Ongoing projects and research opportunities in the Department of Physics

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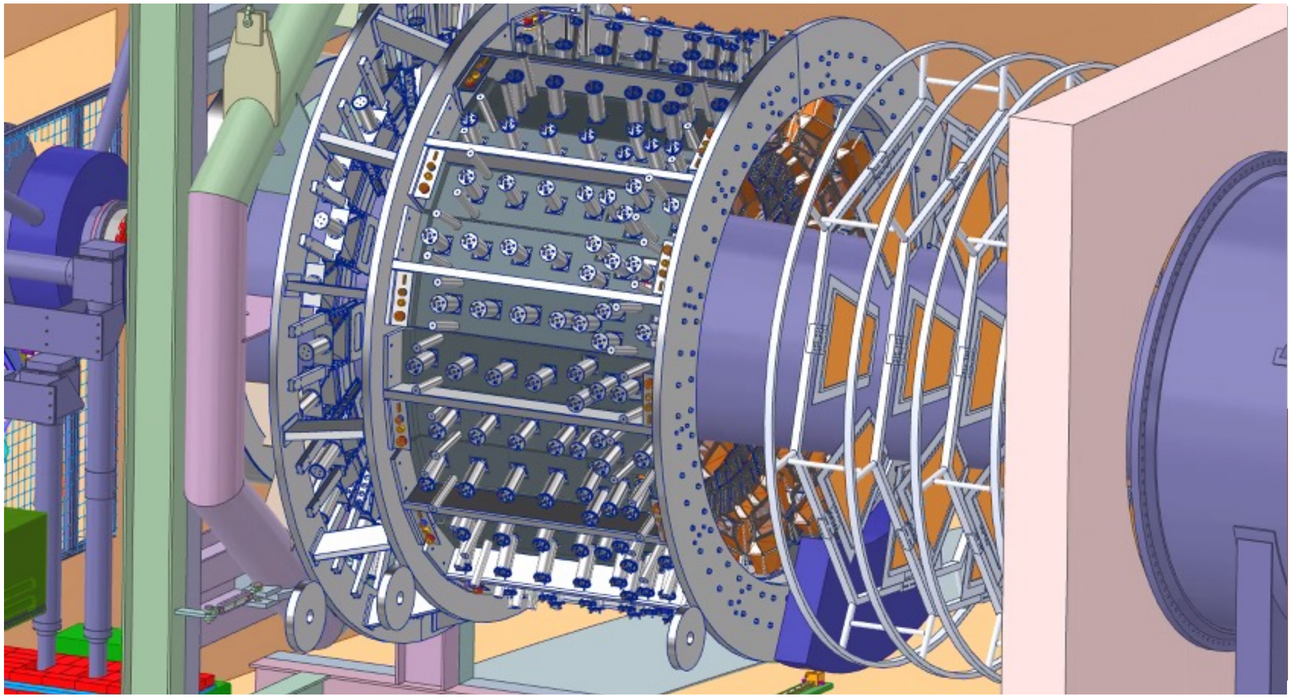
U.S. DEPARTMENT OF ENERGY
Office of Science

Shower-max Design, Detector Logistics, Radiation Tests



Dustin McNulty – Idaho State University

Students:

Sudip Bhattarai
Justin Gahley
Jared Insalaco
Sagar Regmi
Katherine Burke
Edwin Sosa
Freddy Kouakou
Coltyn Fisher
Mitchell Frasure
Gabriel Ladipo
Don Sheetz III

Jefferson Lab

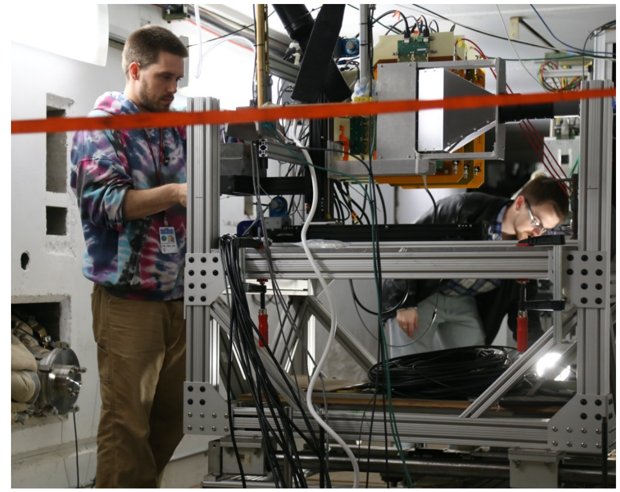
Some opportunities in Physics at ISU

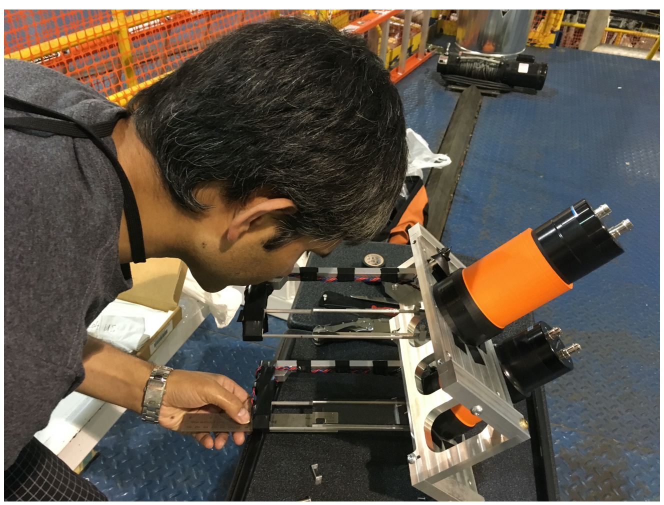
Ongoing research projects:

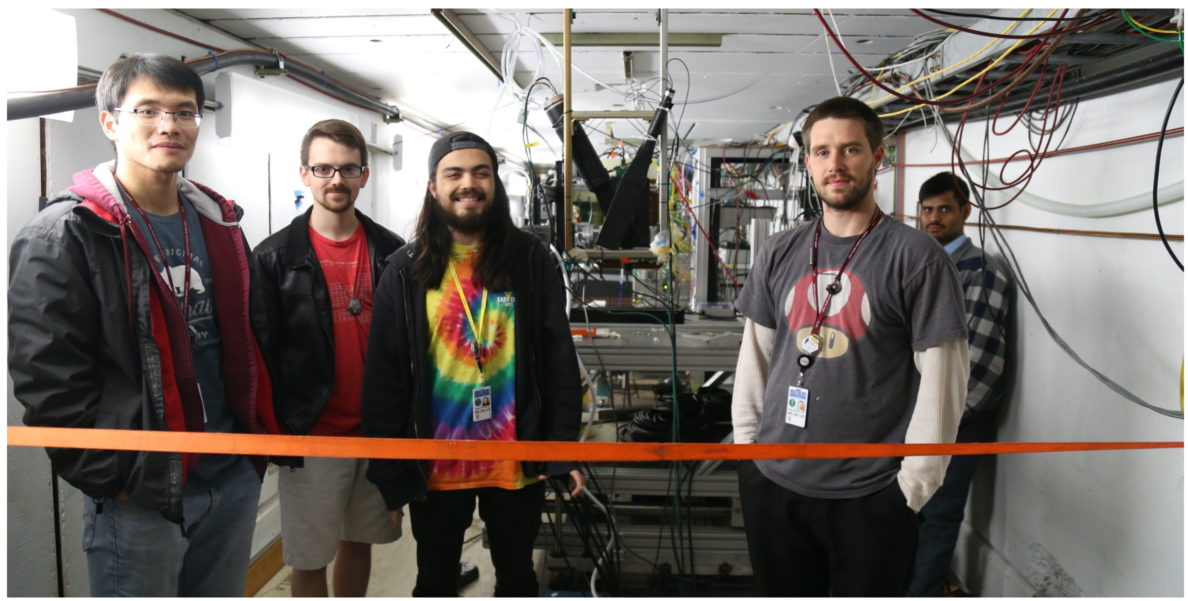
- Designing and constructing the Shower-max detector ring system for MOLLER (taking place in the basement beamlab of PSC)
- Radiation hardness testing of MOLLER detector components
  - Irradiations take place at Idaho Accelerator Center (IAC) on upper campus
  - Testing HPFS (quartz), 3D-printed plastic parts; pmt electronics
- Developing cosmic-ray test stand to be used for validating constructed Shower-max modules -- requires simulation; will also use as learning tool
- Characterizing pmt non-linearity and ideal operating settings for all MOLLER integrating detectors
- Developing main detector cabling plans: cable harness, patch panels, breakout boxes

Past Students

Students at Work at Jefferson Lab and SLAC







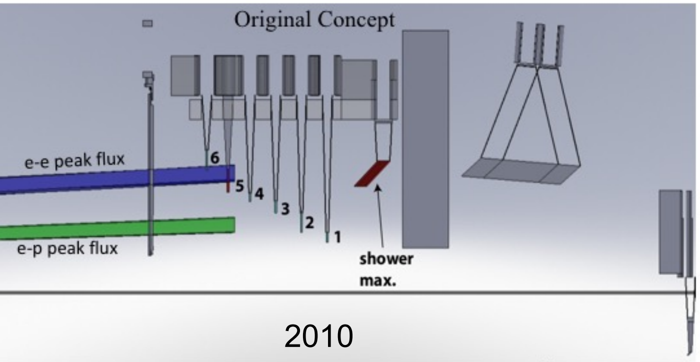
Current Students

Students working at Idaho Accelerator Center

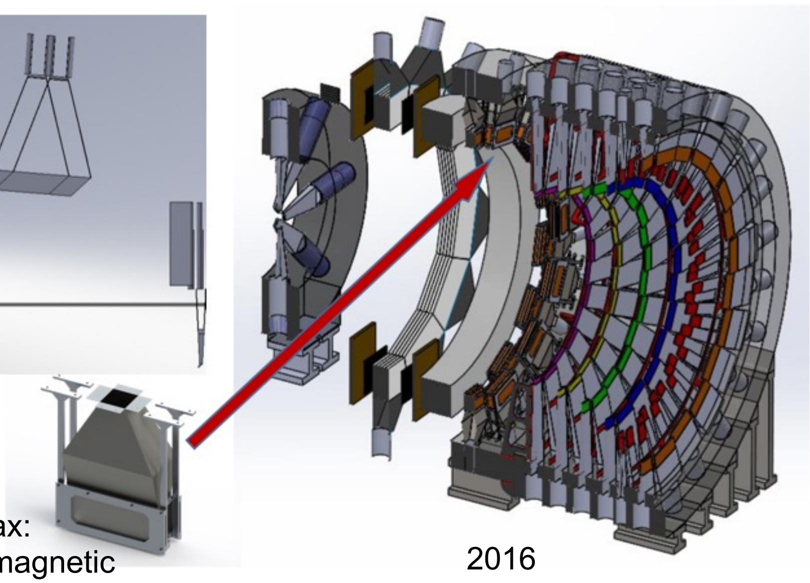
Shower-max Description

Idaho State University

2.04.03	Shower Max Detector	Design, Procurement, Assembly, and Test of the Shower-Max detector system. It is composed of an array interleaved layers of quartz radiatiors and thin tungsten sheets making up an EM shower detector system.

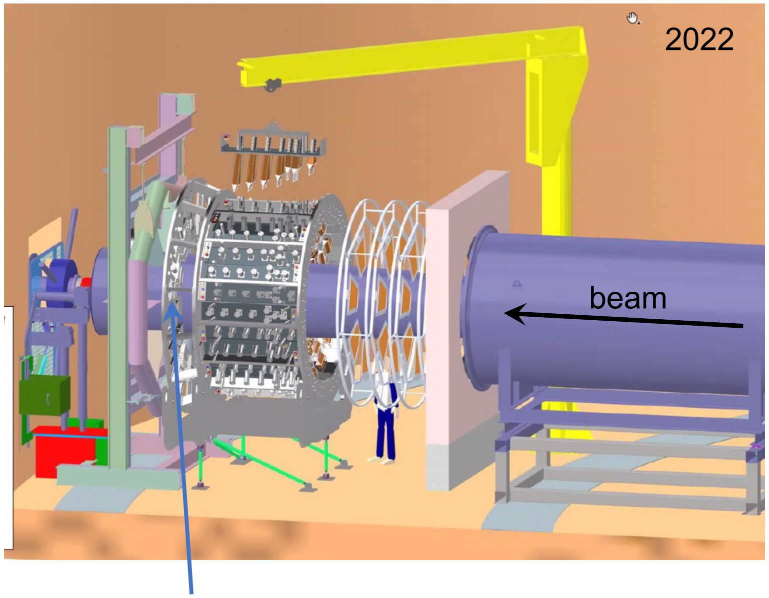


2010



Shower-max:
An electromagnetic
sampling calorimeter

2016



Shower-max ring

- Provides additional measurement of Ring-5 integrated flux
- Weights flux by energy $\Longrightarrow$ less sensitive to low energy and hadronic backgrounds
- Will also operate in tracking mode to give additional handle on background pion identification
- Will have good resolution over full energy range ($\lesssim 25\%$), radiation hard with long term stability and good linearity

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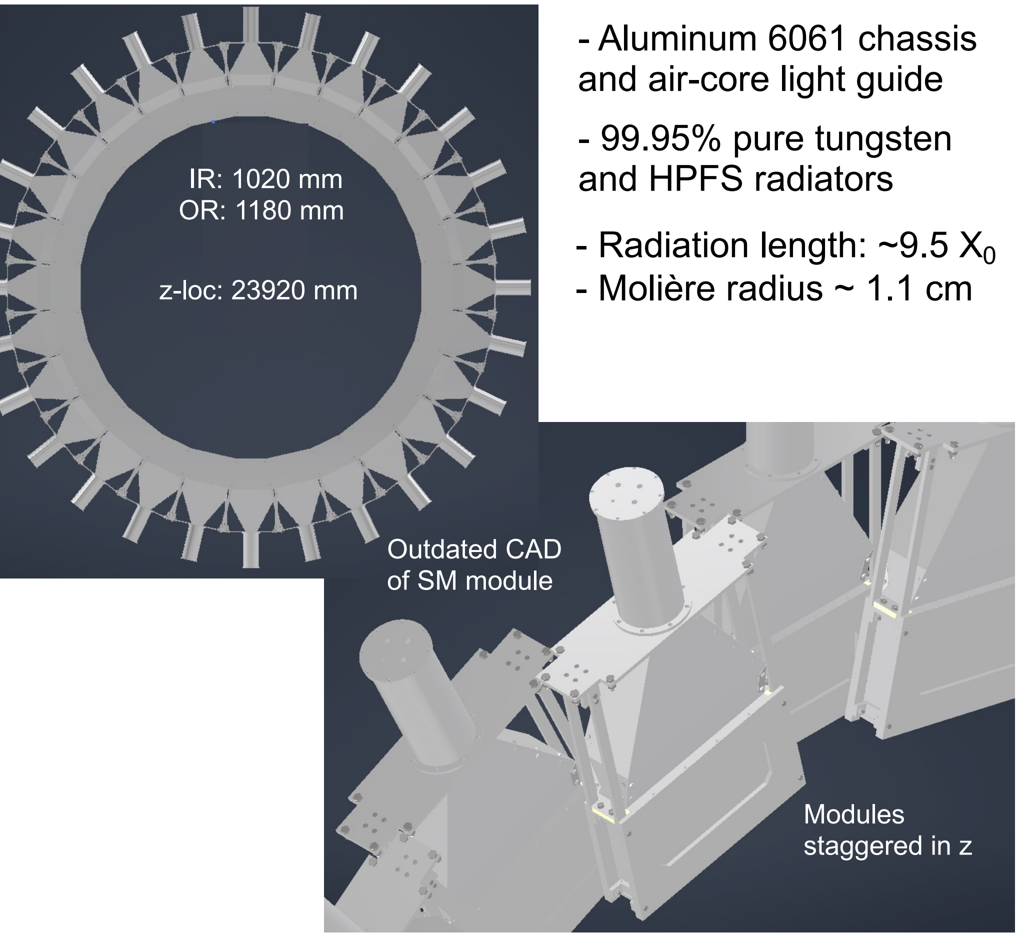
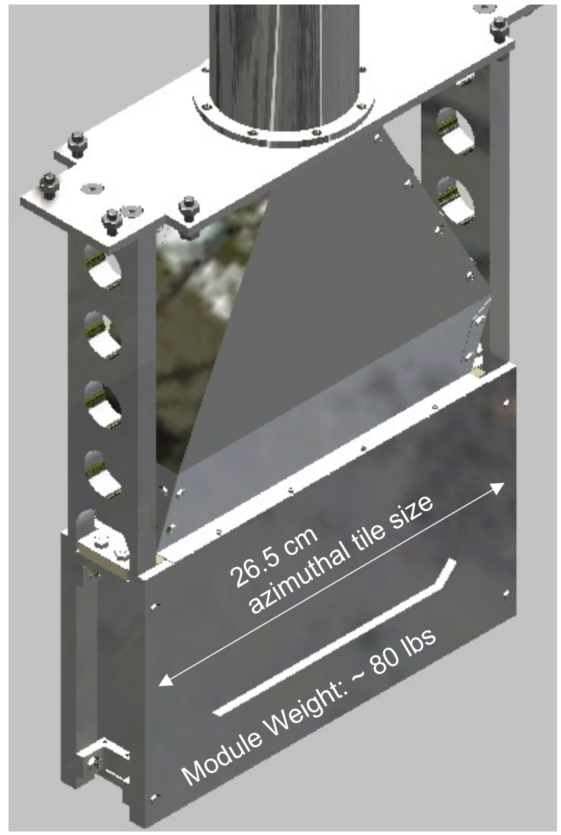
Shower-max module and ring geometry

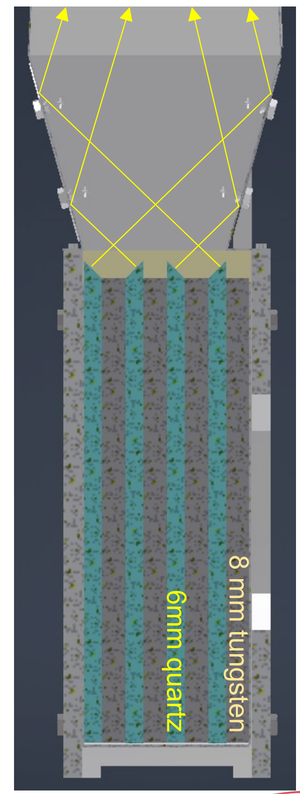
Idaho State University

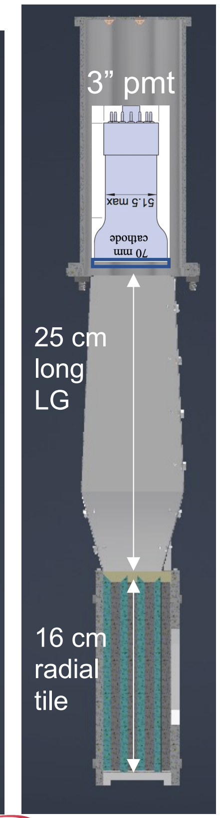
ShowerMax detector: ring of 28 sampling calorimeters intercepting physics signal flux 1.7 m downstream of ring 5



- 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







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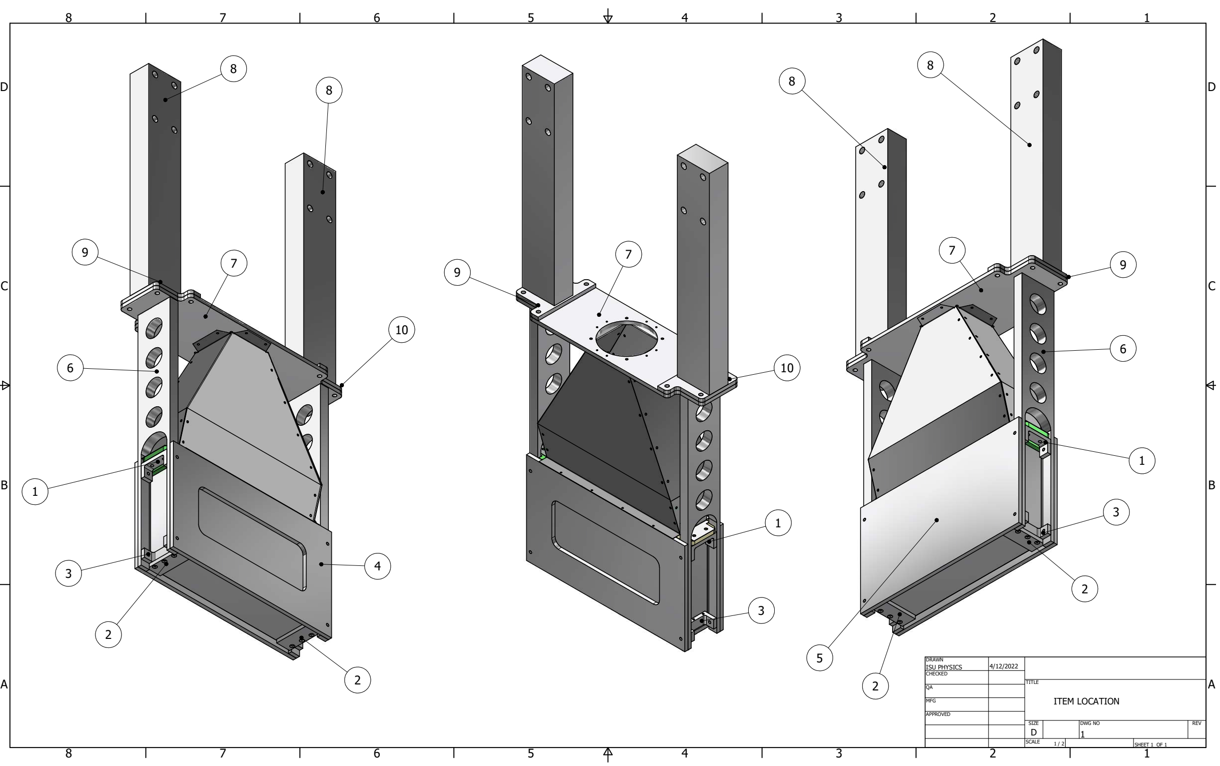
Shower-max: Prototyping – Chassis parts

Idaho State University

- Shop drawings created and chassis parts for two prototypes received in early June



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

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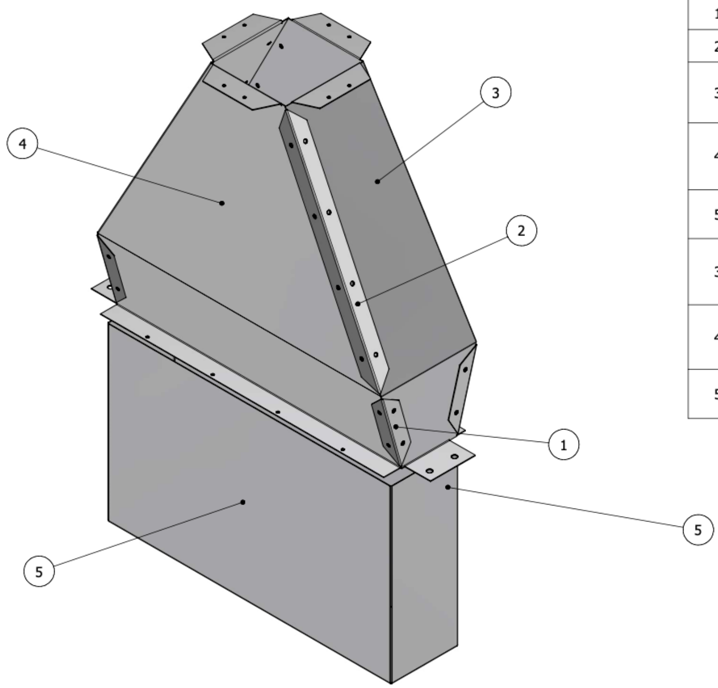
Shower-max: Prototyping – light guide parts

Idaho State University



ITEM NO.	PART NAME	MATERIAL	QTY.
1	SHORT FLAP	0.02" ANOLUX MIRO-SILVER OR MIRO - IV MATERIAL DOES NOT MATTER	16
2	LONG FLAP	0.02" ANOLUX MIRO-SILVER OR MIRO - IV MATERIAL DOES NOT MATTER	8
3	LIGHT GUIDE BACK	0.02" ANOLUX MIRO-SILVER REFLECTIVE ALUMINUM SHEET CAUTION: NO SCRATCH SURFACE REQUIRED	2
4	LIGHT GUIDE FRONT	0.02" ANOLUX MIRO-SILVER REFLECTIVE ALUMINUM SHEET CAUTION: NO SCRATCH SURFACE REQUIRED	2
5	SUITCASE	0.02" ANOLUX MIRO-SILVER REFLECTIVE ALUMINUM SHEET CAUTION: NO SCRATCH SURFACE REQUIRED	4
3	LIGHT GUIDE BACK	0.02" MIRO- IV REFLECTIVE ALUMINUM SHEET CAUTION: NO SCRATCH SURFACE REQUIRED	2
4	LIGHT GUIDE FRONT	0.02" MIRO- IV REFLECTIVE ALUMINUM SHEET CAUTION: NO SCRATCH SURFACE REQUIRED	2
5	SUITCASE	0.02" MIRO- IV REFLECTIVE ALUMINUM SHEET CAUTION: NO SCRATCH SURFACE REQUIRED	4

ISU PHYSICS 5/6/2022

SHEET METAL PARTS

D NA

1 : 1 SHEET 1 OF 1

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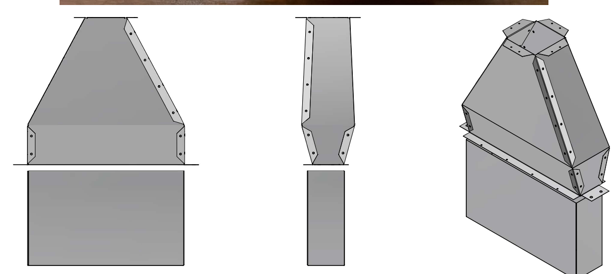
- Shop drawings created and light guide parts for prototypes just received: two Miro IV and two Miro-silver sets
- Starting to fold them this week
  - Unfortunately, machinist did not use sandwiching technique during water jet cutting and protective films were ripped off. We are re-doing them



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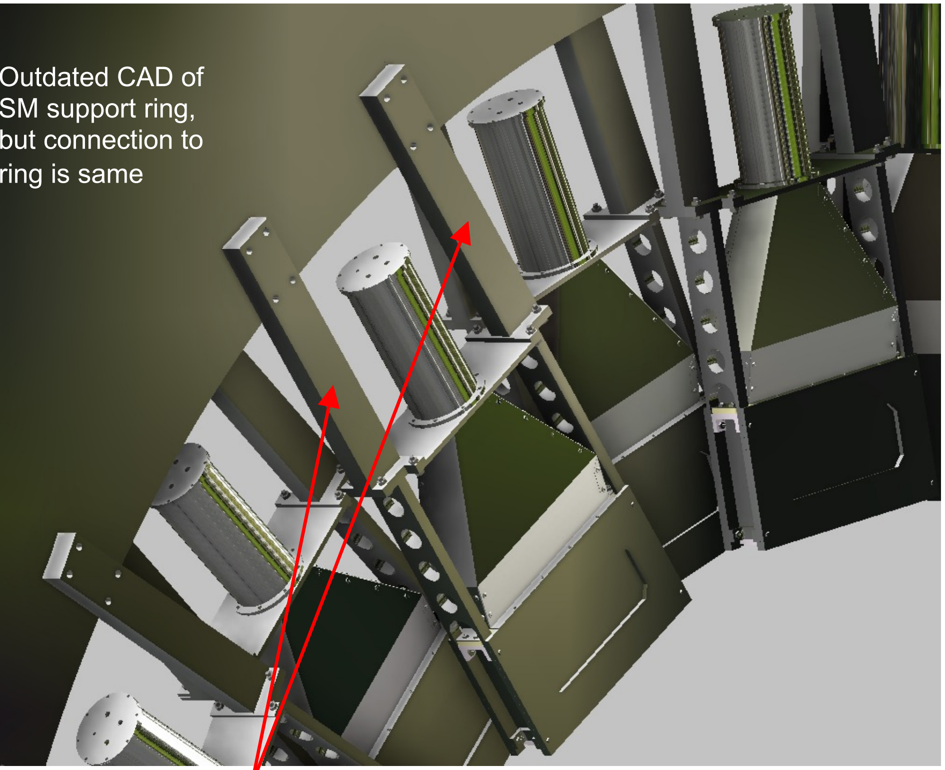
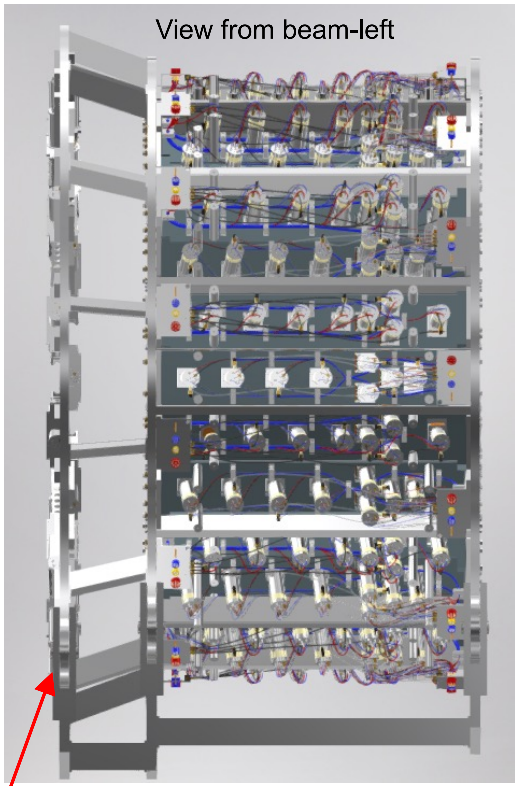
Shower-max Ring Support Structure

Idaho State University



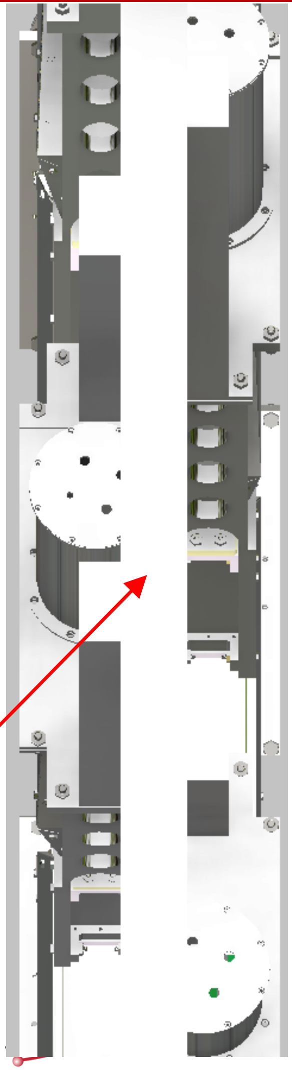
Aluminum bars (15 x 1.25 x 2.5 in^3) attach modules to ring structure--which is 2 inch thick (along z)

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



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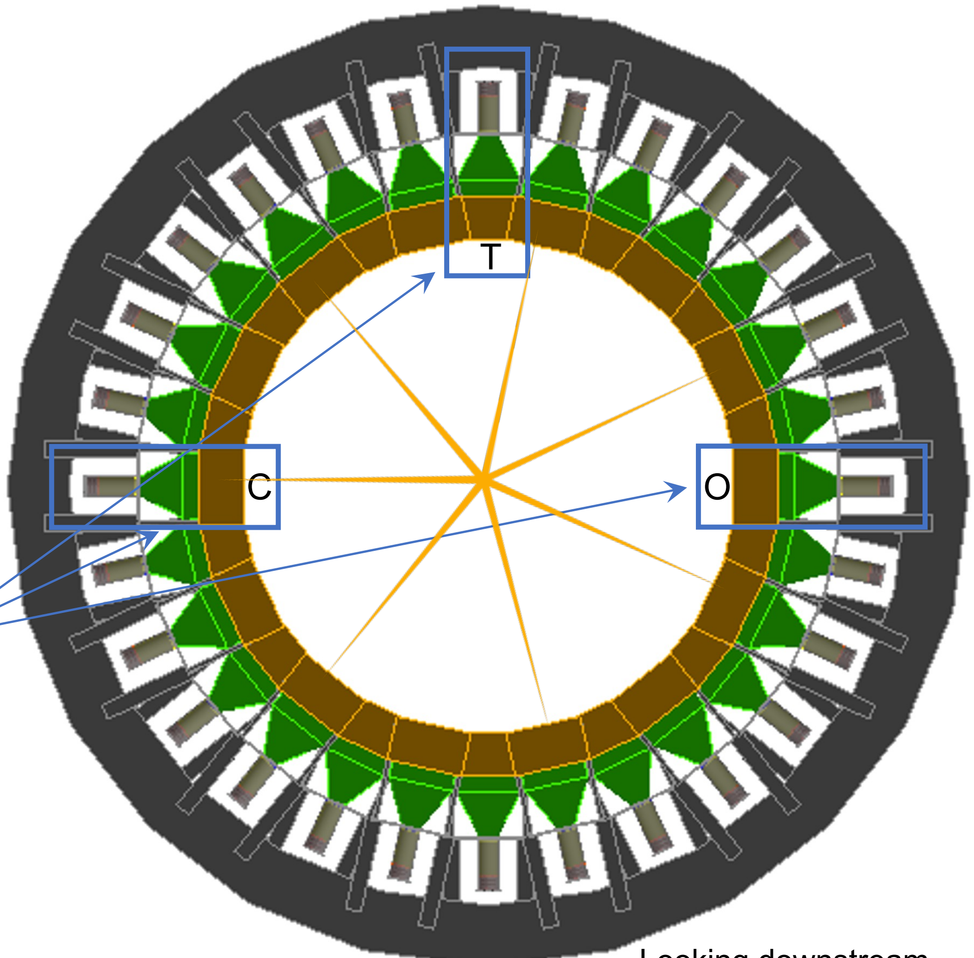
Shower-max dose simulations using remoll

Idaho State University

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

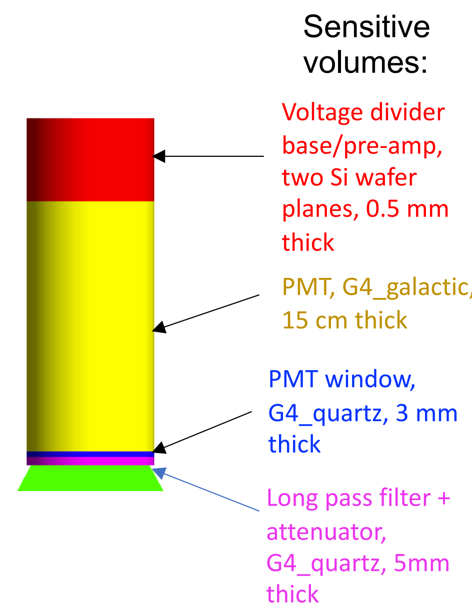


Looking downstream

Quartz layer dose study:

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

PMT region dose study:



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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

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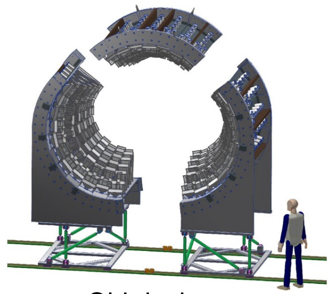
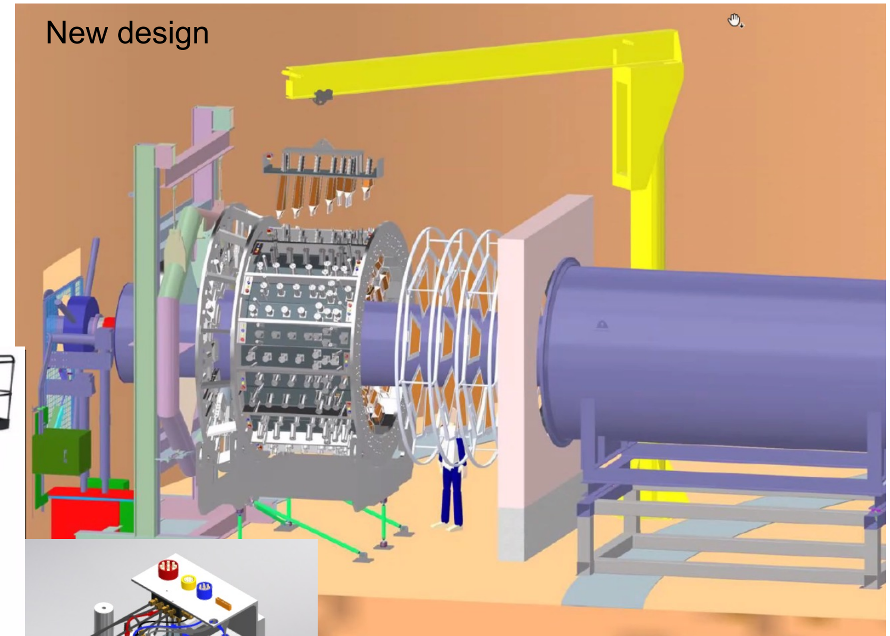
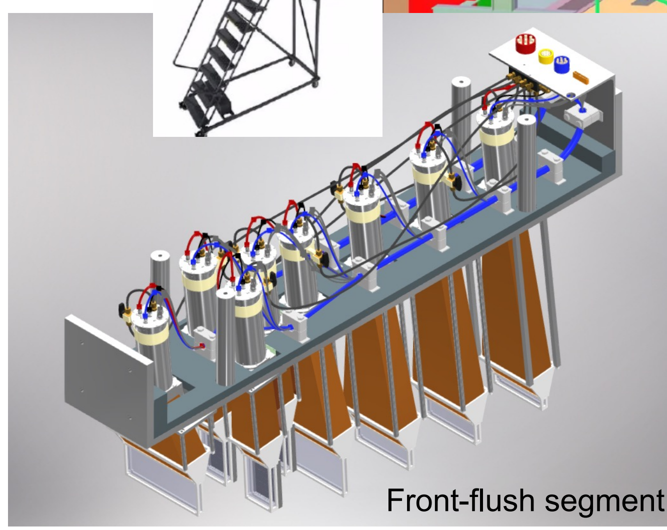
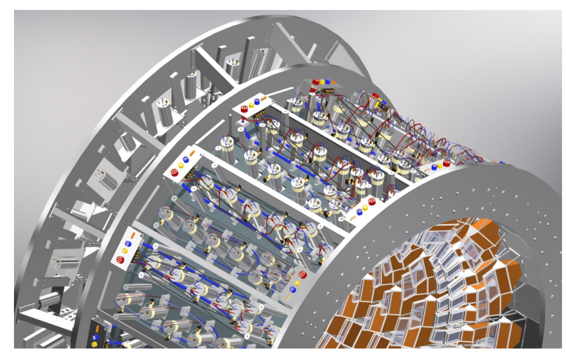


Old design





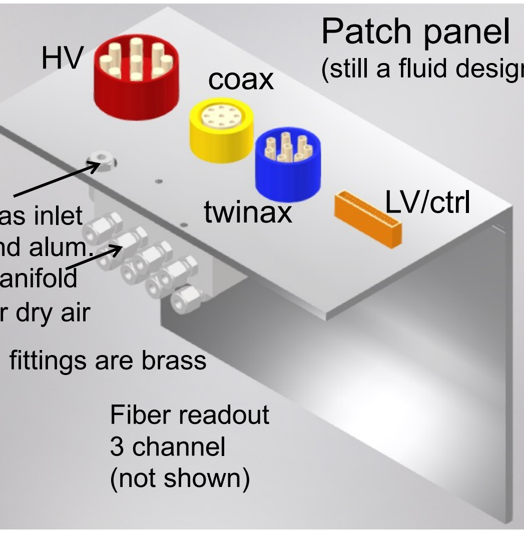
Front-flush segment



Jefferson Lab

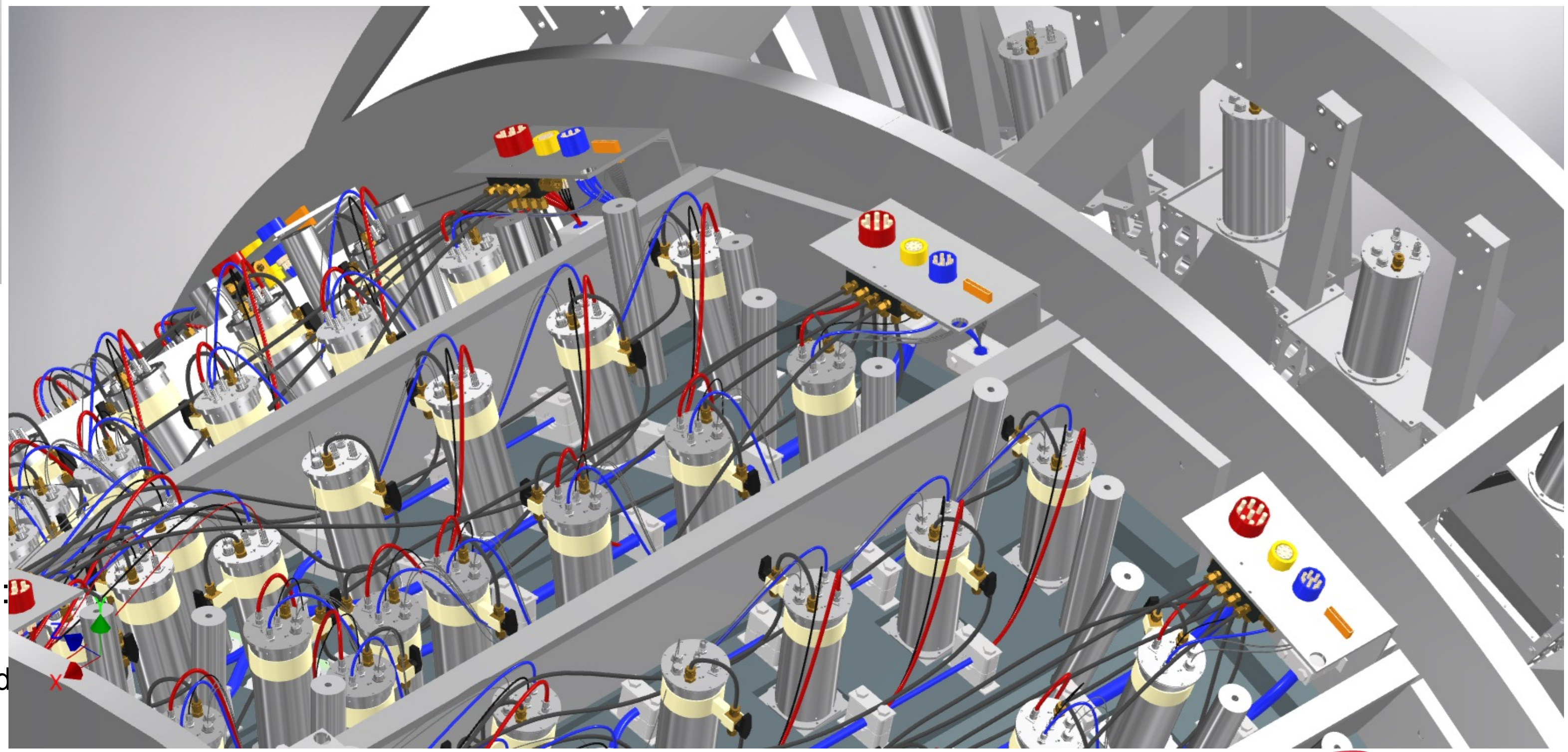
Snapshot of Technical Progress (detector cabling)

Idaho State University



Main detector cabling (CAD work by Edwin Sosa)

- Connector CAD models are place holders, but match dimensionally our candidates
- LV/control HD connector is least developed; we are moving away from ribbon style
- Gas distribution system design (manifold, tubing size, etc.) is very preliminary



8 detectors per tray,
each detector requires:

HV cable
signal cables (coax and twinax)
(2) LV control wire(s)
gas inlet

3 HVMAPs per tray, each needs:

Fiber Optic readout cable
gas inlet (could use separate manifold
everal LV power wires (not shown)

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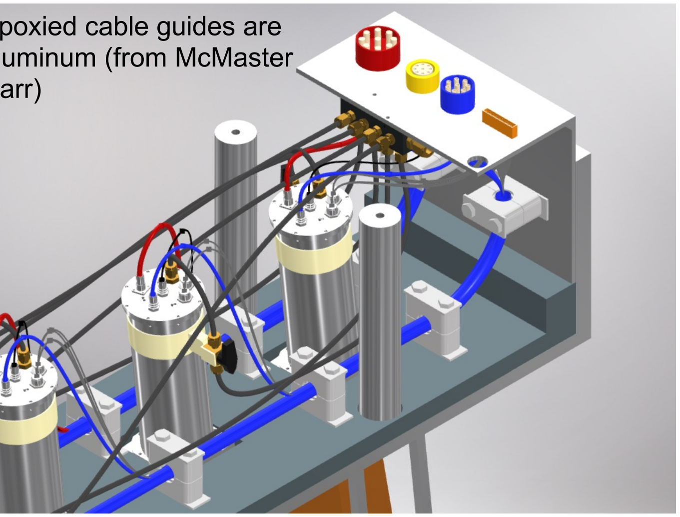
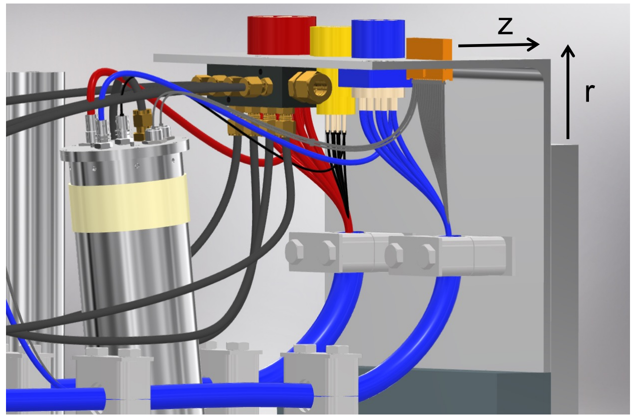
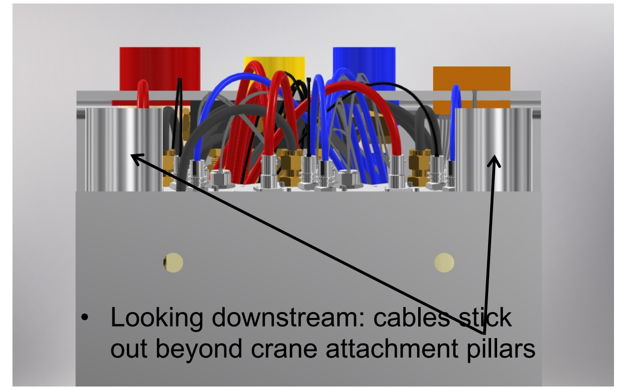
Patch Panel and harness views

Idaho State University

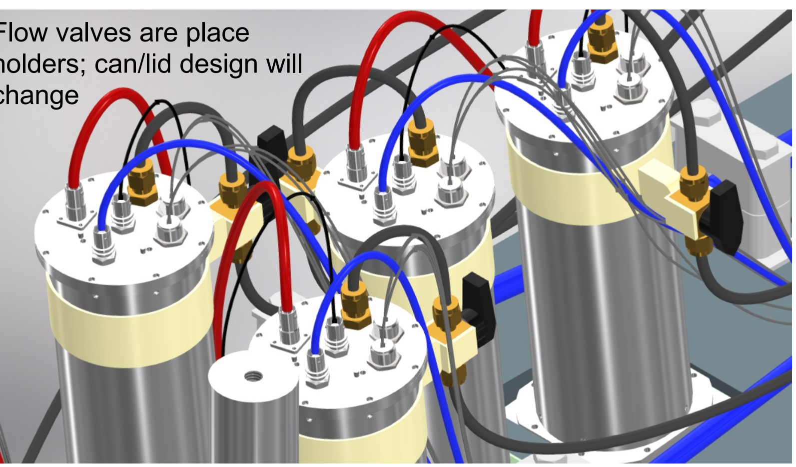


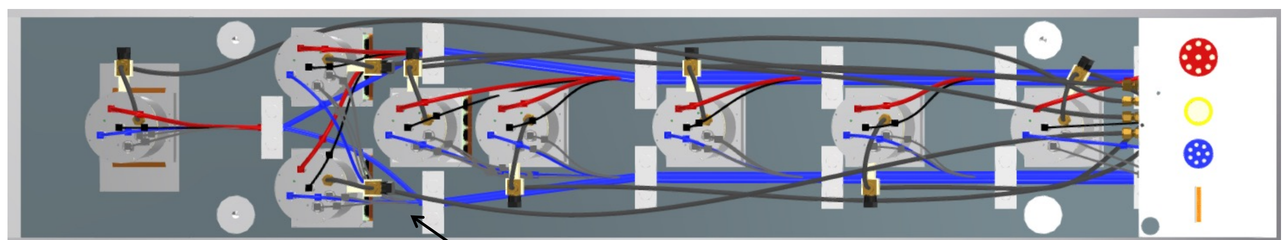


- Patch panel “L” bracket size was increased along both r and z to allow needed space



- Looking downstream: cables stick out beyond crane attachment pillars





- 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

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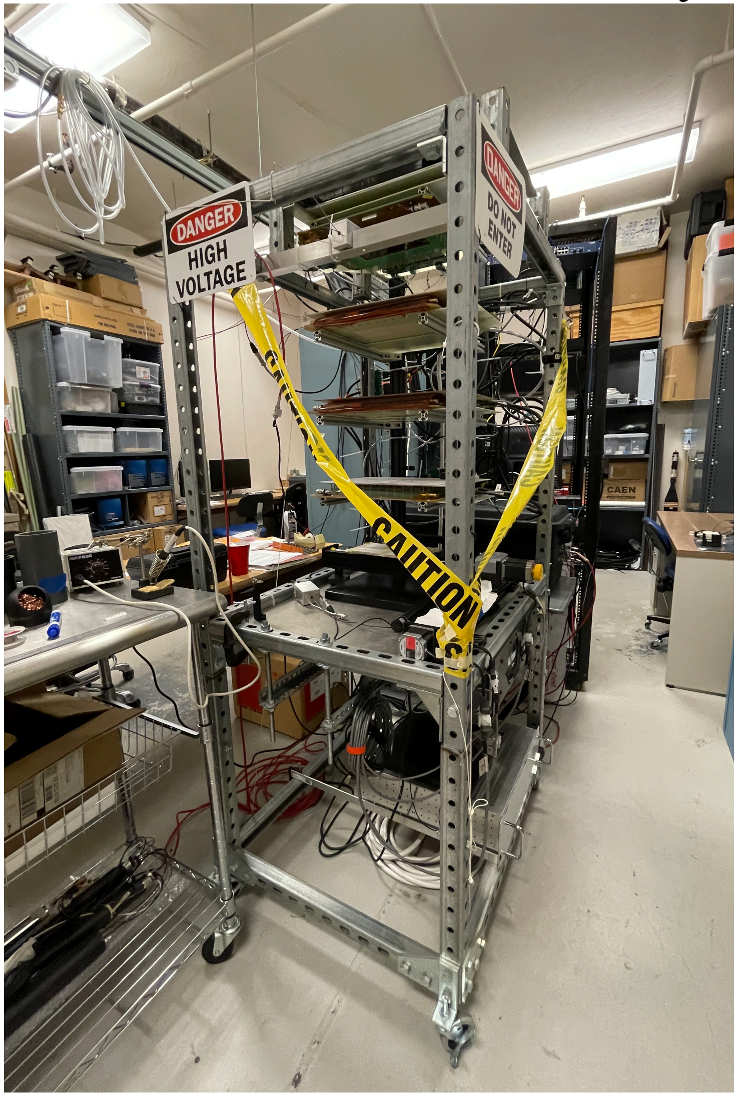
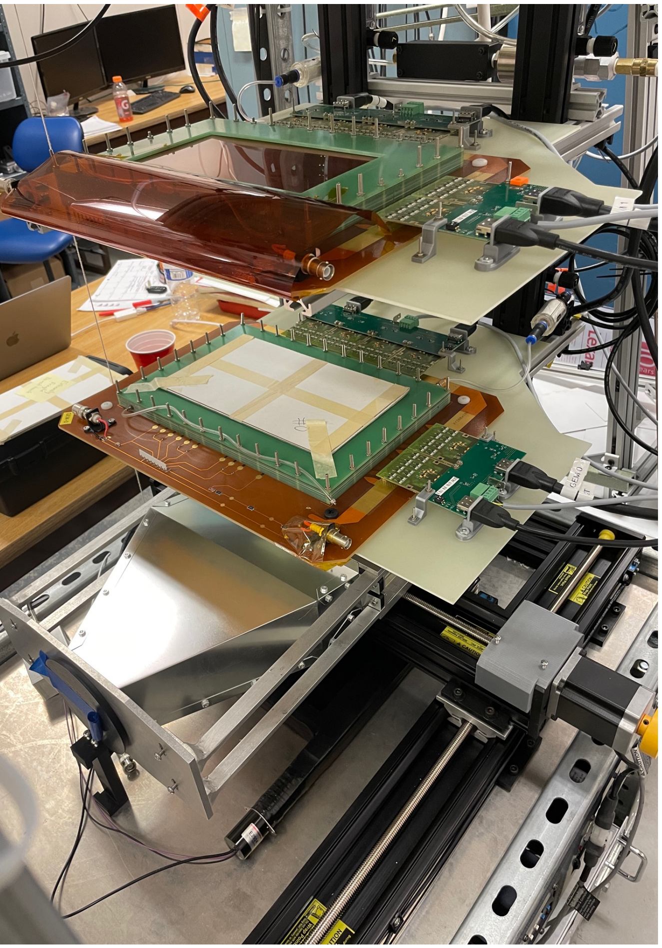
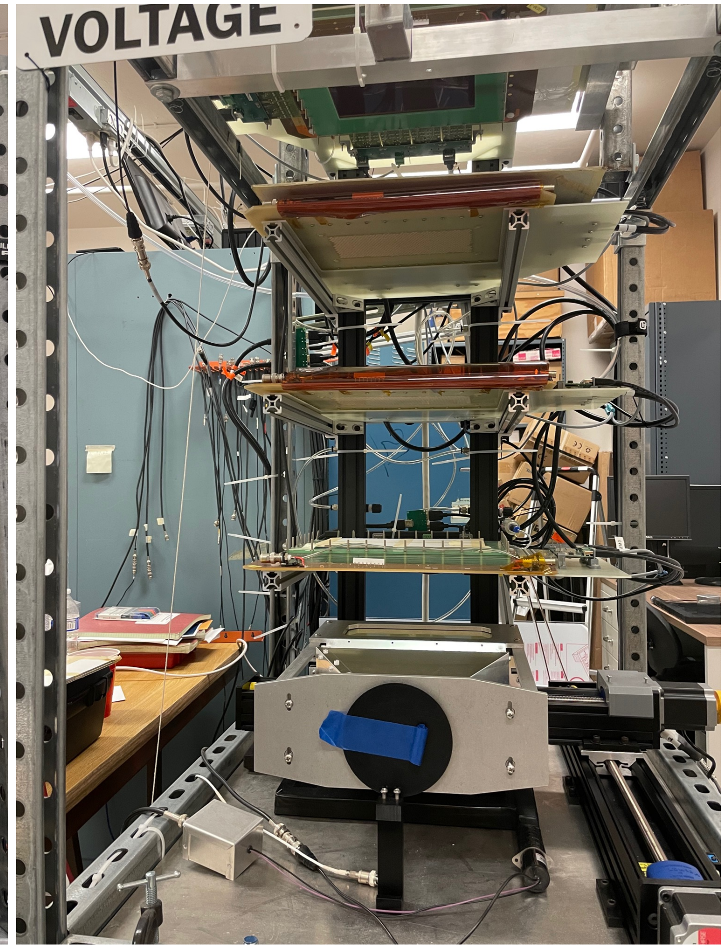
Cosmic-ray Stand in PSC basement

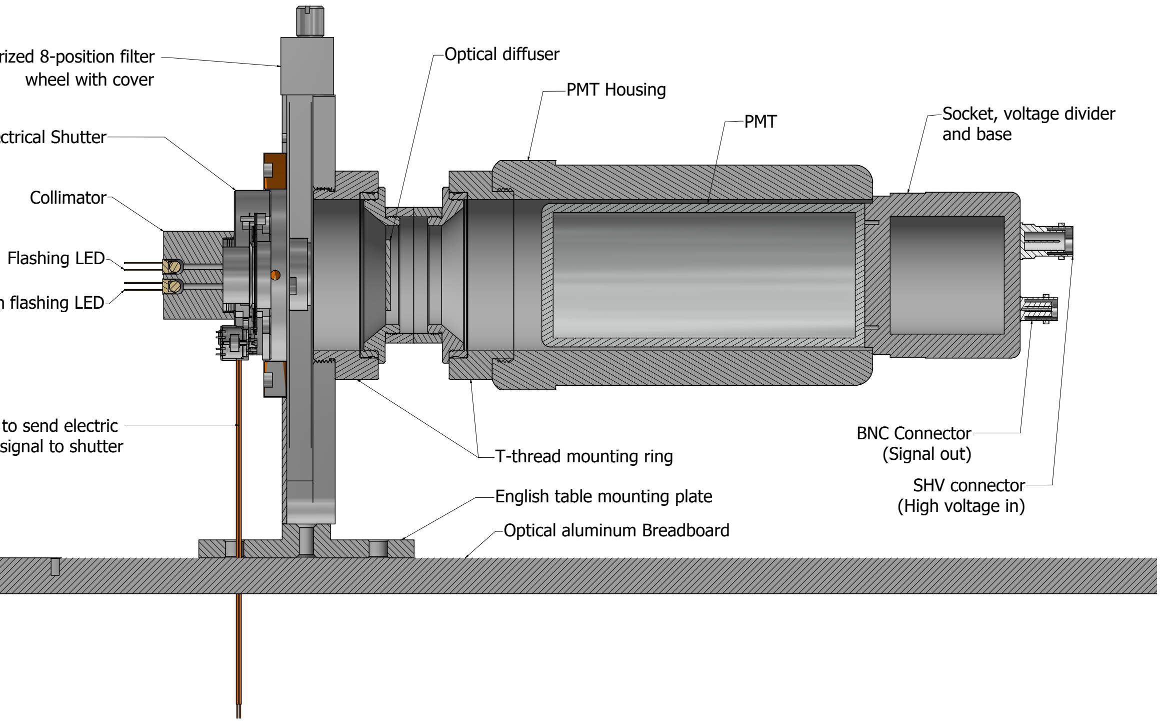


Cosmic-ray Stand in PSC basement





PMT non-linearity measurement apparatus



Idaho Accelerator Center

Provides opportunities for scientists and engineers from the University, the private sector and the national laboratories to utilize specialized nuclear facilities for R&D in nuclear physics applications in materials science, biology, homeland and national security.

Quartz radiation tests 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

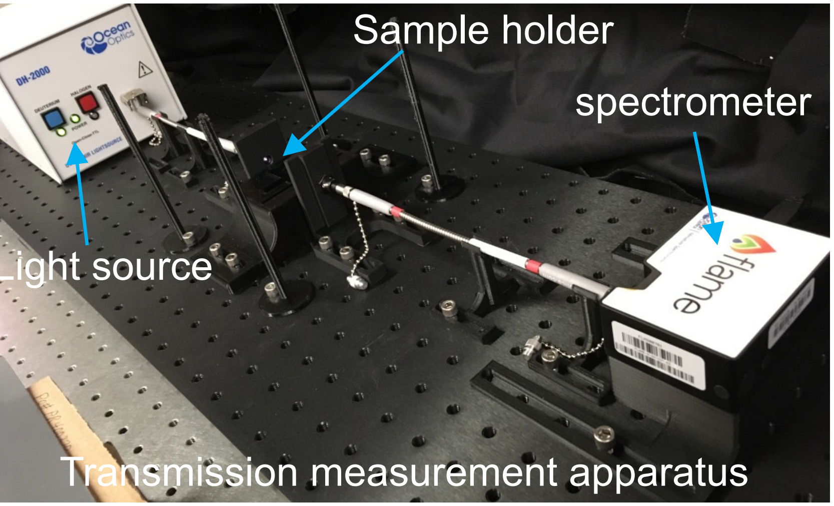
Five candidate artificial fused silica (quartz) samples chosen for testing: from Corning, Ohara, and Heraeus

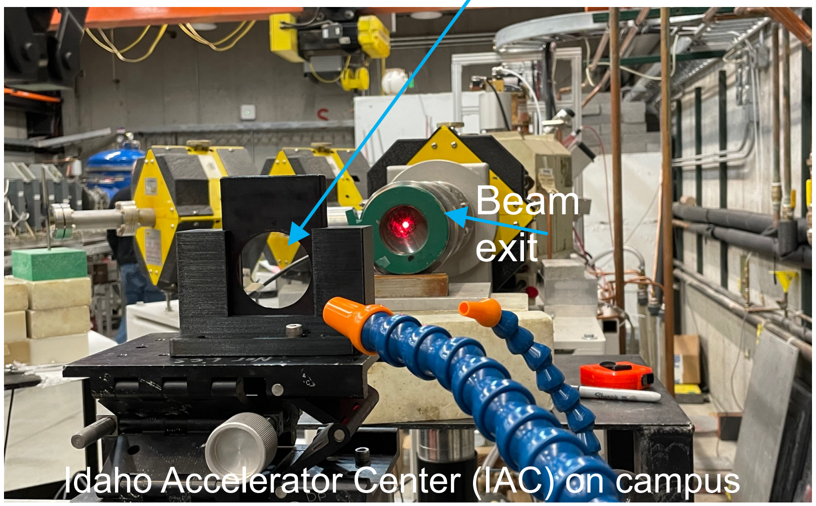
Irradiations conducted at the Idaho Accelerator Center using 8 MeV pulsed electron beam, ~40 mA peak current, ~1 μs pulse width (~40 nC/pulse) at 200 Hz repetition rate; samples are 50 cm from beam exit window

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





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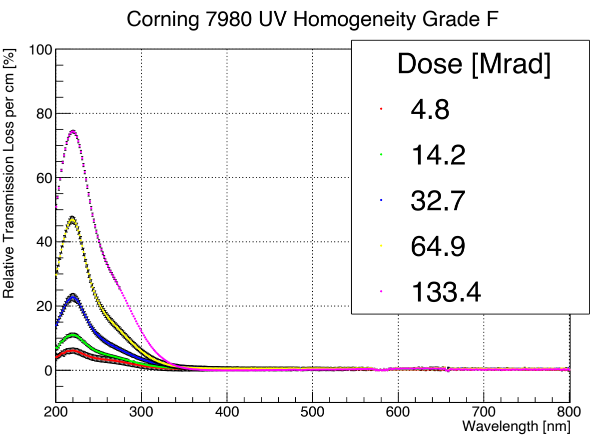
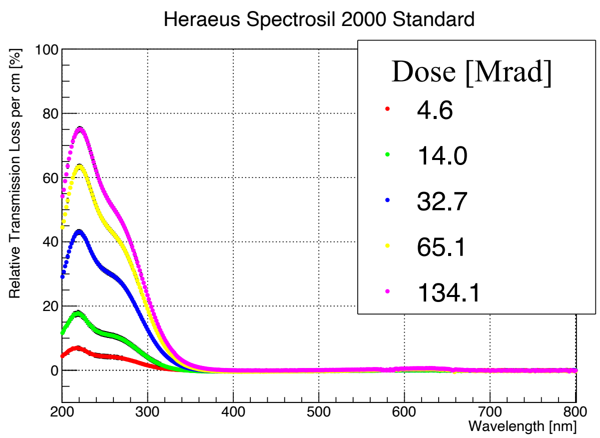
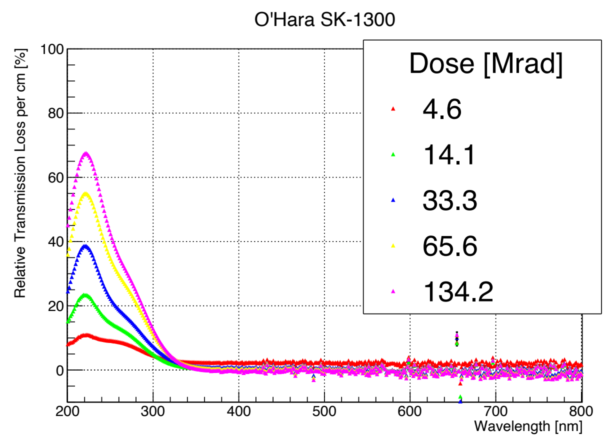
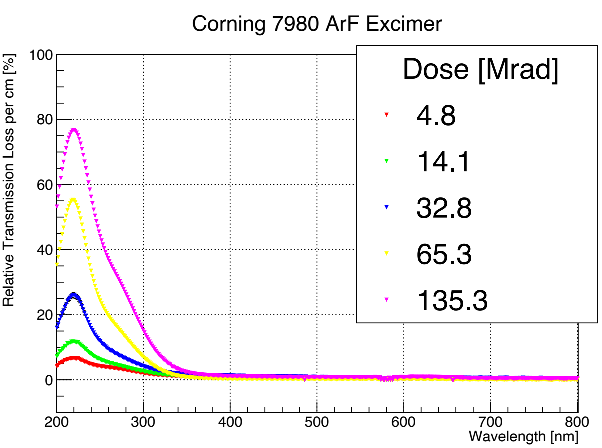
Idaho State University

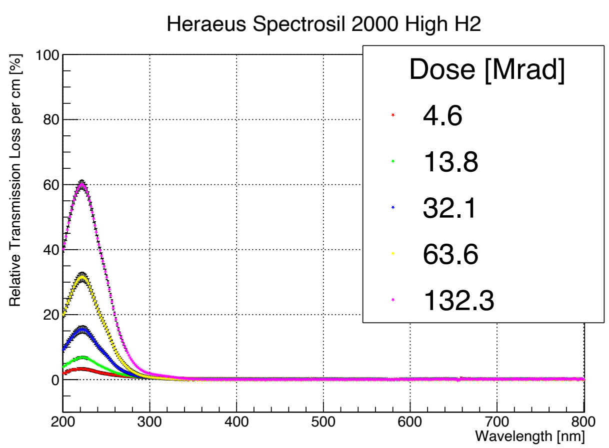
Quartz radiation-hardness results: light loss











--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

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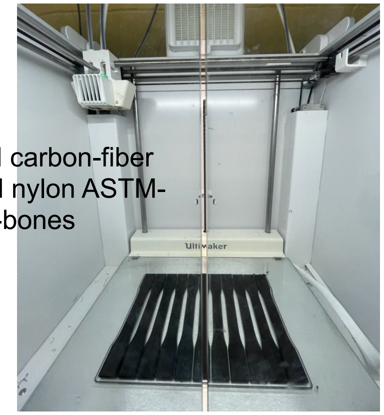
Plastic radiation tests started

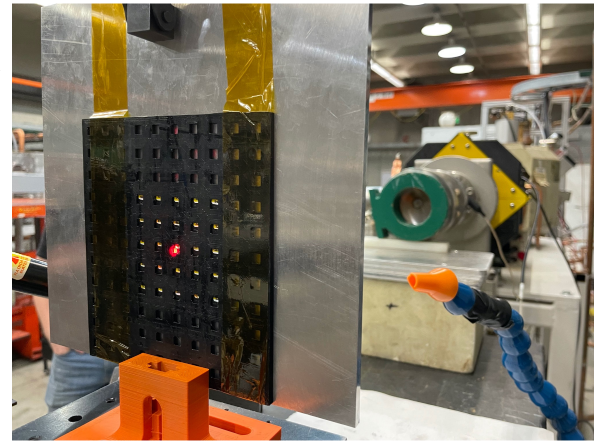
Idaho State University

Irradiated 90 dog-bone samples on 6/16/2022

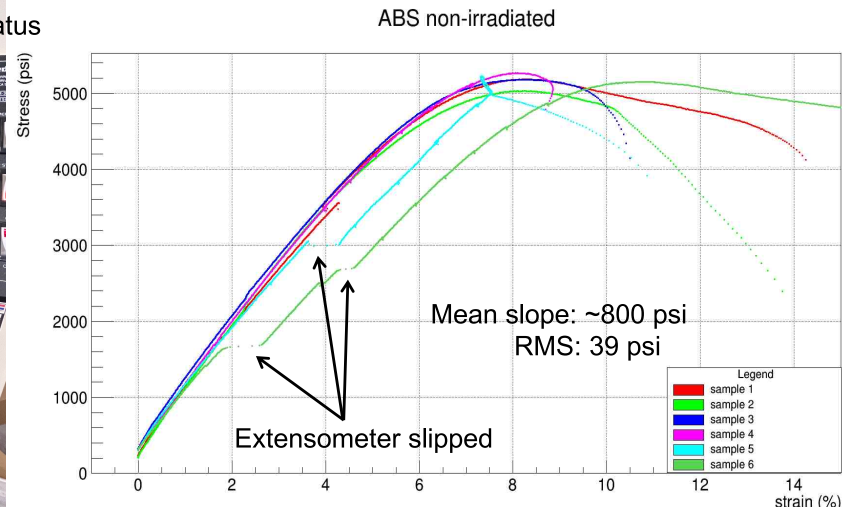
3D-printed carbon-fiber embedded nylon ASTM-D638 dog-bones



Nanodot OSL array beam dosimetry



Tensile testing apparatus



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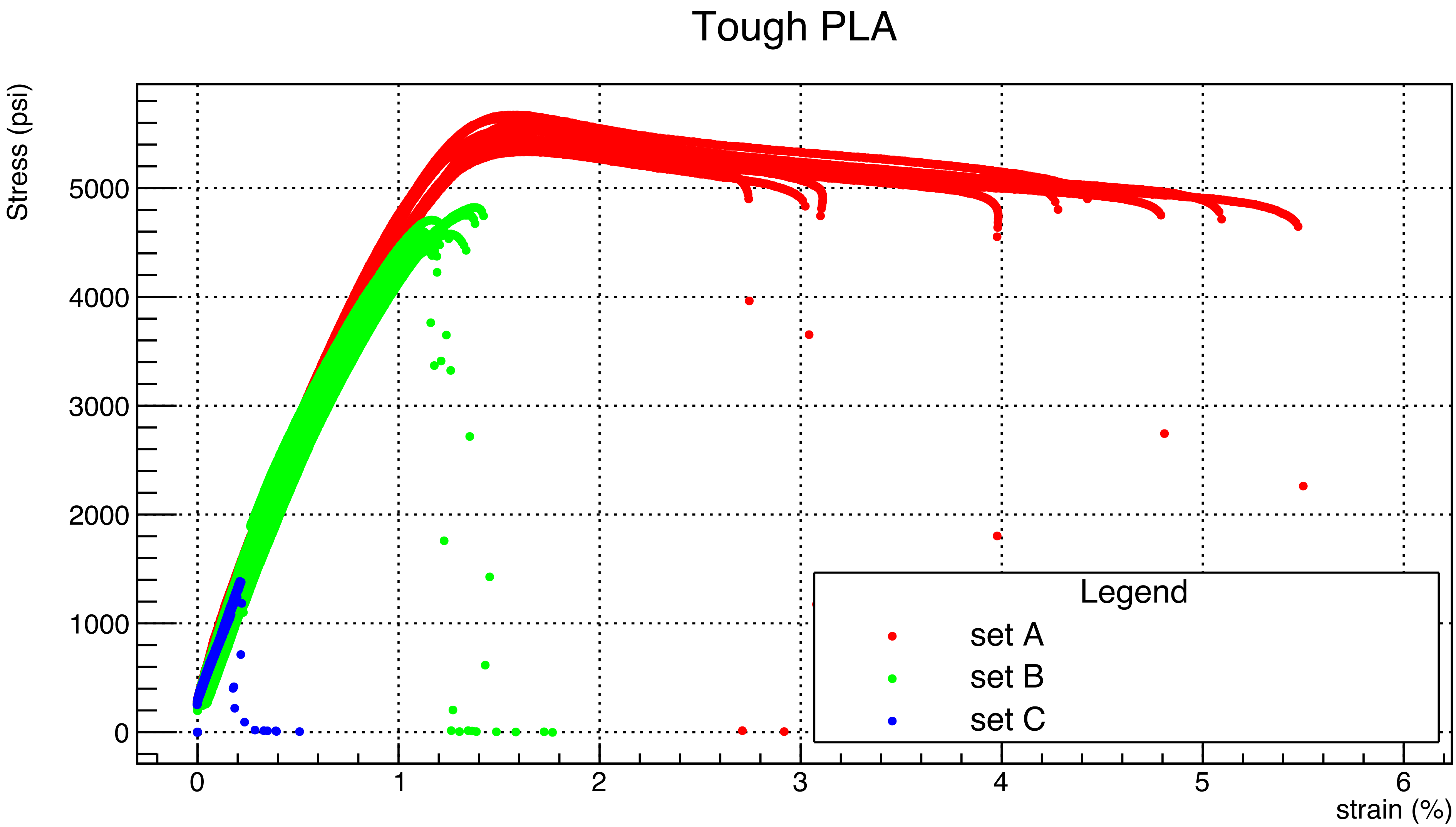
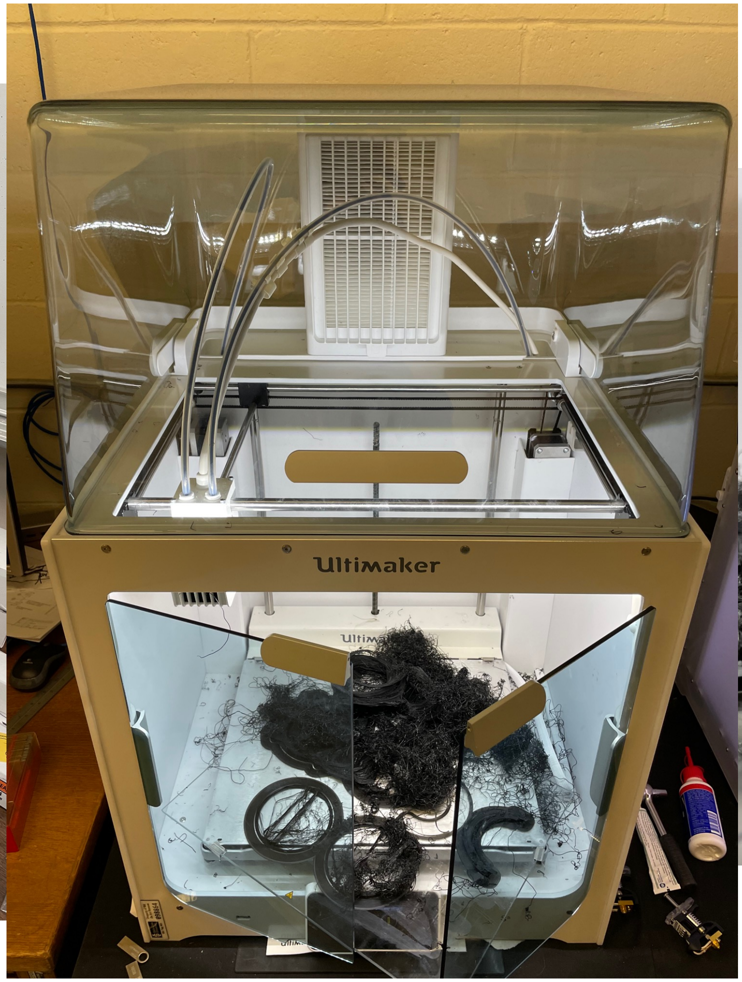

Tough PLA
Stress (psi)
strain (%)
0
1000
2000
3000
4000
5000
0
1
2
3
4
5
6
Legend
set A
set B
set C


Ultimaker