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Neutron Shielding Calculation of a Beam Stopper for the Thermal-TAS at HANARO using MCNP6

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1. Introduction

The thermal neutron Triple-Axis Spectrometer (thermal-TAS) consists of various components. Roughly, it can be classified as a virtual source, neutron optics components, Monochromator Shielding Unit (MSU), Sample table and Analyzer & Detector bank.

At a monochromator, specific wavelength of neutron beam is selected by the Bragg scattering theory. Because the neutron beam comes from reactor source has high intensity, massive shielding units are placed around monochromator. After monochromator, selected neutron beam goes toward sample table. At the sample table, the neutron beam is incident on a sample and diffracted. The diffracted neutron beam goes to Analyzer & Detector bank and the beam is analyzed and detected. This is a brief account of the Thermal-TAS experiment.

To achieve high quality experimental results, signal noise should be controlled. Signal noise can come from not only electronic hardware system but also un-necessary neutron background. To reduce background, proper shielding components should be placed around optical components. Monochromator, analyzer and detector have their own shielding components but sample table doesn't in current status of Thermal-TAS. To reduce background occurred on sample table, direct neutron beam that comes from monochromator should be blocked. In this paper, basic design and radiation shielding calculation of direct beam stopper shielding component have been conducted.

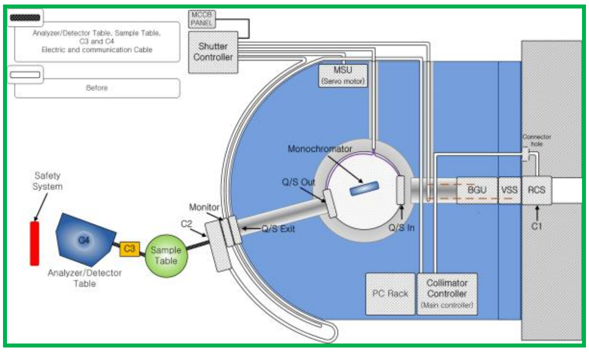
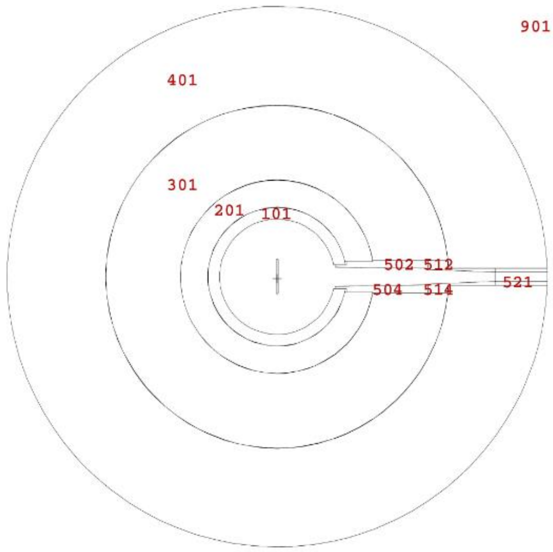


Fig. 1. A schematic of Thermal-TAS

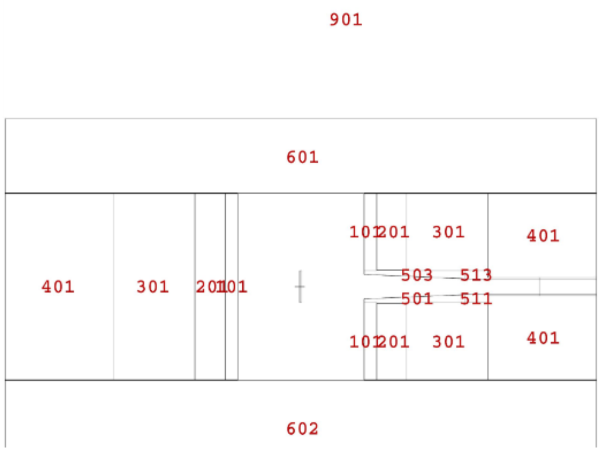
2. MCNP6 coding

2.1 Geometry modeling

Radiation shielding calculation has been conducted using MCNP6[1]. For the shielding calculation, simplified modeling has been conducted. As presented in Fig. 2, the MSU consists of a borated epoxy shield(101), a cylindrical shield(201), a rotating disk(301), outer cover walls(400, 60x) and beam path segments(5xx). A cylindrical shield, a rotating disk and outer cover walls are made with heavy concrete and beam path segments are made with borate polyethylene. As we can see in Fig. 3, the beam stopper consists of thin cadmium plates(702-703) and a borated polyethylene block(701).

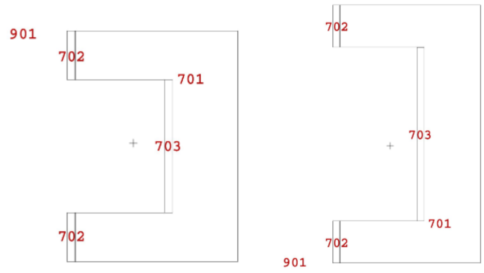


(a)



(b)

Fig. 2. MSU modeling in MCNP6. (a) is a horizontal and (b) is a vertical cross sectional view.



(a) (b)

Fig. 3. Beam stopper modeling in MCNP6. (a) is a horizontal and (b) is a vertical cross sectional view.

Table 1: Composition of materials

Material	Composition, (Density)
Borated Epoxy	H: 25.81%, B: 39.15%, C: 23.75%, N: 6.45%, O: 4.84%, (1.46 g/cm^3)
Heavy Concrete	H: 0.4476%, B: 3.132%, C: 0.868%, O: 18.55%, Si: 15:49%, Ca: 3.5%, Pb: 58%. (5.7 g/cm^3)
Borated Poly - ethylene	H: 13.57%, B: 5%, C: 81.43(3.4 g/cm^3)
Cadmium	Cd: 100%(8.65 g/cm^3)

2.2 Source define

Generally, simulation results using MCNP6 can be utilized for simulations using McSTAS[2] as source data. However, results of McSTAS are not utilized in MCNP6 calculations as source data because McSTAS does not support radiation production simulations. Nevertheless, McSTAS simulation data is utilized to define source data for MCNP6 calculation because of bellowing 2 reasons.

The first reason is that gamma ray calculation result will not be considered. The thermal-TAS already has enough shielding walls to protect user and workers from gamma-rays. Also, gamma-ray does not affected on experimental results. The second is that there's no measured neutron flux data at the monochromator position. An energy distribution of radiation is necessary to define source in the MCNP6 but here's no measurement. Therefore, source data has been defined with a result of McSTAS simulation as 7~10 meV Maxwell distribution. (Peak at 6meV)

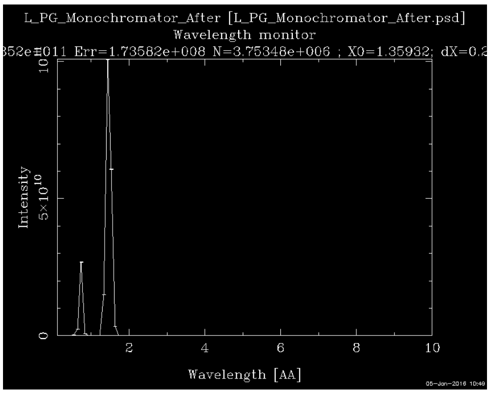
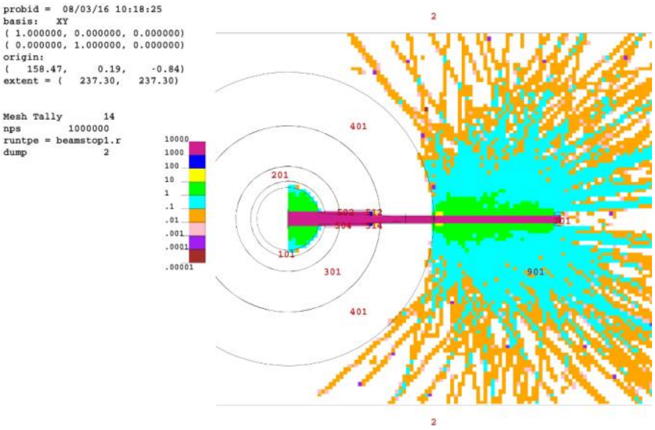


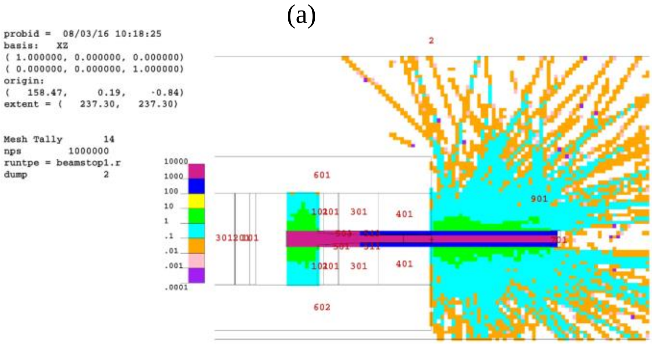
Fig. 4. A simulation result using the McTAS.

3. Simulation result

A simulation is conducted using MCNP6. Mesh tally is utilized to confirm direct beam shielding performance and the result has been plotted in 2-D space using the mcplot function of the MCNP6. As shown in Fig. 5, the direct neutron beam is almost blocked by a beam stopper.



(a)



(b)

Fig. 5. Neutron beam shielding calculation using MCNP6. (a) is a horizontal and (b) is a vertical cross sectional view.

4. Conclusion

A conceptual design and shielding calculation of a neutron beam stopper for the thermal-TAS at HANARO has been conducted. With this result, a beam stopper segment will be fabricated. After further procedures such as mechanical, electronic design and fabrication of a driving part of the stopper, a neutron beam stopper system will be installed on the thermal-TAS at HANARO.

REFERENCES

[1] MCNP6, A general monte carlo n-particle transport code, Los Alamos National Laboratory, http://mcnp.lanl.gov
[2] McSTAS, A neutron ray trace simulation package, DTU Physics, NBI KU, ESS, PSI and ILL, http://www.mcstas.org