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Focusing Multi-layer Guide for Cold Neutron Instrument

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1. Introduction

A neutron is an attractive tool for the structural analysis of material such as single crystal and thin film. However, it's difficult to obtain the sufficient high flux of neutron beams. Because of difficulties to increase the neutron intensity from the moderator of the built target system, several research groups have adopted the focusing devices using neutron supermirror to improve the loss of neutron beams[1,2,3]. In this report, we will present the results from a systematic neutron guide geometries. We used the neutron ray-tracing simulation package McStas (Monte Carlo simulation of triple axis spectrometers) to calculate intensity, spatial, and angular distribution of a neutron beam at a sample. The McStas component code for the multi-layer guide was written for our purpose based on the algorithms of the software components "Mirror Parabolic" and "Mirror Elliptic"[4,5].

2. Multi-layer Guide

A conceptual diagram of the multi-layer guide is shown in Fig. 1. The parabolic mirror focuses the incoming neutron beam at the focal point. In this case, if the two parabola mirrors in the outer layer and the two parabola mirrors in the inner layer have the same curvature, then the beam intensity increases while the angular distribution is maintained. In order to have a compact structure, parabolic mirrors with the same curvature were arranged in equal intervals. This concept will allow for the provision of neutrons having improved beam intensity and beam divergence.

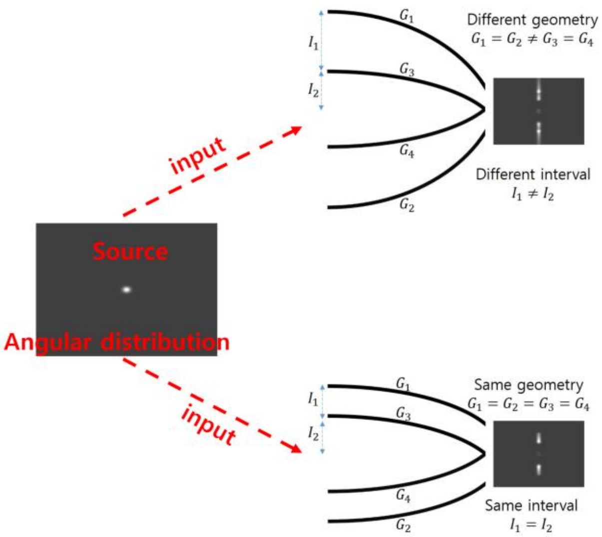

Fig. 1. Concept diagram of the multilayer guide using a parabolic mirrors. *I* and *G* represent the illumination width and the geometrical parameter that is required for determining the shape of the parabolic guide, respectively.

3. McStas Modeling and Simulation

Fig. 2 shows the McStas modeling for the multilayer guide using a parabolic and a elliptic supermirror. The modeling reflected the geometry of bent supermirror with same curvature and interval. We considered a new optical design which is combined additional parabolic mirrors and elliptic mirrors. The parabolic mirror focuses the incoming neutron beam at the first focal point and the elliptic mirror focuses it again at the second focal point. In the beam focusing system using the conventional method, some of the incoming neutrons are absorbed by the beam stop. However, in the method proposed in this paper, additional parabolic mirrors are placed instead of the beam stop, and the absorbed part is scraped and transported to the outer doubly elliptic mirror to prevent beam loss. The neutrons focused on the three focal points that occur in the system converge into the sample positon of the typical system by adjusting the tilting angle of the axis with respect to the center of the outer elliptic mirror.

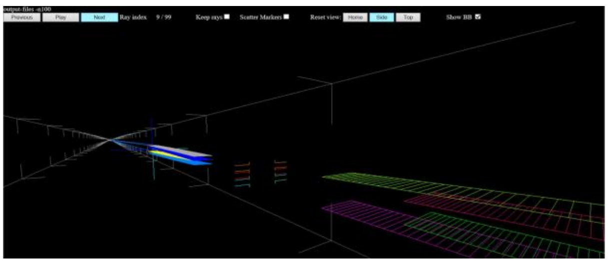

Fig. 2. McStas modeling of the multi-layer guide using a parabolic mirror and a elliptic mirror.

Fig. 3 shows the simulated angular distribution image and wave length distribution graph at the exit of long straight guide. The data used here were obtained by integrating events within the PSD that is the McStas monitor component. Fig. 4 shows the divergence images of the parabolic converging system and the

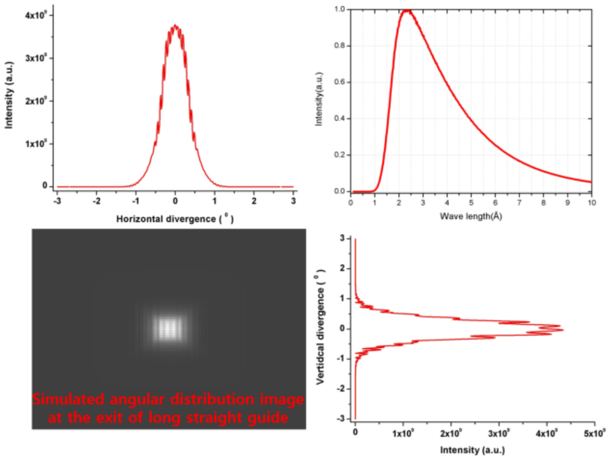

Fig. 3. Simulated angular distribution image and wave length distribution graph at the exit of long straight guide.

elliptic converging system at the focal points used for the PSD. Fig. 5 shows the simulated spatial distribution images for the parabolic converging system and the elliptic converging system at the focal points used for the PSD. The images show the equal intervals on both sides of first focal point. It is finally focused into second focal point.

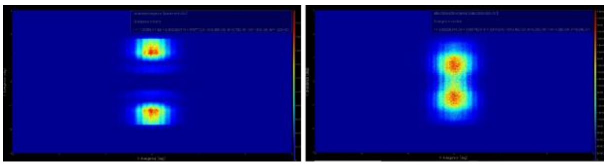

Fig. 4. Simulated images for angular distribution of parabolic focusing system and elliptic focusing system. The divergence detector was placed at the focal point of the parabola and ellipse.

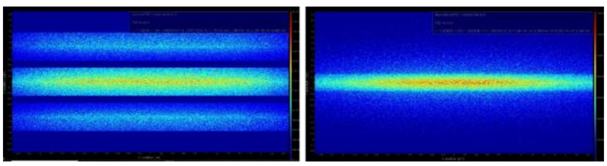

Fig. 5. Simulated images for the spatial distribution of parabolic focusing system and elliptic focusing system.

4. Summary

In this study, we designed focusing multilayer guide for cold neutron instrument. Computational simulation was performed to increase the yield of neutrons incident on the sample of the neutron experiment device. In other words, by arranging a neutron guide in a virtual space, conditions such as neutron flux, beam divergence, experimental space, and accessibility were optimized. Actually, we have not yet decided neutron beam lines. After the specification of the accelerator related to the beam power and energy is decided, the specification of neutron beam lines will be optimized for the spallation target system. In future, further studies will be conducted to apply this result to construct the neutron beam line for a structural analysis of material through the spallation neutron source. Also, a more complex computational simulation process is required to determine the curvature and M-value of the supermirror considering the characteristics and wavelength of each beamline.

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