



JT-60SA FILD Update

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and the PSFT, WPSA, F4E and QST Teams

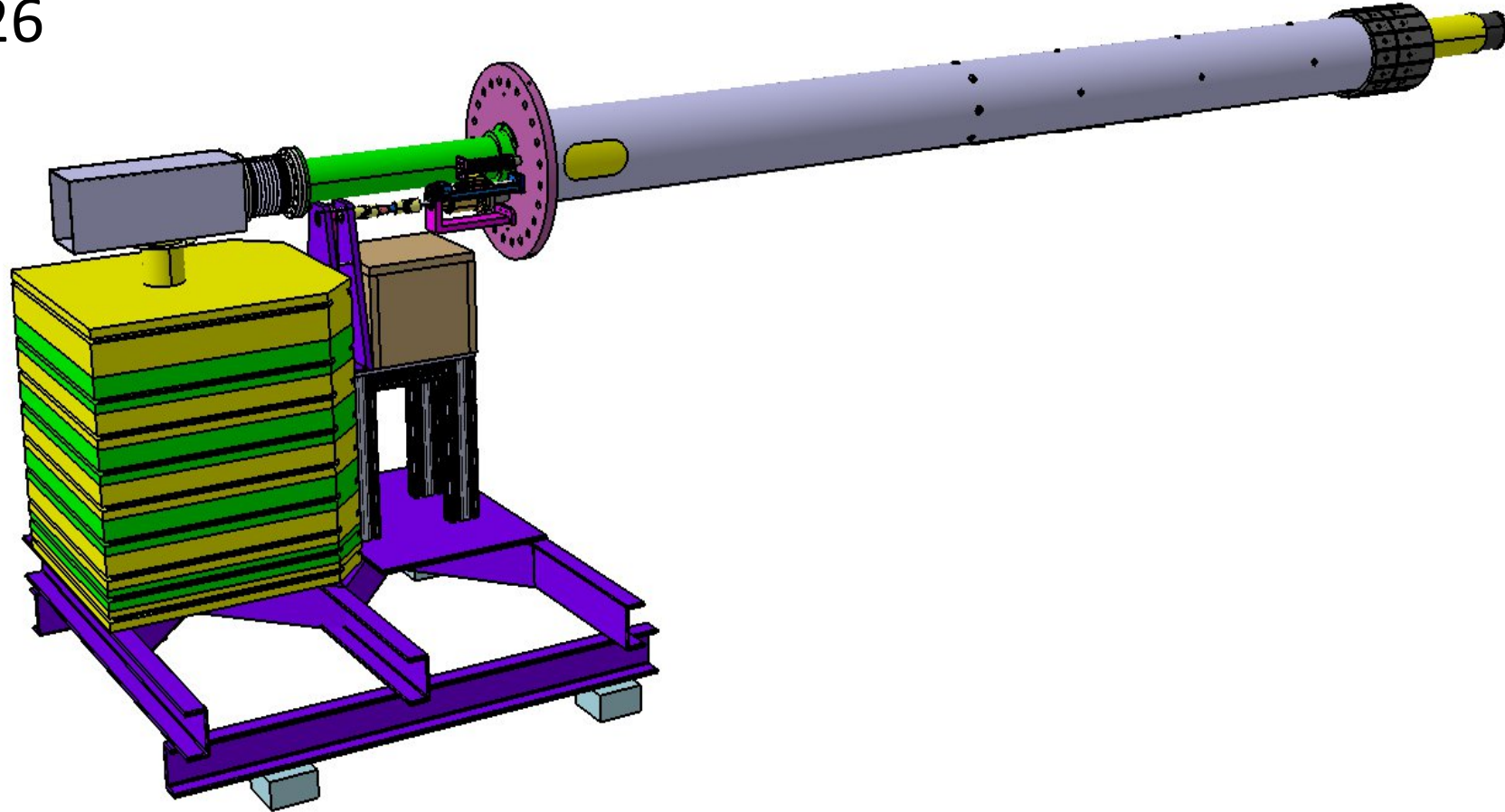


**FUSION
FOR
ENERGY**

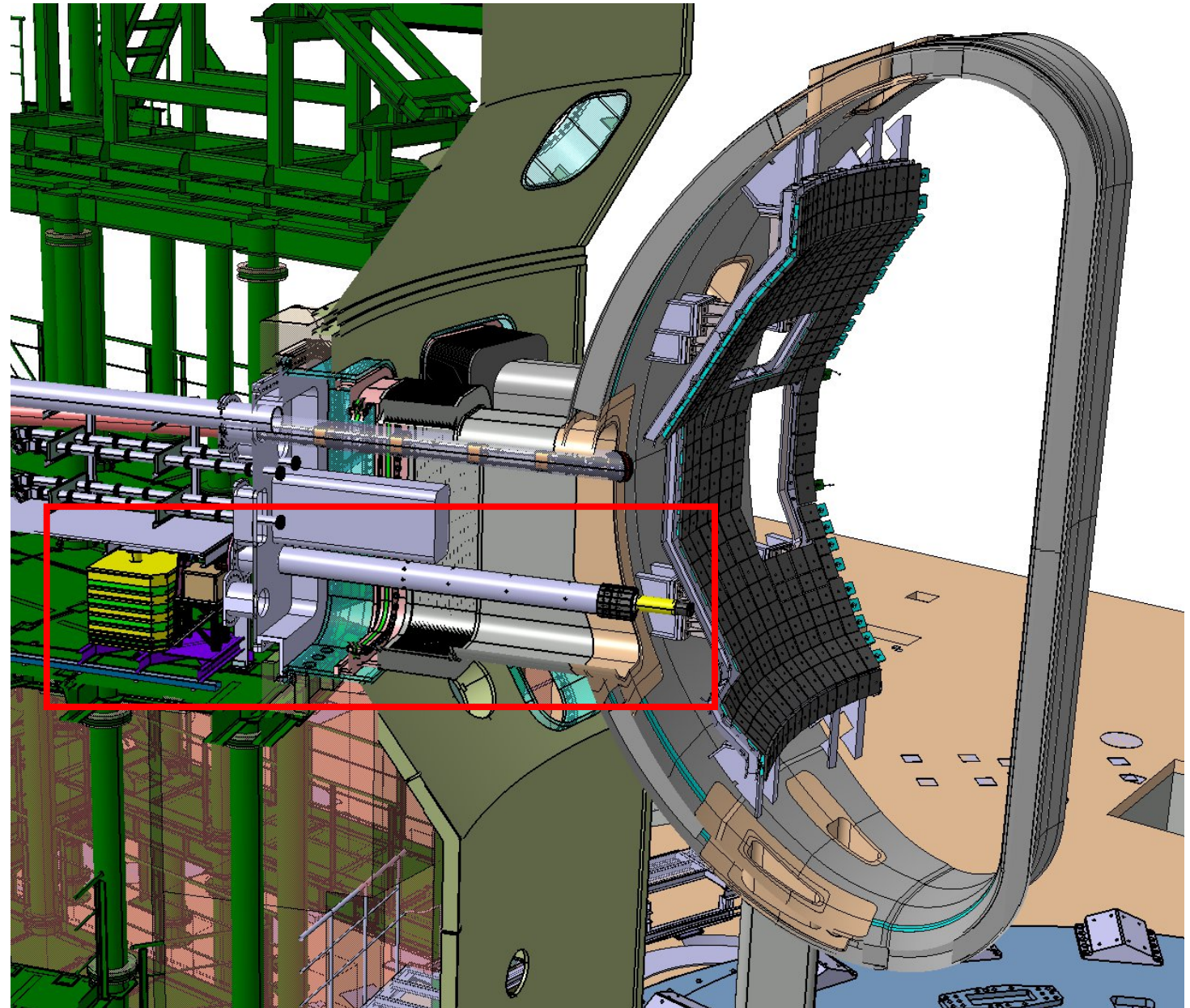


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- FILD status overview
- Progress in design in 2026
 - Driving unit
 - Neutronics assessment
 - Support structure
 - Electronics cabinet
 - Grounding/connection schemes
- Plans for 2027

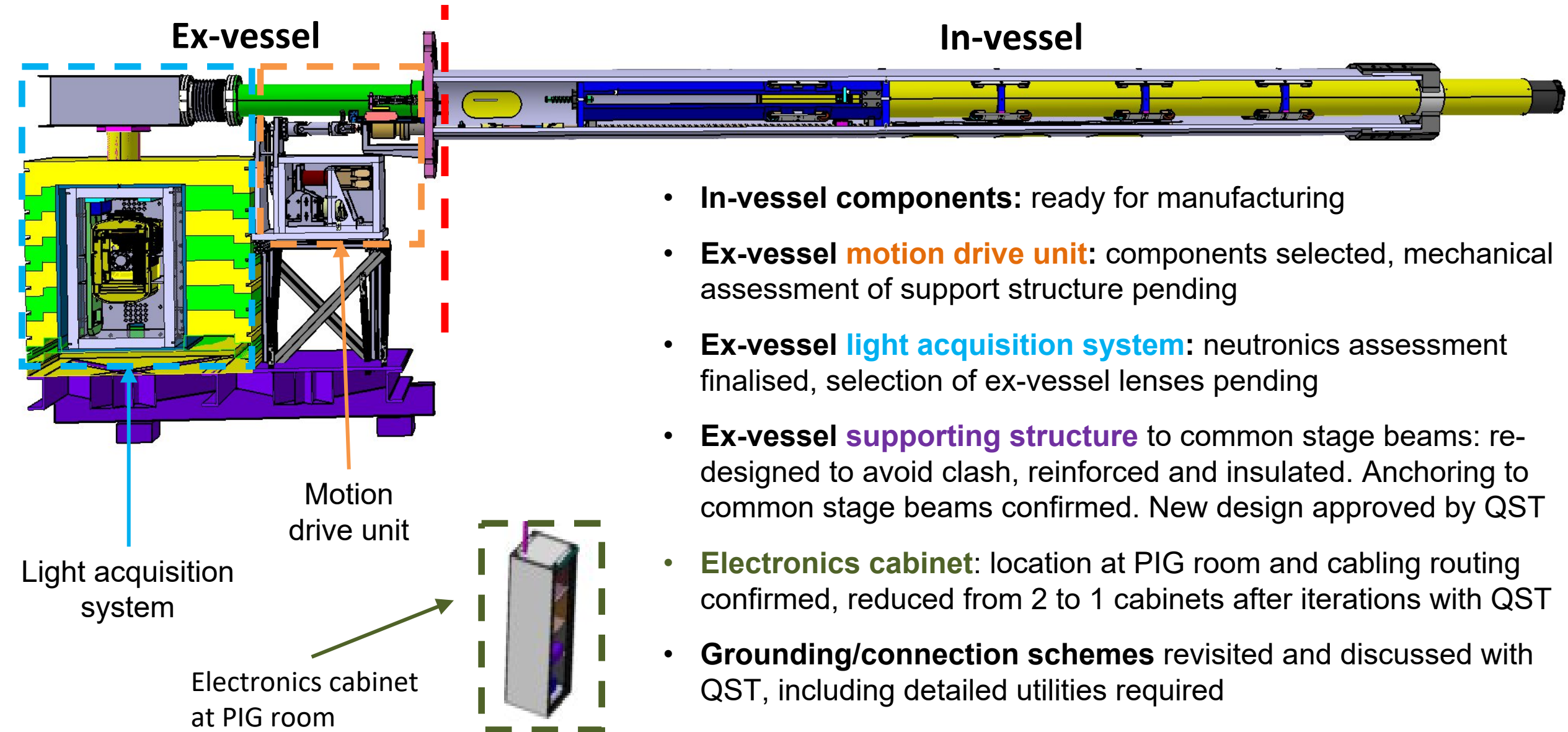


FILD Located At Equatorial Port In Sector 18, Slightly Below Midplane

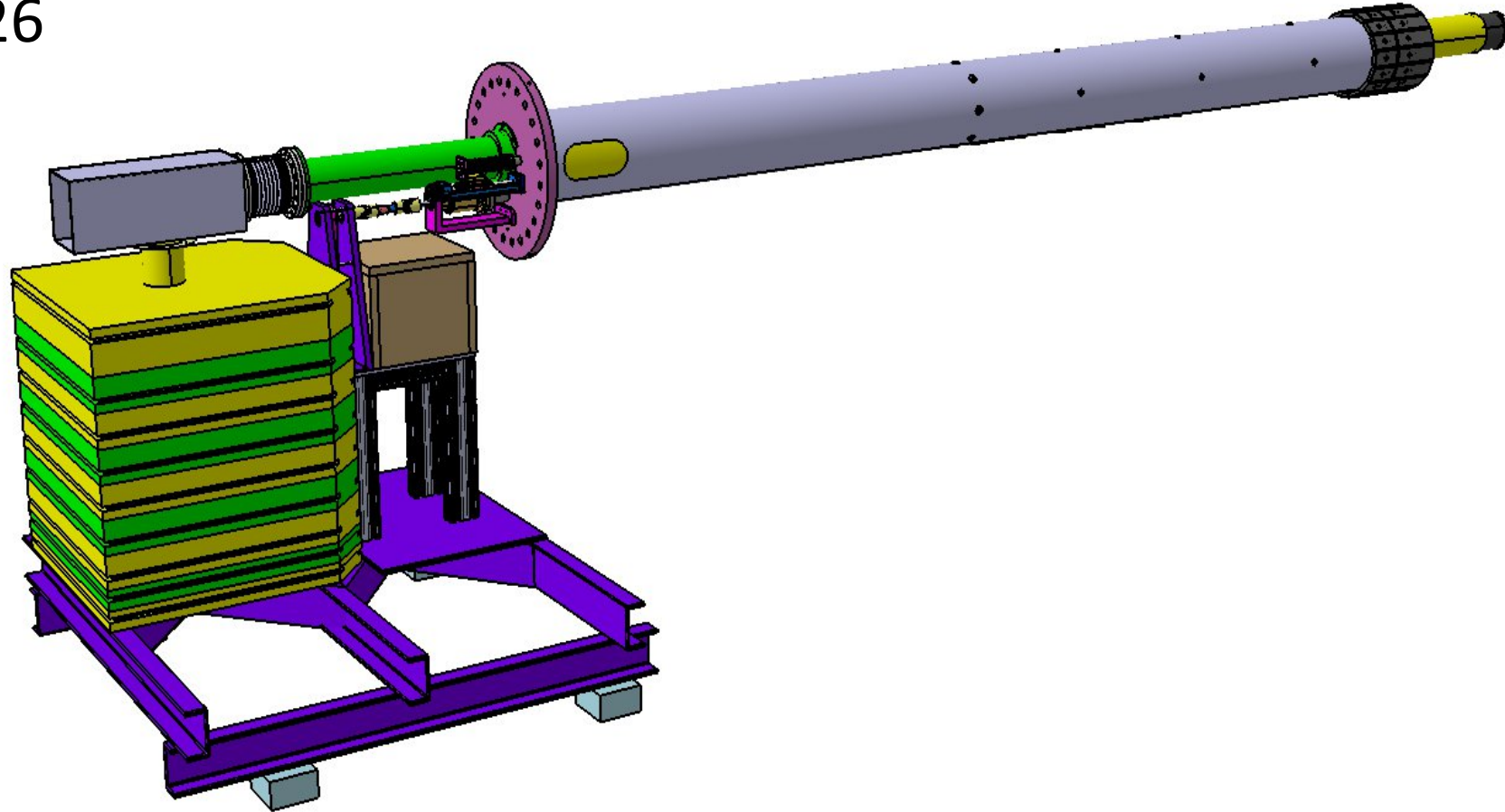




FILD system status overview



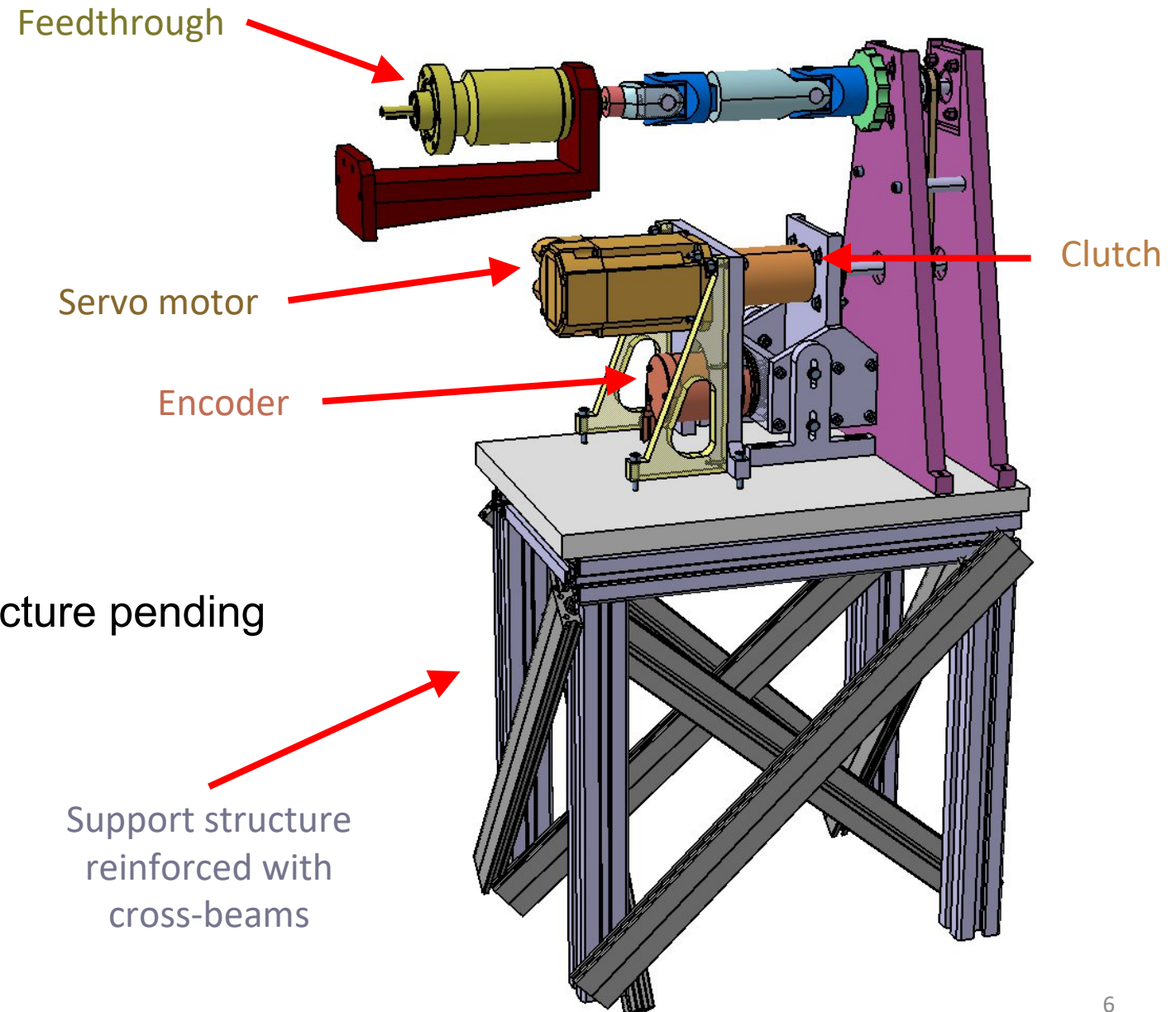
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Ex-vessel driving unit designed in detail, components selected



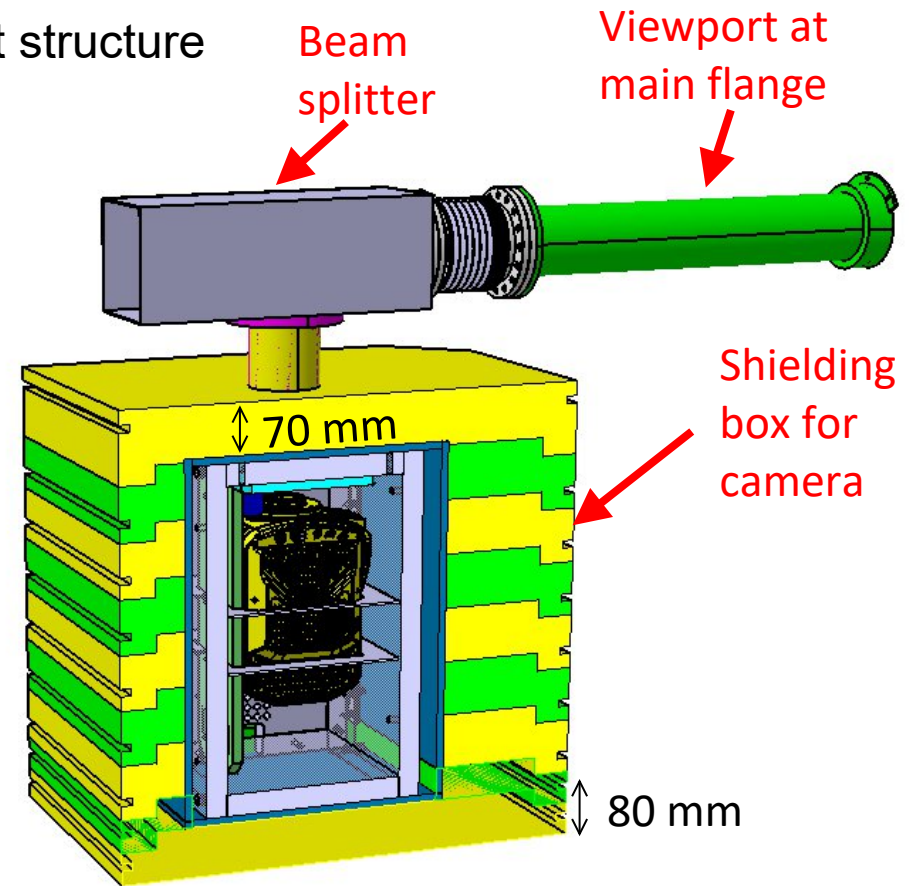
- Detailed design finalised
- Components selected
 - Servo motor
 - Encoder
 - Clutch for torque limiting
 - Servo driver
- Support structure reinforced
- Mechanical assessment of support structure pending



Ex-vessel light acquisition system



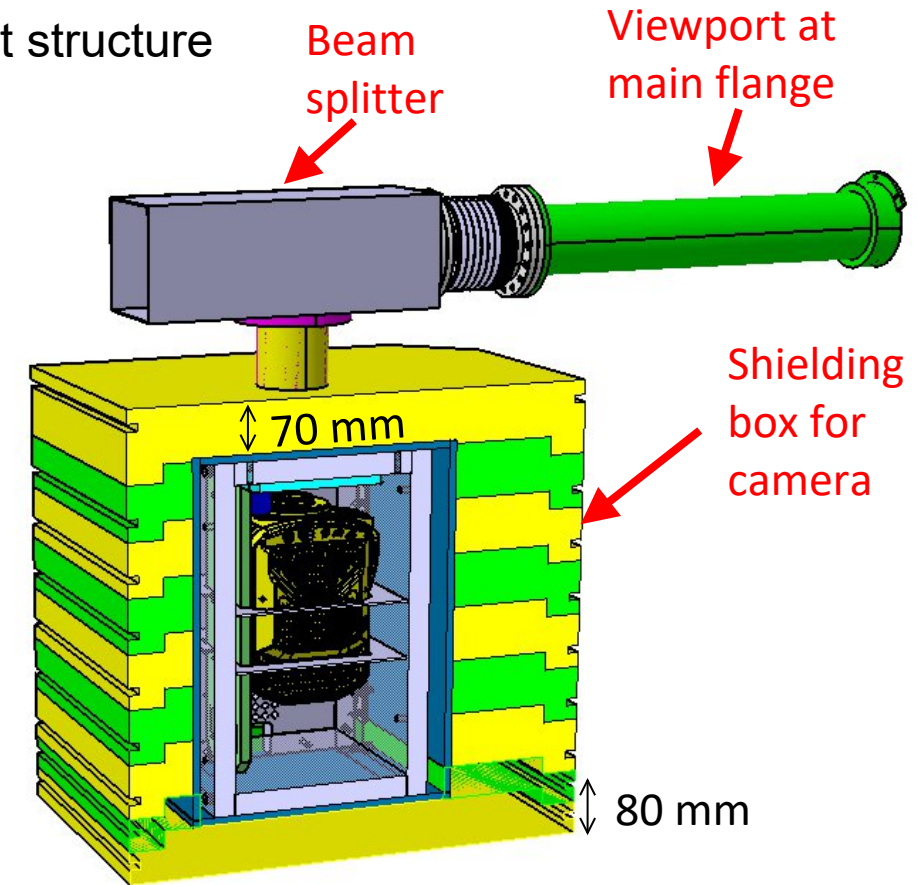
- Shielding box base slightly reduced to accommodate changes in support structure



Ex-vessel light acquisition system



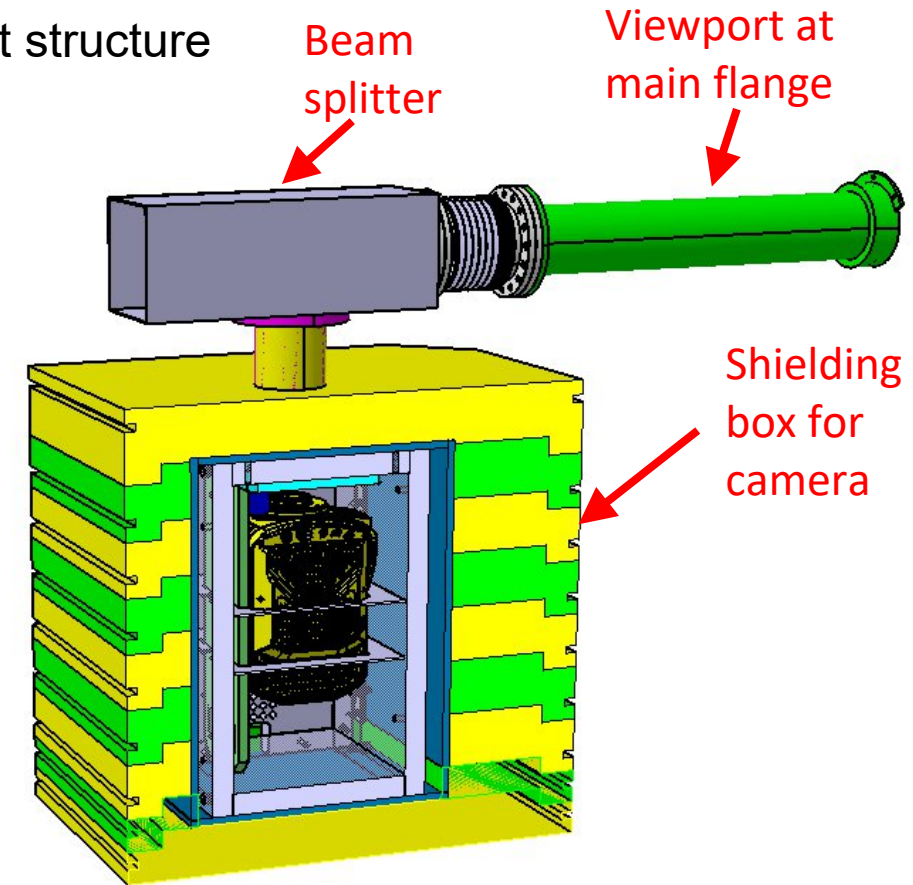
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 - Phantom camera (larger, shown in image)
 - XIMEA camera (smaller)



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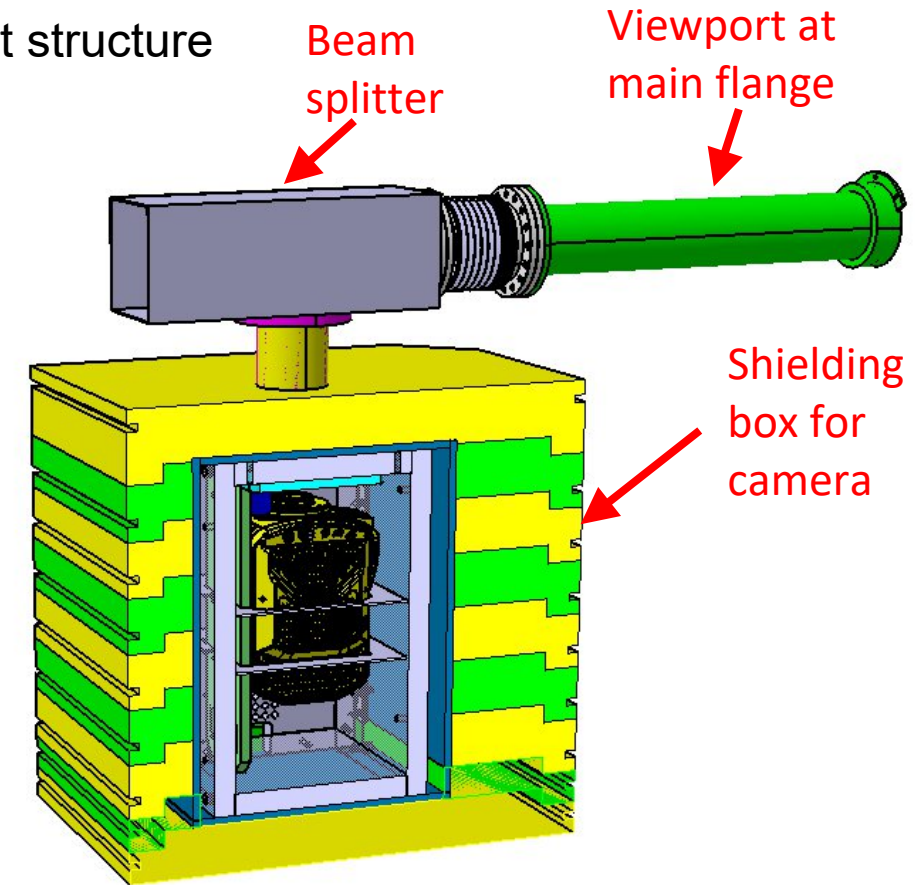


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- Visible camera neutronics assessment finalised



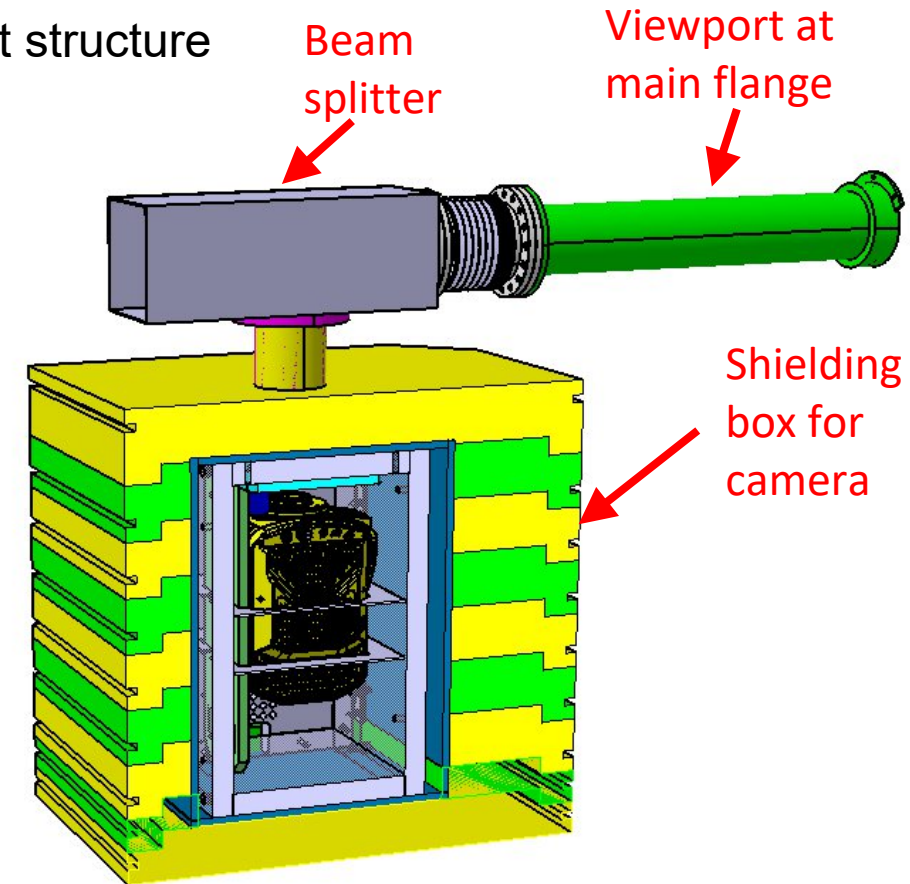
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 - If OP2 neutron budget ($4\text{E}19$ neutrons) was consumed, **predicted total fluence reaching FILD: $5.1312\text{E}10 \text{ neutr}/\text{cm}^2$**



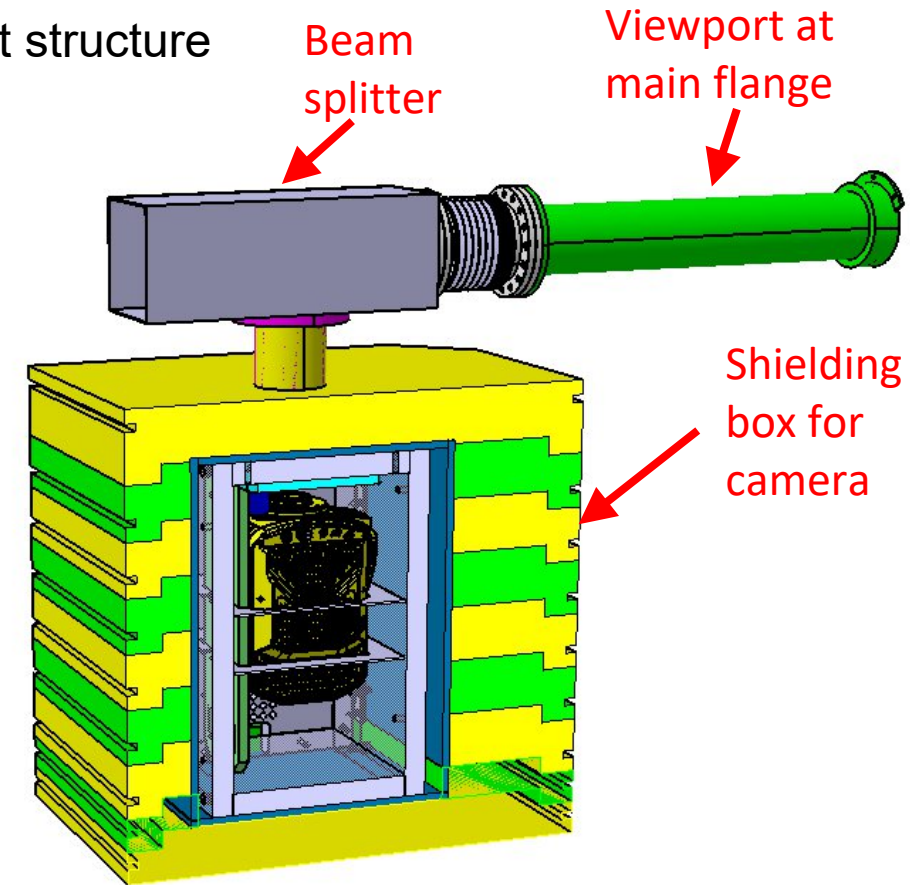
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 - From Fission Chamber, total neutrons produced since XIMEA camera was installed: $8.9\text{E}16 \text{ neutr}$
 - **Fluence received by the XIMEA: $1.5\text{E-}6 \times 8.9\text{E}16 = 1.3\text{E}11 \text{ neutr}/\text{cm}^2$**



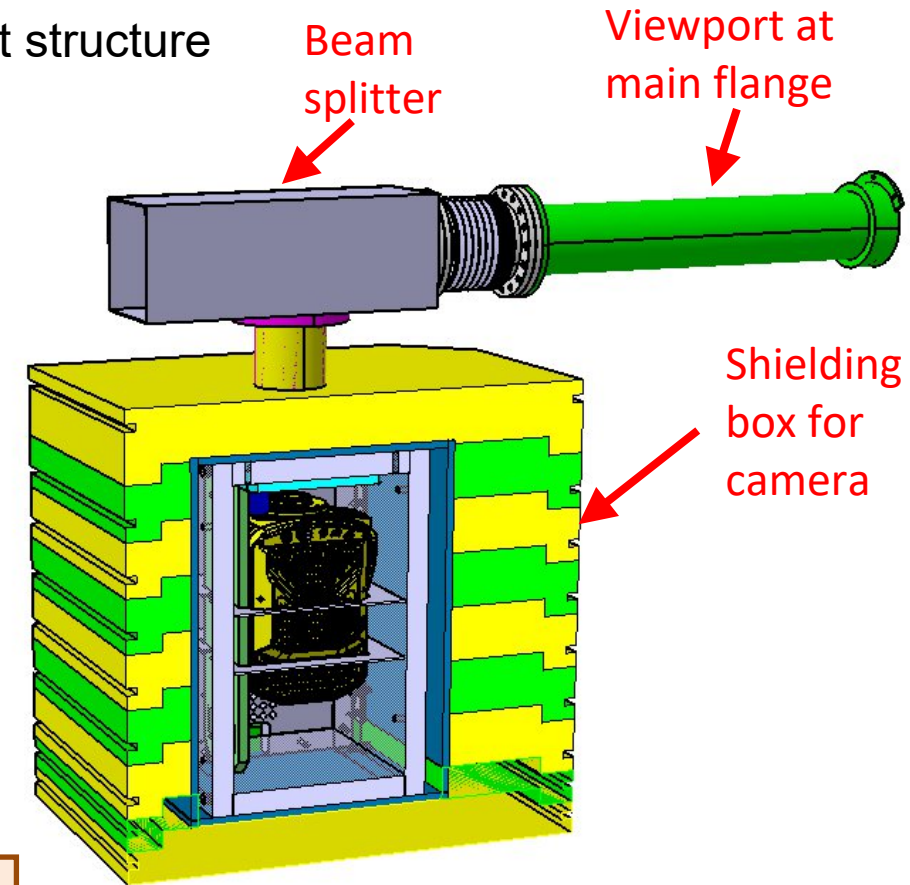
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- ⇒ **Both cameras would perform well for at least 2 campaigns that consumed the full OP2 neutron budget**

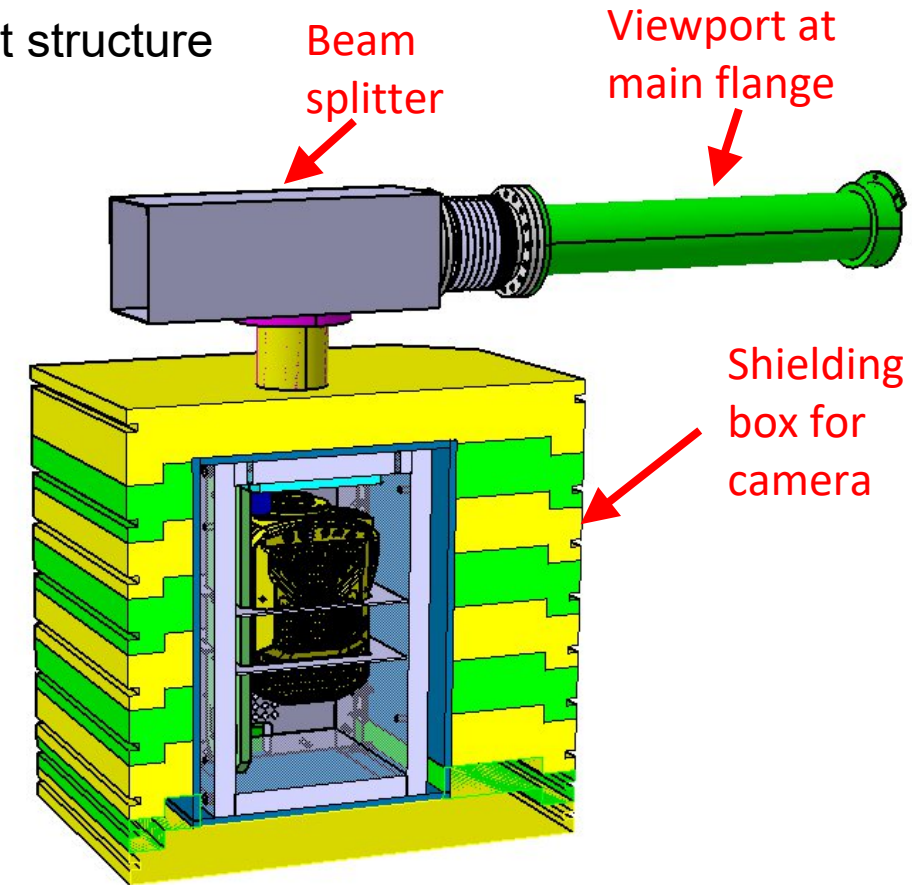


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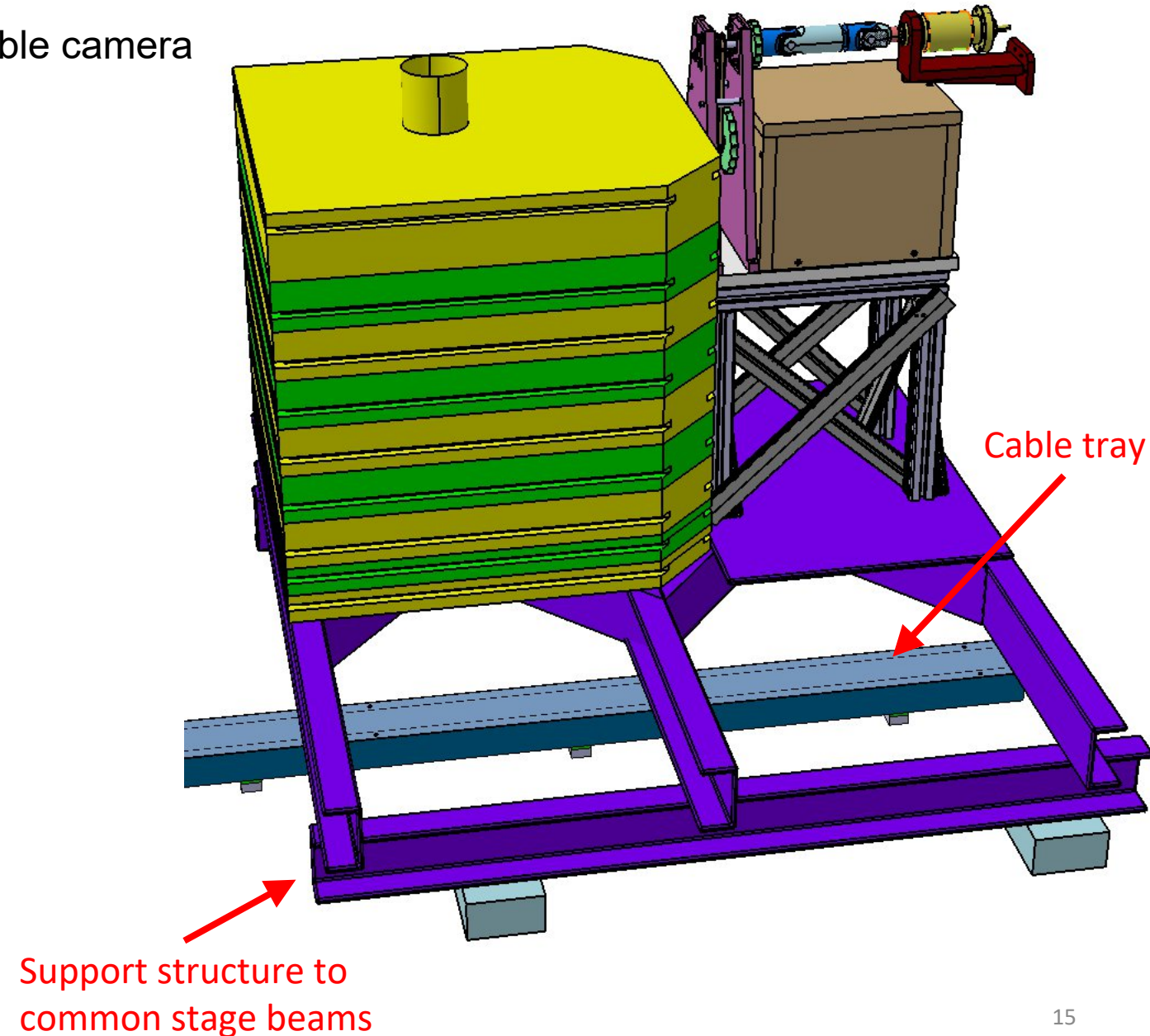
- Design of ex-vessel lenses pending (depends on exact position of beam splitter, camera sensor and PMTs)



Ex-vessel support structure re-designed and approved by QST



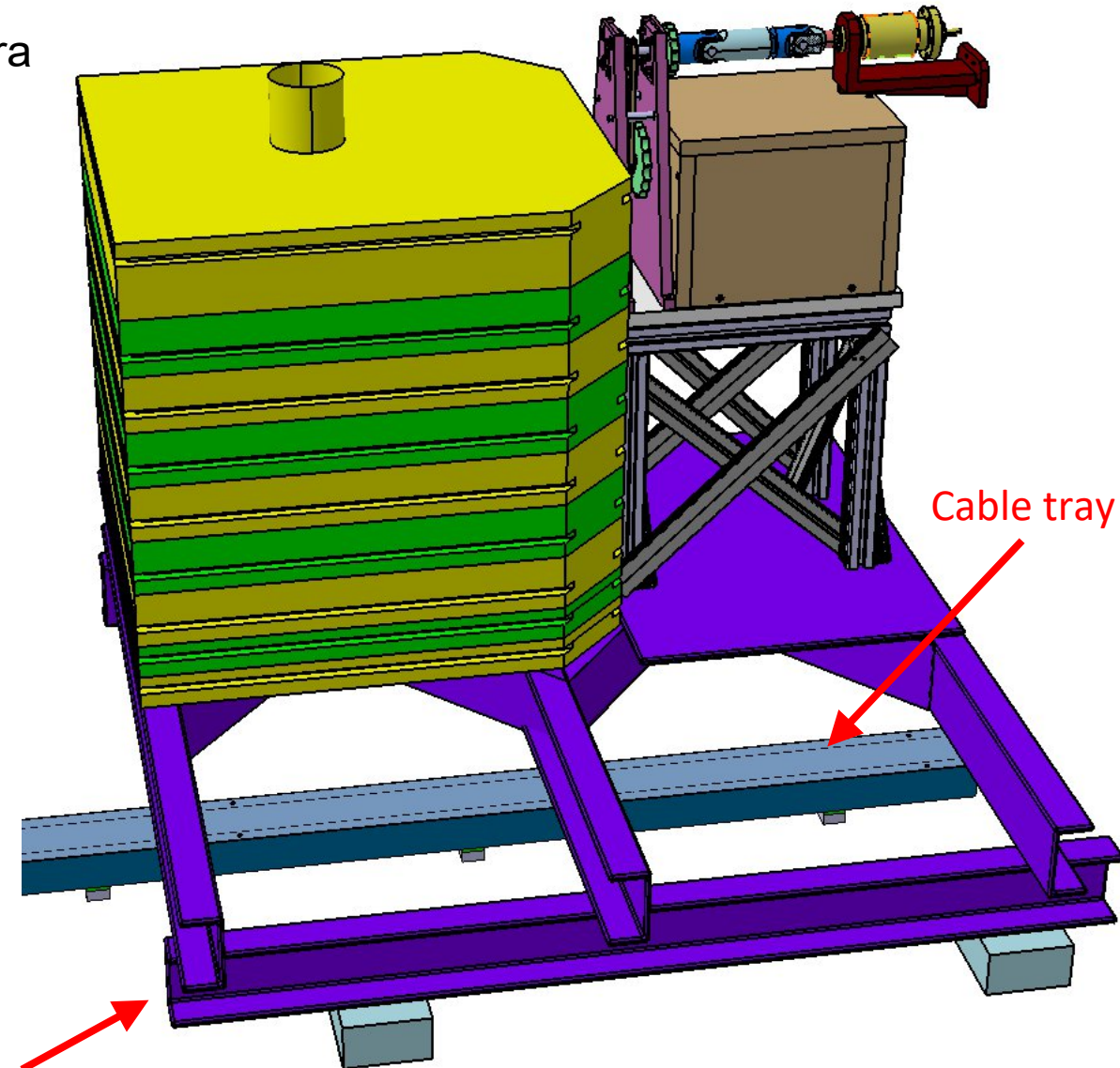
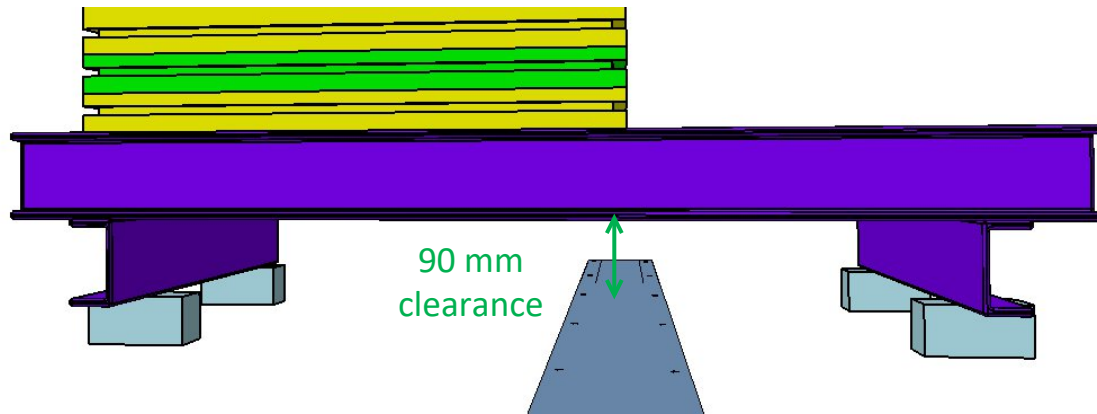
- New design avoids clash with cable tray for visible camera



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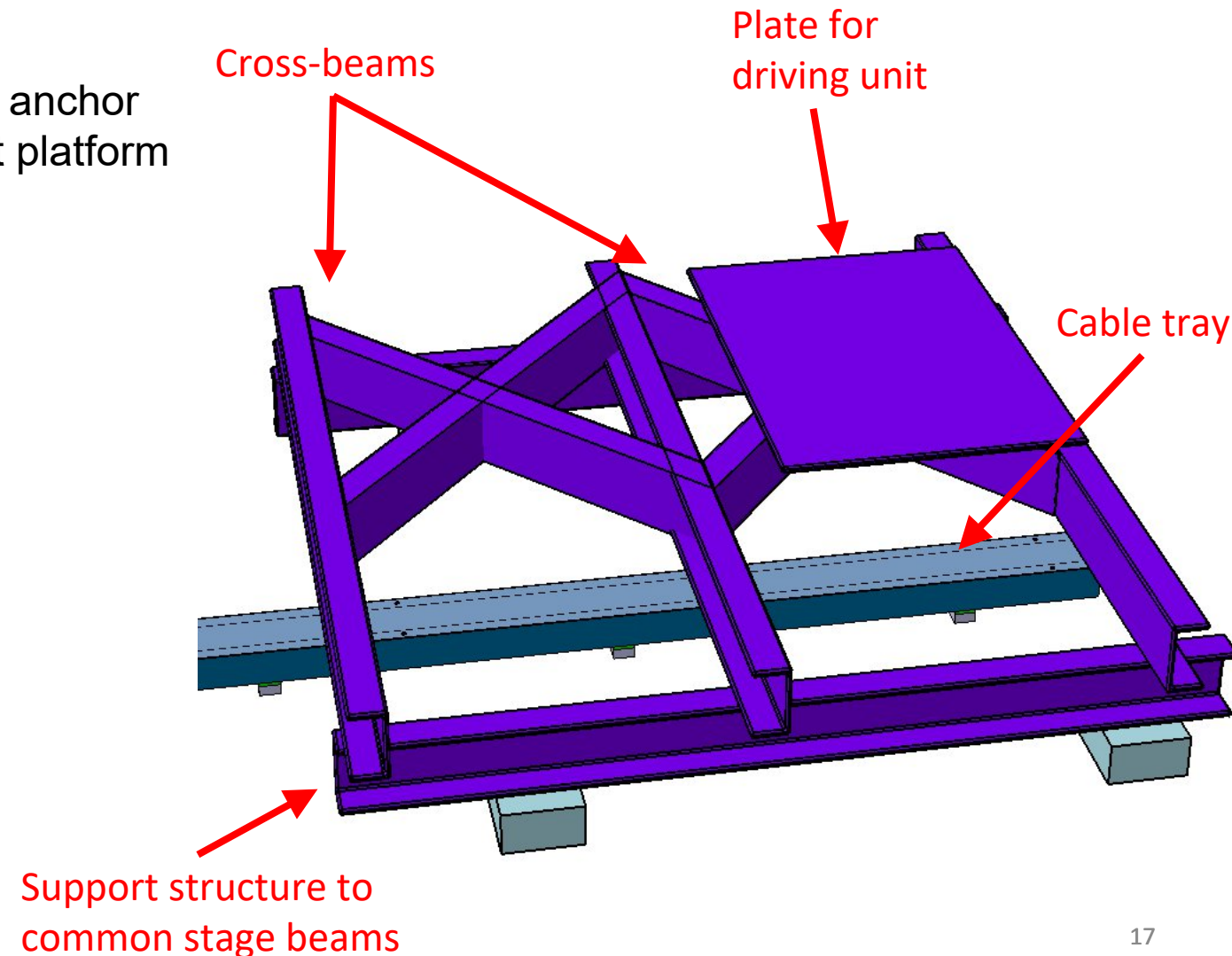
- New design avoids clash with cable tray for visible camera
 - 90 mm clearance



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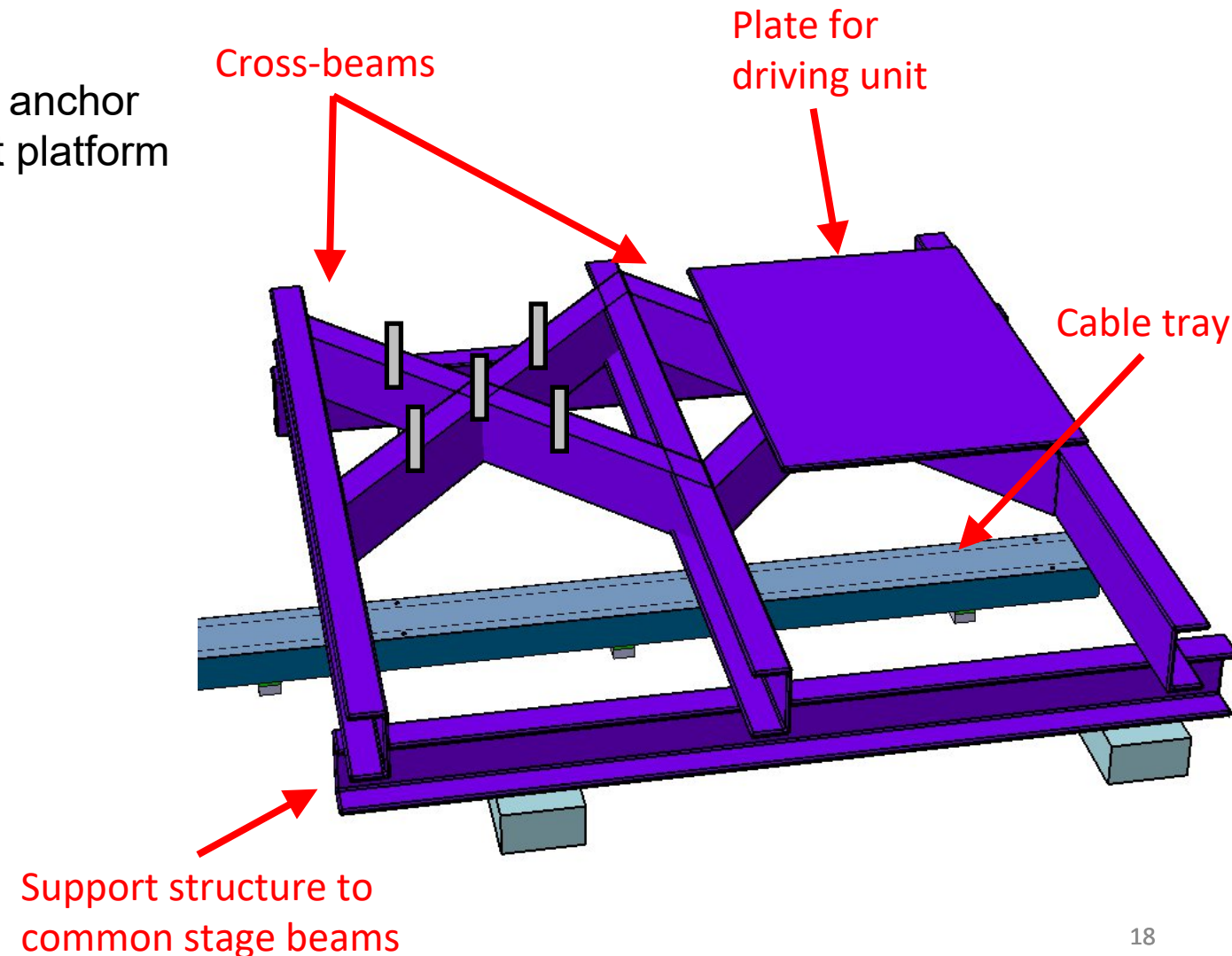
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- Cross-beams included for reinforcement and to anchor shielding box for visible camera and driving unit platform



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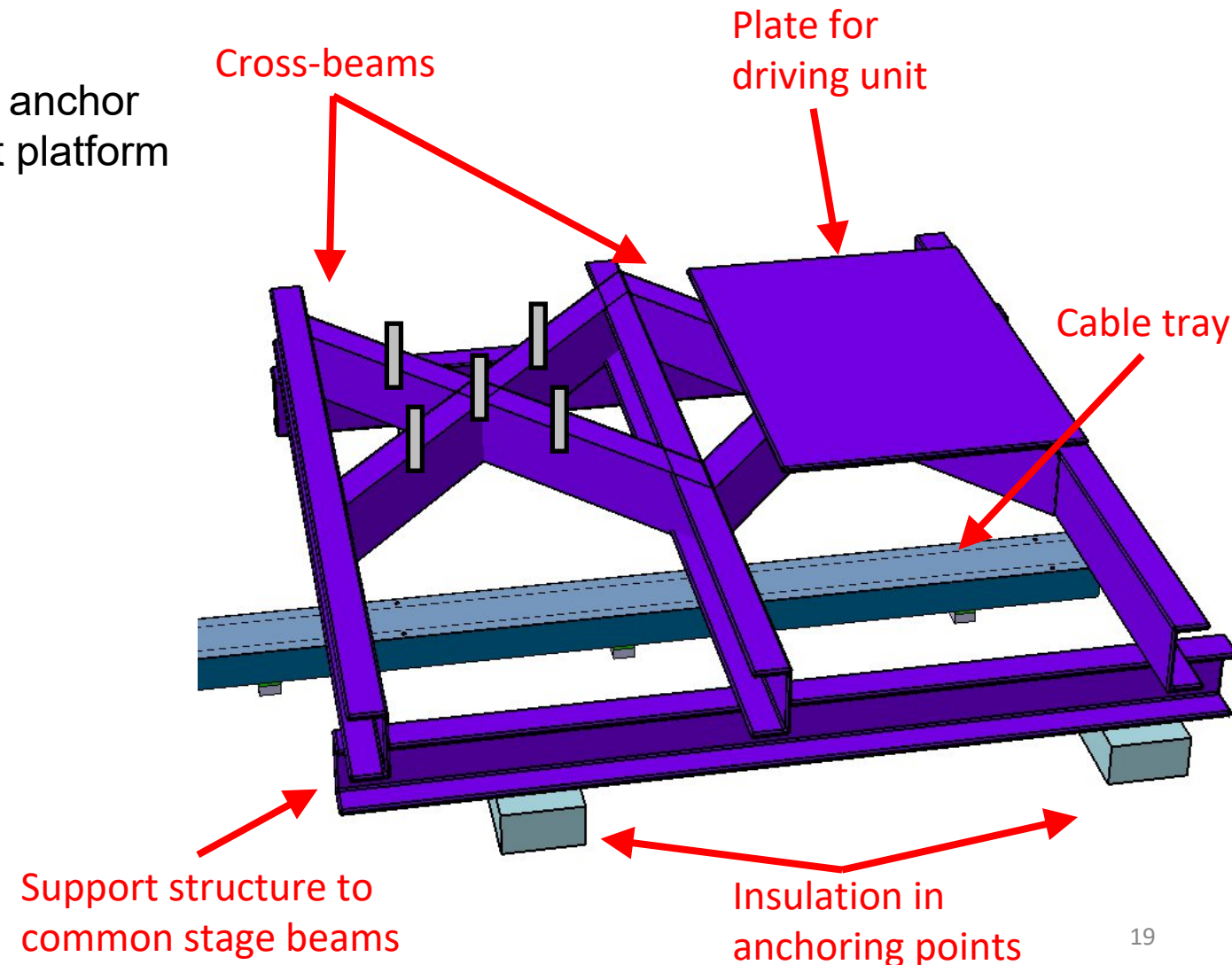
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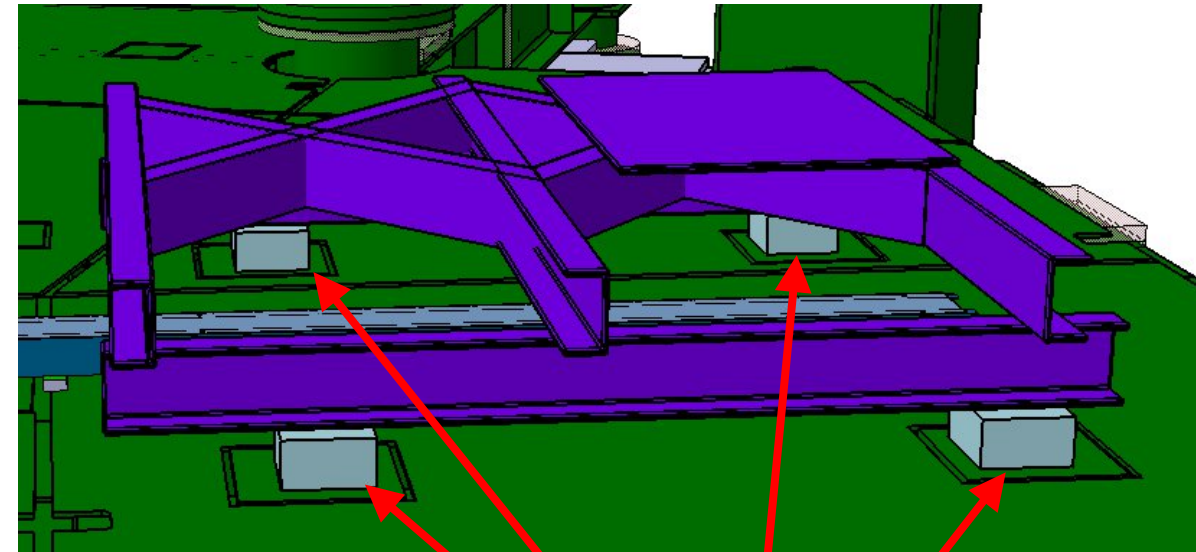
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- Insulation from common stage beams included



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- Anchoring points to common stage beams confirmed with F4E and QST

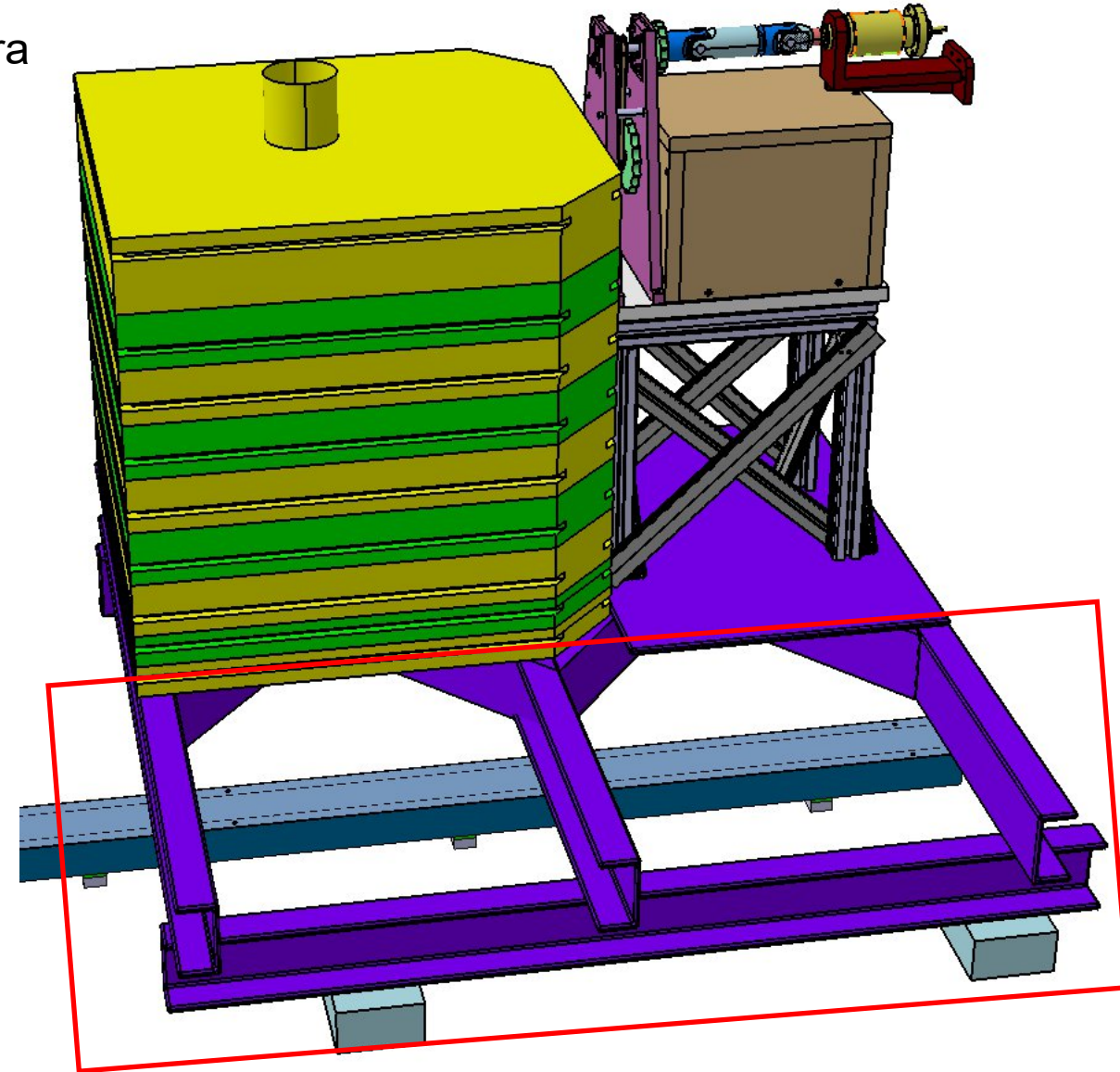


Anchoring points

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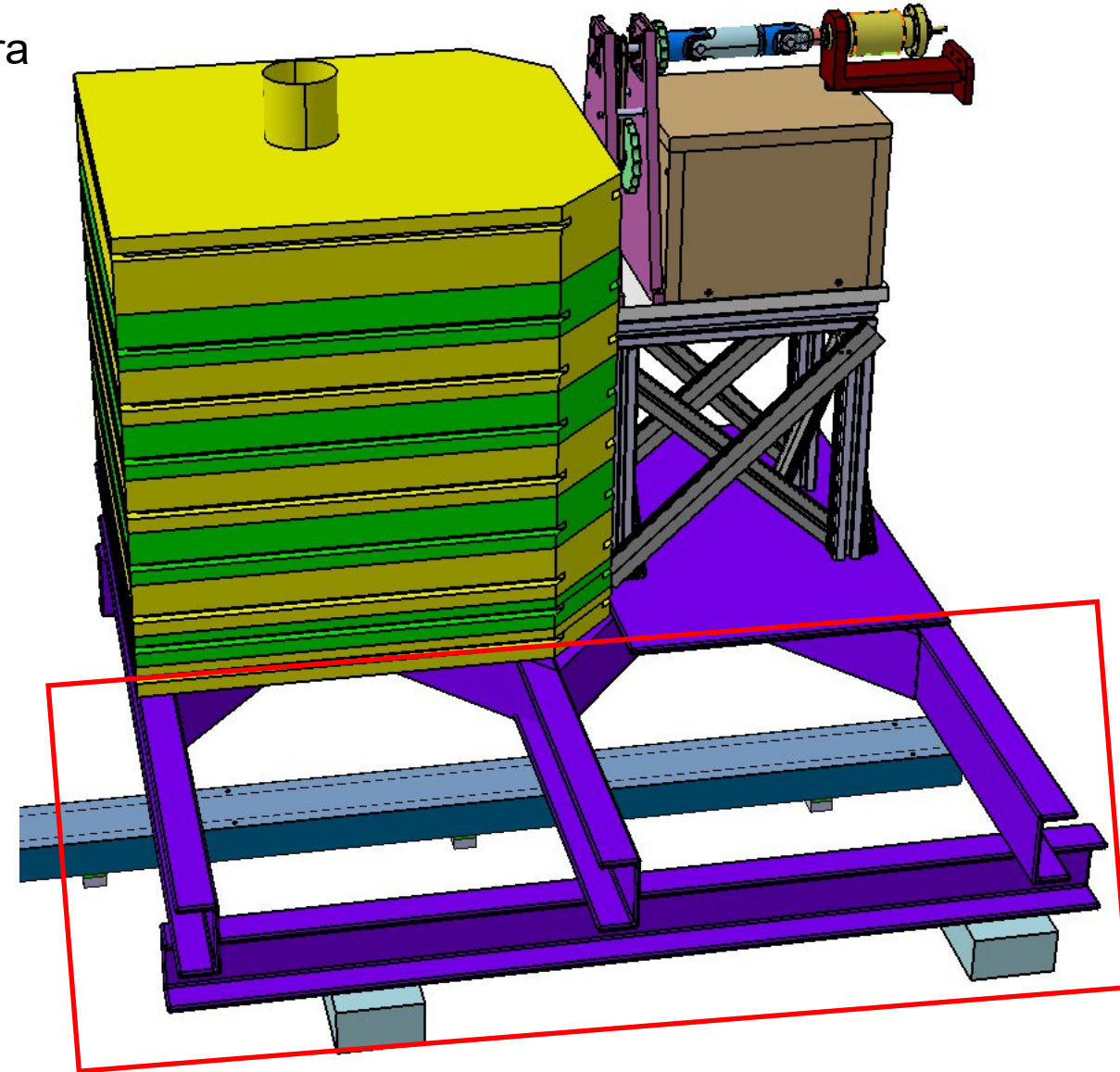
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- Free space available in support structure than can be used for another system



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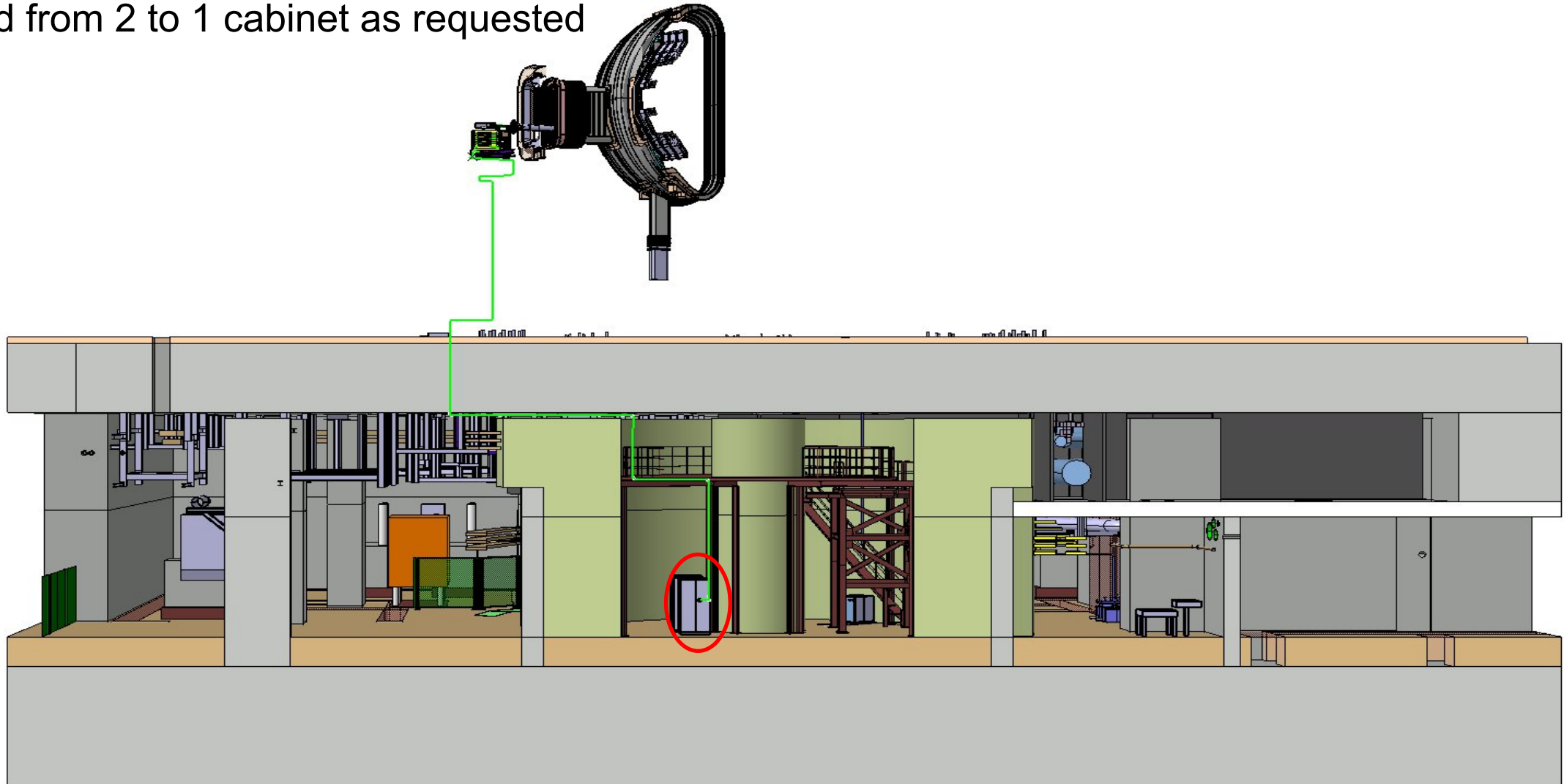
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- Free space available in support structure than can be used for another system
- New design has already been approved by QST, pending structural & seismic analysis (in progress)



Electronics cabinet location at PIG room agreed



- New location and cable routing proposed by QST, ~30 m length
- Reduced from 2 to 1 cabinet as requested

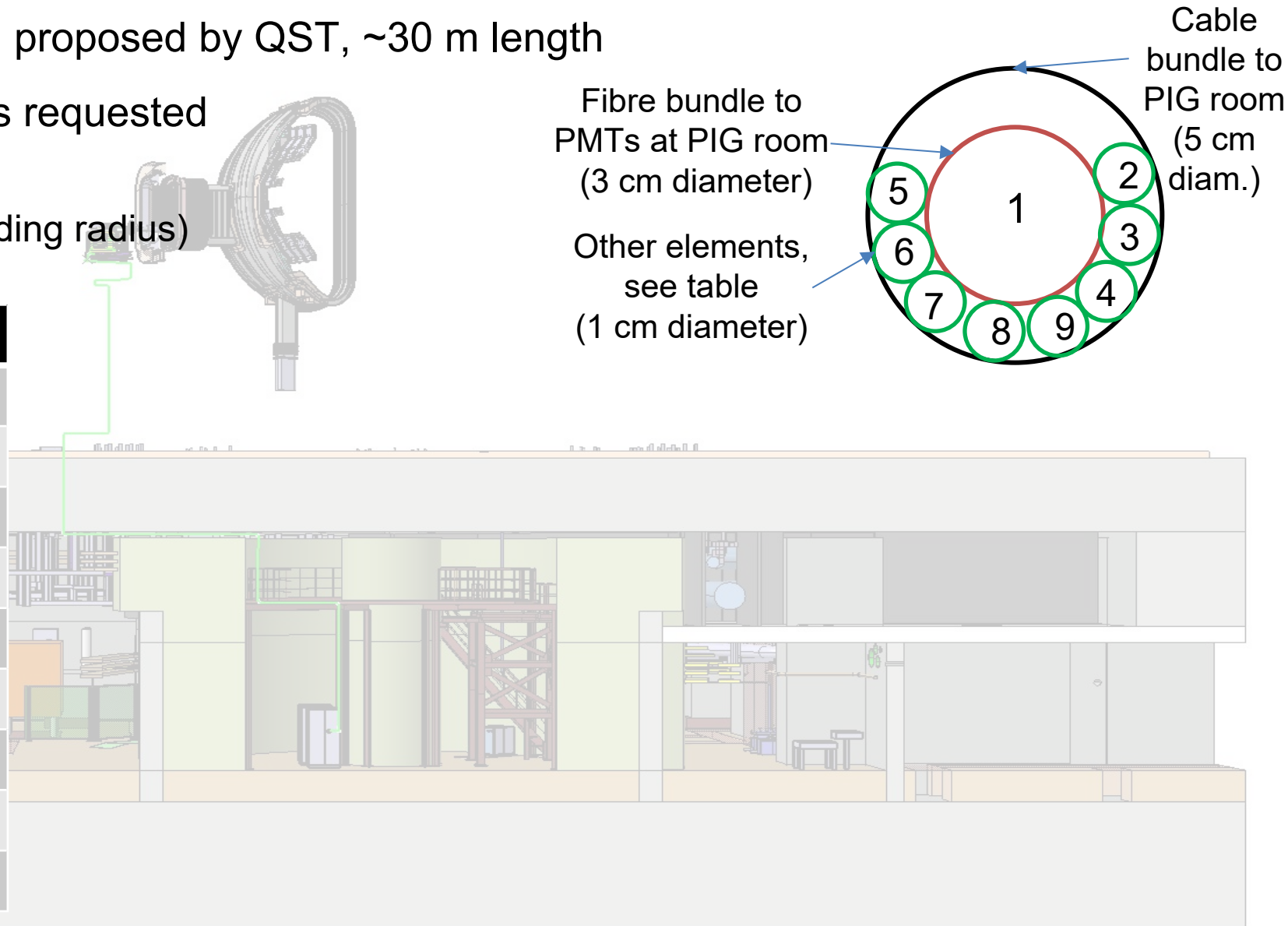




Electronics cabinet location at PIG room agreed

- New location and cable routing proposed by QST, ~30 m length
- Reduced from 2 to 1 cabinet as requested
- Cable bundle to PIG room
(5 cm diameter / 120 mm min bending radius)

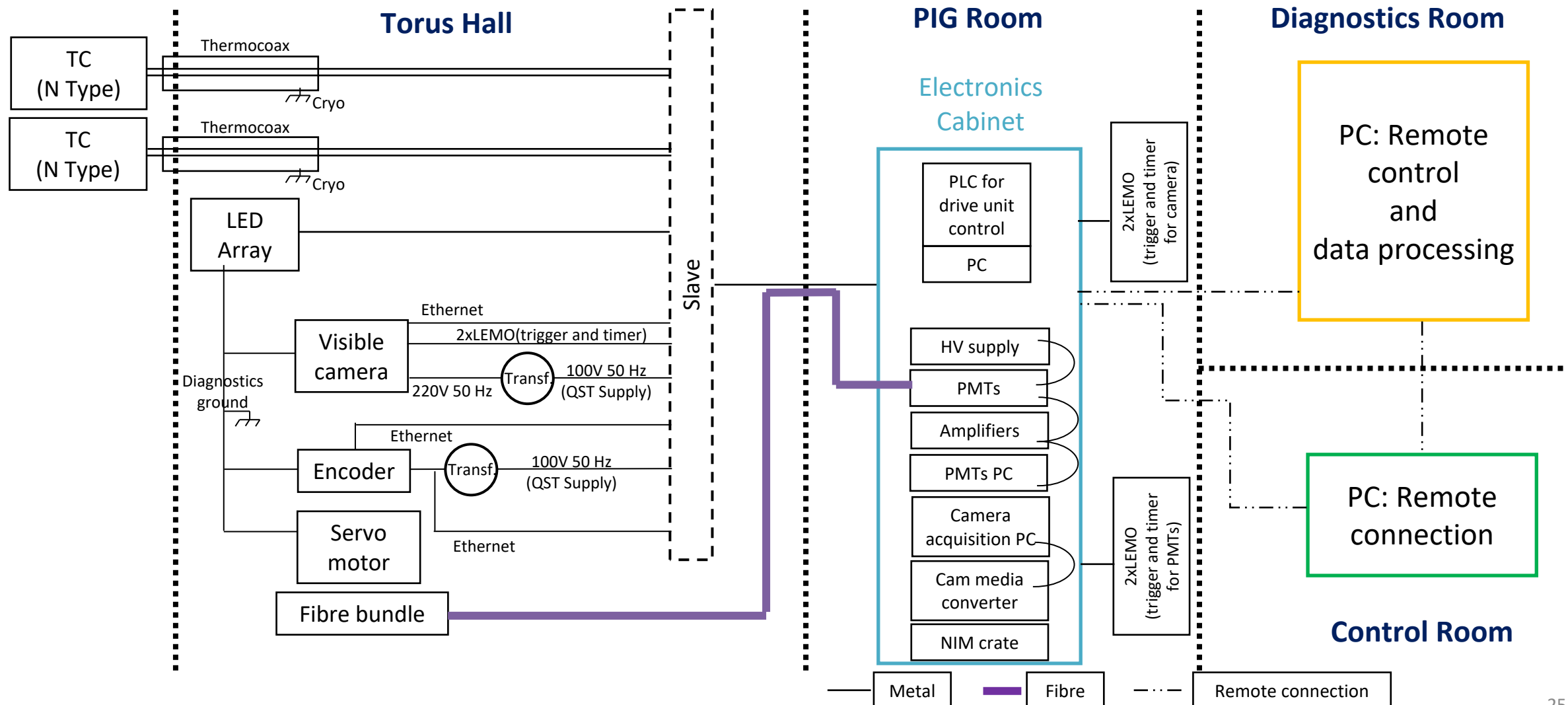
Id.	Purpose
1	Fibre bundle for Photomultipliers
2	Visible camera electrical feed
3	Visible camera data
4	Stepper motor (feed and control)
5	Encoder (feed and data)
6	Thermocouple 1 (2 wires)
7	Thermocouple 2 (2 wires)
8	Switch insertion (2 wires)
9	Switch retraction (2 wires)





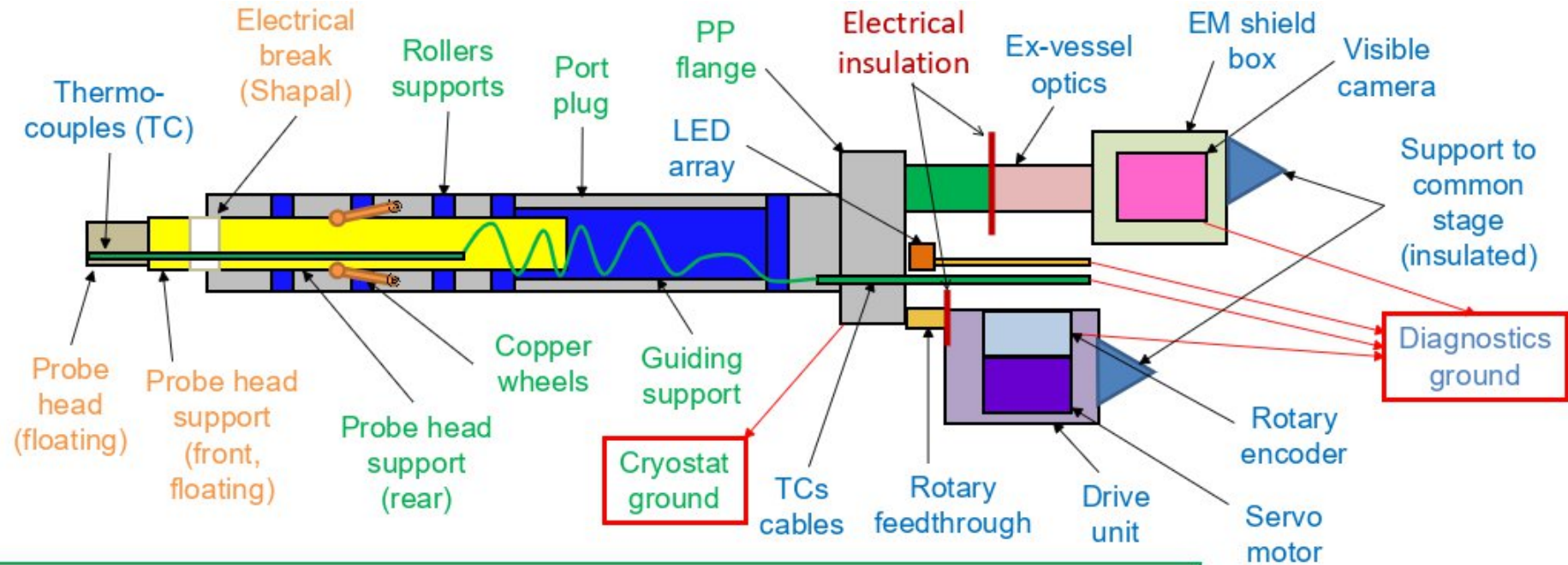
Connections and grounding schemes revisited with QST

- Connections scheme approved: 2 computers {
 - 1 in PIG room → inter-shot raw data processing
 - 1 in Diagnostics Room → FILD control PC



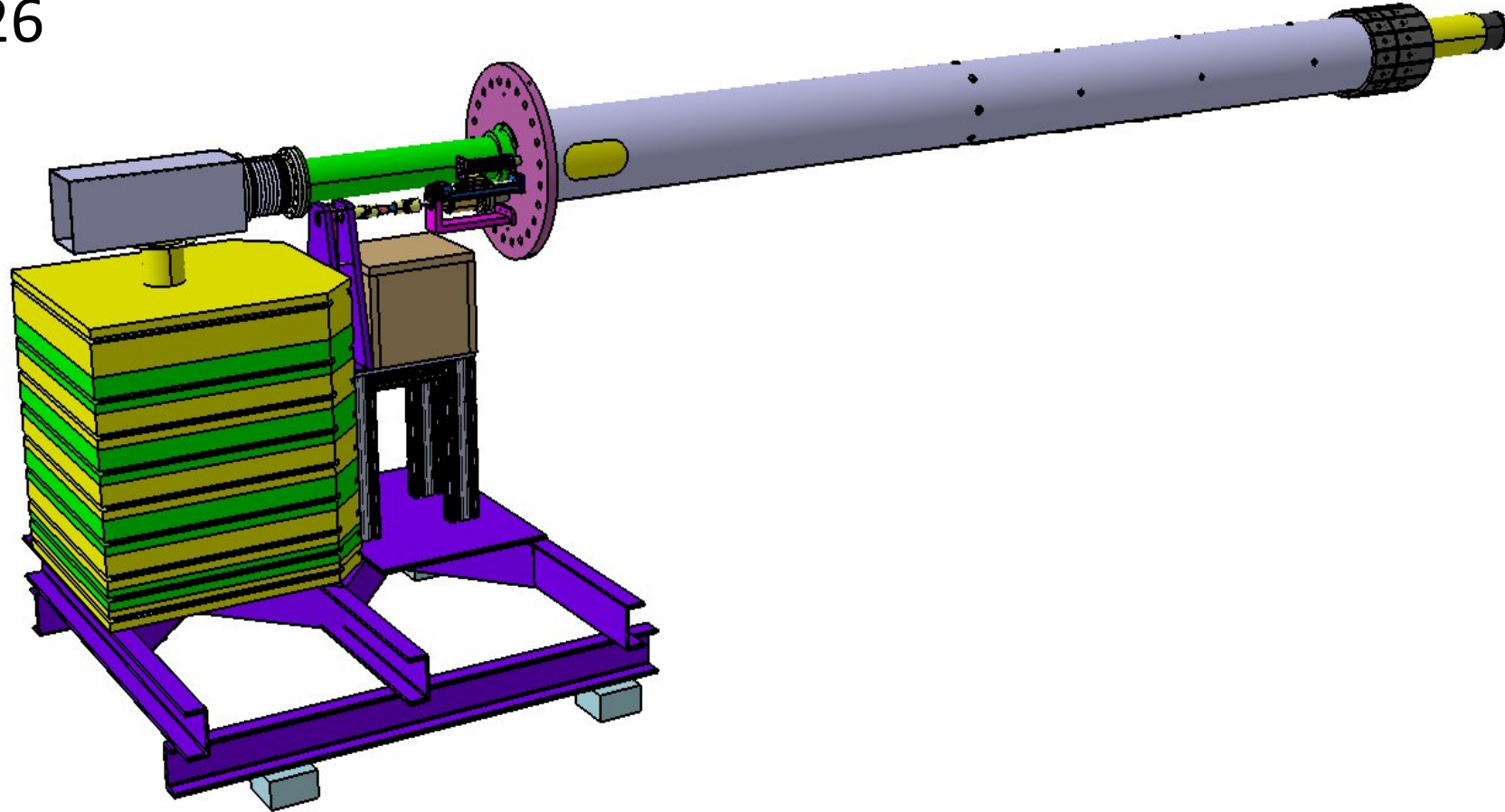
Connections and grounding schemes revisited with QST

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 - 1 in PLG room → inter-shot raw data processing
 - 1 in Diagnostics Room → FILD control PC
- Grounding scheme approved

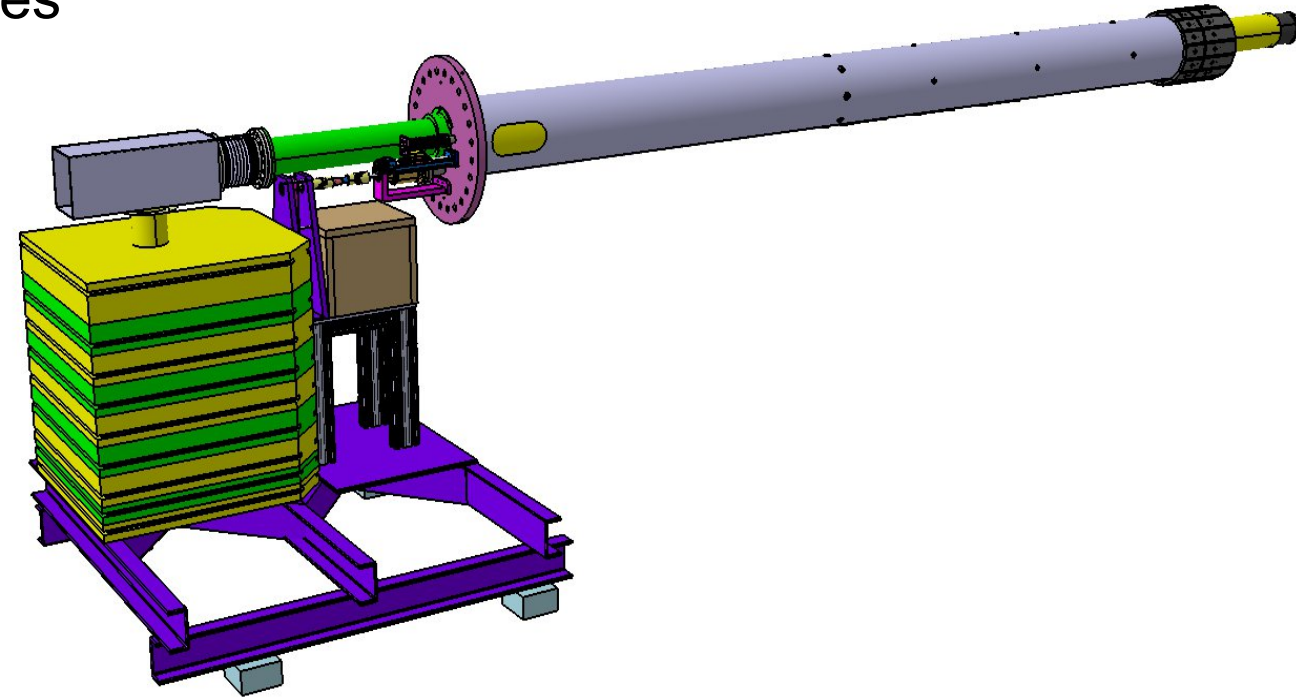


- Port plug, guiding support, probe head support (rear), optics (in-vessel) are electrically interconnected and grounded to cryostat ground
- Electrical components (drive unit including servo motor and rotary encoder, visible camera, calibration lamp, thermocouples), ex-vessel optics and EM shielding box connected to diagnostics ground and isolated from all other components
- Special case: Probe head and probe head support (front) electrically floating while measuring, connected to cryostat ground in parking position using copper wheels

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- Mechanical analysis of supporting structures
- Ex-vessel lenses design
- Estimation of FILD data storage needs
- Launch calls for tender (in/ex-vessel)
- DRM for PA signature, date to be confirmed with F4E and QST



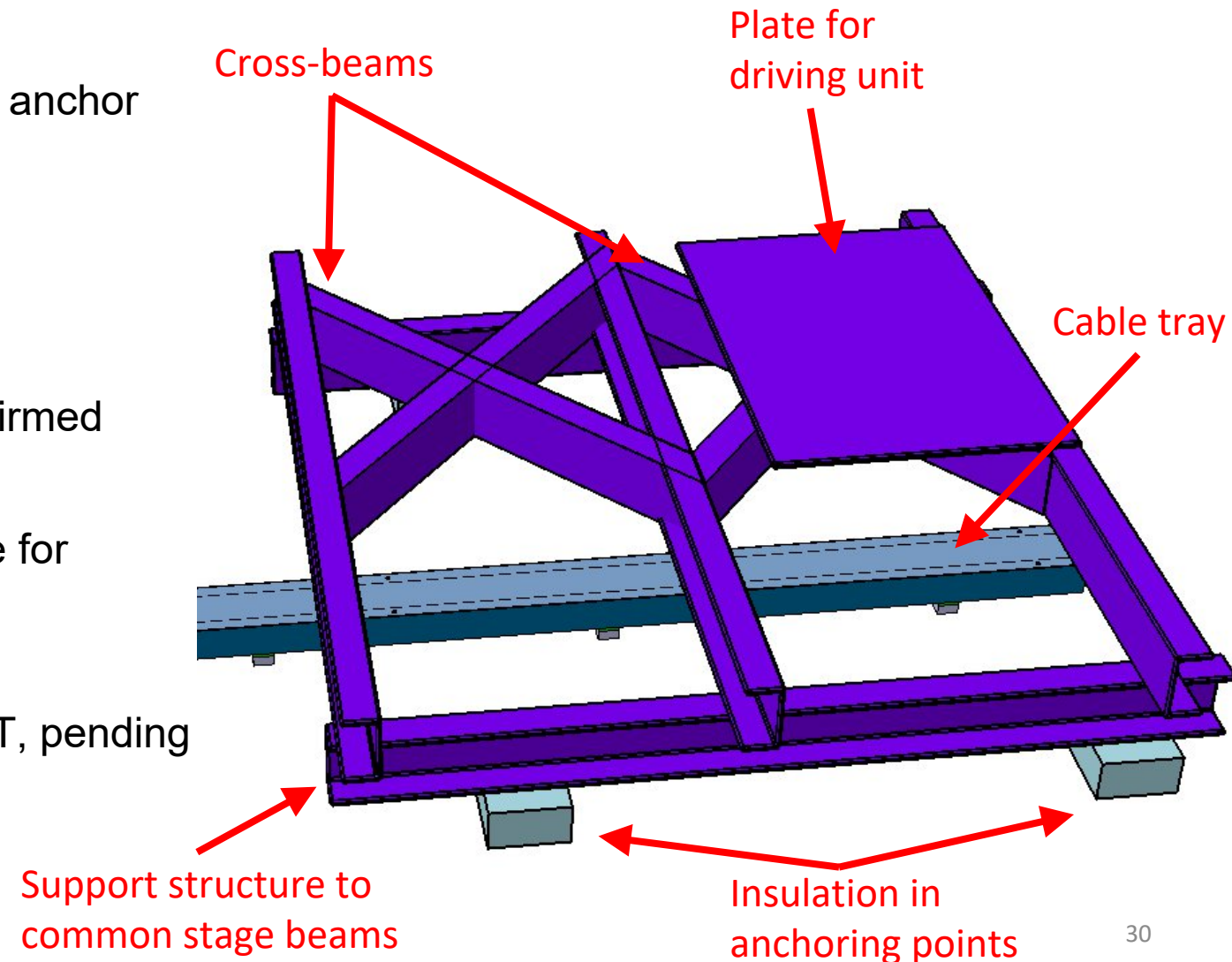


Back-up

Ex-vessel support structure re-designed and approved by QST



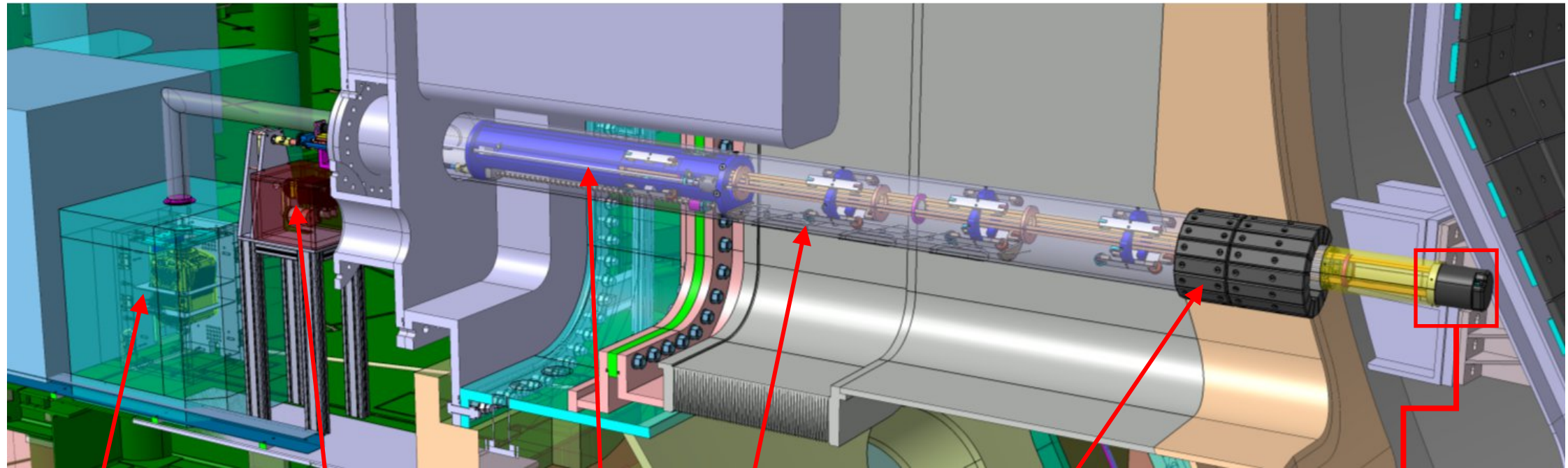
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- Insulation from common stage beams included
- Anchoring points to common stage beams confirmed
- Free space available in support structure to use for another system
- New design has already been approved by QST, pending structural&seismic analysis (in progress)





- Weight distribution of the components
 - PE shielding box: 206 kg
 - 20kg each intermediate module, 7 modules -> 140 kg + 36 bottom + 30 upper
 - Lead box: 112 kg
 - Iron box: 183 kg, including Phantom (Only the plates: $33+28+33+33.2+15+16$)
 - Total shielding box (w Phantom camera, 8 kg): 501 kg

FILD Head Collects Fast Ions Escaping From Plasma



Light acquisition system

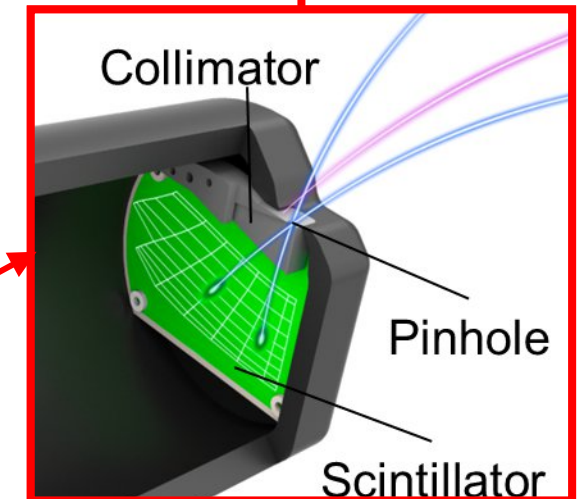
Motion drive unit

Motion guide system

Port plug

Graphite shield

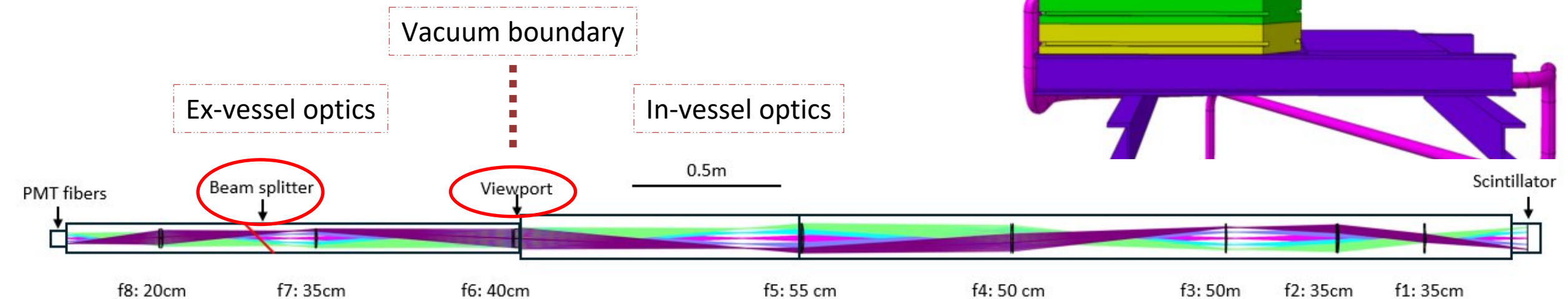
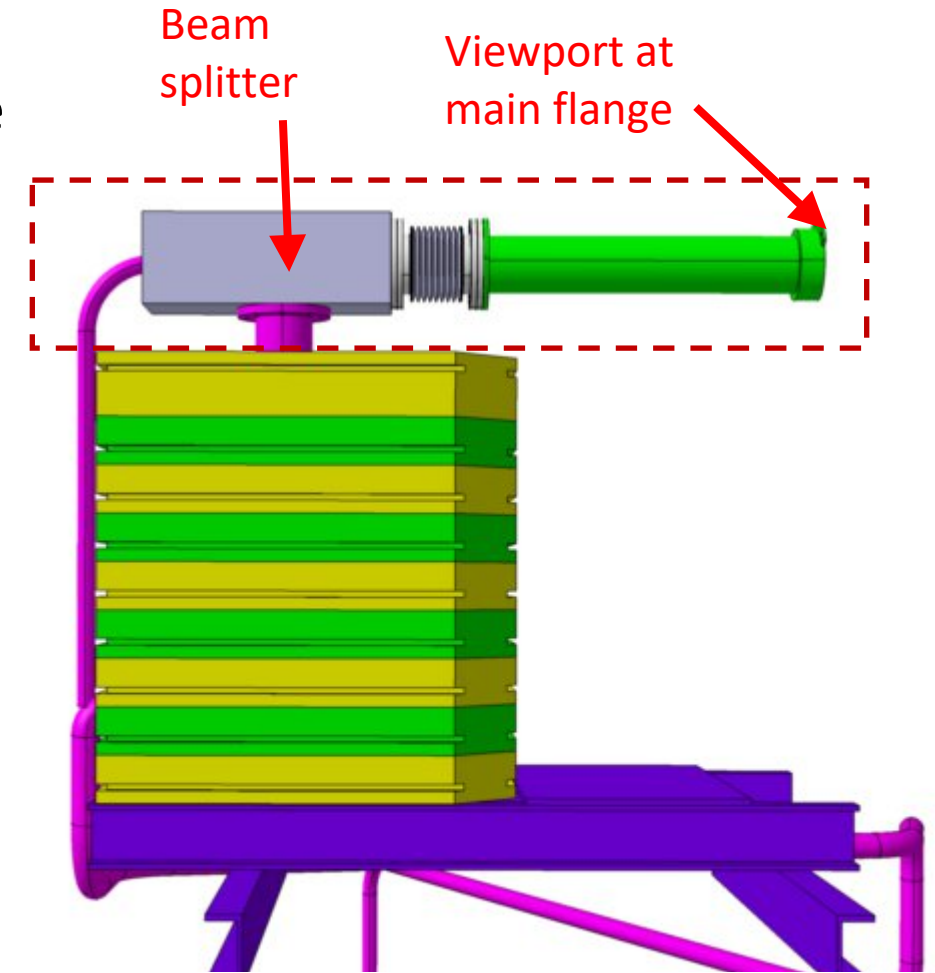
Probe head (measuring)





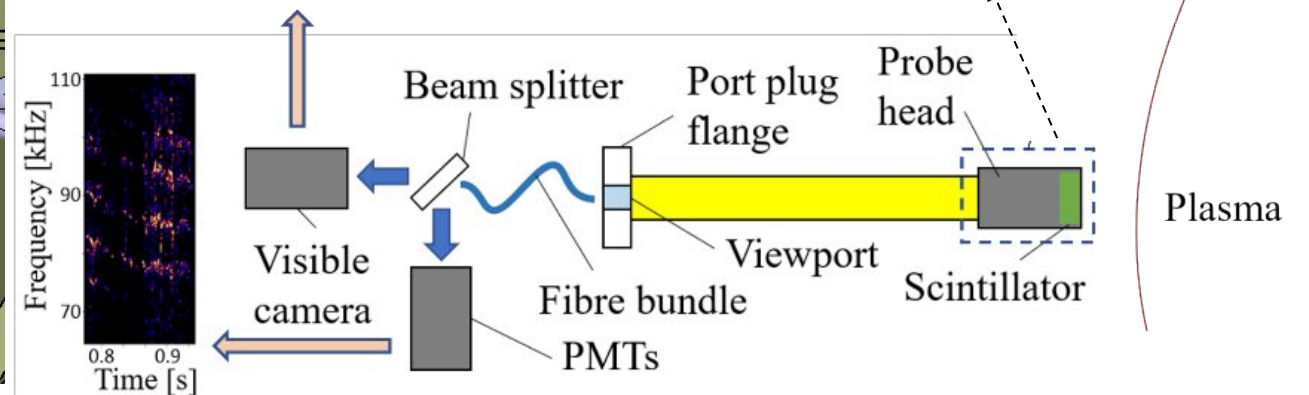
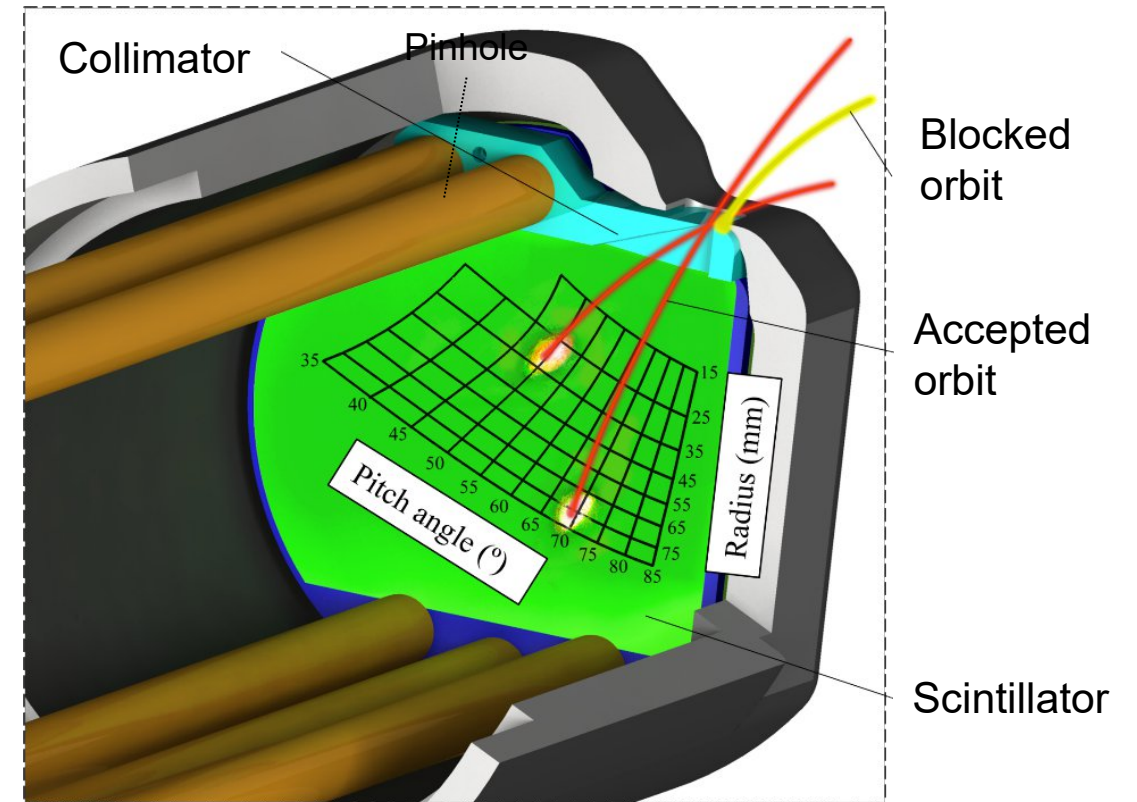
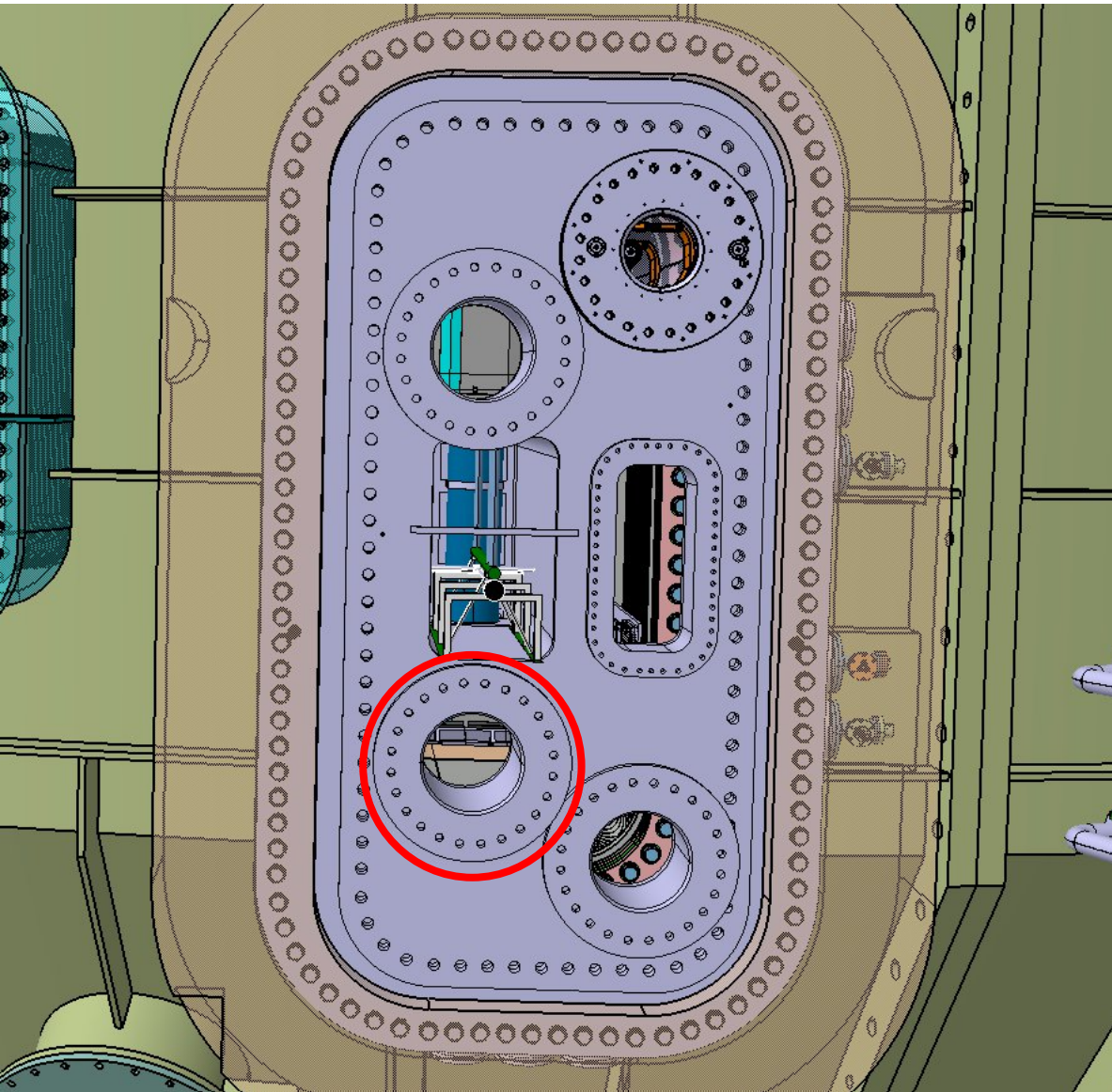
Ex-vessel optical system design being finalized

- Ex-vessel Optical Path components guide light to beam splitter that splits light into shielded box and fibre bundle
- Components in torus hall ambient: no interface with vacuum (non-metallic below to avoid external light)
- Optics already designed and selected - Lenses and fibre
 - Need to finalize ex-vessel design, depending on exact position of beam splitter, camera sensor and PMTs



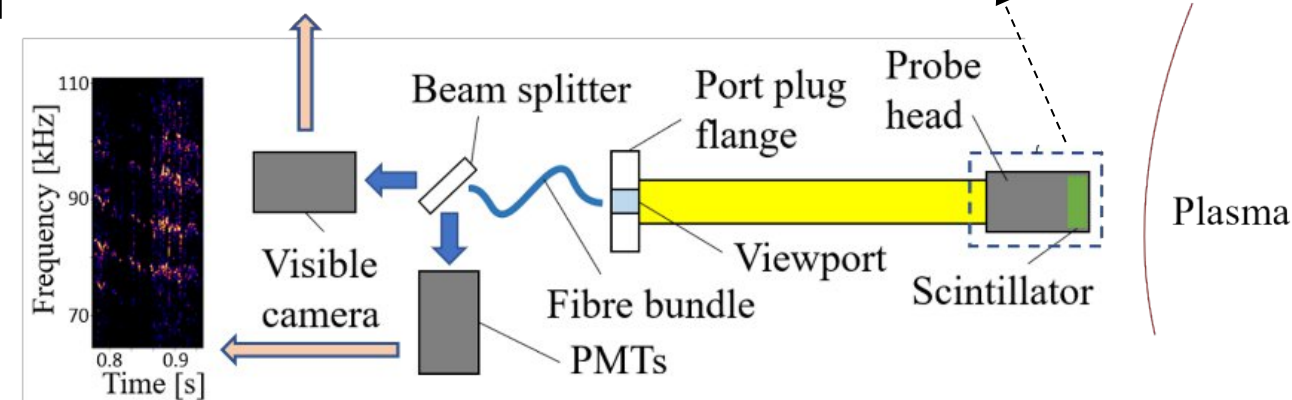
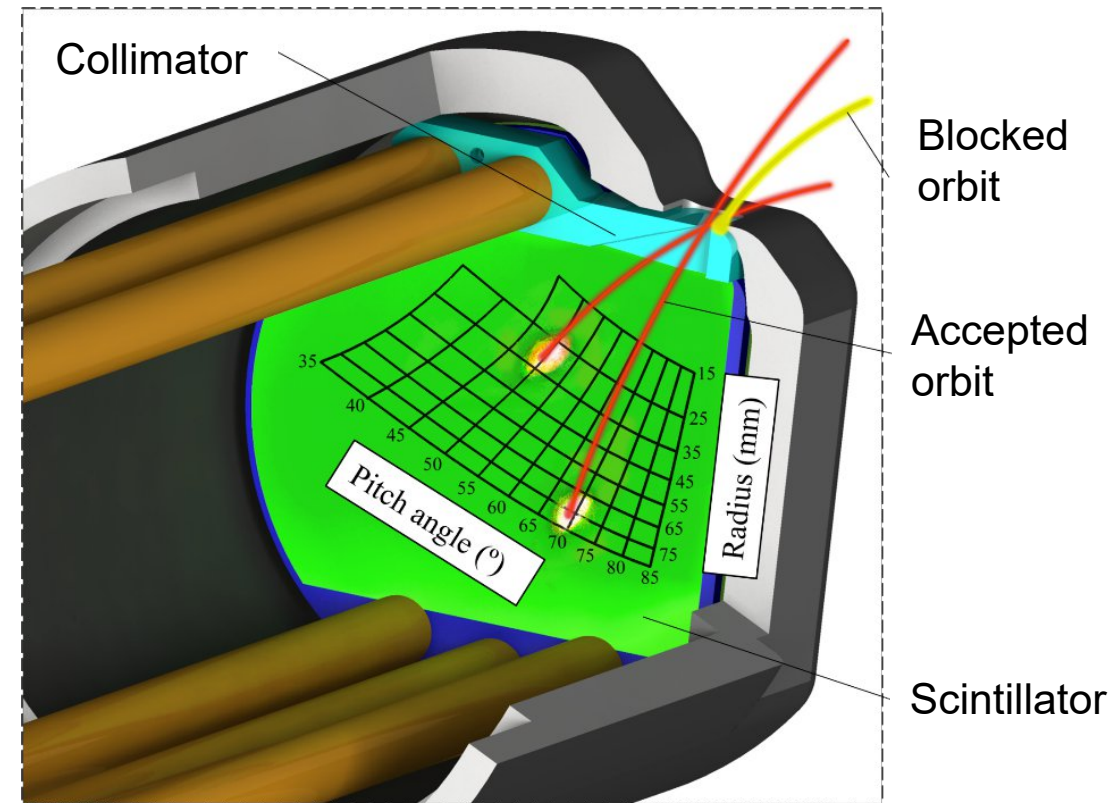


FILD used in all major devices to study fast ion losses



FILD used in all major devices to study fast ion losses

- Works as a magnetic spectrometer **collimating and dispersing ions onto a scintillator plate**
- Strike points on the scintillator plate depend on **particle gyroradius and pitch-angle**
- FILD provides **local time-resolved energy and pitch angle measurements** of escaping ions
- **CCD camera:** High spatial resolution
 - **Energy range:** 25-500 keV (15-170 keV resolution)
 - **Pitch angle range** ($v_{\text{perp}} / v_{\text{tot}}$): 30°-75° (5° resolution)
- **PMTs system:** High temporal resolution (up to **1 MHz**)
- Allows studying **transport mechanisms provoking fast ion losses**



FILD working principle



Here some text on FILD

- The Fast-ion Loss Detector (FILD) measures fast ion losses escaping from the plasma due to different mechanisms such as magnetohydrodynamic instabilities and/or externally applied magnetic fields.
- This diagnostic system collects, collimates and disperses the escaping ions onto a scintillator plate. The impinging position of the ions on the scintillator plate depends on their energy and pitch-angle and, tracking it, allows determining complete information on their velocity-space.
- Also, the use of fast scintillator materials and fast light acquisition systems provide high temporal resolution. This makes it possible not only to identify the mechanism responsible for the fast-ion losses, but also to define and validate strategies for plasma instabilities mitigation.
- The detector head, containing the scintillator plate, collimator and heat shield, is mounted on a reciprocating arm allowing its insertion, for measuring, up to the stabilizing plate level. This reciprocating system allows the definition of different FILD operational cycles during full plasma pulses. This means that, depending on the plasma scenario, the detector head can be alternatively held in measuring and park positions during specific periods of time.