MAGNETIC SHIELDING AND THERMAL SHIELDING

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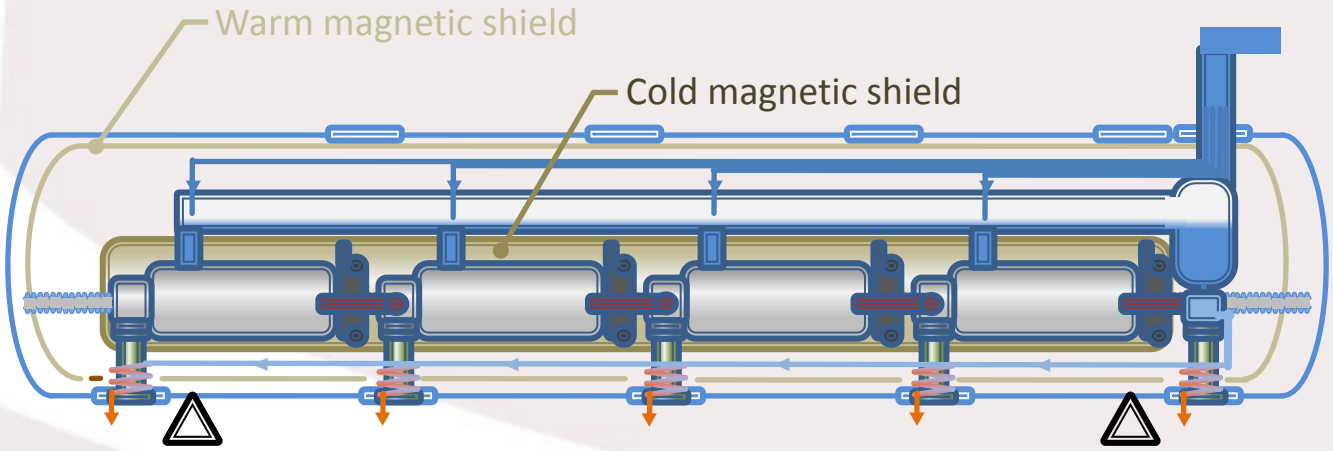
Overview

Surface resistance of superconducting cavities can be deteriorated by the trapped DC magnetic field in Nb.

The magnetic shielding for pure Nb cavity is one of the major parameter that affects the performance of the cavity and also the cryogenic loss.

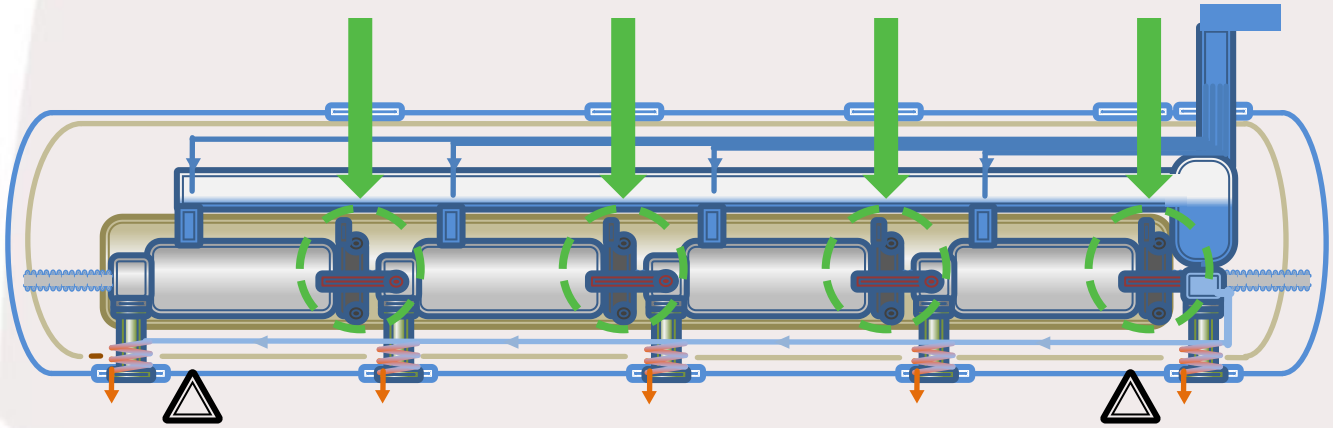
$\Rightarrow$ Double shielding:

- Warm magnetic shield (@ room T°)
- Cold magnetic shield (@ cryogenic T°)



Overview

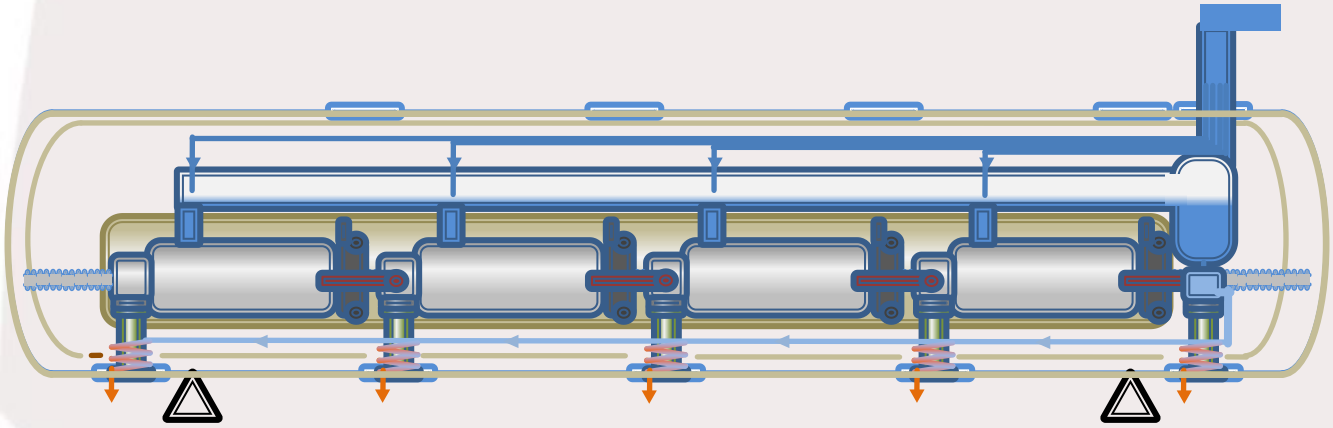
- Access for maintenance (tuner, HOM)
- (Possibly) Access to the inter-cavity connections during the (pre-)alignment phase



Warm magnetic shield

- Replaced by the use of low-carbon steel for the vacuum vessel

Warm magnetic shield



Cold magnetic shield

Material: Cryoperm, A4K (TBD)

→ Required magnetic properties (permeability) obtained

- Below a critical T°
- If the material is annealed

Avoid apertures and sharp angles

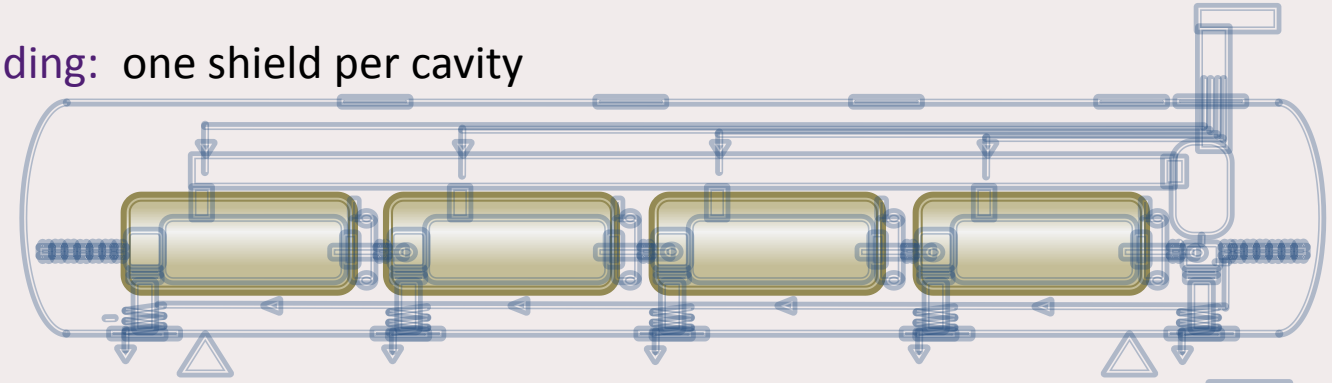
⇒ Use of simple shapes

⇒ No mechanical modification possible after annealing

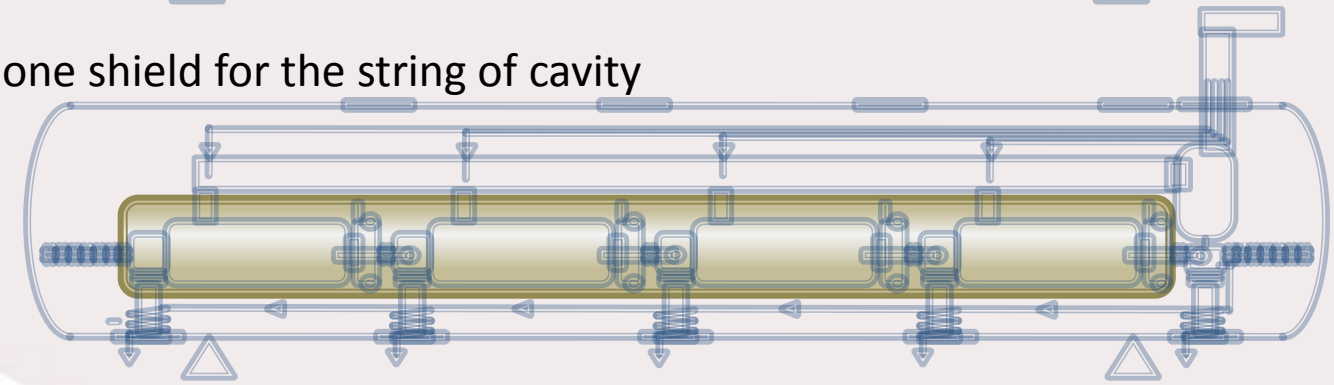
Cold magnetic shield

2 possible solutions:

Discontinuous shielding: one shield per cavity

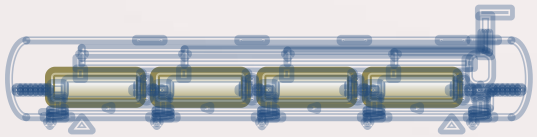


Continuous shield: one shield for the string of cavity



Cold magnetic shield

One shield per cavity

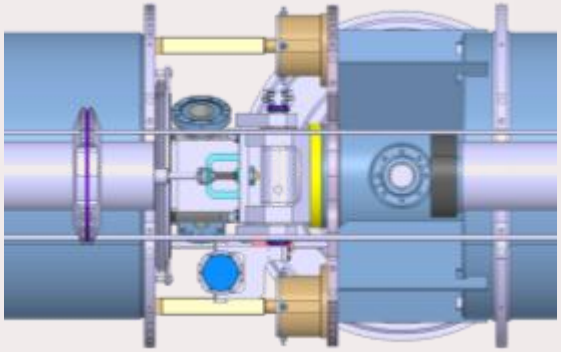


Main advantages

Permanent access to the cavity interconnections

Mounted before the alignment procedure

(no alteration of the alignment)



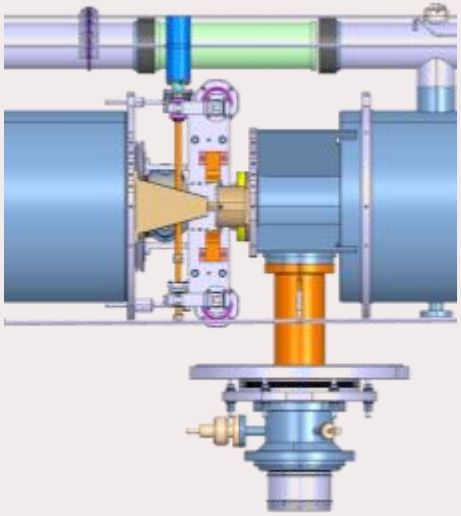
Related problematic

Assembly procedure → need to be mounted before the tuner

End cap closures:

- Lack of space (presence of the tuner, cavity interconnections…)
- Needs of several apertures (tuner supports)

→ solution abandoned



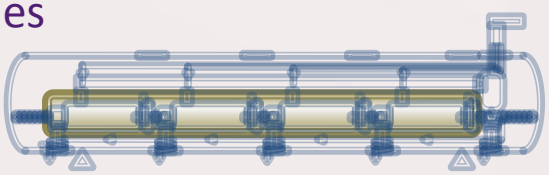
Alternative studied solution (CERN) : magnetic shield inside the cavity LHe tank

→ difficulty to manufacture the tank

→ solution abandoned

Cold magnetic shield

One shield for the string of cavities



Main advantages

Simpler geometry (and construction)

Available space

Related problematic

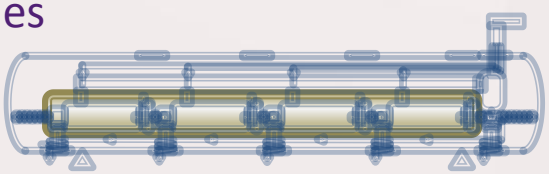
Maintenance access (tuner, HOM)

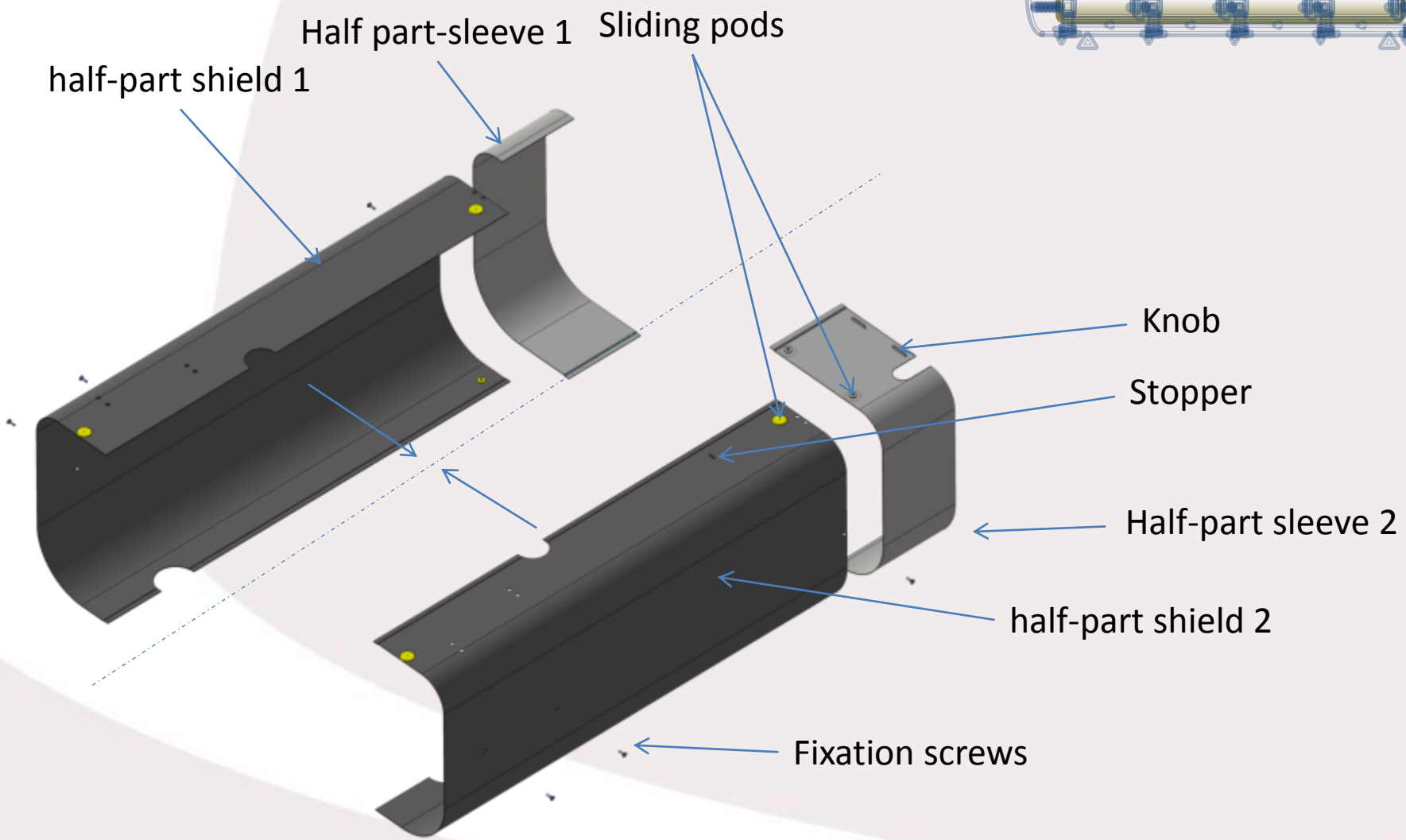
Access to the cavity interconnections for the alignment procedure

⇒ Solution proposed

Cold magnetic shield

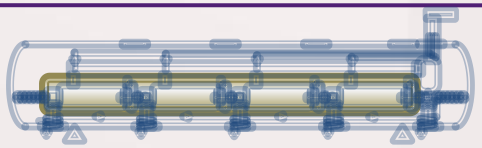
One shield for the string of cavities

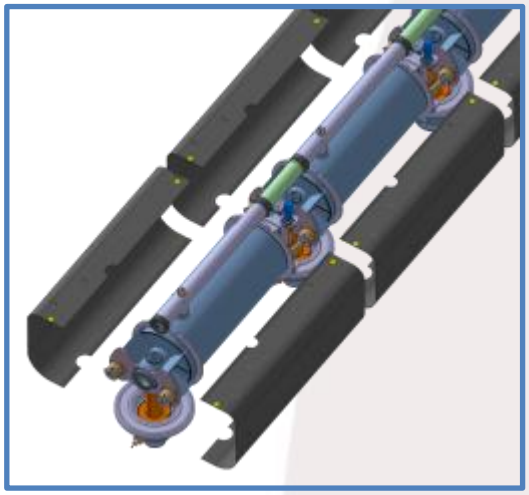




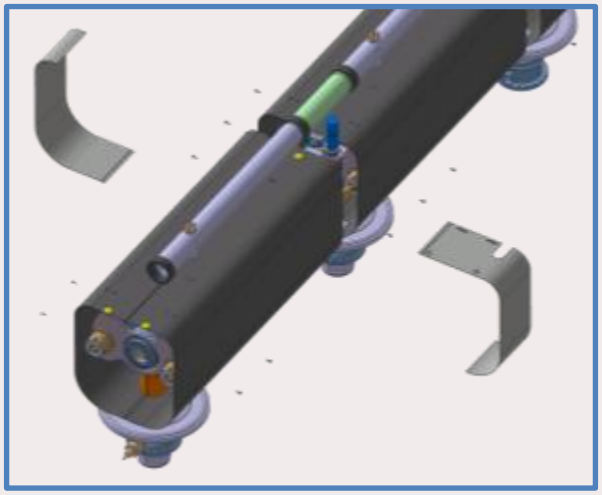
Cold magnetic shield

One shield for the string of cavities

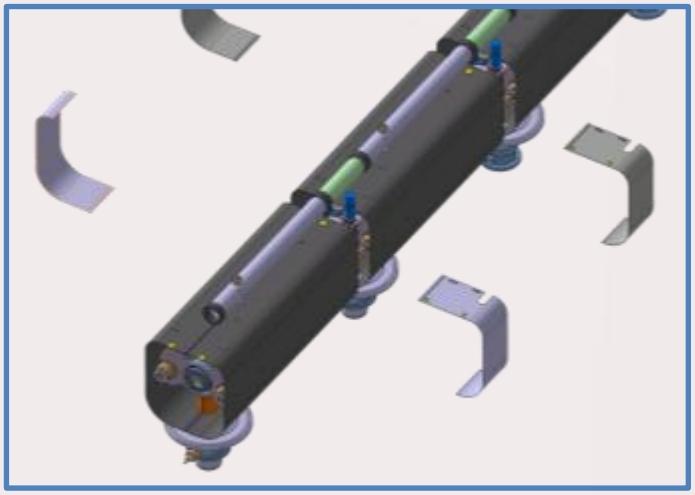




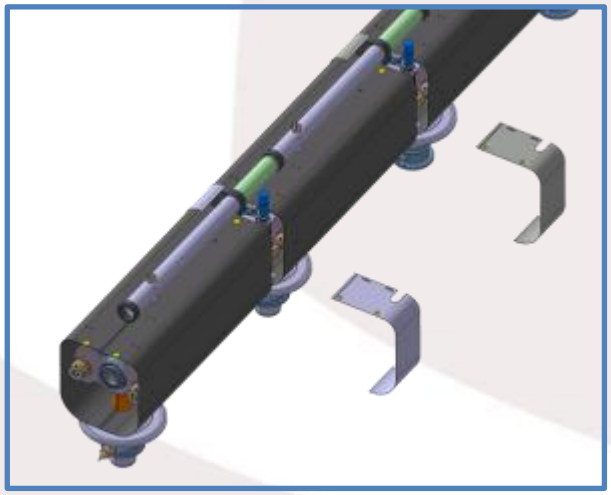
1- Positionning of the half screens

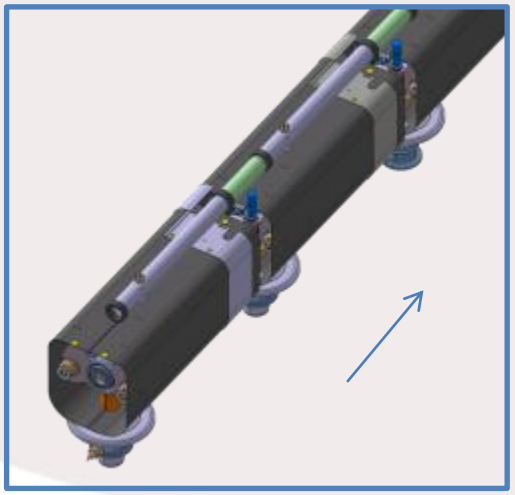


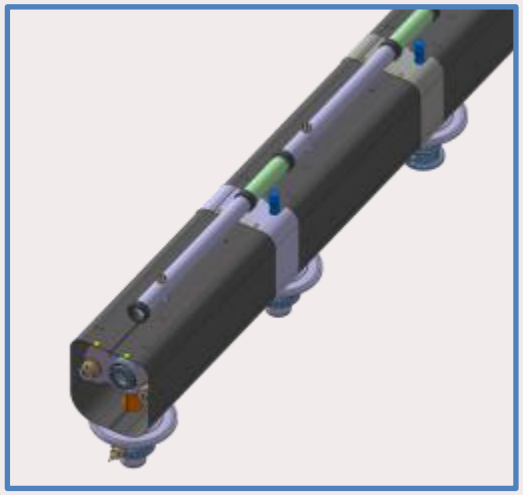
2- Fixation with screws on the tank interface



3- Positionning of the half sleeves







4,5 & 6- Positionning of the half sleeves

Overview

Thermal radiation from the ambient T° vacuum vessel to the 2K cold mass must be reduced in order to lower the static losses.

Thermal shield aim at reducing the radiant heat.

The attenuation factor depends on:

- The number of shields (the highest, the better)
- The temperature difference between cold mass and its closest shield (the lower the better) → also related to the temperature homogeneity of the shield
- The emissivity of the shields (the lower the better)
- The area of the shield (the lower the better)
- The shape of the shields (the view factor)

Thermal shielding concept

Number of thermal shield: 1

T°: 50 -75K

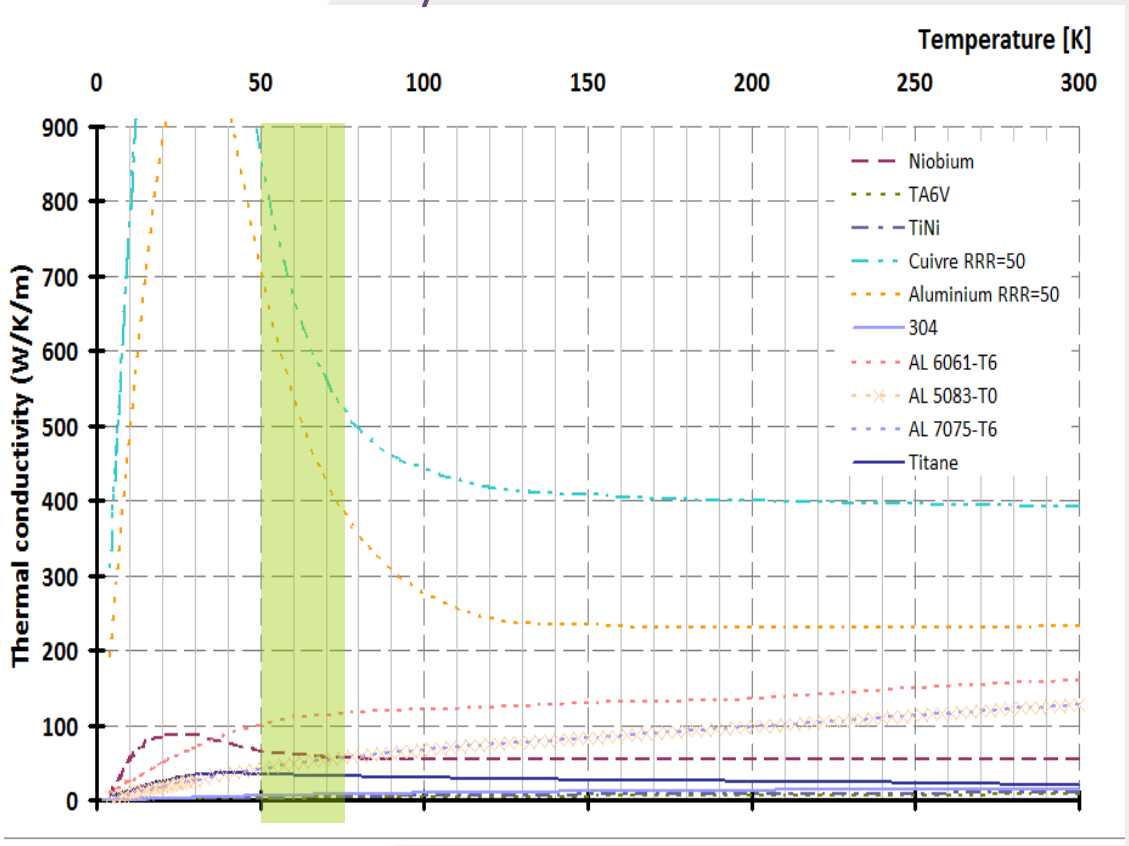
Emissivity: the shield will be covered with a reflective MLI (20-30 layers) having a low emissivity

Material: high thermal conductivity allowing for:

- An effective cooling of the shield during the cool down phase;
- A good homogeneity of the shield temperature (reducing the thermal losses);

Thermal shielding concept

Thermal conductivity for different materials



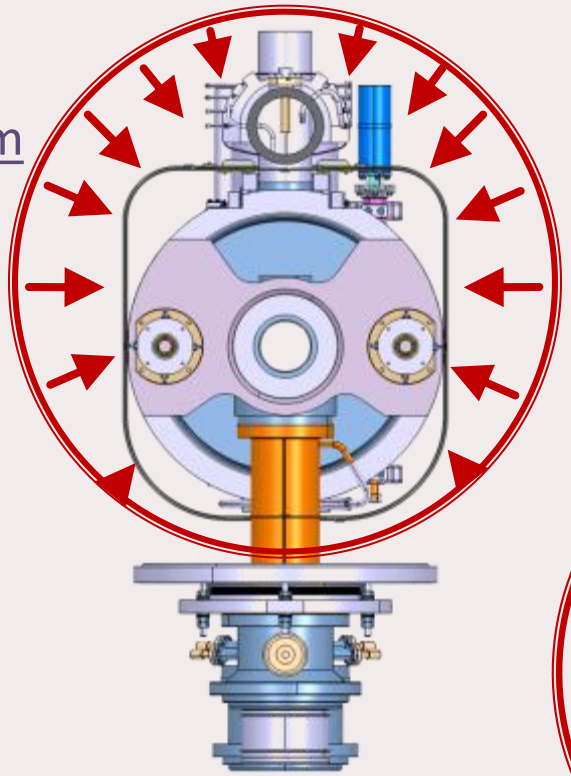
Estimated losses on the thermal shield : 240W (full length cryomodule)

For 2mm thickness, $\Delta T < 4K$ for materials having a thermal conductivity above 100W/m/K

Material of the thermal shield will be proposed based on construction consideration

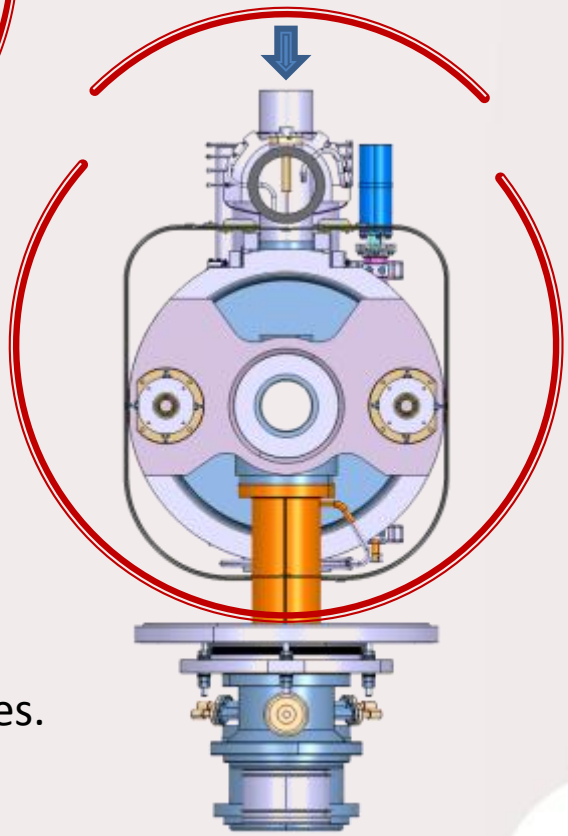
Thermal shielding concept

Shield inserted within the vacuum vessel (before cryostating)



Larger area (larger diameter)

Shape: larger view factor



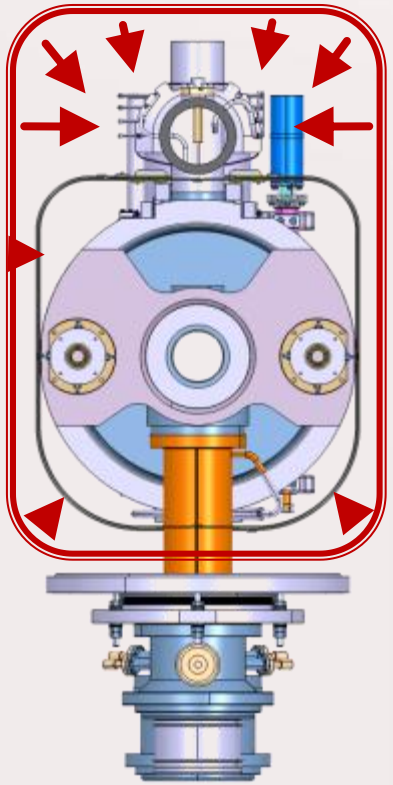
NB1: Needs of a dedicated tooling for its insertion within the vessel

NB2: Needs of an opening for the insertion of the string of cavities. The cover must be actively cooled (large area)

Thermal shielding concept

Shield positioned around the string of cavities

before cryostating



Smaller area

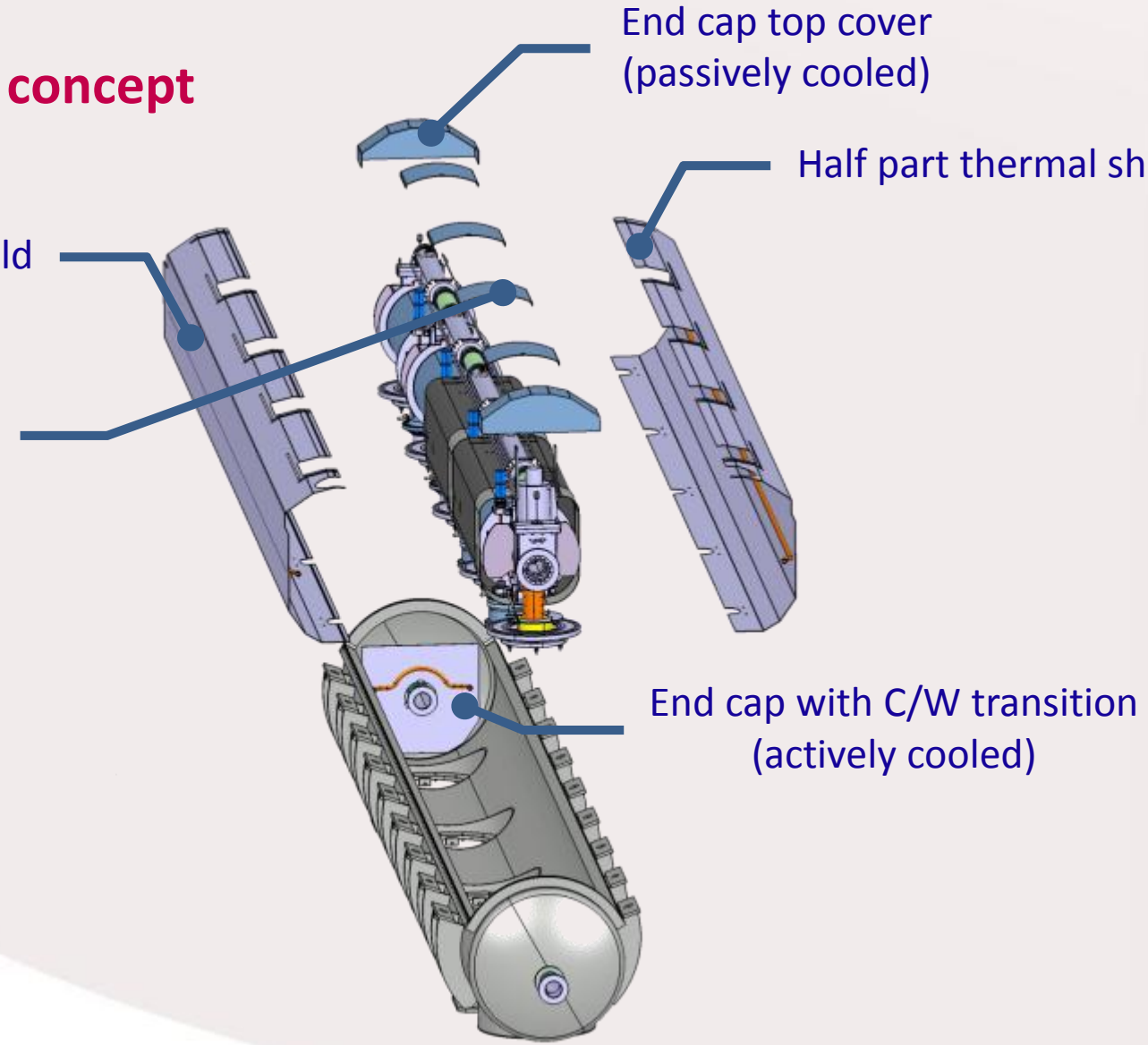
Shape: smaller view factor

Mounted on the string of cavities during the dressing phase

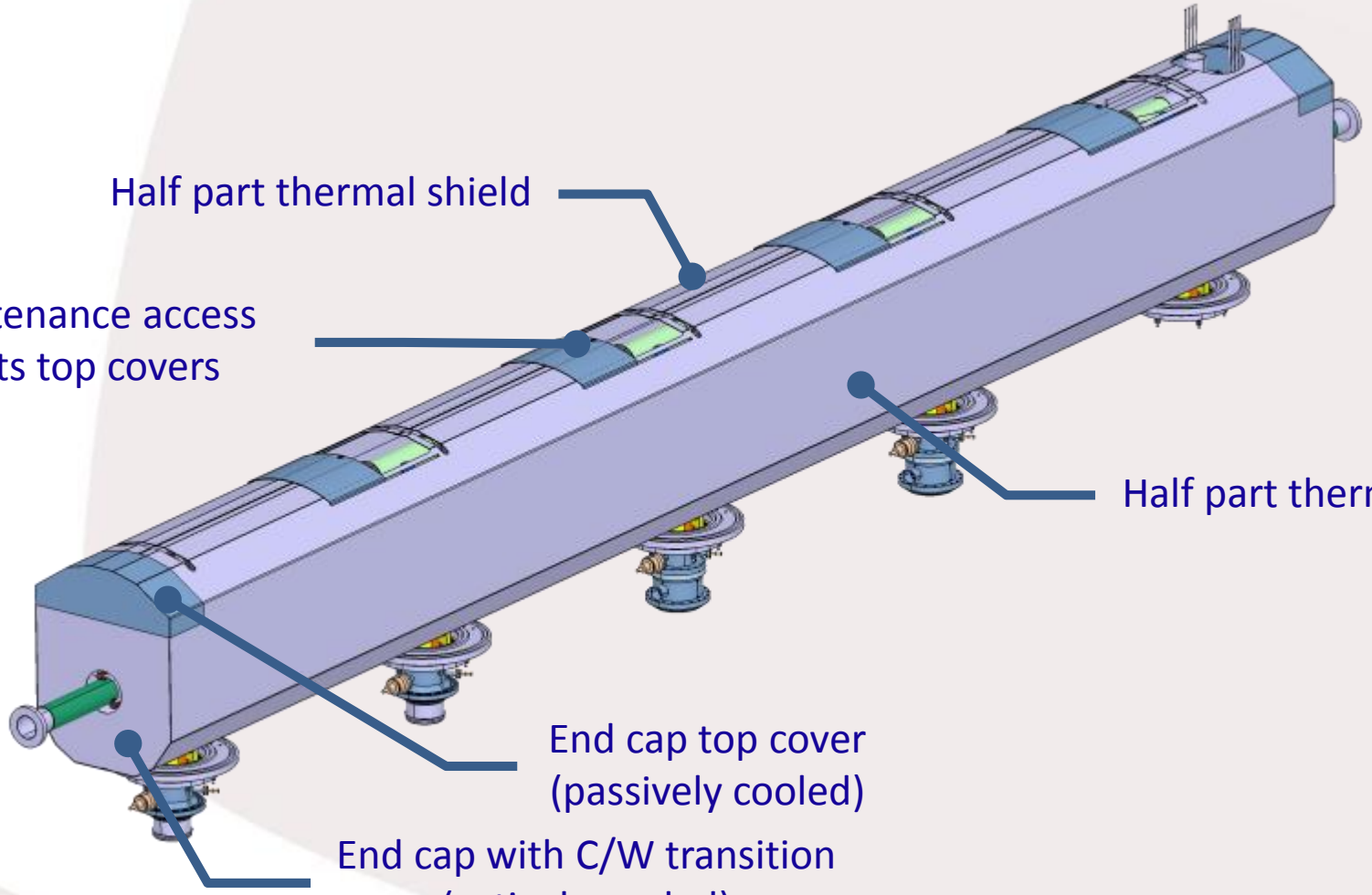
⇒ inserted within the vacuum vessel with the string of cavities during the cryostating (same tooling)

⇒ Solution proposed

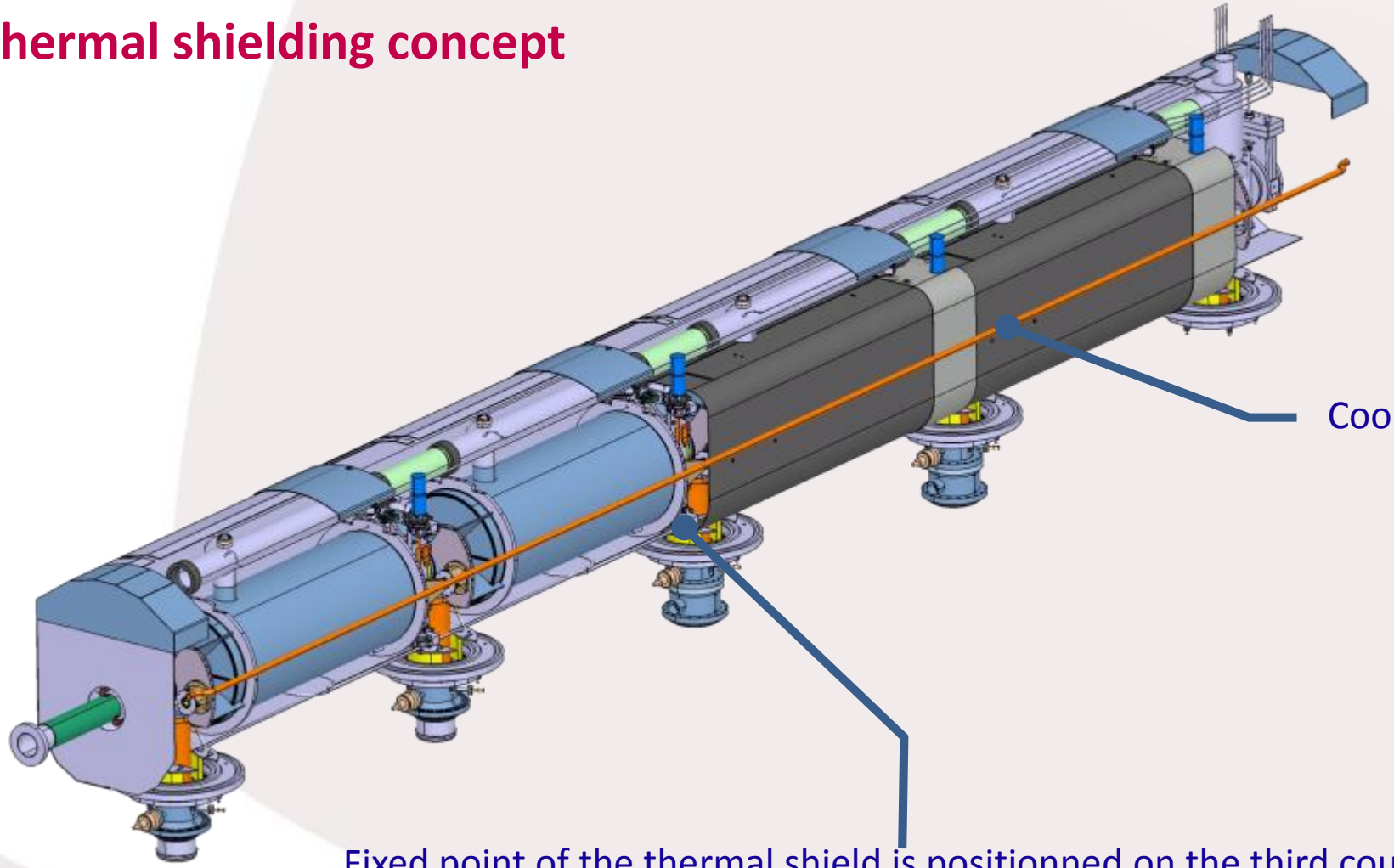
Thermal shielding concept



Thermal shielding concept



Thermal shielding concept



Fixed point of the thermal shield is positionned on the third coupler
→ 25mm of max thermal displacement (at extremities)

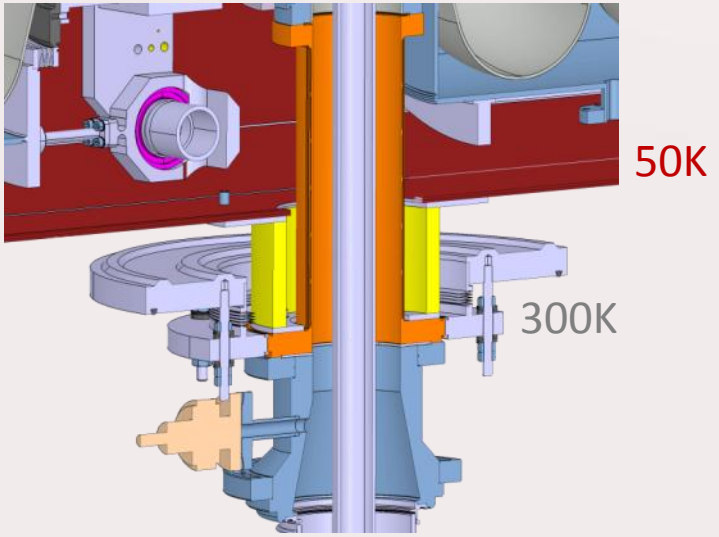
Thermal shielding concept

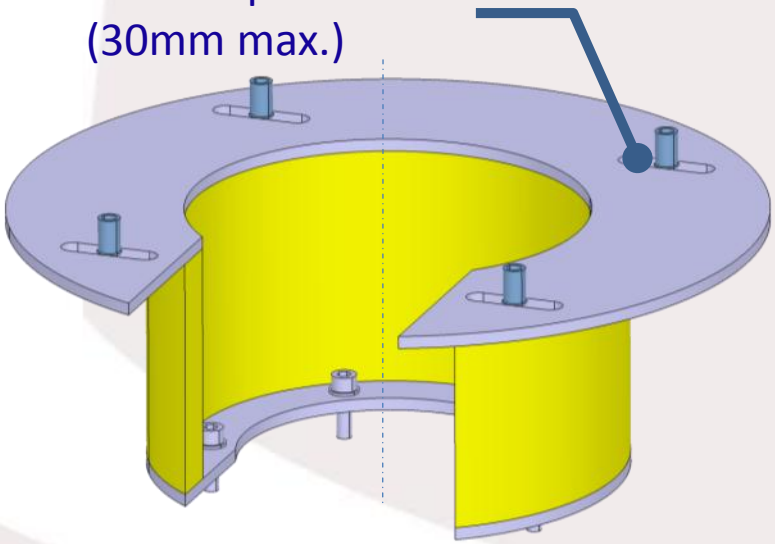
Support

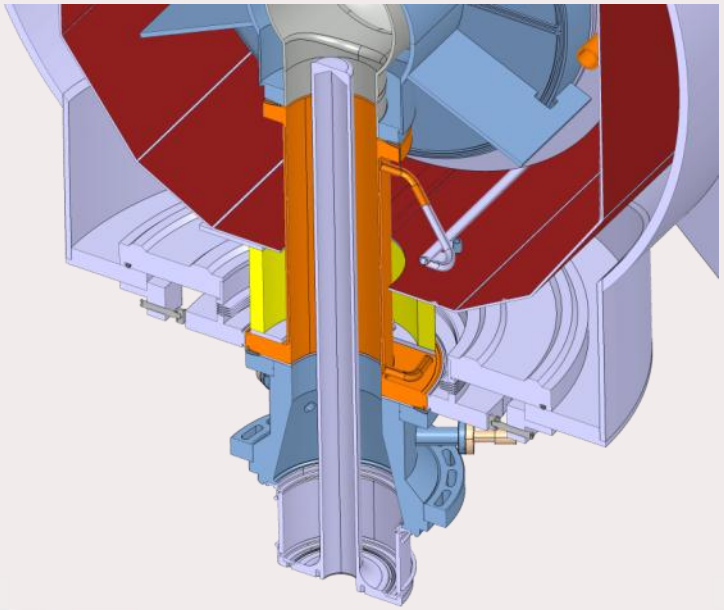
The thermal shield is not interfaced on the cold mass to limit the thermal losses @ 2K

→ interface on the coupler flange @ 300K

Support material: composite (epoxy glass)



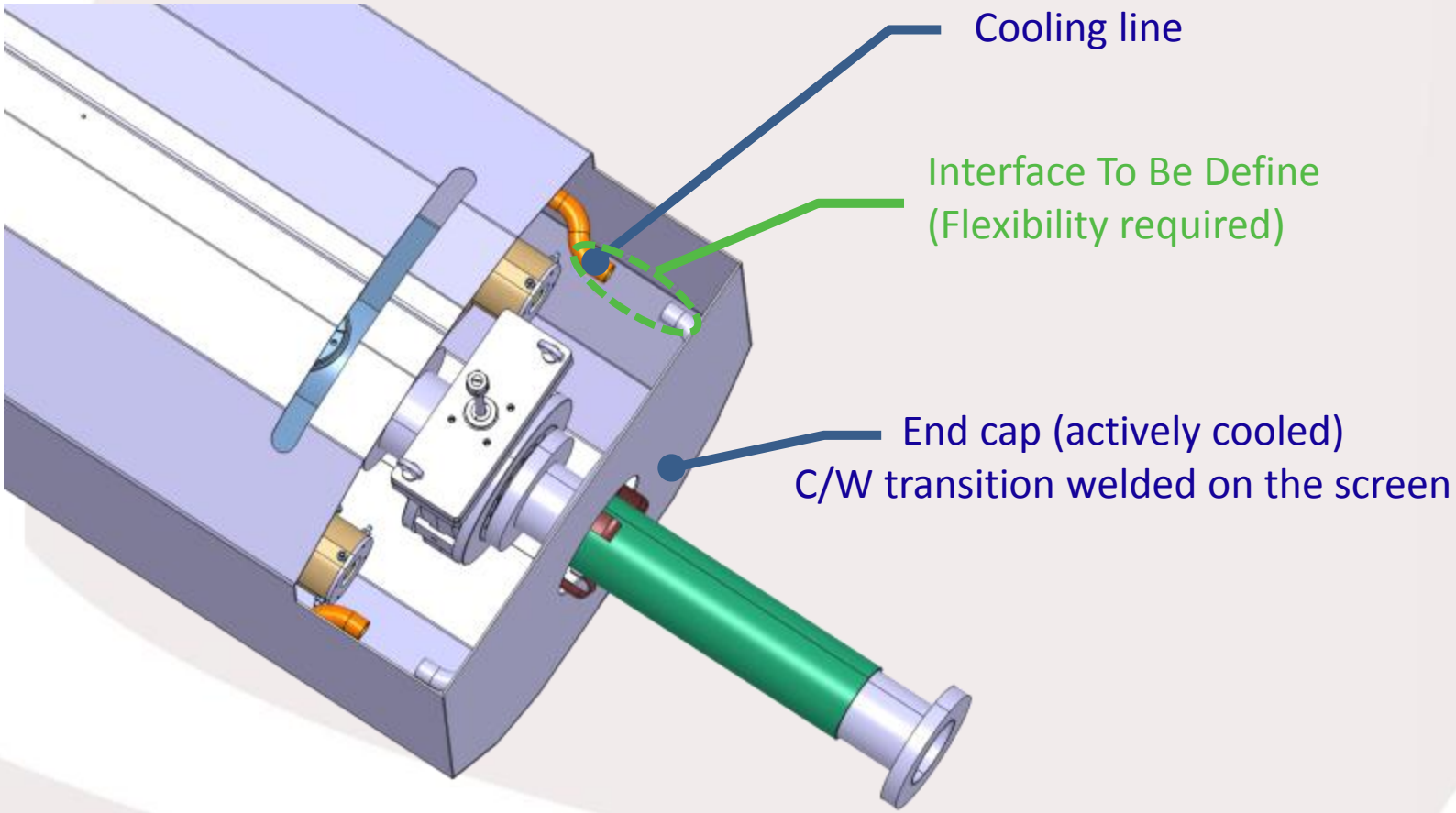




Thermal shielding concept

Cold/Warm transition

The thermal shield is not interfaced with the cold



Thermal shielding concept

Cold/Warm transition

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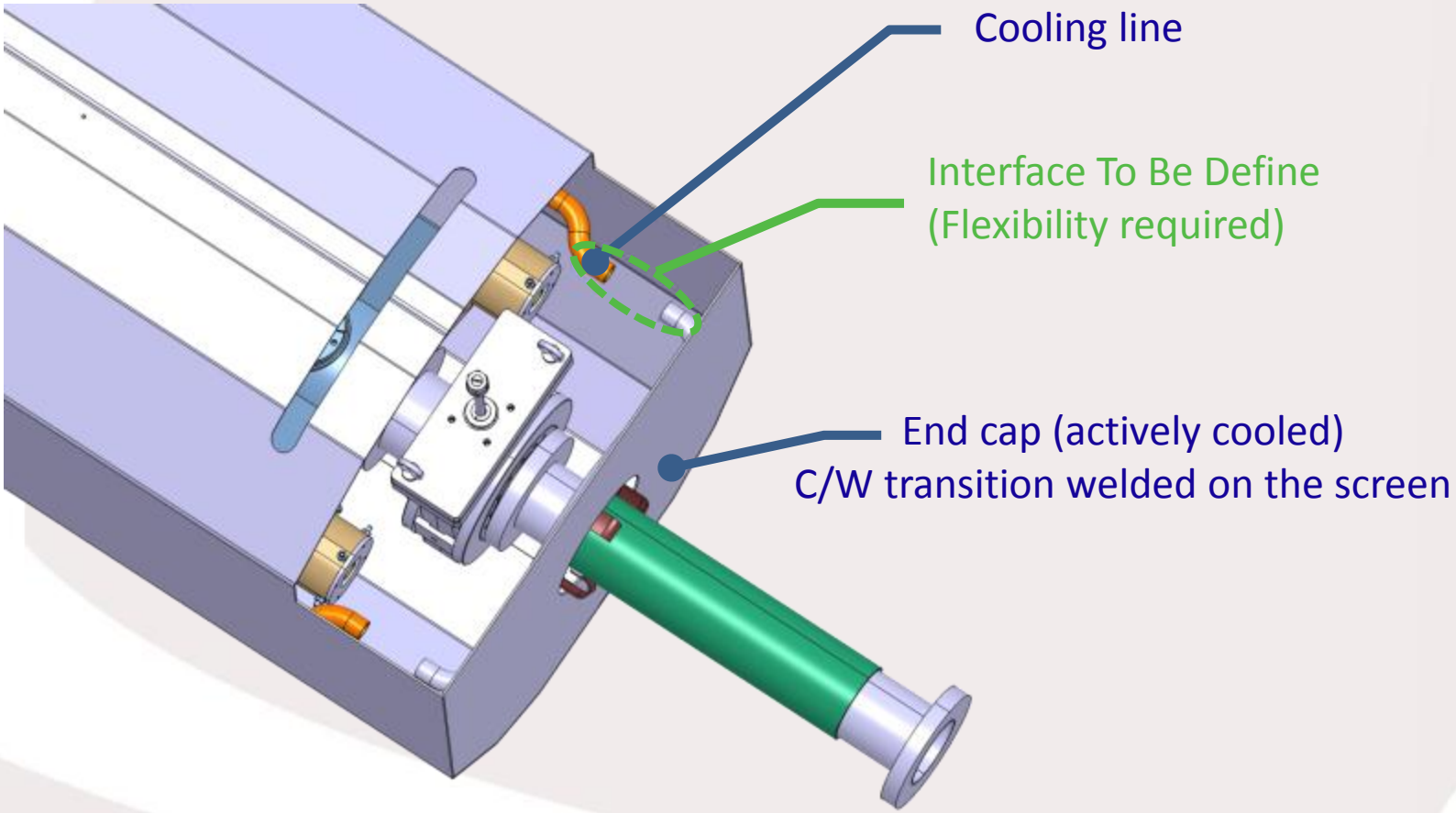

CONCLUSION

Magnetic shield

Continuous magnetic shield (covering the string of cavities) proposed

- Simple geometry
- Movable sleeves to keep a (small) maintenance access to the tuner and HOM

⇒ Needs of magnetic computations to validate the geometry → CERN

Thermal shield

Small thermal shield around the string of cavities proposed

- Supported on the coupler flange
- Movable top covers for maintenance access required

THANK YOU FOR YOUR ATTENTION

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