Design Work with Purdue

Alex Eslinger (Jlab)

3-10-25

Design Discussions

By priority:

1. Sensor Plane Design
2. Aerogel Plane Design
3. Mirror Design

These Slides

4. Installation and Assembly
5. Services
6. Cooling
7. Grounding, etc.

Slides Forthcoming

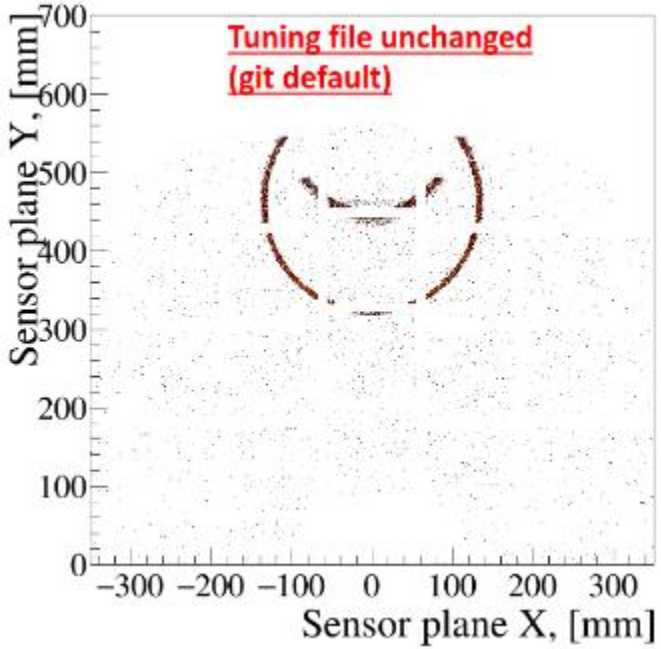
Sensor Plane Topics:
Pyramid Mirrors

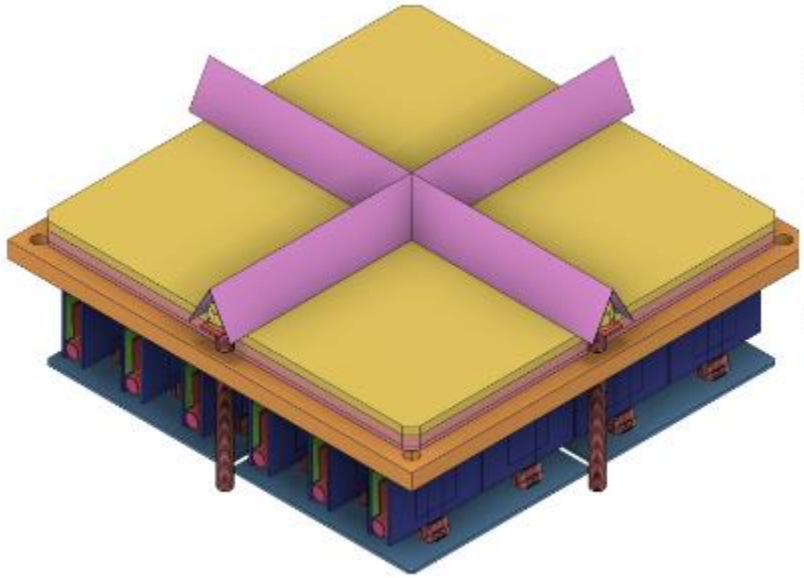
Background:

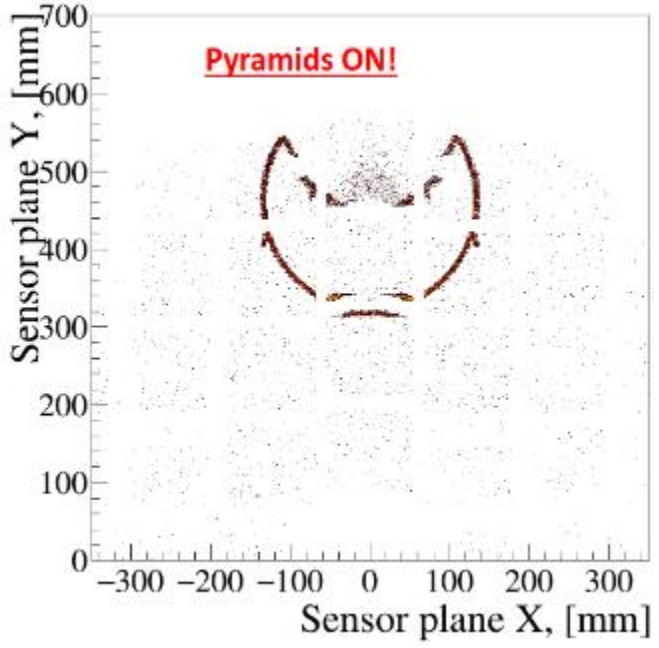
The pyramid mounting scheme has only been discussed briefly in the past. When the project added an extra disk just ahead of us in ePIC, we lost 5cm in expansion volume. This motivated pfRICH to consider the pyramid mirrors as a baseline instead of an optional way to add additional efficiency to the detector.

Prior discussions have focused heavily on how to coat the mirrors and how to subdivide the parts of the mirror to coat them as individual flat pieces.

The design constraint for the mirrors (after talking to Alexander) is that the flatness of the mirror is more important than the overall position, since we can tune for slight/minor misalignments with software.

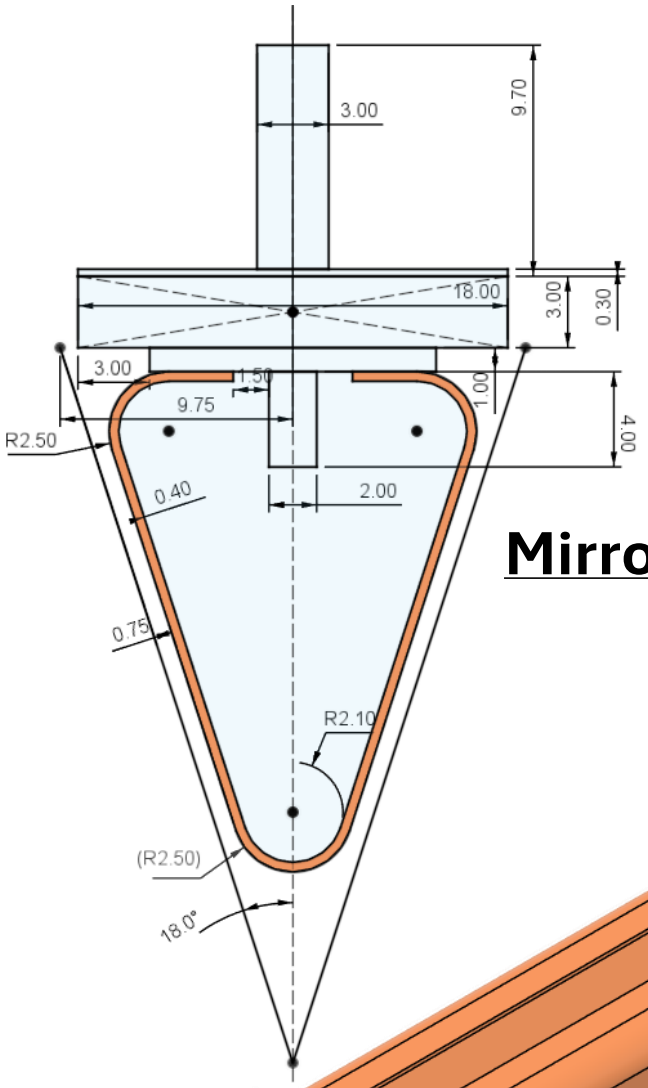




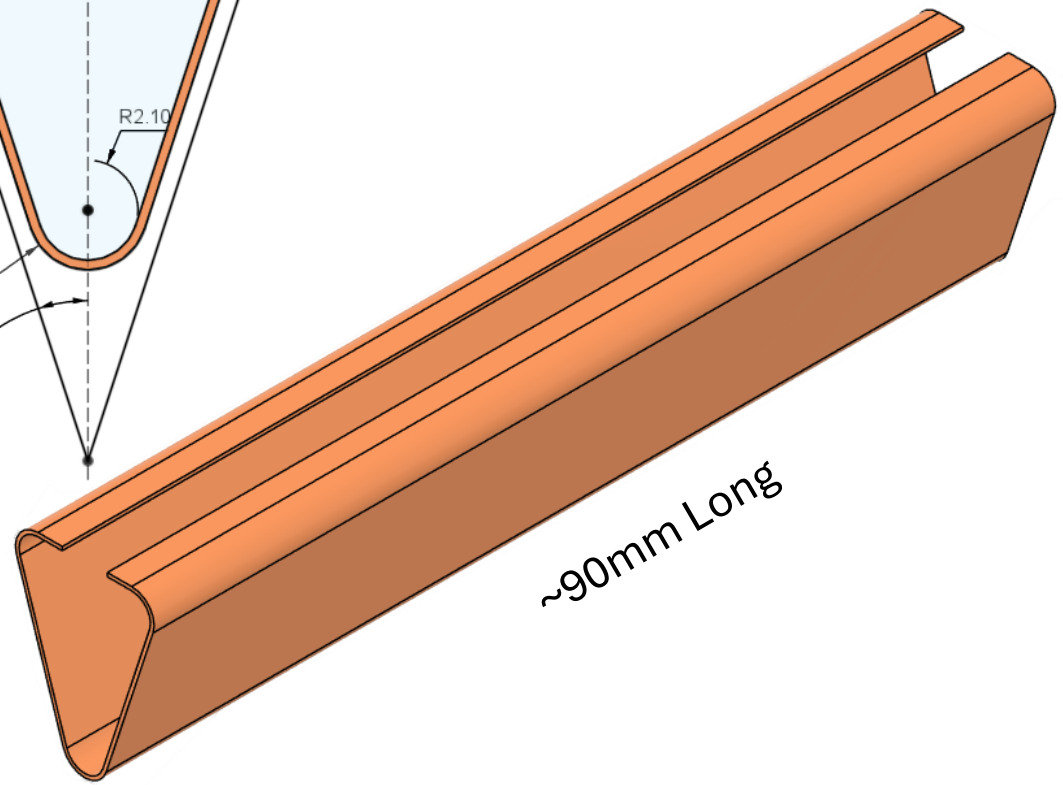


Pulled from Alexander's slide for PID review (July 5-6th, 2023)

Sensor Plane Topics: Pyramid Mirrors (Cont'd)



Mirror Support Fixture



Mirror Support Fixture

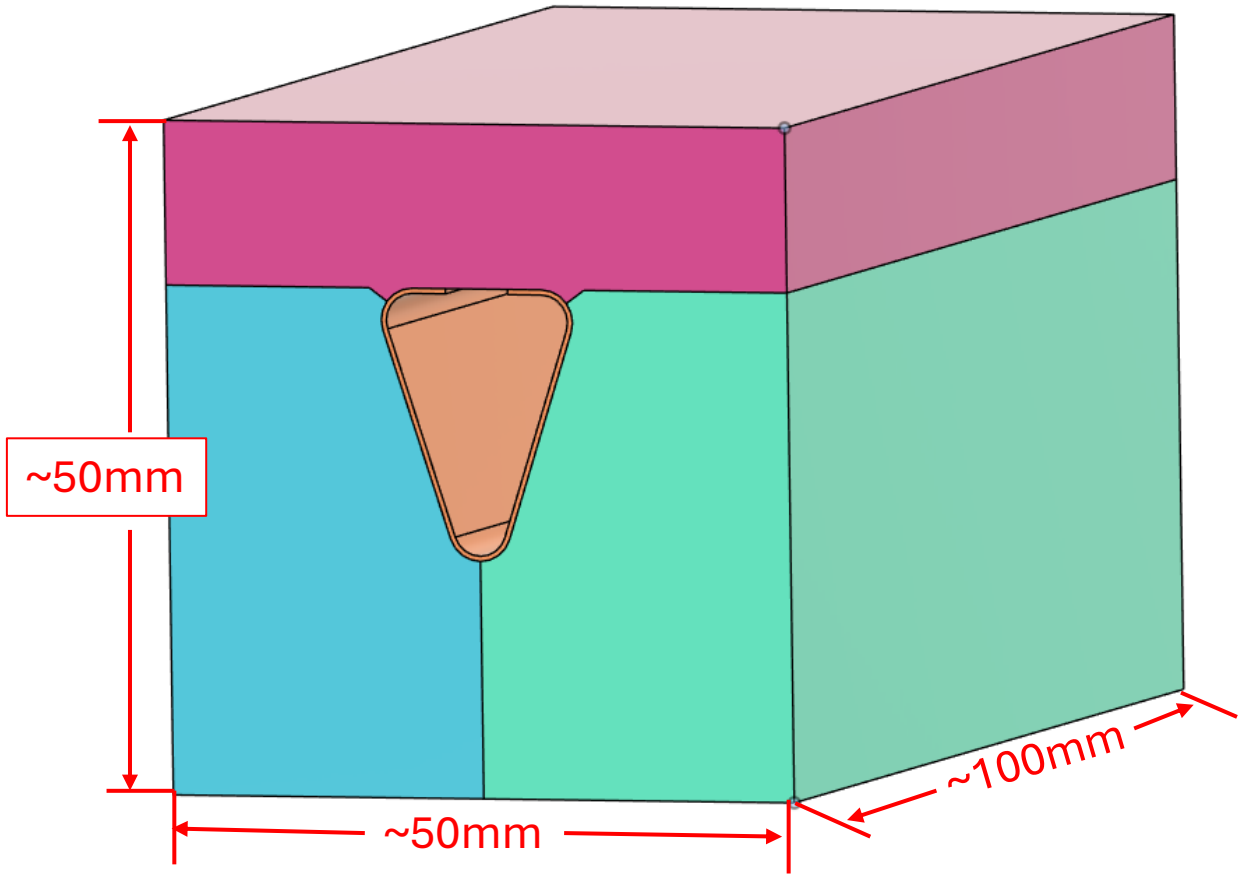
Design Concept Advantages:

- Very thin carbon fiber (~0.4mm / ~3-4 plies)
- Prioritizes flatness
- Relatively simple to manufacture
- Modular
- Allows Mirrors to be manufactured and coated flat

Concerns:

- Flexible (to be addressed)
- How to accurately index? (to be addressed)

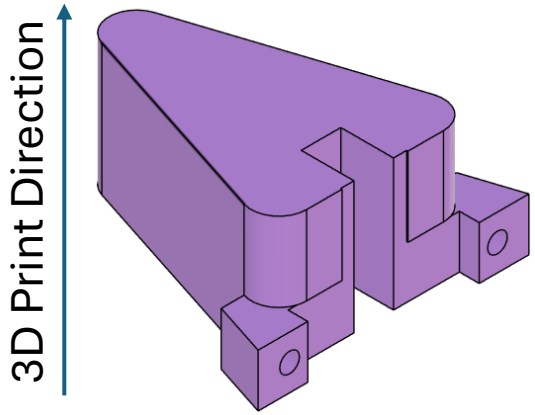
Sensor Plane Topics:
Pvramid Mirrors (Cont'd)

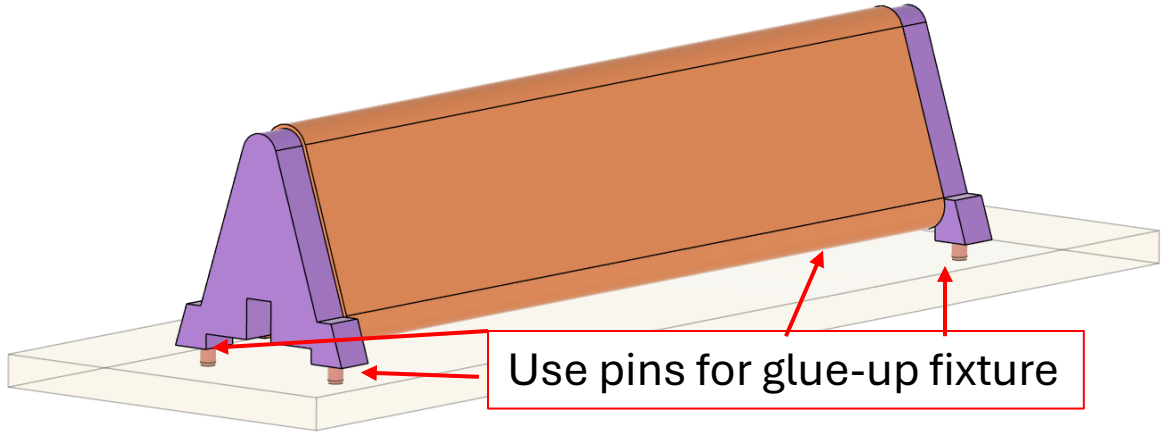


Possible Carbon Fiber Mold Configuration:

- 3-Pieces
- Could be wire EDM'd in one operation
- Joint is at non-critical location (flashing)
- Minimal post-processing
- Vacuum bagged from the inside out
- Allows for flatness to be controlled by the mold

Sensor Plane Topics: Pyramid Mirrors (Cont'd)



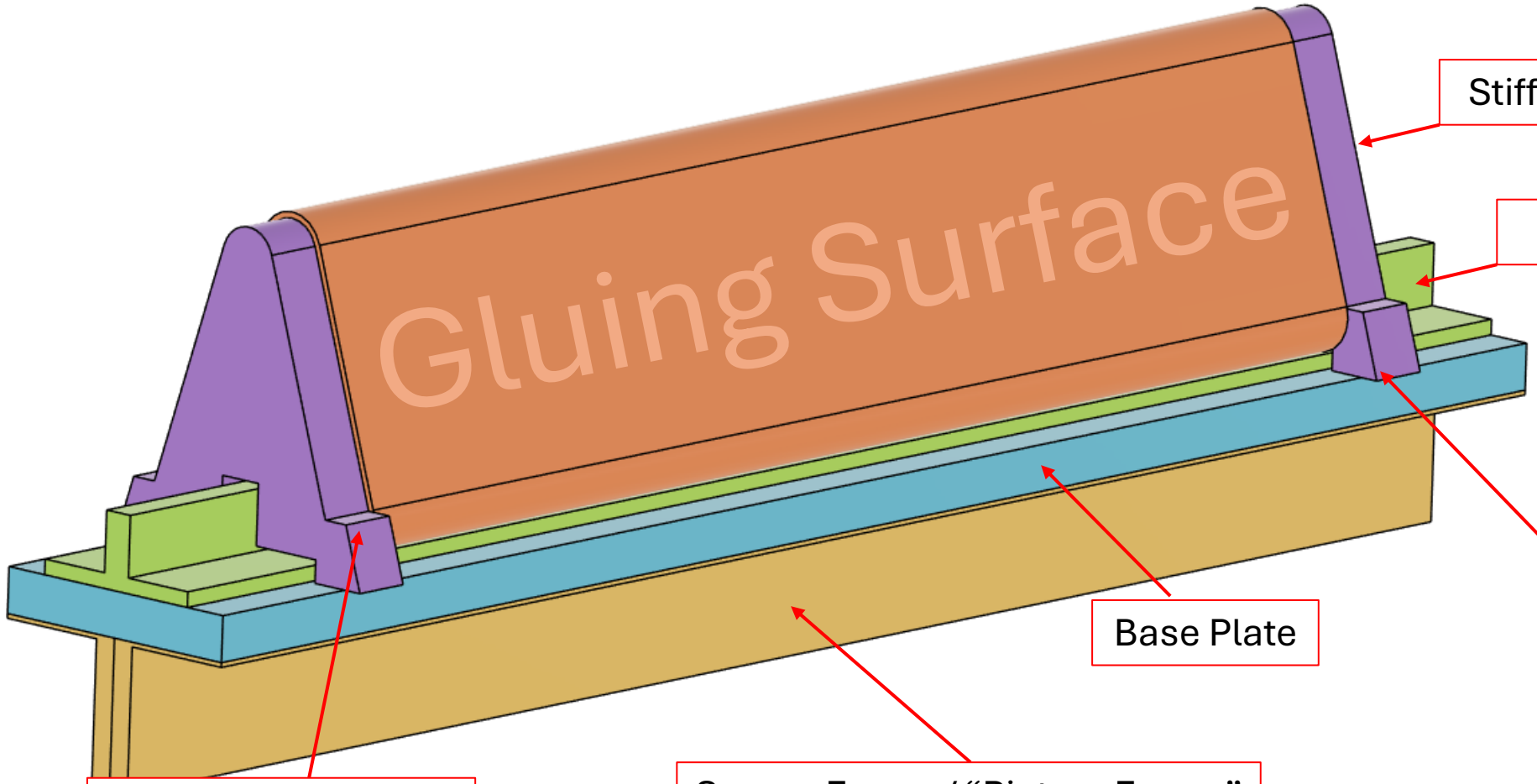


Stiffening and Fixturing:

- Fixtures and stiffens the mirror support
- Pins only to CNC machined base plate; floats over stiffening beam
- 3D-Printed fixturing requires no overhangs
- Can be epoxied into place after manufacturing of the support (basic glue-up fixture shown above)
- Modular design, two pins for entire assembly, 4 pins used for glue-up

Sensor Plane Topics: Pyramid Mirrors (Cont'd)

Implementation:
Once each mirror support module is built, it is pinned and glued into the sensor plane



Stiffeners/Fixturing

T-Beam

Pinning Locations (Base plate to Stiffeners)

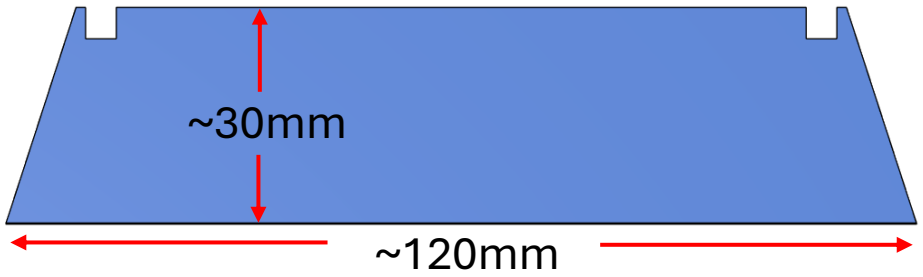
Base Plate

Sensor Frame / "Picture Frame"

Mirror Indexing Tabs

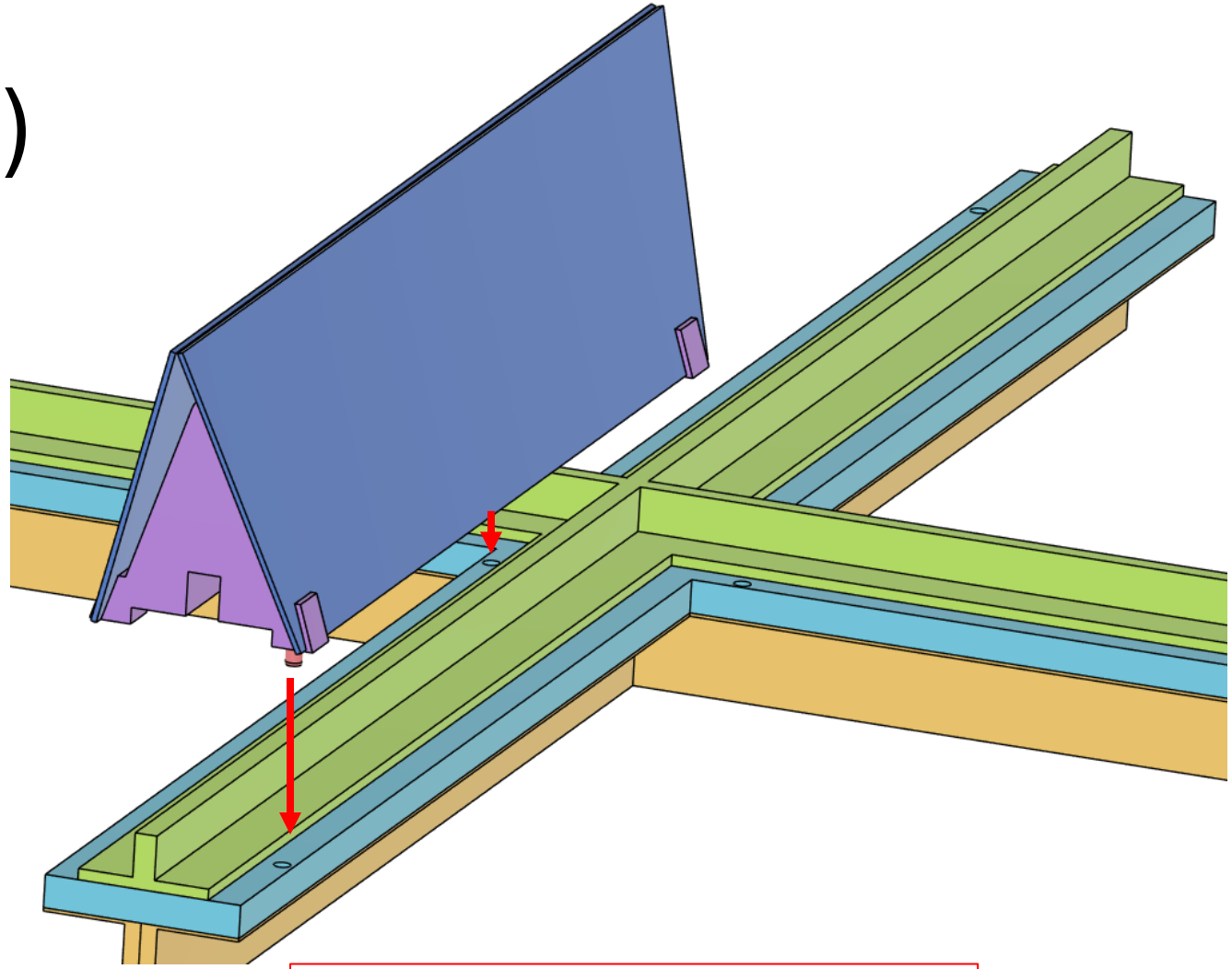
TO I.P. / Aerogel Plane

Sensor Plane Topics: Pyramid Mirrors (Cont'd)



Mirror Pattern

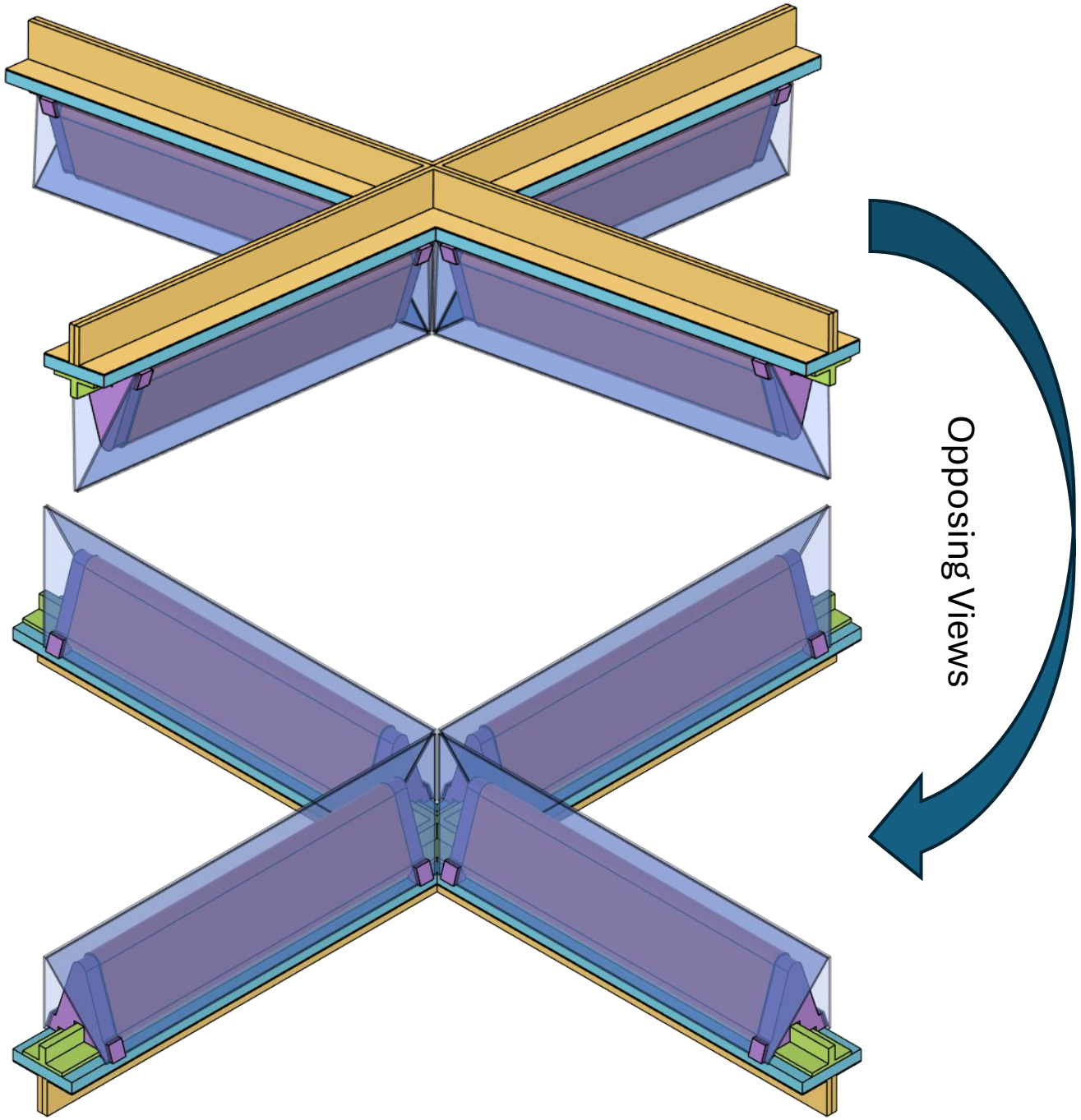
- Slots for glue-up fixturing
  - These may need to be moved inboard depending on cutting capabilities
- Most mirrors will have this same approximate dimension
- Can be manufactured and coated flat (much like we already do)



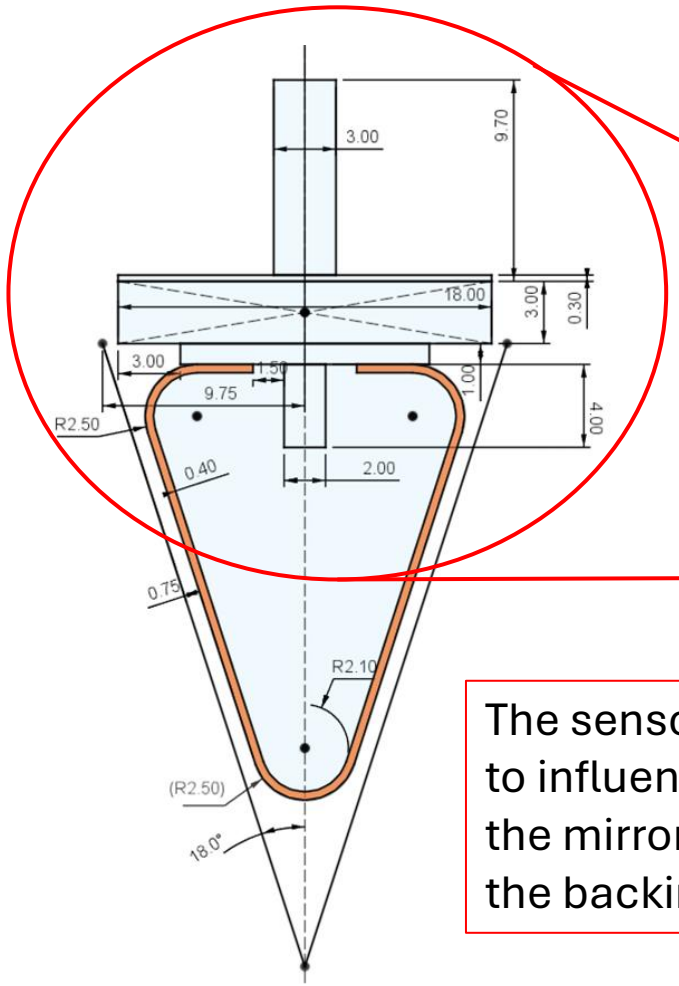
Placing a Pyramid Mirror "Module"

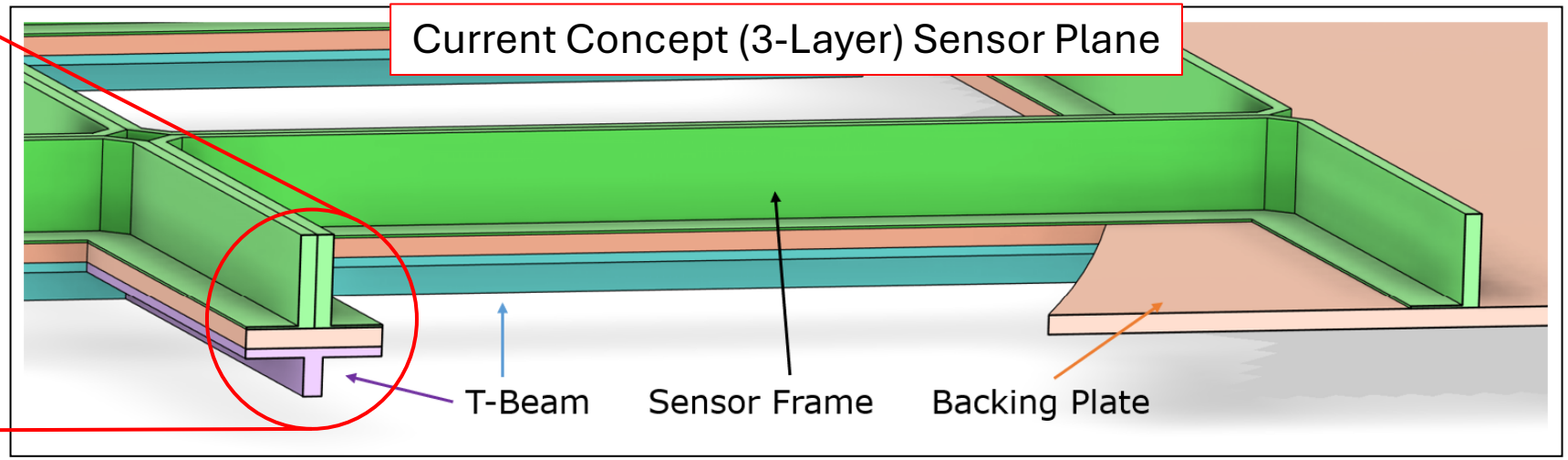
Sensor Plane Topics: Pyramid Mirrors (Cont'd)

- On the right we can see four mirror modules in place at a rough approximation of a crossing point of the sensor plane.
- The HRPPDs sit in the yellow "picture frames" and the "mirror modules" are placed on the other side (mirrors are shown opaque).
- The base plate aligns the stiffeners, the stiffeners align the mirrors, therefore we should achieve tight tolerances
- However, we should still add some amount of tolerance to the mirrors to account for variability



Sensor Plane Topics:
Adjustments for Pyramid Mirrors



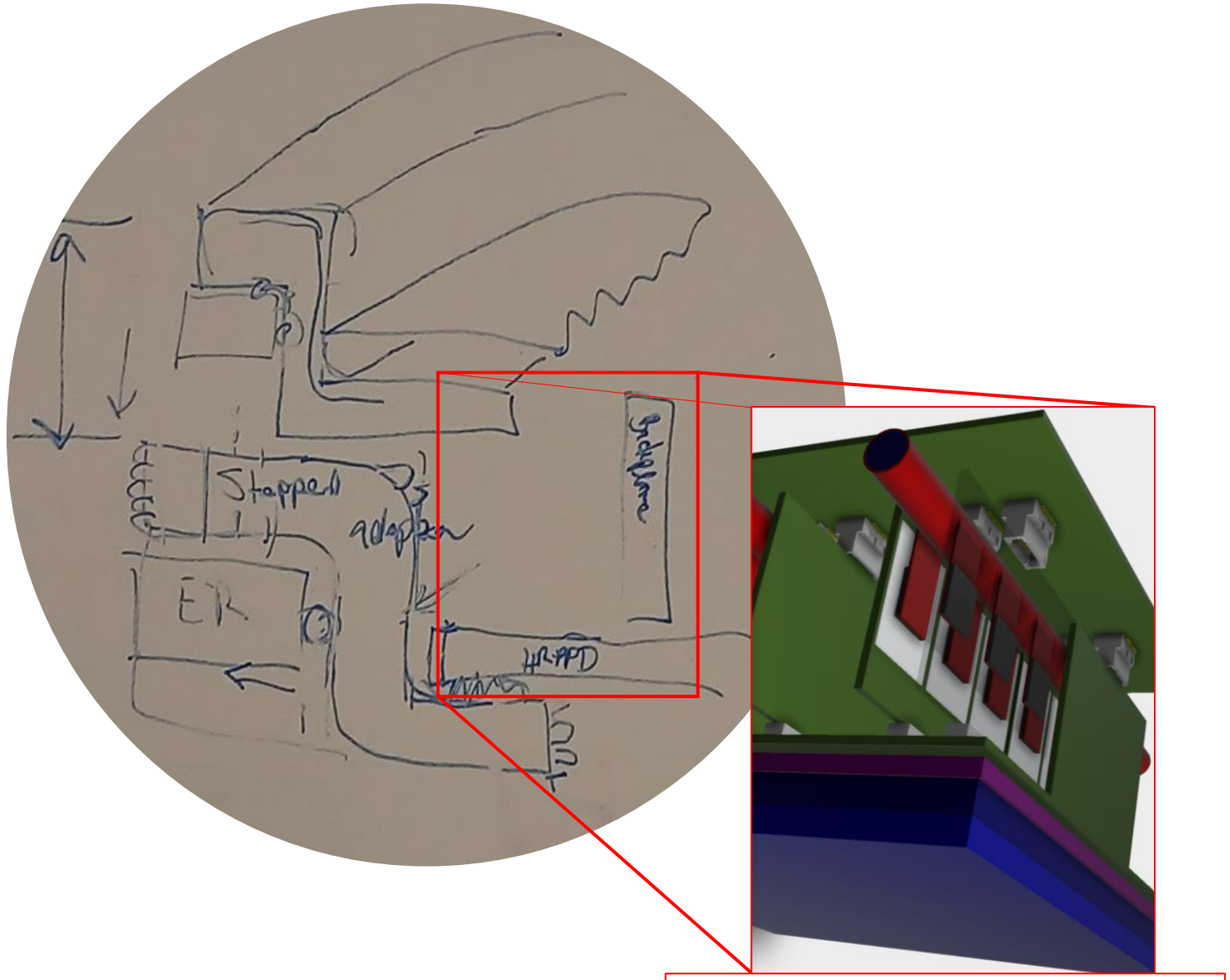


The sensor plane needed to be slightly modified. We didn't want the glued-on t-beams to influence the alignment of the mirrors, so they were adjusted inwards to account for the mirror module. This also allowed for the ~1.5 x ~3 mm dowel pins to be included in the backing plate (which will be cut in once piece on a CNC machine)

Sensor Plane Topics:
Vertical ASIC/Readout

Below is for conceptual purposes only. The ASIC decision is still unknown; therefore, the layout, configuration, and size of the readout is not defined. The purpose of this slide is only for documentation, as we may need to come back and consider this option when we have a better understanding of the way ahead.

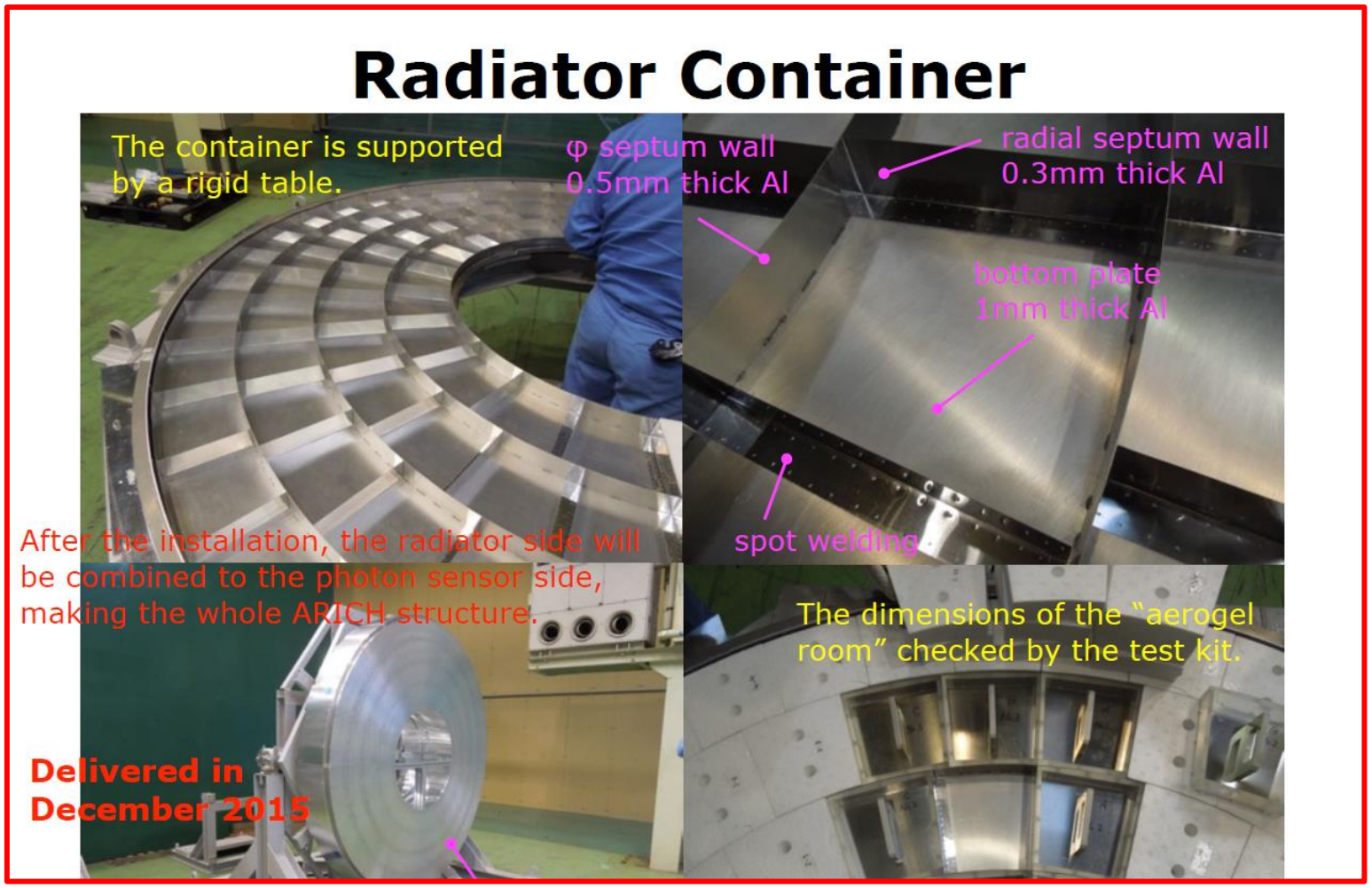
- Since the ASIC decision is still forthcoming, we may need to consider ways to move the sensor plane into the expansion volume.
- The ASICS/VTRx+ Boards/Backplane may need to be placed vertically, like shown in 2023 (picture on the right)
- Conceptually, we can make a ‘z’-shaped adapter where the height of the middle of the ‘z’ would dictate how far into the expansion volume the sensor plane would be placed.
- **Advantages:** We may be able to use a radial seal for the o-ring which would drastically reduce the number of bolts needed on the end ring. This adapter could be 3D printed and post-machined and bonded to the sensor plane.
- **Concerns to be addressed:** Can we still fit all 68 HRPPDs with this design methodology and current tiling scheme?



Vertical Backplane Concept Circa 2023

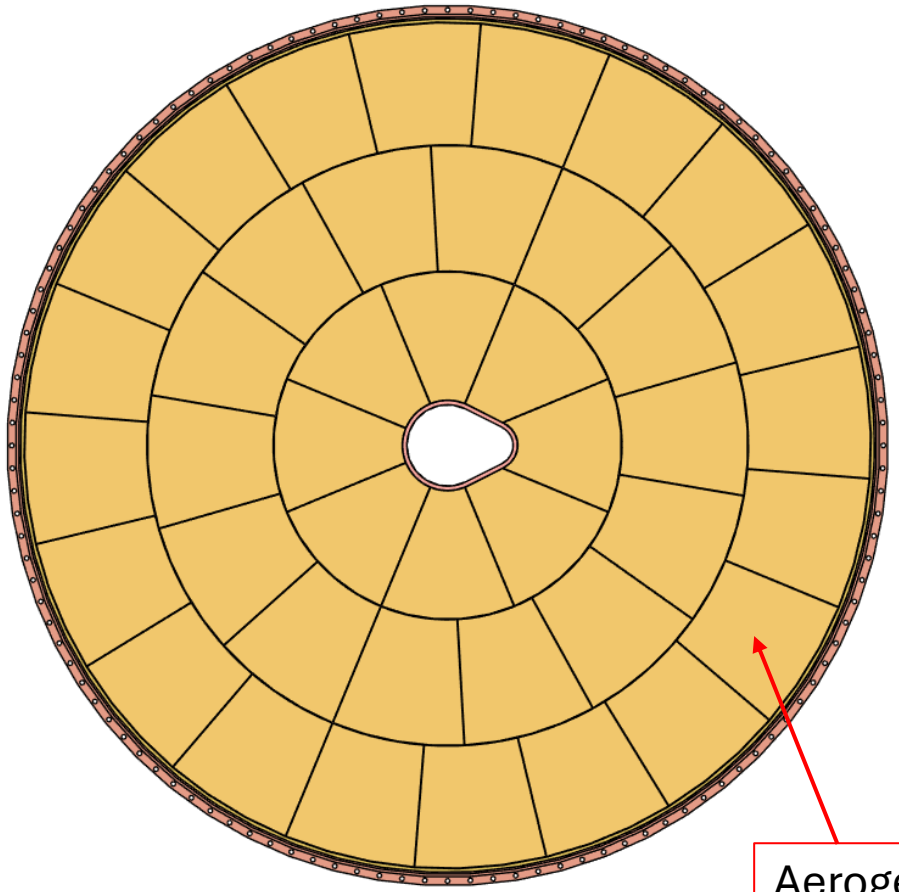
Aerogel Plane: Background

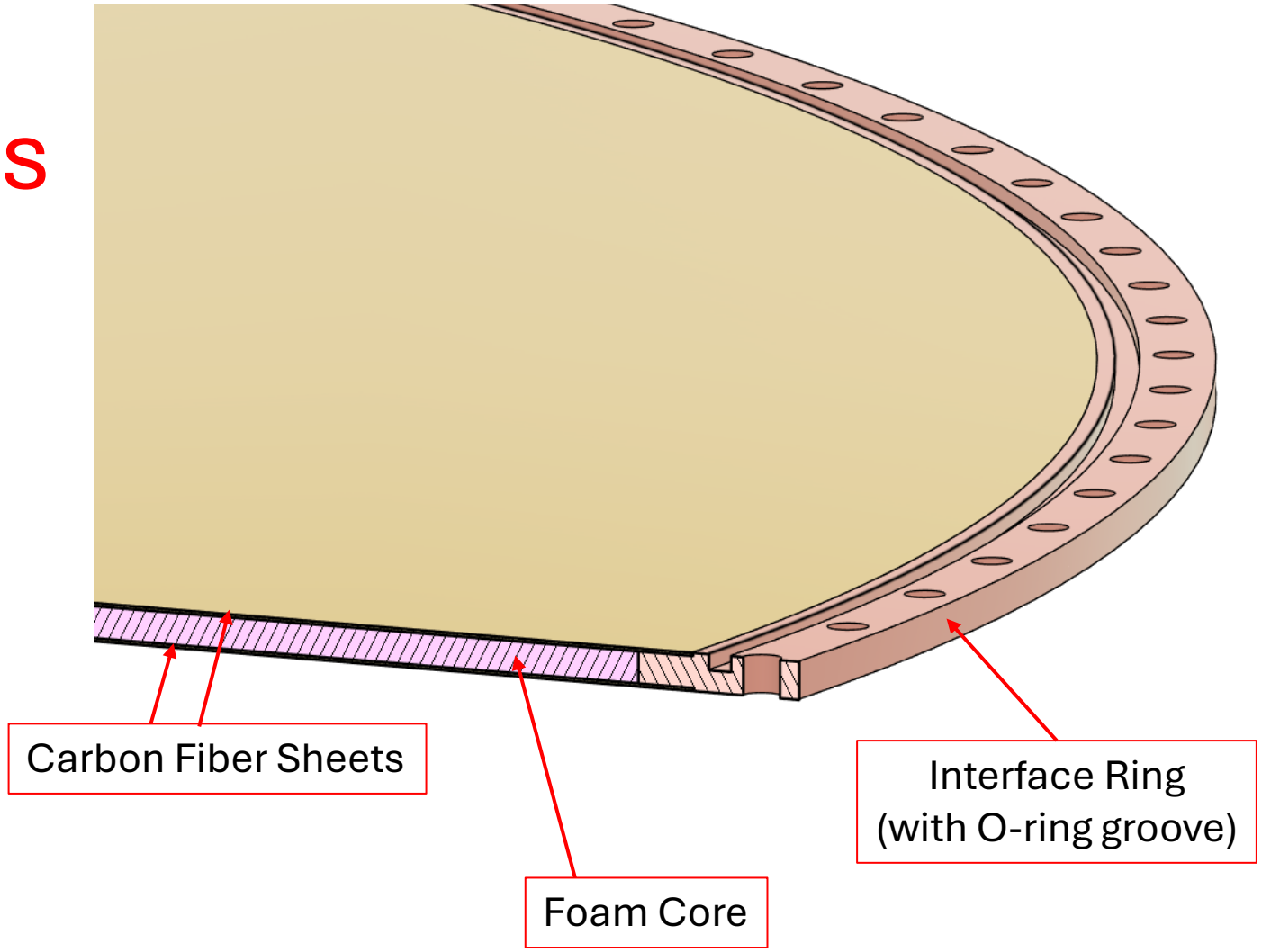
- Reminder: Our aerogel plane for the final design is based very much on the Belle II aerogel tiling shown on the right.
- In their scheme, they used a 1mm sheet of aluminum with 0.5mm radial bands welded into place. They used 0.3mm sheet metal folded to 90deg and spot welded to the back wall.
- It is unclear to me why they chose aluminum over carbon fiber.



Picture from: 9th Int'l Workshop on RICH Detectors, 2016
Ichiro Adachi (KEK)
2016.09.09

Aerogel Plane:
Current Design Details



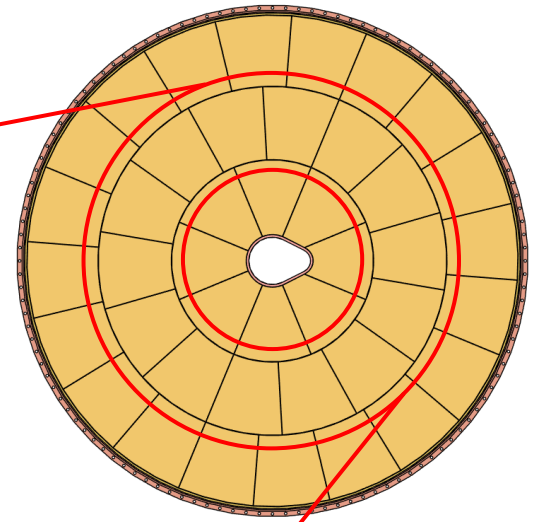


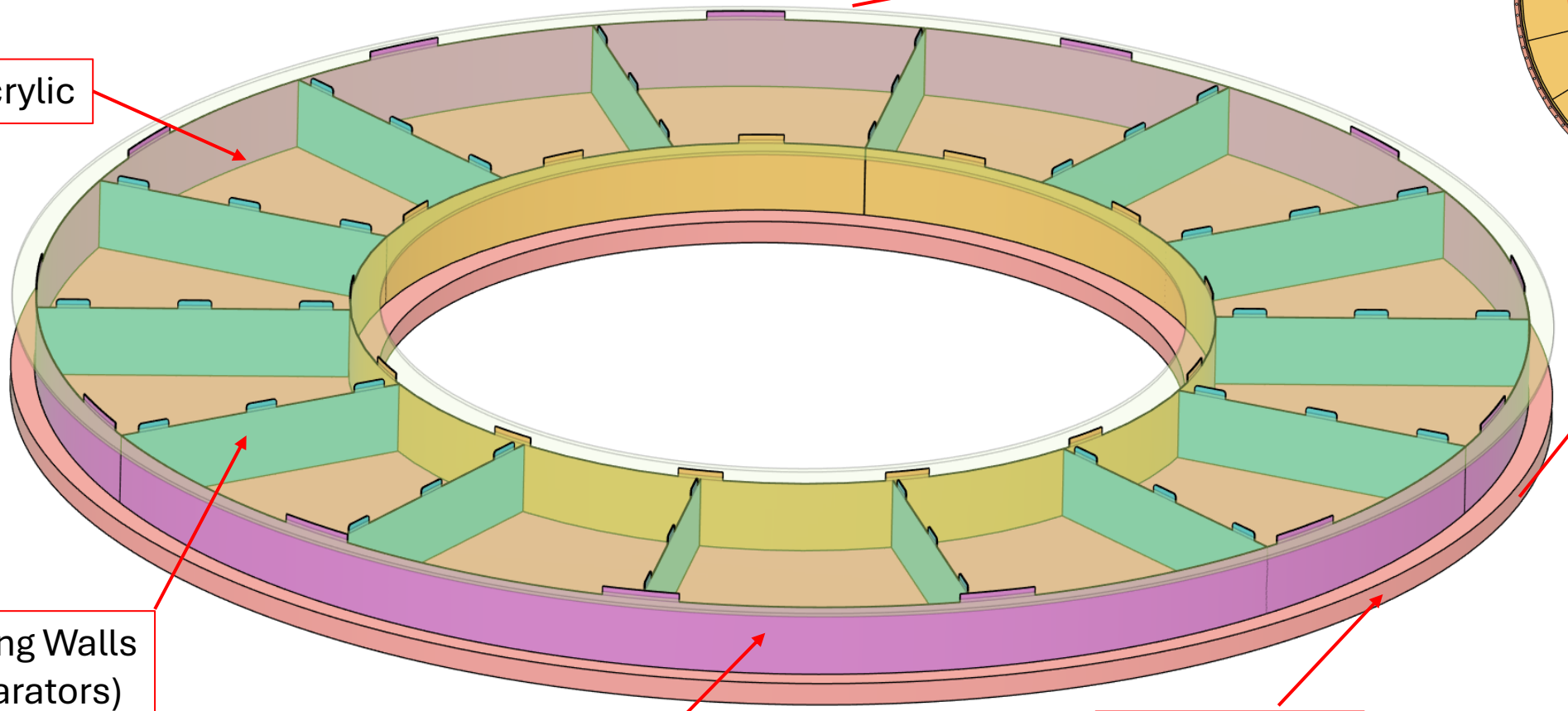
Aerogel Plane:
Additional Details

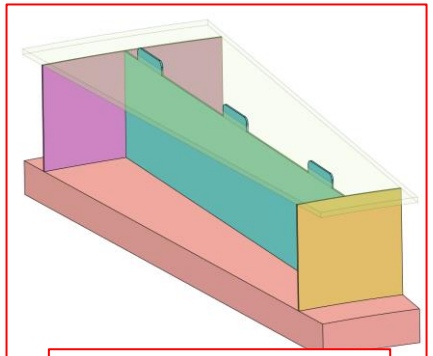
- Up to this point, certain parts of the design of the aerogel plane have only been conceptualized.
  - How are we going to make the individual aerogel compartments?
  - How are we going to add an acrylic (UV filter)?
  - How do we decouple the mechanical stress from the vessel to ensure that the aerogel tiles do not fracture?
  - What retention mechanism will we utilize to hold the tiles in place?

Aerogel Plane:
Tab and Slot Concept

Just the middle ring is shown as a concept







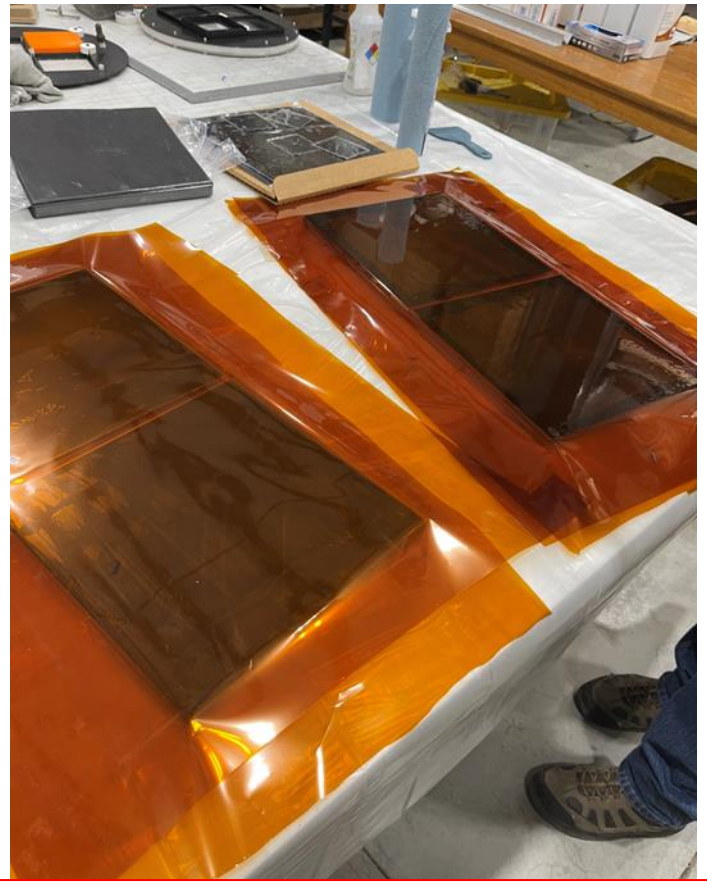
Tab and slot

Aerogel Plane:
Tab and Slot Concept (Cont'd)

- How are we going to make the individual aerogel compartments?
  - Utilizing tab and slot design, we can cut flat sheets of thin carbon fiber and epoxy them into the foam core of the aerogel wall.
  - The thin carbon fiber needs to be thin enough to be flexible but thick enough to be light-tight
- How are we going to add an acrylic (UV filter)?
  - We can utilize a similar system onto a CNC-cut sheet of acrylic.
  - A retaining system needs to be considered for the acrylic sheet. It may be possible to add a system of clips in the tab to make it be removable and serviceable
- How do we decouple the mechanical stress from the vessel to ensure that the aerogel tiles do not fracture?
  - We need to ensure that the pockets are slightly oversized and fill with a lightweight foam or paper, if necessary. The current preliminary mechanical model shows that our aerogel plane will not deflect significantly. Once we have a better model, we can size the openings for the tiles appropriately.
- What retention mechanism will we utilize to hold the tiles in place?
  - By surrounding the aerogel with the acrylic sheet, we have contained the aerogel on all sides.

Mirror Design: Co-Bonding

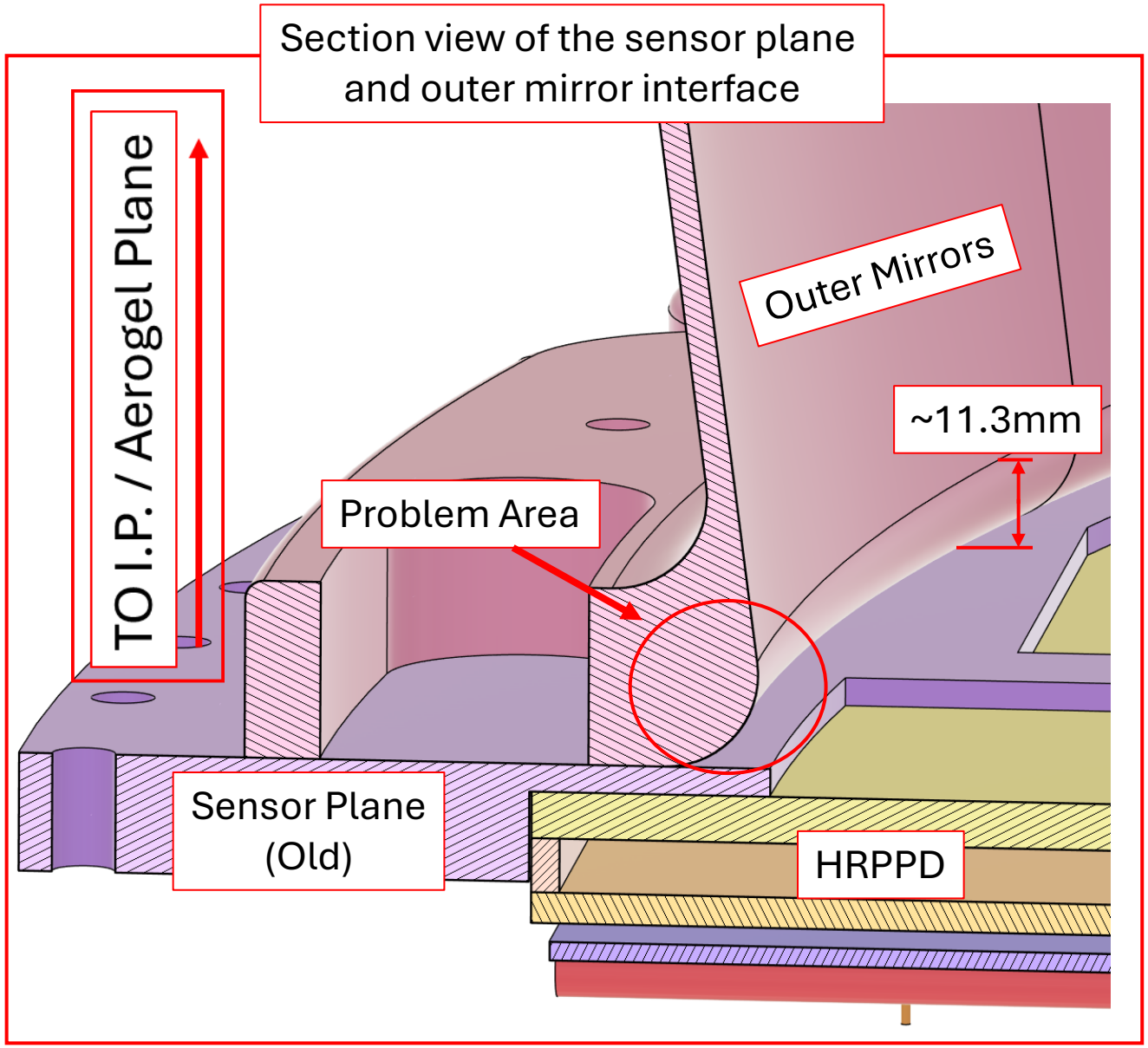
- Discussions about co-bonding the Lexan to the carbon fiber substrate has been ongoing.
- Sushrut and I were able to do some co-bonding with DP460 and PT 2712 while I was at Purdue on the 24th – 26th
- Slides are posted here that show the results of that (including detailed videos and our way ahead:
  - https://indico.bnl.gov/event/27076/



Four completed samples at Purdue

Mirror Design

- In the mirror design (both inner and outer), there is a problem area that needs to be resolved in the current design.
- The radius that is needed won't allow the carbon fiber to lay properly in the mold creates a compound curve. This means that when we attempt to bond the substrate to it, we won't be able to have any additional mirror material here.
- Initial thoughts were that we have four options:
    1. We let the Lexan continue past the fillet and hang cantilever, or
    2. We ignore this area and only bond up to the beginning of this fillet
    3. We design a piece that supports this cantilevered portion as an additional piece
    4. We change courses totally and use a thick piece of Lexan as a self-supported piece and then bond it to a form that will support it and let it maintain it's shape.
- This is a discussion piece going forward, a decision hasn't been made.



Questions/Discussions?