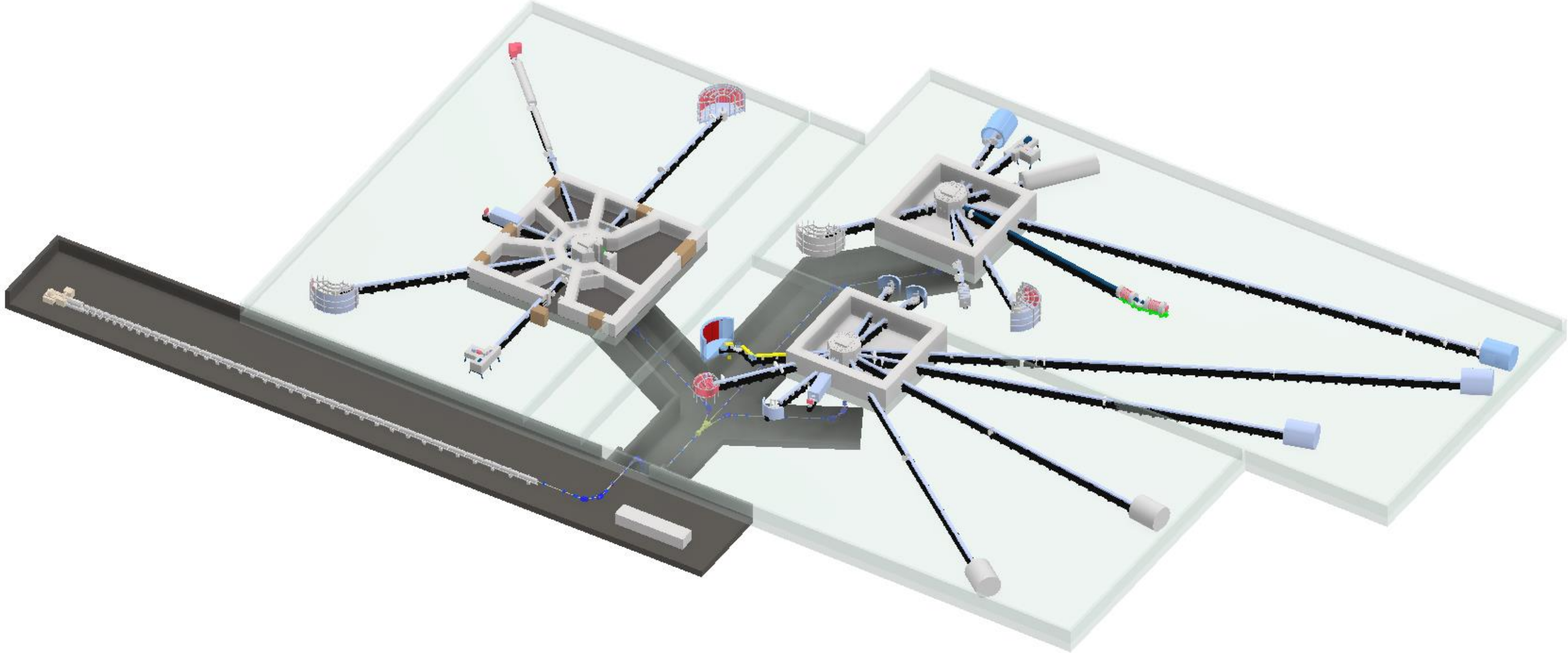
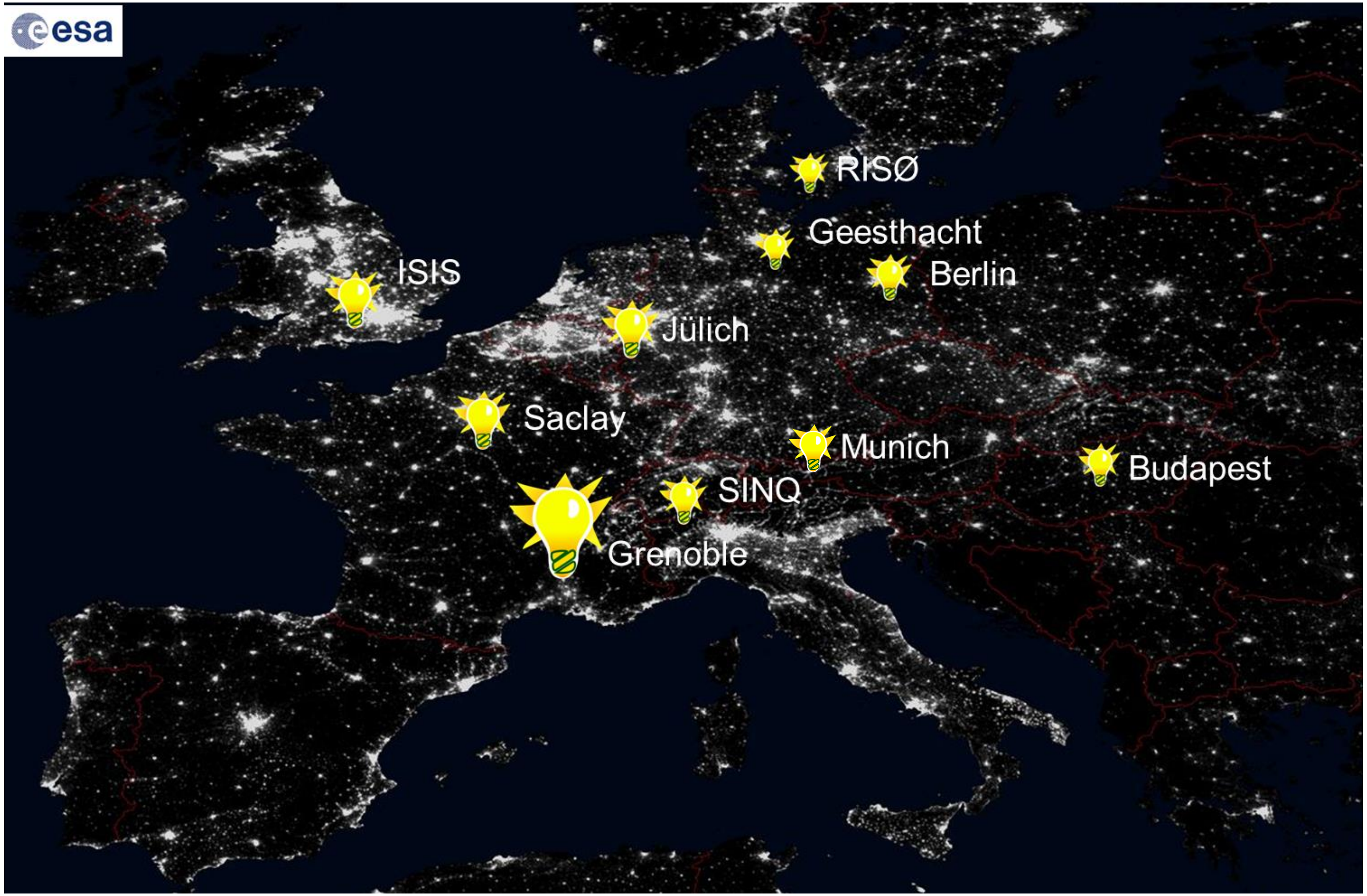


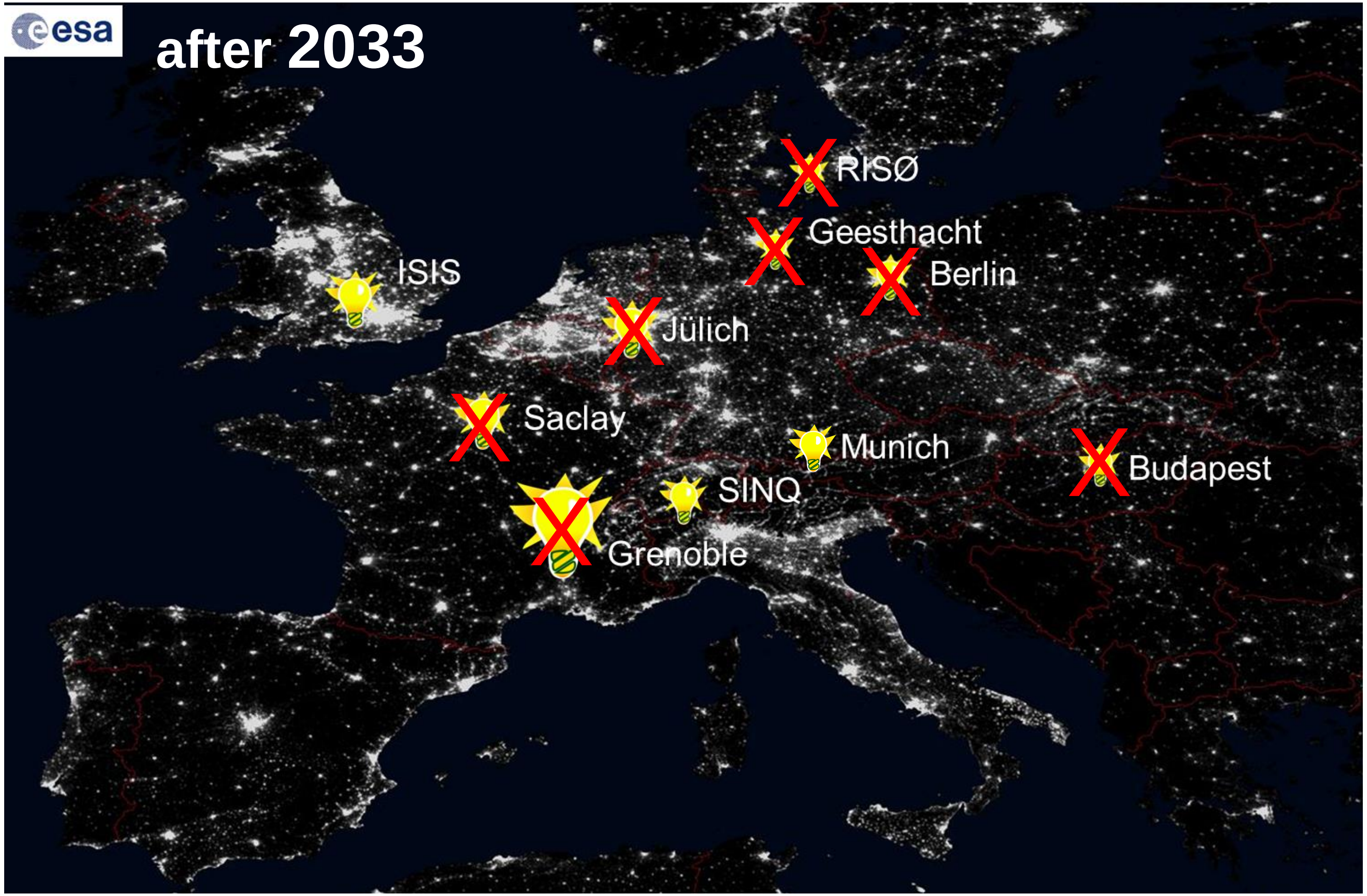
The Jülich High-Brilliance Neutron Source Project

Paul Zakalek, JCNS

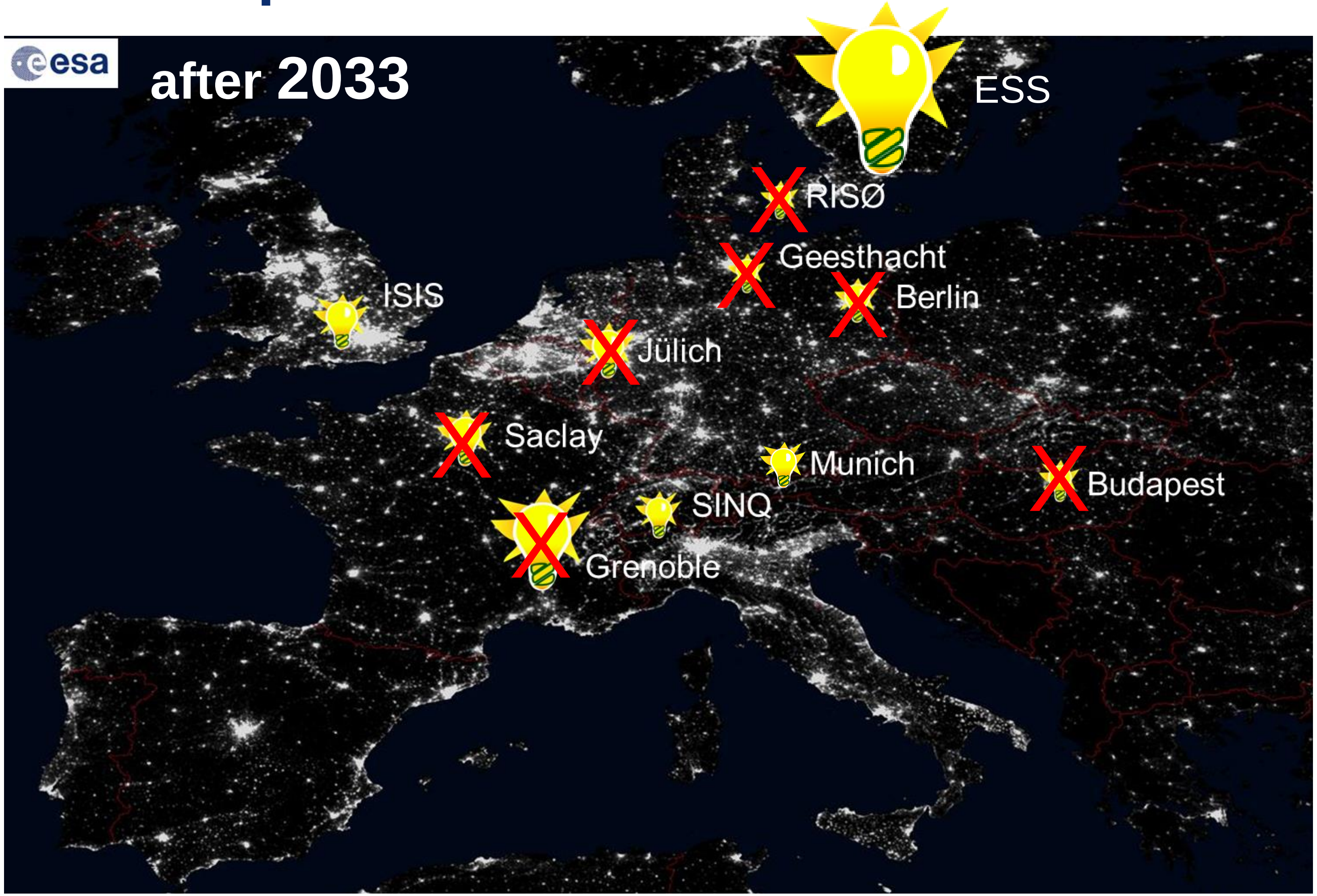
European Landscape



European Landscape

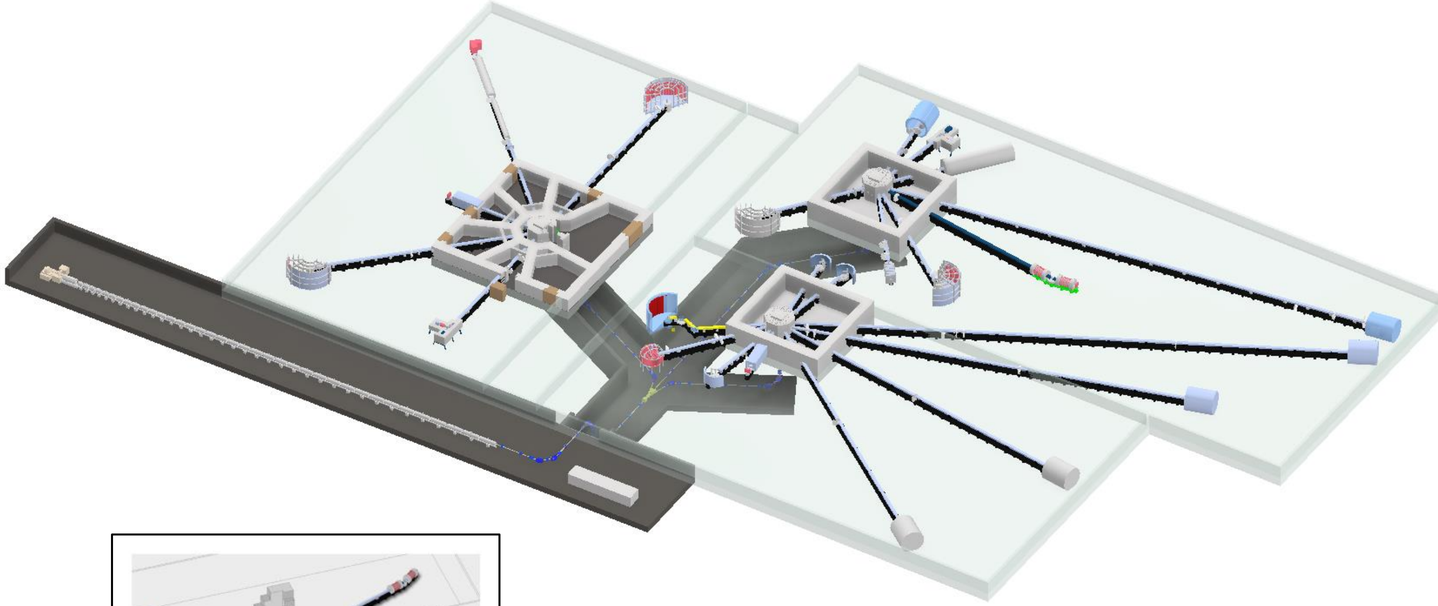


European Landscape



HBS, a High-Current Accelerator-driven Neutron Source (HiCANS)

Project rationale



High current linear accelerator

- 100 mA, 70 MeV pulsed proton beam
- Variable frequency

Several target stations

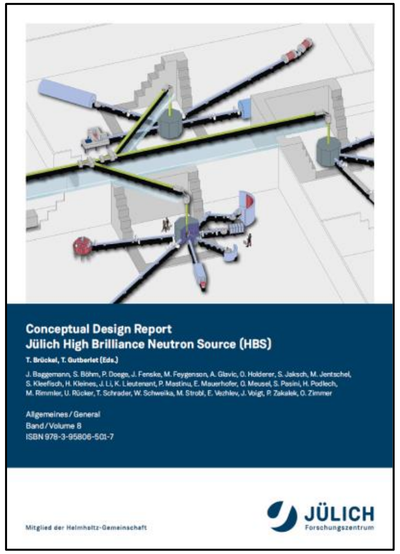
- Optimize pulse structure (length, rep. rate)
- Optimize thermal spectrum

Every beam port serves only 1 Instrument

- Optimize neutron source spectrum
- Optimize geometry
- Integrate neutron optics with beam port

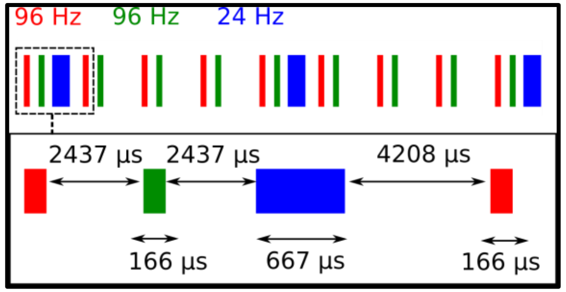
Small shielding

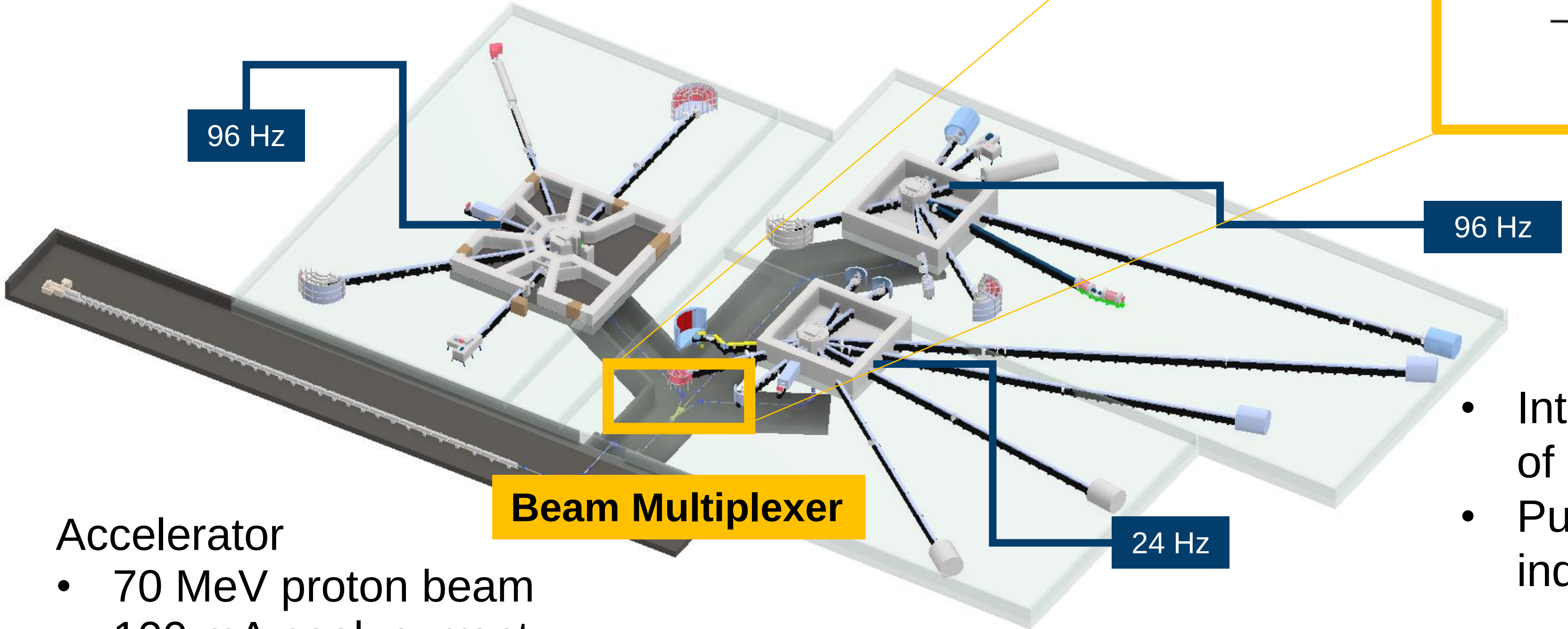
- Neutron guide around cold source
- Chopper at <2 m from target

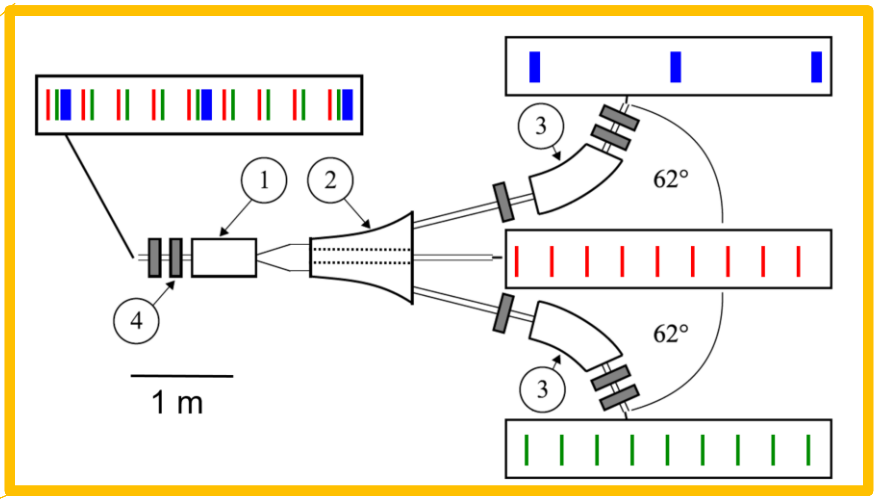


www.fz-juelich.de/jcns/jcns-2/EN/Forschung/High-Brilliance-Neutron-Source/_node.html

HBS Layout







- Interlaced pulse structure allows operation of multiple target station with same power
- Pulse structure can be optimized to individual target stations

Accelerator

- 70 MeV proton beam
- 100 mA peak current
- 100 kW averaged per target station

HBS Target

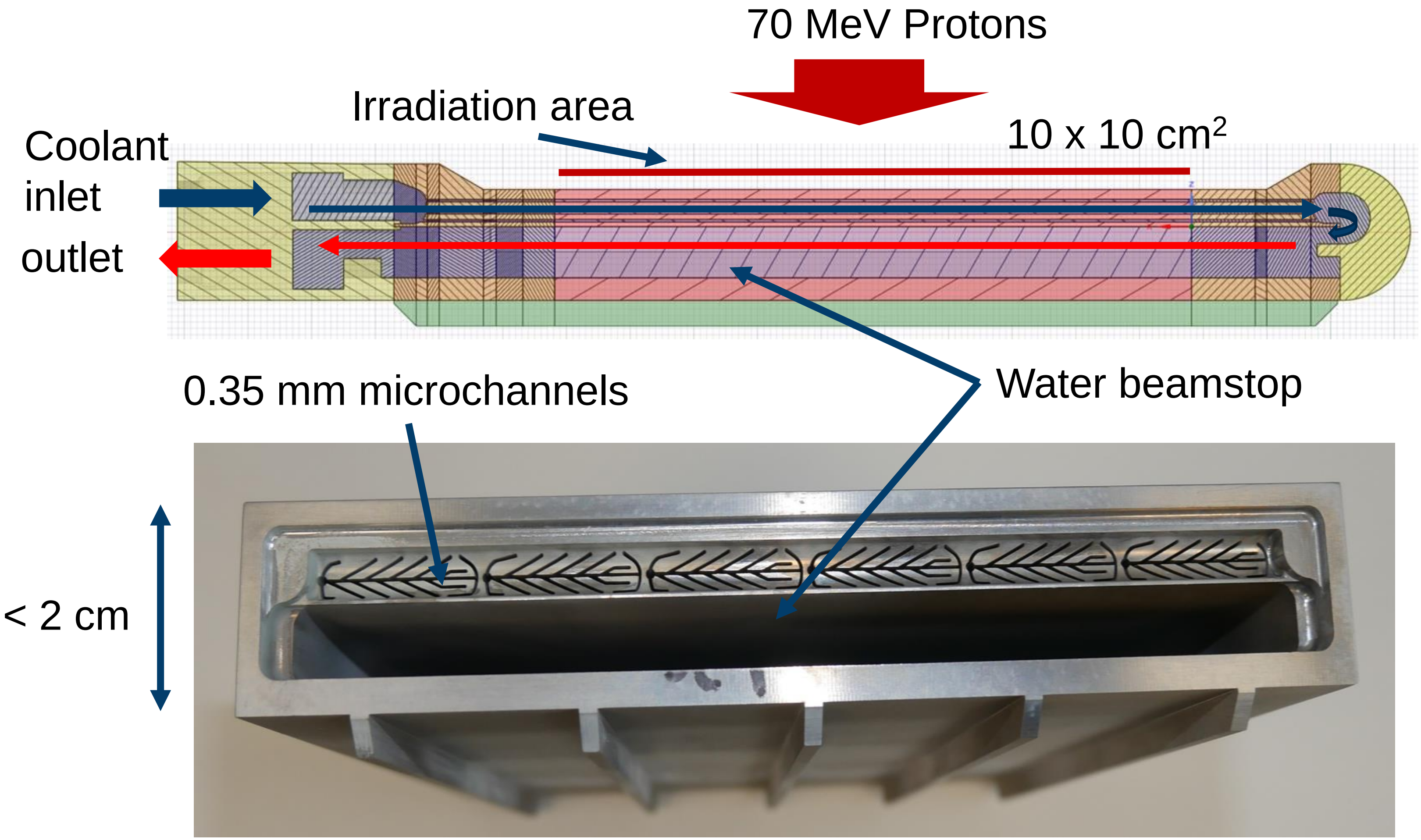
Neutron production

Requirements:

- High blistering threshold
- Compact design allowing efficient feeding of moderators
- Save operation at 100 kW at 100 cm² (1kW/cm²)
- Reliable

→ Tantalum target with microchannel design

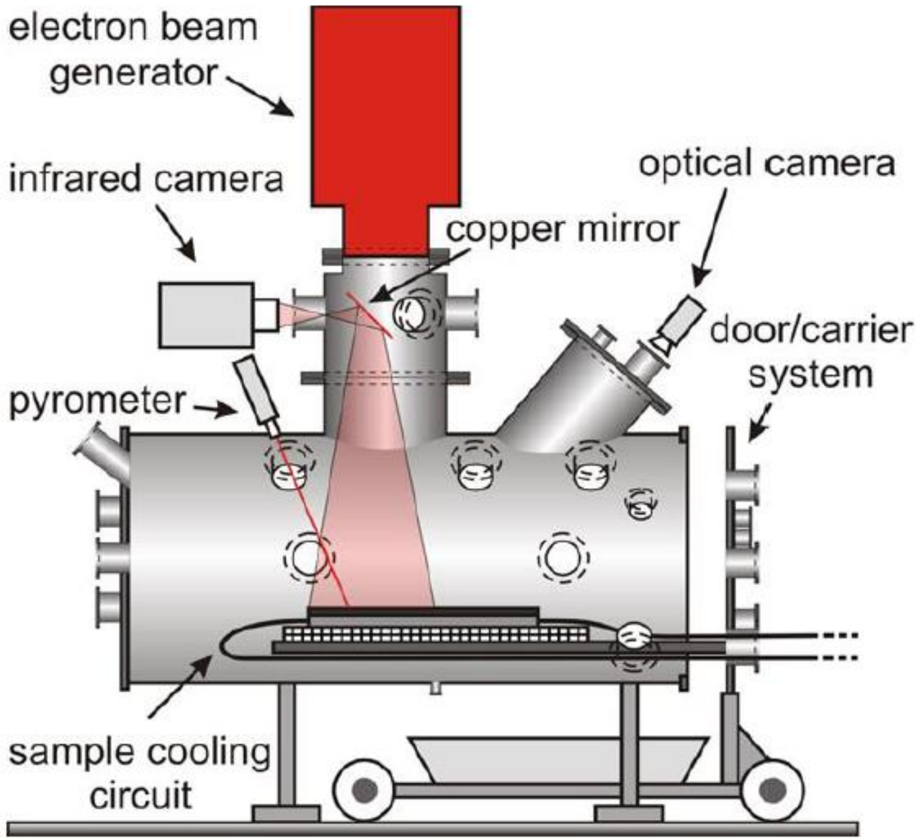
- Neutron yield of 10^{15} n/s



Target system

Probing target stability

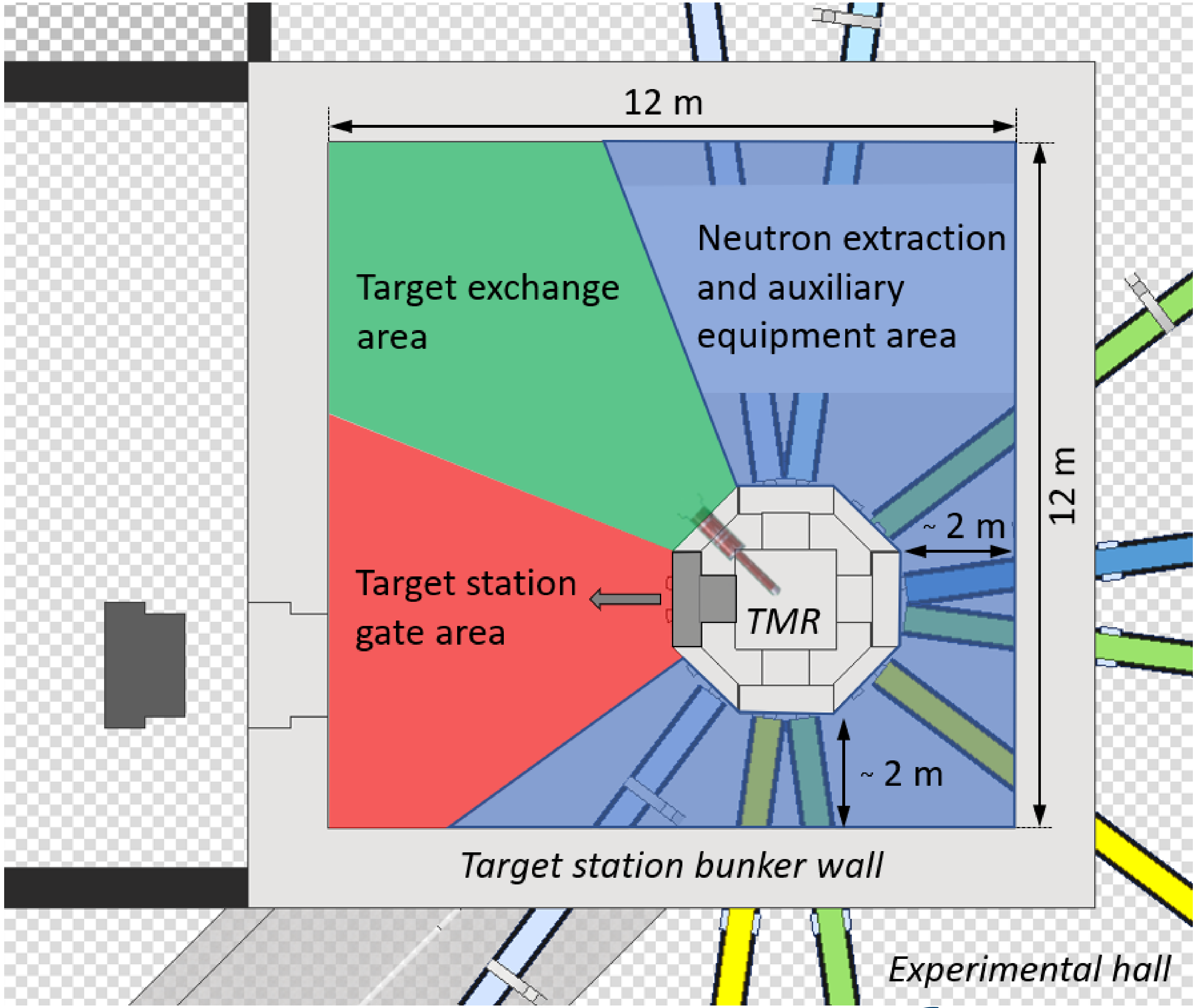
Succesful test at JUDITH-2 electron gun with up to 1 kW/cm² heat input on the surface indicating a possible higher power deposition



Further experiment planed to determine critical heat flux and power limit

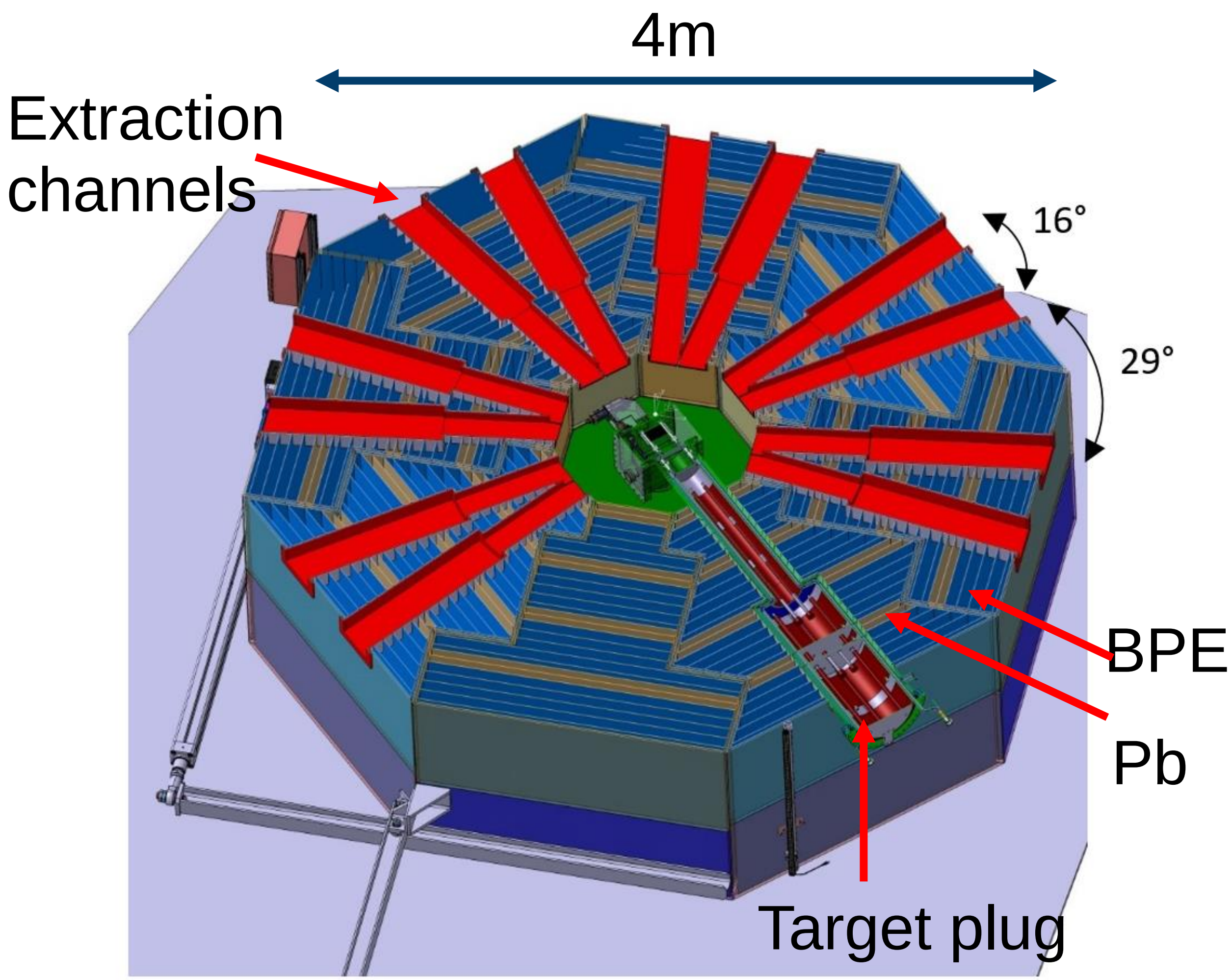
Target station bunker

- Compact target station with 4 m diameter
- Easy access after shutdown and maintenance possibilities
- Around 270° available space for instruments
- Optical elements can be placed close to moderator inside target bunker room

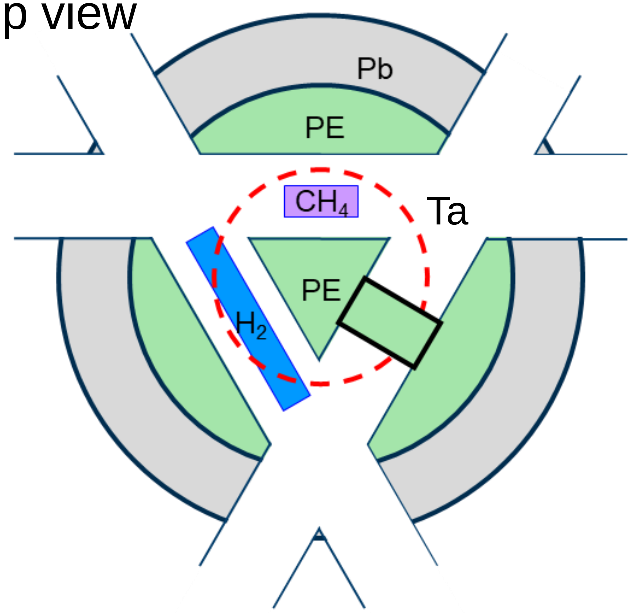


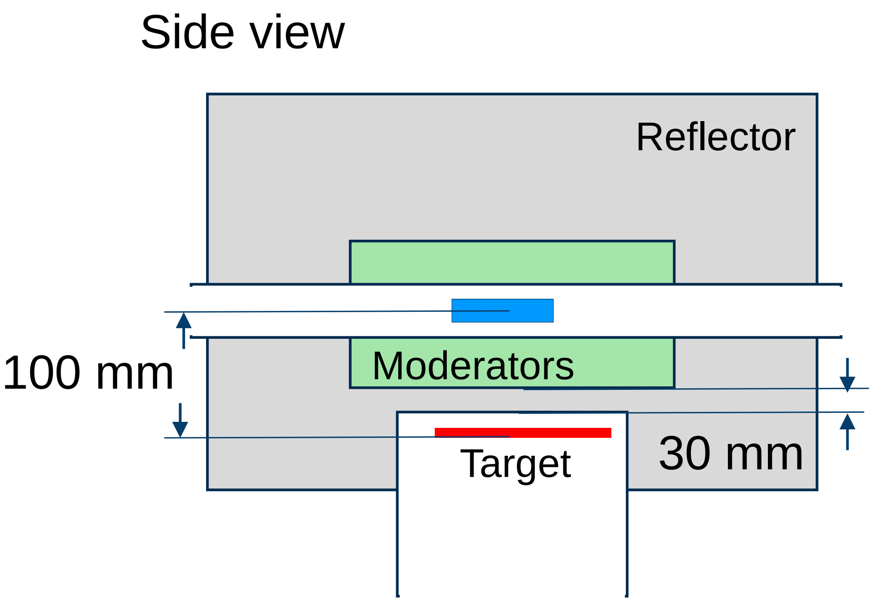
Target station

- Layered shielding design of BPE & Pb allows compact target station design
- Optical elements like choppers and neutron guides can be placed close to moderator surface
- Vertical beam allows extraction within large angular arc



Target-Moderator-Reflector



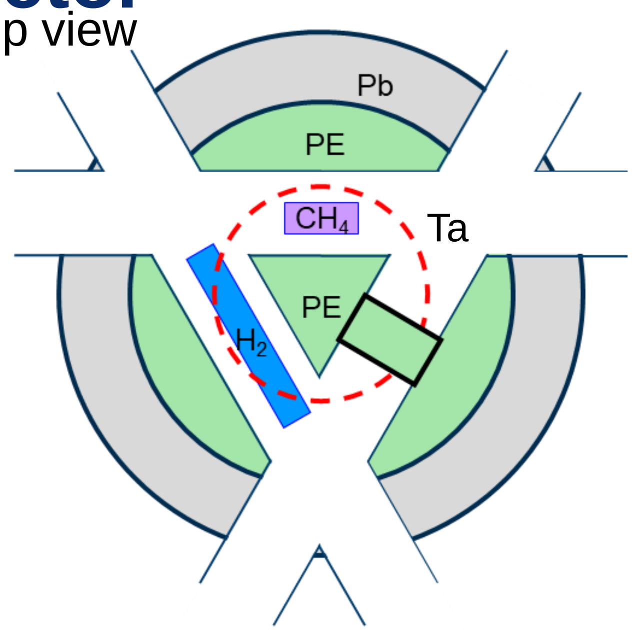


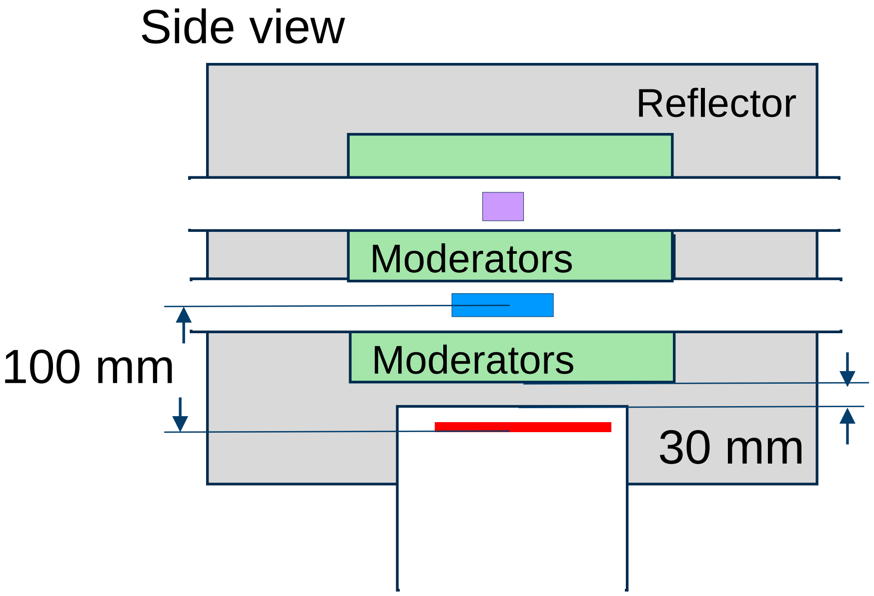
- Compact TMR design:
  - Efficient coupling of neutron production and moderation
  - High neutron flux in moderator

→ High Brightness

- Variable extraction channel design allows thermal, cold, bispectral and very cold extraction

Target-Moderator-Reflector





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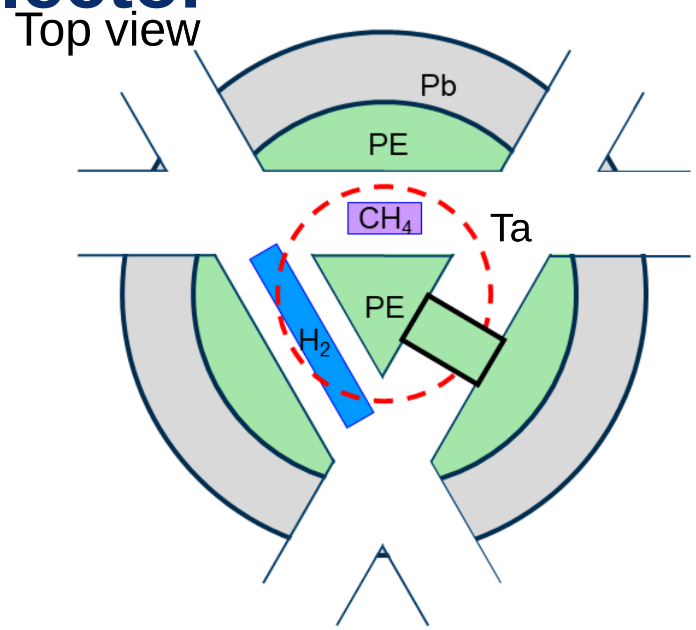

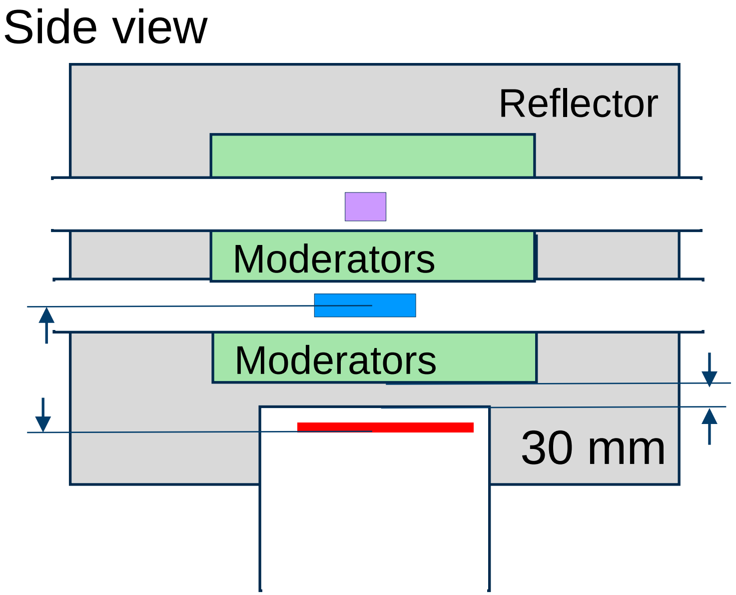

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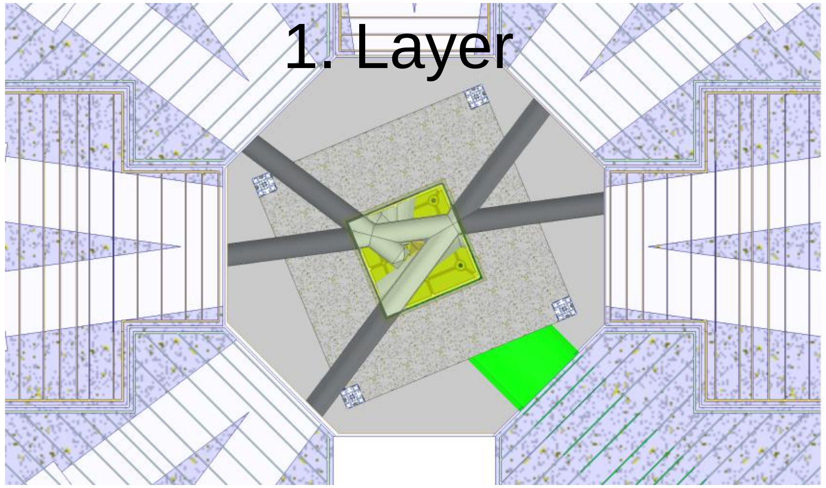
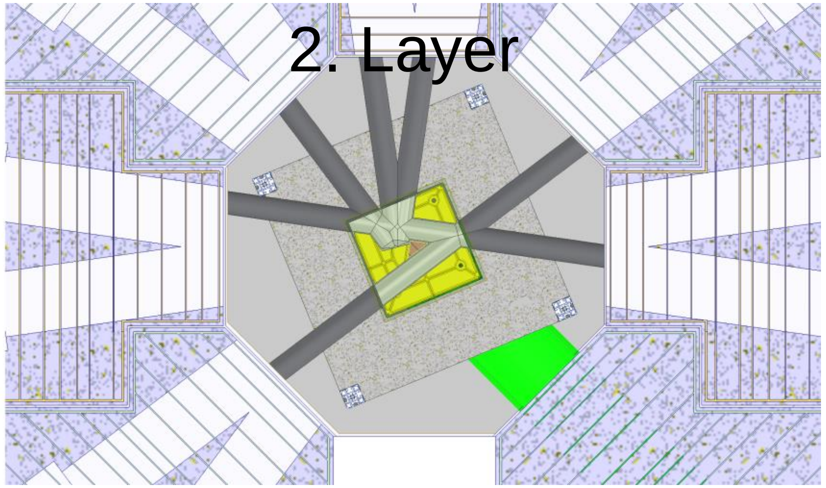
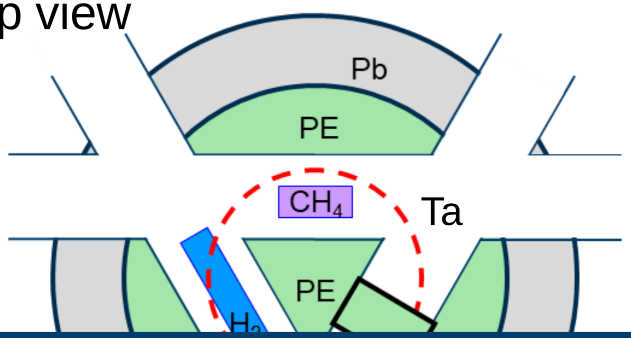
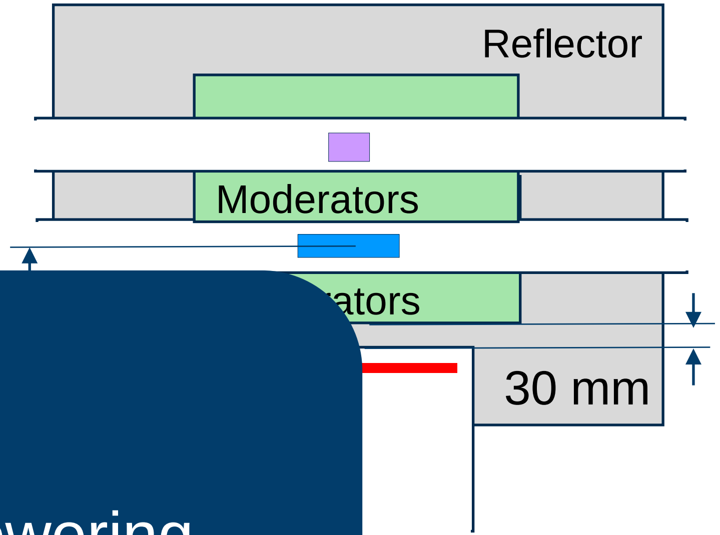




Target-Moderator-Reflector





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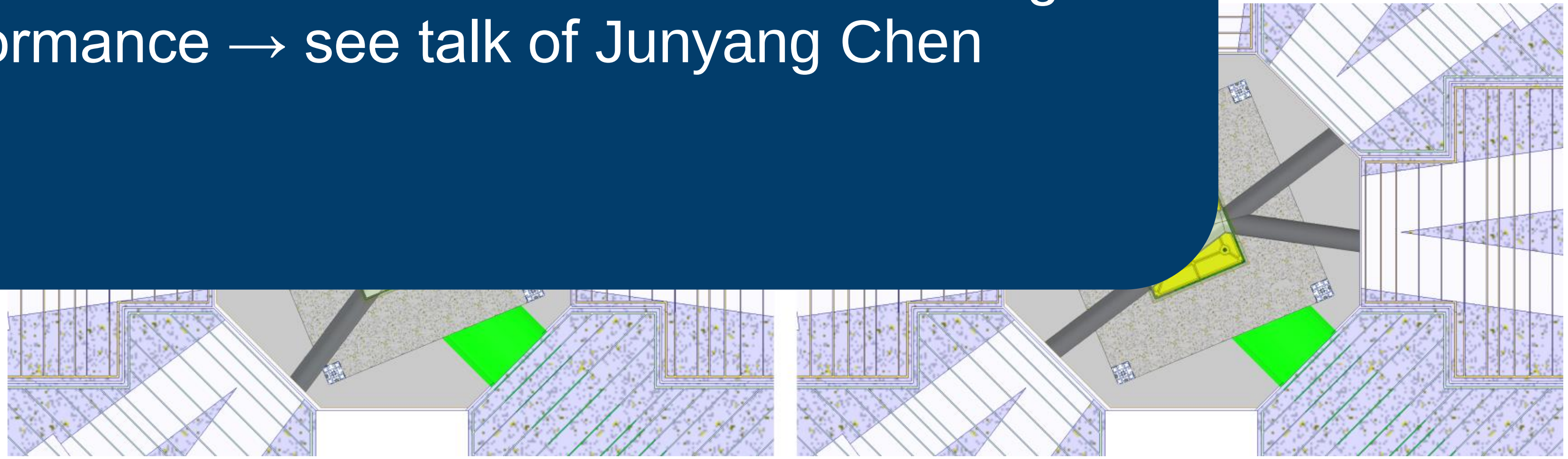
  - Efficient cou
    neutron pro
    moderatio
  - High neutr
    moderator

→ High Brig

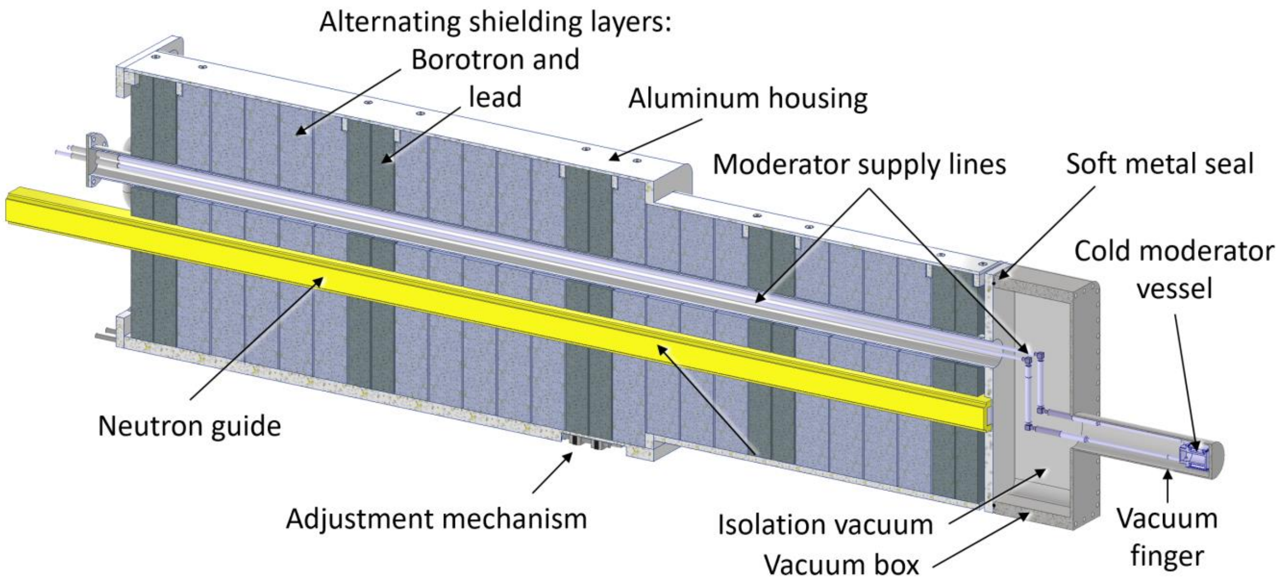
- Variable extrac
  design allows the
  bispectral and very cold
  extraction

Dilution of thermal moderator and thus lowering performance → see talk of Junyang Chen

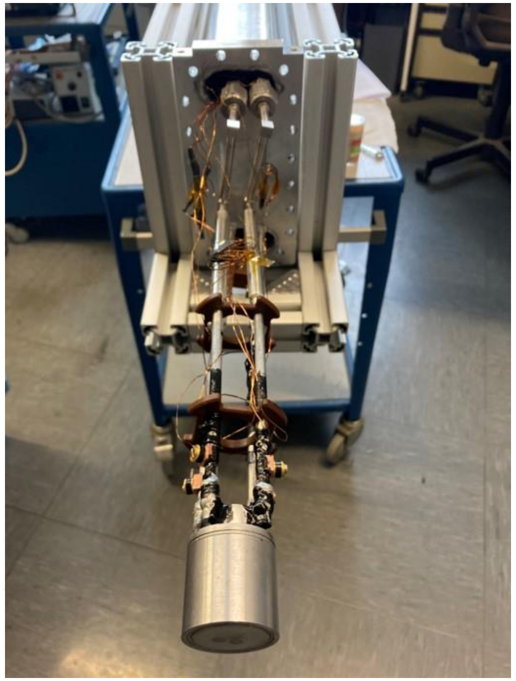


Moderator Plug

- Individual and optimized moderators for each instrument tailoring neutron energy spectrum
- Easy replacement and modification of single moderators
- Neutron guides placed as close as 40 cm to moderator surface extraction large divergence



Moderator Plug



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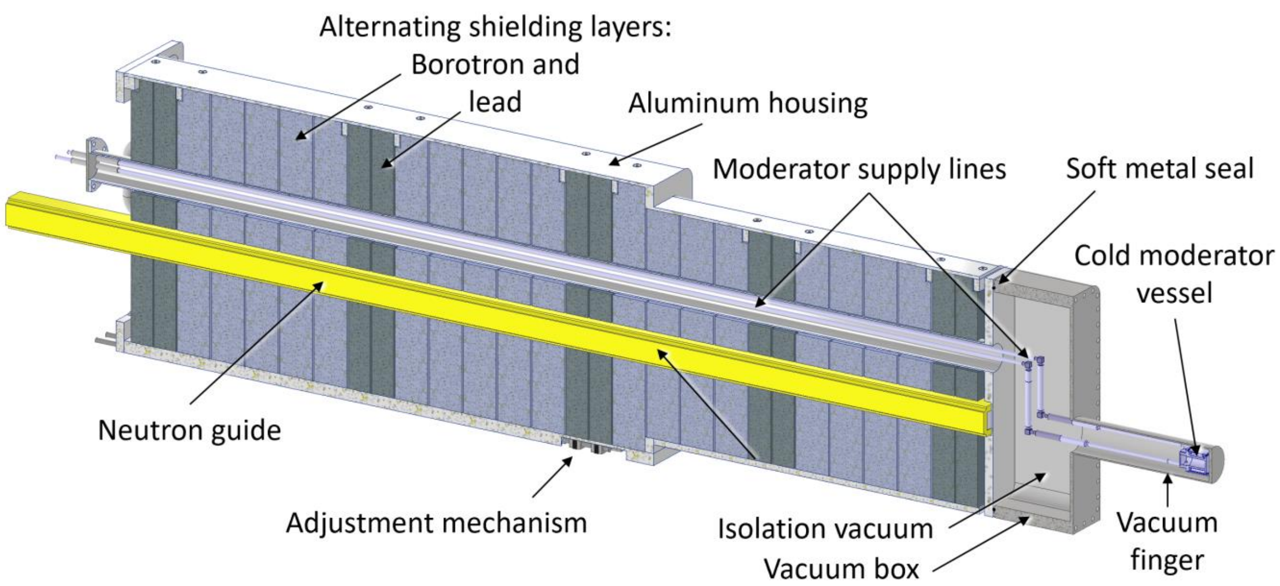

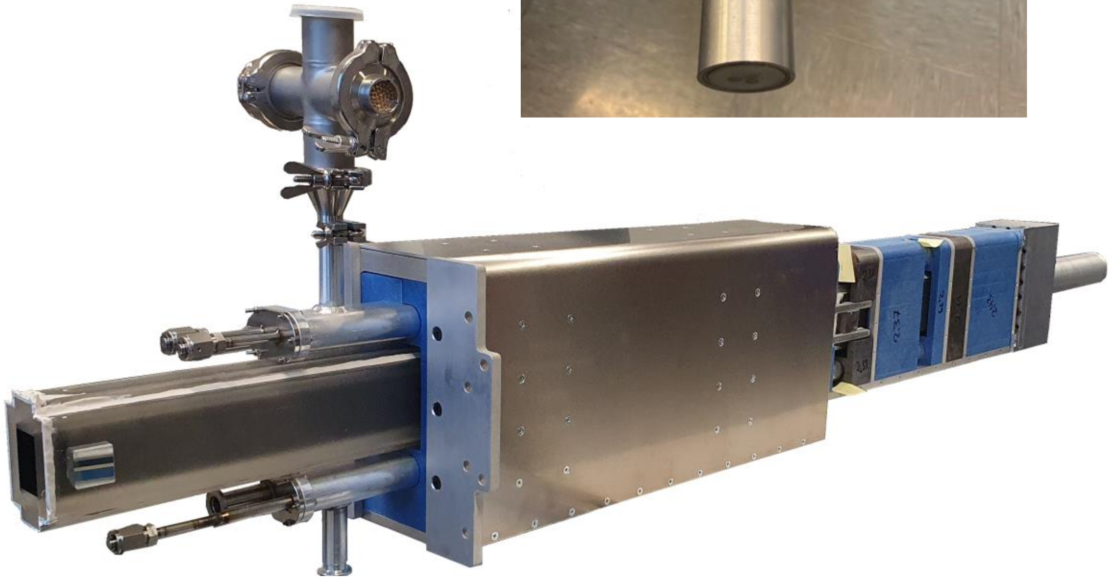

Moderator Plug

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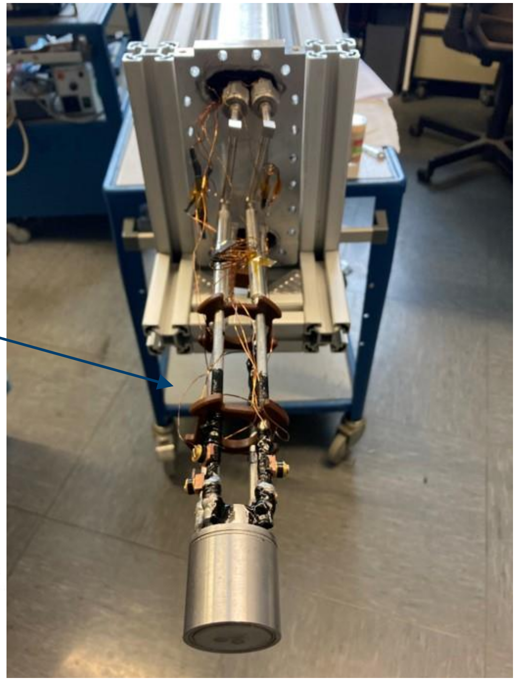
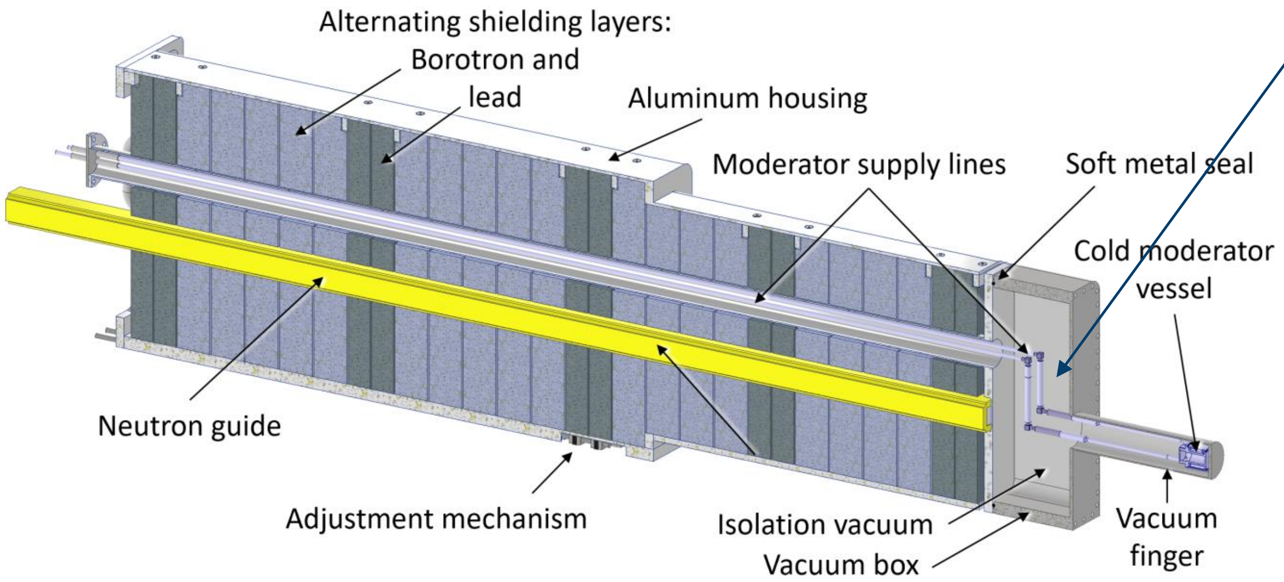
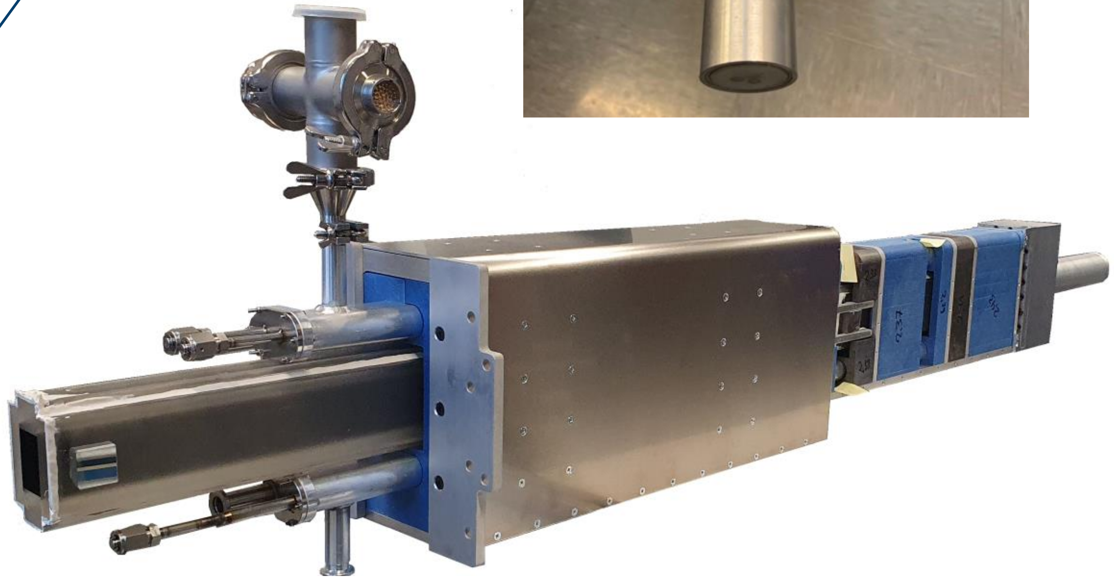
- Easy replacement and modification of single moderators
- Neutron guides placed as close as 40 cm to moderator surface extraction large divergence

To many swagelok connection and thus difficulty to get leak tight







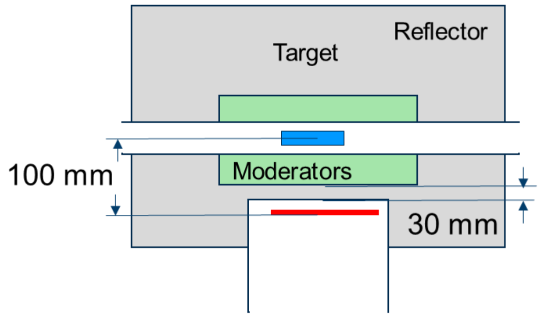
Jülich Centre for Neutron Science

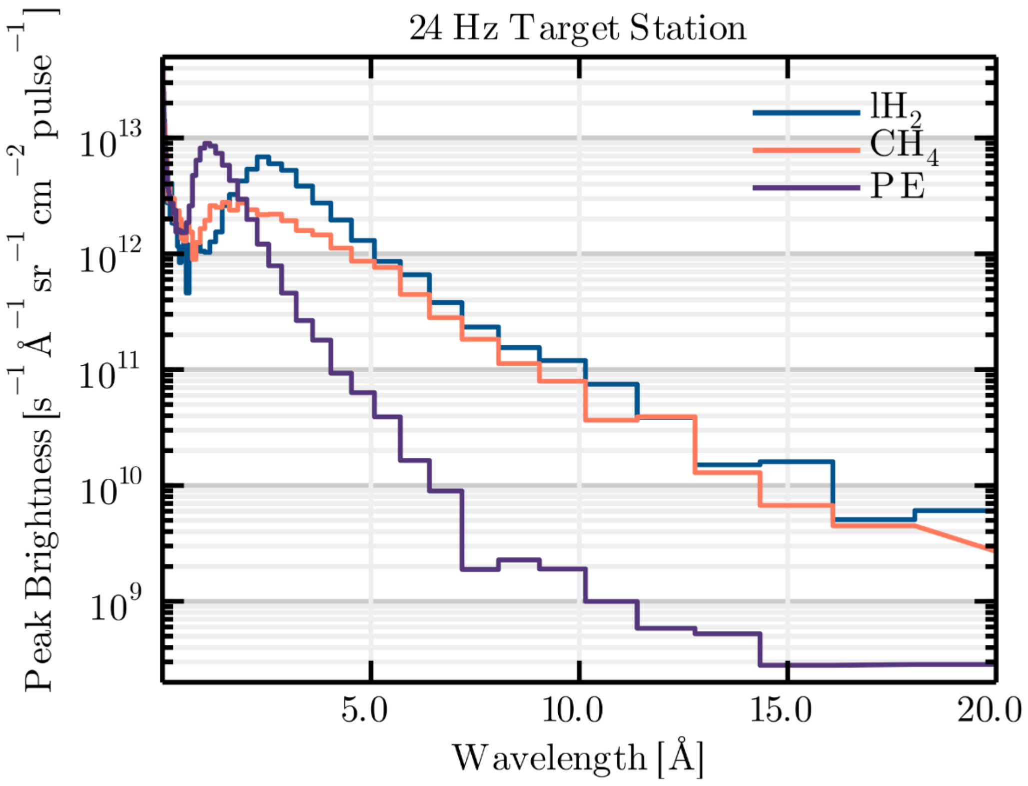
HIGH BRILLIANCE SOURCE

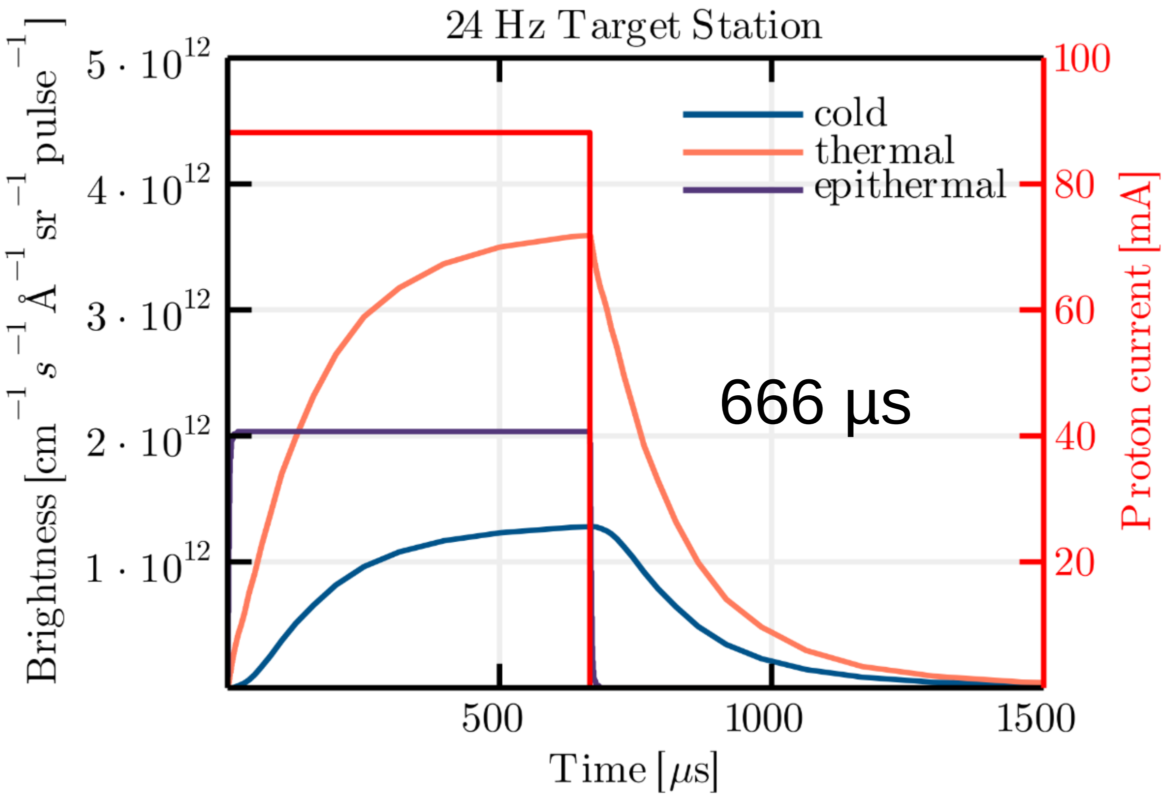
JÜLICH Forschungszentrum

Peak Brightness

24 Hz Target station







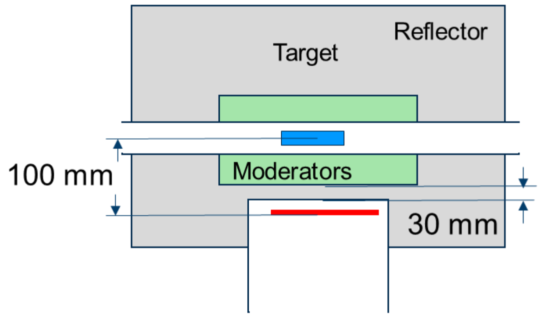
Jülich Centre for Neutron Science

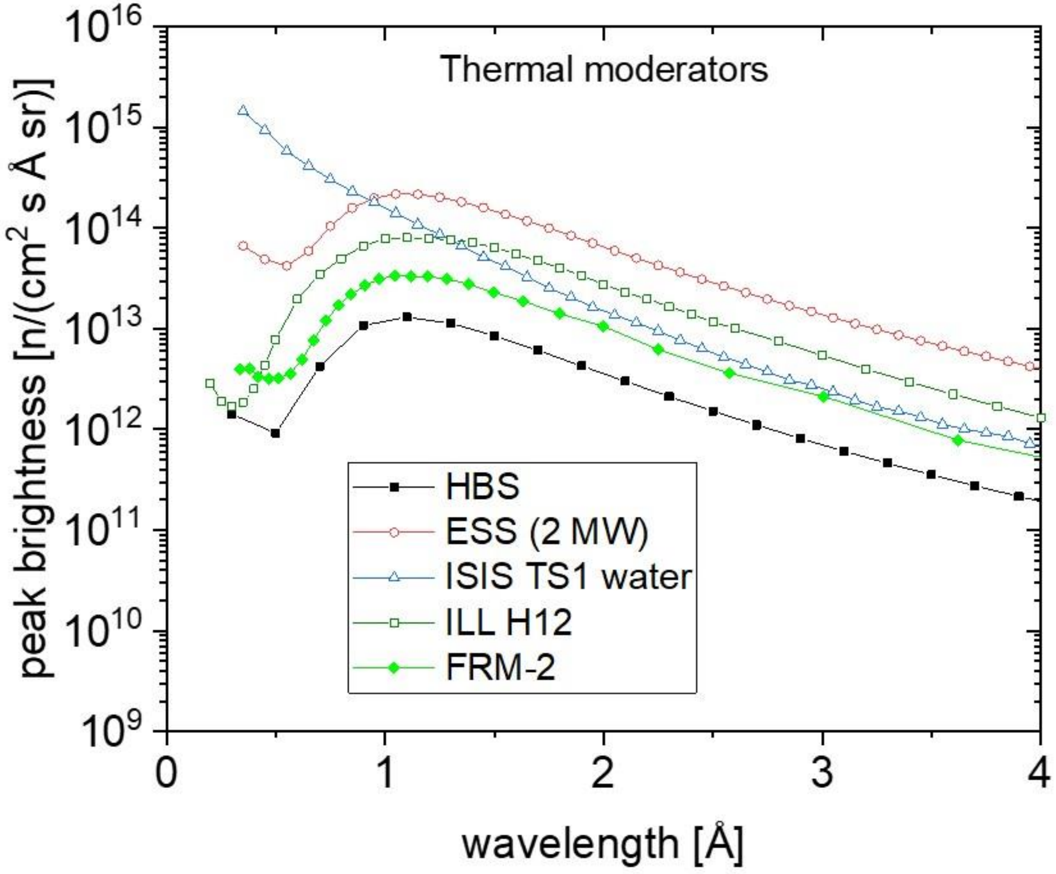
HIGH BRILLIANCE SOURCE

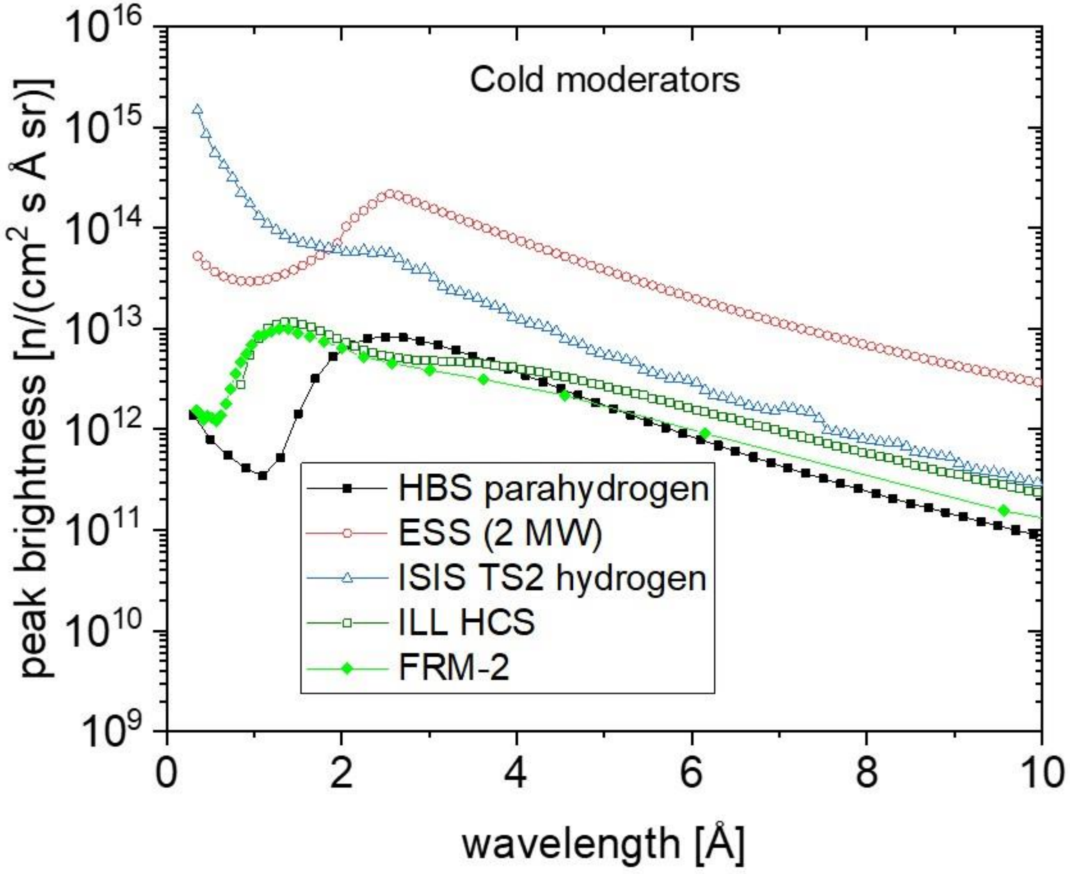
JÜLICH Forschungszentrum

Peak Brightness

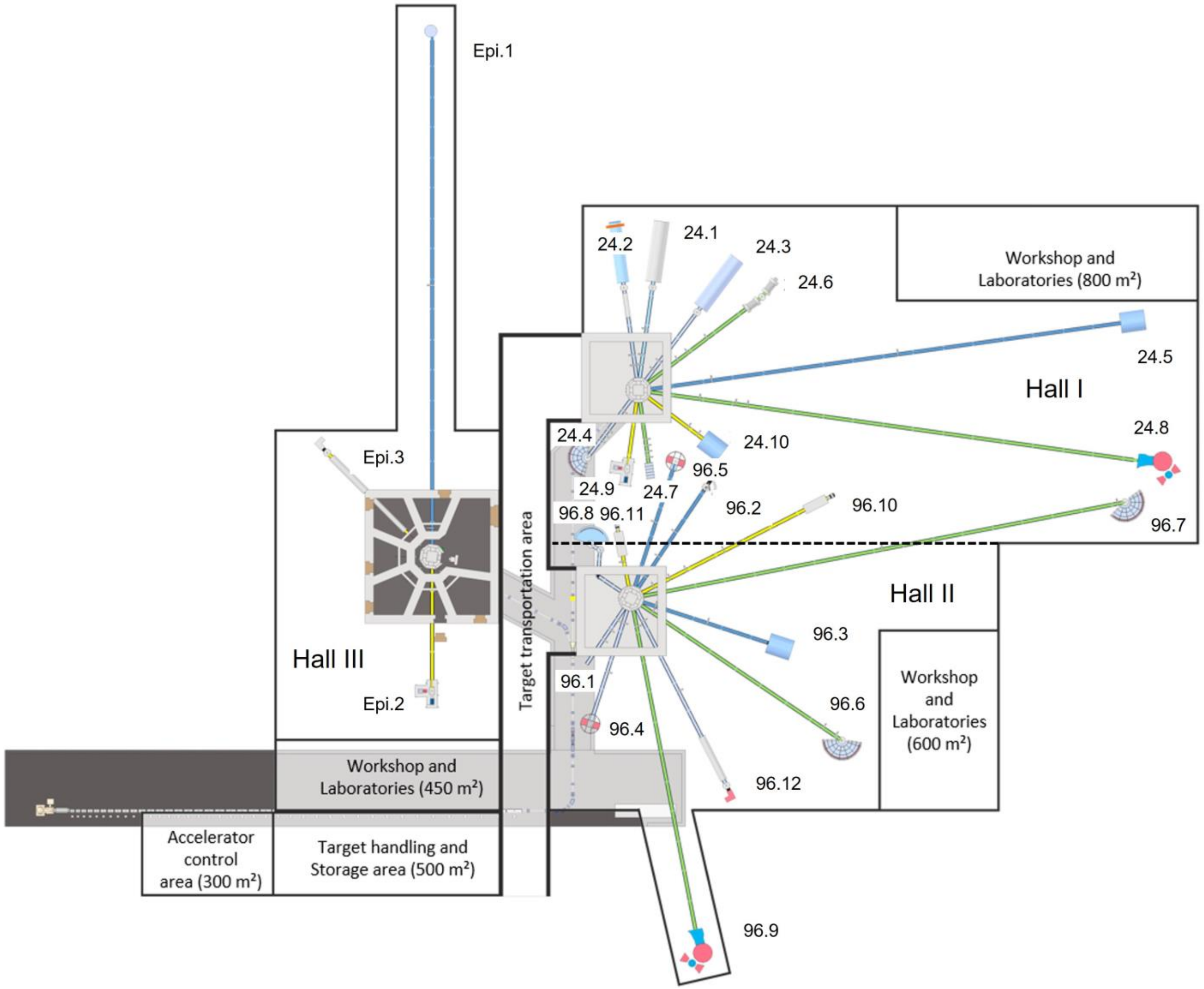
Comparison







HBS Facility



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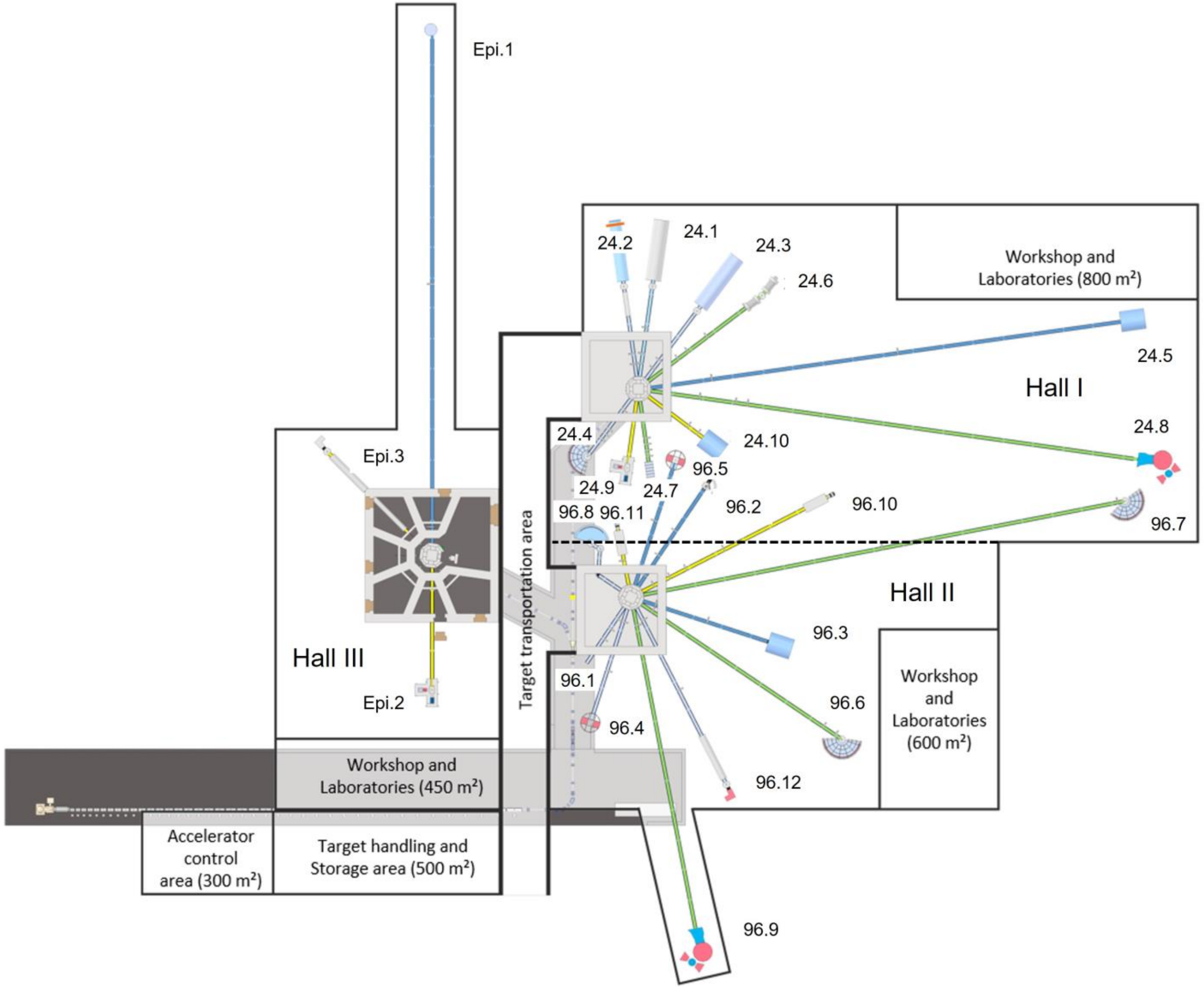
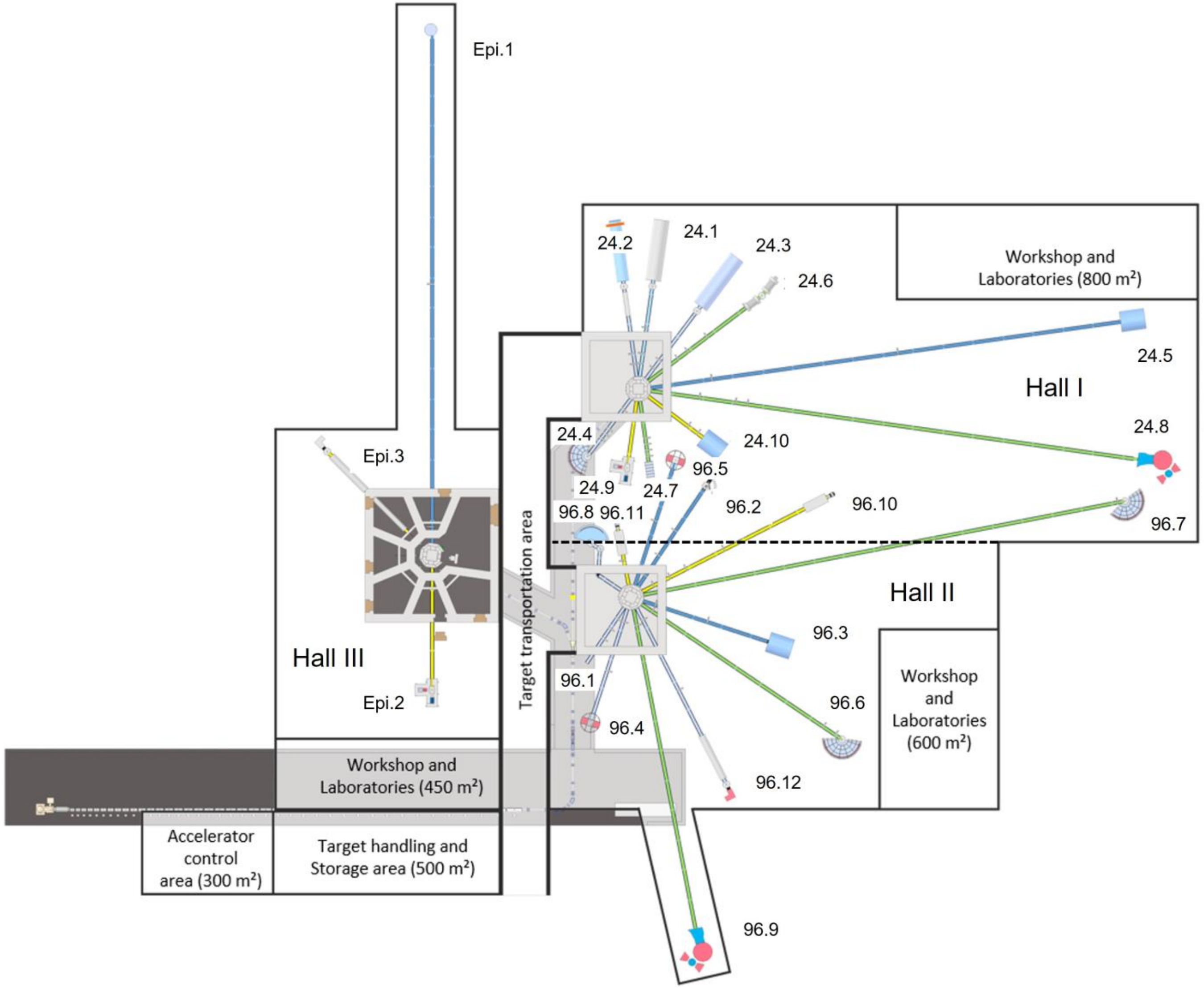


	Instrument	τ_{pulse} [μs]	L_{tot} [m]	Det. Cov. [Sr.]	λ_{min} [Å]	λ_{max} [Å]	$\frac{\delta\lambda_{pulse}}{\lambda_{min}}$ [%]	$\frac{\delta\lambda_{pulse}}{\lambda_{max}}$ [%]	$\phi_{average}$ 10^6[n/cm^{2}s]	Remarks
24.1	High Throughput SANS	667	24	0.01	2.0	8.7	5.5	1.3	2.2	Low angle
			15	0.7	2.0	8.7	8.8	2.0	220	Wide angle
24.2	SANS + GISANS	667	24	0.01	3.0	9.8	3.7	1.1	2.2	Low angle
			15	0.7	3.0	9.8	5.9	1.8	220	Wide angle
24.3	SANS + VSANS	667	23	0.01	2.0	9.0	5.7	1.3	2.7	Low angle
			15	0.7	2.0	9.0	8.8	2.0	220	Wide angle
24.4	Offspecular Reflectometer	667	13	0.08	2.0	12.5	10.1	1.6	1.1	
24.5	Therm. Powder Diffr.	29	80	6.25	0.6	2.7	0.2	0.1	0.7	High Res., 2 frames
		667	80	6.25	0.6	2.7	5.5	1.2	120	High Int., 2 frames
24.6	NSE	667	35	0.04	5	16	1.3	0.5		Very cold neutrons
24.7	NRSE	667	14	0.04	5	16	3.8	1.2		Very cold neutrons
24.8	Backscattering Spectrometer	70	85	2.5	5.8	7.8	0.06	0.04	8	
24.9	PGNAA-1	667	12.4		0.03	9			220	
24.10	NDP	667	15		2	15			44000	

HBS Facility



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24.5	Therm. Powder Diffr.	29	80	6.25	0.6	2.7	0.2	0.1	0.7	High Res., 2 frames
		667	80	6.25	0.6	2.7	5.5	1.2	120	High Int., 2 frames
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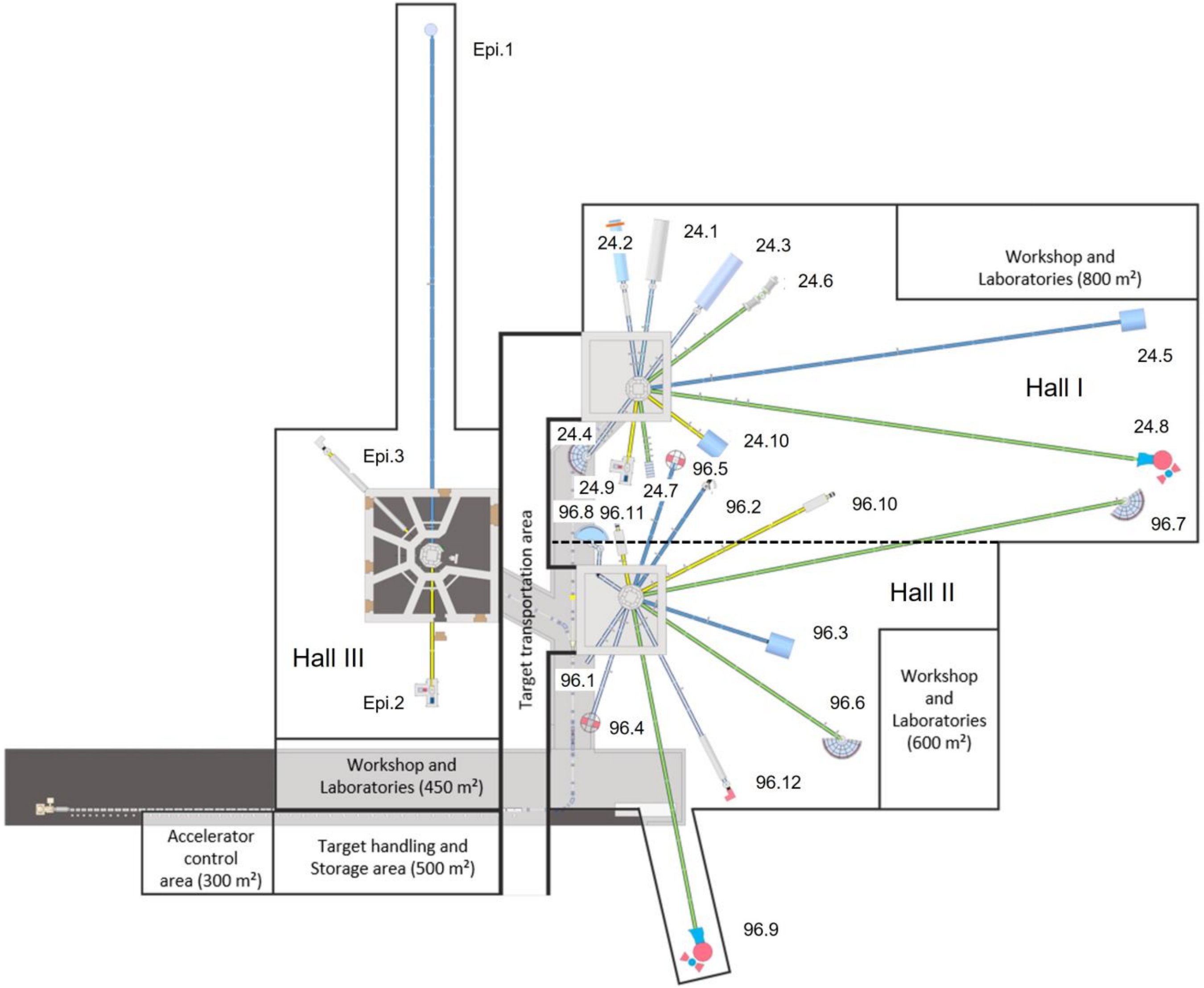
24.9	PGNAA-1	667	12.4		0.03	9			220	
24.10	NDP	667	15		2	15			44000	
96.1	Hor. Reflectometer	252	11	0.01	5	8.64	1.8	1.0	87	Small sample
		252	11	0.01	1.6	5.25	5.7	1.7	14	Multi Beam
96.2	Engineering Diffr.	35	21.8	3.0	0.8	2.68	0.8	0.2	0.5	
96.3	Diffuse scatt. Spectr.	252	21.5	2.39	2	3.9	2.3	1.2	96	
96.4	Pol. Diffuse Neutron Spectr.	252	21.5	2.04	2	3.9	2.3	1.2	21	
96.5	Small sample Diffr.	252	20.4	9	2	4	2.4	1.2	49	
96.6	Cold Chopper Spectr.	252	18.5	3.14	2	10	1.5	0.7	0.9	
96.7	Thermal Chopper Spectr.	252	60	3.14	0.9	3.5	2	0.5	0.1	5 frames
96.8	CRYSTOF	252	10.5	3.14	0.9	3.5	3	1.5	0.4	
96.9	Indirect Geom. Spectr.	252	60	1.7	3	3.7	0.6	0.4	120	
96.10	Cold imaging	252	15		1	15	6.6	0.4	1.6	High Res.
		252	5		1	15	19.9	1.3	12	High Int.
96.11	Thermal imaging	252	10		0.5	4.5	20	2.2	7.8	High Res.
		252	4		0.5	4.5	50	5.5	49	High Int.
96.12	Diffr. Imaging	252	35		1	15	2.8	0.2	8	

HBS Facility



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			15	0.7	2.0	9.0	8.8	2.0	220	Wide angle
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		667	80	6.25	0.6	2.7	5.5	1.2	120	High Int., 2 frames
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24.8	Backscattering Spectrometer	70	85	2.5	5.8	7.8	0.06	0.04	8	
24.9	PGNAA-1	667	12.4		0.03	9			220	
24.10	NDP	667	15		2	15			44000	
96.1	Hor. Reflectometer	252	11	0.01	5	8.64	1.8	1.0	87	Small sample
		252	11	0.01	1.6	5.25	5.7	1.7	14	Multi Beam
96.2	Engineering Diffr.	35	21.8	3.0	0.8	2.68	0.8	0.2	0.5	
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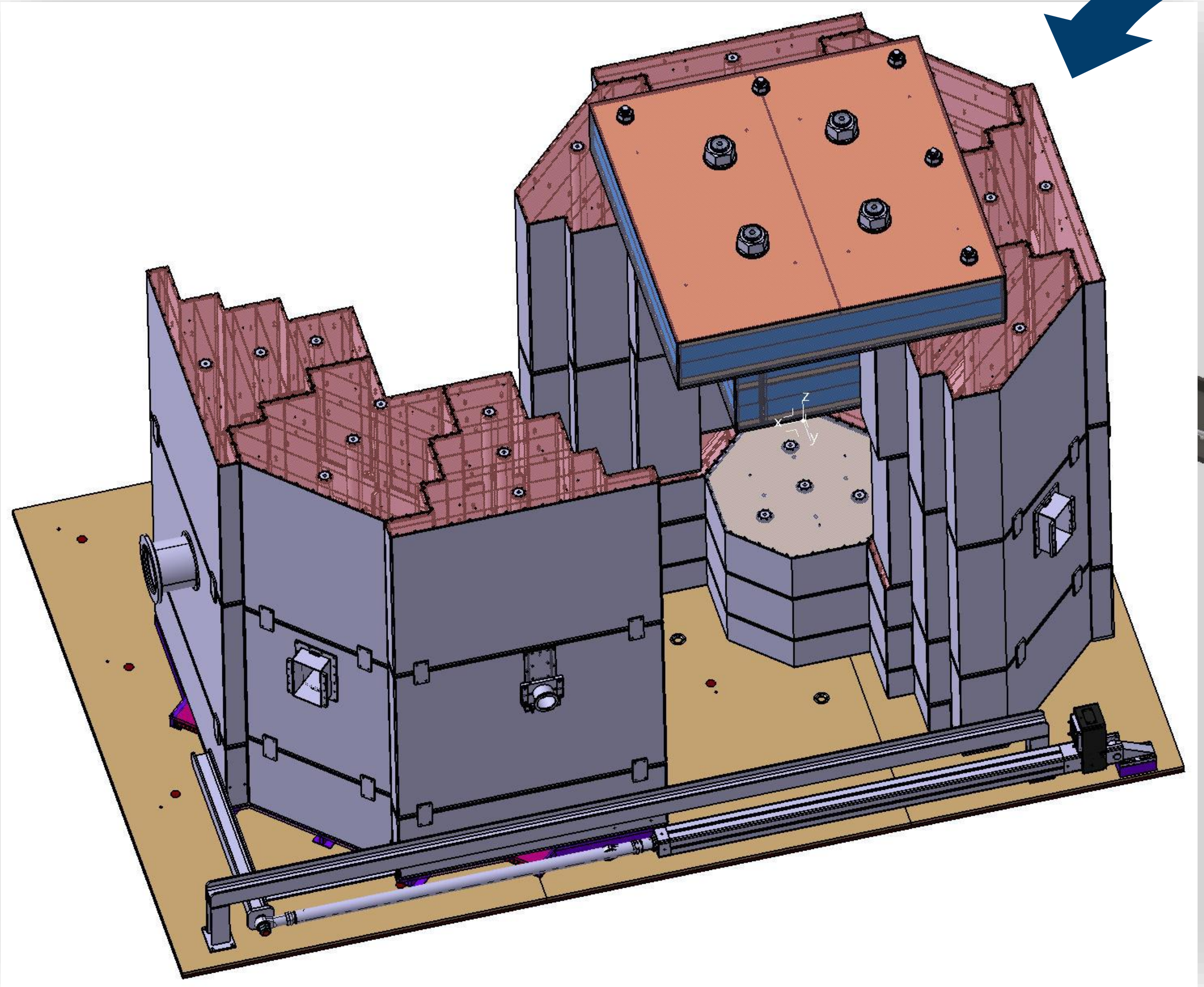
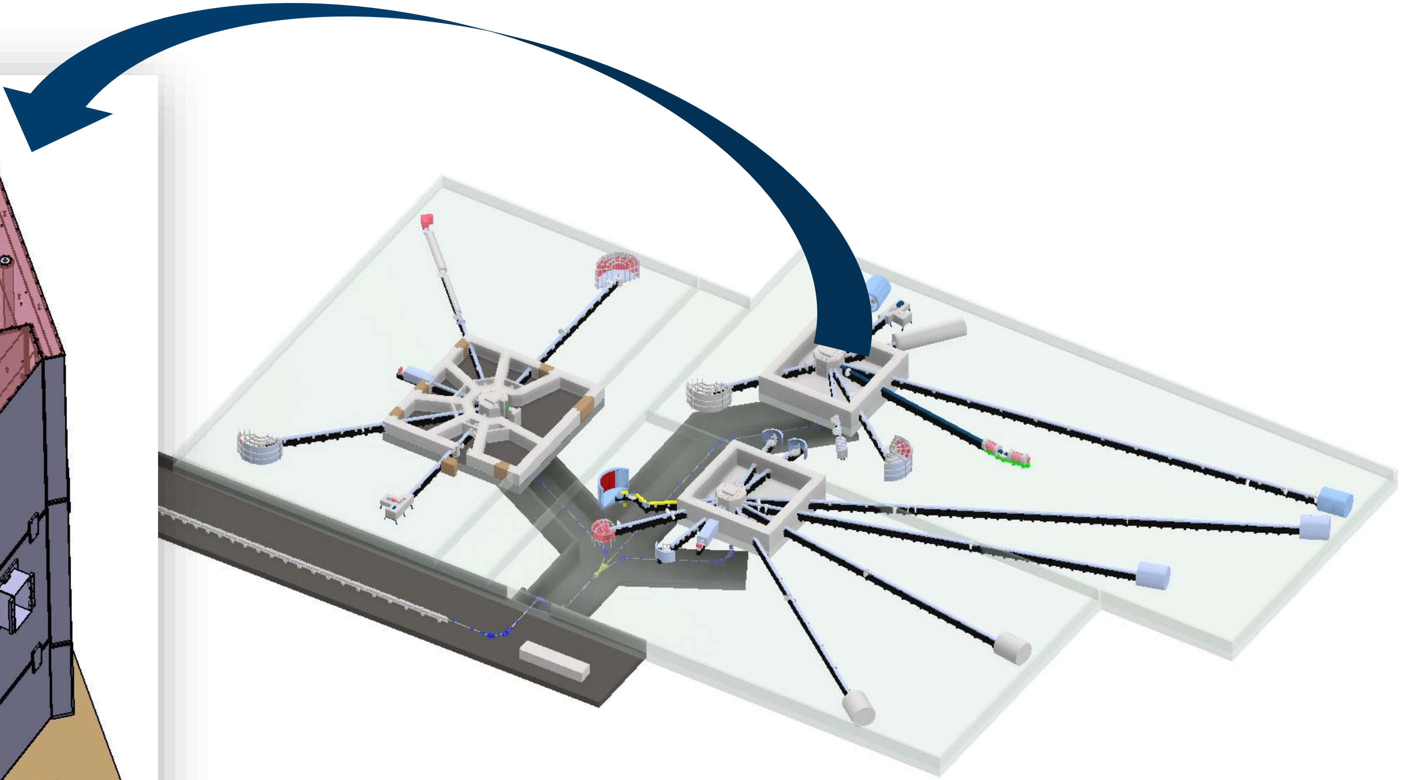
96.10	Cold imaging	252	15		1	15	6.6	0.4	1.6	High Res.
		252	5		1	15	19.9	1.3	12	High Int.
96.11	Thermal imaging	252	10		0.5	4.5	20	2.2	7.8	High Res.
		252	4		0.5	4.5	50	5.5	49	High Int.
96.12	Diffr. Imaging	252	35		1	15	2.8	0.2	8	
Epi.1	Dis. Mat. Diffr.	167	85	4.5	0.1	0.6	7.8	1.3		
Epi.2	PGNAA-2	167	21						4.4	
Epi.3	Epitherm. Imaging	167	35	0	1.8					

Target-Moderator-Reflector Unit



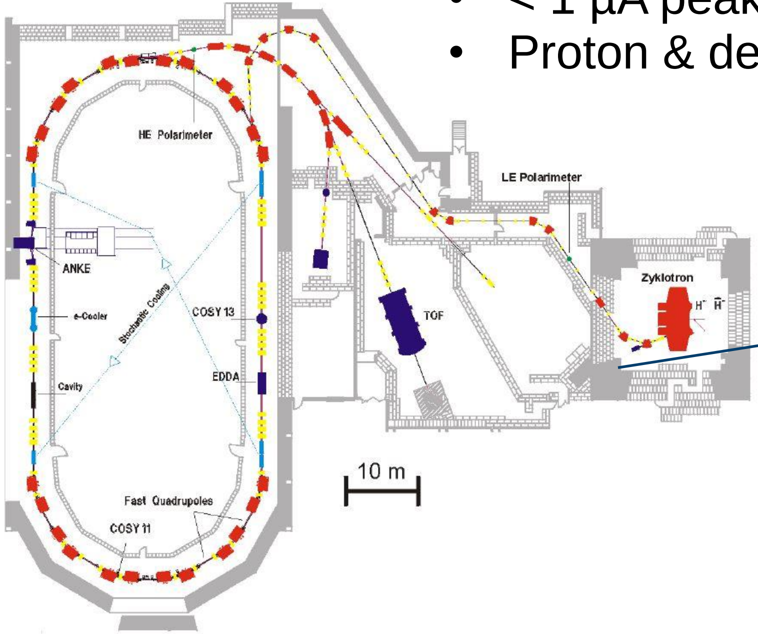


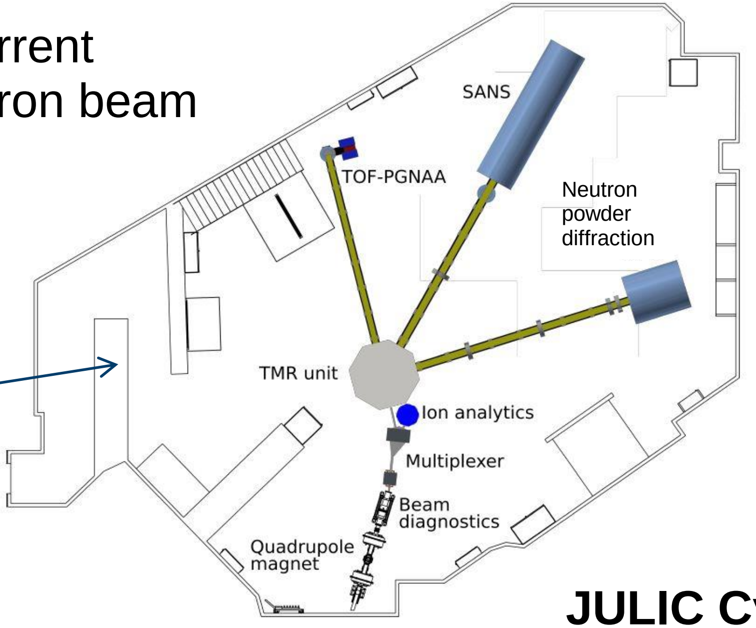
HBS Target-Moderator-Reflector Unit

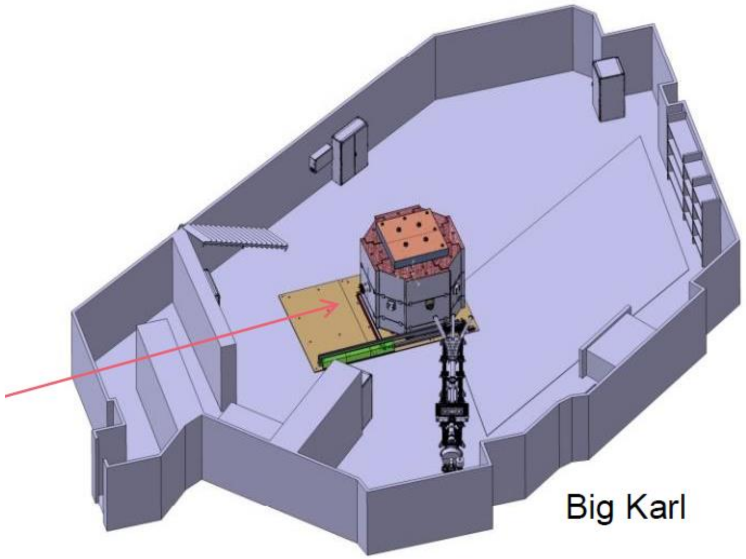
Experimental Platform at Big Karl @ COSY

COSY synchrotron

- GeV energy
- < 1 µA peak current
- Proton & deuteron beam





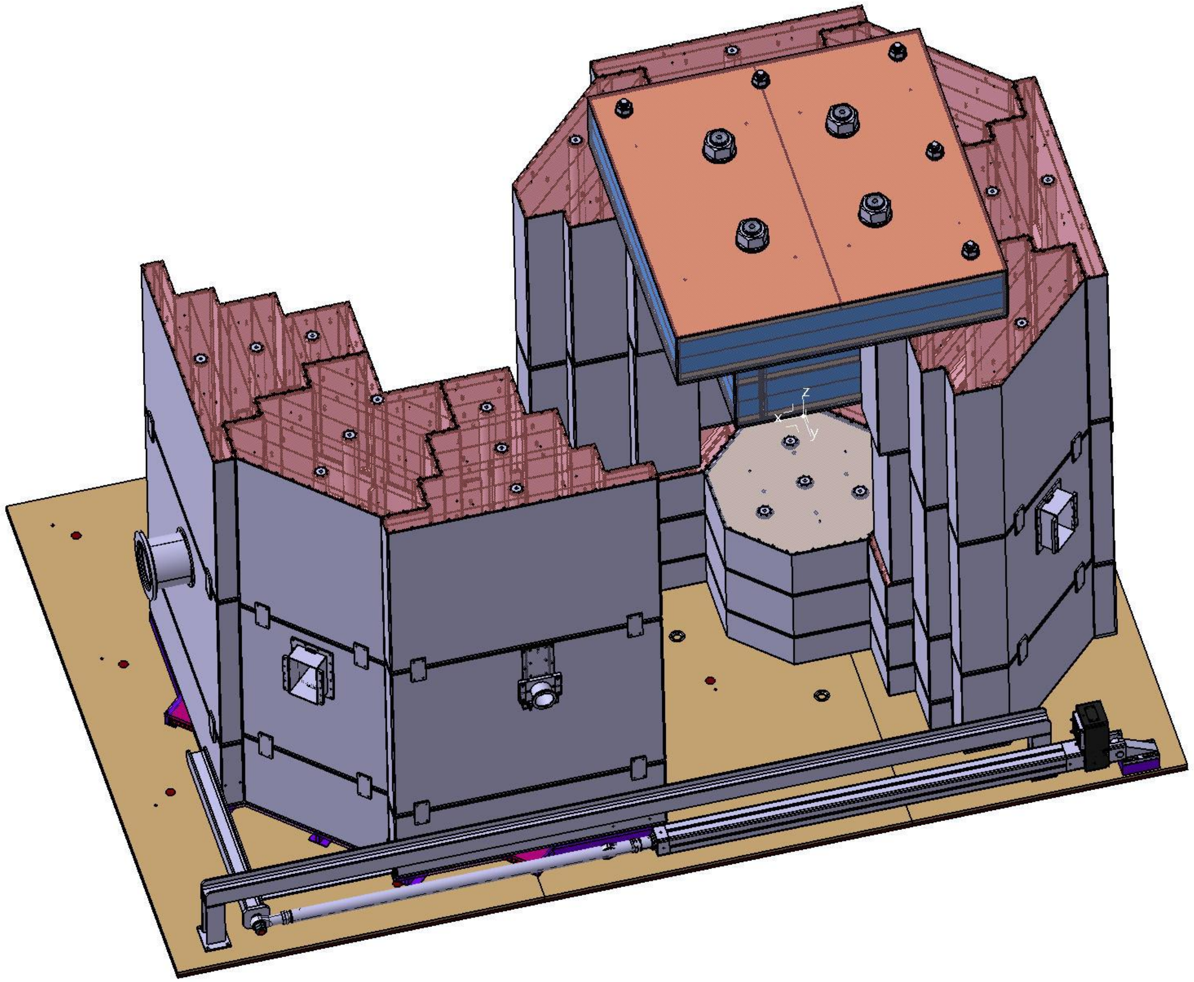


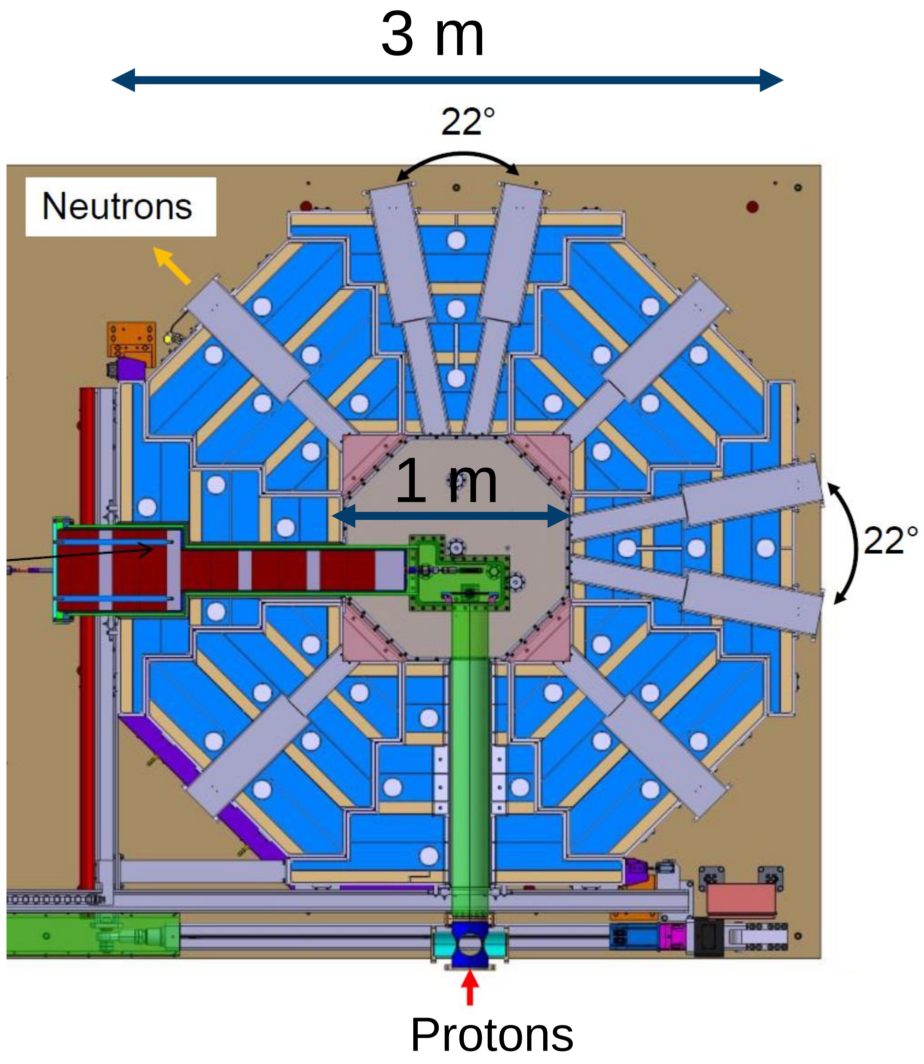
JULIC Cyclotron

- 45 MeV proton beam
- 10 µA peak current
- Variable pulse length
- Variable frequency

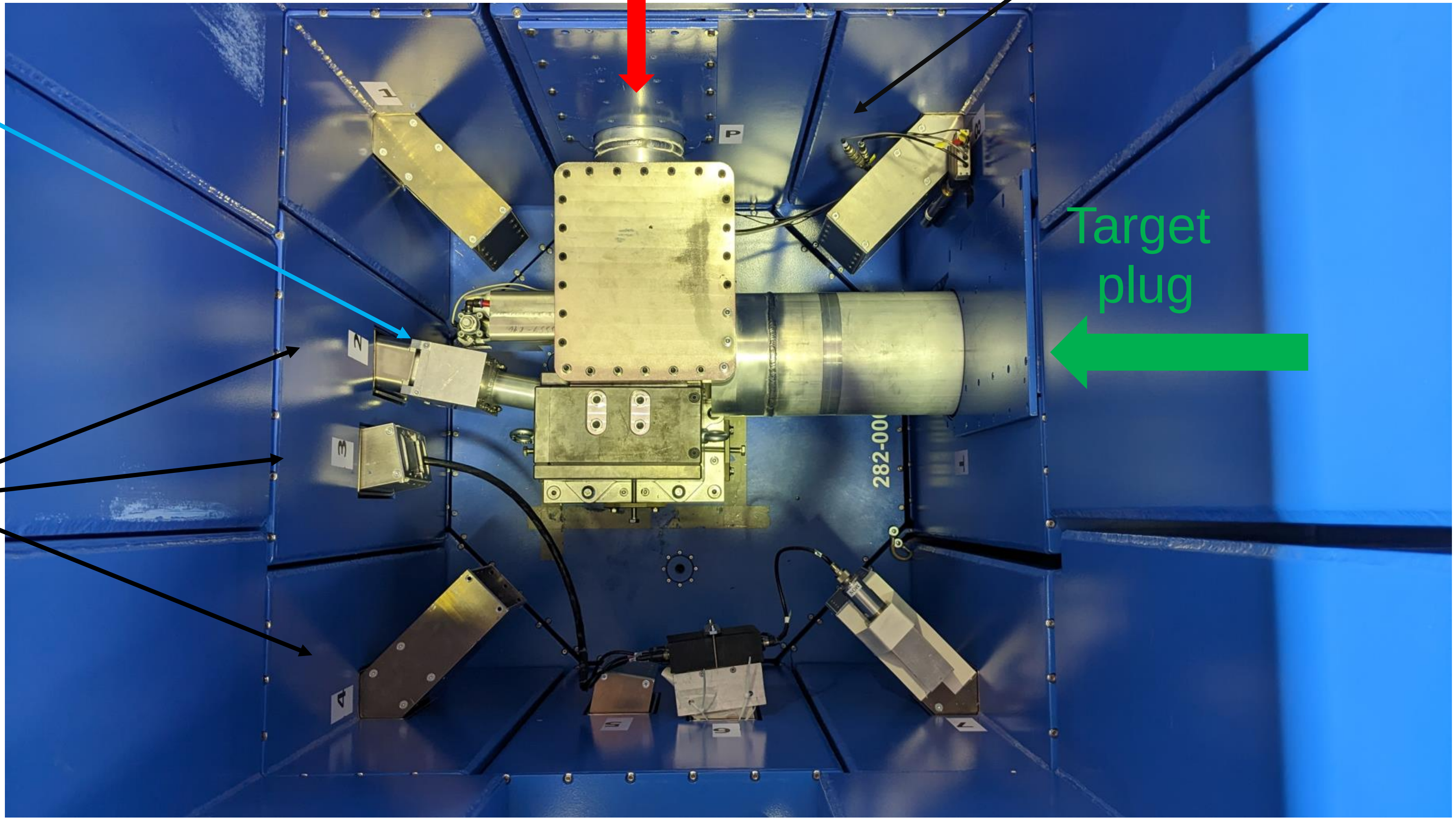
HBS Target-Moderator-Reflector Unit

Experimental Platform at Big Karl @ COSY





Mock-up TMR


1 cm^3 accessible space
Protons
Moderator plug with cryogenic vessel
Target plug
Moderator reflector
Extraction ducts

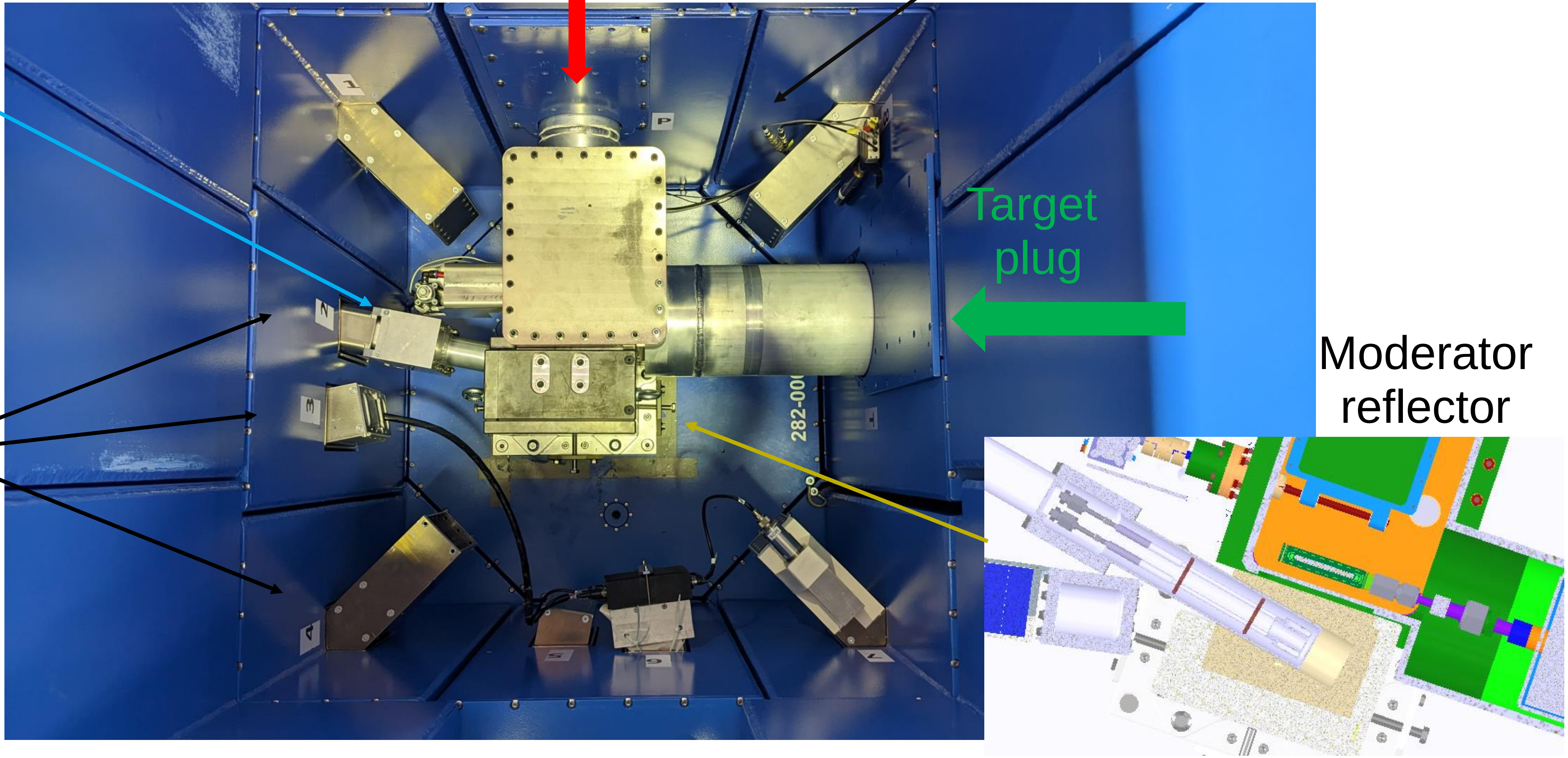
Mock-up TMR

1 cm^3 accessible space

Protons

Moderator plug with cryogenic vessel

Extraction ducts

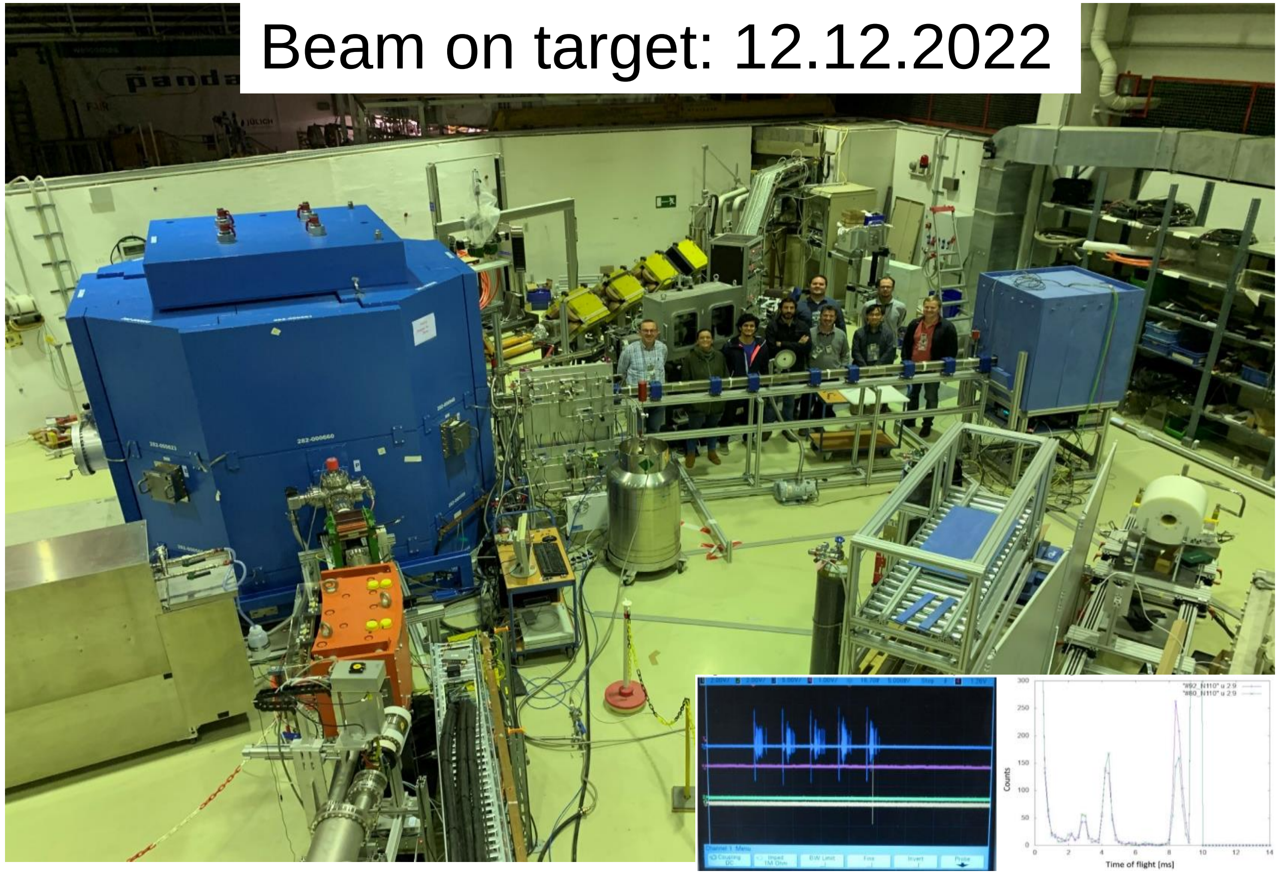


Moderator reflector

HBS Target-Moderator-Reflector Unit

Experimental Platform at Big Karl @ COSY


Baseplate mounting
10.06.2022

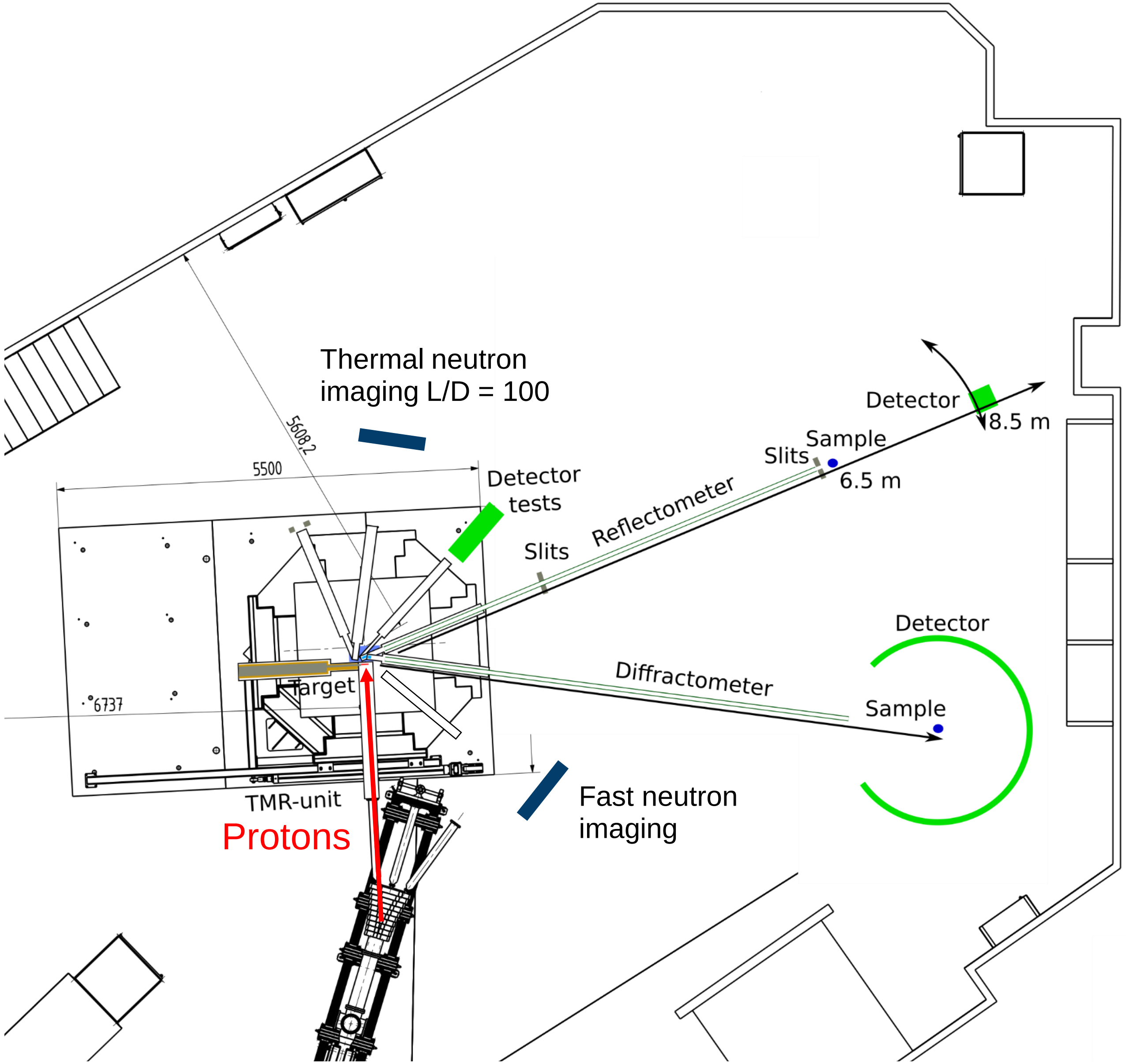


Beam on target: 12.12.2022

JULIC Neutron platform

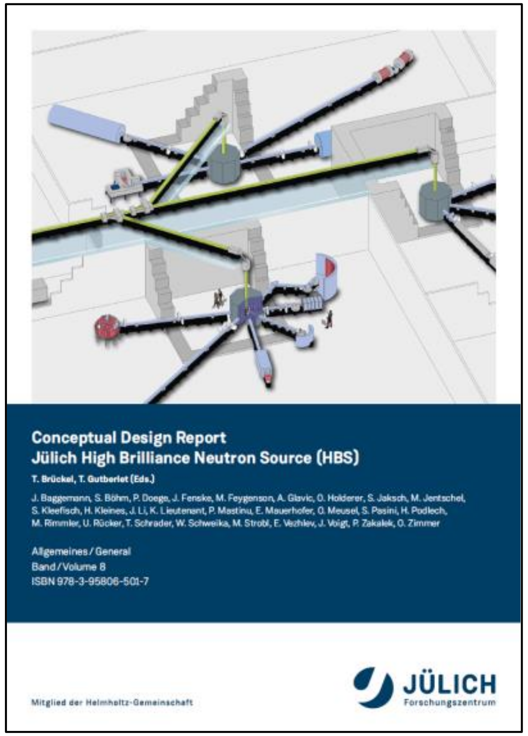
	Big Karl	HBS
Particle type	Proton	Proton
Energy	45 MeV	70 MeV
Peak current	10 µA	90 mA
Duty cycle	4 %	1.6 %
Average power	18 W	100 kW
Neutron yield	$1 \cdot 10^{11}\ s^{-1}$	$2 \cdot 10^{15}\ s^{-1}$

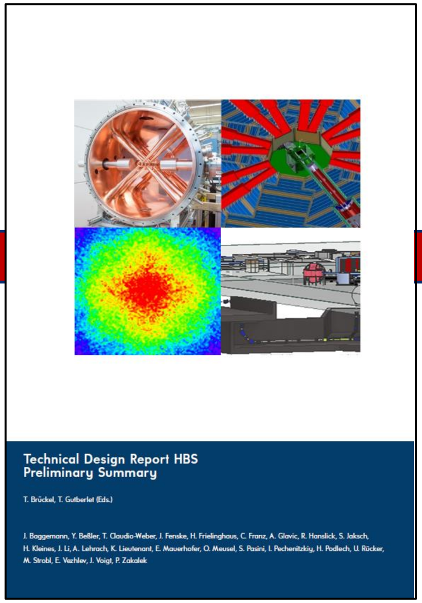
Big Karl experimental area allows performing basic neutron scattering experiments in time-of-flight mode



High Brilliance Neutron Source Project (HBS)

Conceptual Design Report → Technical Design Reports (06.2023)





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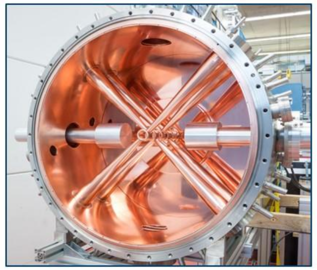

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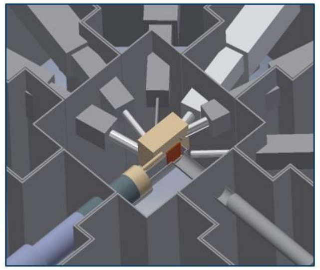

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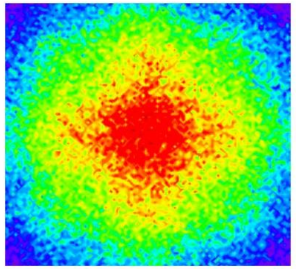

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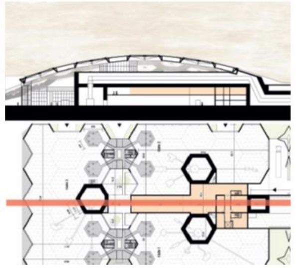


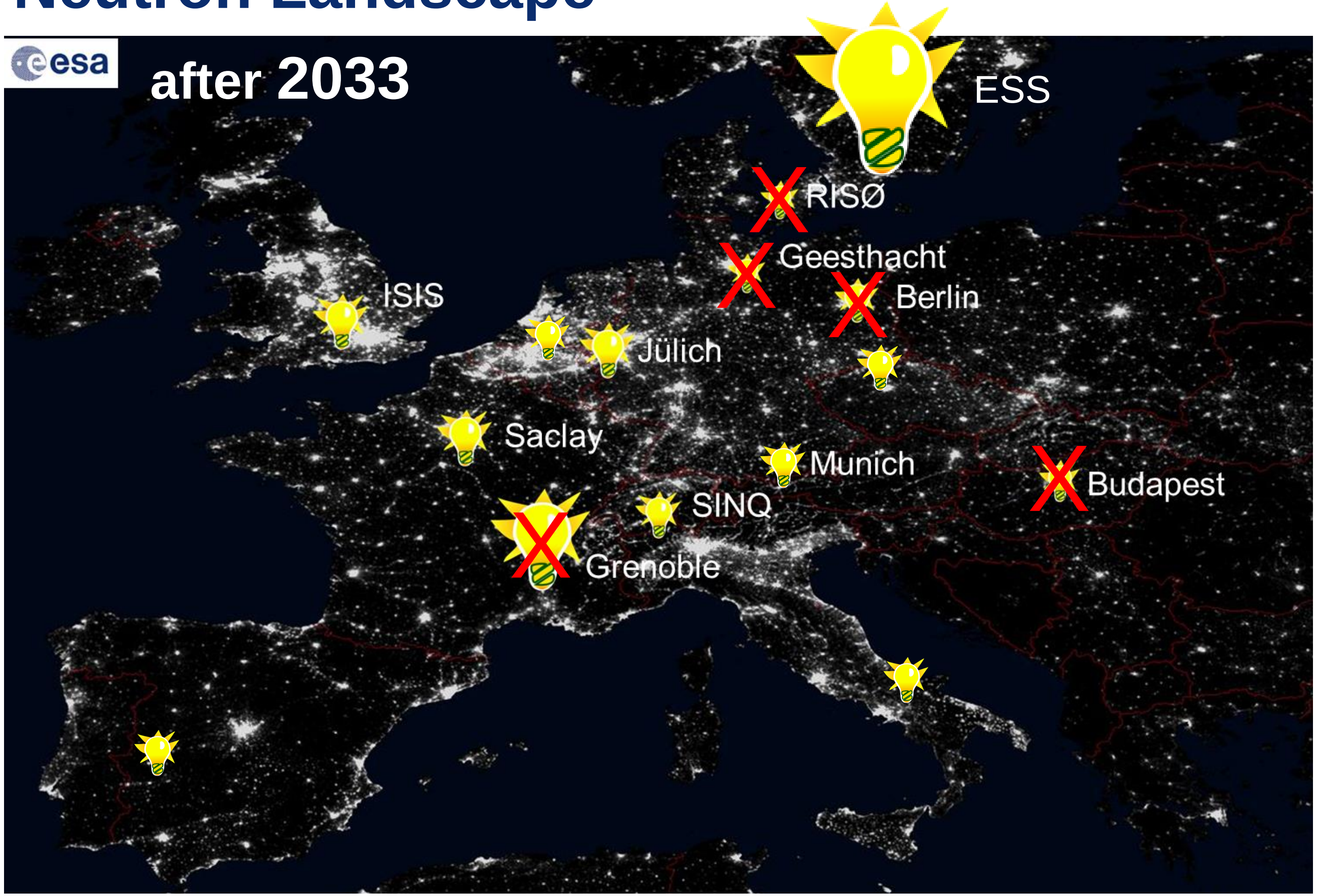
www.fz-juelich.de/jcns/jcns-2/EN/Forschung/High-Brilliance-Neutron-Source/_node.html

HBS

Jülich Centre for Neutron Science
HIGH BRILLIANCE SOURCE
JÜLICH Forschungszentrum

European Neutron Landscape

European Neutron Landscape



European Neutron Landscape

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INM-5:

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- Radio isotopes

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GSI Helmholtzzentrum für Schwerionenforschung GmbH

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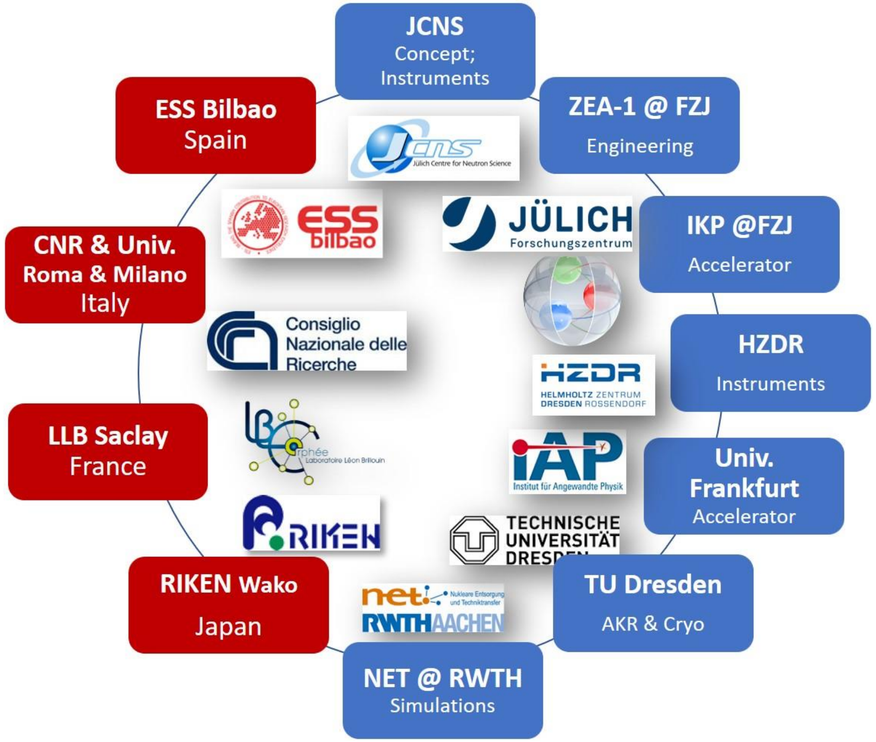
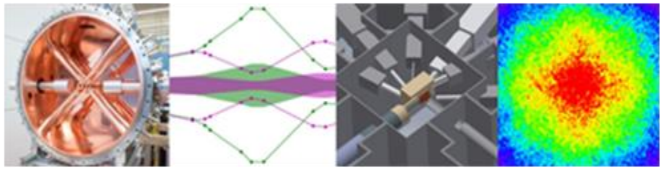


HBS Innovationpool Project



Federal Ministry of Education and Research

FB Matter: MML, MT

Jülich Centre for Neutron Science

HIGH BRILLIANCE SOURCE

JÜLICH Forschungszentrum

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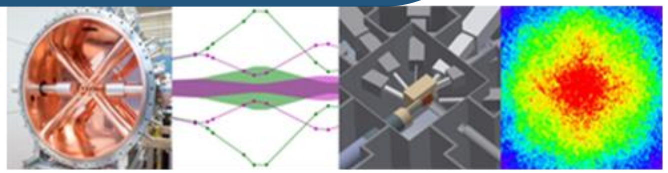
W. Barth

- Accelerator

THANK YOU FOR YOUR ATTENTION

HBS Innovationpool Project



Federal Ministry of Education and Research

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HIGH BRILLIANCE SOURCE

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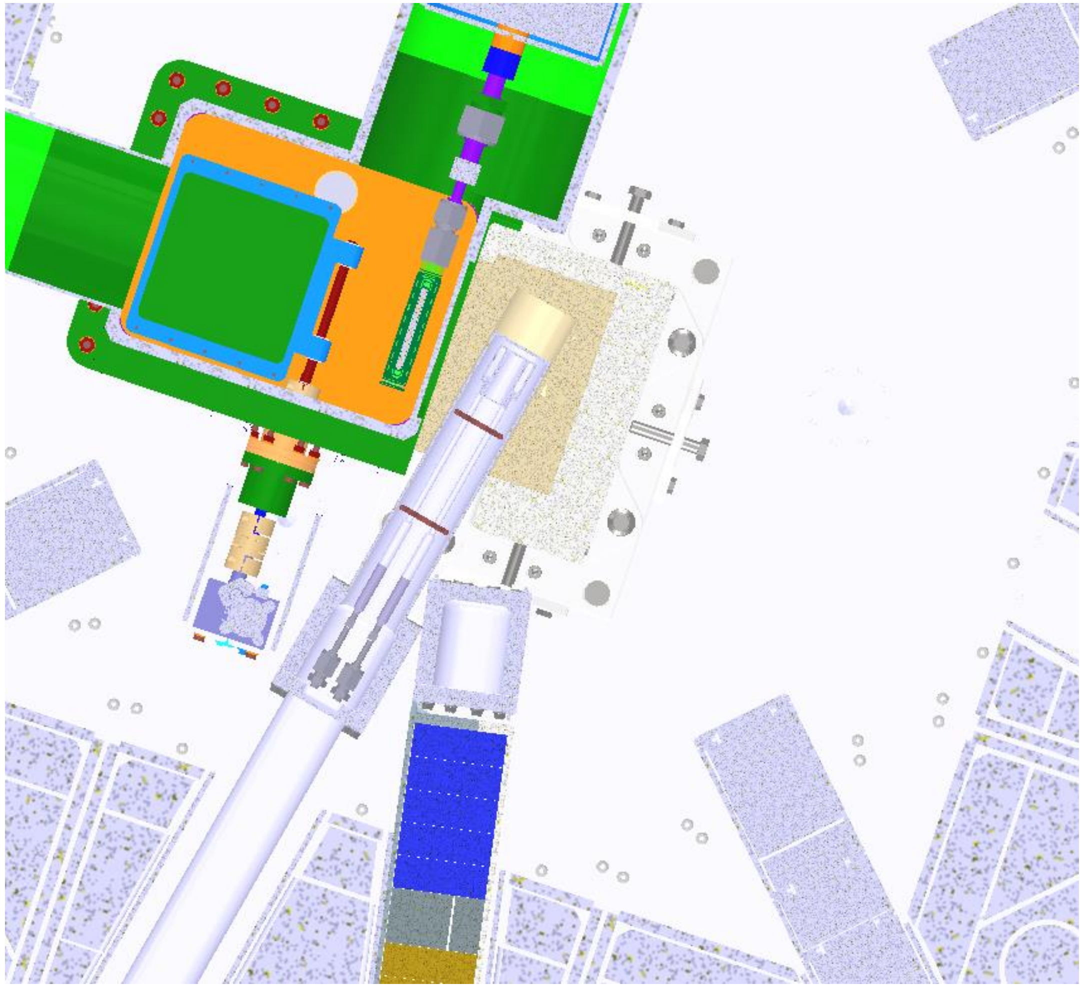
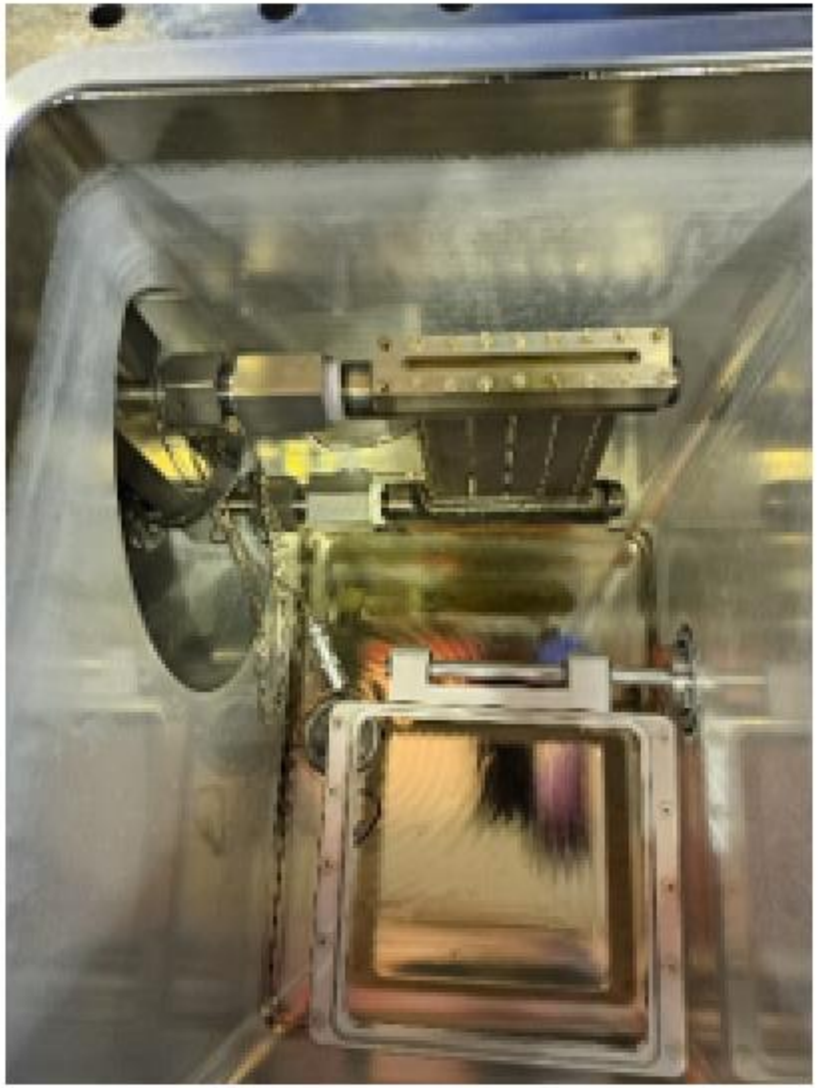
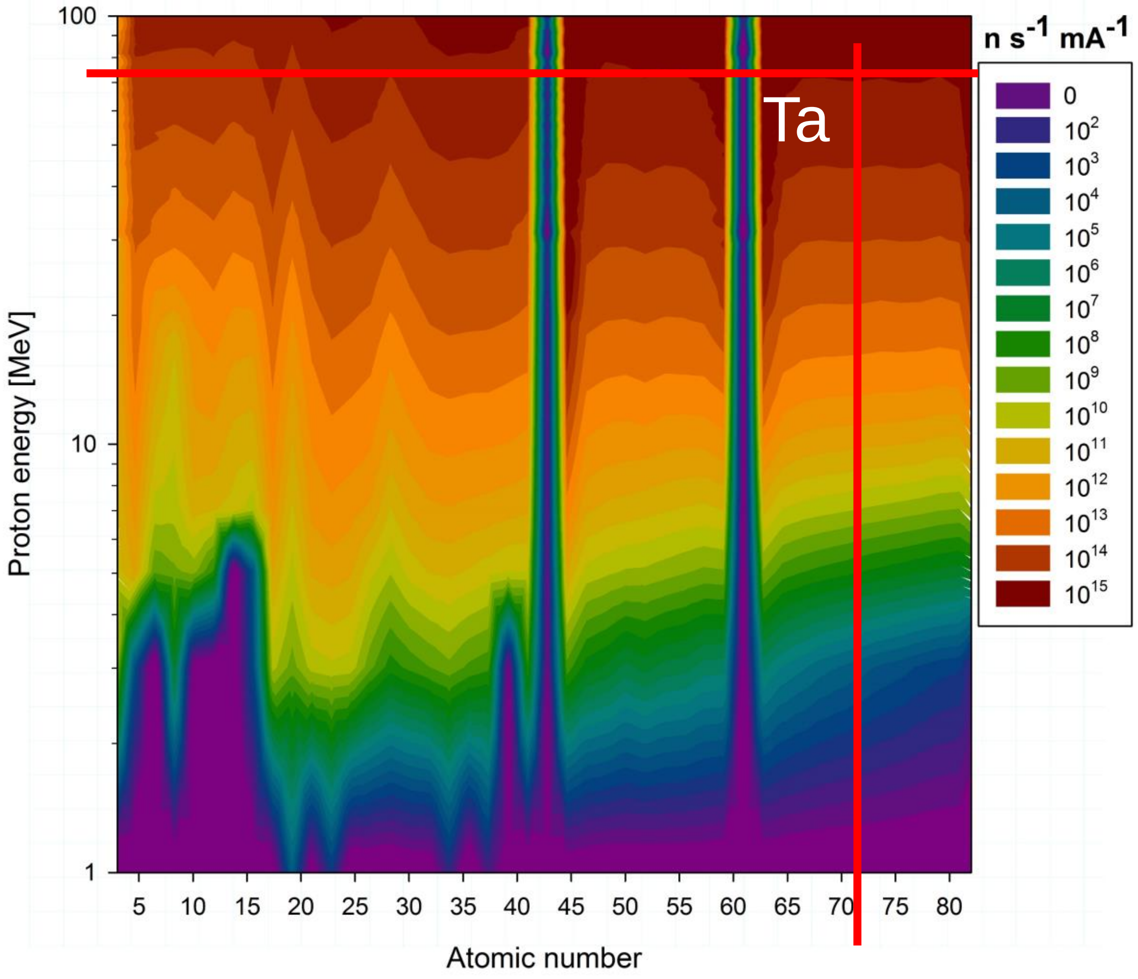
Mock-up TMR



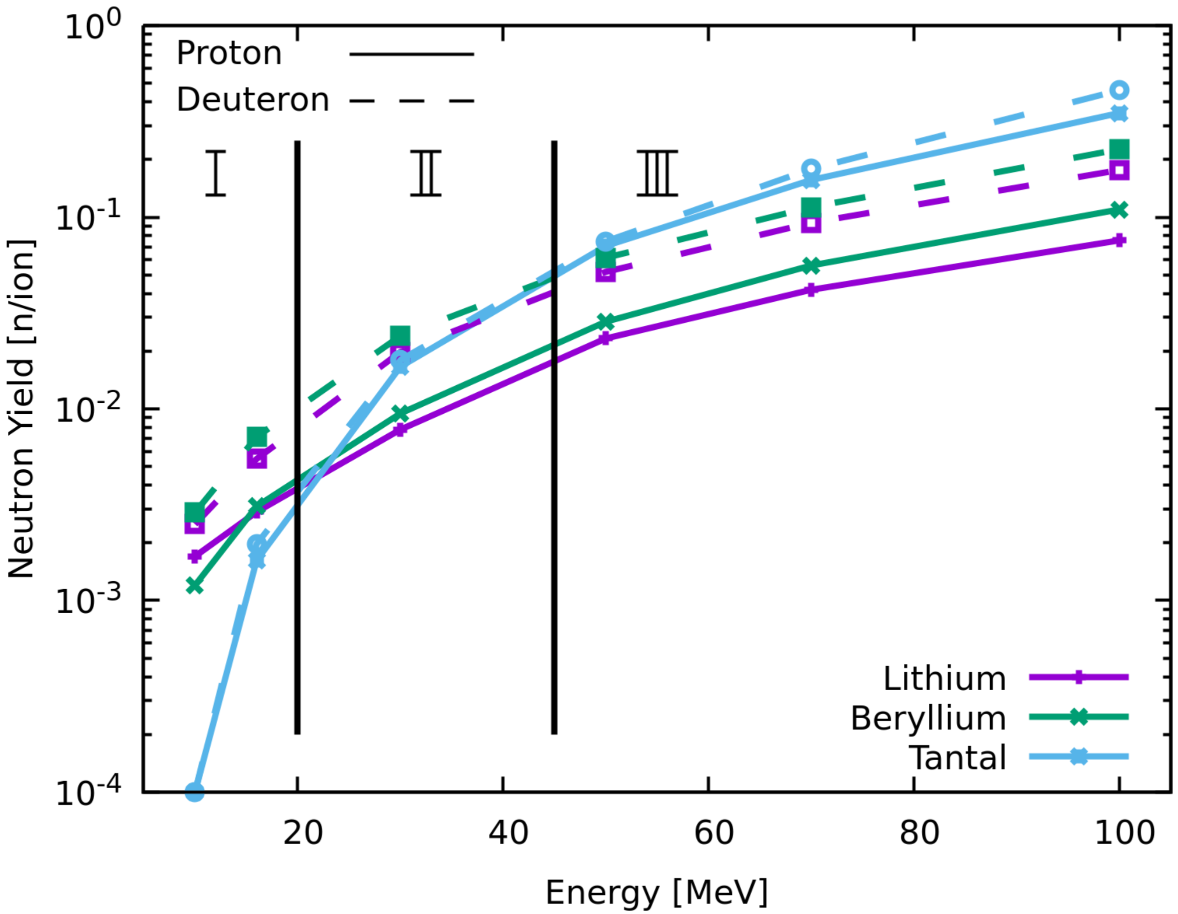


Neutron Yield

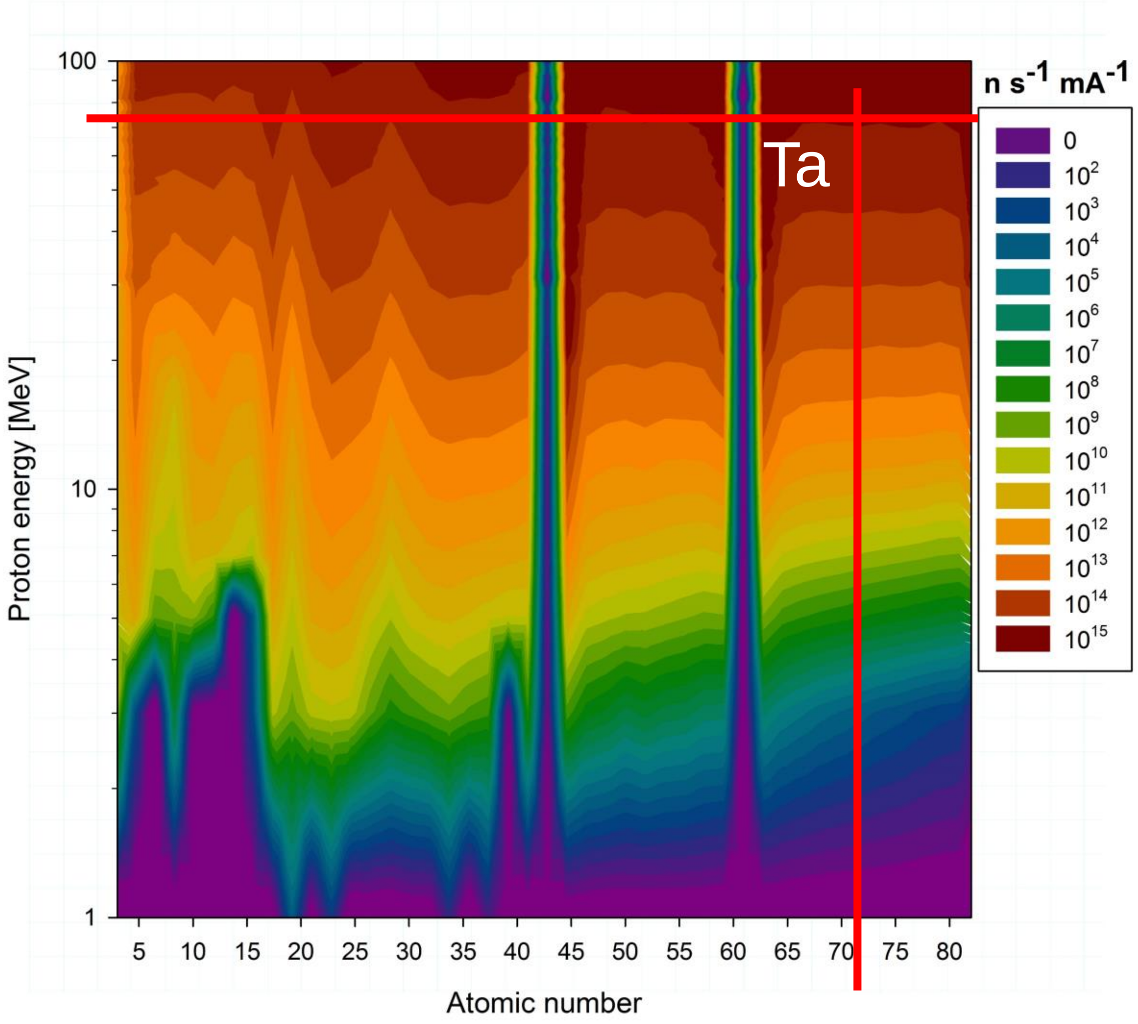


Tantalum

- High blistering threshold
- High neutron yield



Neutron Yield



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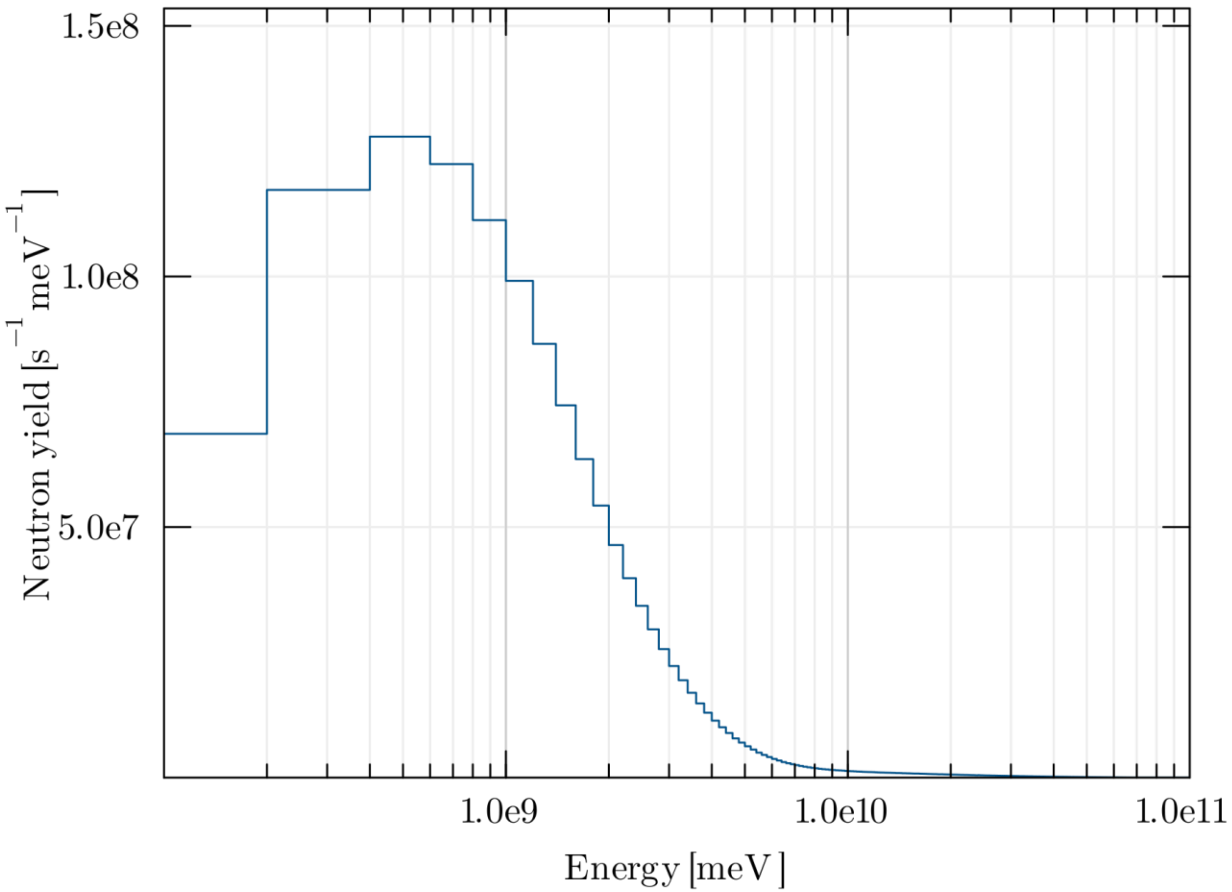
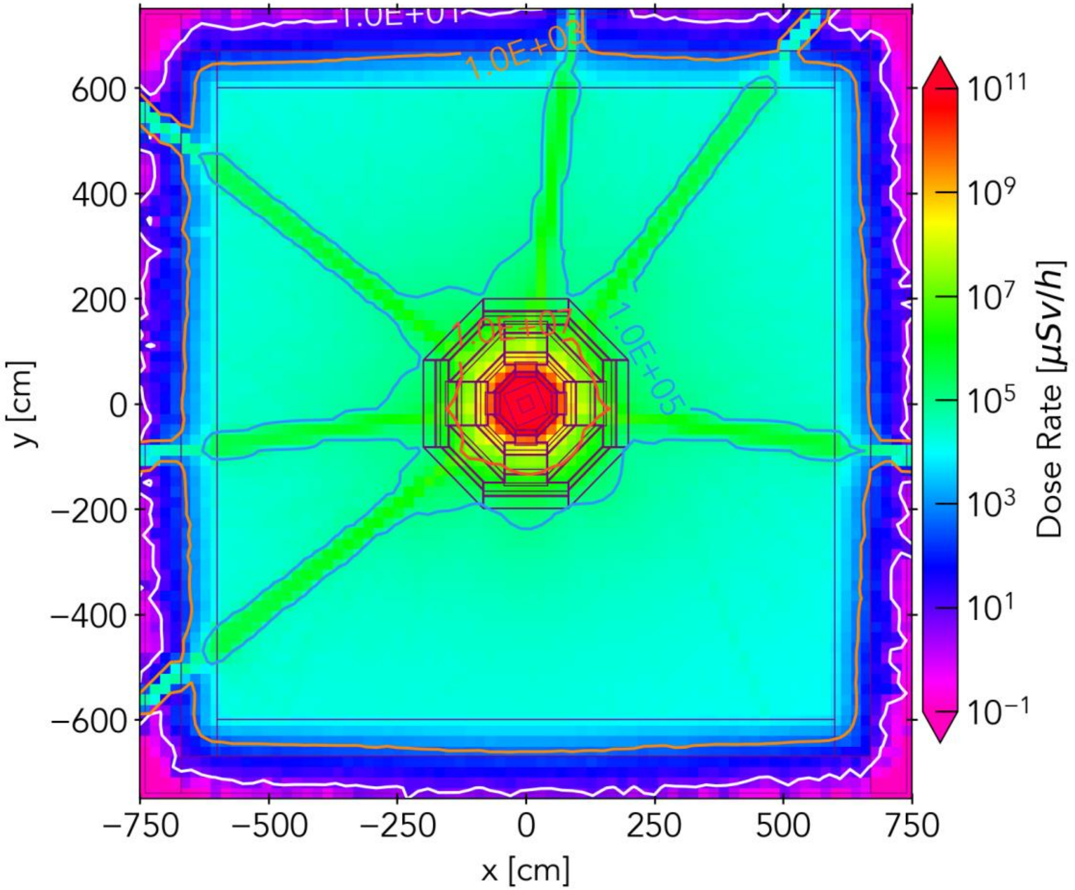


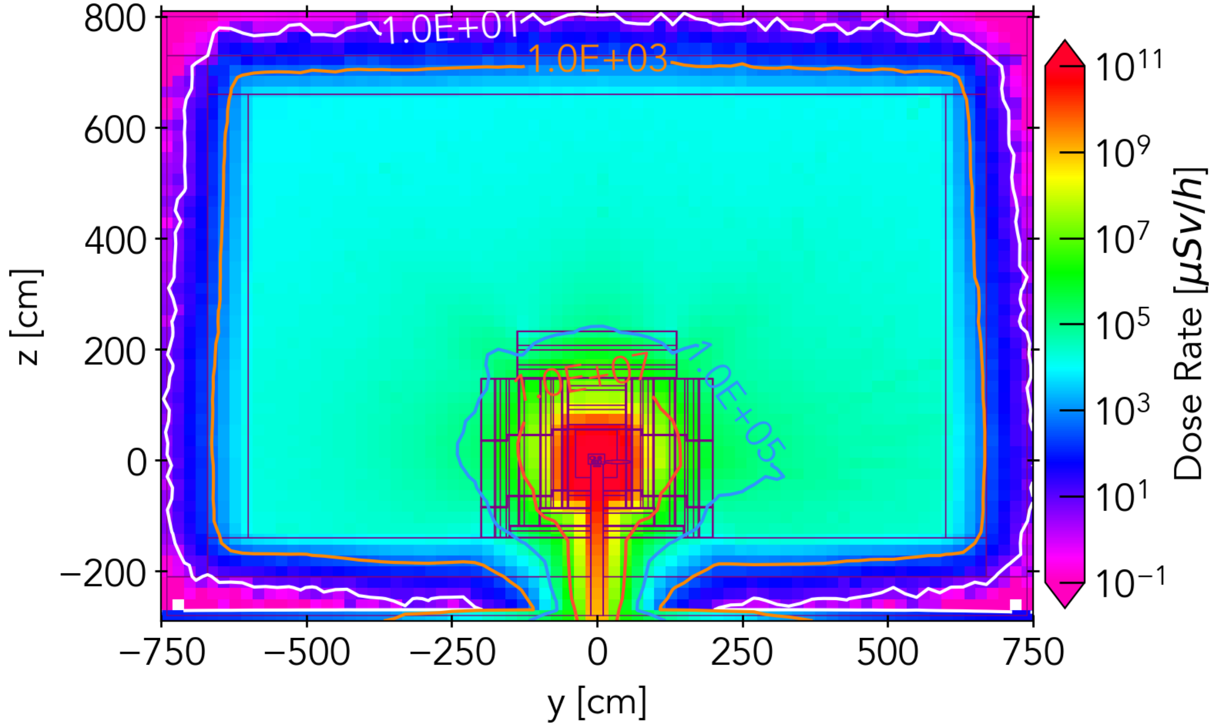
RADIATION DOSE MAPS

Total dose rate (neutron and photon) map

- Dose rates during operation on the outer surface of the wall and bunker are less than 10 $\mu Sv/h$.

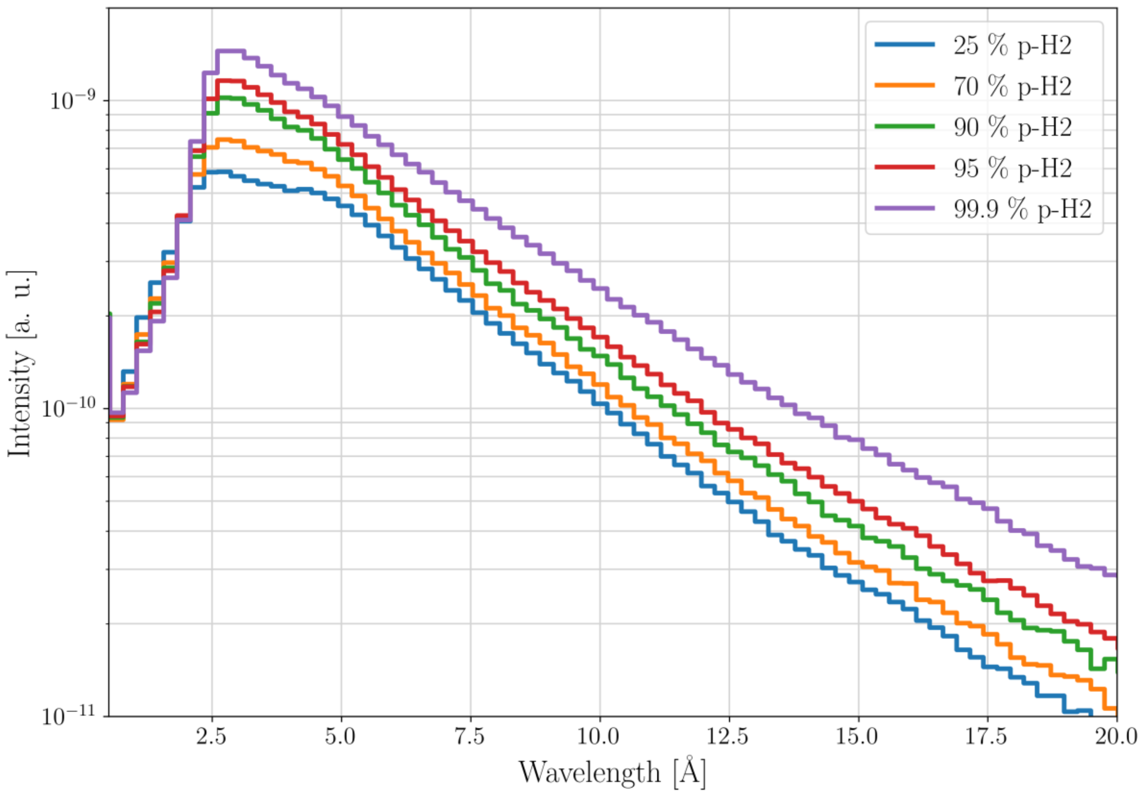


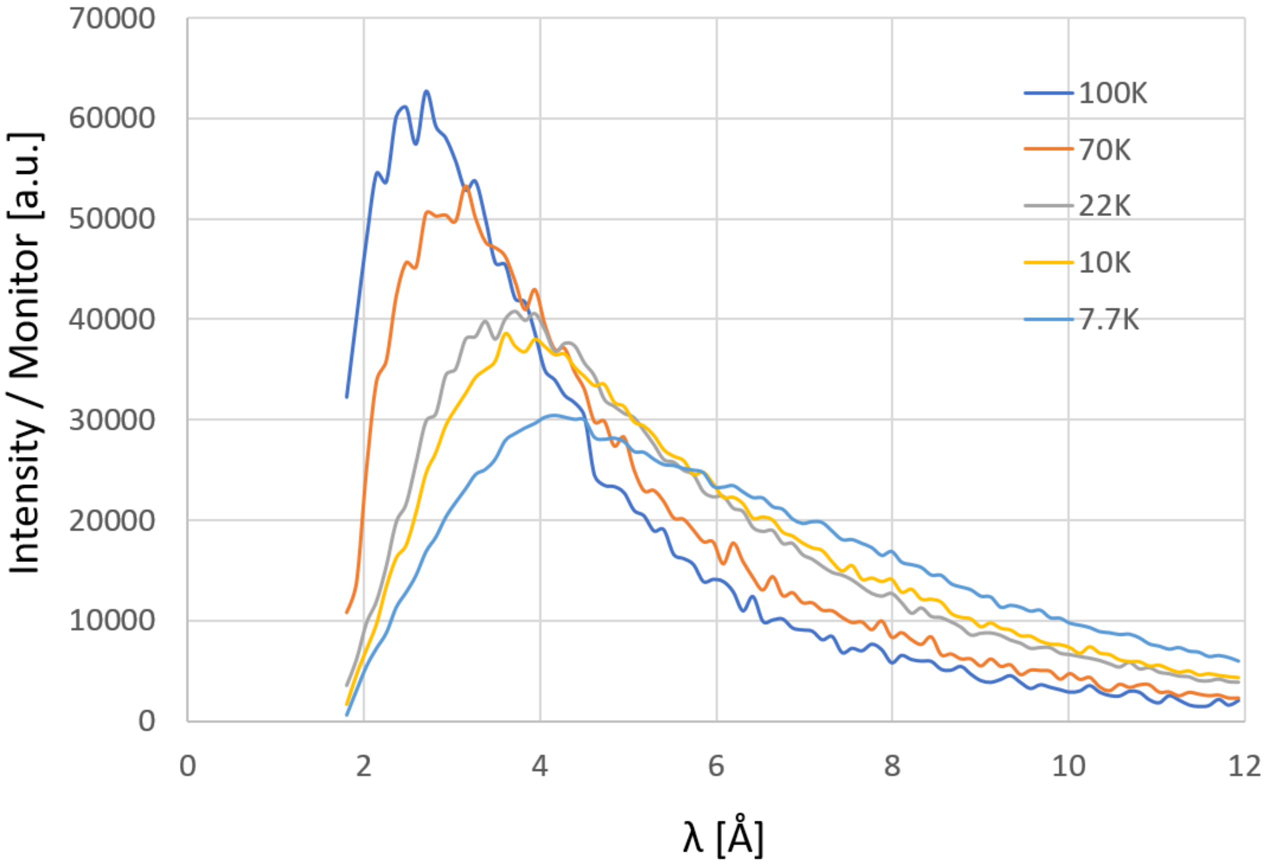
in horizontal (XY cross section) direction
at the height z = 0 cm



in vertical (YZ cross section) direction
along the x = 0 cm

MEASUREMENTS AT BIG KARL





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