ICANS-XVI
16th Meeting of the International Collaboration on Advanced Neutron Sources
May 12 – 15, 2003
Düsseldorf-Neuss, Germany

Performance Comparisons of Four Direct Geometry Spectrometers Planned for the Spallation Neutron Source

G.E. Granroth and D.L. Abernathy

Spallation Neutron Source, Oak Ridge National Laboratory,
P.O. Box 2008, MS6474, Oak Ridge, TN 37831 USA

ABSTRACT

Four direct geometry spectrometers are planned for the SNS. The CNCS is a multiple chopper instrument that uses cold neutrons. The HYSPEC spectrometer uses disc choppers and a vertically focusing monochromator to select cold and thermal neutrons. The ARCS spectrometer is a Fermi chopper instrument with a large angular coverage that uses thermal to epithermal neutrons. The SEQUOIA spectrometer is a Fermi chopper instrument with a long final flight path that uses thermal to epithermal neutrons. To compare the performance of these four instruments, each one has been simulated using the McStas Monte Carlo package. The resulting calculations of flux on sample are compared for various incident energy (E_i) and energy resolution ($\Delta\omega$) conditions. The results show that the CNCS is optimized for fine $\Delta\omega$ measurements using cold neutrons, HYSPEC is optimized for coarse $\Delta\omega$ measurements using cold to thermal neutrons, ARCS is optimized for moderate $\Delta\omega$ and large **Q** range measurements with thermal to epithermal neutrons, and SEQUOIA is optimized for fine $\Delta\omega$ measurements with thermal to epithermal neutrons.

1. INTRODUCTION

Four direct geometry inelastic spectrometers are planned for the Spallation Neutron Source. Each spectrometer has been optimized for different sets of experiments. The Cold Neutron Chopper Spectrometer (CNCS) has been optimized for fine wave-vector transfer ($\mathbf{Q} = \mathbf{k}_i - \mathbf{k}_f$) and energy transfer ($\omega = E_i - E_f$) resolutions for incident neutron energies $E_i < 30.0$ meV. The ARCS instrument is optimized for large **Q** range using $E_i > 30.0$ meV. The SEQUOIA instrument is optimized for fine **Q** and ω resolution using $E_i > 30.0$ meV. These three spectrometers are designed with fixed detector banks that cover large portions of solid angle. Therefore they are well suited to perform broad surveys in **Q** and ω space in a single measurement. HYSPEC uses $E_i = 5$ - 90 meV neutrons, is optimized for coarse $\Delta\omega$ resolution, and fine resolution of the **Q** component perpendicular to the beam in the horizontal direction. This instrument sacrifices **Q** resolution in the vertical direction for increased flux. Furthermore, HYSPEC has a movable detector bank that covers a limited portion of scattering angle. With these detector tank and **Q** resolution constraints, HYSPEC is optimized for systems where specific points in **Q** need to be studied. Furthermore the small detector bank and increased flux makes this instrument ideal for polarized inelastic experiments using currently available technology. This document compares the operating regions of these different spectrometers showing where each one excels.

2. MODELS

The primary method used to compare these instruments was Monte Carlo simulation using the McStas package [1]. Each moderator was simulated by interpolation of the MCMPX generated source distributions of E. Iverson [2]. The neutrons were monitored in two locations on each instrument during the simulation. A 20 cm x 20 cm x vs. y detector, divided in 2 mm x 2 mm pixels, monitored the flux at the sample position and a time of flight detector monitored the flux at the detector position. The detector position monitor was used to determine $\Delta\omega$. A brief description of the details of each instrument is provided below and Table 1 summarizes the optimal operating conditions and some instrument parameters for the 4 spectrometers. Note that all of the spectrometers are designed for polarization analysis when an efficient method for transmission polarization becomes available. Nevertheless, HYSPEC plans to use existing technology to provide polarization capabilities from its first day of operation.

Table 1 Optimized operating regime and instrumental parameters for the 4 direct geometry spectrometers. Note the energy resolution does not include sample or detector size contributions.

	ARCS	CNCS	HYSPEC	SEQUOIA
$\Delta\omega/E_i$ ($\omega = 0$)	$\Delta\omega/E_i > 1.0\%$	$0.75\% < \Delta\omega/E_i < 10\%$	$\Delta\omega/E_i > 3.0\%$	$0.5\% < \Delta\omega/E_i < 10\%$
E_i	30 – 2000 meV	0.8181 – 20.0 meV	5.0 – 50.0 meV	30 – 2000 meV
Q_{max} (E_i,$\omega = 0$)	4.05 – 49.7 Å^{-1}	1.16 – 7.03 Å^{-1}	2.87 – 12.2 Å^{-1}	2.20 – 26.9 Å^{-1}
Horizontal scattering angle(ϕ) at $\chi = 0^\circ$	-30° – - 5°, 5° – 135°	-135° – -3°, 3° – 135°	0° – 135°	-30° – - 5°, 5° – 60°
Vertical scattering angle (χ) at $\phi = 0^\circ$	-30° – 30°	-30° – 30°	-7.5° – 7.5°	-30° – 30°
Incident Beam Polarization	Ready for transmission polarizer	Ready for transmission polarizer	Heusler Monochromator	Ready for transmission polarizer
Scattered Beam Polarization	Ready for Wide angle transmission polarizer	Ready for wide angle transmission polarizer	Super mirror bender array	Ready for wide angle transmission polarizer
Sample size (w x h)	4 cm x 4 cm	2 cm x 4 cm	2 cm x 2 cm	4 cm x 4 cm

2.1 CNCS [3]

The CNCS is a multiple chopper spectrometer optimized for a wide range of $\Delta\omega$ conditions for neutrons of E_i < 30 meV. This E_i range is well matched to the spectrum of the Coupled H_2 moderator. Therefore this spectrometer is planned for beamline 5. Neutron guide starts 1.5 m downstream from the moderator and continues to as close to the sample as possible. The front end of the guide accepts a 5 cm (w) x 10 cm (h) beam. A 15 m curved section with a radius of 2 km is used to put the sample position out of line of sight. Then after a 7 m straight section, a 5 m section of funnel reduces the beam size to 1.5 cm (w) x 5 cm (h) at the sample position. A Fermi chopper will be placed 6.4 m from the moderator and a pair of counter rotating double disc choppers will be located at 34.7 m from the moderator. For the purpose of order and frame overlap removal, additional 60 Hz disc choppers are in the design but were not needed for the purposes of these simulations. For this present comparison, the Fermi chopper was modeled as a single disc chopper having a slit width that matched the guide and ν = 300 Hz. To relax the resolution of this instrument to match the

HYSPEC resolution, this first high speed chopper is not needed. Therefore it was not included in the model for that specific comparison. The detector position is located 3.5 m from the sample position.

2.2 HYSPEC [4]

The HYSPEC instrument is a hybrid between a crystal monochromator spectrometer and a chopper spectrometer. It is optimized to work in a range of E_i = 5 - 90 meV and therefore will also view a Coupled H_2 moderator. This instrument transports the neutrons from the moderator to a monochromator crystal via a neutron guide. A selection of vertically focusing monochromators is planned for this instrument. A pyrolitic graphite (PG(002)) monochromator was used in these simulations and its wavelength (λ) dependent reflectivity was modeled as 80% for $\lambda > 4.04$ Å, 70% for 2.00 Å $\lesssim \lambda < 4.04$ Å, and 60% for $\lambda < 1.88$ Å. Furthermore it has a 60 minute mosaic in the horizontal direction and a 24 minute mosaic in the vertical direction. Three meters before the monochromator, a counter rotating double disc chopper, with each blade spinning at ν = 300 Hz, is used to shape the neutron pulse. The chopper blade has a triangular slot of 4 cm width at the disc radius. The vertically focusing monochromator and the guide produce a 2 cm (w) x 2 cm (h) beam at the sample position. The detector position is 4.5 m downstream of the sample position.

2.3 SEQUOIA

SEQUOIA is a Fermi chopper spectrometer designed for fine ω and **Q** resolution for 30 meV < E_i < 2 eV. The Decoupled Ambient Water moderator is the optimal moderator for this E_i range, and SEQUOIA will view it from beamline 17. The flight path for this instrument tapers continuously to produce a 4 cm x 4 cm beam at the sample position. From the shutter to within 1 m of the sample, at 19.5 m, the flight path is lined with guide to increase the low energy neutron flux on the sample. At 17.5 m a Fermi chopper is placed in the beam. For the purposes of this simulation, the curvature of the chopper blades was optimized for each E_i and ν value. The detector position is 5.5 m downstream of the sample position.

2.4 ARCS [5]

ARCS is a Fermi chopper spectrometer designed for moderate ω and **Q** resolution and large **Q** range for 30 meV < E_i < 2 eV. The Decoupled Ambient Water moderator is the optimal moderator for this E_i range, and ARCS will view it from beamline 18. The flight path for this instrument tapers continuously to produce a 4 cm x 4 cm beam at the sample position. From the shutter to within 1 m of the sample, at 13.5 m, the flight path is lined with guide to increase the low energy neutron flux on the sample. At 11.5 m a Fermi chopper is placed in the beam. For the purposes of this simulation, the curvature of the chopper blades was optimized for each E_i and ν value. The detector position is 3 m downstream of the sample position.

3. FLUX COMPARISONS:

This section compares the flux on sample for each instrument with all the other instruments. Since each instrument is optimized for different operating conditions, a single comparison encompassing all instruments is not possible. The following sub sections describe the flux on sample for each instrument operating under its optimized conditions. When the other instruments can operate in the same E_i and $\Delta\omega$ regime, their flux on sample is discussed as well. The best possible comparisons were ensured by matching both $\Delta\omega$ ($\omega = 0$) and E_i for each instrument. The time monitor, placed at the detector position on each instrument, provided a means to measure $\Delta\omega$. The following method was used to calculate

$\Delta\omega$. The value of E_i was assumed to be exact, therefore the uncertainty in $\Delta\omega$ reduces to an uncertainty in E_f (ΔE_f). Or in other words, the many terms that contribute to the uncertainty in $\Delta\omega$, were all lumped into ΔE_f. The timing uncertainty observed in the detector (Δt_f) is related to ΔE_f by:

$$\Delta E_f = 2\frac{\Delta t_f}{t}E_i$$

where t is the time required for neutrons of energy E_i to cover the distance between the sample and the detector. The quantity Δt_f was the FWHM of the observed time pulse and was obtained from a fit. For most cases a triangular function provided a good fit to the observed time pulse. However for the case where the CNCS resolution was relaxed to match the HYSPEC resolution a square pulse with rounded corner provided a better fit. Resolution contributions from sample and detector size are ignored in this study.

These four different spectrometers are also optimized for different sized samples. To accommodate all the sample sizes in the easiest possible way, a sum was performed over the appropriate beam area on the monitor at the sample position. The resultant count value was normalized by the area to arrive at the optimized flux for that instrument.

3.1 CNCS optimal conditions

The CNCS spectrometer is optimized for fine $\Delta\omega$ with cold neutrons. To explore the performance of this spectrometer operating under optimal conditions, the counter rotating disc choppers were spun at 300 Hz apiece and the width of the triangular shaped opening in each disc was 22.0 mm. Since this instrument is optimized for cold neutrons, wavelength (λ) is a more natural unit to characterize the incident neutrons and is used in this comparison. Furthermore the optimal sample size for this spectrometer is 4 cm tall by 2 cm wide.

To match the CNCS performance, the cutout width of the counter rotating HYSPEC disc choppers was decreased from its optimal width while ν was fixed at 300 Hz for each disc. An alternative approach to provide sharper resolution with a chopper system is to increase ν. This method was not chosen because ν = 300 Hz is close to the physical limits of current disc technology. The HYSPEC design calls for a possible Fermi chopper. Should this configuration be used, the flux values would be higher for fine $\Delta\omega$. The comparisons shown here are for the PG(002) monochromator. The HYSPEC design also includes a fluorinated mica monochromator. With this monochromator, longer λ can be accessed. To match the resolution of the ARCS and SEQUOIA spectrometers the size of the slits in the Fermi choppers was varied. Since both of these spectrometers are located on the Decoupled Water moderator, they are not optimized to work for λ > 3 Å. The parameters used to match the $\Delta\omega$ of the HYSPEC, ARCS, and SEQUOIA spectrometers to the $\Delta\omega$ of the CNCS spectrometer are provided in Table 2.

Table 2 Chopper parameters used to match $\Delta\omega$ of the other spectrometers to the CNCS spectrometer's optimized values

	HYSPEC		ARCS		SEQUOIA	
λ (Å)	ν(Hz)	Cut out width (mm)	ν(Hz)	Slit width (mm)	ν(Hz)	Slit width (mm)
2	300	18.4	600	3.0	600	9.4
3	300	18.8	600	5.0	600	10.0
4	300	18.8				

The results of this comparison are summarized in Figure 1. The major feature to note is that CNCS is the only spectrometer optimized for $\lambda > 4.0$ Å. The HYSPEC instrument has a significant flux for $\lambda < 4.0$ Å. However, this increased flux comes at the expense of **Q** resolution. The ARCS and SEQUOIA instruments are not optimized to operate in this λ regime.

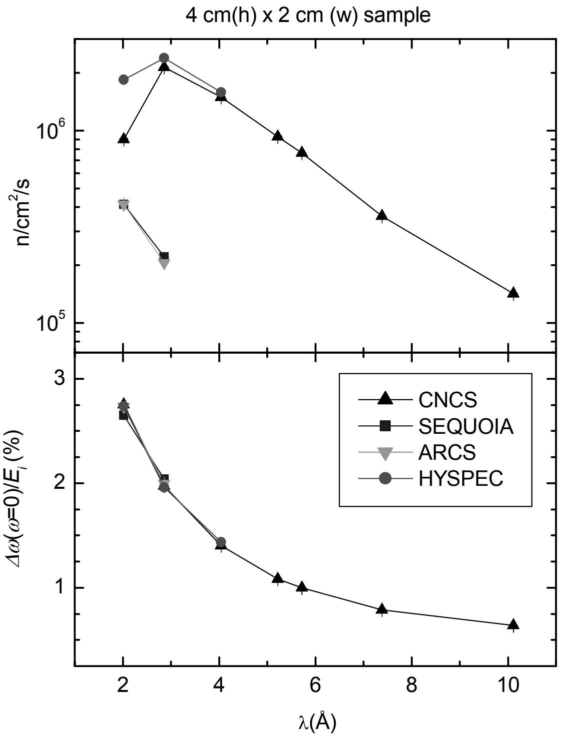

Figure 1 Flux on sample and energy transfer resolution optimized for the CNCS spectrometer. The upper panel shows the flux on sample at the resolution values in the lower panel. Note that only the CNCS is optimized to operate for $\lambda > 4$ Å.

3.2 HYSPEC optimal conditions

The HYSPEC instrument is optimized for flux with coarse $\Delta\omega$ and coarse **Q** resolution. To run under these conditions, the cutout width in each of its counter rotating discs was set at its optimal value of 4 cm. HYSPEC is optimized for a 2 cm x 2 cm sample. The comparisons have been performed for the HYSPEC operating regime of E_i = 5 – 90 meV.

For E_i < 10 meV the ARCS and SEQUOIA instruments are far enough from their optimal conditions to have insufficient operational flux rates. Therefore, 5 meV points were calculated only for the CNCS and HYSPEC instruments. In addition, CNCS will routinely operate at E_i < 5 meV, so a 2 meV point was calculated for it.

The CNCS, SEQUOIA, and ARCS spectrometers are optimized for finer $\Delta\omega$ operation than HYSPEC. Therefore, their $\Delta\omega$ was relaxed to match the HYSPEC value. In order to perform this matching of $\Delta\omega$, the chopper parameters were changed on the various instruments. For ARCS and SEQUOIA the slot width and ν were varied and for CNCS the width of the chopper cutout and ν were varied. The specific chopper parameters used in this study are recorded in Table 3. It should be emphasized that these resolution conditions are optimized only for HYSPEC and are sub optimal for the other spectrometers.

Table 3 Chopper parameters used to relax $\Delta\omega$ for CNCS, ARCS and SEQUOIA to the optimal values for HYSPEC.

	ARCS		SEQUOIA		CNCS	
E_i (meV)	ν (Hz)	Slot width (mm)	ν (Hz)	Slot width (mm)	ν (Hz)	cutout width (mm)
2					300.0	33.0
5					300.0	33.0
10	600.0	10.0	300.0	10.0	300.0	33.0
20	540.0	9.8	240.0	8.5	300.0	33.0
30	540.0	10.0	240.0	8.5	240.0	30.0
40	540.0	9.6	240.0	8.2	240.0	31.0
50	480.0	9.2	240.0	8.6	240.0	28.0
60	480.0	9.1	240.0	8.5	240.0	28.0
70	480.0	9.2	240.0	8.5	240.0	28.0
80	480.0	9.1	240.0	8.5	240.0	28.0
90	480.0	9.2	240.0	8.5	240.0	28.0

Figure 2 shows the resulting $\Delta\omega/E_i$ at each E_i value where the flux was calculated for each spectrometer. The major feature to note is the large flux that HYSPEC puts on the sample for 10 meV < E_i < 50 meV. These large flux values arise primarily from the increased vertical divergence on the sample provided by the vertically focusing monochromator.

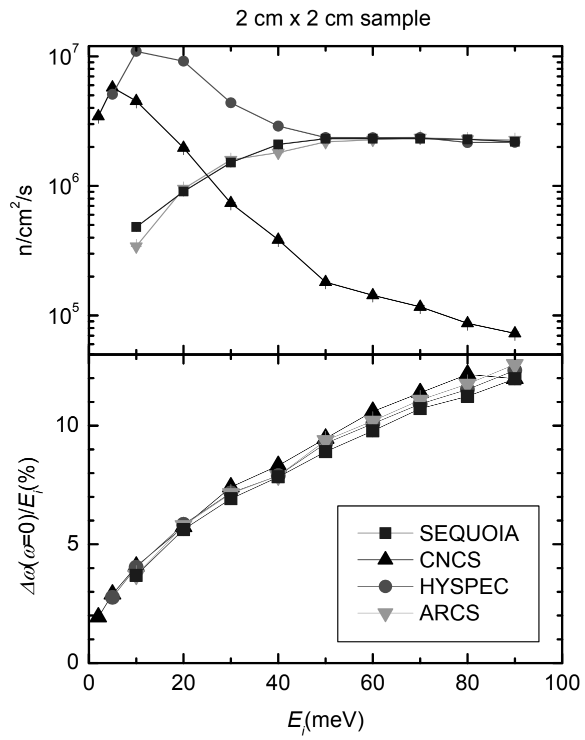

Figure 2 Flux on sample and energy transfer resolution for the spectrometers under conditions optimized for the HYSPEC spectrometer. HYSPEC provides the most flux in the overlap region between CNCS and the Fermi chopper spectrometers.

However this flux enhancement comes at the expense of **Q** resolution. The vertical divergence is ~ 2 x larger for HYSPEC than the other spectrometers. This accounts for the flux being twice as high as the CNCS flux at the lowest energies and equal to the ARCS and SEQUOIA flux at the highest energies. For SEQUOIA in this $\Delta\omega$ regime, the moderator and long initial flight path provided less E_i bandwidth than the chopper will accept. ARCS with the shorter initial flight path, has a better matching between the moderator and chopper bandwidth. Therefore the flux values for ARCS and SEQUOIA are approximately equal in this $\Delta\omega$ regime. The fall off in flux for E_i < 40 meV, exhibited by the Fermi chopper instruments, results from the neutron spectrum produced by the Decoupled Water moderator. The CNCS and HYSPEC instruments are positioned on Coupled H_2 moderators which are better optimized for E_i < 40 meV. The flux for the CNCS spectrometer falls off significantly faster than HYSPEC for E_i >20 meV. This effect results from the curved guide that reduces the number of E_i > 80 meV neutrons incident on the disc choppers. Unfortunately curved guides do not provide a sharp energy cutoff. For the CNCS guide configuration, the E_i > 80 meV restriction also means that, for E_i as low as ~ 20 meV, the flux is reduced when compared to an equivalent straight guide. Finally notice that only the CNCS instrument has a point at 2 meV. The HYSPEC instrument can not access E_i < 5 meV with the PG(002) monochromator. A mica monochromator is also planned for HYSPEC and it will allow access to neutrons with E_i < 5 meV albeit with an intensity lower than that of the CNCS.

HYSPEC is optimized for coarse resolution measurements in the thermal neutron range. Furthermore its E_i regime with the most flux covers the overlap region between the CNCS and Fermi chopper spectrometers.

3.3 SEQUOIA Optimal conditions

The SEQUOIA spectrometer is optimized for fine $\Delta\omega$ operation for 30 meV < E_i < 2 eV. To achieve this fine resolution a chopper with 1.5 mm slits is spun at 600 Hz. Specifically, these chopper operating conditions provide $\Delta\omega/E_i$ = 2% for elastic scattering when E_i = 500 meV. A limited range of this $\Delta\omega$ – E_i parameter space can be accessed by CNCS, HYSPEC, and ARCS. Table 4 summarizes the chopper parameters required to operate the other spectrometers in this parameter regime.

Table 4 Chopper parameters used to match the ARCS and HYSPEC energy transfer resolution to the optimal values for the SEQUOIA spectrometer.

	ARCS		HYSPEC		CNCS	
E_i (meV)	ν(Hz)	Chopper slit width (mm)	ν(Hz)	Chopper cutout width (mm)	ν(Hz)	Chopper cutout width (mm)
10			300	3.9	300	5.0
20			300	3.8	300	5.0
30			300	3.6	300	4.0
50			300	3.0	300	4.0
300	600	0.1				
500	600	0.5				
1000	600	0.7				

The restricted operation range of CNCS, HYSPEC, and ARCS, demonstrates that the SEQUOIA operating conditions are far from optimal for these spectrometers. Even though the ARCS spectrometer is designed to operate in the same E_i range, its significantly shorter final flight path, 3.0 m instead of 5.5 m, prohibits it from operating with as fine an energy resolution as SEQUOIA over the entire E_i range. Specifically it can not match the resolution of SEQUOIA below E_i = 300 meV. The HYSPEC spectrometer, with the PG(002) monochromator, can not access E_i > 90 meV. The curved guide of the CNCS is ineffectual to provide E_i > 50 meV neutrons.

Figure 3 shows the results of the comparison described above. Notice that SEQUOIA is the only instrument optimized for fine $\Delta\omega$ operation using 30 meV < E_i < 1eV neutrons. The quick fall off of the flux values from CNCS, HYSPEC, and ARCS demonstrates, as explained above, that none of these spectrometers are optimized for this $\Delta\omega$ - E_i range.

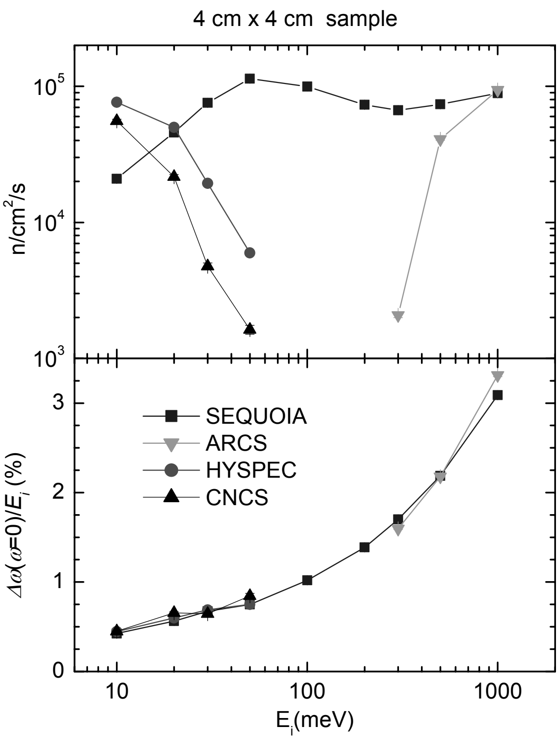

Figure 3 Flux on sample and energy transfer resolution for the spectrometers under resolution conditions that are optimized for the SEQUOIA spectrometer. The flux on sample is in the top panel and $\Delta\omega/E_i$ is in the bottom panel. Notice only the SEQUOIA spectrometer performs well for 30 meV < E_i < 1 eV under these conditions of fine resolution.

In addition for ARCS to match the resolution of SEQUOIA at E_i = 300 meV, the slit width has to be reduced to 0.1 mm. Since the chopper slats are expected to be 0.5 mm, the transmission through the chopper under these conditions is only 17%. Similarly HYSPEC and CNCS have also discarded most of their beams by operating with such small cutouts in their chopper discs. Therefore SEQUOIA is the only spectrometer optimized for fine $\Delta\omega$ operation with thermal to epithermal neutrons.

3.4 ARCS optimal conditions

The ARCS spectrometer is optimized for moderate $\Delta\omega$ using 30 meV < E_i < 2 eV neutrons. Furthermore it is optimized to cover vast areas in **Q** space. Comparisons of this parameter are provided in section 4. To provide a fixed point for comparison, a slit package for the ARCS spectrometer was chosen with a slit width of 2 mm and spun at 600 Hz. These chopper operating conditions provide $\Delta\omega/E_i$ = 5% for elastic scattering when E_i = 500 meV.

The SEQUOIA spectrometer is optimized for fine $\Delta\omega$ over the same E_i range as the ARCS spectrometer. Therefore its chopper slit width was increased and ν was decreased to relax $\Delta\omega$ to the optimal ARCS values. The HYSPEC and CNCS spectrometers are optimized for coarser $\Delta\omega$. Therefore, their chopper cutout widths were reduced to match $\Delta\omega$ to the ARCS values. Furthermore the curved guide and the PG(002) monochromator limit the E_i range for CNCS and HYSPEC, respectively. Table 5 summarizes the chopper parameters used to match $\Delta\omega$ as a function of E_i.

Table 5 Chopper parameters used to match SEQUOIA and HYSPEC resolution conditions to the ARCS resolution conditions.

	SEQUOIA		HYSPEC		CNCS	
E_i (meV)	ν(Hz)	Chopper slit width (mm)	ν(Hz)	Chopper cutout width (mm)	ν(Hz)	Chopper cutout width (mm)
10	480	4.0	300	10.4	300	12.0
20	480	4.0	300	10.0	300	12.0
30	540	4.0	300	8.7	300	10.0
50	540	4.0	300	8.8	300	
100	540	3.5				
200	480	3.0				
300	480	3.0				
500	480	3.0				
1000	480	3.0				

Figure 4 shows the results of this comparison. ARCS provides the most flux on sample for E_i > 200 meV. However for E_i < 200 meV, a combination of guide gain and relaxed bandwidth allows the SEQUOIA spectrometer to put more flux on sample than the ARCS instrument.

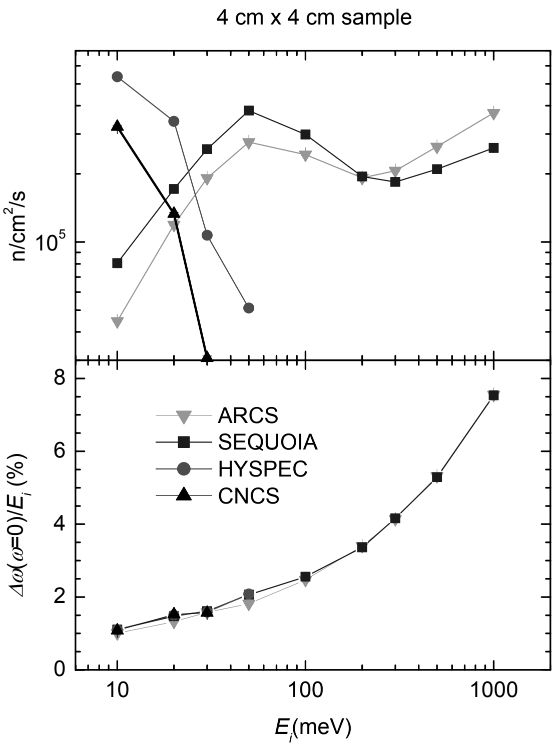

Figure 4 Flux on sample and energy transfer resolution for the spectrometers under conditions optimized for the ARCS spectrometer. Through guide gain and a wider bandwidth on the sample, SEQUOIA puts more flux on sample than ARCS for E_i < 200 meV. Nevertheless ARCS is the best performer at the largest E_i values.

The HYSPEC spectrometer puts the most flux on sample for E_i < 30 meV. This follows from the fact that the Coupled H_2 moderator is better matched to this E_i range than the Decoupled Water moderator. The flux for the CNCS falls of quickly with increasing E_i.

ARCS will be the instrument of choice for the highest E_i studies. Furthermore, it uniquely provides coverage of large ranges of **Q** space.

4. Q RANGE

This section compares the **Q** range coverage of the four spectrometers and shows that this parameter is the one for which ARCS is optimized. The **Q** range of a spectrometer is controlled by its E_i range and angular coverage. Figure 5 shows the accessible Q_x vs. Q_z space for the operating regimes of the different spectrometers, where the z axis lies along the neutron beam path and the x axis is in the horizontal plane. Specifically the CNCS, ARCS, SEQUOIA, and HYSPEC curves assume operating energy ranges of E_i = 2 – 50 meV, E_i = 30 – 500 meV, E_i = 30 – 500 meV, and E_i = 5 – 90 meV, respectively. The angular coverage for these instruments is provided in Table 1. The upper E_i limit of the ARCS and SEQUOIA instruments on this plot is E_i = 500 meV so the CNCS and HYSPEC curves can be observed on the same scale. ARCS and SEQUOIA can access even larger magnitudes of **Q** when operated with E_i up to 2eV. These calculations are for $\omega = 0$ and only results for the positive scattering angle portion of the detector bank are shown.

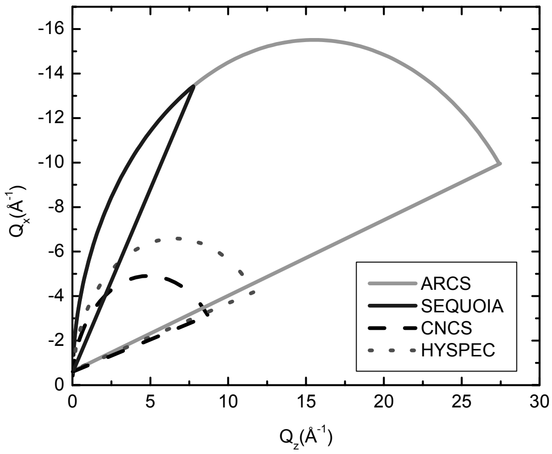

Figure 5 **Q** *range in the horizontal plane for positive scattering angle. Note that HYSPEC has a movable detector bank that covers a range of 60^o. Therefore multiple runs will be required to cover the full indicated* **Q** *range.*

The larger magnitude of **Q** for ARCS and SEQUOIA results from the larger incident energies used on these spectrometers. Note that large **Q** magnitude comes at the expense of **Q** resolution and $\Delta\omega$. The larger Q_z range for ARCS, CNCS, and HYSPEC, results from the wider angular coverage possible with these detector banks. For SEQUOIA, ARCS, and CNCS, the full **Q** range, set by the incident energy, is covered in a single measurement. However HYSPEC has a movable detector bank that covers 60^o. Therefore, at least 2 scans at different angles would be required to cover the full **Q** range. Note that ARCS is the only spectrometer that can access the largest values of **Q**

5. CONCLUSIONS

Four direct geometry inelastic instruments planned for the SNS have been compared. The multichopper spectrometer CNCS is optimized for fine ω and **Q** resolution with cold neutrons. Its large detector bank makes this instrument suited towards mapping **Q**-ω space when cold neutrons are used. The SEQUOIA instrument is its complement in the thermal to epithermal neutron energy range as it is also optimized for fine ω and **Q** resolution. To obtain these resolution results, it operates over a limited **Q** range. Therefore SEQUOIA is ideally suited towards mapping **Q**-ω space of magnetic and other systems that require fine resolution. The ARCS instrument covers the largest **Q** range making it ideally suited for mapping **Q**-ω

space of lattice vibrations. Finally the HYSPEC instrument bridges the cold and thermal to epithermal energy ranges. It uses a vertical focusing monochromator to maximize the flux on sample. However this extra flux is at the expense of Q_y and ω resolution. Furthermore it is designed with limited Q_y range. This additional flux and focus on the horizontal plane make the HYSPEC instrument an ideal instrument to use for polarized inelastic studies and studies of specific positions in **Q-**ω space. In summary, the suite of direct geometry inelastic instruments planned for the SNS will meet the broad needs of the user community.

ACKNOWLEDGEMENTS

We wish to thank V. Ghosh for making her instrument files for HYSPEC and CNCS available for our use. We are grateful to the stimulating discussions with K. Herwig, S. Nagler, I. Zaliznyak, S. Shapiro, L. Passell, and V. Ghosh on topics of instrument design and simulation. We gratefully acknowledge P. Sokol and J. Pearce for providing descriptions of the CNCS instrument. SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy.

REFERENCES

[1] K. Lefmann and K. Nielsen, Neutron News **10**, 20, (1999).
[2] E. Iverson, Spallation Neutron Source, Report TSR-202.
[3] J. Pearce and P. Sokol, Private Communications.
[4] S. Shapiro, I. Zaliznyak, and V. Ghosh, Brookhaven National Laboratory Report, BNL-52677.
[5] D. Abernathy, Spallation Neutron Source, Report IS-1.1.8.4-6033-RE-A-00, Private Communications.