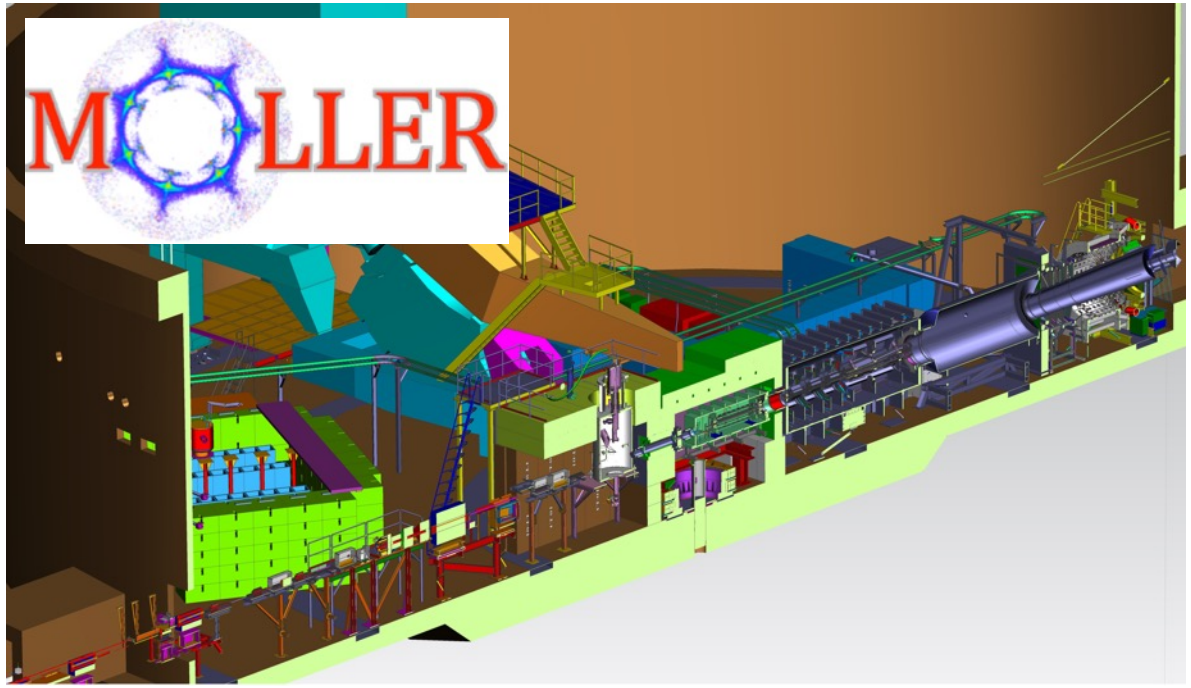
SBM and Scanner Detectors Quartz and PMT Purchases

Presentation for MOLLER Technical Board,
July 30, 2024



Mark Pitt
Virginia Tech

Jefferson Lab

NSF

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

Request

We are requesting approval for the final procurement of phototubes and quartz for the Scattered Beam Monitor and Scanner Detector systems

- Electron Tubes 9305QKB, 3 inch, bialkali photocathode, fused silica window, 10 stages
  - Same as used for main detectors and shower max detectors
  - To be used for large angle monitors, diffuse beam monitors, and scanners
  - Order for 52 tubes ~ $86k

- Hamamatsu R375, 2 inch, multialkali photocathode, fused silica window, 10 stages
  - Used successfully for small angle monitors during Qweak and PREX/CREX
  - To be used for the small angle monitors
  - Order for 10 tubes ~ $16k

- Quartz (fused silica) from vendor Beijing HYRD Photonics, Co., Ltd.
  - Same vendor as Dustin McNulty has successfully used
  - Four different types of pieces, total order ~ $23k

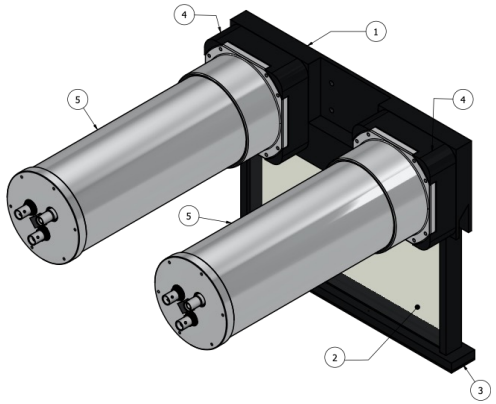
Outline

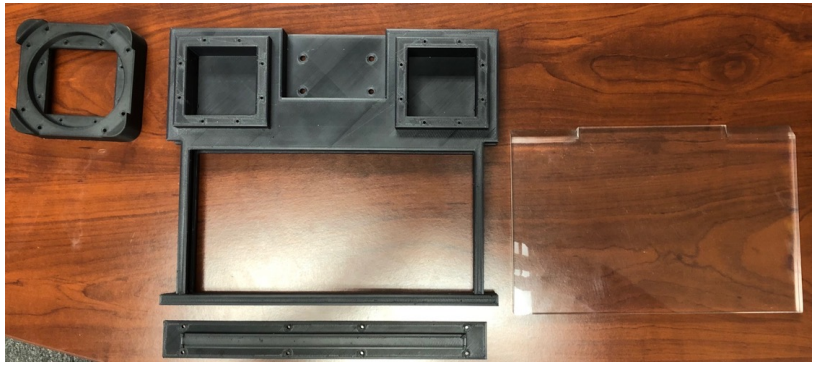
- Brief overview of Scattered Beam Monitor and Scanner subsystems
- Performance results of the required four different geometries of HYRD Photonics Co. Ltd. Quartz pieces
- Justification for the phototube choices
- Review of request

Scattered Beam Monitor Detectors

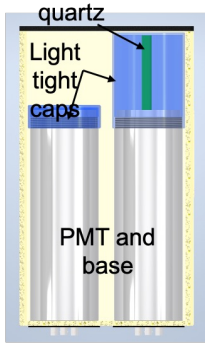
Purpose: Monitor potential false asymmetries in reducible background that results from the primary scattered beam interacting in downstream collimators, beampipes, and shielding. Locate in regions of high flux/small physics asymmetry and where flux from primary target is small.

LAM (large angle monitor) detectors (7): 25 x 16.5 x 1 cm^3 quartz radiator read out by two 3 inch PMTs

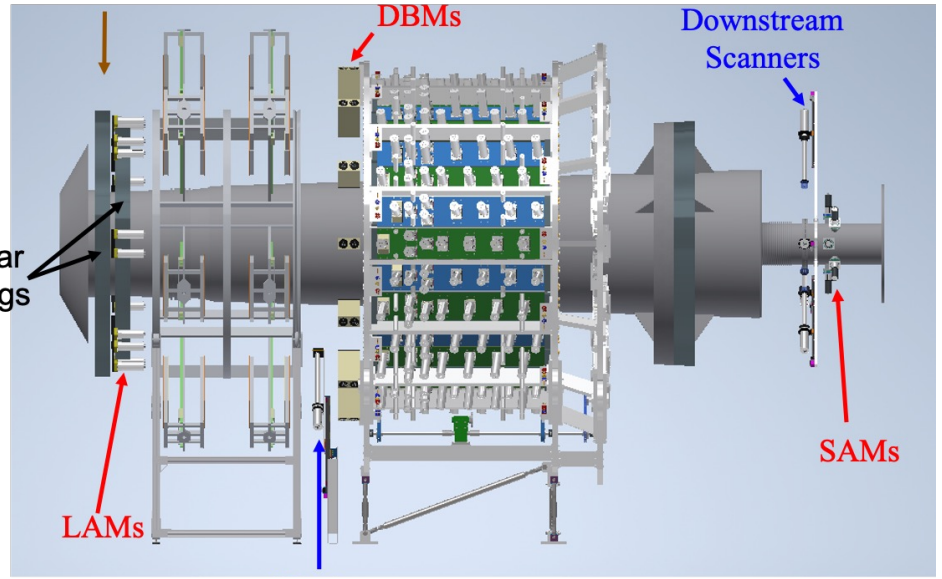




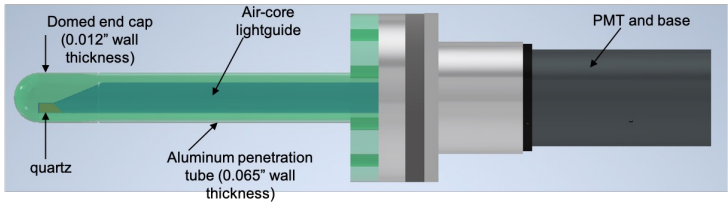
DBM (diffuse beam monitor) detectors (14): Bare PMT and PMT + quartz



Barite wall not shown



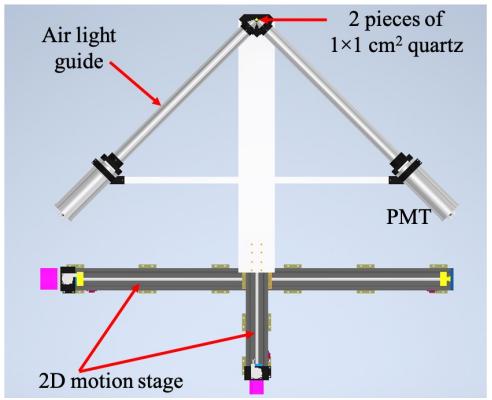
SAM (small angle monitor) detectors (8): Small quartz block, air-core light guide, 2 inch PMT detecting at small (0.1°) lab scattering angle

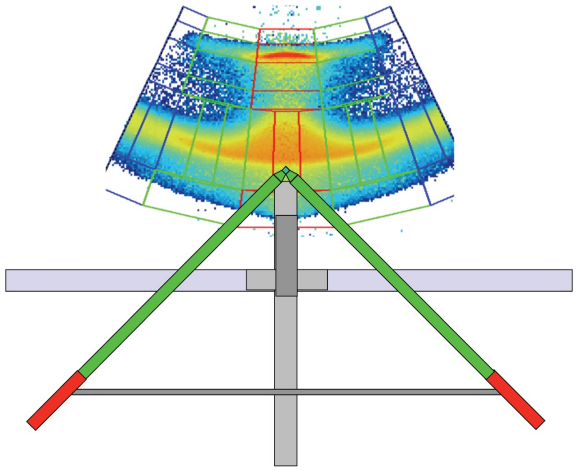


Scanner Detectors

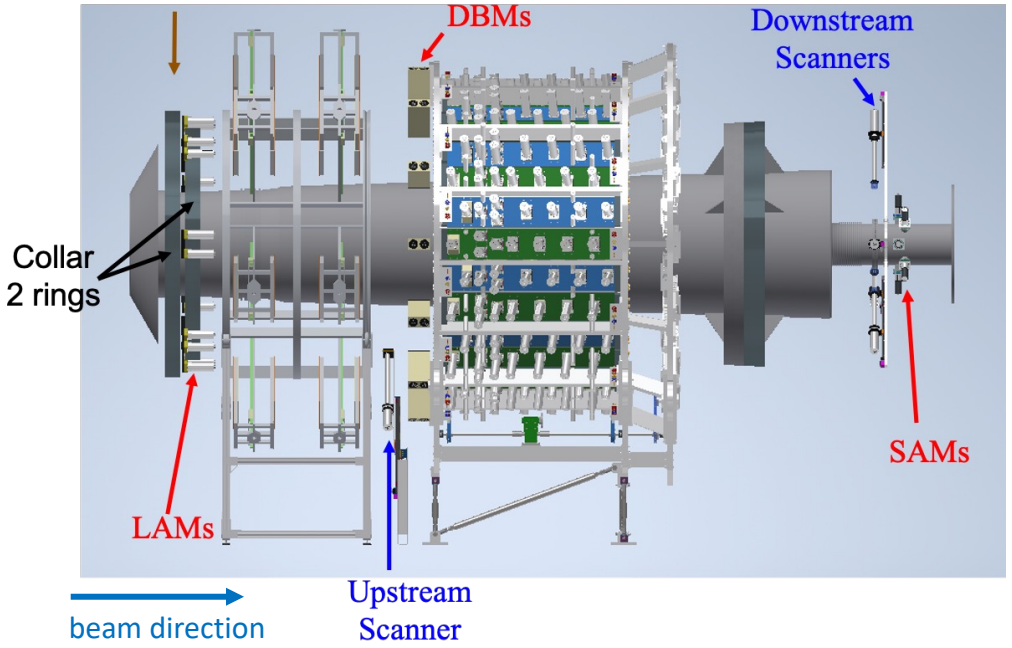
Scanner detectors will be used to measure the 2D scattered profile (at all beam currents) in one septant and to measure the radial beam profile at a location sensitive to the alignment of the primary collimator.

Upstream scanner: 2D profile scanner in one septant

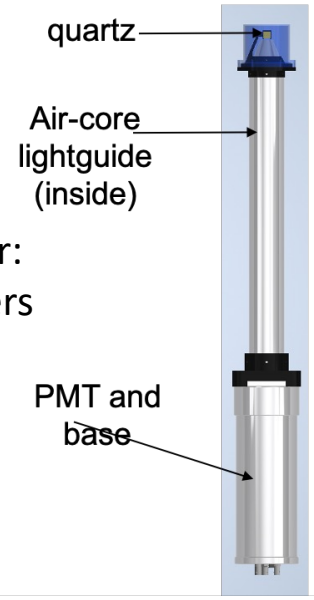




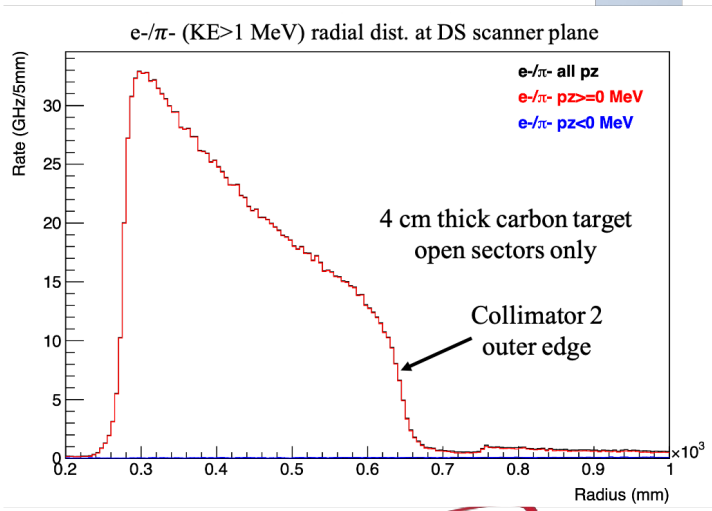
Barite wall not shown



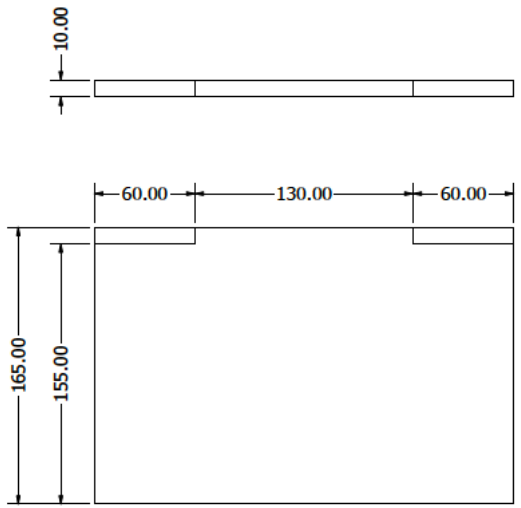
Prototype parts for scanner detectors

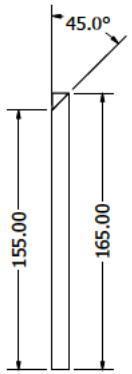


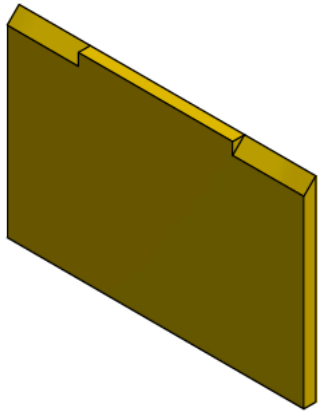
Downstream scanner: four identical scanners that scan radially

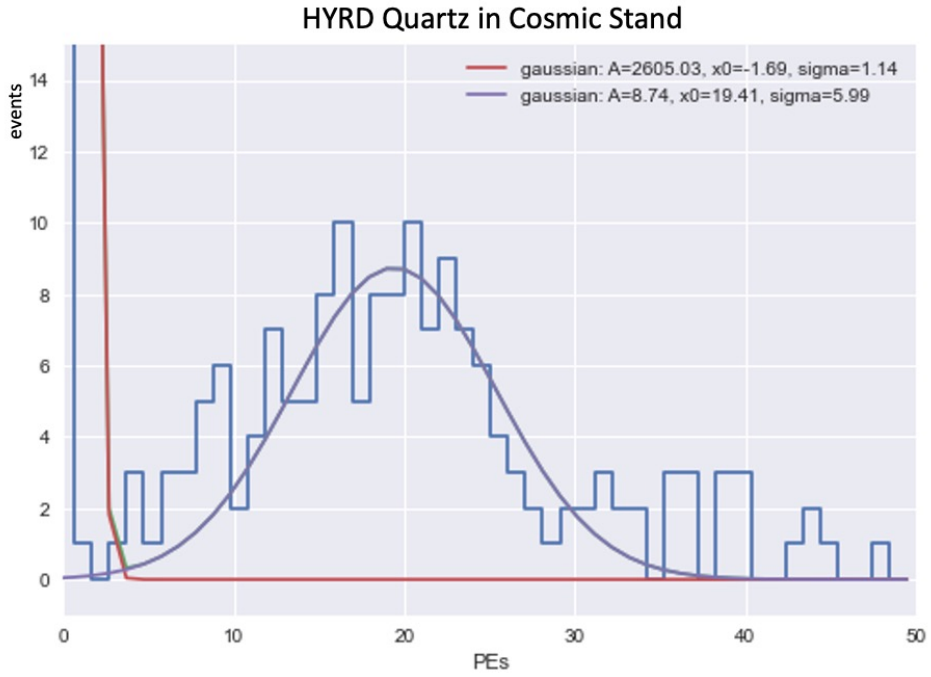


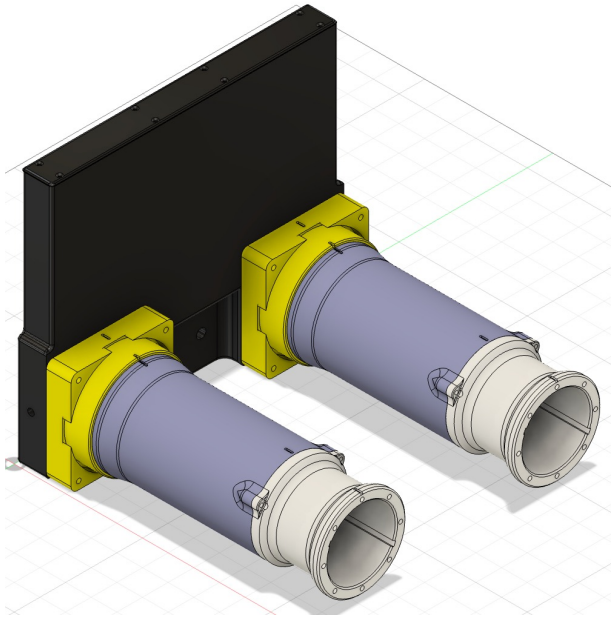
Large Angle Monitor Quartz







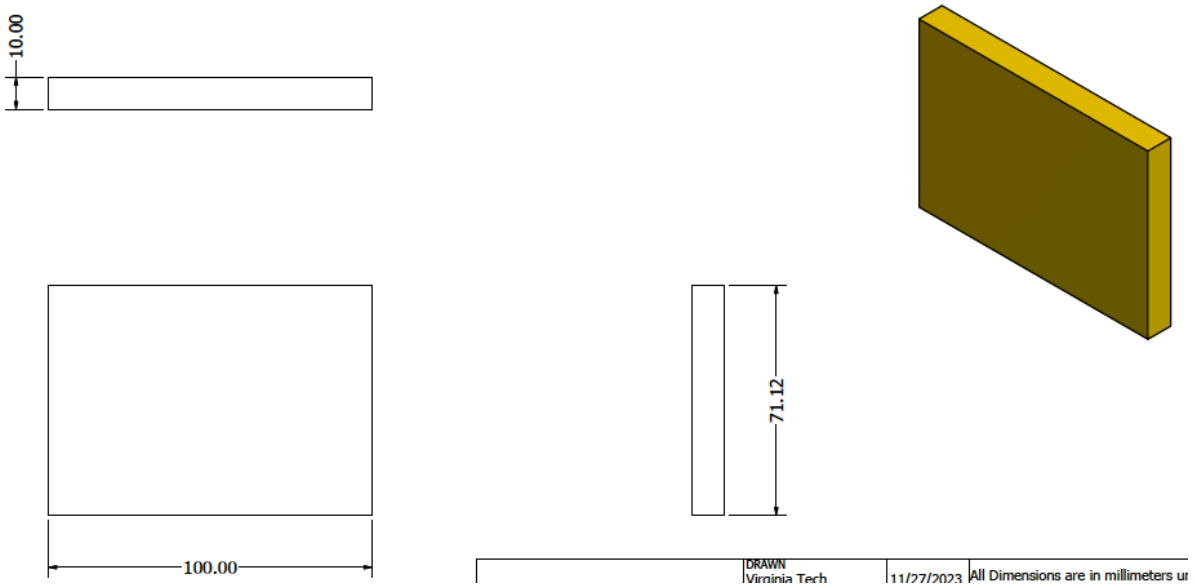


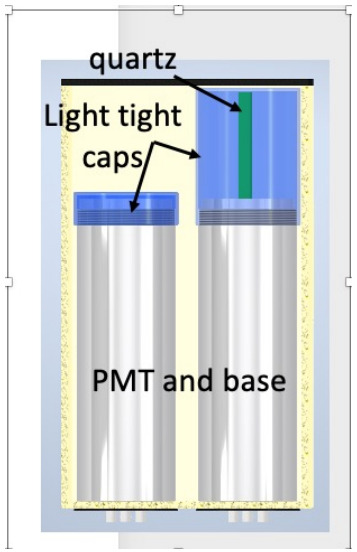


Cosmic test stand results:

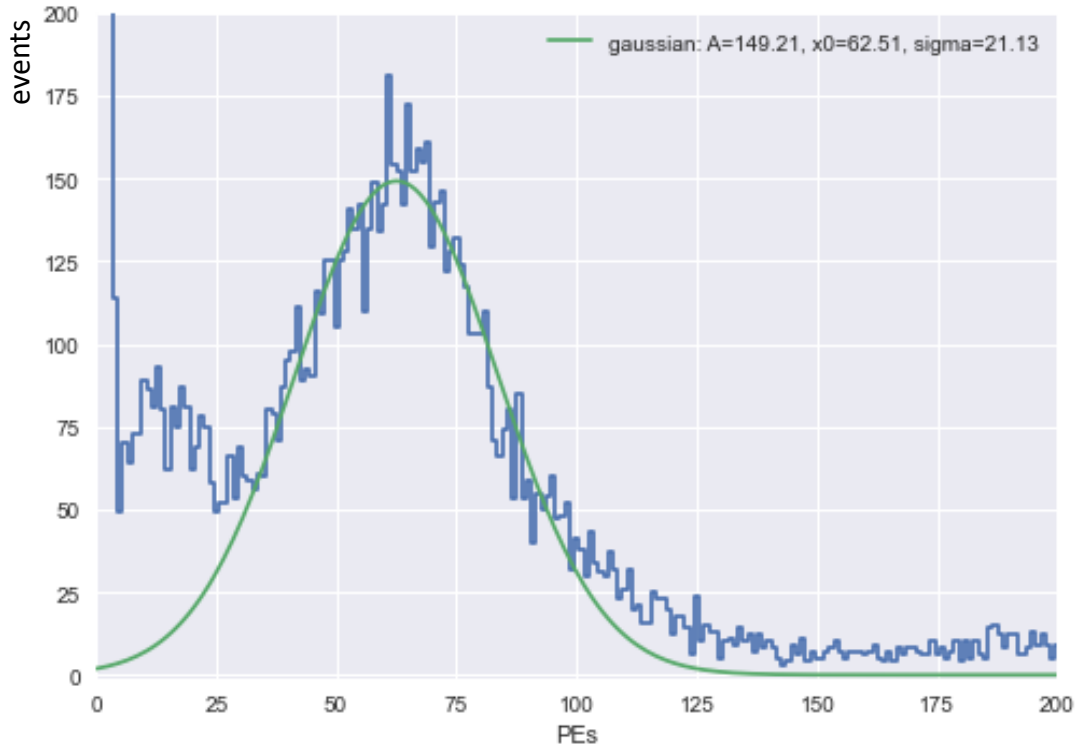
- 21 PE/event $\sigma/\langle PE\rangle \sim 28\%$ (when combining both tubes)
- Goal > 10 PE combined

Diffuse Beam Monitor Quartz





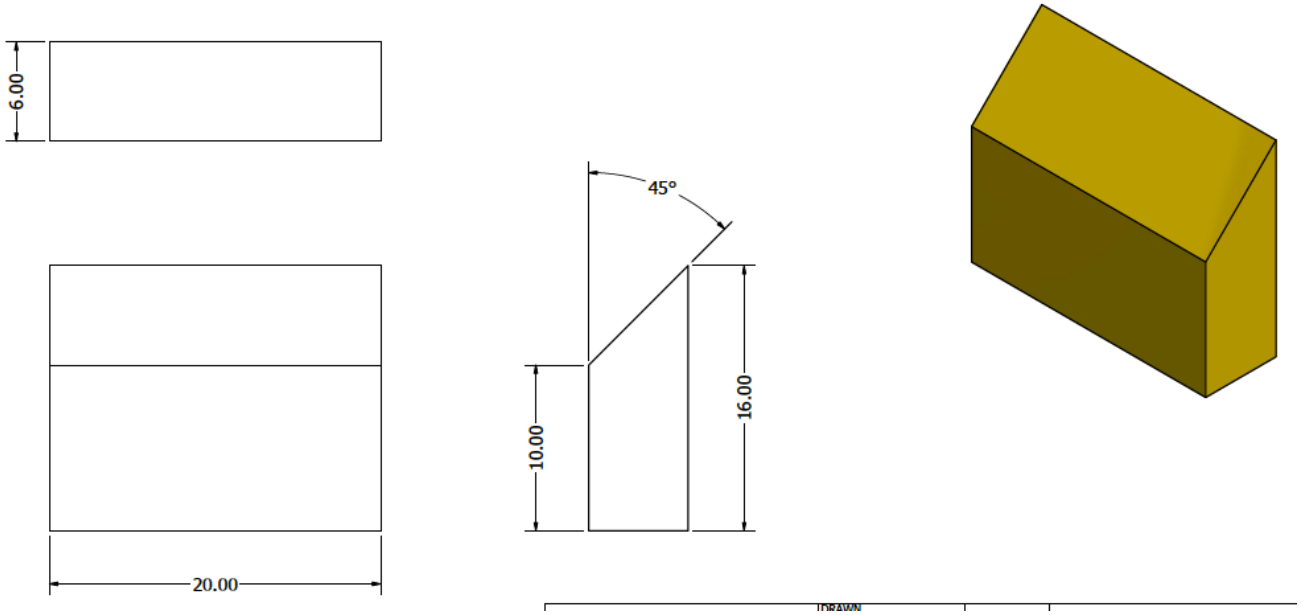
HYRD quartz in Cosmic Stand

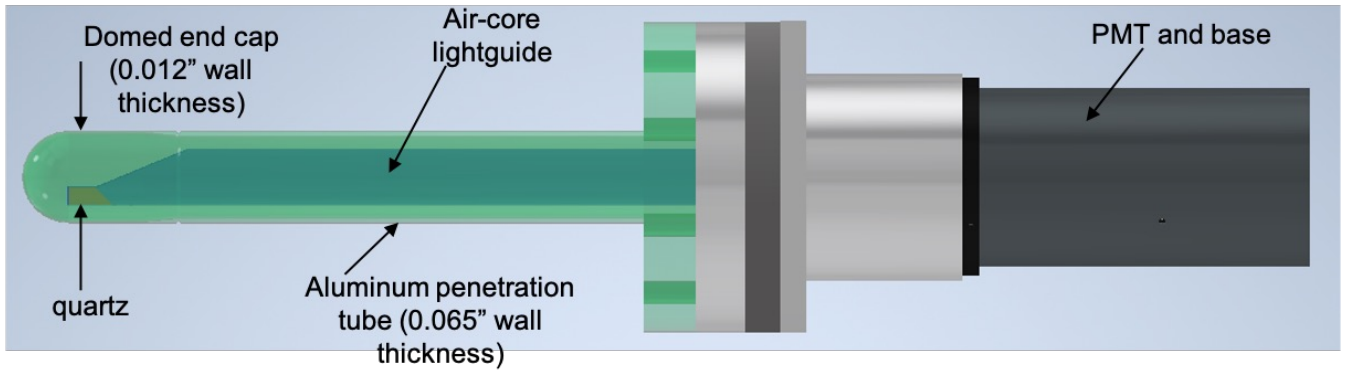


Cosmic test stand results:

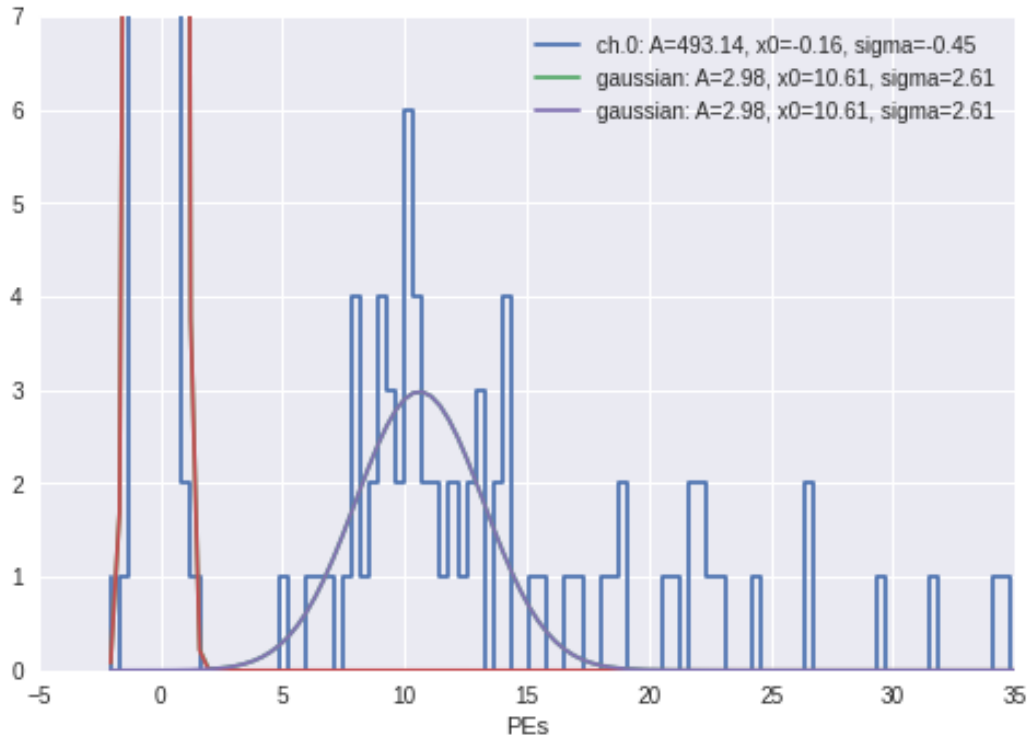
- 60 PE/event $\sigma/\langle PE\rangle \sim 35\%$
- Didn't have a particular goal for this one since we knew the yield would be large

Small Angle Monitor Quartz





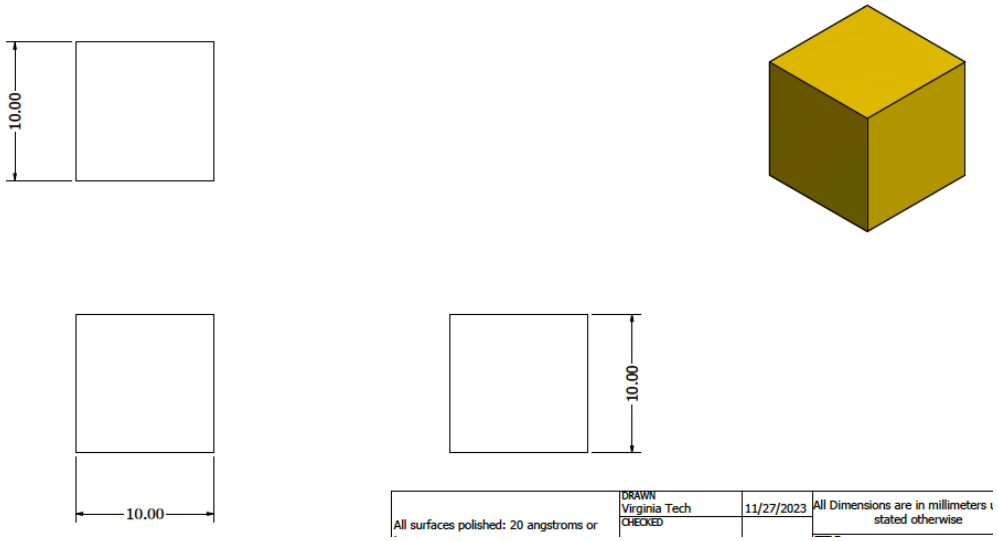
HYRD quartz in Cosmic Stand

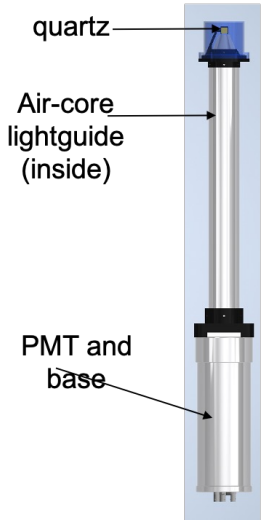


Cosmic test stand results:

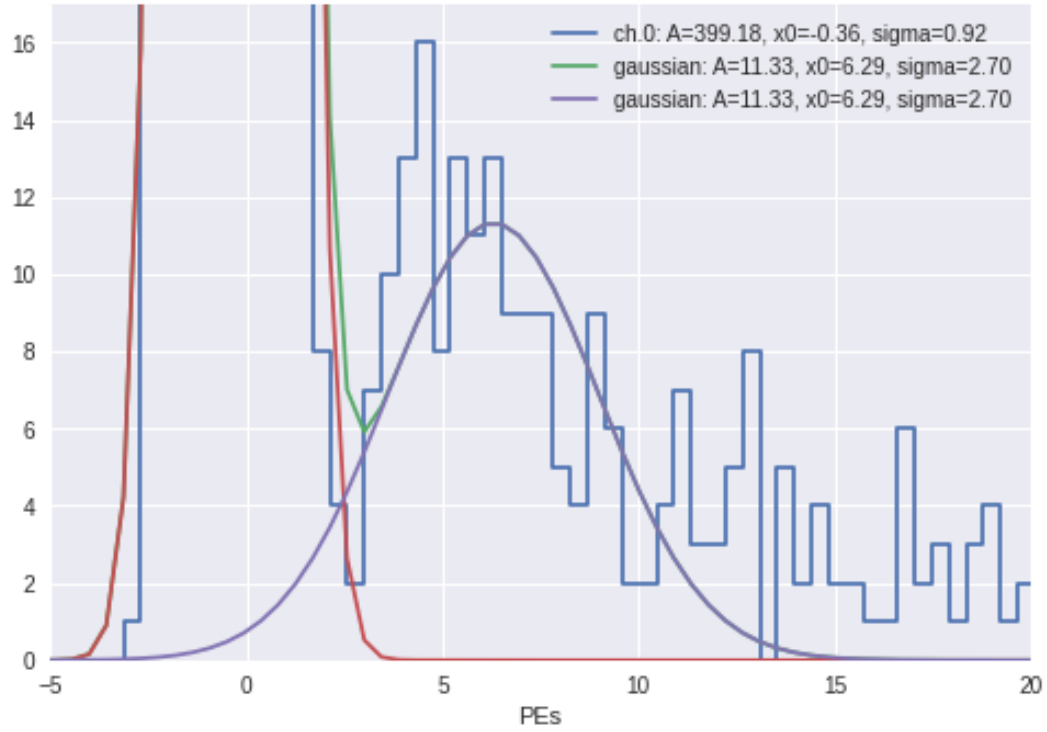
- 10 PE/event
- Goal > 5 PE/event

Scanner Detector Quartz





HYRD quartz in Cosmic Stand



Cosmic test stand results:

- 6.7 PE/event $\sigma/\langle PE\rangle \sim 40\%$
- Goal > 5 PE/event

Phototube Choice

Detector	PMT type	PE	Rate (GHz)	I_cathode (nA)	PMT gain	I_anode (uA)	I-V gain (MOhm)	Vout (V)
SAM	R375, 2 inch	10	450	720	1	0.6	2.00	1.2
LAM	ET9305, 3 inch	10	4	6	781	5.0	0.50	2.5
US scanner	ET9305, 3 inch	5	0.170	0	14706	2.0	1.00	2.0
DS scanner	ET9305, 3 inch	7	1.390	2	2569	4.0	0.50	2.0
DBM	ET9305, 3 inch	60	0.036	0	11574	4.0	0.50	2.0
Ring 5	ET9305, 3 inch	25	5	20	500	10.0	0.25	2.5
QweakSAM	R375, 2 inch	60	150	1,440	1	1.4	4.00	5.76

Comments:

- We selected ET9305 tube for all detectors except SAM to be consistent with the choice for rest of experiment (main detectors and shower-max), particularly for the LAM and DBM

- For the SAM, it is run in unity gain mode, and there is a very high cathode current. We selected Hamamatsu R375 because it has been proven through Qweak and PREX/CREX experience to handle that cathode current without degradation.

Request

We are requesting approval for the final procurement of phototubes and quartz for the Scattered Beam Monitor and Scanner Detector systems

- Electron Tubes 9305QKB, 3 inch, bialkali photocathode, fused silica window, 10 stages
  - Same as used for main detectors and shower max detectors
  - To be used for large angle monitors, diffuse beam monitors, and scanners
  - Order for 52 tubes ~ $86k
  - Reason for choice: compatibility with main detectors and shower max
- Hamamatsu R375, 2 inch, multialkali photocathode, fused silica window, 10 stages
  - Used successfully for small angle monitors during Qweak and PREX/CREX
  - To be used for the small angle monitors
  - Order for 10 tubes ~ $16k
  - Reason for choice: demonstrated to handle the cathode currents we expect
- Quartz (fused silica) from vendor Beijing HYRD Photonics, Co., Ltd.
  - Same vendor as Dustin McNulty has successfully used
  - Four different types of pieces, total order ~ $23k
  - Prototype studies have shown they will provide the required light yields