dE/dx studies for particle identification in SPD

Ruslan Akhunzyanov

LHEP JINR

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Outline

1. Introduction

2. Impact of experimental dE measurement error on dE/dx resolution.

3. dE/dx for tracks with different values of θ.

Truncated mean dE/dx method

- For each track:
  - dE/dx is calculated for each hit of the track;
  - 35% of the highest values of dE/dx are rejected;
  - Mean of the remaining values is calculated («truncated mean dE/dx»).
- Mean and sigma of the distribution of the truncated mean dE/dx are parameterized for each particle type (π, K, p) as function of momentum and [sigma] number of hits of the track.
- Based on these values, likelihoods are calculated.

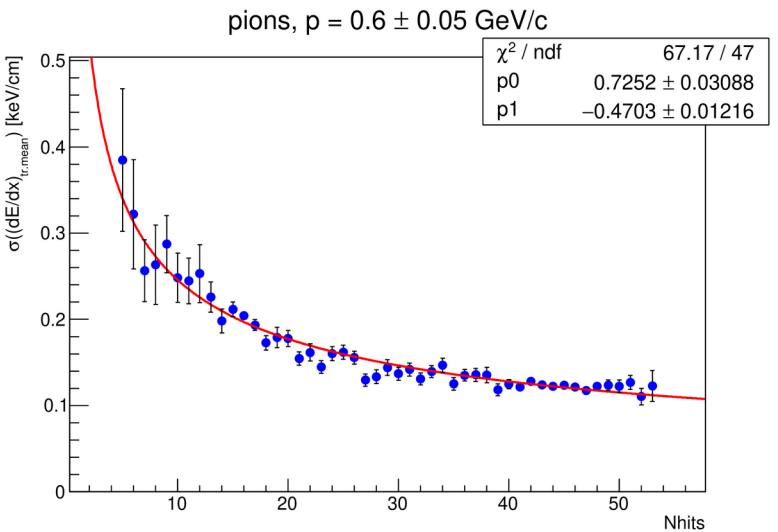
Notes

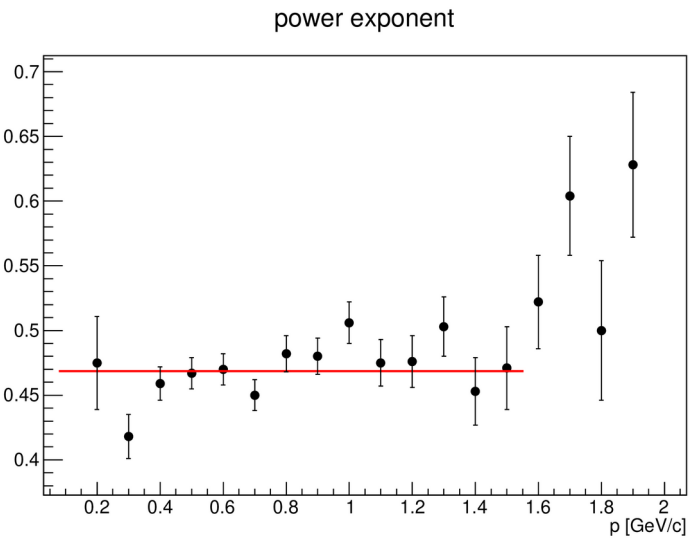
- Currently MC values are used for dE and dx.
- Momentum is calculated as $p = \frac{p_{first\ state} + p_{last\ state}}{2}$, where $p_{first\ state}$ and $p_{last\ state}$ are momentum values from the fit in the first and in the last point (hit) of the track.
- Parameterisations in SpdRoot were last updated in April 2022.

σ dependency on number of hits

- $\sigma \sim 1/\sqrt{N_{hits}}$ - to be checked again

Plots from my presentation in March 2022:





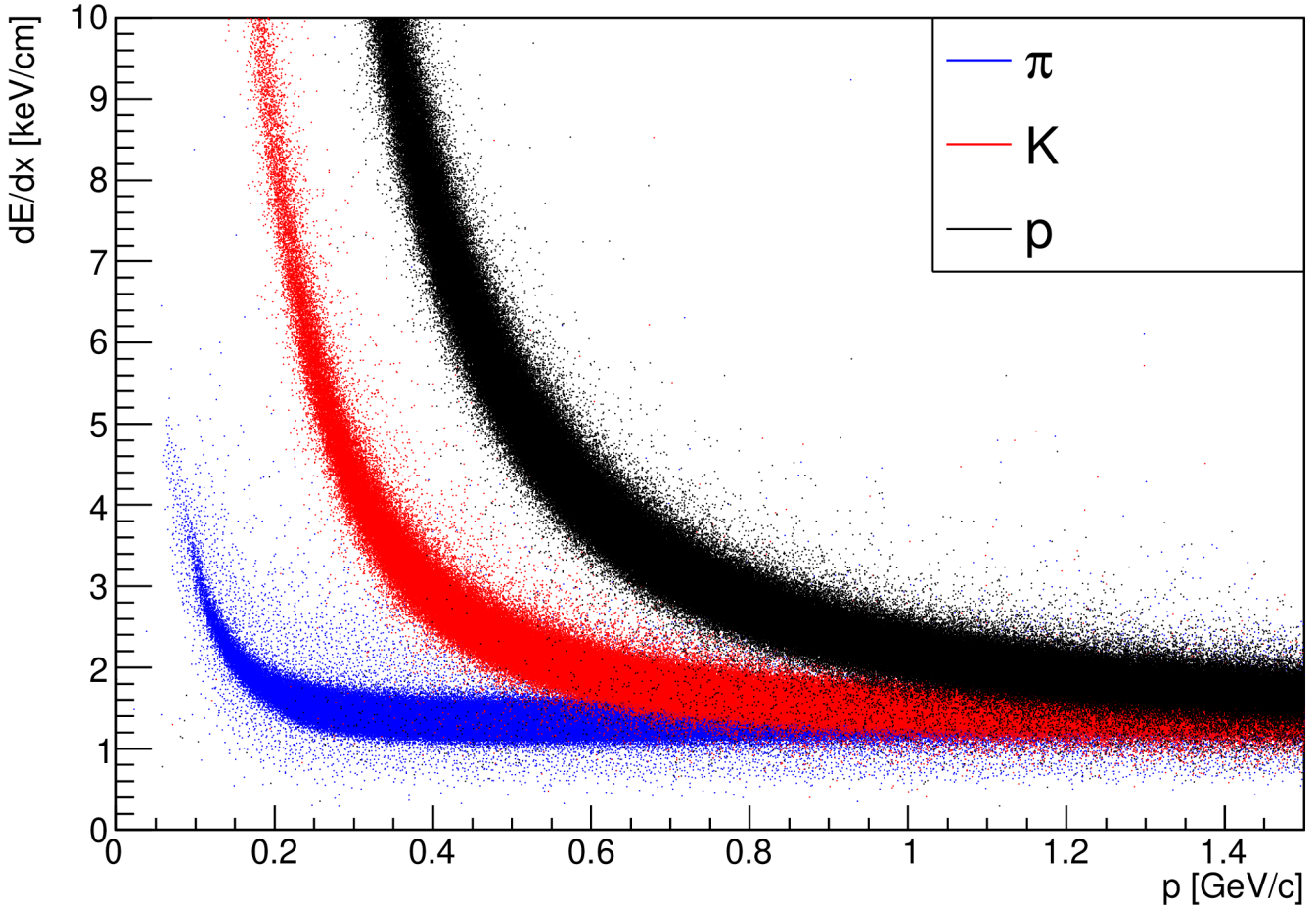
Note on geometry

- During this study, I noticed that I have made a mistake in Straw Tracker Endcap geometry description:

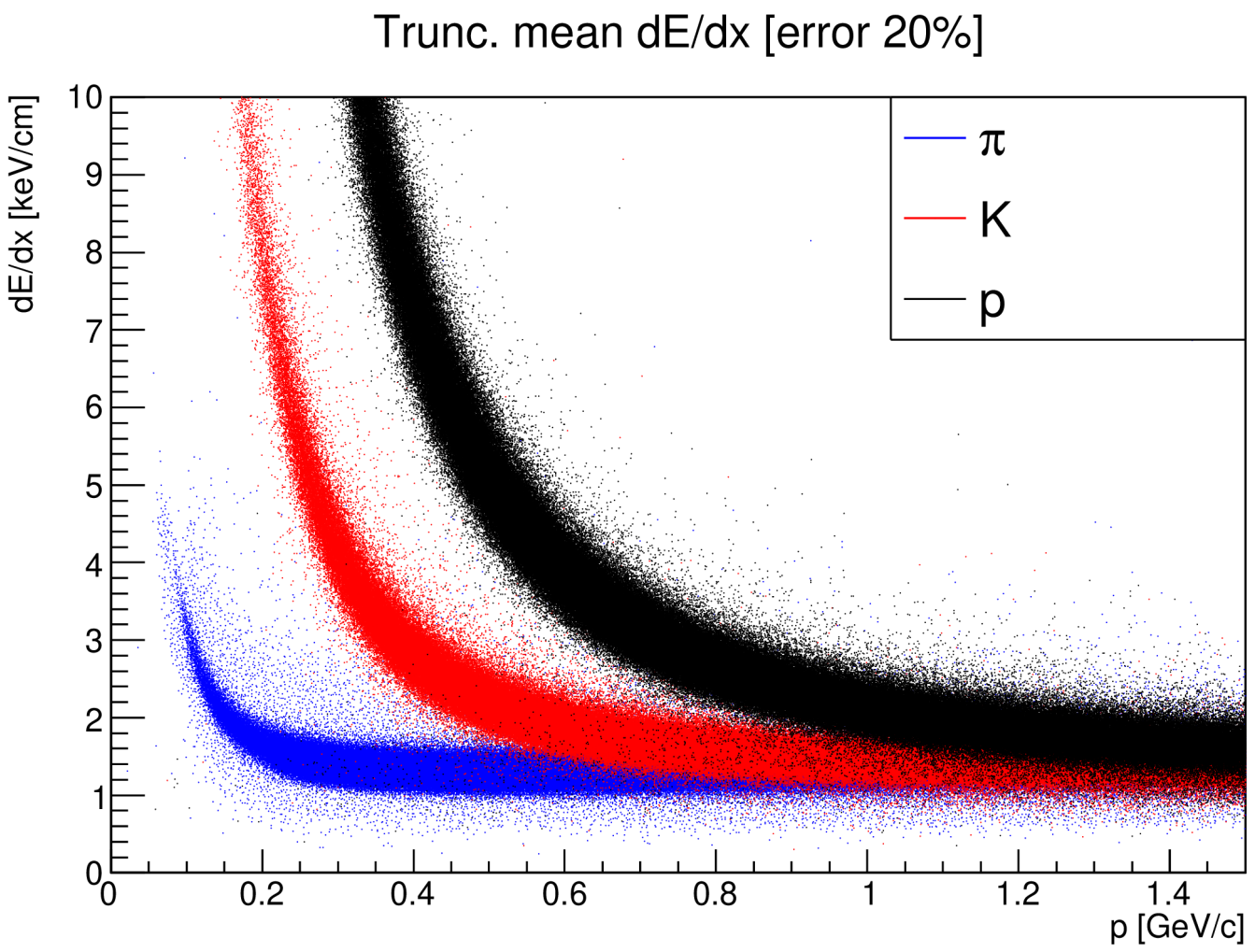
  central gap was 2*150 mm instead of 150 mm.

Impact of experimental error of dE measurement

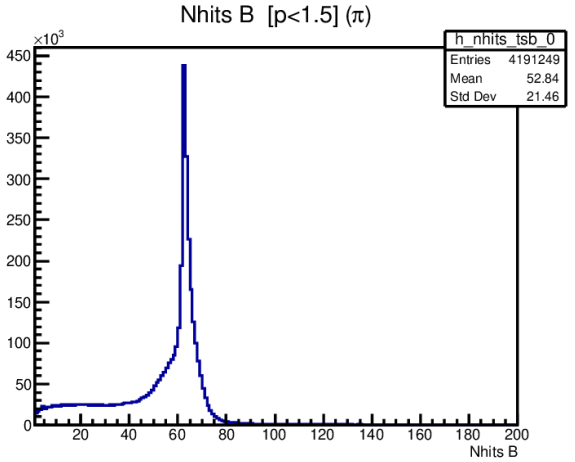
- To estimate the impact of experimental error of dE measurement, in each straw hit MC dE value was smeared according to gaussian distribution with sigma = 20%.
- Distributions of truncated mean dE/dx vs momentum are compared without and with this additional smearing.
- Minimum bias sample, 2M events.
- The following cuts on track quality are applied:
  - convergency = 1;
  - $\chi^2/ndf < 4$;
  - N hits in ST >= 3.

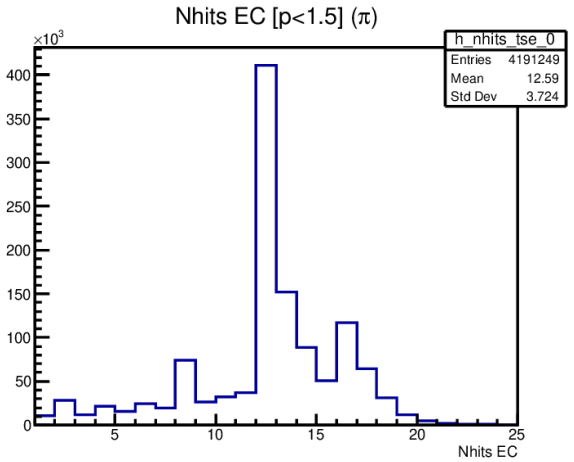


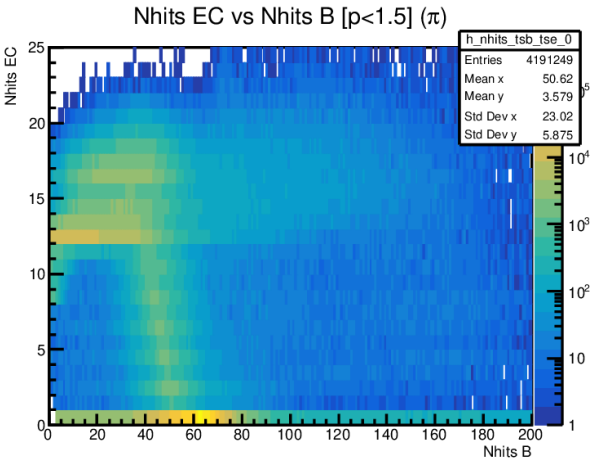
$$\left(p = \frac{p_{first\ state} + p_{last\ state}}{2} \right)$$

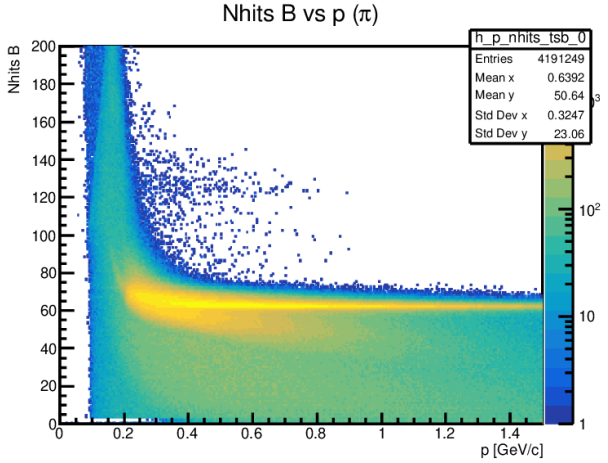

Trunc. mean dE/dx [error 20%]
dE/dx [keV/cm]
p [GeV/c]
π
K
p
0
1
2
3
4
5
6
7
8
9
10
0.2
0.4
0.6
0.8
1
1.2
1.4

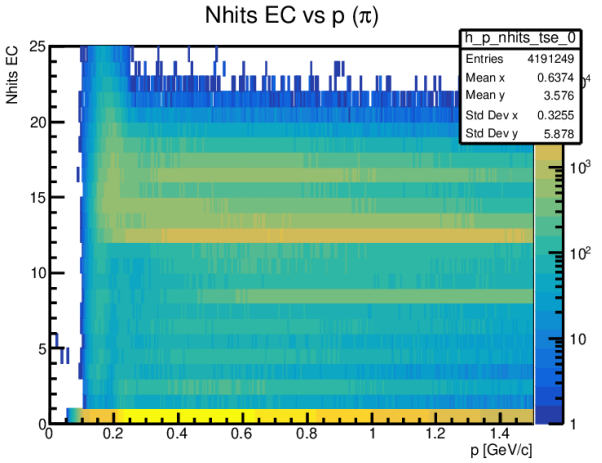
Number of hits distributions

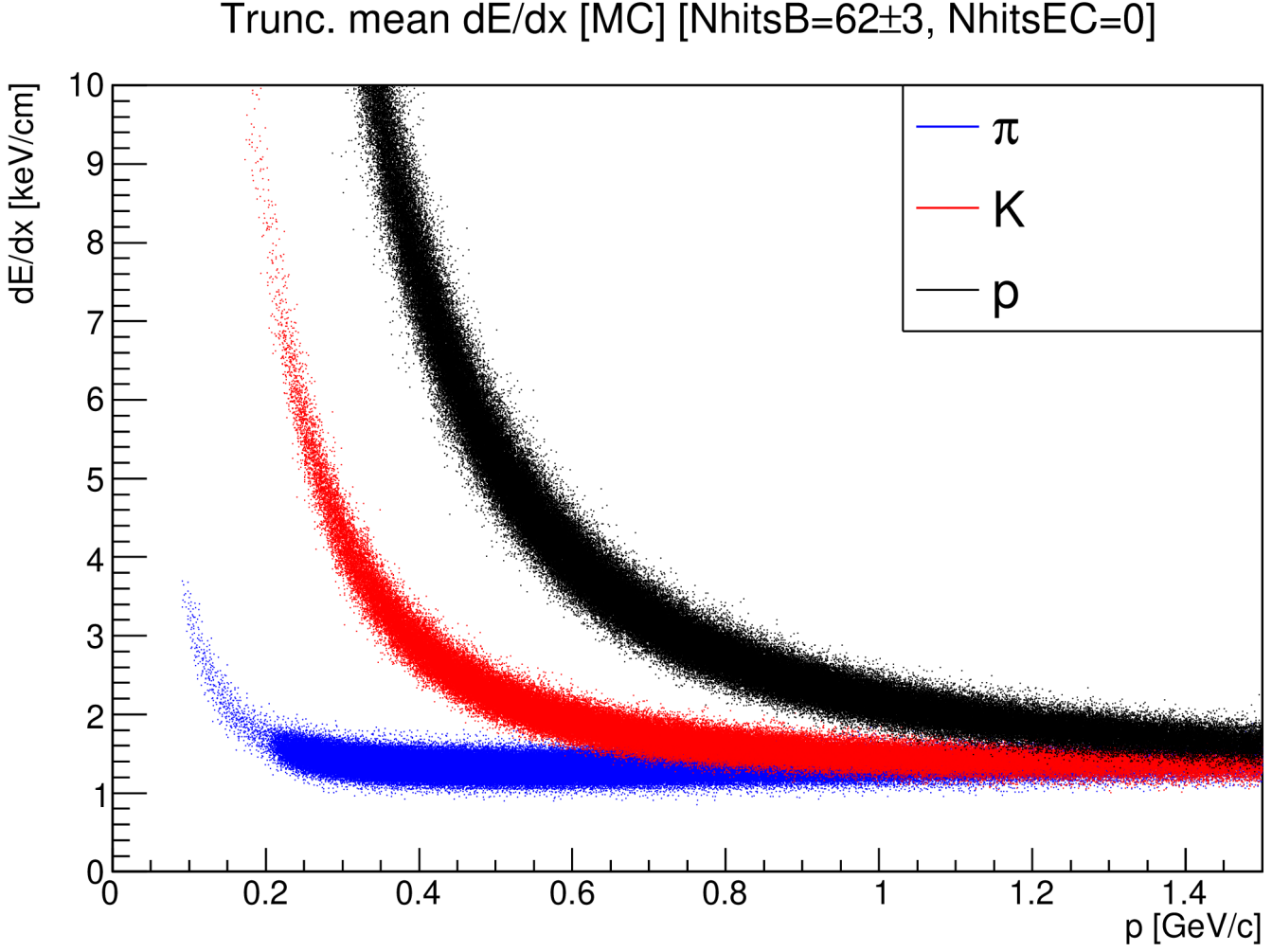


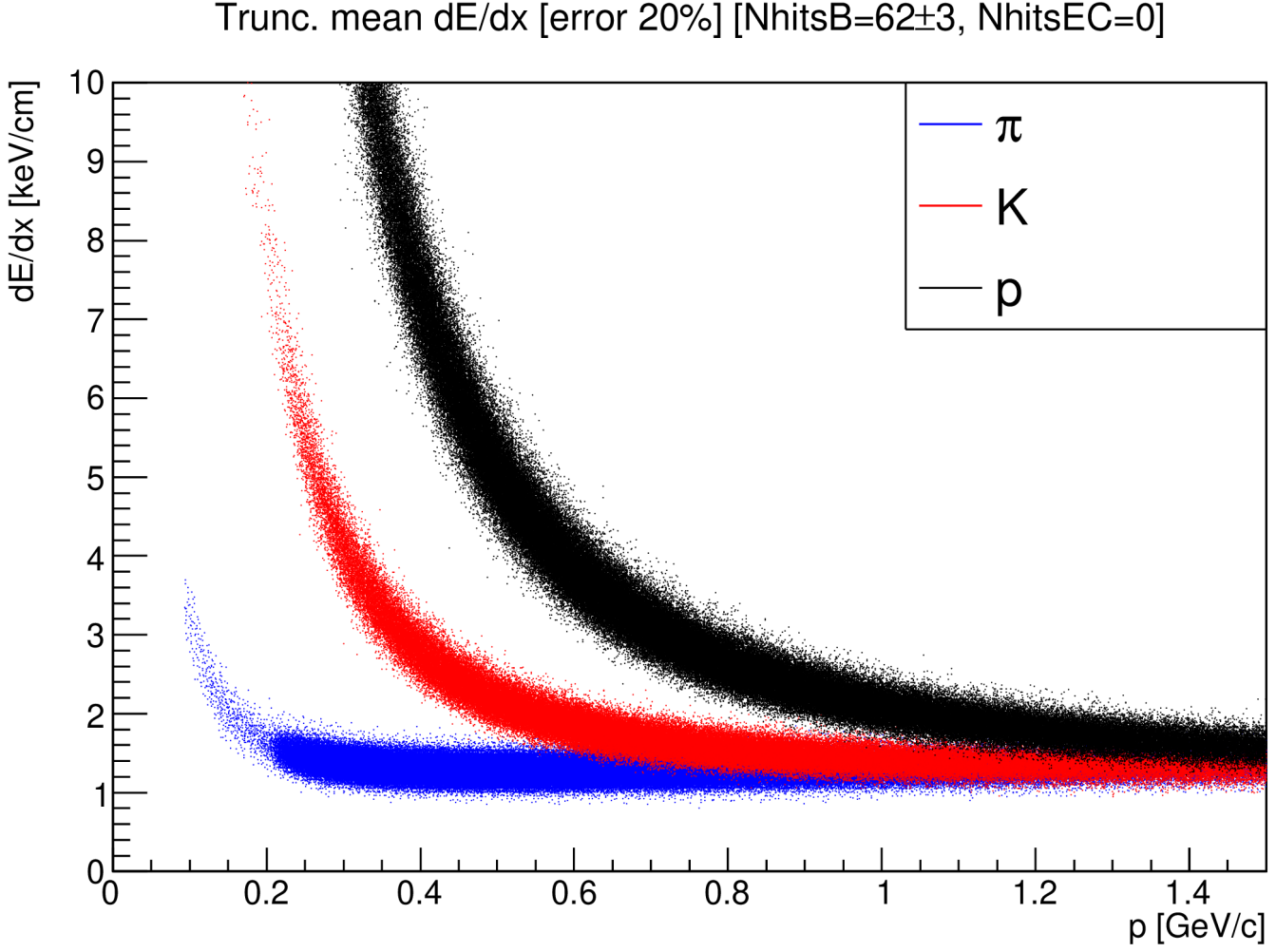






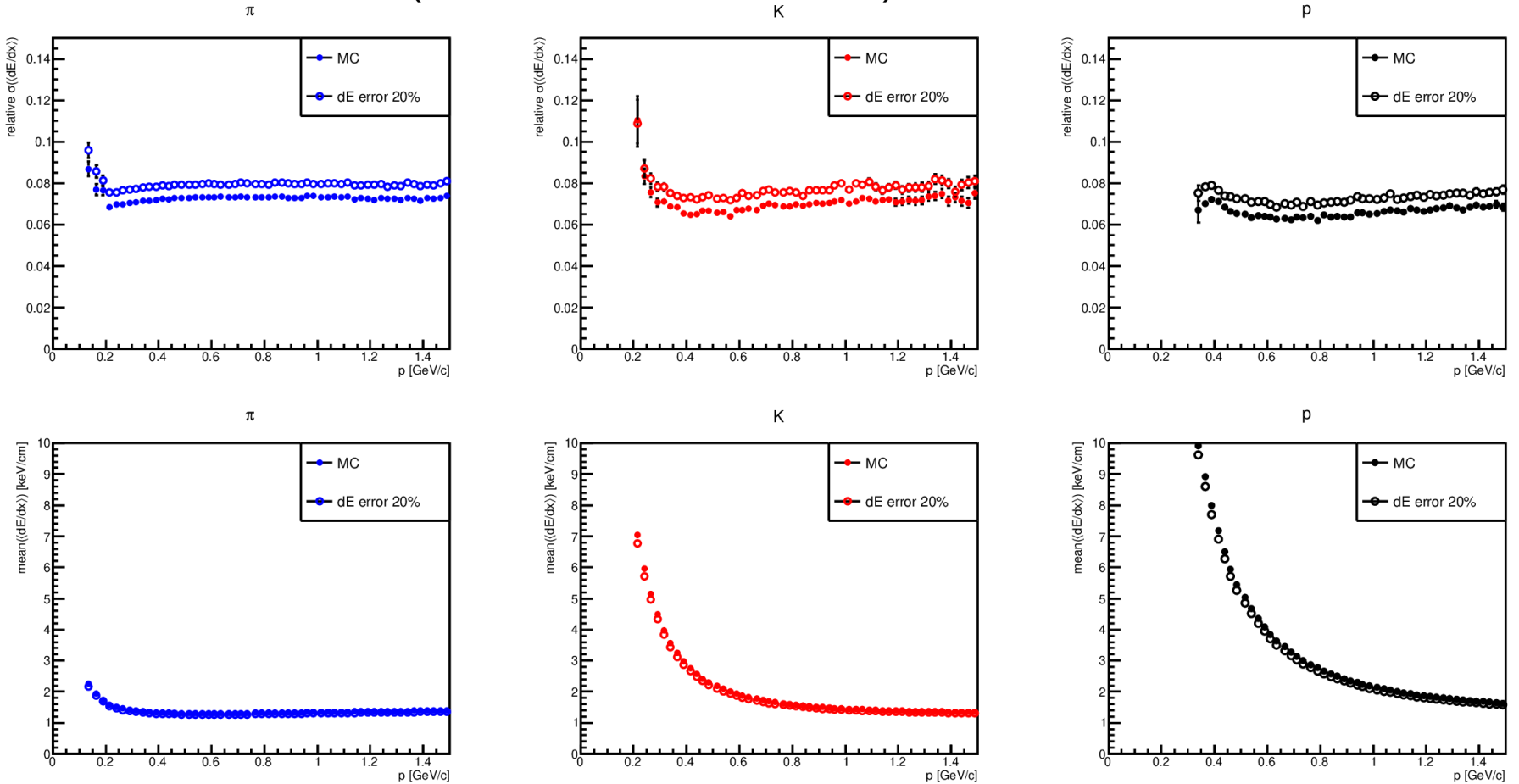



Trunc. mean dE/dx [MC] [NhitsB=62±3, NhitsEC=0]
dE/dx [keV/cm]
p [GeV/c]
π
K
p
0
1
2
3
4
5
6
7
8
9
10
0.2
0.4
0.6
0.8
1
1.2
1.4

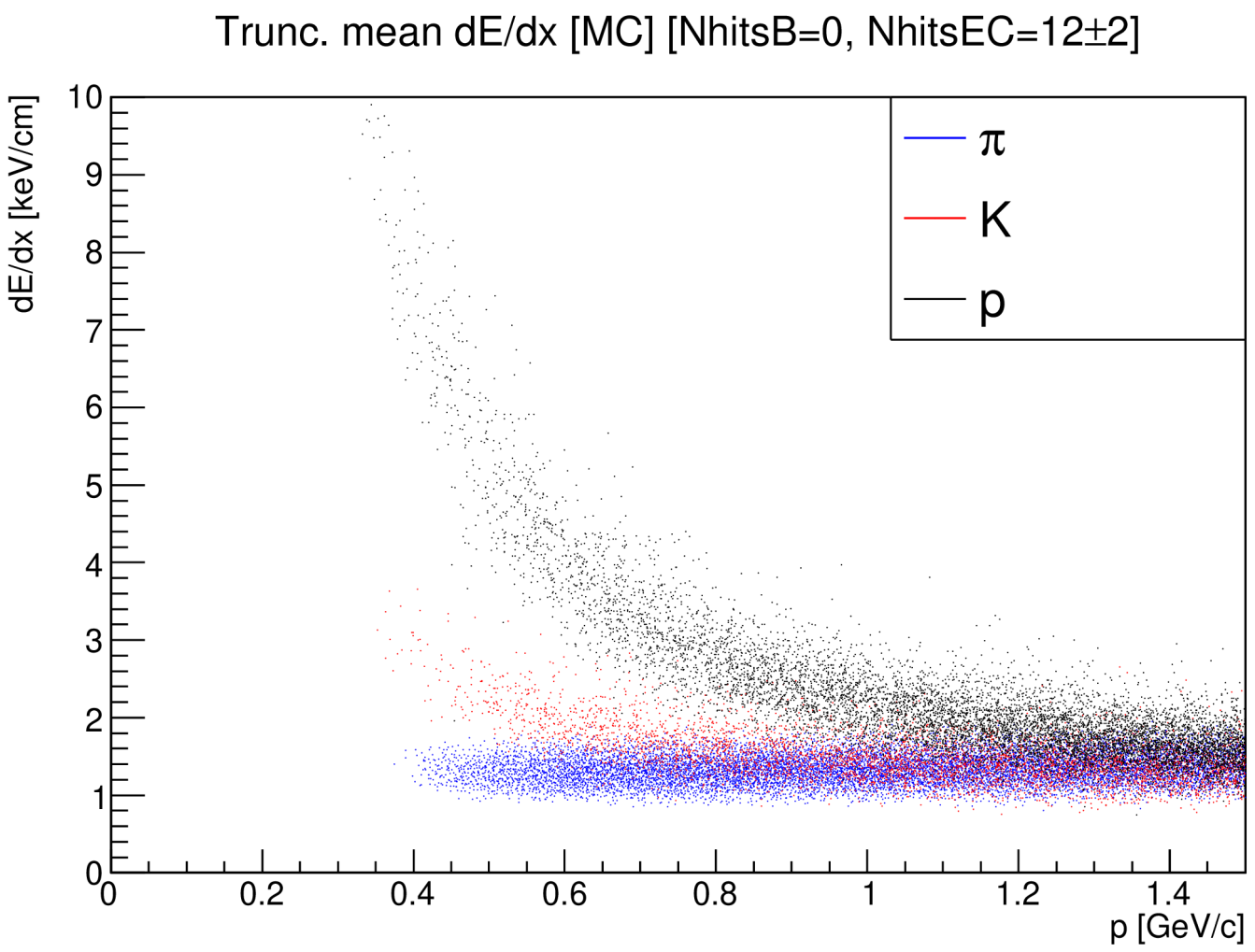

Trunc. mean dE/dx [error 20%] [NhitsB=62±3, NhitsEC=0]
dE/dx [keV/cm]
p [GeV/c]
π
K
p
0
1
2
3
4
5
6
7
8
9
10
0.2
0.4
0.6
0.8
1
1.2
1.4

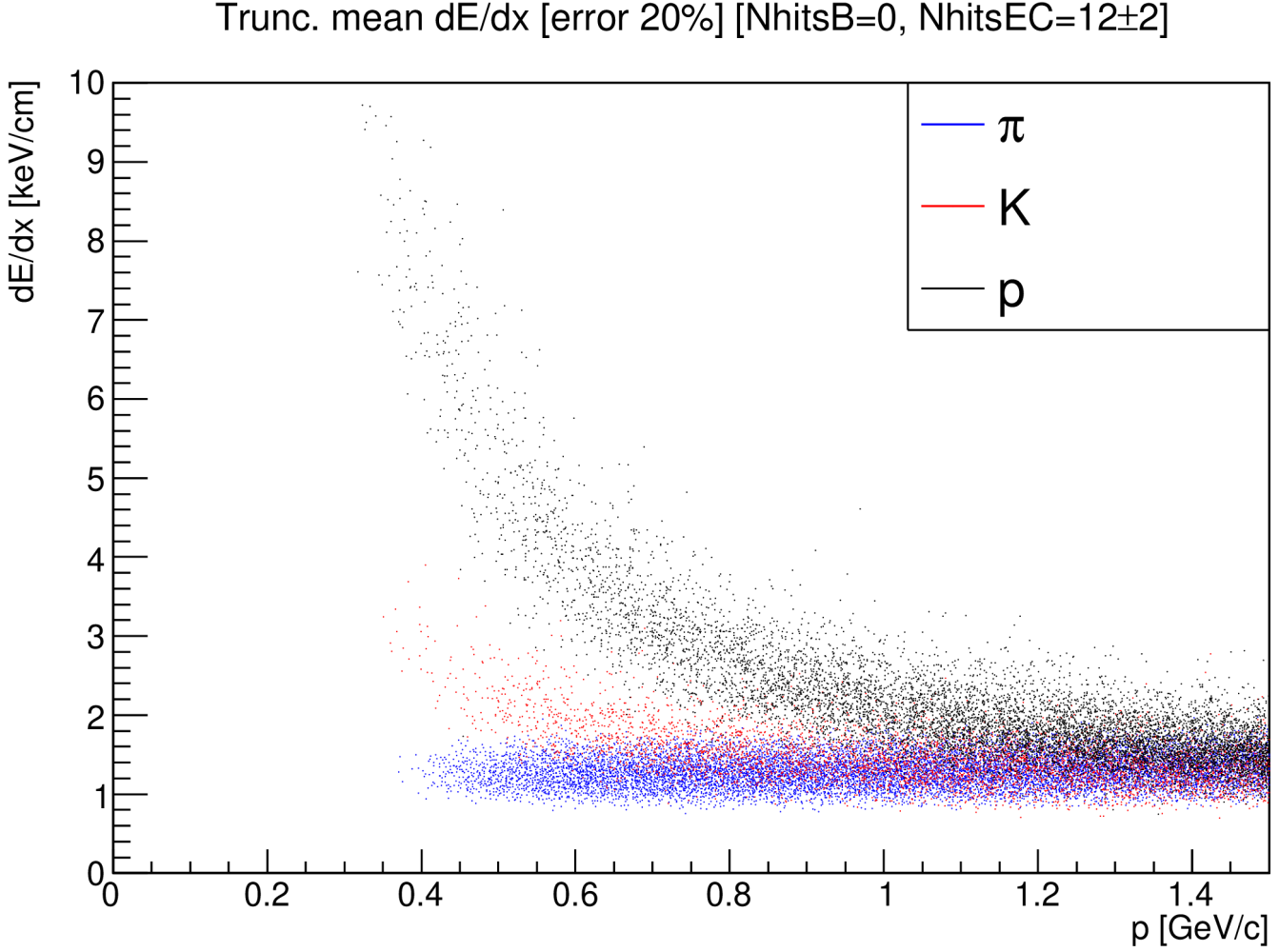
Comparison of mean and relative sigma of truncated mean dE/dx

(Nhits B = 62±2, Nhits EC = 0)



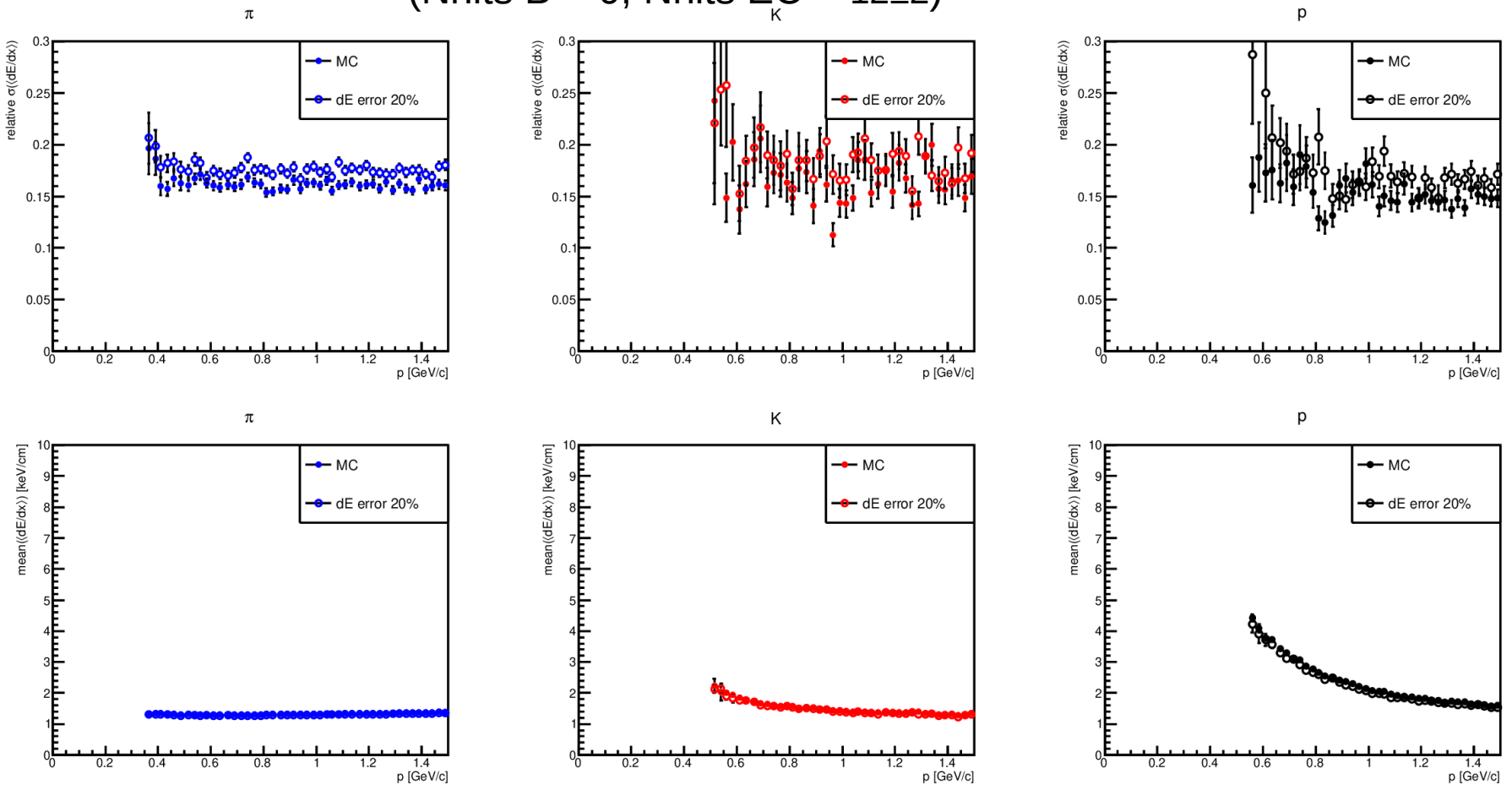
For pions sigma/mean changes from 7.3% to 8%; increase in 1.09 times.


Trunc. mean dE/dx [MC] [NhitsB=0, NhitsEC=12±2]
dE/dx [keV/cm]
p [GeV/c]
π
K
p
0
1
2
3
4
5
6
7
8
9
10
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Trunc. mean dE/dx [error 20%] [NhitsB=0, NhitsEC=12±2]
dE/dx [keV/cm]
p [GeV/c]
π
K
p
0
1
2
3
4
5
6
7
8
9
10
0
0.2
0.4
0.6
0.8
1
1.2
1.4

Comparison of mean and relative sigma of truncated mean dE/dx

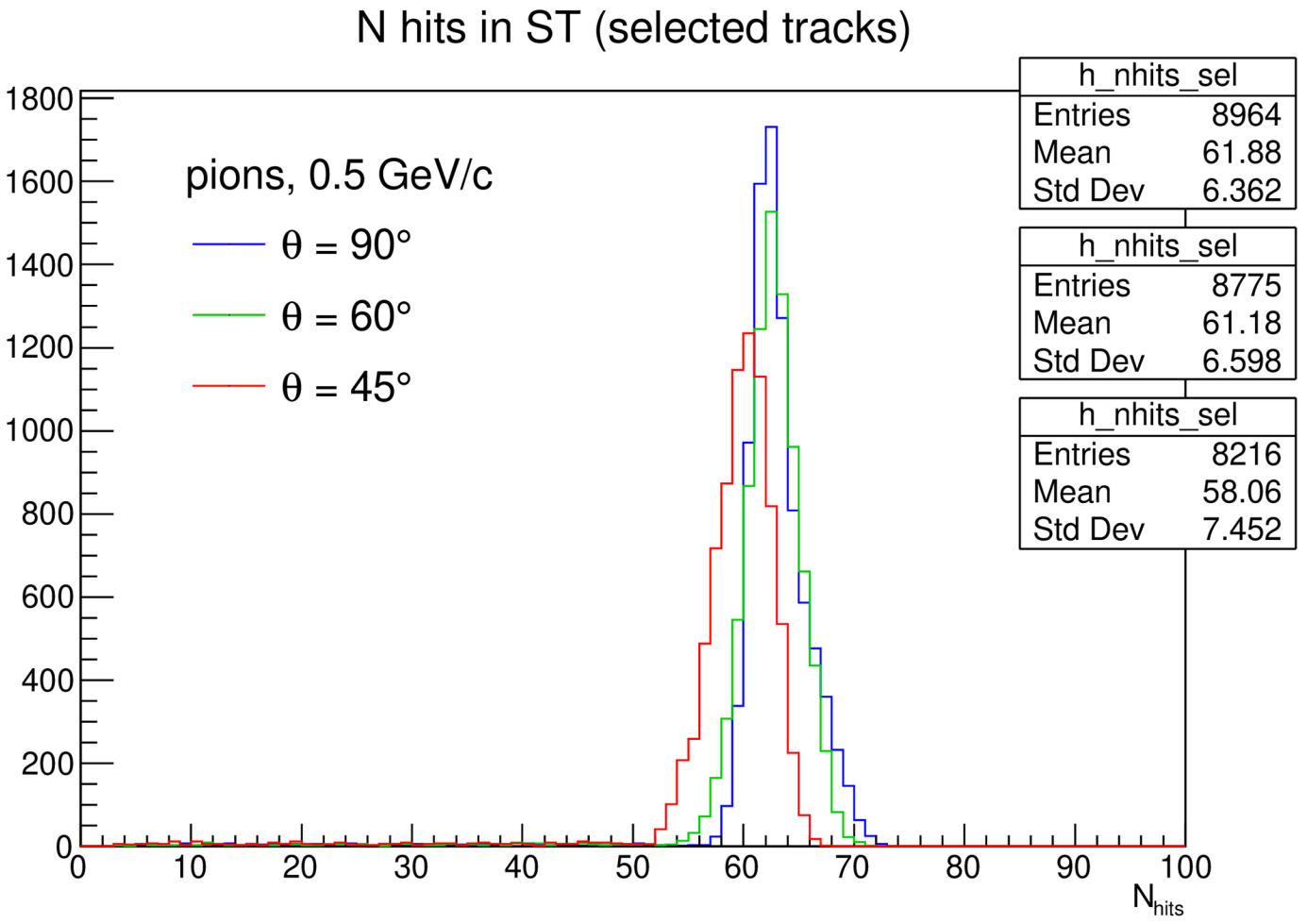
(Nhits B = 0, Nhits EC = 12±2)

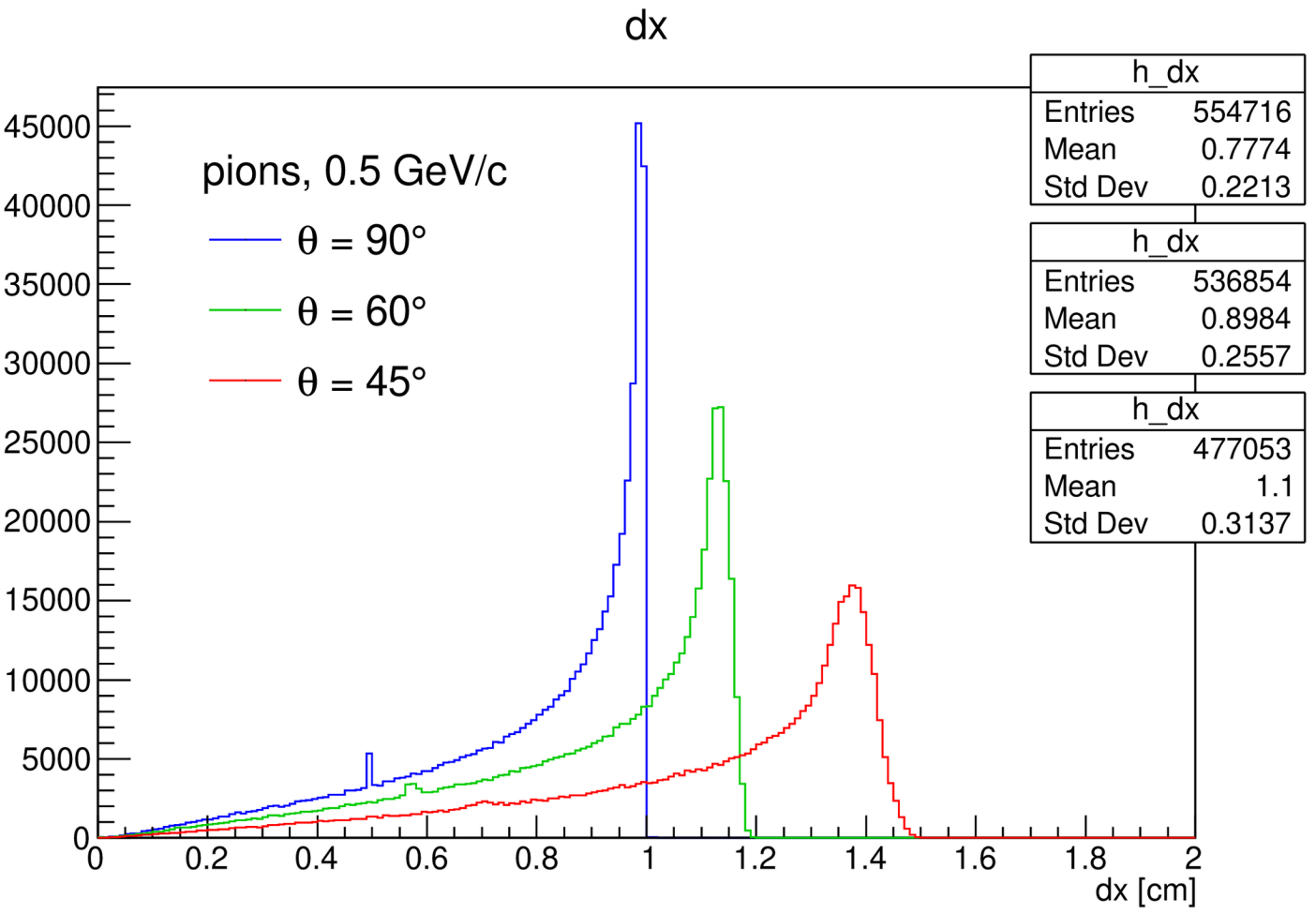


For pions sigma/mean changes from 16% to 17.5%; increase in 1.09 times.

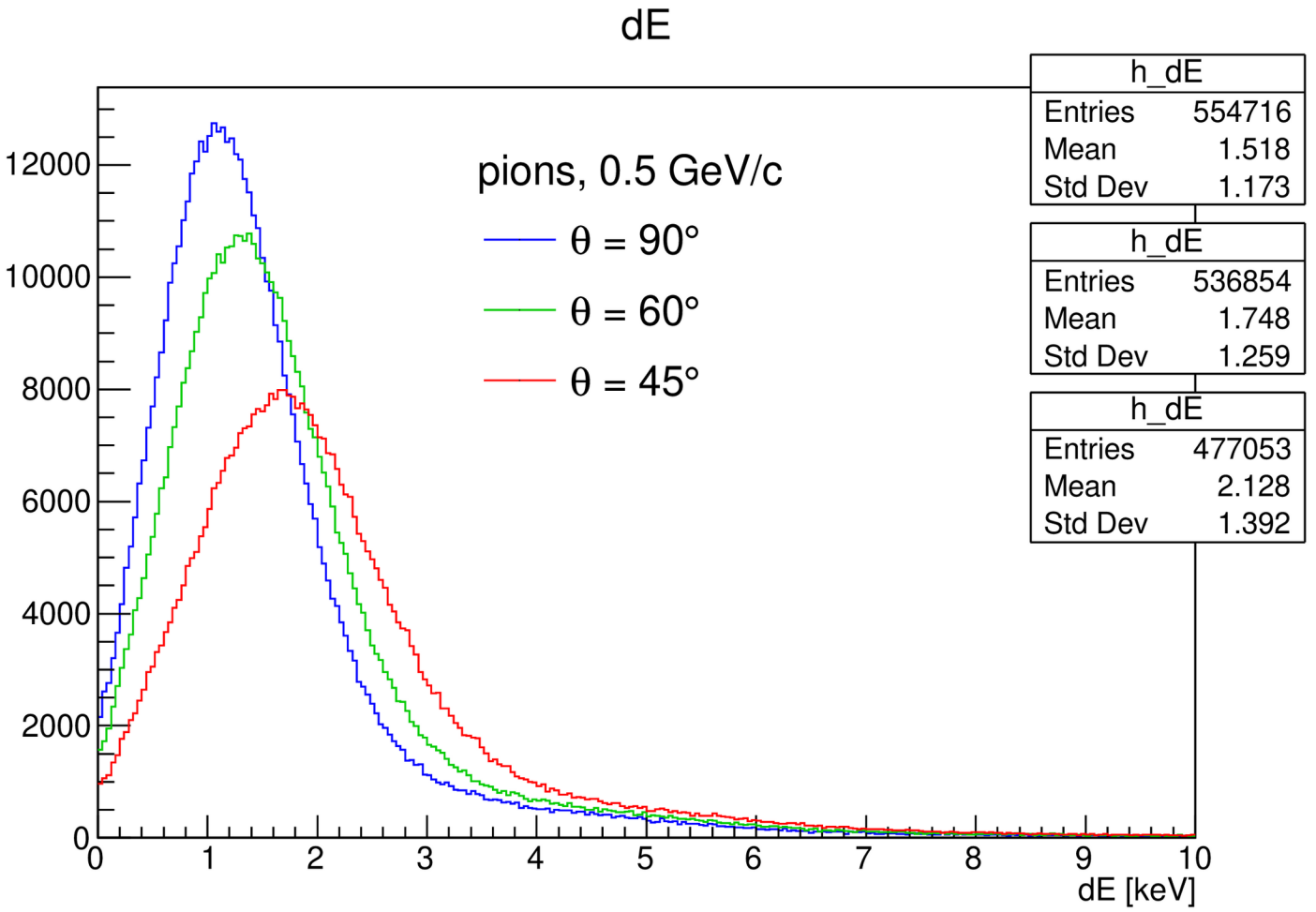
dE/dx for tracks with different values of θ

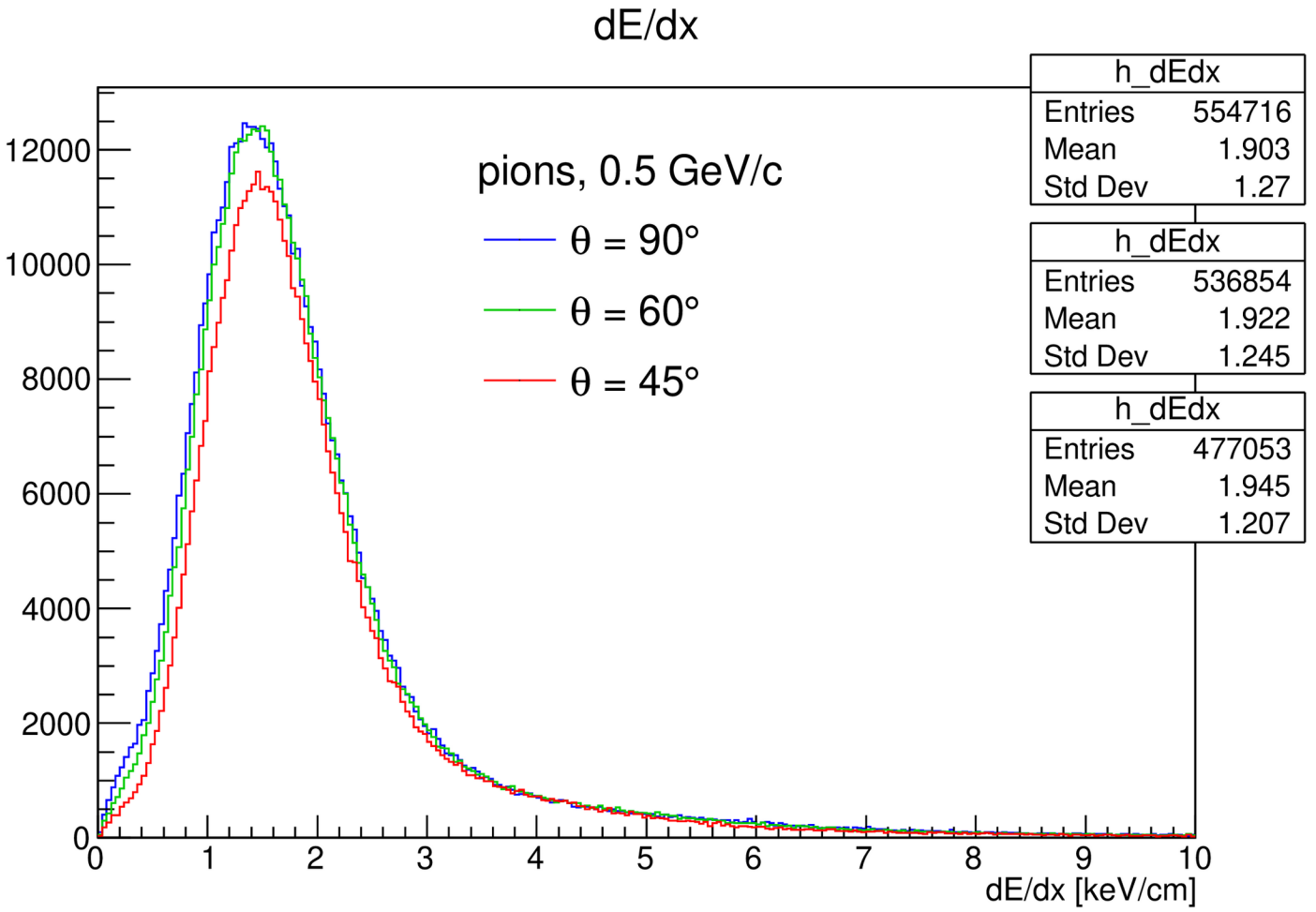
- For each type of particle (π, K, p) three artificial samples were prepared:
  - θ = 90°±1°, 60°±1°, 45°±1°;
  - initial momentum = 0.5 GeV/c;
  - φ = 0° .. 1°;
  - vertex in (0,0,0);
  - 10 000 particles in each sample.
- For such values of θ average number of hits is approximately the same.
- The same cuts on track quality as mentioned above were applied.

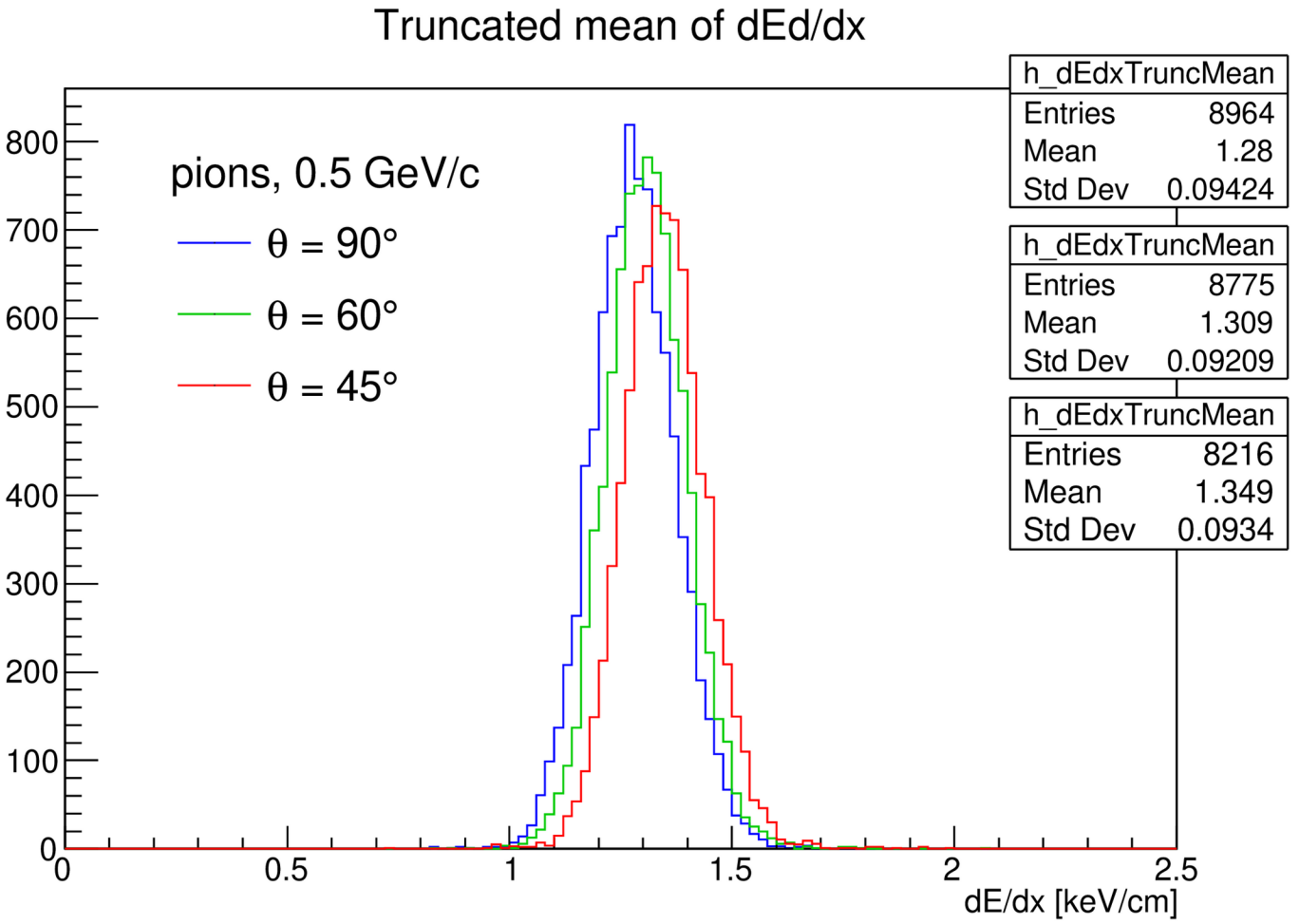

N hits in ST (selected tracks)
pions, 0.5 GeV/c
θ = 90°
θ = 60°
θ = 45°
h_nhits_sel
Entries 8964
Mean 61.88
Std Dev 6.362
h_nhits_sel
Entries 8775
Mean 61.18
Std Dev 6.598
h_nhits_sel
Entries 8216
Mean 58.06
Std Dev 7.452
1800
1600
1400
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
90
100
N_hits



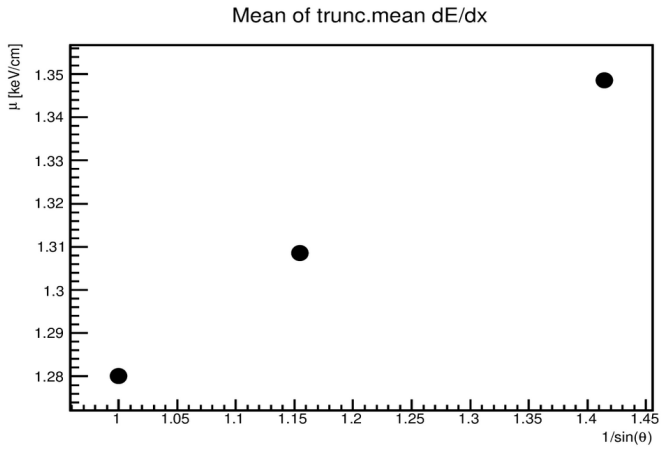
Max. dx corresponds to 1/sin(θ) cm.

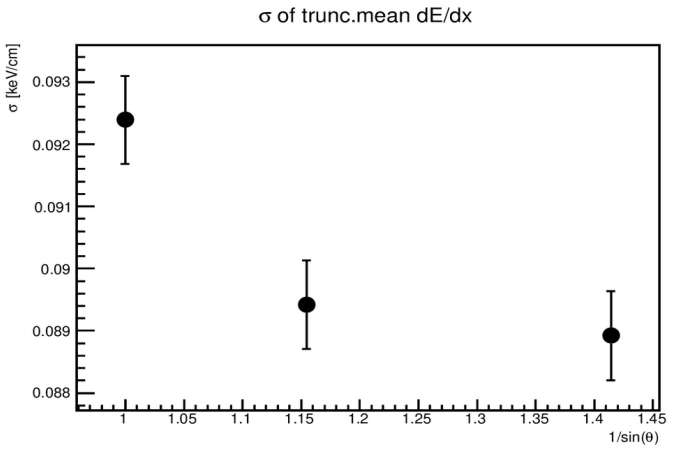

dE
pions, 0.5 GeV/c
θ = 90°
θ = 60°
θ = 45°
h_dE
Entries 554716
Mean 1.518
Std Dev 1.173
h_dE
Entries 536854
Mean 1.748
Std Dev 1.259
h_dE
Entries 477053
Mean 2.128
Std Dev 1.392
12000
10000
8000
6000
4000
2000
0
0 1 2 3 4 5 6 7 8 9 10
dE [keV]

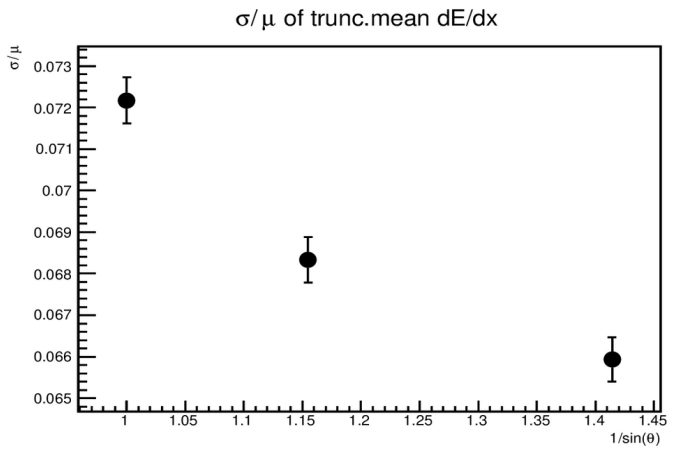

dE/dx
pions, 0.5 GeV/c
θ = 90°
θ = 60°
θ = 45°
h_dEdx
Entries 554716
Mean 1.903
Std Dev 1.27
h_dEdx
Entries 536854
Mean 1.922
Std Dev 1.245
h_dEdx
Entries 477053
Mean 1.945
Std Dev 1.207
12000
10000
8000
6000
4000
2000
0
0 1 2 3 4 5 6 7 8 9 10
dE/dx [keV/cm]

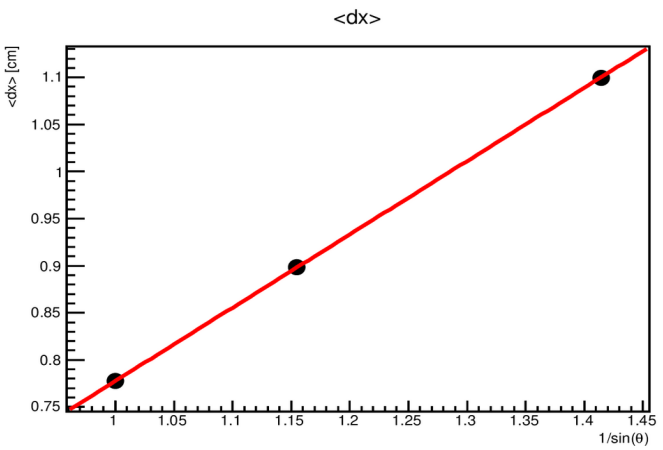

Truncated mean of dEd/dx
pions, 0.5 GeV/c
θ = 90°
θ = 60°
θ = 45°
h_dEdxTruncMean
Entries 8964
Mean 1.28
Std Dev 0.09424
h_dEdxTruncMean
Entries 8775
Mean 1.309
Std Dev 0.09209
h_dEdxTruncMean
Entries 8216
Mean 1.349
Std Dev 0.0934
800
700
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
dE/dx [keV/cm]

Pions, p_0 = 0.5 GeV/c



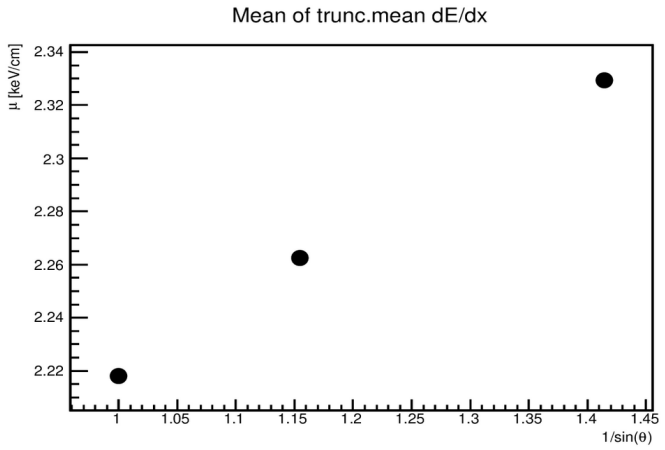


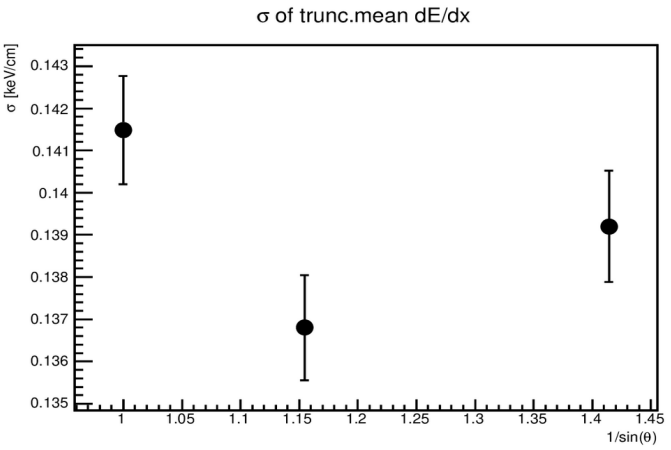


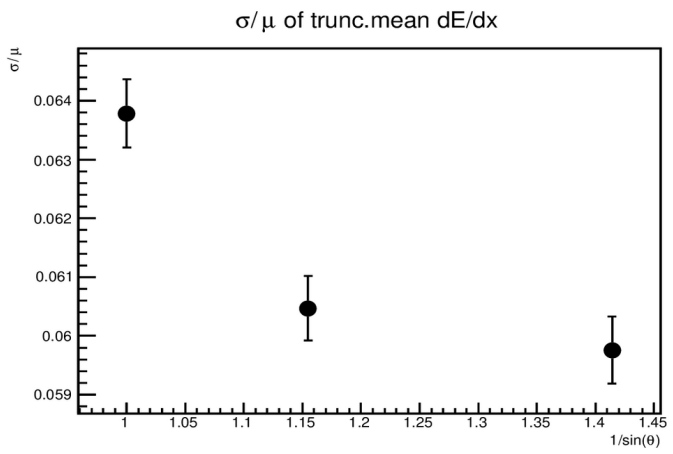


Mean changes by 5.4% when dx changes by 41%.

Kaons, p_0 = 0.5 GeV/c

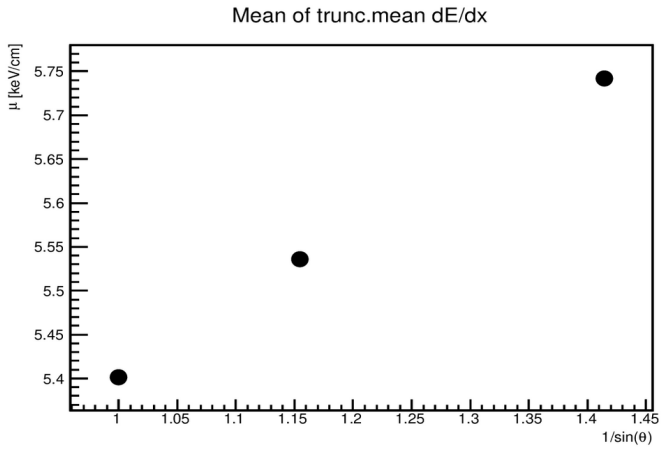


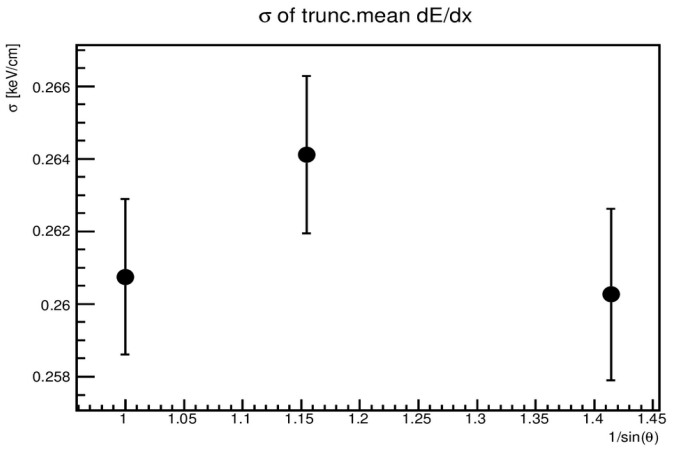


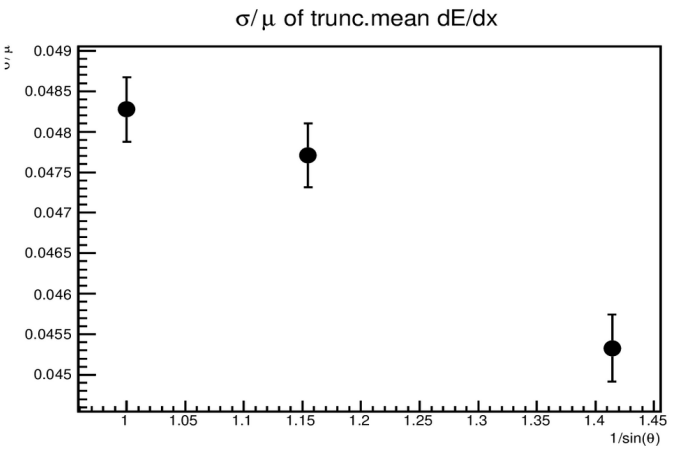


Mean changes by 5.1% when dx changes by 41%.

Protons, p_0 = 0.5 GeV/c







Mean changes by 6.3% when dx changes by 41%.

Conclusions

- Additional 20% error of dE measurement leads to an increase in relative sigma of dE/dx by a factor of 1.1.
- Mean dE/dx increases as dx increases.
- Errors in determining dx have not yet been taken into account.