ICANS XIX,
19th meeting on Collaboration of Advanced Neutron Sources
March 8 – 12, 2010
Grindelwald, Switzerland

PROSPECTS FOR SINGLE PULSE SPECTROSCOPY: A CASE STUDY FROM SEQUOIA

J.P.C. Ruff[1], A.I. Kolesnikov[2], J.P. Clancy[1], K.A. Ross[1], B.D. Gaulin[1] and G.E. Granroth[2]

[1]*Department of Physics, McMaster University*
Hamilton, Ontario, L8S 4M1, Canada

[2] *Neutron Scattering Sciences Division, Oak Ridge National Laboratory*
Oak Ridge, TN 37831, USA

ABSTRACT

A new thermal Fermi chopper spectrometer SEQUOIA is operating at the SNS. Several commissioning experiments have elucidated the performance of the spectrometer. One specific measurement of interest was a study of the crystal field levels of $Tb_2Ti_2O_7$. Though the measurement of the crystal fields is of interest in itself, these measurements were also used to establish the minimum experiment time to see a signal above background. Specifically 1 minute, 30 second, and 10 second durations were cut from the event data file. Signal was observed even for the 10 second counting time. Scaling from this data taken on a 6.7 g sample covering 13% of the beam at 400 kW source power to the sample required for single pulse neutron spectroscopy when the source is at full power will be presented.

1. Introduction

A new thermal Fermi chopper spectrometer SEQUOIA [1] is operating at the SNS. The commissioning phase of the instrument is underway. SEQUOIA is designed to utilize neutrons of an incident energy E_i between 10-2000 meV. A monochromatic beam is provided on a sample, 20 m from the decoupled ambient temperature H_2O moderator, by filtering the white beam with a Fermi chopper located 18 m from the source. After interacting with the sample, neutrons are detected by a 3 row array of 1.2 m long ^{3}He linear position sensitive tubes located on a vertical cylinder with a radius of 5.5 m. These three rows cover from – 30 to 60 degrees in the horizontal plane and the array is offset ~4 cm from symmetric above and below the beam. A narrow bandwidth T_0 chopper is located 10 m from the moderator to reduce background.

2. $Tb_2Ti_2O_7$

Several commissioning experiments have elucidated the performance of the spectrometer. One specific measurement of interest was a study of the crystal field levels of $Tb_2Ti_2O_7$. Though the measurement of the crystal fields is of interest in itself, these measurements were also used to establish the minimum experiment time to see a signal above background. Specifically 5 minutes, 1 minute, 30 seconds, and 10 seconds durations were cut from the event data file. Signal was observed even for the 10 second counting time (see Fig. 1).

Scaling from this data, taken on a 6.7 g sample covering 13% of the beam at 400 kW source power, to a sample which completely covers the incident neutron beam (51.5 g) on the neutron source at full power 1.2 MW, shows that about 25 pulses (~0.42 sec) are needed to produce a spectrum with the similar statistics to those observed after 10 sec.

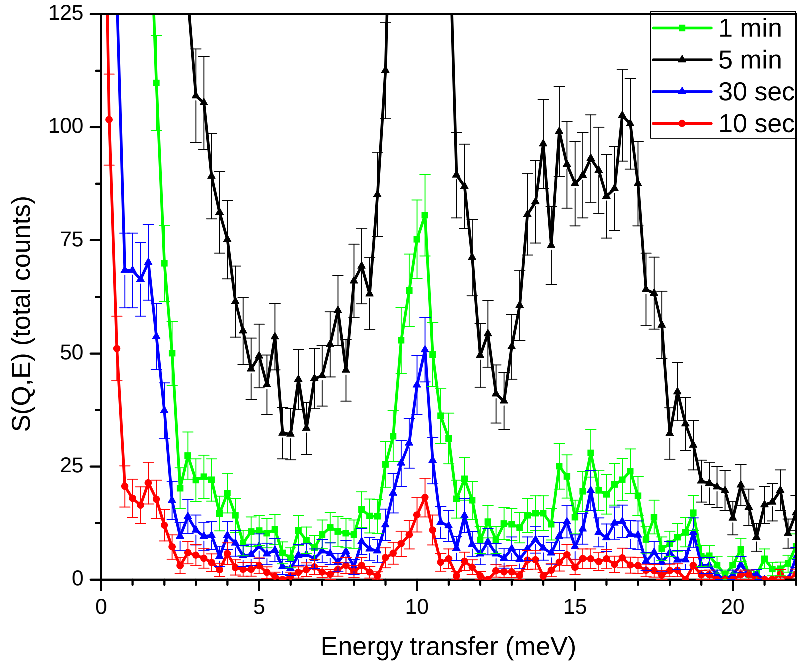

Fig. 1. INS spectra for $Tb_2Ti_2O_7$ at T=7 K measured with SEQUOIA for time 5 min, 1 min, 30 sec, and 10 sec. We used Fermi chopper 1 rotating at speed of 420 Hz (T0 at 90 Hz), neutron incident energy was E_i=28 meV, and the data were summed over momentum transfer Q=0.8 to 3.2 $Å^{-1}$.

3. MeH

To investigate the possibility to do INS spectroscopy at SEQUOIA in just one neutron pulse, estimates of the S(Q,E) spectrum for a strongly scattering sample were made and are reported here. The specific sample was a metal hydride with total hydrogen content of 0.1 g (which corresponds to 80% of thermal neutron transmission for 5x5 cm^2 sample cross-section, if we neglect neutron scattering from the metal atoms). We modeled the metal hydride (MeH) with the energy of the main peak corresponding to the fundamental band of hydrogen vibrations around 55 meV and with the high energy shoulder extending to 100 meV (e.g., case of PdH, see e.g. [2]). The estimates show that to have a minimum acceptable statistics (10 counts at peak maximum) in just one neutron pulse (see Fig. 2) the power of neutron source should be 3 MW.

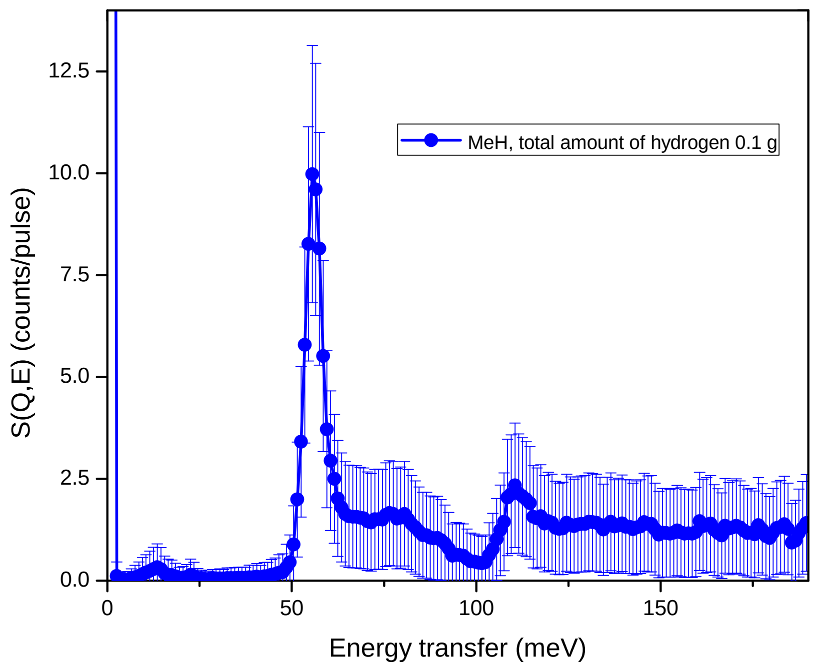

Fig. 2. Estimated S(Q,E) spectrum for model metal hydride with total amount of hydrogen 0.1 g (5x5 cm^2 sample area with 80% transmission for thermal neutrons) if measured at SEQUOIA spectrometer with Fermi chopper 1 rotating with 600 Hz. Ei=200 meV and the data summed over Q=2 to 8.5 $Å^{-1}$, the power of neutron source 3 MW.

4. Conclusions

Therefore the current generation of spectrometers on the highest power Spallation neutron sources are tantalizing close to enabling single pulse spectroscopy. Broad classes of single pulse experiments, that include both examples$Tb_2Ti_2O_7$ and MeH, are likely to be realized only with next generation sources. However when the SNS is running at 2 MW, upgrading the guides and Fermi chopper split packages on SEQUOIA to the state of the art, at that time, is likely to provide the additional gain to enable single pulse spectroscopy for some MeH samples.

5. Acknowledgements

We are greatful for the help with data reduction provided by P. Peterson.Work at ORNL was supported by the Scientific User Facilities Division Office of Basic Energy Sciences, DOE and was managed by UT-Battelle, LLC, for DOE under Contract DE-AC05-00OR22725.

6. References

1. G.E. Granroth, A.I. Kolesnikov, T.E. Sherline, J.P. Clancy, K.A. Ross, J.P.C. Ruff, B.D. Gaulin, and S.E. Nagler, *J. Physics: Conf. Series* (2010) in print.
2. D.K. Ross, V.E. Antonov, E.L. Bokhenkov, A.I. Kolesnikov, E.G. Ponyatovsky, and J. Tomkinson, *Phys. Rev.* **B58** (1998) 2591.