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Current Development Status of Time-of-Flight Inelastic Neutron Spectrometer at HANARO

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1. Introduction

As part of the Cold Neutron Research Facility (CNRF) project launched in 2003, disk chopper time-of-flight (DC-TOF) spectrometer was proposed for the study of slow dynamics of all condensed matter sciences, which has been increasingly proven to be invaluable information. Here we present the current status of the DC-TOF instrument development.

The HANARO research reactor has started operation since 1995 and reached its full operation power of 30 MW in 2004. Three neutron scattering instruments such as HRPD, FCD and SANS have been since running for user program, both domestic and foreign researchers. Till now, however there has been no inelastic neutron spectrometer in Korea, which has deterred otherwise natural growth of an inelastic neutron scattering community.

Disk chopper time-of-flight inelastic neutron spectrometer is an advanced neutron scattering instrument, which has been proven worldwide to be very versatile for both basic science and material engineering studies. Therefore, when the Korea Atomic Energy Research Institute (KAERI) started the CNRF project in 2003, it was a natural choice that it decided to build DC-TOF for the cold neutron laboratory. Day-1 instruments of the CNRF project include a DC-TOF, a cold TAS, a 40m-SANS, and two reflectometers. In this paper, we present the current design specifications of the DC-TOF at the KAERI.

A DC-TOF instrument is mainly divided into two parts: one is a primary spectrometer and the other a secondary spectrometer. The primary spectrometer produces monochromatic neutrons with a desired pulse-shape by making use of a chopper-cascade system. The then monochromatic neutrons are guided into the secondary spectrometer: first a small area of the sample, and the scattered neutrons from the sample are subsequently collected as function of time by wide-angle covering detectors.

We have optimized our design parameters by making full use of two Monte-Carlo simulation codes, VITESS and McStas[1]. Before carrying out our own simulations, we have also undertaken a bench-mark test of VITESS using measured values from one of currently operating DC-TOF instruments, the NEAT of the HMI, with helps of Dr. R. Lechner[2].

2. Spectrometer Design

2.1 Primary Spectrometer

According to the present layout of the guide hall, our DC-TOF will be located at the end position of the CG2A beamline with entrance cross-section of 3 cm × 15 cm. This beamline provides relative higher flux on the thermal neutron range than the other beamlines. To focus neutrons from such a large cross-section onto a relatively smaller sample size of 3 cm × 5 cm, we have used a supermirror ballistic guide design with m=3 and 3.6. This guide design gives us theoretically maximum flux at the sample position and so makes practically feasible a wide range of resolution coverage. Using this guide design, in our Monte-Carlo simulations we could achieve an overall gain of 2.2 over the straight guide for neutrons from 3 A to 10 Å region.

Our DC-TOF will employ 7 disk chopper cascade units[3]: Three counter rotating chopper pairs and one single chopper. Flight path from the first choppers to the last one is designed to be 12.0 m and the maximum chopper rotation speed is estimated to be about 18000 rpm. Using these design parameters, we could achieve high energy resolution, $\Delta E/E$~2.7 %for 10 Å.

2.2 Secondary Spectrometer

In order to have maximum detector coverage, we decided that the sample-detector distance should be 2.5 m with detector coverage of around 4 sr. from -96 deg to 127 deg. We will use 1D position sensitive detector in order to have good Q as well as E resolutions. As we expect that there will not be enough funding available for the full 4 sr. detector coverage at the beginning of the DC-TOF instrument development, we will initially populate about 1.0 sr. of the detector coverage and continuously fill in the empty detector area as soon as further funding is made available. With the designed detector coverage, we will be able to have a full E-Q coverage as shown in Figure 1.

Suite of auxiliary equipments considered in our proposal includes a general purpose CCR, a He^4 Cryostat, and a cryofurnace together with high magnetic field and pressure environments. These equipments are considered to be essential for physics, chemistry and biology-related researches.

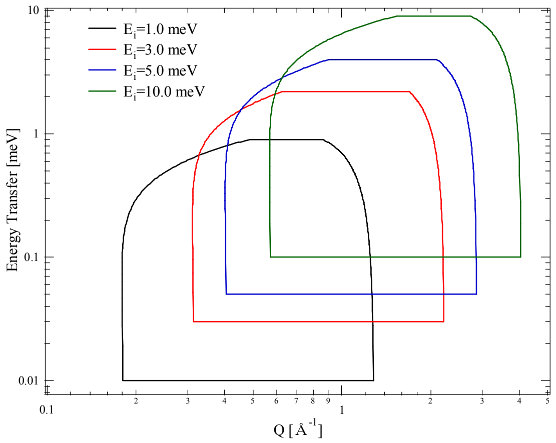

Figure 1. Energy and momentum coverage of DC-TOF at KAERI.

2.3 Monte-Carlo Simulation

We have simulated whole spectrometer using MCSTAS and VITESS, which are the most popular packages for instrument simulation. The neutron flux in Table 1 comes from MCSTAS calculation. We have performed VITESS simulations to get almost same results. Table 1 compares the instrument capacity of HANARO DC-TOF with other international TOF instruments.

Instrument	**Neutron Flux On Sample @ 10% Resolution**	**Total area [m^2 or sr]**
DC-TOF (HANARO)	4.0x10^4	22.32 m^2 (3.0 sr)
DCS (NIST)	1.0x10^4	~0.65 sr
NEAT (HMI)	1.0x10^4	~1.0 sr
IN5 (ILL)	6.8x10^5	0.8 sr (current) 1.7 sr(2007)

Table 1. Neutron Flux at sample site and detecting area of HANARO DC-TOF and other TOF instruments.

3. Conclusions

With completion of the DC-TOF and two planned TAS, the KAERI will be able to have world-class research capabilities in the area of inelastic neutron scattering. This will open up a new opportunity of inelastic neutron scattering not only for Korean users but also overseas users, in particular in the Asian region.

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REFERENCES

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