MOLLER Task Tracking bluejeans Meeting 2018July16, ISU Tasks: Dustin McNulty & ISU Parity Group

Subsystem	Task	Description	Status	Owner	Relation to Director's Review Report	Estimated Completion Date
Detectors	Radiation hardness of detector components	Investigate which detector components need radiation testing and carry out 50 MRad test	Michael and Dustin devise a plan. Status: Initial list being established	Dustin	Page 12:``…, all components in the scattered beam envelope should show negligible damage up to 50 MRad."	May 2019
Detectors	QA plan for main detector quartz	Devise plan to evaluate robustness of main detector quartz (Redundant with ``radiation hardness of detector components")	Michael and Dustin to devise a plan? Not yet started	Dustin	Page 12: Recommendation: ``Conduct radiation damage tests to at least 50 MRad to qualify fused silica for use in the thin detector	May 2019
Detectors	Shower-Max module mechanical assembly design	This task incorporates the physical design and prototyping of the showerMax detector, as well as the associated mechanical mounting structure	Advanced state of first prototype design, including mechanical assembly	Dustin	Not explicitly mentioned	May 2018

Radiation Hardness Test plan Update

- RAD testing of mechanical assembly materials and parts (ISU, UM)

  - ❖ Irradiated several light-guide (LG) material samples over a 3 day test run from Mar 22 - 24, 2016 at the Idaho Accelerator Center (IAC) using 8 MeV, 65 mA I_{peak}, 4µs pulse width at 250 Hz rep-rate (dose exposure rate was calculated but too high to measure):
    - Measured LG specular reflectivity for 200 – 800 nm at 90, 60, 45, and 30 degrees.
    - No measurable change in reflectivity was detected for >>50 MRad exposure
  - ❖ Other assembly materials to test could include Kapton and Tedlar (light tight wrappings) and possibly 3D-printed custom plastic assembly components (Nylon, ABS, PLA, …) as well as high-density shielding plastics, epoxies, …
    - Planning for future irradiation tests at IAC —*need guidance on what materials to test and how to quantify or assess their radiation hardness, mechanically or otherwise*

- Main Detector Quartz Robustness (radiation hardness, QA, etc.) (ISU, UM)

  - ❖ Preparations underway to measure quartz optical transparency during irradiation dose study at the IAC:
    - Apparatus developed to make relative transparency measurements between 200 – 800 nm
      - ➢ Uses Ocean Optics USB spectrometer, UV-Visible light source, custom holder/stand
    - Energy deposition calculations (dE/dx and brem) underway for 8 MeV beam and 1.5 cm thick quartz—for heating and thermal expansion considerations (do not want to crack quartz)
    - Investigating ability to calibrate and monitor beam dose exposure during study
    - Will have a 1 day IAC test run in April/May to calibrate dose exposure rates for upcoming studies

ShowerMax Prototyping and Testbeam Plan Update

- Finalized prototype stack configurations last fall; SBU purchased prototype quartz and tungsten in Nov 2017

- Finalized full-scale prototype design and sent drawings to machine shop – we've made two complete detectors (configs 1A and 1B) including miro-silver light guides

- Finalized the benchmarking detector design and printed all parts for configs 1A and 1B

- Purchased two 3 inch PMTs to use for prototype testing; they were delivered in mid June

- Our SLAC testbeam time request was approved; we're planning for a testbeam run in September

Radiation Hardness QA for quartz and other components

25 MeV LINAC (Main Hall and Airport)

RF Frequency: 2856 MHz (S-Band)

Energy Range: ~4~25 MeV (current varies)

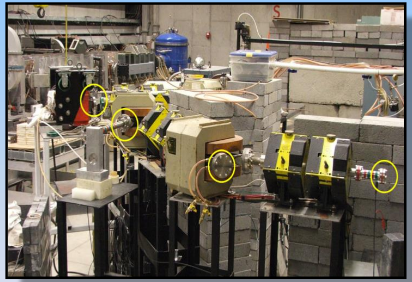
Pulse Width: ~50ns to 4 micro seconds

Repetition Rate: single pulse to 360 Hz

Ports: 0 degree, 45 degree and 90 degree (Beam energy resolution ~ 1+/-15%)

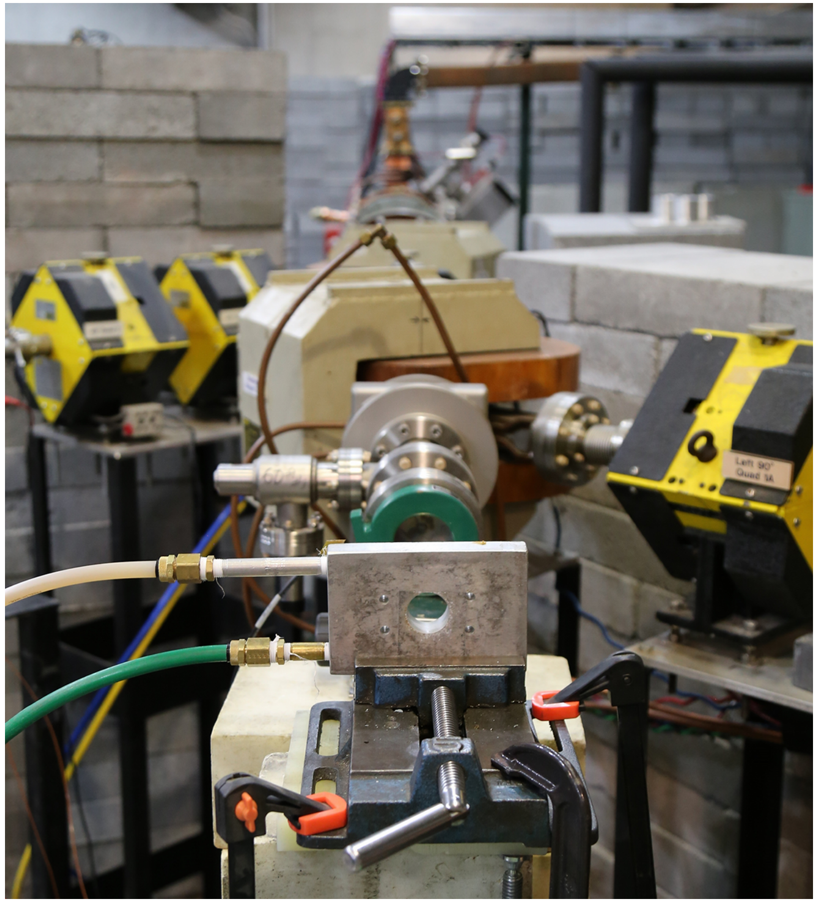
25B Energy vs Current

Energy (MeV)	0 port (mA)	45 port (mA)	90 port (mA)
23	55	55 @ 3.8uS	46 @ 3.6 uS
20	100	70 @ 4 uS	65 @ 4 uS
16	100	48 @ 3.6 uS	48 @ 3.6 uS
13	80	30 @ 3.3 uS	15 @ 3.3uS
10	60	18 @ 3 uS	7.5 @ 3 uS
9	110	30 @ 4uS	15 @ 4 uS
6	100	60 @ 4 uS	60 @ 4 uS
4	50	20 @ 4 uS	20 @ 4 uS

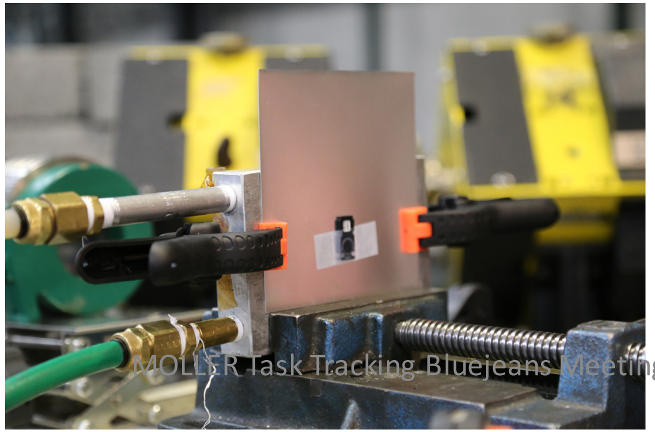


ISU

Idaho Accelerator Center



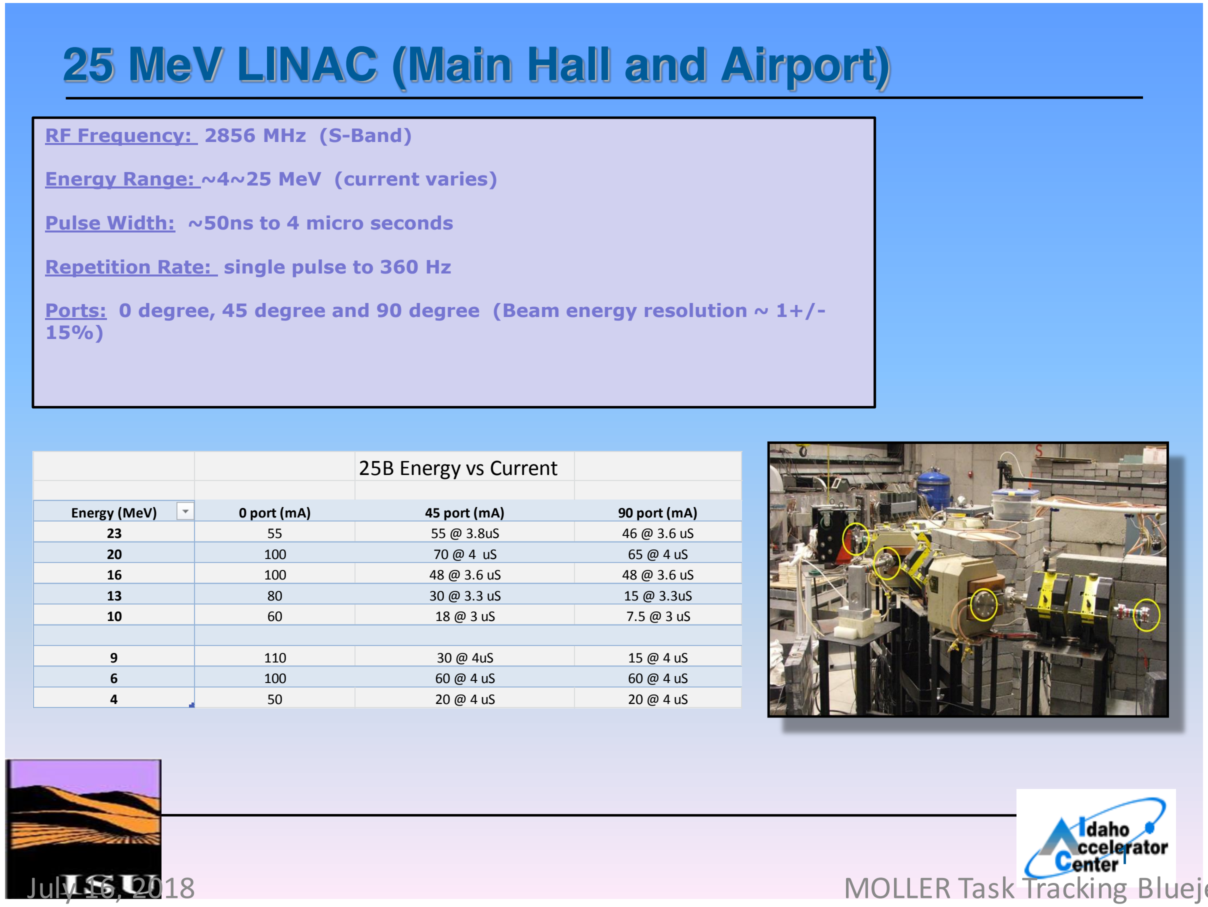
- A key issue is how well can we calibrate dose exposure?



- Planning for a 1 day engineering run late spring or early summer to address these questions.

Radiation Hardness QA for quartz and other components

- Performed 1 day irradiation study on Spectrosil 2000 quartz and 3D printed ABS plastic samples
- Tests performed on May 31, 2018 at the Idaho Accelerator Center (IAC) using 8 GeV electrons
- Dose exposure rates calibrated using thermographic film dosimetry measurements
- Quartz transparency measurements taken at 10, 30, and 60 MRad exposure levels
- Plastic dogbones radiated at similar levels and tensile strength (stretching) measurements made



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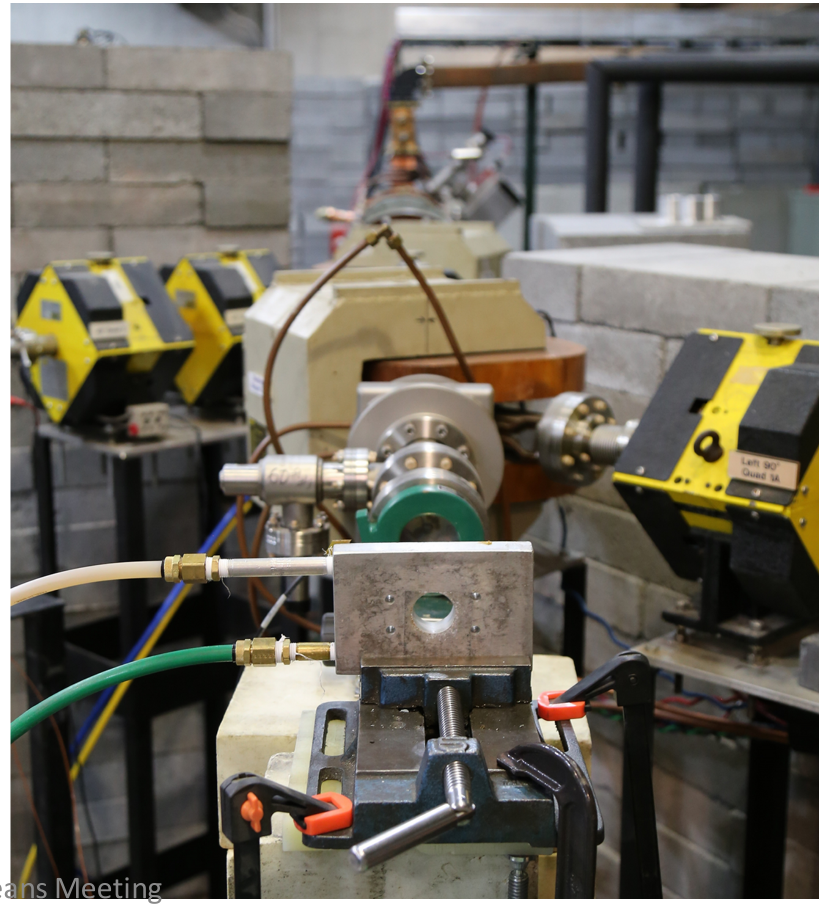
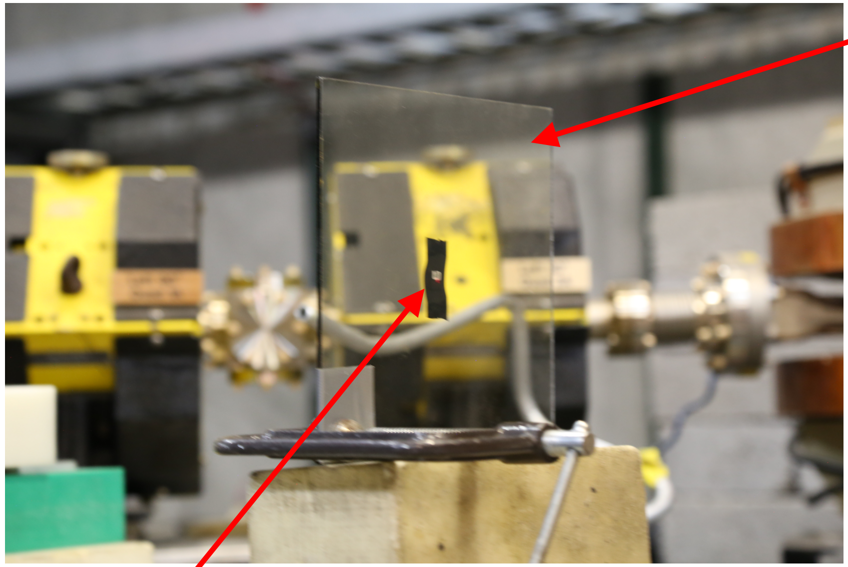
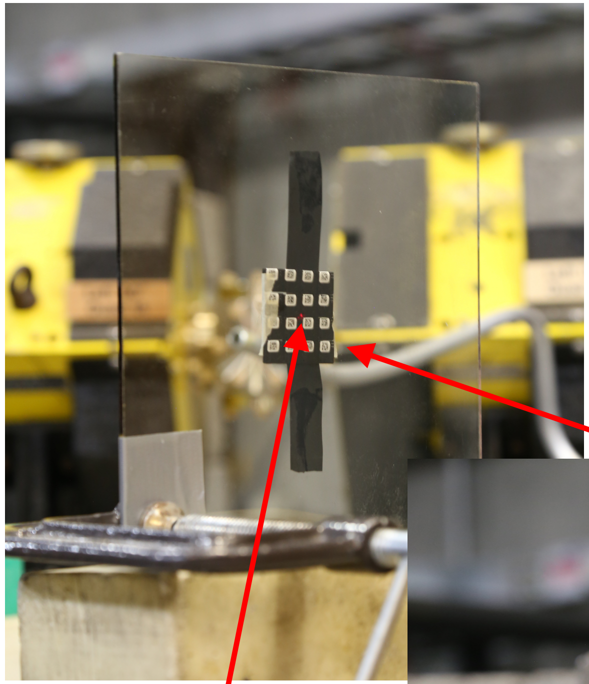
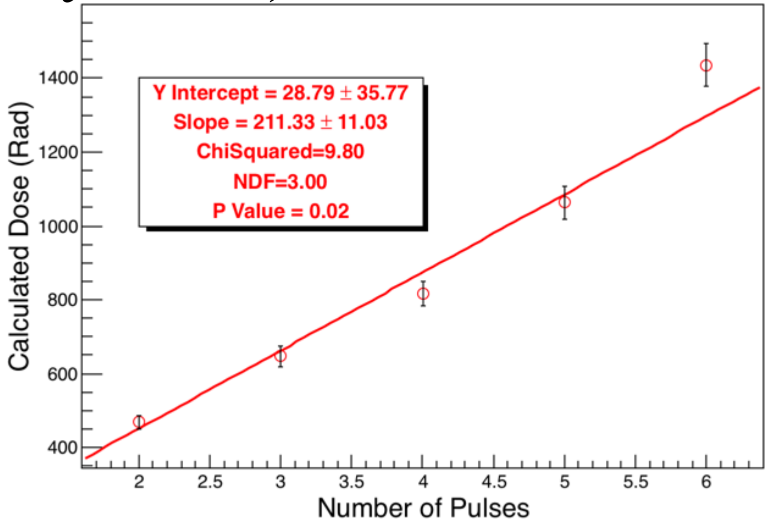


Beam Dose Exposure Rate Calibrations (May 2018)



Glass slide for spot profile measurements

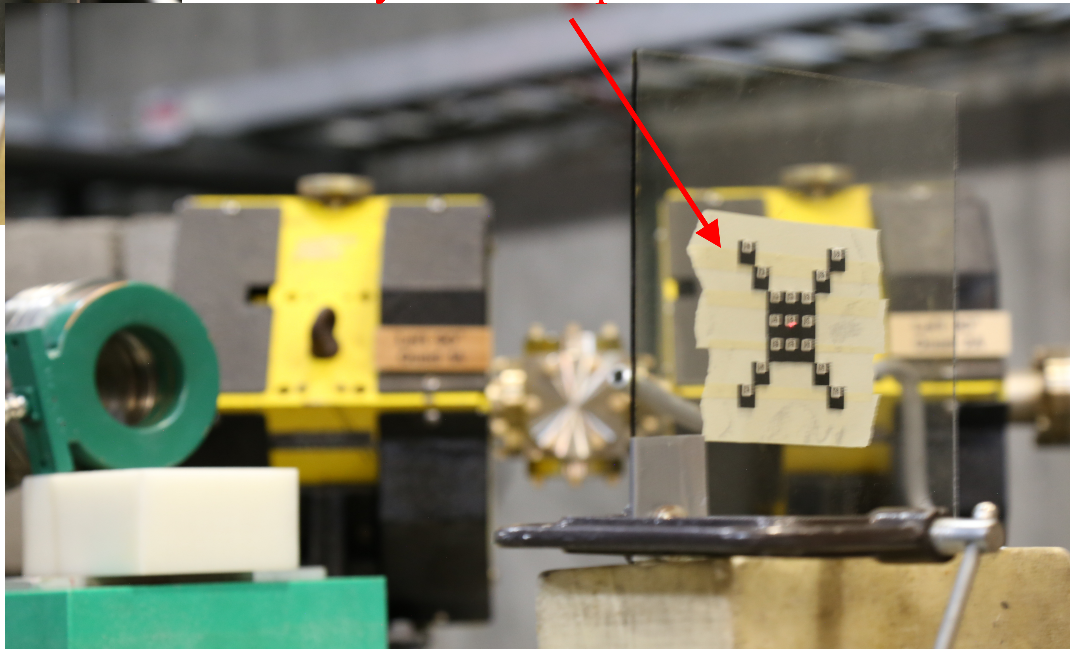




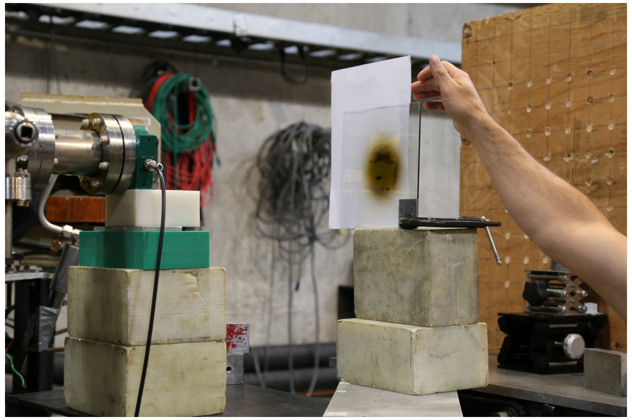
Optically Stimulated Luminescence (OSL) dosimeter (~ 7 mm by 7 mm square)

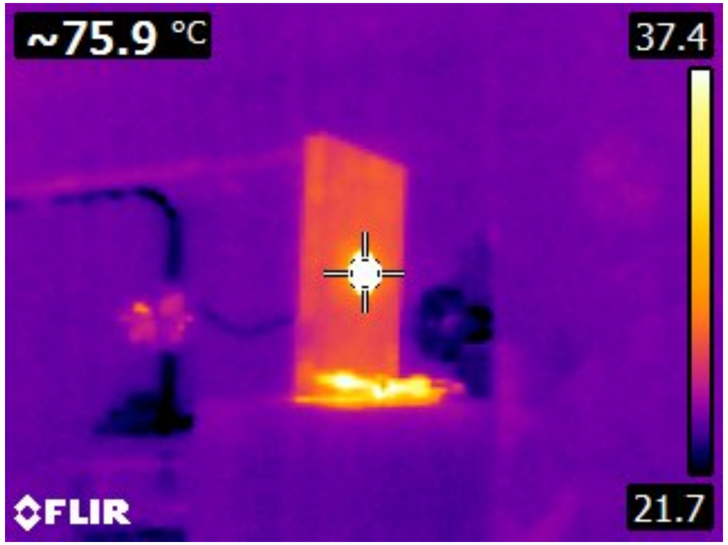
OSL arrays for dose profile measurements

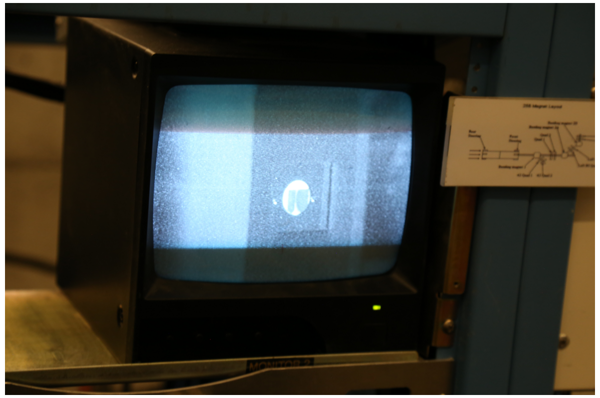
Laser alignment

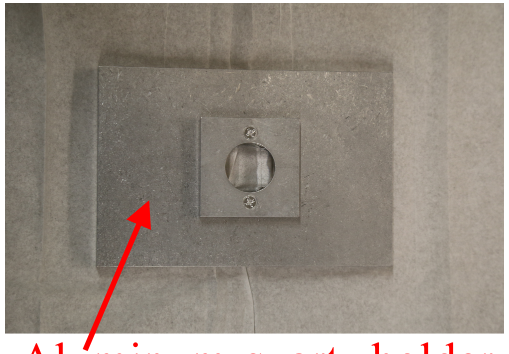


Quartz Irradiations (May 2018)



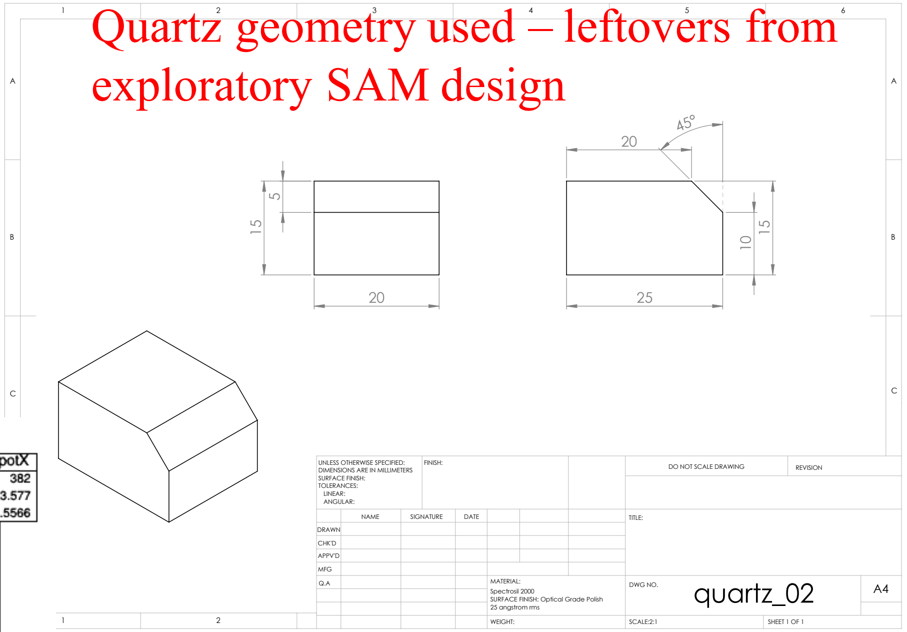


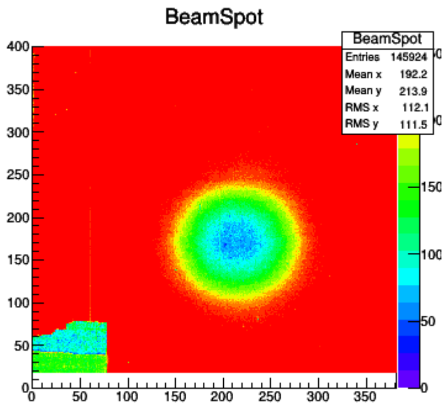


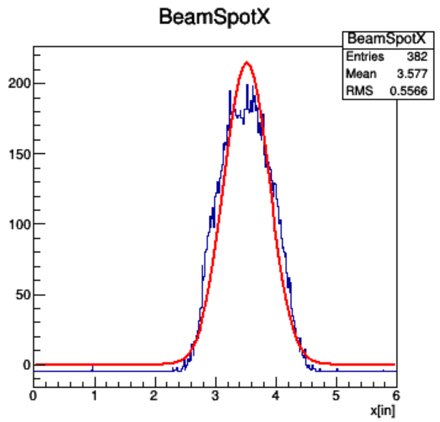


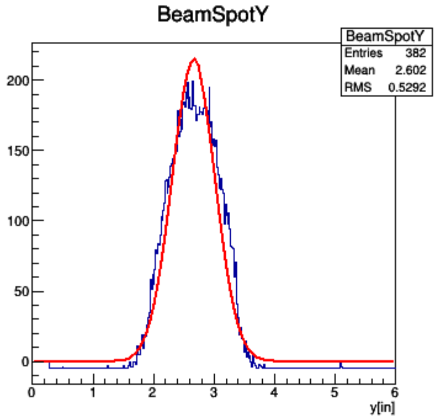
Aluminum quartz holder

Quartz geometry used – leftovers from exploratory SAM design









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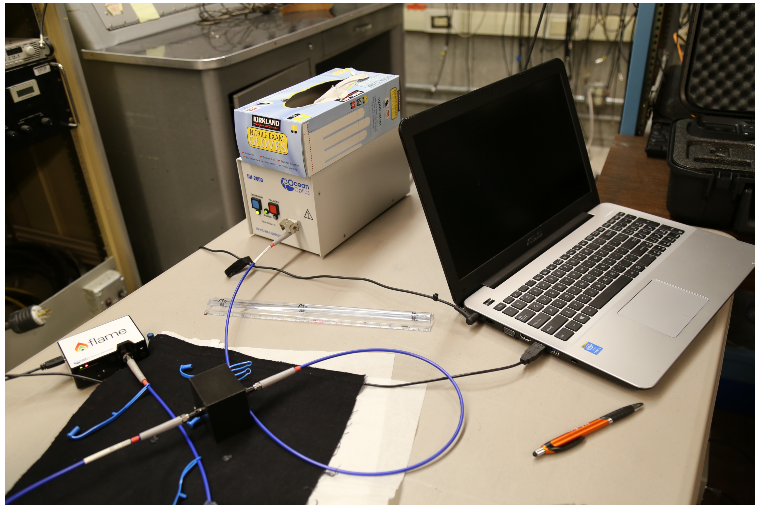
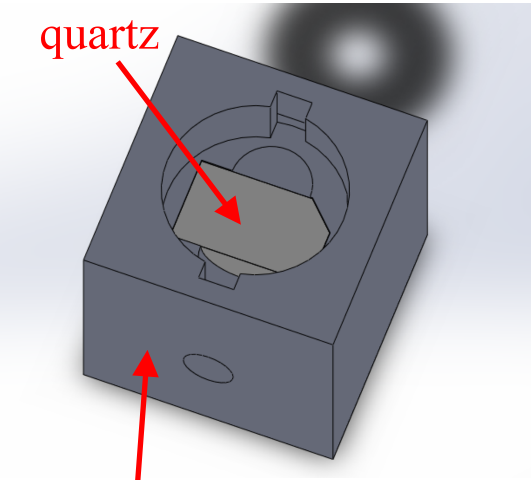
x-center = 3.512 in, y-center = 2.661 in

glass plate at 50cm from beam window

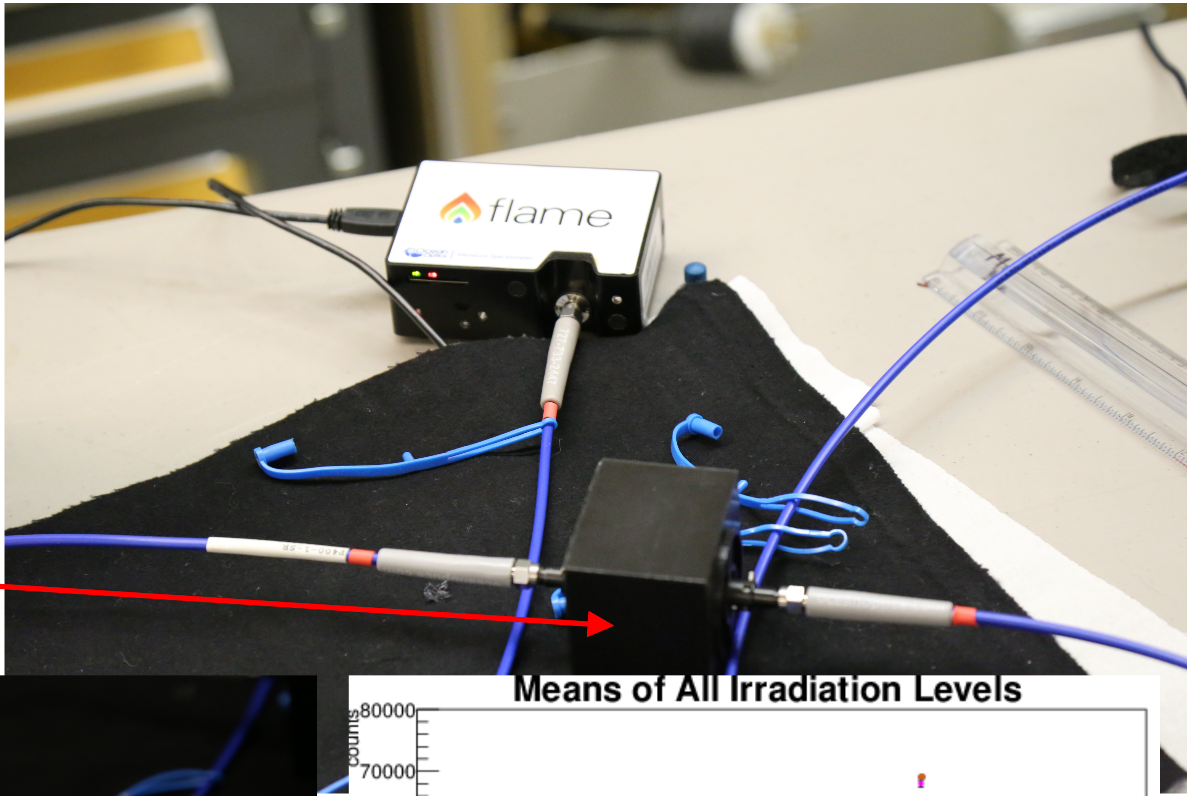
Quartz Transparency Measurements

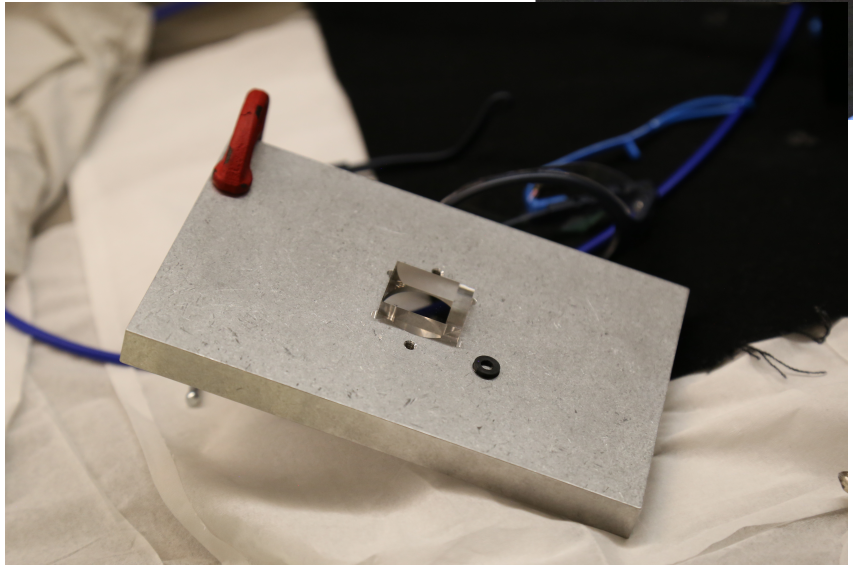


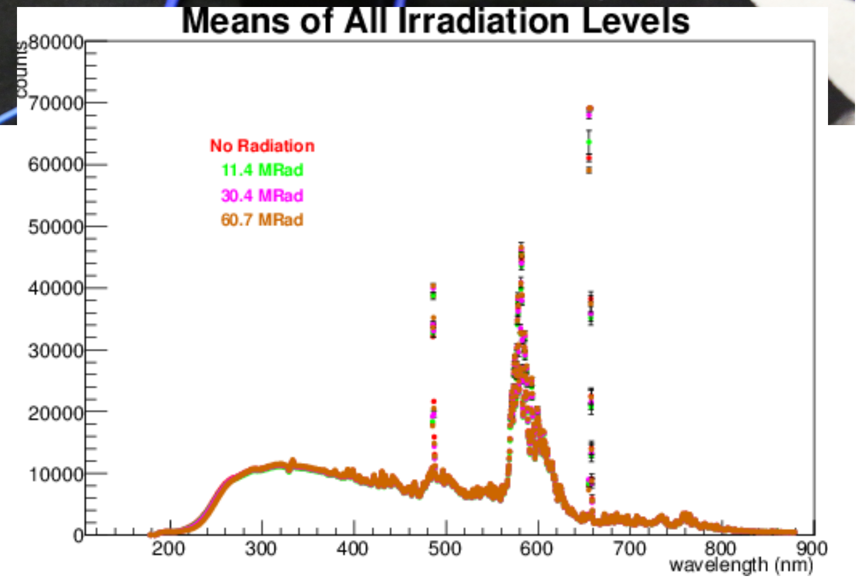


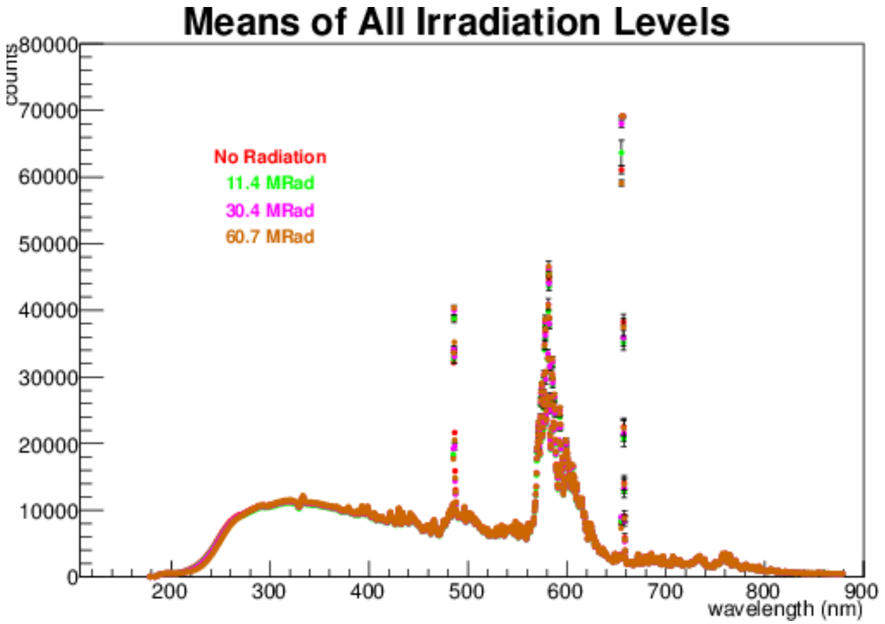
quartz

Transparency measurement holder



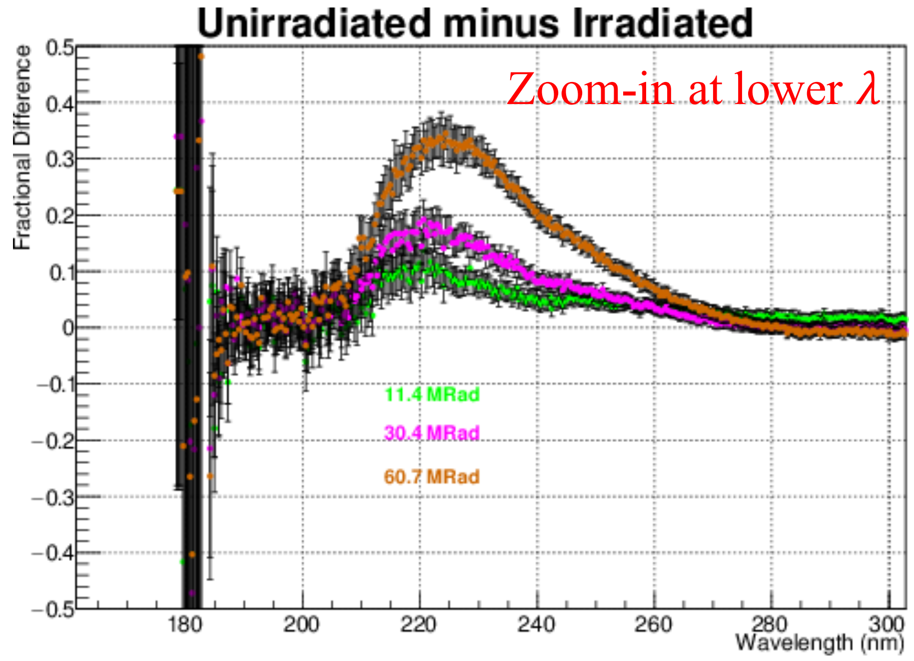


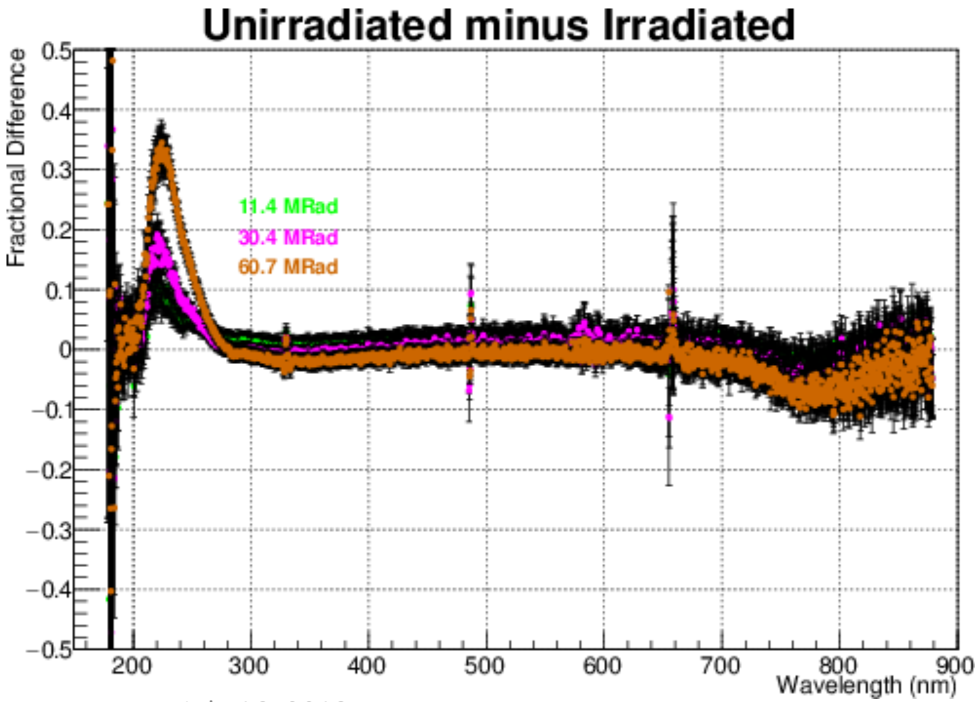


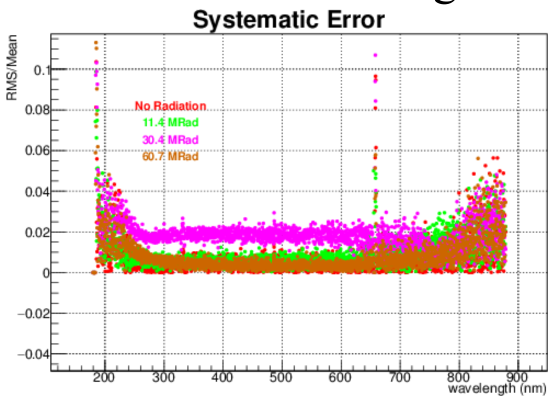


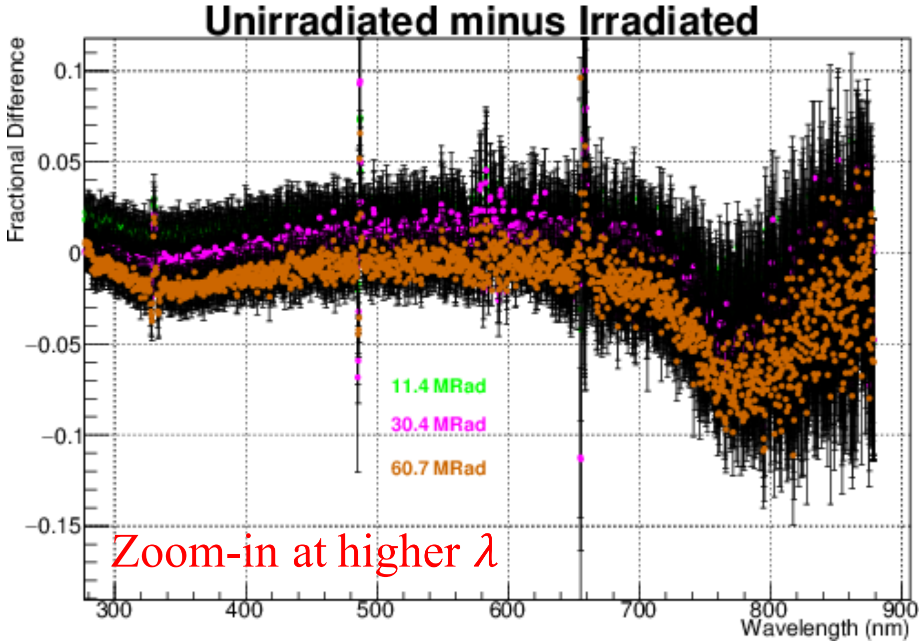
Quartz Transparency Preliminary Results

- Beam setup: 8 MeV, 50 mA I_{peak}, 500 ns pulse width at 250 Hz rep-rate
- Quartz sample mounted 0.5 m from beampipe exit window
- Dose exposure calibrations give ~253 Rad/pulse
  - Irradiated sample for 3, 8, and then 16 minutes
  - Measured light transmission (four times) after each irradiation and averaged





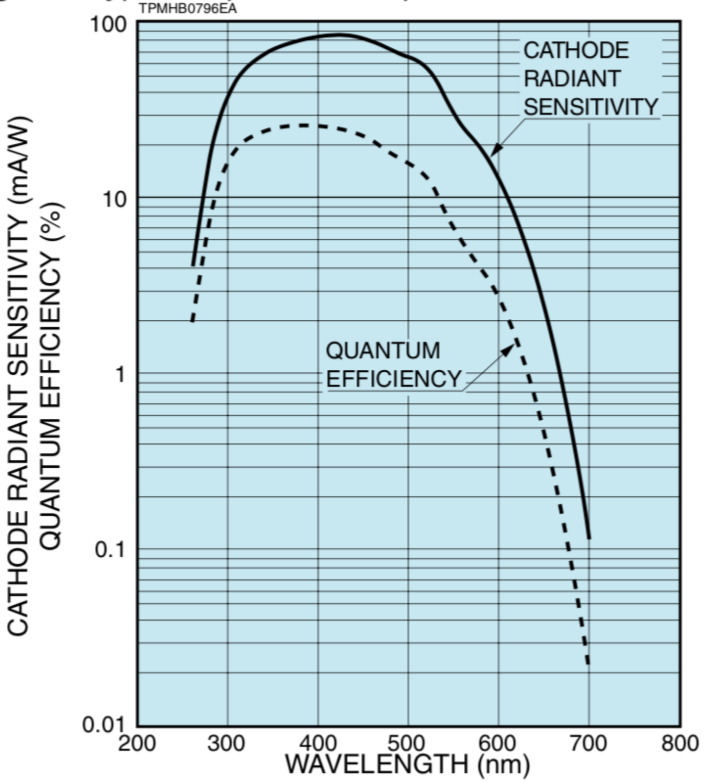




Quartz Transparency Preliminary Results
Summary

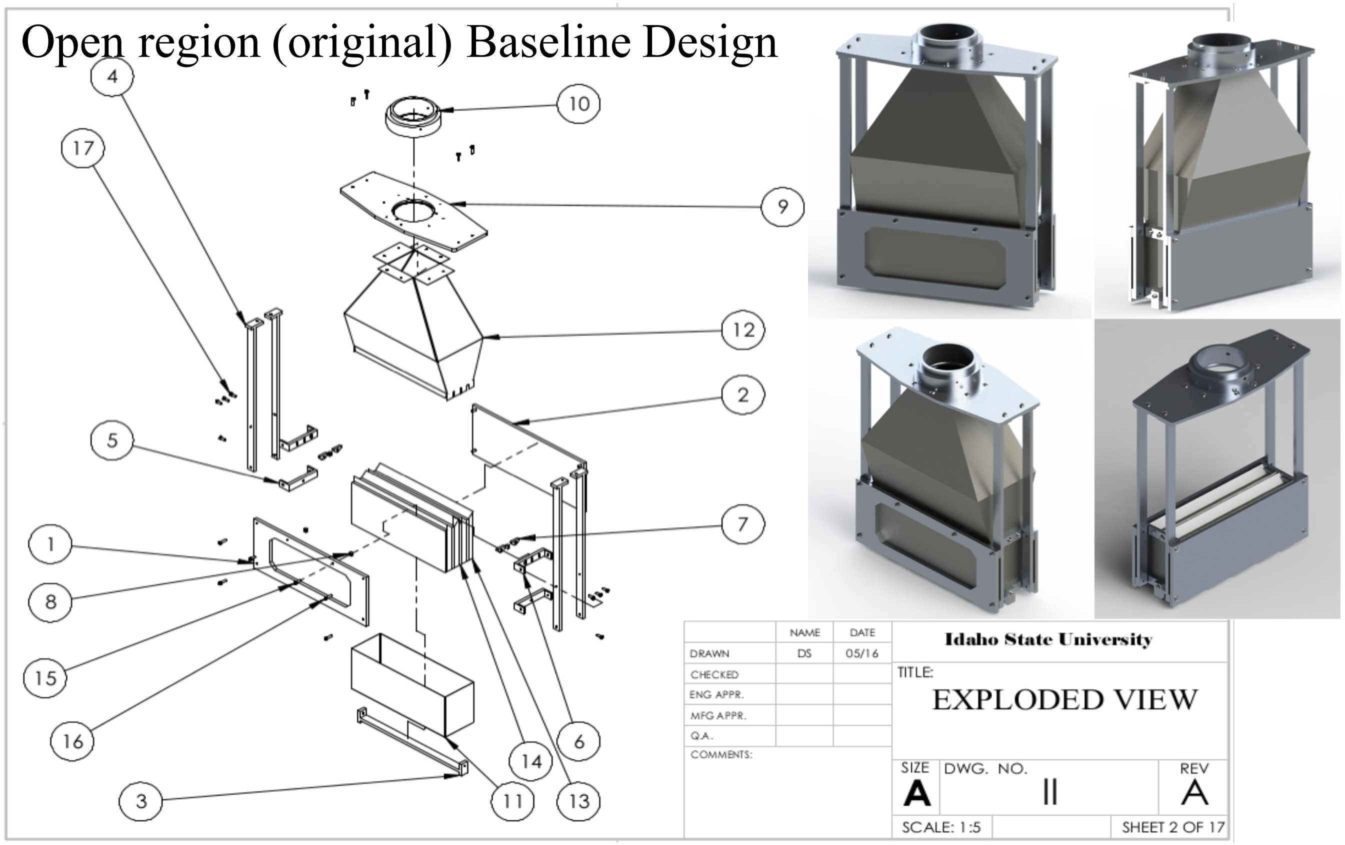
- Apparent onset of radiation damage seen in the UV region (between 200 – 270 nm)
- These results need to be double-checked with a more in-depth future irradiation study: We'll examine a few different pieces (same geometry), perform more transparency measurements at smaller intervals of exposure, and redesign apparatus to give less systematic variations
- We've already seen from reflectivity measurements, combined with beamtest results, that the deep UV part of the spectrum is not as important or contributing as the UV/Vis part--due to cathode sensitivity and QE
- Perhaps a measurement using a SAM-type or even Moller ring-5 prototype detector during irradiations could show how this effect is dampened by the PMT; use a cathode with very low QE in the < 280 nm region.

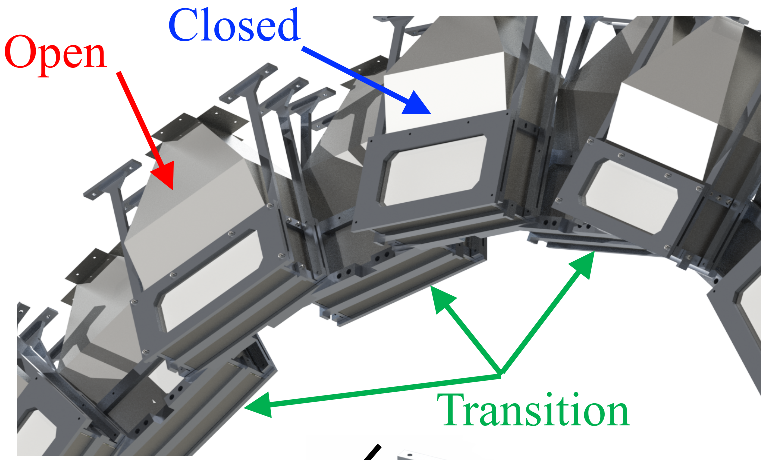
Figure 1: Typical Spectral Response

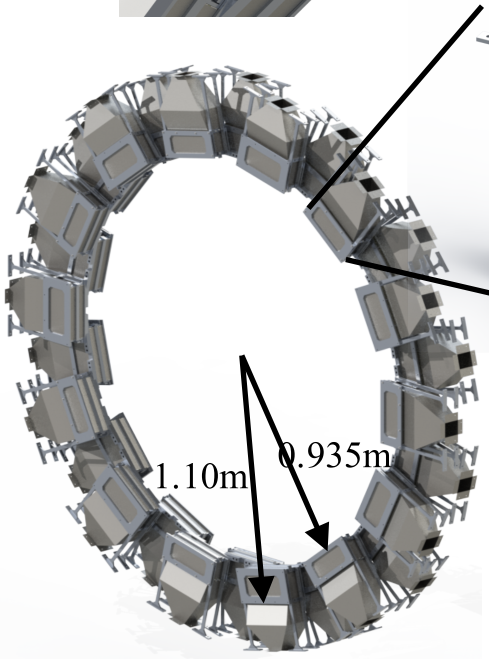


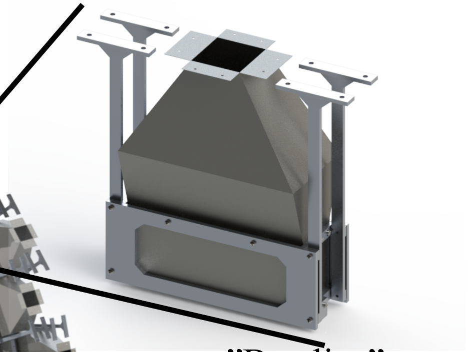
Baseline ShowerMax Design and Ring Concept

Open region (original) Baseline Design









"Baseline"

- Engineered shop drawings for full-scale prototypes in hand
- ***PLANS***: Finalized prototype Stack designs last fall and ordered prototype quartz in Nov 2017, construct in winter/spring 2018 and test in summer/fall using 2 - 10 GeV electron SLAC testbeam
- 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

<u>Costs: Total w/ spares</u>
quartz: \$150k (Heraeus)
tungsten: \$60k
<u>alum.: \$10k (machined)</u>
grand total: \$220k

<u>Weights of each assembly:</u>
Open: 39.7 lbs.
Transition: 42.5 lbs.
Closed: 50.8 lbs.
ring weight: 1230 lbs.

Quartz and tungsten purchased by SBU in Nov 2017

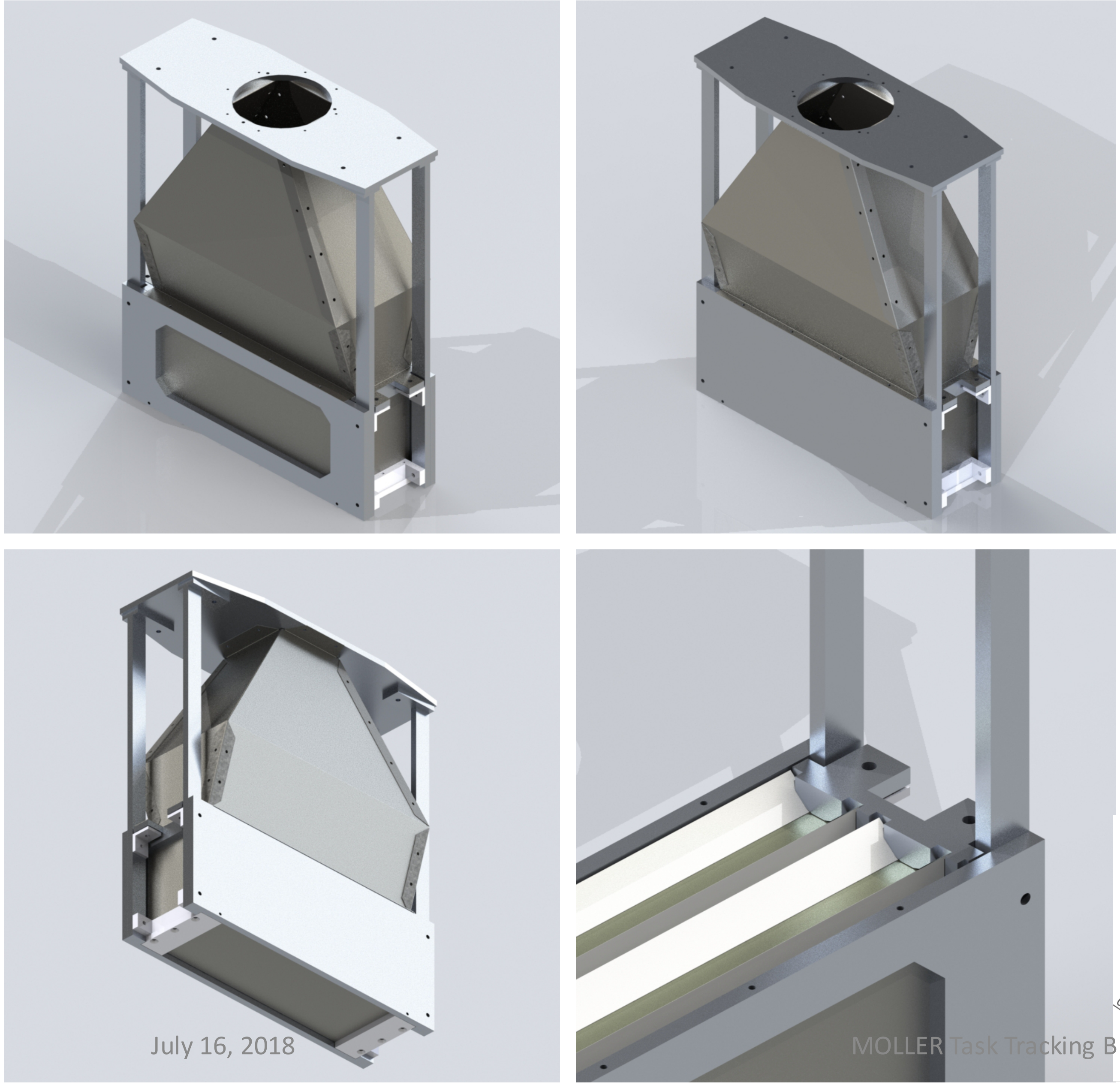
- For “full-scale” prototype stack:
  - Quartz: 6 mm (thick) by 111 mm (tall) by 246 mm (wide) -- 4 pieces (~$1750/piece = $7.0k)
  - Quartz: 10 mm (thick) by 115 mm (tall) by 246 mm (wide) -- 4 pieces (~$1940/piece = $7.8k)
  - Tungsten: 6 mm (thick) by 105 mm (tall) by 246 mm (wide) – 4 pieces ($600/piece = $2.5k)
  - Tungsten: 8 mm (thick) by 105 mm (tall) by 246 mm (wide) – 4 pieces ($820/piece = $3.2k)
  - Tungsten: 2 mm (thick) by 105 mm (tall) by 246 mm (wide) – 4 pieces ($200/piece = $0.8k)
- For “benchmarking” prototype stack:
  - Quartz: 6 mm (thick) by 86 mm (tall) by 40 mm (wide) --4 pieces ($975/piece = $3.9k)
  - Quartz: 10 mm (thick) by 90 mm (tall) by 40 mm (wide) --4 pieces ($1005/piece = $4.0k)
  - Tungsten: 6 mm (thick) by 80 mm (tall) by 40 mm (wide) – 4 pieces ($85/piece = $340)
  - Tungsten: 8 mm (thick) by 80 mm (tall) by 40 mm (wide) – 4 pieces ($110/piece = $440)
  - Tungsten: 2 mm (thick) by 80 mm (tall) by 40 mm (wide) – 4 pieces ($25/piece = $100)

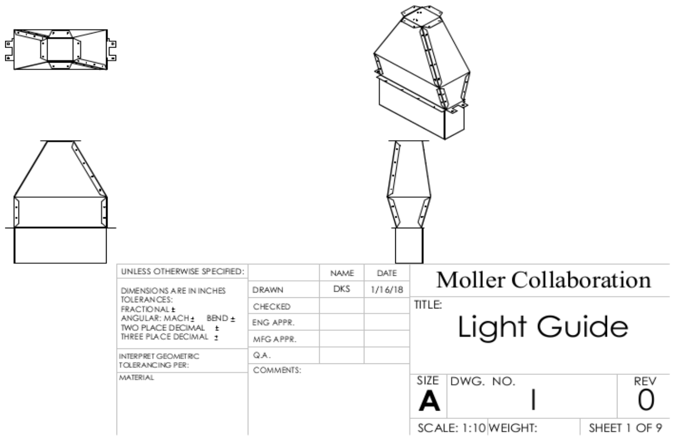
Purchasing these pieces allows for Configs 1, 3, and 4 (A and B) to be tested

Total quartz: $25k, total tungsten: $7.5k: Total = $32.5k

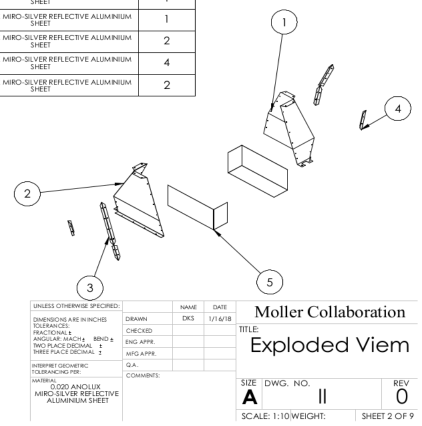
- Going with 6mm tiles allows construction of two benchmarking and two full-scale prototype sets
- Building two sets of prototypes will allow for more efficient testing during both SLAC testbeam and cosmic tests at SBU and ISU. We can each build a different configuration to test

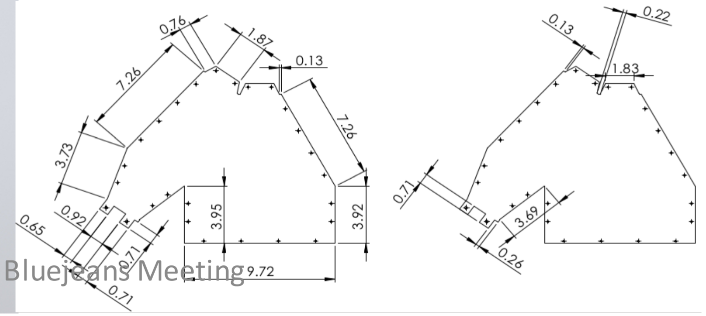
Updated Full-Scale Prototype (1A) for Beamtest





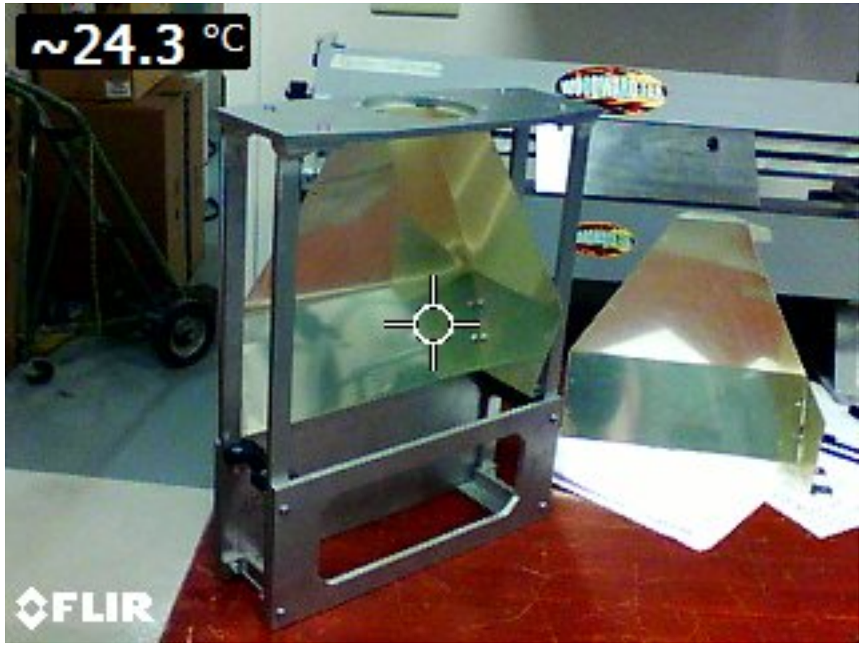
ITEM NO.	PART	MATERIAL	QTY.
1	Light Guide - Back	0.020 ANOLUX MIRO-SILVER REFLECTIVE ALUMINIUM SHEET	1
2	Light Guide - Front	0.020 ANOLUX MIRO-SILVER REFLECTIVE ALUMINIUM SHEET	1
3	Long Flap	0.020 ANOLUX MIRO-SILVER REFLECTIVE ALUMINIUM SHEET	2
4	Short Flap	0.020 ANOLUX MIRO-SILVER REFLECTIVE ALUMINIUM SHEET	4
5	Suitcase	0.020 ANOLUX MIRO-SILVER REFLECTIVE ALUMINIUM SHEET	2



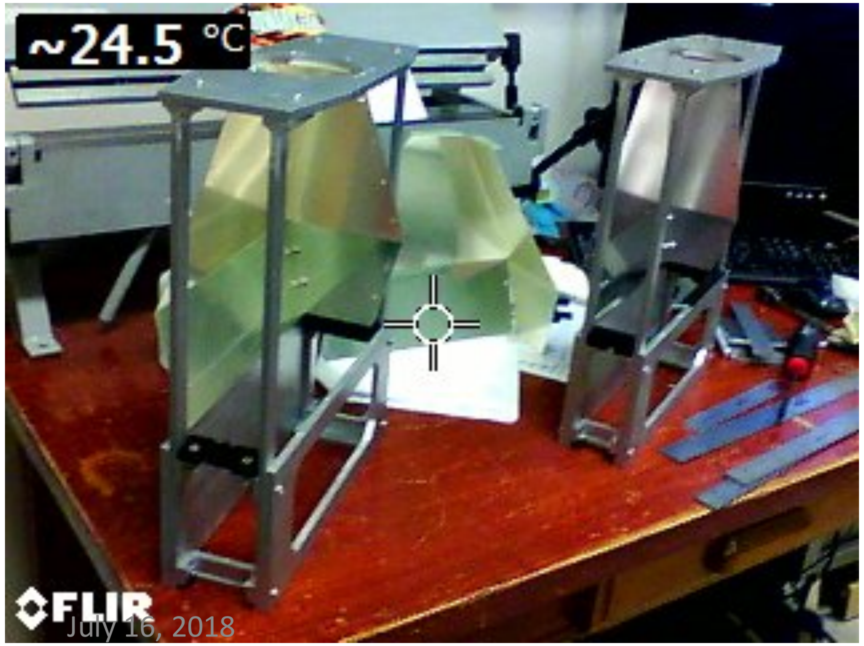


Building two full-scale prototypes: Drawings for Configs 1A and 1B sent to the shop, including light guide cut-outs which will be bent in April/May

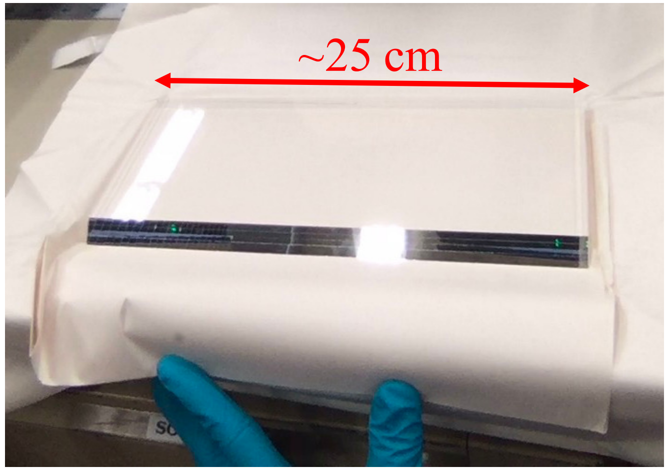
ShowerMax Prototype Construction Timeline



- Feb - Mar 2018: Benchmarking prototype frames fabricated with 3D-printer using ABS plastic (configs 1A and 1B)
- April 2018: Full-scale aluminum frame and light guide cut-outs fabricated at machine shop
- May 2018: Light guide bending and frame assembly at ISU for full-scale configs 1A and 1B
- June 2018: Config 1A full-scale and benchmarking prototype frames and LG delivered to SBU for stack assembly and installation



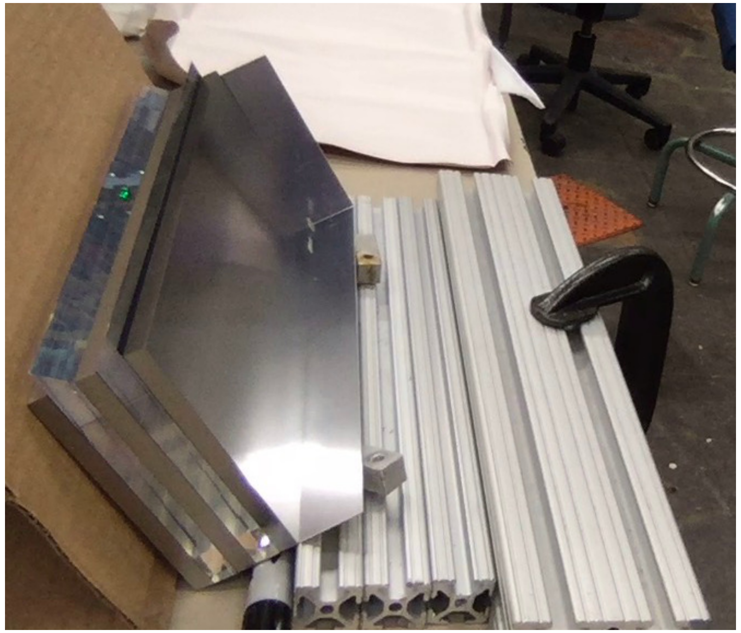
1A Full-scale Stack Assembly at SBU, June 2018



Aluminum sheet coffin

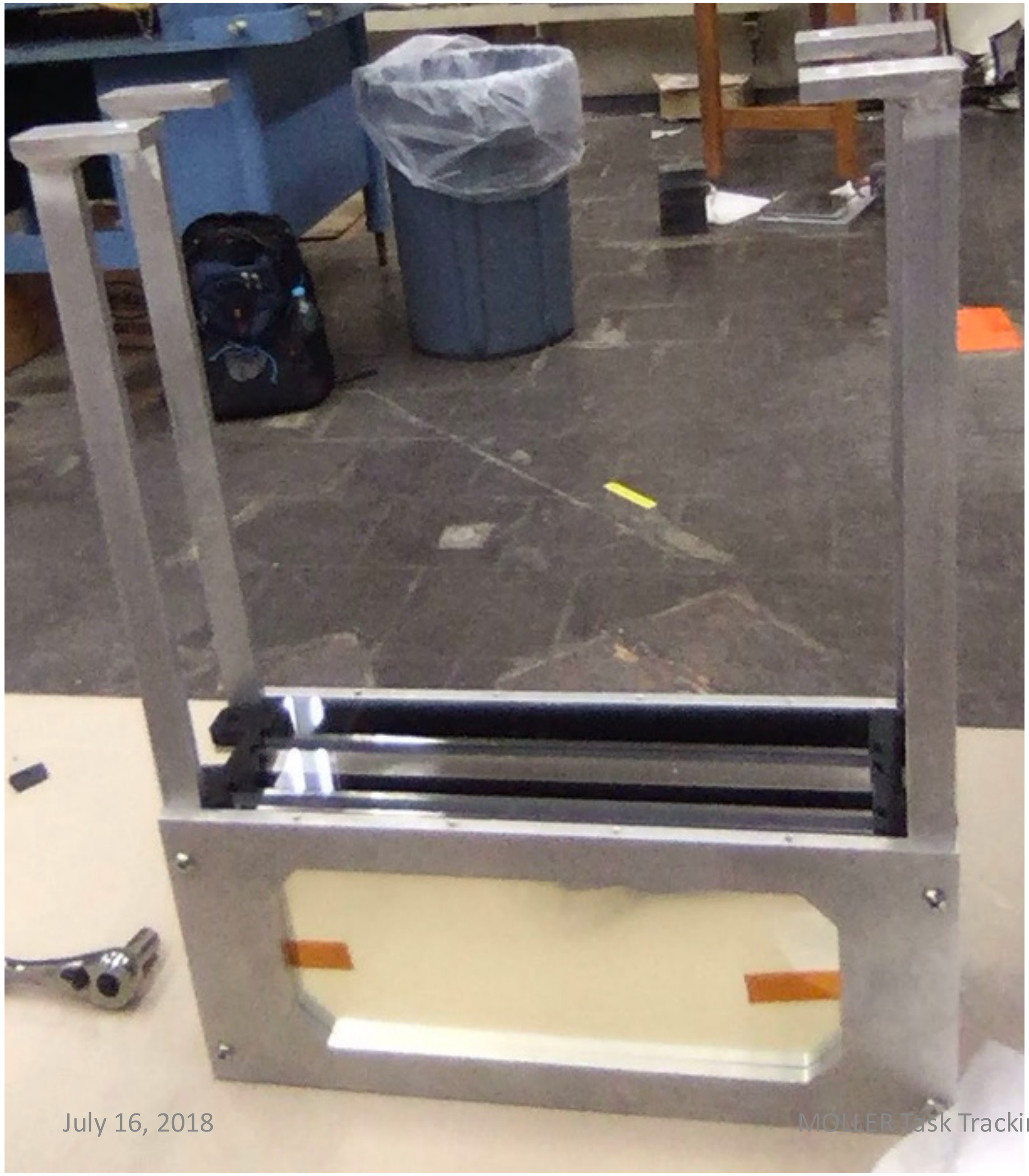
Fully assembled stack weighs ~40 lbs

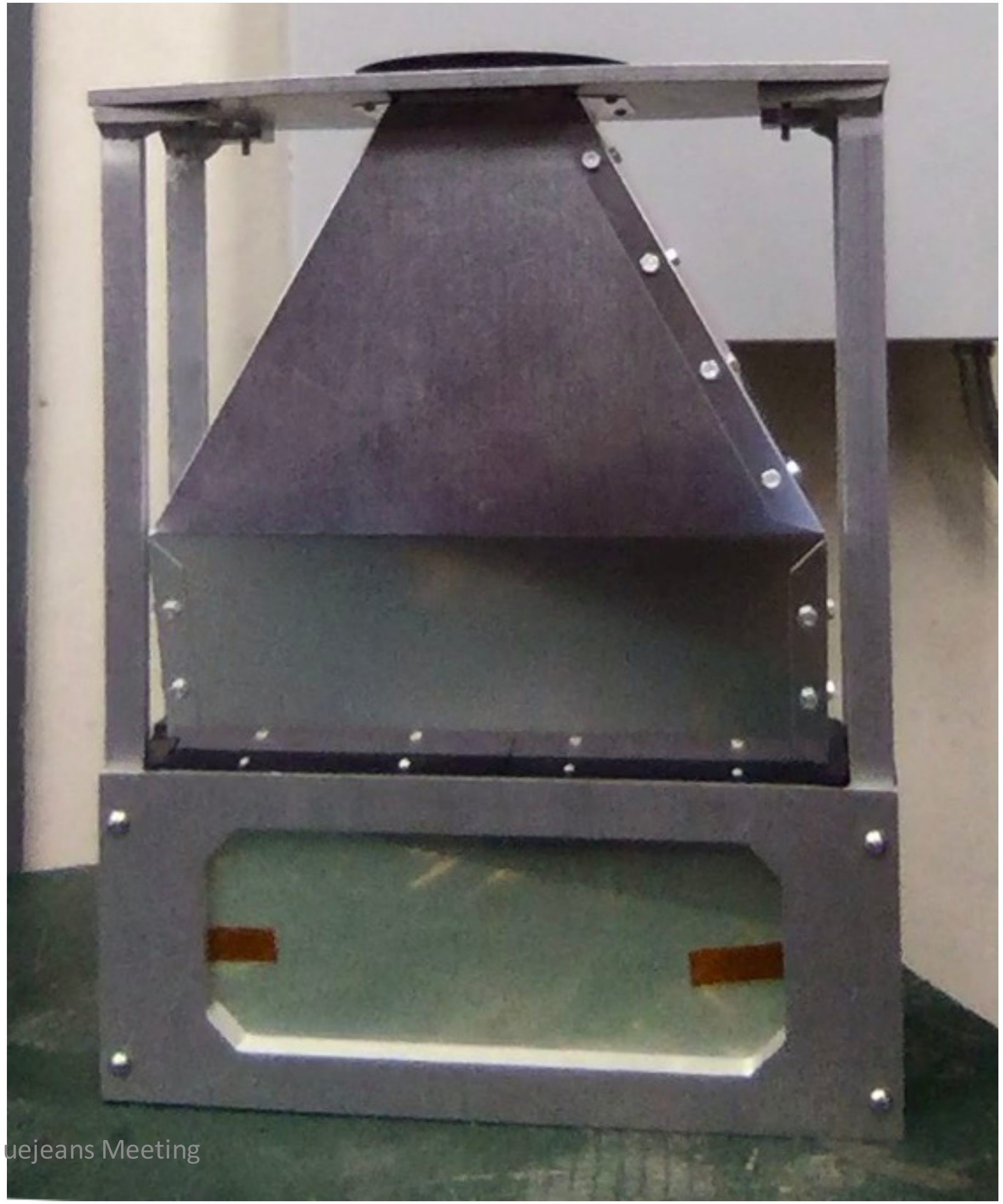
Quartz wrapped in black Kapton



8 mm thick 99.95% pure tungsten plates

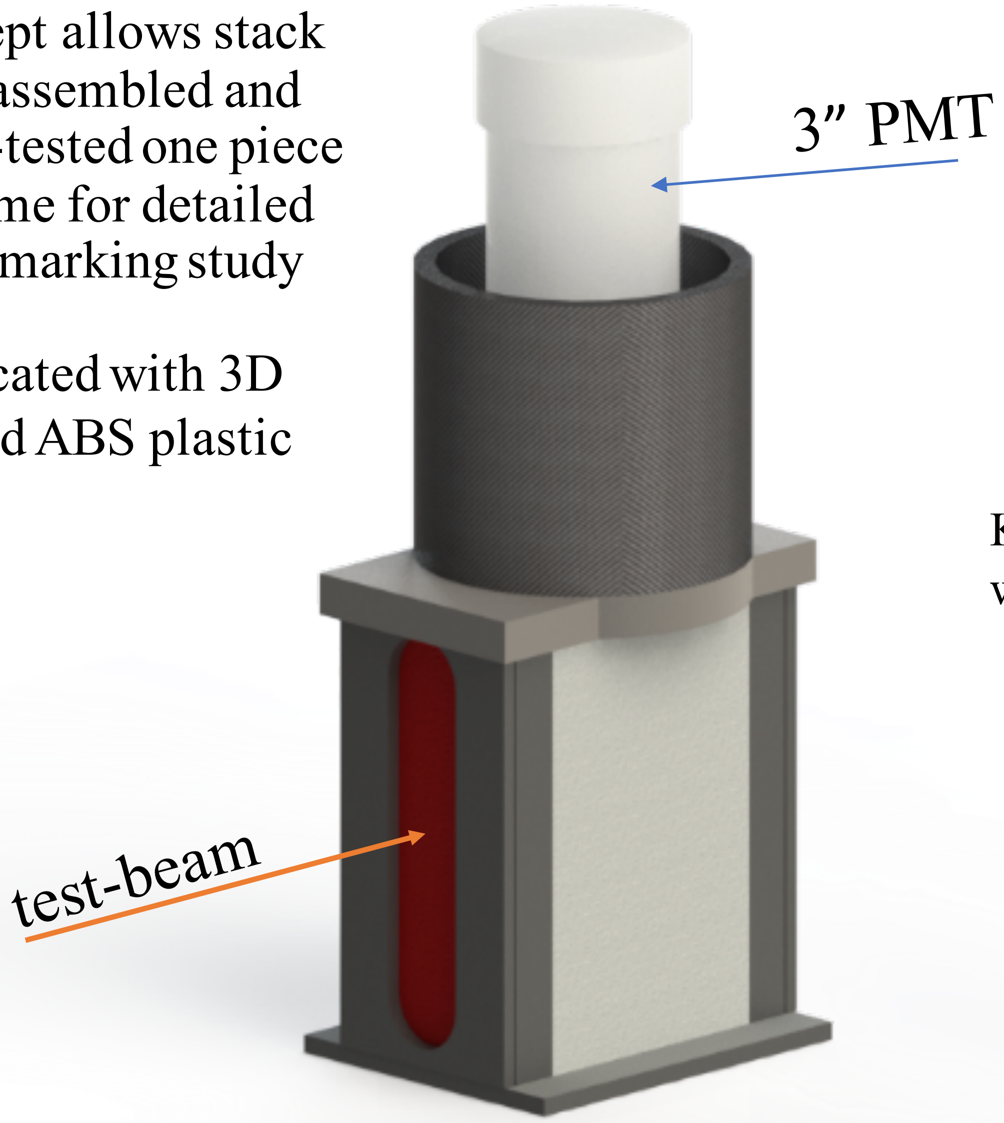
Assembled 1A Full-scale ShowerMax Prototype

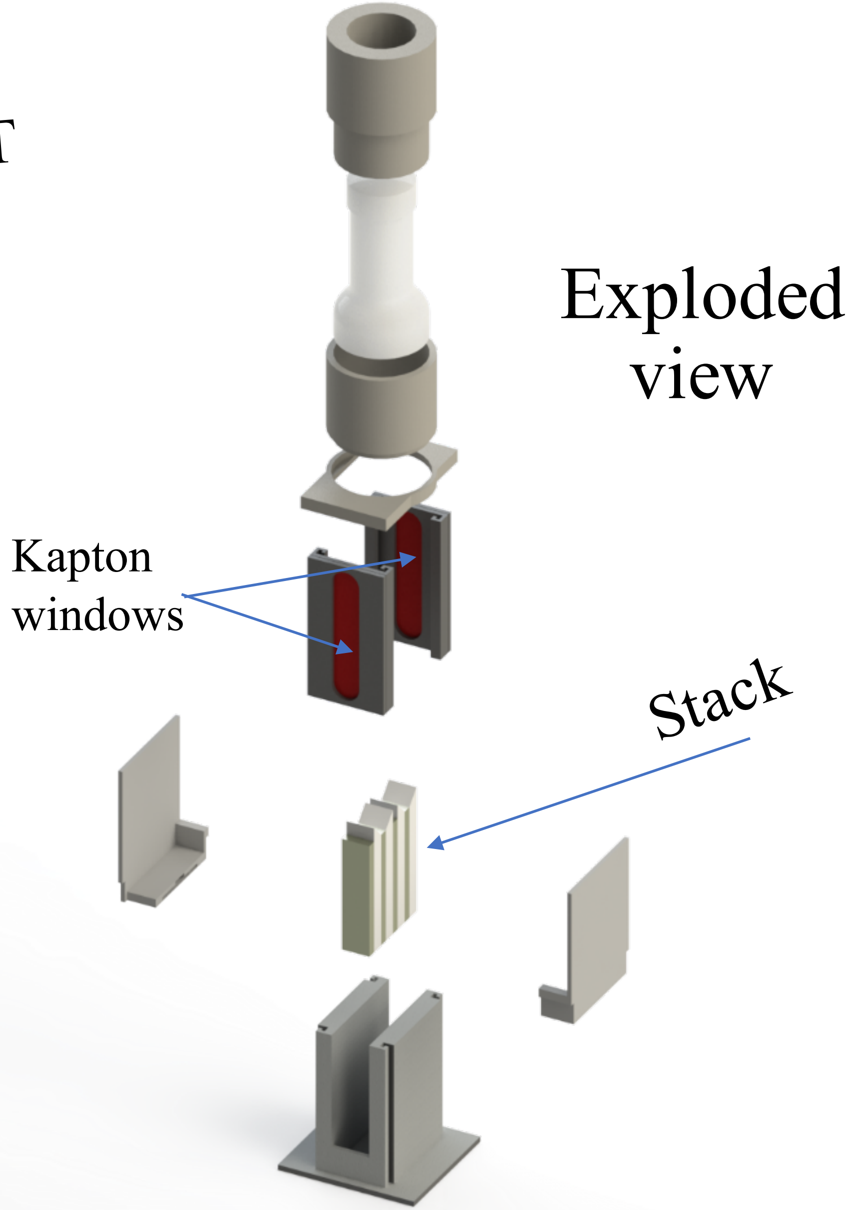




ShowerMax Benchmarking Prototype Concept

- Concept allows stack to be assembled and beam-tested one piece at a time for detailed benchmarking study
- Fabricated with 3D printed ABS plastic





Config #1 (original baseline) benchmarking Prototype

ShowerMax Prototype Construction and Testing

- 1A and 1B full-scale and benchmarking detectors constructed and ready for testbeam and cosmic-ray tests
- Testbeam request approved; planning for a September run: 12 hour per day for 5 consecutive days; not completely sure of beam energy