Thermal moderator-reflector design of the 24Hz target station for the High Brilliance Neutron Source

Junyang Chen, Ulrich Rücker, Jörg Voigt, Paul Zakalek, Egor Vezhlev, Jingjing Li, Thomas Gutberlet, Thomas Brückel

JCNS, Jülich Forschungszentrum GmbH, Germany

Introduction

- High Brilliance Neutron Source (HBS) : produce less but use more efficientlv

Proton beam:
100kW 70MeV

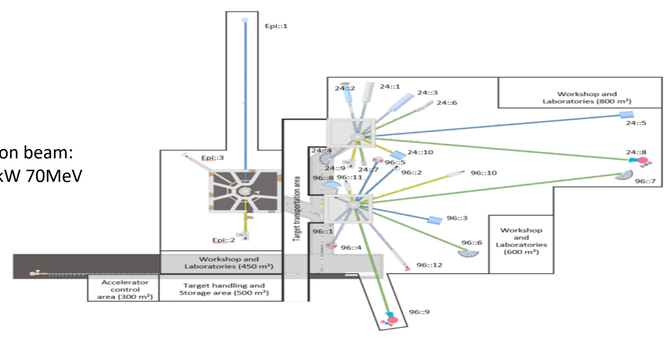
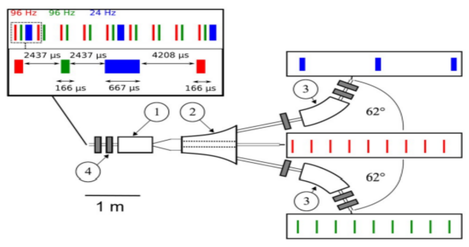


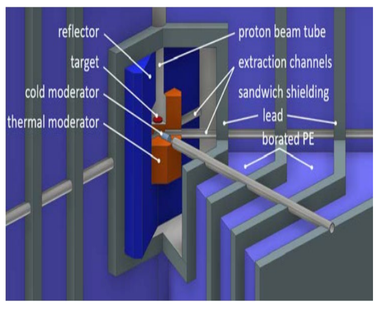
Image is from Conceptual Design Report Jülich High Brilliance Neutron Source (HBS) and Dr. Ulrich Rücker's and Dr. Jingjing Li's report

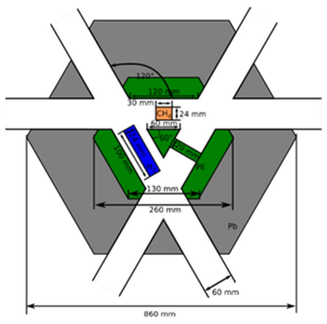
- Multiple target stations with different pulse lengths



1: Bipolar kicker magnet, 2: Septum magnet with three different field regions, 3: Sector bending magnet, 4: Quadrupole magnet (all in gray)

- Target-Moderator-Reflector (TMR) unit: Producing, moderating and reflecting neutron





Two layer with triangle arrangement

Basic idea and Method

Time distribution of emitting neutron

$f_{proton}(t) \otimes f_{transport}(t) = f_{emitting}(t)$

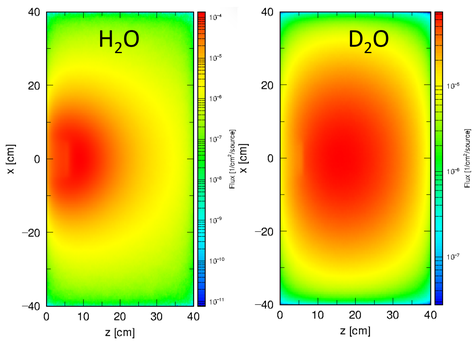
convolution

$f_{proton}(t)$: Time distribution of proton beam → long pulse

$f_{transport}(t)$: Time extension of neutron diffsuing → can be longer

→ increasing neutron flux with longer tail

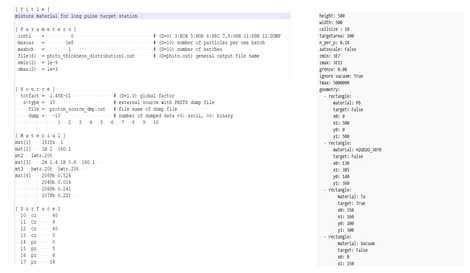
Neutron cloud distribution in different material



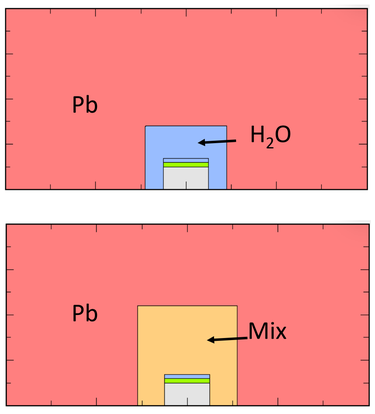
- H: high absorption; high moderation efficiency
- D: low absorption; long decay time

Mixture material: 70%D2O+30%H2O

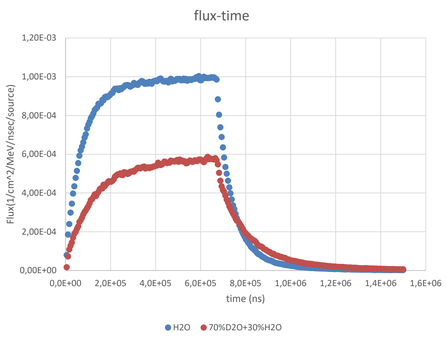
- Monte Carlo simulation: PHITS
- Diffmod (developed by Dr. Ulrich Rücker)



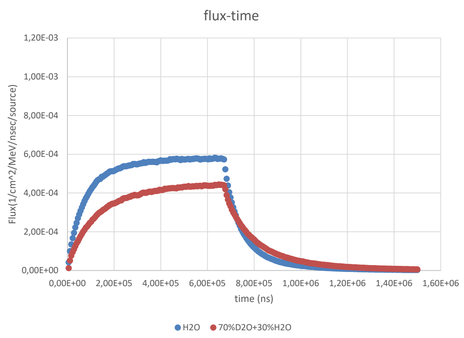
Result



Model without channel

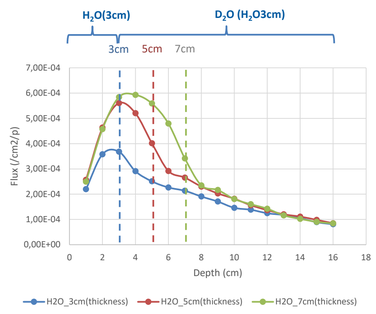


Tally in center position



Tally in marginal position

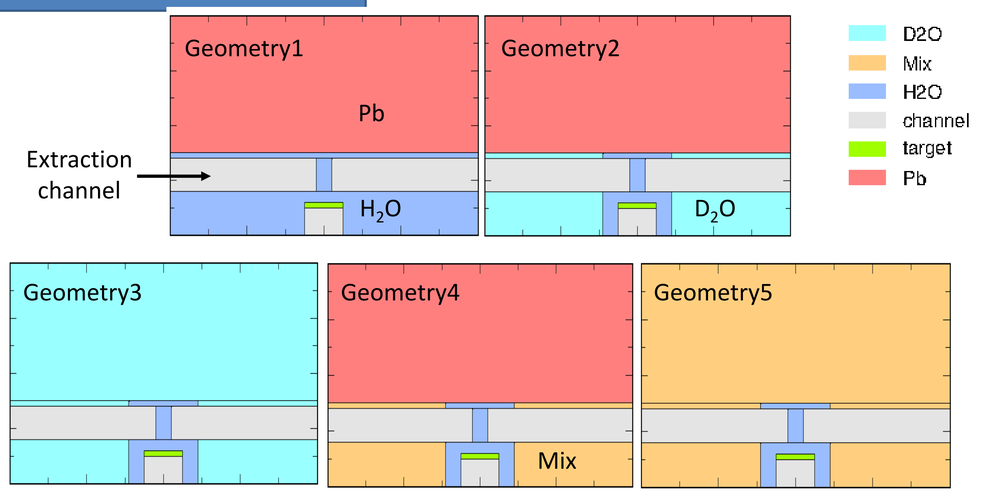
Dash line indicates the dividing line between H_2O and D_2O

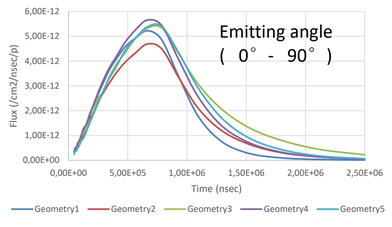


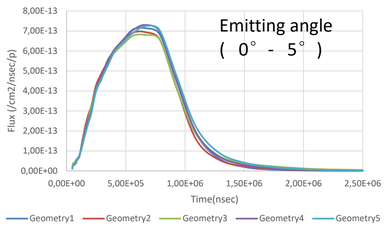
Increasement of neutron cloud density > Increasement of lower absorption

H_2O ↑ D_2O ↑

Result







Surface detector 40cm

	Geometry1	Geometry2	Geometry3	Geometry4	Geometry5
time integral / $cm^{-2}p^{-1}$ (emitting angle:0°-90°)	3.81E-06	3.83E-06	5.12E-06	4.55E-06	4.60E-06
decay time(µs) (emitting angle:0°-90°)	318	400	536	396	456

Surface detector 40cm

	Geometry1	Geometry2	Geometry3	Geometry4	Geometry5
time integral / $cm^{-2}p^{-1}$ (emitting angle:0°-5°)	5.00E-07	4.92E-07	5.03E-07	5.16E-07	5.28E-07
decay time(µs) (emitting angle:0°-5°)	255	238	250	257	276

Point detector 10m

	Geometry1	Geometry2	Geometry3	Geometry4	Geometry5
time integral / $cm^{-2}p^{-1}$ (point detector 10m)	7.44E-10	7.46E-10	7.50E-10	7.72E-10	7.82E-10
decay time(ms) (point detector 10m)	1.91	1.88	1.96	1.96	1.96

Conclusion

Gradual Moderator Structure

Target — H_2O — Mixture — D_2O — Neutron guide

H_2O: confinement

D_2O: multiple collisions area: less absorption

Reflected neutrons increase beam divergence

Current and Future work

- Two target arrangement for one station
  - Pancake moderator structure