EUROPEAN SPALLATION SOURCE

TIK3.1 and TIC3.2
Moderator & Reflector System

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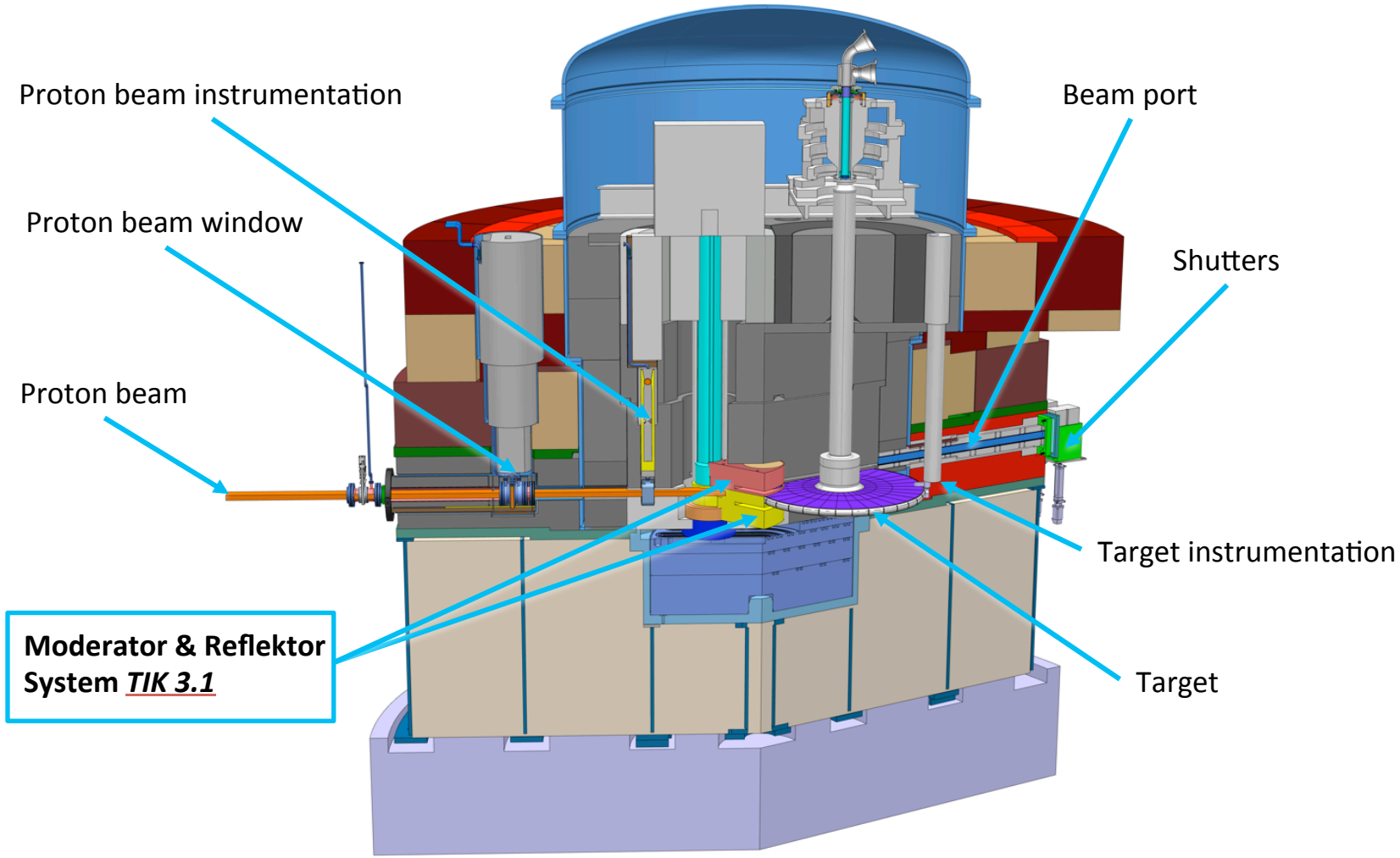
Outline

- Highlights
- Schedule performance
- Near-term plans
- Risks and issues
- Concluding remarks

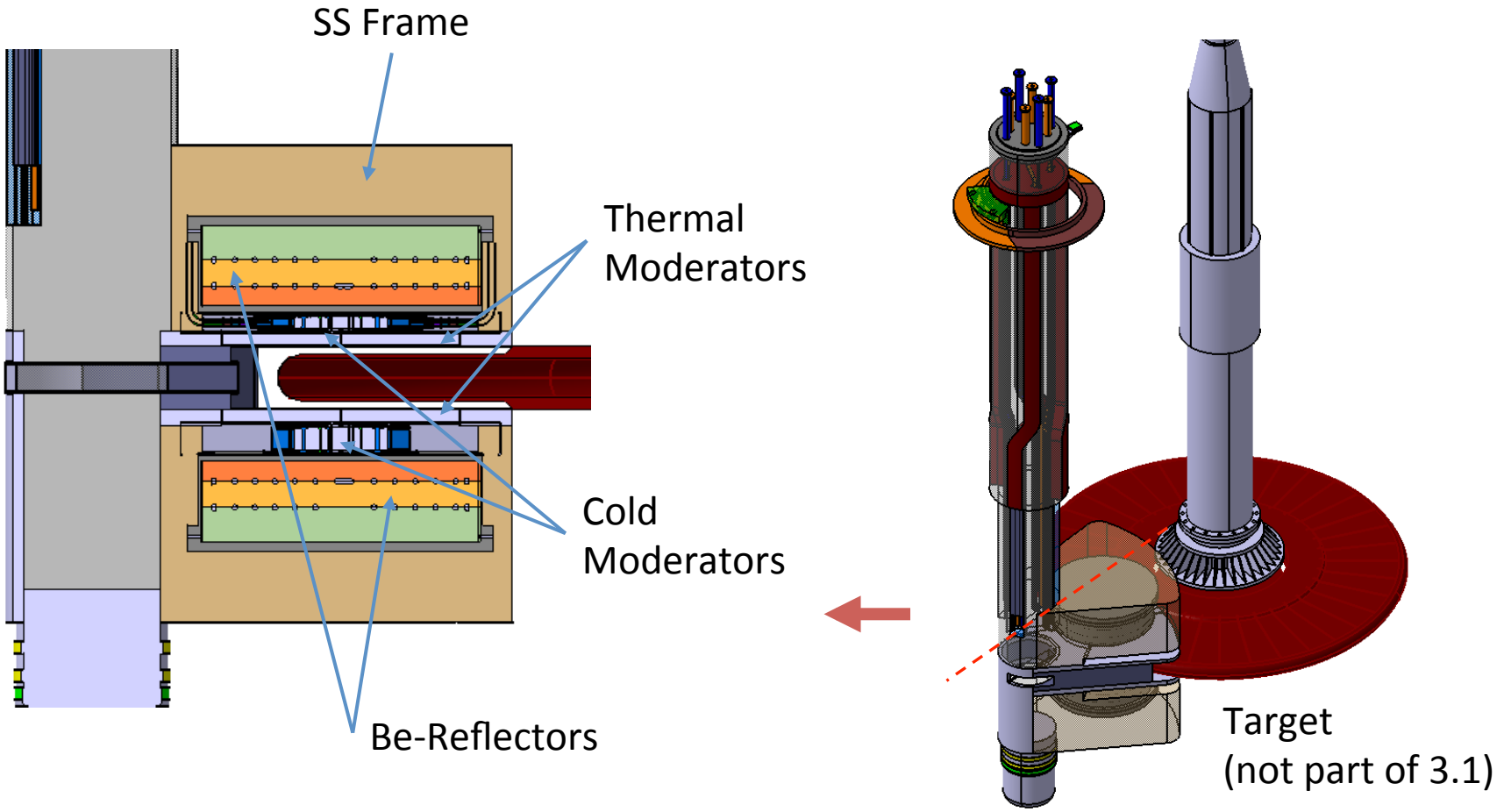
ESS Target Monolith



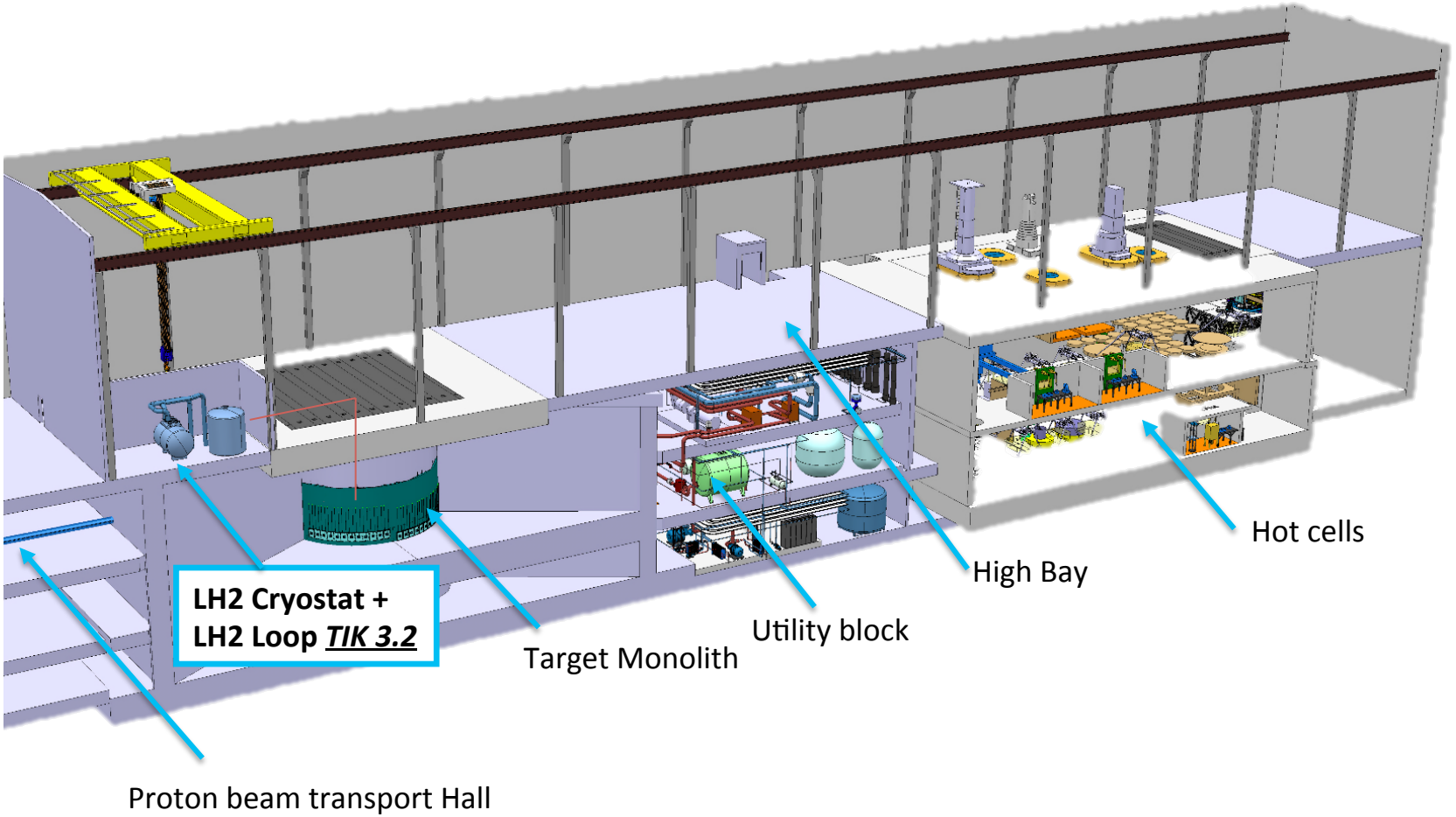
ESS Target Monolith Layout

Moderator Reflector Plug (TIK3.1)

"Twister" Support and handling structure



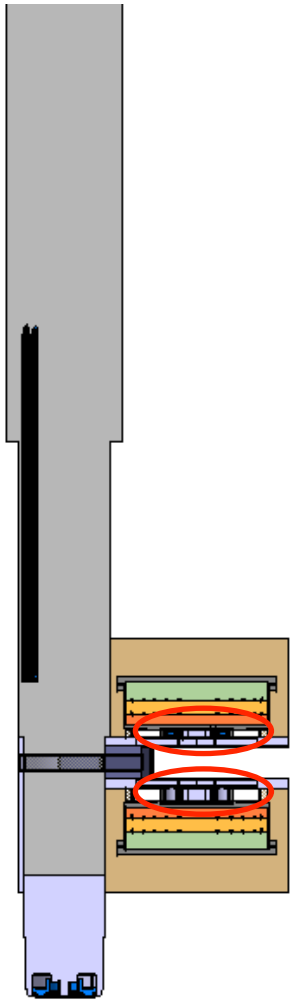
ESS Target Station



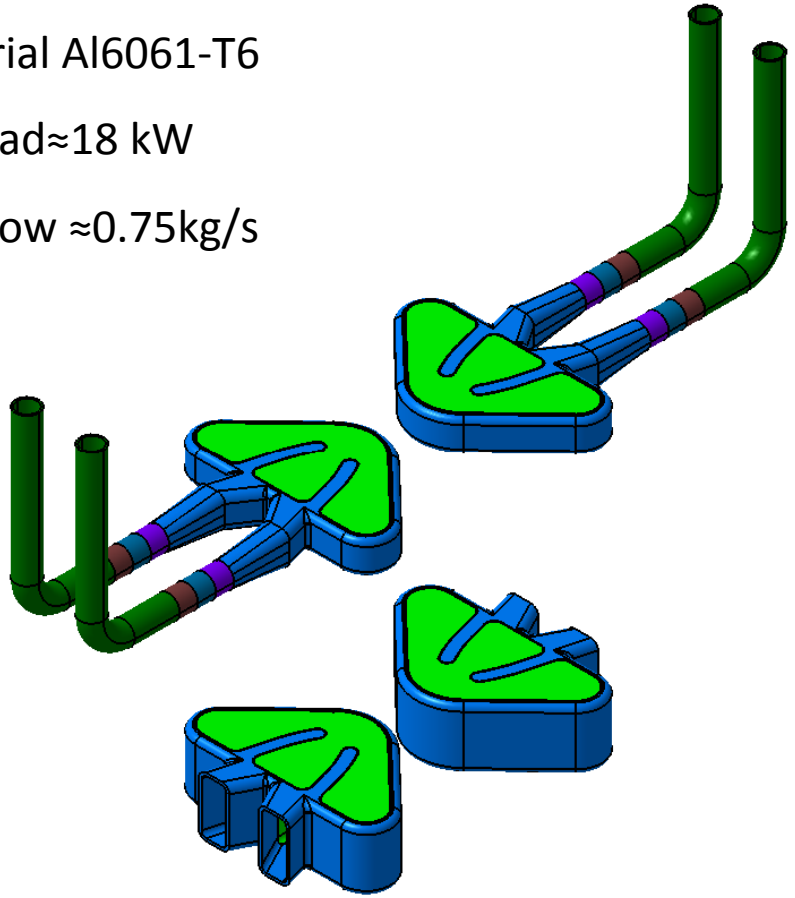
ESS Target Station Layout

- **Highlights**
- Schedule performance
- Near-term plans
- Risks and issues
- Concluding remarks

Cold Moderators



- Fluid liquid Hydrogen
- Vessel material Al6061-T6
- Total heat load≈18 kW
- Total mass flow ≈0.75kg/s



Cold Moderators

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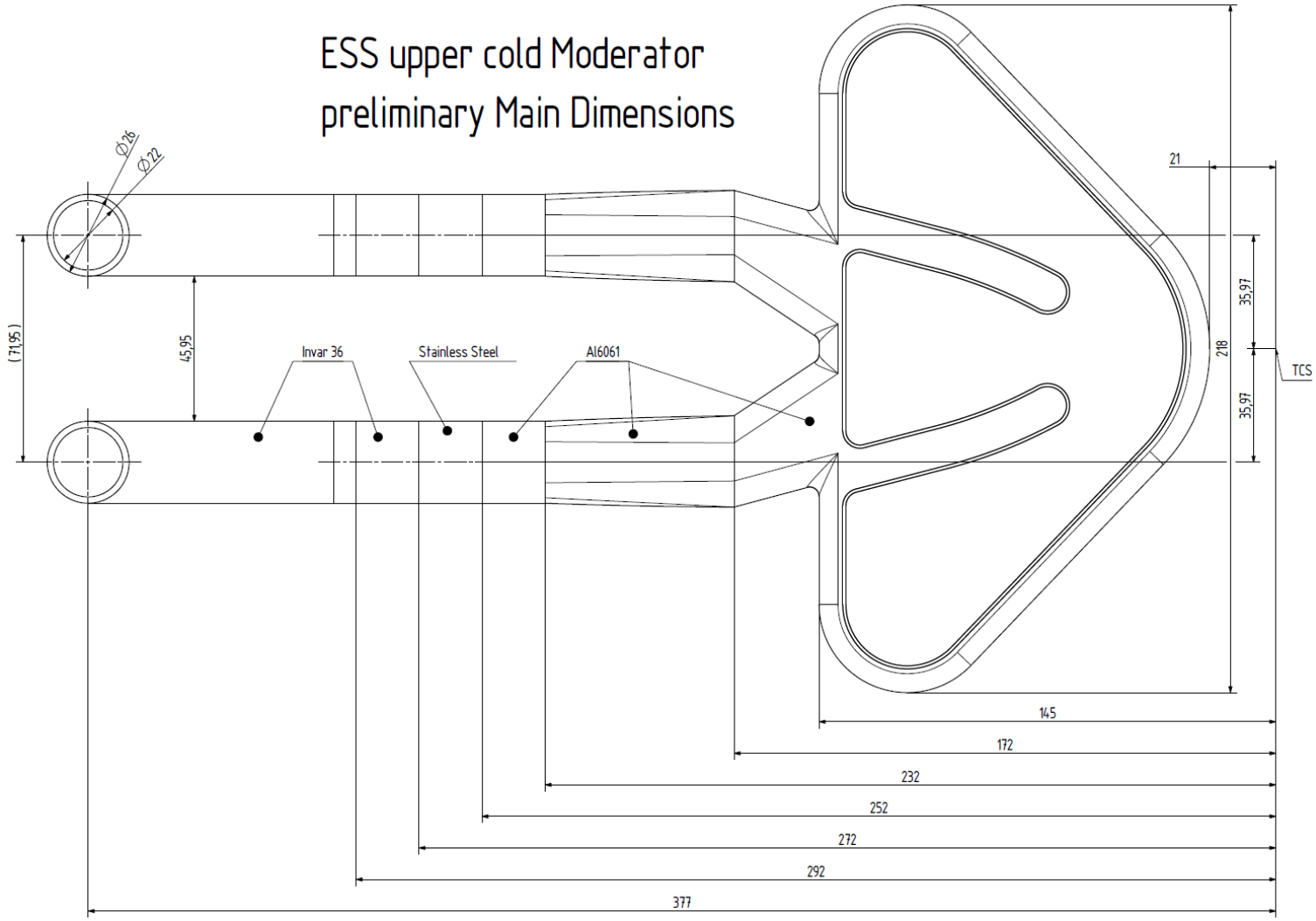
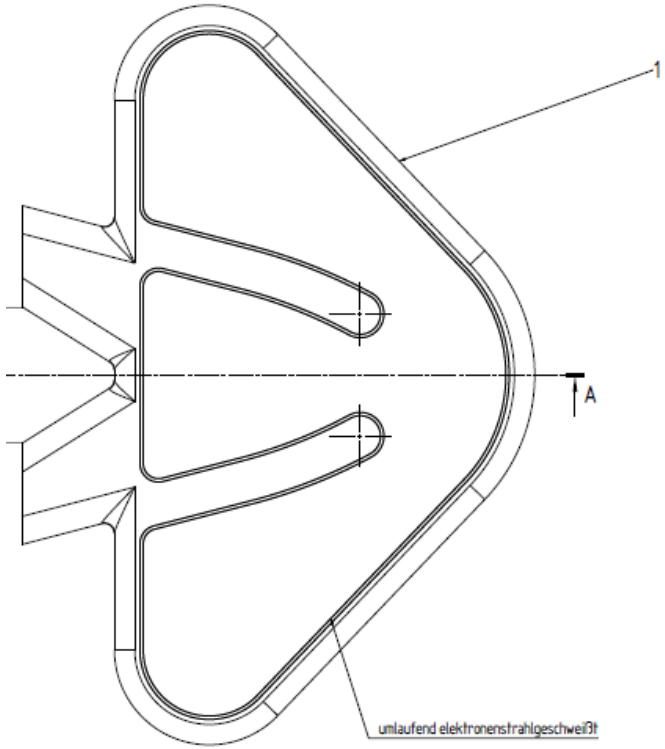
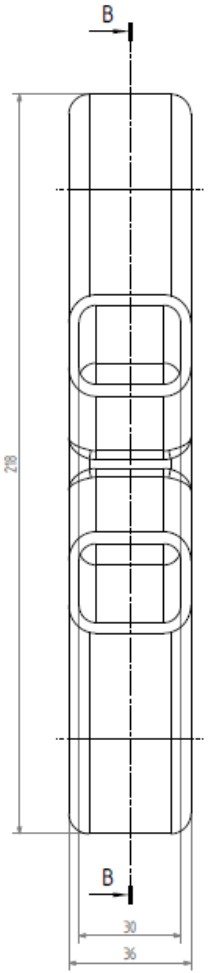
- ✓ First design optimization
- ✓ Structure mechanical simulation
- ✓ Fluid dynamic simulation (steady state)
- ✓ Fluid dynamic simulation (transient)
- Manufacturing test (in progress)
- Final design
- Manufacturing of the final cold Moderators

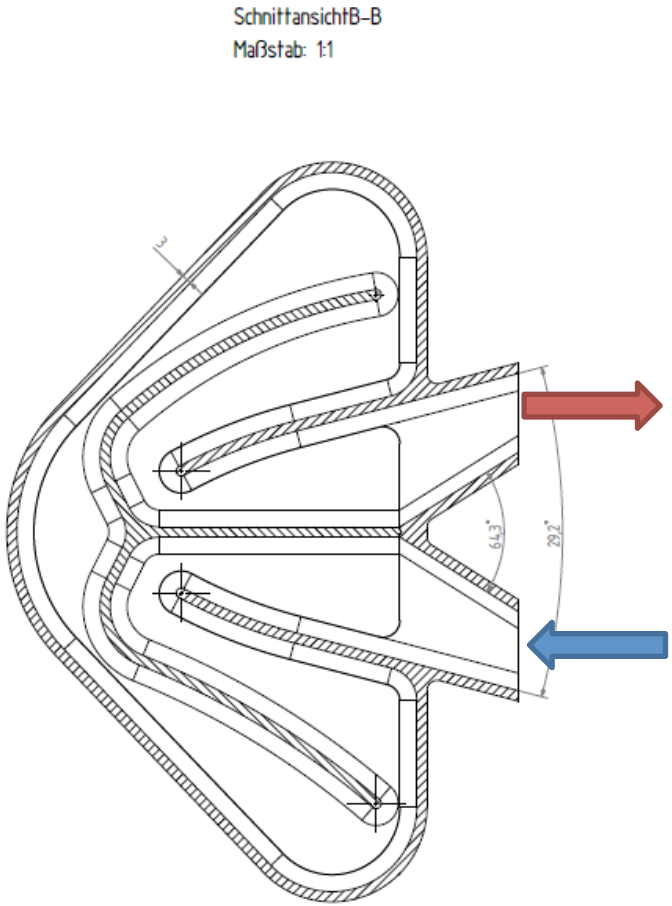
Cold Moderator (design)



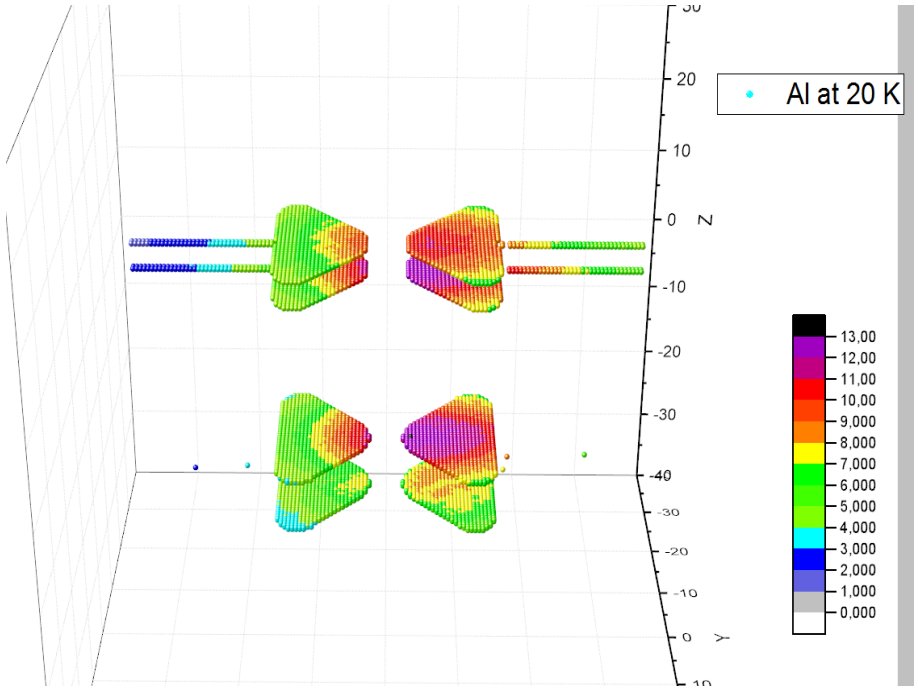
Cold Moderator (fluid guide structure)

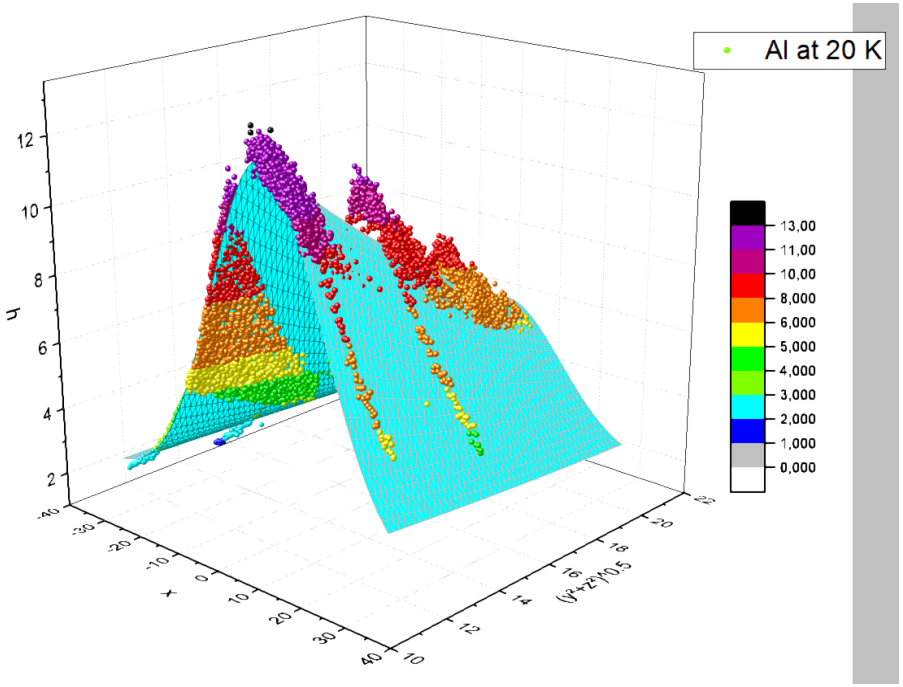






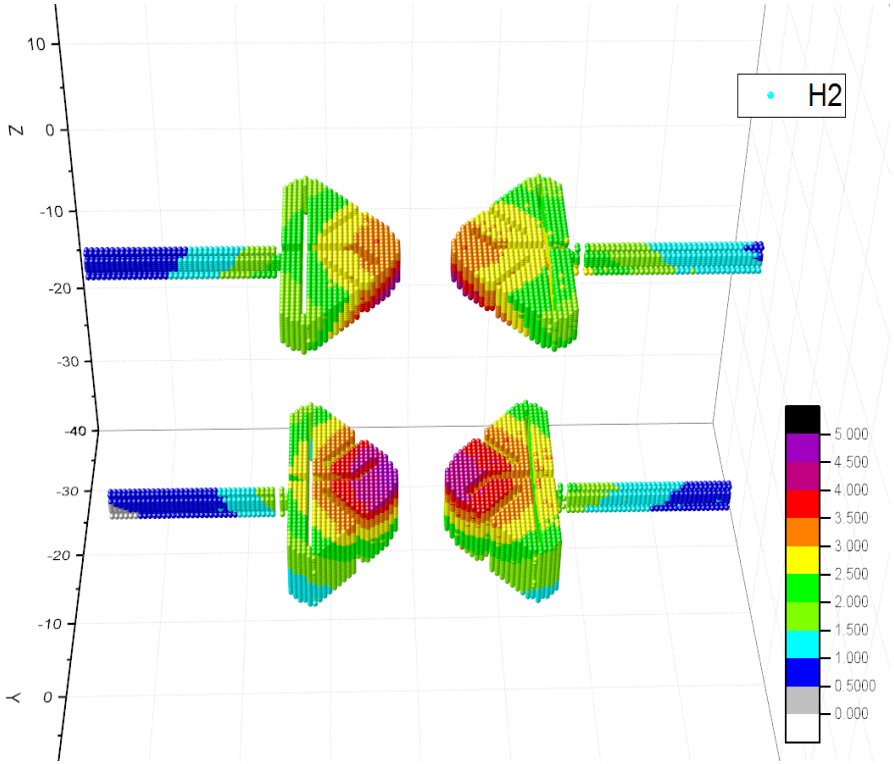
Cold Moderator (Heat Al)

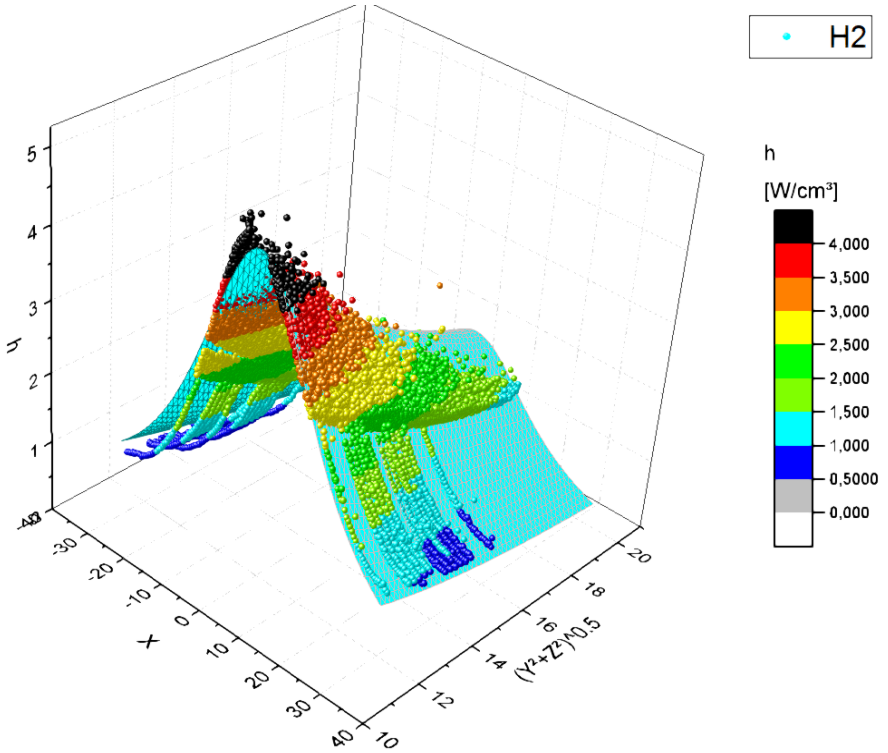




$$h(x,y,z) = 2.287 + 33.9exp\left[-\frac{1}{2}\left(\frac{x-5.34}{13}\right)^2 - \frac{1}{2}\left(\frac{\sqrt{y^2+z^2}+17.24}{18.18}\right)^2\right]$$

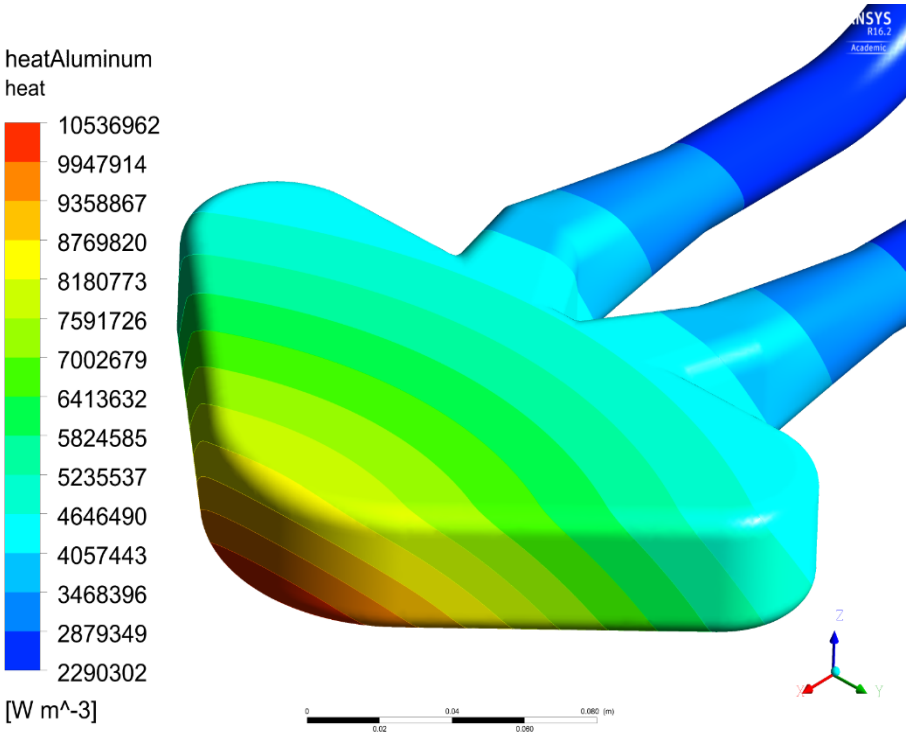
Cold Moderator (Heat H2)

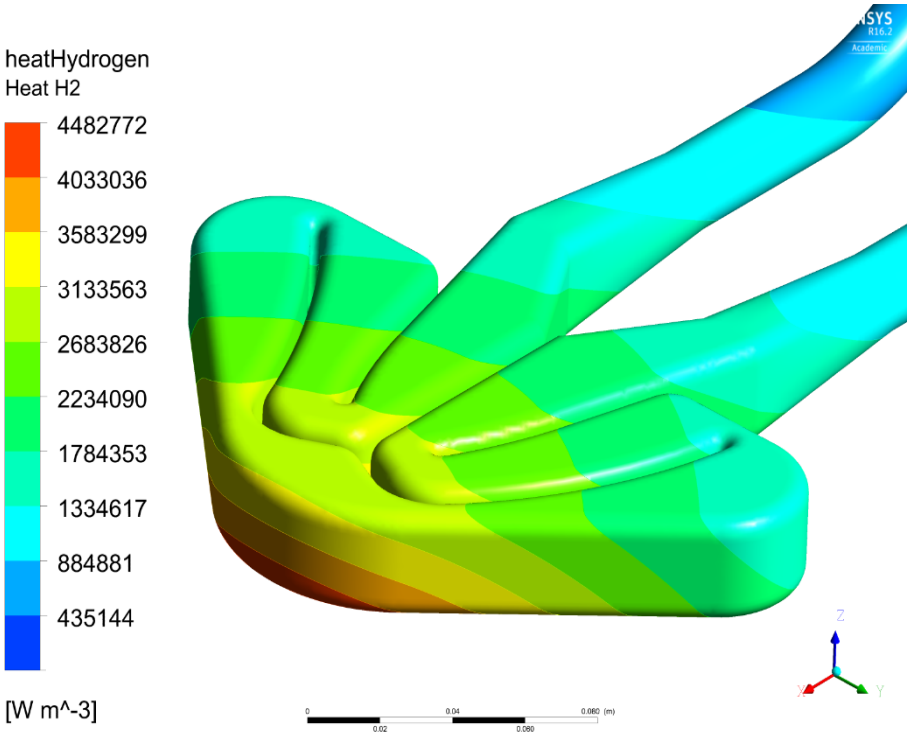




$$h(x,y,z) = -0.17317 + \frac{101.78613}{\left[1+\left(\frac{x-0.42345}{18.20385}\right)^2\right]\left[1+\left(\frac{\sqrt{y^2+z^2}+3.56612}{3.34324}\right)^2\right]}$$

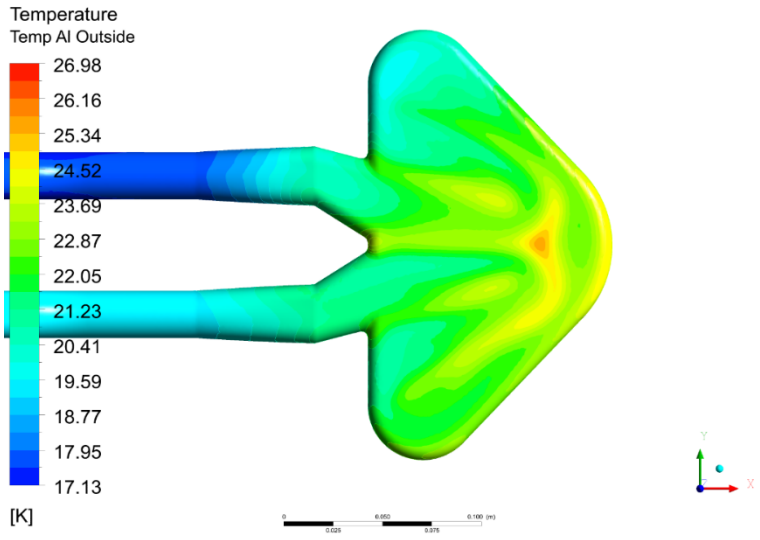
Upper cold Moderator (Heat Al+H2)

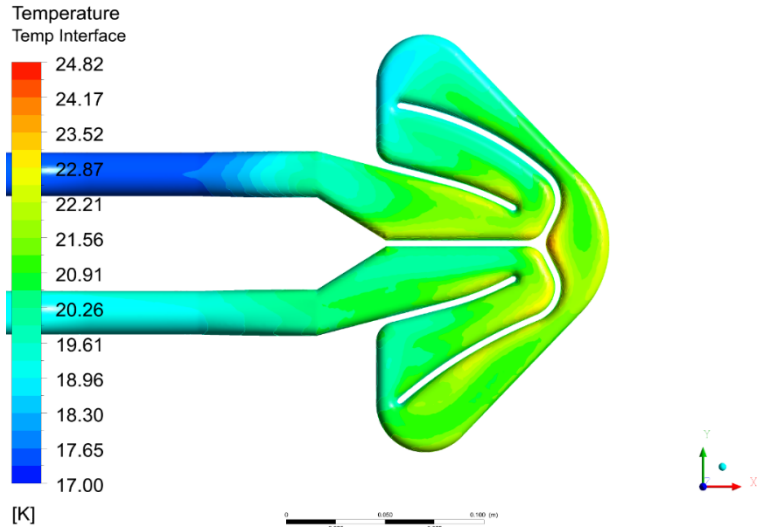


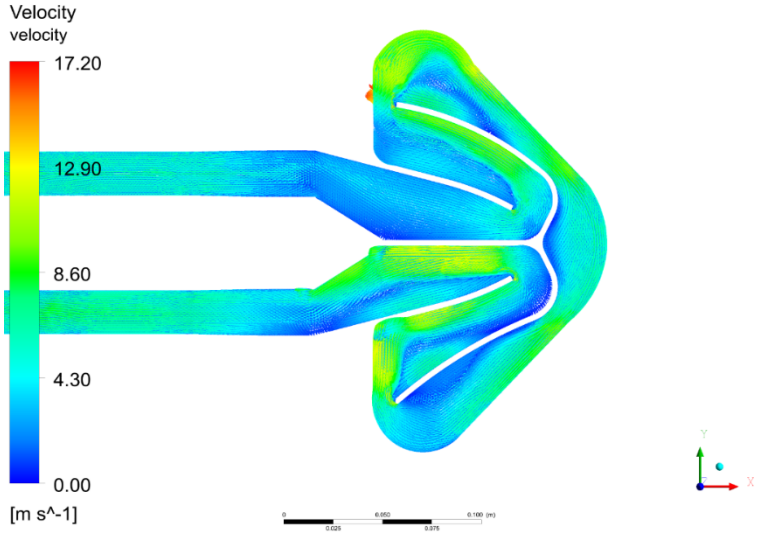


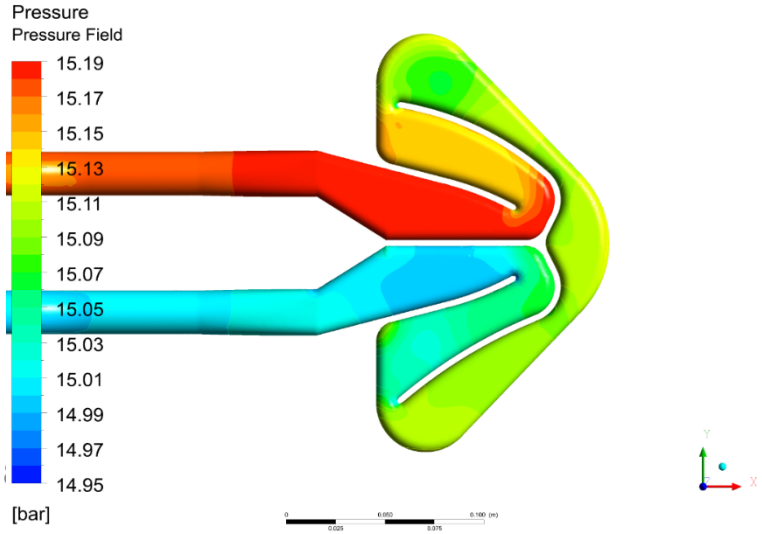
∑ upper cold Moderators ≈7.0 kW

Cold Moderator CFX results (steady state)

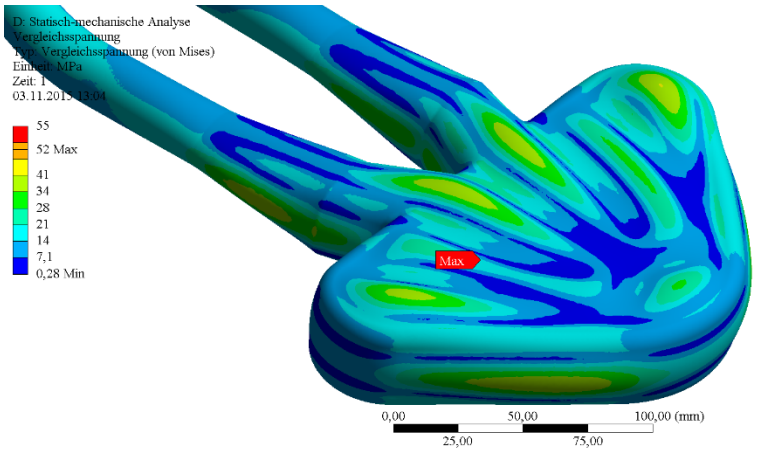




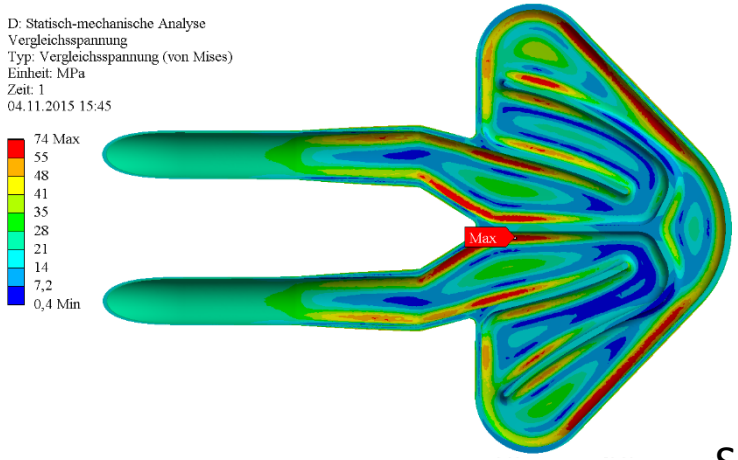




Cold Moderator results (FEM)

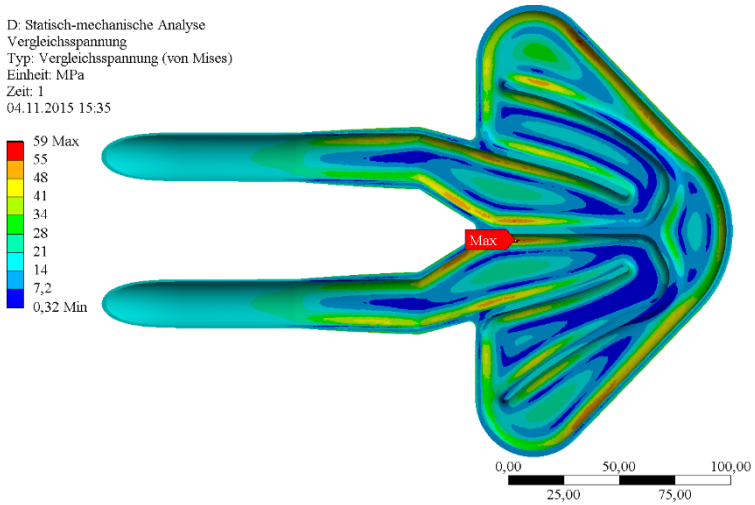


Stress @15 bar / 20 K **operation case**

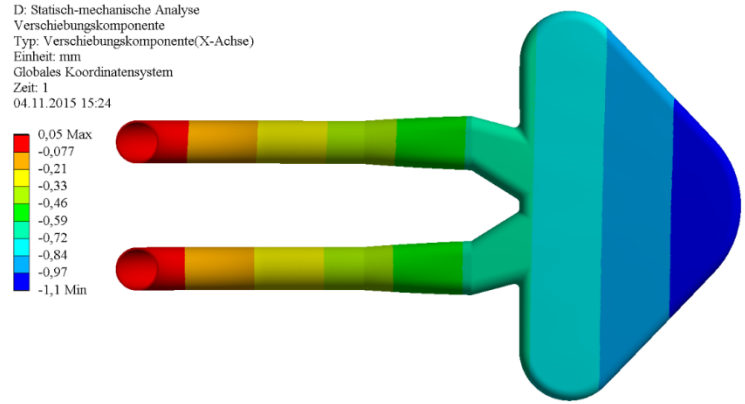


Stress @21,45 bar / 300 K **test case** S>55

S=55MPa
(RCC MRx)

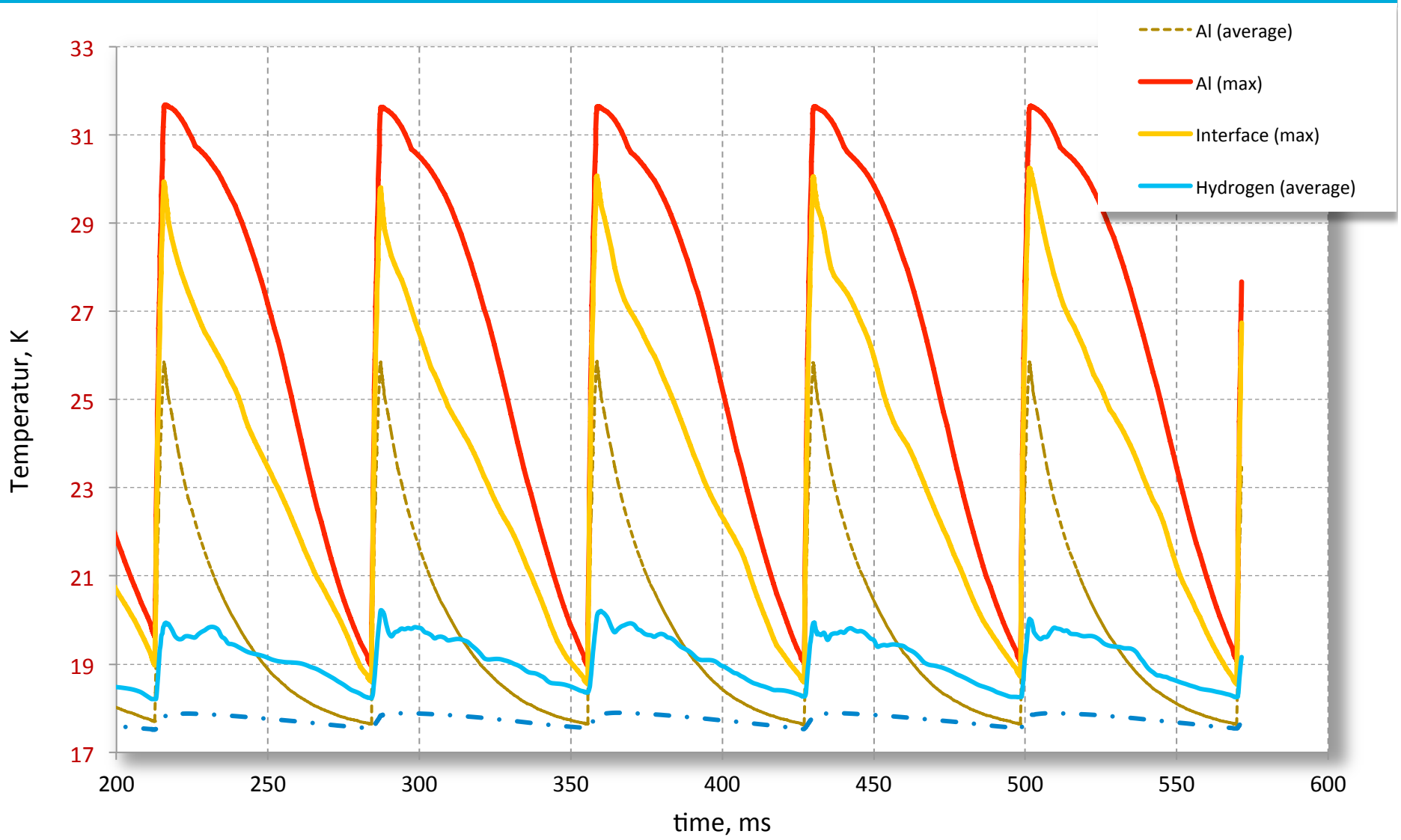


Stress @17 bar / 20 K **design case** S<=55 MPa

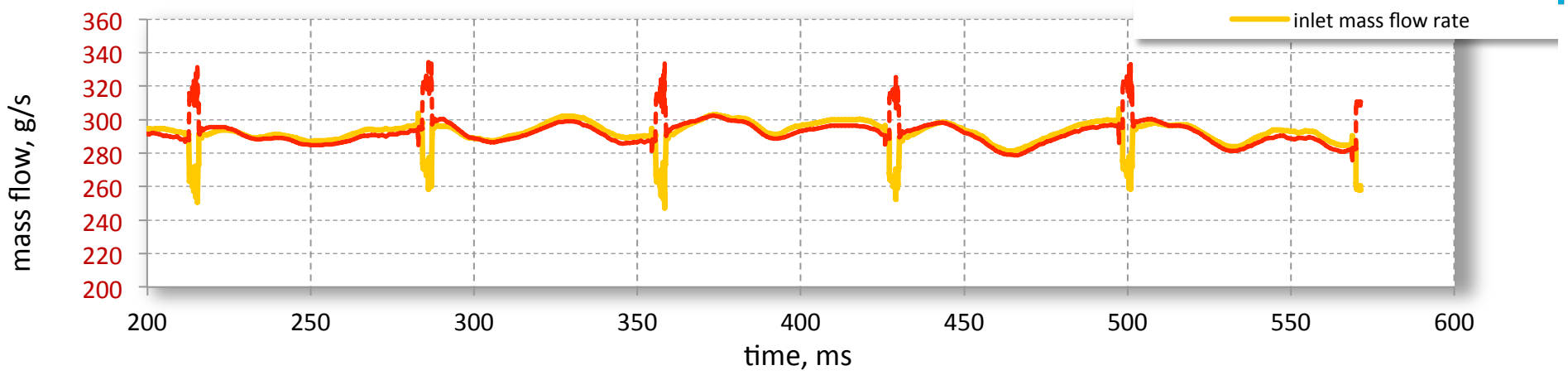


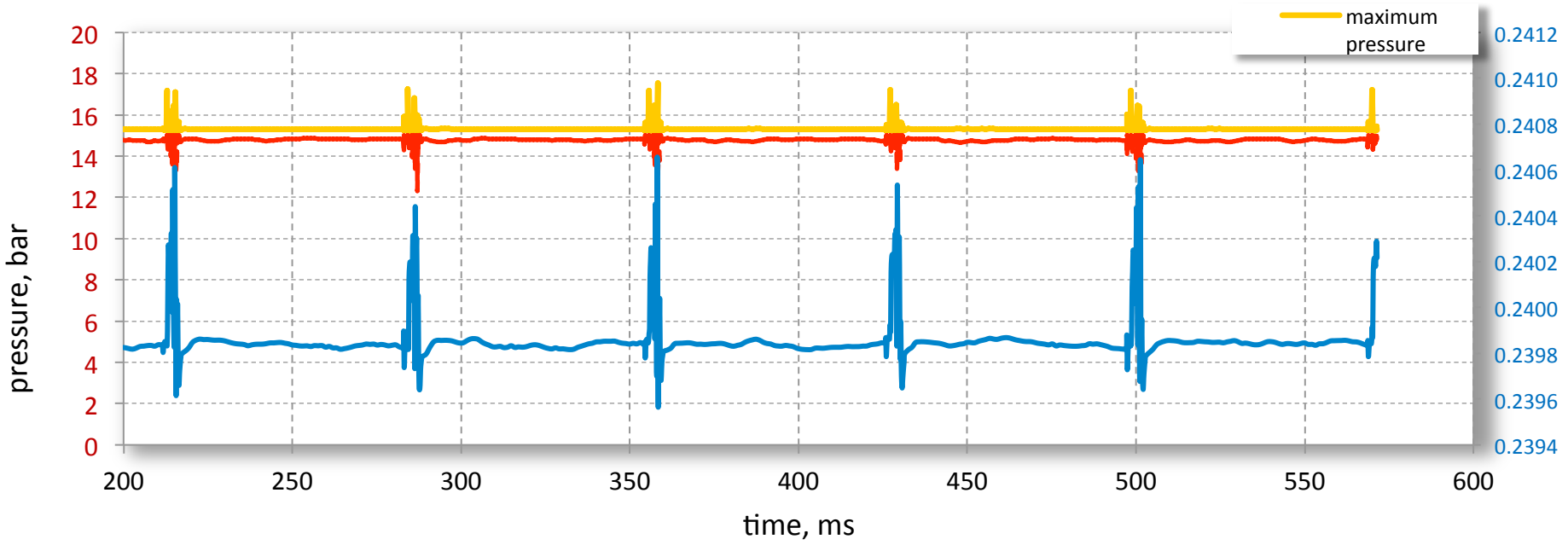
Deformation (without Invar)

Cold Moderator CFX results (transient)



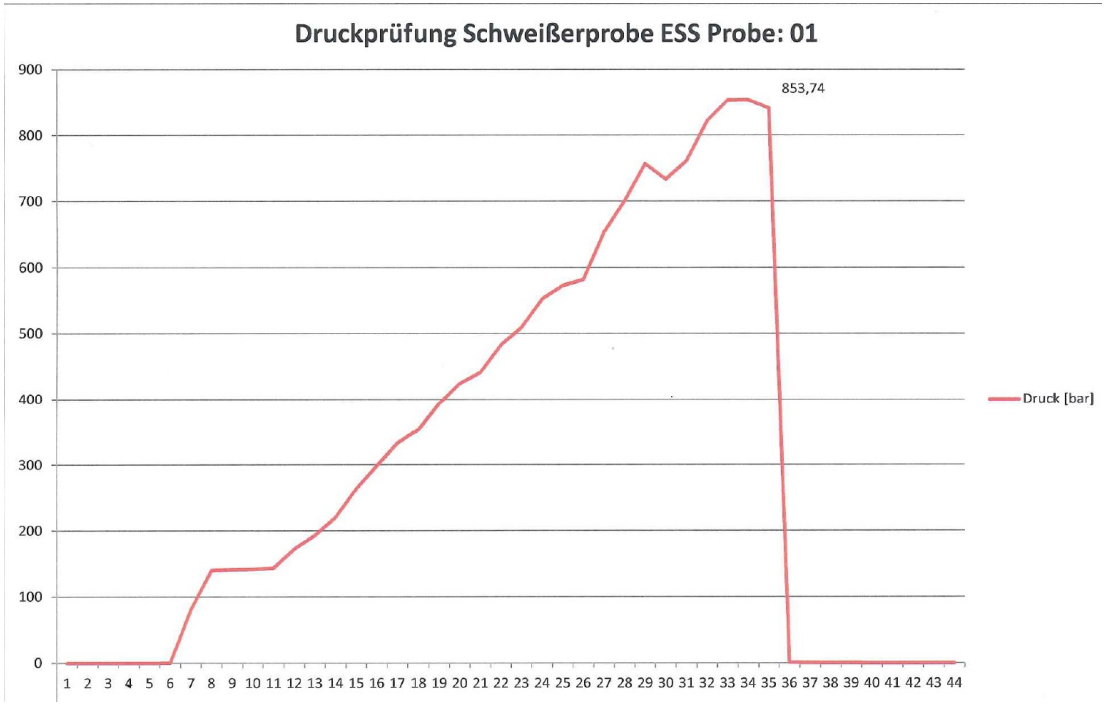
Cold Moderator CFX results (transient)





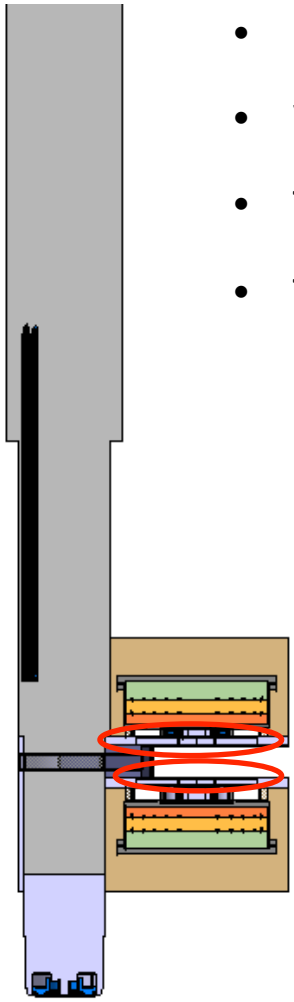
Cold Moderator pipework (Invar-Invar test)

Burst test Invar-Invar welding

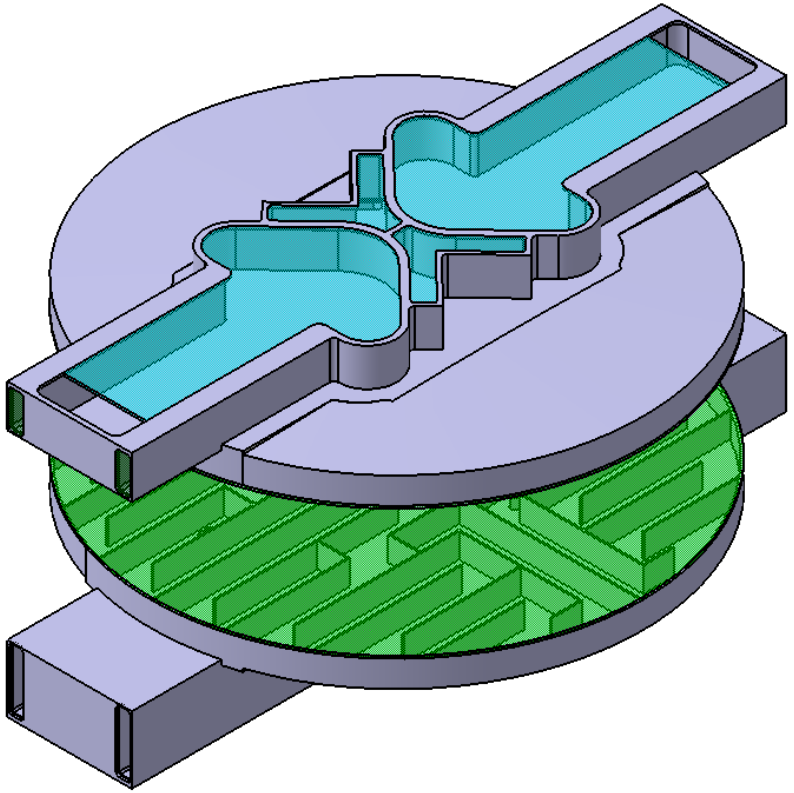


Burst pressure

Thermal Moderators



- Fluid Water
- Vessel material Al6061-T6
- Total heat load≈172 kW
- Total mass flow ≈1.2kg/s



Thermal Moderators

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- Fluid dynamic simulation (transient), in progress
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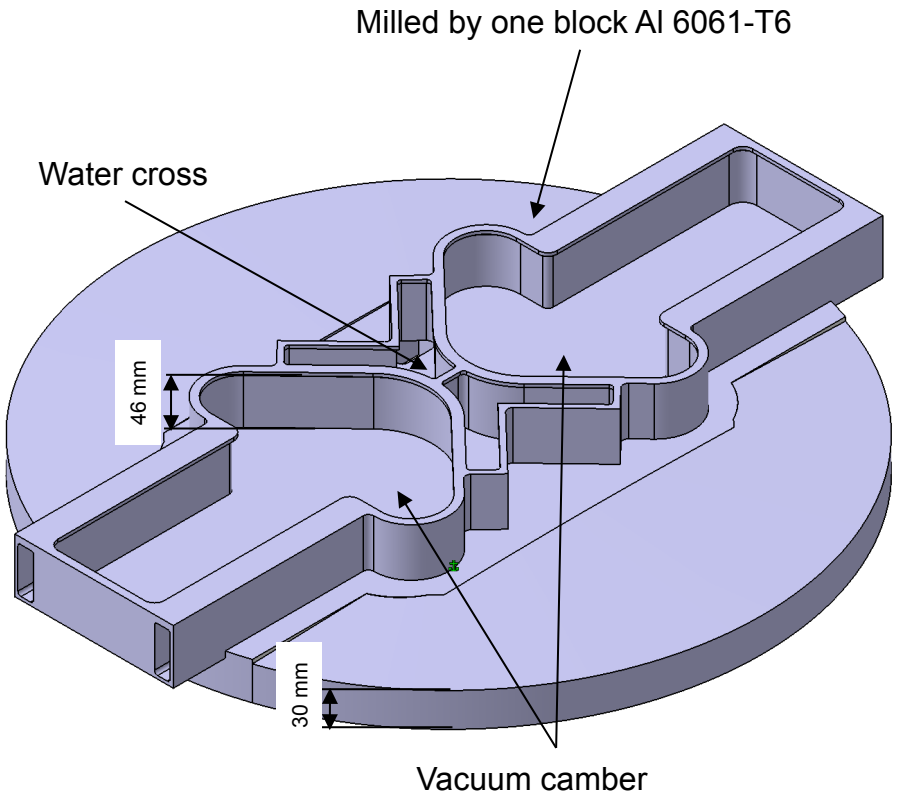
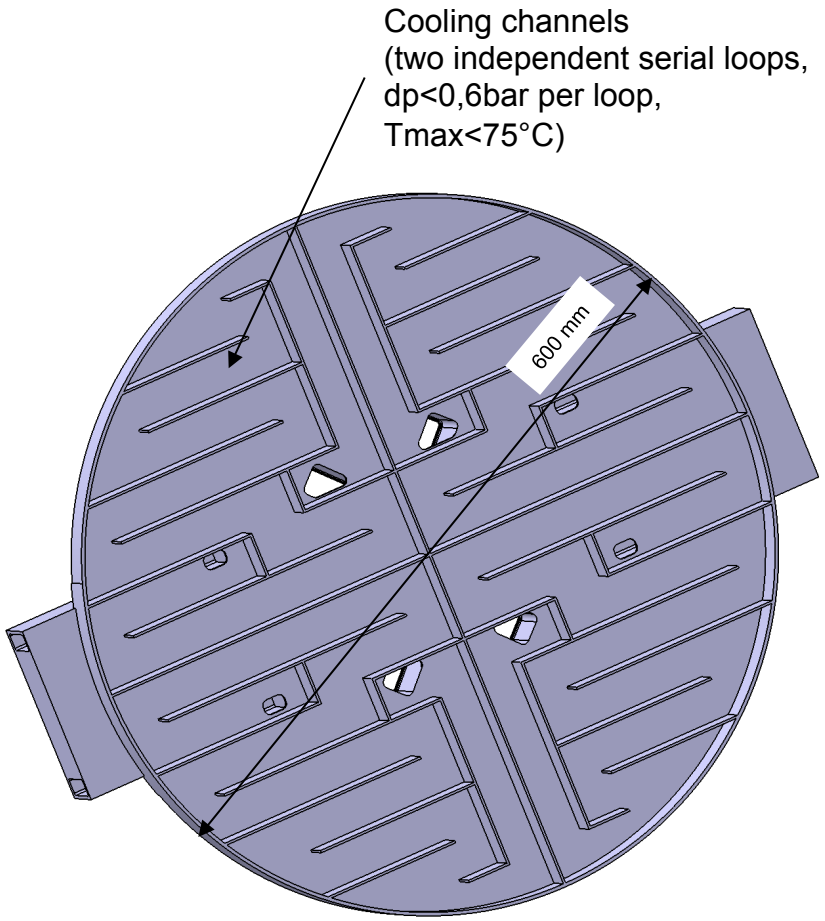
Thermal Moderator design

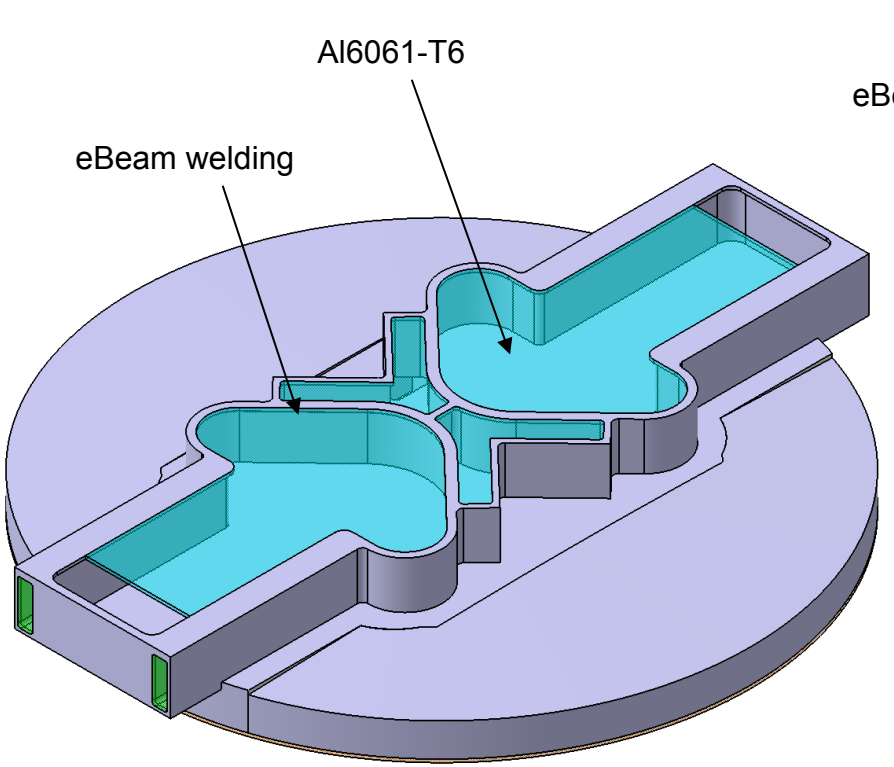


View from Reflector

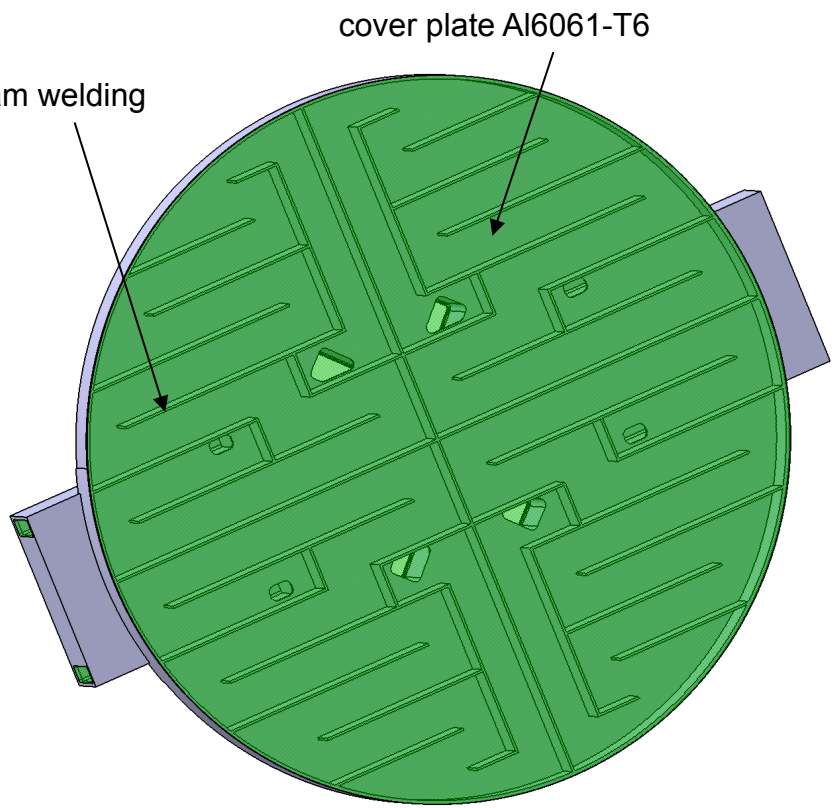


View from Target

Thermal Moderator design

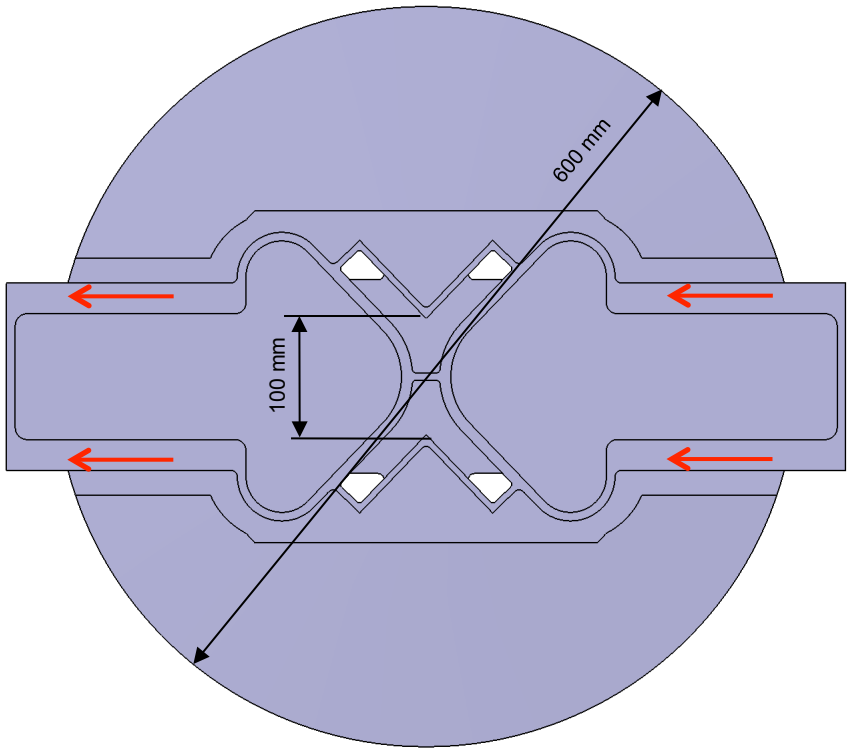


View from Reflector

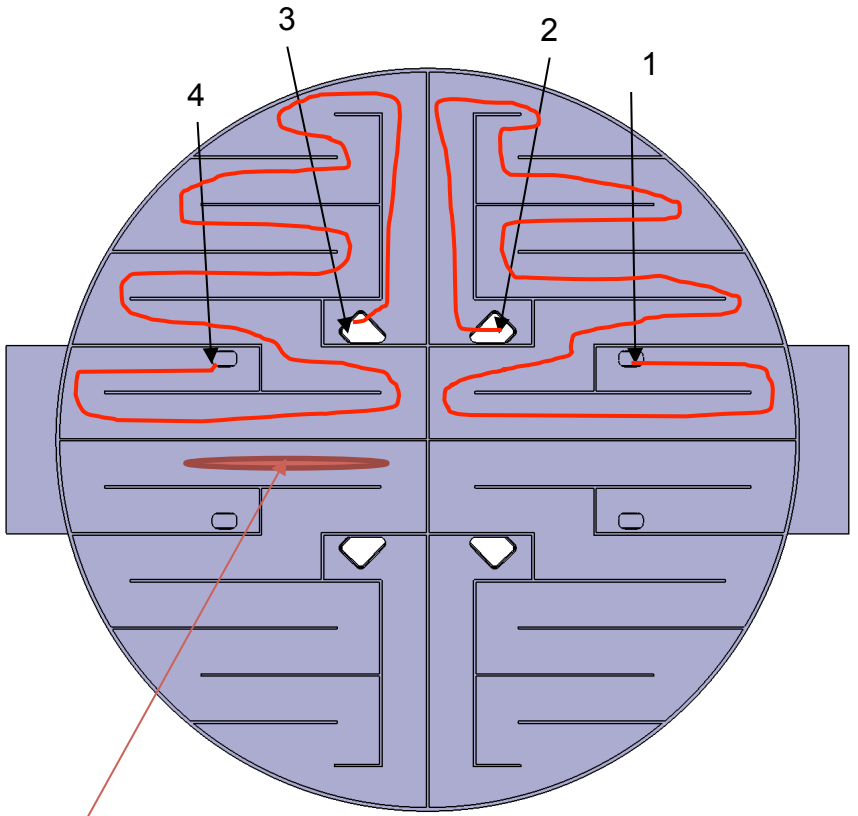


View from Target

Thermal Moderator design (fluid guides)



View from Reflector



View from Target

Interface: ***irradiation module***

Thermal Moderator (Heat Al+H2O)

EUROPEAN SPALLATION SOURCE

- Aluminum for thermal moderator
  - Gaussian fit:

$$P_{Al_{300K},G}(x,y,z) = 2\frac{W}{cm^3} + 205.6\frac{W}{cm^3}\cdot e^{-\frac{1}{2}\left(\frac{\frac{x}{cm}-5.43}{14.4}\right)^2-\frac{1}{2}\left(\frac{\frac{\sqrt{y^2+z^2}}{cm}+31.616}{17.37}\right)^2}$$

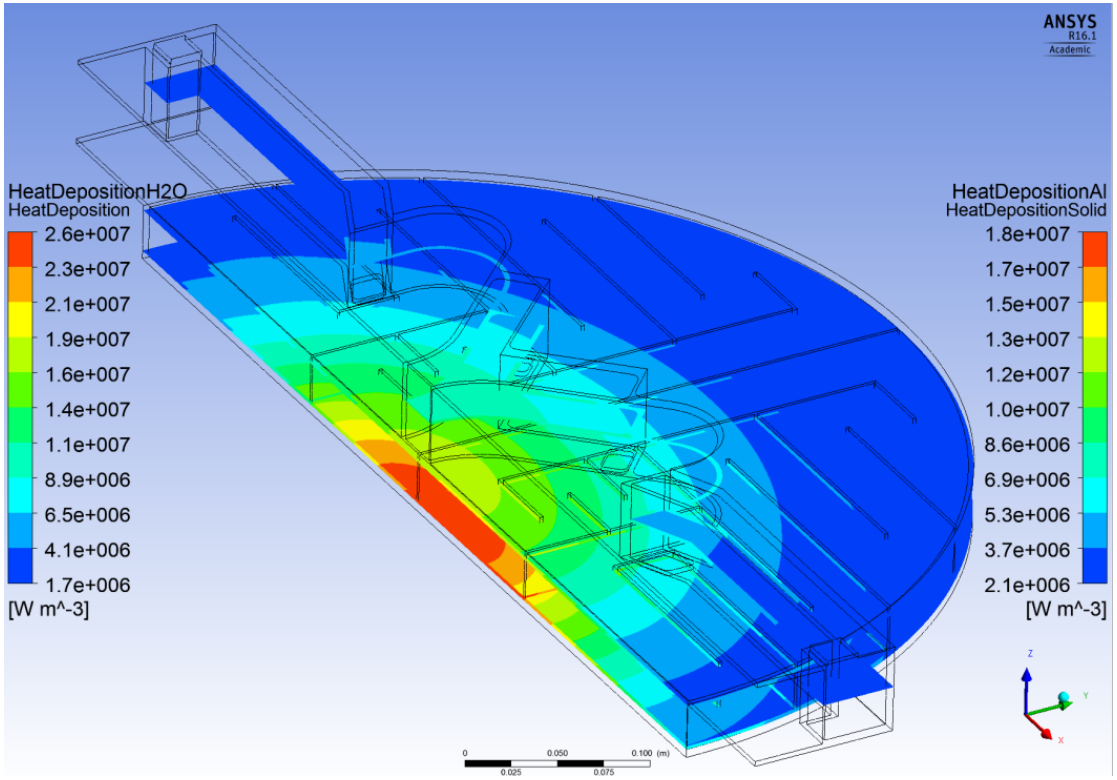
  - rational fit:

$$P_{Al_{300K},r}(x,y,z) = \frac{81.5255 + 0.11046\cdot\frac{x}{cm} - 2.96746\cdot\frac{\sqrt{y^2+z^2}}{cm} + 0.03388\cdot\frac{(y^2+z^2)}{cm^2} - 0.0000203\cdot\frac{(y^2+z^2)^{\frac{3}{2}}}{cm^3}}{1 - 0.09314\cdot\frac{x}{cm} + 0.01233\cdot\frac{x^2}{cm^2} - 0.00006276\cdot\frac{x^3}{cm^3} + 0.28717\cdot\frac{\sqrt{y^2+z^2}}{cm} + 0.00302\cdot\frac{(y^2+z^2)}{cm^2}}$$

- Water (Gaussian fit):

$$P_{H_2O}(x,y,z) = 1.656\frac{W}{cm^3} + 15740.65\frac{W}{cm^3}e^{-\frac{1}{2}\left(\frac{\frac{x}{cm}-1.77}{13.05}\right)^2-\frac{1}{2}\left(\frac{\frac{\sqrt{y^2+z^2}}{cm}+69}{21.25}\right)^2}$$

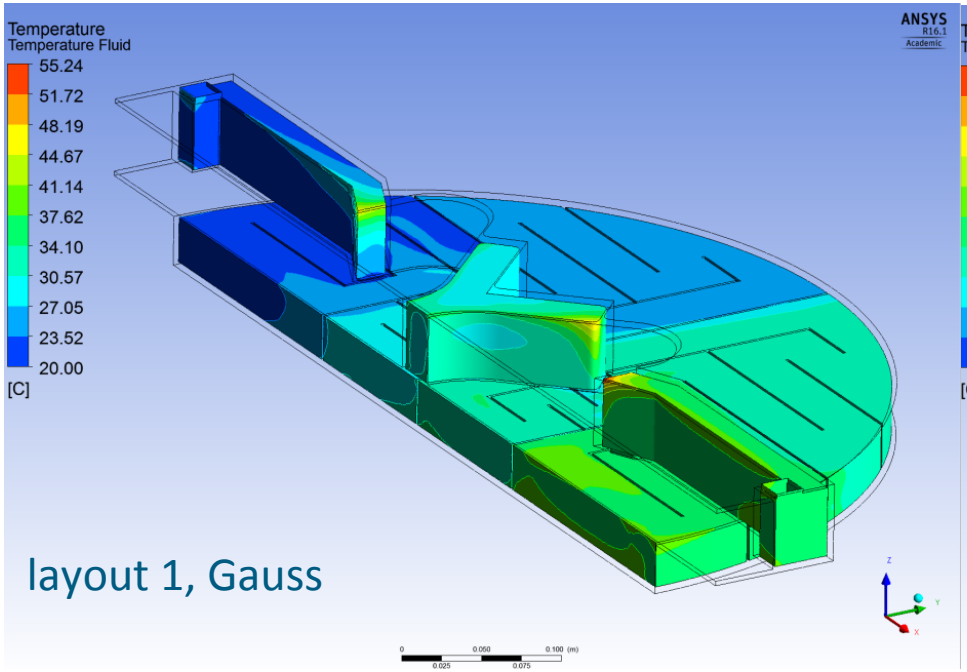
Thermal Moderator (Heat Al+H2O)

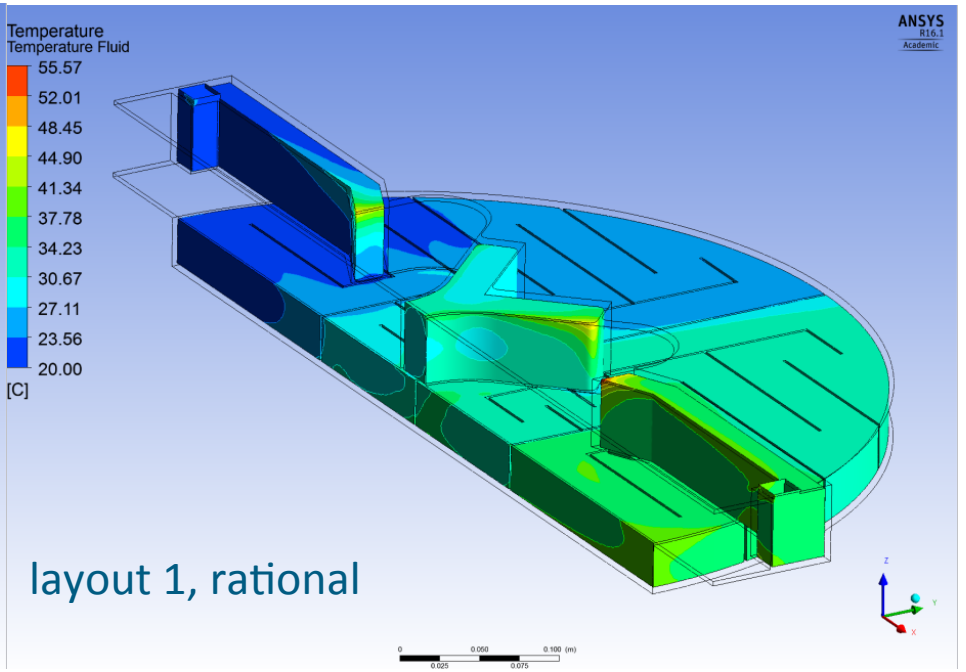


- total heat deposition values for half-model (Gauss / rational):

aluminum:	8.8 kW / 8.8 kW	10.1 kW / 10.2 kW
water:	28.0 kW	29.9 kW
total:	36.8 kW / 36.8 kW	40.0 kW / 40.1 kW

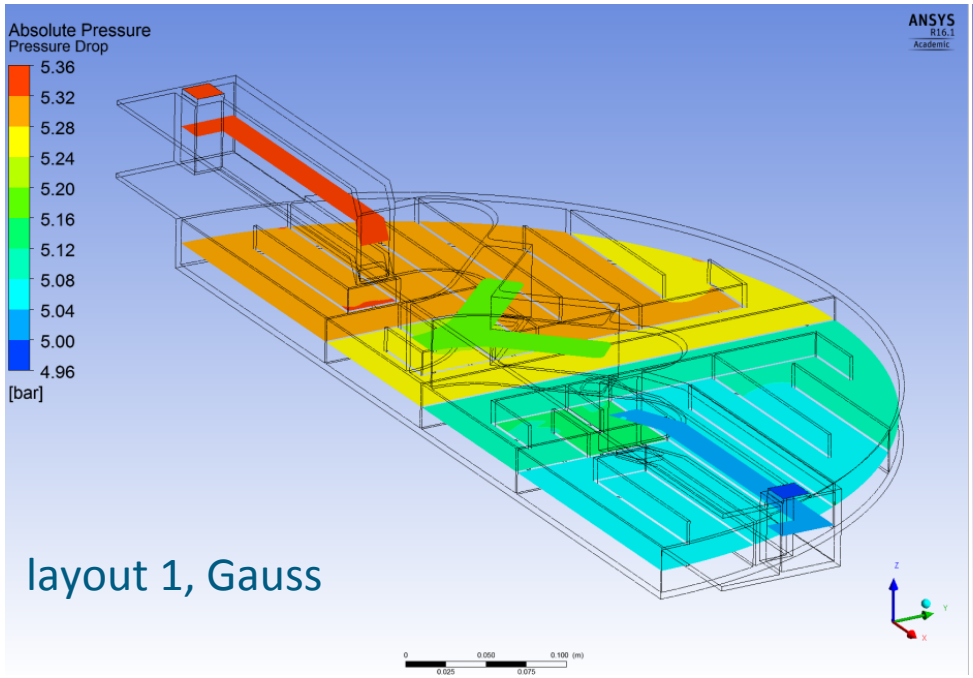
Cold Moderator CFX results (steady state)

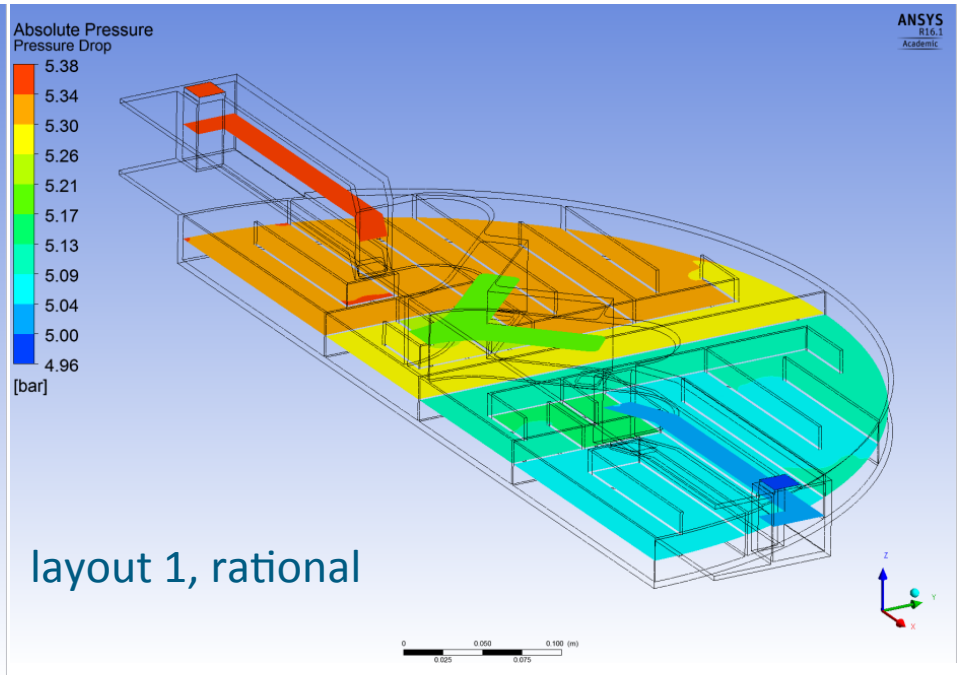




Fluid temperature

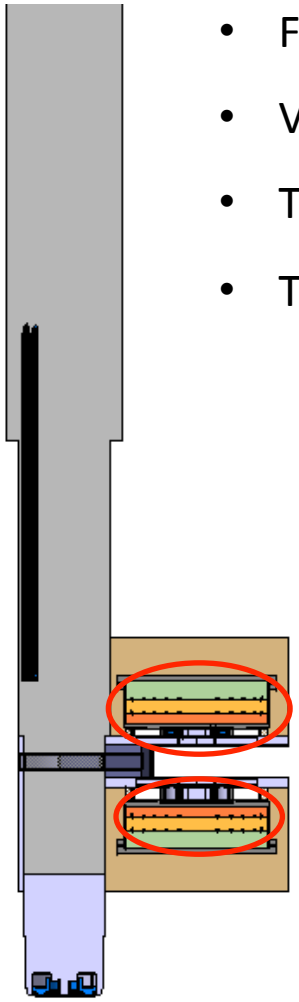
Cold Moderator CFX results (steady state)



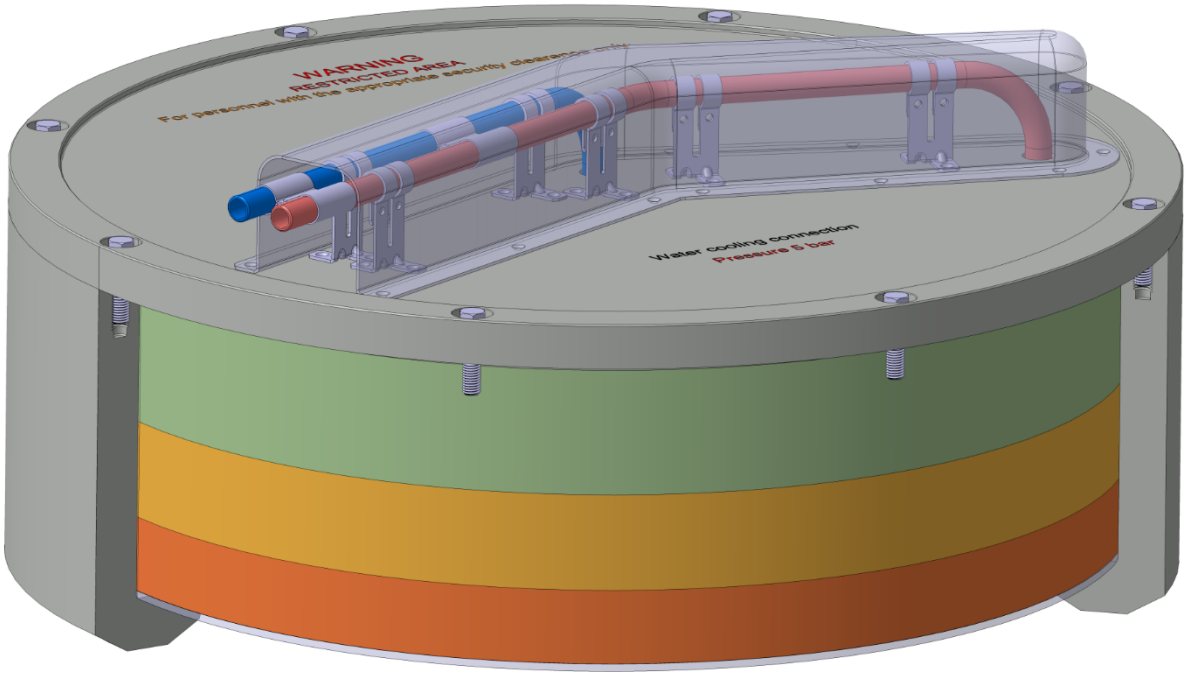


Pressure loss

Beryllium Reflectors



- Fluid Water
- Vessel material Al6061-T6
- Total heat load≈185 kW
- Total mass flow ≈1.5kg/s



Beryllium Reflector dimensions: Ø700 mm, H = 200 mm

Beryllium Reflectors

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- ✓ First design optimization
- Structure mechanical simulation, in progress
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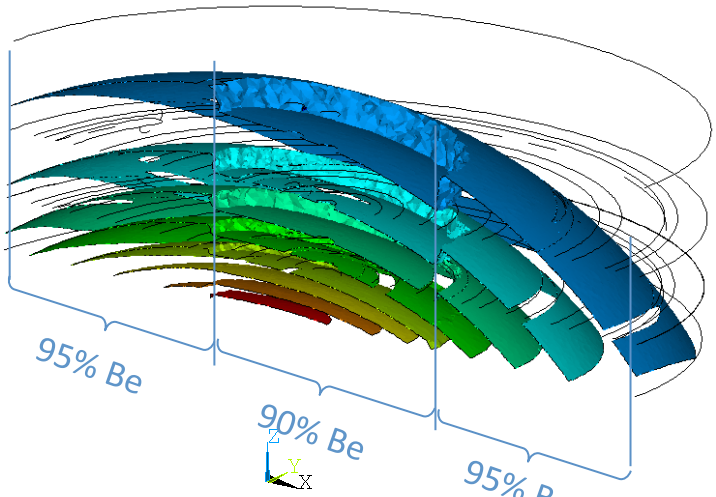
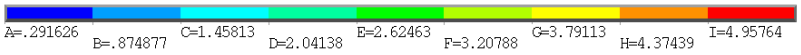
Upper Reflector (Heat)

Heat deposition in Beryllium



max: 5,25 W/cm²



Distribution of heat deposition in W/cm²

➢ total heat deposition: 94 kW

- Heat deposition is approximated by functions that are fitted based on heat deposition data from neutronic calculations:

- Cells with 95% Be and 5 % H_2O:
  - Modell: Gauss 2D

$$h(x,y,z) = 0{,}436\frac{W}{cm^3} + 21\frac{W}{cm^3} \cdot exp\left(-0{,}5\left(\frac{x+7{,}8}{20{,}76}\right)^2 - 0{,}5\left(\frac{\sqrt{y^2+z^2}+17{,}87}{20{,}2}\right)^2\right)$$

- Cells with 90% Be and 10% H_2O
  - Modell: Rational 2D

$$h(x,y,z) = \frac{1891.2 - 1.3x - 111.47\sqrt{y^2+z^2} + 2.48(y^2+z^2) - 0.02(y^2+z^2)^{\frac{3}{2}}}{1 + 1.48x + 0.17x^2 + 0.004x^3 + 7\sqrt{y^2+z^2} - 0.036(y^2+z^2)}\frac{W}{cm^3}$$

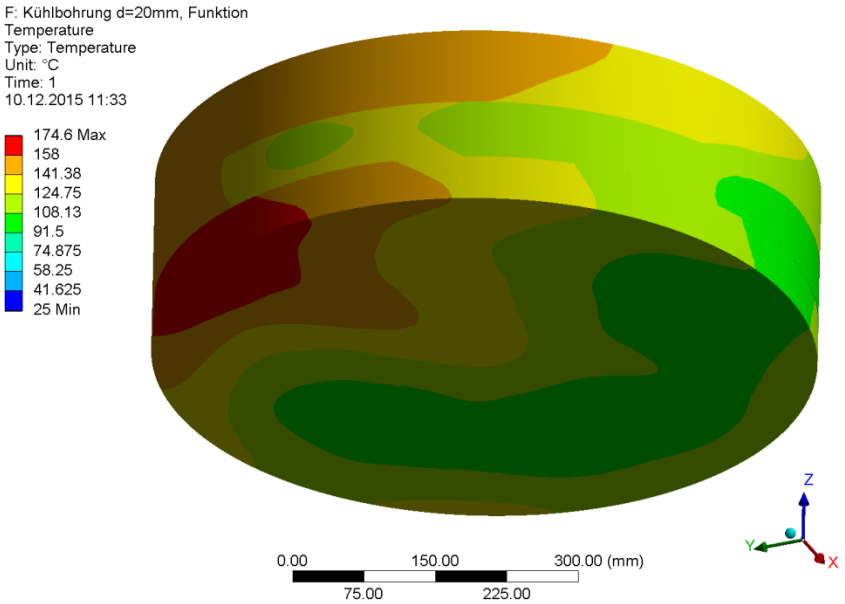
Upper Reflector (Thermal Calculation)

(1)

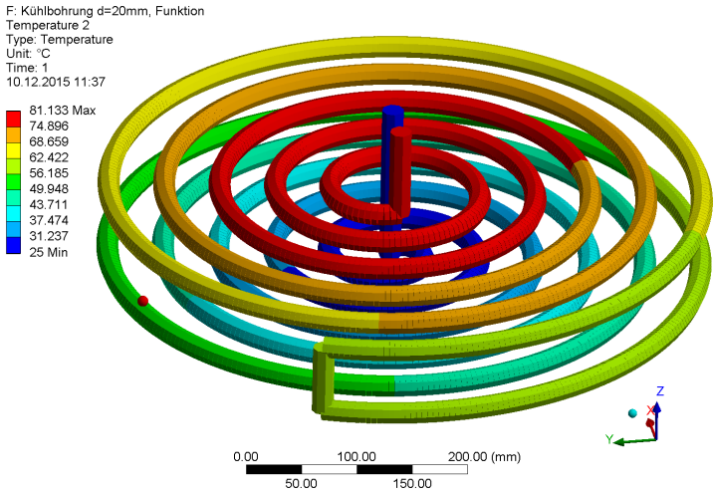
- ✓ < 5% water content!
- mass flow cooling water: **0,4 kg/s**
- ✓ pressure loss: 0,16 bar
- cooling channels: Ø 20 mm
- water inlet temperature: 25 °C
- water outlet temperature: 81 °C

(2)

- ✓ < 5% water content!
- mass flow cooling water **0,8 kg/s**
- ✓ Pressure loss 0,65 bar
- cooling channels: Ø 20 mm
- water inlet temperature: 25 °C
- ✓ water outlet temperature: 53 °C

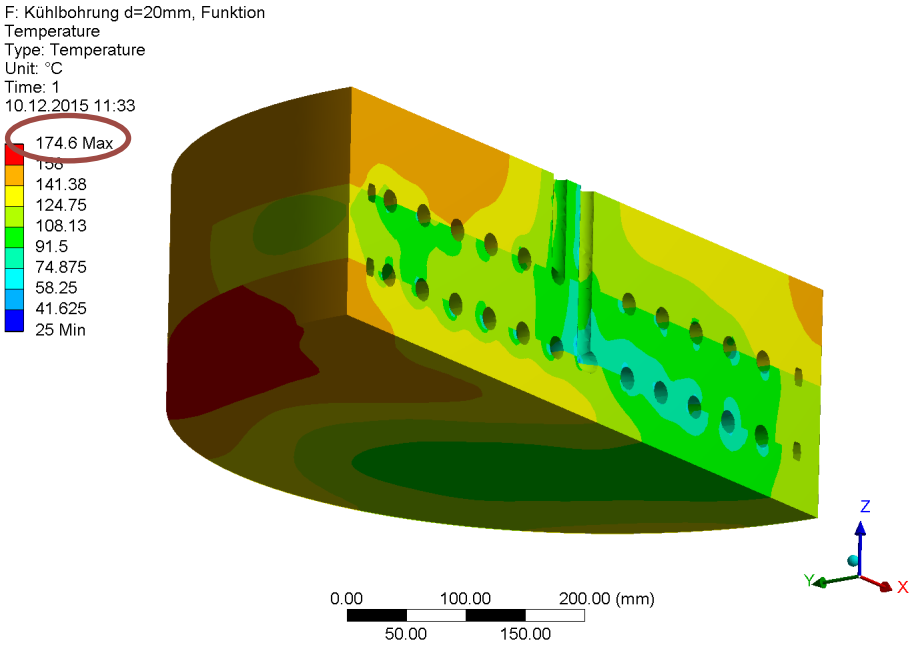


Temperature of Be-reflector in °C (1)

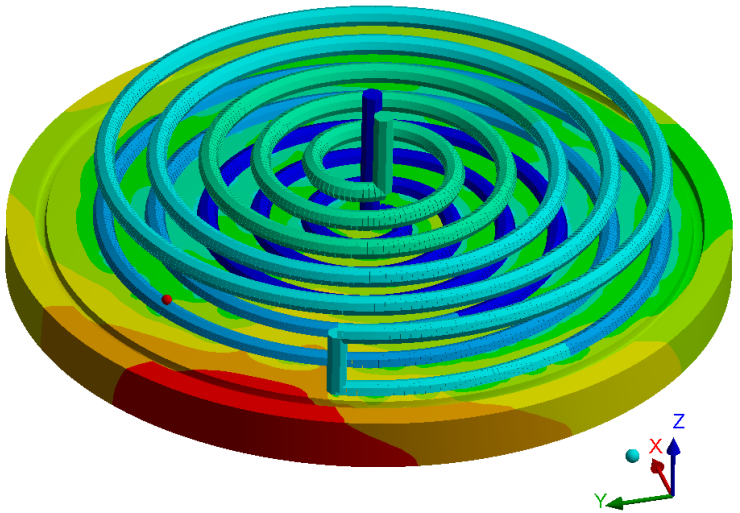


Temperature of cooling water in °C (1)

Upper Reflector (Thermal Calculation)

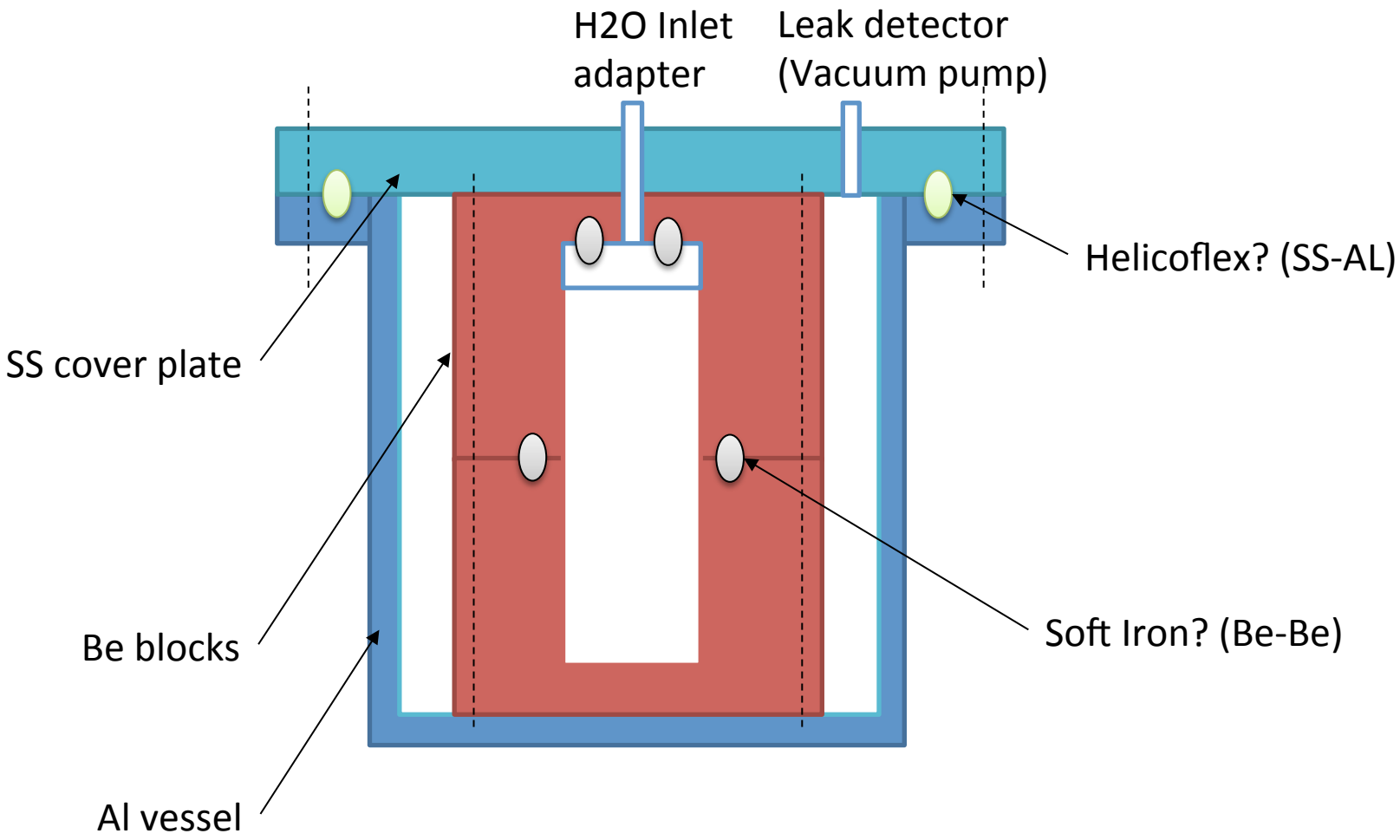


Temperature of Be-reflector in °C - cross section view (1)



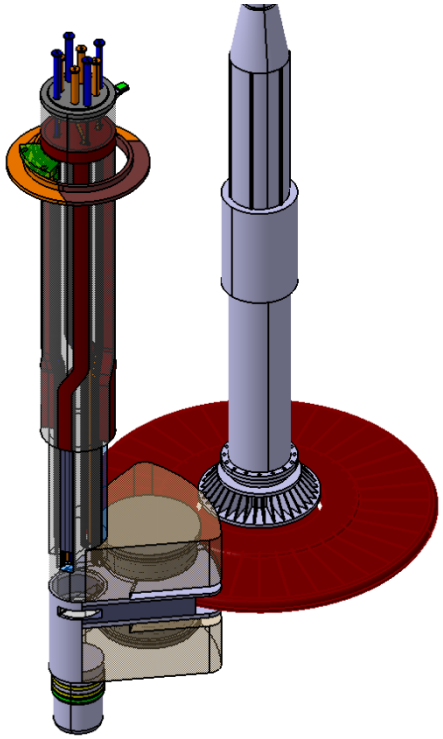
Temperature of Be-reflector in °C - volume of highest temperature at lower disk (1)

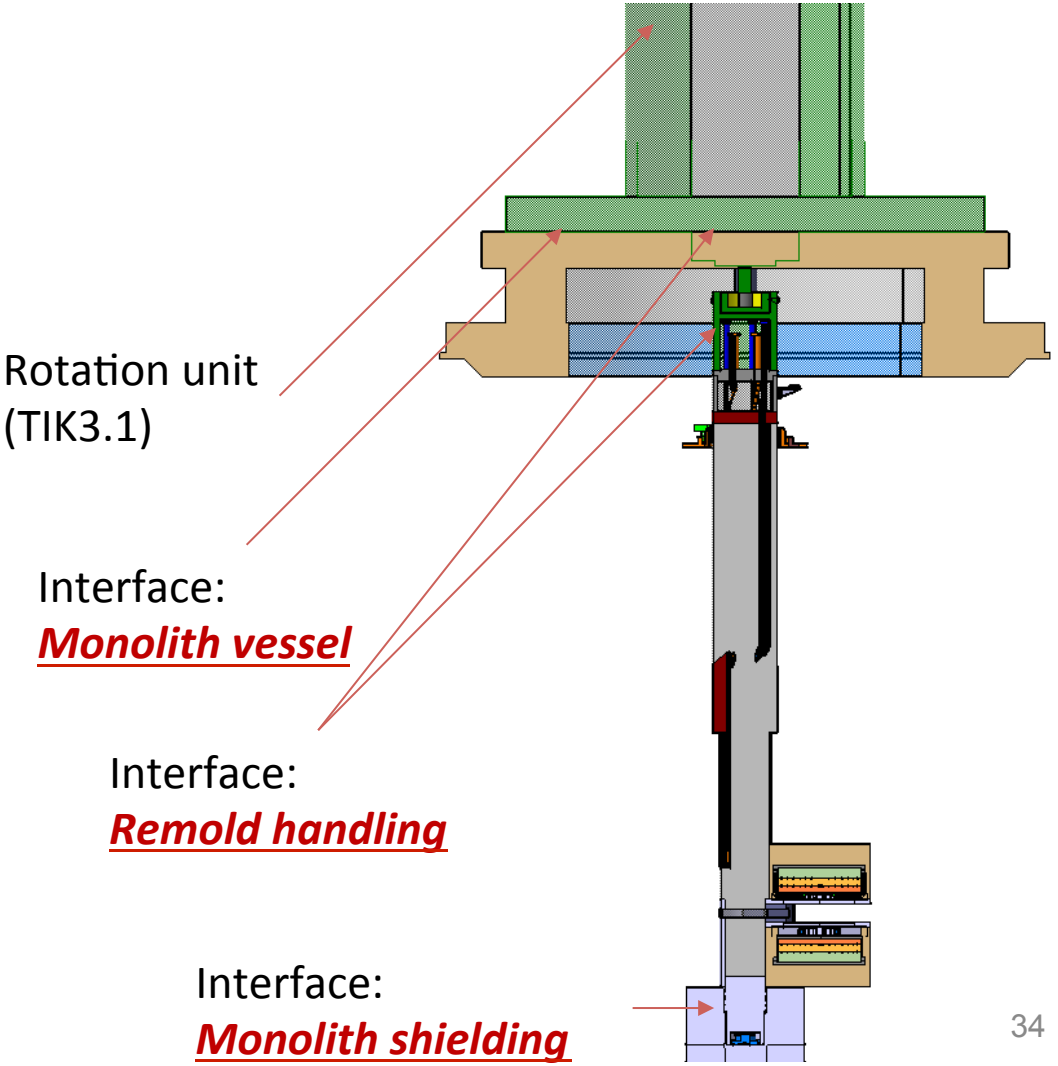
Reflector planed sealing test



Twister (frame, shaft, rotation unit)

- Fluid Water
- Structure material SS
- Total heat load≈490 kW
- Total mass flow ≈4,7kg/s

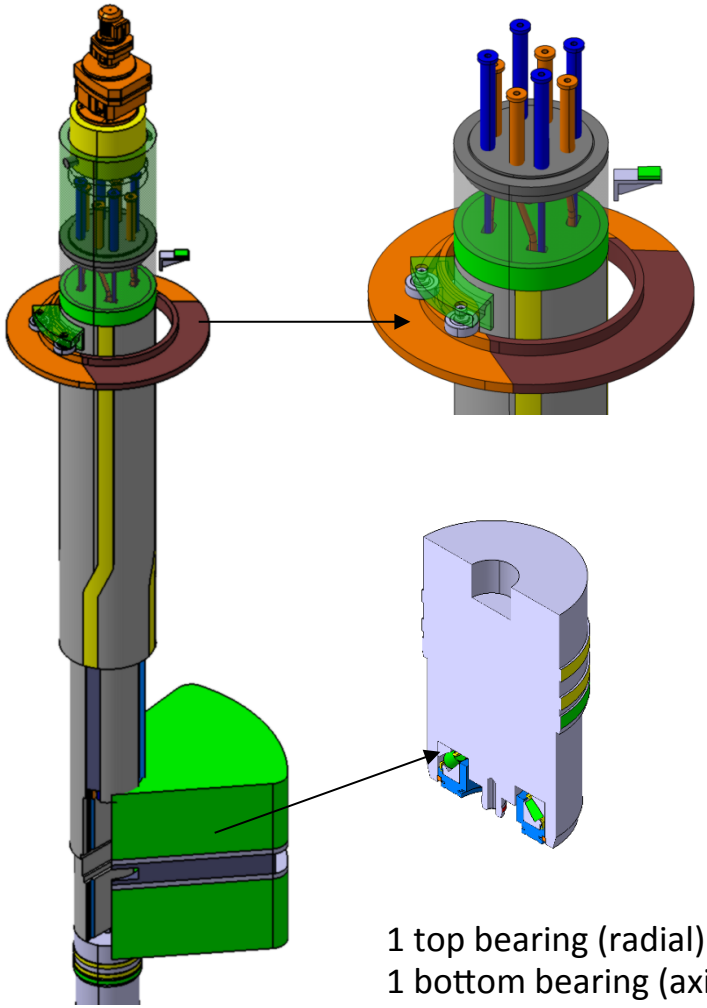




Thermal Moderators

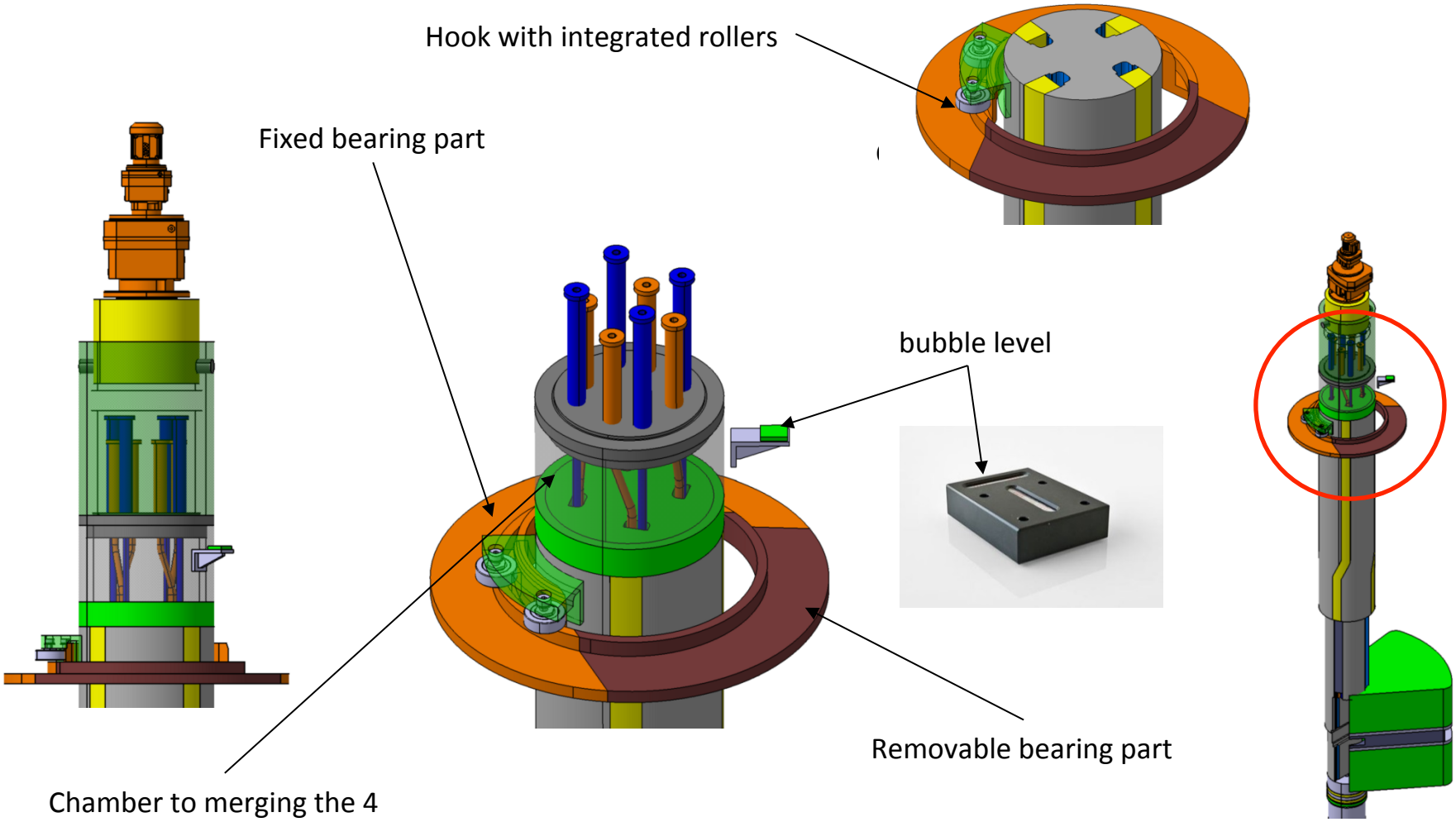
- ✓ First design optimization
- Structure mechanical simulation (in progress)
- Fluid dynamic simulation (steady state)
- Fluid dynamic simulation (transient)
- Manufacturing test
- Final design
- Manufacturing of the final Twister

Bearing and alignment

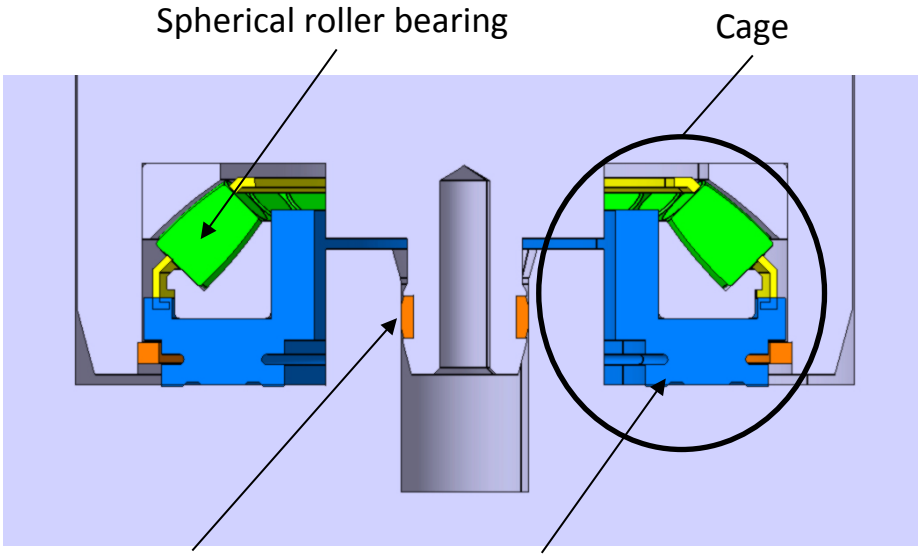


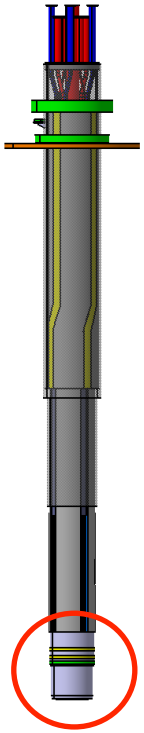
1 top bearing (radial)
1 bottom bearing (axial)

Bearing and alignment

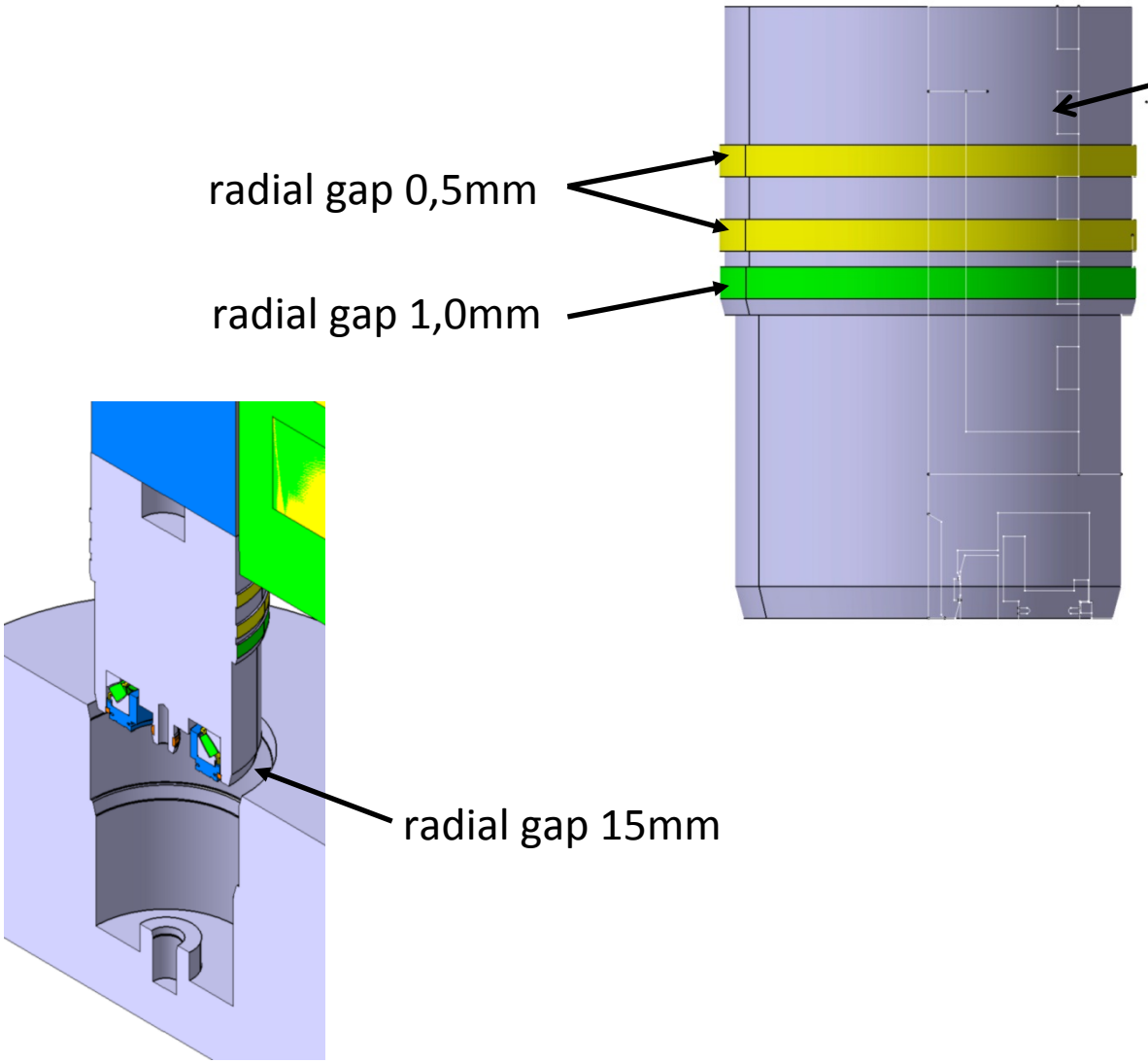


Bearing and Alignment

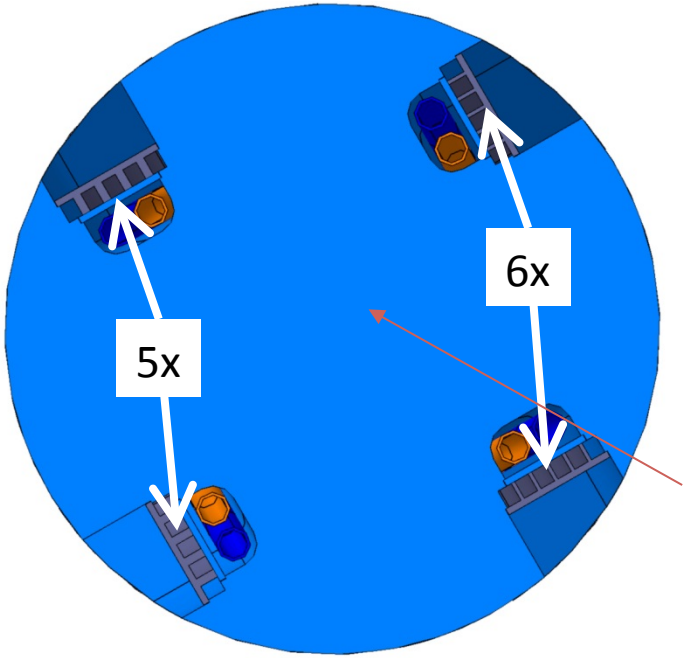




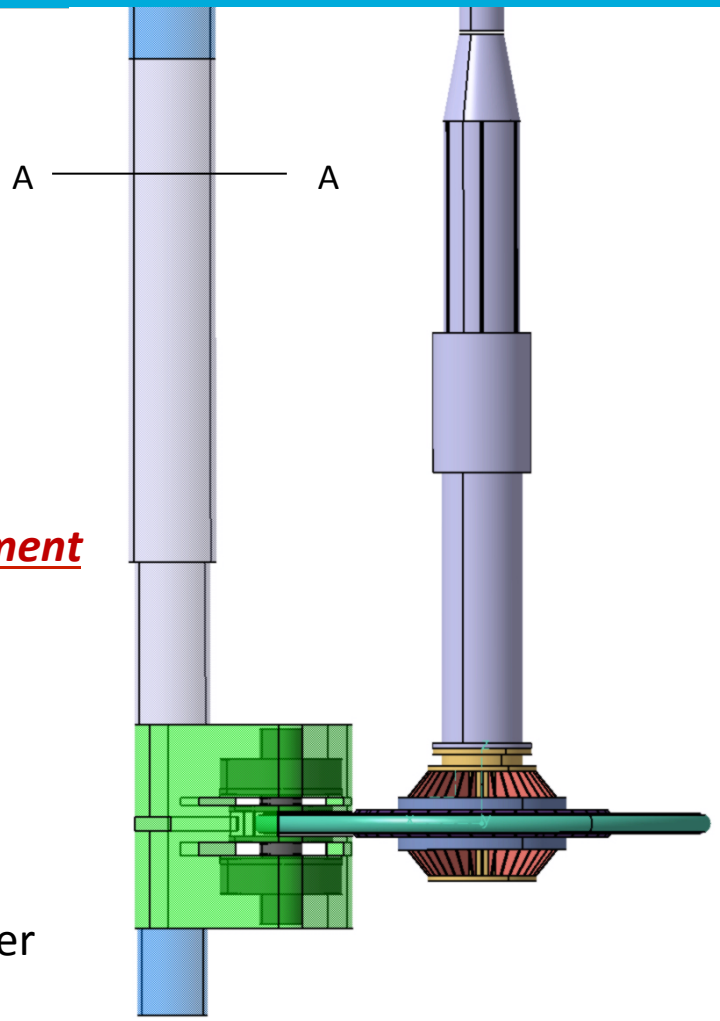
Alignment and Cooling of the foot



Pipework Cross-sections



Interface:
Water management

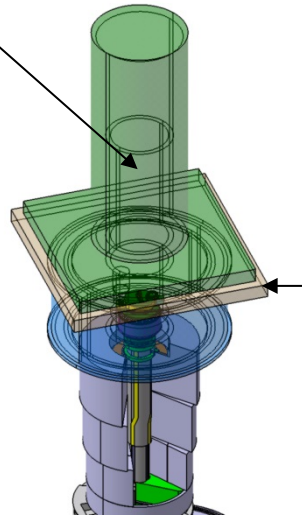


11 Independent Water loops (max!)

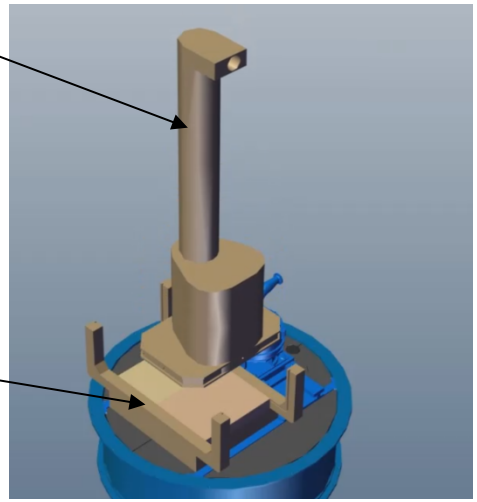
4 Waterdisc
2 BE Reflector container / 2 BE Reflector container
2 outer Reflector
1 Twister foot

Twister Rotation Unit - Concept

Twister rotation unit

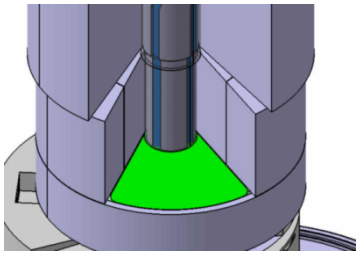


Twister Cask ESS

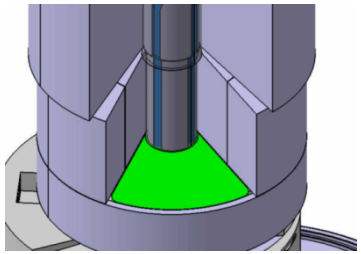


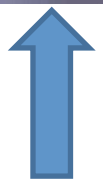
Joint docking interface

Rotation of the Twister



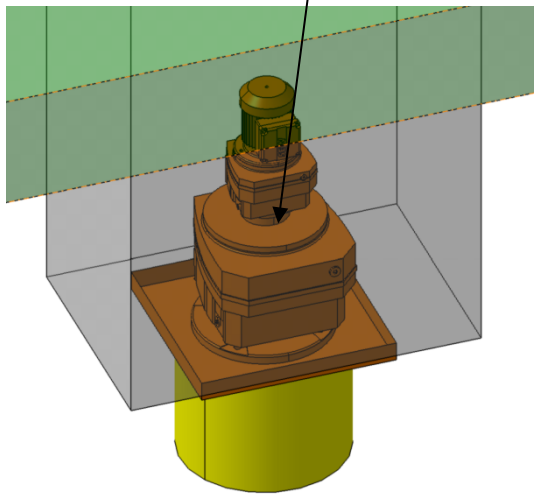
Lifting of the Twister



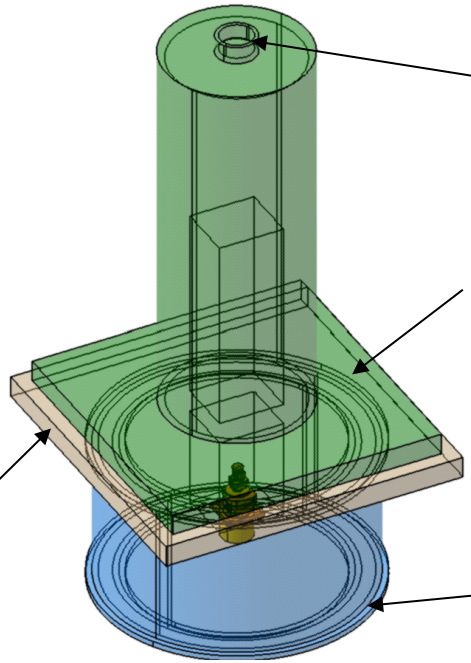


Twister Rotation Unit - interfaces

Motor and Gearbox

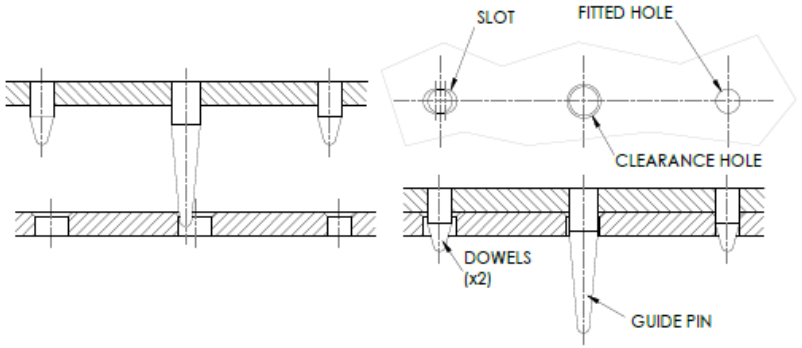


Current concept FZJ



To be defined:

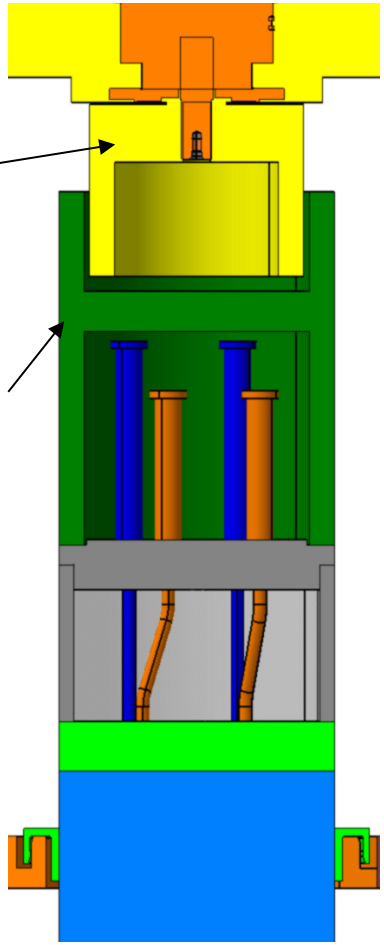
- Hight of the valve plate
- Interface alignment pins
- Lifting interface as for the twister?

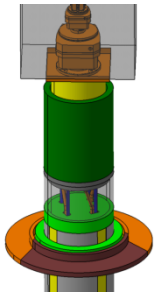


Twister Lifting adapter & drive

Lifting hook
Cardanian hook – male part

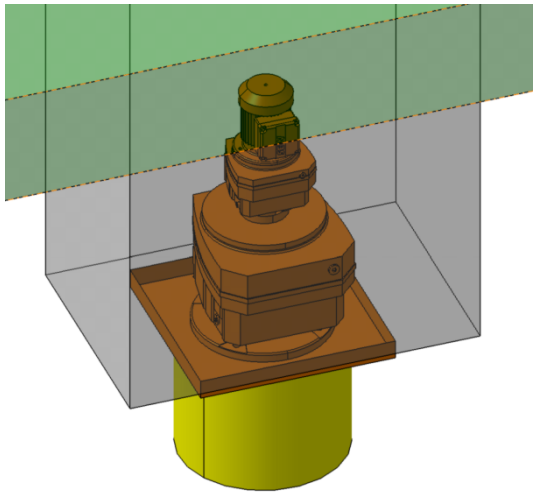
Lifting adapter
Cardanian shaft – female part



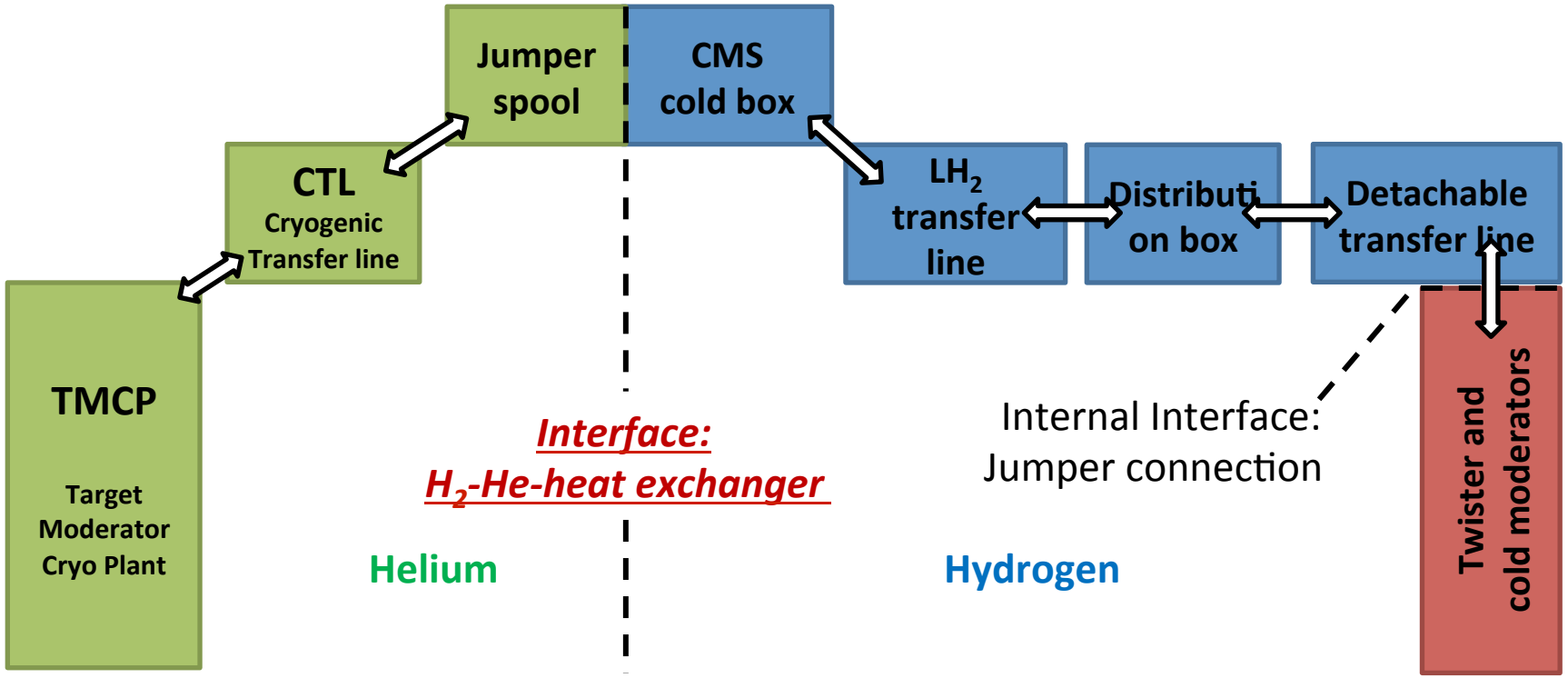


Motor Gearbox Unit - SEW

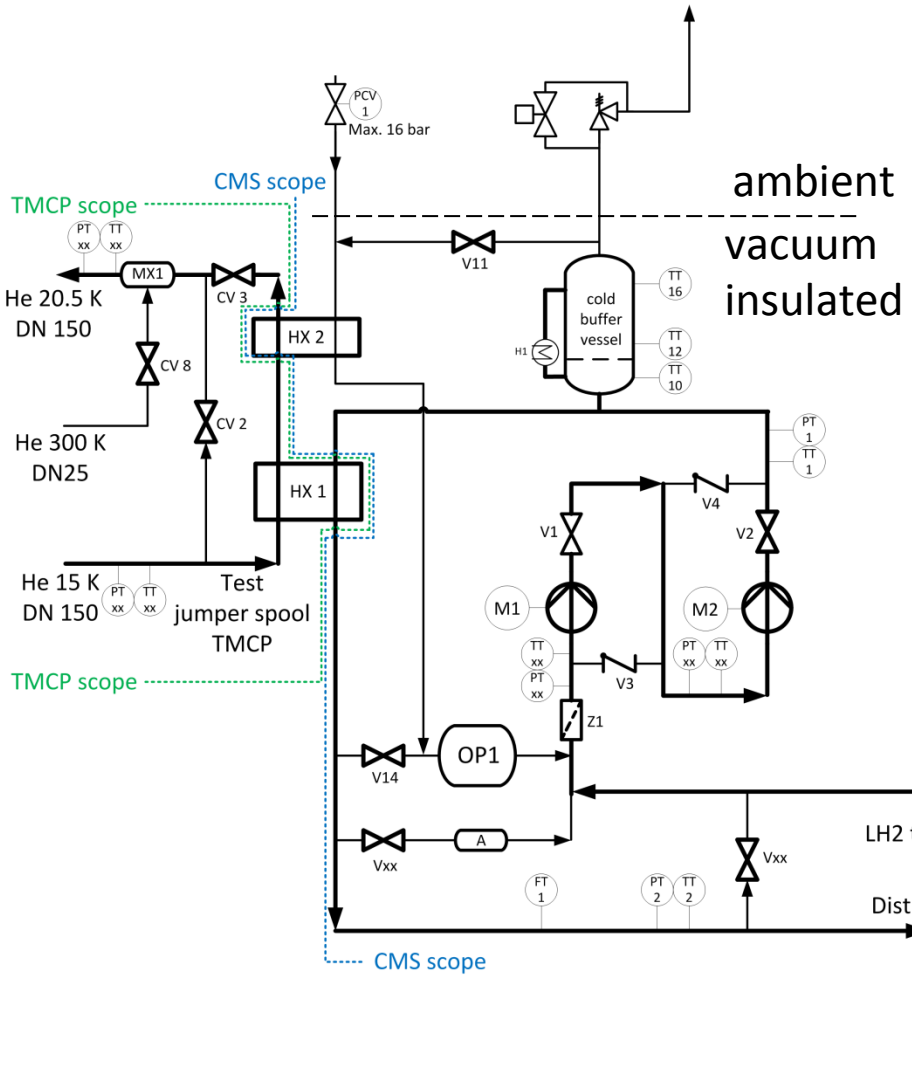
RF97R57DR63S4
M_{ab}=2080Nm
N_{ab}=0,5u/min (25s für 75°Rotation)
Need for brake resistor?



Hydrogen loop – CMS (TIK3.2)



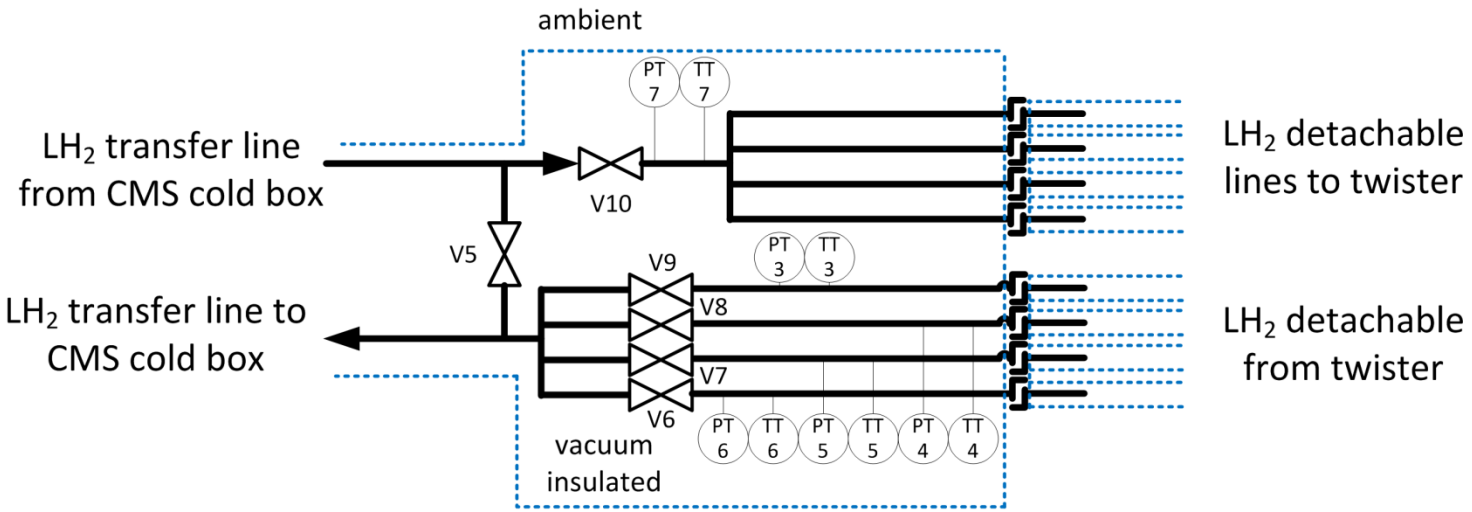
CMS – detailed flow chart



- Two LH_2 pumps in series
- Cold buffer vessel for pressure control
- Ortho-para-H_2 catalyst in bypass

CMS – Distribution box

Control, Split, unite or bypass overall flow in four streams for butterfly moderator cooling

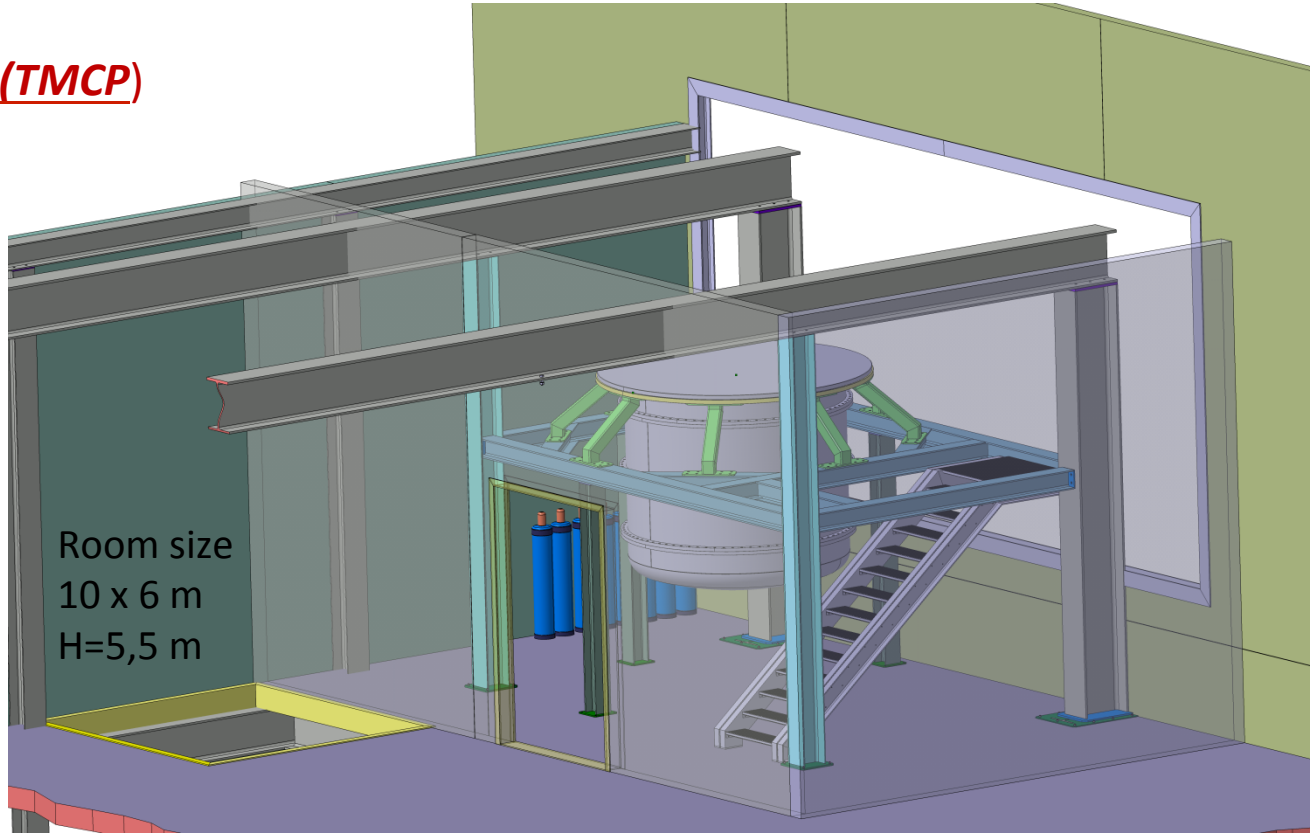


Cryostat (LH2 room design)

Interface:

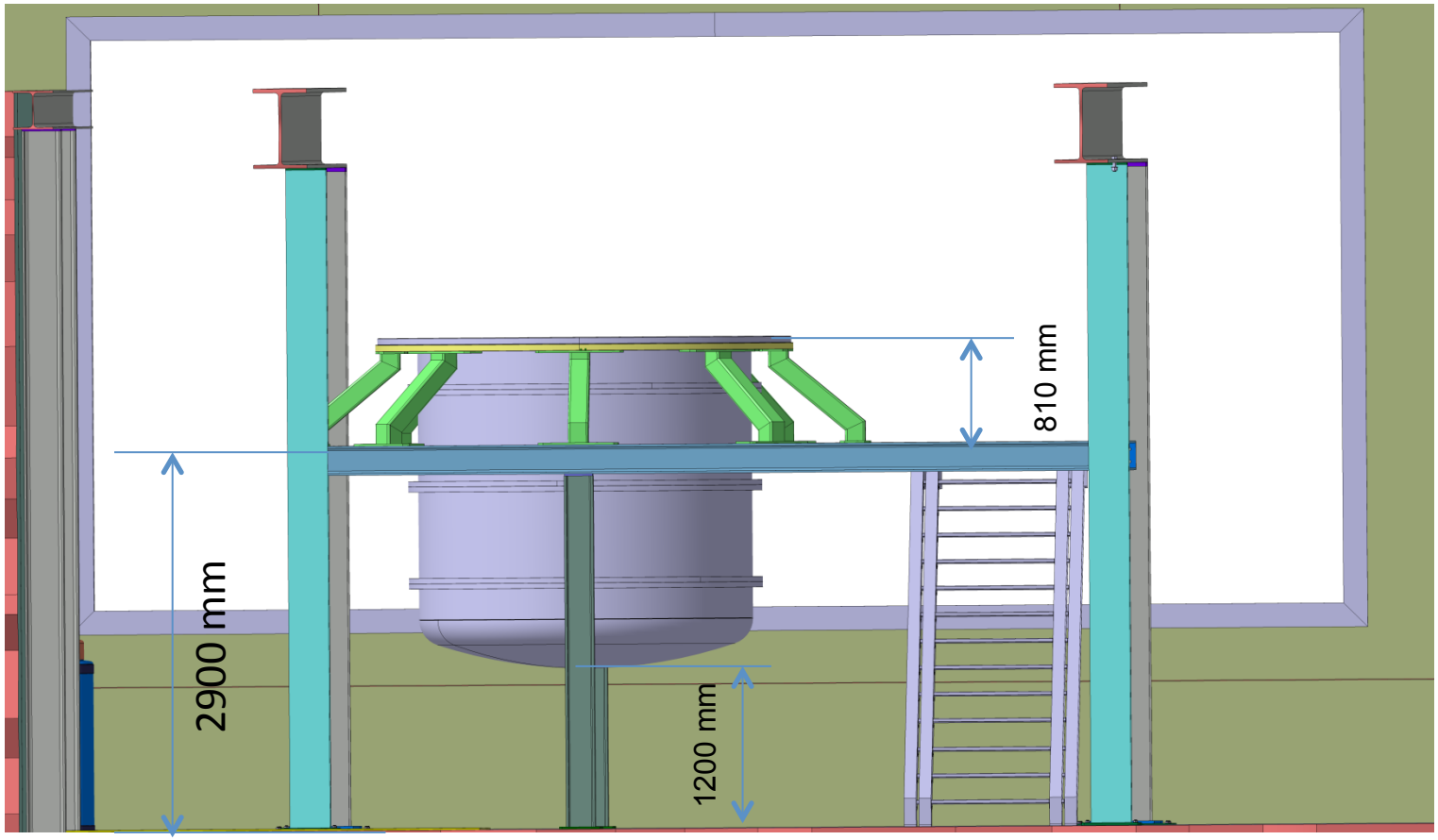
1) Building

2) Cryoplant (TMCP)

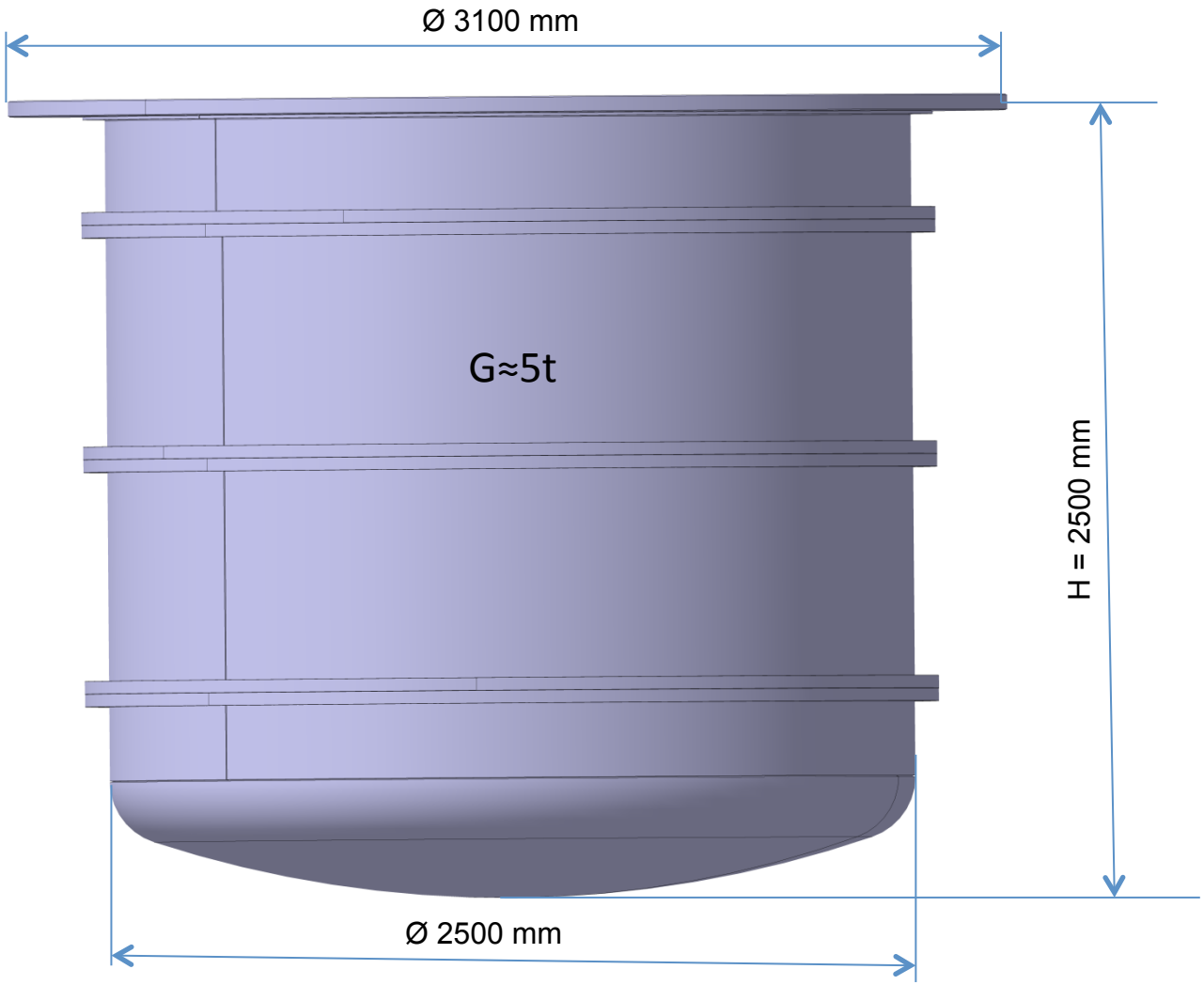


Hydrogen room structure (general view)

Cryostat (LH2 room design)



Cryostat design



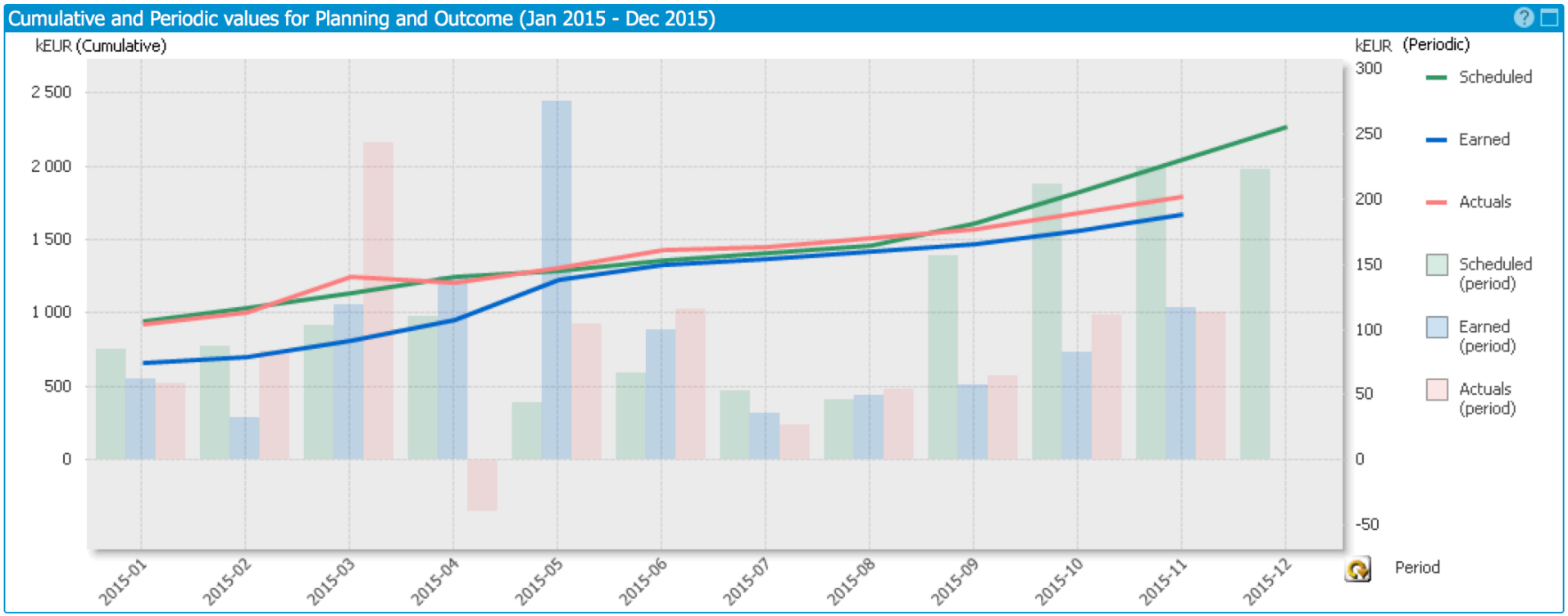
- Highlights
- **Schedule performance**
- Near-term plans
- Risks and issues
- Concluding remarks

Schedule Performance
EVM Graph

EUROPEAN SPALLATION SOURCE

Performance graphs

Show EVM performance | Performance | Outliers



Comments:

Falling slightly behind scheduled plan since last months. Since June when the in-kind partner work started up, very little of this work has been included in the reporting so a significant amount of the work has not been included in the earned/actuals.

Milestones

ID	Name	Planned Date	Current Forecast or Actual	Delay (W.Days)
A80110	Preliminary Design Moderator Reflector Plug	2015-03-26	2015-06-15	7
A38520	Preliminary Design Review of Cryogenic Moderator System (LH2)	2015-06-17	2015-06-16	0
A38670	Preliminary Design Review of Cryogenic Moderator System (LH2)	2015-10-17	2015-06-16	-12
A49360	CDR MR Handling System	2016-04-26	2016-04-26	0
A42220	CDR Cold Moderator	2016-09-28	2016-09-28	0
A42880	CDR Thermal Moderator	2016-08-24	2016-08-24	0
A43330	CDR Reflectors	2016-07-10	2016-07-10	0
A39800	CDR Cryogenic Liquid Hydrogen System	2016-12-15	2016-12-15	0
A49440	Delivery MR Handling System	2018-03-31	2018-03-31	0
A42300	Delivery Cold Moderator	2018-03-31	2018-03-31	0
A42960	Delivery Thermal Moderators	2018-03-31	2018-03-31	0
A43410	Delivery Reflectors	2018-03-31	2018-03-31	0
A39810	Delivery Cryogenic Liquid Hydrogen System	2018-06-30	2018-06-30	0

- Highlights
- Schedule performance
- **Near-term plans**
- Risks and issues
- Concluding remarks

Near Term Plans

- *Cold Moderator manufacturing, welding, burst test completed*
- *Thermal Moderator manufacturing, welding, burst test completed*
- *Ordering Be-reflector, LH2-pumps, Material with 3.2 certificate (if funding is finally releasing)*
- *First contact to Accredited inspection body*
- *Implementation of the last change requests*

- Highlights
- Schedule performance
- Near-term plans
- **Risks and issues**
- Concluding remarks

Risks and Issues

EUROPEAN SPALLATION SOURCE

- ***Funding still not in place***
- ***Interface descriptions not yet completed***
- ***Accredited inspection body not selected/contracted***
- ***Impact of late project changes***
- ***Unclear RCC-Code requirements (LH2,….)***
- ***Design risks in general***

- Highlights
- Schedule performance
- Near-term plans
- Risks and issues
- **Concluding remarks**

Concluding Remarks

- Cold and thermal Moderators close to final design (manufacturing tests will be finalized in the next period)
- General agreement for proposed concept for structural support and rotation unit
- Due to funding issues components with long lead time are on the critical way (Be-reflector, LH2-pumps,..)
- Focus on CMS in the next period