NBI Heat Shield Thermography for OP2. Immersion tube and optical design (AET20/21).

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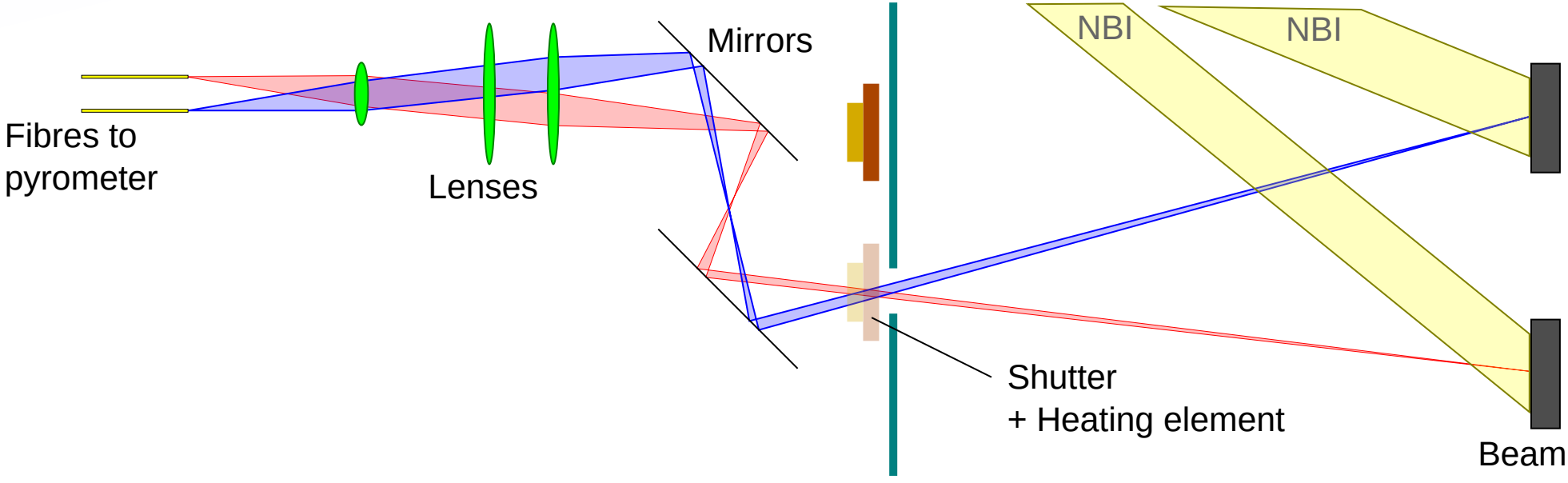
Requirements

- OP1.2 used H-alpha type 2 tube from IR video system that are unsuitable for OP2 18GJ.
- Optical design using retroreflector and Y-piece optical fibres was unsatisfactory.

New design concept:
- Cooled front-plate and cooled shutter for 18GJ operation (shutter mostly closed).
- Small aperture and metal mirrors to cope with heat loads during NBI operation and keep vacuum window far from plasma.
- Heating element on shutter for HST self-tests (instead of retroreflectors).

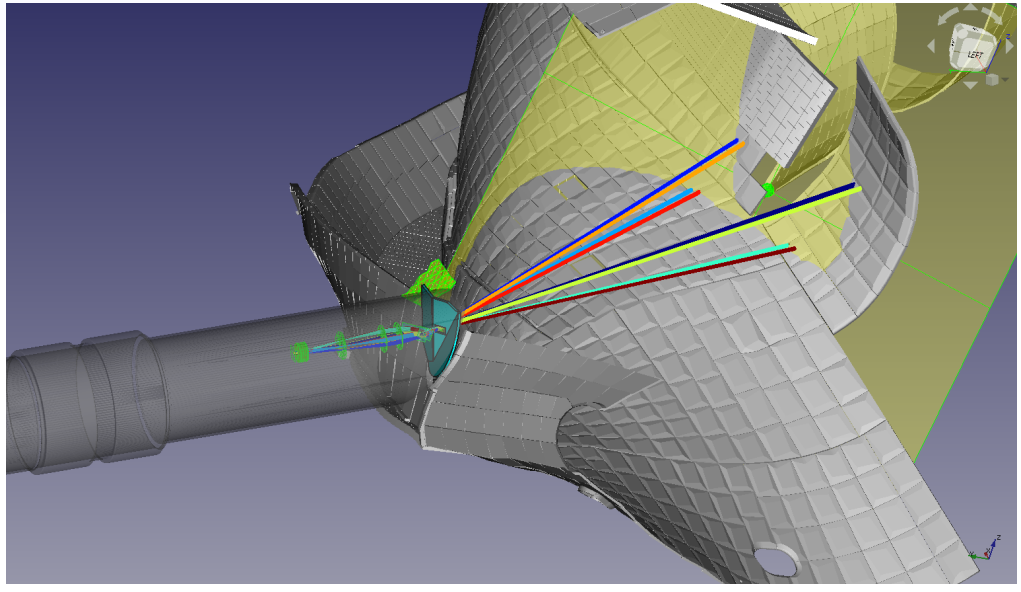
- Re-optimise piggy-back optical system for CXRS (QSK/P122).

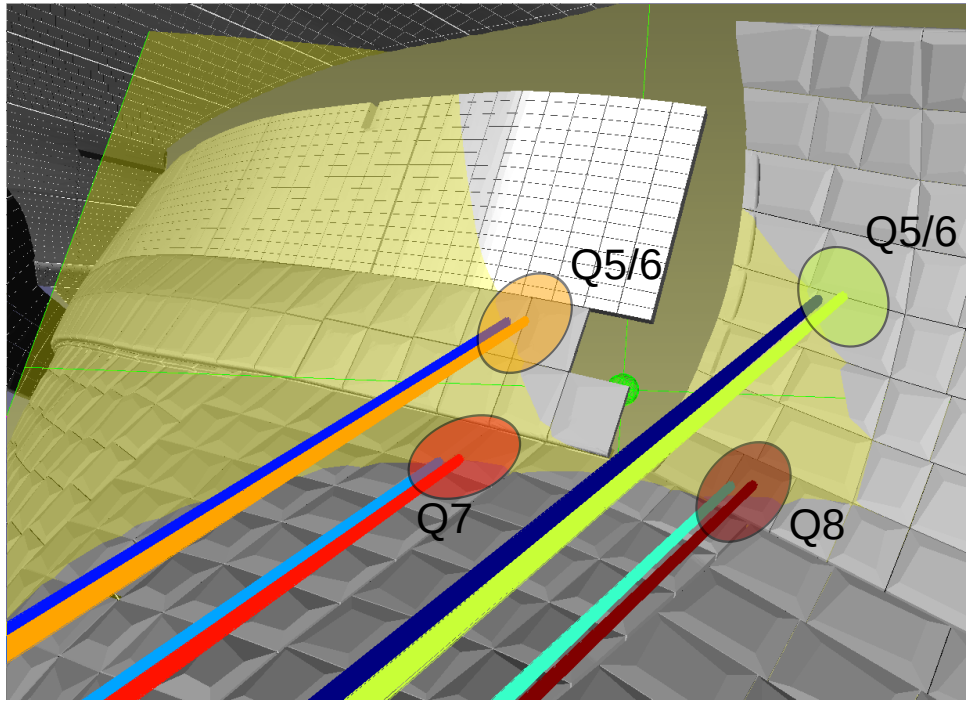


HST Targets

Optical requirements:
- **HST:** Image 4 points on baffle/shield tiles used as NBI beam dumps on to optical fibres connected
  to the HST pyrometers.

HST:



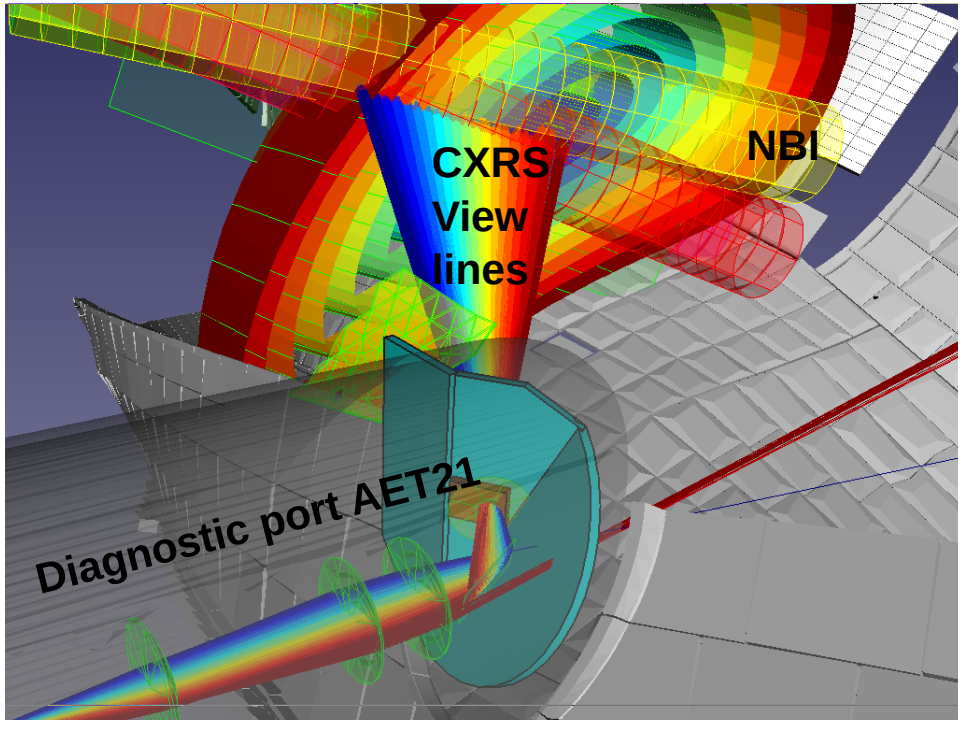


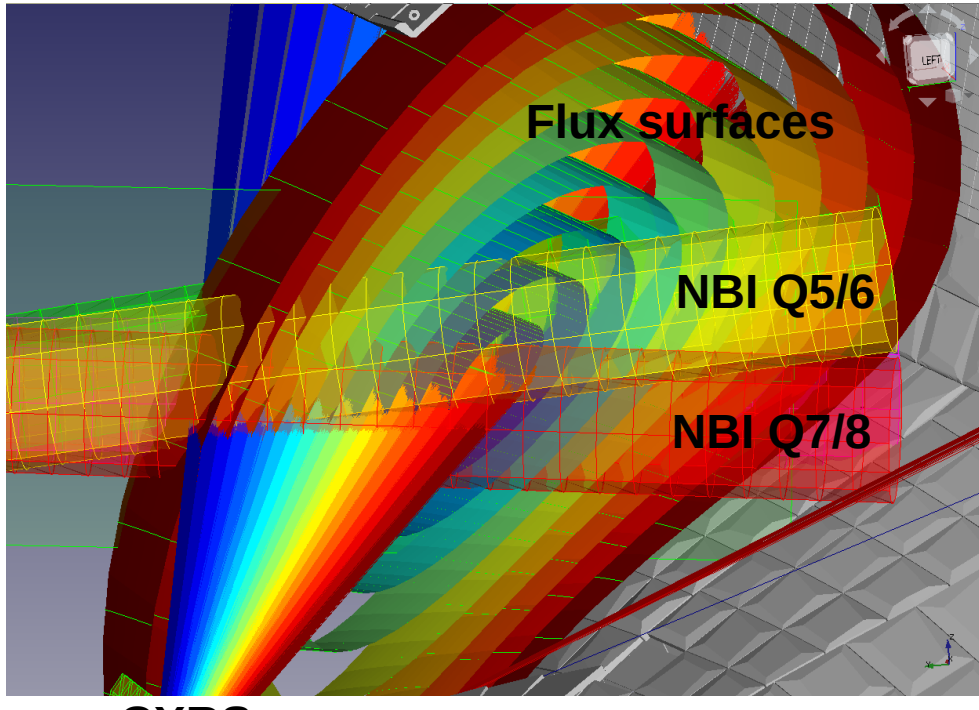
CXRS Target

Optical requirements:
- **HST:** Image 4 points on baffle/shield tiles used as NBI beam dumps on to optical fibres connected
  to the HST pyrometers.
- **CXRS:** Image several points along NBI on to fibres connected to the CXRS spectrometers.

CXRS:

Flux surfaces

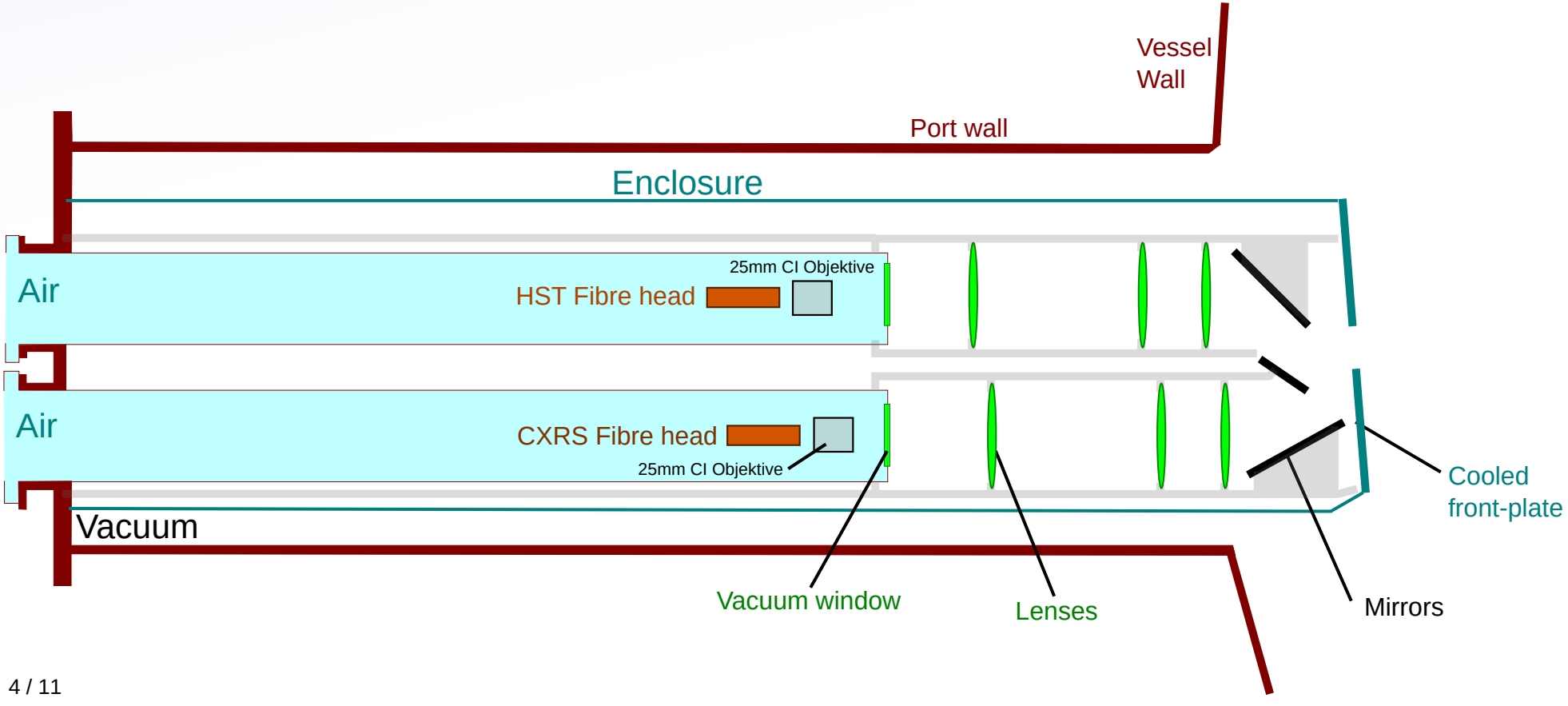




CXRS
View lines

Concept overview

Concept:
- Two parallel optical systems with 1 small aperture.
- Single or dual immersion tube(s) with vacuum window away from plasma.
- Cooled metal mirrors as first viewing surfaces.
- Intermediate in-vacuum lenses to field light to immersion tube.



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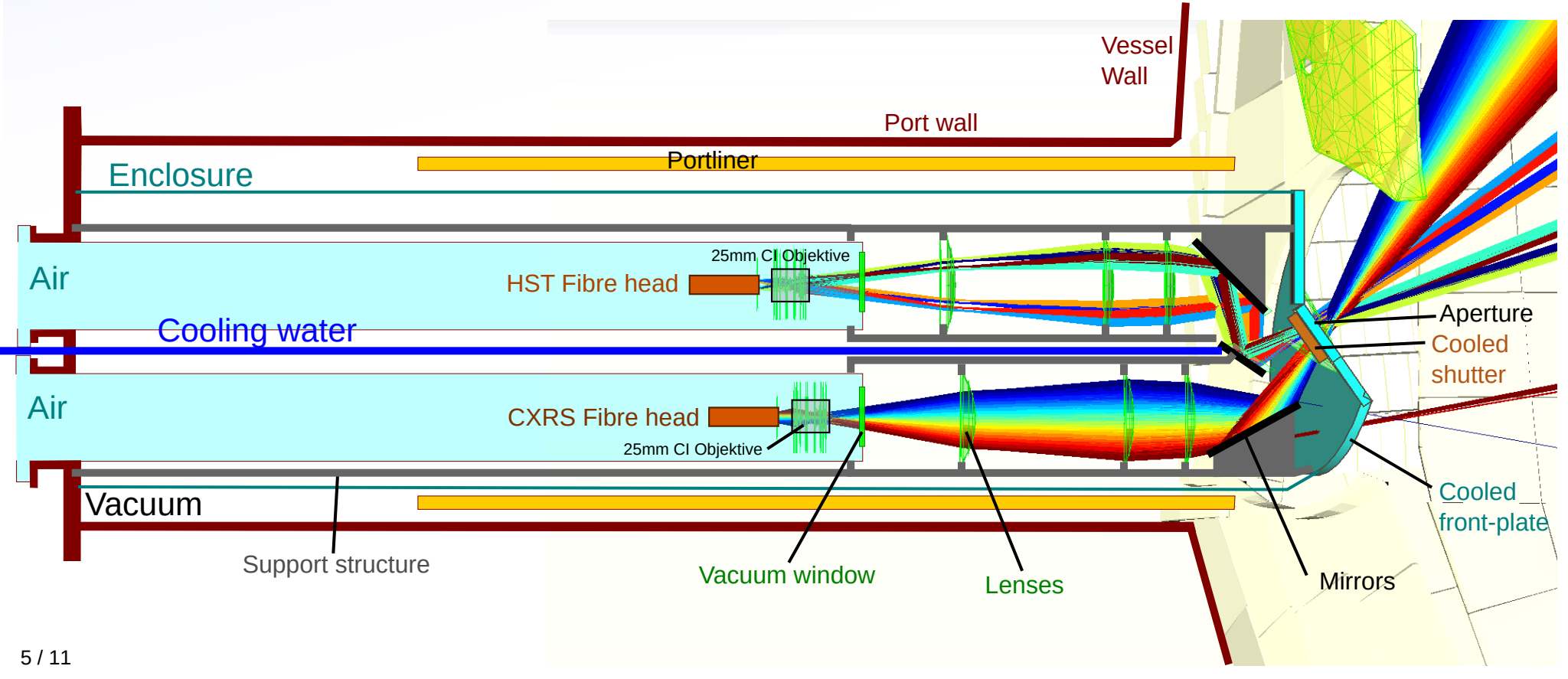
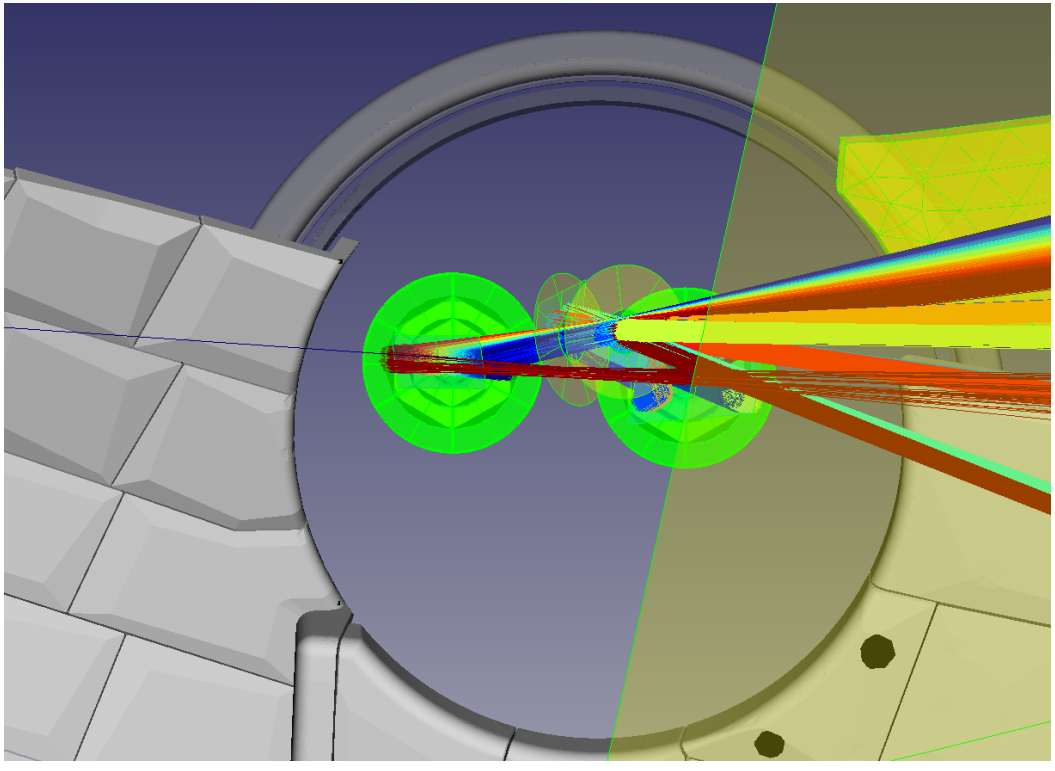
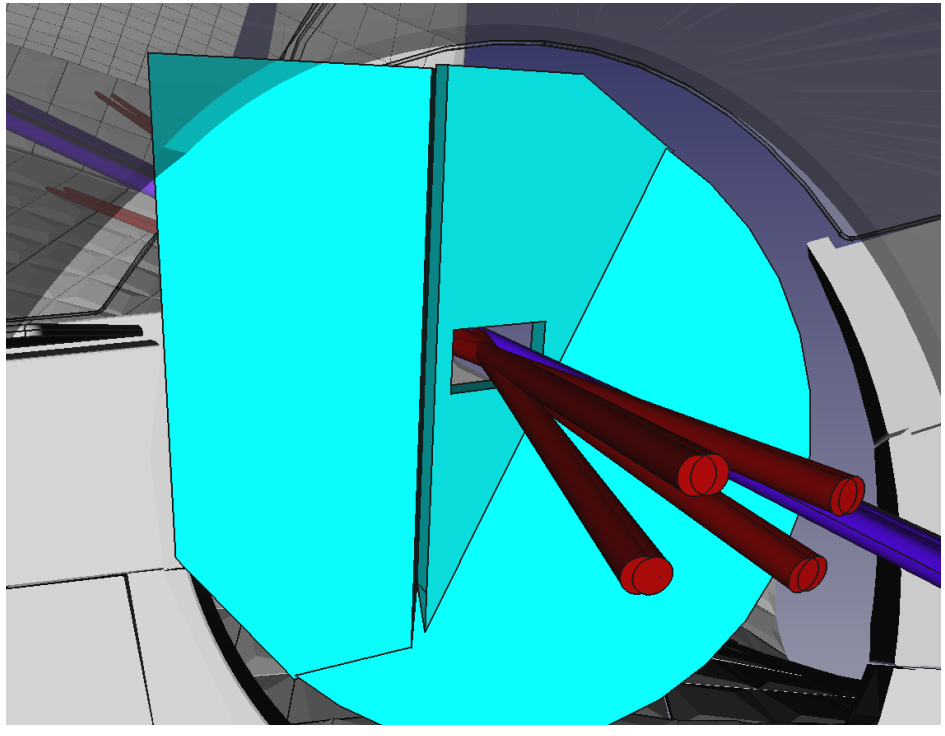


Space usage

Concept:

- Optical systems parallel to port axis for simplicity.
- Use relatively small fraction of port - space available for shutter.
- Small ~3cm aperature shared by both systems.

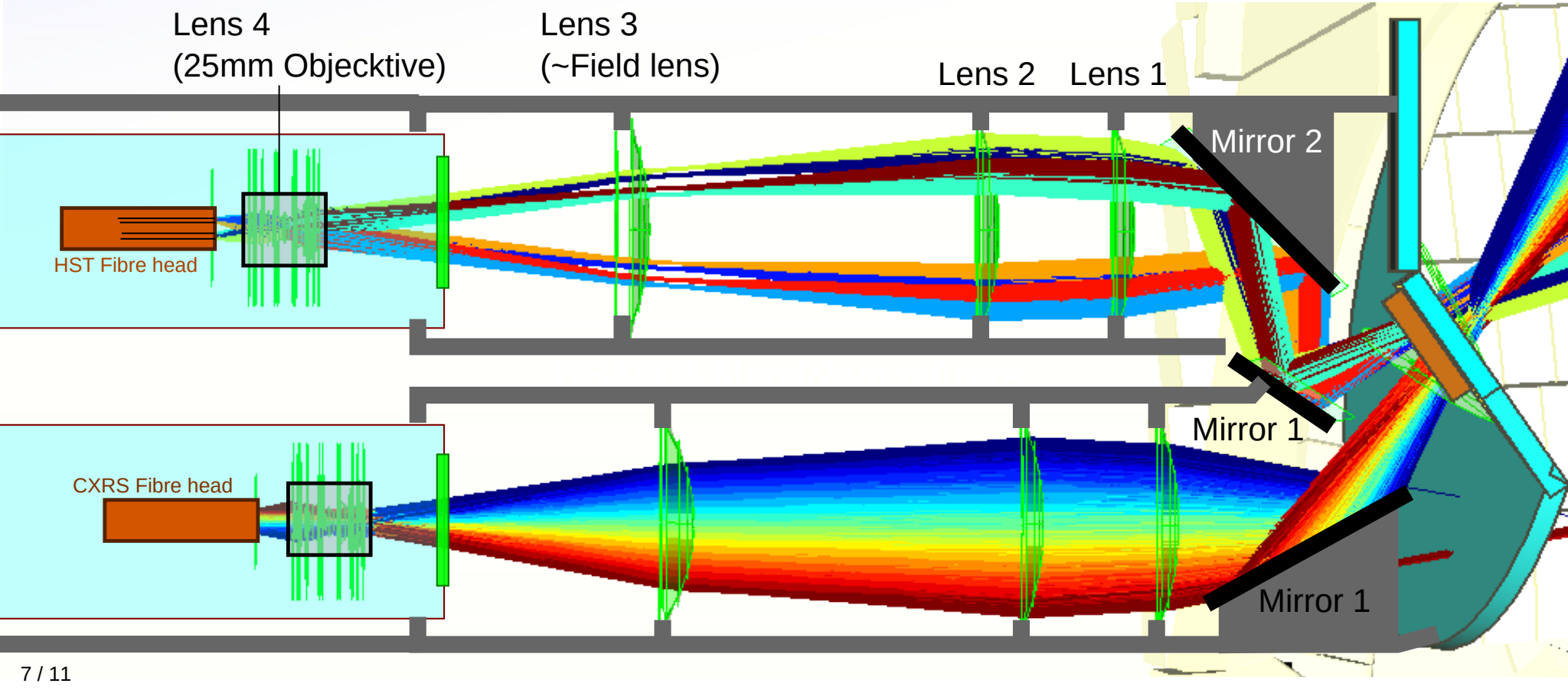




Optical design

Optical design:

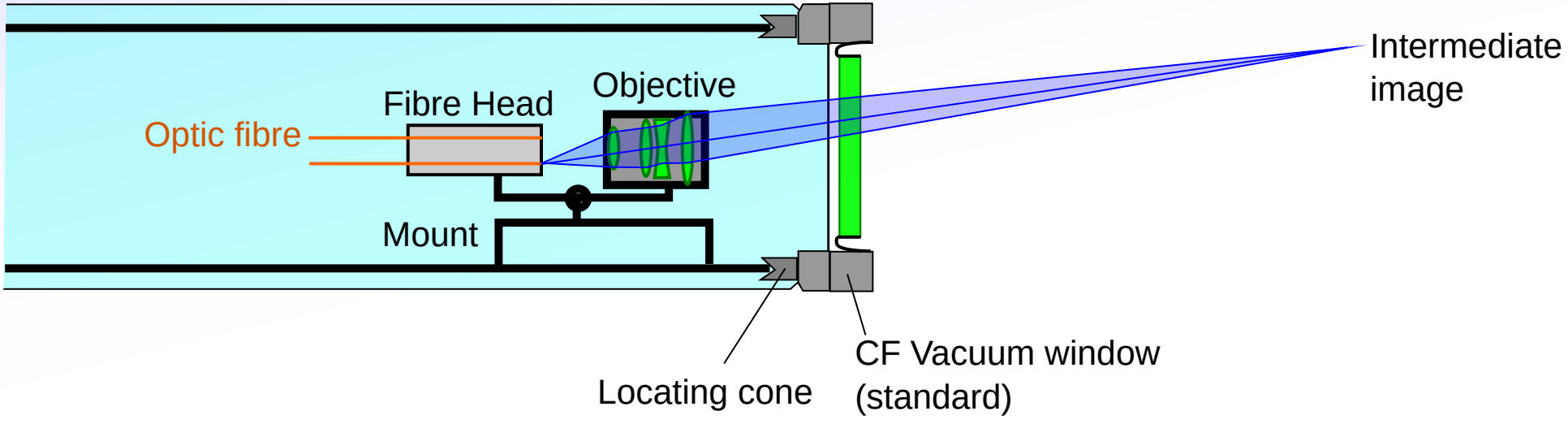
- Wide field of view using small aperture --> Large or close collecting optics.
- Simple flat metal mirrors as first surface to handle heat load (Soft-X, UV etc).
- Large/close in-vacuum collection and field lenses to avoid need for large vacuum window.
- Small vacuum window and short focal length (high-power) lens in air.
  Most focusing power in objective lens --> Less sensitivity to positioning of M1-2, L1-3

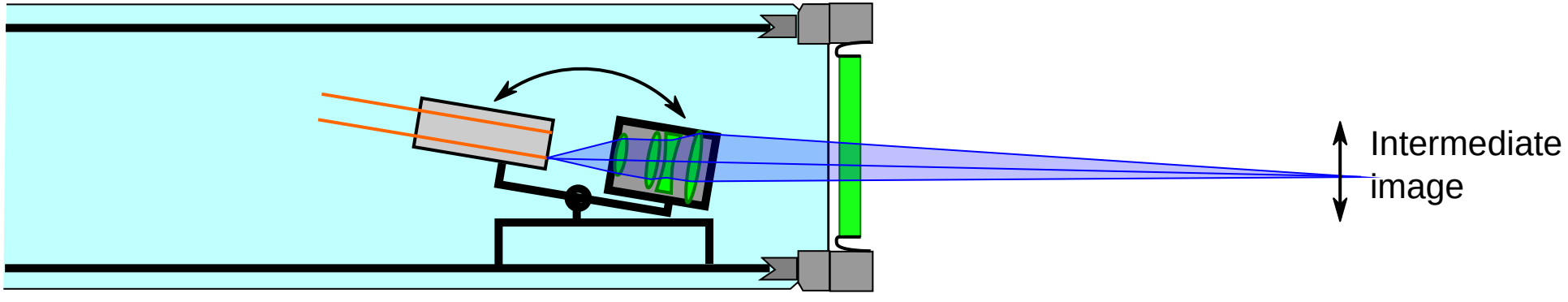


Optical design

Optical design:

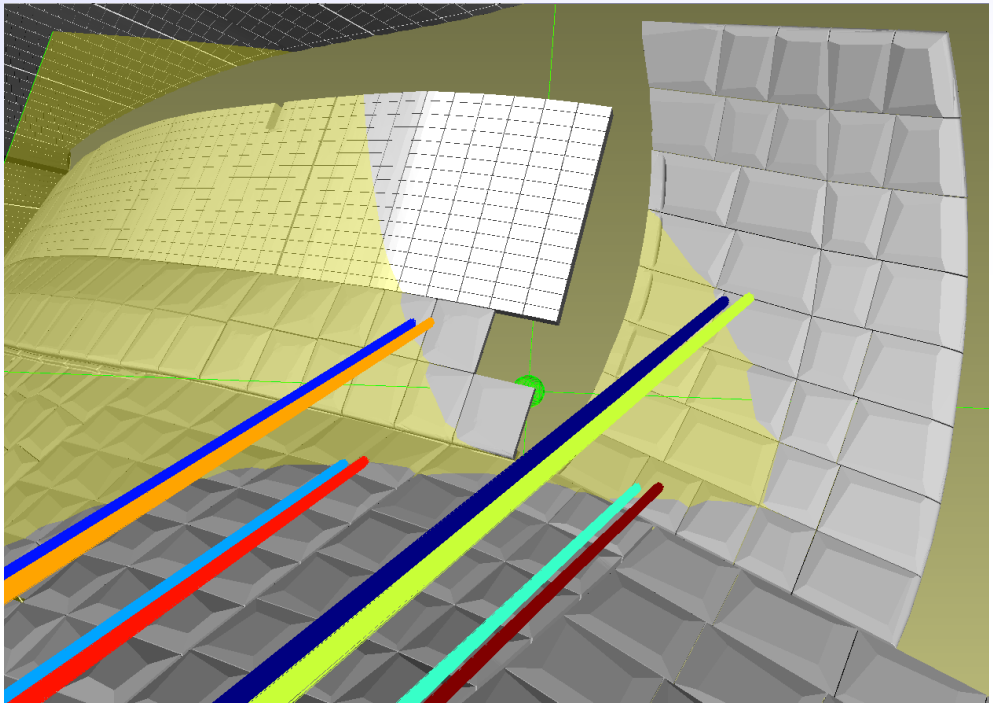
- Final lens and fibre head in air-side on plug-in carriage.
- Small fine adjustment stage with piezzo-motor control for remote steering of HST.

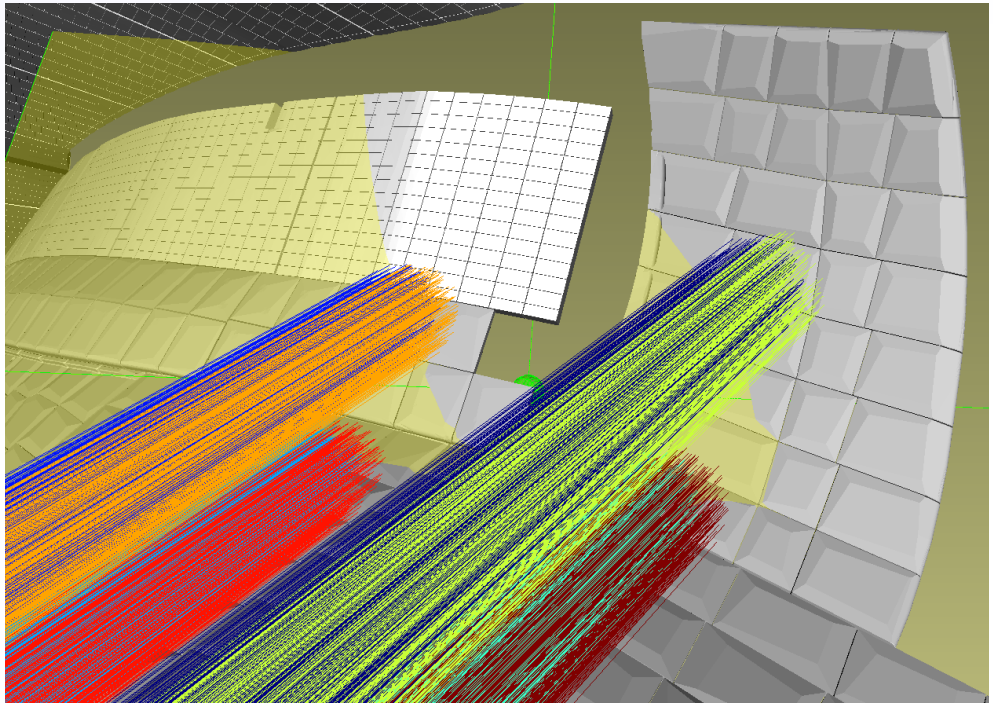




Defocus HST

- Measuring a single facet of a single tile can be misleading.
- HST will be defocused by moving the fibres in the fibre head.





- Extra neighbour fibres for each beam dump fed to scientific (non-safety) measurements.
  --> Low-T measurements to aid calorimetry.
- Defocusing gives almost same area for scientific and safety measurements.

ECRH stray radiation

ECRH stray radiation considerations:

- Enclose all in-vacuum components in sheet metal tube.
- Only ECRH through ~3cm aperture for ~20s (during NBI operation).
- Lenses from fused silica not BK7. (BK7 has 10x shorter absoption depth).
- Some conductive coupling of lenses with cooling to front-plate/mirrors.
- ITO coating not desired on HST system due to possible inference with IR measurement.
- Can add an AlTiO5 absorber on cooling structure to reduce stray radiation in the enclosure.