Pattern Recognition with FD & MIP analysis at SDHCAL TB data

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Motivation

- Motivation: Understand the Nhits profile for different components

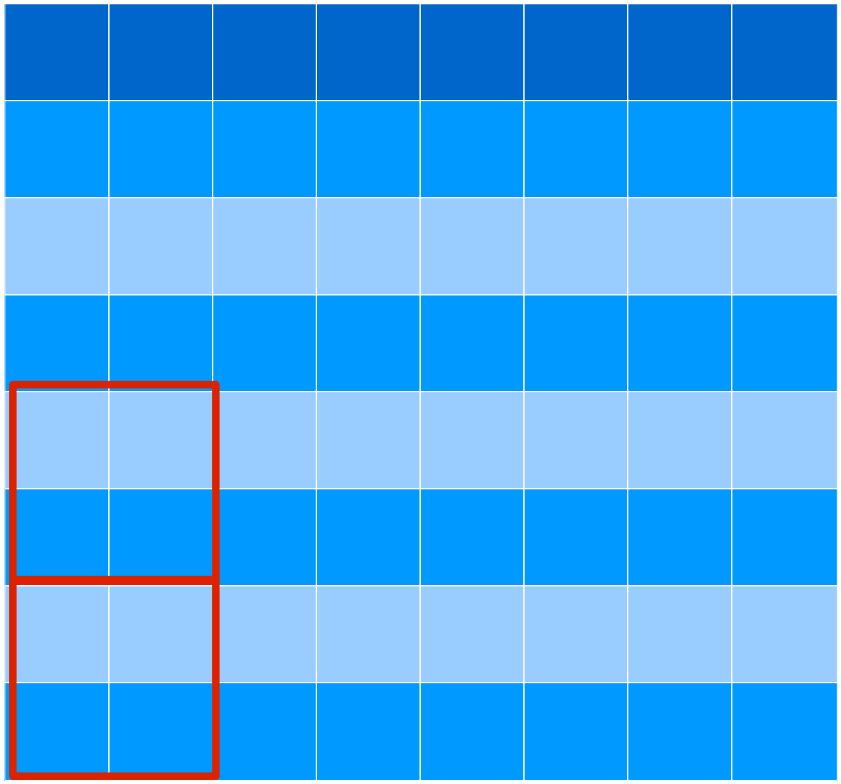
- Nhits profile: Noise, Cosmic, Sailing through MIP, EM & Hadronic showers
  - Why are they behaviour like observed?
  - How can they be described?
  - Are they stable?
  - For EM & Had, what's their dependence on beam energy & other variable?

Outline

- Introduction: Pattern Recognition with Fractal Dimension
  - Interesting Noises
- Run Summary & Evt Selection
  - Noise, Cosmic & Beam MIP
    - Stability
    - Multiplicity & efficiency Measurement
  - EM & Hadronic: Energy Dependence
- Digitizer Tunning & MC-data comparison:
  - Local & Global
- Discussion

FD @ SDHCAL

SDHCAL TB: totally 48 active layers, each layer consist of 96*96 = 9216 cells with 3 thresholds

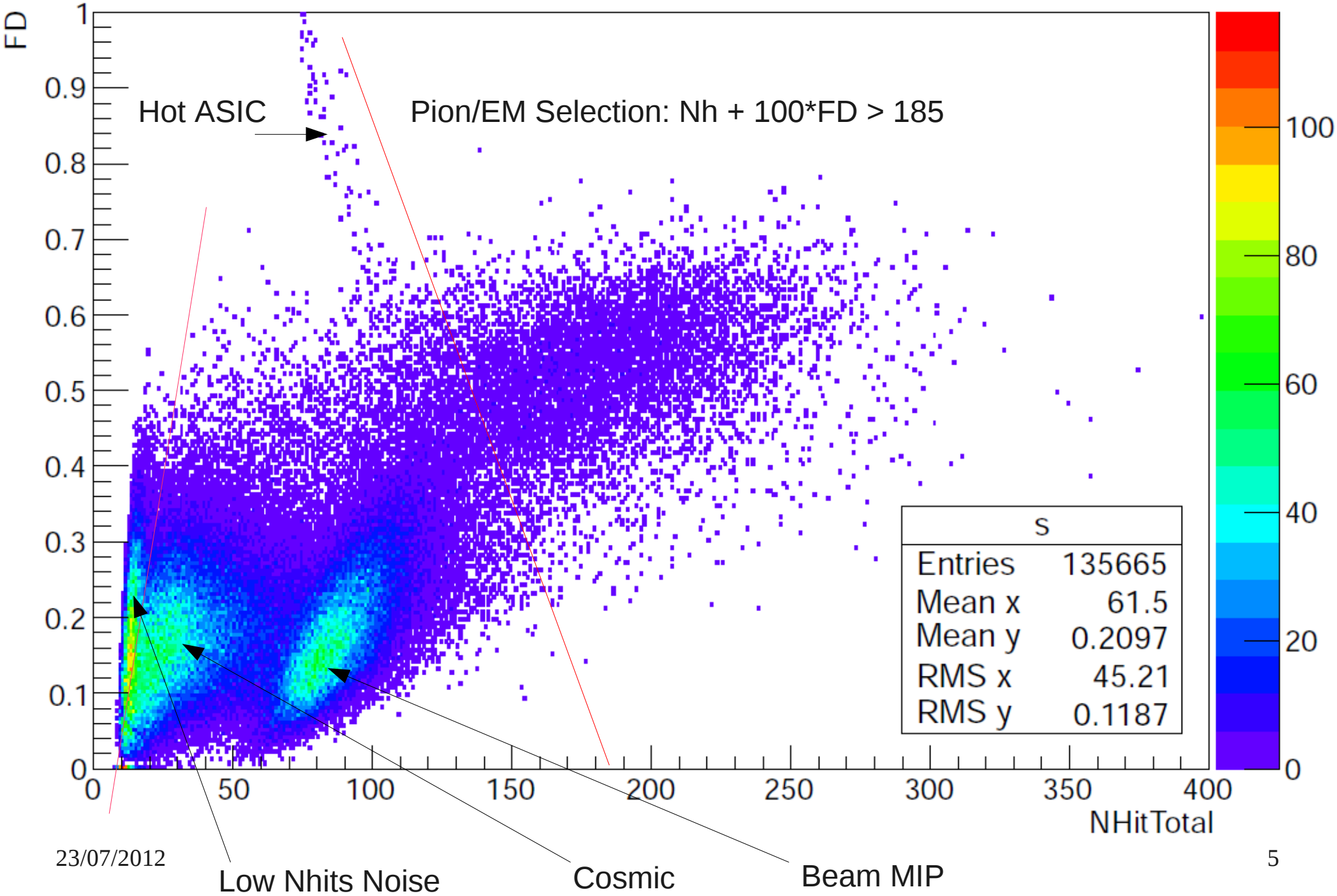


FD Measured from total # hits:

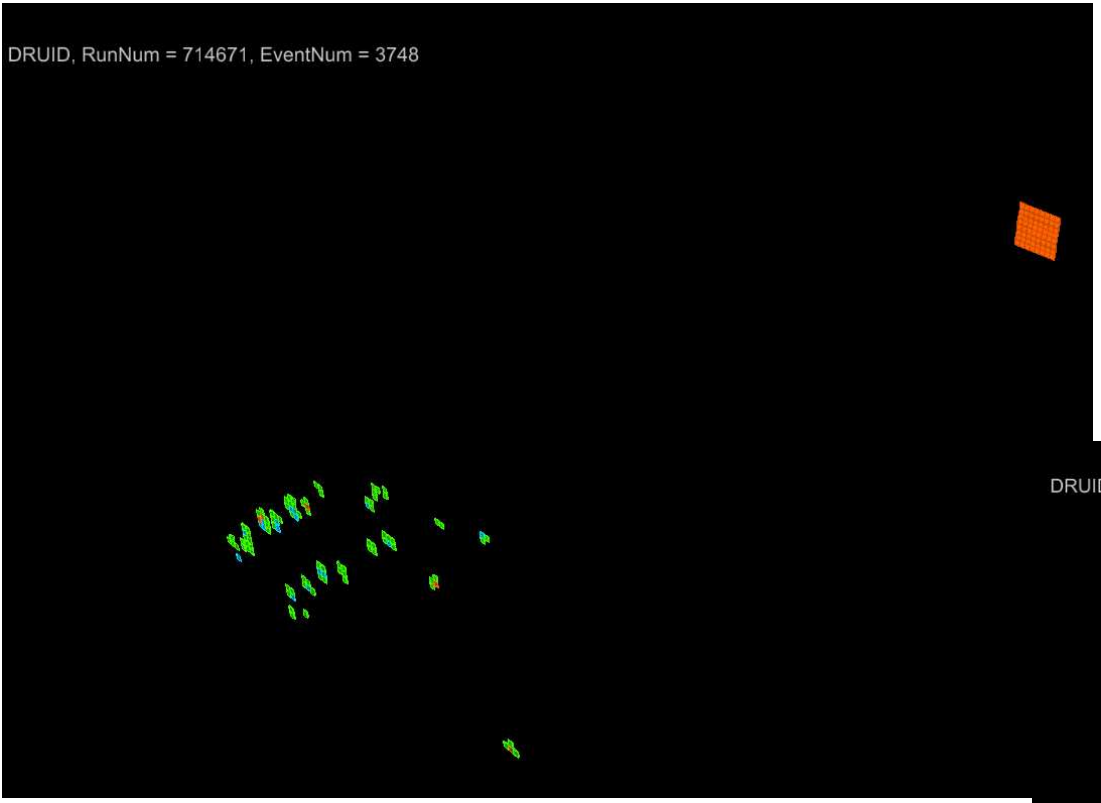
- Varying scale by grouping neighbouring cells
- Count Number of hits at different scale *(define RN**x** = N**1**cm/N**x**cm)*

FD = <log(RNx)/log(x)>; x = 2 – 11 cm

10GeV Pion Run: Run714671_714673



Hot ASICs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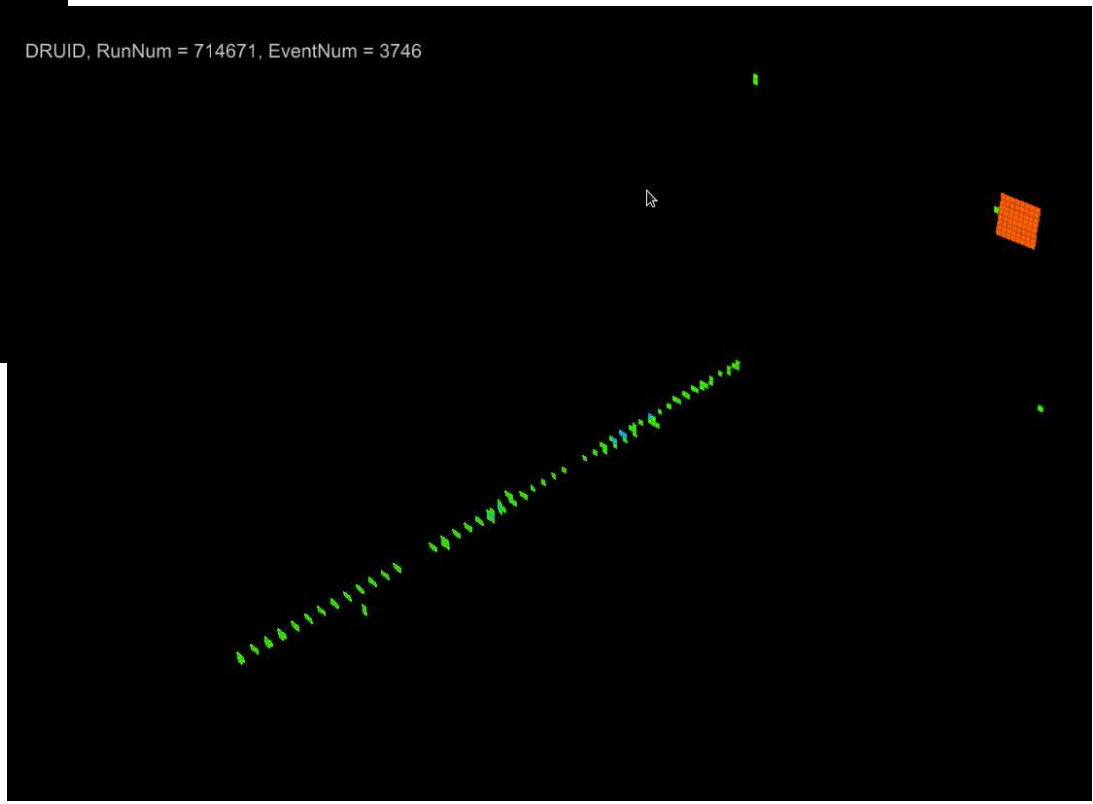
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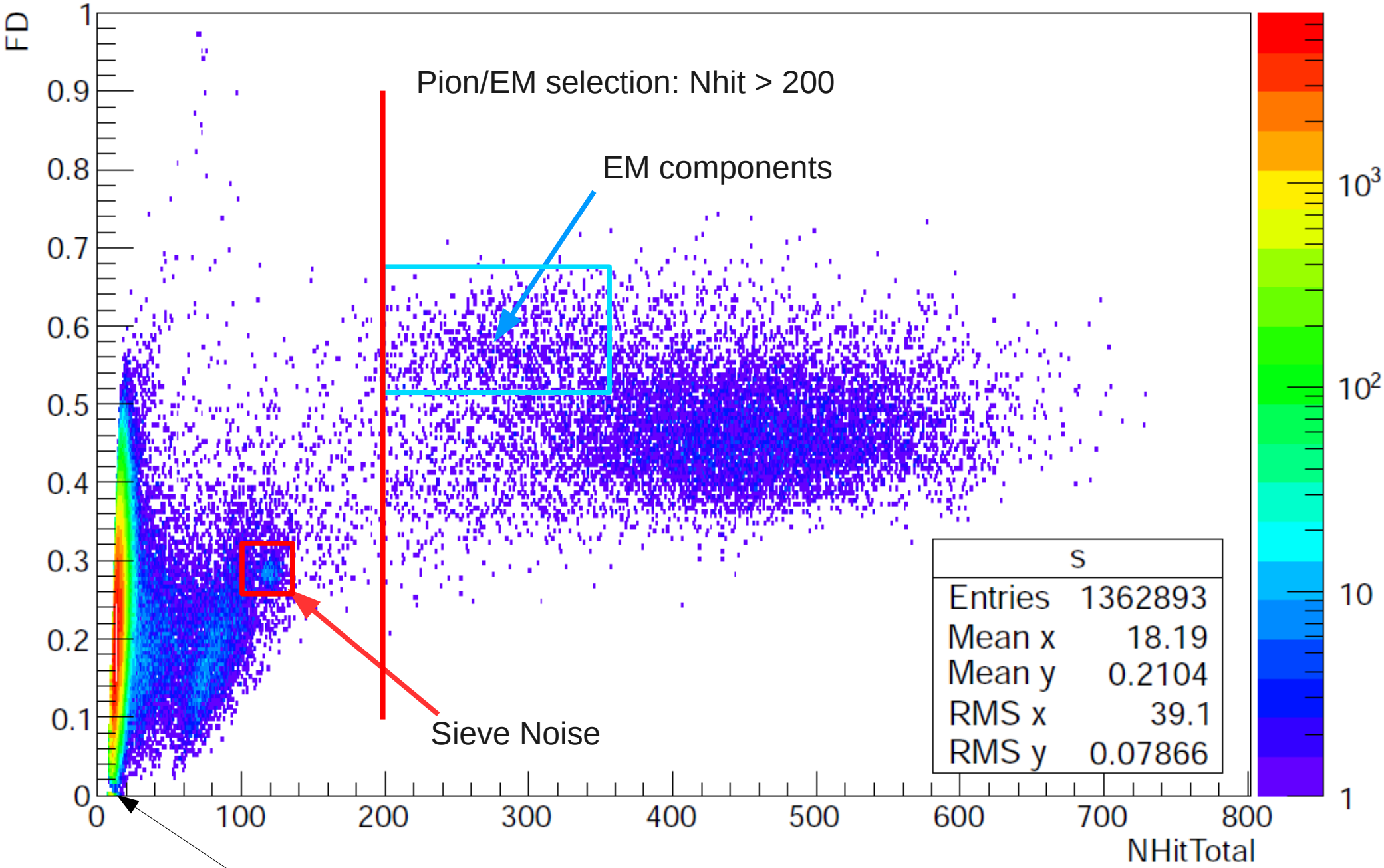
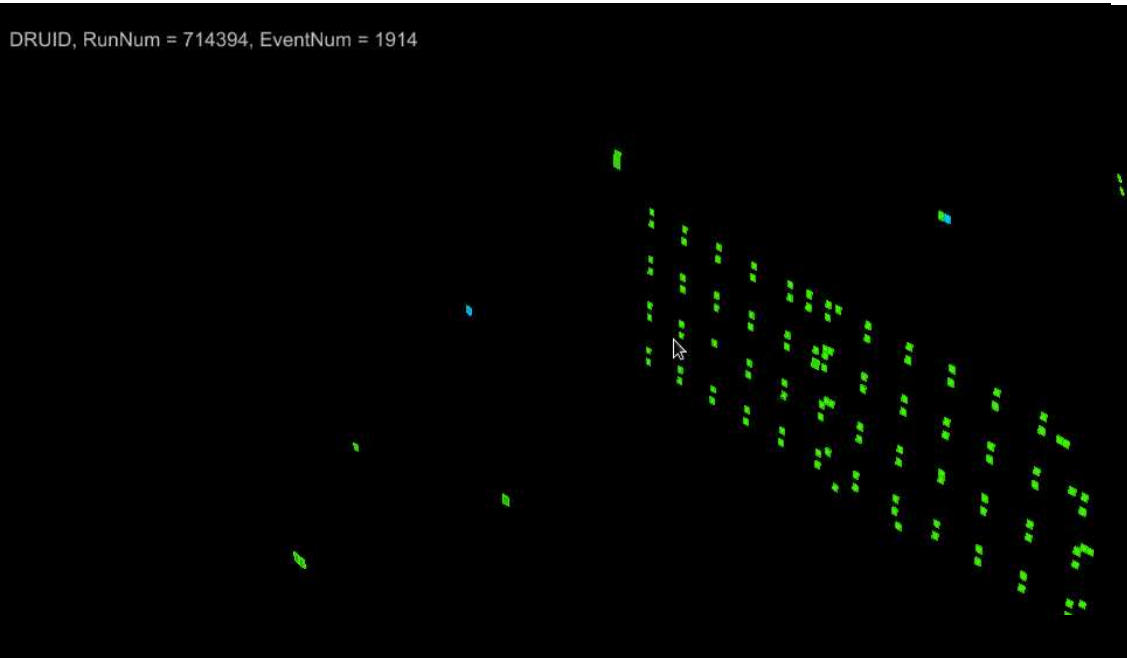
30GeV Pion(mixed) Run: Run714394



Noise dominated Run...: Not even cosmic

Sieve Noise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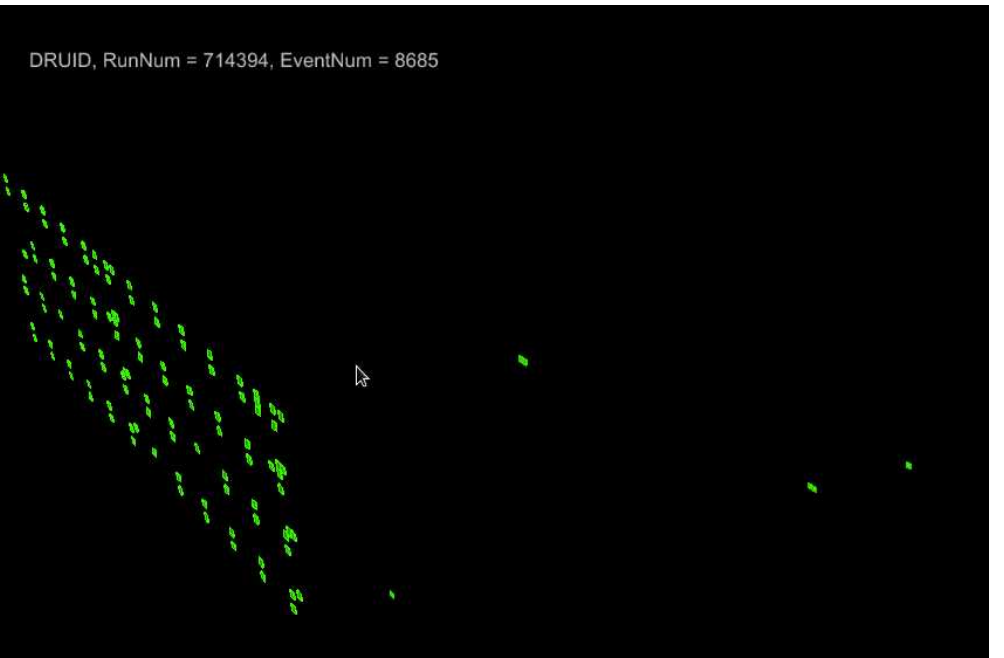
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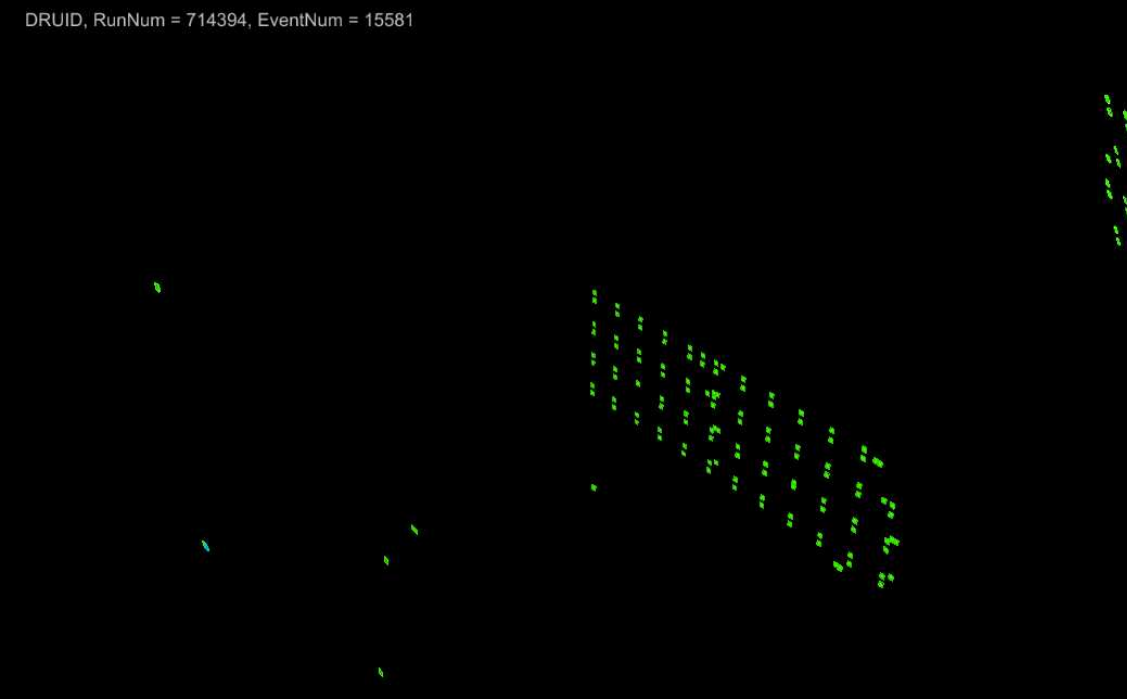
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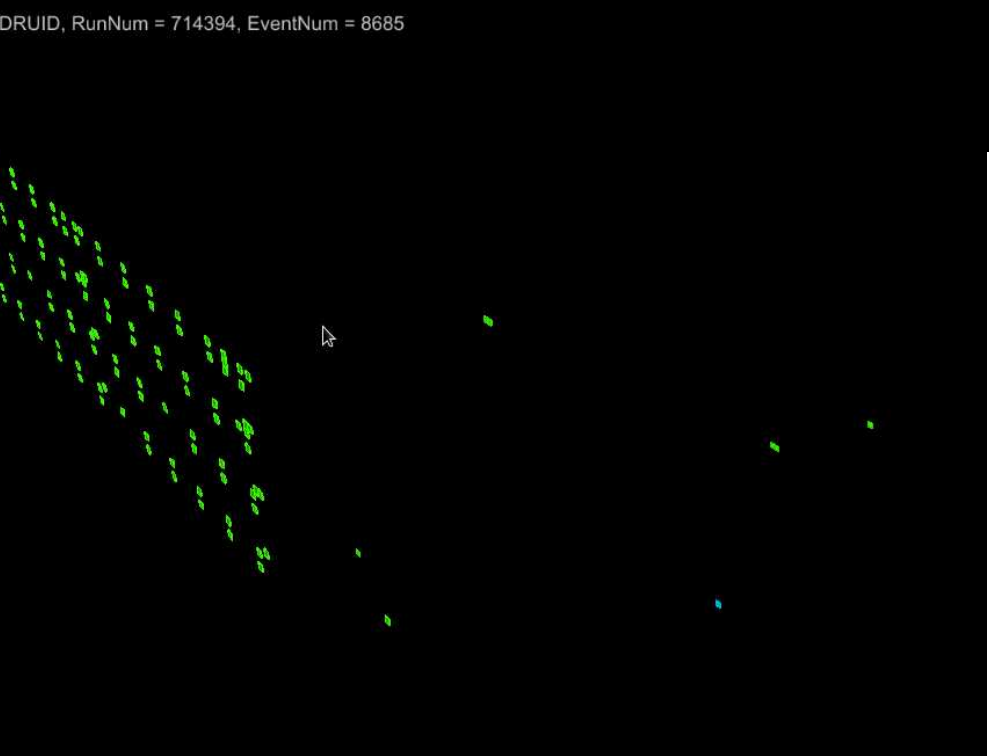
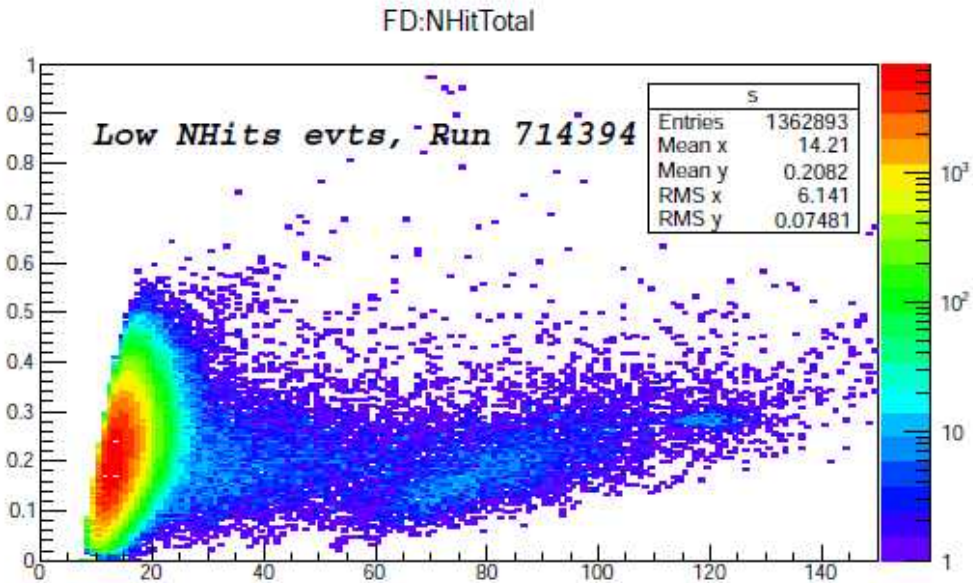
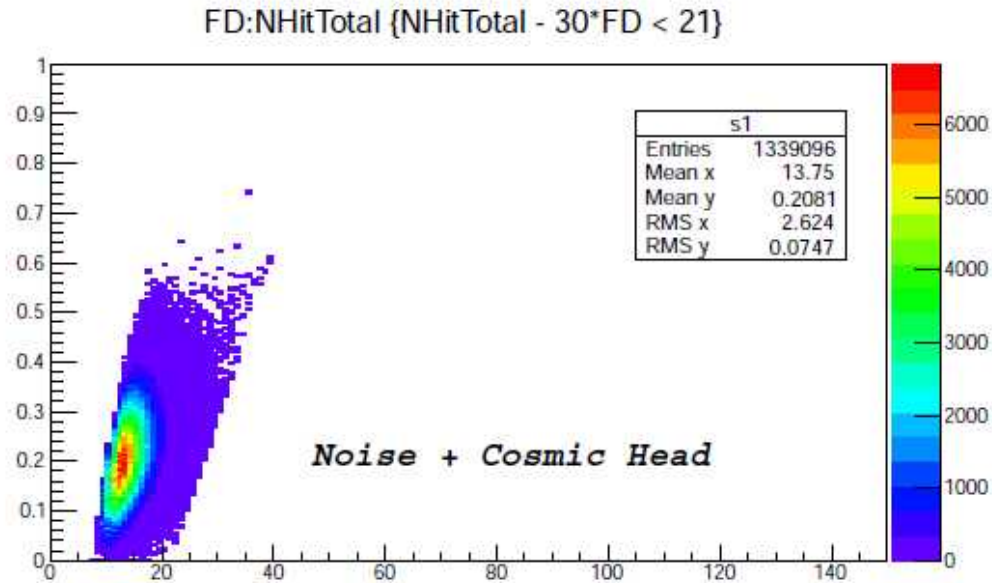
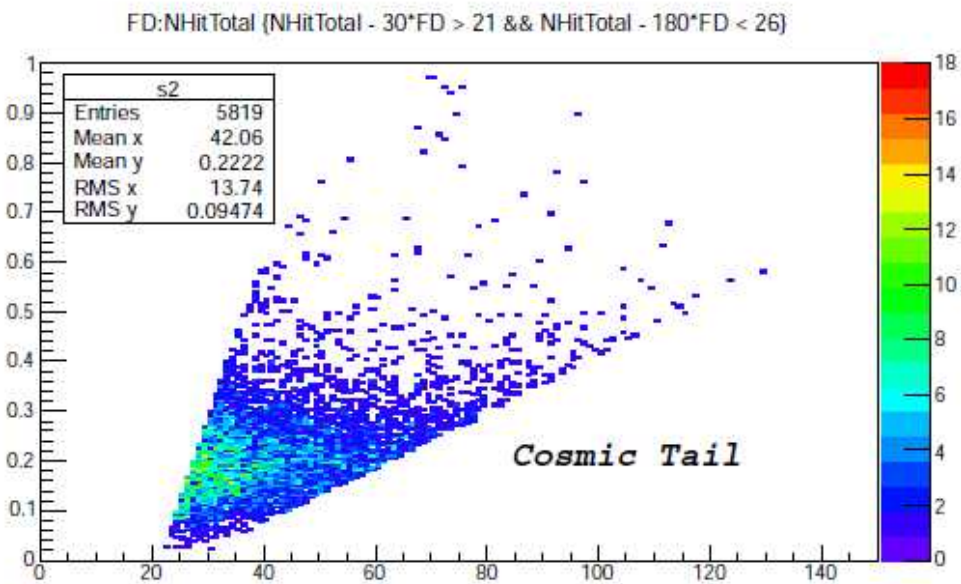
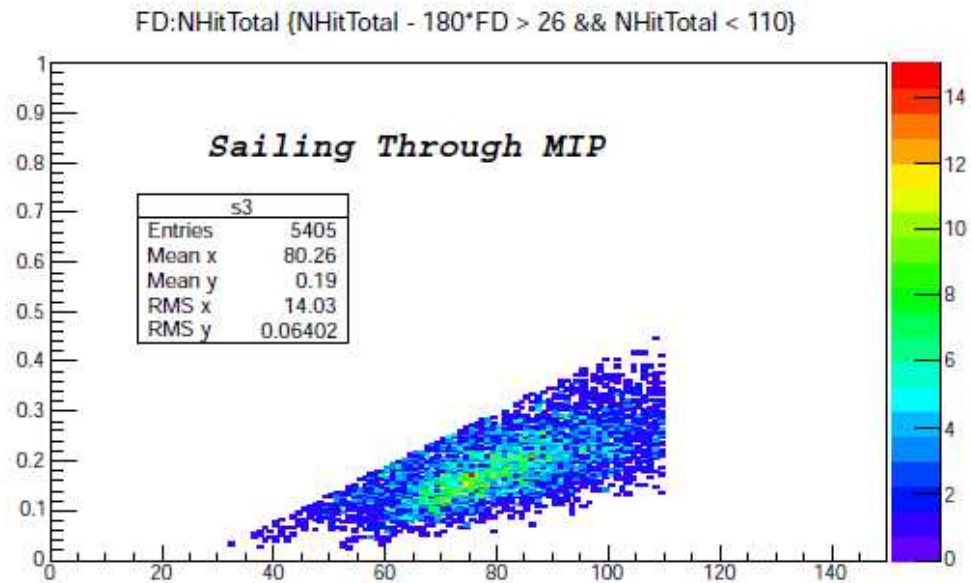

DRUID, RunNum = 714394, EventNum = 8685

Run 714394: Patterns of low Nhits evts

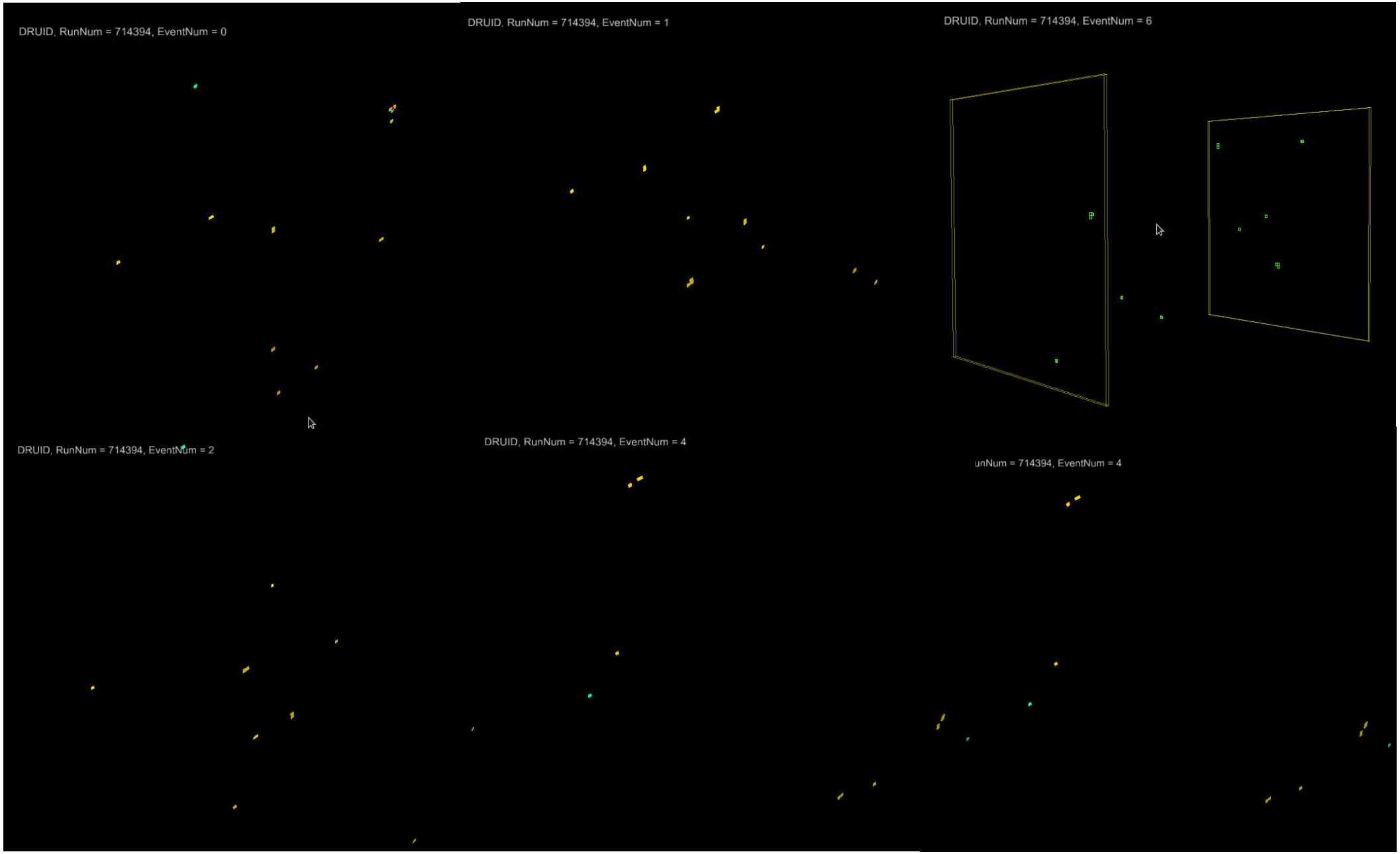




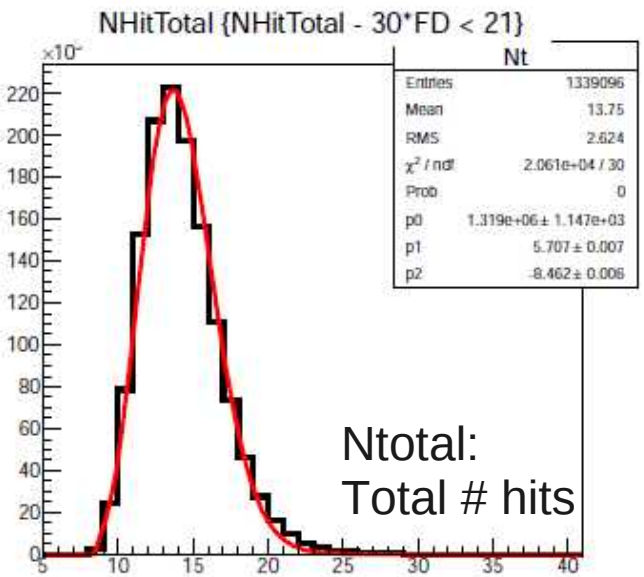


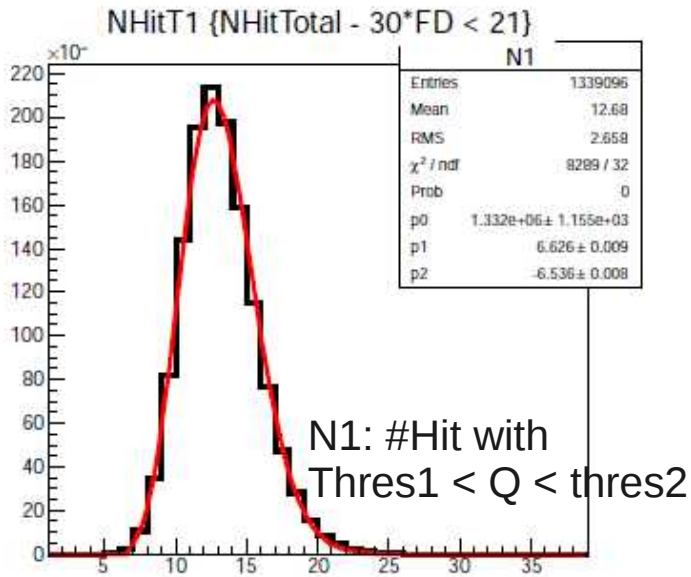


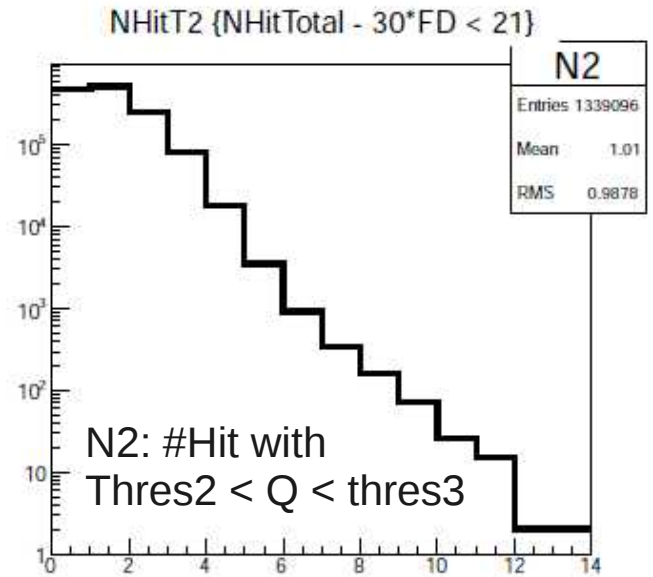
Tagged Noise (Run 717493)

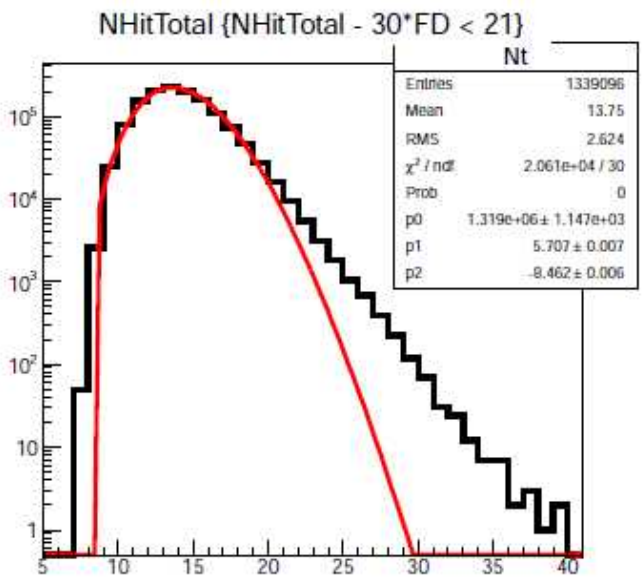


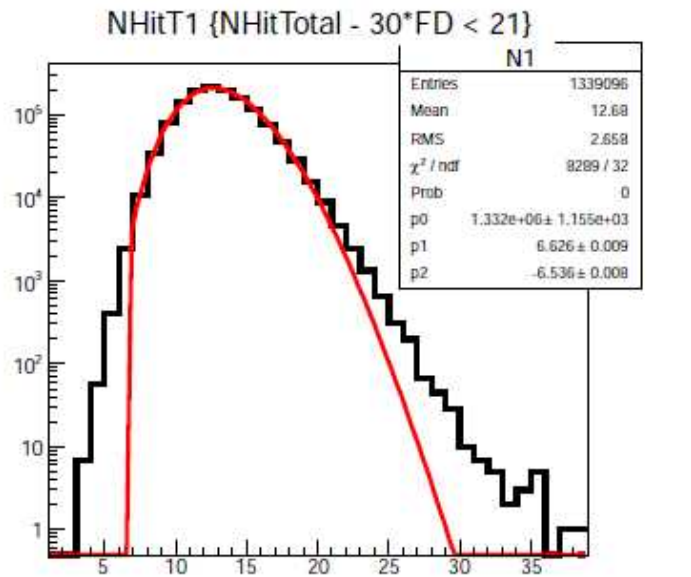
Nhits Profile of “Noise”

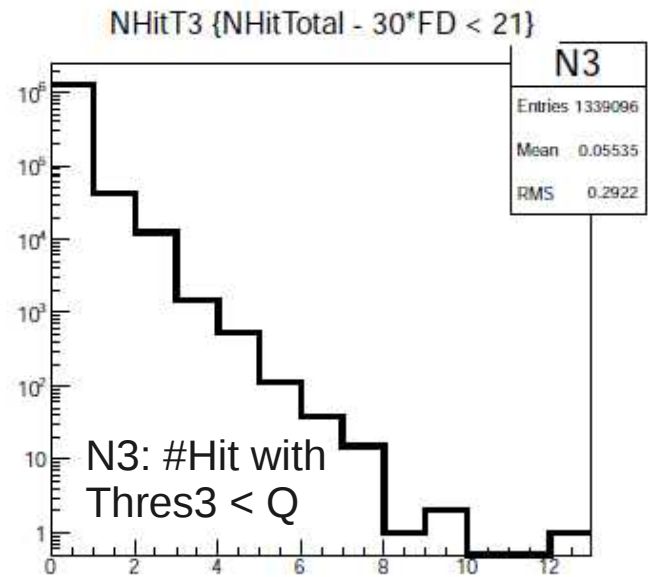






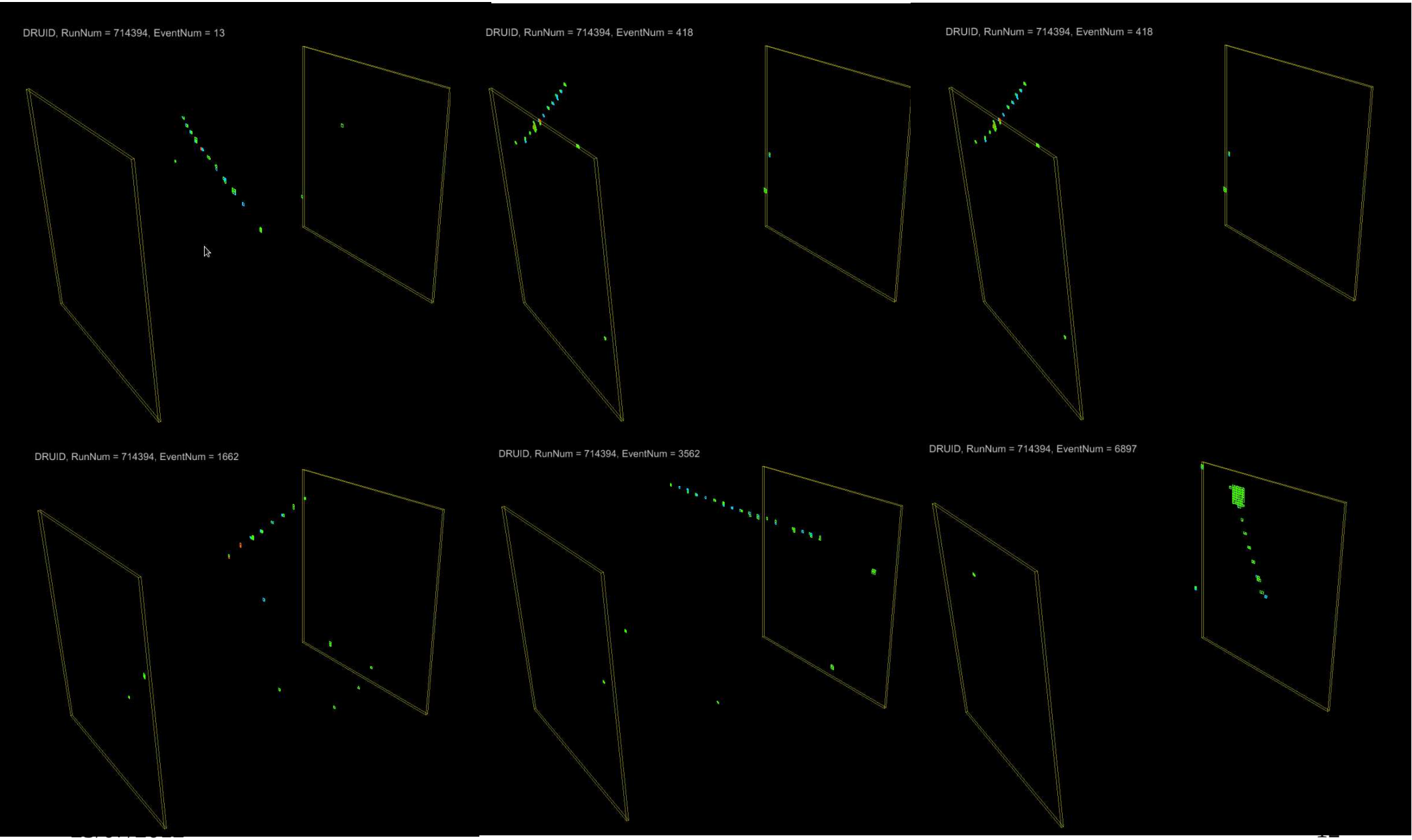






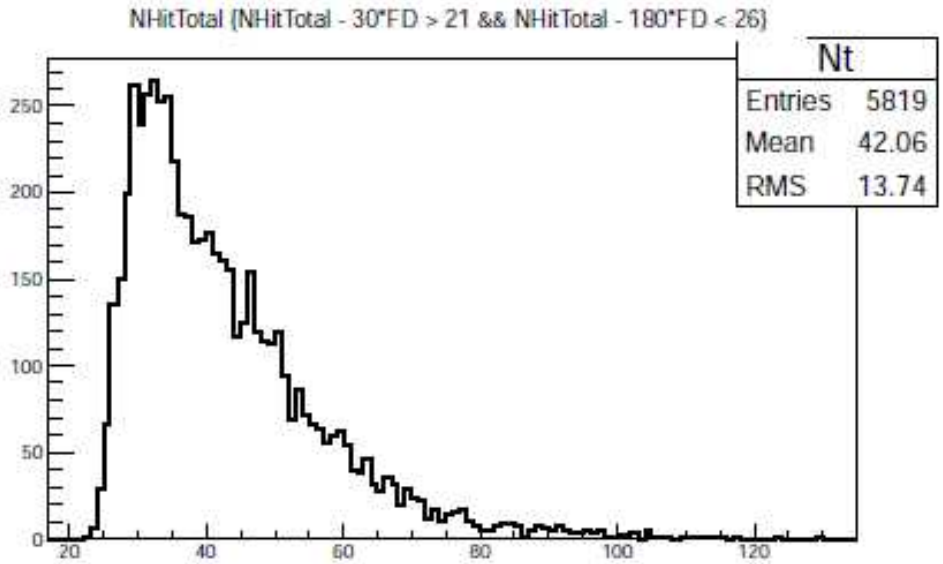
N1, Ntotal: Shifted Poisson + exponential tail

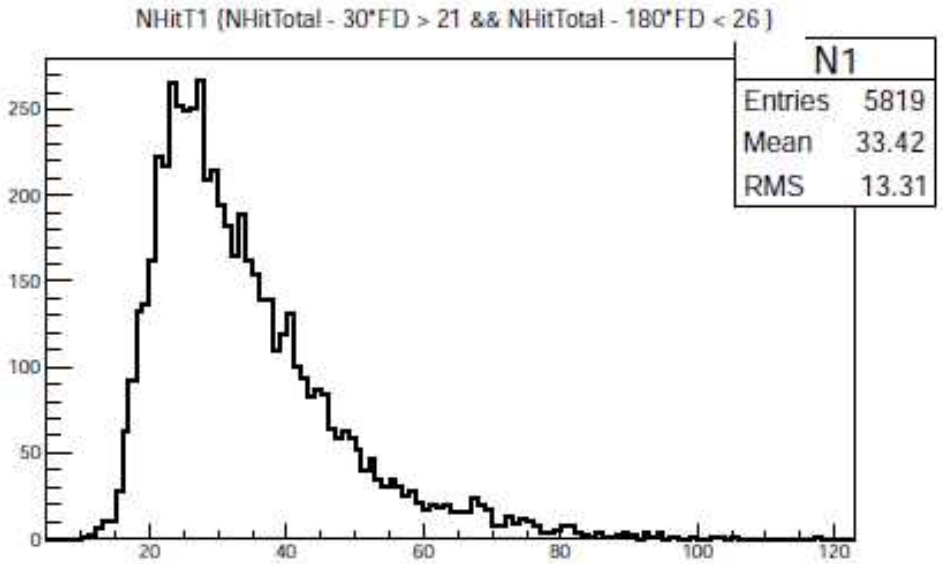
Tagged Cosmic (717493, Purity ~ 70%)

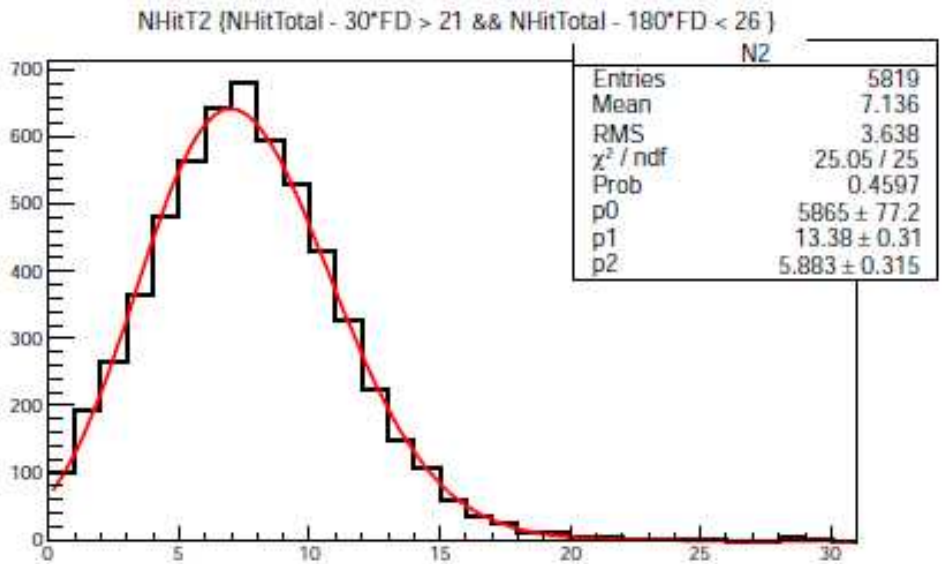


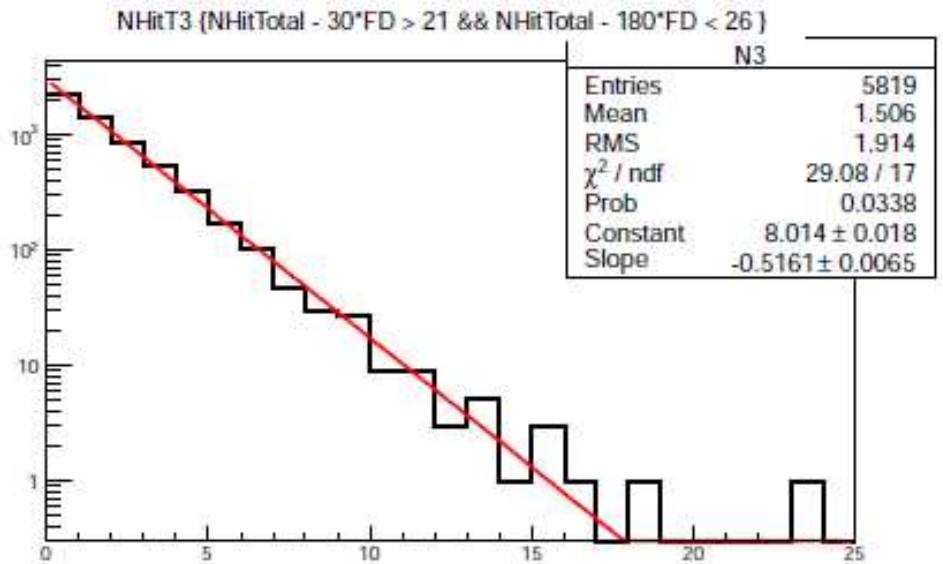
Including a bit noisy event (as sieve noise), and normally inject less energetic muon

Nhits profile of Cosmic



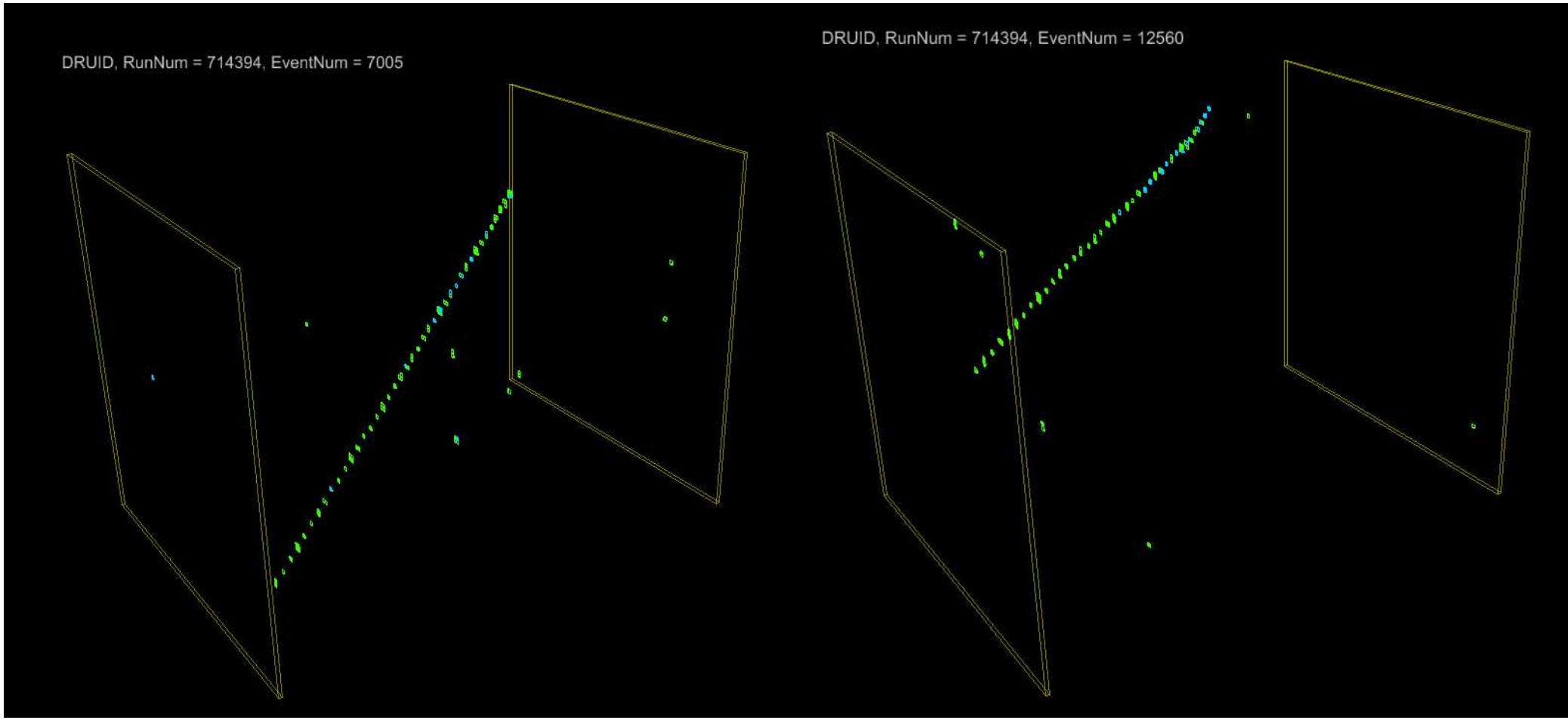




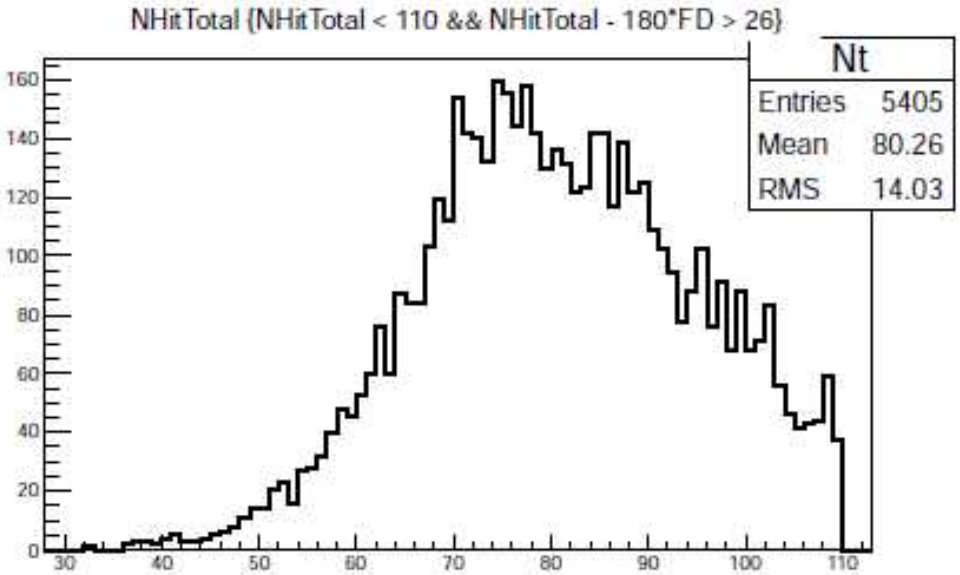


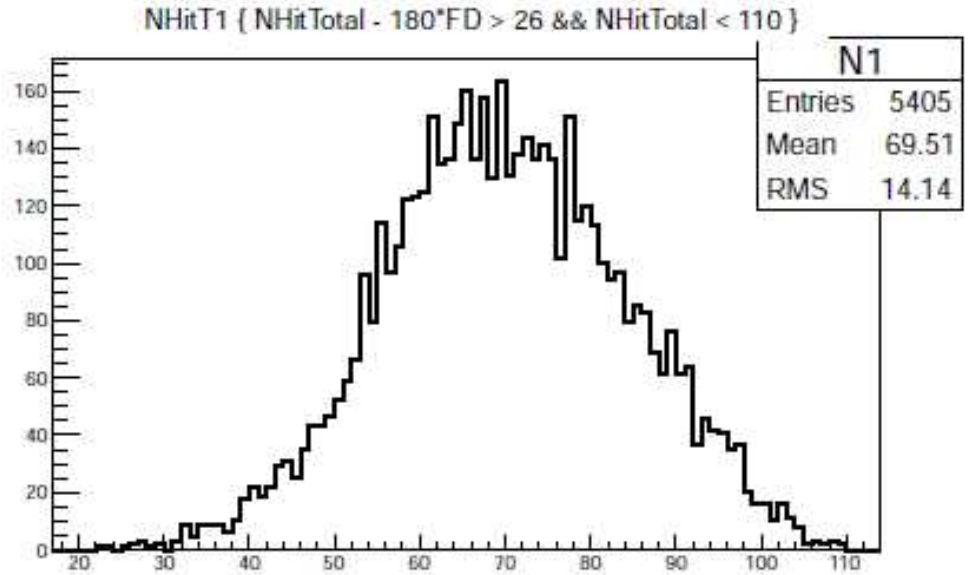
N2: Shifted Poisson & N3, Exponential

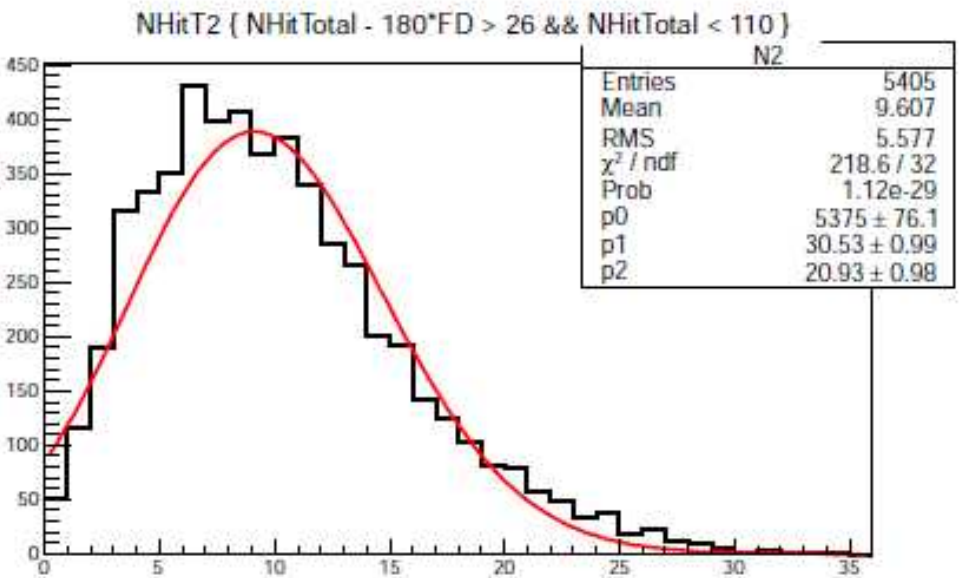
Tagged Beam MIP (717493)

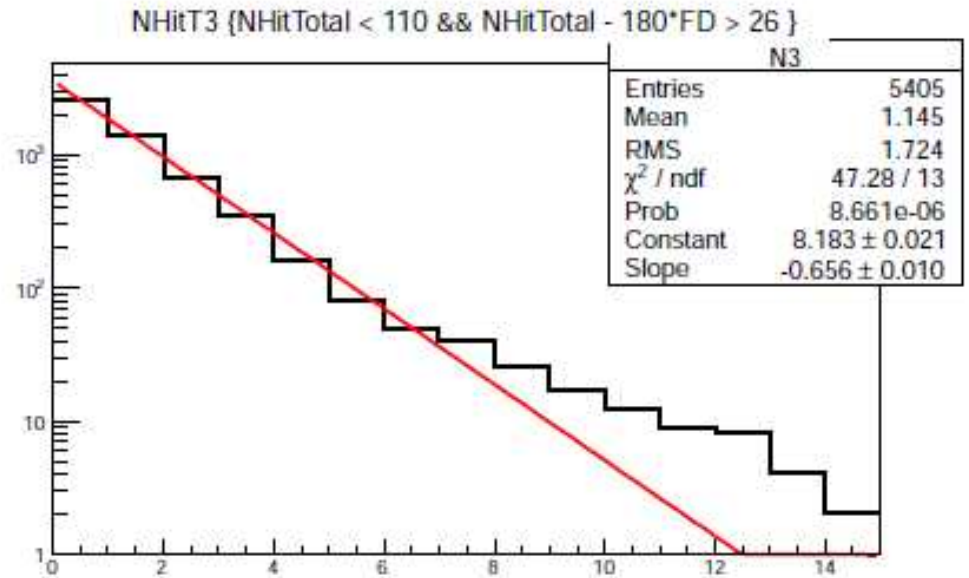


Hits Profile for Beam MIP Evts









Pion Runs

- 10 GeV: 714671, 4673
- 15 GeV: 714439, 4441
- 20 GeV: 714565, 4573
- 30 GeV: 714394
- 40 GeV: 714559, 4561
- 50 GeV: 714596, 4697
- 60 GeV: 714551, 4552, 4553
- 70 GeV: 714541, 4546, 4547
- 80 GeV: 714527, 4531
- 90 GeV: 714525
- 100 GeV: 714486, 4488, 4489
- 110 GeV: 714521

120 GeV: 714495, 4496*, 4502

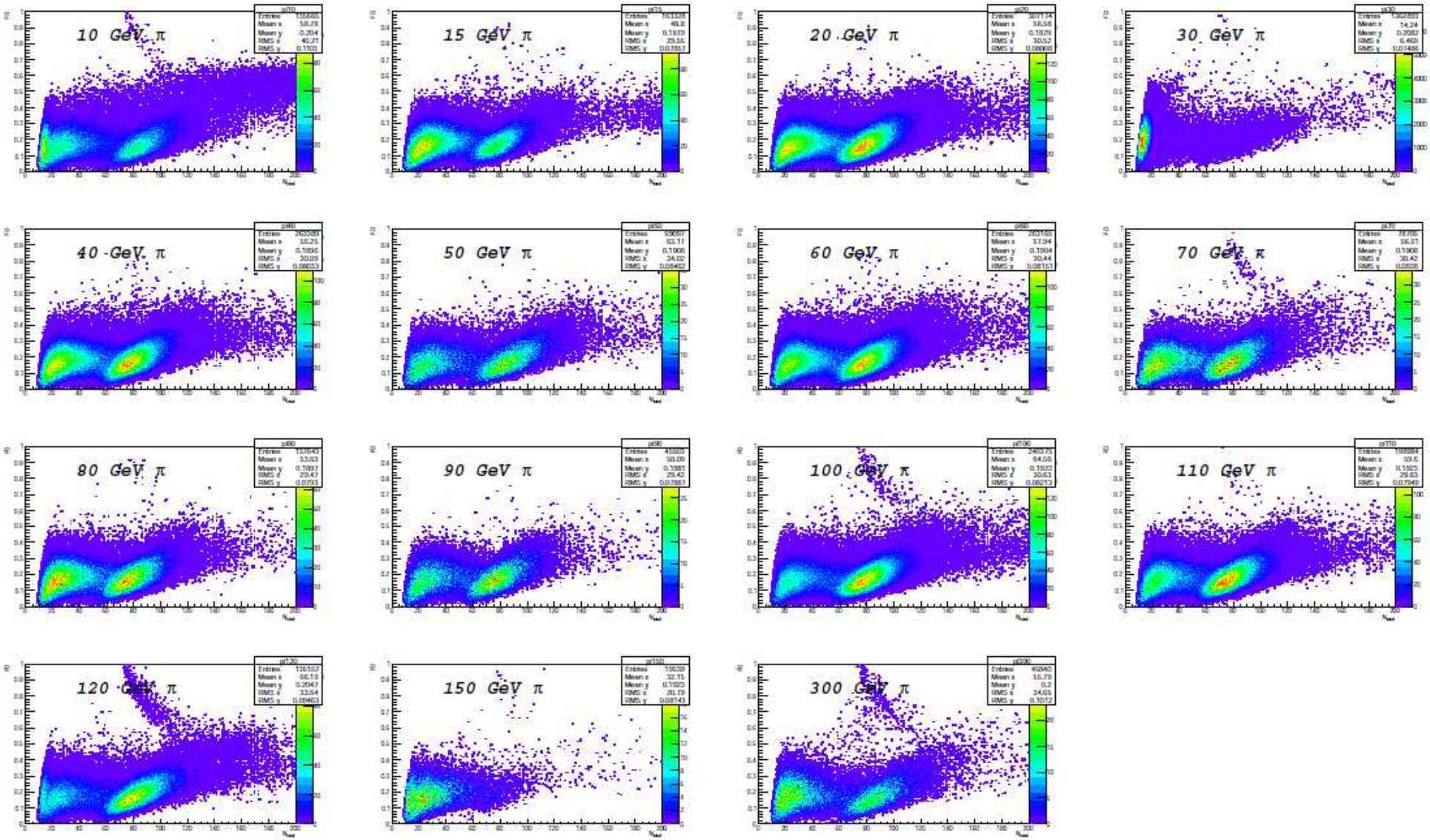
150 GeV: 714415, 4416

300 GeV: 714695

HV = 6.9kV (only for 4496 is 6.8kV)
Thresholds: 170, 500, 345

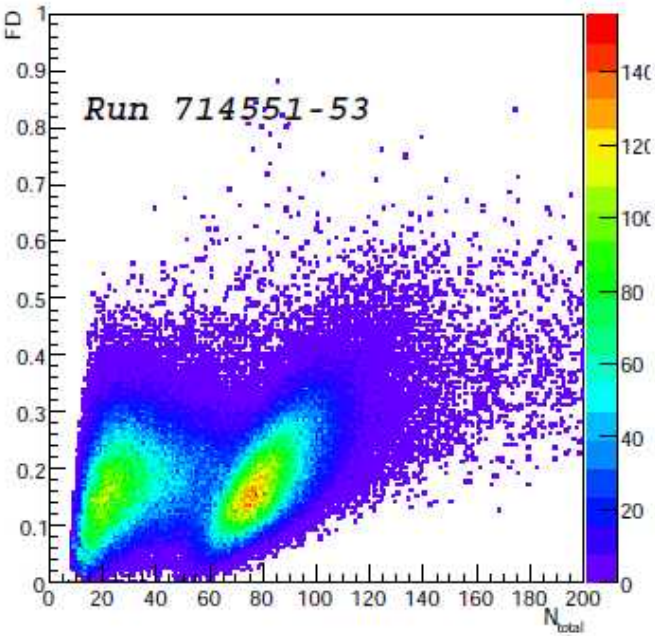
Event Selection: Based on Fractal Dimension and Total Number of Hits

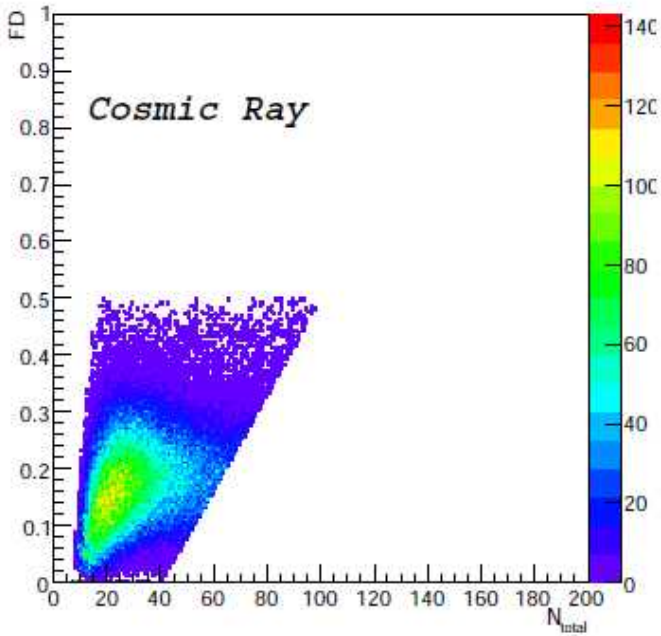
Stability of MIP & Cosmic

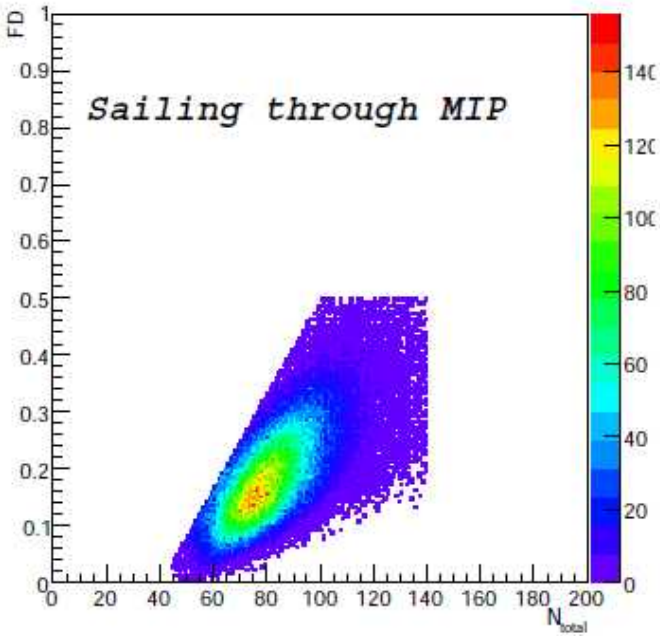


Clear Sailing through MIP at almost every energy (except, 150GeV Runs))
According to low nhits noise (nhits < 40): data divided into Noisy Group (10, 30, 120GeV) and Clean Group (all the others)
Typical Noise created by Hot ASIC

Clean Runs: sailing through or cosmic MIP







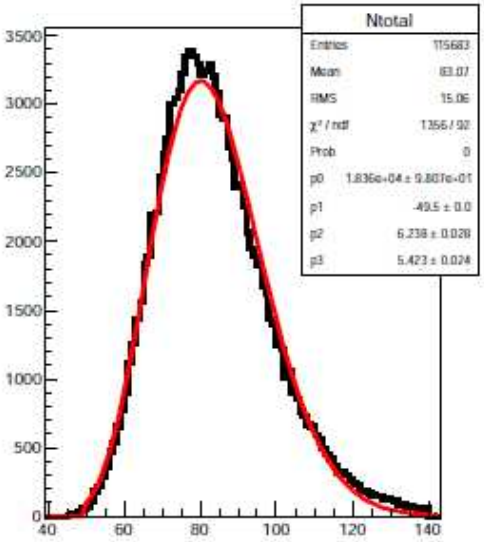
Cuts:

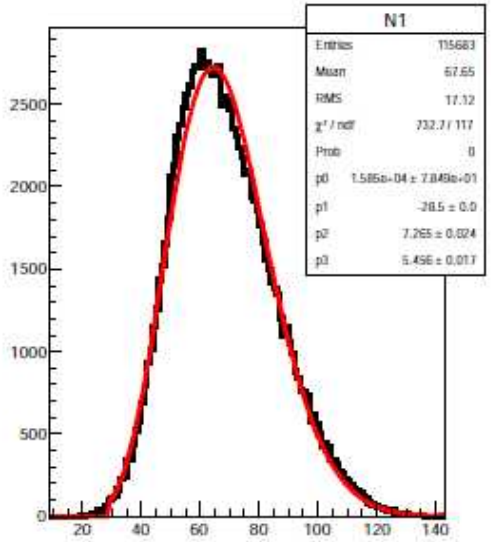
Sailing through MIP (Beam MIPs): NhitTotal – 120 * FD > 40 && NhitTotal < 140 && FD < 0.5

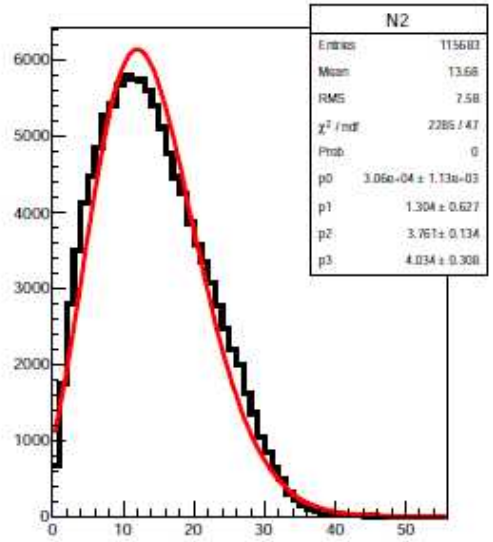
Cosmic Ray: NhitTotal – 120 * FD < 40 && NhitTotal < 140 && FD < 0.5

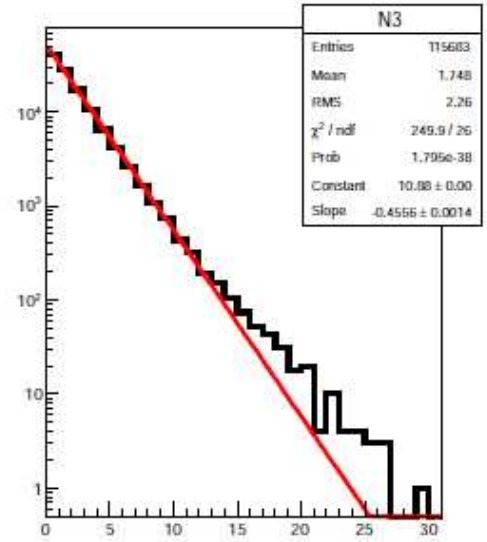
Same cut to be applied on All Clean Runs: 15, 20, 40, 50, 60, 70, 80, 90, 100, 120, 150*, 300 GeV Runs (Small Statistic in 150 GeV Runs).

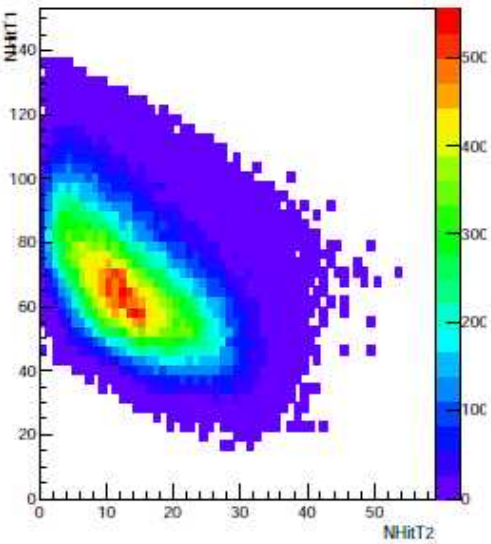
Sailing through MIPs: 60GeV Run

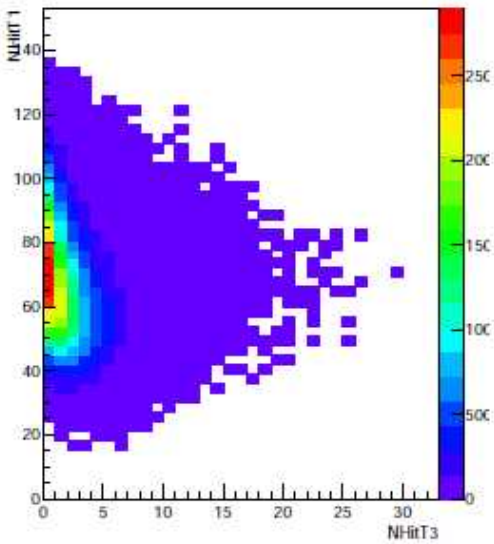


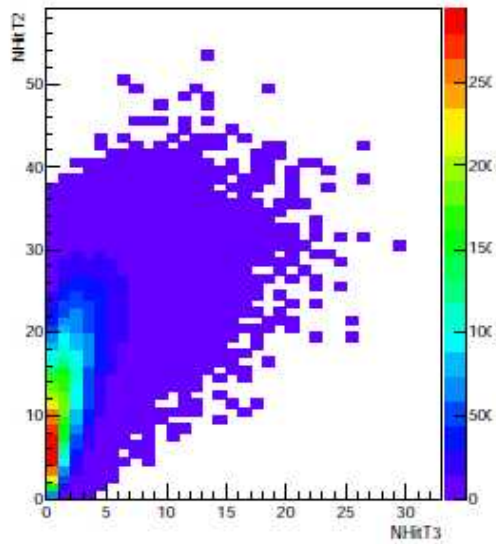








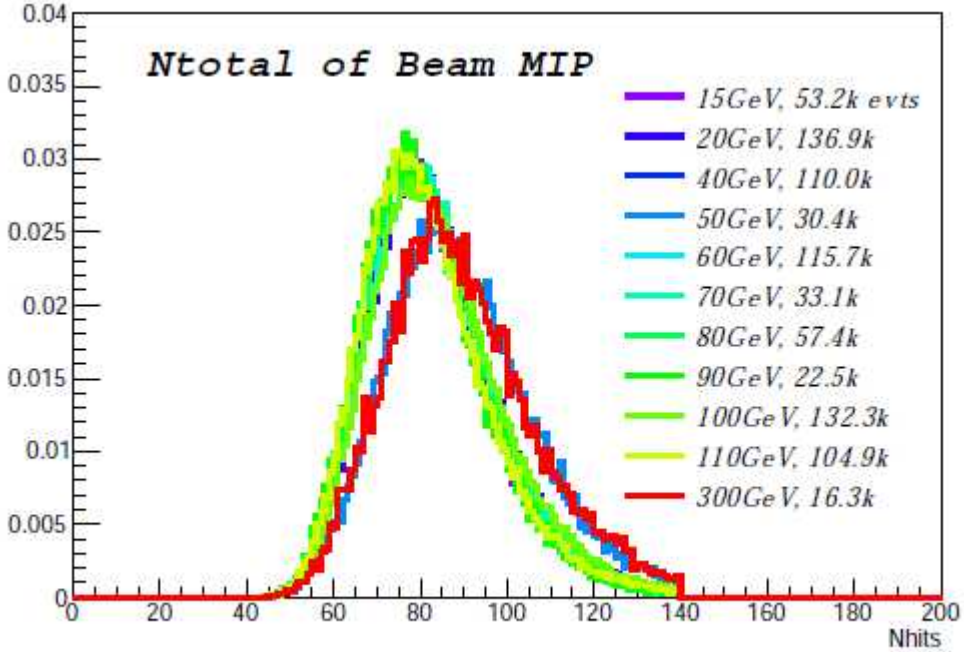


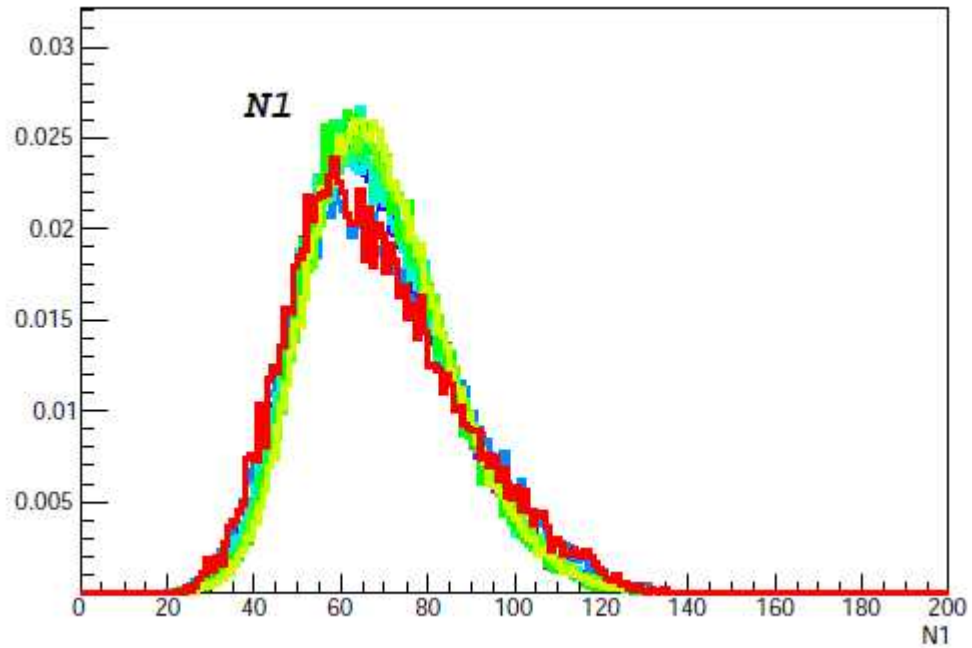


Ntotal, N1, N2: Scaled & Shifted Poisson

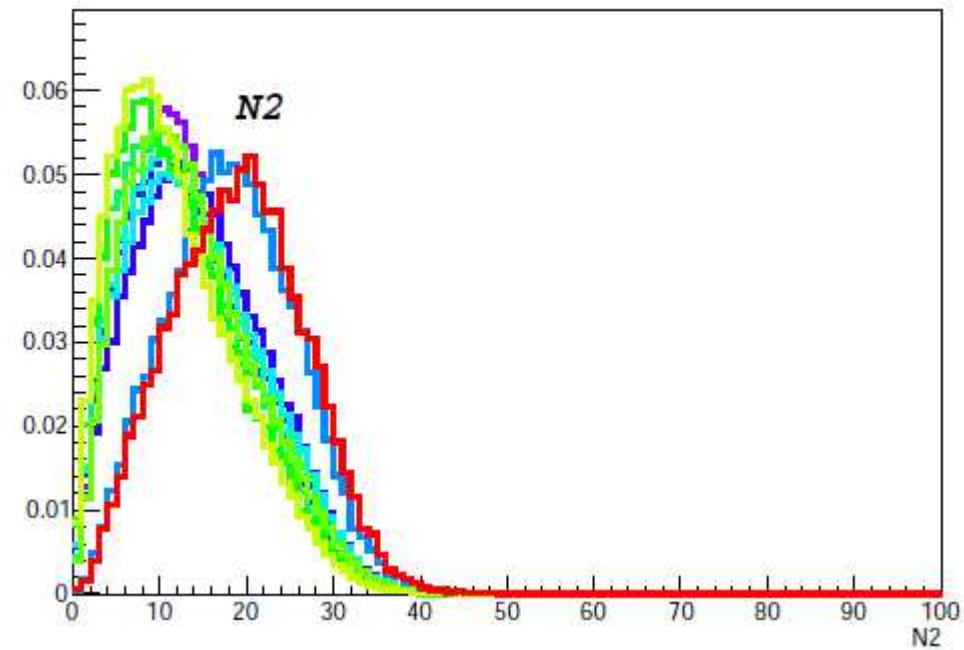
N3: expotential

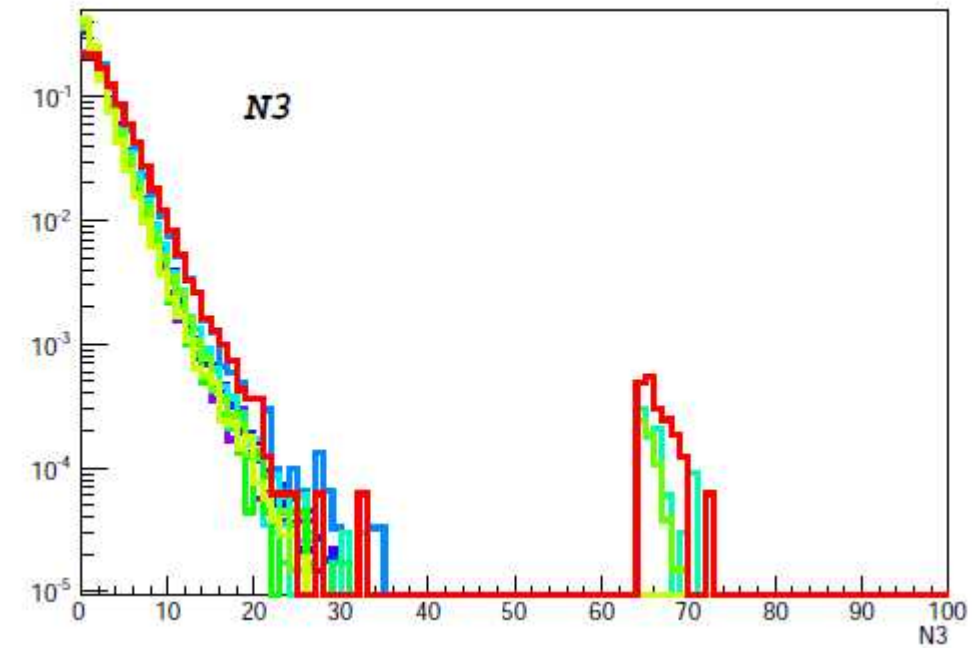
N1 anti correlated with N2 with correlation coefficient ~ 2.5





Number of hit profiles for beam MIPs in pion runs

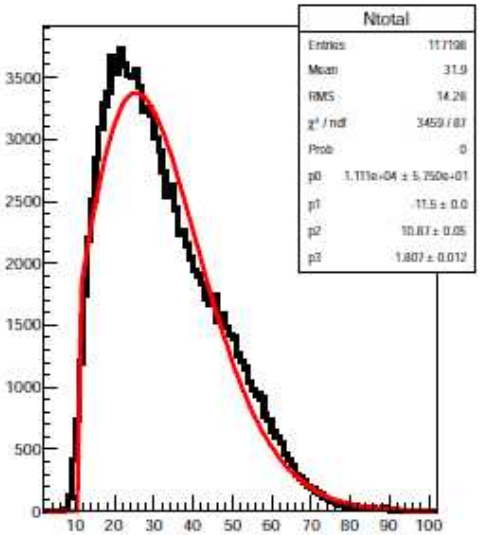


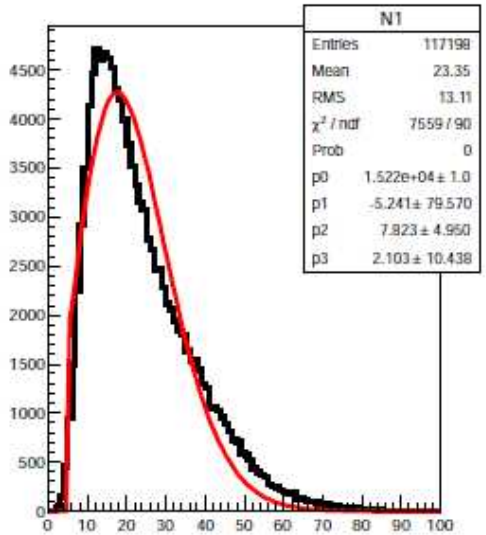


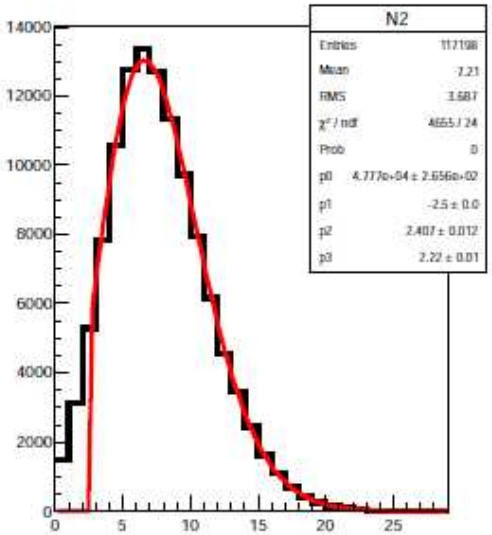
Beam MIPs on Clean Runs

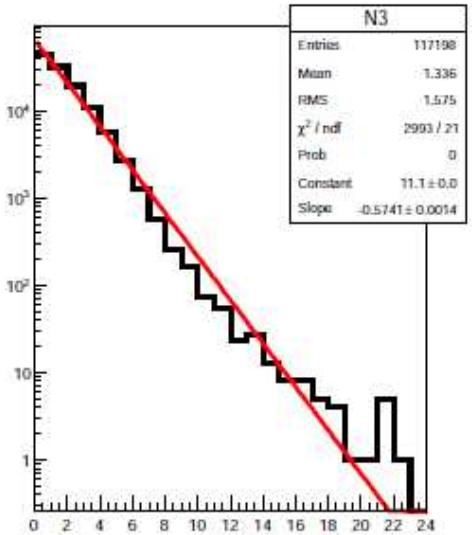
- Stable
  - Exceptional: 50 GeV (714696, 4697) and 300 GeV (714695) Runs, taken at the end of experiments. Recorded HV & thresholds are the same as others.
- N1, N2 and Ntotal follows a shifted & scaled Poisson distribution, N3 ~ exponential
- Hot Asics

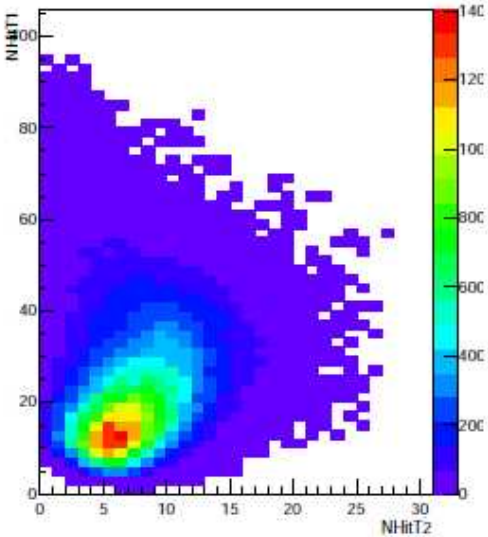
Cosmic: 60GeV Run

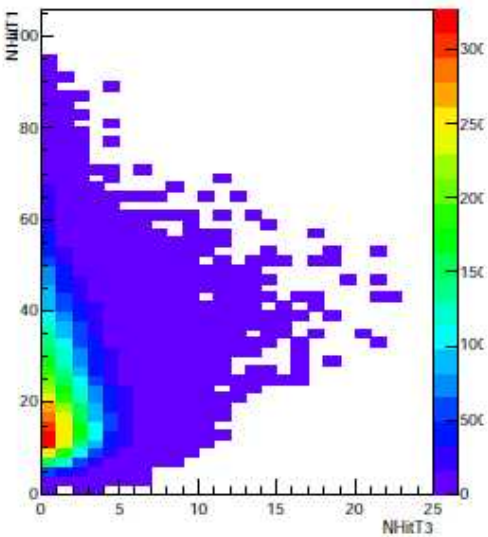


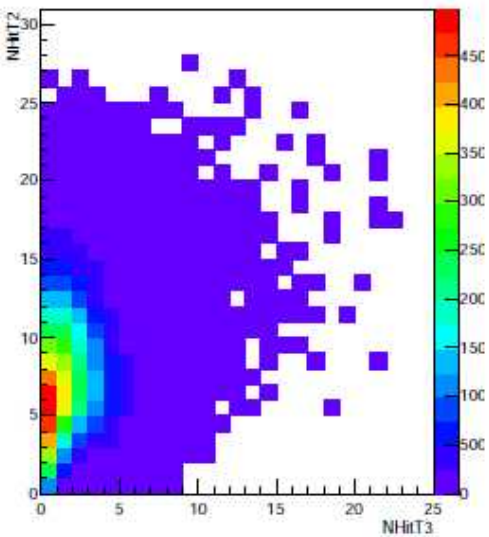








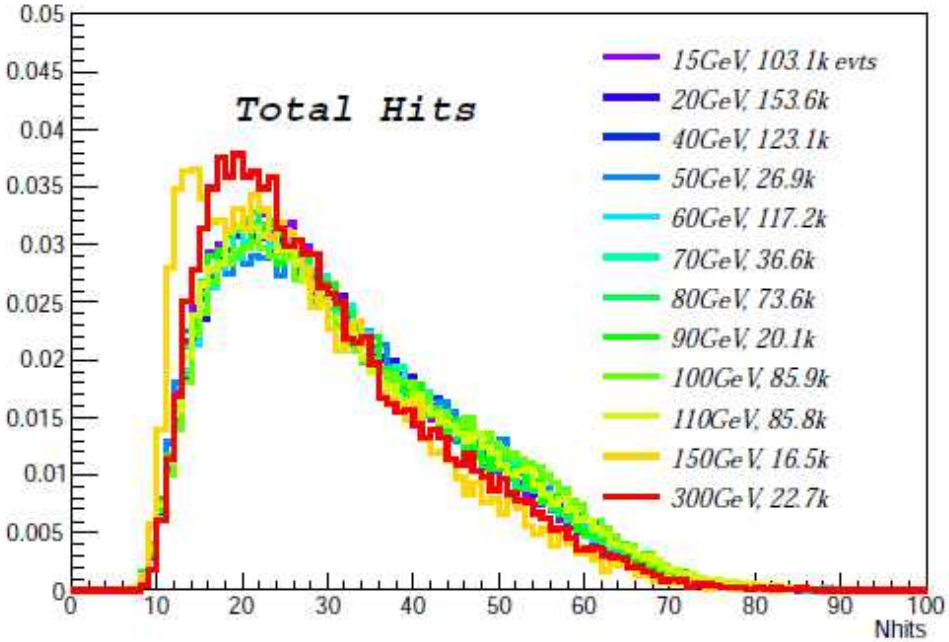


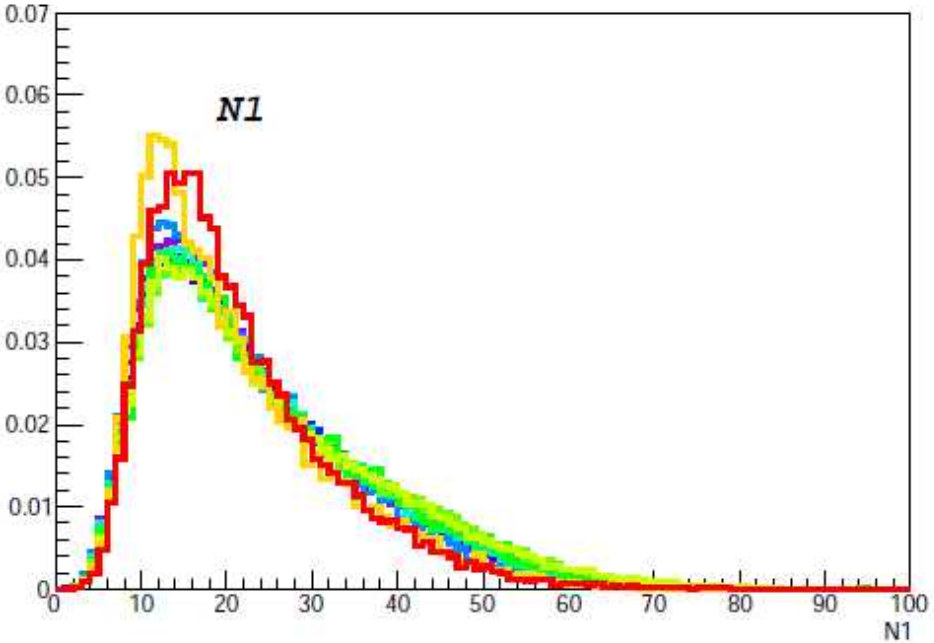


Ntotal, N1, N2: Scaled & Shifted Poisson

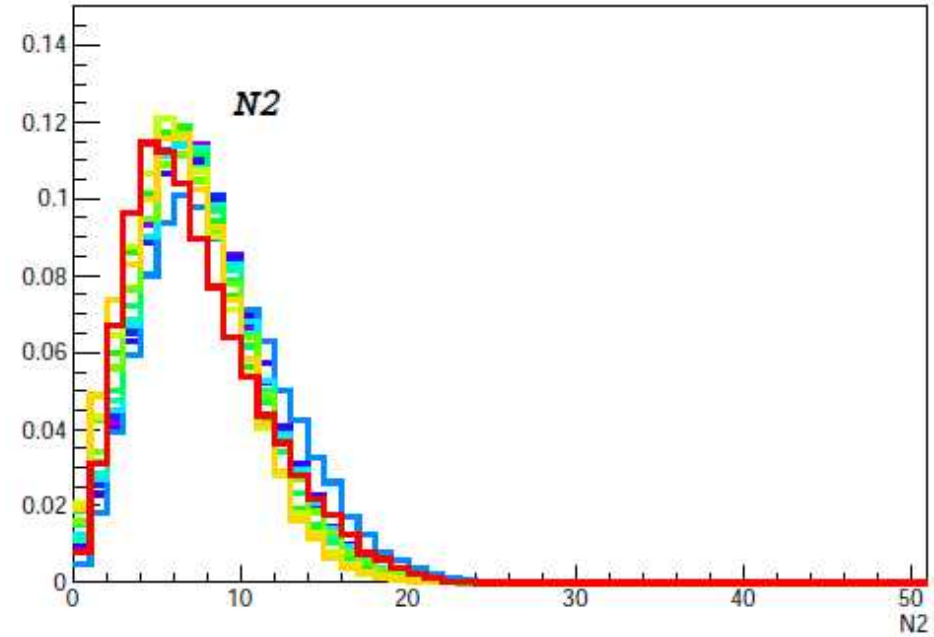
N3: expotential

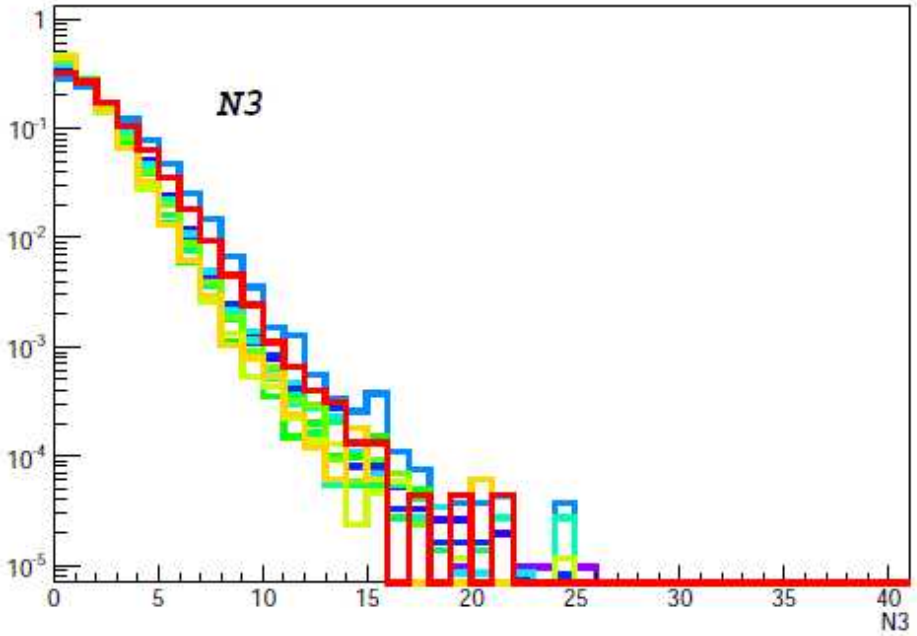
N1 correlated with N2



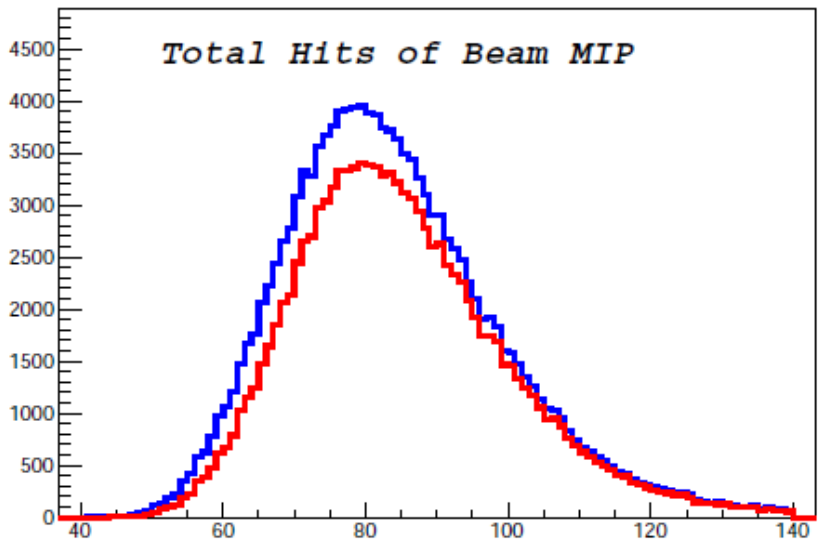


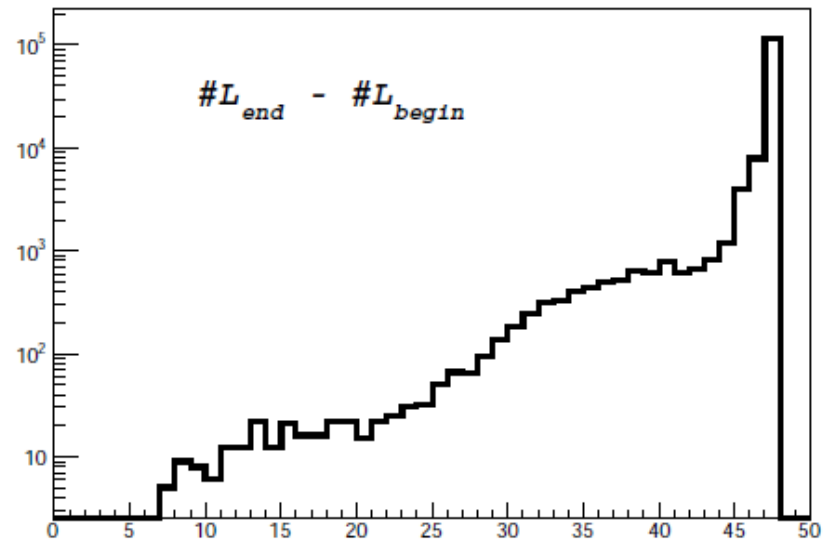
Number of hit profiles for Cosmic rays in pion runs



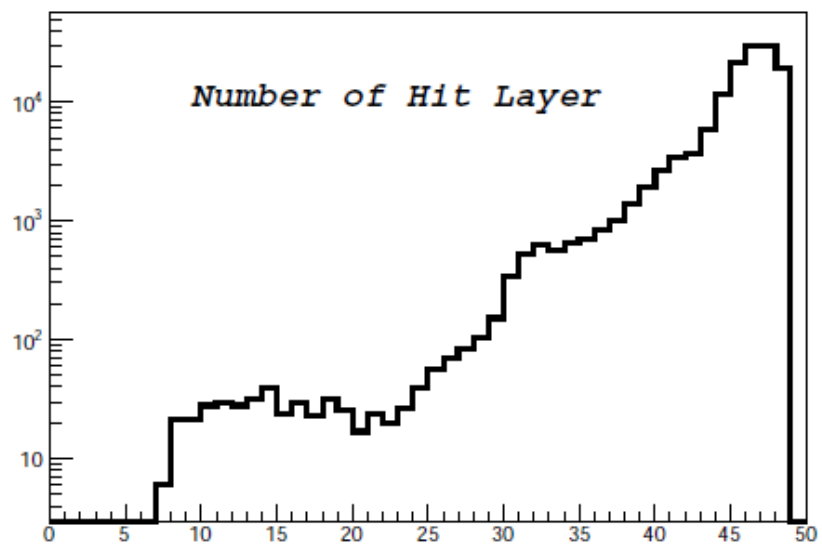


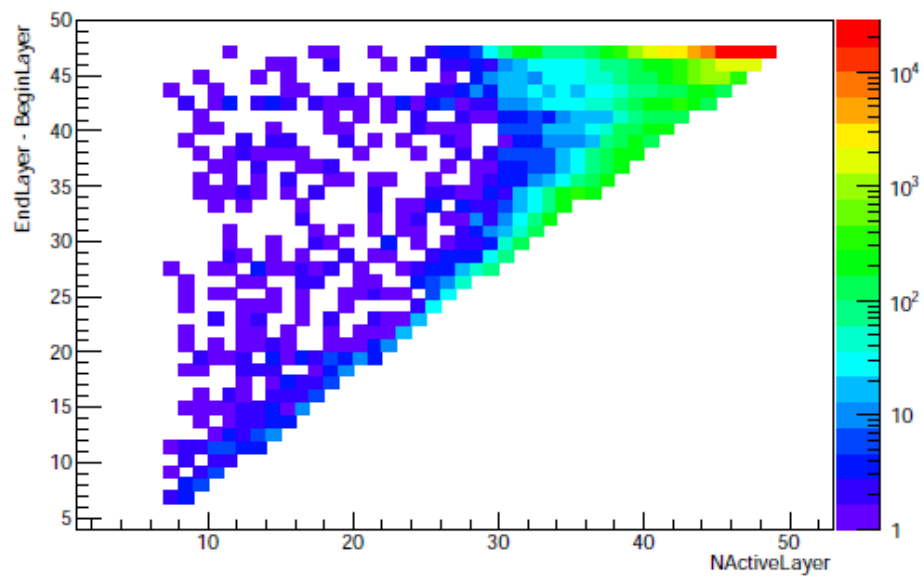
Beam MIP: Multiplicity & Efficiency Measurement





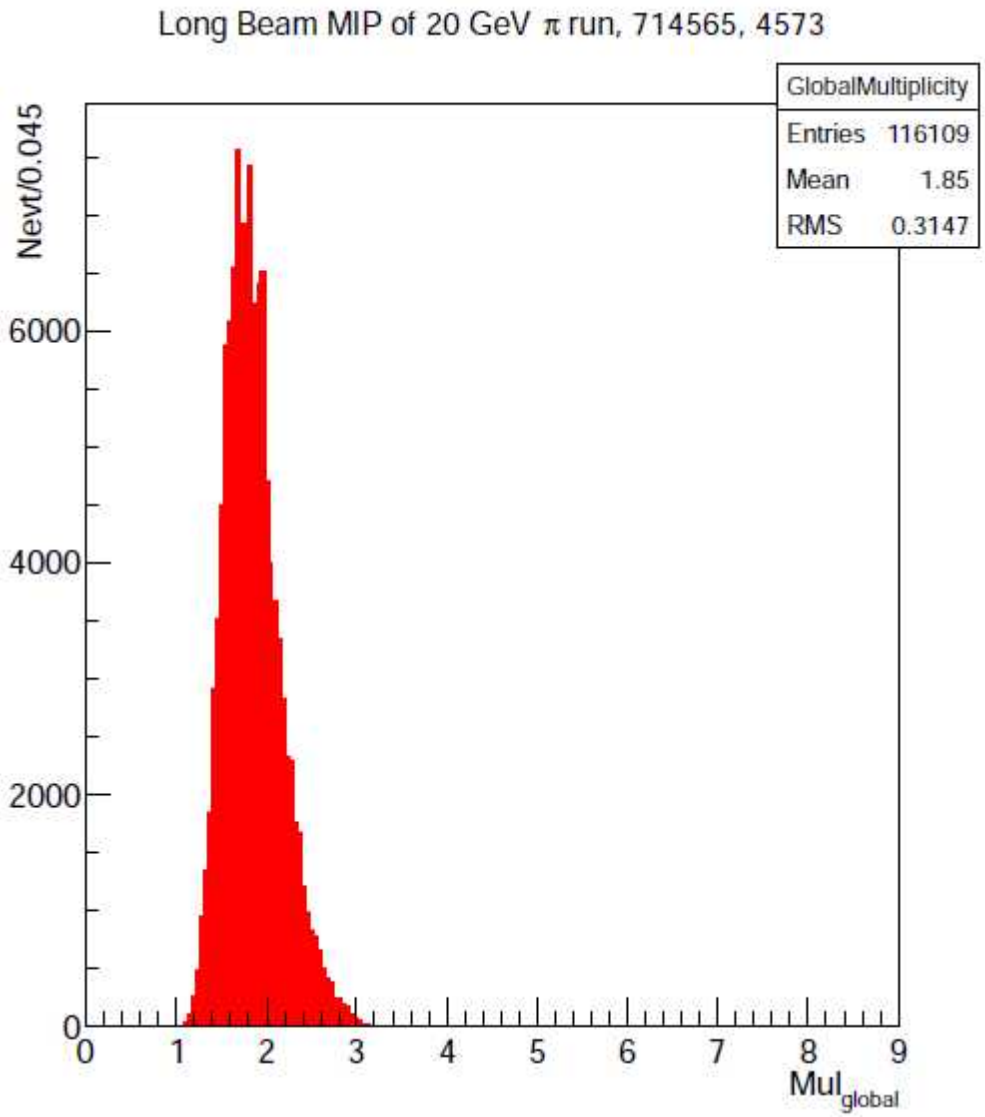
Beam MIPs of 20GeV Pion Run: 714565, 714573

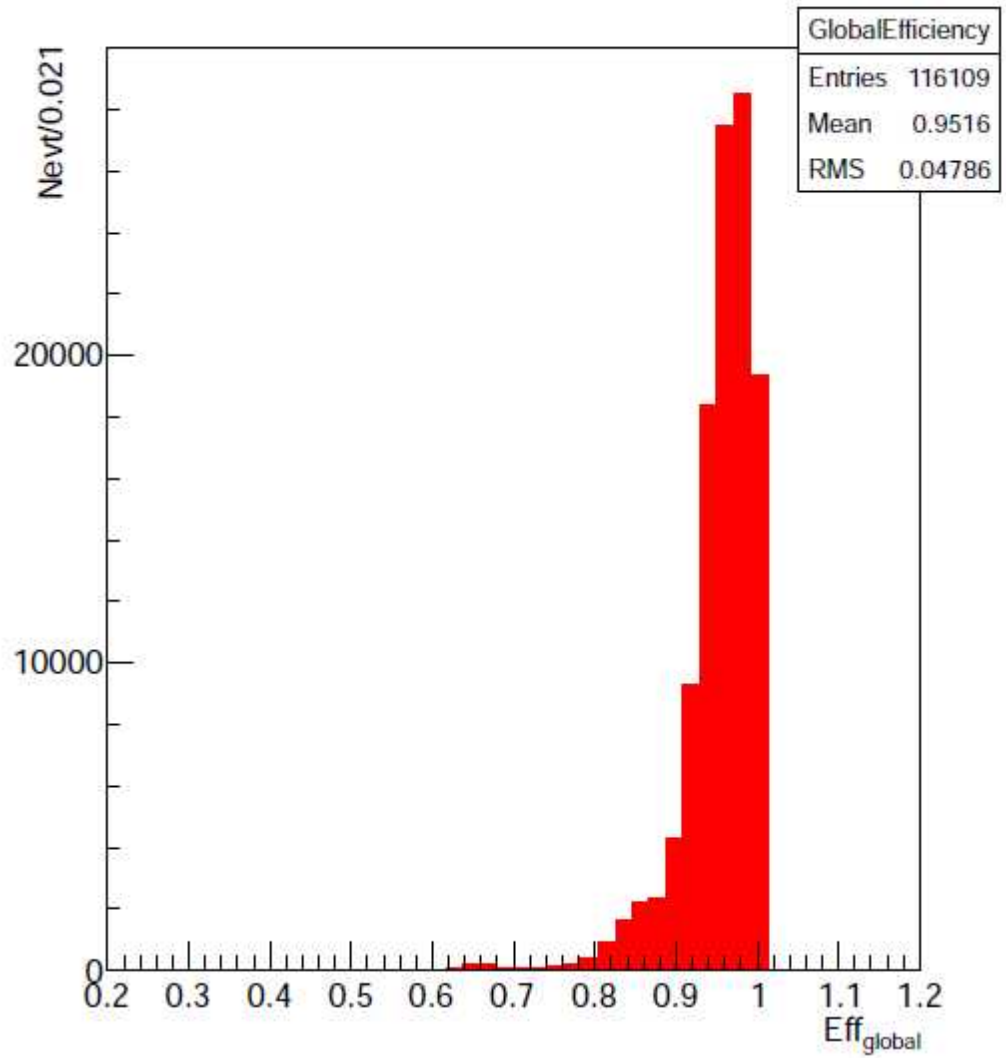




Long Beam MIP events: Hit First and Last Layer. 84.8% of Beam MIP events

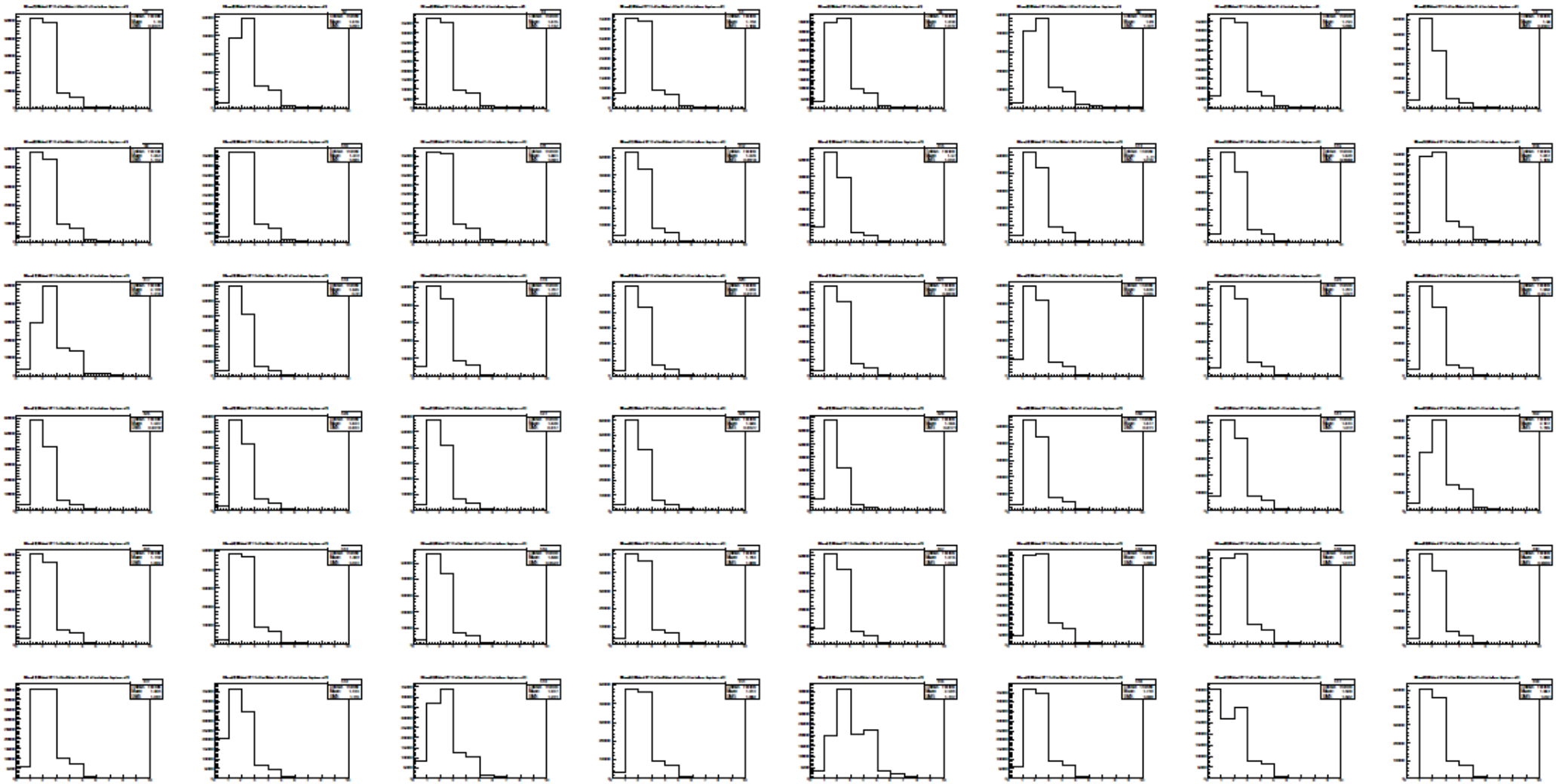
Global Efficiency & Multiplicity from long Beam MIP in Run 714565, 714573



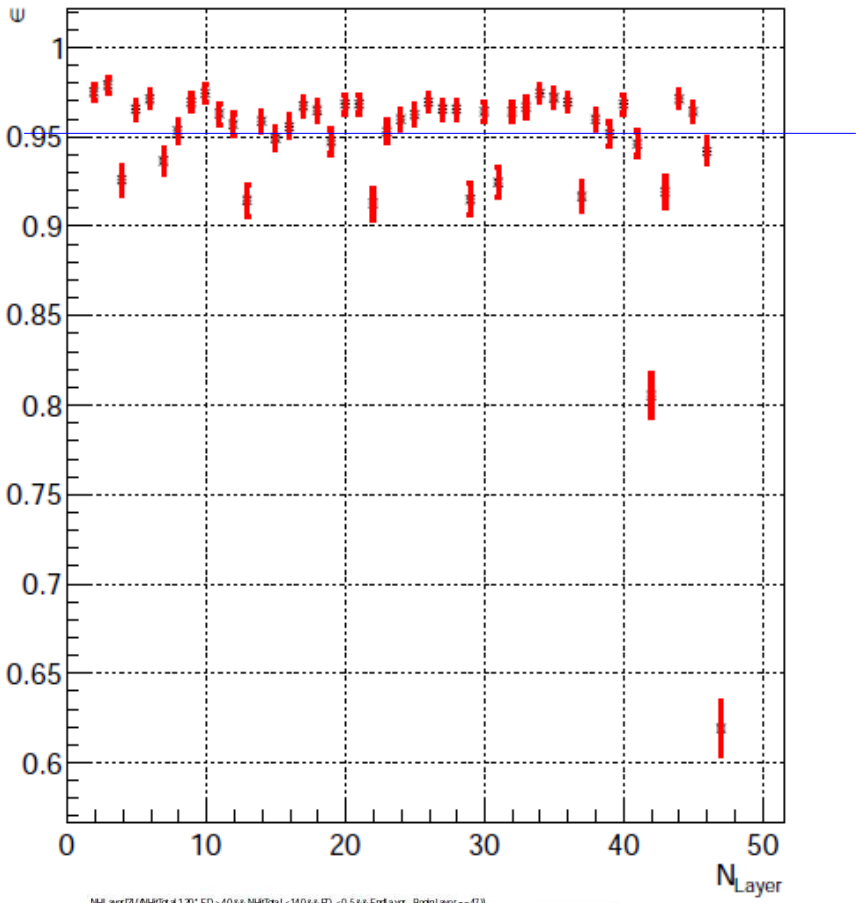


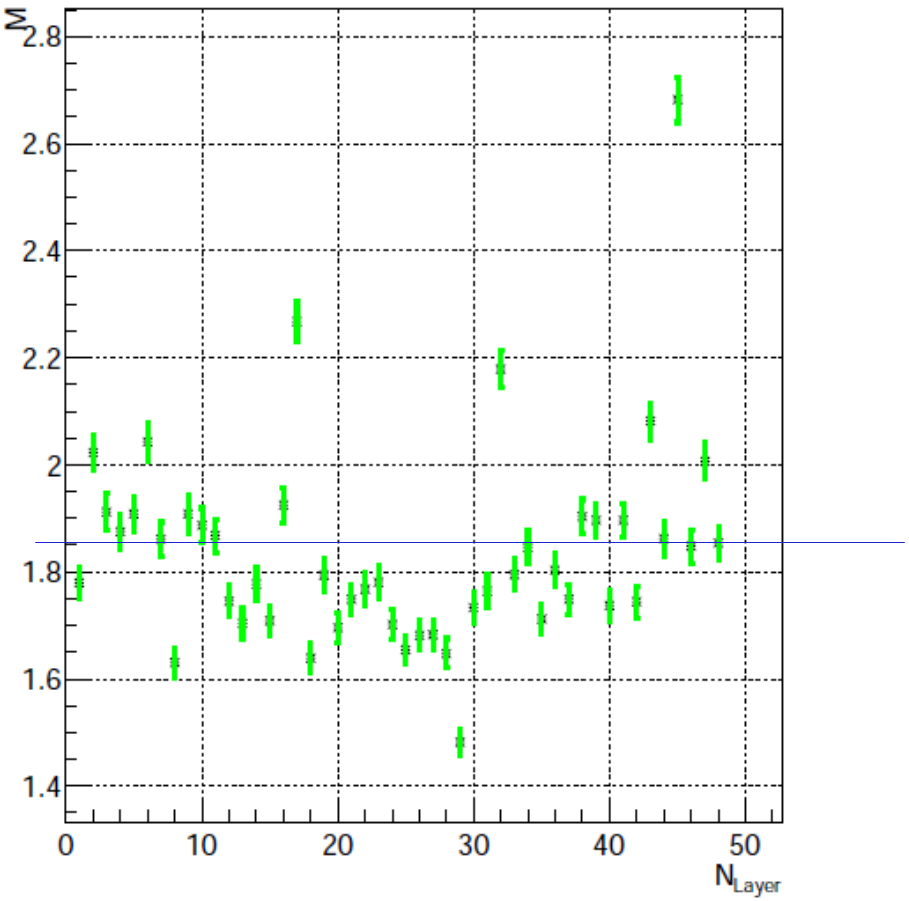
Global Multiplicity = Nhit/NFiredLayer
Global Efficiency = NfiredLayer/48 (Since first and last layer are requested to be fired)

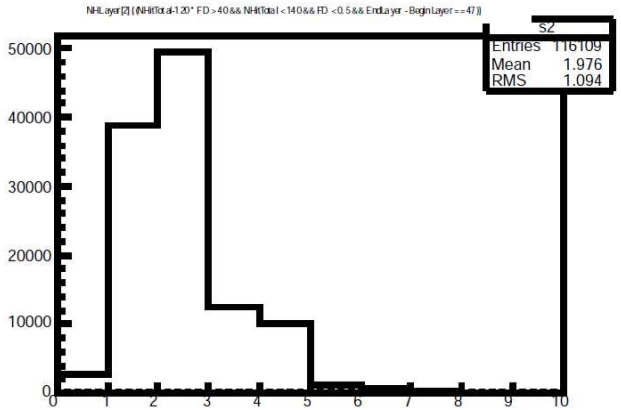
Number of Hits per layer



Efficiency & Multiplicity Per Layer Measured from long Beam MIP in Run 714565, 714573



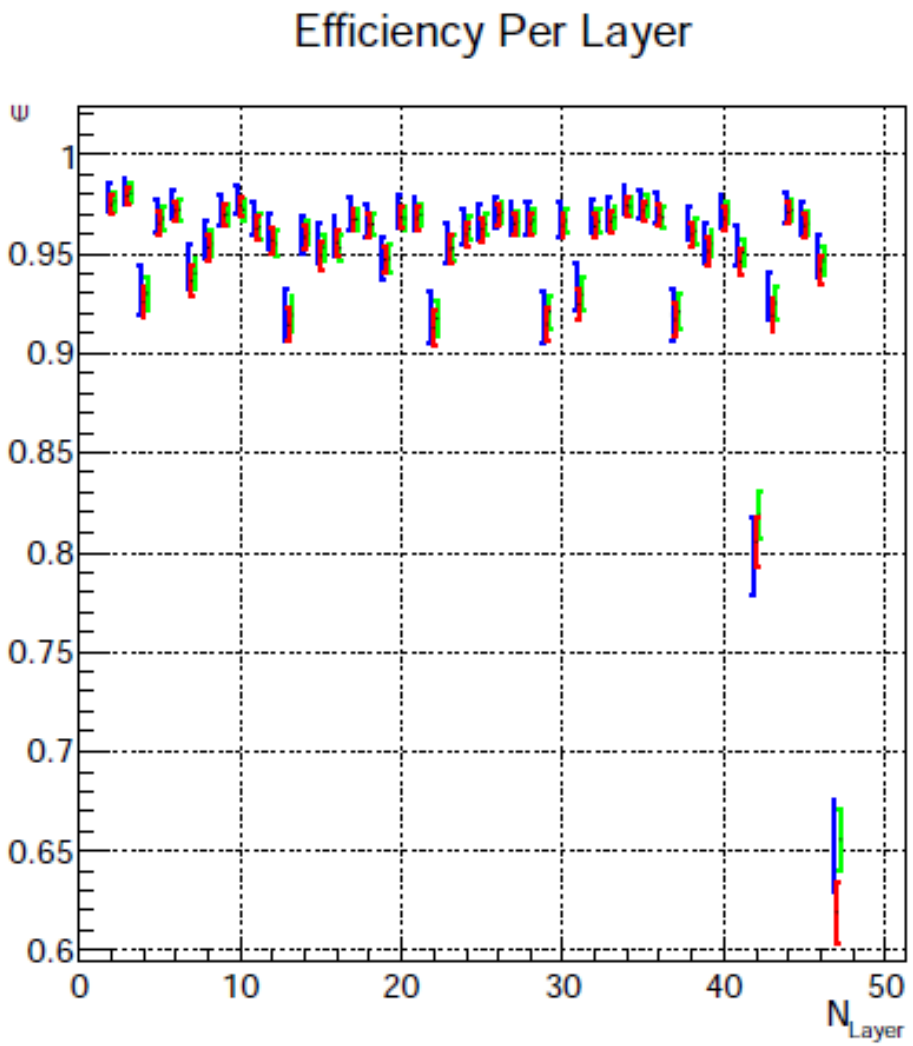


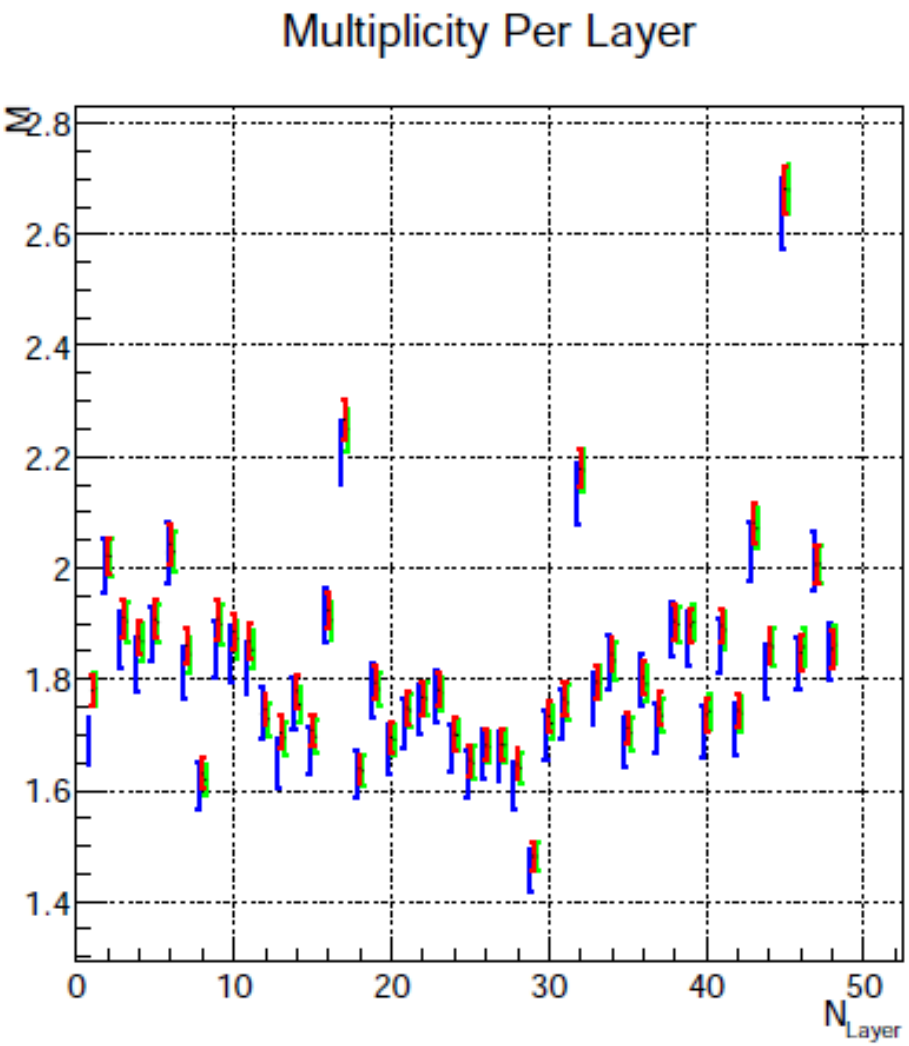


Negligible statistic error (Nevt = 106109).
error bar scaled for 10 times.

Eff = 1 – Nevt(0-hits)/Nevt(total)
EffErr = sqrt(eff*(1-eff)/Nevt)
Mul = <Nhits (Nevt (>0 hits)) >
MulErr = RMS(Mul)/sqrt(Nevt)

Efficiency & Multiplicity: Stability

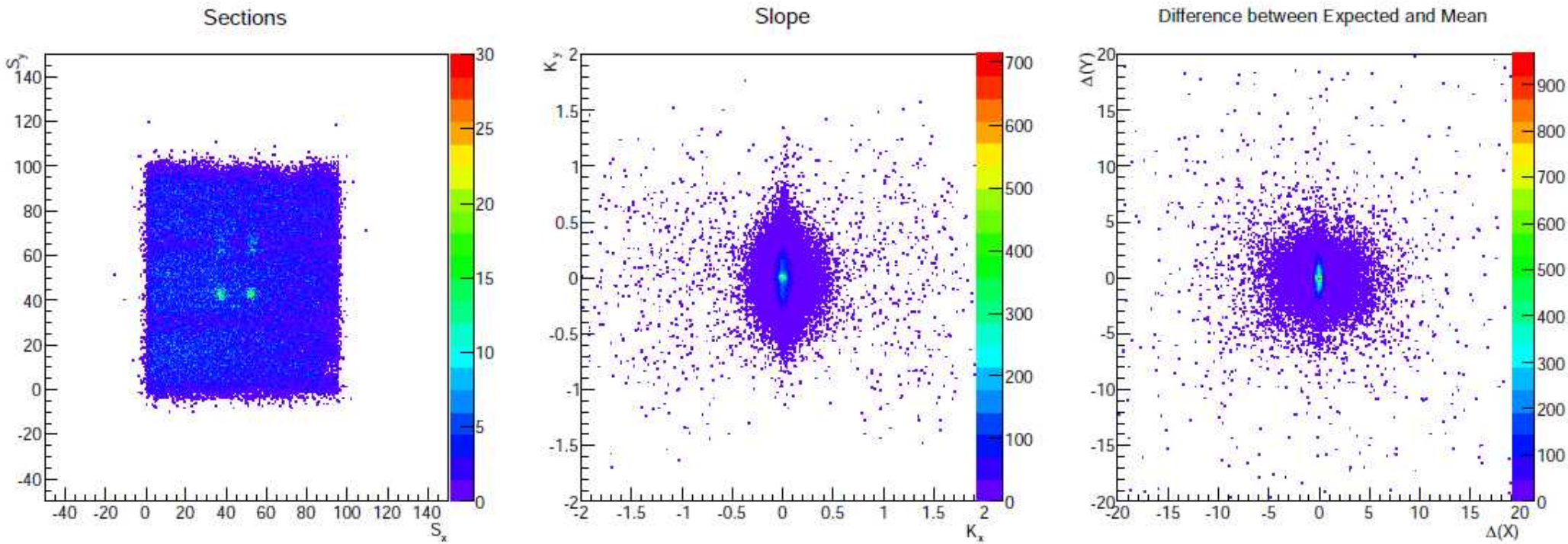




Stable with sensible fluctuation (error bar scaled by 10 times)
15 GeV Pion (714439, 4441): 43797 long beam mip evts
20 GeV Pion (714565, 4573): 103109 evts
60 GeV Pion (714551, 4552, 4553): 98960 evts

Effi & Multi Map: Uniformity

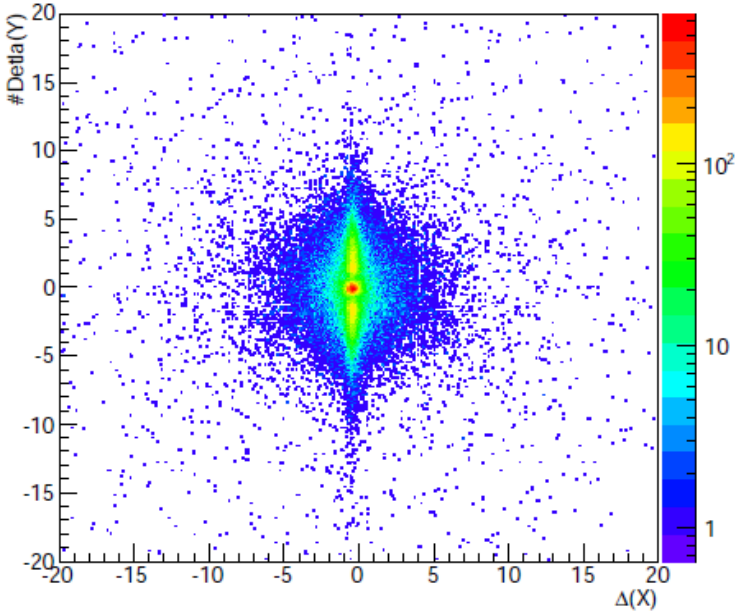
- Straight line fit on indexs without cleaning: I = Kx*K + Bx, J = Ky*K + By



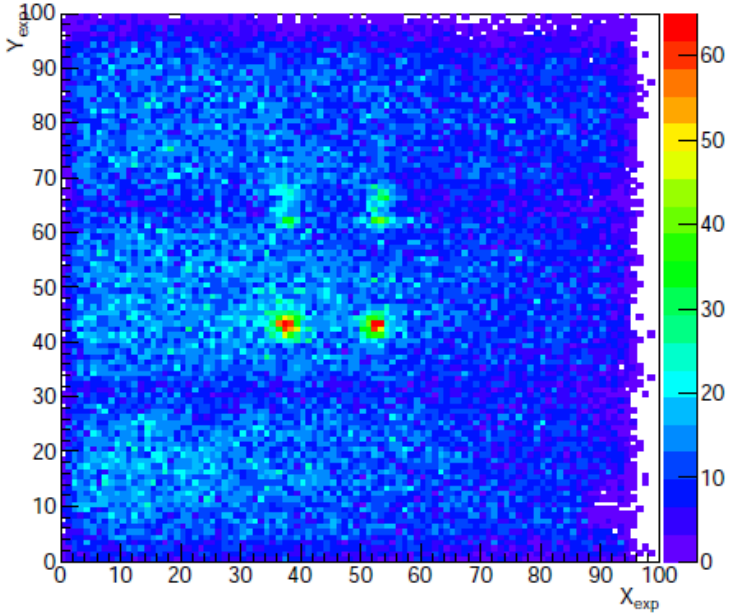
- 98960 long Beam MIPs at 60 GeV Pion Run (714551, 4552, 4553)
- Larger residual in Y direction: prototype deformation (self weight) + wrong DIP mapping in last layer
- To be updated with cleaning & more statistics

Effi & Multi Map: Method

H1



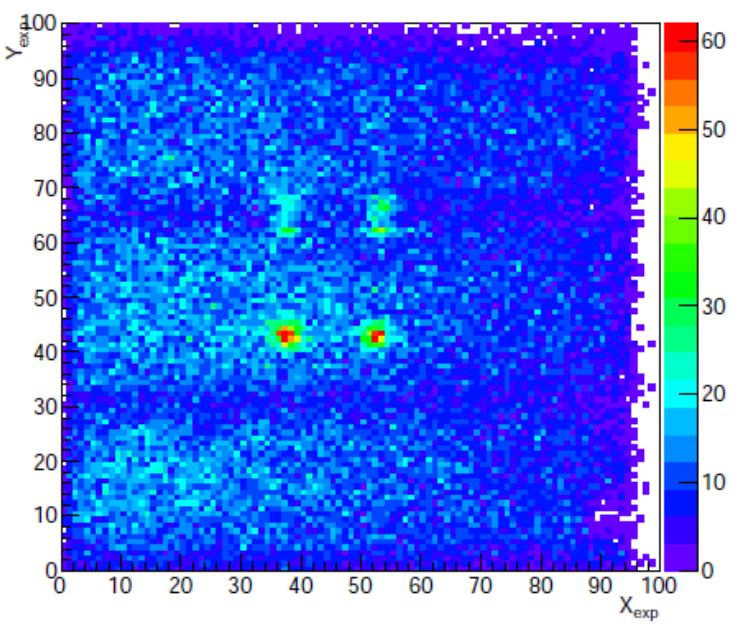
H2



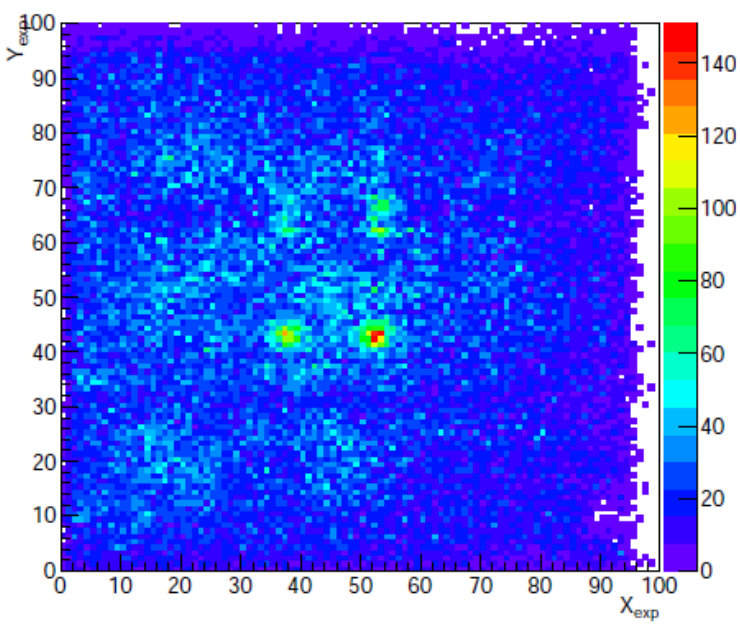
Eff(x, y) = H3/H2

Mul(x, y) = H4/H3

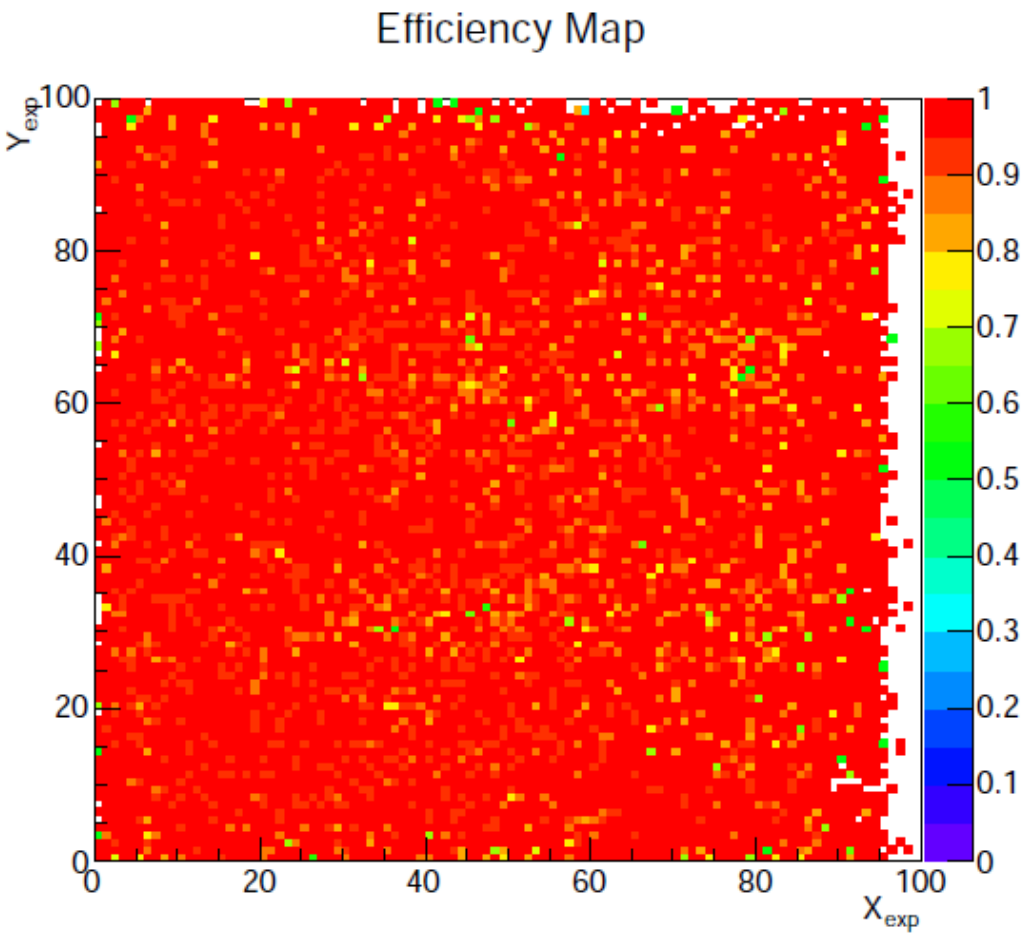
H3

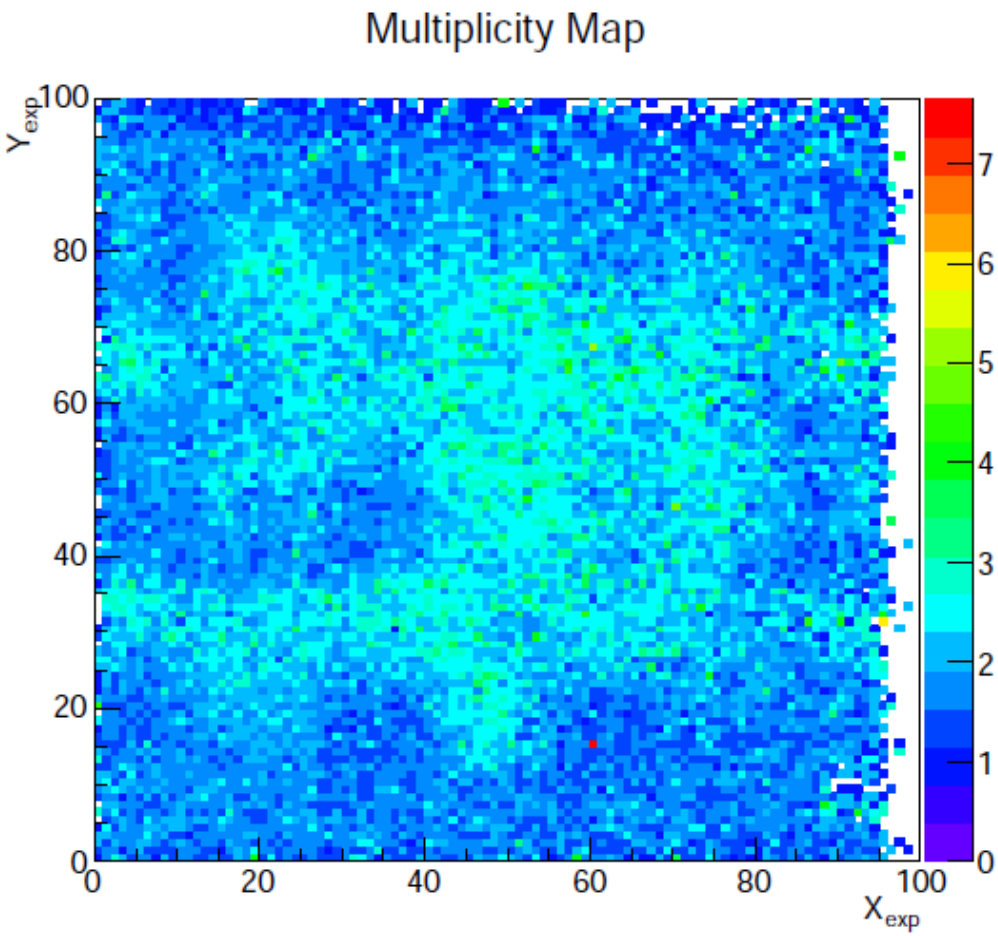


H4

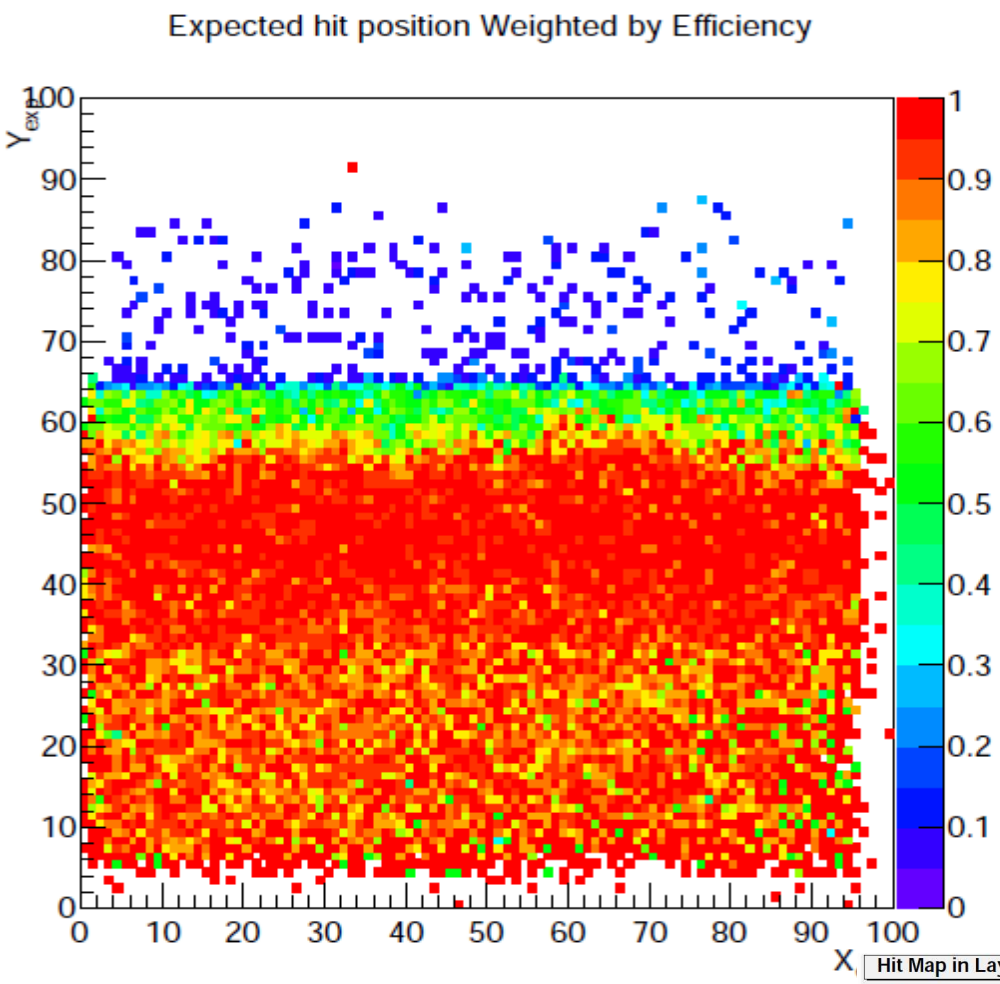


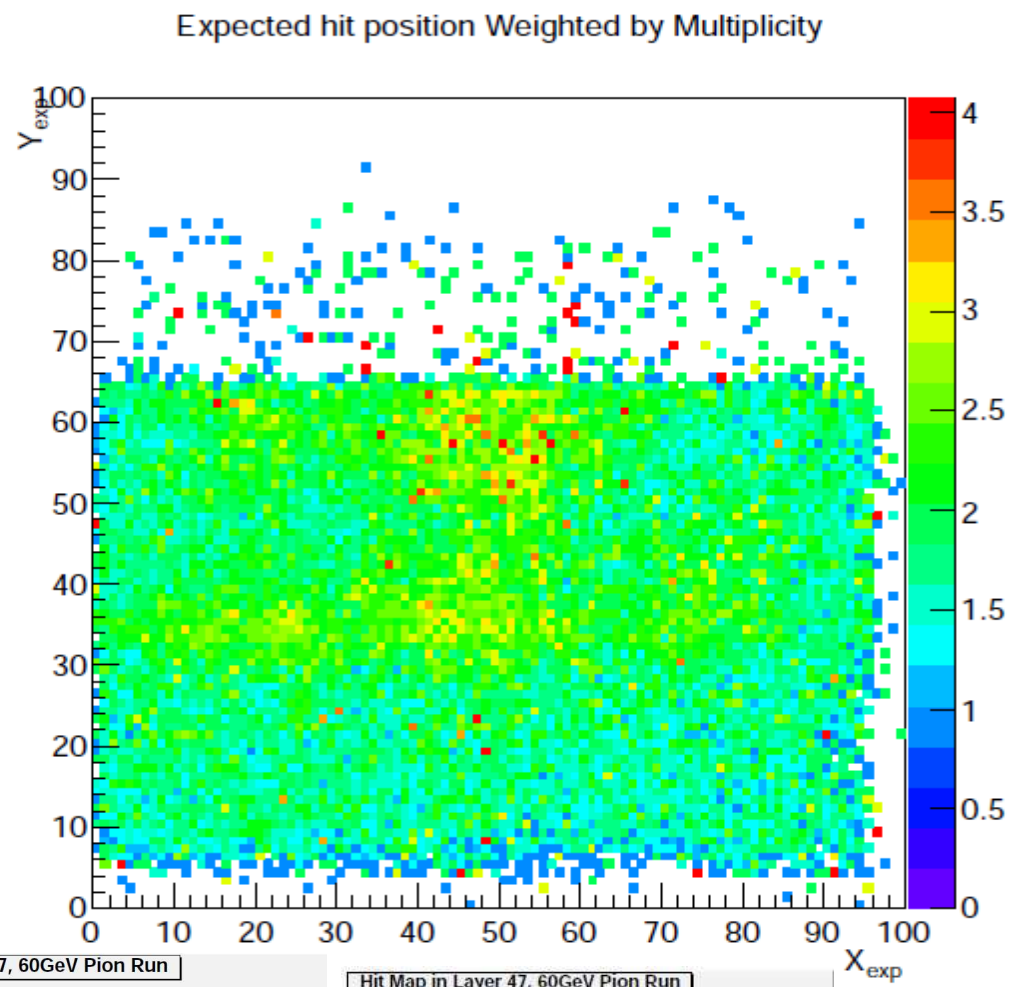
Effi & Multi Map: Layer 2



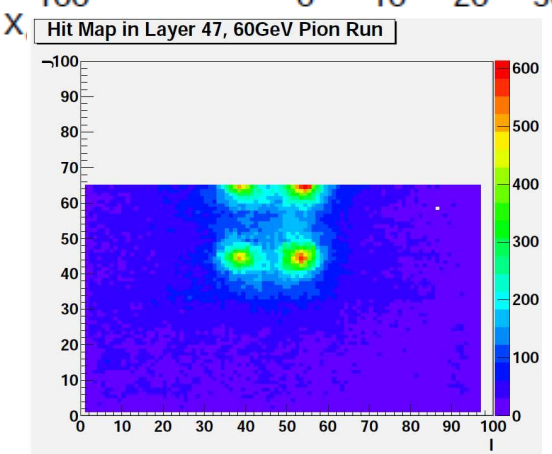


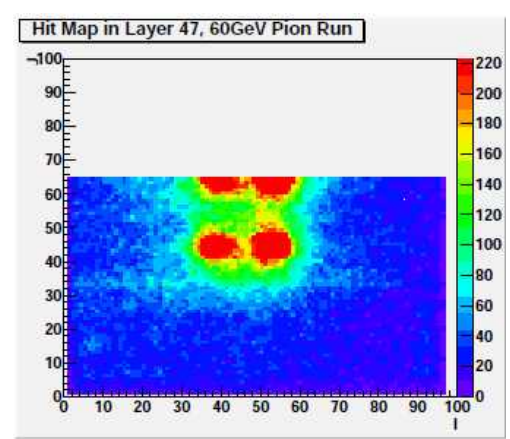
Effi & Multi Map: Layer 47



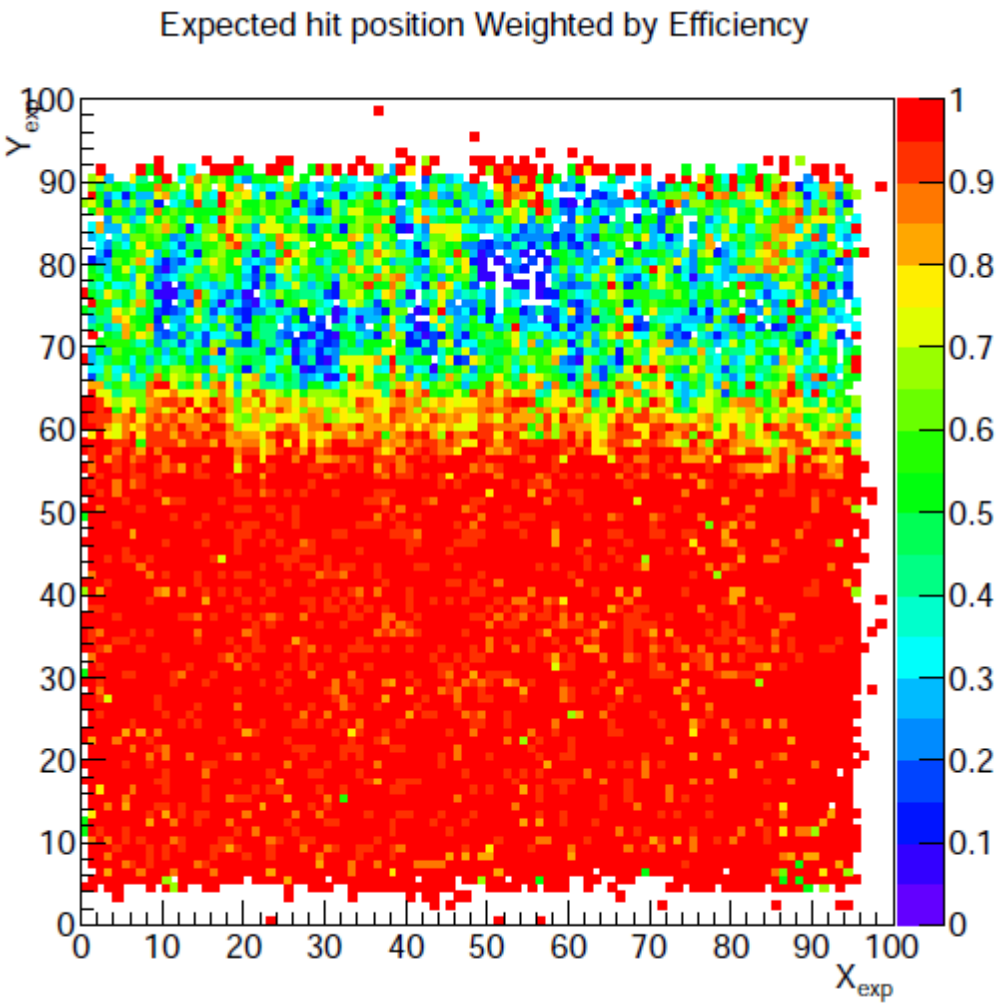


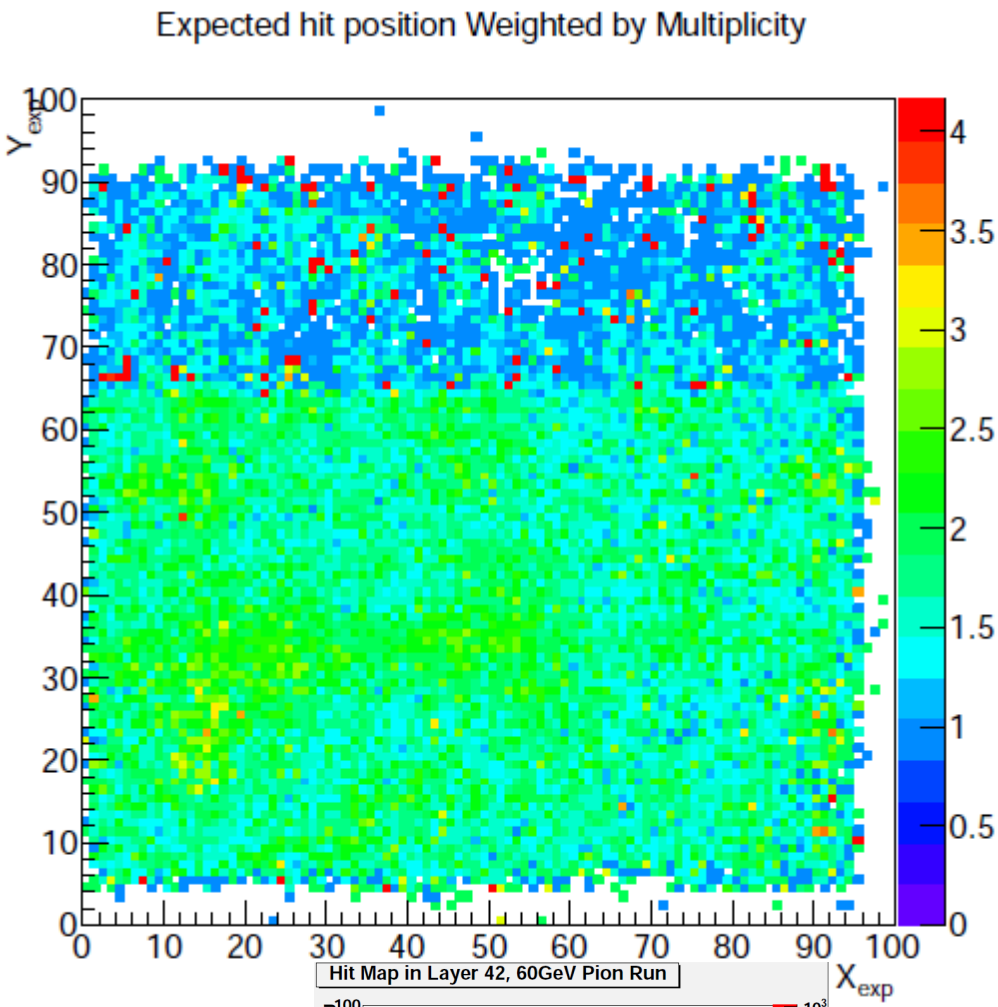
Dead DIF in layer 47



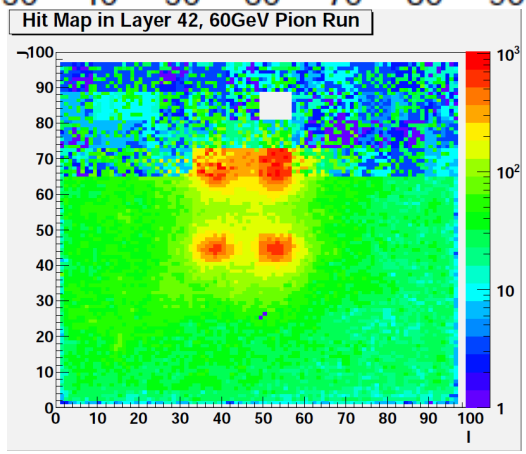


Effi & Multi Map: Layer 42

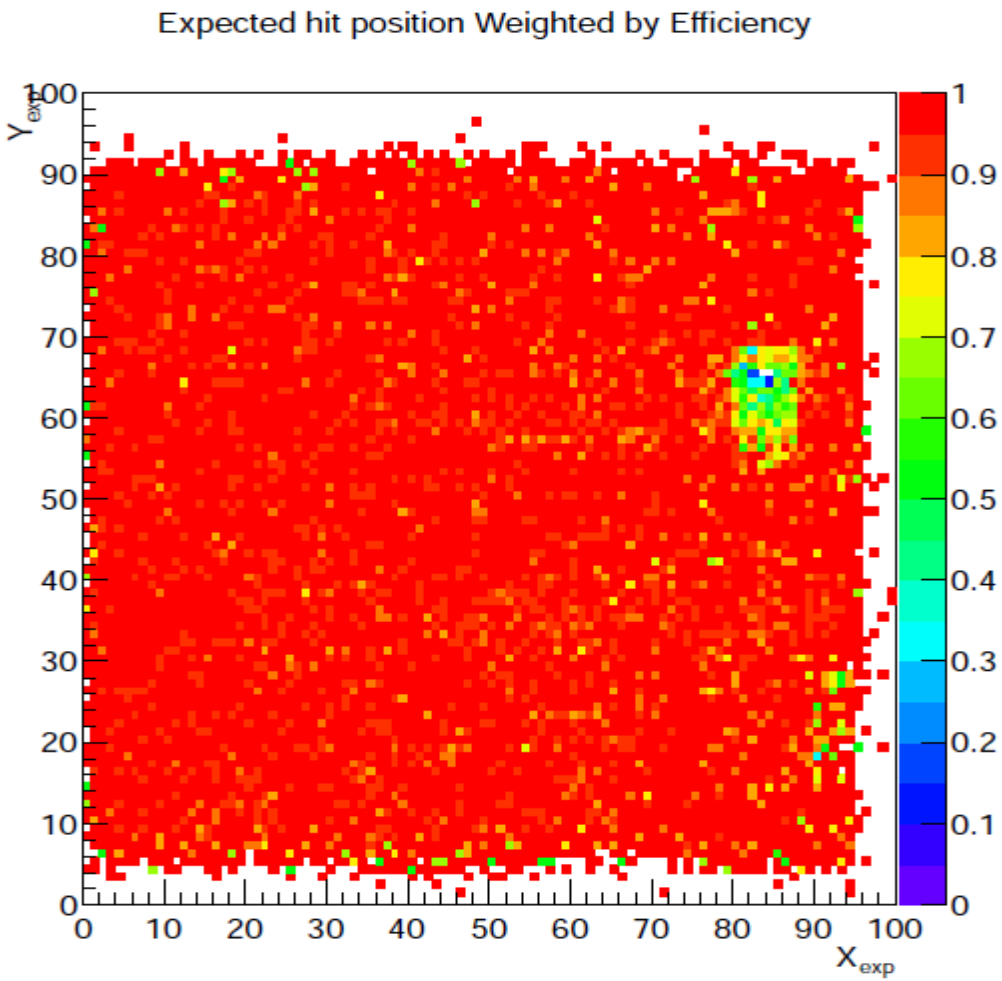


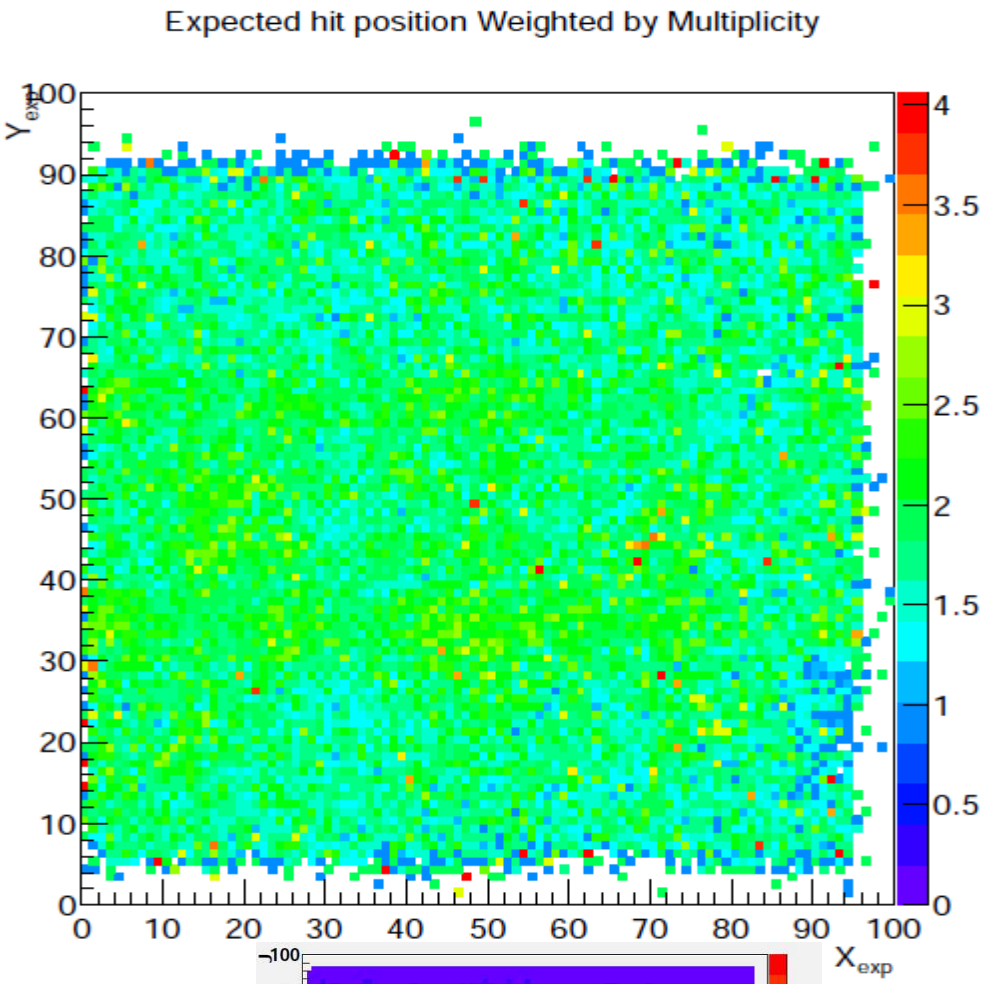


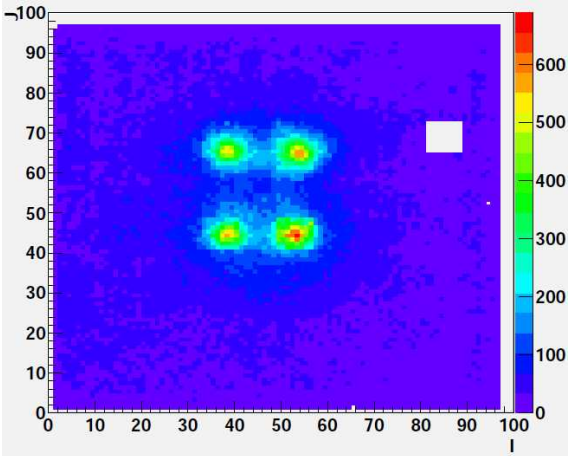
Threshold setting problem in up DIF in layer 42



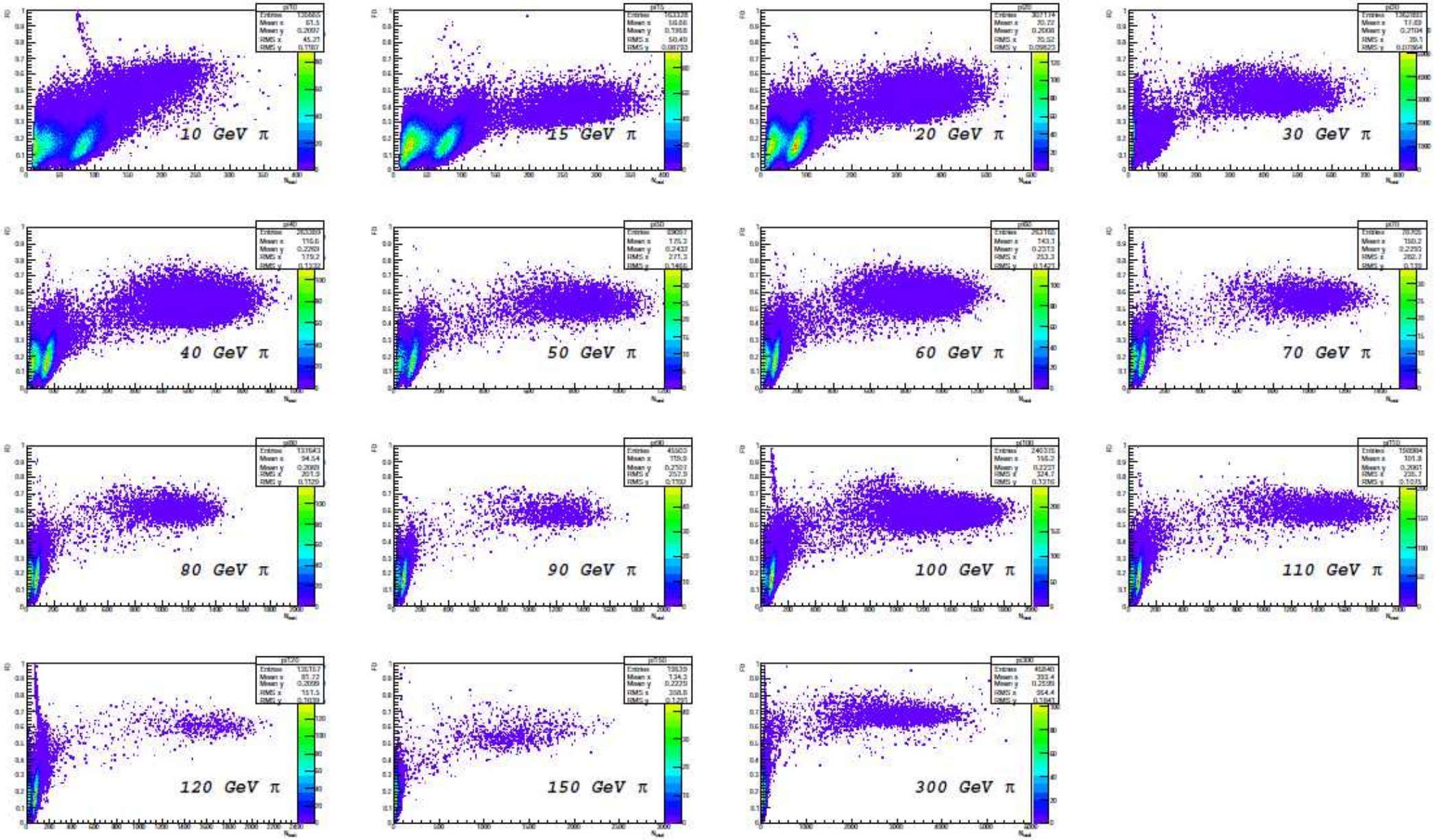
Effi & Multi Map: Layer 44

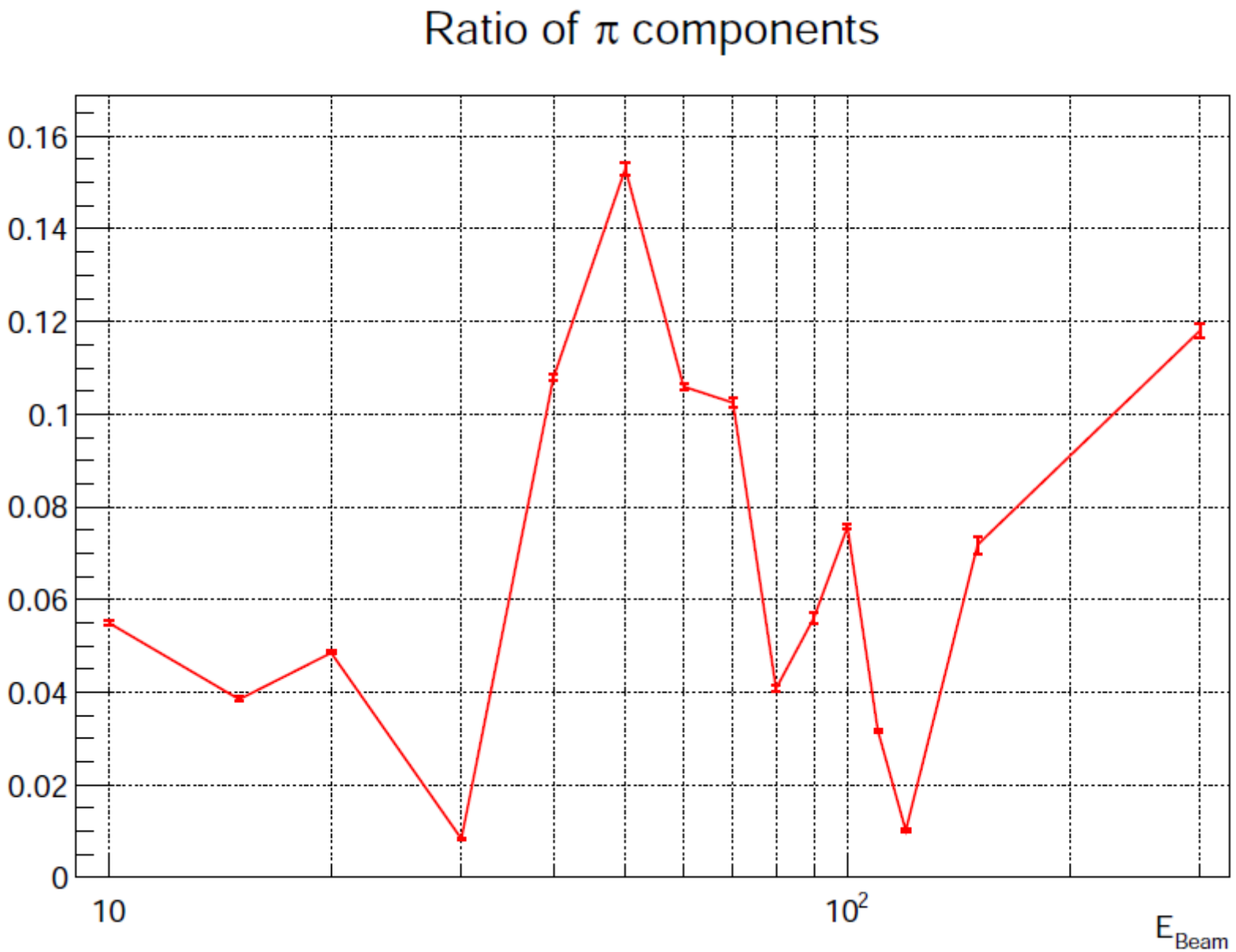






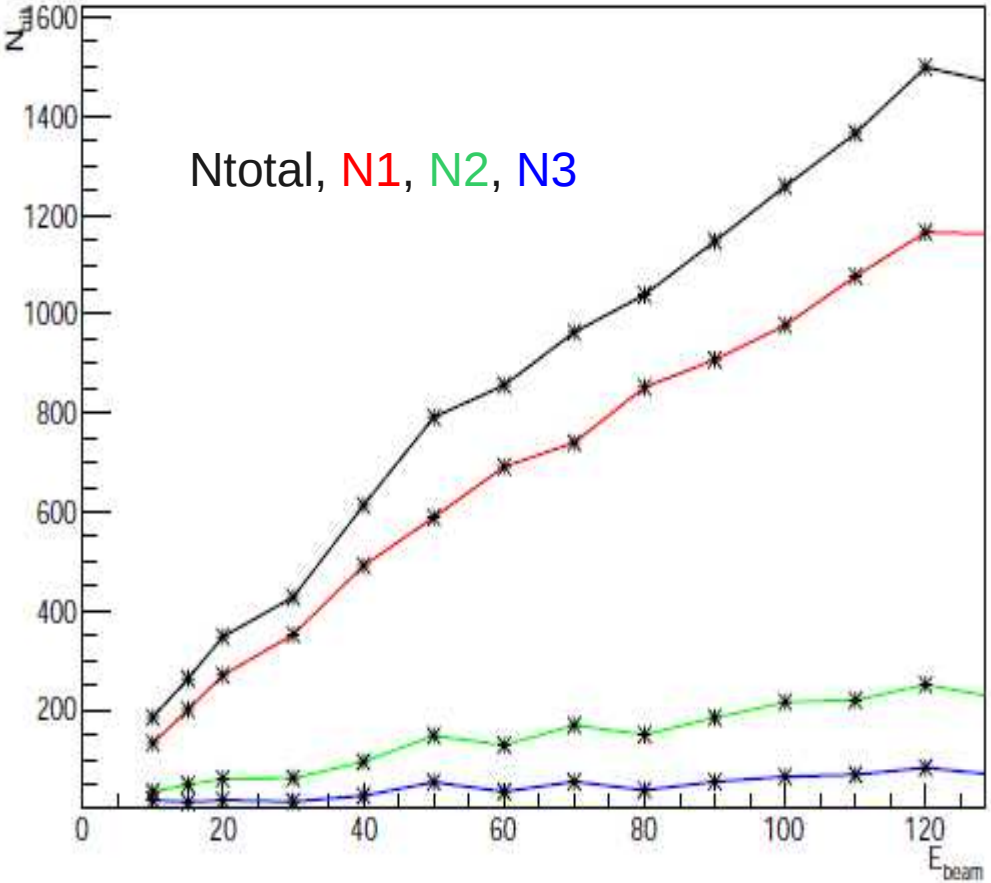
Selection of Pion components:

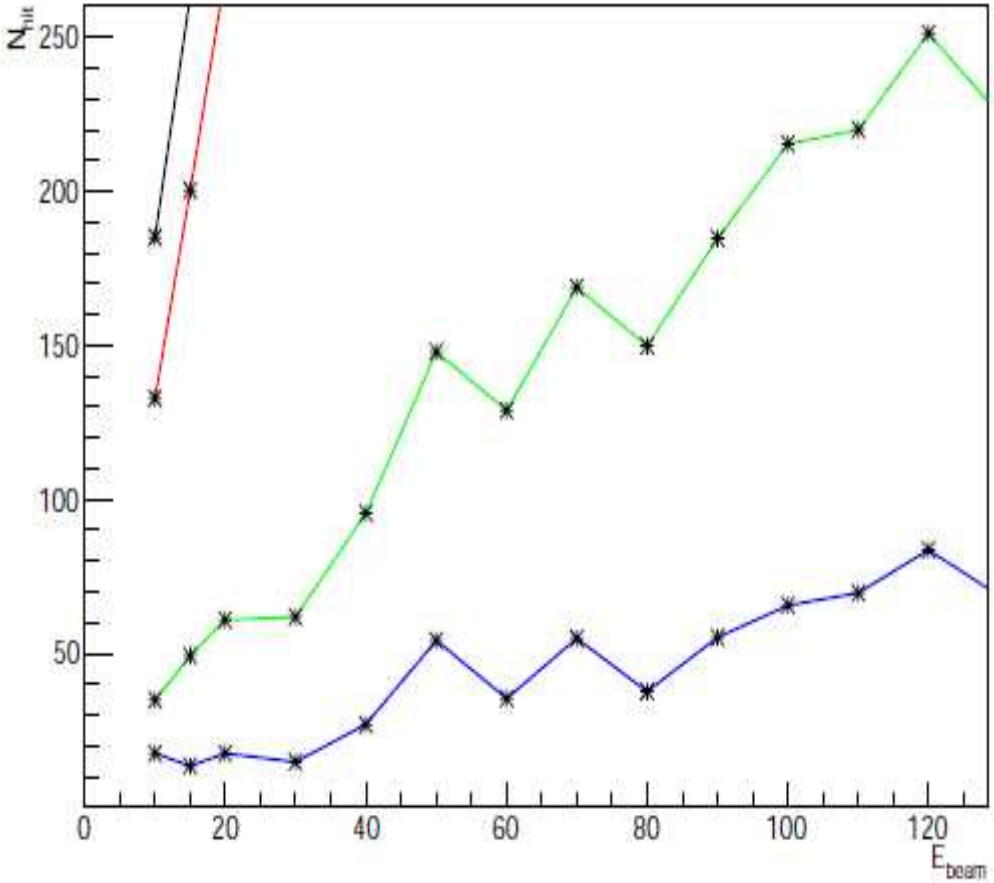




Next Test Beam: defocusing beam spot, get more em/had statistic
Remark: significant cosmic component (~50%).
Beam composition percentage should be boosted by ~ 2.

NHit of Pion Run





Saturation...

Correlated fluctuation and constant term in N2, N3

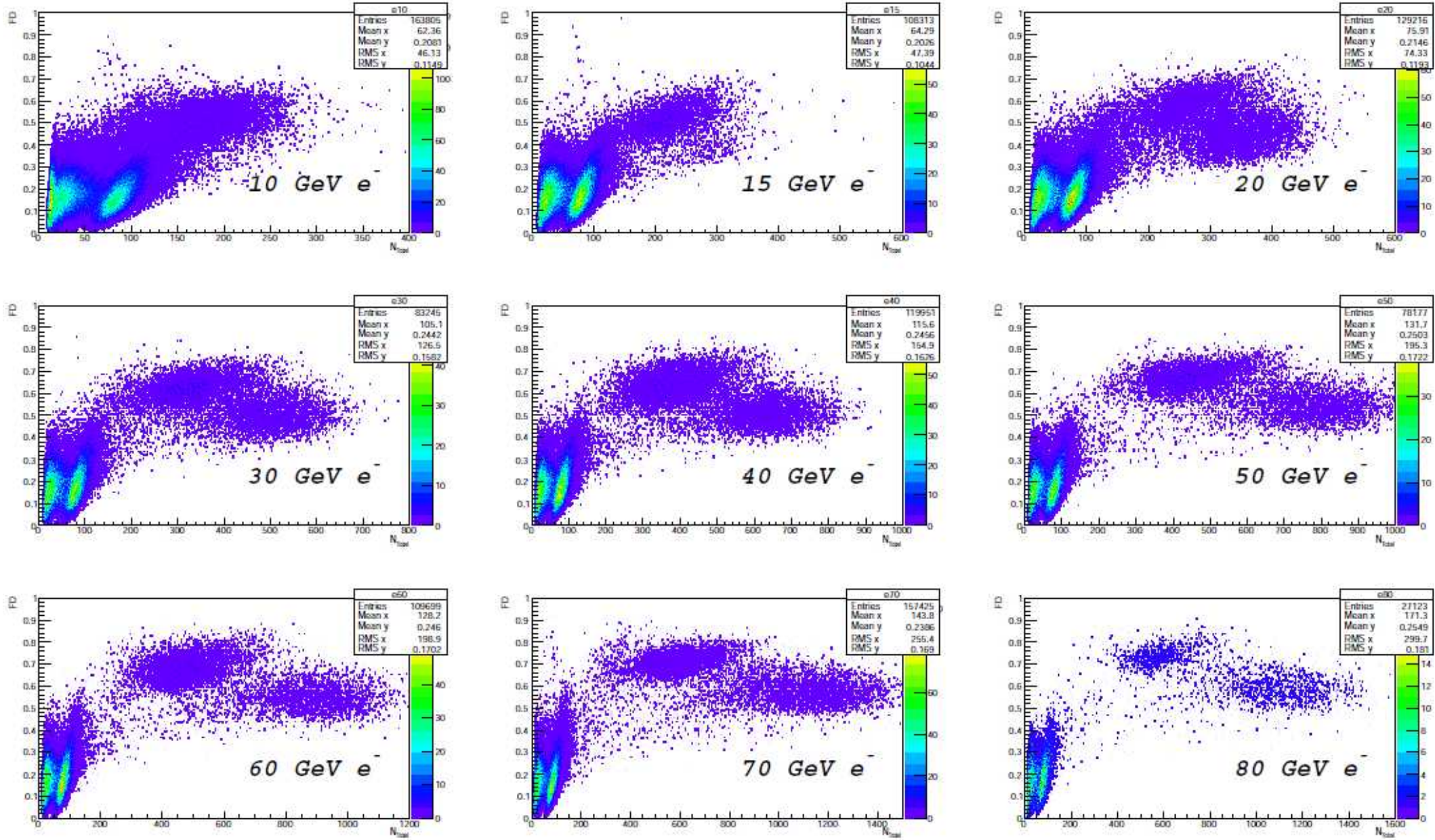
#Nhits of 50GeV Run significantly boosted : correlated with nhits increase for beam MIP components?

Electron Runs

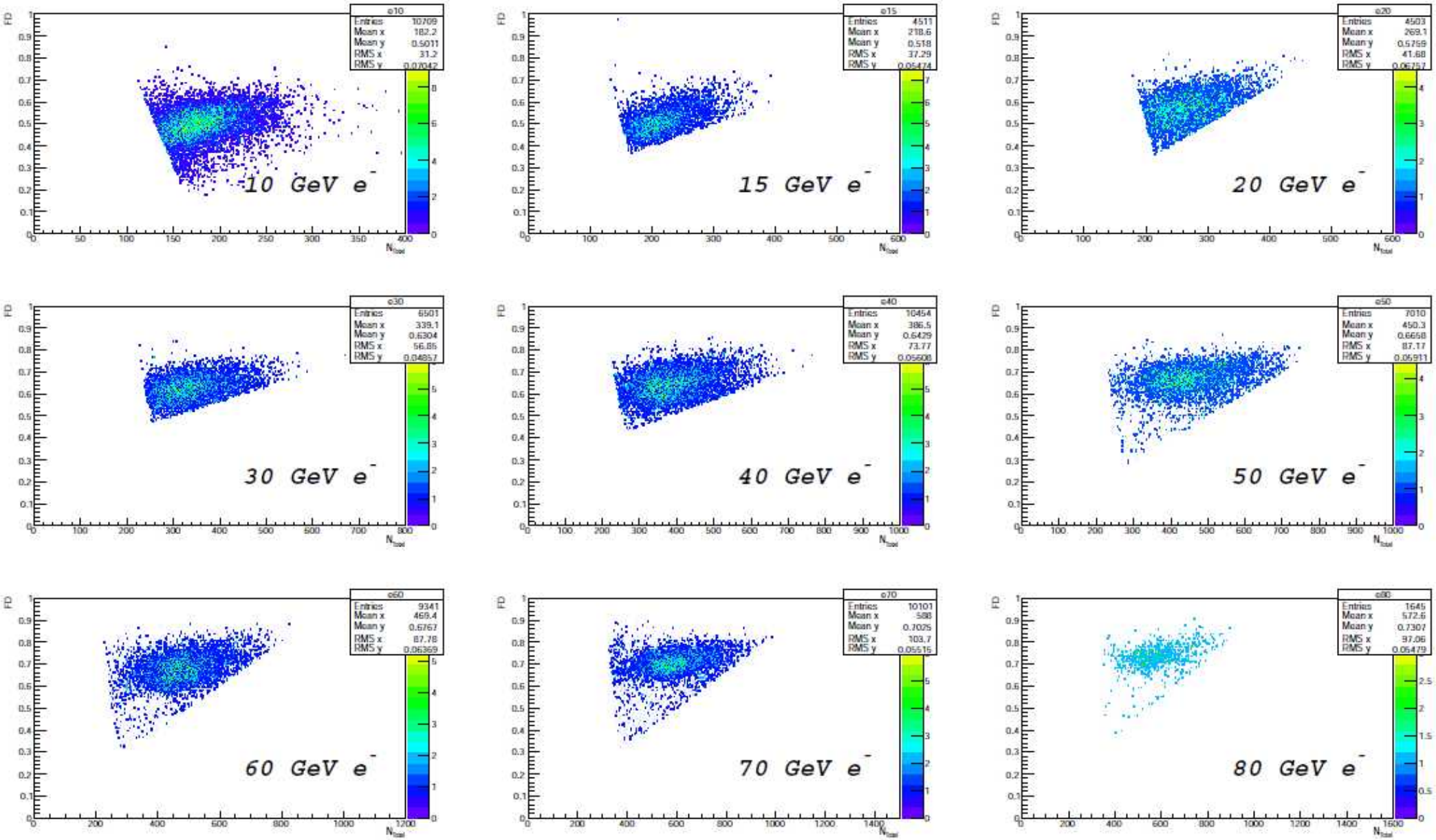
- 10 GeV: 714481, 4692
- 15 GeV: 714474
- 20 GeV: 714576
- 30 GeV: 714614
- 40 GeV: 714593
- 50 GeV: 714613
- 60 GeV: 714594
- 70 GeV: 714693, 4694
- 80 GeV: 714611

HV = 6.9kV
Thresholds: 170, 500, 345

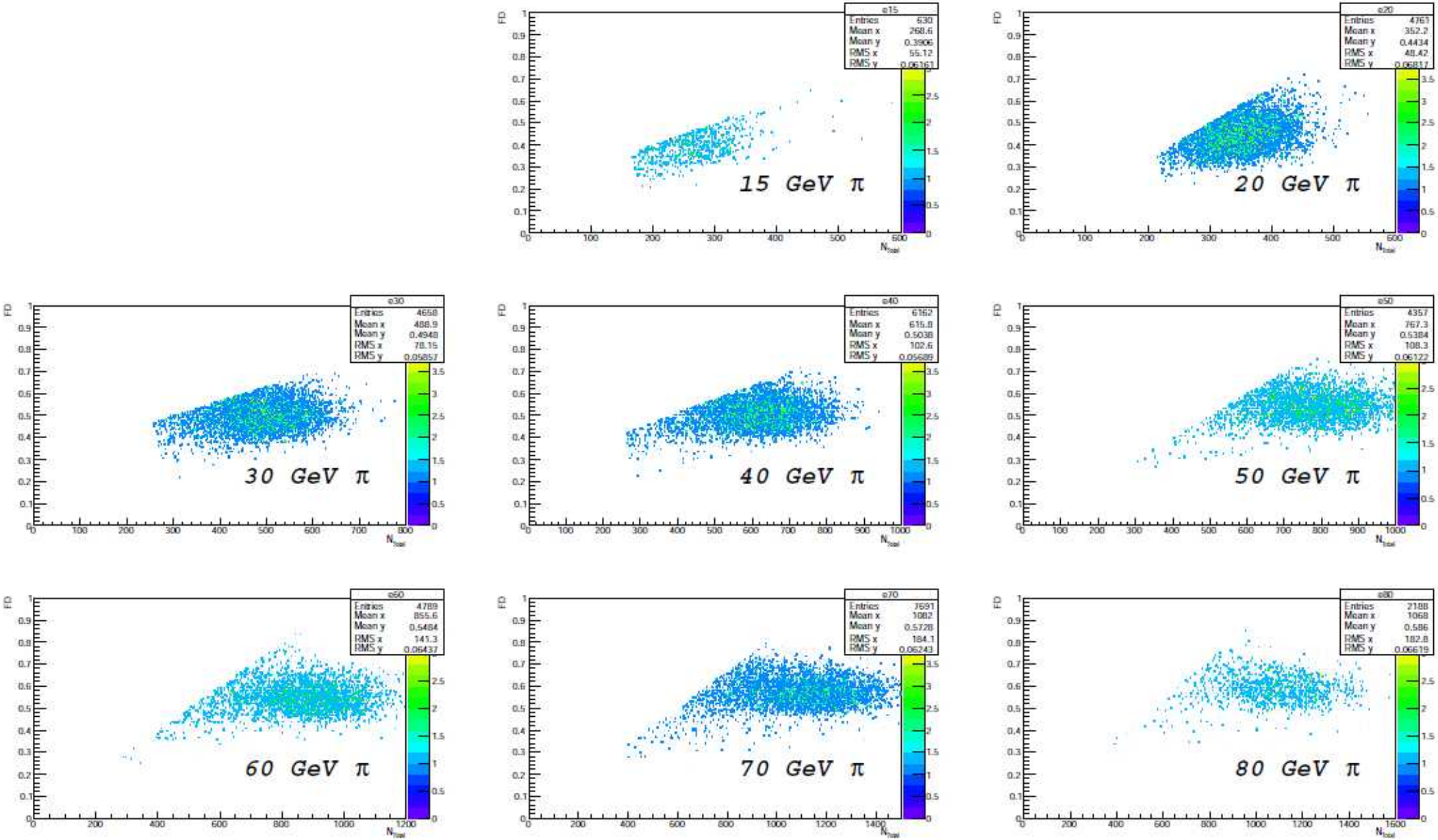
Nhit Vs FD

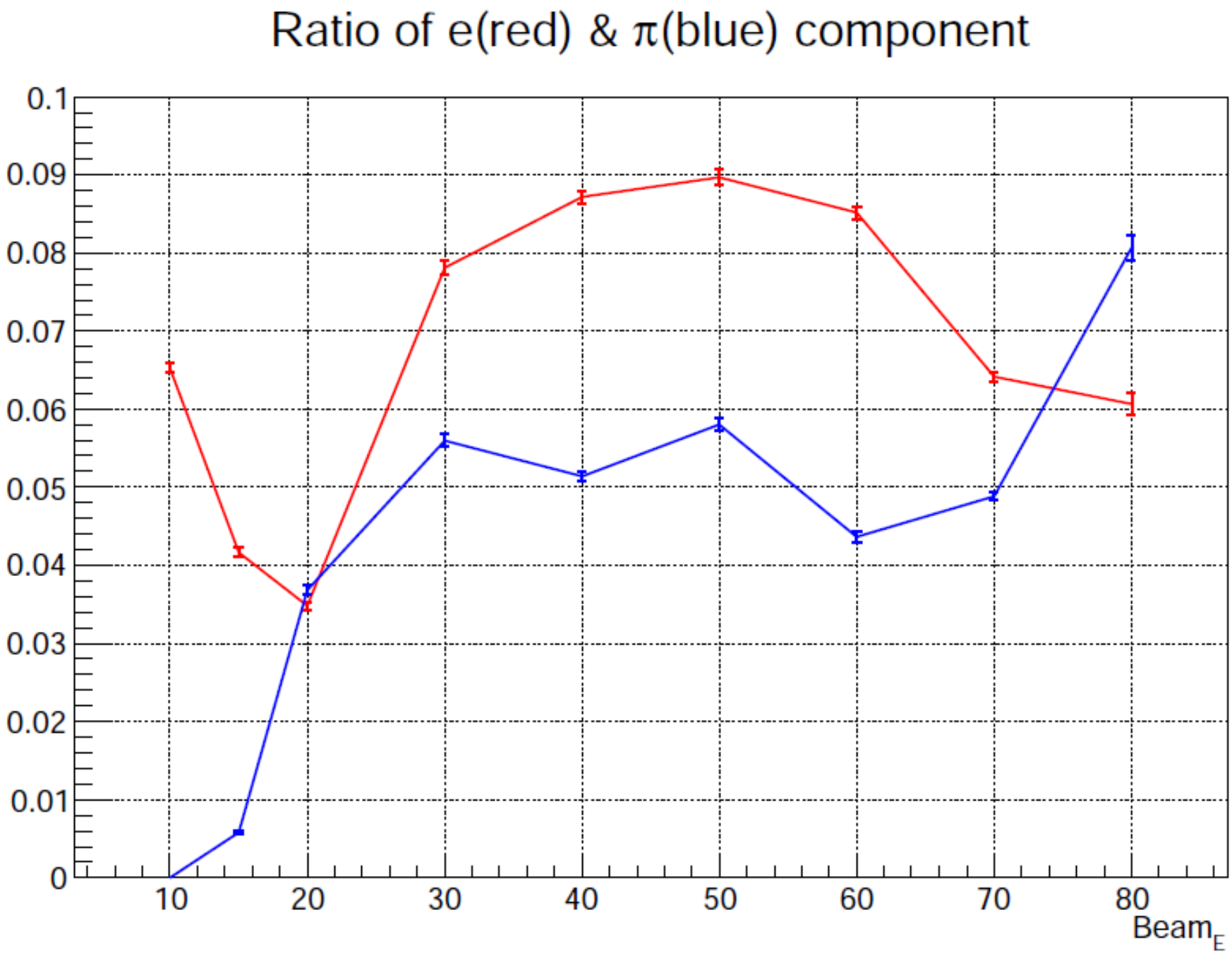

10 GeV e⁻
15 GeV e⁻
20 GeV e⁻
30 GeV e⁻
40 GeV e⁻
50 GeV e⁻
60 GeV e⁻
70 GeV e⁻
80 GeV e⁻
FD
N_total

Cut based electron selection



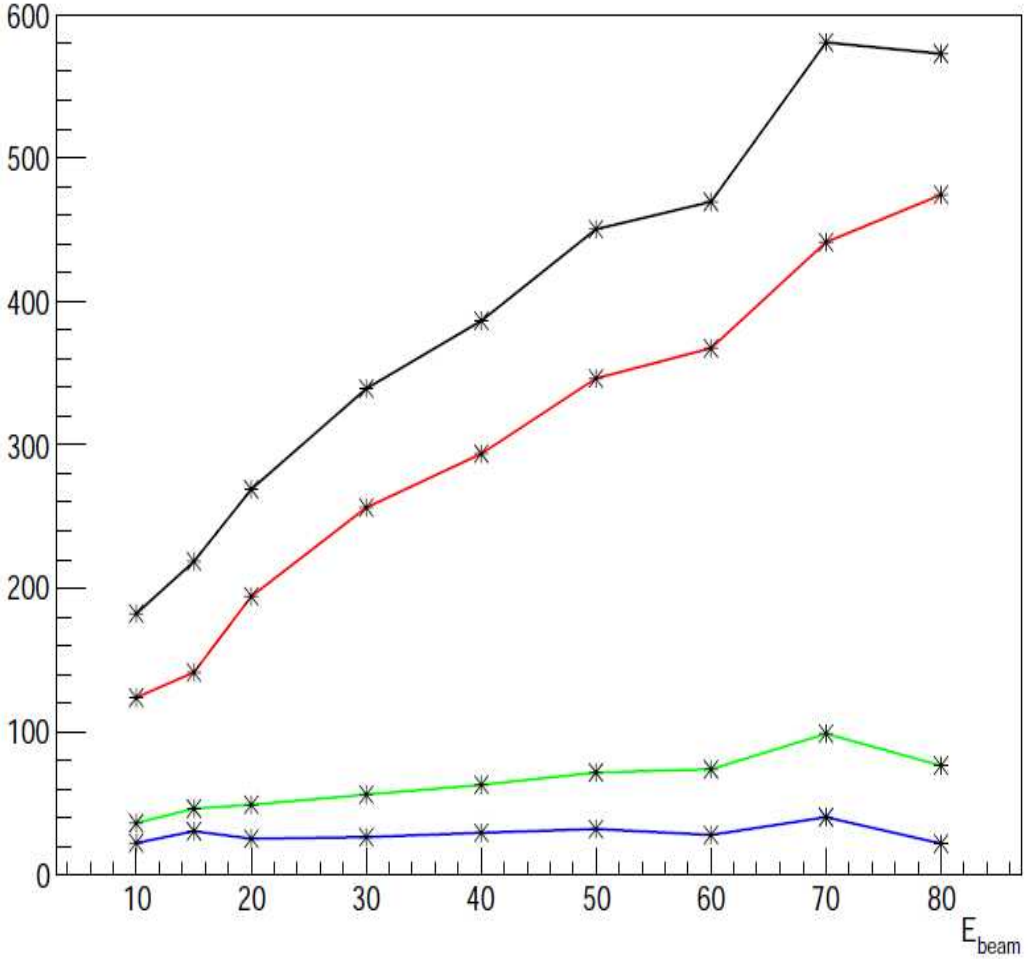
Cut based pion selection

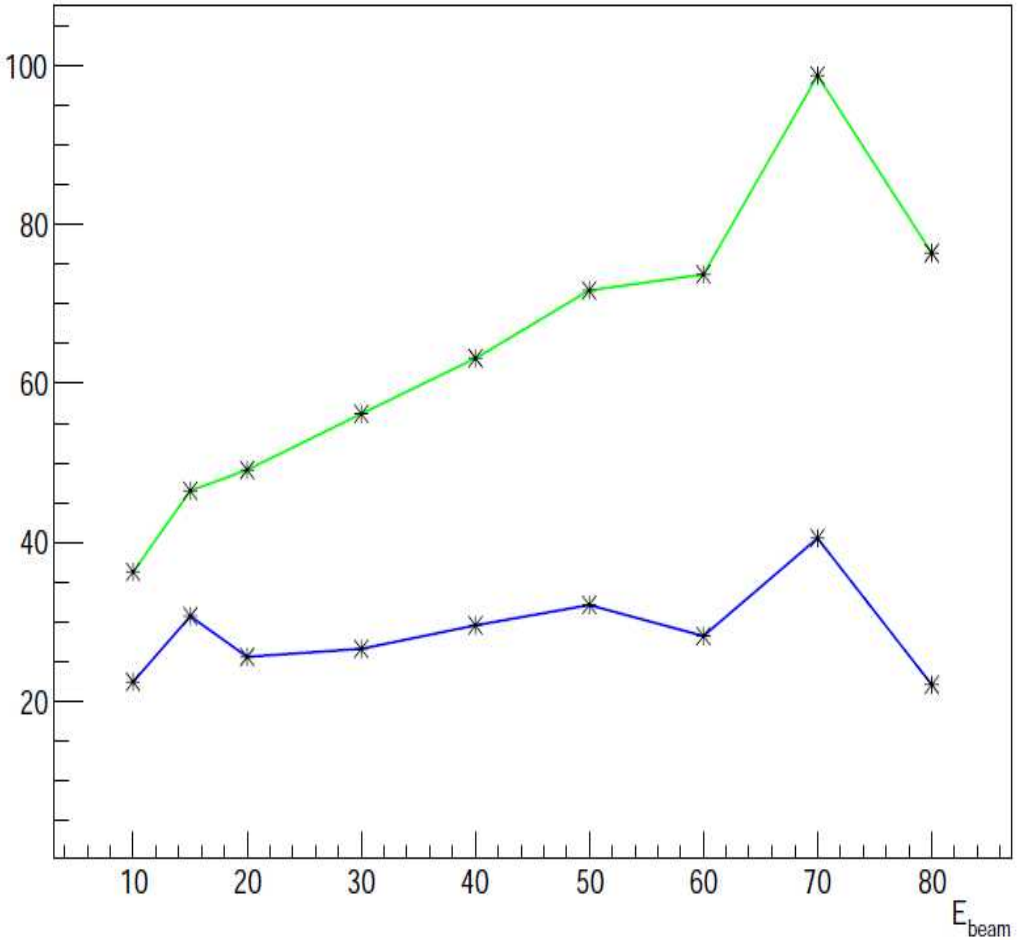




EM/Had percentage: Need to be improved for next test beam!

NHit of Electron Run



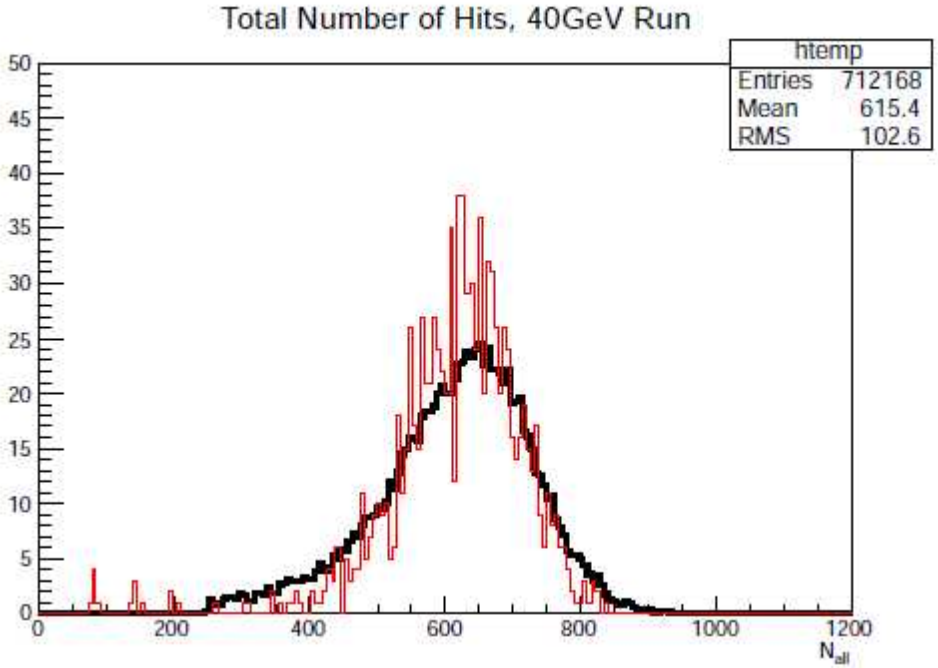


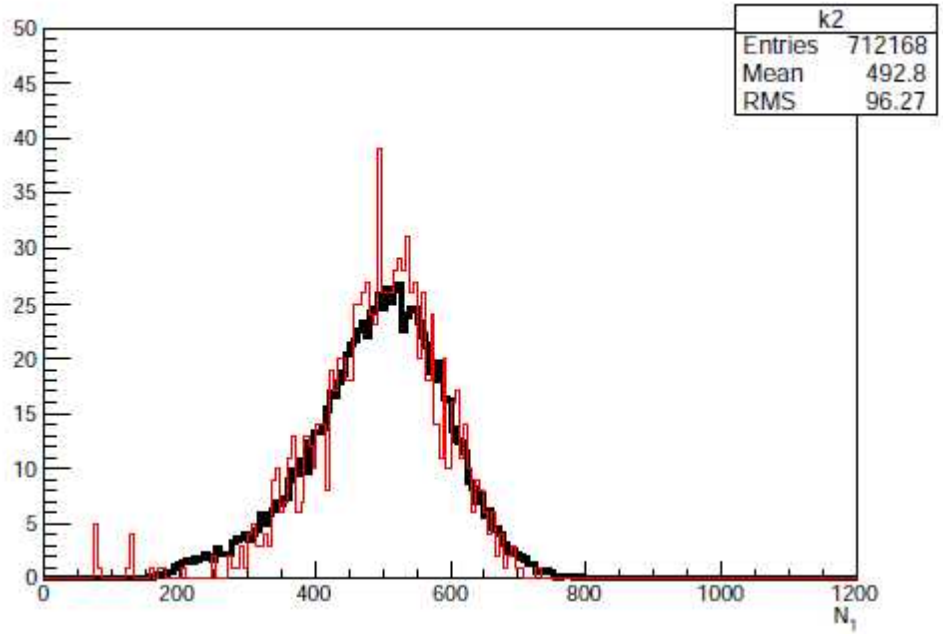
?

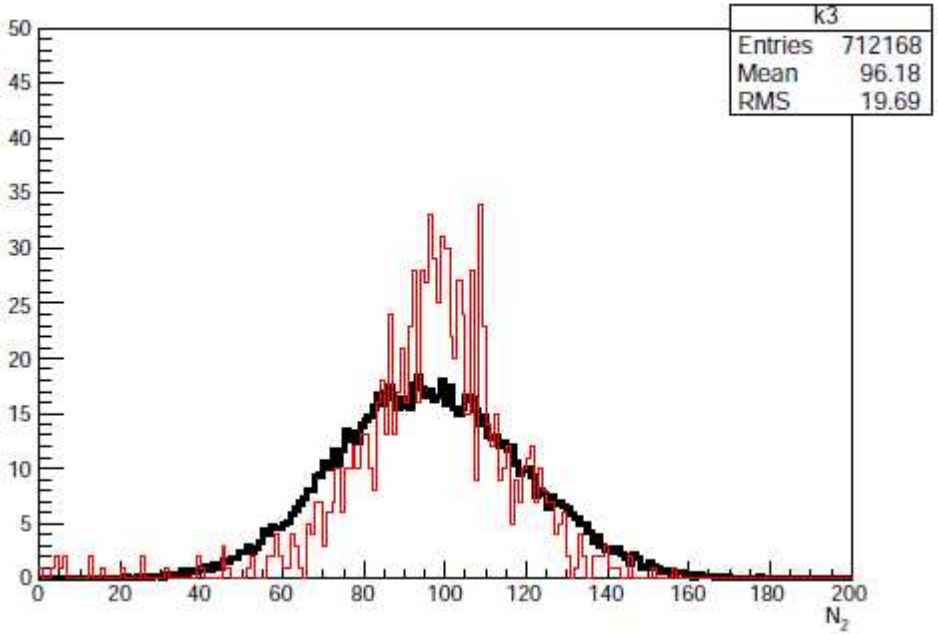
Summary

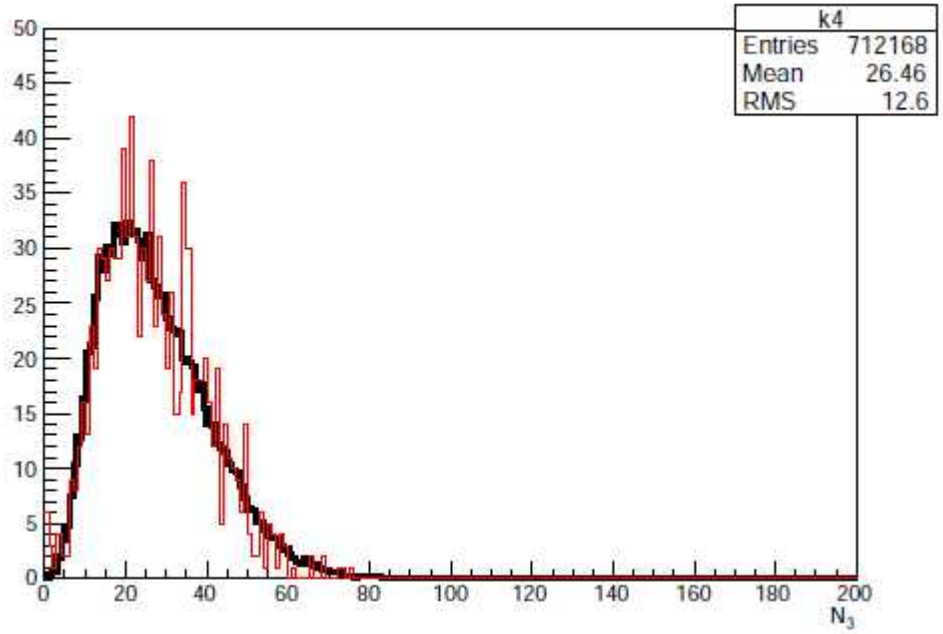
- Noise identified: Sieve & Hot ASIC
- MIP component & Cosmic Component: reasonably stable
  - To be understood: N1, N2 ~ Poisson, N3 ~ exponential
- Long Beam MIP Components: Efficiency & Multiplicity Measurement & Map
  - Tools ready. Need time for more statistics
- EM/Had Response:
  - Low EM/Had Composition. To be improved in next TB
  - Started: unexpected Patterns observed. Especially N2 & N3 for EM showers
- To do: ...

Test on Digitizer: MC-data comparison with locally tuned parameter

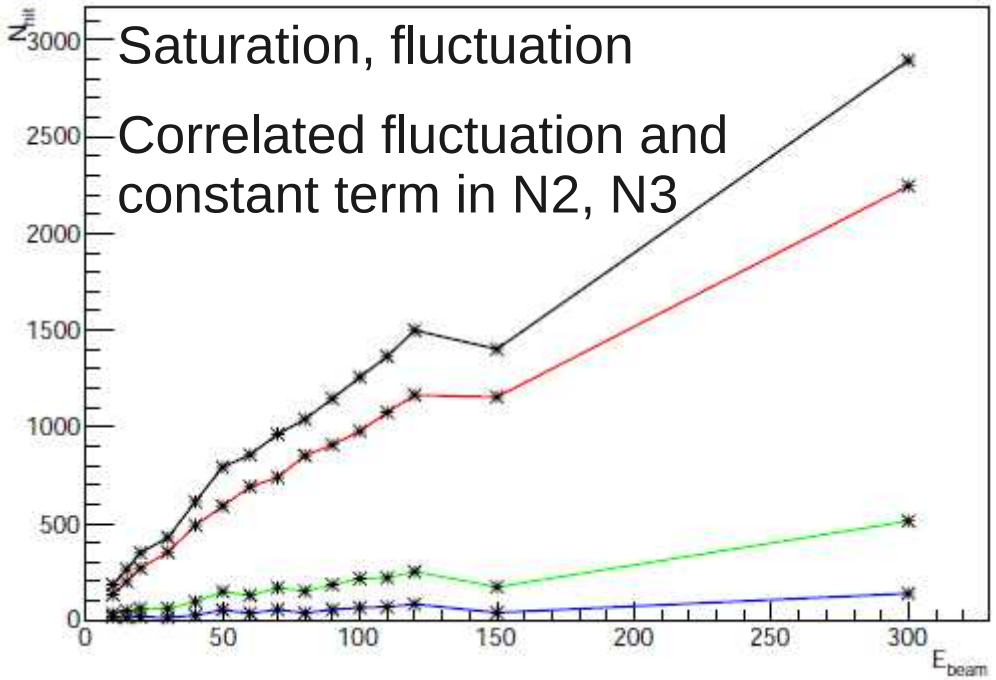


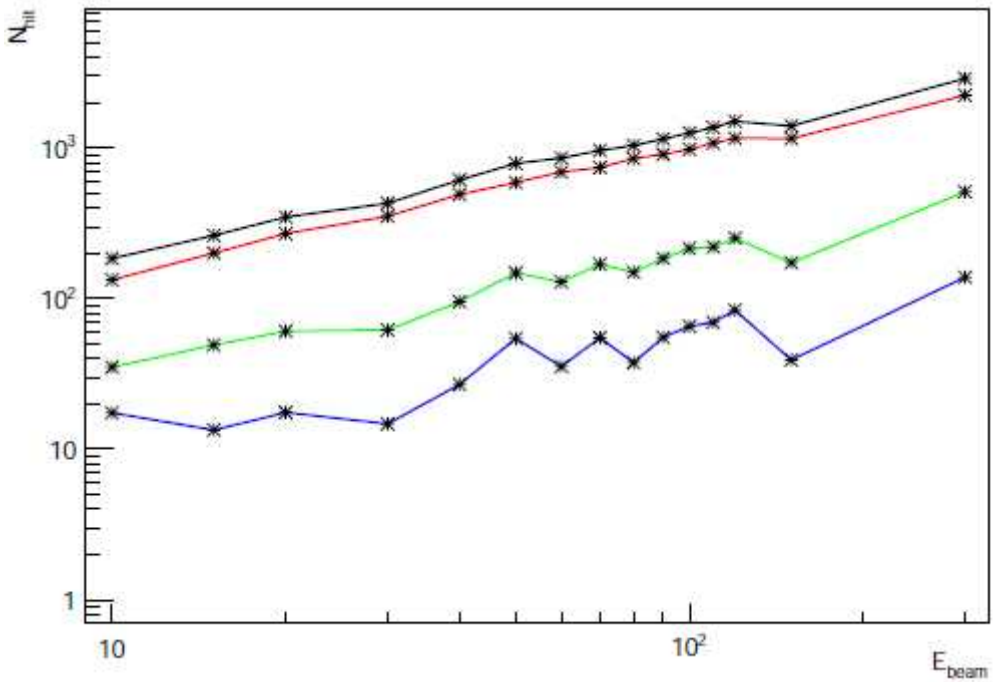


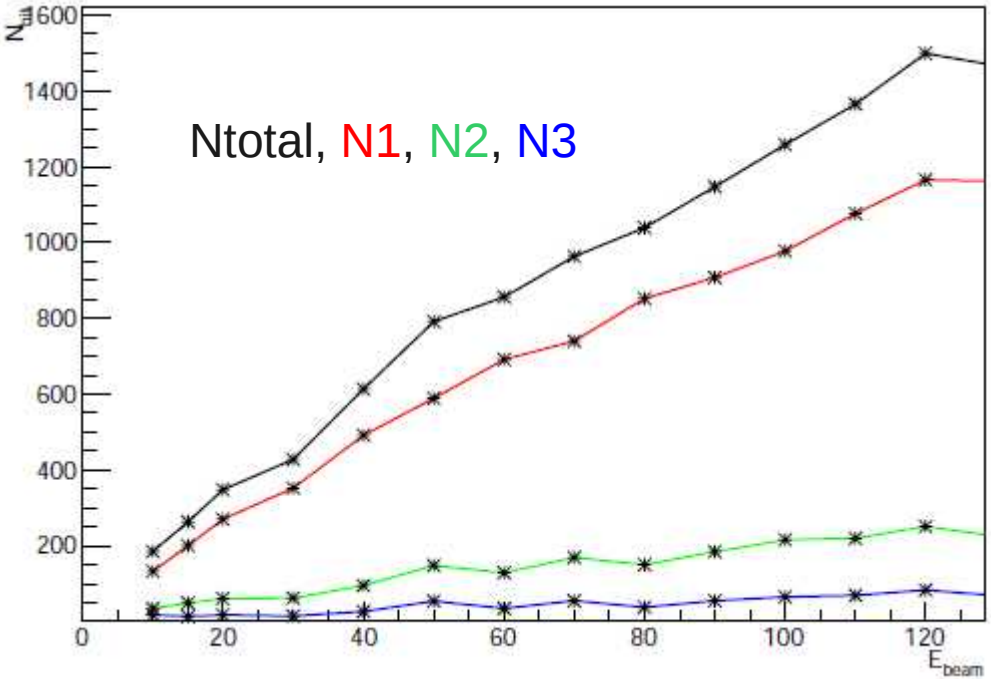


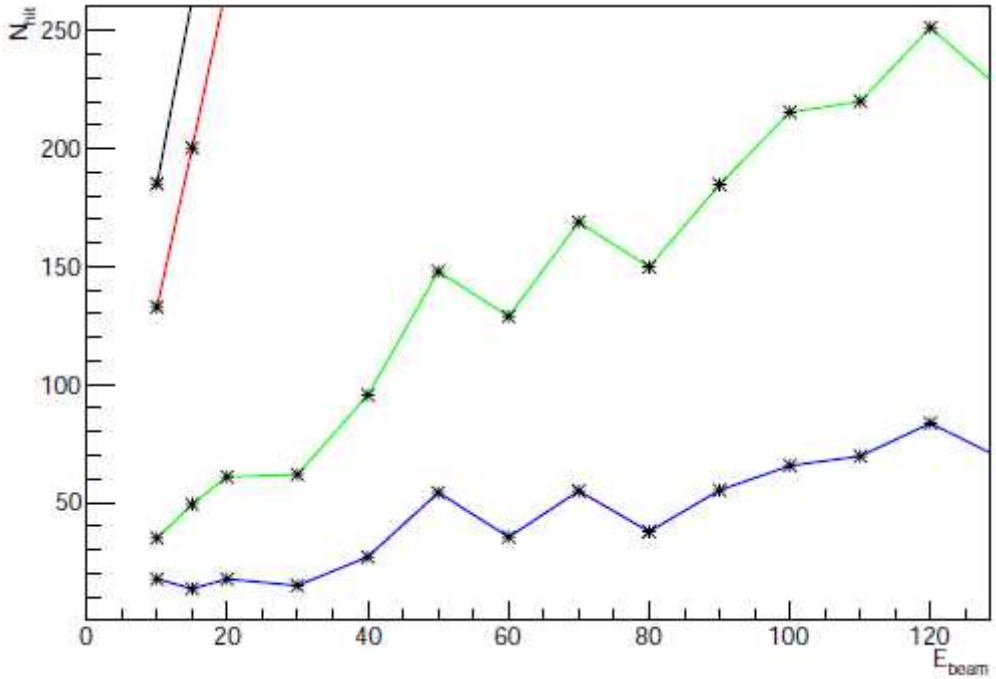


NHit of Pion Run

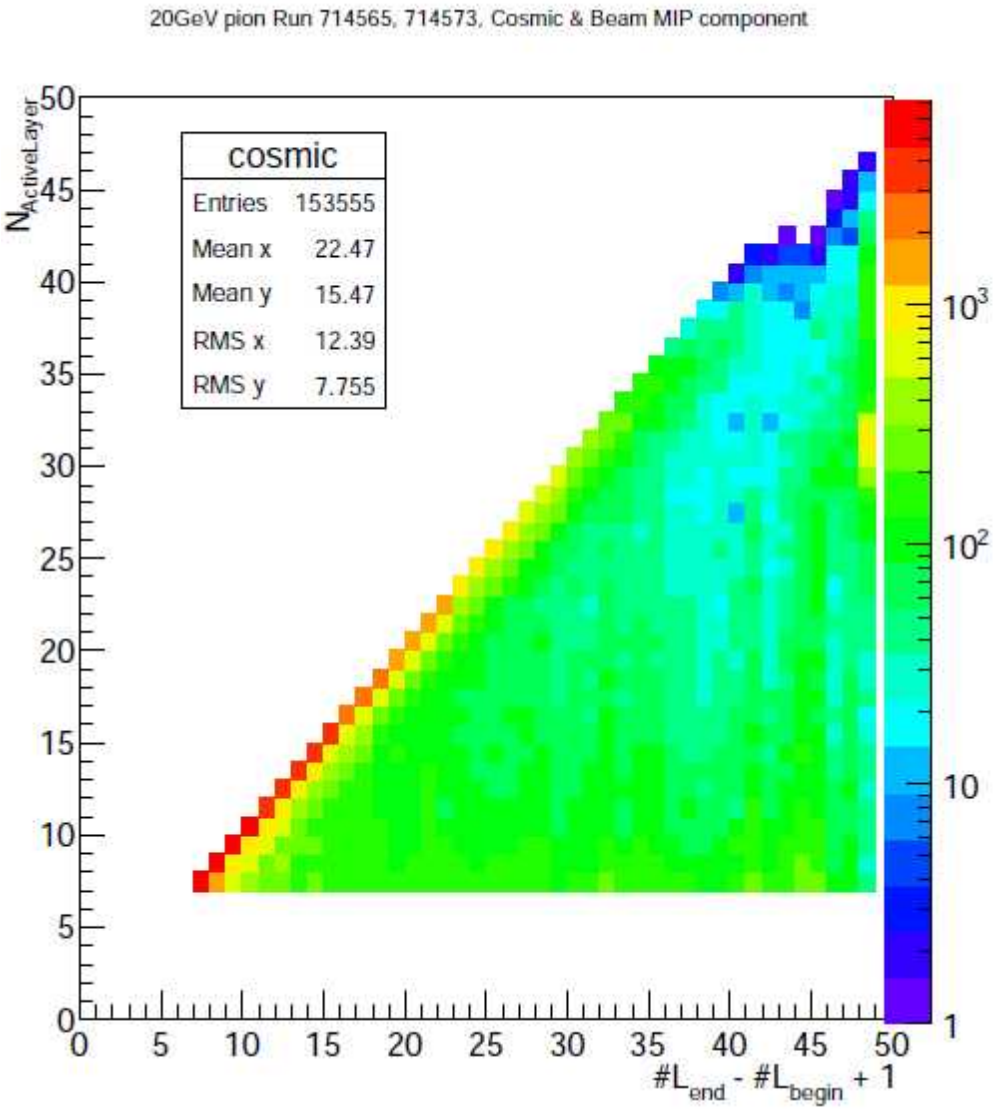


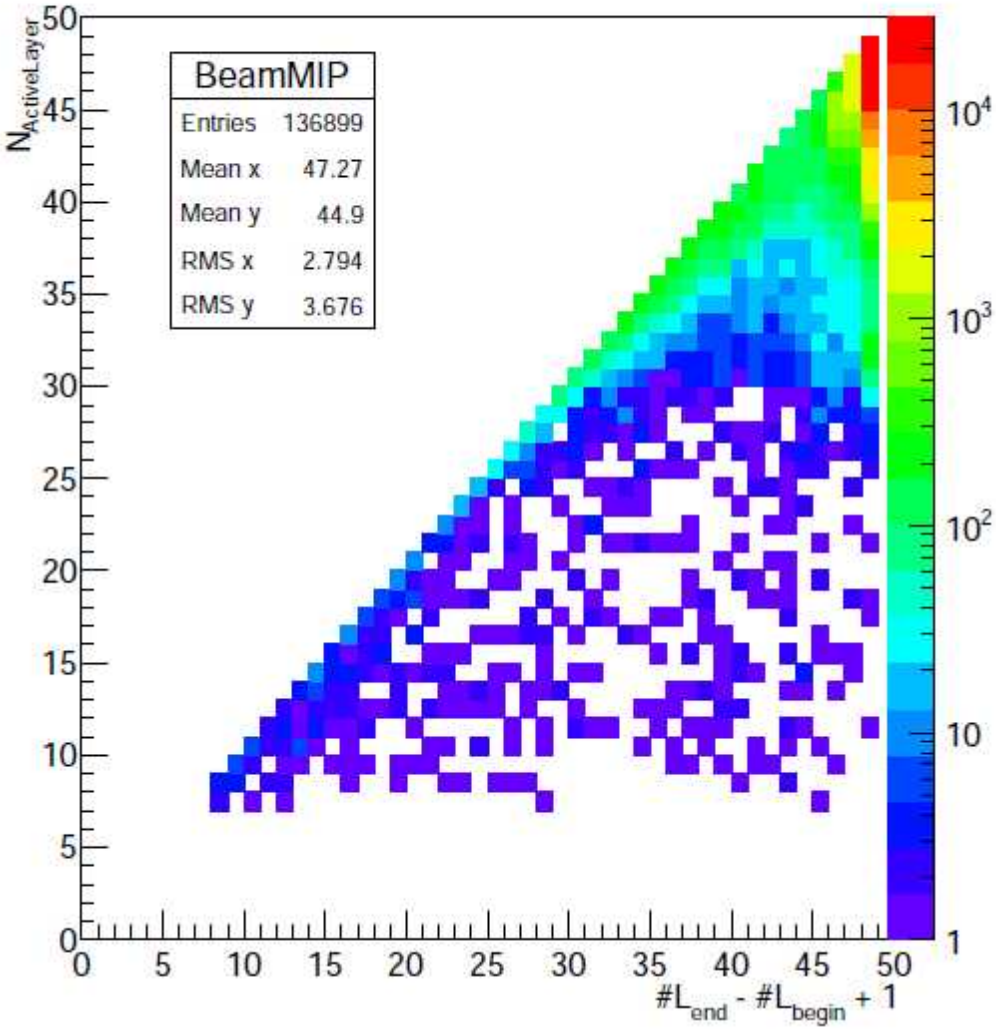






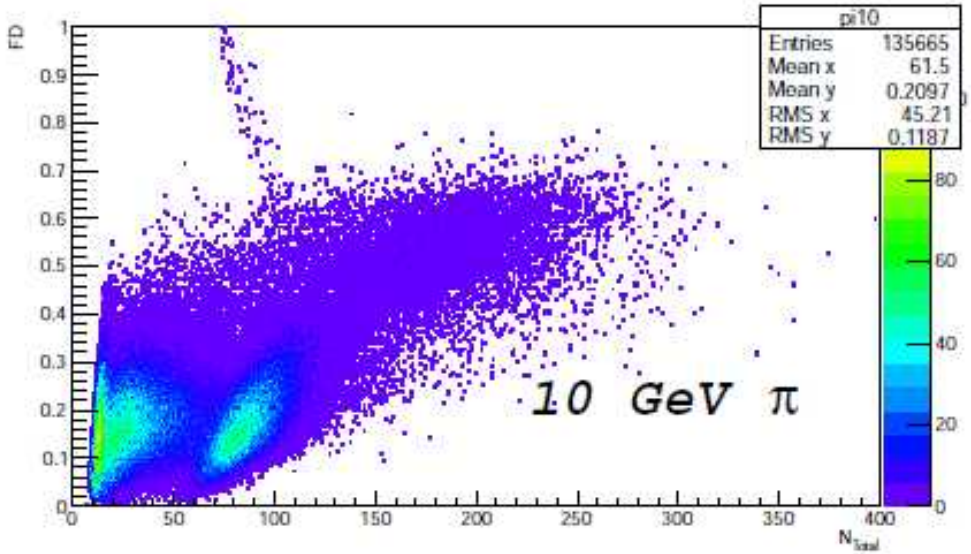
Cosmic Ray Evts

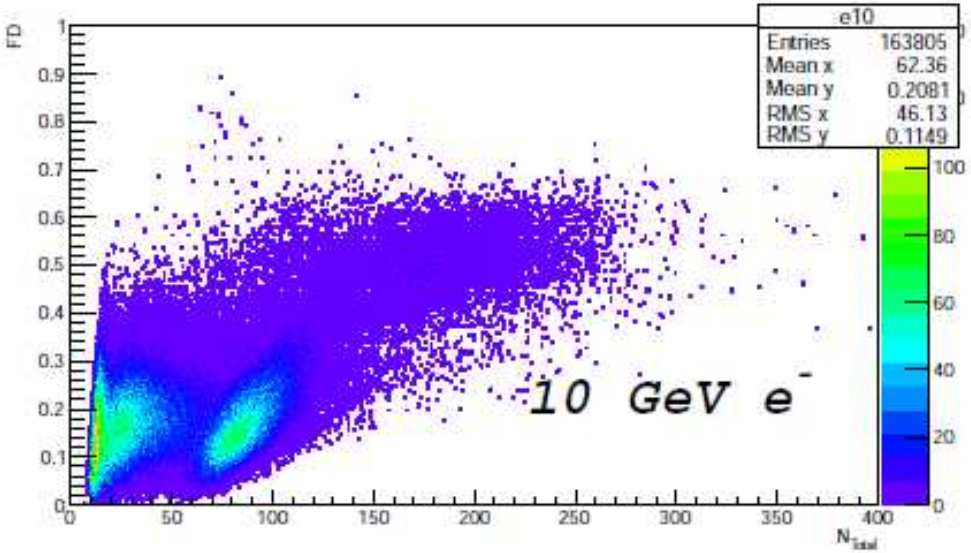


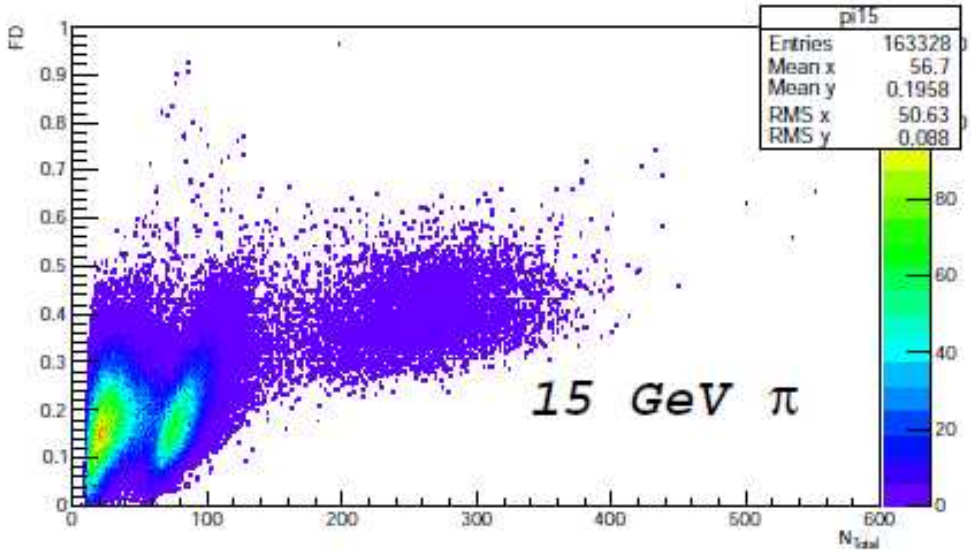


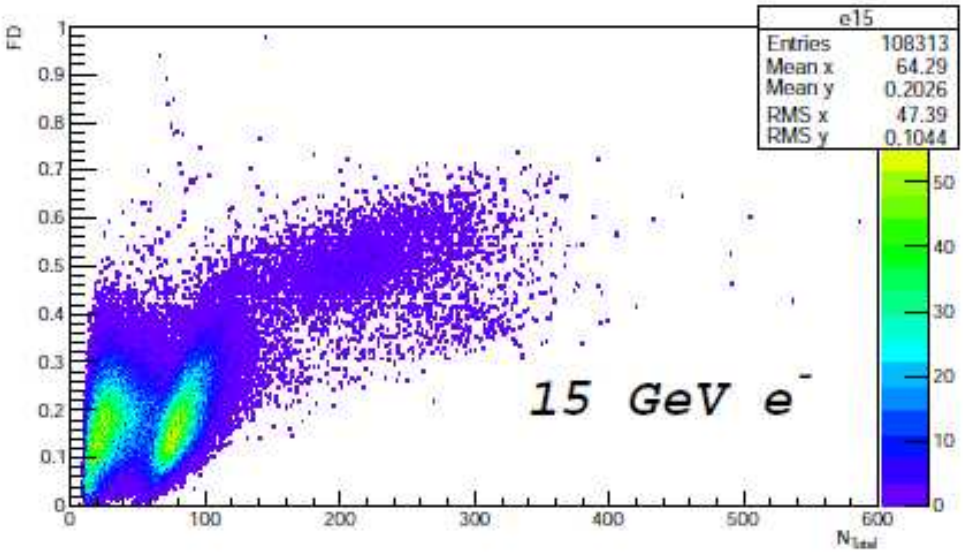
Cosmic Ray Events:

10 & 15 GeV Runs



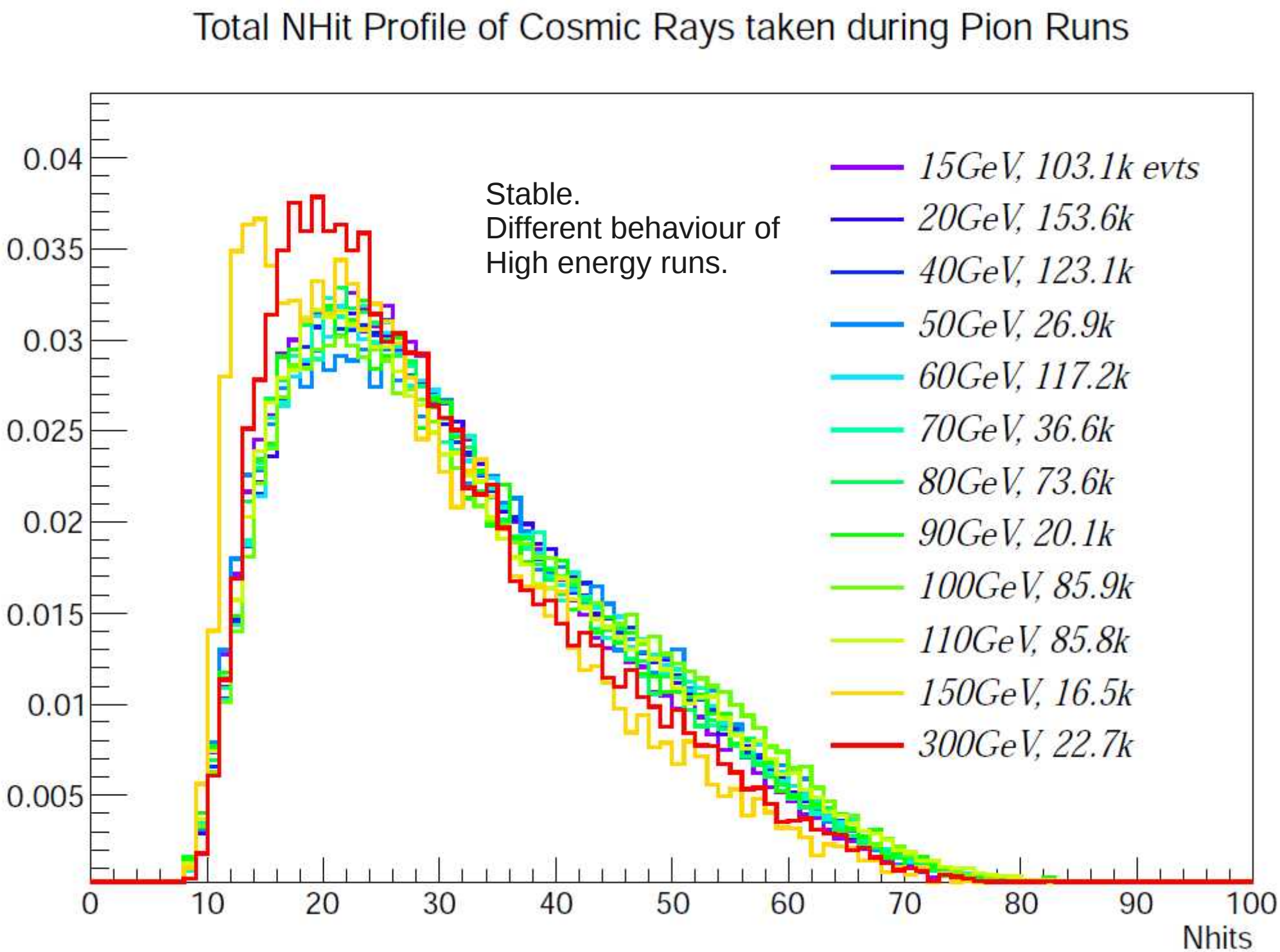




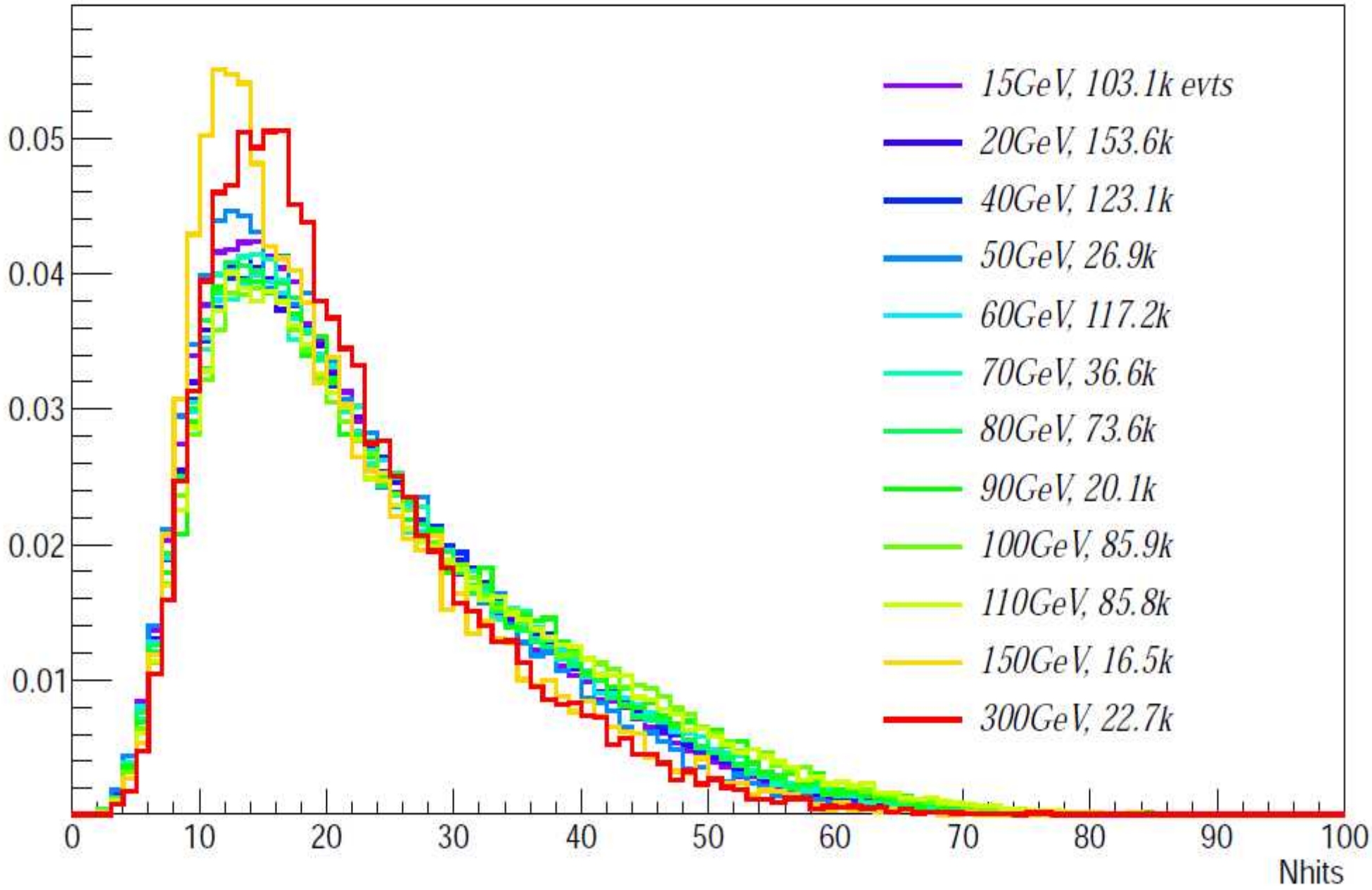


10 GeV Comparison: similar distribution for marked electron & pion run. Actually electron Run

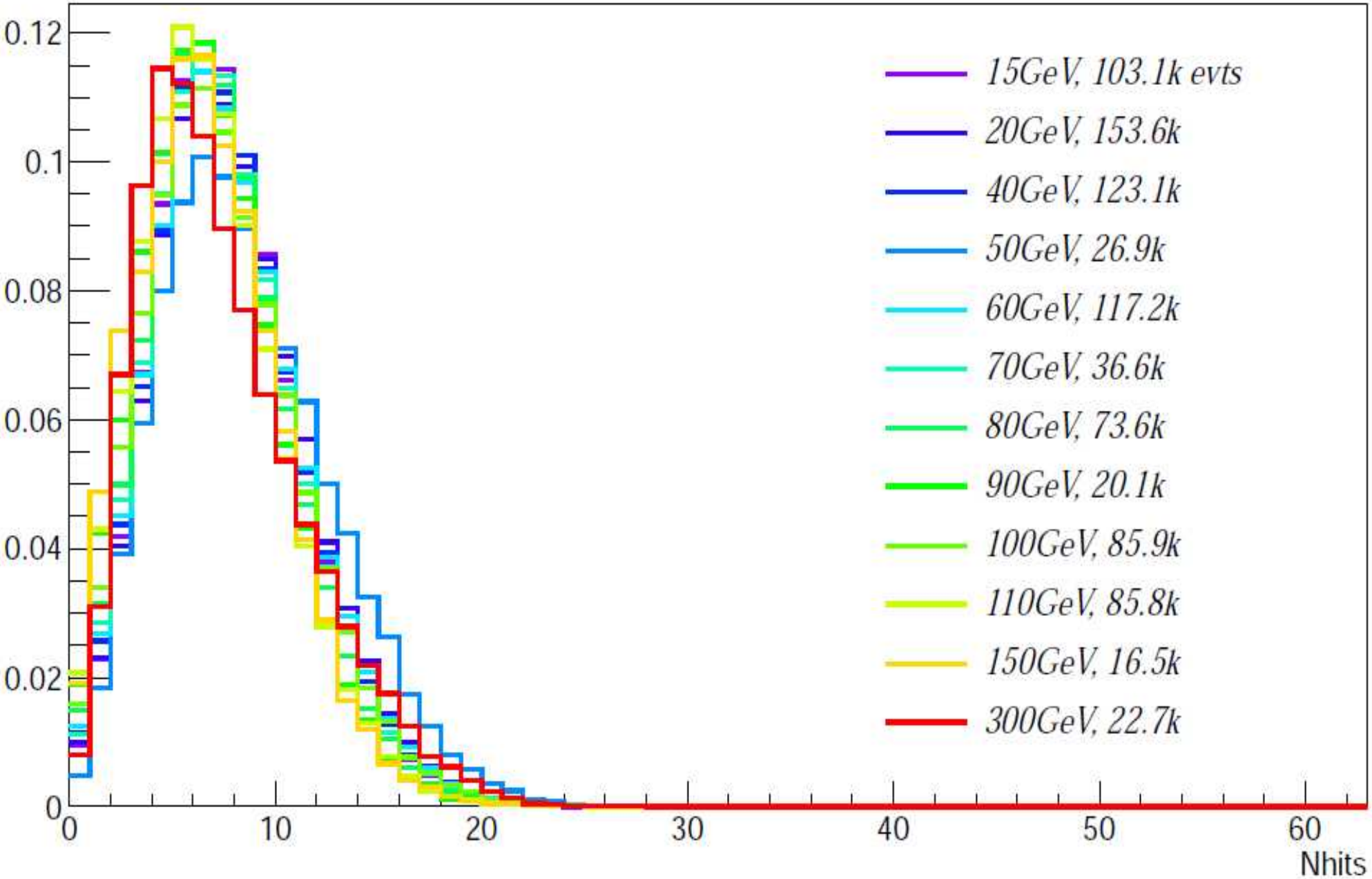
15 GeV Run: different distribution for large Nhit components.


Total NHit Profile of Cosmic Rays taken during Pion Runs
Stable.
Different behaviour of
High energy runs.
15GeV, 103.1k evts
20GeV, 153.6k
40GeV, 123.1k
50GeV, 26.9k
60GeV, 117.2k
70GeV, 36.6k
80GeV, 73.6k
90GeV, 20.1k
100GeV, 85.9k
110GeV, 85.8k
150GeV, 16.5k
300GeV, 22.7k
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
10
20
30
40
50
60
70
80
90
100
Nhits

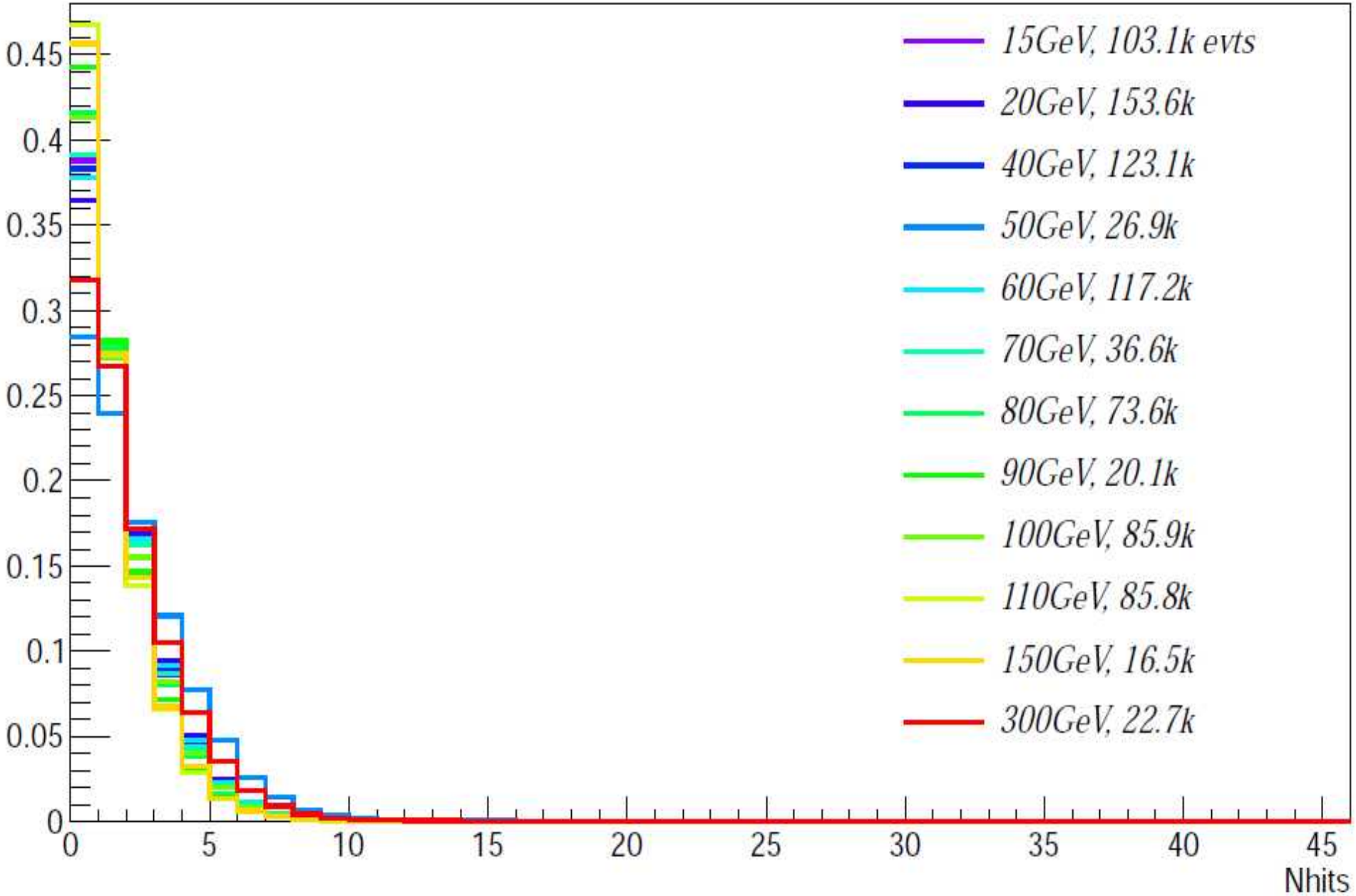
N1 Profile for Cosmic Rays in Pion Runs

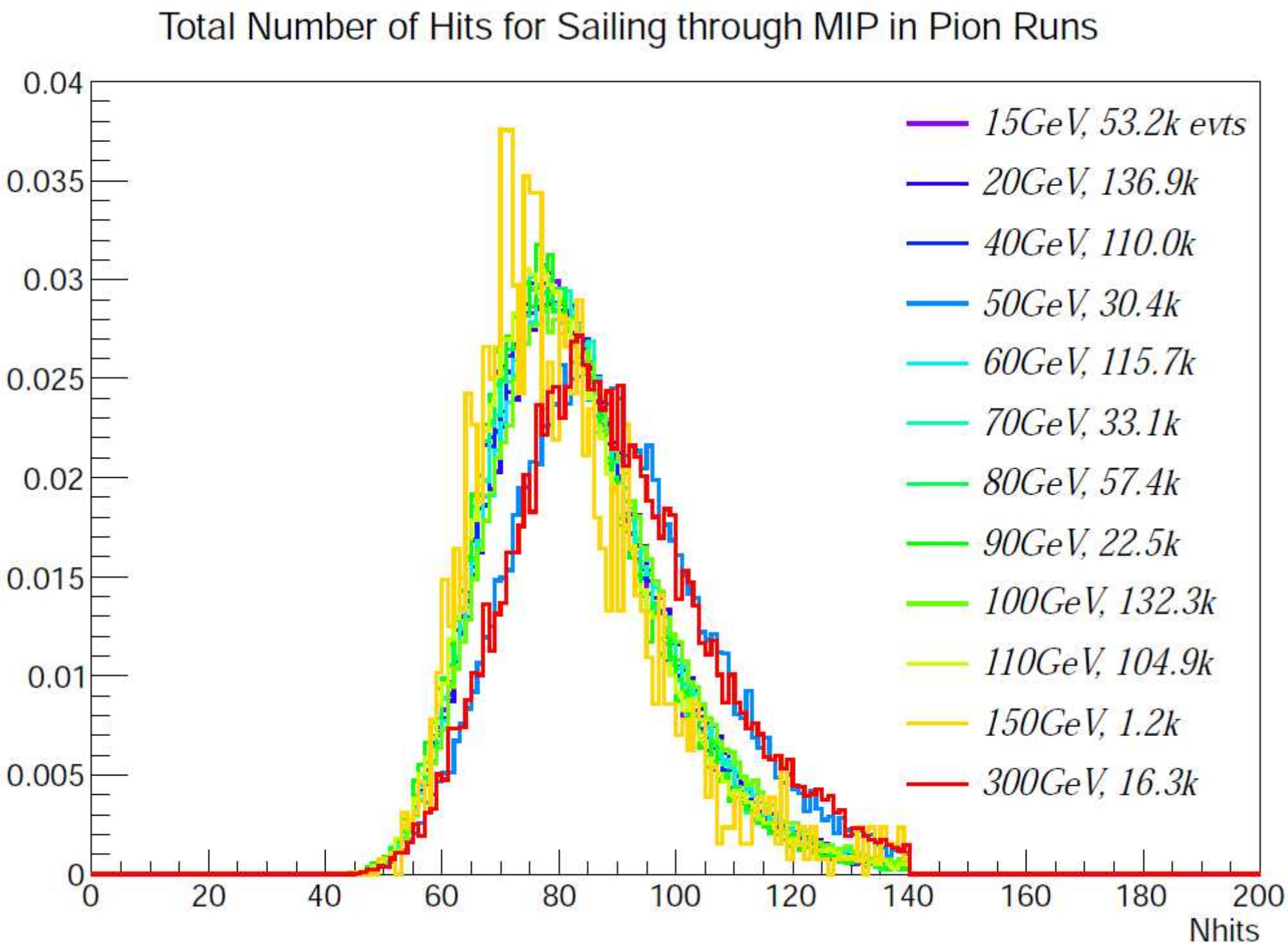


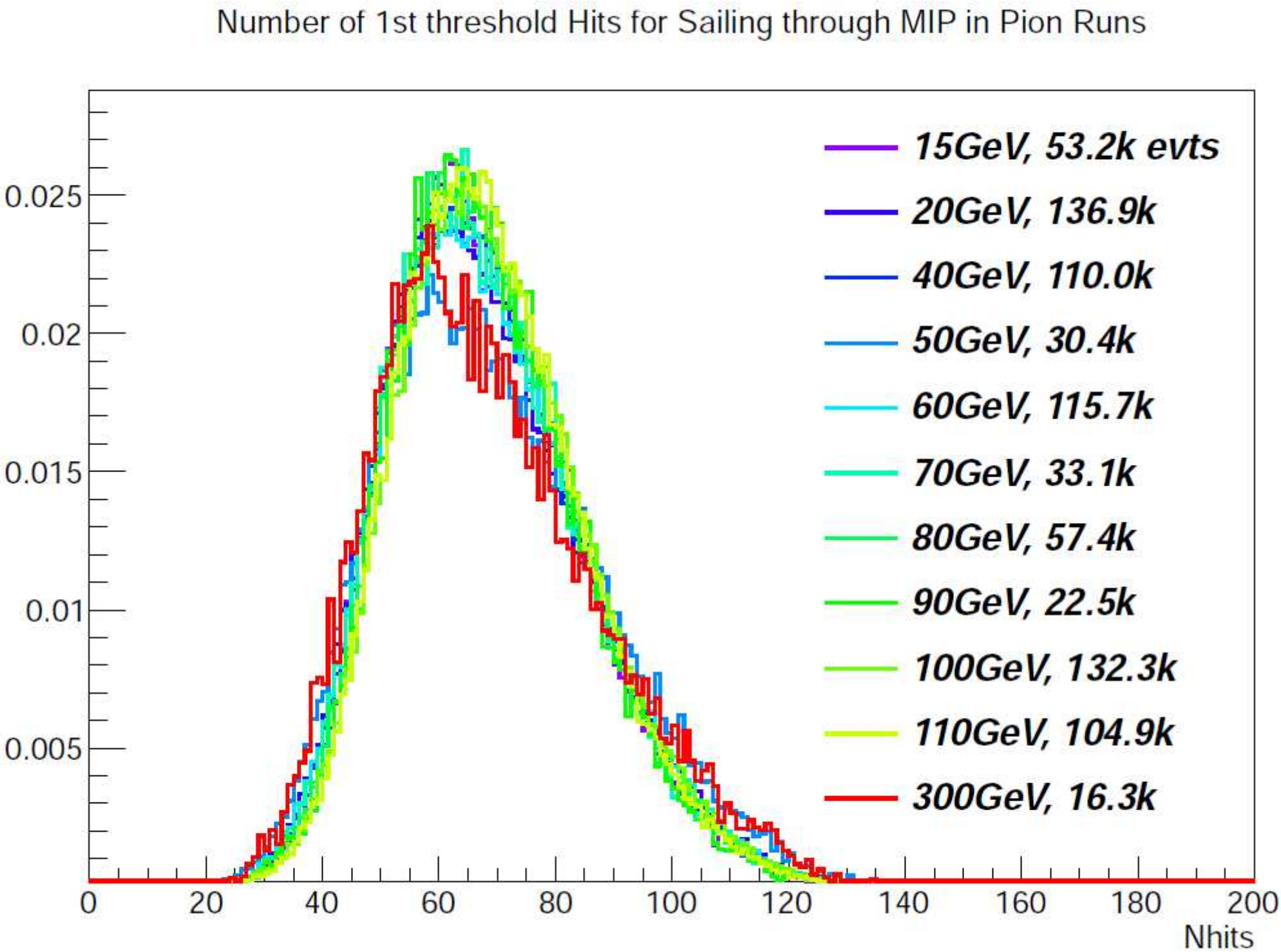
N2 Profile for Cosmic Rays in Pion Runs

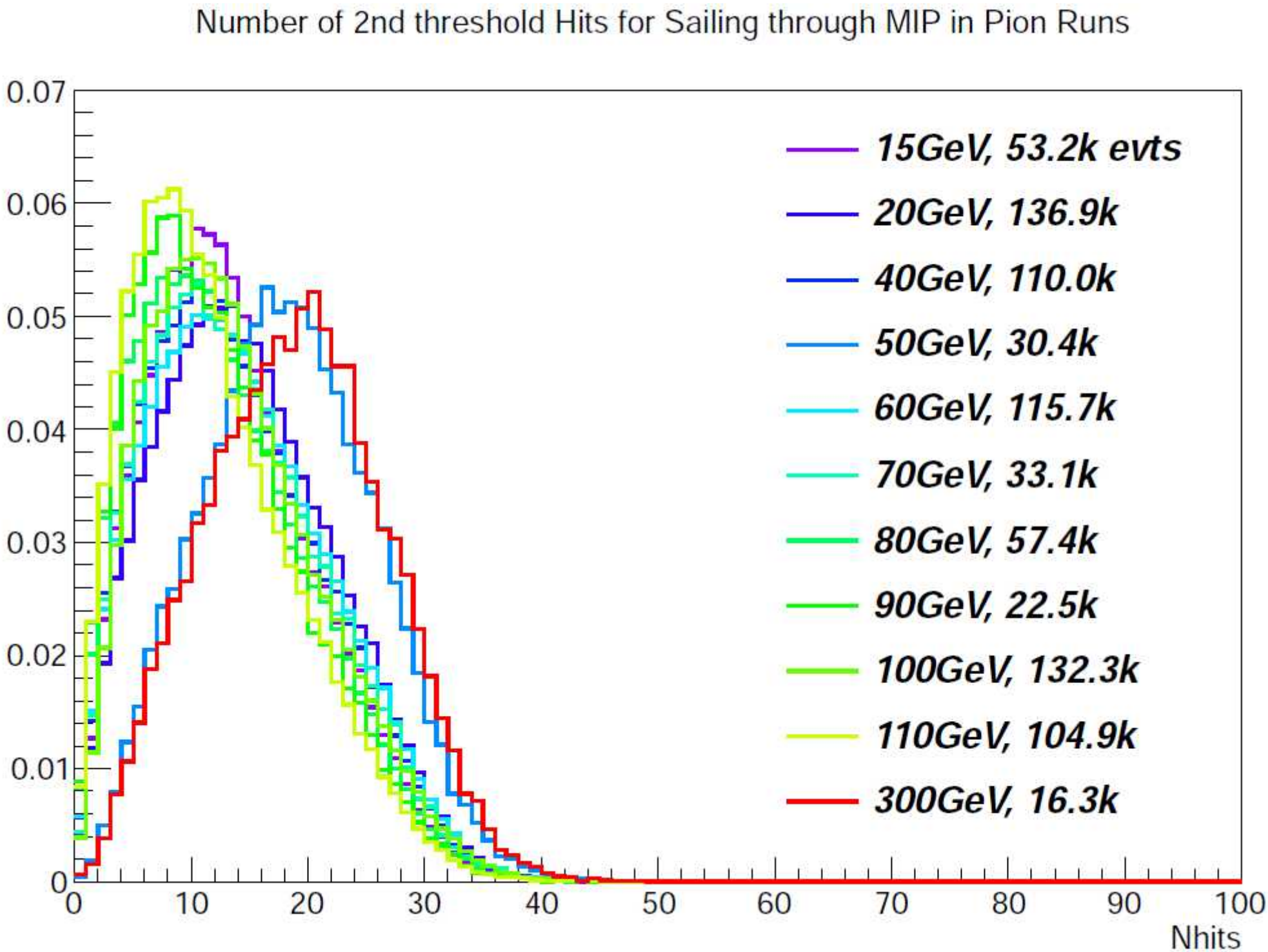


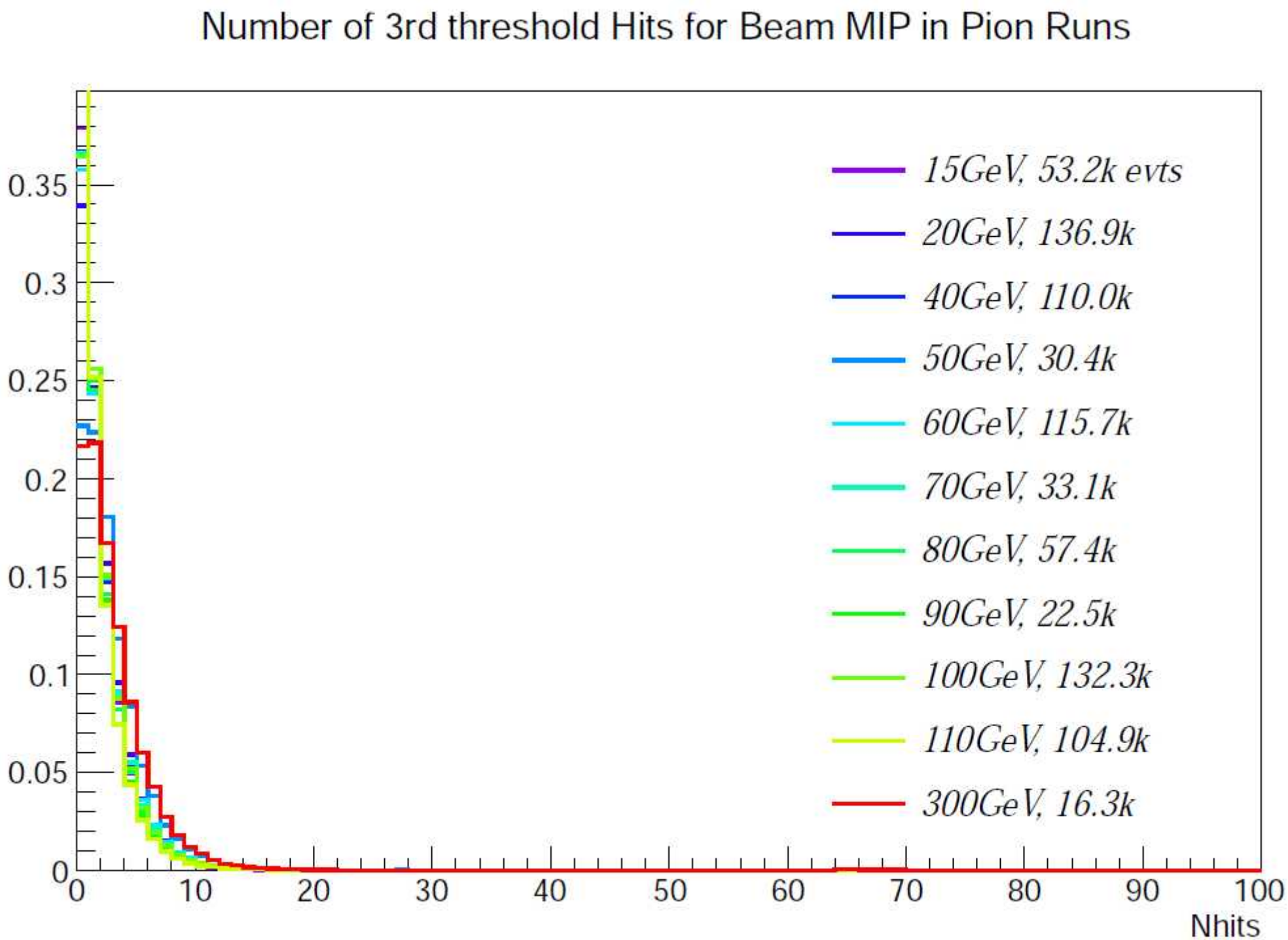
N3 Profile of Cosmic Rays taken during Pion Runs




Total Number of Hits for Sailing through MIP in Pion Runs
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
20
40
60
80
100
120
140
160
180
200
Nhits
15GeV, 53.2k evts
20GeV, 136.9k
40GeV, 110.0k
50GeV, 30.4k
60GeV, 115.7k
70GeV, 33.1k
80GeV, 57.4k
90GeV, 22.5k
100GeV, 132.3k
110GeV, 104.9k
150GeV, 1.2k
300GeV, 16.3k


Number of 1st threshold Hits for Sailing through MIP in Pion Runs
0.025
0.02
0.015
0.01
0.005
0
20
40
60
80
100
120
140
160
180
200
Nhits
15GeV, 53.2k evts
20GeV, 136.9k
40GeV, 110.0k
50GeV, 30.4k
60GeV, 115.7k
70GeV, 33.1k
80GeV, 57.4k
90GeV, 22.5k
100GeV, 132.3k
110GeV, 104.9k
300GeV, 16.3k


Number of 2nd threshold Hits for Sailing through MIP in Pion Runs
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
70
80
90
100
Nhits
15GeV, 53.2k evts
20GeV, 136.9k
40GeV, 110.0k
50GeV, 30.4k
60GeV, 115.7k
70GeV, 33.1k
80GeV, 57.4k
90GeV, 22.5k
100GeV, 132.3k
110GeV, 104.9k
300GeV, 16.3k


Number of 3rd threshold Hits for Beam MIP in Pion Runs
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
10
20
30
40
50
60
70
80
90
100
Nhits
15GeV, 53.2k evts
20GeV, 136.9k
40GeV, 110.0k
50GeV, 30.4k
60GeV, 115.7k
70GeV, 33.1k
80GeV, 57.4k
90GeV, 22.5k
100GeV, 132.3k
110GeV, 104.9k
300GeV, 16.3k