Sequoia
A High Resolution Fermi Chopper Spectrometer for the SNS

G. E. Granroth[1], D. Abernathy[1], and S. E. Nagler[2]
[1] The Spallation Neutron Source Project and [2] Solid State Division, Oak Ridge National Laboratory, Oak Ridge, TN USA

The needs of the Inelastic neutron user community are best met by two Fermi Chopper instruments with an incident Energy range of E_i = 10 - 1000 meV. Currently a wide angle instrument with a best resolution of $\Delta E/E \sim 2\%$ is under construction as the ARCS project. To complete the suite, the concept for a machine optimized for High resolution (HRCS) ($\Delta E/E < 1.5\%$) has been studied and the results are shown here.

Conceptual Instrument Design

The conceptual instrument has an incident flight path of m = 3.6 tapered guide, 15.5 m in length, to propagate neutrons from the decoupled H_2O moderator to a Fermi chopper capable of spinning up to 600 Hz. The sample position is 2 m away from the Fermi chopper. In this section a set of changeable collimators will control the incident divergence on the sample The neutrons are detected by ~ 1500 100 cm x 2.5 cm position sensitive He^3 tubes located on a 5.5 m radius from the sample position. They span - 30° to 60° in the horizontal plane and -30° to 30° in the vertical direction. The sample and detectors will be in an integrated vacuum tank to minimize scattering from Al windows. In addition a T0 chopper will be placed at ~10 m away from the moderator in the incident beam followed by a frame overlap chopper. A rendering of the instrument is shown in Figure 1.

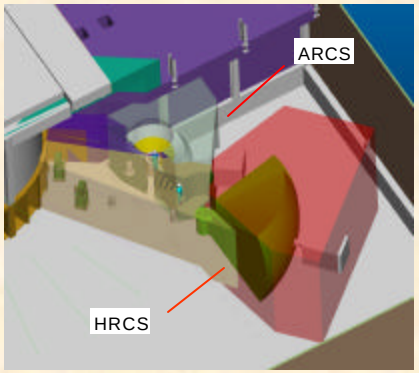

Figure 1. Schematic diagram of the ARCS and HRCS instruments

Instrument Performance

The Instrument performance has been calculated by a combination of numerical and analytical techniques. The results of these calculations are shown in Figures 2 – 4. Besides the parameters described above, the Fermi chopper model consisted of 1.5 mm channels and spinning at 600 Hz. The curvature of the slit package is optimized for each incident energy. To show the complimentarity of the two instruments, the performance for the ARCS instrument is shown as well. The details of the Intensity and resolution[1] calculation are provided in previous documents and only the results are presented here.

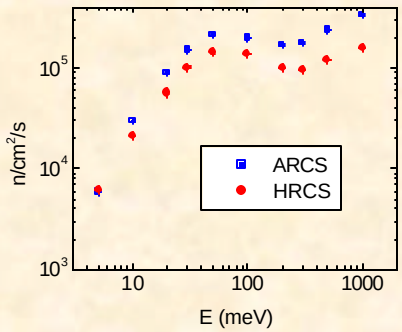

Figure 2. Flux on sample as a function of Incident Energy. Both instruments have identical slit packages

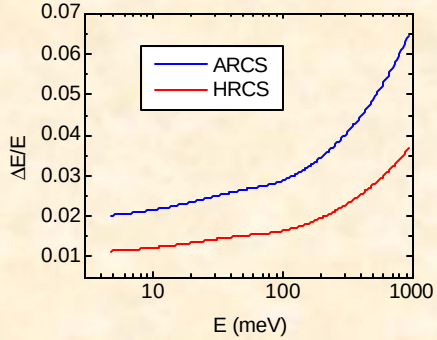

Figure 3 Energy resolution corresponding to the Flux on sample values shown in Figure 2.

Another parameter of interest is the Q resolution ΔQ. Through a series of Monte Carlo calculations using the McStas[2] package, we determined that, for most cases, the incident divergence controls the Q resolution. In all other cases the detector size controls this resolution. For all of these cases ΔQ is determined by the uncertainty in the scattering angle ($\Delta\phi$) which is a constant in ϕ. This constant was determined using Monte Carlo and the results are provided in Table 1.

	HRCS $\Delta\phi$	ARCS $\Delta\phi$
5cm wide sample	0.8°	1.1°
1cm wide sample	0.8°	1.1°
Detector limited	0.3°	0.5°

Table 1 $\Delta\phi$ as determined by Monte Carlo for 50 meV neutrons

The Q resolution is determined by differentiation of the law of cosines with respect to phi namely:

$$\Delta Q = \frac{k_i k_f \sin(f)}{Q}\Delta f$$

The results using the example Monte Carlo data in Table 1 and additional data for energies in the range between 10 - 500 meV are shown in figure 4. All these results are for the case of elastic scattering The ARCS instrument, with its wide angle detector bank, provides the largest Q range and excellent Q resolution above 3 ?$^{-1}$. The HRCS provides superior Q resolution below 2 ?$^{-1}$. This low Q region is crucial for many systems. Therefore both ARCS and the High Resolution Chopper Spectrometer work together to provide the Q resolution required in this range of energies.

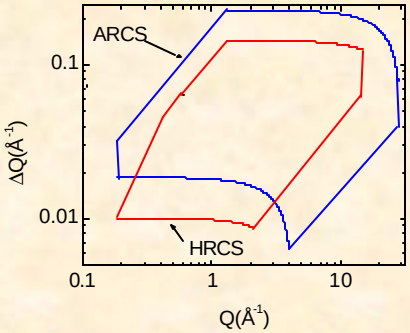

Figure 4 Q Resolution and Q range for the ARCS and HRCS spectrometers

Summary
A conceptual design for a High resolution chopper spectrometer has been presented. Intensity and Energy resolution comparisons between this instrument and the wide angle chopper show that the instruments compliment each other. Monte Carlo calculations have been used to calculate the Q resolution. The results show that ARCS, with it's wide angle coverage, provides access to large Q and the HRCS, with it's long final flight path provides access to fine Q resolution.

References
[1] D. L. Abernathy, SNS document IS-1.1.8.4-6033-RE-A-00
[2] K. Nielsen and K. Lefmann, Riso-R-1175