Showermax Monte Carlo Studies

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Thanks to: Carlos Bula, Brady Lowe, Kevin Rhine

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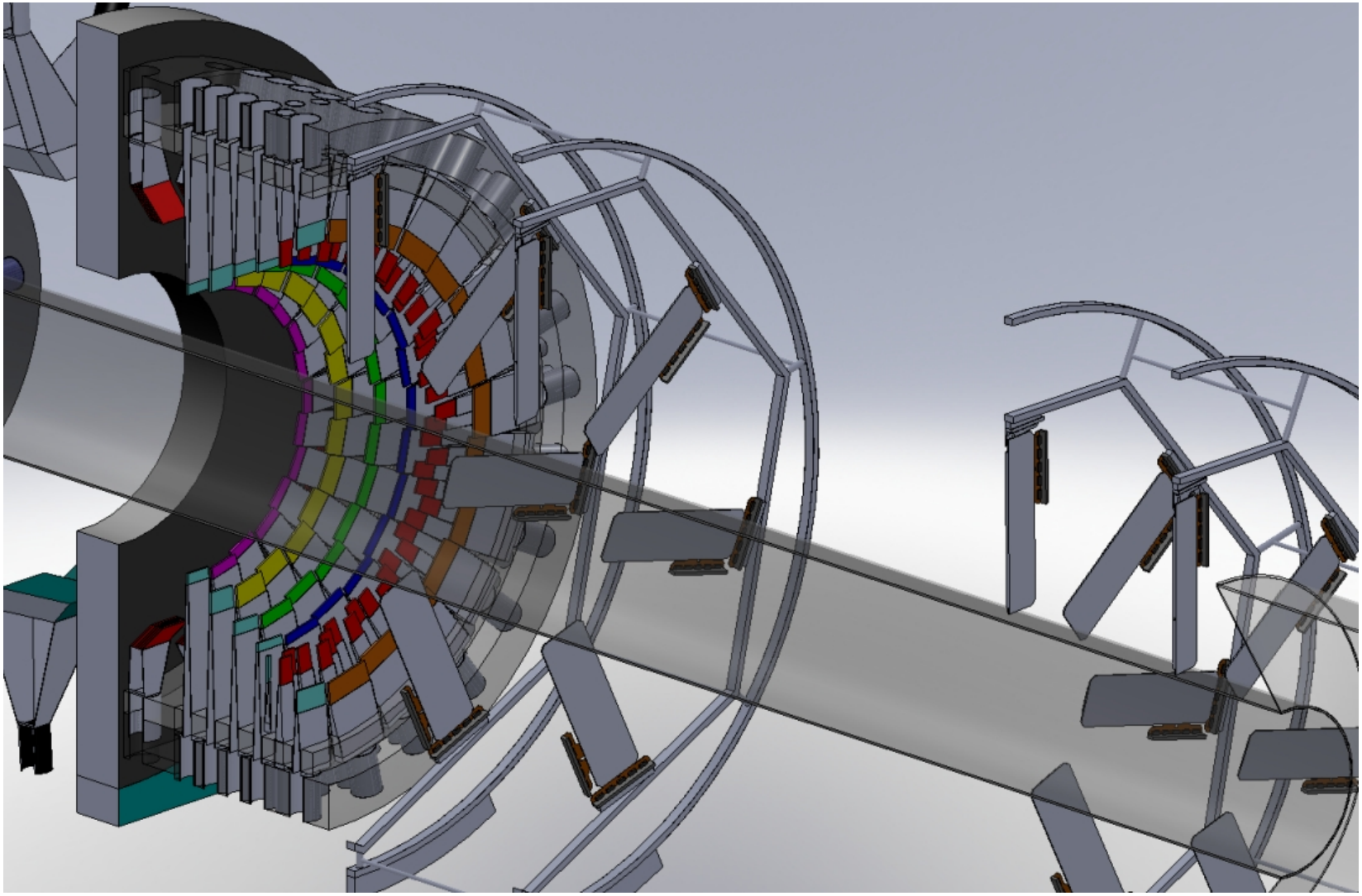
Showermax Monte Carlo Studies

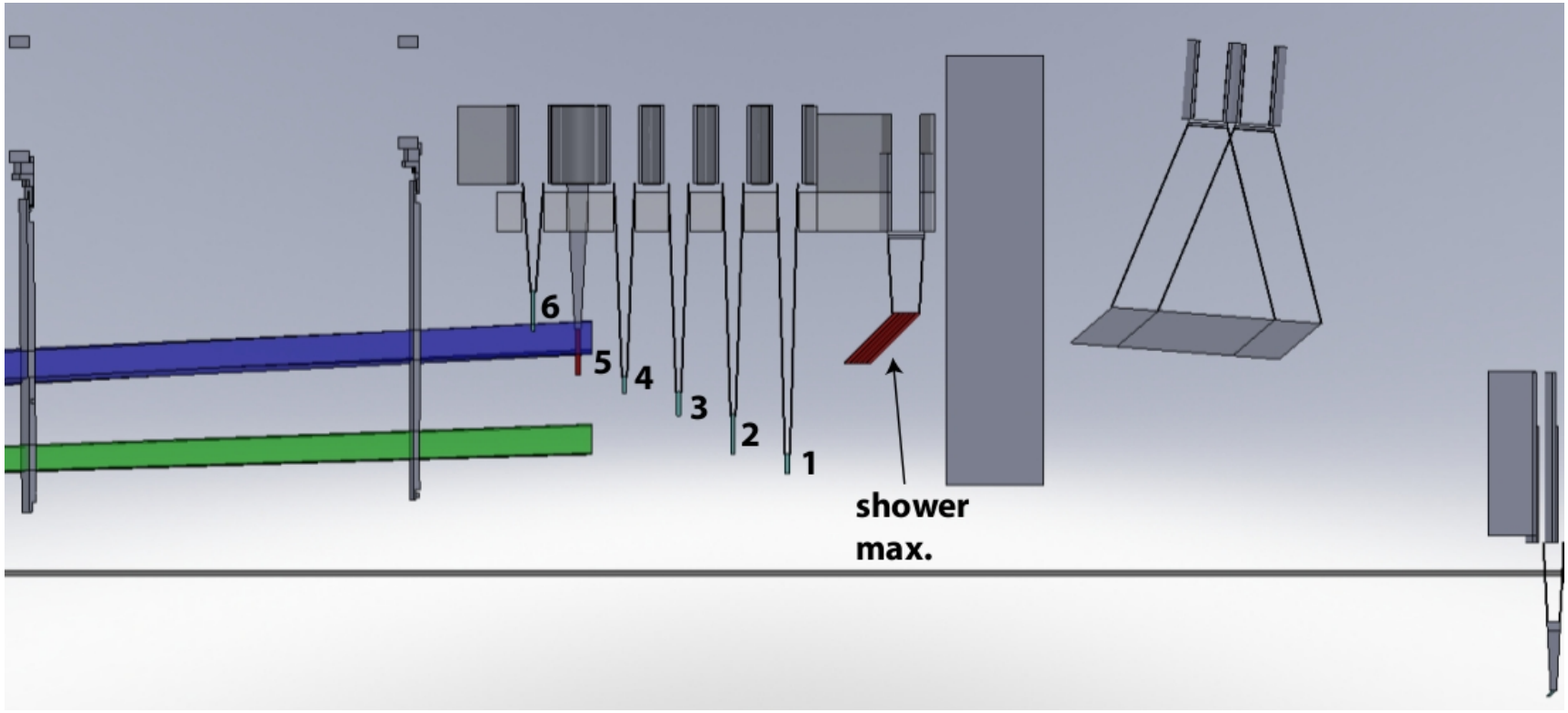
Outline

- Reproduce 2008 "stack" results (benchmarking MC)
- New Showermax Design for MOLLER
  - –Concept
  - –Light guide geometry
  - –Baseline performance (MC)
- Optimizing Design and Prototyping
- Summary

Detector Ring Design Concept



Motivation



- Provides additional measurement of e-e ring flux
- Weights flux by energy $\Longrightarrow$ less sensitive to low energy/low light bkgds

MOLLER Showermax Development

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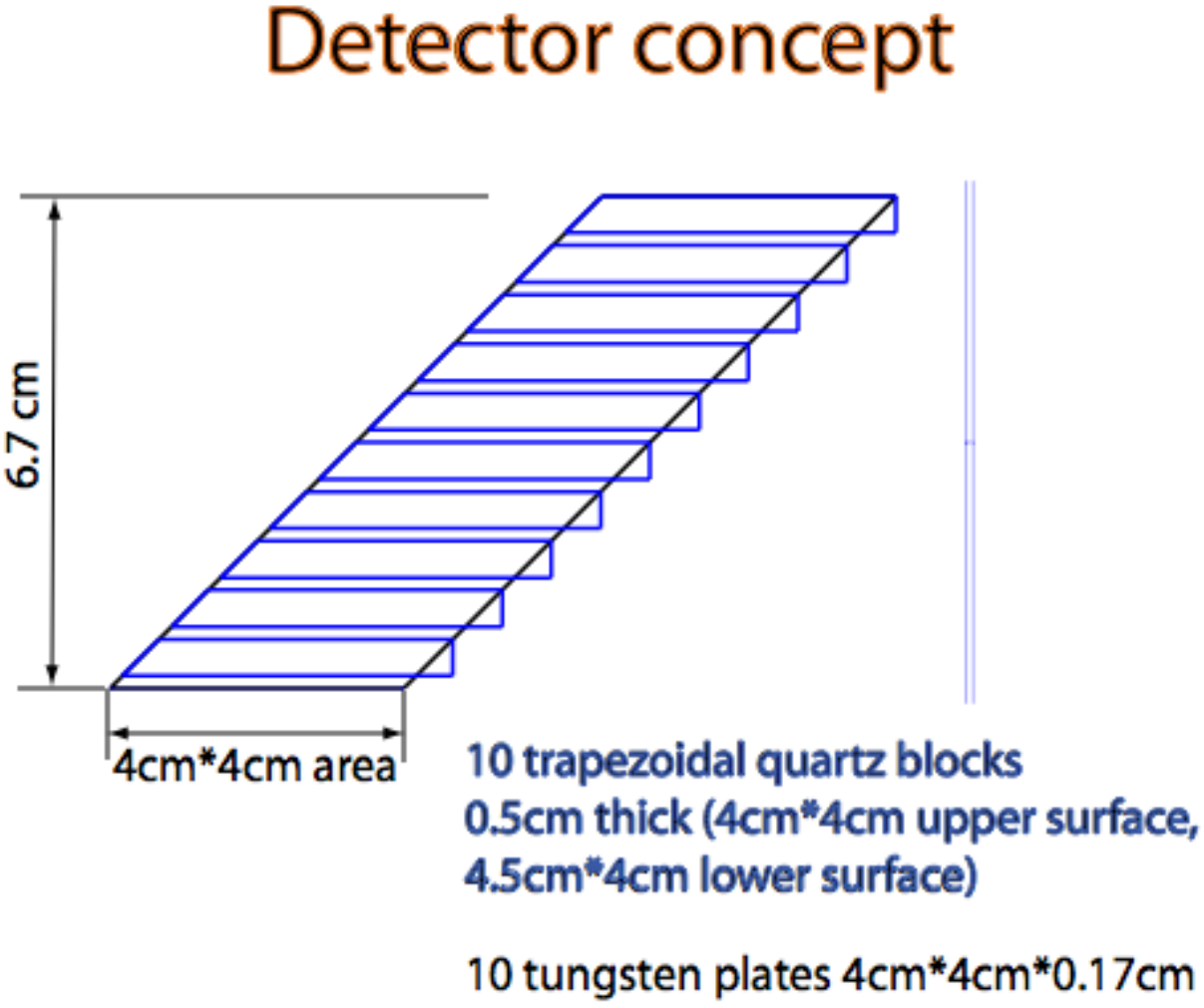
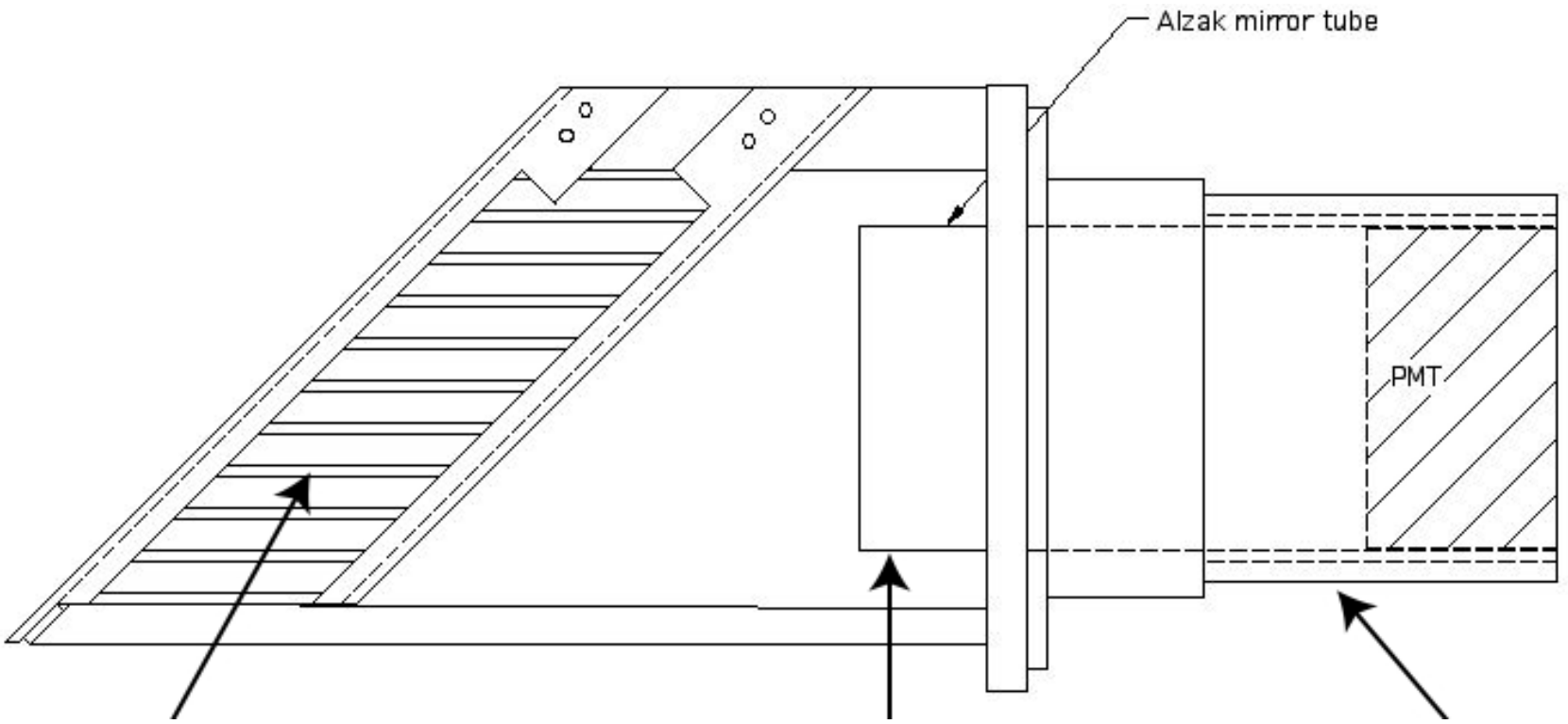
- Build prototype and test with beam (at Mainz?, SLAC)

2008 Showermax "stack"



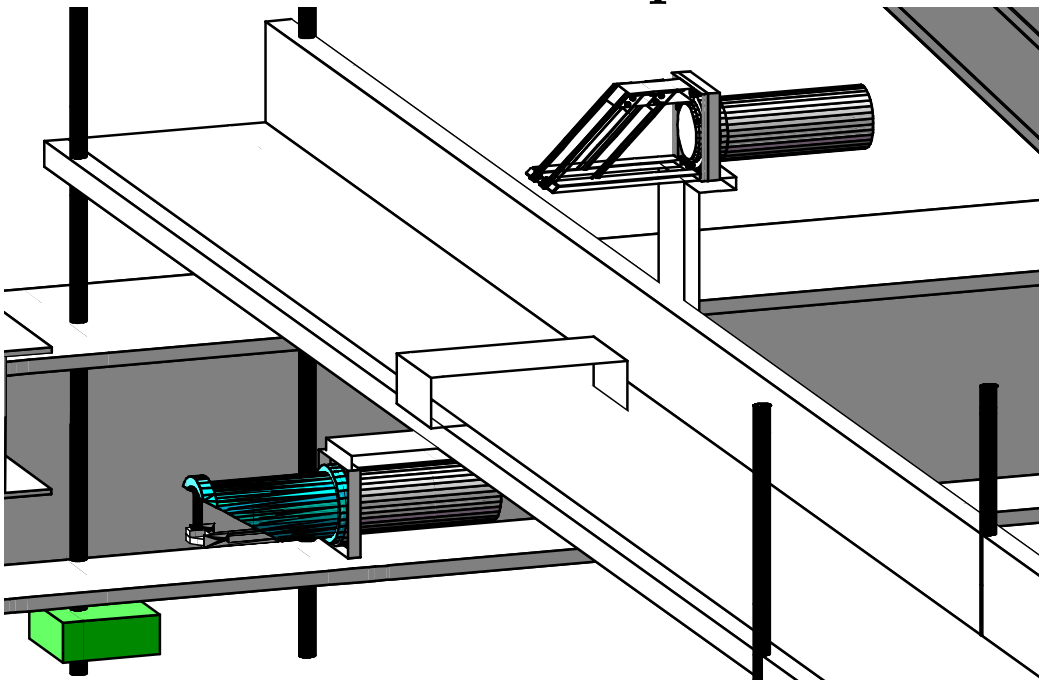
Slide from Piotr

2008 Stack Detector Schematic



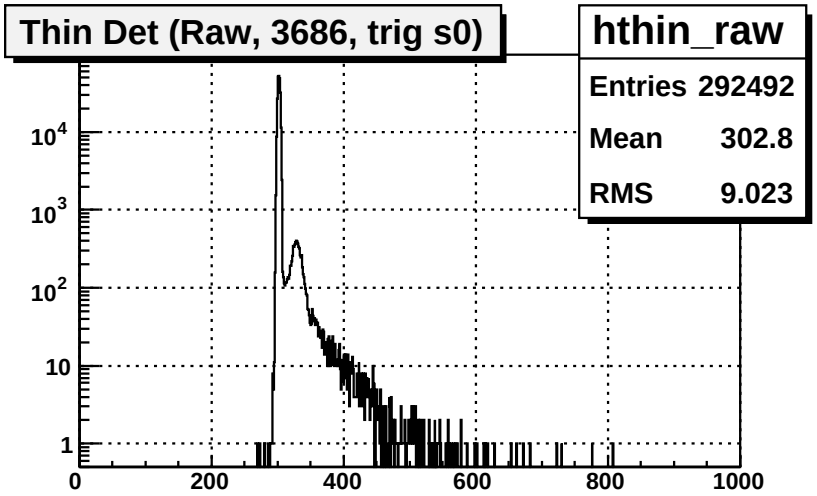
Schematic from Piotr

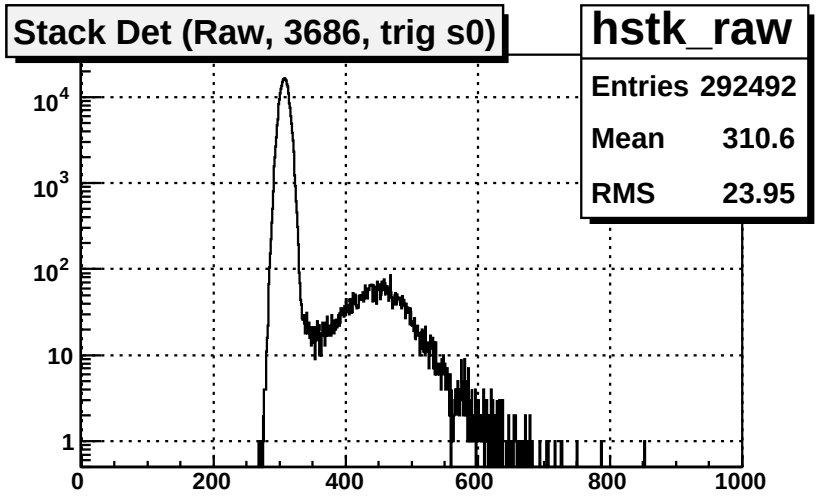
Jan2008 Testbeam Setup and Conditions

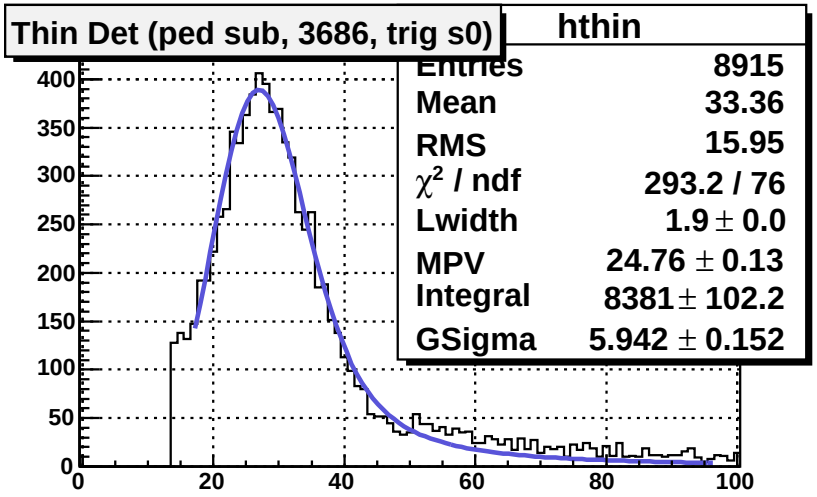


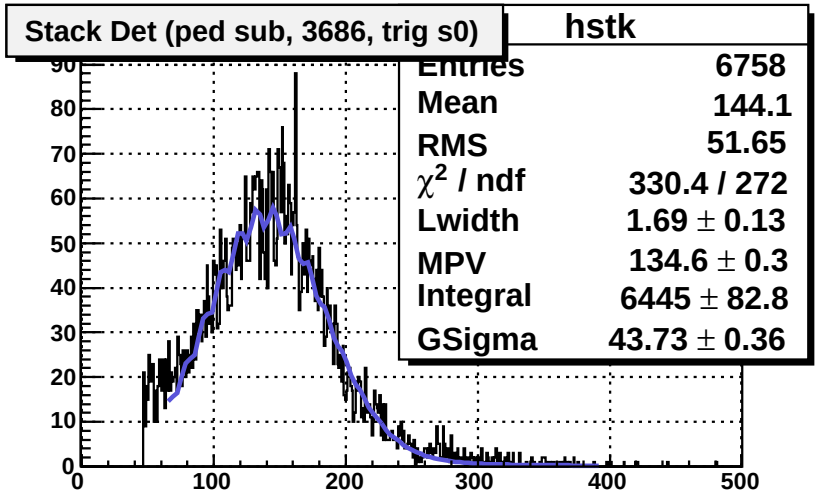
- Thin and Stack dets rigidly mounted along 45° angle; installed above rHRS focal plane (between VDC's and S1 scint. plane)
- E_{beam} = 956 MeV, 5 - 50μA, 100mg/cm^2 Ta target
- rHRS at 19°, using VDC's and s0 trigger (removable)
- Counting rates ~10 Hz/μA

Jan2008 Testbeam Pulse Height Dists



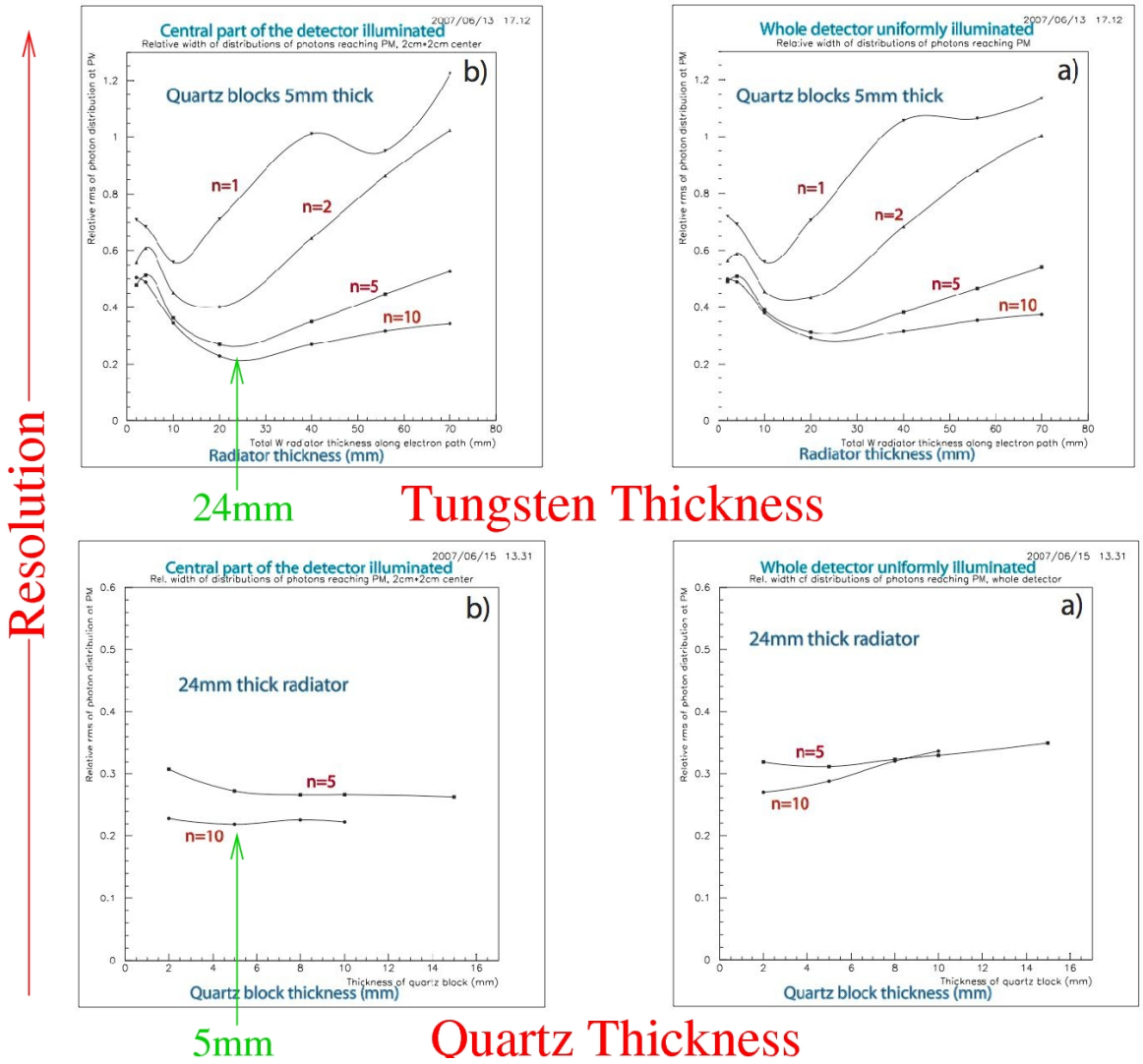






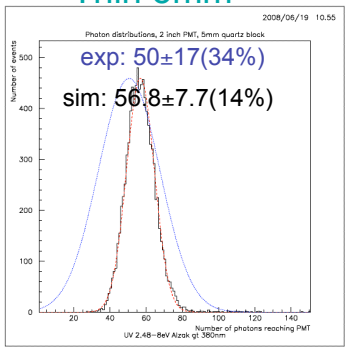
- Stack performance: $51.7/144 = 0.358$ (raw)

Piotr's MC: Tungsten and Quartz thickness study (for ~900MeV electrons)

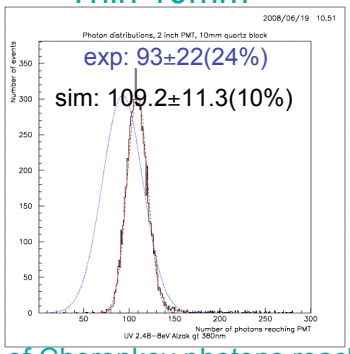


January 2008 PREx detectors tests, comparison with simulations

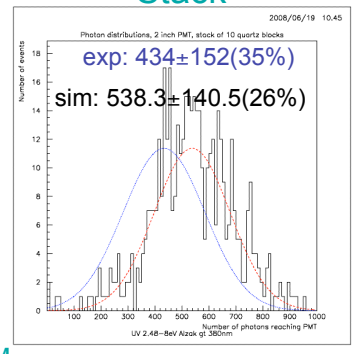
Thin 5mm



Thin 10mm



Stack

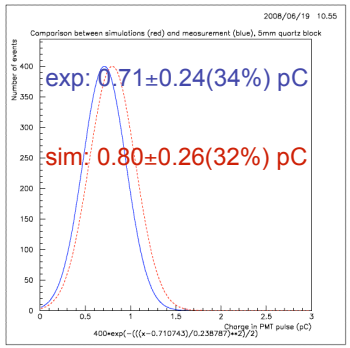


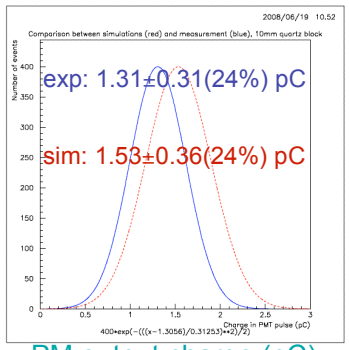
Number of Cherenkov photons reaching PM

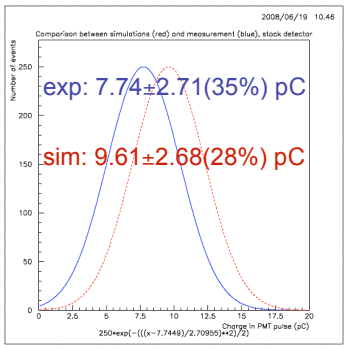
$N_{PE}=0.2N_{ph}$ (<QE>=0.2)

In panels below widths of gaussian fits to the simulated N_{ph} distributions (red lines) are corrected for the PMT resolution according to the formula (for the used PMTs measured value of the δq is 0.23):

$$\delta Q_e = \sqrt{(\delta N_{ph})^2 + \frac{1 - \overline{QE} + (\delta q)^2}{\overline{N}_{PE}}}$$





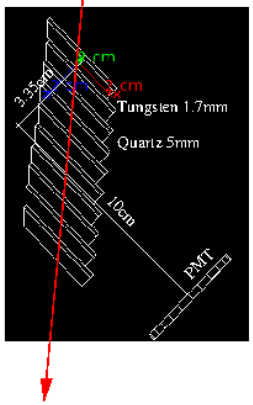


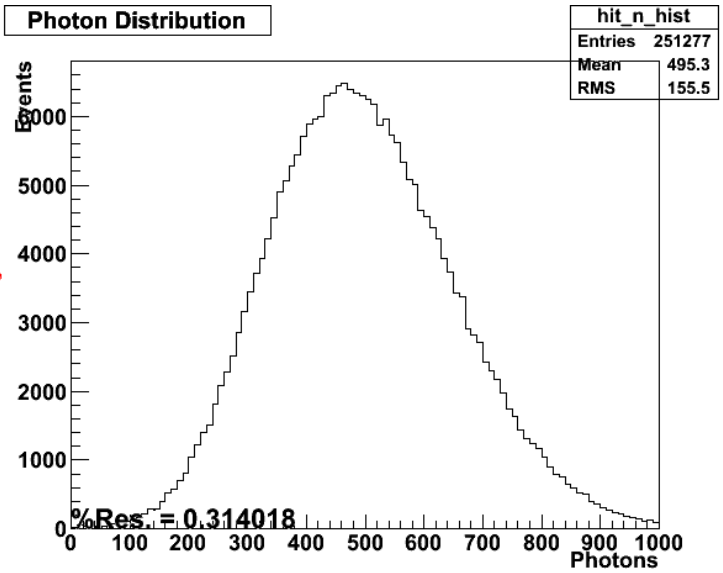
PM output charge (pC)

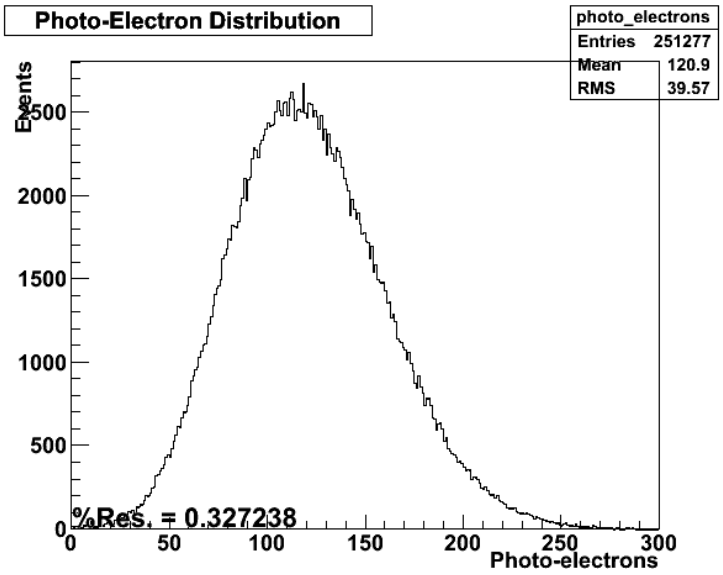
Slide from Piotr

Recent Stack Simulations at ISU

No angle smearing,
850 MeV electrons







Results:
495 photons
121 PEs
32% resolution

2008 Testbeam Data and Simulation Summary

- Results for stack detector were lack-luster: 35% relative width
  - –Why?
  - –Because energy too low? probably not
  - –Or some other reasons? ...det alignment, design... more likely
- Both simulations give reasonable agreement with real data at 15 - 20% level
- Simulations are also in reasonable agreement with each other:
  - –Piotr found 538 Cer. photons reach PMT per electron with 28% relative width
  - –ISU found 495 photons with 32% rel width
  - –Experiment yielded 434 photons with 35% rel. width

MOLLER Showermax Development

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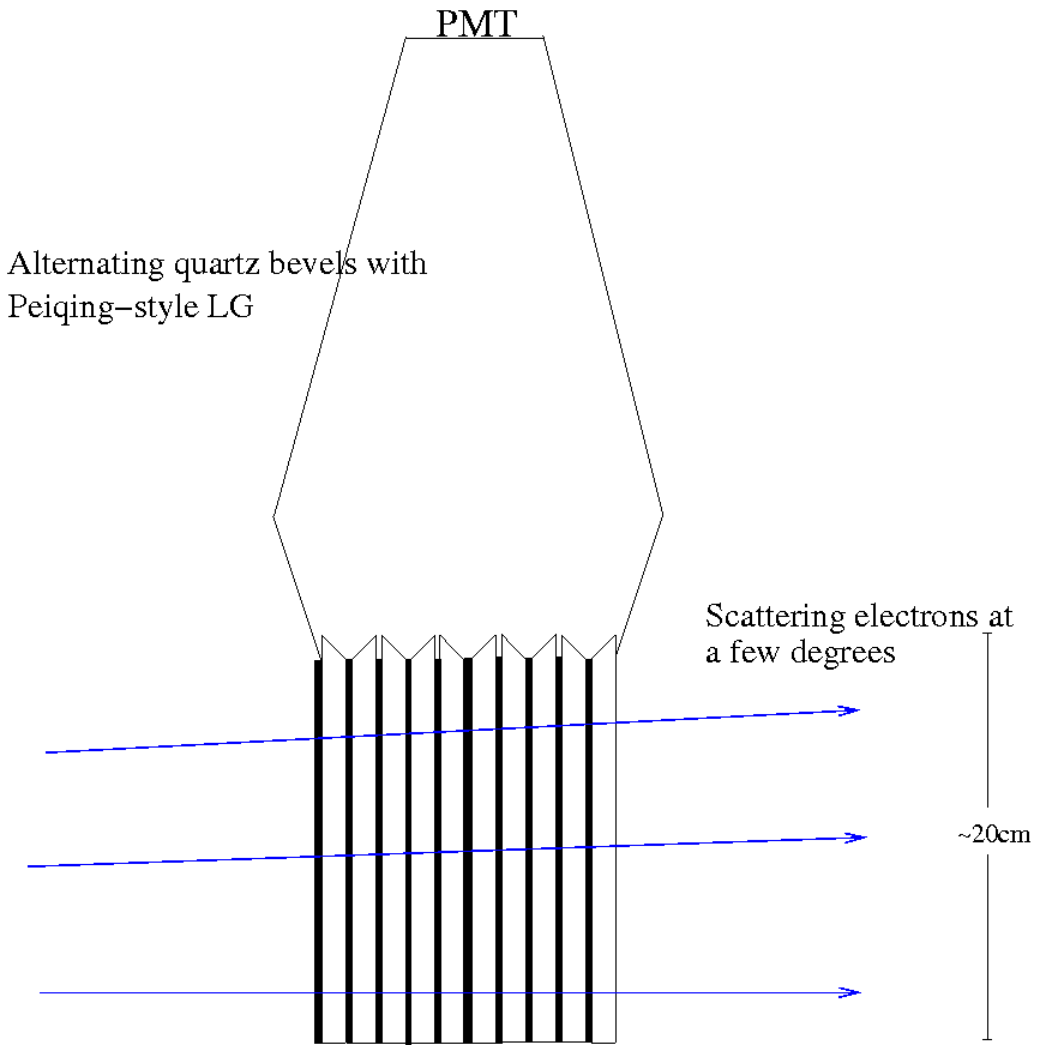
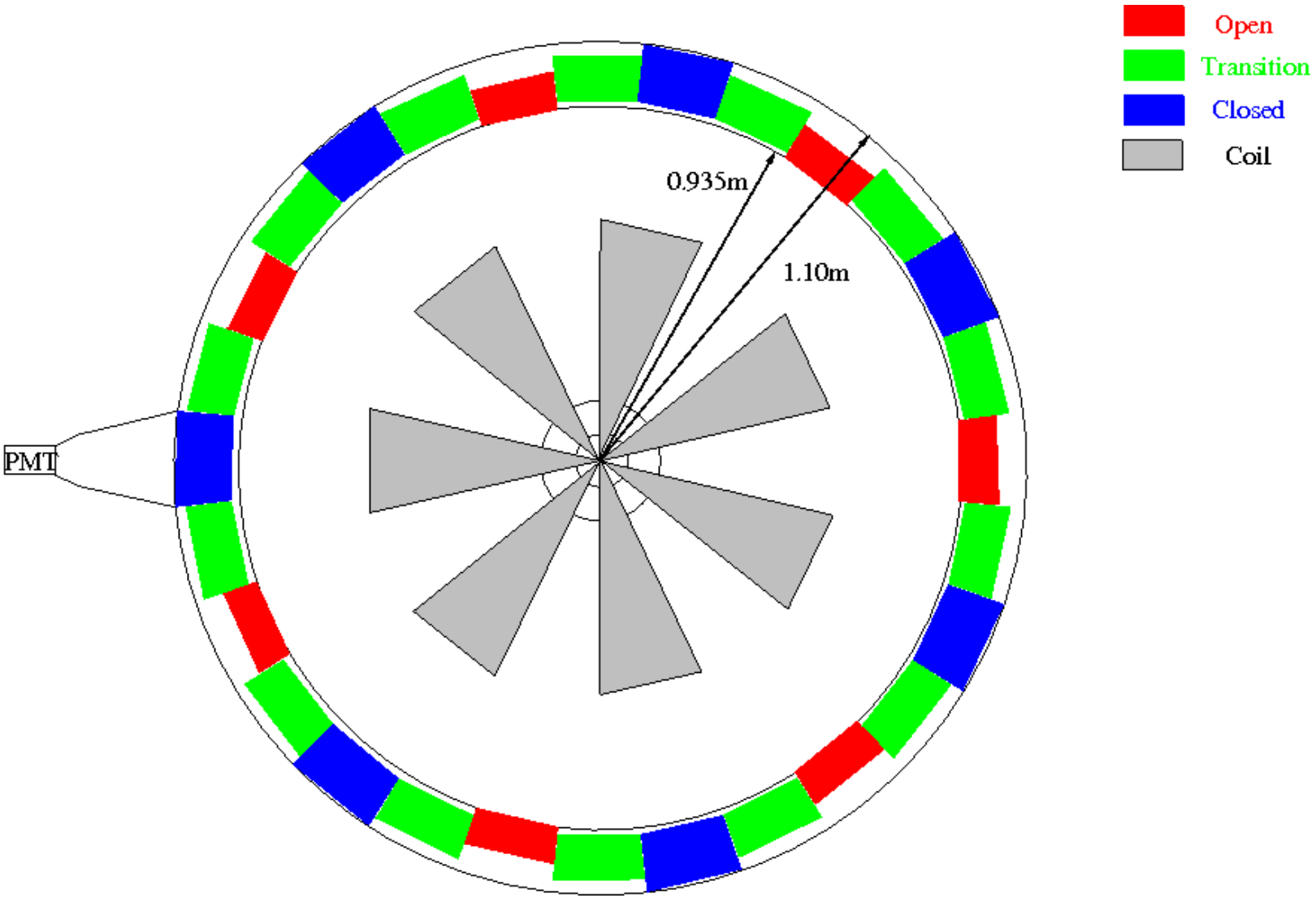
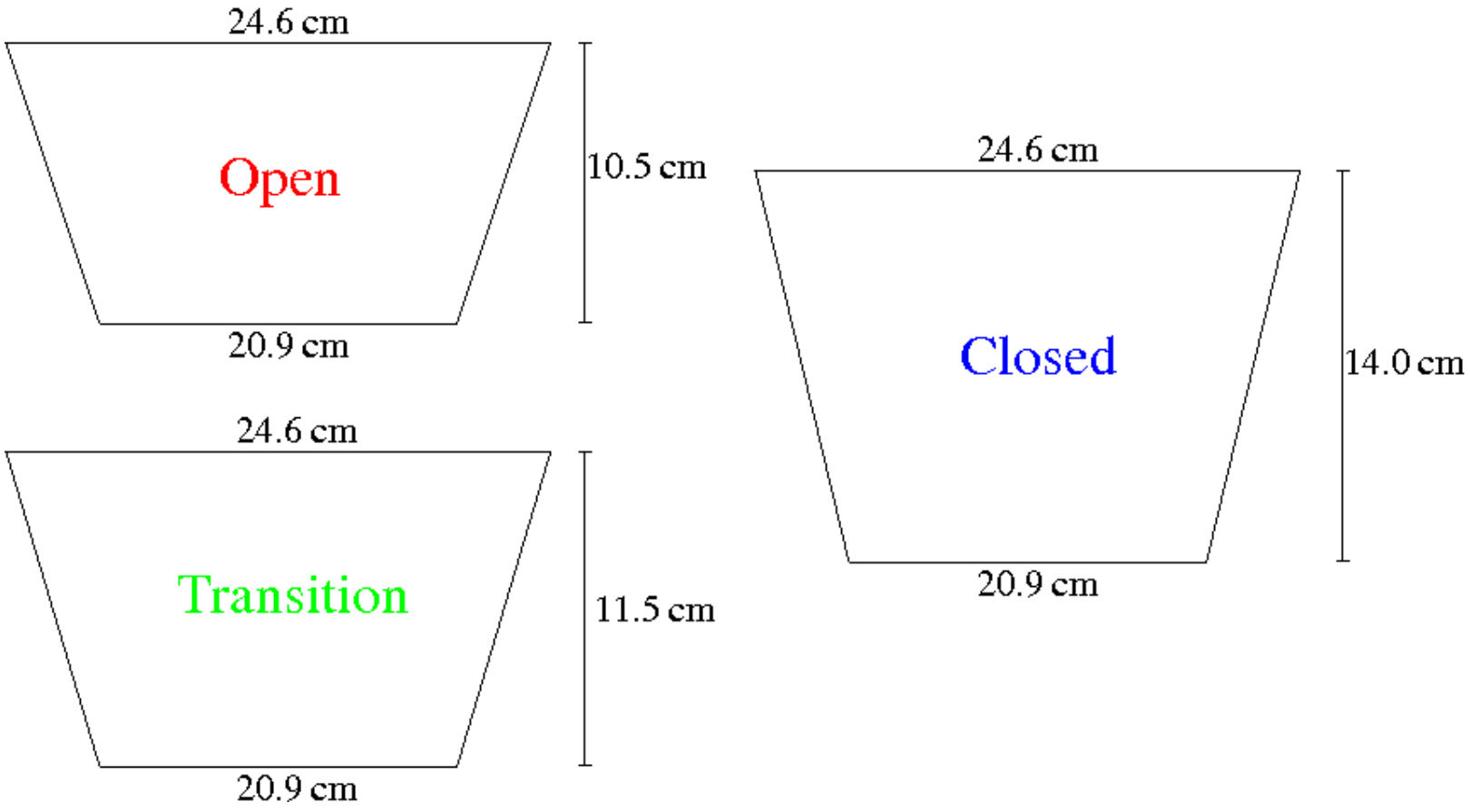
Crude Sketch of MOLLER Showermax Concept



Showermax Detector Ring



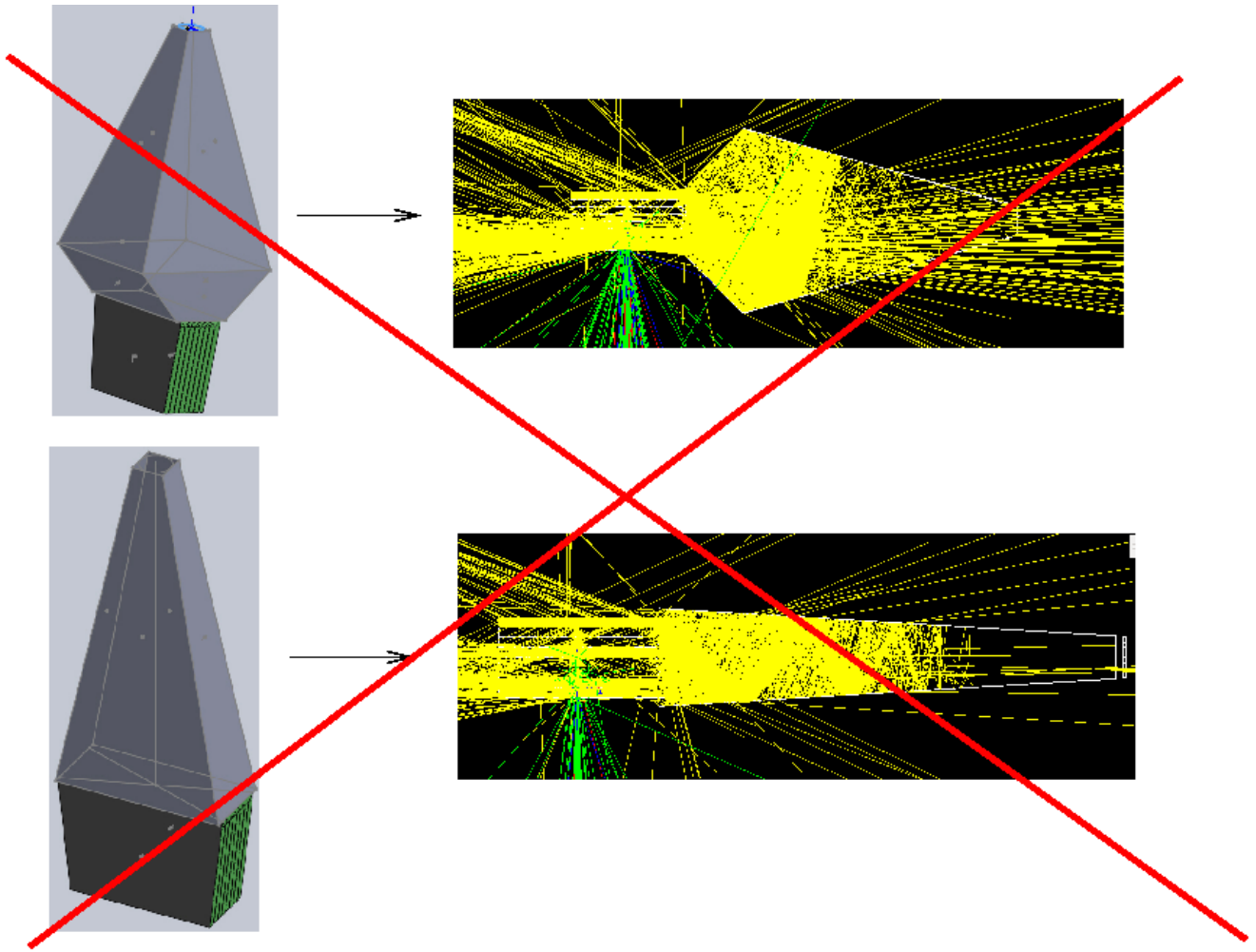
Showermax Quartz



Spectrosil 2000

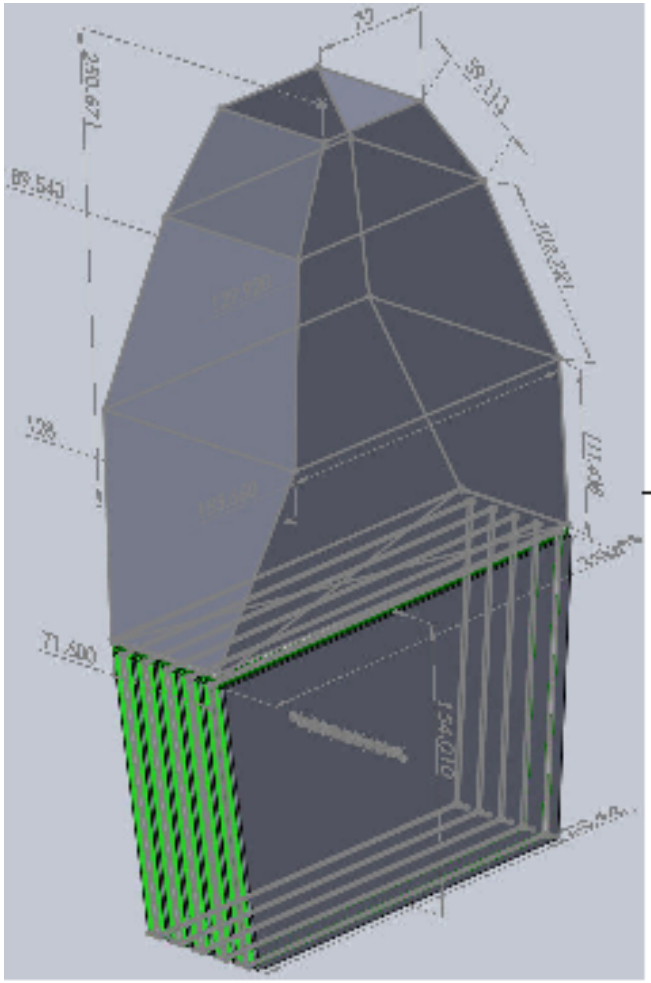
each piece has single 45 deg bevel across long end

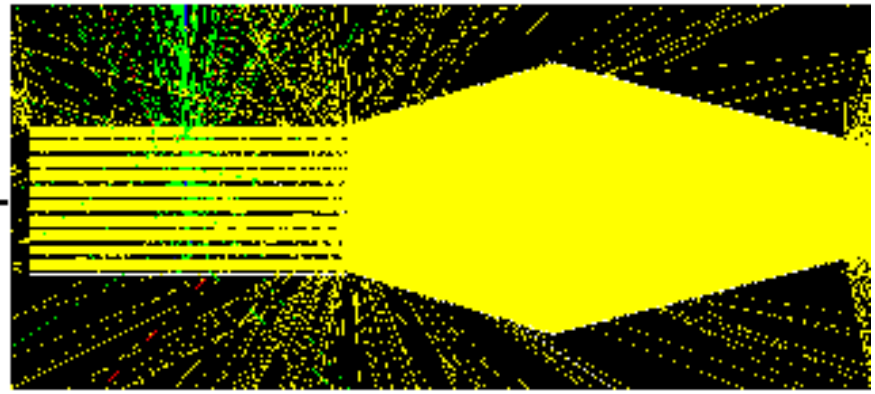
Showermax Lightguide (Bad Examples)



*Lightguide design non-trivial and perhaps most important feature

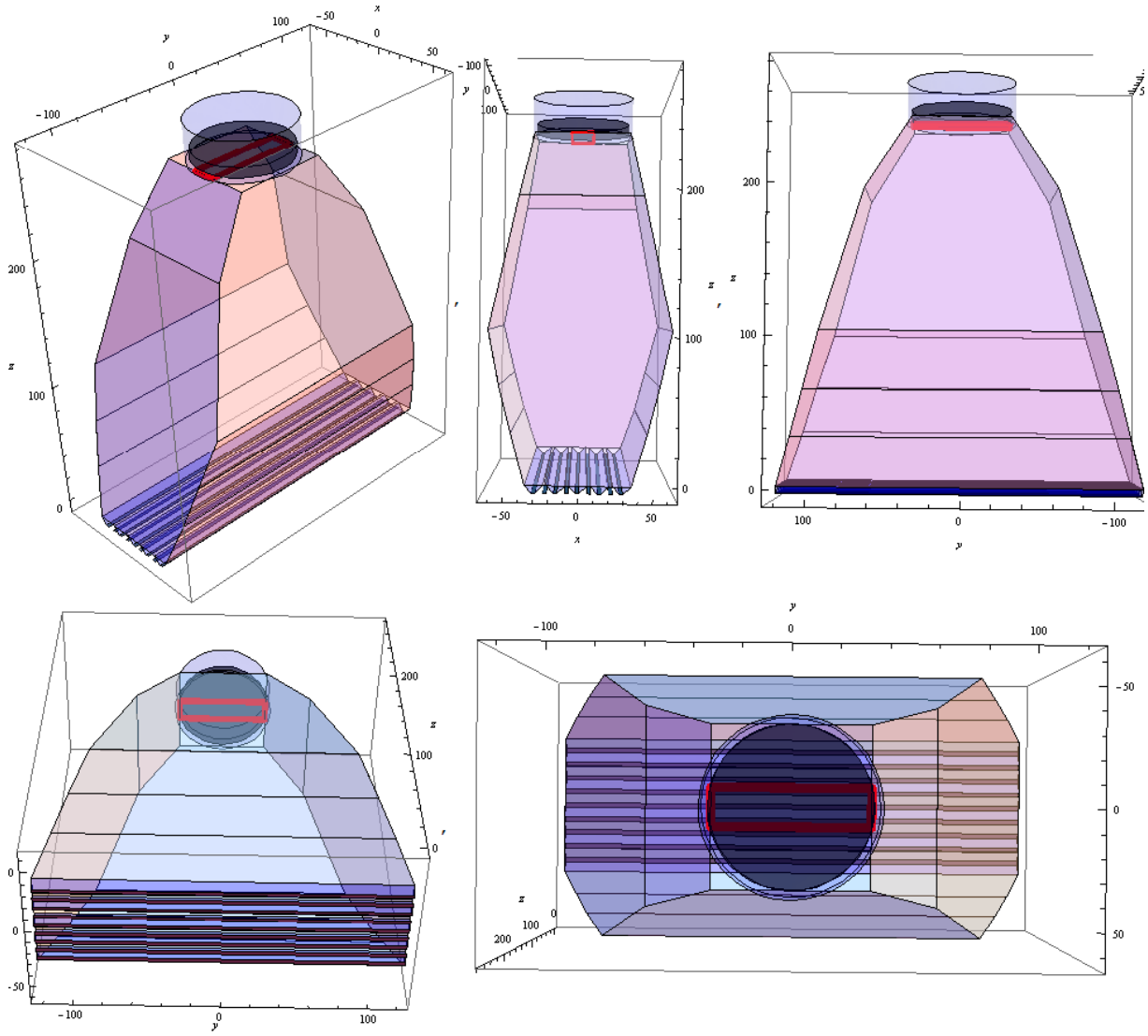
Showermax Lightguide (Good)



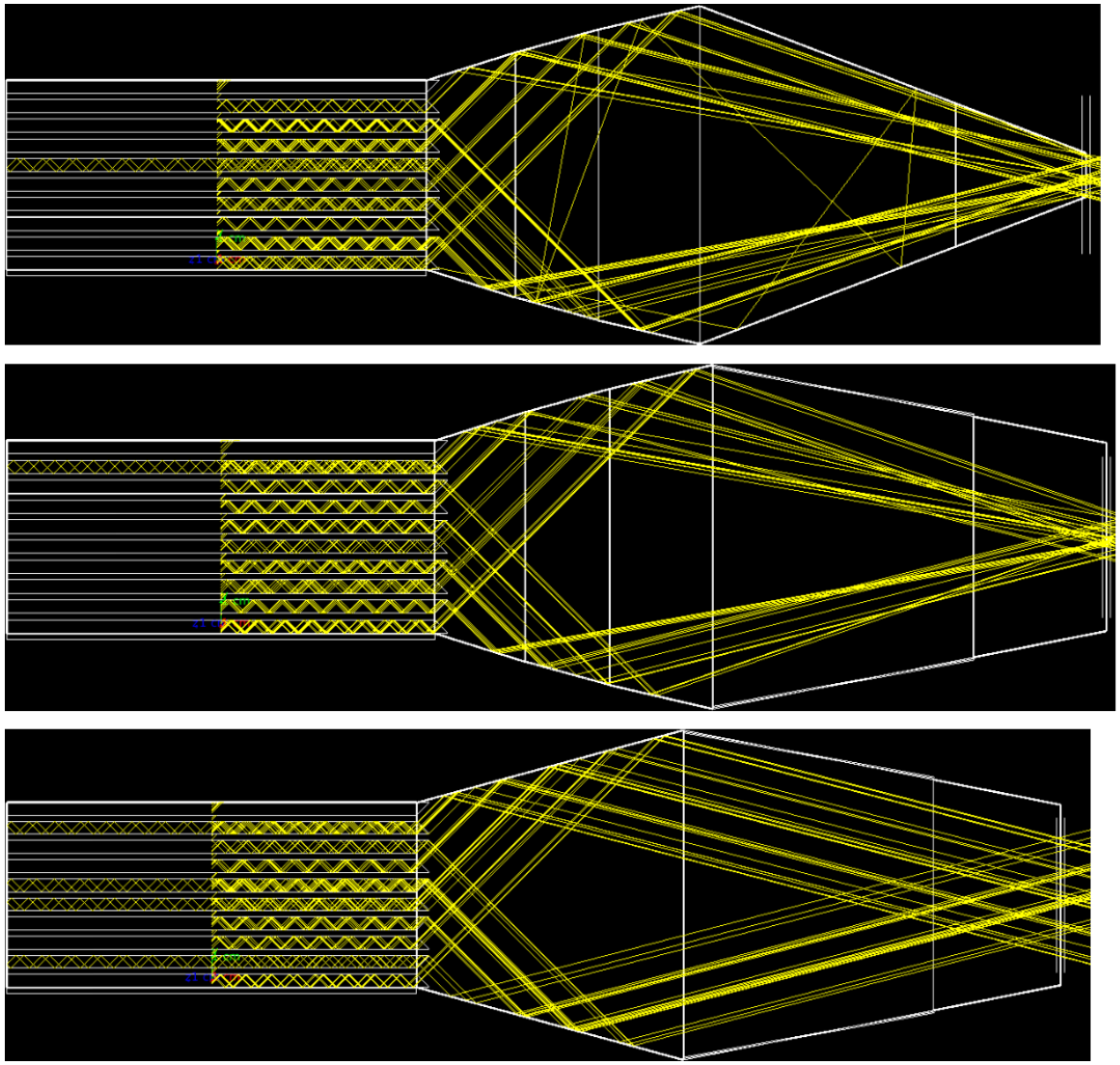


10 pieces of quartz (5mm thick)
10 pieces of W (2.4mm thick)
$0.41 + 6.8 = 7.2\ X_0$
Using 3" PMT

Showermax Lightguide Development

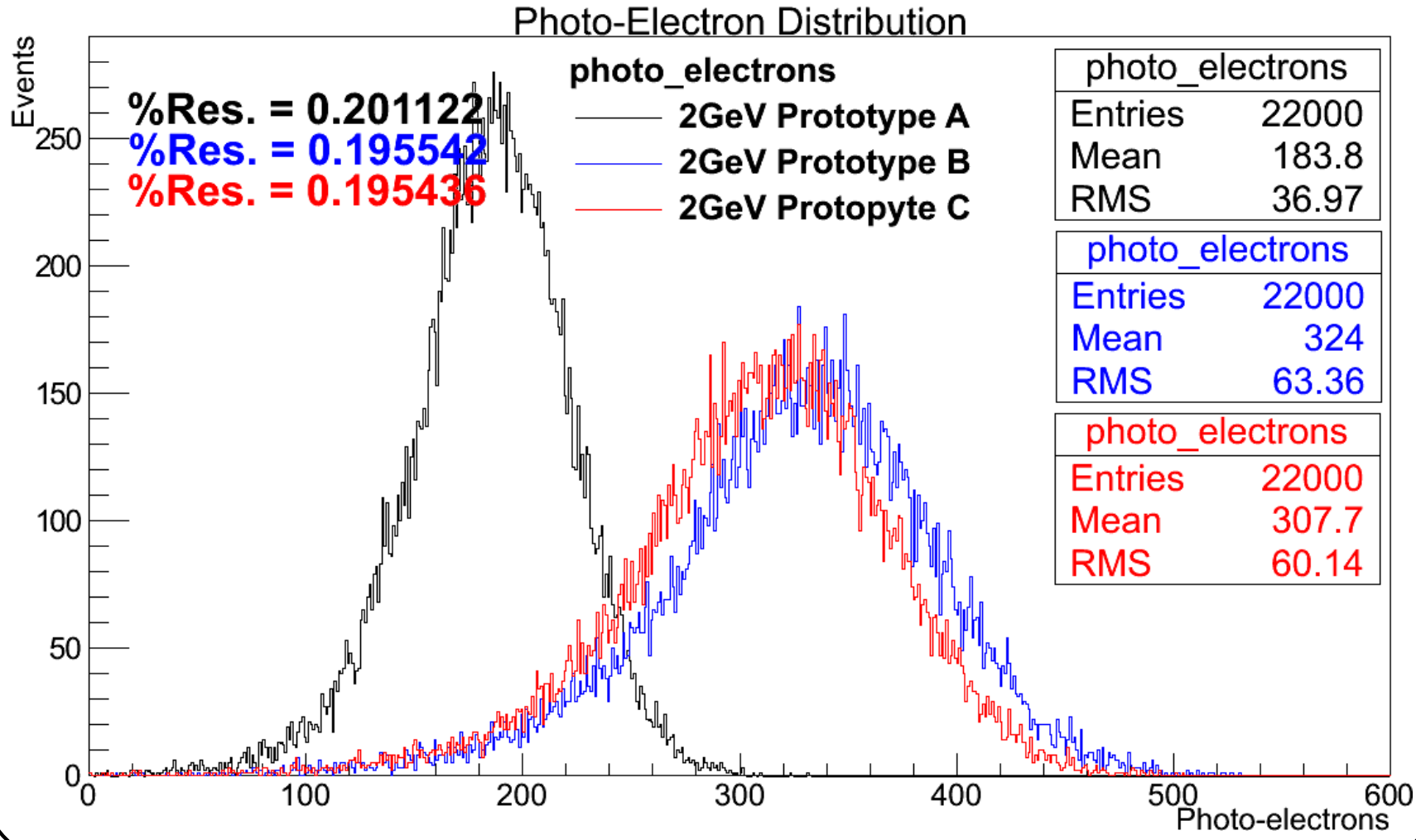


Showermax Lightguide Development



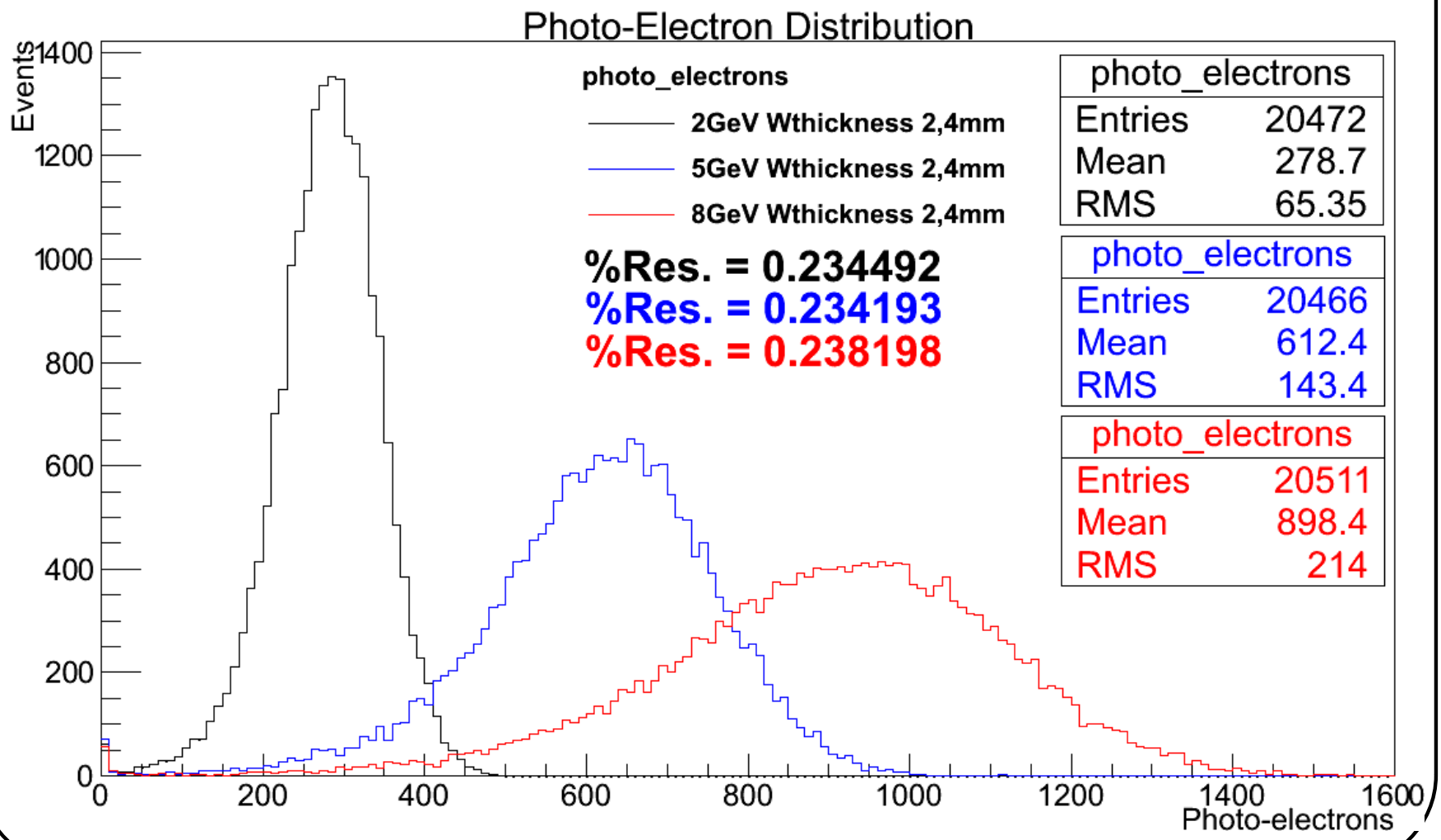
Showermax MC LG Study

- 2 GeV electron beam centered on quartz face; normal incidence



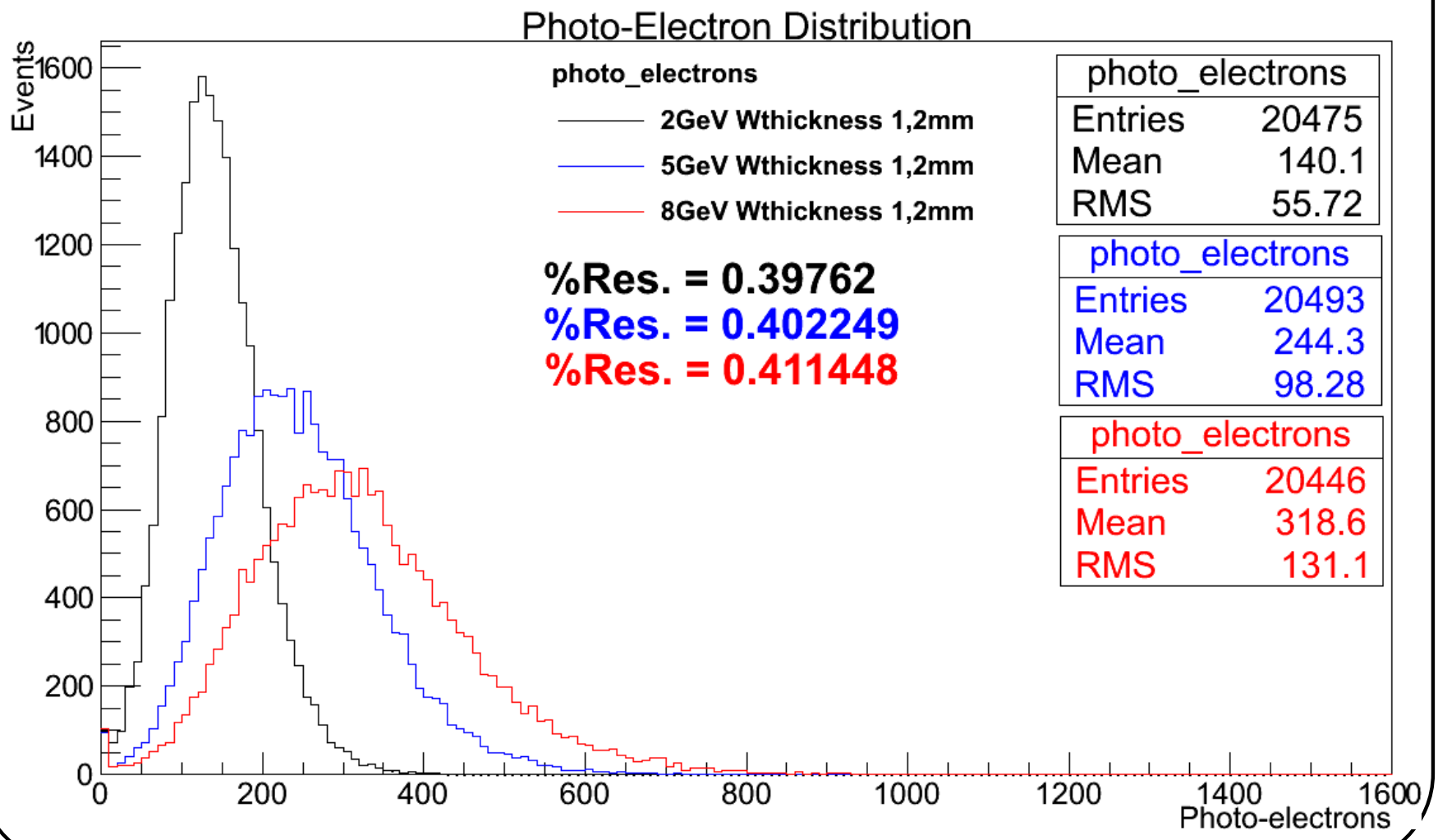
Baseline Showermax MC Results: Lightguide C

- 2, 5, and 8 GeV e^- uniformly sampled over quartz face; normal



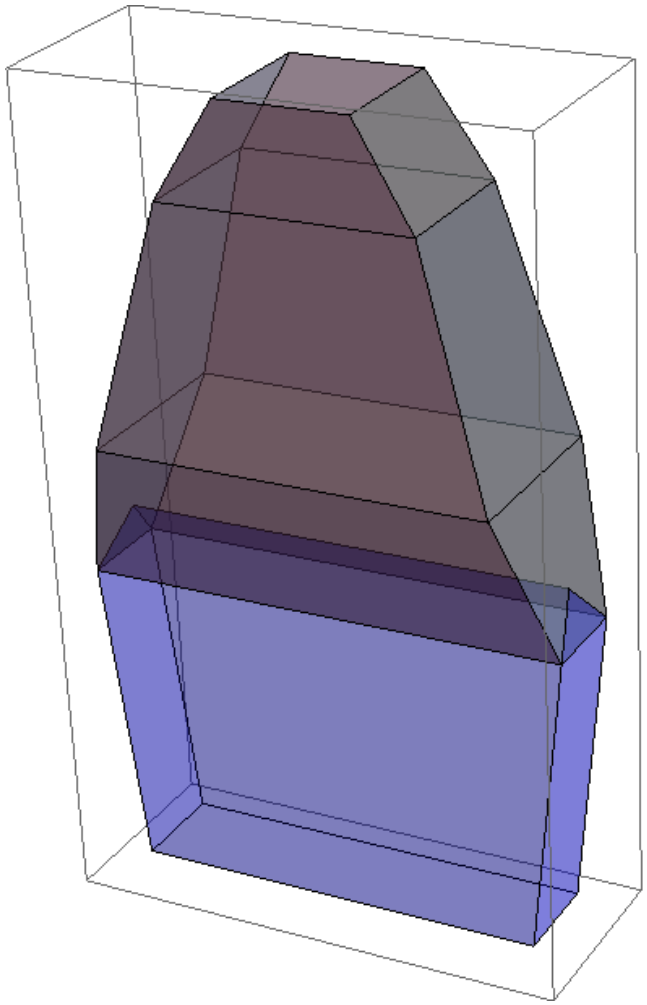
What if thickness of W is halved?

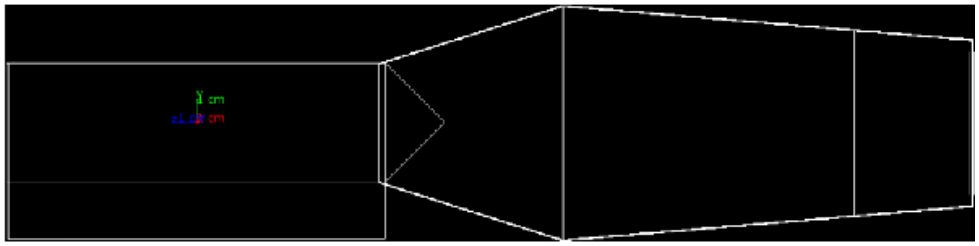
- 2, 5, and 8 GeV e^- uniformly sampled over quartz face; normal



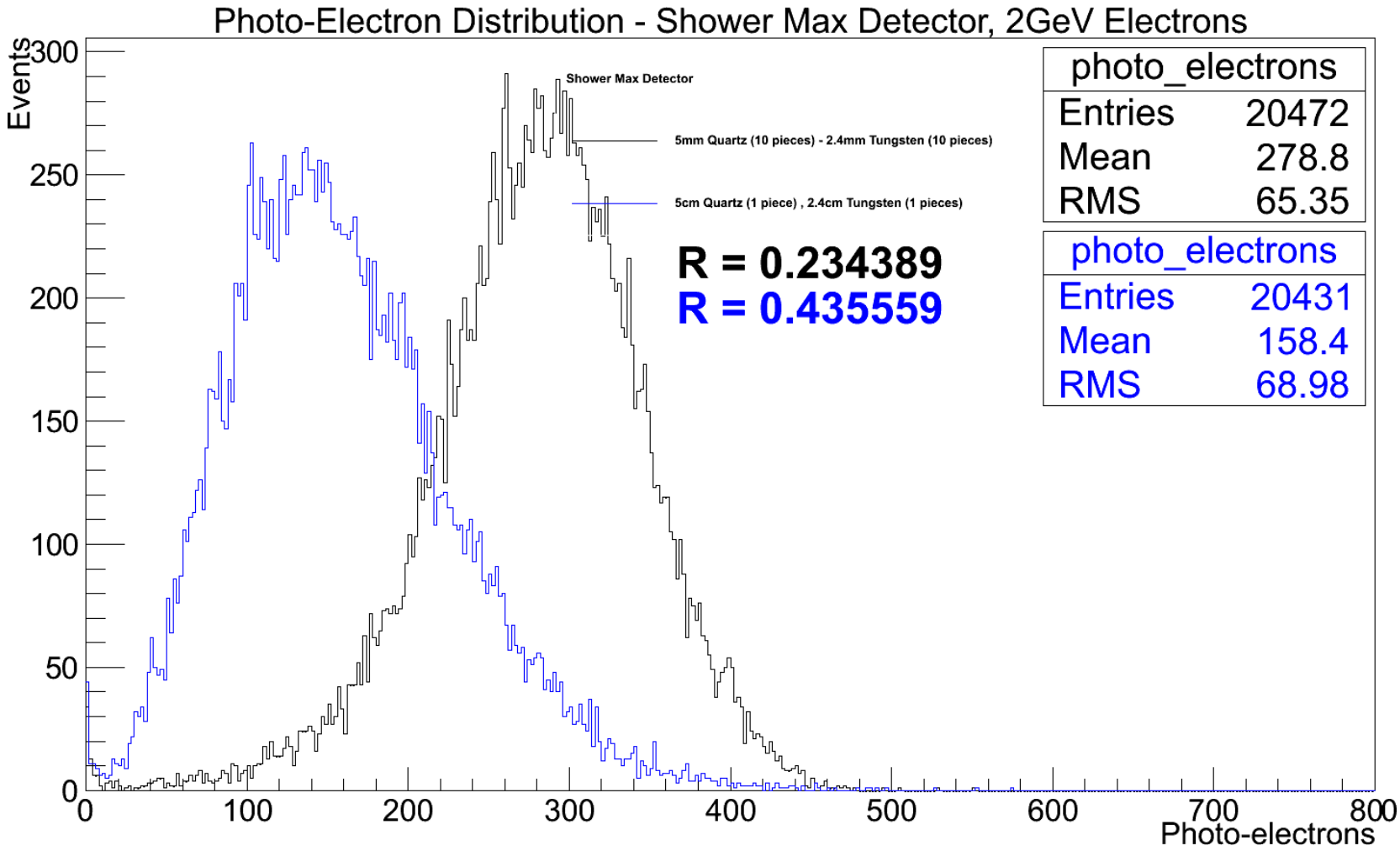
What if just use single piece of W and Quartz?

Answer: Doesn't work well at low energy (but way cheaper!)

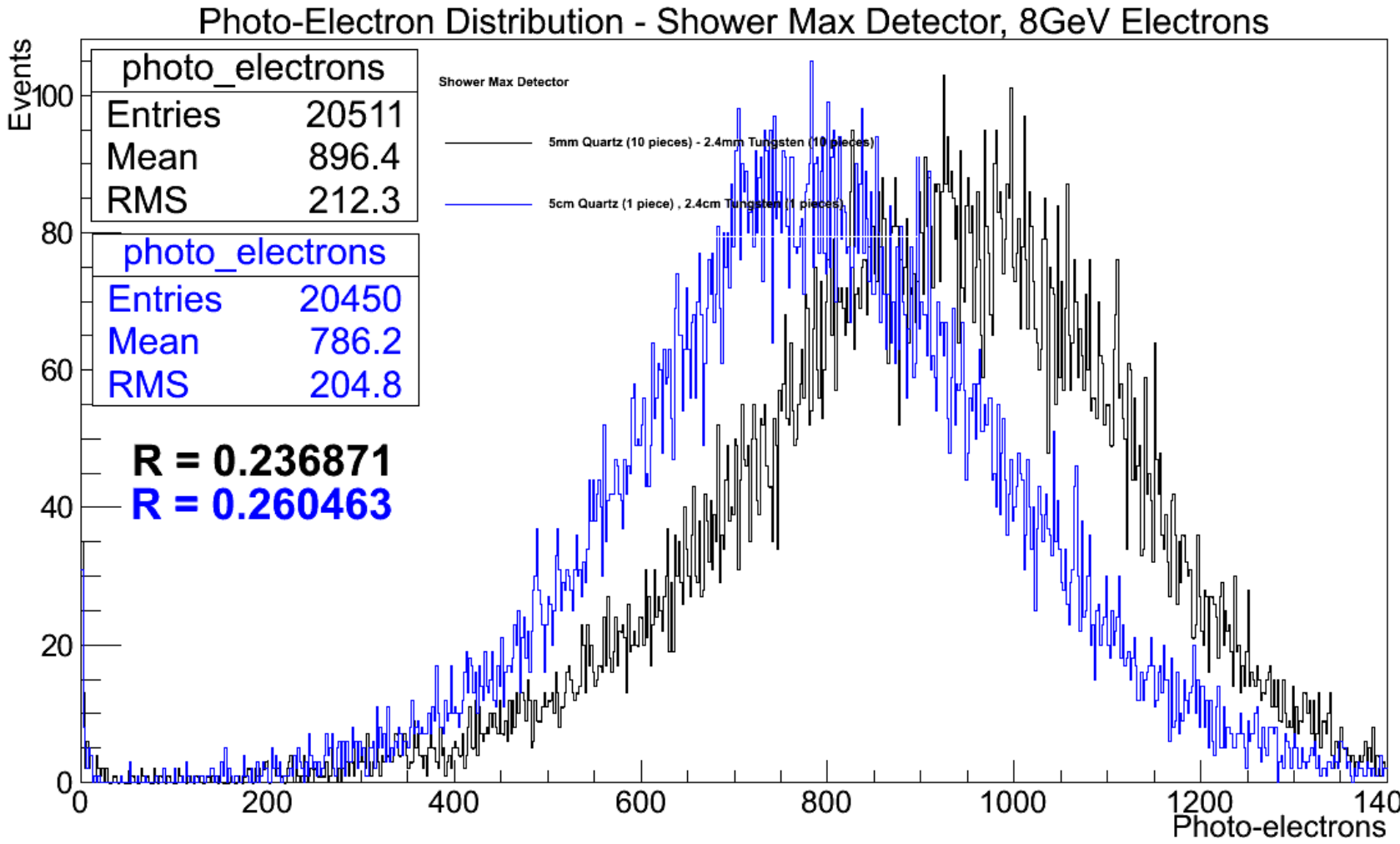




Single piece Design versus Baseline Design at 2GeV



Single piece Design versus Baseline Design at 8GeV



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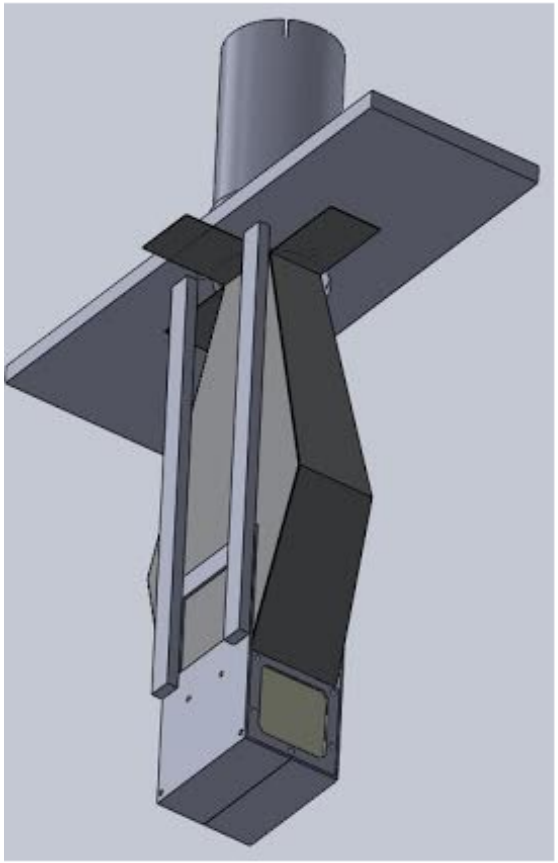
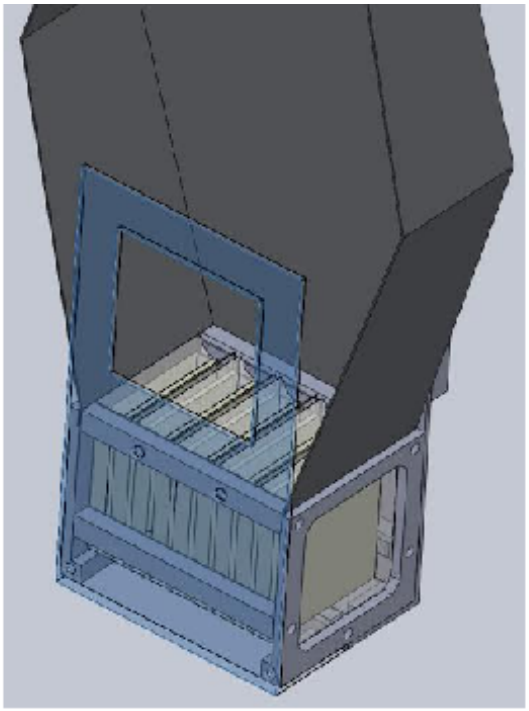
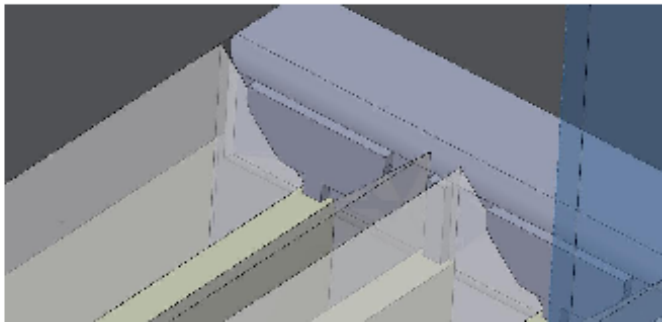
Prel. Prototype design using 2008 Stack pieces







- MC studies needed to understand potential benefits of beamtest

Summary and Future Work

- Optical MC framework for showermax R&D established
  - –Reasonable/good agreement with 2008 beamtest data and Piotr's simulations
- Baseline MOLLER showermax detector design established
  - –Gives strong energy dependent light yields with $\sim 25\%$ relative width
- Optimization of baseline design underway
- Build prototype based on optimized design and test with beam
- Other questions/considerations:
  - –90° LG or 135° (or 45°) LG (Need to decide)
  - –Need to worry about sensitivity to neutrons, pions
  - –PE uniformity/edge effects due to transv. shower leakage
  - –Stray electrons, splashback,...Need optical MC in remoll