Identification of particles by *mean energy loses* in **SPD Straw Tracker** at NICA

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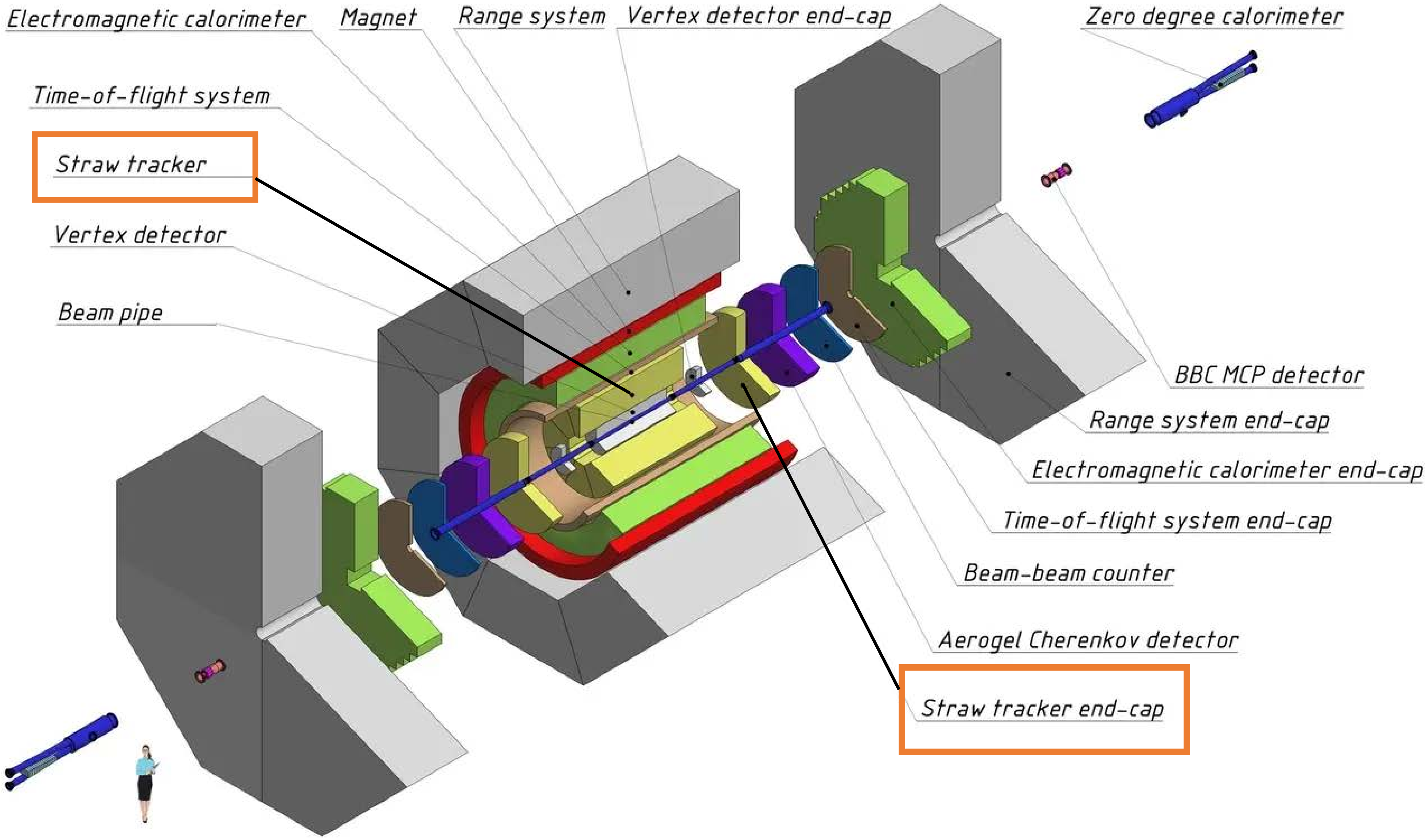
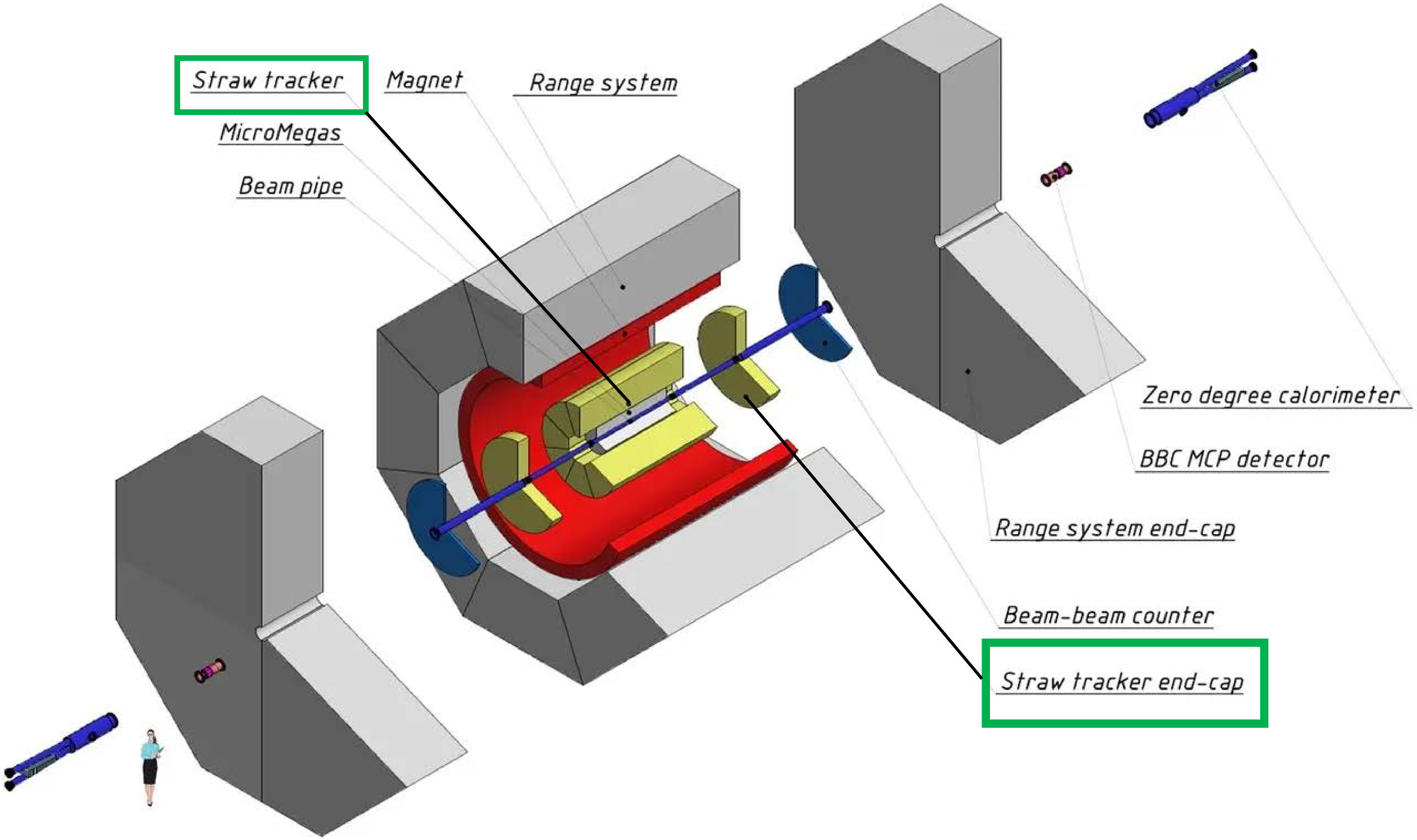
Spin Physics Detector full setup



Spin Physics Detector setup at the first stage



Straw-Based Tracking system (ST)

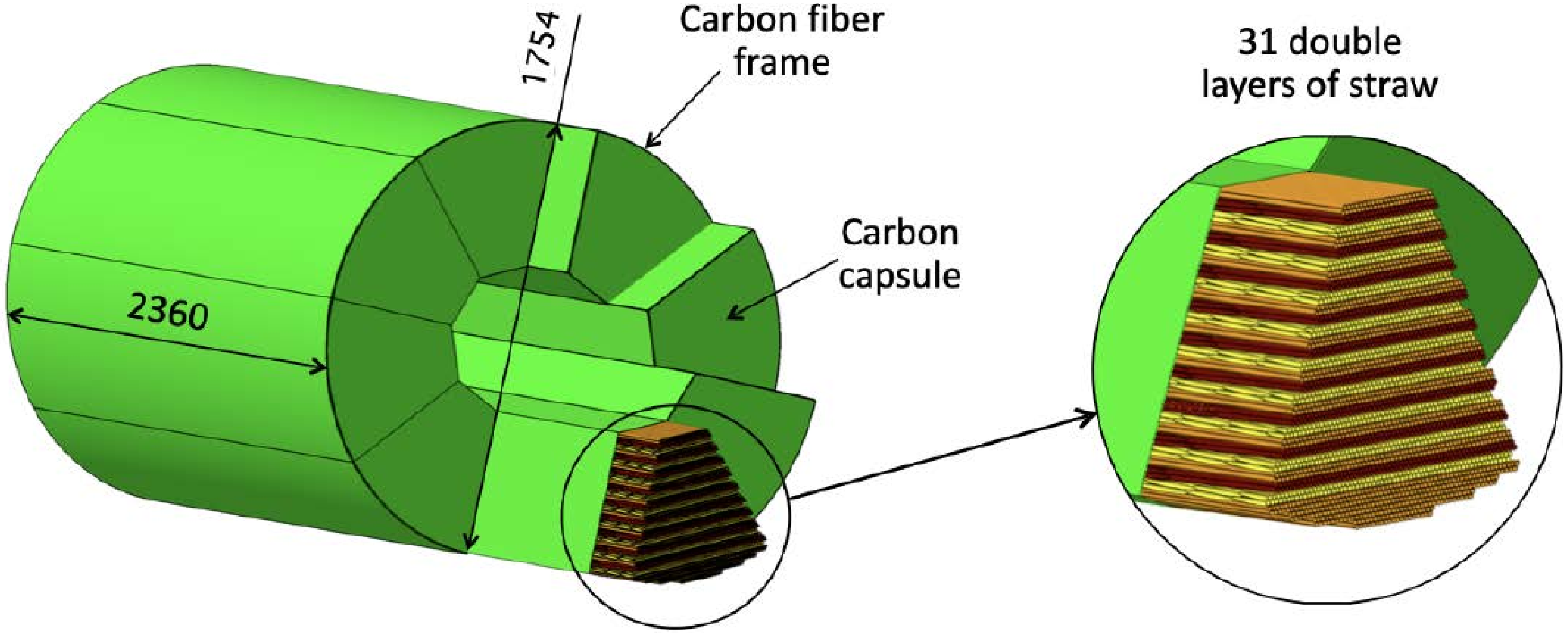
- Main tracking system of SPD
- Spatial resolution ~150 μm
- ~ 26 000 straw tubes
- Three parts: *barrel* and two *end-caps* (different kinds of straw tubes for each part)

The **purposes** of the Straw Tracker:

1. reconstruction of tracks of primary and secondary particles
2. measuring particles’ momenta (based on a track curvature in a magnetic field)
3. particle identification via energy deposition (dE/dx) measurements

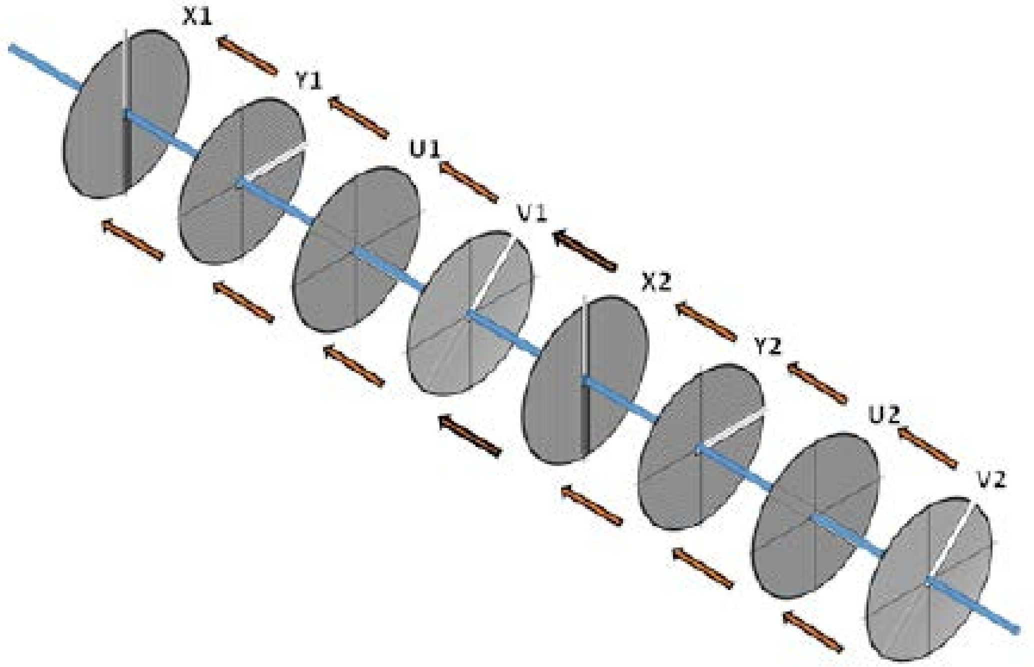
Straw Tracker *barrel*

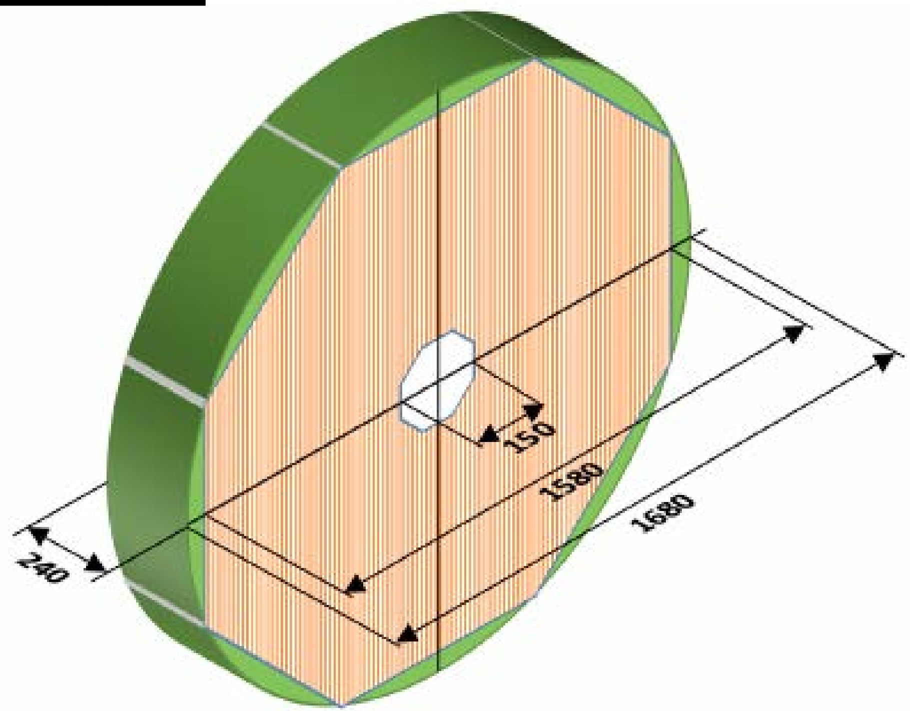
The main axes of the straw direction are Z, U, and V. The Z axis is along the beam axis. The angle between the U, V and Z axes is ±5 degree.



- Barrel part consists of *8 modules* (octants)
- Each module contains *31 double layers of straw tubes* encased in a composite-polymer 400 µm thick capsule

Straw Tracker *end-caps*





- End-cap is proposed with an octagonal arrangement of *8 drift coordinate planes* at an angle of 45 degrees, which form an X, Y, U, V coordinate system.
- Each coordinate plane consists of two halves of a disk with an interval for installing a vacuum tube.

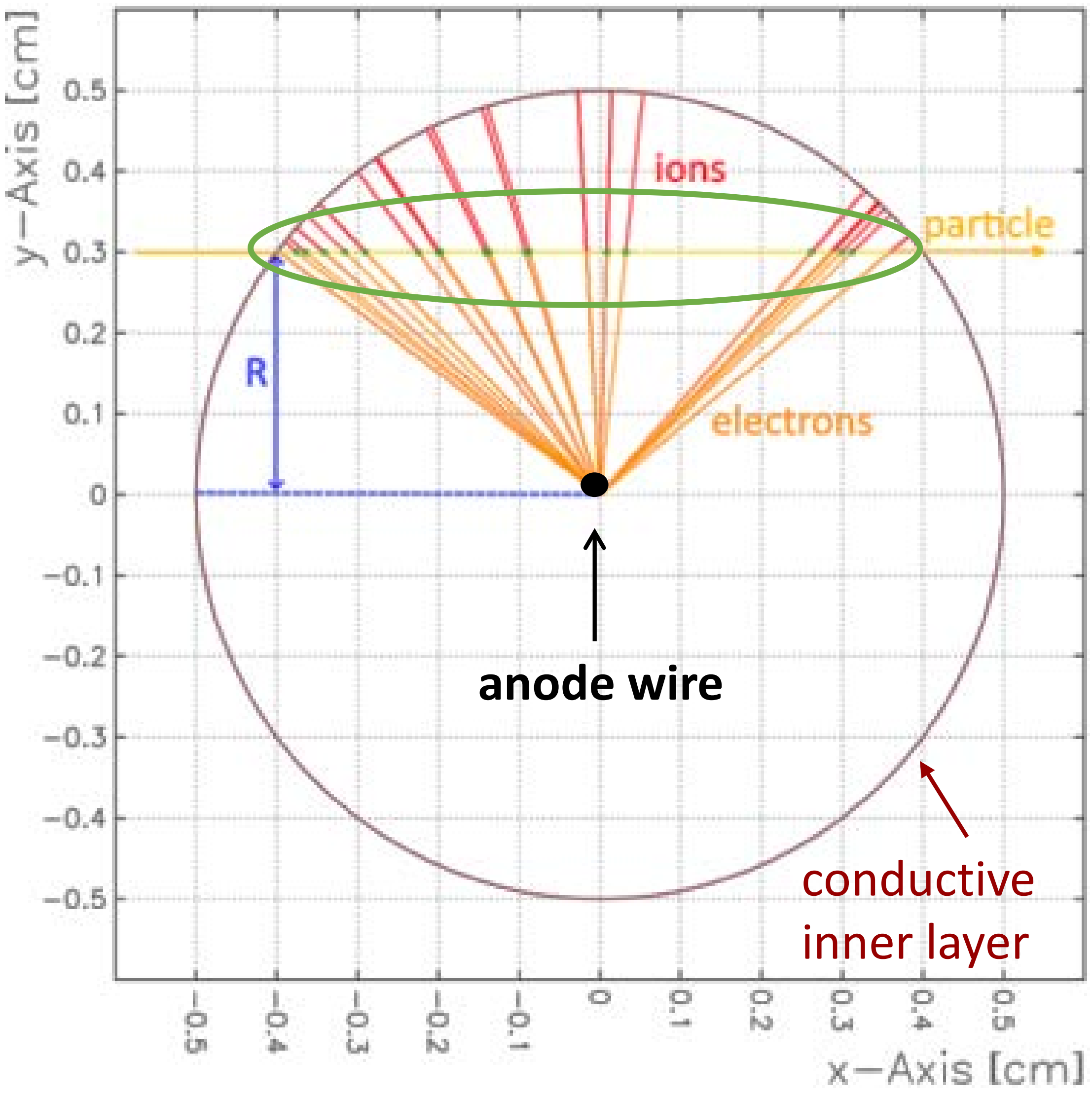
Common view and main dimensions

Particle detection in straw tubes

Straws are filled with gas. An ionizing particle passes at distance R from anode wire, creates primary ionization clusters along its path. Primary electrons drift toward the anode wire.

The relative coordinate of the primary ionizing particle is reconstructed from the measured electron drift time (which defines distance R)

Straws operate in the proportional mode: total charge of the induced signal is proportional to the ionization energy loses *dE*.



Modeled data

- TTree in CERN ROOT
- 1000 runs; 1 run = 1000 events

Characteristics of every track in Ttree

variable	meaning	type
runId	ID of run	Int_t
eventId	number of event in run	Int_t
trackId	number of track in event	Int_t
pdg	PDG code of particle	Int_t
convergency	+1 – fit has converged 0 – fit has not converged -1 – fit has converged partly	Int_t
chi2	χ^2 of track	Double_t
ndf	number of degrees of freedom	Int_t

Characteristics of track fitting quality (convergency, chi2, ndf)

Variables for calculations

variable	**meaning**	**type**
	Parameters of every track	
nhits_tsb	the sum of hits in Straw Tracker barrel	Int_t
nhits_tsec	the sum of hits in Straw Tracker endcaps	Int_t
first_mom	momentum in the *first hit*	TVector3
last_mom	momentum in the *last hit*	TVector3
	Parameters of every hit	
dE	Energy loses for each hit	vector<Double_t>
dx	Segment's length for each hit	vector<Double_t>

nhits (nhits_tsb, nhits_tsec)

p *(px, py, pz)* (first_mom, last_mom)

dE/dx [i] (dE, dx)

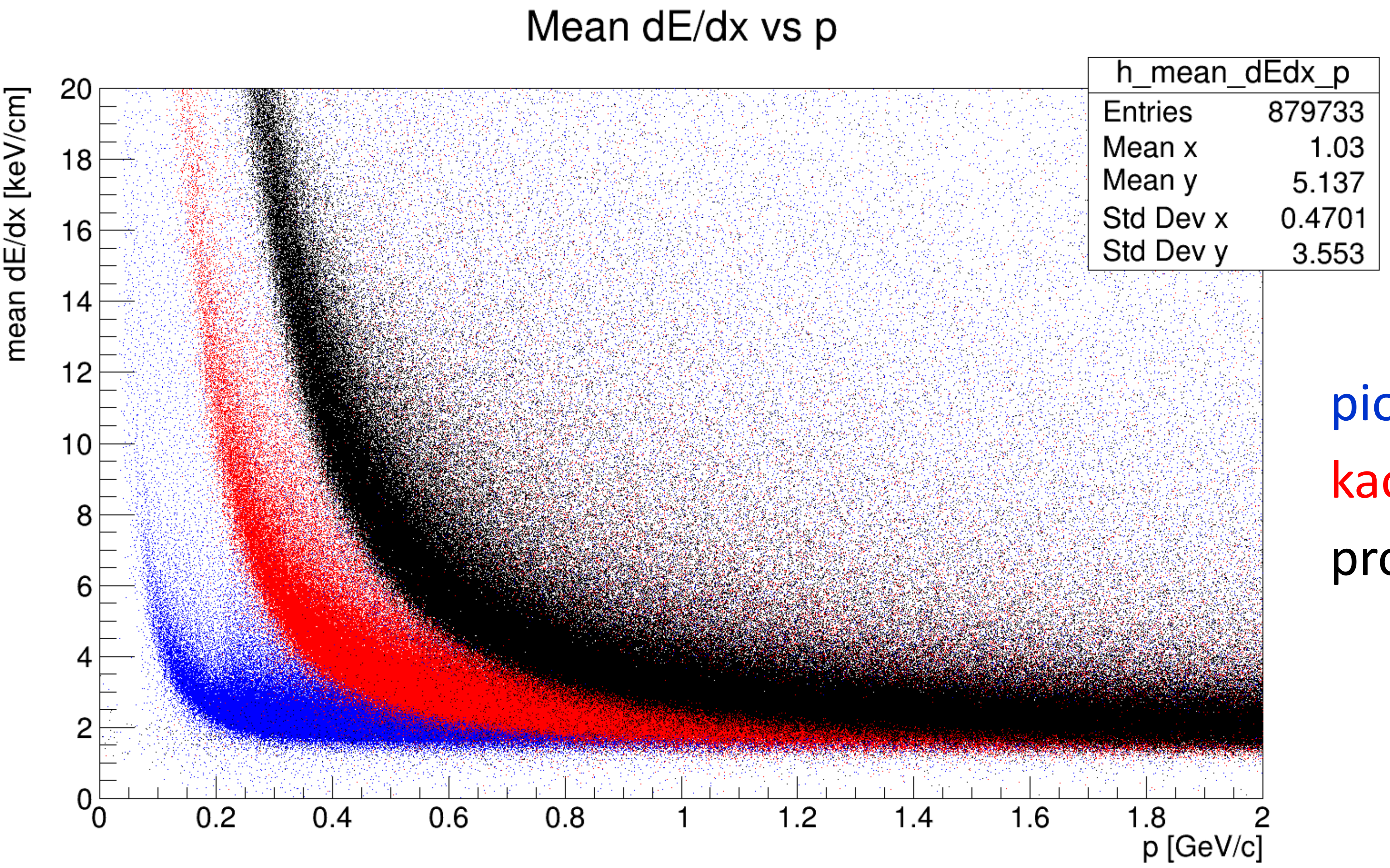
Obtaining mean energy loses for track

dE, dx → array $\frac{\boldsymbol{dE}}{\boldsymbol{dx}}[\boldsymbol{i}]$ with size ***nhits*** = nhits_tsb + nhits_tsec

$$\left\langle \frac{dE}{dx} \right\rangle_{nhits} = \frac{\sum_{i=1}^{nhits} \frac{dE}{dx}[i]}{nhits}$$

momenta ***p*** = (first_mom + last_mom)*0.5

Exclude tracks with (*chi2/ndf* > 2) and (*convergency* ≠ 1)



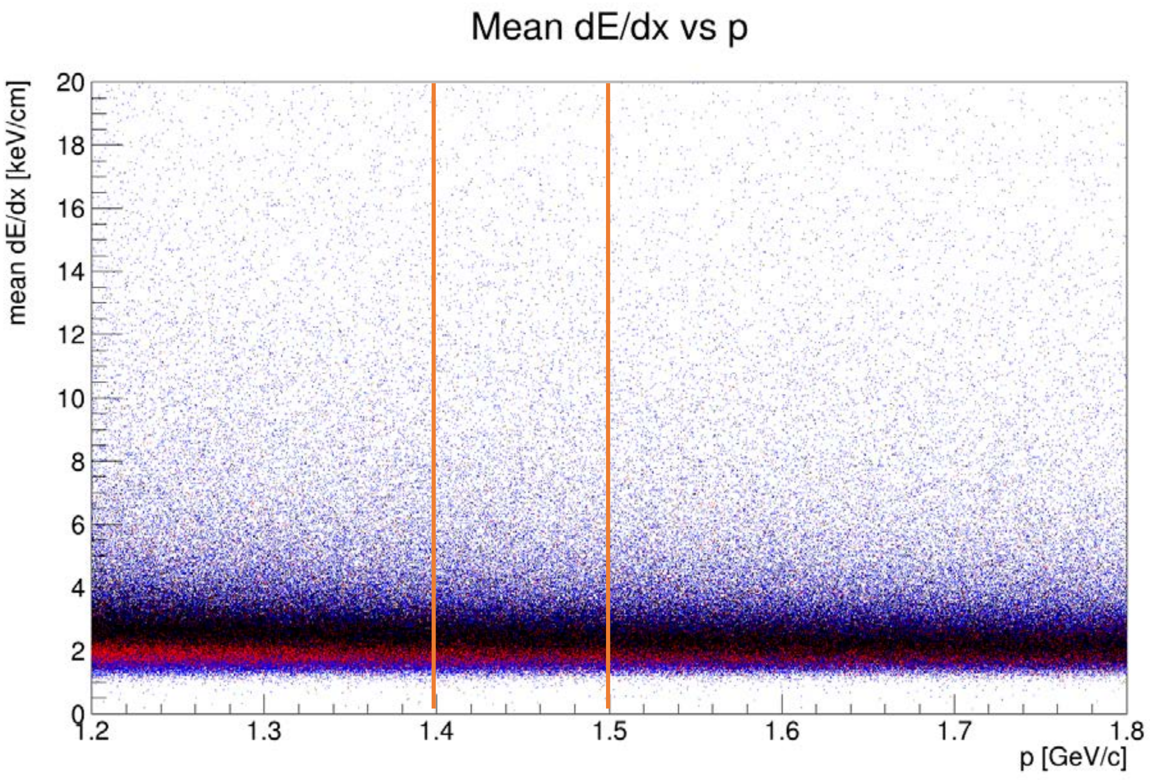
pions

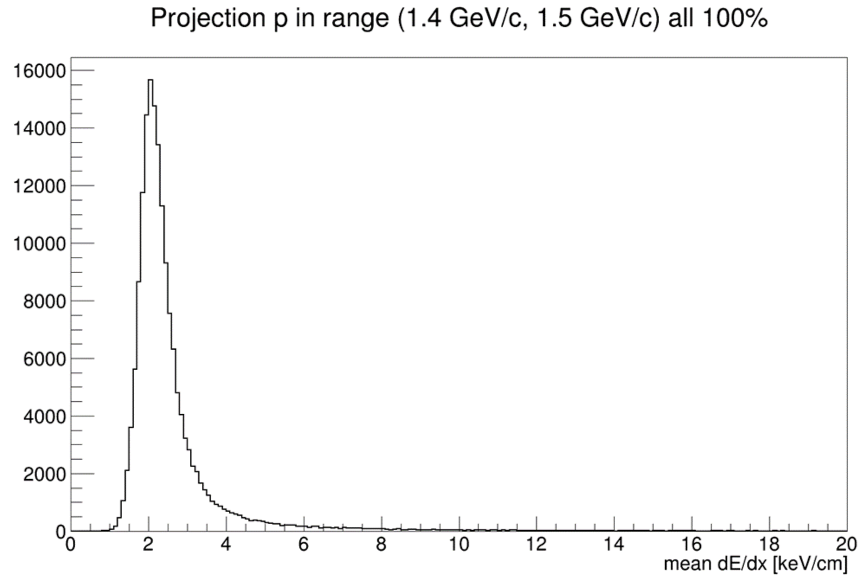
kaons

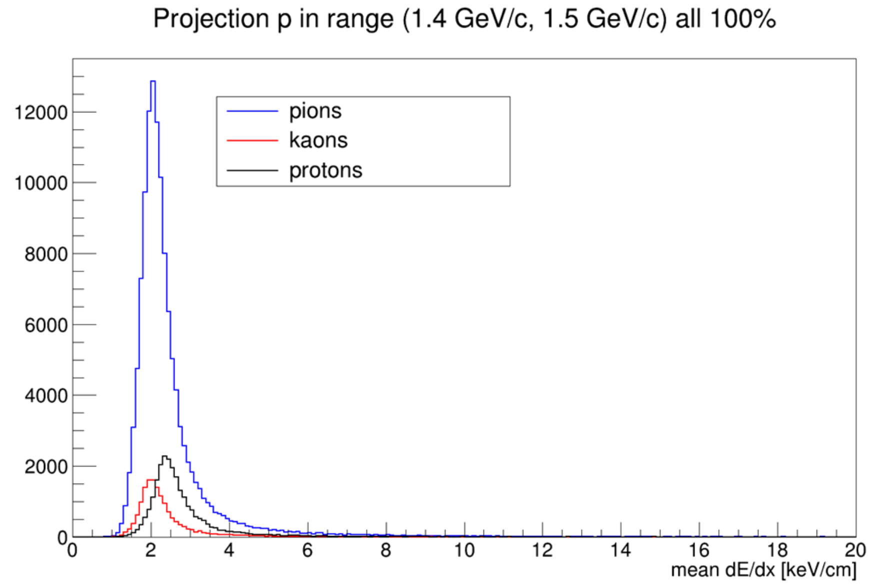
protons

Projection along Y

Project a 2D histogram into a 1D histogram along Y (TH1D* ProjectionY in ROOT) for *p* values in range [1.4; 1.5] GeV/c





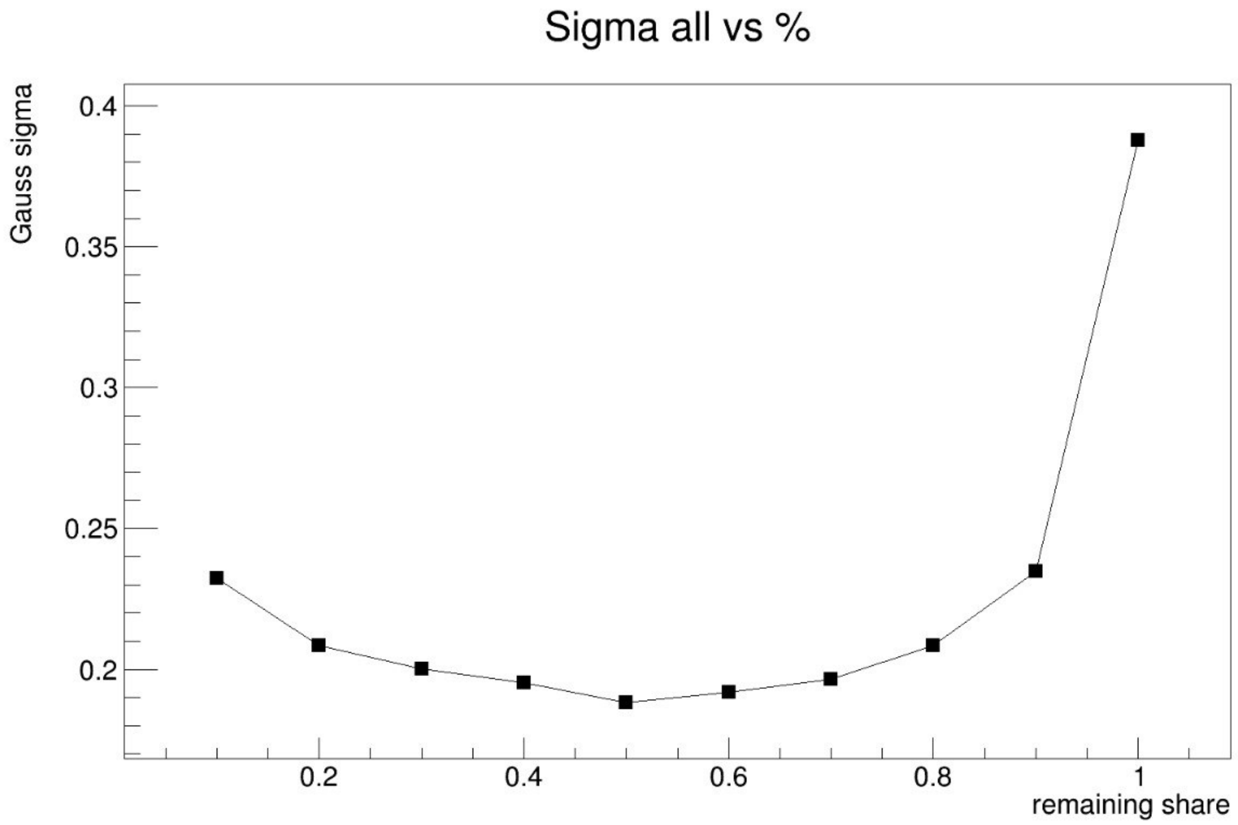


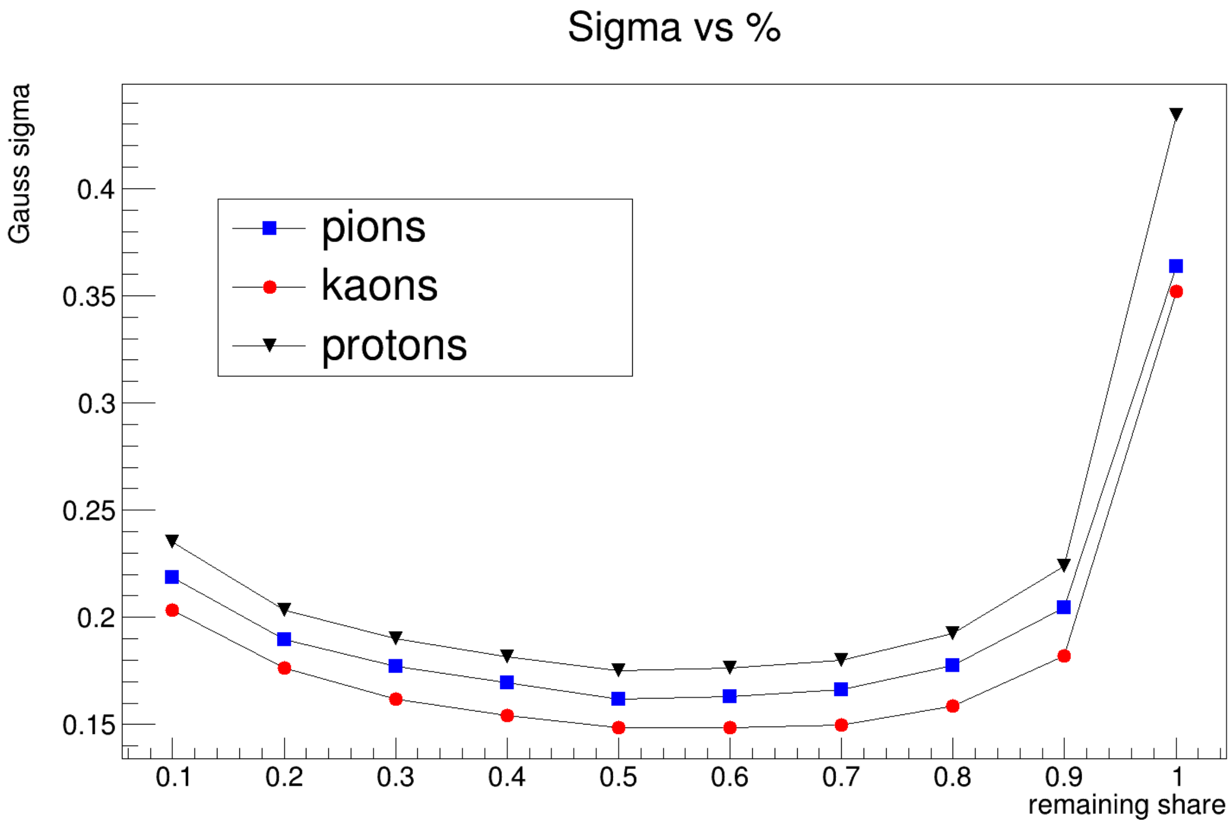
The truncated mean method

1. Varying ***k*** in range [0; 1] (*k* would be the remaining share of original array)
2. Sorting $\frac{dE}{dx}[i]$ in increasing order; i = 1, 2, … , ***nmax*** = *nhits*k*
3. Calculating mean energy loses for every meaning of *nmax* (for remaining part of dE/dx array)

$$\left\langle \frac{dE}{dx} \right\rangle_{nmax} = \frac{\sum_{i=1}^{nmax} \frac{dE}{dx}[i]}{nmax}$$

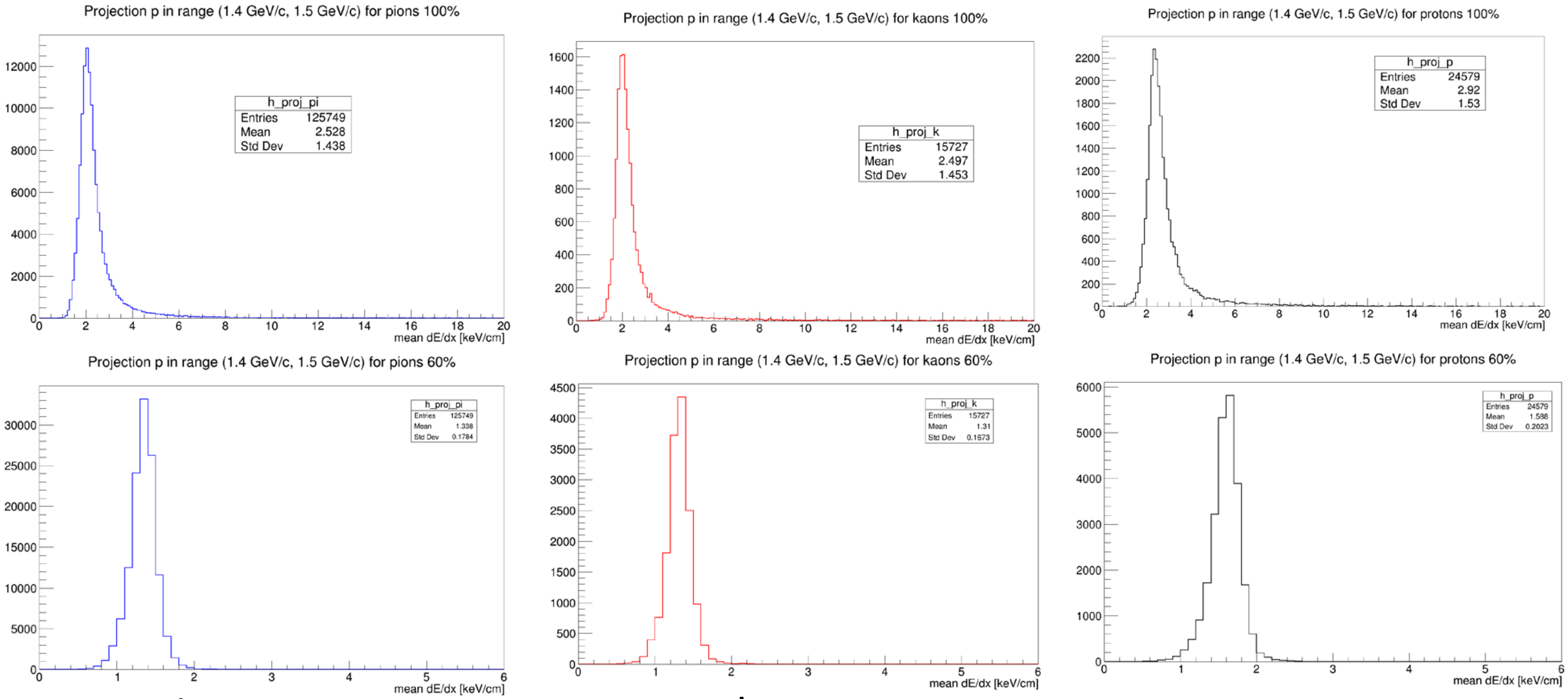
4. TH1D* ProjectionY for remaining part of $\frac{dE}{dx}[i]$ array
5. Fitting 1D histogram with gauss ⟶ $\boldsymbol{\sigma}$ of distribution
6. Choosing k with minimum σ



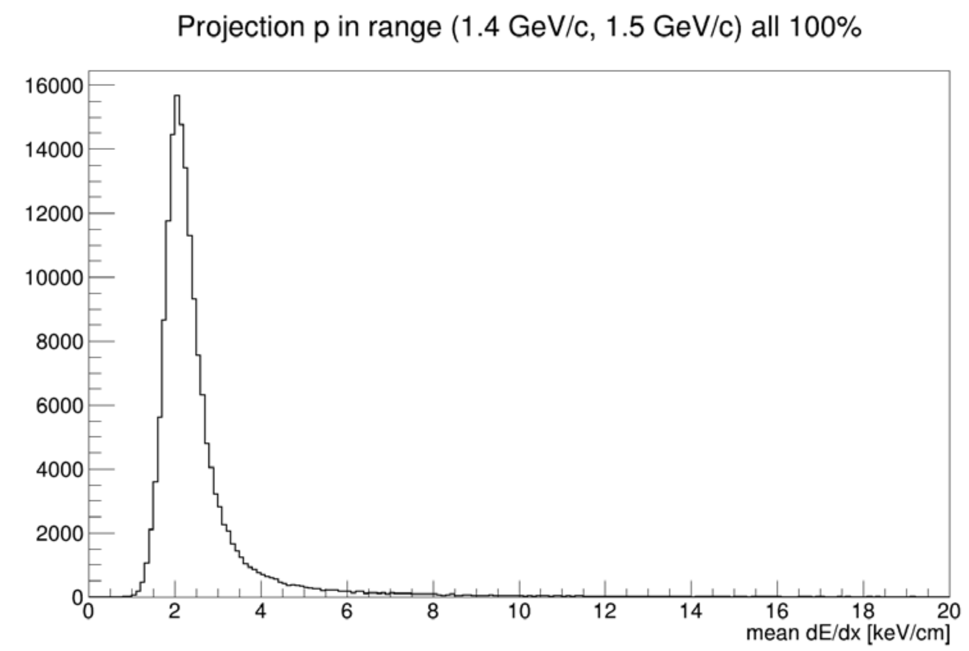


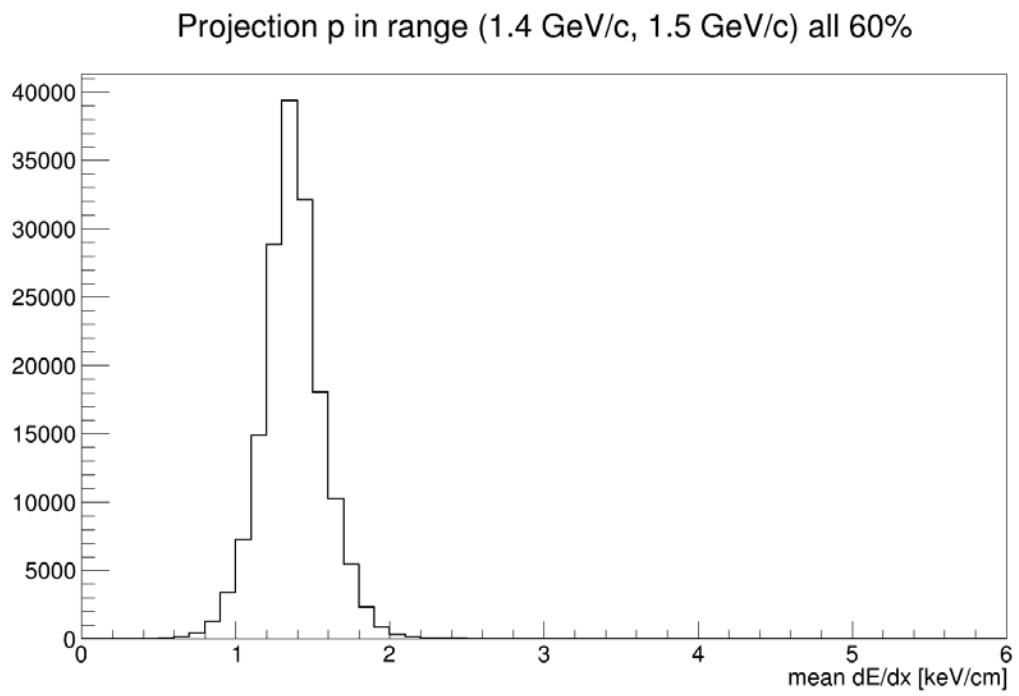
σ (k = 0.6) - minimum

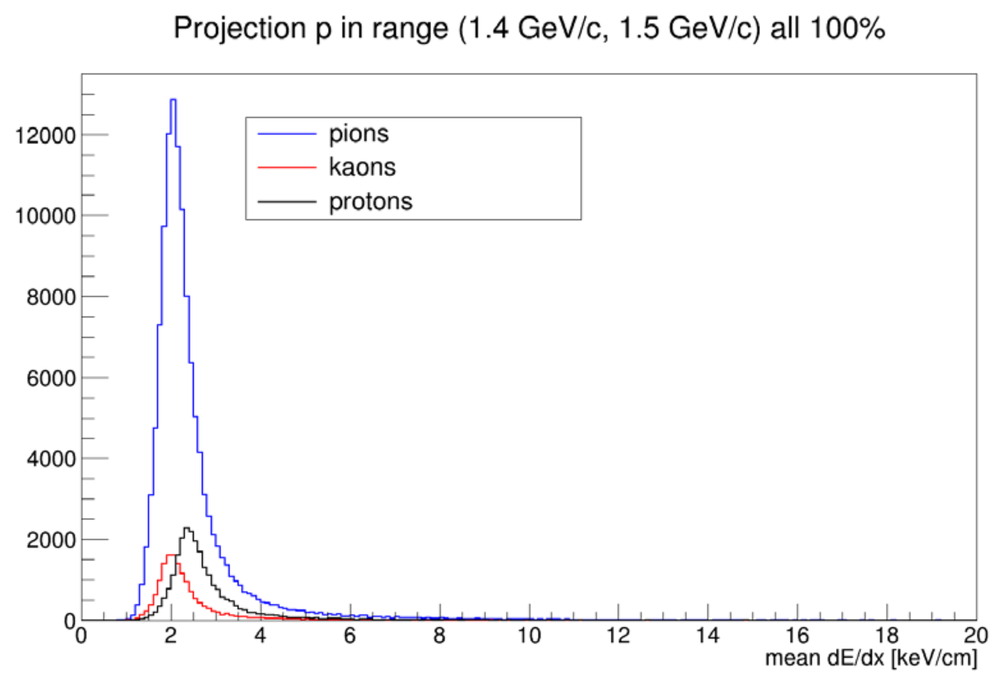
Comparison original $\left\langle \frac{dE}{dx} \right\rangle$ and cut

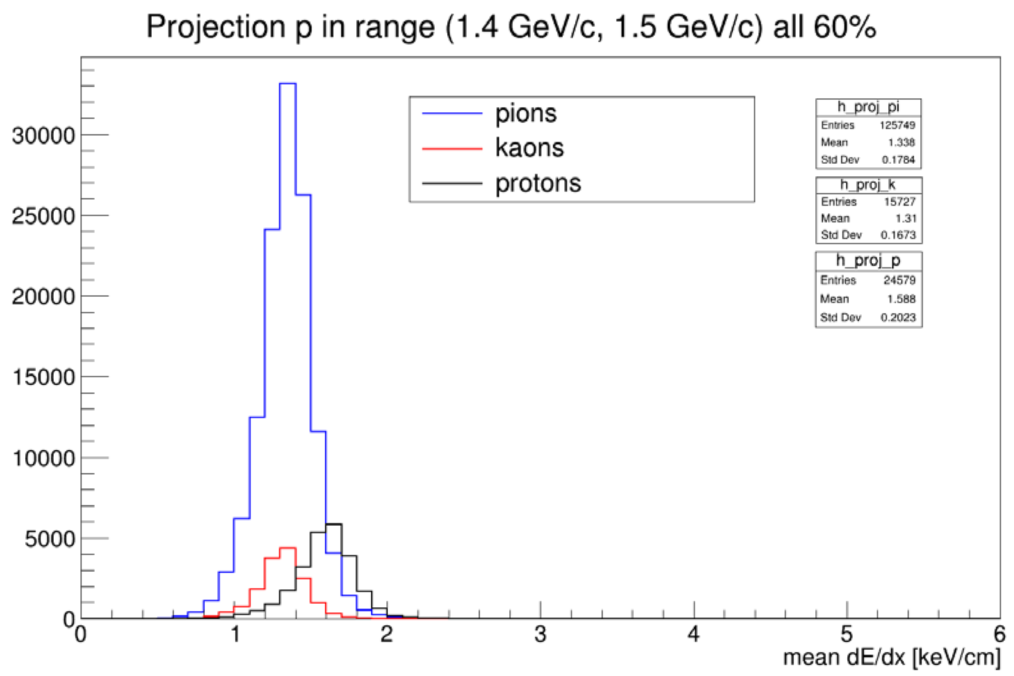


pions kaons protons

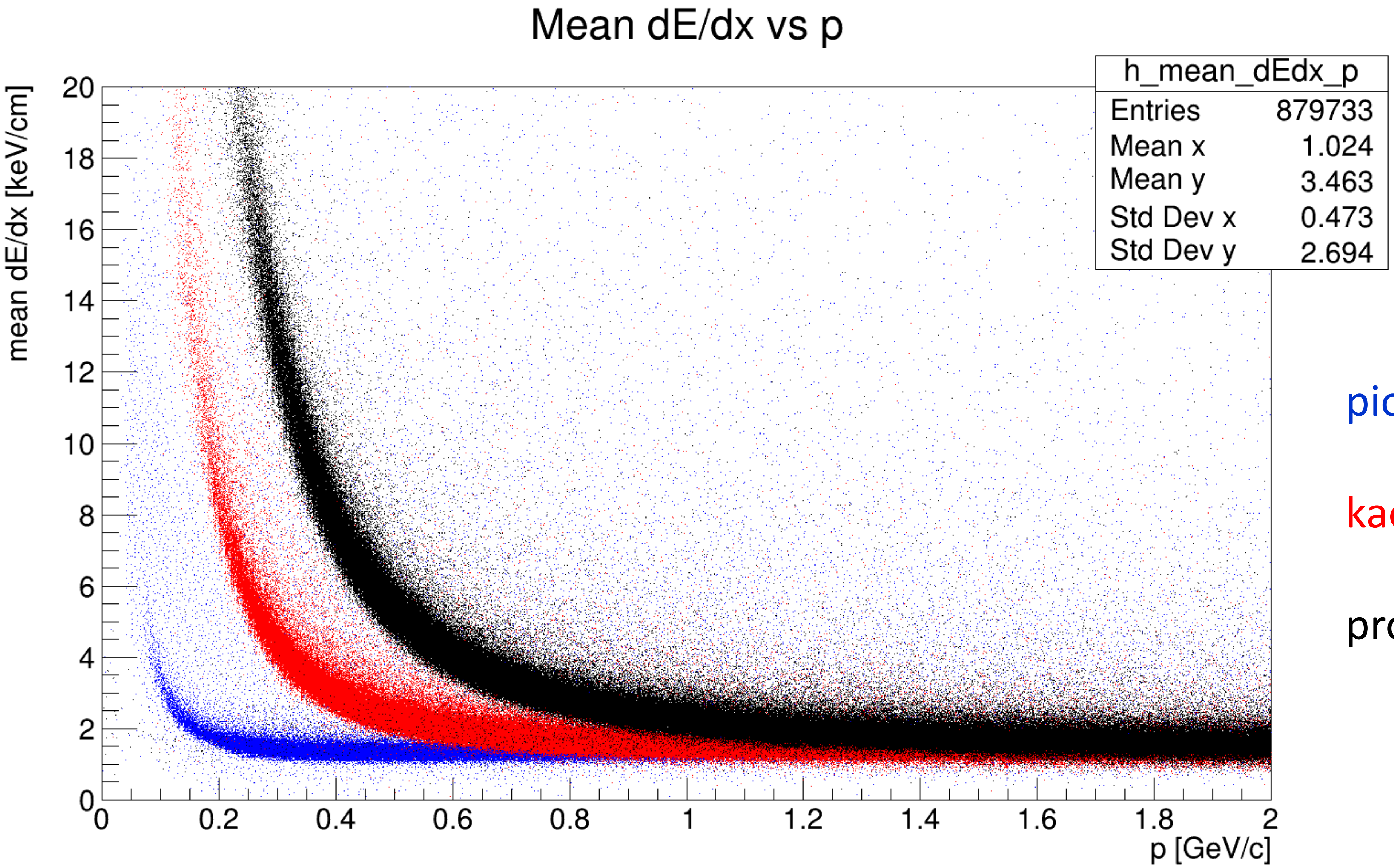

Projection p in range (1.4 GeV/c, 1.5 GeV/c) all 100%
mean dE/dx [keV/cm]


Projection p in range (1.4 GeV/c, 1.5 GeV/c) all 60%
mean dE/dx [keV/cm]


Projection p in range (1.4 GeV/c, 1.5 GeV/c) all 100%
pions
kaons
protons
mean dE/dx [keV/cm]


Projection p in range (1.4 GeV/c, 1.5 GeV/c) all 60%
pions
kaons
protons
h_proj_pi
Entries 125749
Mean 1.338
Std Dev 0.1784
h_proj_k
Entries 15727
Mean 1.31
Std Dev 0.1673
h_proj_p
Entries 24579
Mean 1.588
Std Dev 0.2023
mean dE/dx [keV/cm]

Energy loses with truncated mean method (60% remain)



pions

kaons

protons

Summary

- In Straw Tracker system PID via dE/dx loses measurements is possible
- Truncated mean method allows to separate areas of mean energy depositions for different types of particles
- $\left\langle \frac{dE}{dx} \right\rangle (p)$ become constant for pions at p ~ 0.3 GeV/c

  for kaons at p ~ 0.7 GeV/c

  for protons at p ~ 1.4 GeV/c