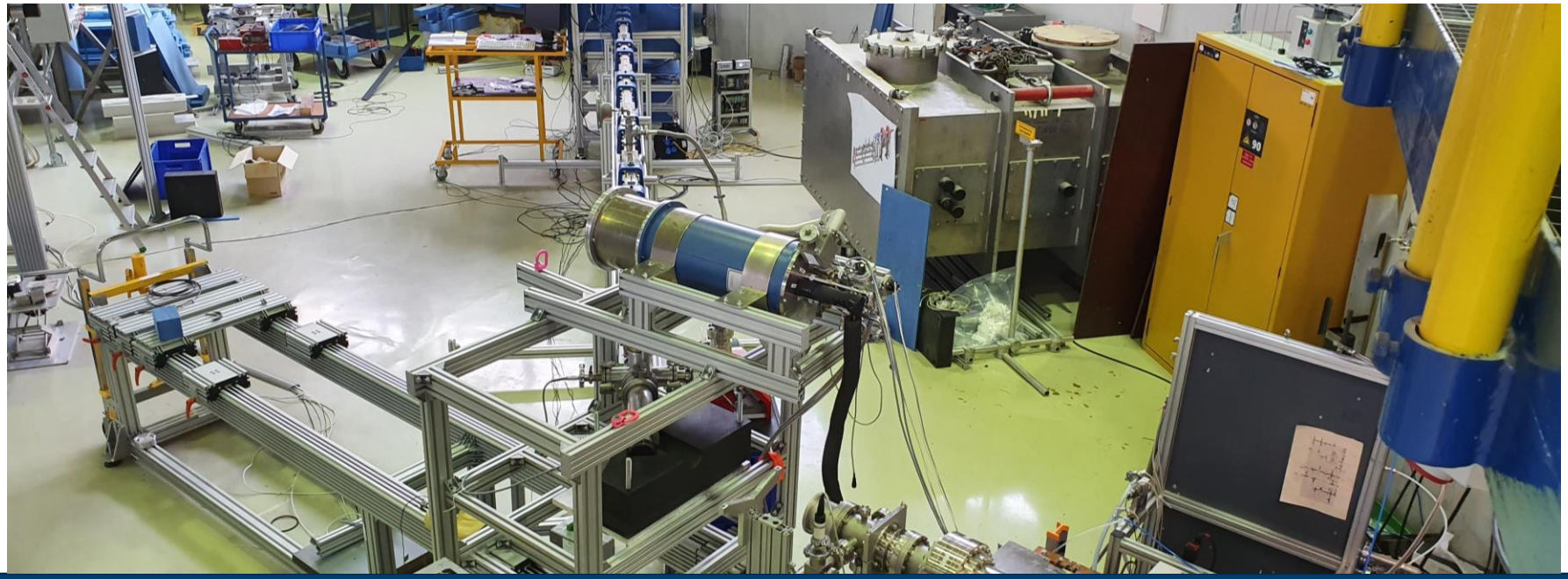


SOLID COLD MODERATOR DEVELOPMENTS AT THE HIGH BRILLIANCE NEUTRON SOURCE

Workshop on Very Cold and Ultra Cold Neutron Sources for ESS

3RD FEBRUARY 2022 I A. SCHWAB

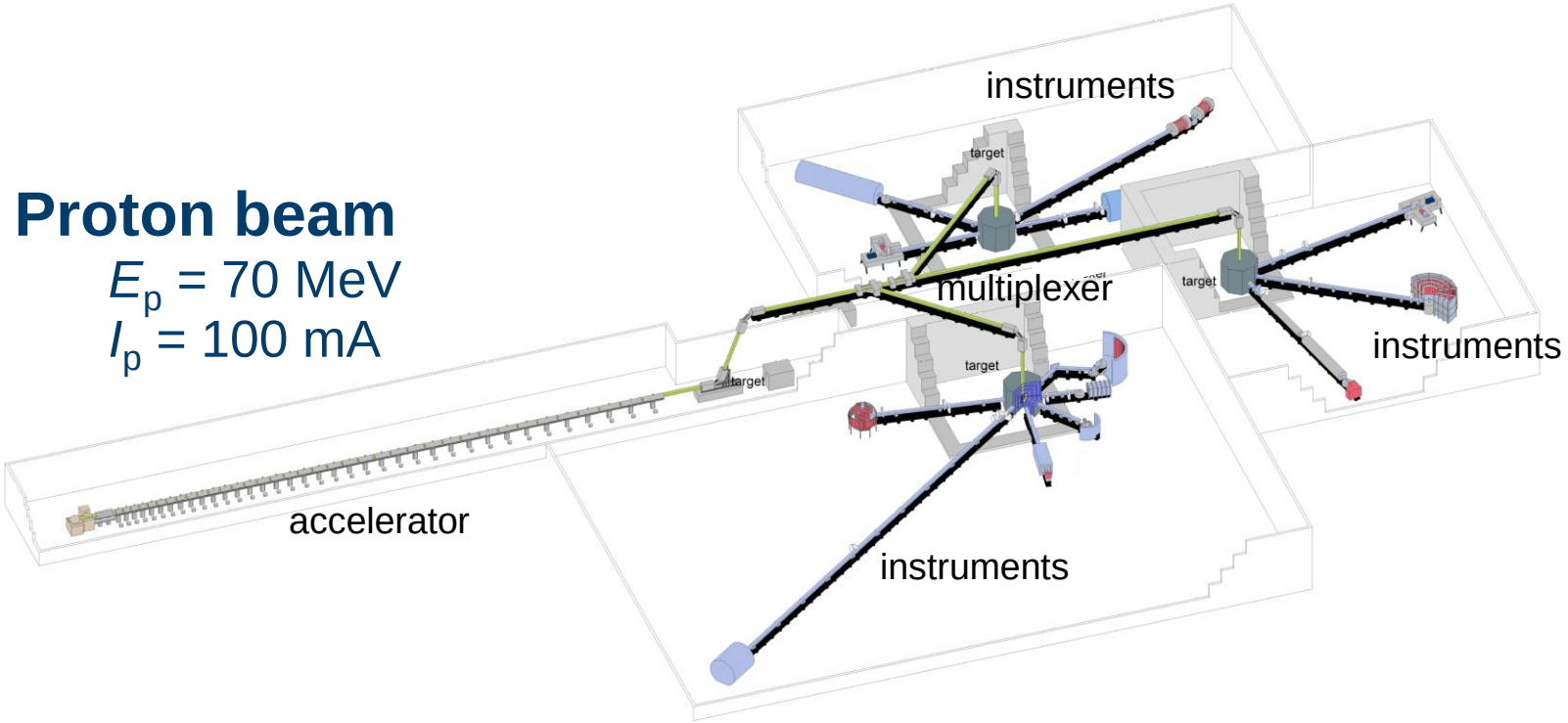
INTRODUCTION

High Brilliance Neutron Source (HBS)

Proton beam

E_p = 70 MeV

I_p = 100 mA



JÜLICH Forschungszentrum

INTRODUCTION

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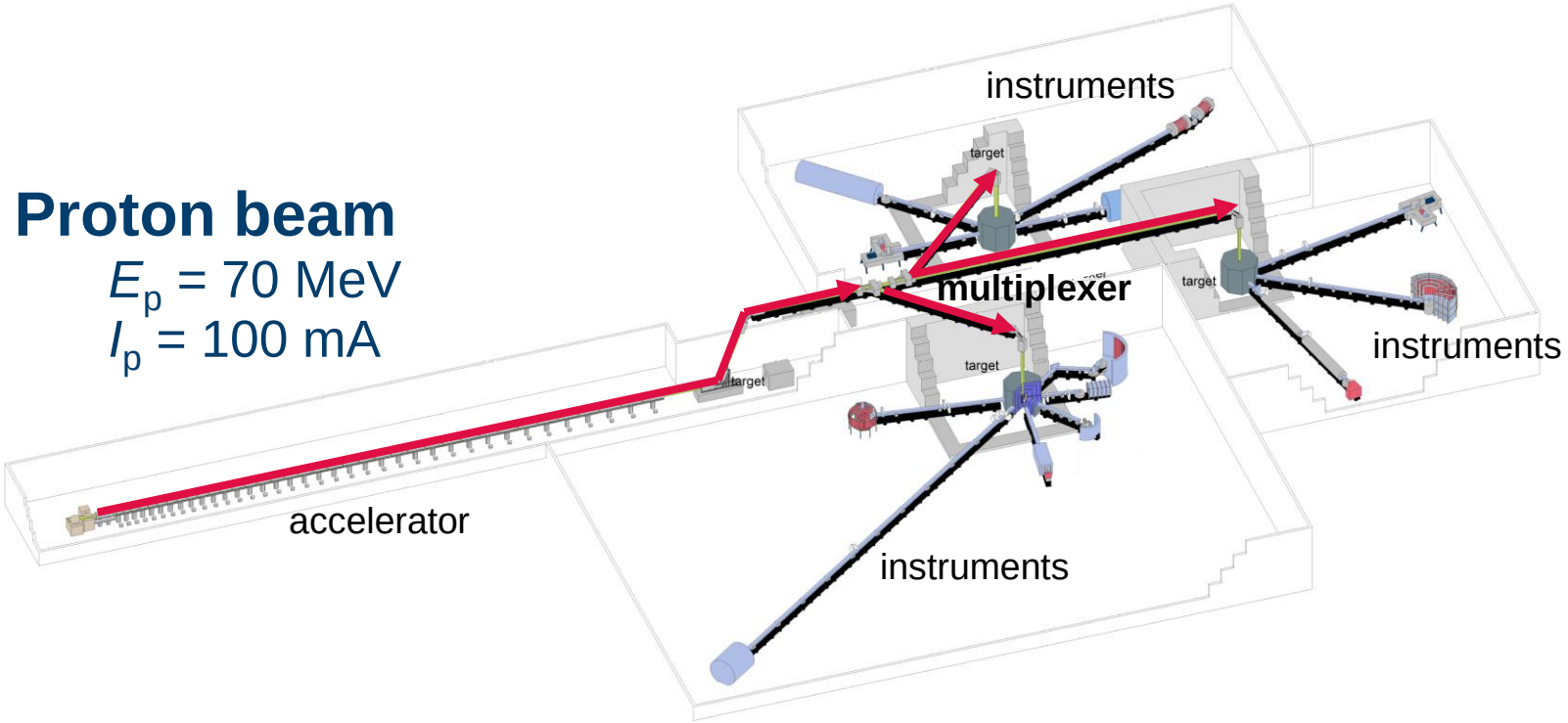
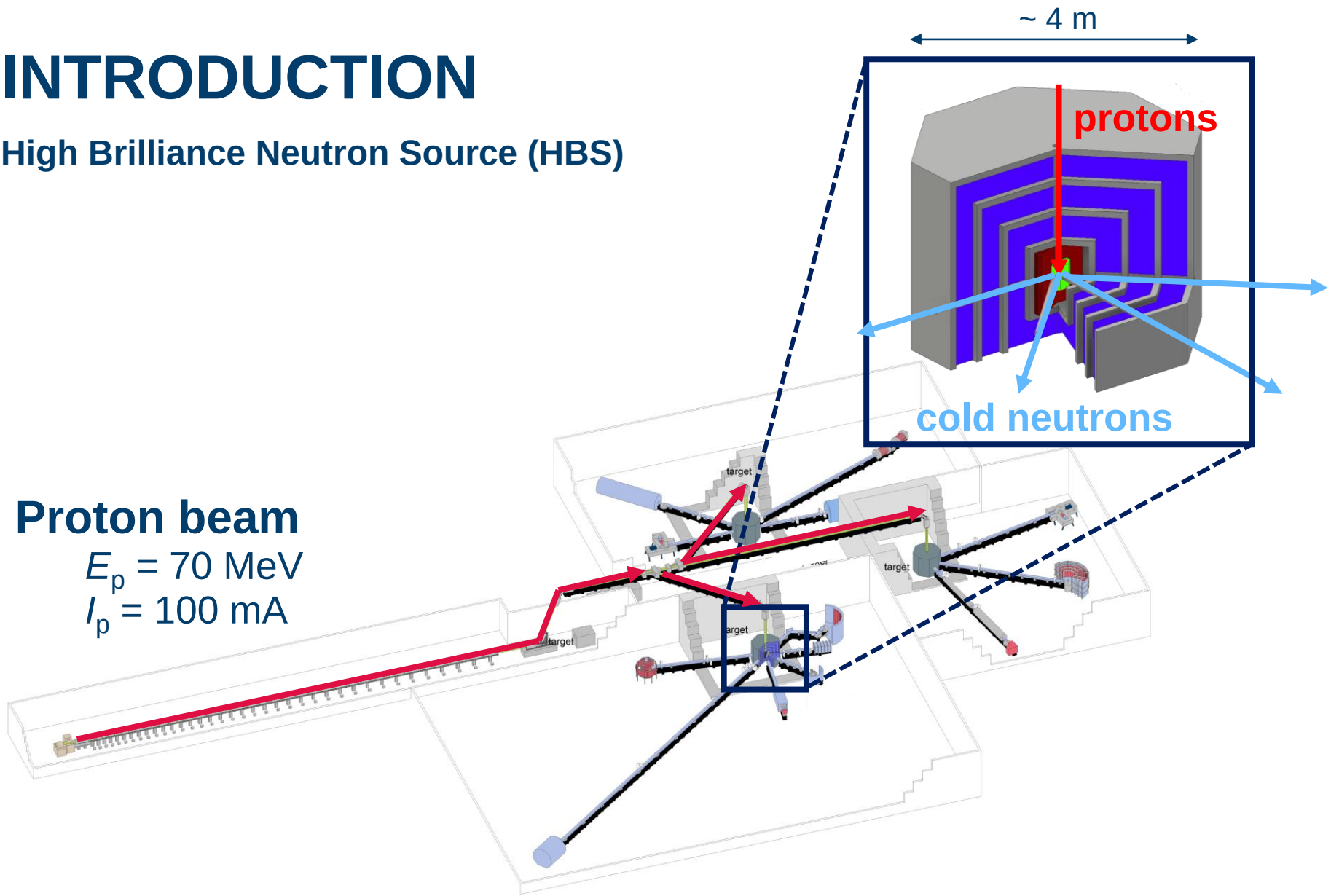


INTRODUCTION

High Brilliance Neutron Source (HBS)



Proton beam

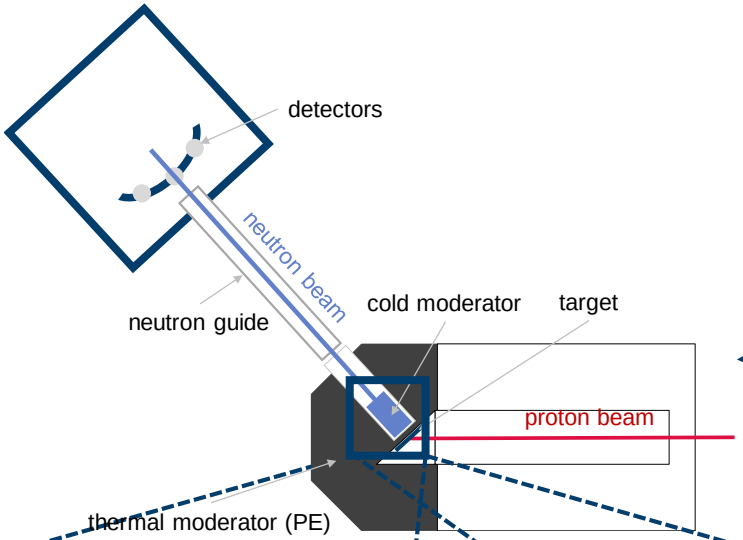
E_p = 70 MeV

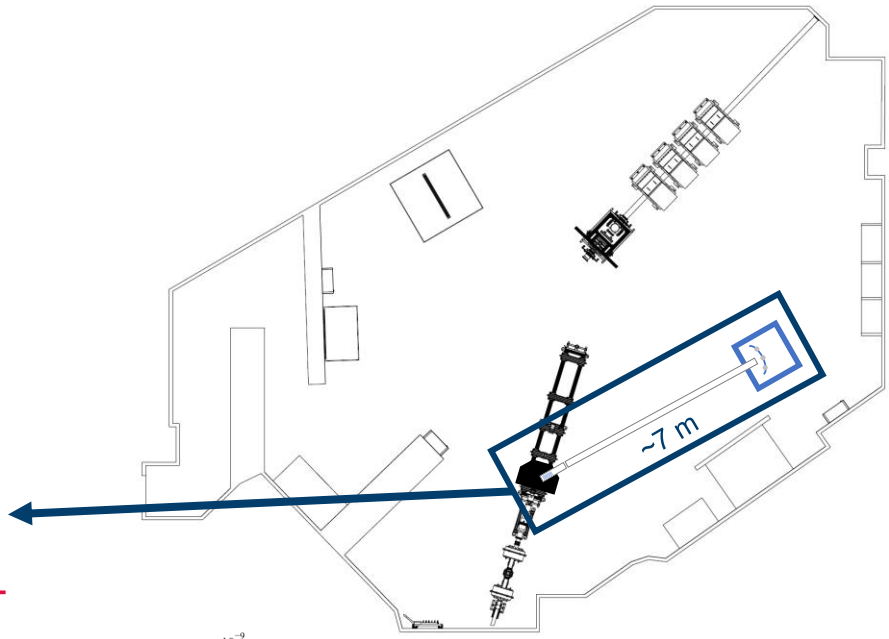
I_p = 100 mA

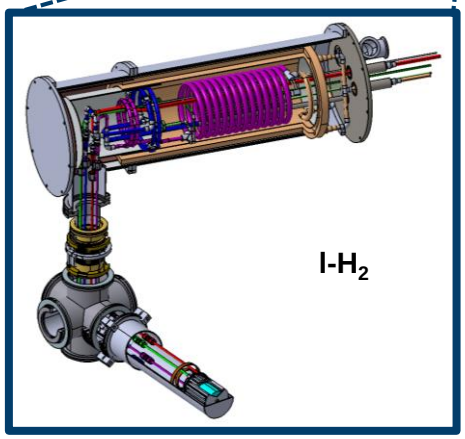
JÜLICH Forschungszentrum

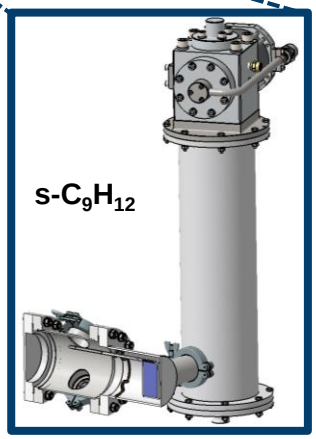
COLD MODERATORS

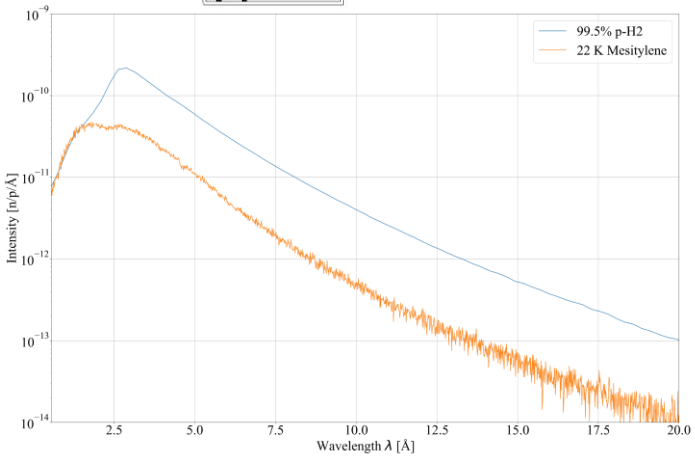
Previous measurements









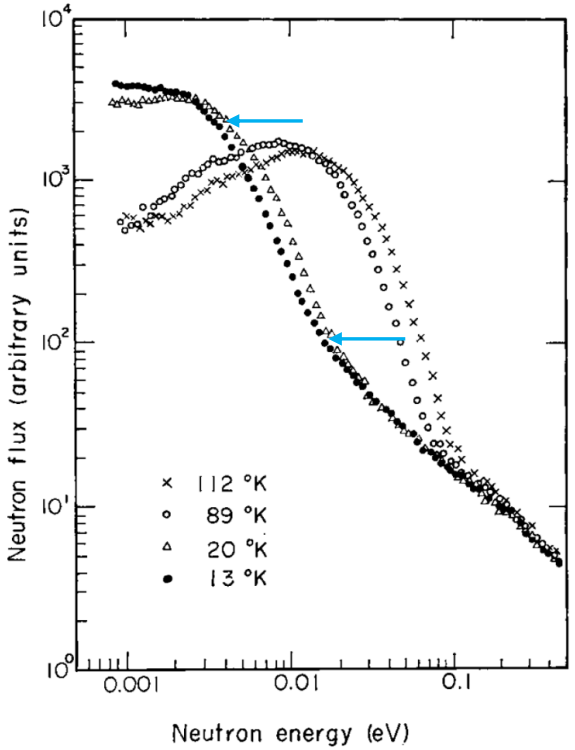


COLD MODERATORS

Cryogenic solid moderator system

- Increasing cold neutron yield by decreasing temperature below 20 K
- Promising materials: CH_4 & D_2
- Deuterium requires large volume

  → opposed to compact geometry

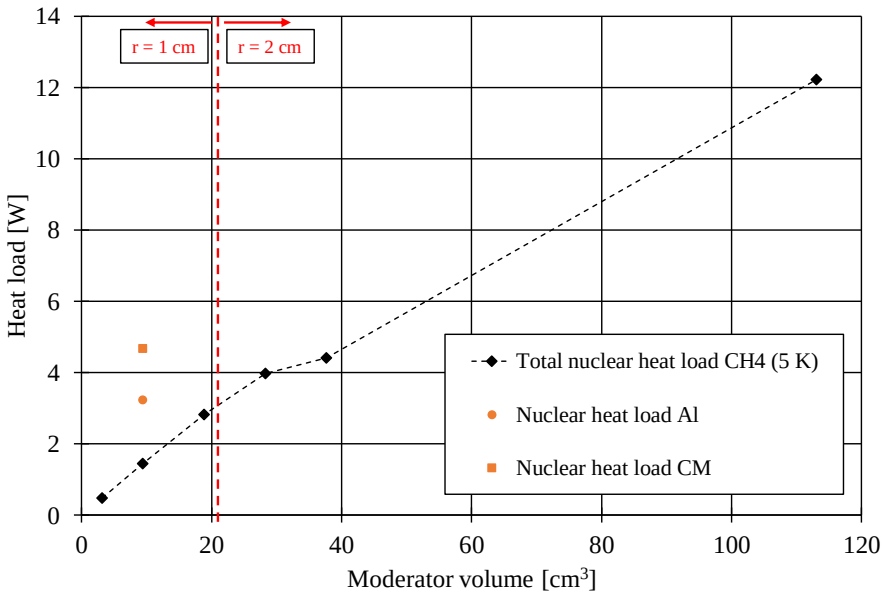


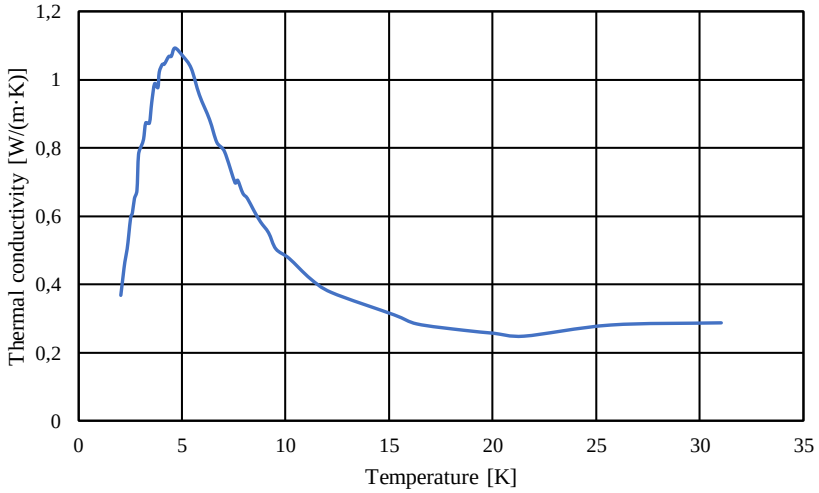
Neutrons have been extracted through re-entrant hole. All spectra are normalized to the $1/E$ distributions.

Fig. 1 Neutron spectra in liquid and solid methane

Source: Inoue et al. (1972)

ENERGY DEPOSITION

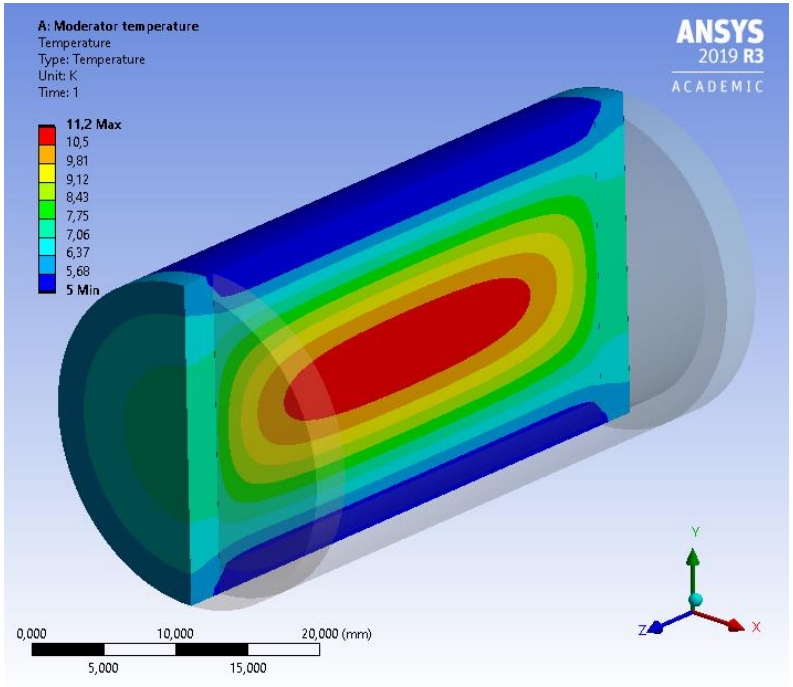


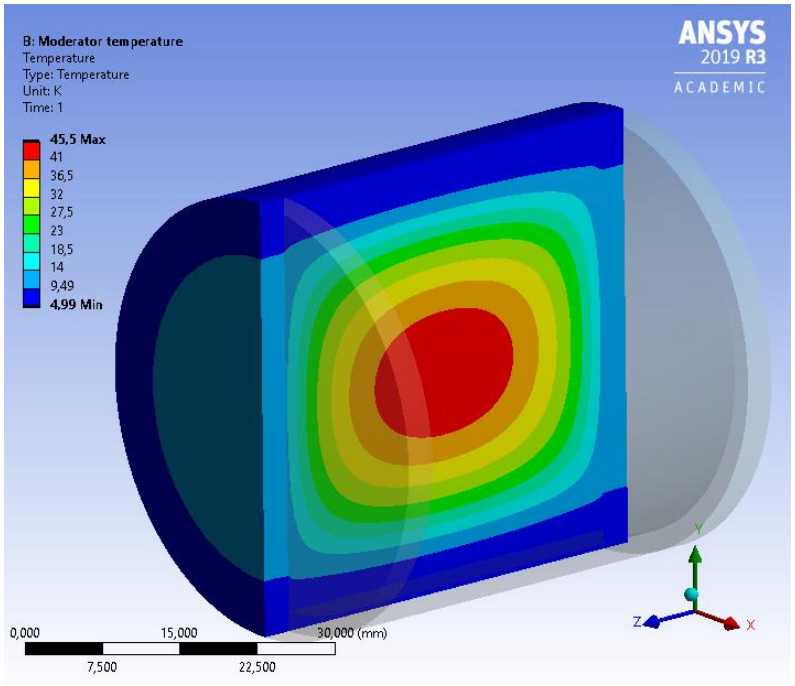


- Time-averaged energy deposition from MCNP
- Total heat load increases with volume
- Solid moderators generally have poor λ_{th}

ENERGY DEPOSITION

→ **effect**: temperature gradient along solid moderator volume





- Highly simplified model (constant wall temperature, ideal thermal connections, no pulse shape & position with regard to target included)
- → in reality: situation even worse!

AL STRUCTURES

Foam

+ high porosity

- lower λ_{th} for press fitting than fibres

Fibres

+ higher λ_{th} for press fitting than foam

- low porosity (max. 80%)

Additive manufacturing

+ design flexibility

- no press fitting

- Aluminum structures can increase λ_{eff}
- High porosity desired
- Thermal connection either by press fit or solder

PROTOTYPE TMR

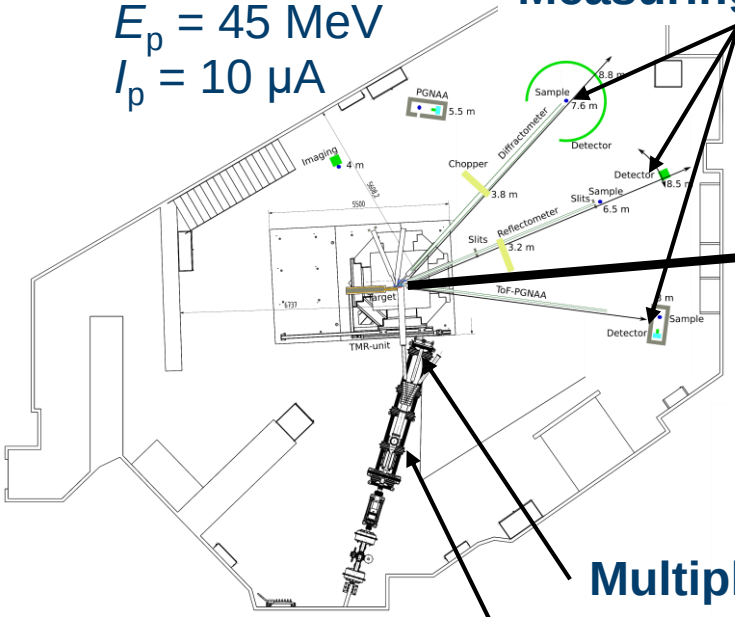
Floor plan „Big Karl“

Proton beam

E_p = 45 MeV

I_p = 10 µA

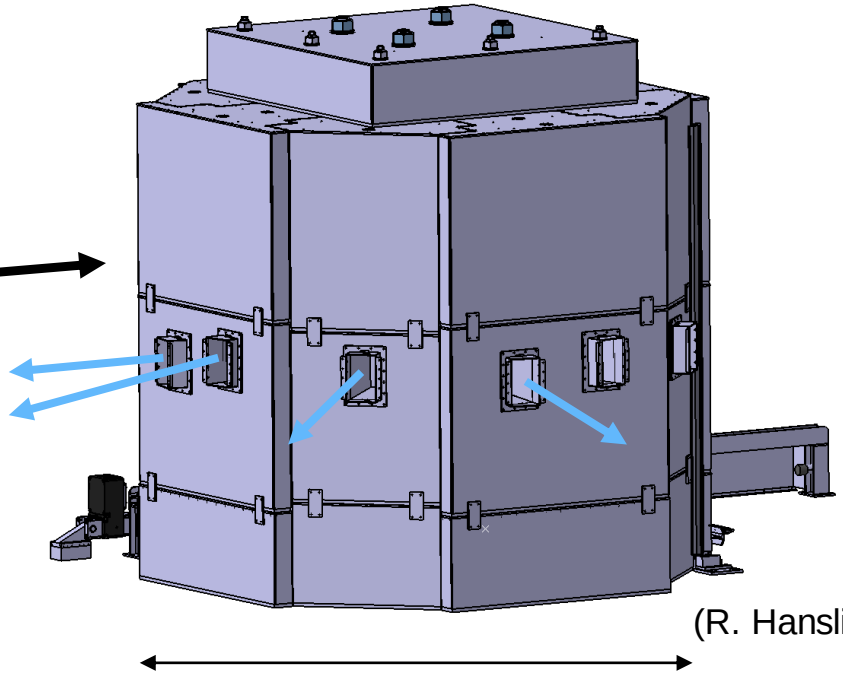
Measuring stations



Multiplexer

Beam line

Prototype TMR unit

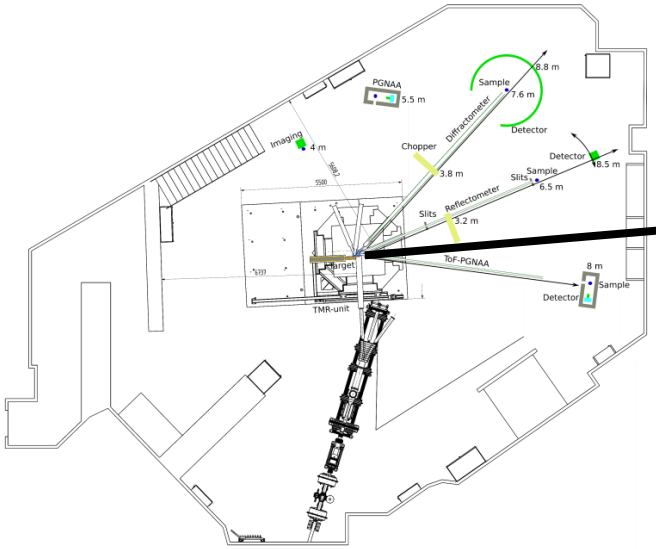


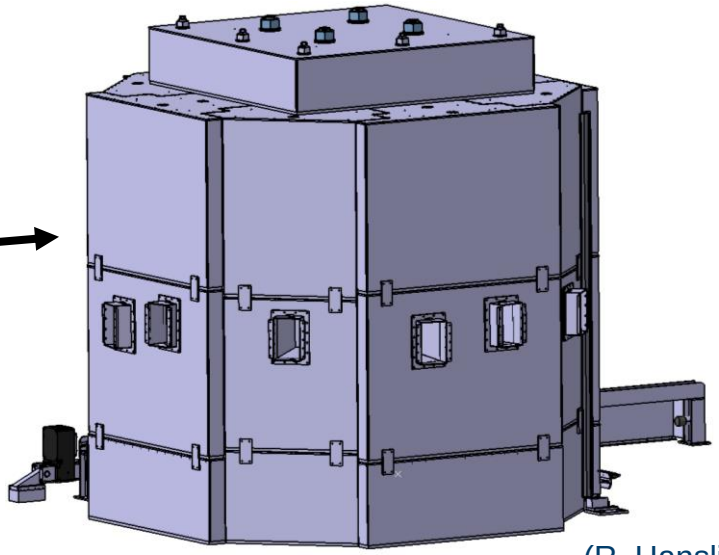
(R. Hanslik)

~ 3 m

cold & thermal neutrons

MODERATOR PLUG

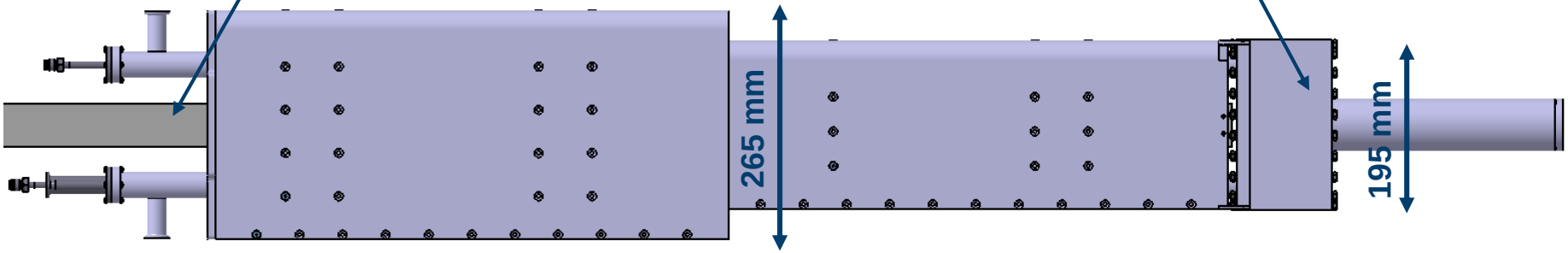




(R. Hanslik)

Neutron guide

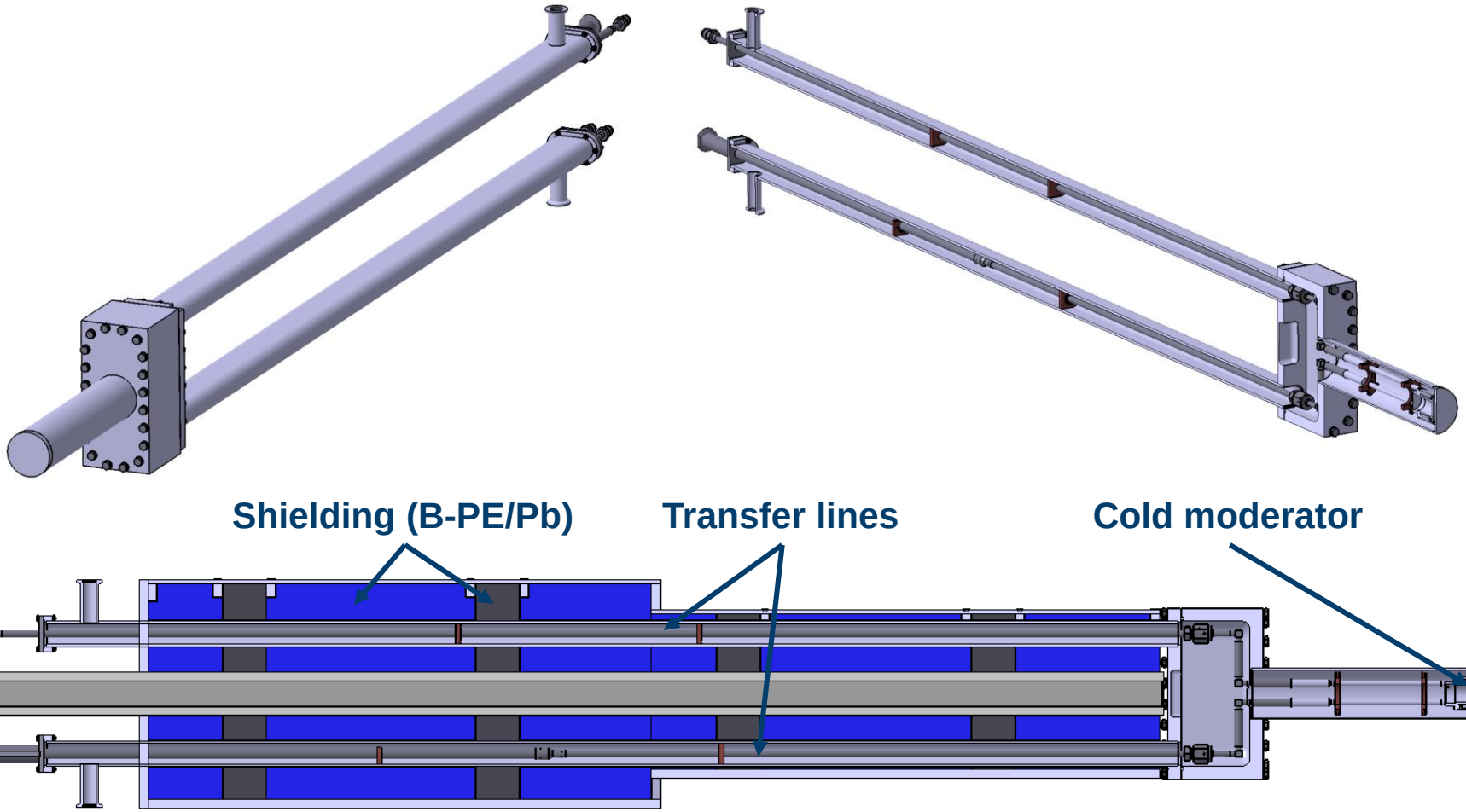
Moderator Plug Cryostat (MPC)



approx. 1800 mm

(Design of shielding part by R. Similon, IKP)

MODERATOR PLUG



(Design of shielding part by R. Similon, IKP)

10K CRYOSTAT

Minimum temperature:

- ∽ 5…10 K

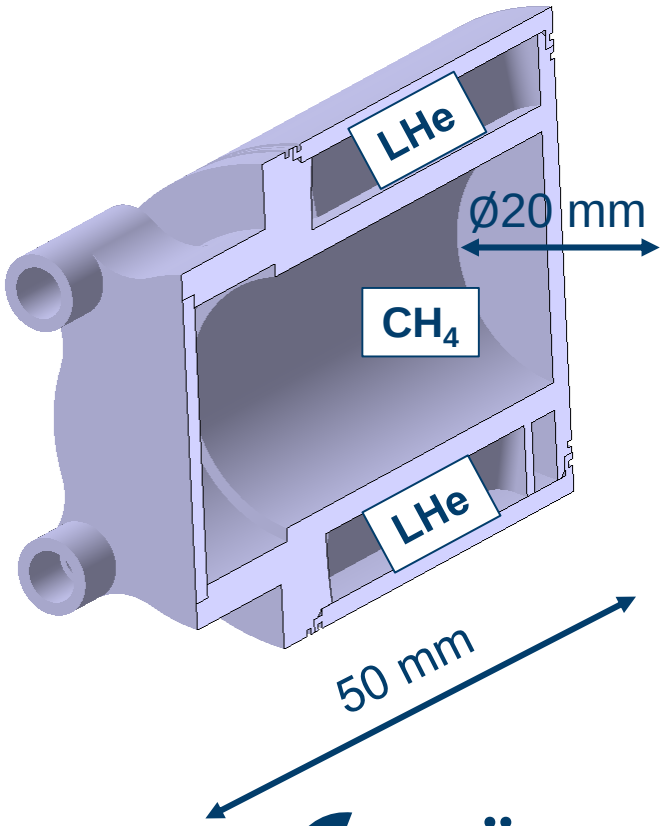
Moderator:

- Methane (Phase II)

  & possibly other hydrocarbons

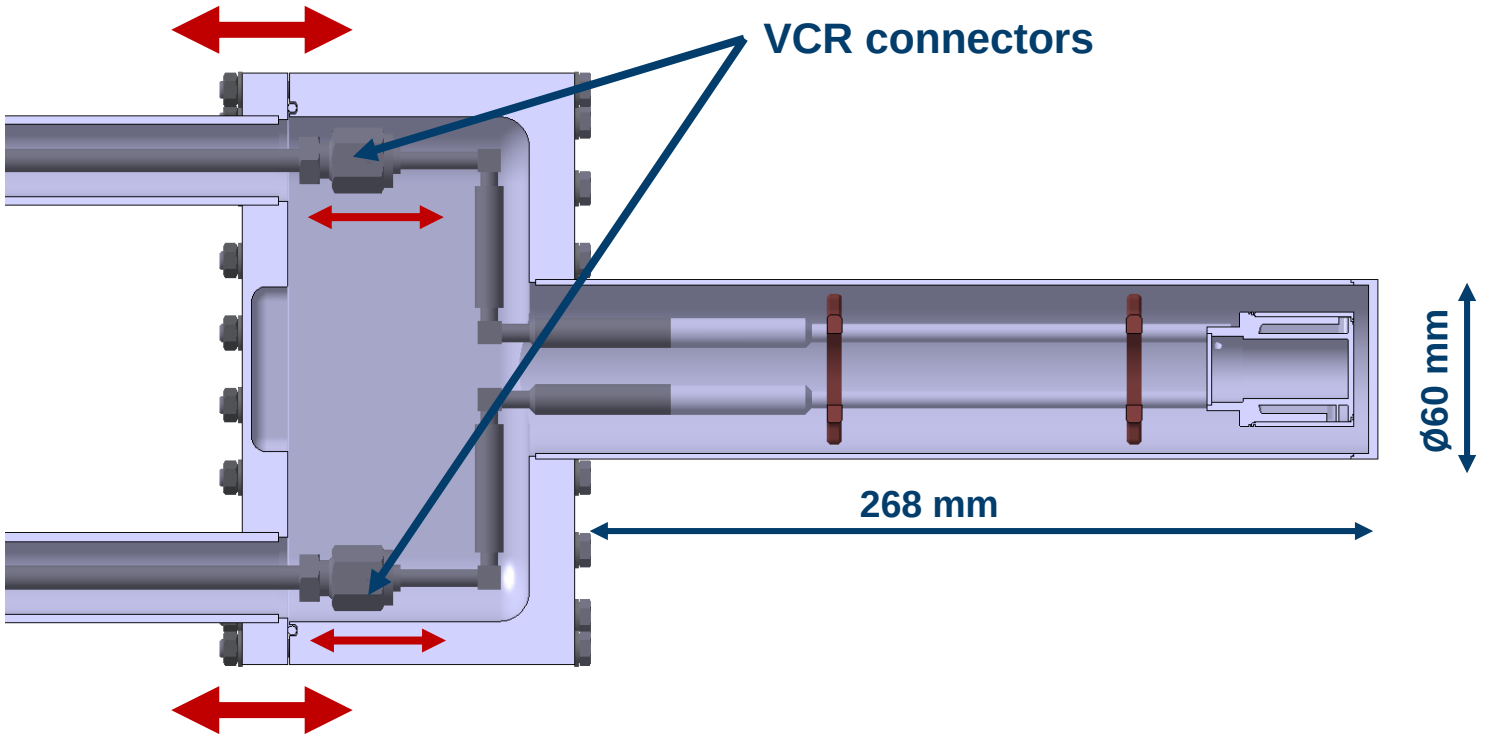
Coolant:

- Liquid helium (LHe)



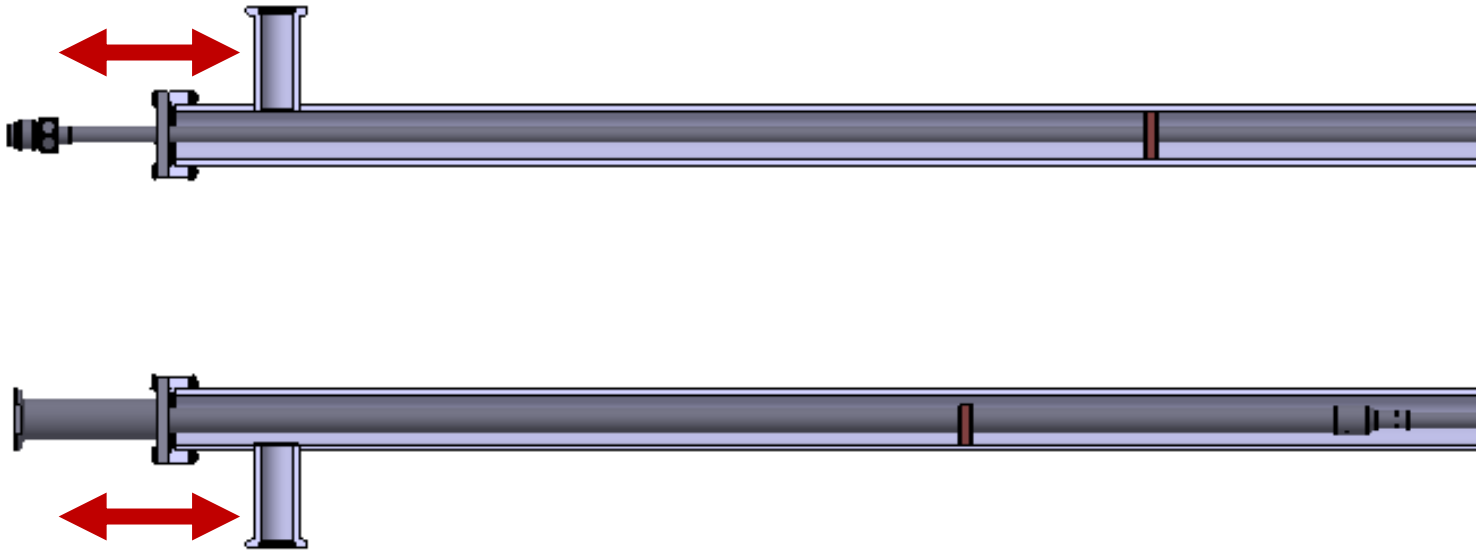
10K CRYOSTAT

- Demountable metal-sealed VCR adapters to ensure changing of moderator vessel



10K CRYOSTAT

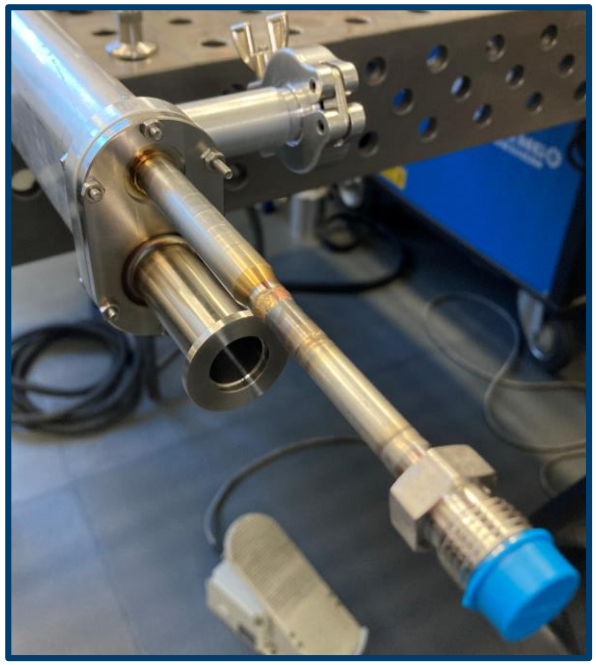
- Demountable elastomer-sealed flanges to ensure changing of transfer line section



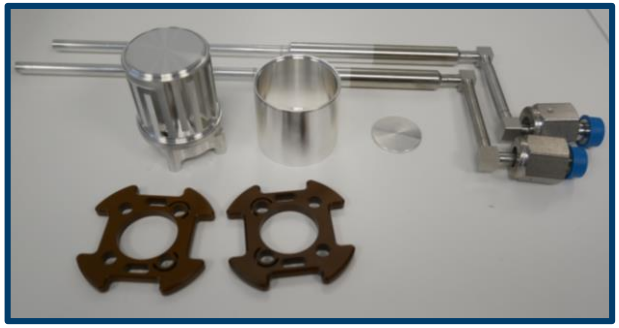
MANUFACTURING STATUS

Vacuum recipient

Transfer lines

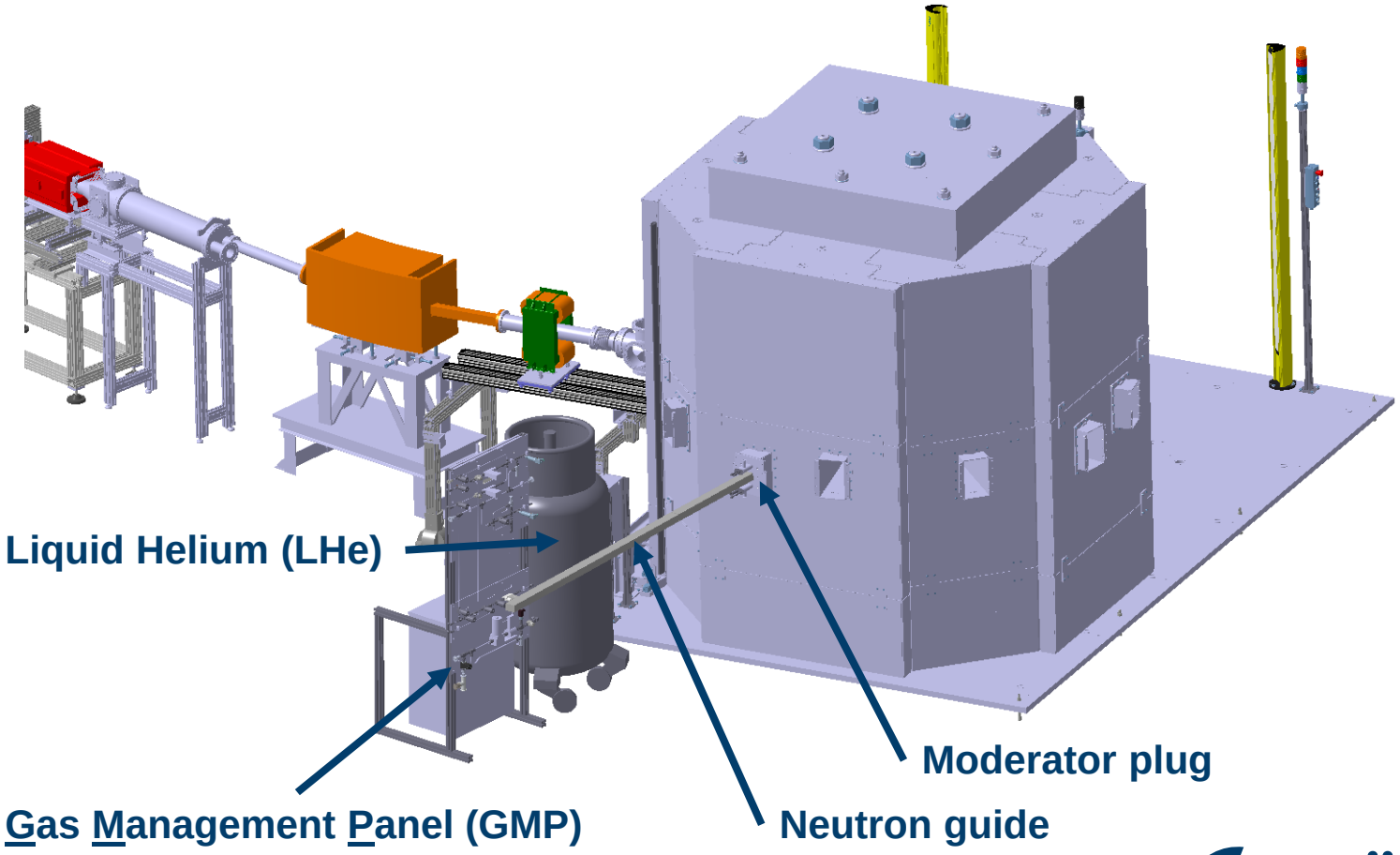


Moderator vessel



Gas management panel

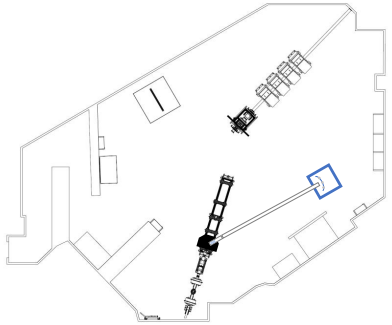
PLANNED SETUP AT PROTOTYPE



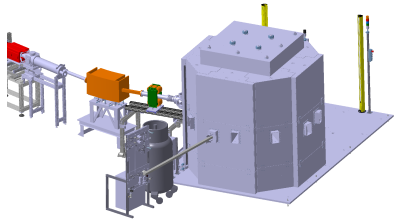
OUTLOOK

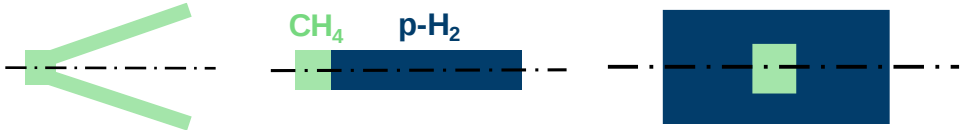
- **Experiments on thermal conductivity of different Al structures for increasing $\lambda_{th,eff}$ of cryogenic solid neutron moderators**

- **Measurement of neutron spectrum with solid methane at approximately 5 K with & without Al foam**



- **Commissioning of cryogenic solid moderator system at prototype TMR**
- **Experimental investigation of different moderators & geometries**





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Thank you for your attention!