Laser Calibration Mirrors

Technical Integration Meeting

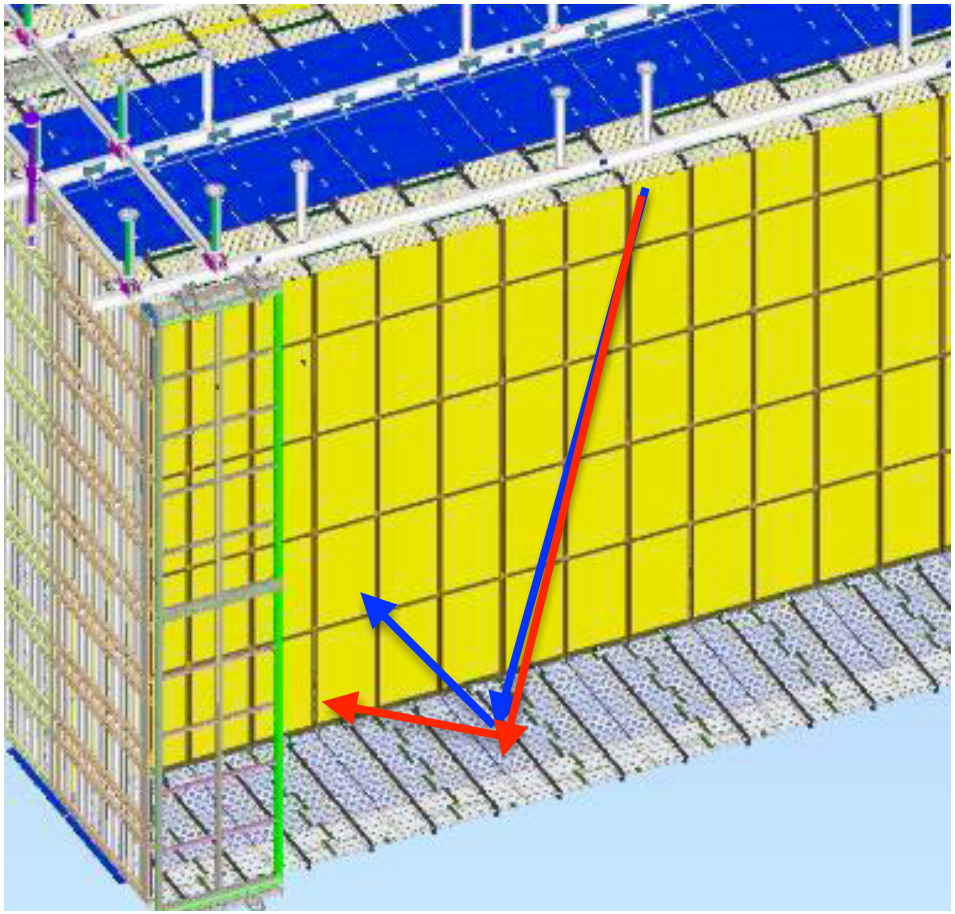
January 9, 2020

LIP
LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
DUNE

The problem

- E-field precision measurement requirement: 1%
- Field distortions measured by track path distortions
  - A 1% distortion on E over a 0.5 m region leads to a 5 mm shift
  - Not useful to go much better than 5 mm since that's the wire spacing
- So: need for 5 mm (**Total**) beam position uncertainty
- Challenge since DUNE is big!
- Mechanical precision of calibration laser periscope should do it, but how do we check it?
  - as a Roman poet said: ***Quis custodiet ipsos custodes?*** ("Who watches the watchmen"?)
  - we say: How do we **calibrate the calibration system**?

The idea



- Aim the beam at a mirror in a known location. Precision ~ size of the mirror.
- We know the beam hit the mirror when we observe the reflection
- Cluster about 5 mirrors together to make it easier to find them
- Each mirror with a different angle
- Reflected beam angle unambiguously identifies which mirror was hit

Pros and cons

- Fully passive system, no cables
- Easy installation

- Works only with the TPC on

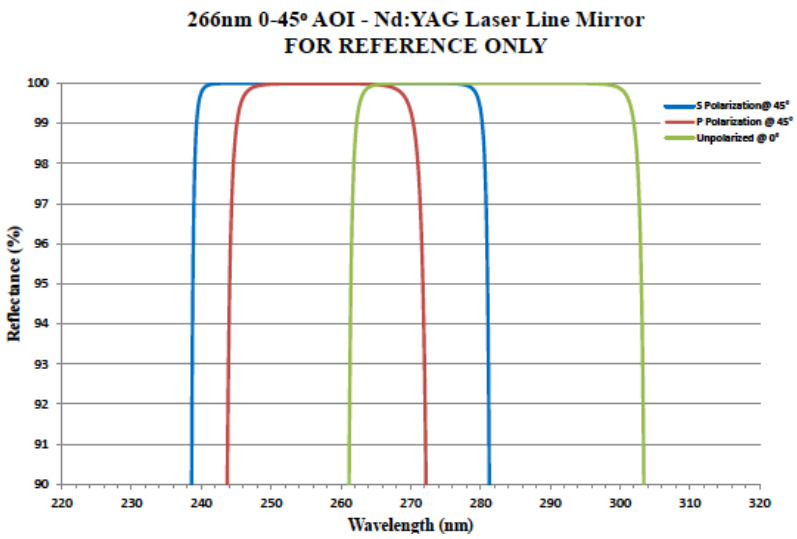
Requirements

- Each laser should have at least 2 mirror sets visible
- One of them should have a distance close to the maximum in each “laser volume”, i.e., horizontally close to 60 m/4 = 15 m.
- The positions/angles should be such that the reflection is at least 1 meter long
- The reflection angles should be such that no beam impacts the APA plane

- If possible, each laser should have 2 mirror sets aligned with itself so that it can point to both without changing the phi angle, just theta. This is because we expect theta to be the most critical one

The mirrors

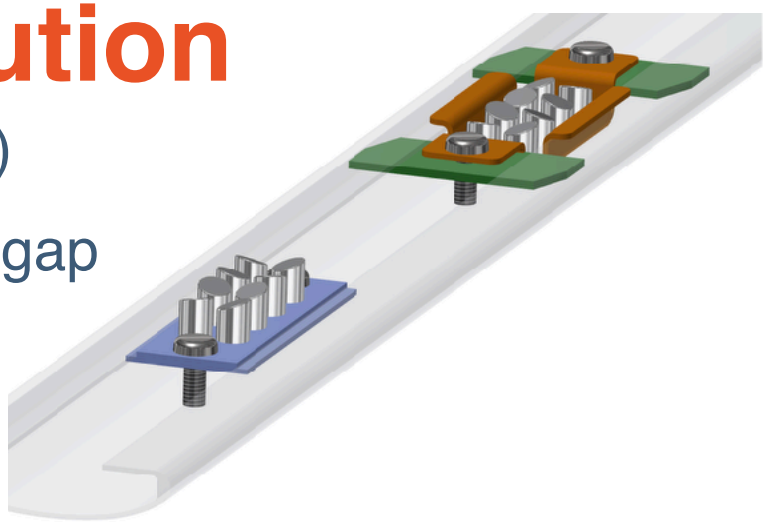
- Edmund Optics Nd:YAG Laser Line
  - substrate: fused silica
  - coating: dielectric
  - surface quality: 10-5
  - wavelength range: 263-268 nm
  - Rabs >99.8% @ 266nm
  - Angle of incidence range: 0 - 45 deg
  - Size (2 options for us)
    - Radius: 6.35 mm, thickness: 4 mm
    - Radius: 4 mm, thickness: 3 mm
  - Cost: ~ 100 € each

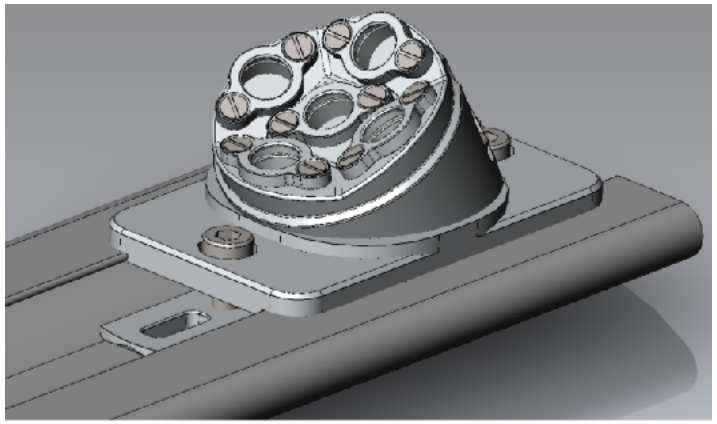


https://www.edmundoptics.eu/f/ndyag-laser-line-mirrors/39566/

Holder design evolution

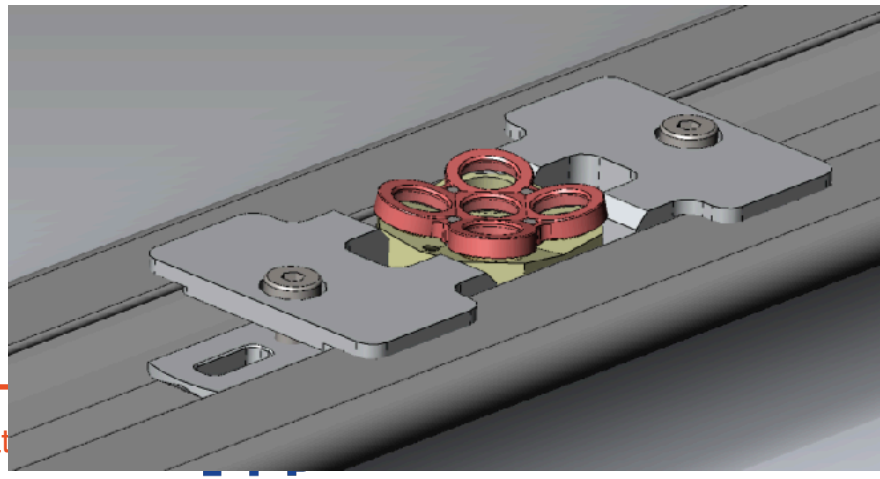
- Initial drawings by Bo Yu (BNL)
- ✔ Attached to inner FC profile gap
- ✘ Polished aluminum surfaces (maybe not reflective enough)



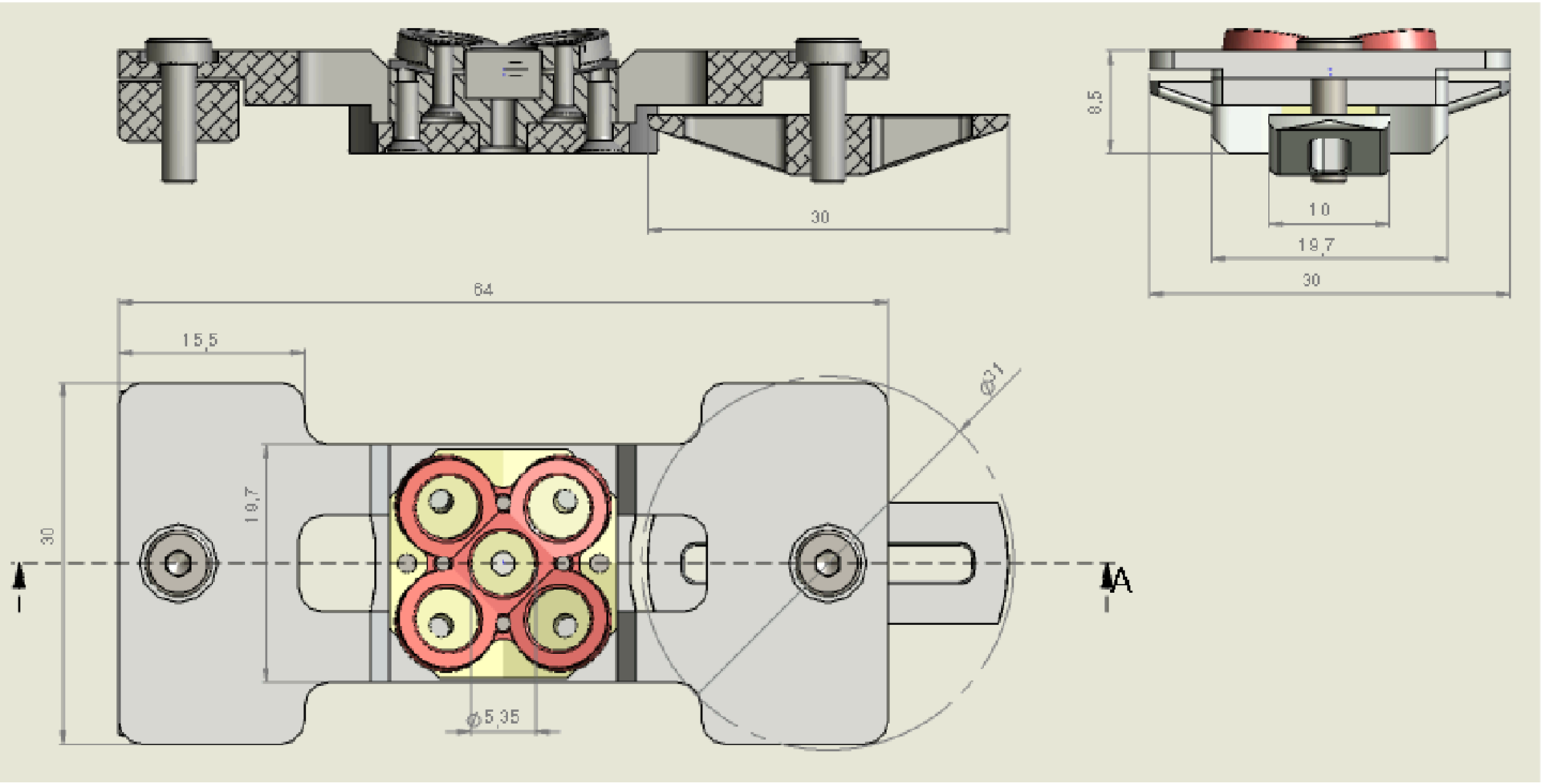


- First version from Rui Alves (LIP)
- ✔ Holder for commercial mirrors
- ✘ Standing too much out from FC

- Second version from Rui Alves (LIP)
- ✔ Holder for commercial mirrors
- ✔ Lowered into gap

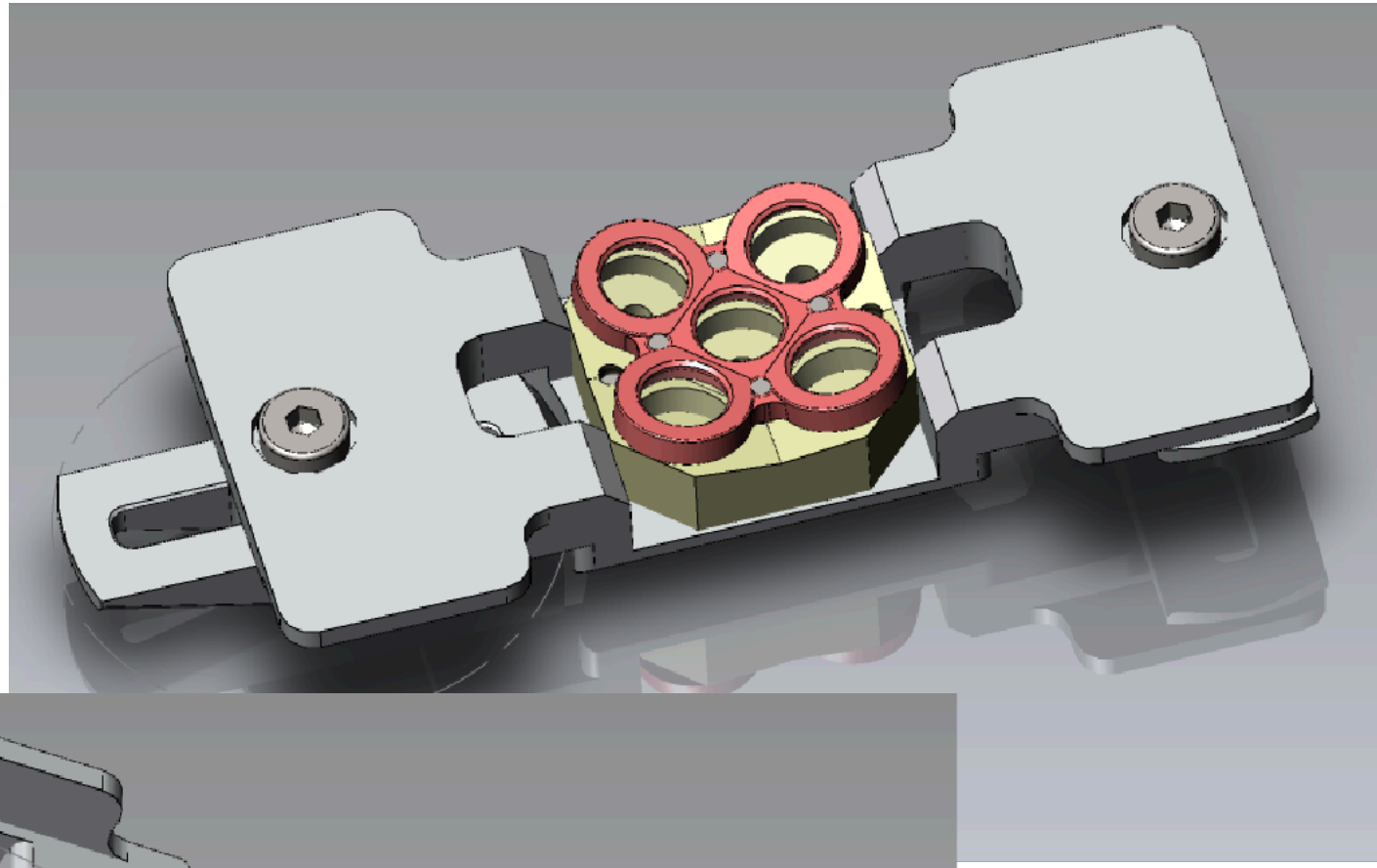


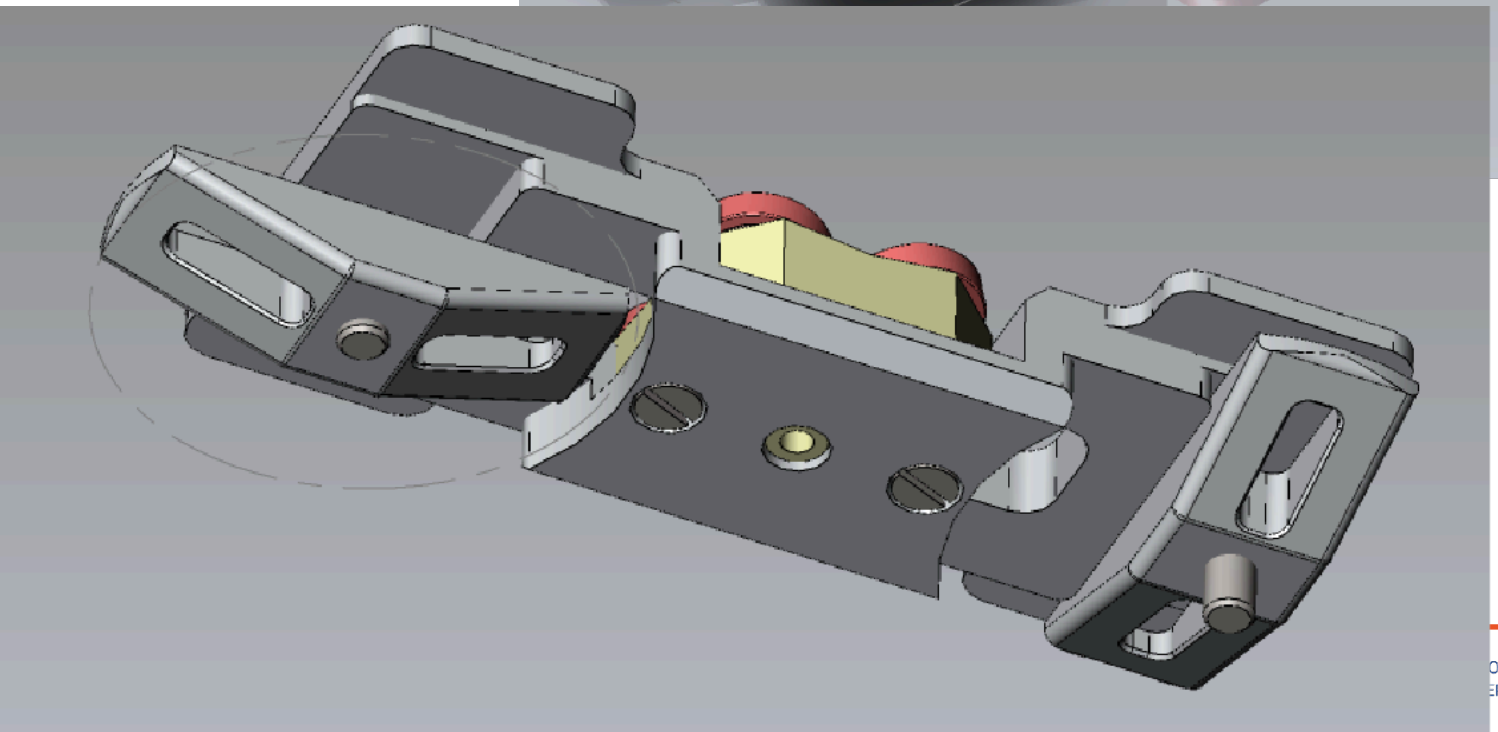
Current mirror holder design



- all parts in aluminum

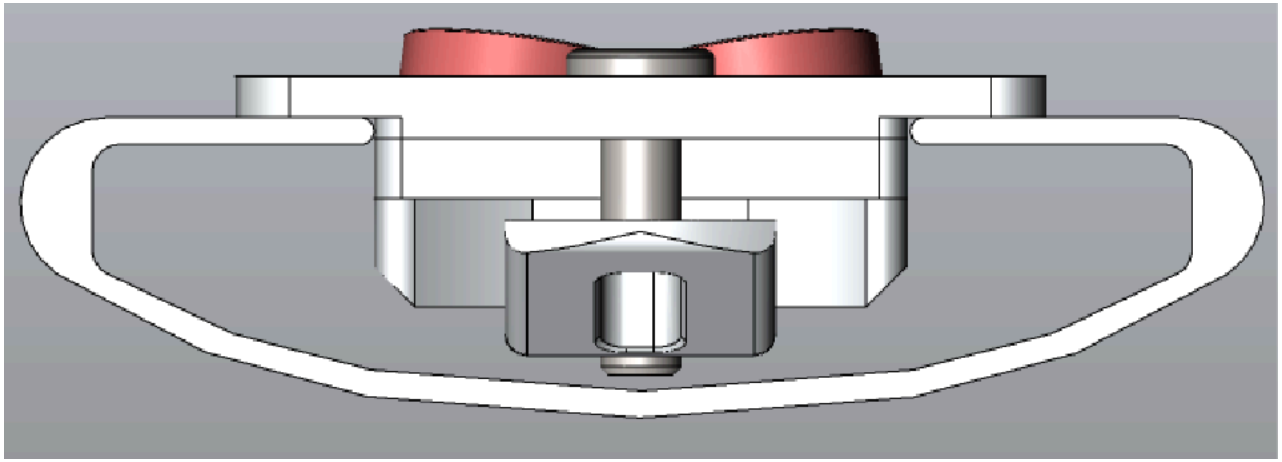
Overview



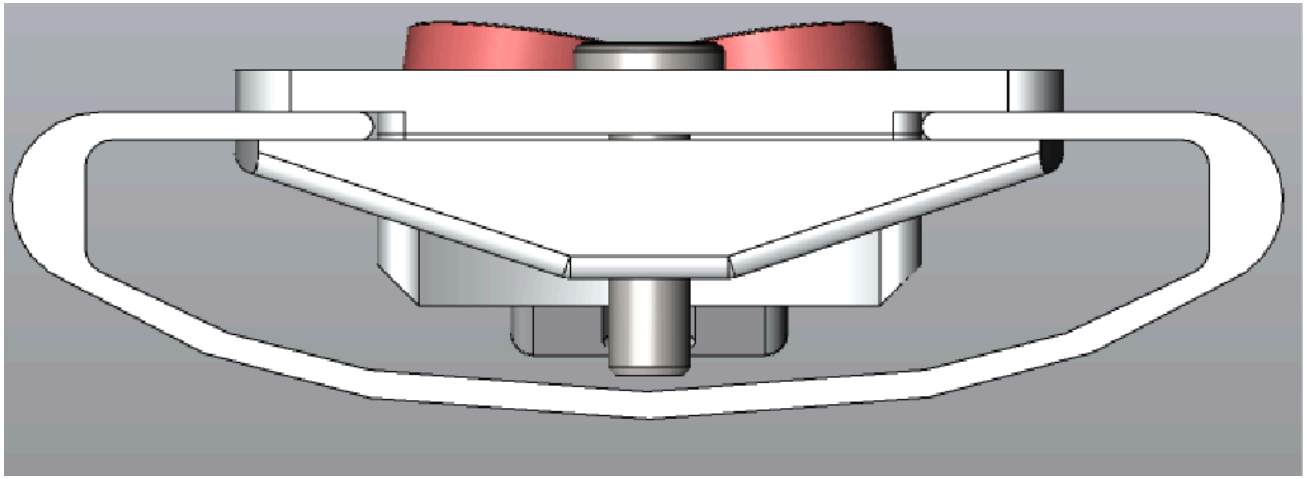


Fixation to FC

- First, enter the gap



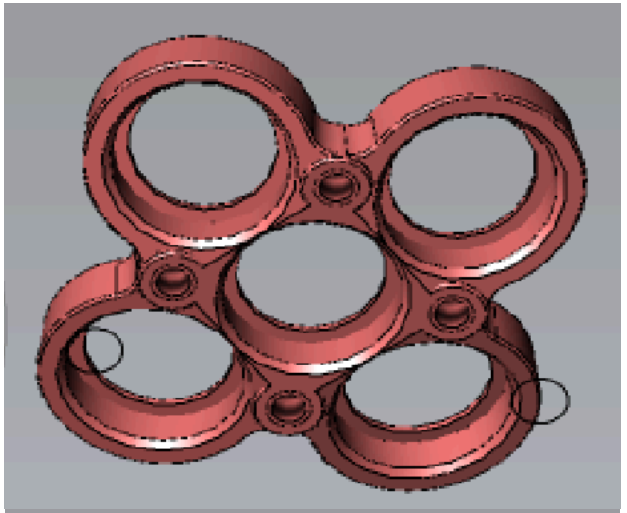
- Second, rotate bracket into place and tighten screw

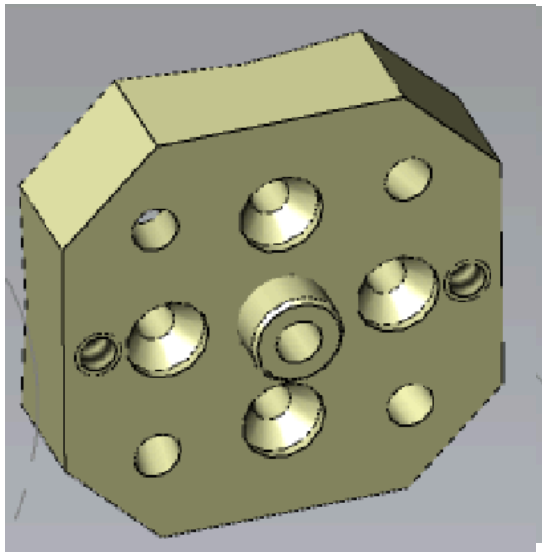


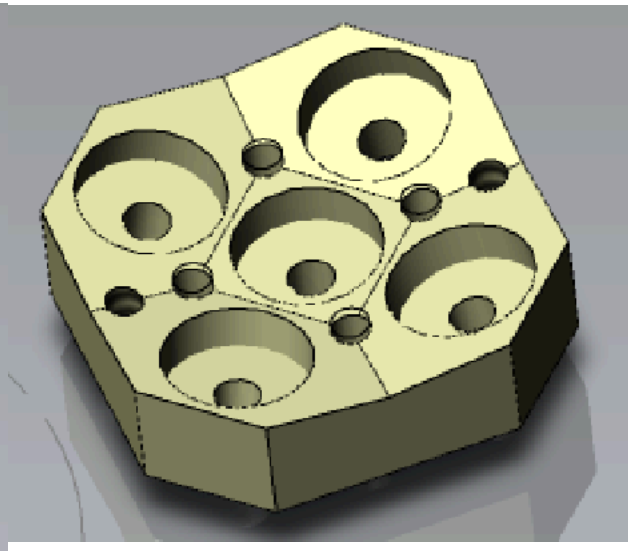
- Tighten only the edges, avoid pressing against the bottom of the FC

Mirror holder piece

- Separate from FC attachment
- Different angles possible







Next steps

- Mechanical design
  - Try to have mirror holder fixed from the top
  - Round all edges
  - Estimate effects of thermal contraction on mirror (we don't want to break them!)
- Define the positions
  - Try out a few positions on the bottom and end-wall FC
  - See if they meet requirements
  - Should have a minimum of 2 in ProtoDUNE, maybe 4
- "Value engineering"
  - one the ProtoDUNE holder could have polished aluminum discs instead of mirrors