



# Tangential phase-contrast imaging diagnostic for JT-60SA

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WPSA New Enhancements kick-off meeting, 3.6.2024

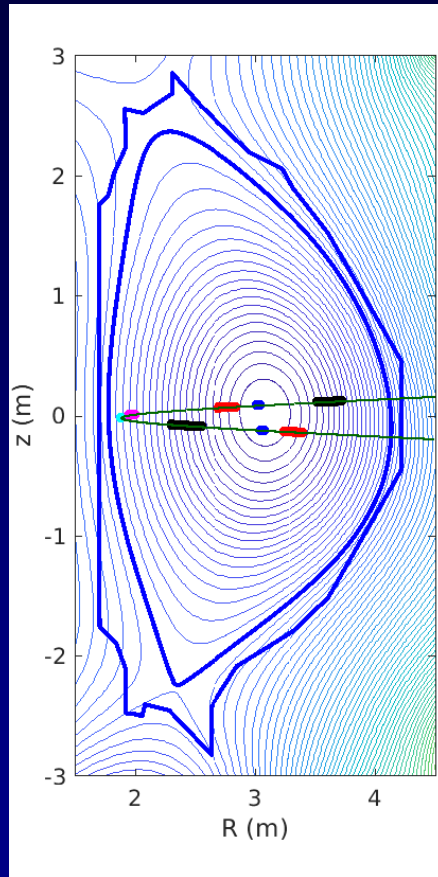


This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.



- Will provide localized density fluctuation measurements across the minor radius and in all plasma regimes
  - $\delta n/n \sim 10^{-5}$ ,  $0.06 < k\rho_i < 12$  (ITG/TEM/ETG)
  - high spatial resolution in the center and at the edge (very favorable configuration on JT-60SA)
- First real opportunity to study turbulence and turbulent transport, **and validate models**, in a reactor-grade device
- Gyrokinetic modelling support proposed in parallel, with comparisons mediated by a synthetic diagnostic (ongoing GENE work)
- Europe/NIFS collaboration, with Japanese funding (JSPS) already secured

S. Coda et al, Nucl. Fusion **61**, 106022 (2021), DOI:10.1088/1741-4326/ac2081



- While well-localized in  $\rho$ , at mid-radius the measurement picks up signal from both the HFS and LFS
- HFS and LFS can be resolved separately by doubling the detection system (splitting the transmitted beam to create two separate images)



- Beam generation
  - CO<sub>2</sub> laser of ~60-100 W power
  - Beam expansion by telescopic arrangement
  - Relay mirrors all off-vessel (max 32-cm diameter)
- Vacuum interfaces
  - ZnSe windows
- Beam collection
  - Relay mirrors all off-vessel (max 45-cm diameter)
  - Reflective-refractive focusing and imaging system:  
**must be close to vessel since scattered components diverge rapidly**



- Neutron + gamma shielding, fire-safety beam shielding planned
- Automated LN<sub>2</sub> cooling included in design
- Mechanical vibrations are **not** a cause for concern.  
DIII-D and TCV have optics mounted on vessel and feedback focusing system counteracts vibrations very effectively

# Cost split and budget

Cost split (roughly equal) with K. Tanaka (NIFS), recipient of JSPS grant

- NIFS will provide
  - detectors (multiple, recycled from LHD)
  - LN2 generator and fueling system (purchased, under test at NIFS)
  - neutron and  $\gamma$  shielding (partly ordered)
  - ADCs
- F4E will provide (estimated budget 360 k€)
  - optics and mounts (around torus hall + on optical table)
  - vacuum windows
  - optical table
  - CO2 laser with associated chiller
  - mechanical supports



- Detailed mechanical and optical design (including all mirror boxes, supports, tubing, etc.) well underway, to be completed in 2024
- Final costing being finalized with detailed quotes along with design
  - Budget sharing between NIFS and Euratom
  - Procurements have begun on the NIFS side (LN2 filling station, radiation shielding)
  - NIFS is also proposing reuse of LHD equipment (detectors, etc.)
- First full design review envisioned by September
- **European procurements can start immediately afterwards. It is possible and desirable to install and commission in M/E-1**
- Hiring of dedicated staff will be required
  - 1-2 postdocs and/or 1-2 Ph.D. students envisioned (Europe/NIFS)

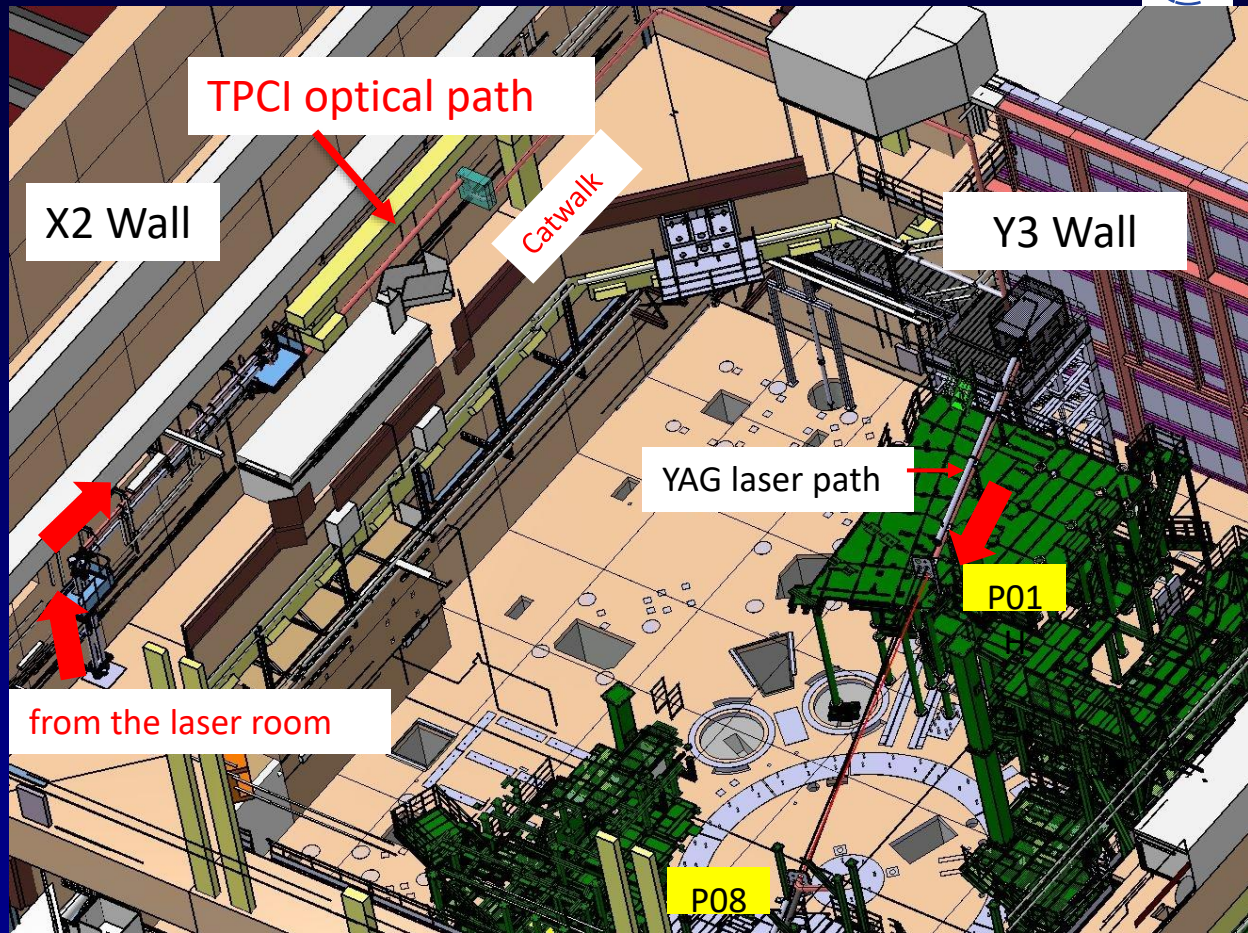


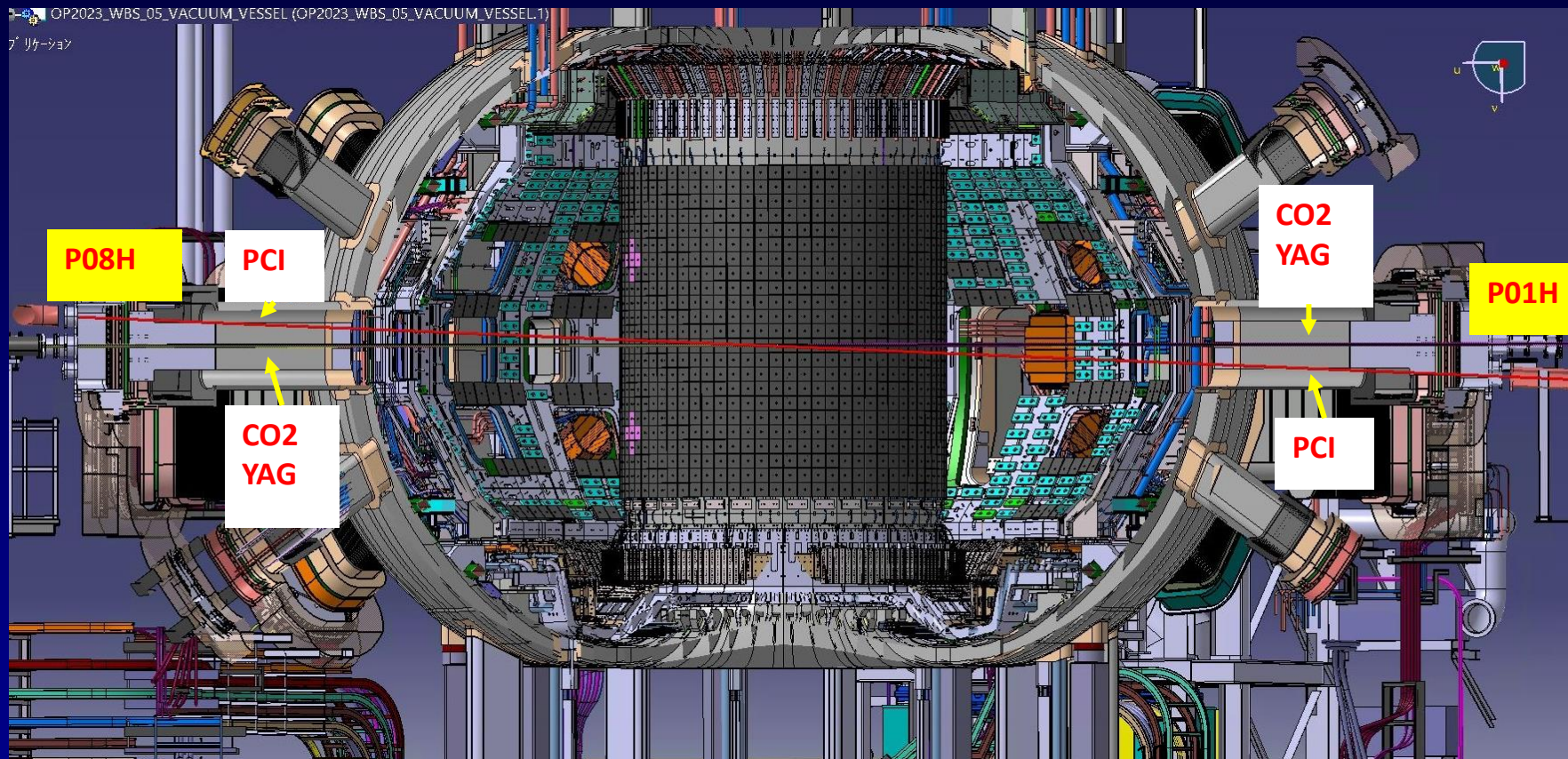
- Initial evaluation: based on
  - projected radiation rates (e.g.,  $\sim 1 \times 10^{21}$  neutrons/year in integrated research phase)
  - resulting neutron and  $\gamma$  rates at the detection point
  - estimated thresholds (lifetime-integrated) for equipment tolerance
- This led to the decision to initially plan for the same shielding used on the LHD PCI system, namely, 10 cm of polyethylene and 1 cm of lead
- This appears borderline to avoid eventual damage but was driven by the need to proceed with purchases on the NIFS side – still, augmentations remain possible
- MCNP analysis now being performed by F4E



# Current layout

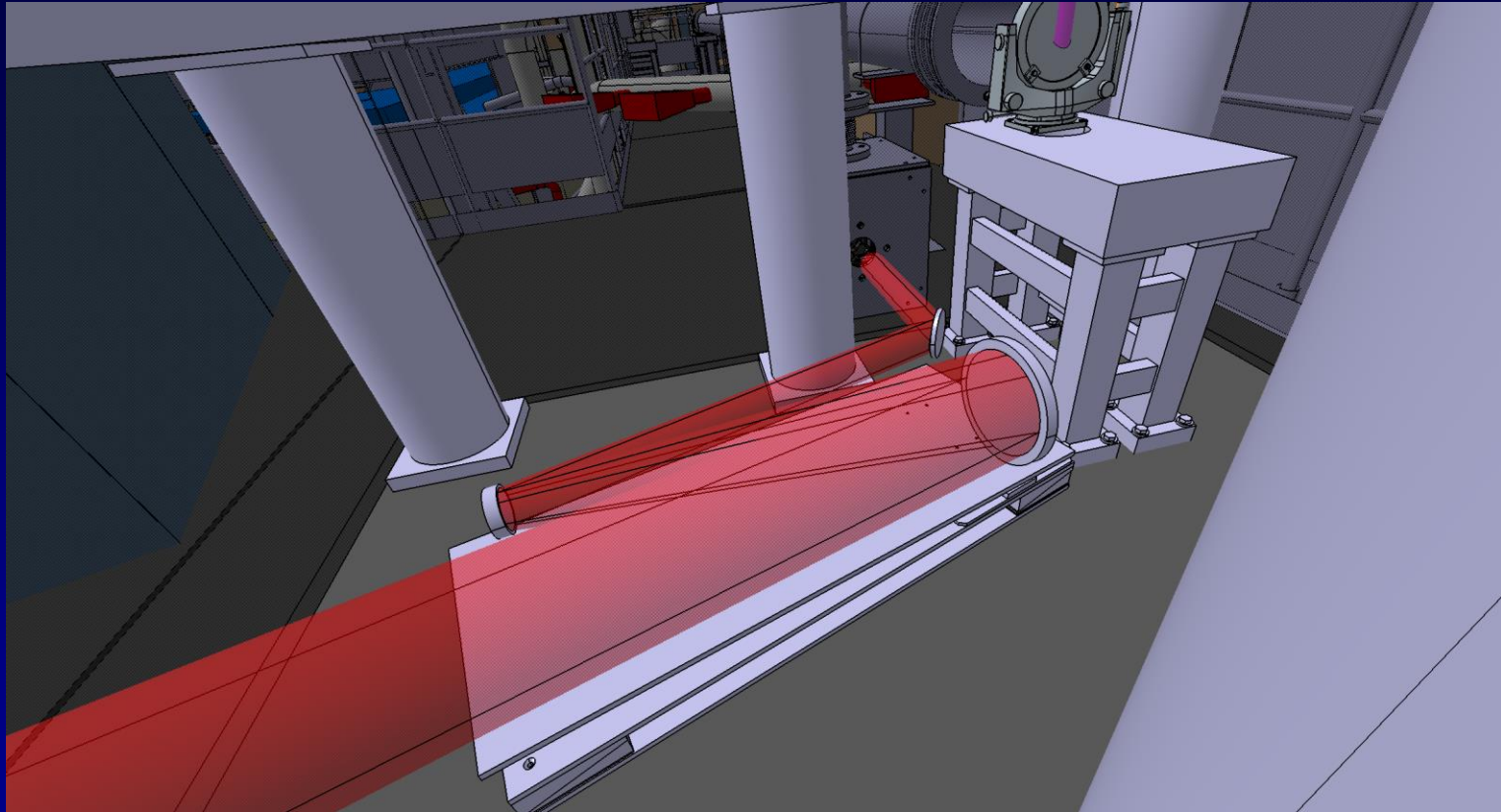
- QST requested to avoid upper stage, and to keep laser system outside torus hall for easier maintenance
- Data acquisition in basement: reduced radiation
- Conservative design, hugging the walls to avoid conflicts with cranes and other structures





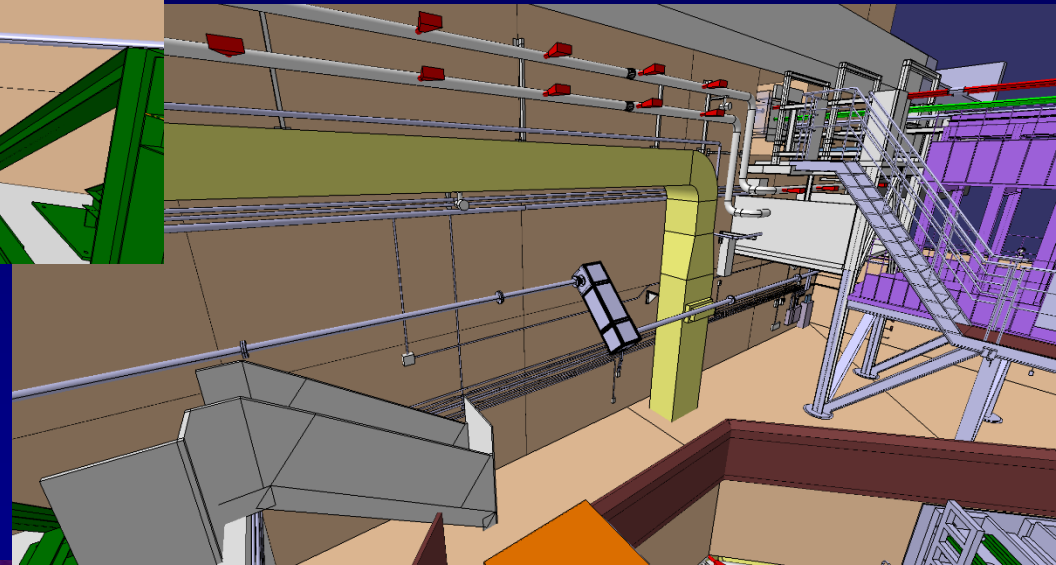
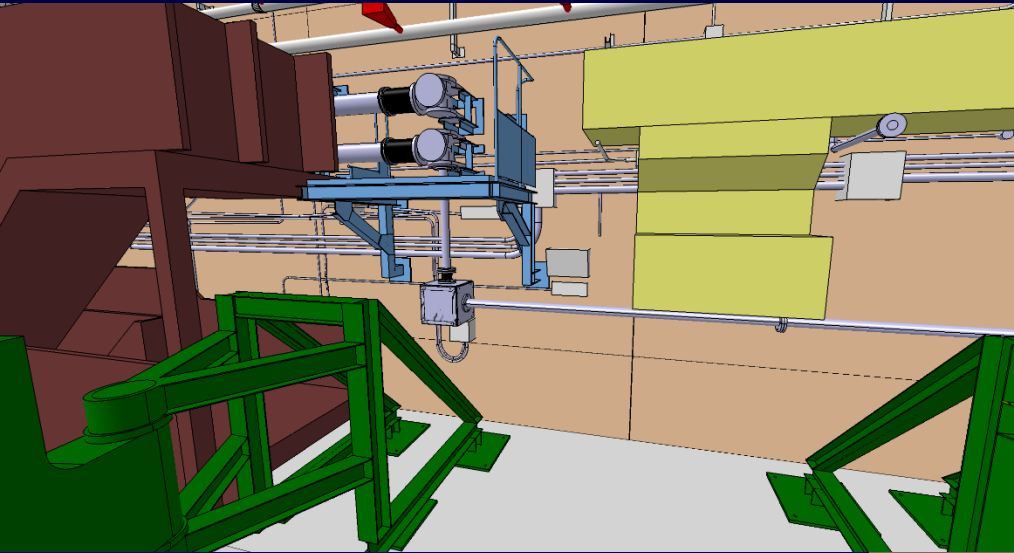


## Beam expander



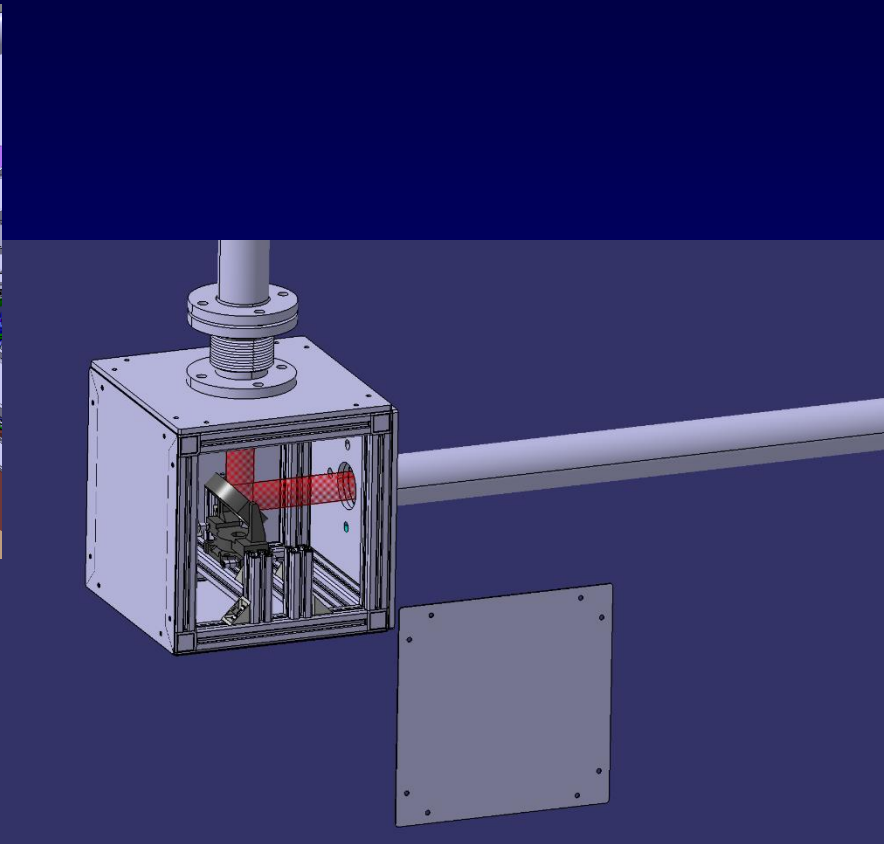
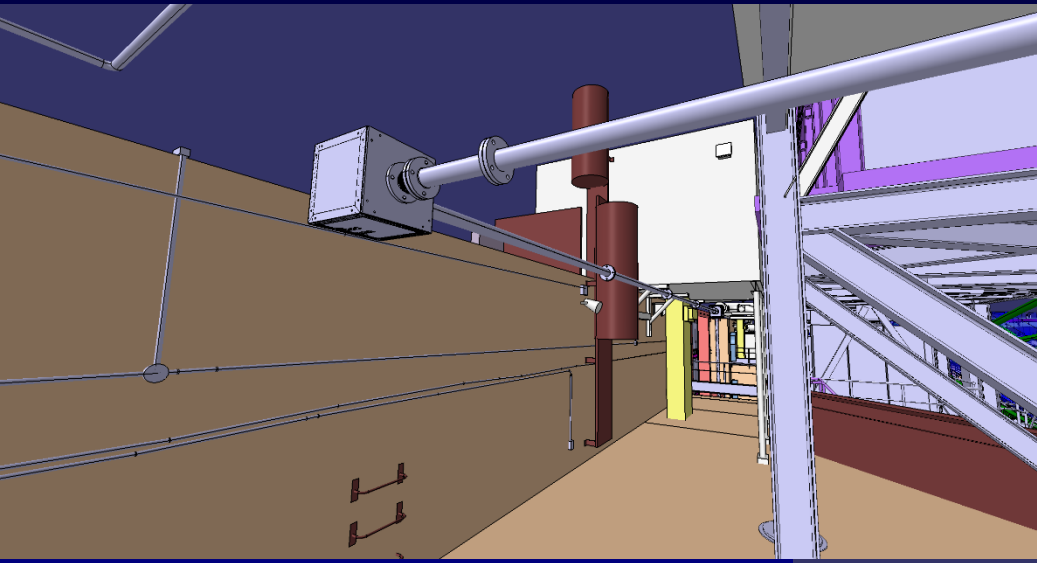


## Mirror supports



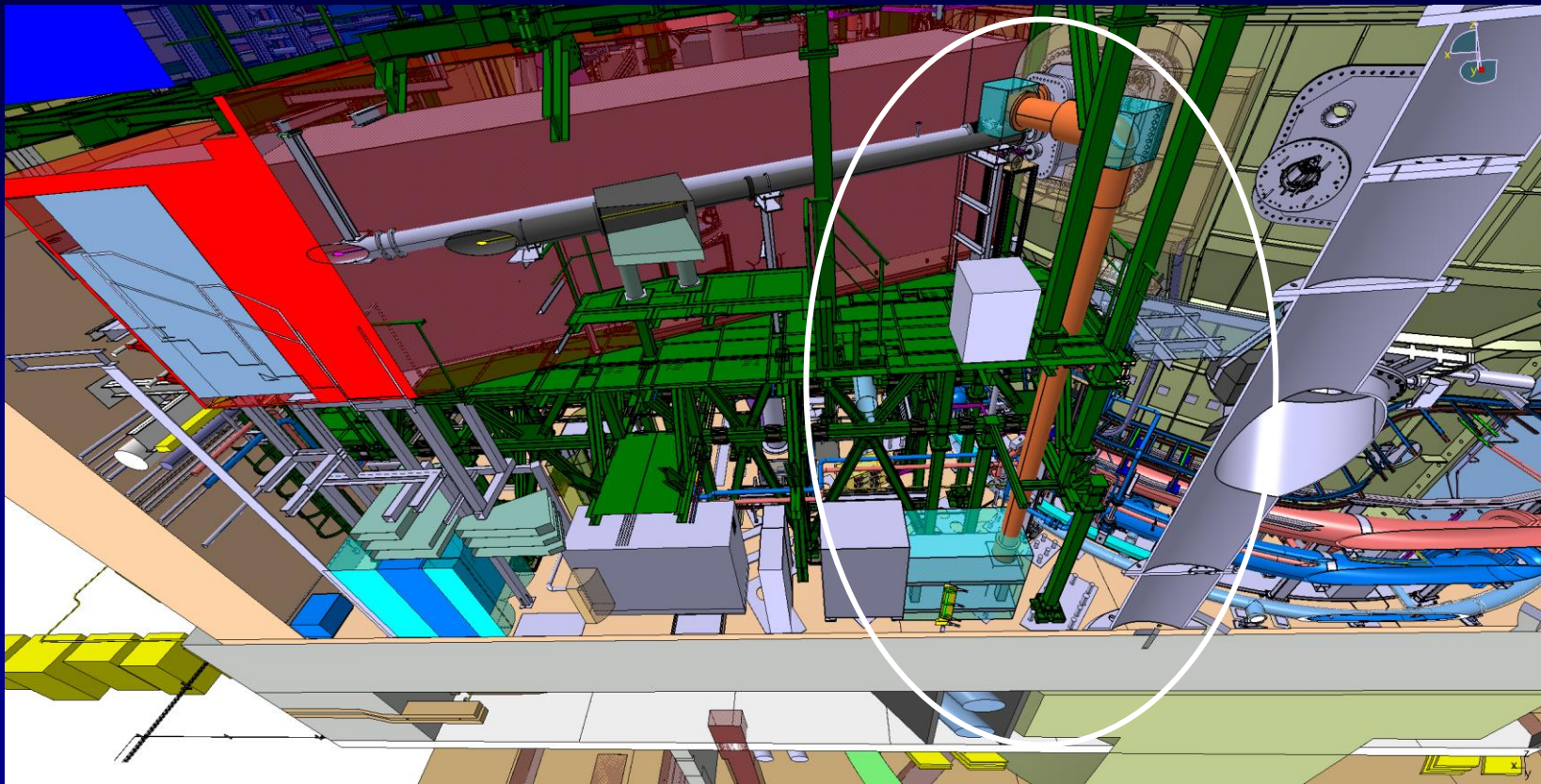


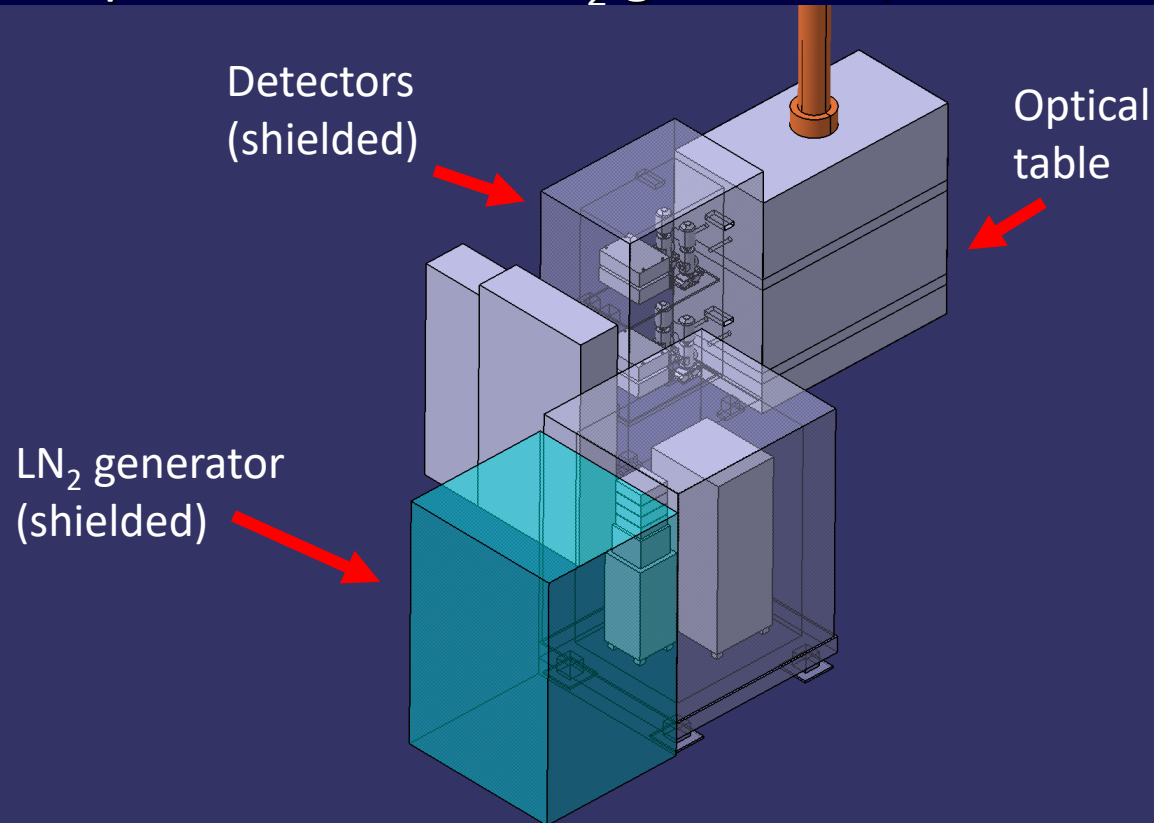
## Mirror supports



# Mechanical design

## Exit port and optical table



Optical table and LN<sub>2</sub> generator, with shielding



- If it is agreed that procurements will originate from EPFL, a 30% overhead is expected to apply (similarly to ITER, to be confirmed for JT-60SA)
- As a reminder, EPFL is currently acting as an institutional partner to ITER, as Switzerland is excluded





- We have at present no major information gaps preventing the completion of the design
- Further questions will be asked if and when they arise
- A visit to QST by S. Coda and M. Noël sometime in September-November would probably be most fruitful to iron out final details