Mechanical Structures for EPIC pfRICH

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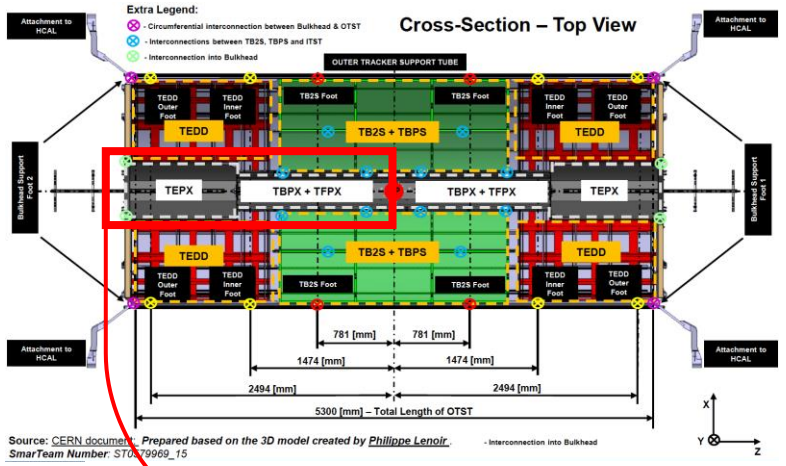
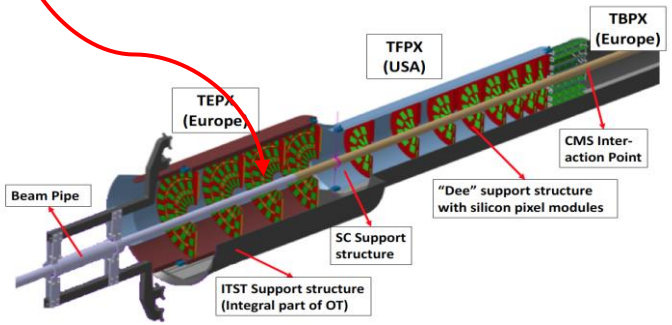
Resources at Purdue

- Composite Manufacturing & Simulation Center (CMSC) at Purdue, completed in summer 2016
  - Purdue Center of Excellence across disciplines: Aeronautics, Chemical Eng, Materials Eng, Aviation Tech, Computer graphics, **and Physics**
  - A. Jung – Associated member of CMSC
- Professional composite experience:
  - Seven full-time technical staff, five post-doctoral researchers, twenty grad's
  - 35,000 sq. ft. of office and laboratory space
    - 2 large pressurized ovens, 1 larger oven with vacuum hook-ups
    - Larger ovens accessible with industry partners

CMS mechanics @Purdue

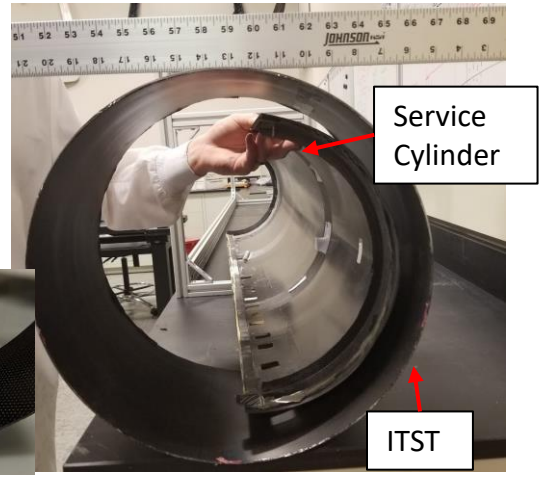
- CMS upgrade relies on Purdue for design & manufacturing of mechanical support structures
  - Service Cylinder housing the Inner Tracker (IT)
    - 4+2 half cylinder structures with a length of 2.9m and transition region between small & large radii
    - Barrel, Forward, and Extended Pixel Detectors
  - Components for Inner Tracker pixel
    - Sandwich structures to mount pixel modules (Dee's) for the forward pixel (US project)
    - CFRP structures for the barrel pixel (European led)
  - Inner Tracker Support Tube (ITST)
    - Supports the 4 IT Service Cylinders, separates Inner Tracker and Outer Tracker volumes
    - Longitudinal stiffness for the entire Outer Tracker
  - Components for Outer Tracker (OT) modules
    - CFRP stiffeners for the OT modules assembly
  - Barrel Timing Layer Tracker Support Tube
    - Support the entire IT + OT + Timing Layer of CMS

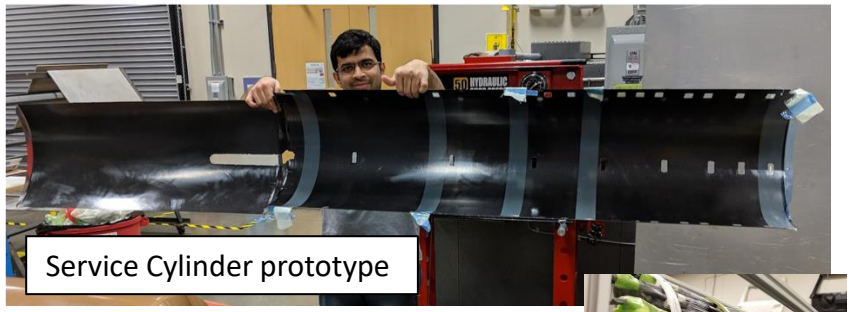


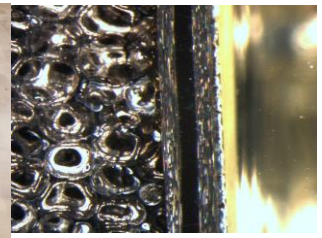


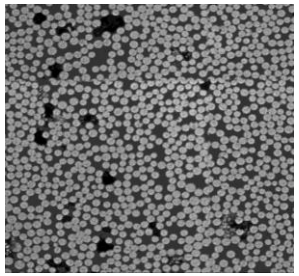
Resources @ Purdue

- Prototyping & Manufacturing related to ITST, SC, Dee's
  - Prototypes confronted with FEA predictions, multiple iterations
  - Prototyping and Development of additional structures for IT pixel
    - Cartridges, Portcard holders, all extensively studied for high thermal performance
    - Accompanied by irradiation campaigns: sample prep, characterization, etc.
    - Dedicated measurement of thermal conductivities
    - High thermally conductive materials for 3D printed parts

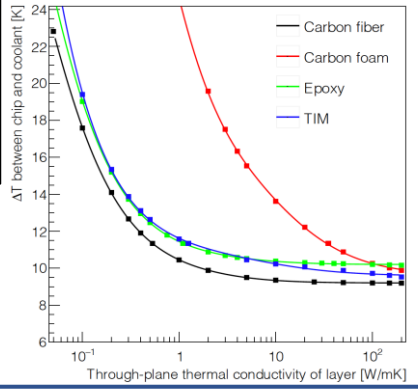


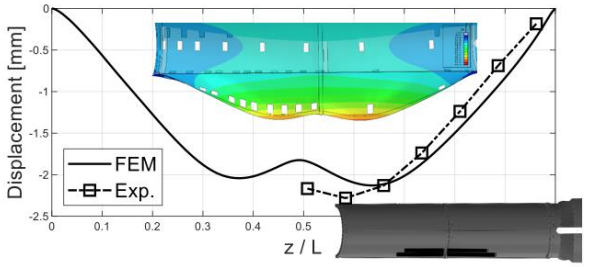






- Forward pixel dee prototype
- Co-cured samples
- Microscopies
- 3D printed mechanical supports
- Critical interfaces via FEA

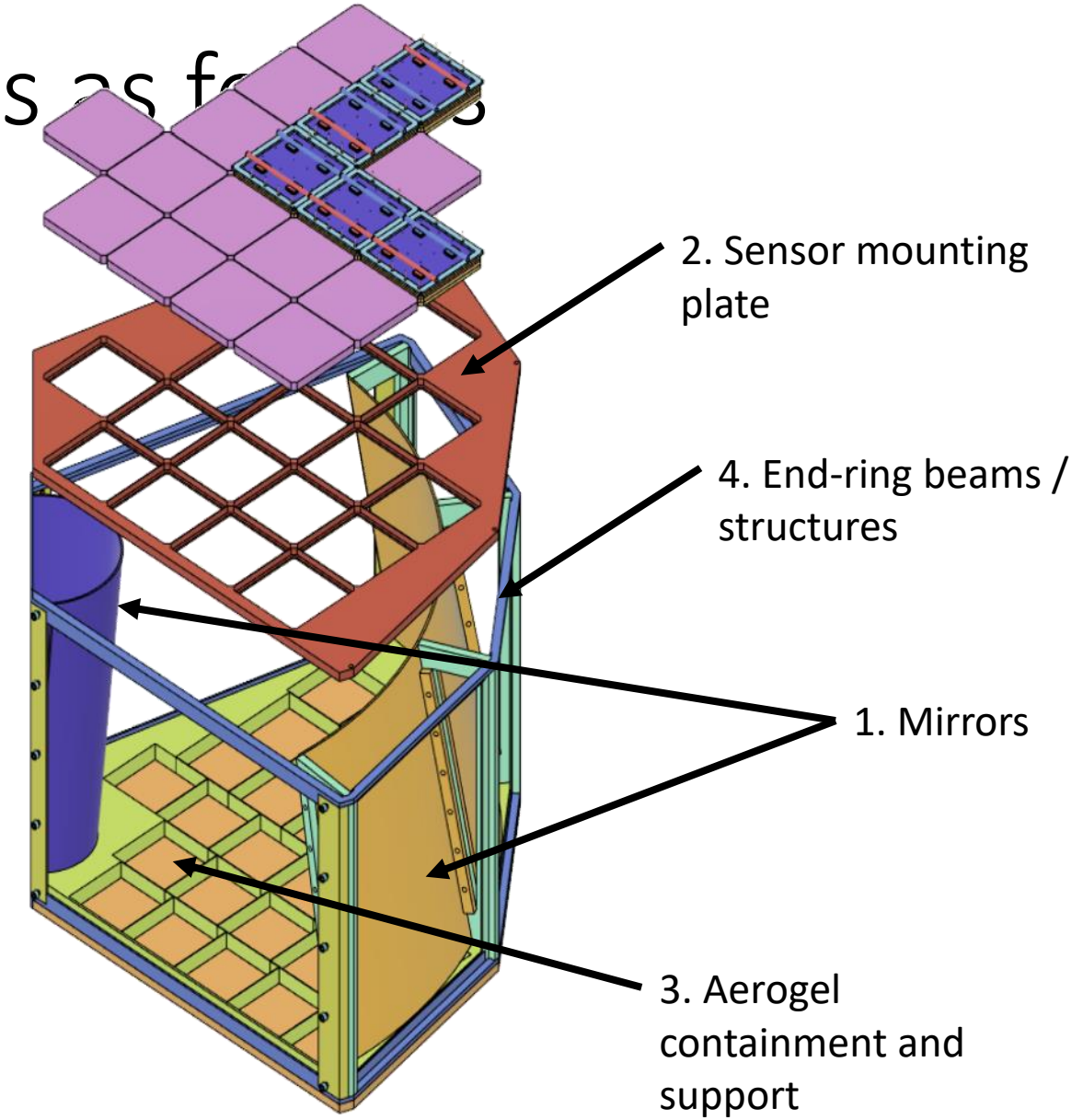




Plan is split into 4 sections as follows

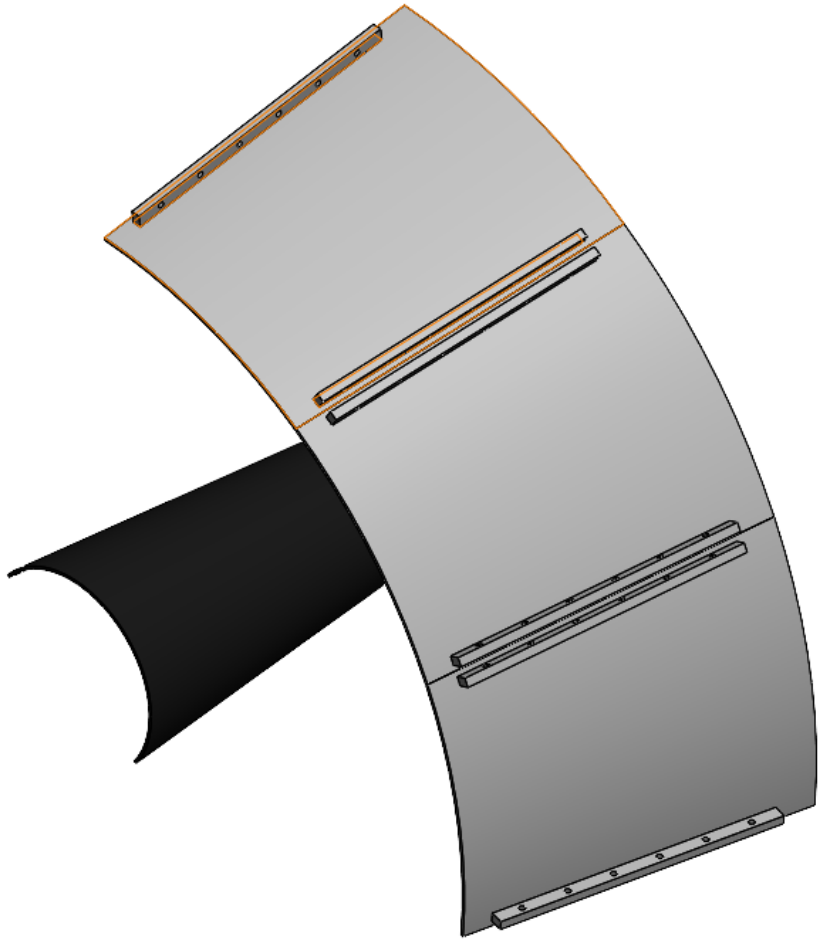
Line items currently at Purdue:

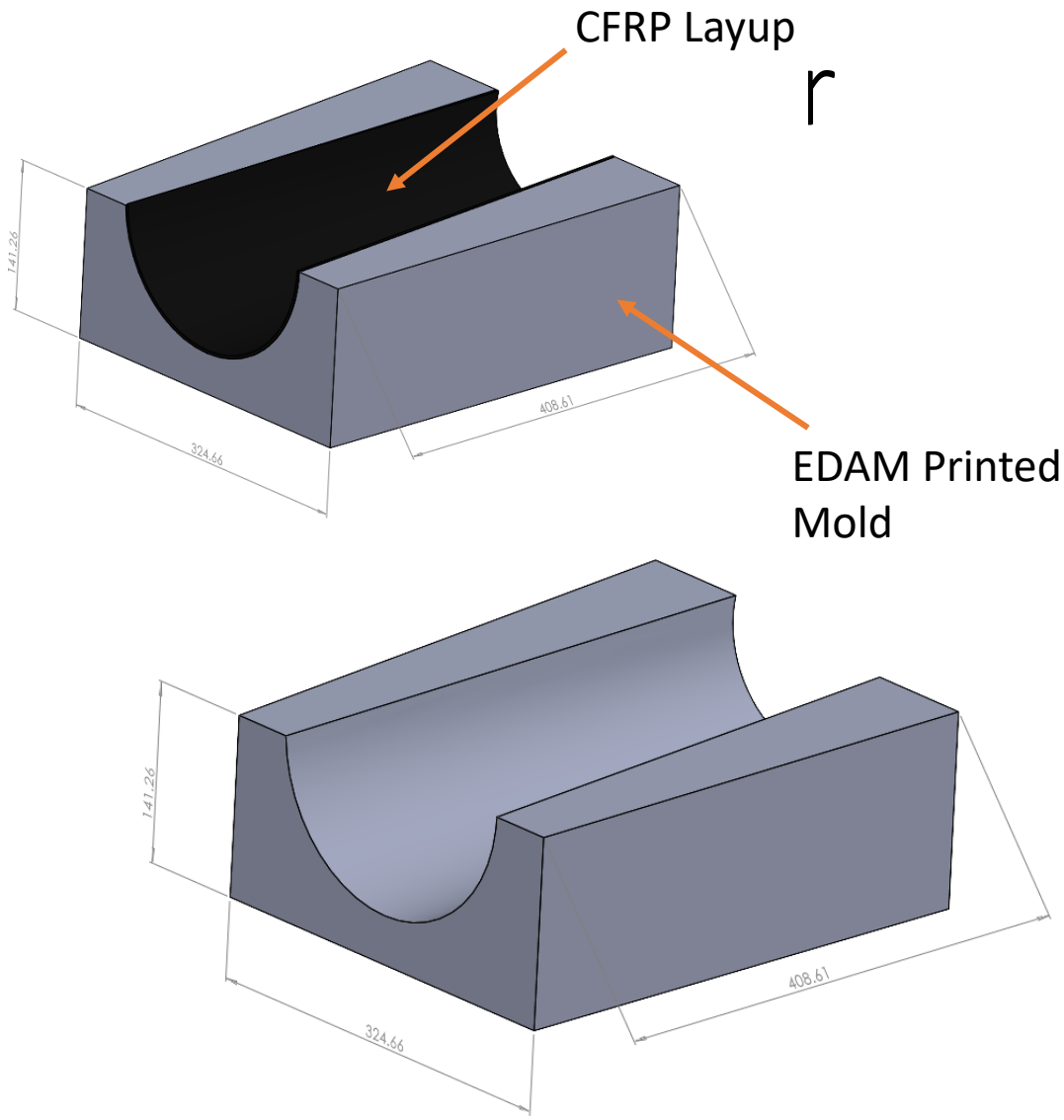
1. a 60 degree outer mirror sector (suffices for a test)
    1. 1/4 of the inner mirror
2. 1/4 of the rear sensor mounting plate with 17 square openings
3. 1/4 of the front plate with a bunch of aerogel pockets
    1. Sandwich + face sheets
4. the end-ring structures / beams
    1. Layup



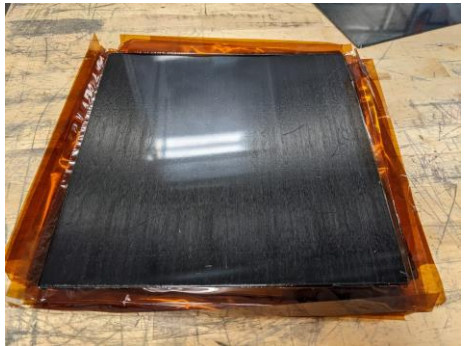
1. Mirrors

- The plan is to 3D print the tools needed for the composite layup
- Composite layup for the inner and outer mirror support structures – control surface as follows –
  - Outer surface of the inner mirror
  - Inner surface of the outer mirror



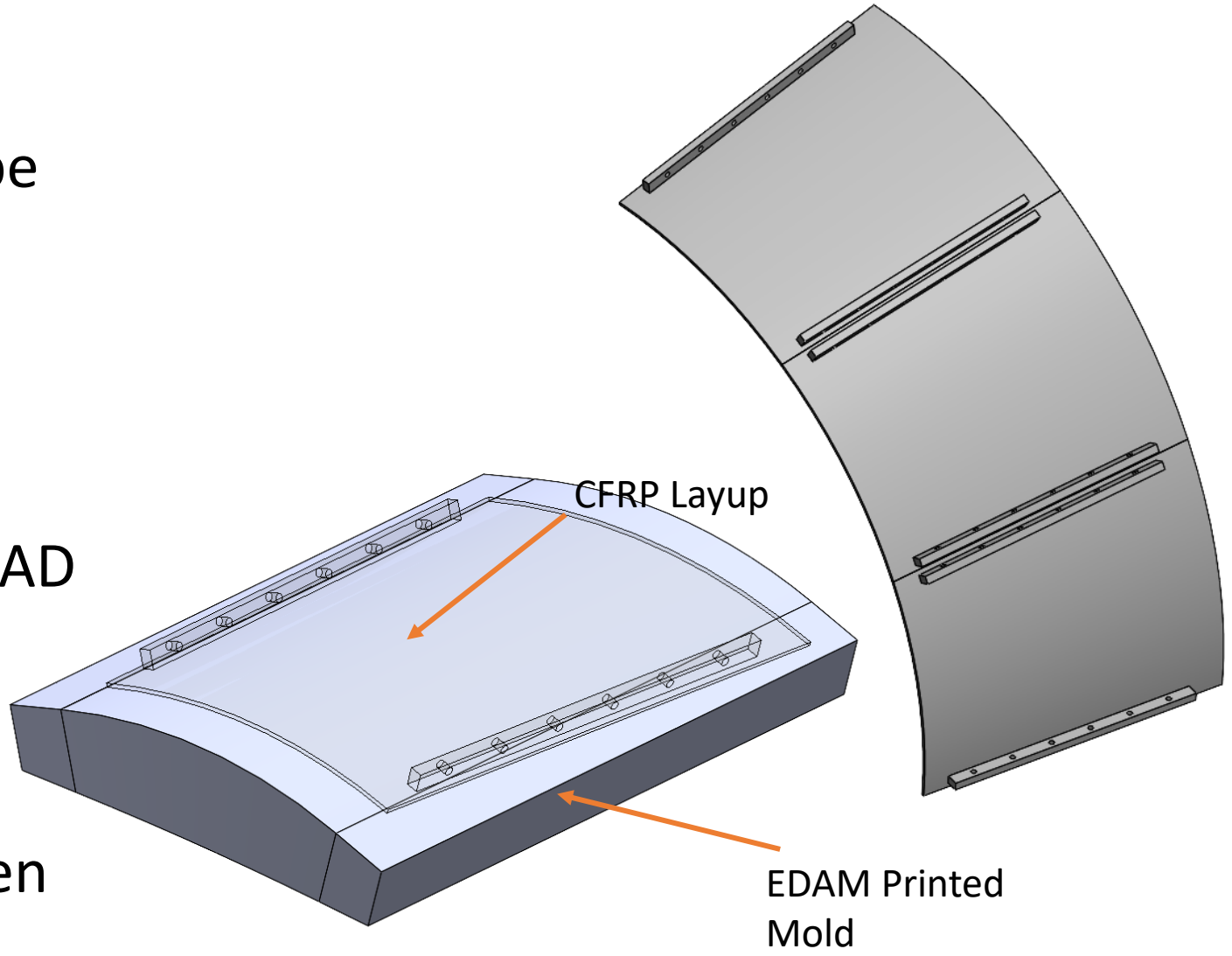


- 3D print the mold and machine after gel coating
- Received samples from Stony Brook – surface roughness measurements undergoing
- We are making (short timescale) prototypes to see what smoothness we can achieve



1.2 Outer Mirror manufacturing will be similar to inner mirror

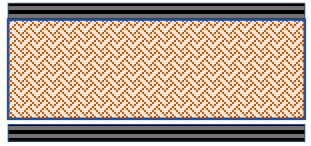
- 3 part mirror for the prototype
- Autoclave high temp tooling with EDAM has been studied and developed at Purdue for many years
- Tolerances for difference to CAD and for overall “flatness” of mirror substrates is an open question
- Surface roughness – to be seen

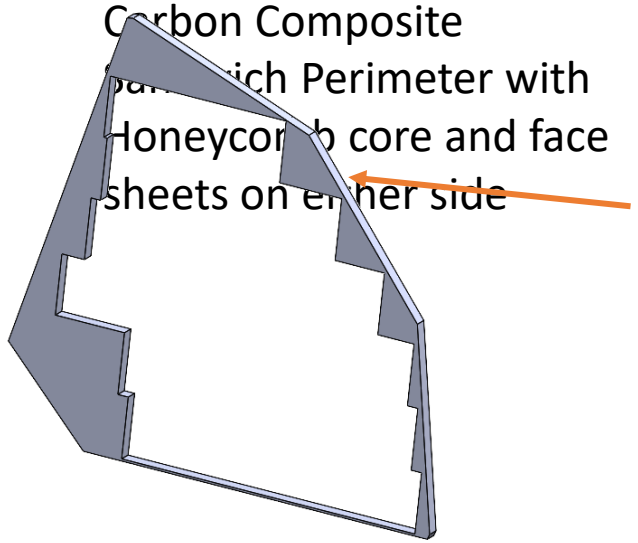


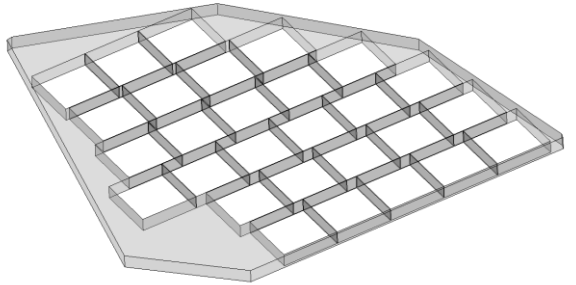
2. 1/4th rear sensor mounting plate
3. 1/4th front plate with aerogel pockets

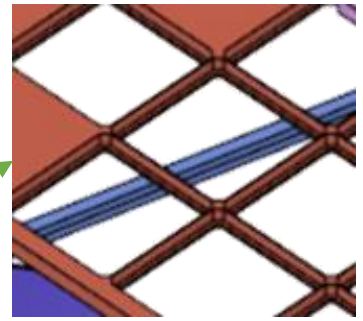
The approach for manufacturing of both will be similar so illustrating only one time

- The plates are 23 mm thick
- The perimeter will be made from a face sheet honeycomb structure to reduce mass.
- For aerogel the back sealing panel will be a simple CFRP layup cut and bonded in place
- Ribs have 2 options
  1. 3D printed using FormLabs High Temp Resin2 (known and tested to be radiation hard up to 300MRad of Co_{60} gamma radiation.) – data part of unpublished CMS work – but available to be shared upon reasonable request
  2. Made from strips of CFRP that are joined using a precision assembly jig





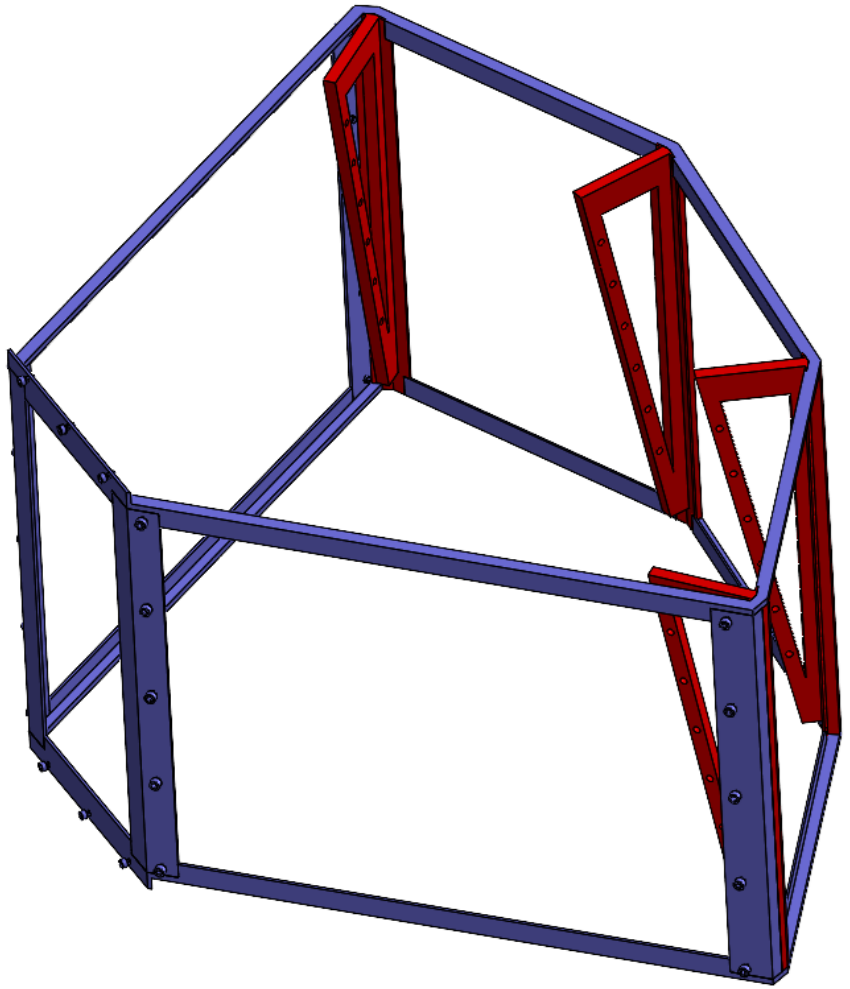




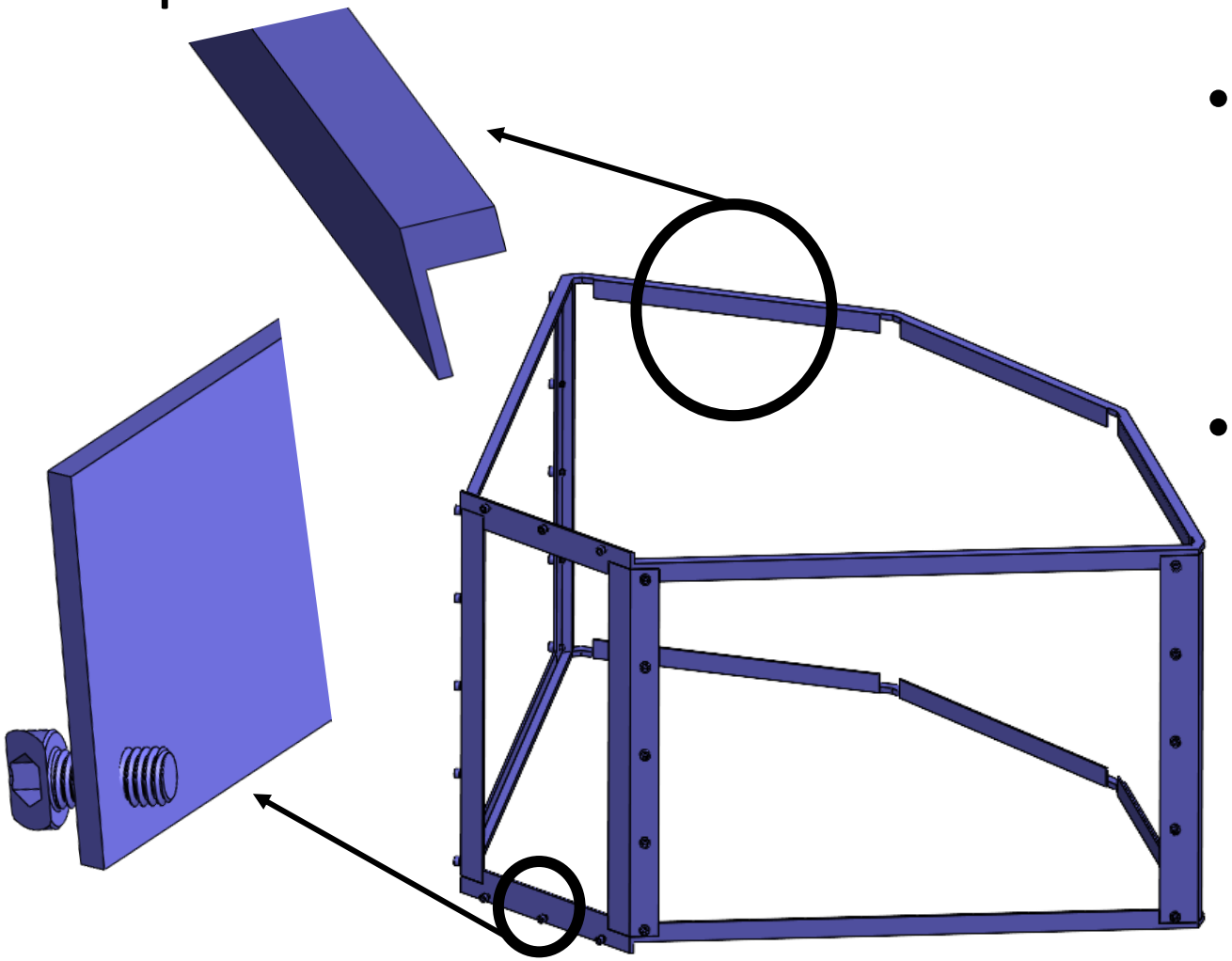
NOTE – the ‘lip’ needed for the sensor mounting plate can be achieved with both rib techniques

4. End ring structures / beams

- Question – Are the triangular supports that in the CAD are shown in red as a part of containment panels within Purdue manufacturing scope?
- Assumption is yes, since these integrate with the blue end ring support to form an integral part of the mechanical structure.
- All structures will be made from plain weave and uni-directional CFRP layups using multipart tools



4. The other end ring structures are simple L-profiles and flat sections

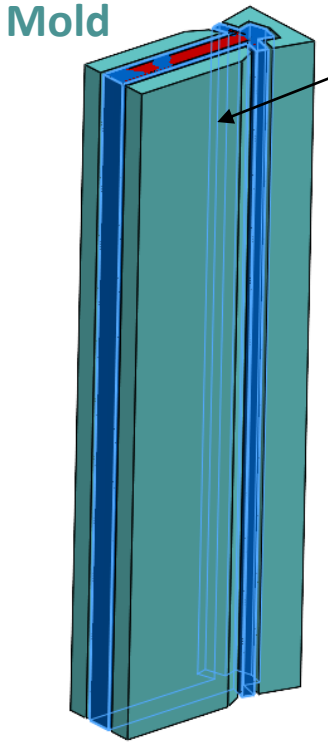


- The are simple to manufacture as independent CFRP solid beams of the appropriate cross-section
- The hole locations will be CNC machined and then using an assembly jig the structure will be assembled.

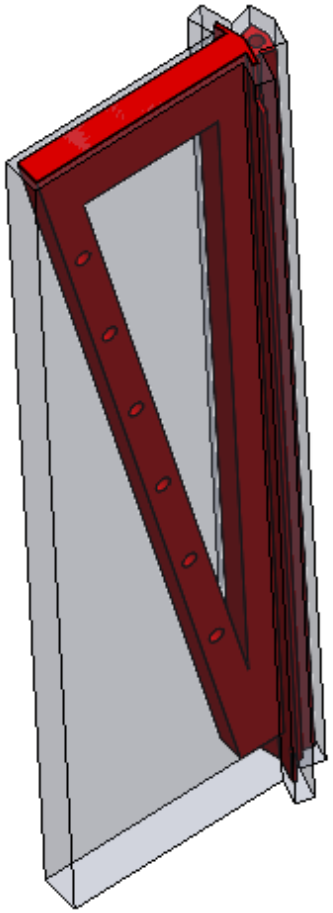
Summary

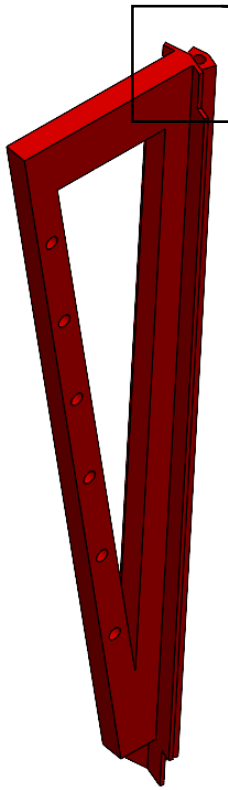
Backup – More details

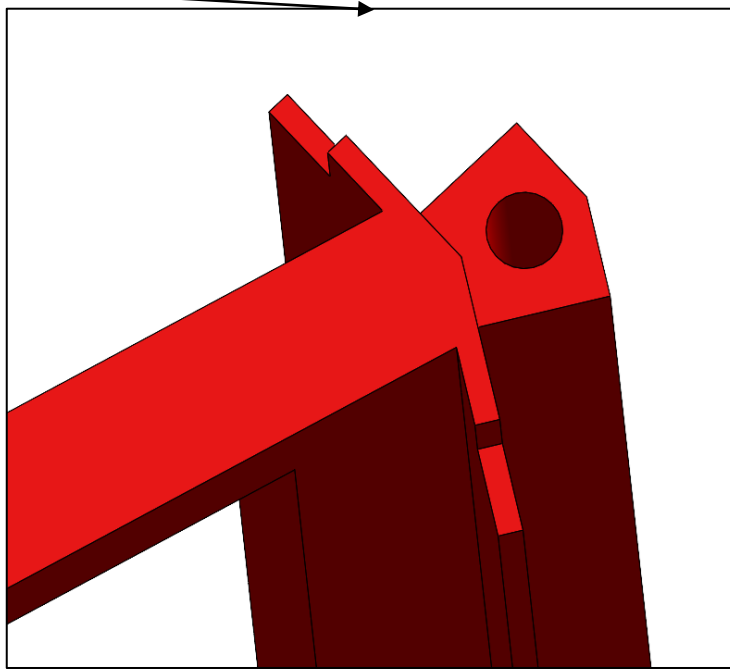
To be made from 3 part layup tool and then machined to size – the rib is 0.5” thick – this will have some kind of core and face sheet structure



Part to be CNC trimmed







This is a through hole – does it have any function ? If not this is very difficult to manufacture – and will be removed