FUTURE
CIRCULAR
COLLIDER

IR CHAMBER & CALCULATIONS

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Introduction

Since the FCC week 2021 some steps have been taken; some discussions were held during the MDI session.

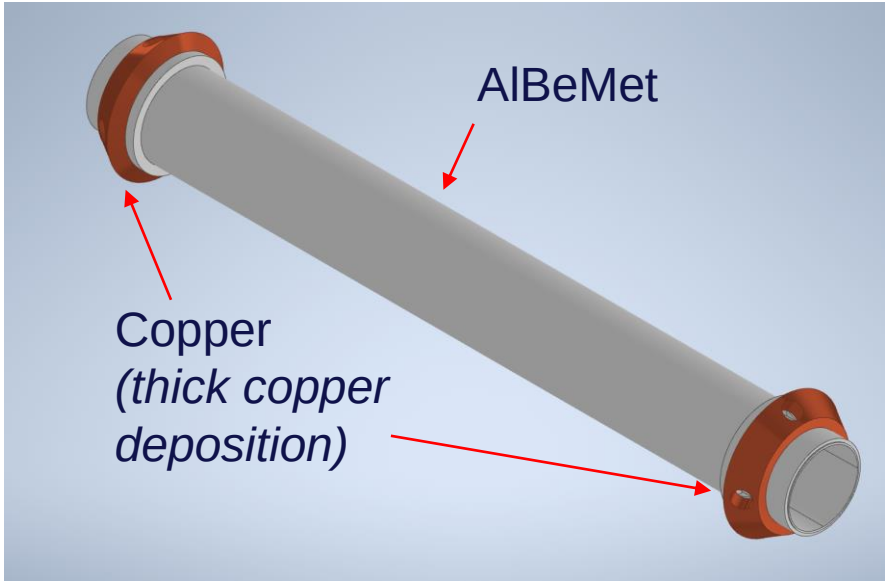
- We started a progressive change from a conceptual design of the chamber to an engineered design:
  - ➢Central chamber
  - ➢Trapezoidal chamber
  - ➢Bellow
- We performed a Finite Element Analysis to consider every thermo-structural aspect using a detailed model
- We updated the assembly using the new version of the magnet system proposed by Michael Koratzinos

Central chamber

The main aspects of the central chamber are:

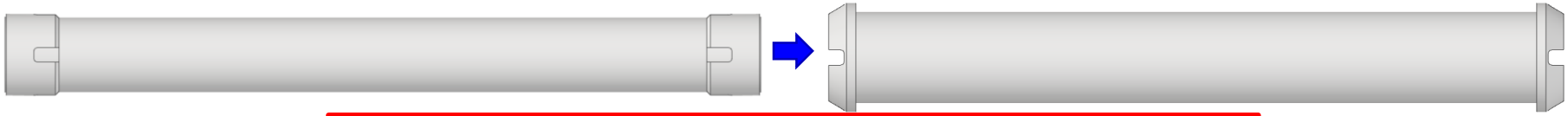
- **Thin wall**
- **Annular gap** for paraffin flow
- **AlBeMet162** as main material

To create an innovative design, we are evaluating the possibility to use the "*thick copper deposition*", a technique that allows to create a copper deposition over a built part. In this way is possible to create **complex geometry** and to assure the **hydraulic tightness.**

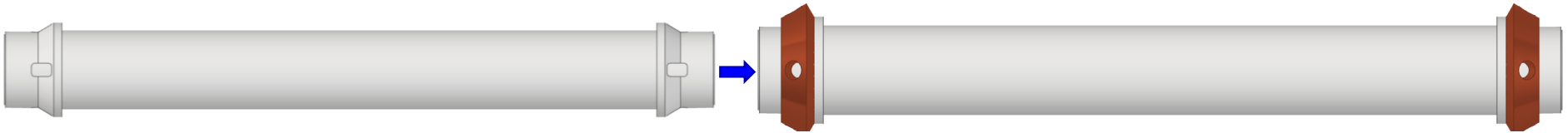


Central chamber

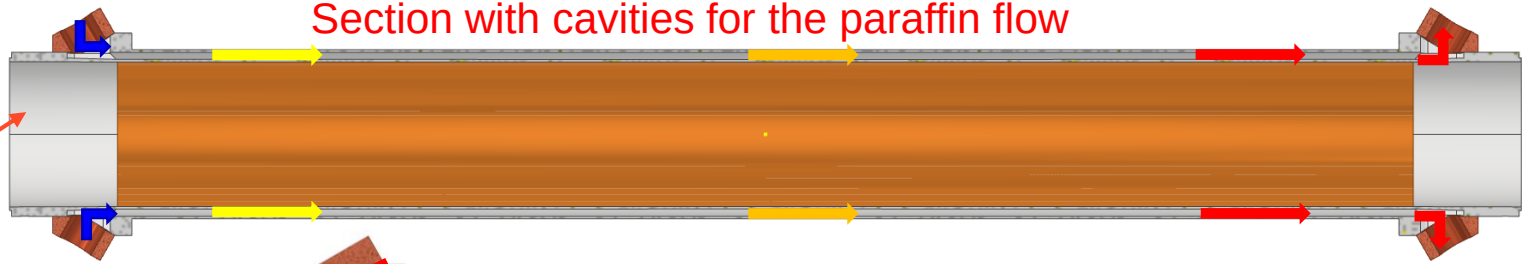
Insertion of the internal part

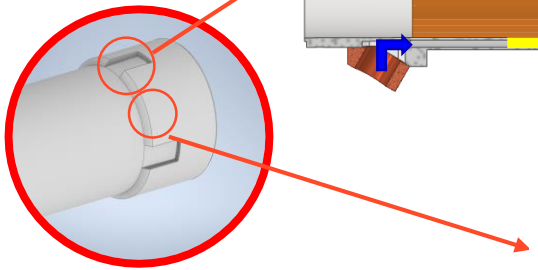


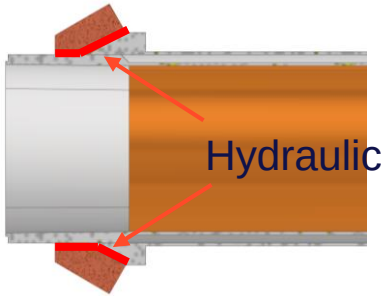
Thick copper deposition to create the cooling inlet and outlet



Section with cavities for the paraffin flow







Hydraulic tightness

The channel for paraffin is opened only in the part where the internal central chamber has cavities. Using the "*thick copper deposition*" the hydraulic tightness is assured in the parts in contact with AlBeMet

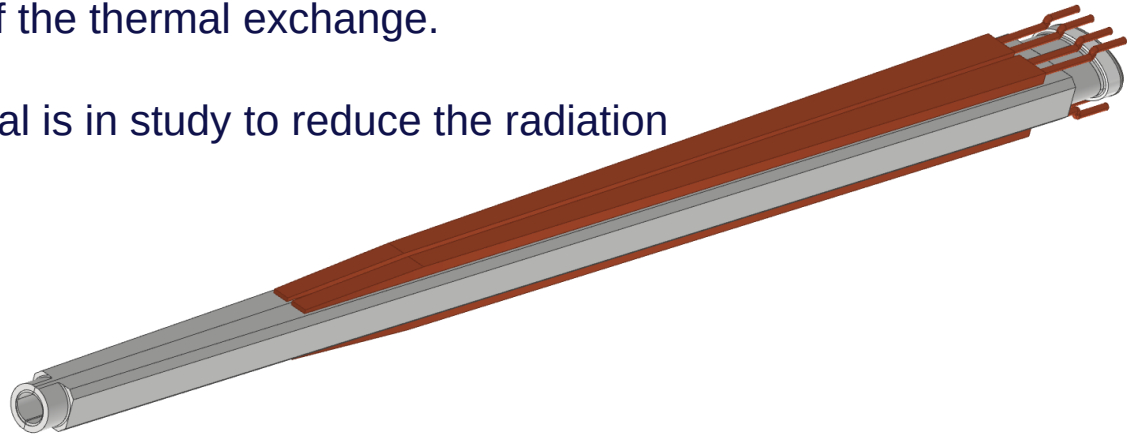
Trapezoidal chamber

The main aspects of the trapezoidal chamber are:

- **Structural thickness**
- **Cooling channel** for water flow
- **AlBeMet162** as main material

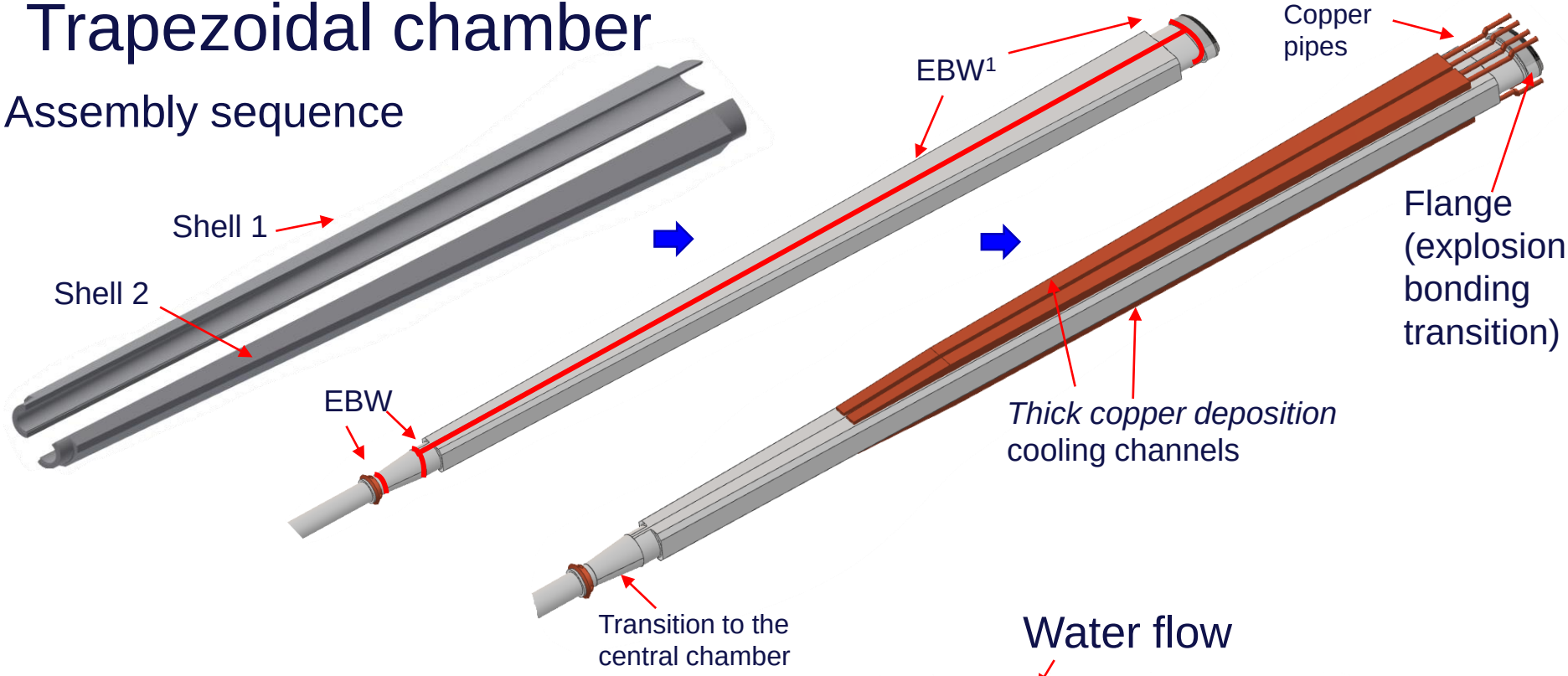
The cooling channels could be built using the same “thick copper deposition” technology as the central part. This additive technique could allow creating a strong adhesion between AlBeMet162 and copper, increasing the efficiency of the thermal exchange.

- Different cooling system material is in study to reduce the radiation length



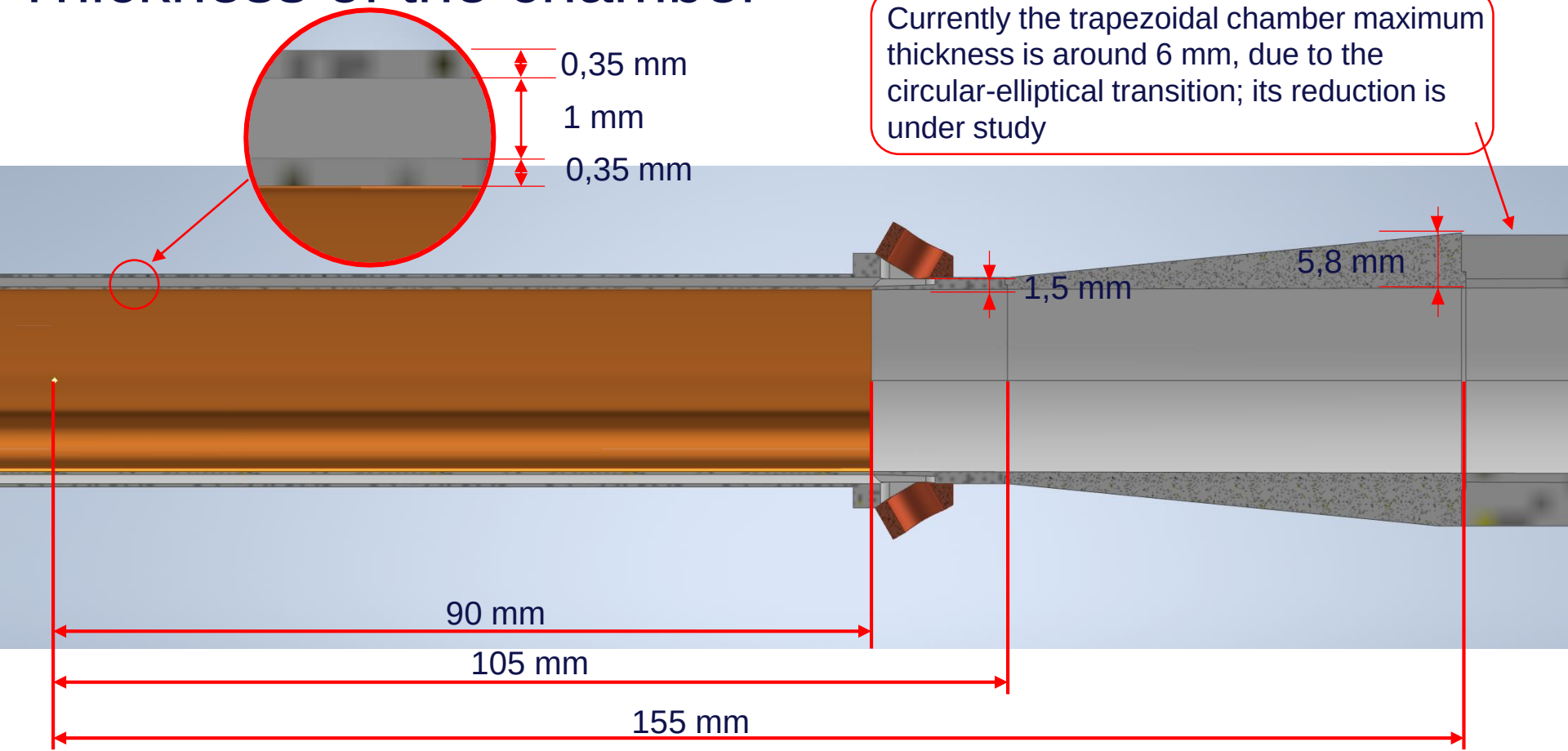
Trapezoidal chamber

Assembly sequence



1=electron beam welding

Thickness of the chamber

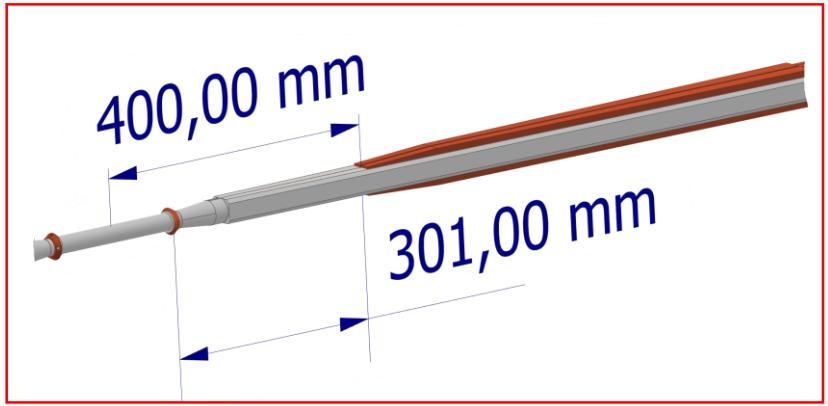


Currently the trapezoidal chamber maximum thickness is around 6 mm, due to the circular-elliptical transition; its reduction is under study

Thermal analysis

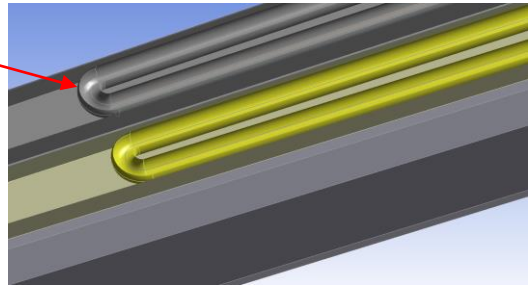
It is necessary to **consider** every **thermo-structural aspect** using a detailed model ➡ FEA (Ansys) ➡ **Temperature distribution** along the pipe

- Start of the cooling over the trapezoidal chamber

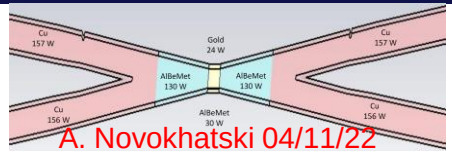


- **Paraffin flow**
  - Flow rate: 0,015 kg/s
  - Section: 68,17 mm^2
  - Velocity: 0,3 m/s
  - Inlet temperature: 18°C
  - Convective coefficient: 900 W/m^2K

- **Water flow** (8 different channel)
  - Flow rate: 0,0196 kg/s
  - Section: 19,64 mm^2
  - Velocity: 1 m/s
  - Inlet temperature: 18°C
  - Convective coefficient: 1200 W/m^2K



Thermal analysis - results



A. Novokhatski 04/11/22

Heat load : →

Thanks to **Alexander Novokhatski**

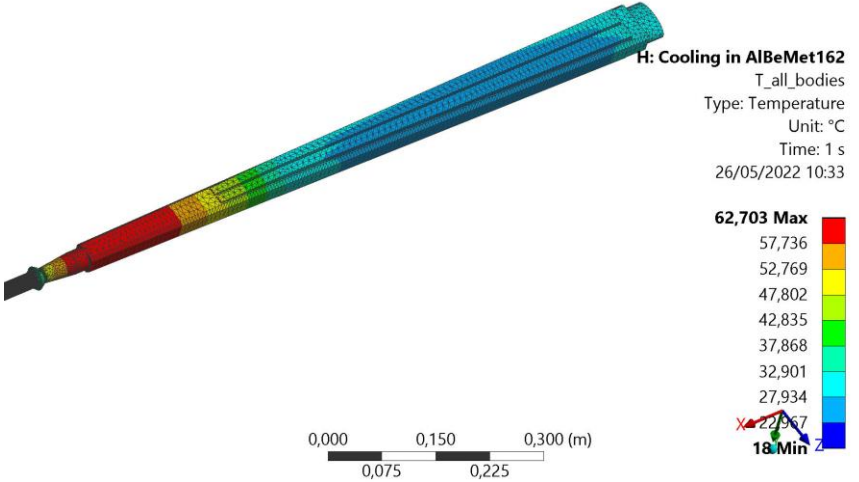
- 54 W central
- 130 W AlBeMet162 for each part

Hypothesis:

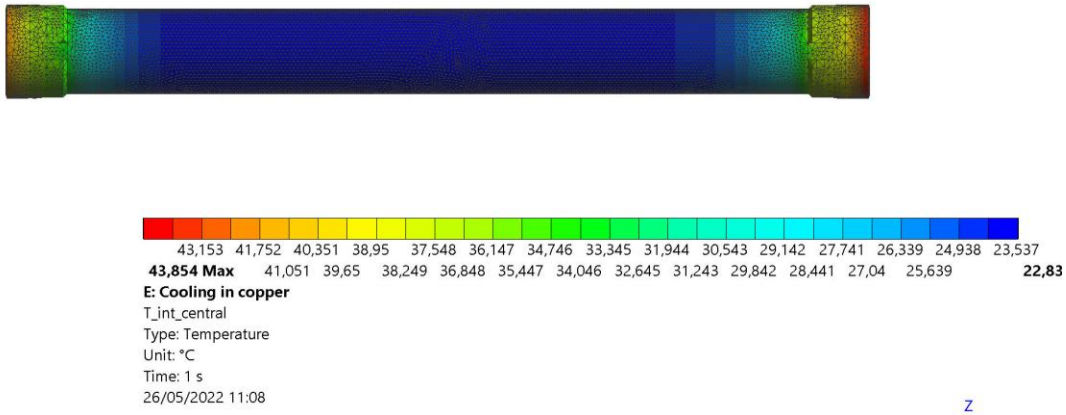
- Perfect thermal contact between the materials

Two cases have been analyzed:

	Trapezoidal cooling in copper	Trapezoidal cooling in AlBeMet162
Maximum temperature [°C]	60,309	62,703
T_out paraffin [°C]	19,22	19,27
T_out water [°C]	33,04	33,98



Temperature distribution in the central part

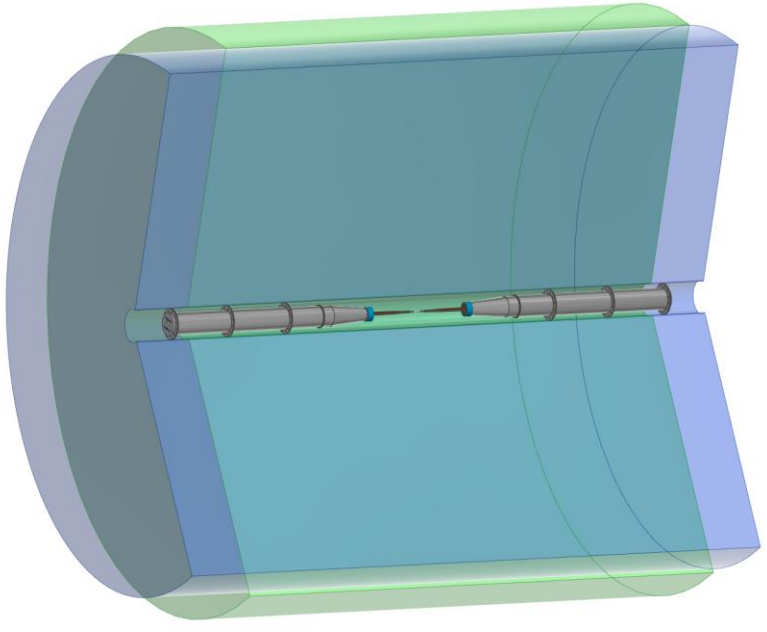


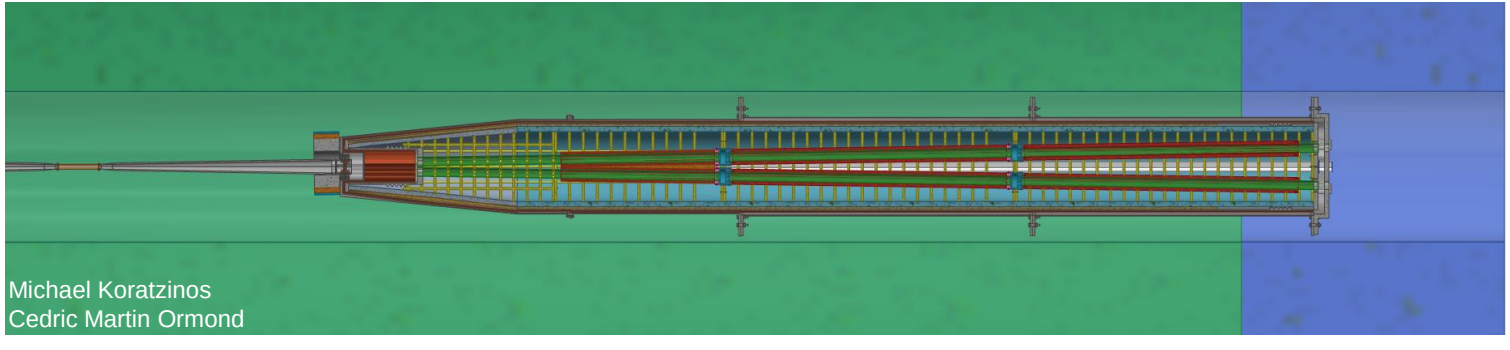
Thermal analysis - consideration

- The solution using the trapezoidal cooling channel in AlBeMet162 is quite similar in term of maximum temperature reached, but the construction of the channel is more complicated than the tick copper deposition; in fact, is not possible to create the channel embedded into a single piece.
- The thermal contact between two plates of AlBeMet is worse than the thermal contact between AlBeMet162 and the copper deposition.

CAD Integration

Along with the design work, we take care of including the new versions of each component of the MDI. Recently we integrated the IR magnets and cryostat updated model into the general assembly. Their **compatibility** with the **vacuum chamber** and the **Luminometer** is under check.



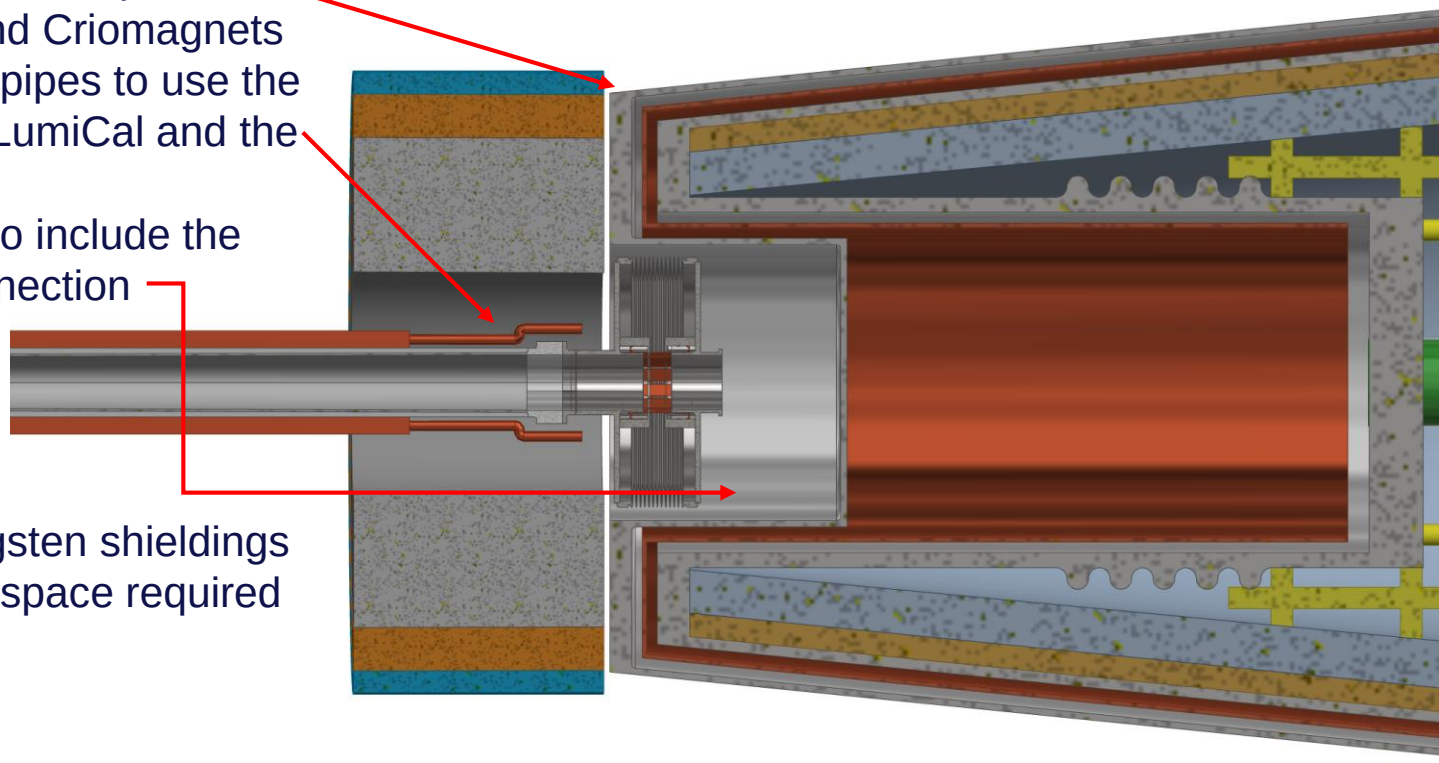


Michael Koratzinos
Cedric Martin Ormond

CAD Integration– integration with the chamber

It is necessary more study to:

- Increase the current little space between LumiCal and Criomagnets
- Arrange the cooling pipes to use the space between the LumiCal and the bellow
- evaluate the space to include the remote vacuum connection

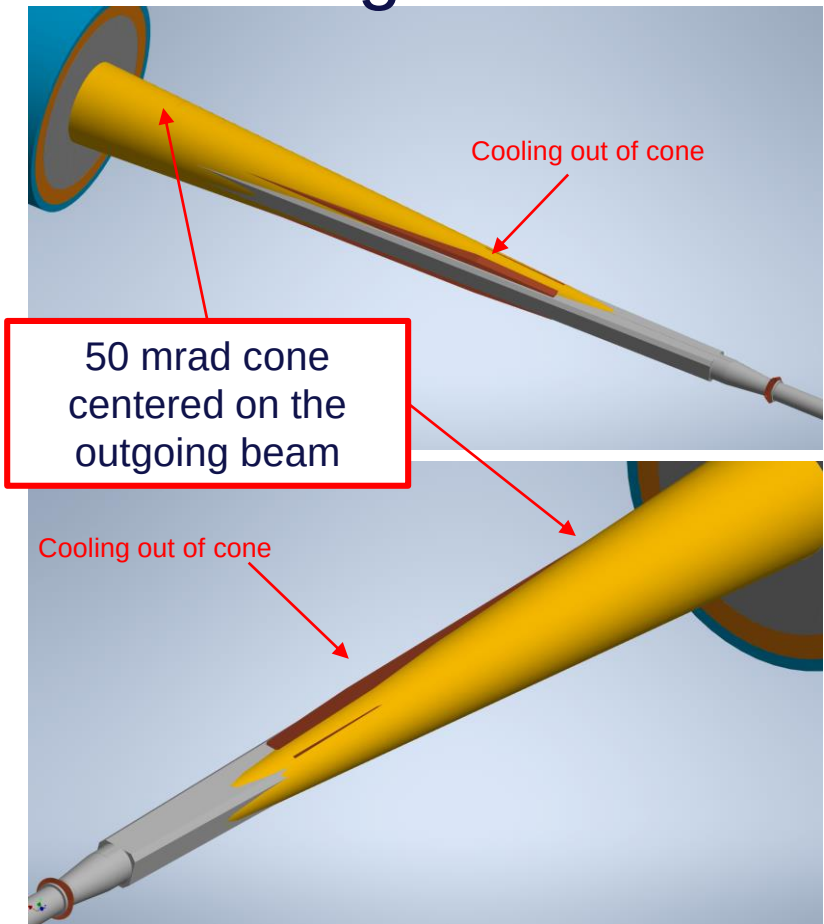


- Need to know if tungsten shieldings are needed and the space required

Study of the interference between cooling and luminometer acceptance

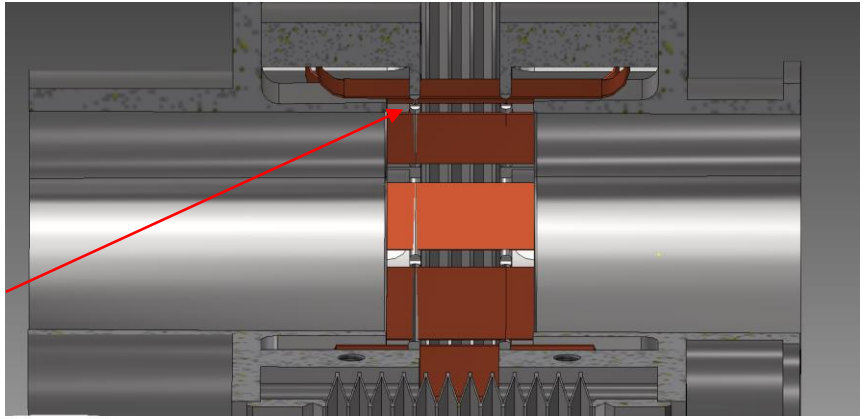
- There is an asymmetric interference between the cooling and the cone.
- We are waiting the evaluation of the influence that the material has over the measurement, before evaluating different cooling position.

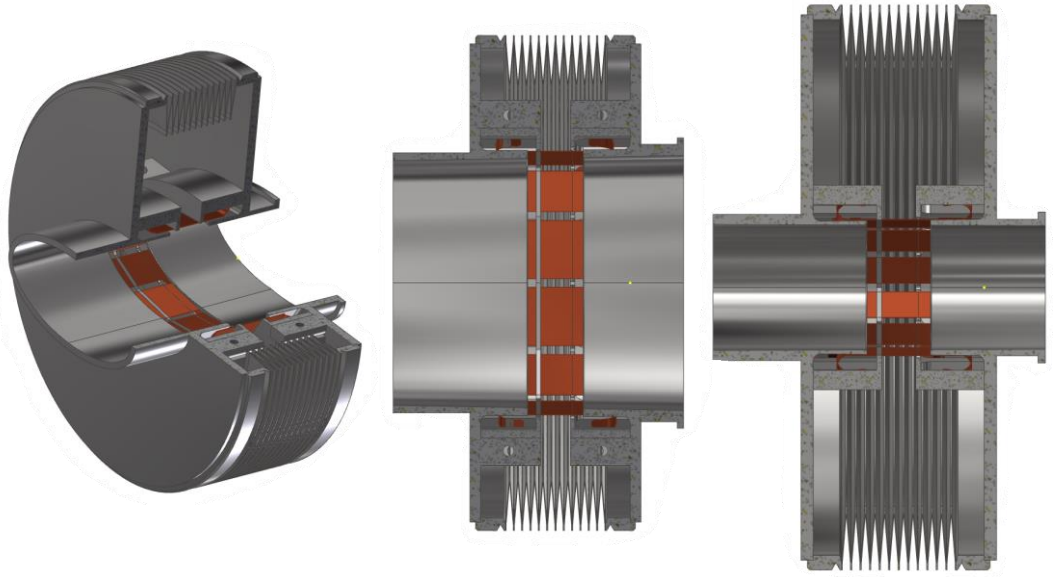
Geant4 simulation for the impact of the material budget of engineered beam pipes model has recently started.
(A. Ciarma)



Bellow

- 12 RF copper springs (can be increased to 16)
- Compact size in length
- 8mm stroke (-5mm +3mm)
- Finger to ensure contact between RF-spring to bellow (like ESRF bellow)





Future steps for the bellow:

- Simulation to validate the design from thermal point of view
- Optimization of the size and the convolutions number
- Inclusion of cooling
- Evaluation of different designs

Prototypes

Some prototypes are foreseen to study the real behavior of some components and manufacturing processes

Prototype of:

- Central IP chamber in order to:
  - ➢set and test the paraffin cooling system with temperature control
  - ➢verify the assembly procedure from a vacuum point of view
  - ➢study and test the thick copper deposition of the inlet and outlet
- AlBeMet162- steel transition in order to:
  - ➢study the shape of the transition
  - ➢optimize the EBW process according to our design
- Bellow in order to:
  - ➢study the manufacturing and assembly process
  - ➢test the behavior in terms of displacement allowable
  - ➢test from vacuum and thermal point of view
- Welding in order to:
  - ➢study the EBW process for an elliptical geometry

Conclusion and future steps

- The main assembly has been updating
- A preliminary thermal analysis has been done to understand the temperature distribution
- The engineered chamber design is in progress (central chamber, trapezoidal chamber, bellow)

Future steps:

- Continue the CAD integration in order to develop a conceptual proposal for assembly and supports (chamber support, LumiCal support, etc.)

- Structural analysis of the chamber according to the constraint configuration

Thank you for your attention.

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