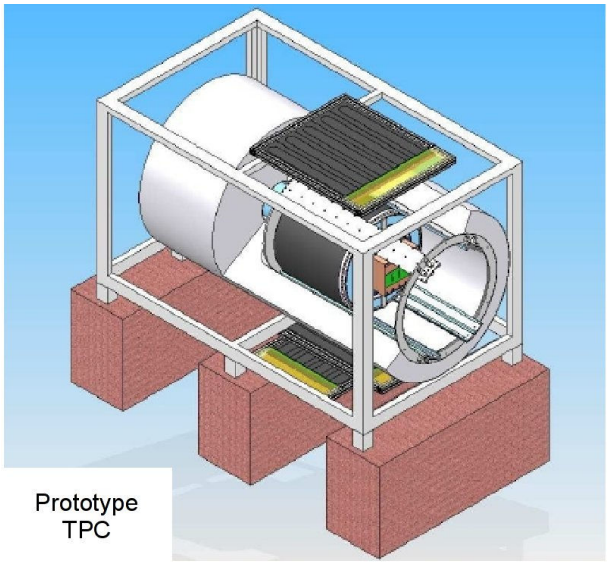
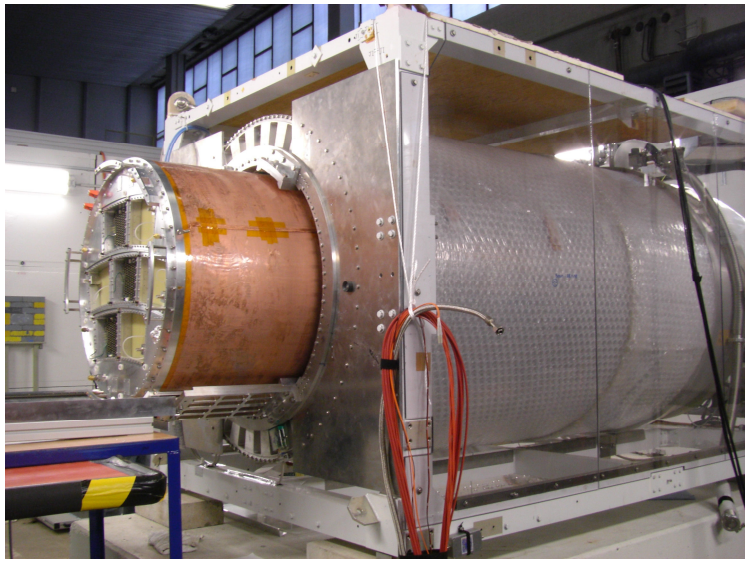
Track analysis from the beam tests with the Japanese GEM's and the Altro electronics

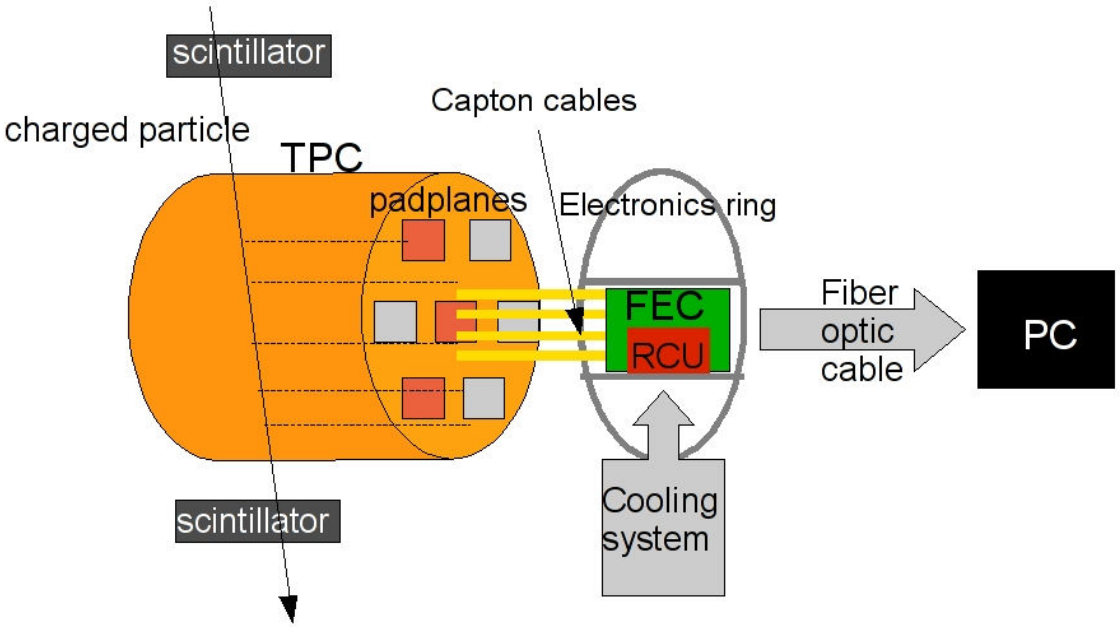
(Performed by Tuva Richert and Lene Bryngemark)

(Presented by Leif Jönsson)

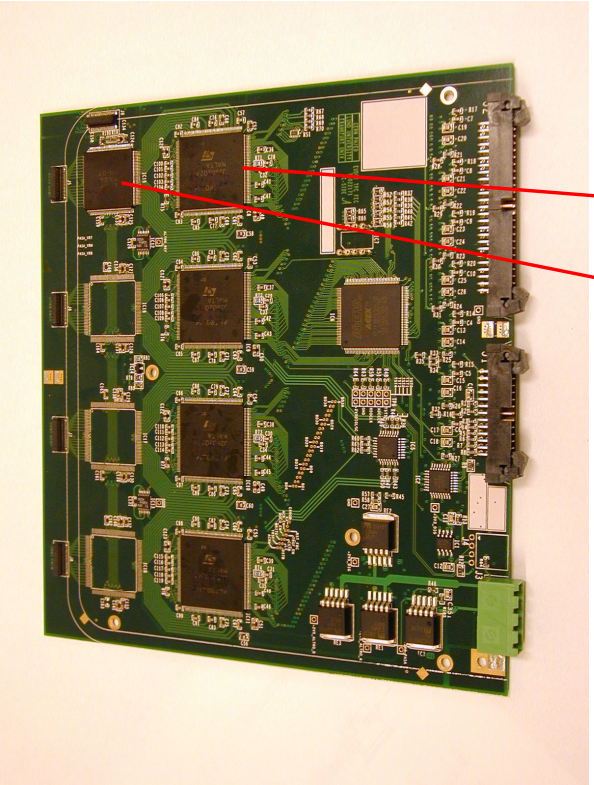
The set-up

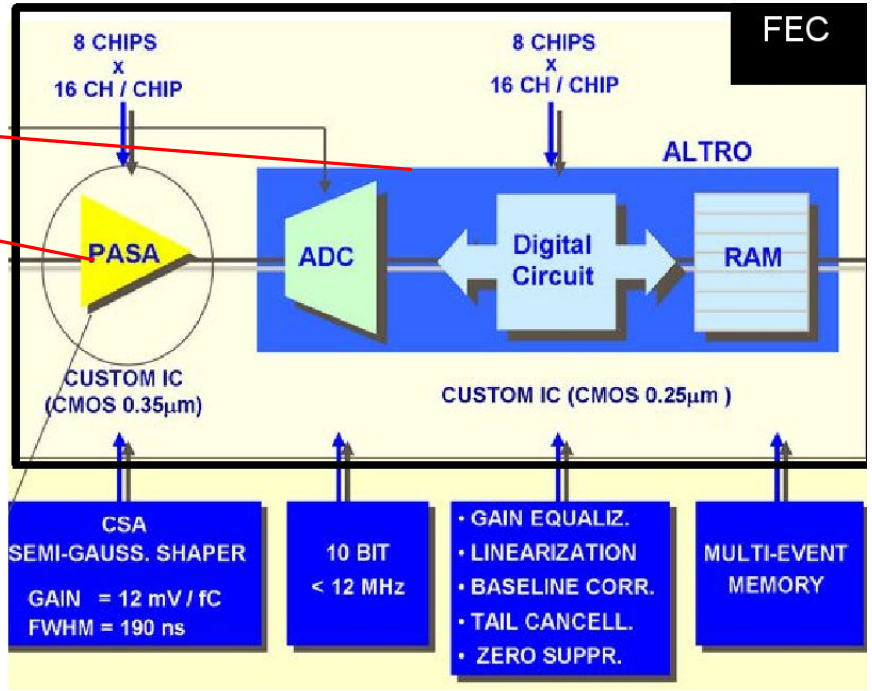

Prototype
TPC




scintillator
charged particle
TPC
Capton cables
padplanes
Electronics ring
FEC
RCU
Fiber
optic
cable
PC
Cooling
system
scintillator

The front end card



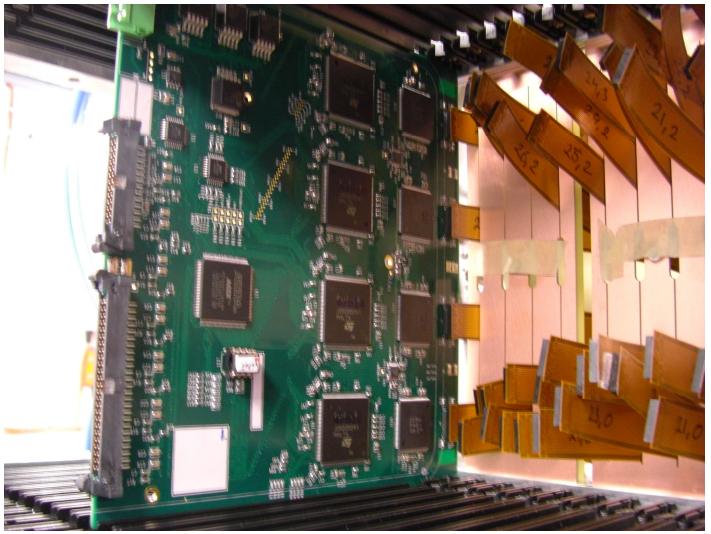


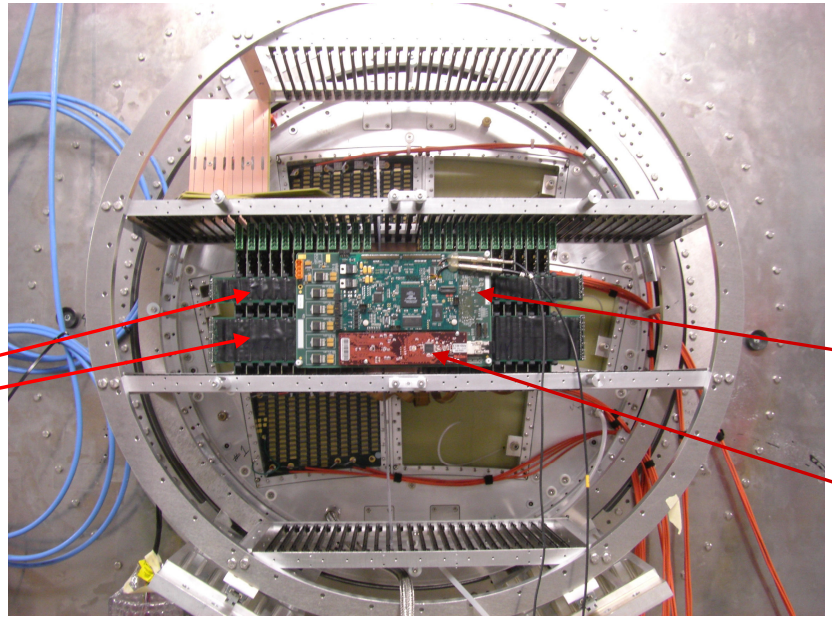
PCA16: Charge sensitive amplifier
Parameter choice:
Gain: 12, 15, 19, 27 mV/fC
Shaping time: 30, 60, 90, 120 ns

Can also be run in non-shaping mode with variable decay time

Altro:
ADC digitizes the PCA16 analogue signal of 1.2 V to a 10 bit digital value
Sampling frequency: 20 MHz (40 MHz)
Buffers data while waiting for store/discard decision
Perform pedestal subtraction and zero suppresion

What it looks like in real life



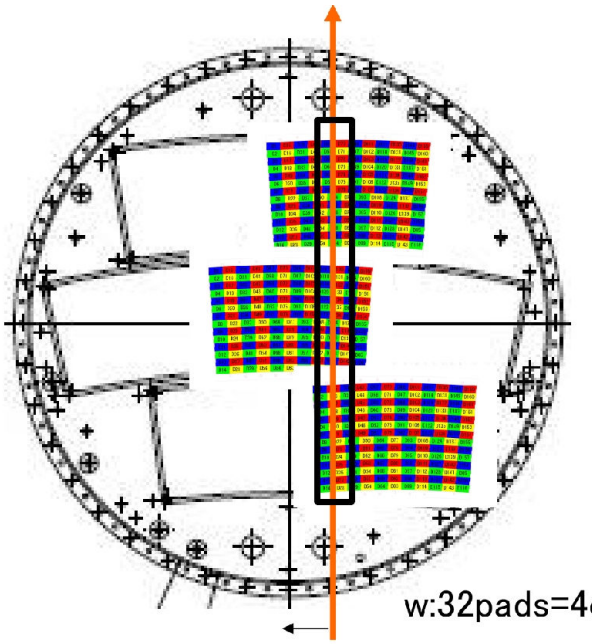


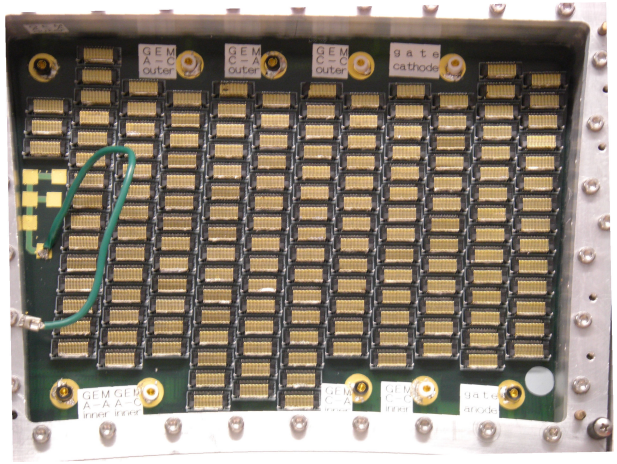
Backplanes

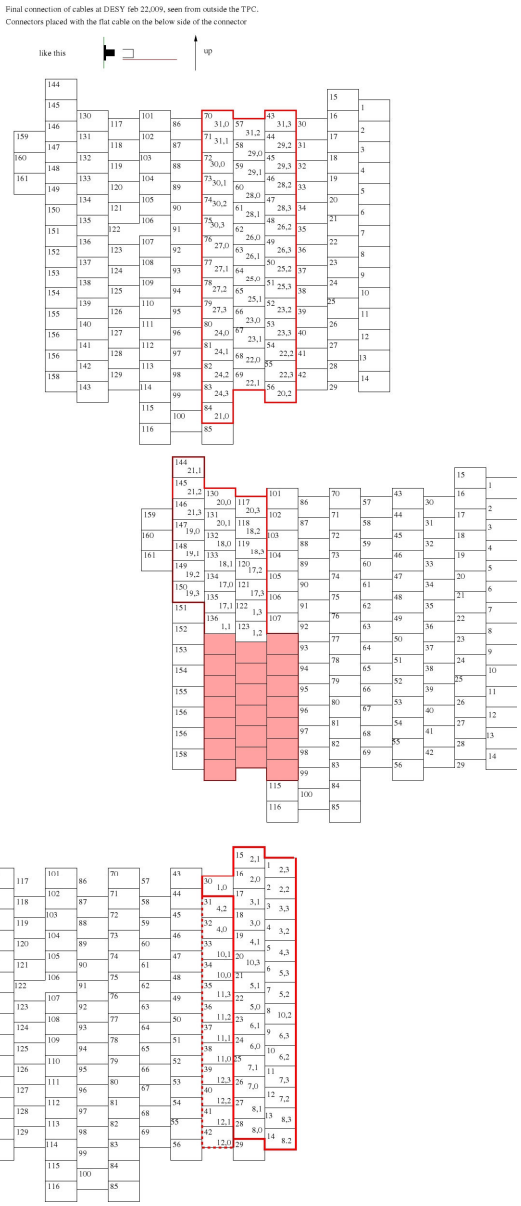
RCU
(Readut Control Unit)

SIU
(Source Interface Unit)

Modules and pad arrangement

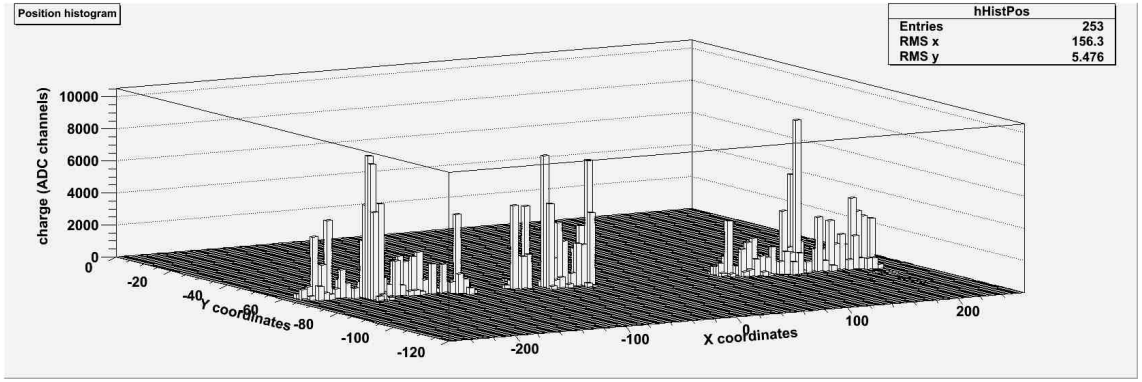


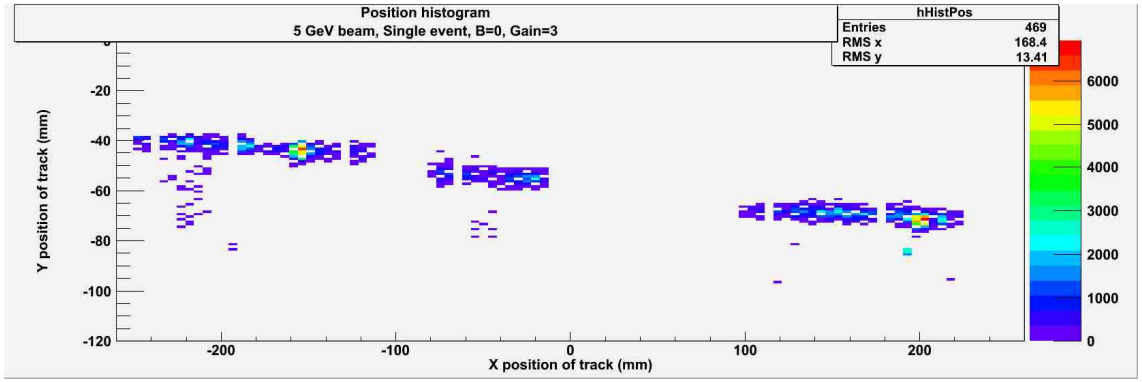




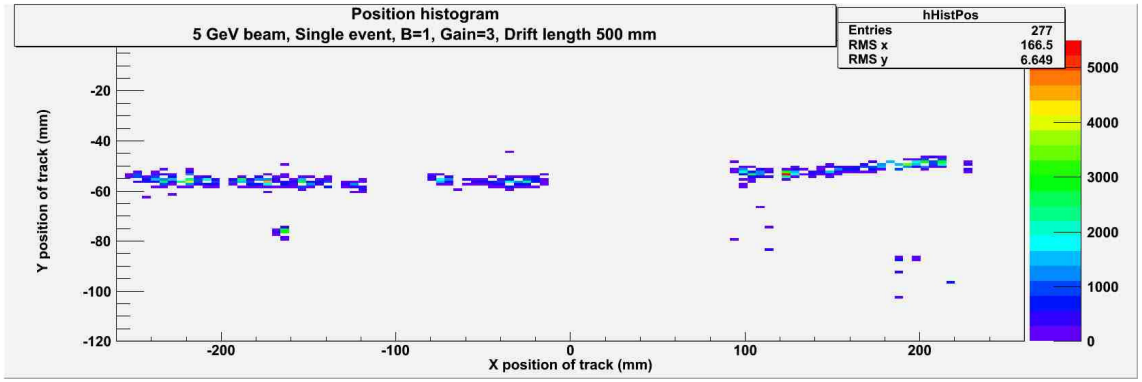
Track visualization

5 GeV electrons
B=0 Tesla
Drift length 200mm





5 GeV electrons
B=1 Tesla
Drift length 200 mm

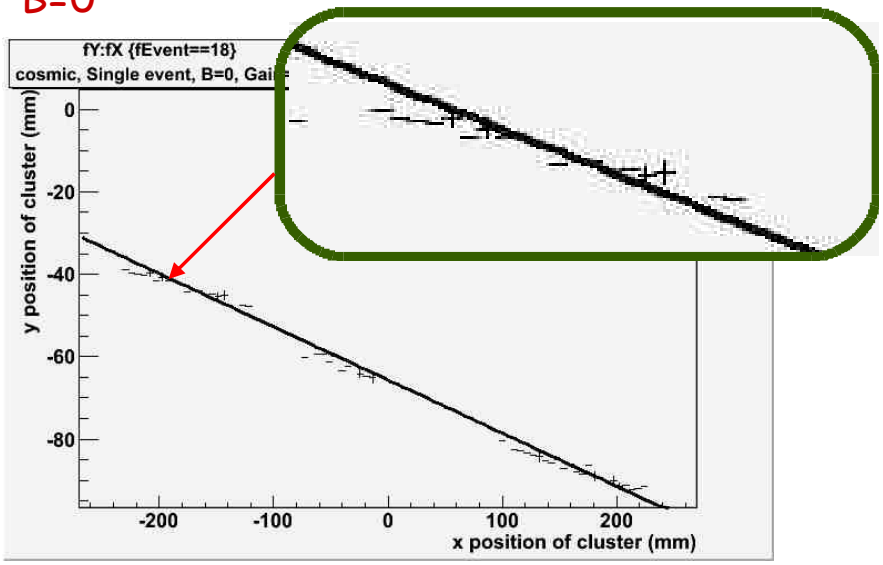


Cluster finding and track reconstruction

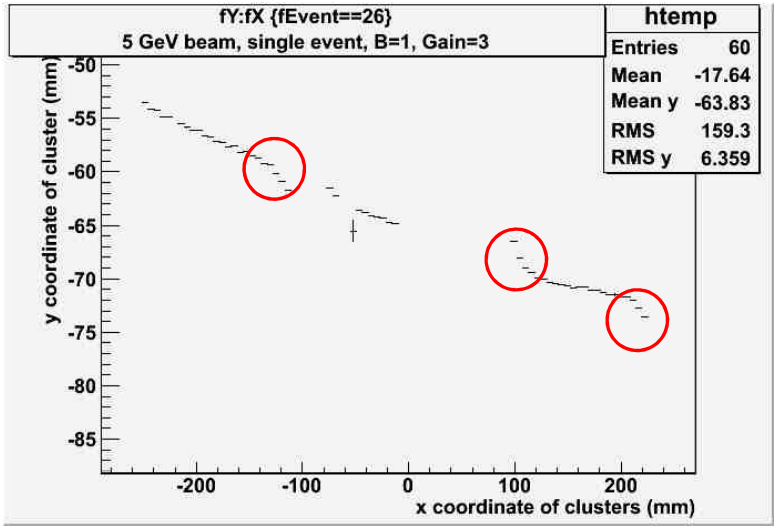
- Find peak of charge distribution for each pad row $\Rightarrow$ cluster
- Calculate the weighted mean position of the cluster;
  $\langle y \rangle = \Sigma Q_i y_i / \Sigma Q_i$ where y_i is the pad position and Q_i is the charge on pad i
- Translate position to space coordinates
- Fit a polynomial $\Rightarrow$ distance from the "real track" to reconstructed track
  $= \Delta Y$ (residual)
- Histogram the residuals
- Fit a Gaussian
- The standard deviation corresponds to the position resolution

Track studies

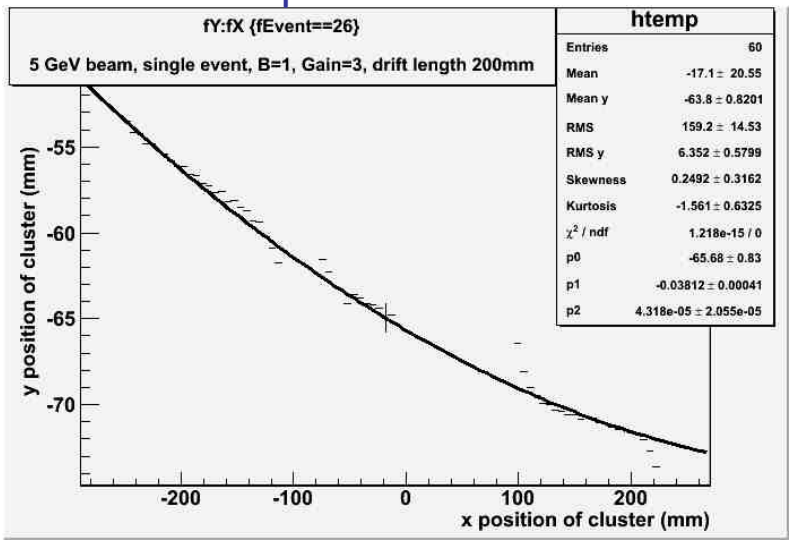
B=0



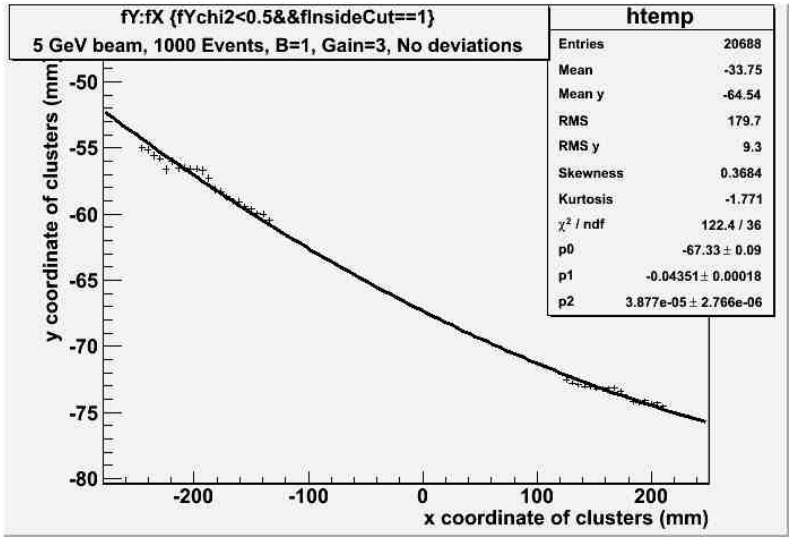
B=1



B=1 fit to all points

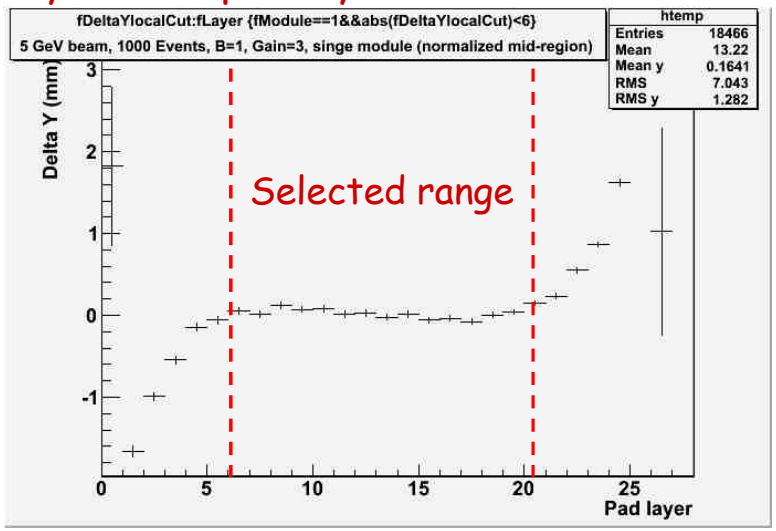


B=1 fit with distorted regions removed

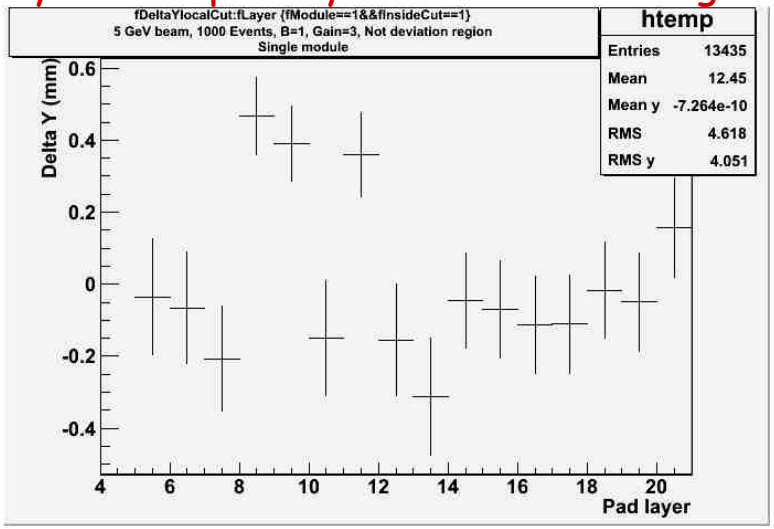


Position resolution

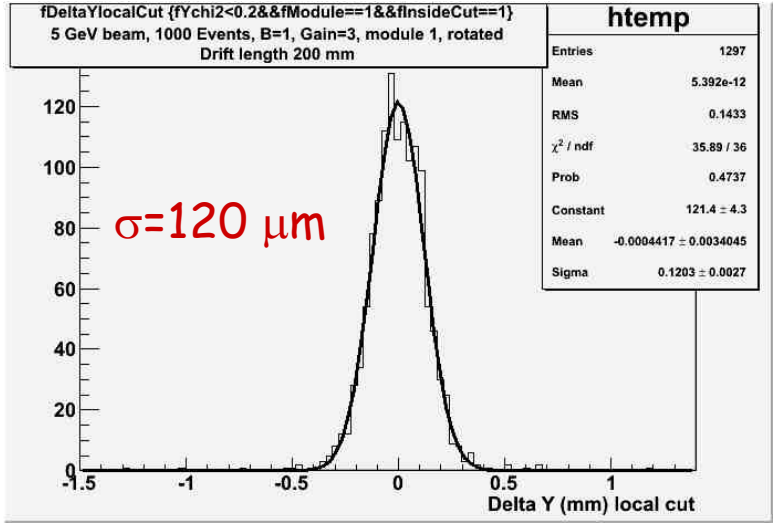
Δy versus pad layer



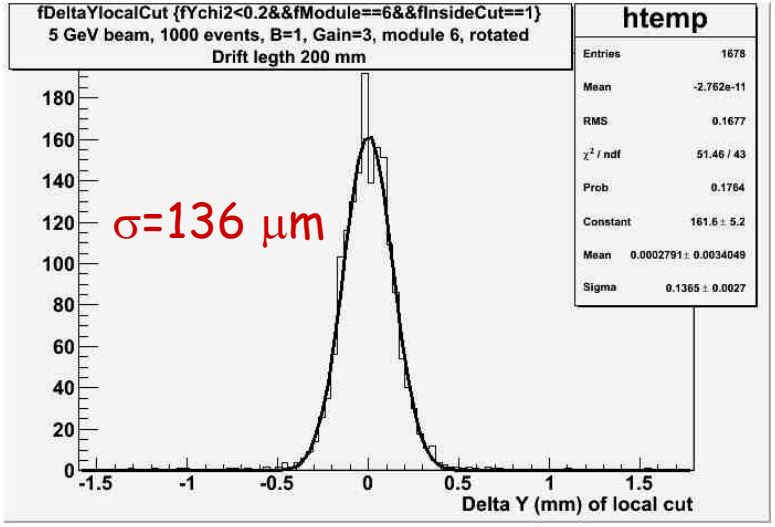
Δy versus pad layer in selected range



Distribution of residuals; module 1



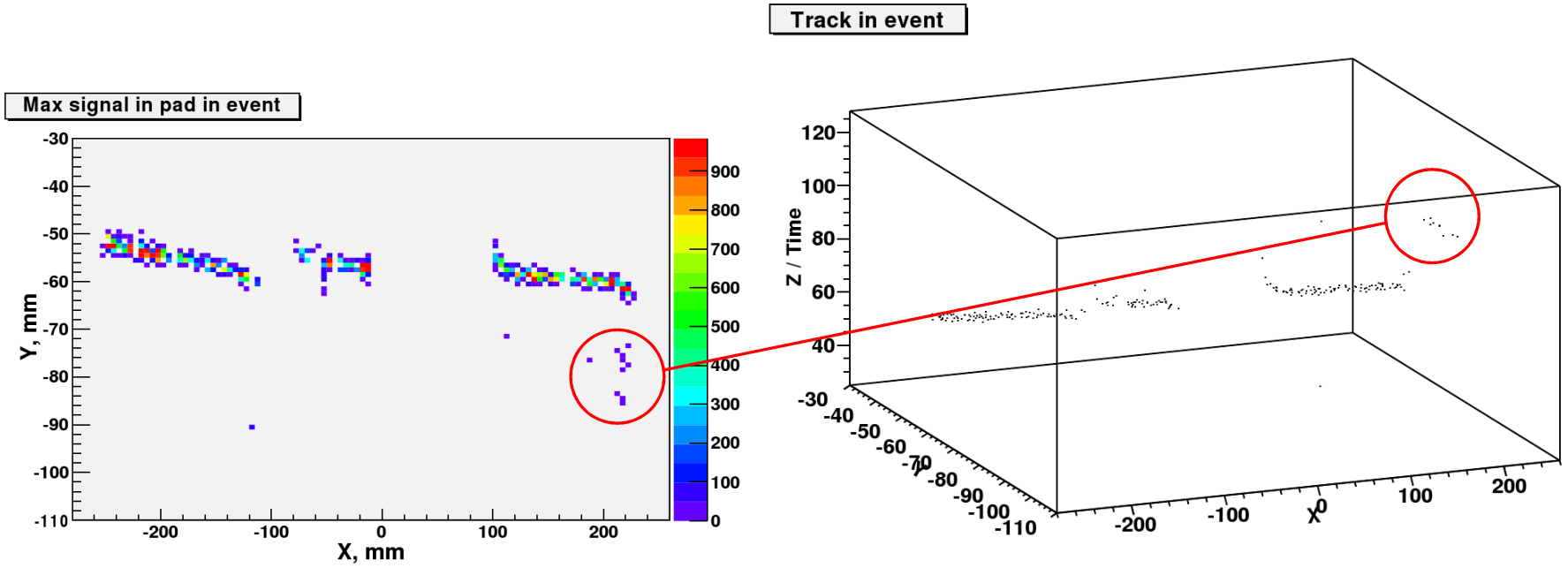
Distribution of residuals, module 3



Drift time (z-coordinate)

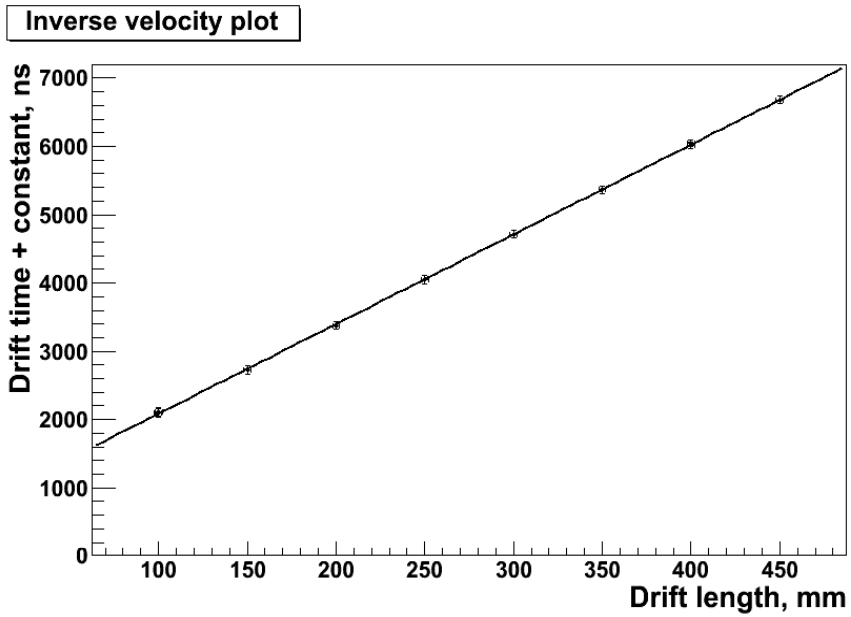
5 GeV electrons
B=1 Tesla

The z-axis is given in time bins of
50 ns/bin



The noise region can be removed by applying a cut in time (or z)

Drift time measurement



The drift time is taken to be the mean of a Gaussian distribution in the z-direction fitted to the first non-zero sample of every readout channel in a run

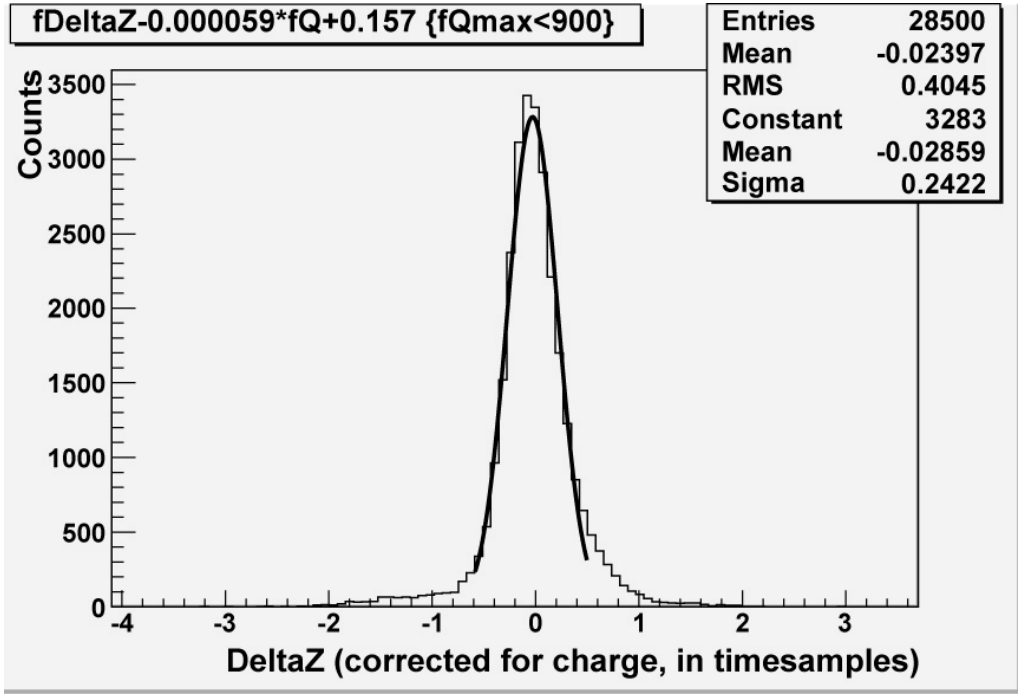
The offset is due to the time it takes for the electrons to travel from the trigger telescope to the TPC and for the electronics to respond to a trigger signal

$\Rightarrow$ drift velocity: 7.62 ± 0.09 cm/μs

$\Rightarrow$ drift length of 3.8 mm per time sample (at 20 MHz readout)

The z-resolution

- Fit a first order polynomial to the cluster coordinates in the z direction
- Histogram deviations of cluster times to the fitted line $\Rightarrow$ distribution in Δz
- Fit a gaussian to the Δz distribution
- The standard deviation (σ) gives the resolution



Result: 0.242± 0.002 time samples $\Rightarrow$ 0.920±0.007 mm

Conclusions

- Tracks read out by GEM's and the Altro electronics have been studied.
- Results on position resolution in the x-y plane of 120-130 μm was obtained
- The drift velocity was measured to 7.62±0.09 cm/μs and the resoultion in the z-direction was determined to 0.920±0.007 mm
- For B=0 Tesla, some deviations from a straight track is observed, which might indicate misalignment or rotations of the modules with respect to each other
- For B=1 Tesla, distorsion of the tracks are observed at the edges of the modules. This might be due to the influence of the GEM support structure on the electric field.