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SiD ECal Energy Resolution for MAPS Variations

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Contributions to the study in this talk from
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Option SiW ECal MAPS

- Monolithic technologies have the potential to provide higher granularity, thinner, intelligent detectors at lower overall cost.
  - Significantly lower material budget
    - Eliminate the need for bump bonding or other challenging interconnect methods.
    - Can be thinned to less than 100 um.
  - Smaller pixel size.
    - Not limited by bump bonding.
  - Lower costs
    - Can be implemented in standard commercial CMOS technologies (ATLAS estimated a savings in cost of about $35M switching to MAPS for the ITK upgrade).

UO Simple Stack = SiD Model

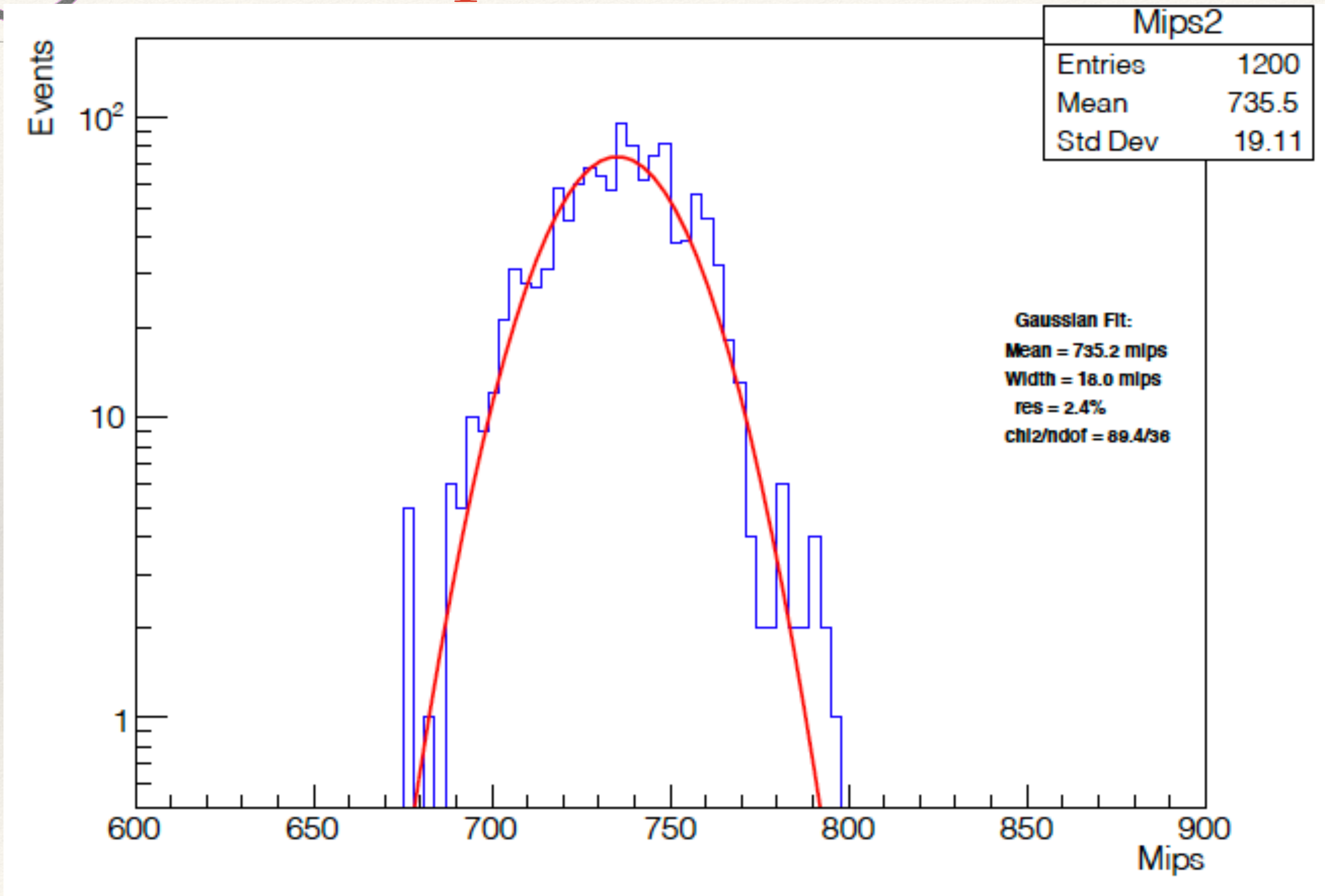
- 40 cm x 40 cm width
- 40 layers of
  - 2.243 mm tungsten
  - 0.012 mm sensitive silicon
- Simulate SiD by ignoring odd layers from 21-39
  - 20 thin layers and 10 thick layers
- Consider transverse segmentation to model MAPS pixels
  - Compare to analog resolution of 5% at 10 GeV (16% / $\sqrt{E}$)

Pixel Variations Investigated

- Currently envisaged MAPS pixels: 0.025 mm x 0.10 mm
- Two variations: 0.050 mm x 0.050 mm (square)

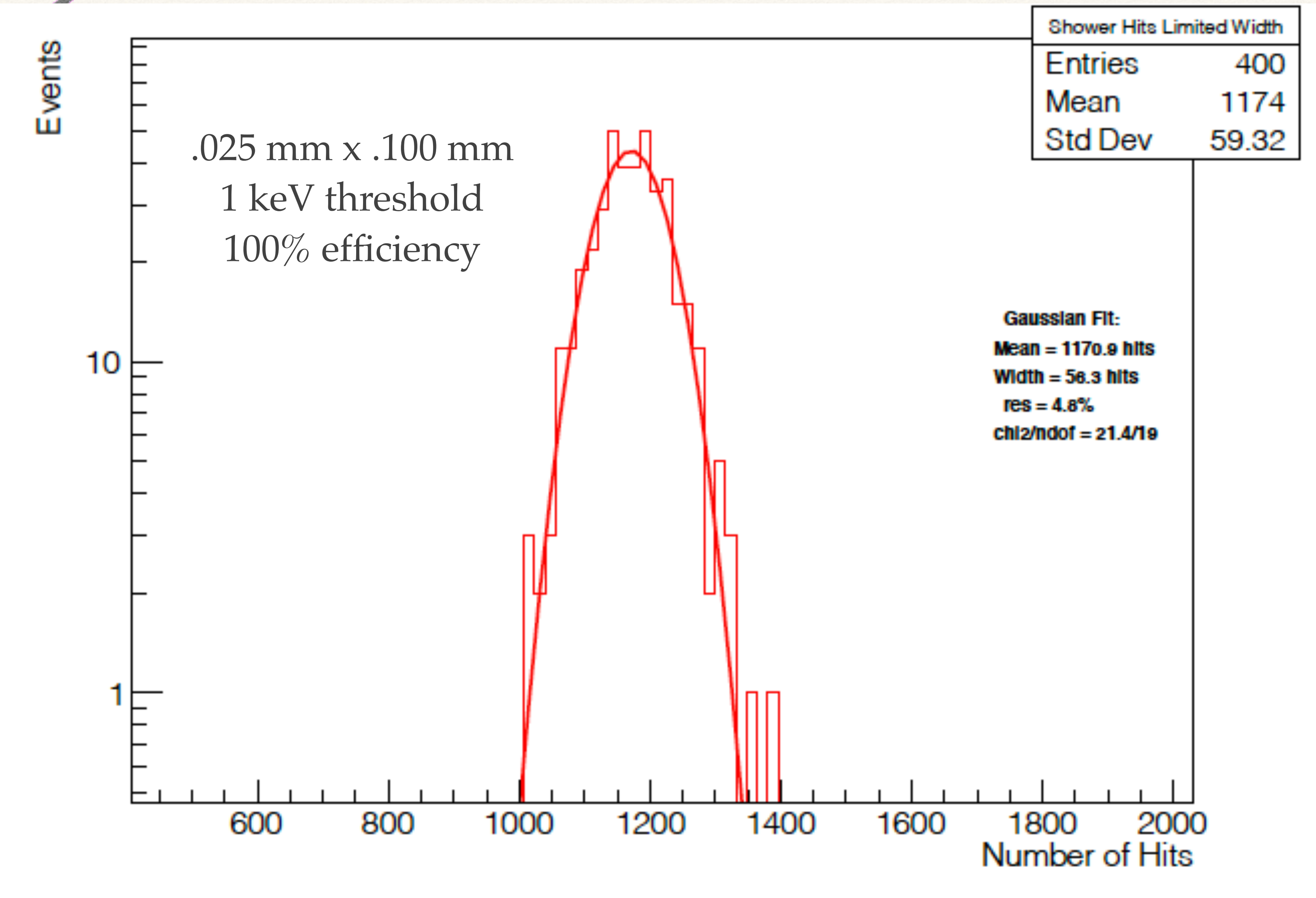
  0.0125 mm x 0.20mm (longer)
- 1 keV threshold (and 2 keV, and 3 keV) - digital
- Inefficiencies (0, 5 and 10 %)
  - Studied so far for 10, 20 & 50 GeV electrons
  - Today report 10 GeV variations

Mips (>0.1 MeV)

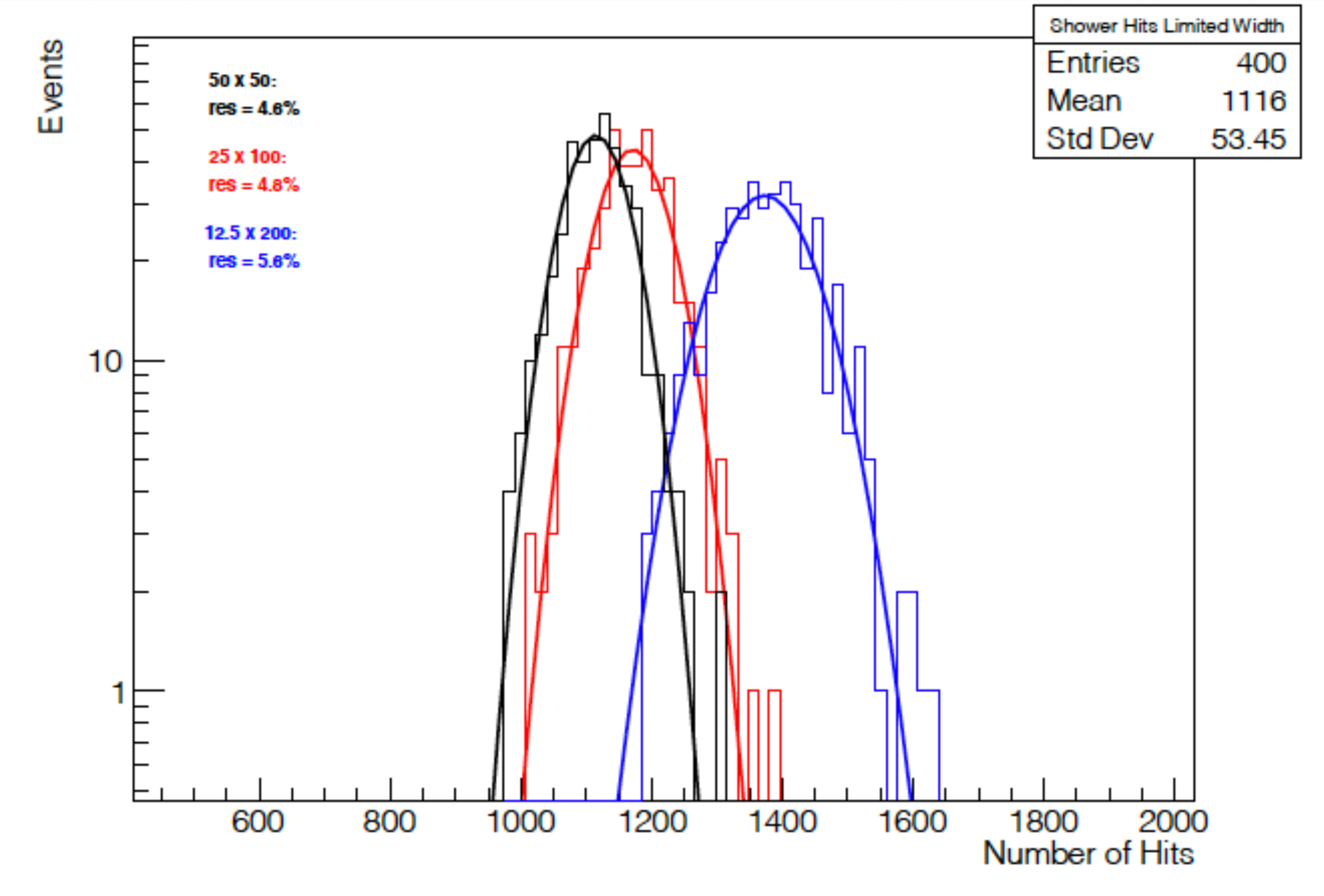


Mips2
Entries 1200
Mean 735.5
Std Dev 19.11
Events
10^2
10
1
Gaussian Fit:
Mean = 735.2 mips
Width = 18.0 mips
res = 2.4%
chi2/ndof = 89.4/36
600
650
700
750
800
850
900
Mips

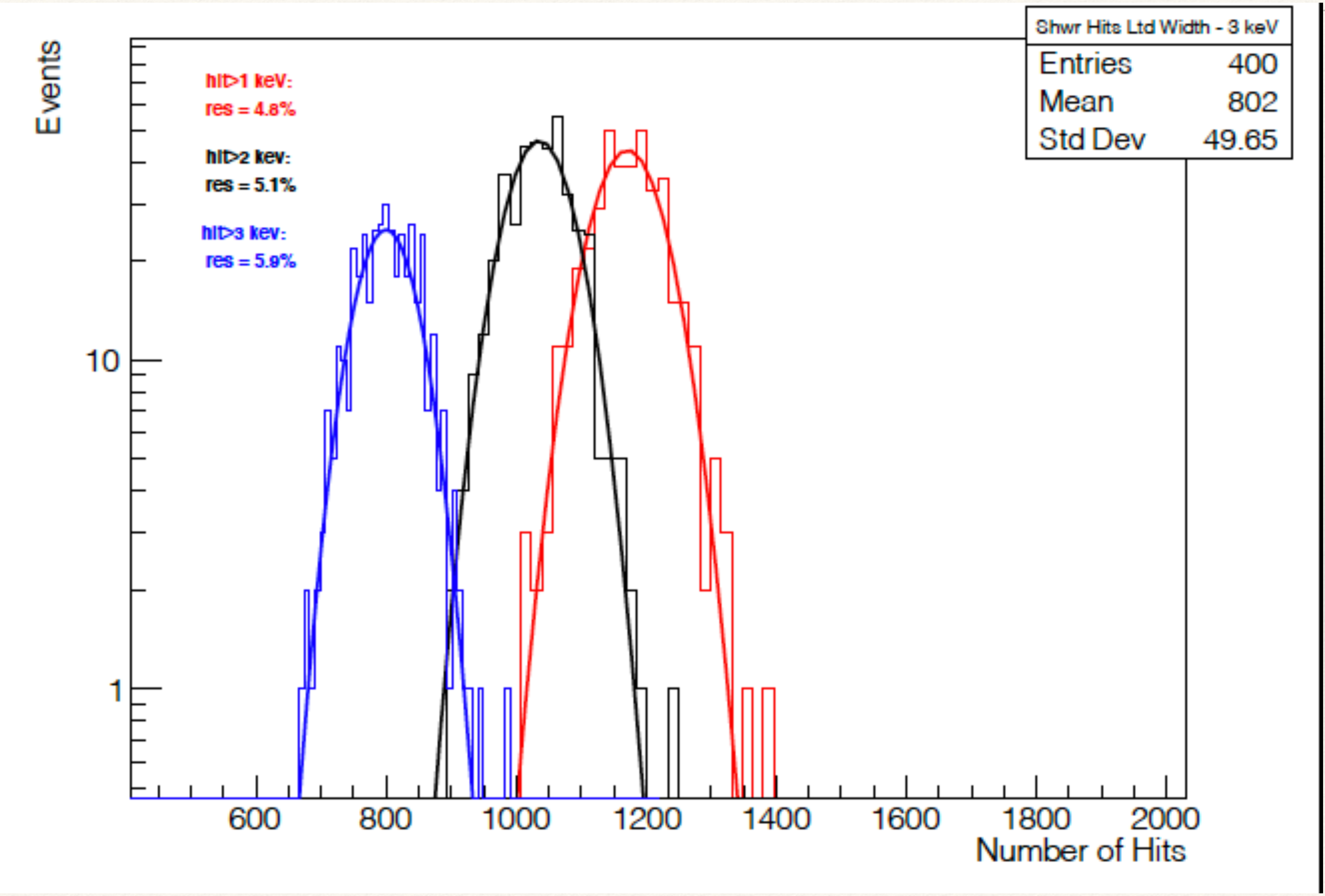
Nominal Conditions



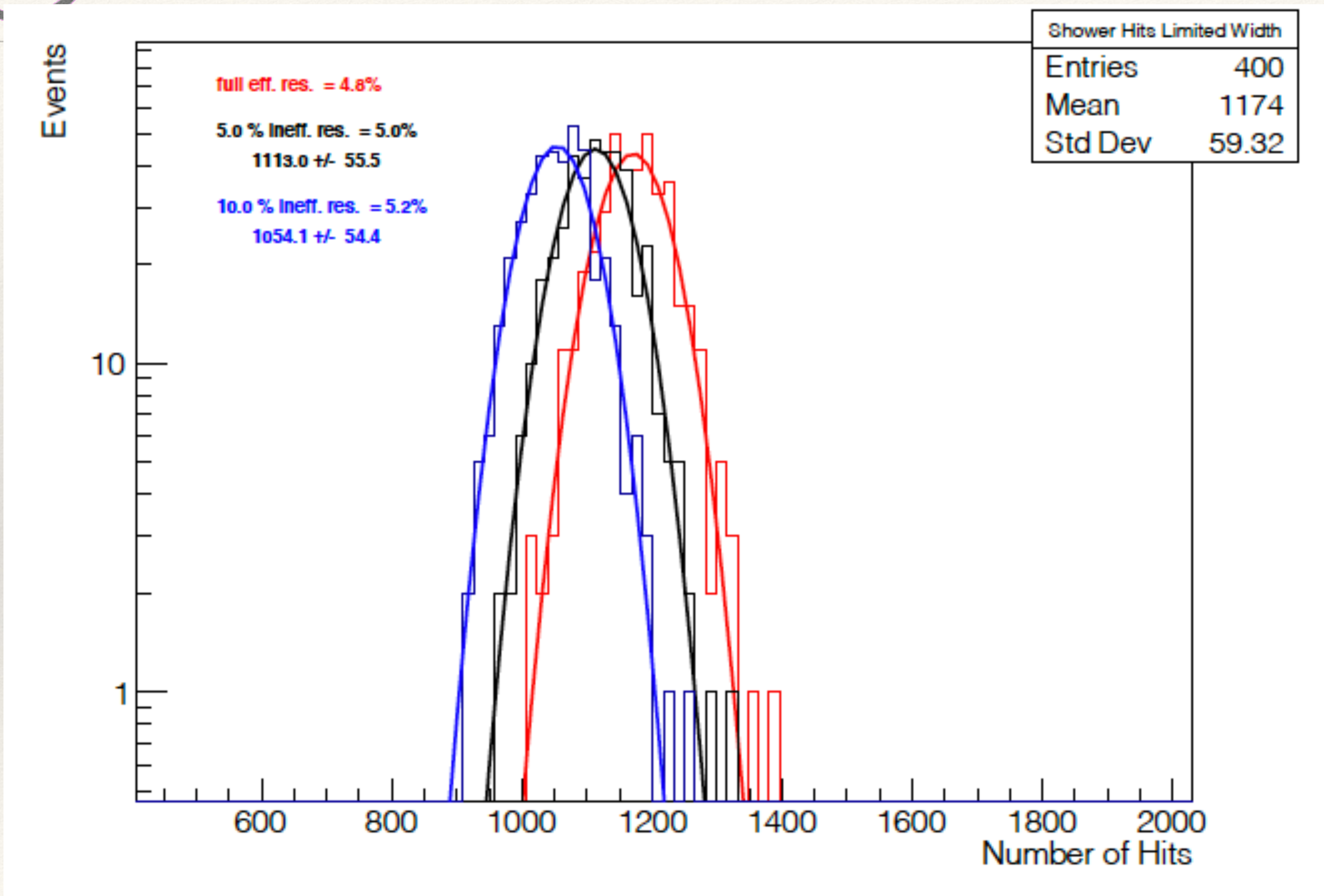
Geometric Variations



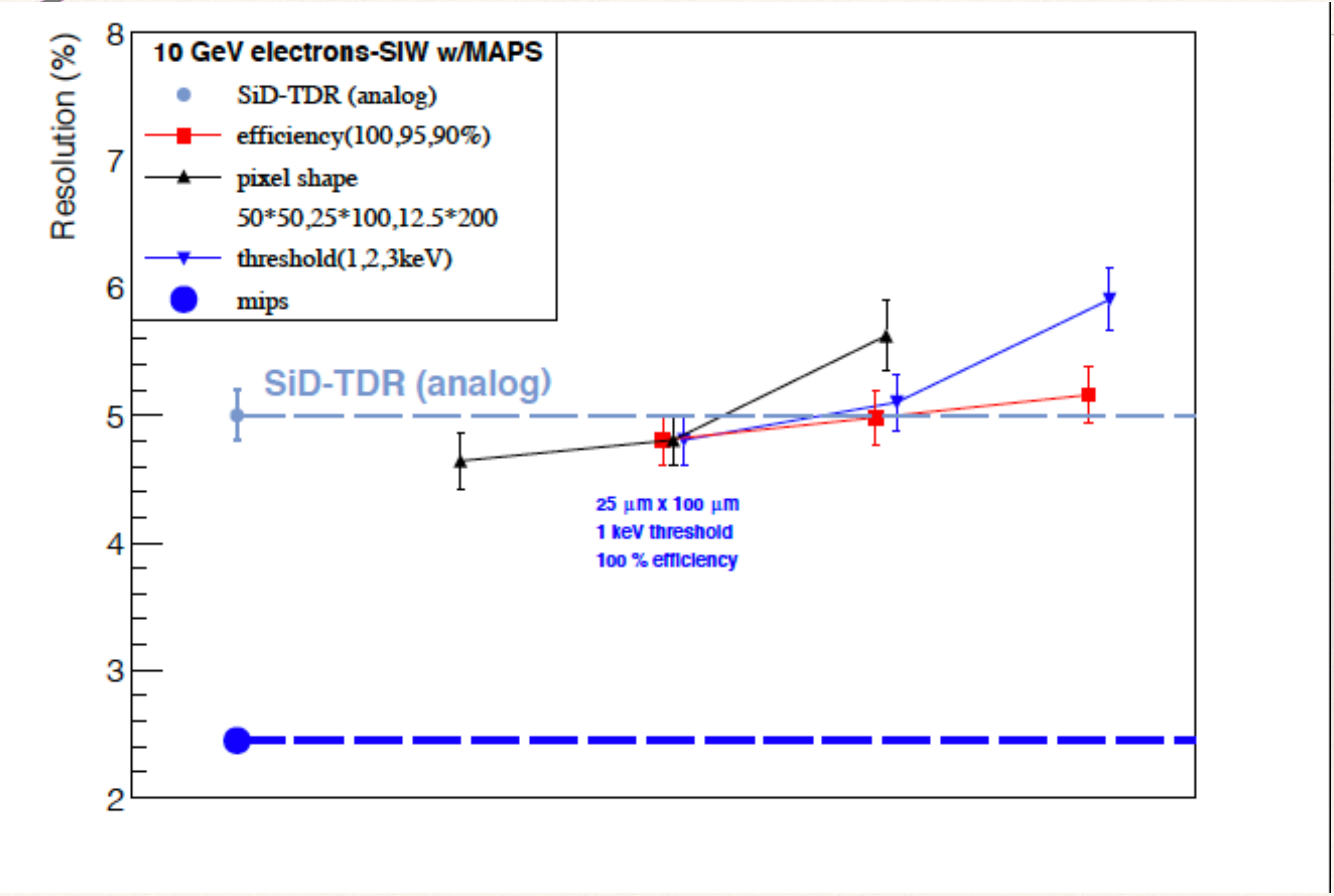
Threshold Variations



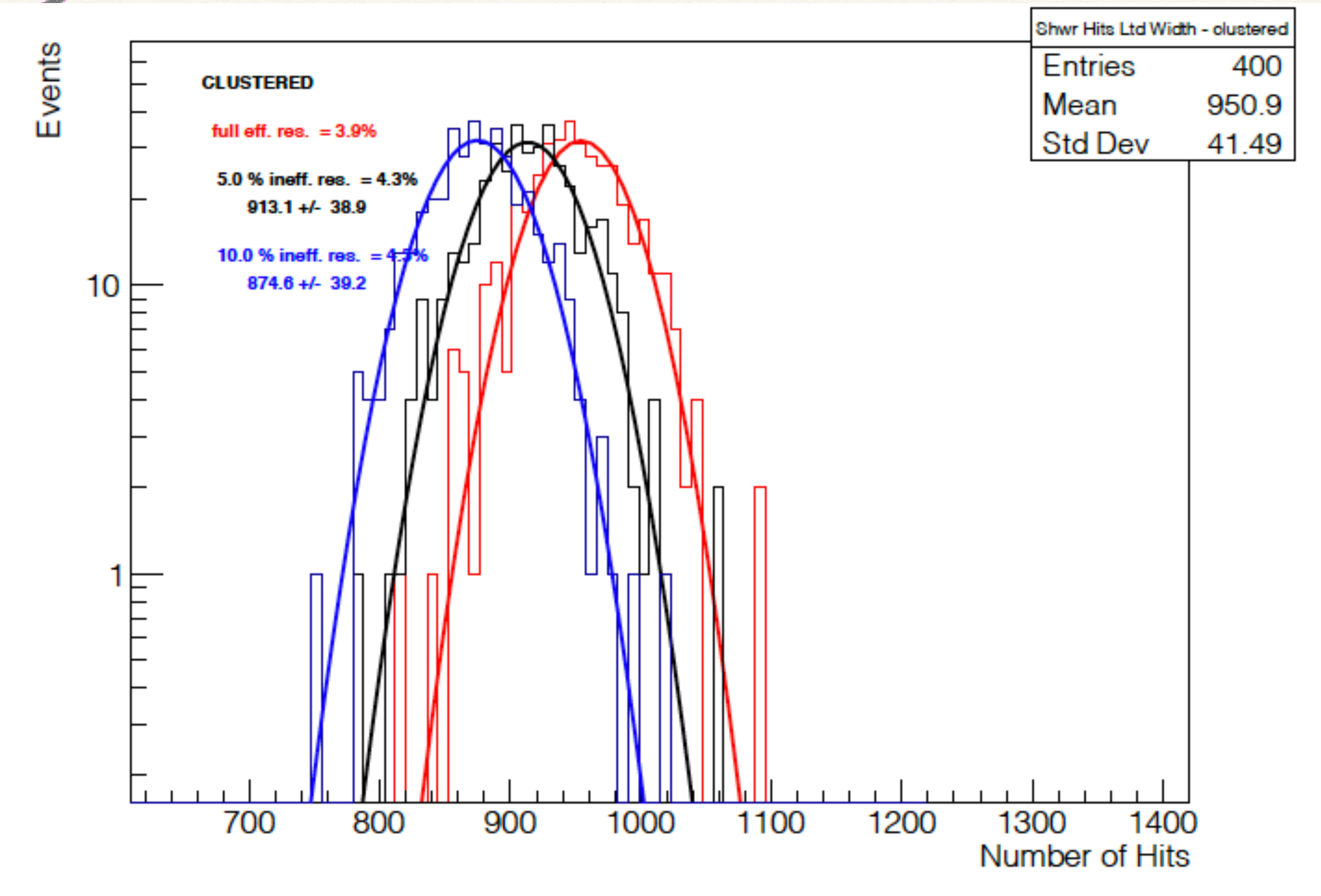
Efficiency Variations



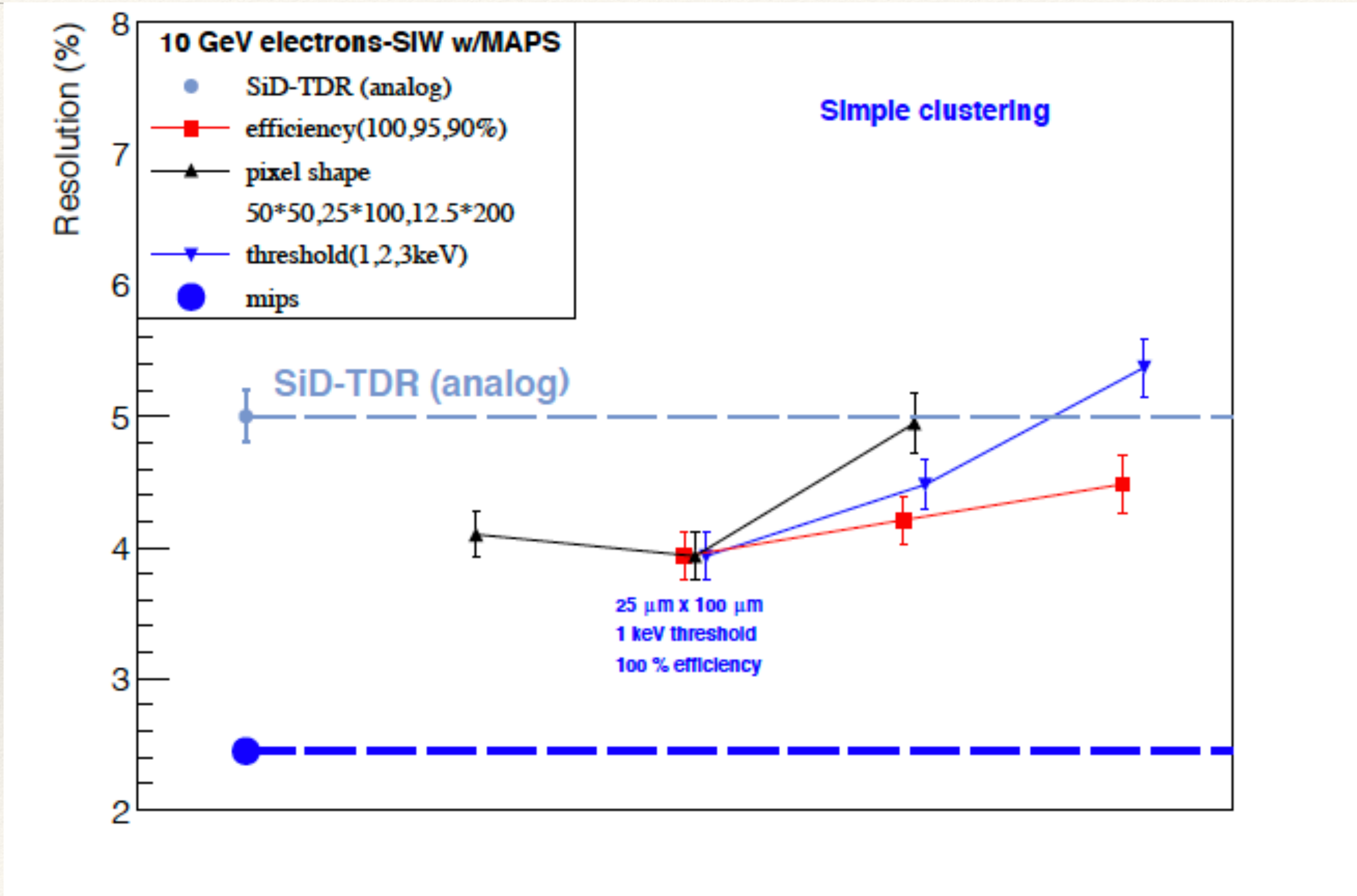
Resolution Dependencies



Simple Clustered Detection



Resolution Dependencies



Summary

- Results now show pixels with significantly better digital resolution than the SiD analog version
- 10 GeV: analog: 5%. (mips = 2.4% = 7.6% / √E))
  simple clustered digital: 3.9%. (This is 12% / √E)
  expect we can do better.
- Future studies:
  - Finer pixels: eg. 25 um x 25 um
  - Lower thresholds: eg. 0.5 keV
  - Better clustering algorithms
  - Other energies (eg. 5 GeV, 20 GeV, 100 GeV)
  - Photons