Lumi Testbeam results and Shower Max Detector

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Thanks to: Carlos Bula, Brady Lowe, Kevin Rhine, and Max Surgeon

Aug 13, 2015

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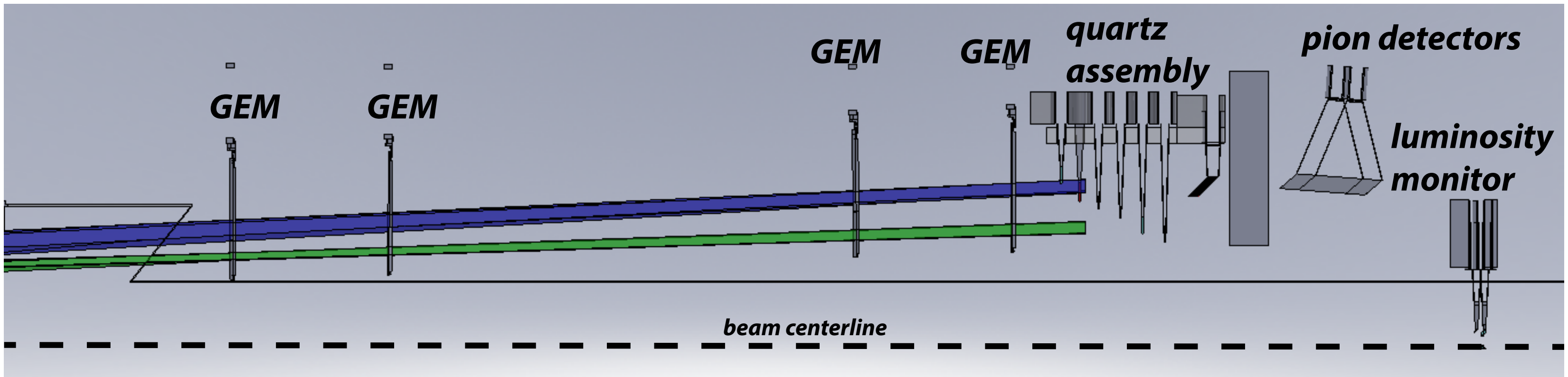
Outline

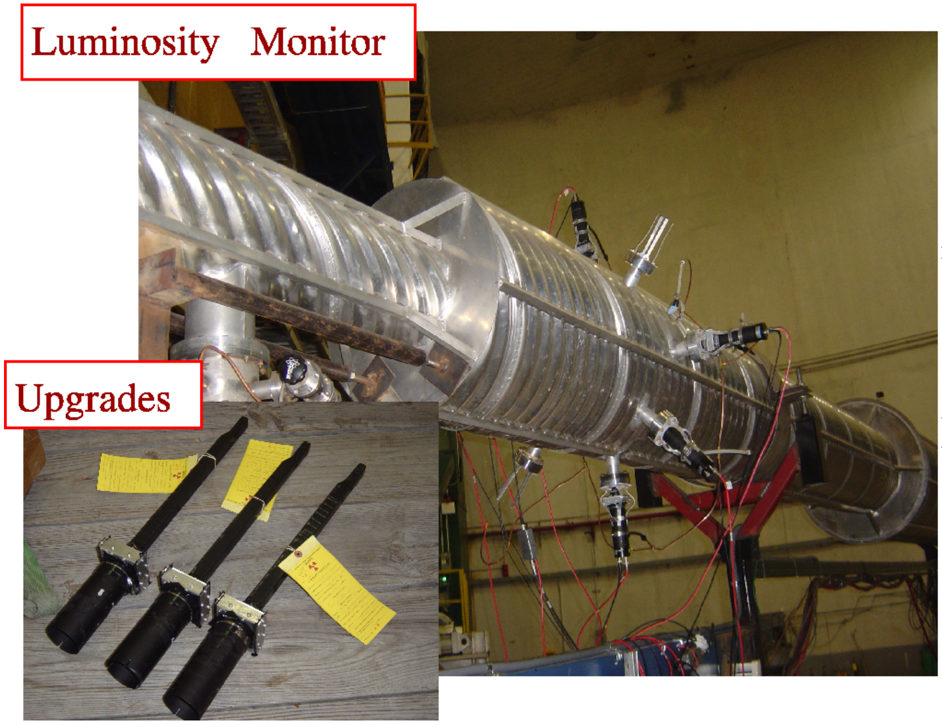
- New Hall A downstream Lumi
  - –Design
  - –Monte Carlo
  - –Test beam studies and results
- New Shower-max baseline design
  - –Design
  - –Monte Carlo
  - –Baseline performance (MC)
- Optimizing Designs and Prototyping
- Summary

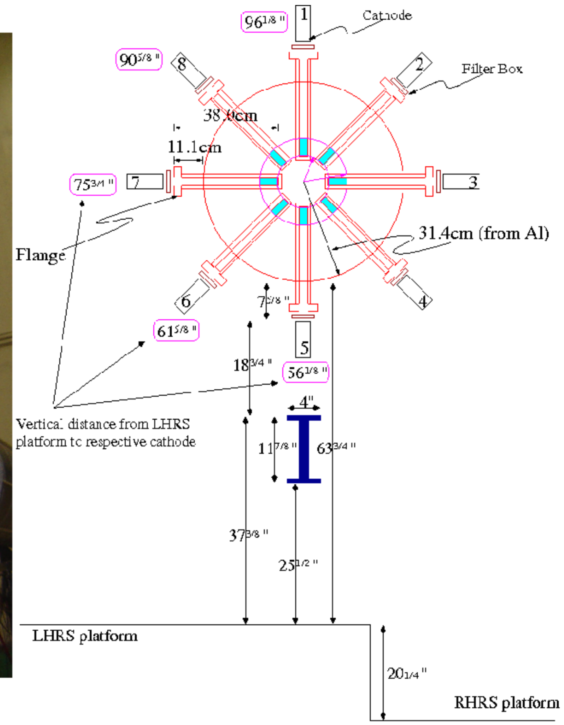
Downstream Lumi/SBM (or SAM) for MOLLER



- Detect charged particle flux at extreme forward angles
- Important diagnostic of target density fluctuations and overall noise floor
- In theory, should have very low/no PV asymmetry and can serve as null asymmetry monitor
- Can use upcoming PREX as a learning opportunity for MOLLER Lumi development

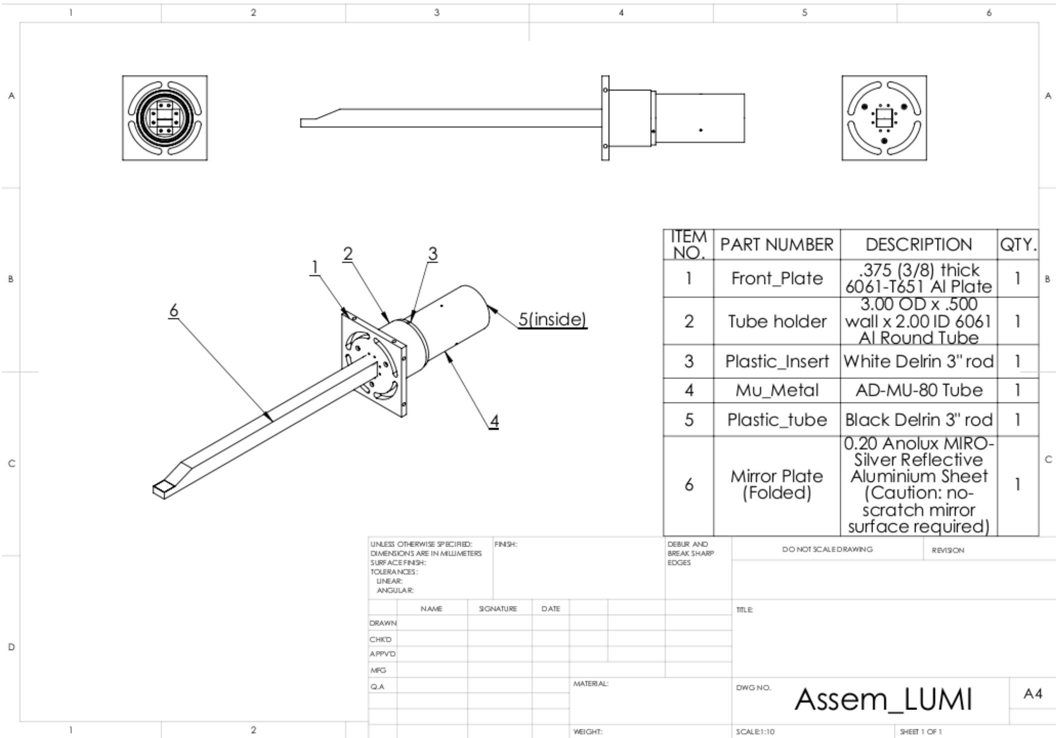
Hall A Luminosity Monitor



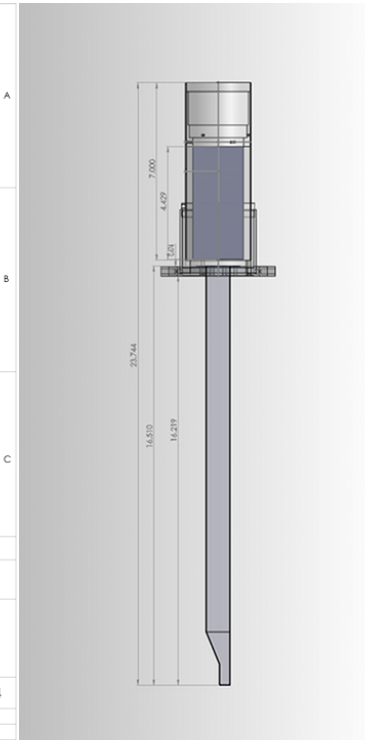


- Conceptual Design 2002 – Riad Suleiman
- 8 quartz Cherenkov detectors with air-core light guides placed symmetrically around beam line 7.5m downstream of pivot
- Used $6.0 \times 2.0 \times 1.0$ cm^3 quartz placed 4.5 cm from beam center $\Rightarrow$ 0.3 - 0.8 deg polar angle acceptance

New Hall A Luminosity Monitor

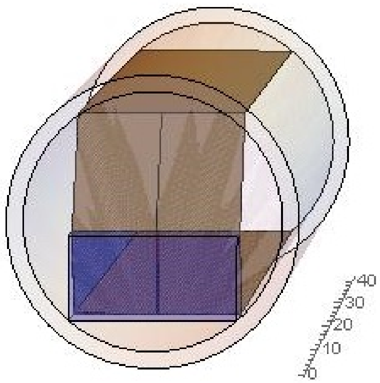


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Front_Plate	.375 (3/8) thick 6061-T651 Al Plate	1
2	Tube holder	3.00 OD x .500 wall x 2.00 ID 6061 Al Round Tube	1
3	Plastic_Insert	White Delrin 3" rod	1
4	Mu_Metal	AD-MU-80 Tube	1
5	Plastic_tube	Black Delrin 3" rod	1
6	Mirror Plate (Folded)	0.20 Anolux MIRO-Silver Reflective Aluminium Sheet (Caution: no-scratch mirror surface required)	1

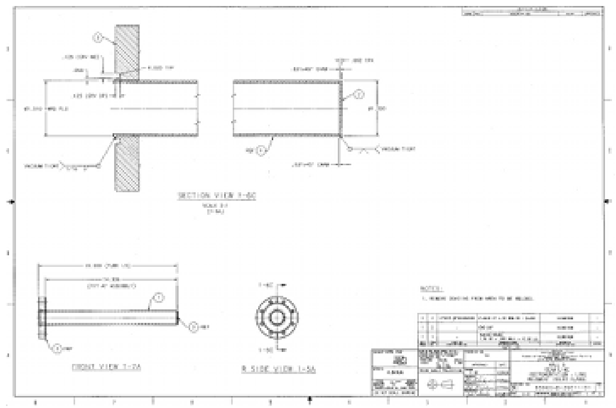


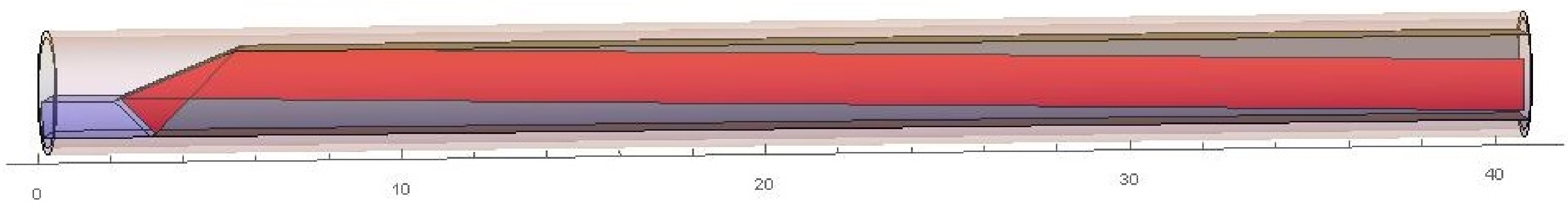
- Incorporate Qweak's downstream Lumi experience:
  - –Use pre-radiator and "unity gain" PMT
  - –Use radially smaller, but thicker quartz
  - –May achieve desired linearity at anticipated photocathode currents
- Work within constraints of existing beampipe insertion tubes

Lumi v1 Lightguide Design



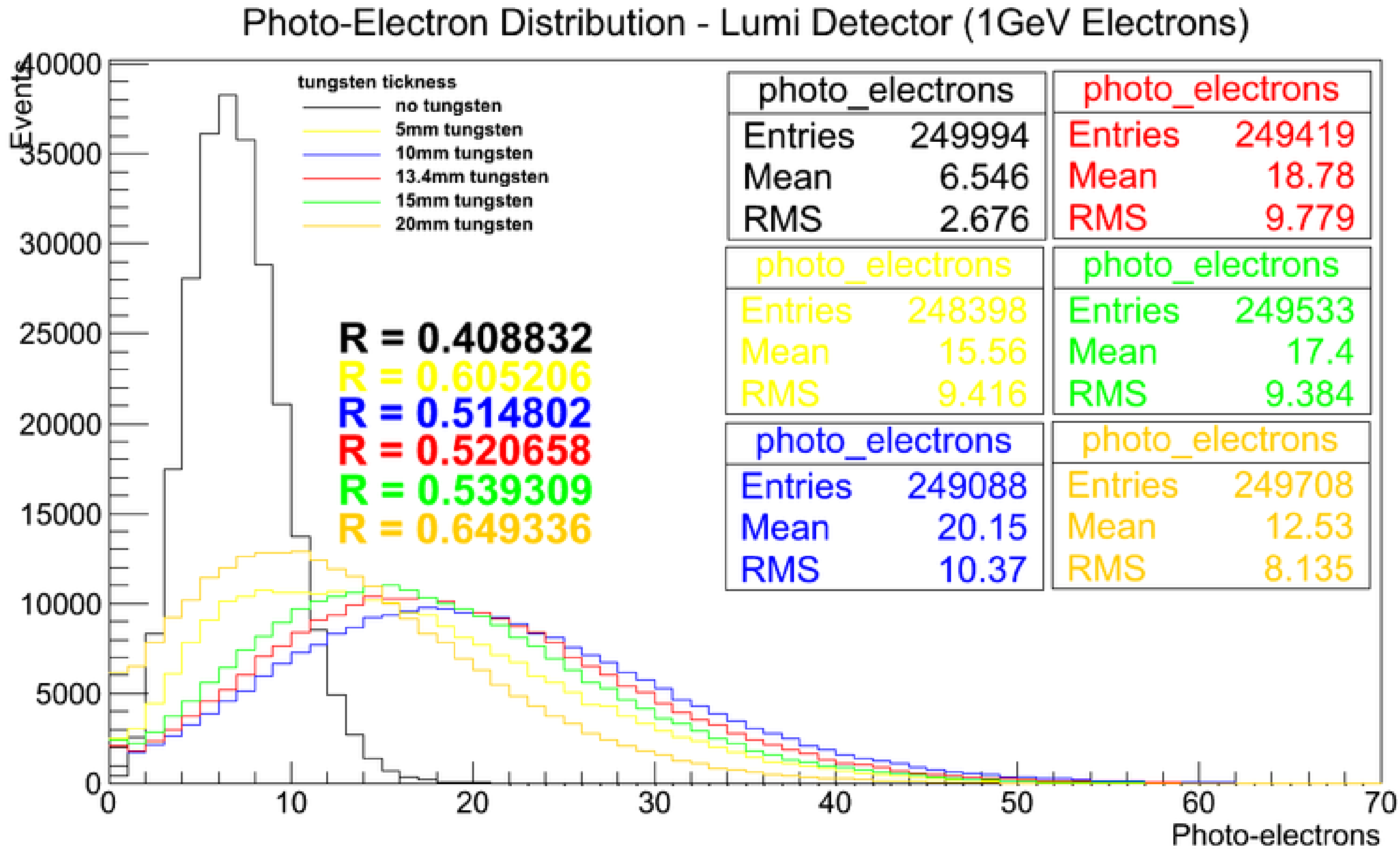
R = 1.54 cm
Quartz Dimensions:
Small Face 2x2 cm
Big Face 2x3 cm
Thickness 1 cm
Total Length 41 cm

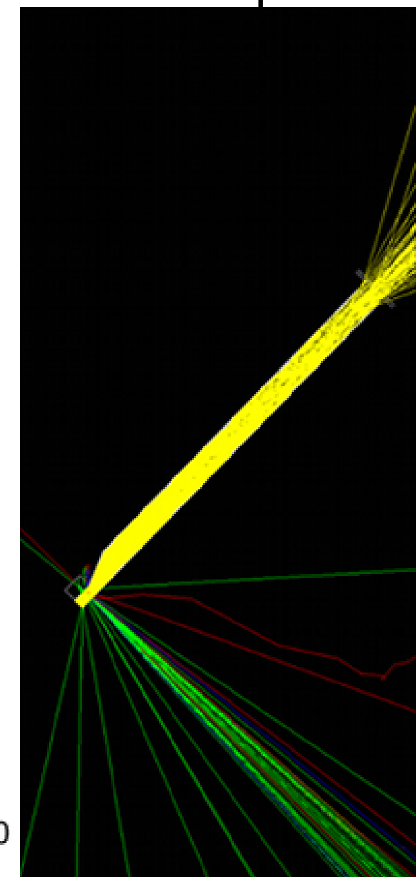




- Constraints of existing beam pipe insertion tubes...light guide is long and narrow
- Optimized? one-bounce design

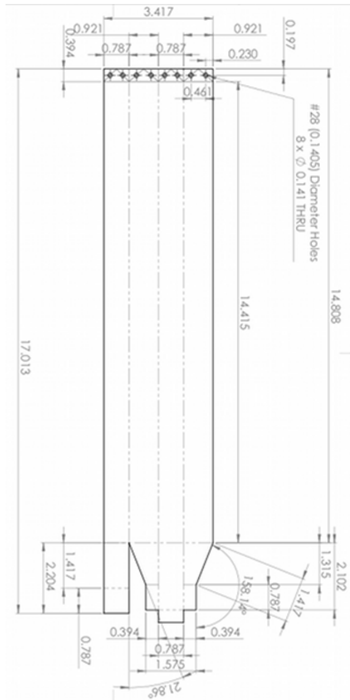
New Hall A Luminosity Monitor (Simulations)

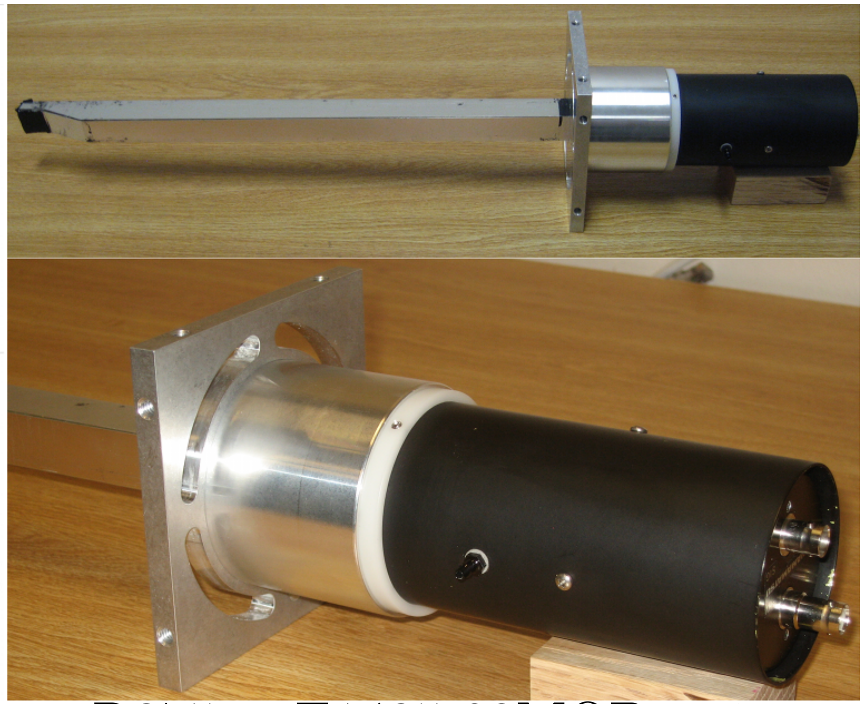




- G4 optical simulations:
  –lumi v1: $3.0 \times 2.0 \times 1.0$ cm^3, 41cm one-bounce lightguide (air)
  –Used 1GeV electrons, centered on quartz with 90^o incidence
  –Varied tungsten thickness from 0 to 20mm

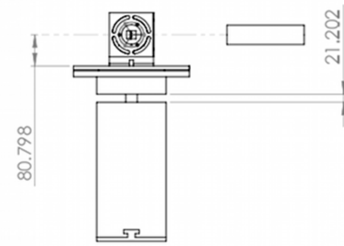
New Hall A Luminosity Monitor (Prototype)

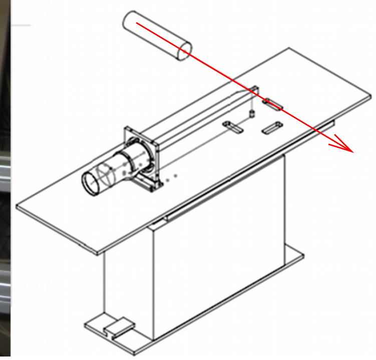




- Using 2” Hamamatsu R375 + E1435-02MOD unity gain base
- PMT and base fully housed in mu-metal shield
- Anolux Miro-Silver light guide; dry N_2 purge/flush
- Spectrosil 2000 quartz: $3.0 \times 2.0 \times 1.0$ cm^3 (prototype)
- Tungsten: $2.0 \times 2.0 \times 1.0/1.5$ cm^3; Aluminum and Delrin frame

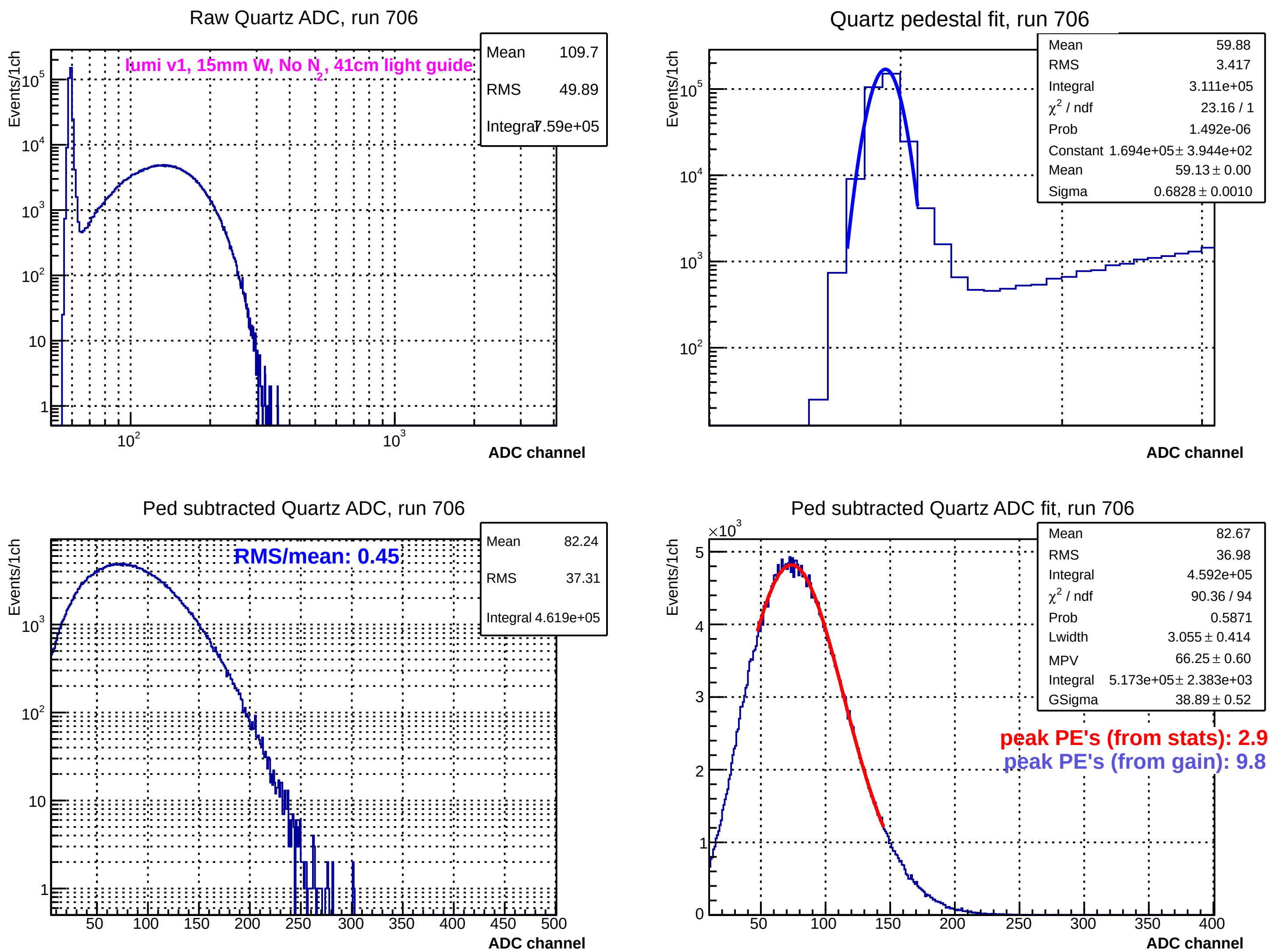
MAMI Testbeam (Lumi Tests)





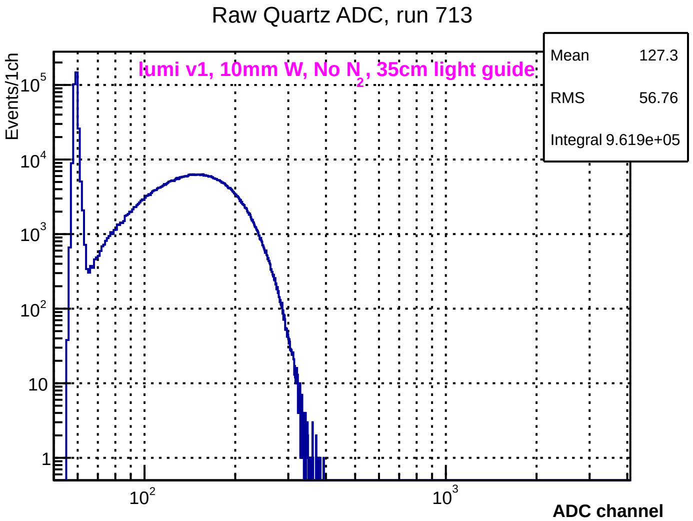
- Recent testbeam: May 29 - June 1, 2015: MOLLER, PREX/CREX
- Half a shift for Lumi prototype tests:
  - –Different tungsten thicknesses: 0, 10, and 15 mm
  - –Different lightguide lengths: 41 and 35 cm
  - –With and without N_2 purge

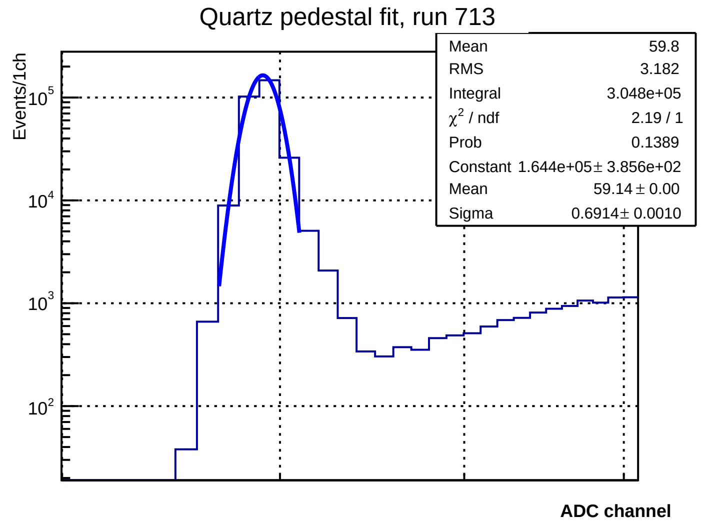
Lumi Testbeam Data

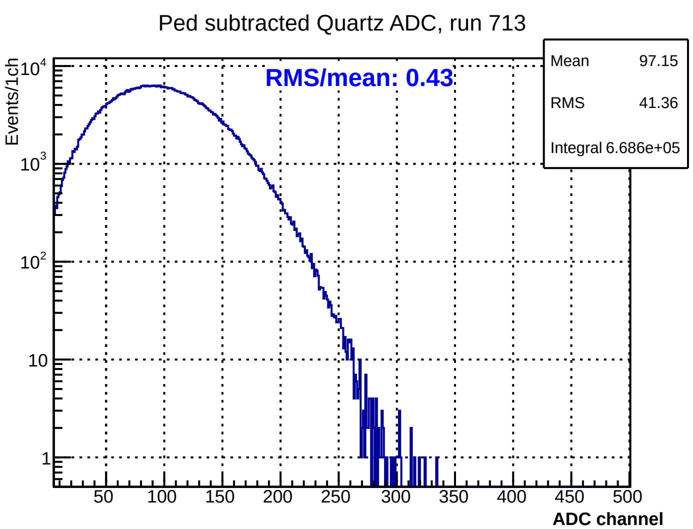


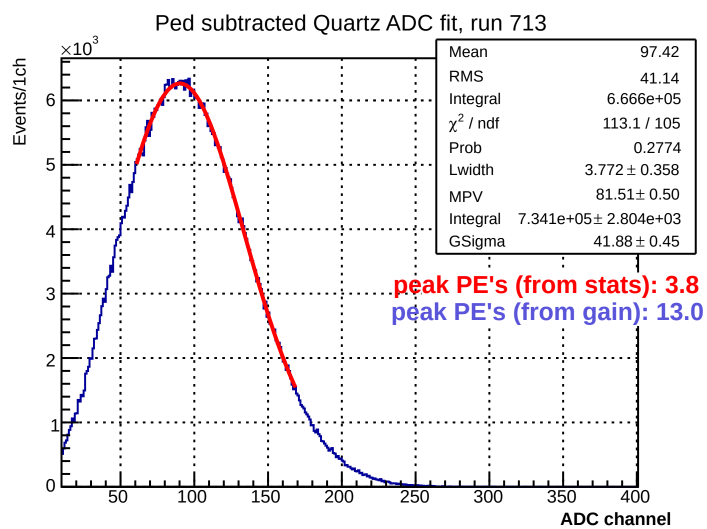
Sample spectra: Lumi v1, 15mm tungsten, 41cm LG, no N_2

Lumi Testbeam Data



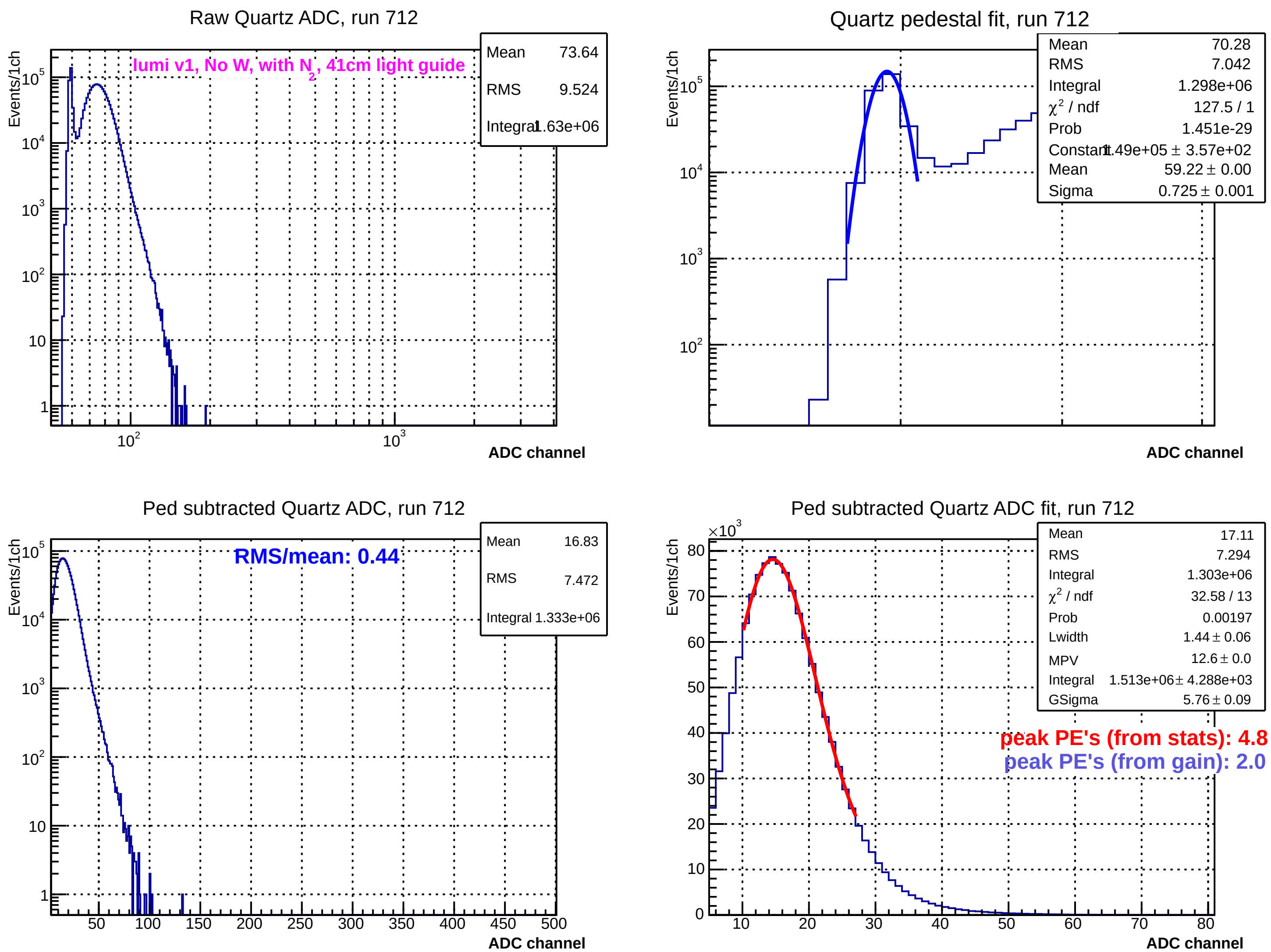






Sample spectra: Lumi v1, 10mm tungsten, 35cm LG, no N_2

Lumi Testbeam Data



Sample spectra: Lumi v1, no tungsten, 41cm LG, with N_2

Prelim. Lumi Testbeam Results

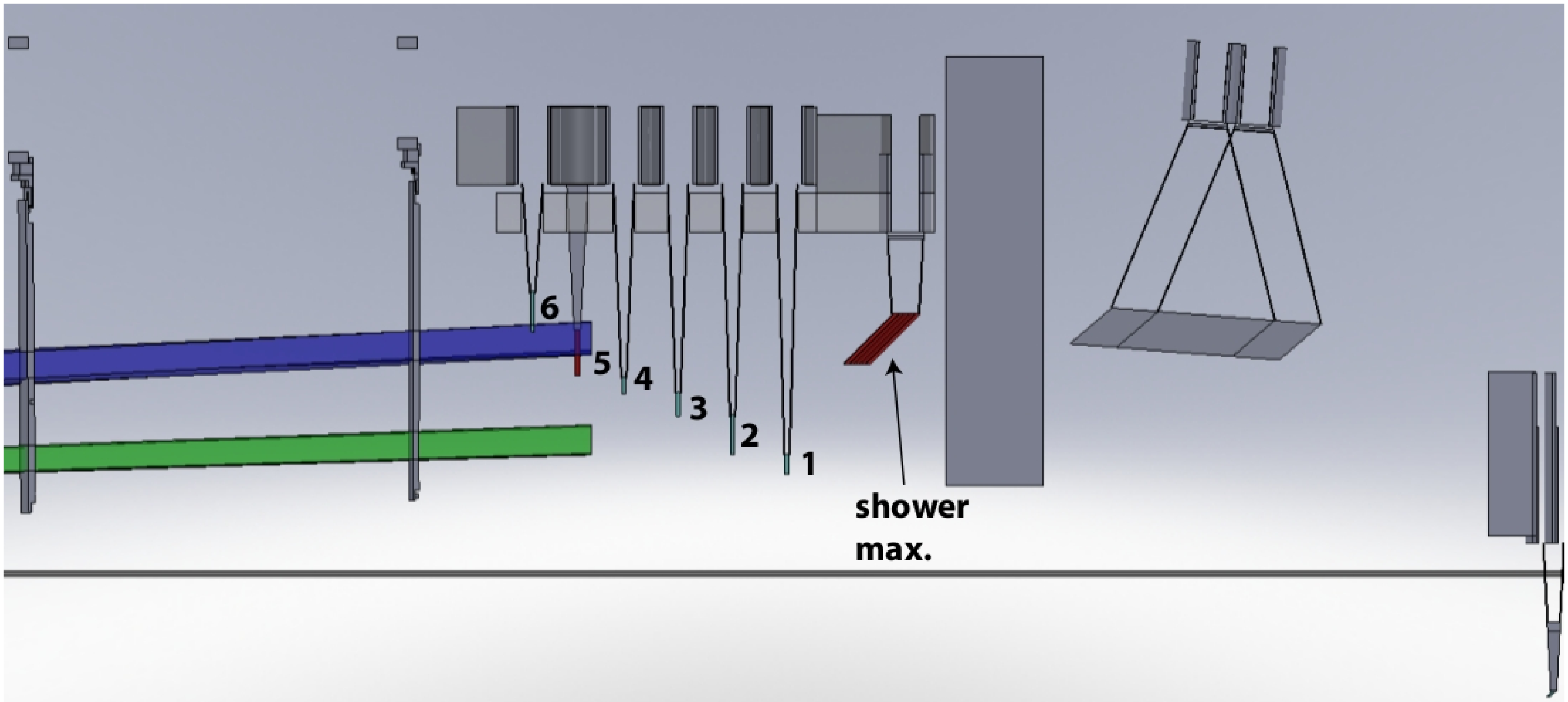
Run #	LG	Tungsten	with N_2	peak PEs (gain)	peak PEs (sim)
652	41cm	0mm	No	1.3	5
643	41cm	10mm	No	8.0	15
706	41cm	15mm	No	9.8	13
712	41cm	0mm	Yes	2.0	not gen.
716	35cm	0mm	Yes	2.2	not gen.
713	35cm	10mm	No	13	20

- 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%)

Lumi R&D Summary

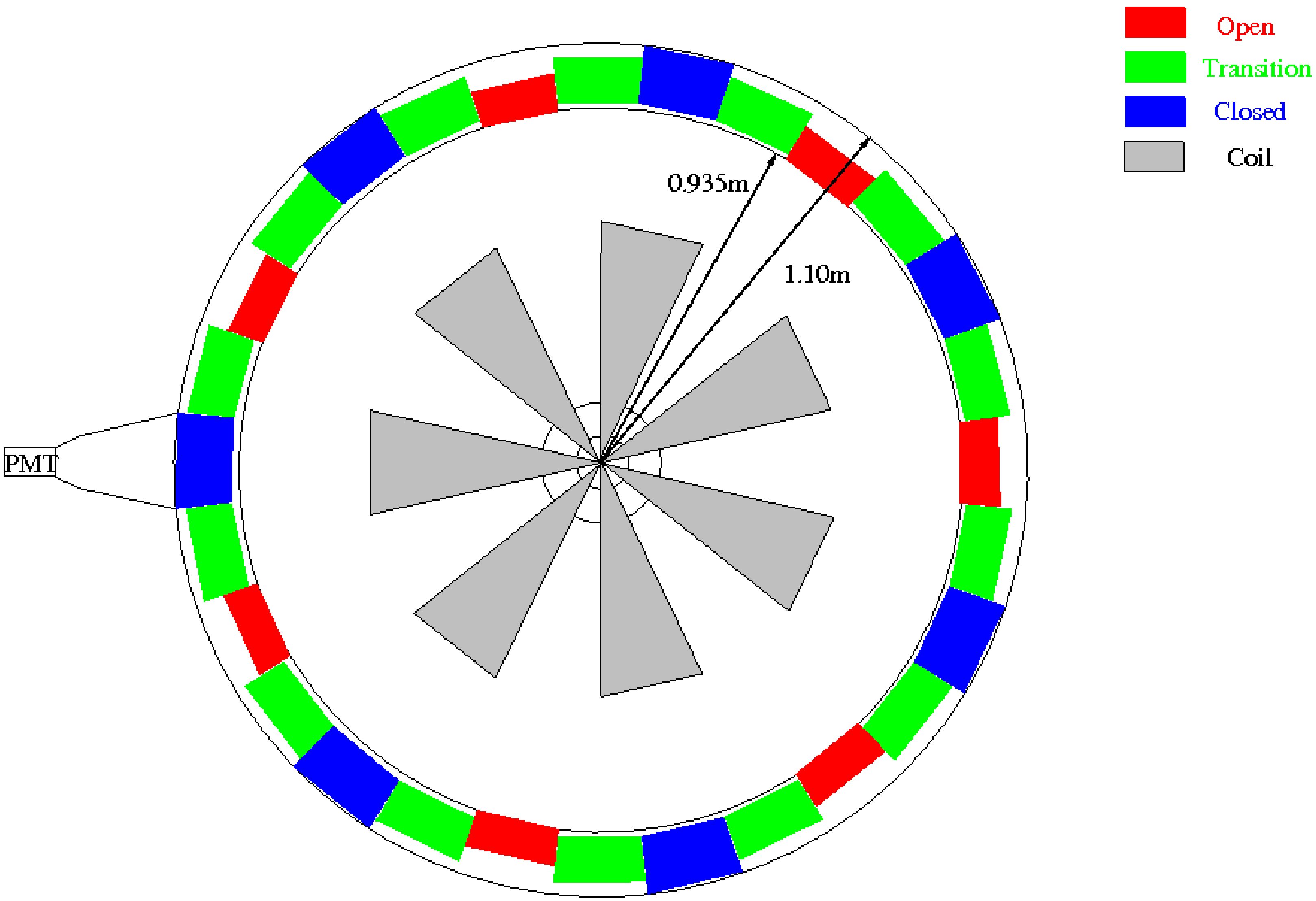
- Results are preliminary; analysis and simulation work ongoing
- Narrow beampipe insertion tubes significantly restrict light collection at PMT
- Qualitative agreement between initial simulations and test beam data. But why peak PE values have ∼large disagreement?
  - –Incident MAMI beam angle was 86^{o}, 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?

Showermax Detector

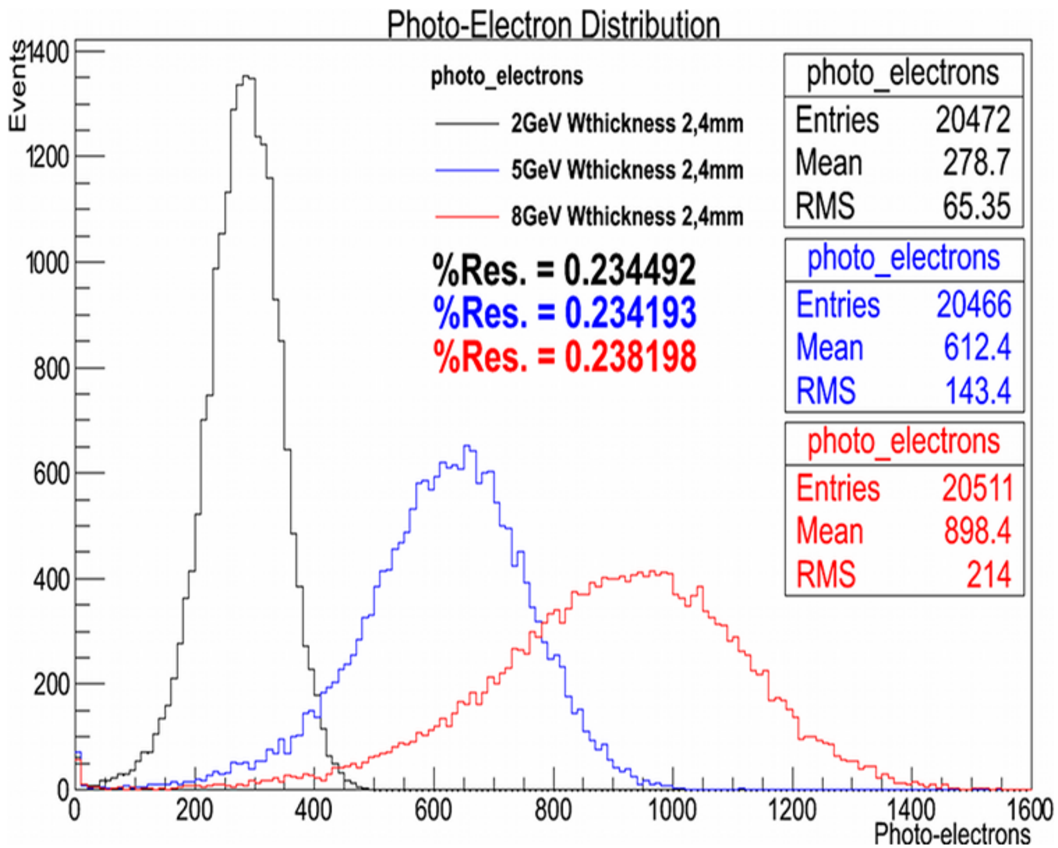


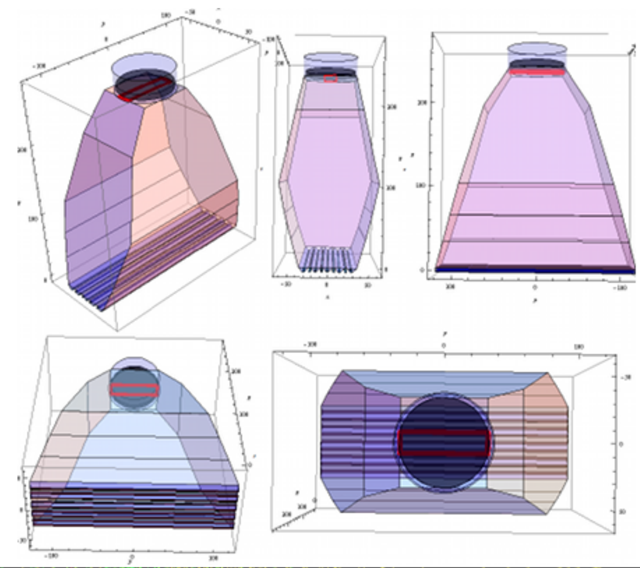
- Provides additional measurement of e-e ring flux
- Weights flux by energy $\Longrightarrow$ less sensitive to low energy/low light bkgds

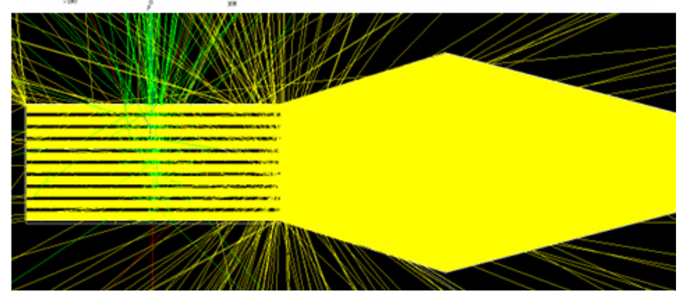
Showermax Detector Ring



Showermax Detector (10 piece stack)

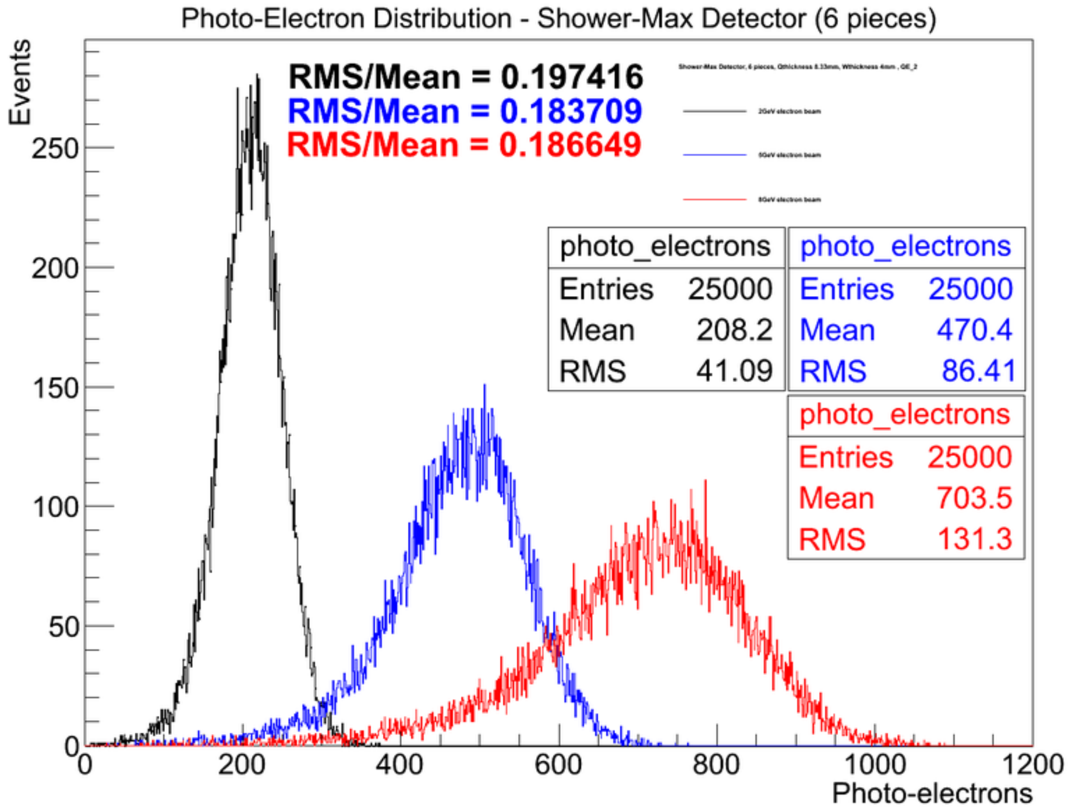


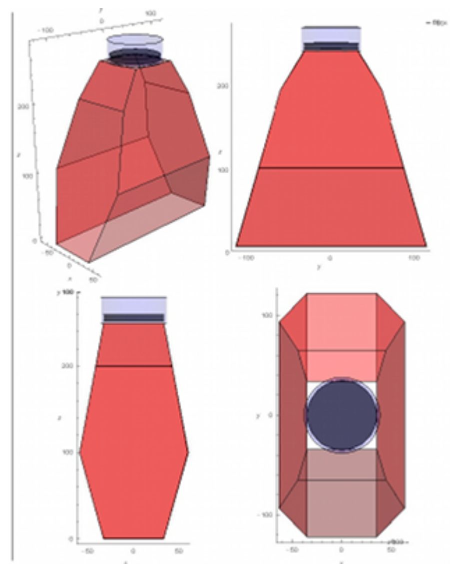


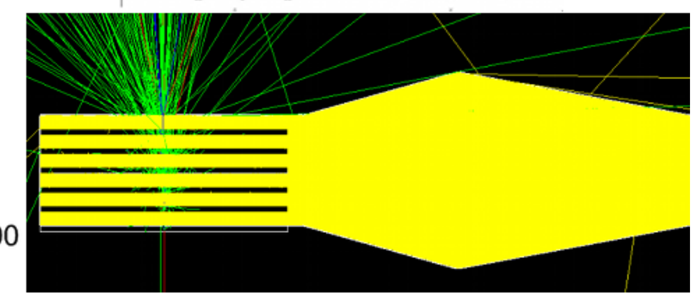


- 10 pieces quartz (each 5.0mm thick): 0.41 X_0
- 10 pieces tungsten (each 2.4mm thick): 6.8 X_0
- 25 cm Miro-silver LG; 3” PMT. *Note:Uniform sampling, trapez. Q*

Showermax Detector (6 piece stack)

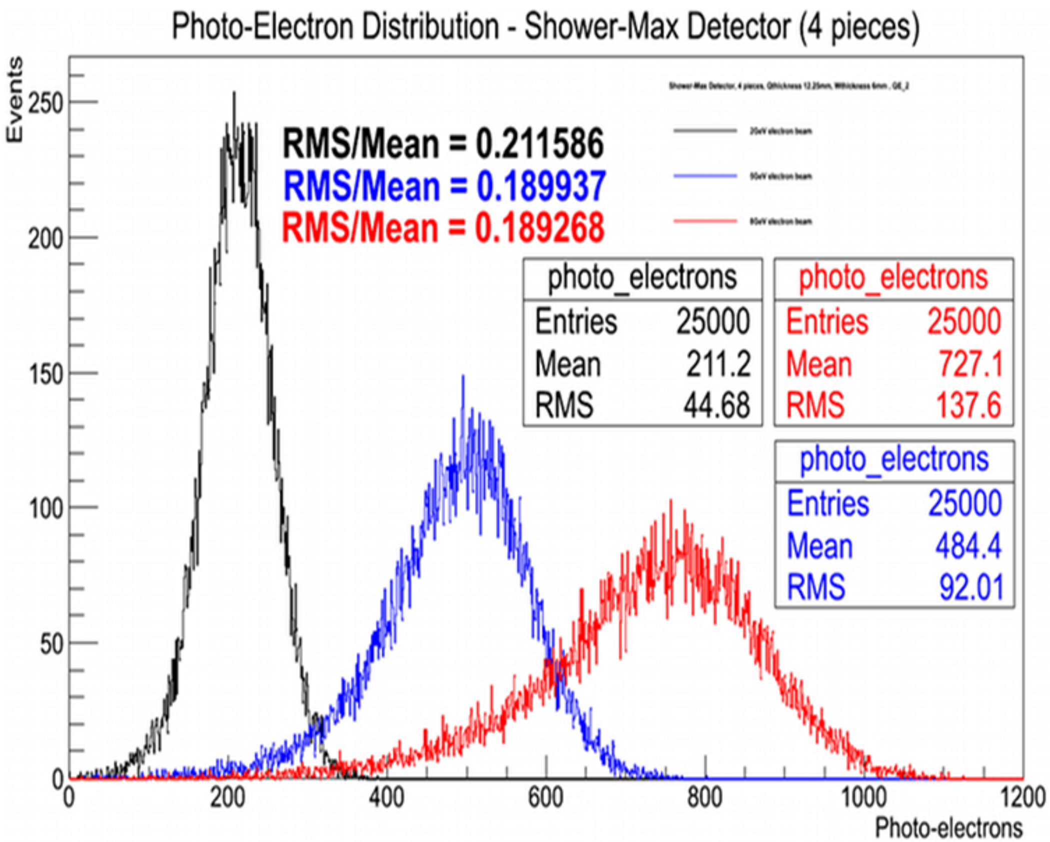


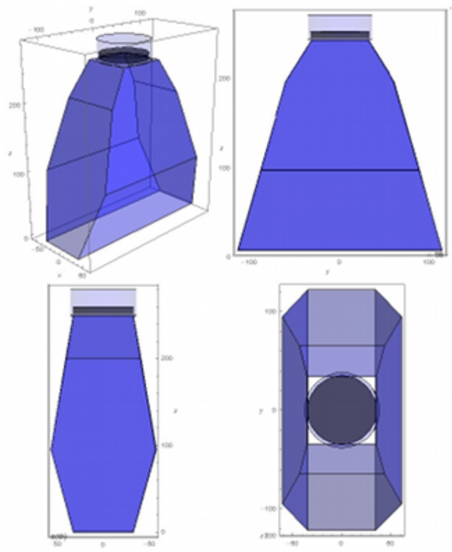


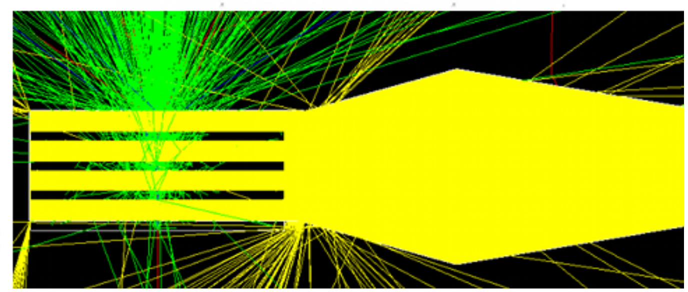


- 6 pieces quartz (each 8.33mm thick): 0.41 X_0
- 6 pieces tungsten (each 4mm thick): 6.8 X_0
- 25 cm Miro-silver LG; 3" PMT. *Note: center sampling, new QE*

Showermax Detector (4 piece stack)

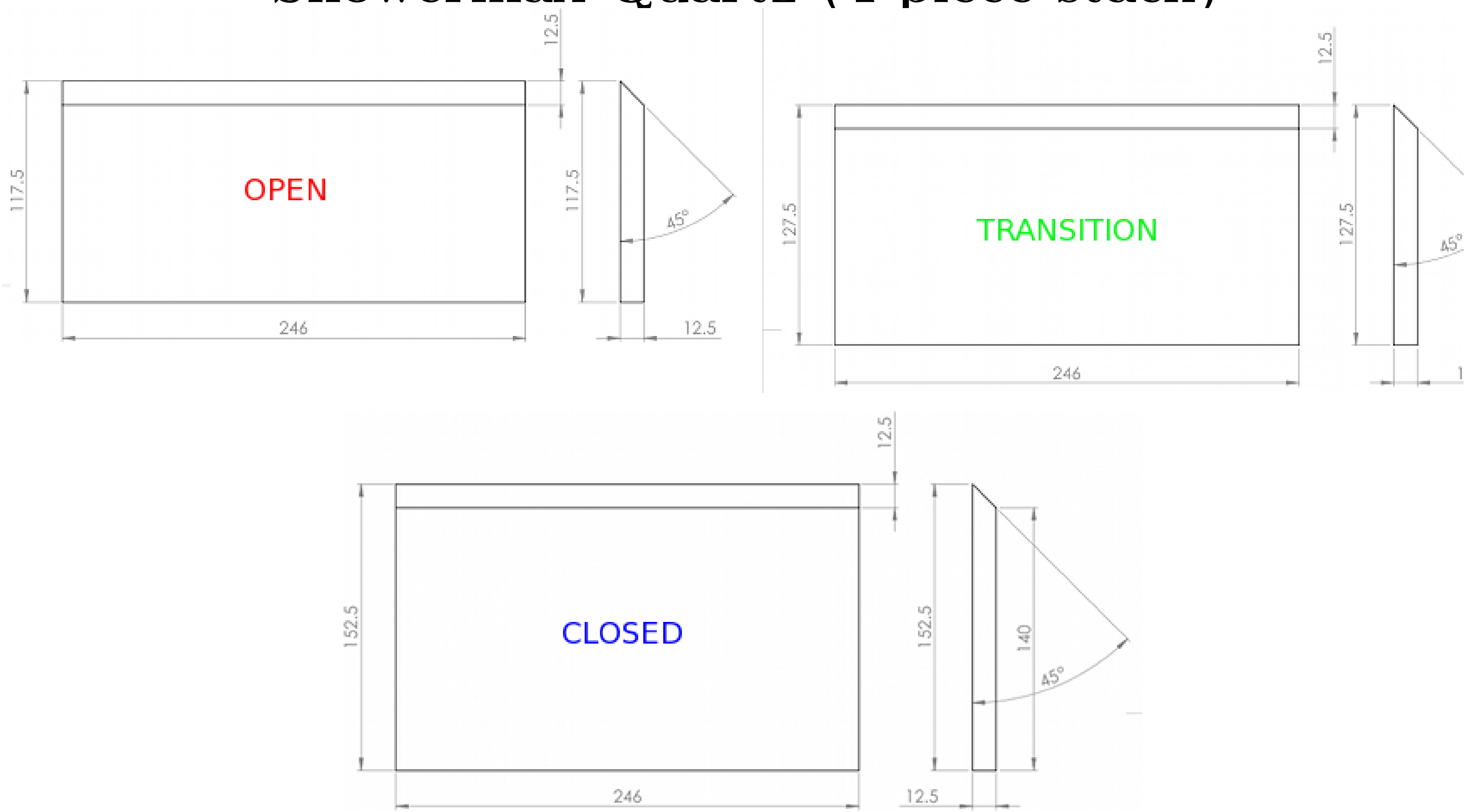






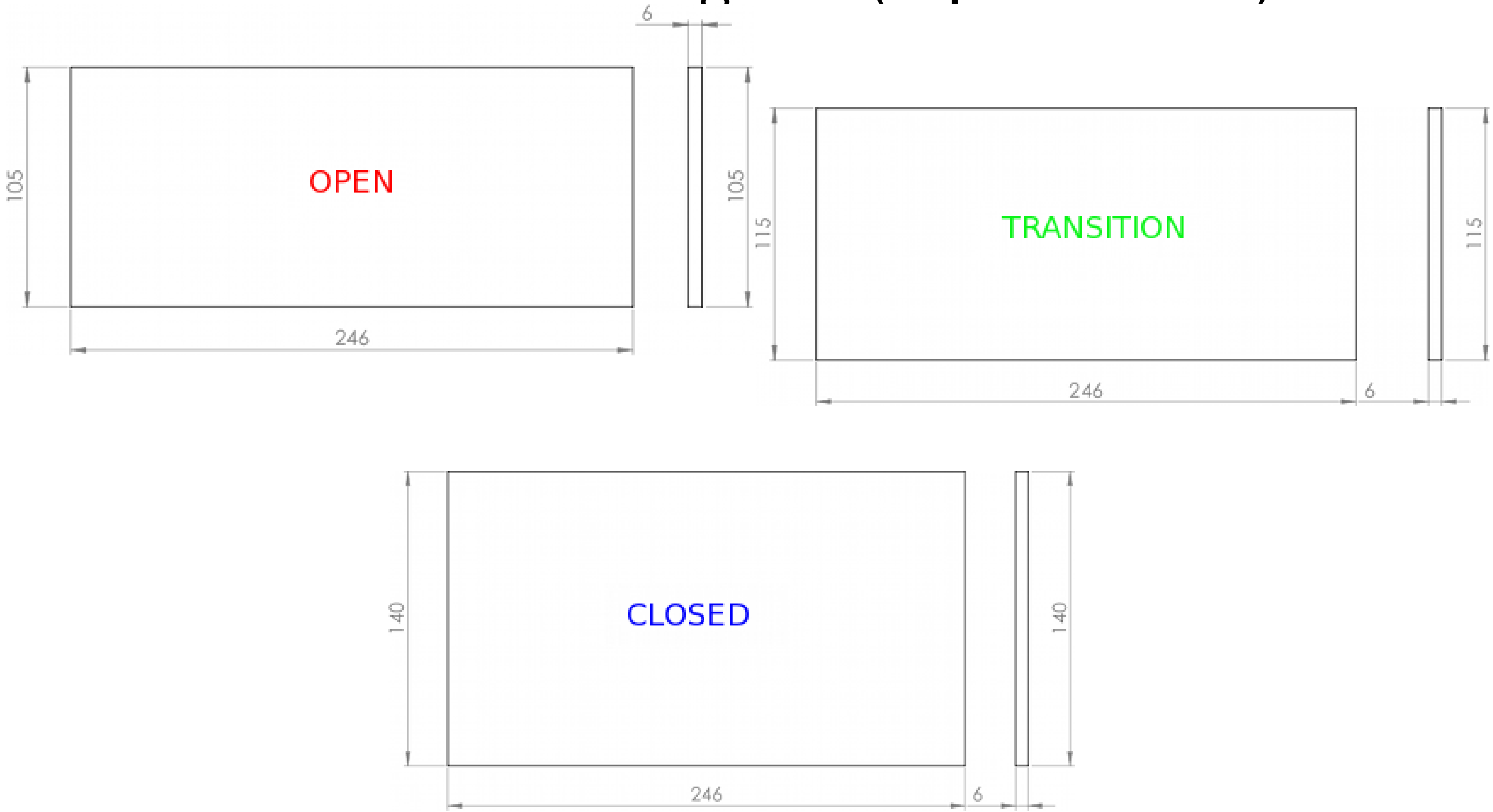
- 4 pieces quartz (each 12.5mm thick): 0.41 X_0
- 4 pieces tungsten (each 6mm thick): 6.8 X_0
- 25 cm Miro-silver LG; 3" PMT. *Note: center sampling, new QE*

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. Waiting for price quote from Heraeus for 31 OPEN, 31 CLOSED, and 62 TRANSITION

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

Summary and Future Work

- Optical MC framework for showermax R&D established
  - –Will use simpler, single quartz detector prototype testbeam data to benchmark MC
- New baseline MOLLER showermax detector design (4 piece stack):
  - –Gives strong energy dependent light yields with $\sim 25\%$ relative width
  - –Much cheaper than 10 piece stack with no loss in performance
- Will continue studying and optimizing baseline design
- Build prototype and test with beam