WORKSHOP ON VCN AND UCN AT ESS

Moderator cooling at ESS

2022-03-02  |  Y. BEßLER
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Content

1. Cryogenic Moderator System (CMS) overview
2. Liquid 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
WORKSHOP ON VCN AND UCN AT ESS

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WORKSHOP ON VCN AND UCN AT ESS

1. Cryogenic Moderator System (CMS) overview

TMCP+CMS schematic flow diagram

TMCP ca. 30 kW @20K

LH2 cryostat up to 1000 g/s pLH2

Up to 4 LH2 Moderators (baseline)
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1. Cryogenic Moderator System (CMS) overview

TMCP+CMS overall layout

Accelerator building

Target Station building

Ca. 30 m

Ca. 300 m
1. Cryogenic Moderator System (CMS) overview

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
- LH₂ mass flow 1000+-50 g/s
- Parahydrogen content ≥99.5%
- Pressure drop: 1.6 bar
- Inventory: ca. 26 kg H₂
WORKSHOP ON VCN AND UCN AT ESS

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WORKSHOP ON VCN AND UCN AT ESS

2. Liquid Hydrogen cryostat

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

“inside the cold box”

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WORKSHOP ON VCN AND UCN AT ESS

3. Moderator & Reflector Plug (Twister)

Twister
- Height 6.5 m
- Total weight 13,000 kg
- Life time @5MW 1-2 Years

Moderator & Reflector Plug „Twister“

Target wheel

Neutron beam extraction

Proton Beam
3. Moderator & Reflector Plug (Twister)

- Lower plug empty in first generation
- Available for Moderator upgrades

Upper Moderator & Reflector

Outer SS reflector

“Twister” assembly
WORKSHOP ON VCN AND UCN AT ESS

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WORKSHOP ON VCN AND UCN AT ESS

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)
WORKSHOP ON VCN AND UCN AT ESS

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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 Moderator vs. BF2 Moderator

First generation

Second 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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WORKSHOP ON VCN AND UCN AT ESS

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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

Cold Neutrons

Fluid guides

Cold Be-Filter

Cold Neutrons

Fast Neutrons

Pre-Moderator (light water)

LD2

Be-Reflector (water cooled)

Vacuum jacket

the small filter will probably be replaced
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6. Draft design of ortho-Deuterium Moderator - Dimensions

Proton beam channel

Dimension: Ø740 mm, t=400 mm
6. Draft design of ortho-Deuterium Moderator – Twister Integration

Cryo pipes + vacuum jacket
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