Shower-max Requirements and Status

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Jefferson Lab MOLLER
CD-1 Review

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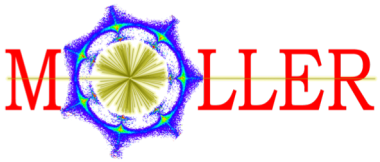

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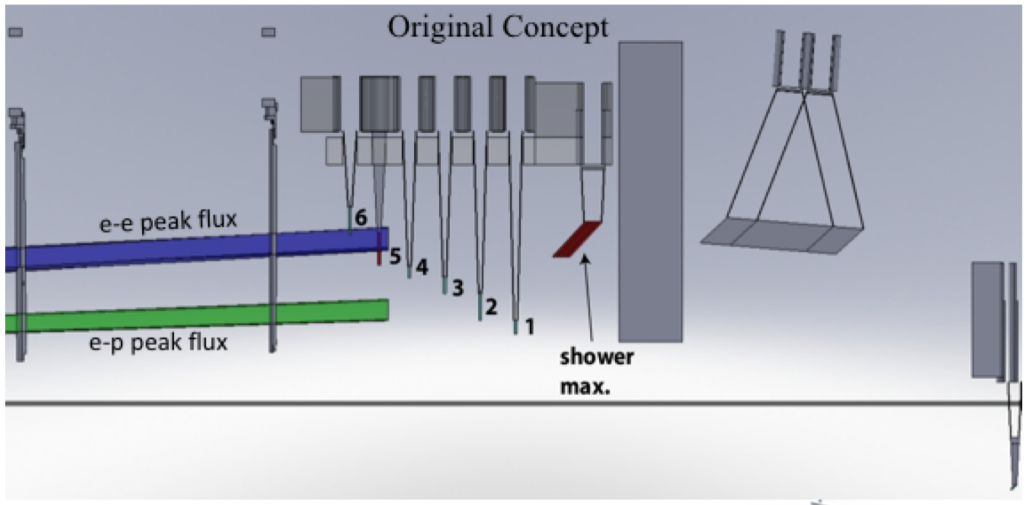
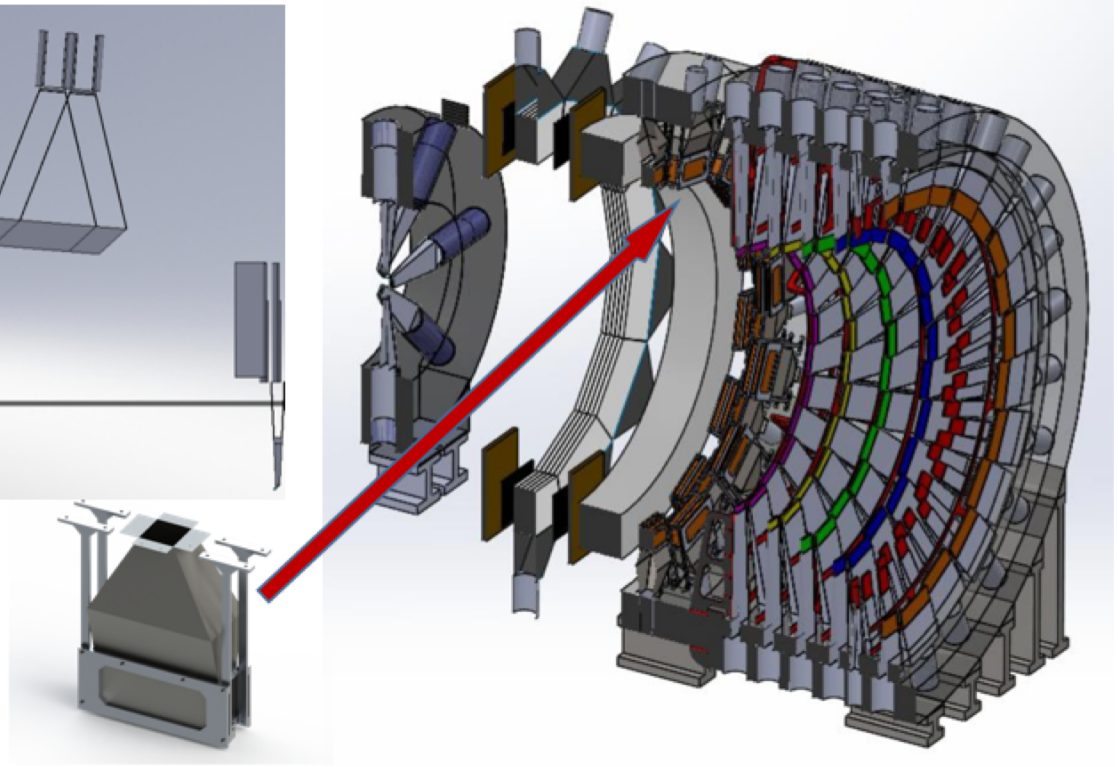
Outline

- System motivation and requirements
- Design Concept and Status
- Acceptances and resolutions
- Prototyping and initial testbeam
- Summary

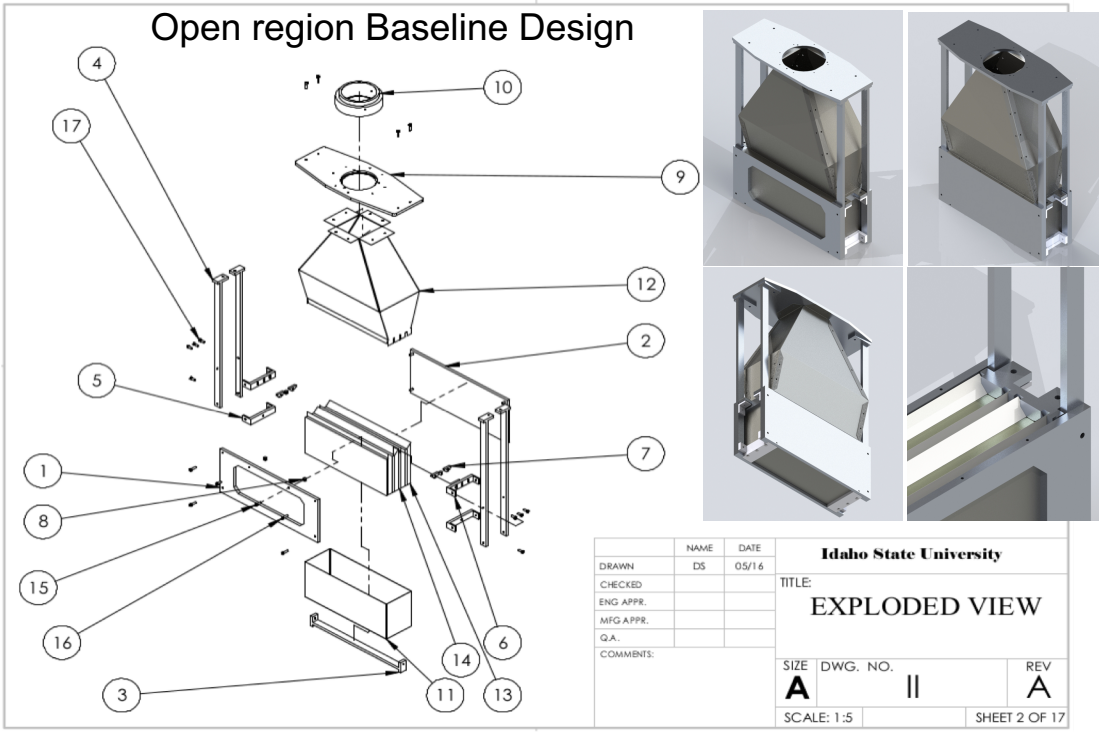
Shower-max: Motivation and Requirements

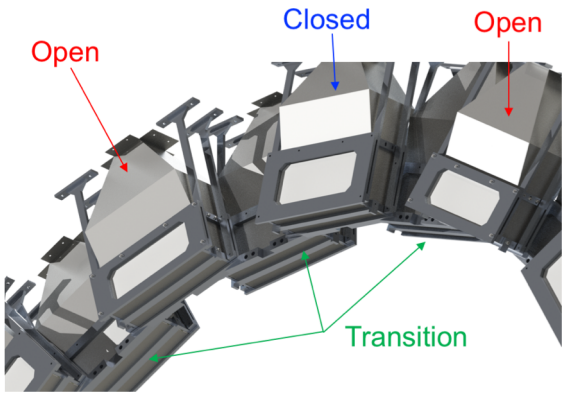


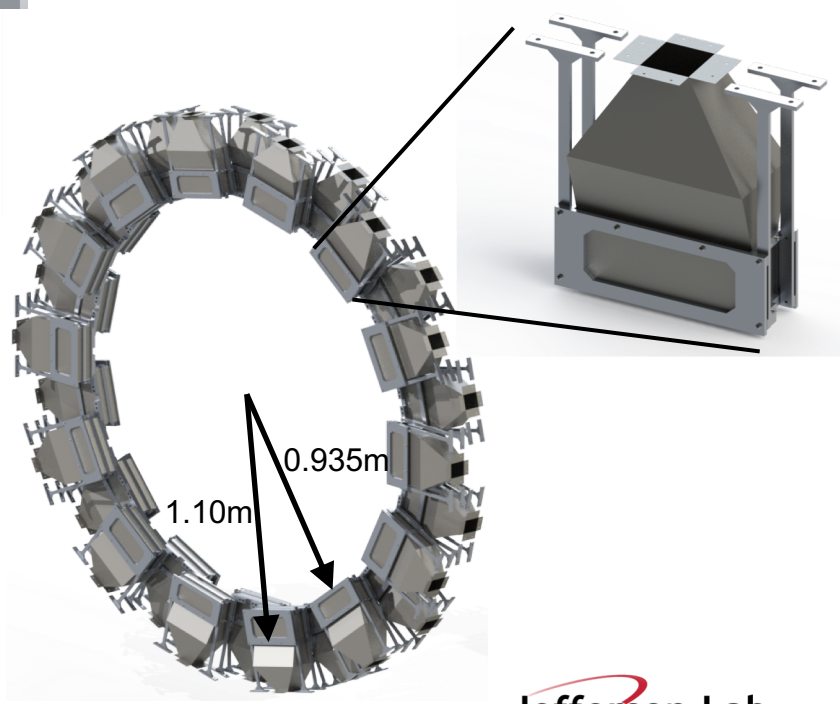


- Provides additional, independent measurement of e-e ring integrated flux
- Weights flux by energy $\Longrightarrow$ less sensitive to low energy and hadronic backgrounds
- Could possibly operate in tracking mode to give additional handle on background pion identification – gives sizeable MIP-like signal
- Will have good resolution over full energy range ($\frac{\sigma}{\langle n \rangle} \lesssim 30\%$), $\mathrm{radiation\ hard}$ with long term stability and good linearity

Shower-max: Design Status and ring geometry





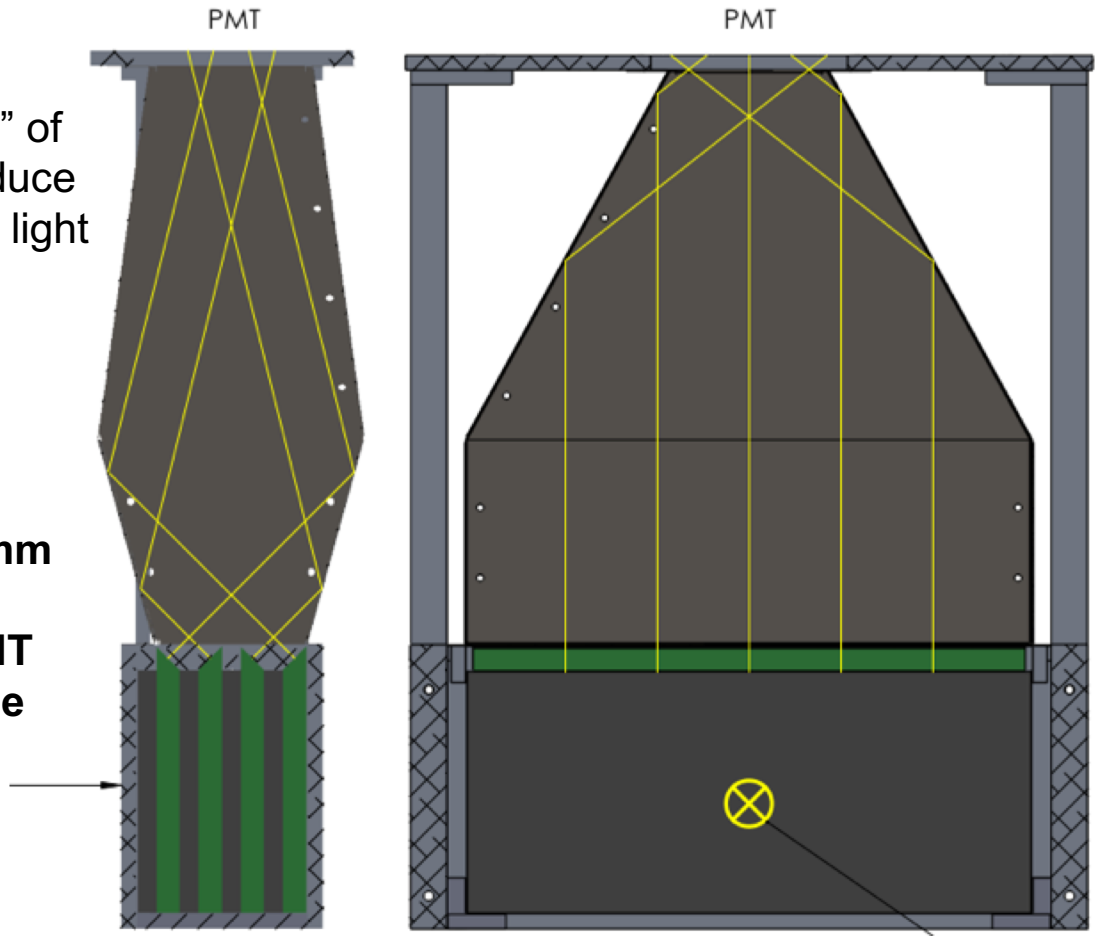


- Engineered shop drawings for full-scale prototypes
- Shower-max ring design concept: staggered in $\hat{z}$ with reinforced struts and brackets. 28 detectors in ring: 7 Open, 7 Closed, and 14 Transition
- Constructed two full-scale prototypes in 2018 and tested at SLAC with 3, 5.5, and 8 GeV electron testbeam

Shower-max: Detector Concept and Materials

- Detector concept uses a layered “stack” of tungsten and fused silica (quartz) to induce EM showering and produce Cherenkov light

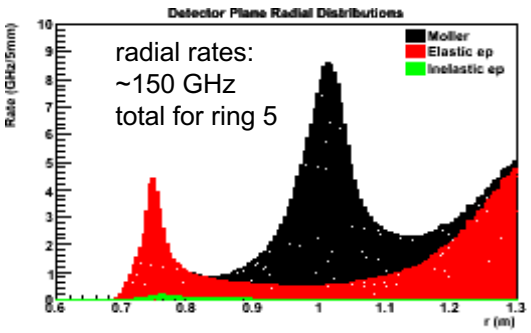
- “Baseline” design developed using GEANT4 optical MC simulation:
  - Design uses a **4-layer stack** with **8 mm tungsten** and **10 mm quartz** pieces
  - Cherenkov light directed to **3inch PMT** using **air-core, aluminum light guide**

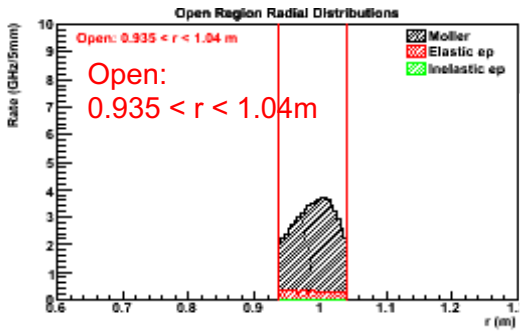


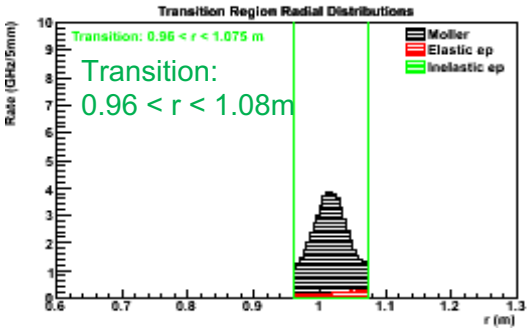
Materials (all rad-hard):

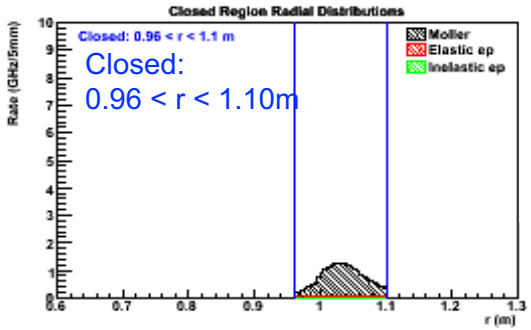
- Tungsten is high purity (99.95%) and quartz is optically polished Spectrosil 2000
- Light guides are aluminum specular reflectors (Miro-silver 27, Anolux, or aluminized mylar, …)
- Total radiation length: 9.1 X_0 tungsten + 0.4 X_0 quartz = 9.5 X_0

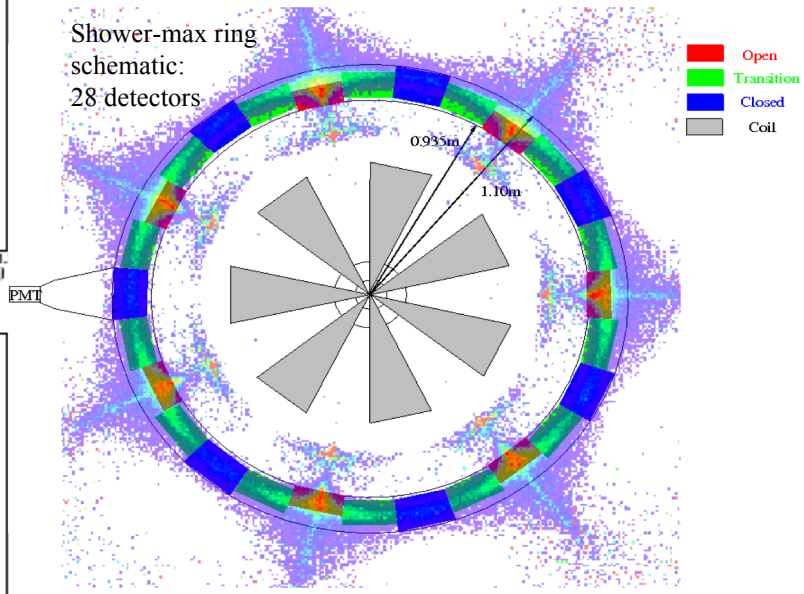
Shower-max: Energy and rate acceptances





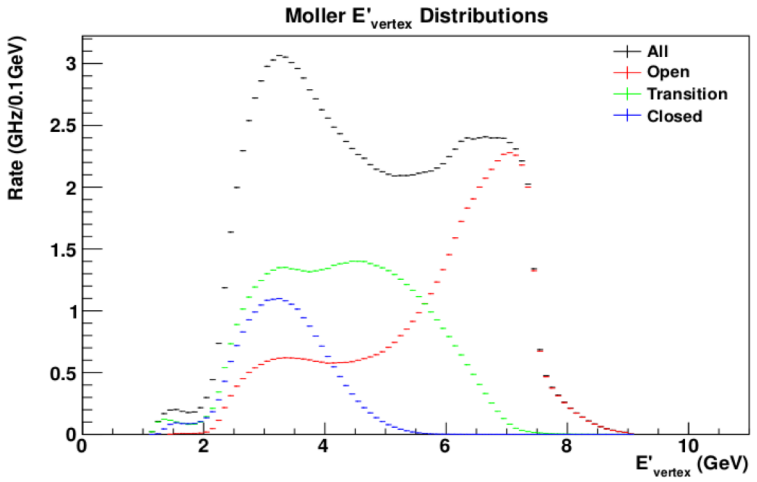




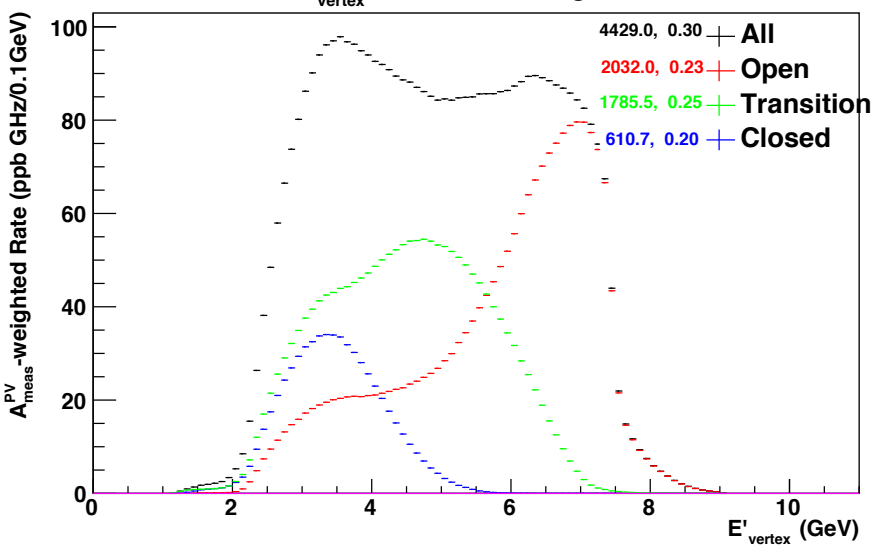


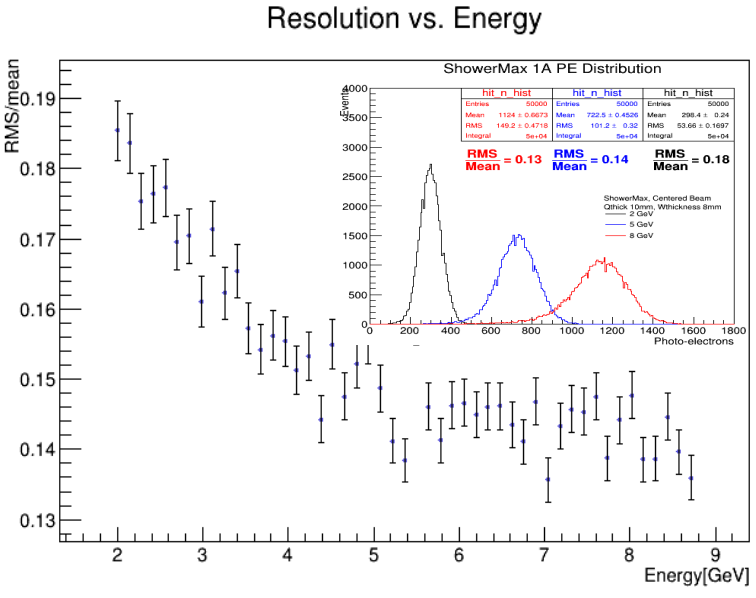
- Large range of rates and energies for different phi-region detectors:

- Open ~9 GHz/det; 2 - 9 GeV, peak at 7 GeV…
- Closed ~3.5 GHz/det; 2 - 5 GeV, peak at ~3 GeV
- Transition ~4.5 GHz/det; 2 - 7 GeV, 3 – 5 GeV plateau

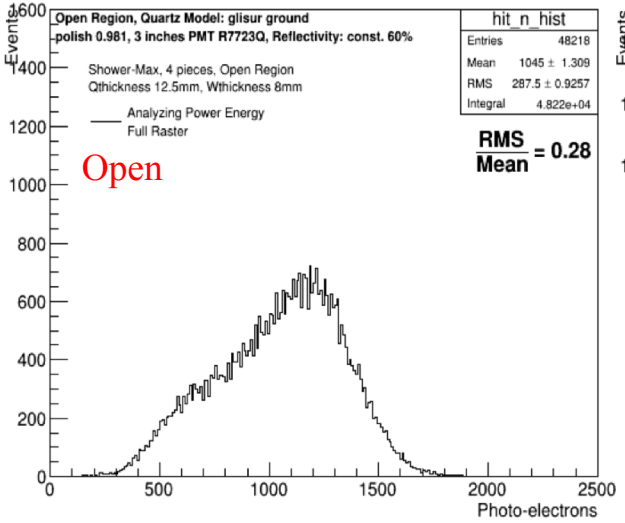


Shower-max: Resolutions

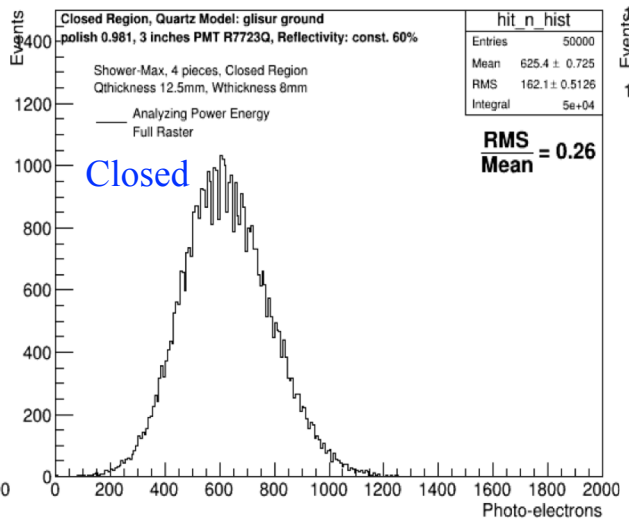




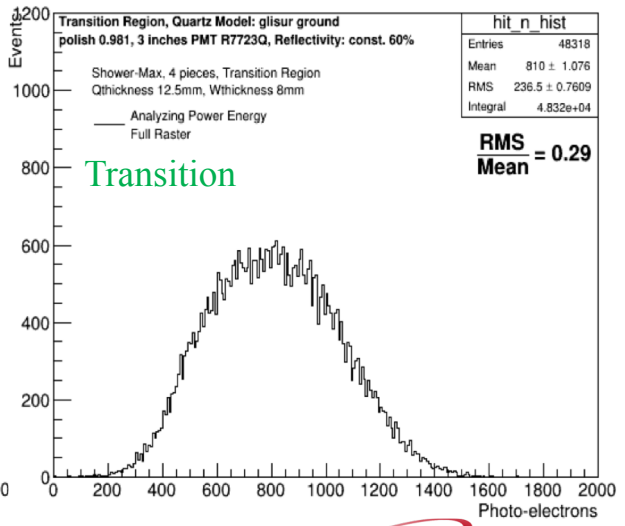
Open ShowerMax Photo-Electron Distribution



Closed ShowerMax Photo-Electron Distribution

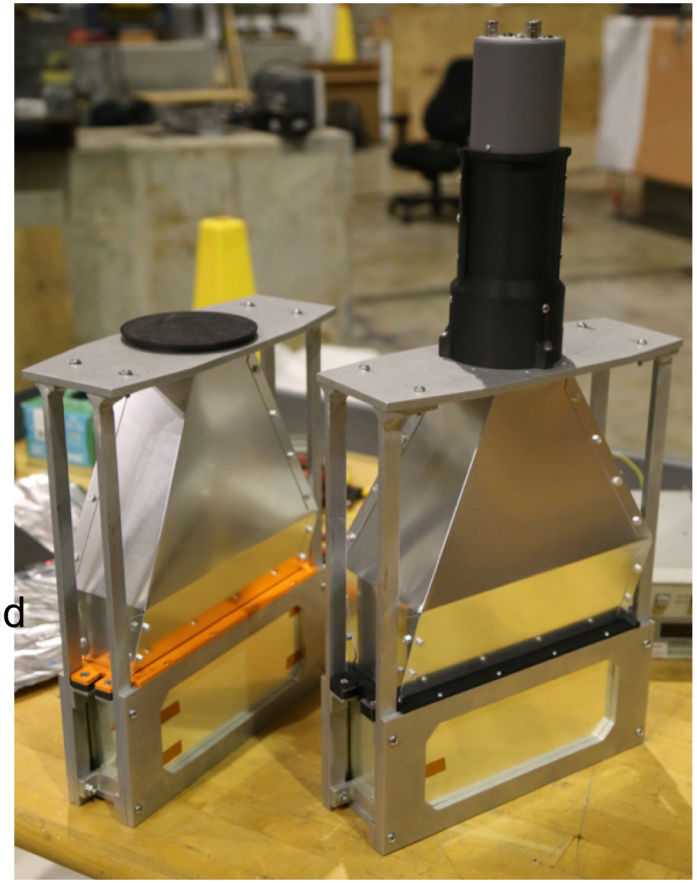


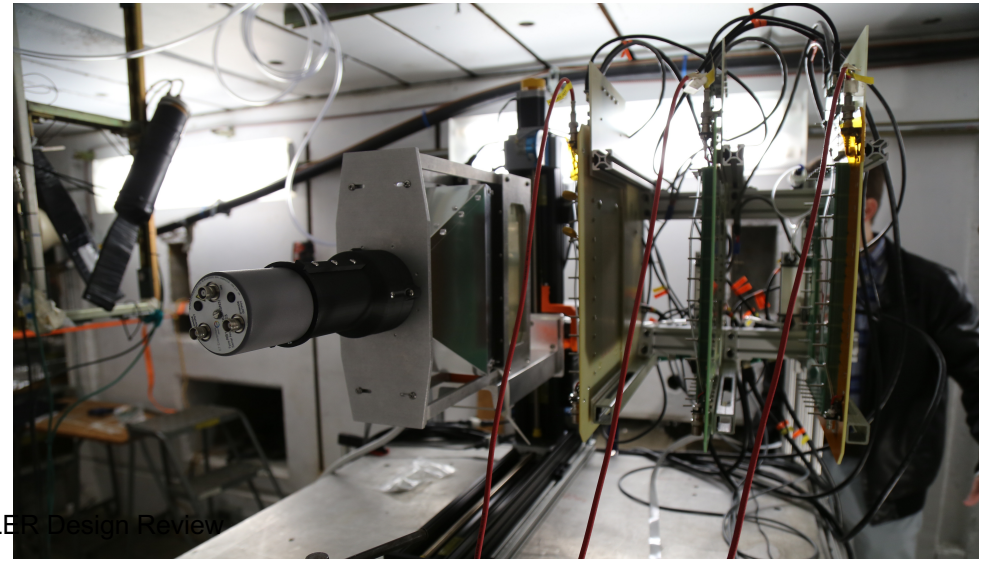
Transition ShowerMax Photo-Electron Distribution



Shower-max: Prototyping and testbeam

- First prototypes constructed: two different “stack” configs: 8 mm thick tungsten and 10 mm thick or 6 mm thick quartz
  - 1st-pass engineered design concept vetted
  - Light guide construction techniques developed
- SLAC testbeam T-577 run: Dec 6 – 12, 2018
  - Exposed prototype to 3, 5.5, and 8 GeV electrons
  - Validated our optical Monte Carlo quartz and cathode properties and G4’s EM showering processes (but not the light guide yet)
  - Stack design validated--number of layers/thicknesses; yields and resolutions match G4 predictions
  - Prototype beam performance sufficient for MOLLER and 2nd-pass mechanical design improvements underway





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Summary

- Baseline design concept meets requirements:
  - Proportional energy response and background suppression
  - Large light yields and good resolution
  - Radiation hard material construction
- 1st pass mechanical design validated through prototype construction: support frame design and light guide assembly
- Initial beamtest performance validated optical MC and stack design; baseline prototype (as is) is sufficient for MOLLER
- Future testbeam runs will be used to finalize the design mechanics and light guide

- Thank You