GENERAL MEETING

- Yannick Beßler, Christoph Happe, Mathias Strothmann
  Forschungszentrum Jülich GmbH

- WP5 Engineering
- 21.06.2022, Lund, Sweden

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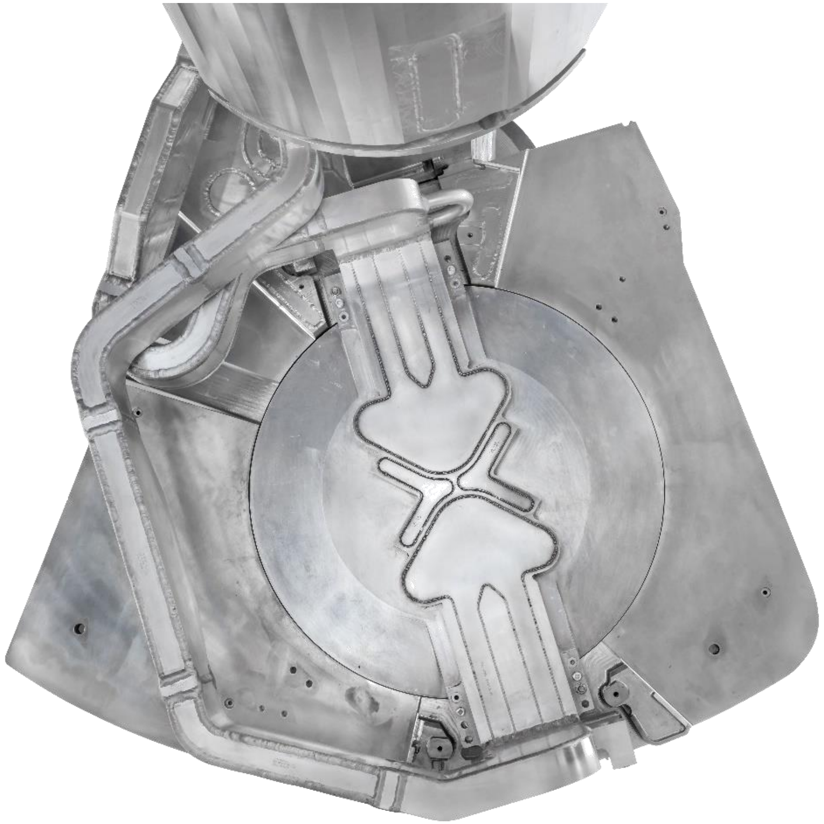

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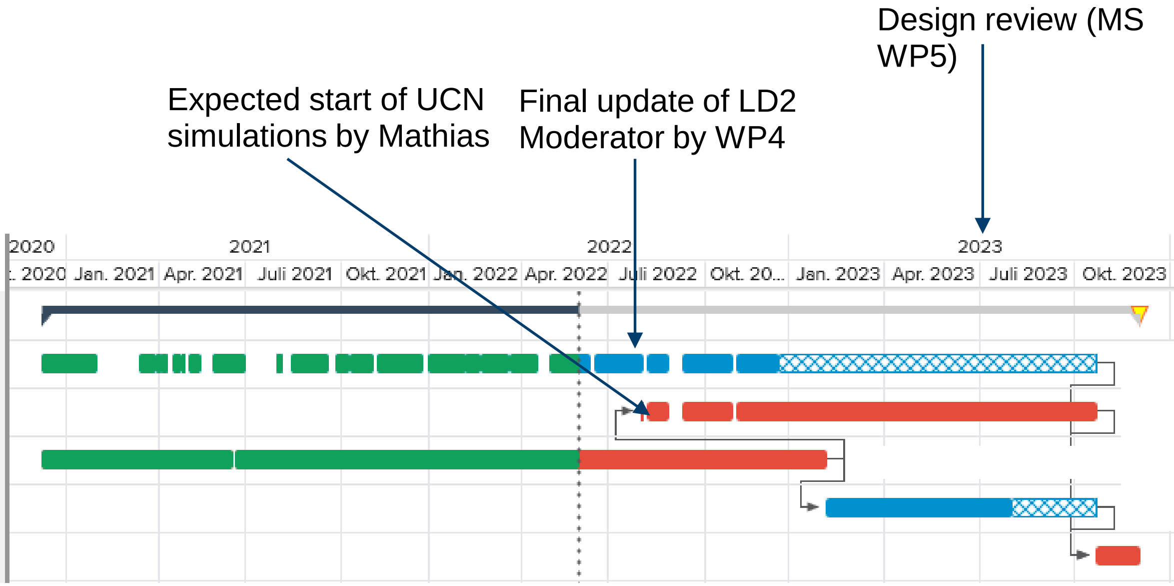
Project team and schedule update

Project team at Forschungszentrum Jülich:

- Work package leader: Yannick Beßler
- Engineering Design: Christoph Happe
- PhD student Mathias Strothmann
- Experiments: Eberhard Rosenthal

Project schedule:

Name	Dauer	Anfang	Ende
290_HighNESS	747,00t	01.12.20	30.11.23
Task 5.1. Detail design of D2 Moderator	18,00m	01.12.20	15.12.22
Task 5.2. Draft design of UCN & beam extraction system	14,00m	03.08.22	20.10.23
Task 5.3: Flow and structural mechanic simulation and development of the cooling concepts	20,00m	01.12.20	06.02.23
Task 5.4: Prototype of the moderator and advanced beam extraction system	6,00m	07.02.23	01.08.23
Final Report	1,38m	23.10.23	30.11.23



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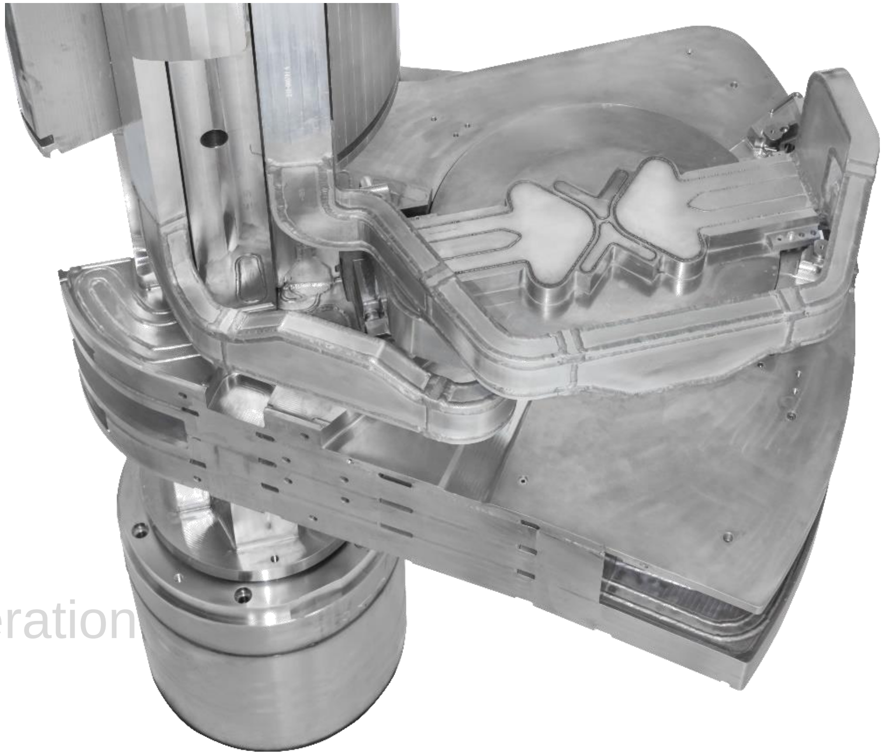

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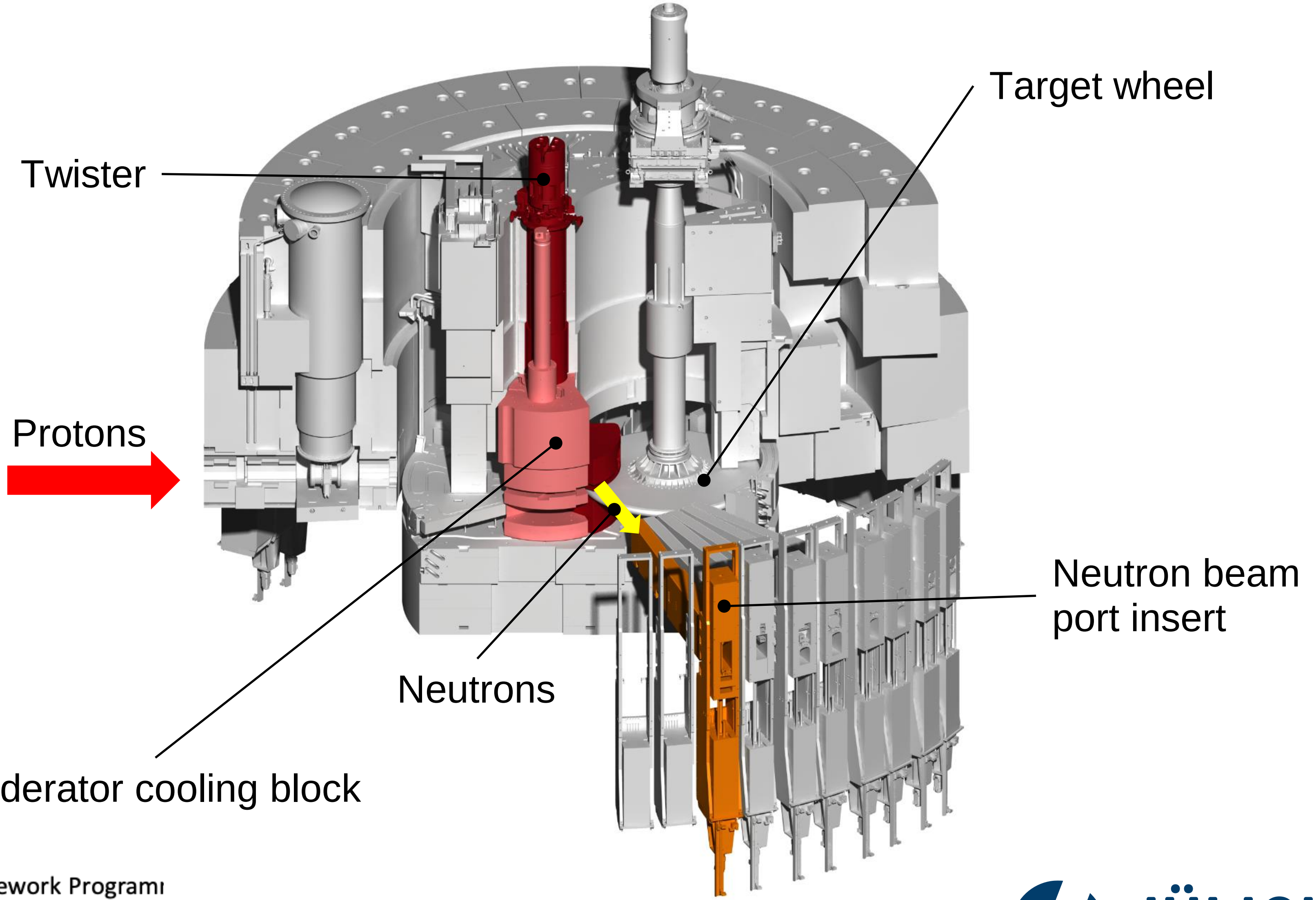
General overview

ESS Target Monolith

- dark red: location for deuterium moderator (Twister)
- light red: possible location for ultra-cold source (moderator cooling block)
- orange: possible location for nano diamond neutron beam extraction system (neutron beam port inserts)



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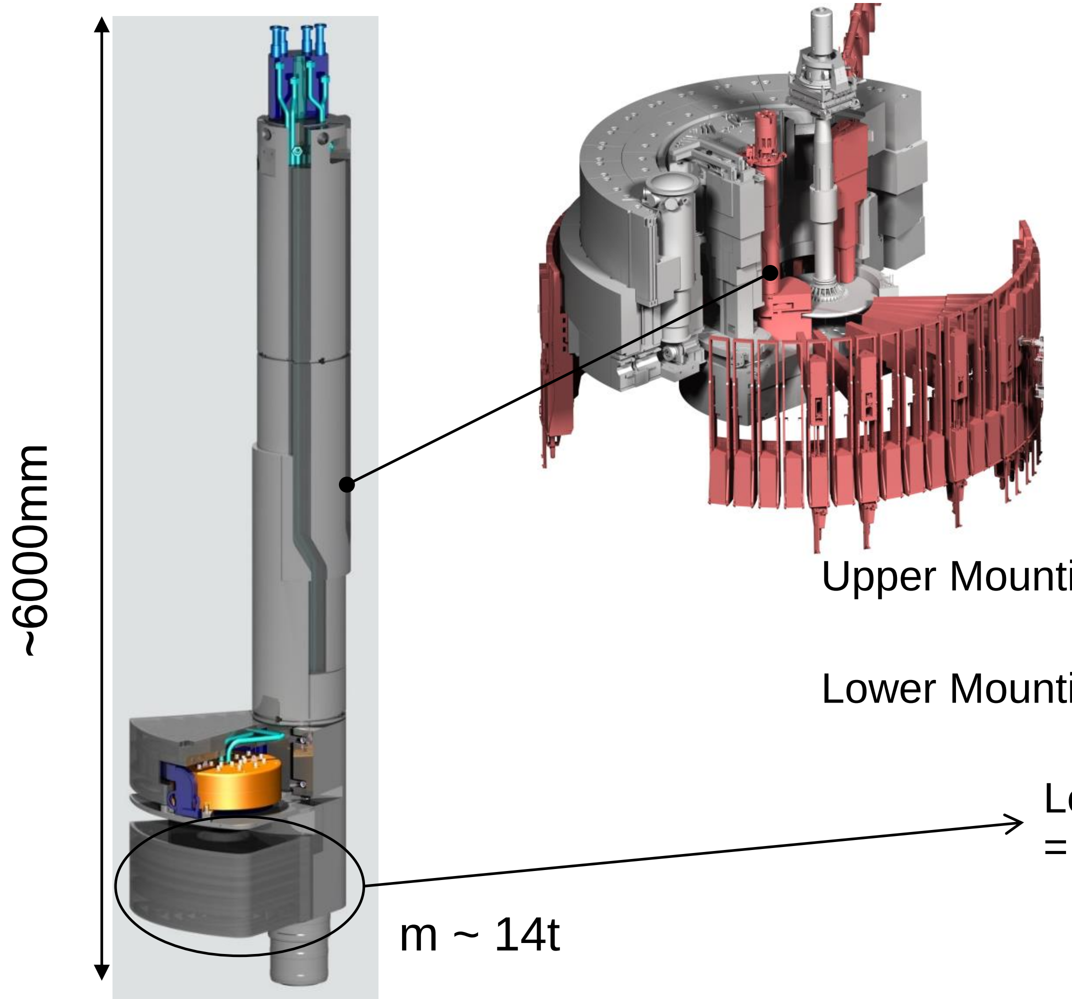
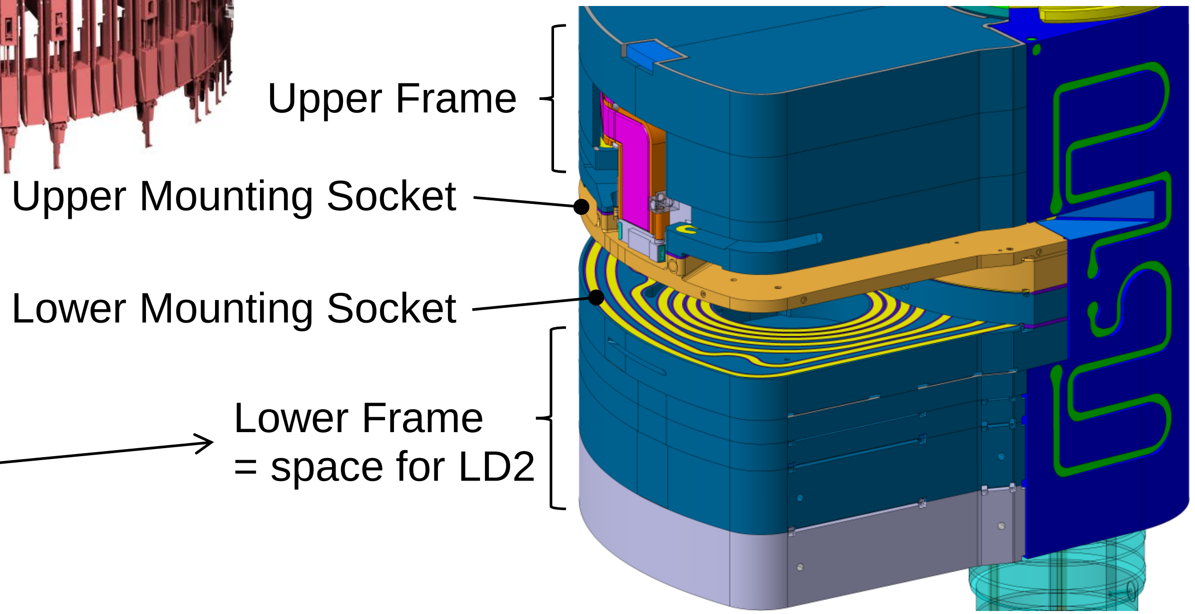
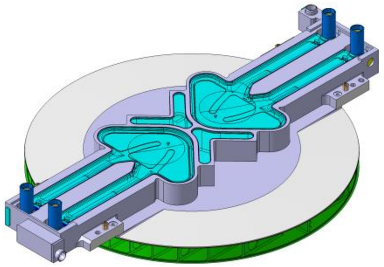
General overview



Twister upper mounting socket and frame above the target contain:

- Thermal moderator
- Be-Reflector
- Supply with cooling water and LH_2 through the shaft





Upper
th./cold Moderator

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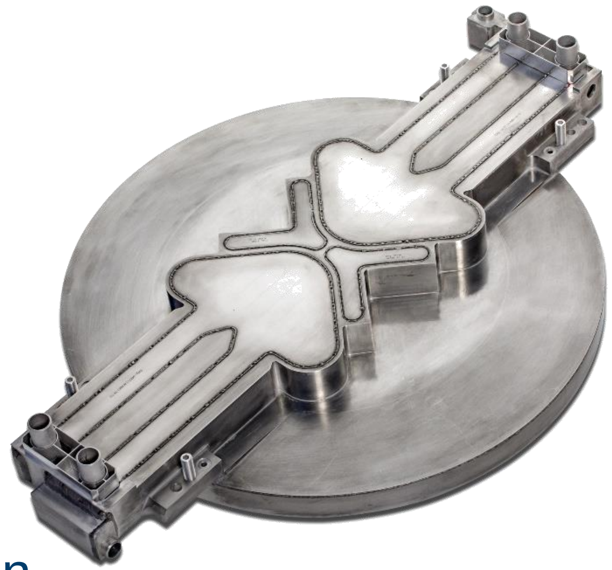

1. Project team and schedule
2. General overview
3. Technical design solution of current twister generation
4. Draft design of the oLD2-Moderator
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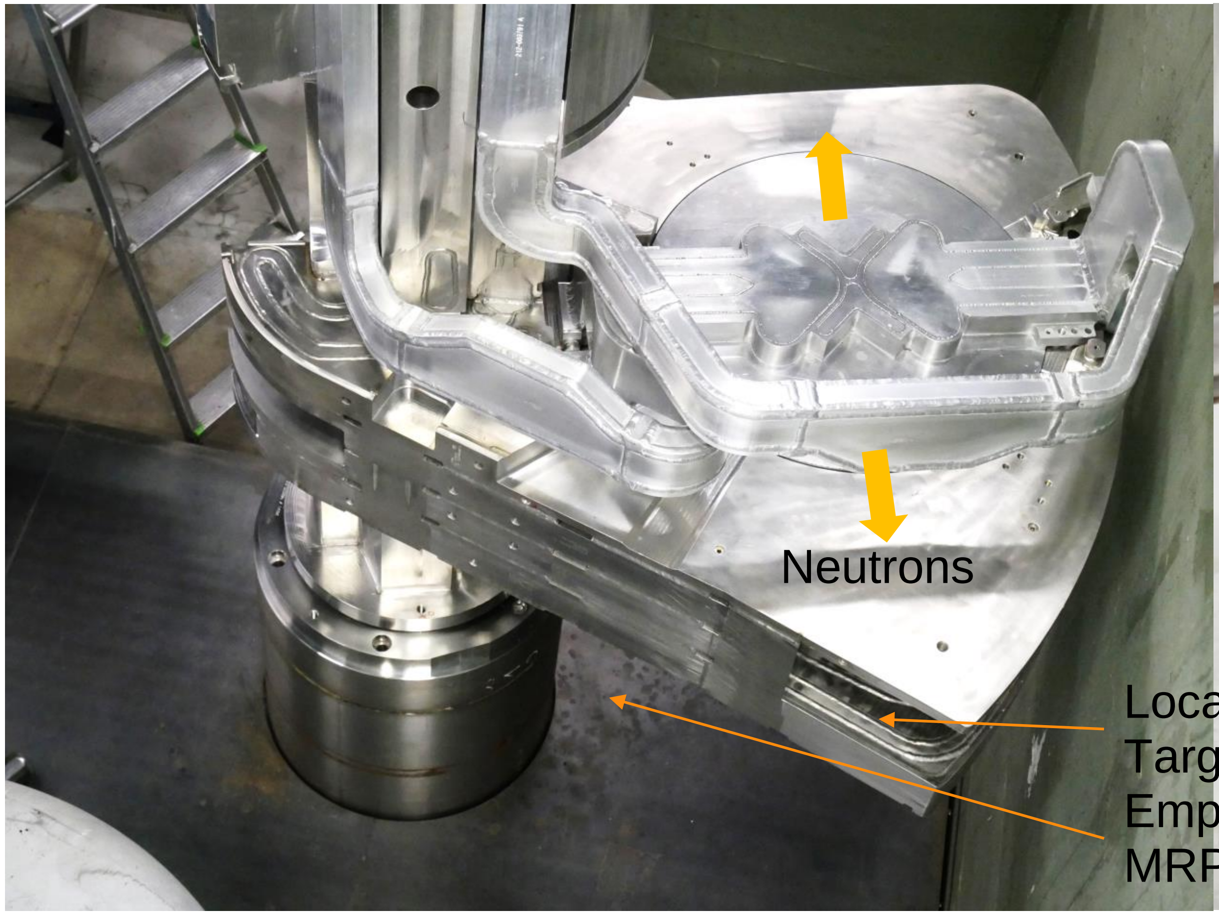
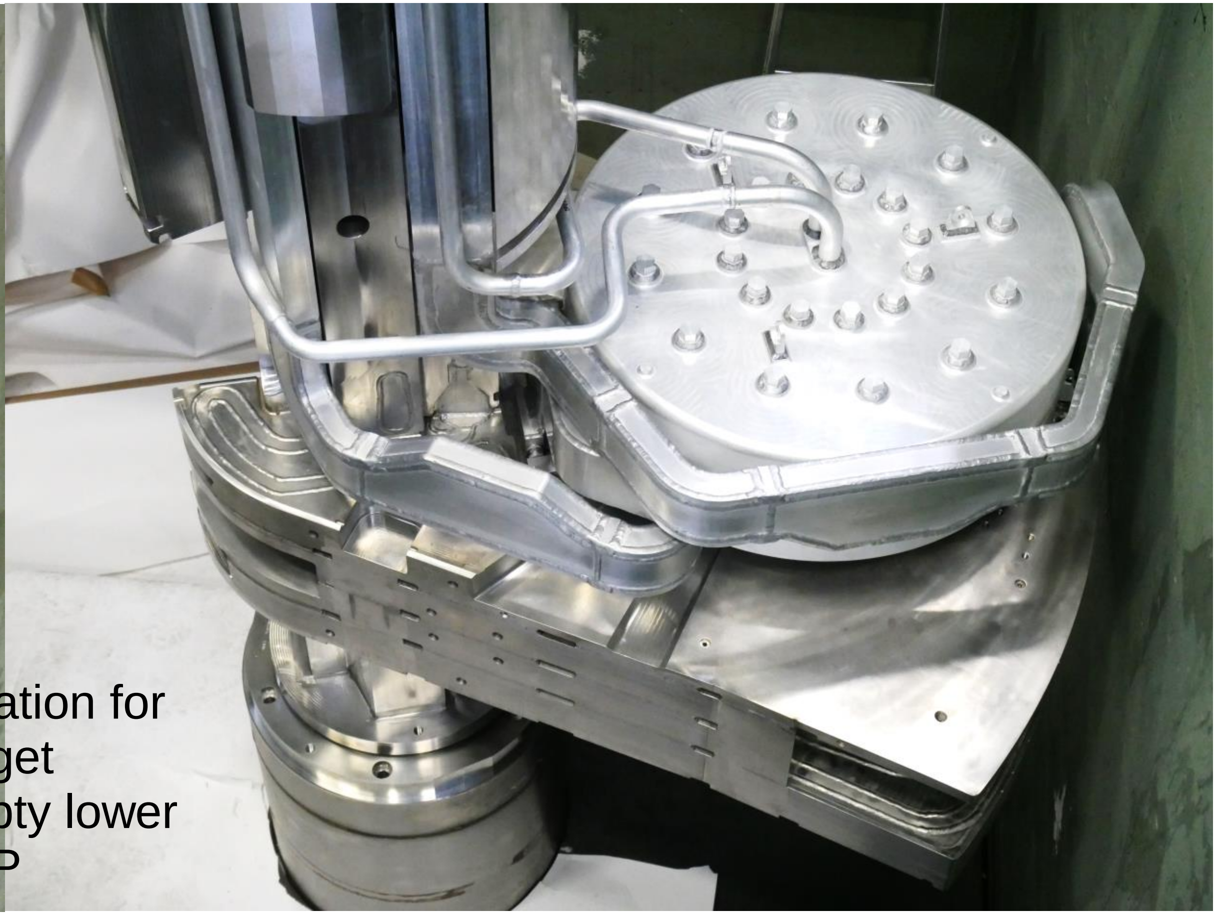
Technical design solution of current twister generation



Upper Moderators



Upper Moderators & Beryllium reflector

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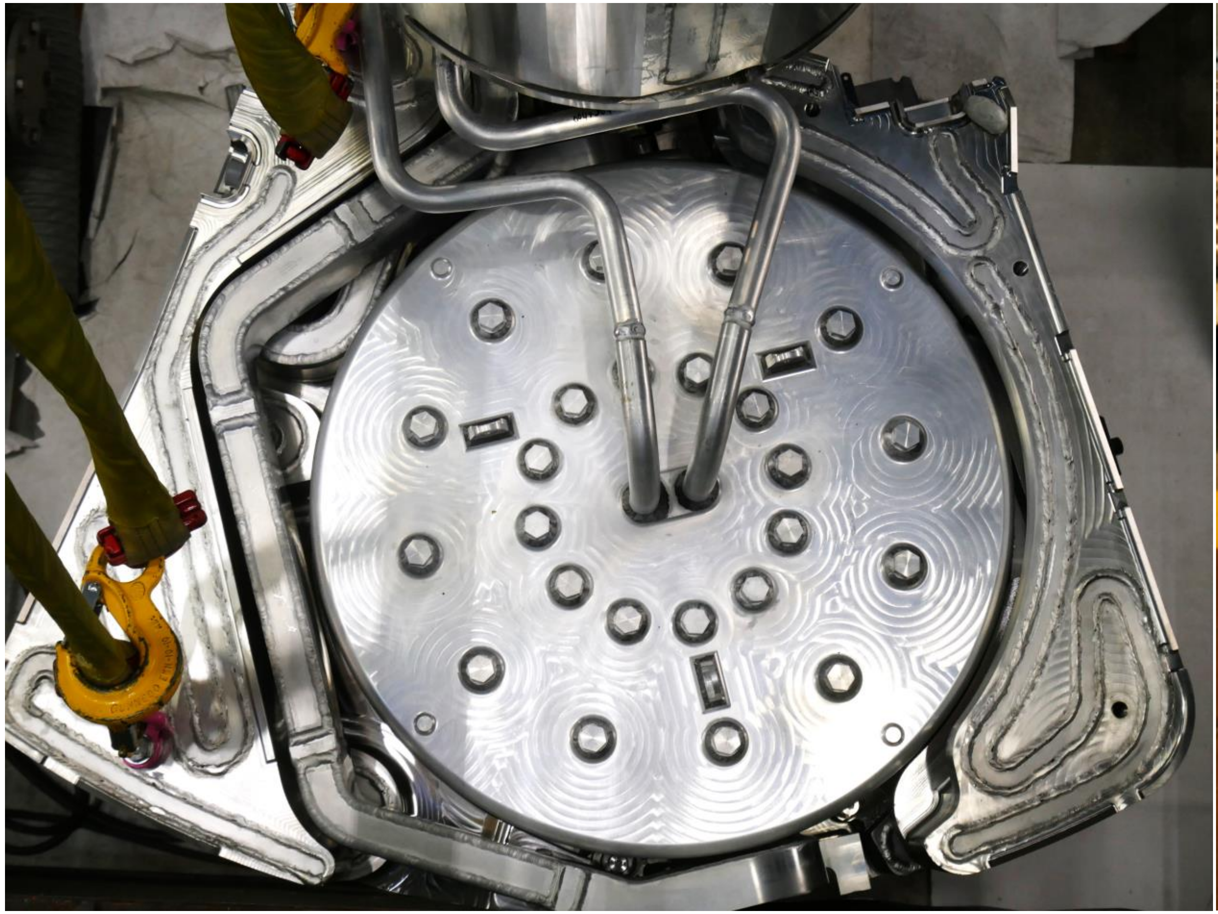
Technical design solution of current twister generation



Top view upper Moderator & Reflector Plug

Lower Moderator Plug replacement

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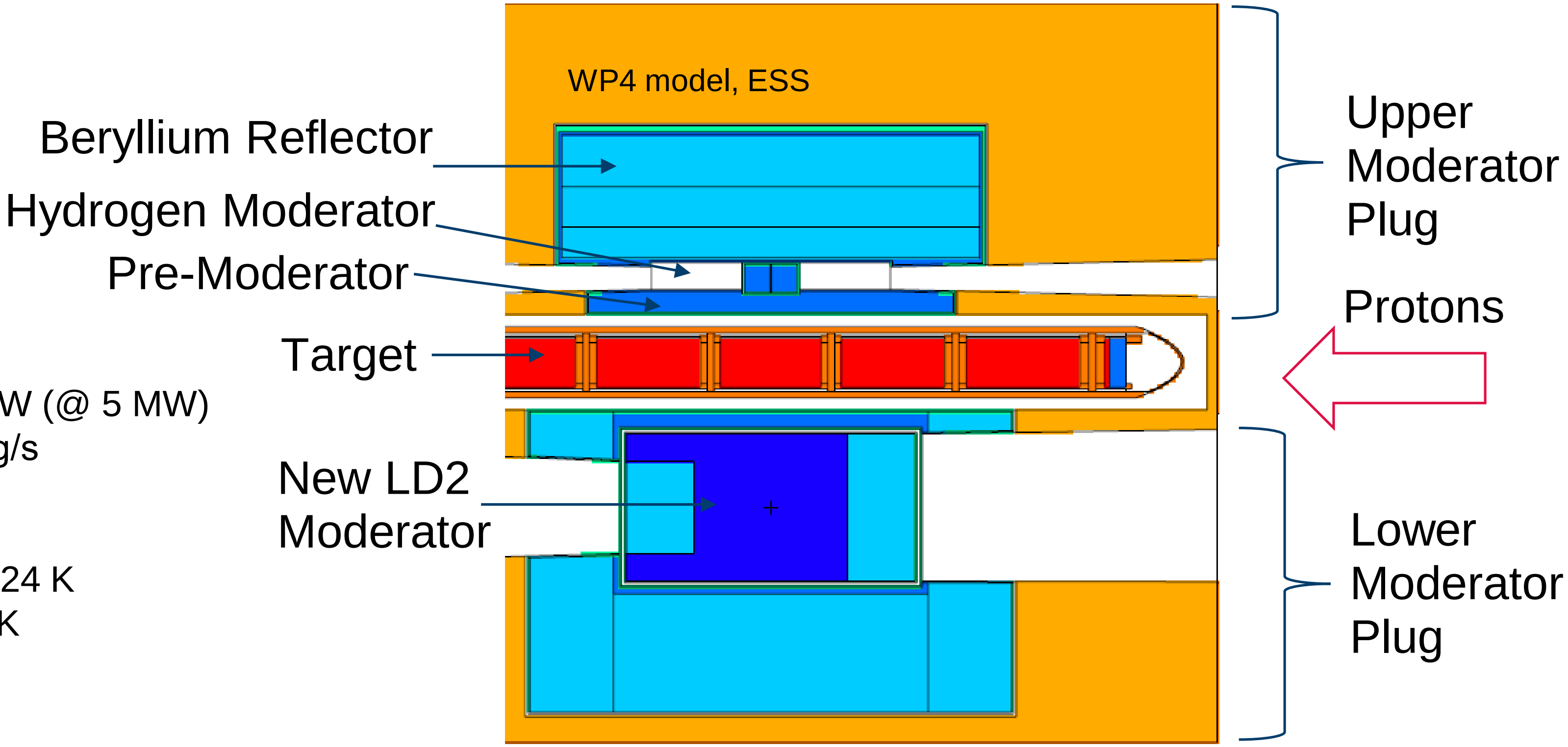
Draft design of the ortho-Deuterium Moderator – neutronic model

- First model

- ca. 34L liquid ortho-Deuterium
- Pre-Moderator 25 mm H_2O
- Be reflector, water cooled

- Heat load into oLD2-moderator: Q = 56.6 kW (@ 5 MW)
- Mass flow of liquid deuterium: $\dot{m} \geq 3400$ g/s
- Average temperature increase: $dT \leq 3$ K
- Static liquid pressure: p = 5 bar
- Moderator inlet/outlet temperature: $T_{in/out} = 21/24$ K
- Average moderator temperature: $T_{av} = 22.5$ K
- Flow velocity: $w \leq 5$m/s
- Pipe diameter inlet/outlet: d = 70 mm



− orange: steel (twister frame, inner shielding, etc),
− dark blue: liquid ortho-deuterium,
− blue: light water,
− light blue: beryllium,
− green: aluminum.

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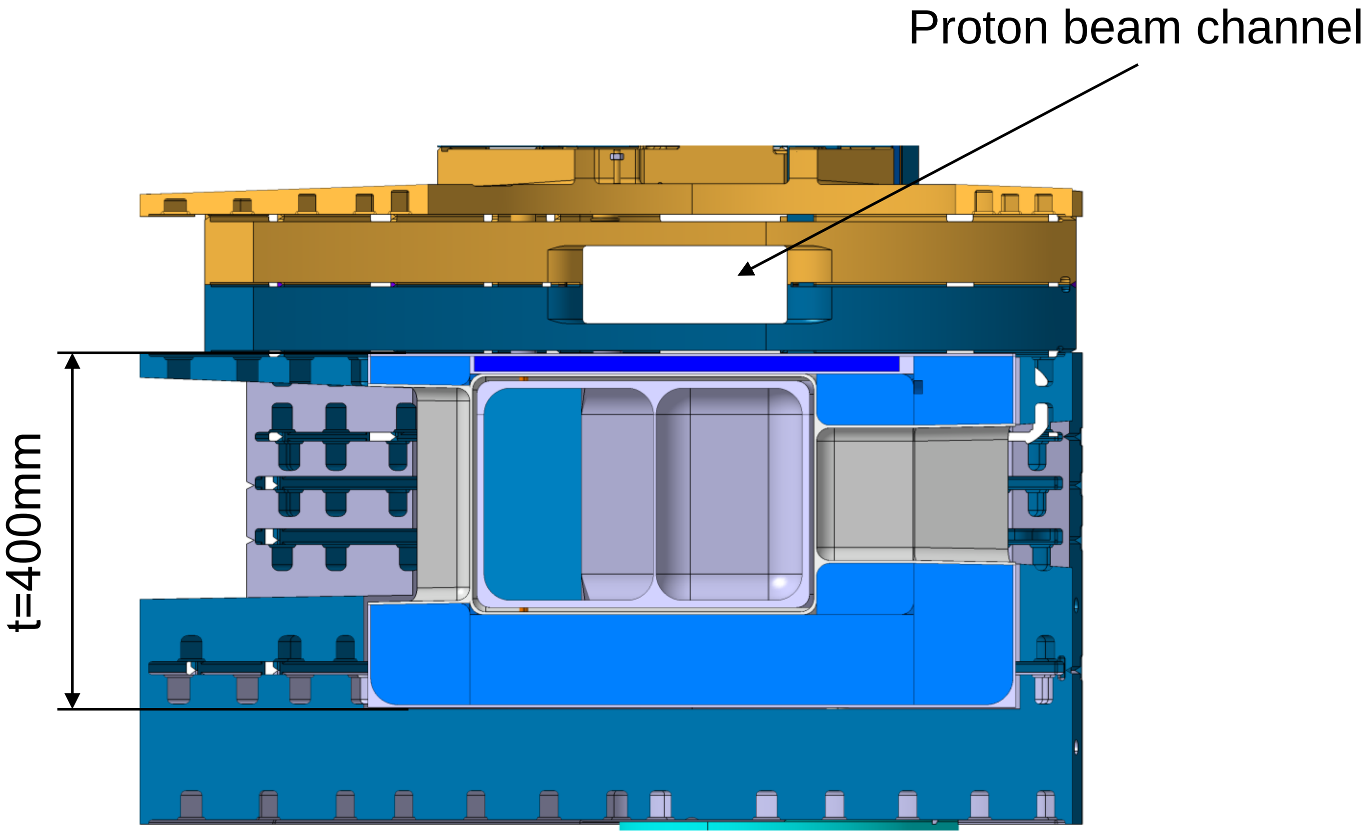
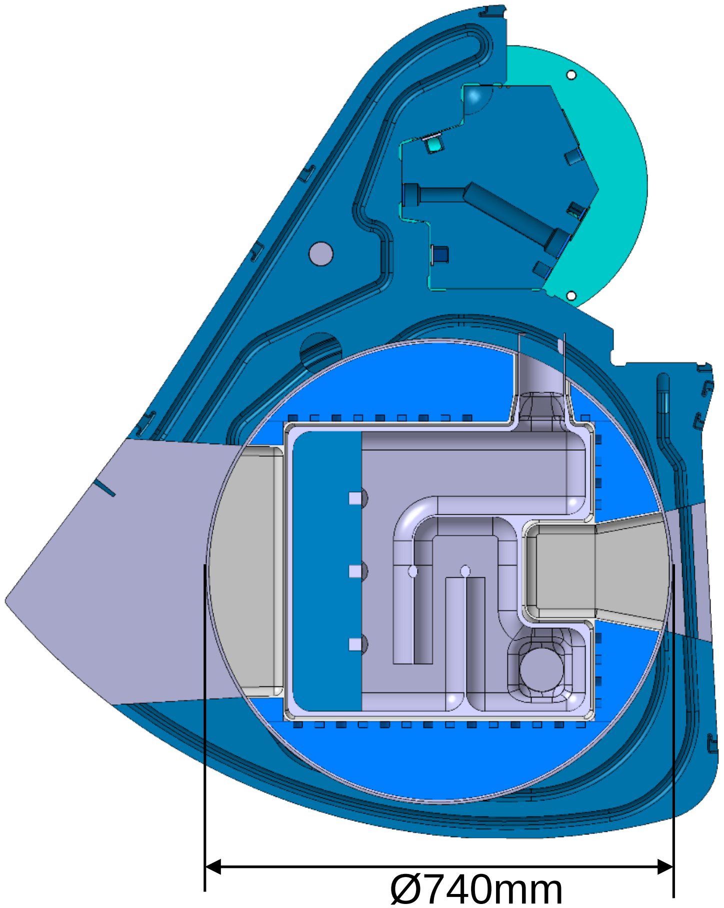
Draft design of the ortho-Deuterium Moderator - Dimensions





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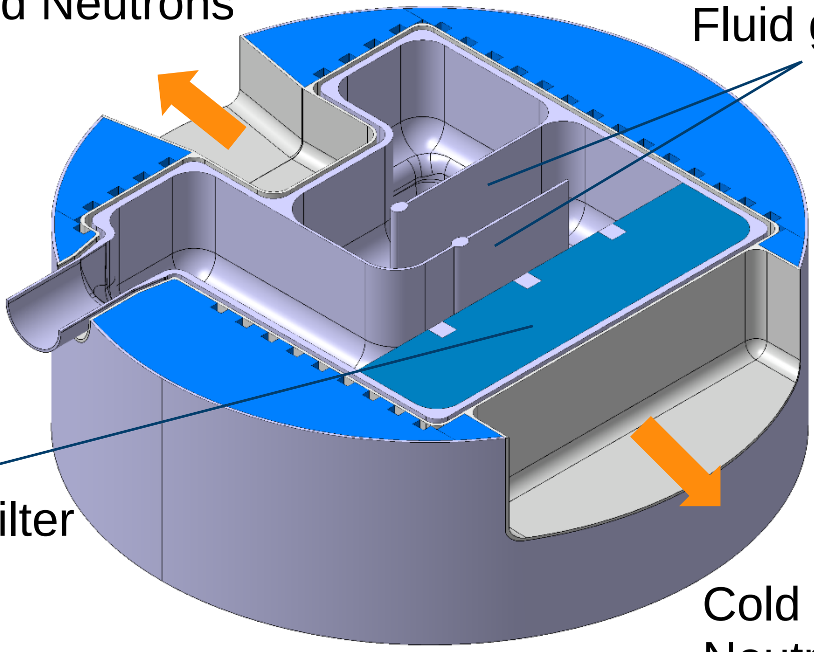
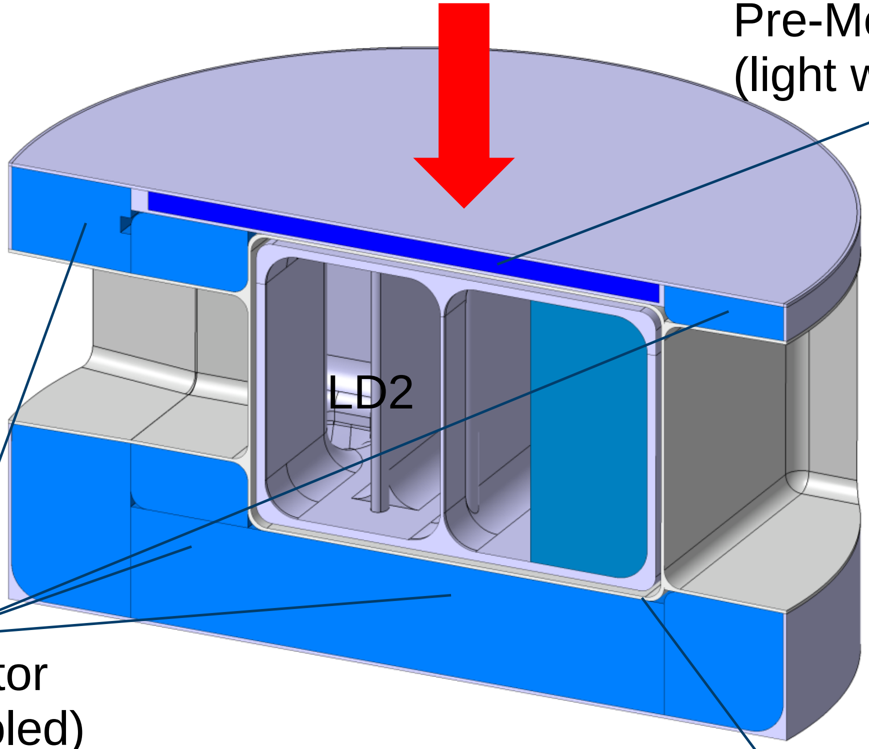
Draft design of the ortho-Deuterium Moderator - Structure





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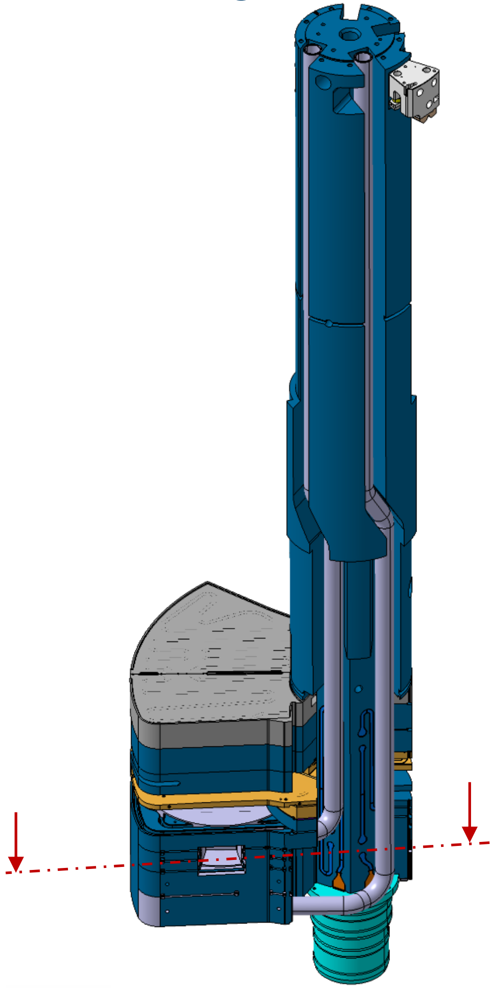
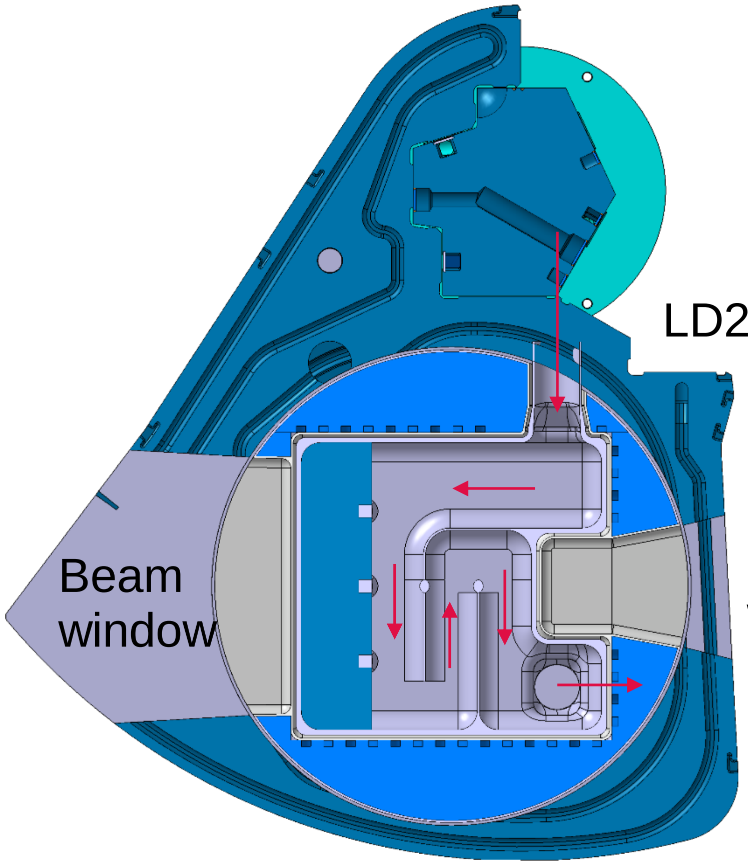
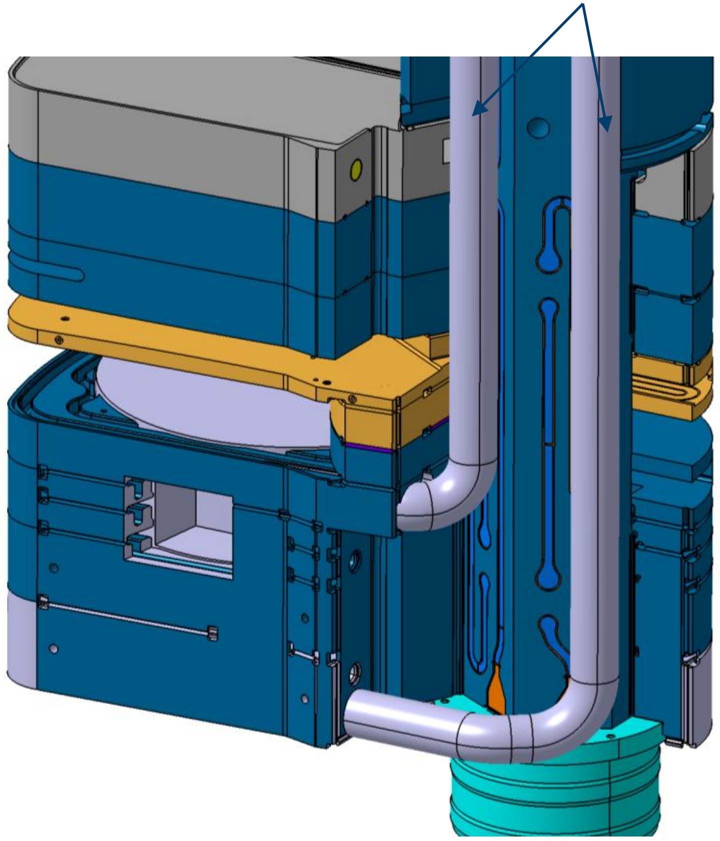
Draft design of the ortho-Deuterium Moderator - Twister Integration







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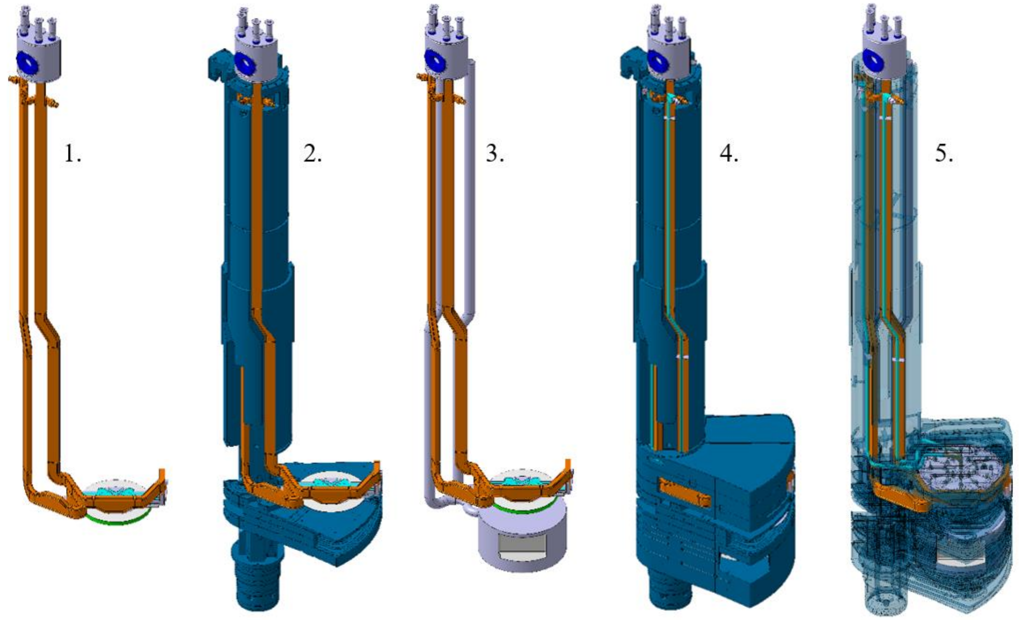
Draft design of the ortho-Deuterium Moderator - integration into the lower moderator plug of the Twister

1. upper moderator plug only
2. upper moderator plug installed in the moderator support structure
3. full moderator plug with oLD2 moderator
4. full moderator plug installed in the in the moderator support structure
5. full moderator plug installed in the in the moderator support structure



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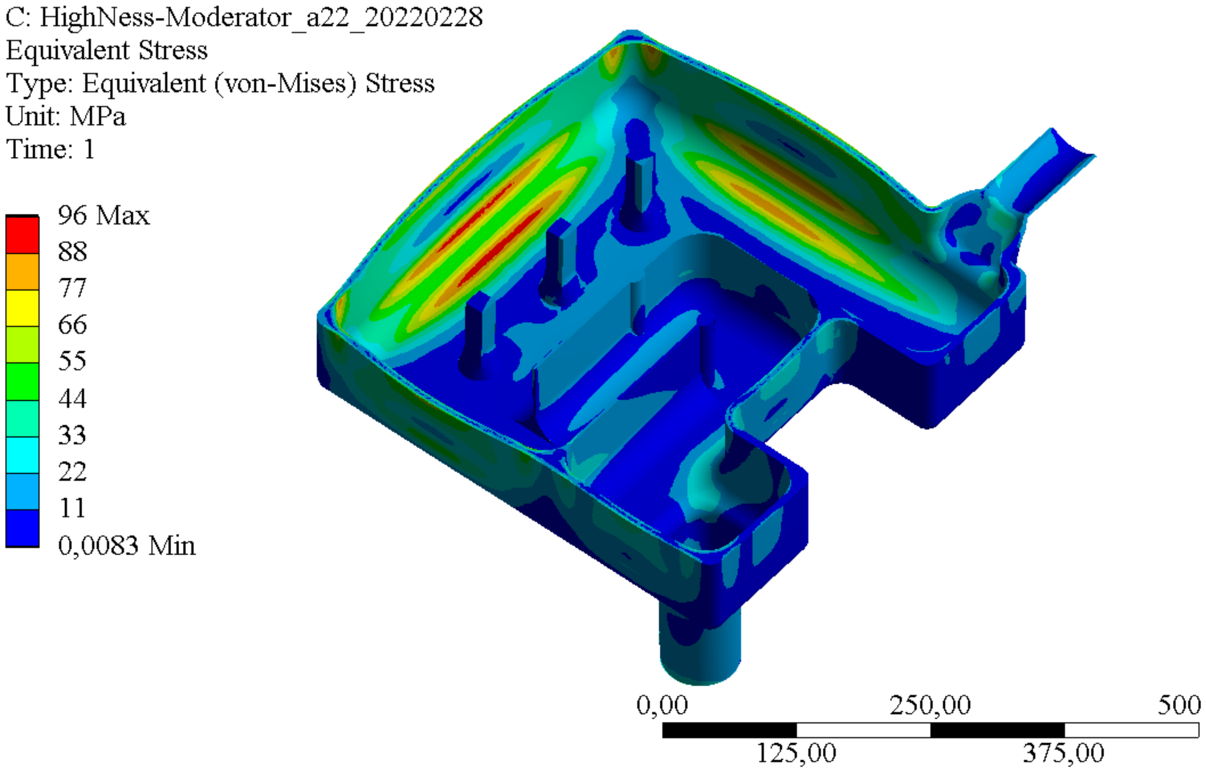
First structural mechanics simulation results

- The mechanical stresses are already well below $\sigma_m \leq 87$ MPa at the most areas and that the stress limit is only very locally exceeded
- Further optimizations will follow with the final design
- However, it can be assumed already that the structural-mechanical requirements will be met based on the preliminary analyses
- The flow simulation is currently being prepared in order to finally validate the engineering feasibility of such a moderator



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UCN

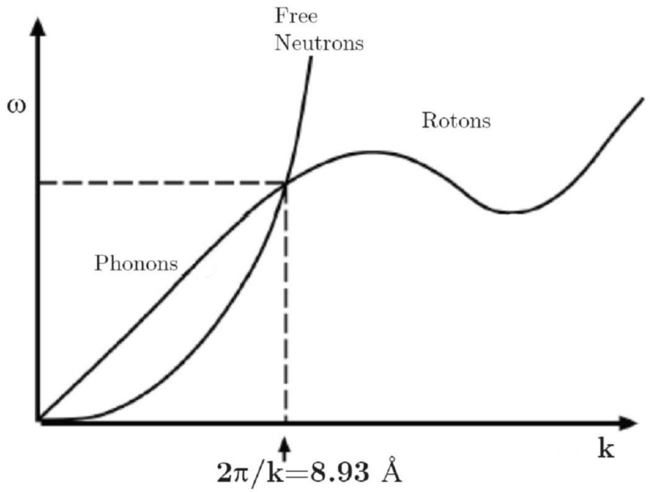
^{4}He-II as UCN Converter Medium

- Phase transistion from liquid ^{4}He in superfluid phase (He-II) at **2,17K**
- Plainly simple temperature reduction of l^{4}He bath by pressure reduction:

Bath temperature:	4,2 K	→	1,6 K
Pressure:	1000 mbar	→	7,6 mbar
Bath filling	100 %	→	58 %

Superthermal process:

- High energy transfer for **~8,9 Å** neutrons to He-II (in just one interaction directly to UCN)
   Premoderation should be optimised for high 8,9 Å gain
- Energy transfer to a „thermal reservoir“ in He-II (system not in thermal equilibrium)
   Effective UCN temperature can be lower then He-II temperature
- Upscattering Process is suppresed
- He-II has the highest known thermal conductivity
   Heat is directly transfered to surounding surface



[2]

- He-II is a good choice for an UCN converter
- Experimental investigation regarding the He-II phase stability is planned

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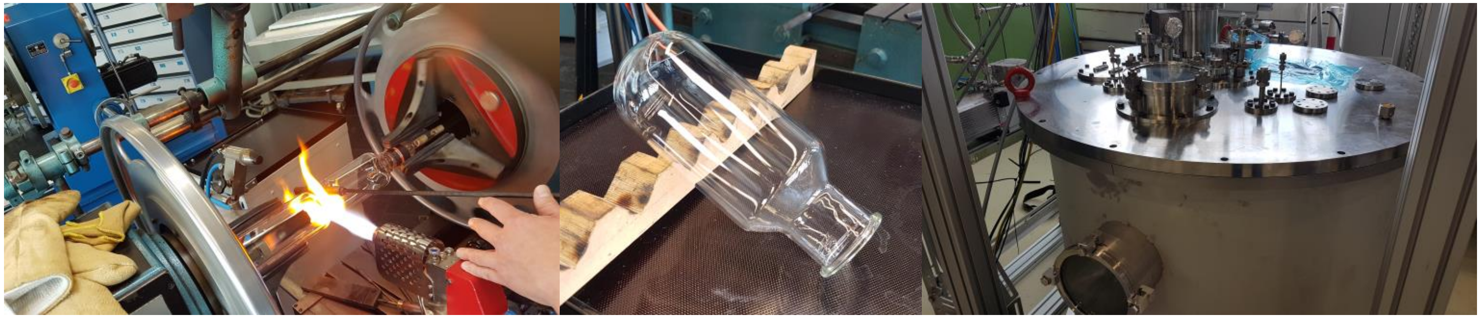
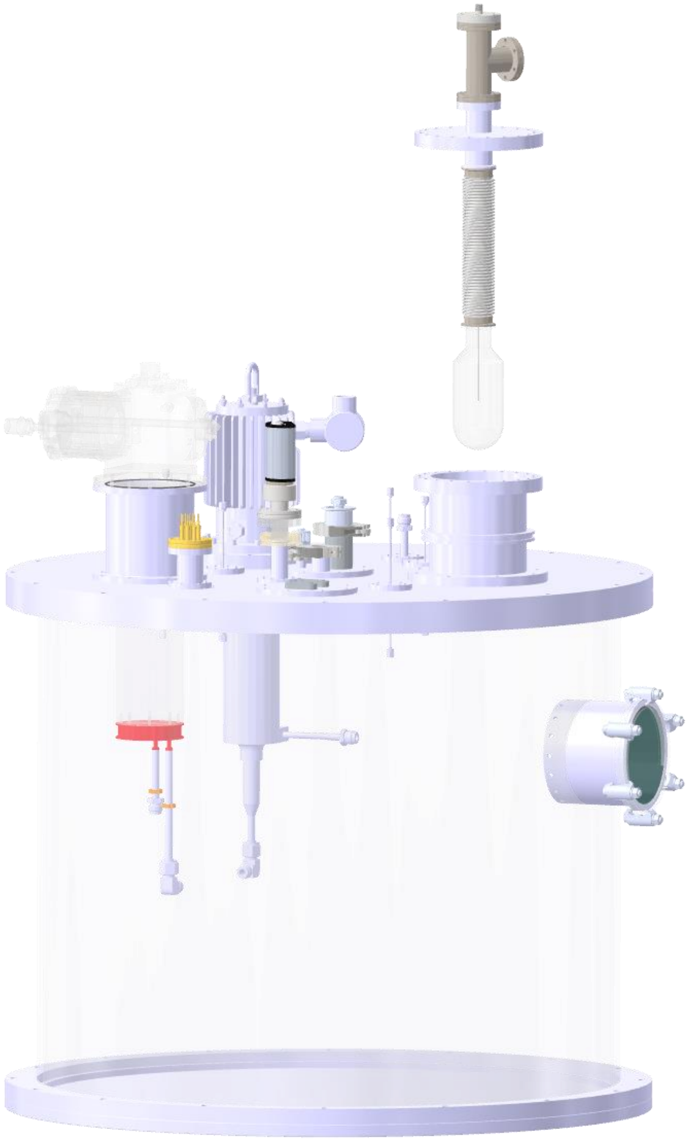
[2] J. Yoder - Measurement of wall relaxation times of polarised ^{3}He in bulk: Liquid ^{4}He for the neutron electric dipole moment experiment. Diss. University of Ilinois, 2010

UCN

Experimental investigation of He-II properties

- Glass-cryostate for visual investigation of the ^{4}He-I to ^{4}He-II phase-change
- Filling of glass vessel by connection to Helium dewar
- Cooling of ^{4}He bath from 4,2K to 1,6K by pressure reduction with vacuum pump to induce phase-change
- Investigating phase stability by applying heat load into the center of the bath





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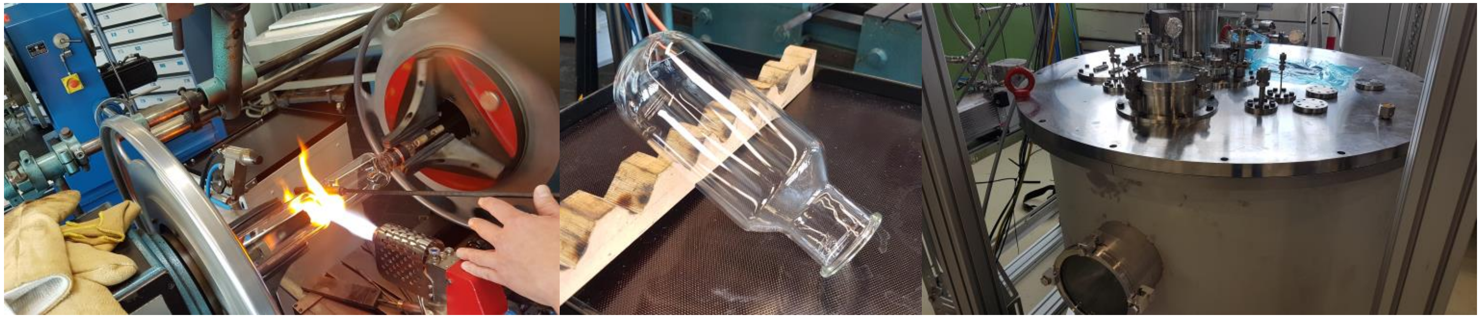

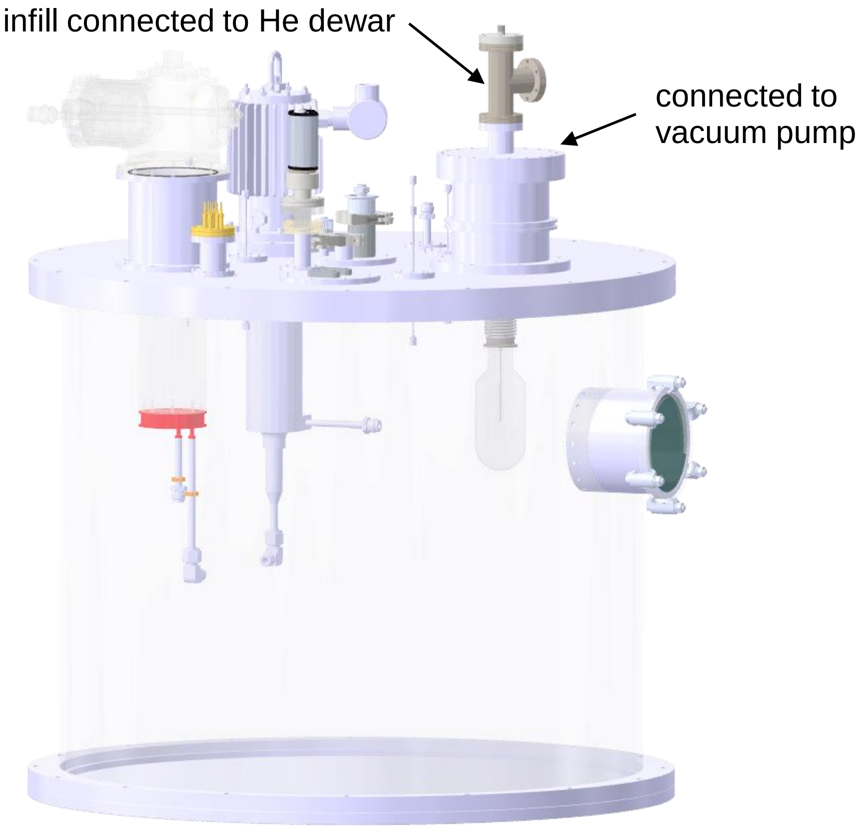

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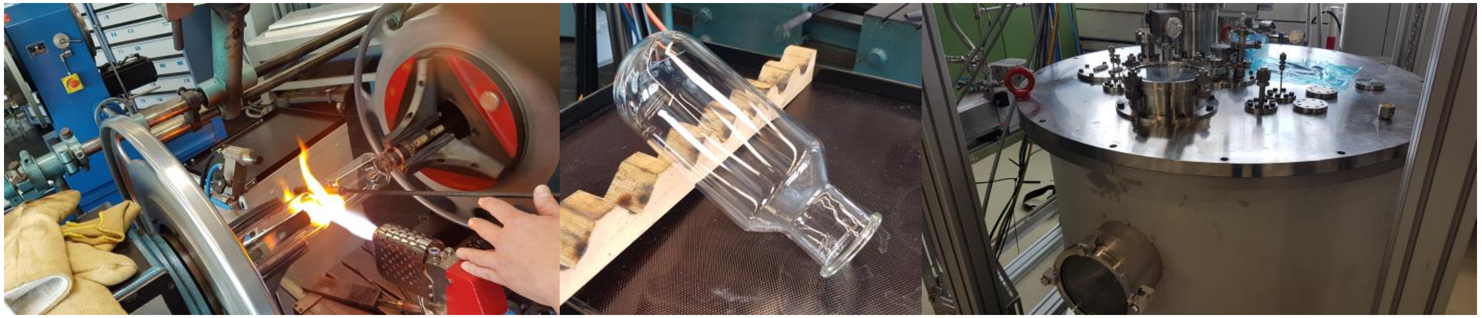

Bath temperature:	4,2 K
Pressure:	1000 mbar
Bath filling	100 %

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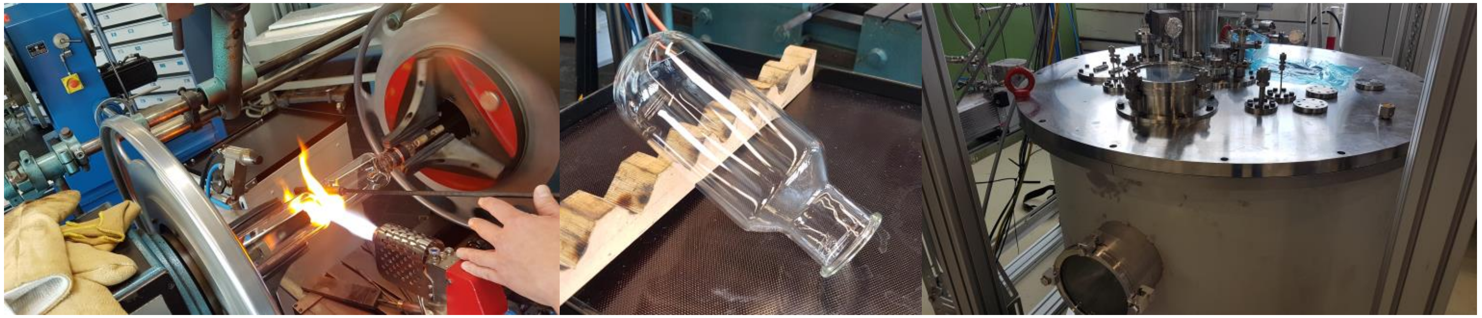

Bath temperature:	1,6 K	
Pressure:	7,6 mbar	Phase II
Bath filling	58 %	

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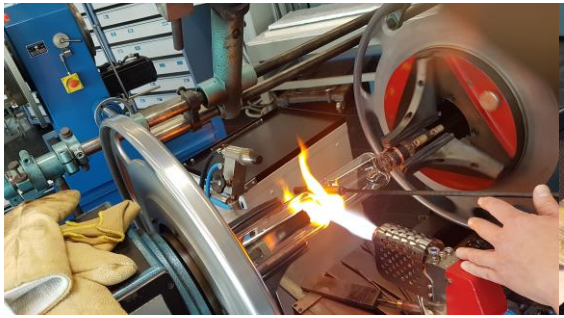
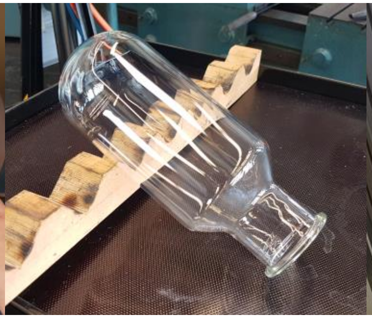
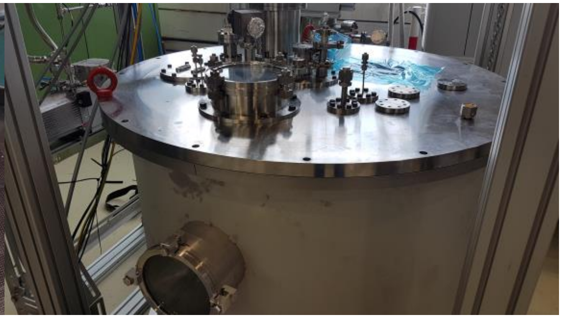

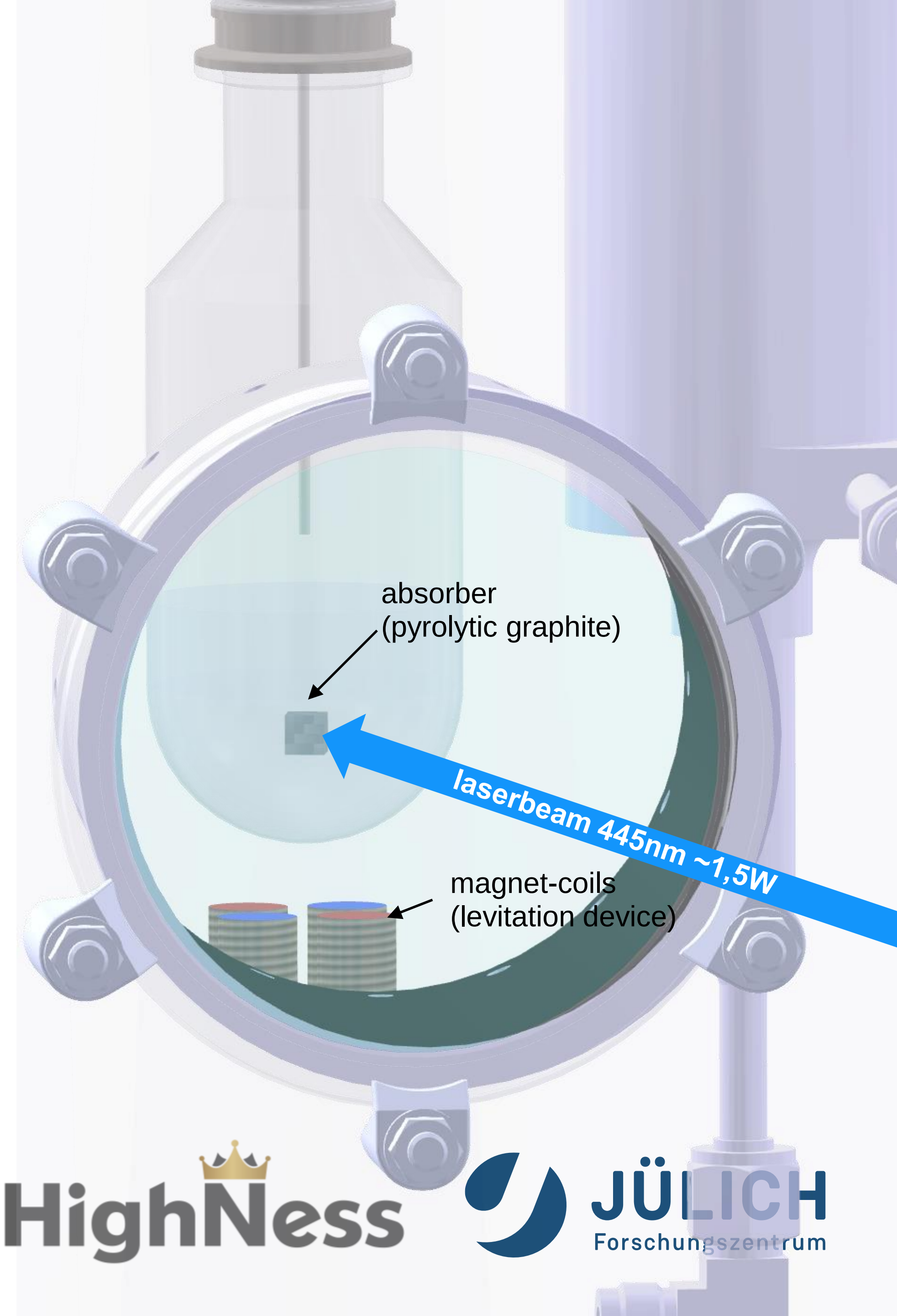

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Summary & outlook

Detailed Plan for 2022/2023

LD2 Moderator
- Finalizing 3D design optimization and iteration with WP4
- Finalizing CFD+FEM simulations
- Creating of a detailed flow chart of LD2 loop
- Cost estimation “LD2 Moderator”
- Integration into the ESS monolith

UCN Moderator
- Neutronic and engineering design of UCN for ESS with He II. Investigating phase stability of He II.

Experiment at Budapest reactor & Nano diamond prototype

Next deliverables in WP5 mid 2023 (design review)

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