Mechanical design of ET-Payload with crystal suspension

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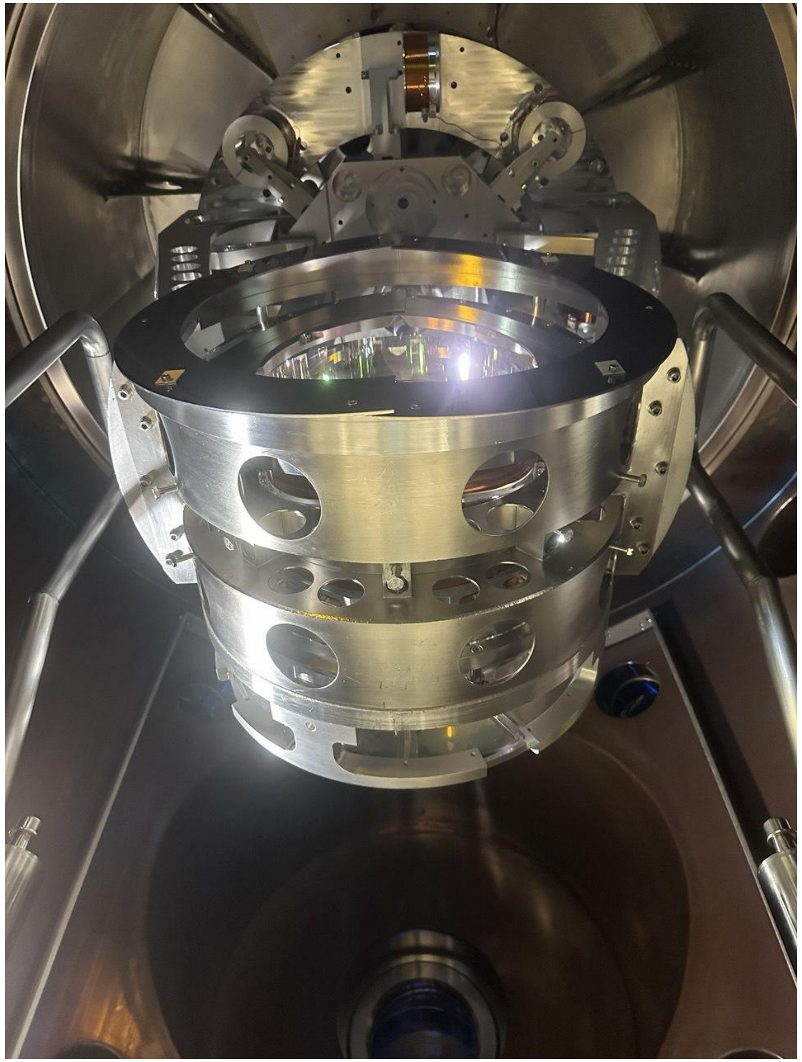
Scope of the presentation

- Payload mechanical aspect:
  - Design consideration

- Payload integration:
  - Integration requirements
  - Integration sequence proposal
  - Mechanical interfaces

- Open problems → R&D



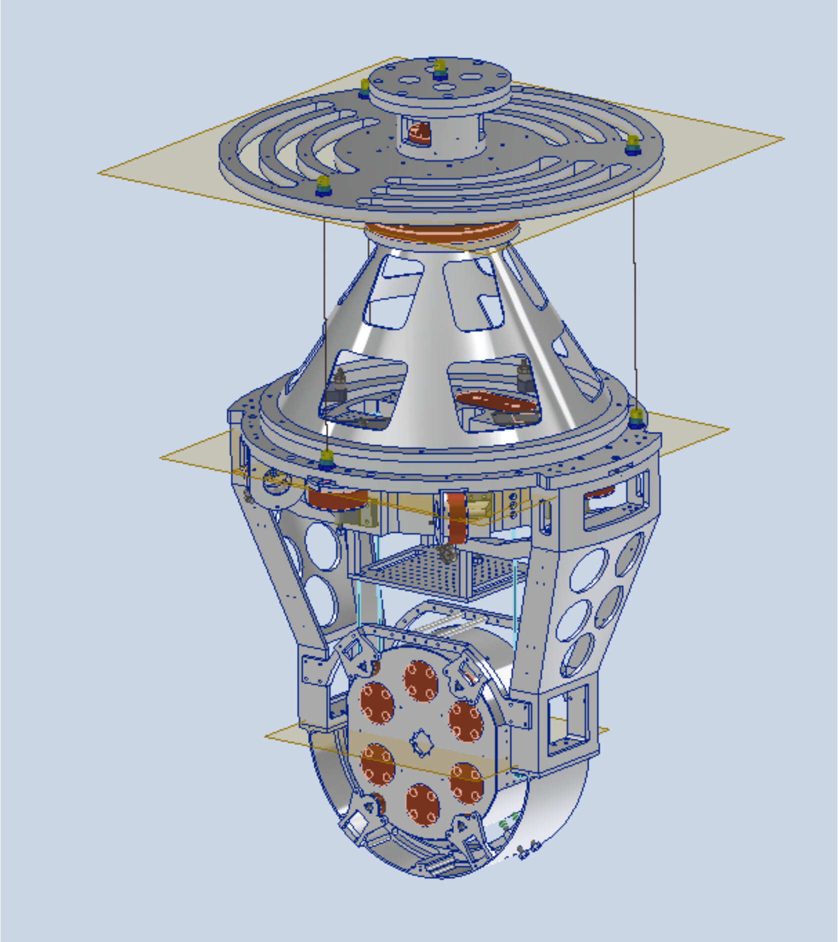
Payload mechanical design

- Center Of Mass position → this influences:
  - The angular softness/stiffness
  - Couplings between DOFs

→ Controllability (M. Pinto)

- Material Choice → two “categories”
  - Component with high stress → these need also high Q
  - Component with low stress

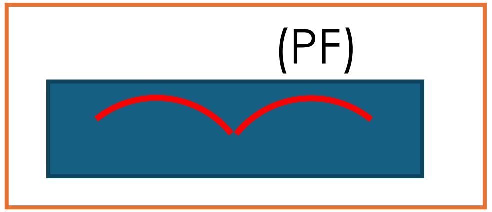
Both of them need an high thermal conductivity!



Payload prototype in ARC Rome

Payload integration requirements

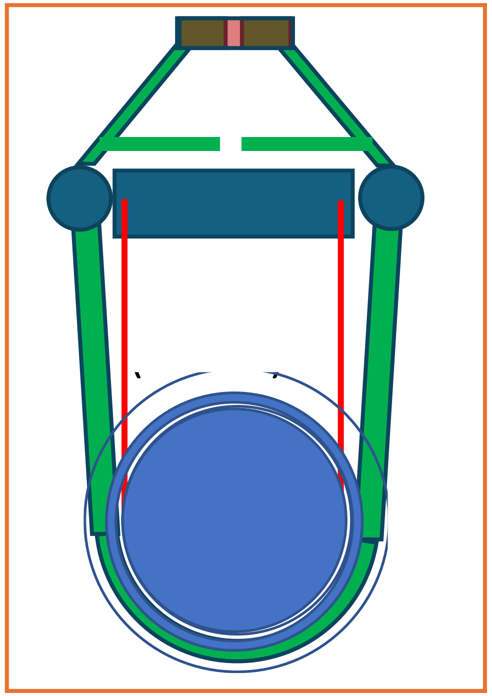
Part 1



- Payload should be pre-assebled before integration into the tower
- Payload need to be divided into two parts → issue with clean room under tower
  - Part 1: platfrom
  - Part 2: other payload's component
    - Actuation Cage (Recoil Mass)
    - Marionette
    - Mirror

- Payload max dimensions:
  - Max diameter: 1m
  - Max height: 3,8m → Internal Inner Thermal Shield height

Clean room height is 4m
5m directly under the tower



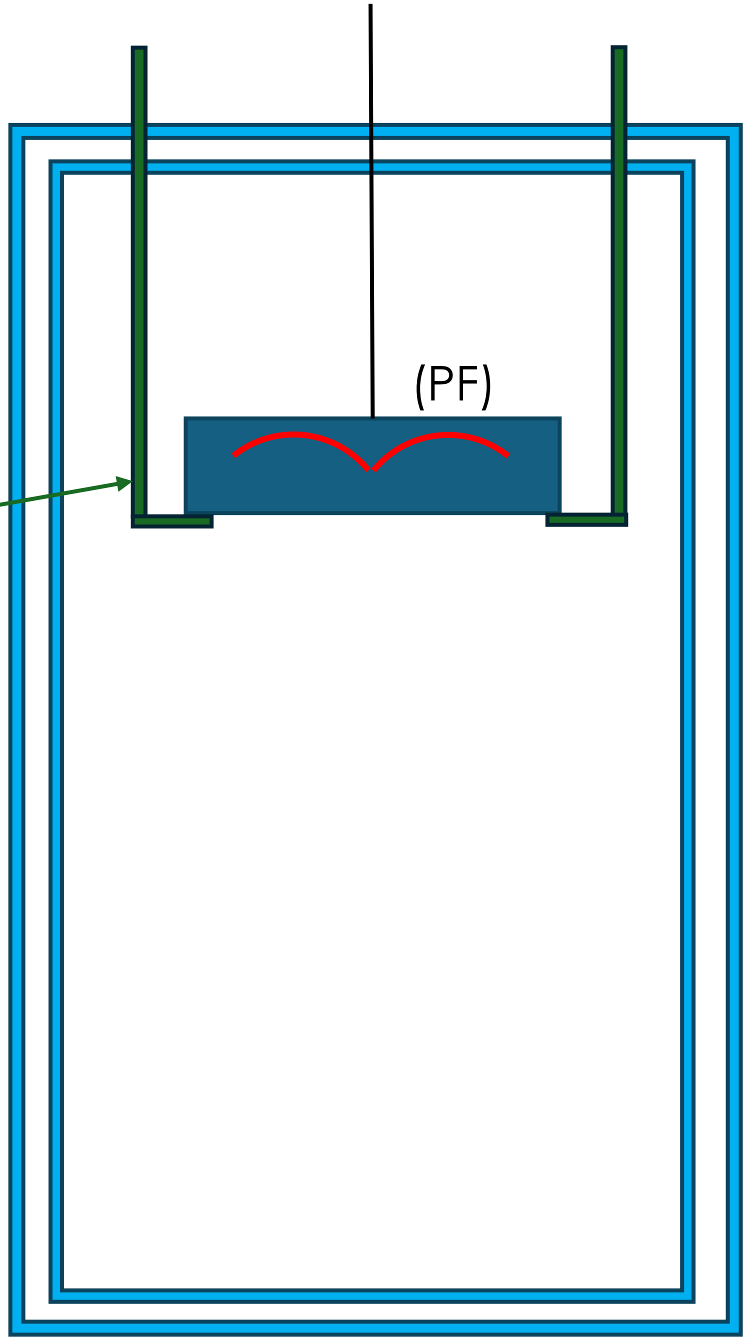
Part 2

Payload integration steps

Integration is ment to be by bottom access

1. Platform gets into the cryostat

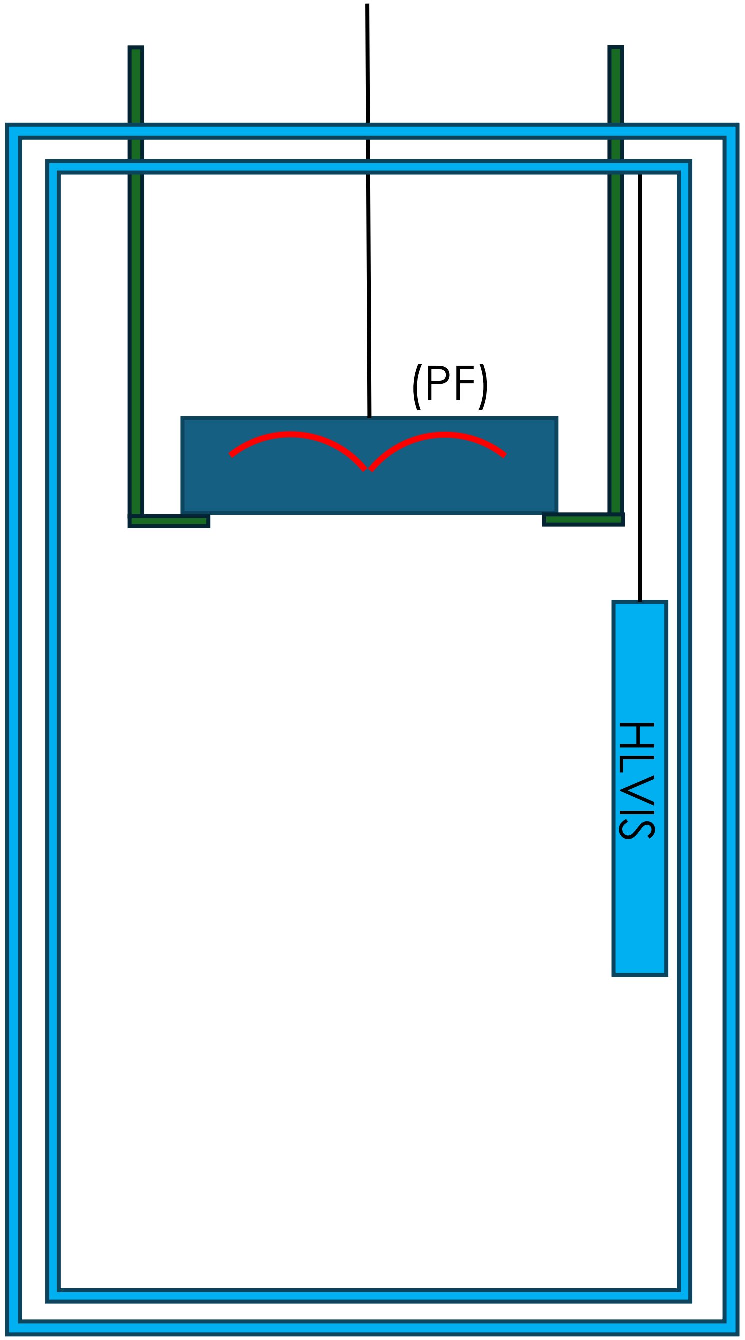
    - Need a SUPPORT to place and hold the platform



Payload integration steps

Integration is ment to be by bottom access

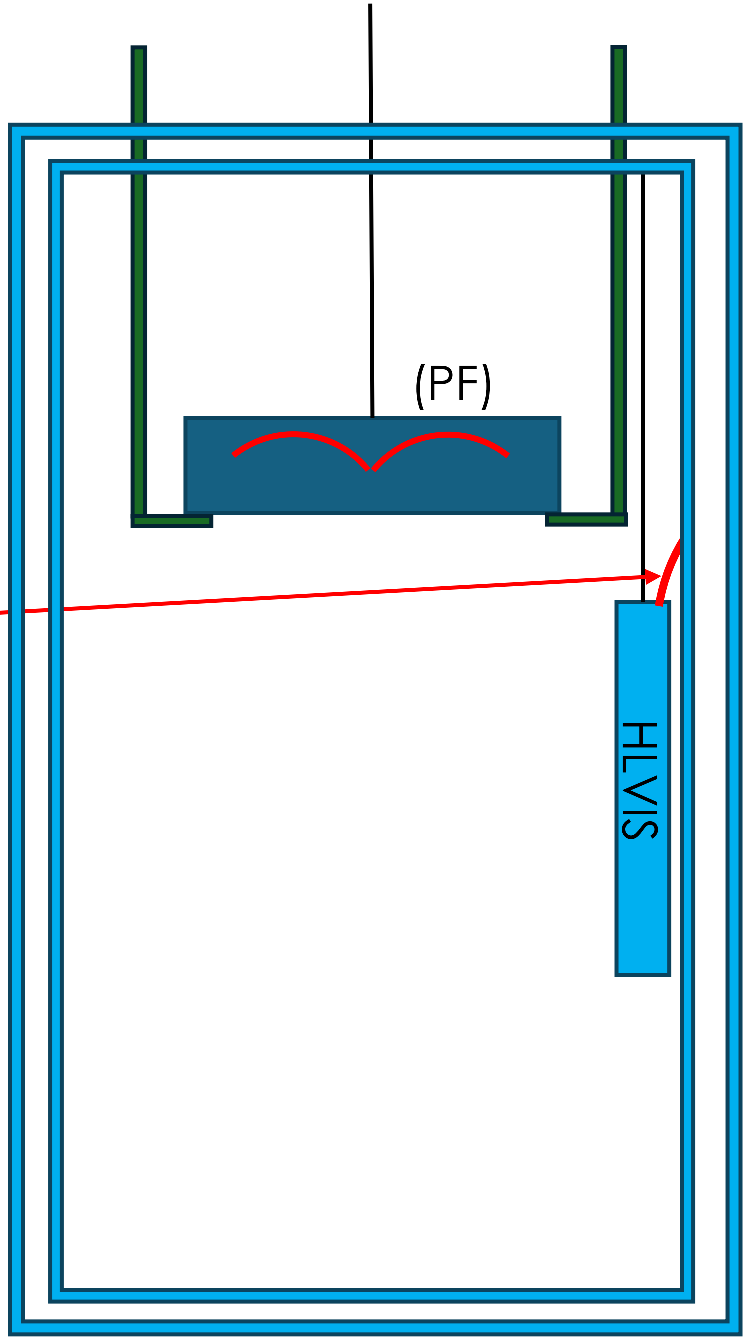
1. Platform gets into the cryostat
2. Mount Heat Link Vibration Isolation System → HLVIS



Payload integration steps

Integration is ment to be by bottom access

1. Platform gets into the cryostat
2. Mount Heat Link Vibration Isolation System → HLVIS
3. HLVIS thermal connection:
   - Connection with cryostat «cold point»

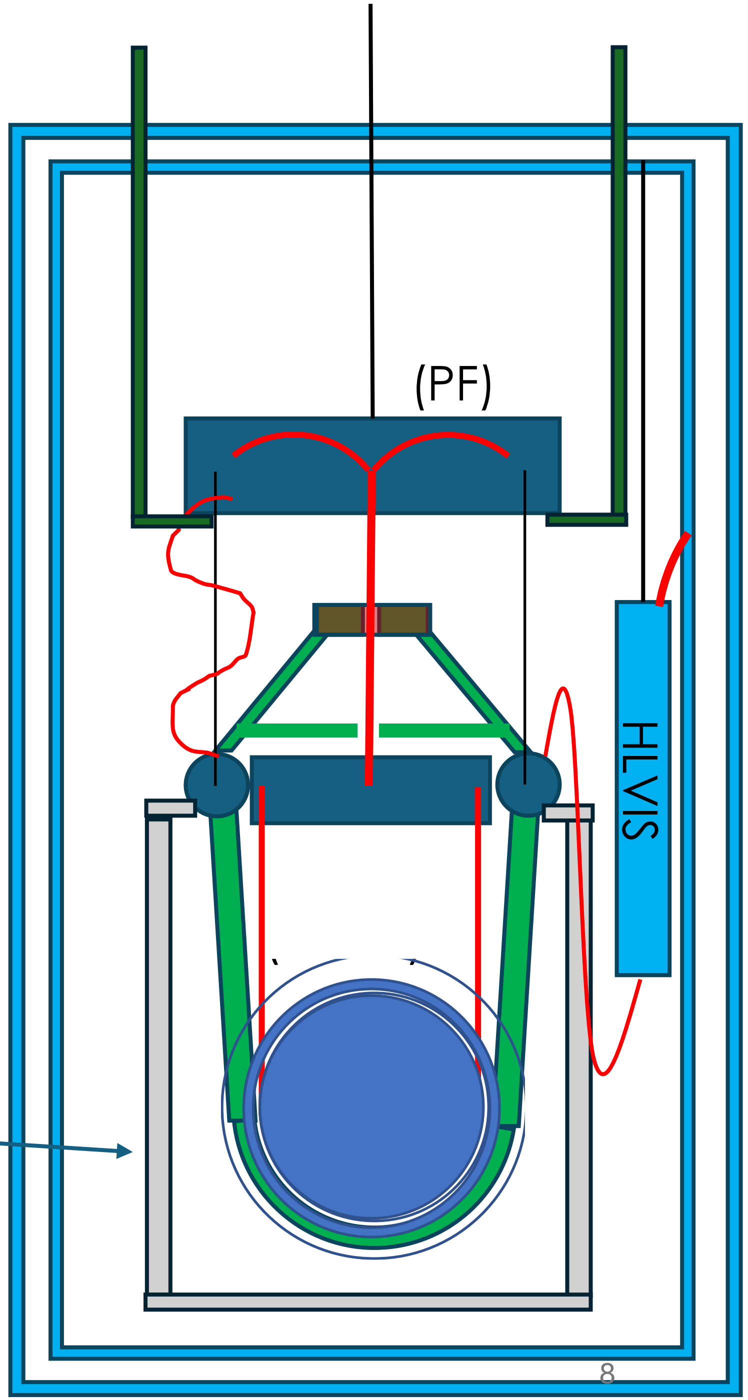


Payload integration steps

Integration is ment to be by bottom access

1. Platform gets into the cryostat
2. Mount Heat Link Vibration Isolation System → HLVIS
3. HLVIS thermal connection
4. Payload gets into the cryostat → part 2 pre –assembled
    - Thermal connection between HLVIS and Cage
    - Mechanical and thermal connections between marionette and platoform
    - Mechanical and thermal connections between platform and Cage
    - Electrical connections

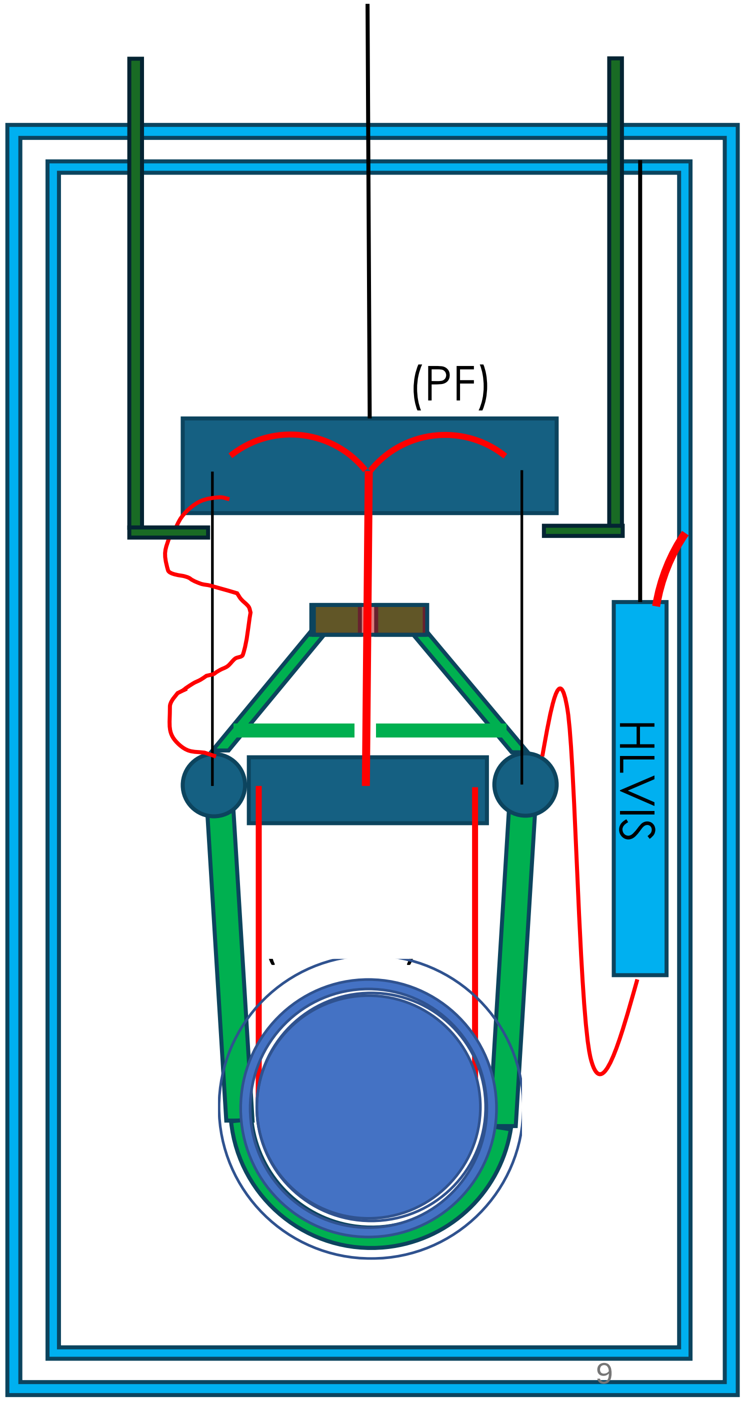
*During operation at point 4 need a support structure around the paylaod



Payload integration steps

Integration is ment to be by bottom access

1. Platform gets into the cryostat
2. Mount Heat Link Vibration Isolation System → HLVIS
3. HLVIS thermal connection
4. Payload get into the cryostat → Mechanical, thermal and electrical connections
5. Suspend the overall payload
   - Remove the support frame around payload
   - Load the super attenuator



Payload integration steps

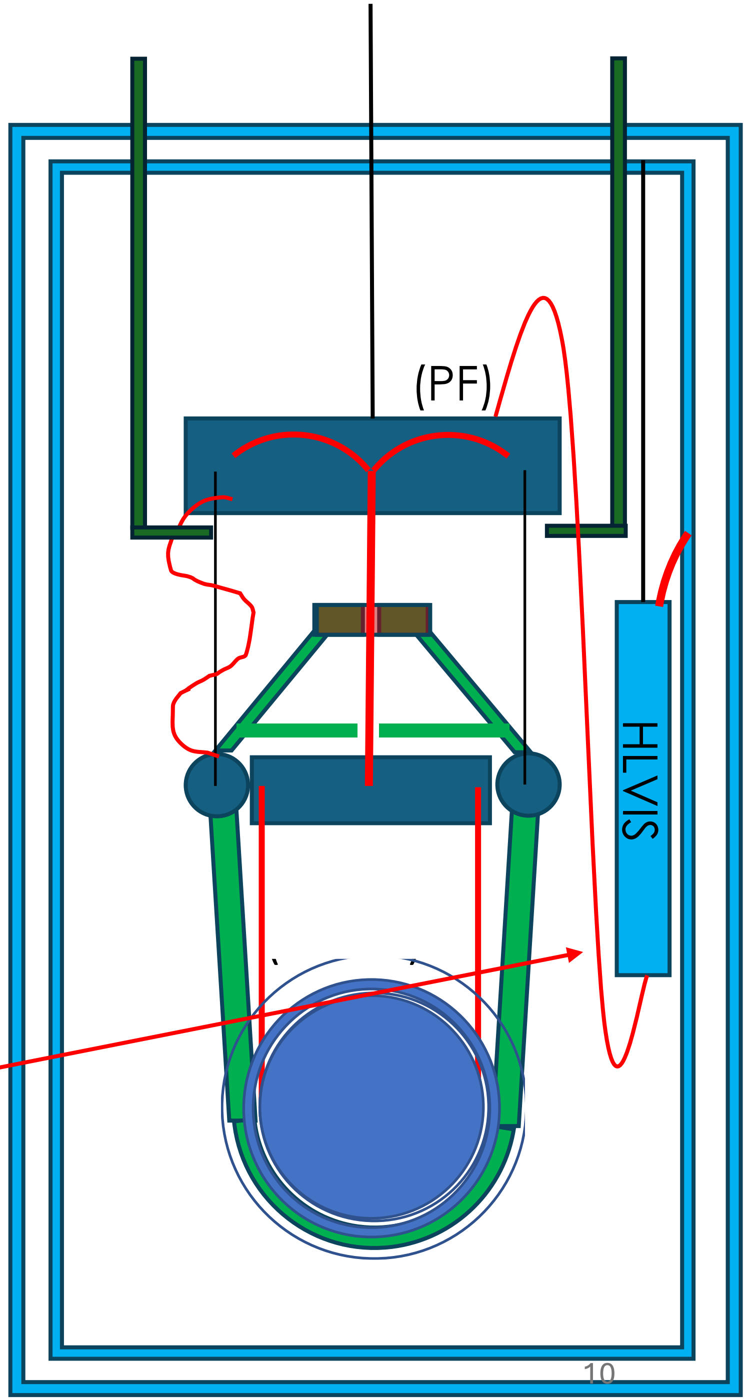
Integration is ment to be by bottom access

1. Platform gets into the cryostat
2. Mount Heat Link Vibration Isolation System → HLVIS
3. HLVIS thermal connection
4. Payload get into the cryostat → Mechanical, thermal and electrical connections
5. Supend the all payload

- **This sequence is proposed considering a small number of thermal link!**
    - **PRO:** heat link will have an additional damping stage

- With a large number thermal link is good to connect them at the platform
    - to avoid complex procedure in tower with small space

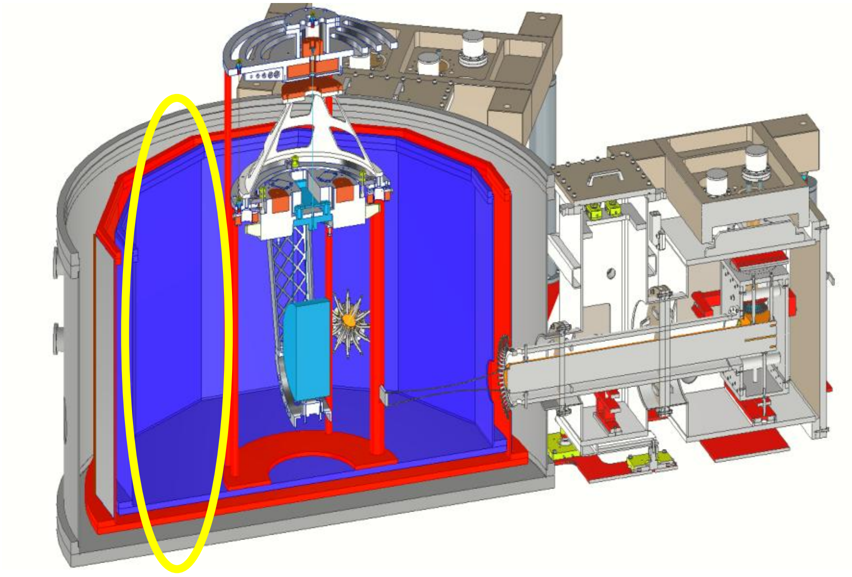
About the number of thermal links M. Ricci presentation



Mechanical interfaces: space around payload

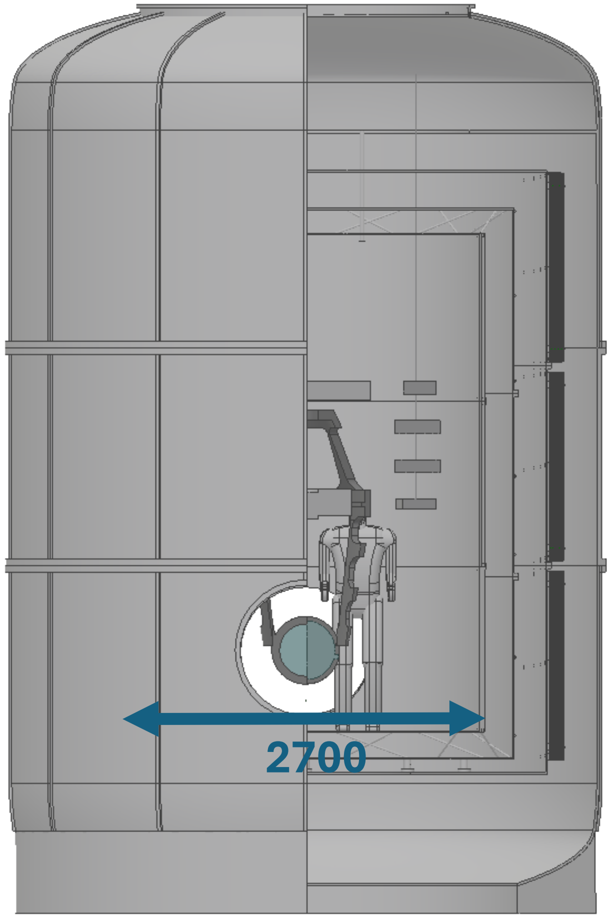
There must be enough space between payload and cryostat to let people work

In our prototype ARC we have 50cm



It was a choice due to lab dimensions
It's not enough

A minimum of 80cm is necessary



With a diameter of 270cm of the Internal Inner Thermal Shield (IITS) there is 85cm space

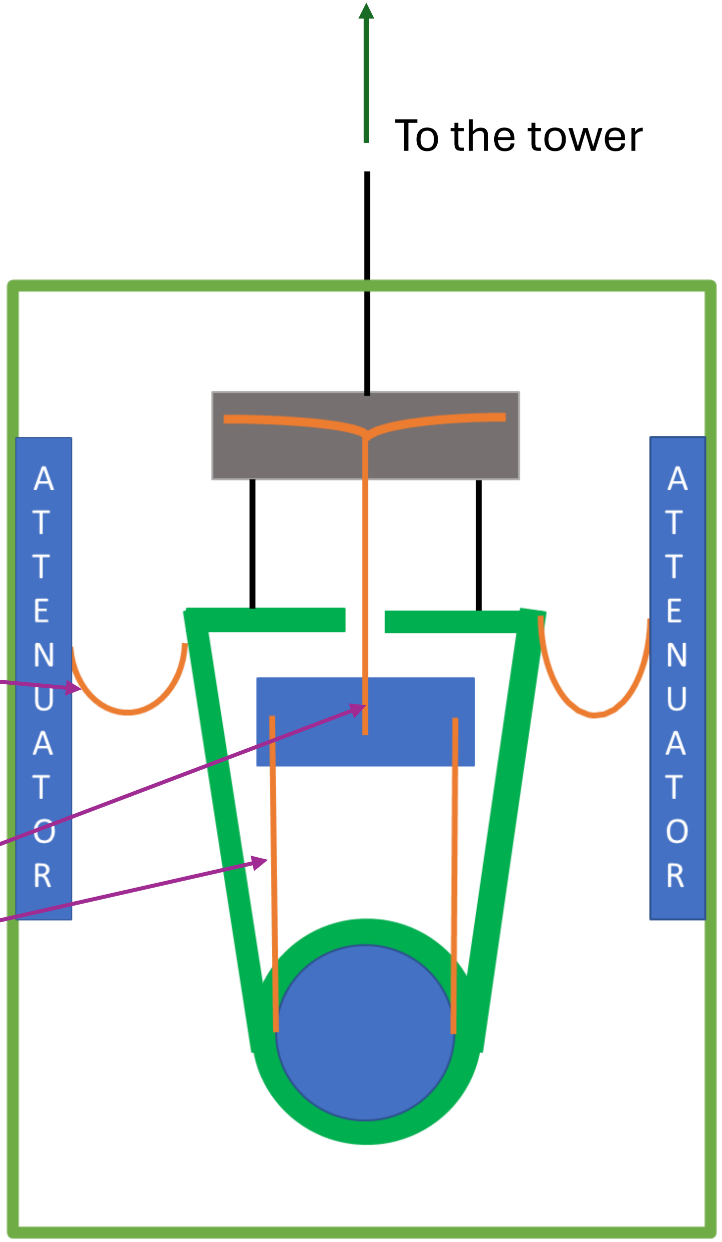
This considering the payload diameter 1m

* V. L. Hoang Presentation

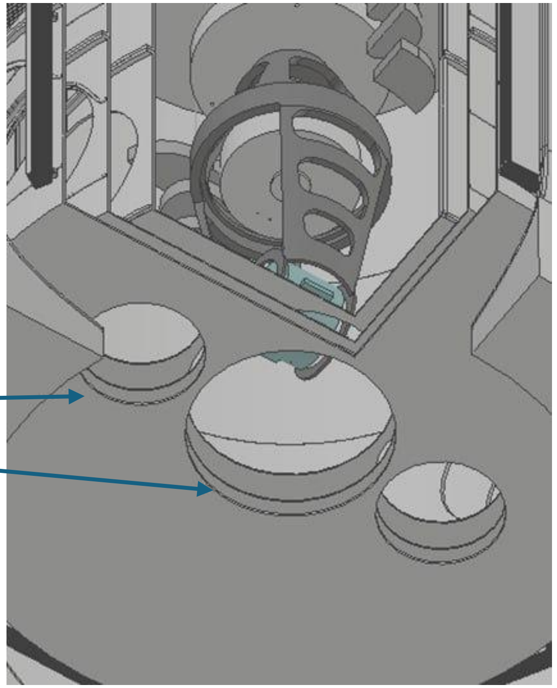
Mechanical interfaces

- Payload’s outside mechanical interfaces:
    - Cryostat:
        - 4m height clean room (5m height directly under the cryostat)
        - Working space around payload
    - Thermal links
        - Need a good connection to reduce contact resistance
    - Suspension tower

- Payload mechanical interfaces:
    - High Q High Thermal conductivity rod between platform and marionette
    - High Q High Thermal conductivity suspension between marionette and mirror



Open problems



- Definition of the apertures under the cryostat
- Connection between platform and marionette:
  - Feasibility of the sapphire rod → length, surface quality
  - Mechanical connection of the sapphire rod

In ARC-ETCRYO there's an R&Ds on sapphire

R&D with Kyocera: rod mechanical connection

- On going R&D with Kyocera on sapphire
- Study about mechanical coupling with sapphire rod

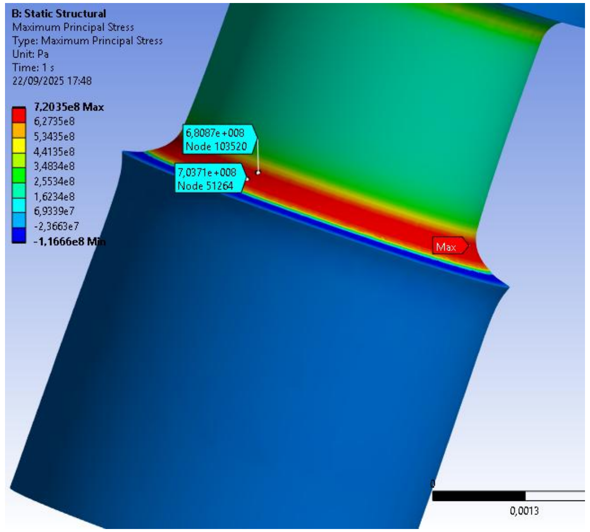
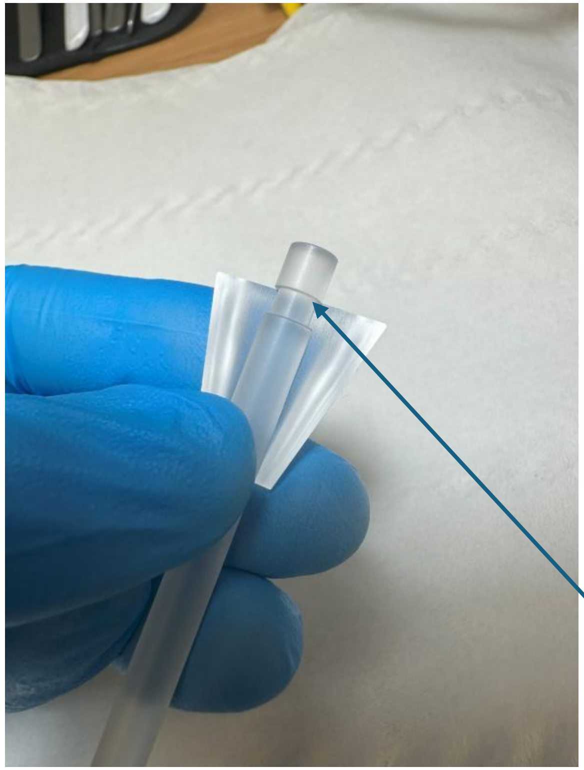


Table of Design Points

	A	B	C	D
1	Name	P1 - Group1	P2 - Maximum Principal Stress Maximum	Retain
2	Units	mm	Pa	
3	DP 0 (Current)	0,2	8,6207E+08	☑
4	DP 1	0,3	7,2035E+08	☑
5	DP 2	0,4	7,3203E+08	☑
6	DP 3	0,5	1,245E+09	☑

Max principal stress changing the radius



Here there's a R0,2

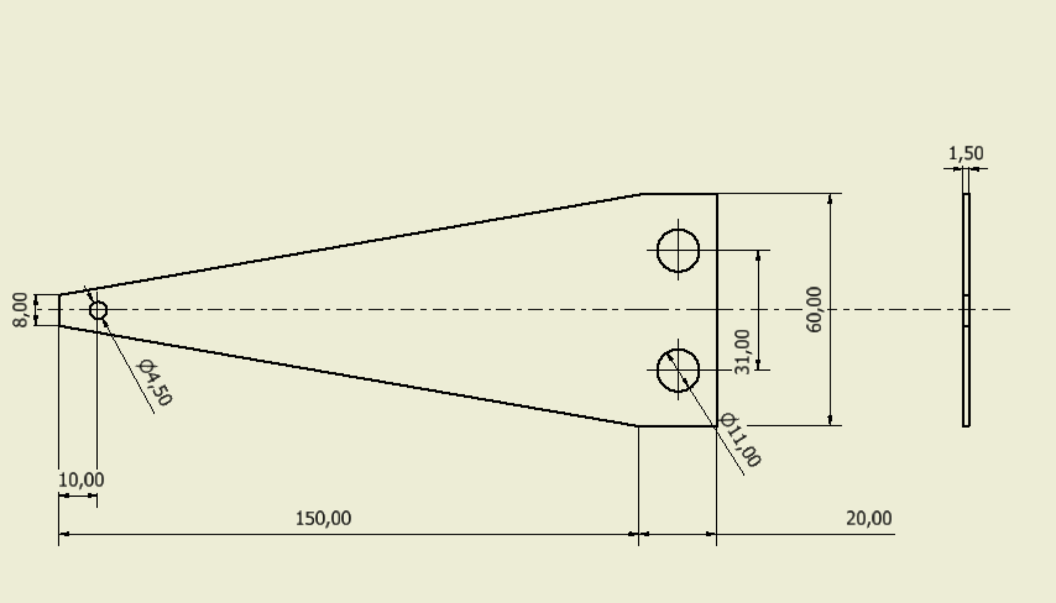
Use of cone with teeth

- At the moment there's a study about the mechanical connection
- Issue with rod length → no possibility to have 760mm length rod

R&D with Kyocera: sapphire blade

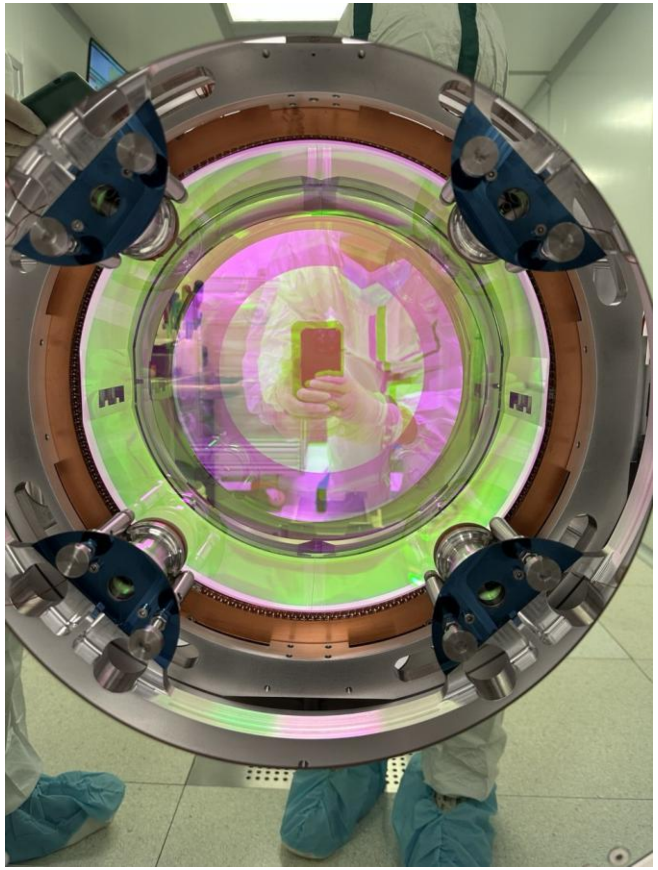
- Ongoing R&D with Kyocera on sapphire blades
- Blades on platform to improve vertical isolation
  - Sapphire for high Q and high themal conductivities

Sapphire blade's geometry
Design load: 6kg



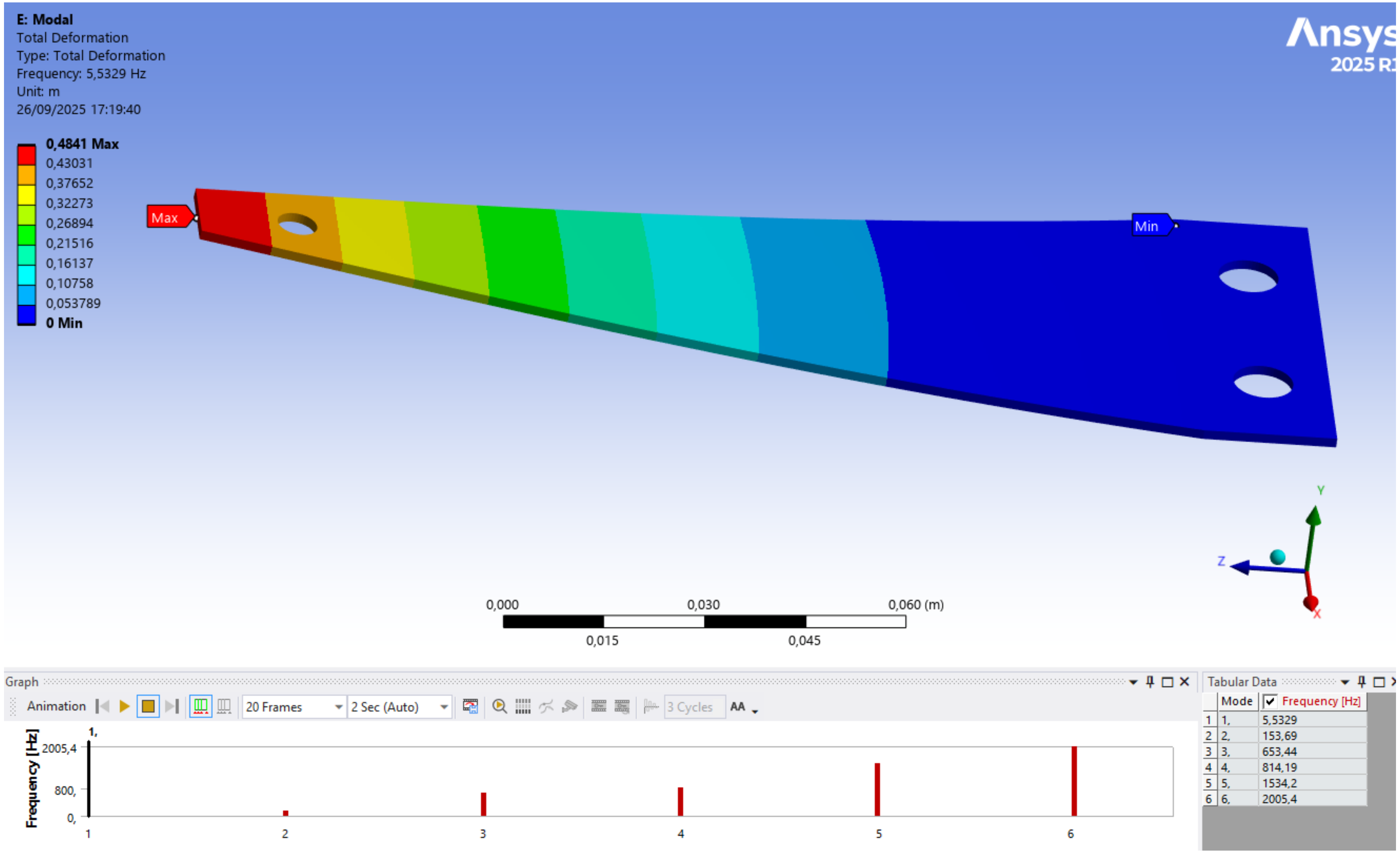
Conclusion

- Payload integration steps → differences based of number of thermal links
- Payload mechanical interfaces
- Sapphire R&D → Rod and Blades



Thank you for your attention

BACK UP



	Mode	Frequency [Hz]
1	1,	5,5329
2	2,	153,69
3	3,	653,44
4	4,	814,19
5	5,	1534,2
6	6,	2005,4

blades calculus

$\sigma y_{sapp} := 690\ MPa$ Yeld strength of sapphire

$E_{sapp} := 440\ GPa$ Young modulus of sapphire

$Lb := 150\ mm$ Blade length

$B := 60\ mm$ Blade base

$s := 1.5\ mm$ Blade thickness

$\sigma_{max} := 0.6 \cdot \sigma y_{sapp}$ stress limit in use

$F := \dfrac{\sigma_{max} \cdot B \cdot s^2}{6 \cdot Lb} = 62.1\ N$ force to have sigma max

$$f := \frac{1}{2 \cdot \pi \cdot Lb} \cdot \sqrt{g} \cdot \sqrt[4]{\frac{6 \cdot F \cdot Lb}{B}} \cdot \sqrt[4]{\frac{E_{sapp}^{\,2}}{\sigma_{max}^{\,3}}} = 4.195\ \frac{1}{s}$$