

Particle ID

$e^-/\mu^-/\pi^-$ separation optimised for low energy TB May pion runs

Vladimir Bocharnikov

Tokyo Testbeam Analysis Workshop, 9 Aug 2018

Outline

Introduction

Observables

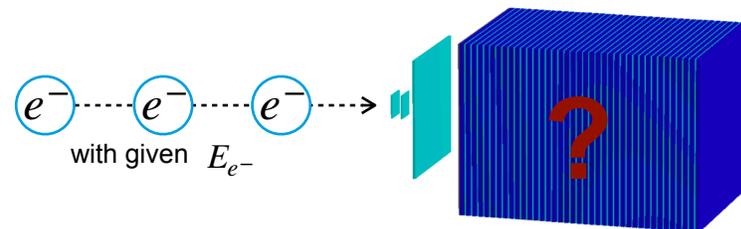
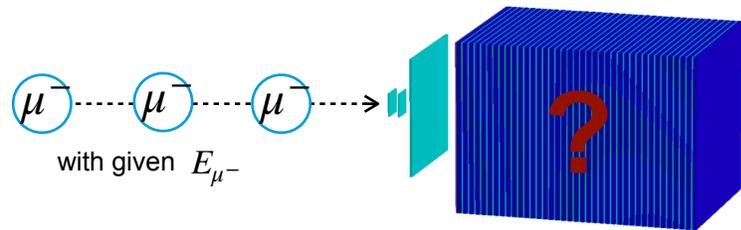
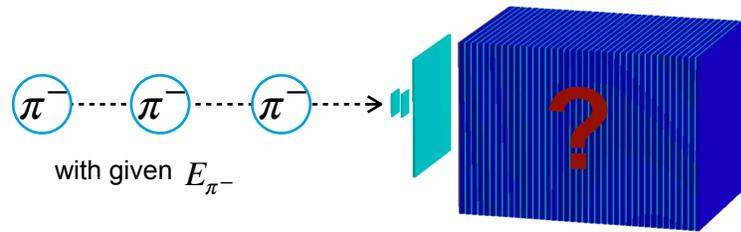
- Definition
- Calculation
- 2D combinations (MC data)

Event selection

- Cuts
- MC preliminary results
- TBMay preliminary results

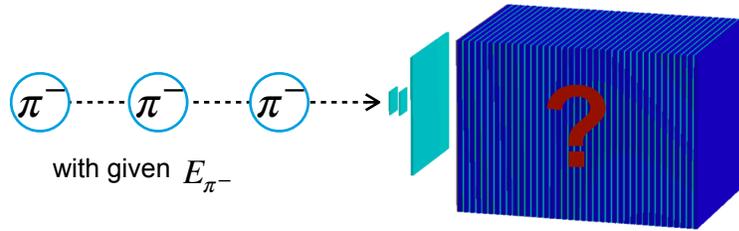
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What do we want to investigate

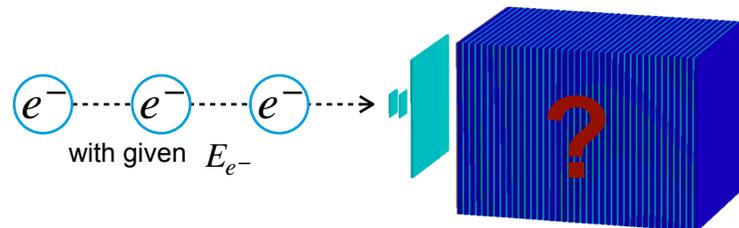
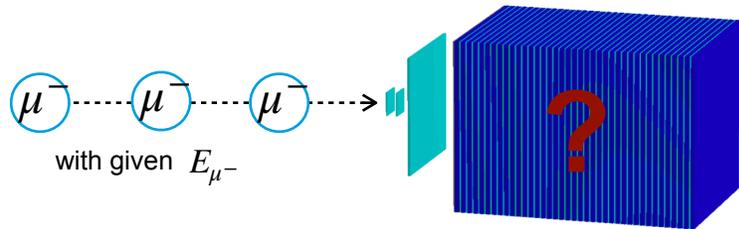


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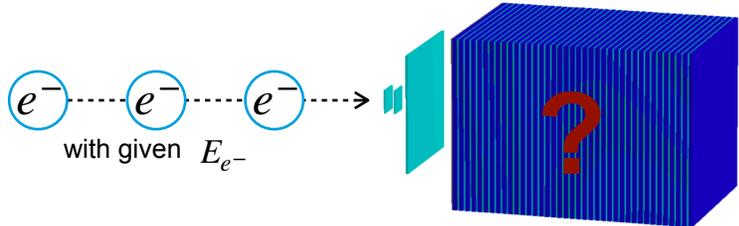
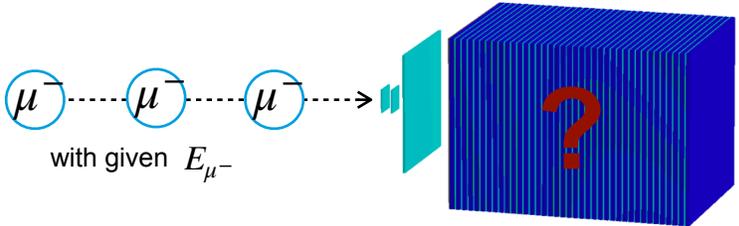
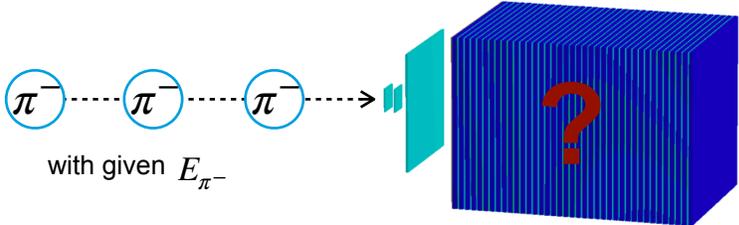


What if we want to check the energy resolution for 10GeV pion run?



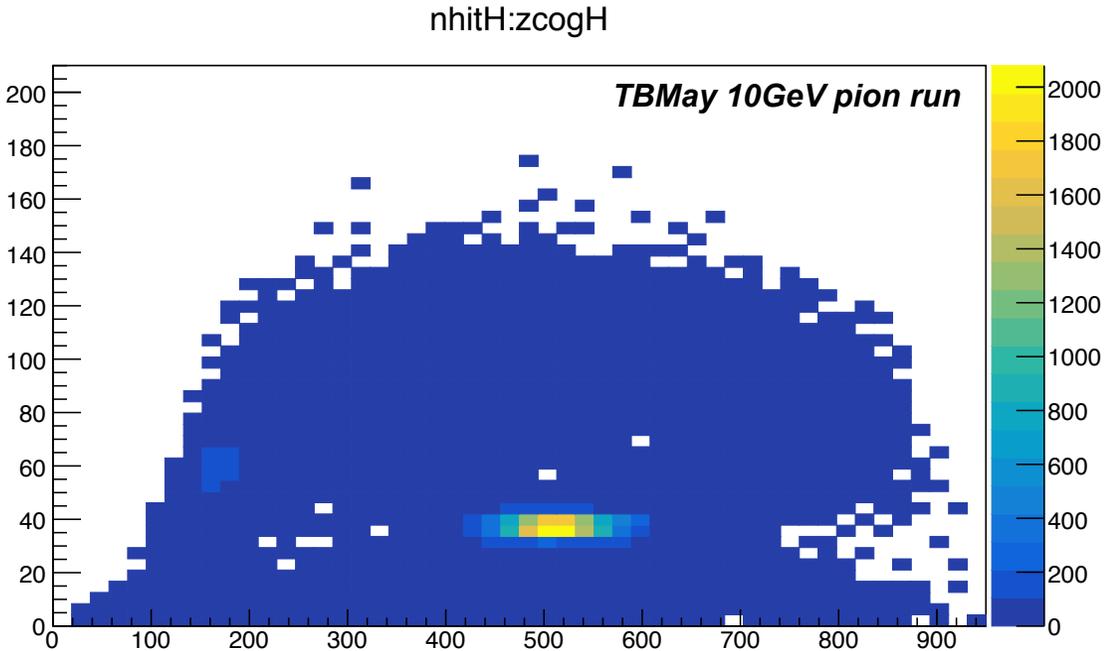
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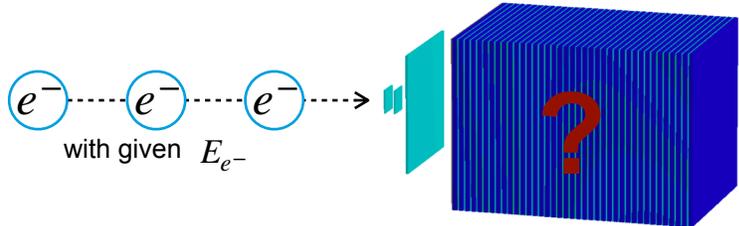
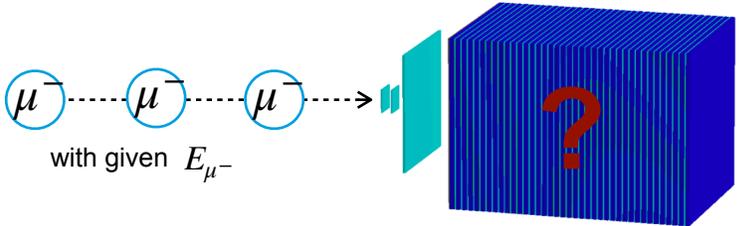
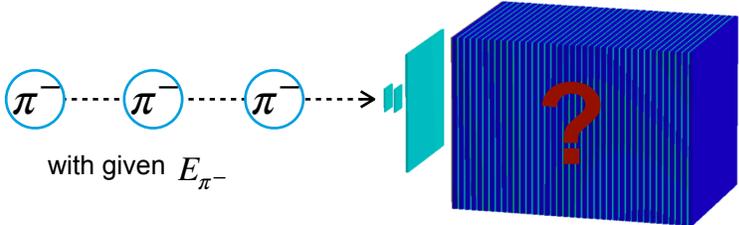
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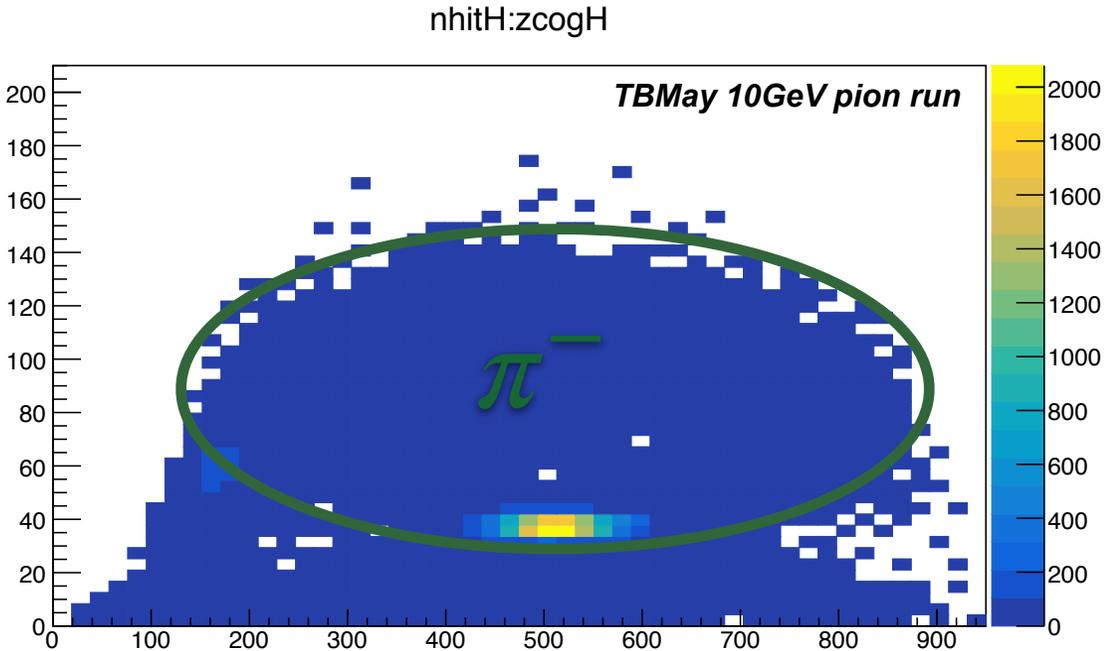
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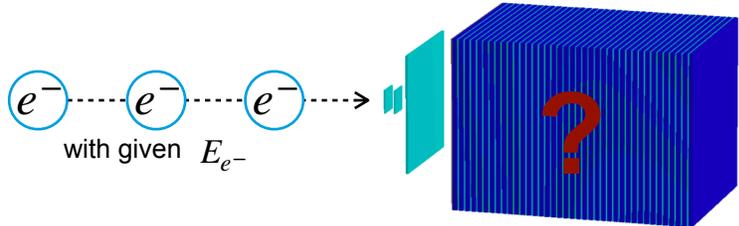
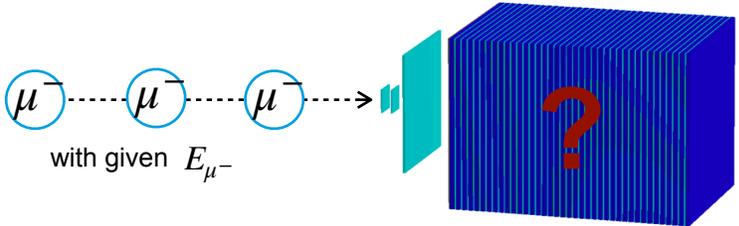
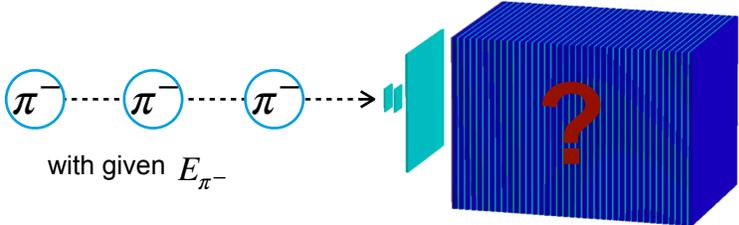
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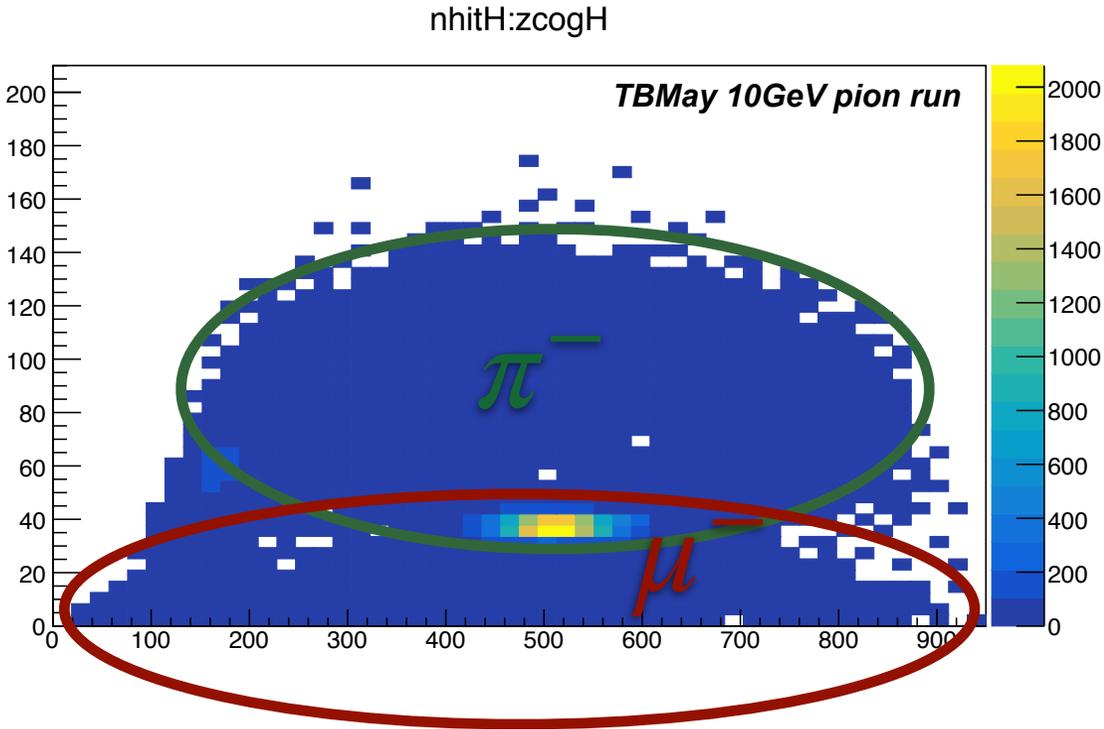
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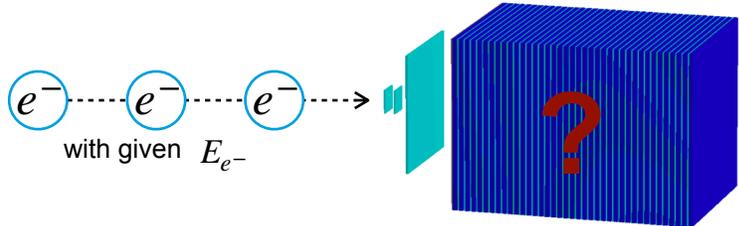
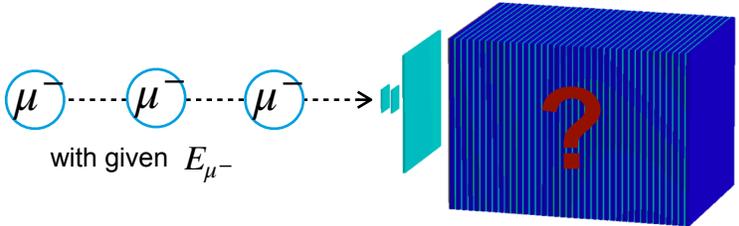
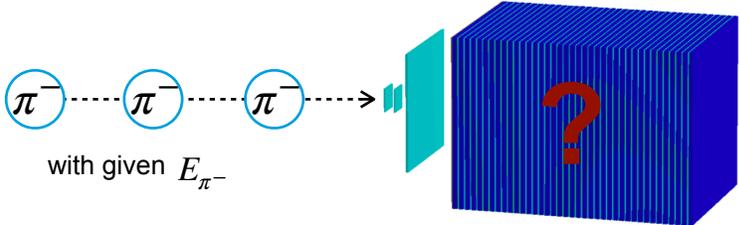
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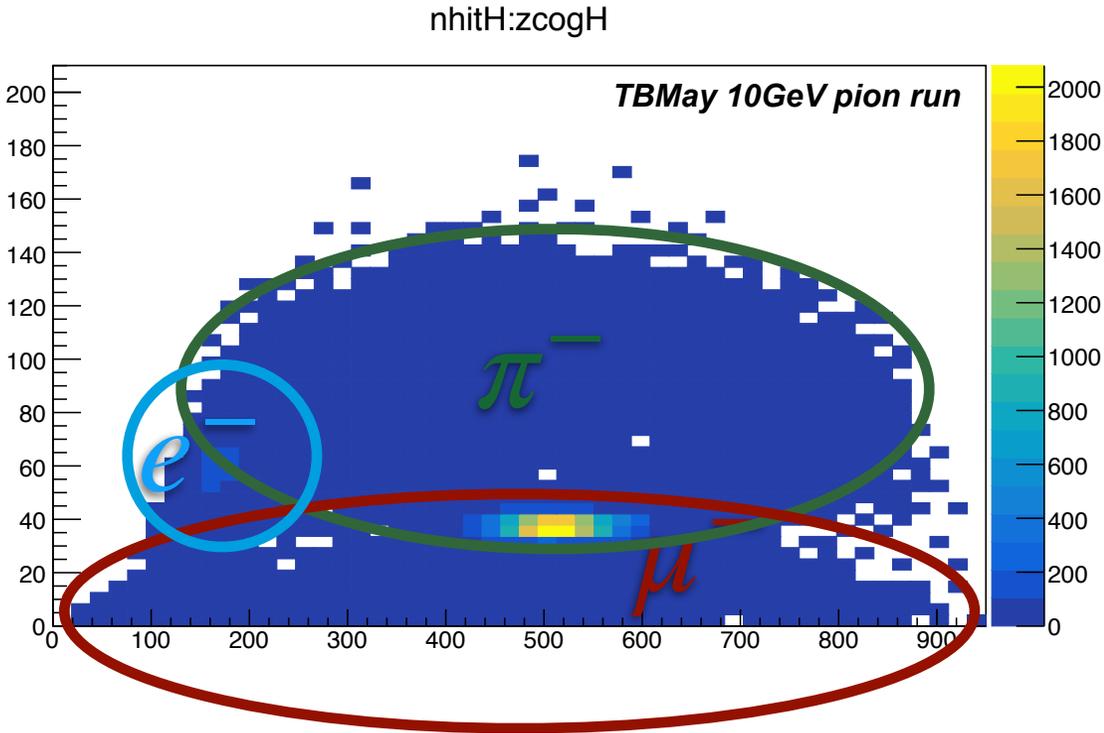
Introduction

What do we want to investigate



What if we want to check the energy resolution for 10GeV pion run?

What do we have



Introduction

How the particles can be separated

- Distributions of observables
- Track studies
- Clustering studies

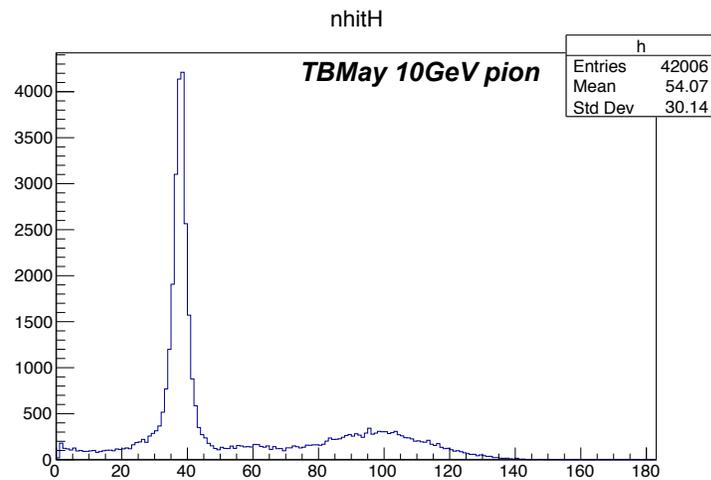
Observables

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From the standard reco tree

Number of hits per event

- “clean” μ^- : $N_{hits} \approx N_{layers}$

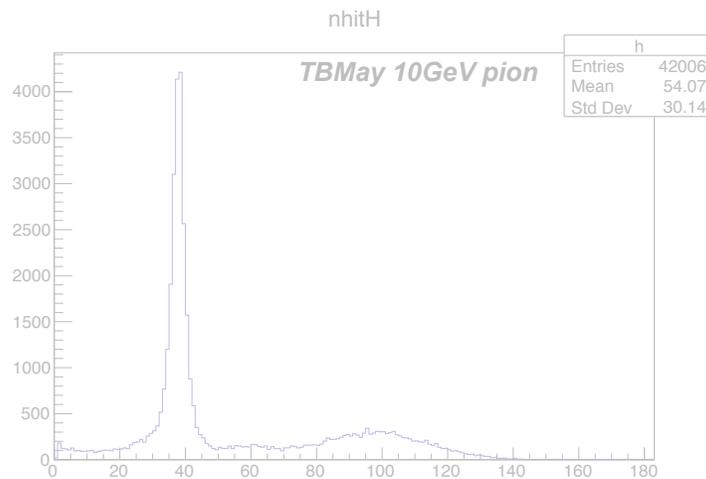


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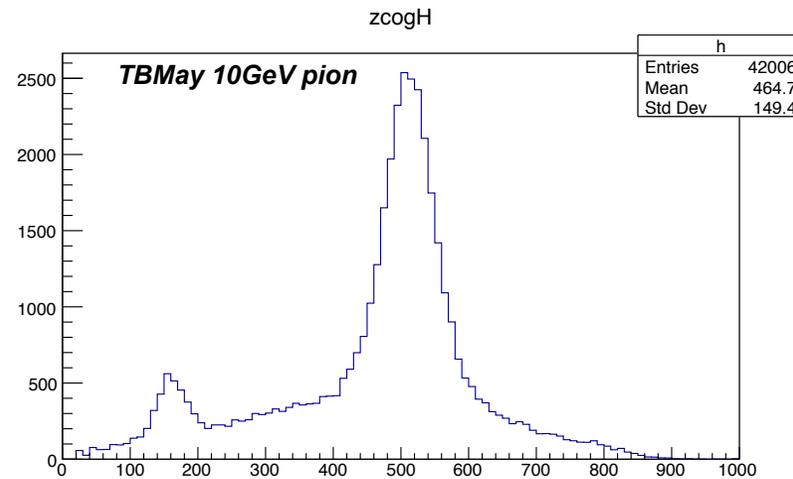
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Center of gravity in z

- μ^- : z_{cog} peaks in the middle of detector
- e^- : z_{cog} peaks in the first half of detector
- π^- : z_{cog} more-less spread

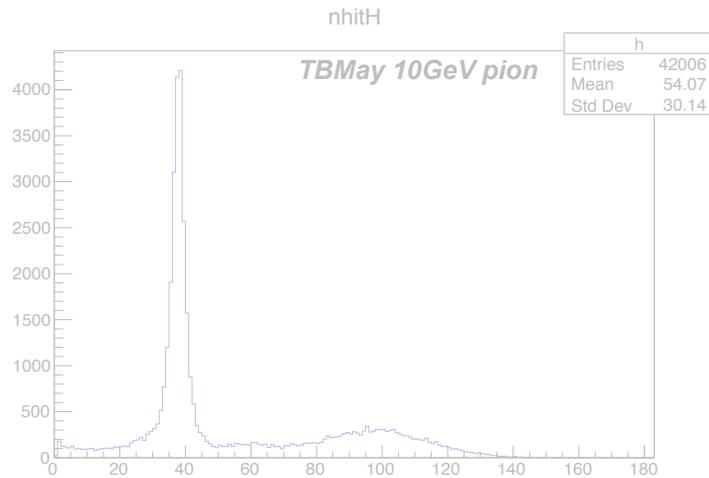


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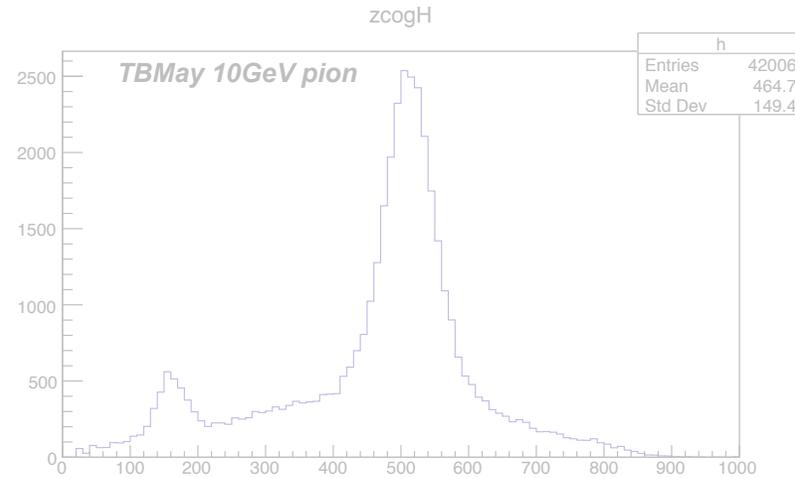
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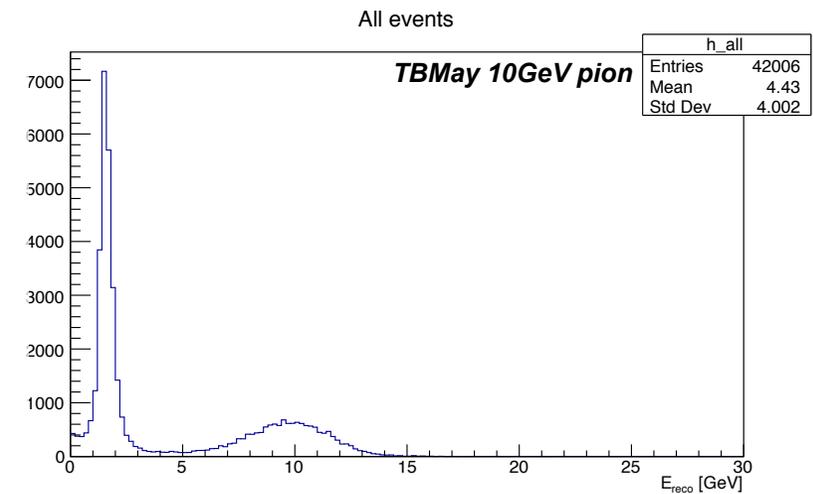
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Energy sum per event

- “clean” μ^- : $E_{sum} \approx N_{layers} * MIP$



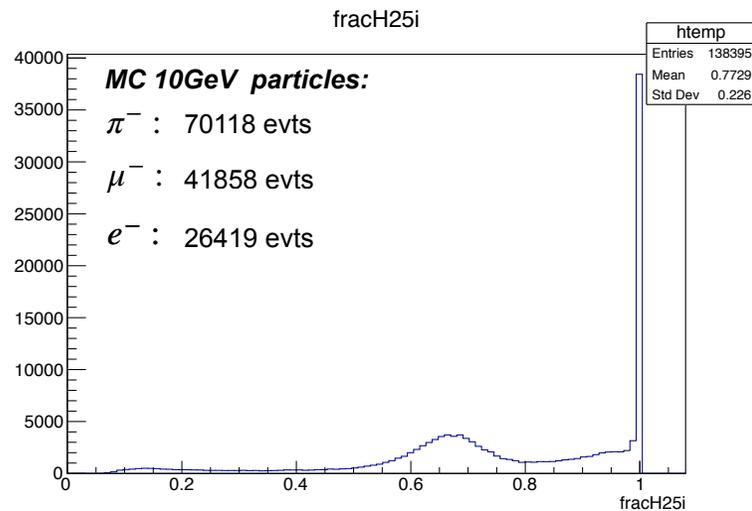
Observables

Which require additional calculation

Fraction of energy in first 25 layers

$$(E_{25l}/E_{total})$$

- μ^- : fraction peaks at $25/N_{layers}$
- e^- : fraction ≈ 1
- π^- : fraction more-less spread



Observables

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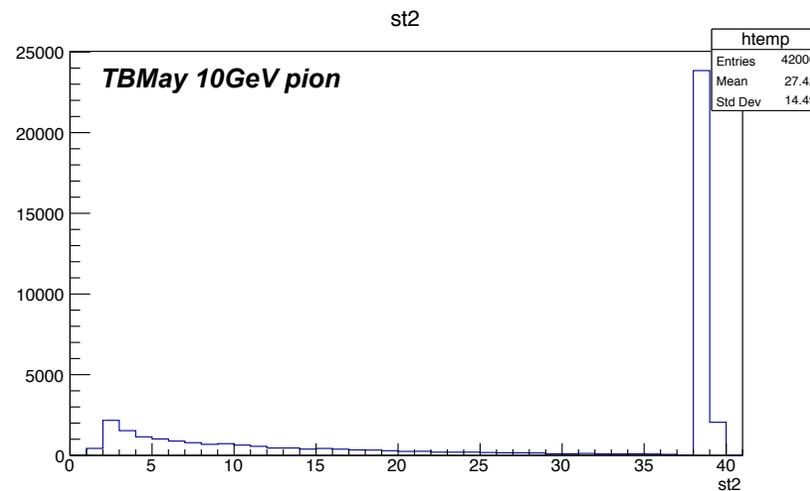
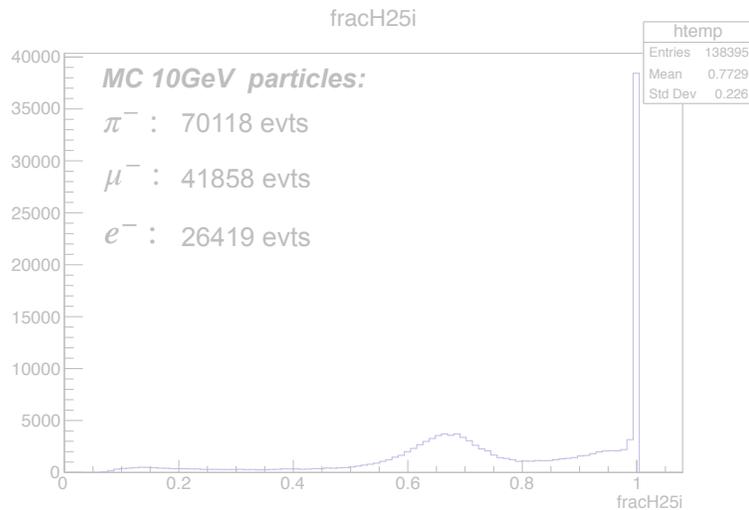
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- “clean” μ^- : no shower
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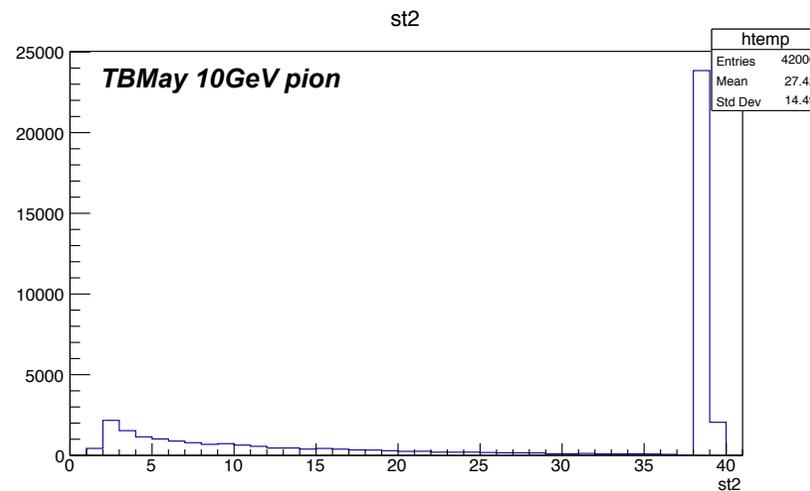
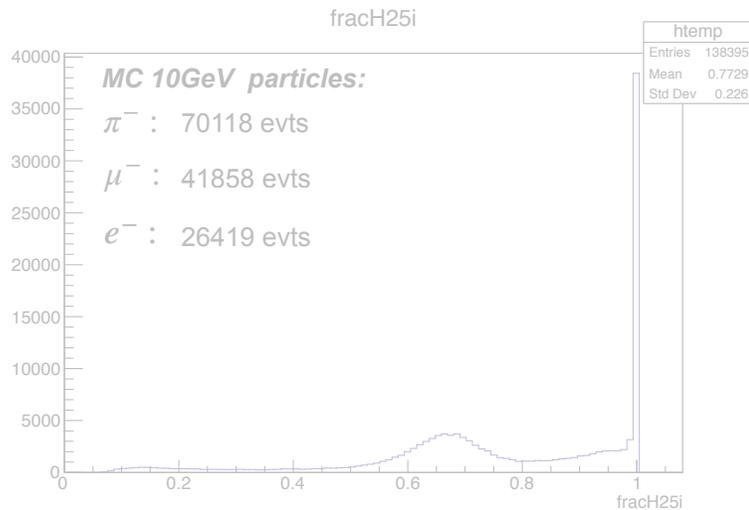
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2 ways to calculate:

- by energy in layer and hit radius criterium - st0 (in addition isolated hits can be excluded - st1)
- by neighbouring hits criterium - st2



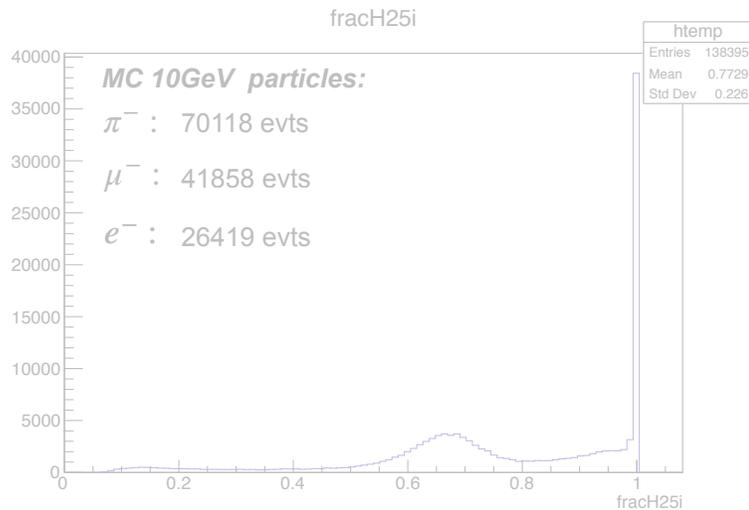
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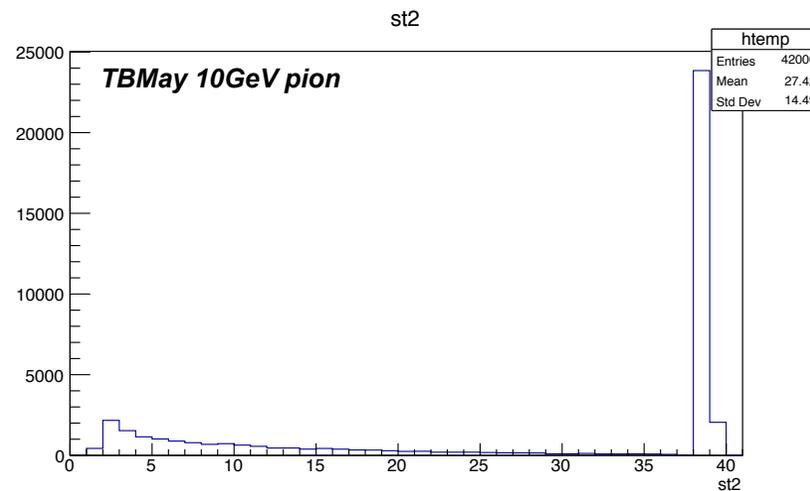
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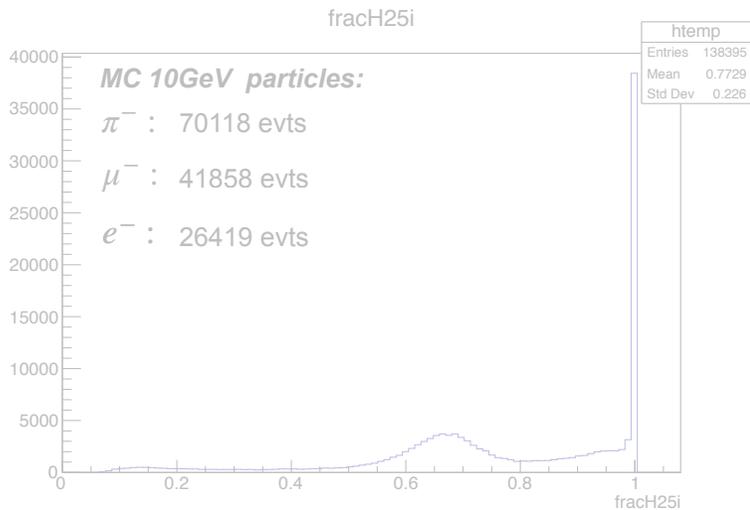
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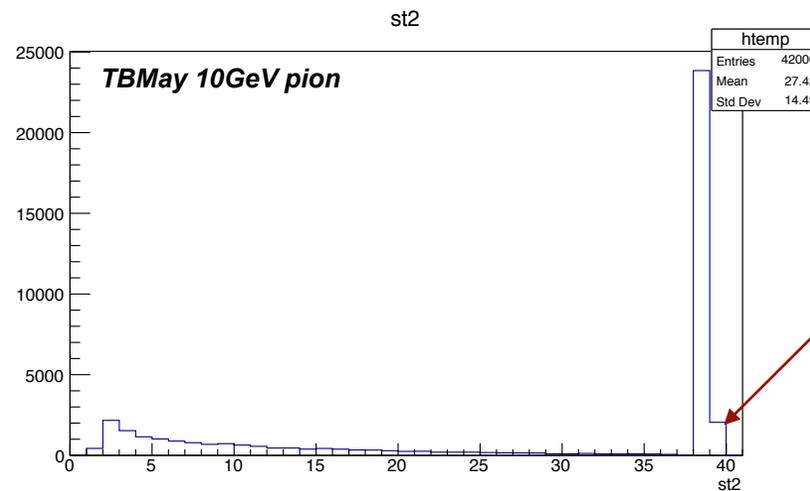
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Should not be $> N_{layers}$
(in “todo” list)

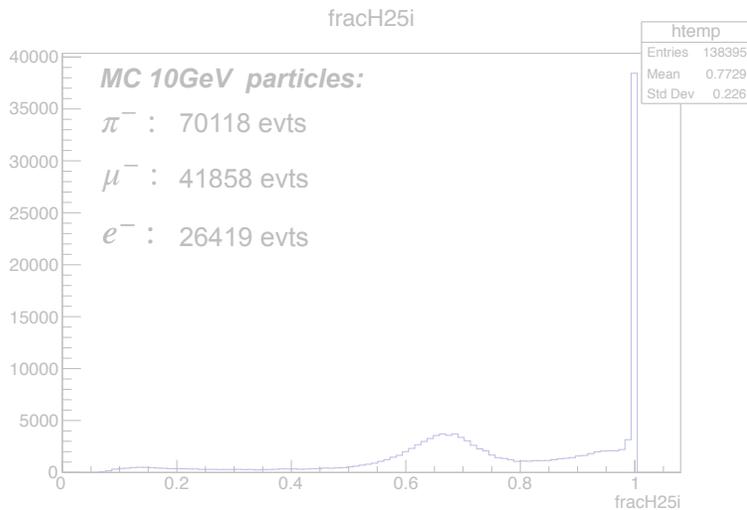
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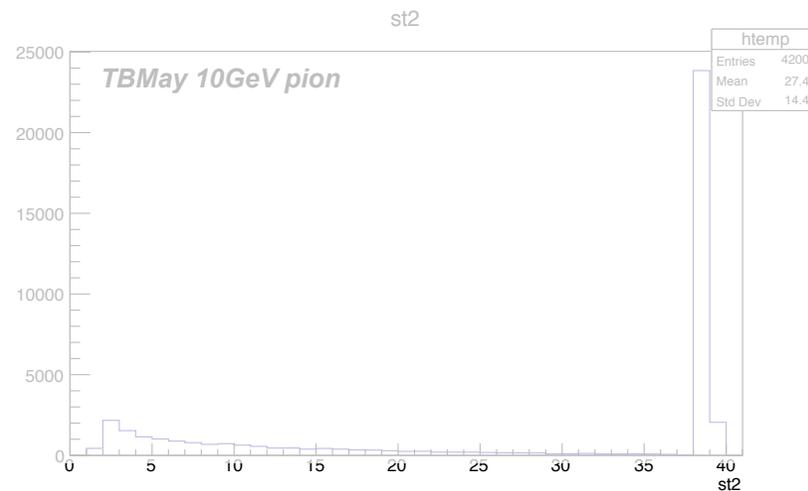
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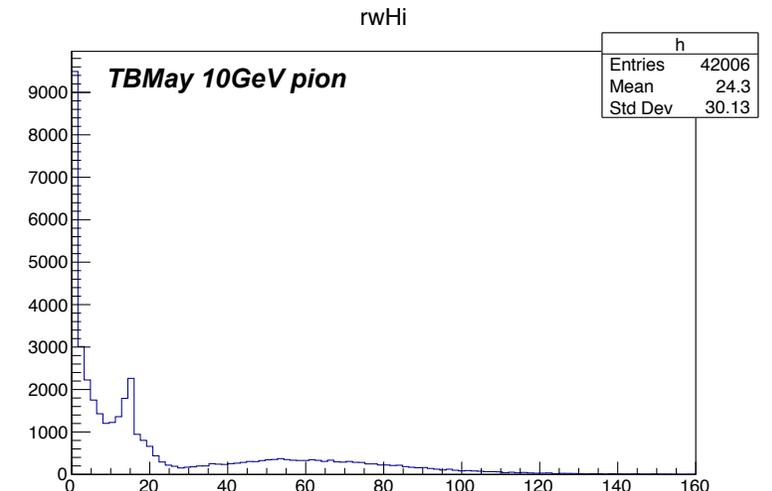
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Shower radius

- “clean” μ^- : no cluster ($r_{cl} = 0$)
- e^- : R has a peak
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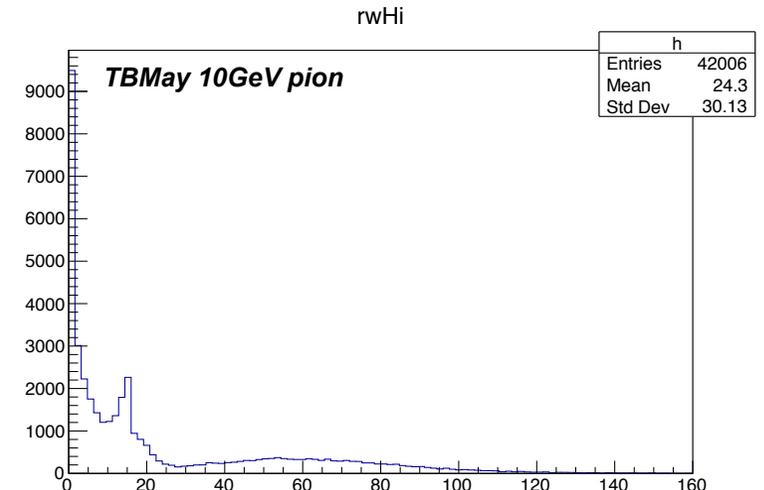
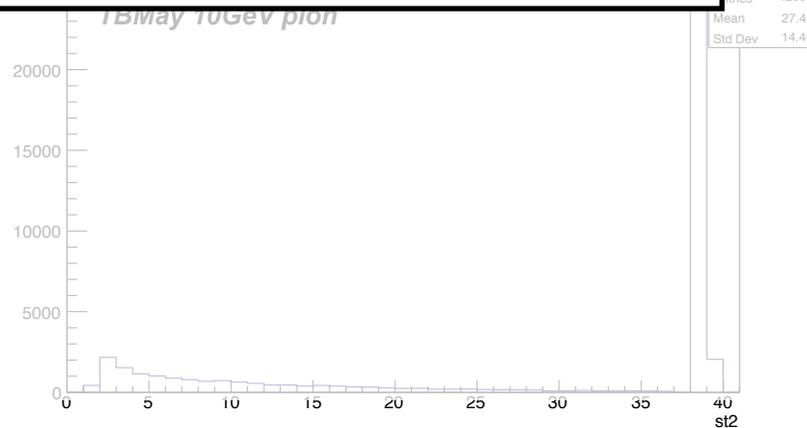
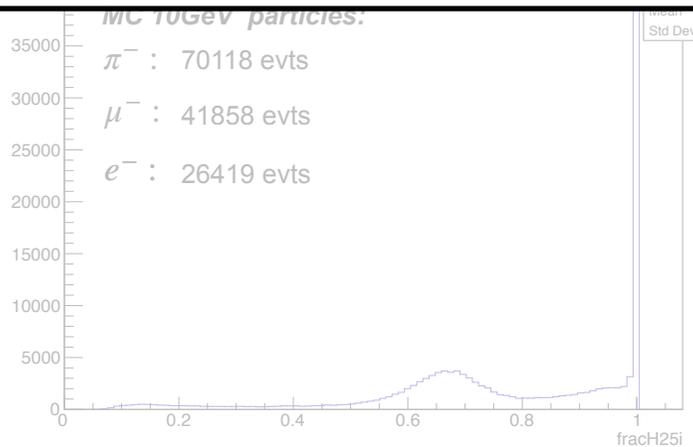
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In each event: $R = \frac{\sum_{i=1}^{N_{sh}} e_i \cdot r_i}{\sum_{i=1}^{N_{sh}} e_i}$
 N_{sh} is the number of shower hits
 e_i is the hit energy
 $r_i = \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2}$ is the hit radial distance from shower axis (x_0, y_0)

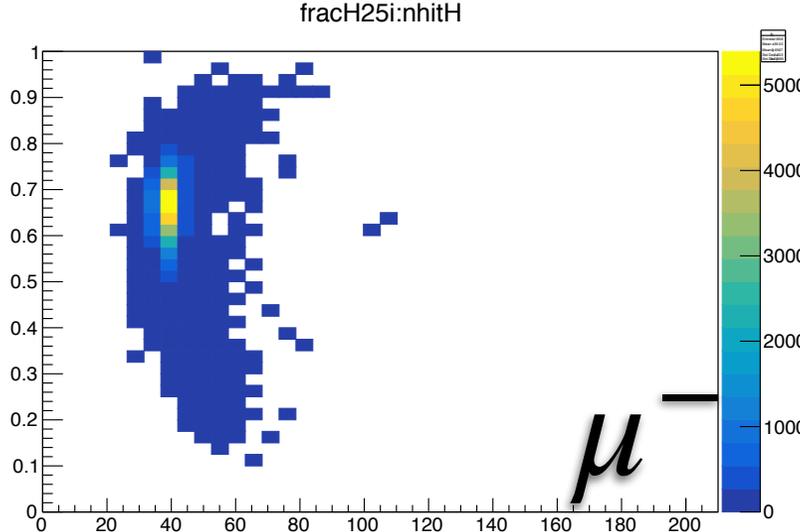
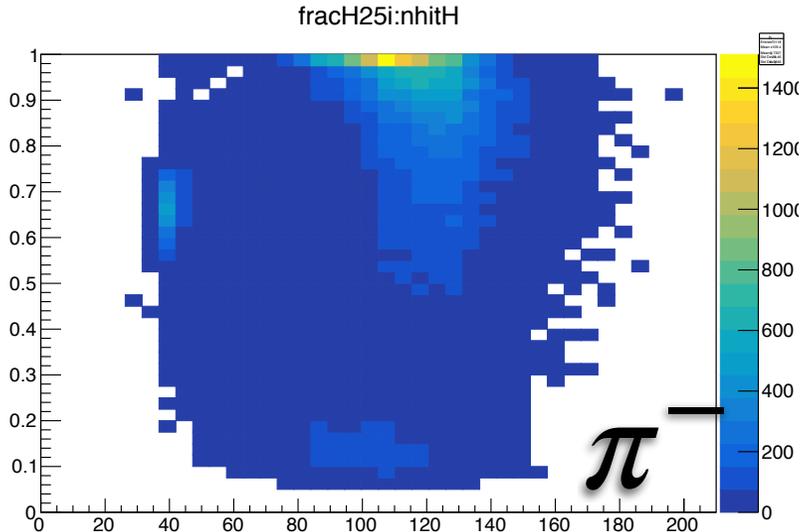
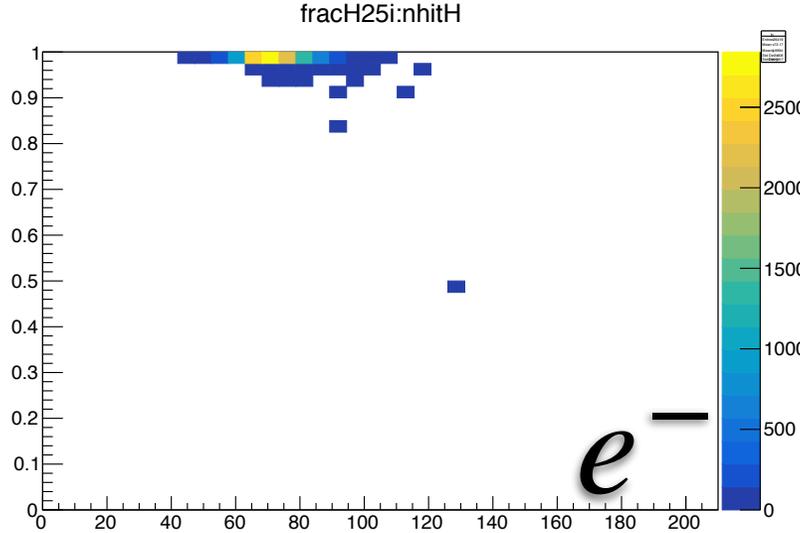
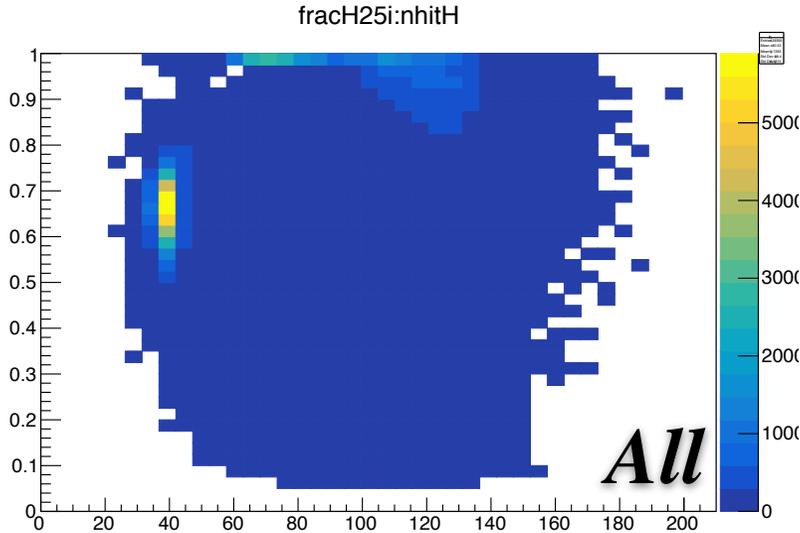


2D plots of observables

Fraction in first 25 layers vs number of hits.

MC 10GeV particles

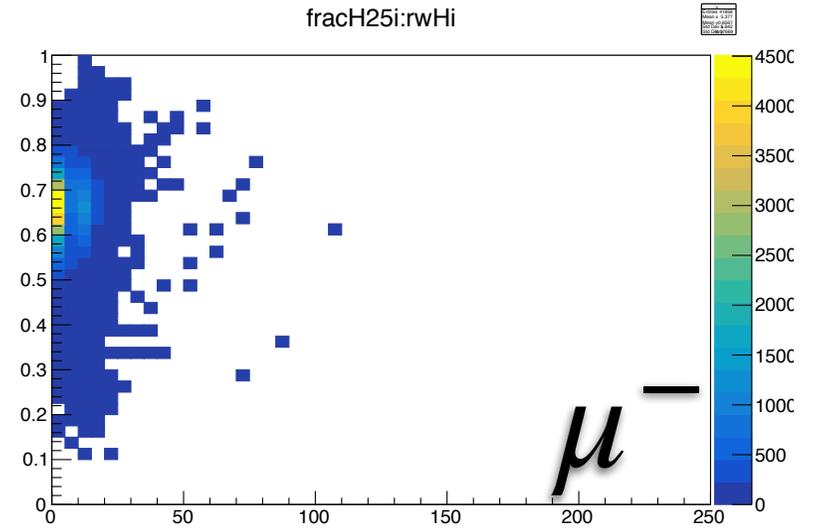
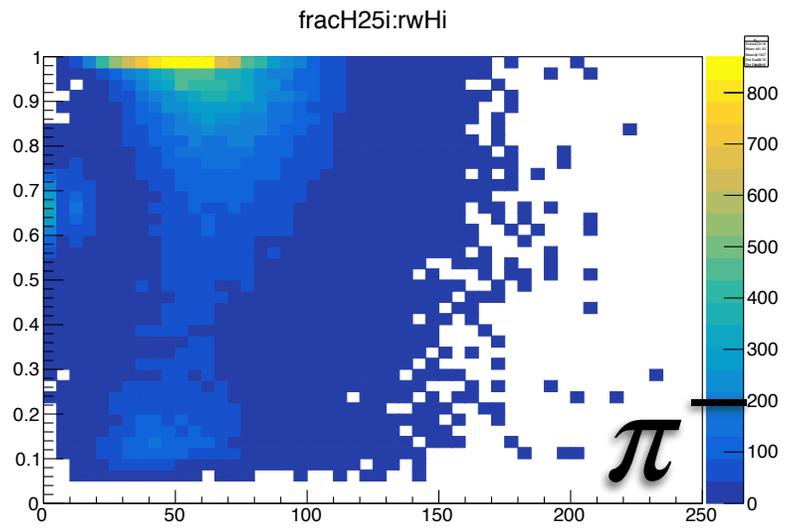
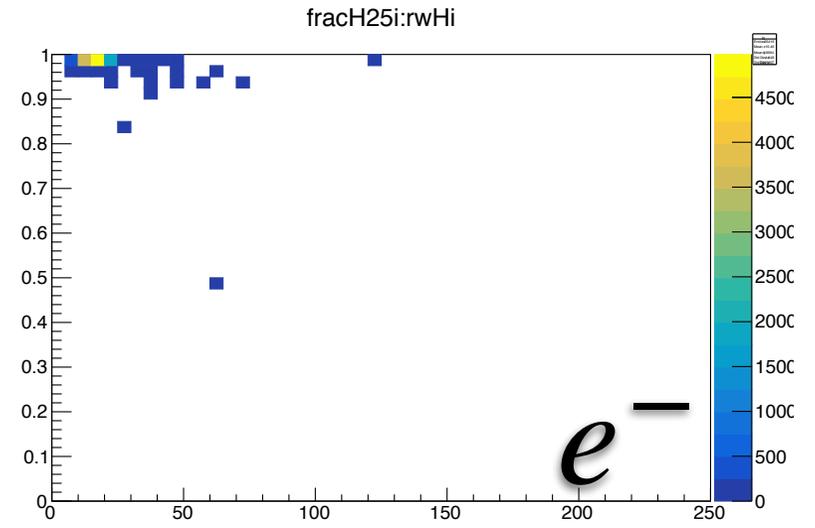
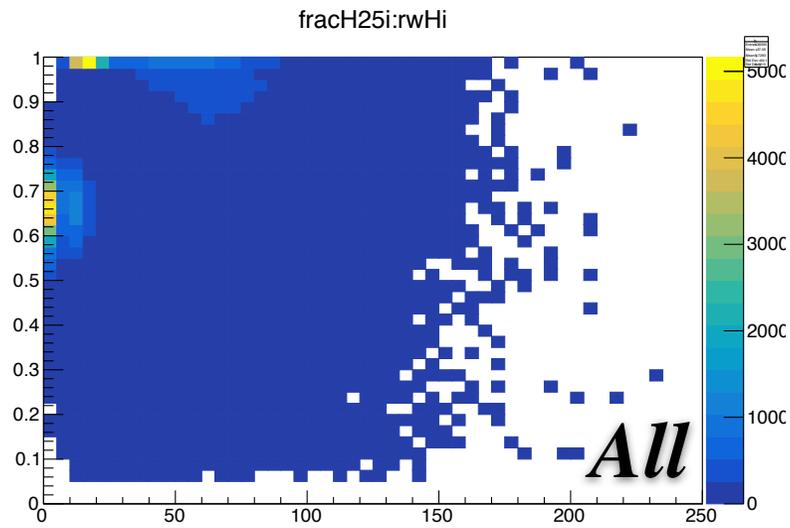
- π^- : 70118 events
- μ^- : 41858 events
- e^- : 26419 events
- total* : 138395 events



Fraction in first 25 layers vs shower radius.

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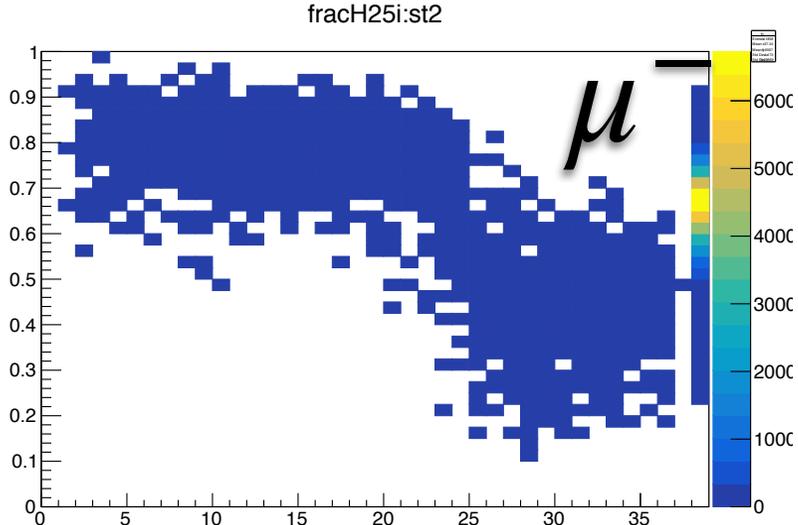
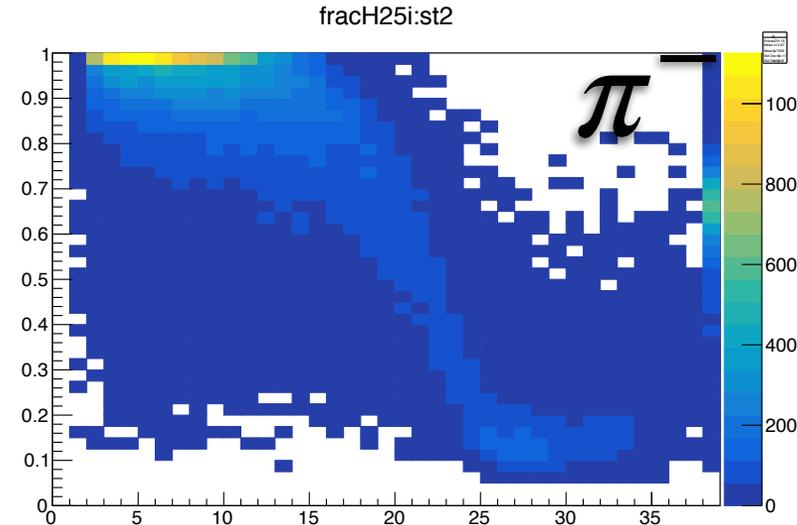
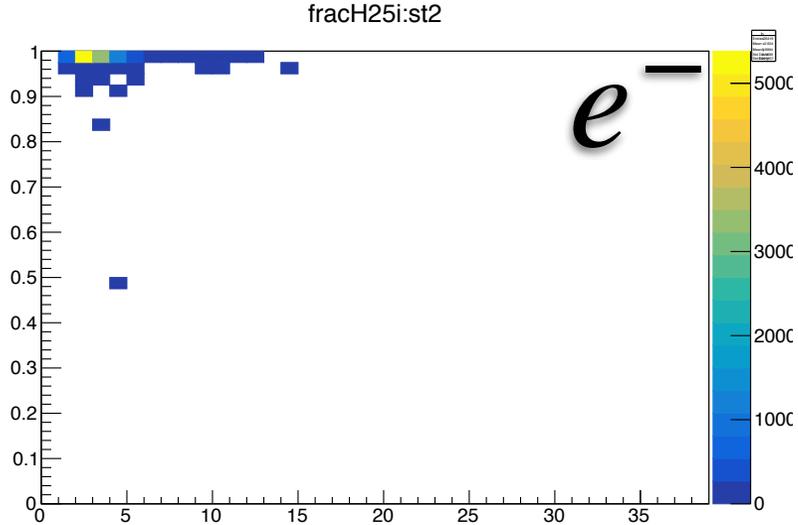
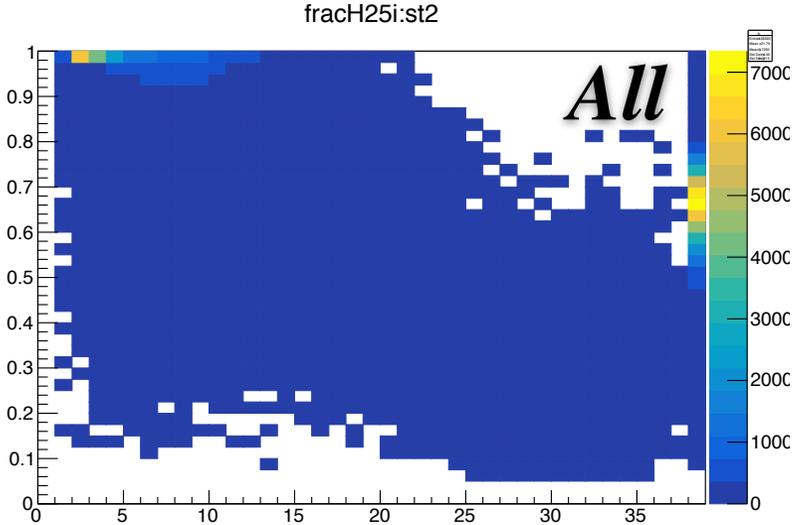
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Fraction in first 25 layers vs shower start layer.

MC 10GeV particles

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Fraction in first 25 layers vs center of gravity in z.

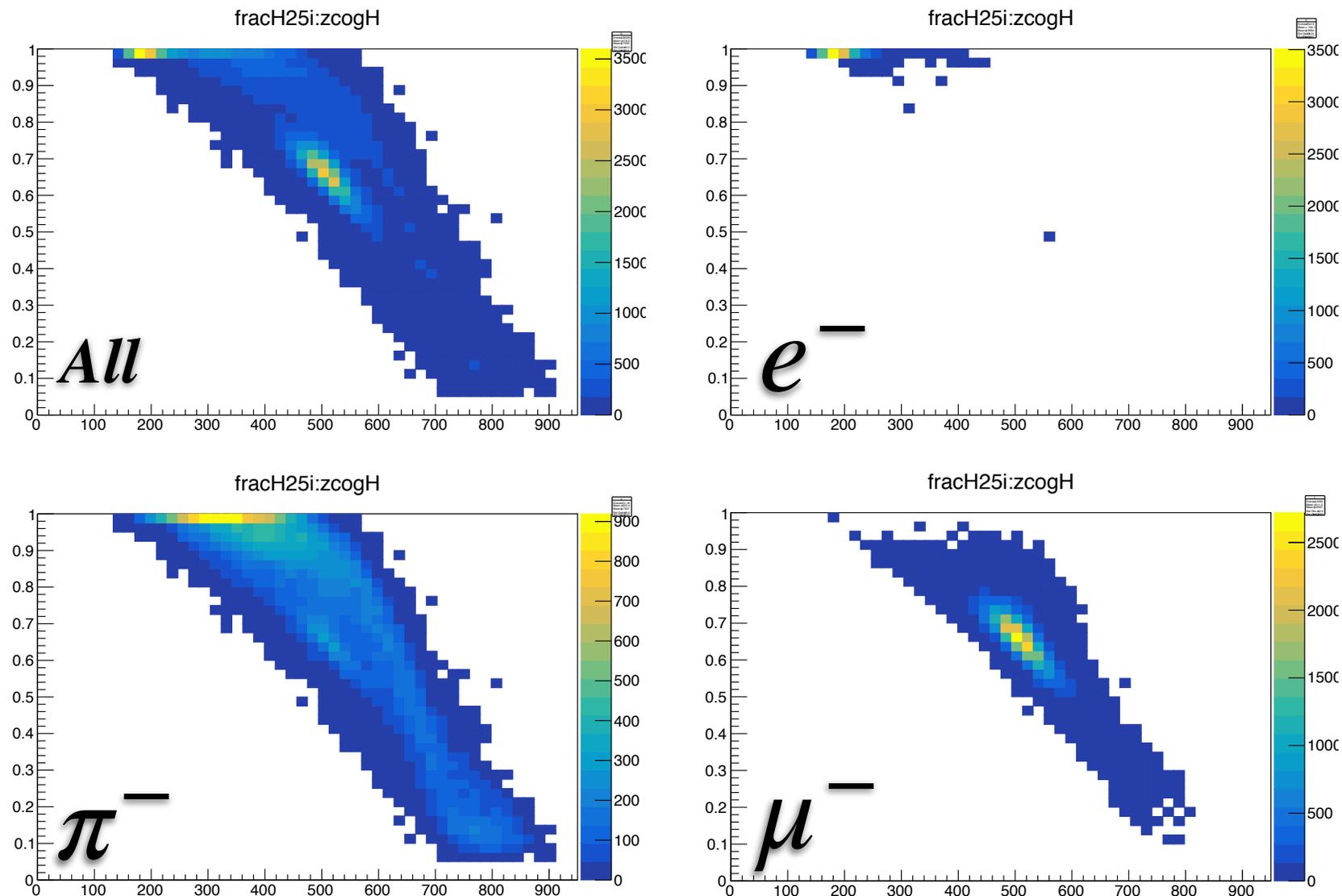
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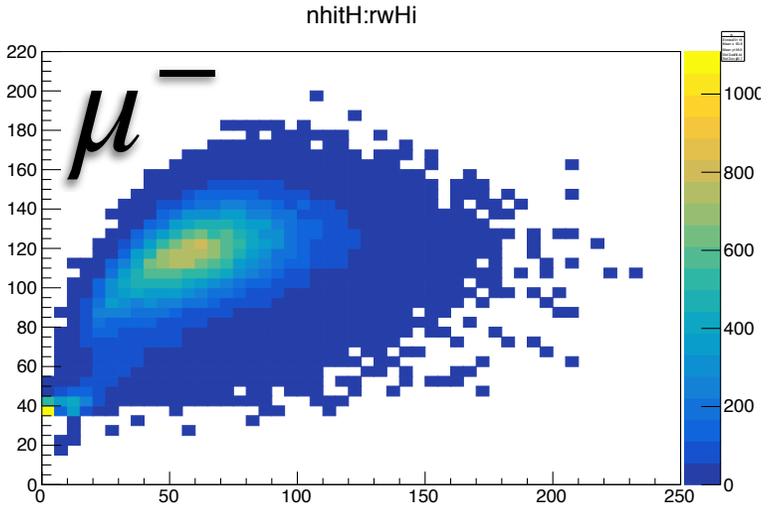
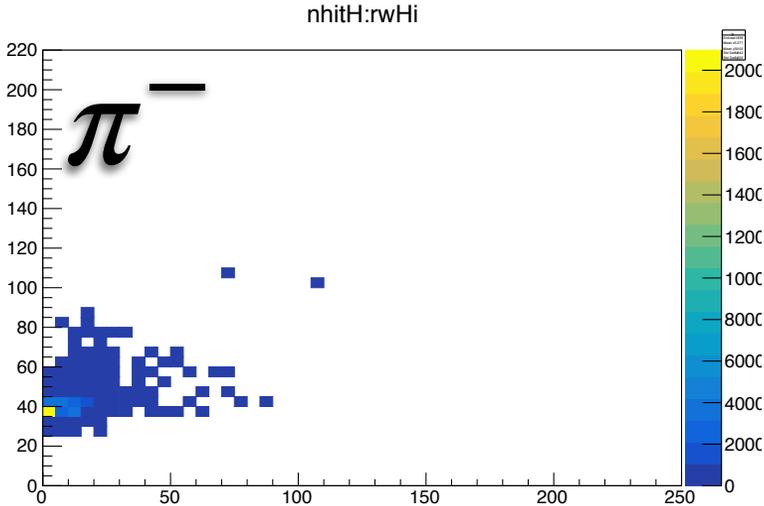
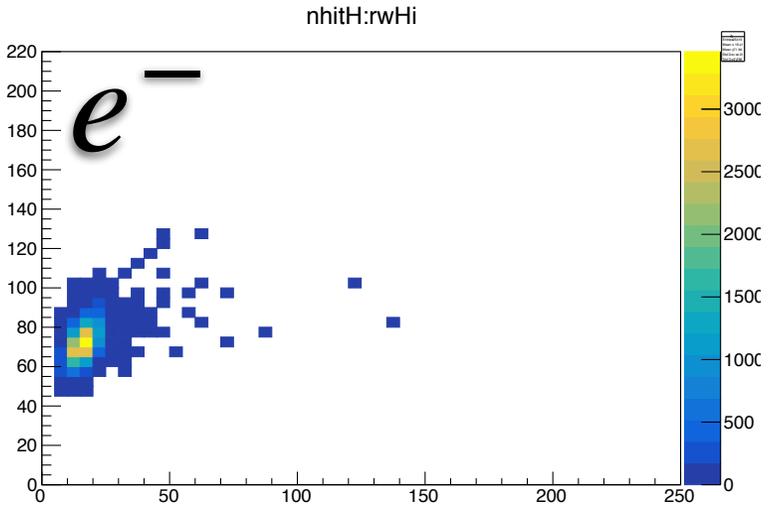
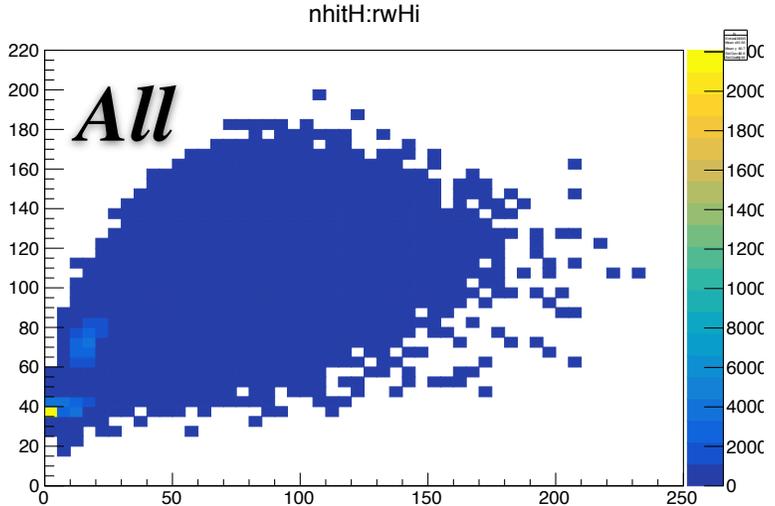
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Number of hits vs shower radius.

MC 10GeV particles

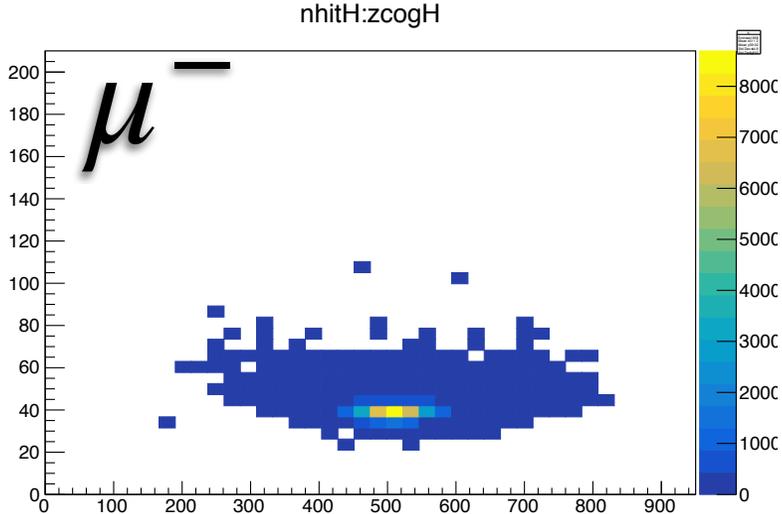
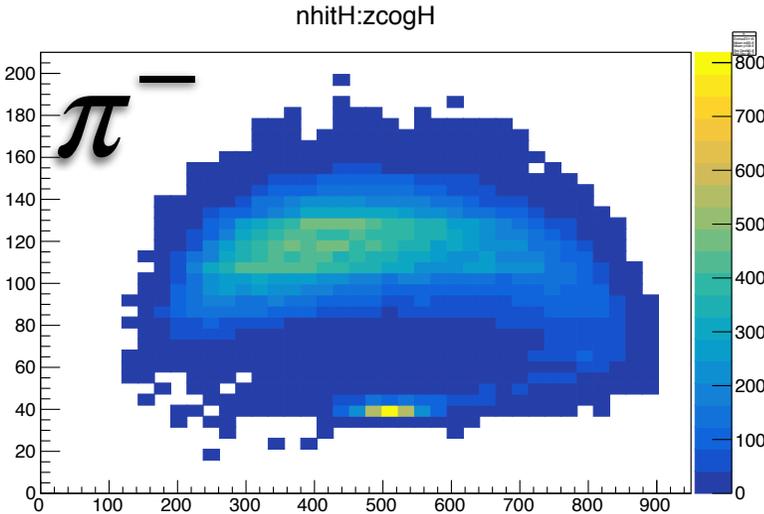
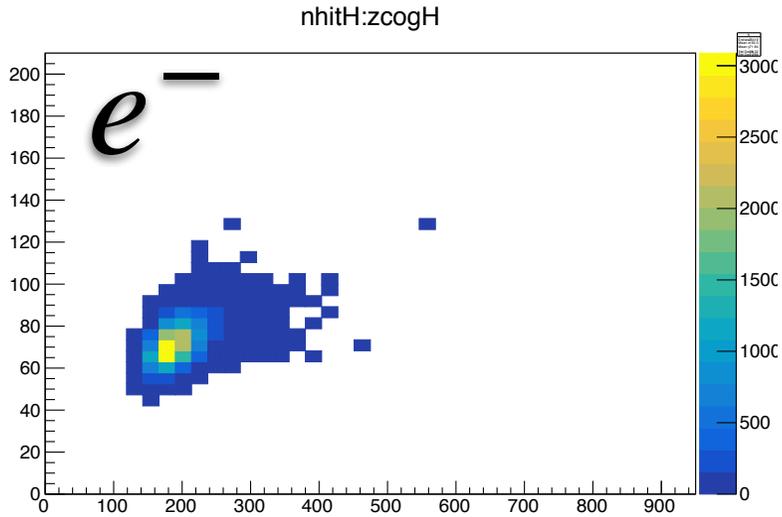
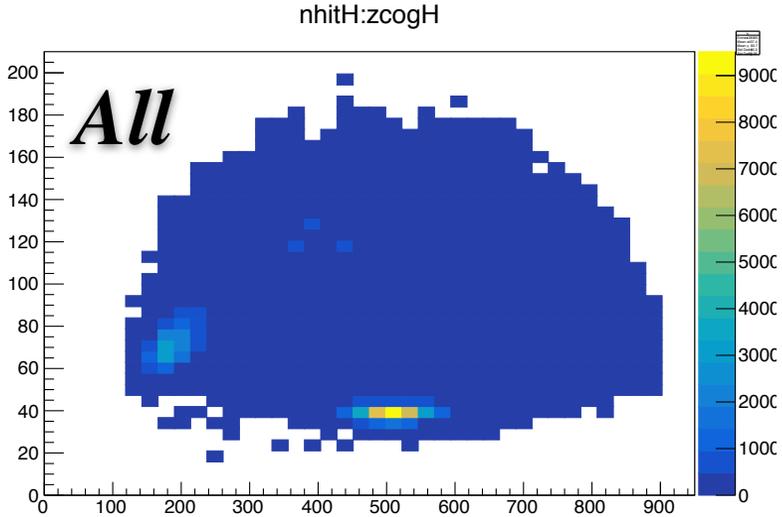
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Number of hits vs center of gravity in z.

MC 10GeV particles

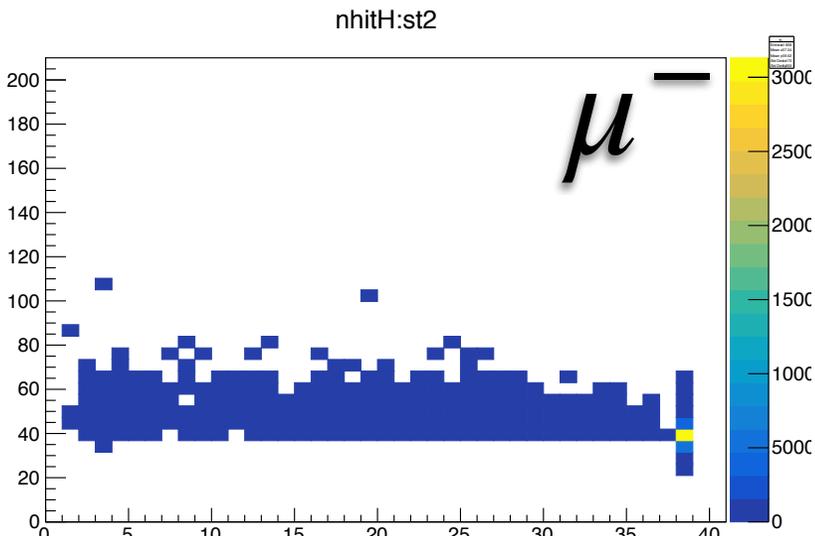
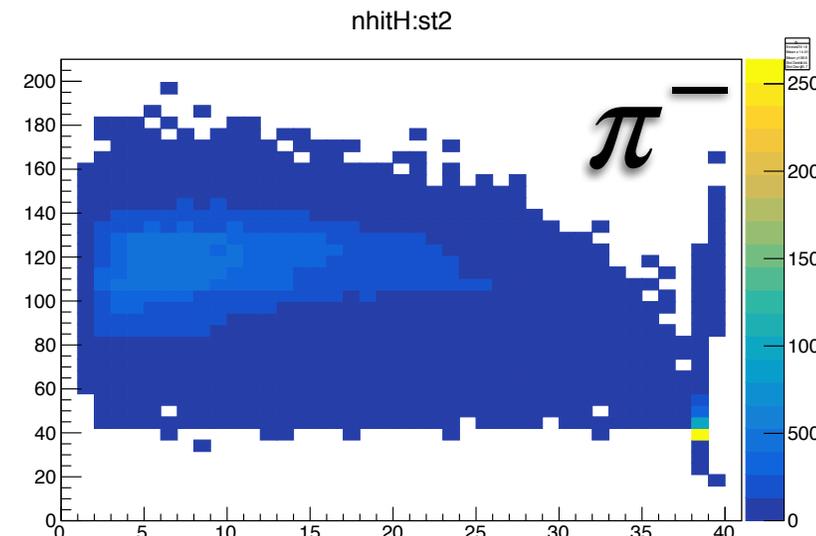
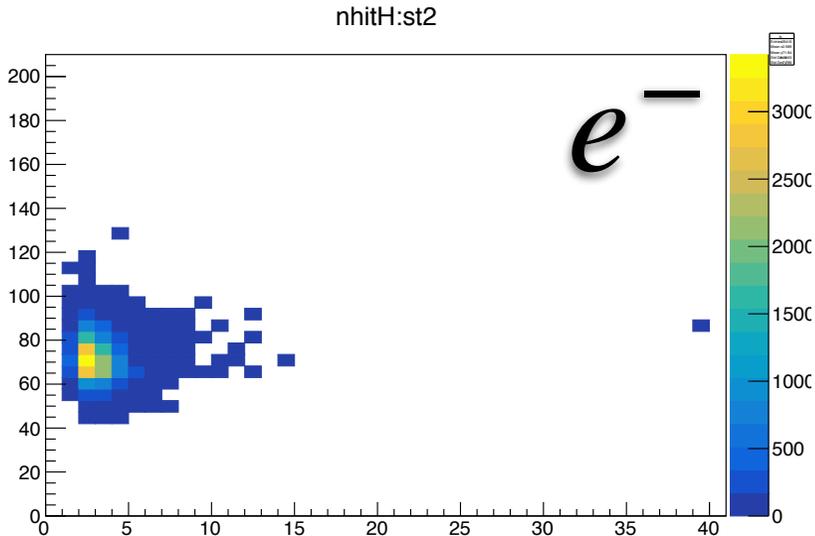
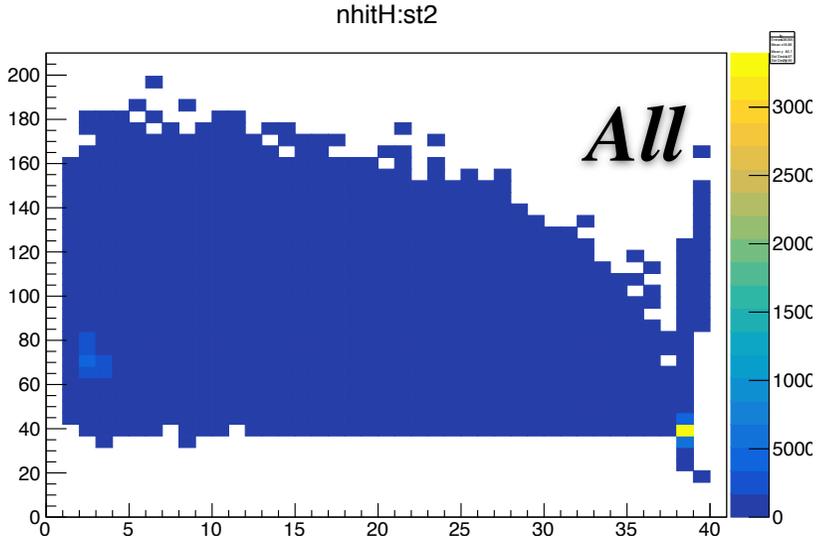
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Number of hits vs shower start layer.

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- total* : 138395 events



Shower radius vs shower start layer.

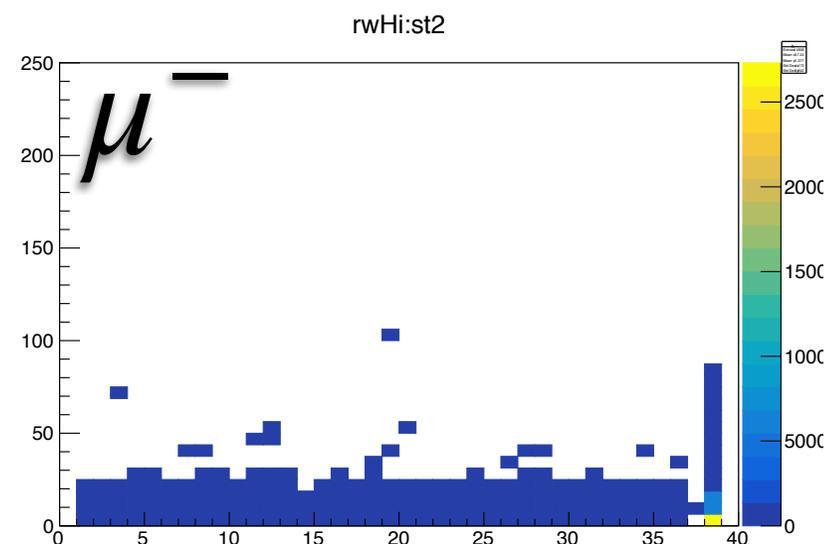
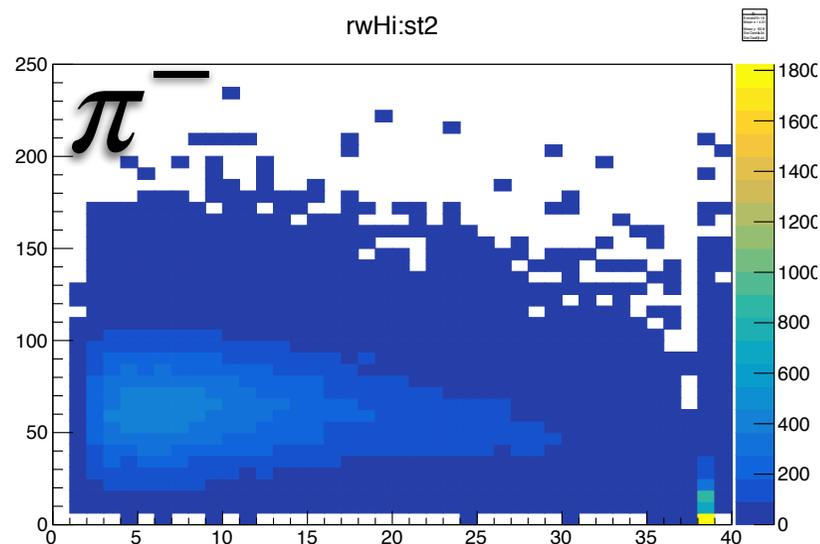
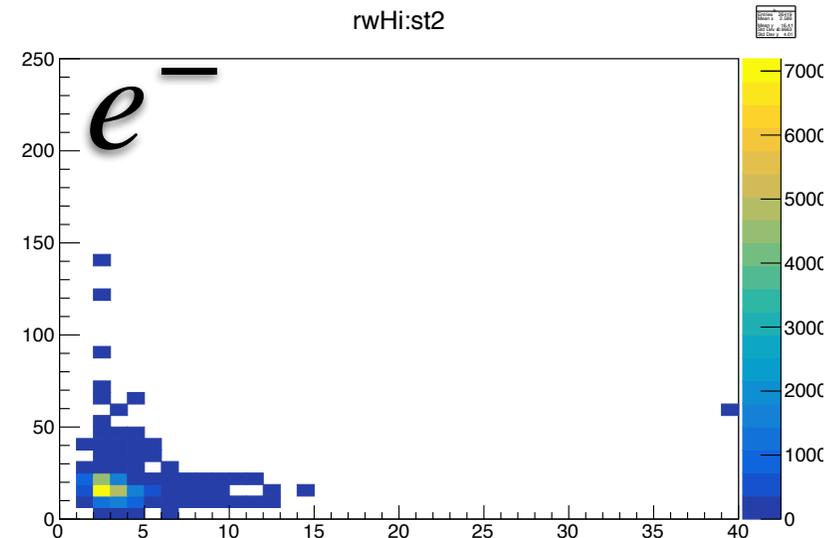
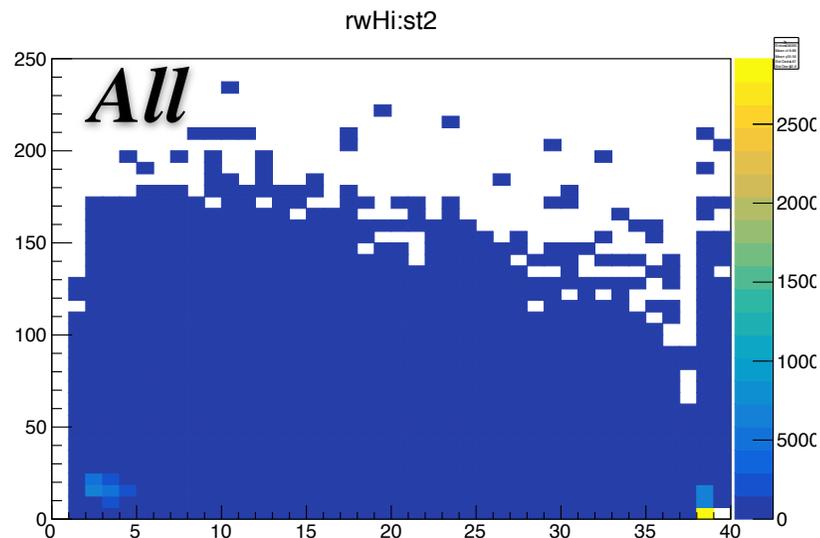
MC 10GeV particles

π^- : 70118 events

μ^- : 41858 events

e^- : 26419 events

total : 138395 events



Center of gravity in z vs shower start layer.

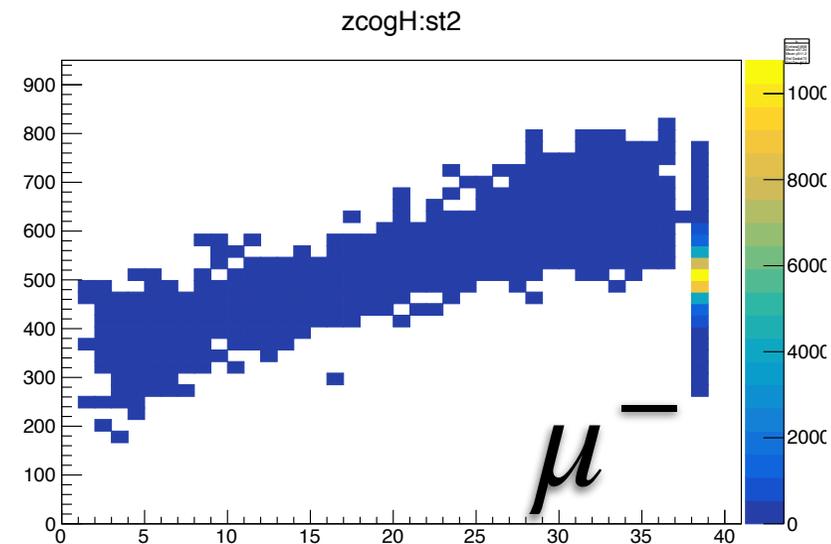
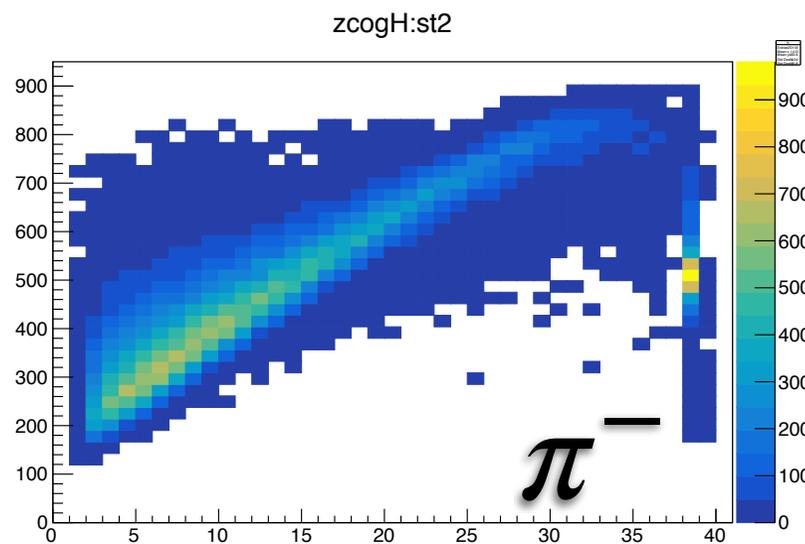
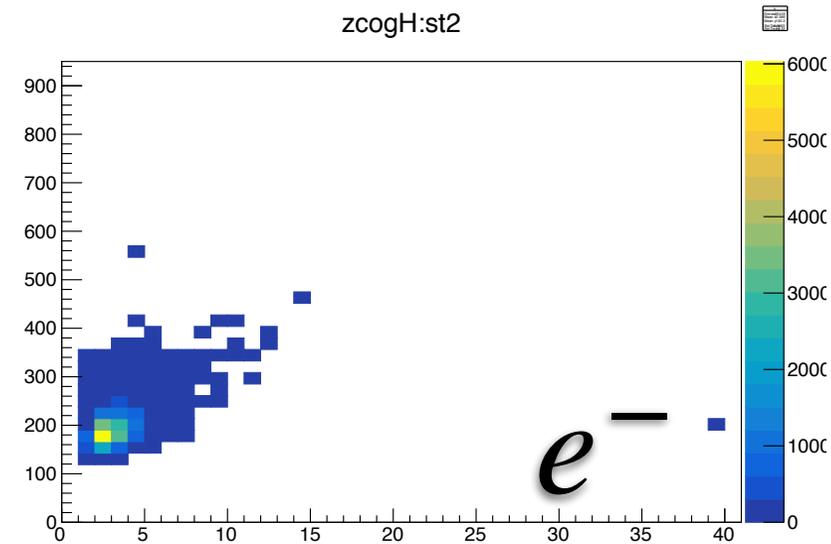
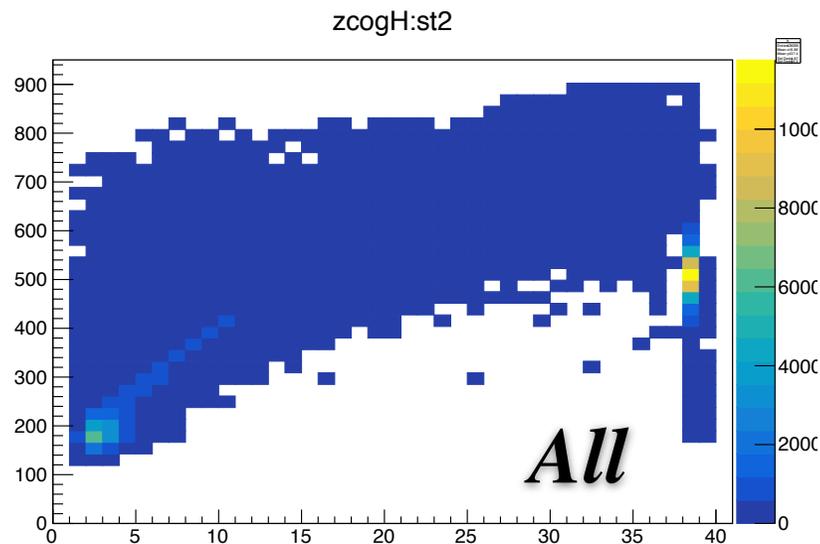
MC 10GeV particles

π^- : 70118 events

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Center of gravity in z vs shower start layer.

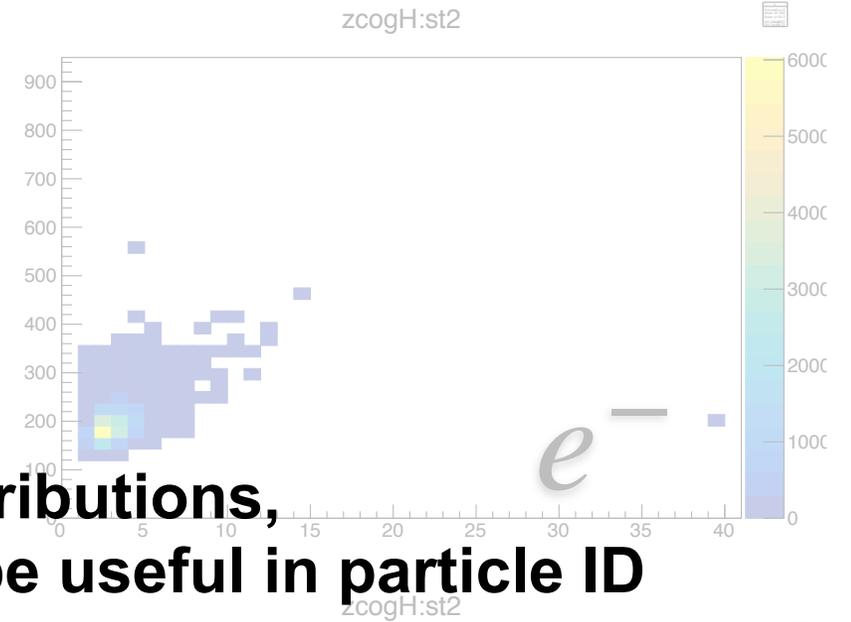
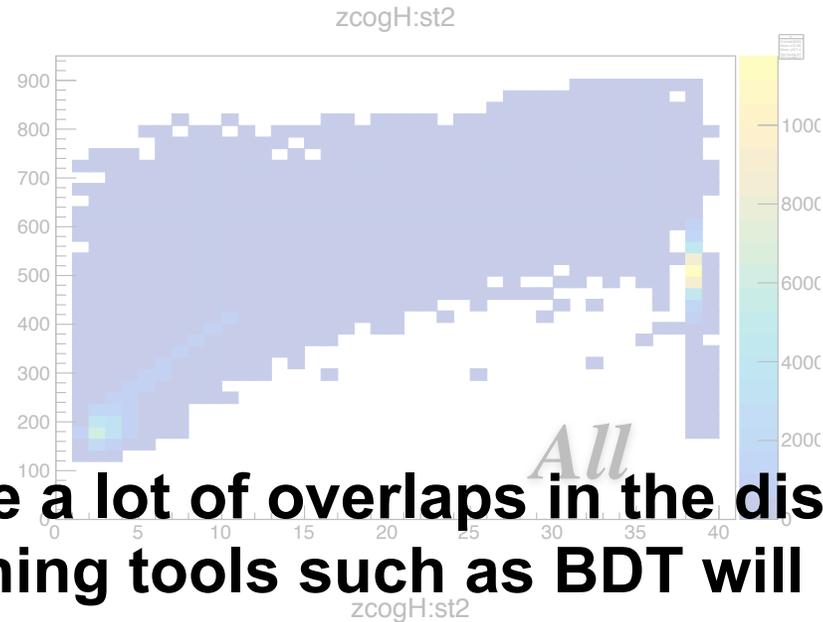
MC 10GeV particles

π^- : 70118 events

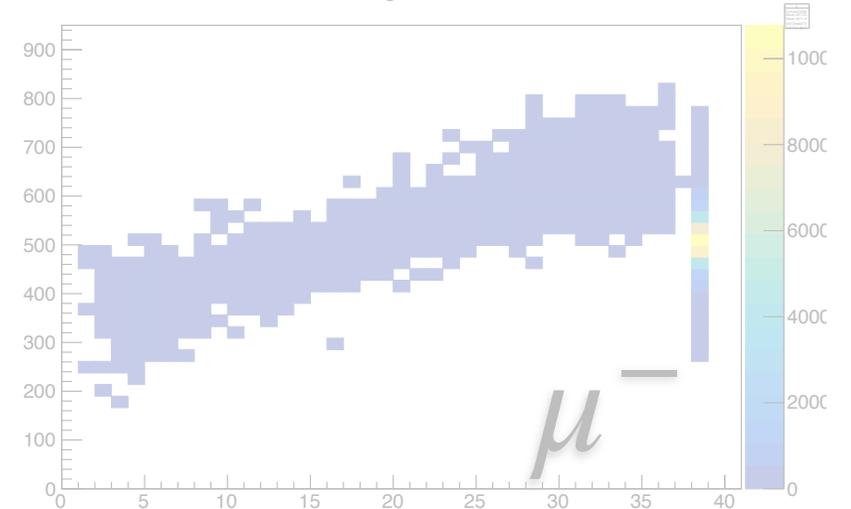
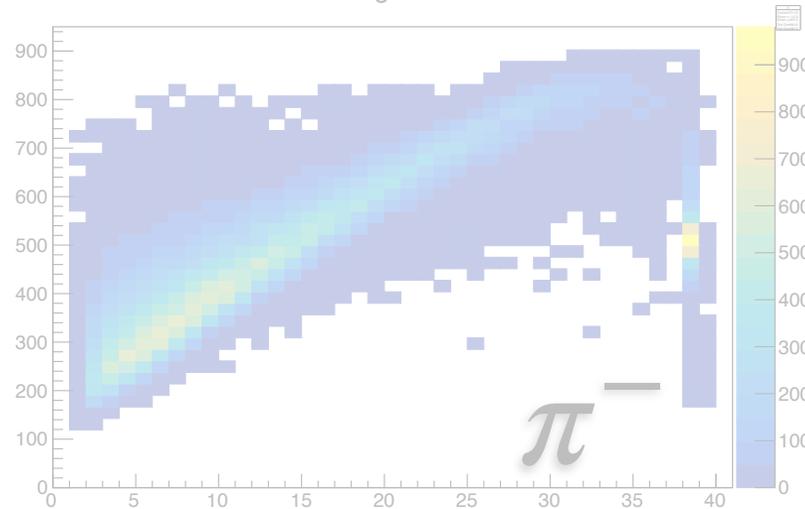
μ^- : 41858 events

e^- : 26419 events

total : 138395 events



Since we have a lot of overlaps in the distributions, machine learning tools such as BDT will be useful in particle ID



Event selection

By now optimised for low energy pion TB runs

Event selection

By typology and cluster properties. Based on the physics prototype study*.

Clustering, primary track and shower start finding precedes particle identification.
The set of cuts need to be tuned more precisely.

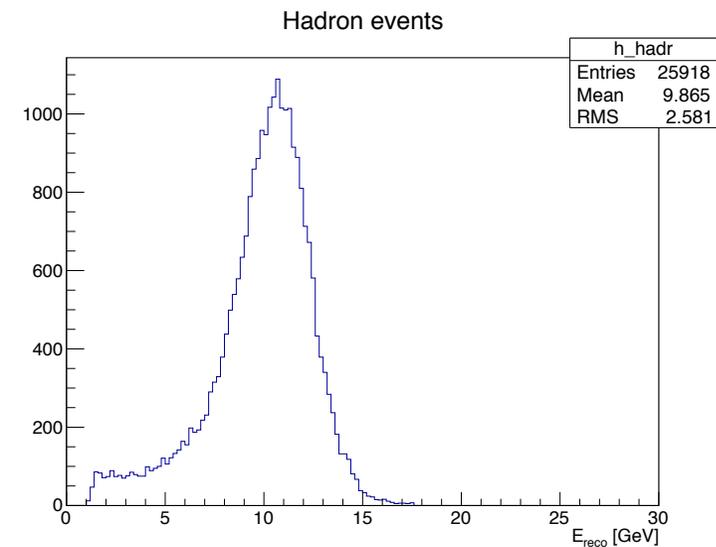
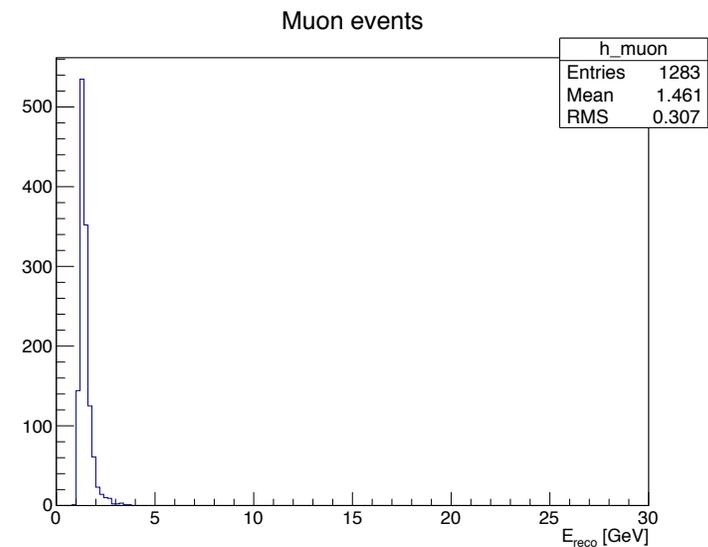
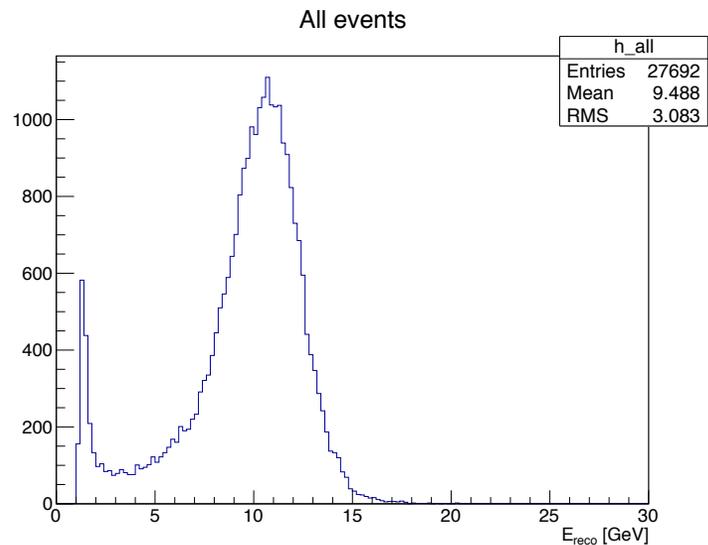
- **Multi-particle events**
 - Several clusters in first layers
 - Parallel tracks
 - Too high deposition
- **Muons or muon-like events**
 - Number of hits
 - Track finding
 - Shower start (optional w/o tail catcher)
- **Electrons**
 - Cluster radius
 - COG depth
 - 90% of measured energy deposited in first 25 layers
 - Shower start before 6th layer
- **Hadrons**
 - Remaining events
 - Events with shower start at first layer(electrons) and after 7th layer(muons, muon-like) can be rejected

*https://agenda.linearcollider.org/event/7454/contributions/38731/attachments/31380/47203/chadeeva_Fe-W_LL2017.pdf

MC pions 10 GeV

Energy distributions

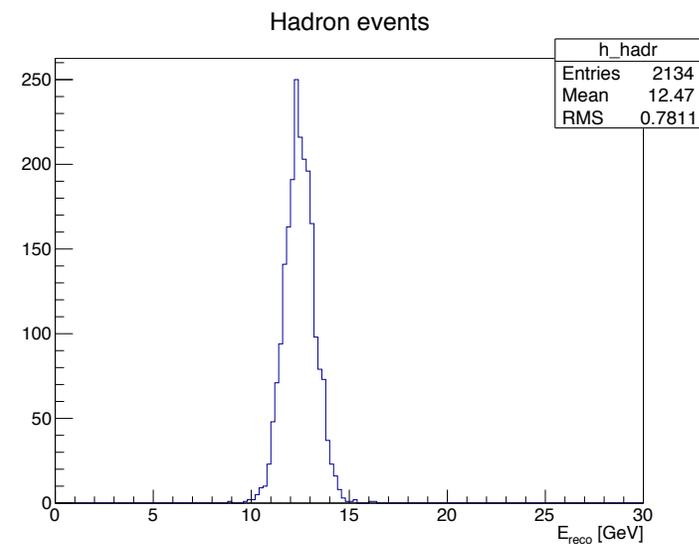
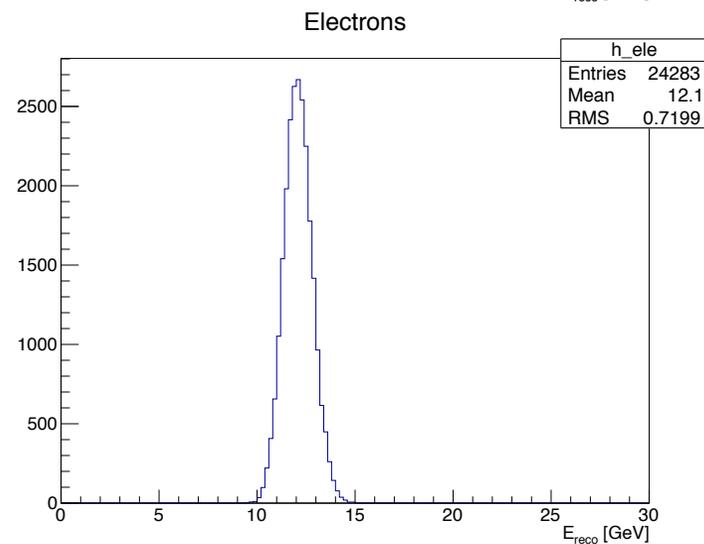
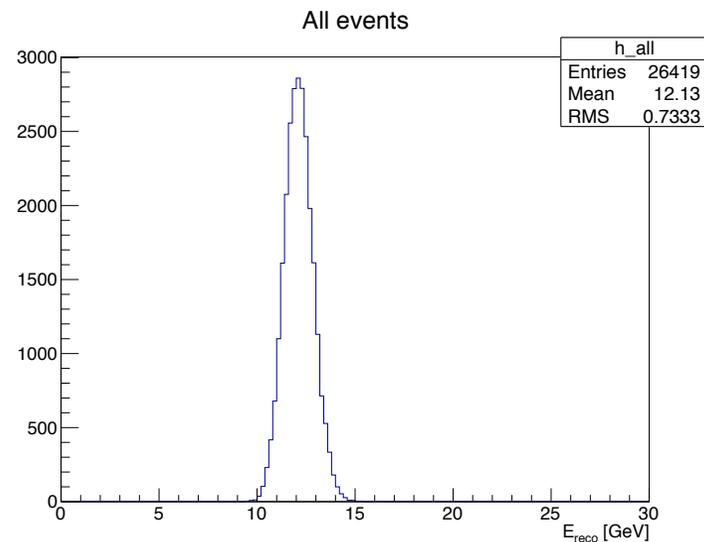
- **27692** events in total
- **1** - empty (low number of hits or deposited energy)
- **1283** muon-like events
- **415** multi-particle events
- **75** electron events
- **25918** hadron events (**~94%**)



MC electrons 10 GeV

Energy distributions

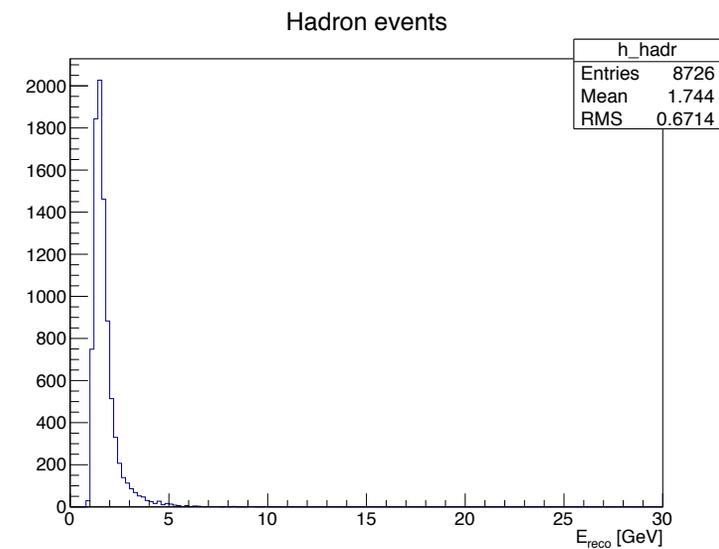
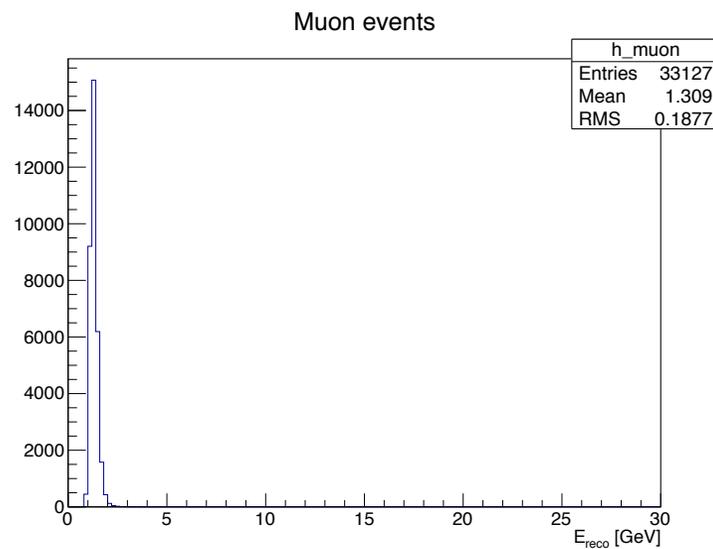
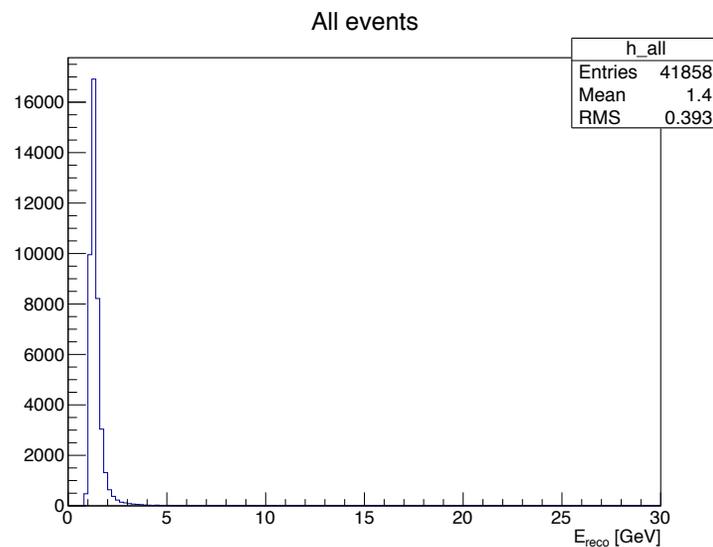
- **26419** events in total
- **0** empty events (low number of hits or deposited energy)
- **0** muon-like events
- **2** multi-particle events
- **24283** electron events (**~92%**)
- **2134** hadron events



MC muons 10 GeV

Energy distributions

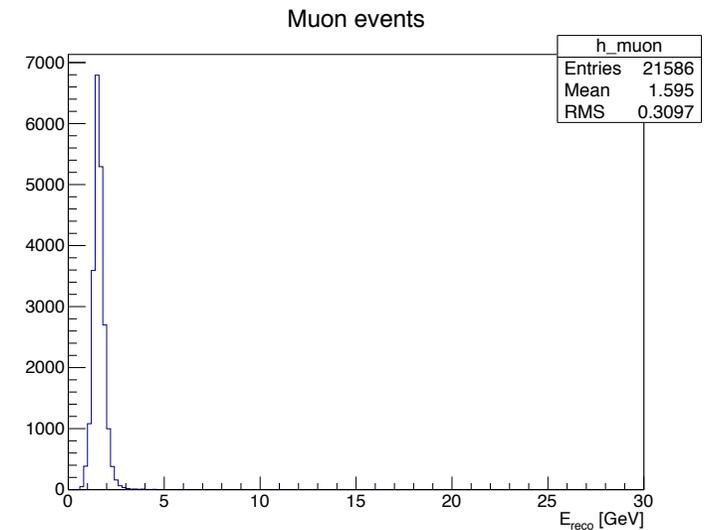
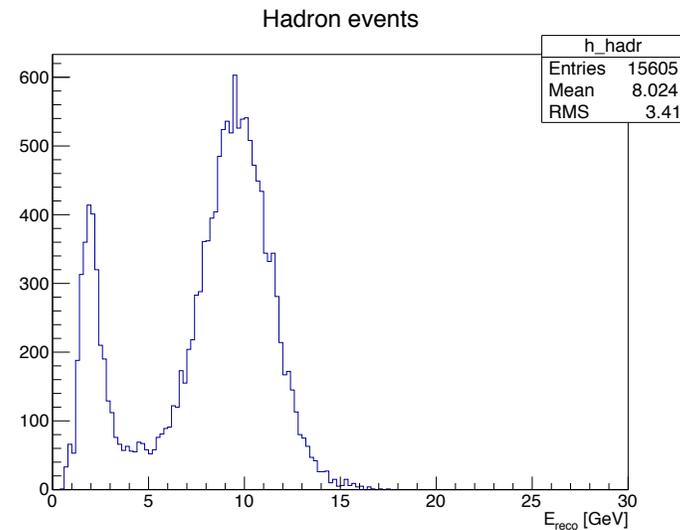
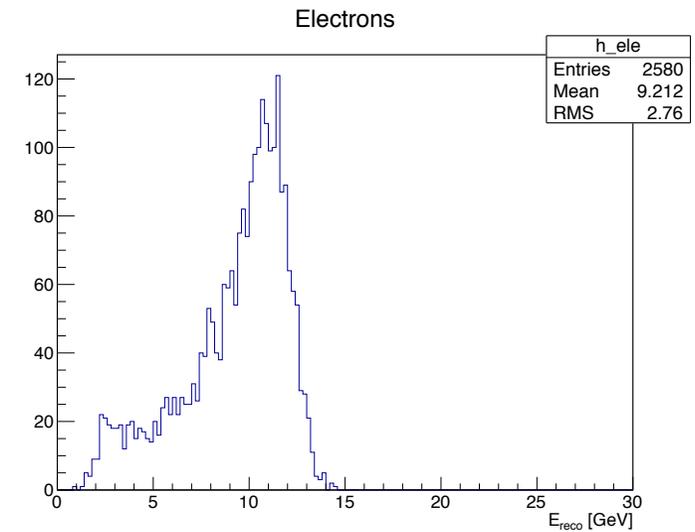
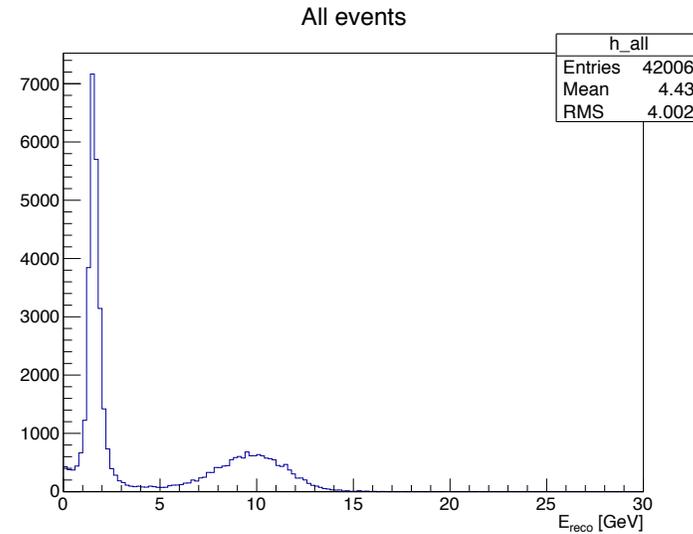
- **41858** events in total
- **0** empty events (low number of hits or deposited energy)
- **33127** muon-like events (~79%)
- **0** multi-particle events
- **5** electron events
- **8726** hadron events



TBMay 10GeV pion run

Energy distributions. Run 60629.

- **42006** events in total
- **2042** empty events (low number of hits or deposited energy)
- **21586** muon-like events
- **193** multi-particle events
- **2580** electron events
- **15605** hadron events



TBMay 10GeV pion run

Energy distributions. Run 60629.

- 42006 events in total
- 2042 empty events (low number of hits)

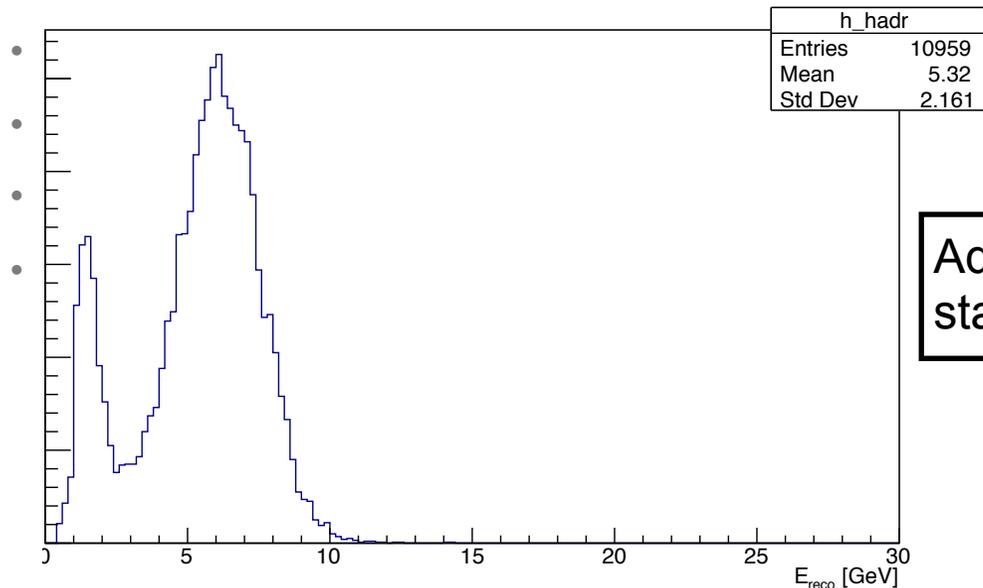
All events



Electrons

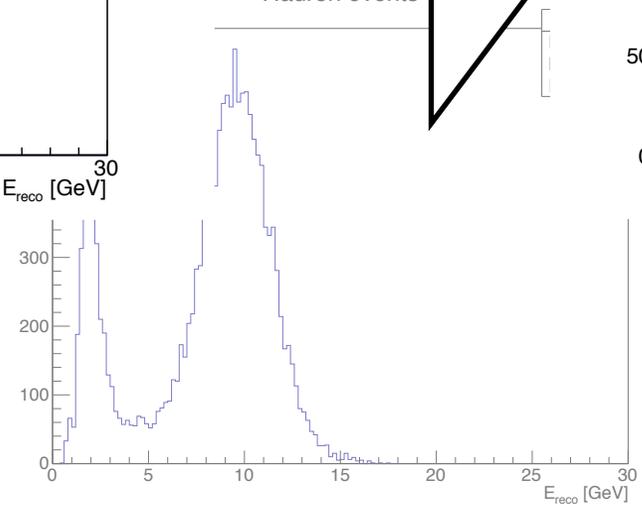


Hadron events

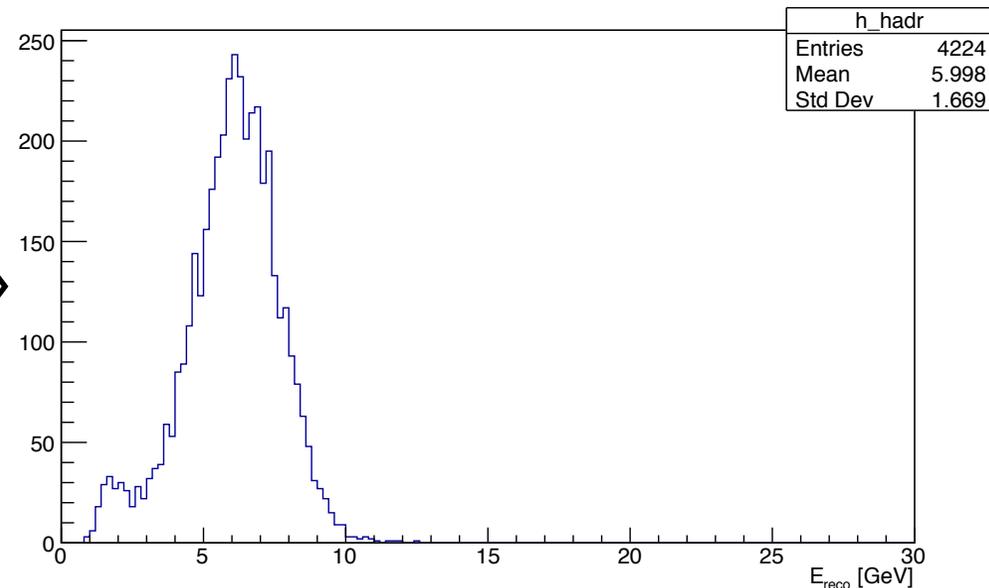


Additional shower start cut

Hadron events



Hadron events



Thank you