Showermax update and new Hall A SAMs

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April 30, 2016

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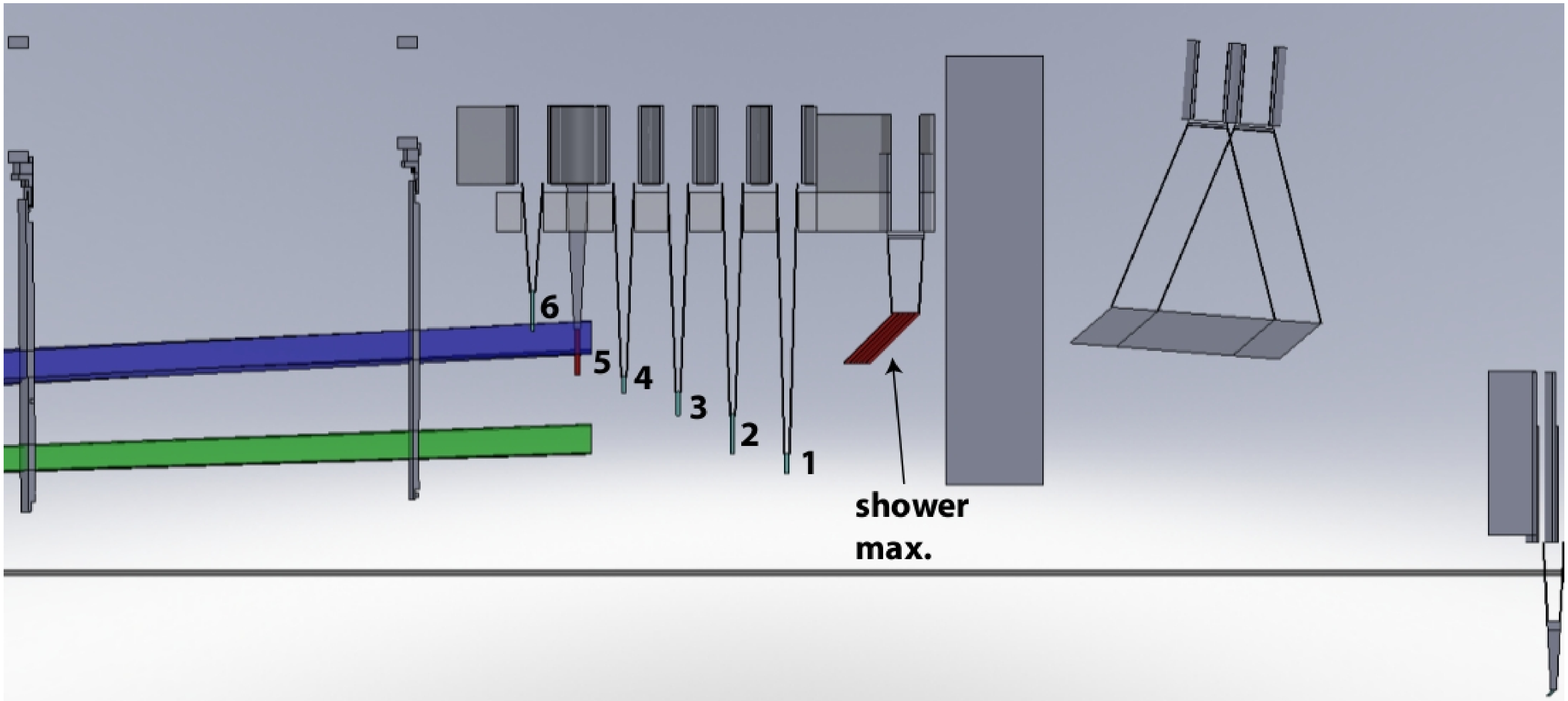
Outline

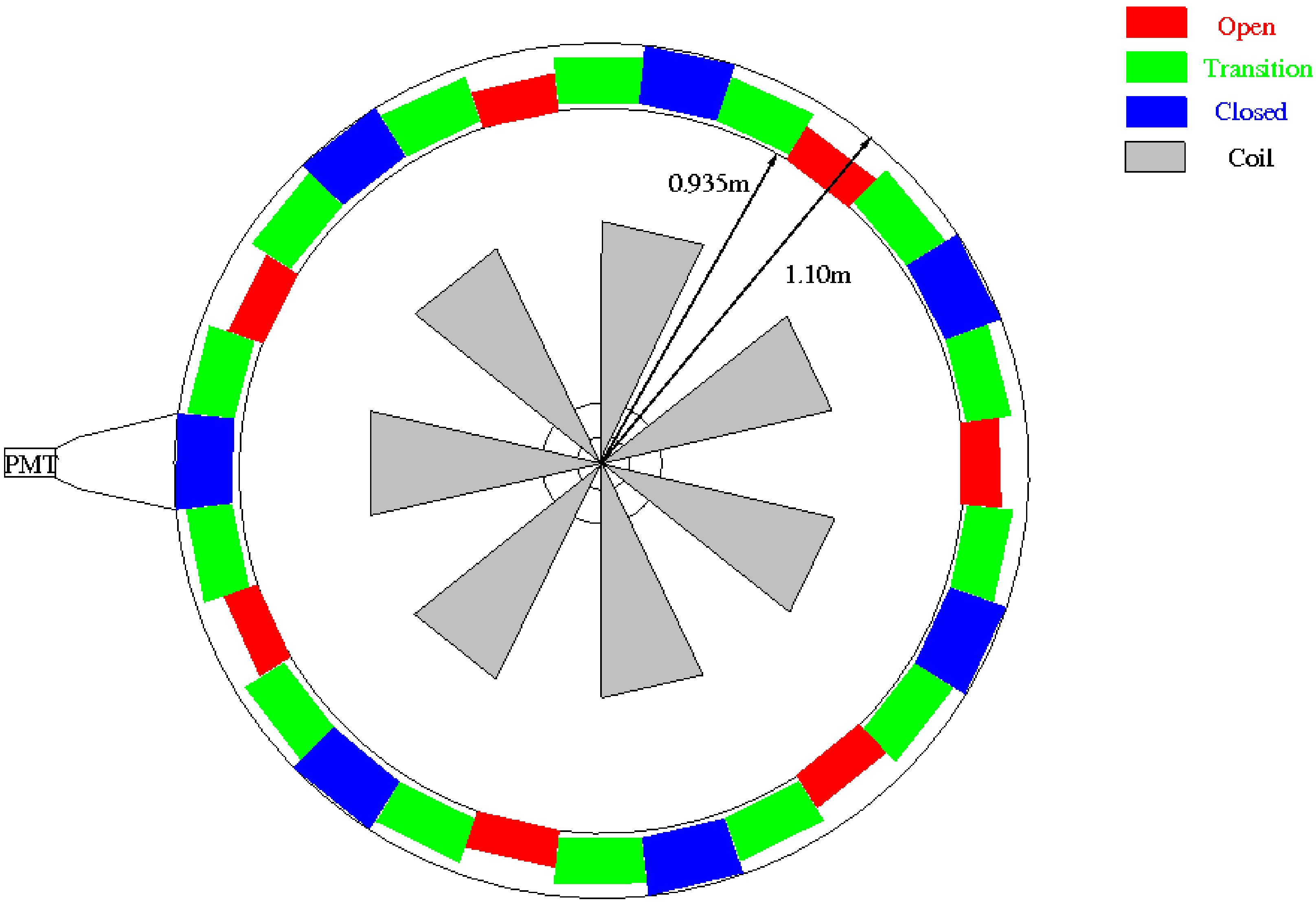
- Showermax Detector Update
  - –Design: alternating 4-piece quartz/tungsten stack
  - –Optical G4 sims: bench-marked quartz properties
  - –Engineered prototype design
- Hall A Small Angle Monitors SAMs (f.k.a. Lumis)
  - –Motivation and re-design
  - –Prototype and testbeam results
  - –Final design and installation
  - –Simulated Rates for parasitic tests
- Summary and Plans

Showermax Detector

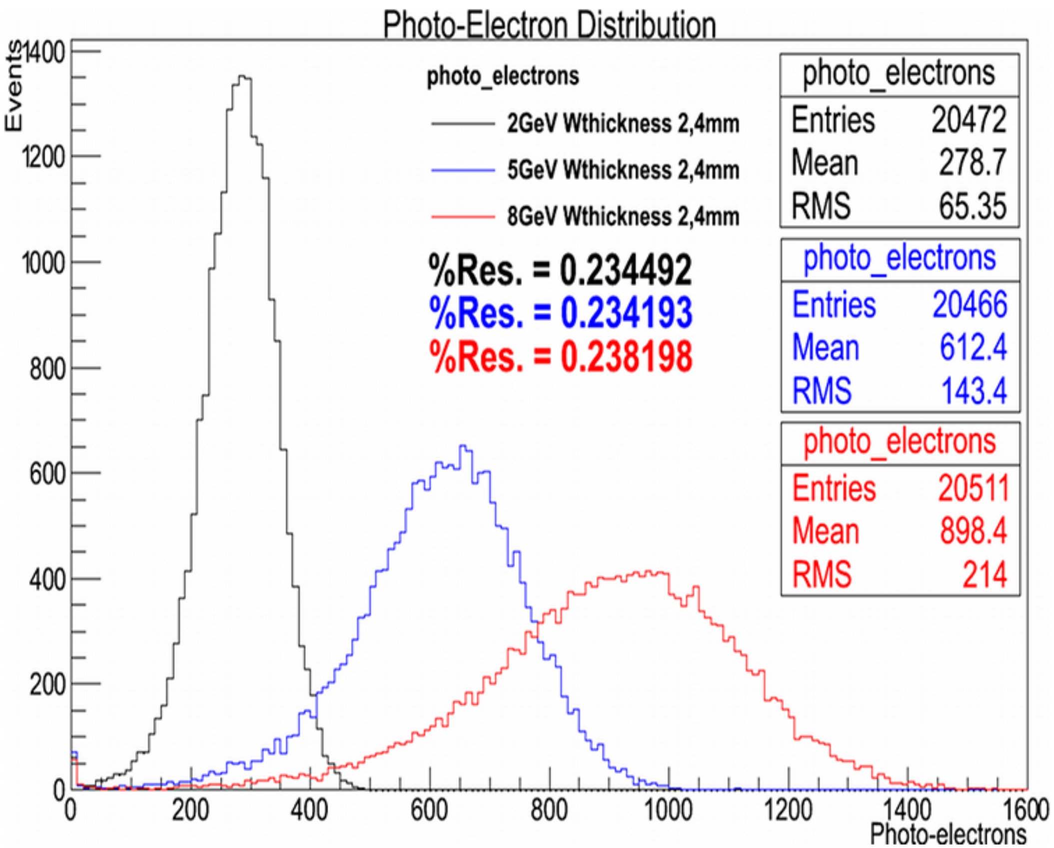


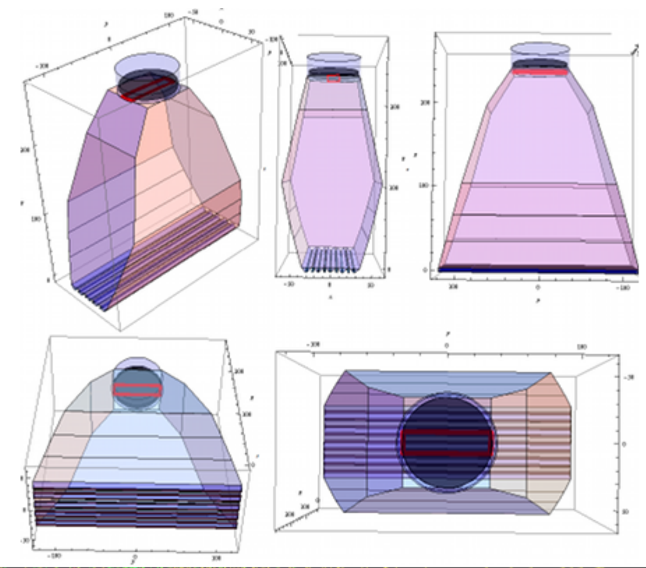
- Provides additional measurement of e-e ring flux
- Weights flux by energy $\Longrightarrow$ less sensitive to low energy/low light bkgds

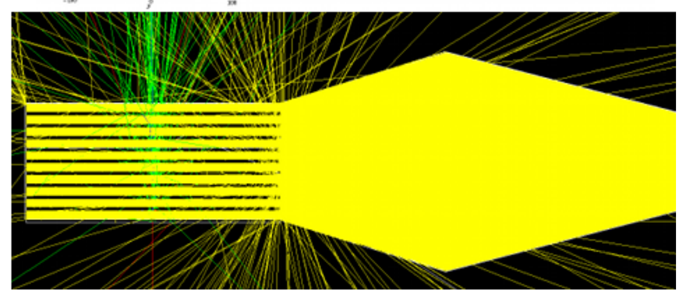
Showermax Detector Ring



Showermax Detector (10 piece stack)

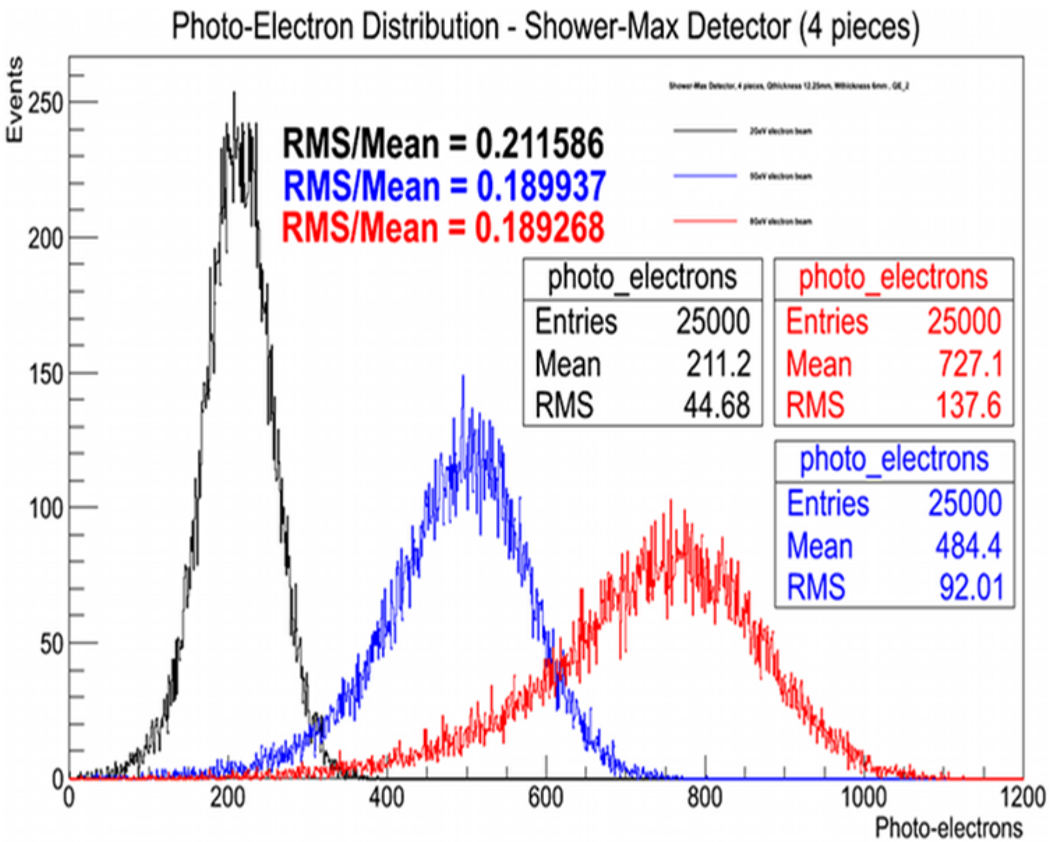


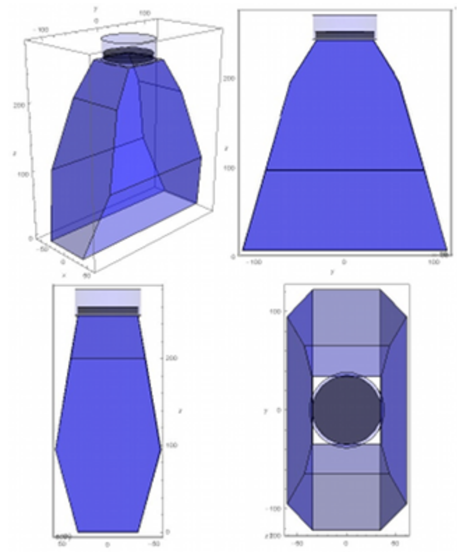


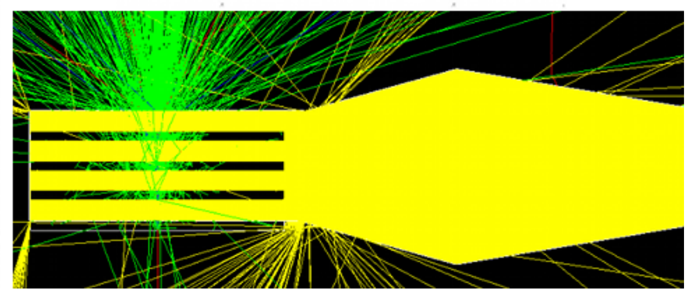


- 10 pieces quartz (each 5.0mm thick): 0.41 X_0
- 10 pieces tungsten (each 2.4mm thick): 6.8 X_0
- 25 cm light guide 3” PMT. *Note:Uniform sampling, trapez. Q*

Showermax Detector (4 piece stack)

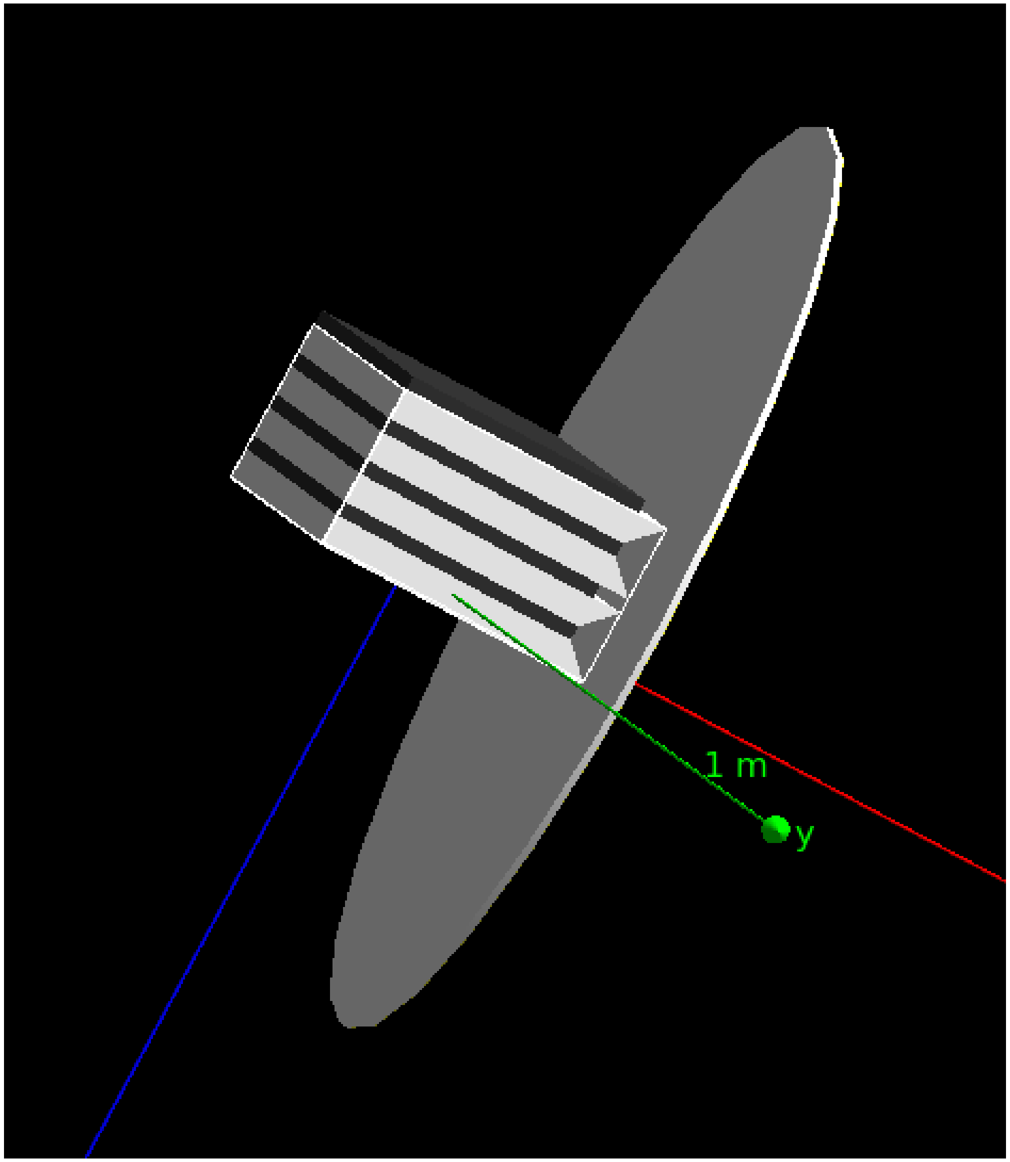




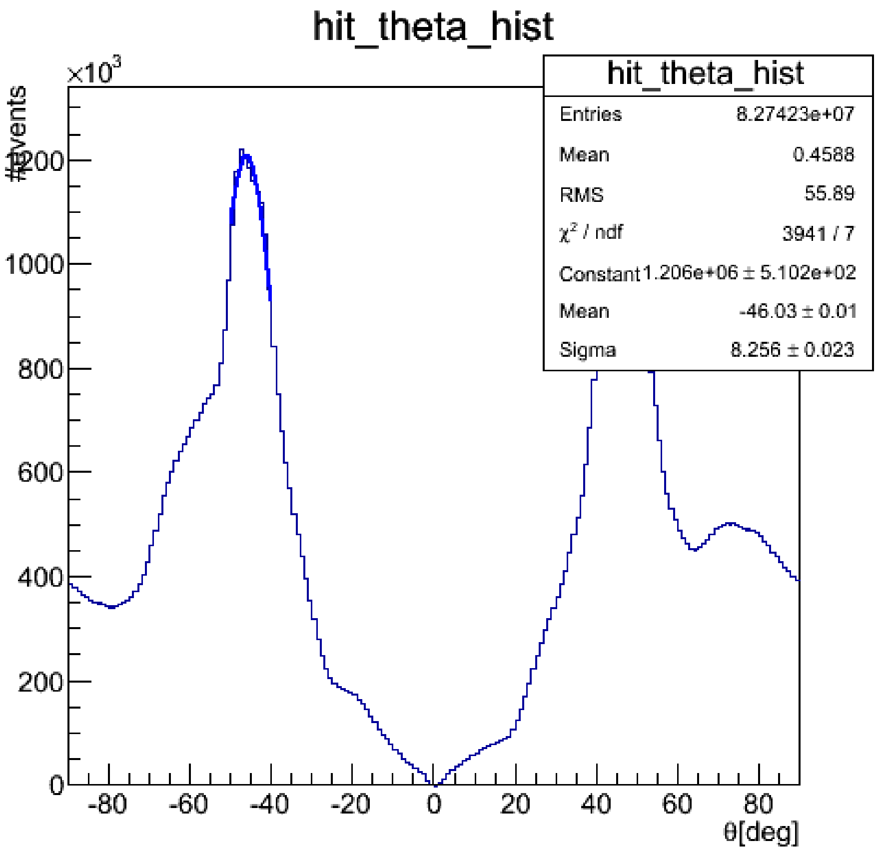


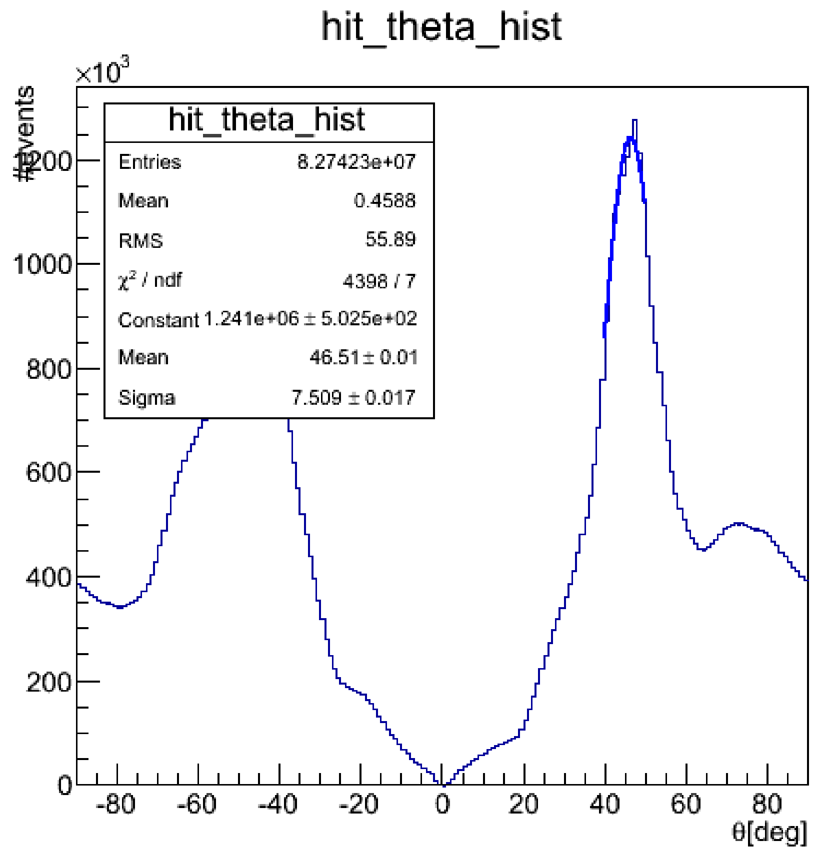
- 4 pieces quartz (each 12.5mm thick): 0.41 X_0
- 4 pieces tungsten (each 6mm thick): 6.8 X_0
- 25 cm LG; 3" PMT. *Note: center sampling, rectangular Q, new QE*

Optimal funnel-mirror angle study



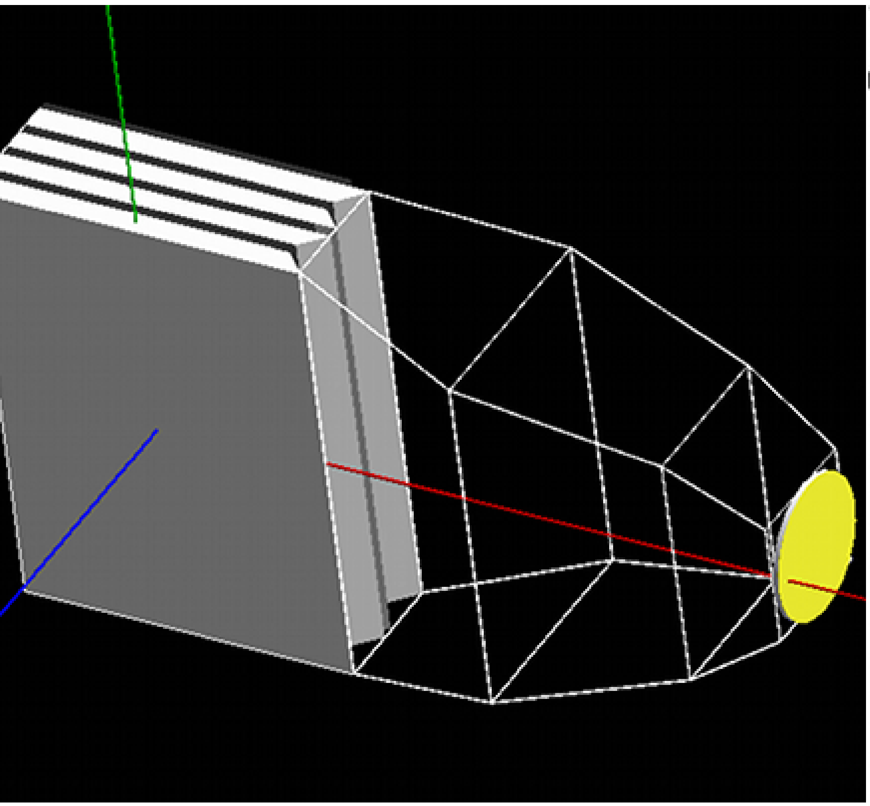
Optimal funnel-mirror angle

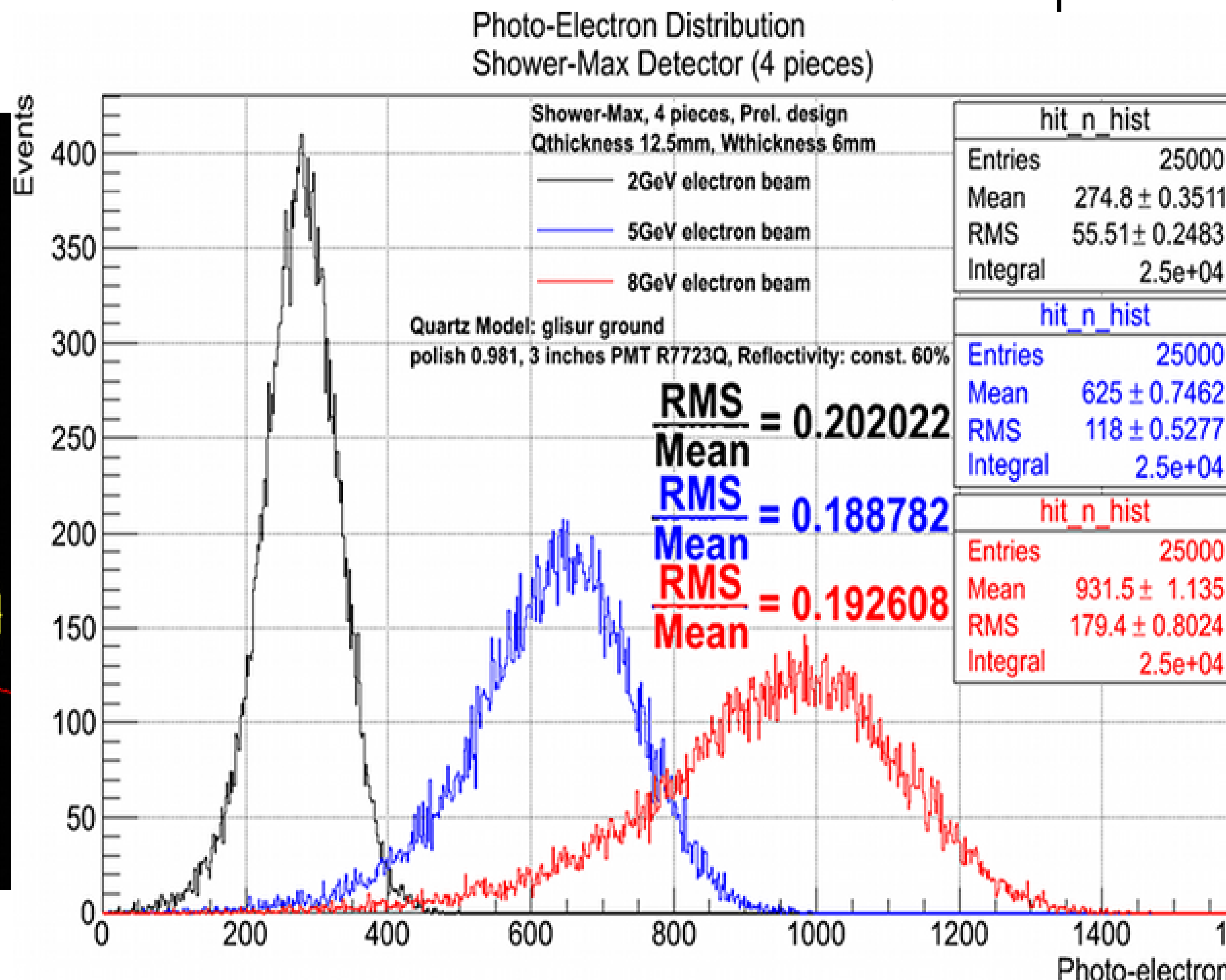




- Peak light exits quartz at -46.0° and 46.5° for 8 GeV and closer to 45° for lower energy (that is ∼normal to bevelled face)
- Means our original light guide design is near optimal

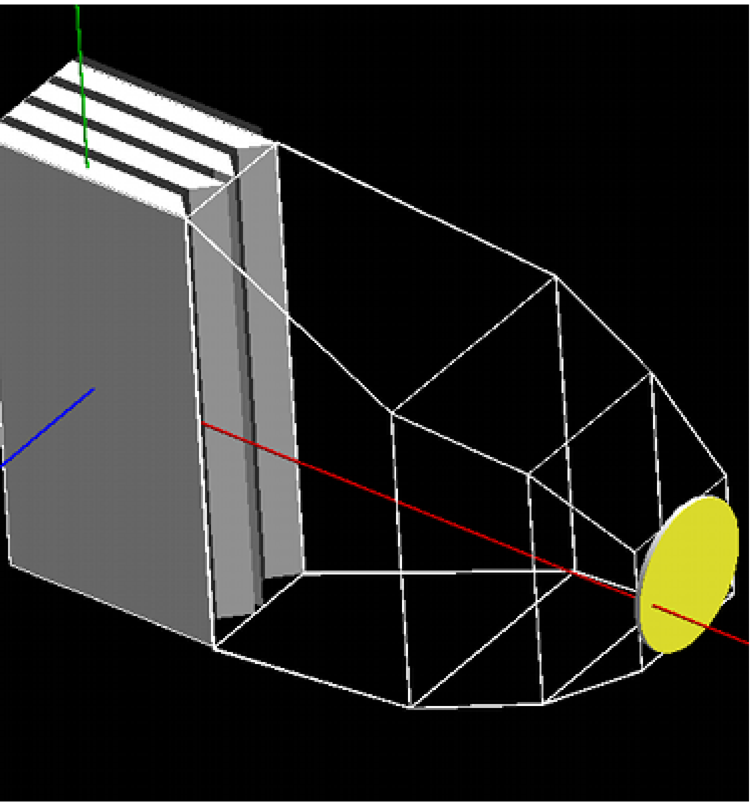
New Monte Carlo results: Using benchmarked quartz properties and simple 60% reflectivity

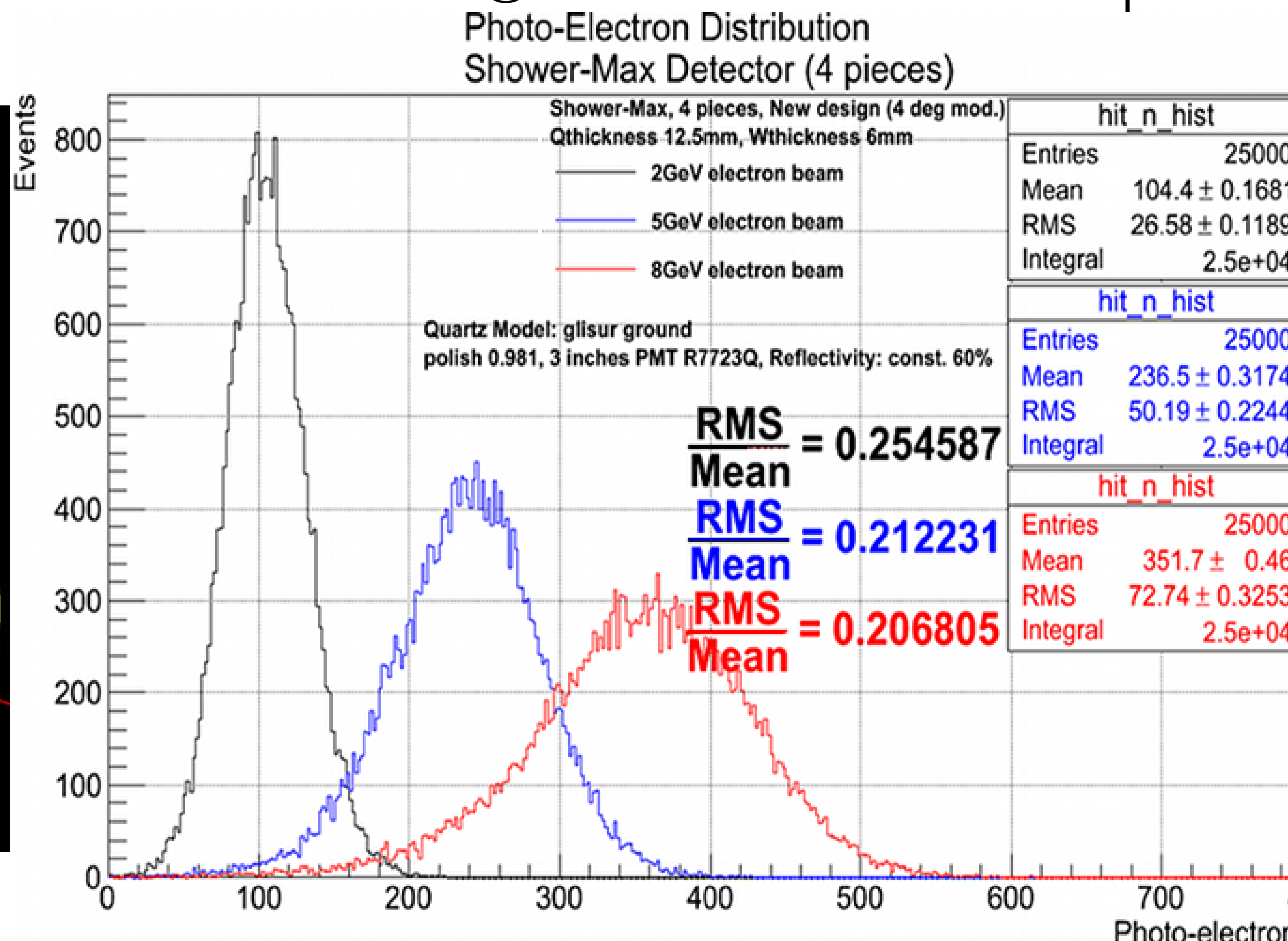




- Original Light guide geometry: designed for $\pm 45^{o}$ light output

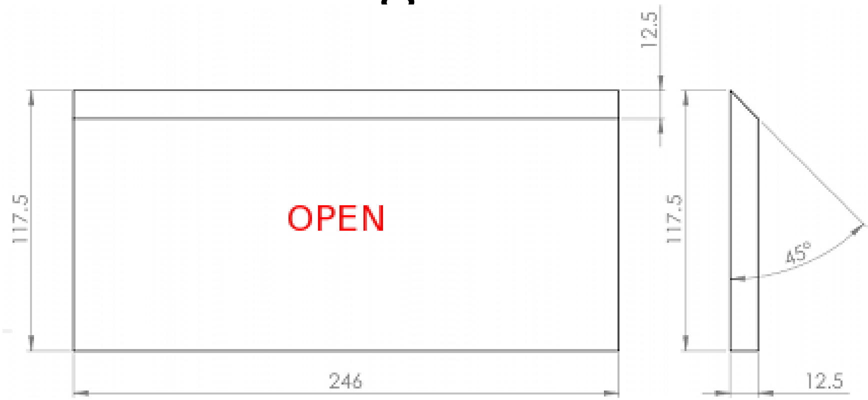
Precise funnel-mirror angle is crucial

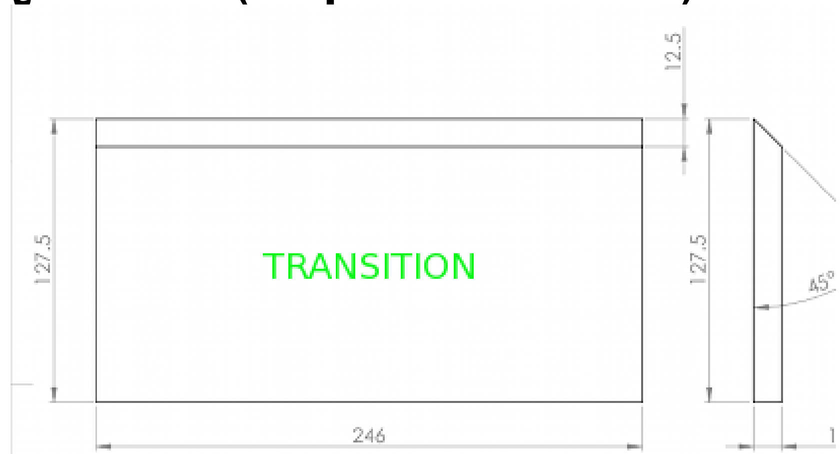


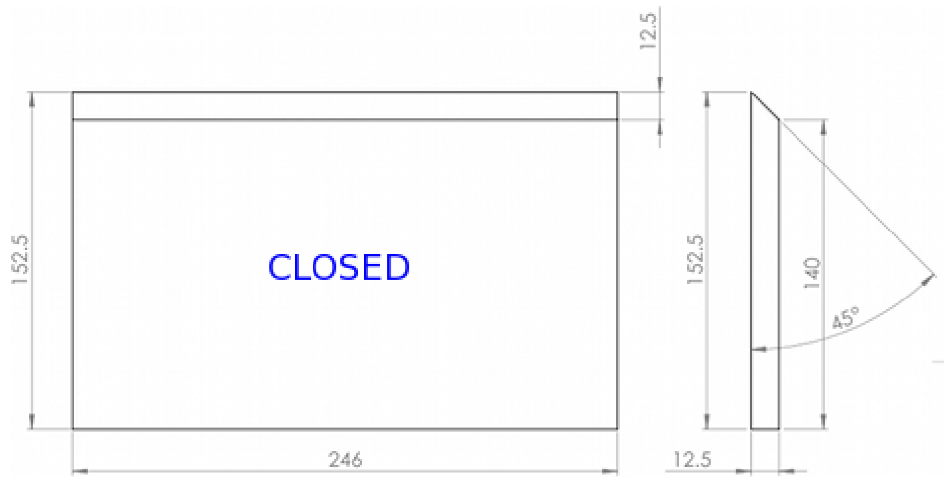


- Experimental LG geometry: designed for $\pm 53^{\circ}$ light output
- Only 4° angle difference (and elongated) – gives 60% less PEs

Costing: Showermax Quartz (4 piece stack)

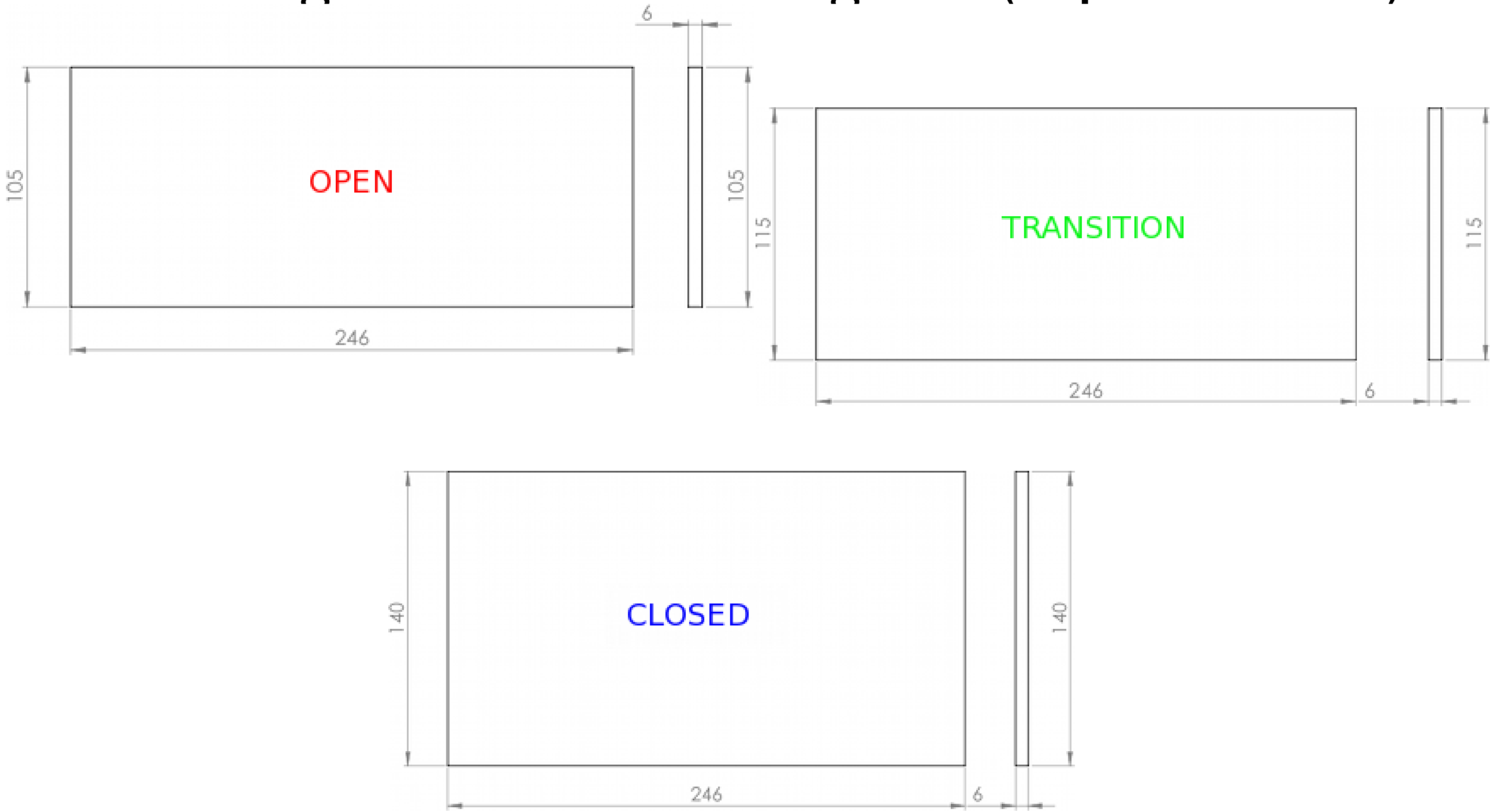






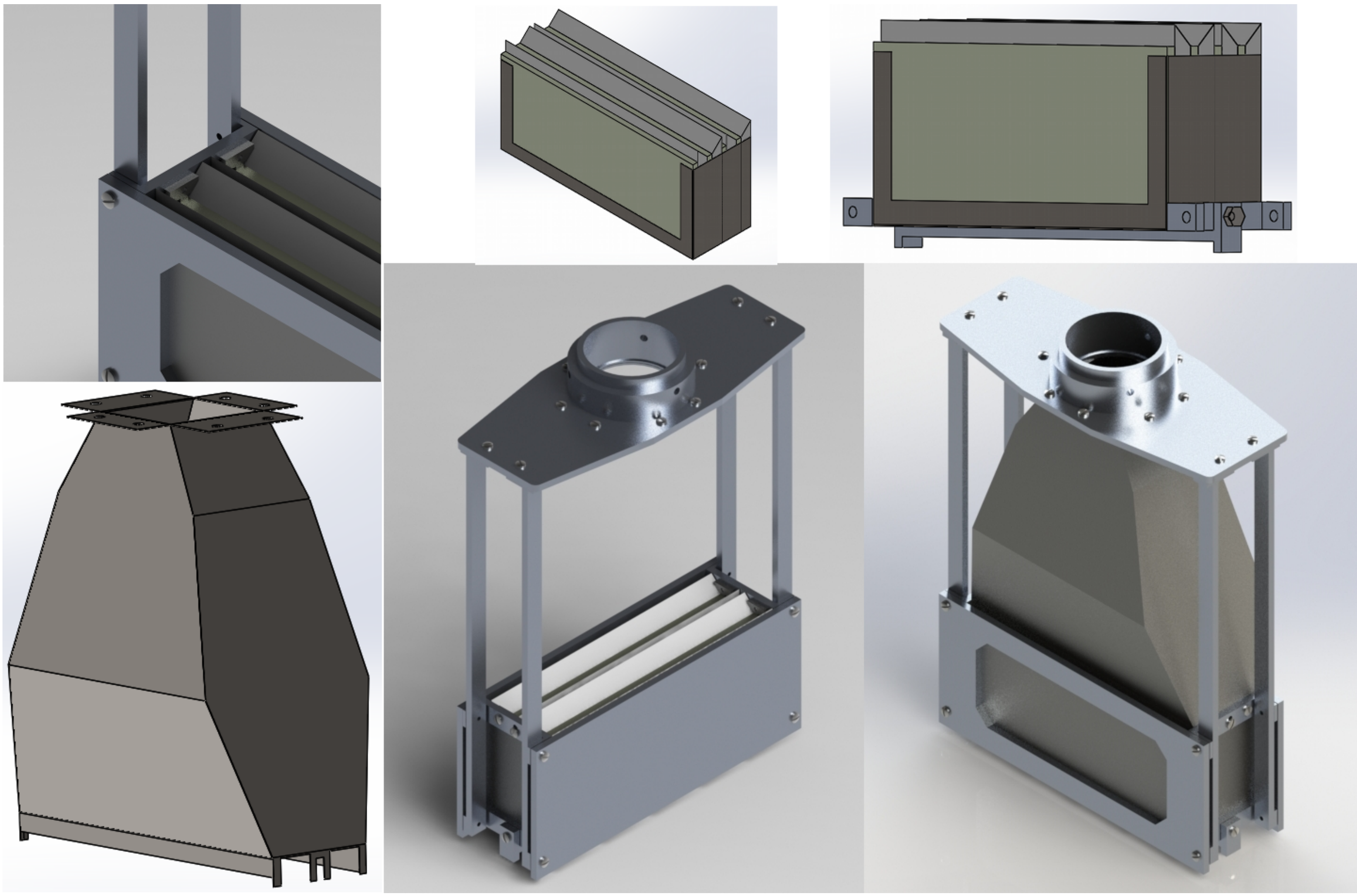
Spectrosil 2000: One 45 degree face, all surfaces polished to ≤ 20 Å, no small edge-bevels. OPEN–$1043/piece ($32k), CLOSED–$1265/piece ($39k), TRANSITION–$1080/piece ($67k); total quartz cost is $138k

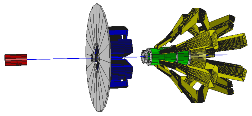
Costing: Showermax Tungsten (4 piece stack)



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

Showermax prototype CAD

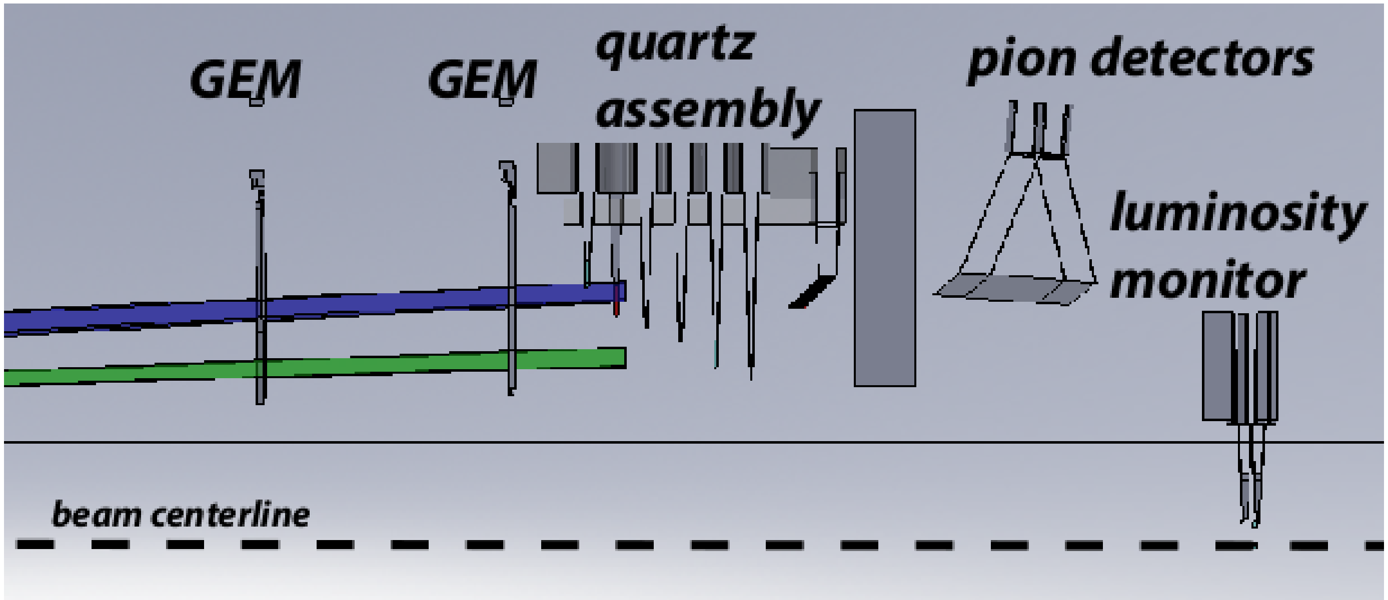




Showermax Summary and Plans

- Quartz optical properties benchmarked: tuned G4 Glisure polish parameter (0.981) using PREX detector testbeam data
- Mirror optical properties under investigation (see next talk); MC currently uses uniform 60% reflectivity for all λ and angles
- Baseline design gives strong energy dep. light yields ($\sim$20% res)
- Will continue to study and optimize baseline design: thicknesses of quartz/tungsten pieces and LG geometry
- $45k line item in MOLLER pre-R&D proposal to build three Showermax prototypes–one for each phi region
- Starting to plan for the prototyping process this summer and SLAC testbeam next year

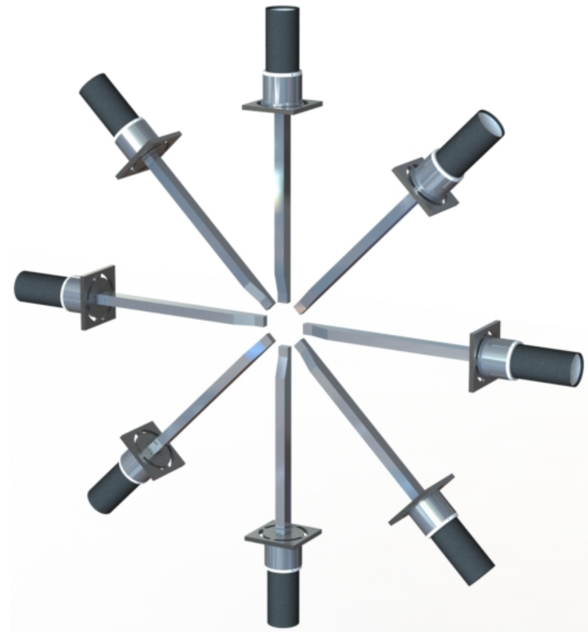
SAMs (downstream lumis) for MOLLER



- Detect charged particle flux at extreme forward angles
- Important diagnostic of target density fluctuations and overall noise floor
- Can use parasitic tests for upcoming PREX as a learning opportunity for MOLLER SAM development

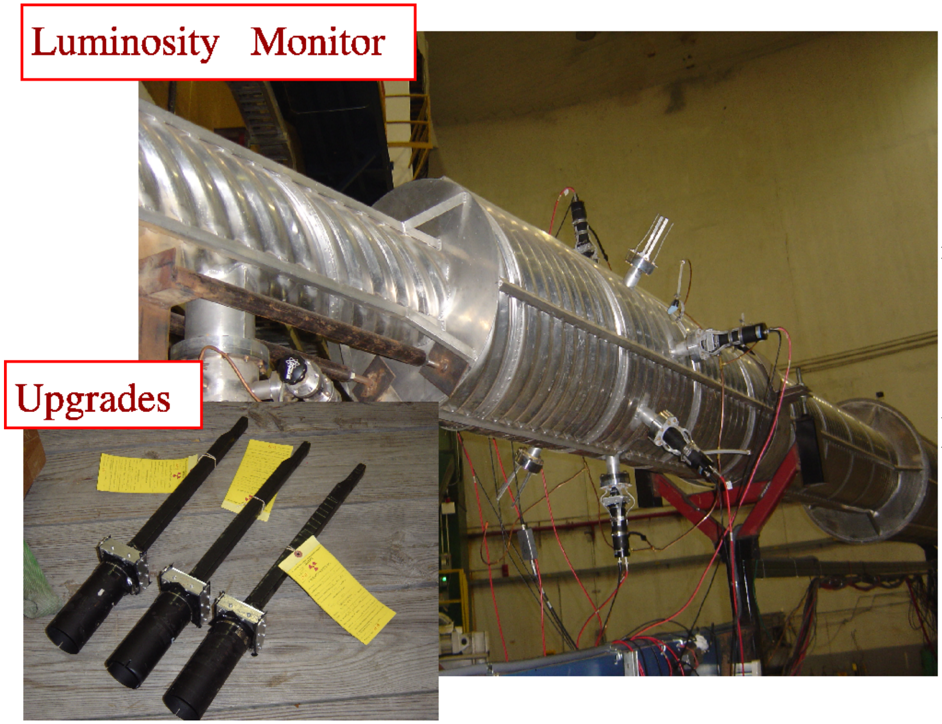
Motivations for SAM's

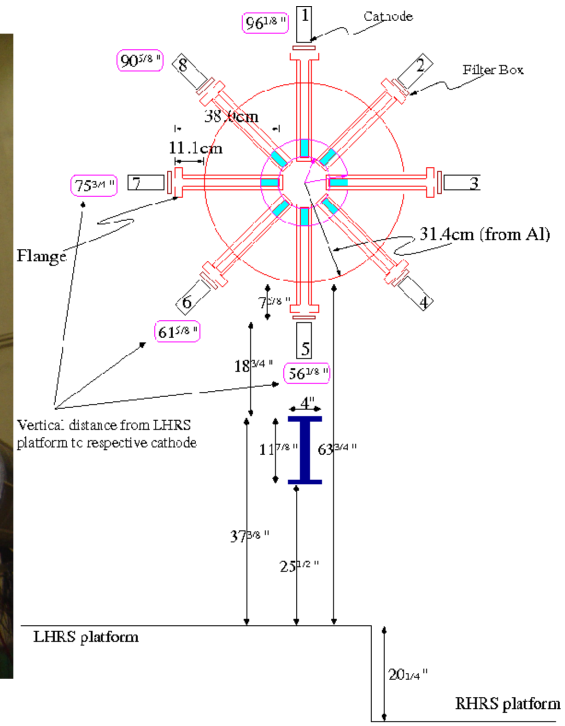
- Need them for their high sensitivity to helicity-correlated beam parameters
  - Detect charged particle flux at extreme forward angles
  - Very high rates and thus narrow pulse-pair widths – powerful diagnostic tool



- Provides measure of overall electronic noise floor in the hall
- In theory, should have very low/no PV asymmetry and can serve as null asymmetry monitor
- Symmetric 8 piece design helps disentangle beam position and angle HCBP's while 8 SAM sum is insensitive
- Could provide important tests of regression procedures

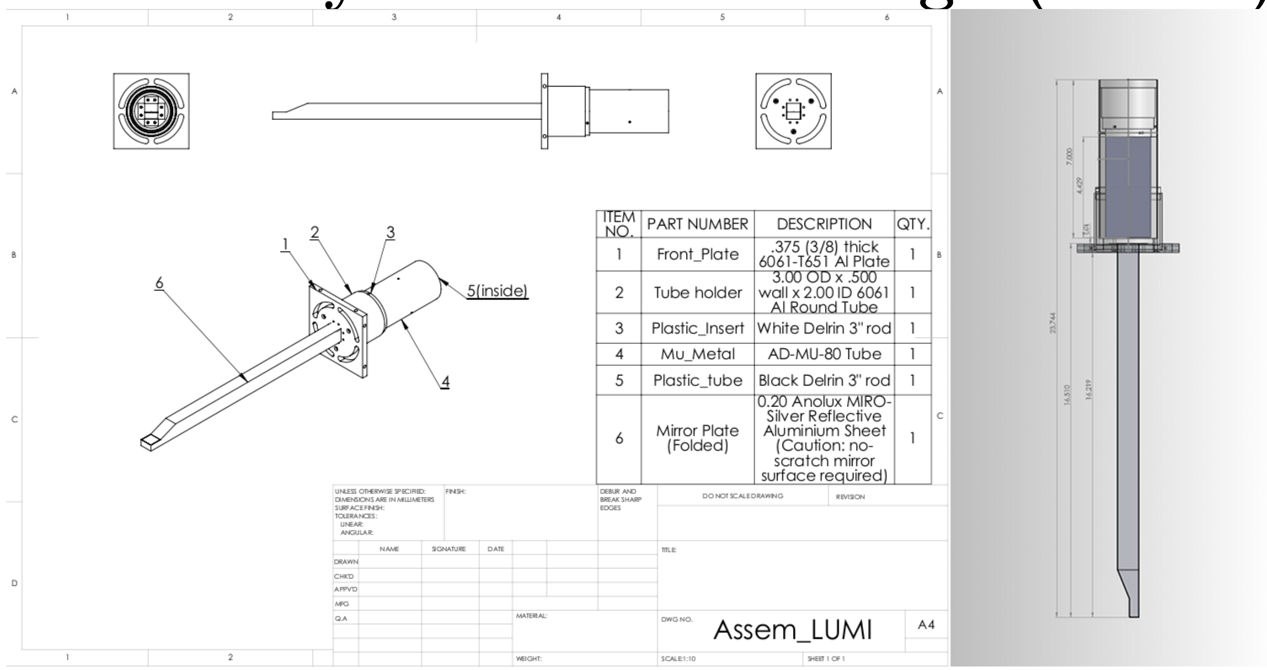
Old Hall A Luminosity Monitor





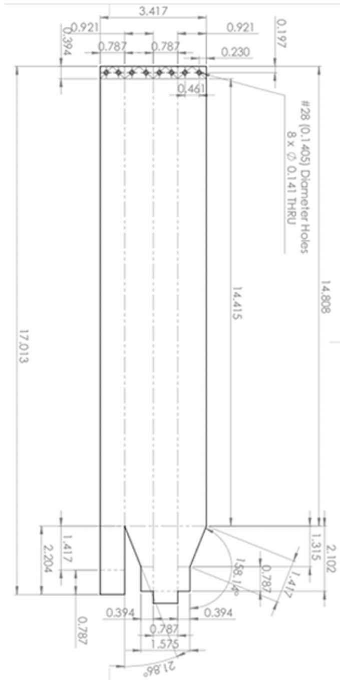
- Conceptual Design 2002–Riad Suleiman; refurbished in 2008
- 8 quartz Cherenkov detectors with air-core light guides placed symmetrically around beam line 7m downstream of pivot
- Used $6.0 \times 2.0 \times 1.0$ cm^3 quartz placed 4.5 cm from beam center $\Rightarrow$ 0.3 - 0.8 deg polar angle acceptance

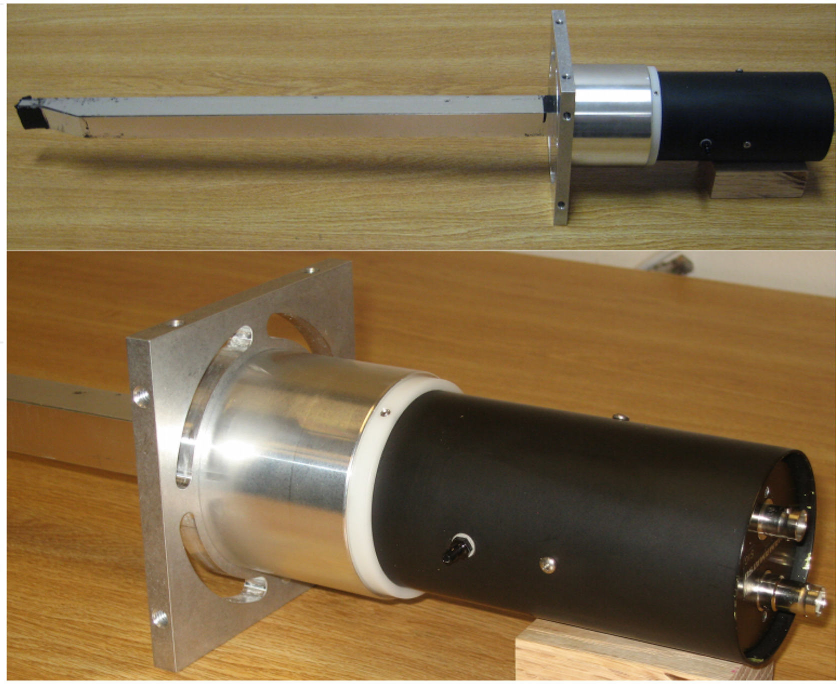
Luminosity Monitor Re-design (SAMs)



- Incorporate Qweak's downstream Lumi experience:
  - –Use pre-radiator (maybe) and "unity gain" PMT
  - –Use radially smaller, but thicker quartz
  - –May achieve desired linearity at anticipated photocathode currents, but running unity gain mode may guarantee it
  - –Use TRIUMF preAmps at SAM for signal cond. and gain
- *Work within constraints of existing beampipe insertion tubes!*

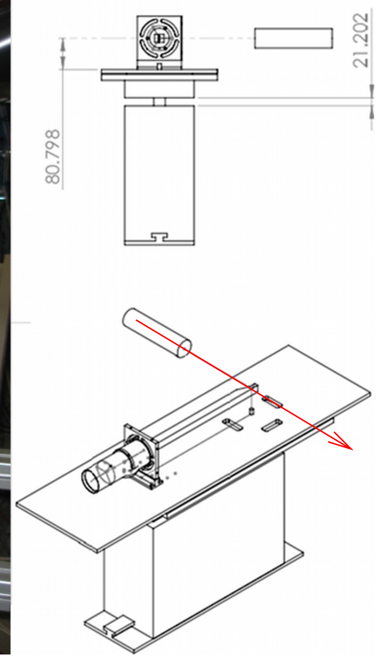
Prototype SAM for MAMI Testbeam (May 2015)





- Using 2” Hamamatsu R375 (multi-alkali, 10 stage) + E1435-02MOD unity gain base housed in mu-metal shield
- Anolux Miro-27 light guide; N_2 purge/flush
- Spectrosil 2000 quartz: $3.0 \times 2.0 \times 1.0$ cm^3 (prototype)
- Tungsten: $2.0 \times 2.0 \times 1.0/1.5$ cm^3; Aluminum and Delrin frame

MAMI Testbeam (SAM Tests)



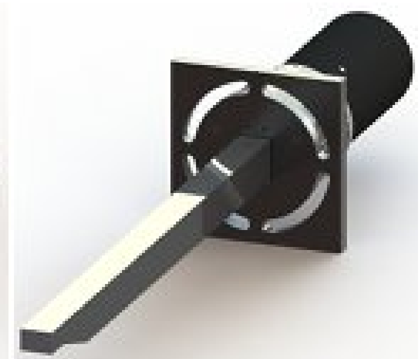
- Last testbeam: May 29 - June 1, 2015: MOLLER, PREX/CREX
- Half a shift for Lumi prototype tests:
  –Different tungsten thicknesses: 0, 10, and 15 mm
  –Different lightguide lengths: 41 and 35 cm
  –With and without N_2 purge

Prototype SAM Testbeam Results

Run #	LG	Tungsten	with N_2	peak PEs (gain)	peak PEs (sim)
652	41cm	0mm	No	1.3	5
643	41cm	10mm	No	8.0	15
706	41cm	15mm	No	9.8	13
712	41cm	0mm	Yes	2.0	not gen.
716	35cm	0mm	Yes	2.2	not gen.
713	35cm	10mm	No	13	20

- For no tungsten, adding N_2 (compare runs 652 and 712) increases PEs from 1.3 to 2.0 (+50%)
- For no tungsten, shrink LG by 6cm (compare runs 712 and 716) increases PEs from 2.0 to 2.2 (+10%)
- For 10mm tungsten, shrink LG by 6cm (compare runs 643 and 713) increases PEs from 8.0 to 13 (+60%)
- For 41cm LG, increase tungsten from 10mm to 15mm (compare runs 643 and 706) increases PEs from 8.0 to 9.8 (+23%)

Final SAM Design

(*will calibrate PE yield at MAMI this May*)

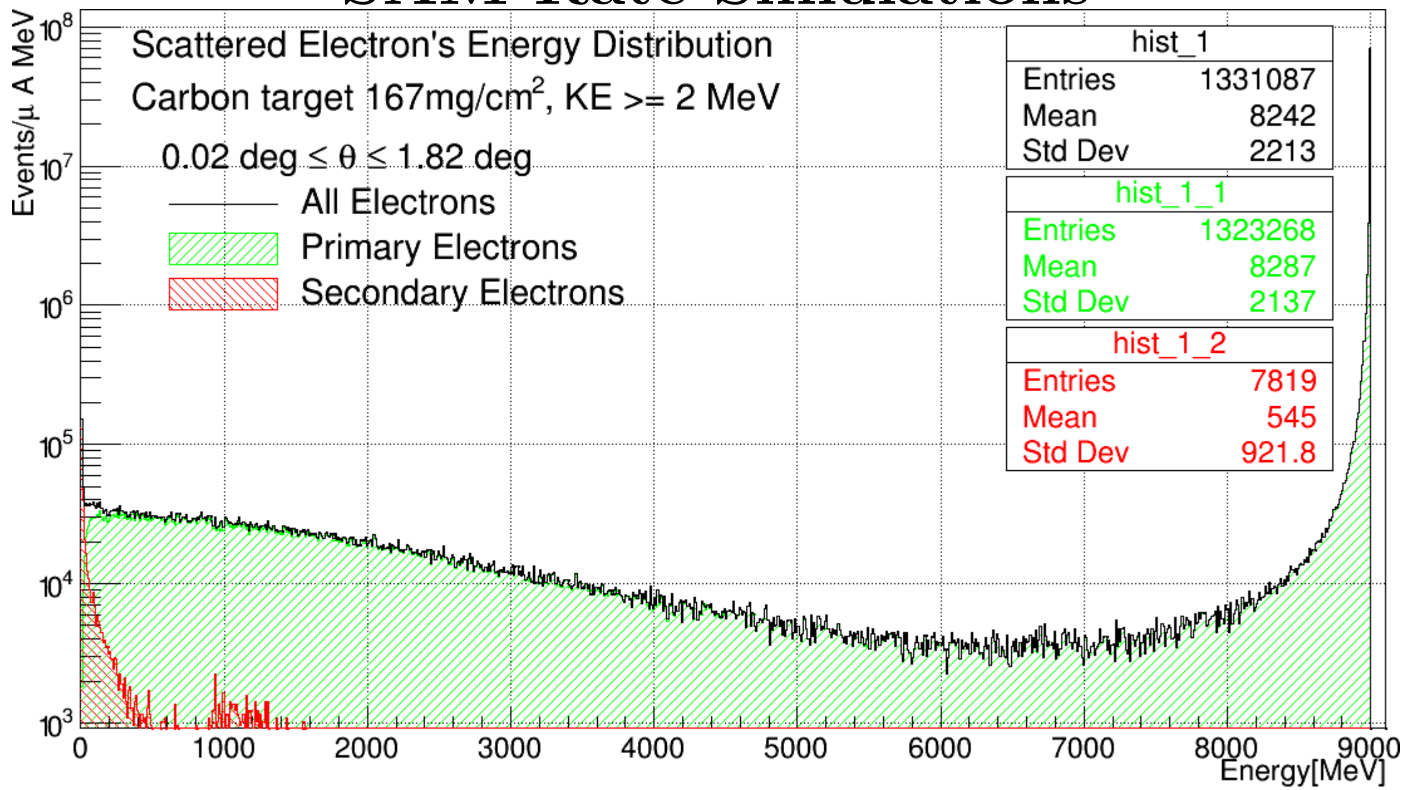
Improvements over prototype:

- Increased thickness of quartz: 33 mm × 20 mm × 13 mm
- Shortened light guide and made it taller and slightly wider; also changed its one-bounce mirror by 4° based on optical sims
- Includes custom CF flange mounting adapters – for easier de-install/re-install and alignment tuning
- Includes gas exhaust ports and quartz securing mechanism
- Question of tungsten pre radiator not yet decided

SAM Assembly (Nov 2015)

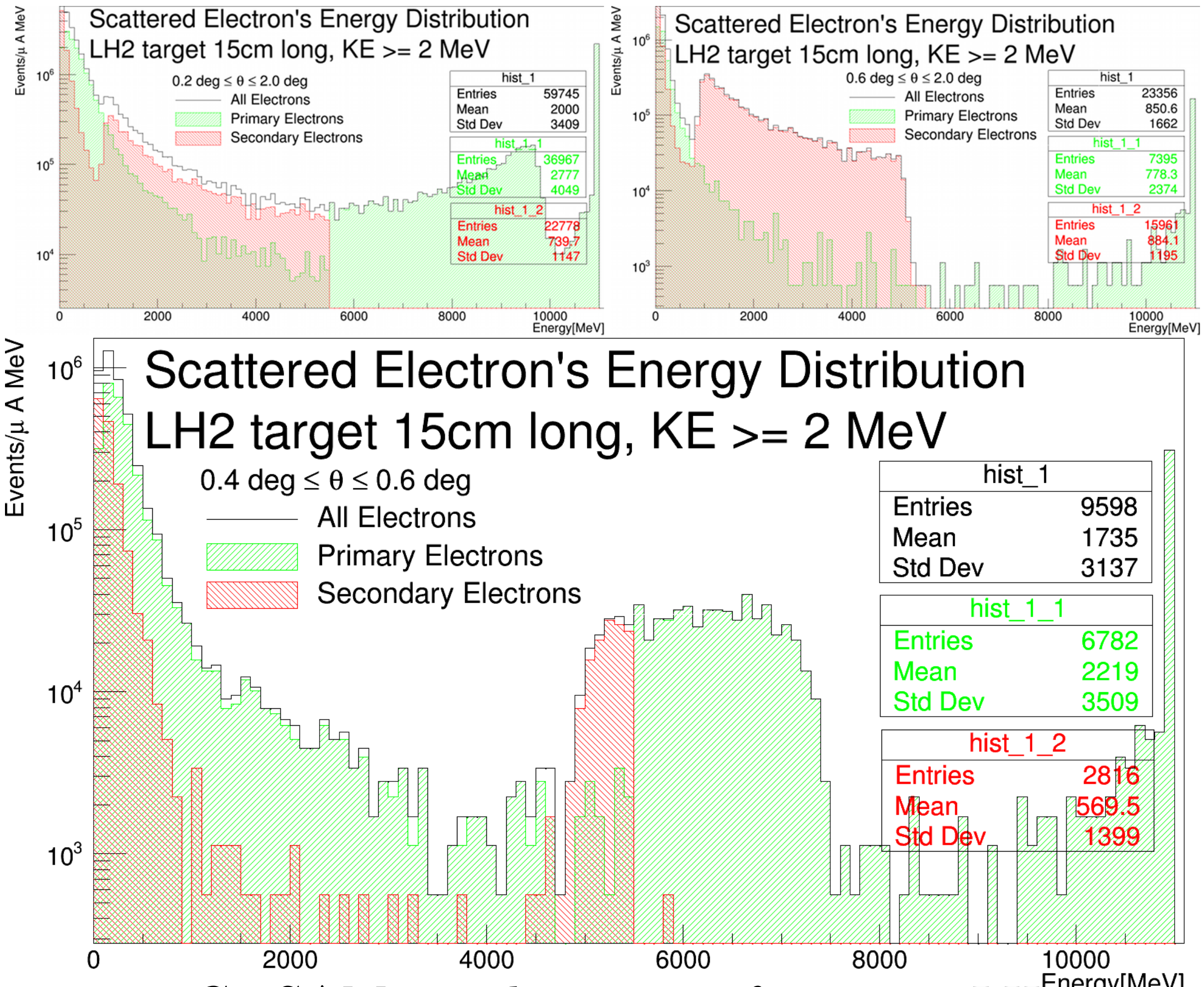
SAM Installation (Dec 2015)

SAM Rate Simulations



- New stand-alone G4 simulation for estimating SAM rates
- Simulation uses _BERT phys. library and handles all processes
- Tallies scattered primary electrons, as well as any secondaries that pass through annulus centered on the beamline, 7 meters downstream of the target

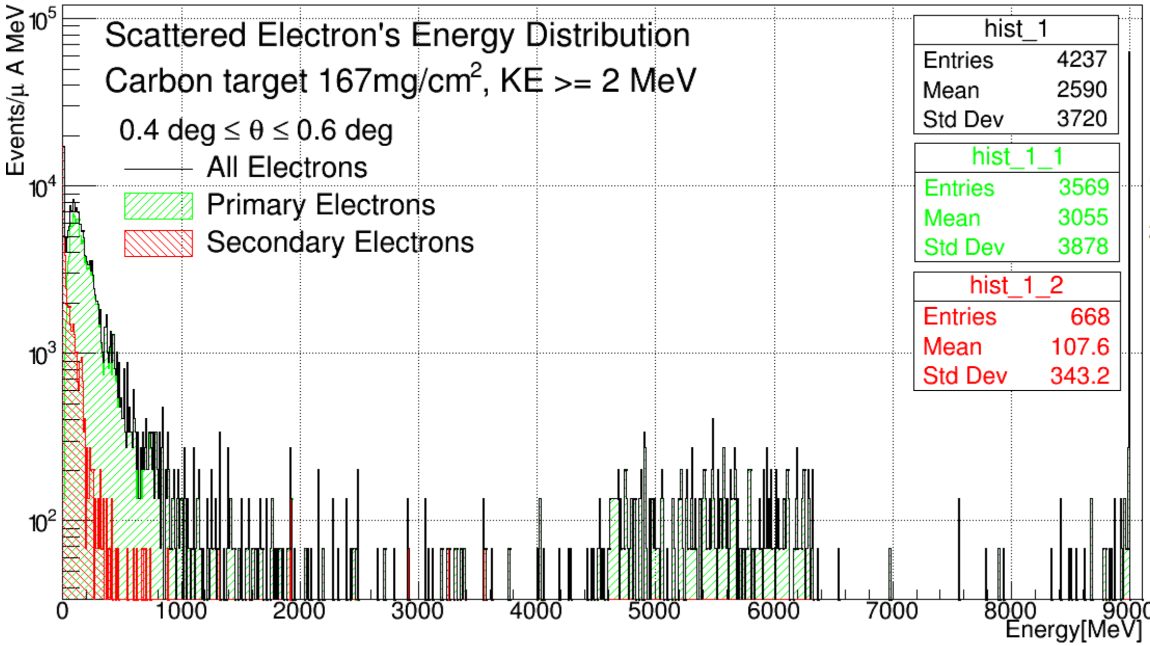
Simulated SAM Rates for DVCS Parasitic Tests

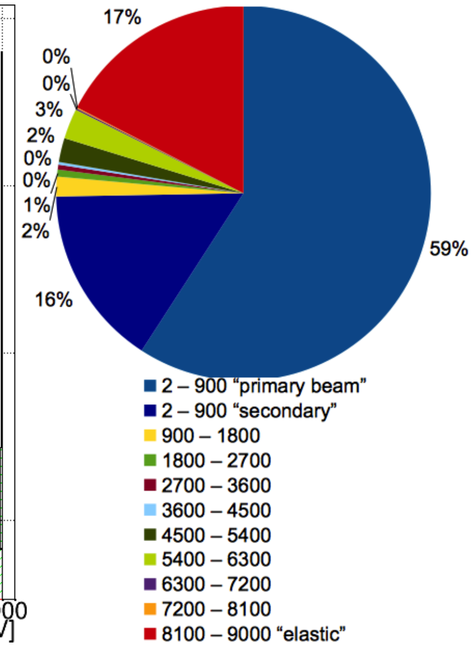


Results from new G4 SAM simulation run for 15 cm LH_2 target and 11 GeV beam with 2 by 2 mm^2 raster: Rate per SAM per μA is ∼80MHz

(Note that most of the rate is coming from 1 GeV or less electrons)

Simulated SAM Rates for 167mg Carbon at 9GeV





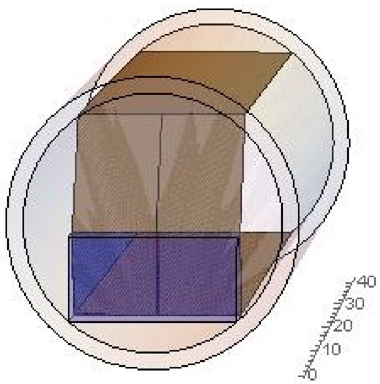
- Results for 9 GeV pin-point electron beam on 167 mg C target
- 10^8 beam electrons thrown; results are scaled to give events/uA
- SAM polar angle accept. estimated to be from 0.4 to 0.6 degree
- Rates calc using sim results and estimated azimuthal accept.
- ~260 MHz/μA/SAM with over 75% of rate from 1 GeV or less

Summary and Plans for SAMs

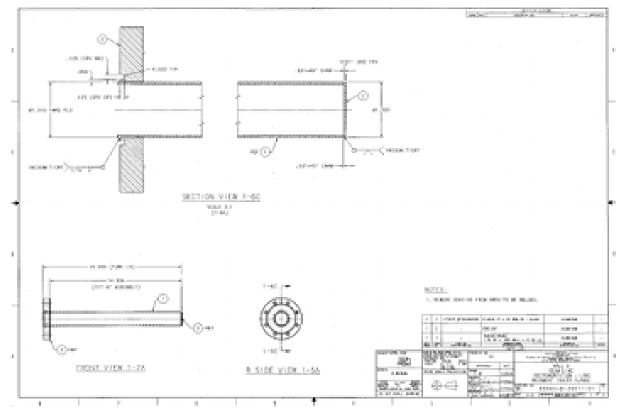
- New Hall A SAMs constructed and installed
- Present configuration gives flexibility for future parasitic tests
- Will take spare SAM to Mainz for PE yield calibration, pre-radiator, and LG study
- Preliminary LG reflectivity measurements in hand; will use MAMI testbeam results to benchmark mirror properties in MC
- Will likely replace SAM LGs depending on testbeam results; may replace Miro-silver-27 with Anolux-UVS or Anolux-I

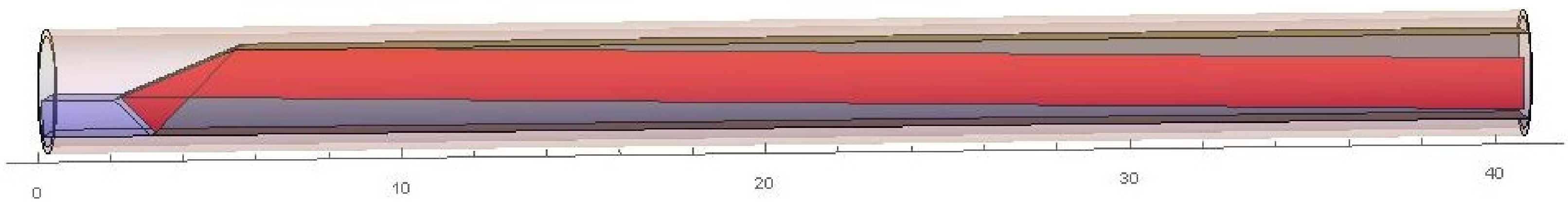
Extra Slides

Lumi v1 Lightguide Design (Prototype SAM)



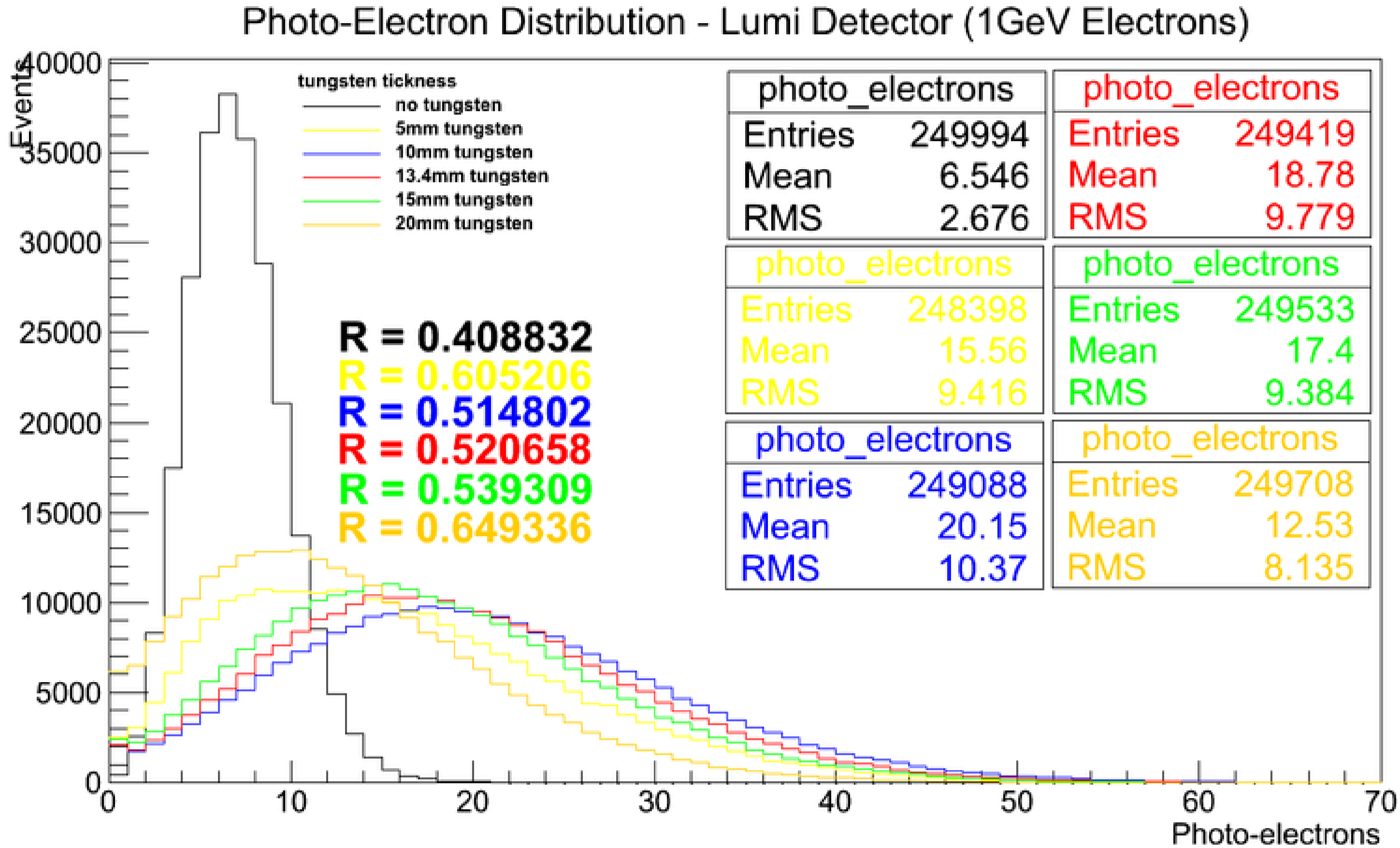
R = 1.54 cm
Quartz Dimensions:
Small Face 2x2 cm
Big Face 2x3 cm
Thickness 1 cm
Total Length 41 cm

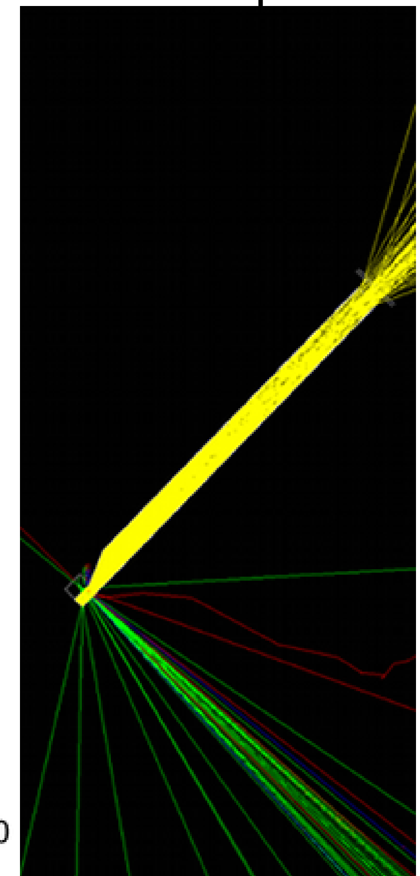




- Constraints of existing beam pipe insertion tubes...light guide is long and narrow
- Optimized? one-bounce design

Prototype SAM Optical Simulations





- G4 optical simulations:
  –lumi v1: $3.0 \times 2.0 \times 1.0$ cm^3, 41cm one-bounce lightguide (air)
  –Used 1GeV electrons, centered on quartz with 90^{o} incidence
  –Varied tungsten thickness from 0 to 20mm

Lumi R&D Summary

- Results are preliminary; analysis and simulation work ongoing
- Narrow beampipe insertion tubes significantly restrict light collection at PMT
- Qualitative agreement between initial simulations and test beam data. But why peak PE values have ∼large disagreement?
  - –Incident MAMI beam angle was 86^{o}, not 90^{o}
  - –LG reflectivity coeffs. in MC need verification/improvement
  - –Bending LG into proper shape is not trivial...
- Can use this data (combined with other prototype detector tests) to help benchmark optical MC
- Pre-radiator significantly increases PE yield by factor of 5 or 6
- Flushing with dry N_2 increased signal size by 50% (whoa!)
- Sum of quartz and tungsten thicknesses must be $\leq$ 2.3cm – so if quartz is 1cm, then W can be upto 1.3cm...What is best configuration?

SAM configuration (Jan 2016)