Improving Efficiency of PLT

Spring 2016

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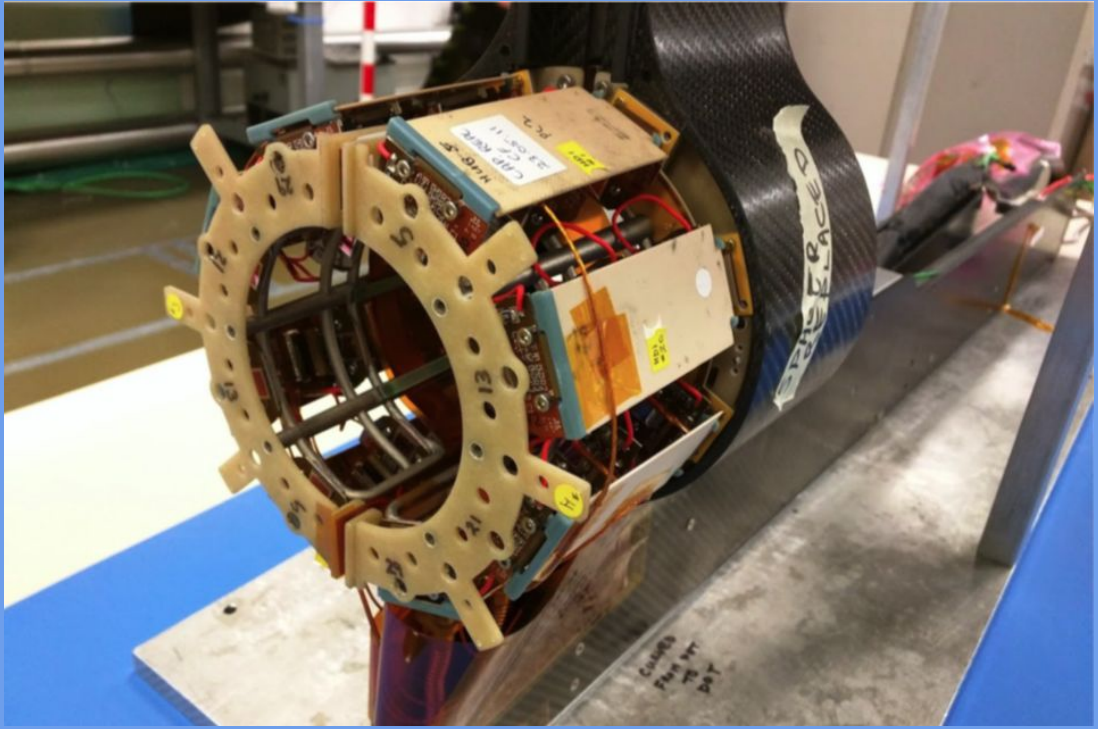
Pixel Luminosity Telescope



Specs

- Two detectors located 1.75 m from the Interaction Point (IP) on both sides
- Each 7.5 cm long and 5 cm from beam line
- Two arrays of eight “telescopes,” each consisting of three planes of pixel sensors
  - 2 detectors x 2 arrays x 8 telescopes x 3 planes = 96 planes
- Each plane is 8 mm x 8 mm, containing 4160 pixels in rows of 80 and columns of 52

How it works

- Particles revolve around the LHC at about 11 kHz (1 revolution in 0.09 ms)
- “Bunches” of particles are separated by 25 ns
- Bunches are made to collide at IP
- “Tracks” are created by particles flying from collisions and pass through planes, or “Readout Chips” (ROCs), of the telescopes
    - Set off silicon pixels
- Count number of tracks detected and calculate the Luminosity of CMS

$$L = \frac{1}{\sigma}\frac{dN}{dt}.$$

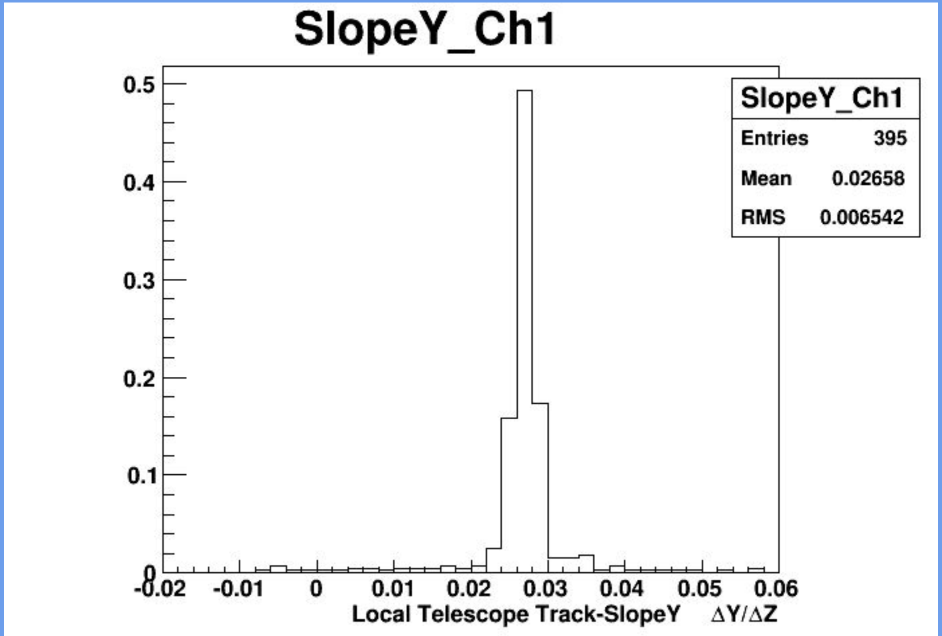
- Current Luminosity: 10^{34} cm^{-2} s^{-1}

Goal

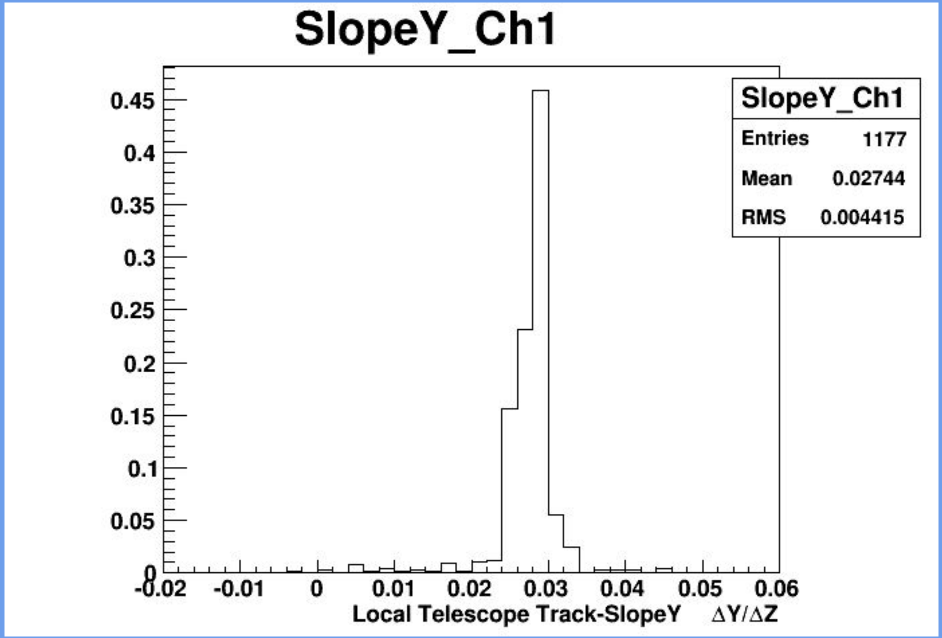
- Minimize bad tracks being recorded
- Maximize good tracks being recorded
- Done by adjusting “Active Regions” on ROCs
    - “Turn off” certain areas in an ROC to eliminate bad tracks being recorded
- Choose a Geometry that doesn’t record as many bad tracks, but records as many good tracks as possible
- Check alignments of ROCs

Simulations

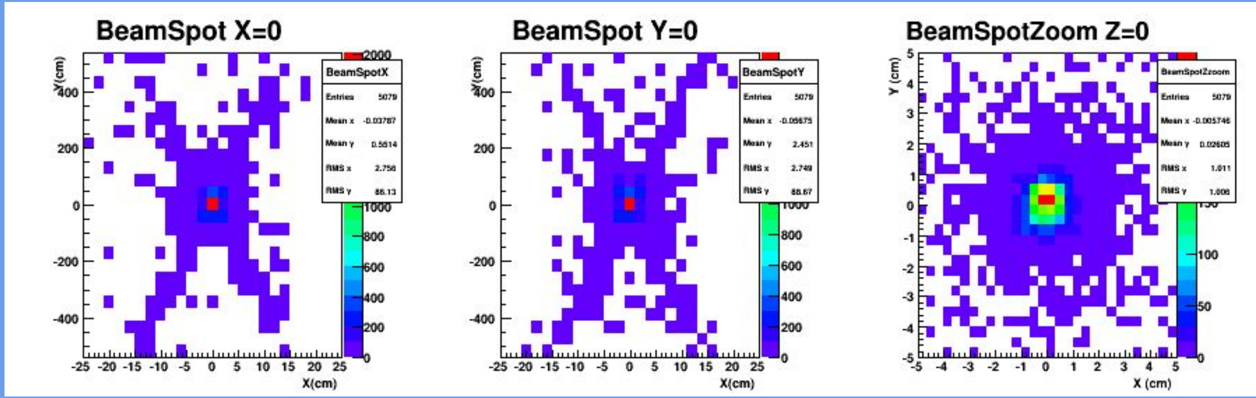
- Edited C++/G++ package from https://github.com/cmsplt/PLTOffline
  - My edits: https://github.com/sbrudney/PLTOffline
- Simulates "tracks" of particles that move through Readout Chips (ROCs)
- Two types of tracks
  - Good: Originate from Interaction Point (IP), useful in calculating Luminosity
  - Bad: Do NOT originate from IP, various causes, throw off Luminosity if considered
- 100,000 tracks simulated
- Number of good vs. bad tracks determined from older runs
  - ~88% good
- Good tracks follow angular distribution of a gaussian centered at 0.027
  - Comes from older runs



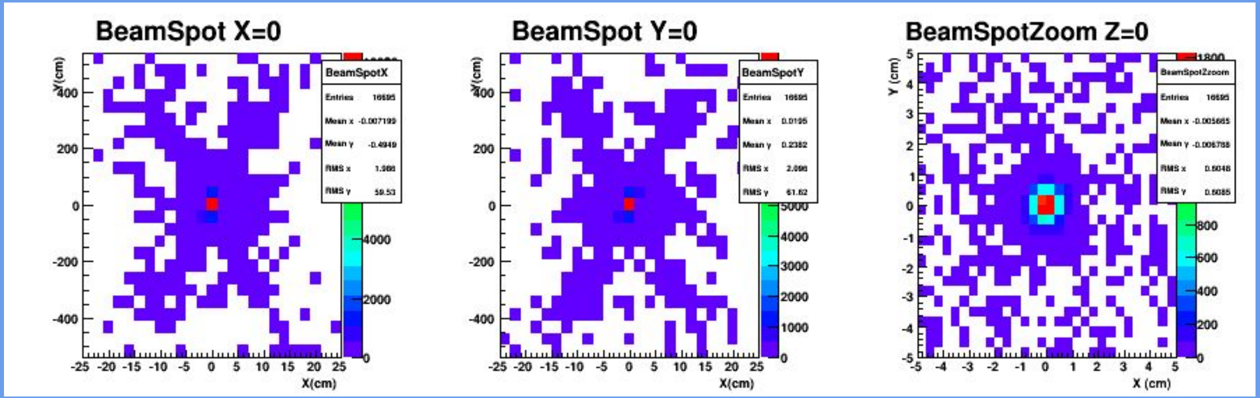
Real Data



Simulation

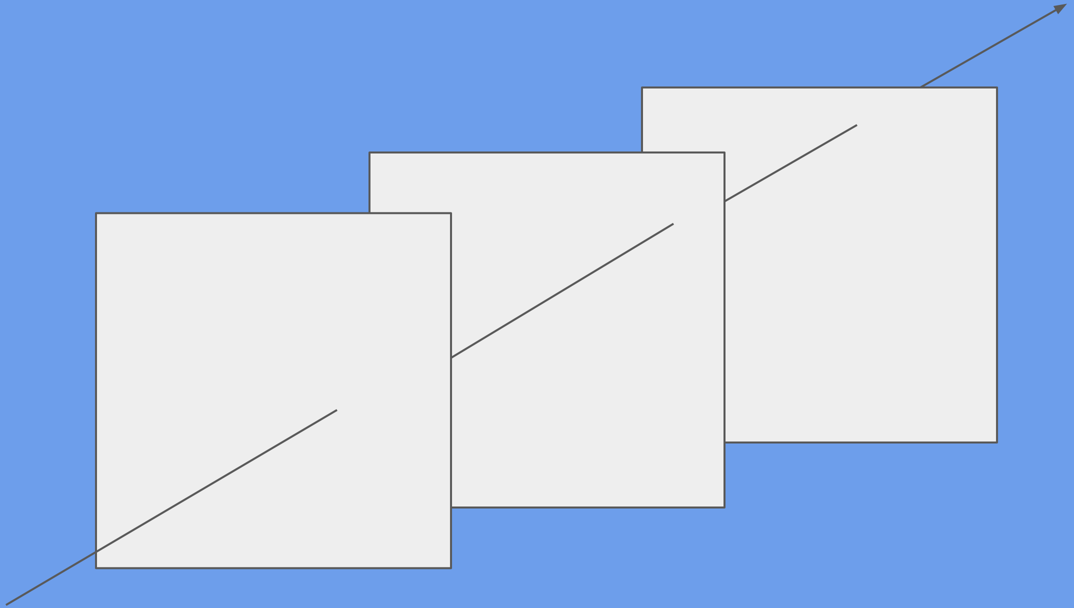


Real Data



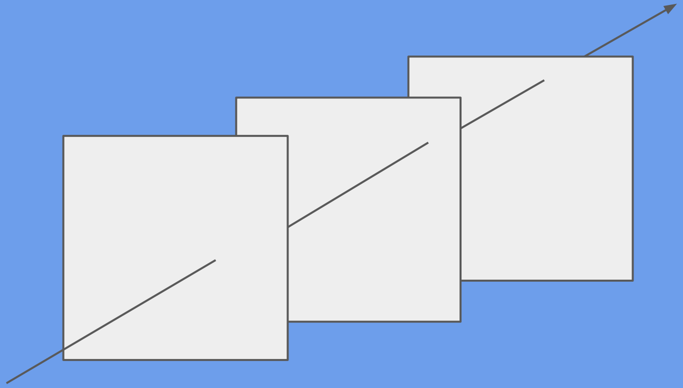
Simulation

Unadjusted ROCs

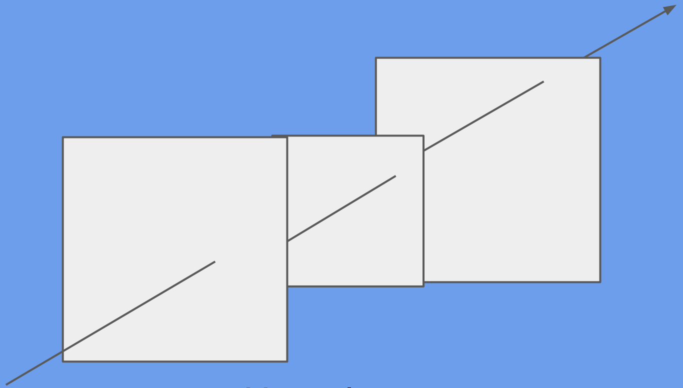


1st 2nd 3rd

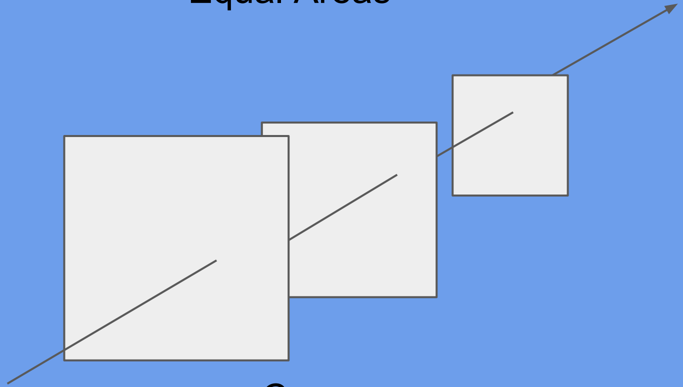
Four Geometries Considered



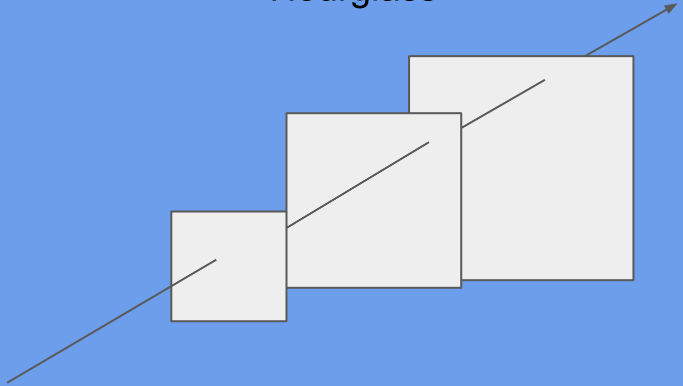
Equal Areas



Hourglass

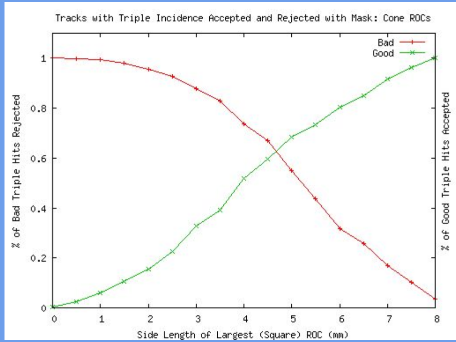


Cone



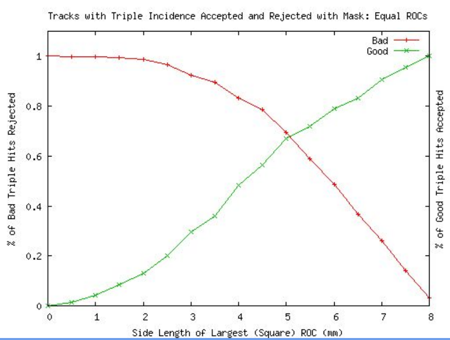
Inverted Cone

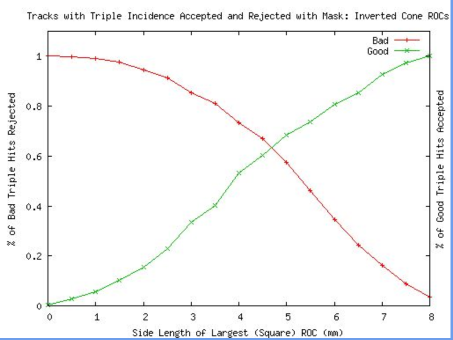
Results So Far



Cone

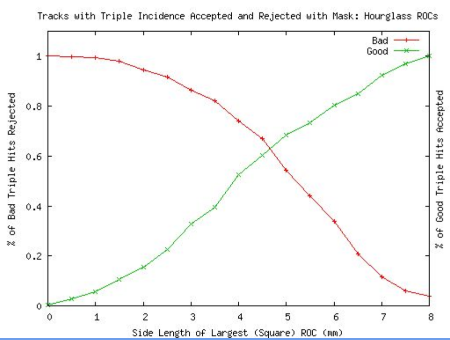
Equal



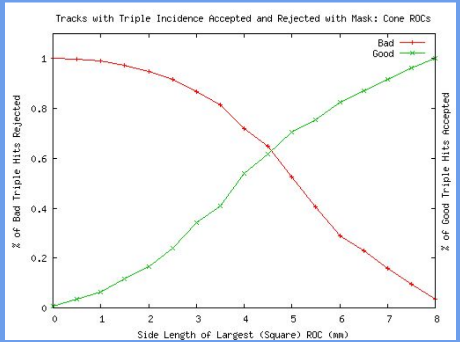


Inverted Cone

Hourglass

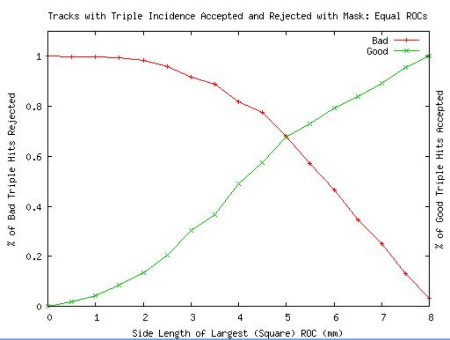


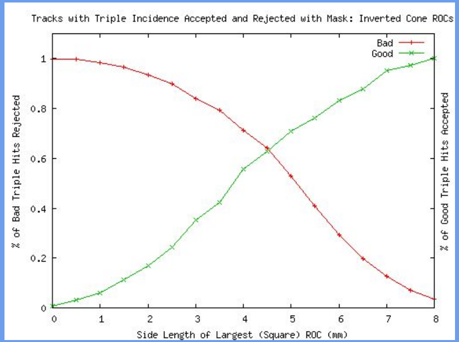
Changing Center of ROCs



Cone

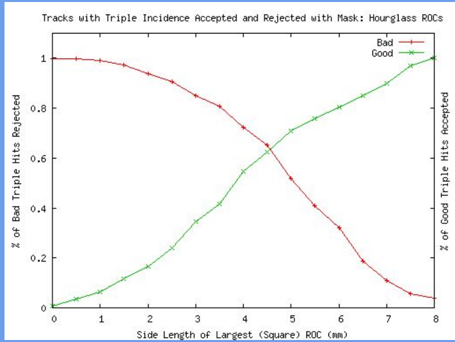
Equal





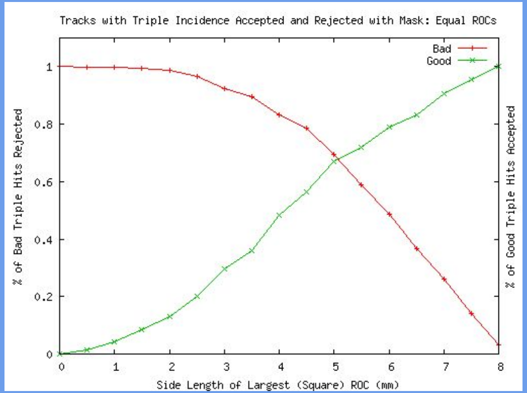
Inverted Cone

Hourglass

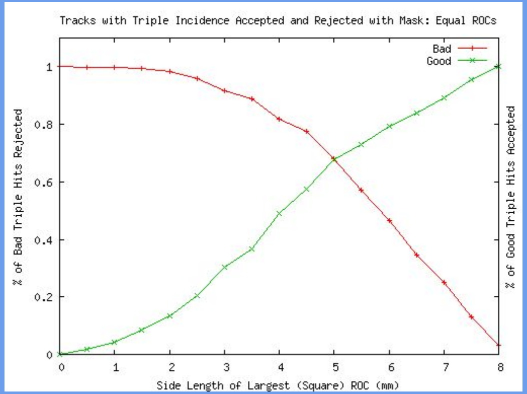


Equal ROCs

Centered:



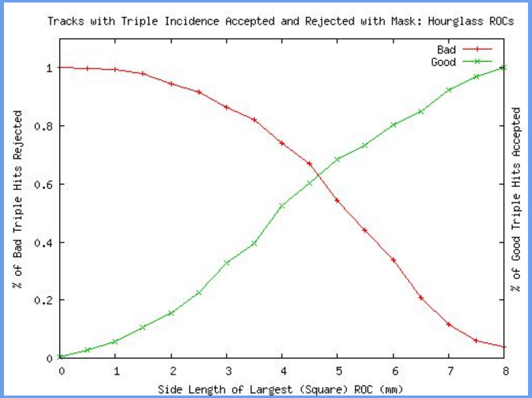
Adjusted:



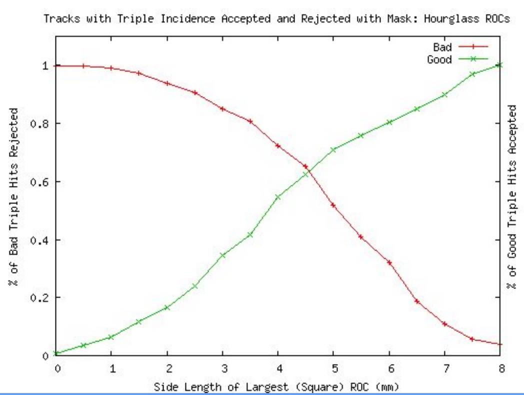
- Good Tracks are obviously high because almost all tracks are recorded
- Bad Tracks are also high
- All other geometries have lower Bad Tracks
- Adjusting the center has large impact on lowering good tracks at large sizes
- At smaller sizes there is no difference

Hourglass

Centered:



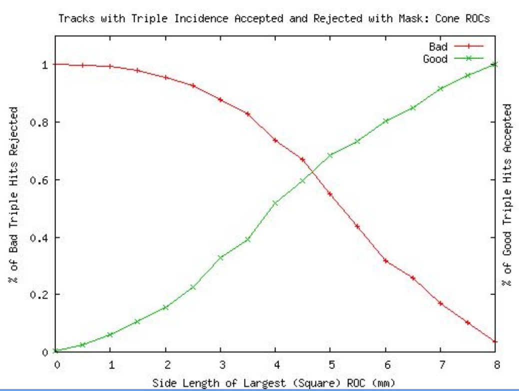
Adjusted:



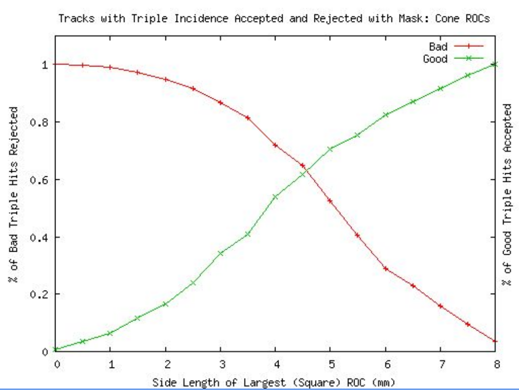
- No Good Tracks or bad tracks seem to be lost from smaller 2nd ROC

Cone (1st ROC Largest)

Centered:



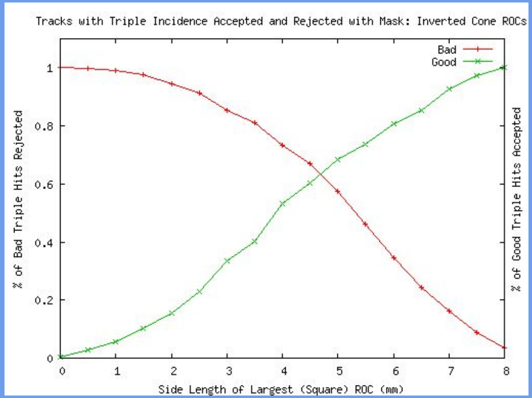
Adjusted:



- Good Tracks are much lower than equal and hourglass shapes
- Low incidence of Bad Tracks
- For adjusted
  - 2nd ROC lowered 1 mm
  - 3rd ROC lowered 0.5 mm

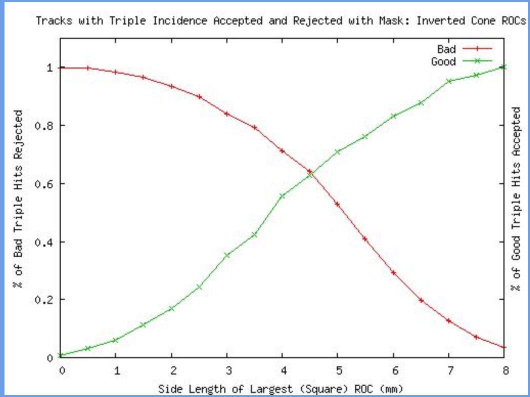
Inverted Cone (1st ROC Smallest)

Centered:



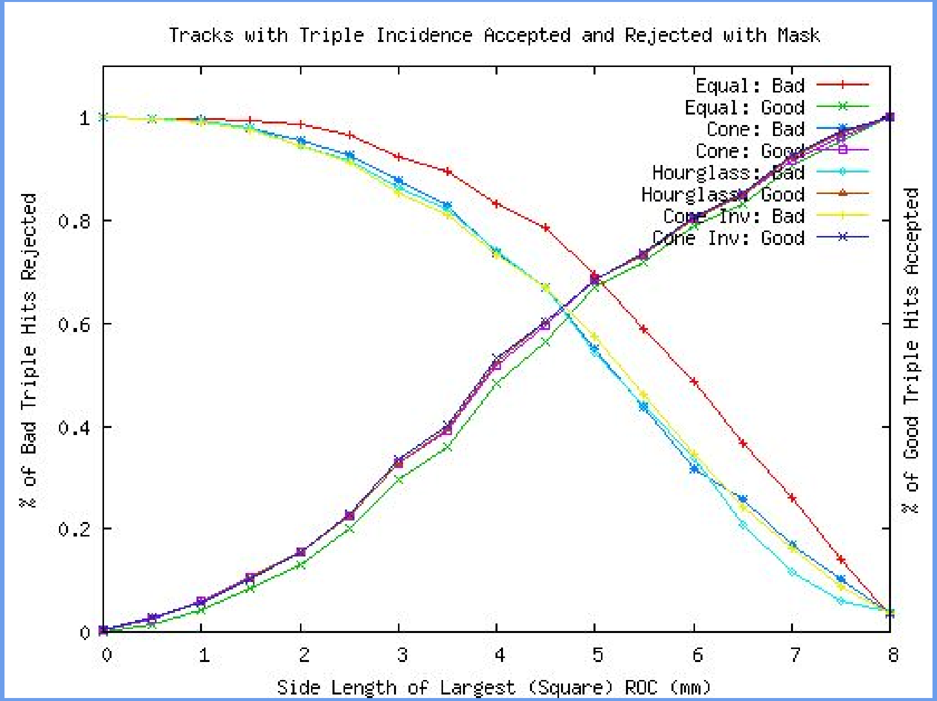
- Inverted cone should have best results
- Needs more work on centering 1st & 2nd ROCs

Adjusted:

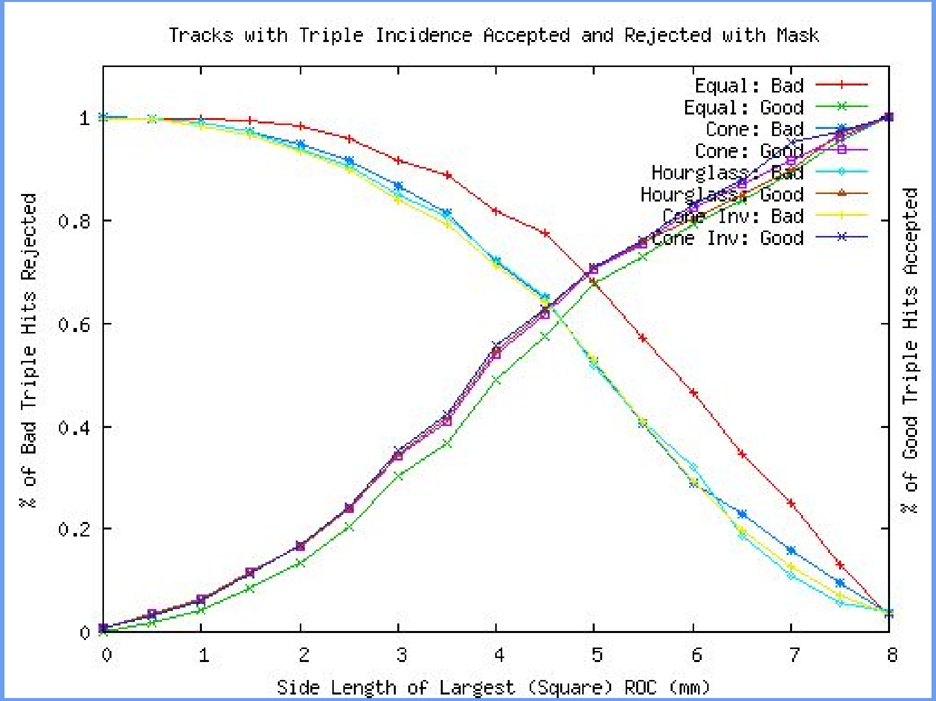


- 1st ROC is centered 0.3 mm down
- Little difference from unadjusted

Full Comparison



Centered



Adjusted

Next Steps

- Adjust Inverted Cone centering to maximize Good Tracks
- Further reduce Bad Tracks in all Geometries
- Improve code to be streamlined

Sources

- Kornmayer, Andreas. "The CMS Pixel Luminosity Telescope." *ScienceDirect* (2015): n. pag. Web.
- Dabrowski, Anne. "Upgrade of the CMS Instrumentation for Luminosity and Machine Induced Background Measurements." *CERN Document Server*. N.p., 2014. Web.
- Van Der Meer, S. "Calibration of the Effective Beam Height in the ISR." *CERN Document Server*. N.p., 1968. Web.