Status report of TPC-research at Karlsruhe

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ECFA/DESY workshop
Amsterdam, 1-4/4/2003

bmb+f - Förderschwerpunkt
TESLA
Großgeräte der physikalischen Grundlagenforschung

Outline

Chamber

Cosmic ray setup

STAR-electronics

Reconstruction and analysis

Comparision CERN and Karlsruhe data

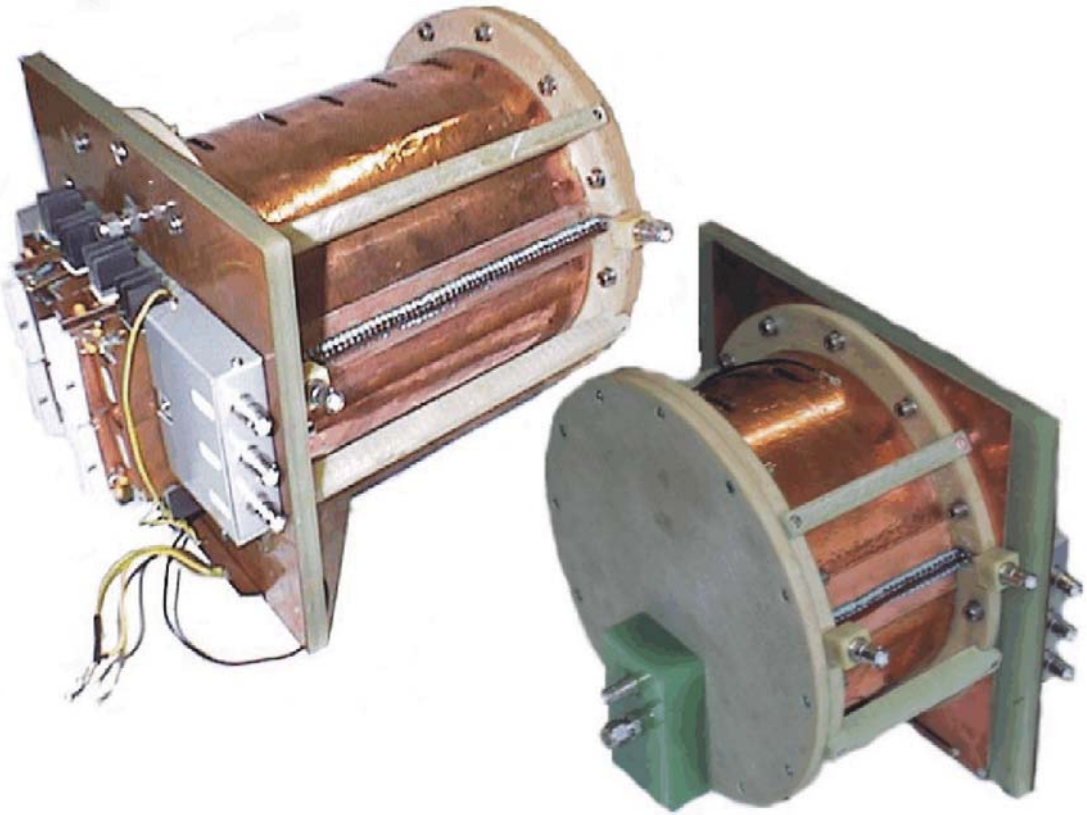
Conclusion and outlook

Chamber

dimensions:
- length: 12.5cm and 25cm
- inner diameter: 20cm
- outer diameter: 26cm

double layer field cage

flexible readout endcab



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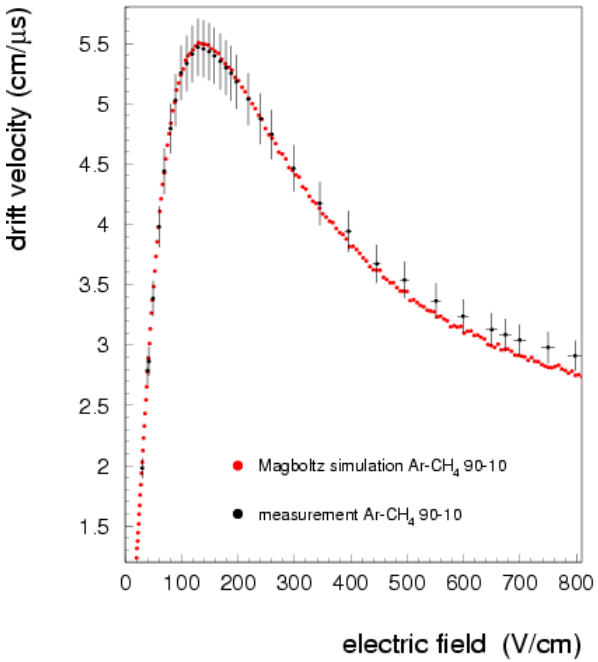
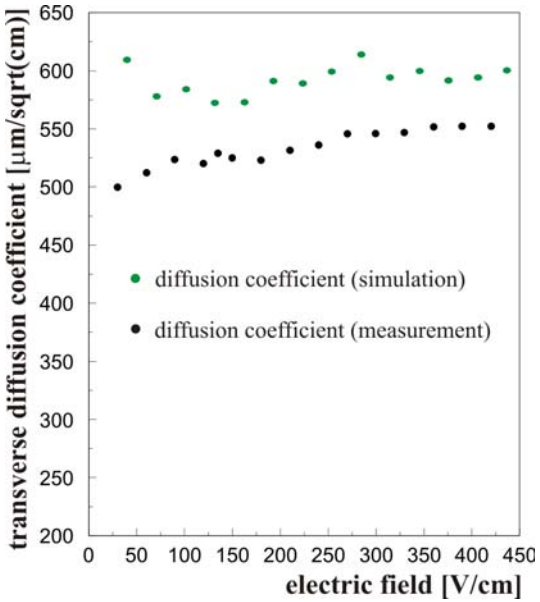
Old electronics

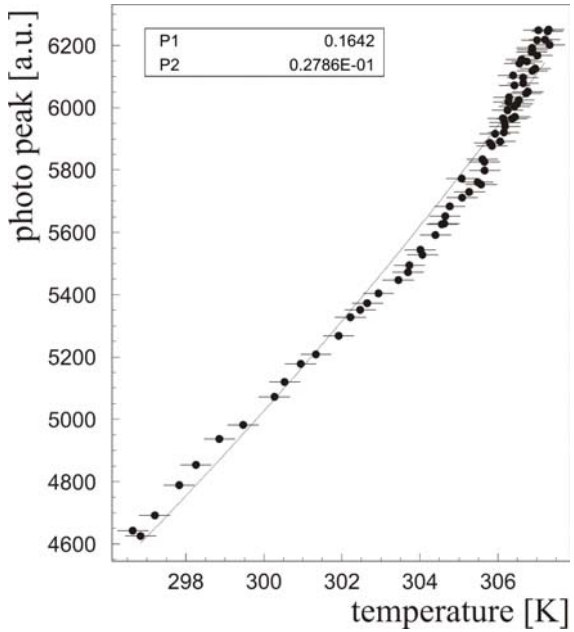
system check and measurement of fundamental properties



drift velocity

diffusion coefficient





temperature dependency of gas gain

=> do not heat gas

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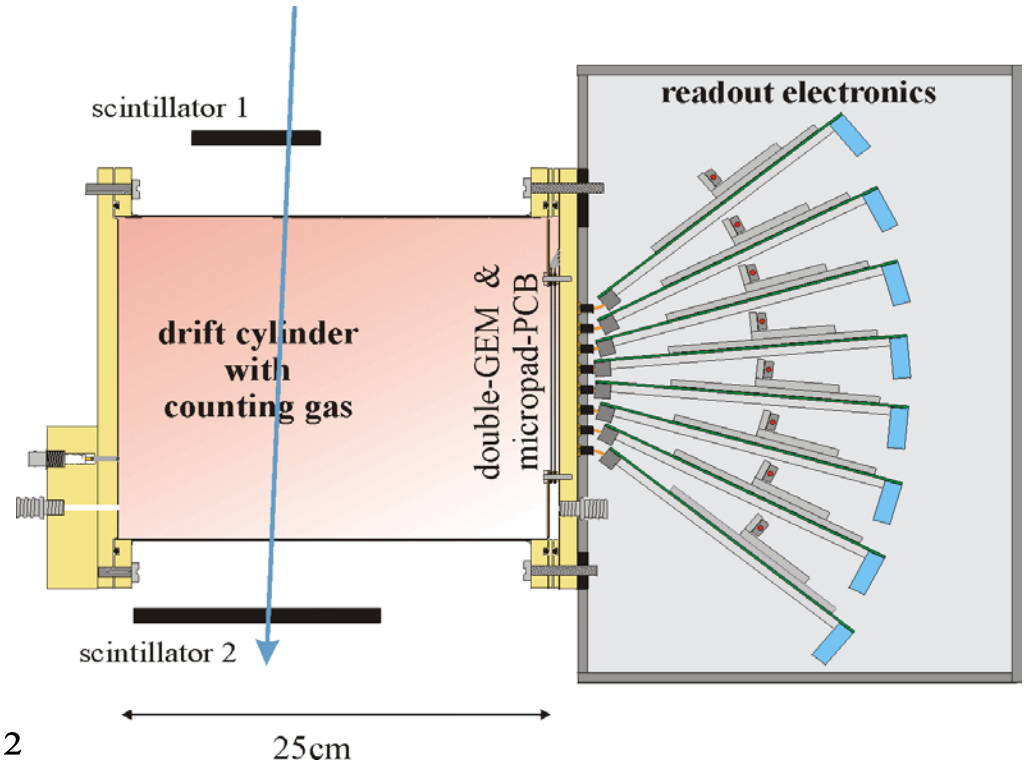
Cosmic ray setup (I)

gas: mixture Ar:CH4 90:10 flux: 80ccm/min.
0.6 volume exch./h

amplification:
GEMs 140/70/60
transfer gap: 2mm
induction gap: 2mm

trigger: CERN:
2 scintillators 12∗20cm²
1 scintillator 1∗10cm²
Karlsruhe:
1 scintillator 7.1∗3cm²
1 scintillator 19∗4.5cm²



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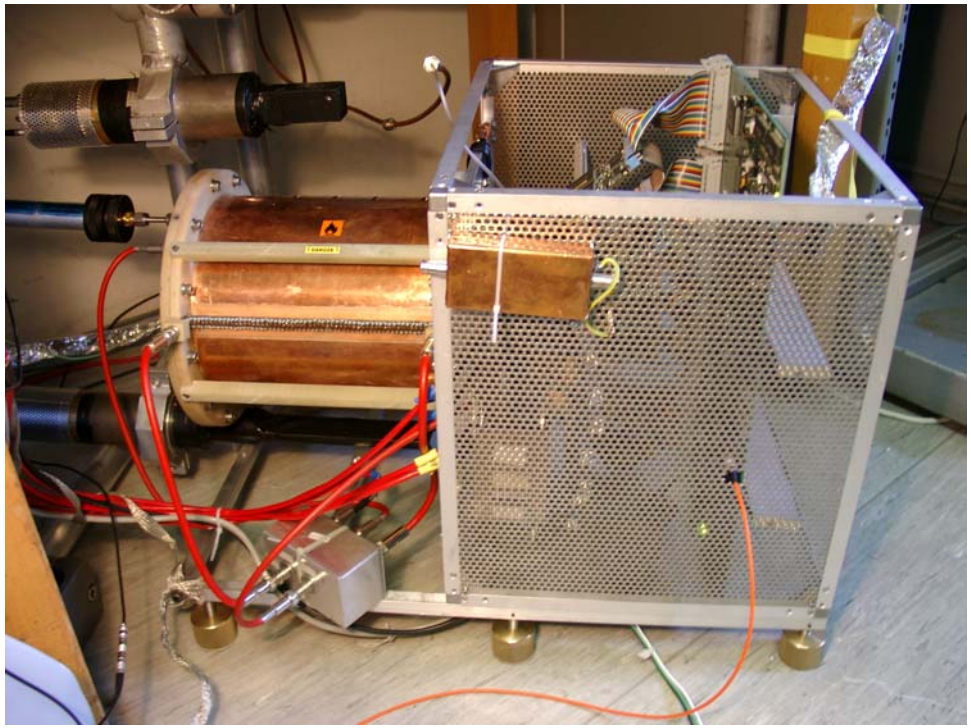
Cosmic ray setup (II)

	CERN	Karlsruhe
<u>fields (V/cm):</u>		
drift f.	141	135
transfer f.	3500	2500
induction f.	3500	3500
<u>GEM-voltages (V):</u>		
upper GEM	360	370
lower GEM	350	360



<u>layout of readout structure:</u>

Size: 1.27∗12.5mm²

8∗32 pads connected

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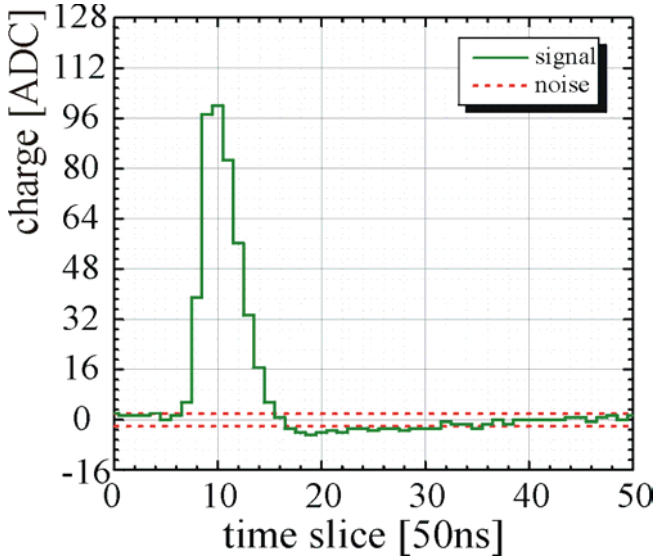
STAR electronics



FEE-cards - mounted directly to the end plane
=> digitization at end plate
=> low noise (about 1.5 ADC units)

sampling rate: 19.7 MHz (variable 10-40MHz
on clock and trigger-board)
peak time and FWHM of pulse: 180ns

minor restrictions for the use with MPGDs:
+ designed for positve signals => FEE-card modification for negative signals
+ ion tail correction leads to undershoot
+ long timing constant (doesn't exploit detector's two-track resolution)

data transport: - via flatband cables to RDO-board
- via optical fibre link to VME module
- via ethernet cable to computer

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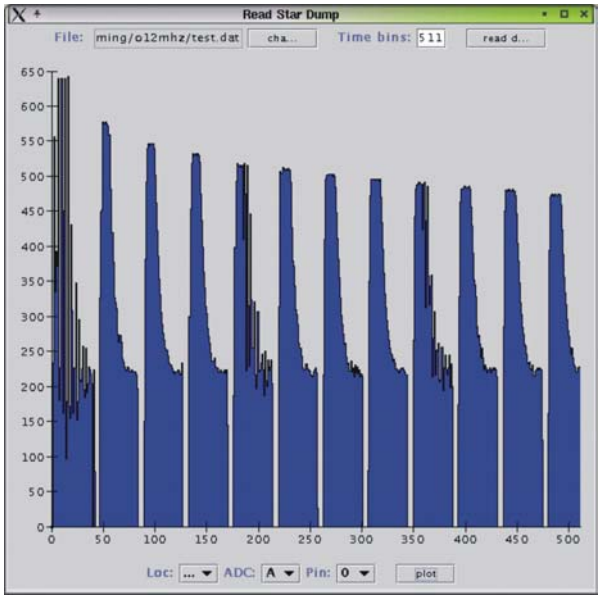
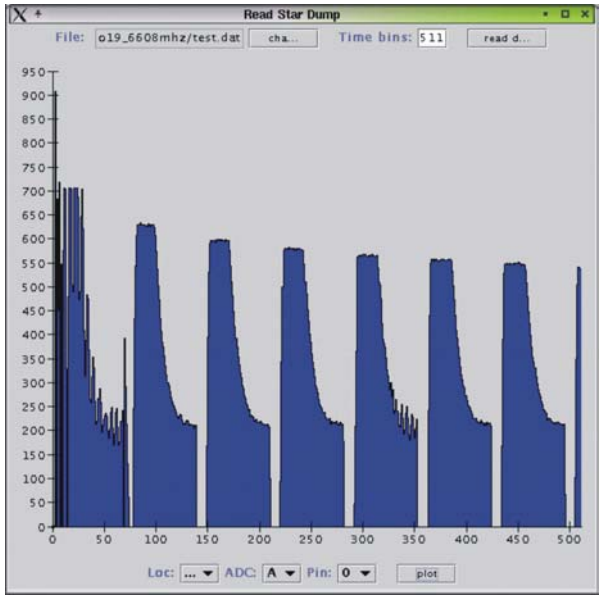
Timing tests

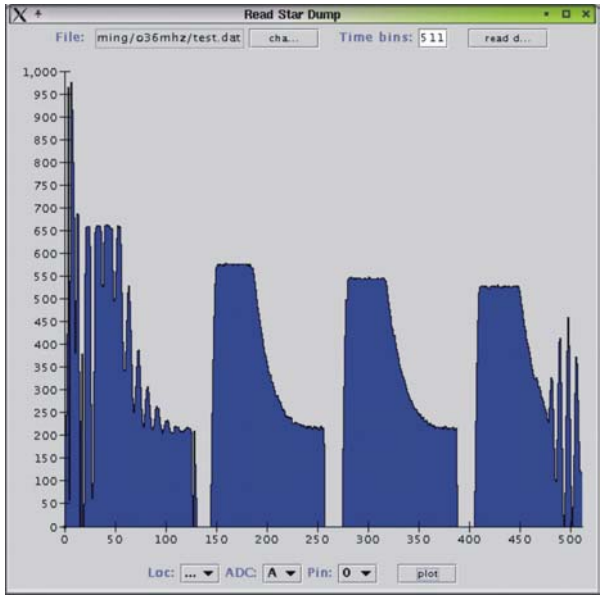
Test pulse with a frequency of 0.28 MHz was given on one channel.
Different oscillators ranging from 12 to 40 MHz were tested.



nom.: 12.000 MHz
mes.: (11.992 ± 0.007) MHz

nom.: 19.6608 MHz
mes.: (19.67 ± 0.018) MHz





nom.: 36.000 MHz
mes.: (36.06 ± 0.034) MHz

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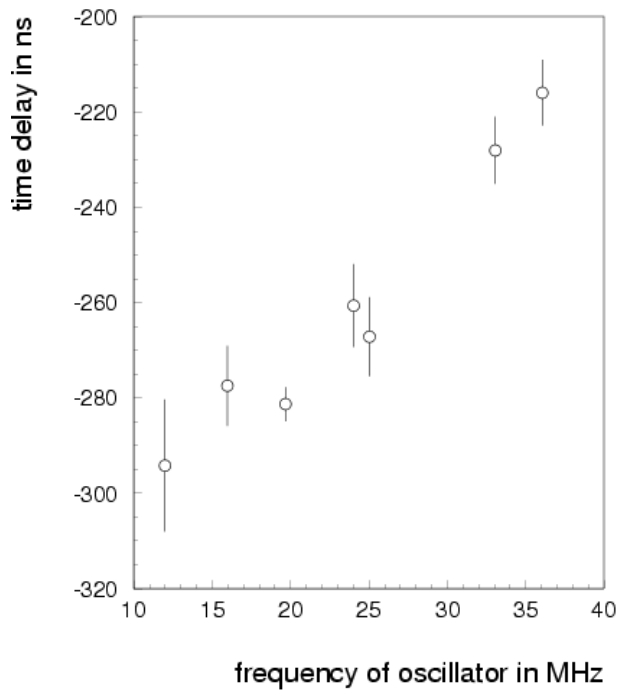
More details

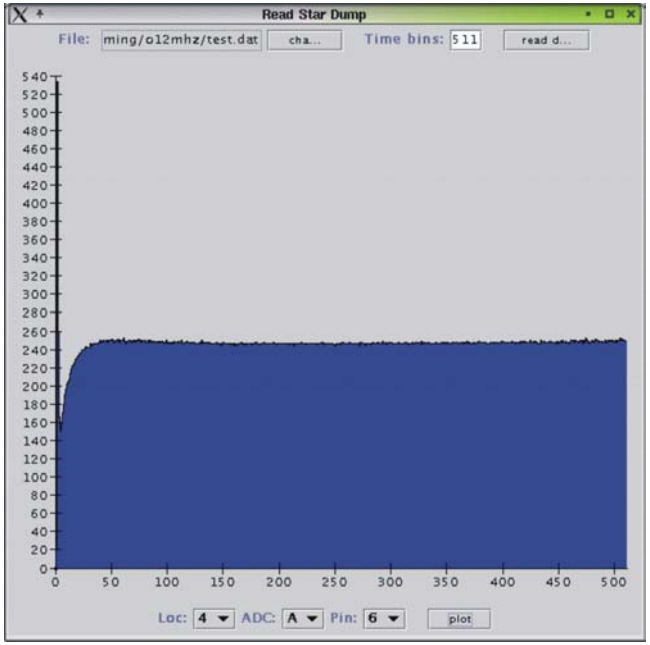
time delay



readout-
speed

improved to:
1.16 Hz
(8 FEE-cards
= 256 channels)

average noise
and pedestals



$noise_{CERN}$: ca. 1.6 ADC
$noise_{Karlsruhe}$: ca. 1.4 ADC

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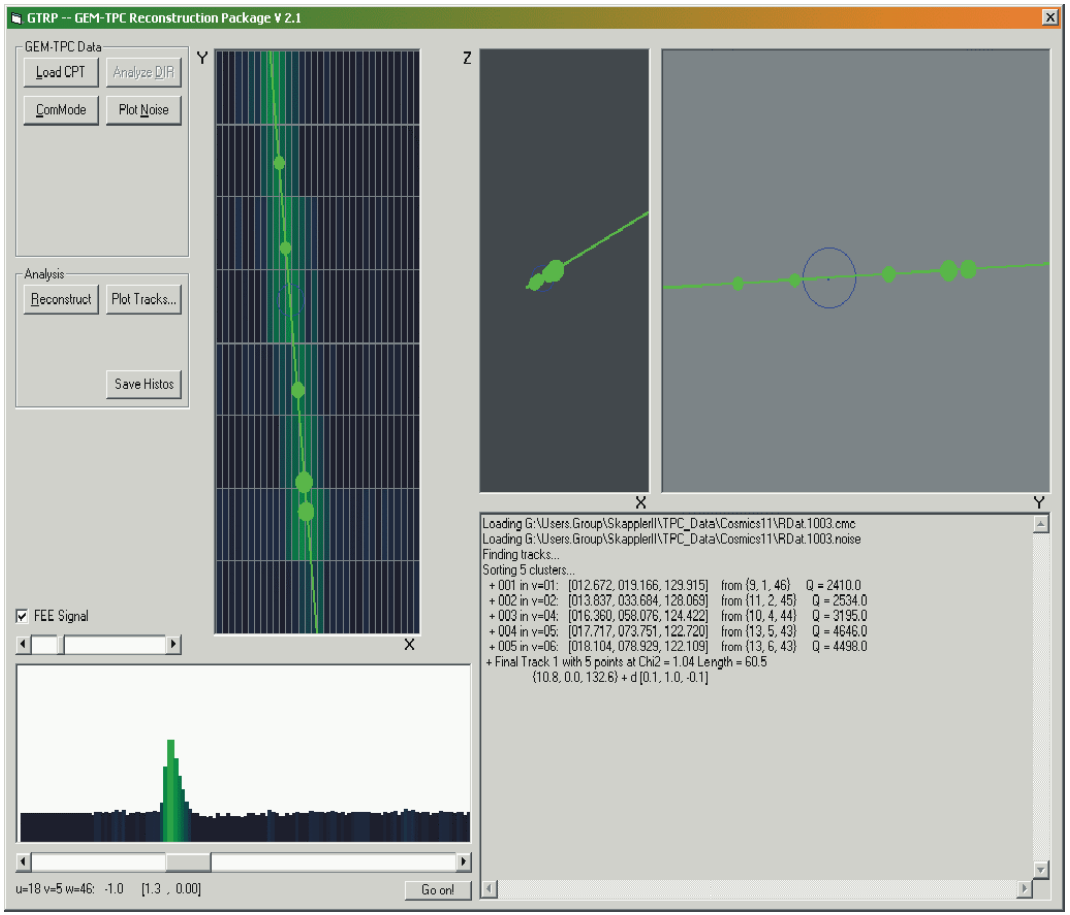
Reconstruction software

visualization
signal inversion and
  common mode correction
clusterfinding + anlysis
  max. strip > 3*noise
  cluster charge > 5*noise
trackfinding + analysis
  4th row is target row
  ”combinatorical“ trackfinder
  3D linear regression
    of space points
  cuts: min. 5 space points
    min. length 5mm
    $\chi^2 < 2.0$



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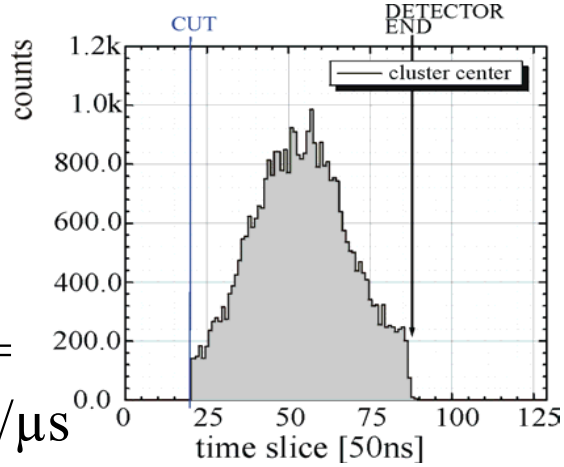
Cluster properties

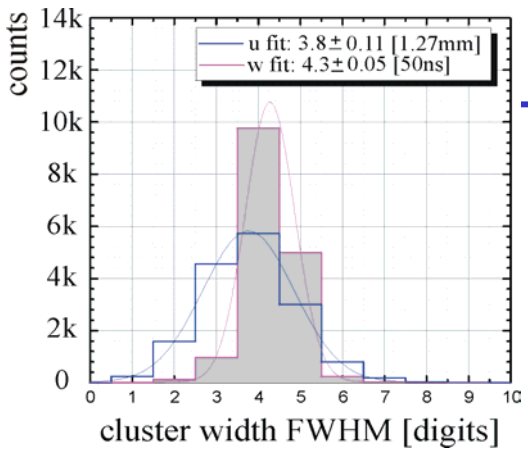
drift time of clusters

cluster width

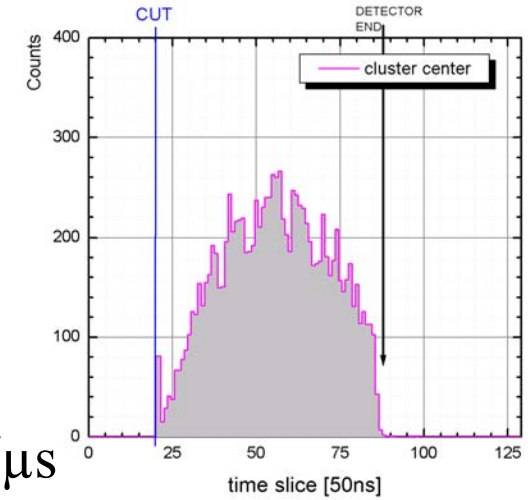


v_{drift}= 5.47cm/µs

CERN

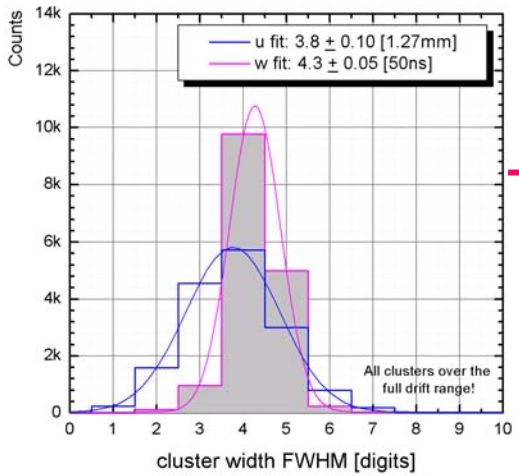


transverse cluster width



v_{drift}= 5.50cm/µs

Karlsruhe



longitudinal cluster width

same amount of strips was hit

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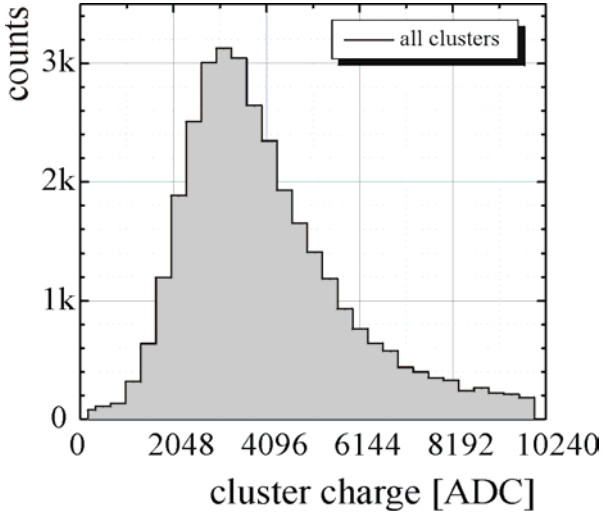
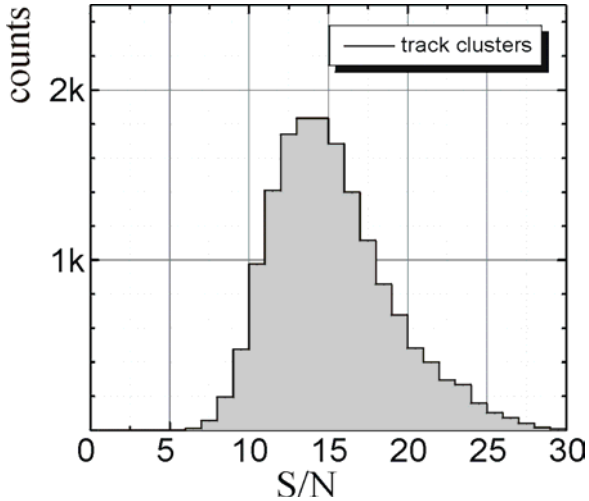
Cluster charge and signal to noise

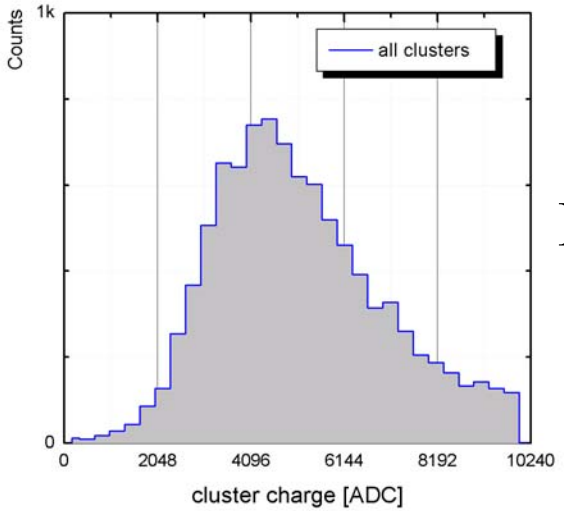
cluster charge of all clusters found

signal to noise of all clusters in a track

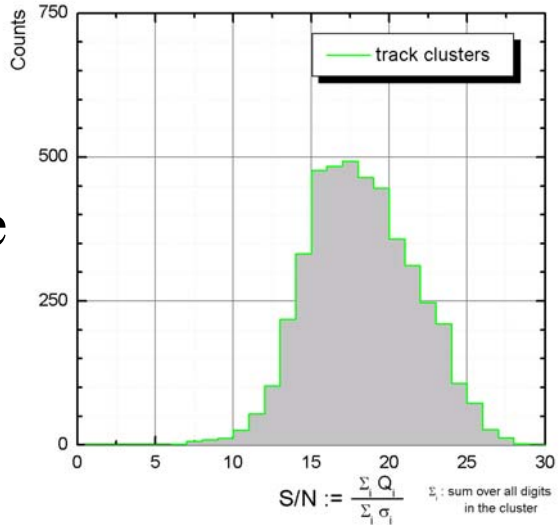


CERN





Karlsruhe



$S/N = \Sigma_i Q_i / \Sigma_i \sigma_i$

summing over all the digits in a track cluster

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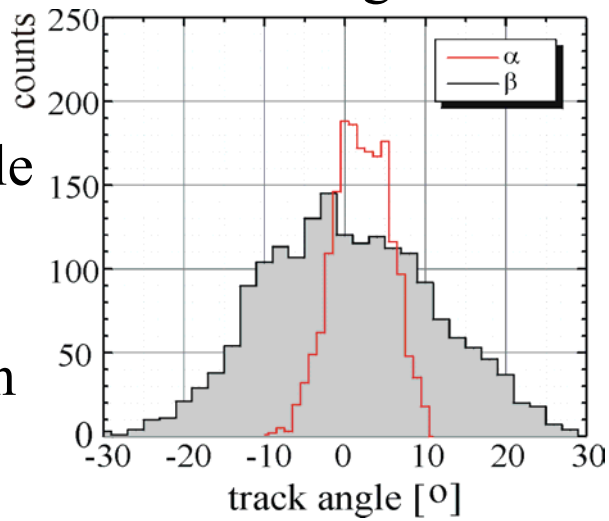
Track properites

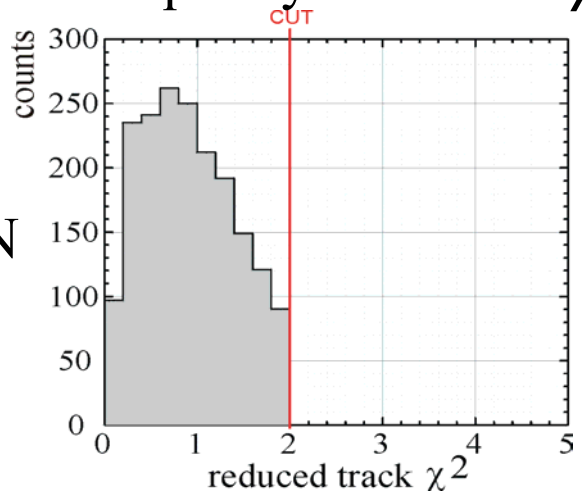
track angles

track quality – reduced χ^2

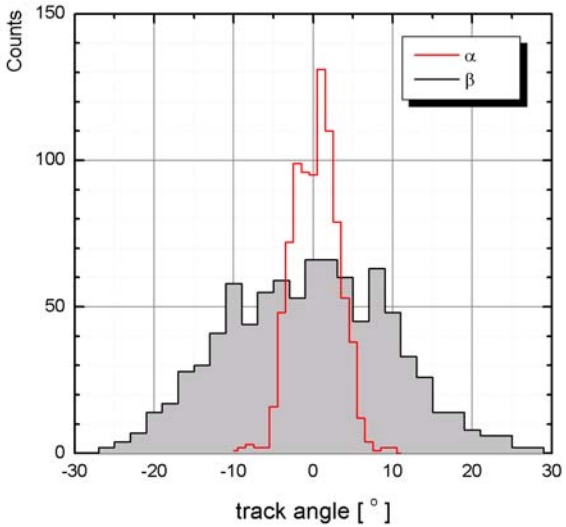
α = angle of track with x-direction



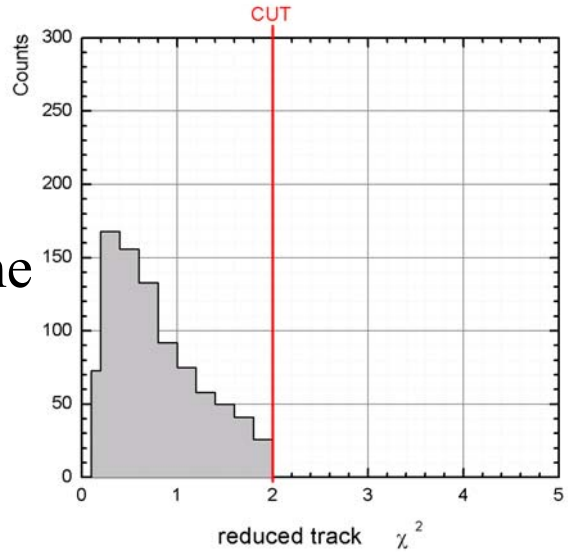
CERN



β = angle of track with drift direction (z)



Karlsruhe



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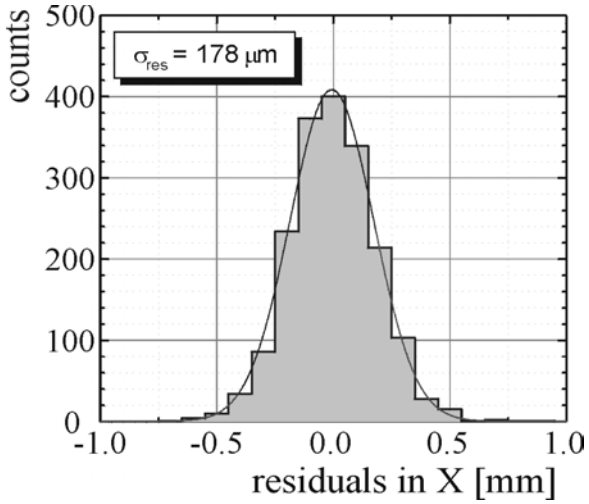
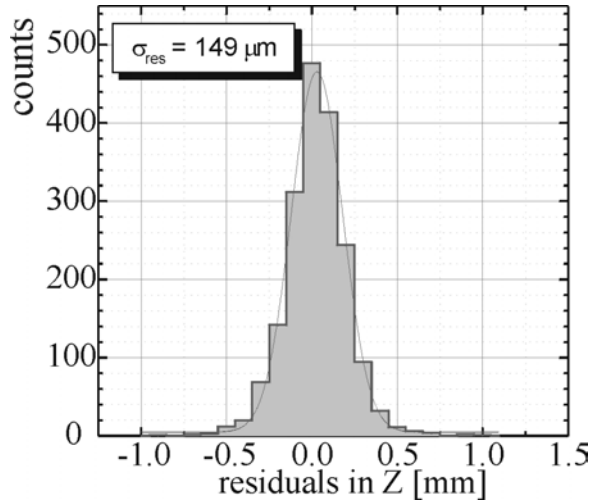
Space resolution





<u>residuals:</u>

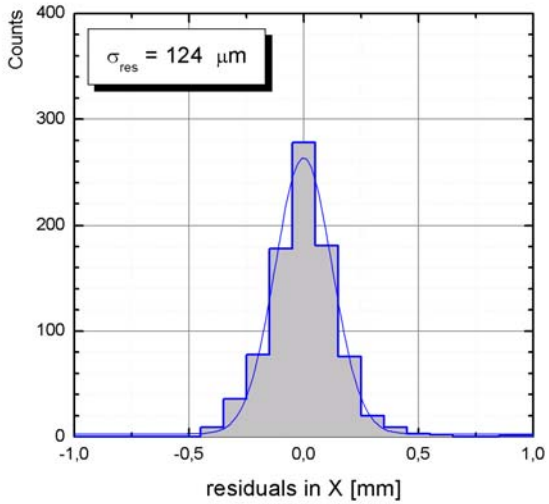
shortest vector from cluster in target row to the track

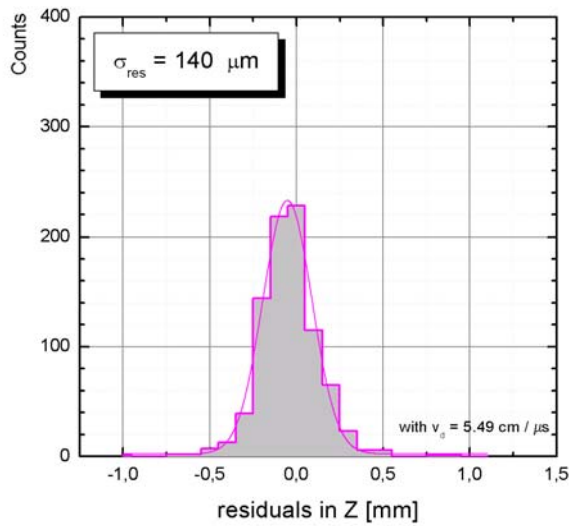
for conversion of drift time to distance a drift velocity of v=5.49 cm/µs (MAGBOLTZ) was used.

relation between residuals and space resolution:

$$\sigma_{res}^2 = \sigma_{space}^2 + \sigma_{track}^2$$

⇒ residuals represent upper limit for space resolution





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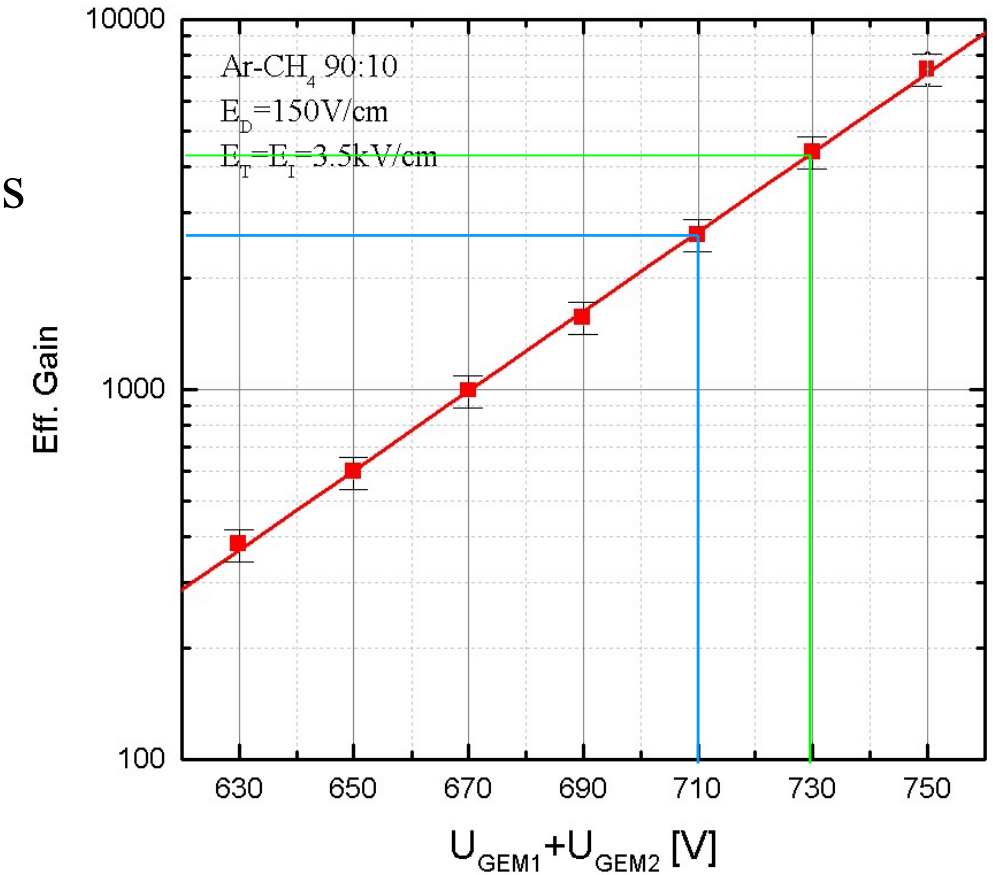
Efficiency

CERN: (96.8 +/- 2.3) % at gain ~ 2800

Karlsruhe: (97.0 +/- 3.4) % at gain ~ 4500

gain calibration:
”standard“ double-GEMs
Ar:CH_4 90:10



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Conclusion and Outlook

A TPC with double GEM-readout has been used in a cosmic ray test setup.
gas mixture of Ar: CH_4 90:10 rectangular pads 1.27∗12.5mm²
two different amplification voltages: (1) 360V/350V and (2) 370V/360V

The STAR-electronic has been used to take cosmic ray data and
the following preliminary results were obtained:
signal to noise: (1) 15:1 and (2) 18:1
width of residuals in x-direction: (1) 178μm and (2) 124μm
efficiency: (1) (96.8±2.3) % and (2) (97.0±3.4) %

Further work is in progress:
- efficiency studies with cosmics
- B-field test at DESY
- beam test at CERN

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