BEAM GUIDE SHIELDING WITHIN LOS

Towards the Common Shielding Concept

T. Randriamalala | FZJ GmbH, Jülich Center for Neutron Science

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OUTLINE

SIMULATION SETUP

General Consideration

- Simulated instrument: DREAM
- Codes:
  - Particle transport: PHITS[1]
  - Input compilation: PHITS and McStas
  - Geometry implementation: CombLayer[2]
- Normalization factor: 1.56×10^{16} protons per second (beam power: $5MW$, beam energy: $2GeV$)
- Flux-to-dose conversion factors: ESS-0019931

[1]T. Sato et al., J. Nucl. Sci. Technol. 50:9,913-923 (2013)
[2]S. Ansell, https://github.com/SAnsell/CombLayer

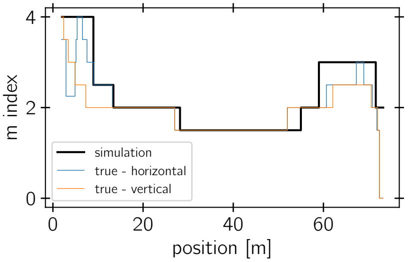
SIMULATION SETUP

Physical Properties of the DREAM Beam Guide

- Specificities of the outside bunker beam guide. Length units are in cm.

Start	End	Substrate	Geometry	W×H Start	W×H End
2819	5500	Borosilicate	Straight, Square	5.86×5.86	5.86×5.86
6400	7161	Borosilicate	Ellipse, Octagon	5.86×5.86	4.07×4.07

- Supermirror coating index



- Coarsed m-index values to optimize the simulations
- Neutron loss underestimated
- Worse case scenario

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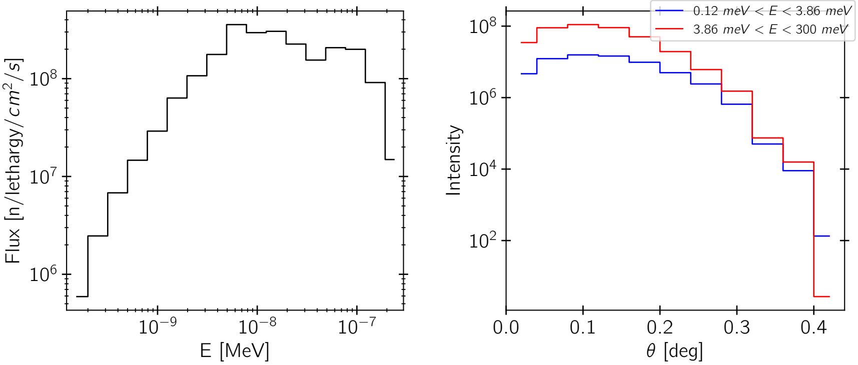
SIMULATION SETUP

Primaries Generation - Good Neutrons

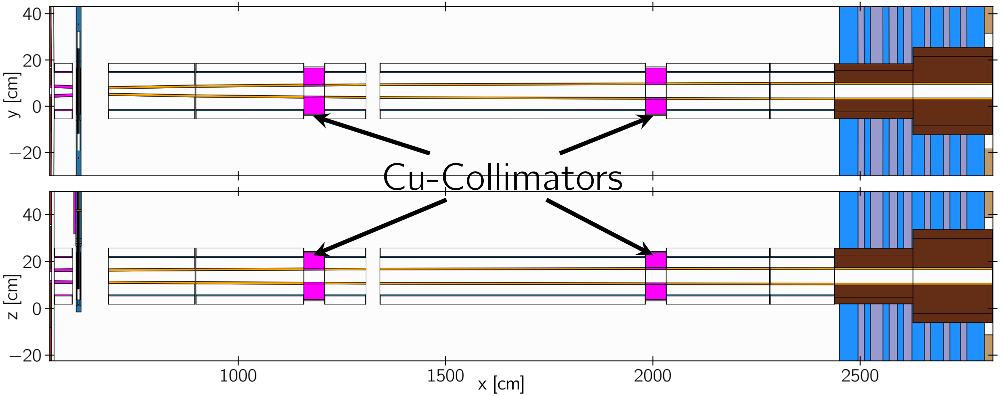
- For $E_n < 300 meV$: Source Term derived from McStas simulations
- Energy and θ-angle distributions of good neutrons (simulation done by M. Feygenson)



SIMULATION SETUP

Primaries Generation - Bad Neutrons

- For $E_n \geq 300 meV$: Source Term derived from dumped neutron tracks at the bunker exit
- Comparison of two configurations, with and without (in-bunker) collimators



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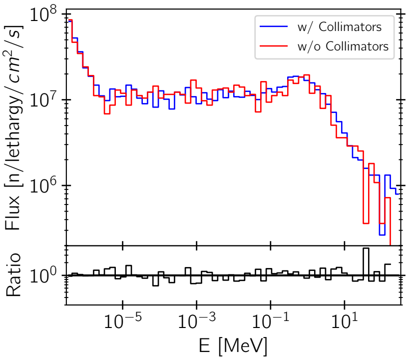
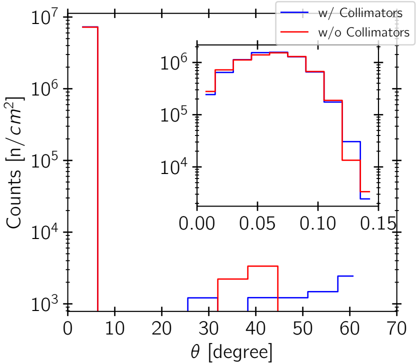




SHIELDING GEOMETRY

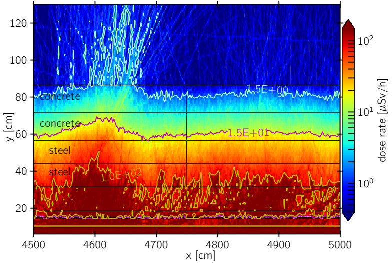
Initial Configuration

- Tube-like having inner layer steel and outer layer regular concrete
- Dimensions determined from the m-value of the guide coating and the distance from the moderator

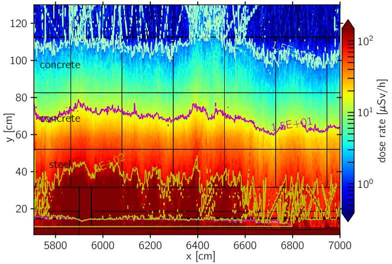
Section Name	Start Pos. [cm]	Steel Thickness [cm]	Concrete Thickness [cm]
P1	2800.0	35.0	30.0
P2	4500.0	25.0	30.0
P3	5000.0	21.0	60.0

SHIELDING GEOMETRY

Initial Configuration



Neutron dose map at the edge of the shielding structure

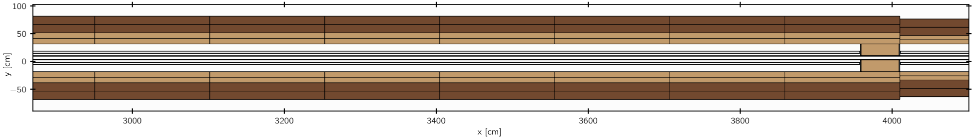


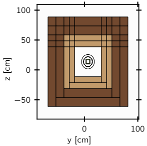
- High energy neutrons "leaking"
- High energy neutrons cannot be attenuated by only increasing the steel thickness

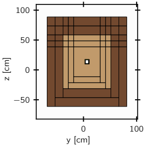
SHIELDING GEOMETRY

Bi-Directional Shielding Configuration

- Stop high energy neutrons *asap* with the help of collimators







- Collimator layers: B_4C-Steel-B_4C
- Positions of the collimators deduced from the direction of incoming neutrons
- Collimators potentially lead to the reduction of the thicknesses of the layers

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SHIELDING GEOMETRY

Bi-Directional Shielding Configuration

Properties of the shielding structure

Beam Guide Shielding			
Section Name	Start Pos. [cm]	Steel Thickness [cm]	Concrete Thickness [cm]
P1	2800.0	20.0	30.0
P2	3990.5	15.0	30.0
P3*	5110.0	10.0	36.0
Collimators			
Name	Center Pos. [cm]	Steel Thickness [cm]	B4C Thickness [cm]
Collim 1	3964.5	50.0	1.0
Collim 2	5084.0	50.0	1.0
Collim 3*	5900.0	100.0	1.0

* Change from square to octagonal shape of the beam guide cross section.

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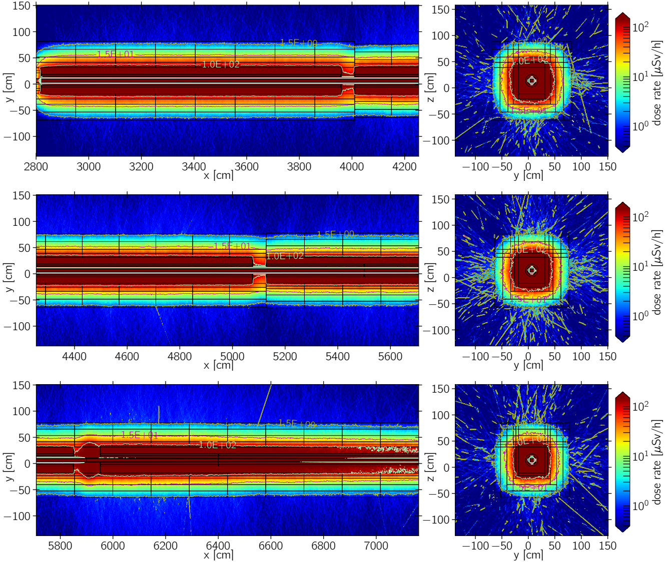
SHIELDING GEOMETRY

Bi-Directional Shielding Configuration

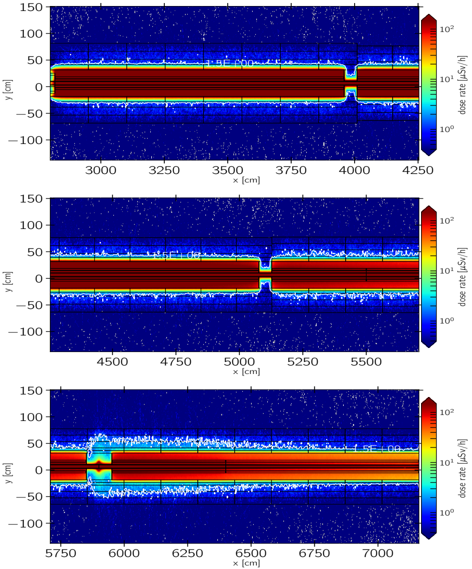


Radiation (neutron & photon) dose map along the beam guide

- $1.5\mu Sv/h$ line laying on the shielding structure edge

SHIELDING GEOMETRY

Bi-Directional Shielding Configuration



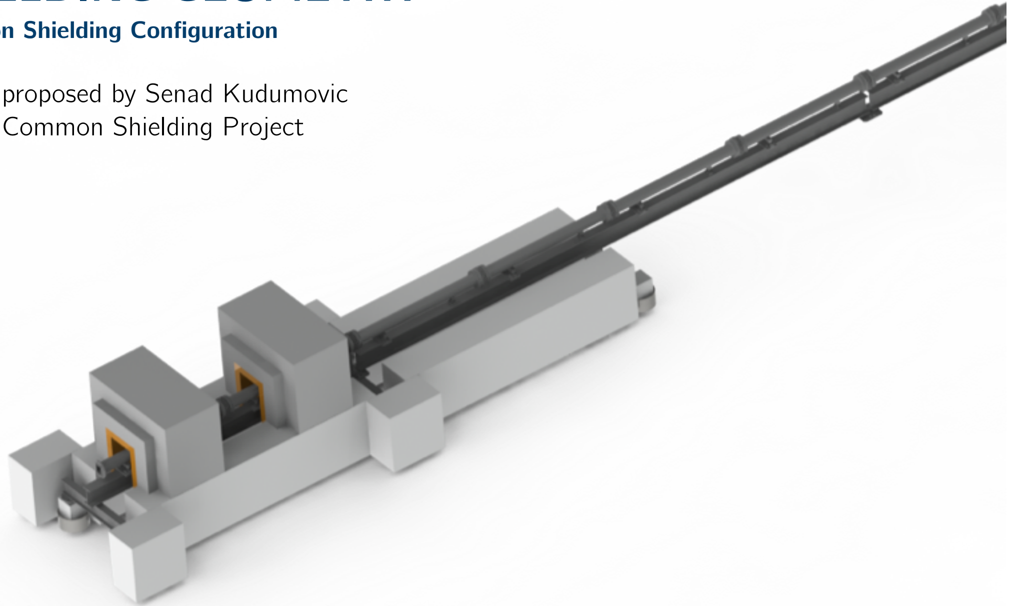
Photon dose map along the beam guide

- Photon mostly absorbed by the innermost steel layer
- More than 99.5% of the dose rate brought by neutrons at the next layers

SHIELDING GEOMETRY

Common Shielding Configuration

Design proposed by Senad Kudumovic
for the Common Shielding Project

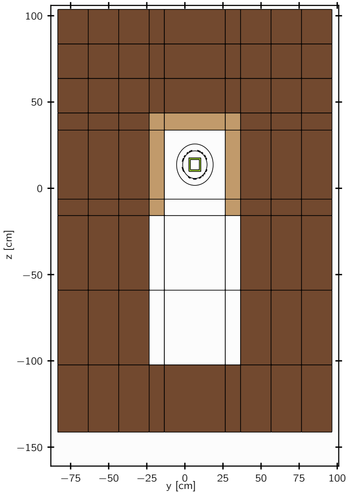


SHIELDING GEOMETRY

Common Shielding Configuration

- $\Theta_{Steel} - x \Rightarrow \Theta_{Reg.Conc.} + 3x$
- Thicknesses of layers:

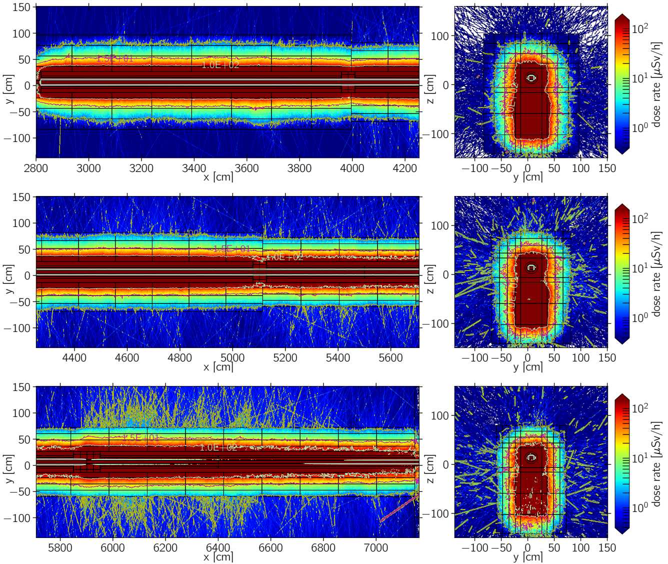
Section Name	Θ_{Steel} [cm]	$\Theta_{Reg.Conc.}$ [cm]
P1	10.0	60.0
P2	10.0	45.0
P3	10.0	36.0



Shielding configuration implemented in PHITS

SHIELDING GEOMETRY

Common Shielding Configuration



Radiation (neutron & photon) dose map along the beam guide (Preliminary)

- Layer thicknesses at Section P1 are sufficient enough to meet the safety requirement.

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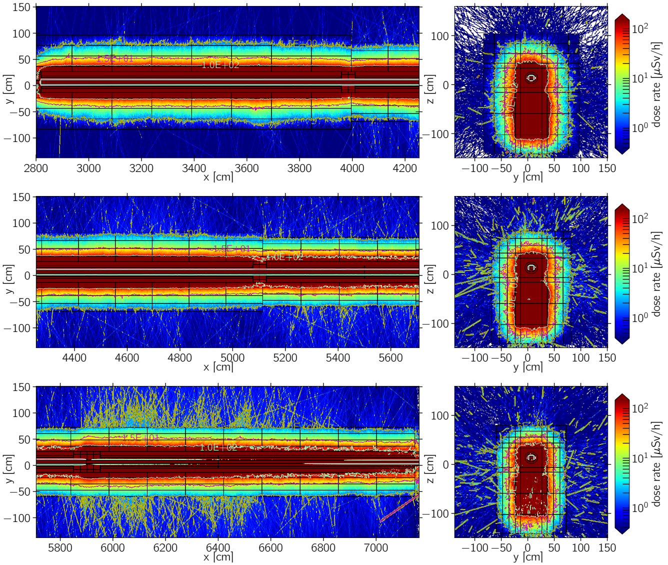
SHIELDING GEOMETRY

Common Shielding Configuration



Radiation (neutron & photon) dose map along the beam guide (Preliminary)

- Layer thicknesses at Section P1 are sufficient enough to meet the safety requirement.
- Section P3 fails.
- Reason?
  - Reduction of the layer thickness at P2
  - Shielding layers brought closer to the beam axis (from 25cm to 20cm)

TAKEAWAYS

- (First) configuration for the common shielding is promising.
- Collimator system might not be useful w.r.t background reduction, but can also be considered as part of the shielding system.
- For beam guide within LOS, radiation is dominated by *albedo*-neutrons.

TAKEAWAYS

- (First) configuration for the common shielding is promising.
- Collimator system might not be useful w.r.t background reduction, but can also be considered as part of the shielding system.
- For beam guide within LOS, radiation is dominated by *albedo*-neutrons.
- Innermost layer borated concrete can be skipped out.
- Borated material might be placed between steel and concrete layers.

ACKNOWLEDGMENT

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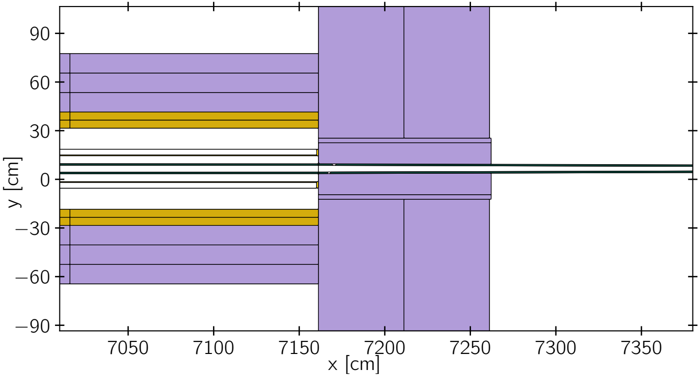
[3] Jülich Supercomputing Centre. (2018). JURECA: Modular supercomputer at Jülich Supercomputing Centre. Journal of large-scale research facilities, 4, A132. http://dx.doi.org/10.17815/jlsrf-4-121-1

Backup

Beam guide insertion in the experimental implemented in the simulations



Impact position distributions of the neutron tracks on the surface at the sample position