ProtoDUNE-SP – Study of 1 GeV Protons

Heng-Ye Liao, Glenn Horton-Smith, Tingjun Yang
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Outline

- Motivation
- Data sample
- Analysis procedure
- Event display
- Summaty & Outlook

Motivation

- Detector response for protons (i.e., Proton dE/dX)
  → Tag stopping protons firstly for the study

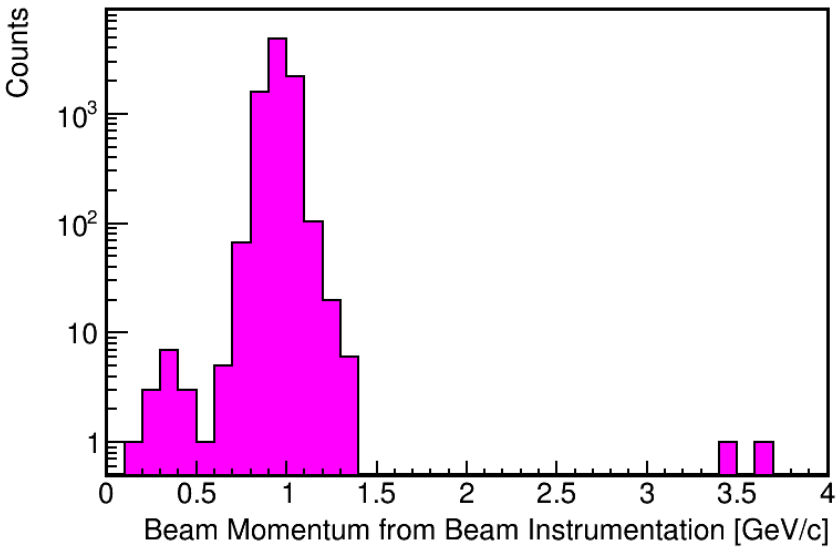
Data Sample

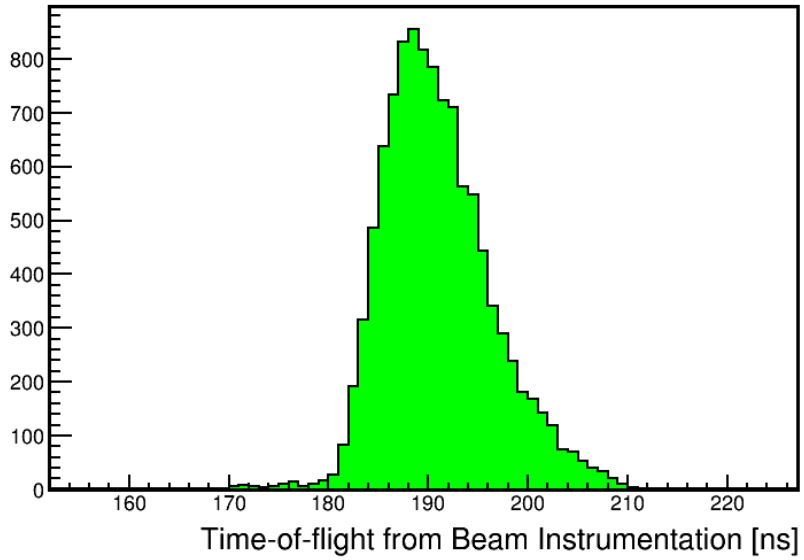
- Use recommended run from Owen
  → See Owen's good run list in:
  https://indico.fnal.gov/event/19262/contribution/14/material/slides/0.pdf

- Run number: 5387
- Use entire run for this analysis
- Run info:
  - High voltage: 180 kV
  - Beam momentum: 1 GeV/c
  - Purity: > 5ms

Filter & Sanity Check

- Use Justin Hugo's filter to select 1GeV beam protons (see Justin's slides for more details: https://indico.fnal.gov/event/19185/contribution/2/material/slides/0.pdf)
- Use Jack Calcutt's LArSoft module to get beam info (https://wiki.dunescience.org/wiki/Look_at_ProtoDUNE_SP_data#Parsing_Beamline_Information)

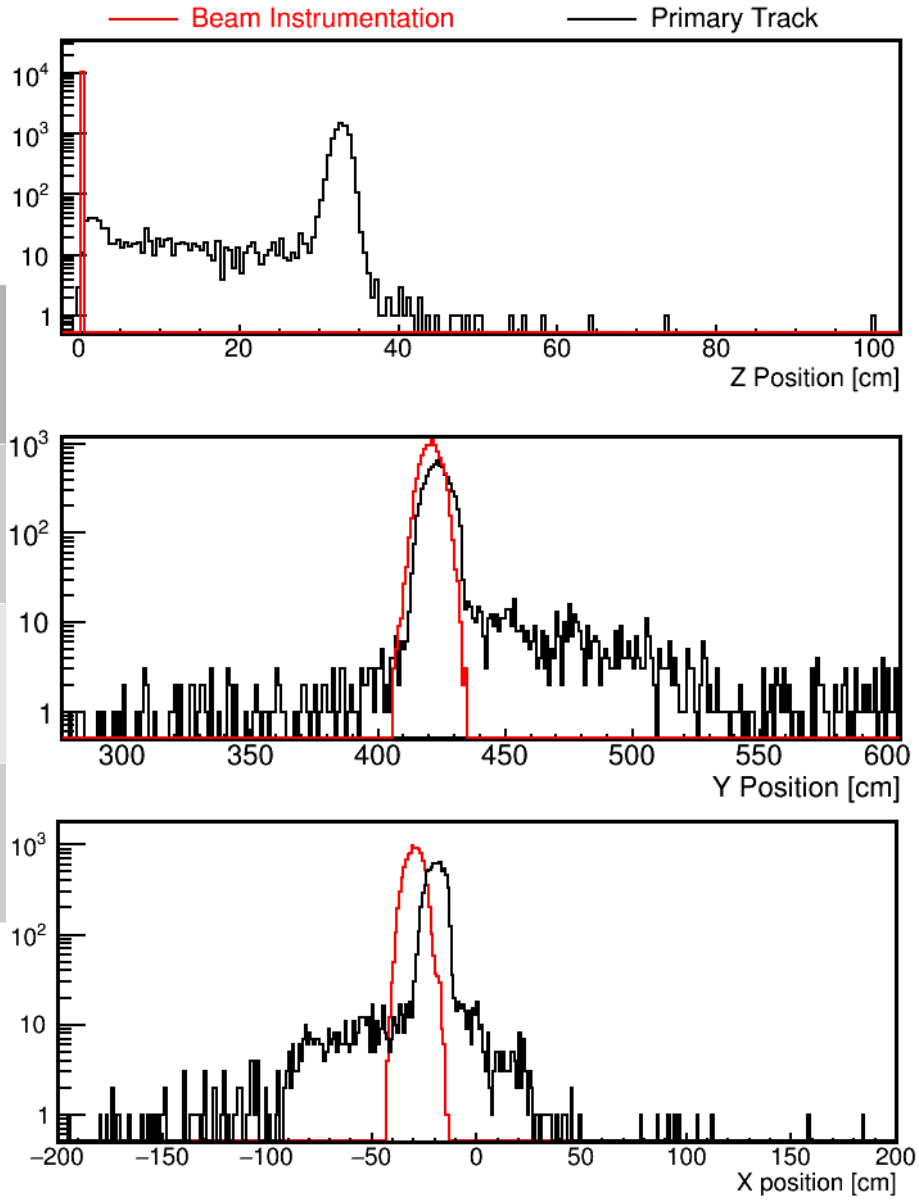




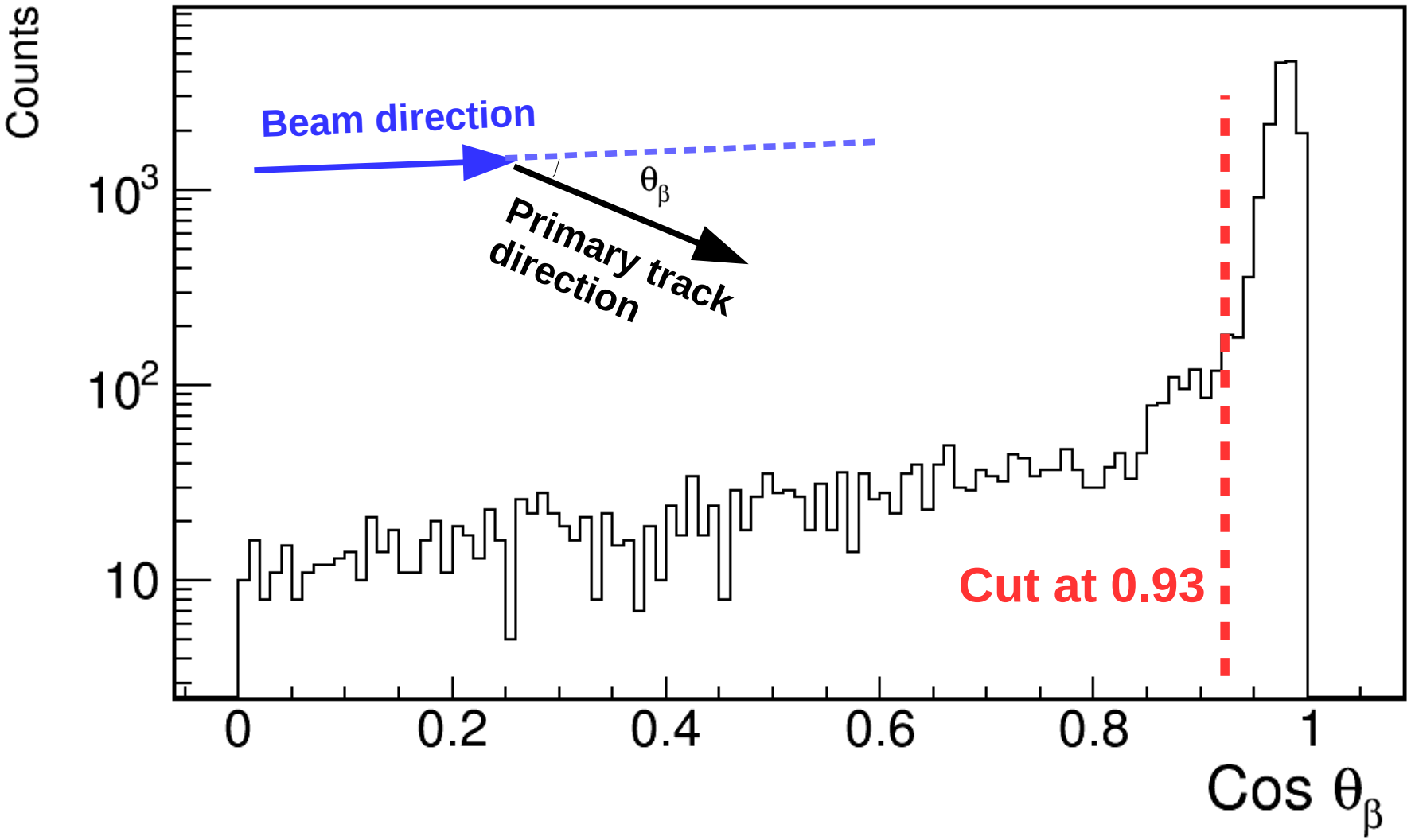
Beam Position

	Beam Inst. [cm]	Primary Track [cm]
Z Position	0 (0)	32.73 (0.939)
Y Position	421.01 (3.876)	423.38 (4.753)
X Position	-29.75 (4.118)	-19.43 (4.358)

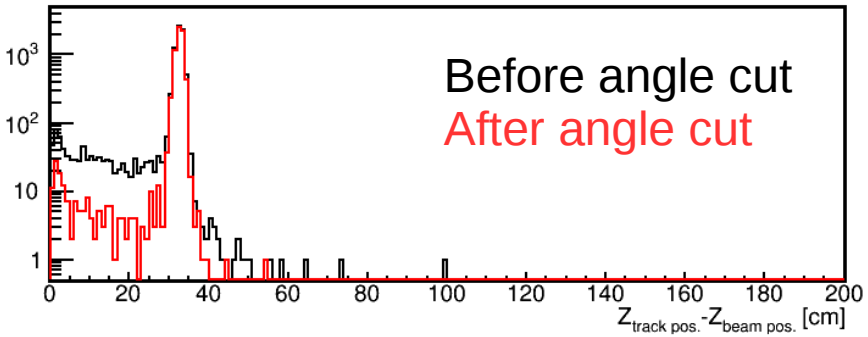
Values in the table: Mean (Sigma)



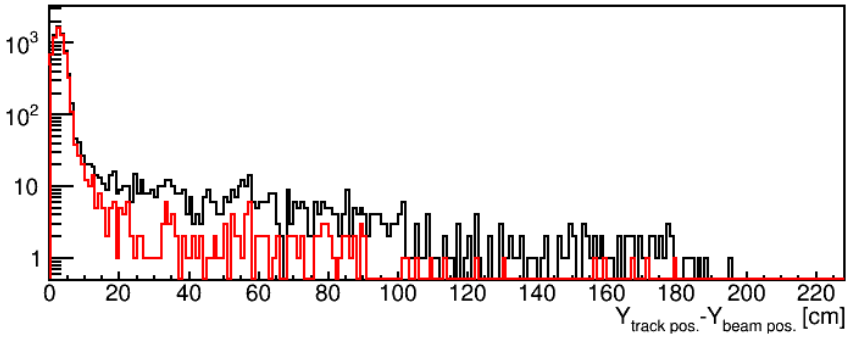
Track Selection – Angle Cut



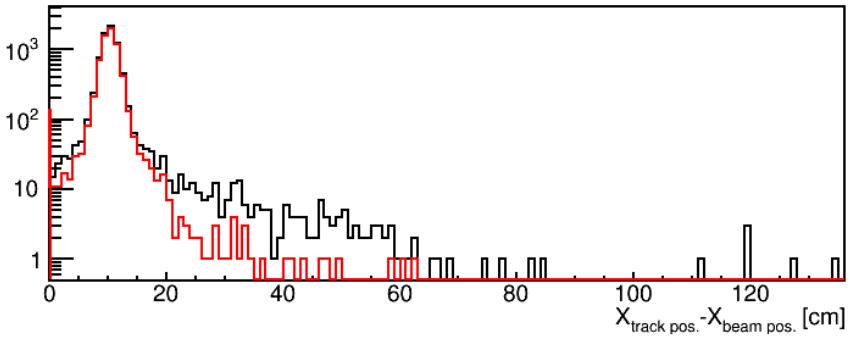
Track Selection – Position Cut



27 < ΔZ < 39 [cm]

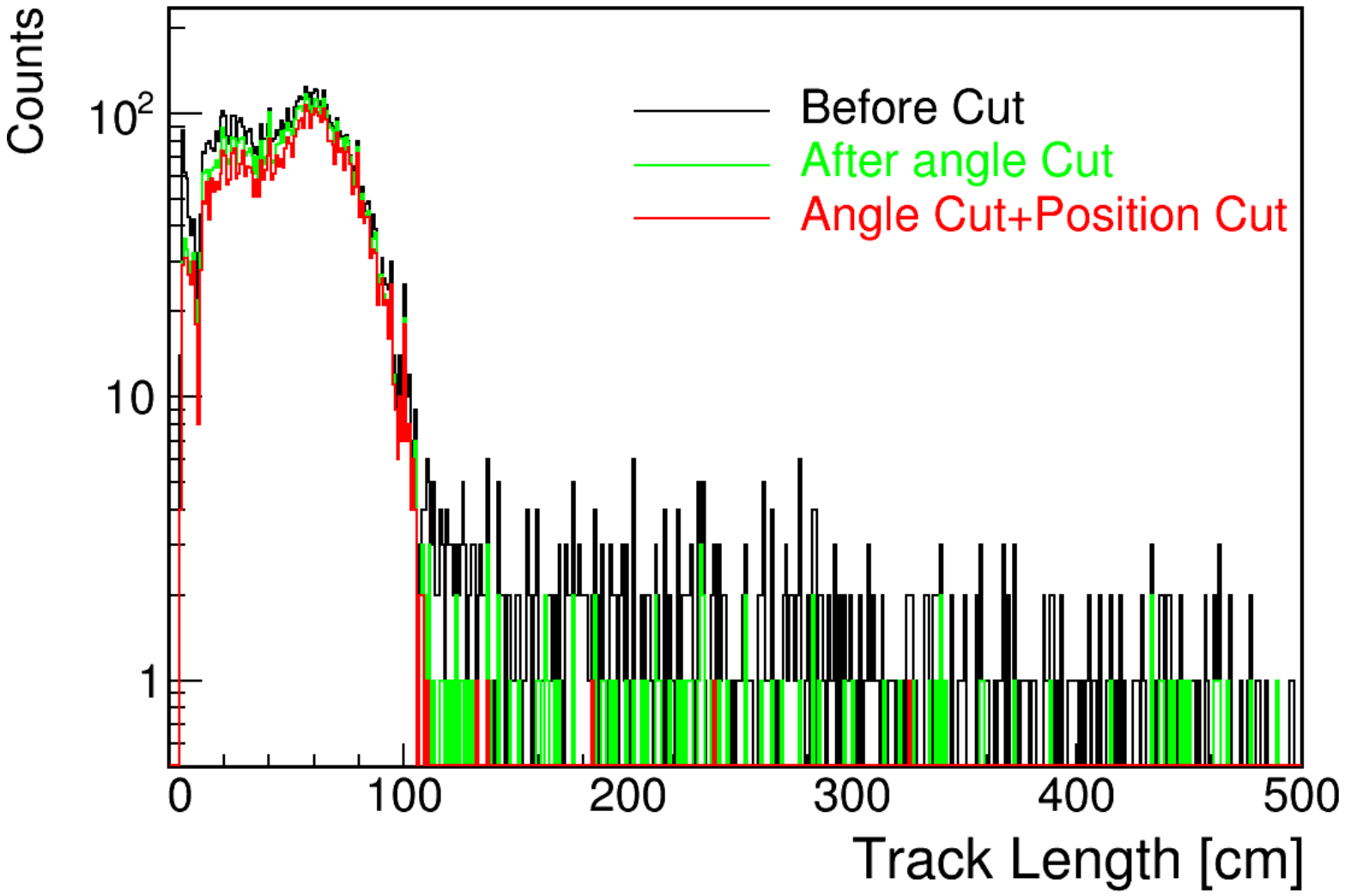


0 < ΔY < 10 [cm]

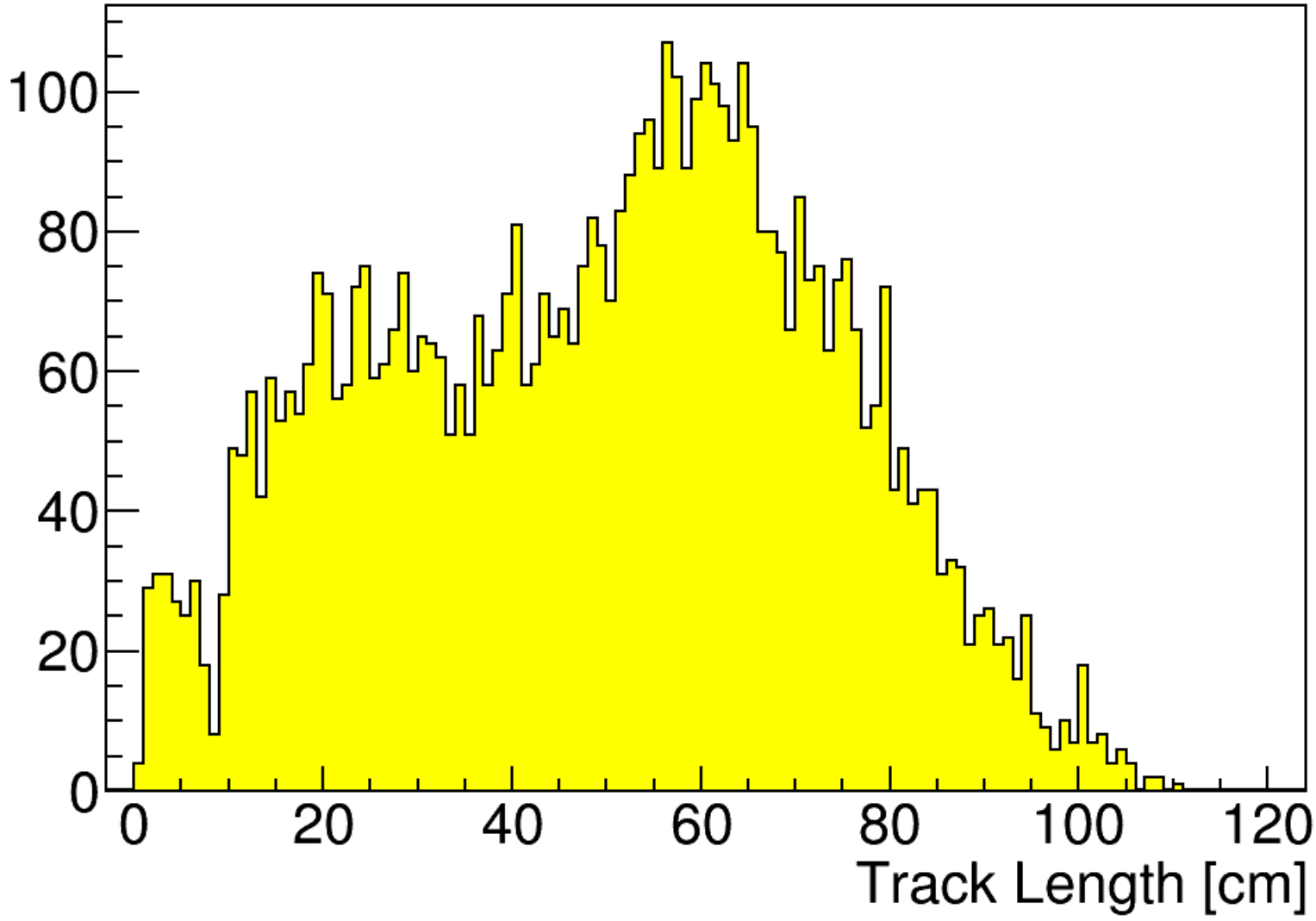


6 < ΔX < 15 [cm]

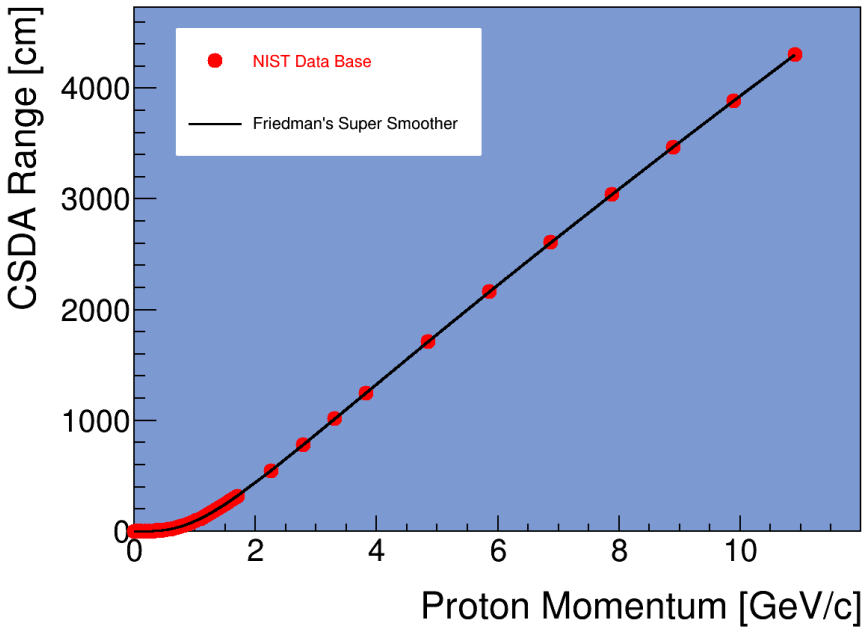
Track Length Distribution

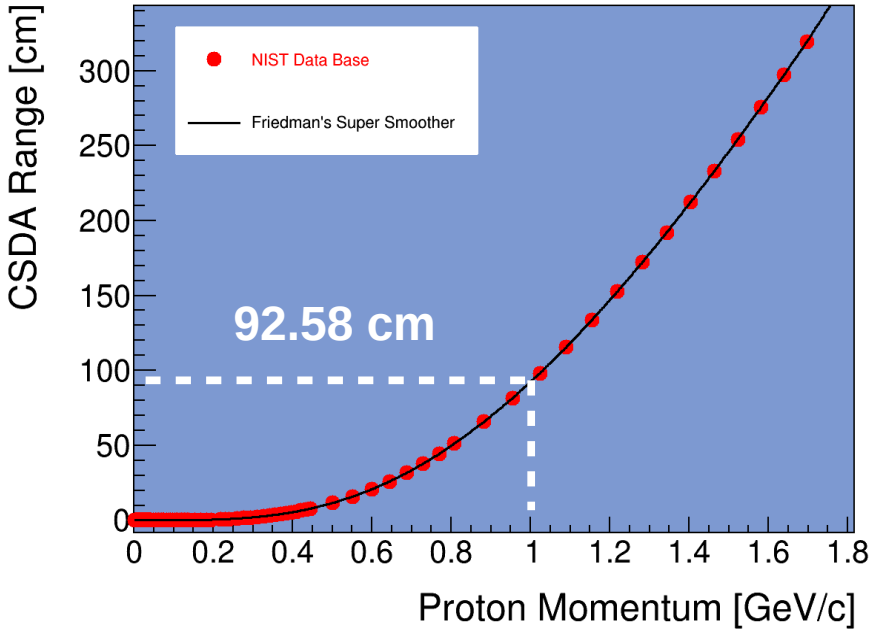


Track Length Distribution



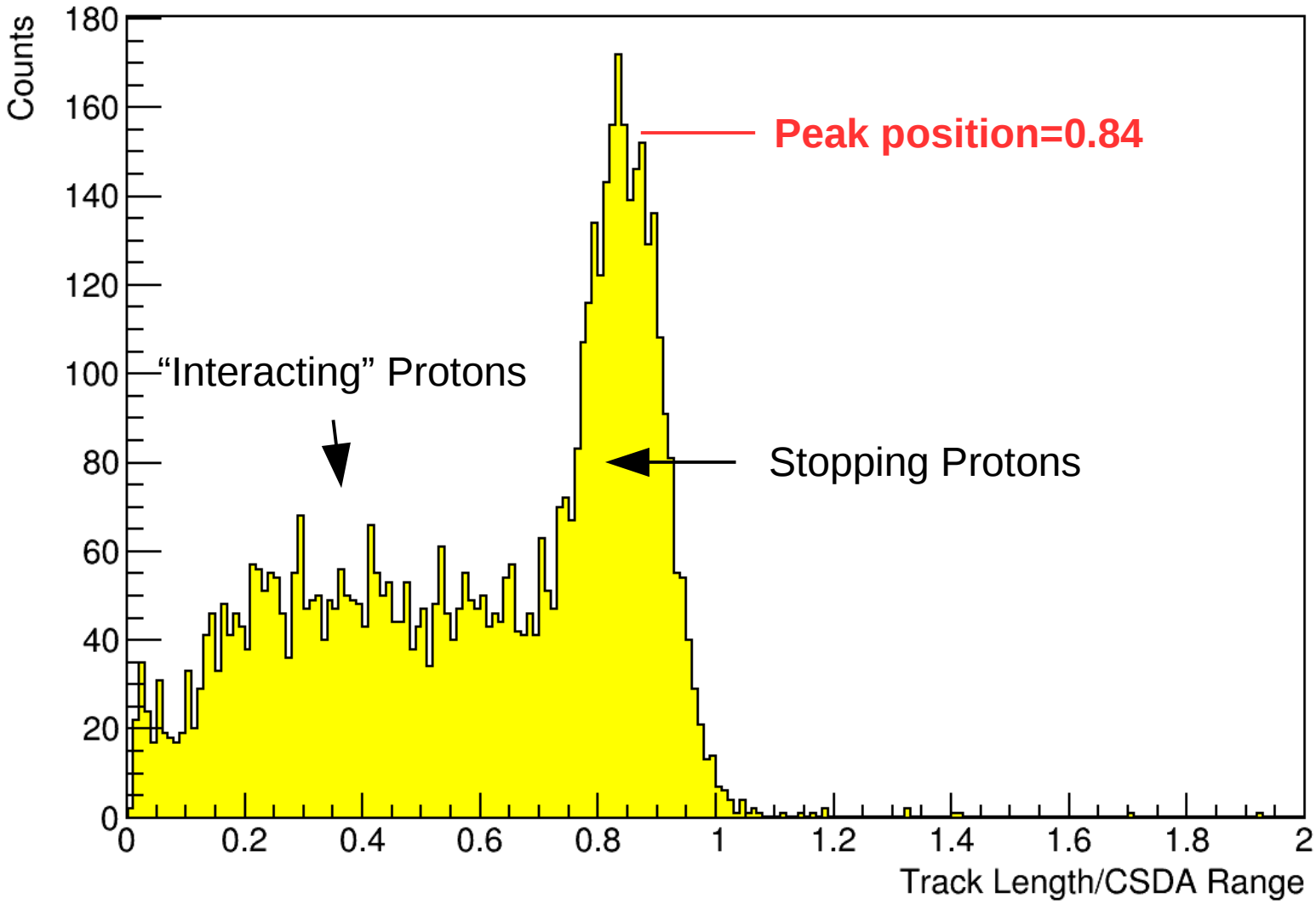
Proton Length



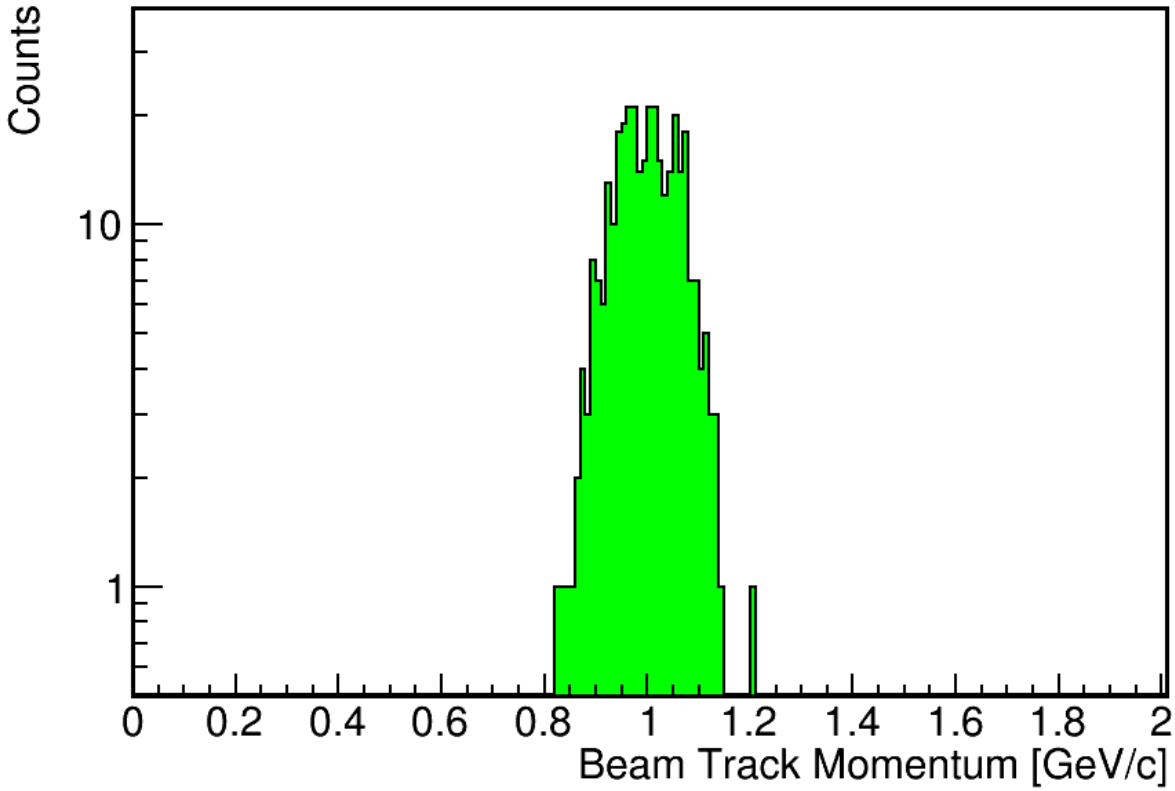


- Convert proton momentum to its CSDA range
  - CSDA range: Average path length traveled by a charged particle as it slows down to rest (continuous-slowing-down approximation)
  - NIST data base of proton travels in argon (https://physics.nist.gov/PhysRefData/Star/Text/PSTAR.html)
  - Use Friedman's super smoother to get the associated function (Friedman, J. H. (1984) SMART User's Guide. Laboratory for Computational Statistics, Stanford University Technical Report No. 1.)

Track Length Distribution

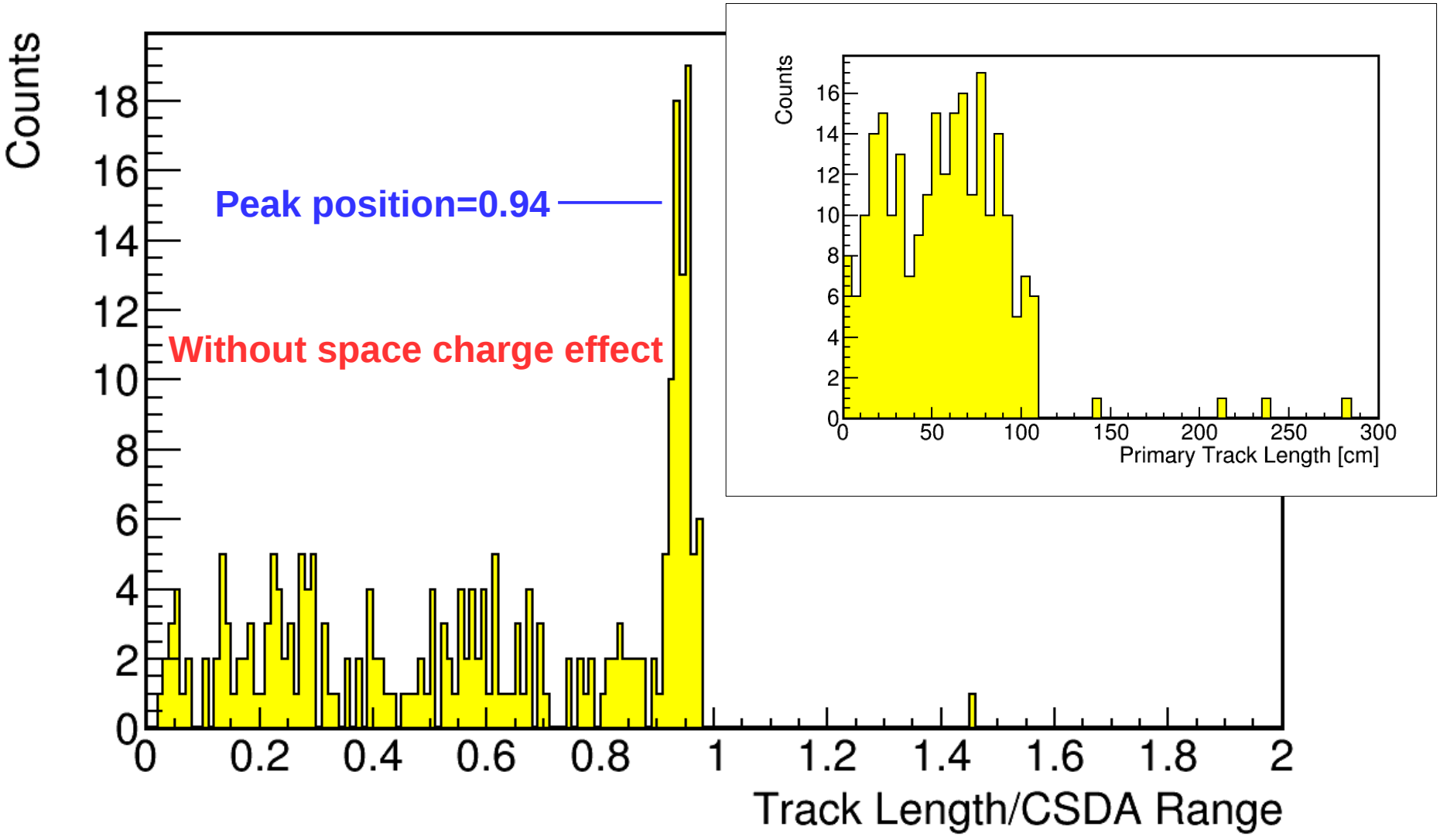


Monte Carlo simulation

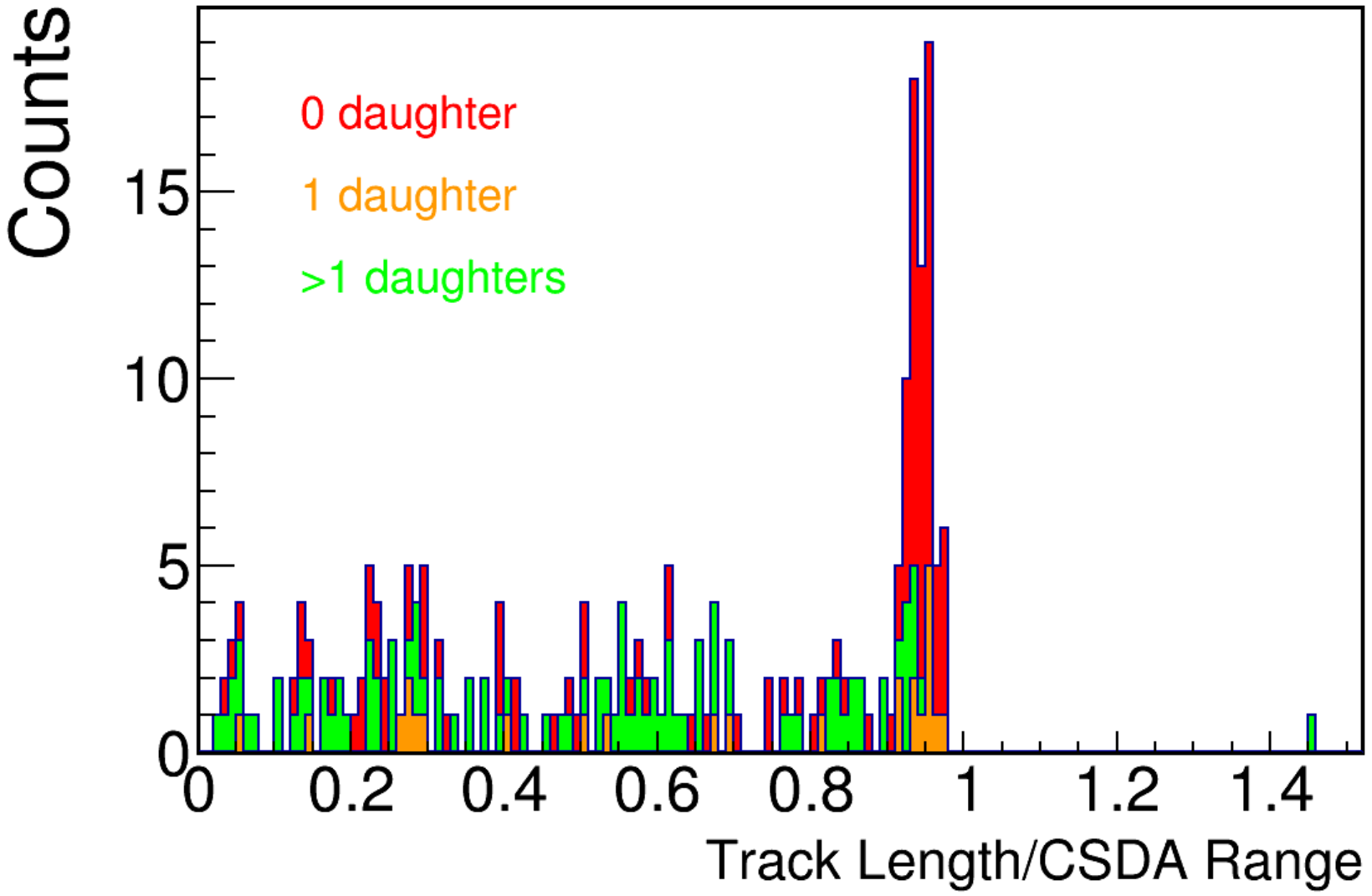


- Use MCC11 1GeV/c proton sample (full data set) to do the same analysis

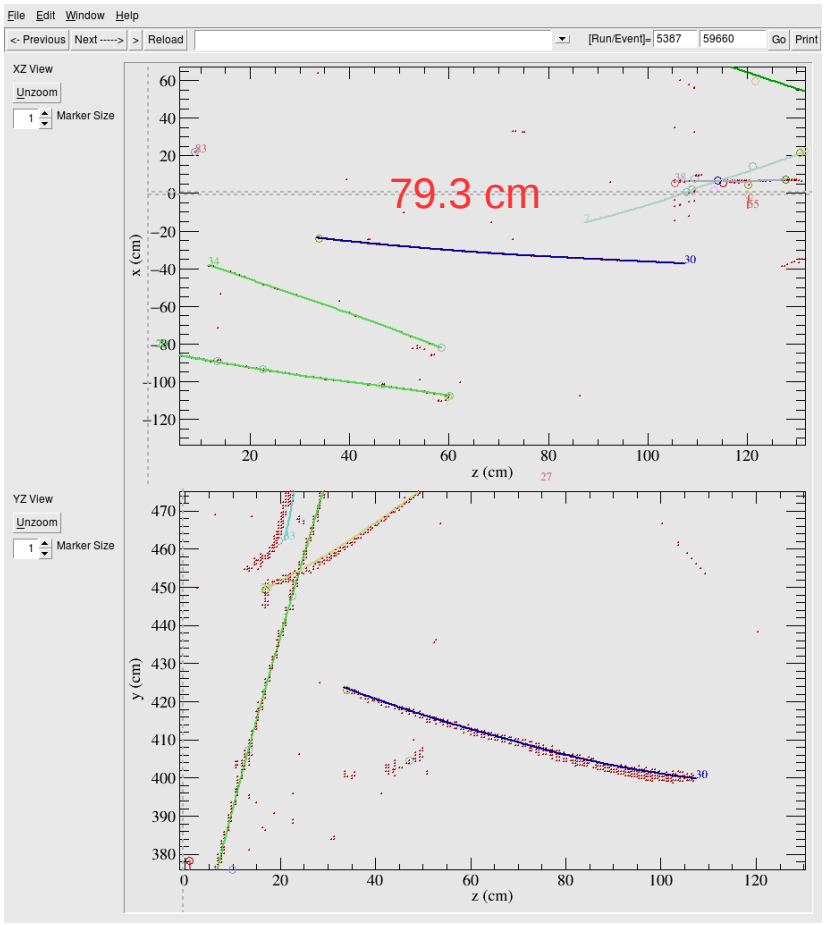
Track Length Distribution (MC)

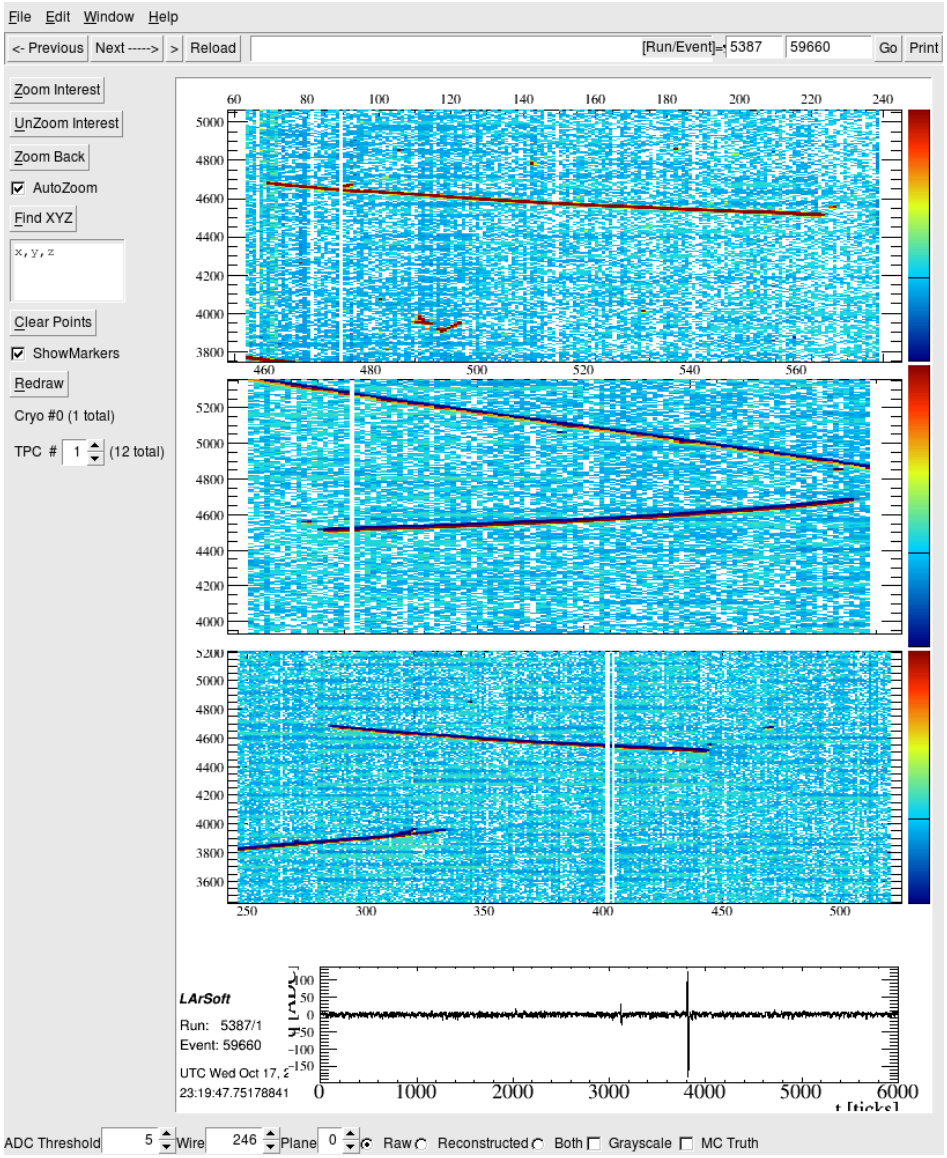


Track Length Distribution (MC)



Event Display





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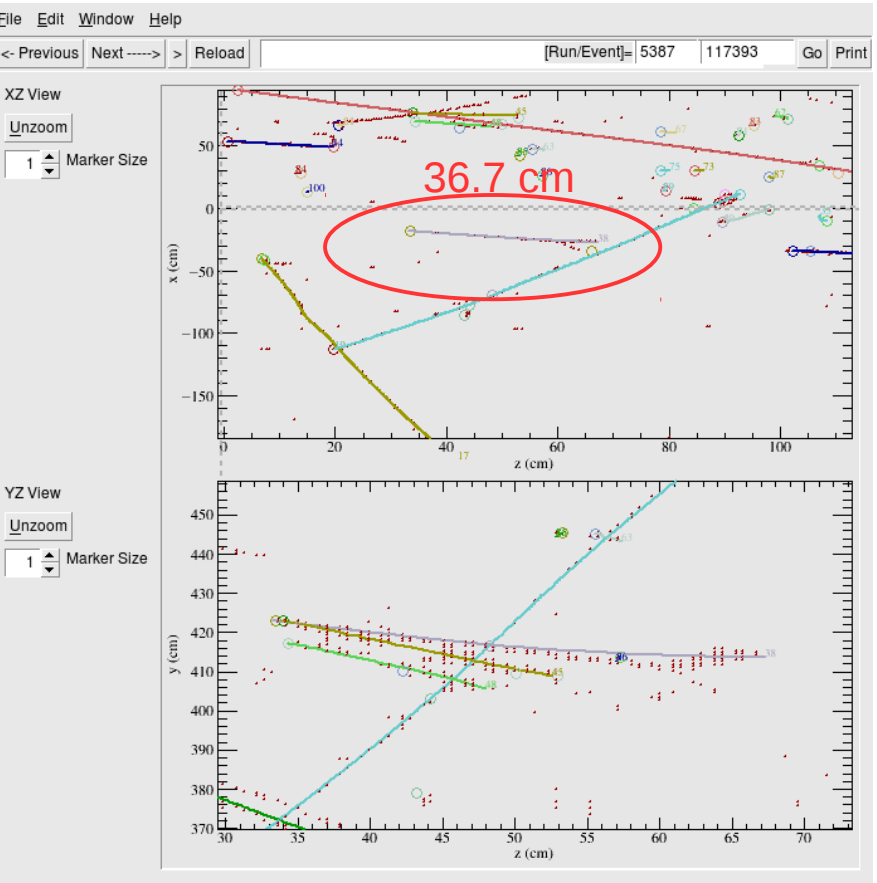

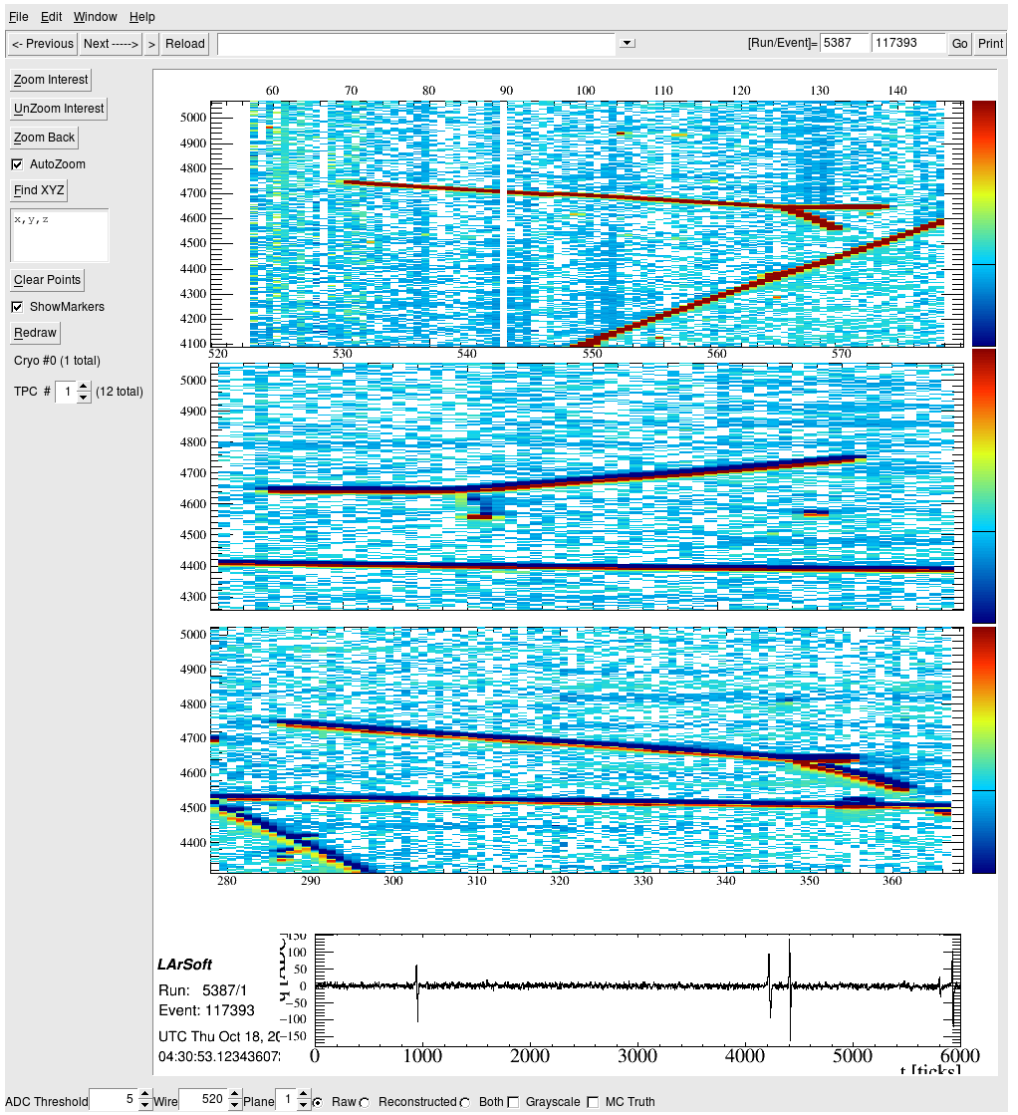

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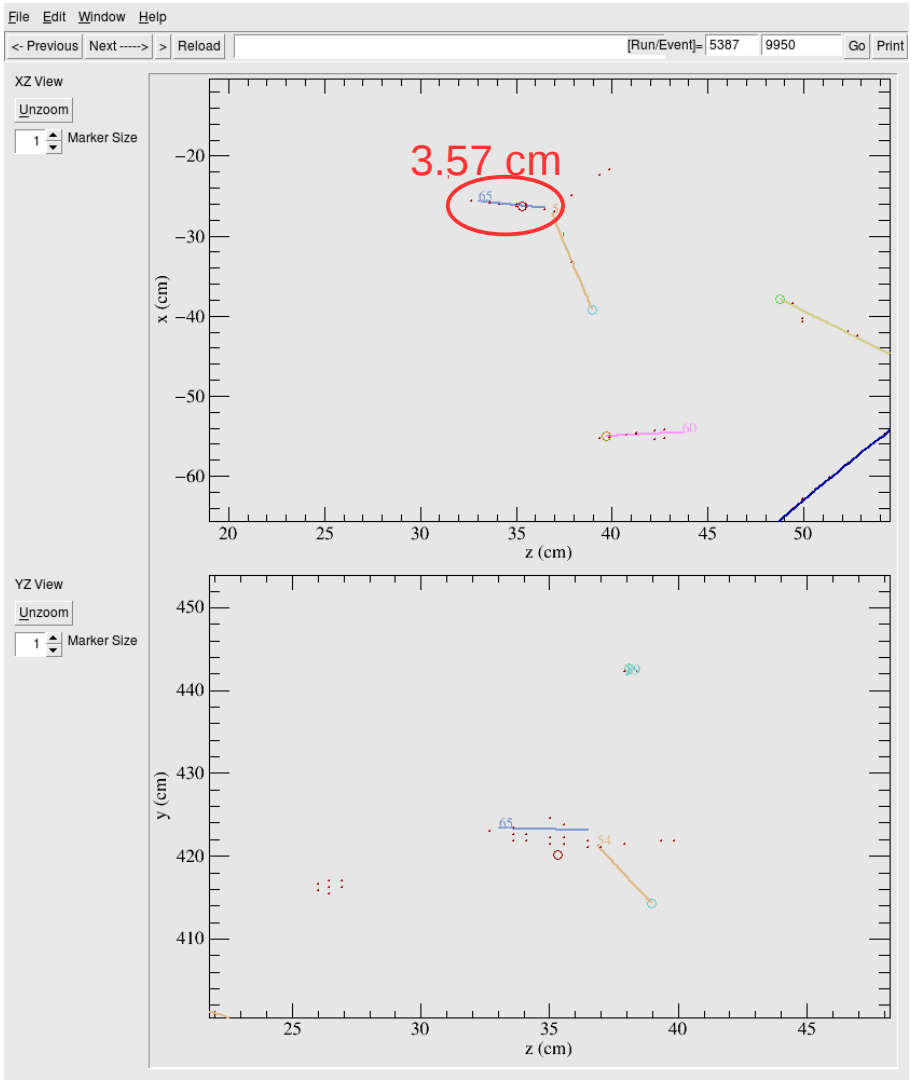

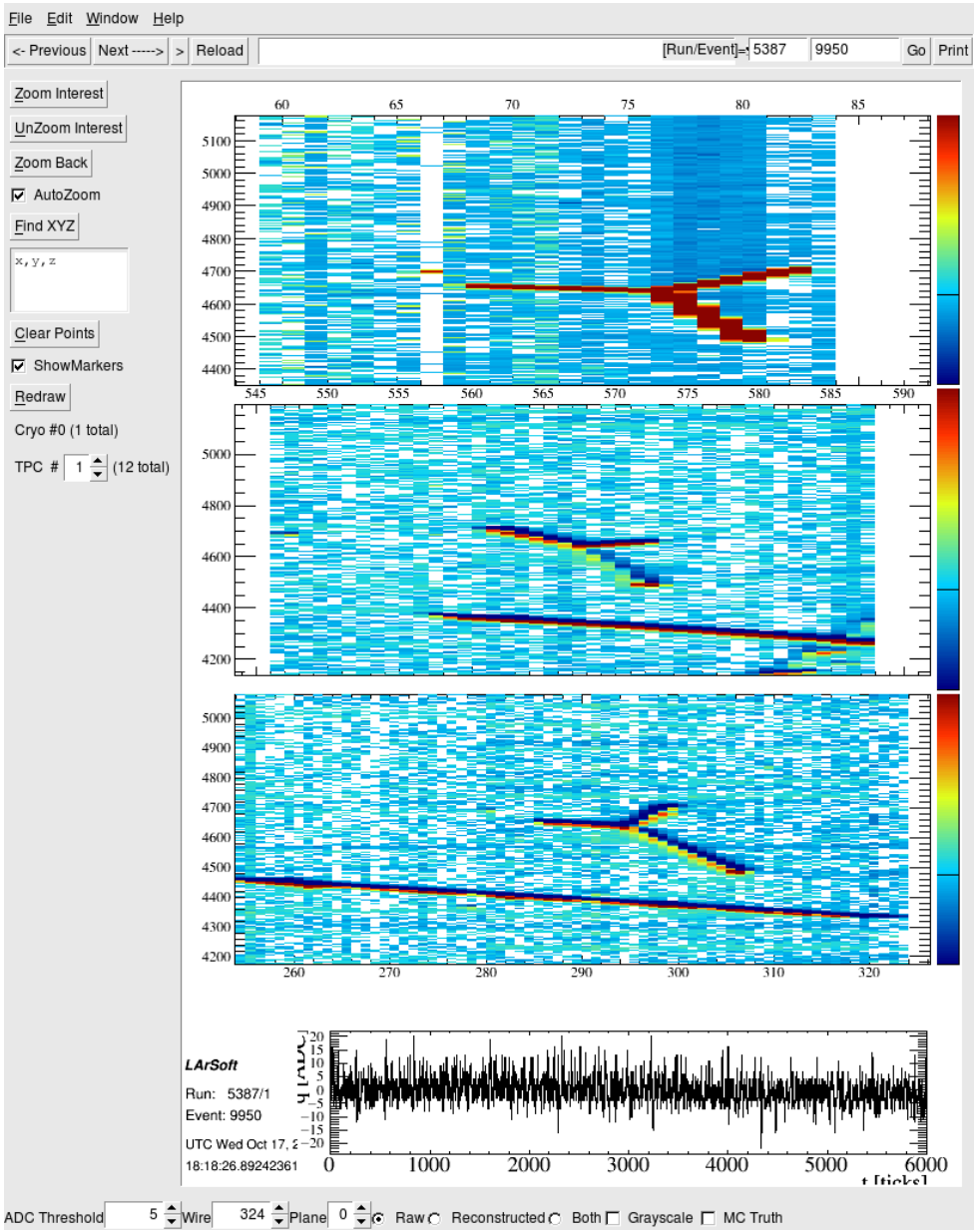

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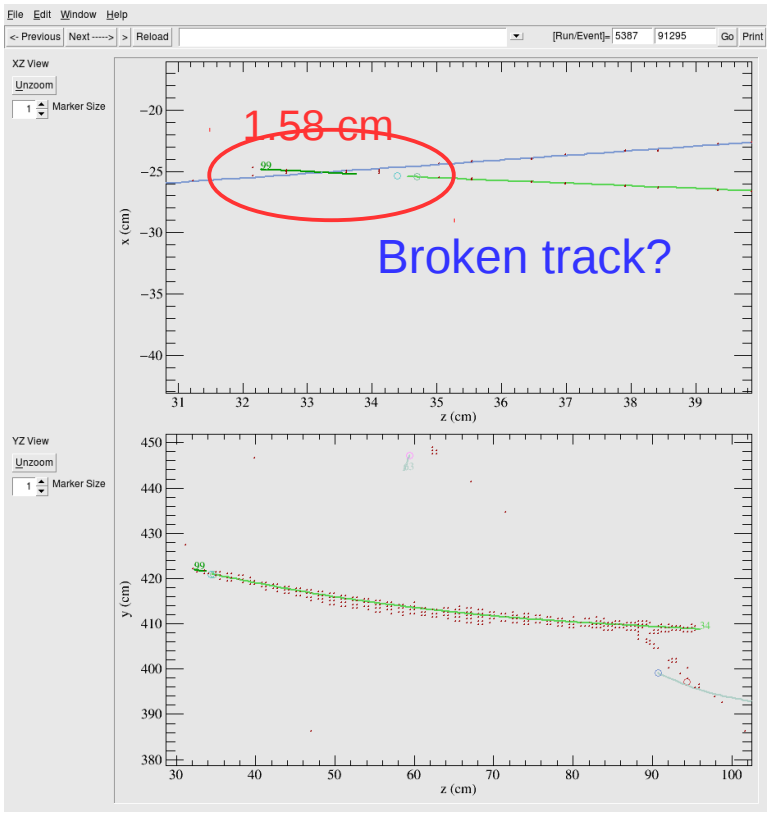

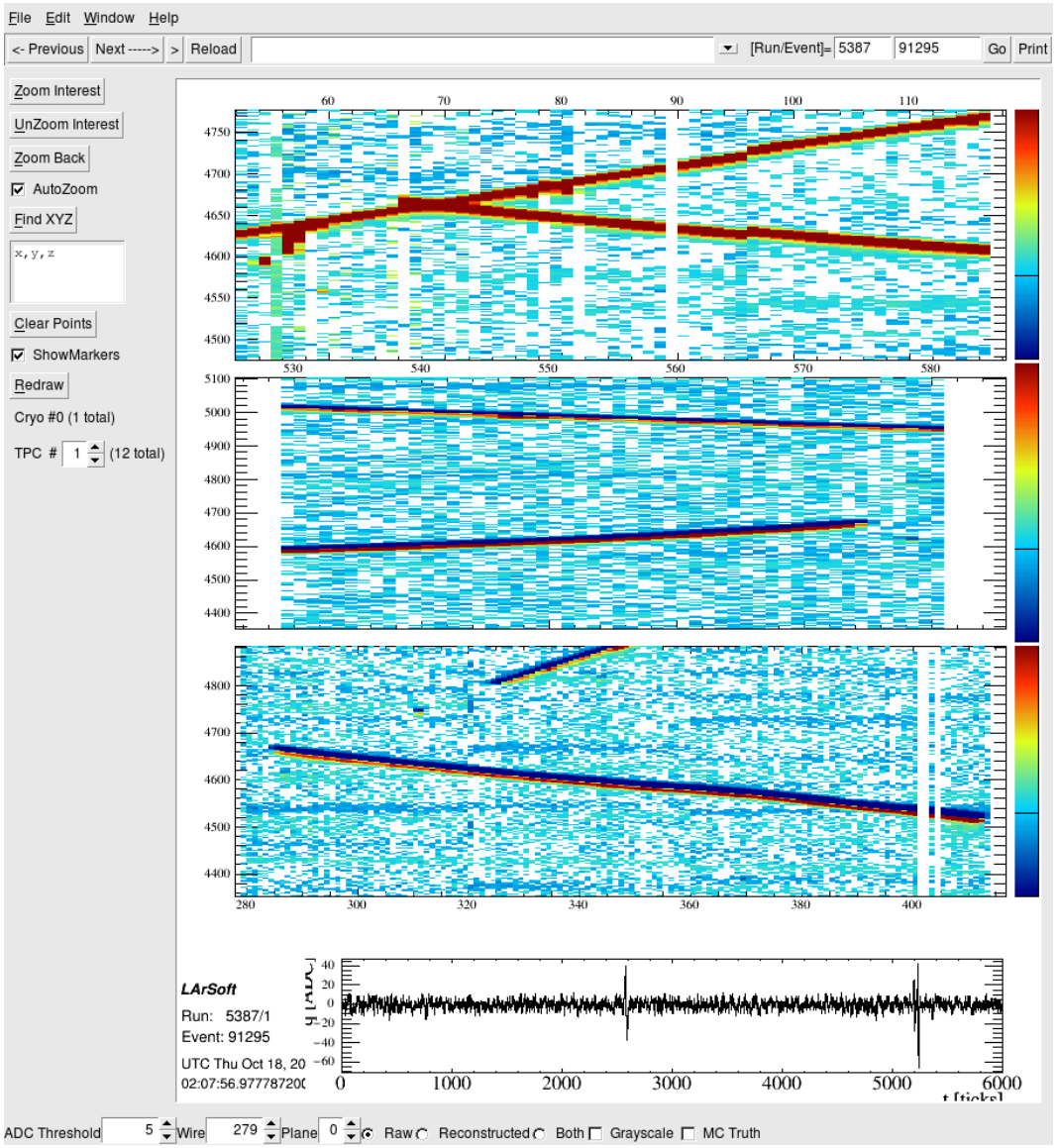

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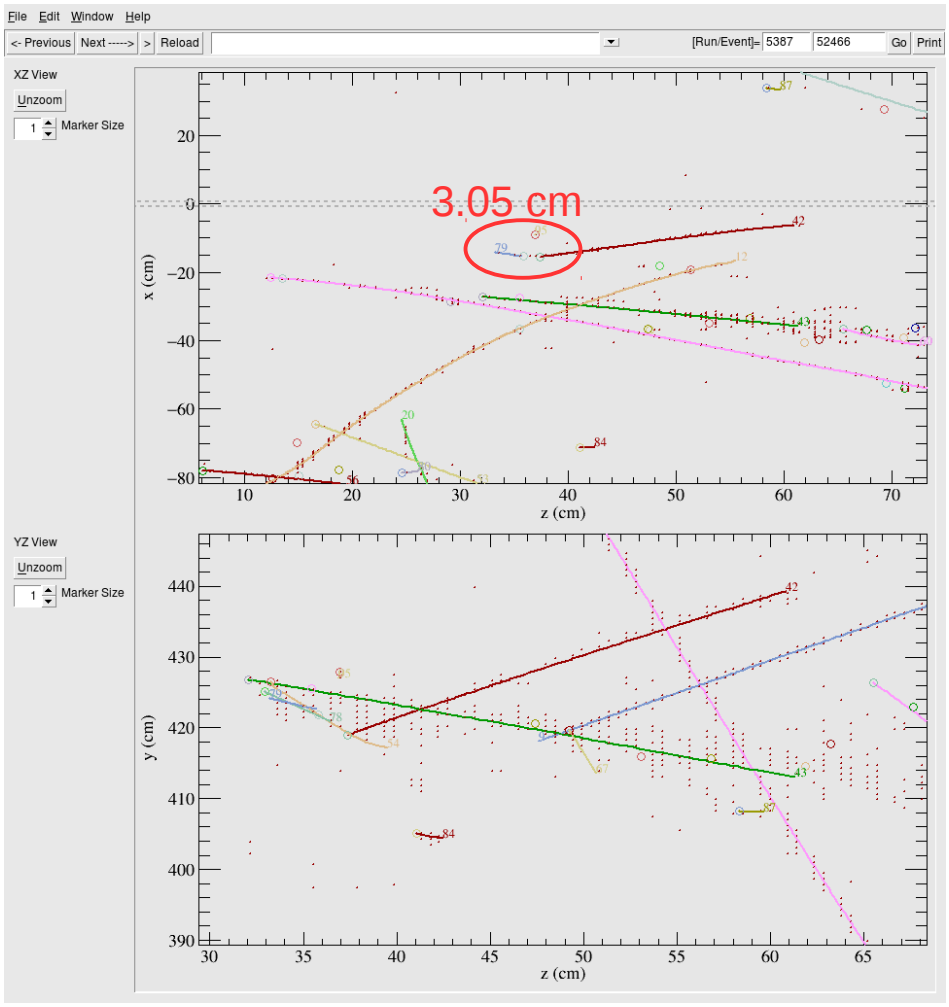

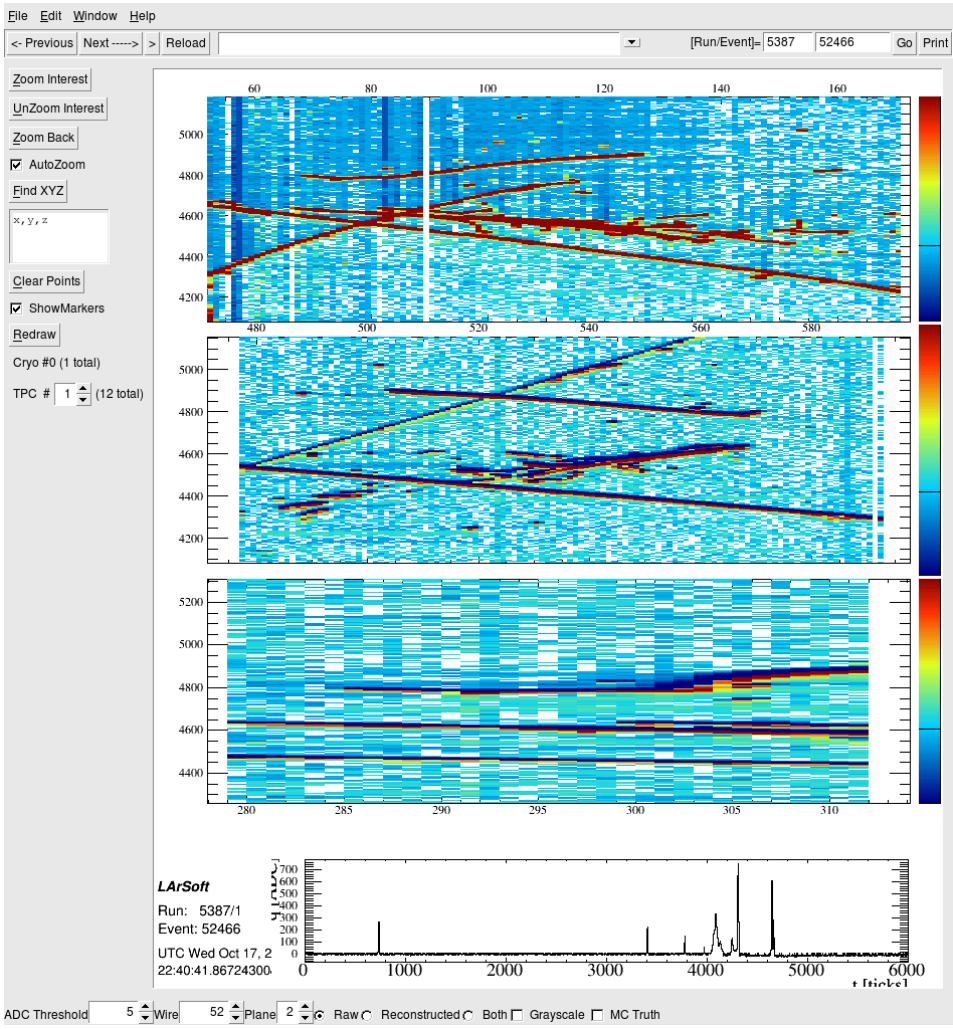

Summary & Outlook

- Developed methods to tag stopping protons

- Next Step:
  - Track length distribution with space charge effect / fluid flow
  - Work on PFparticle product and its application