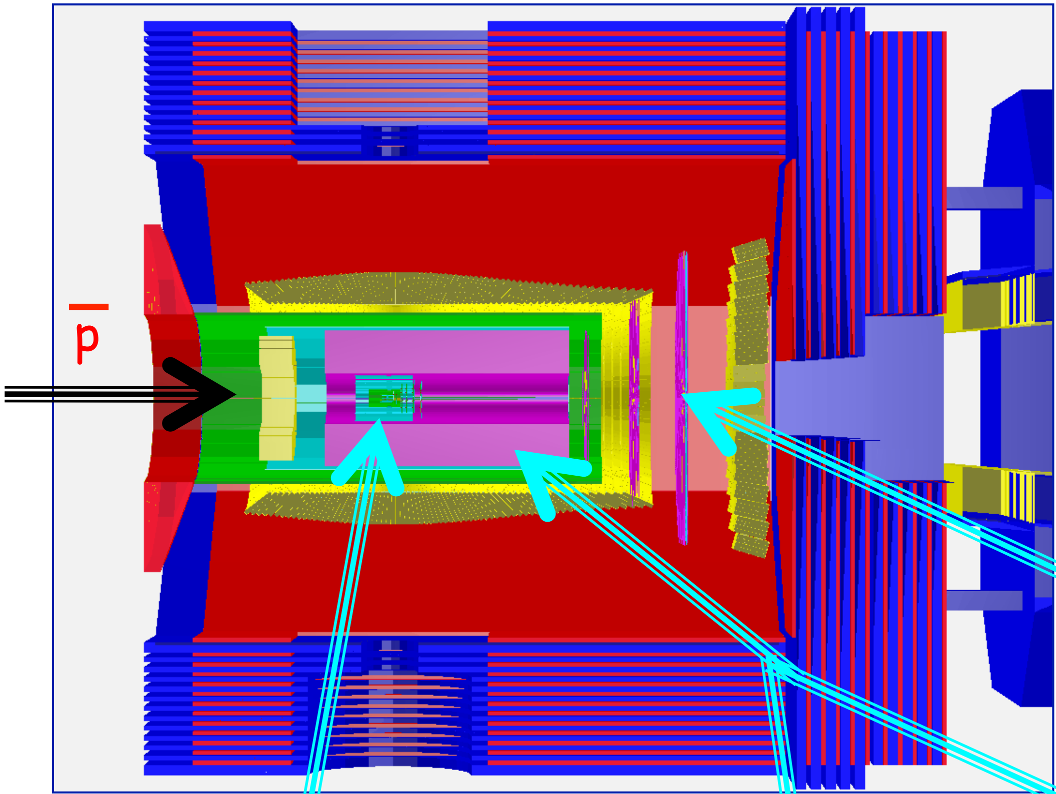
PANDAroot

Malgorzata Gumberidze

Outline

- ✓ Central tracking TDR
- ✓Performance of the STT as the tracking system in PANDAroot
- ✓ pbar p -> e+e- selection in PANDAroot
- ✓ gamma/pi0 separation

Central tracking TDR




FAIR/Pbar/Technical Design Report - TRK

Technical Design Report for:

P̄ANDA
Tracking System

(AntiProton Annihilations at Darmstadt)

Strong Interaction Studies with Antiprotons

P̄ANDA Collaboration

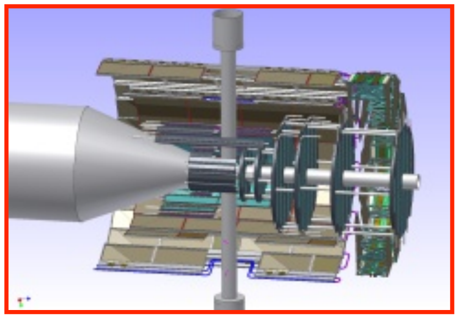
June 9, 2009

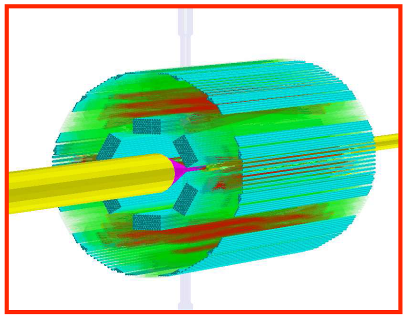
MVD: Bonn, Torino, Julich

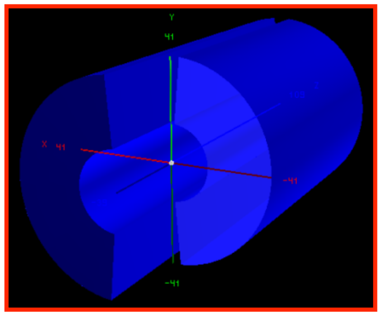
STT: Pavia, Julich

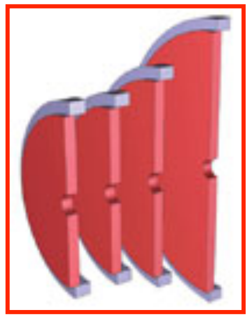
TPC: Munich

GEM: GSI



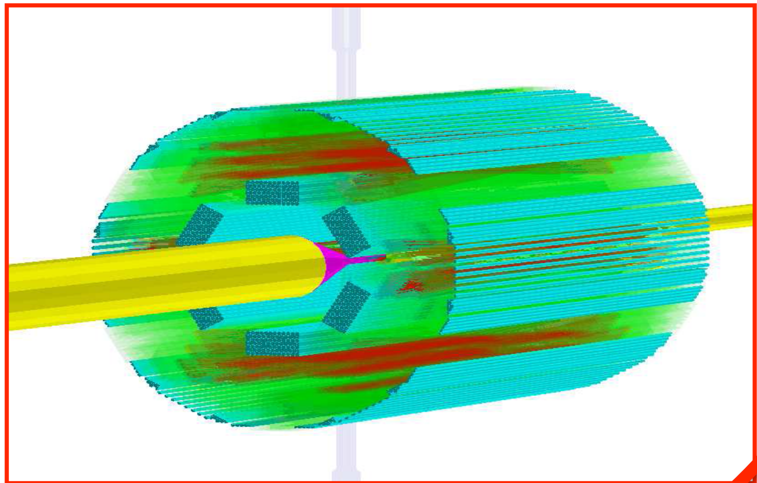




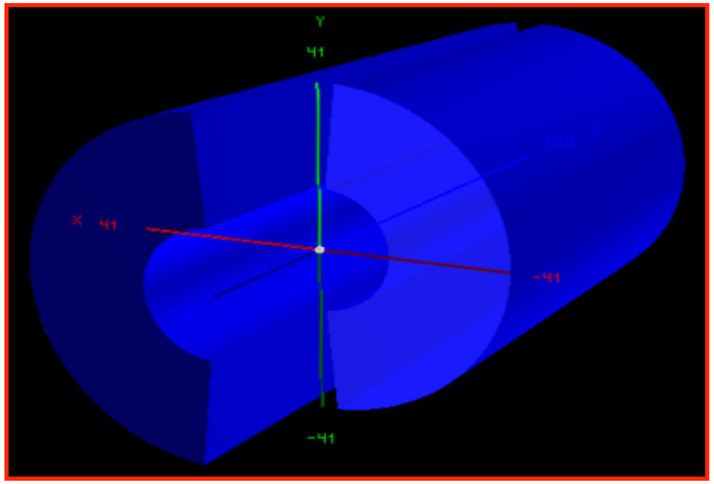


Central tracking TDR

STT:
Pavia, Julich



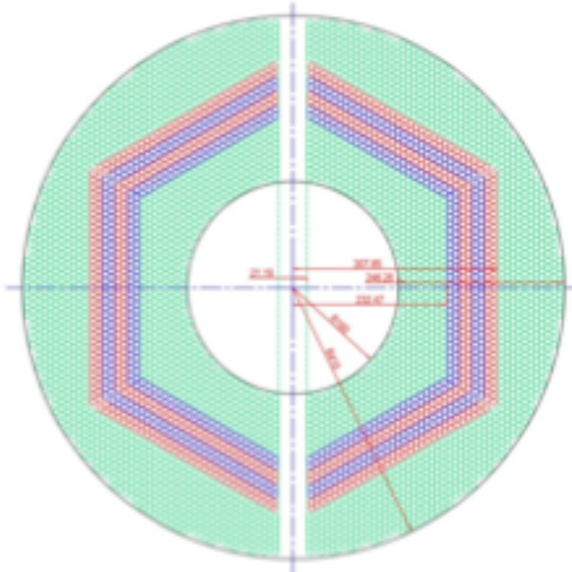
TPC:
Munich

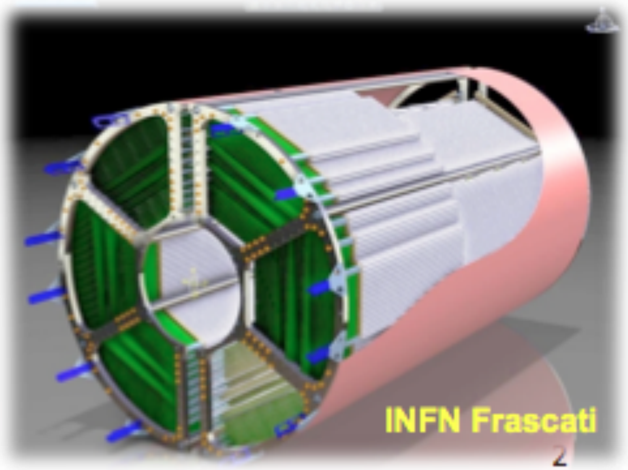


STT Layout

- 4636 Straw tubes in 2 semi-barrels around beam/target cross-pipe
- 23-27 planar layers in 6 hexagonal sectors
  - 15-19 axial layers (green) in beam direction
  - 4 stereo double-layers for 3D reconstr., with ±2.89° skew angle (blue / red)
- Time readout (isochrone radius)
- Amplitude readout (energy loss)
- $\sigma_{r\Phi}$ ~ 150(100) μm , σ_z~ 3.0(2.0) mm (single hit)
- $\sigma_E/E < 8\%$ for π/K identification
- σ_p/p ~ 1 - 2% at B=2 Tesla
- X/X_0 ~ 1.2% ($^2/_3$ tube wall + $^1/_3$ gas)

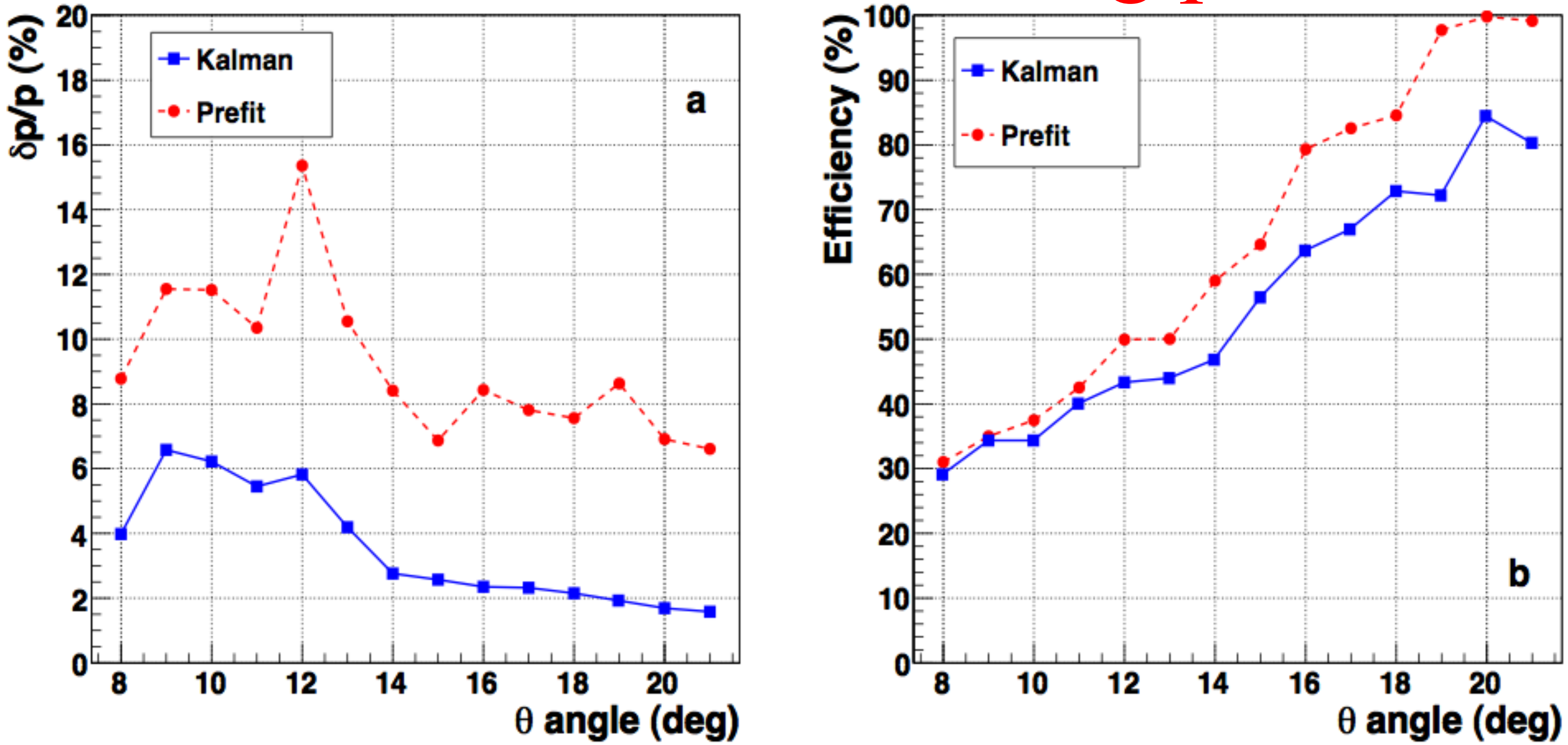
- R_{in}/R_{out}: 150 / 418 mm
- Length: 1500mm + 150mm (RO upstream)





Momentum resolution and track reconstruction efficiency

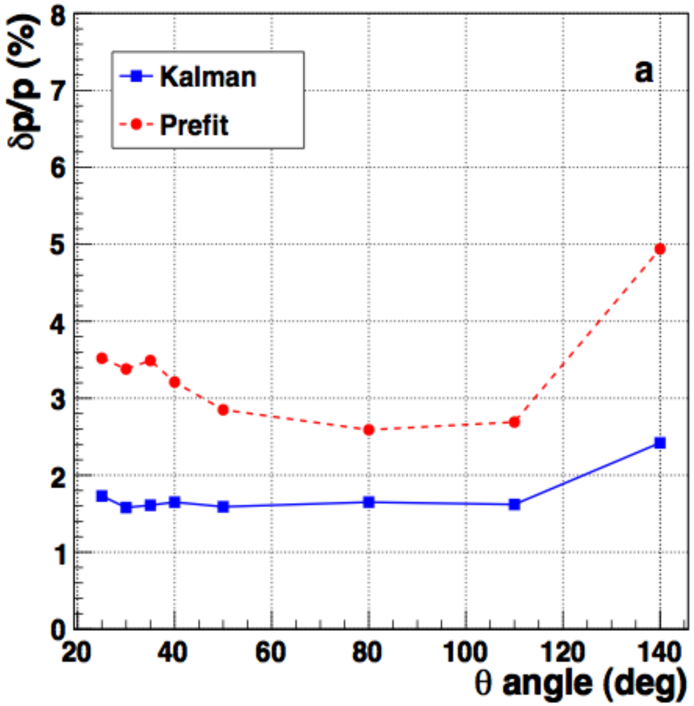
testing particle: 1 GeV/c μ

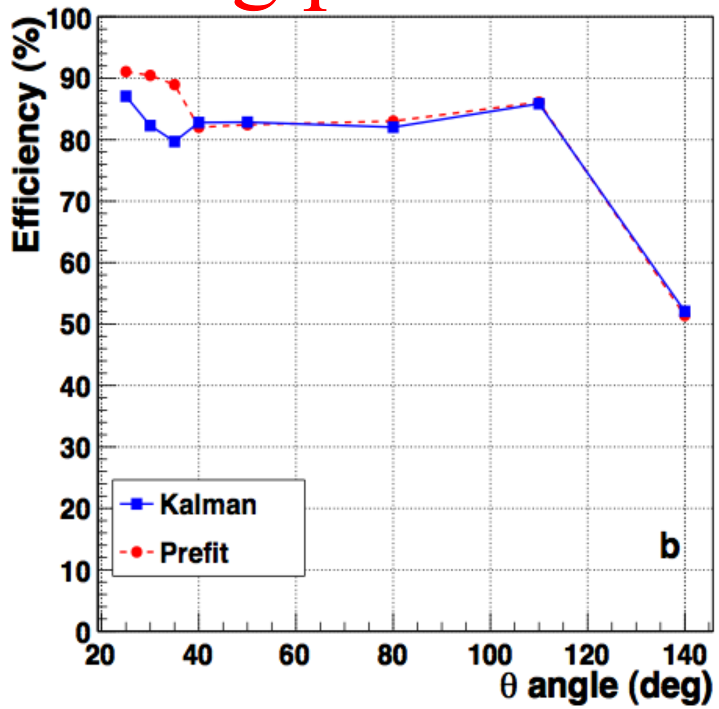


Improvement of the track momentum resolution using Kalman

Momentum resolution and track reconstruction efficiency

testing particle: 1 GeV/c μ





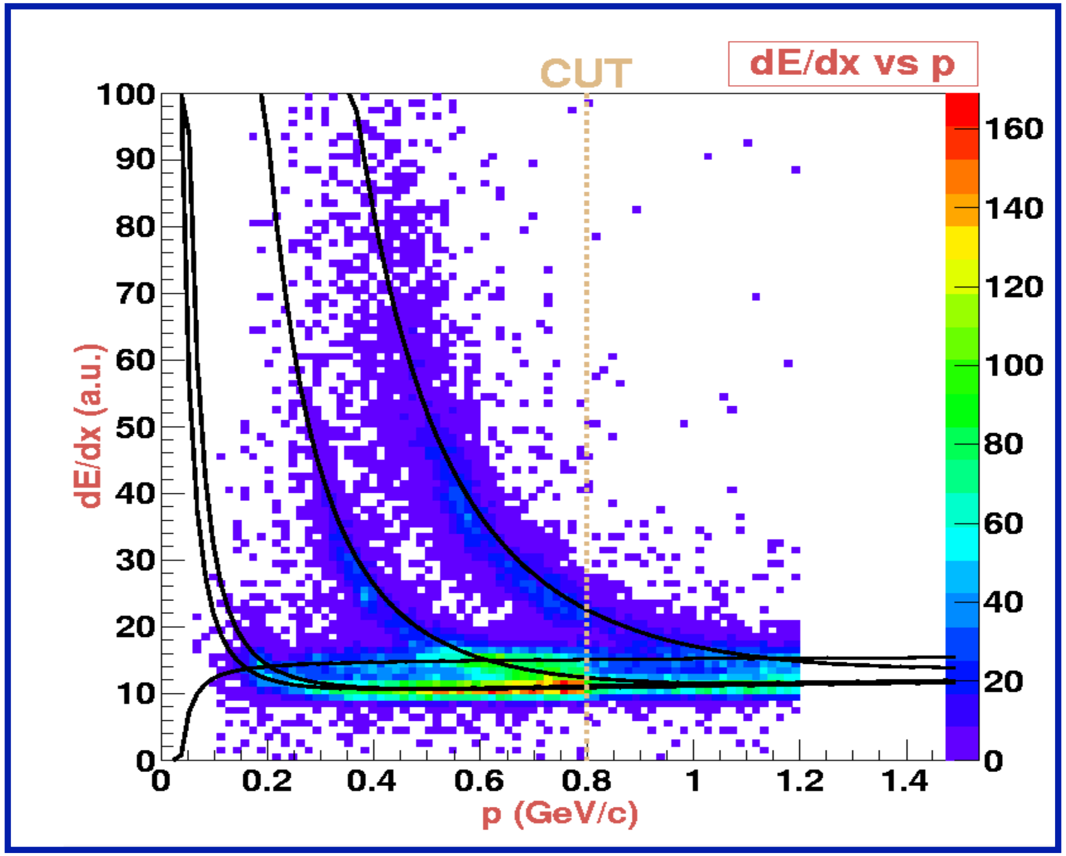
Improvement of the track momentum resolution using Kalman

PID in STT

- Simulation: 1000 particles of each **type** @ momentum in [0.05 – 0.8] GeV/c

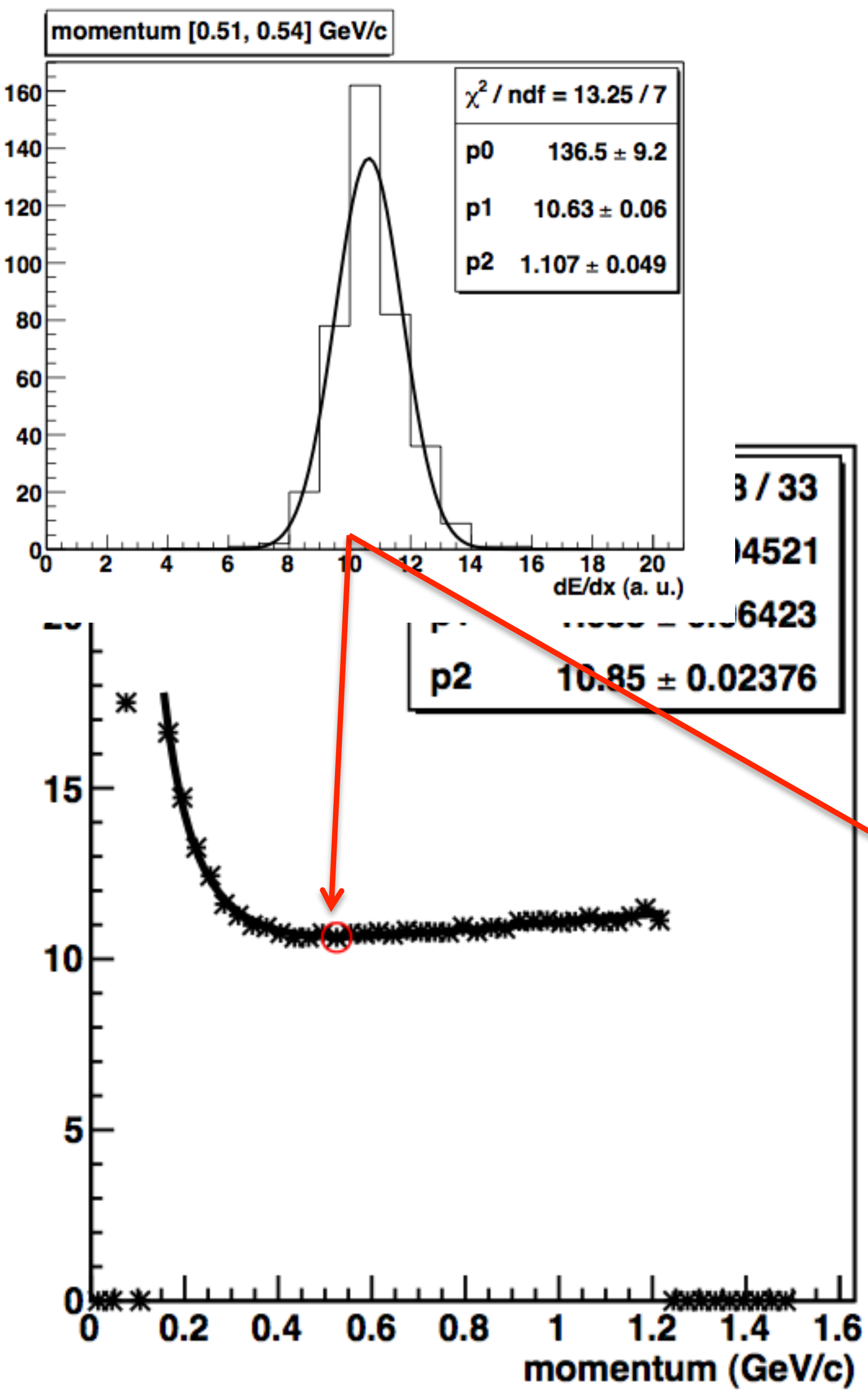
- For each type it has been computed the **frequency** of association with each mass hypothesis (in table)

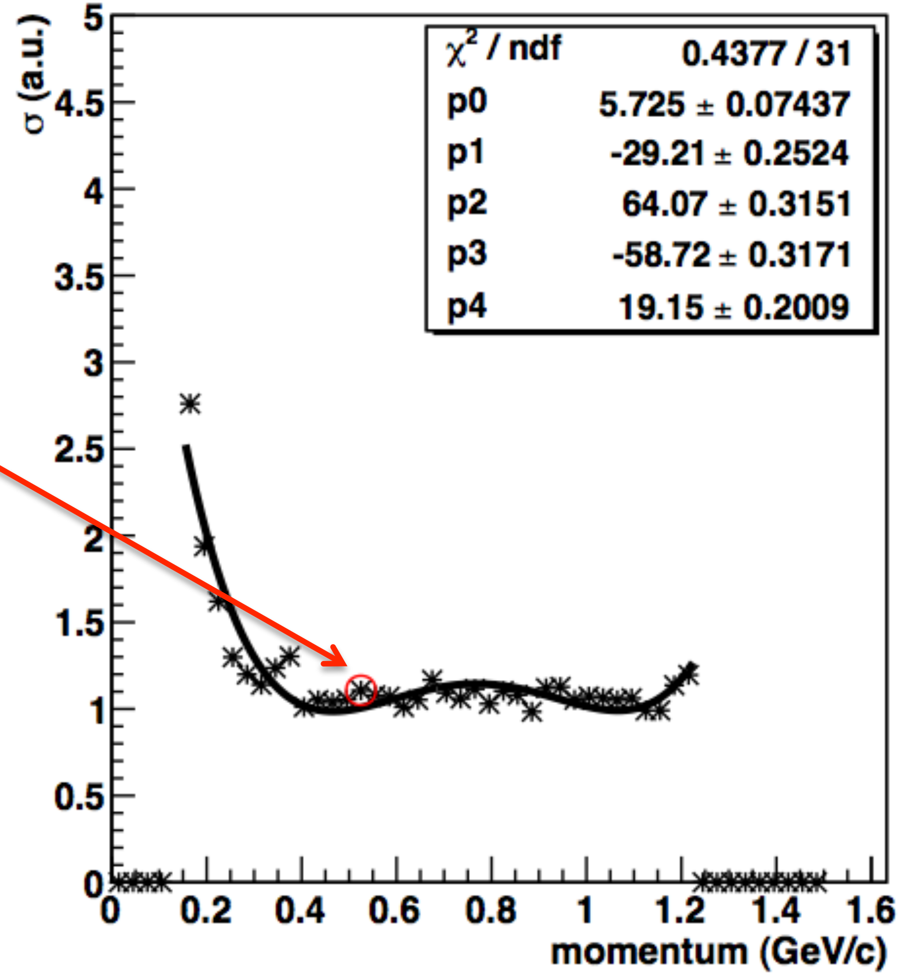
- For a *perfect* pid association only **diagonal** elements of the table should be filled.



Gaus fit performance

trancated mean of 60% has been used in order to cut off higher dE/dx tails





Separation power

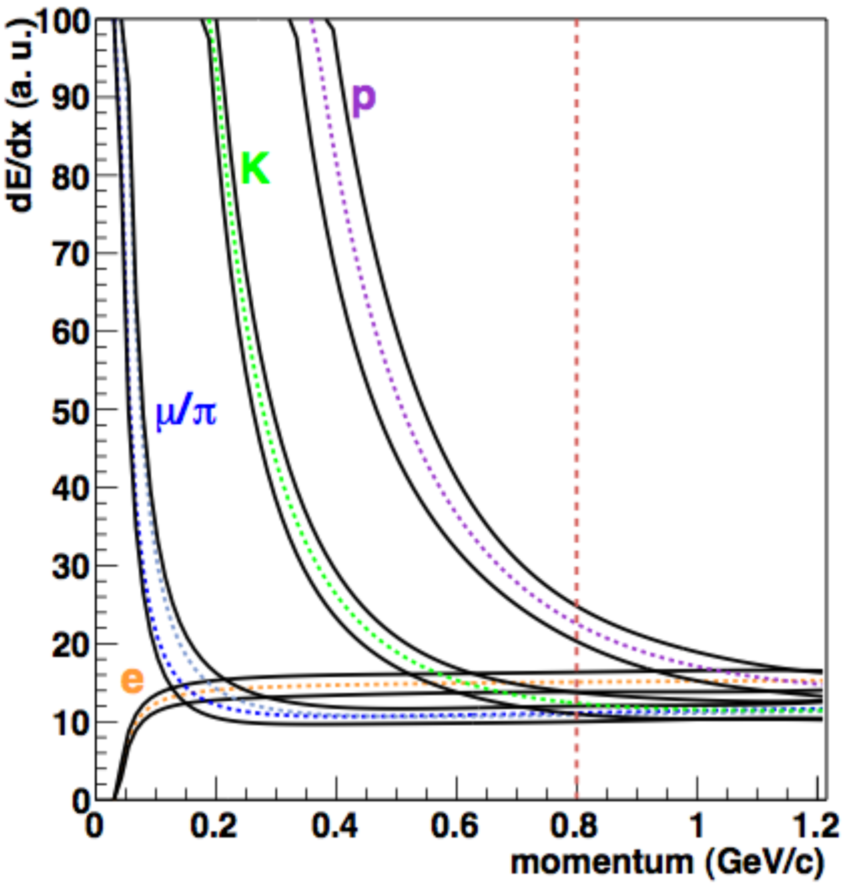


Figure 3.90: The bands identifying the regions of $\mathrm{d}E/\mathrm{d}x$ vs. momentum found for the different particles

Suppression power with STT

		frequencies of p.i.d. (%)				
		e	μ	π	K	p
true part.	e	84	3	3	9	1
	μ	2	58	35	4	1
	π	3	51	42	4	0
	K	30	7	4	56	3
	p	9	0.4	0	8	91

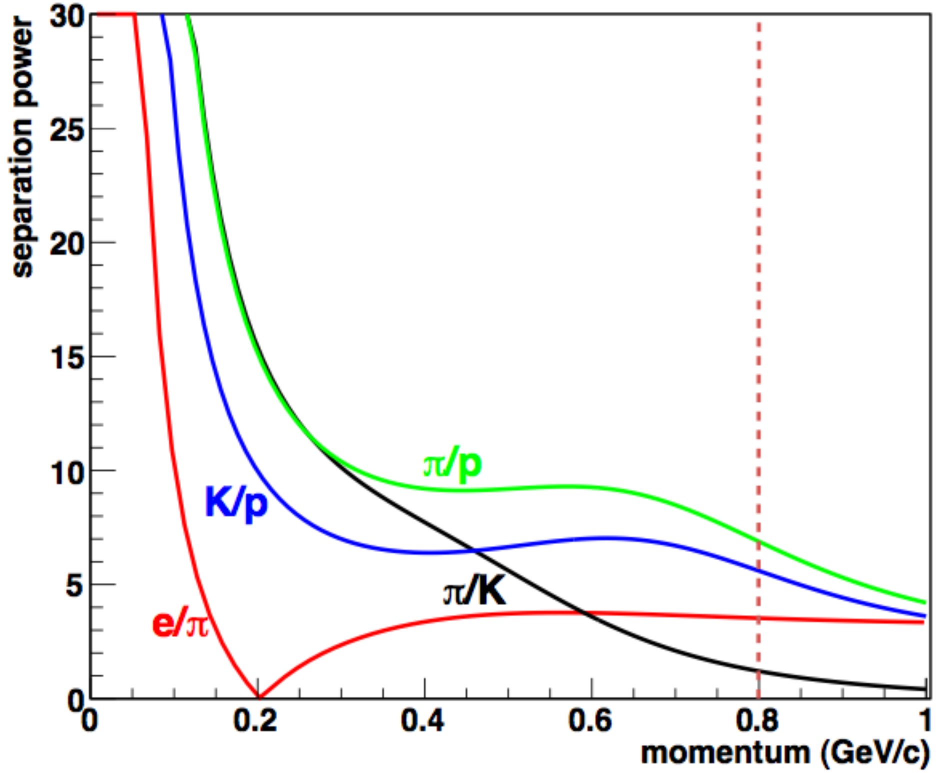
Only up to 0.8 GeV/c PID from STT should be used

The separation power $S = 2\Delta E$ between two particles is defined as the distance between the centres of the two bands $\langle E_1 \rangle$ and $\langle E_2 \rangle$, measured in terms of the standard deviations σ_1 and σ_2 [58]:

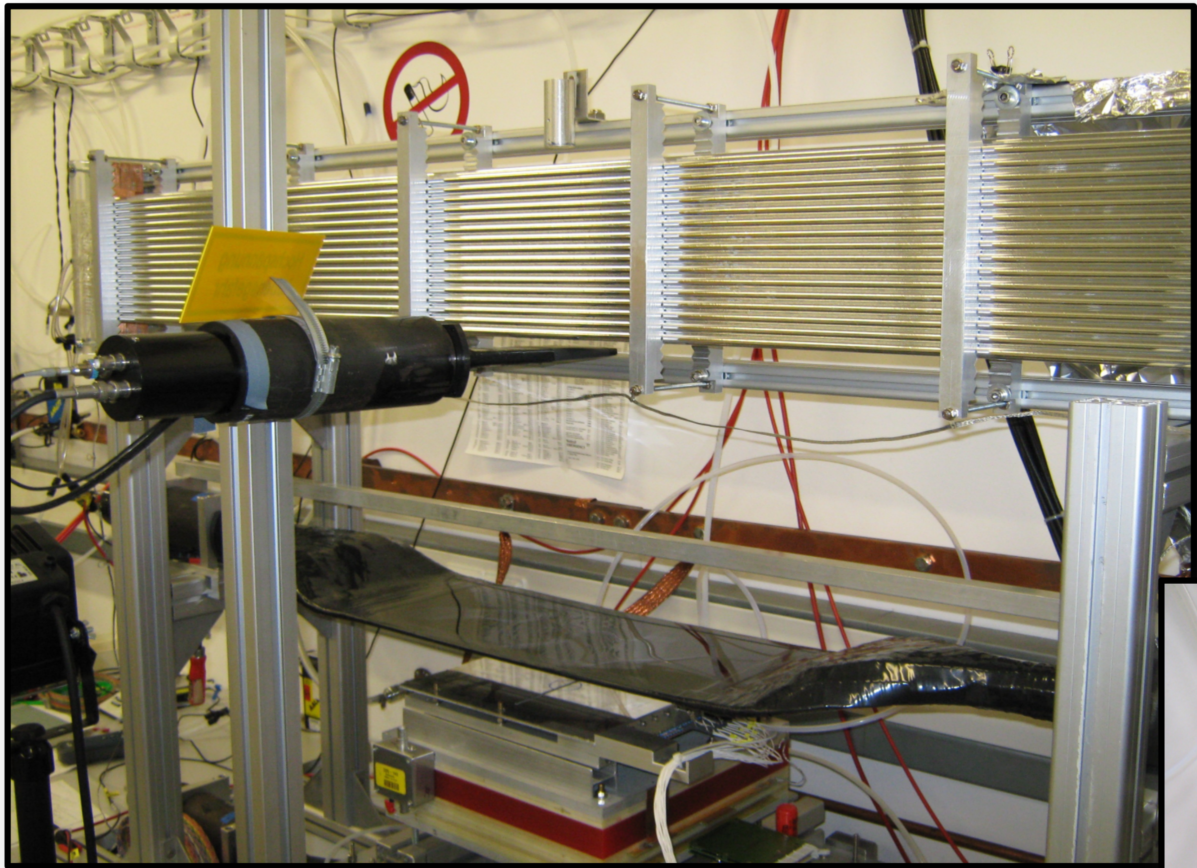
$$\Delta E = \frac{E - \langle E_1 \rangle}{\sigma_1} = \frac{\langle E_2 \rangle - E}{\sigma_2} \ . \qquad (3.27)$$

Eliminating E from the previous equation and re-calculating S the following sparation power is obtained:

$$S = \frac{\langle E_2 \rangle - \langle E_1 \rangle}{\sigma_1/2 + \sigma_2/2} \ , \qquad (3.28)$$

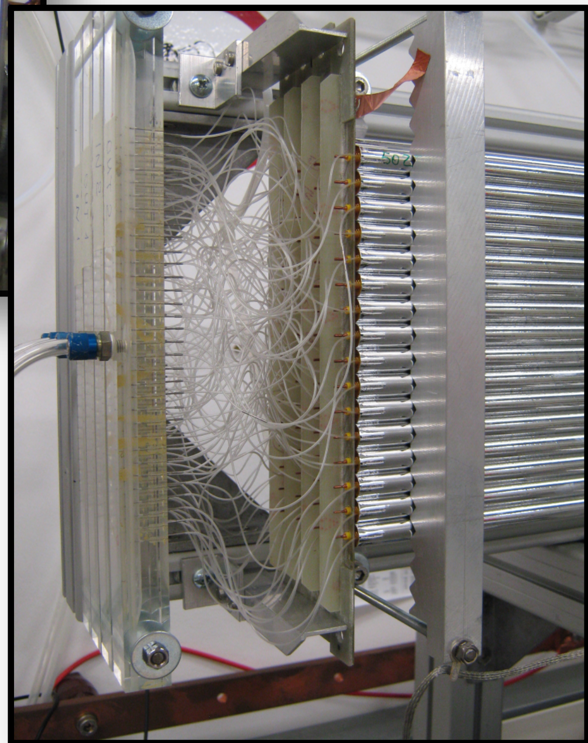


STT prototype @ FZJ



Designed for COSY-TOF and PANDA (P. Wintz)

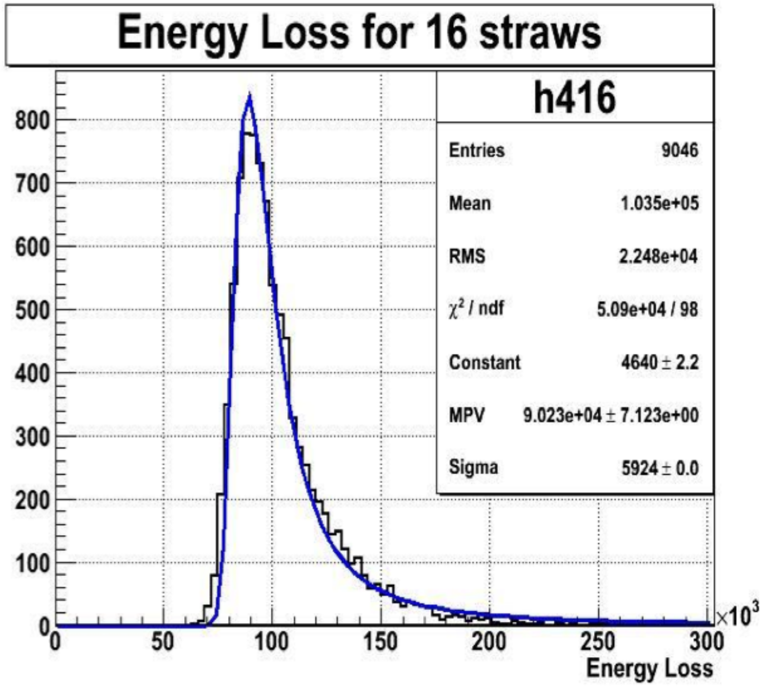
ELECTRONICS:
Standard existing electronics
- 64 channels with CMP16 + F1-TDC
- 64 channels with Fast QDC (160 MHz, 240 MHz in prep)
- from WASA @ COSY

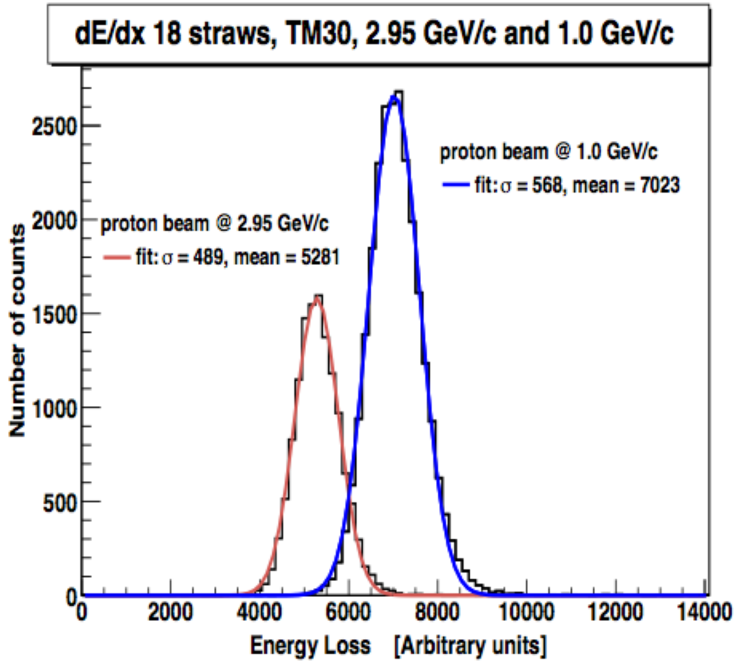


DESIGN
- 4 x (16 x 2) = 128 straws
  (4 self-supporting double-layers, 32 tubes each)
- 1.5 m long
- 30 μm wall thickness (aluminised mylar)
- 20 μm anode wire
- Different gas mixtures ($ArCO_2$ (90/10) - ArC_2H_6 (80/20))
- Operating at overpressure

Energy loss distributions

p@2.95 GeV/c





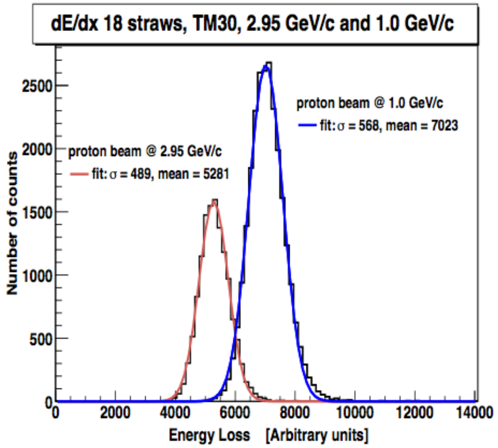
Truncked method of 30% has been used

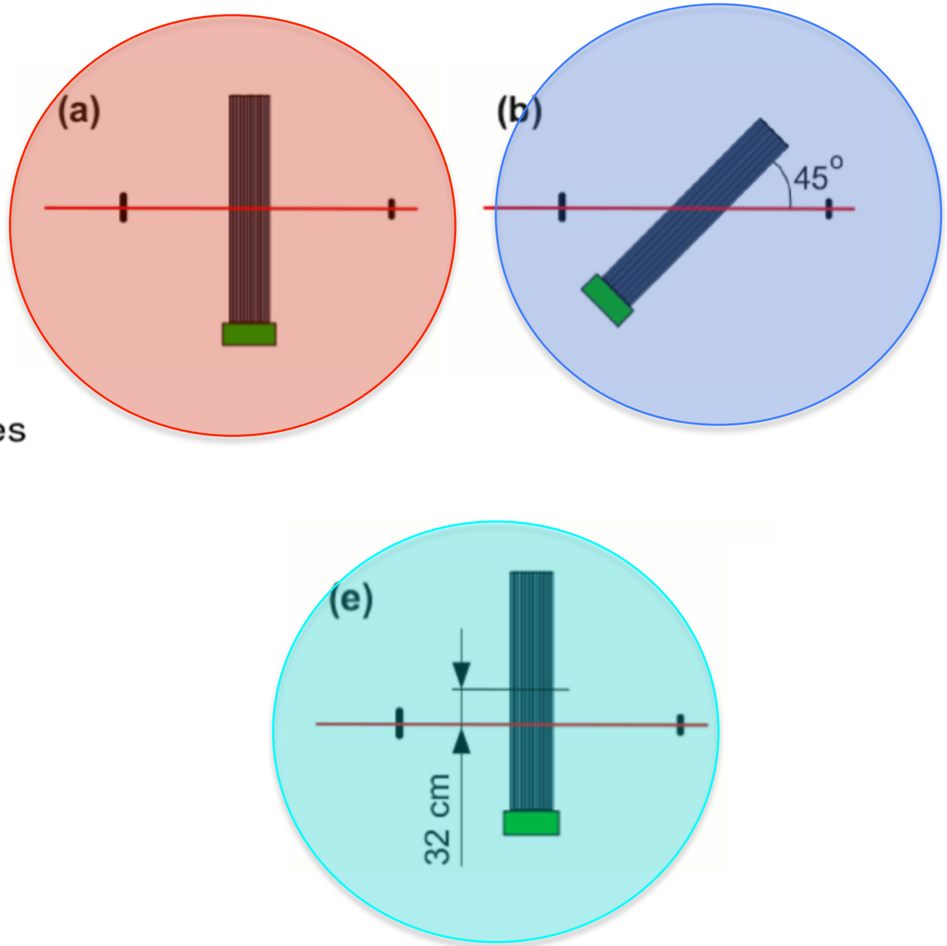
$\sigma_{dE/E}$ = 9.3 % @ 2.9 GeV/c

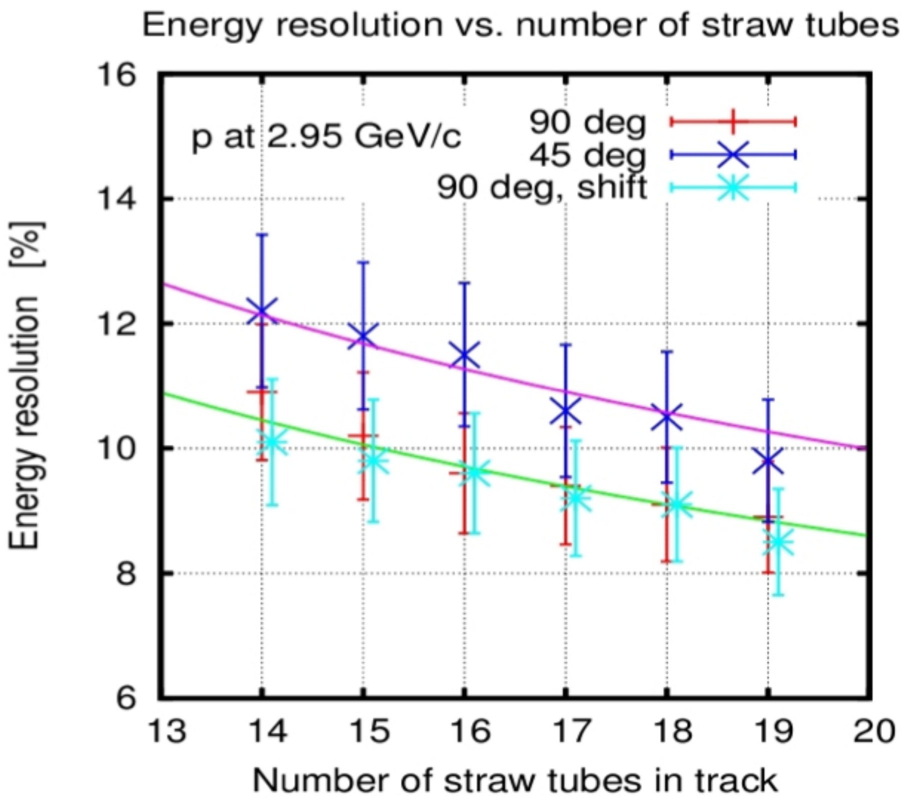
$\sigma_{dE/E}$ = 8.1 % @ 1.0 GeV/c

$\sigma_{dE/E}$ = 7.0 % @ 0.64 GeV/c

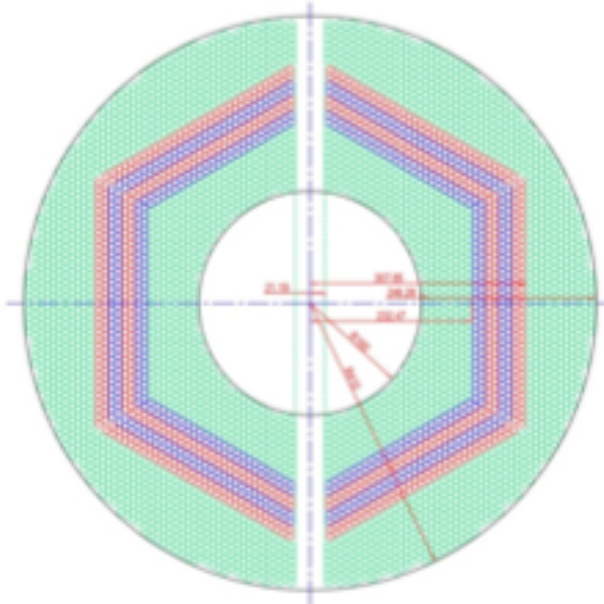
Energy loss resolution







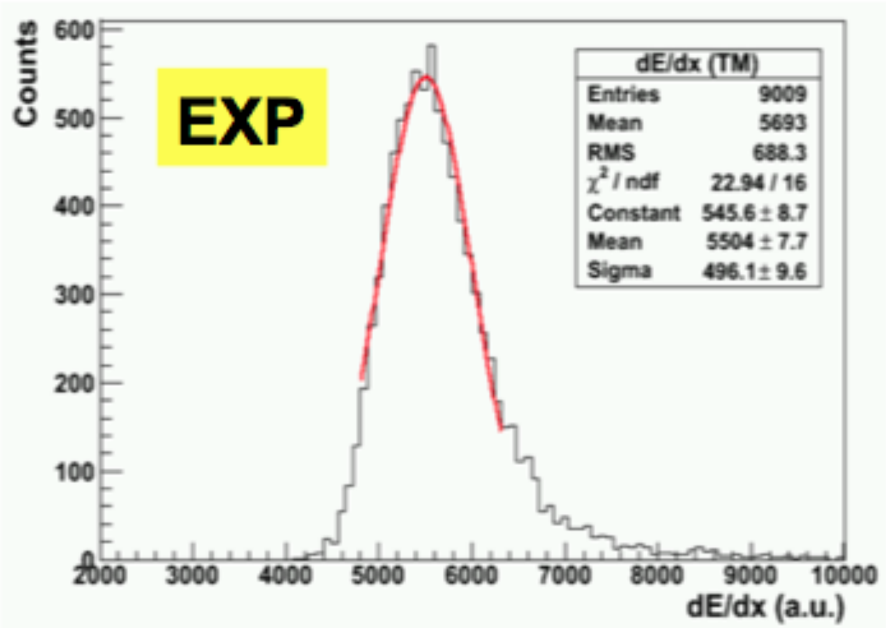
dE/dx Simulations

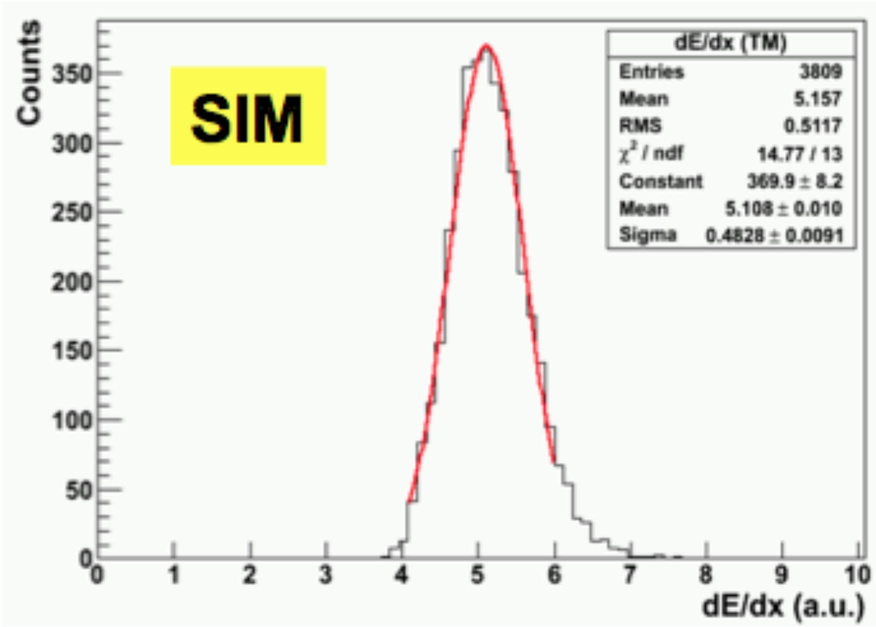


Within the PandaROOT framework:
5000 protons @ 2.9 GeV/c traversing the PANDA STT

1. Simulation, digitization and reconstruction (with Kalman filter)
2. Track selection: number of hits/track in STT limited to 16 to compare with test measurement
3. *dx* calculation (3D): $dx = 2 \cdot \sqrt{r_{tube}^2 - r_{drift}^2} / \cos\lambda$
4. *dE/dx* per track (as for experimental data)

dE/dx: data *vs.* simulation





$(\sigma/\mu)_{exp} = (9.01 \pm 0.17)\ \%$

$(\sigma/\mu)_{sim} = (9.45 \pm 0.18)\ \%$

Statistical significance $$\frac{|9.45 - 9.01|}{\sqrt{0.18^2 + 0.17^2}} \approx 1.8$$

Good agreement of σ, BUT tail seems to be underestimated

dE/dx measurement important for our physics case !!
Still many things to be investigated and cross-check in the simulation.

Closer involvement from our group
Beatrice Ramstein, Bingsong Ma and Thierry Hennino

November test of the dE/dx measurement in Juelich

First step to identify pbar p->e+e- with PANDAroot

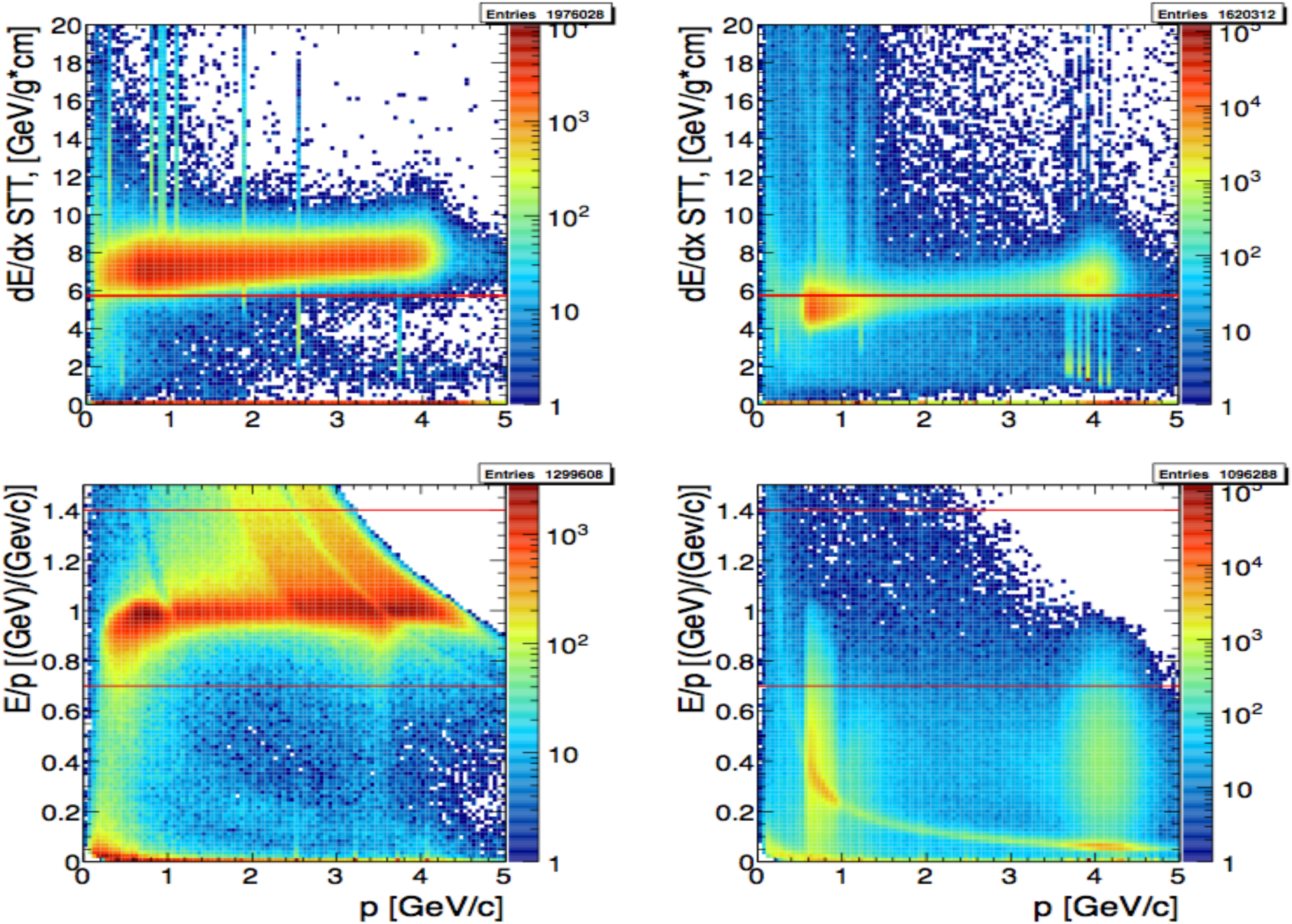
Criteria to separate e/π

Input: 10^6 of signal and background events for p(pbar) = 4 GeV/c

- Both positive and negative particle $0.7 < E/p < 1.4$
- Event must have only one positive and one negative particle after reconstruction
- Both positive and negative particle $\frac{dE}{dx}_{STT} > 5.8[GeV/g*cm]$
- Both positive and negative particle in CM frame
  $\sqrt{s}/2 - \lambda < E < \sqrt{s}/2 + \lambda$
  where $\lambda = (\sqrt{s}/2)/5$ For $P(\bar{p}) = 4GeV/c$,

  $\sqrt{s}/2 = 1.54GeV, \lambda = 0.31GeV$

work of D. Khaneft



(a) $\bar{p}p \to e^+e^-$ (b) $\bar{p}p \to \pi^+\pi^-$

Results

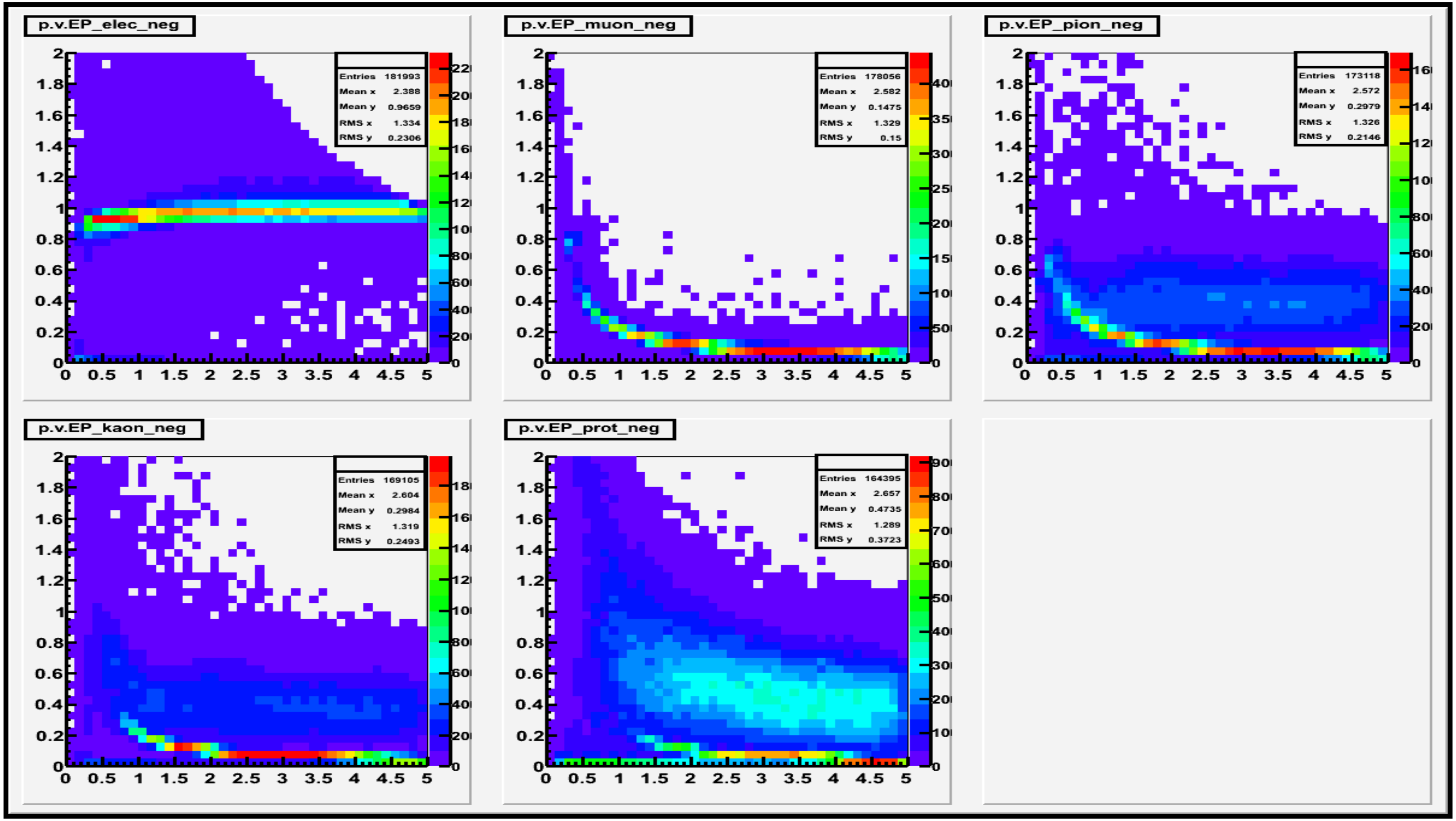
type of event	e^+e^-	$\pi^+\pi^-$
MC events	1000000	1000000
raw EMC + E/p cut	584309	715
cal EMC + E/p cut	568799	1088
raw EMC + all cuts	257228	0
cal EMC + all cuts	277633	0

Signal (e^+e^-) efficiency 25 – 27%

Background ($\pi^+\pi^-$) suppression 100% for 10^6 events

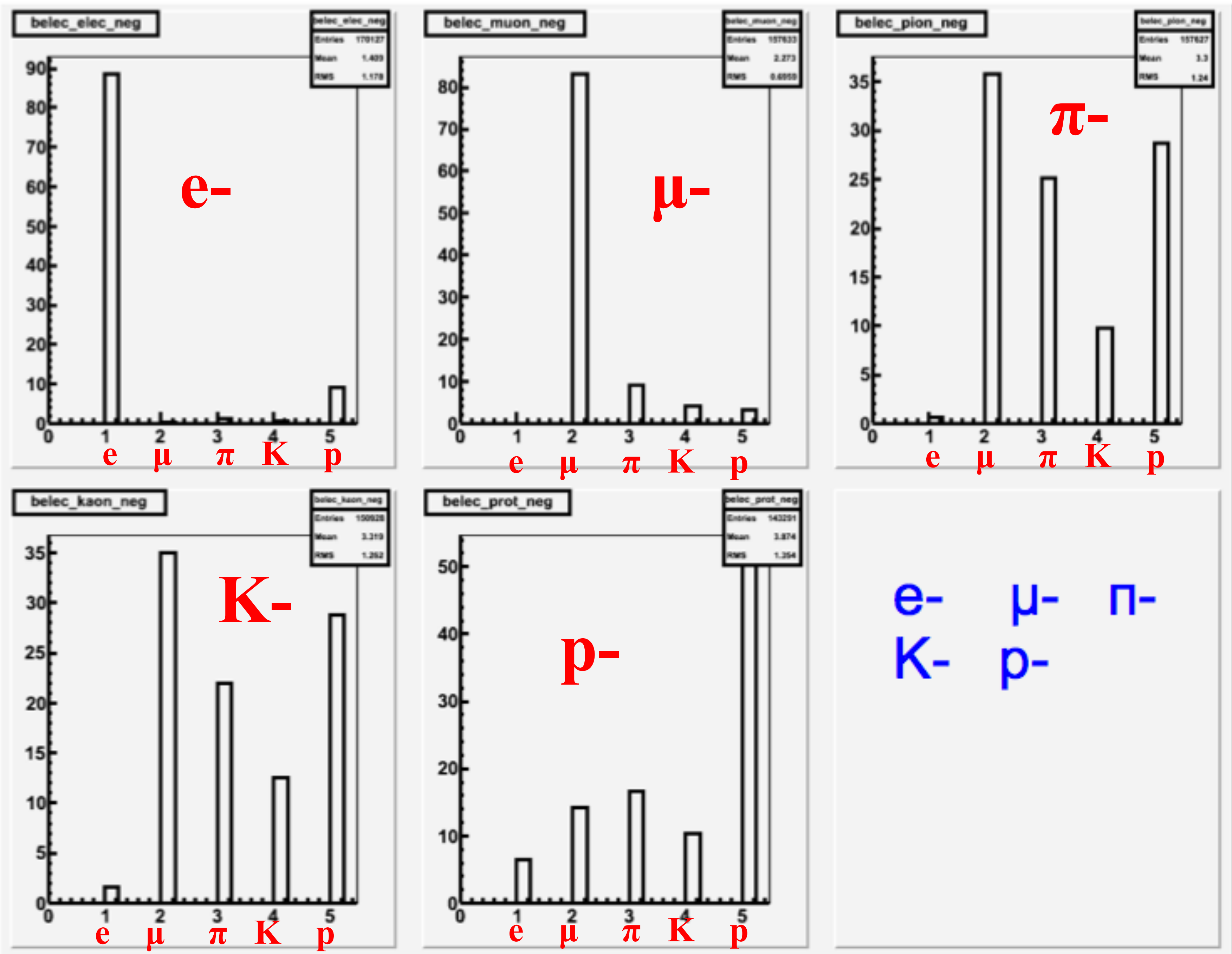
Also other detectors for the PID should be tested: DIRC, MVD, more observables from EMC

Charge particle PID using EMC



Several variable from EMD used to obtain PID: E/p, zernik momenta ….

Select particle with highest %



EMC bayesian method using EMC developed by Ronald Kunne

also available 2 methods (KNN and MLP) within TMVA software integrated into PANDAroot

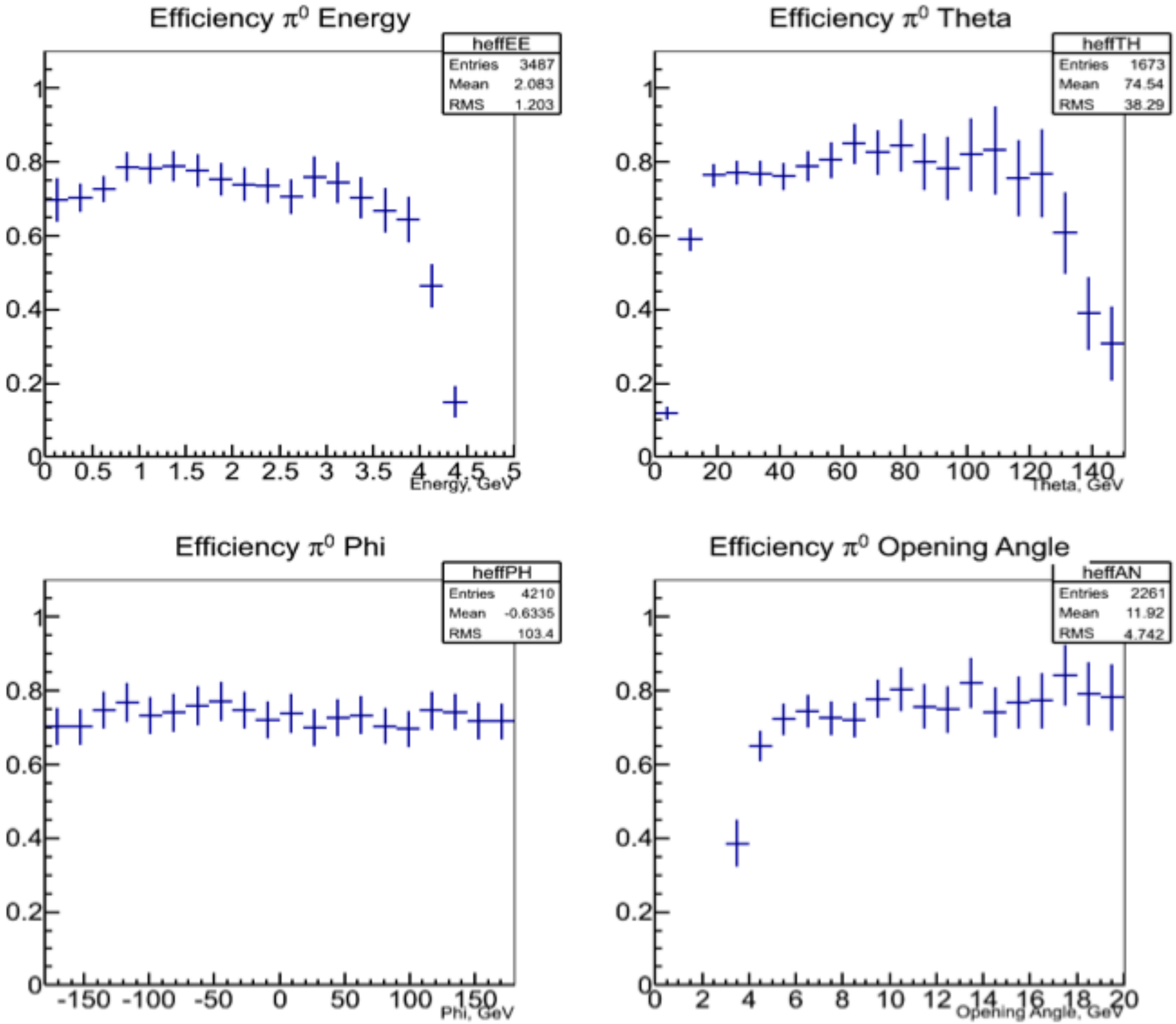
ongoing comparison of the methods

γ/π^0 separation with EMD

π° reconstruction

- Double loop over bumps
- Skip E<25 MeV
- Construct γ momentum vector from bump
- Combine two γ into a π°
- Cut on invariant mass $0.11 < M_{\pi^\circ} < 0.15$ GeV
- Good reconstruction if $\chi^2 = d\theta^2 + d\varphi^2 < 5\ \mathrm{deg}^2$

Reconstruction efficiency



Overall efficiency :

About 75%

Conclusion/Summary

PANDAroot is fast developing, still many things to be done/tested, manpower needed

Energy Loss Measurements

- Investigate **energy loss measurement with straws**
  - Reminder: default dE/dx readout for STT with discriminator and ToT(E)
  - Here: use **full signal amplitude information with FADC** for systematic study
  - Straw cylindrical geometry, different path lengths, track angles, wire posi.
  - Truncated mean method, number of straw hits, ..
- **Beam tests with proton beam**
- **Setup: 8×16 straws = 128 channels**
  - Ar/CO_2 (10%) at p=2bar
  - **Readout: current amplifier + FADC**
  - **FPGA (time, ampl.) + raw mode readout**
  - Sampling rate 240MHz (~4.17ns)
  - Different setup arrangements (a) - (e)