Pixel Readout of GEMs

Motivation
The Setup
Results
Next Steps

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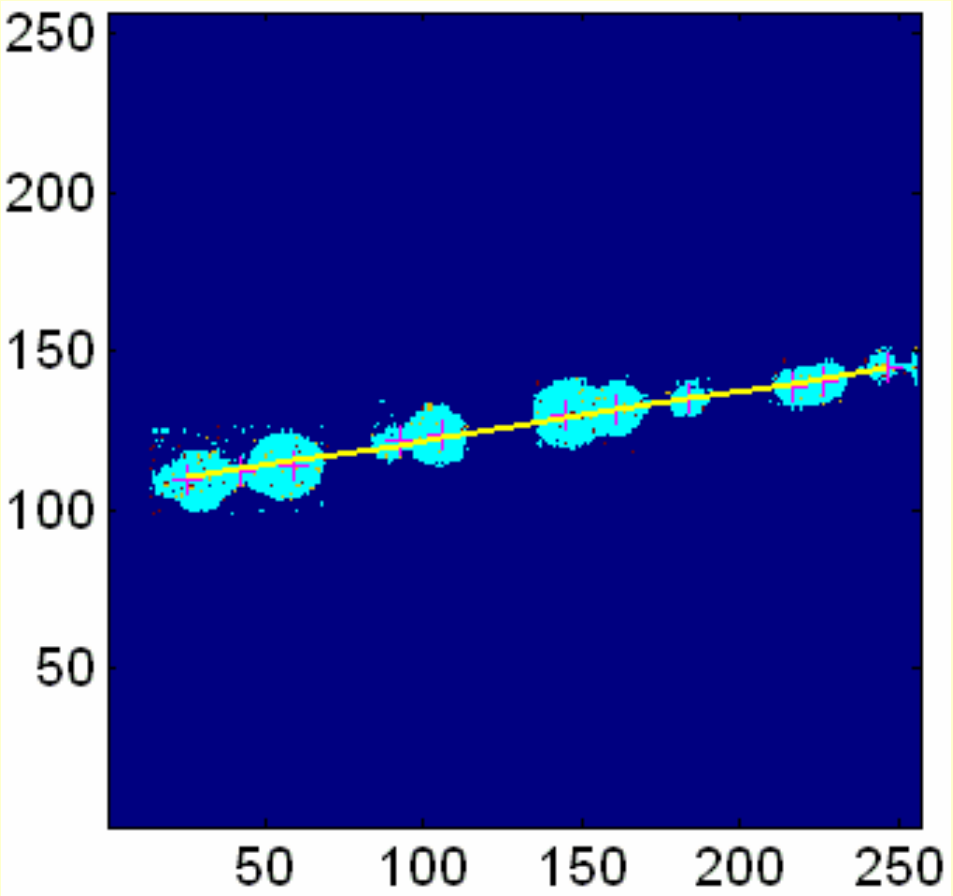


ECFA LC Workshop
Vienna 16/11/2005

Motivation

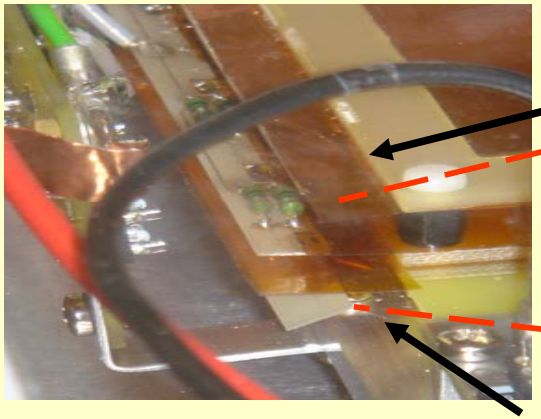
Idea: use a Pixel readout chip (w/o Si sensor) as
integrated device hosting pads + readout electronics for a TPC
(pioneered at NIKHEF)

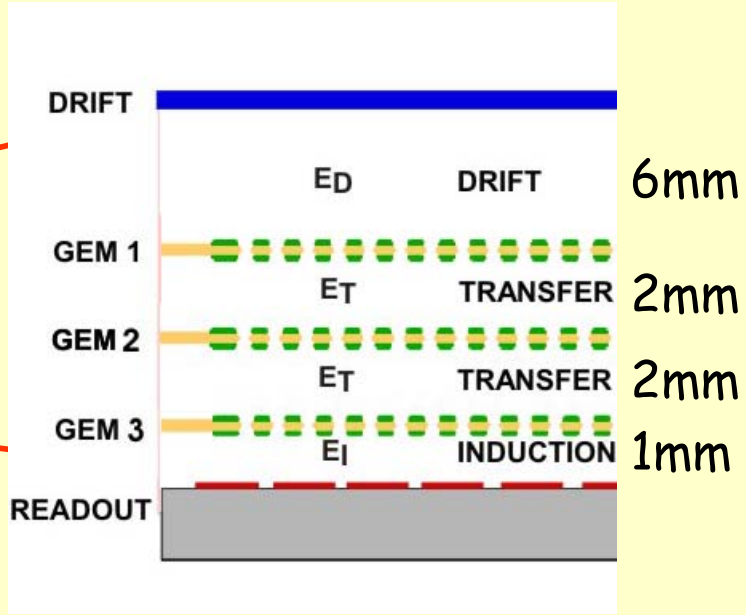
Potential advantages
→ very small (50x50 μm^2) Pads
→ potentially very good point+momentum resolution
→ dE/dx via cluster counting
→ frontend electronics automatically integrated ('active endplate')

Potential concerns
→ diffusion will limit resolution (gas!): how small is necessary?
→ cost?
→ stable operation possible?

Freiburg initial goals:
- demonstrate operability using triple GEM + Medipix2 chip
- measure & understand (details of) charge cloud

The Setup





typ. potentials/fields:

E_D= 1.1 kV/cm

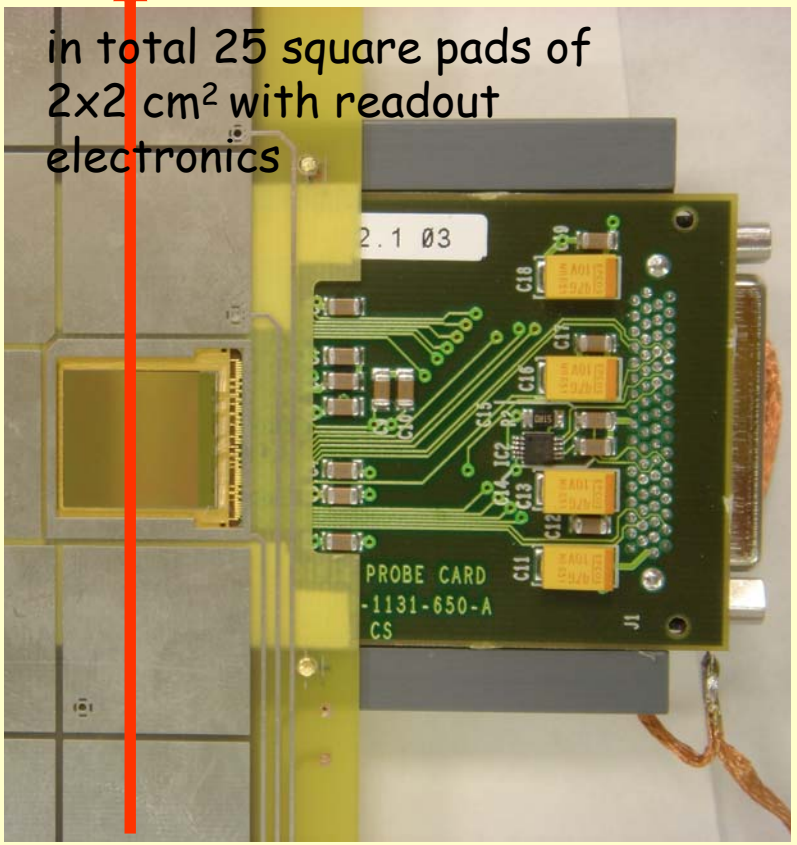
ΔV_{GEM}= 404 V

E_T = 3.2 kV/cm

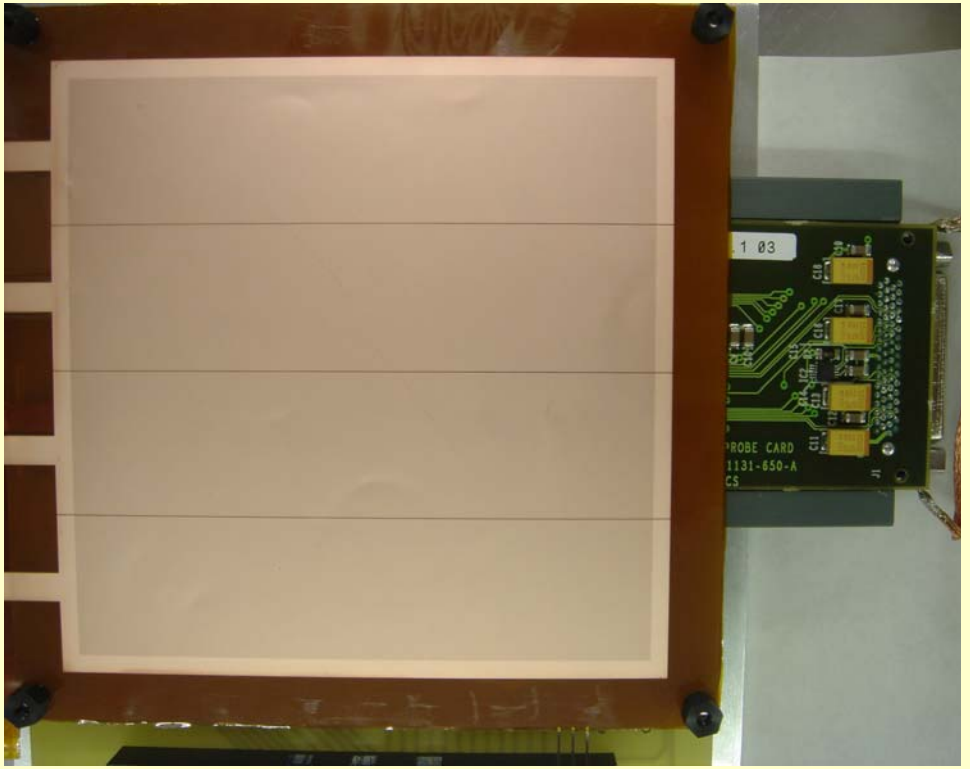
E_I = 4.0 kV/cm

- drift volume 6 mm
- transfer gaps 2 mm
- induction gap 1 mm

The Setup

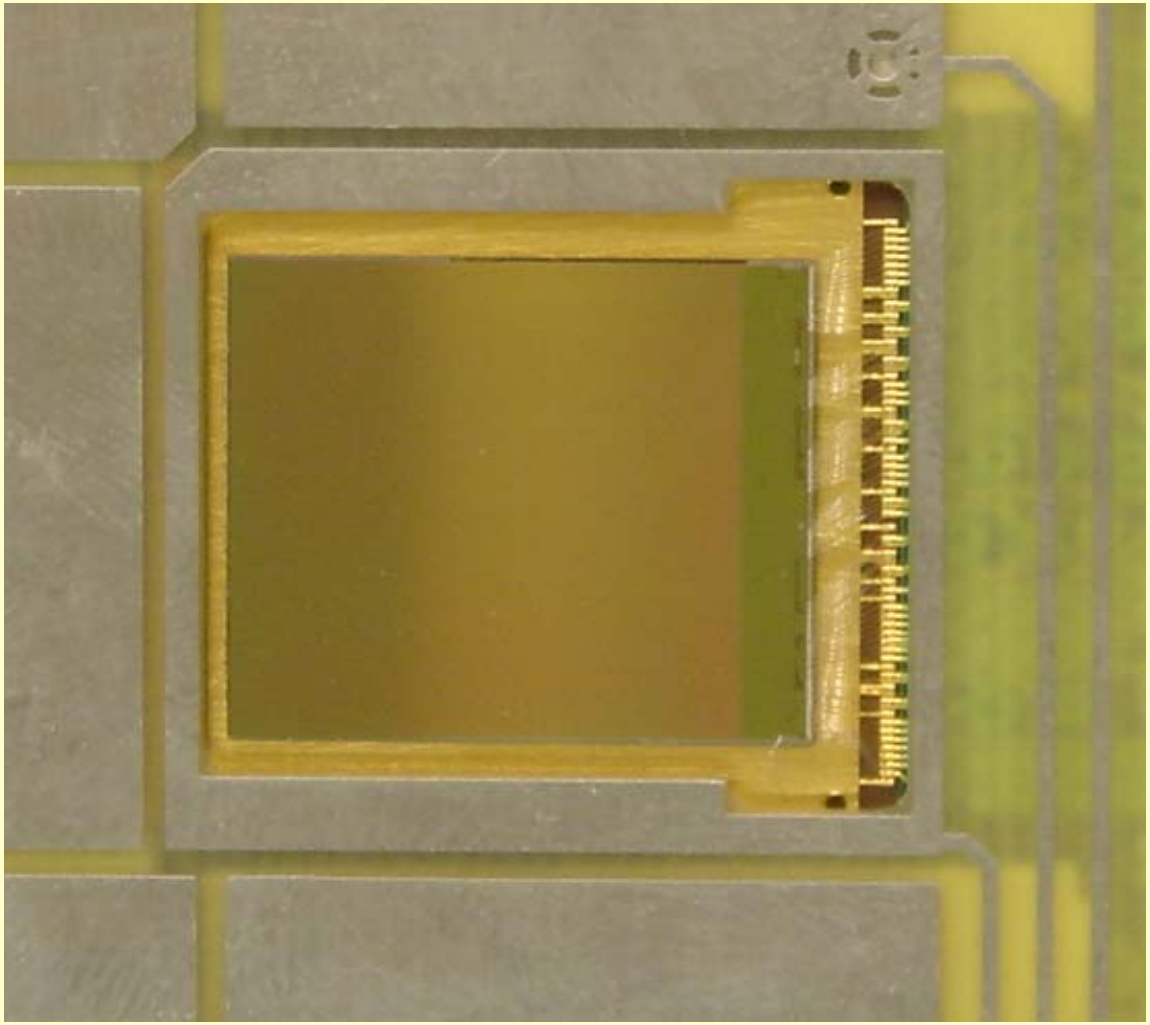


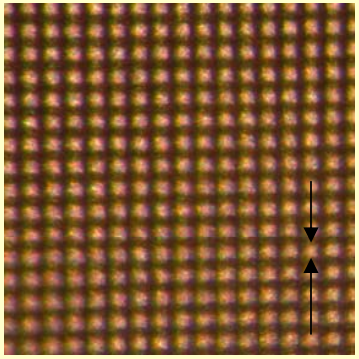
β⁻ source Ru106, 3.5 MeV
from daughter Rh106
crosses 4 pads with
MediPix2 in between



GEM on top of
MediPix2 and pads

The Setup





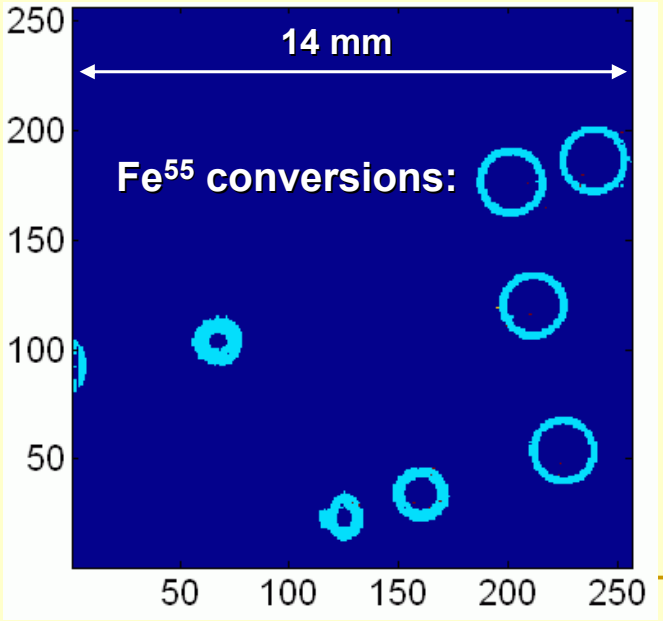
Parameters

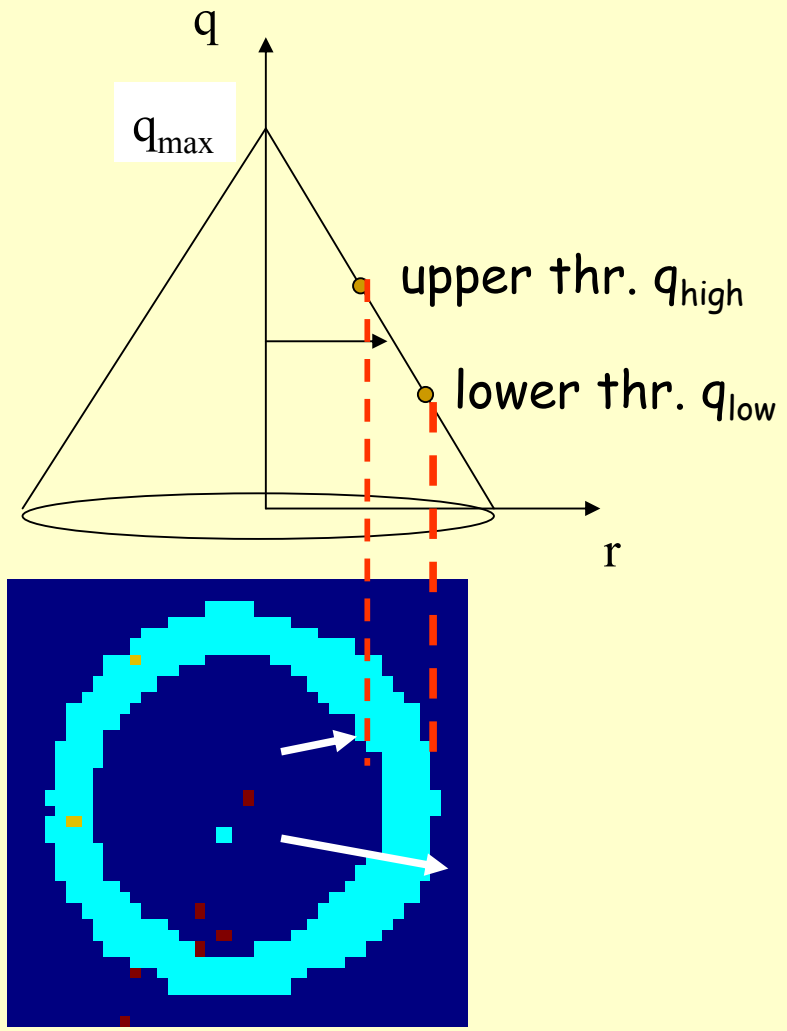
- lower threshold at typically ~1000e^-
- upper threshold used for estimating the total charge of a cluster
- HV 4200 V, 404 V across GEMs → gain 6×10^4
- Use collimated ^{55}Fe source for calibration
- β´s from the ^{106}Ru source used for ~MIP signals
- low trigger level (<$\frac{1}{4}$ of the average pulse height from β´s crossing ~ 8 cm of Ar/CO_2).
- four-fold trigger coincidence to readout MediPix2

Gain determination

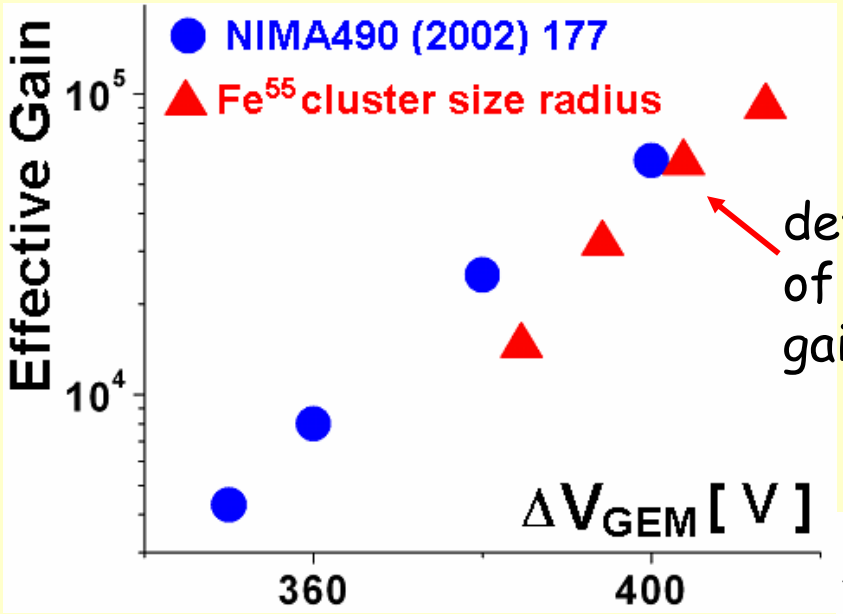
Fe^{55} quanta of 5.9 keV produce ~220 primary electrons
Estimate total charge on the pixels (need to assume shape of cloud (not very critical)

Reconstruct total charge using $(r_{low,}, q_{low})$ and (r_{high}, q_{high})



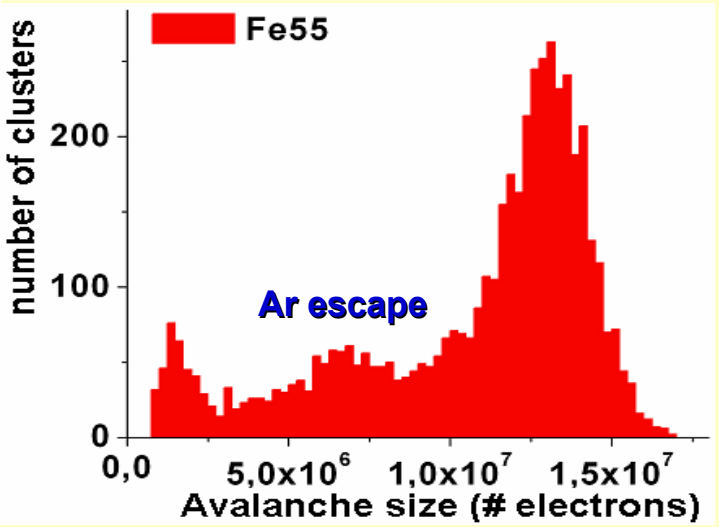


Gain determination



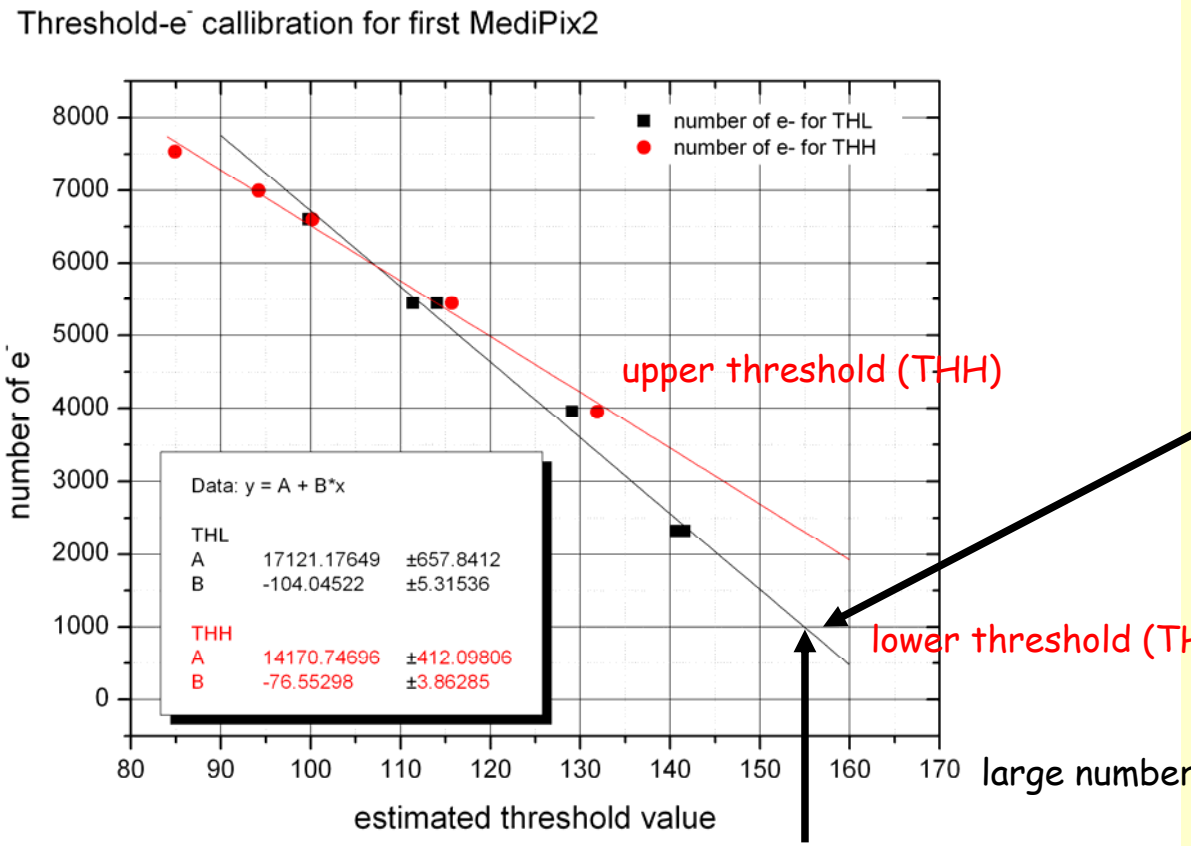
default point of operation: gain = 6×10^4

can even do 'spectroscopy' with cluster radii-method:



Threshold Calibration of MediPix2

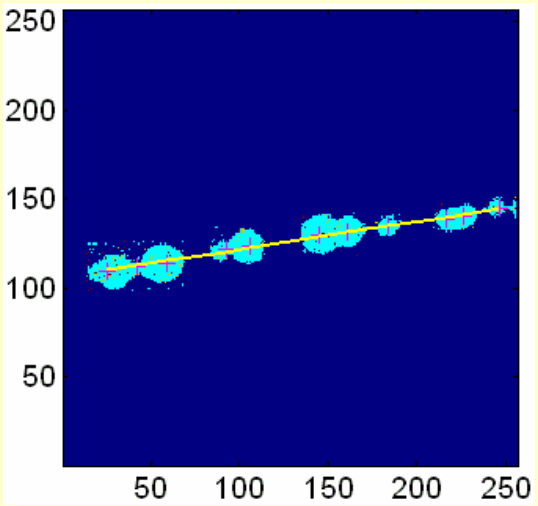
from charge injection + calibration of injector with sources
+ threshold equalization

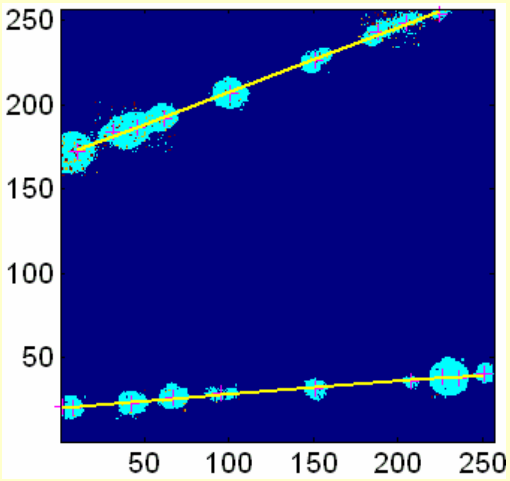


$q_{THL} > 960\ e^-$

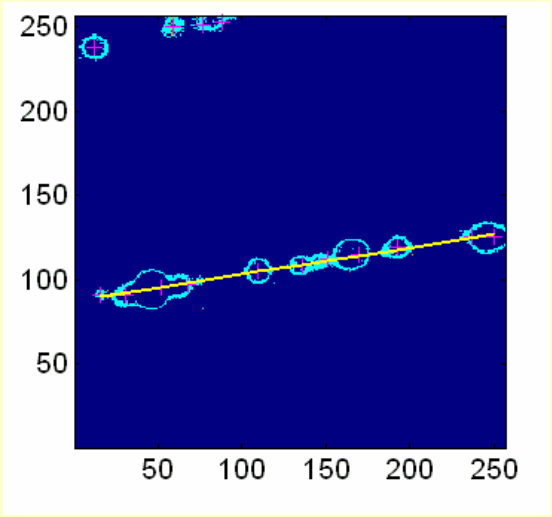
acceptable noise level low THL =155 equ. to 960e⁻

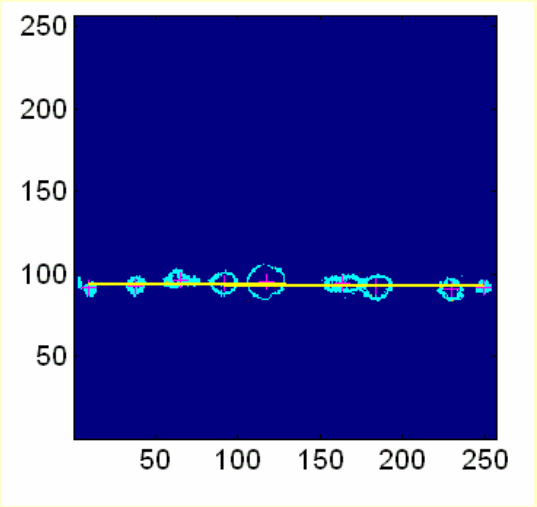
Tracks from ^{106}Ru





using lower thresh. only



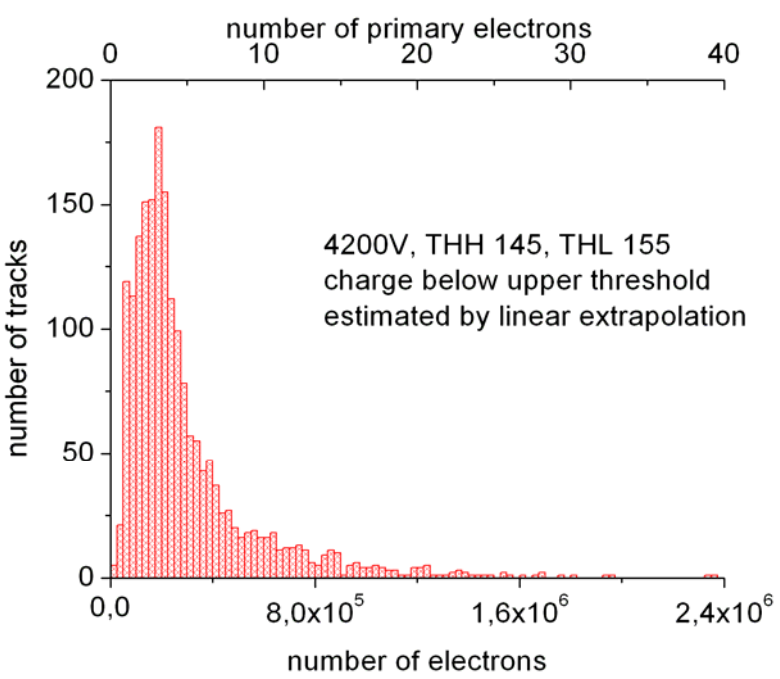


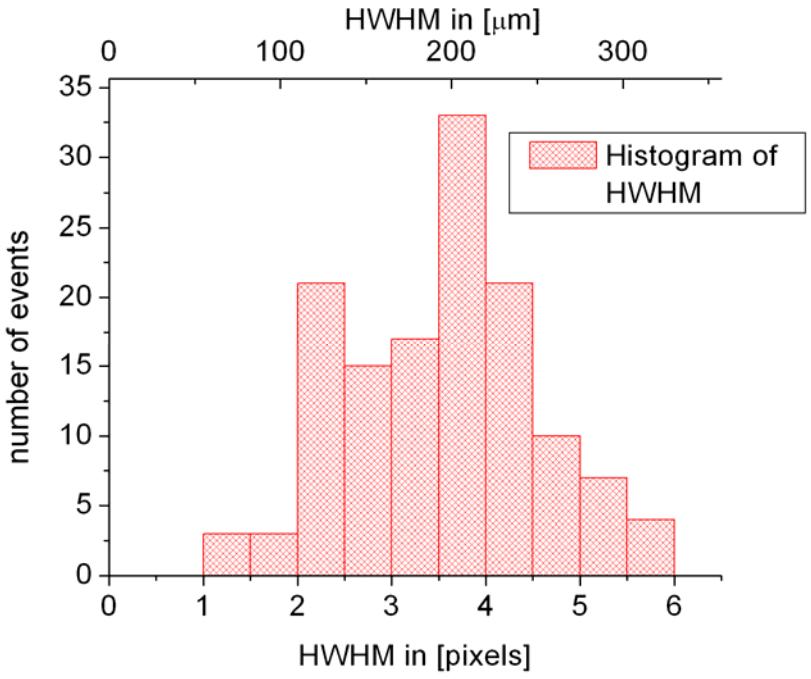
using upper and lower threshold

Cluster charge and size

cluster distribution has a Laundau-ish tail

depletion at low number of primary electrons seen

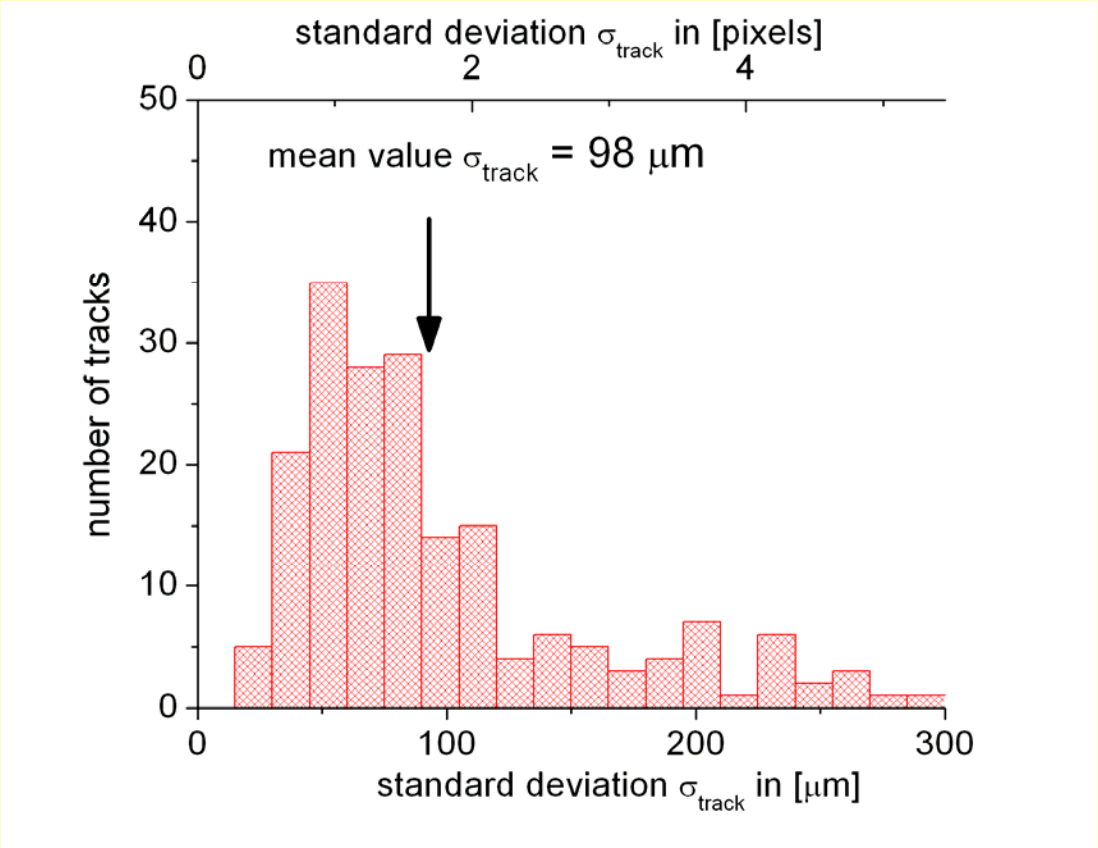




3.5 pixels correspond to 190 μm ↔ $\sigma_{gaussian}$ = 165 μm

Preliminary track fitting

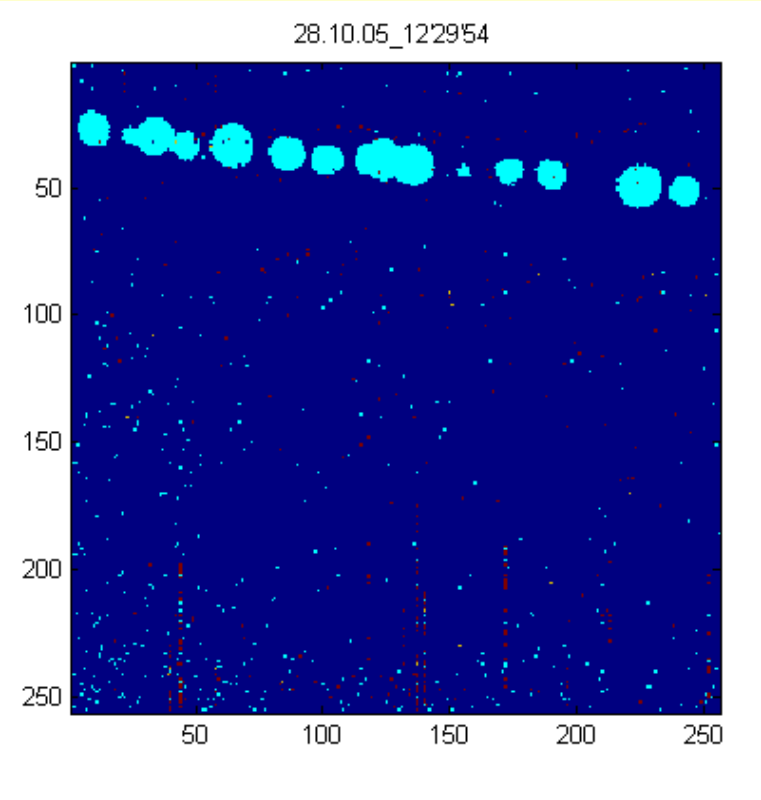
isolated tracks selected
typically 6-8 clusters
standard deviation of straight line fit:

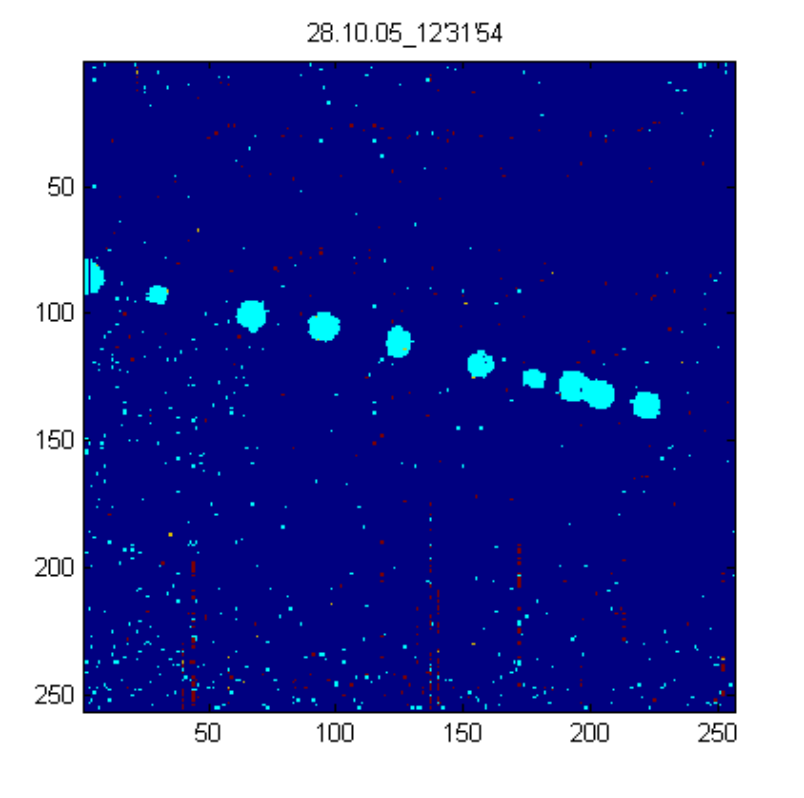


very preliminary
more sophisticated cluster finding and classification needed
(handle overlapping clusters, δ's etc.)

Hot news

He(70%)/CO_2 70/30 tracks





smaller clusters? better separated? quantitative results to come…
operated at higher voltage, need new gain determination

Summary

- triple-GEM – MediPix2 chip setup successfully operated at a gain of ~6 10^4 threshold/pixel below 1000 e^-

- use of low/high threshold allows an estimate of the total charge and cluster size
- gain calibration with ^{55}Fe
- sensitivity to MIPs (o(10) clusters/cm), not yet fully efficient for single electrons (ways out: larger gain, larger pixels? or live with it)
- point resolution clearly better than 100 μm – room for improvement
- stable and safe operation in long term running

Next Steps

- simulation ->M.Hauschild next talk
- study feasibility of huge TPC (cost,cooling,mechanics,readout)
- join TimePix project (within EUDET)
- construct TPC endplate to work with large prototype at DESY
- mechanical aspects
- readout system for TimePix/testbeam

Backup

Trigger

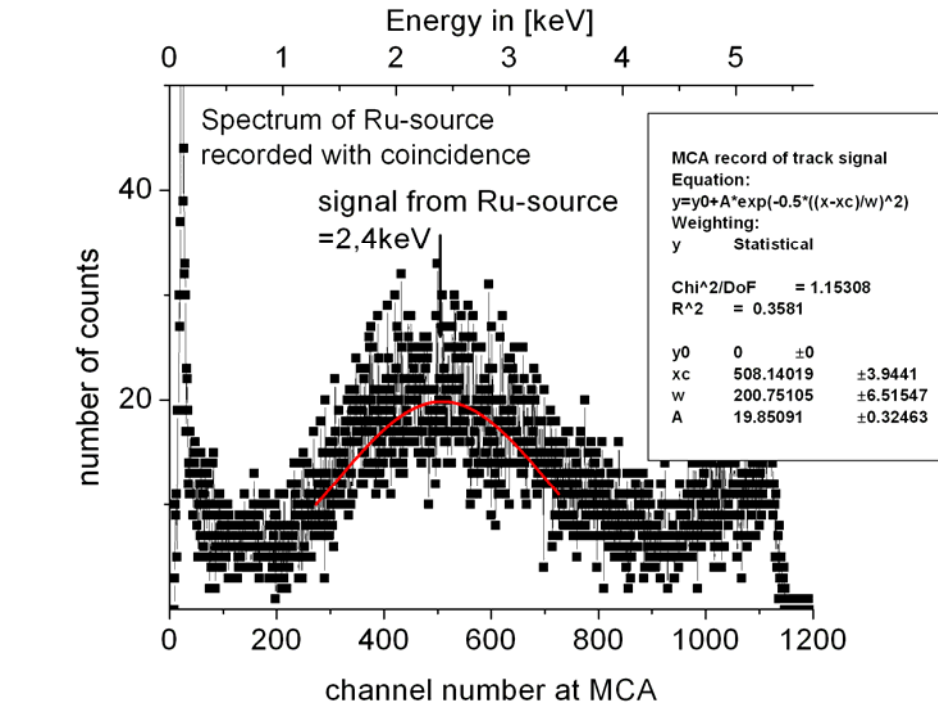
low rate of the source
(100 Hz on first pad)

fourfold coincidence adjusted for gitter due to drift time difference and low trigger level

min. ionizing electrons at
1.25 keV/cm ↔ 46 e-

at the peak calibrated through Fe55 ecape peak
on a pad next to MediPix2 chip

readout of MediPix2 with trigger



observe: FWHM/peak ~100% !

Charge determination

Summed up per track

accepted clusters include also „filled“ blobs

(charge estimated by extrapolated $r\frac{1}{2}$)

the average charge is about

50 e-

the expected value from experiment is

46•1.4 ~ 65 e-

some loss expected due to lower threshold setting at 4200 V