Simulation report for neutron guide and spectrometer layout at HANARO

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1. Introduction

A project called 'infrastructure construction for cold neutron research and utilization technique development' was launched in KAERI in July 2003, in order to raise a domestic basic science with an international level and elevate a international competitiveness for the bio-, nano- and informatics technology area.

At the end of this project, 3 new instruments and 3 instruments to be moved will be installed in the guide hall. In order to accomplish this project until 2008, guide simulation should be performed for an effective use of expensive neutron to meet the requirements such as wavelengths & type of instruments, experimental space, interferences with other instruments.

2. Methods and Results

HANARO guide system consists of a rotating beam shutter and the neutron guide systems inside a biological shielding of the reactor, guide bunker in the reactor and guide hall site and neutron guide hall. In this report, a conceptual design of in-pile plug & main shutter system and a simulation result of a guide shape, structure and characteristics for the guide system were described.

2.1 In-pile plug and guides

The number and size of neutron guide tubes which start in the reactor channel at a distance from the cold neutron source (CNS), is only limited by the diameter of the reactor channel and the final size of the CNS. We reviewed the available spaces regarding the CN beam tube and the HANARO guide hall space.

CN beam port is connected to the CNS vertical beam tube with an inner diameter of 160 mm which is located at about 500 mm from near the boundary of the reactor core. The CN beam port inside the D_2O tank is a divergent type with a nose beam size of 70 mm x 150 mm and an exit beam size of 150 mm x 150 mm which is located 630 mm away from the CN nose. The expansion bellows follows the beam channel and is connected with an in-pile plug inside biological shielding as shown in Fig 1. The in-pile plug is a two stepped type cylinder plug with a 380 mm diameter x 735 mm length and a 700 mm diameter x 1,170 mm length. 5 neutron guide channels start at a distance of 1840mm from the cold source.

The center lines of the guides, named CG1, CG2, CG3, CG4 and CG5 from north to south, are converging onto the CNS and have angles of +3.04, +2.03, +0.54 -0.93 and -2.5 degree respectively, with respect to the beam port axis.

In-pile assembly, a casing with guide tubes installed in the in-pile plug, should be filled with Helium. With a thin metal-alloy, the guide tube casing in the in-pile plug is separated from guide tubes of a main shutter located outside of the biological shielding. The isolation windows should be an Al-Mg alloy (AlMg3) of a 1 mm thickness and withstand a pressure of 5 bar.

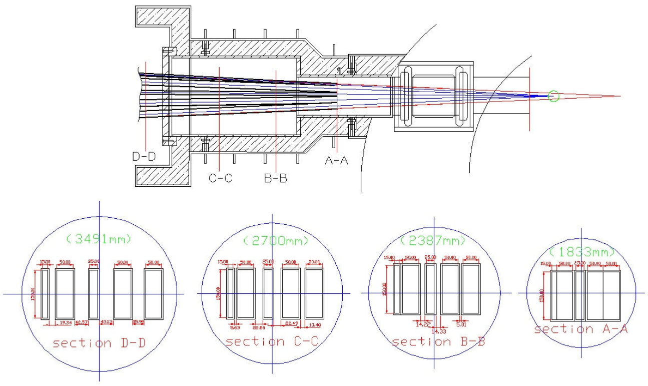

Figure 1 The conceptual layout of in-pile guide channel

2.2 Concept of main shutter

It is very difficult to install a rotary type main shutter with guide beam channels inside a biological shielding due to a lack of available space. Therefore, a main shutter will be installed just after the in-pile plug as shown in Fig. 2.

Five neutron guides are also to be incorporated in a rotating mechanical shutter and operate in helium. When the shutter is in the open configuration, the guides within the shutter should be positioned to the tolerances level specified as follows;

- tolerance on the angle : 10^{-4} radian
- space between reflective surface : 0.5 mm
- position tolerance: ± 0.01 mm.

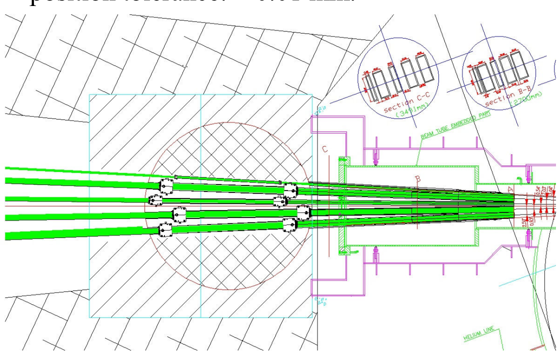

Figure 2 Conceptual layout of main shutter

2.3 Guide bunker and confinements penetration

After the straight guide part inside the main shutter, the 5 neutron guides start to be curved with different curvatures, and two(CG2 and CG5) of the five neutron guides are separated into two or three guides horizontally by a guide.

Before reaching the cold neutron guide hall, the 8 neutron guide tubes cross the containment of the reactor building and are generally kept the curvature to the guide bunker wall in the guide laboratory hall area. The length of the curve guide is considered as generally longer than the direct view of the guide tube in order to station the instruments in the guide laboratory hall effectively.

The reactor containment can be crossed by a single casing, the tightness between the casing and the reactor wall is assured by a rubber sealing. The guide tubes, which extend through the casing into the reactor hall, are closed by thin Al windows and then are evacuated.

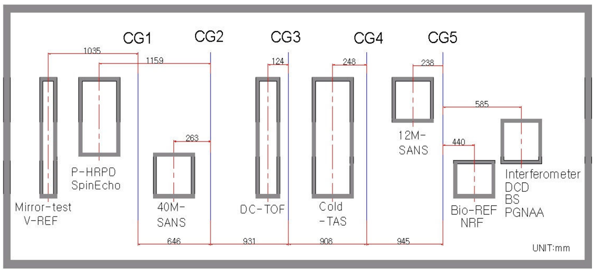

Figure 3 Guide tubes at reactor confinement

2.4 Cold neutron guide hall

In the cold neutron guide hall, we will install eight neutron guide lines, more than 13 cold neutron spectrometers, and utilities. One or more neutron instruments will be equipped at each guide. The guide hall has an area of 47 m width x 65 m length. The space between the guides has enough area to install different kinds of neutron instruments.

Figure 4 shows the HANARO cold guide hall layout. Many different shapes of guide tubes cover the scientific demand of instruments. One type of guide tube is CG1 with a very narrow shape (1.5cm x 15cm) for a vertical type reflectometer with a characteristic wavelength of 2.4 Å. The guide tubes CG3 & CG4 are a similar type to CG1 but have a very high curvature installed in the middle of the guide hall. At these guides, some instruments requiring a short wavelength such as a triple axis spectrometer (TAS) and a disk chopper time-of-spectrometer (DC-TOF) will be installed.

Another type is a rectangular square type guide tube (CG2A&B, CG5A,B&C) with a low curvature relative to CG3 & CG4. At this square type guide tube, long wavelength instruments such as SANS and Cold-NR etc will be installed.

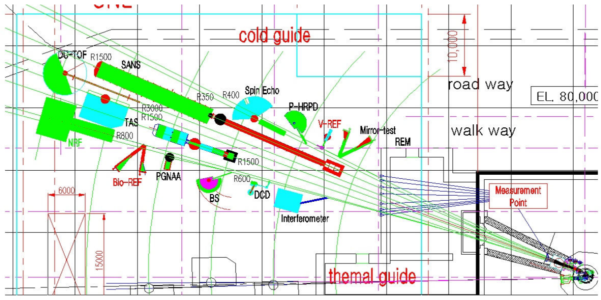

Figure 4 HANARO cold guide hall layout

3. Conclusion

The simulation is performed to meet the requirements from instrument scientists as much as possible. But some problems are still remained, because the beam flux was taken precedence over the other requirements, such as an easy sample access, a sufficient experimental space and interferences from other instruments.

According to the simulation results, the characteristic wavelengths are very low for the 40M-SANS and 12M-SANS, for which a wavelength of 5 Å is required. For the reason of the high transmission of the neutrons, the ratio of λ/λ_* is normally more than 1.6, but a too high λ/λ_* leads to a high background due to the short wavelength neutrons. In case of the both SANS instruments, the curvature should be reduced. On the other hand, the curvature for the Cold-TAS should be increased for the flux of the short wavelength range.

In order to reduce the fast and epithermal neutron flux, the length of the curved section should be increased. Therefore the guide bunker wall in the guide hall should be extended to instrument site. In this case for a sufficient space for the 40M-SANS, the velocity selector should be located inside of the guide bunker and it leads to a γ-background reduction.

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