Recombination correction for hadronic cascades

Dorota Stefan (CERN), Jiyeon Han (Pittsburgh)

Dec. 19th, 2016 / ProtoDUNE reconstruction meeting

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

- Study using the deposited hit information in reconstruction and generator level
  - The ratio of E_{dep} to $E_{dep,MC}$ as a function of $E_{dep,MC}$ for all hits
  - The ratio of E_{dep} to $E_{dep,MC}$ as a function of $E_{dep,MC}$ for EM showers (noted as "E_{dep_em}")
  - (E_{dep} - E_{dep_em}) / ($E_{dep,MC}$ - $E_{dep\_em,MC}$) as a function of ($E_{dep,MC}$ -$E_{dep,MC}$(EM))

- Study the attenuation effect using MC information
  - The ratio of $E_{dep,MC}$ after to before attenuation as a function of $E_{dep,MC}$(before) for all hits
  - The ratio of $E_{dep,MC}$ after to before attenuation as a function of $E_{dep,MC}$(before) for EM showers
  - ($E_{dep,MC,att}$ - $E_{dep\_em,MC,att}$) / ($E_{dep,MC,att}$ - $E_{dep,MC}$) as a function of ($E_{dep,MC,att}$ -$E_{dep,MC}$)

- Plot the scattering distribution for pion and proton (0.5 ~ 5 GeV)
  - Present few selected energy bins in the main slides and others are in back-up slides

Deposited energy definition

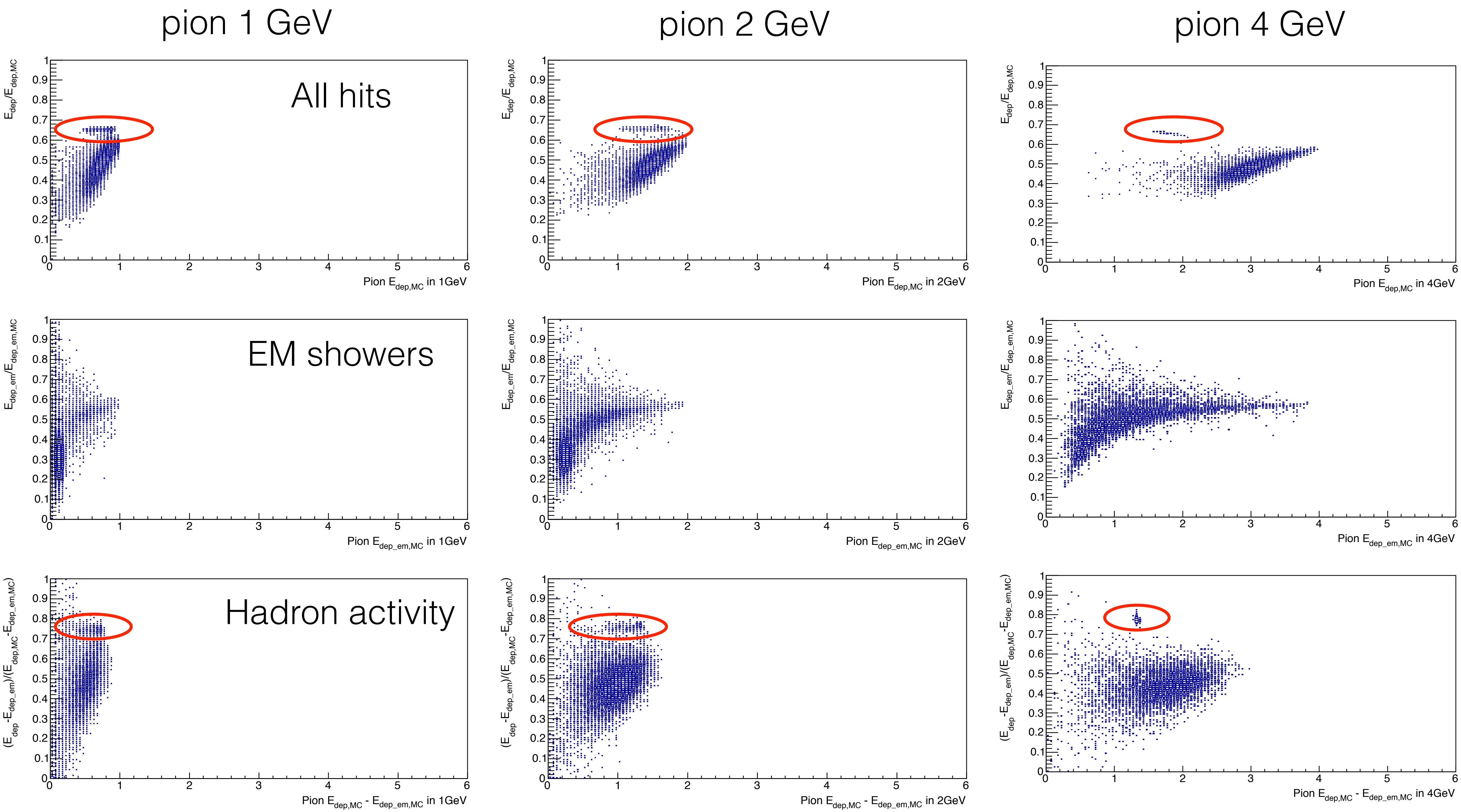
- Deposit energy definition :
  - E_{dep} : sum of electrons from ADC area in plane after lifetime correction (convert to E)
  - $E_{dep,MC}$: sum of energy deposit from TDCIDEMap (for every time slice in simchannel)

- EM showers :
  - EM clustering module, “EmTrackClusterId_module.cc” in larreco package
    - Package path : larreco/RecoAlg/ImagePatternAlgs
  - More details at Robert’s talk (Nov. 28th, 2016) :
    - “EM components selection with CNN” :

      https://indico.fnal.gov/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=13389
  - E_{dep_em} : E_{dep} for EM clustered showers
  - $E_{dep\_em,MC}$: $E_{dep,MC}$ for EM clustered showers (electron or photon)

Ratio of E_{dep} to $E_{dep,MC}$ for pion

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

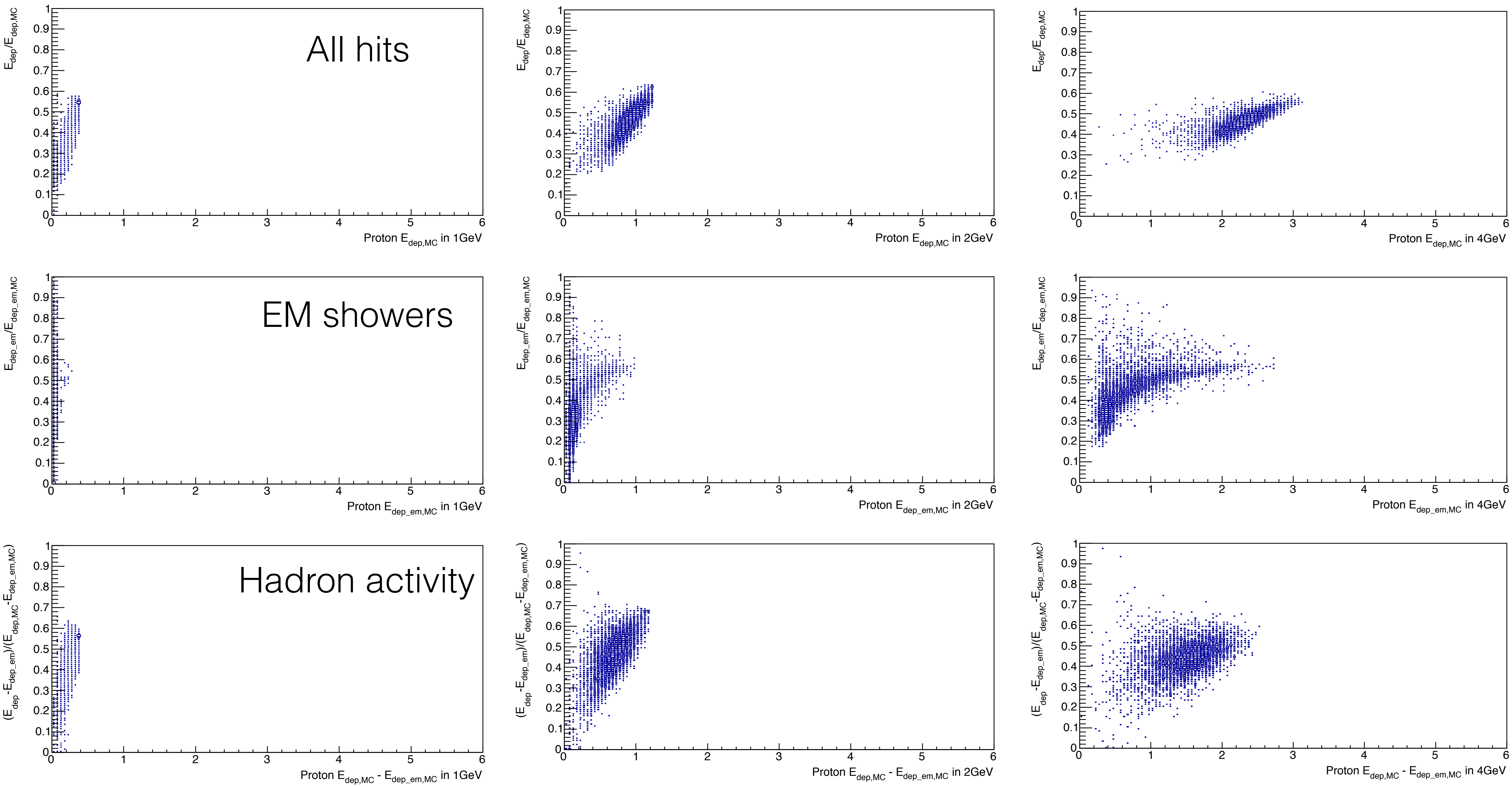


- Event fraction of red circle is ~20% at 0.5 GeV pion, but decreases a lot, 1.3% at 5 GeV pion

Ratio of E_{dep} to $E_{dep,MC}$ for proton

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

proton 1 GeV　　proton 2 GeV　　proton 4 GeV

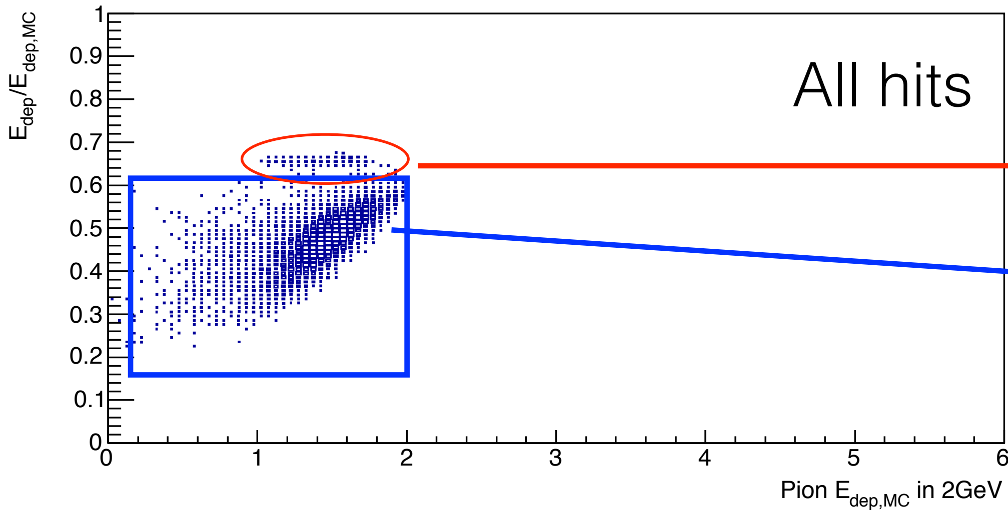


- Proton doesn’t have the distinguished event group in the large ratio region

2 GeV Pion events

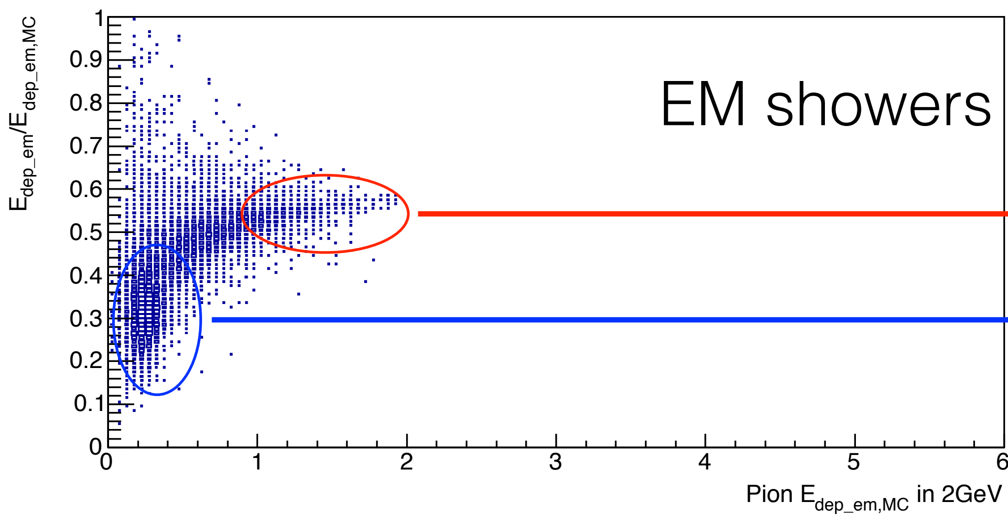
- 2D plot for deposit energy ratio ($E_{dep}/E_{dep,MC}$)

Try to classify the event topology



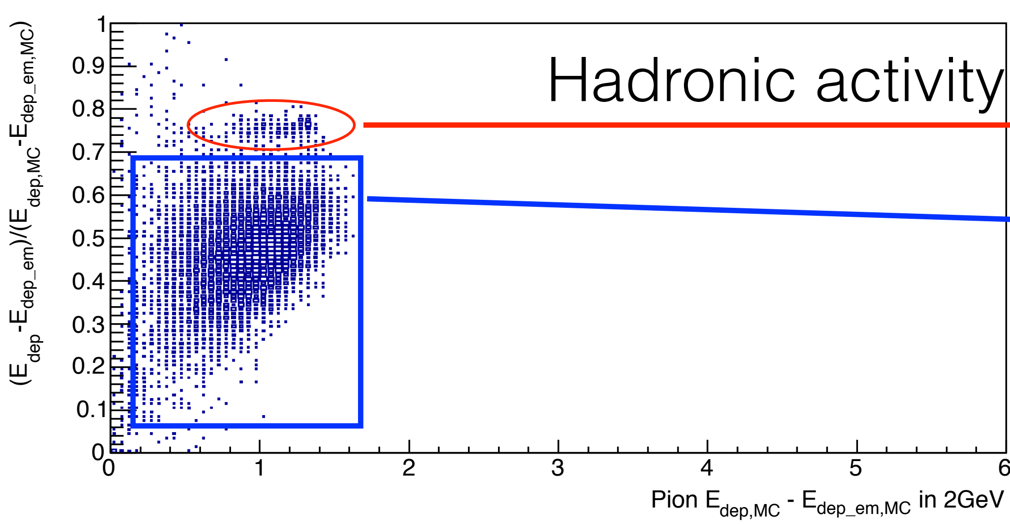
All hits : class A

All hits : class B



EM hits : class A

EM hits : class B



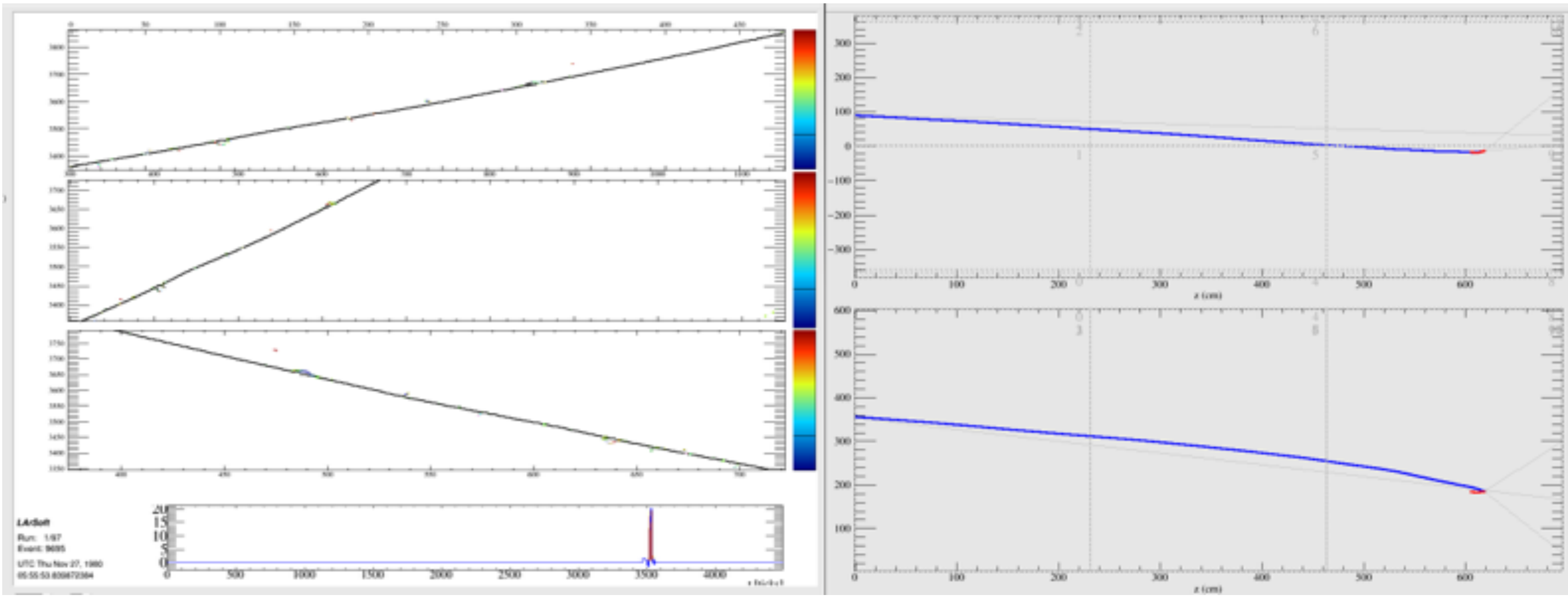
Hadron : class A

Hadron : class B

Found “Hadron : class A” corresponds to “All hits : class A”

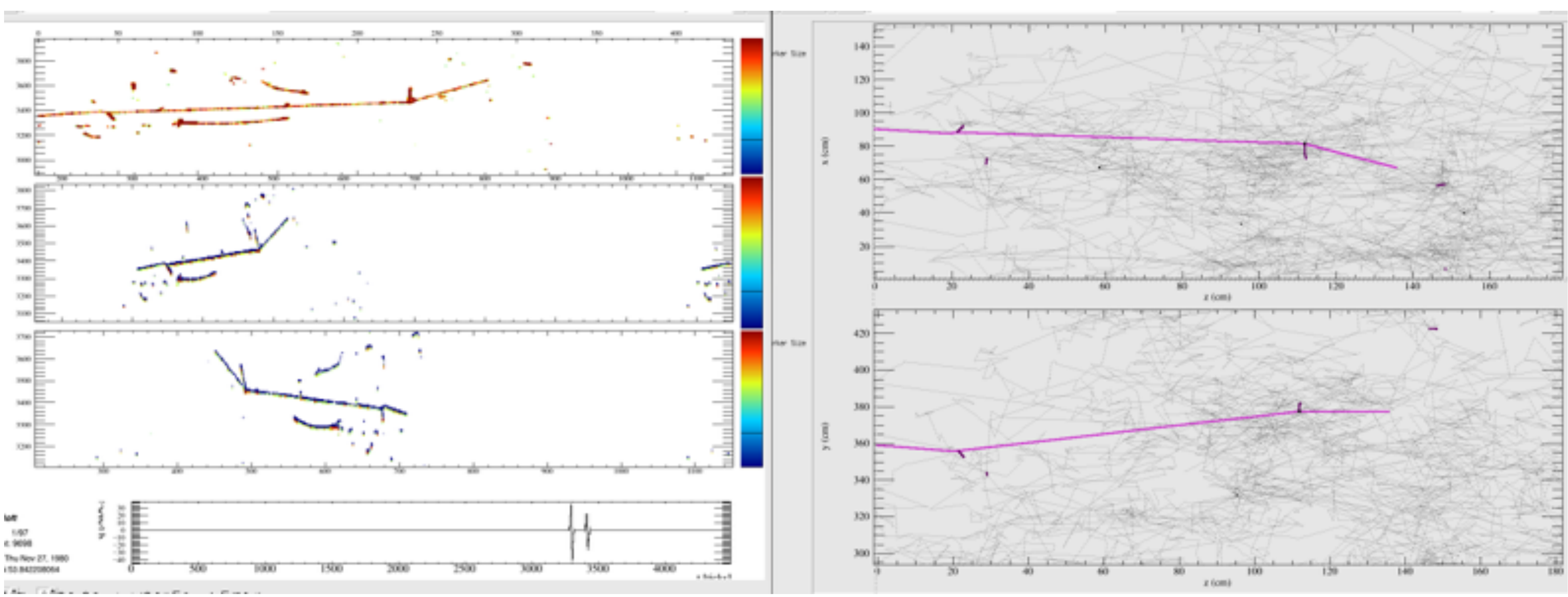
Event display for “All hits”

- “All hits: class A” : the ratio > 0.65 and $E_{dep,MC}$ > 1 GeV



All hits : class A
pion decays to
muon + michel
electron

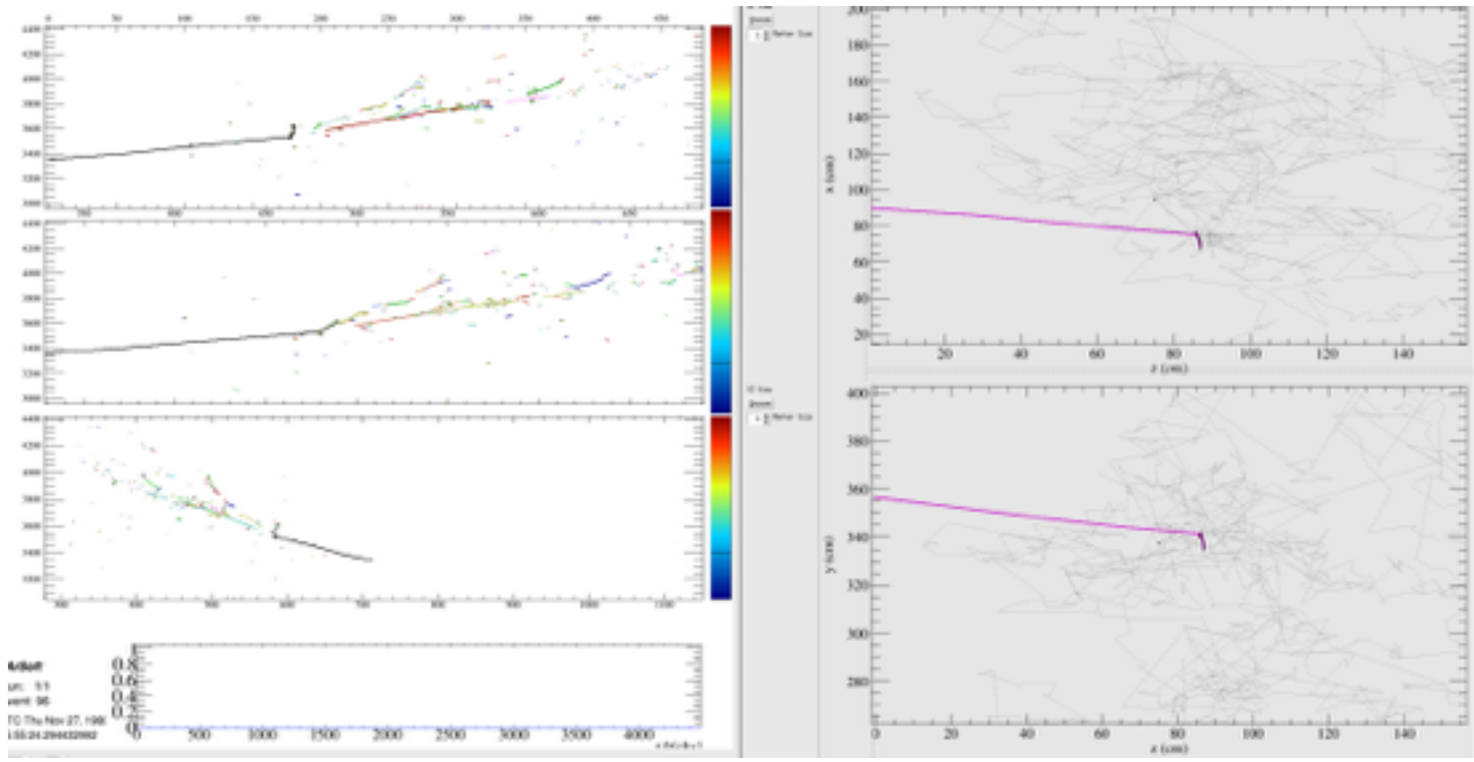
- “All hits : class B” : the ratio < 0.6



All hits : class B
pion mostly
interacts
inelastically

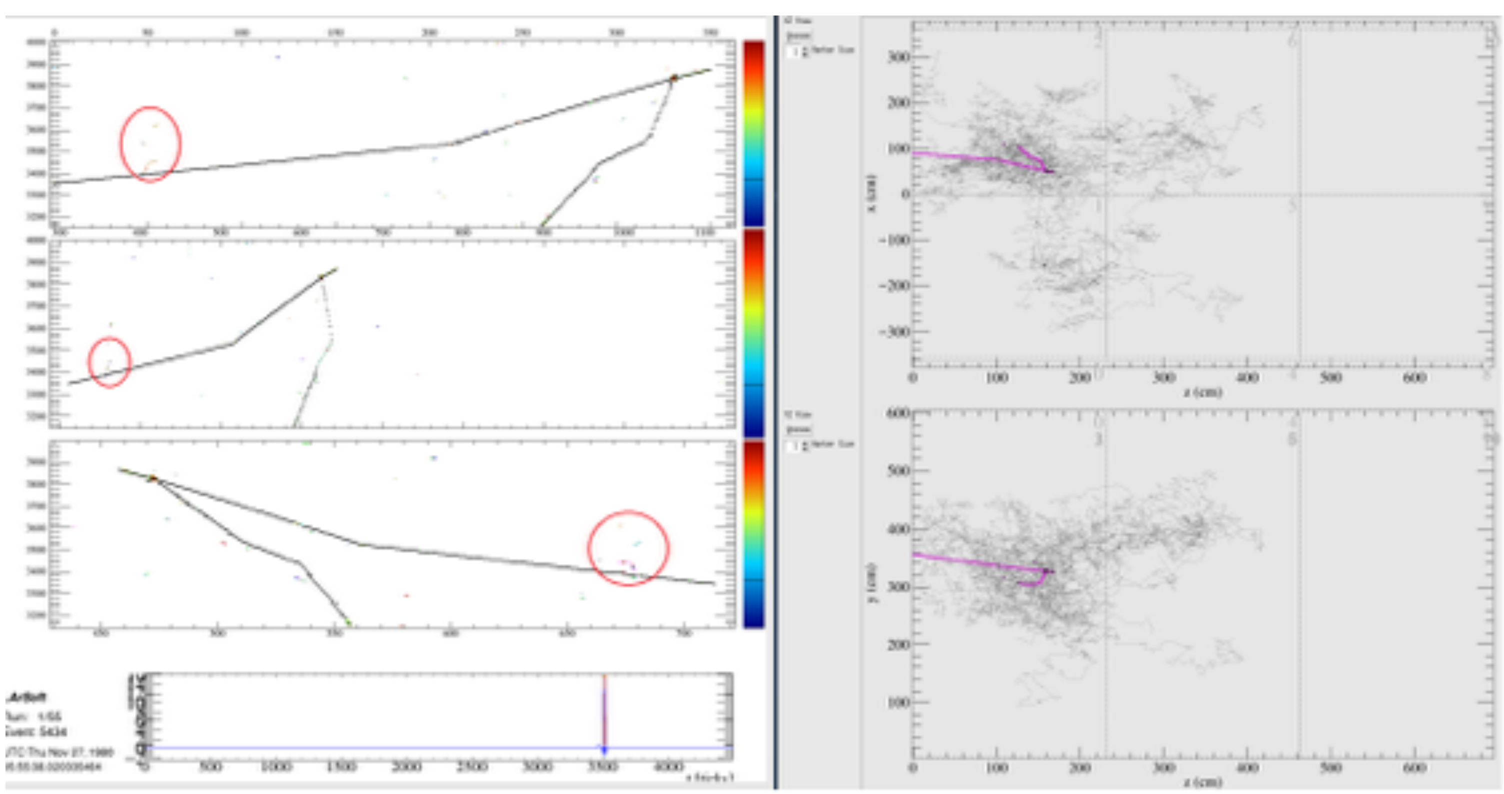
Event display for "EM showers"

- "All hits: class A" : the ratio > 0.5 and $E_{dep\_em,MC}$ > 1 GeV



EM showers : class A
Mostly showers from π^0 decay
(relatively visible showers)

- "All hits : class B" : the ratio is around 0.3 and $E_{dep\_em,MC}$ < 0.4 GeV



EM showers : class B
Mainly tracks, and showers
come from electron delta on tracks
(small showers)
Red circles correspond to delta

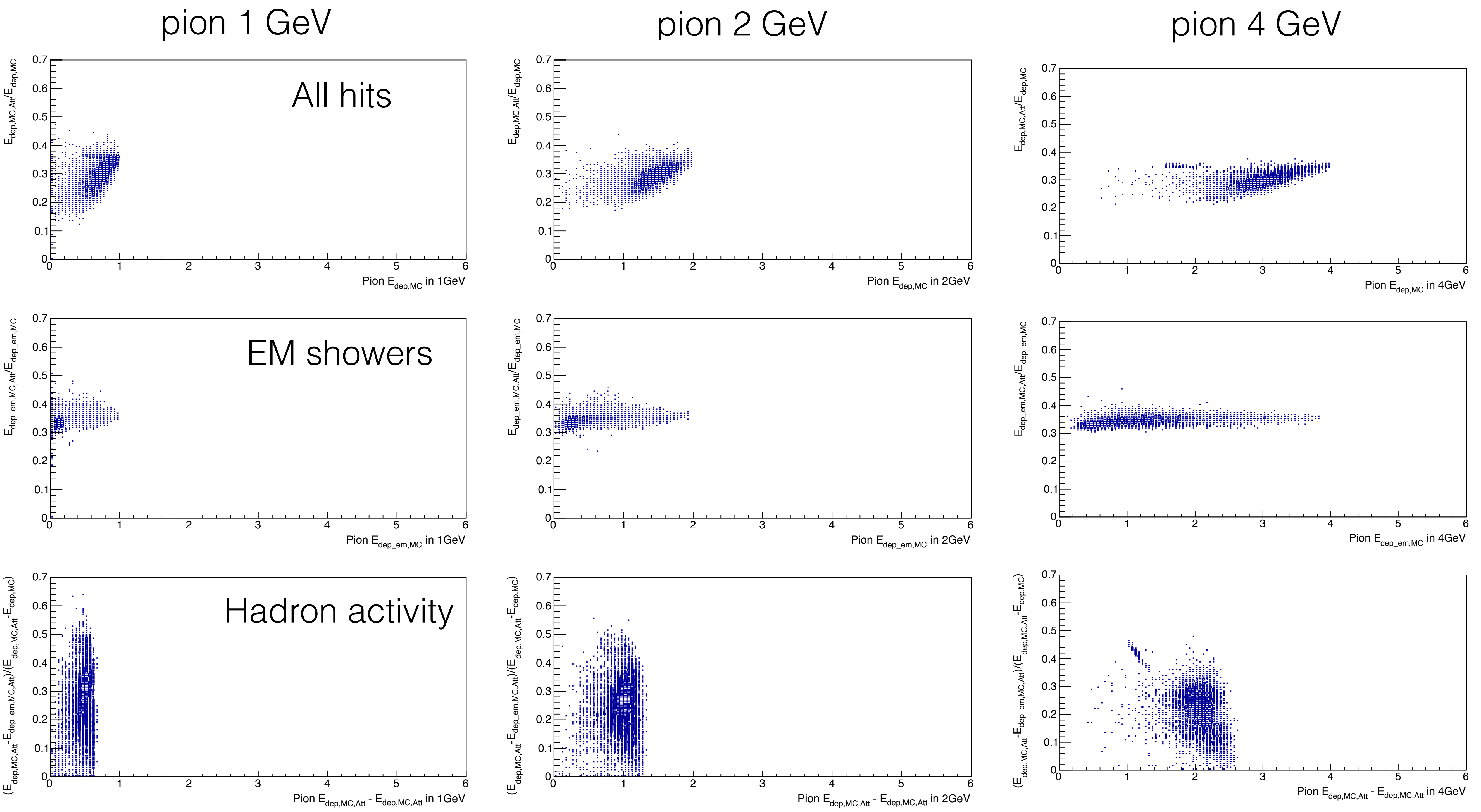
Check attenuation effect

- Plot the scattering distribution to see the attenuation effect : only MC information
  - All hits :
    - $E_{dep,MC,att}$ / $E_{dep,MC}$ as a function of $E_{dep,MC}$
      - $E_{dep,MC}$ is the deposit energy before the attenuation in MC
      - $E_{dep,MC,att}$ is the deposit energy after the attenuation in MC
        - Sum of number of electrons from TDCIDEMap (convert to E)
  - EM showers :
    - $E_{dep\_em,MC,att}$ / $E_{dep\_em,MC}$ as a function of $E_{dep,MC}$
      - $E_{dep\_em,MC}$ is the deposit energy before the attenuation in MC for EM showers
      - $E_{dep\_em,MC,att}$ is the deposit energy after the attenuation in MC for EM showers
  - Hadronic activity :
    - $(E_{dep,MC,att} - E_{dep\_em,MC,att})/(E_{dep,MC,att} - E_{dep,MC})$ as a function of $(E_{dep,MC,att} - E_{dep,MC})$

  - The deposit energy after the attenuation is not corrected for the lifetime

Attenuation effect for pion

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

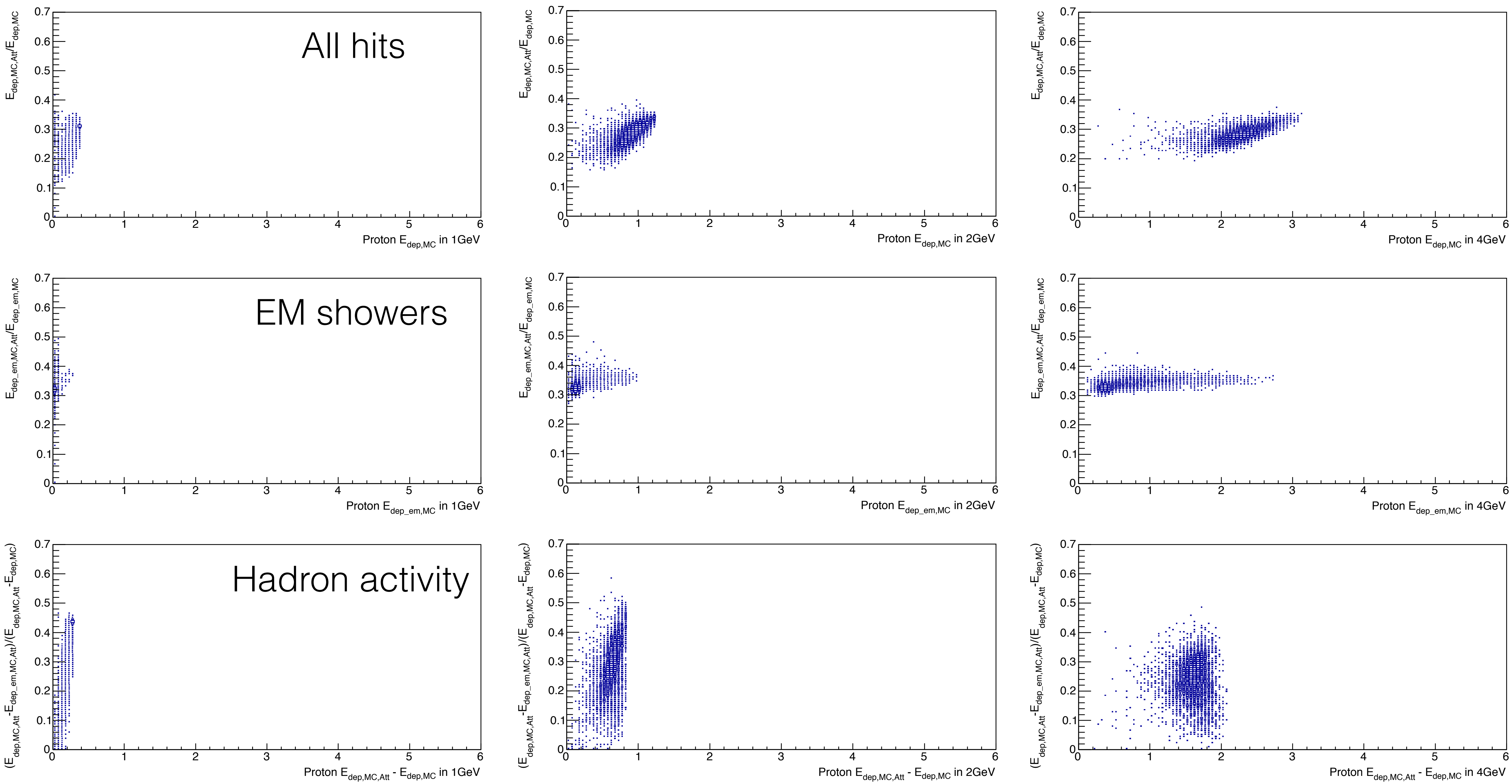


Spread in ratio is narrower and the overall ratio is slightly lower than the ratio with E_{dep}

Attenuation effect for proton

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

proton 1 GeV | proton 2 GeV | proton 4 GeV



Summary

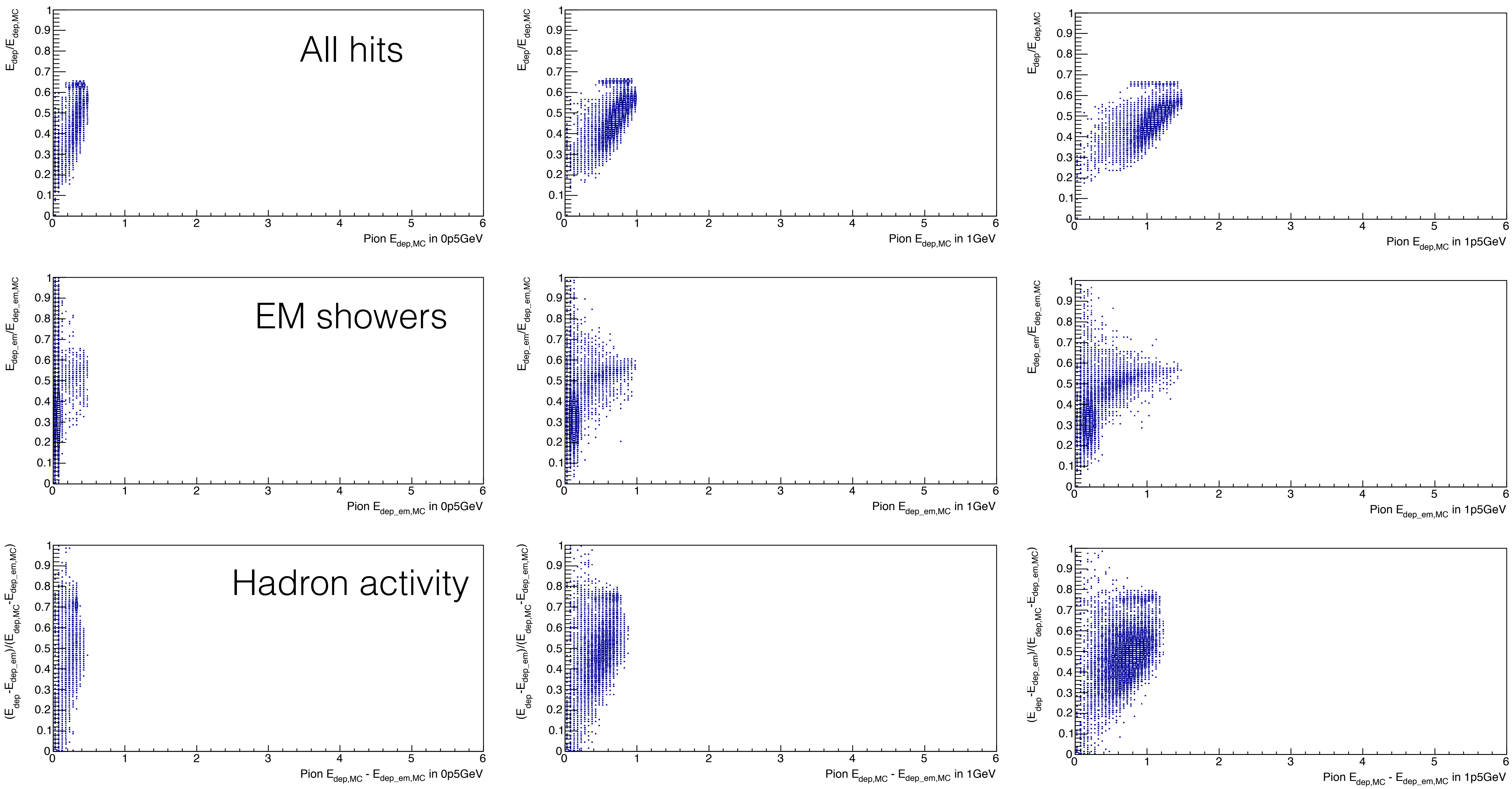
- Look at the deposit hit information using various energy particles
  - Compare the scatter plot for all hits, EM showers, and hadronic activity
  - Compare pion vs. proton case
  - Look at the attenuation effect for all hits, EM showers, and hadronic activity
- Next step :
  - Try to verify the hypothesis using MCtruth information (more classification)
  - Calculate the calibration factor for each event category)

Back-up slides

Ratio of E_{dep} to $E_{dep,MC}$ for pion (I)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

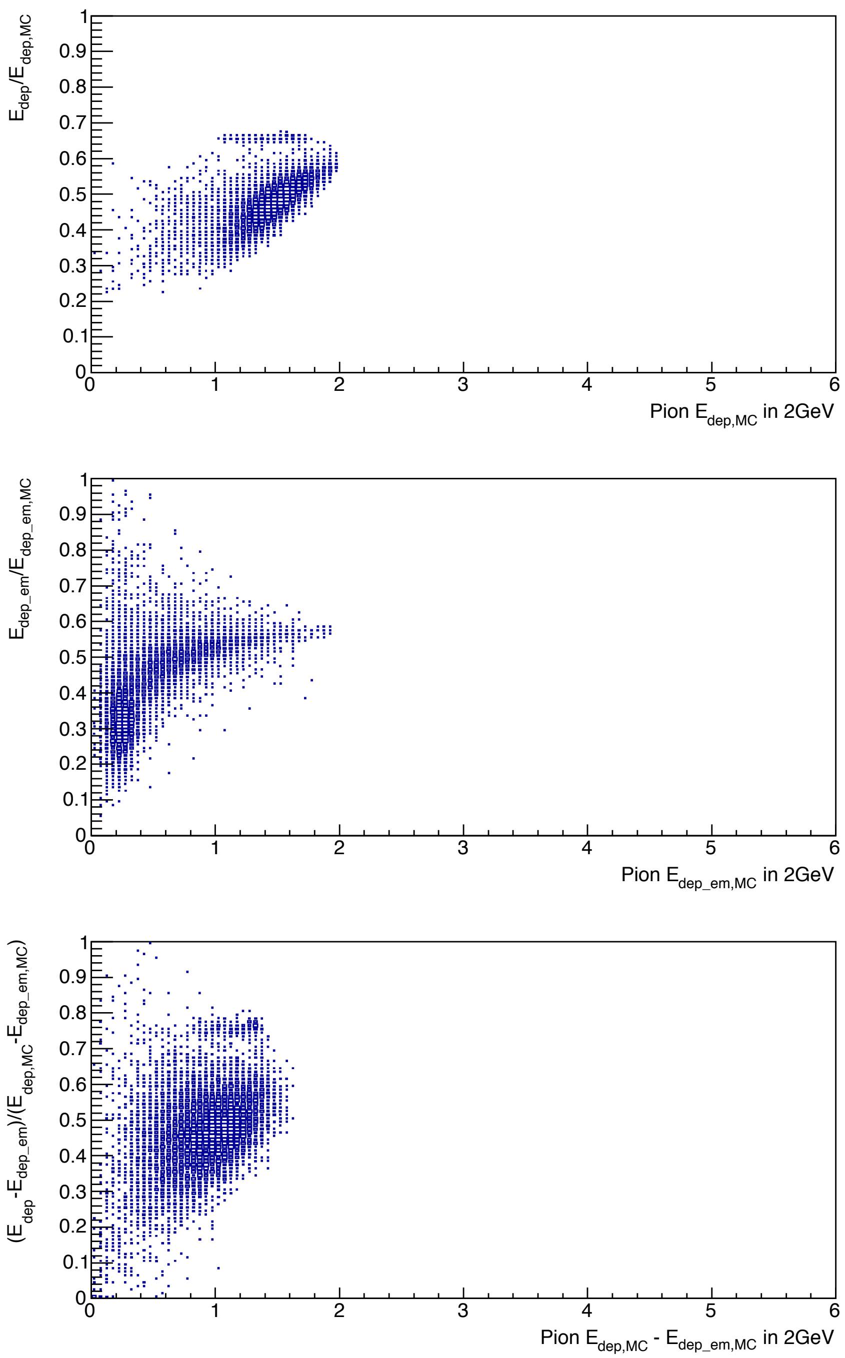
pion 0.5 GeV | pion 1 GeV | pion 1.5 GeV



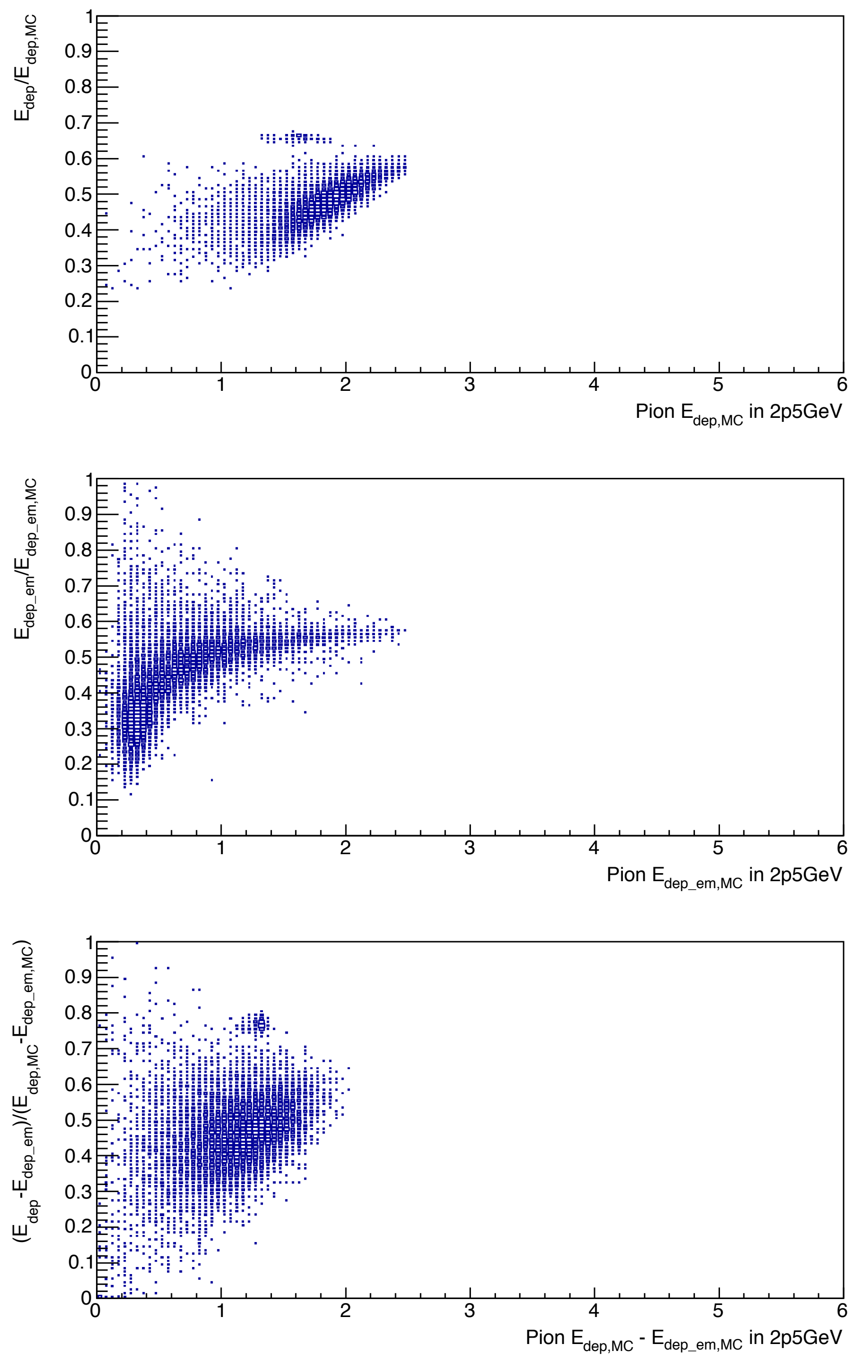
Ratio of E_{dep} to $E_{dep,MC}$ for pion (II)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

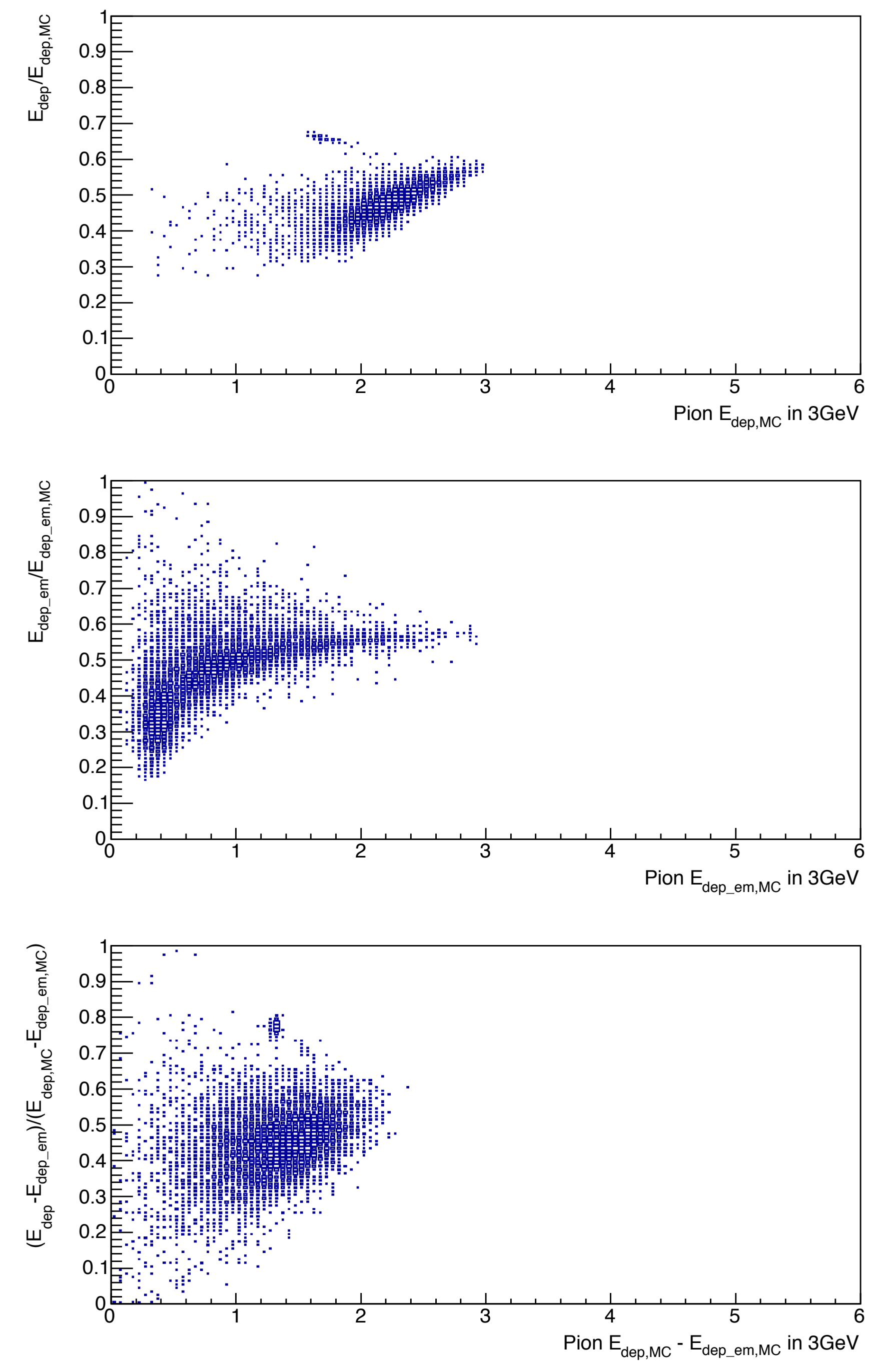
pion 2 GeV



pion 2.5 GeV



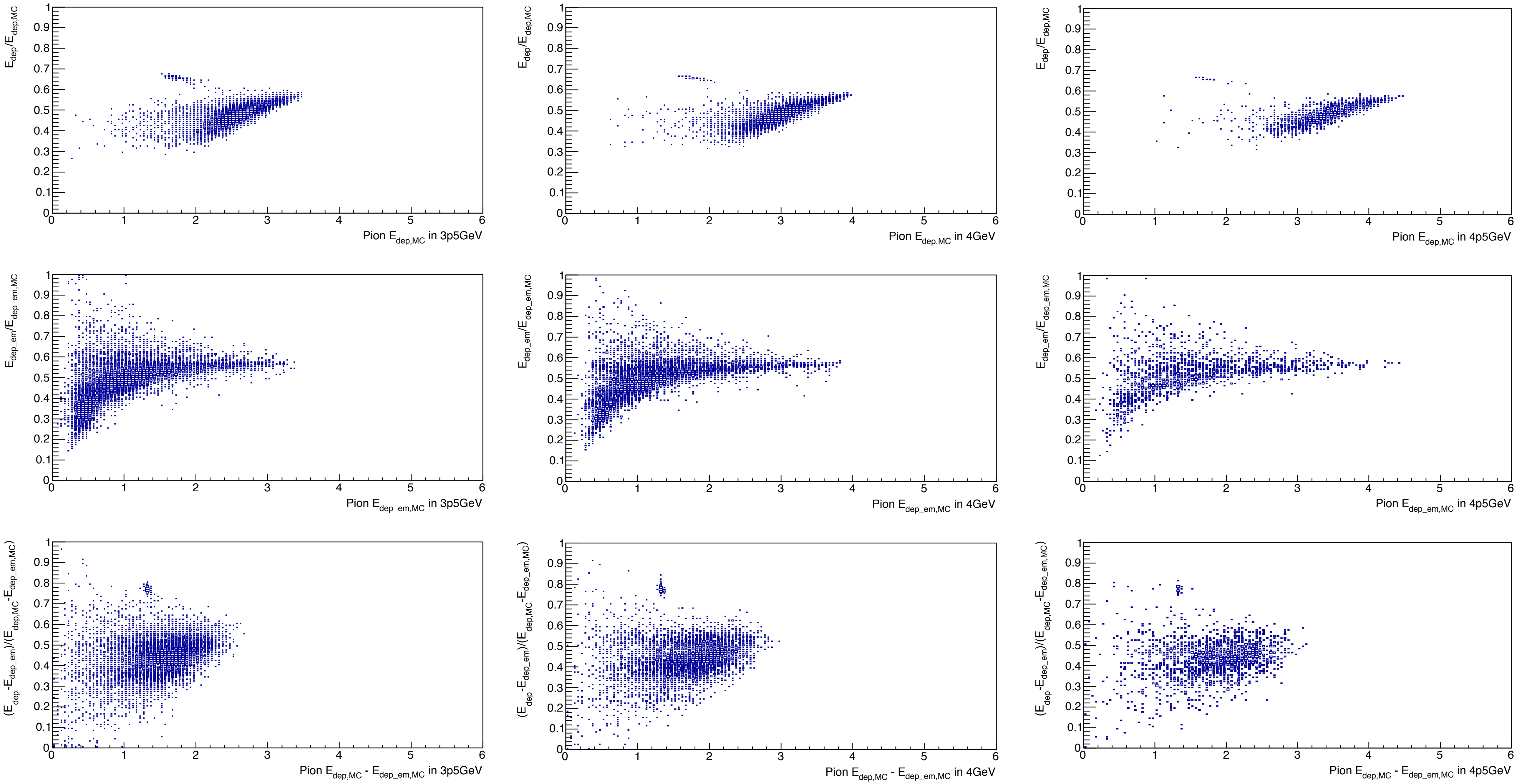
pion 3 GeV



Ratio of E_{dep} to $E_{dep,MC}$ for pion (III)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

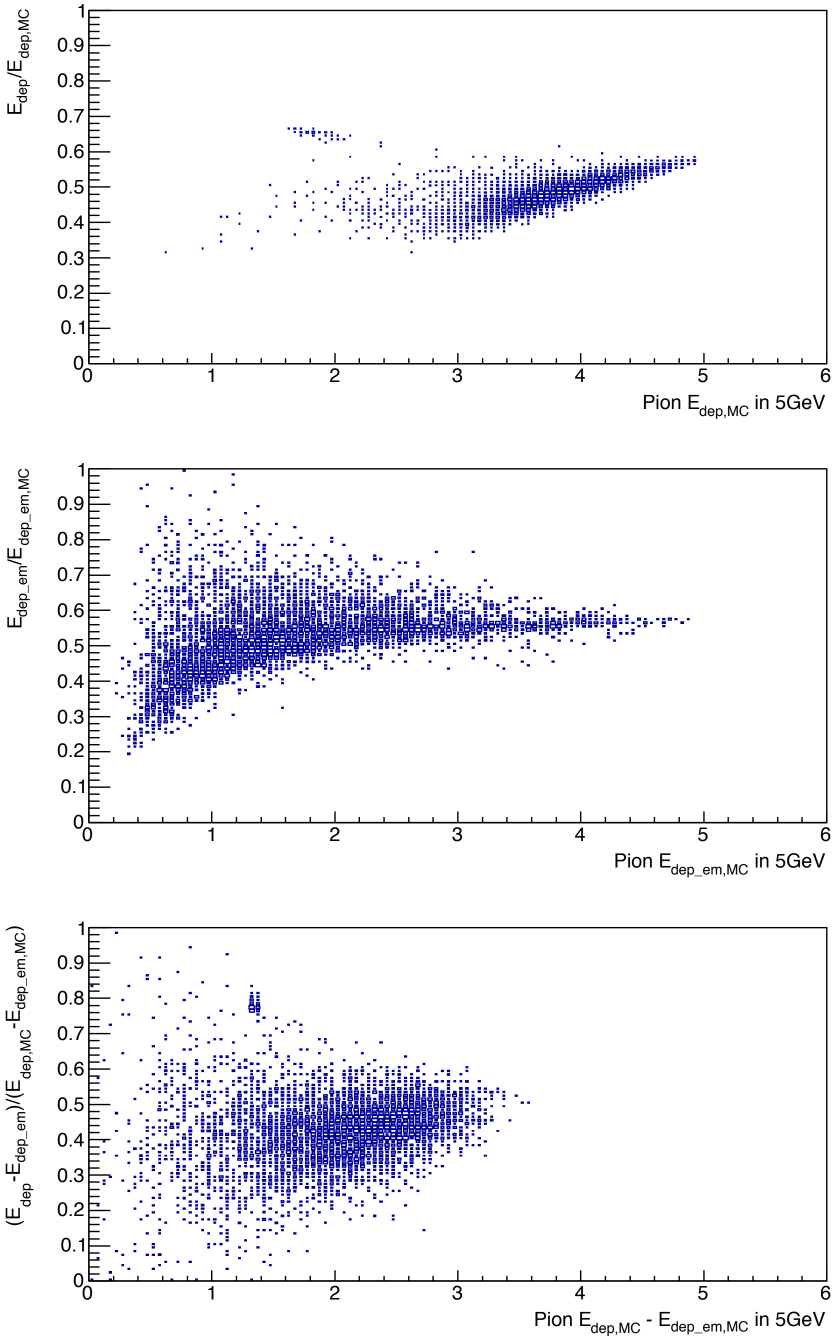
pion 3.5 GeV | pion 4 GeV | pion 4.5 GeV



Ratio of E_{dep} to $E_{dep,MC}$ for pion (IV)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

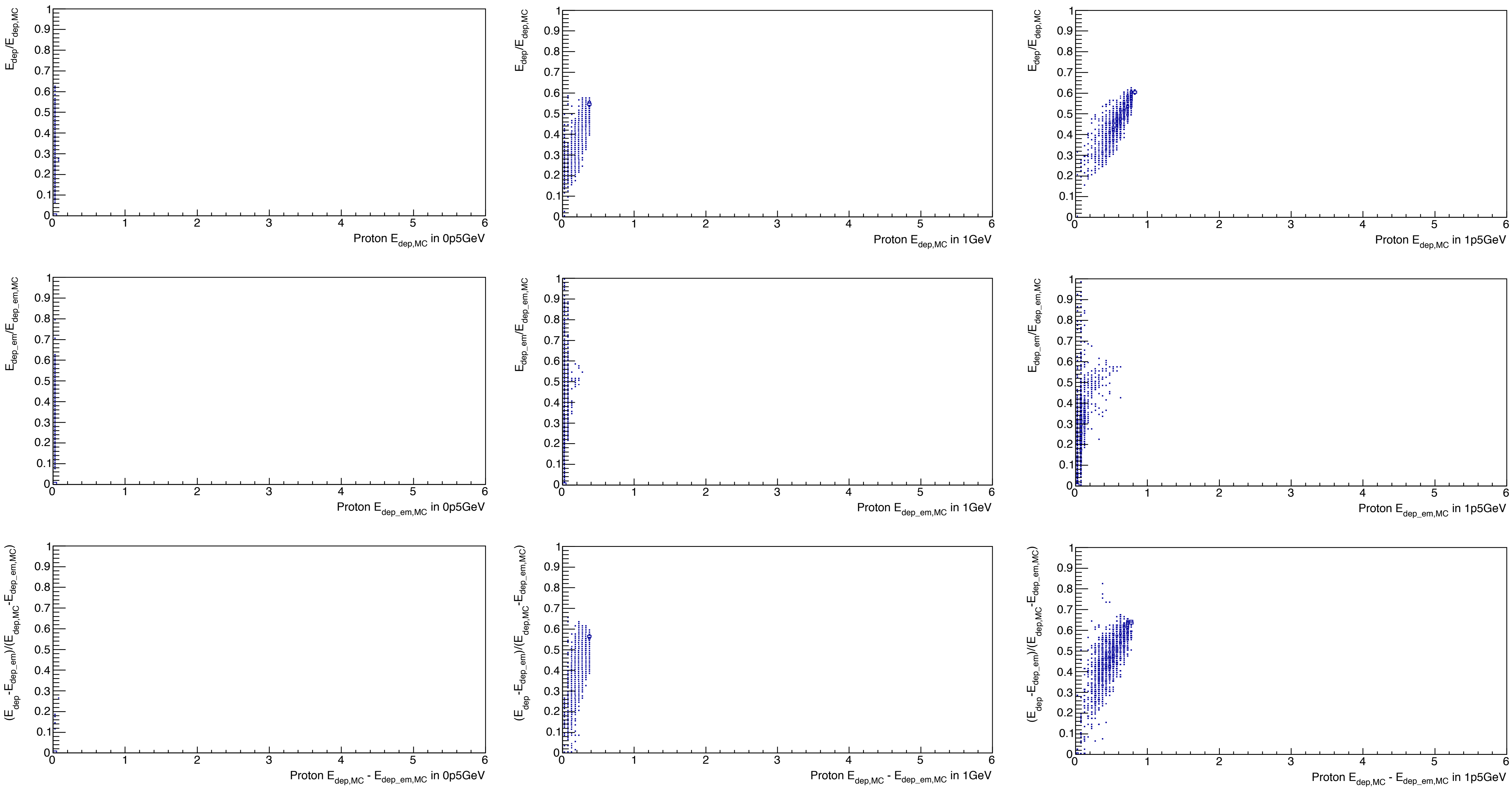
pion 5 GeV



Ratio of E_{dep} to $E_{dep,MC}$ for proton (I)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

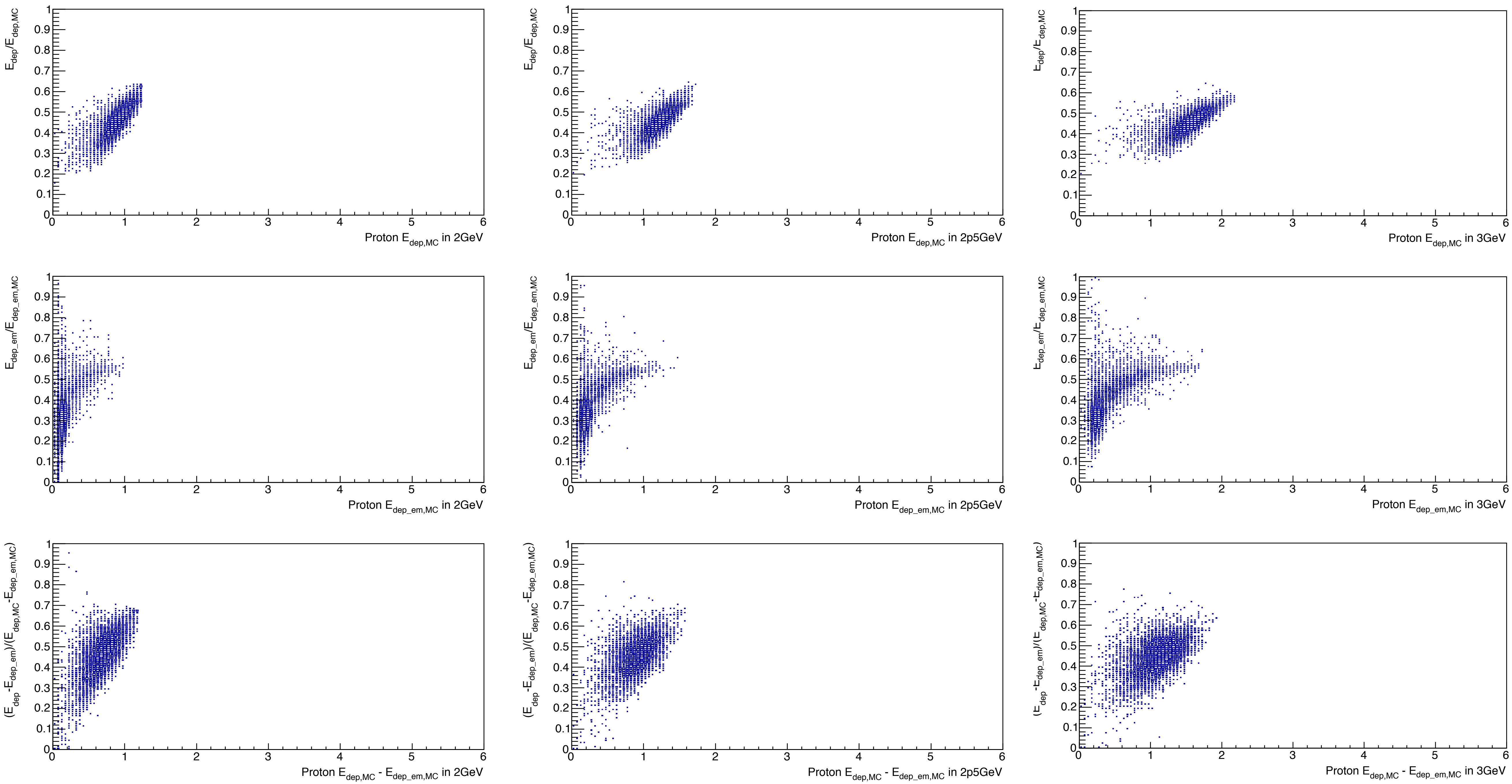
proton 0.5 GeV | proton 1 GeV | proton 1.5 GeV



Ratio of E_{dep} to $E_{dep,MC}$ for proton (II)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

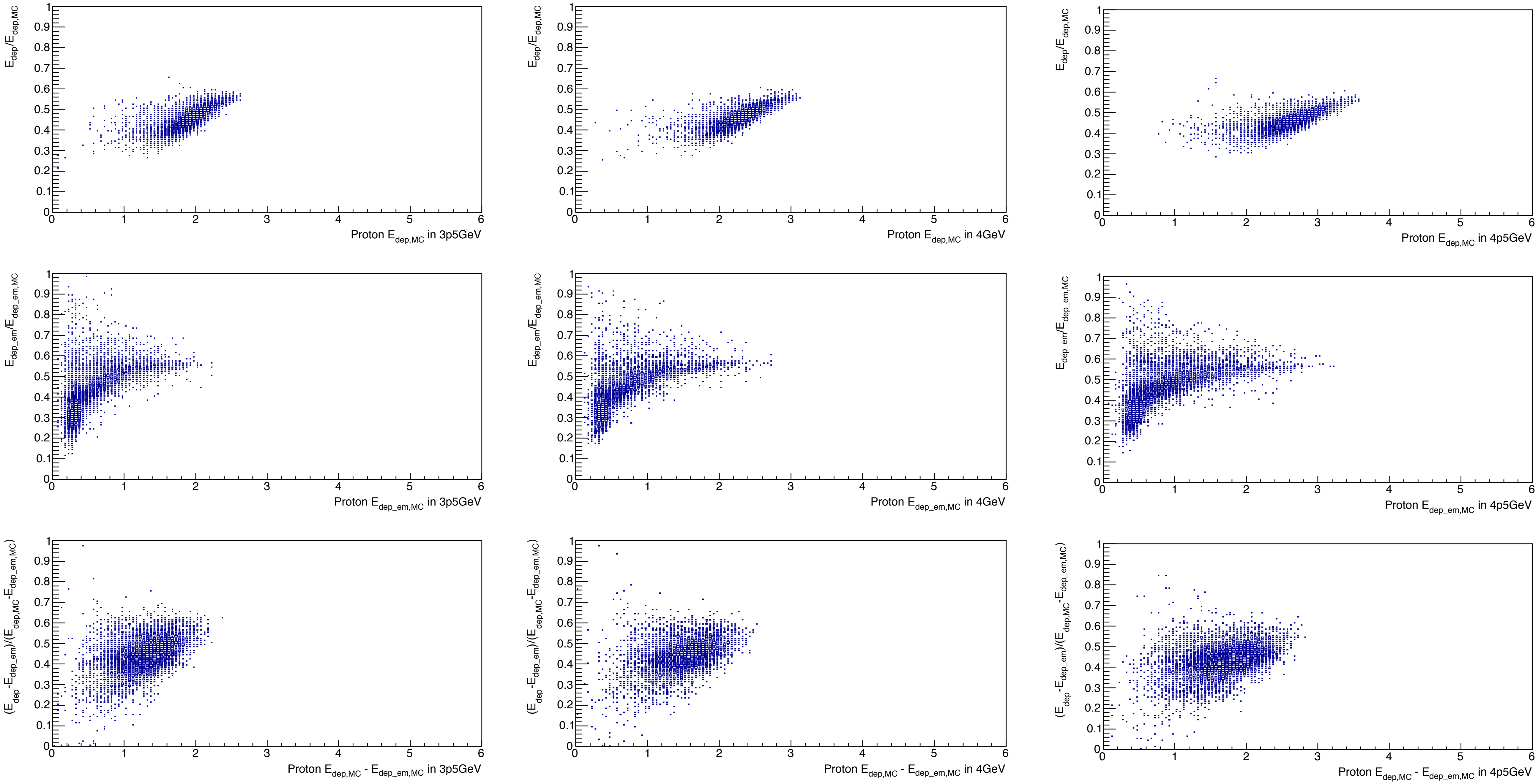
proton 2 GeV | proton 2.5 GeV | proton 3 GeV



Ratio of E_{dep} to $E_{dep,MC}$ for proton (III)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

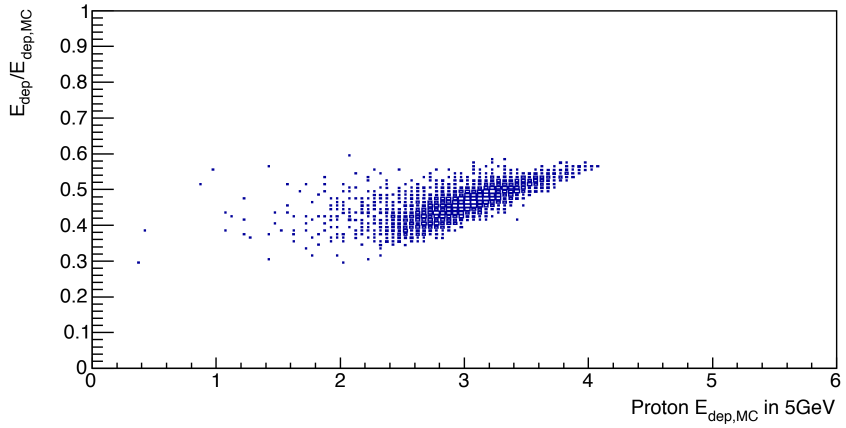
proton 3.5 GeV | proton 4 GeV | proton 4.5 GeV

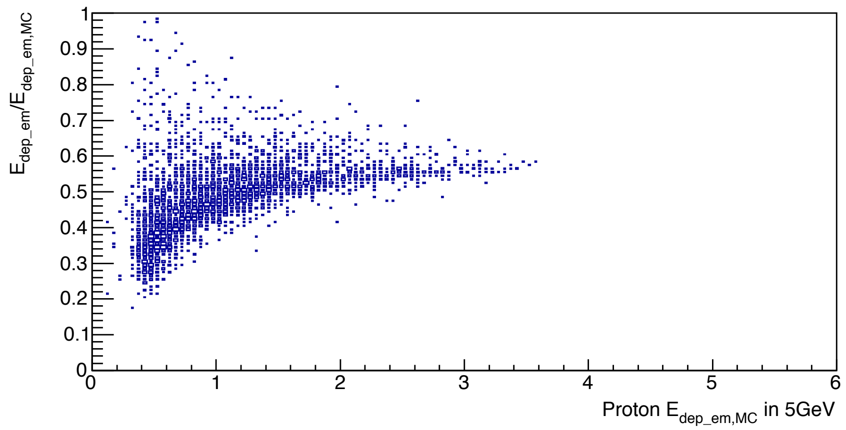


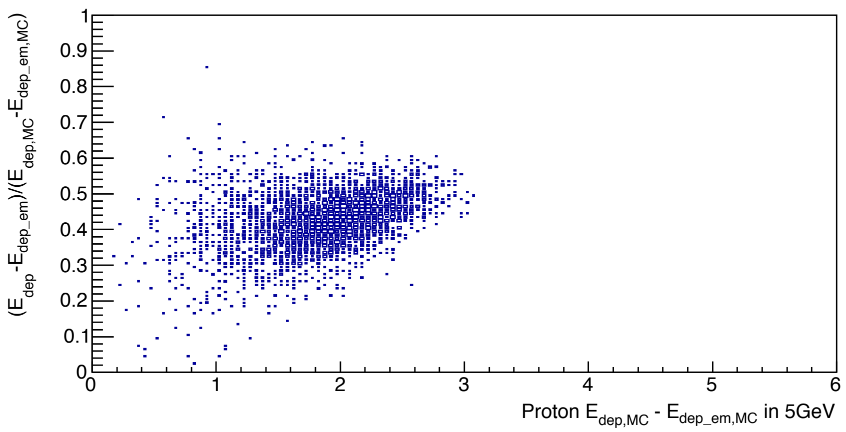
Ratio of E_{dep} to $E_{dep,MC}$ for proton (IV)

- y-axis : ratio of energy deposit in rec to MC, x-axis : energy deposit in MC

proton 5 GeV



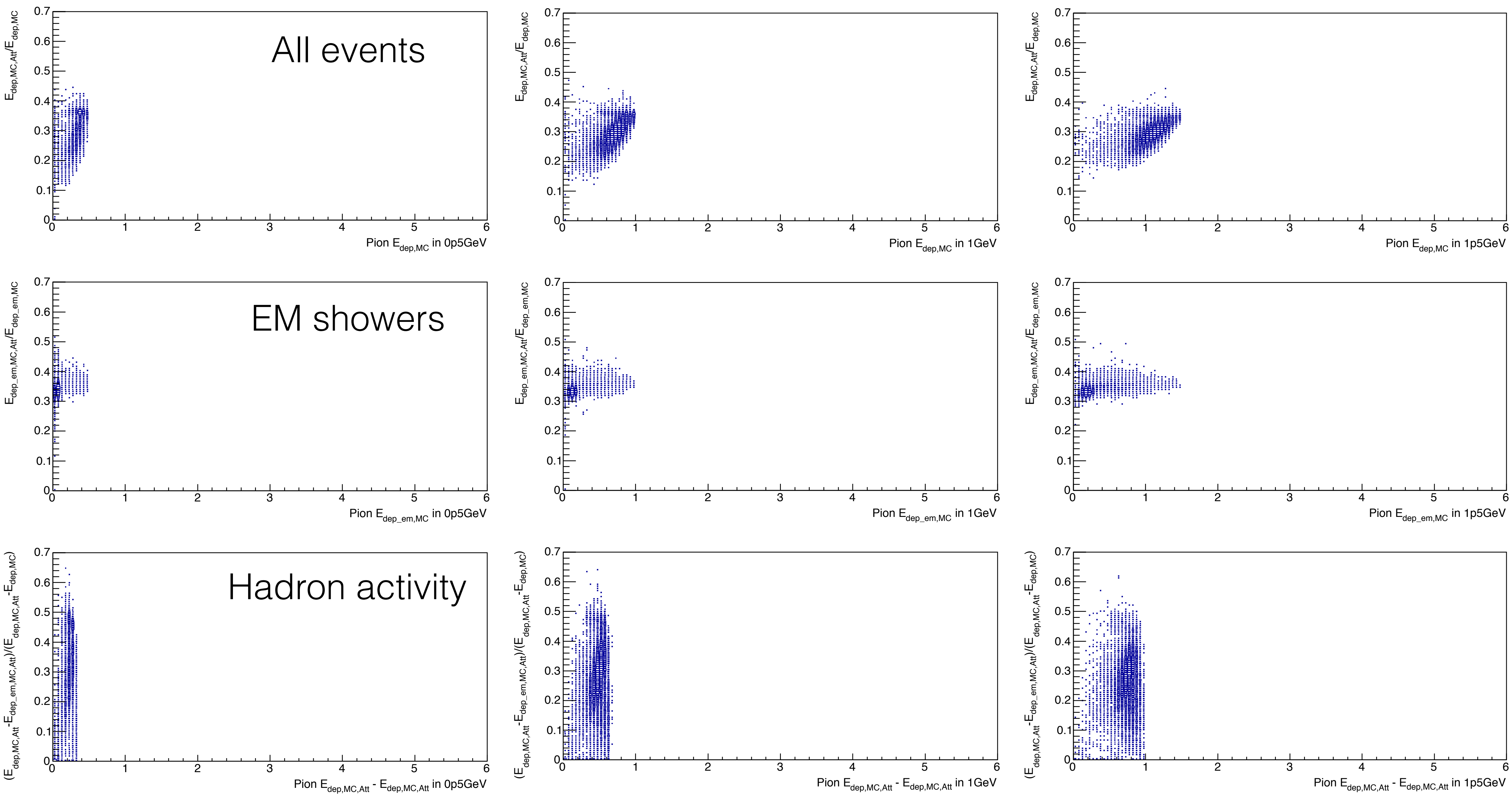




Attenuation effect for pion (I)

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

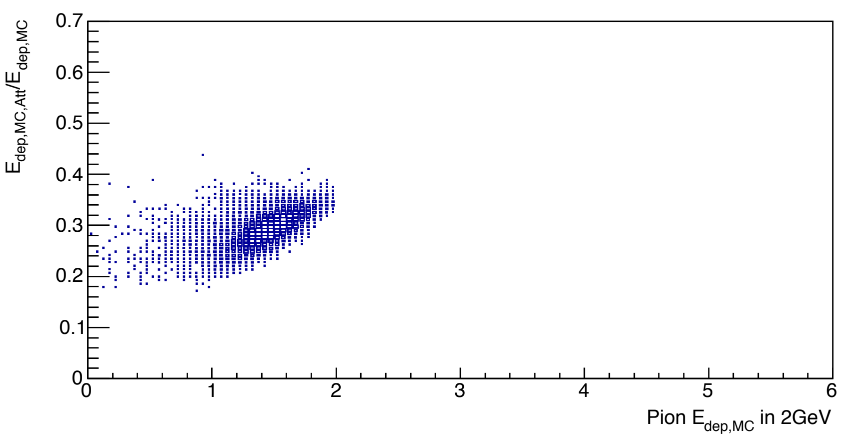
pion 0.5 GeV | pion 1 GeV | pion 1.5 GeV

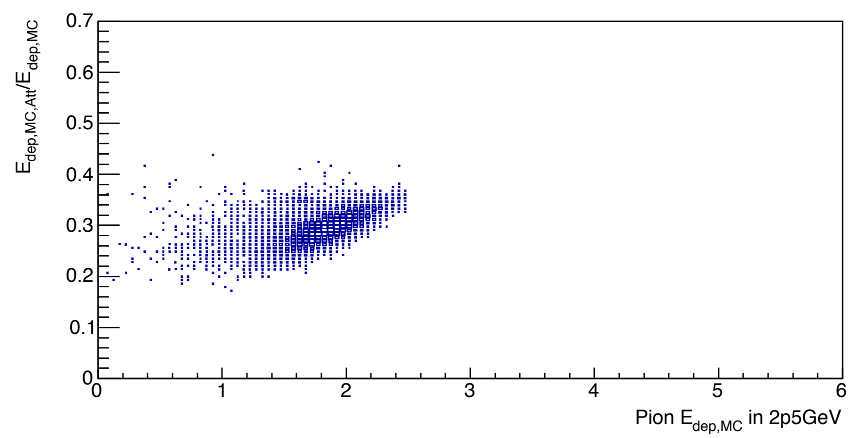


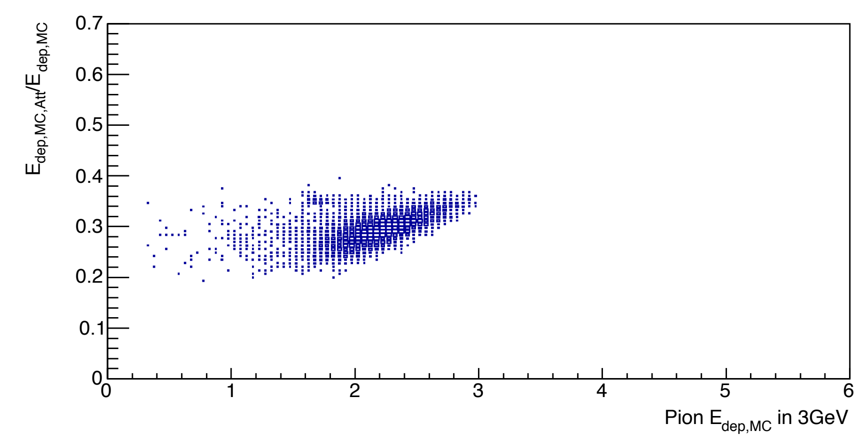
Attenuation effect for pion (II)

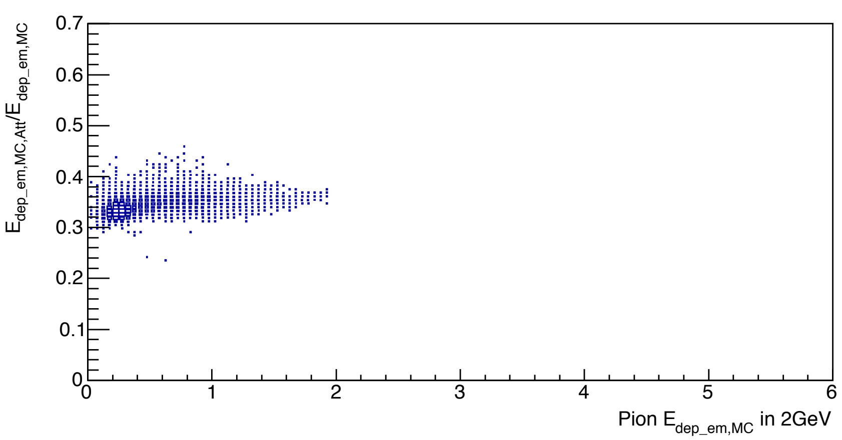
- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

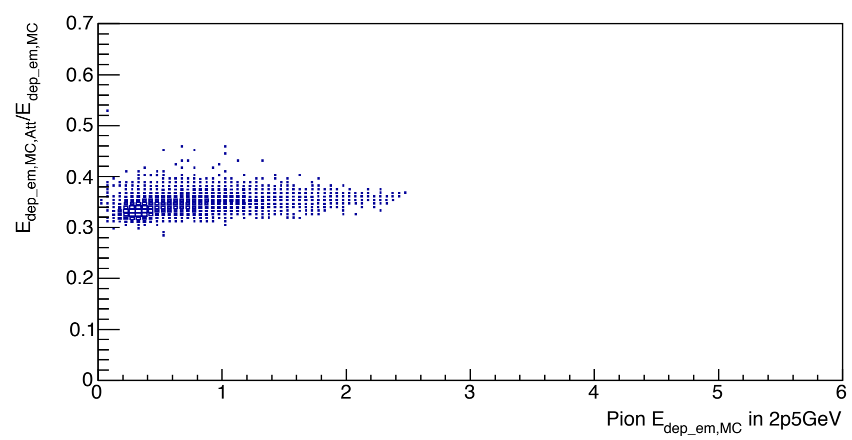
pion 2 GeV | pion 2.5 GeV | pion 3 GeV

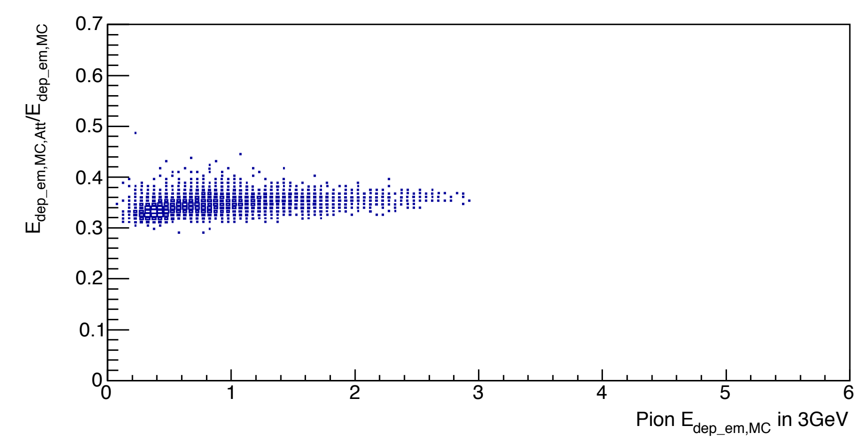


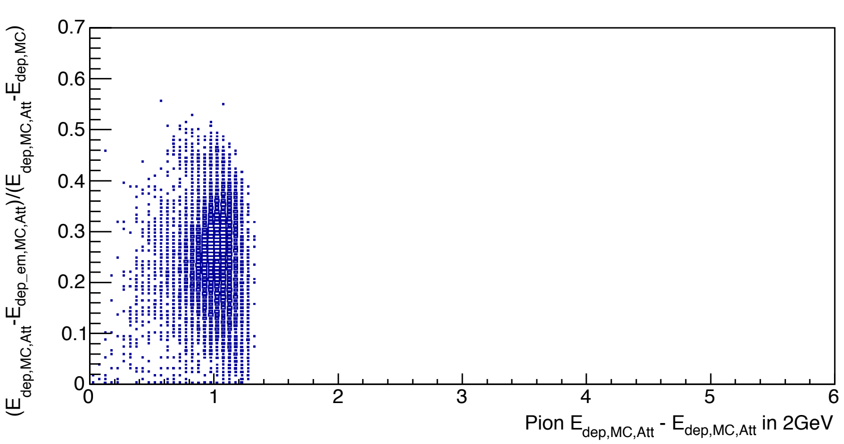


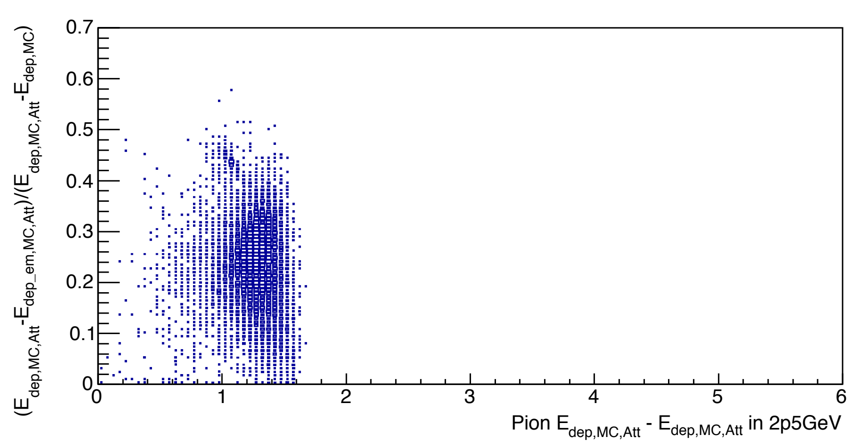


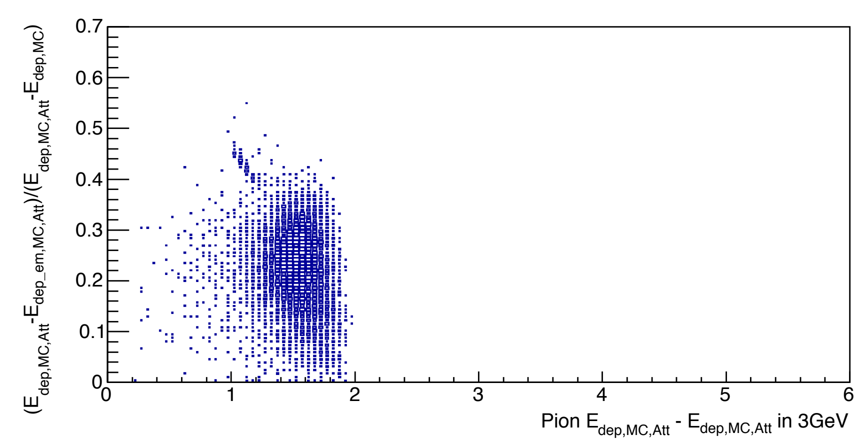








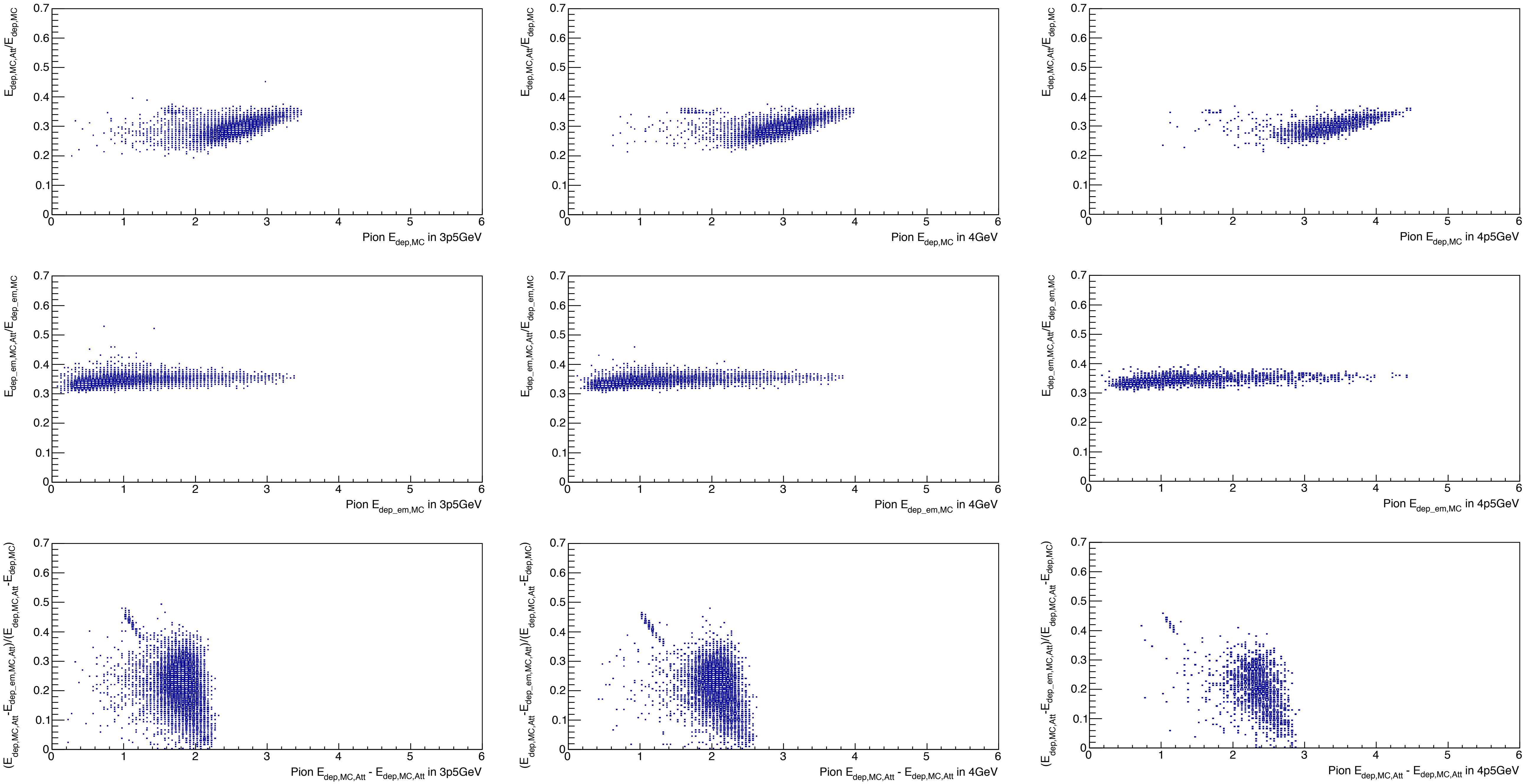




Attenuation effect for pion (III)

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

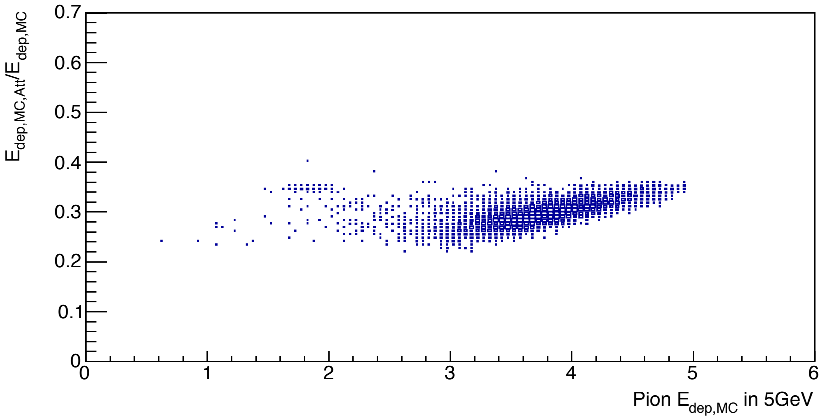
pion 3.5 GeV | pion 4 GeV | pion 4.5 GeV

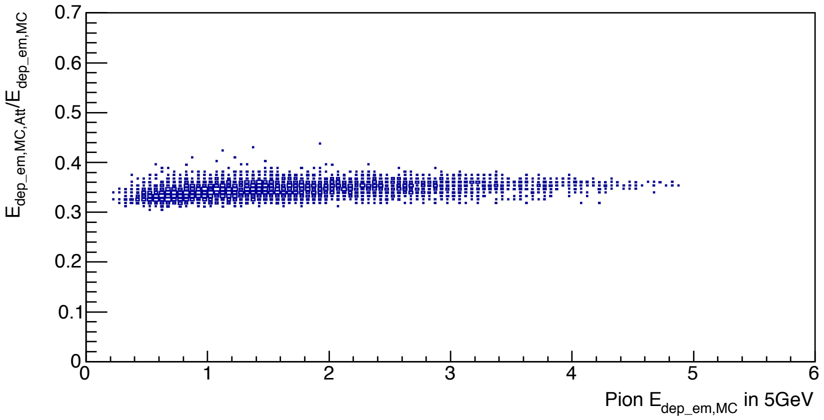


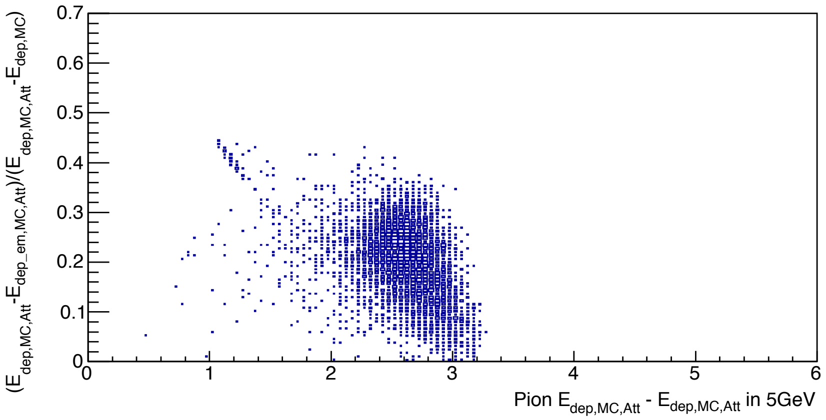
Attenuation effect for pion (IV)

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

pion 5 GeV



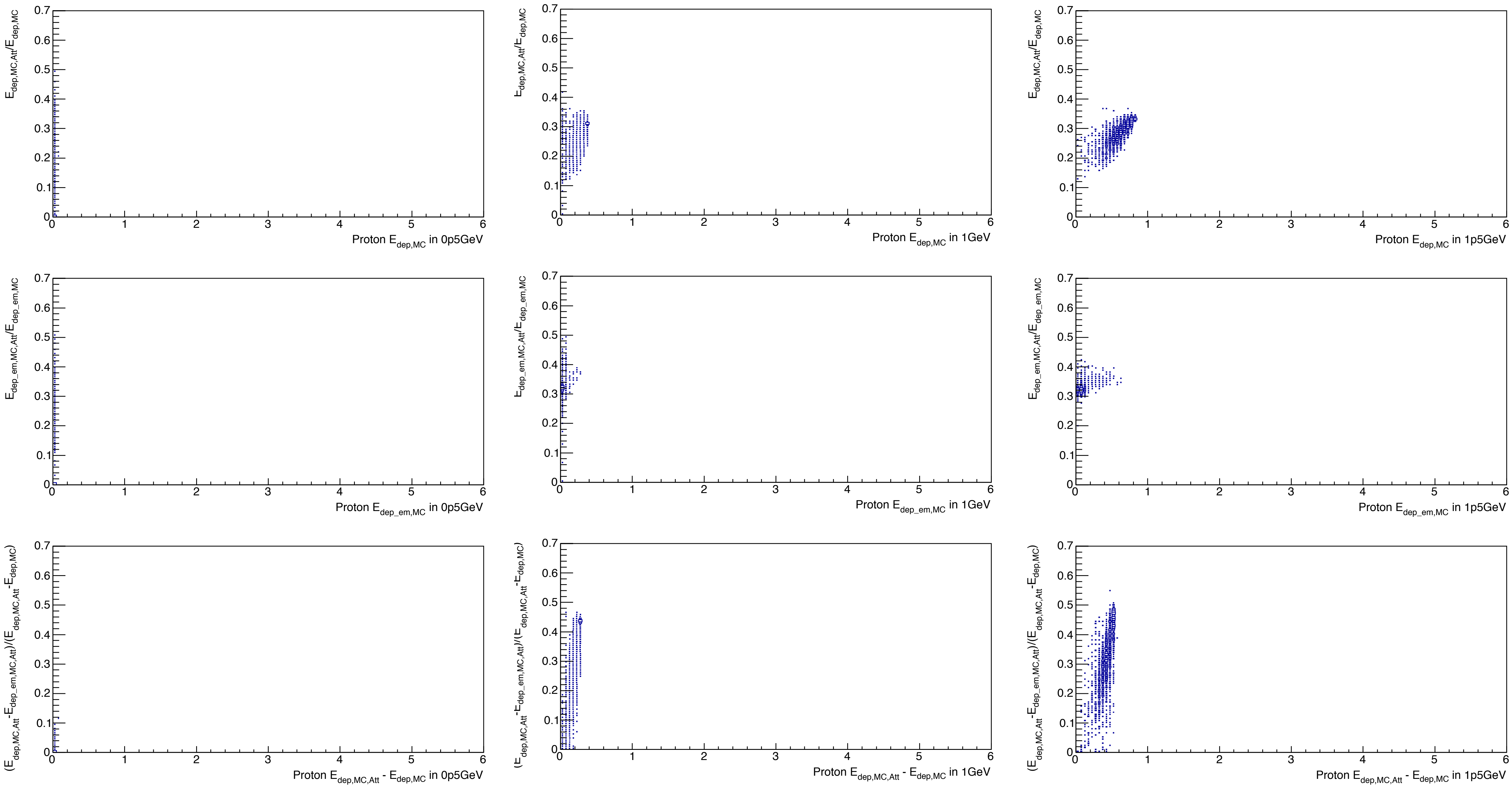




Attenuation effect for proton (I)

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

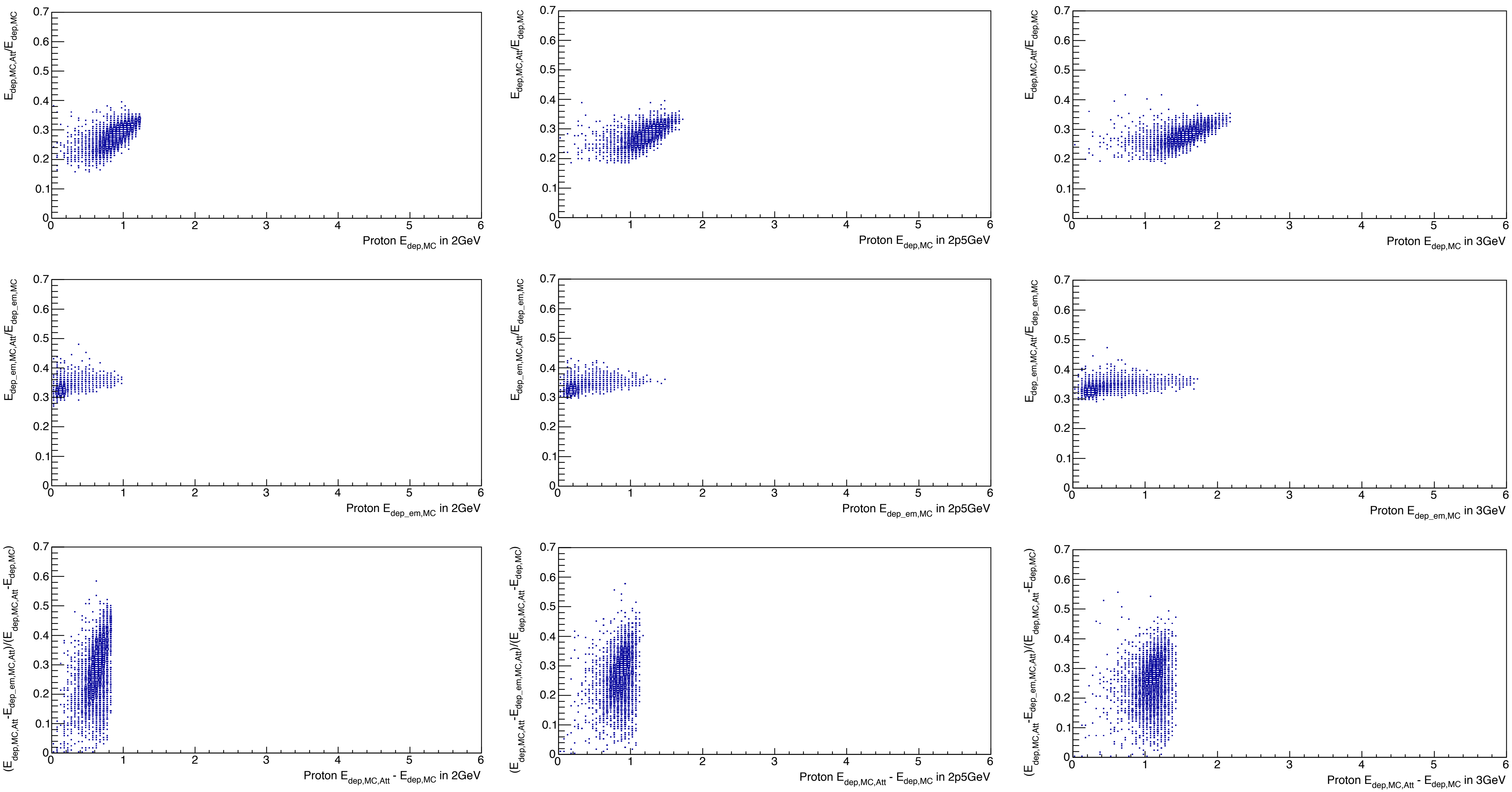
proton 0.5 GeV | proton 1 GeV | proton 1.5 GeV



Attenuation effect for proton (II)

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

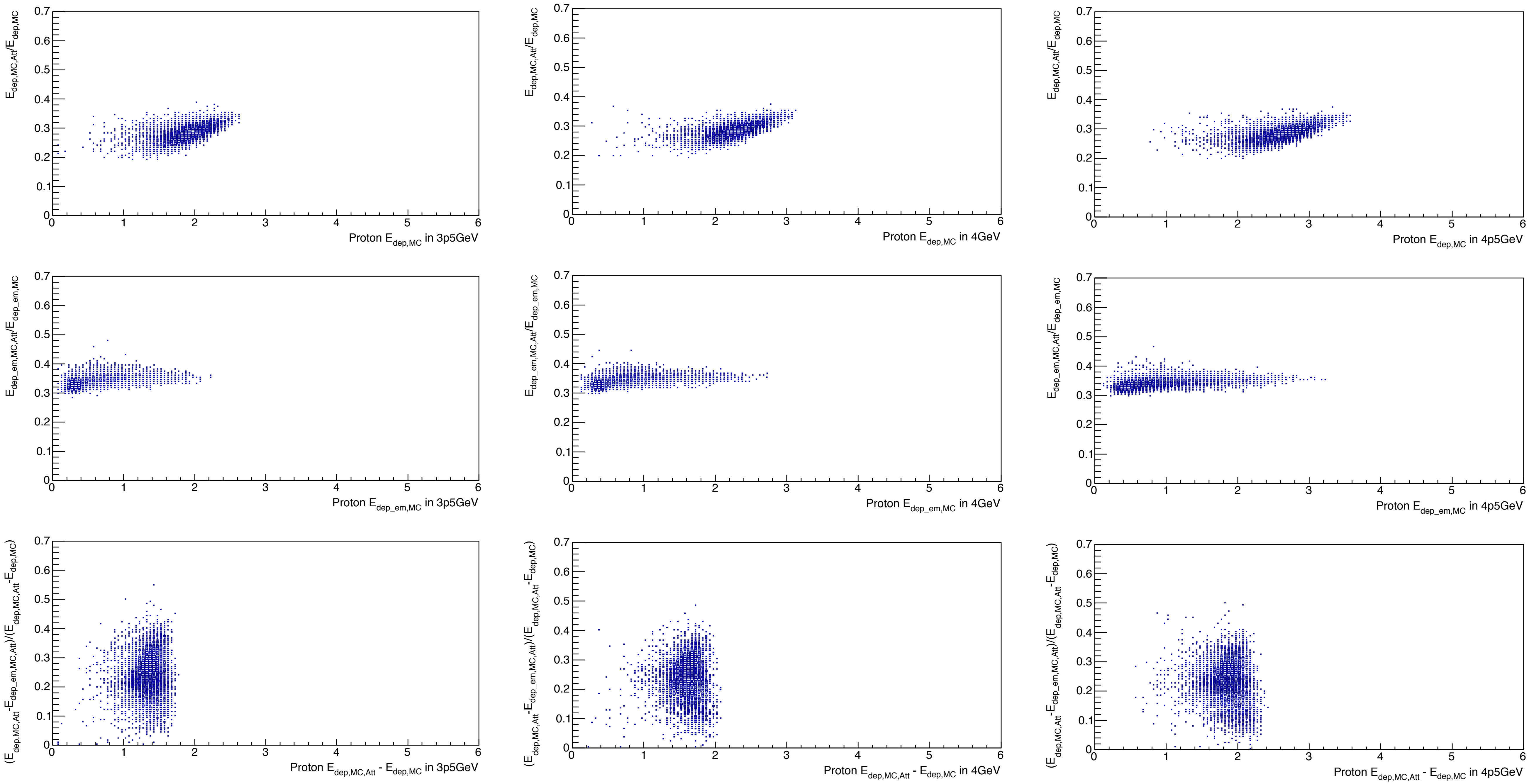
proton 2 GeV | proton 2.5 GeV | proton 3 GeV



Attenuation effect for proton (III)

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

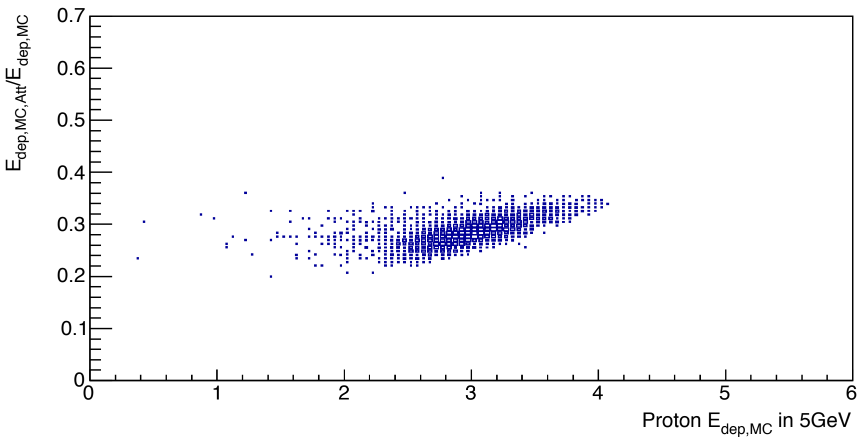
proton 3.5 GeV | proton 4 GeV | proton 4.5 GeV

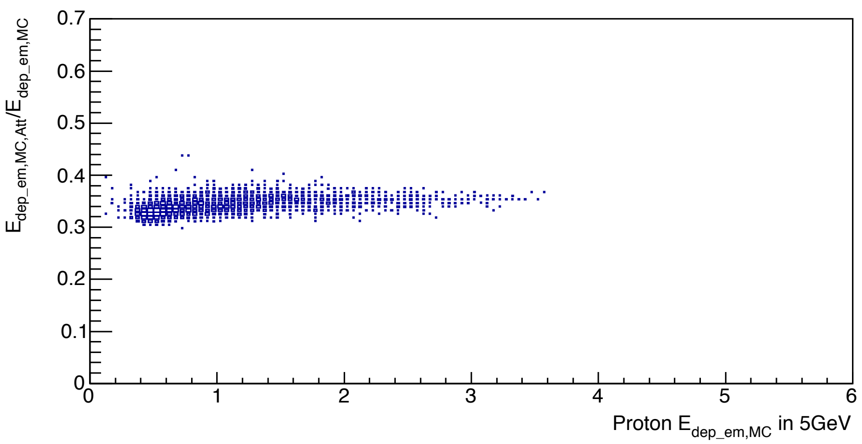


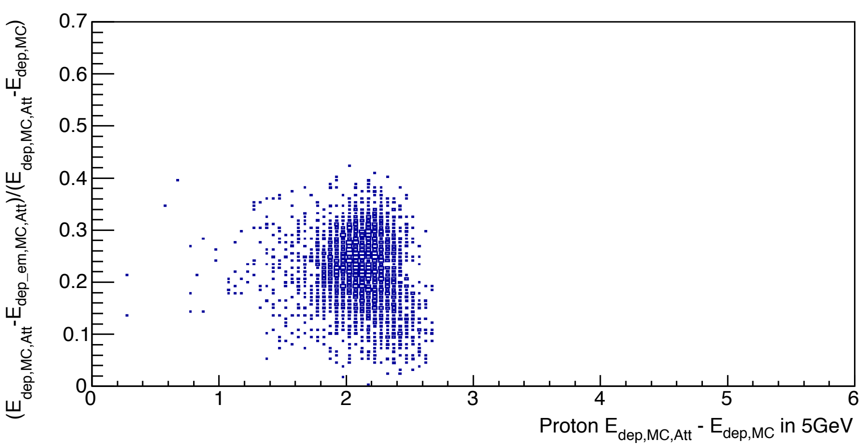
Attenuation effect for proton (IV)

- y-axis : energy deposit ratio in MC before to after attenuation, x-axis : energy deposit in MC

proton 5 GeV

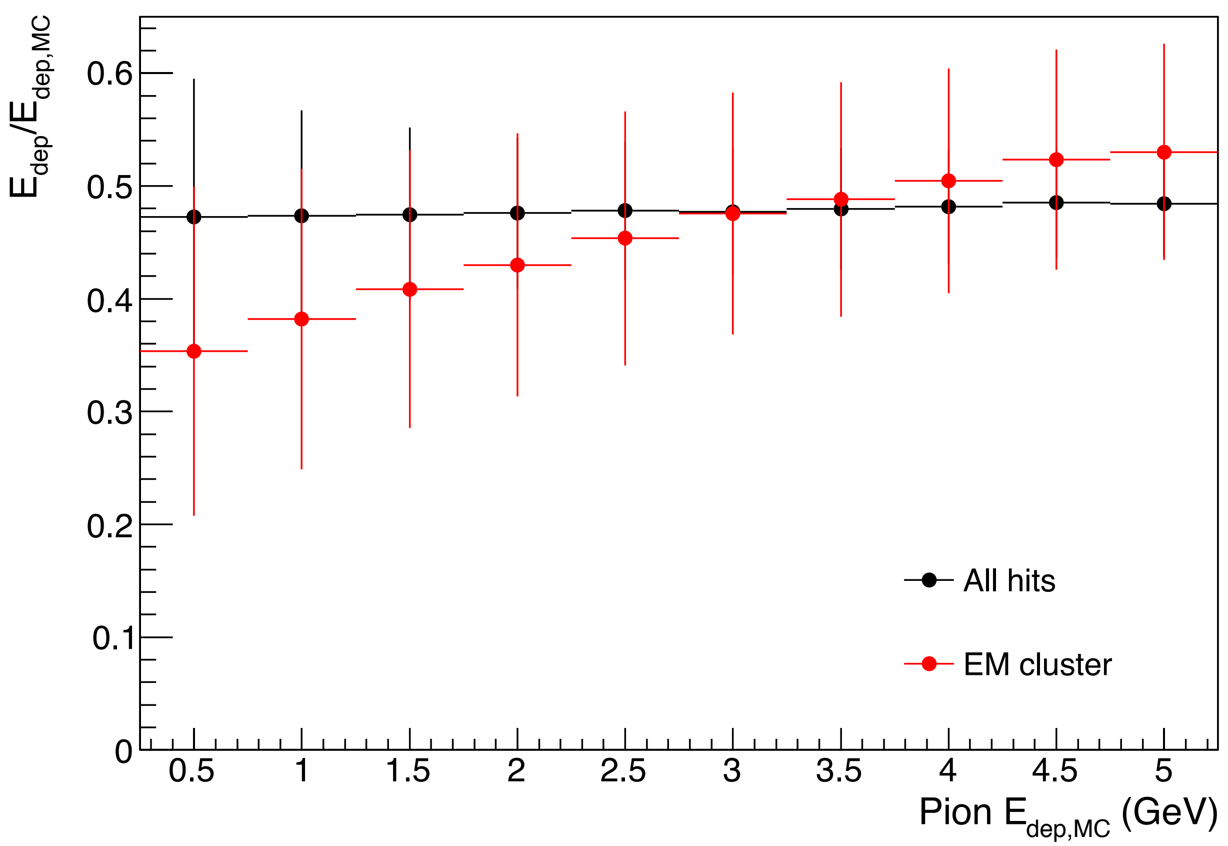


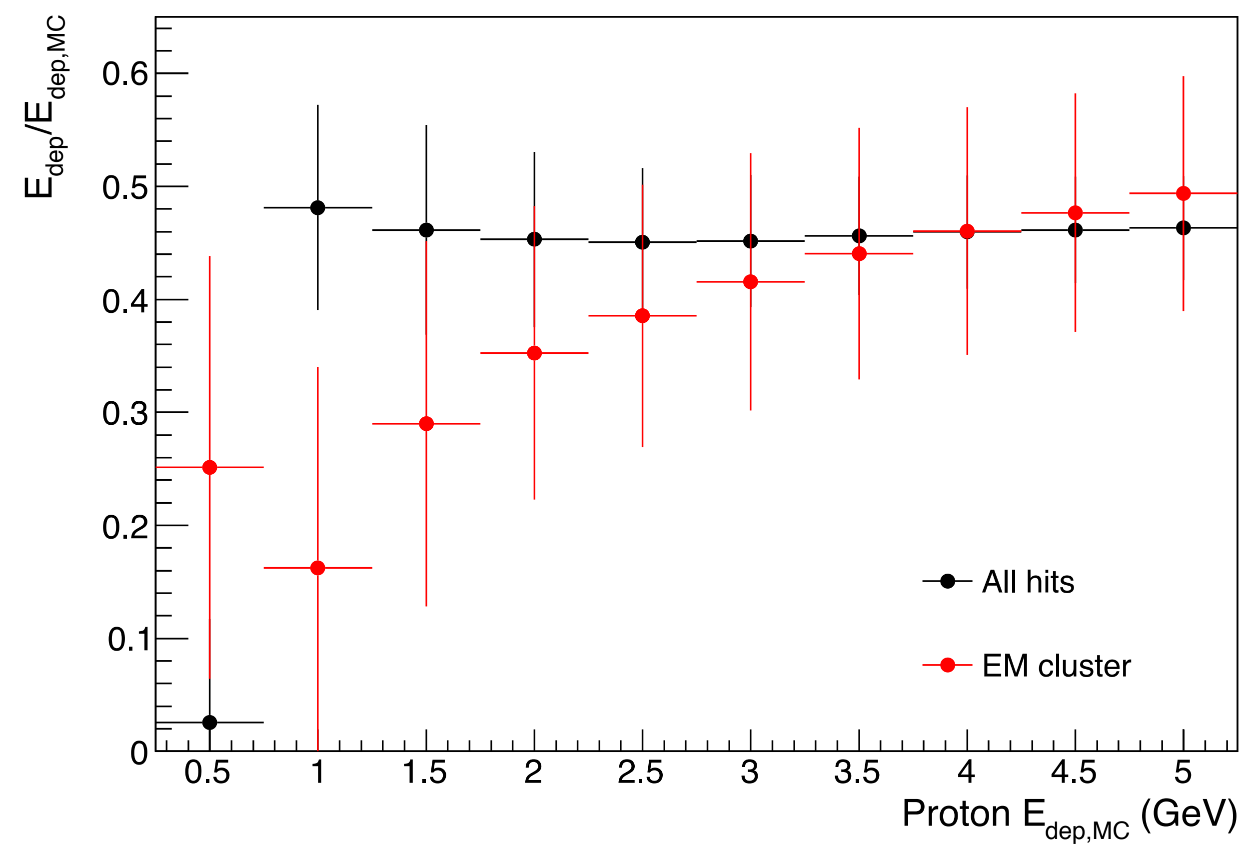




Calibration factor for pion and proton

- Overall calibration factor as a function of particle energy





- Calibration factor for EM showers is lower than all hits, especially for low energy