Intercomparison of Neutron Beam Guides for Cold Neutron Activation Station at HANARO using McStas/VITESS/RESTRAX Codes

Hoang Sy Minh Tuan [a] and Gwang Min Sun [a*]
[a] *Korea Atomic Energy Research Institute (KAERI), PO Box 105, Yuseong, Daejeon 305-353*
[*] *Email: gmsun@kaeri.re.kr*

1. Introduction

The HANARO (KAERI) research reactor has been developed a neutron guide system for cold neutron (CN) research facilities since July, 2003. The neutron guide system plays an important role in transporting cold neutrons from the CN source to the neutron facilities as CN-NDP, CN-PGAA, SANS, etc.

The CN activation station is being installed in the HANARO cold-neutron research project. The CN-NDP and CN-PGAA were selected as two facilities using at this station. At the end position of CG1 and CG2B beam guides, the CN-NDP and CN-PGAA will be installed in the CN guide hall. In order to predict the neutron flux and intensity values at the CG1 and CG2B beam guides, the simulation results of neutron flux at the CG1 and CG2B beam guides are presented by using several Monte Carlo (MC) neutron ray-tracing simulation codes. The intercomparison of neutron flux values between McStas [1], VITESS [2] and RESTRAX [3] are performed for getting fairly correct results at two neutron beam guides.

2. Simulation codes

At present, several MC simulation codes for neuron instruments are available and being used for new instrument designs. In this study, the MC codes including McStas, VITESS and RESTRAX are adopted for simulating the neutron beam guides. According to the study of Seeger et al. [4] regarding various simulation tools, this presented that the level of agreement between these codes are a well-acceptable.

2.1 McStas

McStas is versatile code for neutron ray-tracing simulation. It is based on the ANSI-C language and is covered by special meta-language for easily utilizable aim. This special meta-language are written by user and after that translated to C language. The present version (1.12b) supports to simulate both continuous and pulsed source. Additionally, it includes a library with in total around 100 components.

McStas can simulate all kinds of neutron scattering instruments (spectrometers, reflectometers, TOF, SANS...) for both continuous and pulsed sources.

2.2 VITESS

VITESS is virtual instrumentation tool for simulating the neutron ray-tracing at continuous and pulsed sources.

VITESS has an uncomplicated modular structure consisting of independently executable components that describe the instrument components. Each module refers to the coordinate system provided by the preceding module, changing the neutron beam input. On the other hand the output is a function related only to the parameters of the respective module.

2.3 RESTRAX

RESTRAX is also virtual instrumentation tool for simulating the neutron ray-tracing. It consists of two independent modules as RESTRAX and SIMRES. RESTRAX module is designed for simulating TAS resolution functions, data fitting and a set of modules implementing different scattering functions.

The other module, SIMRES, is simulated the neutron ray-tracing on a more detail level and it provides more flexibility in varying the instrument configuration than RESTRAX. It permits to simulate any user-defined instrument which can be built from available optical components such as source, guides, collimators, samples… In addition, functions for parameter space mapping and numerical optimizations are provided, which makes this module a useful tool for designing novel neutron optical components and instrument configurations.

These MC codes for neutron ray-tracing simulation are supported by a graphical user interface, which generates and controls command lines according to given input. Furthermore, these codes can be performed with different systems as UNIX, Linux, Windows and Mac OS.

3. Methods and Result of simulations

The HANARO neutron guide system consists of several components as CN source, neutron guides, curvature, main shutter, shielding, etc.

3.1 Cold Neutron Source

The CN beams were generated when thermal neutron pass through liquid hydrogen at 22K. The liquid hydrogen was used as a neutron moderator inside the moderator cell. Based on the calculated results of Yu et al. [5], the neutron spectrum at the moderator surface was approximated as total integration flux I_1 = 7.656 x 10^{12} n cm^2/sec at characteristic temperature T_1= 26.264 K and total integration flux I_2 = 6.4 x 10^{13} n cm^2/sec at characteristic temperature T_2= 125.18 K. the parameter couples of total integration flux and temperature are fitted by Maxwellian distribution function (1):

$$f(\lambda)d\lambda = \sum_{i=0}^{i=1} I_i \times 2 \times \left(\frac{\lambda_{T_i}}{\lambda}\right)^4 \exp^{-\left(\frac{\lambda_{T_i}}{\lambda}\right)^2} \frac{d\lambda}{\lambda} \qquad (1)$$

In practical, these parameter couples are passed in the MC codes for generating the CN beams used to following components.

3.2 CG1 and CG2B guide systems

The CG1 and CG2B neutron guides with dimensions were given in figure. 1. The neutrons guides start to curve after 1m from the main shutter. It were made by Bokron glass at the first part and Borofloat at remain part. Table. 1 specifies the length dimensions of CG1 and CG2B guides.

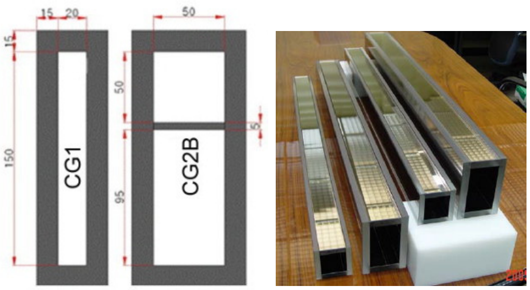

Fig. 1 The CG1 and CG2B neutron guide cross-section dimensions (mm) and its actual pictures.

Table. 1 Specifications of the CN beam guides

CN guide	Curvature (m)	Length of curved part (m)	Line of sight (m)
CG1	400	26.0	8
CG2B	350	26.3	11.832

The CN beam guides and the main shutter are shielded with heavy concrete blocks of high density (5.0 g/cm^3).

3.3 The results of MC codes

In these MC codes for neutron ray-tracing simulation, the neutron fluxes and intensities were gotten at the position of the main shutter, secondary shutter, the monochromators and neutron velocity selector for these CN beam guides by using the specification lengths in table 1. Figure. 2 and 3 show the simulated results for CG1 and CG2B by using McStas simulation.

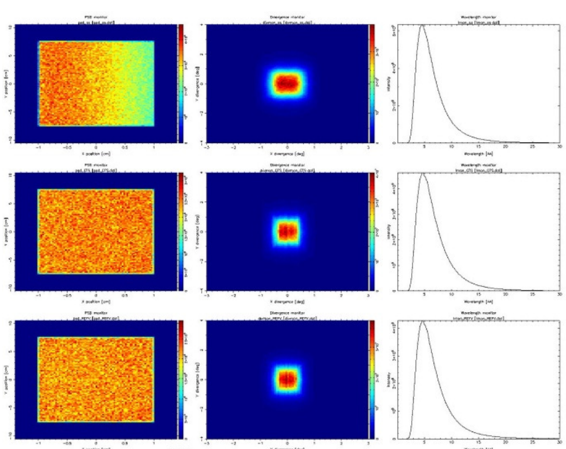

Fig. 2 The 2-dimension neutron distribution and the wave length distribution of CG 1 by using McStas.

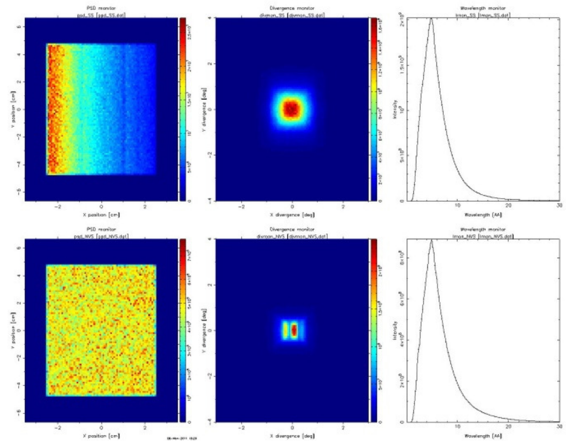

Fig. 3 The 2-dimension neutron distribution and the wave length distribution of CG2 by using McStas.

4. Conclusions

McStas/VITESS/RESTRAX differs in both the physical models underlying simulation of particular components and the structure of their code, depending on the different purposes for which they have been written. While some put emphasis on modularity (McStas, VITESS), which permits one to easily incorporate new components and to test new ideas of experimental techniques, others, like RESTRAX, trade part of their flexibility for a highly efficient sampling strategy permitting to gain several orders of magnitude in computing speed.

Especially, McStas integrated the function to export the output data to MCNP code. This function is convenient and useful for users who want to consequent simulated the facilities at the CN beam guide exiting.

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