New Hall A Small Angle Monitors (SAMs)

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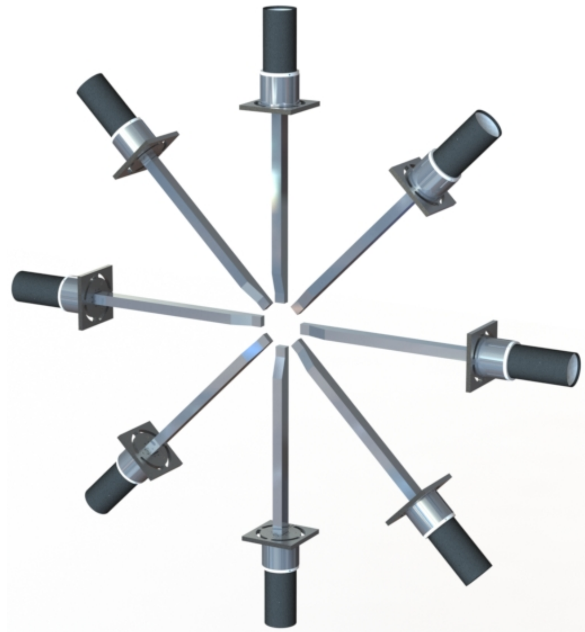
Outline

- Motivation and re-design
- Prototype and testbeam results
- Final design and installation
- Simulated Rates for Parasitic tests
- Summary and Plans

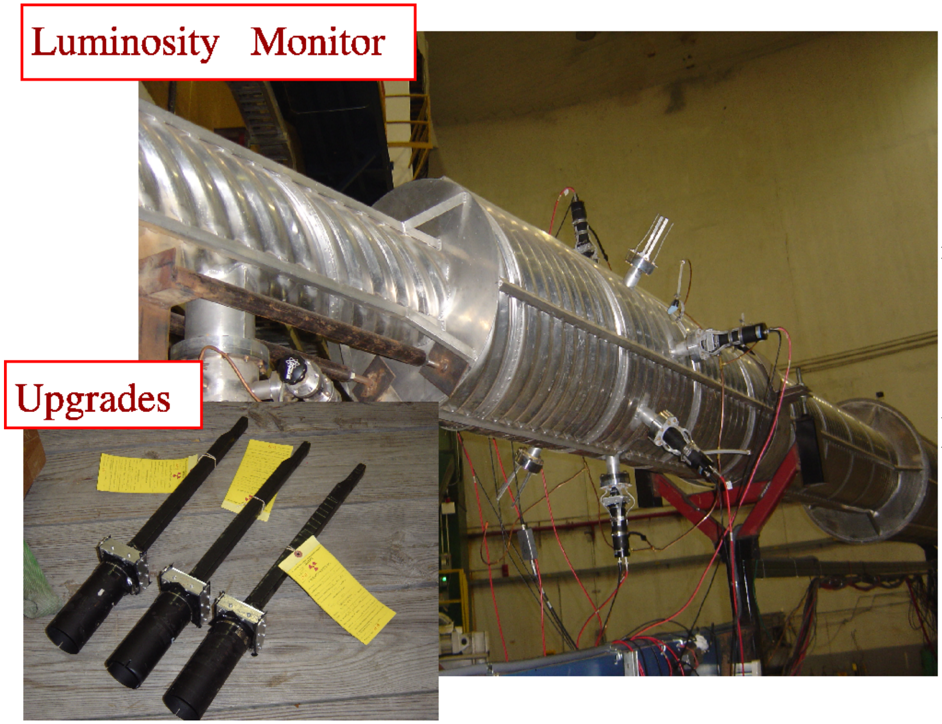
Motivations for Downstream Lumi's or SAM's

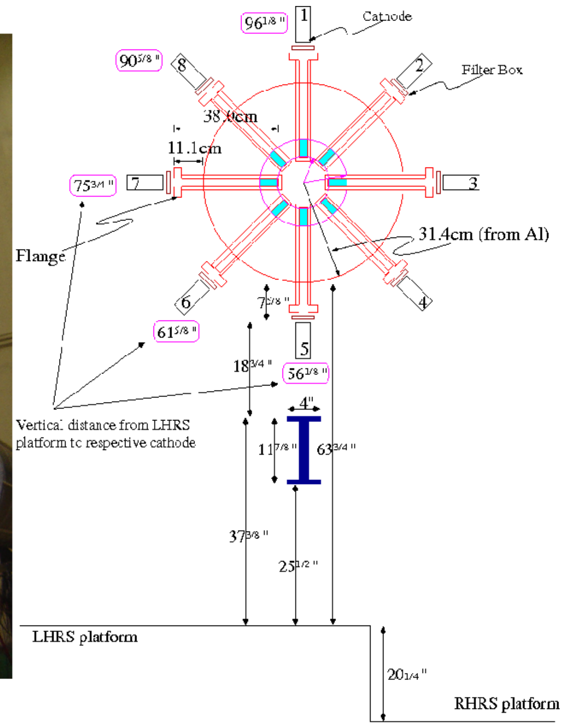
- Need them for their high sensitivity to helicity-correlated beam parameters
  - Detect charged particle flux at extreme forward angles
  - Very high rates and thus narrow pulse-pair widths – powerful diagnostic tool



- 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

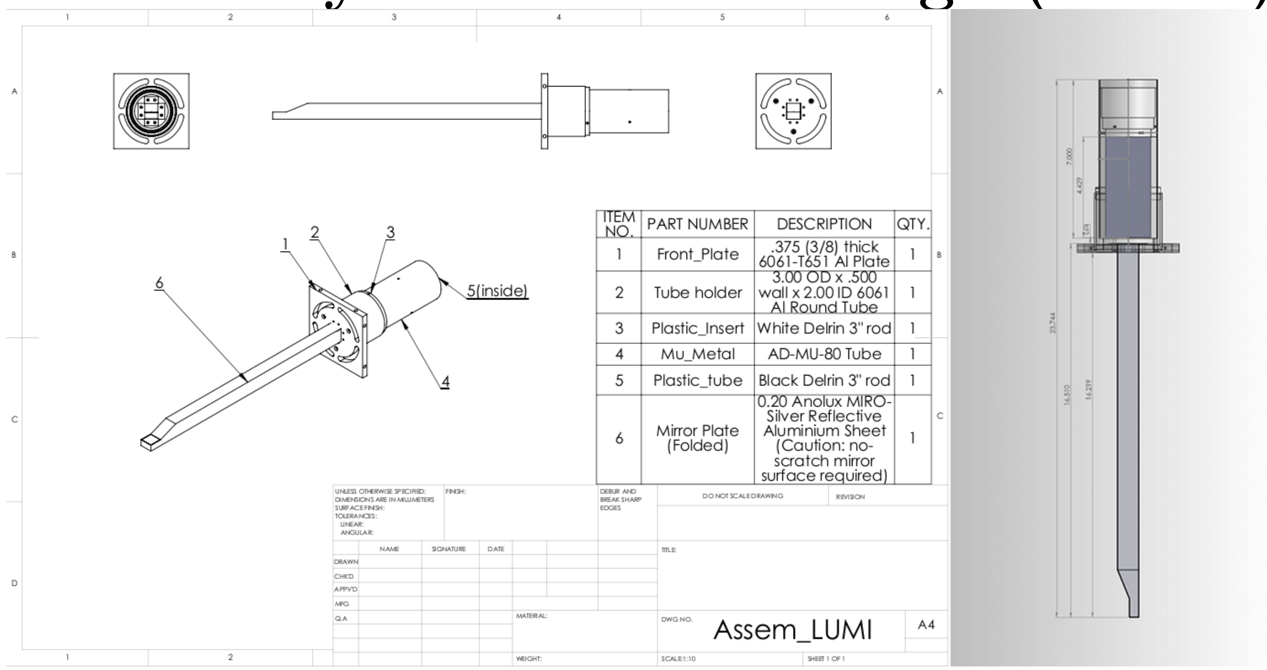
Old Hall A Luminosity Monitor





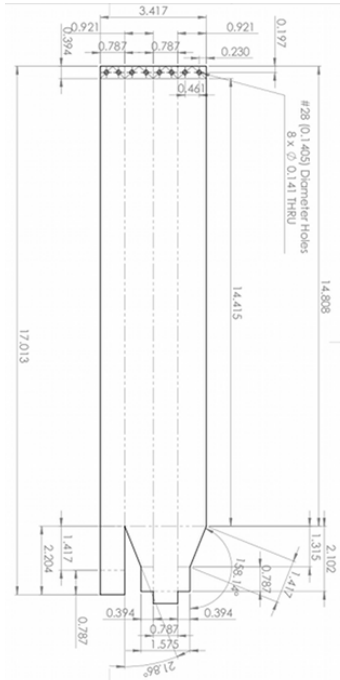
- Conceptual Design 2002–Riad Suleiman; refurbished in 2008
- 8 quartz Cherenkov detectors with air-core light guides placed symmetrically around beam line 7m downstream of pivot
- Used $6.0 \times 2.0 \times 1.0\ \mathrm{cm}^3$ quartz placed 4.5 cm from beam center $\Rightarrow$ 0.3 - 0.8 deg polar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

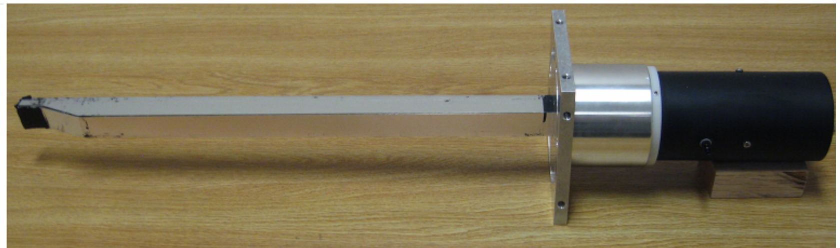
Luminosity Monitor Re-design (SAMs)

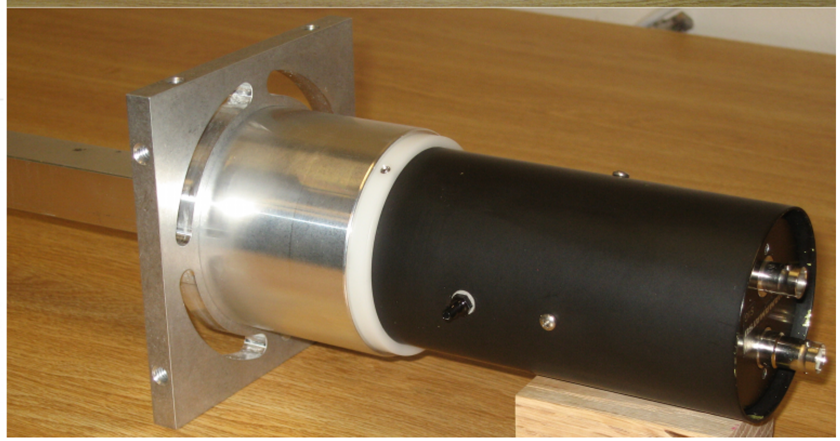


- Incorporate Qweak's downstream Lumi experience:
  - –Use pre-radiator and "unity gain" PMT
  - –Use radially smaller, but thicker quartz
  - –May achieve desired linearity at anticipated photocathode currents, but running unity gain mode guarantees it
  - –Use TRIUMF preAmps at SAM for signal cond.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

Prototype SAM for MAMI Testbeam (May 2015)

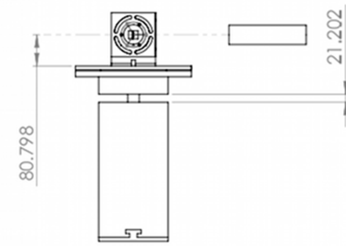


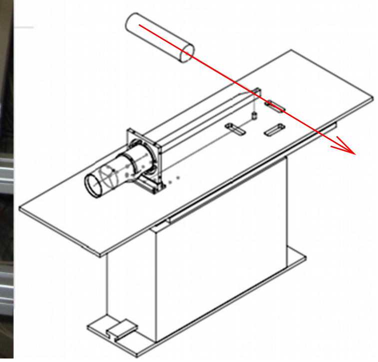




- Using 2” Hamamatsu R375 (multi-alkali, 10 stage) + E1435-02MOD unity gain base housed in mu-metal shield
- Anolux Miro-27 light guide; N_2 purge/flush
- Spectrosil 2000 quartz: $3.0 \times 2.0 \times 1.0$ cm^3 (prototype)
- Tungsten: $2.0 \times 2.0 \times 1.0/1.5$ cm^3; Aluminum and Delrin frame

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*)

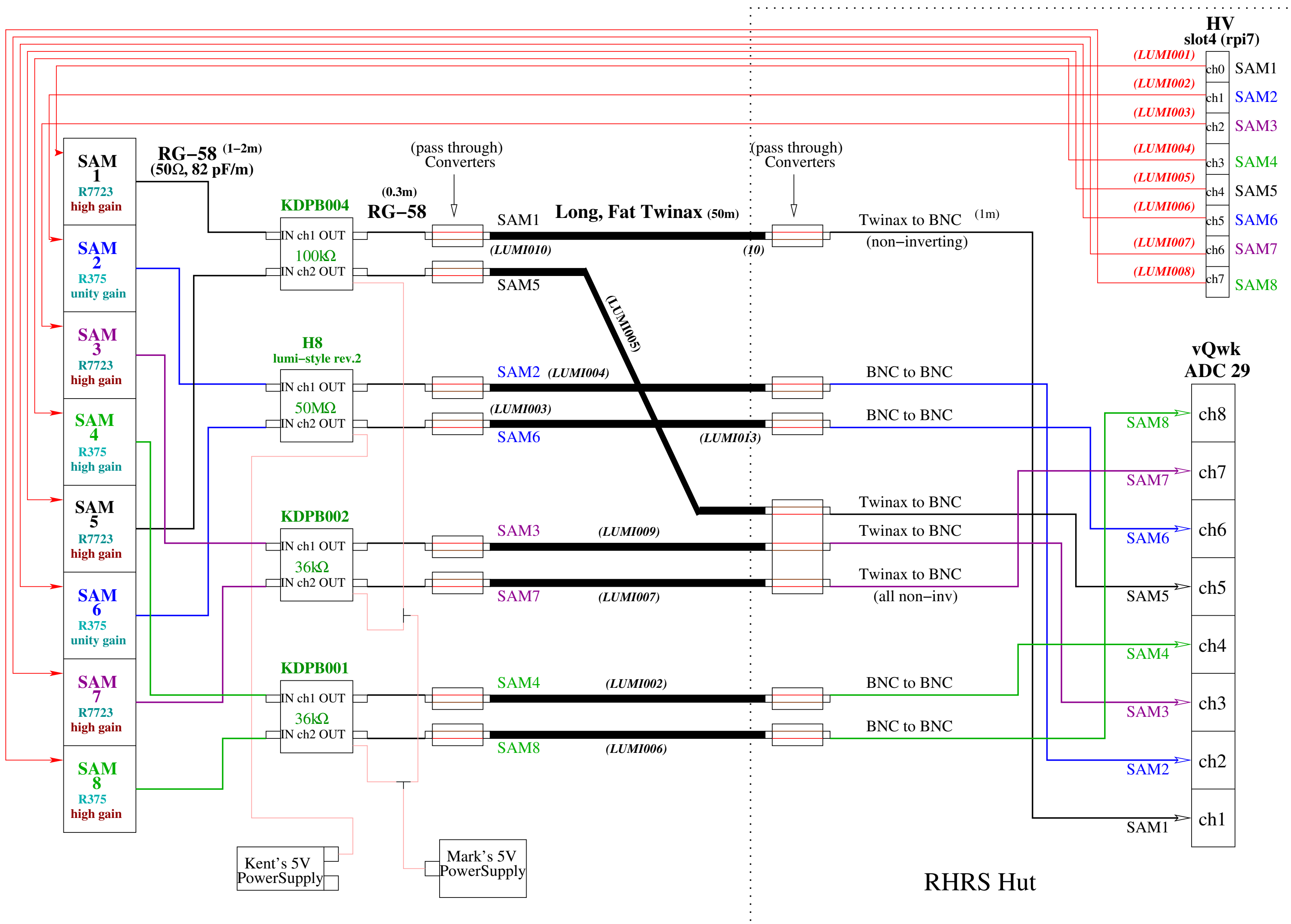
Improvements over prototype:

- 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

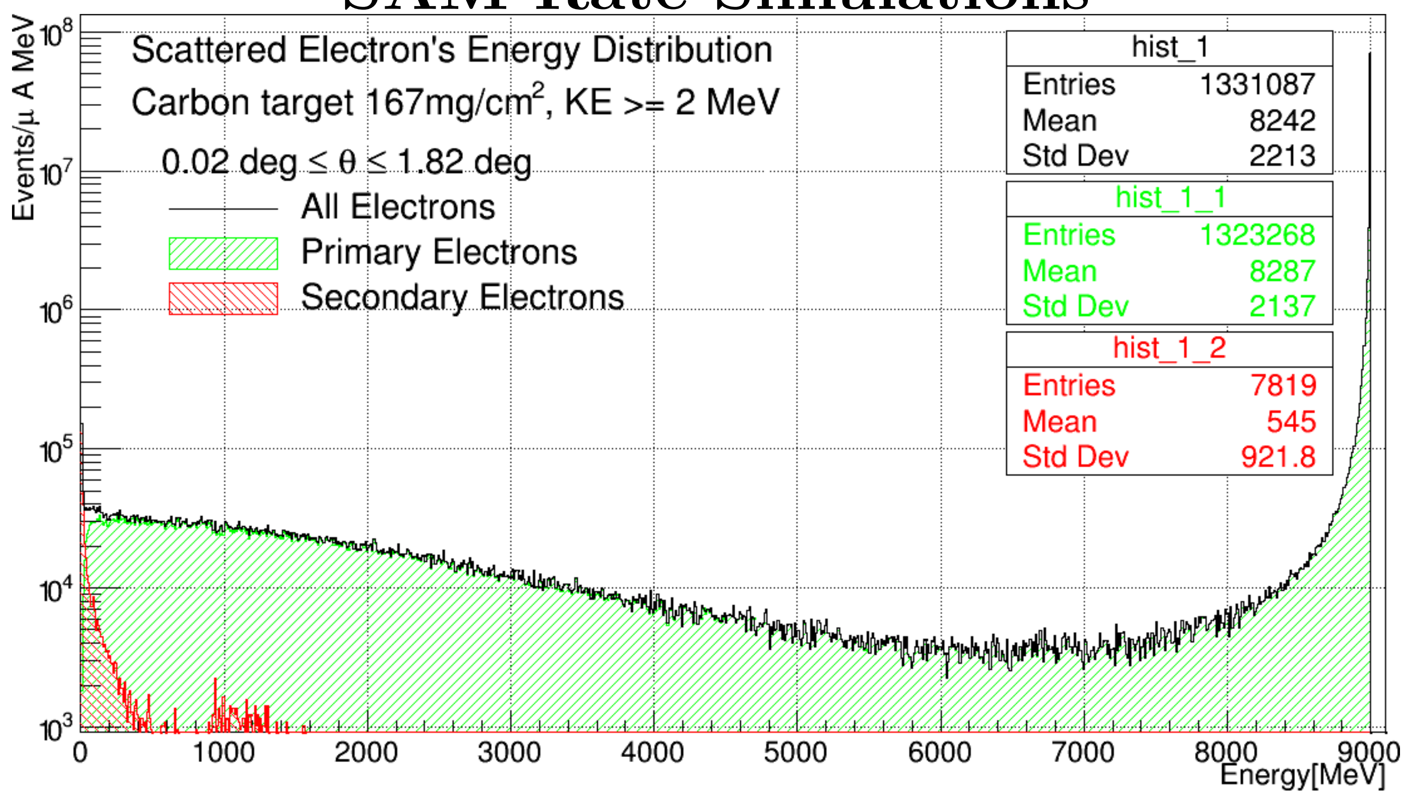
SAM Assembly (Nov 2015)

SAM Installation (Dec 2015)

SAM configuration (Jan 2016)

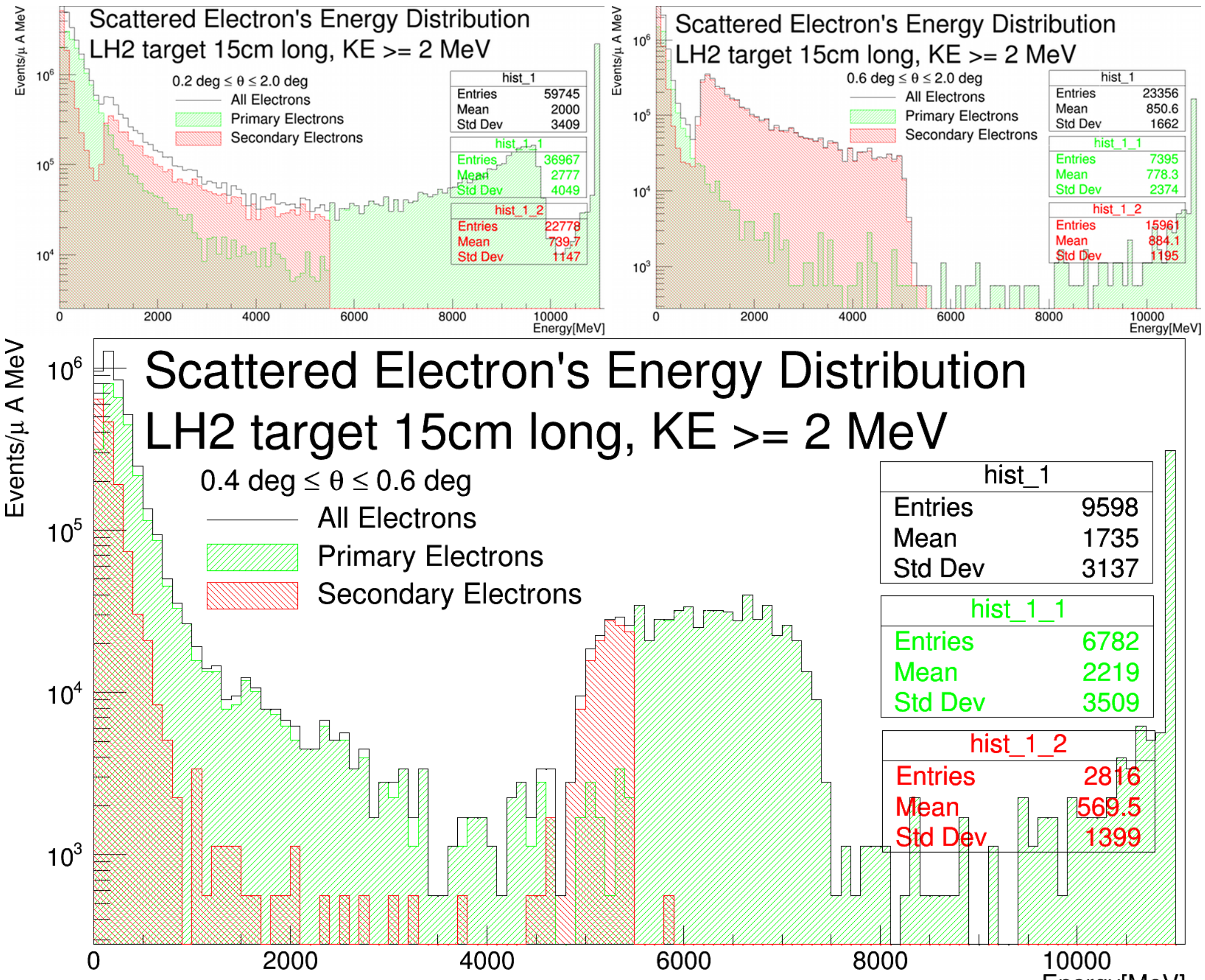


SAM Rate Simulations



- 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

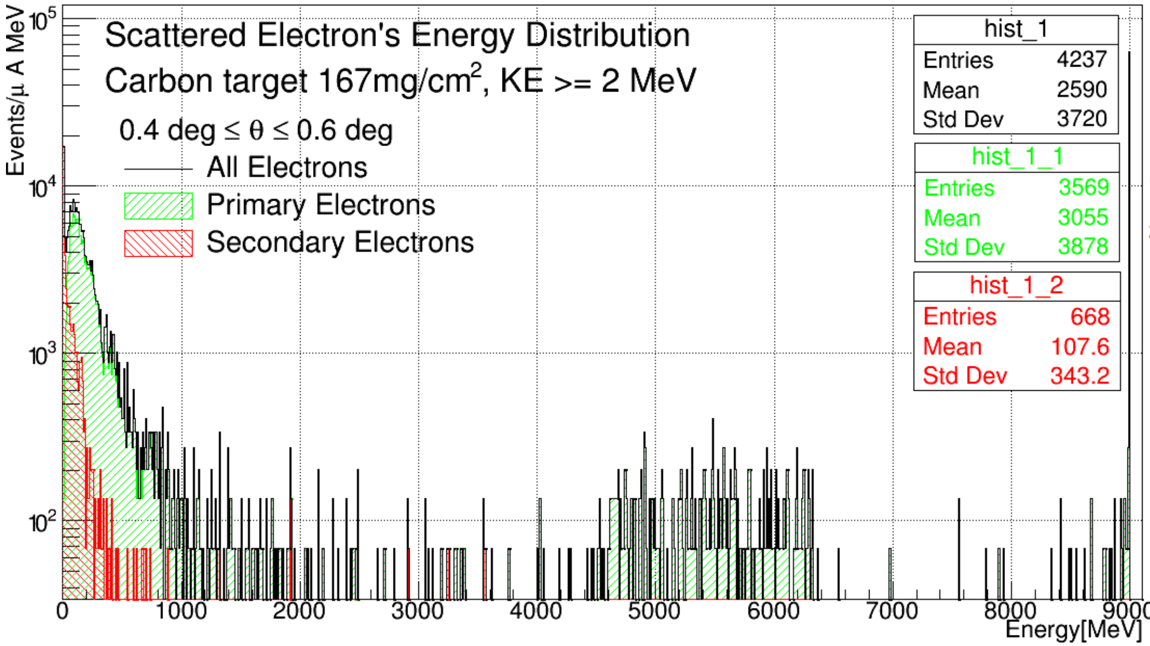
Simulated SAM Rates for DVCS Parasitic Tests

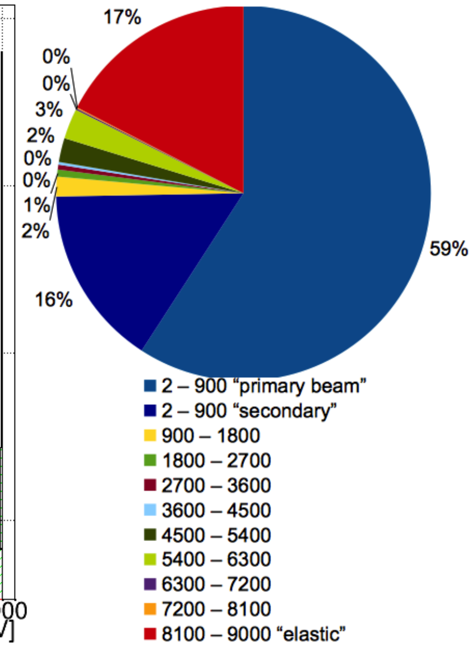


Results from new G4 SAM simulation run for 15 cm LH_2 target and 11 GeV beam with 2 by 2 mm^2 raster: Rate per SAM per μA is ~80MHz

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

Simulated SAM Rates for 167mg Carbon at 9GeV





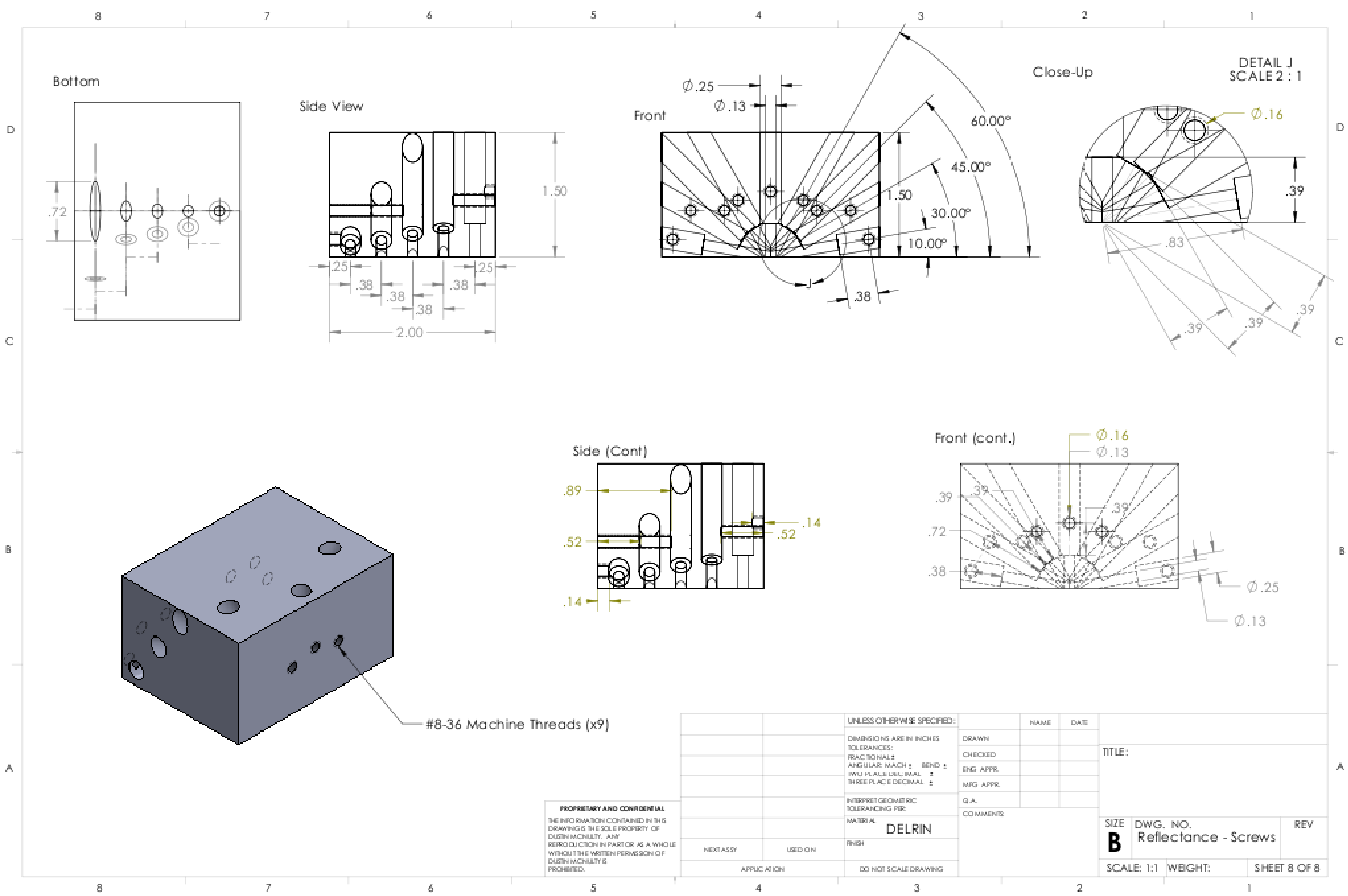
- Results for 9 GeV pin-point electron beam on 167 mg C target
- 10^8 beam electrons thrown; results are scaled to give events/uA
- SAM polar angle accept. estimated to be from 0.4 to 0.6 degree
- Rates calc using sim results and estimated azimuthal accept.
- $\sim$260 MHz/μA/SAM with over 75% of rate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

Summary and Plans

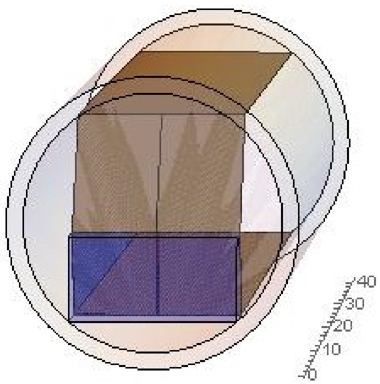
- New downstream Lumis (SAMs) constructed and installed
- Present configuration gives flexibility for upcoming DVCS parasitic tests (see Caryn's talk next)
- Will take spare SAM to Mainz for PE yield calibration, pre-radiator, and LG study
- Will characterize LG reflectivity for $\theta = 10, 30, 45, 60; 90$ deg and 200nm $< \lambda <$ 800nm. Complete apparatus in hand. More on this next time (mostly for MOLLER detector LGs)

Extra Slides

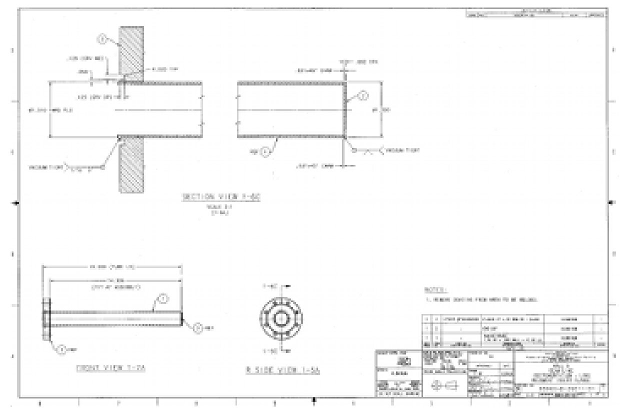
LG Reflectivity Measurement Stand

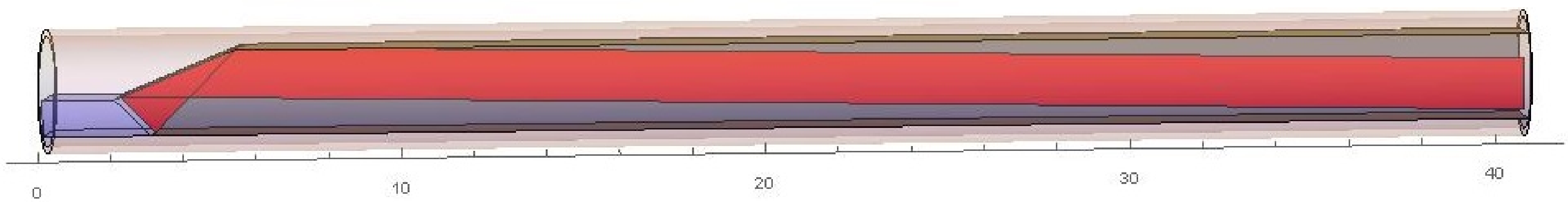


Lumi v1 Lightguide Design (Prototype SAM)



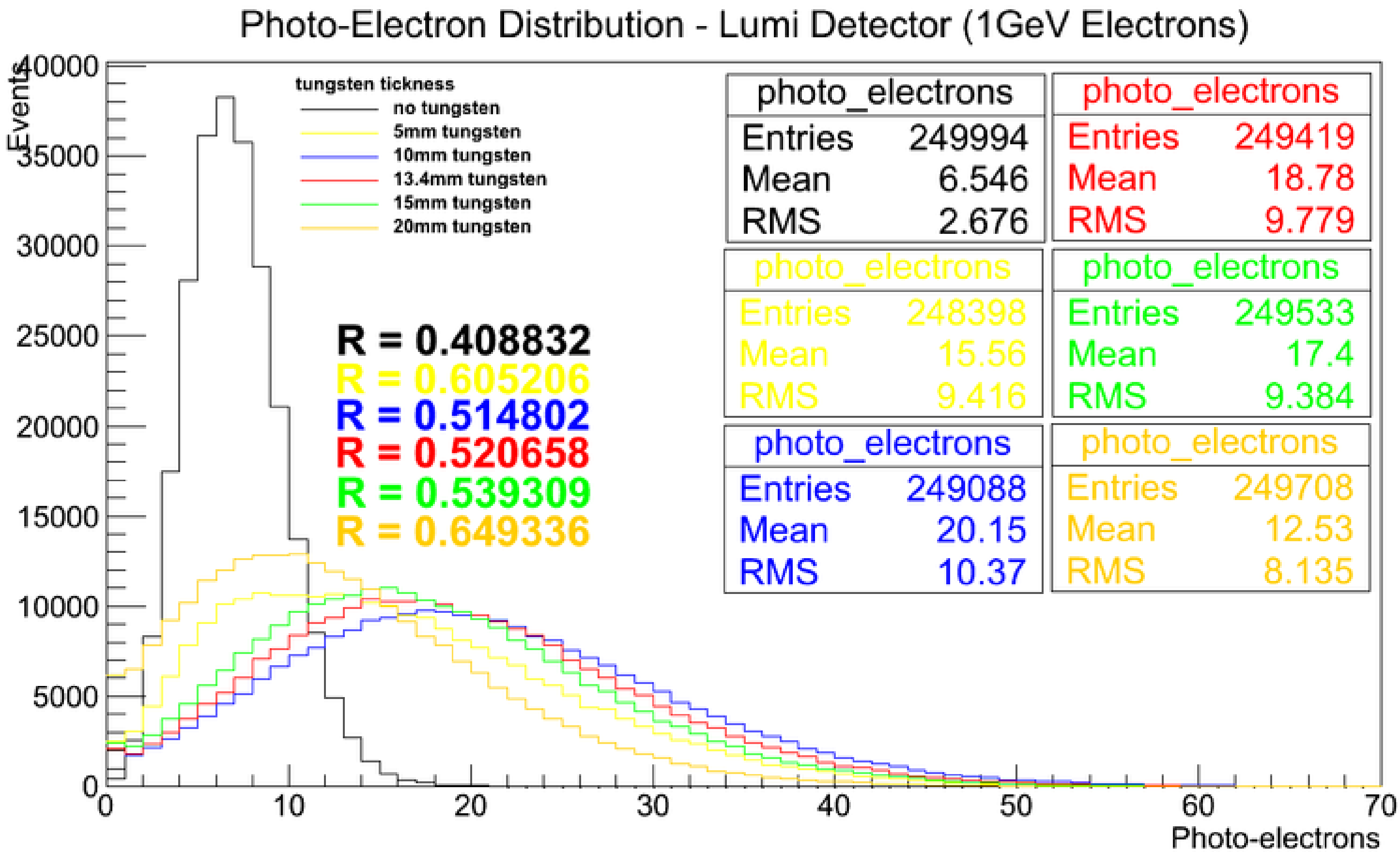
R = 1.54 cm
Quartz Dimensions:
Small Face 2x2 cm
Big Face 2x3 cm
Thickness 1 cm
Total Length 41 cm

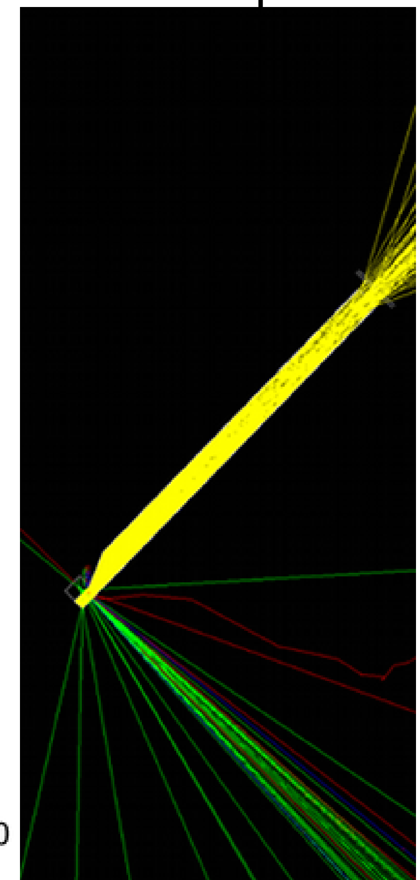




- Constraints of existing beam pipe insertion tubes...light guide is long and narrow
- Optimized? one-bounce design

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