TECHNISCHE UNIVERSITÄT MÜNCHEN

High-Rate TPC for PANDA

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TPC jamboree meeting, 11-05-2009

panda

MLL

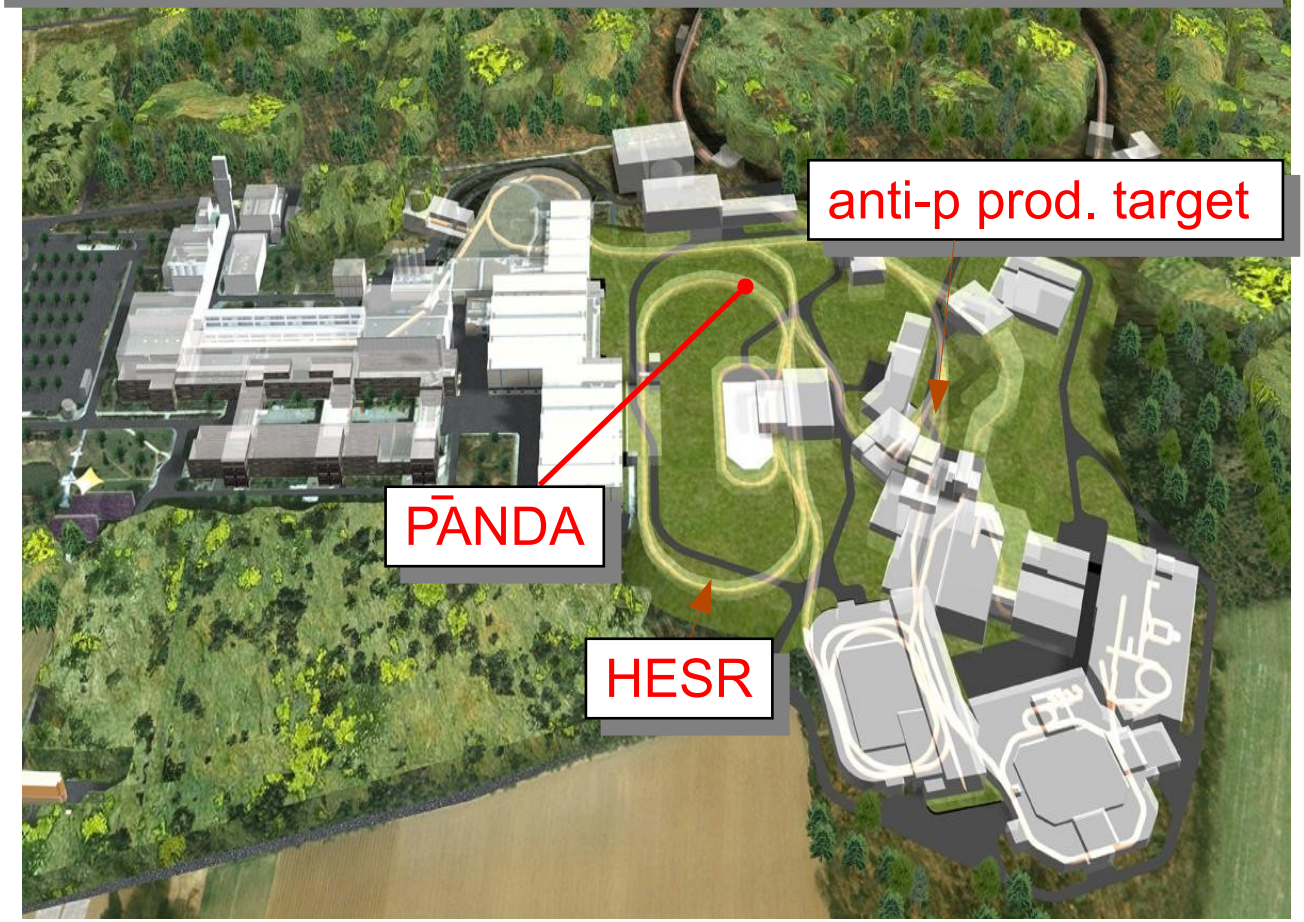
Bundesministerium für Bildung und Forschung

Overview

- The PANDA experiment, spectrometer and requirement
- The GEM-TPC as a central tracker for PANDA
- The GEM-TPC test chamber
- Test beam at ELSA
- Further prototypes

Antiproton Annihilations at Darmstadt

Facility for Antiproton and Ion Research, Darmstadt, Germany



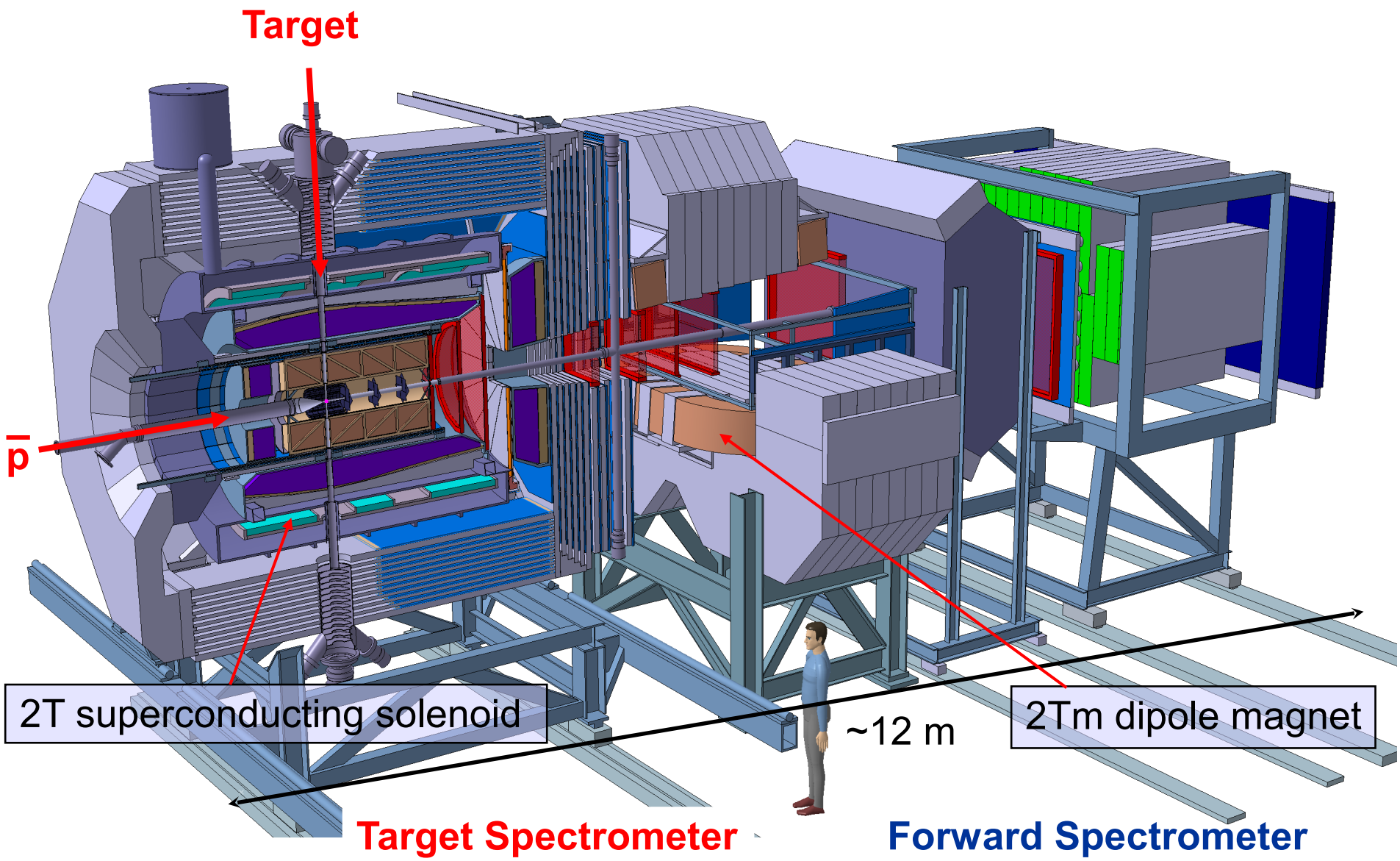
High Energy Storage Ring:

- 1 – 15 GeV antiproton-beam
- Continuous beam
  - *High intensity mode*
    - $L=2.10^{32}cm/s$
    - $\delta P/P=10^{-4}$
  - *High resolution mode*
    - $L=10^{31}cm/s$
    - $\delta P/P=10^{-5}$

Hadron-physics:

- Charm spectroscopy, gluonic excitations, hypernuclei, ….

PANDA overview



PANDA Central Tracker

Requirements

- Full solid angle coverage
- Secondary vertex resolution

$$\sigma_{r\varphi} \sim 150\,\mu\mathrm{m},\ \sigma_z \sim 1\ \mathrm{mm}$$

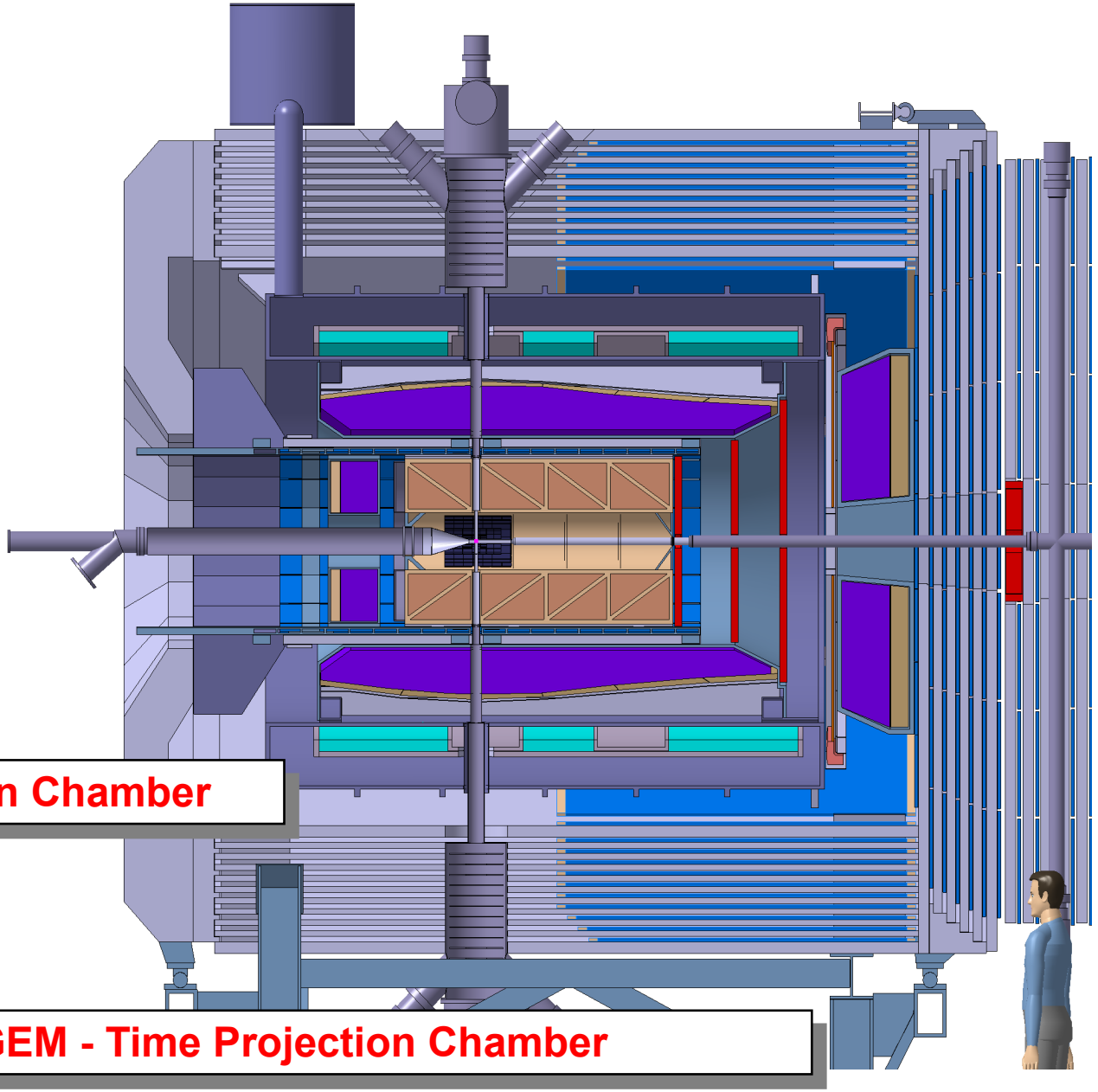
- Momentum resolution

$$\delta p/p \sim \%$$

- Minimal material budget

$$X_0 \sim \%$$

- Particle identification
- Operation in magnetic field



Time Projection Chamber

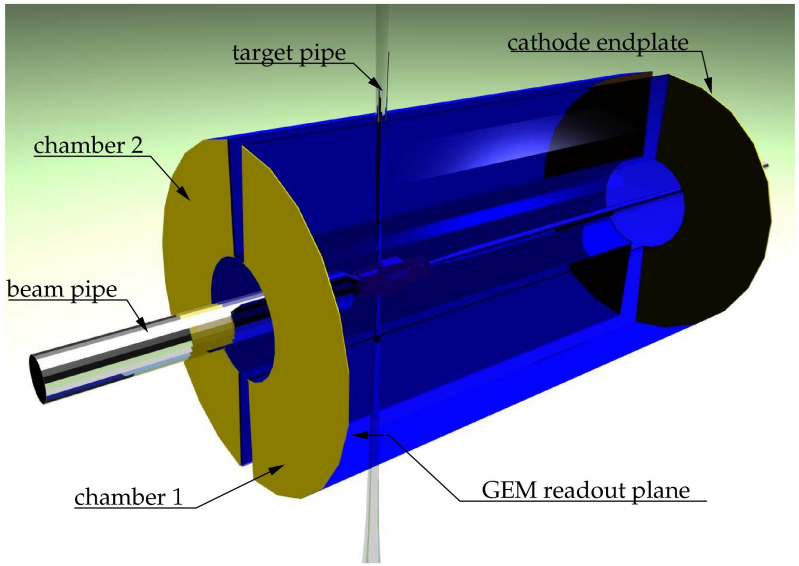
+ Continuous operation

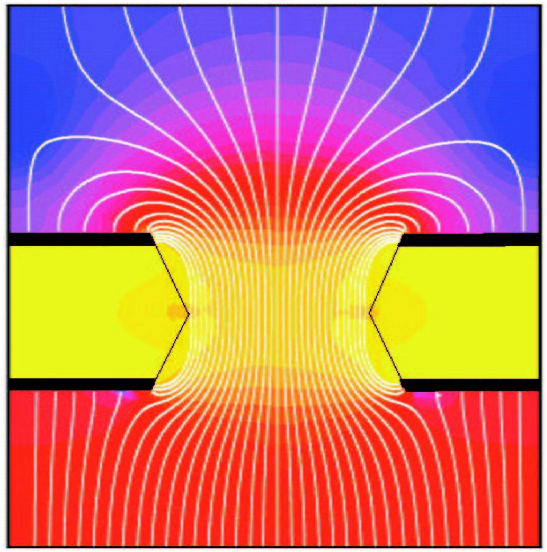
GEM - Time Projection Chamber

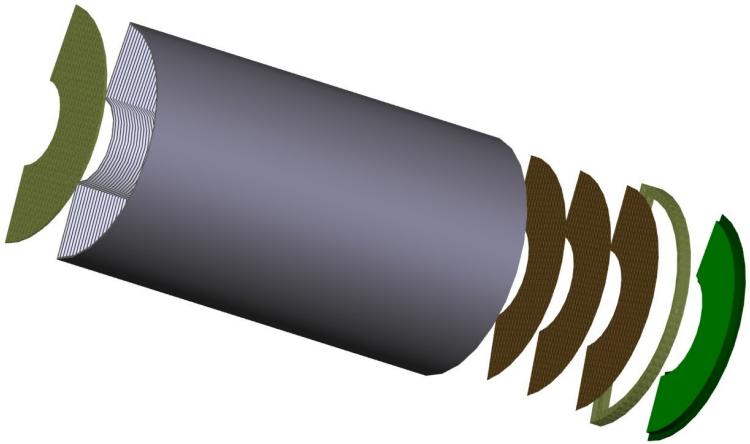
The PANDA TPC

Layout:

- 2 half cylinders
- L=150 cm, R=42 cm
- Multi-GEM stack for amplification and ion backflow suppression
- Gas: Ne/CO_2 (90/10)
- Pad size ~2 x 2 mm^2







The PANDA TPC

Performance:

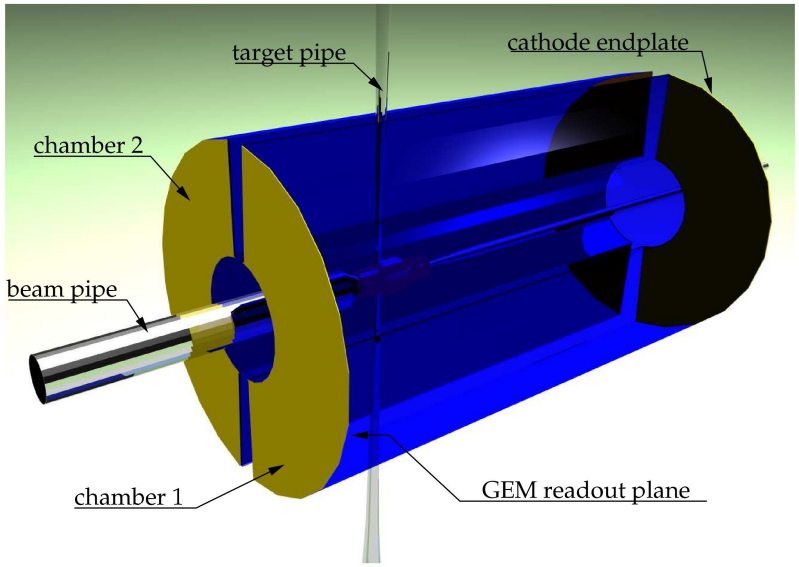
- Resolution
- PID performance
- Vertex reconstruction

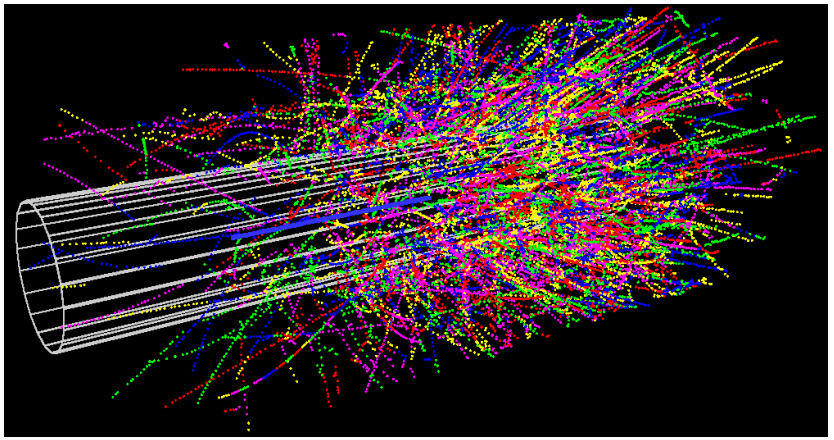
Challenges: continuous operation

- Event deconvolution
- Space charge
  - ➔ Felix Böhmer

Experimental validation:

- Test Chamber
- Beam test at ELSA
- Prototype: FOPI & CB-ELSA

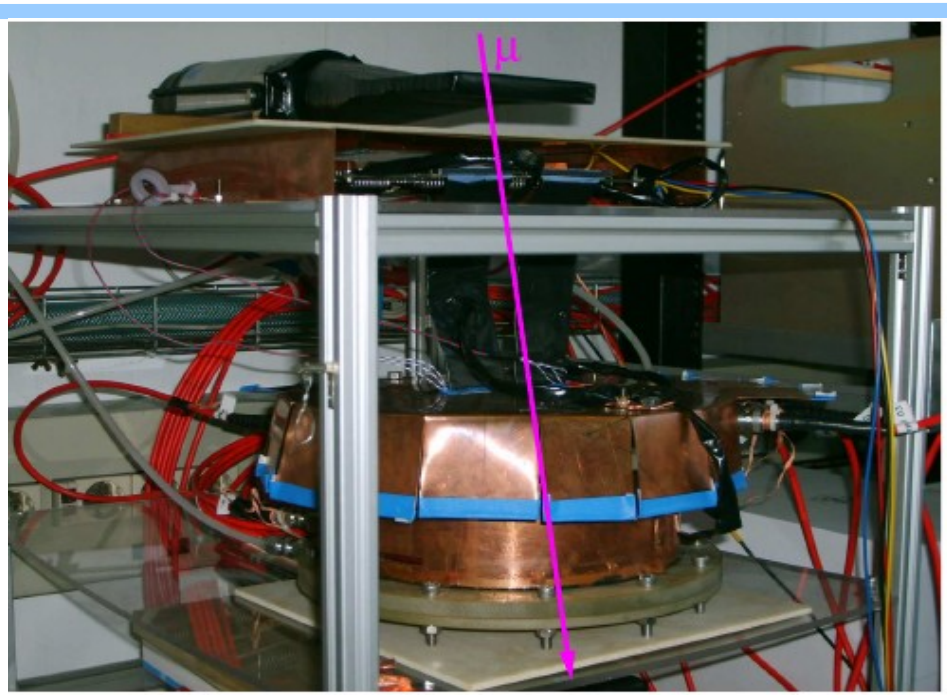




Test with cosmic

Experimental Setup :

- 10 × 10 cm2 active area
- hexagonal pads, r=1.5 mm
- Multi-GEM stack
- Cu strips on Kapton foil
- Honeycomb support
- 7.7 cm drift length
- Noise: 1.88 ADC cts. ~ 1900 e-

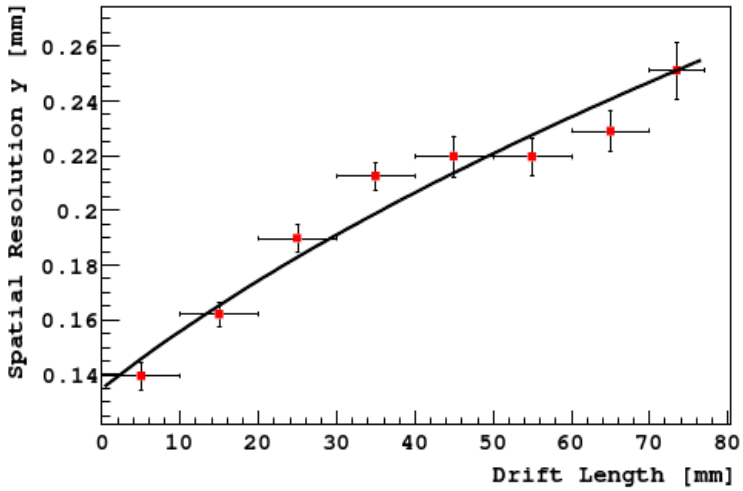


Achievement :

- ~ 13 000 tracks observed
- Different gains and orientations

Resolutions at z=0 :

- y-Resolution: ~ 130 μm
- z-Resolution: ~ 240 μm

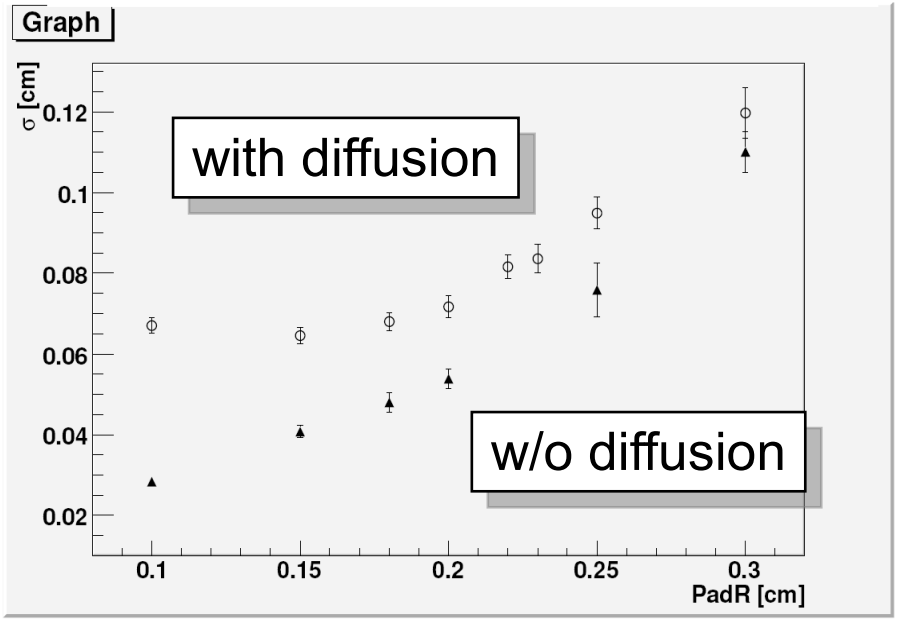


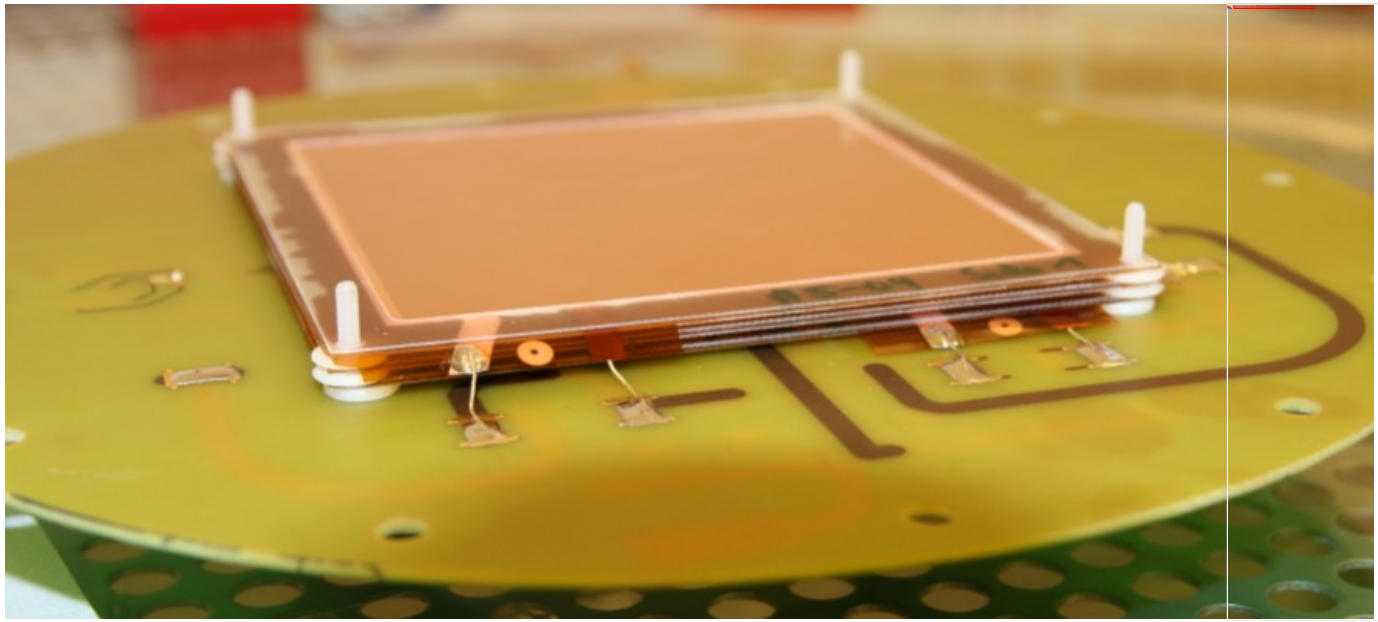
Improvement of the test chamber

- Hexagonal pads of 1.25 mm and 1.5mm
- Thermal sensor
- New readout electronics based on the

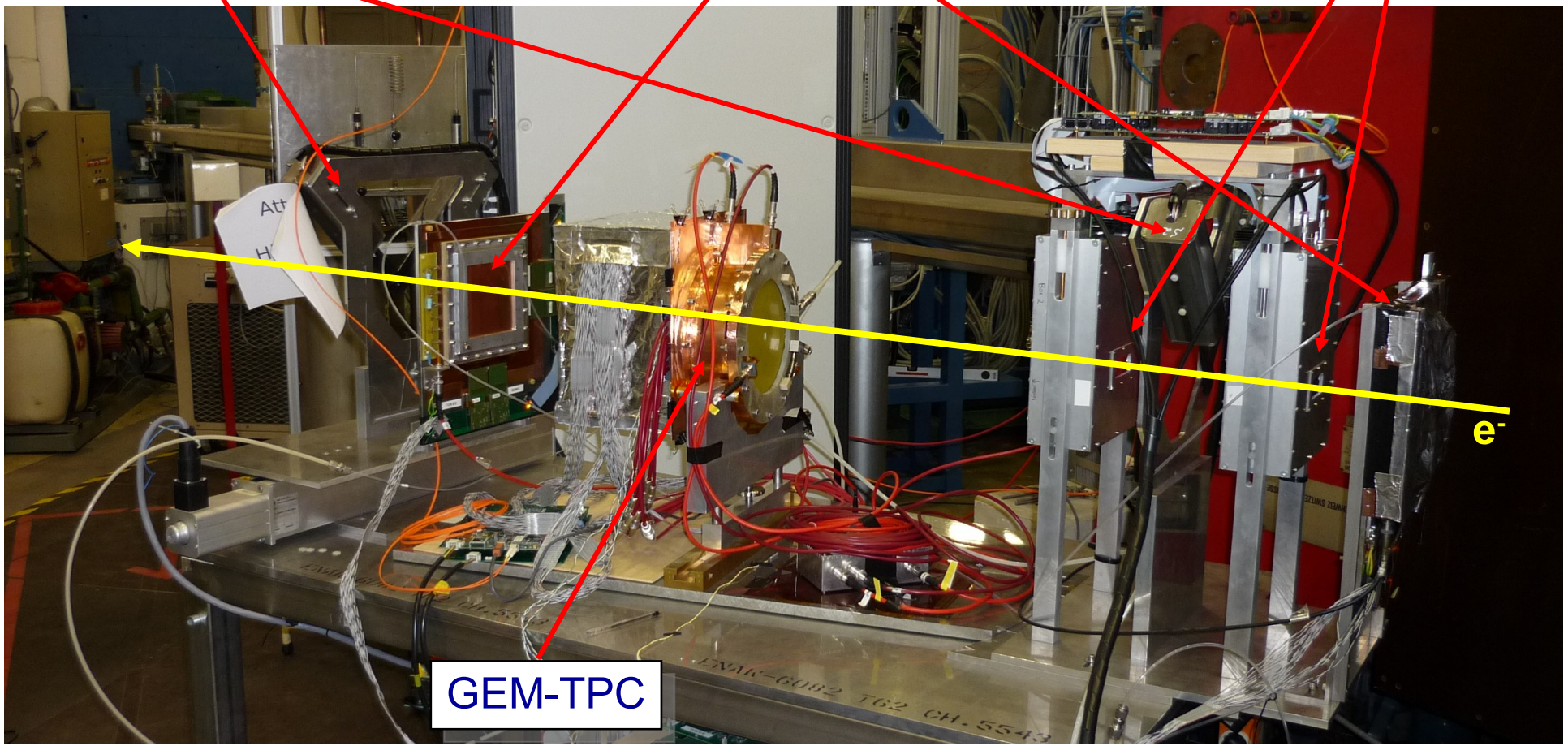
AFTER-T2K chip

Cluster residual width vs pad size





Test beam at ELSA



Beam :

- ELSA accelerator at Bonn
- Electrons at ~500 MeV

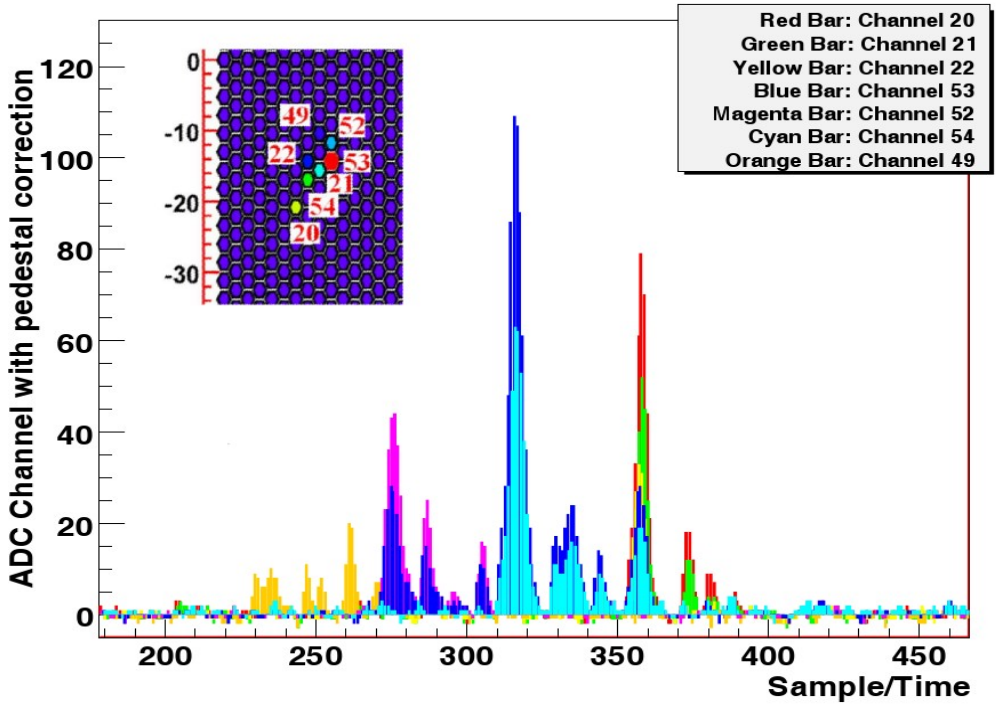
Test bench :

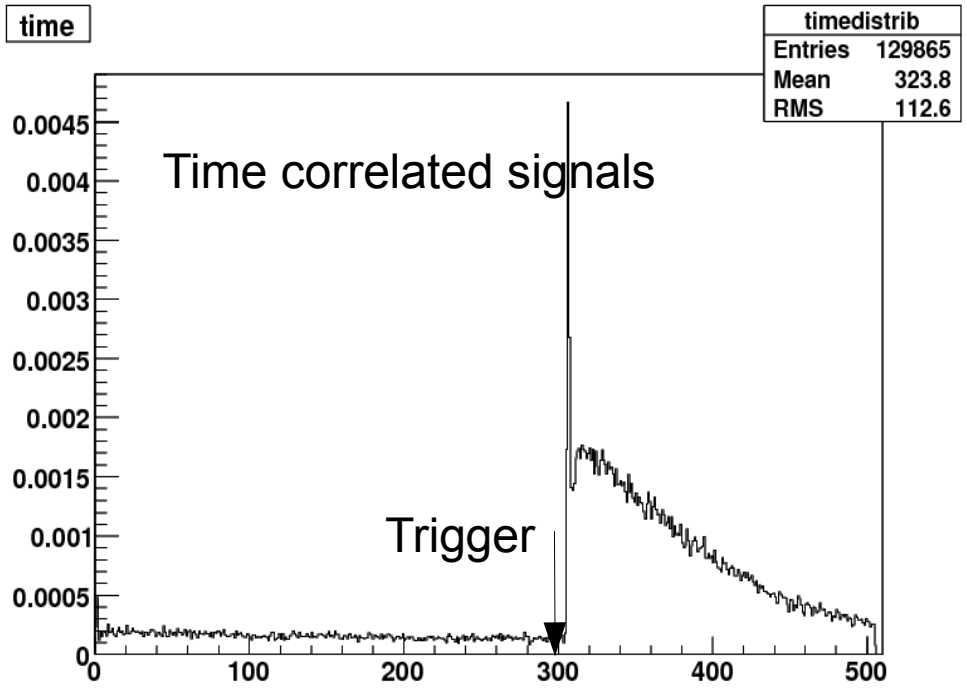
- External tracking
- New electronics
- Resolution with the new pads
- High statistic for systematics studies

Status of the test chamber

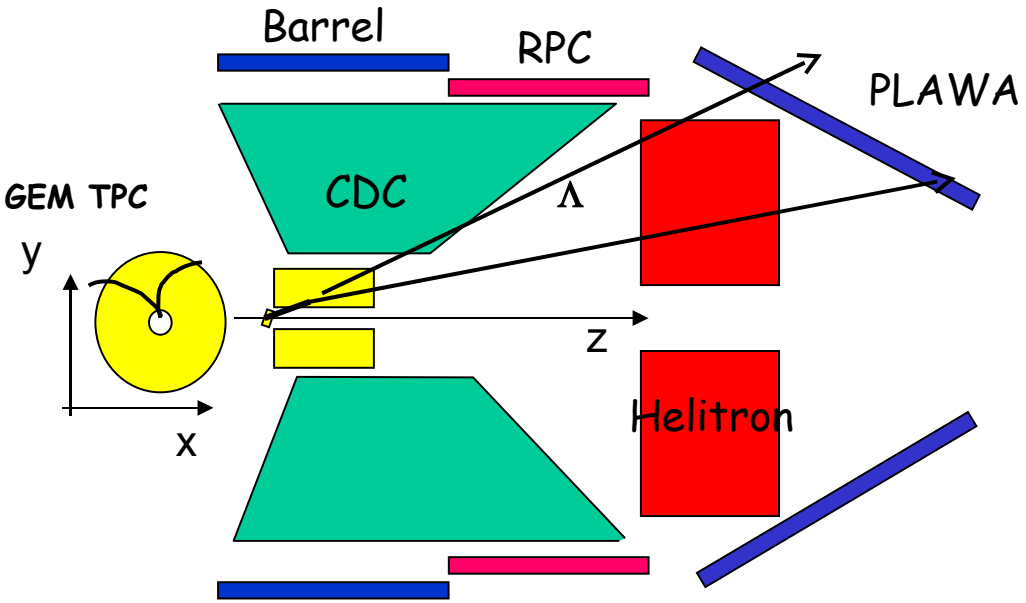
- DAQ commissioned and ready for recording data
- Noise performance of the AFTER-T2K FEE :
  - 800 e- with the detector capacitance
  - 570 e- after offline correction
- First analysis of the latch all mode data of the test chamber

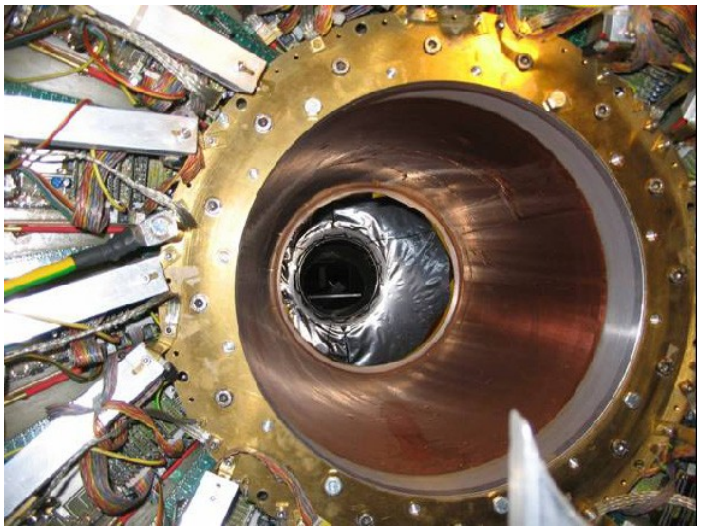
Noise correction

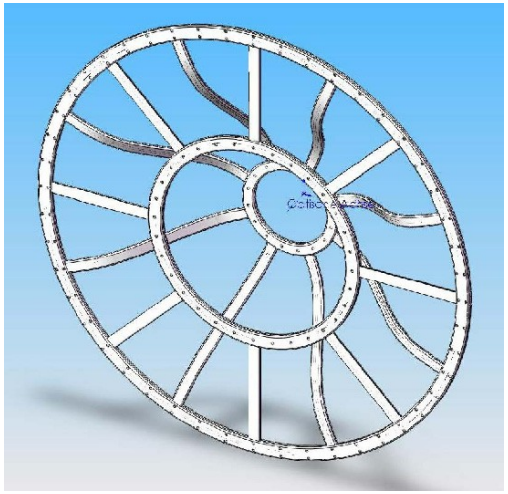


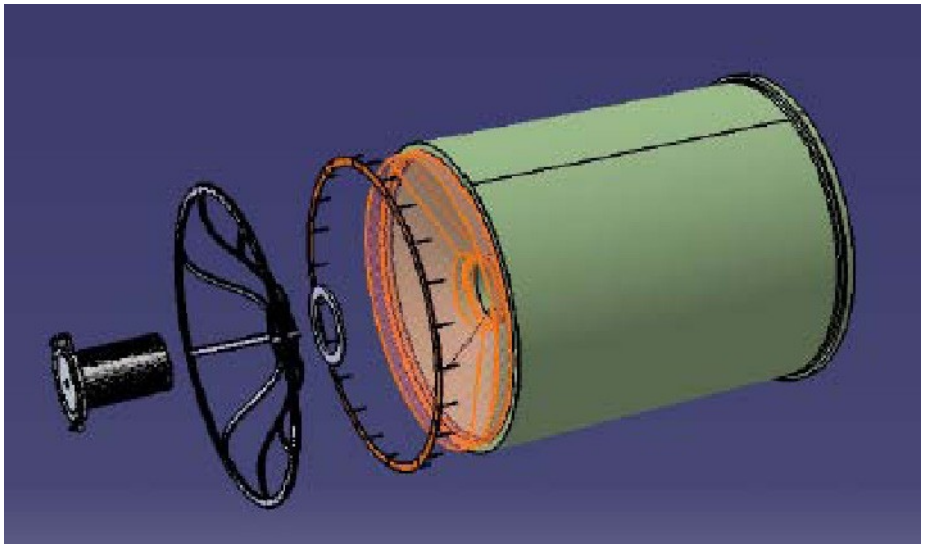


GEM-TPC in FOPI @ GSI



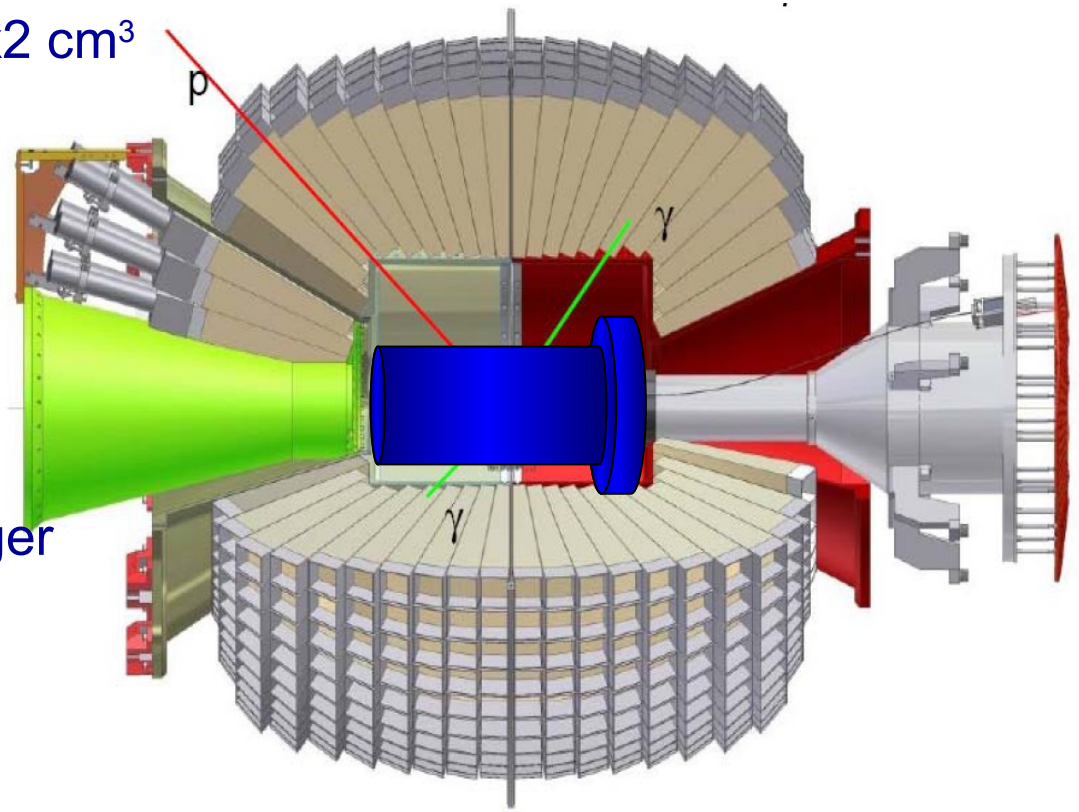






GEM-TPC in CB-ELSA

- Polarized target: butanol 2x2x2 cm^3
- Crystal Barrel Detector
  1230 CsI crystals, 6°x6°
- Inner detector: part. discr.
  cylinder of 513 SciFi
- Forward plug: 12°-30°
  90 CsI crystals with PMT: trigger
- Forward detector (MiniTAPS)
  216 BaF_2, 1°-12°
- CO_2 gas Cherenkov detector
  to suppress e.m. background



no tracking, no timing

TPC

Conclusions

GEM-TPC is a promising option for PANDA Central Tracker

- Spatial resolution ~150 µm
- Momentum resolution ~ 2% (TPC only)
- Vertex resolution ~ 1 mm
- PID dE/dx resolution ~ 7%

Simulations

- Event deconvolution
- Space charge
  - ➔ Felix Böhmer

Experimental validation

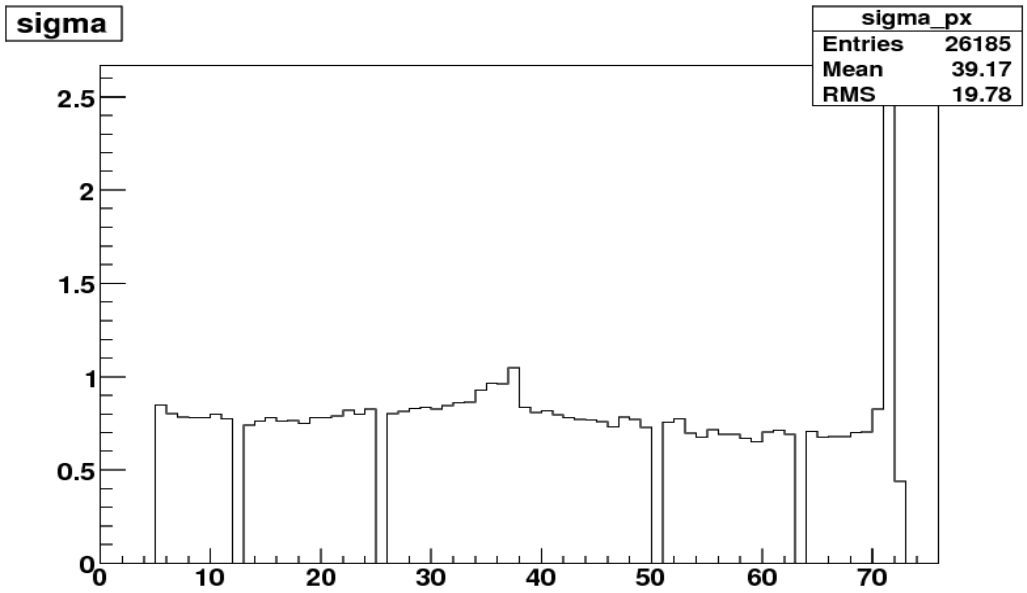
- Cosmic muon characterization
- Test setup at ELSA
- Prototype will be employed at FOPI@GSI & CB@ELSA

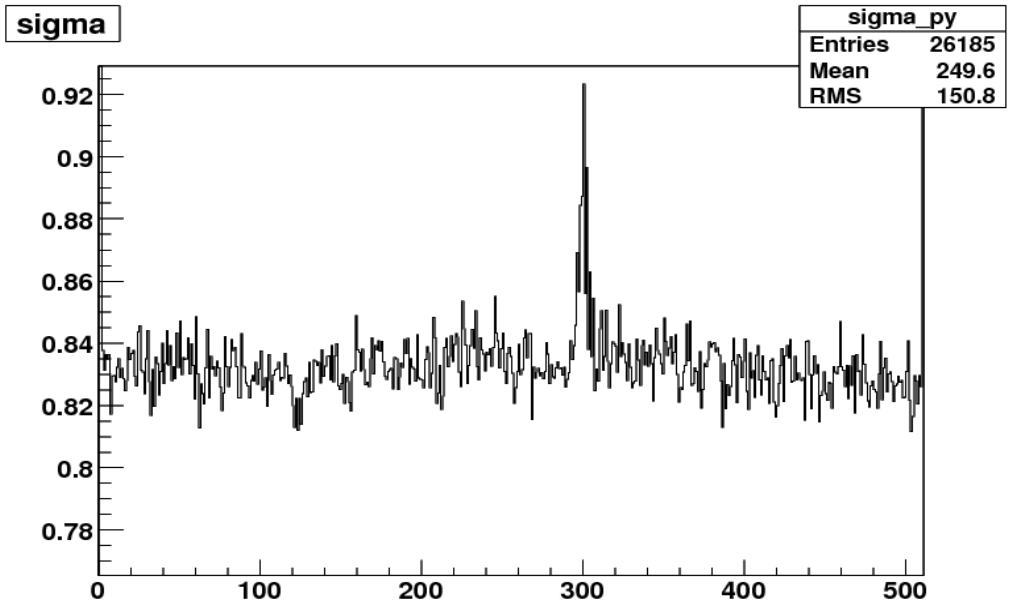
T2K chip - Noise

Sigma with 2D pedestals :

- Unconnected channels at zero (introduced a decrease of 0.11 adc ch of the noise when included)
- PCB edge effect on channel 73

=> 0.82 ADC ch. noise

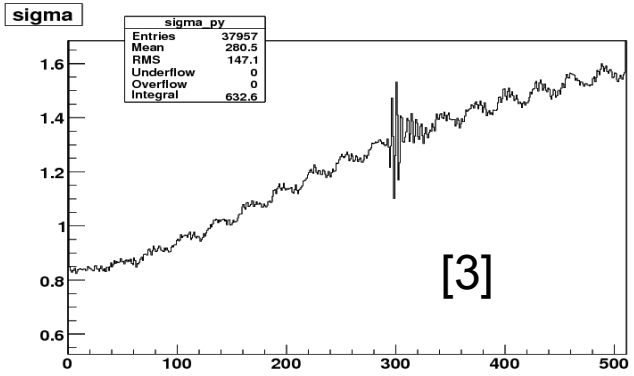


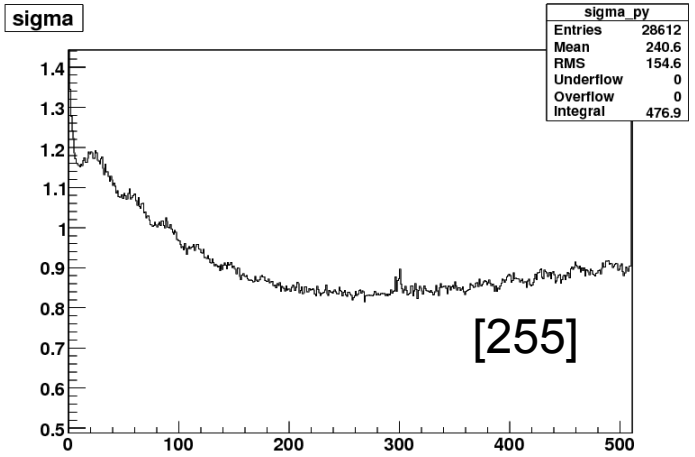


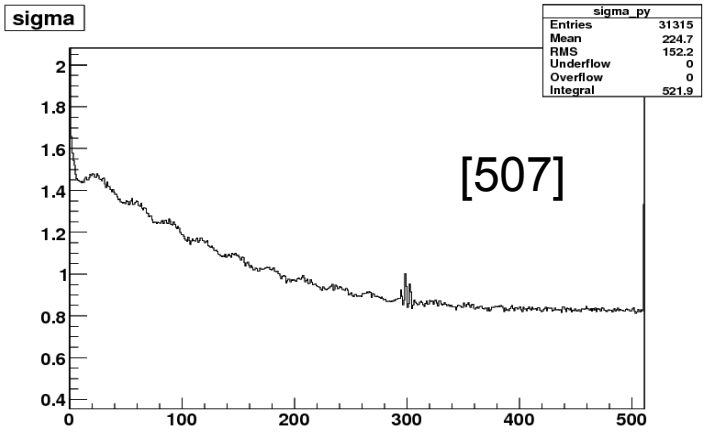
Others correction and noise

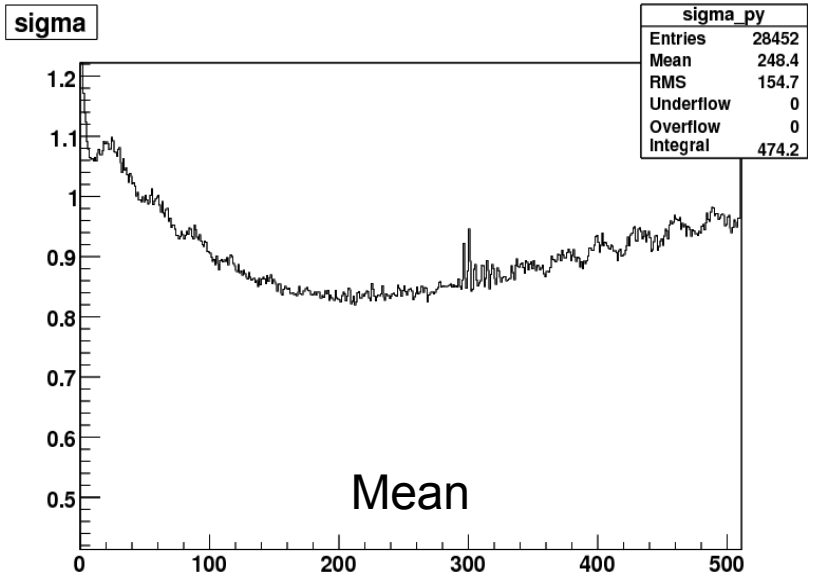
Fixed pedestal for each channel :

- At sample [3] : σ=1.24 ADC ch.
- At sample [255] : σ=0.93 ADC ch.
- At sample [507] : σ=1.02 ADC ch.
- With mean pedestal : σ= 0.93 ADC ch.





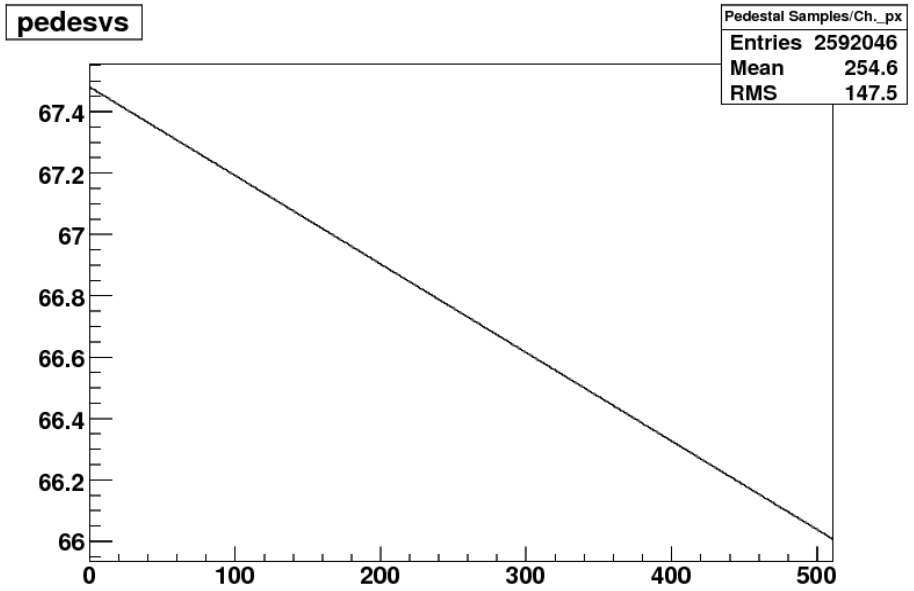


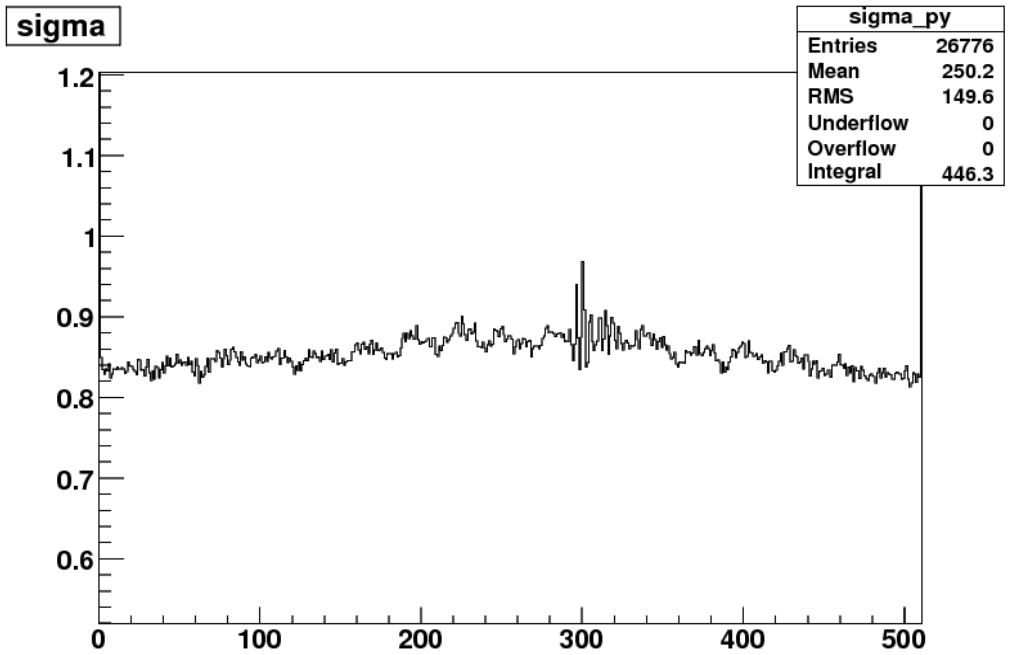


T2K chip - Others correction and noise

Linear correction :

- Using value at [3] and [507]
- σ=0.87 ADC ch. (0.82 for 2D pedestals)
- No 1.8KHz noise suppression





GEM-TPC Test bench setup

Goals :

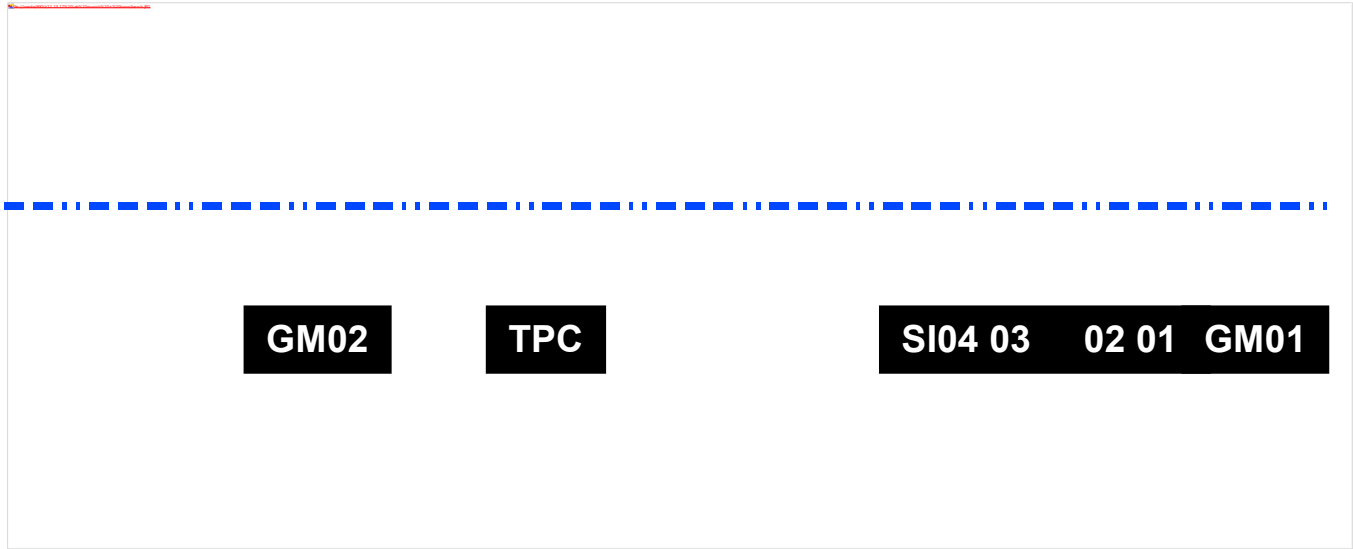
- Test in an electron beam
- External tracking
- New electronics
- Resolution with the new pads

Beam :

- ELSA accelerator at Bonn
- Electrons at ~500 MeV

Tracking telescope :

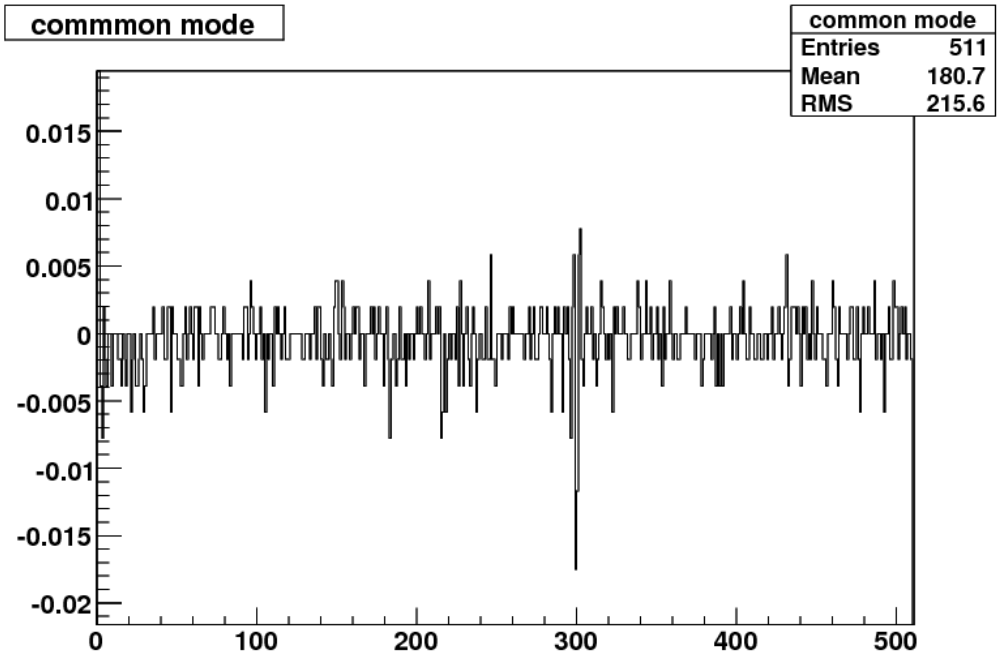
- Trigger
- 4 silicons planes (SI01 to SI04)
- 4 GEM planes (GM01, GM02)
- TPC can be rotated

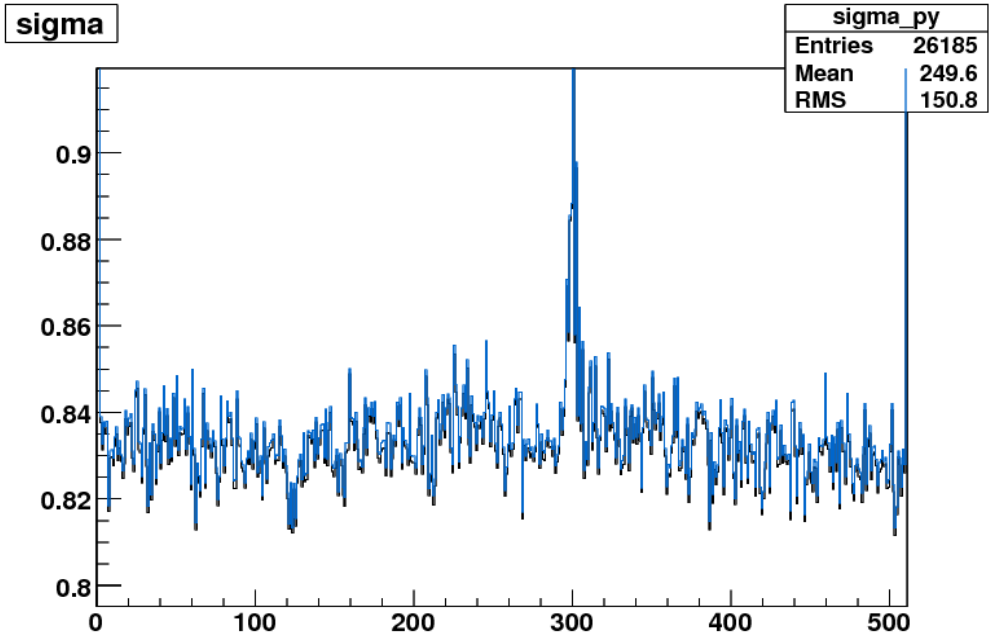


Common Mode correction

Common mode correction :

- Very small correction <2% of 1ADC ch.
- Noise higher with CM correction (integer effect?)





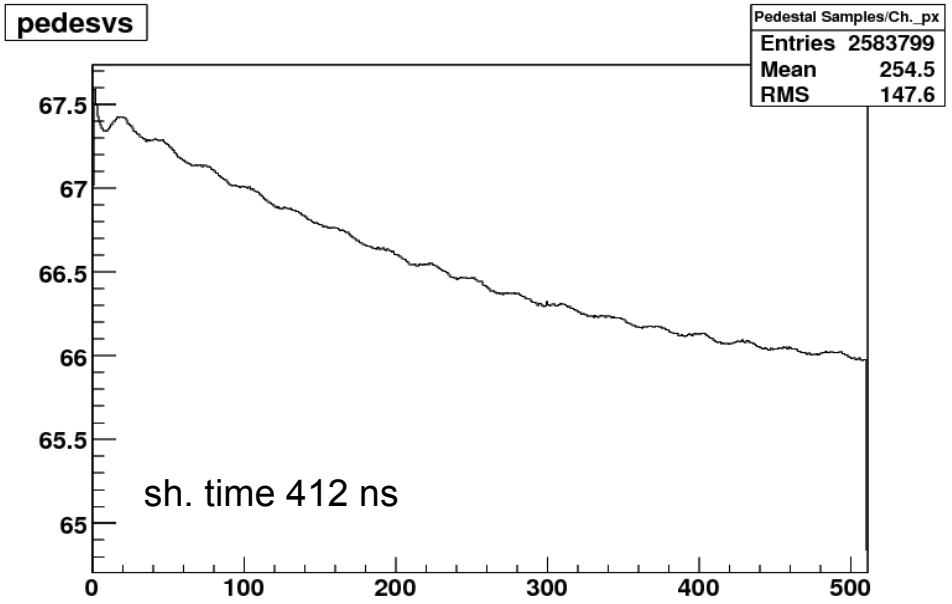
T2K chip-Shaping time influence on noise

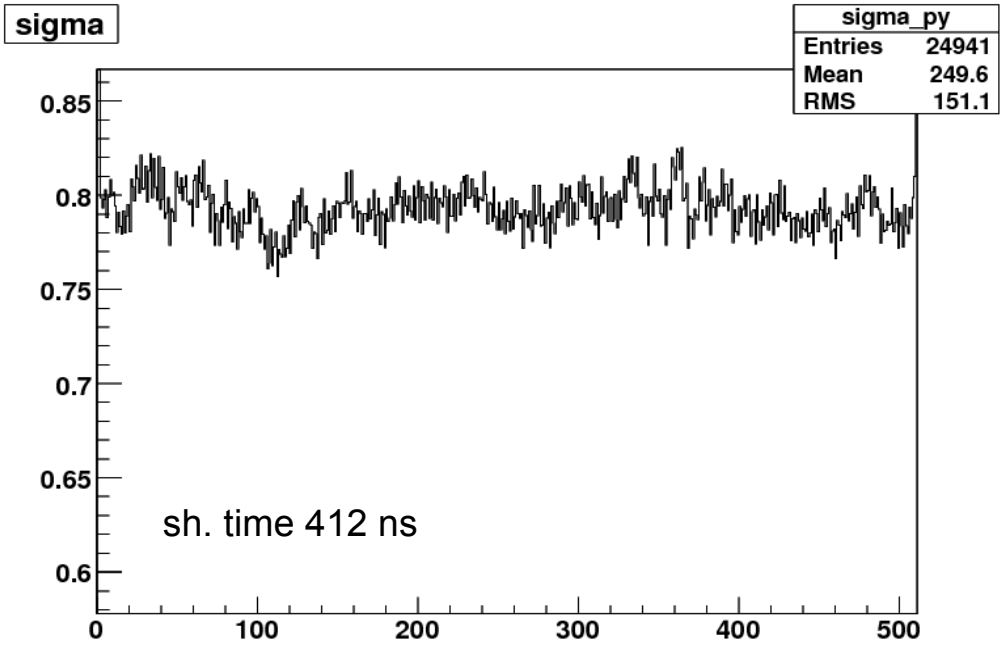
Shaping time :

(with unconnected channel)

- 116 ns : σ = 0.73 ADC ch.
- 200 ns : σ = 0.70 ADC ch.
- 412 ns : σ = 0.70 ADC ch.

- Suppress trigger signal and 1.8KHz noise





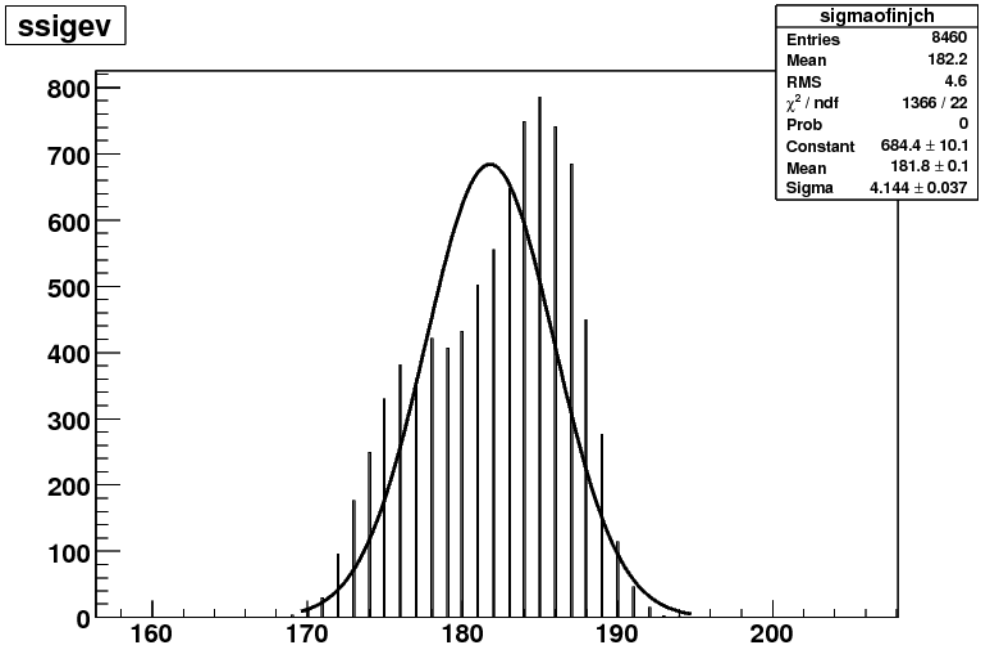
T2K chip – Sensitivity & Linearity

Sensitivity : Distribution of maximum amplitude measured of the test pulse on one channel:

- Between 10 different channels on 1event : σ = ~ 2 ADC ch.
- On one channel, 300 events :σ = ~ 4 ADC ch.

Linearity : Sigma of the max. amplitude distribution for 4 different amplitudes

- 184 mV : σ/max = 2.7% , 2.02mV/ADC ch.
- 360 mV : σ/max = 2.3% , 2.01mV/ADC ch.
- 744 mV : σ/max = 2.4% , 2.10mV/ADC ch.
- 1.360 V : σ/max = 3.6% , 2.34mV/ADC ch.



Conclusion

- First signal seen in the test chamber
- DAQ commissioned
- Noise performance from 0.82 to 0.93 ADC ch. depending on the pedestal correction
- Common mode noise correction <2% adc ch.; increase the noise
- Division of peaking time smooth the noise, reject ext. signals
- Variation of the sensitivity and linearity ok

About measurement

Conditions :

- Measurement in latch all mode
- No particular shielding
- Injection pulse using the test entry

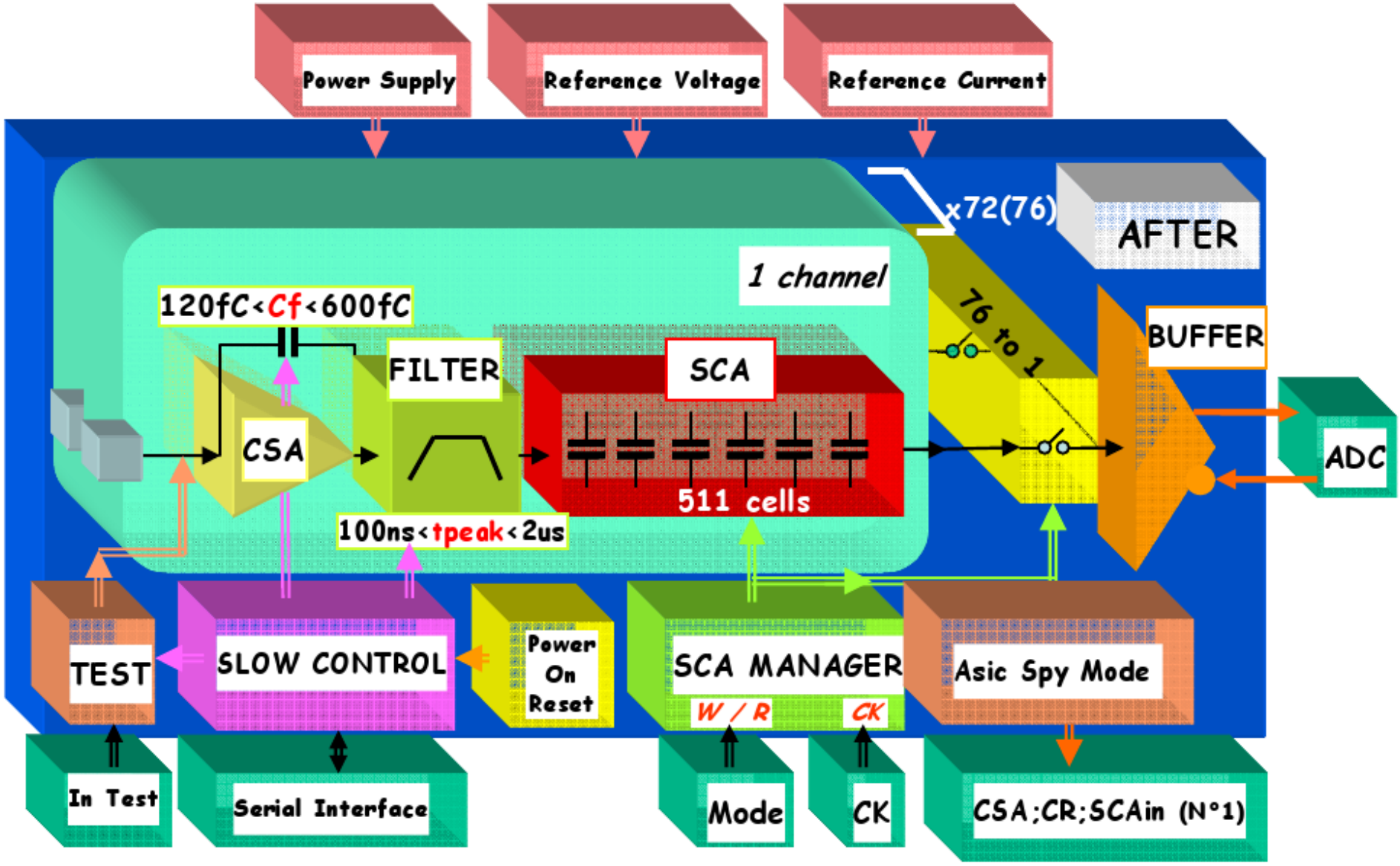
Settings :

- 20MHz sampling frequency
- Shaping time: 116 ns
- Charge range: 120fC

Injection pulse :

- 970ns pulse
- 360mV on ~10 ch.
- Trigger-Pulse delay: 1.27us

AFTER/T2K chip block diagram



SCA : Switched Capacitor Array

High Energy Storage Ring

Antiproton storage ring

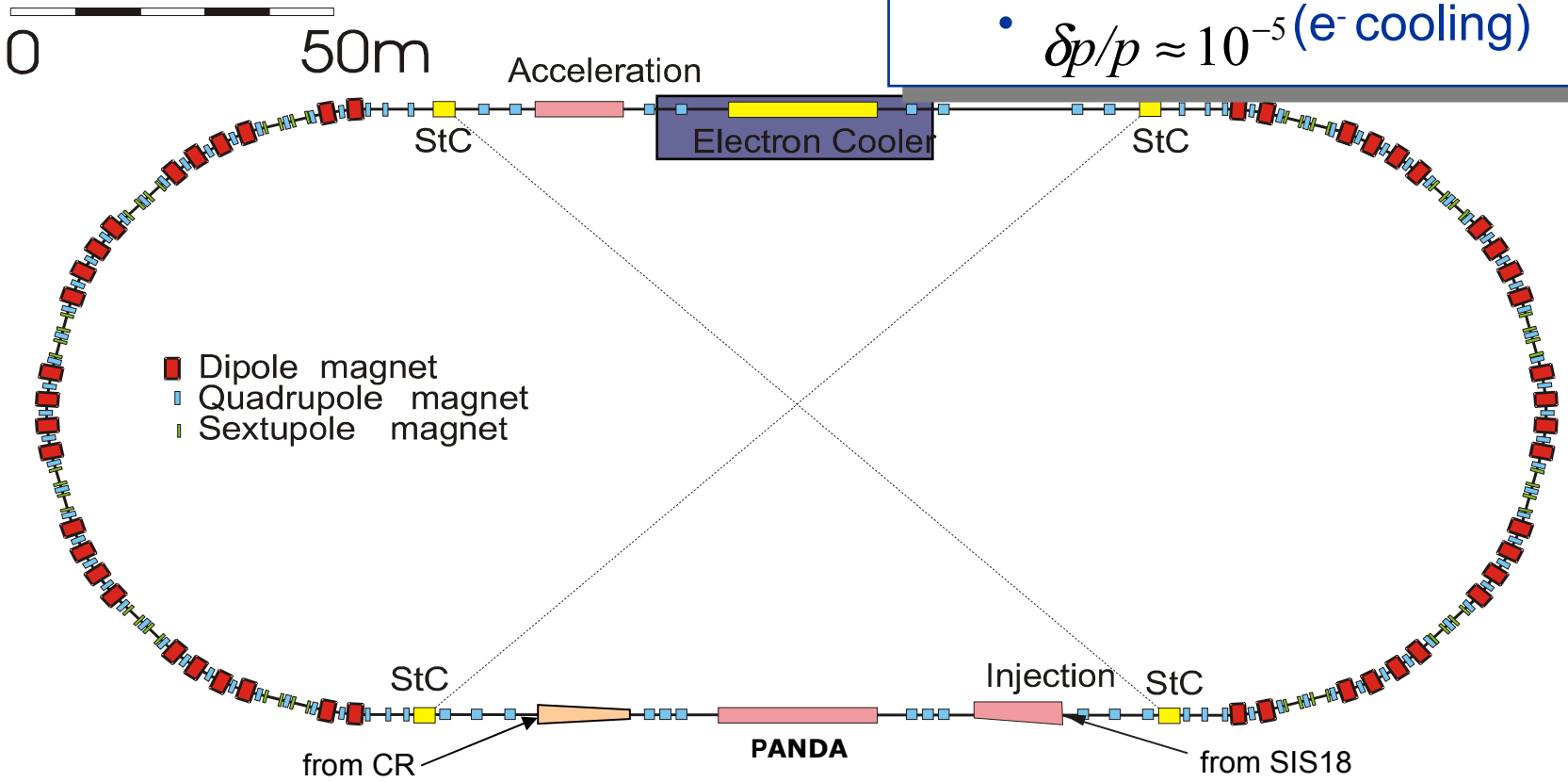
- $\bar{p}$ injection at 3.7 GeV/c
- Synchrotron: 1.5 – 15 GeV/c
- Internal targets: H, nuclei

High intensity mode

- $L = 2 \cdot 10^{32}\,\mathrm{cm^{-2}s^{-1}}$
- $\delta p/p \approx 10^{-4}$ (stoch. cooling)

High resolution mode

- $L = 10^{31}\,\mathrm{cm^{-2}s^{-1}}$
- $\delta p/p \approx 10^{-5}$ (e^- cooling)



Variation of the linearity

Mean maximum amplitude for 4 different pulse amplitudes

on ch. 30 to 45

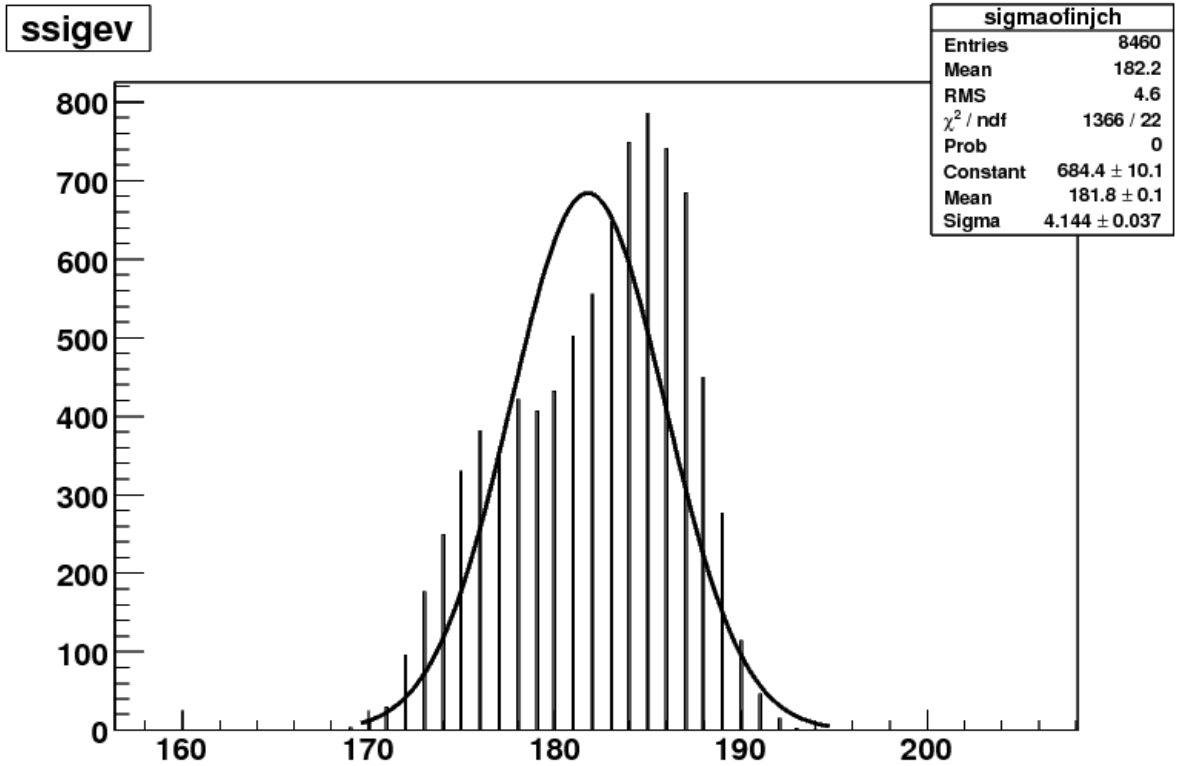
- 184 mV : m = 90.9 ADC ch., σ = 2.4 ADC ch. => 2.02mV/ADC ch.
- 360 mV : m = 179 ADC ch., σ = 4.1 ADC ch. => 2.01mV/ADC ch.
- 744 mV : m = 355 ADC ch., σ = 8.5 ADC ch. => 2.10mV/ADC ch.
- 1.360 V : m = 582 ADC ch., σ = 21 ADC ch. => 2.34mV/ADC ch.

- No amplitude precise measurement, rising time not controlled
- Sigma increase with amplitude

T2K chip - Variation of the sensitivity

Distribution of maximum amplitude measured of the test pulse on one channel:

- For one event :
  - ch.60 to 70 : σ = 1.77 ADC ch.
  - ch.6 to 15 : σ = 2.15 ADC ch.
  - ch.30 to 45 : σ = 1.97 ADC ch.
- For one channel, 300 events :
  - 65 : σ = 3.61 ADC ch.
  - 66 : σ = 4.10 ADC ch.
  - 67 : σ = 3.66 ADC ch.
- For all events, all channels :
  - ch.60 to 70 : σ = 4.25 ADC ch.
  - ch.6 to 15 : σ = 6.89 ADC ch.
  - ch.30 to 45 : σ = 4.144 ADC ch.



T2K chip - At higher noise

Higher noise :

- Noise level stays the same with 2Dpedestal correction
- No increase of the pedestal slope