A Triple GEM detector for the LHCb inner tracker

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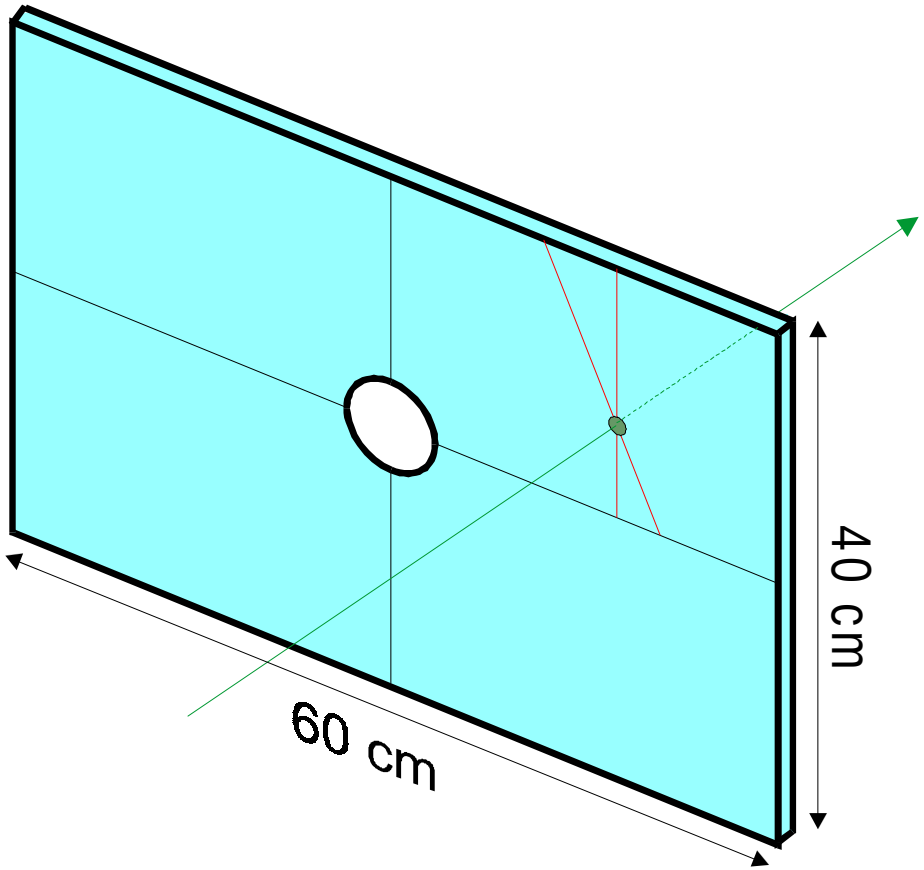
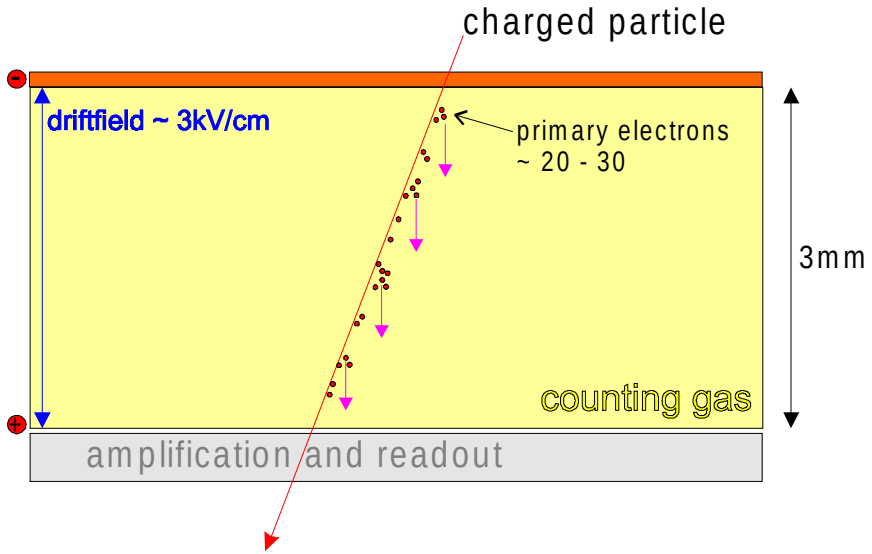


Principle of gas detectors

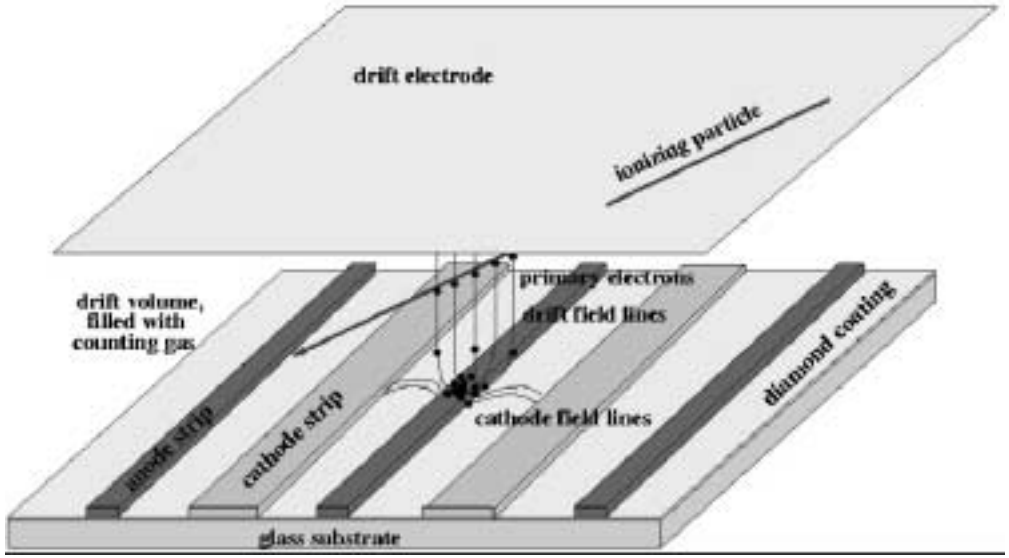
-> gas molecules in the active detector volume are ionized by incomming particles

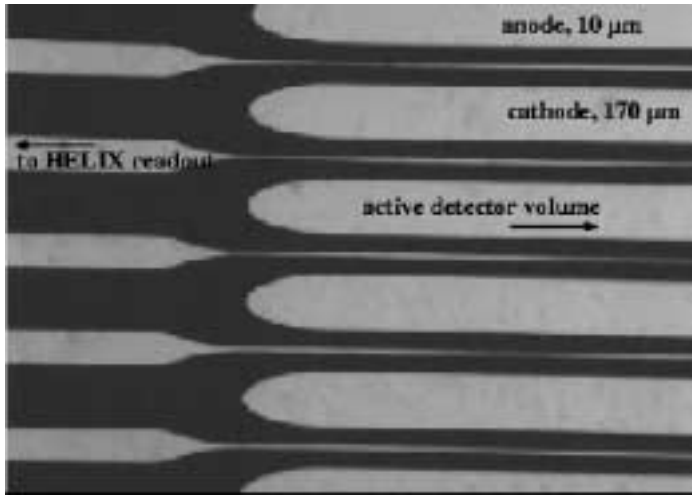


- The *Geiger-Müller Counter,* first described in 1928, can be considered as the basis of gas detectors

- 1968 Multi Wire Proportional Chamber (MWPC), plane of parallel anode wires

1988 Micro Strip Gas Chamber (MSGC)

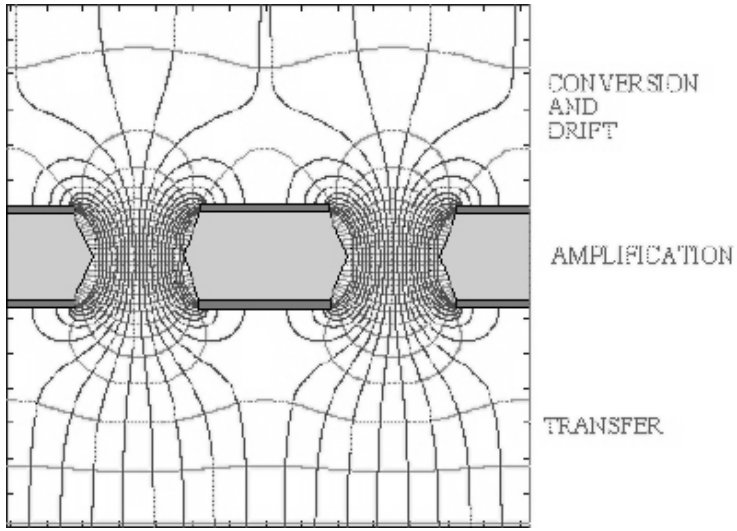


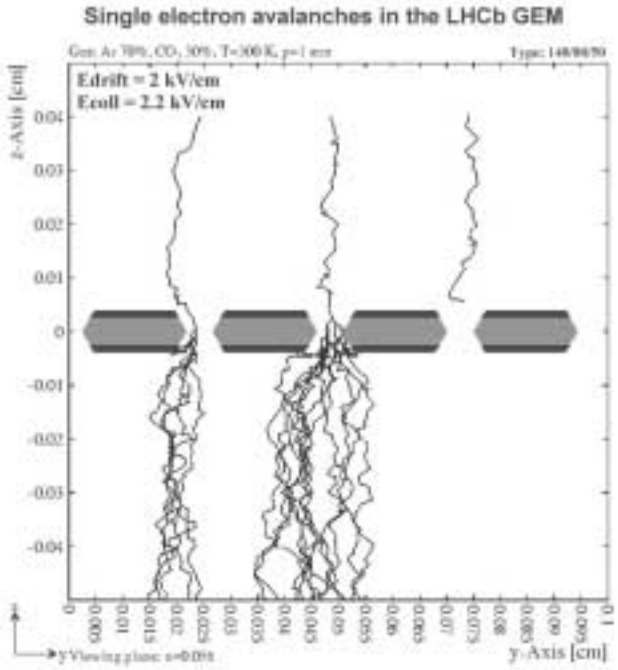


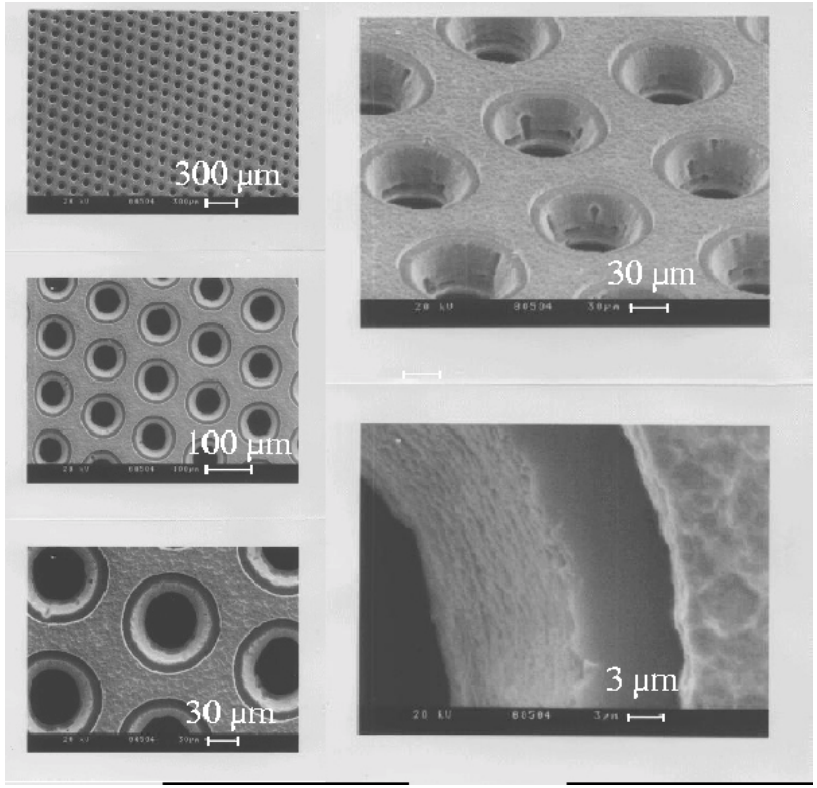
Works only with x-rays

In a hadronic beam high ionising particles produce discharges => damage of the MSGC substrate

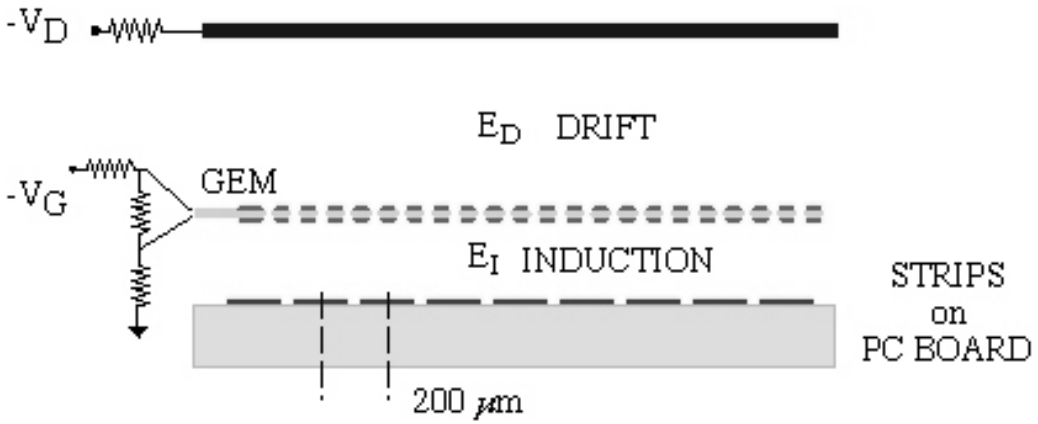
1997 Gas Electron Multiplier (GEM)



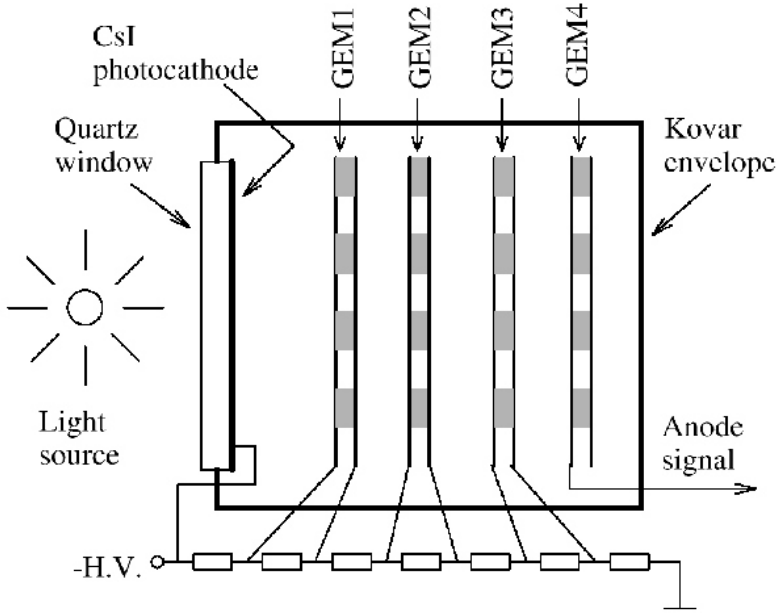




Applications with GEMs



setup for particle detection



TPC with GEMs

GEM Photomultiplier

The Triple GEM Detector

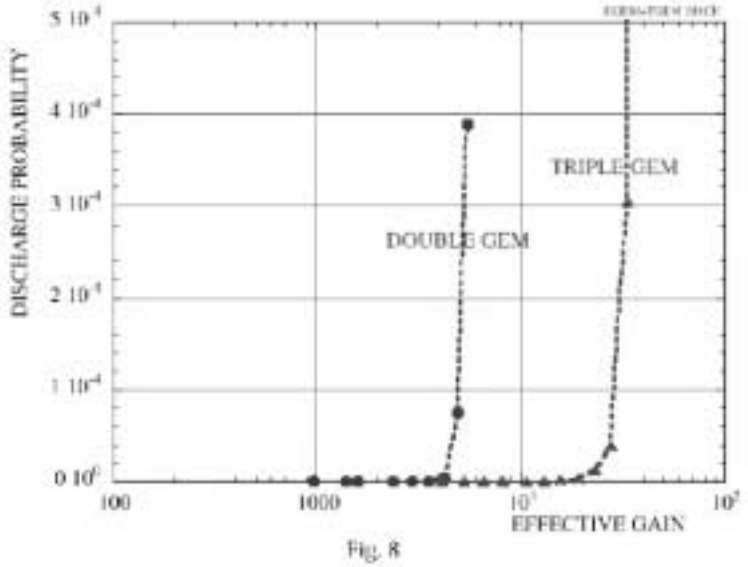
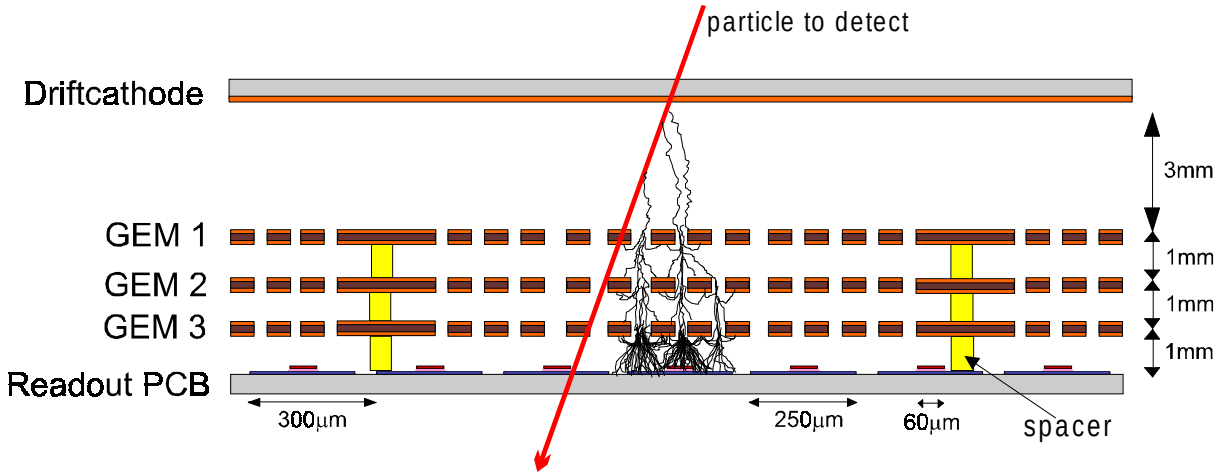


Fig. 8

A cascaded setup of GEMs leads to higher gas gain before discharges start

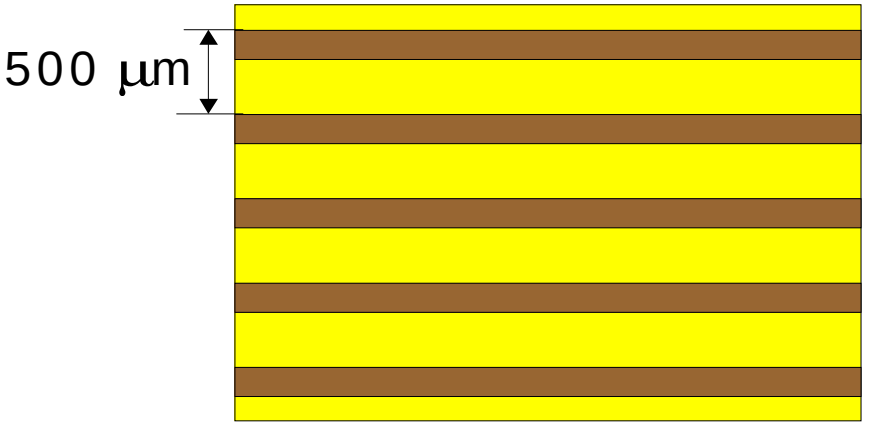
<= discharge probability for Double and Triple GEM detectors under irradiation with α-particles

Amplification factor in each GEM ~ 20 @ U_{GEM} = 360V => gain 10 000

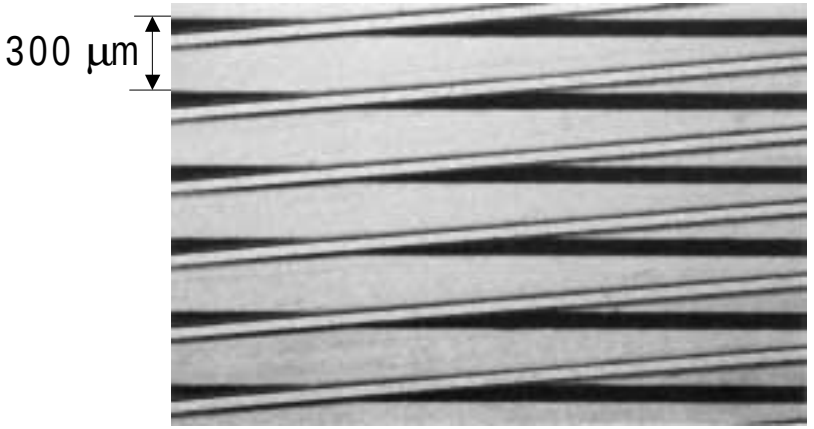


Readout structure

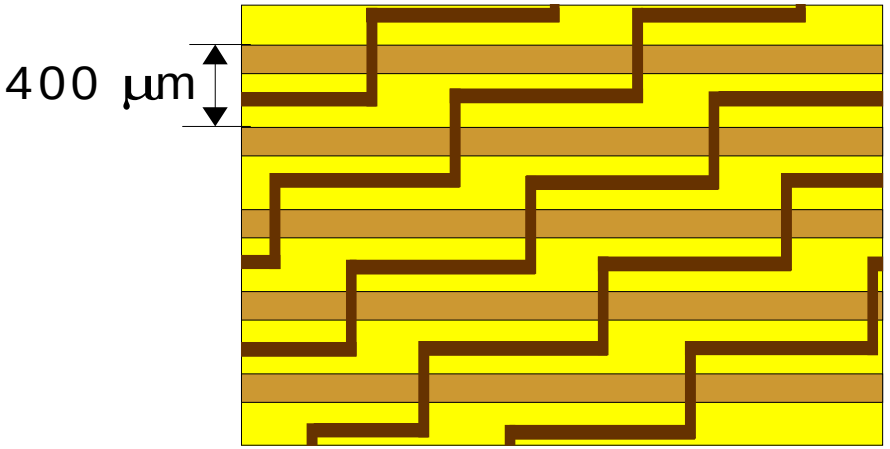
1st prototype (April ´99)
single strips with 500 μm pitch



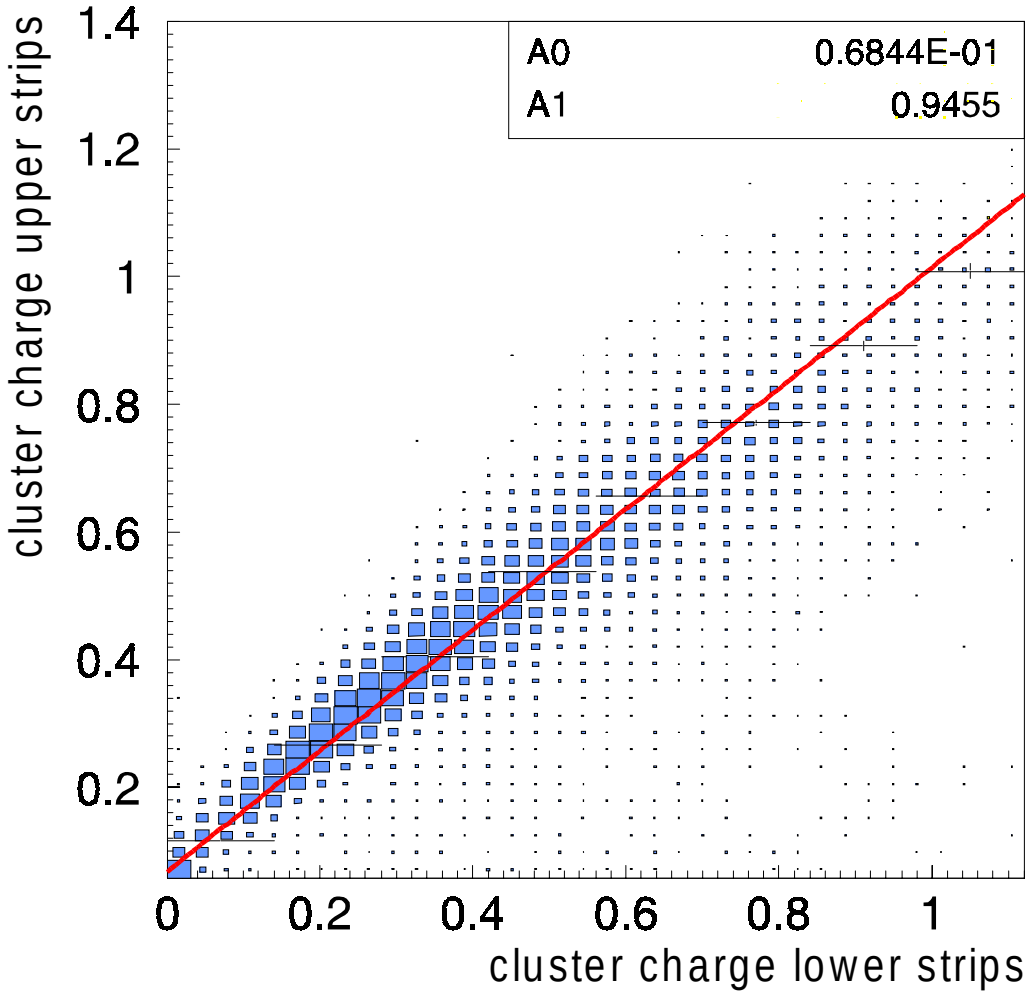
2nd prototype (December ´99)
two-dimensional readout 300 μm pitch
- strip capacity ~ 80 pF => large noise



3rd prototype (December ´00)
Zig-Zag geometry 400 μm pitch
capacity ~ 25 pF



Charge sharing between upper and lower strips



<= charge sharing ~ 1:1

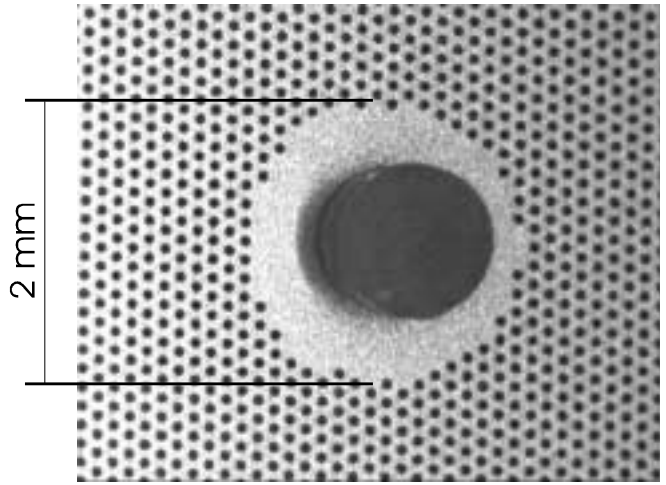
Distance between GEMs

➔ large gaps between GEMs => cluster size increases

➔ small gaps between GEMs => danger of contact between GEMs

1st prototype (April ´99) 3 mm gap between GEMs

2nd prototype equiped with cylinders glued on special places on GEM

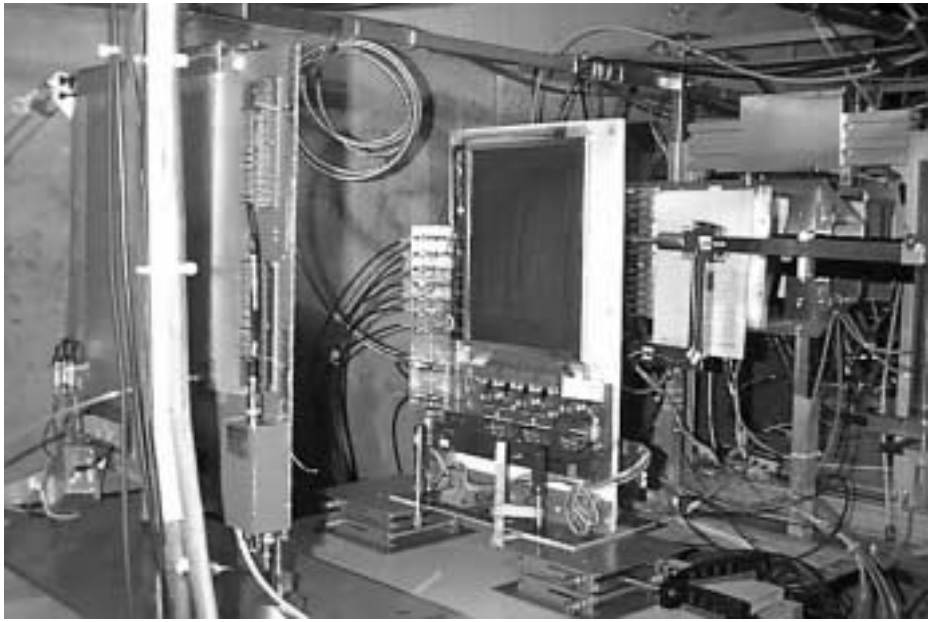


Segmentated GEM

one GEM side is dividet into 10 segments

- less energy in a discharge (reduced capacity)
- less chance to destroy the GEM
- in case of a short only a part of the detector is lost

Detector at the testbeam

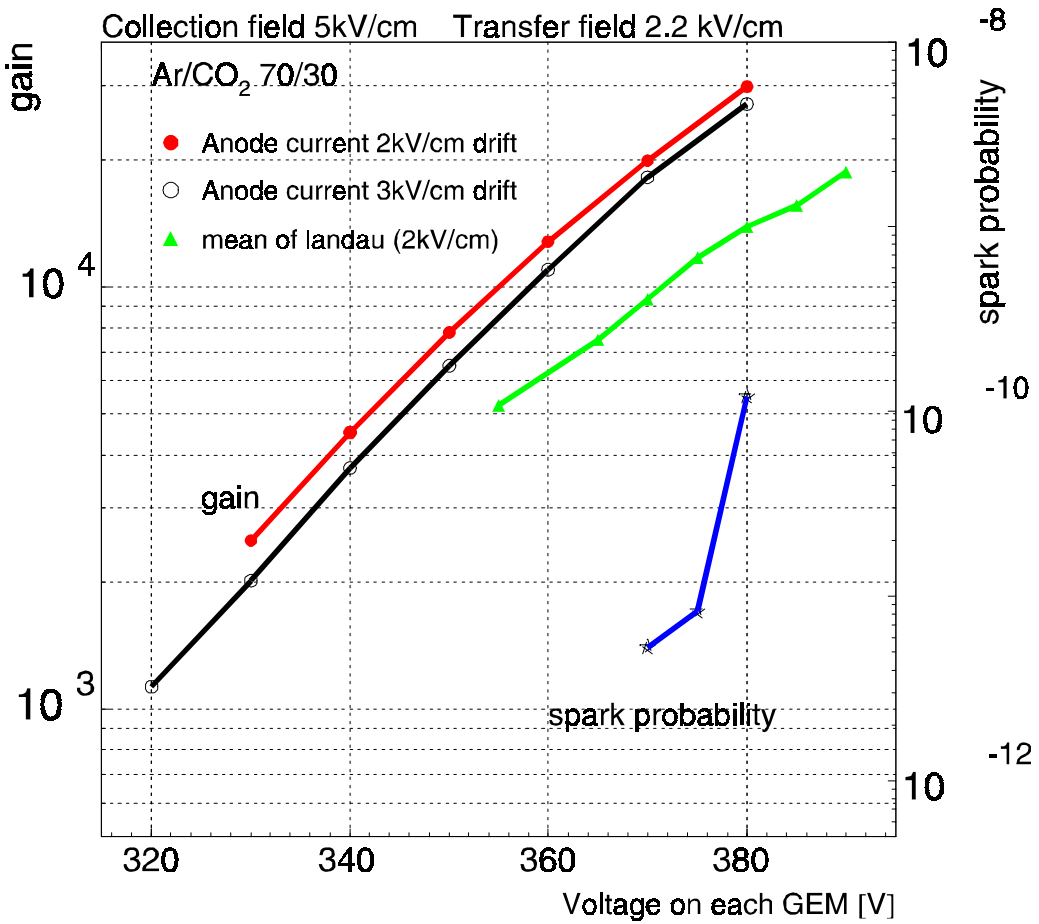


Setup at the PSI (Paul Scherer Institut, Switzerland)

readout 2 x 500 channels per detector

Active area of the detector: 23 cm x 30 cm

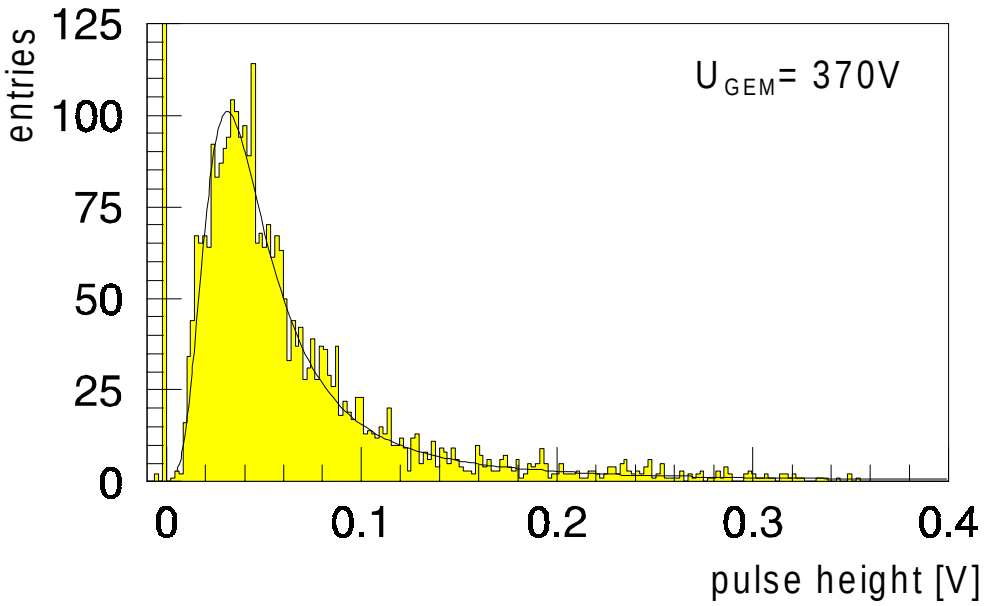
Gain and spark probability



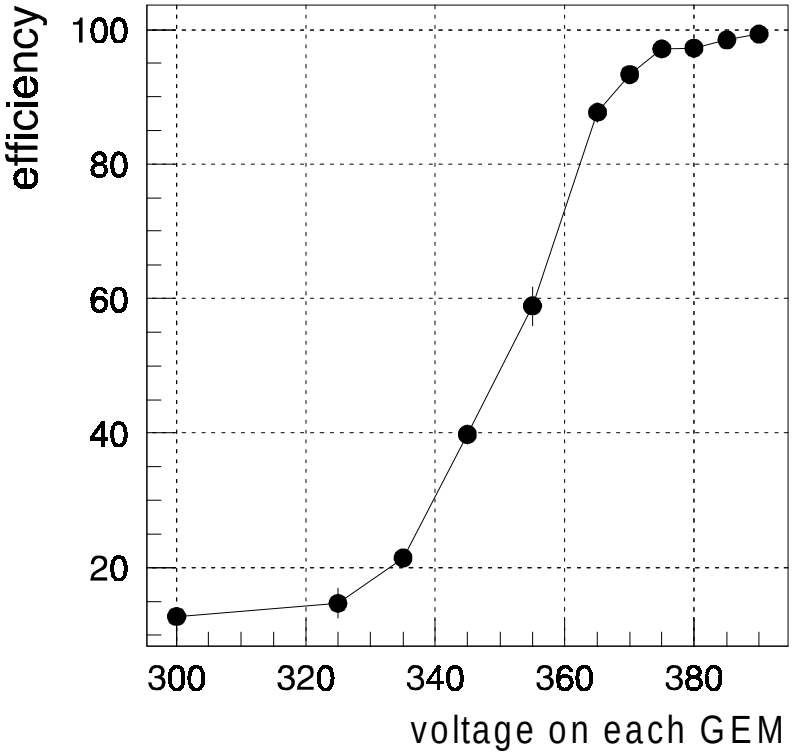
sparkprobability measured with a π^+ 350 MeV/c beam

total rate of 50 MHz

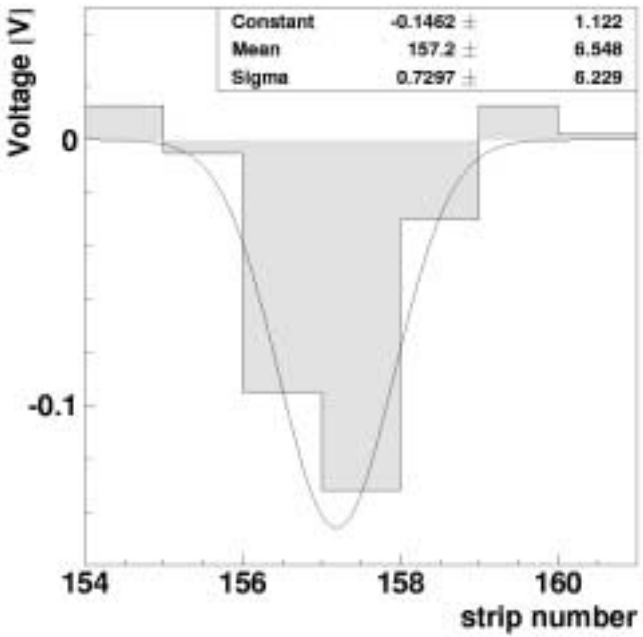
Landau distribution

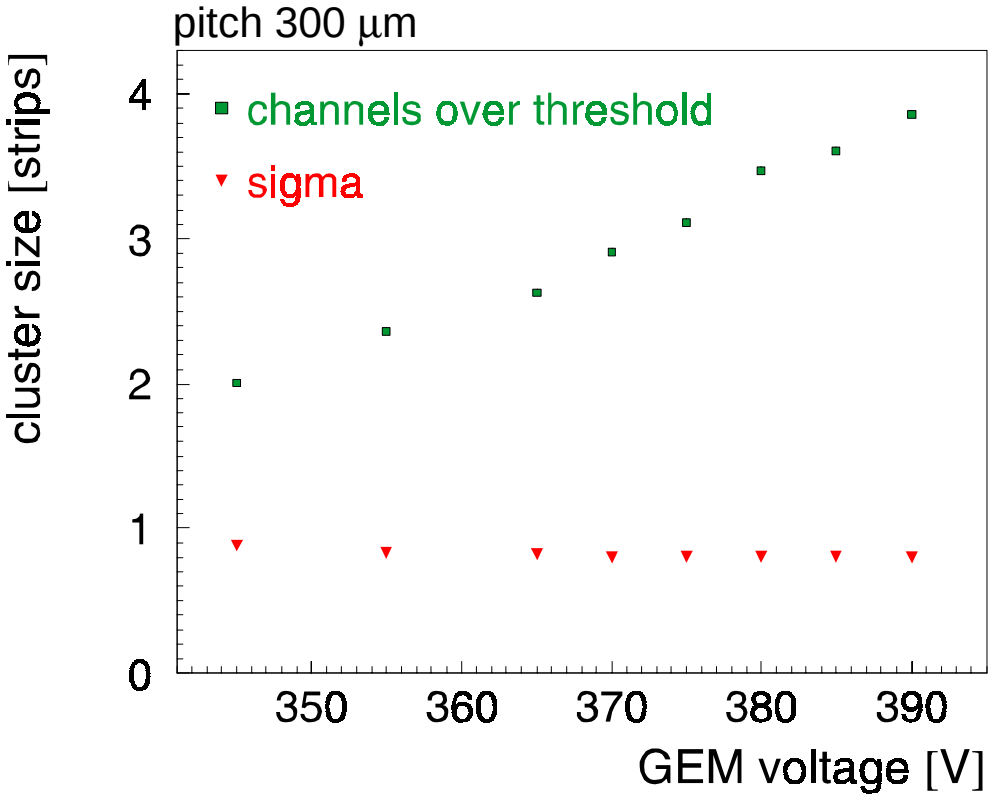


Efficiency curve



Clustersize





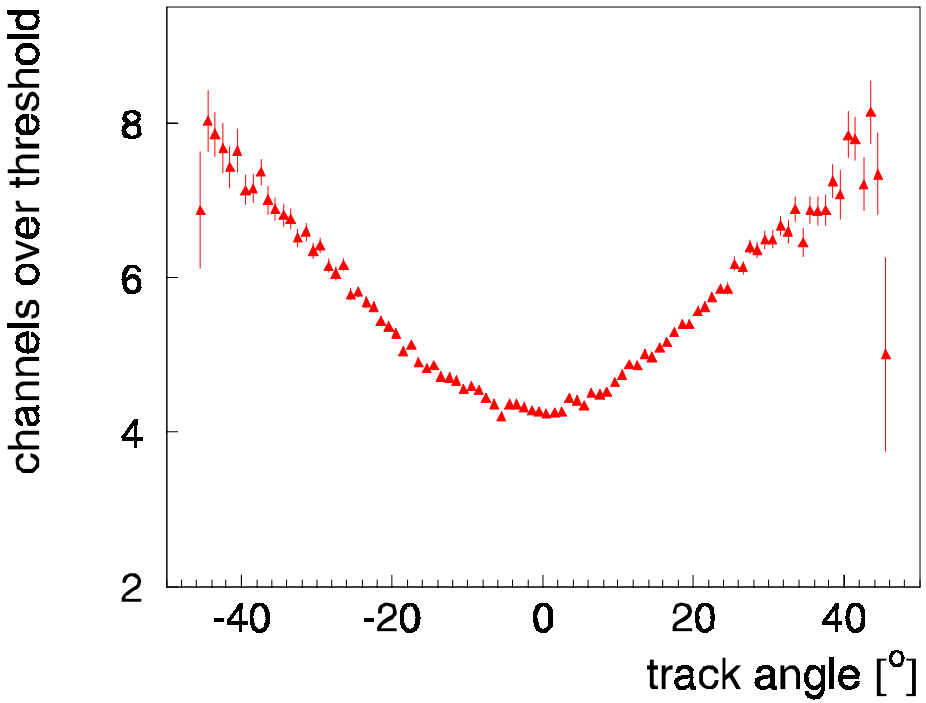
Expected cluster width:

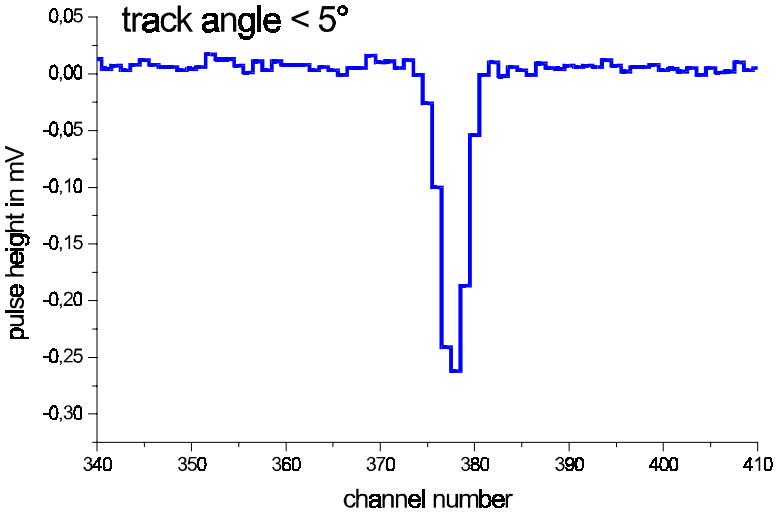
D_t = 300µm / sqr(cm)

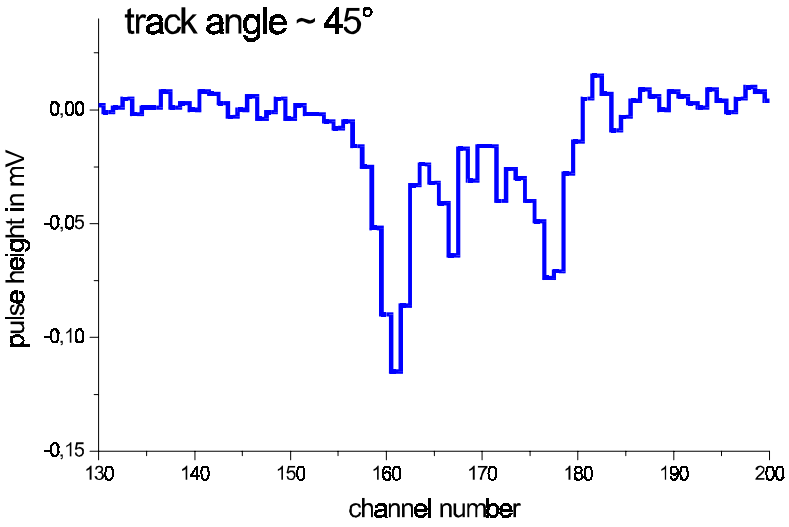
$S_{expected}$ = 200µm

$S_{measured}$ = 240µm

Large angle tracks

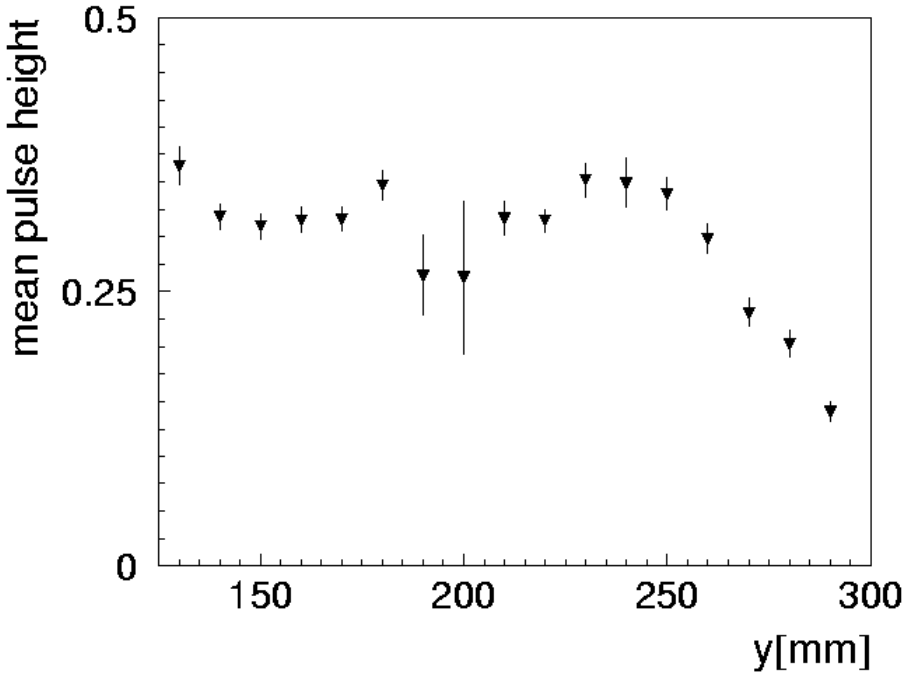






=> Large angle tracks create big clusters

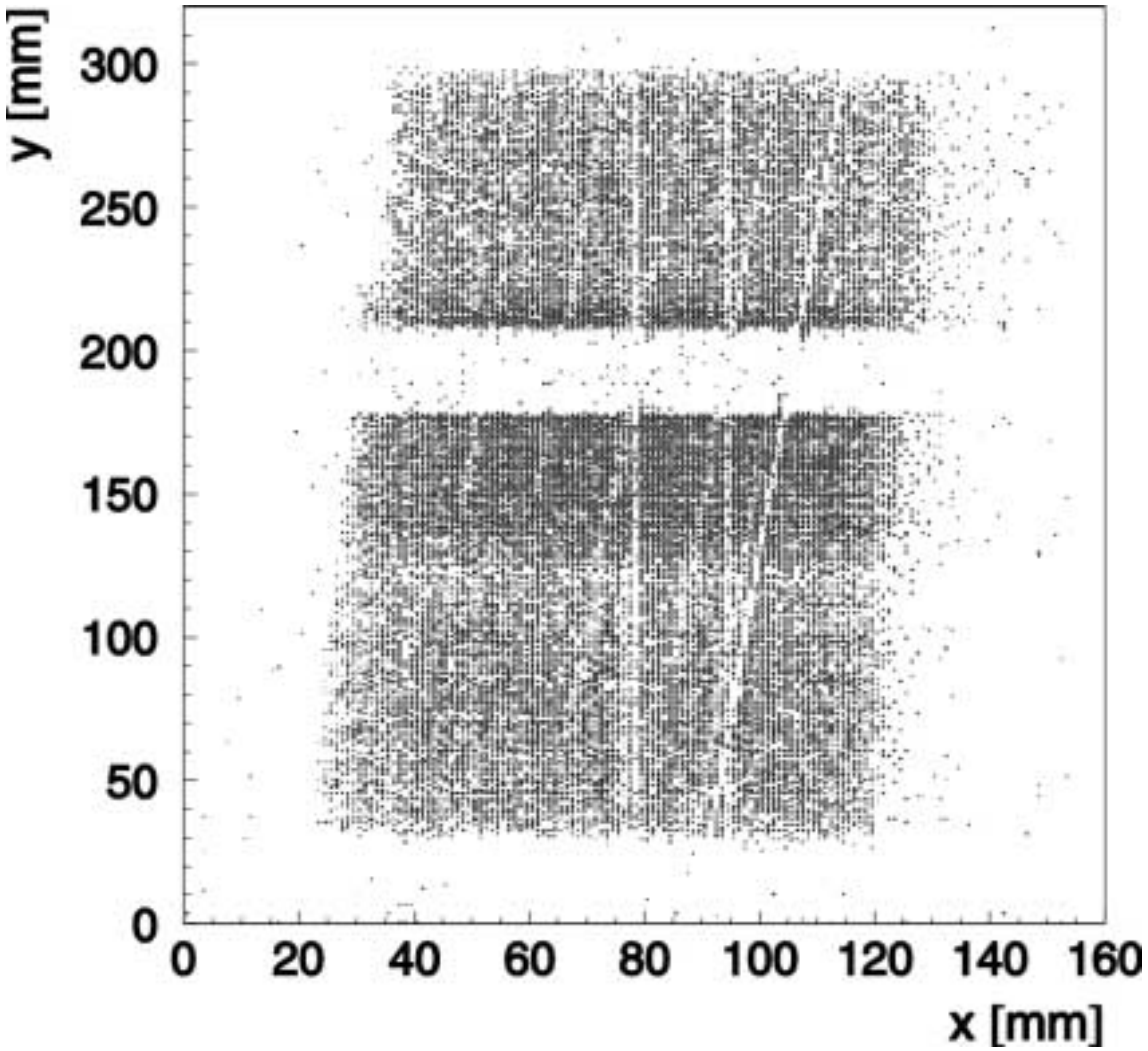
Gain homogenity



At outer part of the detector a gas gain drop was observed

=> maybe misalignement of the GEM holes

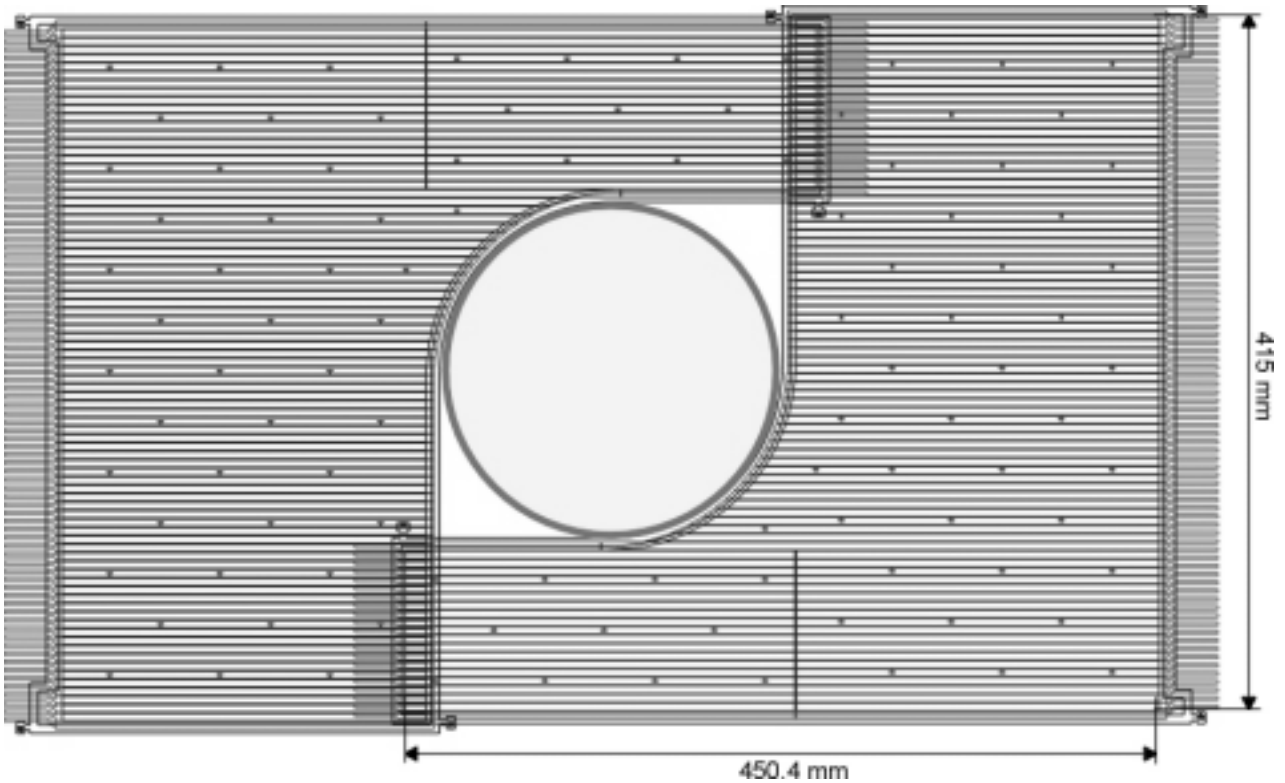
Hitmap reconstructed from cosmic rays



broken anodes are clearly visible

<= disconnected GEM segment

Full size prototype



Two L-shape detectors to cover the Inner Tracker area around the beampipe

New features:

- **finer segmentation**
- **two dimensional readout with „Zig-Zag“ geometry**
- **Beetle readout is intended**

=> Detector will be ready in December 2000