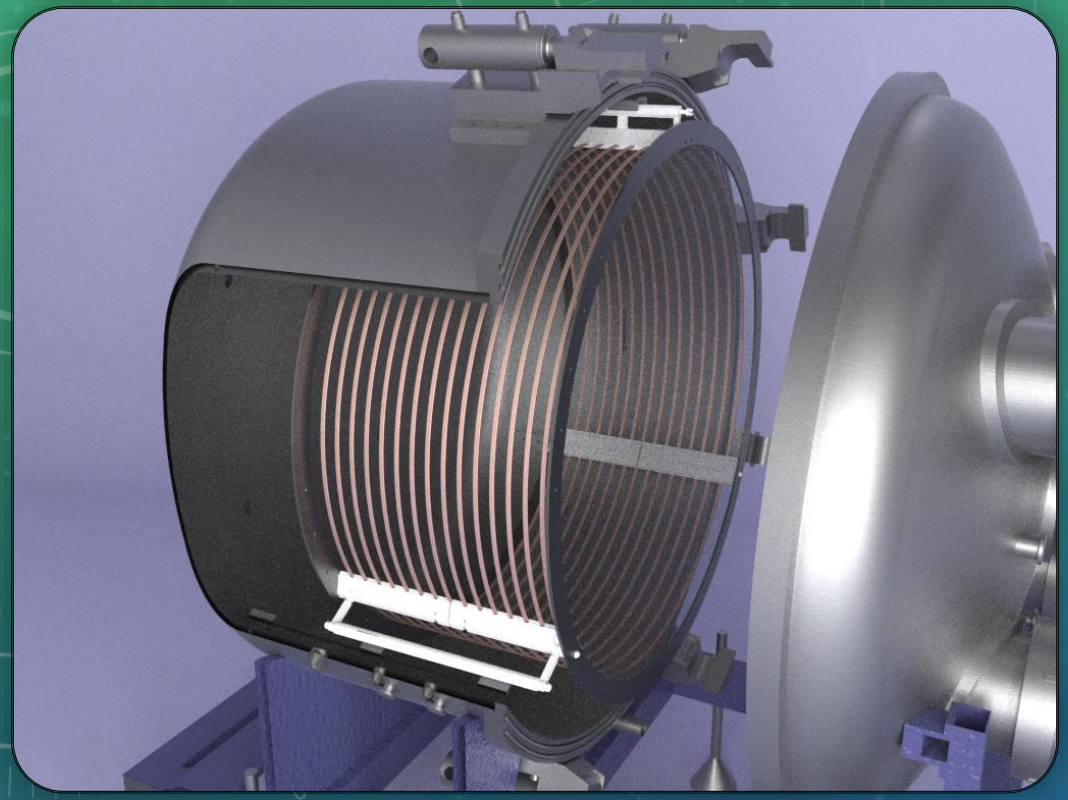

PROTOTYPE HPTPC SIMULATION UPDATE

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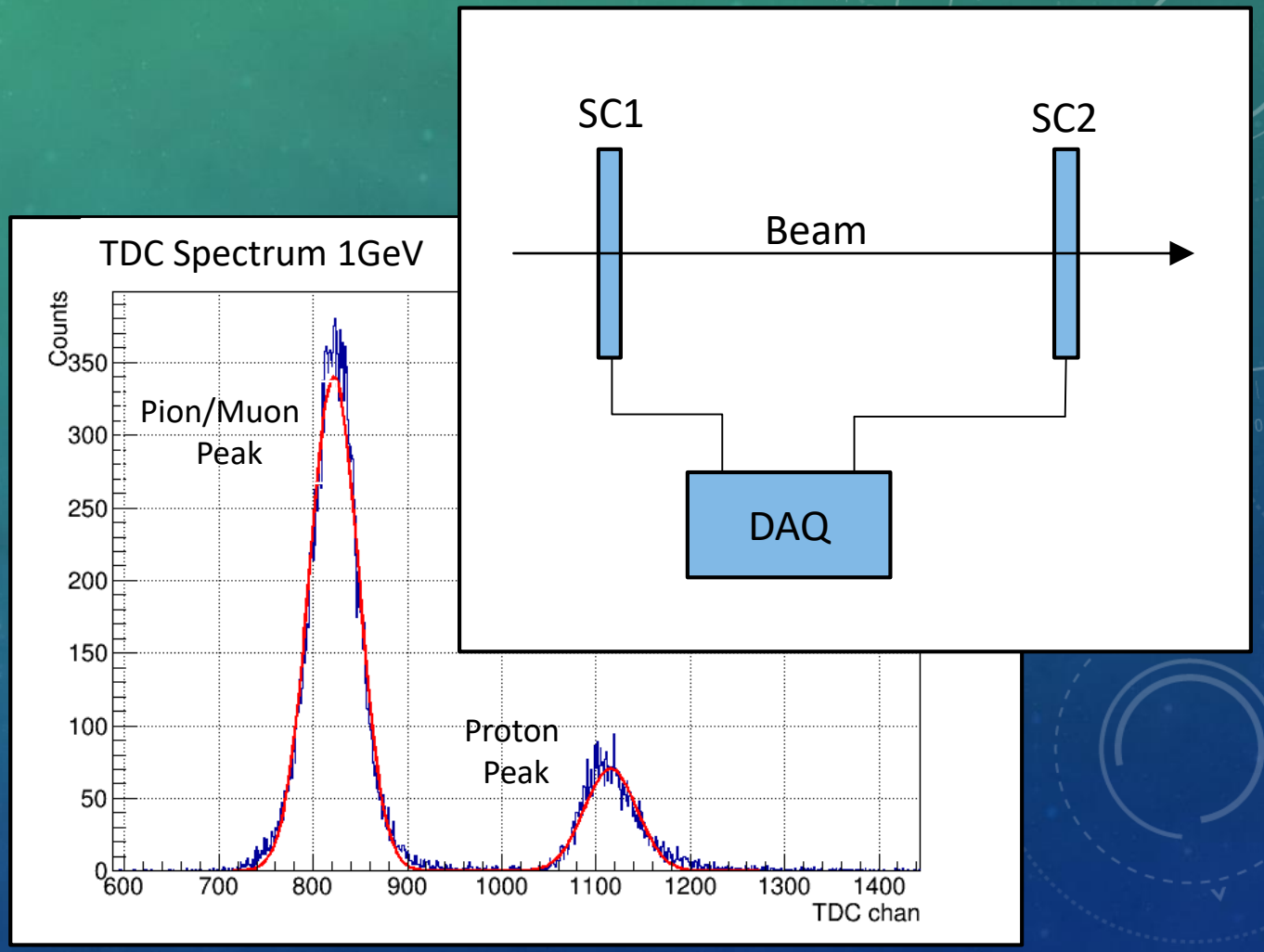
ROYAL HOLLOWAY UNIVERSITY OF LONDON

PROTOTYPE HPTPC

- High pressure gas filled time projection chamber
- 0.7m^3 field cage
- 10mm thickness steel vessel, 2mm thickness aluminium beam window
- Aim – Take test beam data at CERN to measure proton-argon and pion-argon scattering cross sections at energies that would be emitted by neutrino-nucleus interactions

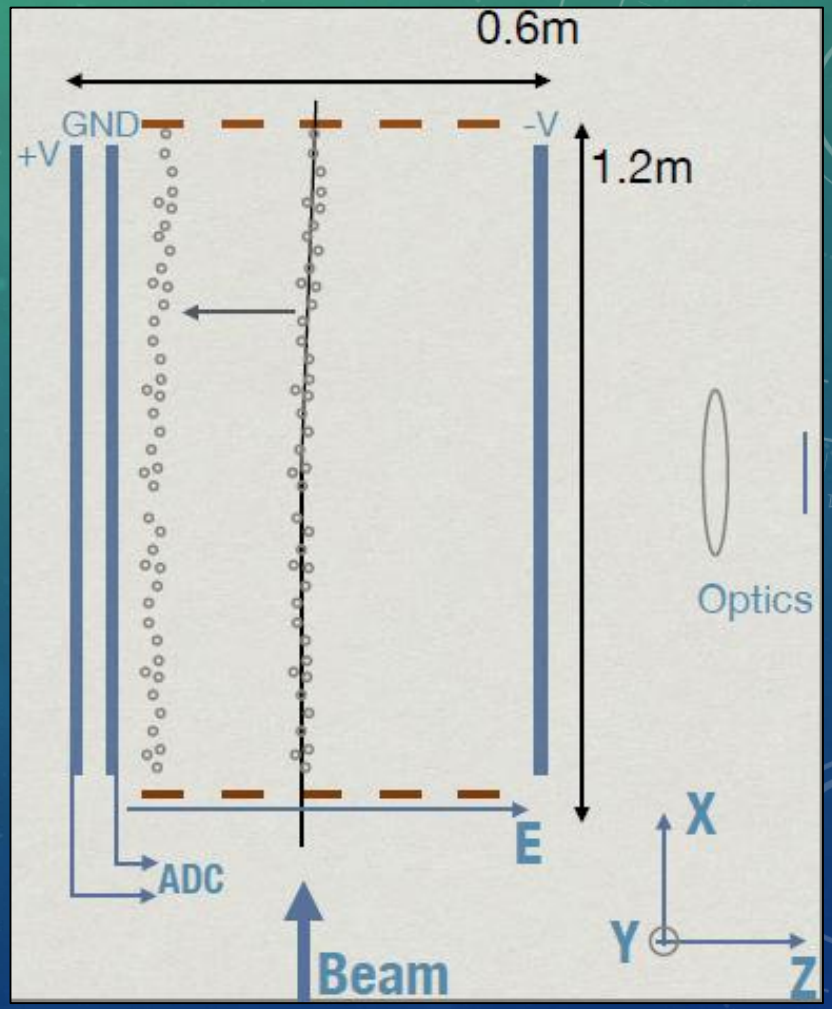
TIME OF FLIGHT IN A TEST BEAM

- Time of flight measurement at the T9 & T10 test beam
- Measure momentum dependant proton & pion fluxes below 1GeV/c at various collimator settings -> Feed data into simulations
- Result – Proton to Pion ratio at 0.3GeV/c on the order of 1:1000 -> Off axis approach

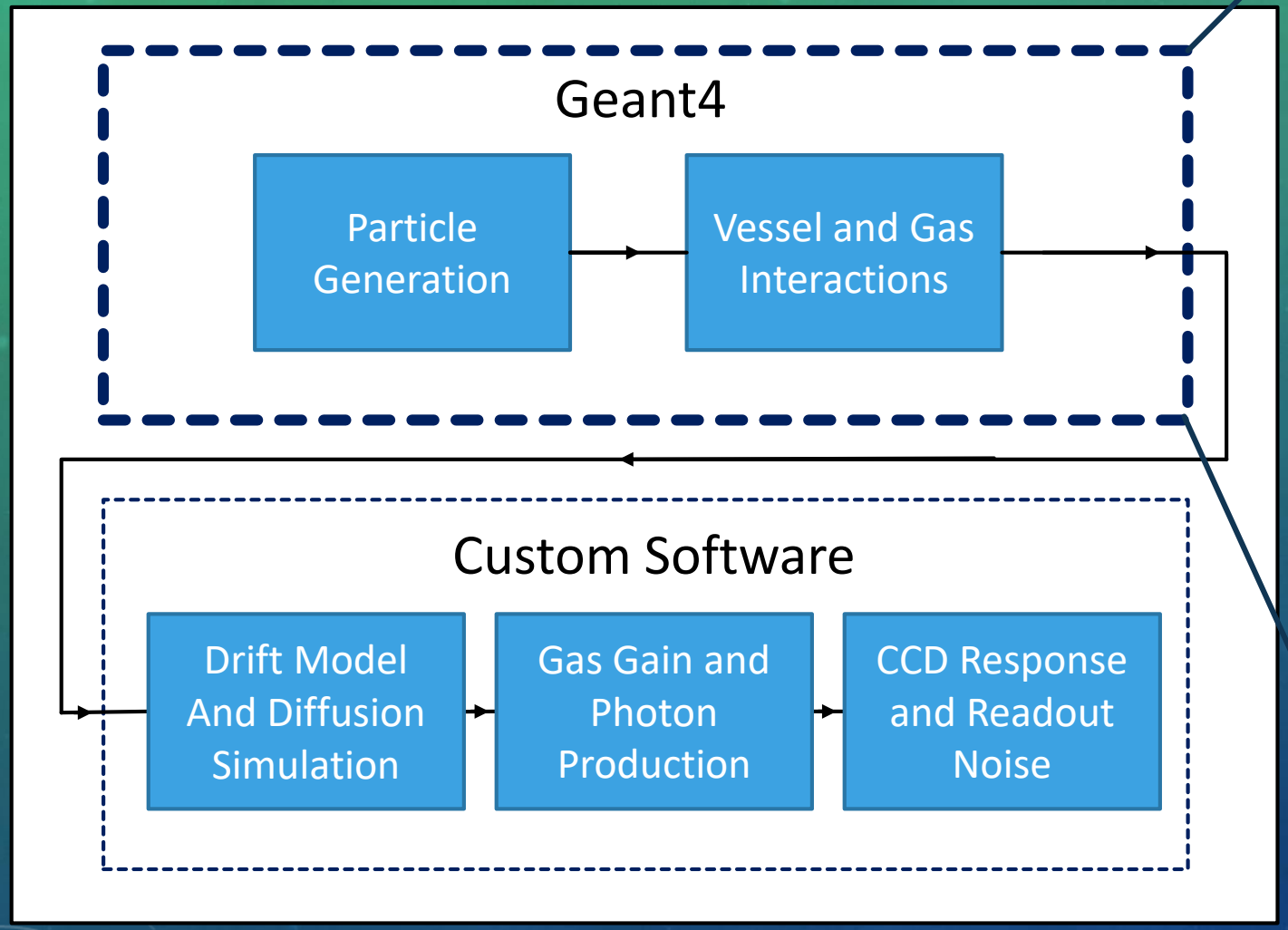


TPC AND READOUT

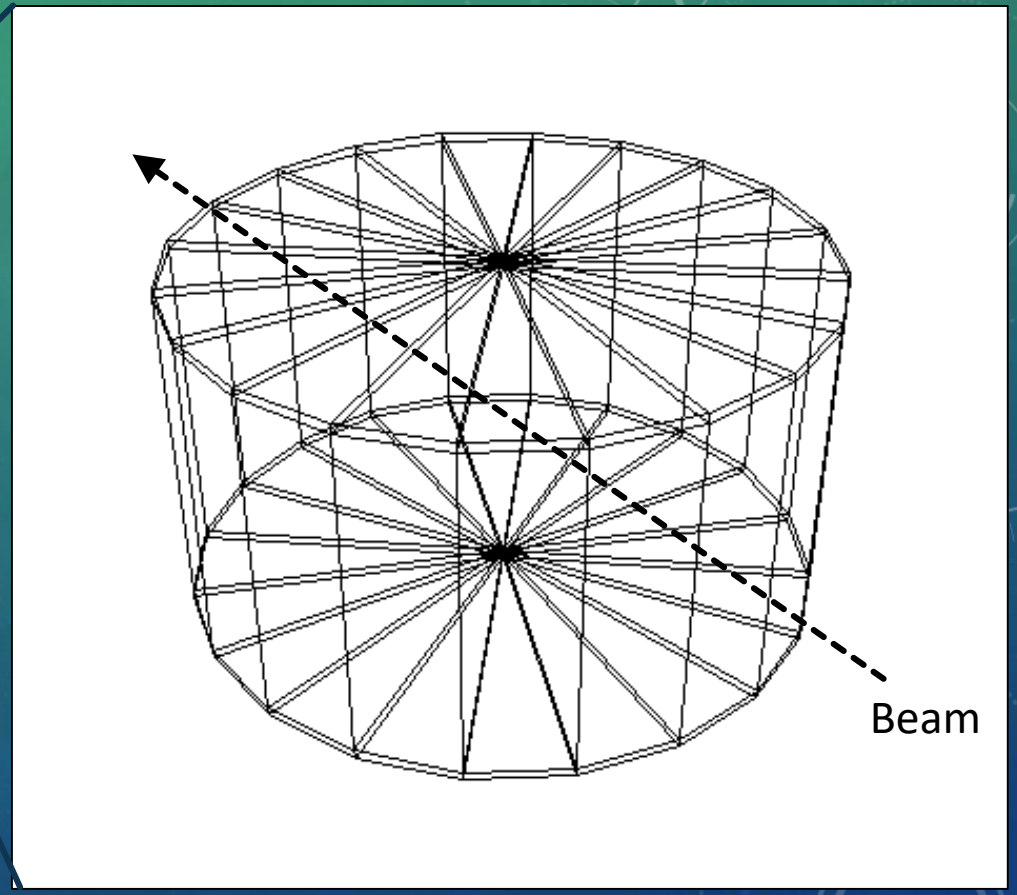
- Particles passing though the chamber ionise the gas producing a track of electrons
- Track of electrons is accelerated towards amplification region via a drift field (100-150V/cm)
- Electrons undergo proportional amplification (of 10^4 - 10^5) creating scintillation photons
- Photons picked up by the CCD camera and charge measured at the amplification region -> 3D track reconstruction
- Proton vs Pion identification via $^{dE}/_{dx}$ and/or integrated charge



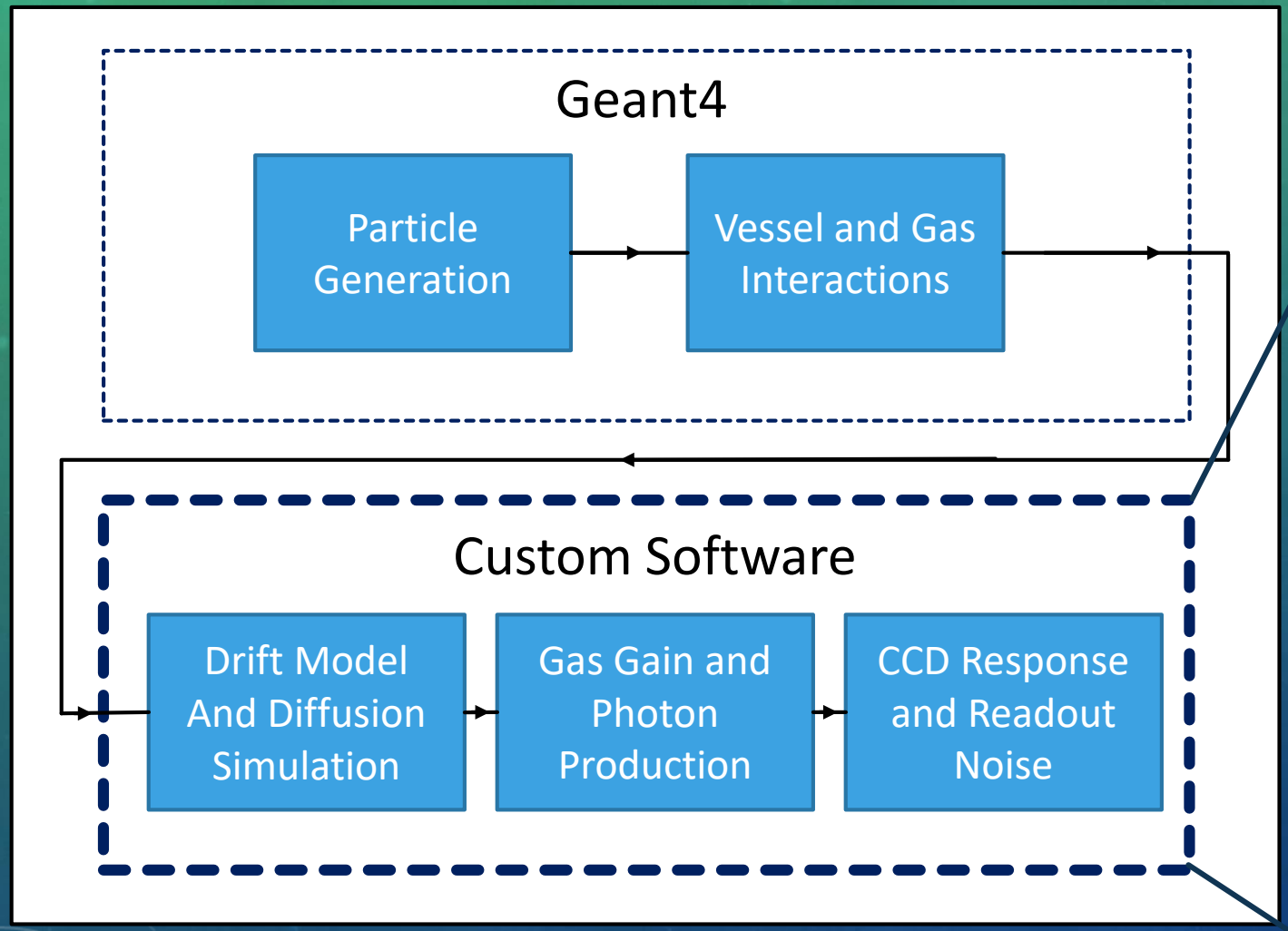
SIMULATION CHAIN



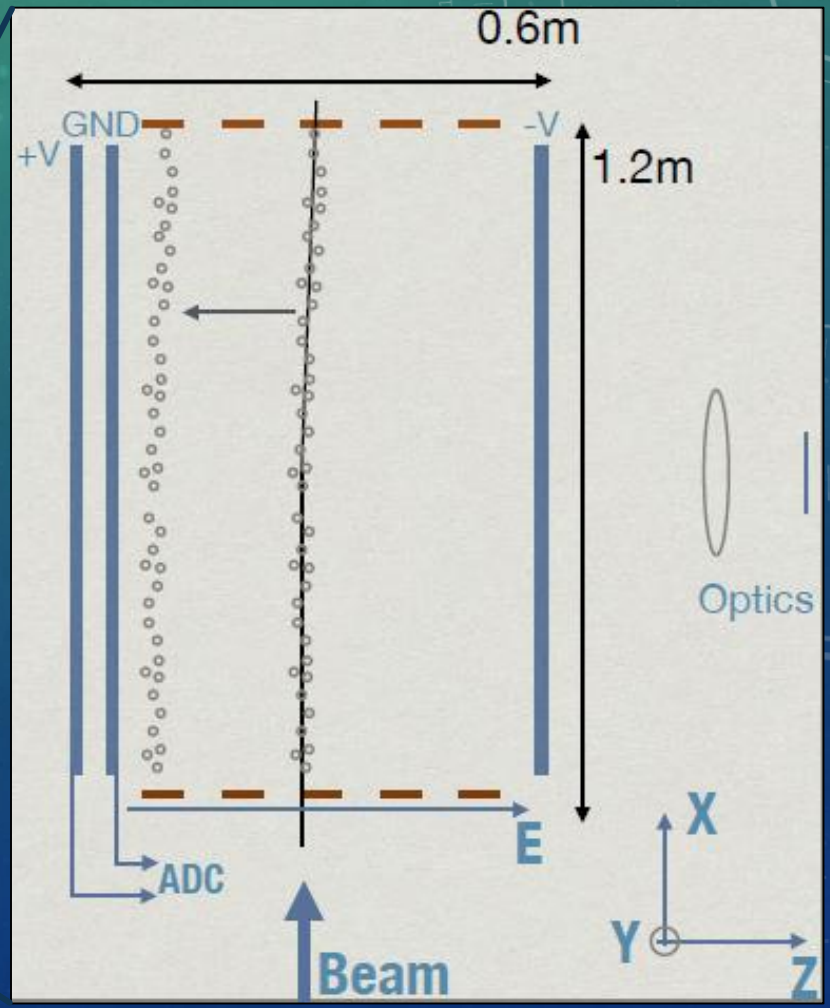
Geant4 Model



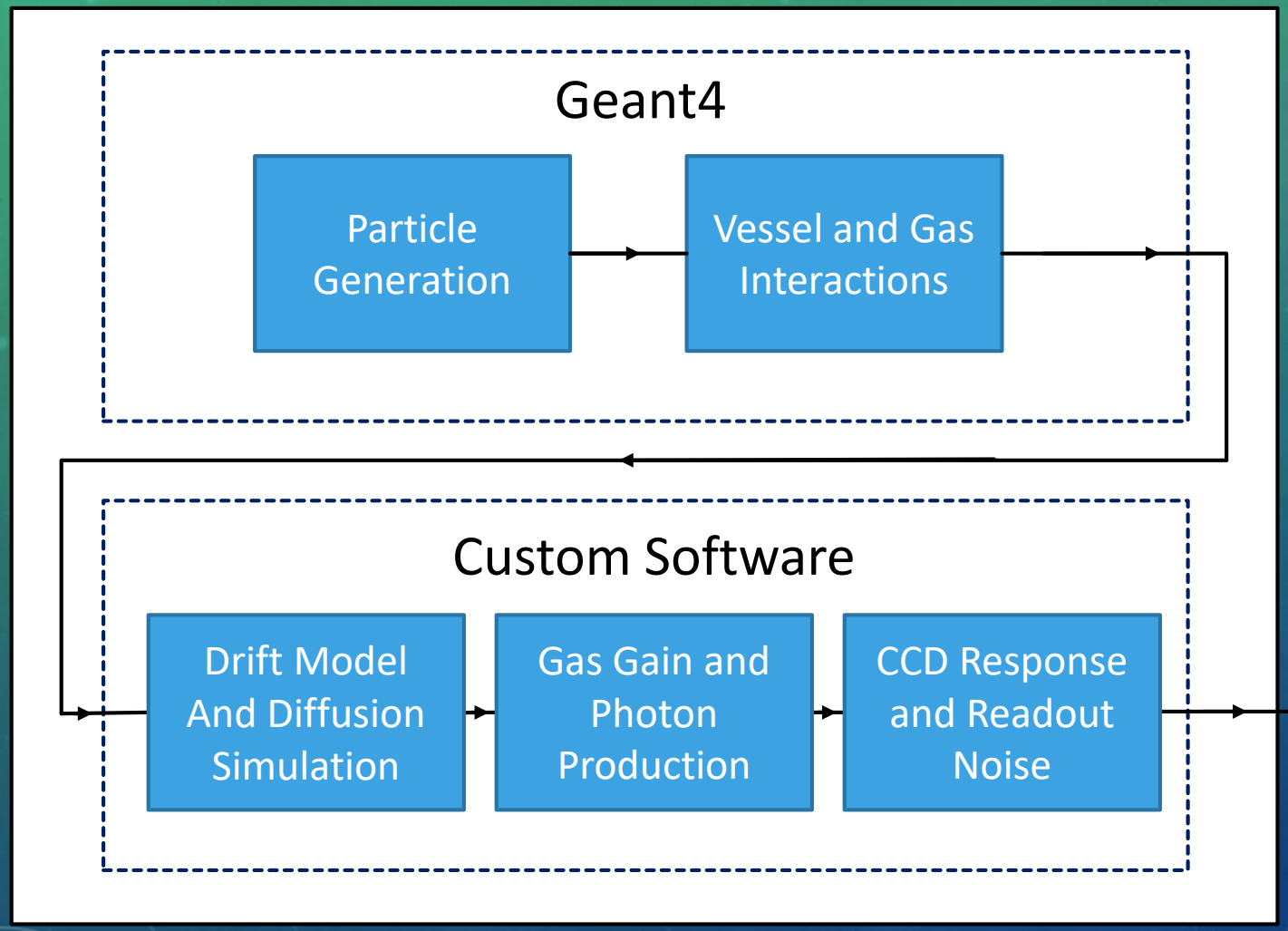
SIMULATION CHAIN



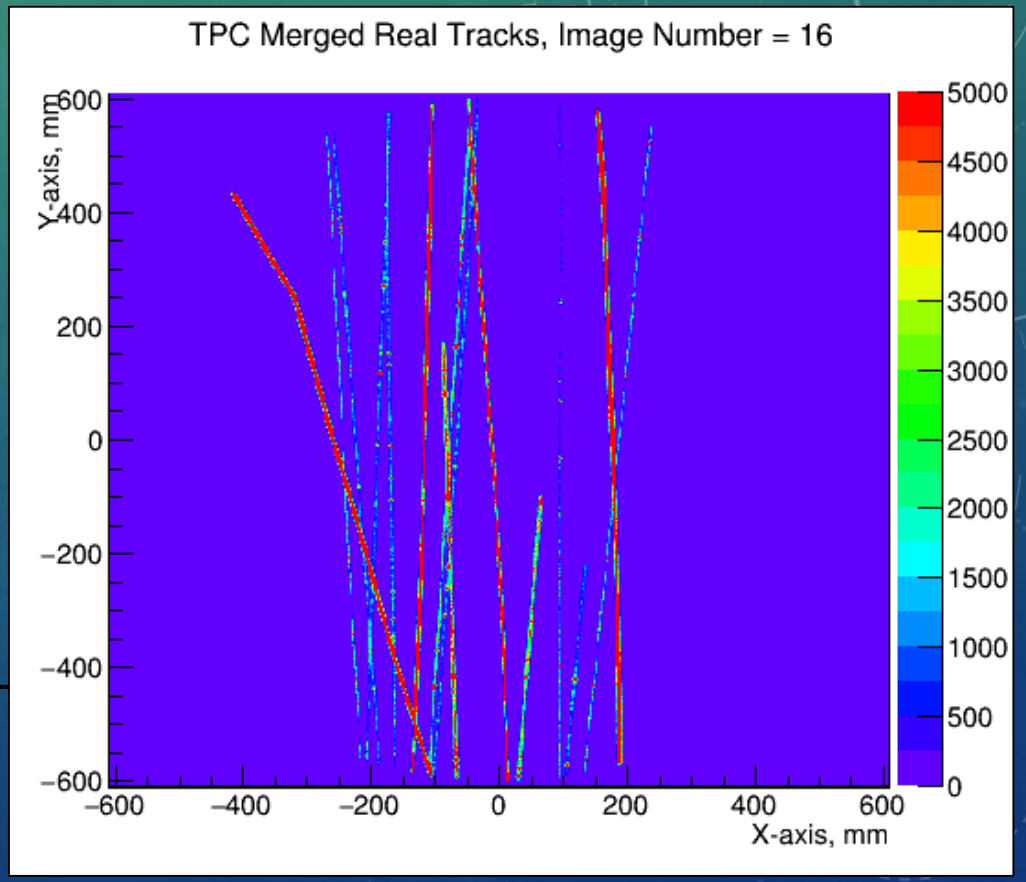
TPC and Readout



SIMULATION CHAIN

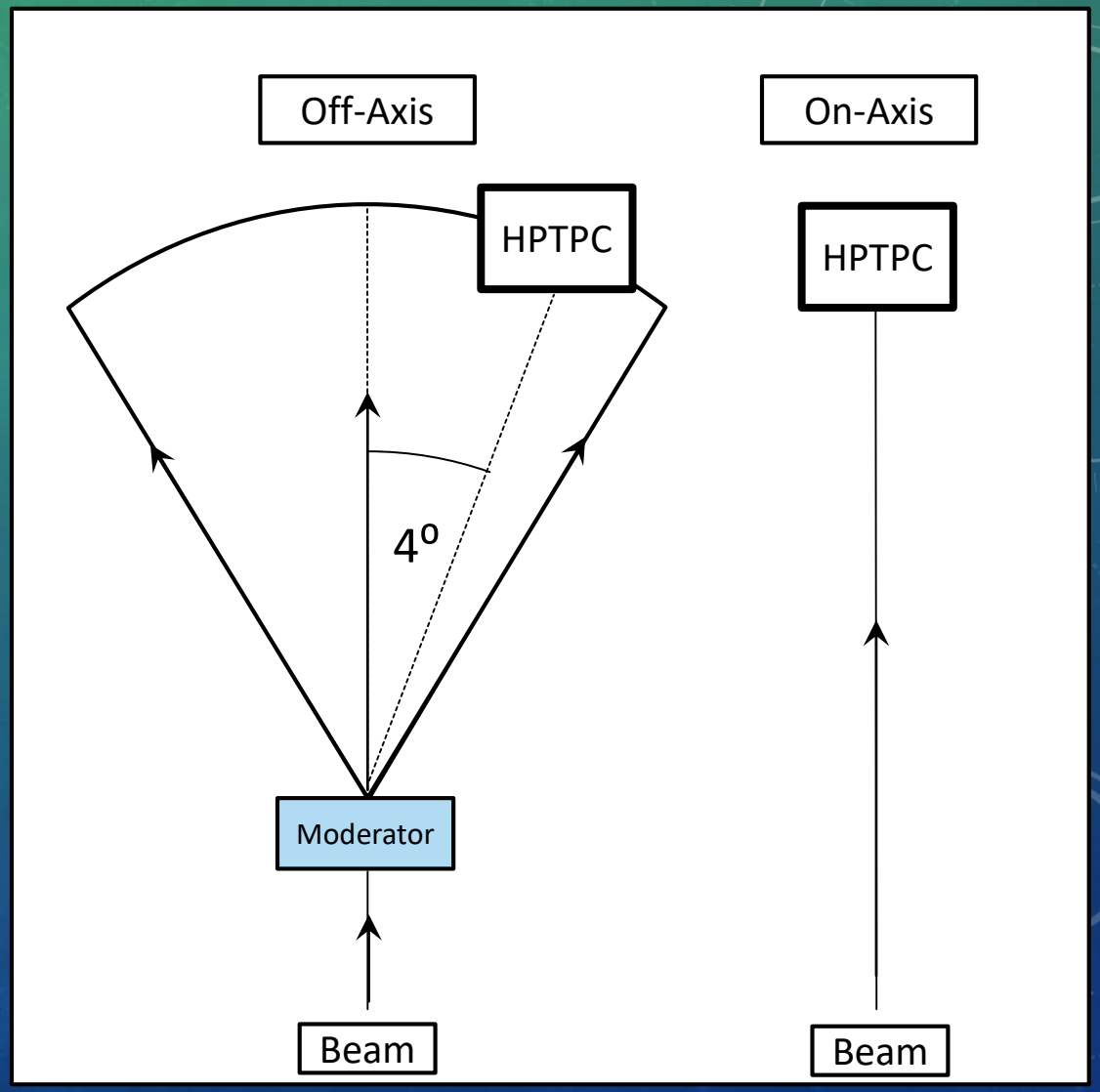


Final Simulated Event



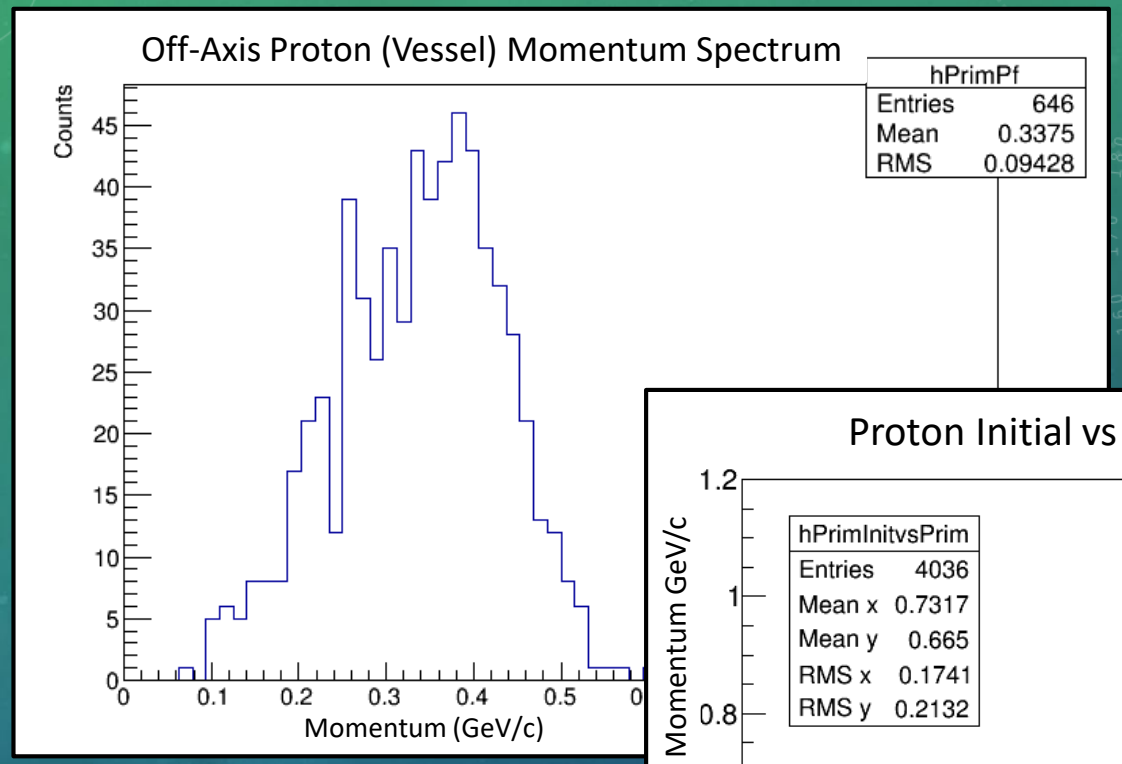
ON VS OFF-AXIS APPROACH

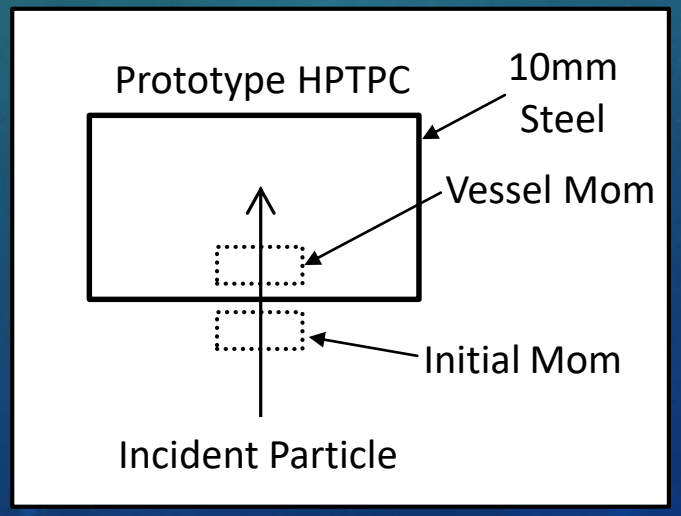
- **On-Axis**:
  - Beam aligned with beam window (2mm Aluminium)
  - More favourable and easily tuneable energy spectrum
  - Proton/pion (0.3GeV/c) ≈ 1/1000
- **Off-Axis**:
  - Using higher energy beam ≈ 1GeV/c with proton/pion ≈ 1/3
  - Beam passes through moderator HPTPC placed off axis.
  - Proton/pion (0.3GeV/c) ≈ 1/2
  - Wider spread energy spectrum

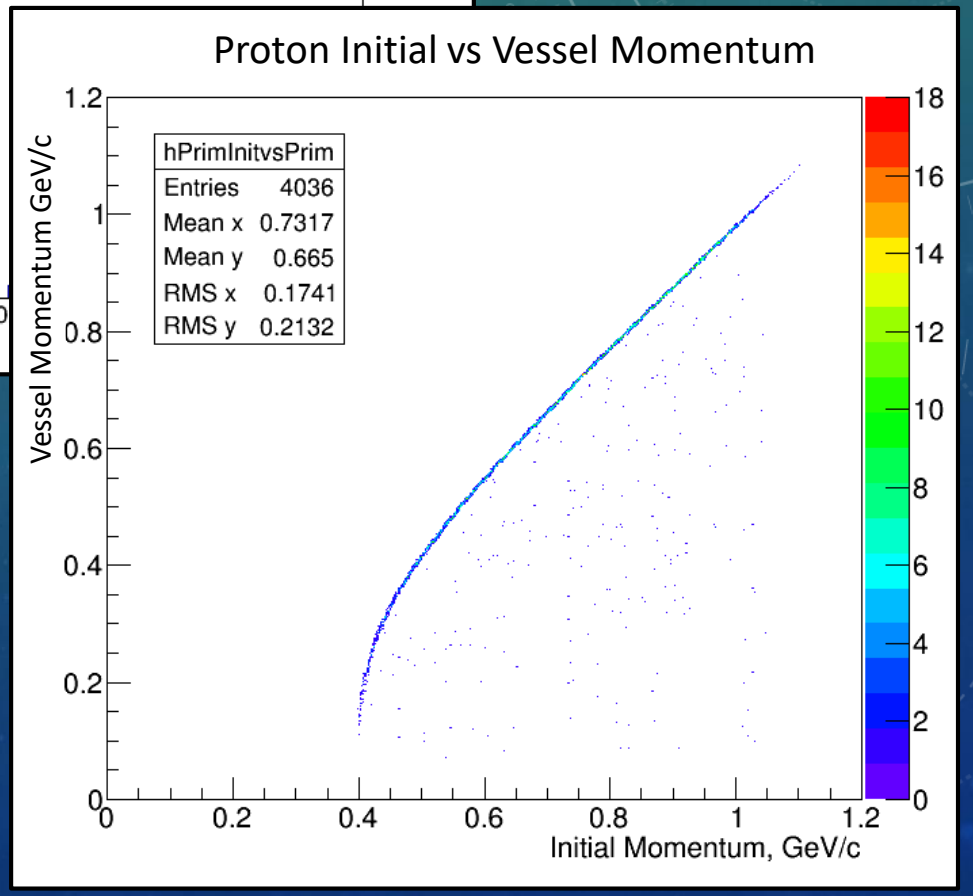


OFF-AXIS APPROACH

- 10mm steel vessel wall acts as additional moderator
- Simulated Setup:
  - 35cm Plastic Scintillator moderator
  - 0.87GeV/c Beam
  - Prototype HPTPC 4^{o} off axis
  - 14m downstream from moderator

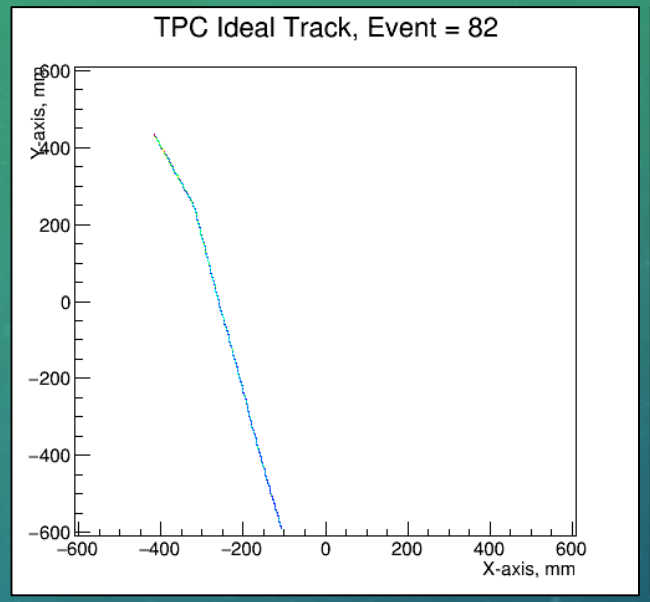


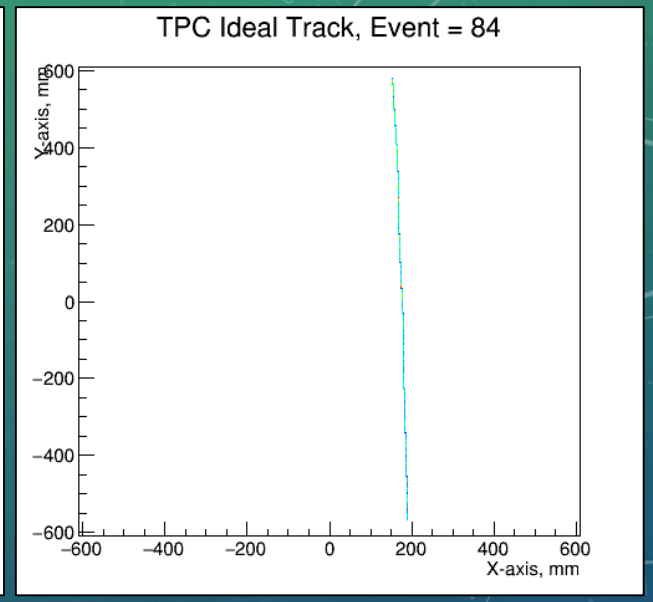


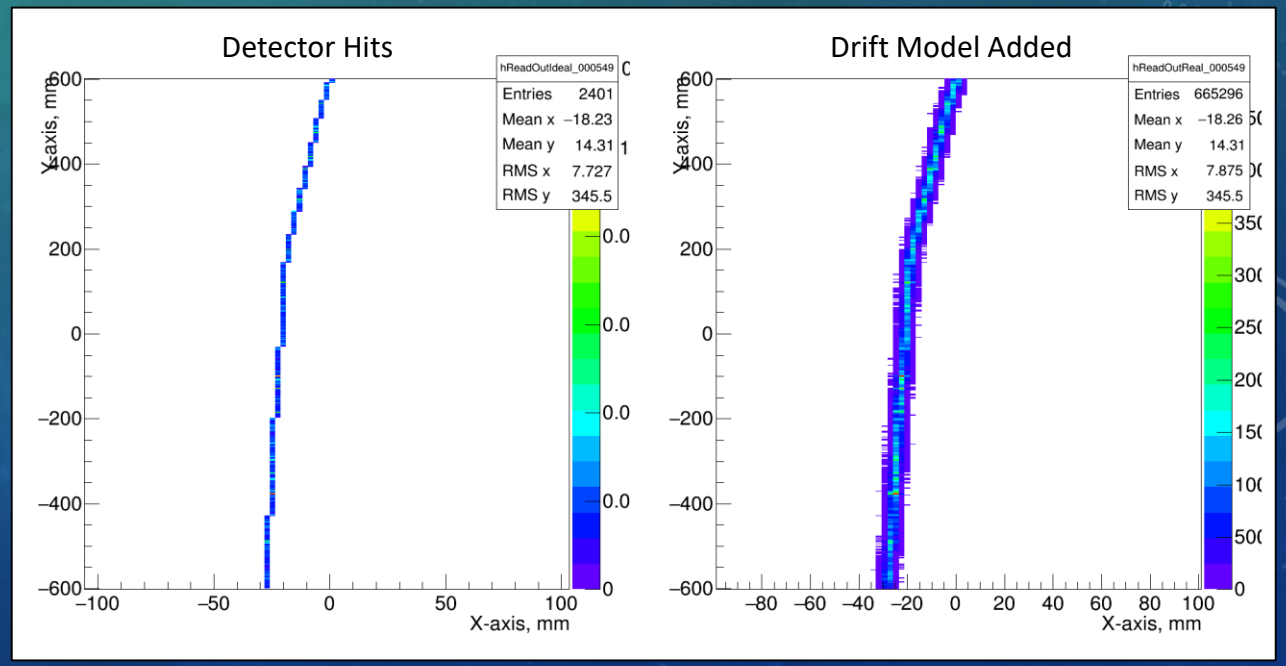


TRACKS SIMULATION

- Particle generation and detector simulation using Geant4 -> results in a series of detector hits
- Hits taken by analysis code which applies the drift model to simulate diffusion
- Simulate incident protons and pions separately producing single tracks

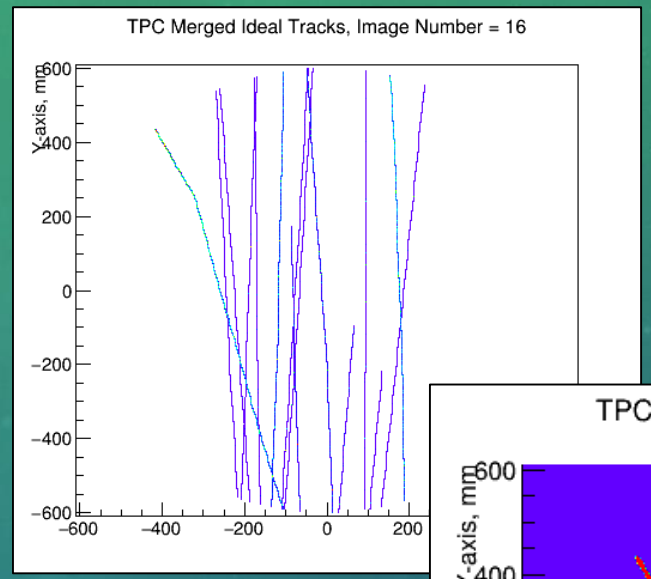




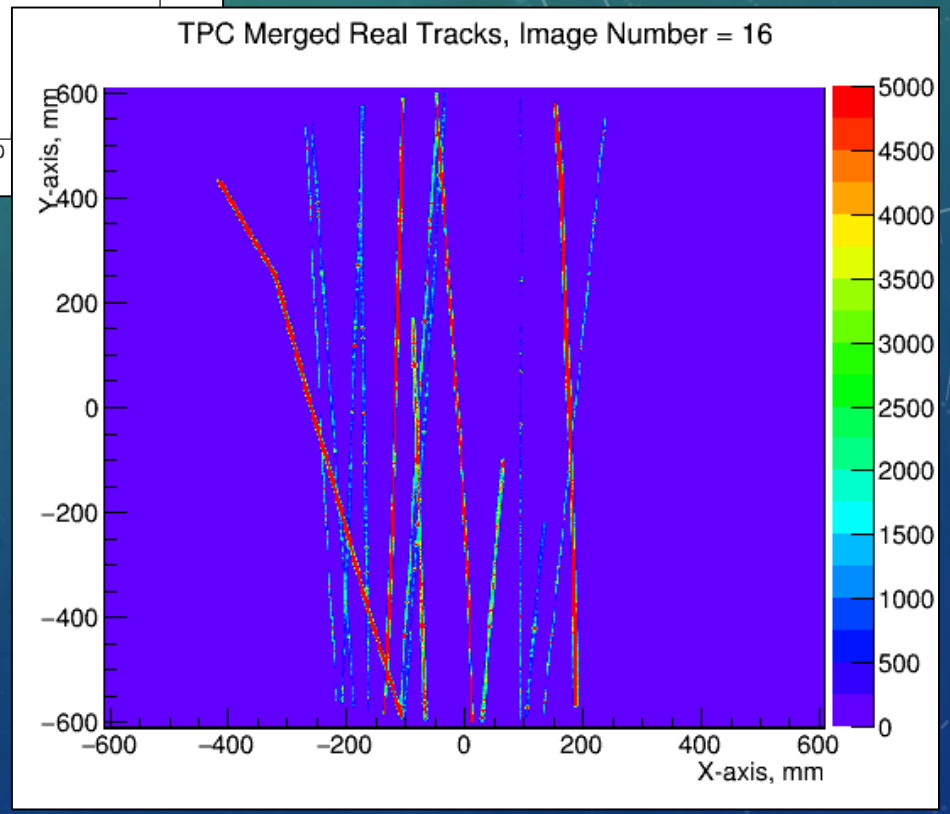


FROM SINGLE TRACKS TO FULL EVENTS

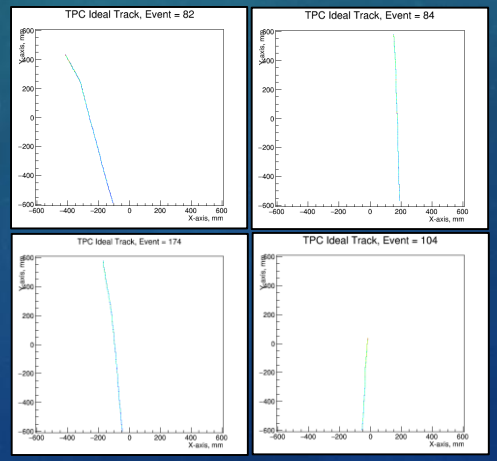
- Merge Poisson-fluctuated proton & pion tracks
  - average of 5 protons and 10 pions for High Multiplicity events, or
  - 1.67 protons and 3.33 pions for low multiplicity events
- Apply CCD response
- Ready for track reconstruction by TREx



CCD response



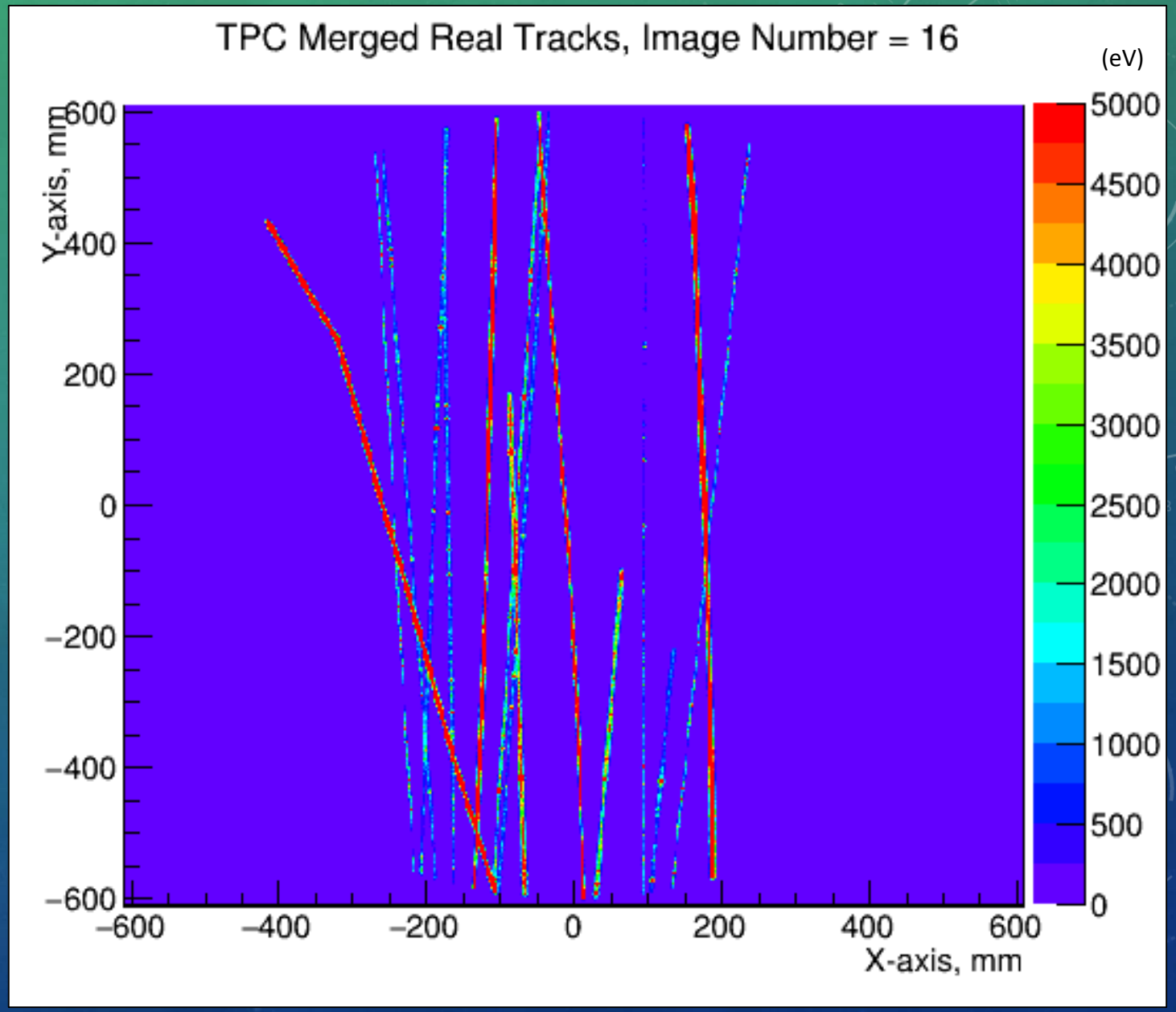
Merge



Single Tracks

FULL EVENT: TRACKS OF INTEREST

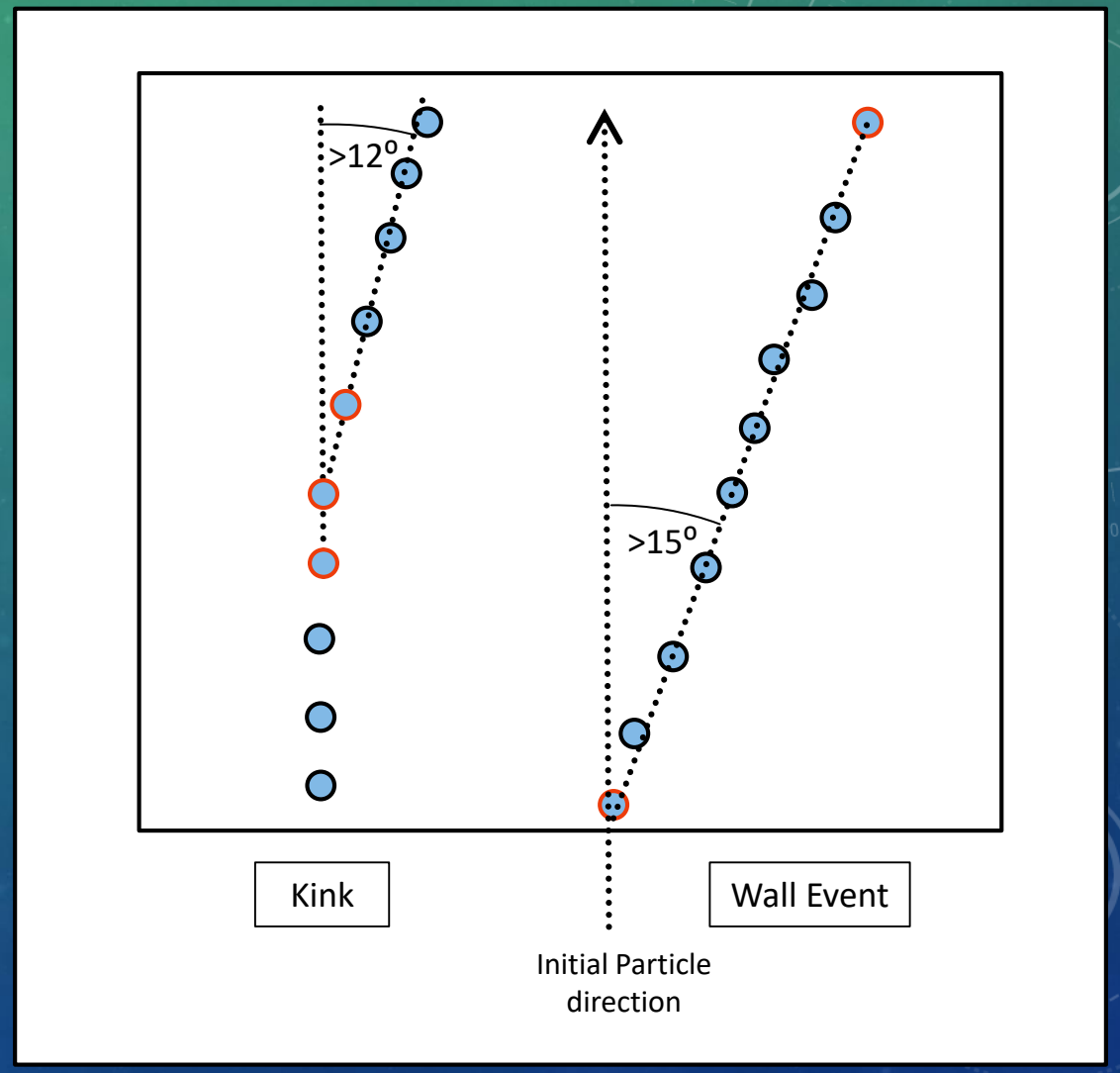
- Proton vs pion ID via $^{dE}/_{dx}$
- Pion vs muon ID requires investigation
- Track Types:
  - Straight through tracks
  - Wall events
  - Kink tracks
  - Stopped tracks



WALL VS GAS EVENTS

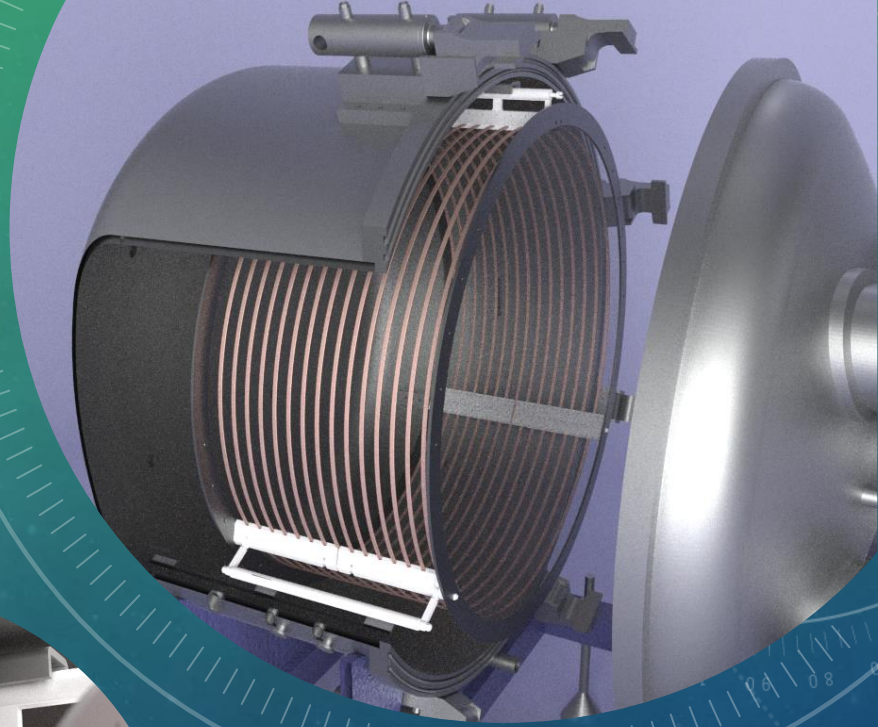
- Currently using a 0^{th} order method to classify wall events and kinks
- 12 degree angle -> Kink
- 15 degree angle from entry -> Wall event

Incident Particle	Avg. Number Per Spill	Wall interactions	Kinks
Proton	3.33 (High Multiplicity)	≈ 10%	≈ 1 %
	1.67 (Low Multiplicity)		
Pion	10 (High Multiplicity)	≈ 11%	≈ 1.5%
	3.33 (Low Multiplicity)		

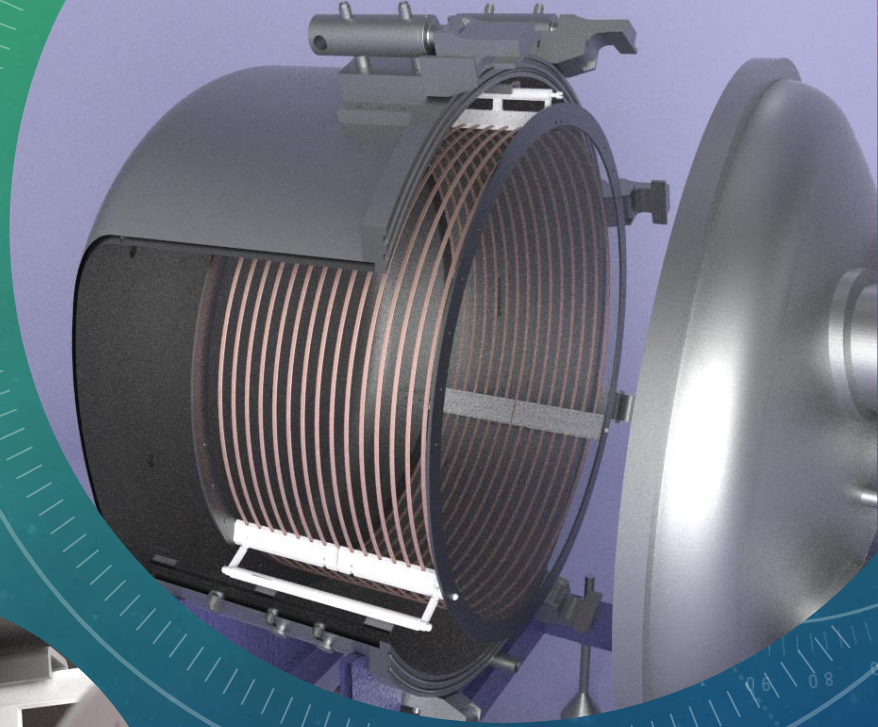


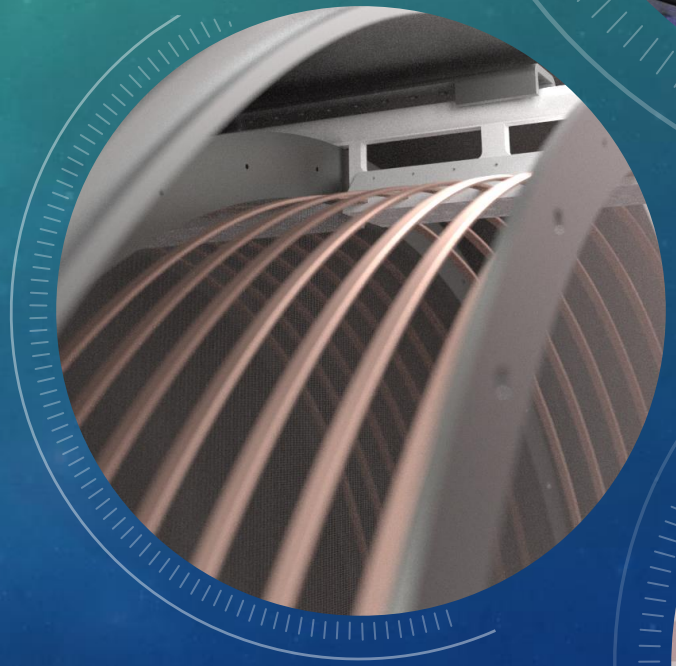
MOVING FORWARD

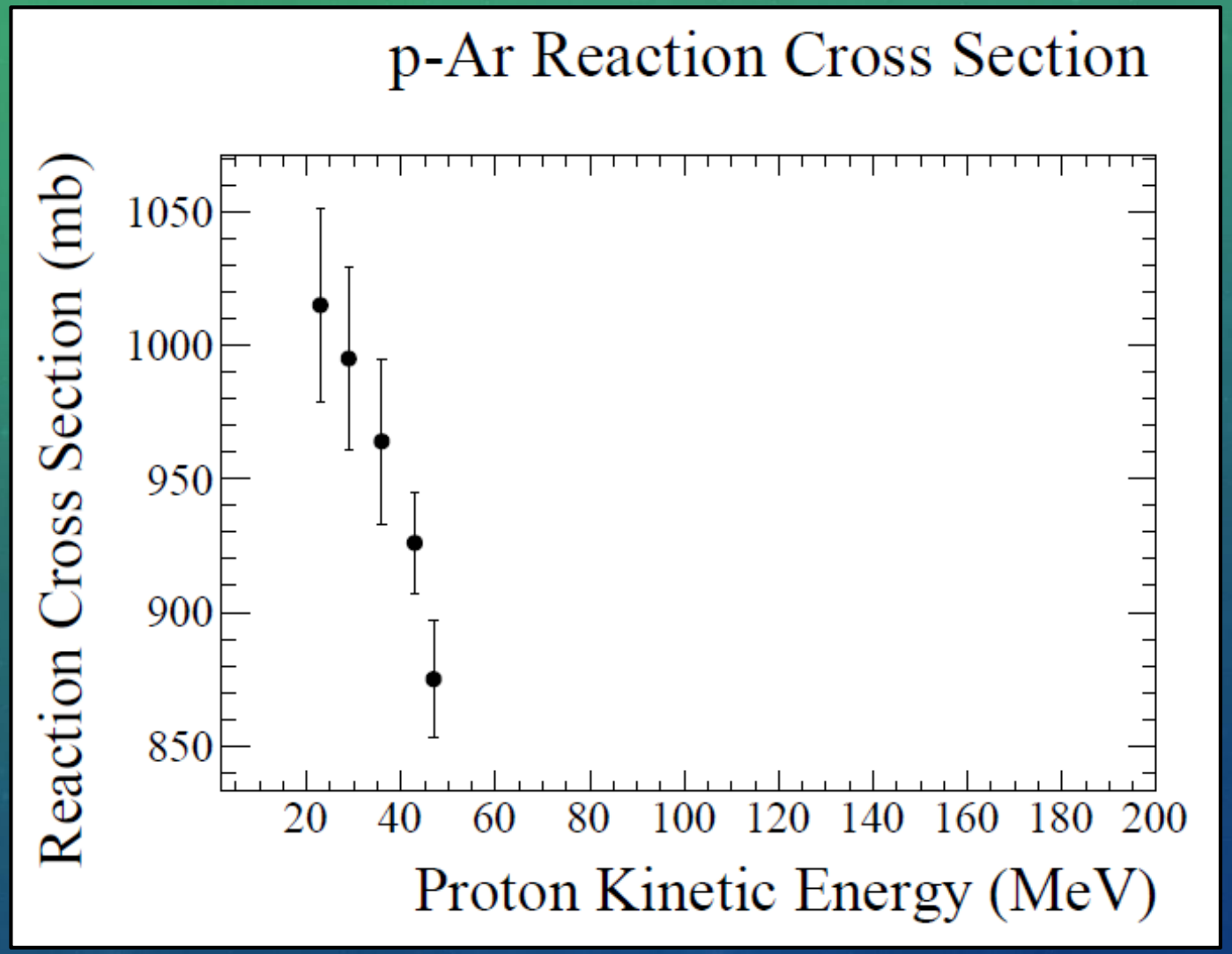
- Truth data structure to aid with TREx track reconstruction
- Addition of charge readout to allow for 3D track information
- Efficiency study with TREx to determine ideal pileup and beam time requirement



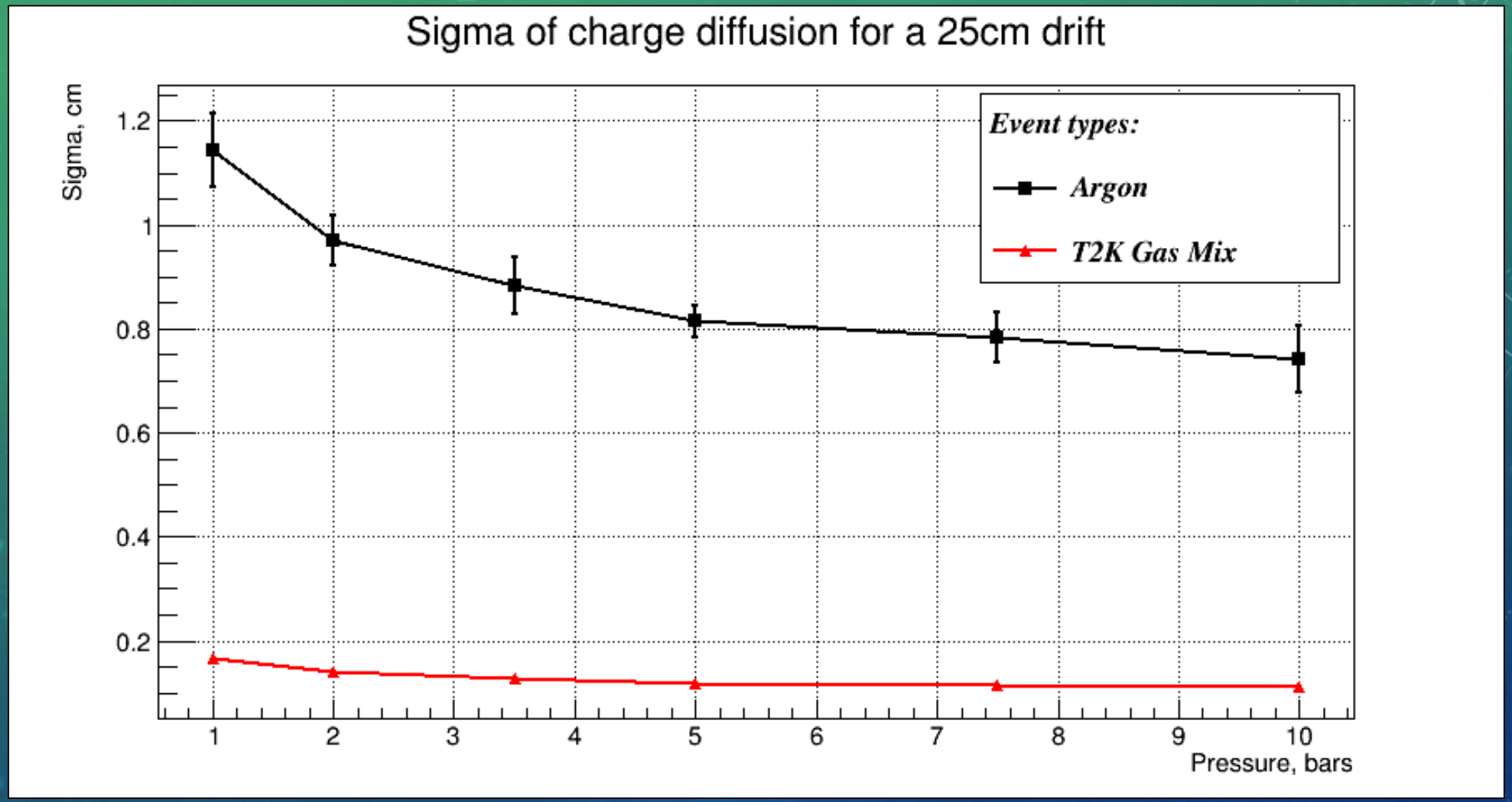
THANK YOU FOR LISTENING, ANY QUESTIONS?





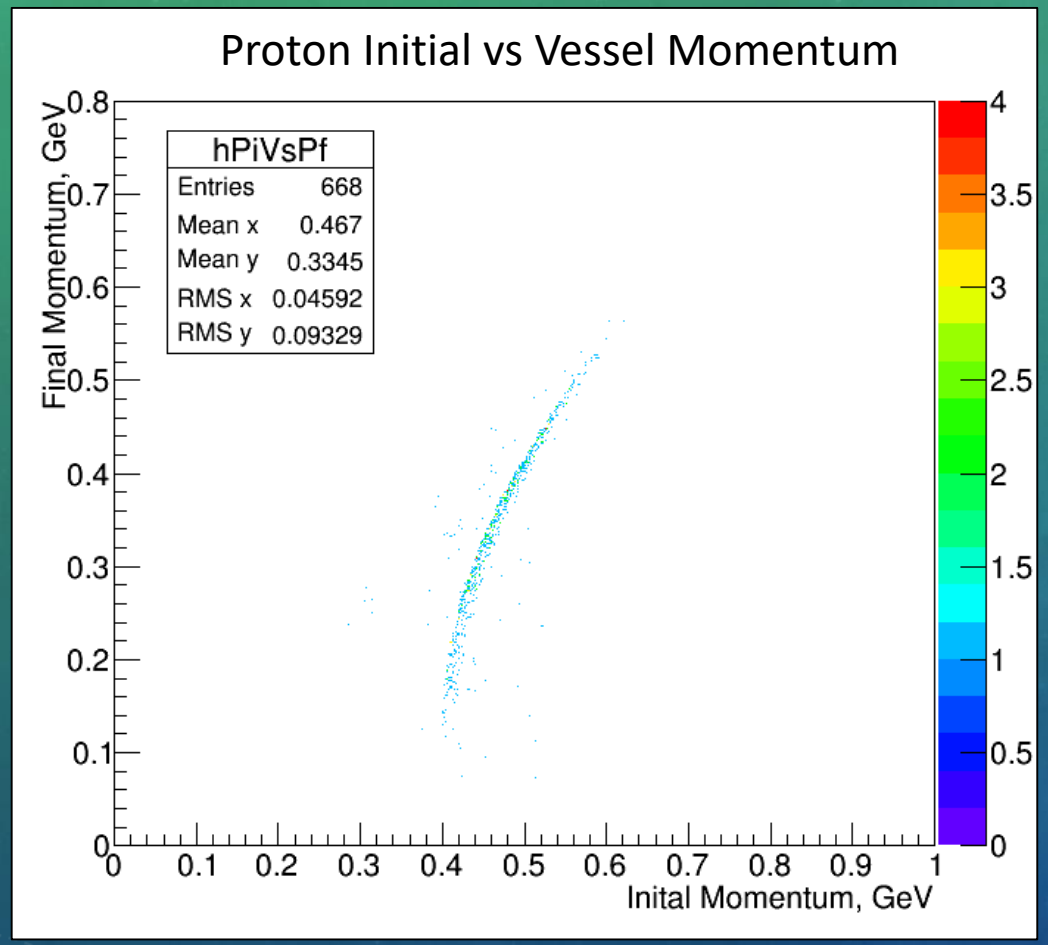


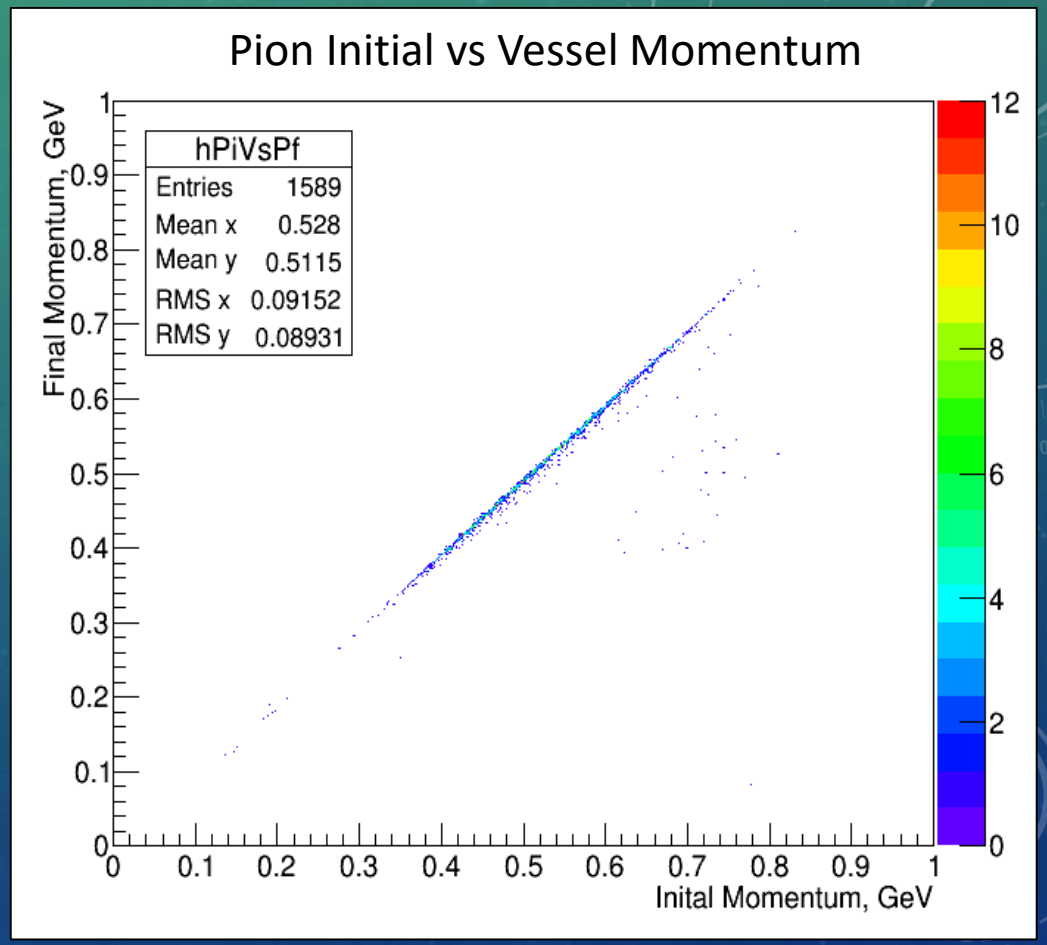
Data From: R. Carlson et al., \Measurements of proton total reaction cross sections for 6 Li, 7 Li, 14 N, 20 Ne and 40 Ar between 23 and 49 MeV," Nuclear Physics A, vol. 445, no. 1, pp. 57{69, 1985.



Data From: R. Carlson et al., \Measurements of proton total reaction cross sections for 6 Li, 7 Li, 14 N, 20 Ne and 40 Ar between 23 and 49 MeV," Nuclear Physics A, vol. 445, no. 1, pp. 57{69, 1985.

10MM STEEL


Proton Initial vs Vessel Momentum
hPiVsPf
Entries 668
Mean x 0.467
Mean y 0.3345
RMS x 0.04592
RMS y 0.09329
Final Momentum, GeV
Inital Momentum, GeV


Pion Initial vs Vessel Momentum
hPiVsPf
Entries 1589
Mean x 0.528
Mean y 0.5115
RMS x 0.09152
RMS y 0.08931
Final Momentum, GeV
Inital Momentum, GeV

2MM ALUMINIUM