Double Quarter Wave Crab Cavity

Helium Vessel

Silvia Verdú-Andrés
on behalf of the DQWCC team
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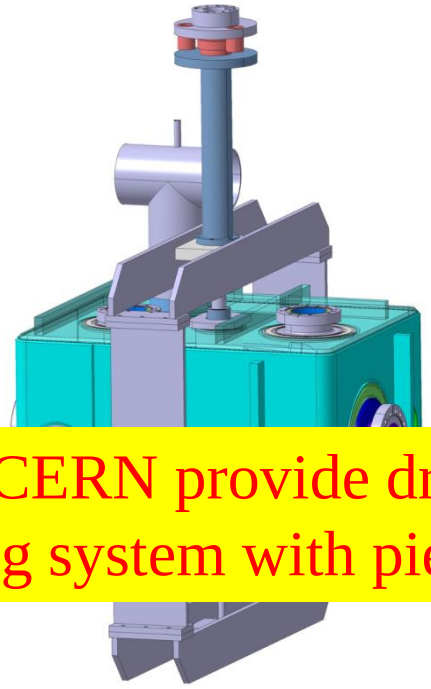
Outline

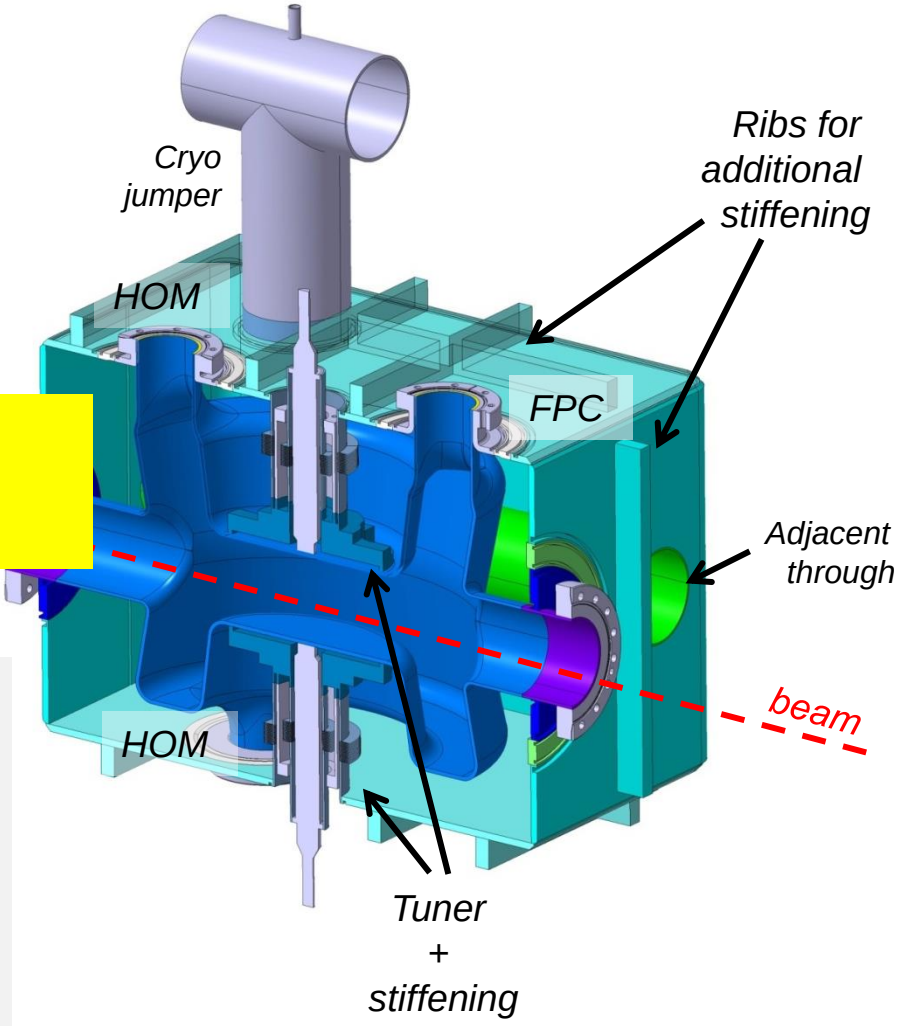
- Conceptual design of the helium vessel and tuning system for the SPS DQWCC
  - Overview: dimensions, weight, He volume
  - Cavity stiffening, pre-tuning and tuning systems
  - Helium vessel and tuning system: assembly sequence, connections and interfaces, materials and joints
- Engineering studies
  - Pre-tuning and tuning range
  - Mechanical stresses
  - Thermal loads
- Summary

- PoP helium vessel to introduce smoothly the conceptual design

Helium vessel - concept

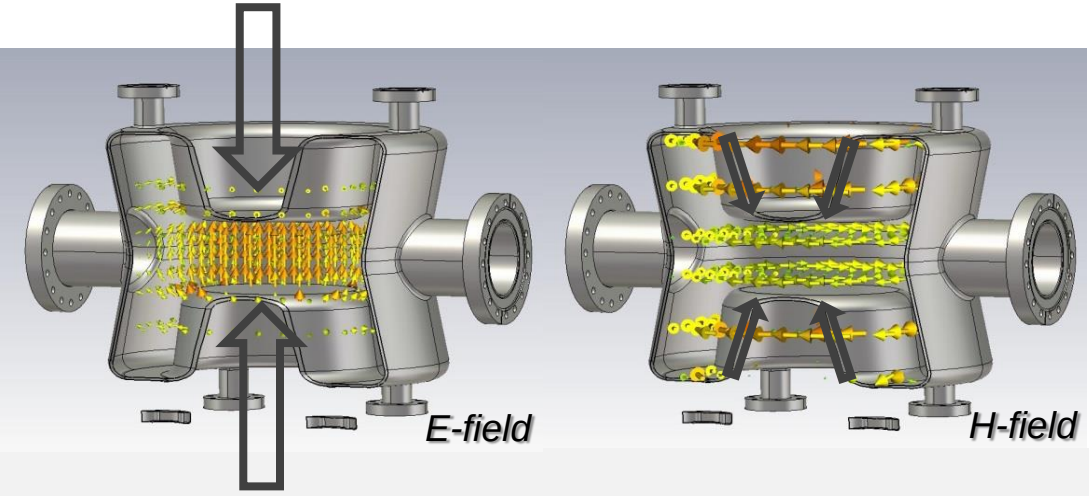


Can CERN provide drawing of tuning system with piezo part?



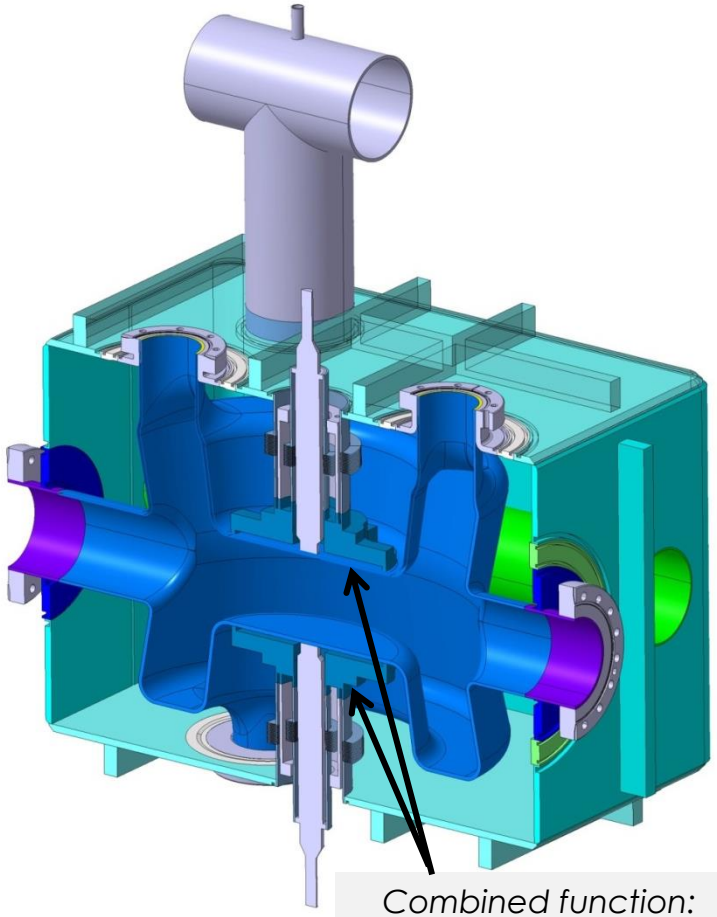
- Titanium and Niobium similar thermal expansion coefficient → *rigid connections for all ports*
- Piezo outside vessel → *larger tuning range*
- Prep rings for eventual disassembly
- All liquid helium – vacuum interfaces welded for best vacuum tightness
- Clearance to access to ports

Pre-tuning and tuning systems



Tuning by actuation on the central plates

Silvia: PoP → SPS

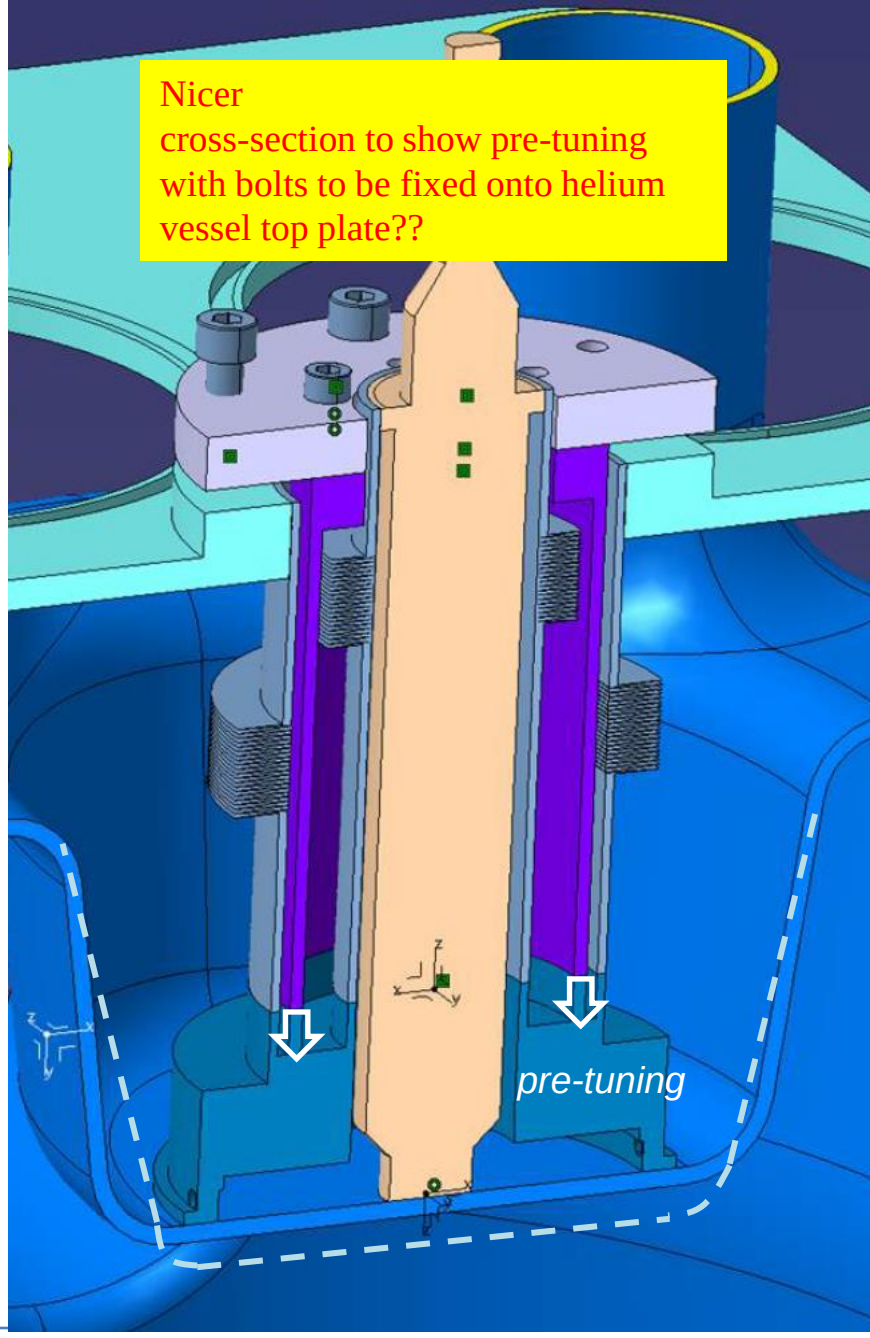


Combined function:
tuning + stiffening

Pre-tuning system

- Pre-tuning ~ 1.6 MHz/mm
  (during assembly of cavity-vessel)
  for machining tolerances

Put Qiong's table with machining tolerances



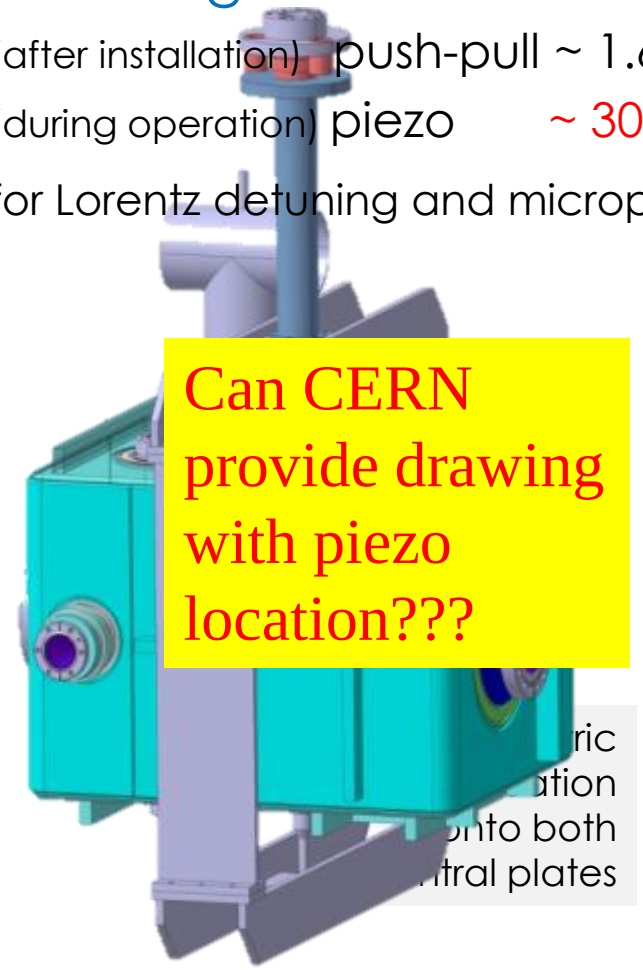
Tuning system

- Tuning

(after installation) push-pull ~ 1.6 MHz/mm

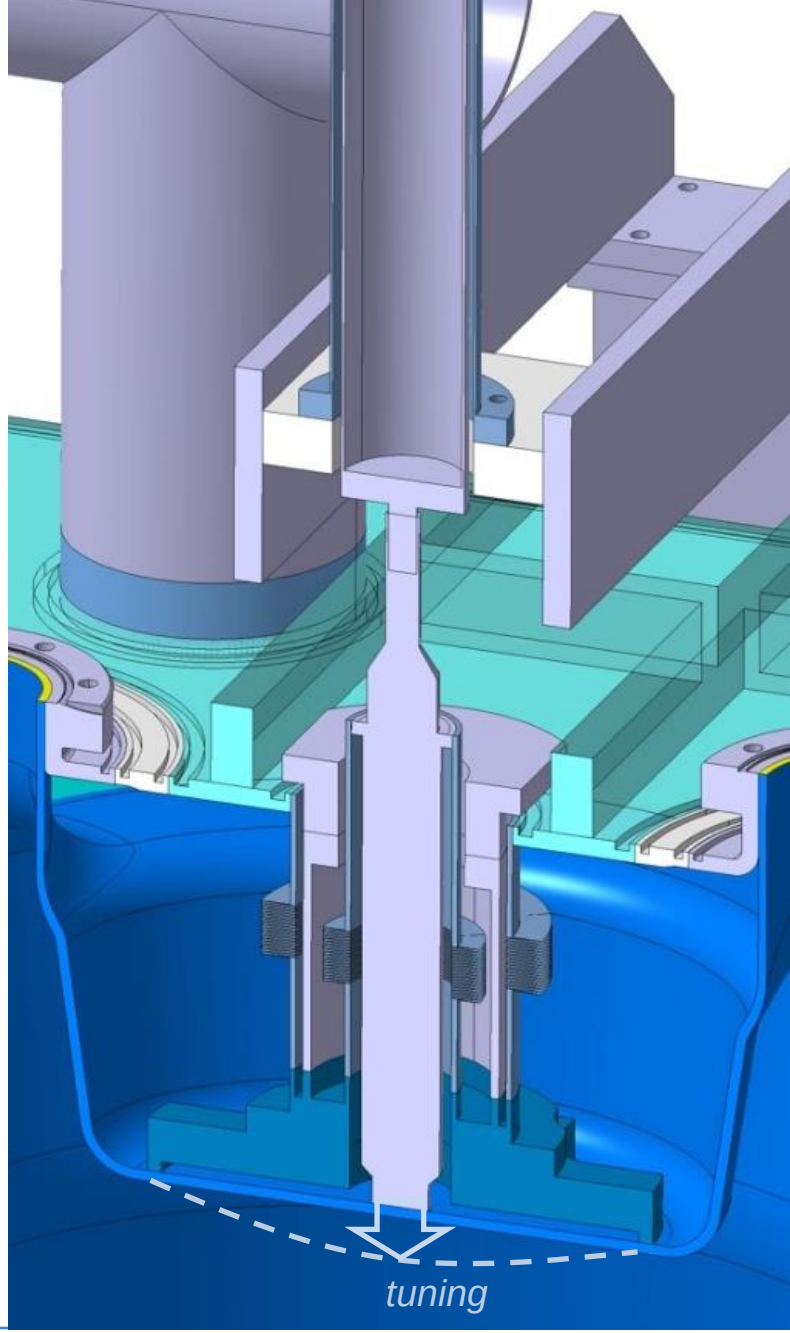
(during operation) piezo ~ 30 μm

for Lorentz detuning and microphonics

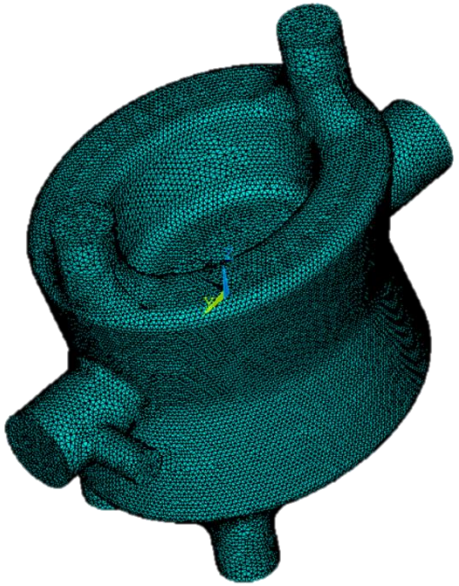


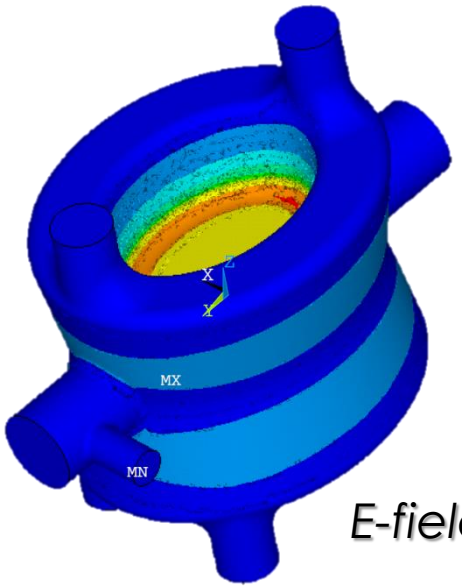
Can CERN provide drawing with piezo location???

ric
ation
nto both
ntral plates

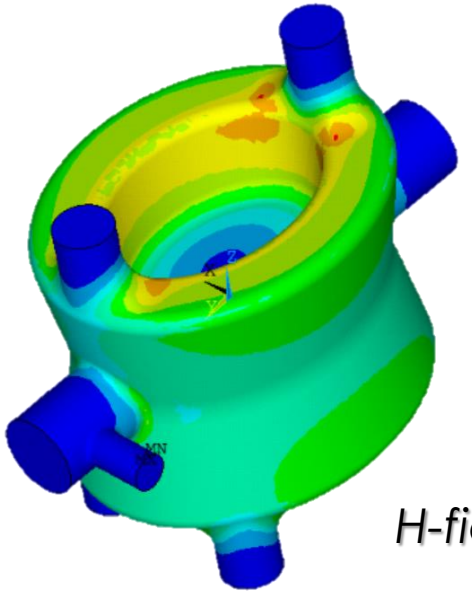


Lorentz detuning



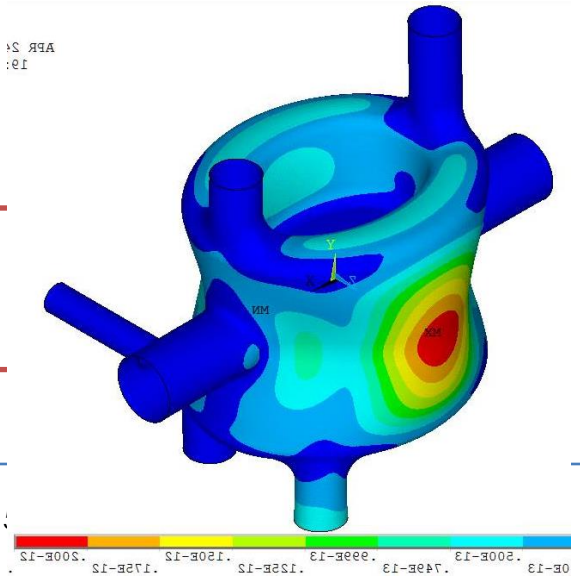


E-field



H-field

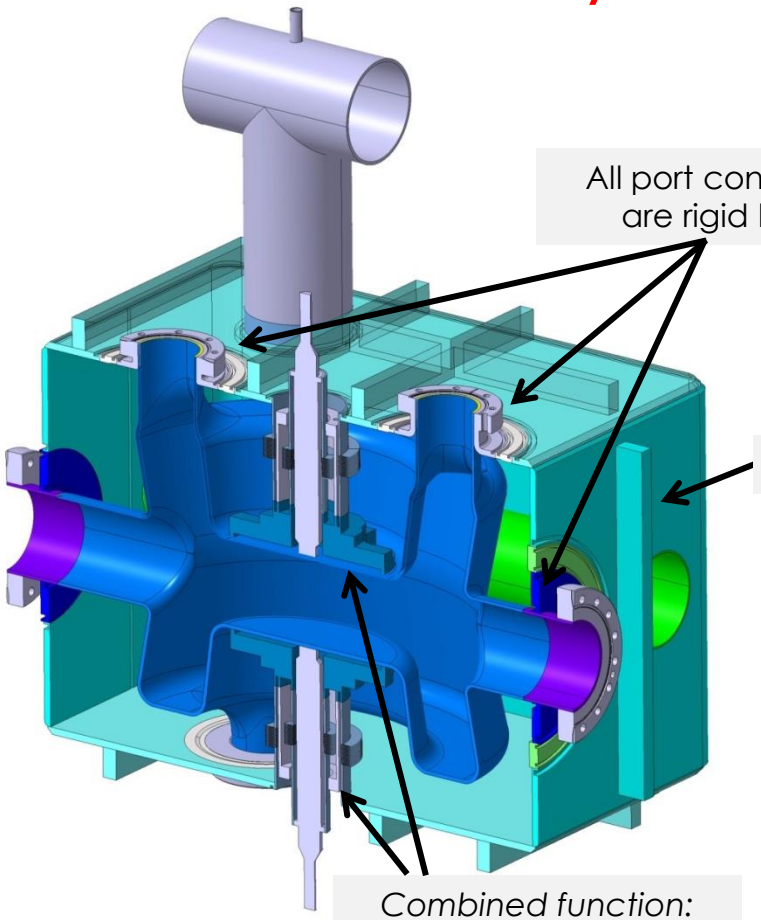
Fixed all ports and central plates (best case scenario)



Lorentz detuning: $P = \frac{1}{4}\left(-\varepsilon_0\left|\vec{E}\right|^2 + \mu_0\left|\vec{H}\right|^2\right)$

0.17 Hz/ (10J) – best case scenario

Stiffening for cavity and helium vessel



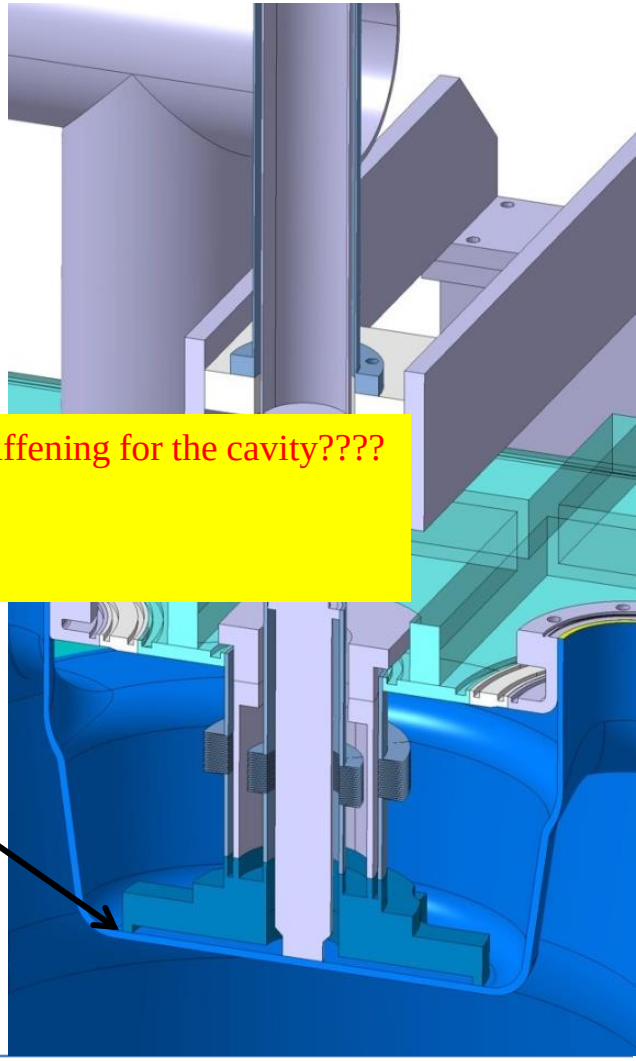
All port connections are rigid but PU

Ribs

Combined function:
tuning + stiffening
on central plates

Any additional stiffening for the cavity????

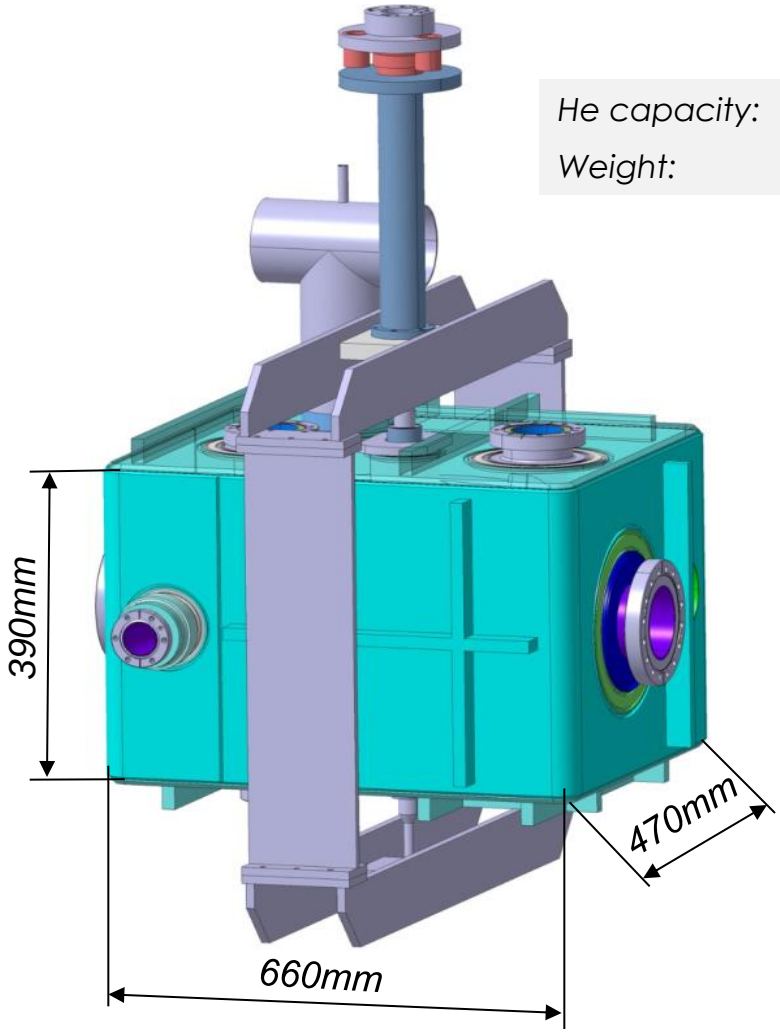
Stiffening during cooling down and pressure changes

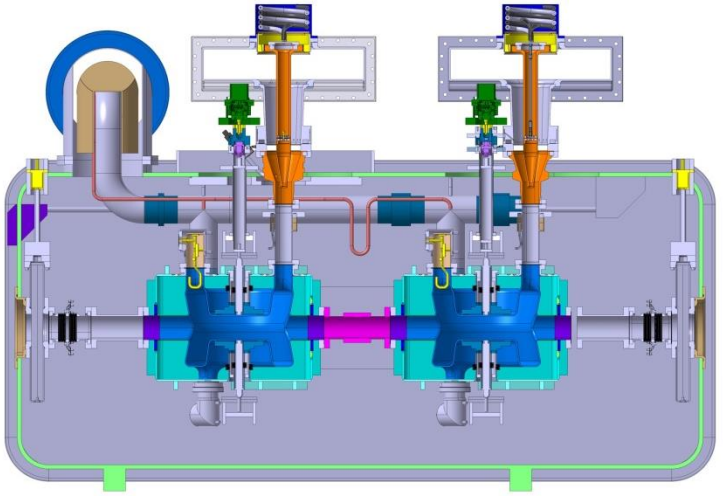


Helium vessel - dimensions

He capacity: ??

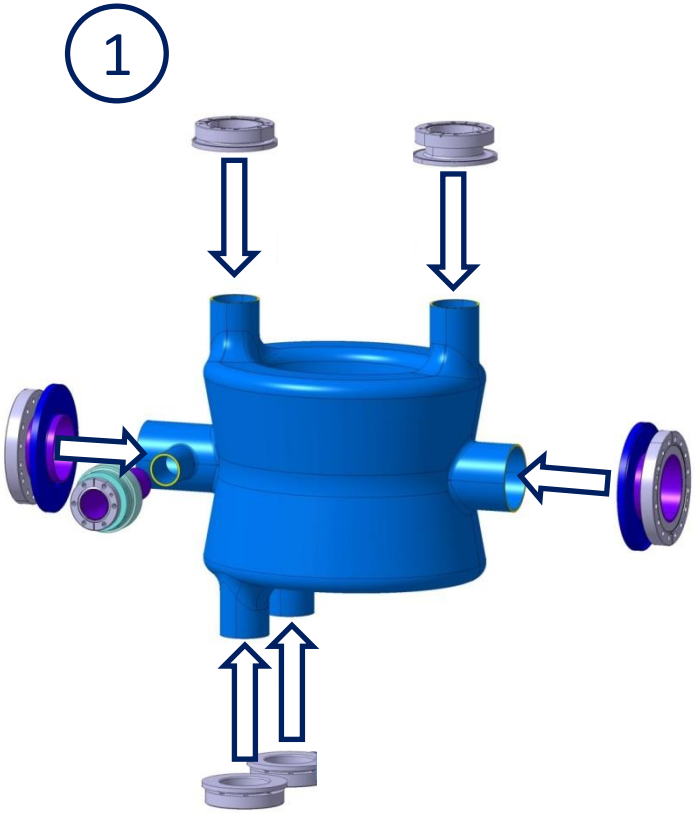
Weight: ??





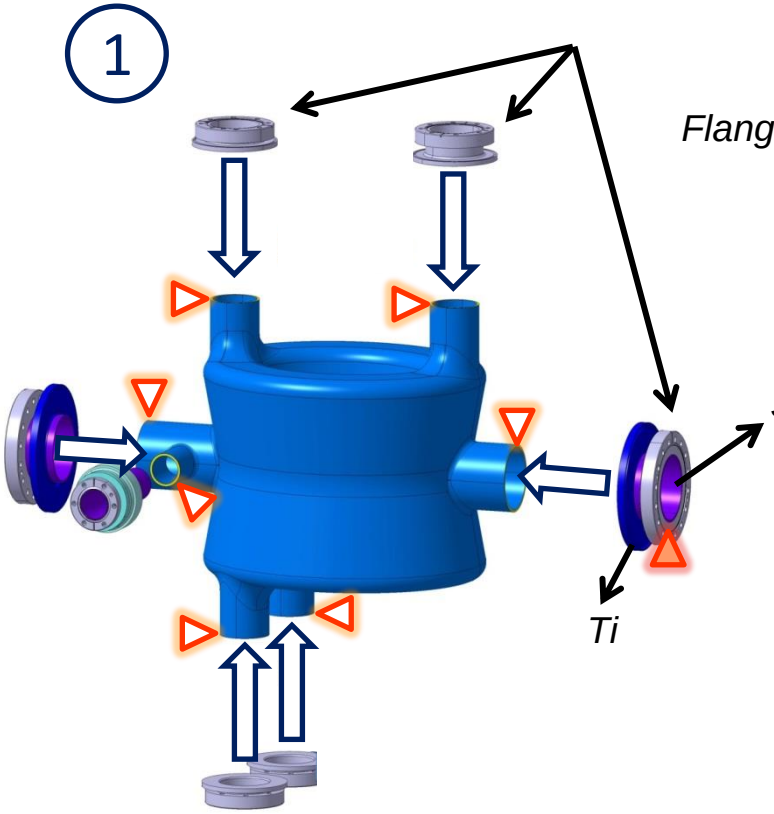
Integration into cryomodule

Cavity assembly

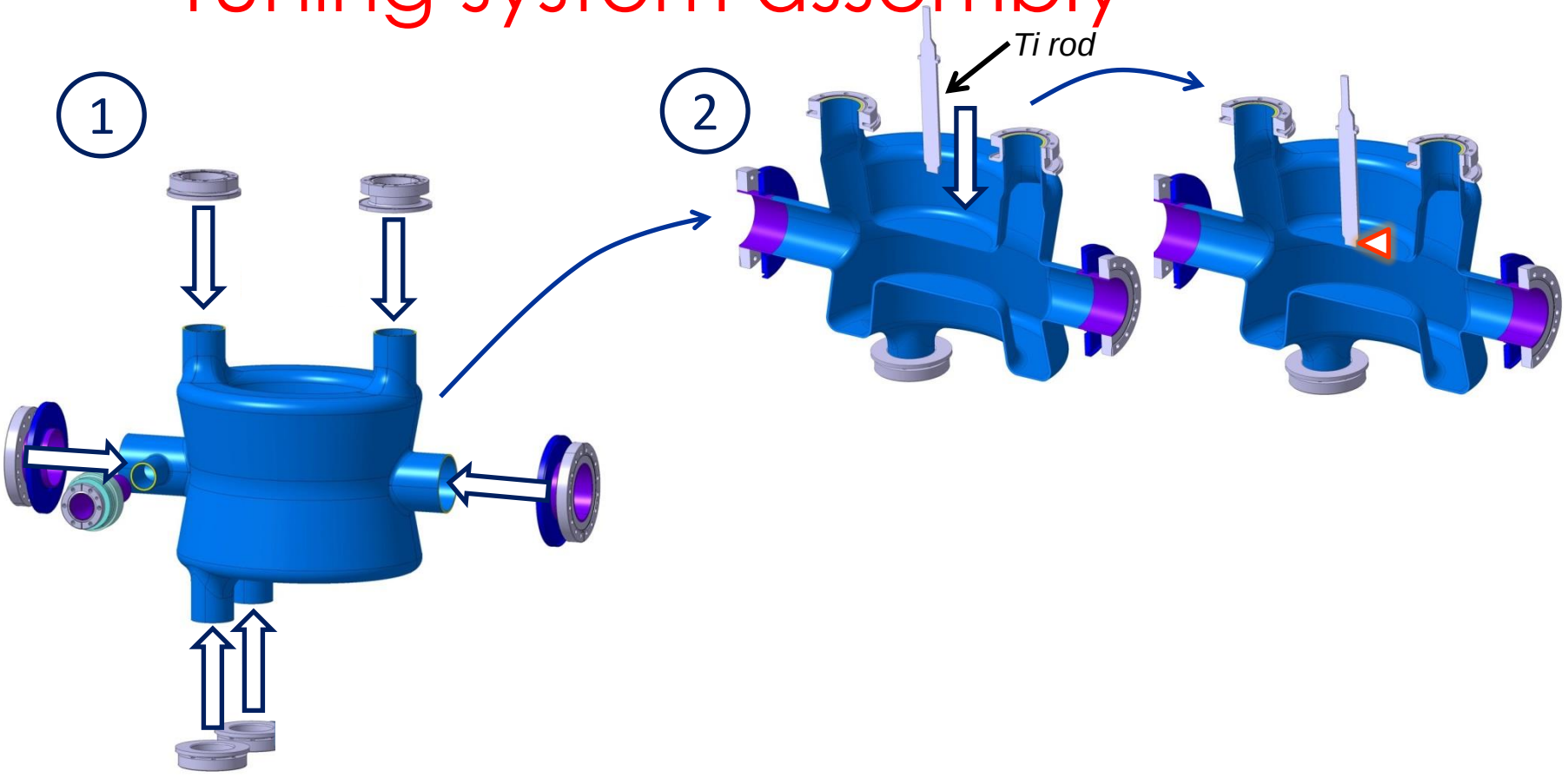


HOM: NbTi flange welded to Ti adaptor and Nb tube

Cavity assembly



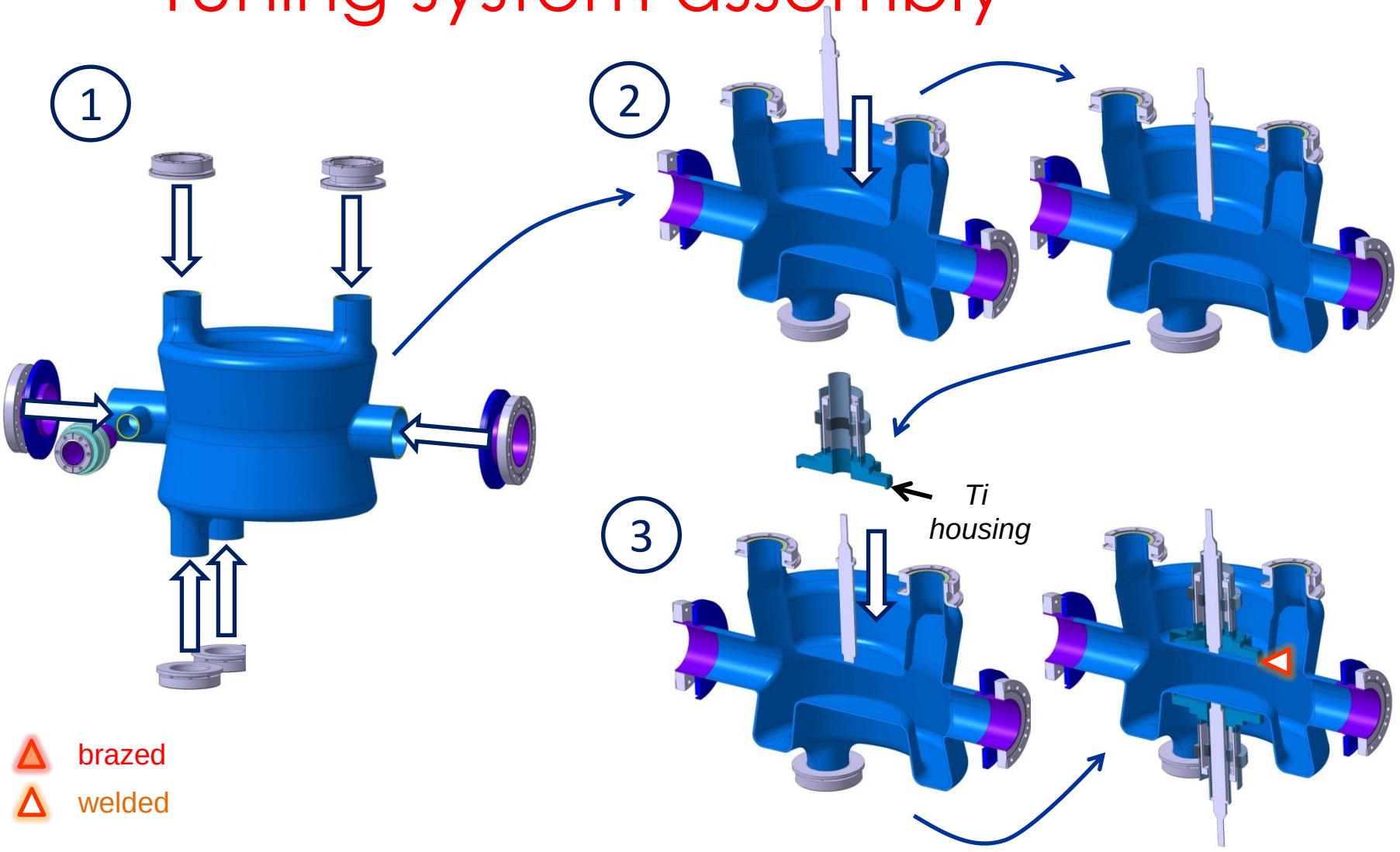
Tuning system assembly



brazed

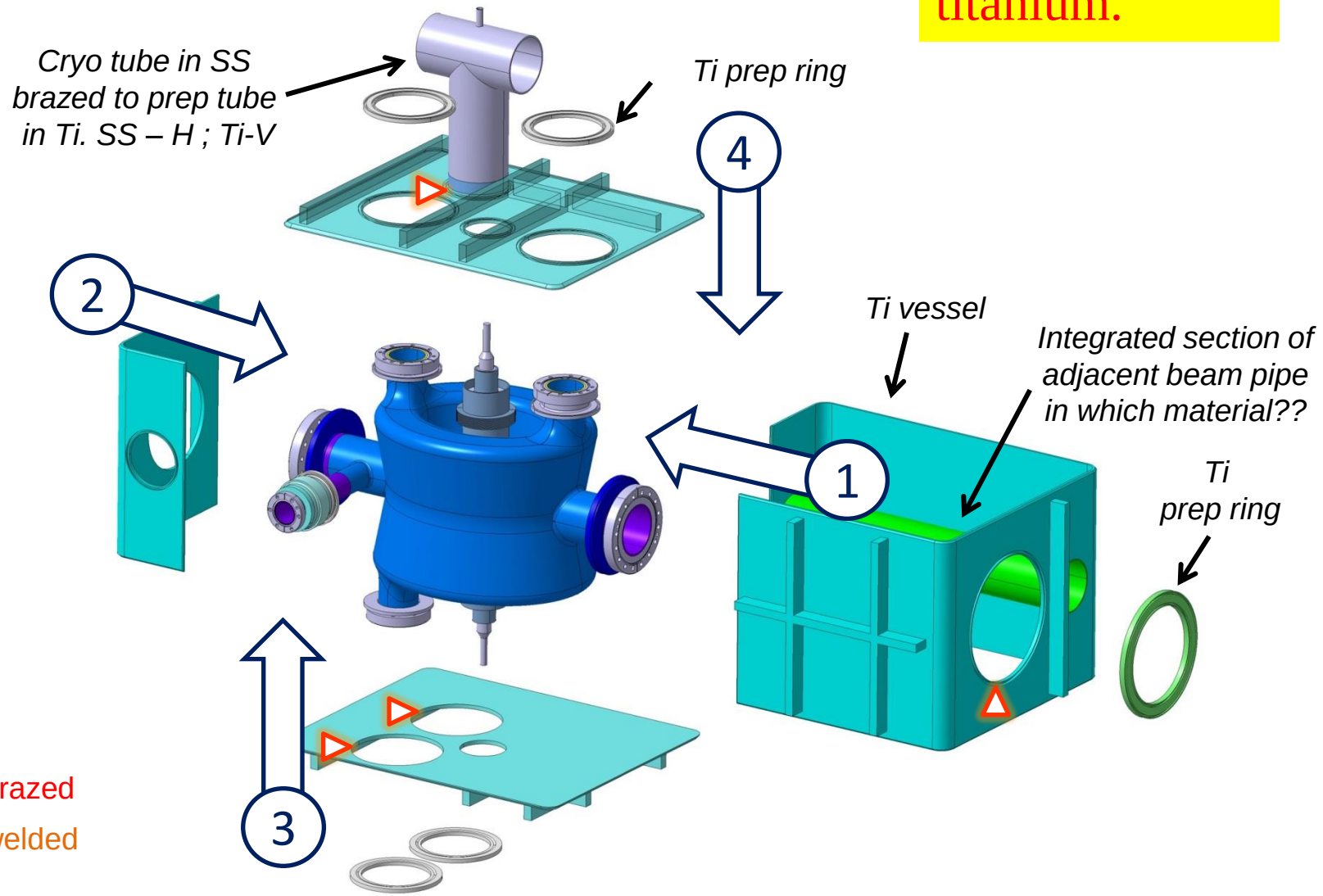
welded

Tuning system assembly

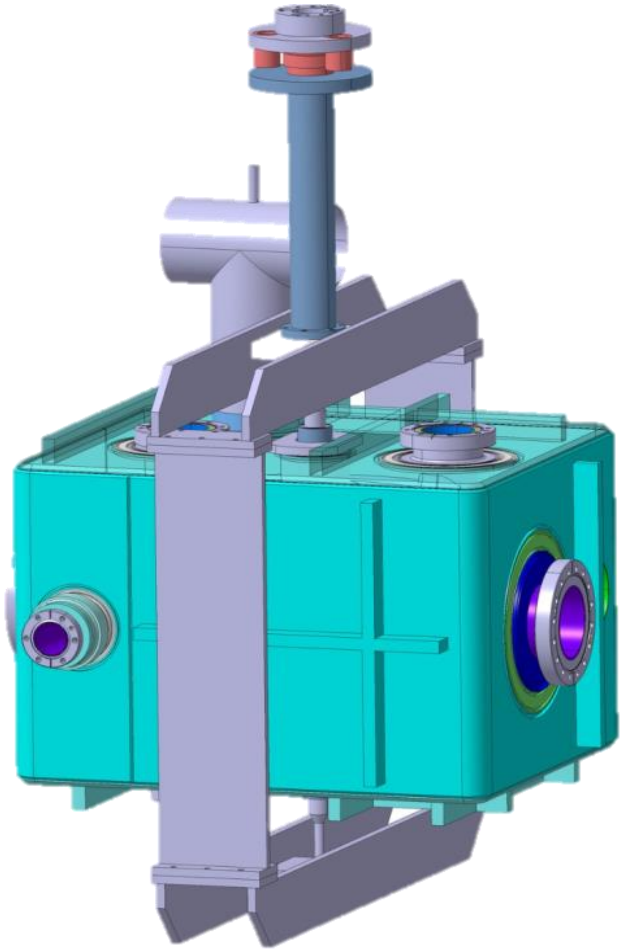


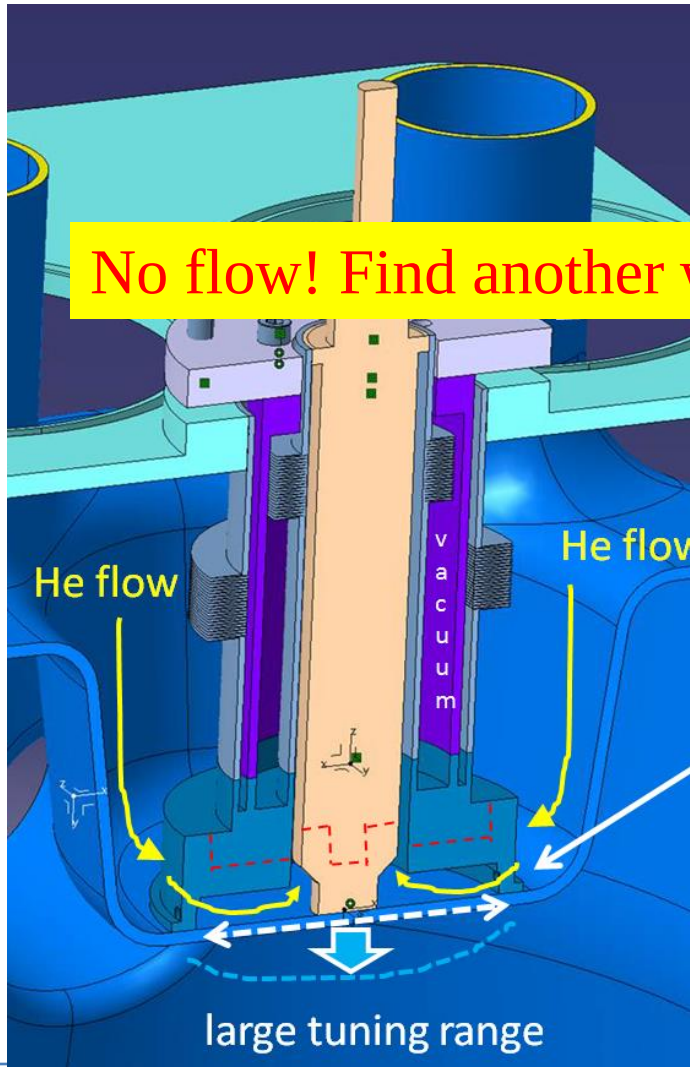
Helium vessel assembly

Grade 2 titanium.



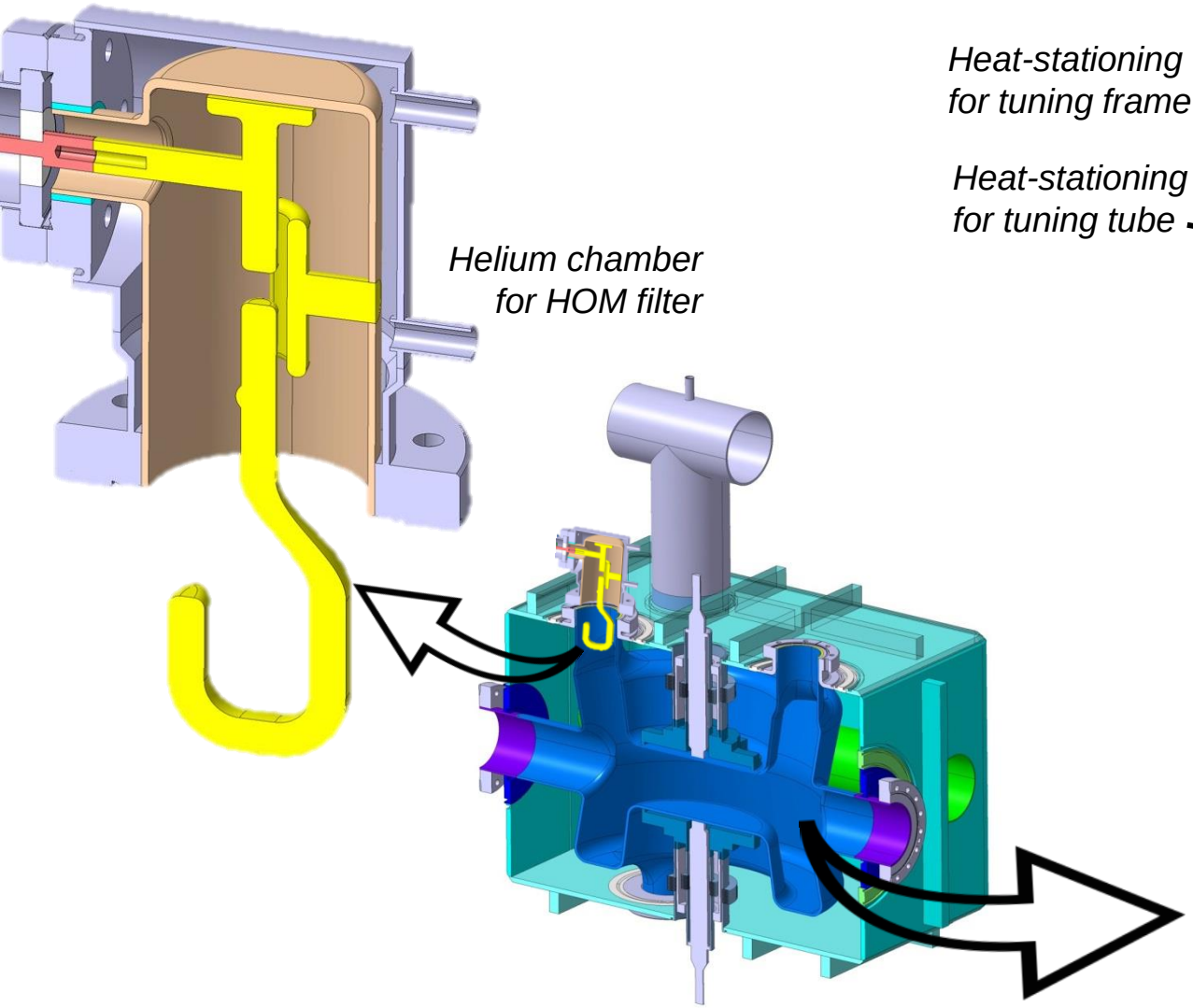
Helium – vacuum interfaces

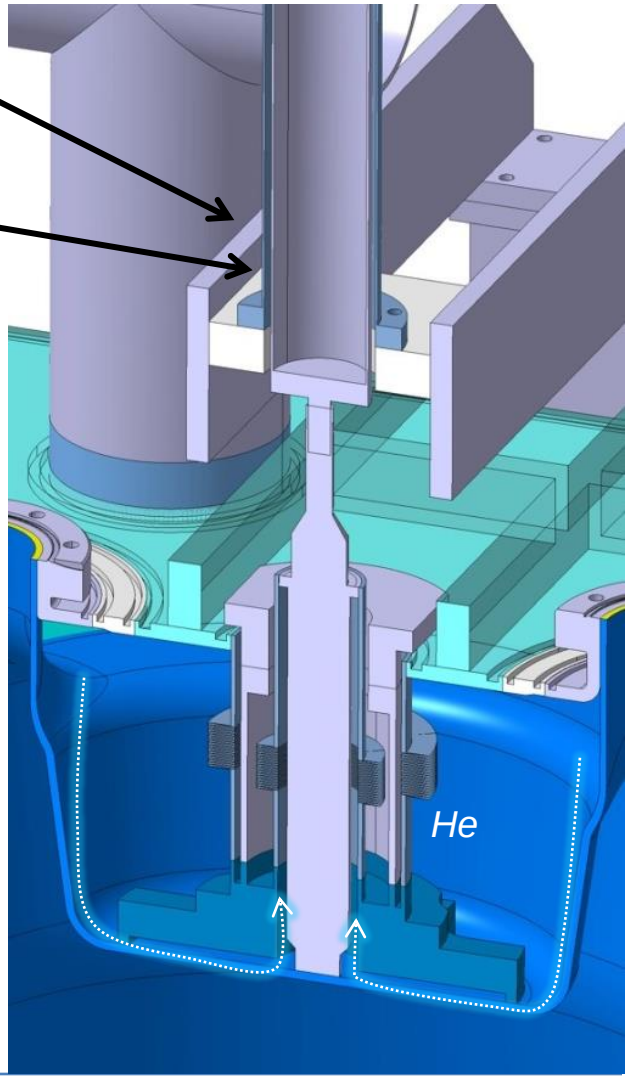




- All liquid helium – vacuum interfaces welded

Cooling and heat-stationing





Heat loads – tuning system

- Picture with temperature to show gradients
- Picture of simulation result

CERN: heat load for tuning system

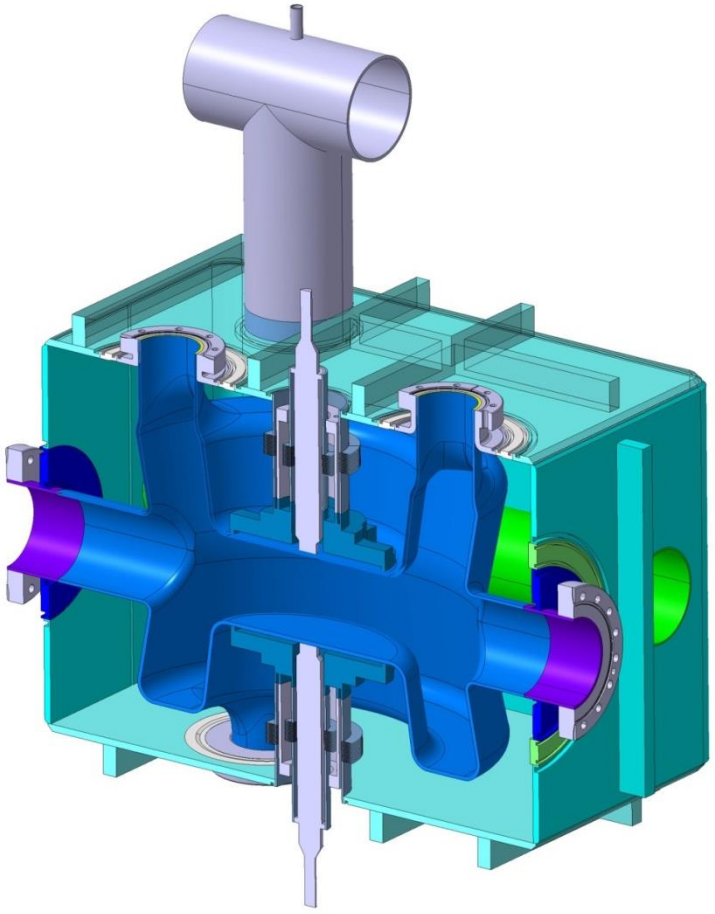
Total heat load

HL per cryomodule		HL @2K [W]	HL @80K [W]	Comments
	Radiation (Cavity + Phase Sep. Cold surface + Thermal shield)	**0.2**	**6.8**	Rescaling from LHC: 0.1W/m^2@cold mass 1.7W/m^2@thermal shield
	CWT	**3.0**	**12.6**	1 heat interceptor not optimized
	Supporting system	**0.2**	**3.3**	HL@2K estimated from SPL
				ube thickness t = 3mm
				ive
				ermalized
				sses found in ODU cryostat: l HOMs (4x0.2W @2K ted from SPL) + 2 "chimneys" HOM (2x2W @2K for a thickness of 3 mm and a length outside He bath of 340 mm); @80K: 4x? + 2x45W
Total Static		**13.6**	**222.7**	
Dynamic	Deflecting mode	**6.0**	**0**	Tentative
	Beam current	**0.5**	**0**	Tentative
	RF couplers	2 x 2 = **4.0**	2 x 5 = **10**	For a tube thickness t = 3mm ; P_{avg} = 100 kW
	Other order modes	**0.6**	**10**	for a P_{avg} = 100 kW; f = 1000 MHz; @2K chimneys: 2x0.1 + small HOM (estimated from SPL): 4x0.1@2K; @80K: 4x?+2x4
Total Dynamic		**11.1**	**20**	
Total losses		**24.7**	**242.7**	

To be updated: Skaritka

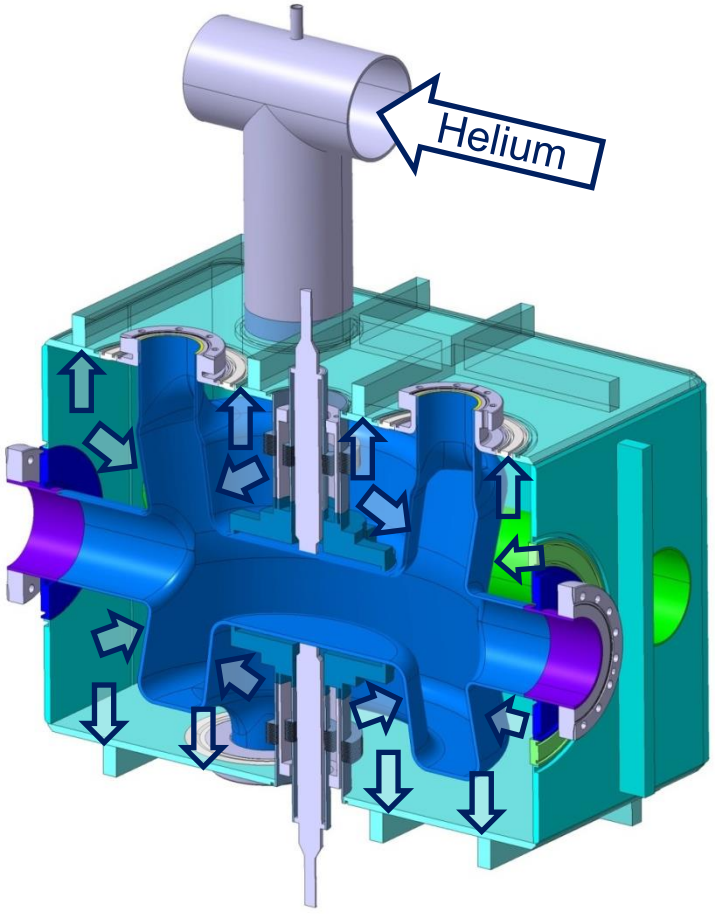
Mechanical stresses

1. Helium pressure
2. 300 K → 2K
3. Actuation of tuning system



Mechanical stresses

1. **Helium pressure**
2. 300 K → 2K
3. Actuation of tuning system

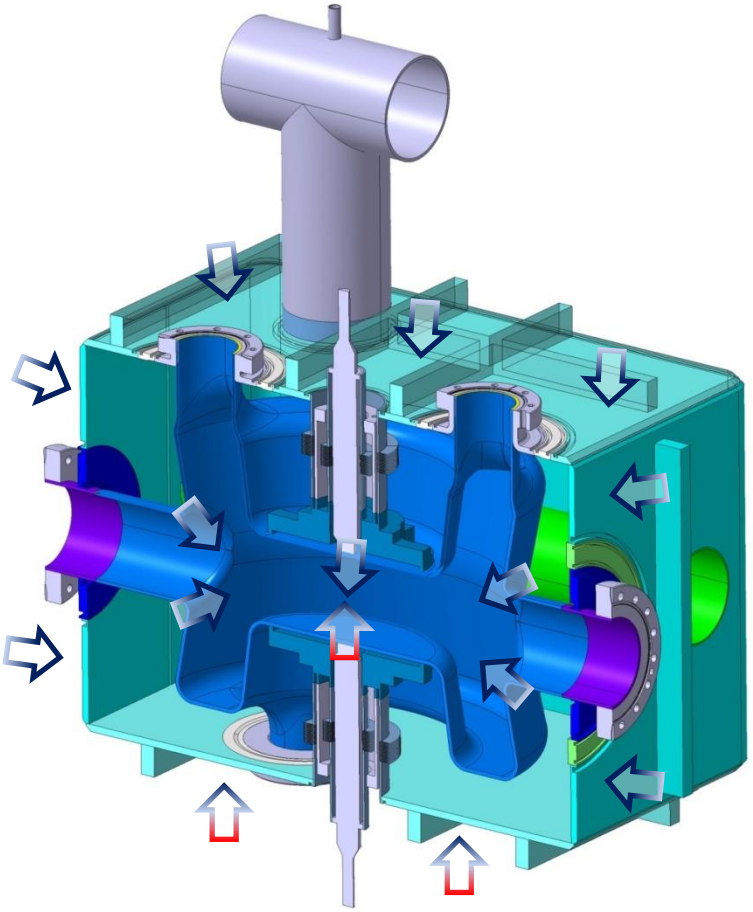


Mechanical stresses due to helium pressure

- Constrains (fixed boundaries, etc)
- Load(s) and number of cycles (if applies)
- Max. stress allowed
- Picture of mesh
- Picture of initial constrains and loads
- Picture of stress value and deformation arrows
- Design elements incorporated to counter-act load effects
- Young modulus and Poisson's ratio

Mechanical stresses

1. Helium pressure
2. **300 K → 2K**
3. Actuation of tuning system

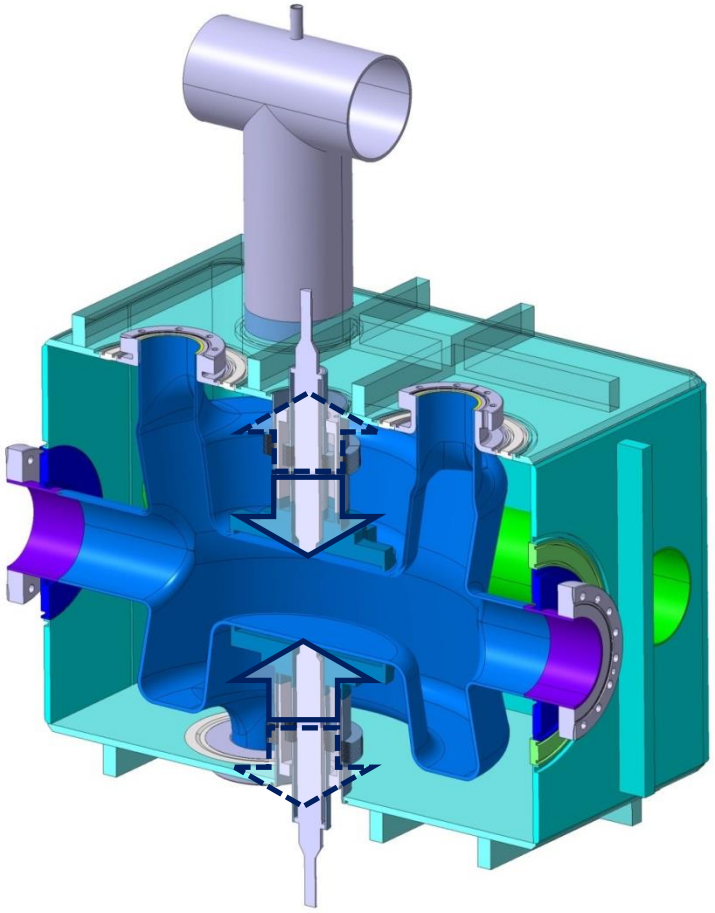


Mechanical stresses due to thermal contraction (300K → 2K)

- Constrains (fixed boundaries, etc)
- Load(s) and number of cycles (if applies)
- Max. stress allowed
- Picture of mesh
- Picture of initial constrains and loads
- Picture of stress value and deformation arrows
- Design elements incorporated to counter-act load effects
- Thermal expansion coefficient for Niobium and Titanium, Young modulus and Poisson's ratio

Mechanical stresses

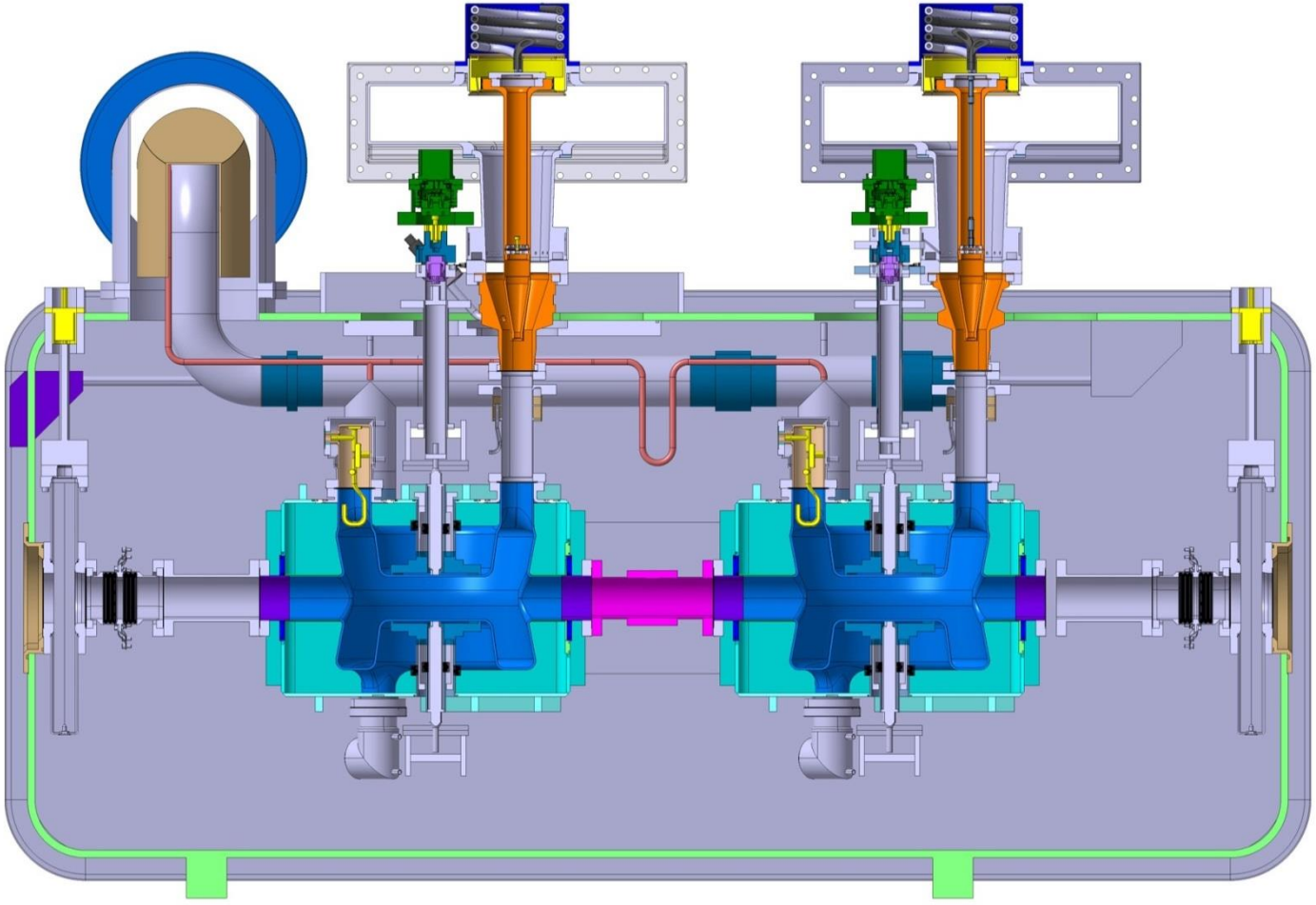
1. Helium pressure
2. 300 K → 2K
3. **Actuation of tuning system**



Mechanical stresses due to tuning system actuation

- Constrains (fixed boundaries, etc)
- Load(s) and number of cycles (if applies)
- Max. stress allowed
- Picture of initial constrains and loads
- Picture of mesh
- Picture of stress value and deformation arrows
- Design elements incorporated to counter-act load effects
- Young modulus and Poisson's ratio

Integration into cryomodule



→ Tomorrow's presentation by John Skaritka

Summary

- **Compact vessel** for compact cavity
- Dedicated vessel design to:
  - **minimize** liquid helium **leak chances** (all helium-vacuum interfaces welded)
  - **ease assembly**, particularly the access to cavity ports
  - **ease disassembly** (prep rings)
- Robust vessel design??
- Appropriate **stiffening** of the cavity provided by rigid connection of cavity ports to vessel and tuning system
- Manifold tuning : **pre-tuning + push-pull + piezo**
- Optimized design for **reduced heat load**??

BNL

Sergey Belomestnykh, Ilan Ben-Zvi, John Skaritka, Silvia Verdú-Andrés, Binping Xiao, Qiong Wu

CERN

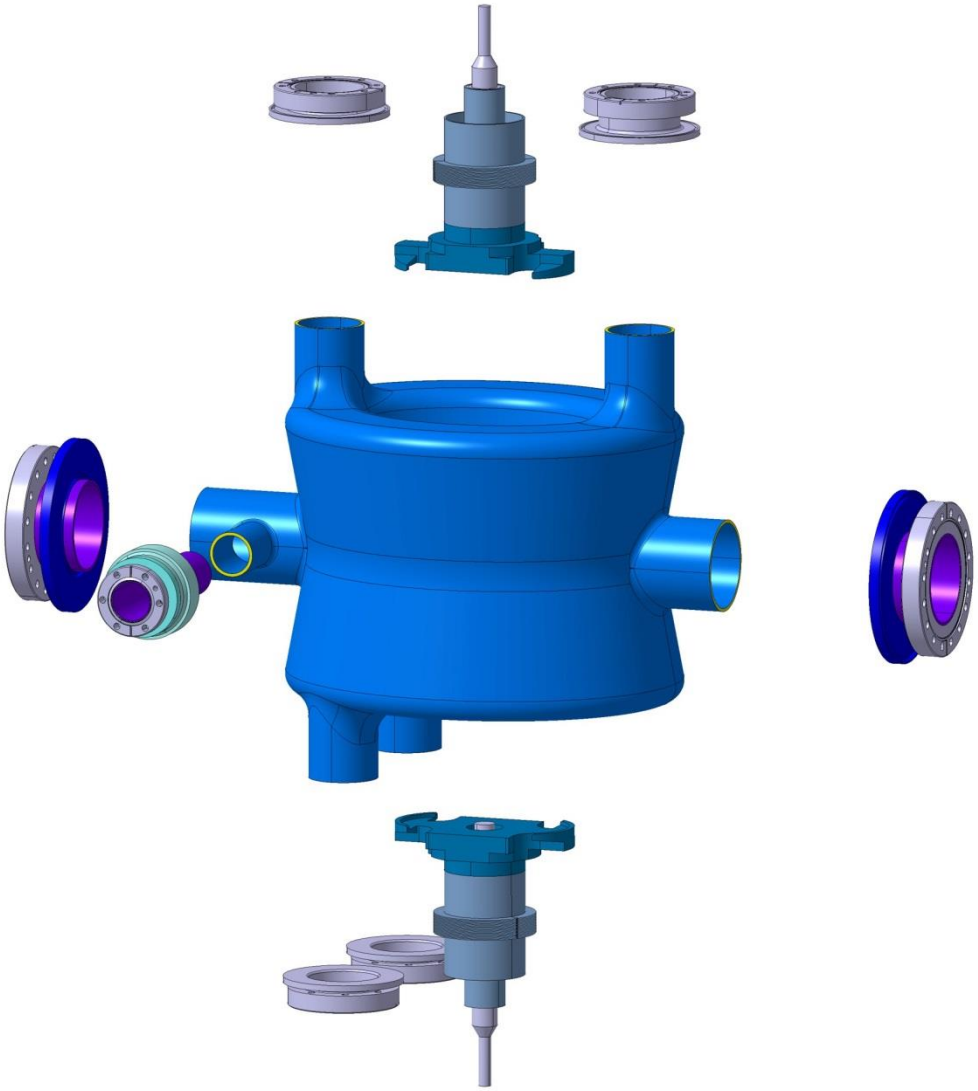
Luis Alberty, Rama Calaga, Ofelia Capatina, Federico Carra, Giuseppe Foffano, Norbert Kuder, Raphael Leuxe, Thierry Renaglia

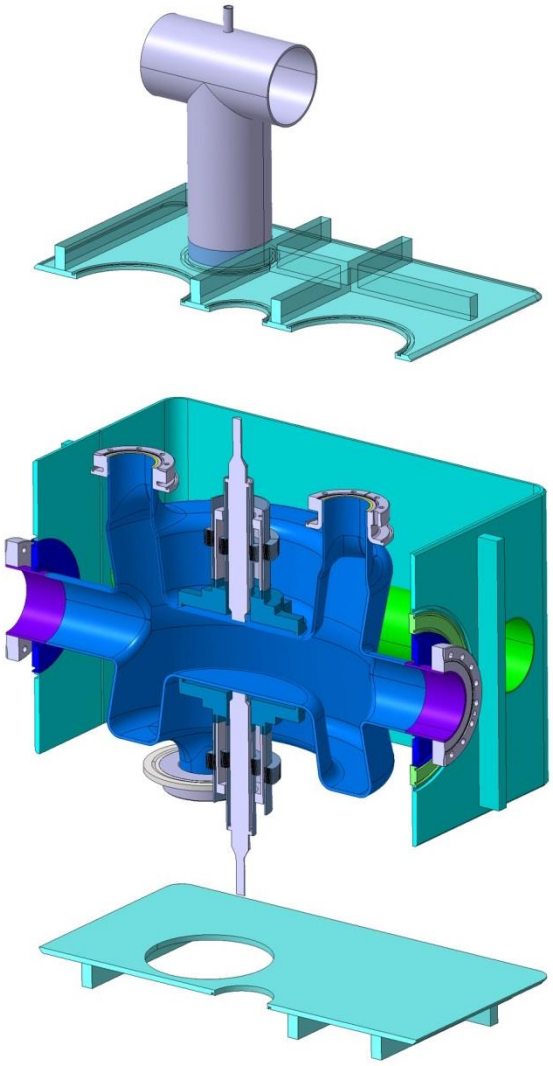
SLAC

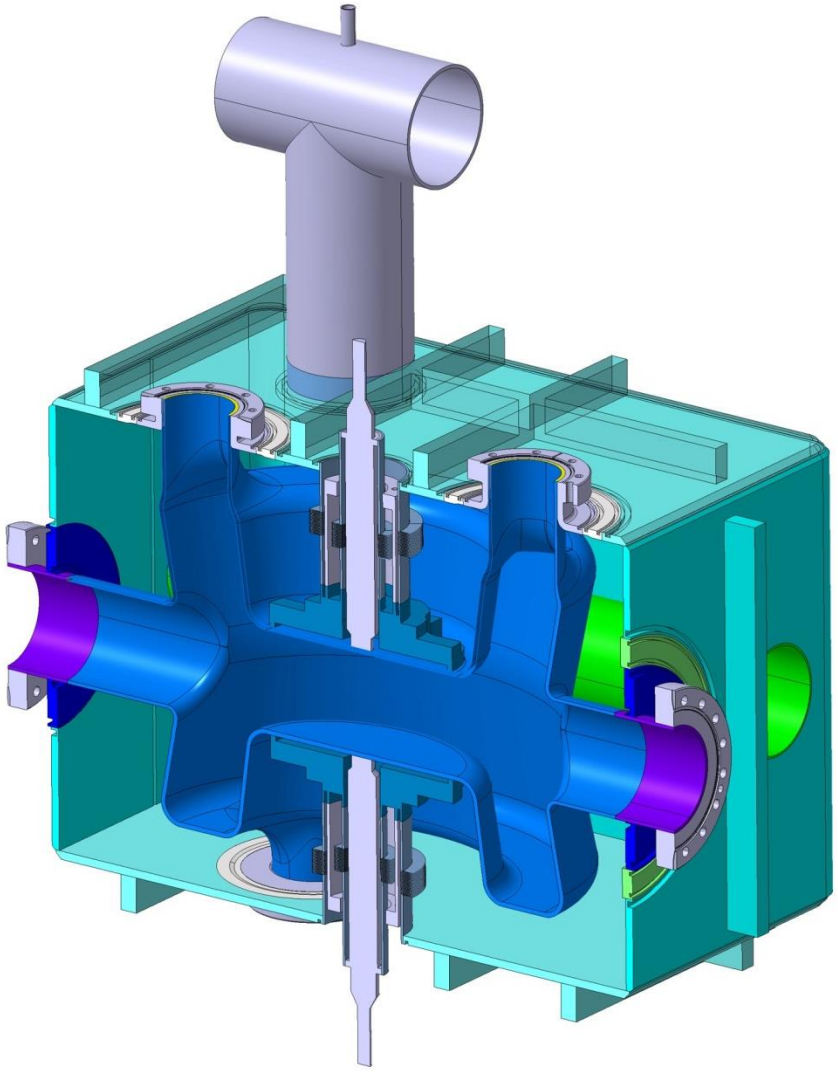
Zenghai Li

Thanks for your attention

Cavity mounting







Integration into cryomodule