WORKSHOP ON VCN AND UCN AT ESS

Moderator cooling at ESS

2022-03-02 I Y. BEßLER

HighNESS is funded by the European Union Framework Programme for Research and Innovation Horizon 2020, under grant agreement 951782

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HighNess

ZEA-1 | Engineering & Technologie
Technologie für Spitzenforschung

JÜLICH
Forschungszentrum

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1. Cryogenic Moderator System (CMS) overview
2. Liquide Hydrogen cryostat
3. Moderator & Reflector Plug (Twister)
4. First generation of para-Hydrogen Moderators (BF2)
5. Second generation of para-Hydrogen Moderator (BF1)
6. Draft design of ortho-Deuterium Moderator

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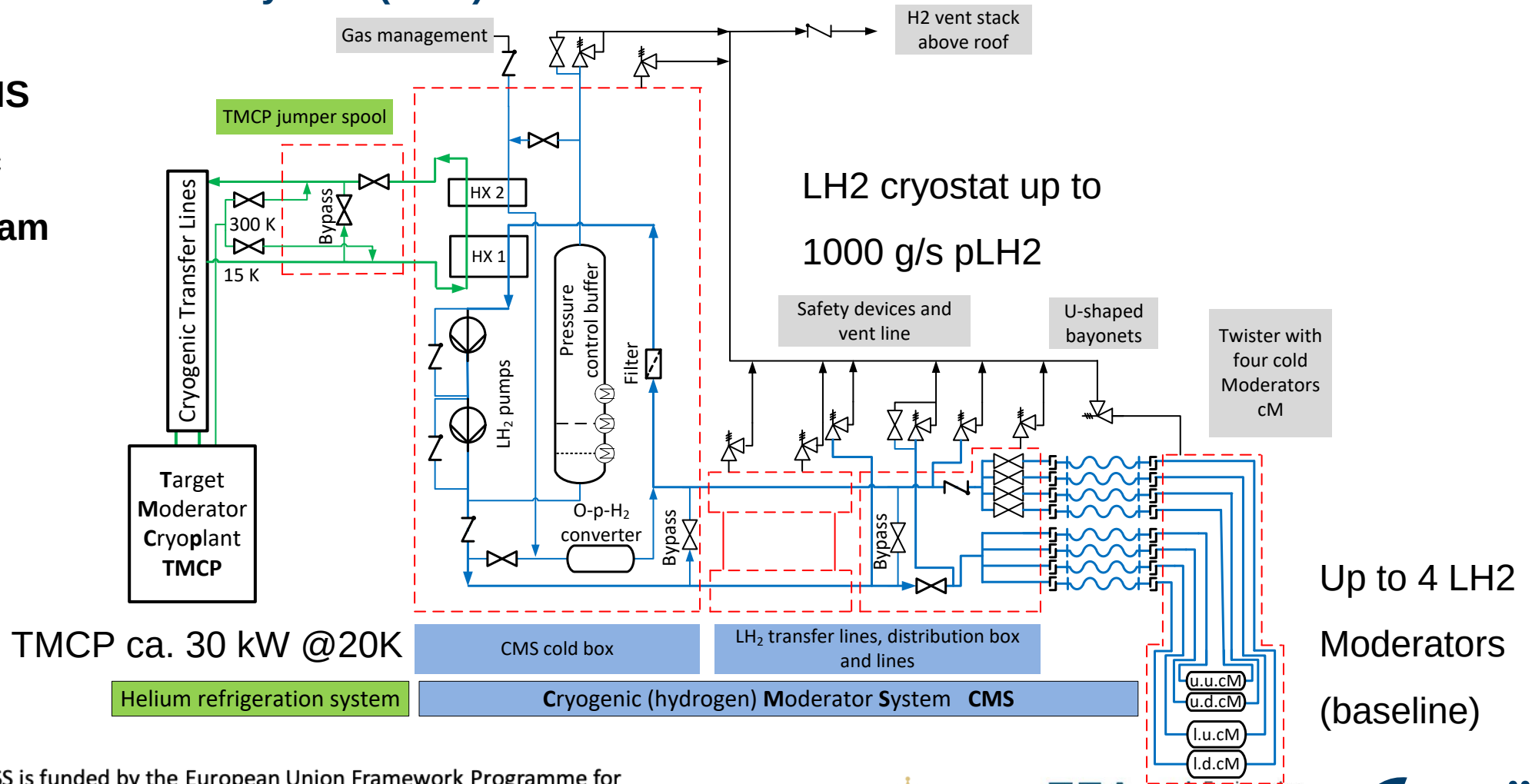
1. Cryogenic Moderator System (CMS) overview

TMCP+CMS schematic flow diagram



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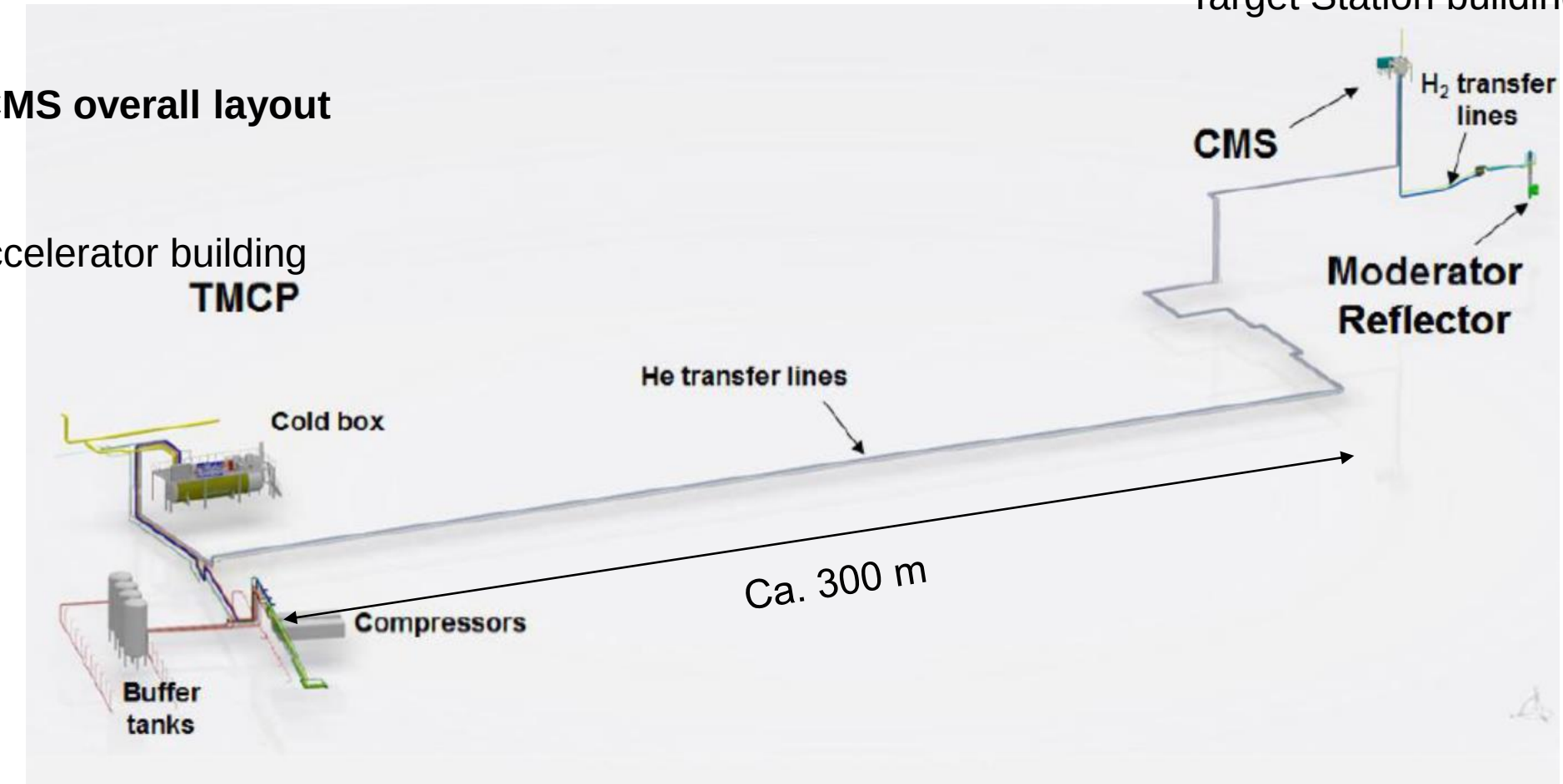
1. Cryogenic Moderator System (CMS) overview

TMCP+CMS overall layout



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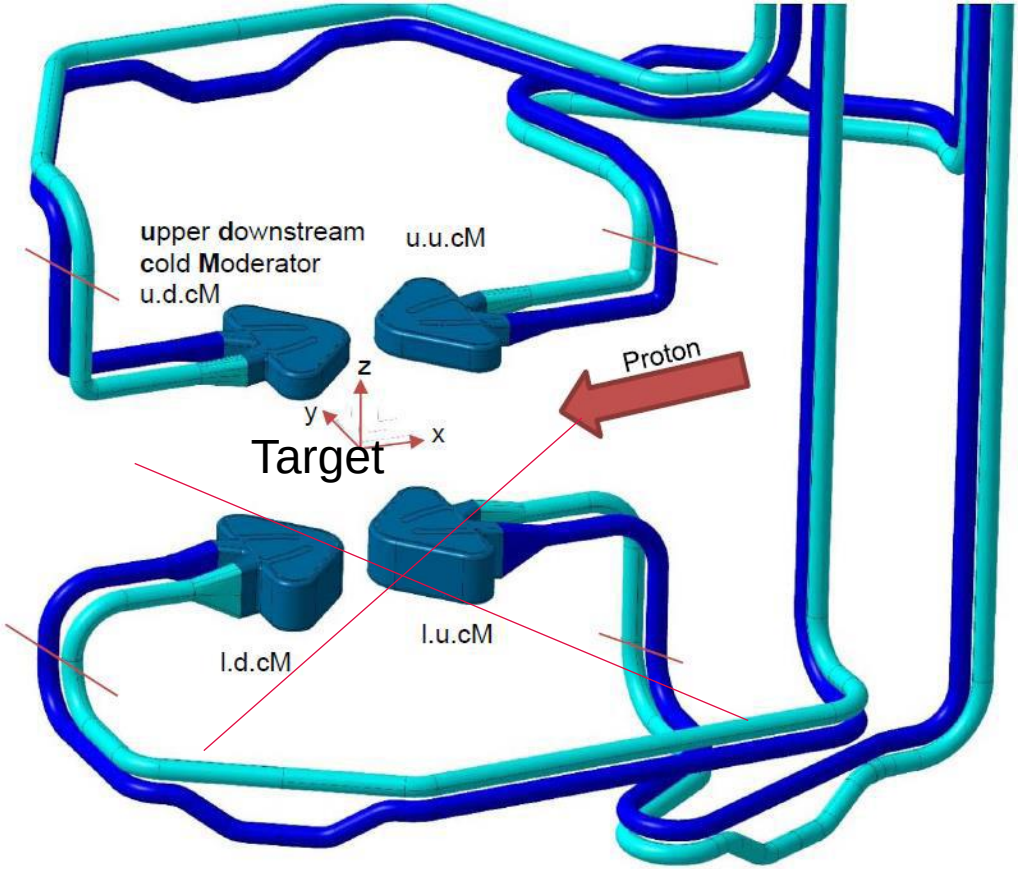

Upper Moderator Plug

Lower Moderator Plug (empty in first generation)

Main parameters of the CMS

- Operating temperature: 17 to 20.5 K
- Operating pressure: 11 bar.abs at pump outlet
- Pressure control (11+-1) bar.abs
- Design pressure: 17 bar.g (against insulation vacuum)
- Static heat load: ca. 6 kW
- Dynamic heat load: ca. 17.2 kW
- LH_2 mass flow 1000+-50 g/s
- Parahydrogen content ≥99.5%
- Pressure drop: 1.6 bar
- Inventory: ca. 26 kg H2

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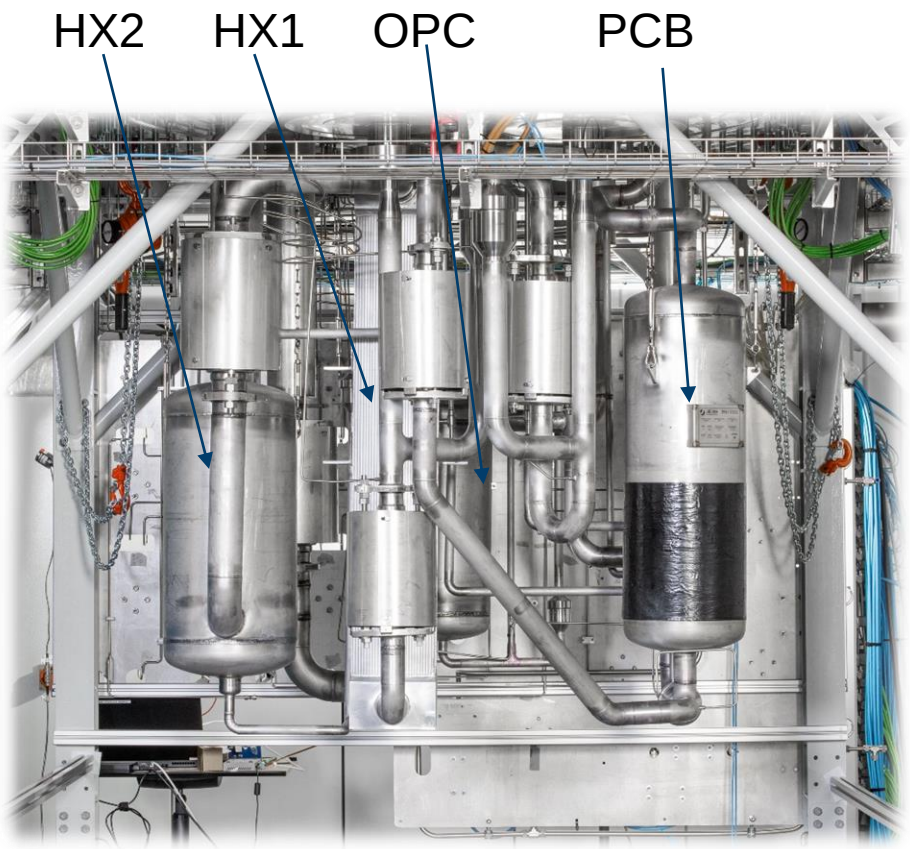
2. Liquide Hydrogen cryostat



"inside the cold box"

Hydrogen cryostat 5x5x4m; up to 1000 g/s LH2 @ 20 K and 10 bar

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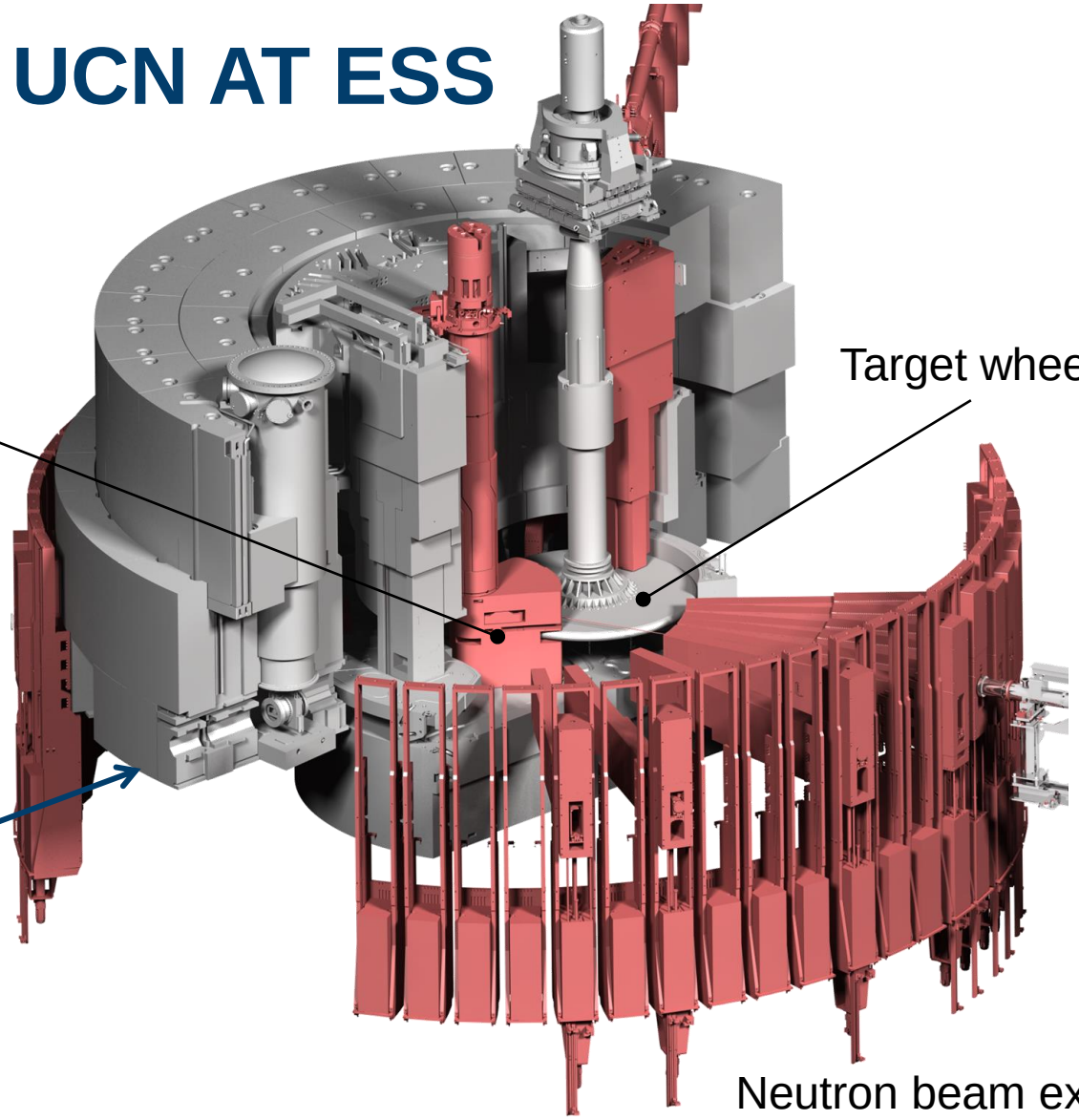
3. Moderator & Reflector Plug (Twister)

Moderator & Reflector Plug
„Twister“

Target wheel



Proton-Beamt

Neutron beam extraction

Twister

-Height 6.5 m

-Total weight 13.000 kg

-Life time @5MW 1-2 Years

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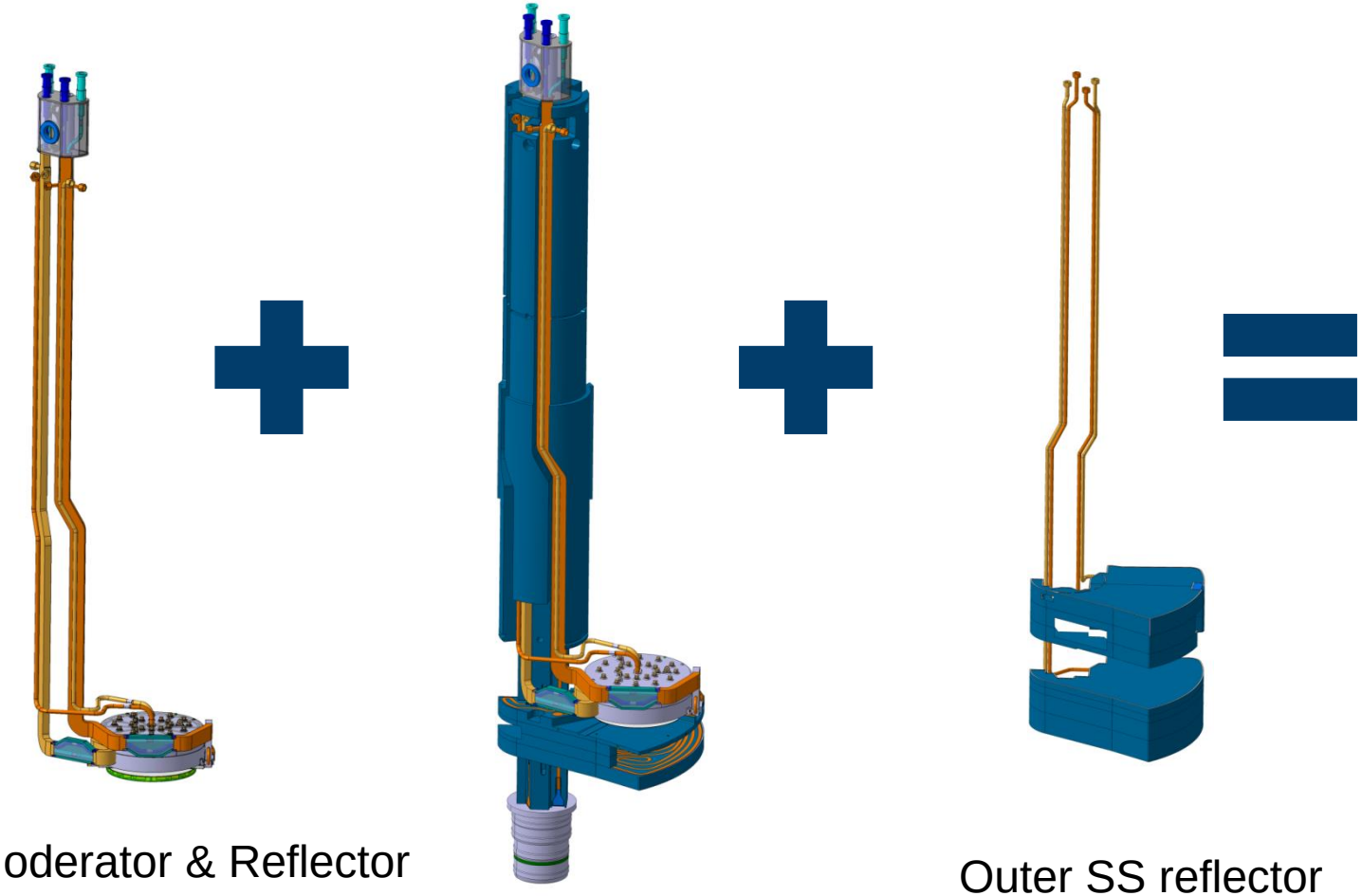
3. Moderator & Reflector Plug (Twister)



Upper Moderator & Reflector

Outer SS reflector

“Twister” assembly

-Lower plug empty in first generation

-Available for Moderator upgrades

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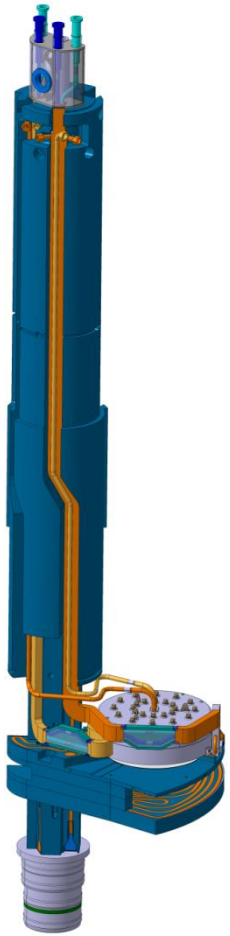
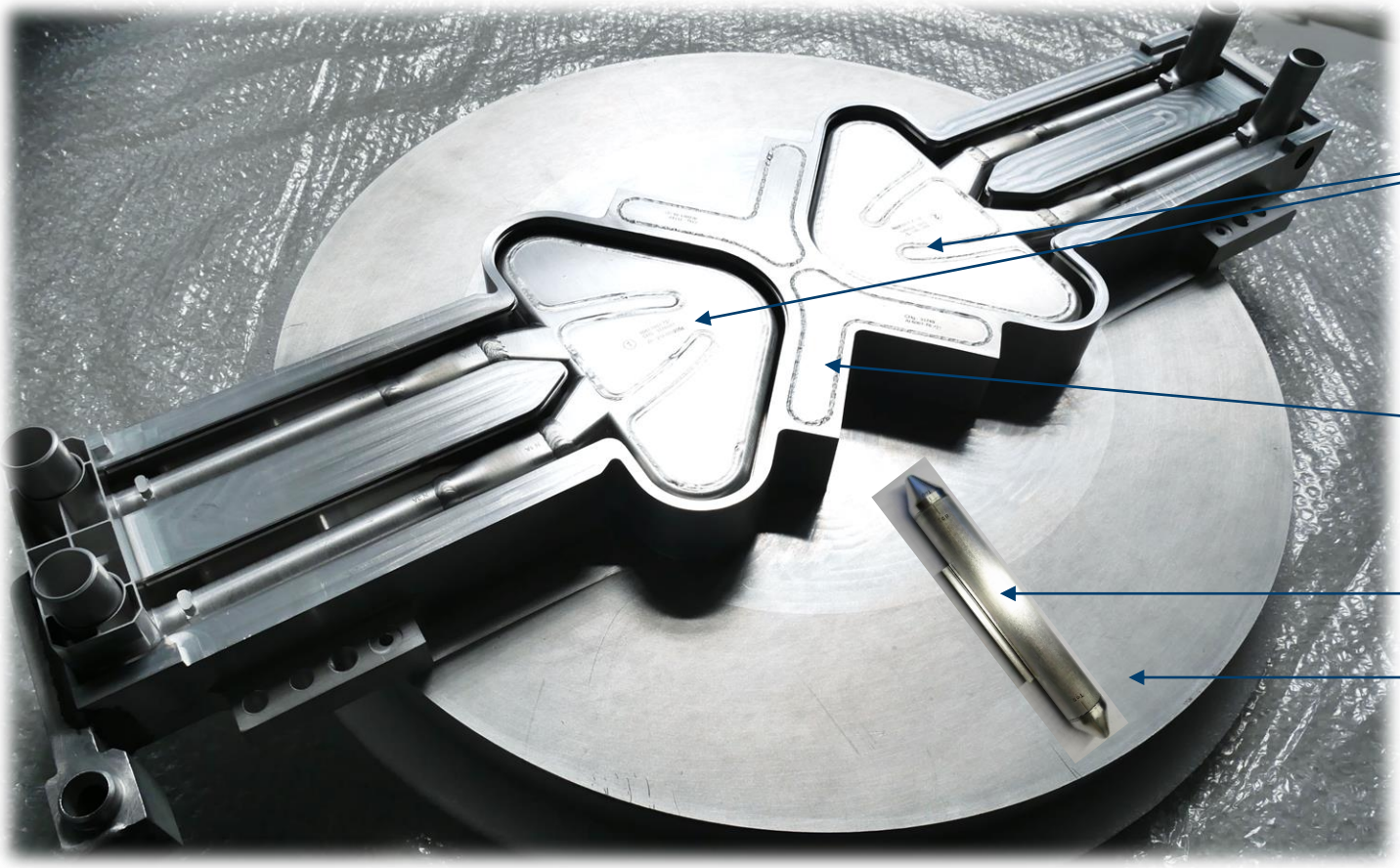
4. First generation of para-Hydrogen Moderators (BF2) – upper Moderator Plug





Cold Moderators
(para-Hydrogen @20K
Mass flow 2x240 g/s
Heat ca. 2x3.5 kW)

Thermal Moderator
(light water)

Irradiation module

Pre-Moderator
(light water)

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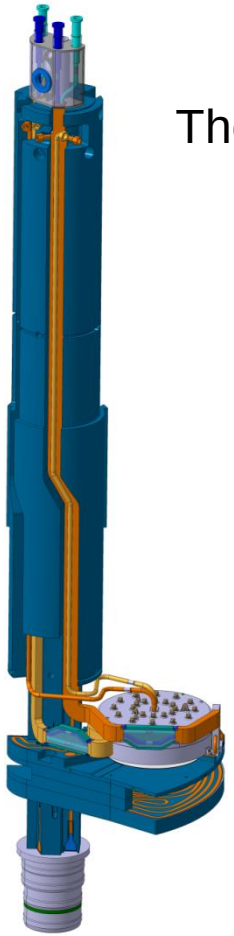
4. First generation of para-Hydrogen Moderators (BF2) – upper Moderator Plug + Twister



Thermal Moderator

Para-Hydrogen Moderators

Cutout for Target wheel

2 x 120° beam extraction (both sides)

Beryllium Reflector (above the Moderators)

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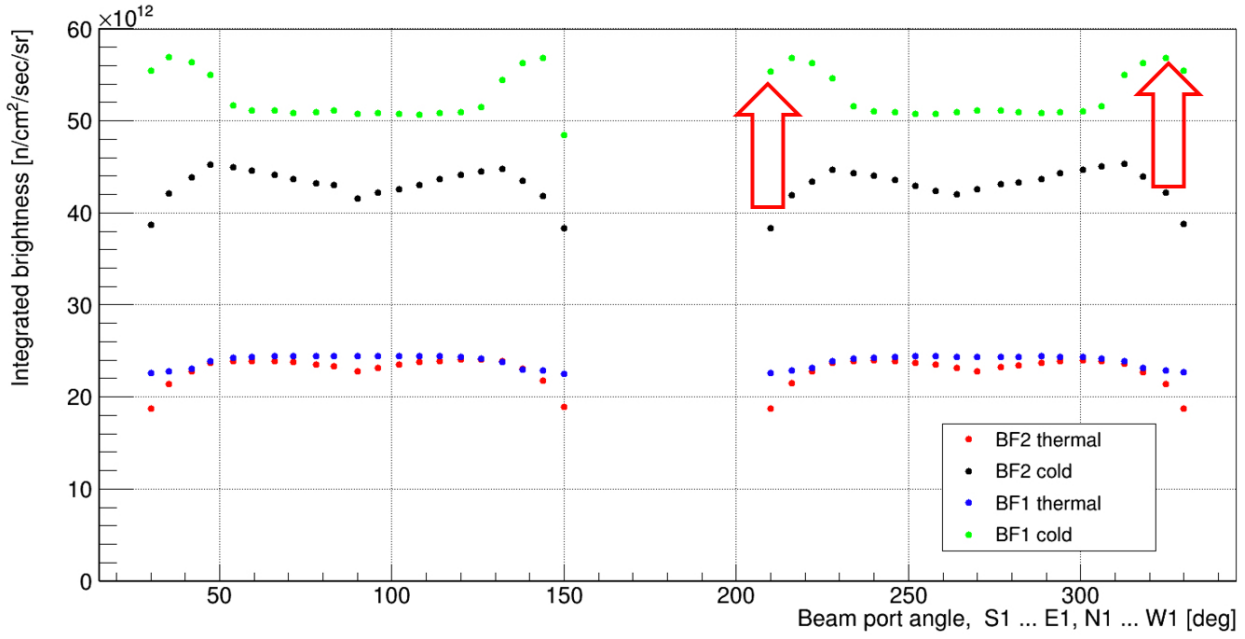
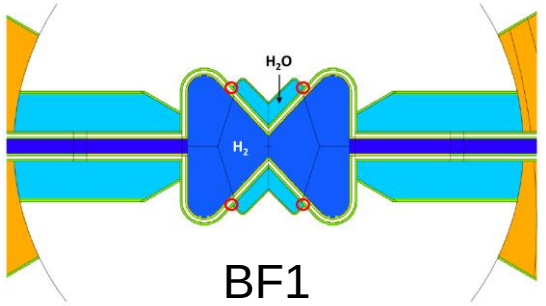
5. Second generation of para-Hydrogen Moderator (BF1)

Up to 30% brightness gain for some beam lines (e.g. NMX, BEER)

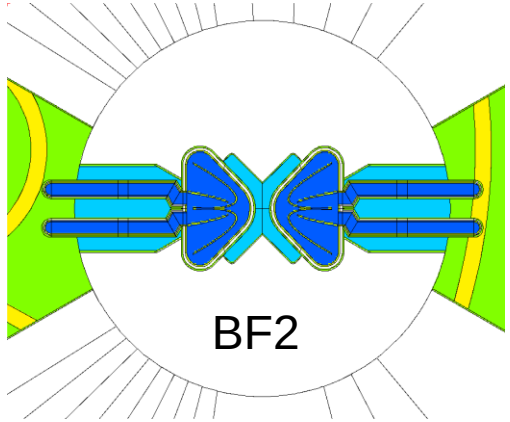




BF1

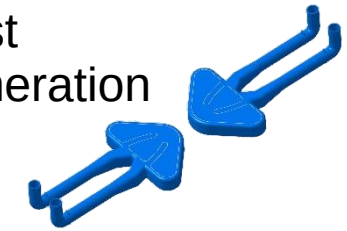
Second generation

BF1 Moderator vs. BF2 Moderator



BF2

First generation



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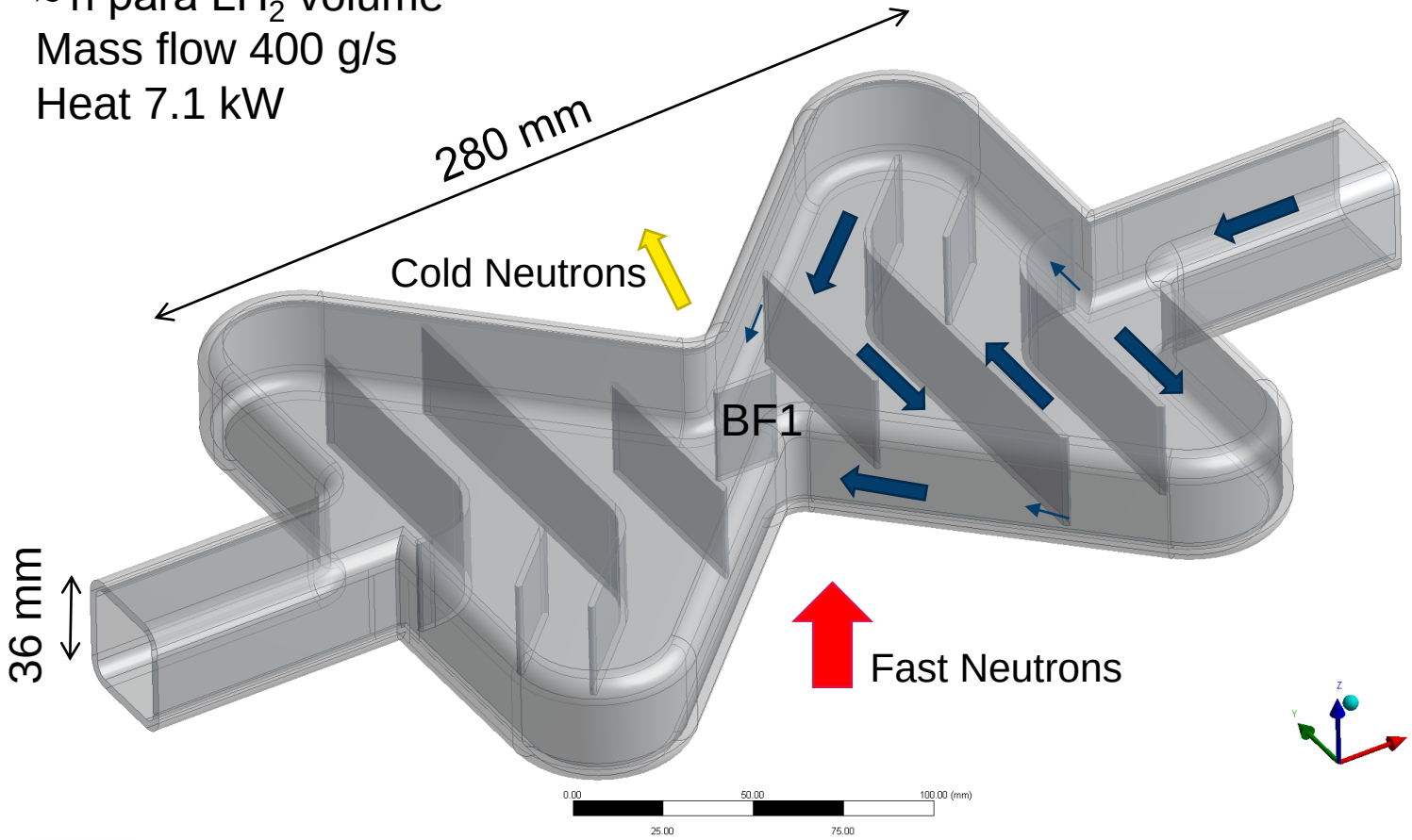
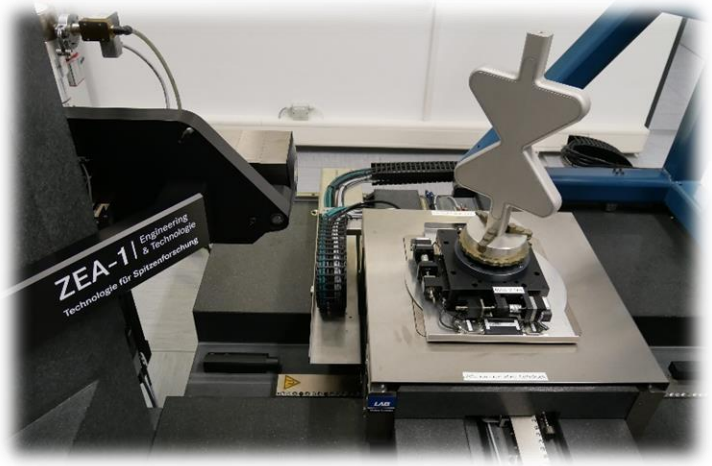
5. Second generation of para-Hydrogen Moderator (BF1)

≈1l para LH_2 volume
Mass flow 400 g/s
Heat 7.1 kW





NDT of first prototype

First prototype

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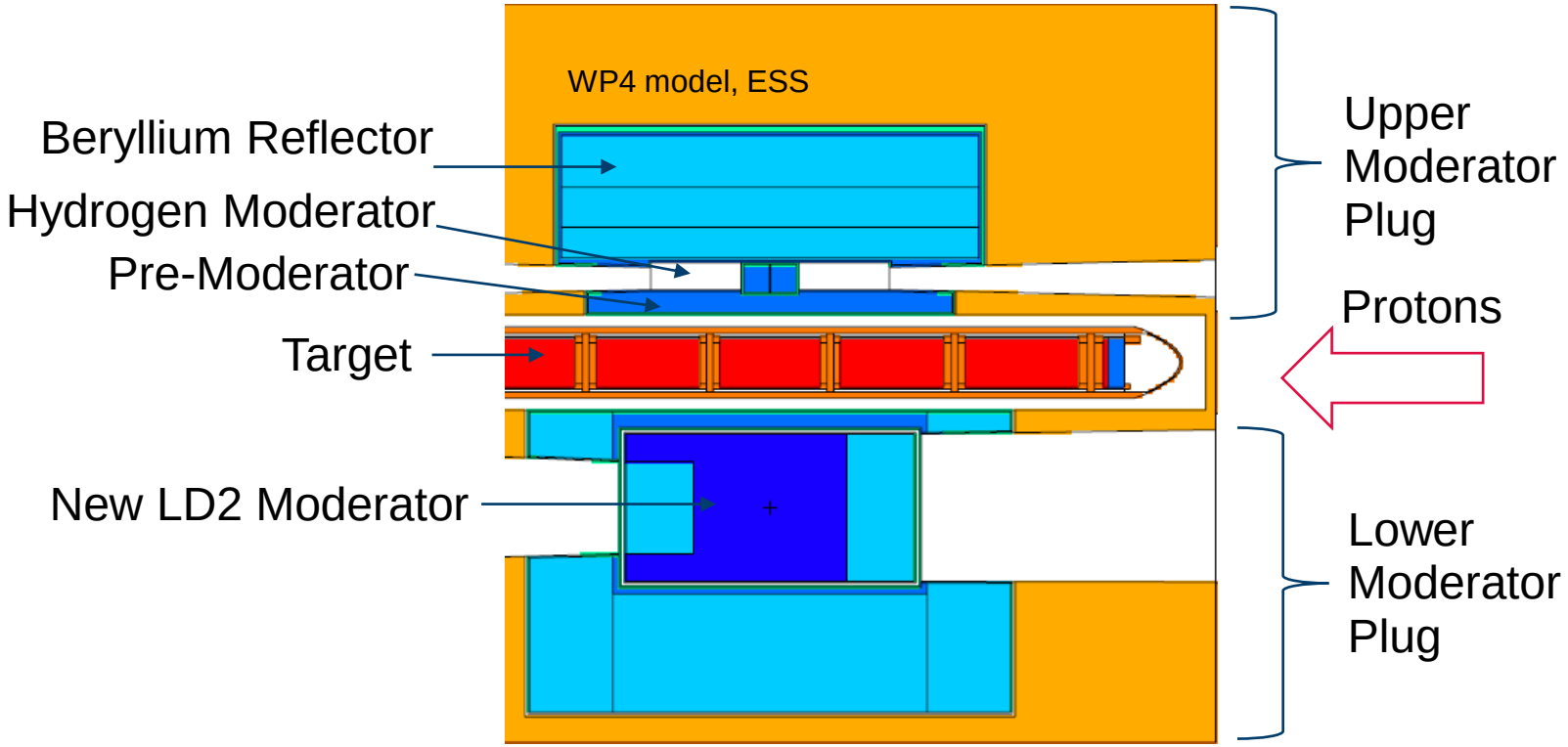
6. Draft design of ortho-Deuterium Moderator –neutronic model

First model

- ca. 34L liquid ortho-Deuterium
- Pre-Moderator 25 mm H2O
- Be reflector, water cooled

- Heat load =56.6 kW
- Pressure =5 bar
- Mass flow =3.4 kg/s
- Temperature =22.5 K



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

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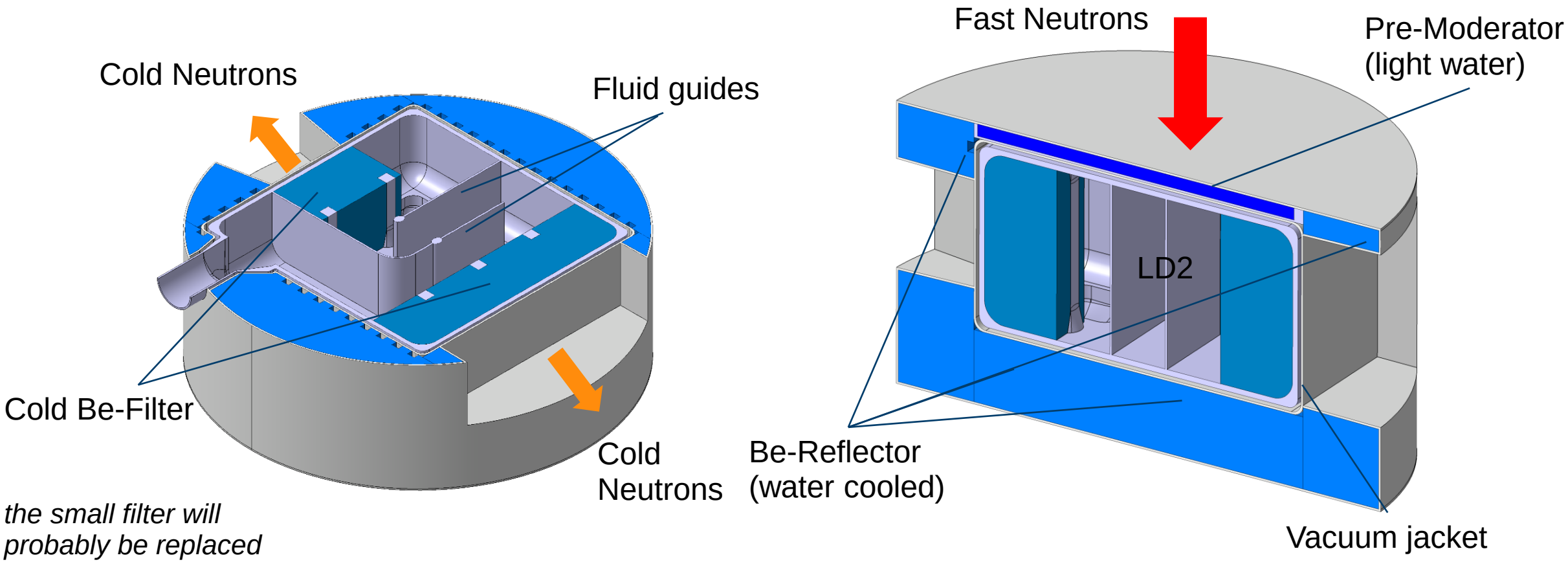
6. Draft design of ortho-Deuterium Moderator – first engineering optimizations



the small filter will probably be replaced

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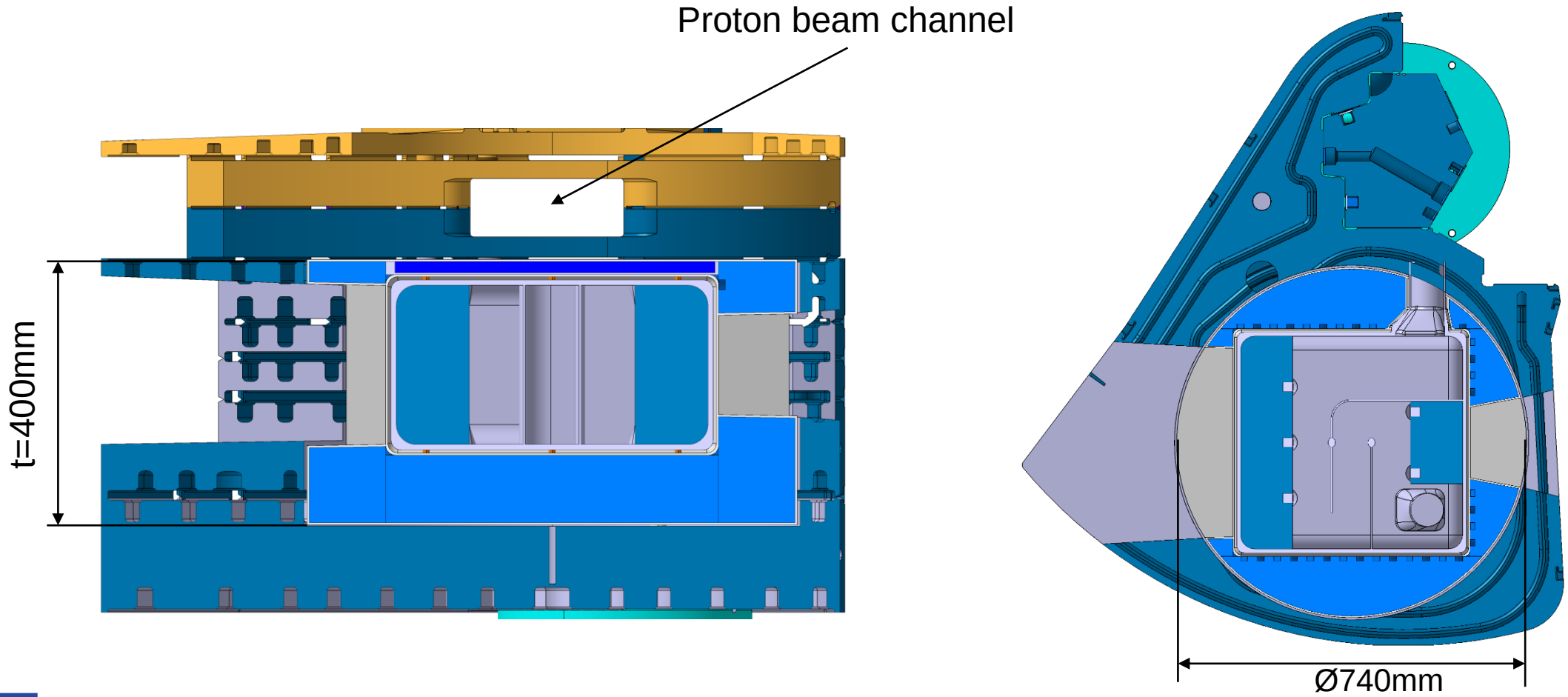
6. Draft design of ortho-Deuterium Moderator - Dimensions



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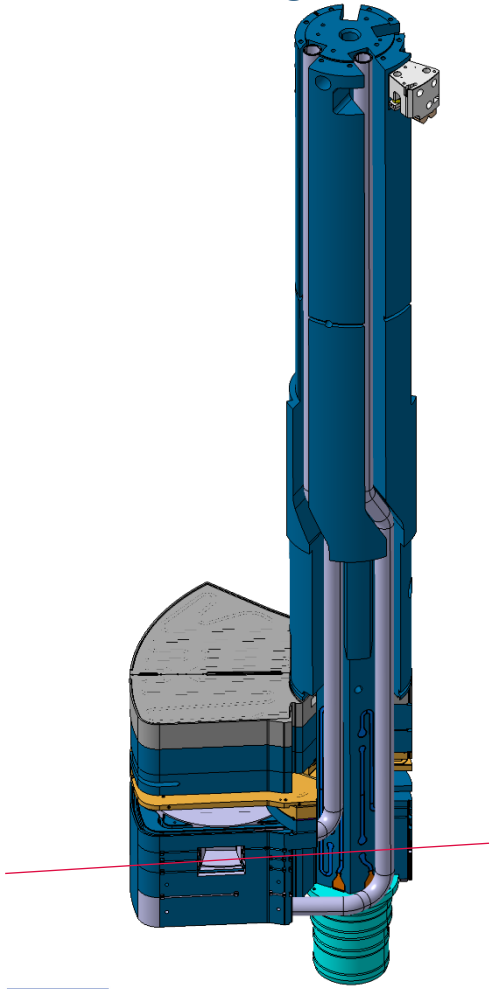
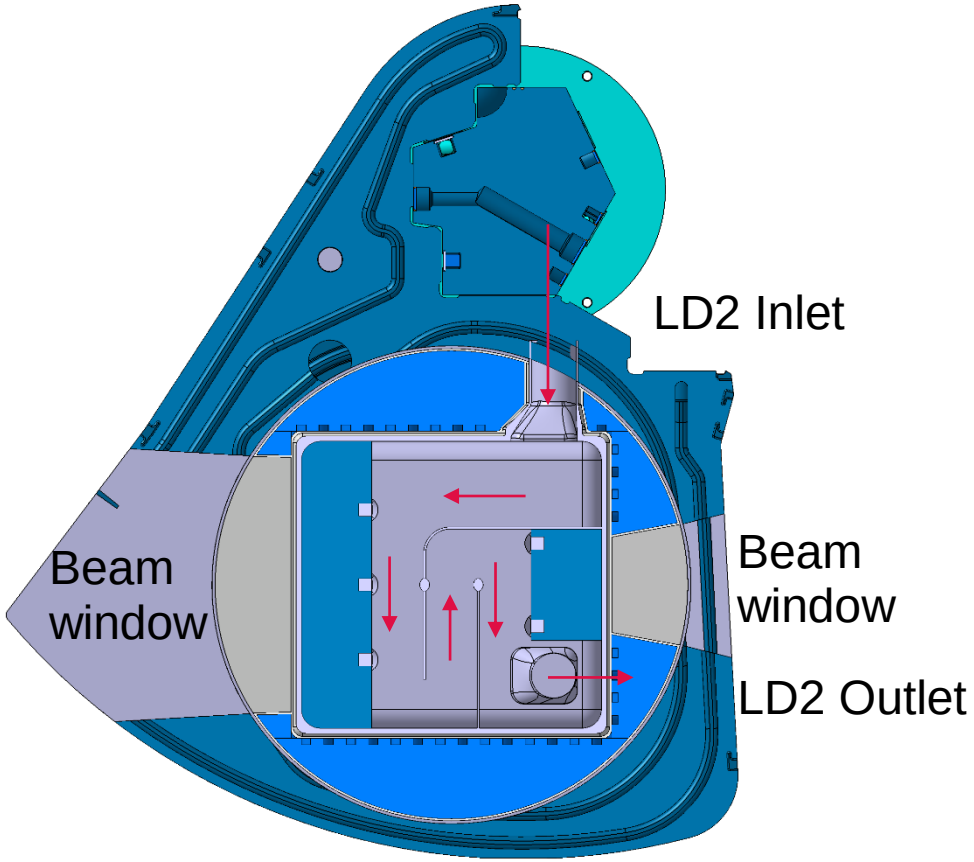
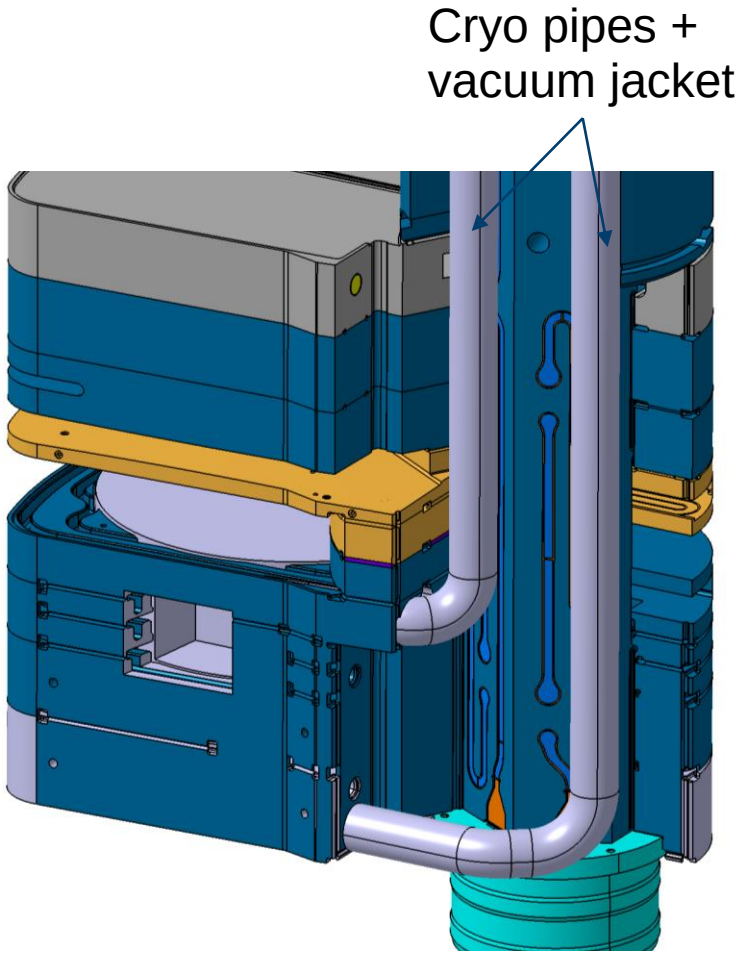
6. Draft design of ortho-Deuterium Moderator – Twister Integration







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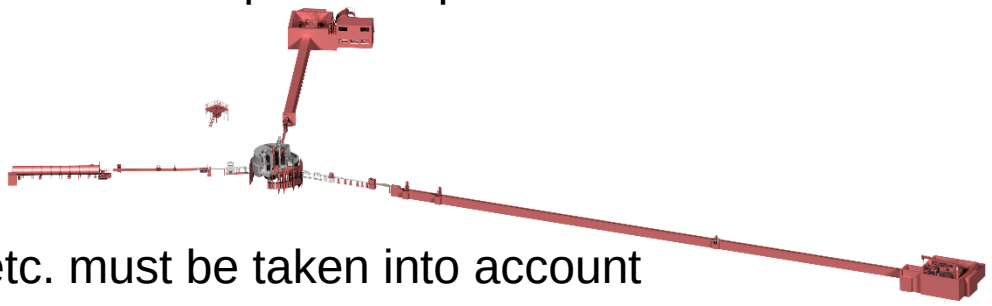
ESS HIGHNESS – WP5 ENGINEERING

Summary & outlook

- There are various ways of integrating the new Moderator concepts into the existing Target Station / Twister
- The Deuterium Moderator in the lower moderator plug, maybe in combination with a VCN, seems feasible
- For reasons of coolability, the UCN must be placed further away from the source
- The existing cryogenic infrastructure must be significantly upgraded due to the parallel operation with Hydrogen and the enormous heat input
- Additional building for the Deuterium Cryostat seems to be required
- Considerable costs for an additional TMCP, for cryo transfer lines, etc. must be taken into account
- Especially for the planned UCN, there is no infrastructure at all near the Target Station at the required temperature level



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