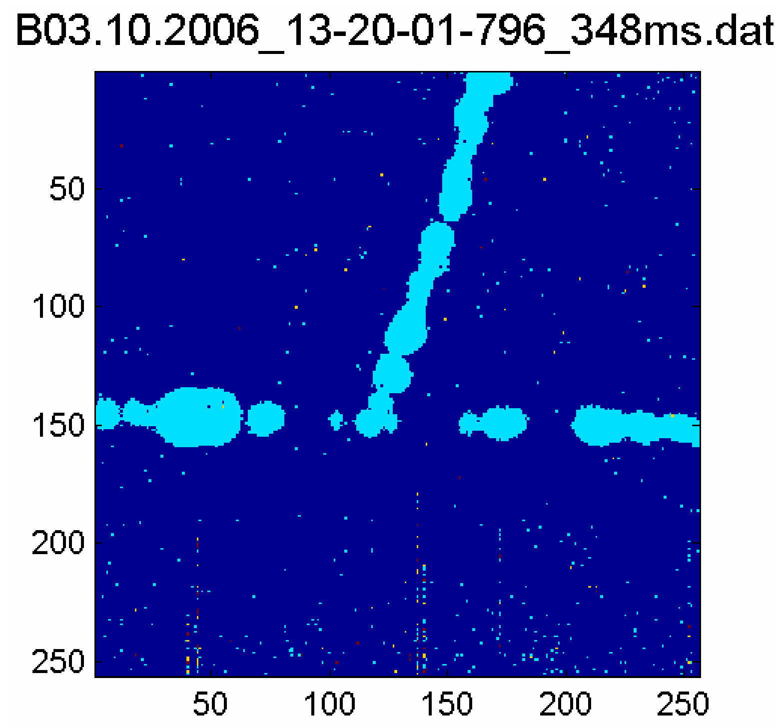


2mm transfer gap — **1mm transfer gap**

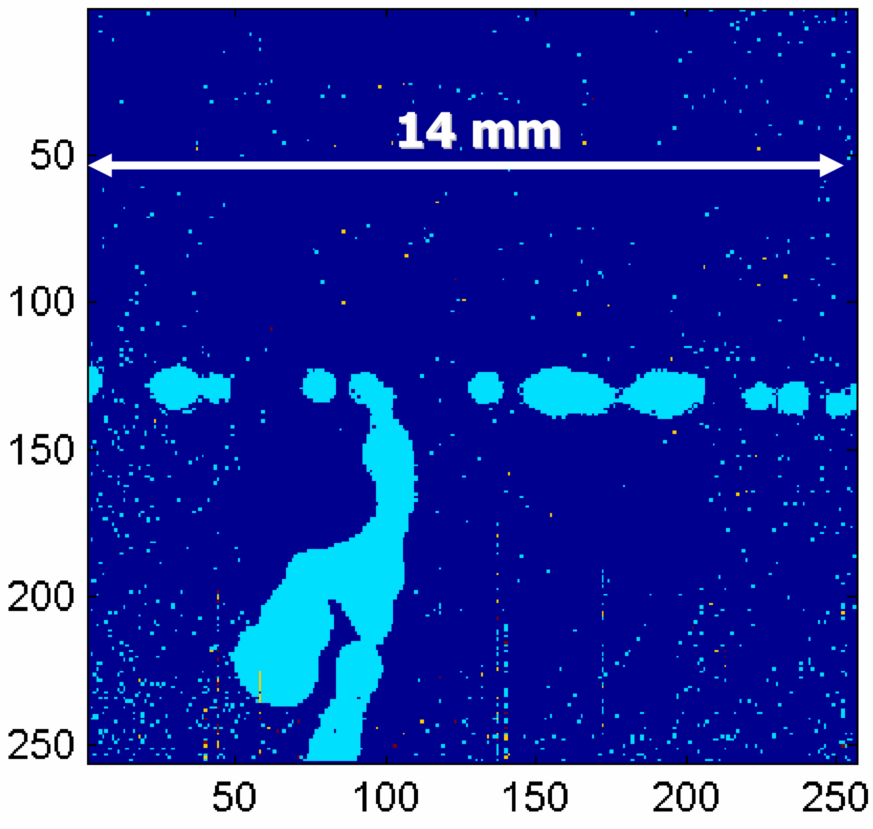
1mm induction gap — **1mm induction gap**

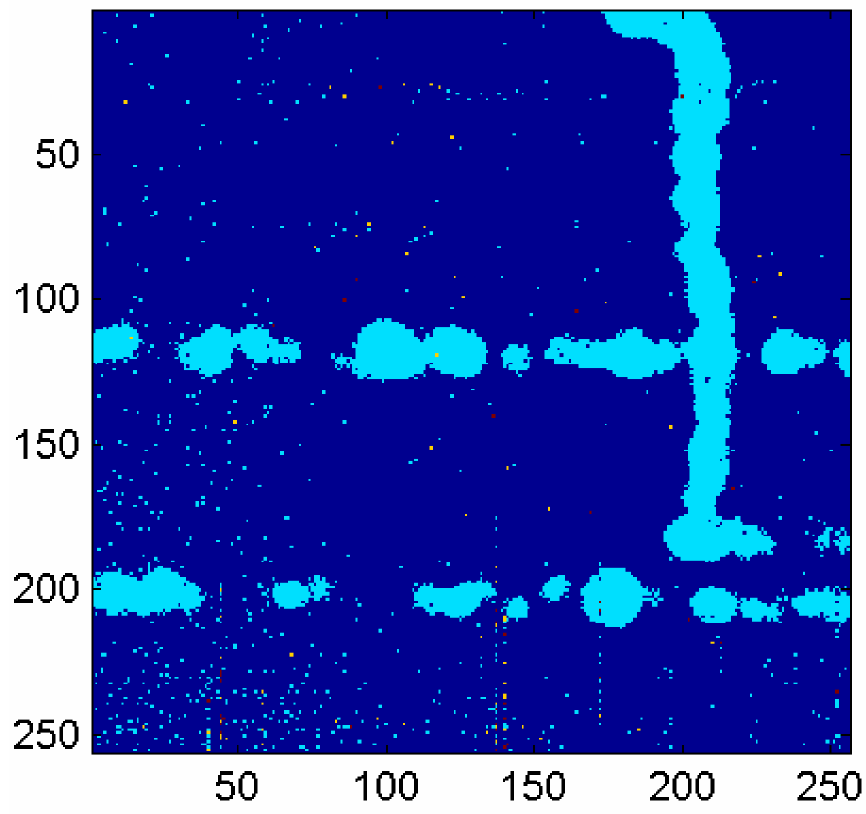
Imaging capability – double tracks & δ-electrons



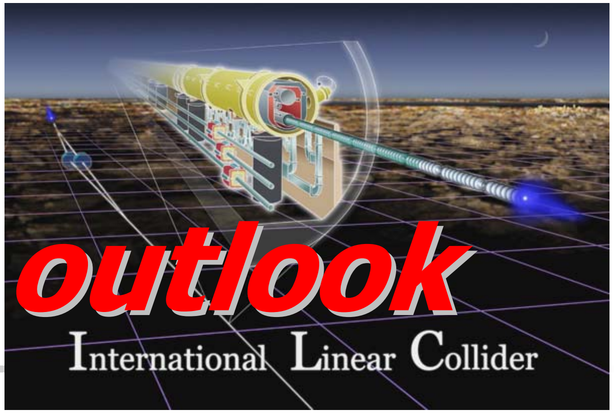


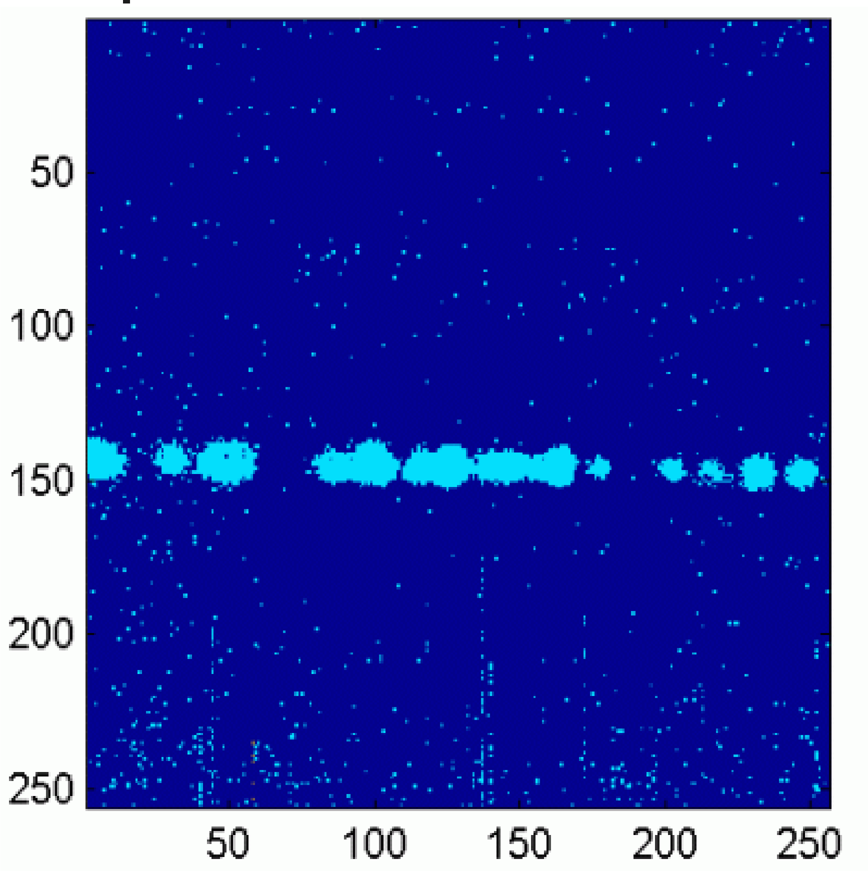
Imaging capability – a few more δ-electrons





Summary and outlook





Up to now achieved

- ✓ More than 1,5 years of regular and stable operation
- ✓ Superb ***point resolution*** achieved: $\sigma_0 \approx 30\mu m$
- ✓ ***Direct energy measurement*** is feasible by using the ***calibrated*** lower and upper ***thresholds of*** the ***MediPix2***-chip.
- ✓ ***Compactification*** of GEM stack

Plans for the future

- ➢ ***Pixel electrode will be enlarged*** at the expense of active pixel pitch to collect more charge per channel. Therefore ***reduce*** the necessary ***gas gain***.
- ➢ Doing ***beam tests*** with the recently available ***TimePix***
- ➢ ***Improvement of*** the ***existing tracking algorithms*** and include robust cluster counting
- ➢ ***Construction of an endplate for a large TPC prototype.***

The End

...or better to say the beginning?