# Mechanical Design Update

## hpDIRC Annual Meeting - 2025
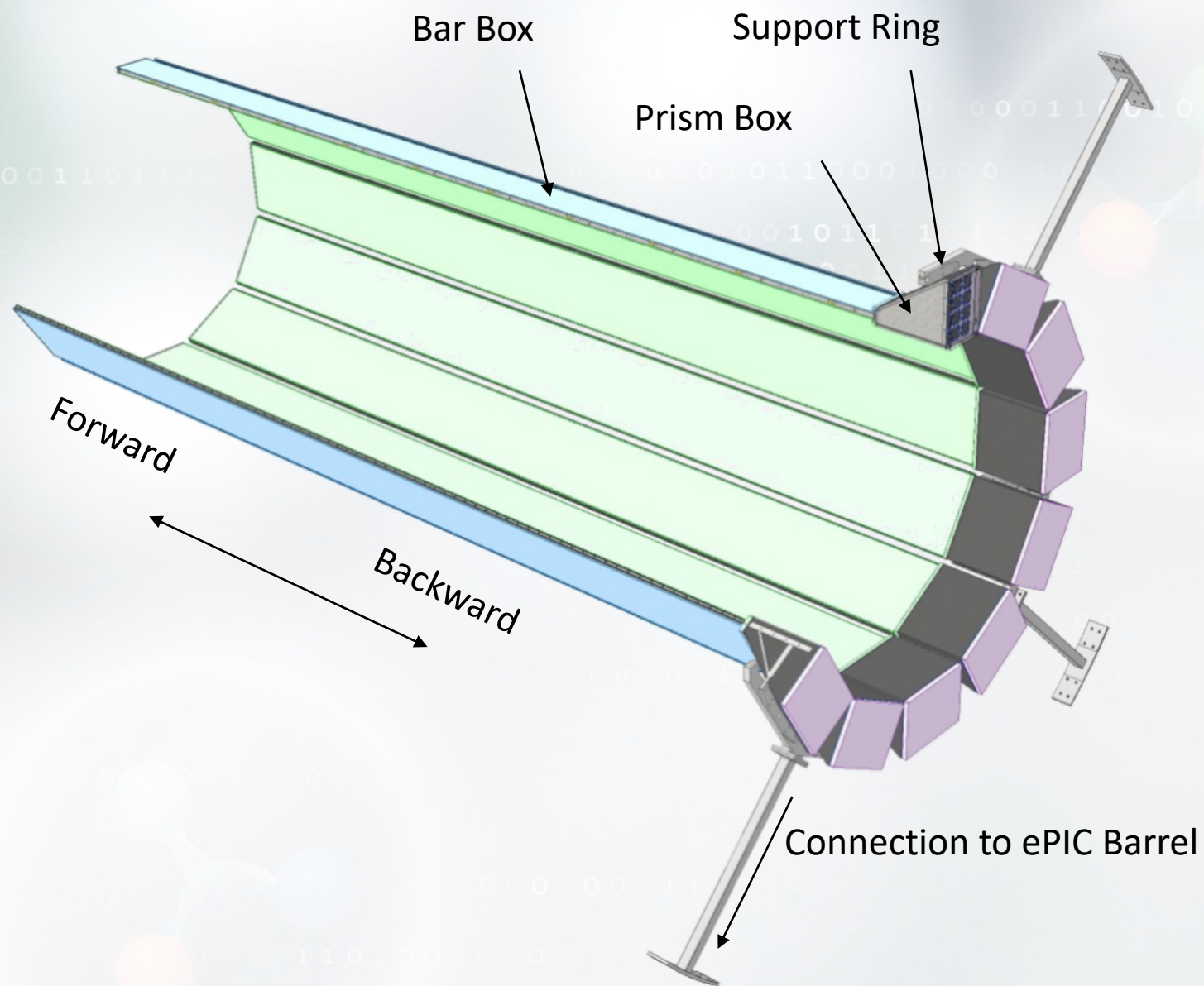
July 1, 2025

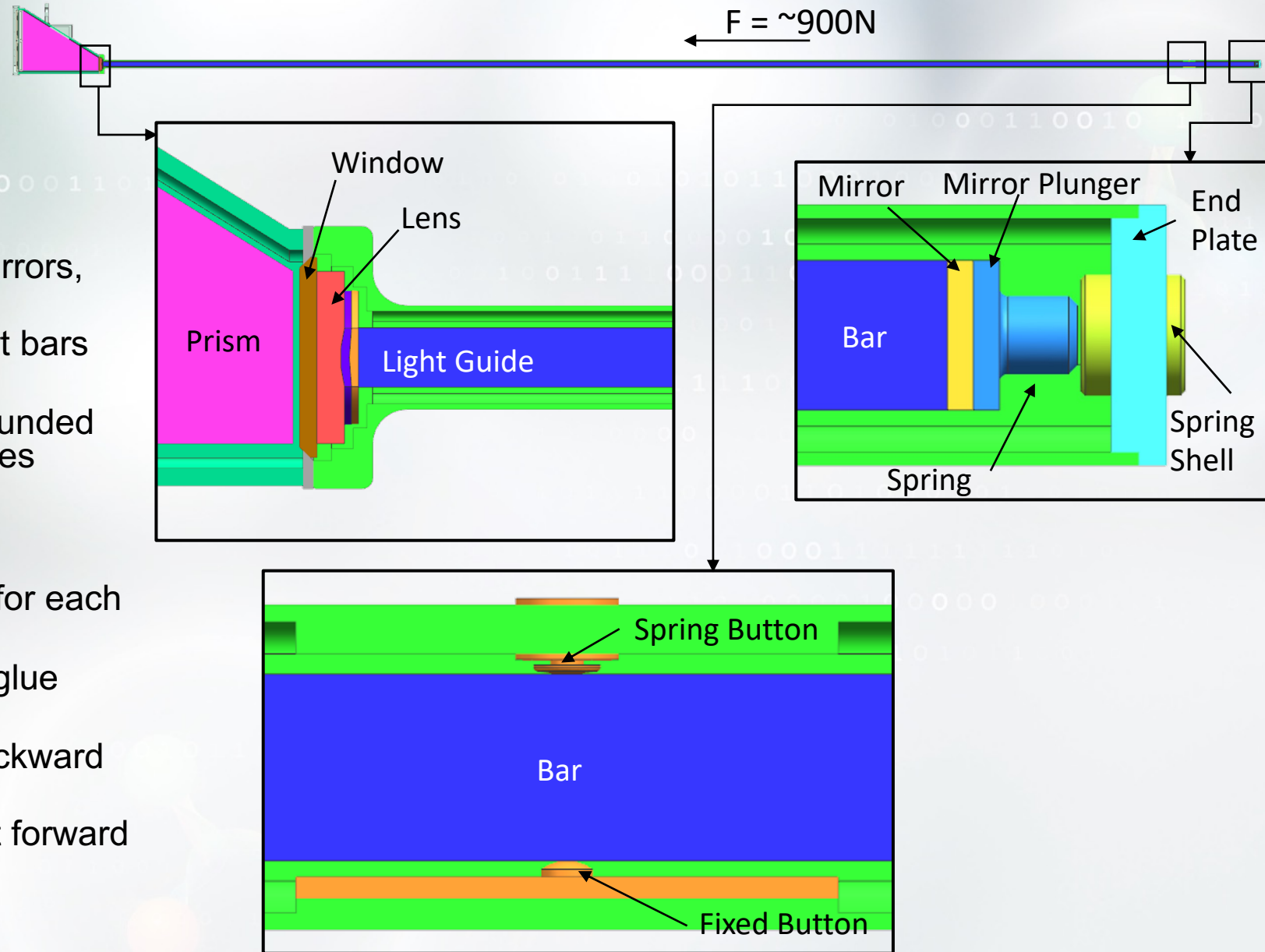Kris Cleveland

Jefferson Lab

U.S. Department of ENERGY
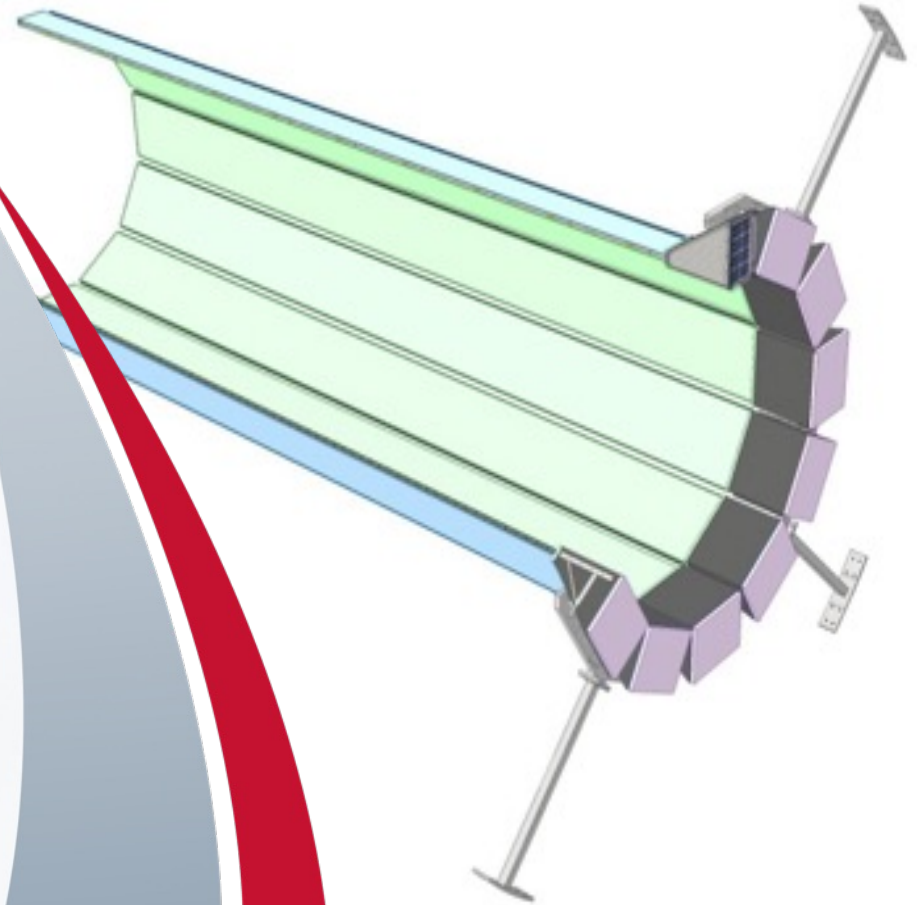
# Contributors

- Kris Cleveland
- Grzegorz Kalicy
- Jochen Schwiening
- Avishay Mizrahi



Bar Box

Support Ring

Prism Box

Forward

Backward

Connection to ePIC Barrel
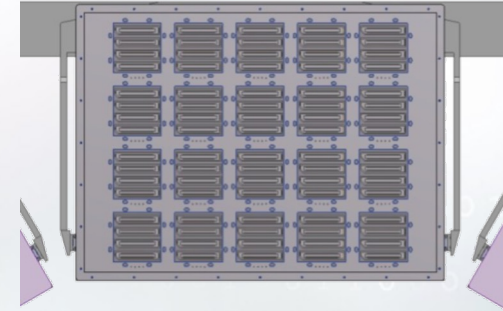
# Bar Box

- CFRP Shell
  - Approximately 4.6m Long
  - Thickness: 1.5 mm – 3 mm
    - more in key locations
- Contains Fused Silica Radiator Bars, Mirrors, and Lenses
  - 10 long bars each formed of 3 short bars and a Light Guide section
    - Radiator bars supported on rounded nylon buttons to minimize losses
- Capped on each end
  - Spring End Plate at Forward End
    - Adjustable spring assemblies for each bar
      - Maintain compression in glue joints
  - Optically transparent window at backward end
    - Counters force from springs at forward end
  - Provides gas tight boundary

F = ~900N

Window

Lens

Prism

Light Guide

Mirror     Mirror Plunger     End Plate

Bar

Spring     Spring Shell
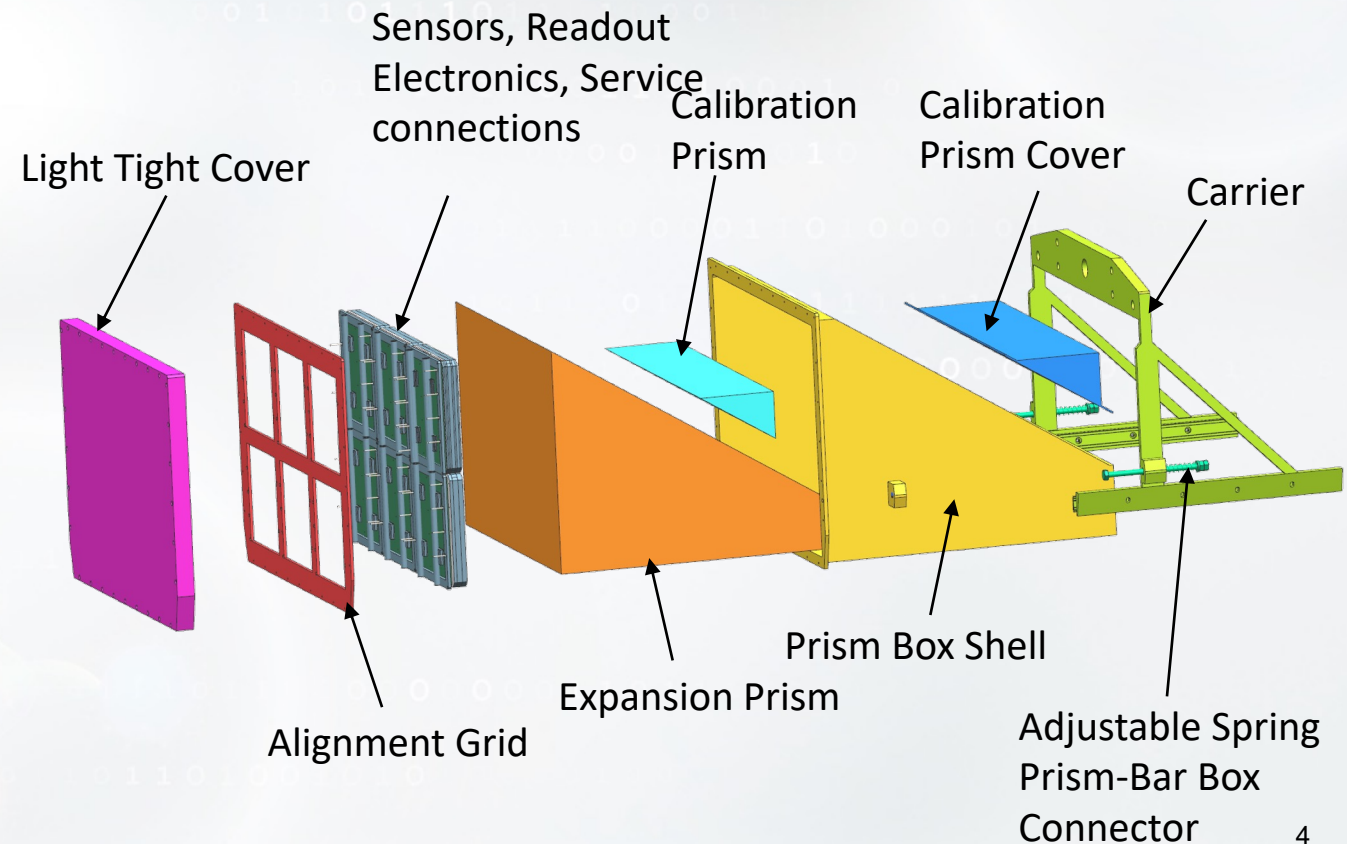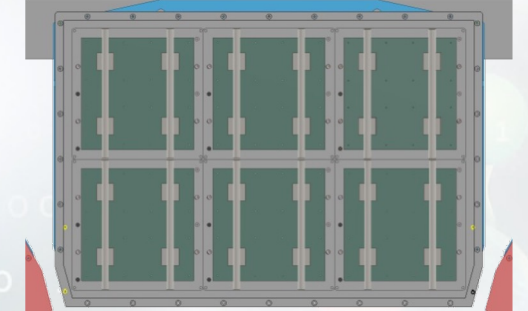
Spring Button

Bar

Fixed Button

# Prism Box

- Box shell
  - Current Material: CFRP
  - Current Thickness: 5 mm

- Contains expansion prism

- Supports sensors, readout electronics, calibration system, and associated services
  - Two sensor options
    - HRPPD
    - MCP-PMT (baseline)
    - Mechanical design solutions for both options

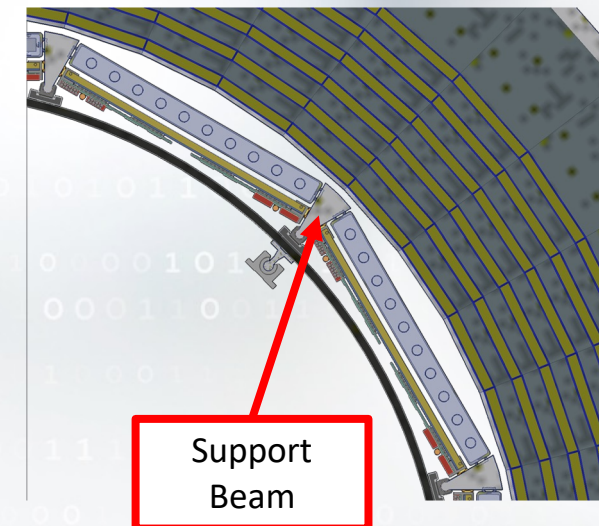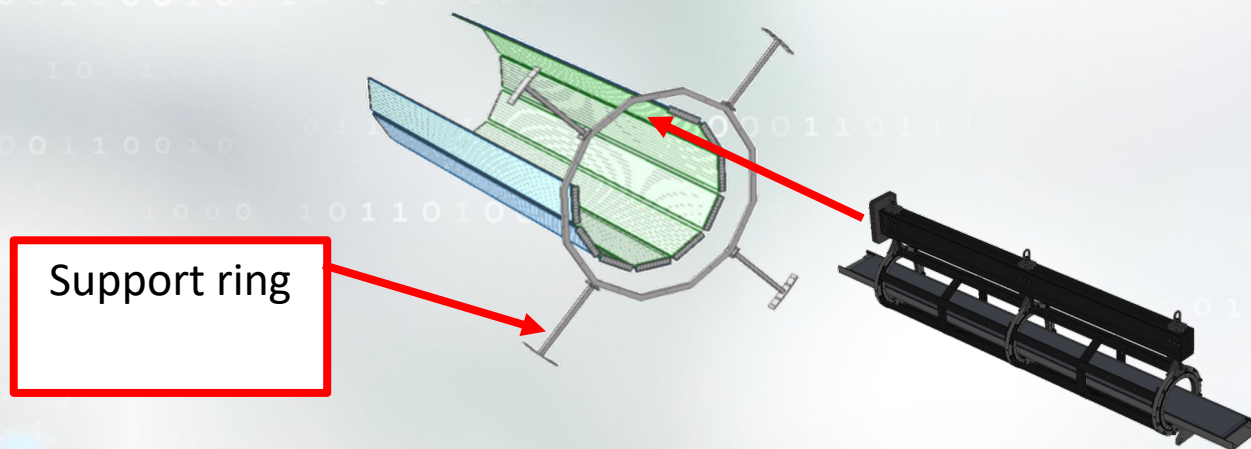- Optical cookie connection between prism and bar box window



MCP-PMT

HRPPD

Light Tight Cover

Sensors, Readout Electronics, Service connections

Calibration Prism

Calibration Prism Cover

Carrier

Alignment Grid

Expansion Prism

Prism Box Shell

Adjustable Spring Prism-Bar Box Connector

# Installation



Support ring



Support Beam

- Bar boxes installed first using existing tooling

- Prism box and carrier attached to support ring

- Prism coupled to bar box window
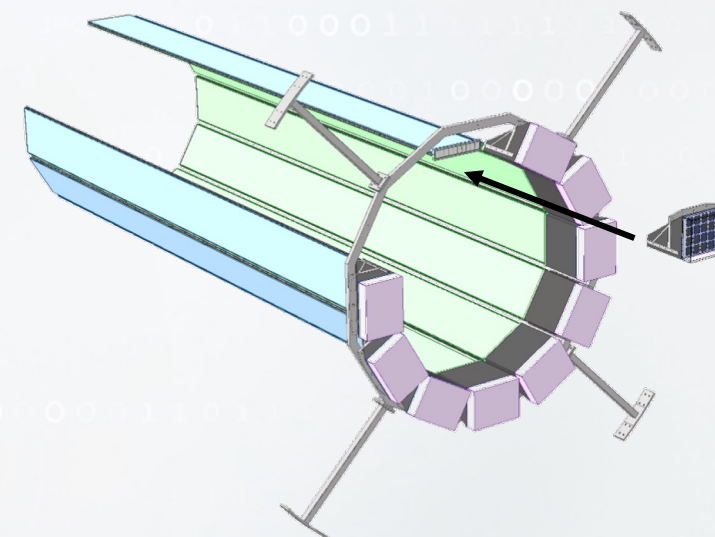
# Installation
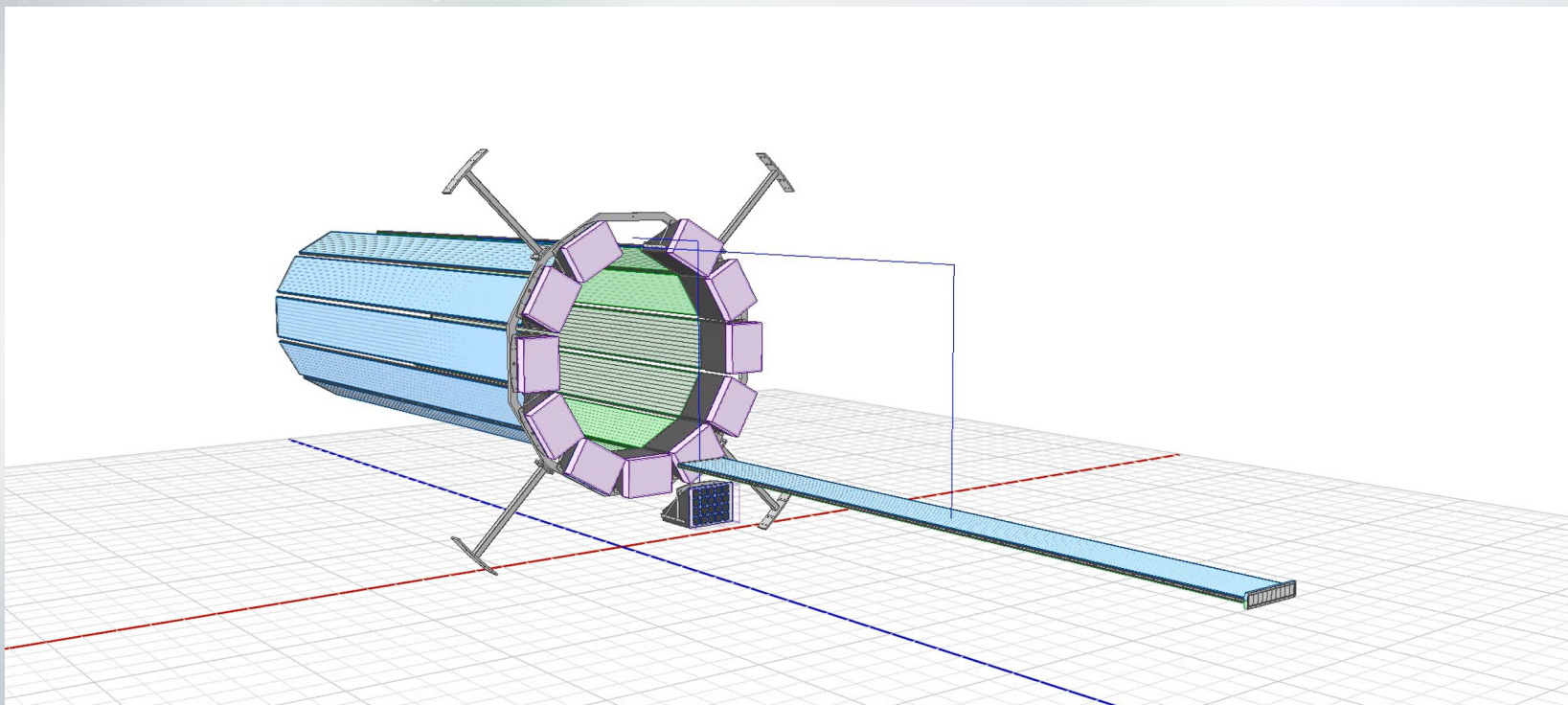
# Recent Updates



- Handover of files and information from Avi

- Geometric shifts requested by integration team
  - 1 cm shift radially outward
  - 3 cm shift backward direction
    - New light guide section shortened
  - Additional space required for alignment and positioning of internal detectors and services
  - Impacts Outer MPGD and hpDIRC

- Window Addition
  - FEA supports 5mm window as sufficient

- Spring system specification

- FEA on bar support buttons

- Bar box button integration
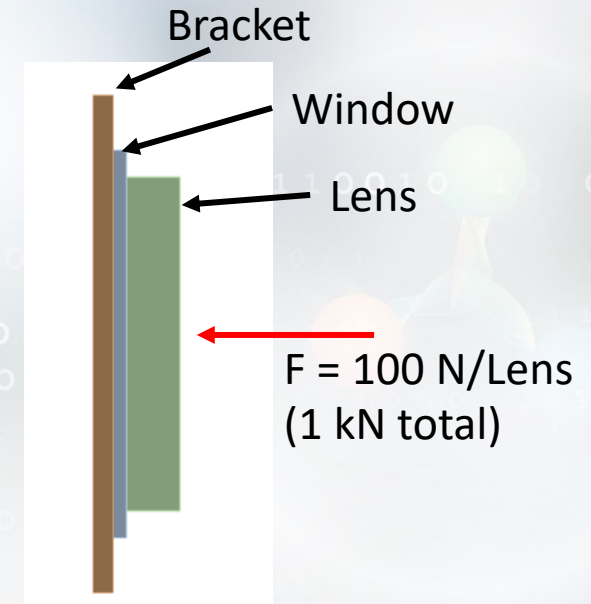
- Prism box to Bar box connection
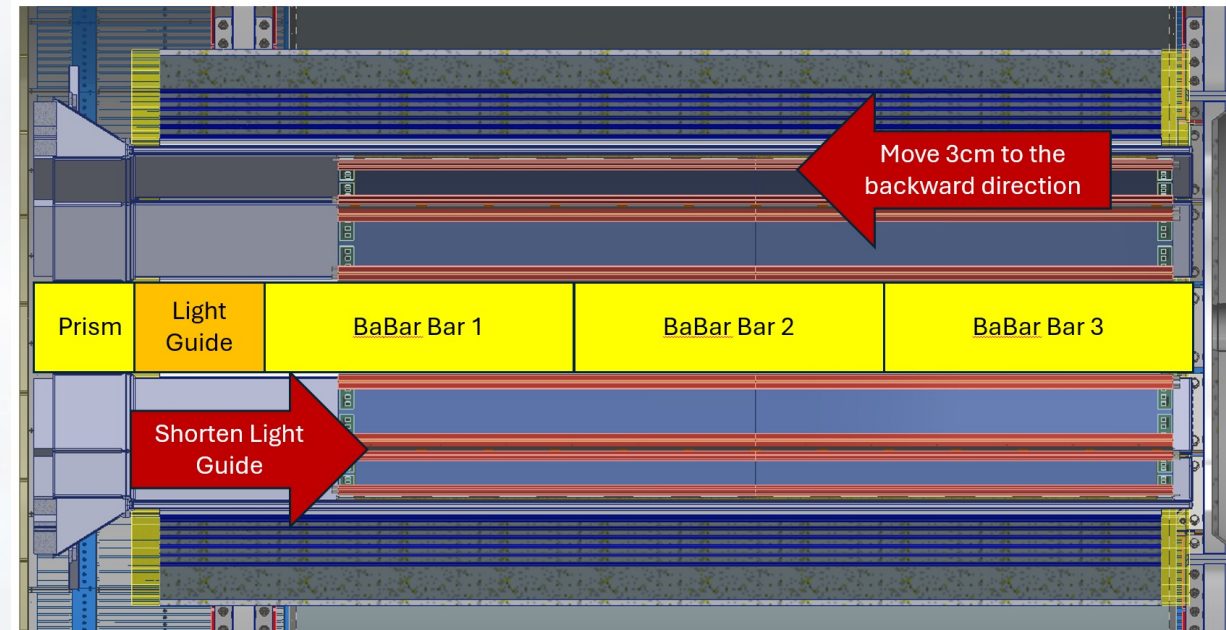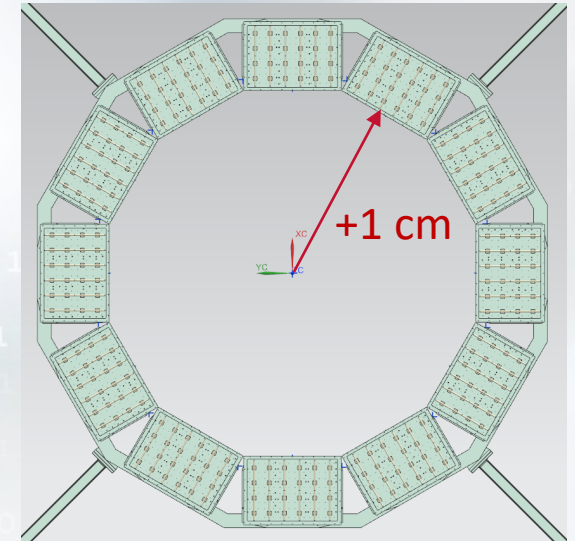
# Window

- Mainly meant to restrain force from springs at forward end

- 5 mm Thick Fused Silica

- Supported by a bracket attached to the bar box flange

- Applied force:
  - 100 N per bar (1 kN total)
  - Slightly greater than anticipated loading

- Peak stresses shown at sharp transitions
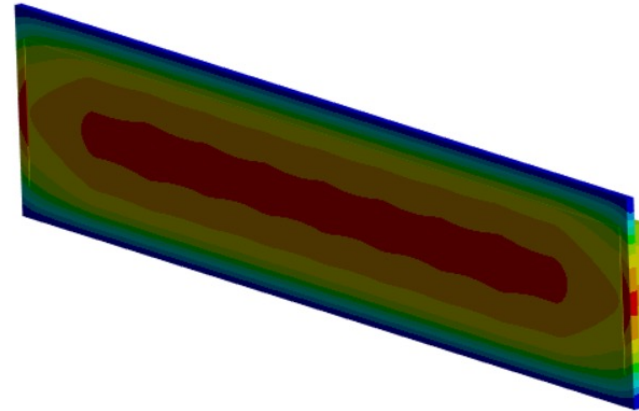  - Potential Mesh singularities
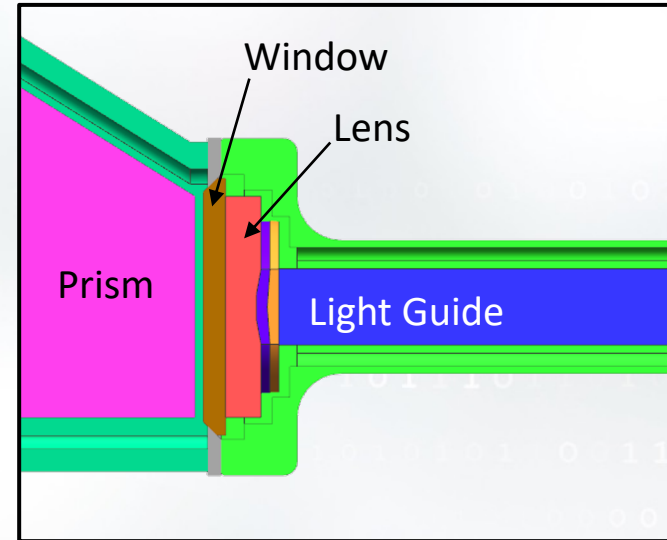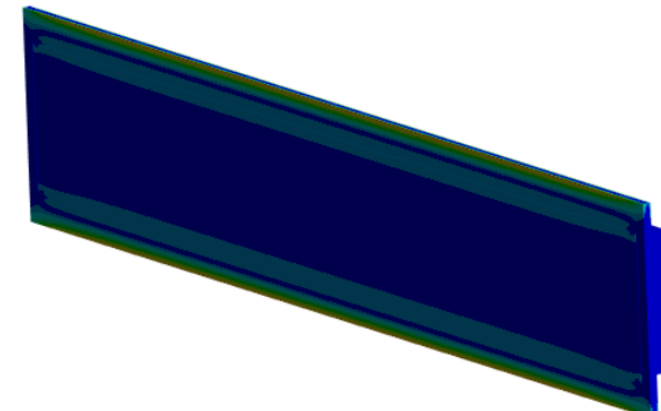


CAD Model



FEA setup

# Support Buttons

- Fixed Reference Buttons paired with adjustable spring buttons
  - Similar design to BaBar

- 4 unique layouts based on position of bar box in detector
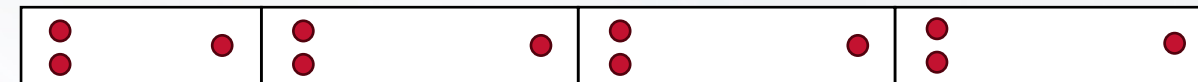  - Swap reference and spring button locations based on gravity relative to each bar box

- Buttons at Airy points of each short bar
  - Where the ends of each short bar would be vertical under gravity alone

- Nylon
  - Prevents damage to bar surface

- Rounded faces
  - Limit surface area in contact with bar face

Spring Buttons
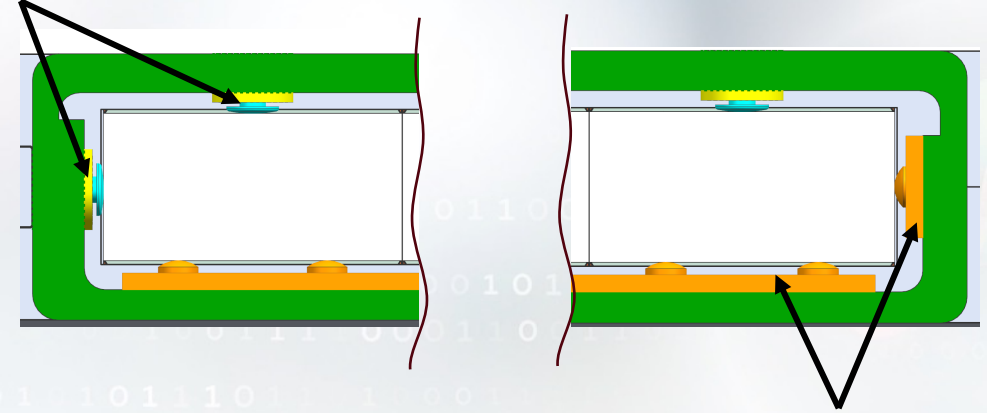
Fixed Reference Buttons

Fixed Button Layout

# Prism Box – Bar Box Connection

- Adjustable spring assembly
  - Provides force to compress optical cookie between prism and bar box window
  - Both sides of each prism box
  - Maintains some force with expansion and contraction

- Removes rigid physical connection between bar box and prism box

- Requires some reworking of flange between the prism box and bar box
  - Provide light tightness
  - Provide gas tightness for prism box
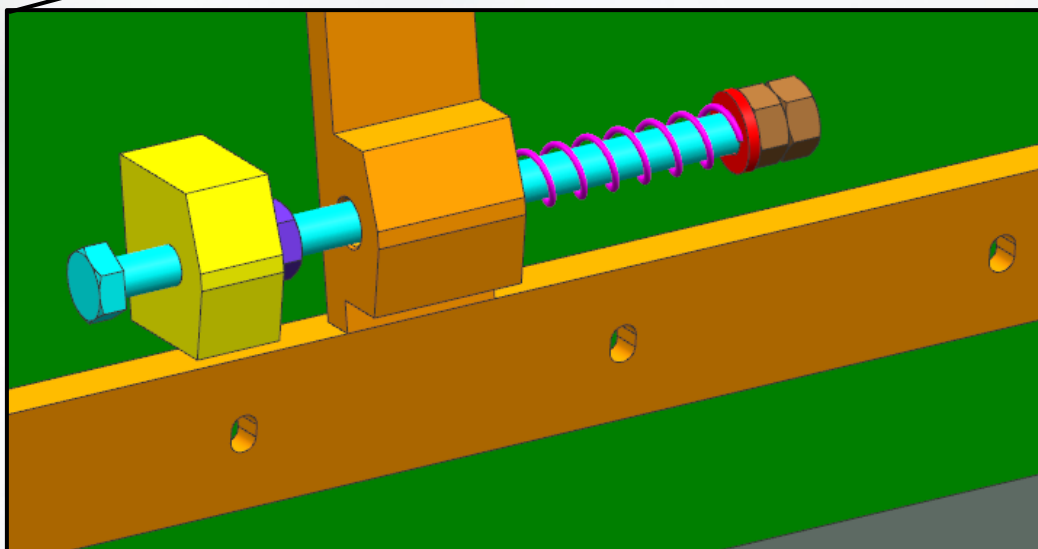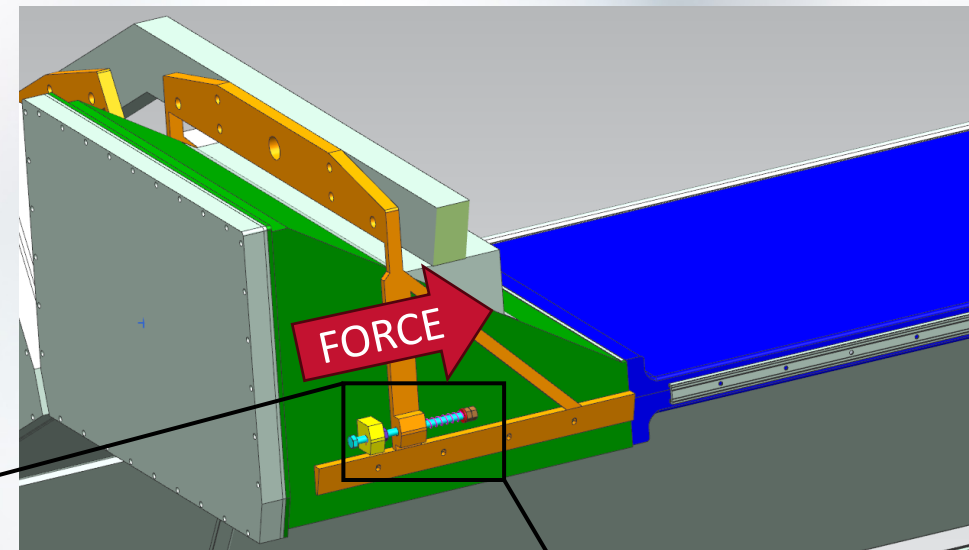
# Outlook

- Continuing detailed design and analysis
- Working in conjunction with project leadership and integration teams
- Next Steps
  - Support Ring Rework and Analysis
  - Bar Box Analysis
  - Nitrogen distribution system
  - Cooling
  - Calibration system
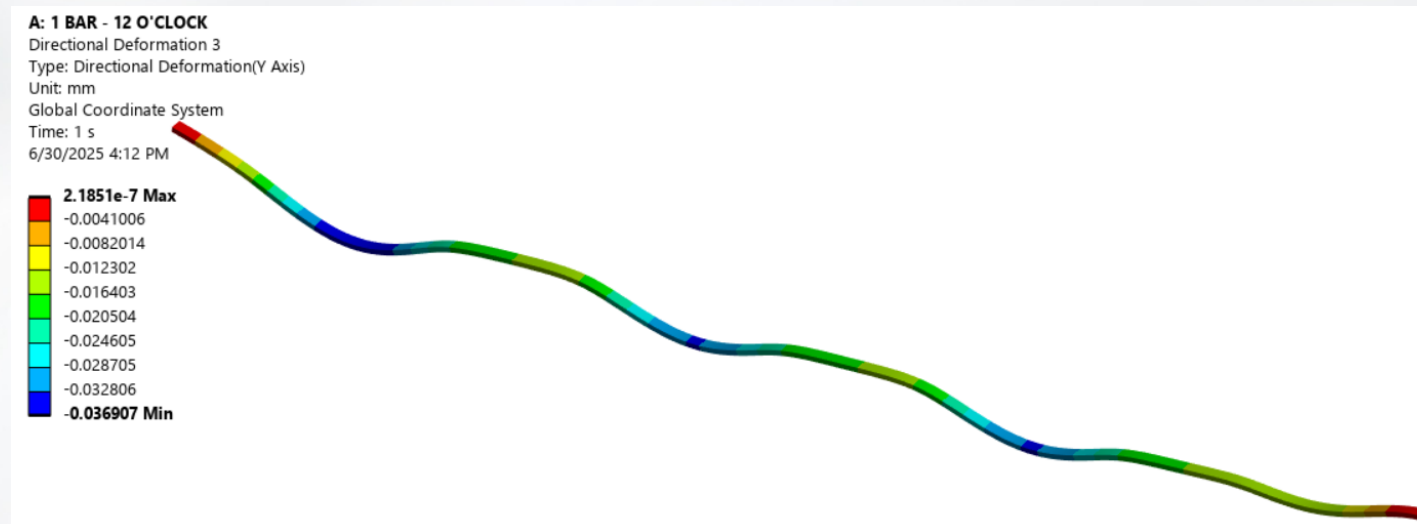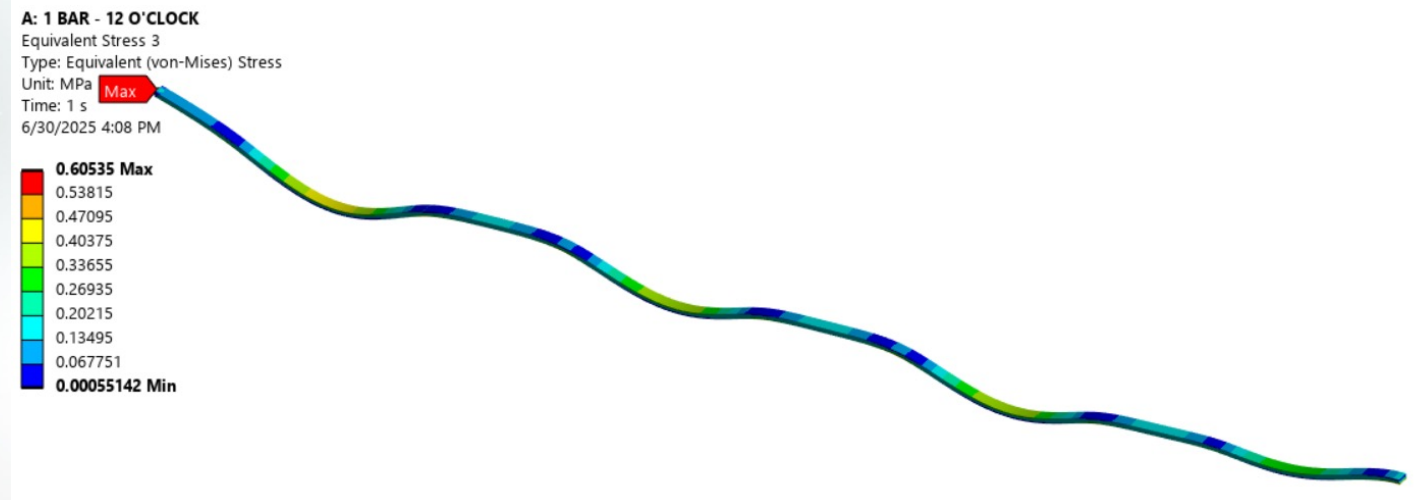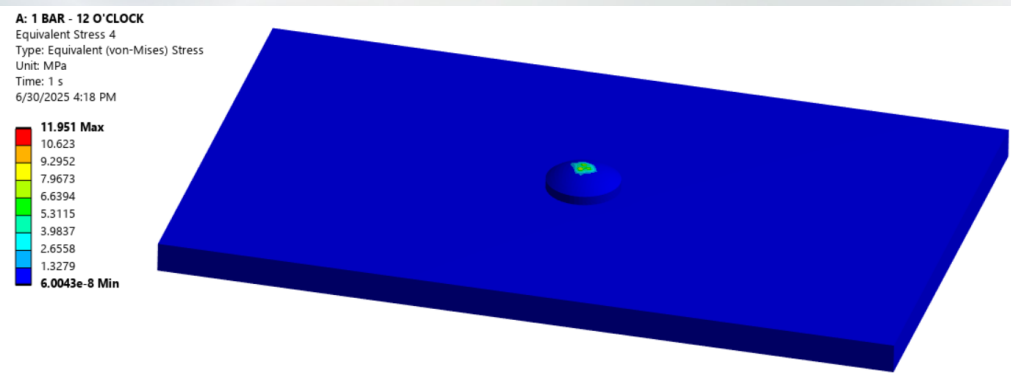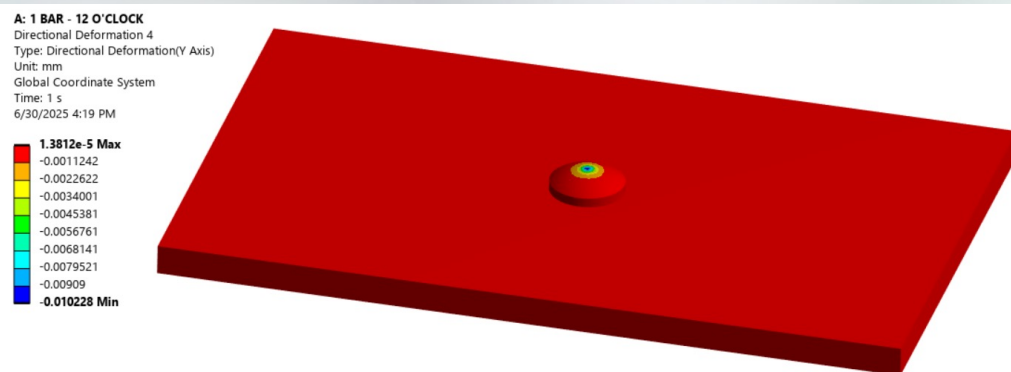  - Further develop installation processes
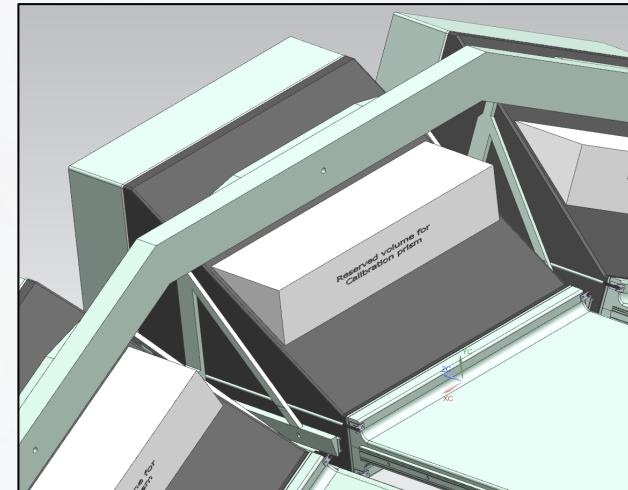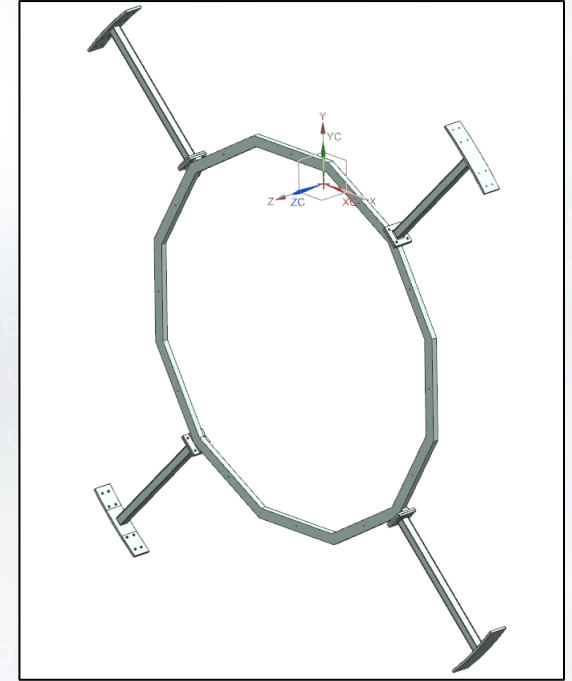
# QUESTIONS?

# Backup – Bar/Button FEA

Bar Box at 12 o'clock position
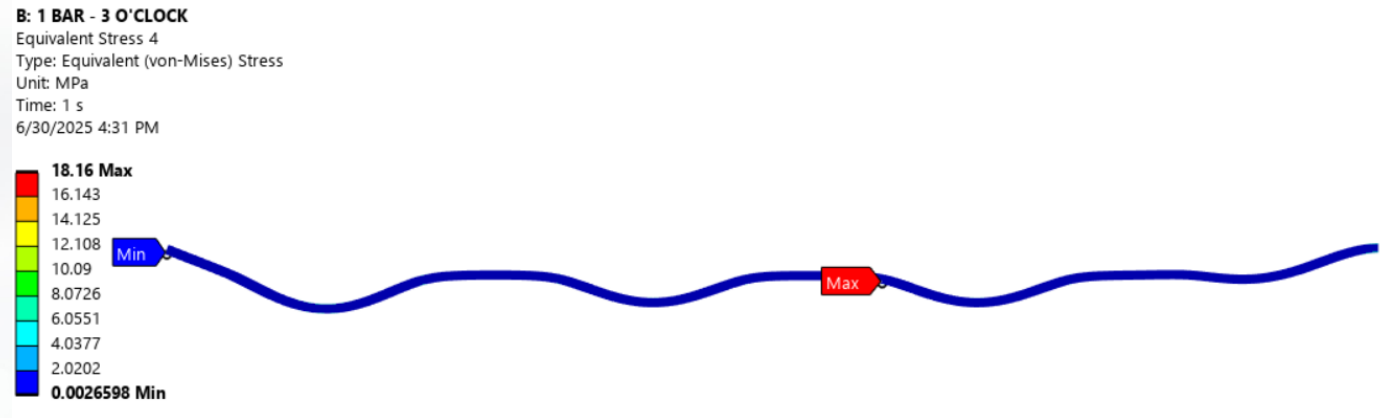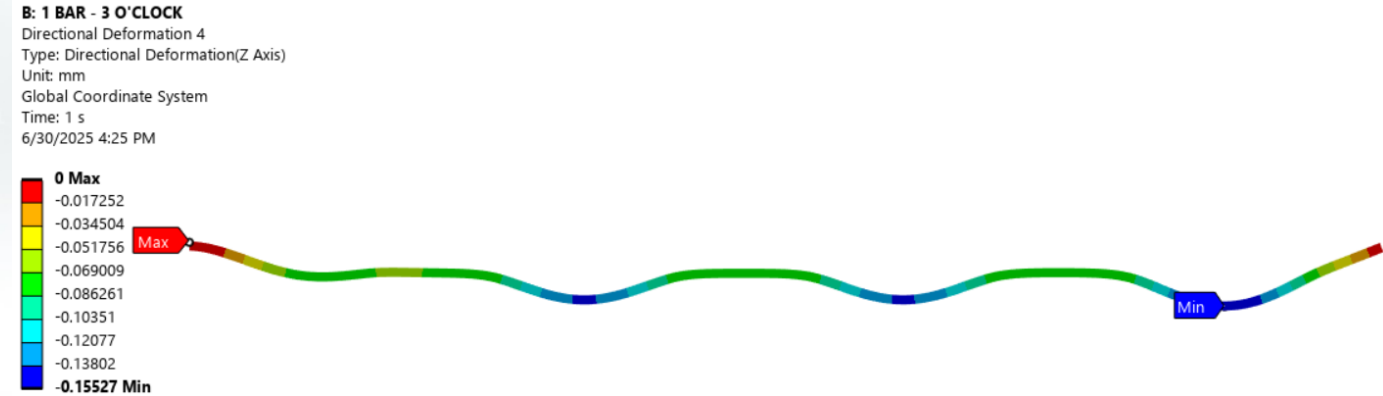Bar Deflection graphically scaled up to show profile

# Backup – Bar/Button FEA

Bar Box at 3 o'clock position
Bar Deflection graphically scaled up to show profile
Needs rework for current dimensions
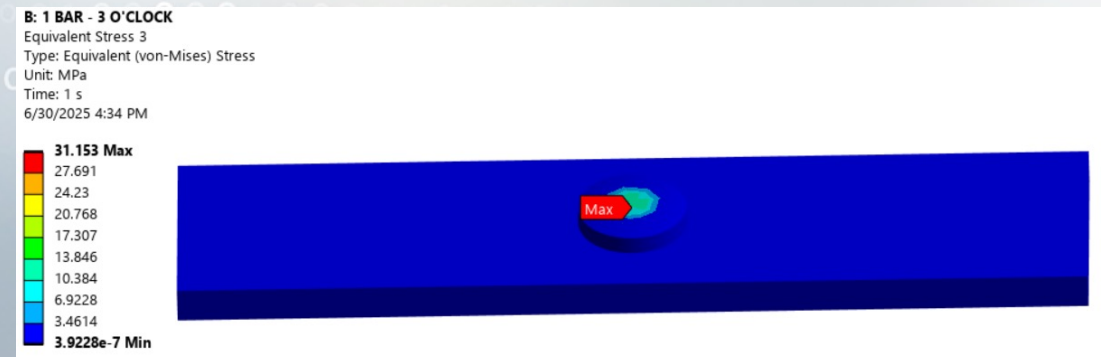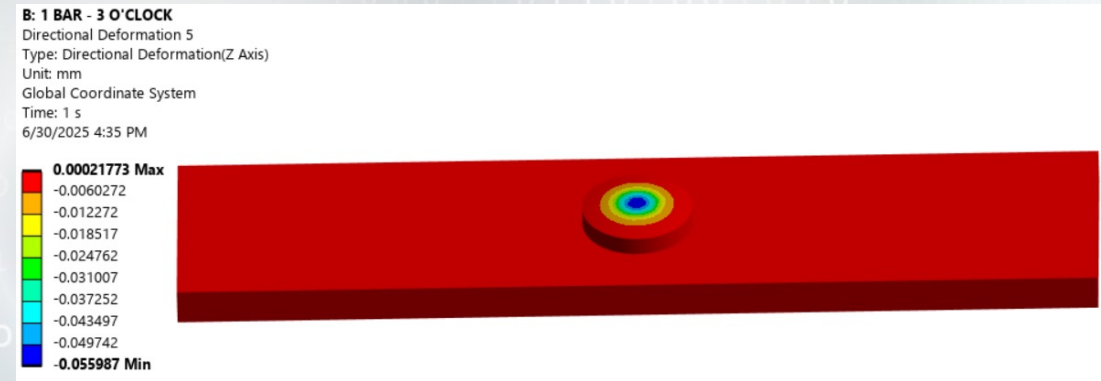
# Prism Box

- Sensor Options (HRPPD, MCP-PMT(baseline))
  - Grid
  - Readout Electronics
  - Light Tight Cover
  - Cooling**
    - To do: Following pfRICH progress
      - Contact
  - Cabling

- Prism support and alignment scheme
  - Inside the cover
    - Need to look into. Concepts in progress.

- Calibration System
  - Prism
    - Conceptual model
  - Laser
  - Cameras

- Connection to Bar Box
  - Concept in place. Other solutions being considered.

- Gas System

# Bar Box

- Window**
  - Mechanical Baseline at the moment
  - Bracket
  - Seals
  - Lens interface
    - Glue vs Cookie. To be verified experimentally. Working in partnership with GSI
- Button Design for Bar support**
  - Design progressing. Influenced by BaBar designs. FEA in progress
- Z-axis spring loading**
  - Design in progress. FEA in progress. Damping analysis to come.
- Gas System
  - Conceptual understanding
- Box Shell FEA
  - Preliminary analysis complete. Need to revisit.
- Thermal Expansion
  - Need to define temperature range. Storage considerations.
- Bar Length
  - Waiting on dRICH coverage simulation results
- Assembly
  - At JLAB then transported to BNL

# Support System

- Support ring**
    - Legs
        - Preliminary design and analysis
    - Interface with external structures
        - Connection to HCAL

- Prism Box Carrier
    - Alignment mechanism

- Rail System

# Installation

- Process

- Tooling for bar boxes**
  - Repurposed from sPHENIX
  - BaBar installation tooling

- Tooling for Prism installation**

# Alignment

- Bar Boxes
  - Datum for positioning
  - Hard stop
    - Slid in and captures
    - Reliably position
- Prism
  - Maybe be detached. Need reliable positioning
- Rails
  - Survey

# Services

- Nitrogen
- Liquid cooling
- Fibers for laser system
- HV cables
- LV cables
- Camera fibers