# UPDATE ON HADRONIC SHOWER RECONSTRUCTION

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# INTRODUCTION

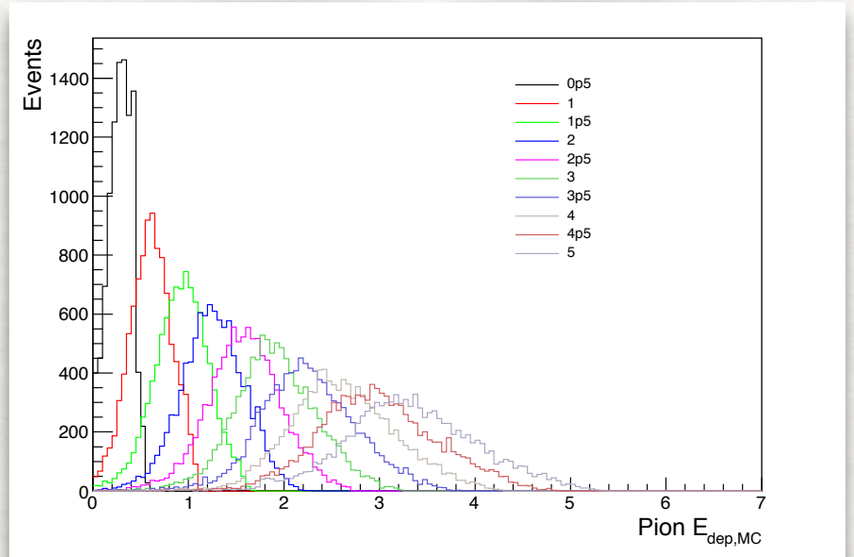
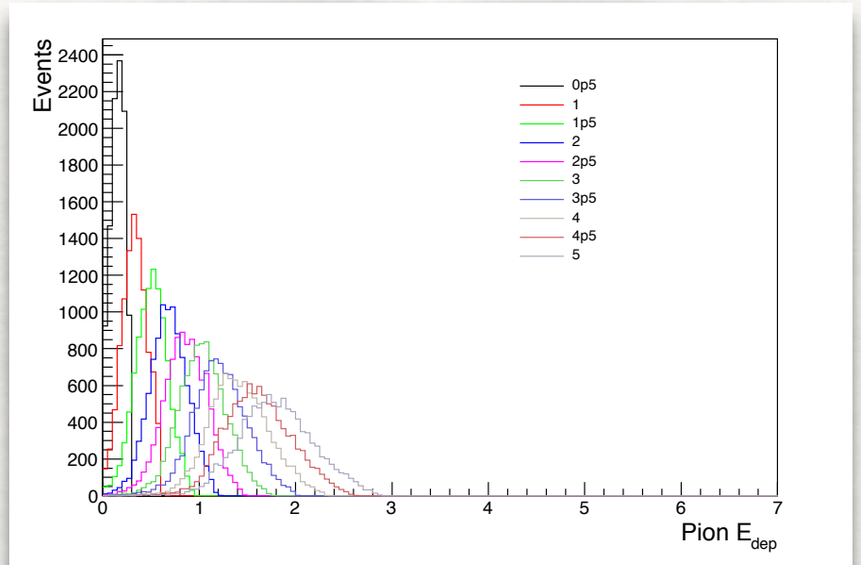
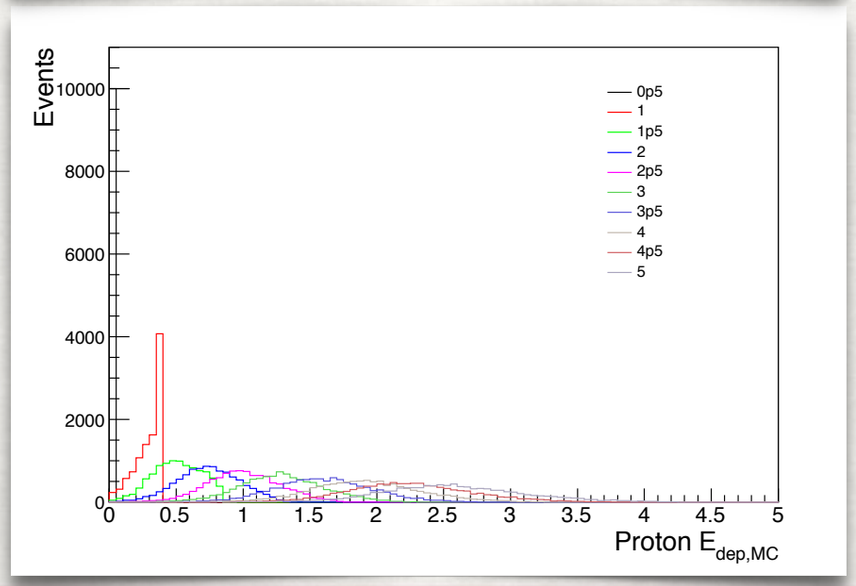
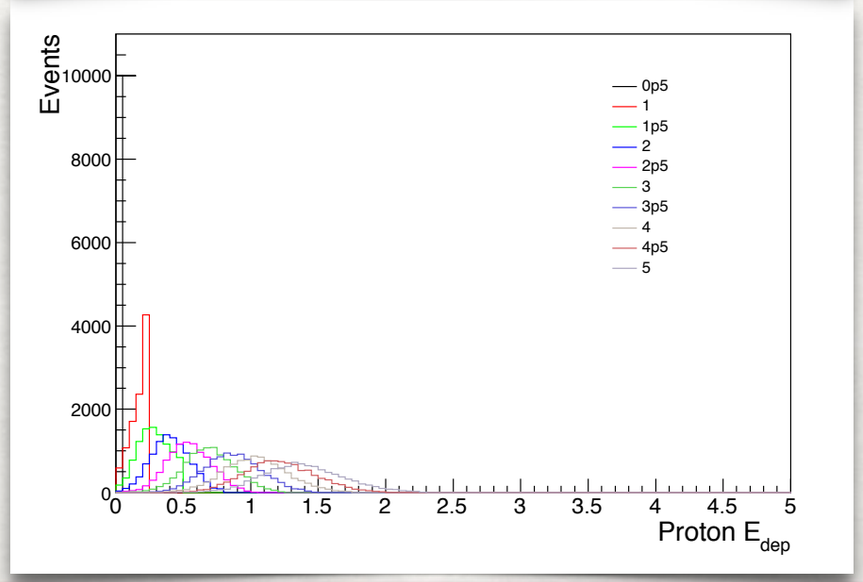
- Hadronic shower reconstruction for energy scale analysis
  - Understanding of hadronic shower topology in energy
  - Splitting events to many topological cases, mostly binned in energy range
    - For measuring the energy accurately
    - For getting the calibration factor for each topology
  - Started the study using 2 GeV pion and proton sample to learn tools
    - Compare the ratio of $E_{dep}/E_{dep,MC}$ : hits info. (2D reconstruction)
    - Check dE/dx using track info. : pattern of dE/dx in range

https://indico.fnal.gov/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=13039

- Update on the study
  - Generate MC samples for pion and proton with different energy
    - Validate MC samples
    - Check the ratio of $E_{dep}/E_{dep,MC}$ (calibration factor) for each sample
  - Calibration factor for EM showers
    - Run EM clustering module on new samples
    - Check the calibration factor for EM contribution

# MC PRODUCTION

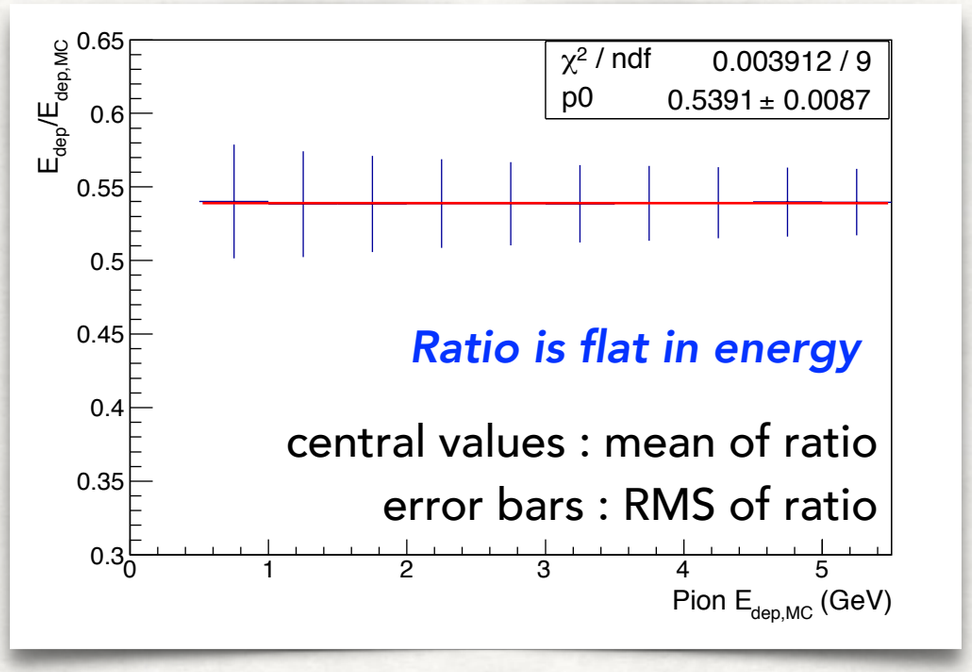
- Produce MC samples for pion and proton
  - Energy range from 0.5 GeV to 5 GeV with 0.5 GeV step
    - Each set has 10K events
    - File location : /pnfs/dune/scratch/users/jyhan/v06_05_00/ at FNAL
  - Validate the samples using $E_{dep}$ calculated from hits in collection plane only

| | $E_{dep,MC}$ | $E_{dep}$ |
|---|---|---|
| Pion |  |  |
| Proton |  |  |

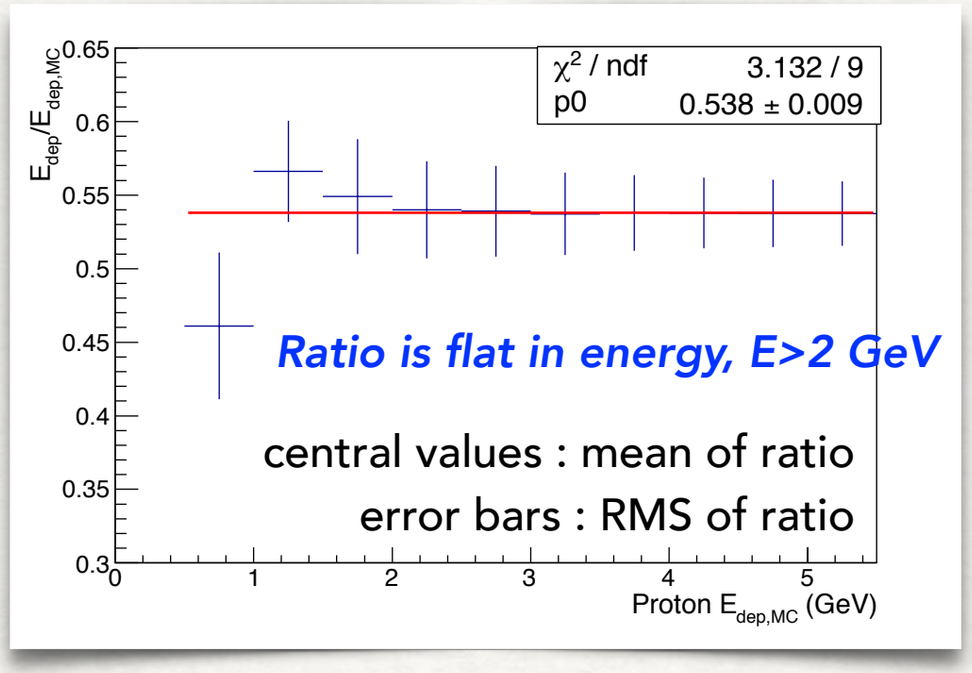
# VALIDATION OF MC SAMPLES

- Check the ratio of $E_{dep}/E_{dep,MC}$ for each sample

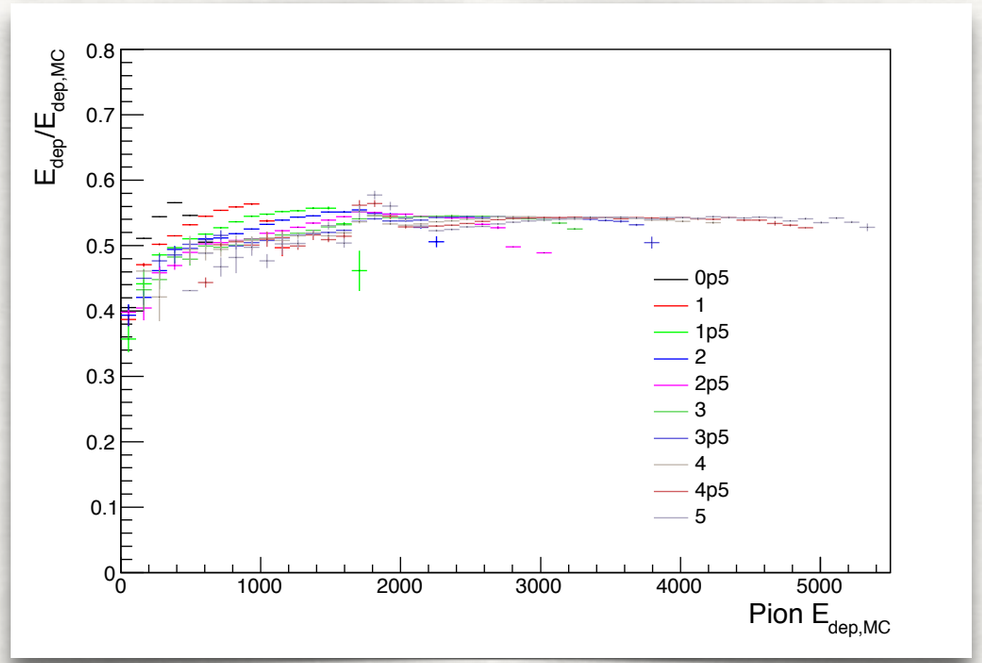
## Overall ratio for each pion sample



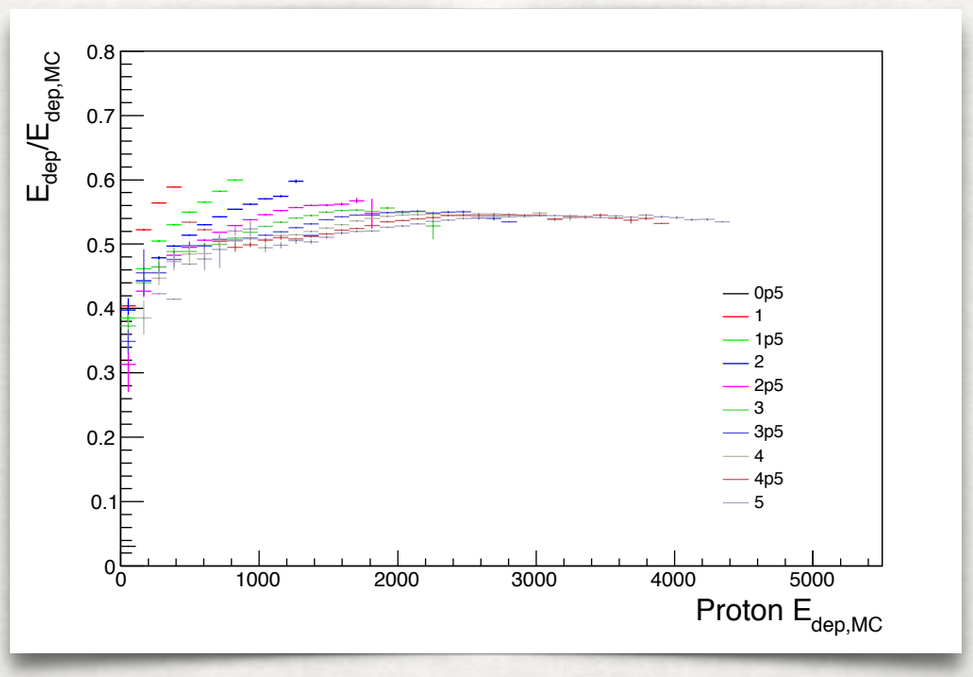

## Overall ratio for each proton sample




## Ratio profile in $E_{dep,MC}$ for pion



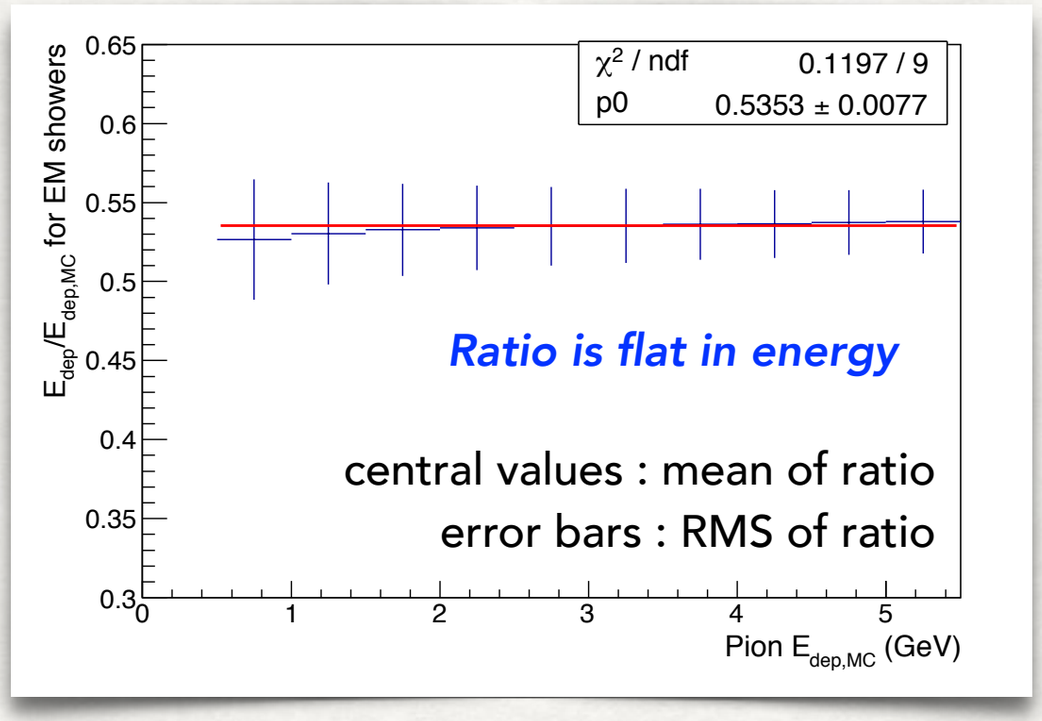

## Ratio profile in $E_{dep,MC}$ for proton



# EM CLUSTERING

- EM clustering :
  - EM clustering module, “EmTrackClusterId_module.cc” in larreco package
    - Package path : larreco/RecoAlg/ImagePatternAlgs
    - More details at Dorota’s talk today, “EM components selection with CNN”
  - Dorota helped to run EM clustering module for new MC samples
  - Calculate the ratio of $E_{dep}/E_{dep,MC}$ for EM showers

Overall ratio for each pion sample
using the clustered EM showers




Deposited energy ratio of EM showers is similar level (~0.54) with all events

Getting the same study for proton case, but it is not done it yet
⇒ Proton case will be updated later

# SUMMARY

- Generated new MC samples for pion and proton in energy
  - Each sample has 10K events so far
  - Energy range : 0.5 ~ 5 GeV with 0.5 GeV step
  - Validate samples and all of samples look good
  - Get the ratio of deposit energy in rec. to gen. as a function of energy
    - The ratio is 0.54 and very flat in energy for both pion and proton

- Try to run EM clustering module to get the calibration factor for EM shower
  - The ratio of $E_{dep}/E_{dep,MC}$ for pion is similar with all events
  - The proton case will be checked, too
  - Need to understand the study more…