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Update on SiD ECal MAPS Simulations

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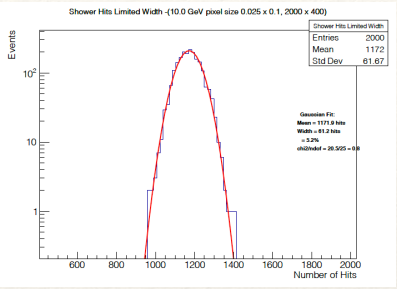
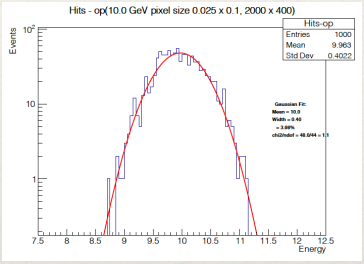
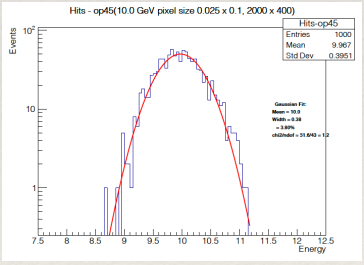
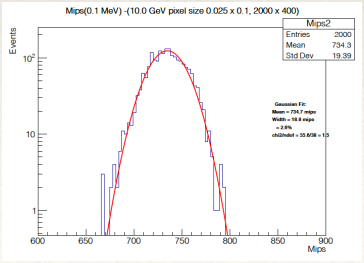
the **200th**
SiD Optimization Meeting

EARLIER REPORT 20 layers (13 X_0) + 10 layers (13 X_0)	Resolution (10 GeV)	Presumed energy dependence
SiD-TDR Analog 3.5 mm x 3.5 mm, 300 um thick Cell min = 30 keV (8170 e's)	5.2%	16% / √E
25 um x 100 um 12 um thick maps Hits > 1 keV (272 e's)	5.2%	16% / √E
25 um x 100 um 12 um thick maps Hits > 1 keV (272 e's) 0 or 1 nbr	4.3%	14% / √E
25 um x 100 um 12 um thick maps Hits > 1 keV (272 e's) 3 par fit, 0,1,2 nbr	4.1%	13% / √E
25 um x 100 um 12 um thick maps Hits > 1 keV (272 e's) 45 par fit, 0,1,2 nbr	3.8%	12% / √E
mips (20+10 layers)	2.6%	8% / √E





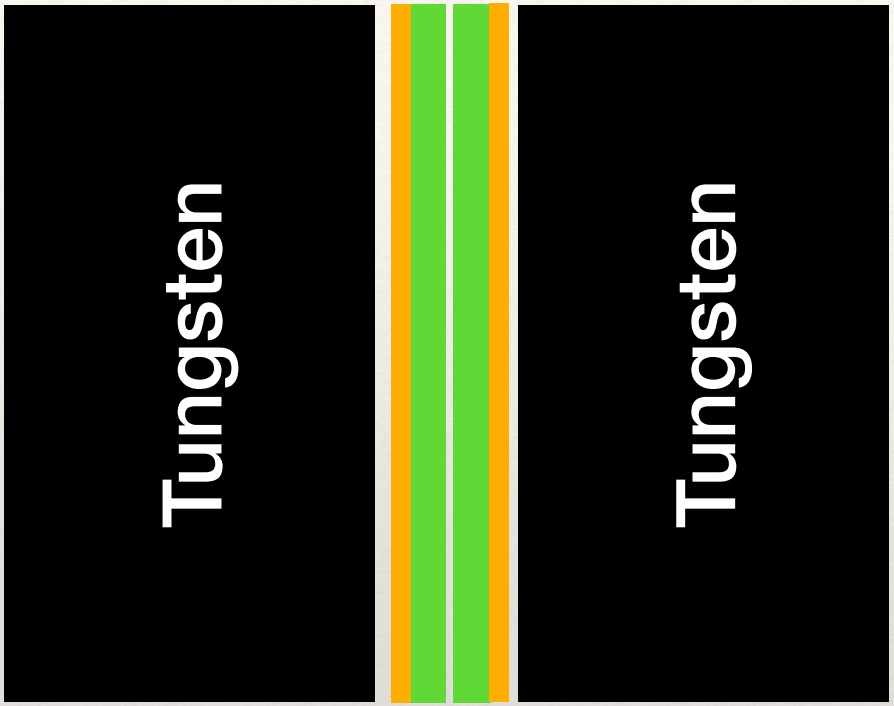


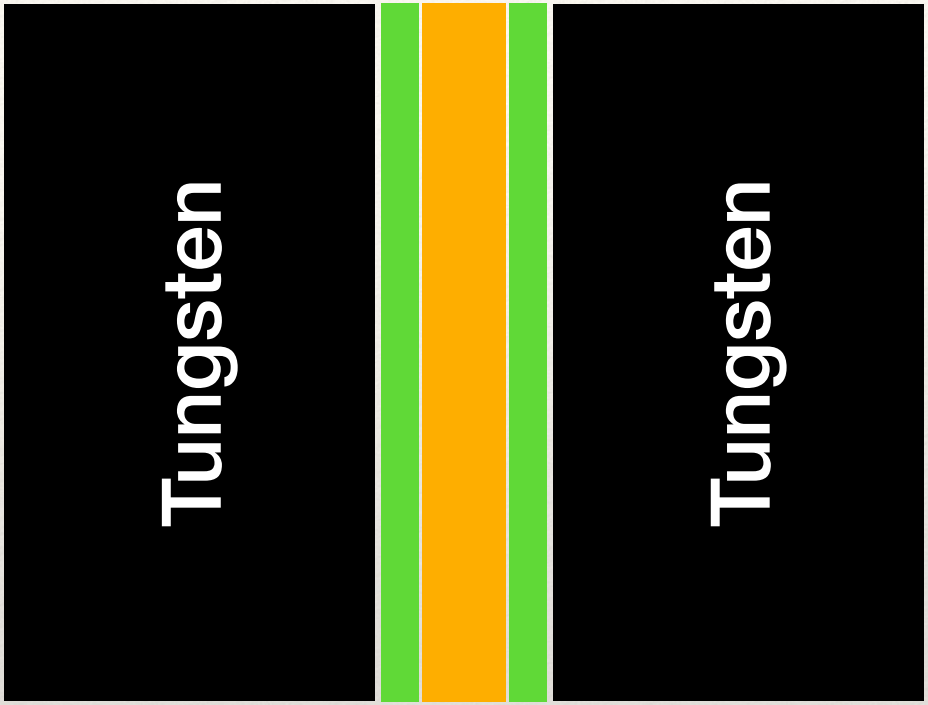


Can we get closer to mip performance?

- Best 10 GeV electron resolution is 3.8%, while mips are 2.6%.
- Is there a detector configuration that can identify mips (and reduce any background)?
- Consider two detectors per tungsten gap and look for coincidences.

Two configurations investigated (so far)





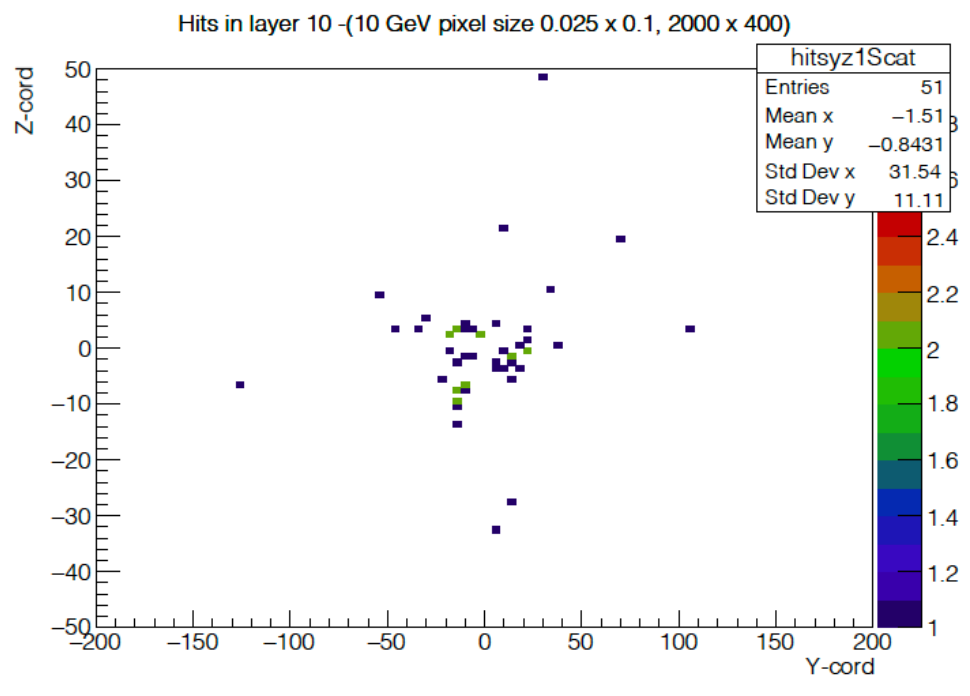
12 um - 12 um

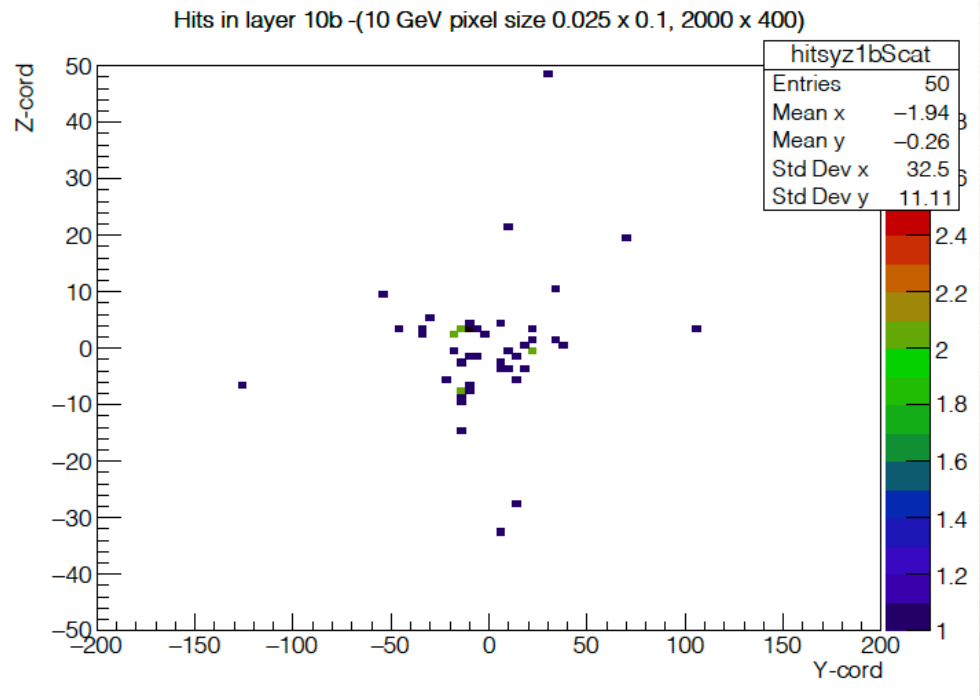
(Substrate not included in simulation)

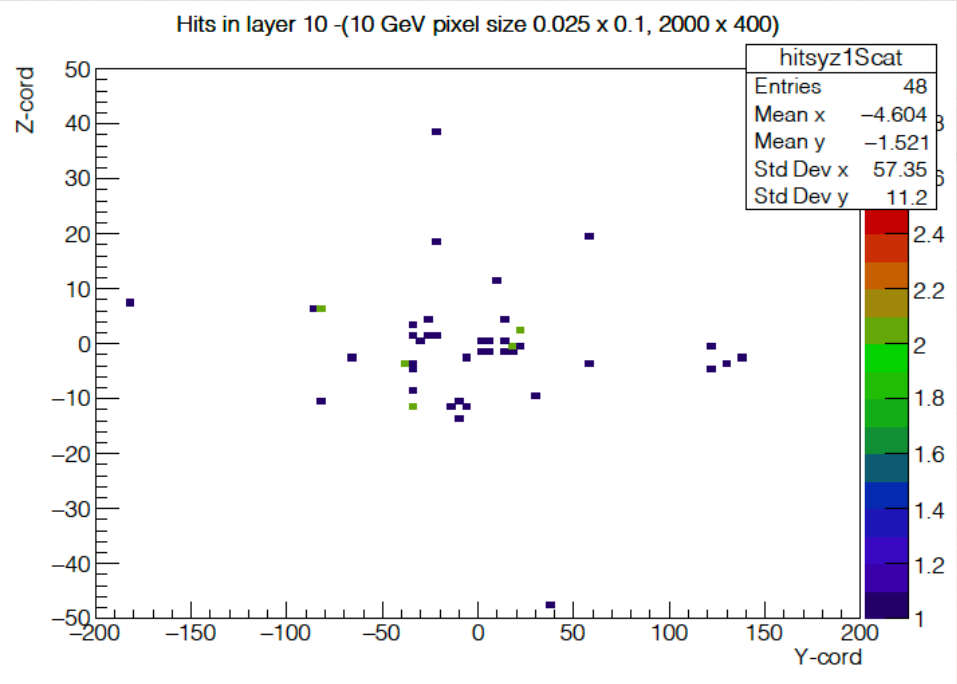
12 um - 600 um - 12 um

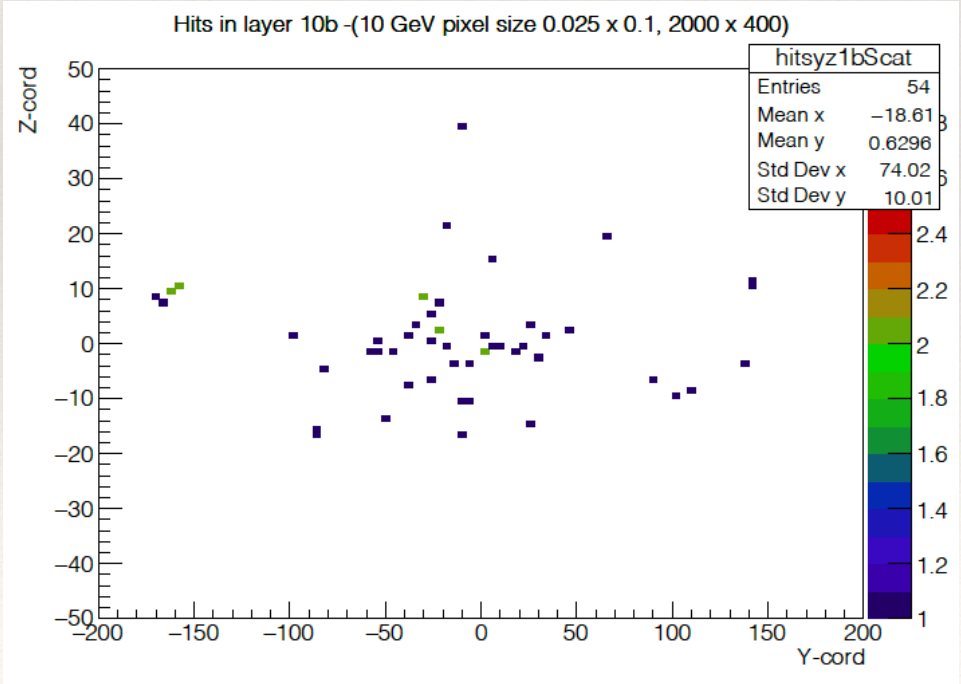
Pixels: 25 um in y, 100 um in z

Layer 10 (near shower max)

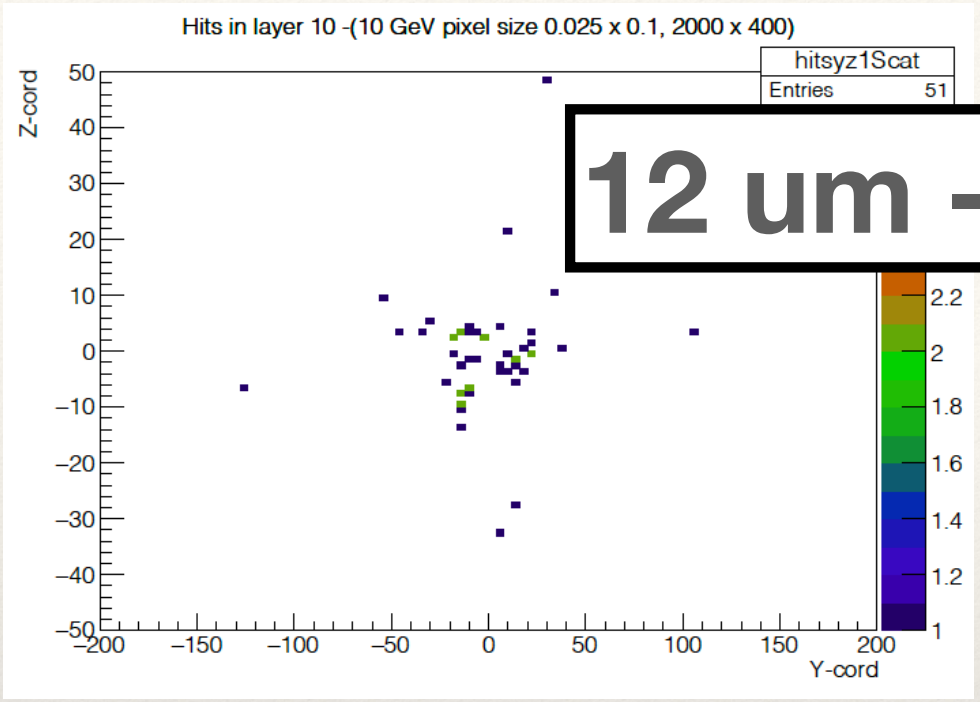




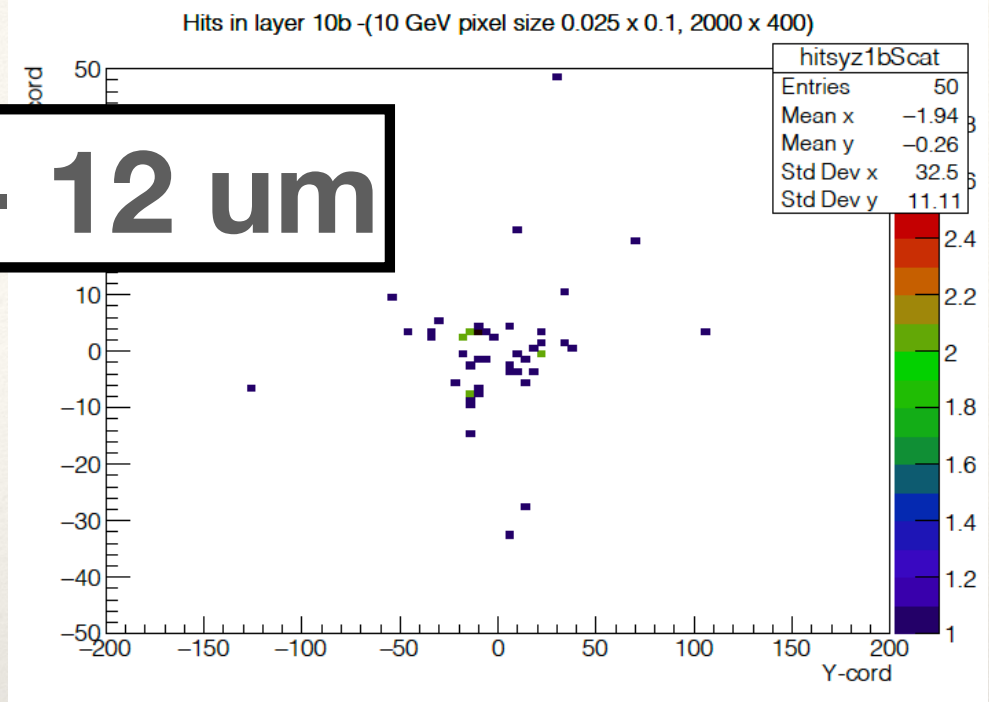


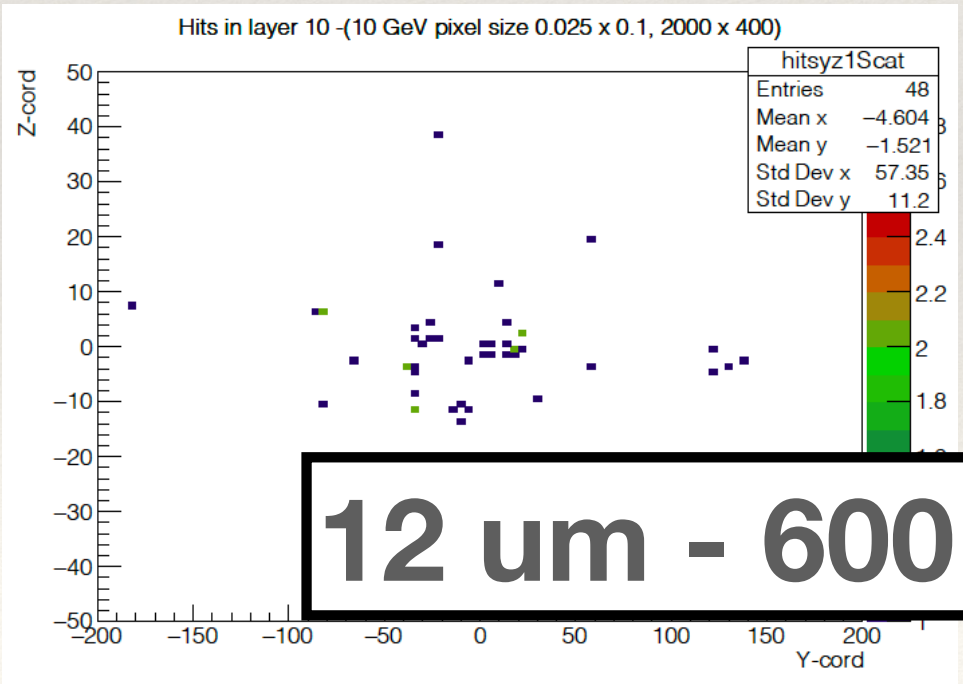


Layer 10 (near shower max)

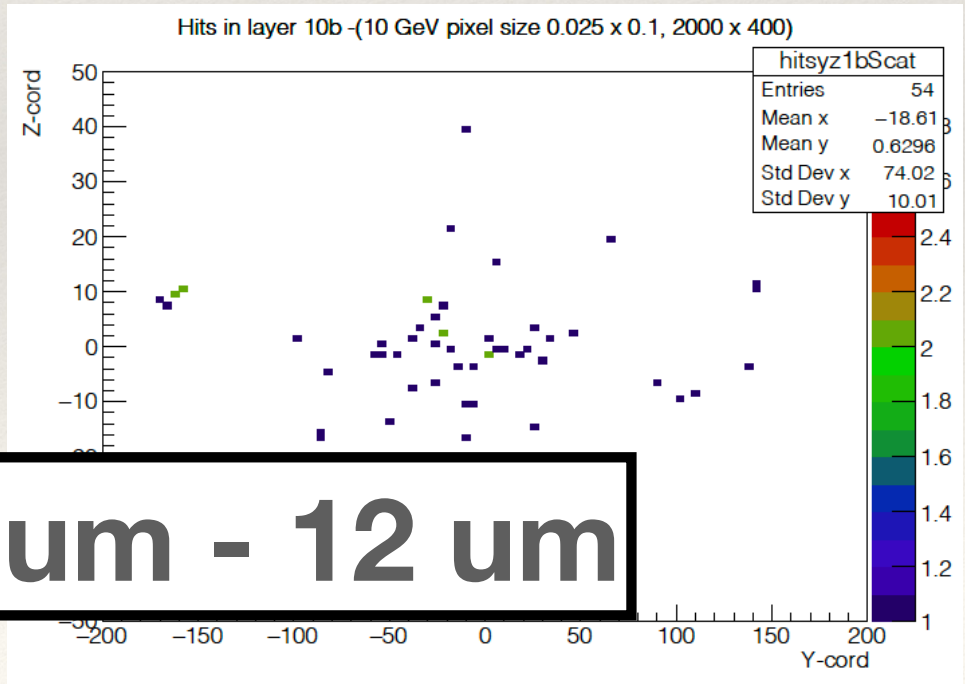


12 um - 12 um



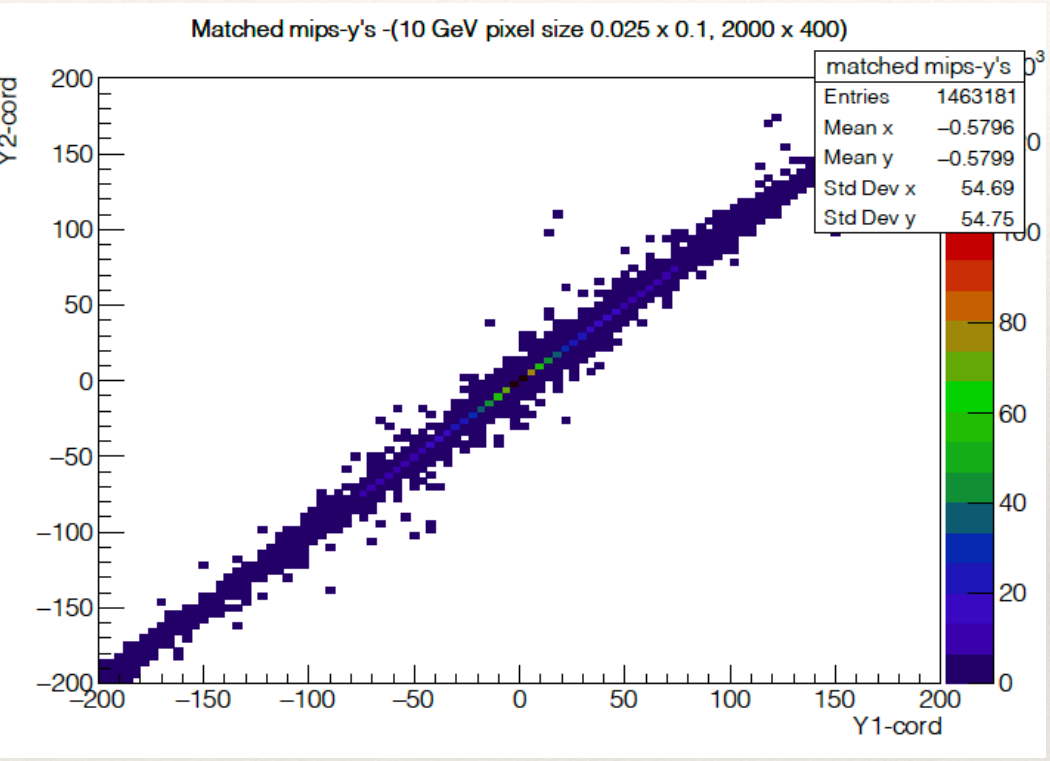


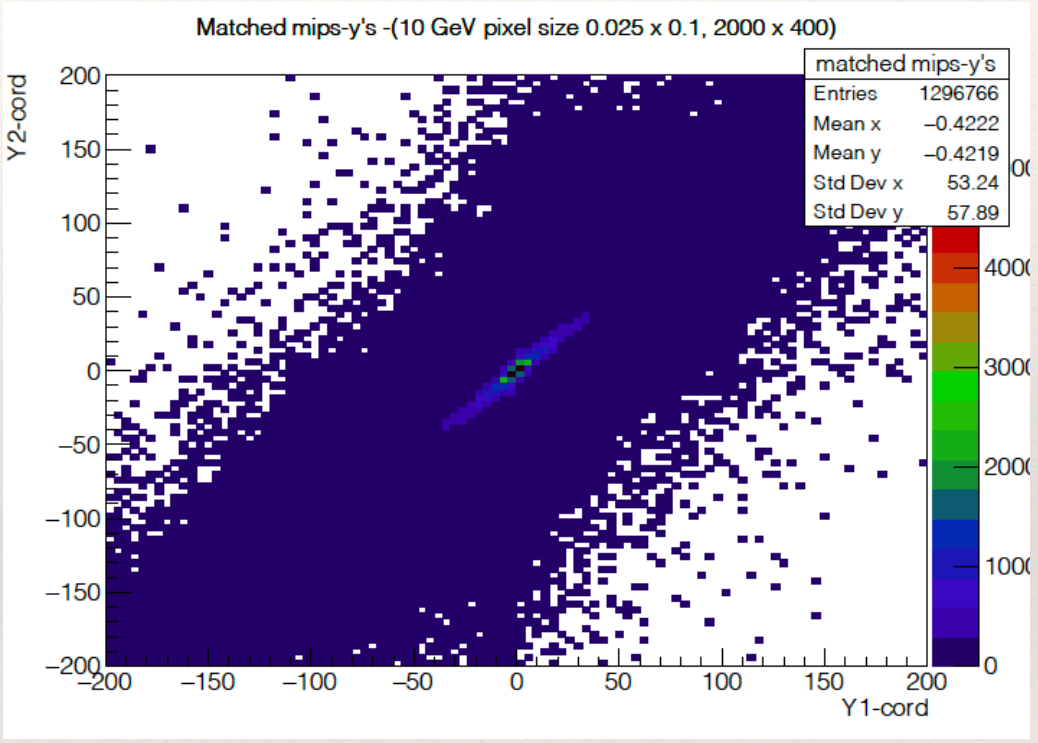
12 um - 600 um - 12 um



ΔY - matched mips - units=pixels

25 um pixels





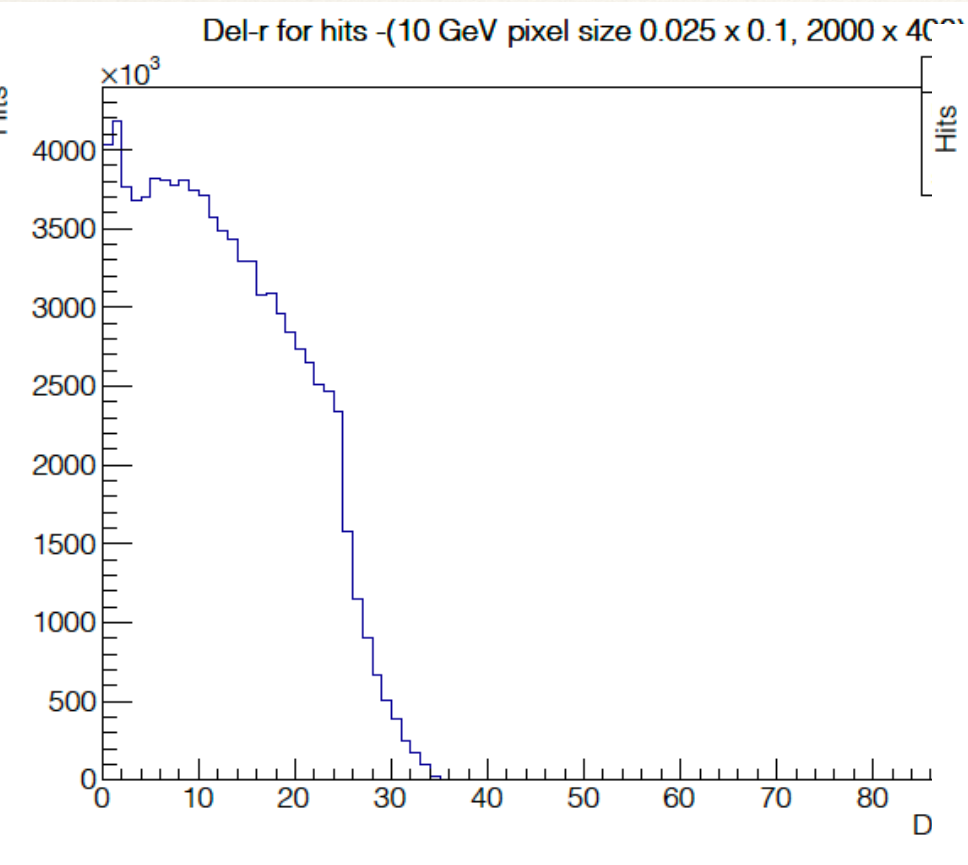
12 um - 12 um

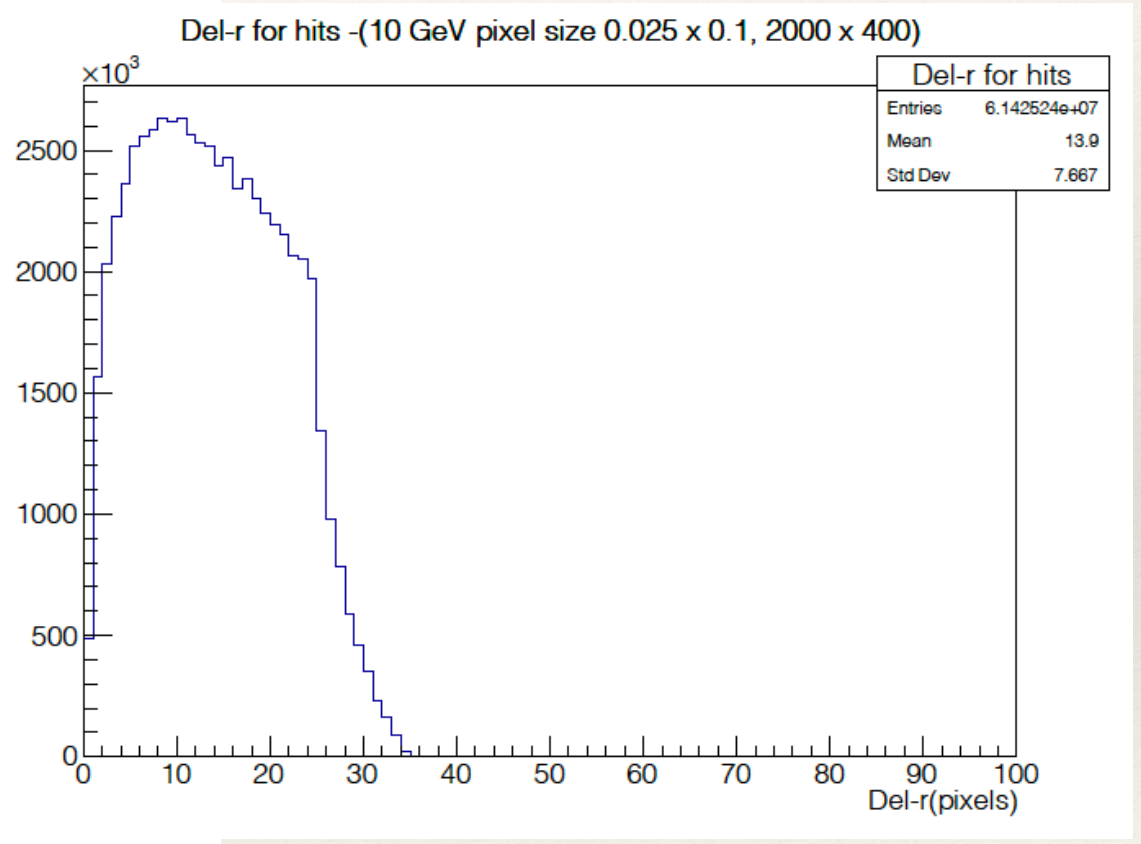
12 um - 600 um - 12 um

$\Delta r = \sqrt{((\Delta Y/4)^2 + \Delta Z^2)}$ - units=Z pixels

$|\Delta Y|<100 \quad |\Delta Z|<25$

25 um pixels **100 um pixels**





12 um - 12 um

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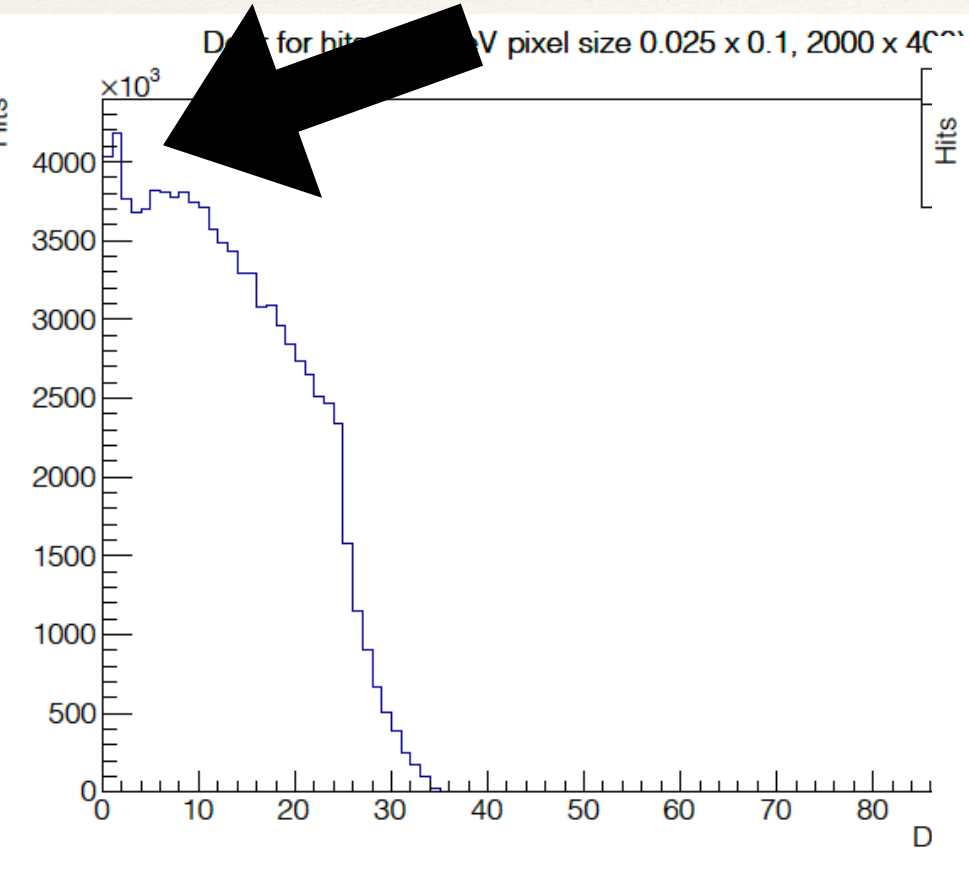
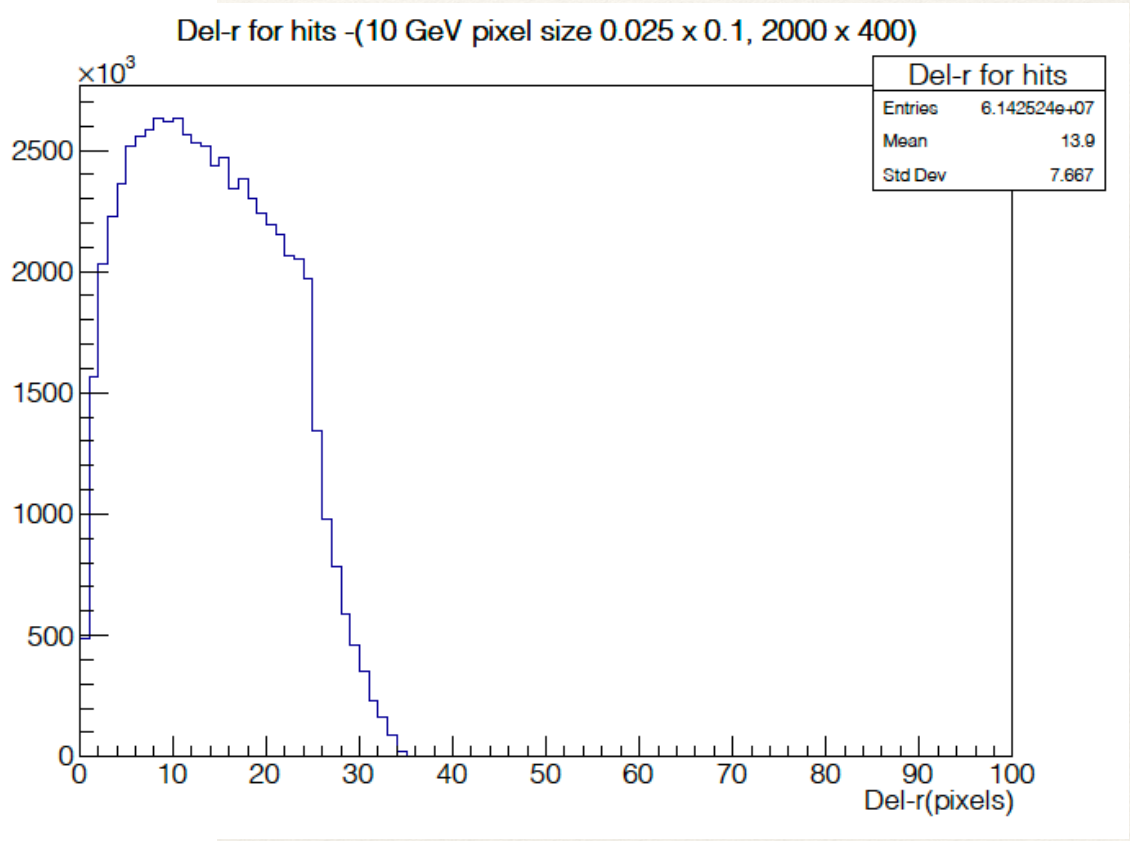
$|\Delta Y|<100$ $|\Delta Z|<25$

25 um pixels **100 um pixels**



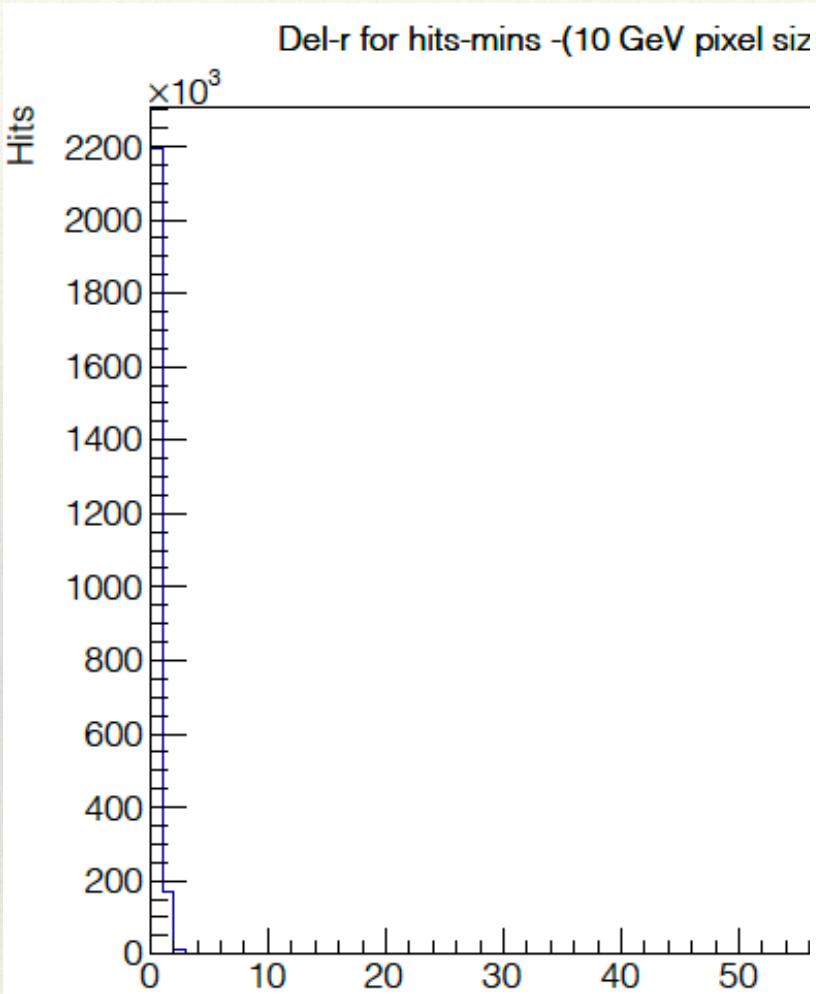


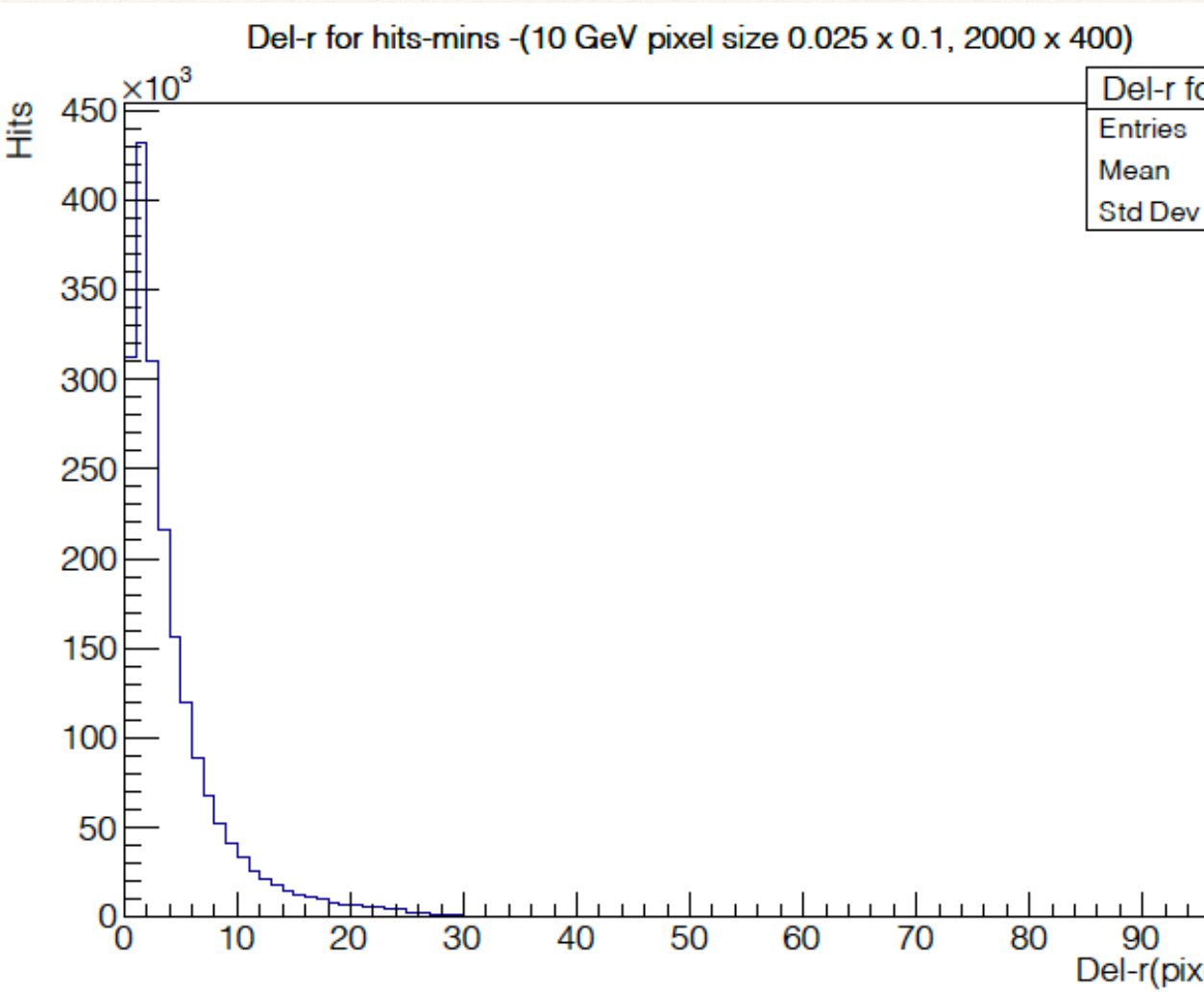
12 um - 12 um

12 um - 600 um - 12 um

Δr_{min} = sqrt((ΔY/4)² + ΔZ²) - units=Z pixels

Min for each hit, or best match

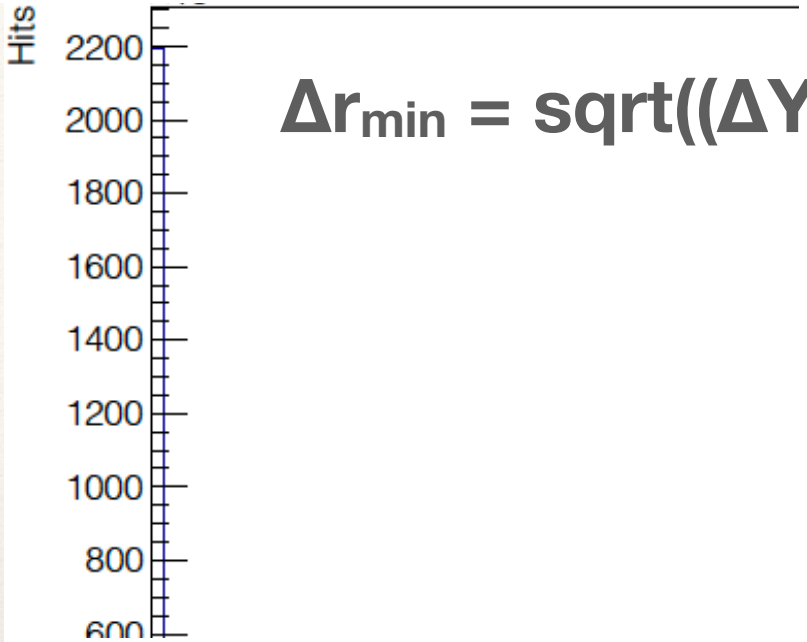


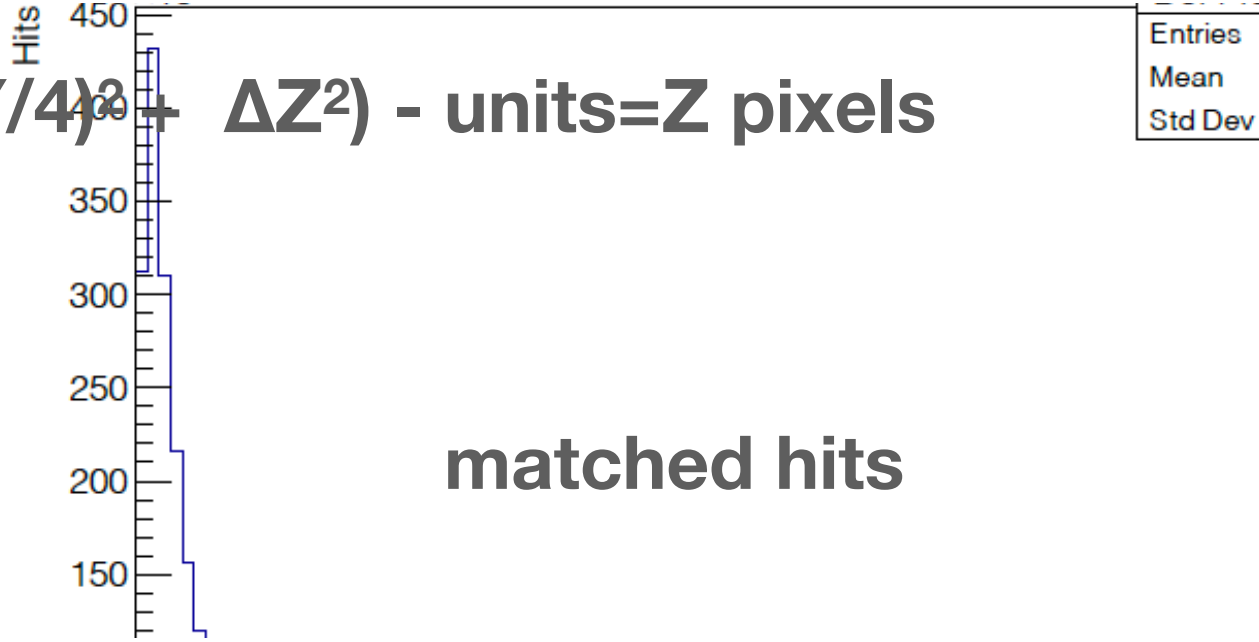


12 um - 12 um

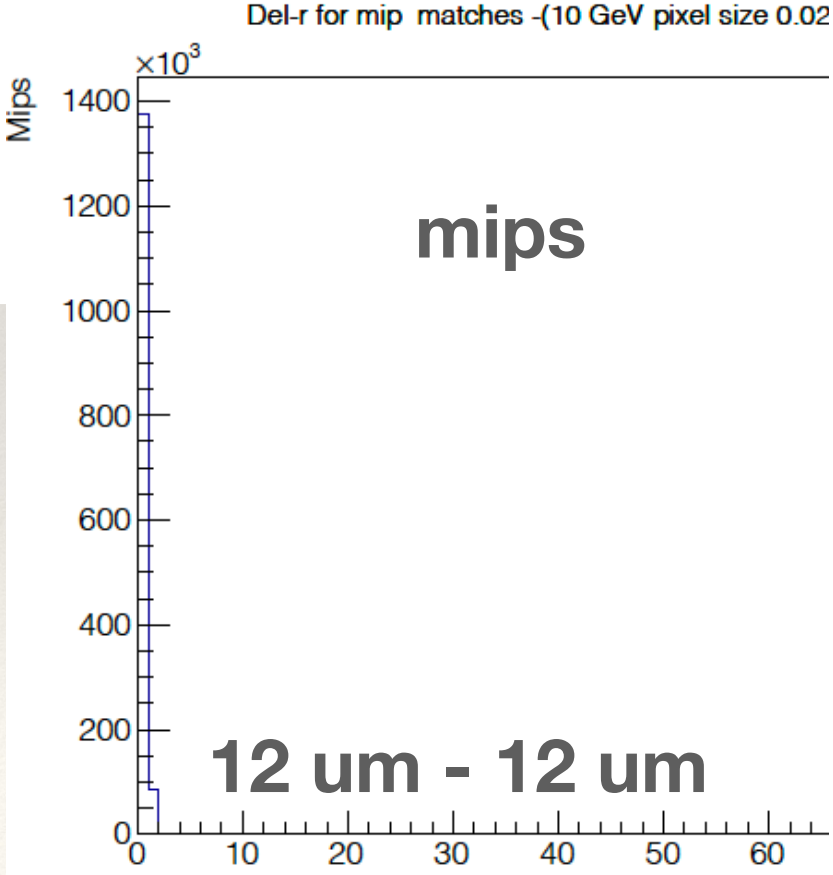
12 um - 600 um - 12 um

$\Delta r_{min} = \sqrt{((\Delta Y/4)^2 + \Delta Z^2)}$ - units=Z pixels



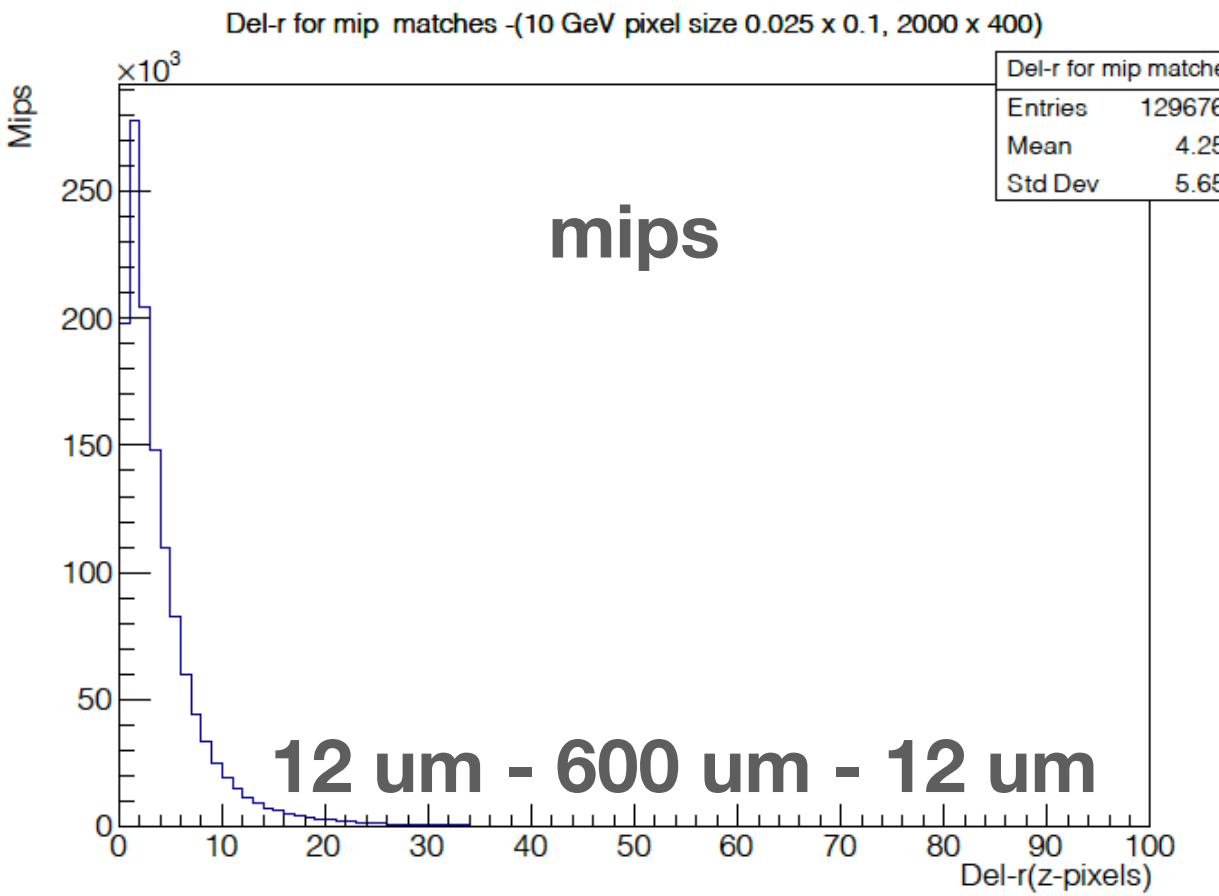


matched hits



mips

12 um - 12 um

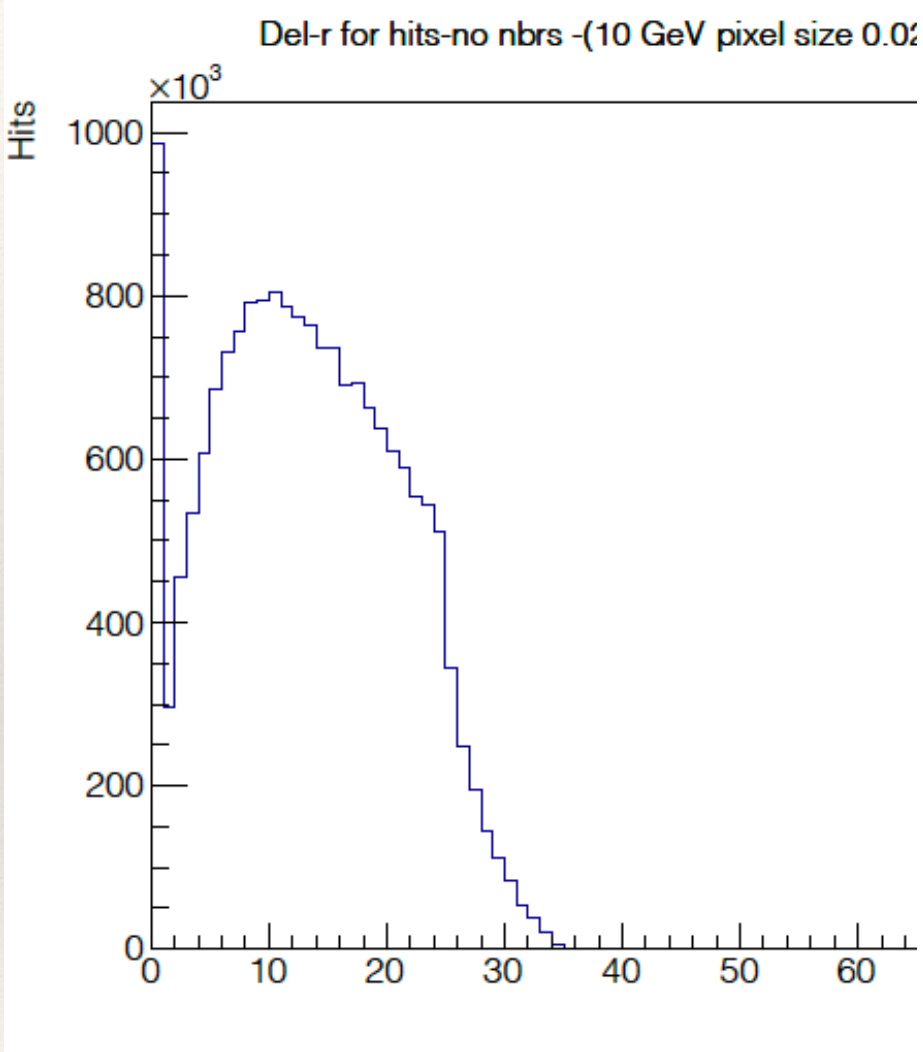


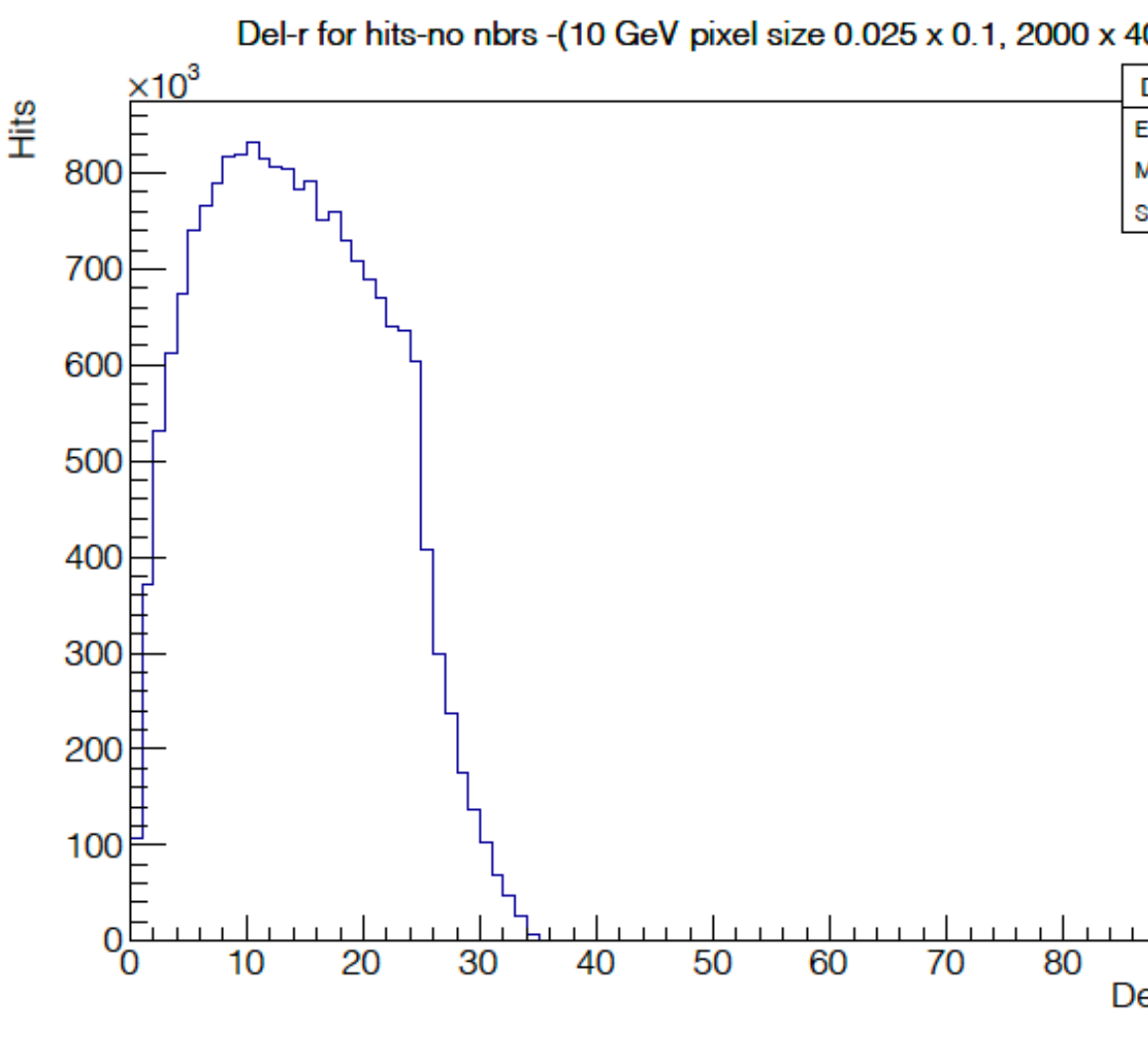
mips

12 um - 600 um - 12 um

Δr_{min} = sqrt((ΔY/4)² + ΔZ²) - units=Z pixels

Hits with no neighbors



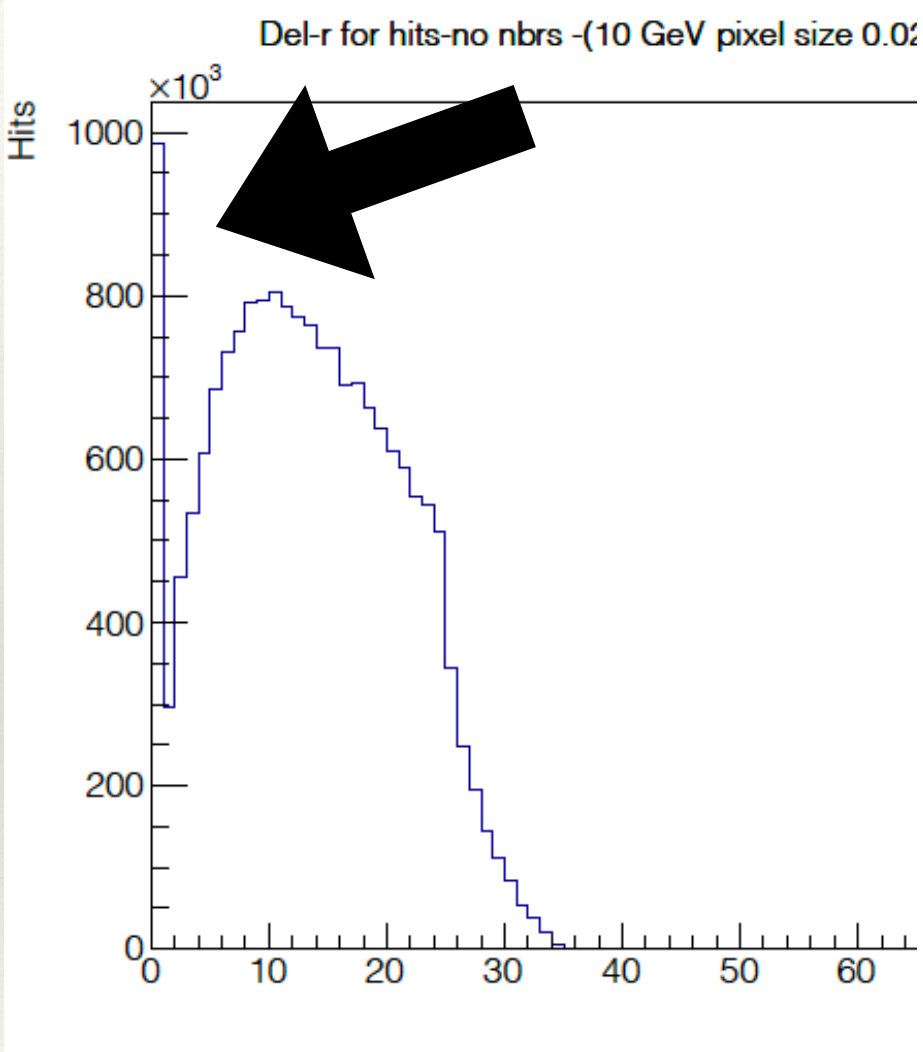


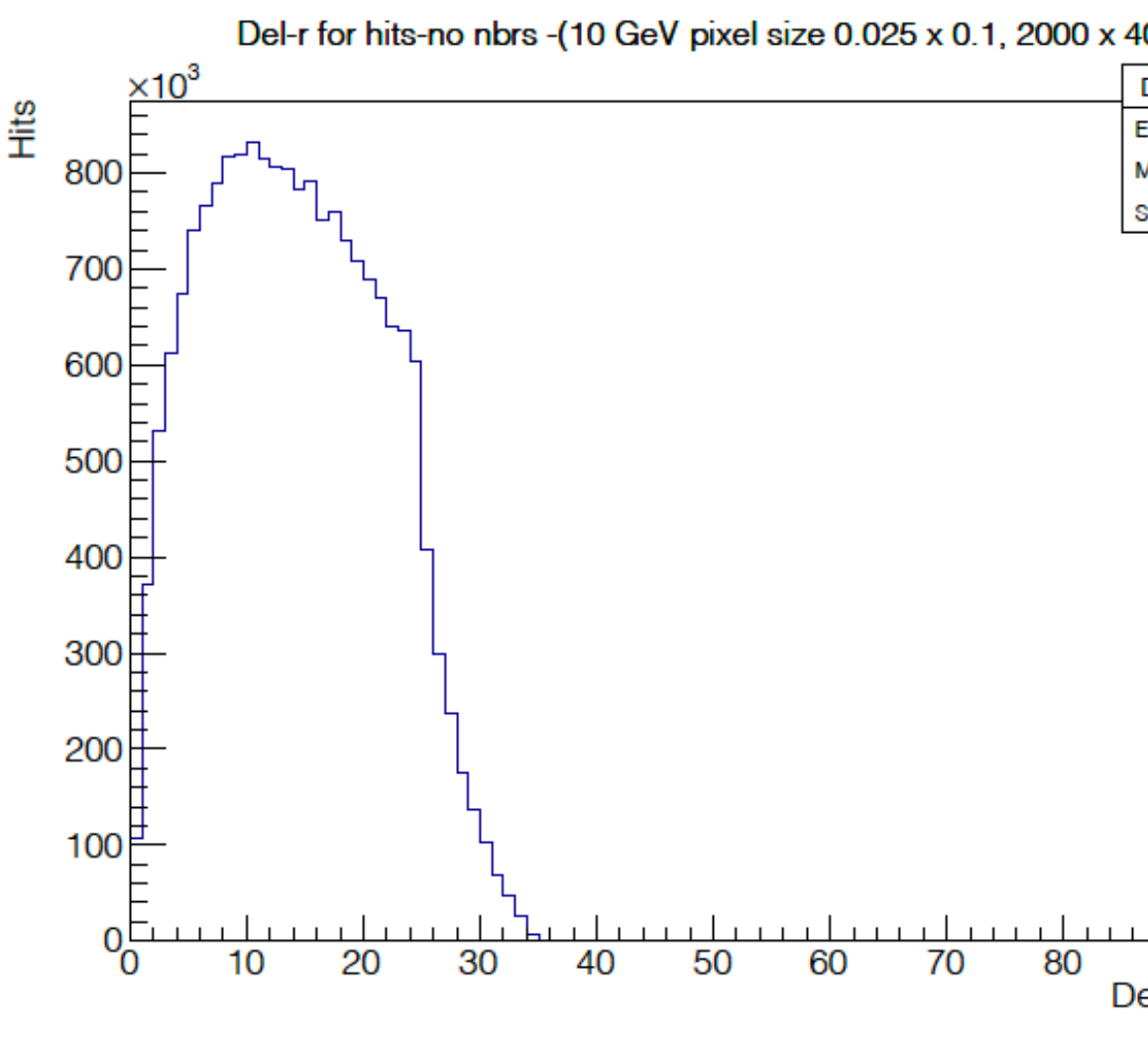
12 um - 12 um

12 um - 600 um - 12 um

Δr_{min} = sqrt((ΔY/4)² + ΔZ²) - units=Z pixels

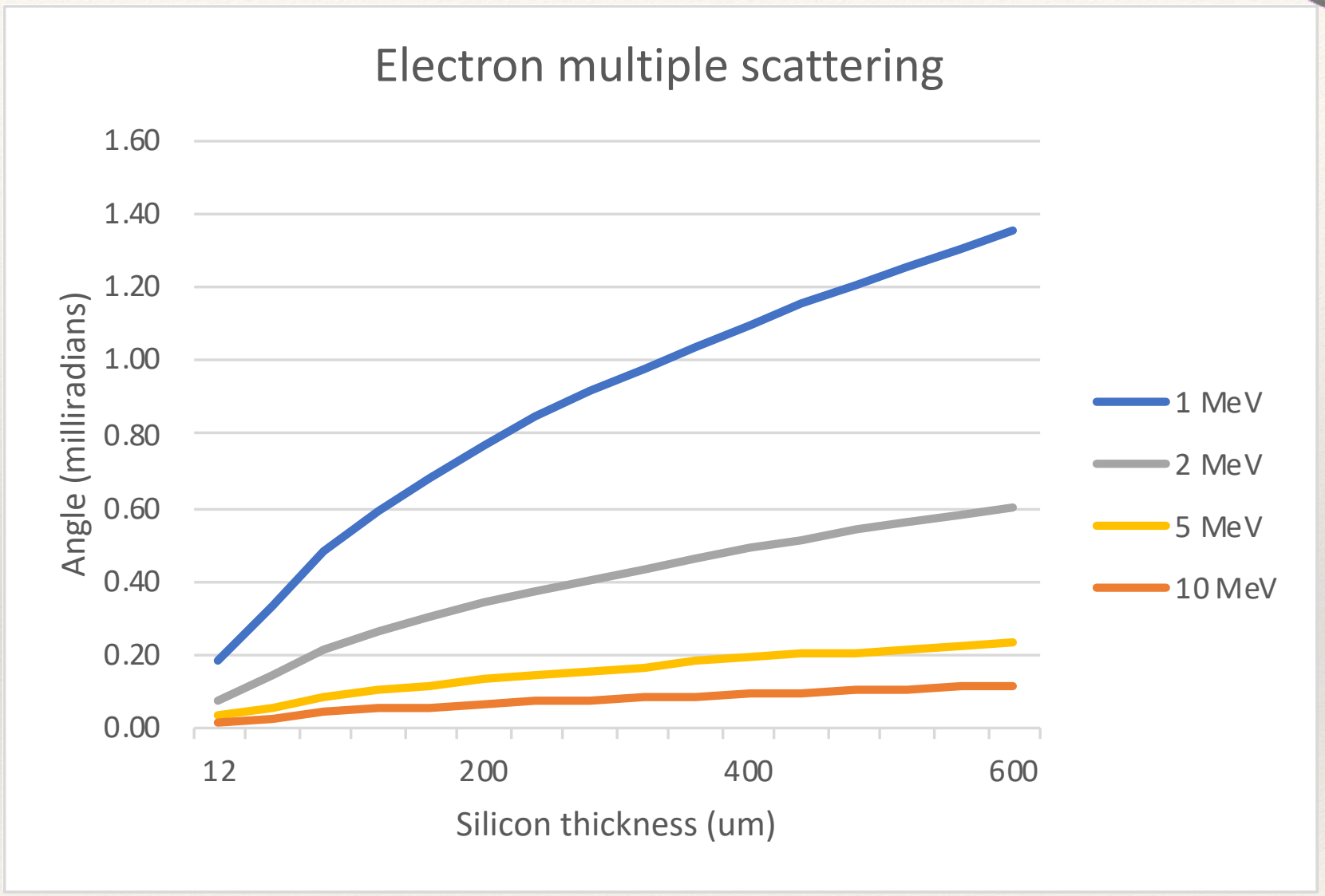
Hits with no neighbors

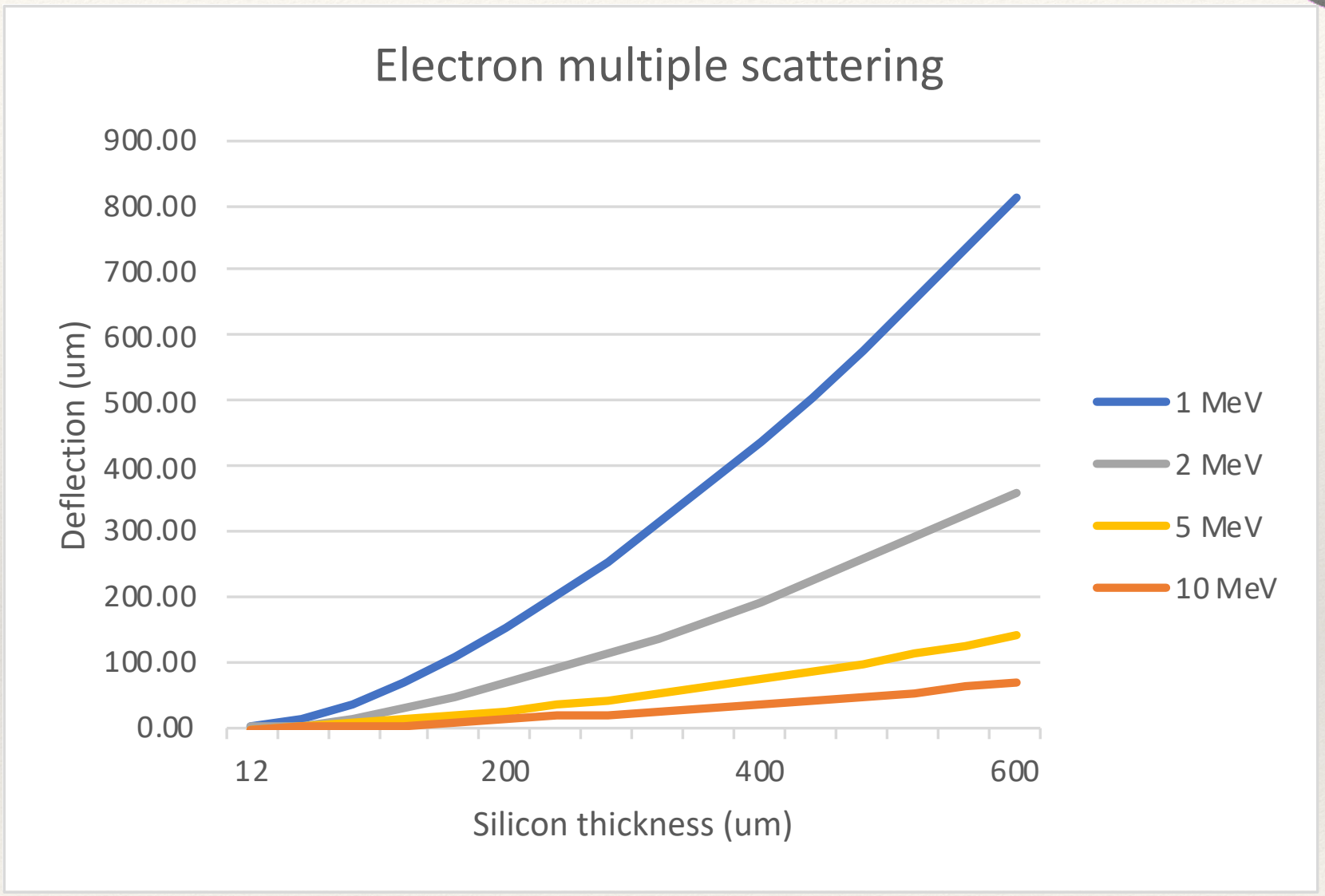


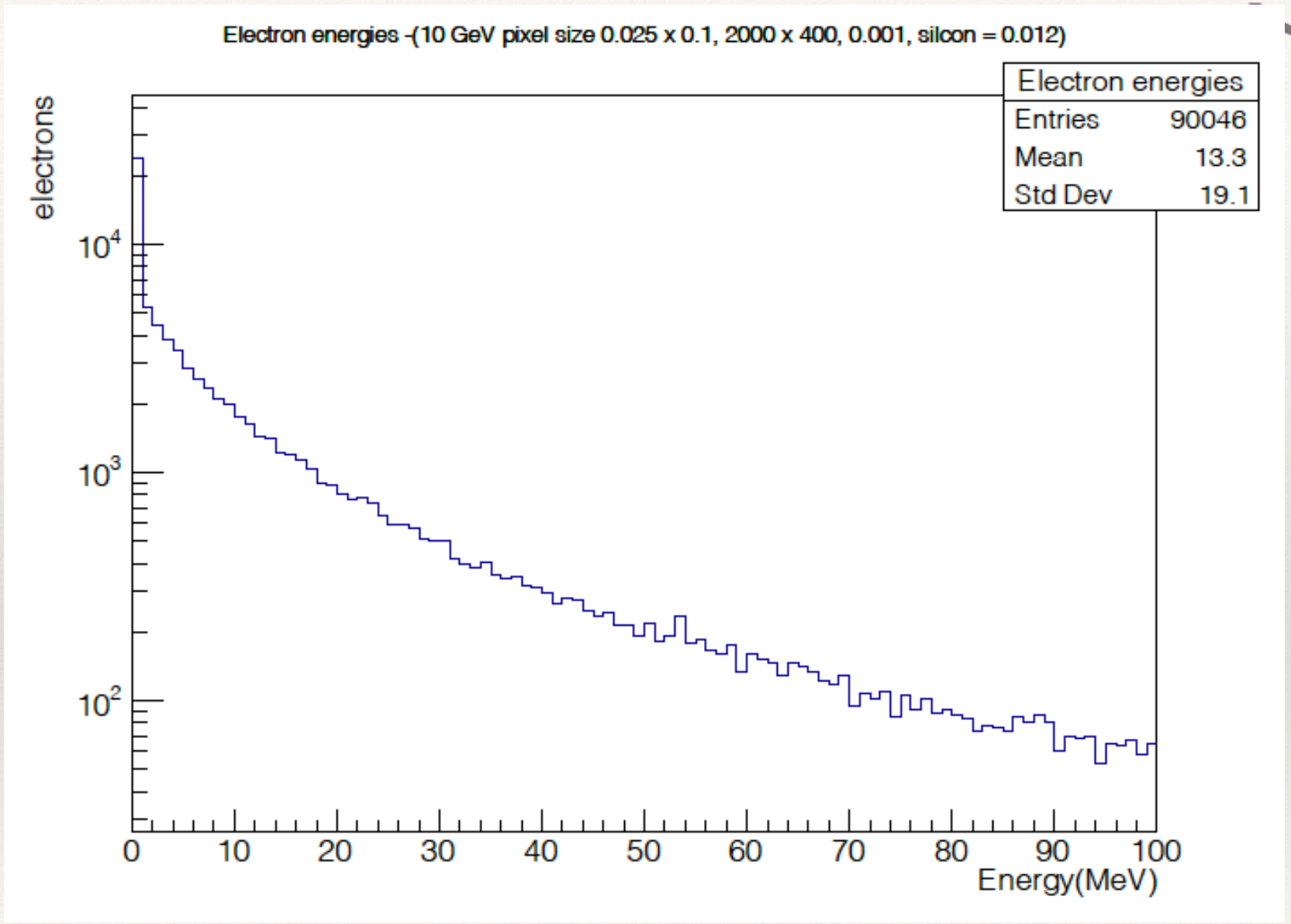


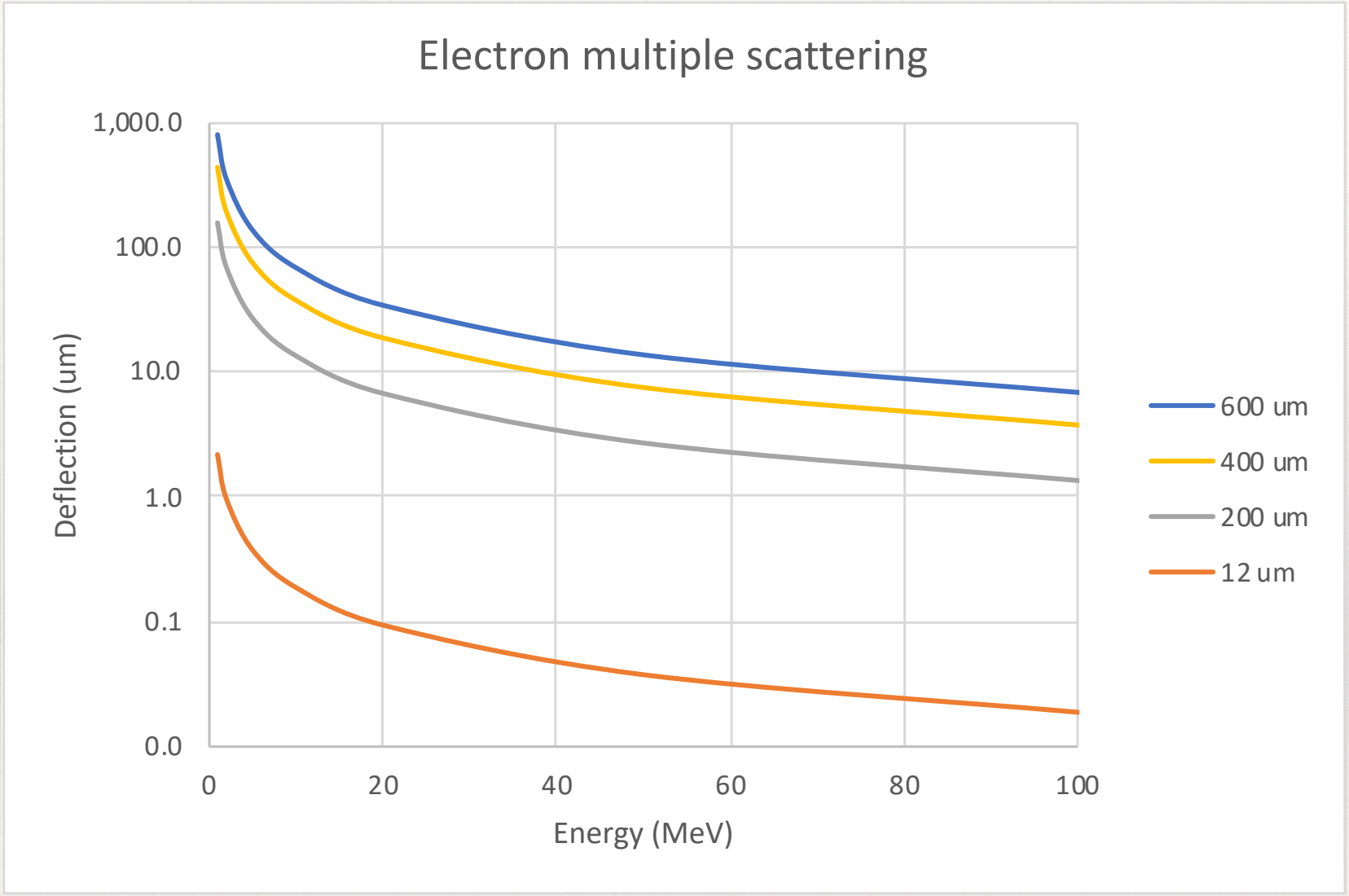
12 um - 12 um

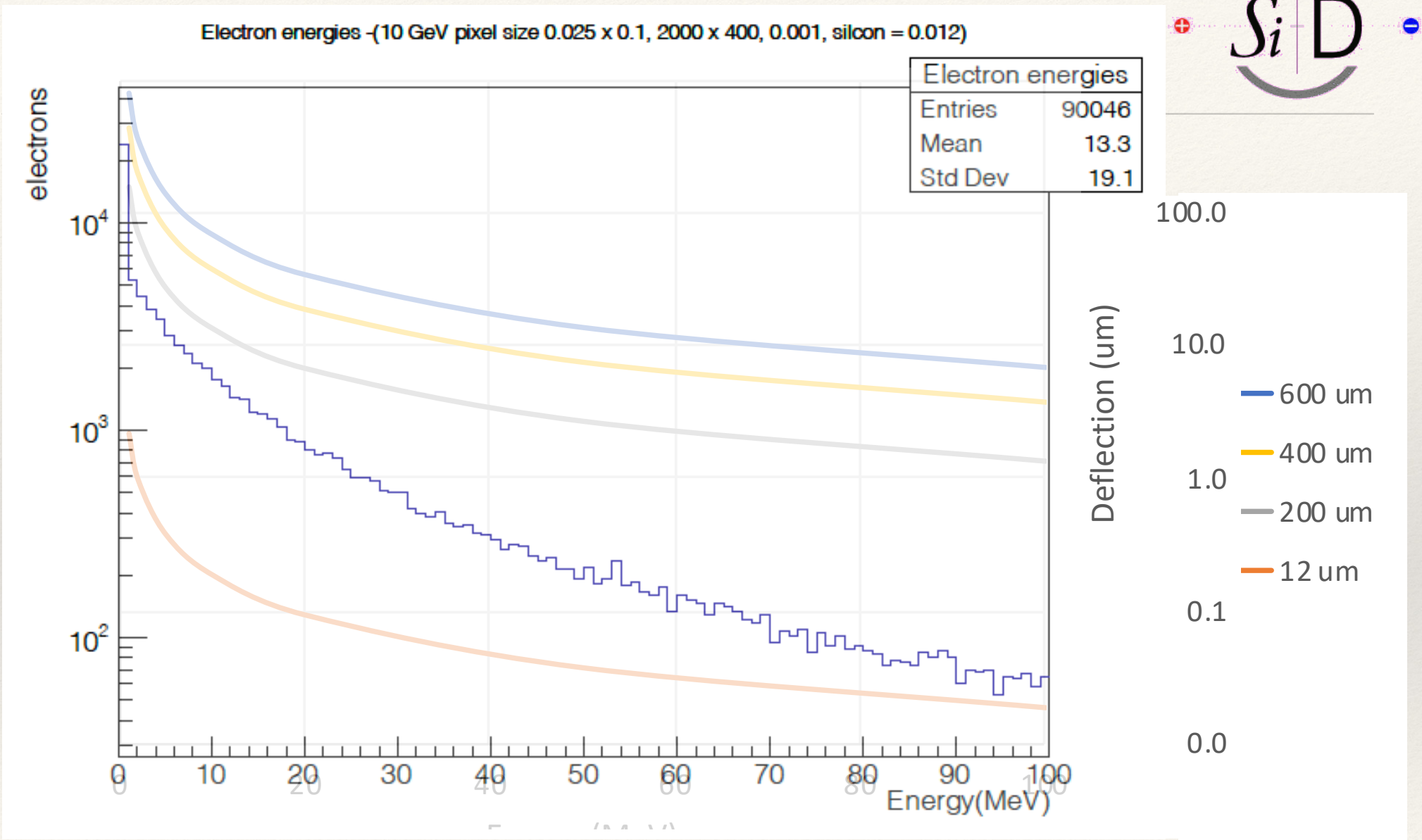
12 um - 600 um - 12 um


Electron multiple scattering
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Angle (milliradians)
12
200
400
600
Silicon thickness (um)
1 MeV
2 MeV
5 MeV
10 MeV


Electron multiple scattering
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Deflection (um)
12
200
400
600
Silicon thickness (um)
1 MeV
2 MeV
5 MeV
10 MeV


Electron energies -(10 GeV pixel size 0.025 x 0.1, 2000 x 400, 0.001, silcon = 0.012)
Electron energies
Entries 90046
Mean 13.3
Std Dev 19.1
electrons
10^4
10^3
10^2
0 10 20 30 40 50 60 70 80 90 100
Energy(MeV)


Electron multiple scattering
1,000.0
100.0
10.0
1.0
0.1
0.0
Deflection (um)
0
20
40
60
80
100
Energy (MeV)
600 um
400 um
200 um
12 um


Electron energies -(10 GeV pixel size 0.025 x 0.1, 2000 x 400, 0.001, silcon = 0.012)
Electron energies
Entries 90046
Mean 13.3
Std Dev 19.1
electrons
10^4
10^3
10^2
0 10 20 30 40 50 60 70 80 90 100
Energy(MeV)
Deflection (um)
100.0
10.0
1.0
0.1
0.0
600 um
400 um
200 um
12 um

Conclusion

- Mips level tagging holds potential for improved energy resolution.
- Mips might be identified through coincidence between two detectors with undetermined (so far) efficiency and background.
- Separation by 600 um of silicon results in significant multiple scattering and degradation in mip matching.
- A smaller separation of light material (silicon, carbon, aluminum,…) might allow mip matching with some isolation.
- Studies on-going.

More studies underway

- Column inefficiencies (column of 25 um vs. 100 um)
- Finer pixels: eg. 25 um x 25 um
- Lower thresholds: eg. 0.5 keV
- More improvement in clustering algorithms
- Other energies (eg. 5 GeV, 20 GeV, 100 GeV)
- Photons