

GEM & TimePix Readout of TPCs: New Results from the Bonn Group

Hubert Blank, Christoph Brezina, Klaus Desch,
Jochen Kaminski, Martin Killenberg, Thorsten Krautscheid,
Walter Ockenfels, Martin Ummenhofer, Peter Wienemann,
Simone Zimmermann

2. Micro-Pattern Gas Detectors (RD 51) Workshop
Paris, October 13th -15th, 2008

GEFÖRDERT VOM



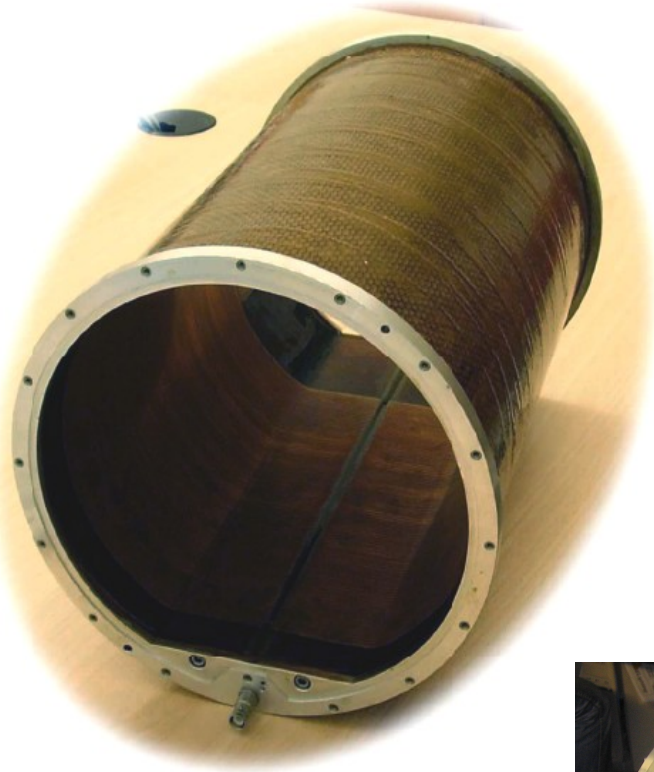
Bundesministerium
für Bildung
und Forschung

TPC Prototype at Bonn



Fieldcage / mechanics designed and produced at RWTH Aachen

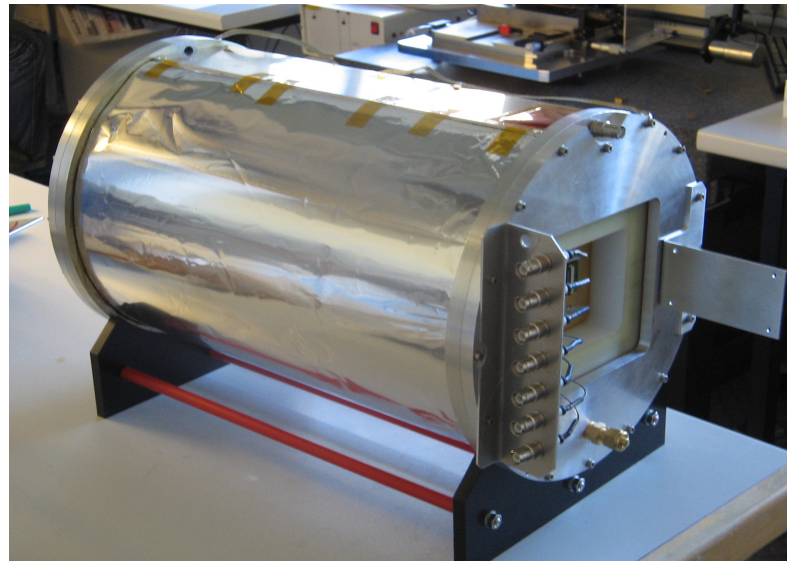
- drift distance: 26 cm
- inner diameter: 23 cm
- material budget: 1 % X_0
- up to 30 kV \Rightarrow drift field of 1 kV/cm



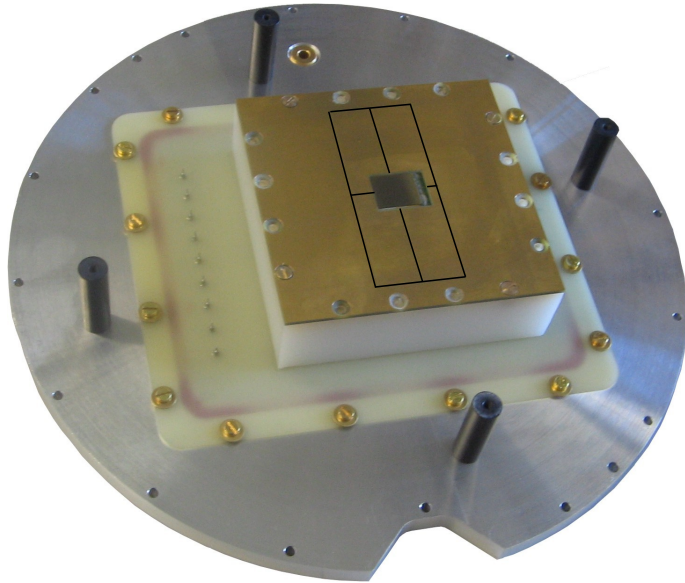
Currently:

Ar : CO₂ 70:30

E_{drift} : 500 V/cm



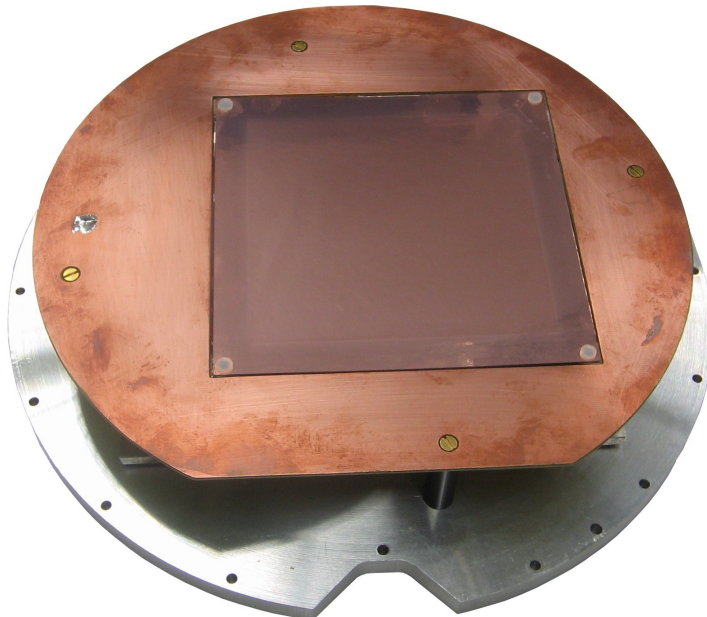
Gas Amplification and Readout



readout:

single TimePix chip

4 large pads connected to
preamplifier / oscilloscope



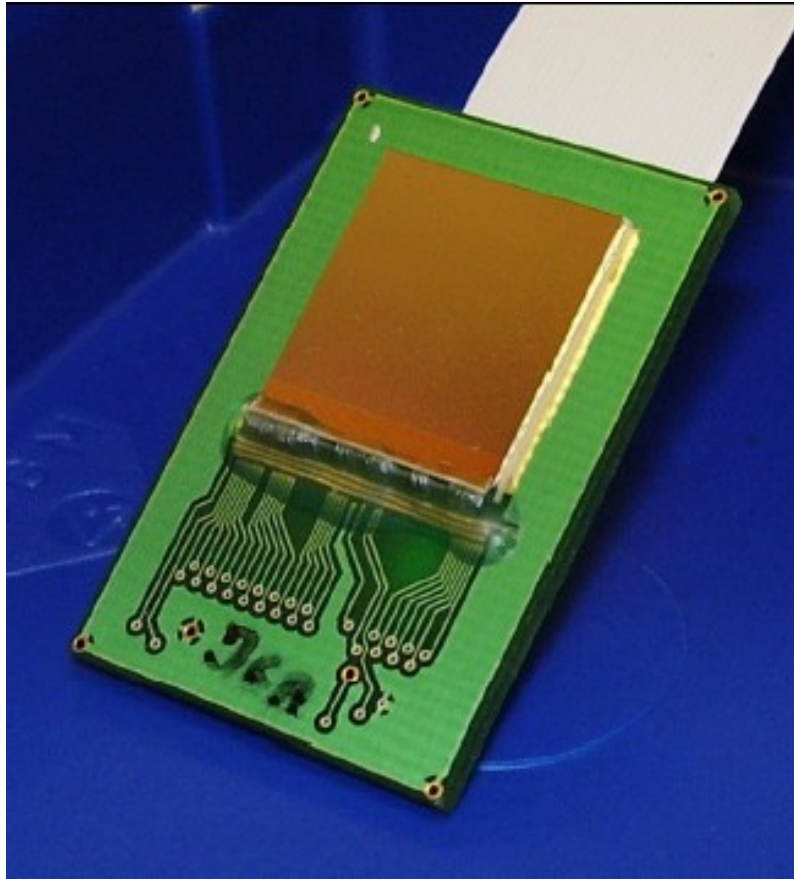
gas amplification:

3 GEMs 1mm apart

390 V across each GEM

transfer fields: 2.5 kV/cm

induction field: 3 kV/cm



256 * 256 pixel

pixel size: 55 * 55 μm^2

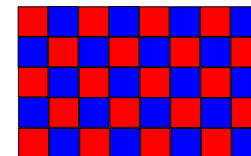
chip dimensions: 1.4 * 1.4 cm^2

Each pixel can be set to one of these modes:

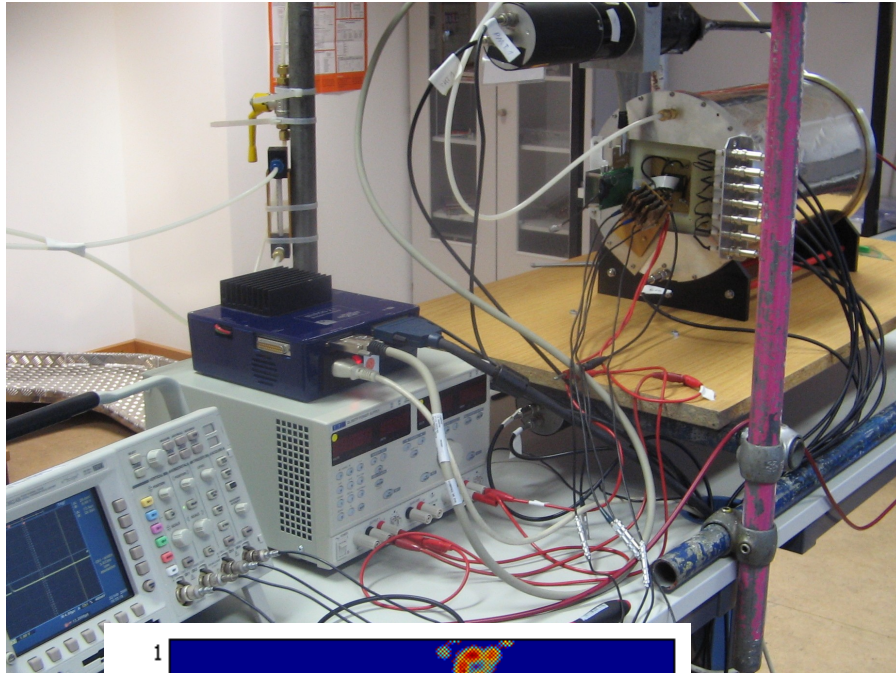
- hit counting
- TOT = time over threshold
gives integrated charge
- time between hit and shutter end
- hit/no-hit

current running condition:

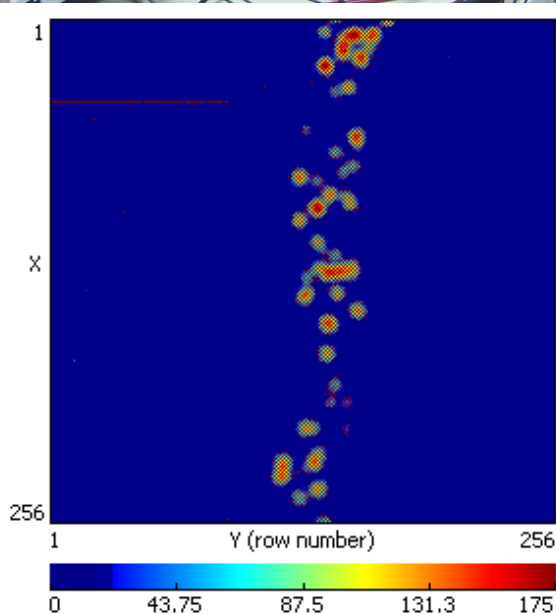
checker-board pattern of TOT and Time



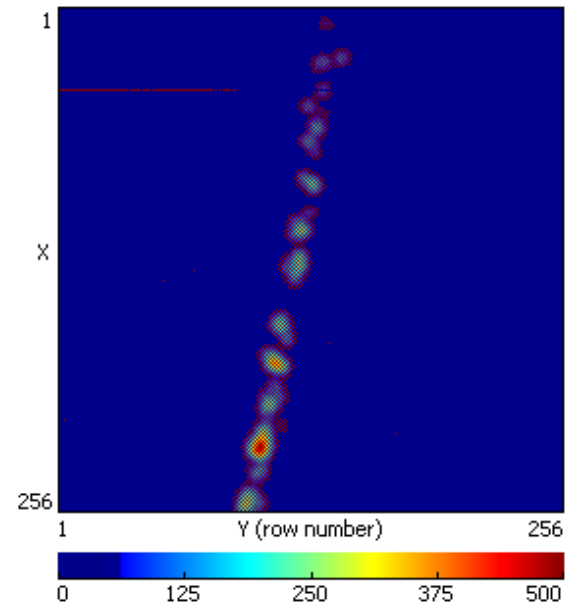
Test stand with cosmic rays



Coincidence of 2 scintillators
($2 * 23 \text{ cm}^2$, $4.5 * 35 \text{ cm}^2$)
gives external trigger for TimePix



long drift
distance

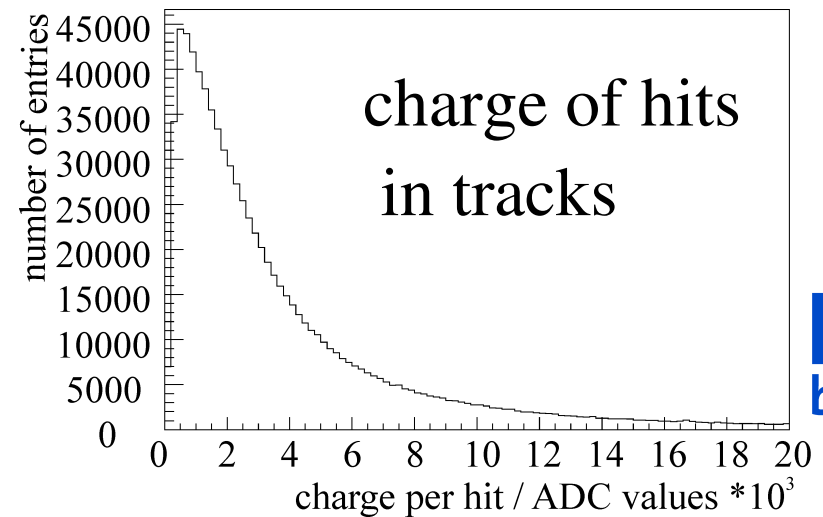
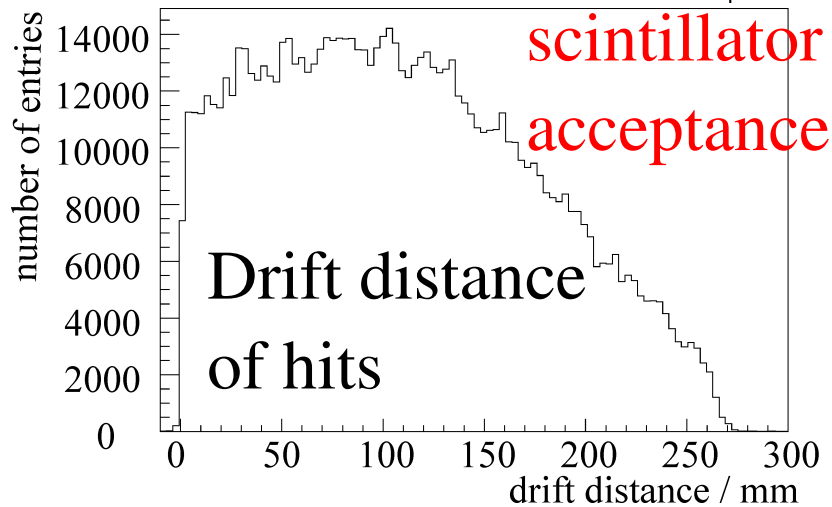
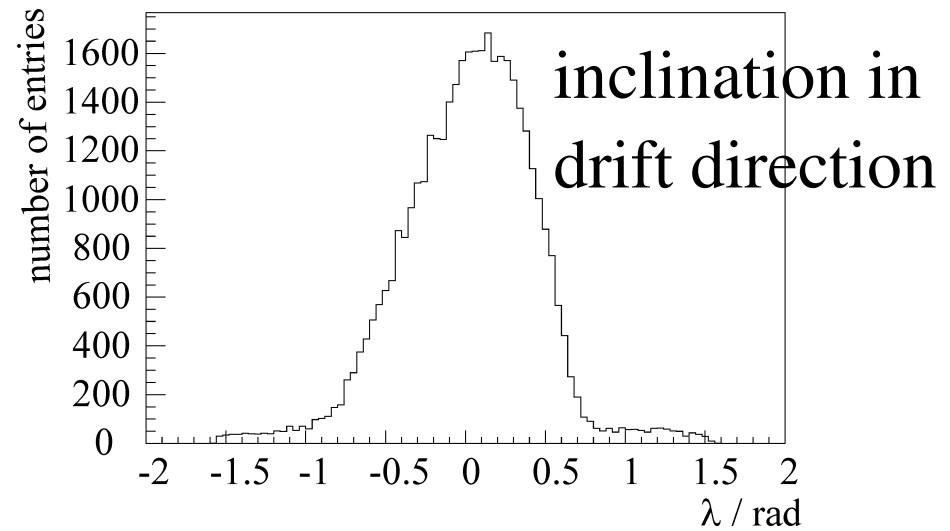
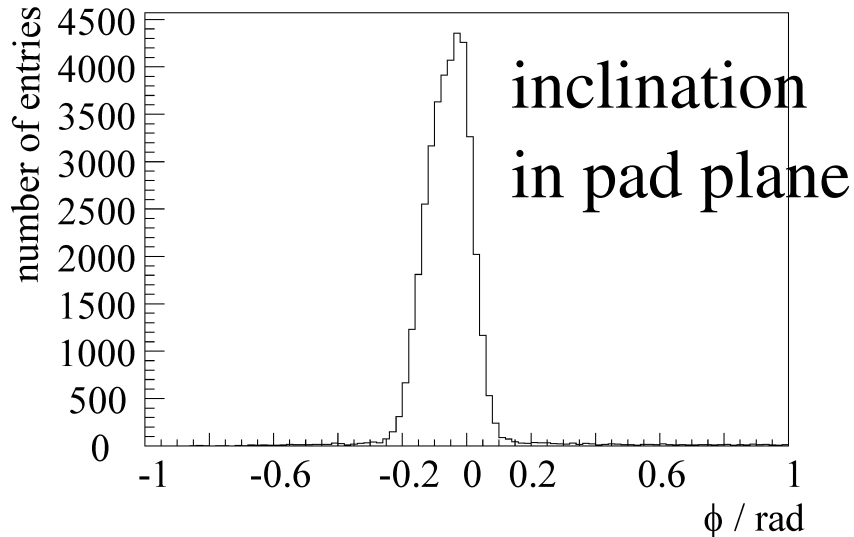


short drift distance

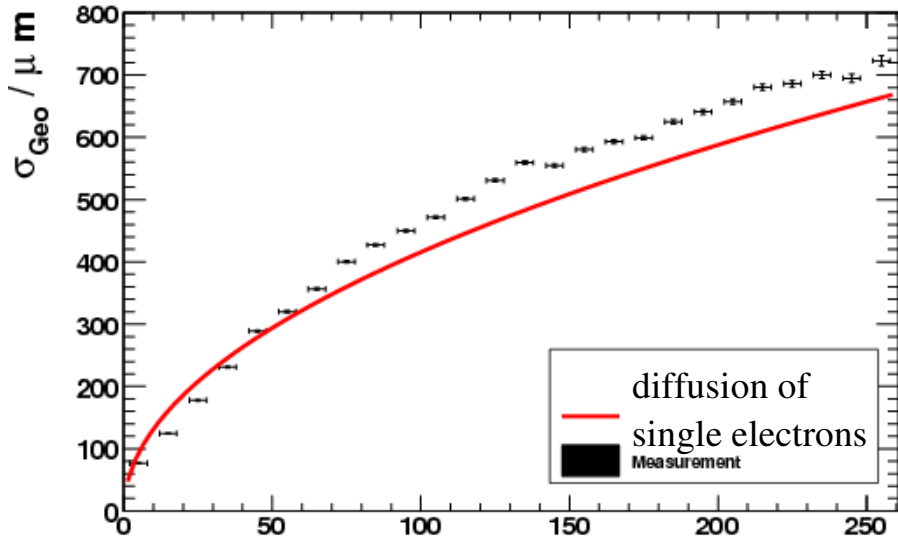
First Results – Track Parameters



In about 1 month of running a data sample of **40,000** tracks was collected.



Transverse Spatial Resolution



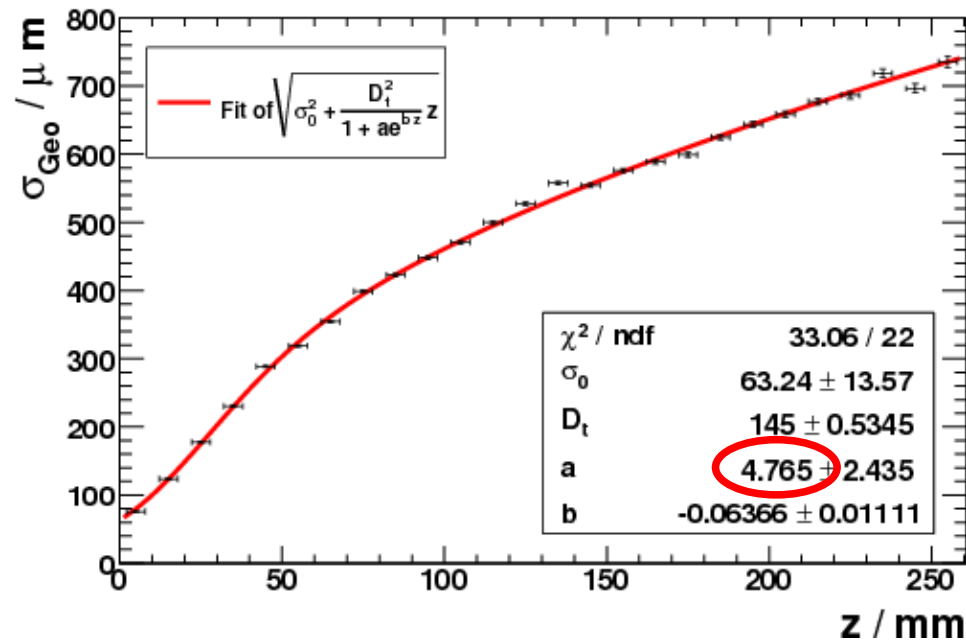
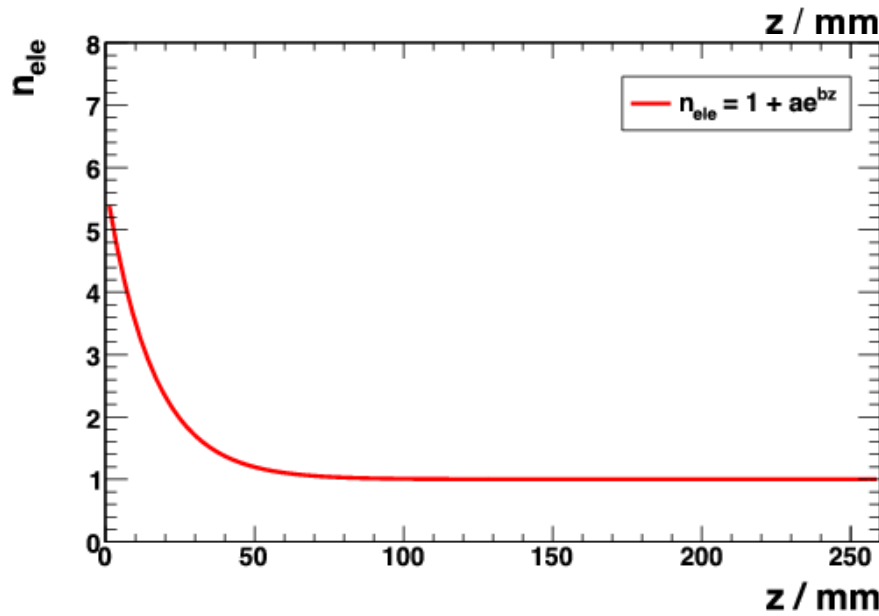
diffusion of single electrons:

$$\sigma(z) = \sqrt{D_t^2 z}$$

but: number of electrons per cluster

$$n_{\text{ele}} = 1 + a e^{bz}$$

$$\Rightarrow \sigma = \sqrt{\sigma_0^2 + \frac{D_t^2 z}{1 + a e^{bz}}}$$



Cluster Size

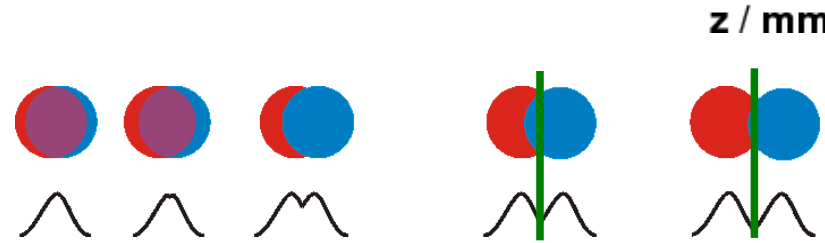
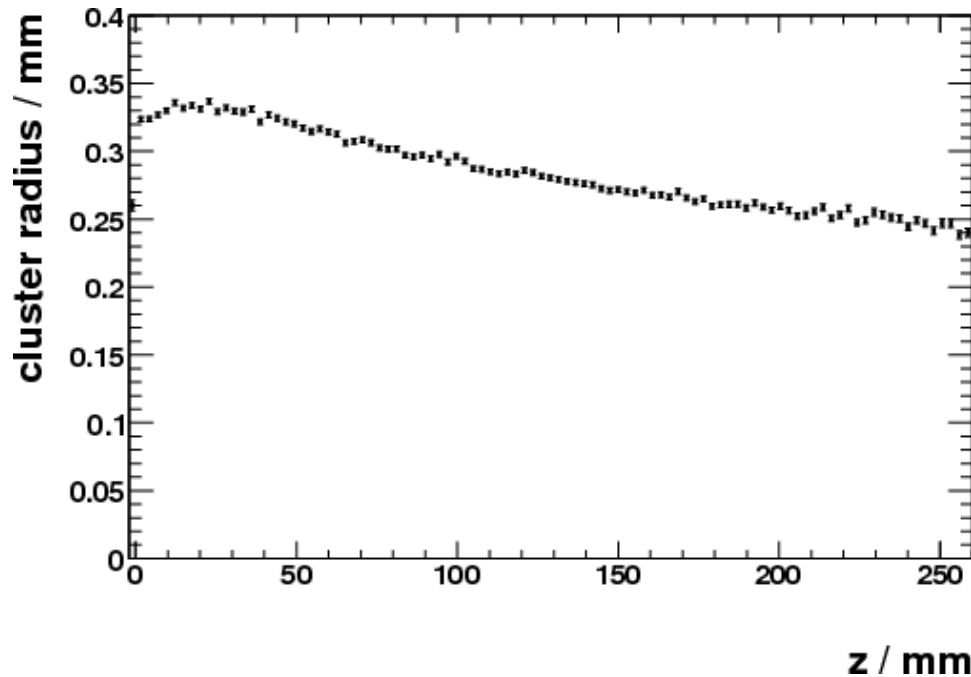
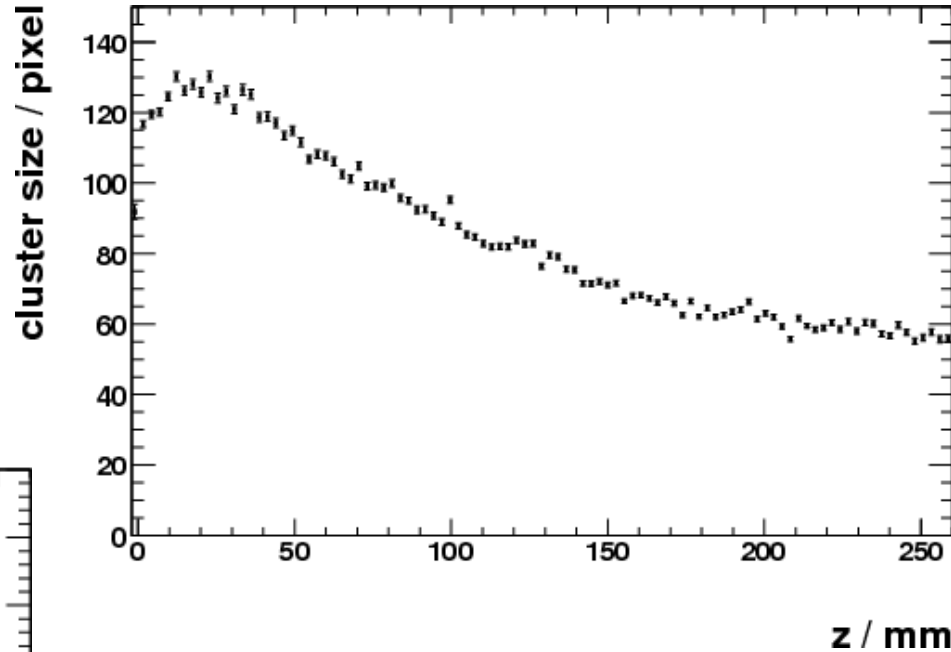


cluster size increases first

-> multi-electron cluster
become wider

cluster size decreases

-> more and more individual
electrons become separable



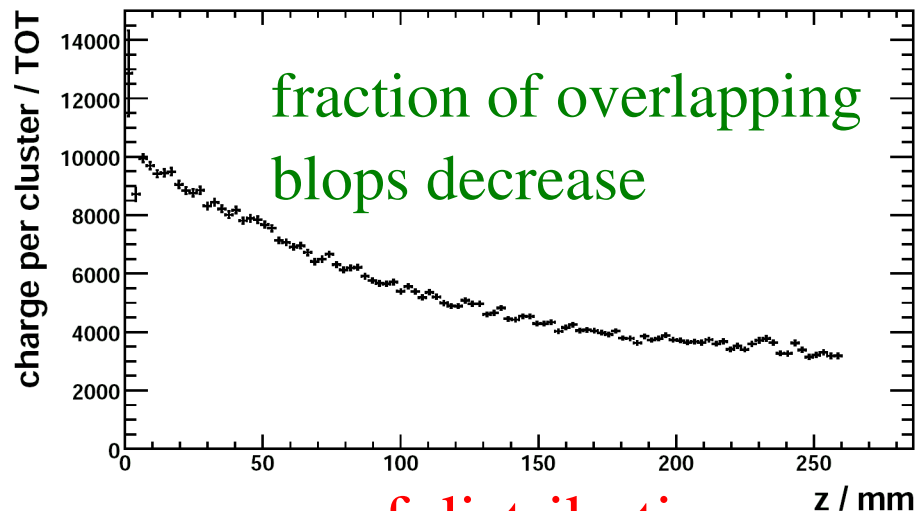
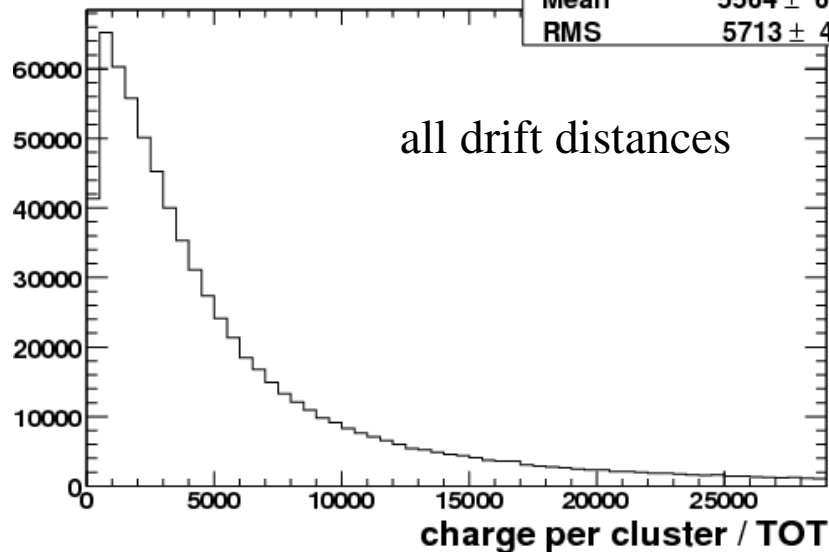
statistical process !

Cluster Charge / Number of Hits



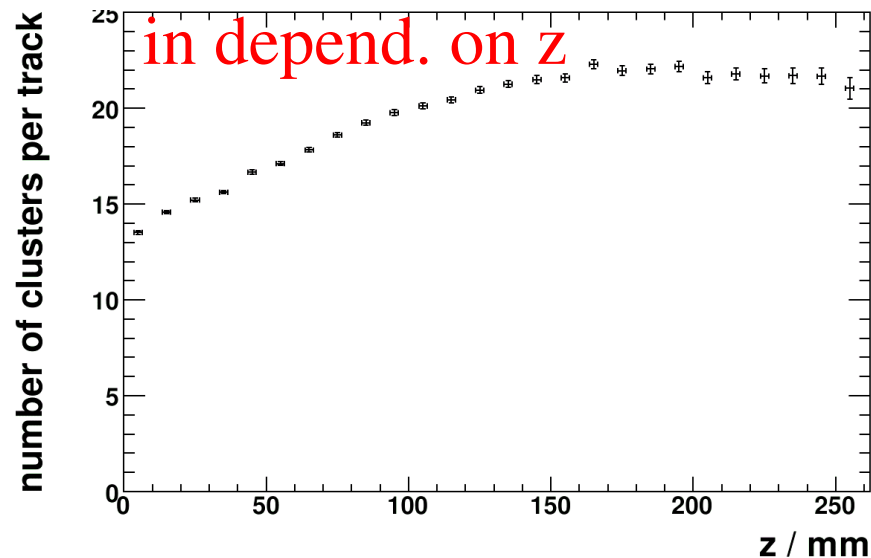
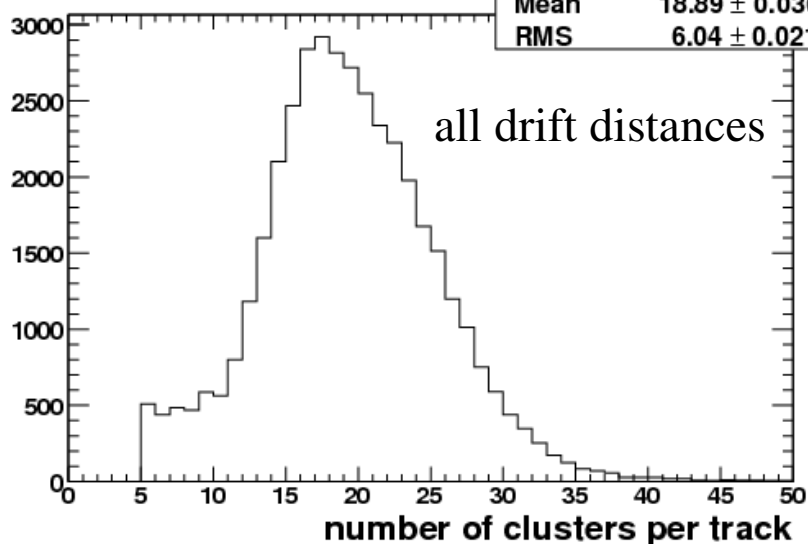
underlines declustering

Entries	782379
Mean	5564 ± 6.719
RMS	5713 ± 4.751

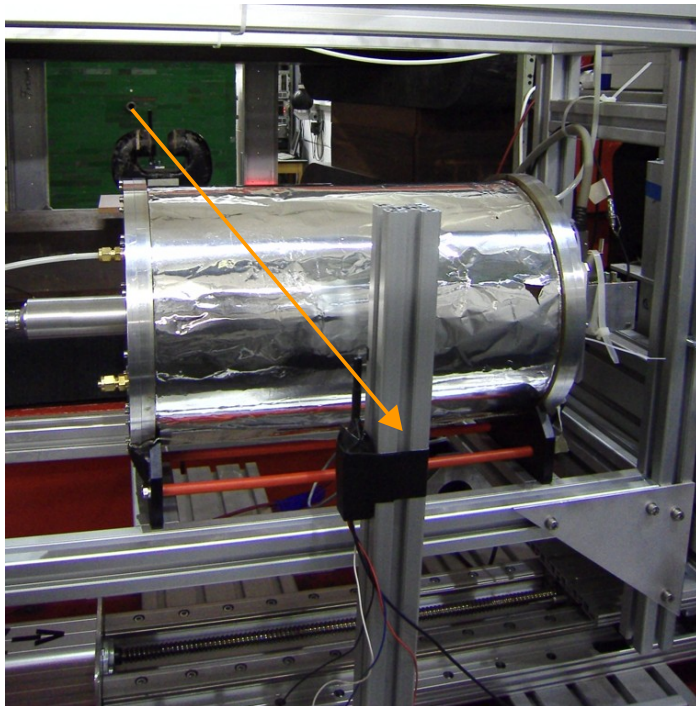
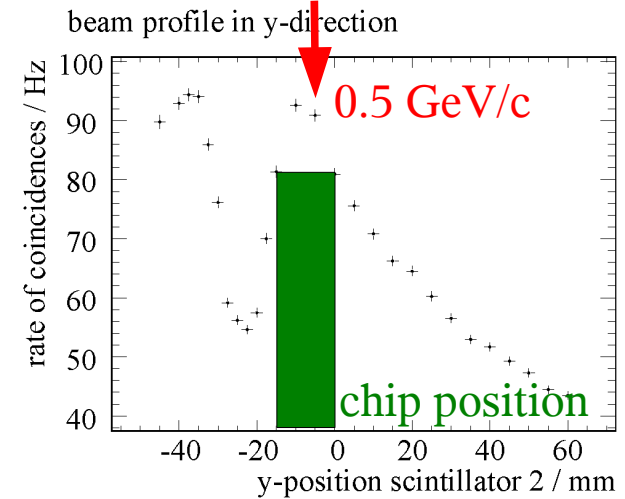
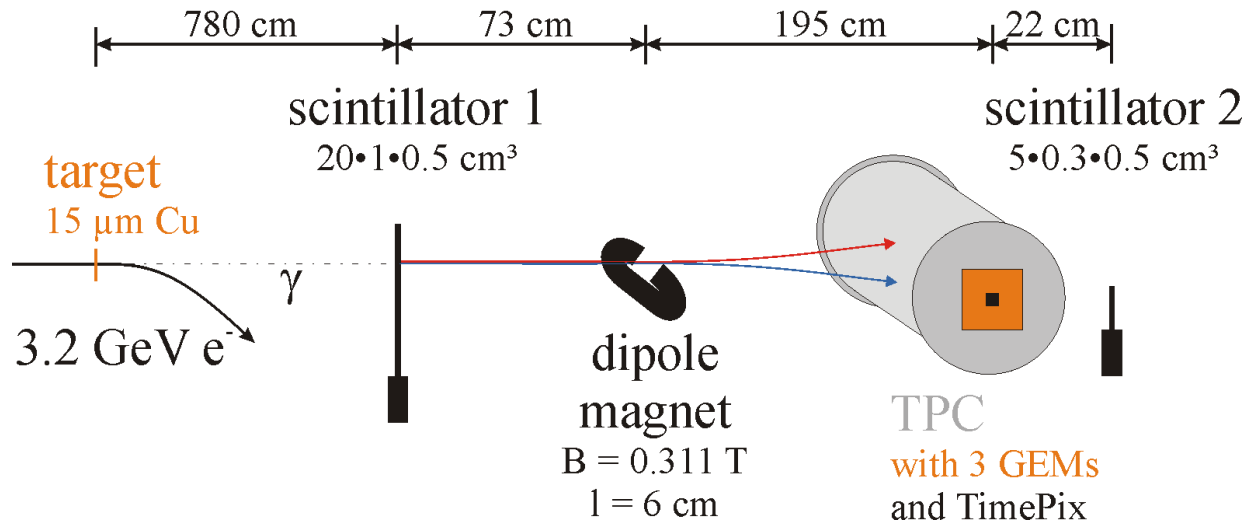


mean of distributions

Entries	40064
Mean	18.89 ± 0.03019
RMS	6.04 ± 0.02135

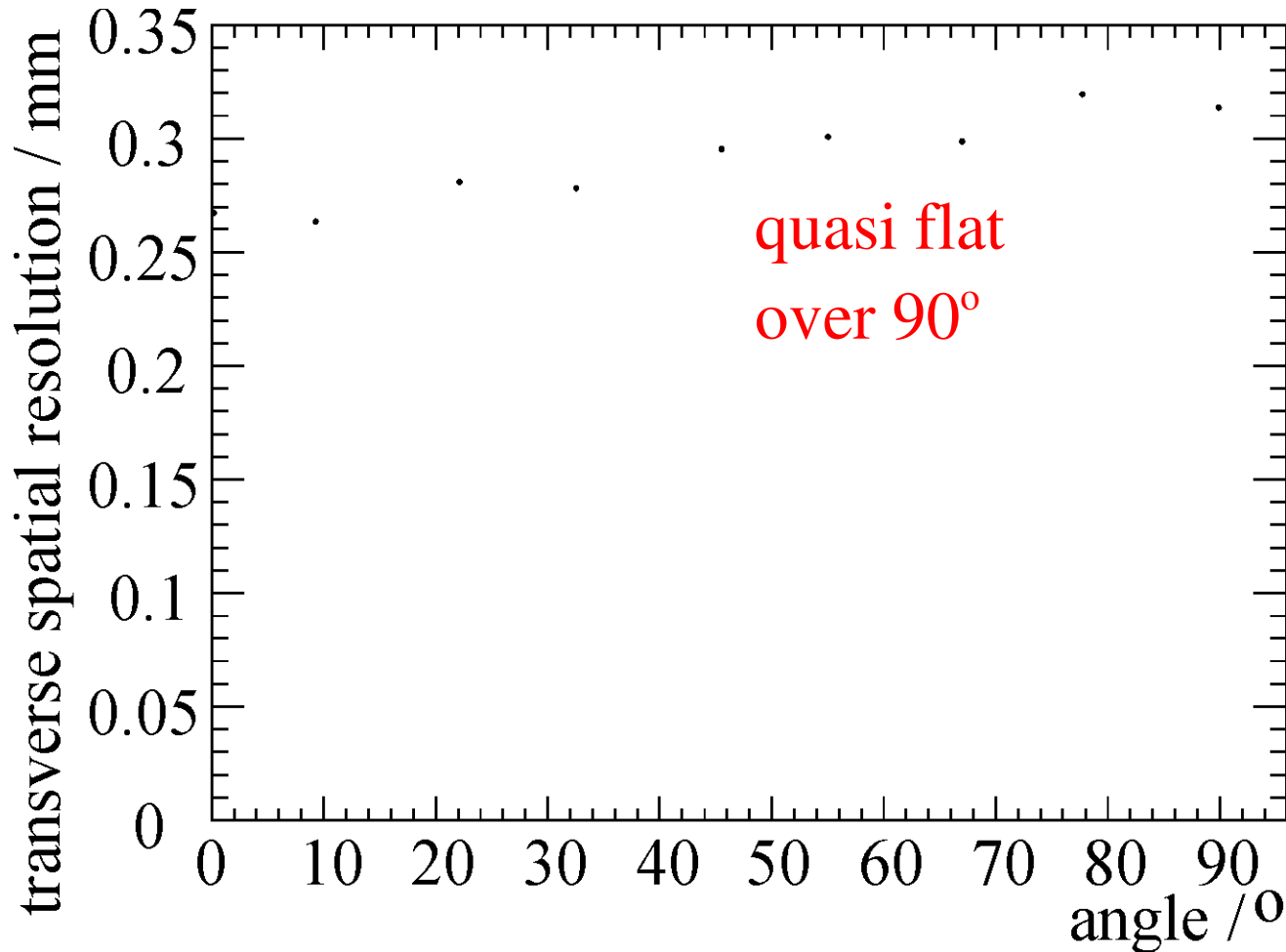


Test Beam Setup



- γ were created at a target
- primary e^- -beam was dumped
- photons converted in scintillator 1
- dipole separated e^+e^-
- coincidence of scinti 1 and 2 select single particle events

Test Beam Results



transverse spatial resolution in
dependence on track inclination

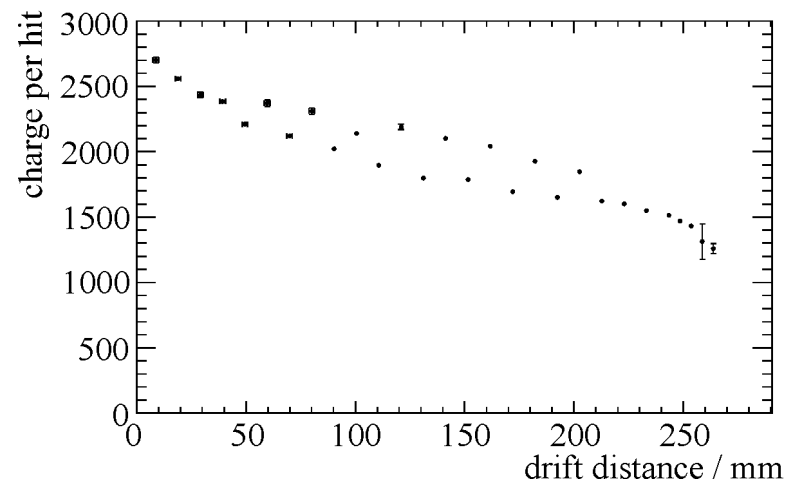
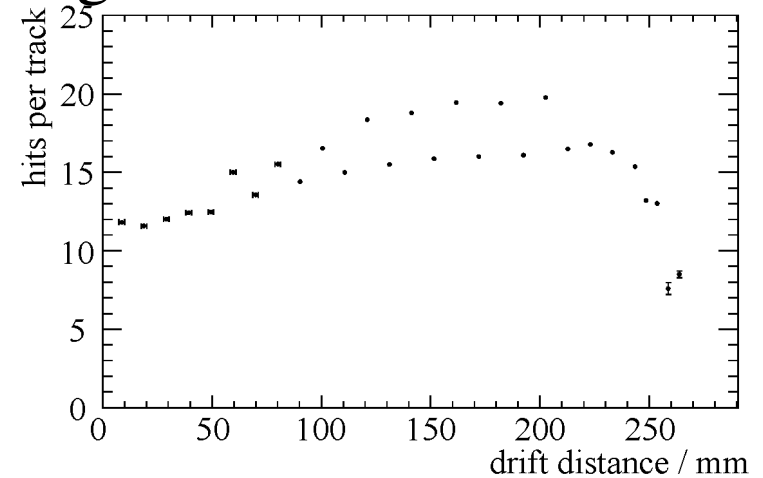
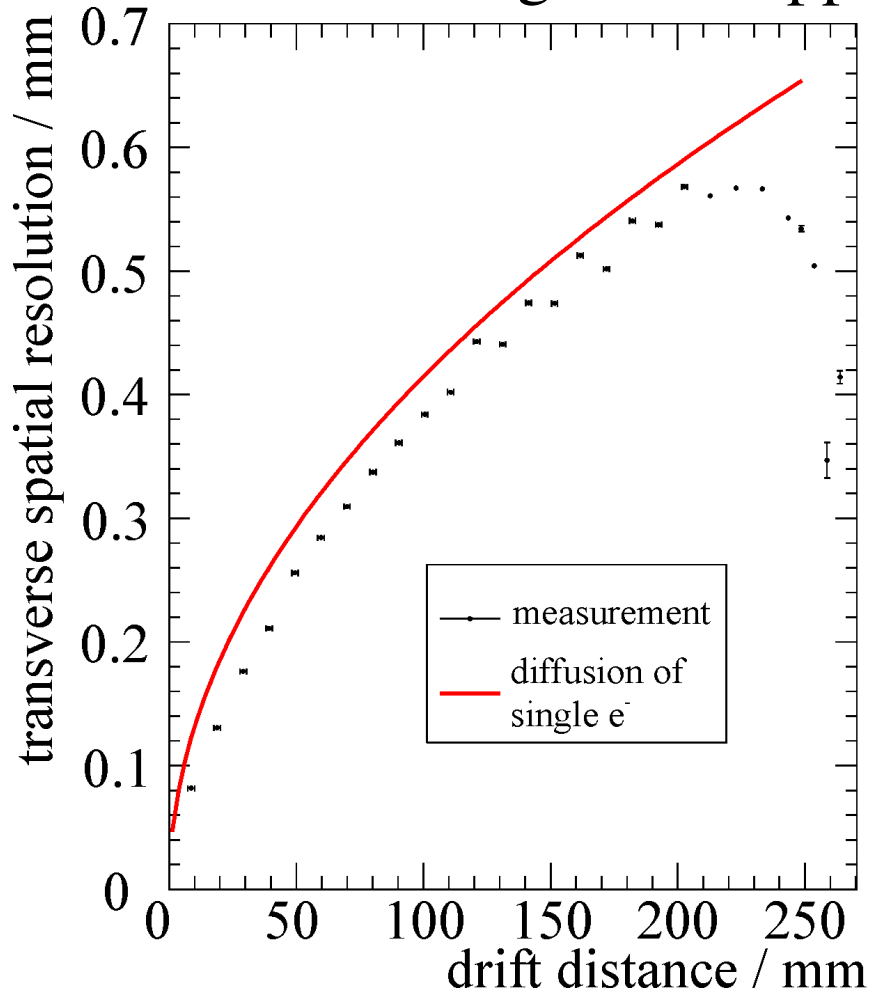
Transverse Spatial Resolution



Problems: • bad gas mixture

• shutter signal for TimePix too short

=> signal is clipped for long drift distances





Detector has performed well with cosmic rays
and in an electron test beam.

Declustering has been observed in detail.

Data of test beam show weak dependency on track inclination.