ShowerMax Design Status and Plans

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(with help from Carlos Bula and Daniel Sluder)

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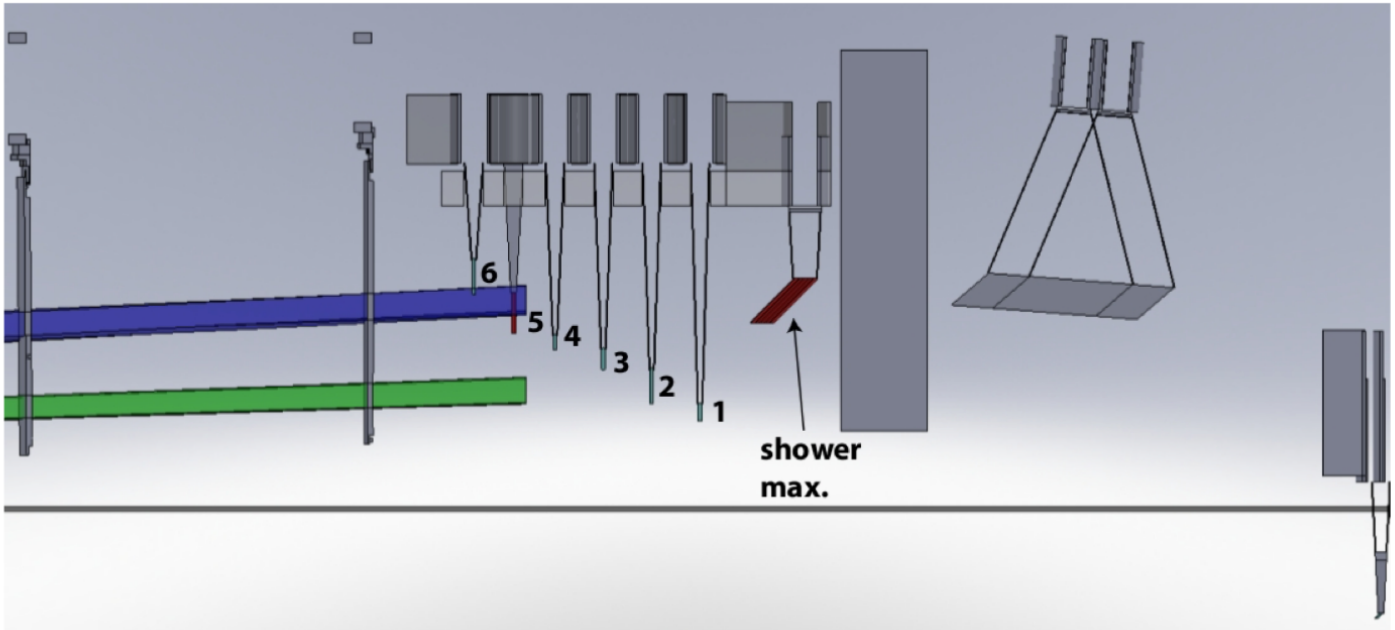
ShowerMax Design Status and Plans

Outline

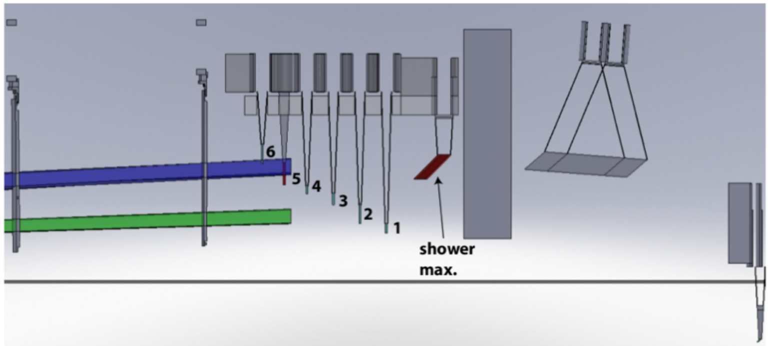
- What's been done
  - G4 optical simulation developed using qsim framework
  - "Baseline" design: 4-layer sandwich stack
  - Engineered shop drawings: Stack support frame and LG
- What's going on now
  - Optimizing the Stack configuration - for best resolution
  - Uniformity studies: PE yield and resolution vs. hit position
  - Light Guide prototyping
- Plans for prototyping and SLAC testbeam
- Summary

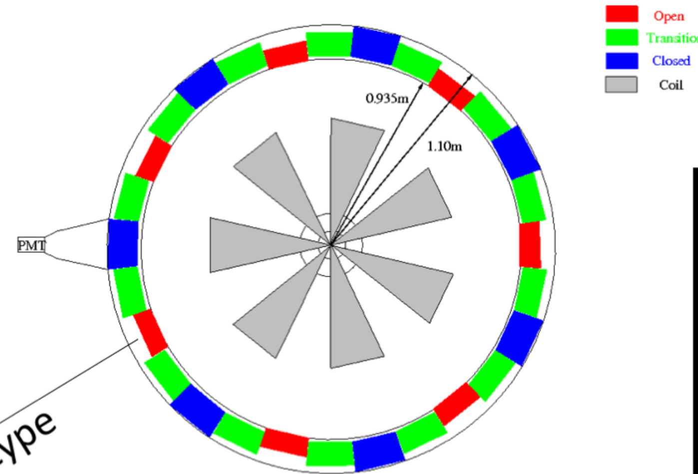
Motivation



- Provides additional measurement of e-e ring integrated flux
- Weights flux by energy => less sensitive to low energy or hadronic backgrounds
- Will also operate in counting mode to provide additional handle on background (pion) identification

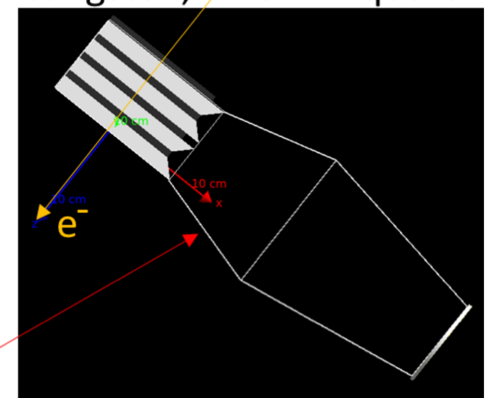
Baseline ShowerMax Design: 4-layer Stack





OPEN type

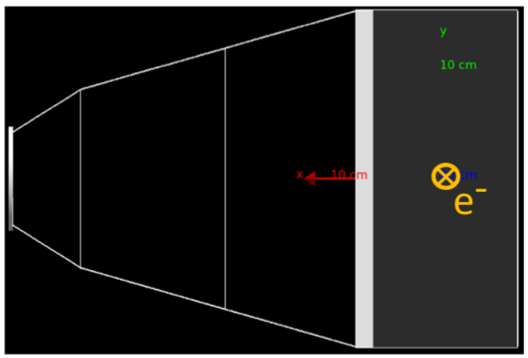
4 layer Stack: 6mm thick tungsten, 12.5mm quartz



Funnel angle and length optimized

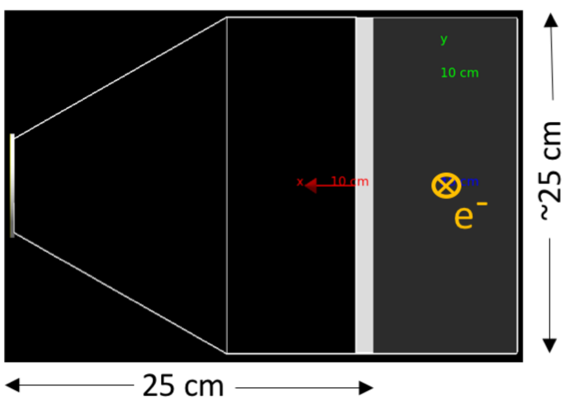
"Baseline" Design

Old "Baseline" LG



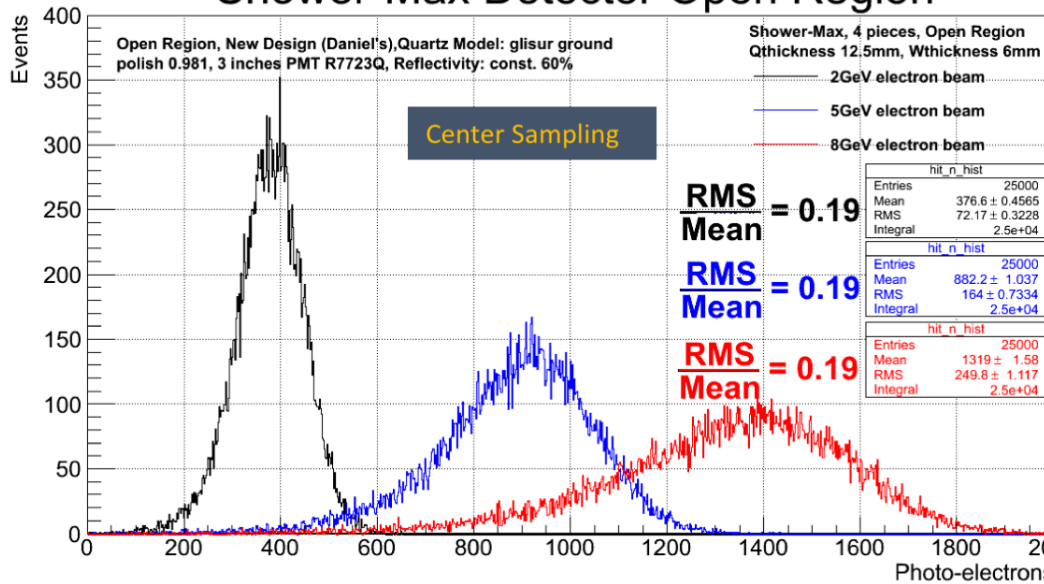
New "Baseline" LG

3inch PMT

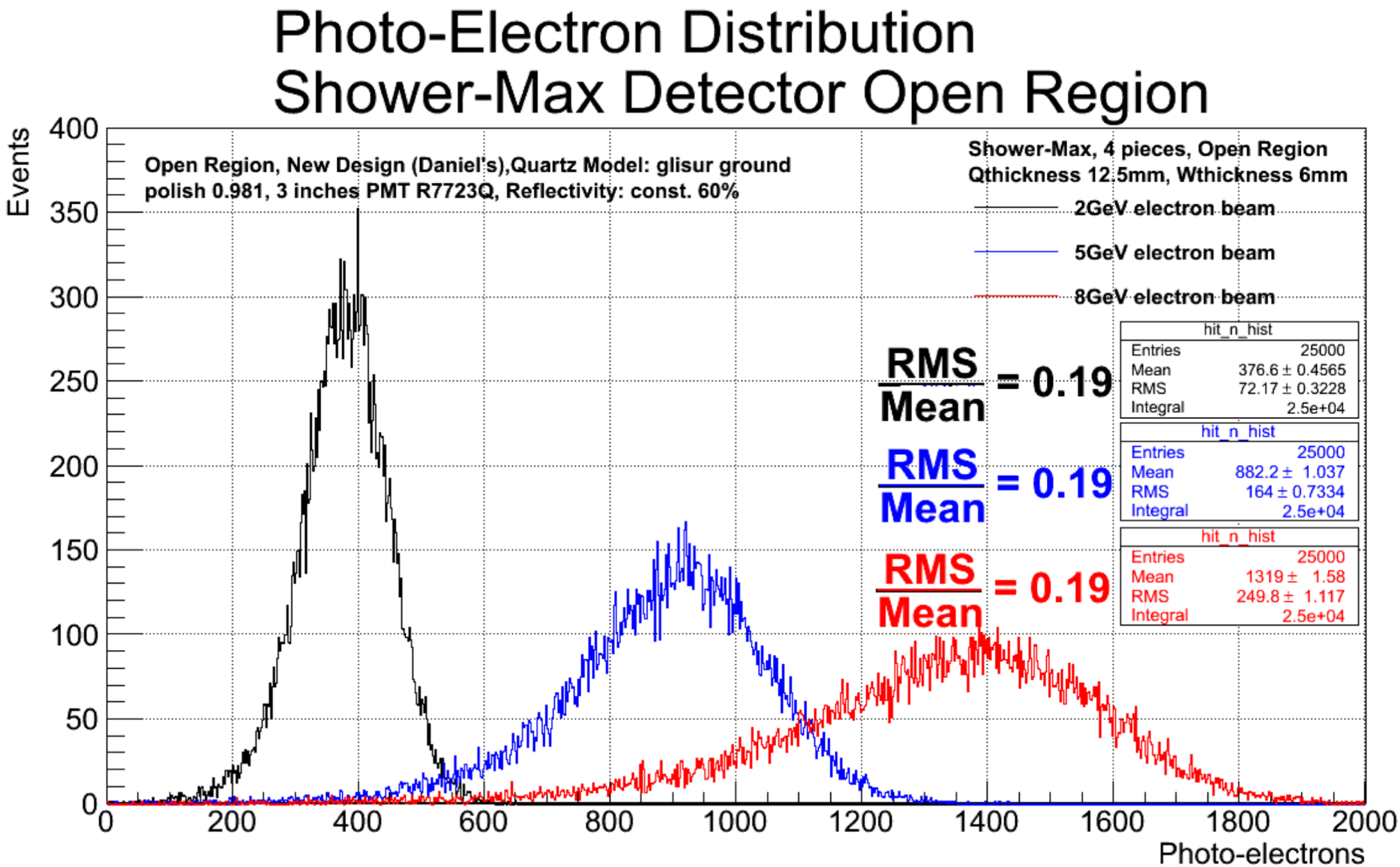


Even more light!

Photo-Electron Distribution Shower-Max Detector Open Region

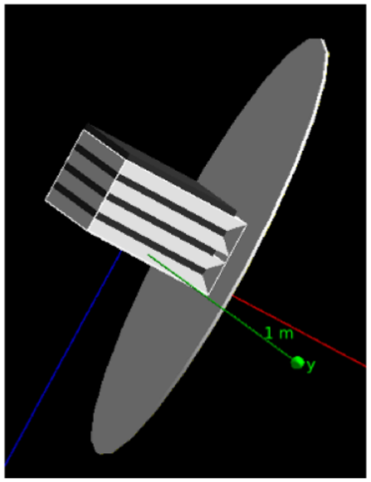


4-layer Baseline PE Dists for 2, 5, and 8 GeV

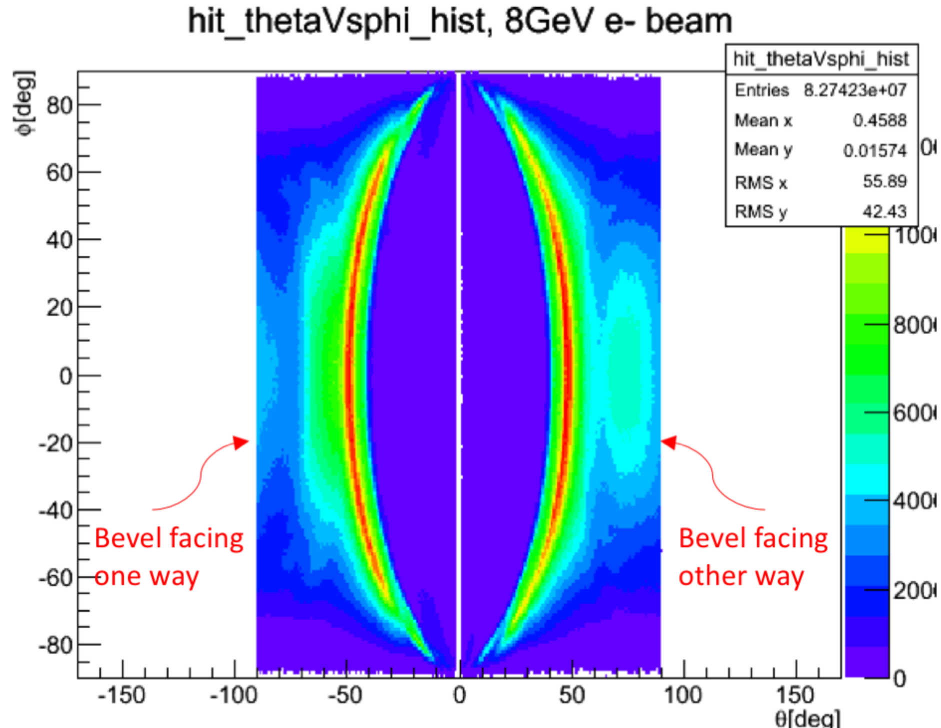


Optimal funnel-mirror angle and length study

Light exit angle study for optimizing funnel mirror



12.5mm quartz, 6mm tungsten, n = 4 layers

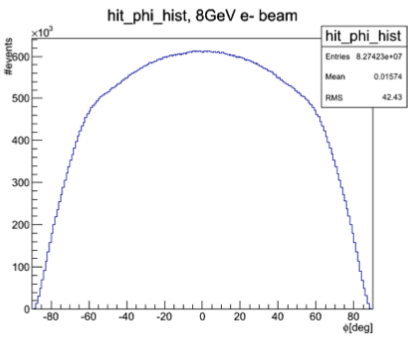


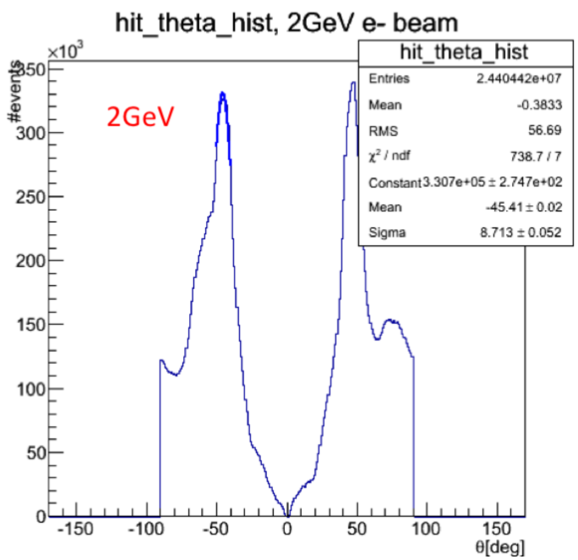
Results:

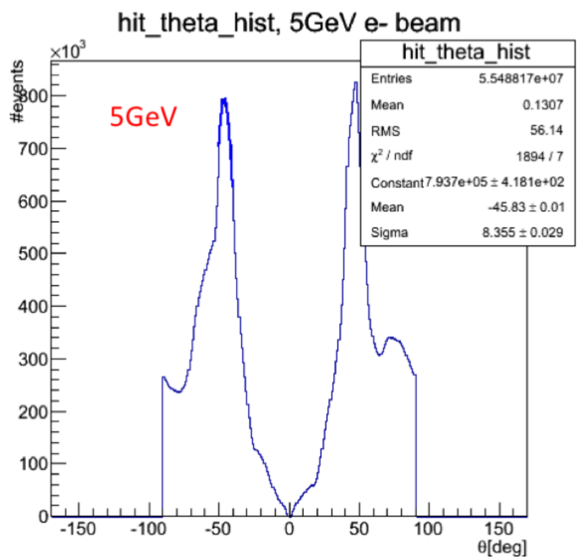
2GeV → θ_{peak} = 45.4°

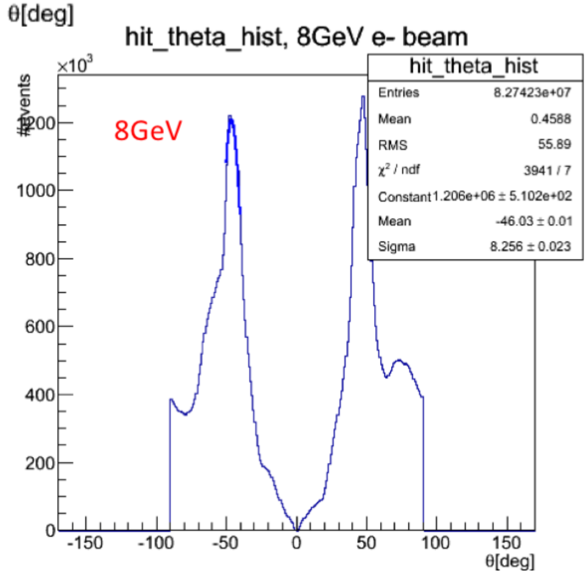
5GeV → θ_{peak} = 45.8°

8GeV → θ_{peak} = 46.0°



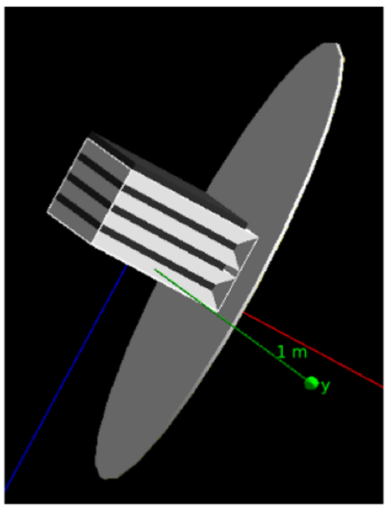




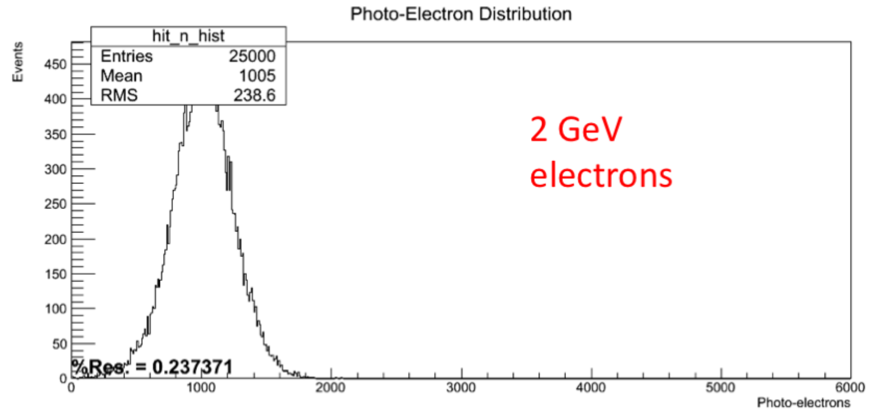


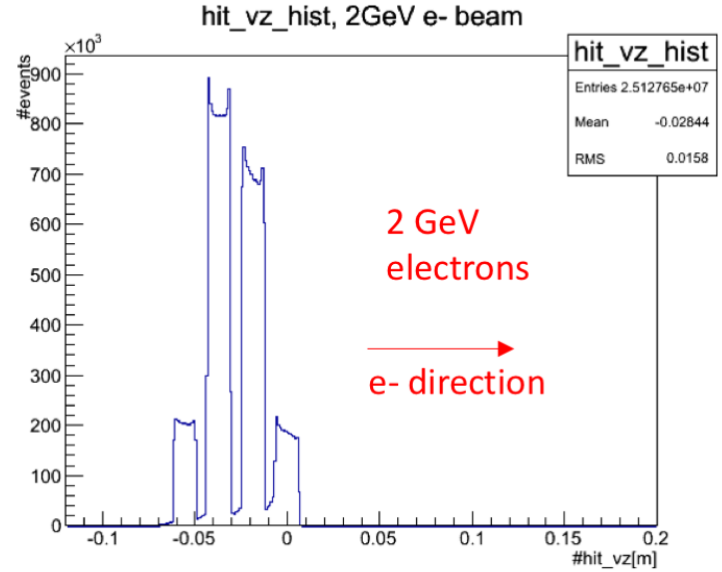
Which layers give the most light?

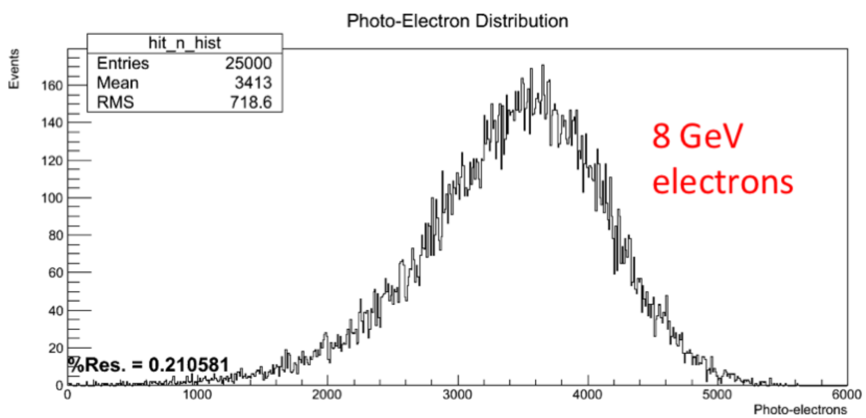
Light exit study for optimizing No. of layers

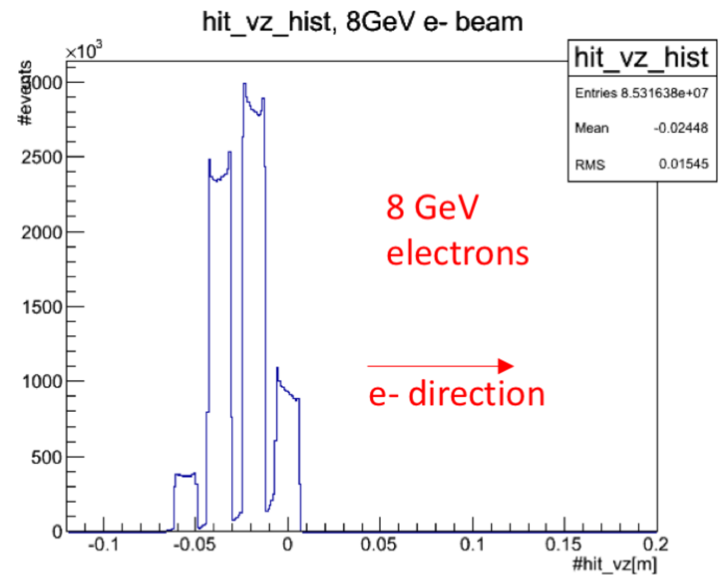


12.5mm quartz, 6mm tungsten, n = 4 layers



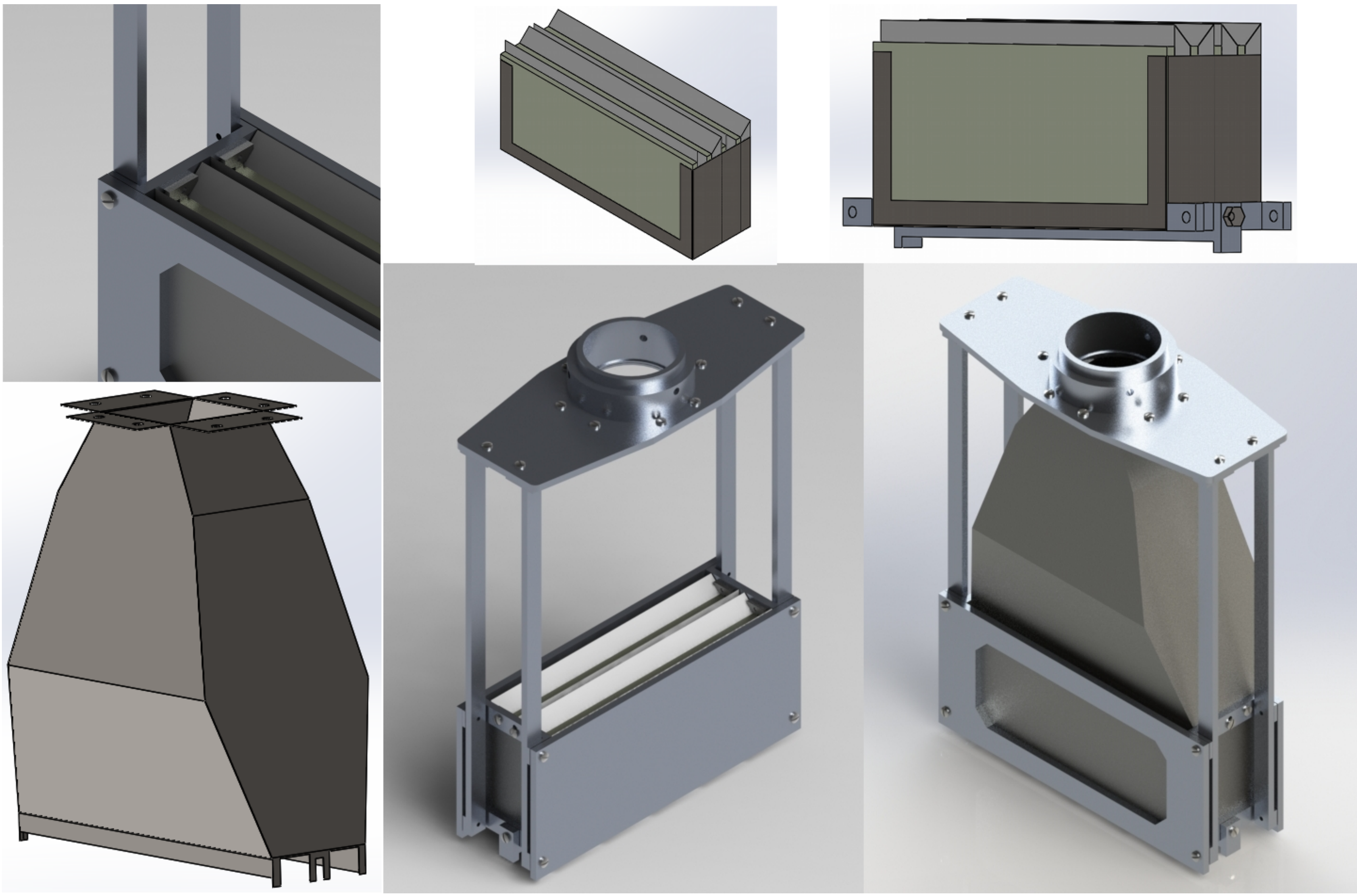






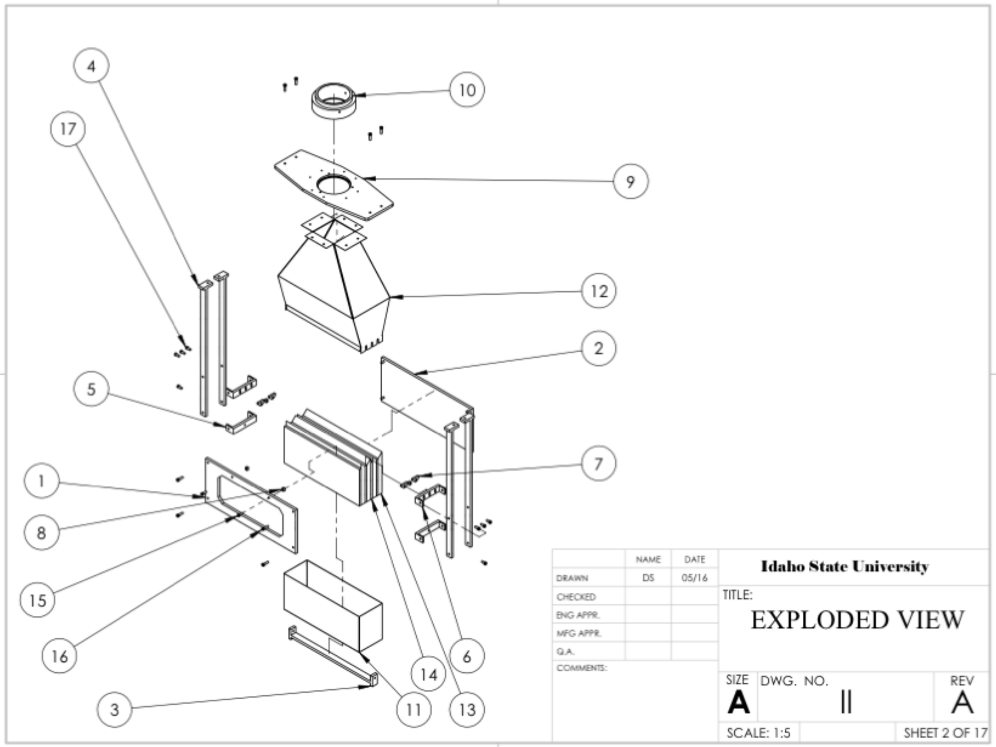
Prototype stack support structure and LG

(CAD and renders by Daniel)

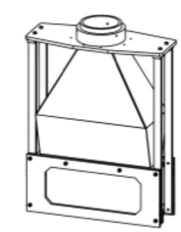


Engineered machine shop drawings in hand

(Drawings by Daniel)

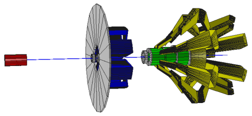


#	PART	MATERIAL	QTY.
1	Face Plate	0.25 (1/4) thick 6061-T651 Aluminum Plate	1
2	Back Plate	0.25 (1/4) thick 6061-T651 Aluminum Plate	1
3	Base Beam	1/4 x 5/8 6061 Aluminum Flat Bar	1
4	Long Beam	1/4 x 5/8 6061 Aluminum Flat Bar	4
5	Lower Side Beam	(1/4 x 5/8) AND (1/8 x 5/8) 6061 Aluminum Flat Bar	2
6	Slotted Side Beam	(1/4 x 5/8) AND (1/8 x 5/8) 6061 Aluminum Flat Bar	2
7	Ledge	3/16 6061 Aluminum	4
8	Ledge-Square	1/4 6061 Aluminum	4
9	topPlate	0.25 (1/4) thick 6061-T651 Aluminum Plate	1
10	3in Ring	4 OD x .500 wall x 3.00 ID 6061 Aluminum Round Tube	1
11	Suitcase	0.020 Anolux MIRO-Silver Reflective Aluminium Sheet (Caution: no-scratch mirror surface required)	1
12	LG-StraightUp(recovery)	0.020 Anolux MIRO-Silver Reflective Aluminium Sheet (Caution: no-scratch mirror surface required)	1
13	4_pc_Quartz_open		4
14	4_pc_Tungsten_open		4
15	CR-FIMS 0.164-32x0.4375x0.4375-N		2
16	CR-FIMS 0.164-32x0.5625x0.5625-N		12
17	CR-FIMS 0.164-32x0.375x0.375-N		8



Idaho State University
TITLE:
BILL OF MATERIALS
SIZE A DWG. NO. III REV A
SCALE: 1:5 SHEET 3 OF 17

- These are ready to go to the shop or can be modified if needed



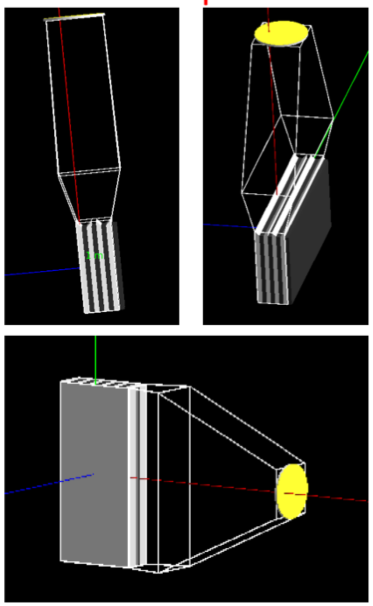
What's going on now

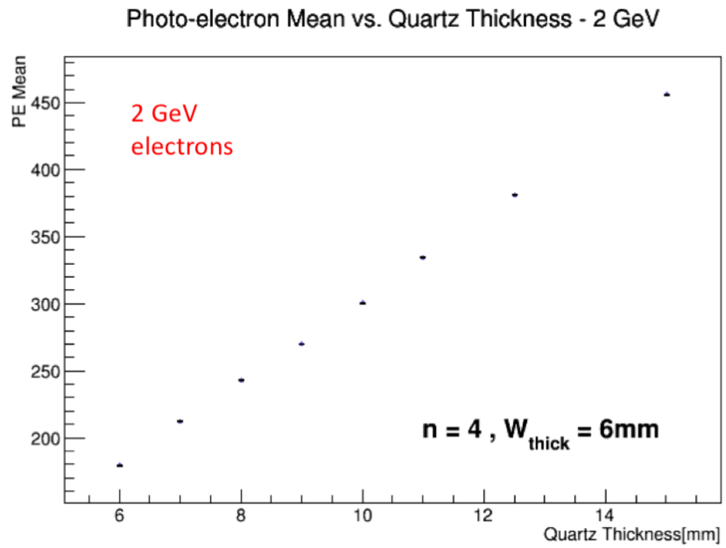
- New grad student Daniel Sluder doing Master's Thesis on Showermax development
  - He's now running G4-qsim on local farm cluster
  - Automated LG code in qsim for variable stack configurations – allowing for optimization studies
- Now studying effect of quartz and tungsten thicknesses on yield and relative width. Specifically:
  - Using a 4-layer stack (n = 4) with 6mm thick tungsten and vary quartz thickness from 6mm to 15mm–completed
  - Using a 4-layer stack with 12.5mm thick quartz and vary tungsten thickness from 5mm to 10mm–on going
  - Note for each test: all 4 quartz pieces are identical and all 4 tungsten pieces are identical (reduces cost)
- Simulated MIP signal from pions

Optimization study1 (2 GeV):

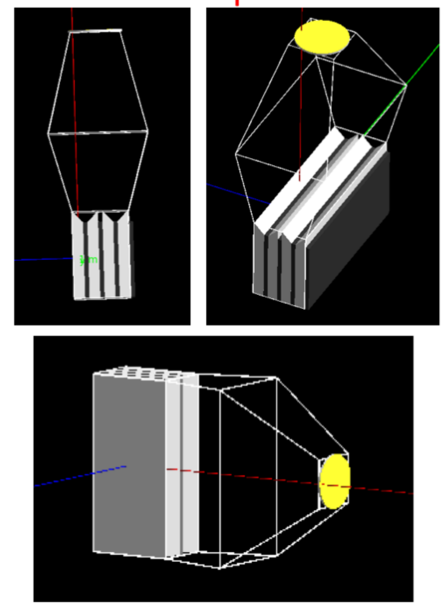
6mm thick tungsten, variable quartz thickness

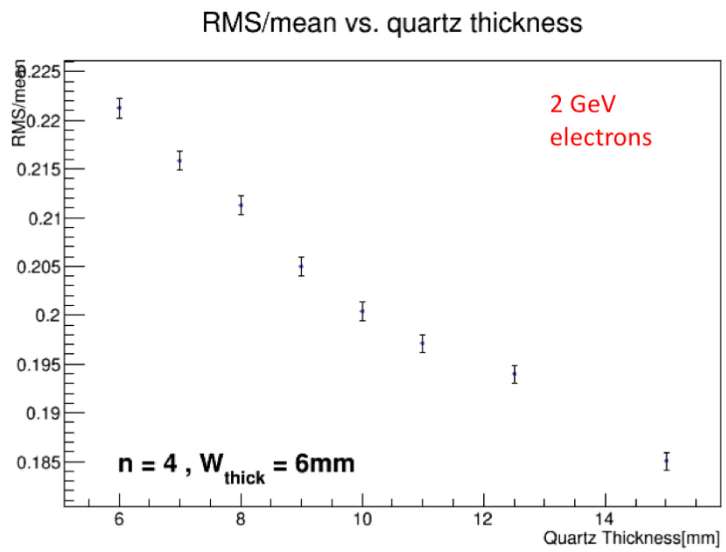
6mm quartz

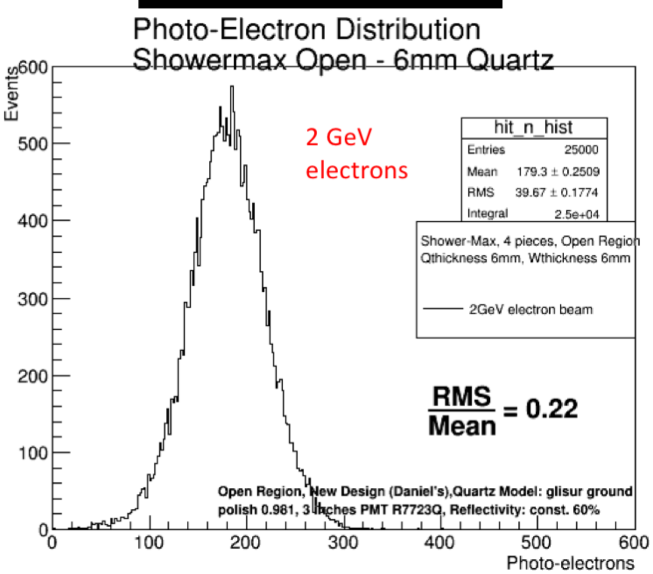


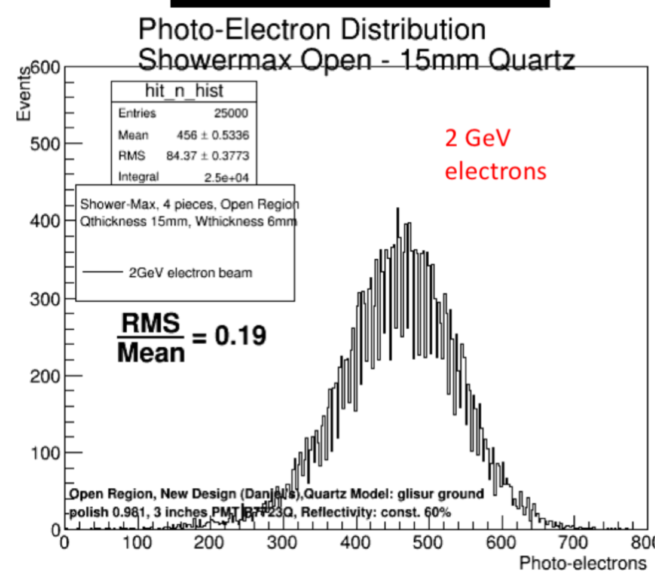


15mm quartz





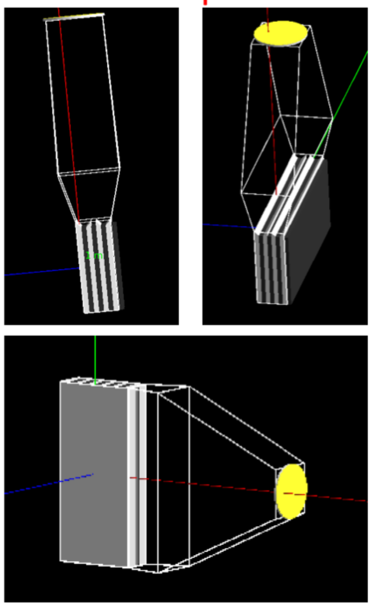


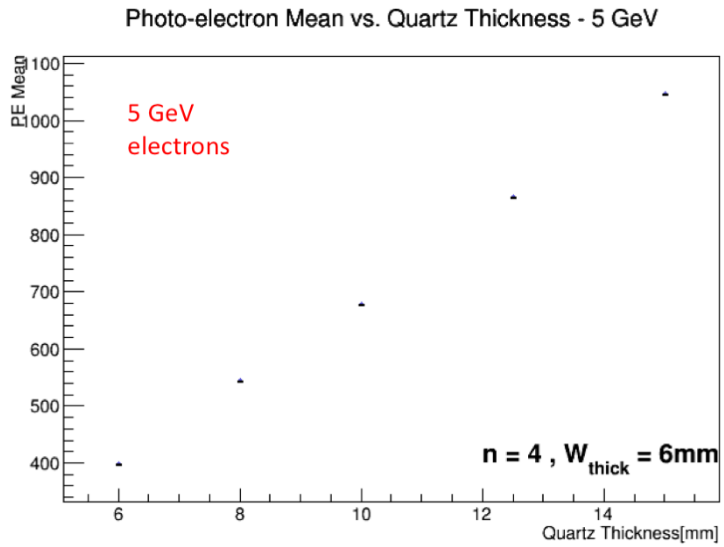


Optimization study1 (5 GeV):

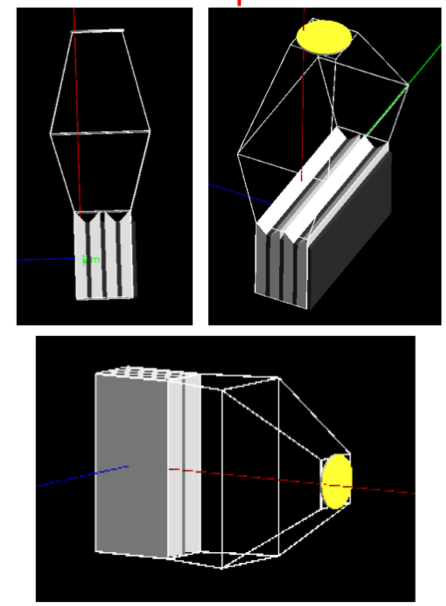
6mm thick tungsten, variable quartz thickness

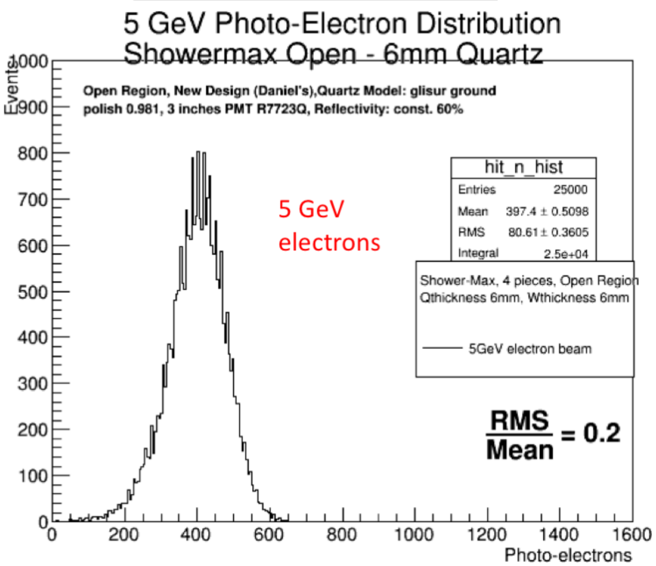
6mm quartz

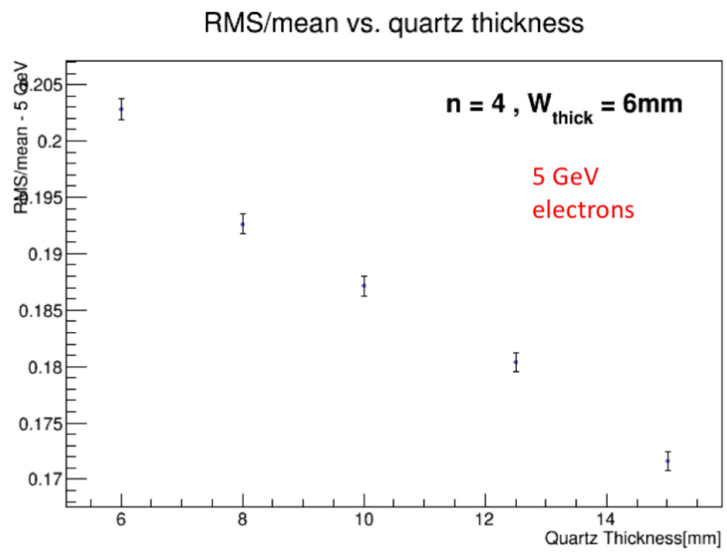


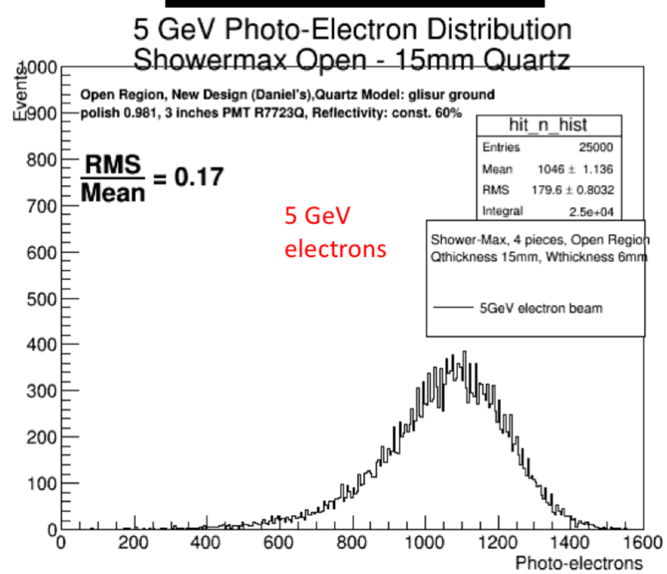


15mm quartz





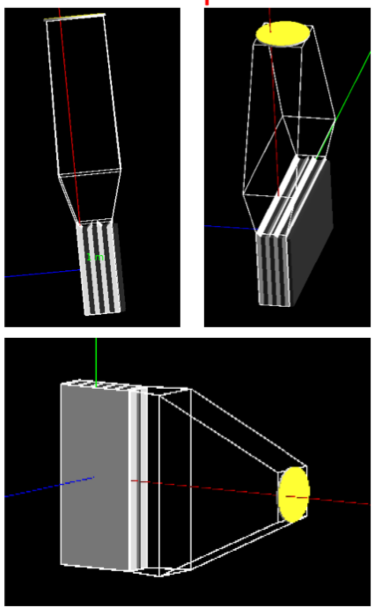


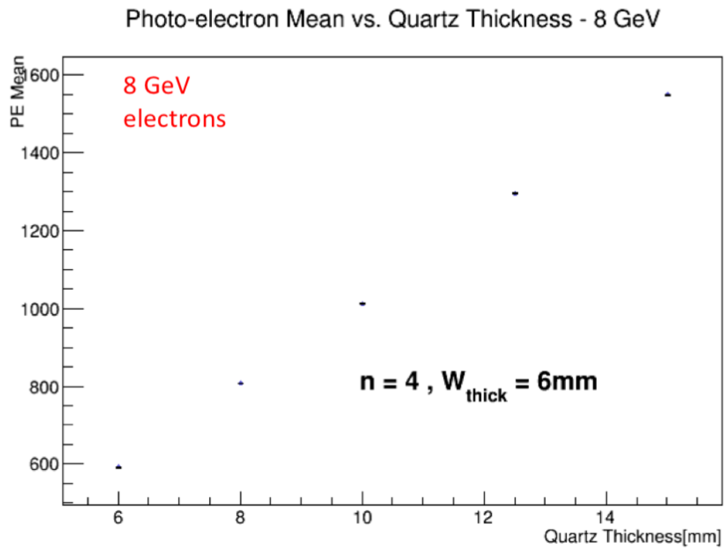


Optimization study1 (8 GeV):

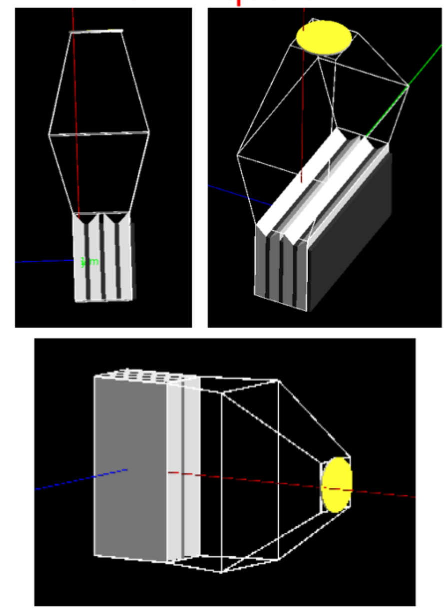
6mm thick tungsten, variable quartz thickness

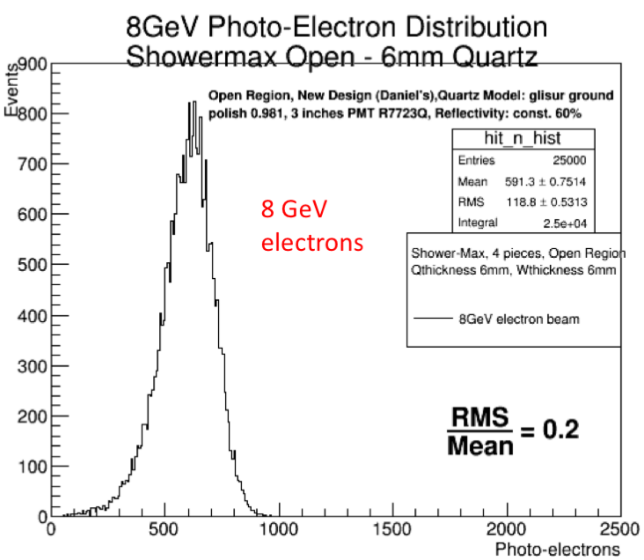
6mm quartz

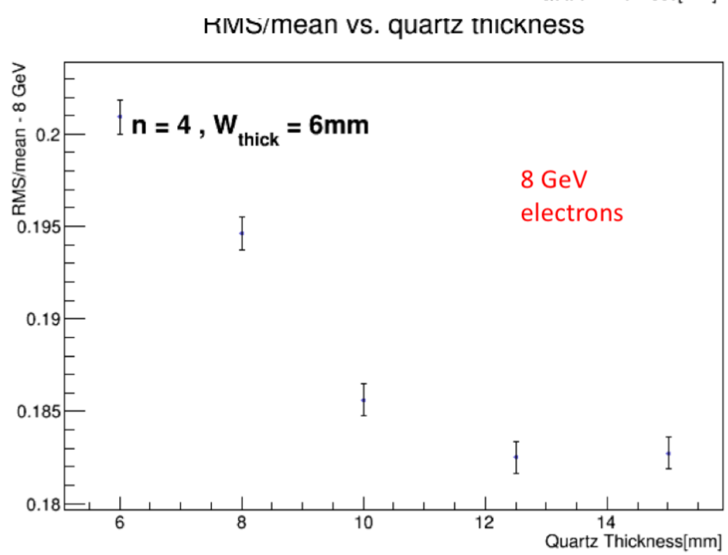


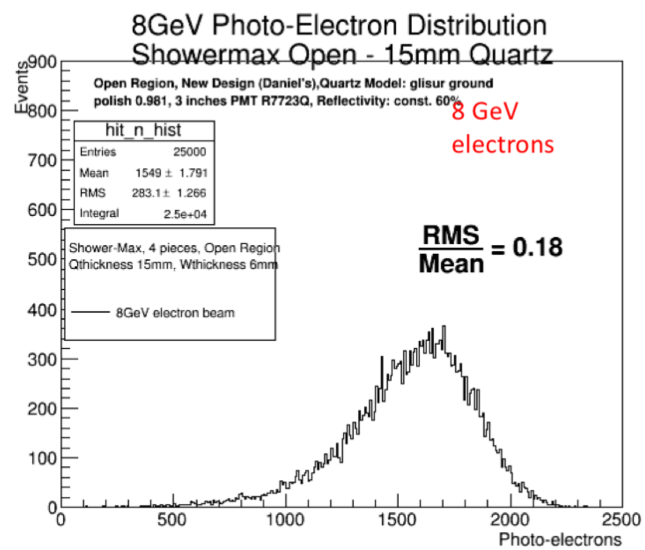


15mm quartz



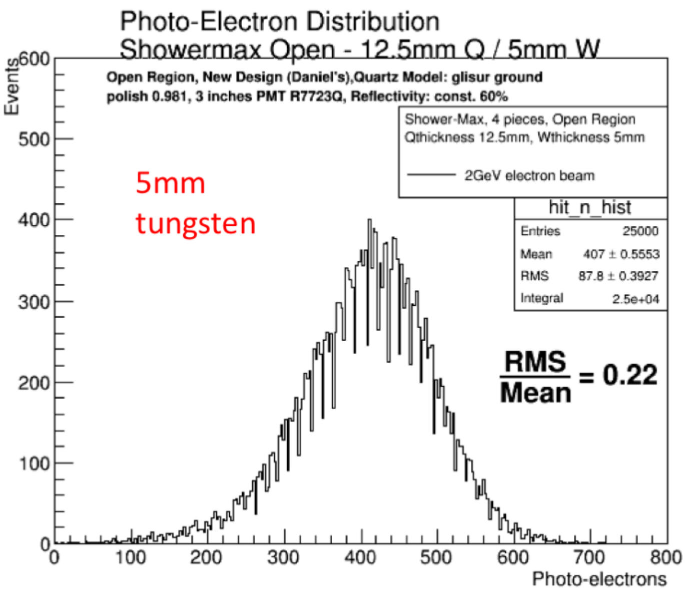


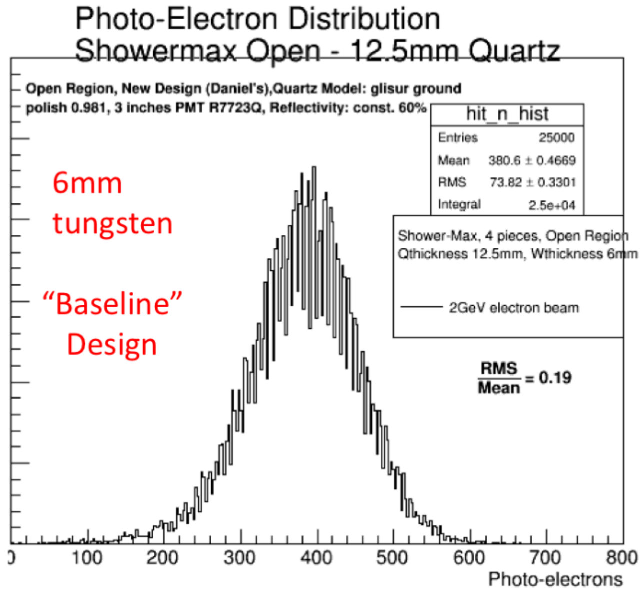


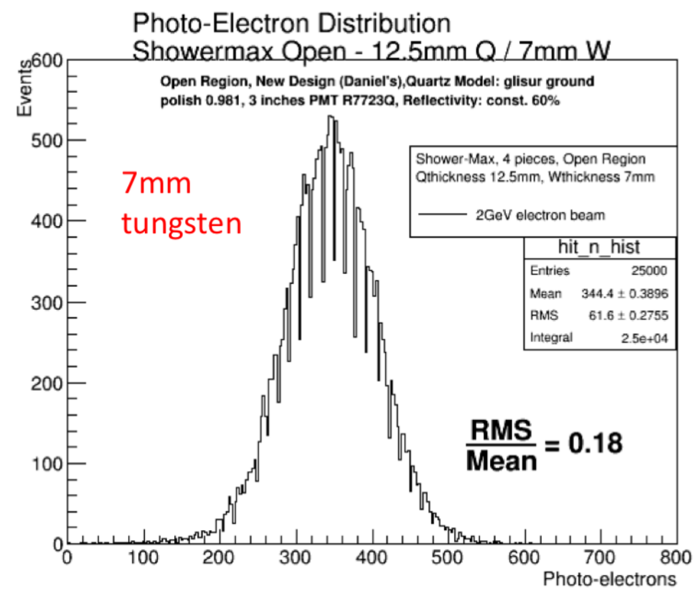


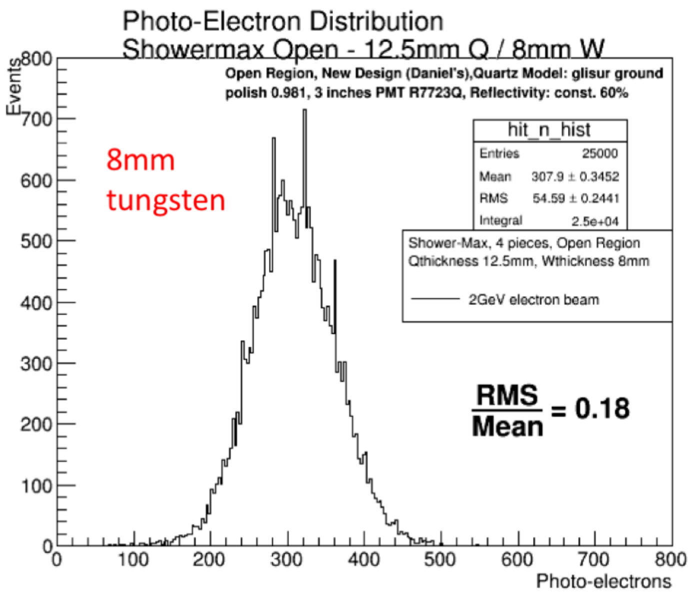
Optimization study2 (2 GeV): (on-going)

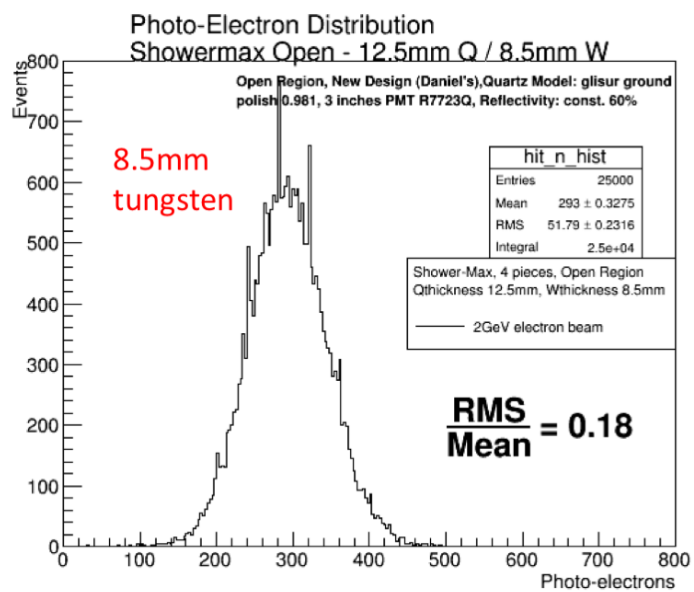
12.5mm quartz, variable tungsten thicknesses



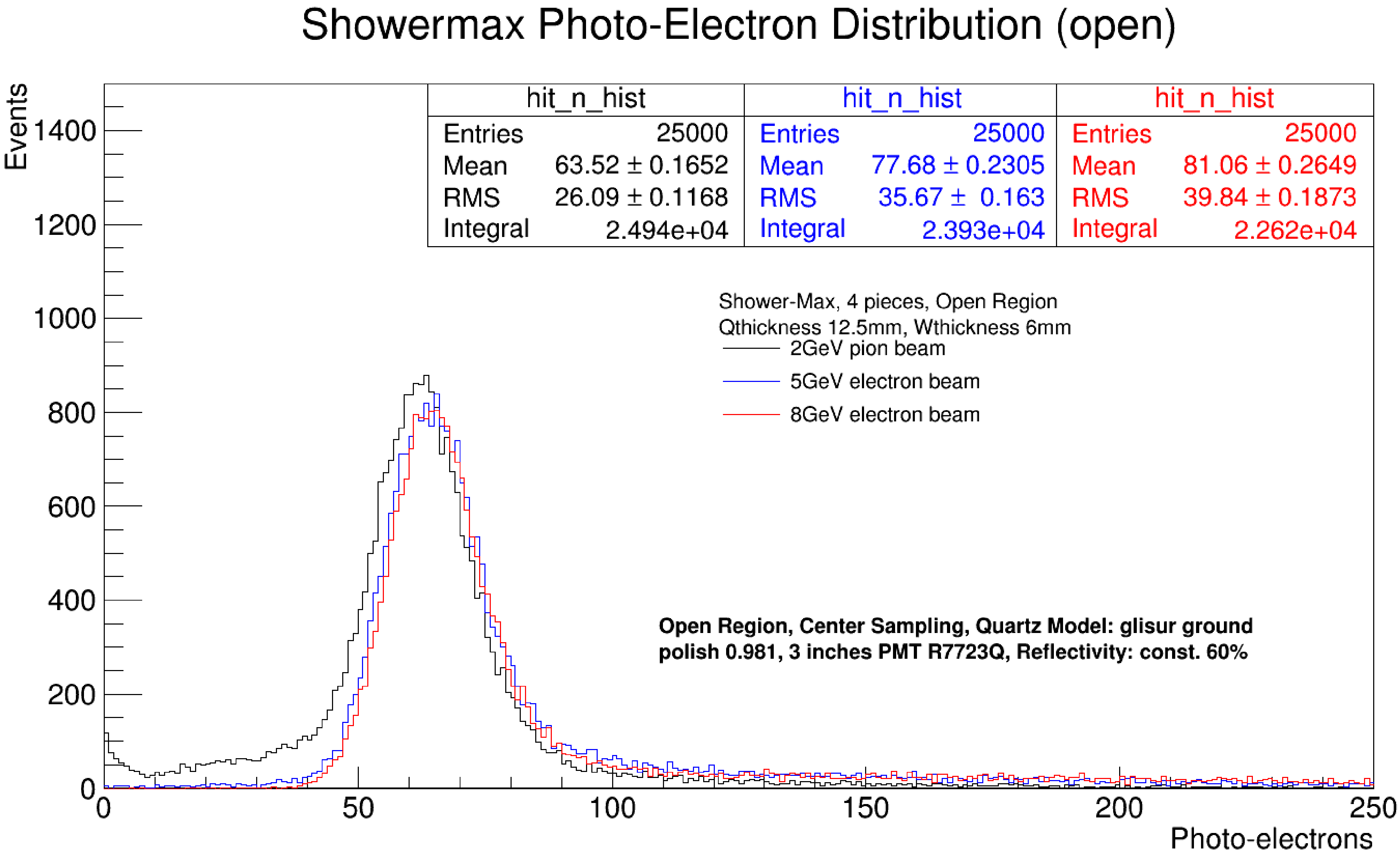








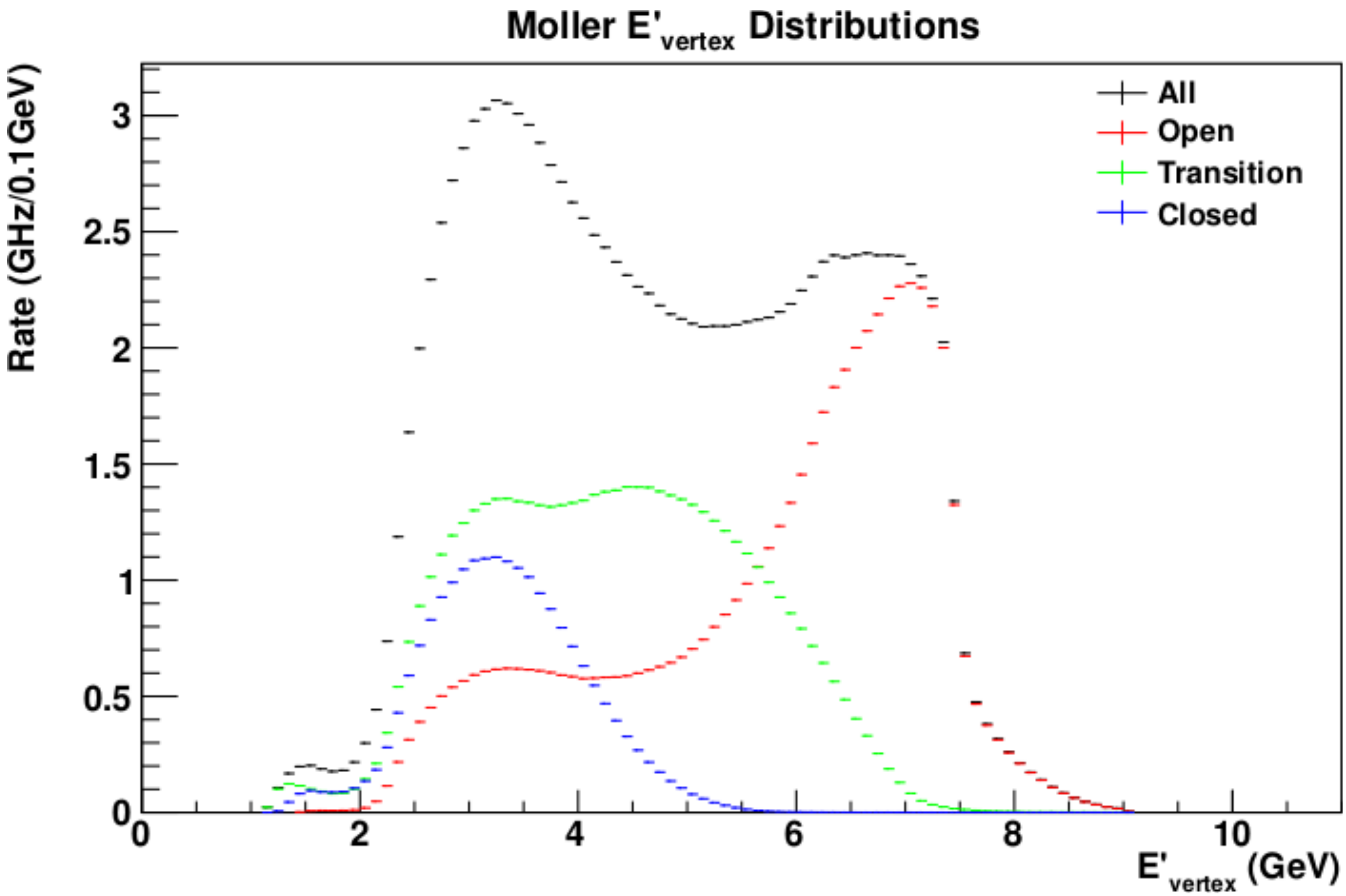
Baseline design PE Distributions for Pions



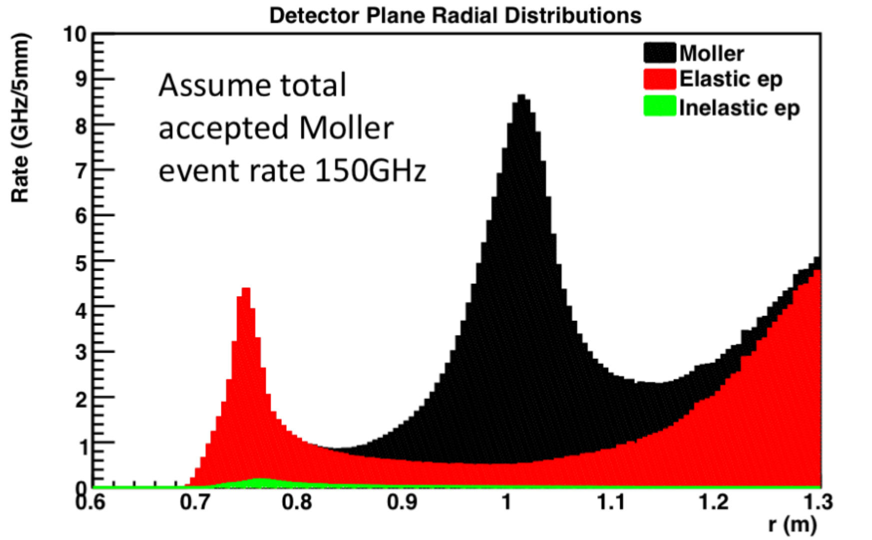
Plans for prototyping and SLAC testbeam

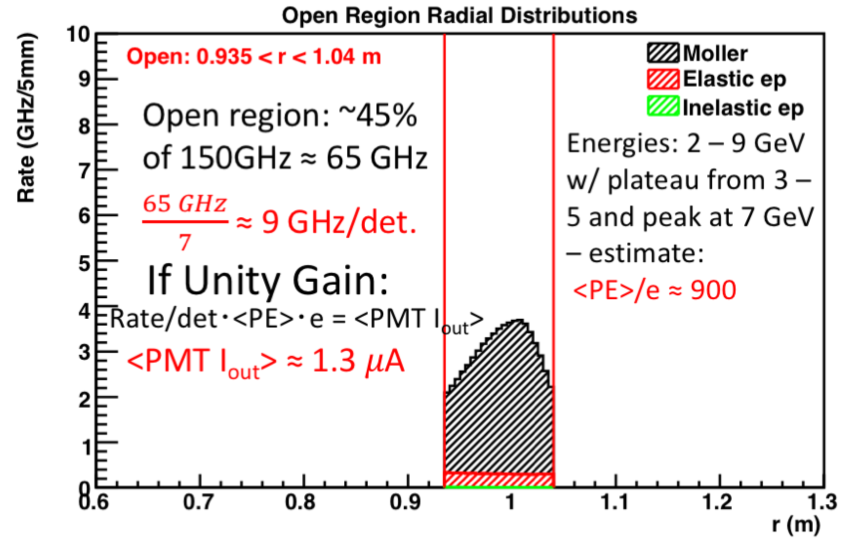
- Finalize prototype stack configuration by end of year and order quartz and tungsten – typically 6 - 8 week lead-time
- Modify machine drawings for new stack and LG and send to shop – typically 2 - 4 weeks
- Assemble prototype(s) in spring 2017
- Take to SLAC for testbeam: Many questions:
  - When, summer or fall 2017?
  - DAQ/trigger and HV? Mounting? Need 3" PMTs.
- Would like to build two prototypes for cross-talk studies

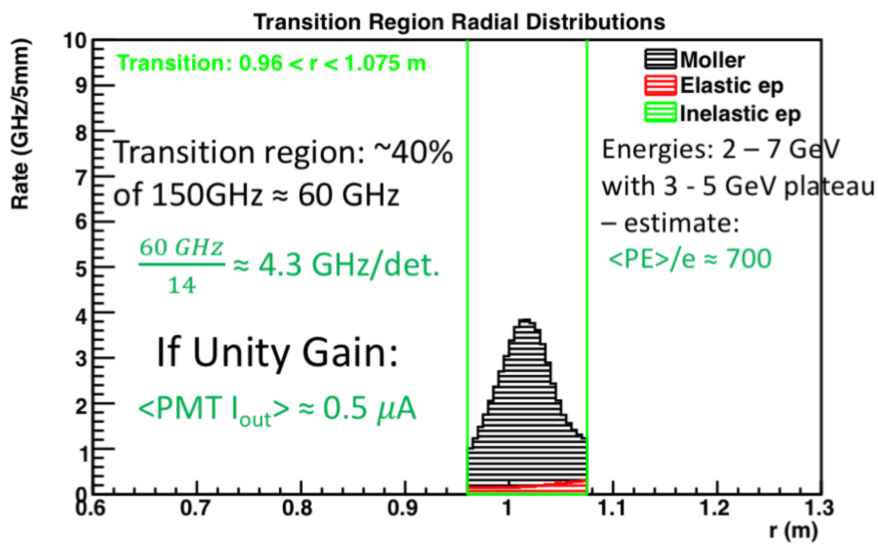
Energy Dists for Open, Closed, and Transition

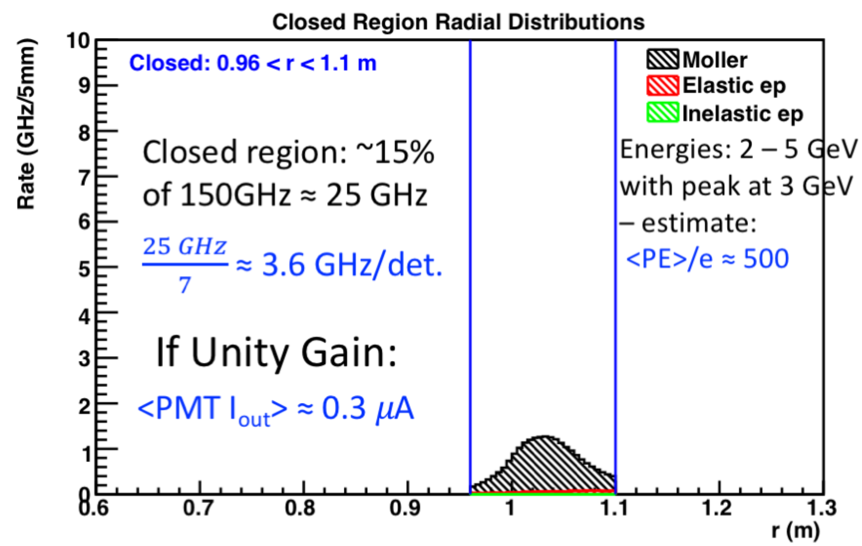


Unity Gain operation with Baseline design?

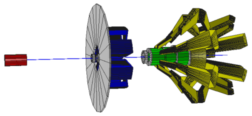








- Could be possible to use conventional 3" pmts with electronic switching between unity gain base (integrating mode) and high gain base (counting mode)

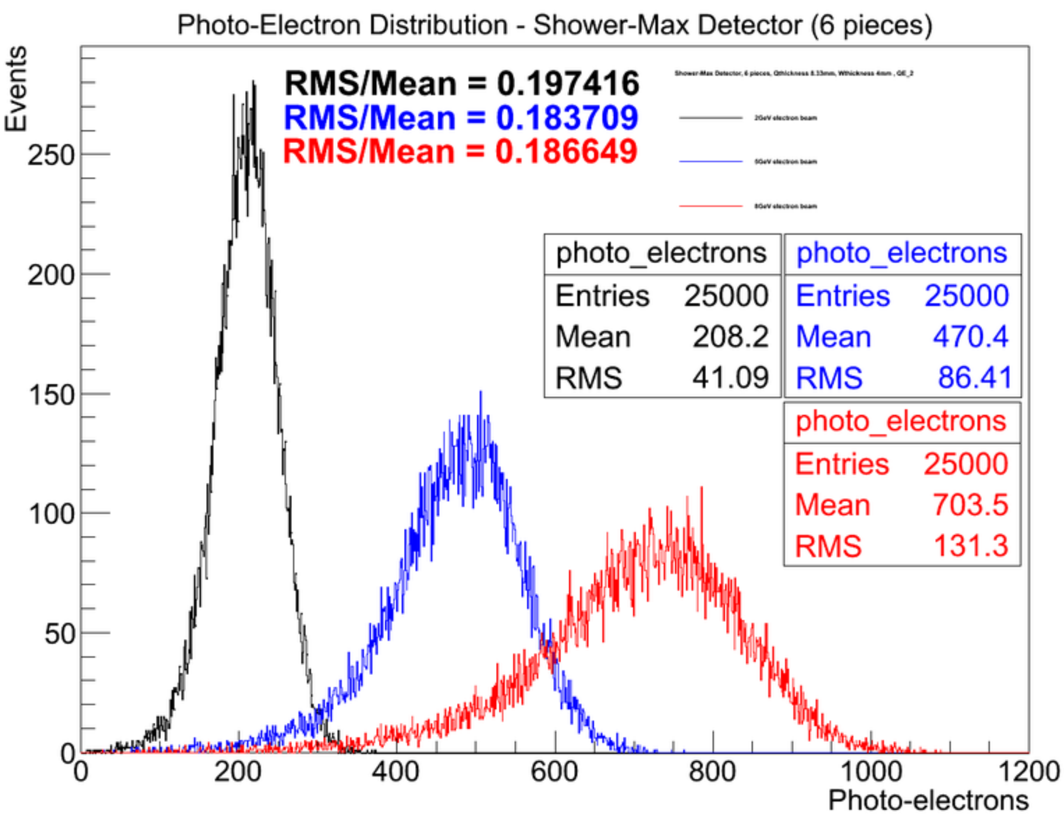


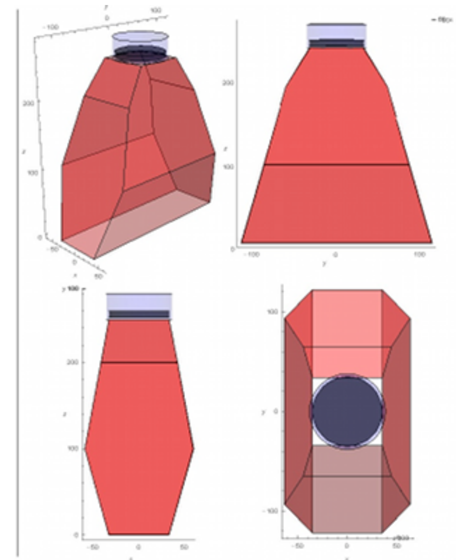
Summary and Future Plans

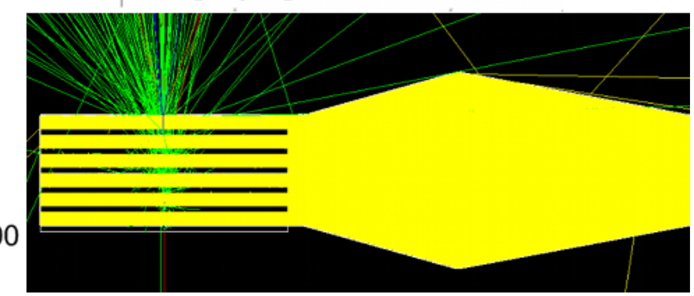
- Goal is to achieve best resolution possible. Baseline (n=4) design gives 18 - 19% resolution. Plan to revisit $n > 4$ configurations which may further improve resolution.
- Will build prototype this spring and take to SLAC testbeam
- Given the high PE yields of the baseline design, it seems feasible to operate them in unity gain mode during integration.
- Do we want to consider having different stack designs for the three types of dets: Open, closed, transition? More $
- Additional Simulation work:
  - Study PE yield and res. uniformity over face of detector
  - Need to incorporate LG reflectivity lookup tables.
  - Sample realistic e^- energy, pos., and angle for each region: Open, closed, and transition.

Ring of staggered Open prototypes

Showermax Detector (6 piece stack)

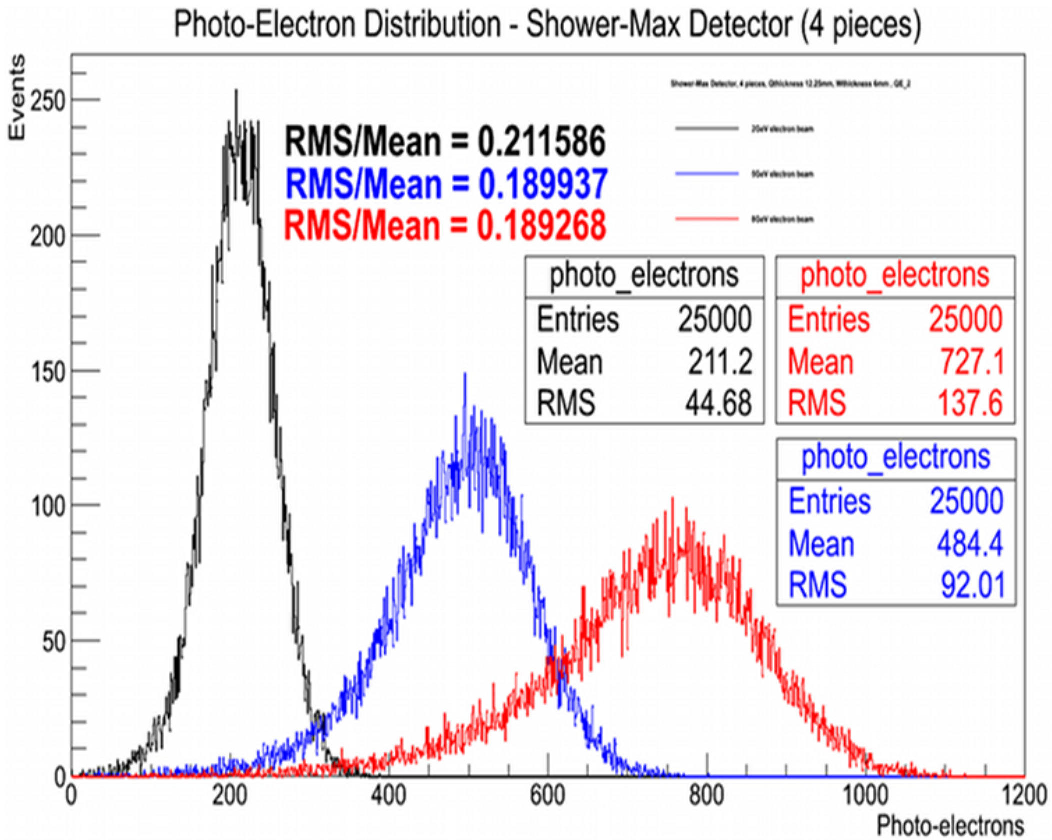


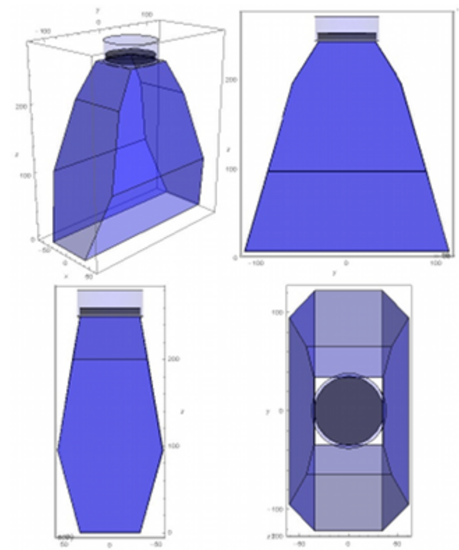


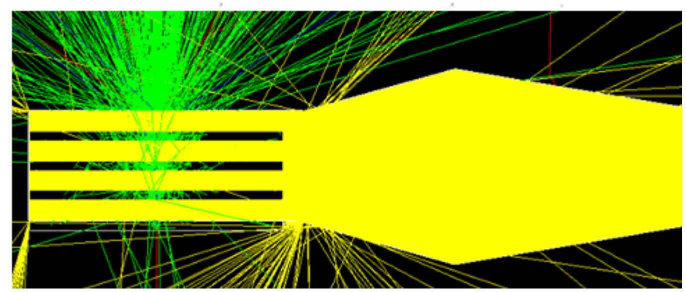


- 6 pieces quartz (each 8.33mm thick): 0.41 X_0
- 6 pieces tungsten (each 4mm thick): 6.8 X_0
- 25 cm Miro-silver LG; 3” PMT. *Note: center sampling, new QE*

Showermax Detector (4 piece stack)

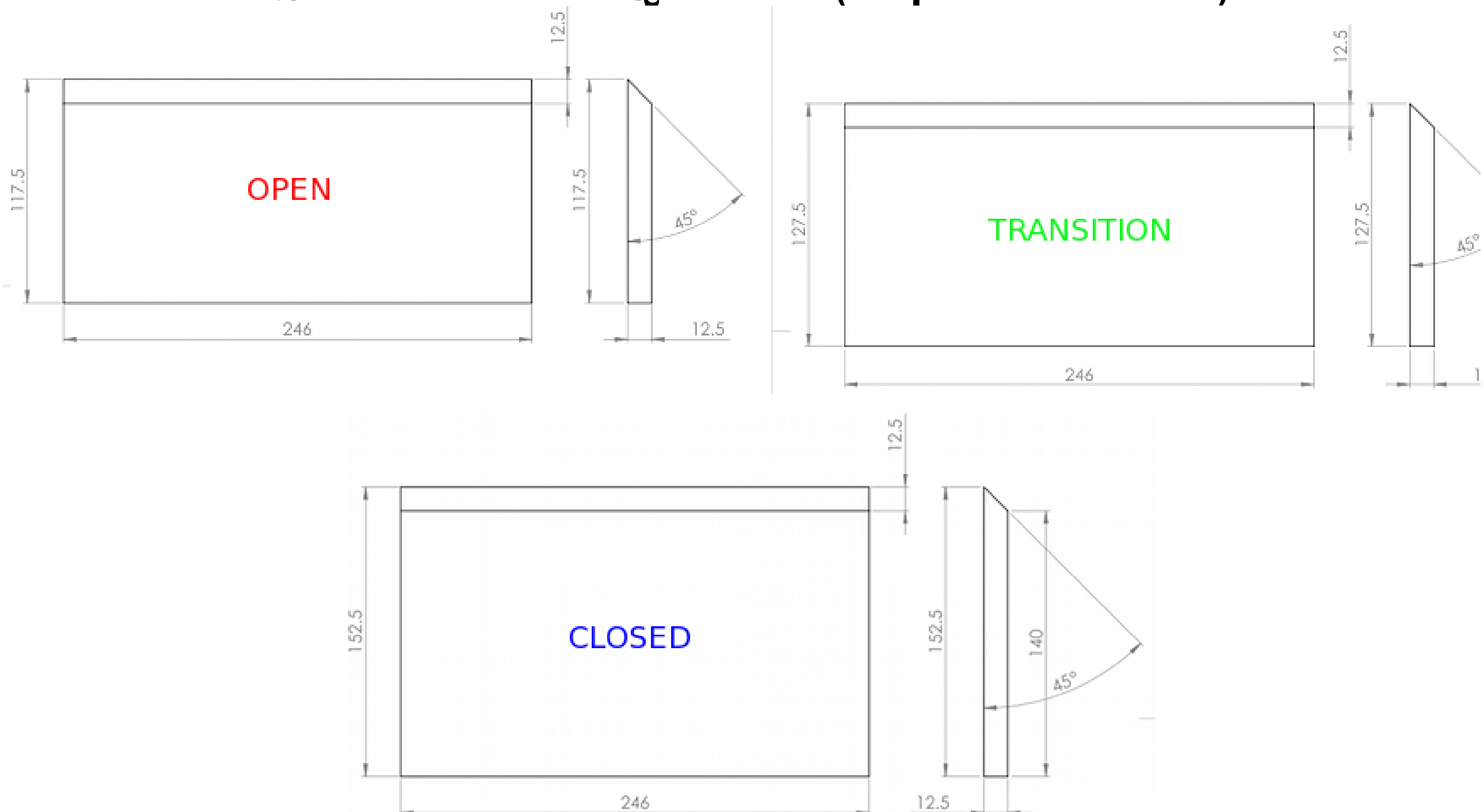






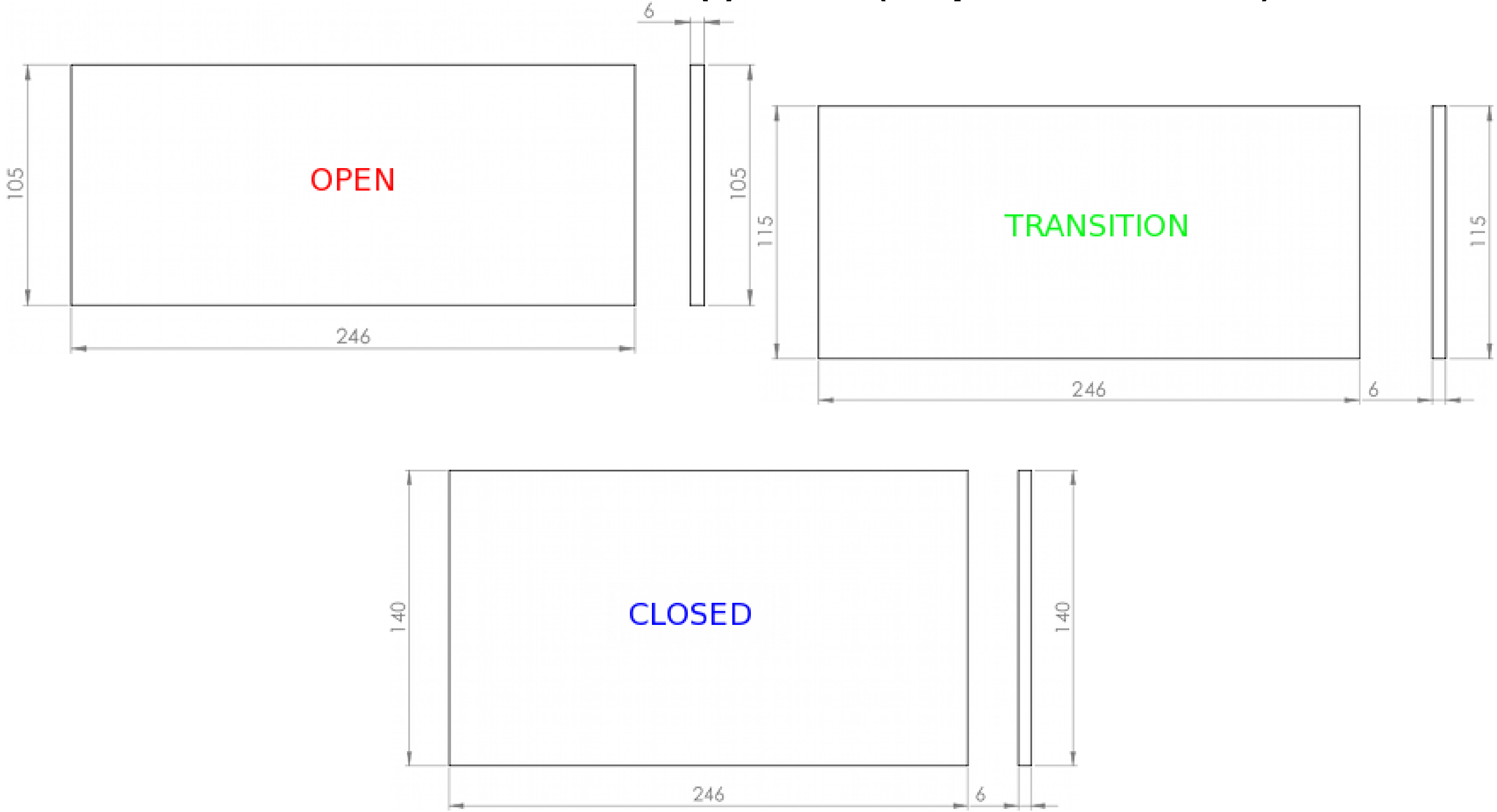
- 4 pieces quartz (each 12.5mm thick): 0.41 X_0
- 4 pieces tungsten (each 6mm thick): 6.8 X_0
- 25 cm Miro-silver LG; 3" PMT. *Note: center sampling, new QE*

Showermax Quartz (4 piece stack)



Spectrosil 2000: One 45 degree polished face, all surfaces polished to 20 Angstroms or better, no small edge/corner bevels. Heraeus quote: ~$1100 per piece. $150k total.

Showermax Tungsten (4 piece stack)



99.95% purity; ±0.005” tolerances. Received quote from company ”Marketech”: OPEN–$484/piece ($13.6k), CLOSED–$647/piece ($18.1k) TRANSITION–$511/piece ($28.6k); total tungsten cost is $60.2k.