Hadronic shower reconstruction for energy scale analysis (SP)

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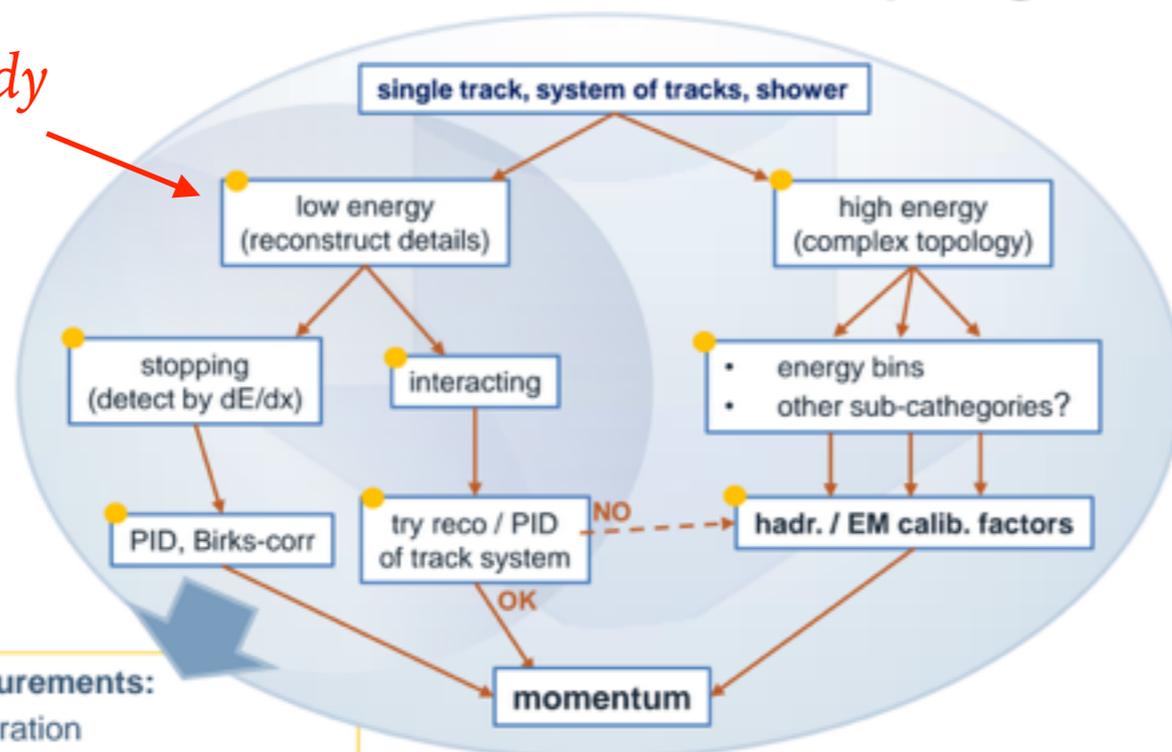# INTRODUCTION

➤ Hadronic shower reconstruction for energy scale analysis

  ➤ Understanding of hadronic shower topology in energy

    ➤ The event topology changes in the particle energy

    ➤ Splitting events to many topological cases (mostly binned in energy range)

      ➤ For measuring the energy accurately

      ➤ For getting the calibration factor for each topology

Final goal

➤ Just started learning tools from very basics (hits) up to more advance (tracks, showers)

Potential use of events with various topologies

Today study focuses on this part

single track, system of tracks, shower

low energy (reconstruct details)

high energy (complex topology)

stopping (detect by dE/dx)

interacting

- energy bins
- other sub-cathegories?

PID, Birks-corr

try reco / PID of track system

NO

hadr. / EM calib. factors

OK

momentum

Other measurements:
- PID calibration
- angular dependencies
- reconstruction tests

**momentum** is a final goal → many calibrations and models testing on the way to it

Introduction from Dorota's slide :

https://indico.fnal.gov/getFile.py/access?contribId=12&sessionId=9&resId=0&materialId=slides&confId=12042

INITIAL STUDY TO UNDERSTAND DIFFERENT PARTICLES

➤ Start looking at several important variables (energy and dE/dx, not binned in E yet)

➤ Samples

  ➤ MCC7 (V06_05_00) : reco sample (~15% of sample used for study, 5K events)

   ➤ 2 GeV pion: /pnfs/dune/scratch/dunepro/v06_05_00/reco/gen_protoDune_pion_2GeV_mono

   ➤ 2 GeV proton: /pnfs/dune/scratch/dunepro/v06_05_00/reco/gen_protoDune_proton_2GeV_mono
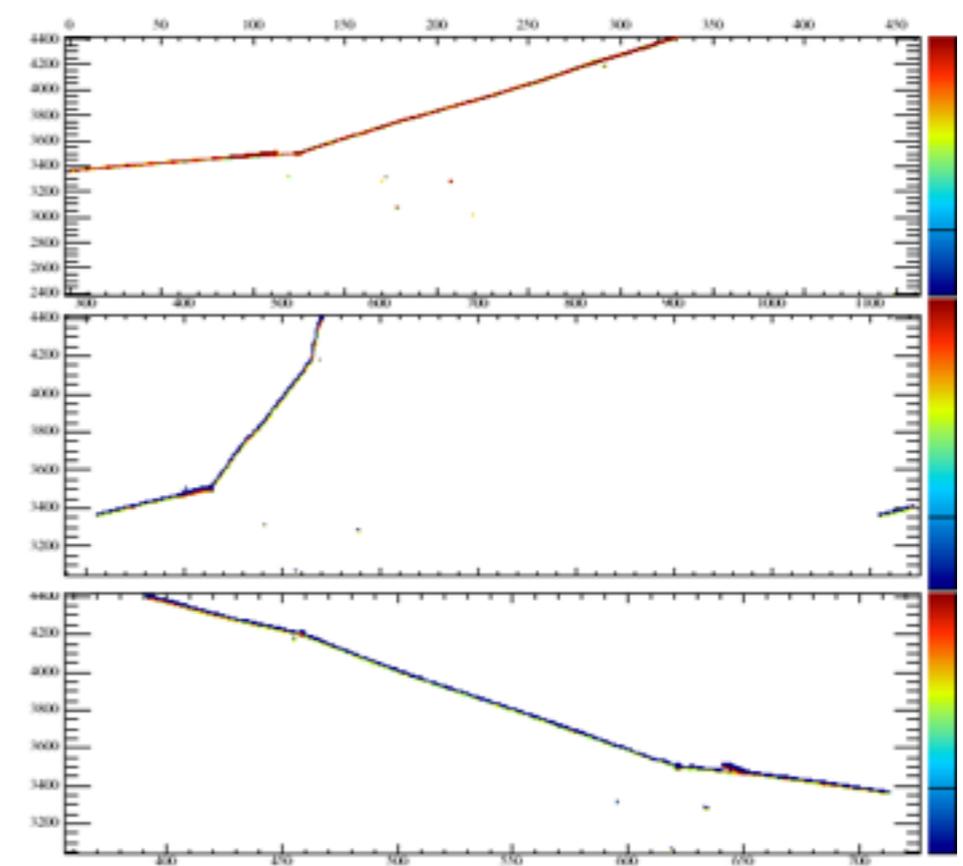
➤ Event display using MC Truth

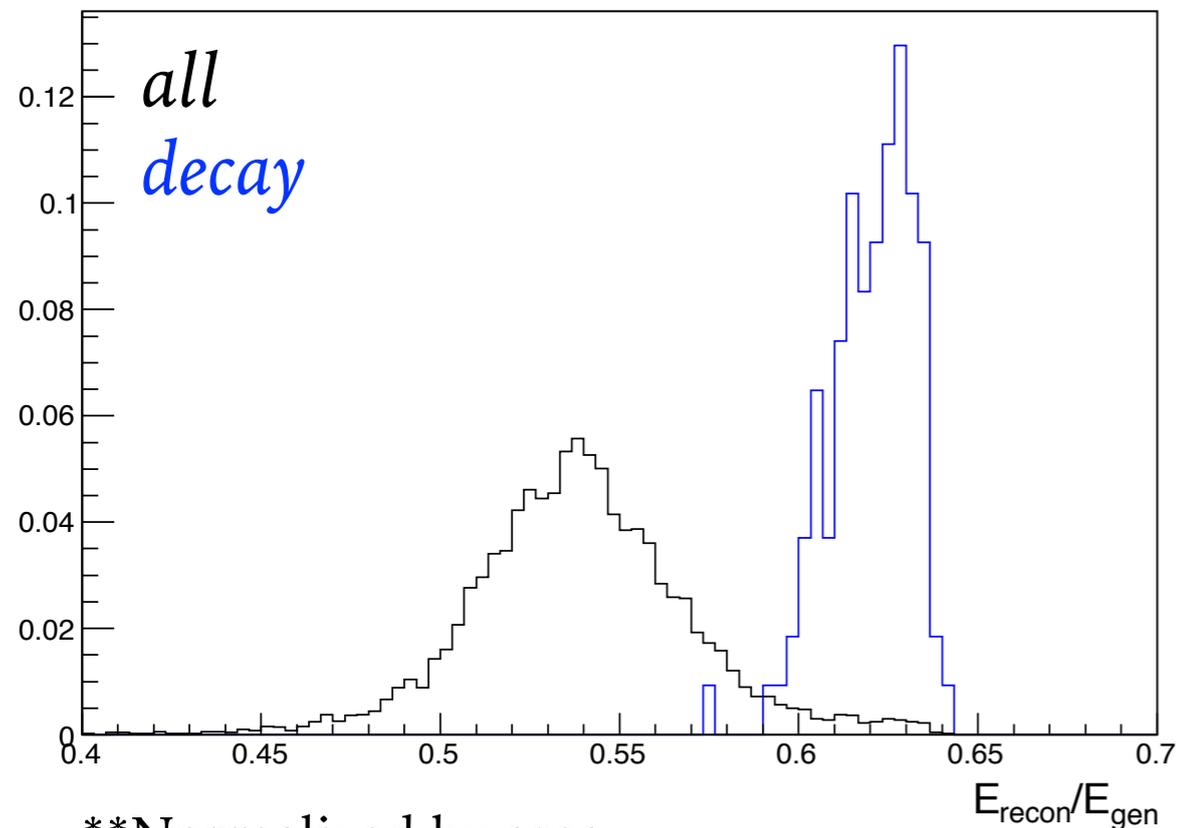*pion (2GeV) : TPC# = 2*   *proton (2GeV) : TPC# = 2*
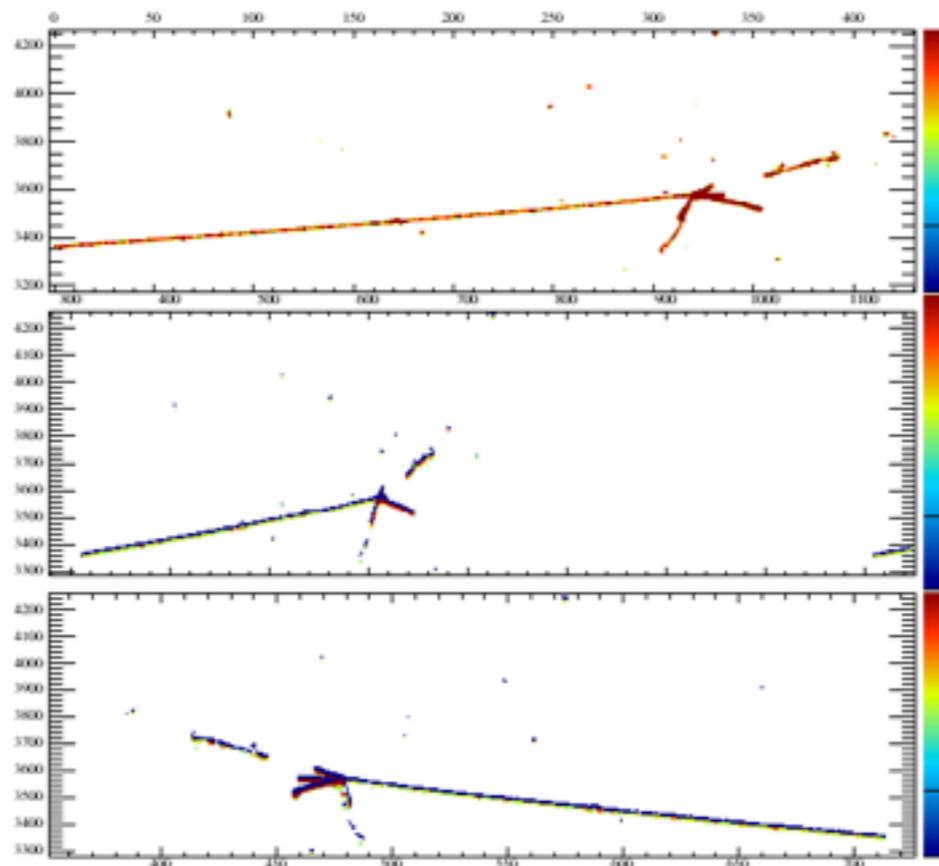
Collection plane

Induction plane

Induction plane
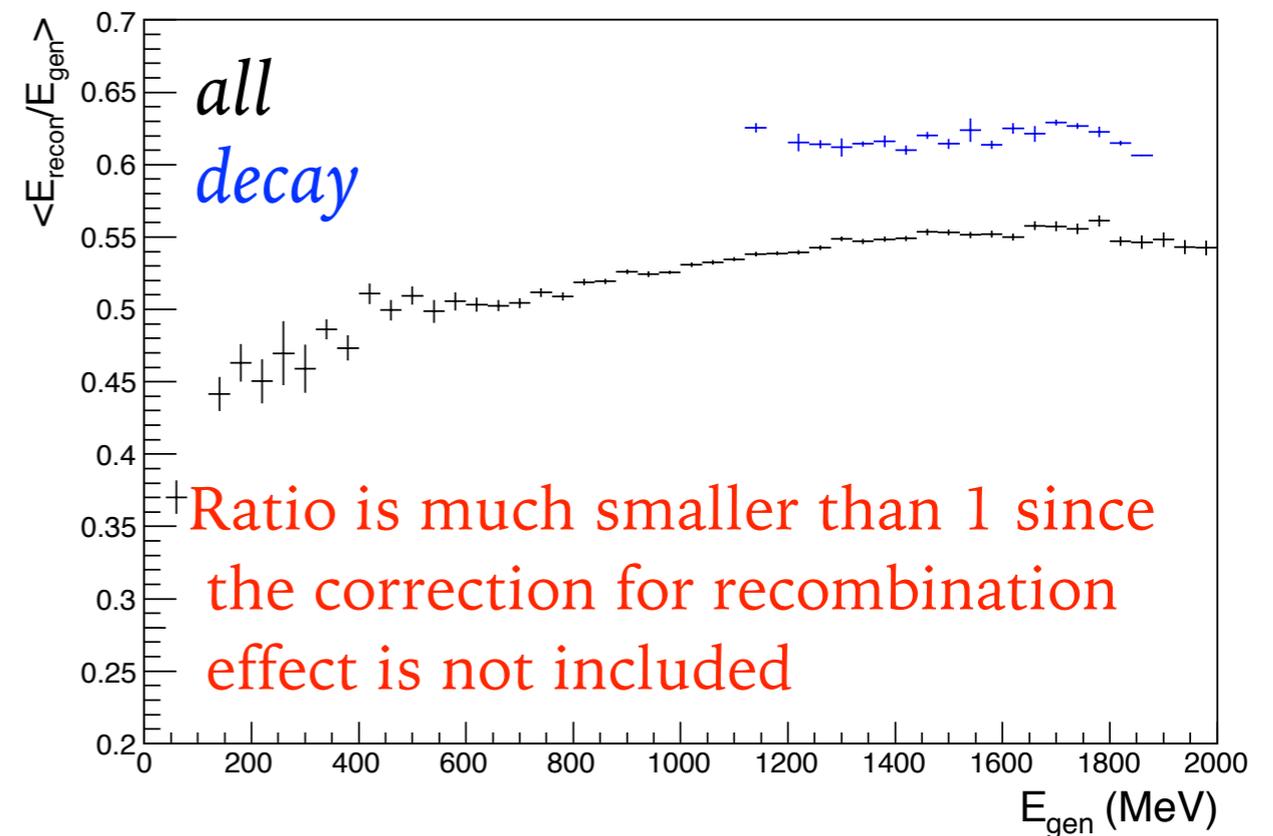
PION EVENTS : *E_dep(recon) vs. E_dep(gen)*

➤ Energy comparison between recon. vs. gen. level

  ➤ Separated the event case which has gen->EndProcess()=="decay" from all

    ➤ The event fraction is ~ 10% of the total

    ➤ The events have the daughter particles → will work on defining better category

  ➤ Compare the ratio of E_dep(recon)/E_dep(gen) in each event category

    ➤ Energy is calculated from hits in collection plane only

    ➤ Energy from hits are corrected for electron lifetime

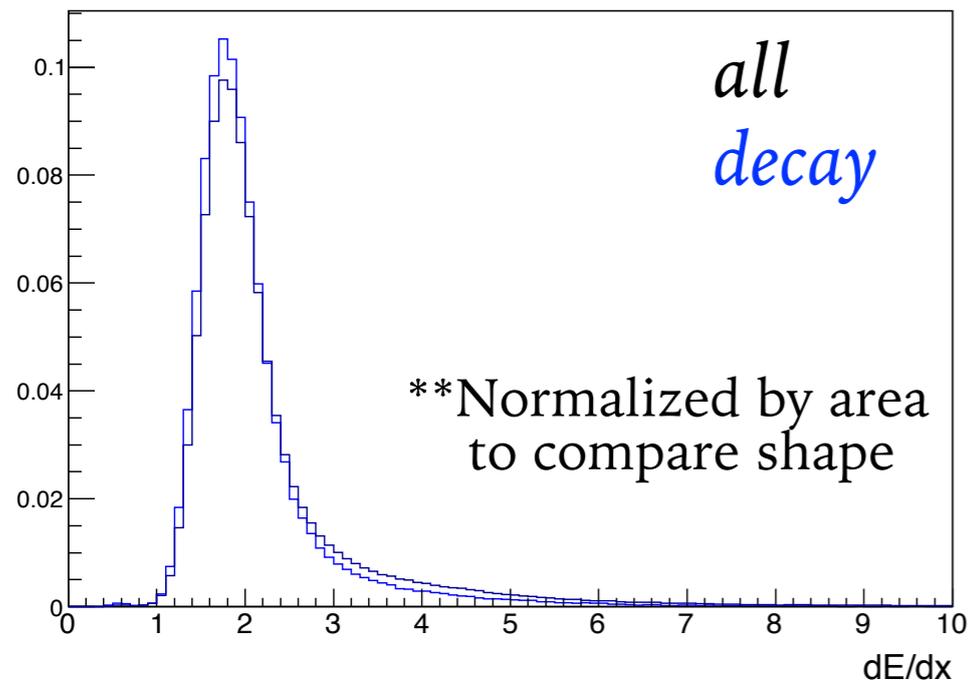Ratio distribution of E(recon)/E(gen)

Ratio profile as a function of E(gen)

**Normalized by area to compare shape

Ratio is much smaller than 1 since the correction for recombination effect is not included
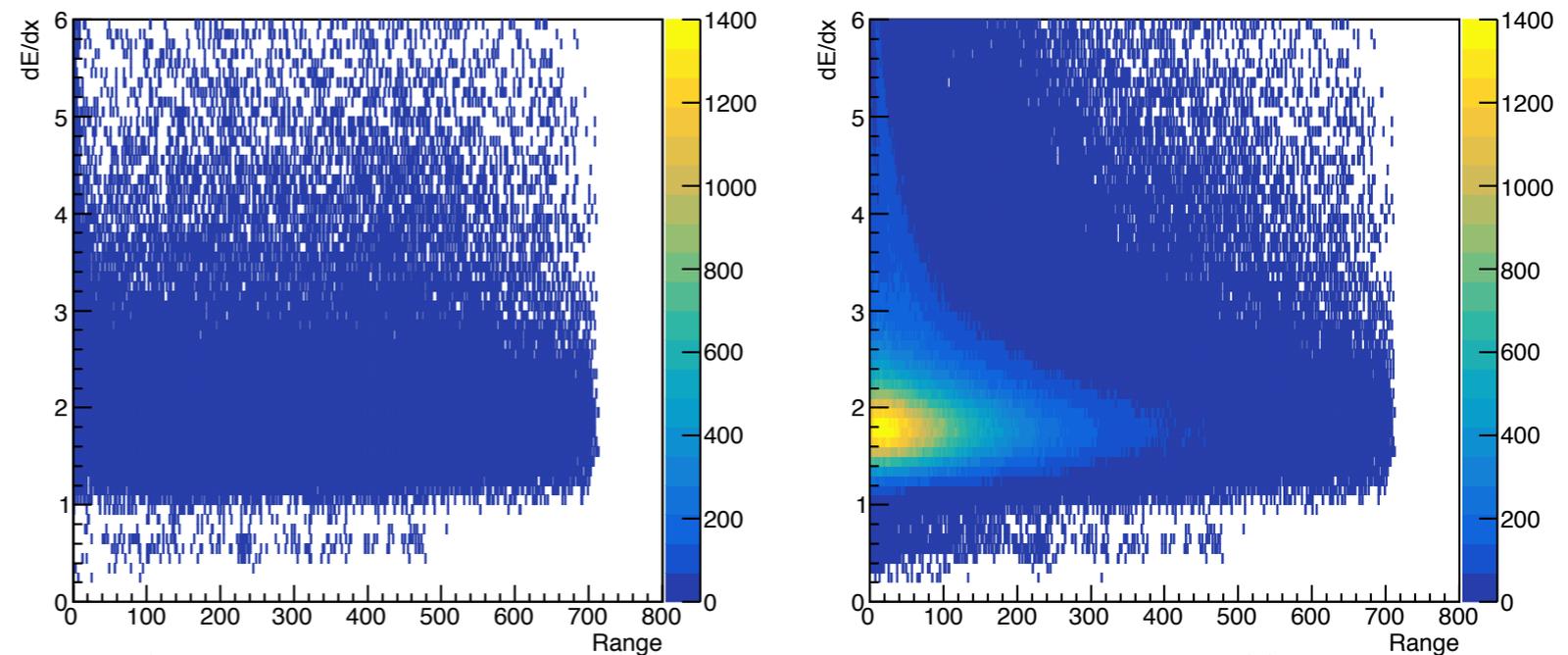
PION EVENTS : *dE/dx distribution*

➤ dE/dx distribution of pion events

dE/dx is calculated using track which enters in the detector (3D reconstruction) Secondary particles are ignored
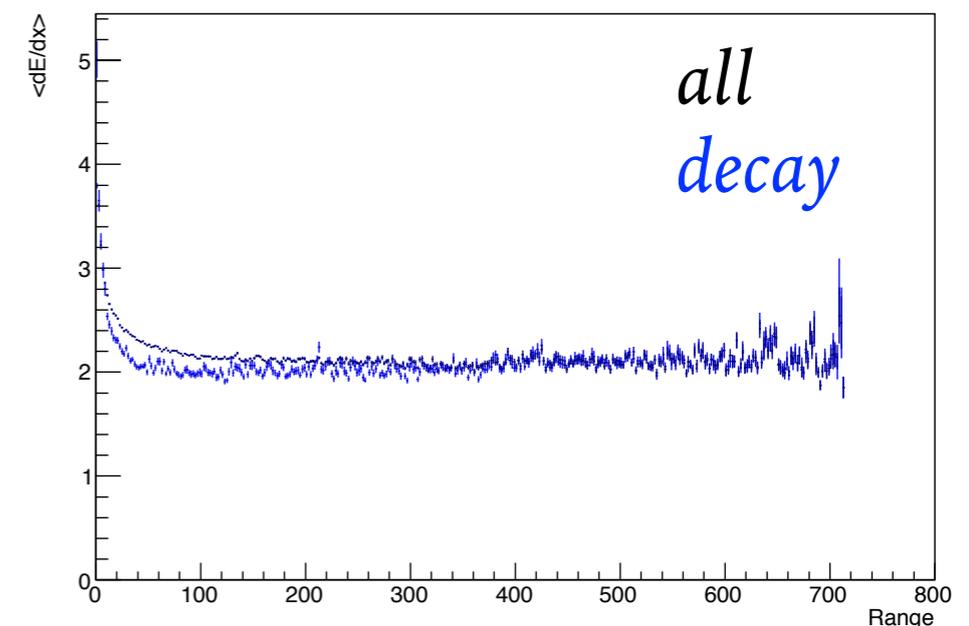
dE/dx vs Range: 2D plot

decay

all

Overall dE/dx distribution

all
decay

**Normalized by area to compare shape
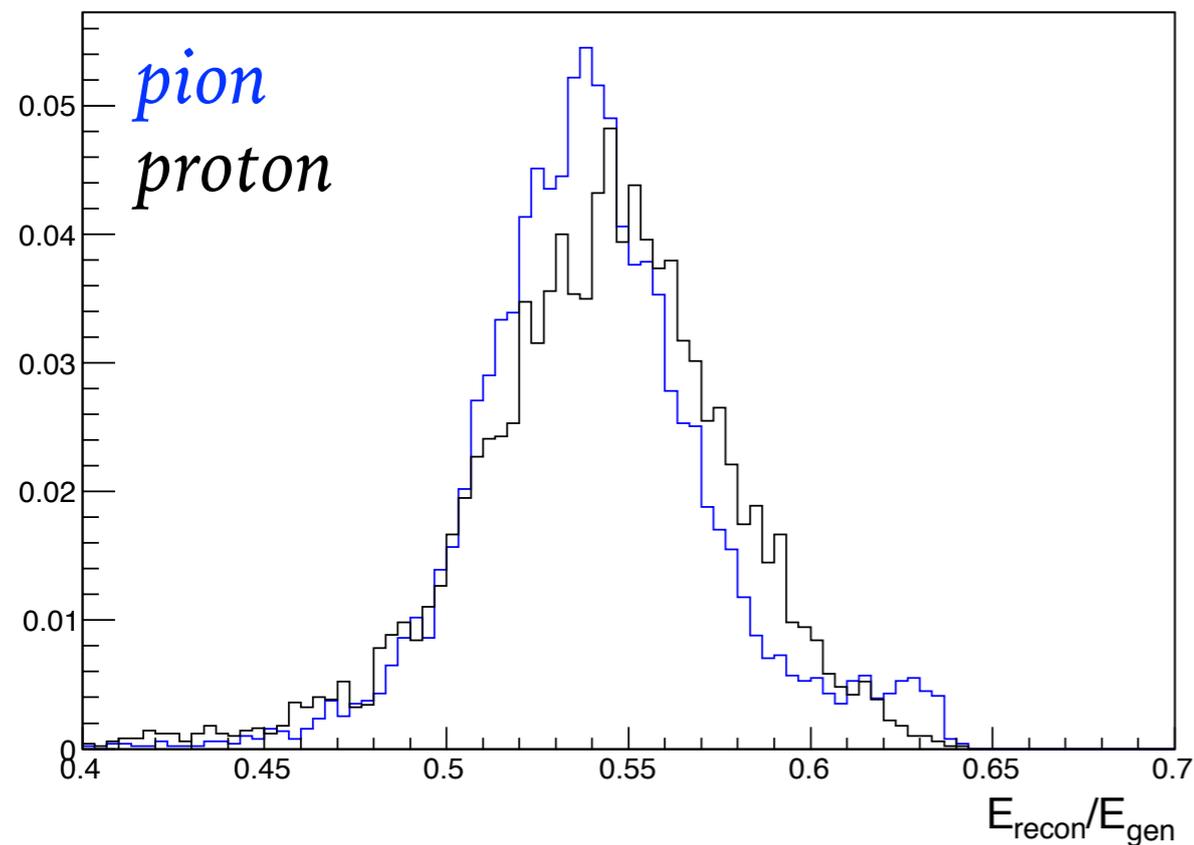
dE/dx profile(<dE/dx>) in Range

all
decay

Overall dE/dx distribution looks similar
However, the pattern in dE/dx vs. Range is different in "decay" case
(low "Range" corresponds to "upstream")

PION VS. PROTON EVENTS : *E(recon) vs. E(gen)*

➤ Compare the energy ratio of recon. to gen. between pion vs. proton (2 GeV)

  ➤ Energy is calculated using hits (2D reconstruction) : same as slide 4

  ➤ Pion events are compared with proton

  ➤ Ratio distribution looks similar between pion and proton

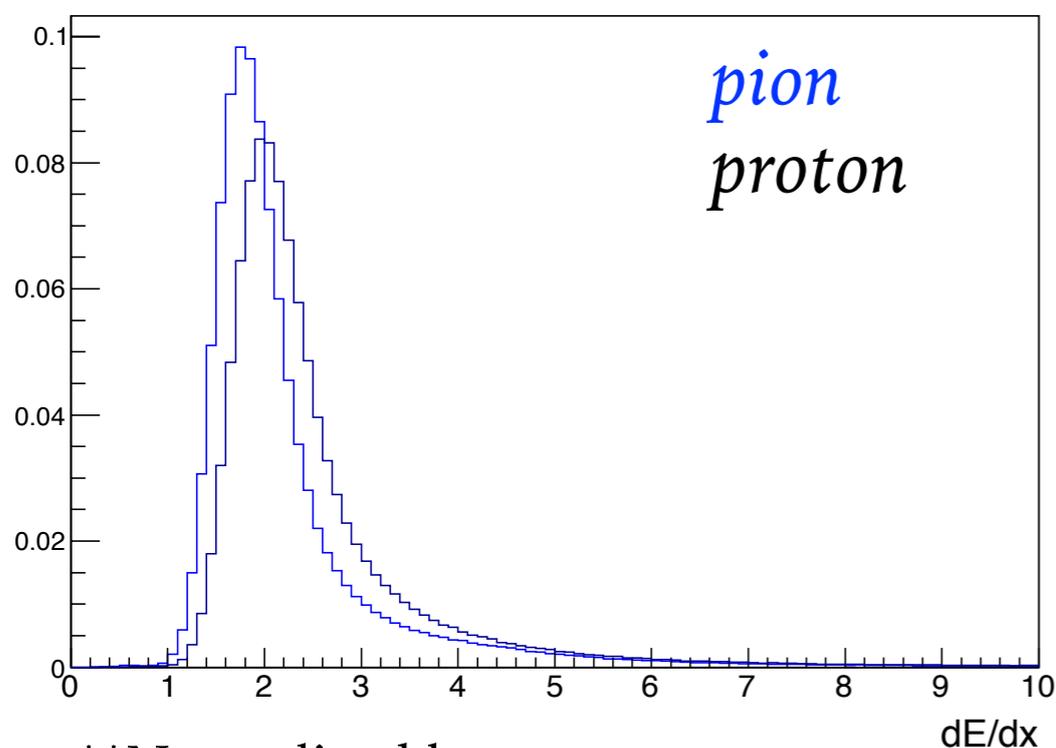 ➤ Slope of ratio in energy is different

Ratio distribution of E(recon)/E(gen)

Ratio profile as a function of E(gen)
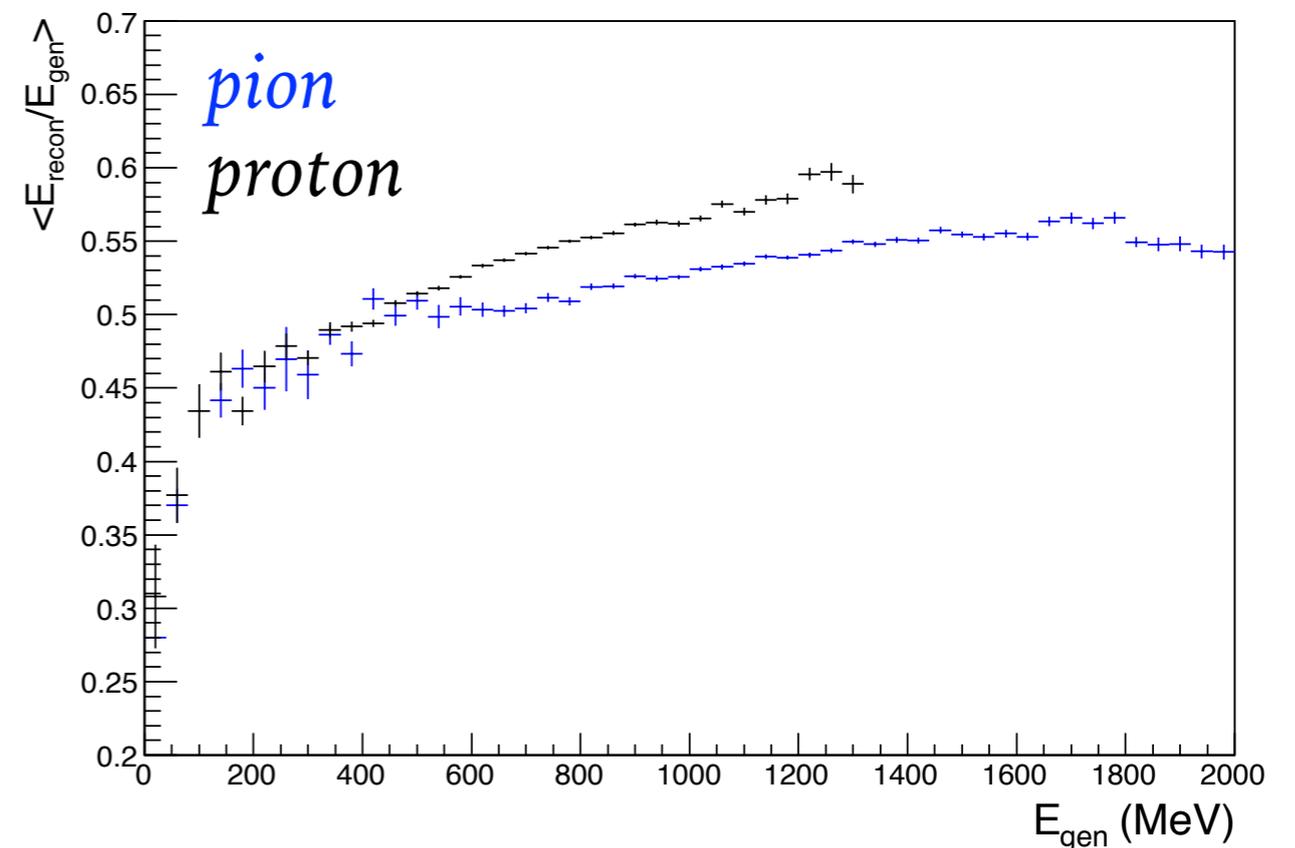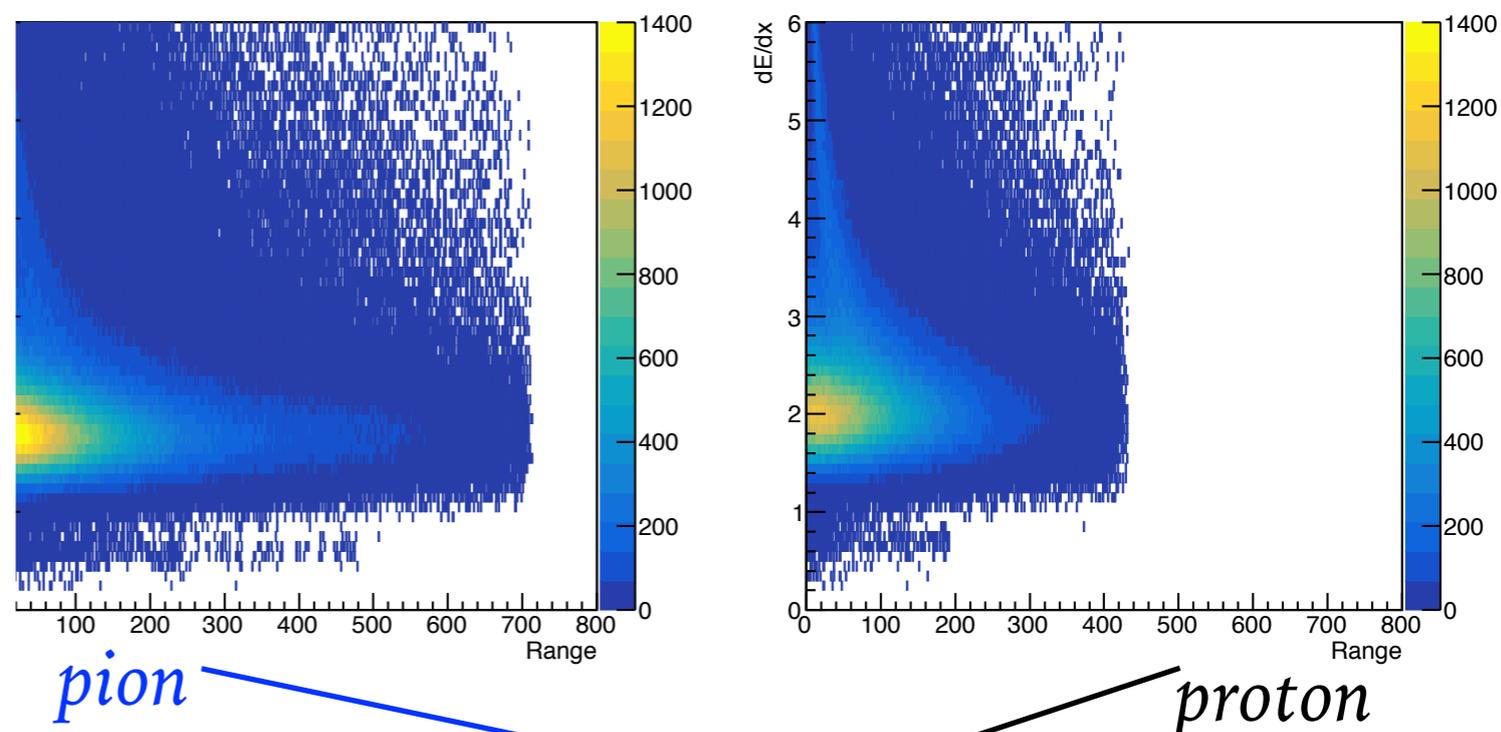
PION VS. PROTON : *dE/dx distribution*

➤ dE/dx (from track) distribution comparison between pion and proton

Overall dE/dx distribution

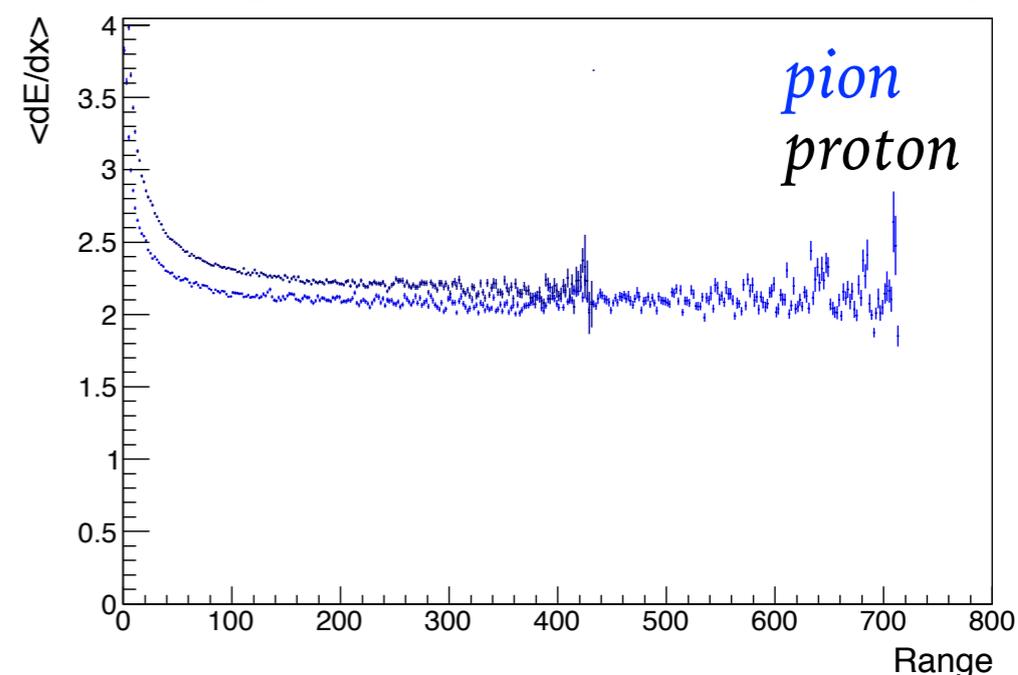
pion

proton

**Normalized by area
to compare shape

dE/dx vs. Range : 2D plot

pion   *proton*

dE/dx profile(<dE/dx>) in Range

pion
proton

Peak of dE/dx distribution is larger in proton,
but proton deposits most of energy in upstream
(Range<430)

Pion has longer tail in dE/dx distribution

SUMMARY AND PLAN

- ➤ Initial study is started to understand hadronic shower reconstruction
  - ➤ Started looking at the energy and dE/dx distribution using MC samples
    - ➤ Still, part of MC sample is used to explore protoDUNE software
    - ➤ Overall features are tested before going further details
      - ➤ Ratio of E(recon) vs. E(gen) distribution (2D reconstruction : hit)
      - ➤ dE/dx distribution (3D reconstruction : track)
      - ➤ pion vs. proton

- ➤ Plan for next step
  - ➤ Study the hadronic shower pattern in terms of energy range
    - ➤ The energy dependence is important to categorize the topological events
      - ➤ Need to improve the definition of event categorization
    - ➤ Need to look at the number of vertices, tracks at the different energy range