SiW Calorimeter Simulations

- Studies by Jason Barkeloo & Teddy Hay (Oregon)
- Geant4 Simulation
  - Simple Calorimeter
  - 40 cm per side square
  - 40 Layers of alternating tungsten/silicon
    - W - 5/7 X_0 (2.503mm)……Si – 320μm
- Investigation of various pixel sizes
  - 13 mm^2 current sensor size

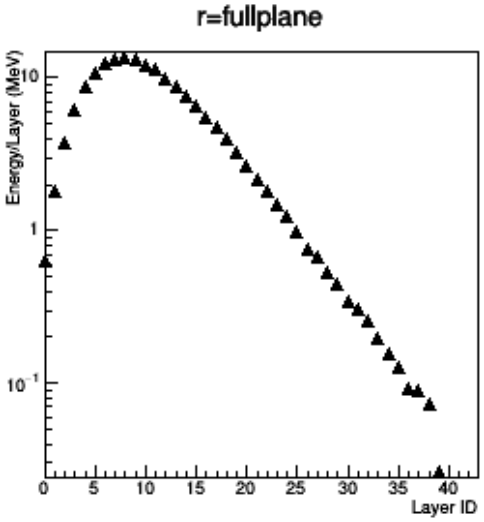
    corresponds to ~2mm radius circular pixel
- Simulation of test beam data, also, 9 layers

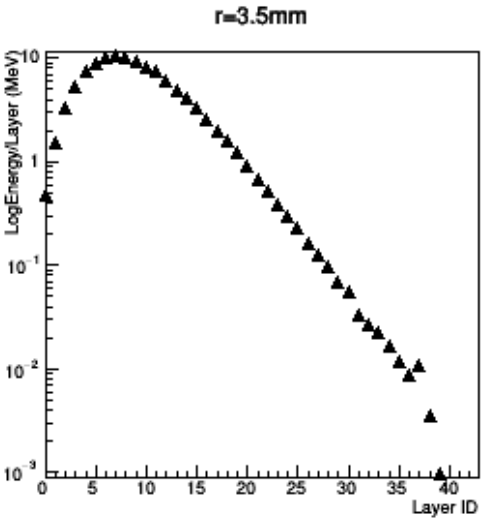
List of studies

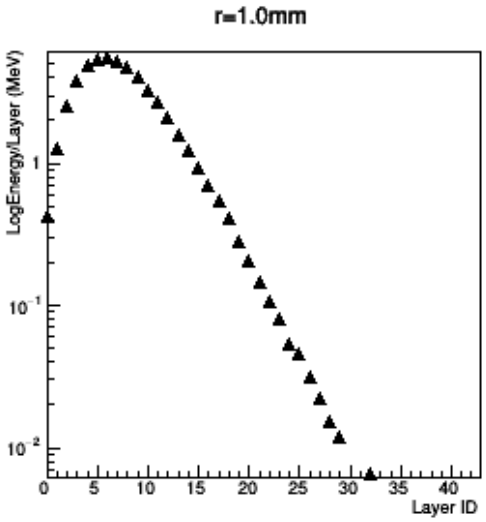
- Energy & mips per pixel vs. pixel radius
  - Motivated by possibility of monolithic devices

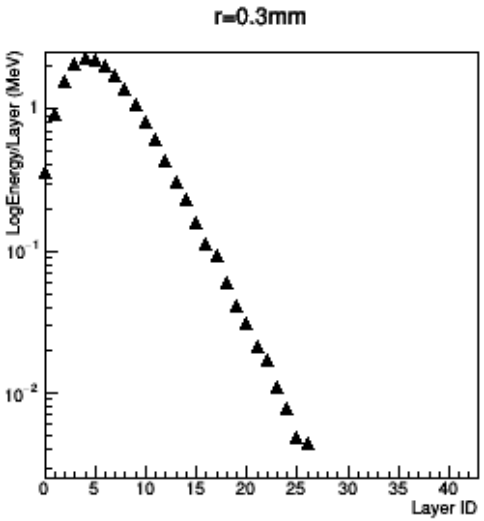
- Test beam analysis
  - Shower counting
  - Energy vs. shower count
  - Motivated to prepare for next/full length prototype

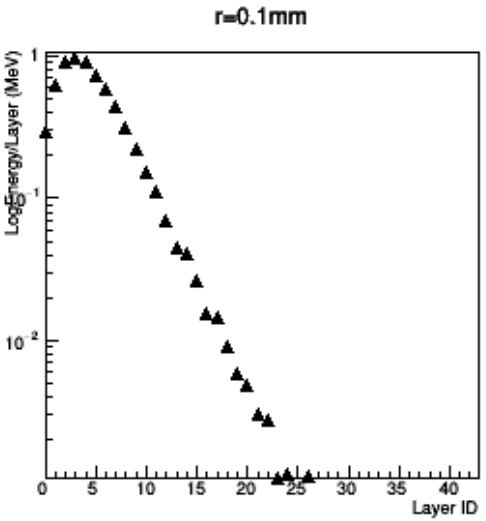
10 GeV – 1000 events











Fullplane max at layer:8.0

3.5mm max at layer:7.0

1.0mm max at layer:6.0

0.3mm max at layer:4.0

0.1mm max at layer:3.0

Fullplane Total E =171.099567904

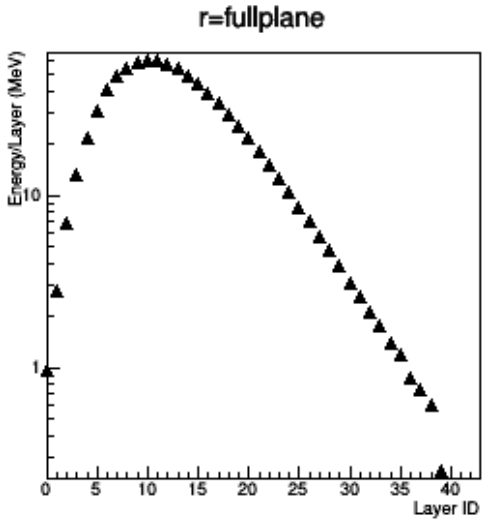
3.5mm Total E =112.439316759

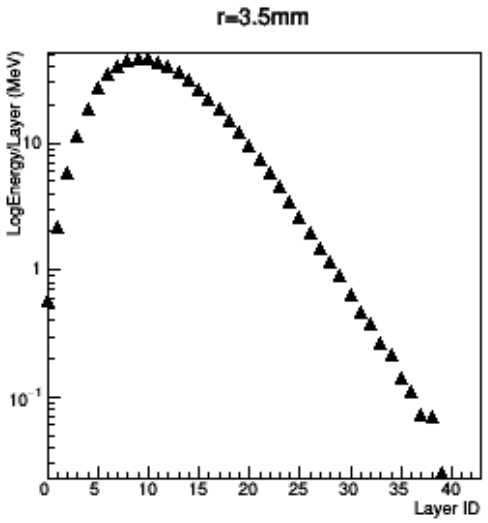
1.0mm Total E =52.1635152531

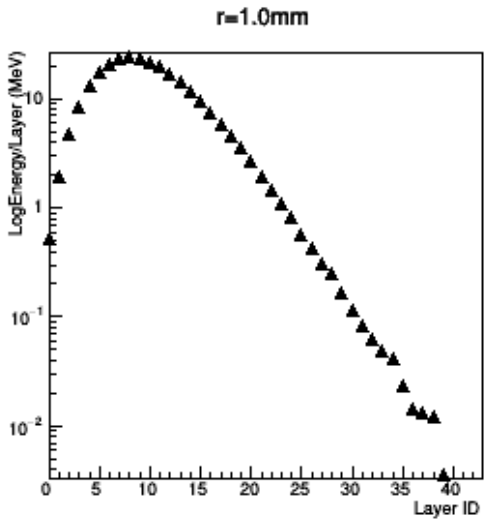
0.3mm Total E =18.4856107452

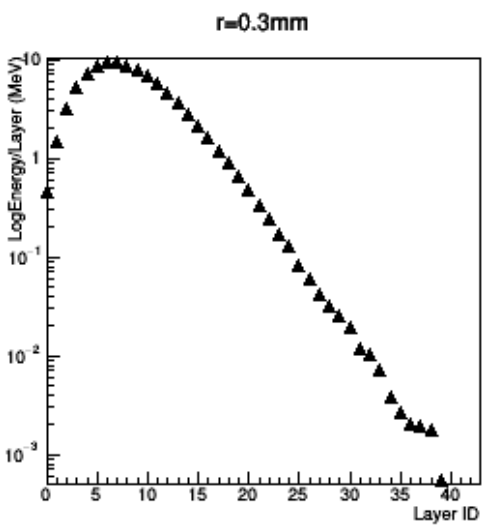
0.1mm Total E =6.50634081986

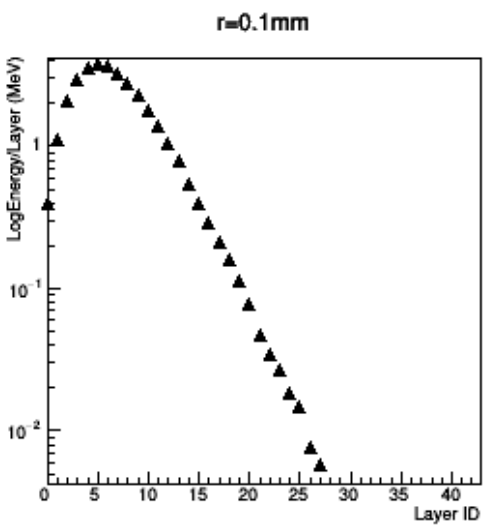
50 GeV – 1000 events











Fullplane max at layer:10.0

3.5mm max at layer:9.0

1.0mm max at layer:8.0

0.3mm max at layer:6.0

0.1mm max at layer:5.0

Fullplane Total E =854.559262213

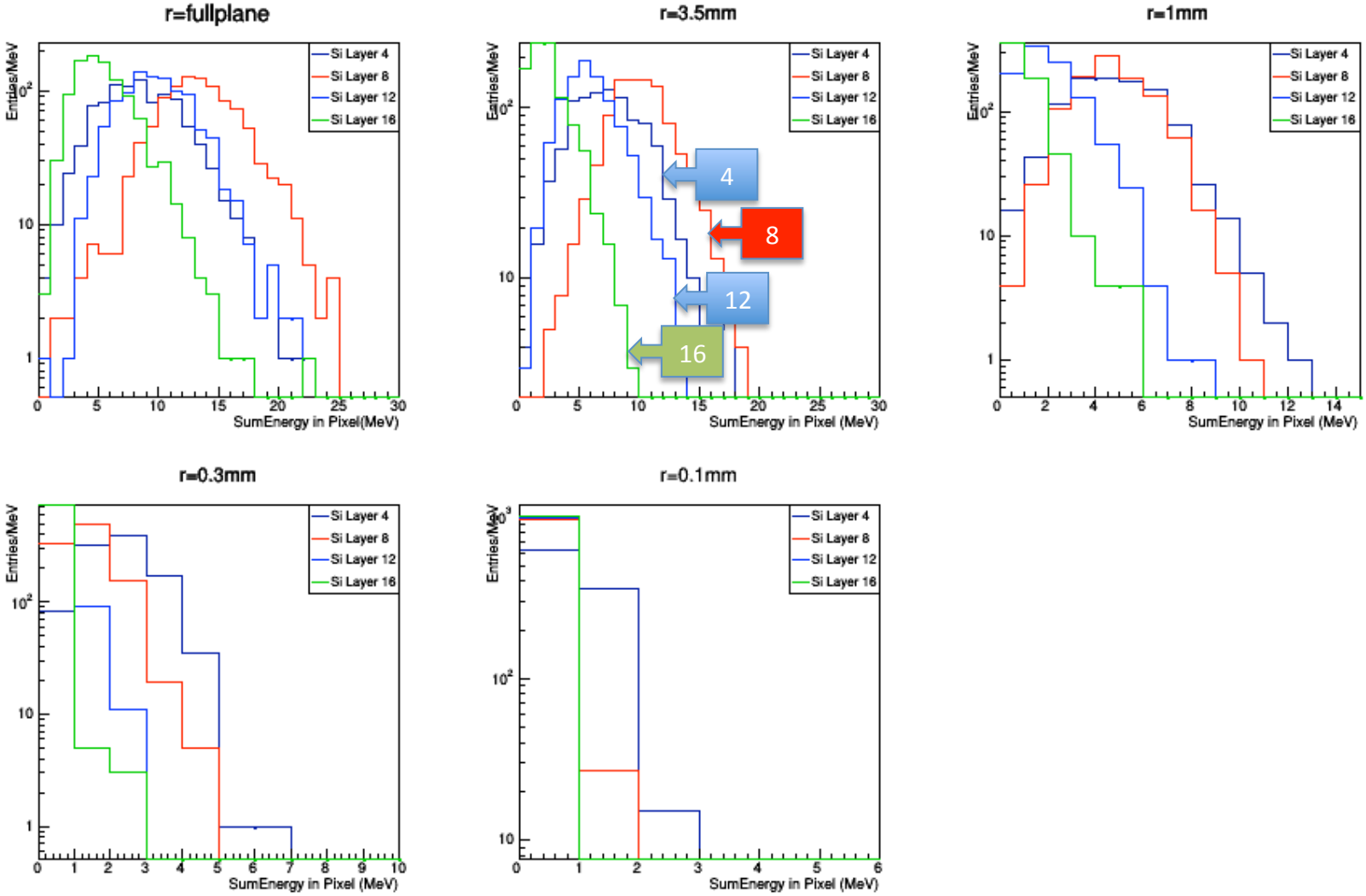
3.5mm Total E =563.712403283

1.0mm Total E =262.111211572

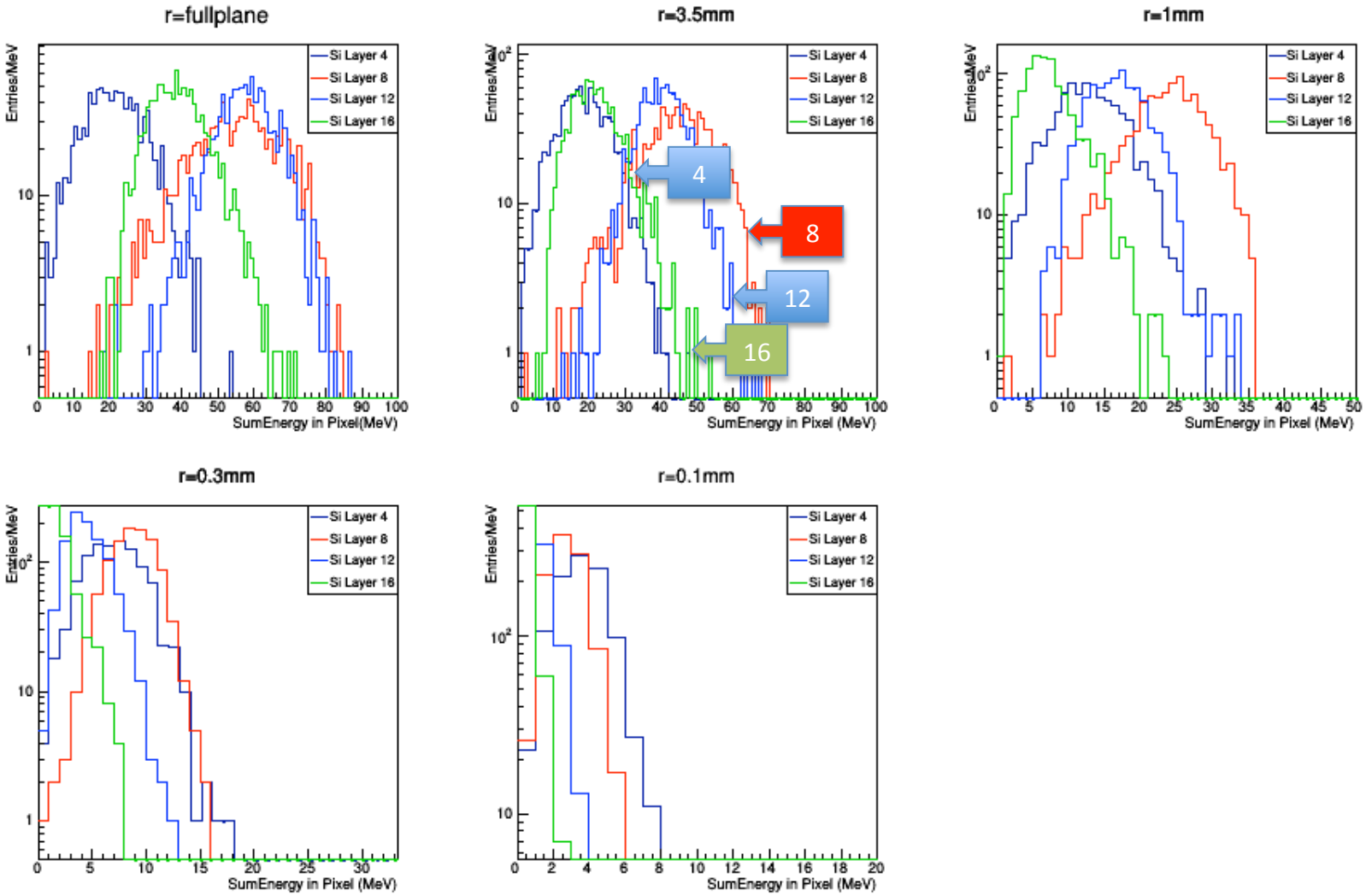
0.3mm Total E =92.6124821995

0.1mm Total E =32.7791474393

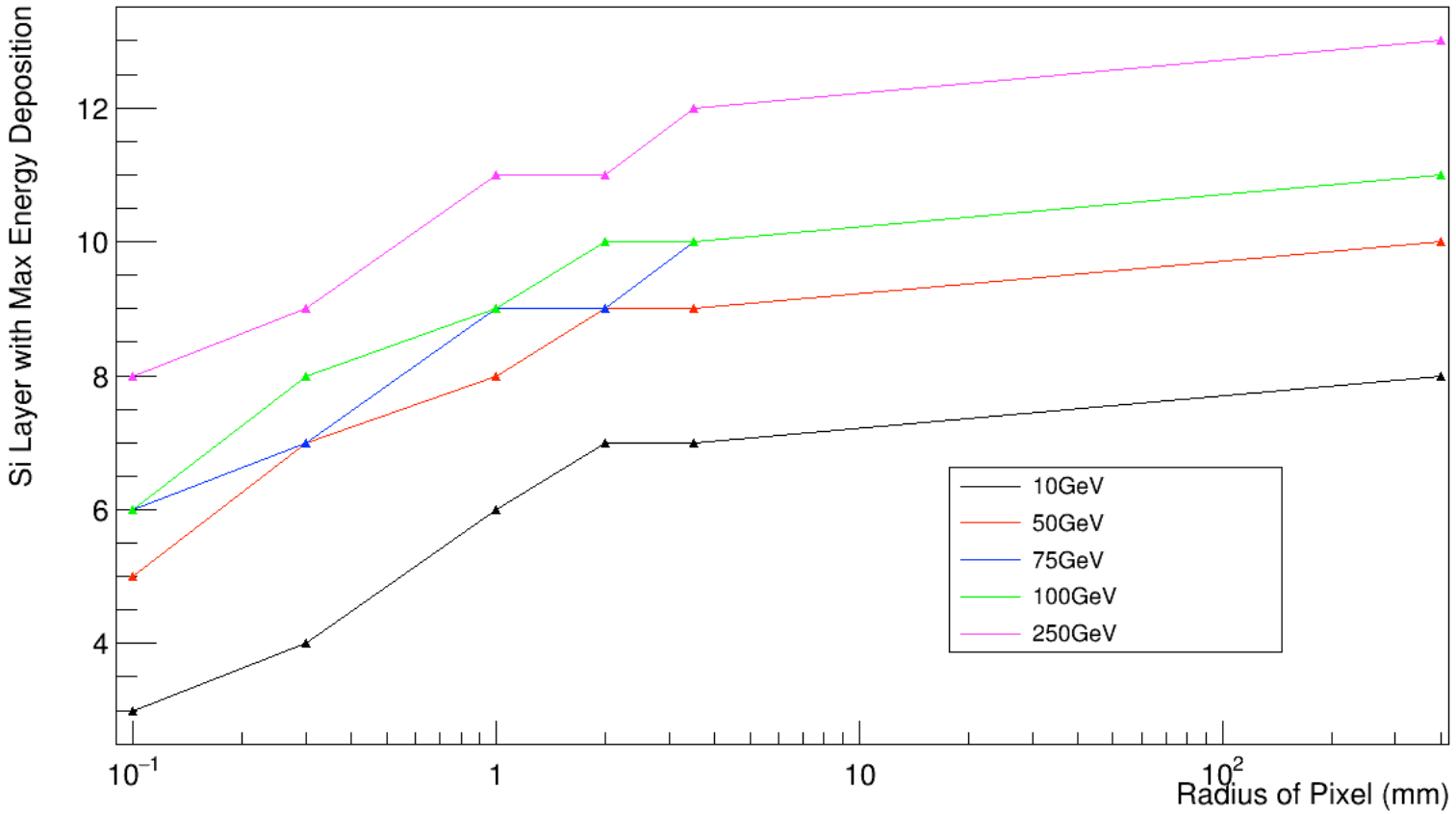
10GeV - Energy in central pixel (variable r)
Si-layers 4, 8, 12, 16



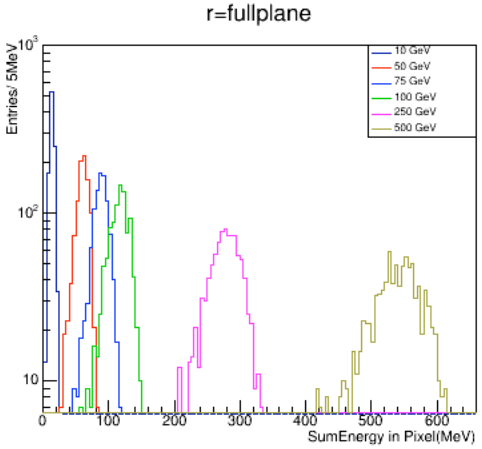
50GeV - Energy in central pixel (variable r)
Si-layers 4, 8, 12, 16

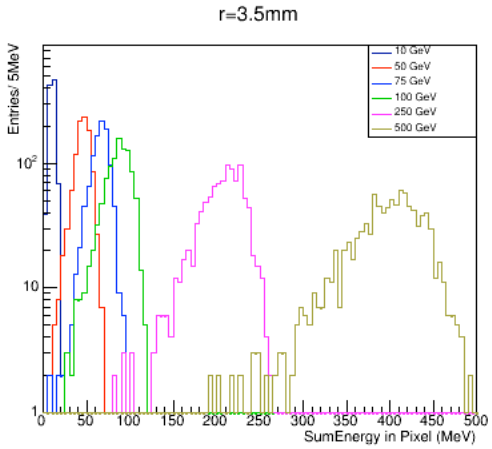


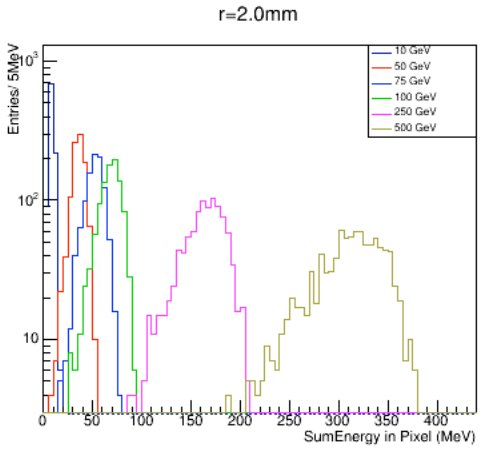
Layer with Max Energy Distribution vs. 'Pixel' Radius

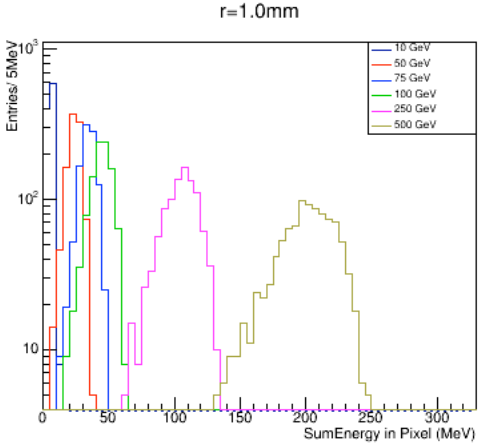


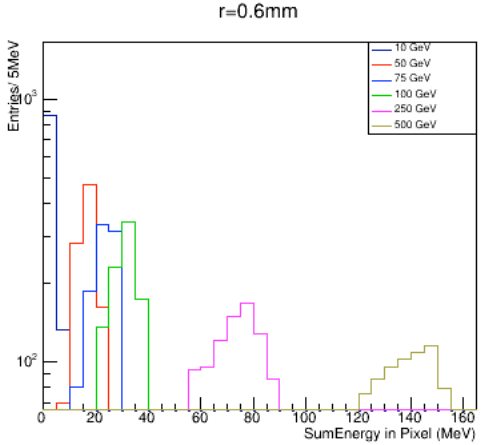
Energy in central pixel at shower max
E = 10, 50, 75, 100, 250, 500 GeV

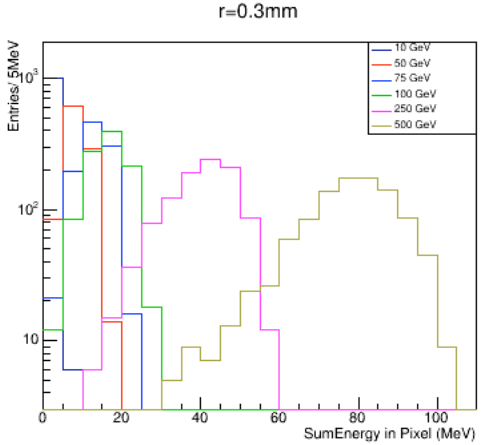




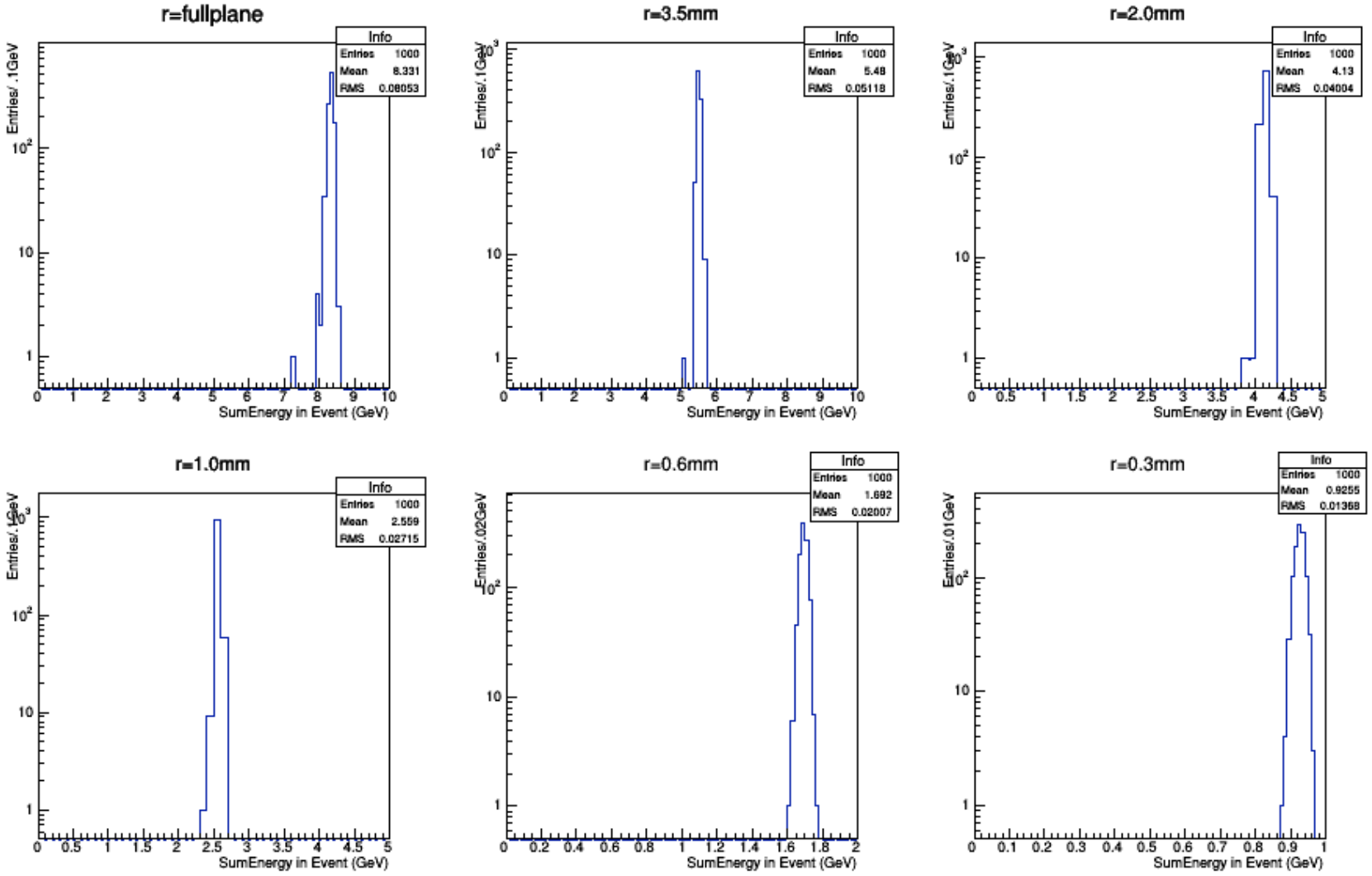




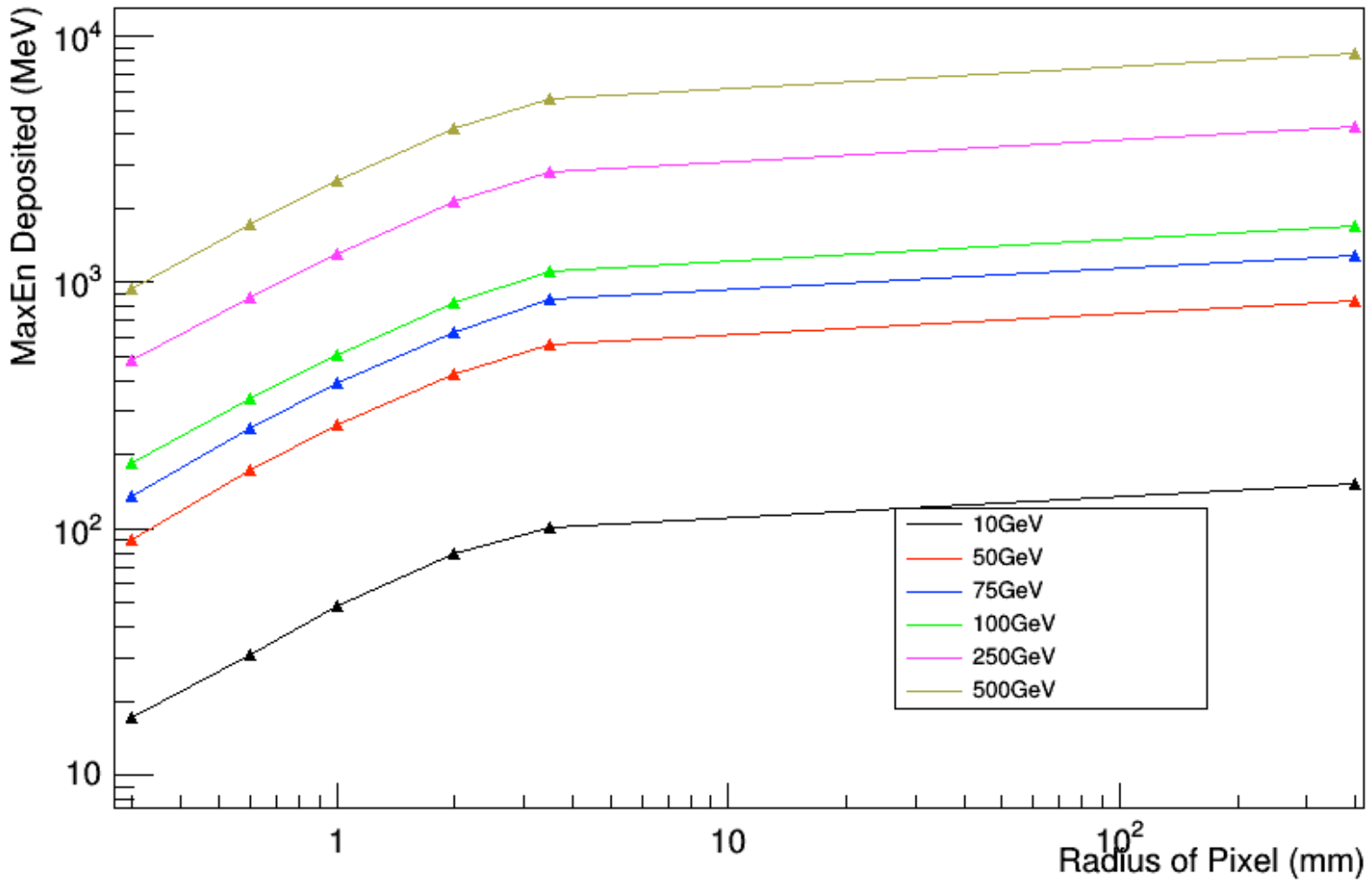




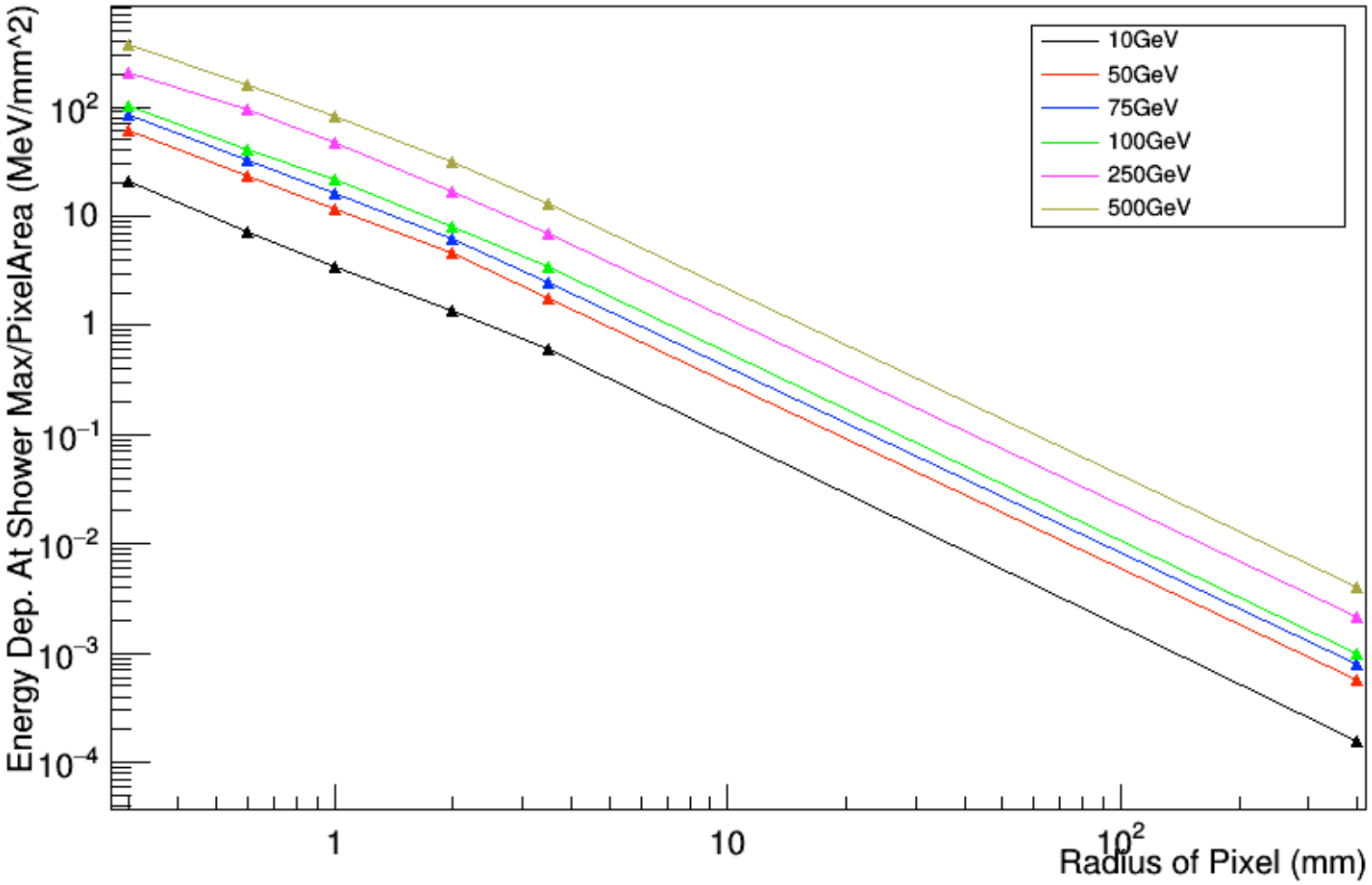
500 GeV energy sum for central pixels vs. pixel radius

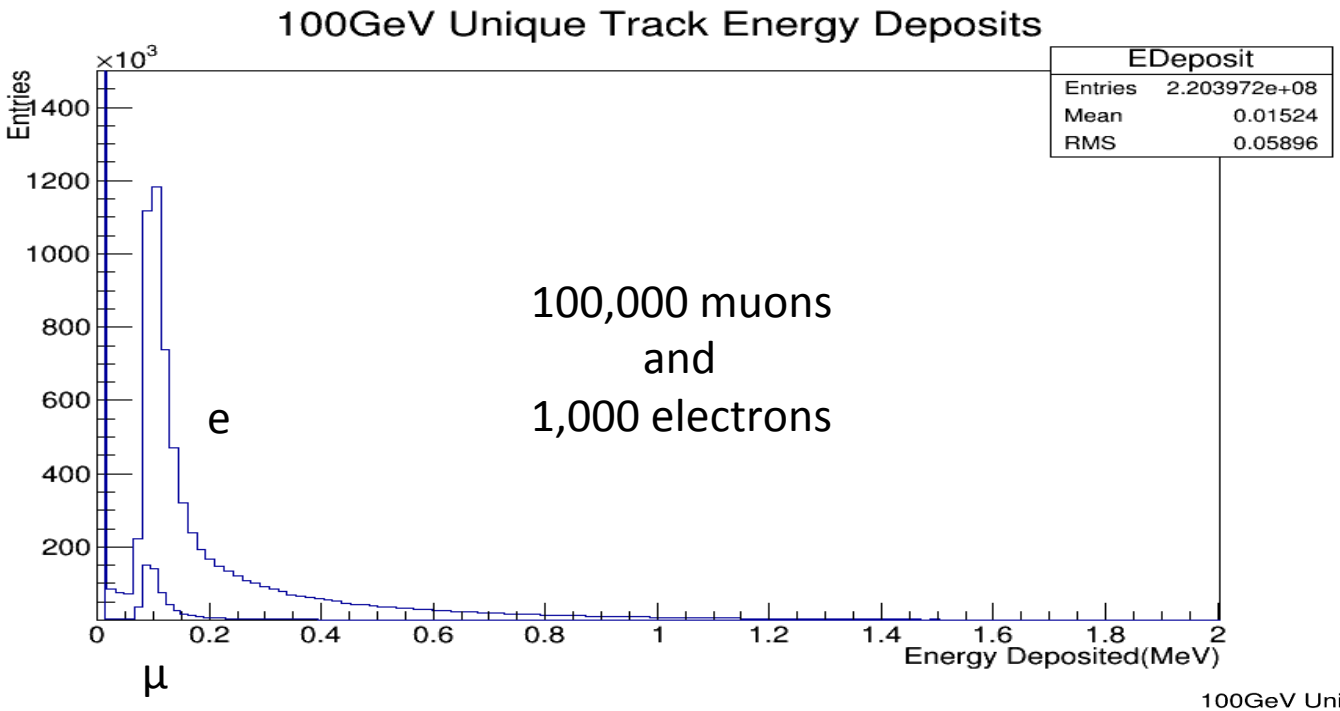


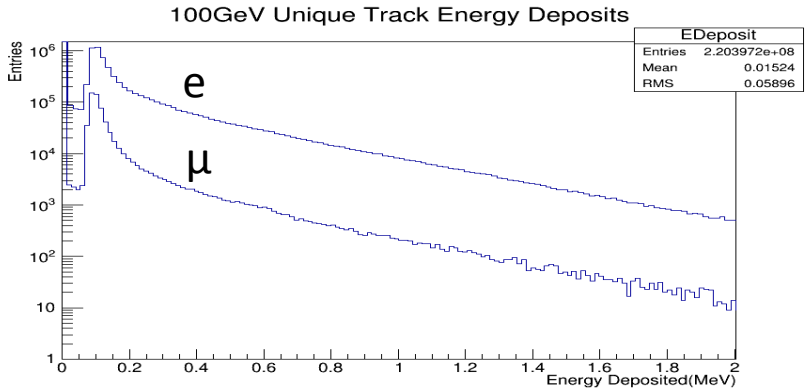
Energy sum for central pixels vs. pixel radius (E=10, 50, 75, 100, 250, 500 GeV)

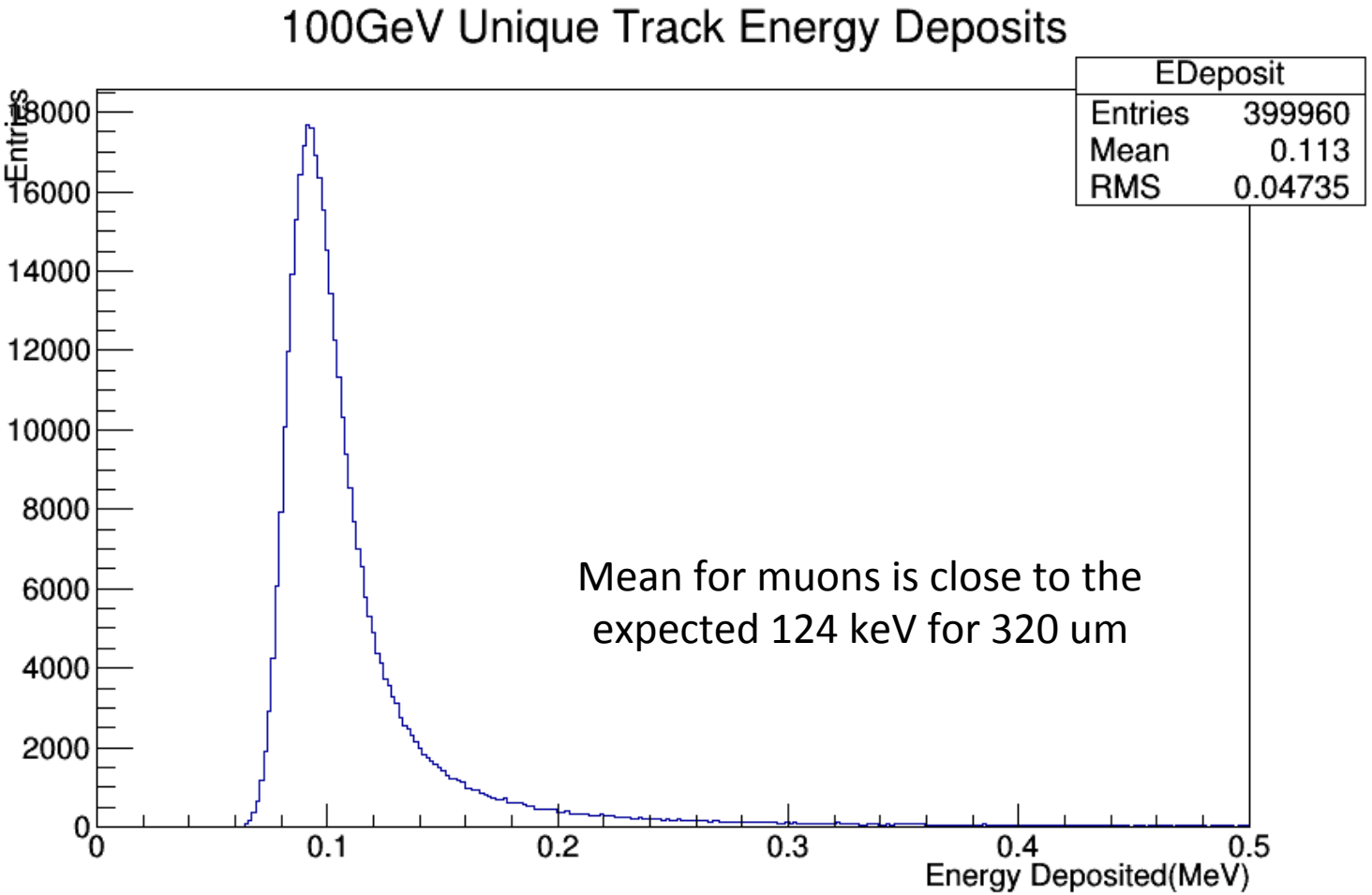


Energy at Shower Max/Pixel Area vs. Pixel Radius

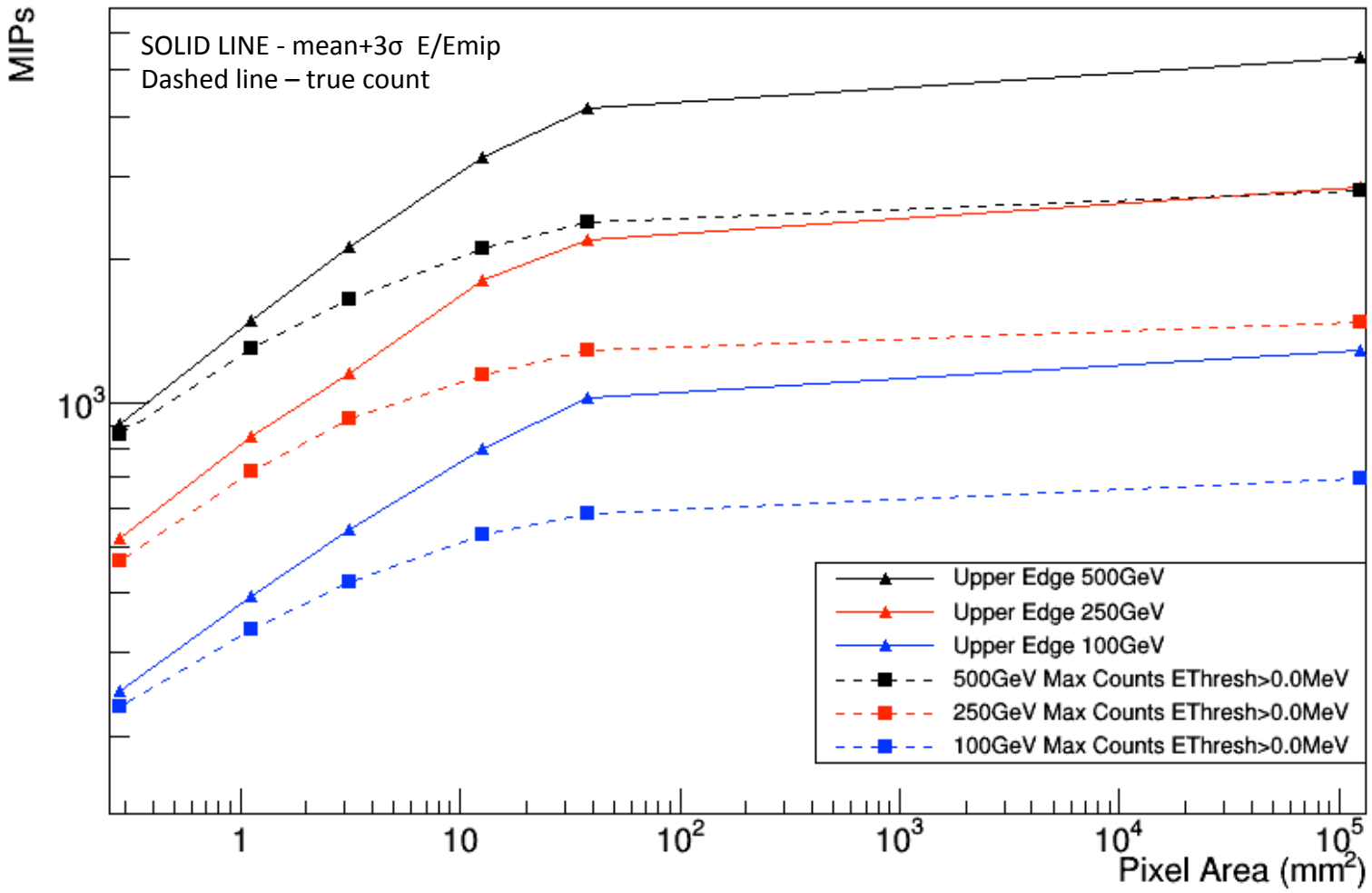


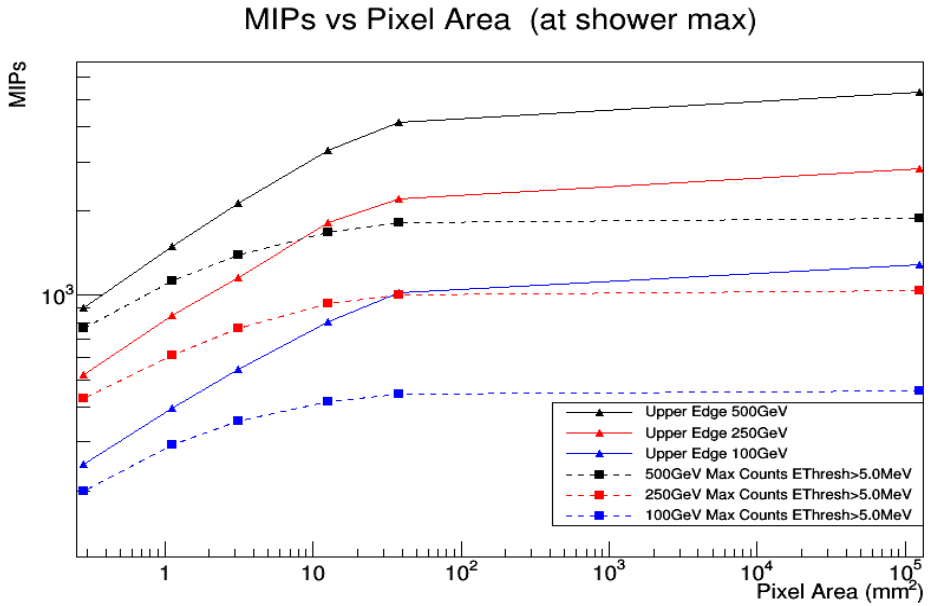

100GeV Unique Track Energy Deposits
EDeposit
Entries 2.203972e+08
Mean 0.01524
RMS 0.05896
Entries
×10³
1400
1200
1000
800
600
400
200
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Energy Deposited(MeV)
e
μ
100,000 muons
and
1,000 electrons


100GeV Unique Track Energy Deposits
EDeposit
Entries 2.203972e+08
Mean 0.01524
RMS 0.05896
Entries
10⁶
10⁵
10⁴
10³
10²
10
1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Energy Deposited(MeV)
e
μ


100GeV Unique Track Energy Deposits
EDeposit
Entries 399960
Mean 0.113
RMS 0.04735
Entries
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.1
0.2
0.3
0.4
0.5
Energy Deposited(MeV)
Mean for muons is close to the expected 124 keV for 320 um

MIPs vs Pixel Area (at shower max)

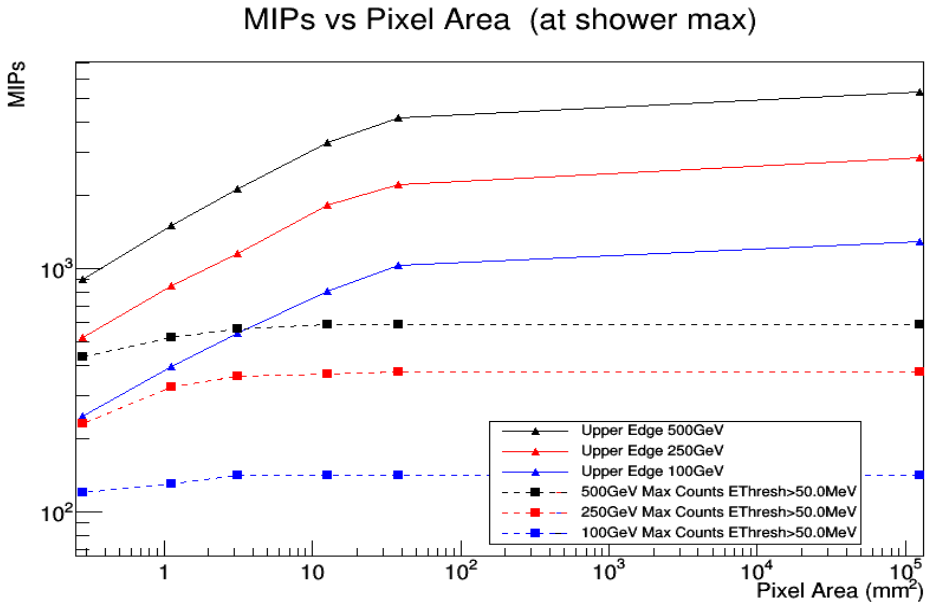


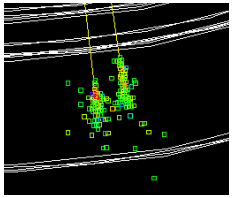


SOLID LINE - mean+3σ E/Emip
Dashed line – true count above threshold

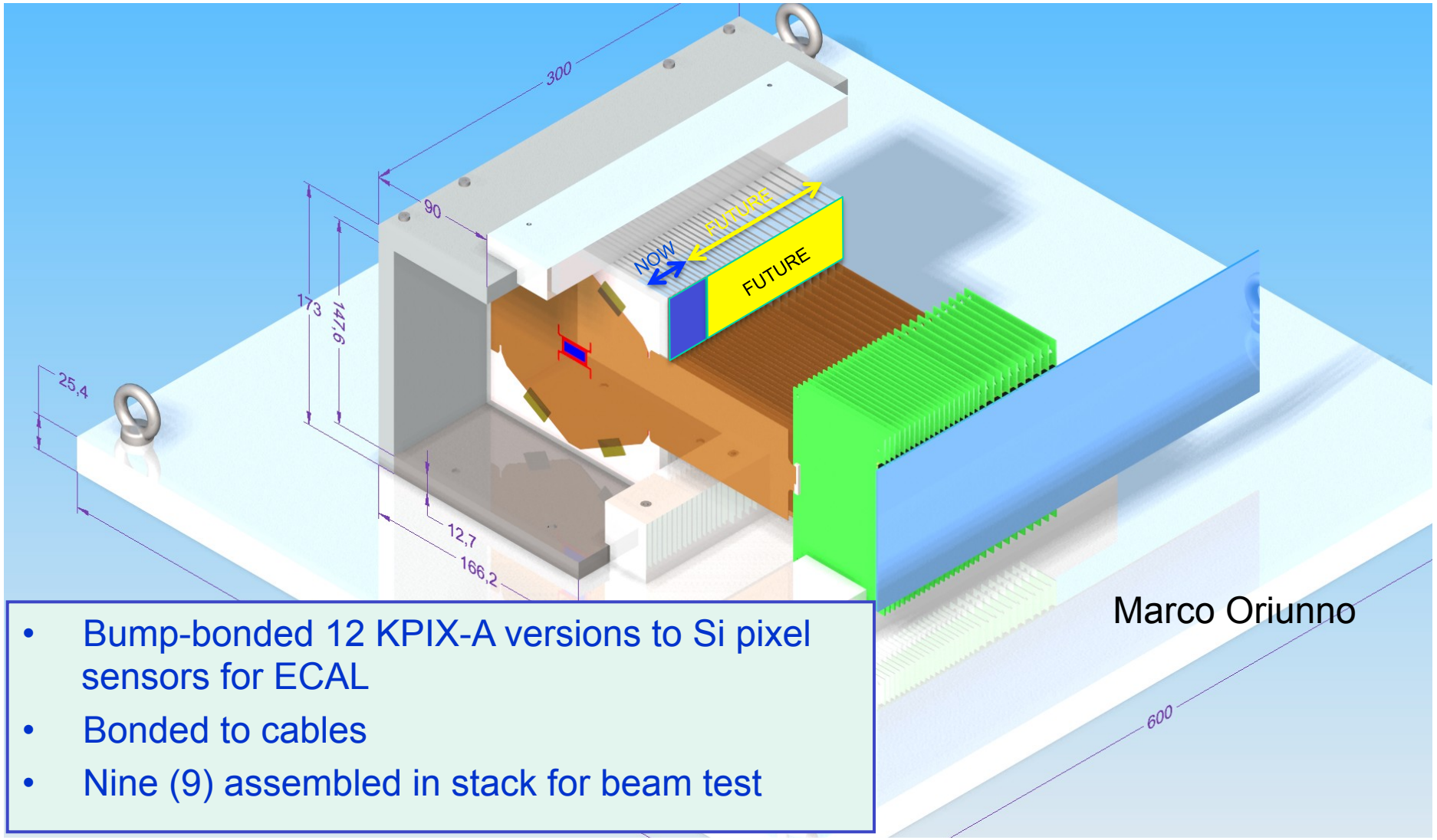
- Vary threshold energy for dashed line

(for understanding the showers – not to be measured)

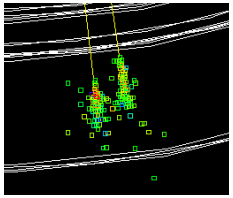




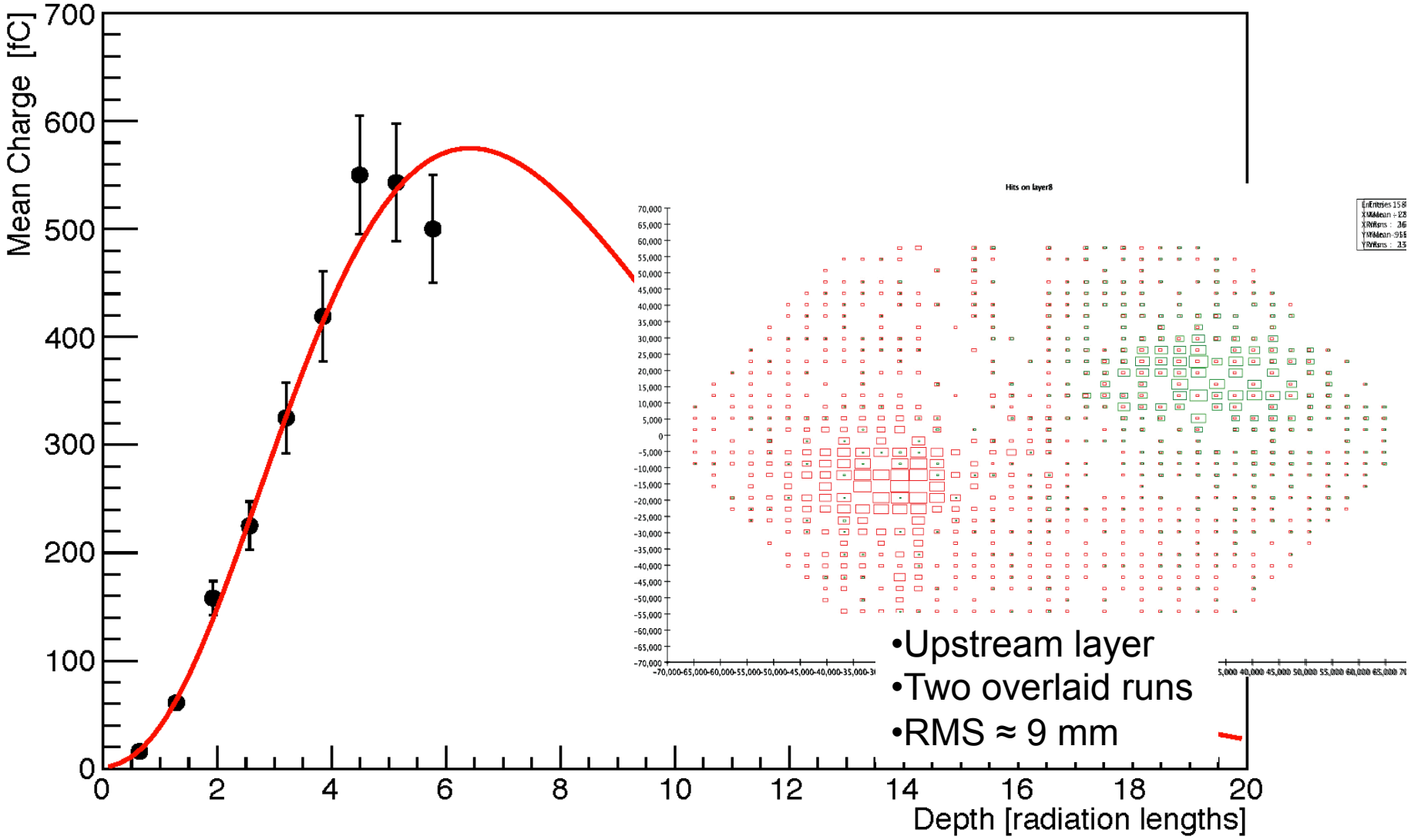
Initial test beam module for T-511 only
9 Si + 8 W layers (~ 6 X_0)

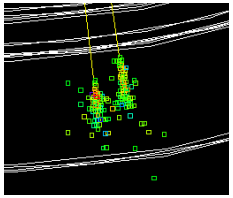


- Bump-bonded 12 KPIX-A versions to Si pixel sensors for ECAL
- Bonded to cables
- Nine (9) assembled in stack for beam test

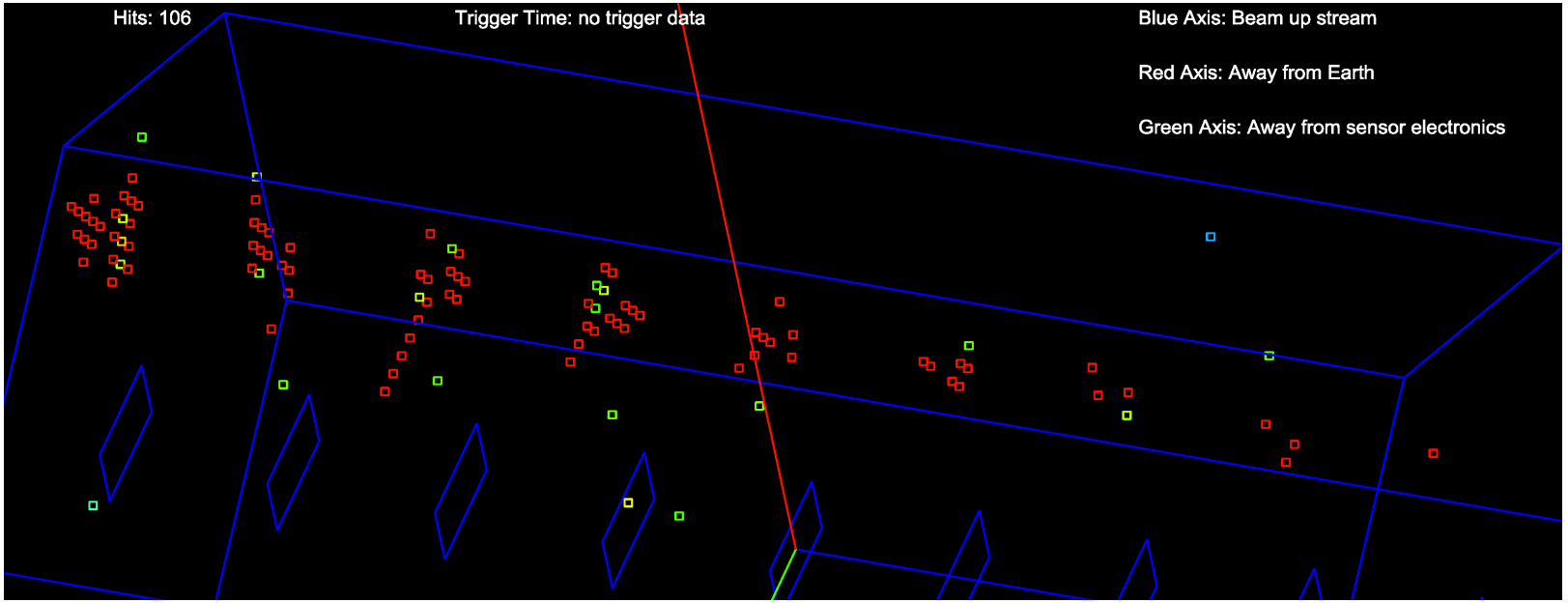


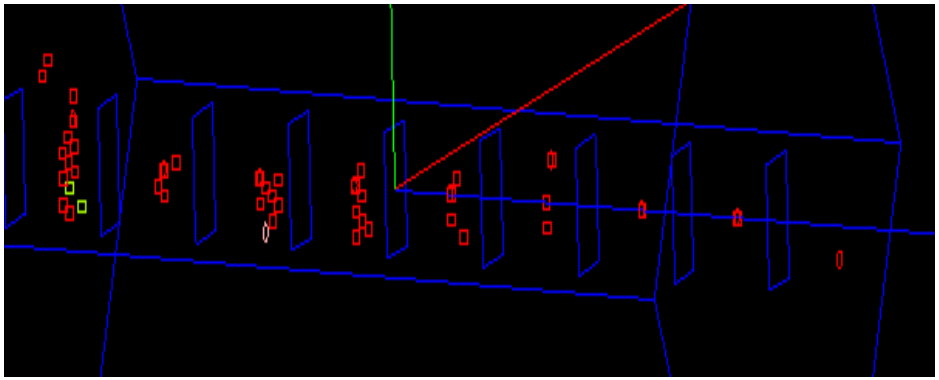
profile in depth and transverse

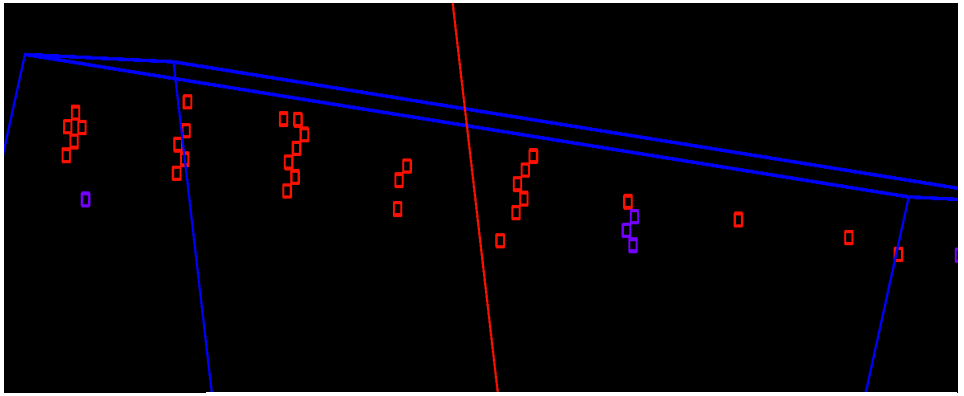




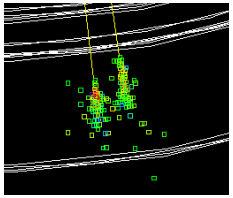
single-electron showers



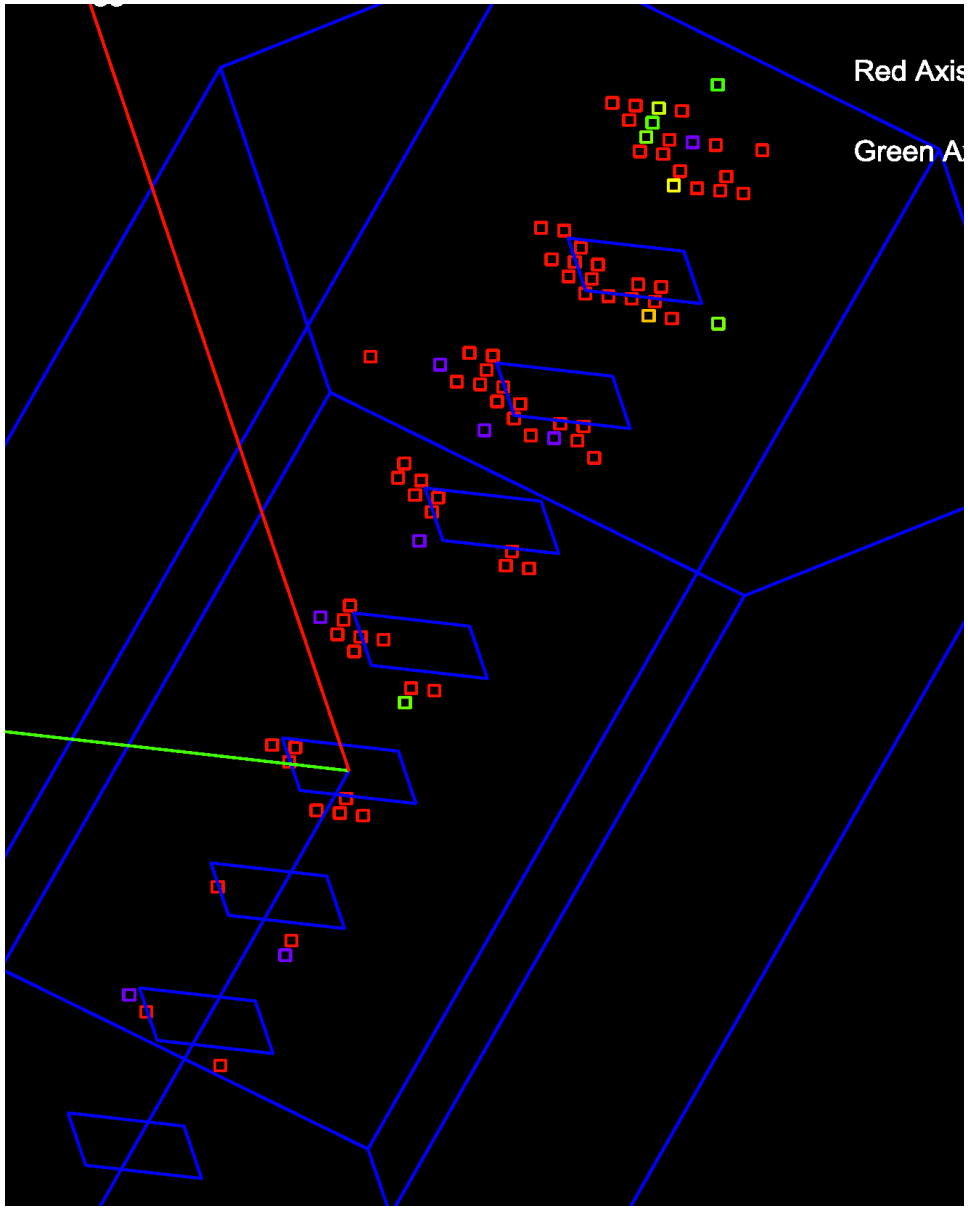


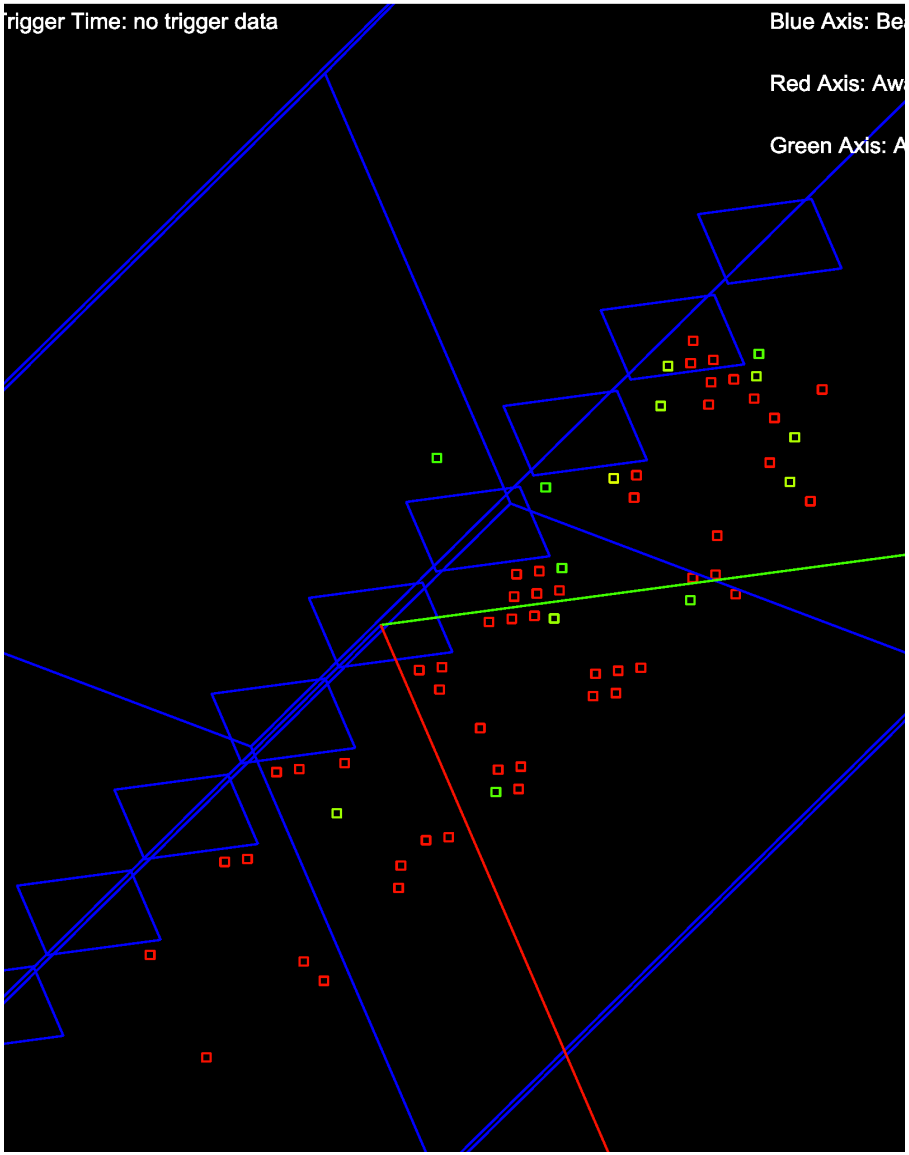


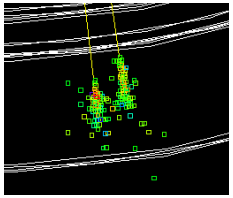
Event display
– Kyle Travis and Dylan Mead



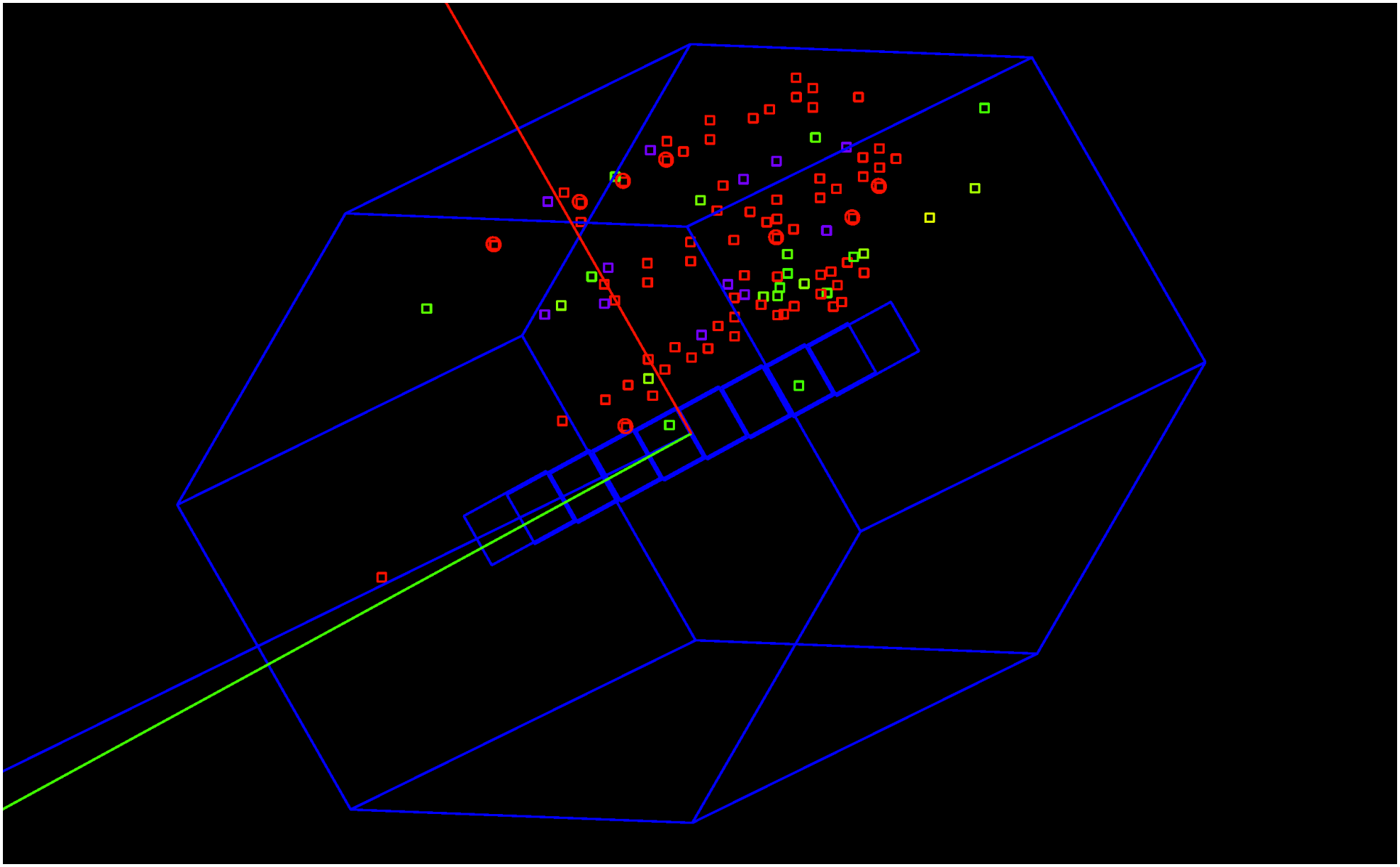
2 electrons

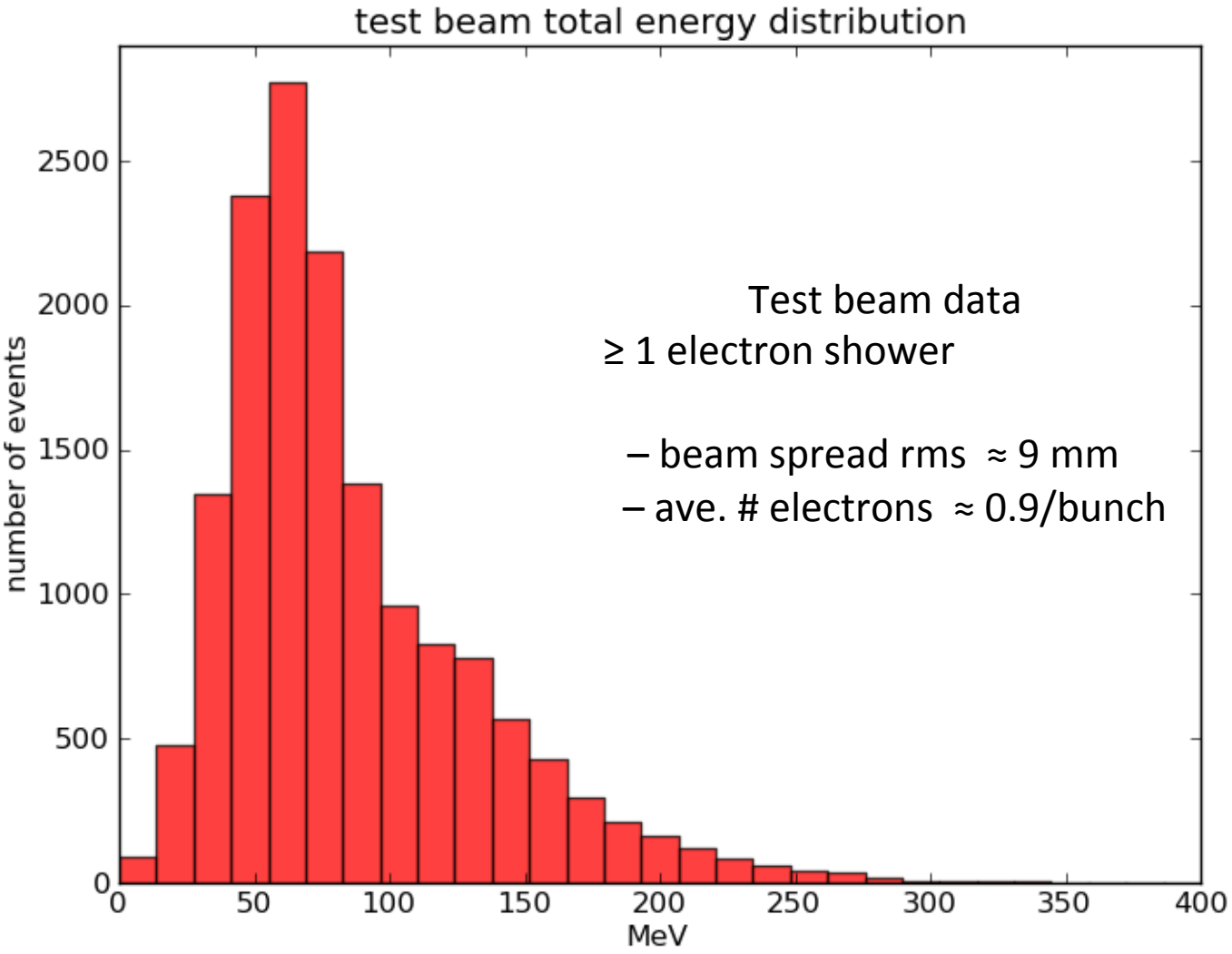

Red Axis
Green A

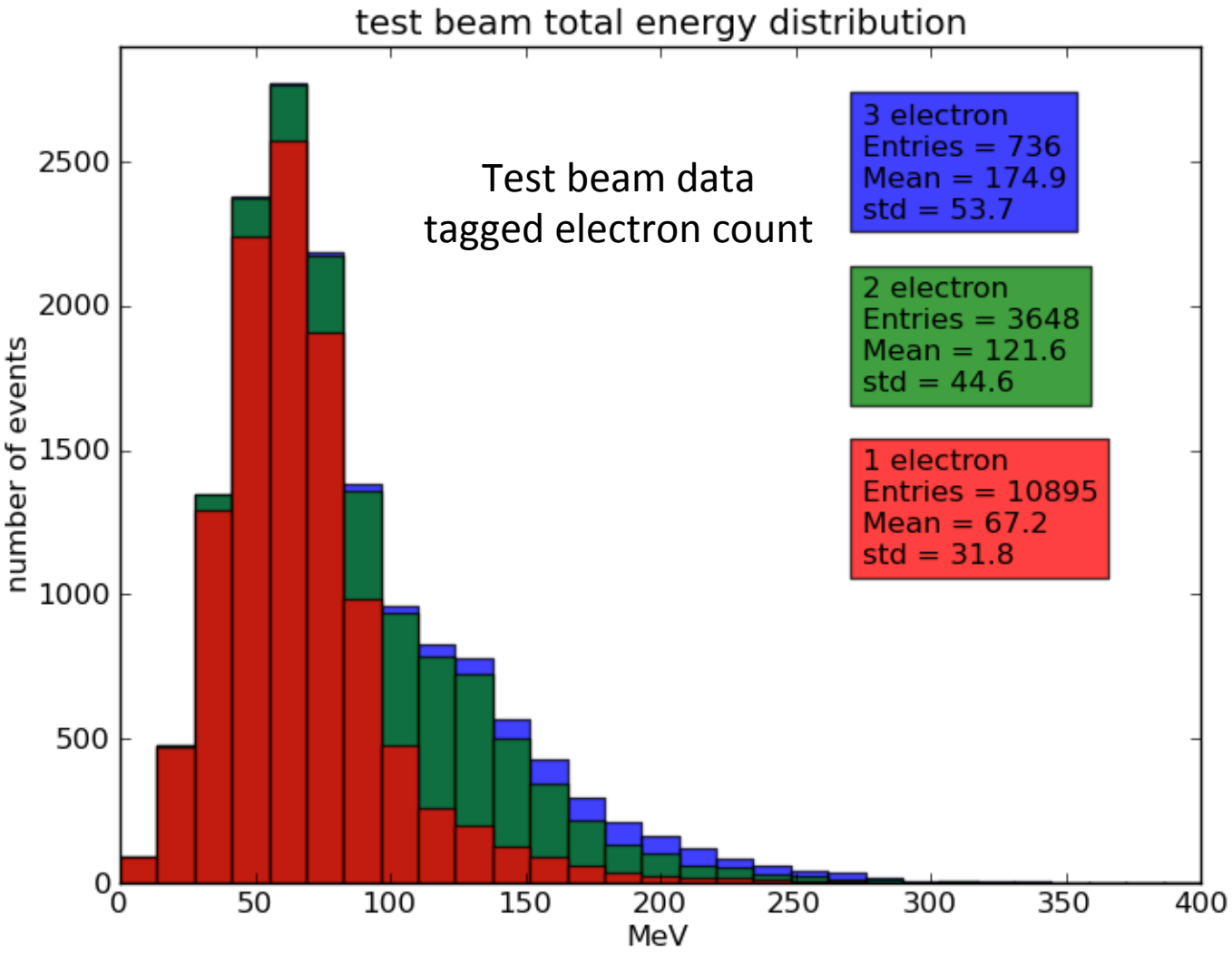

rigger Time: no trigger data
Blue Axis: Be
Red Axis: Aw
Green Axis: A

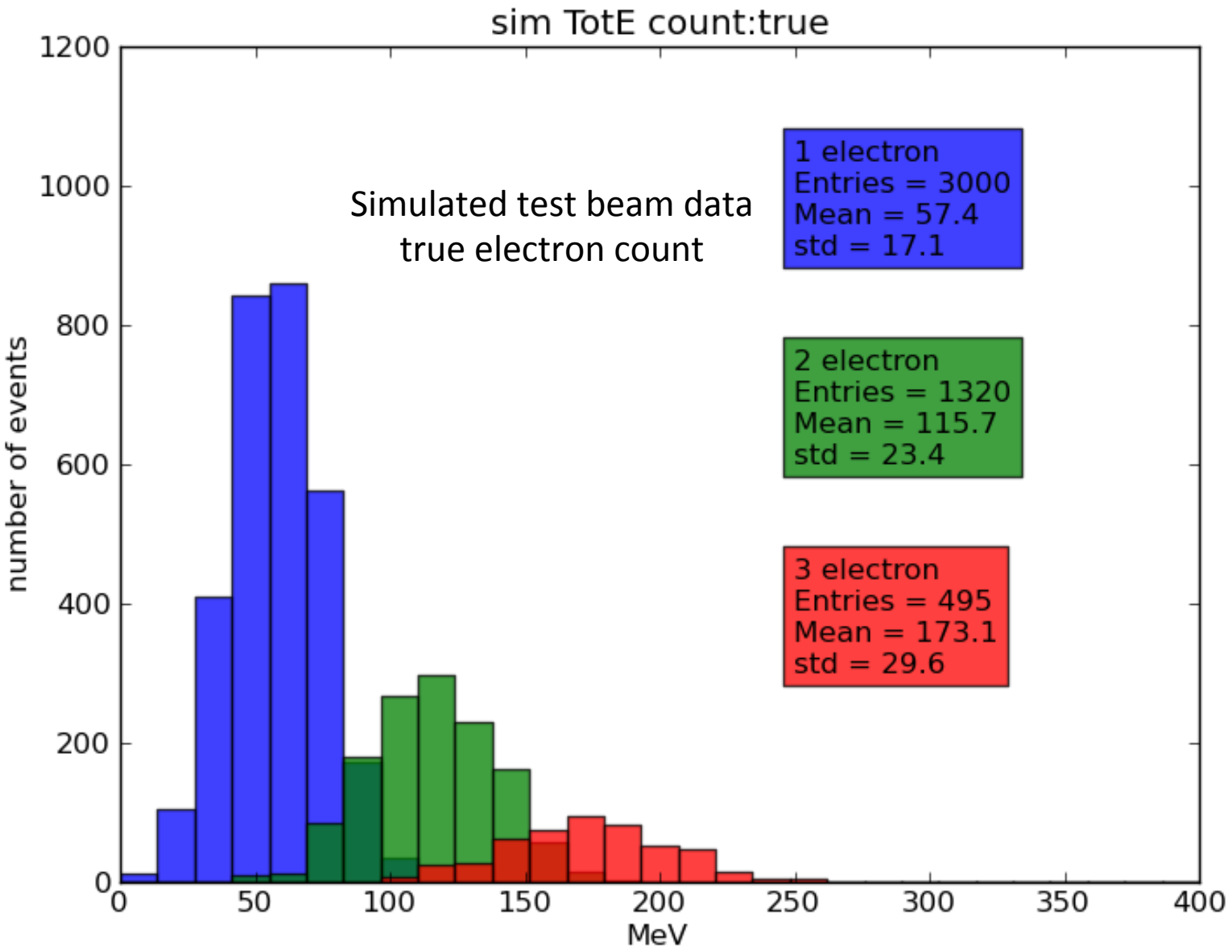


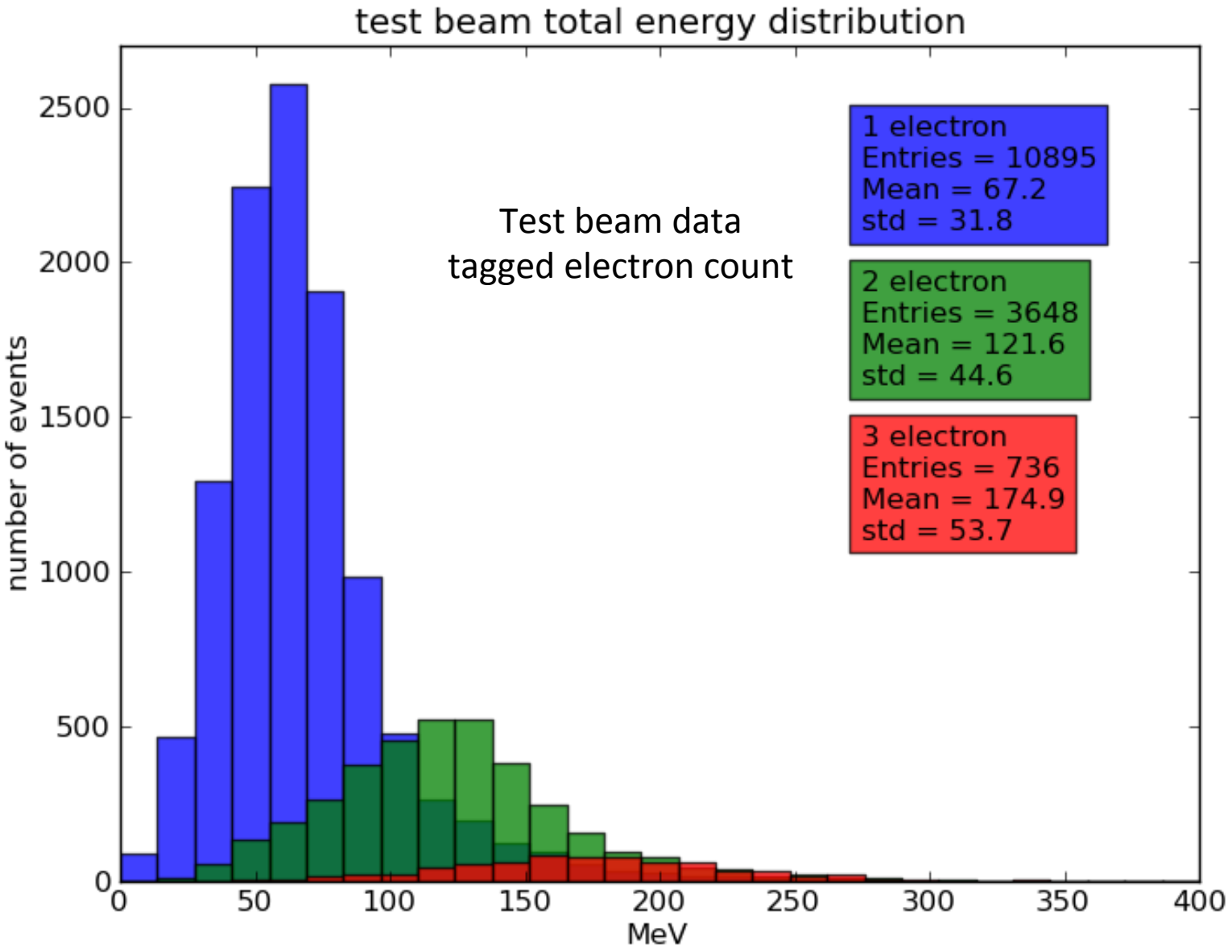
three electrons

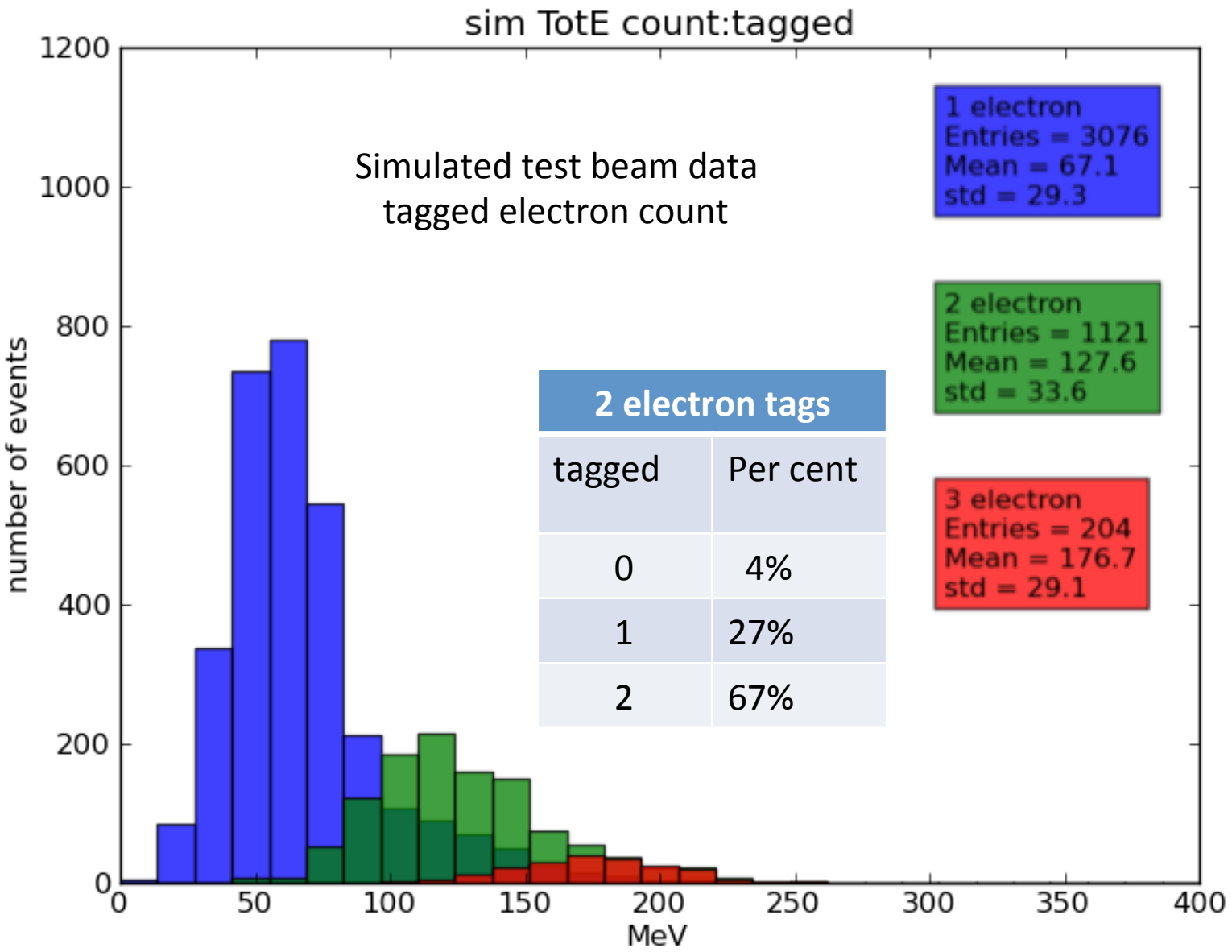



test beam total energy distribution
number of events
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
MeV
Test beam data
≥ 1 electron shower
– beam spread rms ≈ 9 mm
– ave. # electrons ≈ 0.9/bunch


test beam total energy distribution
Test beam data
tagged electron count
3 electron
Entries = 736
Mean = 174.9
std = 53.7
2 electron
Entries = 3648
Mean = 121.6
std = 44.6
1 electron
Entries = 10895
Mean = 67.2
std = 31.8
number of events
0
500
1000
1500
2000
2500
0
50
100
150
200
250
300
350
400
MeV


sim TotE count:true
Simulated test beam data
true electron count
1 electron
Entries = 3000
Mean = 57.4
std = 17.1
2 electron
Entries = 1320
Mean = 115.7
std = 23.4
3 electron
Entries = 495
Mean = 173.1
std = 29.6
number of events
MeV
0
200
400
600
800
1000
1200
0
50
100
150
200
250
300
350
400


test beam total energy distribution
Test beam data
tagged electron count
1 electron
Entries = 10895
Mean = 67.2
std = 31.8
2 electron
Entries = 3648
Mean = 121.6
std = 44.6
3 electron
Entries = 736
Mean = 174.9
std = 53.7
number of events
MeV
0
500
1000
1500
2000
2500
0
50
100
150
200
250
300
350
400



2 electron tags	
tagged	Per cent
0	4%
1	27%
2	67%

Summary

- Energy & mips per pixel vs. pixel radius
  - Prepared summary of distributions

- Test beam analysis
  - Shower counting
  - Energy vs. shower count
  - This study will continue - to understand some differences between test beam data and simulation

Prepared to apply this to a future test beam data with full calorimeter and new sensors and KPiX chips