JÜLICH
FORSCHUNGSZENTRUM

p a n d a

Measurement of the spatial and energy-loss resolution with a prototype Straw Tube Tracker (STT) for the $\bar{P}$ANDA experiment

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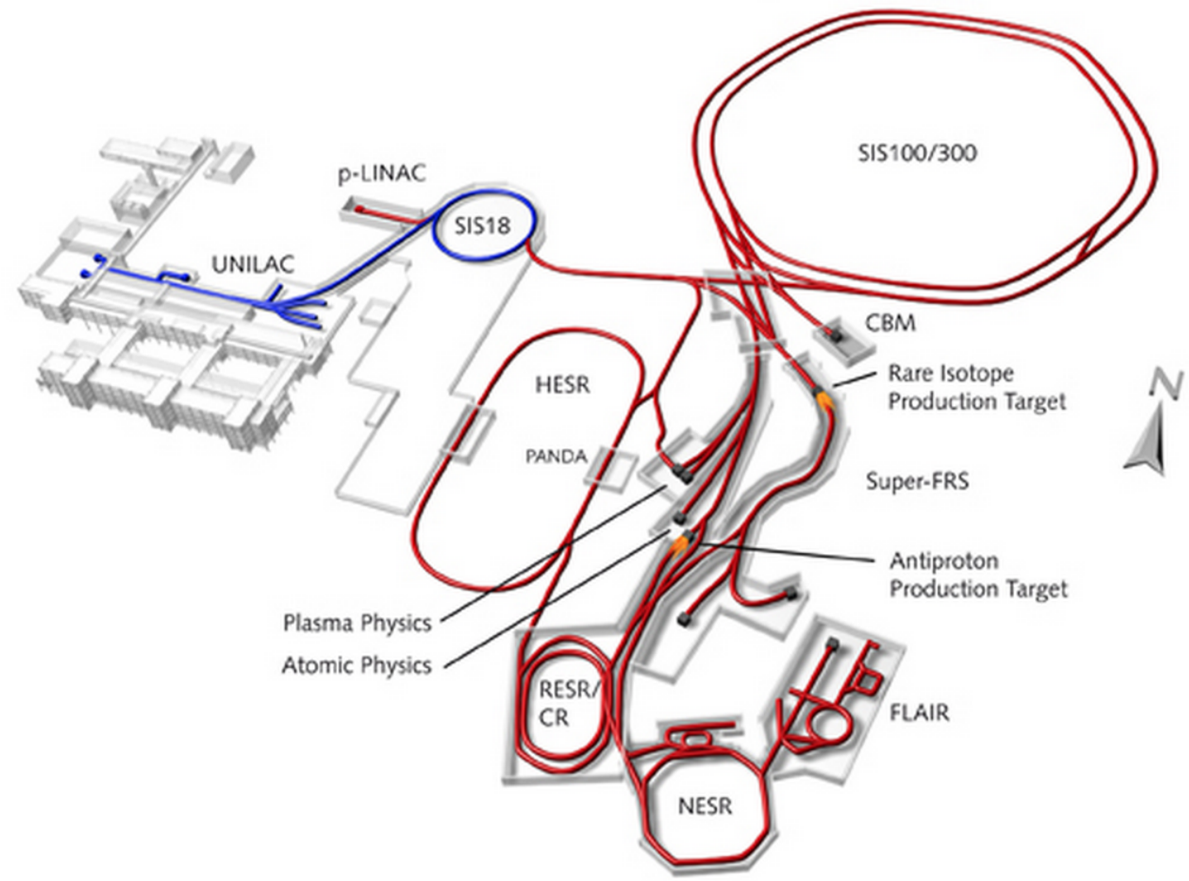
P̄ANDA experiment

P̄ANDA (antiProton ANnihilation at DArmstadt)

Study of the non-pertubative regime and understanding of the QCD spectrum and hadron structure

- One of the key projects at the future Facility for Antiproton and Ion Research (FAIR)
- State-of-the-art general purpose detector
- Precise studies of antiproton-proton annihilations and reactions of antiprotons with heavy nuclear targets
- Centre-of-mass energy between 2.3 GeV and 5.5 GeV



<u>HESR (High Energy Storage Ring)</u>

- Luminosity: 10^{31} - 10^{32} cm^{-2} s^{-1}
- $\Delta p/p$: $4*10^{-5}$ - 10^{-4}

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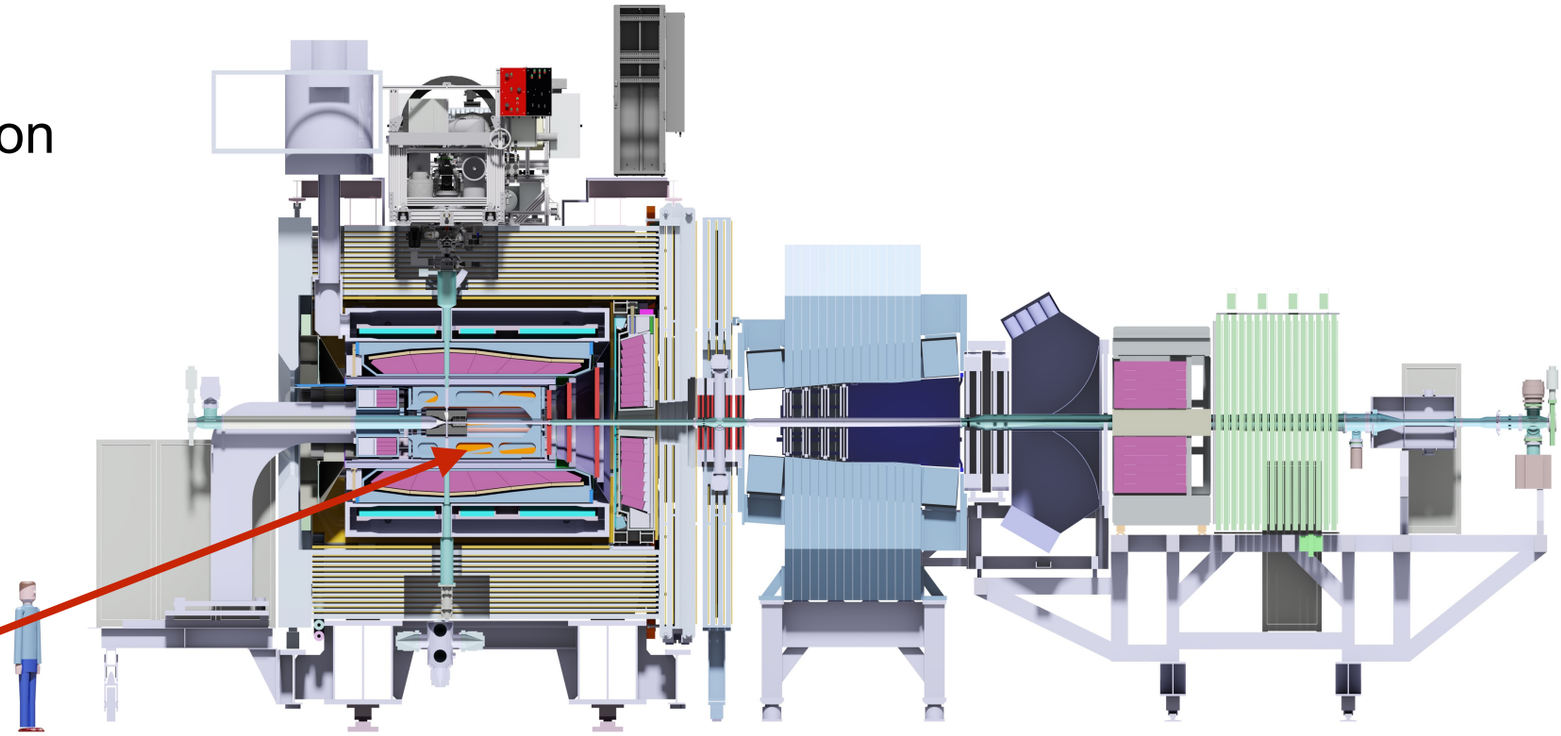
P̄ANDA detector

- 4π acceptance
- High resolution for tracking and particle identification
- High event rate capabilities
- Flexible readout and event selection



Several sub- systems

Tracking detectors (STT, MVD , GEM)

Electromagnetic calorimeters (EMC)

Muon detectors

Cherenkov detectors (DIRC and RICH)

Time-of-flight (TOF) detectors

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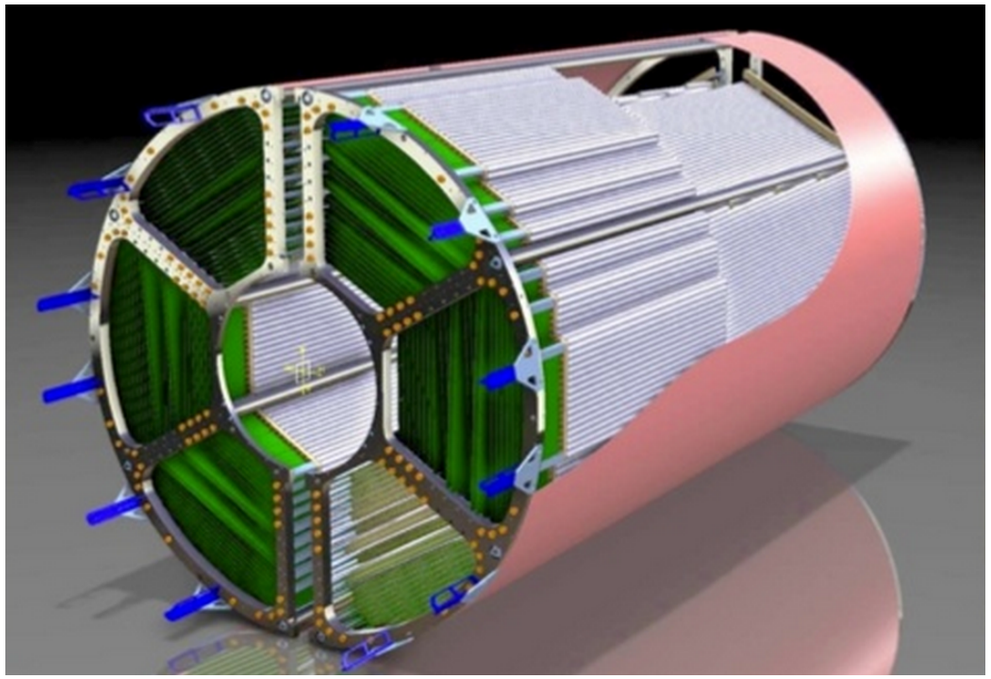
STT specifications

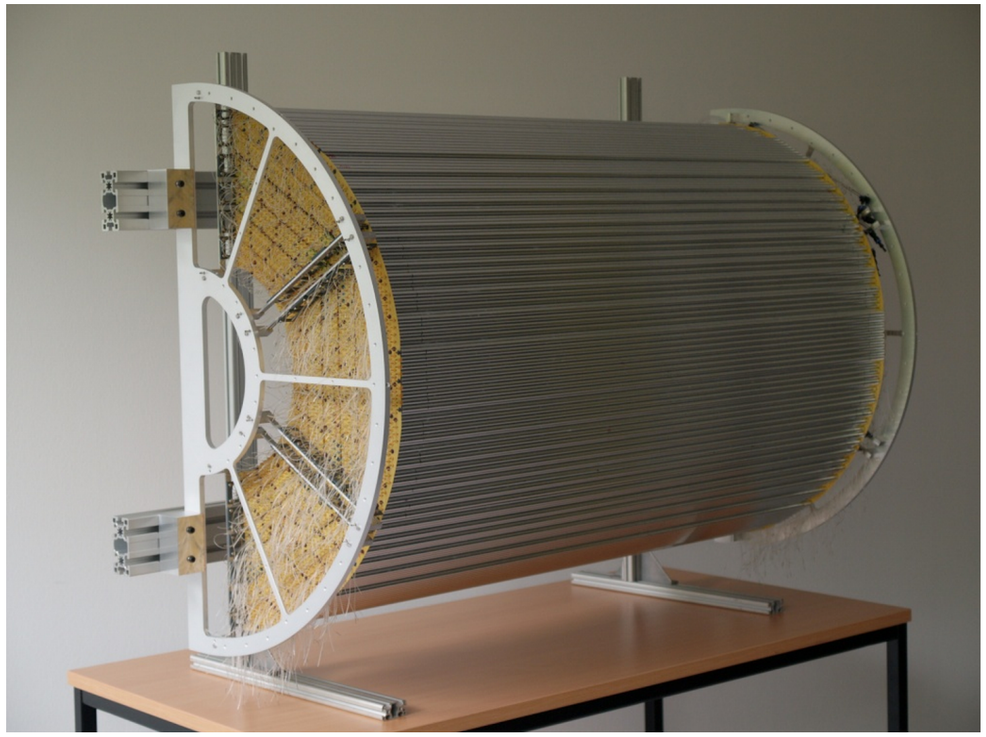
4636 aluminised Mylar tubes

≥ 27 layers of which the 8 central ones are skewed

Single anode wire in the centre made of 20 μm thick gold plated tungsten

90% Ar and 10% CO_2 as quencher





Tasks of STT:

Precise spatial reconstruction of helical trajectories of particles with few 100 MeV/c up to 8 GeV/c

Measurement of the specific energy-loss (dE/dx) for particle identification (separation of protons, kaons and pions in the momentum region below 1 GeV/c)

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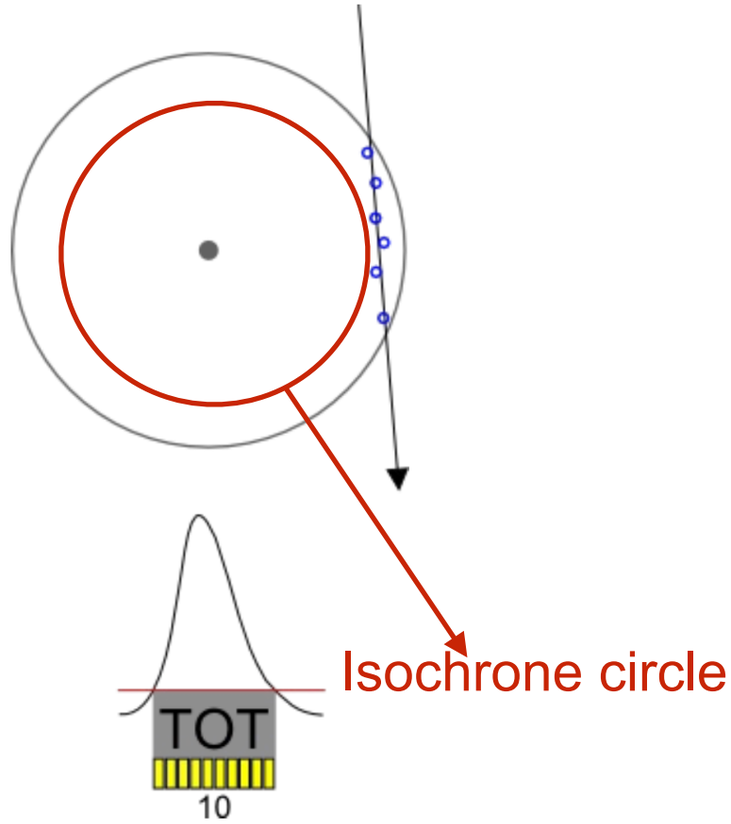
Channel readout

An Application Specific Integrated Circuit (ASIC)
is being developed to read out the straw tube pulses.

<u>Two concepts to measure drift time + signal amplitude (for dE/dx):</u>

- Sampling: Leading Edge Time, Q (for PID)
  - Amplifier-shaper boards front-end at detector
  - Pulse analysis and readout by FPGA

- Time Over Threshold (TOT): Leading Edge Time + Trailing Edge Time, TOT (for PID)
  - Amplifier-Shaper-Discriminator front-end at detector
  - Time Readout Boards (TRB), Time to Digital Converter in FPGA



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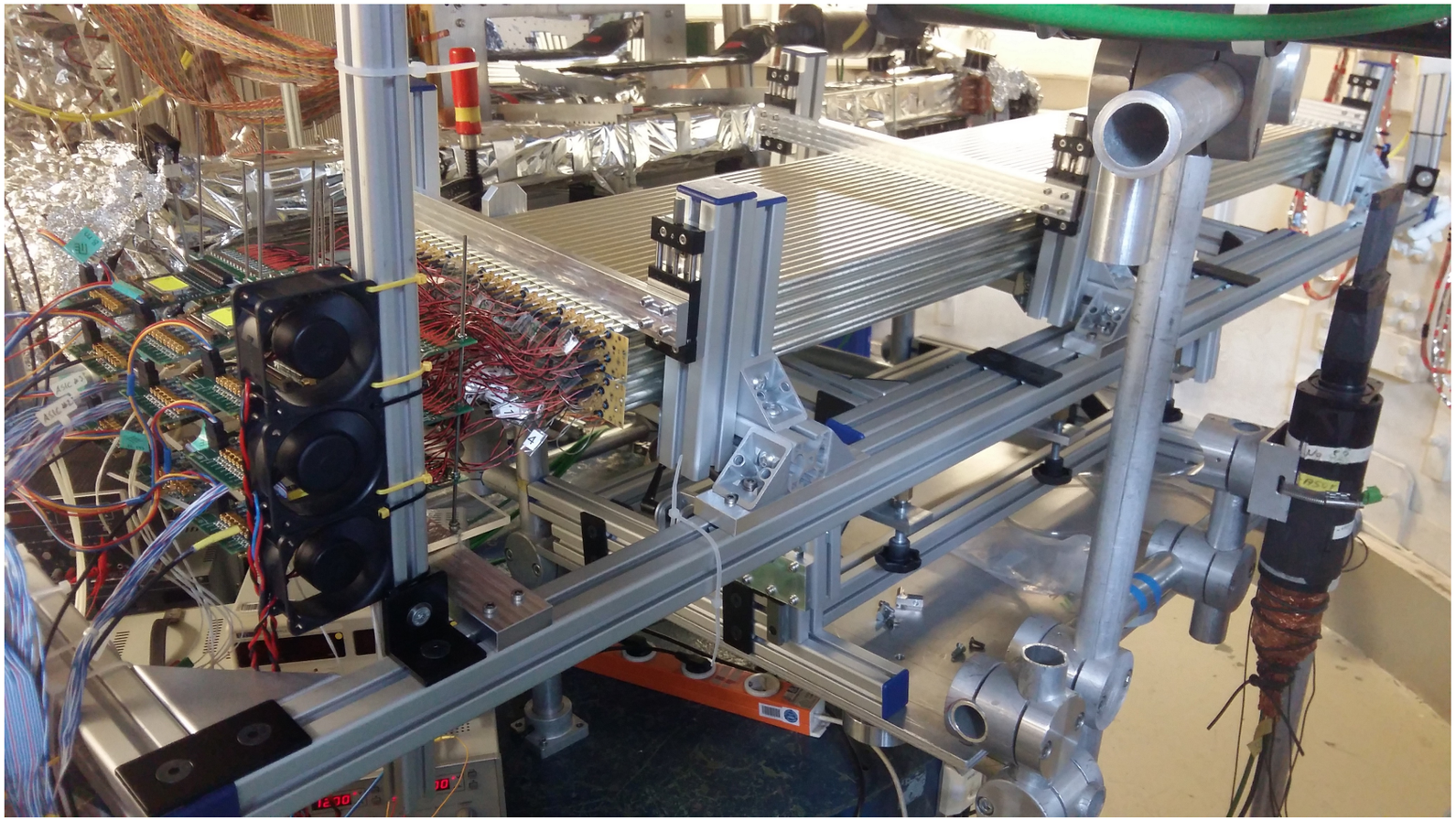
Test beam measurements

Proton beam with 0.8, 1.0, 1.3, 2.0 GeV/c momenta

Beam intensity ranging from 80 kHz to 200kHz

96 channels readout

Voltages: 1700, 1750, 1800, 1850, 1900 V



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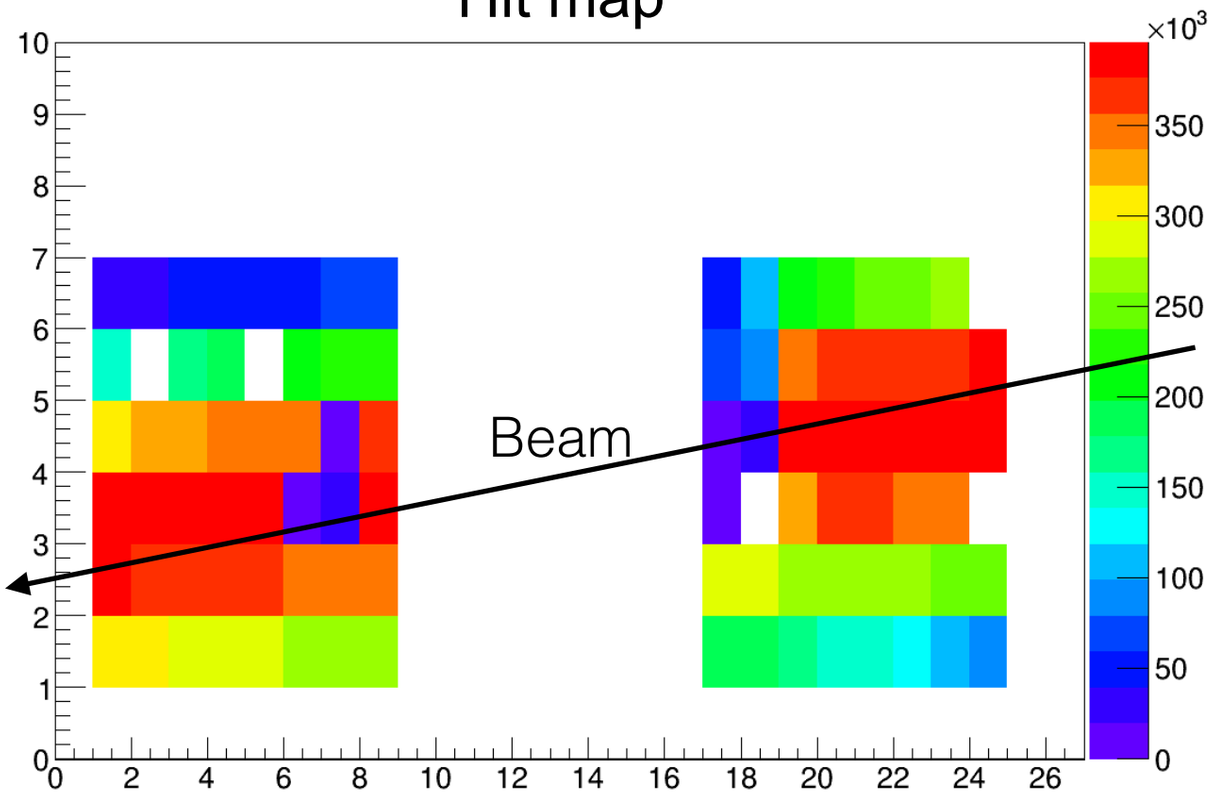
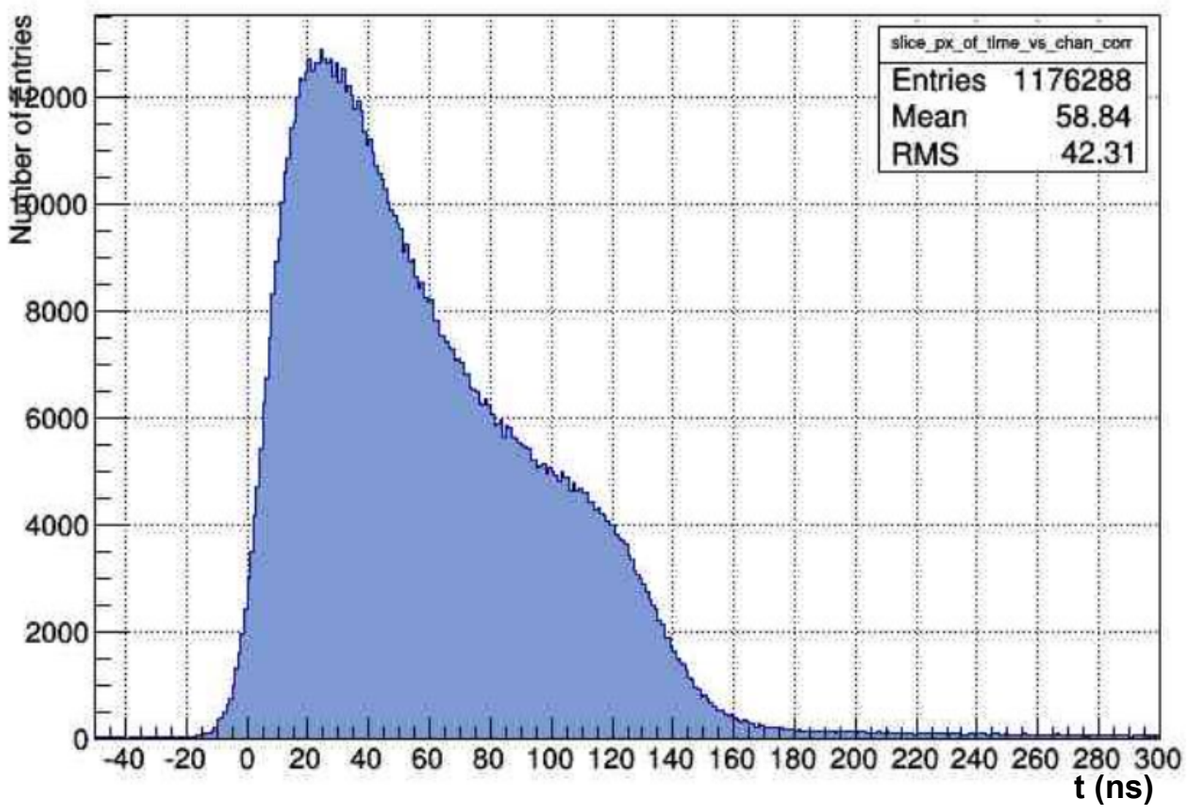
2 GeV/c data

Hit map



Typically 12 hits per event

Drift time spectrum



Drift times: ~160 nsec

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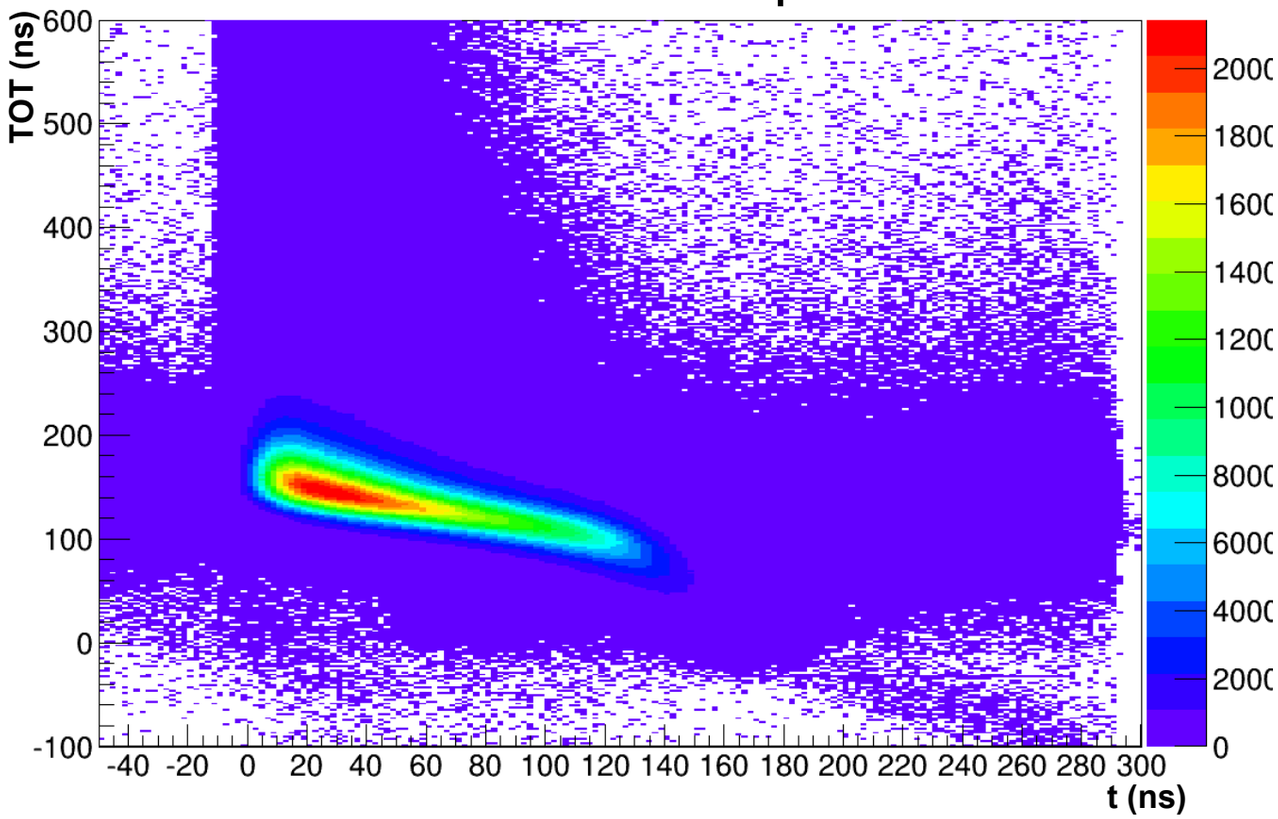
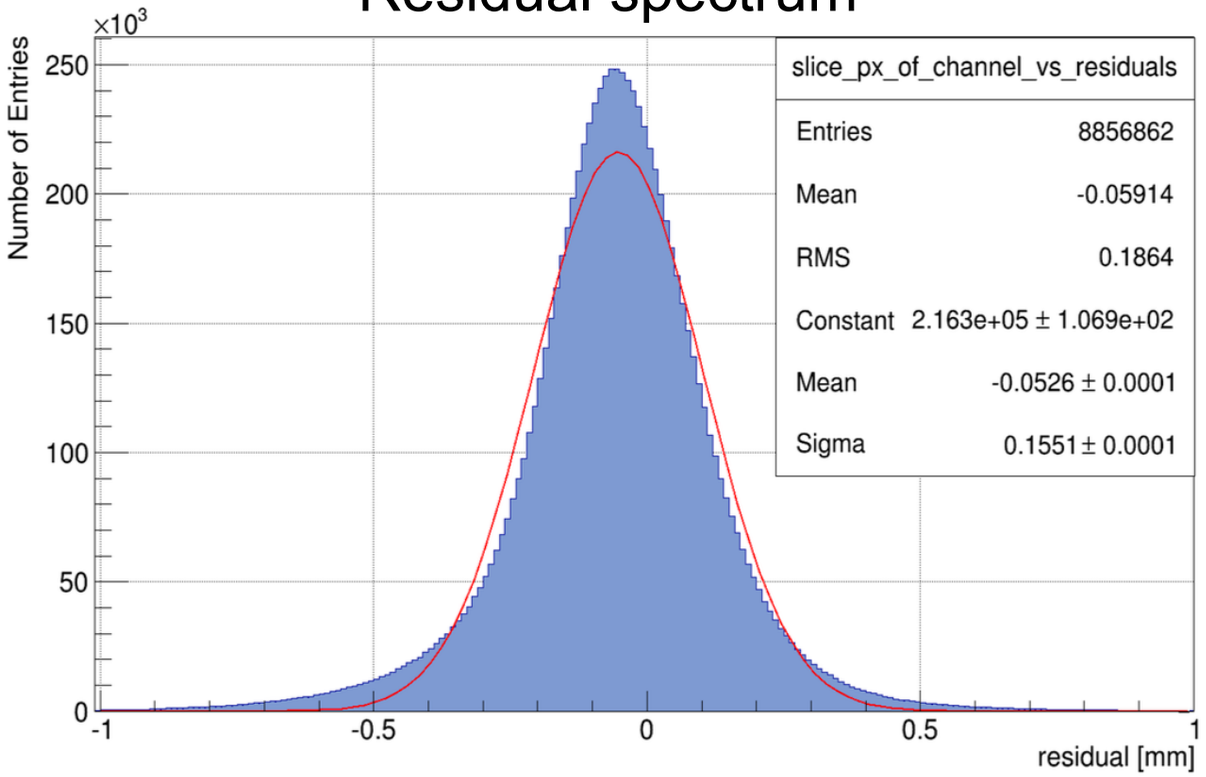
TOT vs drift time spectrum



Clean TOT and drift time spectra
Few background hits

Residual spectrum



Spatial resolution: ~ 155 μm

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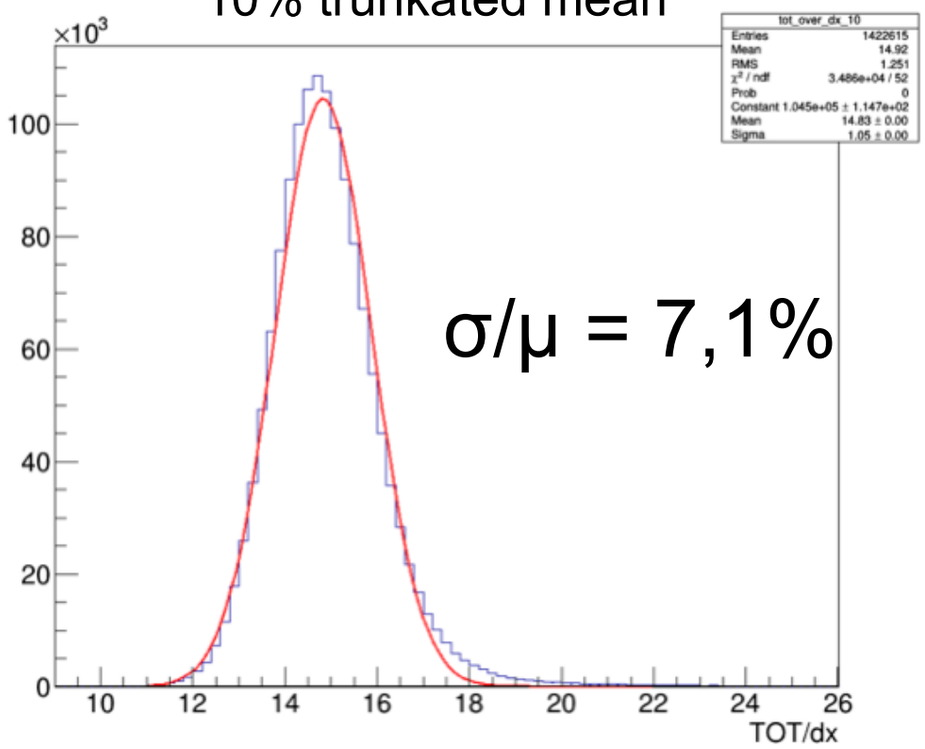
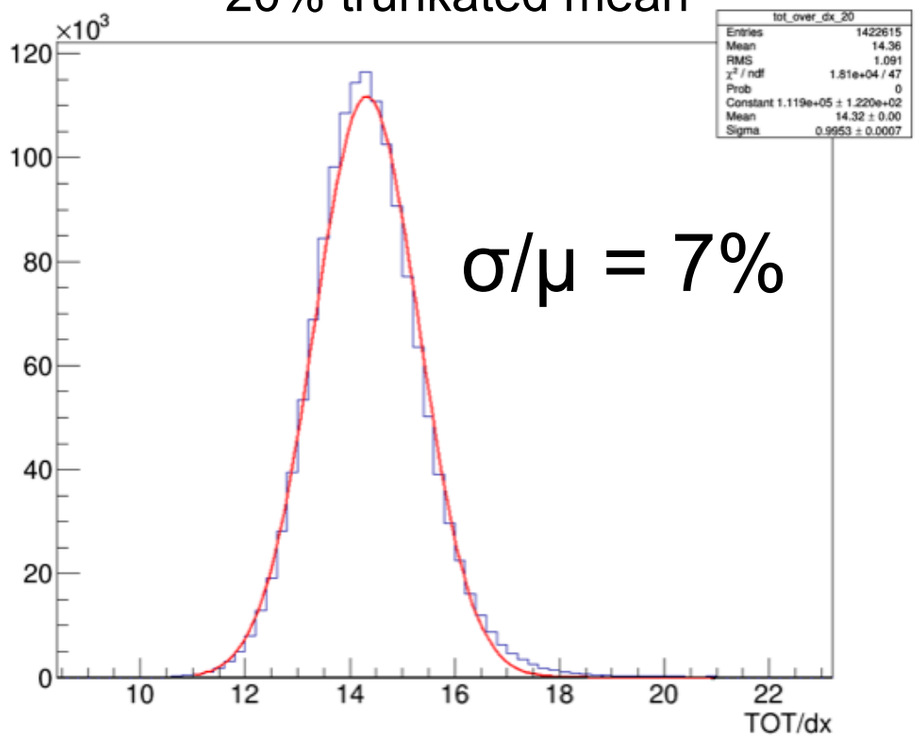
Energy-loss resolution

10% trunkated mean



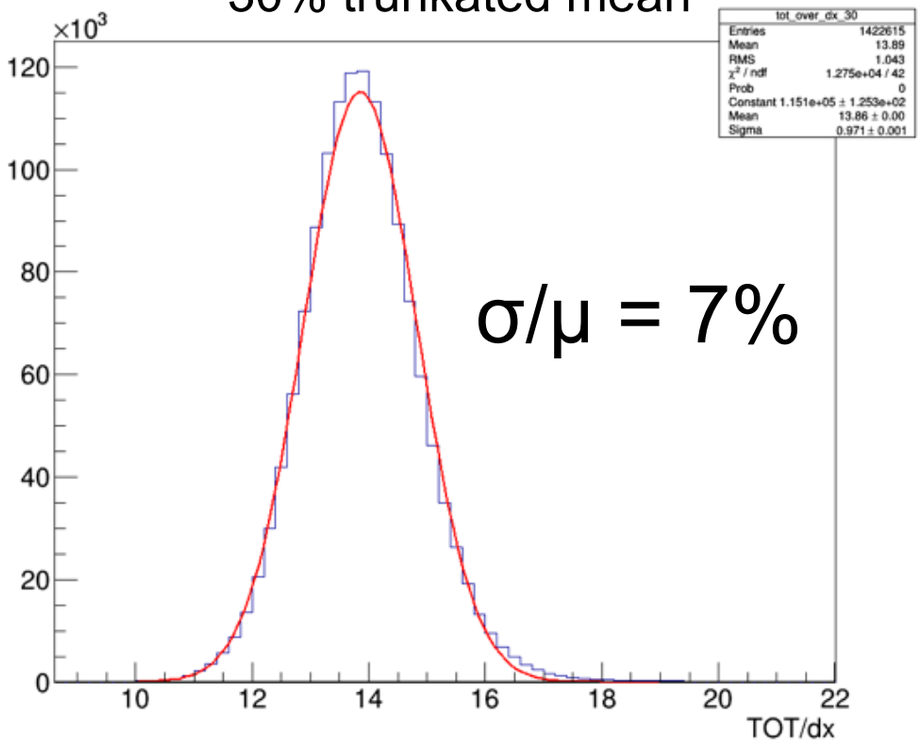
σ/μ = 7,1%

20% trunkated mean



σ/μ = 7%

30% trunkated mean



σ/μ = 7%

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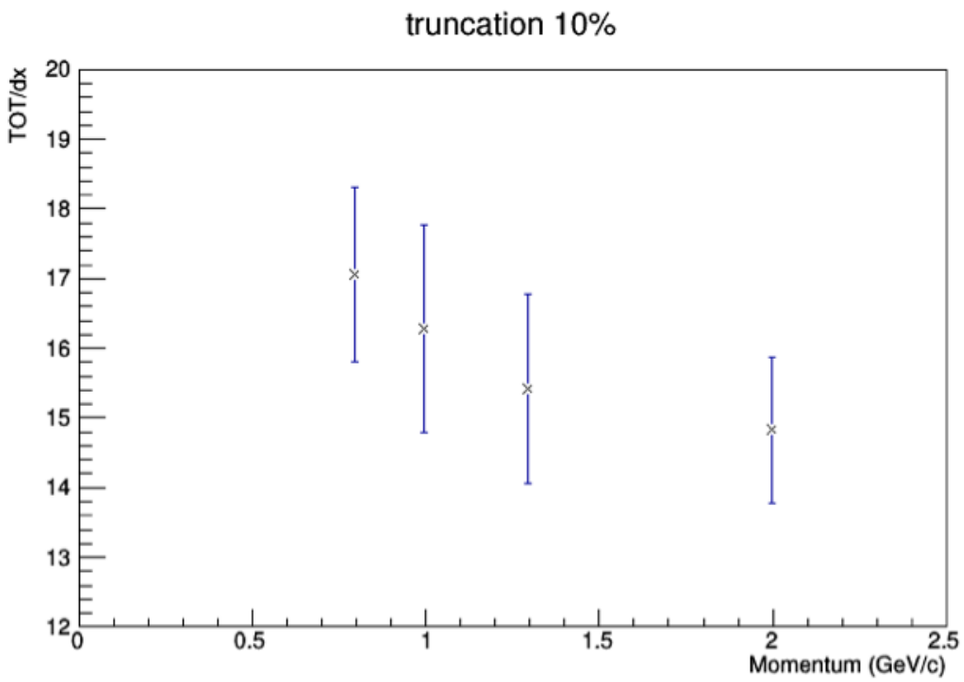
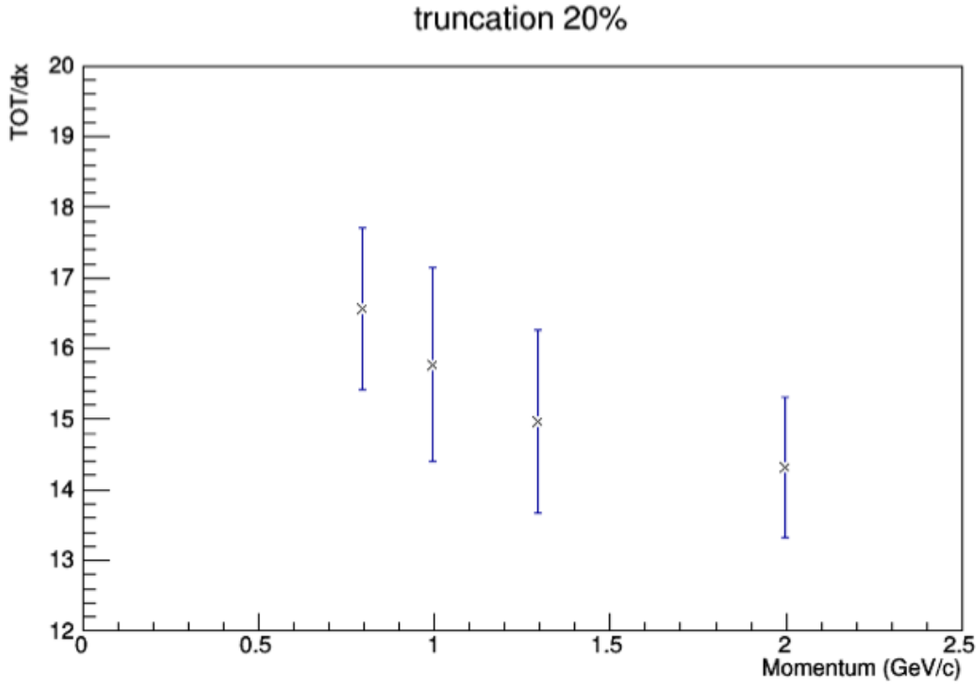
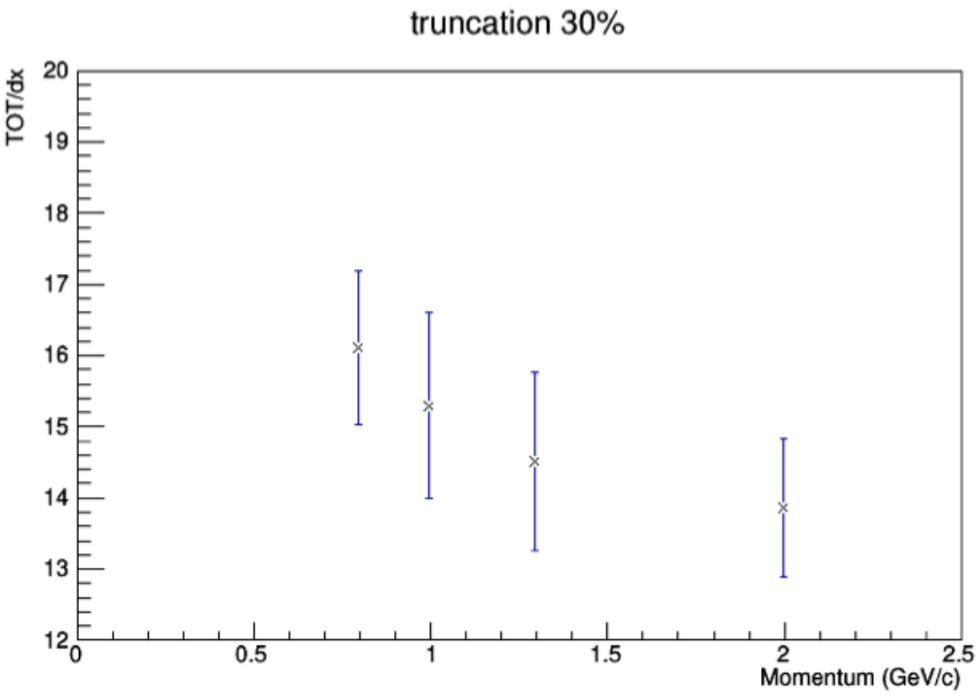
Separation power







- Difference between 0.8 and 2 GeV/c at the order of 15%
- Minor changes for the different truncated mean cuts

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Conclusions

- Spatial resolution (155 μm) achieves specifications
- TOT/dx resolution is better than expected: ~ 7 %
- Correlation of <TOT/dx> versus momentum measured
- Results based on about half of the number of channels per track that expected for the final STT

Future plans

Tests are planned with a larger prototype

New ASIC and TRB electronics will be used

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Back up slides

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Physics program

Study of the non-pertubative regime and understanding of the QCD spectrum and hadron structure

Charmonium Spectroscopy

- Precise measurement of all states below and above the open charm threshold with mass and widths resolutions better than 100 keV for narrow states

Gluonic Excitations

- Two main categories: glueballs (states of pure glue), hybrids ($q\bar{q}$ pair and excited glue)

Open Charm Spectroscopy

- Production of a large number of D meson pairs in combination with the well defined production kinematics $\longrightarrow$ significant charmed meson spectroscopy program

Hyperon Physics

- Spectroscopy of double and triple states, as well as charm hyperons
- Nuclei in which neutrons or protons are replaced by one or two hyperons

Electromagnetic processes

- Investigation of the structure of the nucleon using electromagnetic processes
- Determination of the electromagnetic form factors of the proton

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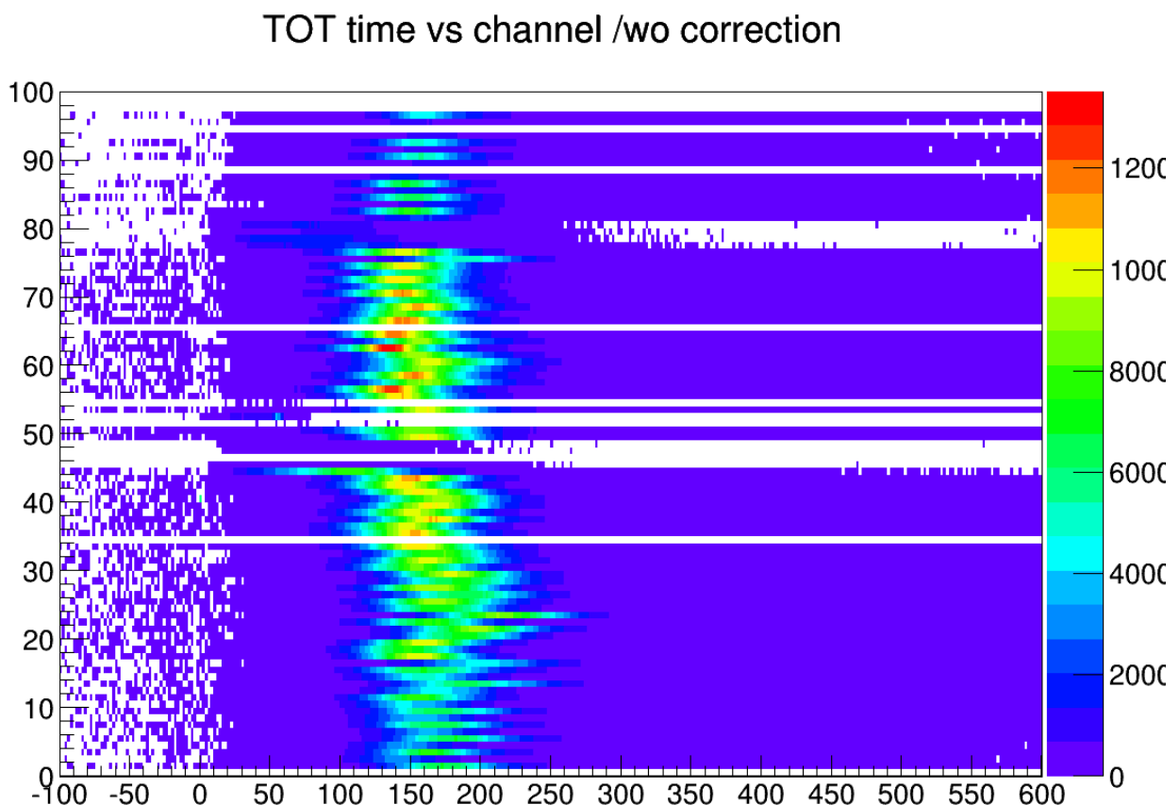

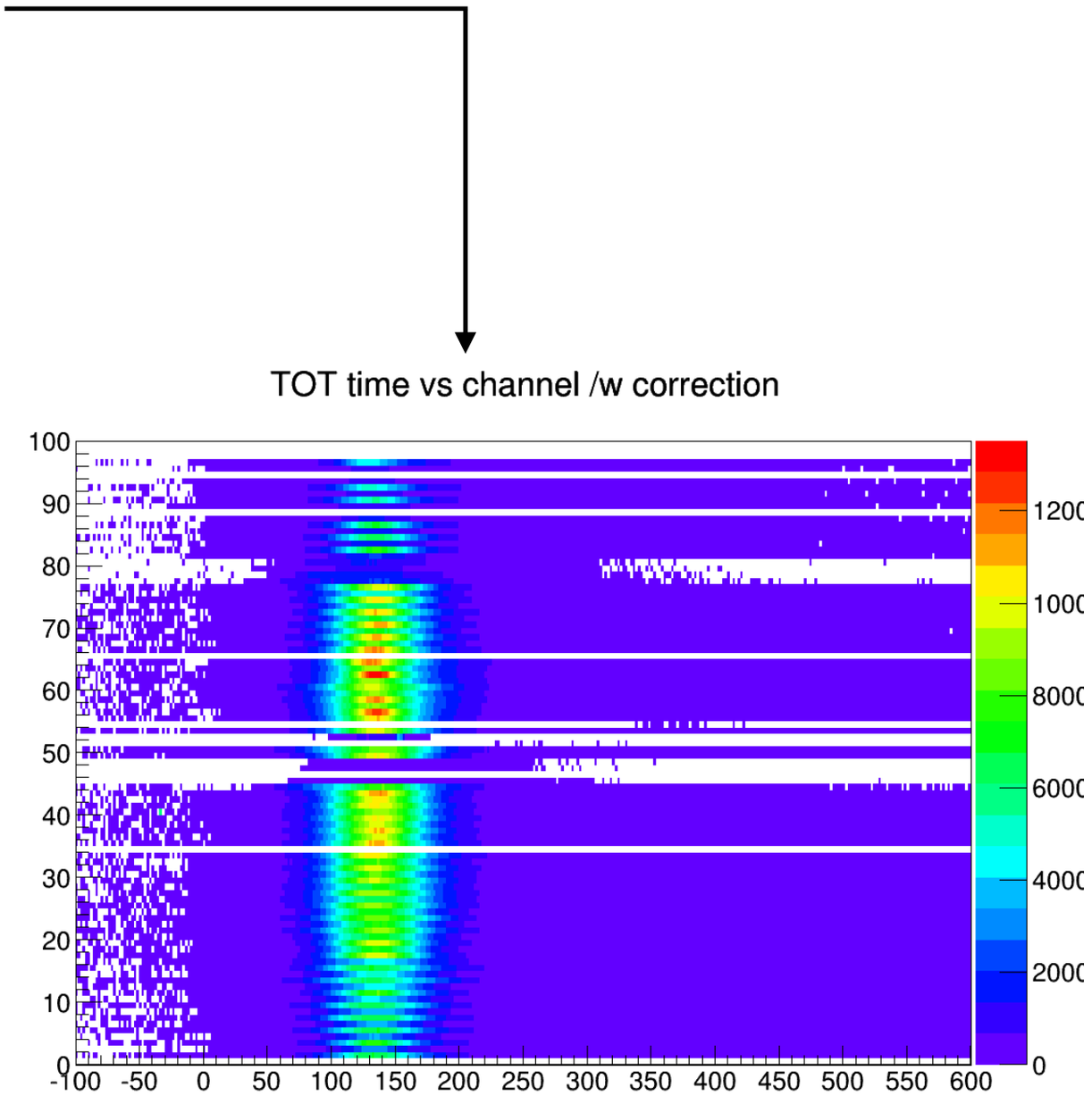

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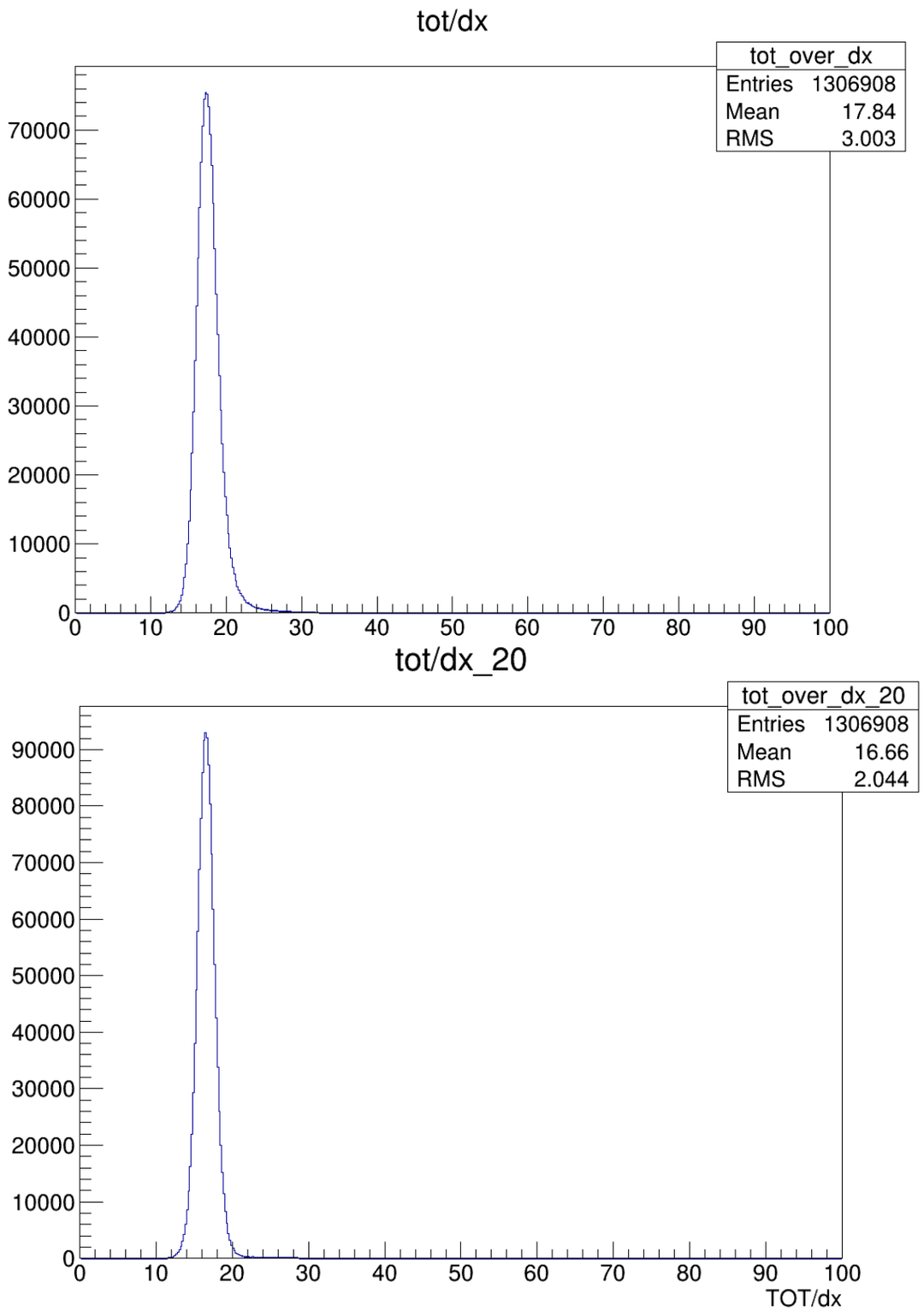
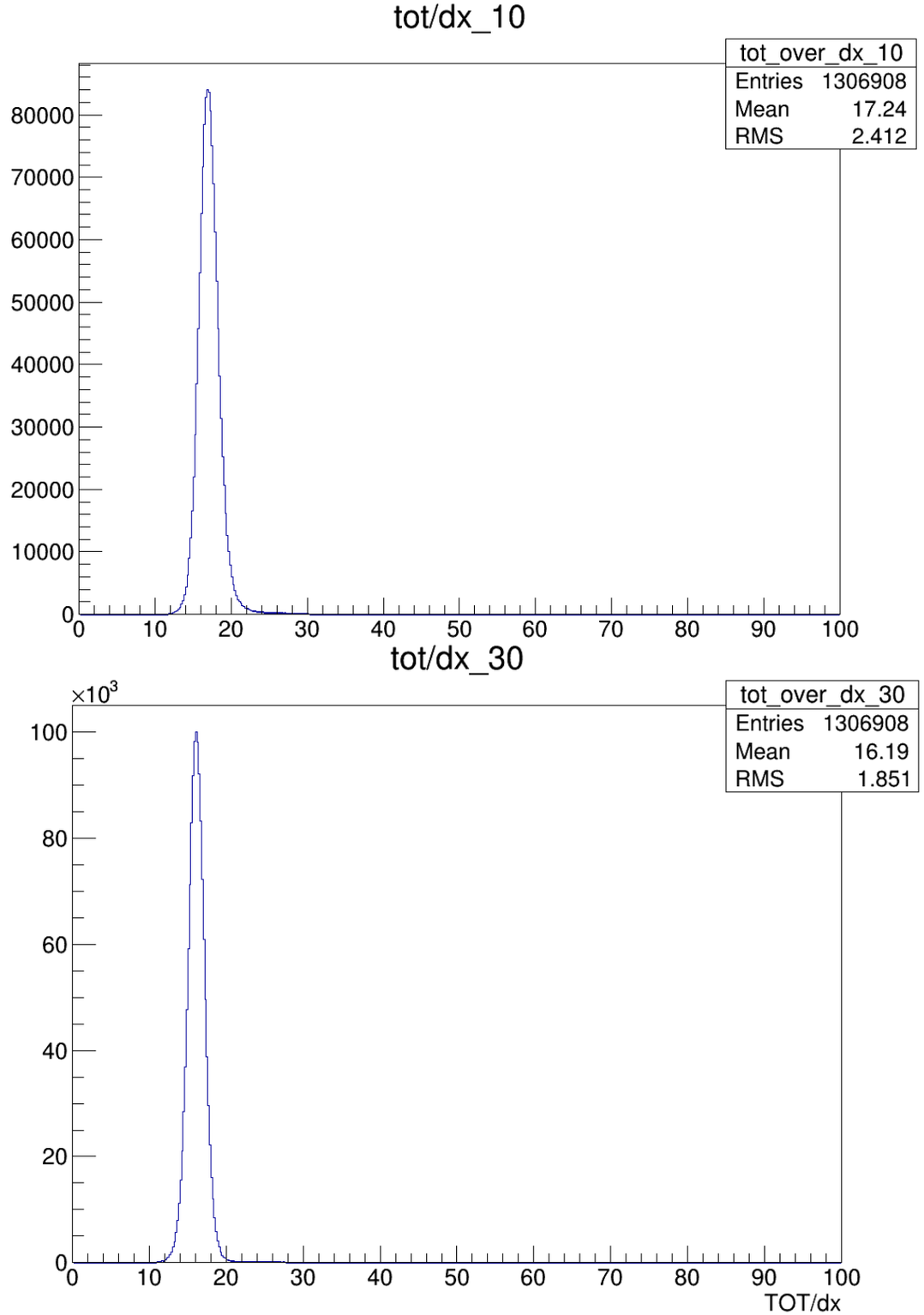
800 MeV/c





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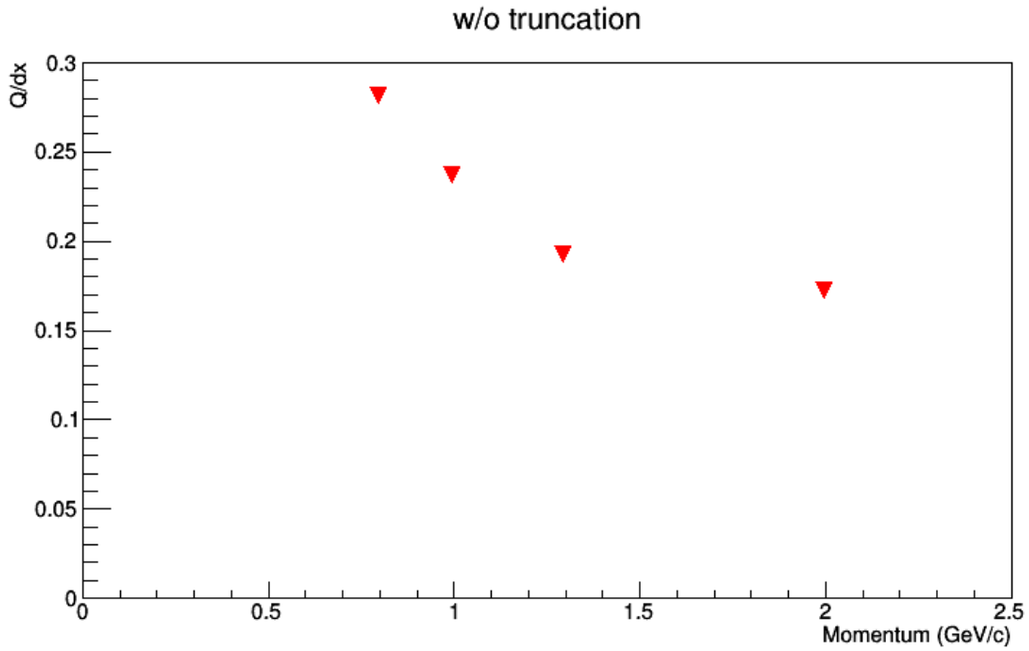
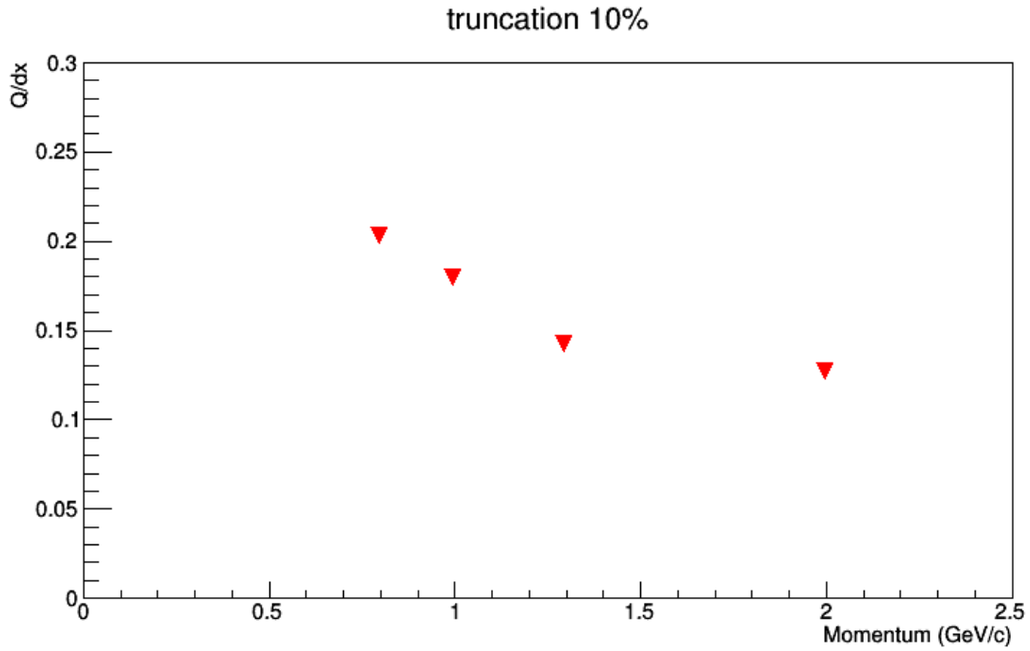
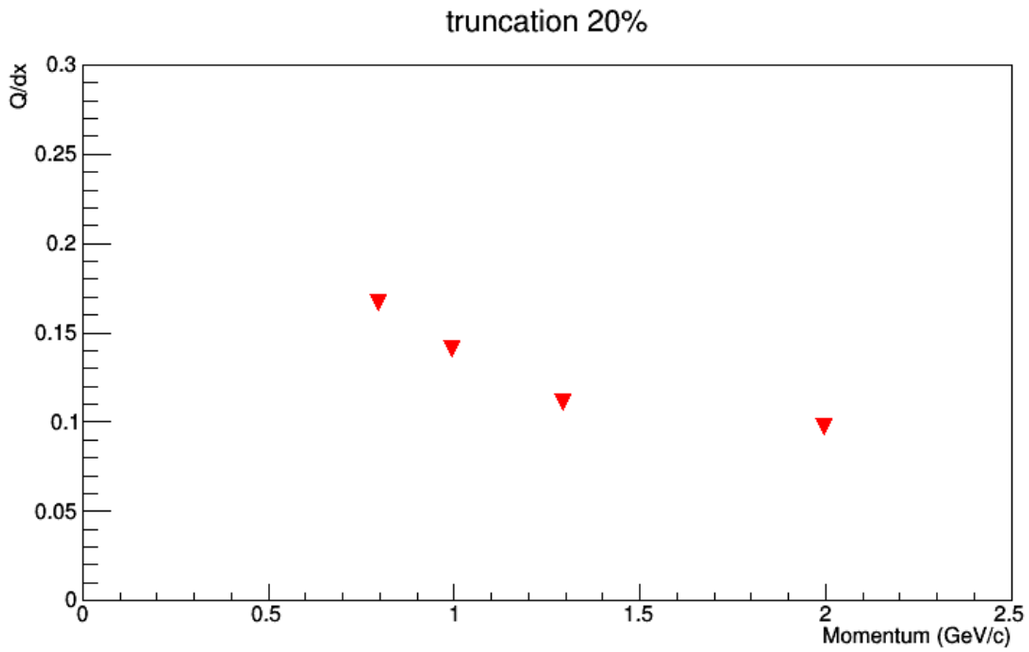
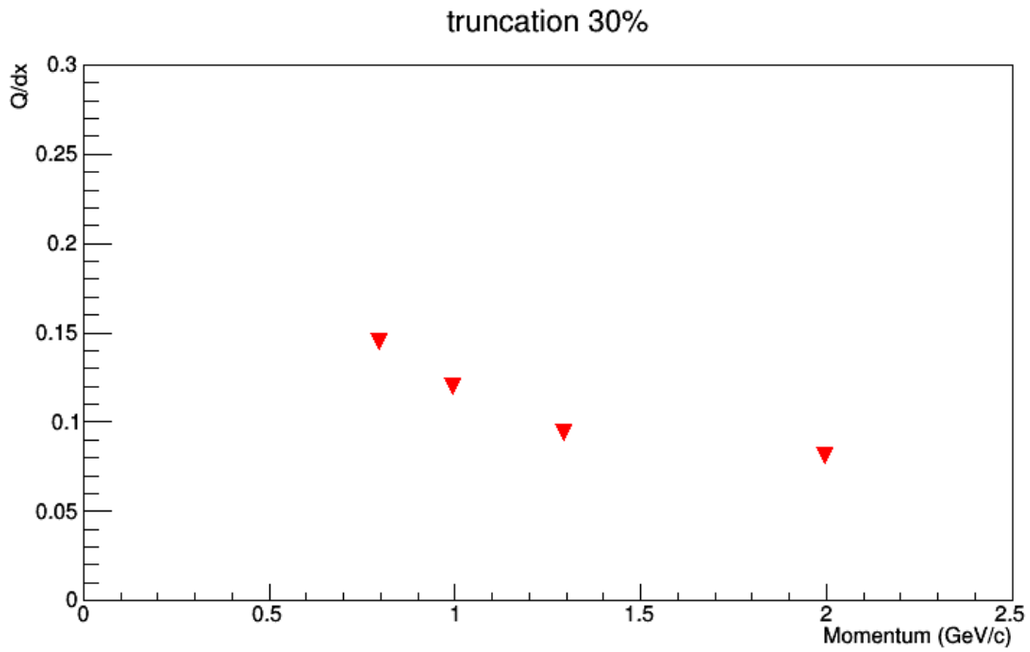
STT data beam time December ‘14

<Q/dx> vs momentum









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MIPs: ~200 electrons/cm for Ar+CO2 @ 2 bar

Charge/distance: ~(200e/cm)*(5*10^{4})*(1,6*10^{-19}C/e) —> 1,6pC/cm

1,6pC/cm corresponds to 5KeV/cm for the MIPs

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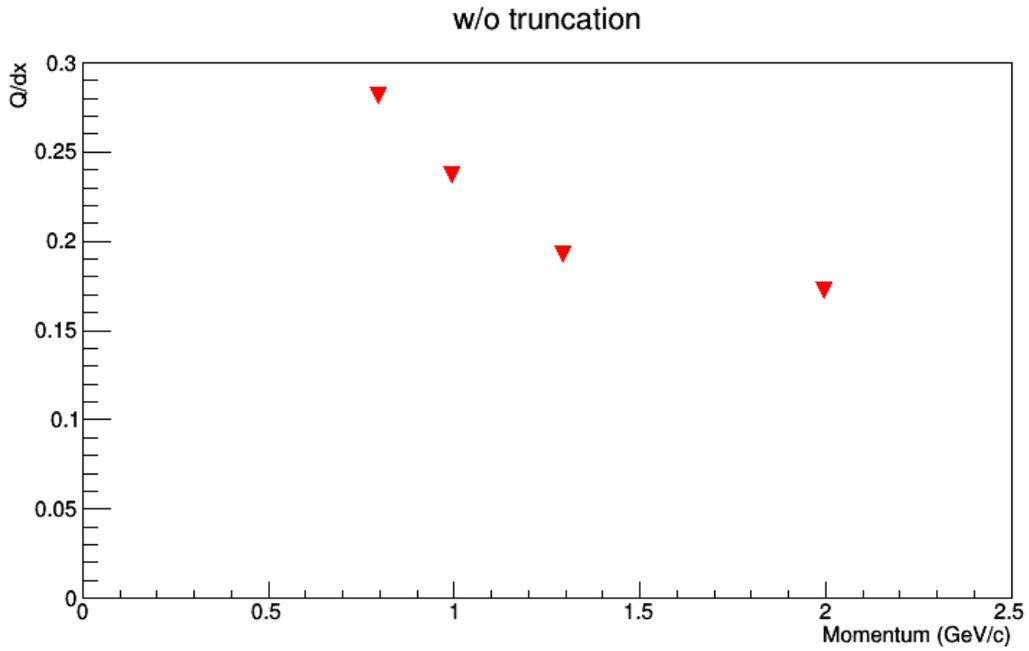
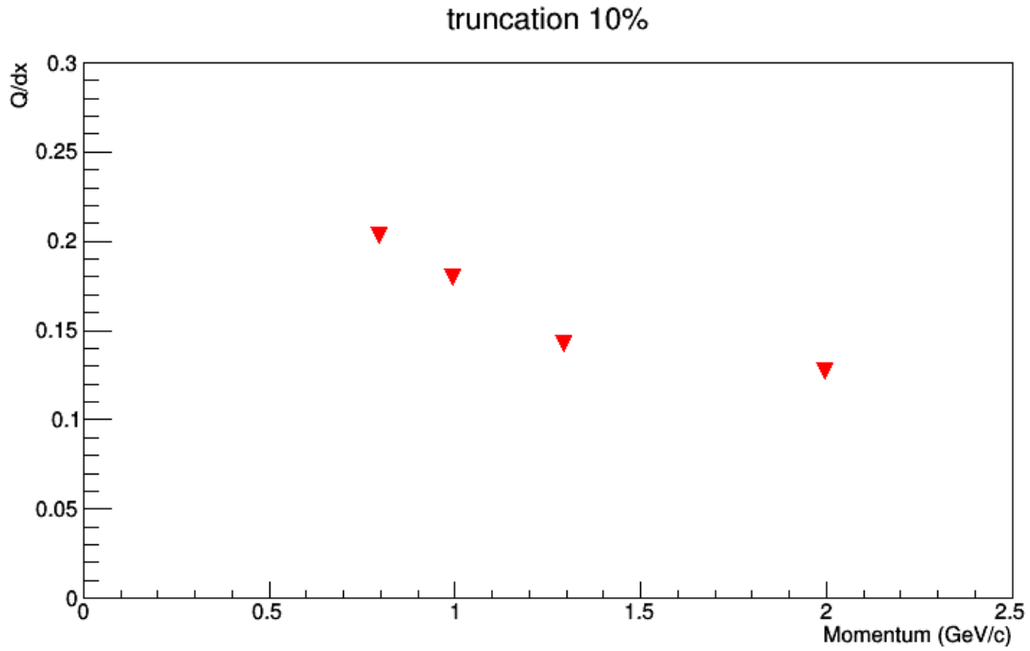
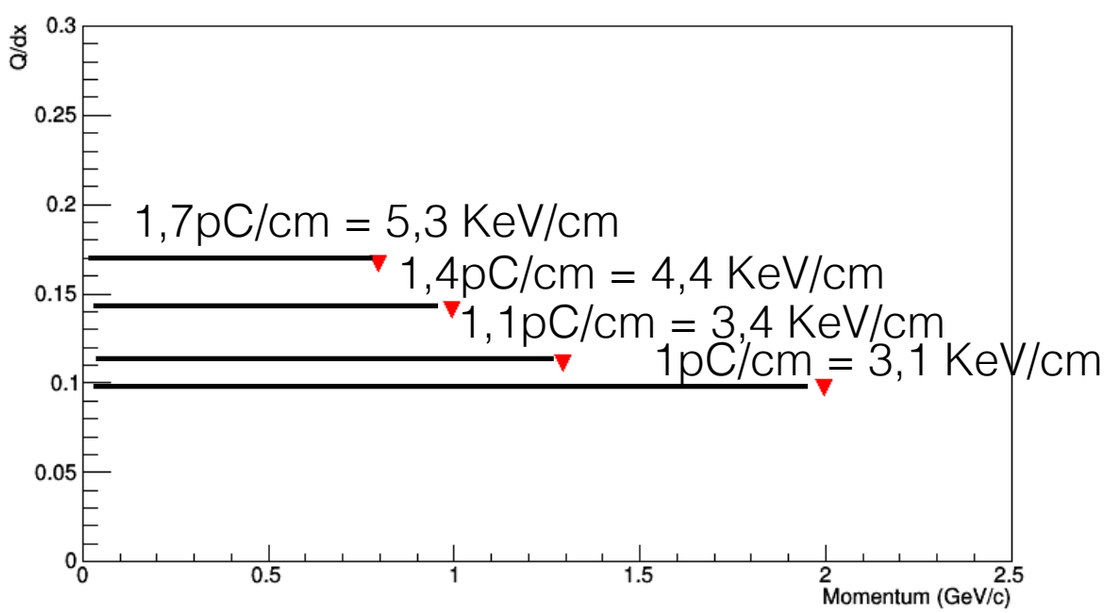
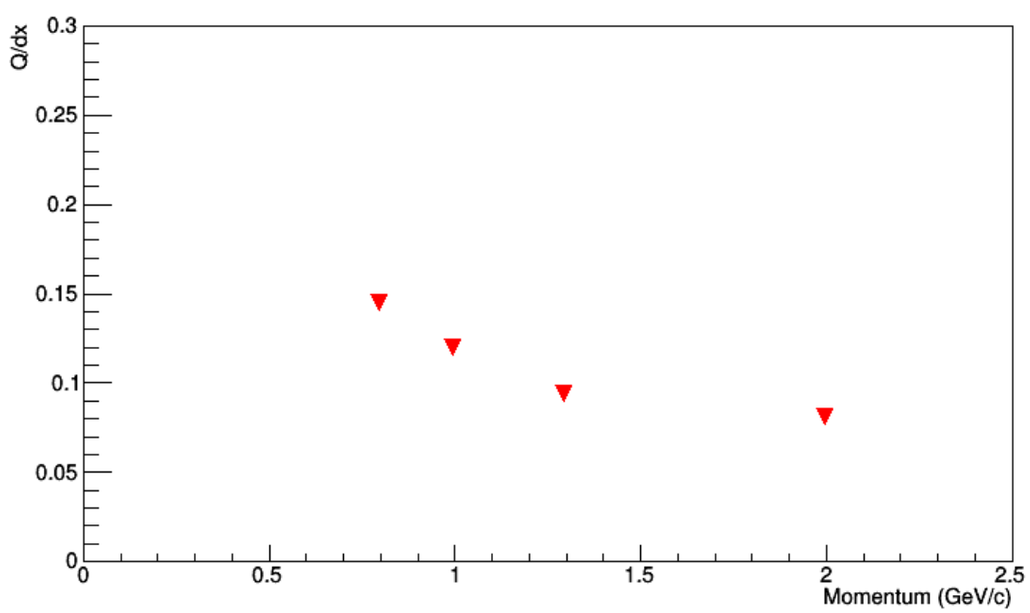
STT data beam time December ‘14

<Q/dx> vs momentum









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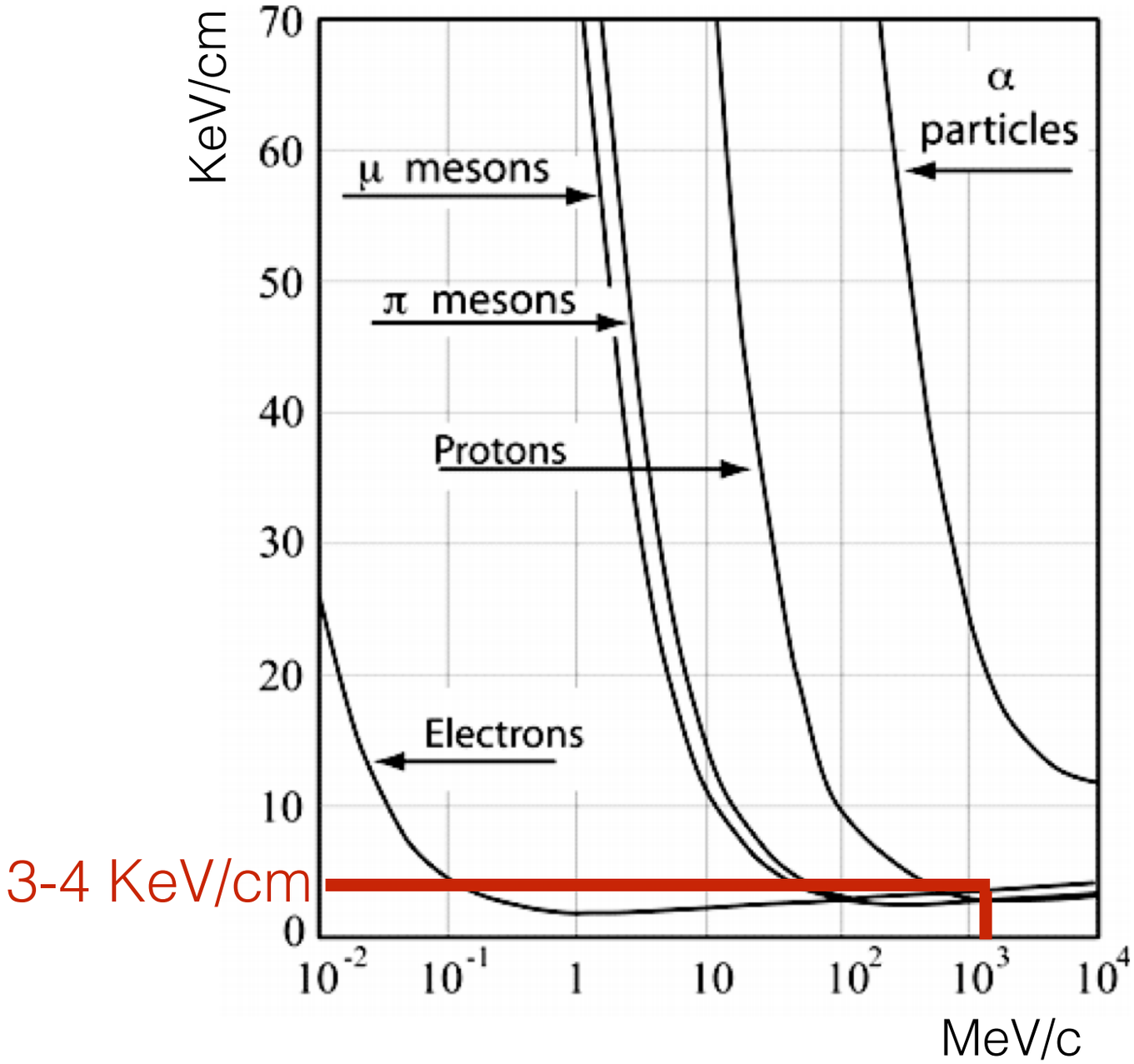

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