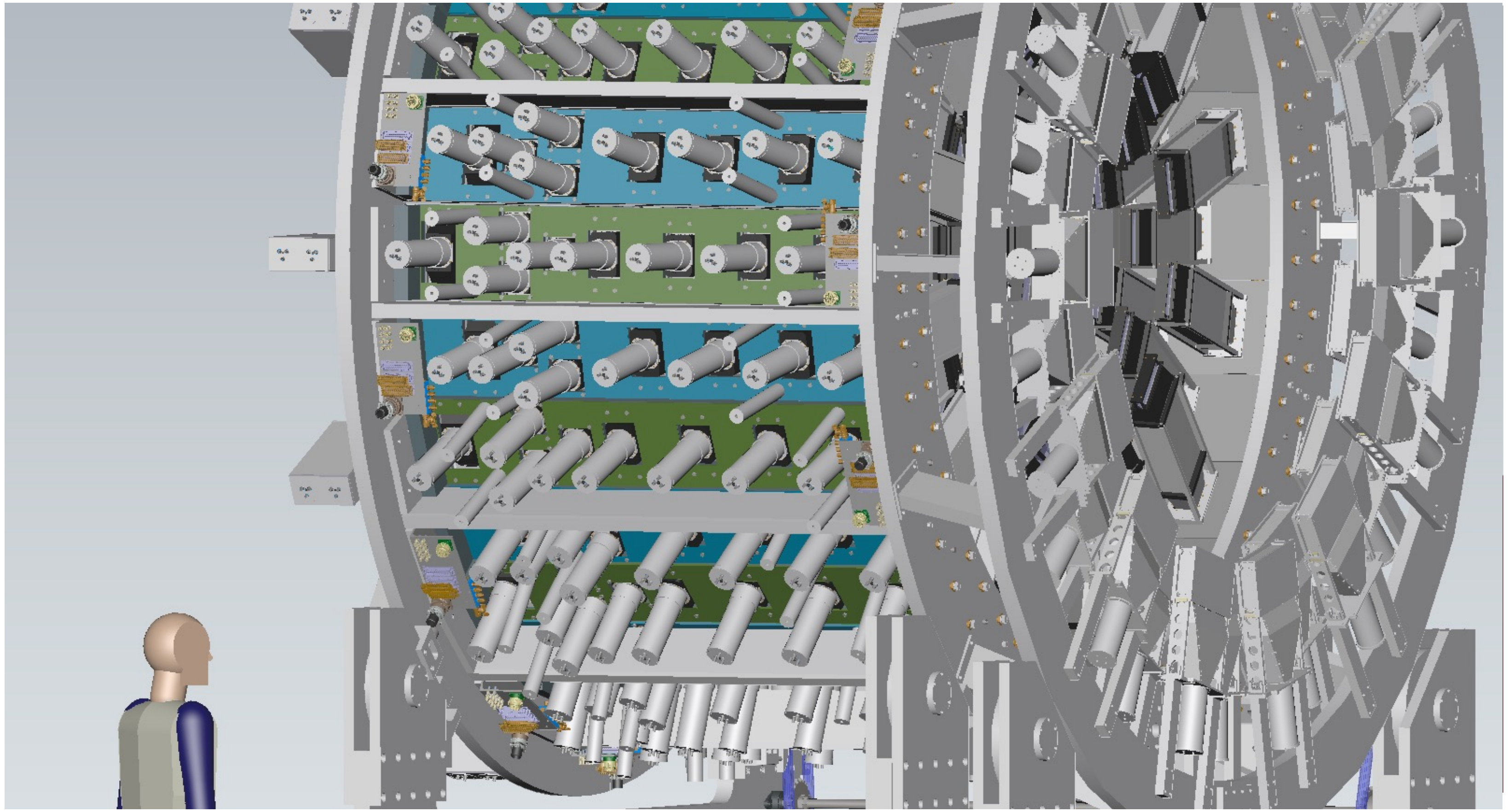
Shower-max Status, Detector Logistics, Radiation Tests



Dustin McNulty – Idaho State University

Students:

Sudip Bhattarai
Sagar Regmi
Jared Insalaco
Justin Gahley
Edwin Sosa
Freddy Kouakou
Coltyn Fisher
Gabriel Ladipo

Outline

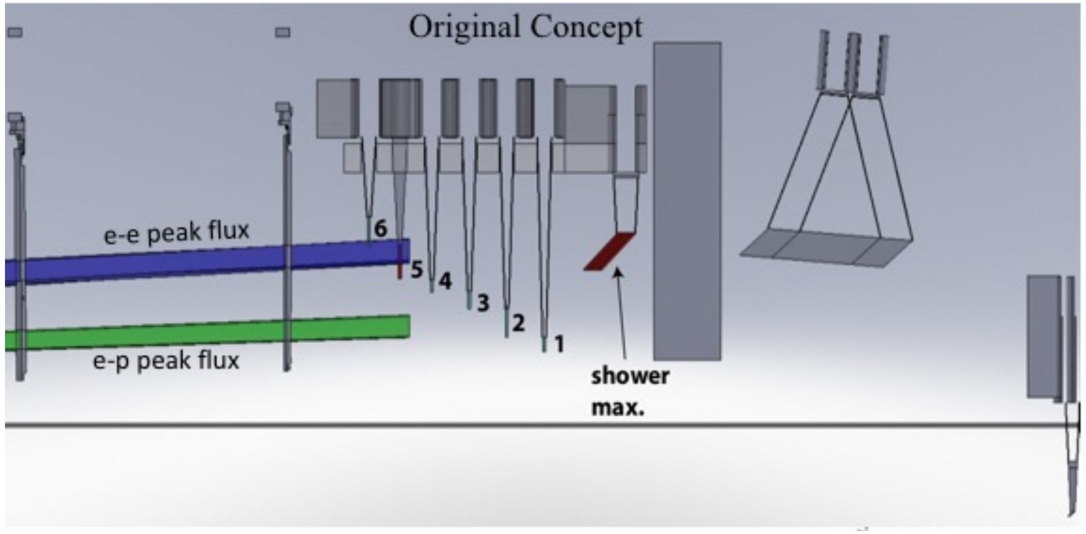
- Shower-max status
  - Subsystem overview
  - Module prototyping/testing plans and progress
  - Remoll lifetime dose estimates for pmt electronics

- Detector Logistics
  - Main detector patch panel, cable harness, and gas distribution system update
  - High density connectors update and prototyping plans

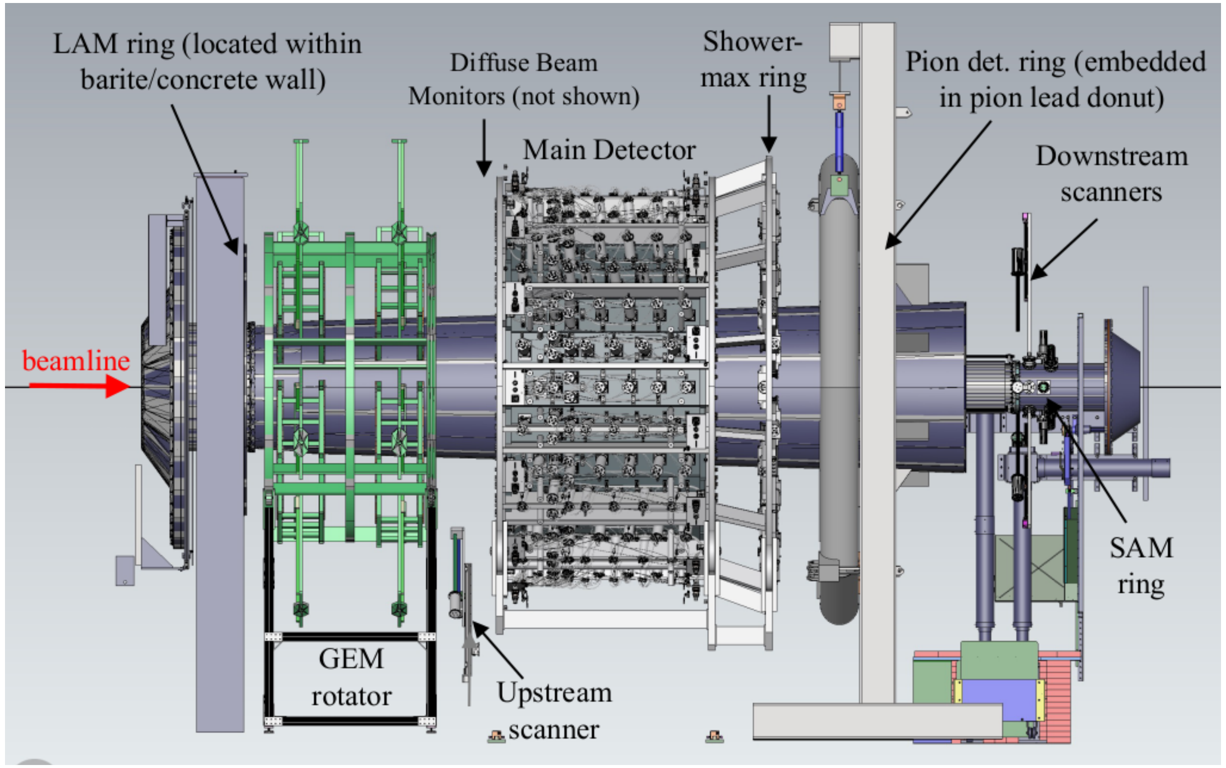
- Radiation Hardness Testing
  - Results from initial tests of pmt electronics; upcoming plans
  - Preliminary test results for 3D-printed plastics;

- Summary and future work

Shower-max Subsystem Overview



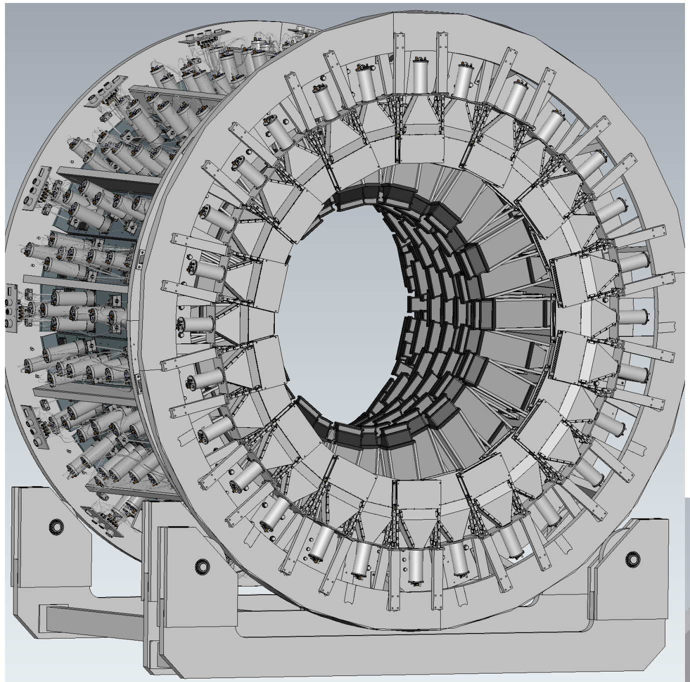
MOLLER Detector Package



- Shower-max is an electromagnetic sampling calorimeter
- Designed and positioned to provide additional measurement of Ring-5 integrated flux (MOLLER A_{PV})
- Weights flux by energy $\Longrightarrow$ less sensitive to soft and hadronic backgrounds
- Also operates in event mode for calibrations and may give additional handle on background pion identification
- Designed to have $\lesssim 25\%$ resolution over full energy range and constructed with rad hard components for long term stability

Shower-max module and ring geometry

ShowerMax detector: ring of 28 sampling calorimeters intercepting physics signal flux 1.7 m downstream of ring 5



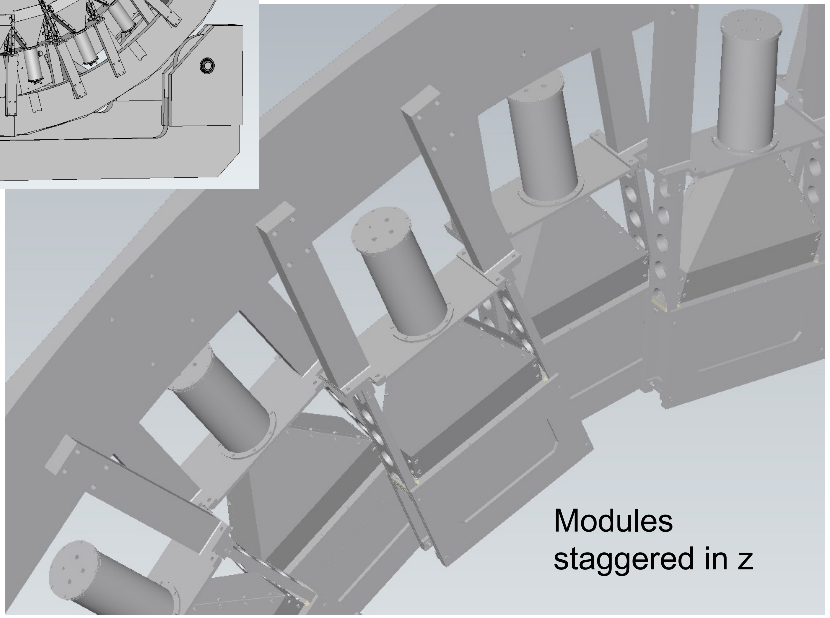
- Aluminum 6061 chassis and air-core light guide
- 99.95% pure tungsten and HPFS radiators
- Radiation length: ~9.5 X_0
- Molière radius ~ 1.1 cm

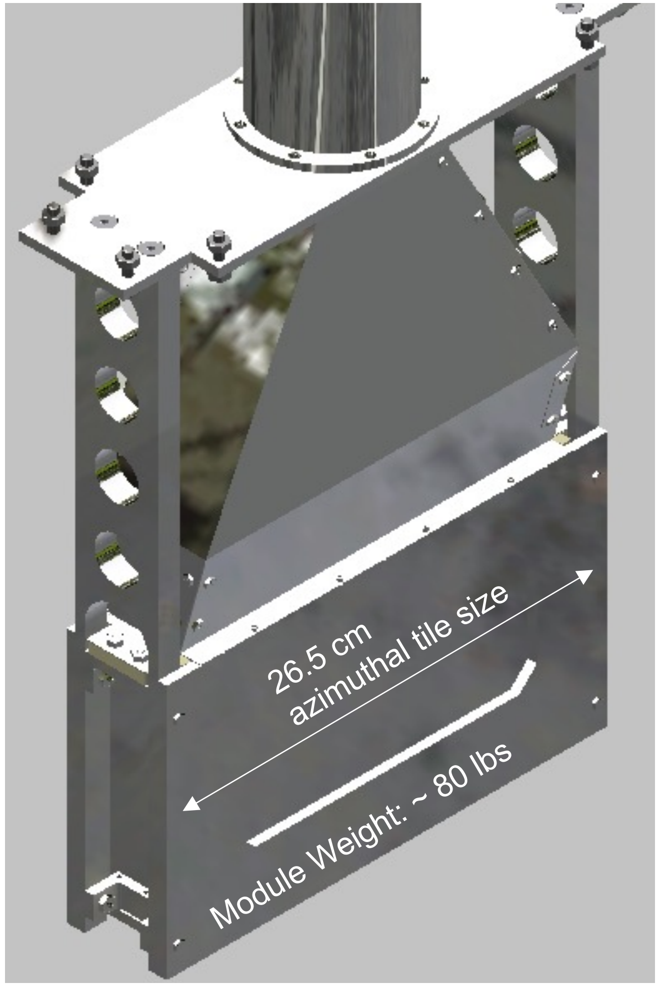
Active region

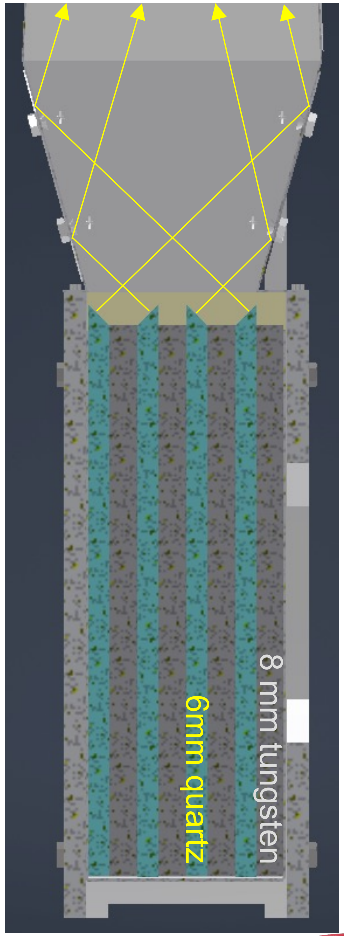
IR: 1020 mm

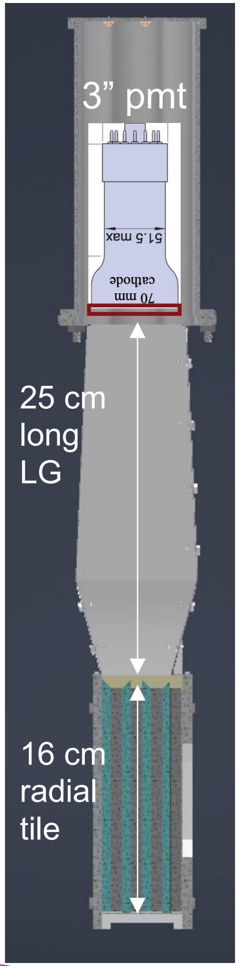
OR: 1180 mm

z-loc: 23920 mm from hall center



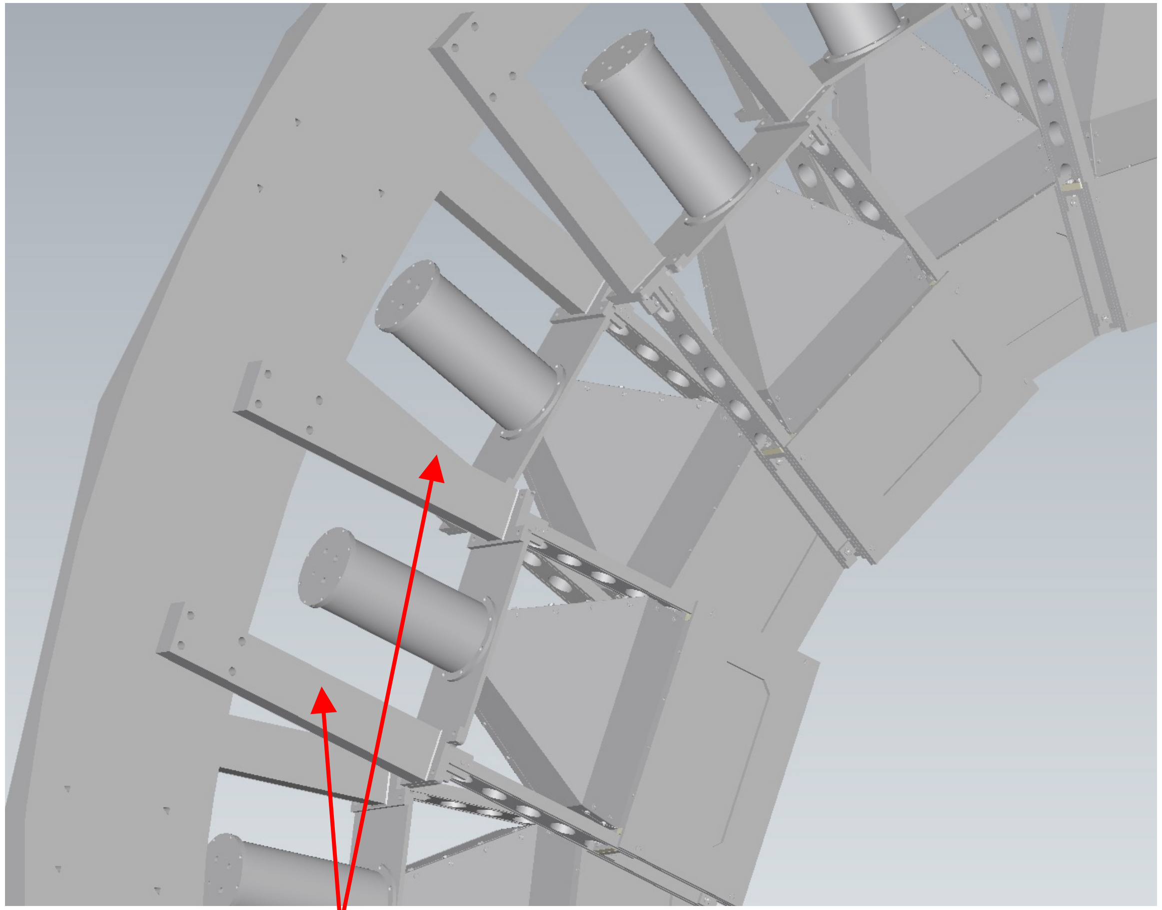




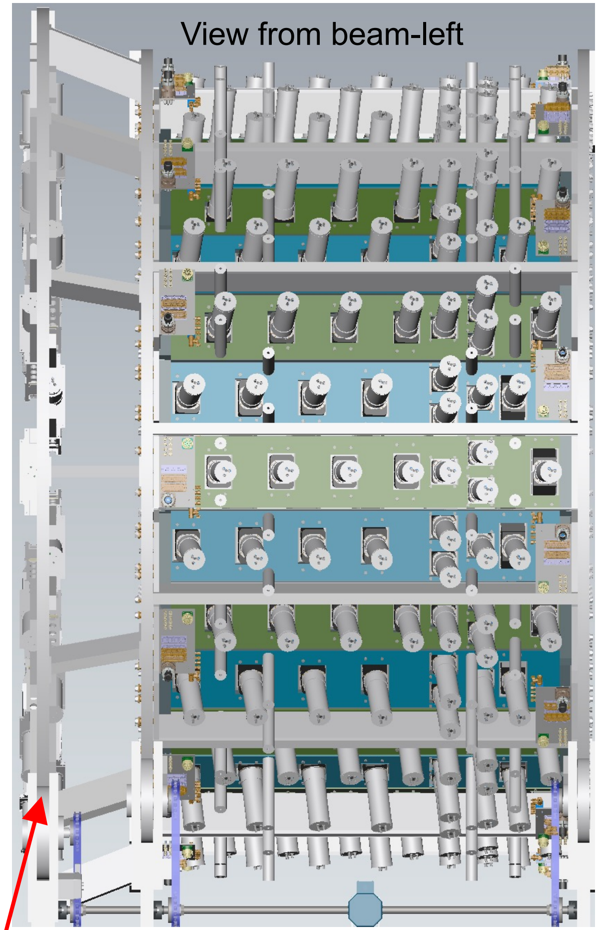


Shower-max Ring Support Structure

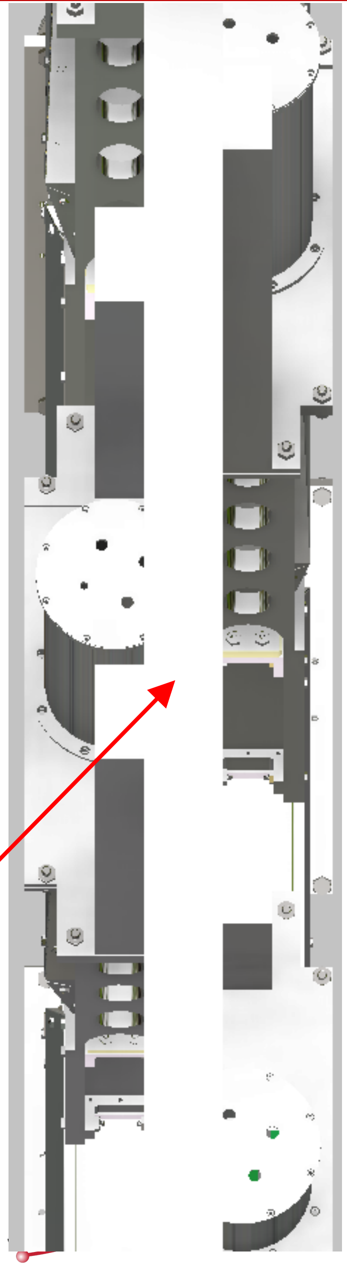
Idaho State University



- Aluminum bars ($15 \times 1.25 \times 2.5\ in^3$) attach modules to ring structure
- Staggered modules are mounted to US and DS face of support ring (in alternating pattern)



Shower-max ring



- View looking radially inward along Shower-max ring
- Shows reasonable clearance for cabling but requires pre-amps external to pmt can

Shower-max: prototyping and testing progress/plans

- Assembled and tested a Shower-max prototype last year (using quartz from 2018 prototype).
  - Tested prototype at Mainz during Nov testbeam
  - Performed radial and azimuthal scans of signal uniformity across the detector face
  - Performed HV scans
  - Performed longpass filter study using a set of 2” diameter filters
  - Also repeated tests with quartz wrapped in aluminized mylar

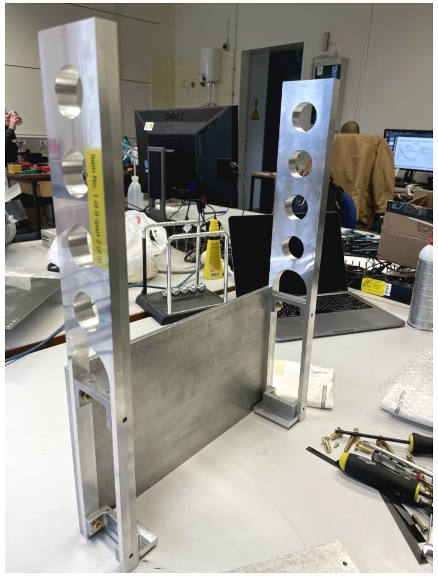
- Building a pre-production prototype this spring and testing with cosmics over summer and possibly at Mainz in September (new quartz is already in hand)

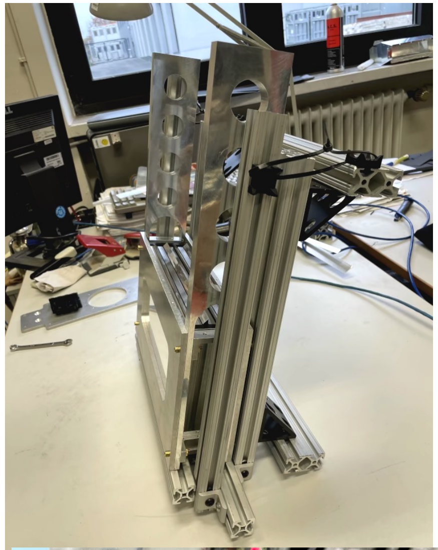
Goals for pre-production prototyping:

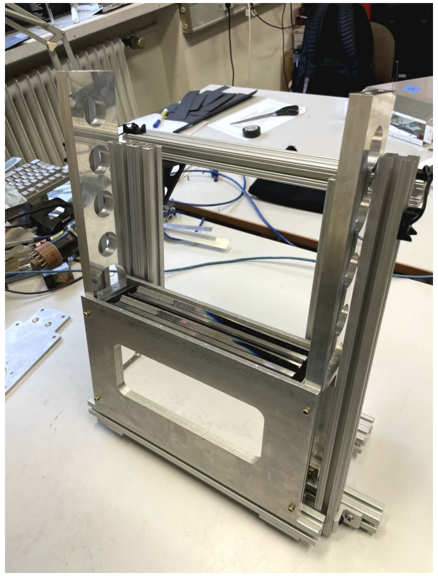
- Test mechanical fitment of final parts and benchmark cosmic-ray signal response
- Validate new quartz from new vendor (Corning 7980 UV grade 5F from HYRDglass)
- Test support bar design (mimic mounting of a horizontal module in the ring)
- Test new pmt can design incorporating 3” diameter longpass filters (already in hand) and gas flow

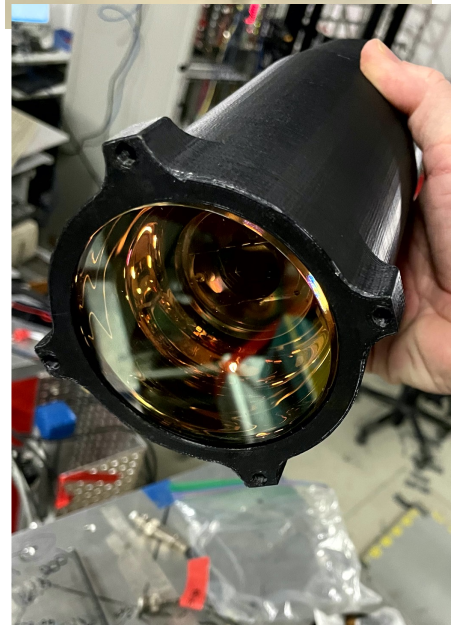
Shower-max: MAMI testbeam (Nov 21 – 28, 2022)

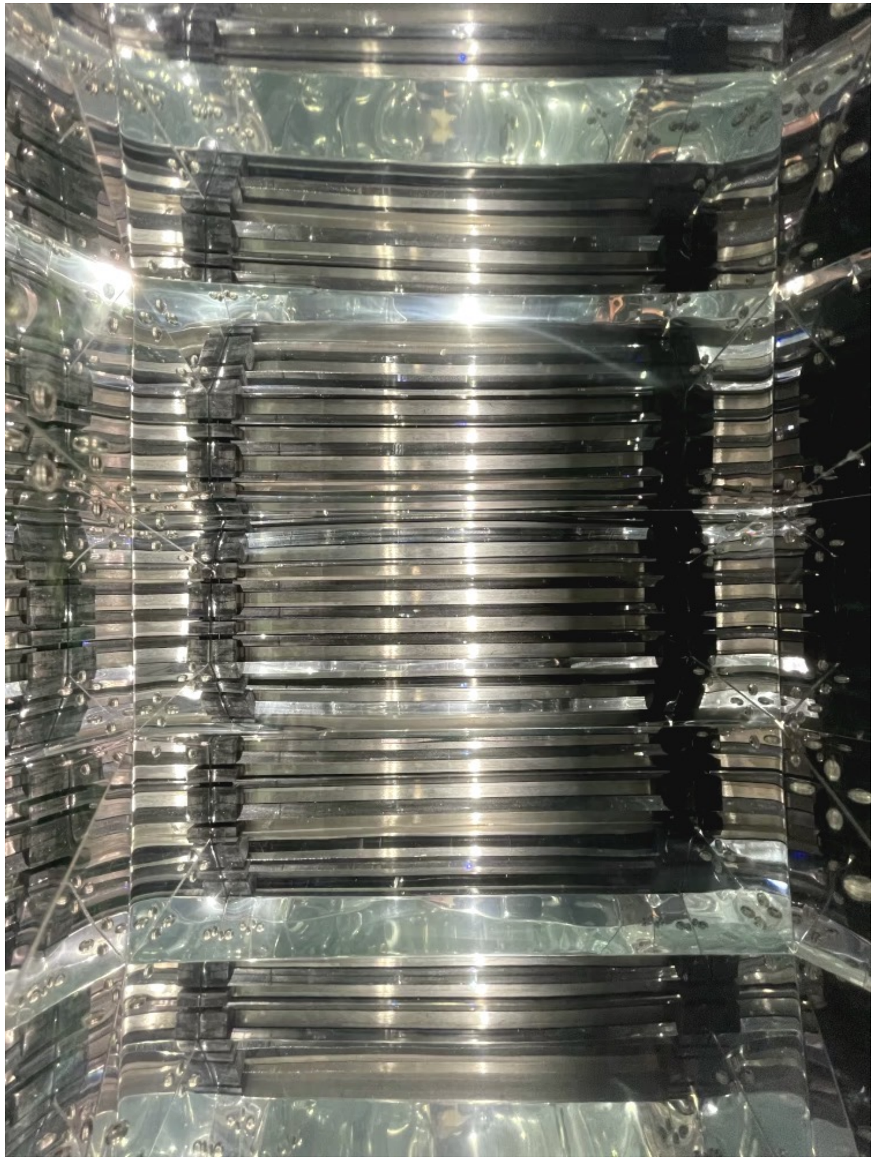
Assembly Photos







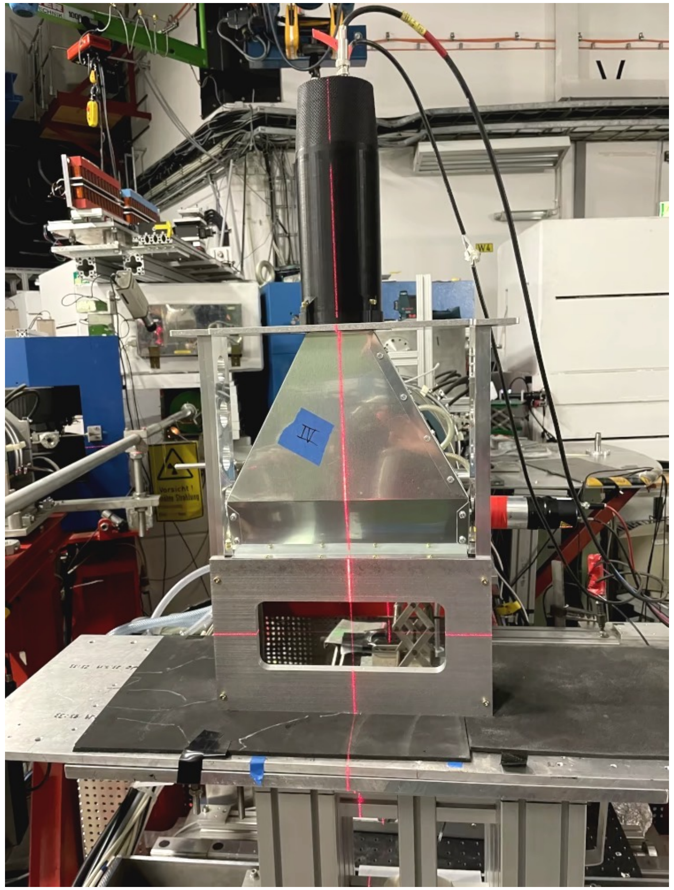


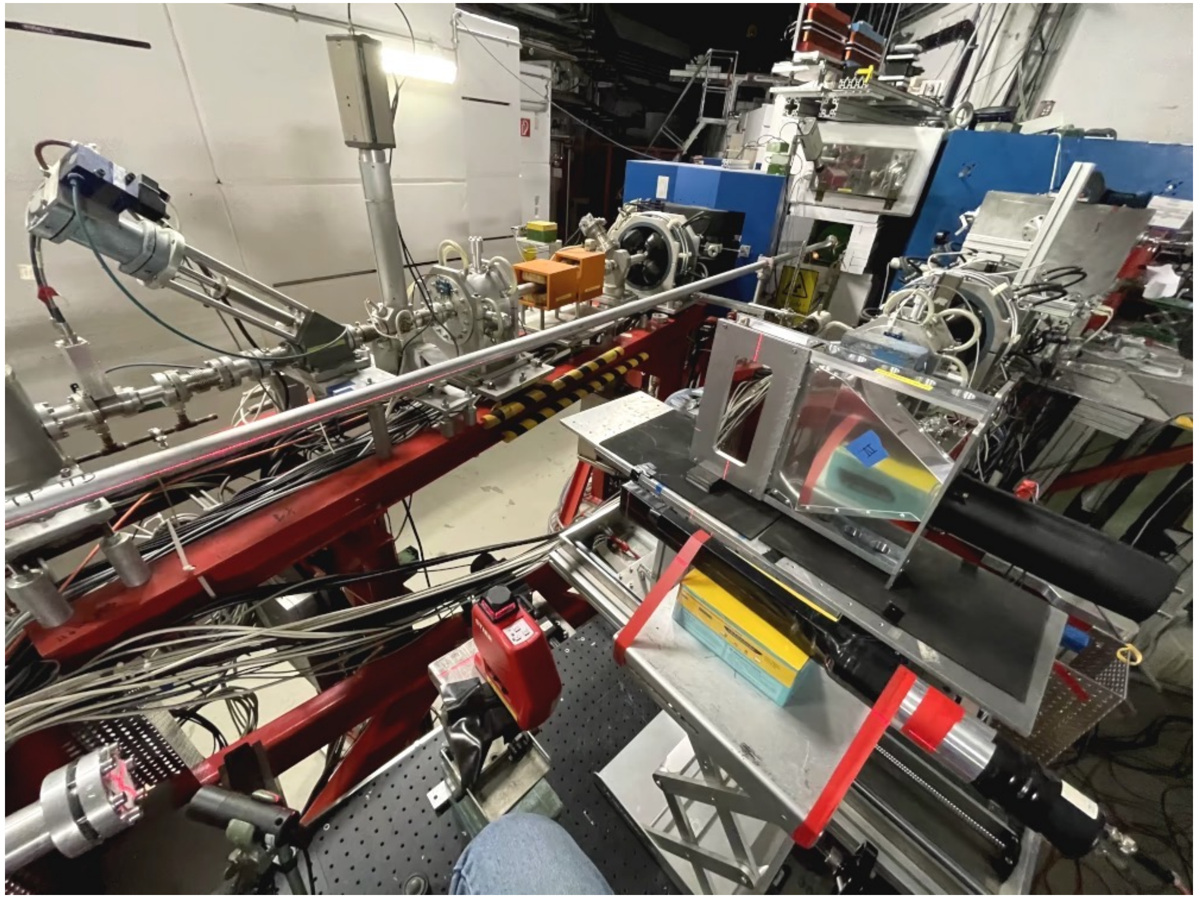


Shower-max: MAMI testbeam Setup

Studies performed over 3 shifts:

- Azimuthal position scan
- HV scan with beam centered on stack
- Radial position scan, including scan along lightguide
- Longpass filter study – 280, 320, and 400nm
- Above tests were performed for both unwrapped (bare) quartz and aluminized-mylar wrapped quartz configs

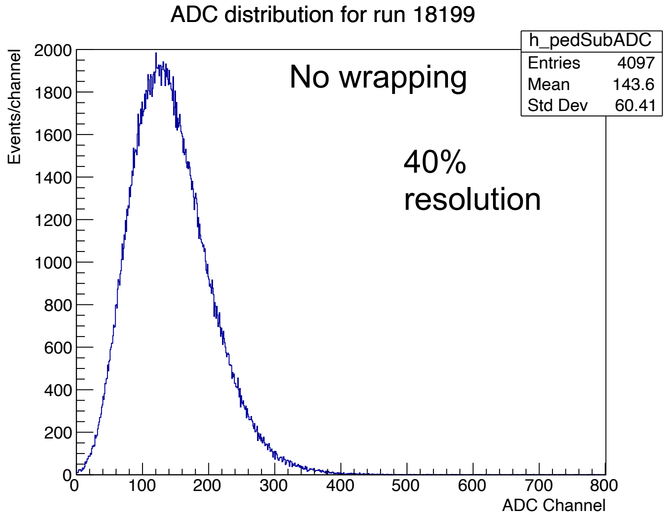


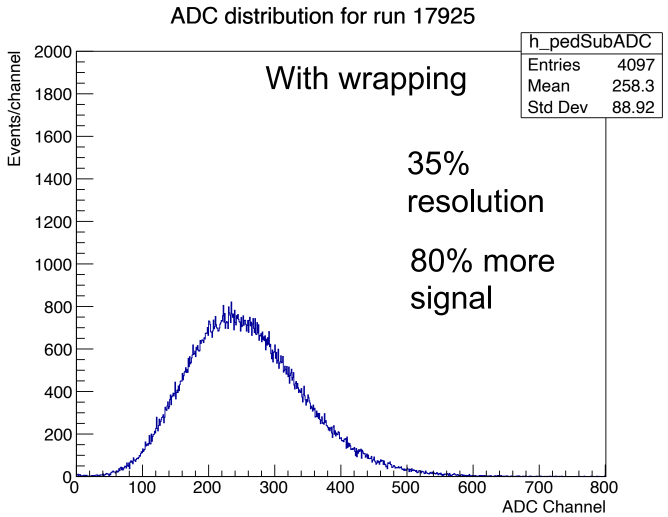


Shower-max: prototype tests (855 MeV electrons)

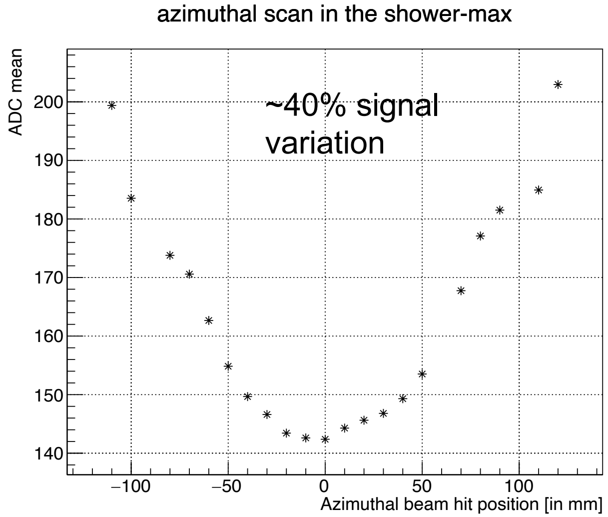
Idaho State University

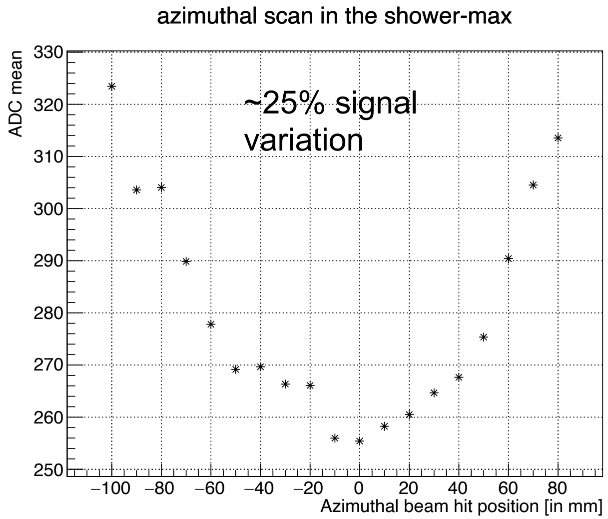
Pulse height Dists



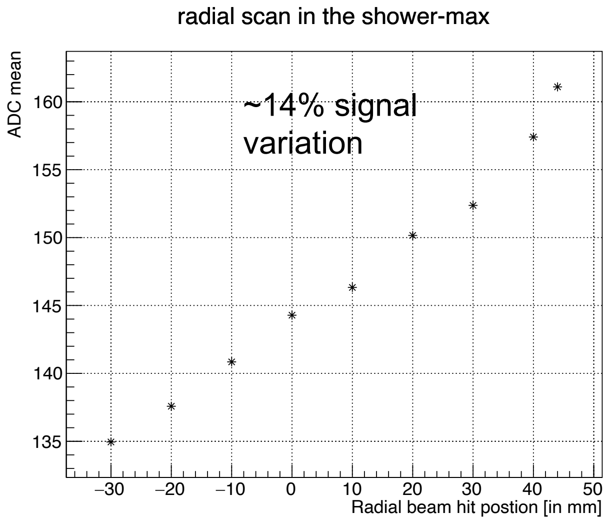


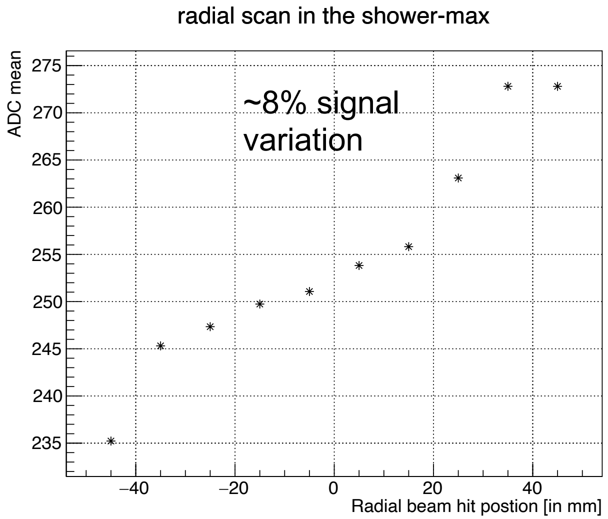
Azimuthal Scans



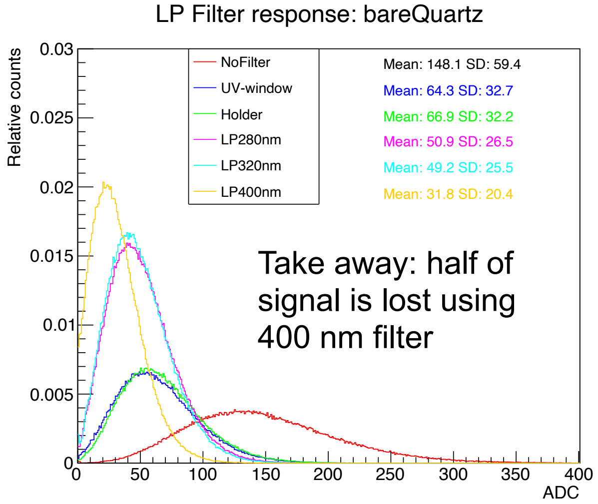


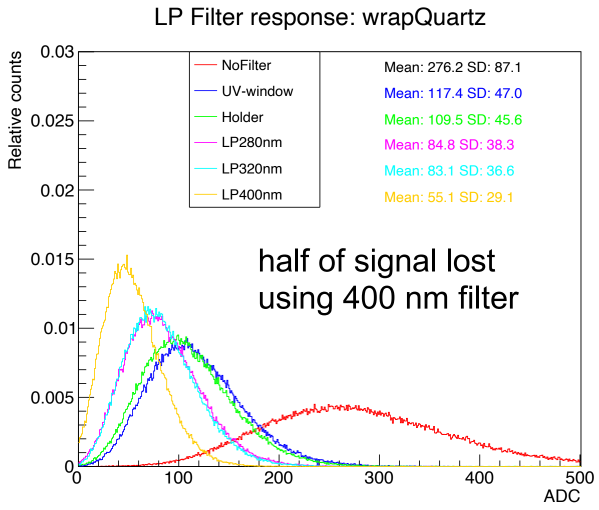
Radial Scans





Filter Studies

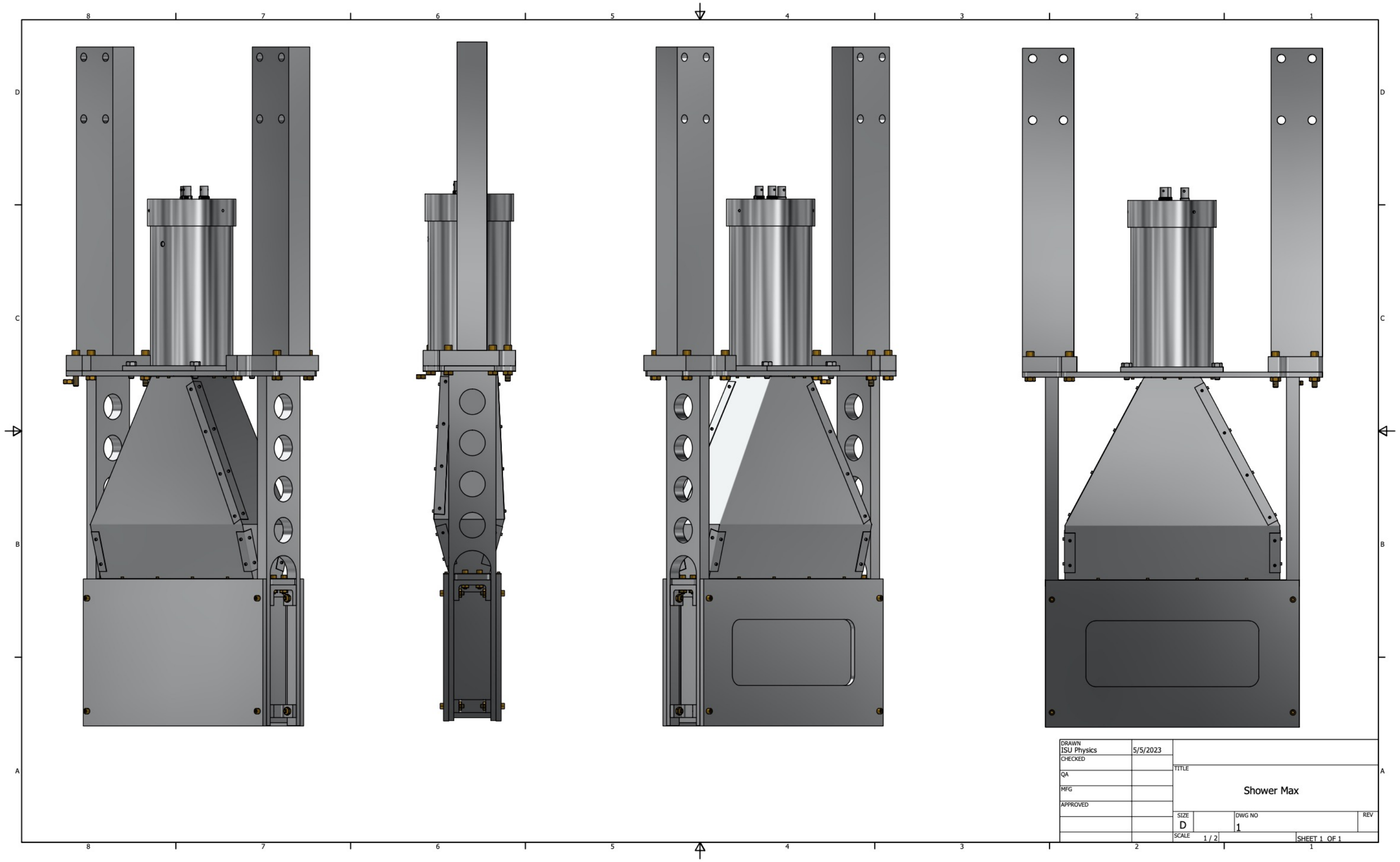




Shower-max: pre-production – Chassis parts

Idaho State University

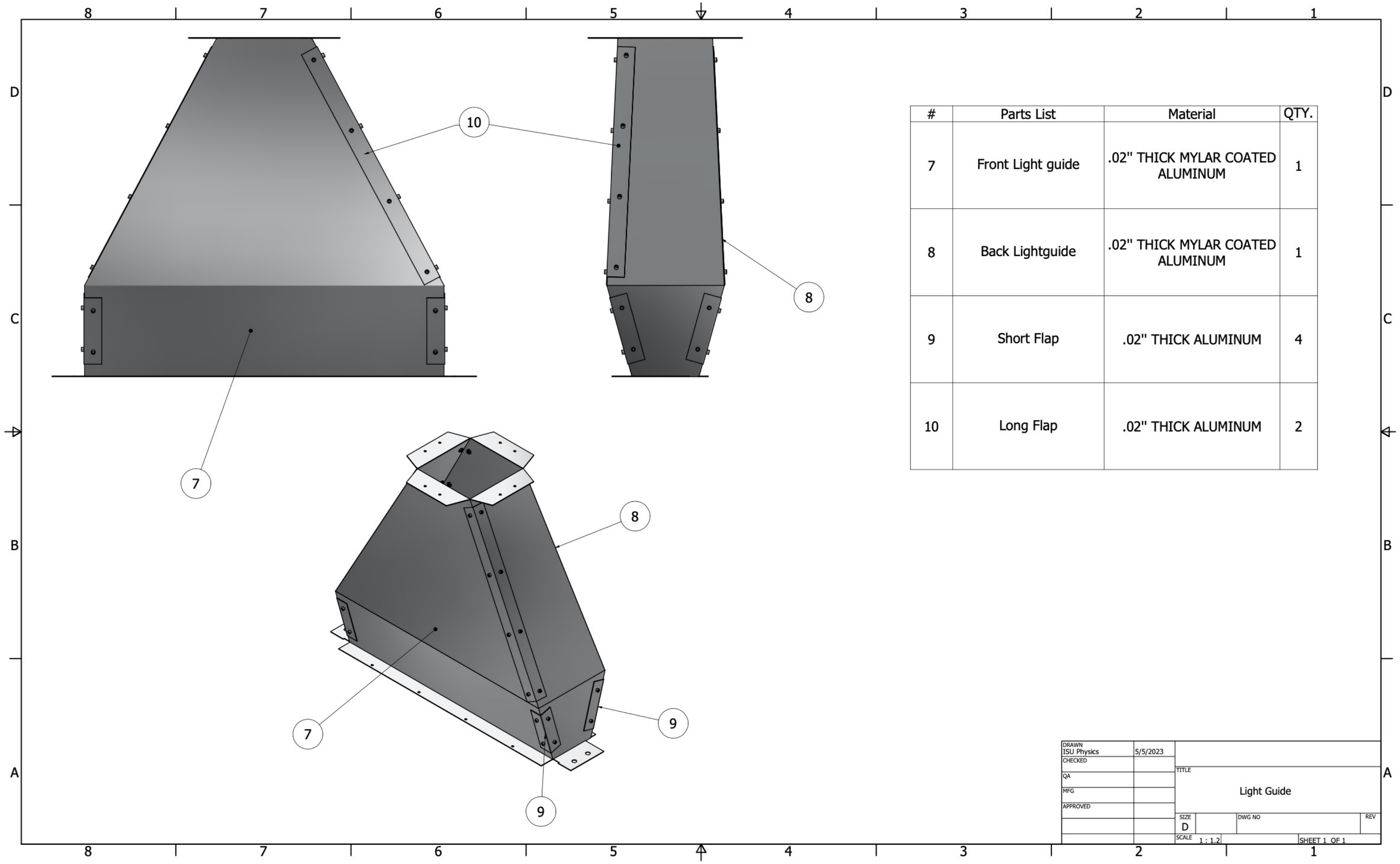
- Shop drawings created and chassis parts out for quotes
- Only minor changes in chassis parts since last year
- New pmt can; removed all countersink screws and modified support strut base



SHOWER MAX PARTS			
ITEM NO.	PART NAME/MATERIALS LIST	Material	QTY.
1	UPPER U CHANNEL	(1/4)" x 2" ALUMINUM 6061	4
2	FLOOR PLATE	0.25 (1/4) THICK 6061-T651 ALUMINUM PLATE	4
3	LOWER U CHANNEL	0.25 (1/4) THICK 6061-T651 ALUMINUM PLATE	4
4	FACE PLATE	0.25 (1/4) THICK 6061-T651 ALUMINUM PLATE	2
5	BACK PLATE	0.25 (1/4) THICK 6061-T651 ALUMINUM PLATE	2
6	WEB PLATE	0.625 (5/8)" THICK ALUMINUM 6061	4
7	TOP PLATE	0.25 (1/4) THICK 6061-T651 ALUMINUM PLATE	4
8	SUPPORT STRUT	1.5 (3/2)" THICK ALUMINUM 6061	4
9	LEFT FOOT PLATE	0.25 (1/4) THICK 6061-T651 ALUMINUM PLATE	4
10	RIGHT FOOT PLATE	0.25 (1/4) THICK 6061-T651 ALUMINUM PLATE	4

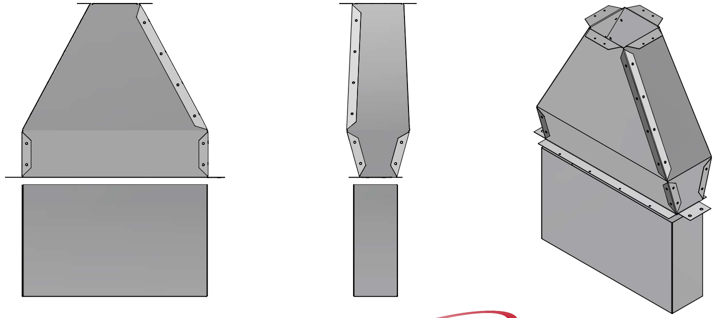
Shower-max: pre-production – light guide parts

Idaho State University



#	Parts List	Material	QTY.
7	Front Light guide	.02" THICK MYLAR COATED ALUMINUM	1
8	Back Lightguide	.02" THICK MYLAR COATED ALUMINUM	1
9	Short Flap	.02" THICK ALUMINUM	4
10	Long Flap	.02" THICK ALUMINUM	2

- Shop drawings ready for original light guide concept
- Also preparing a new, simpler version based on Mainz data
- Planning to use MIRO IV material for construction



Shower-max: pre-production quartz and tungsten

- Found vendor with Corning 7980 UV grade 5F and willing to cut and polish for a great price (HYRDglass)
  - --Ordered and received 4 pre-production pieces for testing Shower-max
  - --Also ordered and received 3 samples for radiation testing QA

ITEM	DESCRIPTION		QTY	EXW UNIT PRICE	TOTAL AMOUT
1	SM 265*166*6, Sample	Material: Corning 7980 5F, all according to the drawing	4	$1,300.00	$5,200.00
2	Quartz glass plates, ¢50mm±0.2, thickness 10mm±0.2. Top and bottom surface polished.	Material: Corning 7980 5F	3	$170.00	$510.00
3	Freight to Idaho 83209		1	$150.00	$150.00
	Total Amout for above				**$5,860.00**
	*********************	***********************	************	****************	*************
1	SM 265*166*6	Material: Corning 7980 5F, all according to the drawing	140	$1,020.00	$142,800.00
2	Freight to Idaho 83209		1	$1,500.00	$1,500.00
	Total Amout for above				**$144,300.00**

- Have also identified domestic sources but none willing to do 45 deg cut and polishing and all are significantly more expensive than HYRD
- Tungsten quotes are easy to get and right at budget; plates cost ~$1k each (7 week lead time)

Jefferson Lab

Shower-max dose simulations using remoll

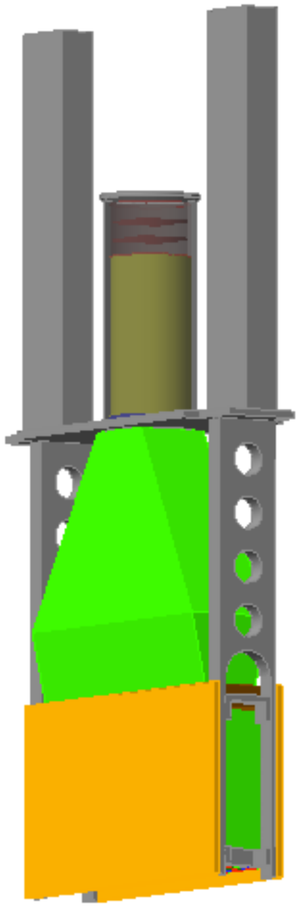
Shower-max ring in remoll GDML:

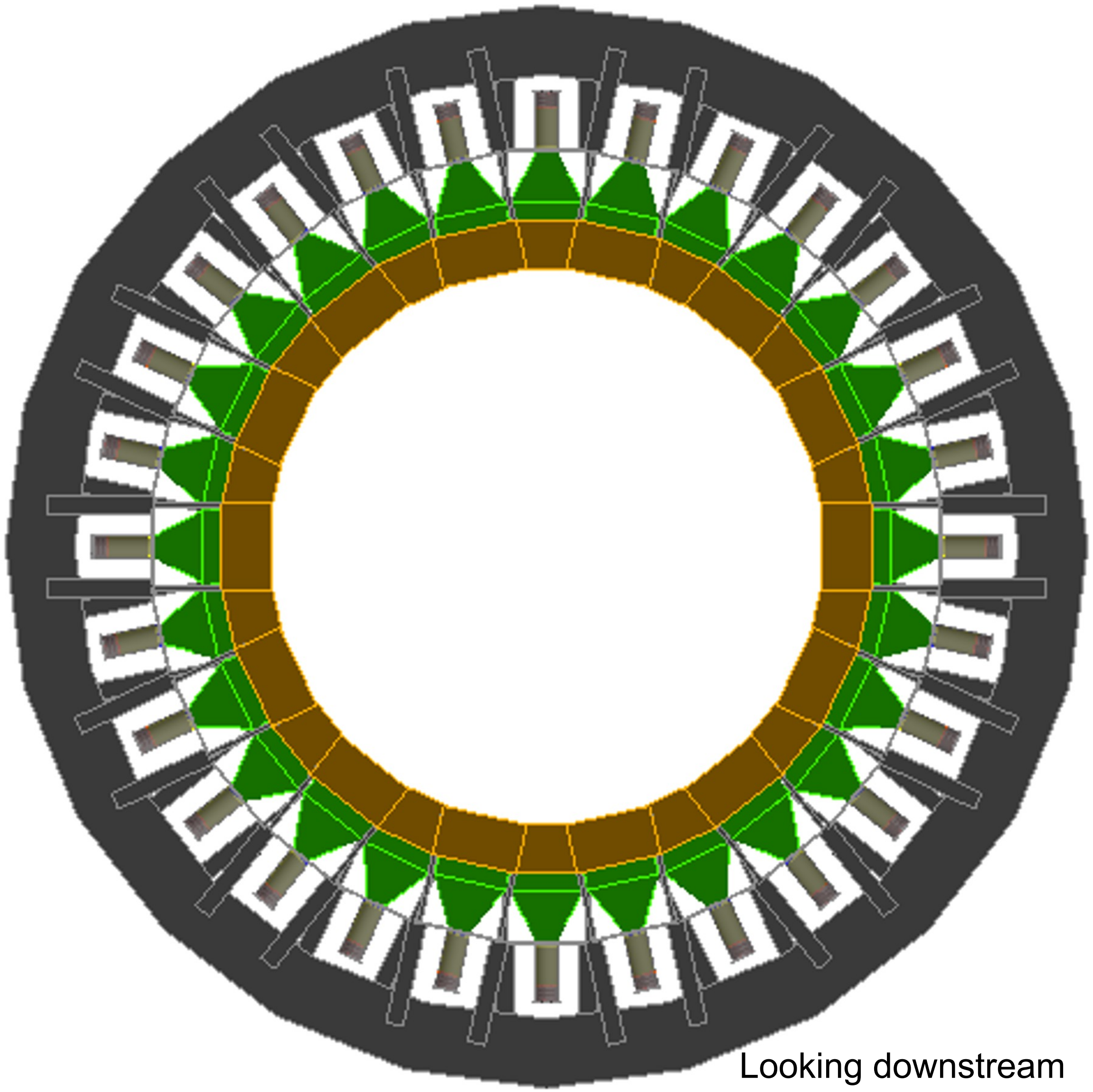
- Work done by Sudip Bhattarai

--We have estimated total dose in each quartz layer of Shower-max during MOLLER lifetime

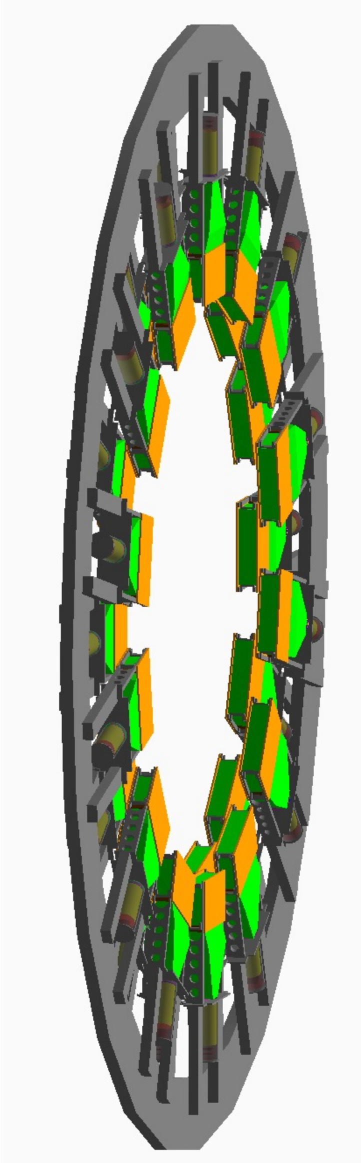
--We also have estimates for the LP filter, PMT window, and pre-amp Si wafers

[docDB #866]





Looking downstream

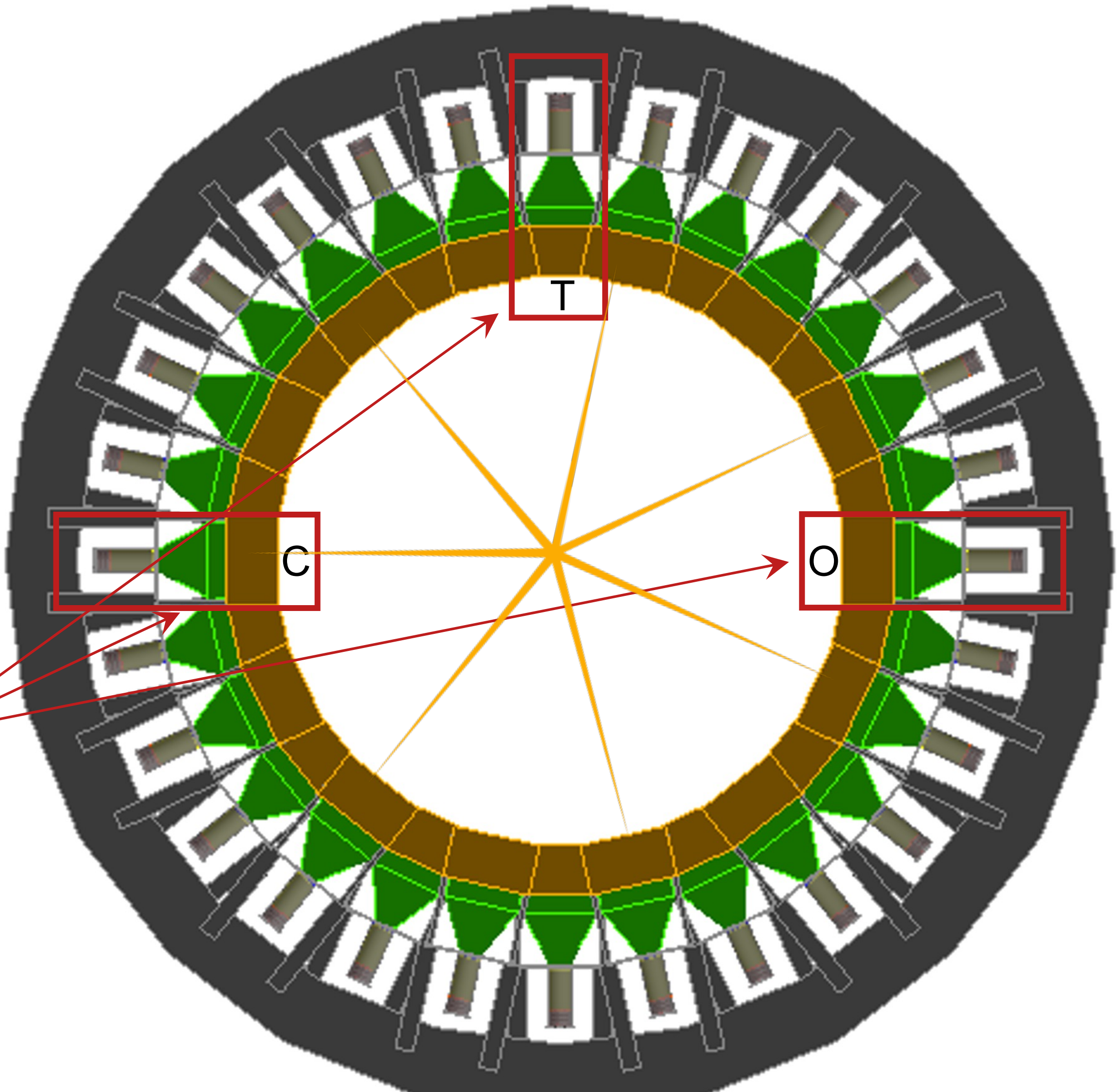


Shower-max dose simulations using remoll

Open and Closed region detectors are upstream of Transition region detectors in the ring

Quartz layer dose study:

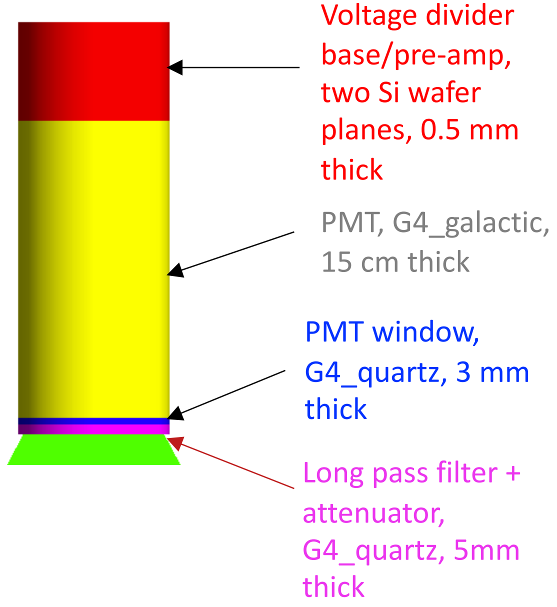
Made each quartz layer sensitive for individual Open, Closed, and Transition detectors located at these specific positions



Looking downstream

PMT region dose study:

Sensitive volumes:



Shower-max lifetime dose estimate summary

--Quartz layers

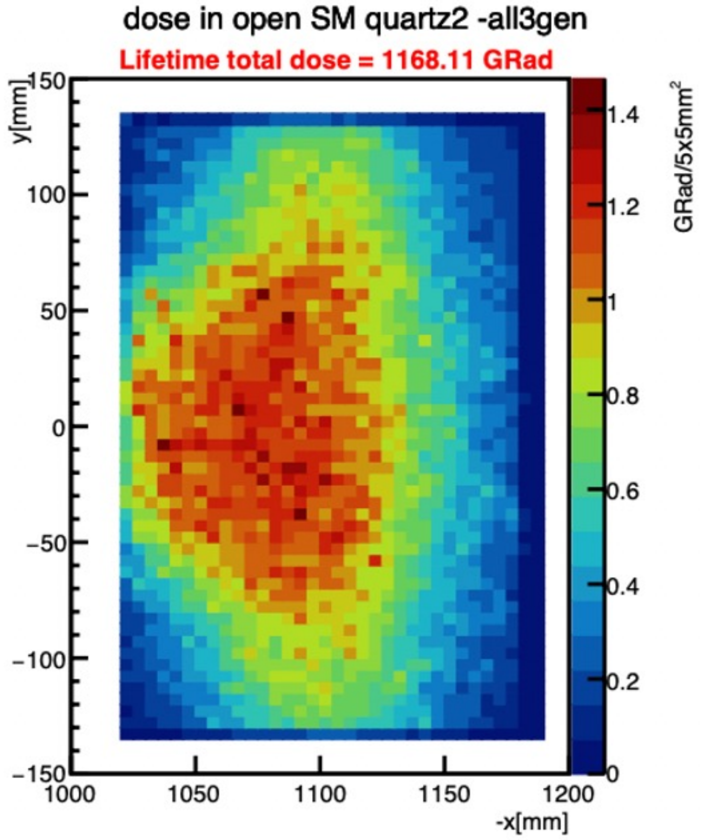
- Ran 5M Moller, ep-elastic and ep-inelastic generator events
- Peak dose density is in 2^{nd} layer at 1.2 Grad/5x5mm^2 pixel
- Closed region are ~4x lower and Transition need to be re-studied

--PMT region average lifetime doses (MRad/pixel):

- Filter region: Open: ~3.3
  Closed: ~1.4
  Trans: ~2.2 (re-do)
- The 5 mm thick filter models both a 3 mm LP filter + 2 mm ND filter. Will redo with no ND filter
- PMT window: Open: ~1.2 MRad/pixel
  Closed: ~0.6
  Trans: ~0.9 (re-do)

--PMT electronics region average lifetime doses (kRad/pixel):

Open: ~75
Closed: ~50
Trans: ~70 (re-do)



MOLLER Detector Logistics (Channel Accounting)

Idaho State University

- Both integrate- and event-mode:

(needs HV, twinax, coax, and base LV)

--Main Detectors: 224
(8 per segment, 28 segments)

--Auxiliary Detectors: 112
LAMs (7x2), US scanner (2), beam halo monitors (2x14), Shower-max (28), Pion detector (28), DS scanners (4), and SAMs (8)

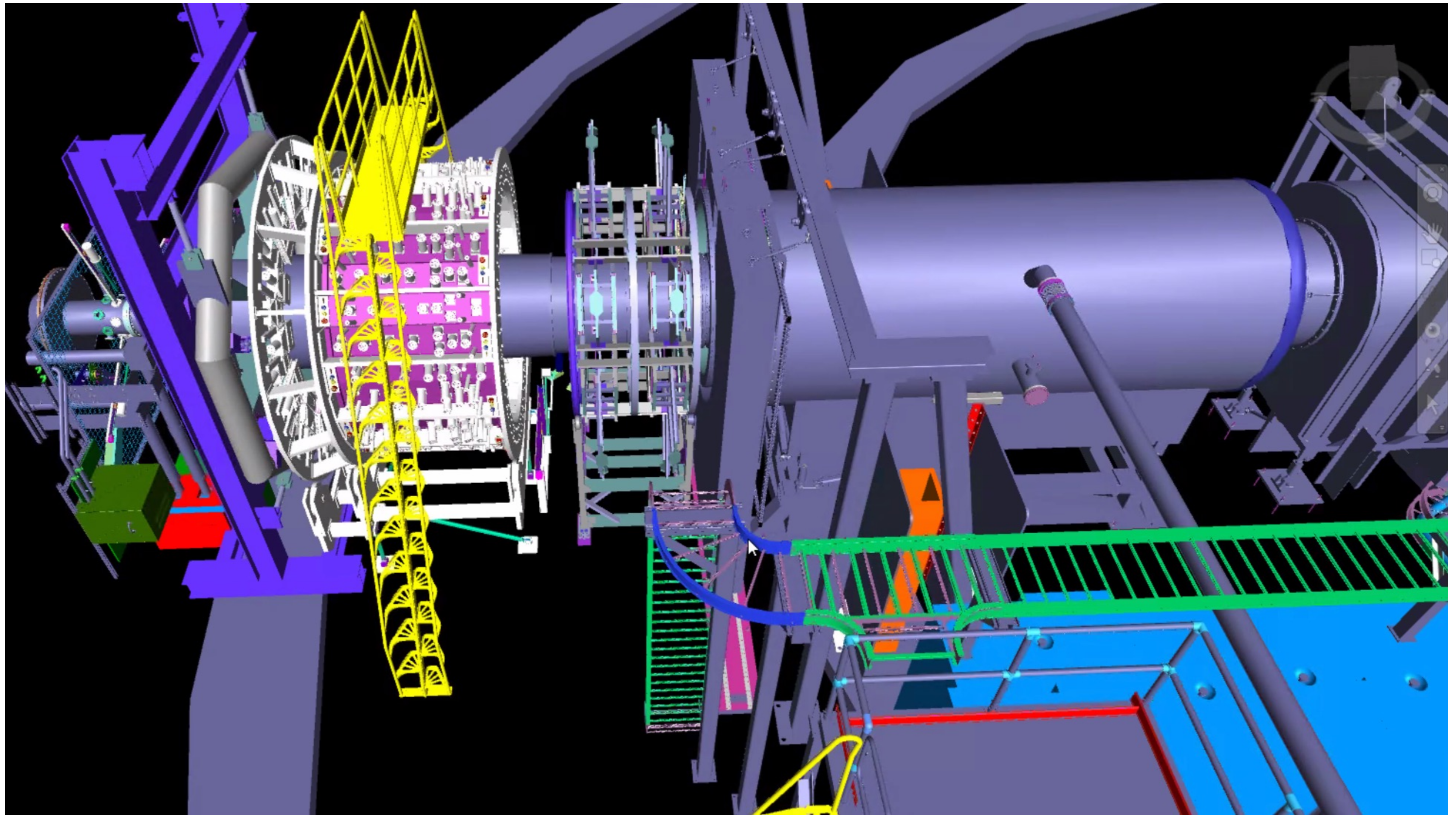
- HVMaps Detectors: 84 (3 arrays per Main detector Segment (power, fiber RO))

- Event-mode only:

(needs HV, coax, fiber RO, and power)

--GEM Detectors: 28 (7 GEMs per wheel, all 4 wheels (HV and fiber RO))

--Trigger Scintillators: 14 (7 paddles per wheel for 2 wheels (HV and coax signal))



❖ All these cables except HVMaps' power route from detector to the SBS bunker

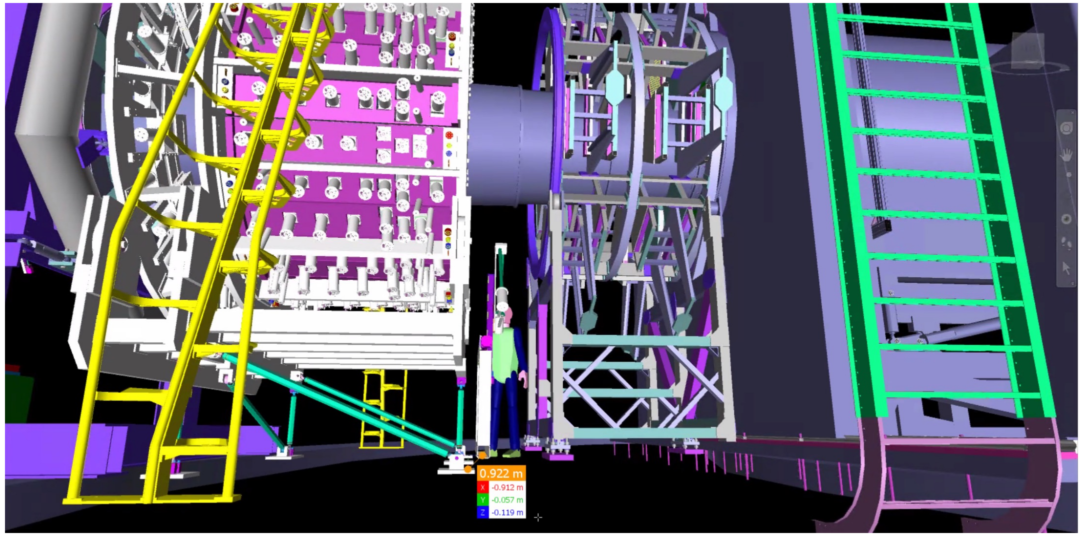
❖ GEM fiber interconnects between GEM electronics racks and SBS bunker electronics

Detailed presentation in docDB #1050

Cable tray bundles

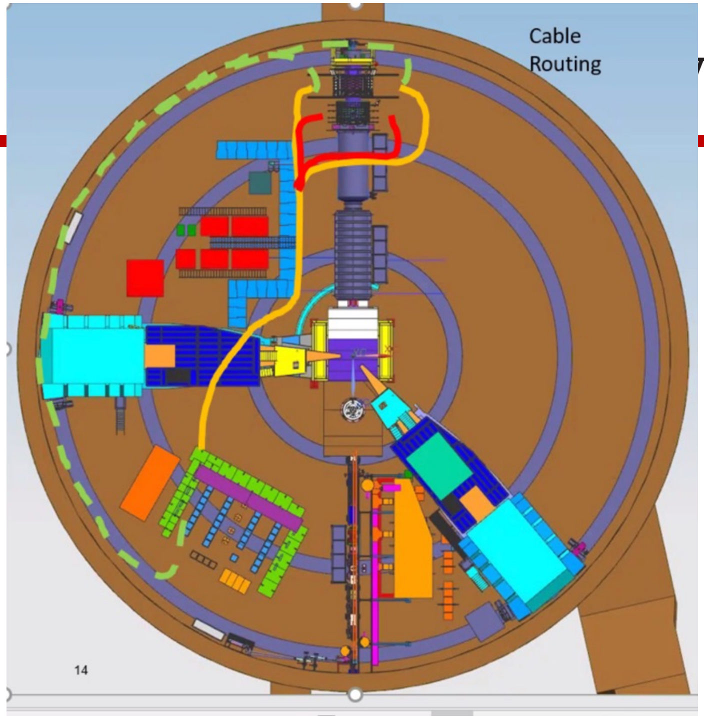
Idaho State University

	All Detectors		70% packing fraction: 30 bundles			
	Bundle No.	purpose	group area (sq.in) 70%	group diam (in) 70%	group width (in) 70%	
Main detectors	1	PMT HV	19.90	5.03	24.19	
	2	PMT twinax	19.90	5.03	24.19	
	3	PMT Coax	12.74	4.03	19.35	
	4	pmt base power	2.25	1.69	8.13	
	5	HVmaps fiber RO	1.87	1.54	7.41	
	6	Hvmaps power	19.10	4.93	23.70	
	7	Hvmaps pow sigs	3.18	2.01	9.67	in feet
	Groups 1 - 5 sum		56.65	17.33	83.26	6.94
	Groups 6 - 7 sum		22.29	6.95	33.37	2.78
Aux detectors	8	PMT HV	9.95	3.56	12.09	
	9	PMT twinax	9.95	3.56	12.09	
	10	PMT Coax	6.37	2.85	9.67	
	11	pmt base power	1.12	1.20	4.06	in feet
	Groups 8 - 11 sum		27.39	11.16	37.92	3.16
GEM detectors	12	PMT HV	3.98	2.25	4.84	
	13	PMT Coax	0.85	1.04	1.29	
	14	GEM fiber RO	1.45	1.36	3.77	in feet
	Groups 12 - 14 sum		6.28	4.65	9.90	0.82
	Total sum in cable tray		**90.32**	**33.15**	**131.08**	**10.92**



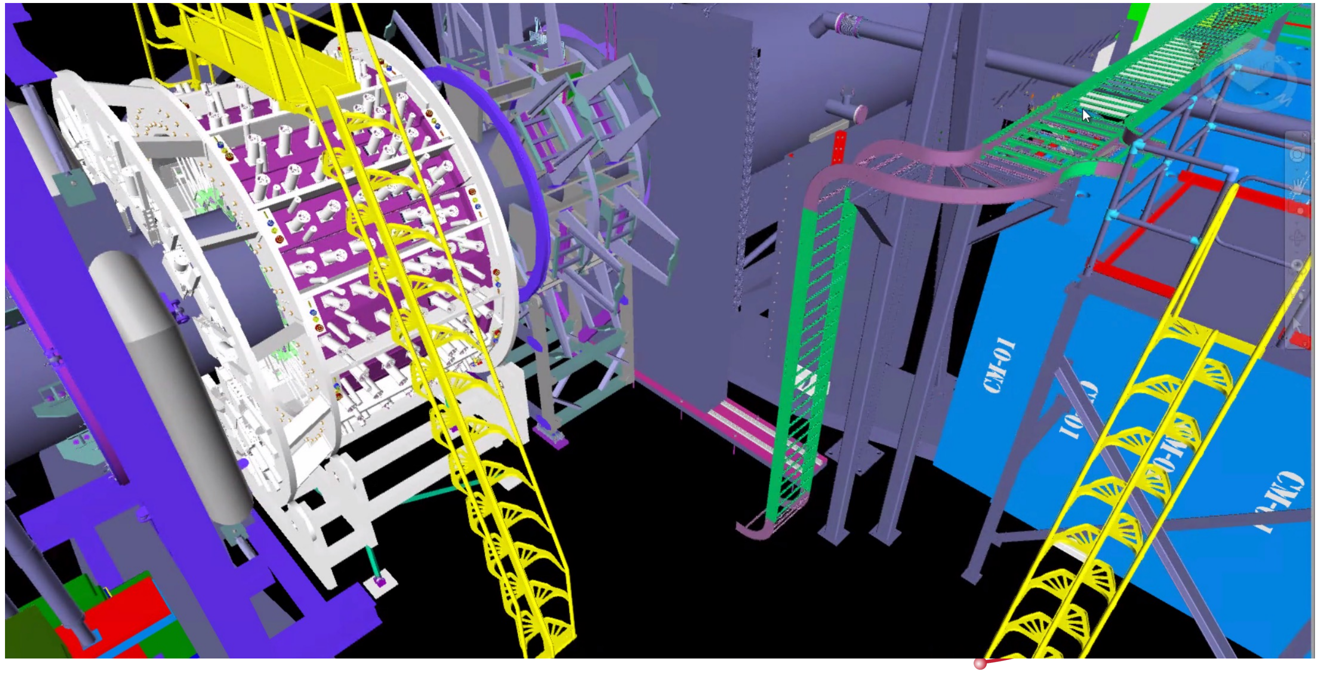
- 90 in^2 total or ~4 in x 2 ft bundle of cables in the tray ⟺ SBS bunker
- 22.3 in^2 total or ~7 in diameter bundle of HVMaps LV power cables; main det ⟺ GEM racks

Cable lengths

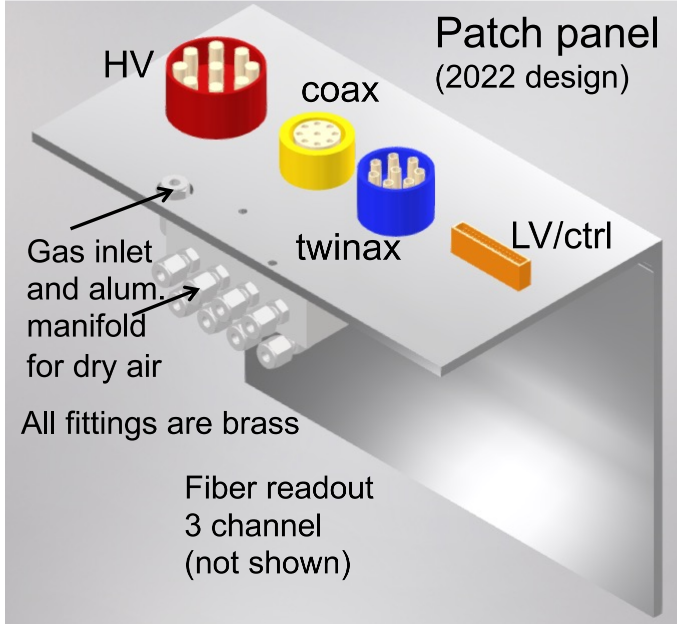


Bundle #	purpose	Bundle destination	Indiv. Cable Length (ft)	Total needed Length (ft)	Grand Total Length (ft)
1	PMT HV	SBS bunker	250	60000	101750
2	PMT twinax	SBS bunker	250	60000	90000
3	PMT coax	SBS bunker	250	60000	94000
4	pmt base power	SBS bunker	250	60000	90000
5	HVmaps fiber RO	SBS bunker	250	22500	
6	Hvmaps power	SBS bunker	spliced	TBD	
7	Hvmaps pow sigs	SBS bunker	spliced	TBD	
8	Aux. PMT HV	SBS bunker	250	30000	
9	Aux. PMT twinax	SBS bunker	250	30000	
10	Aux. PMT coax	SBS bunker	250	30000	
11	Aux PMT base power	SBS bunker	250	30000	
12	GEM /Scint PMT HV	SBS bunker	250	11750	
13	Scint PMT coax	SBS bunker	250	4000	
14	GEM fiber RO	SBS bunker	250	7750	

- These are cable lengths from patch panel or Aux detector to SBS bunker, including spares
- There are also cable lengths needed for routing internal to segment patch panels (~1100 ft for each of HV, twinax, coax, and base power)



Snapshot of technical progress (main detector cabling)



- 8 detectors per tray,
  each detector requires:

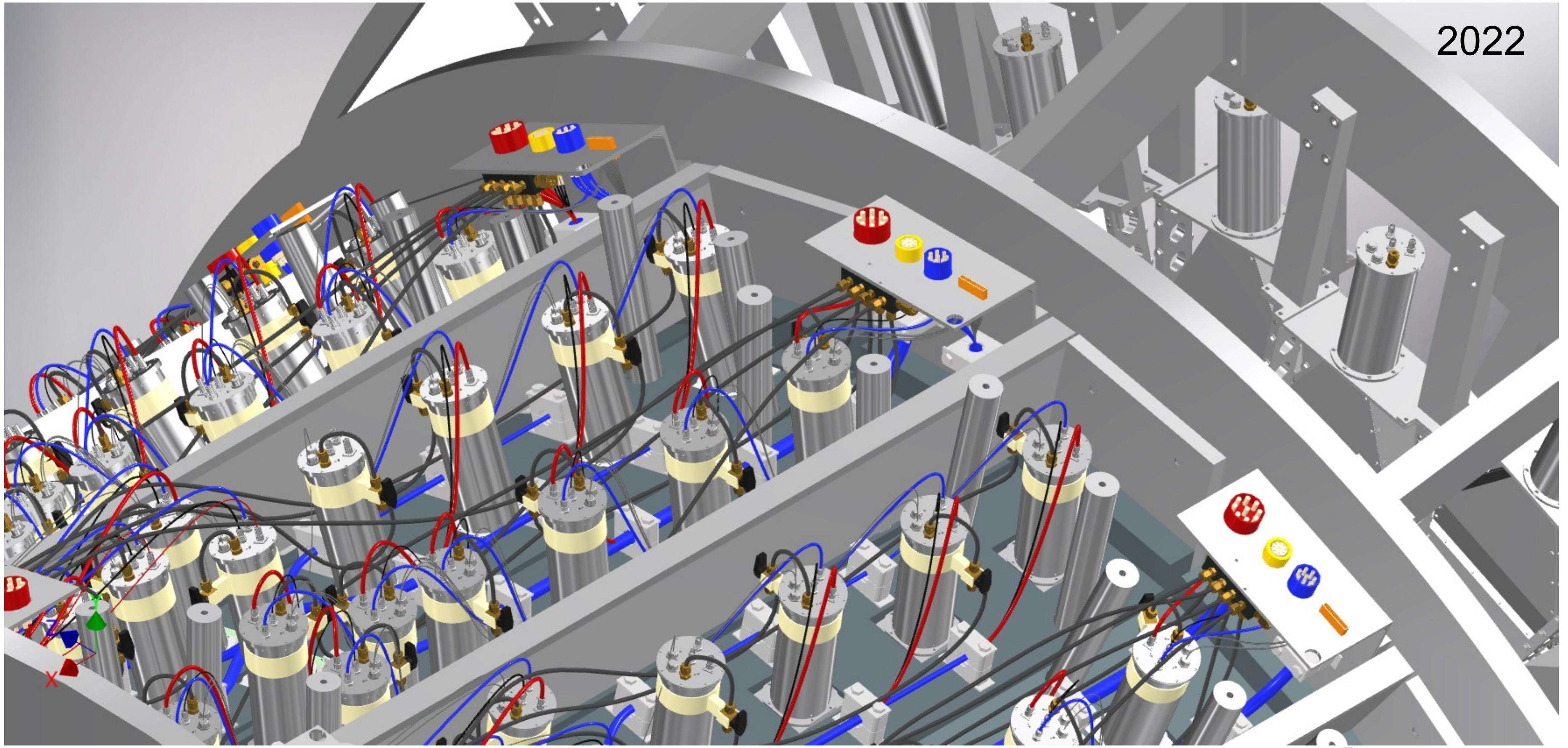
-1 HV cable
-2 signal cables (coax and twinax)
-1 LV power cable
-1 gas inlet

- 3 HVMAPs per tray, each needs:

-A fiber Optic readout cable
-1 gas inlet (separate supply)
-30 LV power wires (not shown)

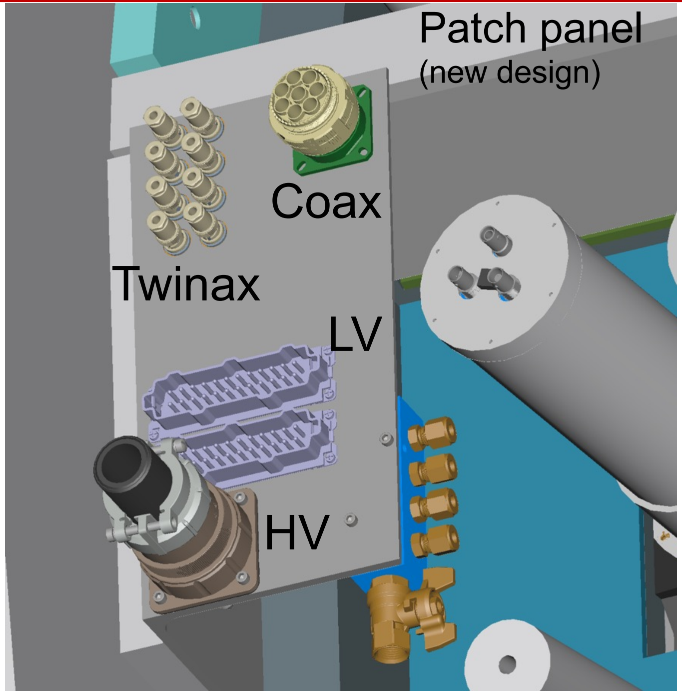
Main detector cabling (CAD work by Edwin Sosa)

- Plans for cabling internal to each segment have not changed; Hvmaps are more defined
- This shows our status as of last year for HV, signals, base power, and pmt gas cables
- A new model for patch panel has been developed with actual connectors and costs



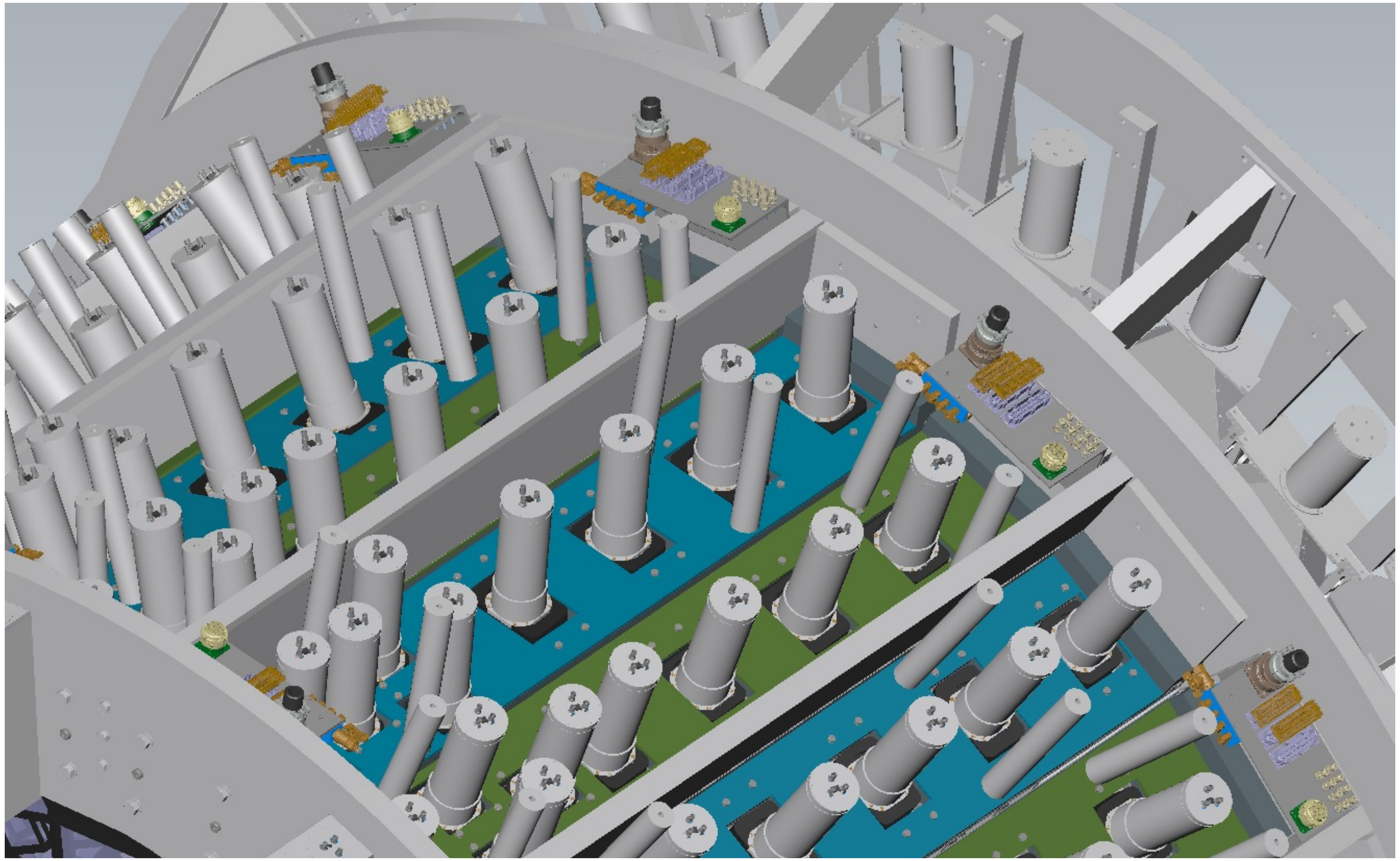
Snapshot of technical progress (main detector cabling)

Idaho State University



Main detector cabling (CAD work by Edwin Sosa)

- New patch panels use HD connectors for HV, coax signal, and LV power
- Twinax (integrate-mode) signals use conventional feedthrough connectors
- 10 port aluminum gas manifold for cooling base electronics and purging light guides



8 detectors per segment, each det. requires:

--1 HV cable
--2 signal cables (coax and twinax)
--1 LV power cable
--1 gas inlet

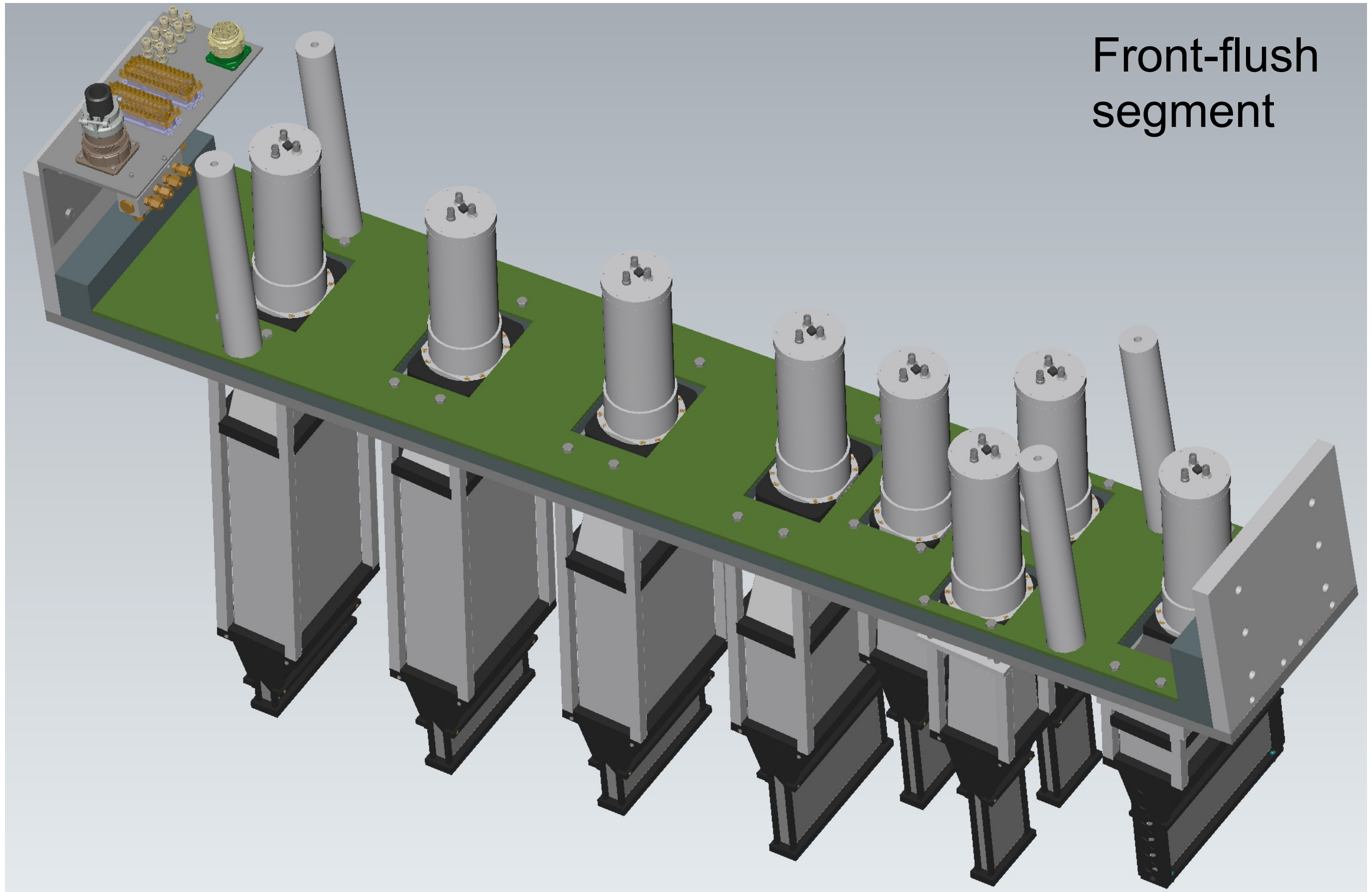
3 HVMAPs per segment, each needs:

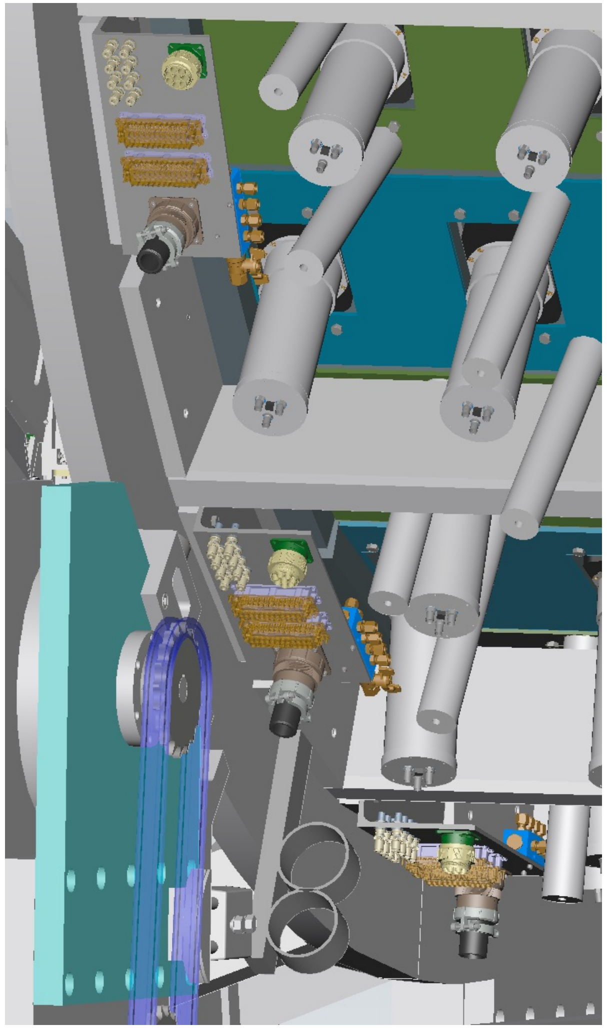
--A fiber Optic readout cable
--1 gas inlet (separate supply)
--30 LV power wires (not shown)

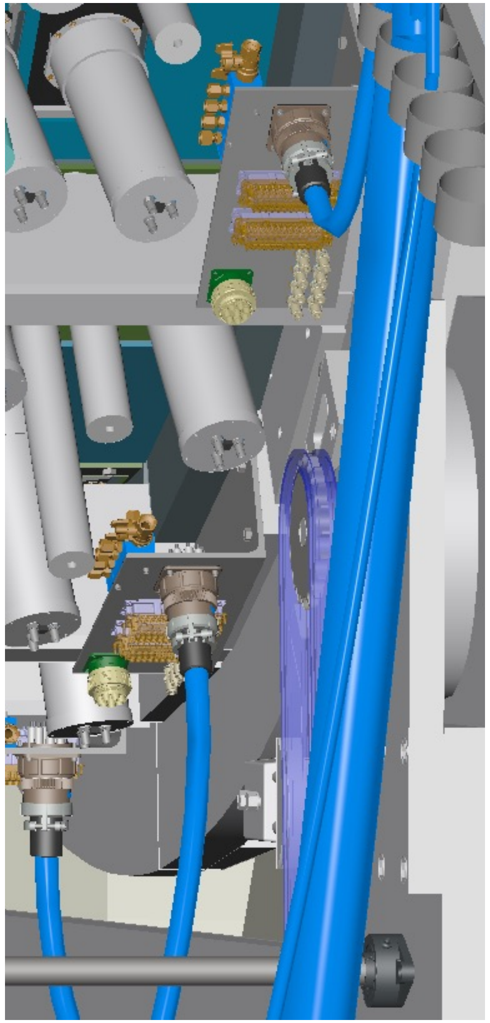
Snapshot of technical progress (main detector cabling)

Idaho State University

Patch panel connectors repositioned to reduce interference with main detector support structure







Connectors/cables clear under carriage components

Jefferson Lab

Radiation hardness tests

Idaho State University

- Candidate quartz radiator tests completed last year (Justin Gahley) write up in docDB #886
  --Heraeus Spectrosil 2000 high H2 doped and Corning 7980 UV grade 5F were best performers
- 3D-printed plastics tests well underway (Jared Insalaco--ISU, Nafis Niloy—U. Manitoba)
- PMT electronics tests have started (Jared Insalaco, Brynne Blaikie—U. Manitoba)

- We use the Idaho Accelerator Center (IAC) for irradiations: 25 MeV linac operated at 8 MeV peak energy. Set up beam to give ~40 nC/pulse for quartz and plastic dosing and ~1 nC/pulse for electronics
- Samples are positioned at 50 cm from beam exit window; laser aligned to beam center
- Beam pulse dose profile is sampled using OSL nanodots dosimeters
- Beam charge per pulse measured during sample dosing for normalizations
- We use simulation, OSL measurements, and beam charge data to determine dose per nC in the sample

3D-printed plastic radiation tests ongoing

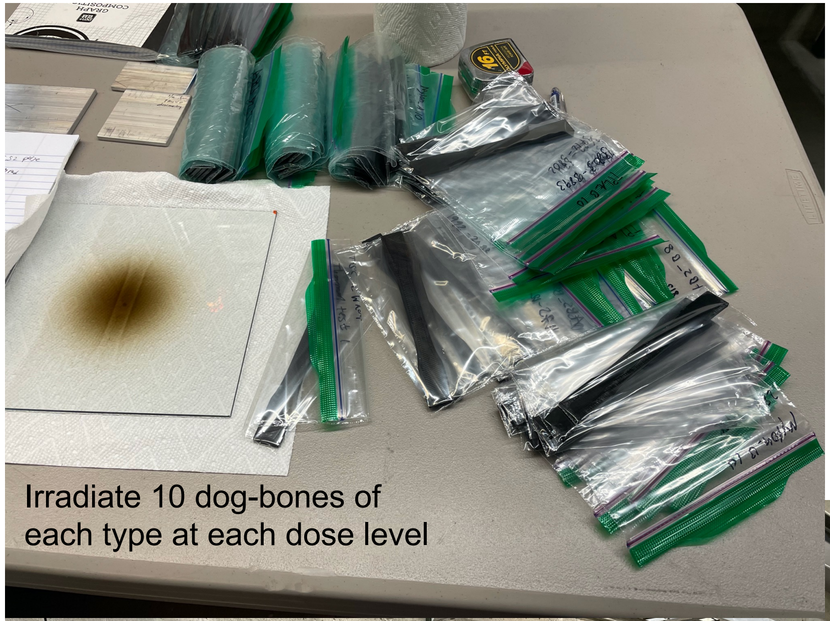
Idaho State University

- Radiation testing of 3D-printed plastic dog bone samples (ASTM D638 standard) well underway
- Have results for some standard plastics: PLA, ABS, and Nylon
- We irradiate samples to various dose levels and break them in tensile strength machine measuring elastic moduli and yield strength

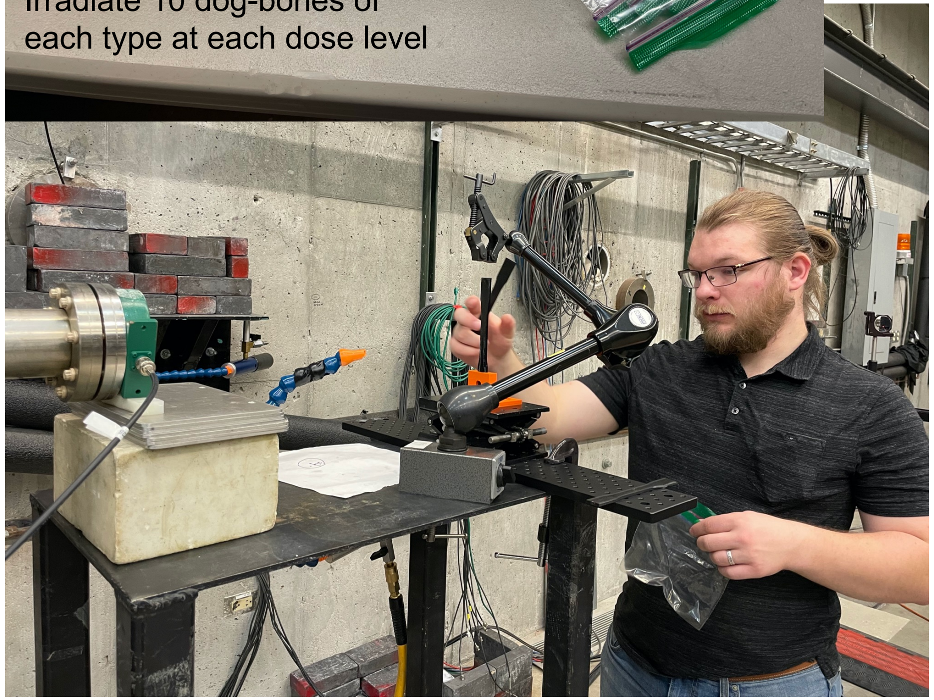
Near term future work

- Will test Carbon-fiber (CF) embedded plastics this month -- CF-Nylon (Onyx and others from UMass). Also plan to test CF-ABS (from U. Manitoba) and possibly including tests of hygroscopic affects on tensile strength and radiation hardness

3D-printed plastic irradiation tests

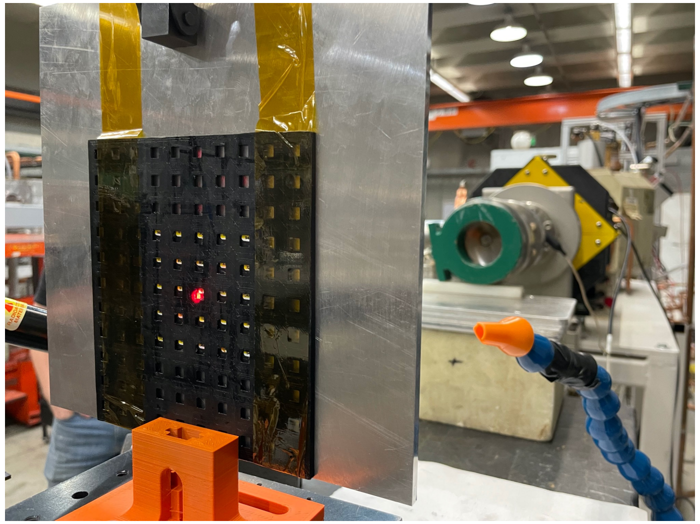


Irradiate 10 dog-bones of each type at each dose level



Tensile strength testing apparatus

Nanodot OSL array beam dosimetry



3D-printed ASTM-D638 dog-bones

3D-printed plastic Irradiation tests

Idaho State University

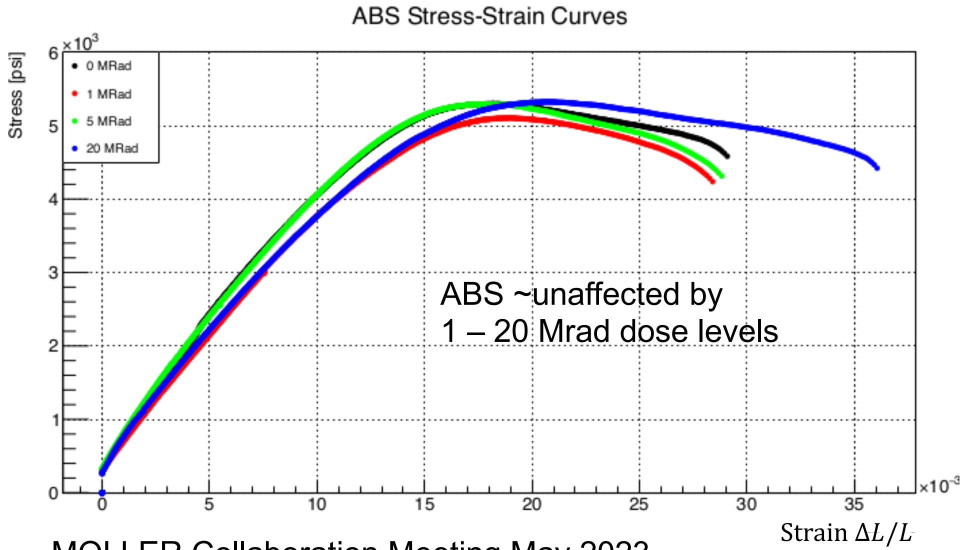
Preliminary results:

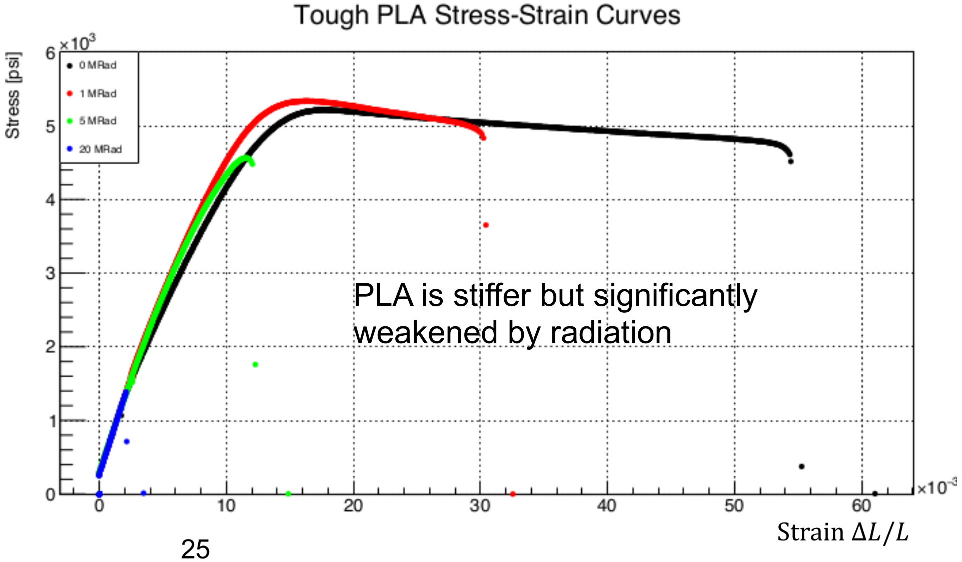
- Results following irradiations:
  - PLA has high stiffness but is weakened by radiation
  - Nylon has low stiffness but is not weakened by dose
  - ABS is least affected by radiation

- Tensile strength results for non-irradiated plastic

	0 Mrad (baseline)	
Material	Modulus [ksi]	Yield [ksi]
ABS	390 ± 20	4.7 ± 0.2
tough PLA	430 ± 20	4.8 ± 0.2
Nylon	250 ± 30	6.1 ± 0.2
C-fiber Nylon	520 ± 50	5.6 ± 0.3

	1 Mrad		5 Mrad		20 Mrad	
Material	Modulus [ksi]	Yield [ksi]	Modulus [ksi]	Yield [ksi]	Modulus [ksi]	Yield [ksi]
ABS	390 ± 30	4.7 ± 0.2	380 ± 20	4.7 ± 0.2	370 ± 30	4.7 ± 0.2
toughPLA	480 ± 20	5.1 ± 0.2	460 ± 30	4.3 ± 0.1	480 ± 30	1.2 ± 0.1
Nylon	380 ± 30	5.0 ± 0.2	230 ± 70	6.2 ± 0.3	220 ± 60	6.1 ± 0.1



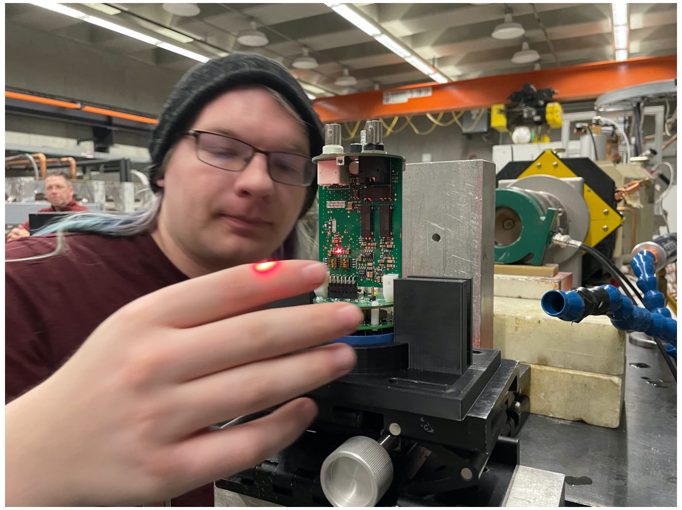


PMT electronics irradiation tests

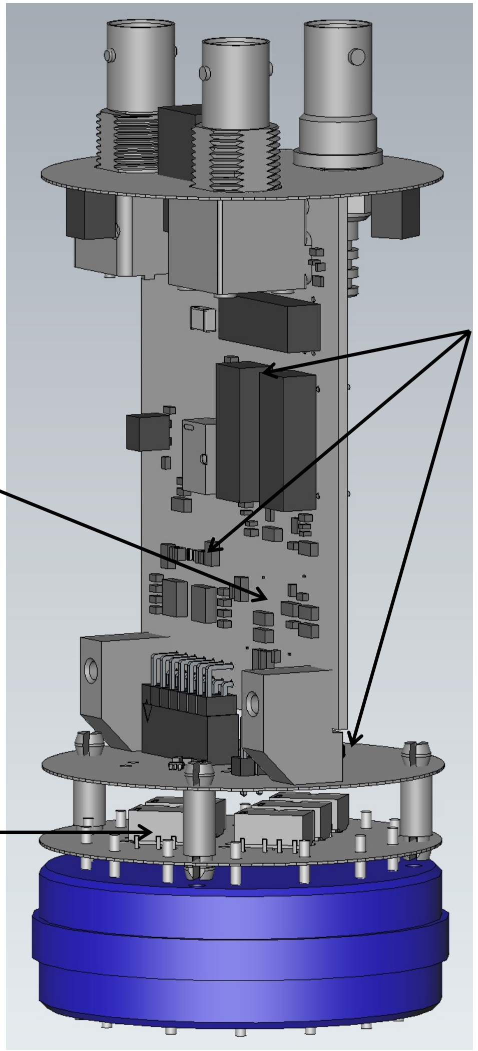
Idaho State University

Initial tests took place last December

- Irradiated two different regions of the PMT base electronics:
  1. the integrate-mode op-amp chip (small aerospace grade chip)
  2. set of three DC-DC converters used for both DAQ modes
- Collimators were used to localize beam dose on specific chips
- Functionality tested by U. Manitoba group in between successive doses
  - Following each dose, we attached base to a PMT and exposed cathode to set of light levels (2, 5, 20, and 27 nC) -- tested gain and signal quality using MOLLER ADC
  - For DC-DC converters, functionality tested by simply applying LV power and measuring the current draw. When chips fail, current draw increased substantially and chips got extremely hot



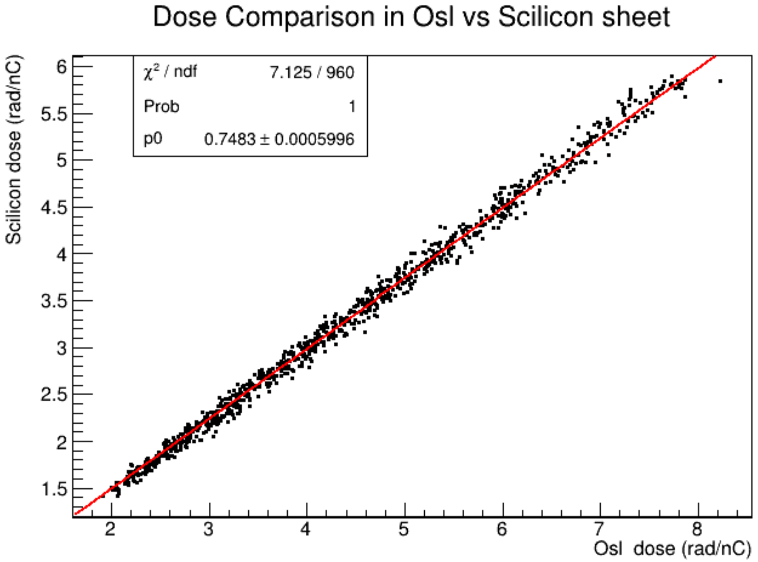
PMT electronics

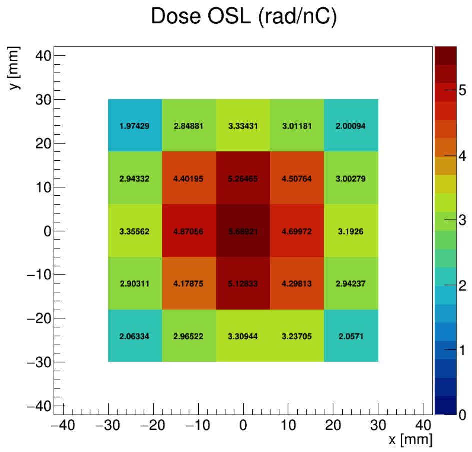


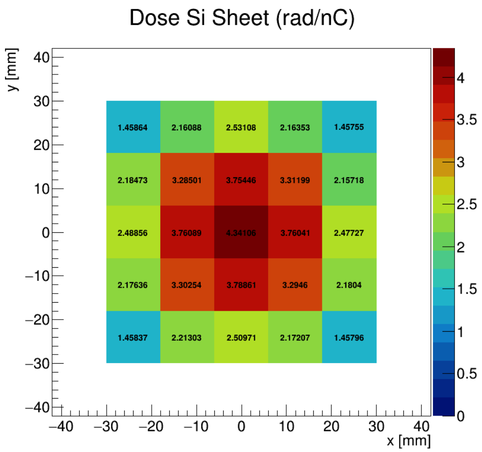
Jefferson Lab

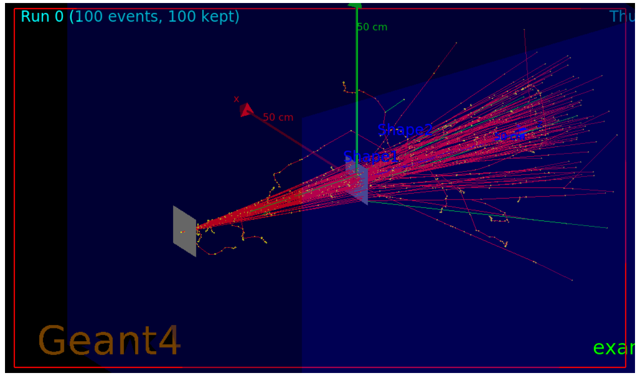
PMT electronics irradiation tests (Simulations)

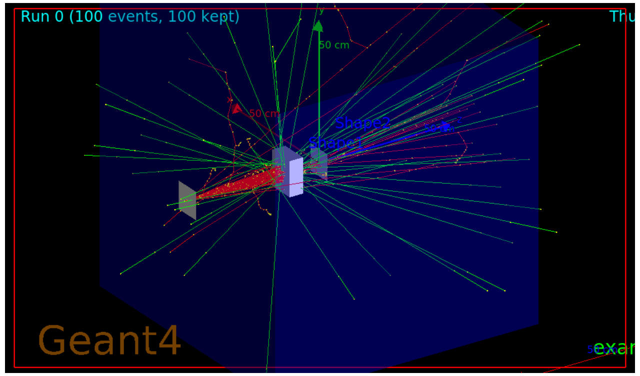
- Realistic geometry: beam exit window, air, collimator, and sensitive volumes of either OSL array or Si sheet (0.6 mm thick)
- Use similar technique as used for quartz tests – vary beam parameters to sample phase space of possible beam profiles (~30 x 30 different simulations for OSL array and separately for Si sheet)
- Bin the Si sheet data into 1.2 x 1.2 mm^2 pixels to match the OSL array simulation and real data measurements; tally energy deposition in bins
- Plot Si sheet dose/nC versus OSL dose/nC – gives linear correlation
- Conclusion: sample receives 75% of OSL dose







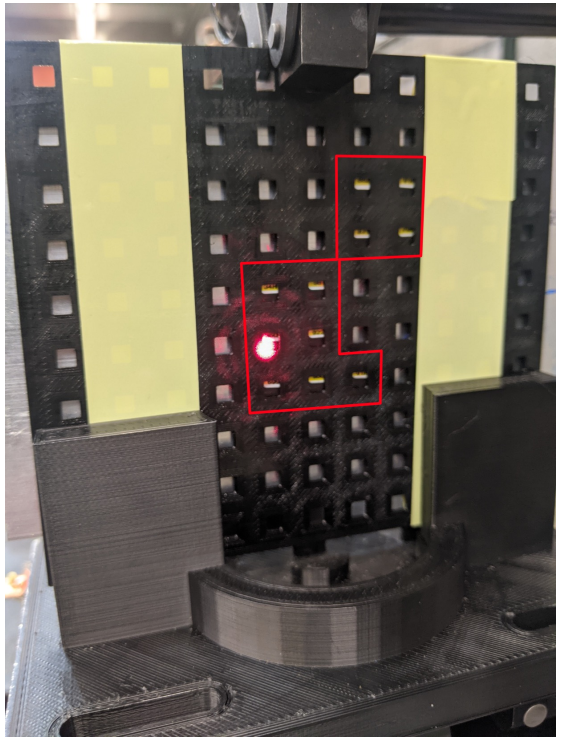




PMT electronics irradiation tests (Beam pulse dosimetry)

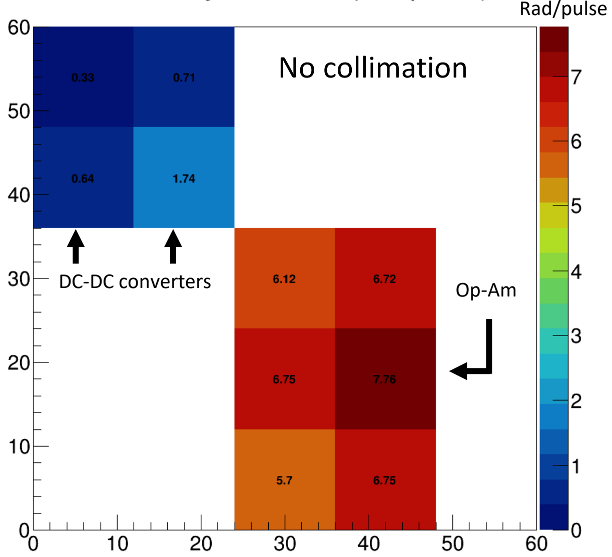
Idaho State University

- Performed beam dose measurements with specialized OSL array shapes overlaying the chip locations of interest

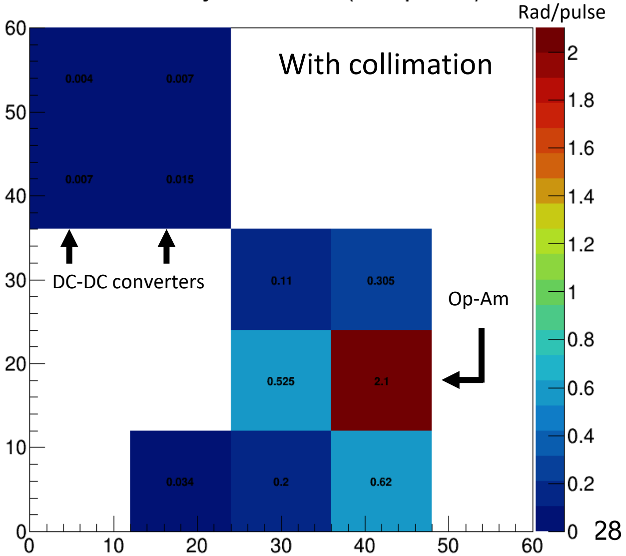


Beam center on Op Amp

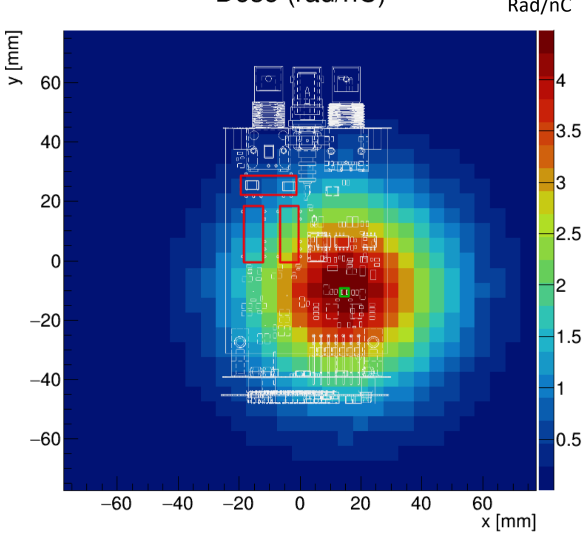
OSL Array A1 Dose (rad/pulse)



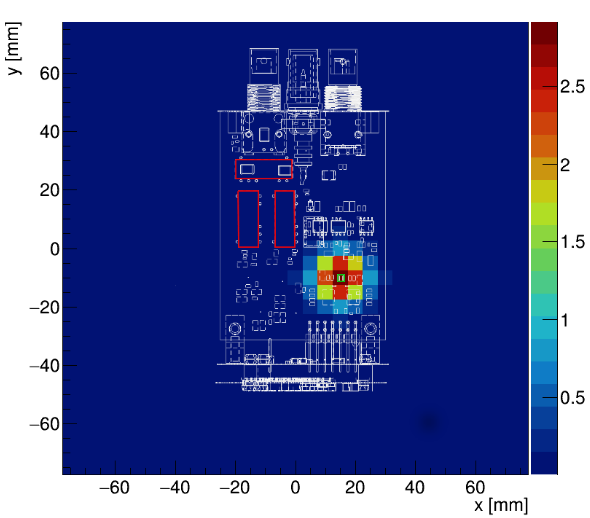
OSL Array A7 Dose (rad/pulse)



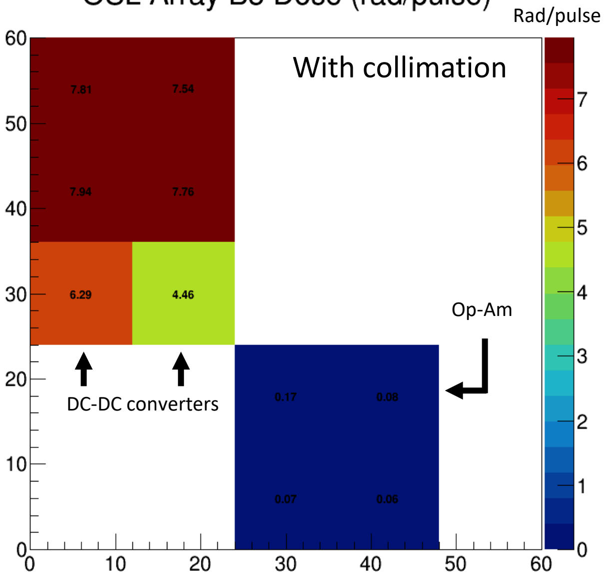
Dose (rad/nC)



Dose (rad/nC)

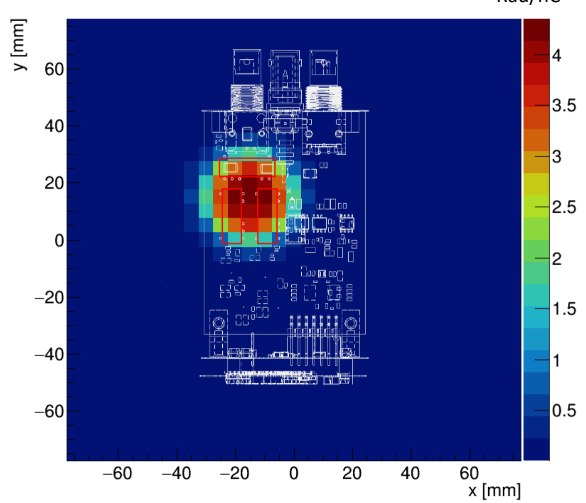


OSL Array B3 Dose (rad/pulse)



Beam center on DC-DC converters

Dose (rad/nC)



PMT electronics irradiation tests (preliminary results)

Idaho State University

- Dose levels per run determined from OSL measurements, beam charge/pulse measurements and conversion factor from simulation

Started to fail (Run 6)

PMT Base 1: Op amp	Dose	Total Dose
Run 0	106 kRad	106 kRad
Run 1	106 kRad	212 kRad
Run 2	210 kRad	422 kRad
Run 3	210 kRad	633 kRad
Run 4	106 kRad	739 kRad
Run 5	106 kRad	845 kRad
Run 6	106 kRad	951 kRad
Run 7	318 kRad	1,270 kRad
Run 8	106 kRad	1,480 kRad
Run 9	210 kRad	1,586 kRad

PMT Base 2: DC-DC Converters	Dose	Total Dose
Run 1	206 kRad	206 kRad

failed (Run 1)

PMT Base 1: DC-DC Converters	Dose	Total Dose
Run 1	10.5 kRad	10.5 kRad
Run 2	42 kRad	52 kRad
Run 3	53 kRad	104 kRad

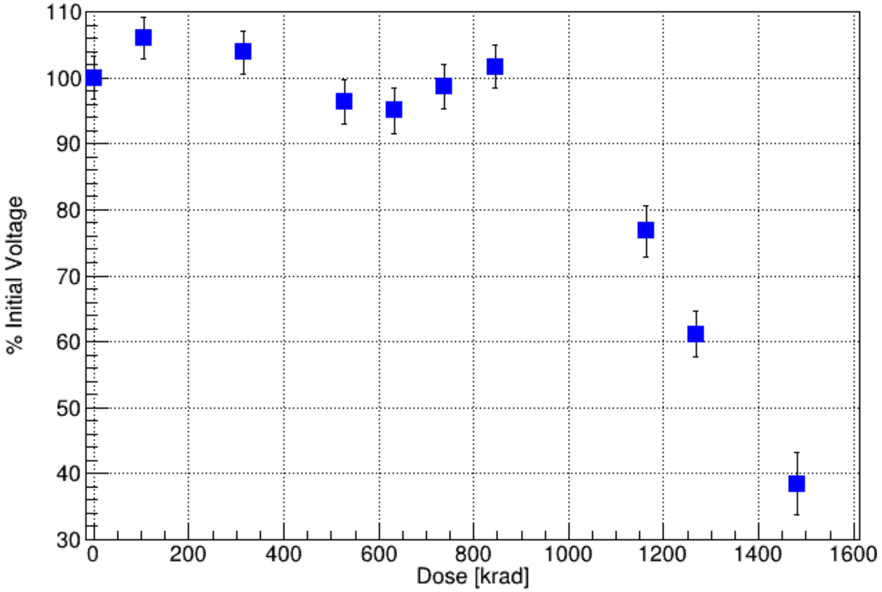
failed (Run 3)

PMT electronics irradiation tests (preliminary results)

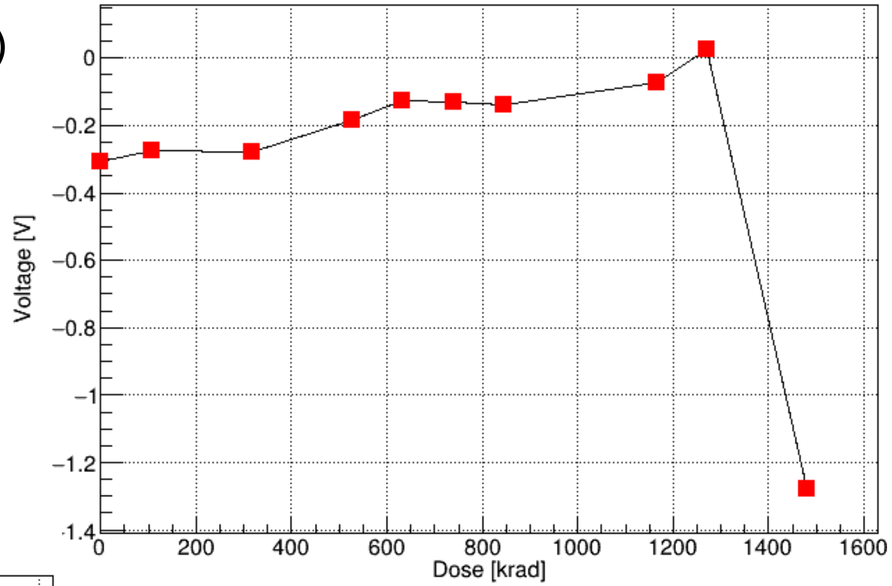
Idaho State University

- Integrating op-amp functionality/gain tests performed using 200 kOhm preamp setting, pmt at -795 V and four cathode currents (2, 5, 20, and 27 nA)

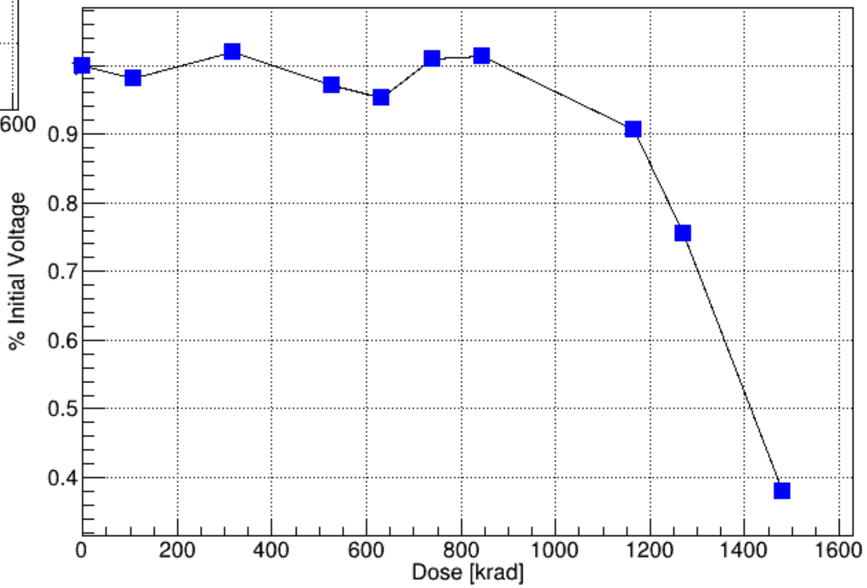
Voltage Drop for 2 nA LED



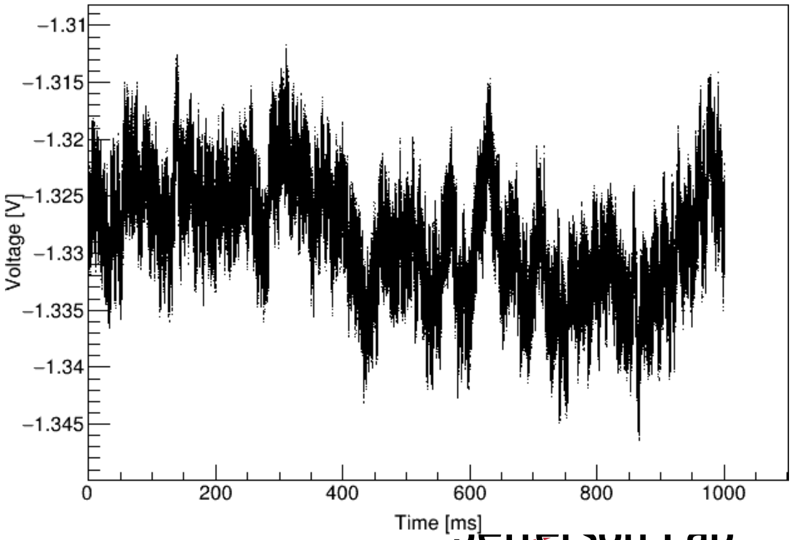
Mean Voltage with LED Off



Voltage Drop for 27 nA LED



1480 krad: 2 nA



Radiation tests summary and future work

Idaho State University

- Will perform followup QA tests of pre-production quartz samples; will also test new 3” longpass filters
- Printed plastic tests are still in progress; ABS and nylon appear to be sufficiently radiation tolerant
- Carbon fiber embedded materials provide much increased stiffness and are expected to also be sufficiently radiation hard for MOLLER detector components (Need better estimates of lifetime doses using remoll)
- We will test printed materials from UMass this month: Onyx® (CF-nylon) and a laser-sintered material
- Integrating op-amp is very radiation hard (~1MRad level) while DC-DC converters died somewhere between 50 and 100 kRad
- We have two new pmt bases to test. One is same as used in December tests and the other has a different DC-DC converter chip set (more radiation hard)
- Radiation tests will be performed using smaller dose steps; we will also start testing other chips—regulators, relay, and event-mode pre-amp

Detector logistics summary and future work

- MOLLER detector connector and cable inventory and cable routing concept well underway
- New patch panel design with all connectors specified with cost estimates; needs to be prototyped
- Insertion test (overdue task) for HD connectors needs to be completed. Can use prototype patch panel or possibly manufacturer specs to address this
- Progress made on HVMaps power cabling plans; progress on dry air gas systems
- Main detector segment internal cabling plan has not changed
- Started planning for and modeling the external barrel cabling; made first pass attempt at a cable support and strain relief system; Larry agreed to think about an alternative design

Shower-max Summary

Idaho State University

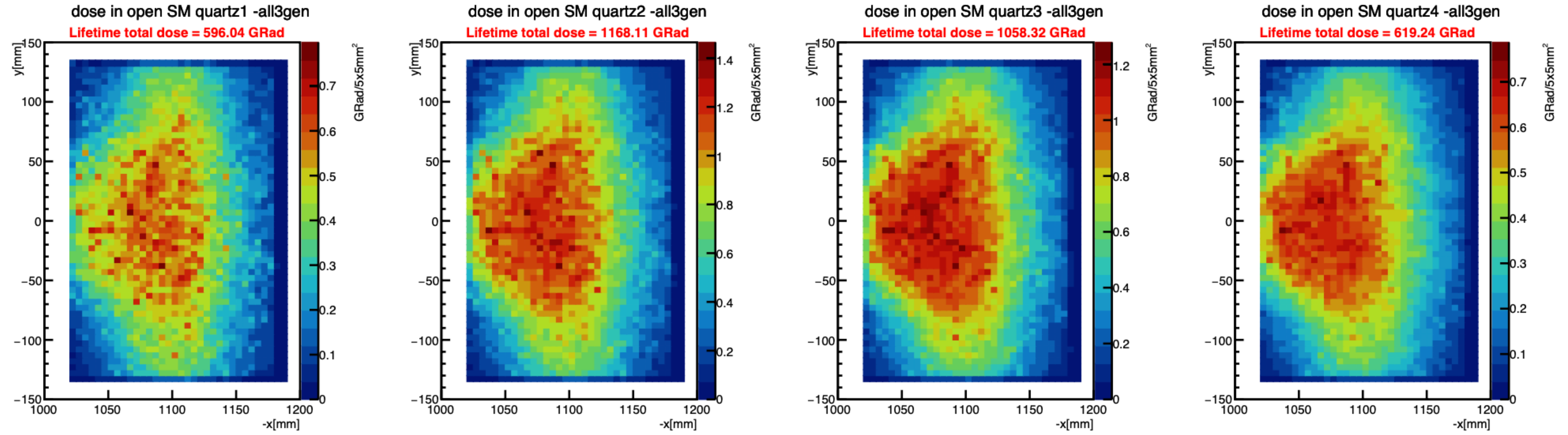
- 2022 Shower-max prototype parts fabrication, module assembly and testing went extremely well. MAMI testbeam results provided critical input to performance parameter expectations and provided assembly and operational experience. We will give detailed presentation of results compared to simulation at upcoming weekly detector meeting
- There have been a few minor tweaks to the chassis and light guide parts based on prototyping experience; these changes are incorporated into final design drawings
- Will construct pre-production prototype and test this spring/summer. This activity is a gate for placing large orders for final production module parts in late summer and starting construction in late fall 2023
- Planning to test with cosmic-rays (and perhaps MAMI testbeam again); now working to get cosmic-ray test stand GEM DAQ system functional
- The ISU group is also working on PMT non-linearity characterizations using MOLLER pmt bases and new integrating ADC. But we will need to implement the full MOLLER readout electronics chain to do proper/reliable measurements

Thank you

Appendix Slides

Shower-max quartz layer lifetime dose estimates

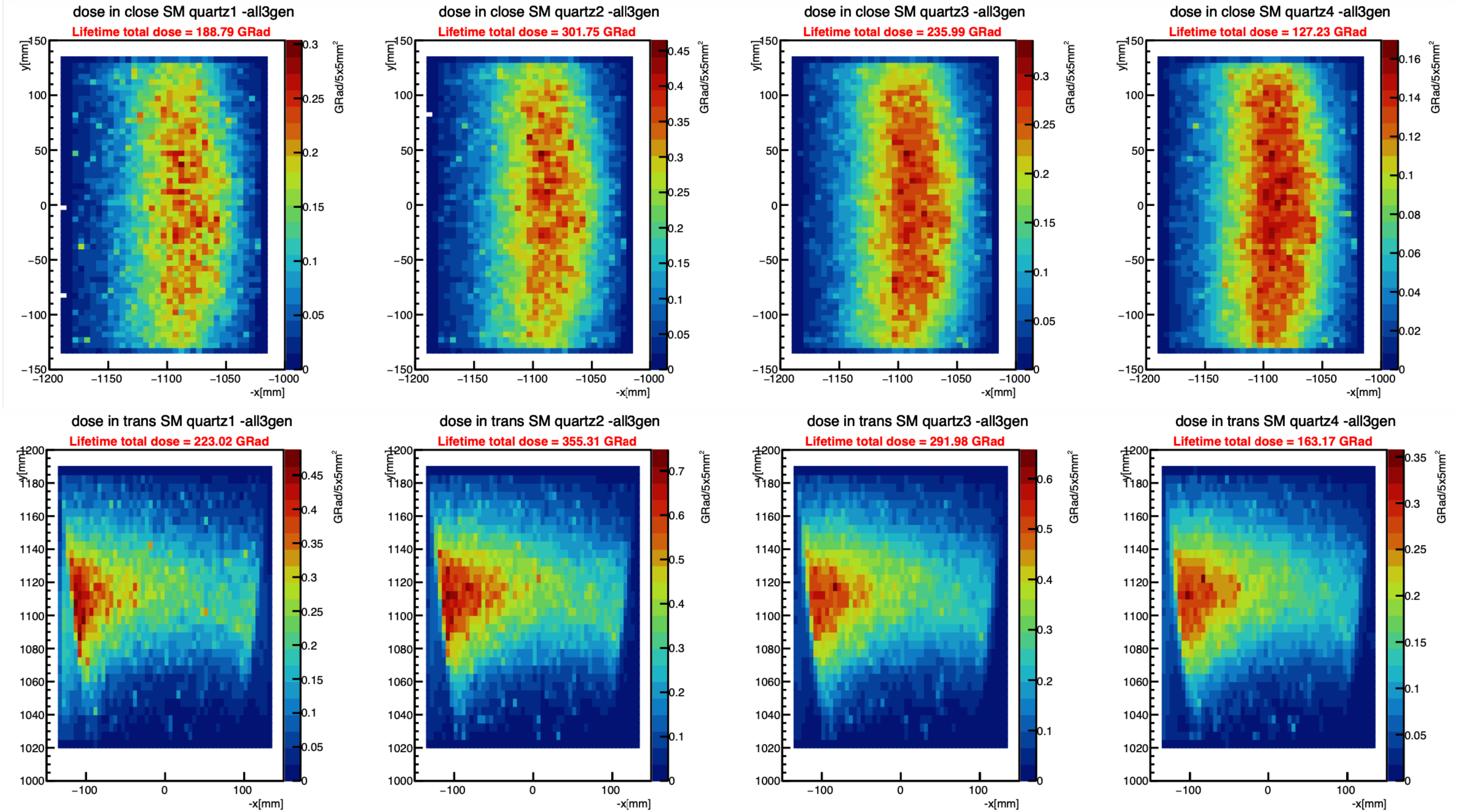
- These are Open-region detector results (worst case)



- Ran 5M Moller, ep-elastic and ep-inelastic generator events
- Peak dose density is in 2nd layer at 1.2 Grad/5x5mm^2 pixel
- Closed region are 4x lower and Transition are ~3 times lower

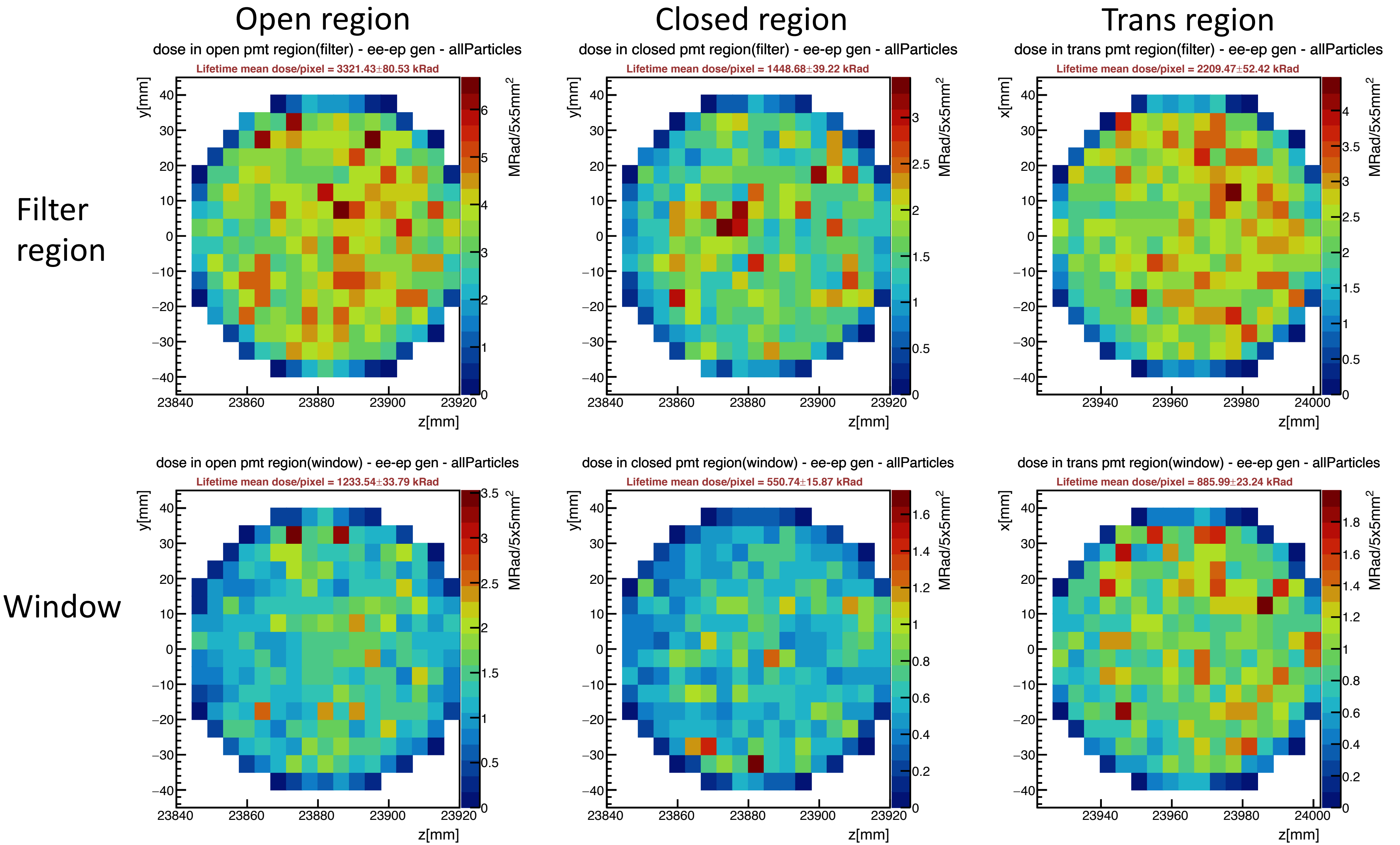
Shower-max quartz layer lifetime dose estimates

Idaho State University



Shower-max long pass filter and PMT window lifetime dose

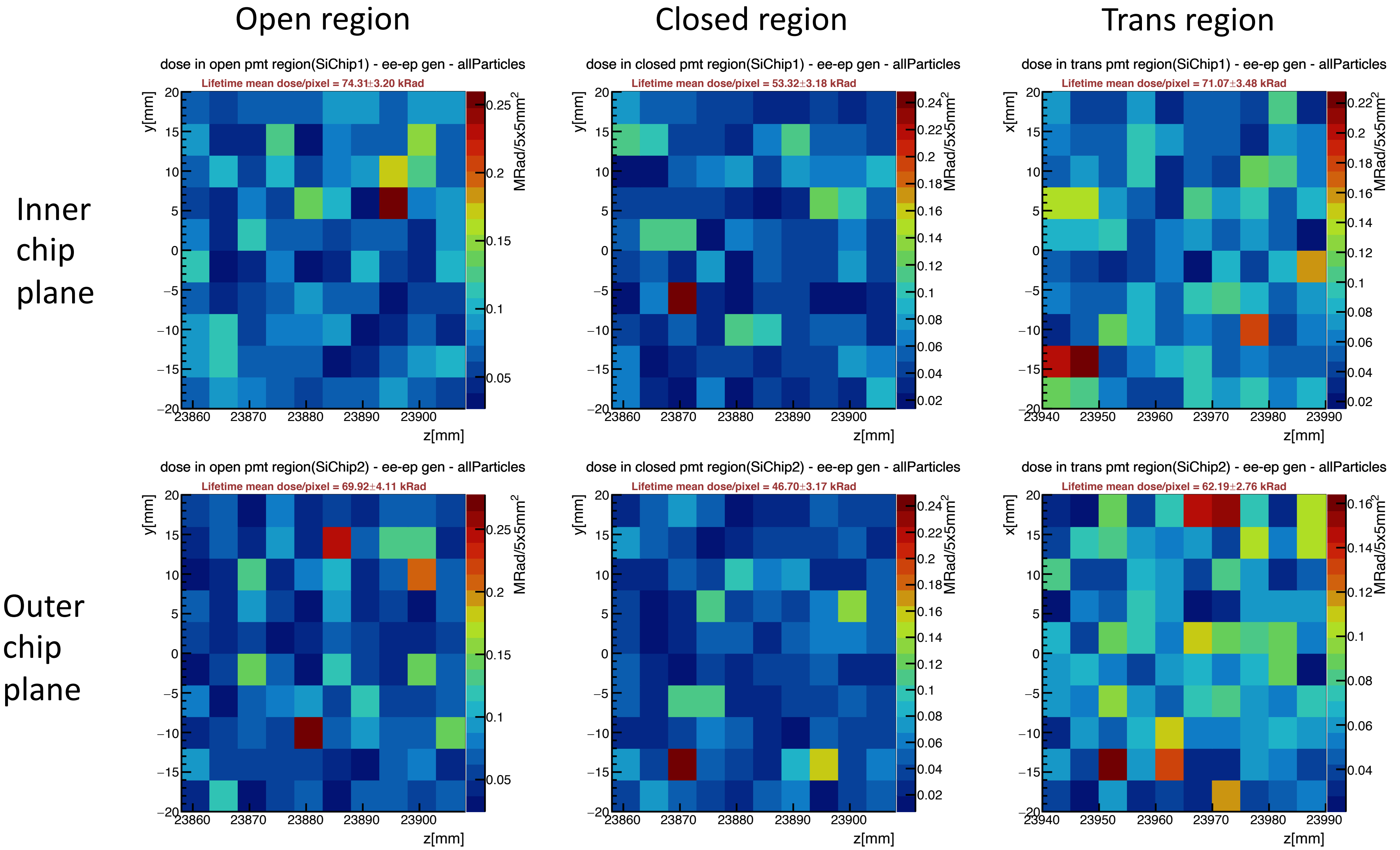
Idaho State University



Average lifetime doses (Mrad/pixel):

- Filter region:
  Open: ~3.3
  Closed: ~1.4
  Trans: ~2.2
- The 5 mm thick filter models both a 3 mm LP filter + 2 mm ND filter
- PMT window:
  Open: ~1.2
  Closed: ~0.6
  Trans: ~0.9

Shower-max pre-amp Si chip lifetime doses



- Average lifetime dose (krad/pixel):

  Open: ~75
  Closed: ~50
  Trans: ~70

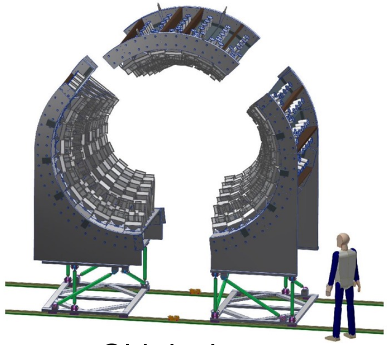
- Peak doses per pixel can fluctuate as high as 100 to 200+ krad

- Simulated Si wafers are 0.5 mm thick but have a huge area (4 x 5 cm^2) to give broad spatial dose sampling

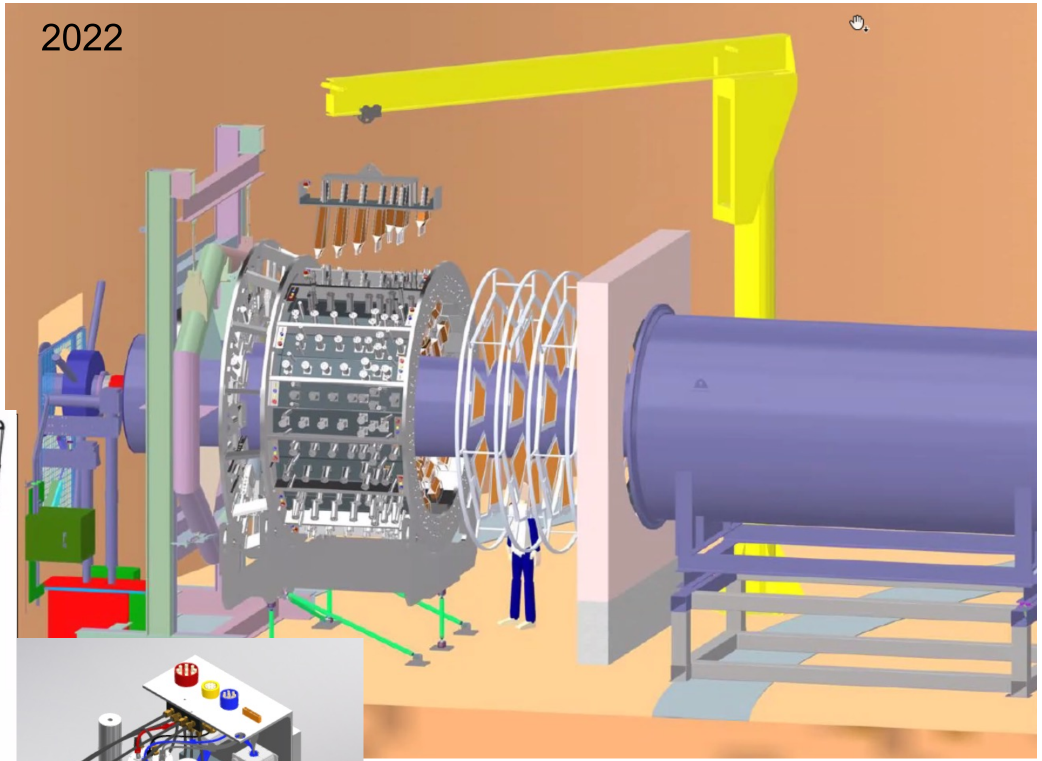
Main detector barrel logistics

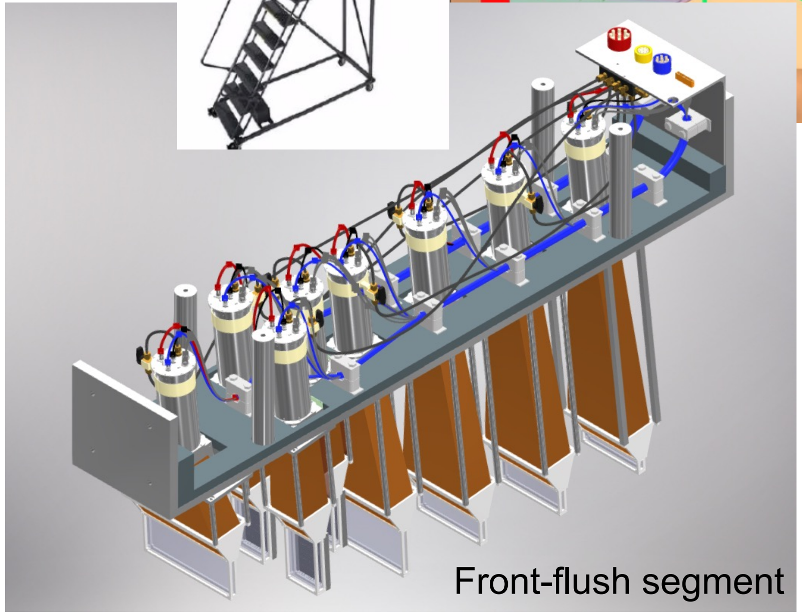
Idaho State University

- We moved away from 3 piece design that opens to a “single” support barrel in 2 pieces that bolt around beampipe and can rotate (see Larry’s talk)
- Shower-max ring now attached to main detector barrel and all detectors rotate together
- Assembly rests on a 6 roller bearing system with cart; cart sits on 6 rod attachment support and alignment system
- Main detector lead trays with fully instrumented detector assemblies are lowered into barrel vertically from above one at a time (no robot arm)
- Main detector patch panels modified to route cables radially (not along z as before)
- Cabling harness adapted to new lead tray hole pattern and new patch panel; model for gas distribution system developed
- We are now quoting/sourcing HD plugs and receptacles for a patch panel and cabling harness prototype

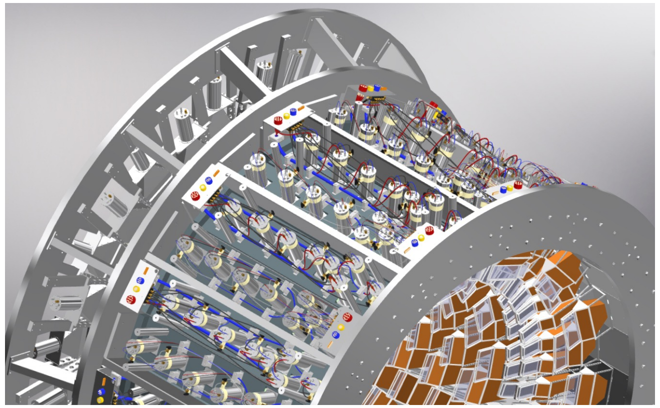


Old design



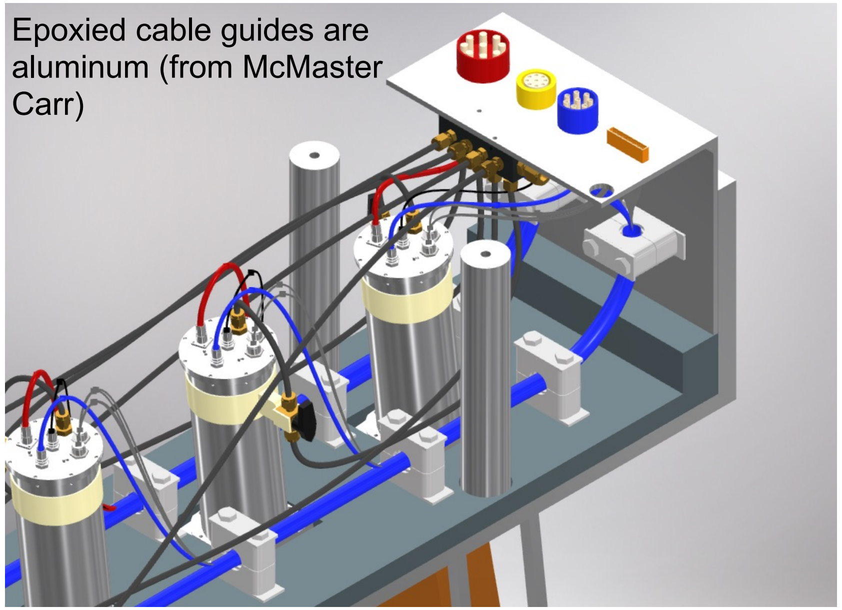


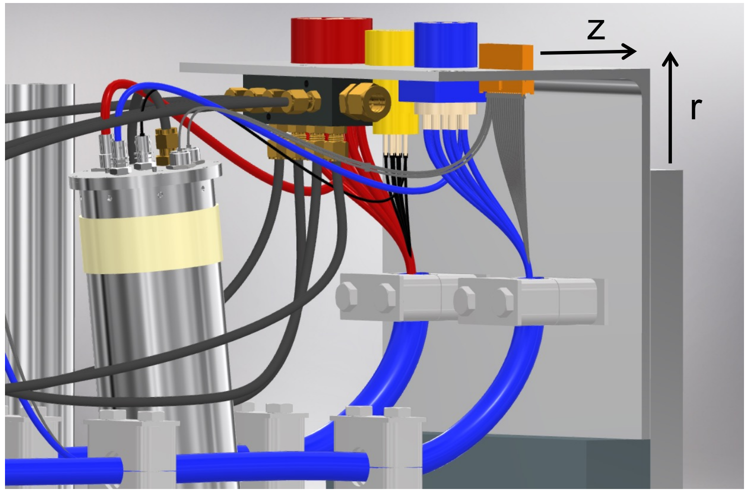
Front-flush segment



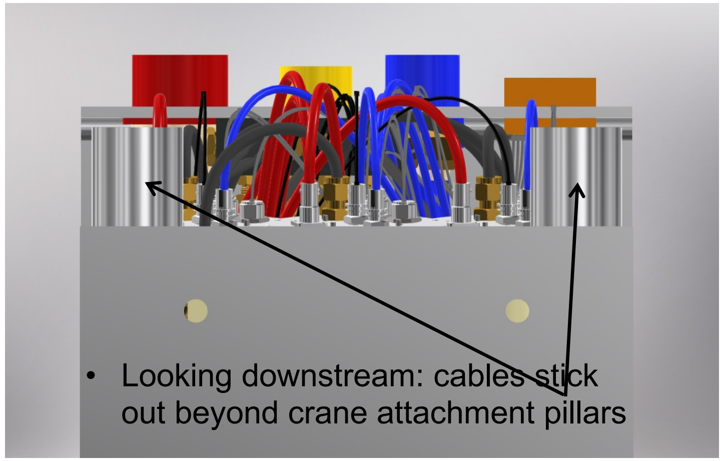
Patch Panel and harness views

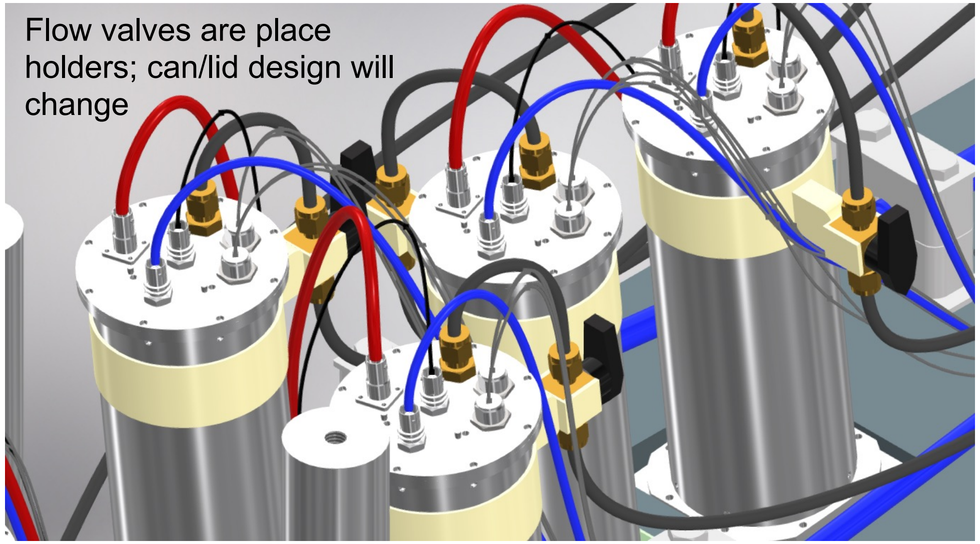
Idaho State University

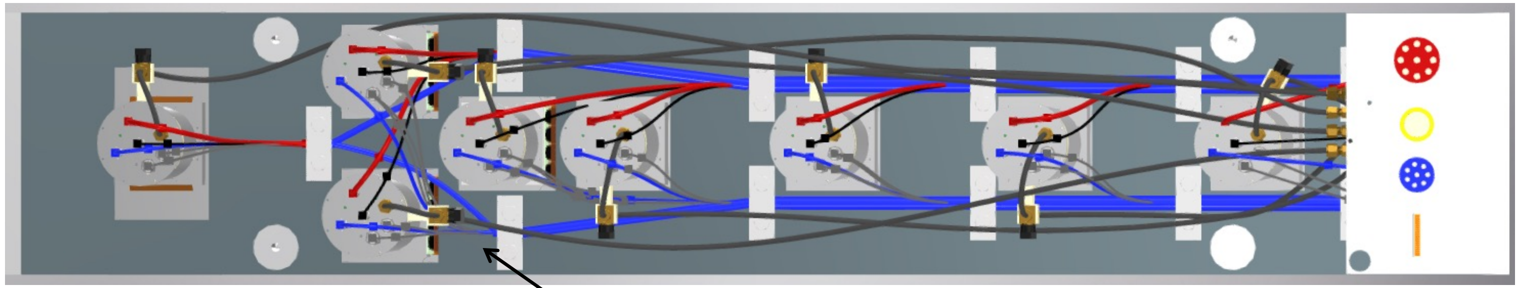




- Patch panel "L" bracket size was increased along both r and z to allow needed space





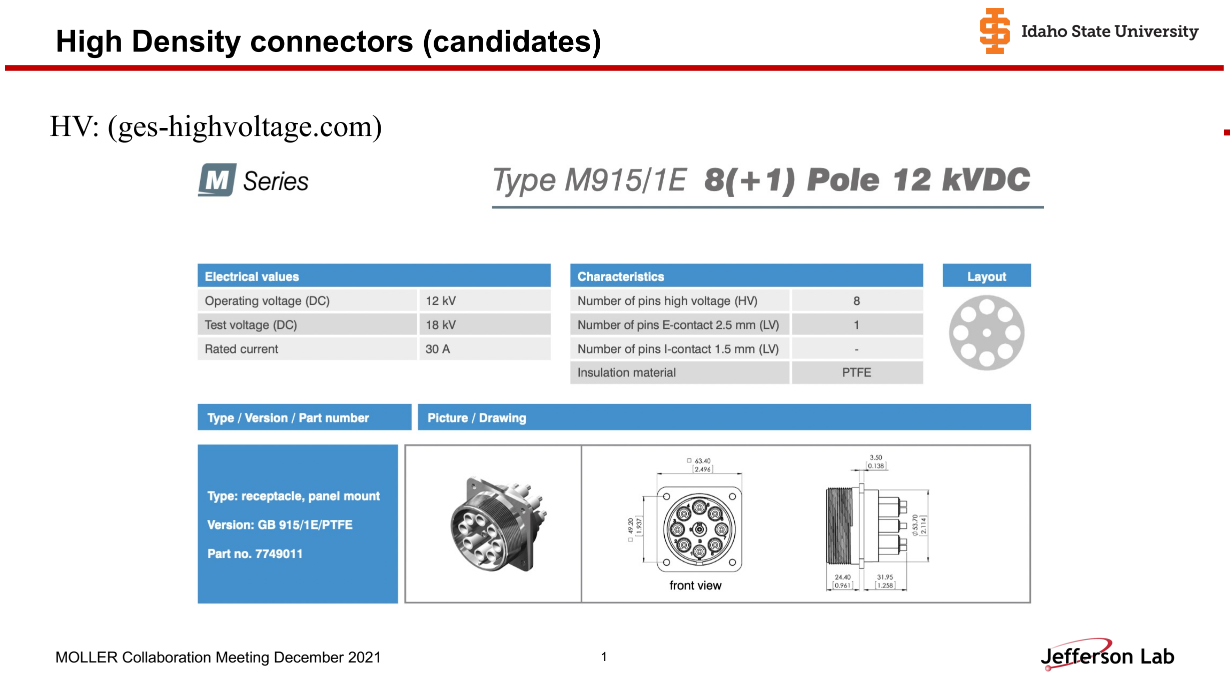


- Most challenging or space constrained area is here (especially for back-flush segments)

- Manifold and tubing sizes are not set. We're showing ¼" OD nylon 12 tubing with the smaller manifold which can have 3/8" or ½" OD input tubing
- We need to determine what gas flow rates we need for the detectors and Hvmaps

High Density connectors (some candidates not available)

Idaho State University



High Density connectors (candidates)

Idaho State University

HV: (ges-highvoltage.com)

M Series — Type M915/1E **8(+1) Pole 12 kVDC**

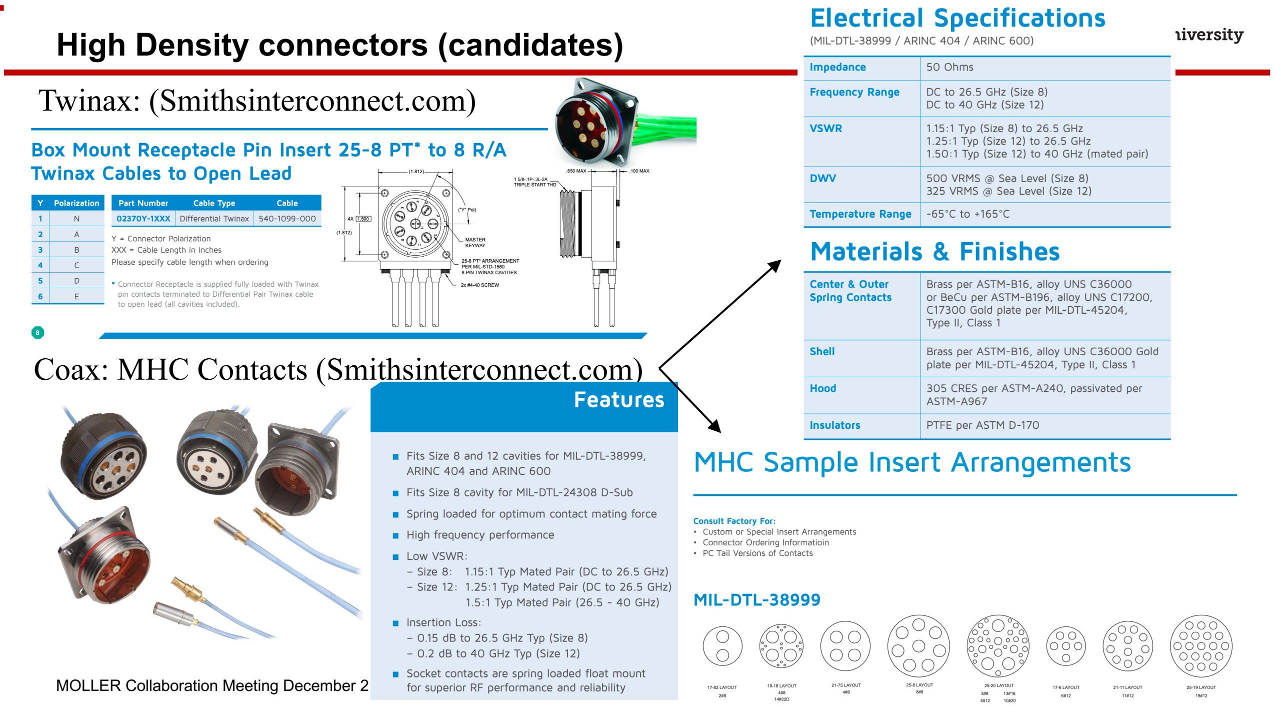
Electrical values	
Operating voltage (DC)	12 kV
Test voltage (DC)	18 kV
Rated current	30 A

Characteristics	
Number of pins high voltage (HV)	8
Number of pins E-contact 2.5 mm (LV)	1
Number of pins I-contact 1.5 mm (LV)	-
Insulation material	PTFE

Layout

Type / Version / Part number	Picture / Drawing
Type: receptacle, panel mount Version: GB 915/1E/PTFE Part no. 7749011	front view

MOLLER Collaboration Meeting December 2021 1 Jefferson Lab



High Density connectors (candidates)

Twinax: (Smithsinterconnect.com)

Box Mount Receptacle Pin Insert 25-8 PT* to 8 R/A Twinax Cables to Open Lead

Part Number	Cable Type	Cable
02370Y-1XXX	Differential Twinax	540-1099-000

Y = Connector Polarization
XXX = Cable Length in inches
Please specify cable length when ordering

Coax: MHC Contacts (Smithsinterconnect.com)

Features

- Fits Size 8 and 12 cavities for MIL-DTL-38999, ARINC 404 and ARINC 600
- Fits Size 8 cavity for MIL-DTL-24308 D-Sub
- Spring loaded for optimum contact mating force
- High frequency performance
- Low VSWR:
  - Size 8: 1.15:1 Typ Mated Pair (DC to 26.5 GHz)
  - Size 12: 1.25:1 Typ Mated Pair (DC to 26.5 GHz) 1.5:1 Typ Mated Pair (26.5 - 40 GHz)
- Insertion Loss:
  - 0.15 dB to 26.5 GHz Typ (Size 8)
  - 0.2 dB to 40 GHz Typ (Size 12)
- Socket contacts are spring loaded float mount for superior RF performance and reliability

MOLLER Collaboration Meeting December 2

Electrical Specifications
(MIL-DTL-38999 / ARINC 404 / ARINC 600)

Impedance	50 Ohms
Frequency Range	DC to 26.5 GHz (Size 8) DC to 40 GHz (Size 12)
VSWR	1.15:1 Typ (Size 8) to 26.5 GHz 1.25:1 Typ (Size 12) to 26.5 GHz 1.50:1 Typ (Size 12) to 40 GHz (mated pair)
DWV	500 VRMS @ Sea Level (Size 8) 325 VRMS @ Sea Level (Size 12)
Temperature Range	-65°C to +165°C

Materials & Finishes

Center & Outer Spring Contacts	Brass per ASTM-B16, alloy UNS C36000 or BeCu per ASTM-B196, alloy UNS C17200, C17300 Gold plate per MIL-DTL-45204, Type II, Class 1
Shell	Brass per ASTM-B16, alloy UNS C36000 Gold plate per MIL-DTL-45204, Type II, Class 1
Hood	305 CRES per ASTM-A240, passivated per ASTM-A967
Insulators	PTFE per ASTM D-170

MHC Sample Insert Arrangements

Consult Factory For:
- Custom or Special Insert Arrangements
- Connector Ordering Information
- PC Tail Versions of Contacts

MIL-DTL-38999

- The HV connector is available and we have a quote for receptacle and plug (we've inquired about insertion test data)

Line	Part No	Description	Qty.	Unit Price	Total
1.	7749011	GB 915/1E PTFE receptacle, panel mount, 9-pole 8x HV pins, female contacts 2.7mm silver plated 1x earthing pin, female contact 2.5mm silver plated	2 ea	$275.55	$551.10
2.	7490417	KS 915/1E PTFE Sym KV plug, cable mount, 9-pole, symetric cable gland 8x HV pins, male contacts 2.7mm silver plated	2 ea	$316.03	$632.06
					$1,183.16
					$1,183.16

- There is also an 8 conductor HD HV cable you can get for these which we are investigating (for routing HV inside trays)

- The twinax connector is no longer actively supported by Smiths Interconnect, but they pointed us to comparable part and supplier (TTI inc.) which we are investigating
- Still waiting to hear about the coax rec. and plug availability

Main Detector Connector costs

Connectors needed per Main detector segment	Location	Prototype Cost (for 1)	Production Cost for 30
8 twinax female bulkhead conn.	at P. Panel	$192	$5040
16 twinax male cable conn.	Internal	$240	$6000
16 twinax male cable conn.	external	$240	$6000
HD HV connector (plg & rec)	at P. Panel	$776	$20340
8 SHV male cable conn.	internal	$320	$8880
8 SHV male cable conn.	external	$320	$8880
1 HD Coax connector (plg & rec)	at P. Panel	$298	$8460
8 Contacts: sockets	at P. Panel	$1144	$27600
8 Contacts: pins	at P. Panel	$760	$13200
8 BNC coax male cable conn.	internal	$56	$1560
8 BNC coax male cable conn.	external	$56	$1560
2 HDC HE 24 conn. (plg & rec; acc.)	at P. Panel	$142	$3420
8 Lemo male cable conn.	internal	$192	$4320
Total Cost:		$4.7k	$115.3k

CFI

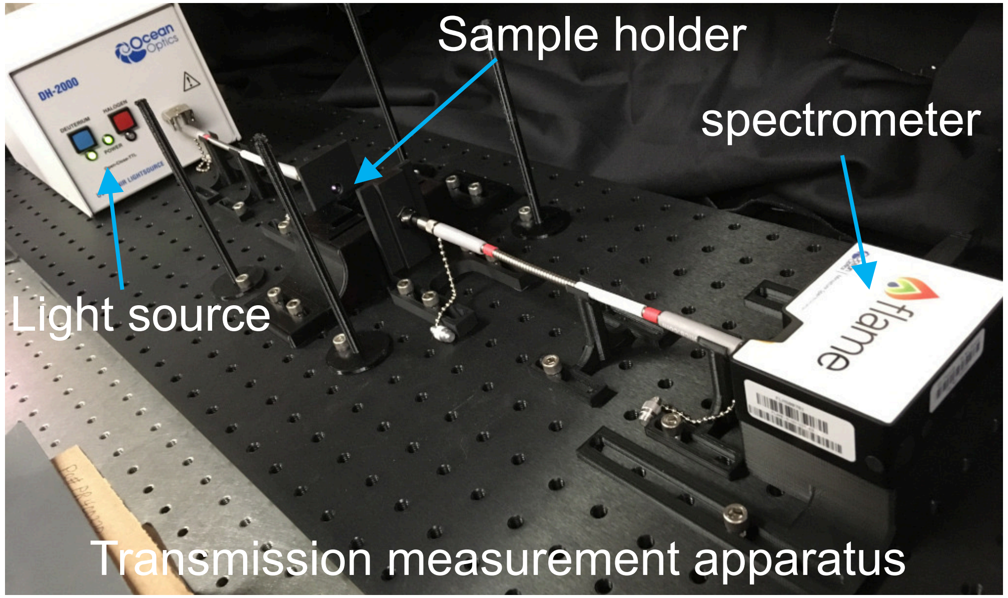
This does not include the cost of HVMaps fiber readout cables/connectors or connectors needed at the HVMaps

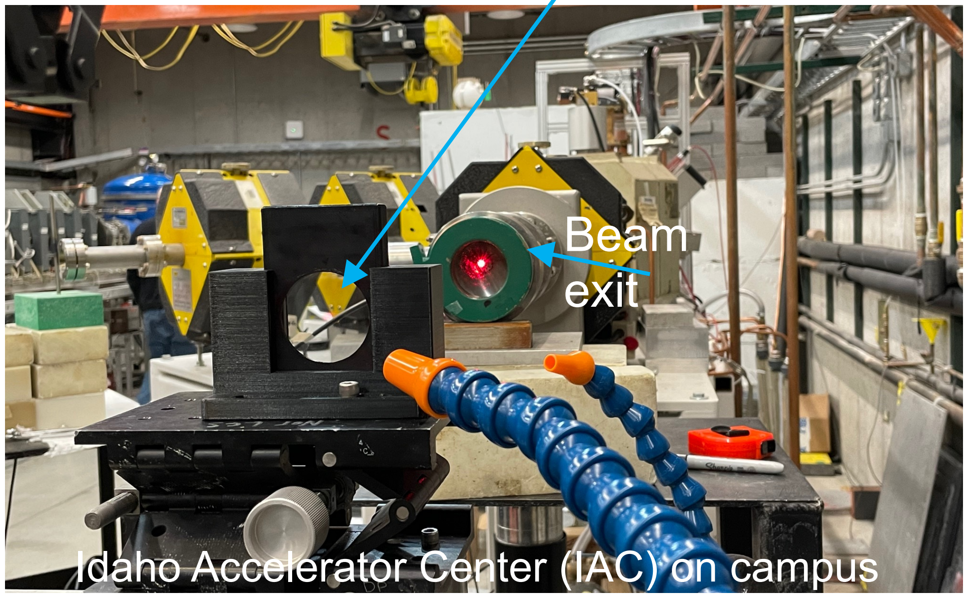
Irradiation Studies: quartz (completed)

Idaho State University

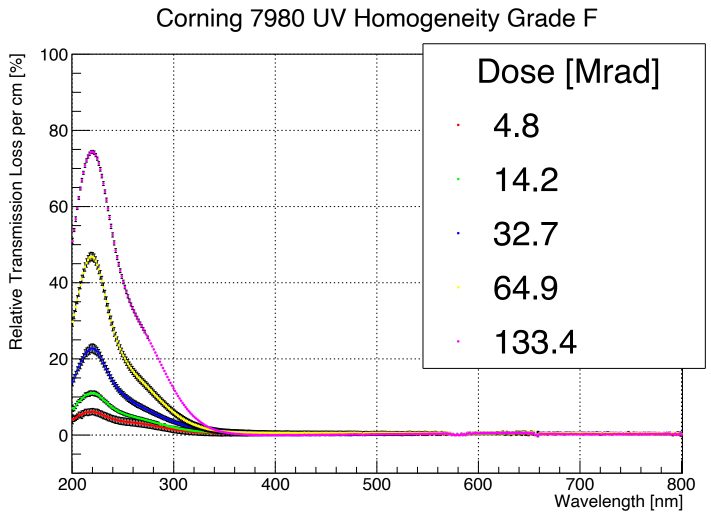
- Goal: quantify light transmission losses in detector radiators due to damage from anticipated radiation dose (for lifetime of MOLLER) – 45 Mrad peak and 120 Mrad peak per 5x5 mm^2 for ring 5 and ring 2, respectively
- Five candidate fused silica (quartz) samples chosen for testing: from Corning, Ohara, and Heraeus
- Irradiations conducted at the Idaho Accelerator Center using 8 MeV pulsed electron beam, ~40 mA peak current, ~1 μs pulse width (~40 nC/pulse) at 200 Hz repetition rate; samples are 50 cm from beam exit window
- Dose deposition quantified with G4 simulation benchmarked to beam dose profile and source measurements
- Work by Justin Gahley; report in [docDB #886]

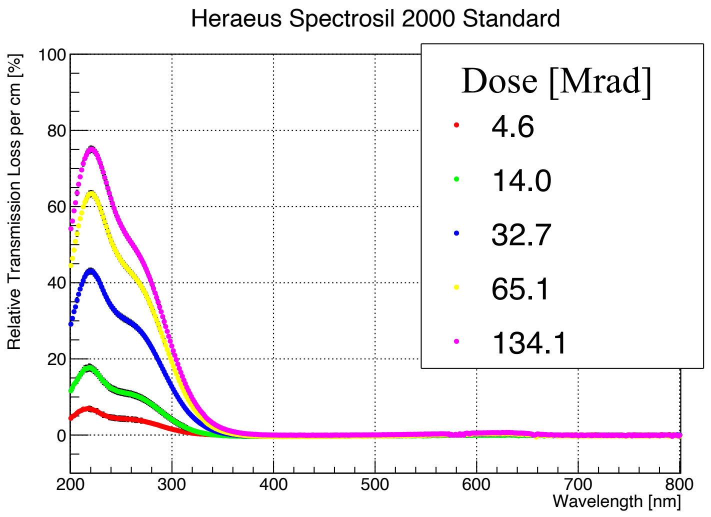
Samples: 5 cm diameter or square, 1 cm thick; polished faces

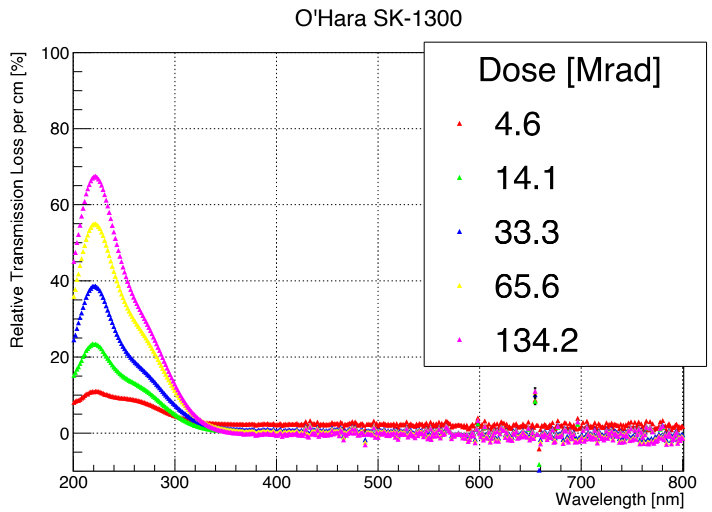


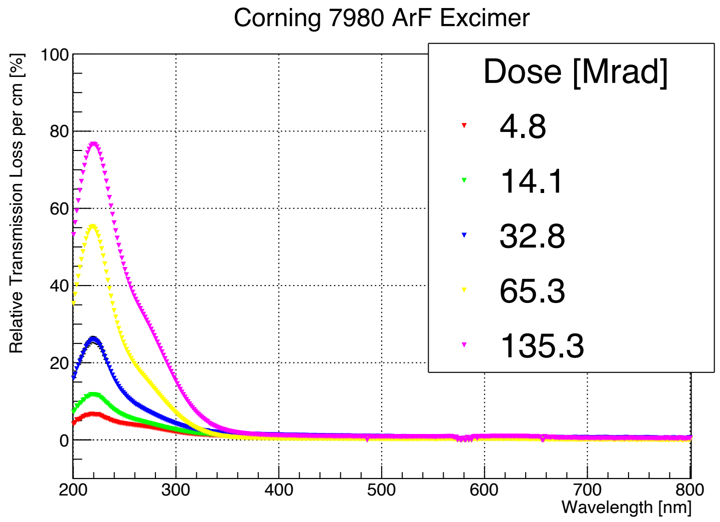


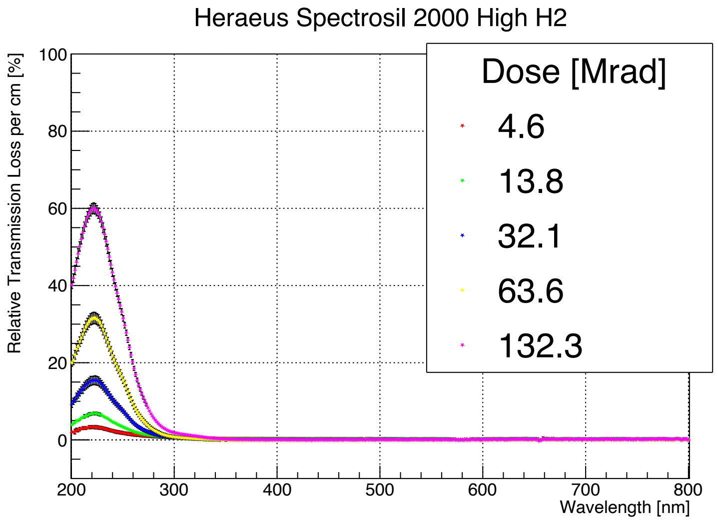
Quartz radiation-hardness results: light loss











--All samples are wet (> 200 ppm OH content), except SK-1300 which is dry; doped Heraeus has high OH and high H2 content

--Main absorption center at 5.6 eV is the E' – unavoidable point-like defects that cause dangling Si atoms which absorb light

--The shoulder structures are from non-binding hydroxide absorption centers around 4.5 – 5 eV

--the doped Heraeus shows very little of this damage center at our doses

Quartz radiation-hardness results : loss vs. dose