Design Criteria for the ARCS Instrument at the SNS

Compiled by Doug Abernathy for the ARCS IDT

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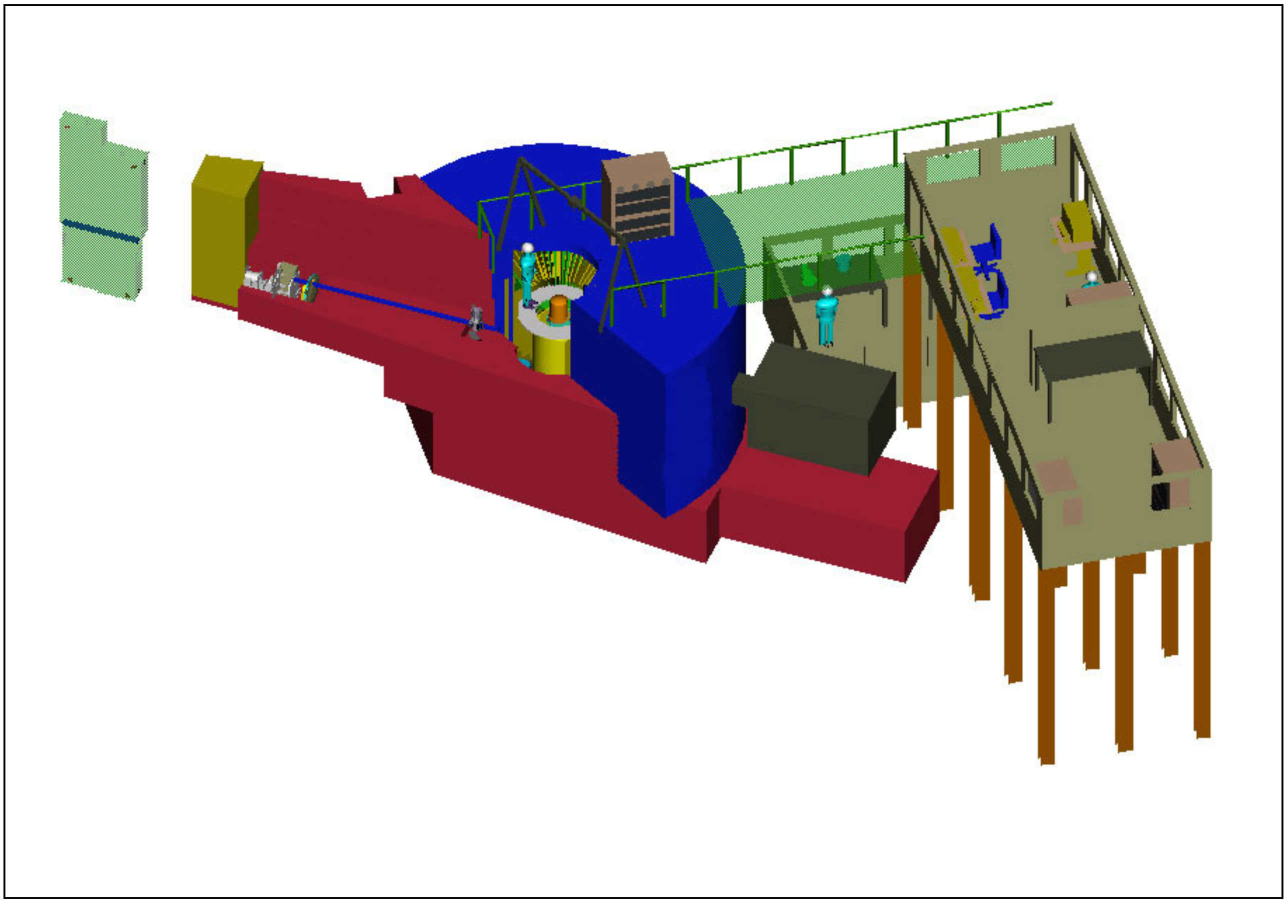

1. Introduction

The U.S. Department of Energy has funded ARCS, A high-Resolution, direct-geometry, time-of-flight Chopper Spectrometer, to be constructed on beam line 18 at the Spallation Neutron Source. ARCS will be optimized to provide a high neutron flux at the sample and a large solid angle of detector coverage. The source-sample distance will be 13.6 m, and the secondary flight path will be 3.0 m at all angles from –30° to 140° horizontally and ± 30° vertically. The dense array of position-sensitive detectors will detect the direction and velocity of neutrons scattered into almost one quarter of the solid angle around the sample. The spectrometer will be capable of selecting from the full energy spectrum of neutrons provided by an ambient water moderator, making it useful for studies of excitations from a few meV to several hundred meV. A supermirror guide in the incident flight path will boost the performance at the lower end of this range. ARCS strives to be the most efficient high-energy chopper spectrometer at any spallation neutron source.

The purpose of this document is to describe the overall conceptual design of the spectrometer, and where possible give specific design criteria for the components of the instrument. In some cases these criteria are based on quantifiable modeling of the instrument performance, while in others it must be based on current best practices in similar spectrometers currently operating around the world. As much as possible the important factors influencing the decisions about engineering and design of the components are listed.

Before turning to specific descriptions of the instrument, it is useful to list the most important general design goals. These should be considered for all decisions about how to implement a feature of the spectrometer:

Safety It is imperative to design the system to operate safely, to protect those who use it as well as to avoid loss of time from accidents and mechanical failures. Examples are radiological safety, such as designing appropriate shielding and interlocked personnel protection system, as well as physical safety about mezzanines, stairs, etc. The fire protection regulations for the SNS target building will dictate some choices for materials used for shielding. Vacuum safety is also a major concern because the sample and detectors will sit inside a large vessel.

Efficiency of use The spectrometer design must take into account how the users will collect data, and allow for the most efficient operation of the instrument. The manipulation of sample environment equipment must be as easy as possible. Fermi chopper slit packages will need to be changed quickly. Operations that use beamtime other than data collection should be minimized. For example, chopper phasing should be as quick and reliable as possible, sample exchange time reduced to a minimum, calibration schemes considered during design of the detectors, etc. A key component in maximizing the effectiveness of the instrument will be good data collection and visualization/analysis software.

Reliability Designing reliable components will reduce the down time for the instrument. Testing of subsystems, such as choppers, will work out significant flaws. The use of monitoring equipment, such as vibration sensors, will help point out problems before they cause catastrophic failure. Using proven components like the ^3He position-sensitive detector, will avoid uncertainty in the design.

Maintainability When maintenance is necessary, it should be planned for and incorporated in the design. Some choppers and vacuum pumps will need regular service and must be accessible. Detectors and their electronics should be removable in packs so that a faulty module may be replaced with a tested spare.

Value Alternate designs should be investigated to determine if the same functionality can be achieved with lower cost. In some cases increasing the reliability of a design or lowering maintenance costs adds value.

The following section describes ARCS and provides some of the detailed requirements for its construction.

2. Instrument Description

ARCS will be installed on flightpath 18 in the SNS experiment hall viewing the ambient water moderator. Figure 1 shows the layout of the instrument. The philosophy guiding the design is the desire to maximize the flux at the sample and the solid angle of detector coverage. This must be achieved with an energy resolution appropriate for the scientific program, typically 2% of E_i or more for elastic scattering. The instrument is designed for single crystal measurements from the outset. This implies a goniometer for crystal rotation and a detector array of linear position-sensitive detectors with few gaps in angular coverage.

The detectors are arrayed into three tiers of 1.0m PSDs at a radius of 3.0m from the sample. The detector bank extends from -30° to 140° degrees horizontally and extends out of the scattering plane by ±30°. The total solid angle covered by all detectors is approximately π steradians. We intend to use SNS standard designs for the detectors, detector electronics, and data acquisition system.

The design of the spectrometer will conform to all safety regulations at the SNS, including radiation protection, fire and earthquake codes. The sample environment inserts will be subject to the same safety concerns as other cryogenic and furnace systems in use at the SNS. The vacuum vessel, being quite large, requires careful engineering to ensure it can be operated safely.

2.1 Incident Flight Path

ARCS will be located on flight path 18 viewing an ambient water moderator. We have not yet optimized the depth of poisoning of the water moderator. At present this depth is set at the midpoint of the moderator (2.5cm depth), which is appropriate for longer flight path instruments with maximum flux in the thermal energy range.

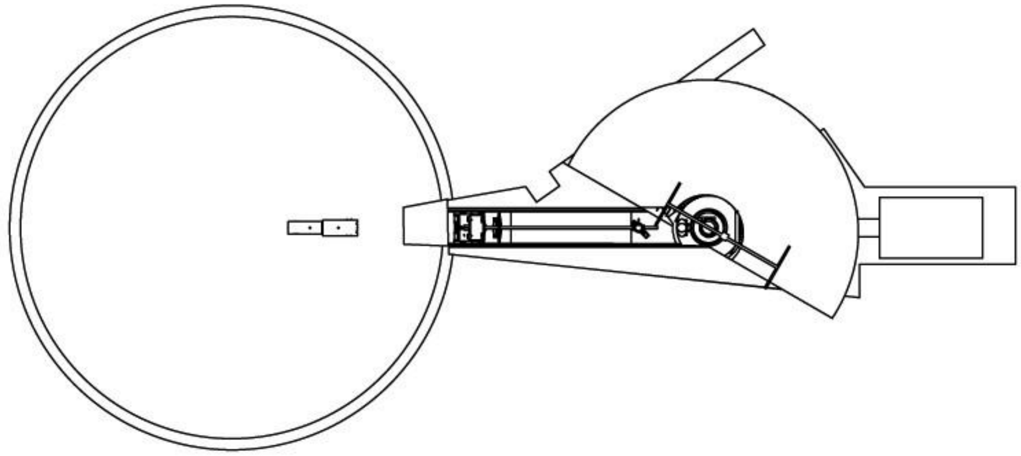

Figure 1: Layout of ARCS on Flight Path 18 (top view).

The main components of the beam–line outside the biological shielding are:

1) The background-suppressing T-zero chopper
2) A "pre-monochromating" disk chopper
3) The monochromating Fermi chopper
4) Adjustable slits and Soller collimators
5) Supermirror guide

One of the important advantages of direct-geometry chopper spectrometers on pulsed neutron sources is the flexibility they provide for optimizing the incident energy and resolution of the measurements. The incident energy can be varied from 10 meV to 1 eV by changing the Fermi chopper phase, speed, and, occasionally, the slit package. ARCS will take full advantage of this flexibility with at least three Fermi chopper slit packages to allow the measurement of energy transfers from 1 meV to 500 meV.

2.1.1 Biological Shielding

Because of the high power of the SNS source, massive shielding will be required for all instruments. For typical instruments, the SNS Shielding Group is presently calculating the composition and thickness of the necessary shielding as a function of the distance from the target monolith. Detailed calculations by this group will be part of the ARCS design effort to ensure that the instrument will meet all SNS requirements for radiation levels in the target building. The shielding configuration must provide necessary access to the beamline components.

As a preliminary design, we assume that the bulk of the shielding will be made of heavy concrete. Where feasible, this will be poured in place, using appropriate material to subdivide it into removable sections. Additionally, pre-cast blocks of concrete will be used. The volume immediately adjacent to the beamline will consist of approximately 0.5m of steel.

2.1.2 T_0 Chopper

The purpose of the T-zero (T_0) chopper, which will be located outside the biological shielding at about 9 m from the moderator, is to suppress the prompt pulse of fast neutrons produced when the proton beam strikes the target. A thick blade of the alloy Inconel is rotated at the source frequency of 60 Hz and phased to block the beamline when this background radiation is produced. There is a maximum energy for which the beamline is not blocked, depending on the blade width, rotation speed, radius of the blade, and position along the beamline. For ARCS this maximum energy is 670 meV. If an experiment required a higher incident energy than 670 meV, the T_0 chopper will be able to rotate at twice the source frequency (120 Hz) to pass neutrons of energies higher than 2 eV.

The ARCS spectrometer will benefit from the prototyping efforts underway in the SNS chopper development group at Argonne National Laboratory. A 60 Hz T_0 chopper is currently installed in the GPPD instrument at IPNS, to help identify design flaws that are apparent only after extended usage. A second prototype able to operate at 120 Hz will be tested in 2002 by the SNS chopper group. This experience will guide the specification for designing, building and installation of the ARCS T_0 chopper.

2.1.3 Disk Chopper

The high rotational frequency of the Fermi chopper causes it to open many times between neutron pulses. One consequence is that neutrons of different velocities could pass through the Fermi chopper at its different openings. These spurious neutron pulses will be suppressed with a disk chopper rotating at a lower frequency, acting as a "pre-monochromator". By spinning at a lower multiple of the source frequency than the Fermi chopper, only neutrons of the correct energy will pass to the sample in the desired data acquisition time frame. Detailed specification of the neutron-absorbing blade will be determined by modeling of the neutronic performance of the chopper system.

2.1.4 Fermi Chopper

The Fermi chopper will be located 11.6 m from the moderator, with 2.0m from it to the sample. Its purpose is to produce a monochromatic burst of neutrons whose energy is determined by the chopper phase. The intensity and resolution of the neutron pulse incident on the sample are governed by both the chopper rotation frequency, which can be any integer multiple of the source frequency up to a maximum of 600 Hz, and the dimensions of the curved collimation slits within the chopper. The relevant dimensions are the slit width, radius of curvature, and external radius of the chopper body. Although precise optimization of the intensity and resolution requires the ability to vary all these parameters, a set of three or four chopper slit packages should provide adequate performance over the entire range of accessible energy transfers, including the flexibility to relax the energy resolution in favor of intensity. This is a common practice at ISIS, for example.

In order to ensure reliable operation of the instrument, two housings with magnetic bearings, motors and controls will be purchased. In addition, there will be interchangeable slit packages available. In this way, a change of the Fermi chopper slit package can be performed and tested outside of the instrument and then the entire housing will be swapped in order to minimize the risk of down time of the spectrometer. The Fermi chopper will be placed on an elevator stage, so that white beam data can be obtained by remotely moving the chopper out of the beam. If necessary, this vertical lift will have a service position that will move the chopper up closer to the top of the shielding for exchange.

2.1.5 Adjustable Slits and Soller collimators

We will install a number of sets of adjustable slits to reduce backgrounds for samples that are smaller than the overall beam size. The locations for these slits remain to be determined. The slits will have both horizontal and vertical adjustments. Since all locations will be inaccessible when safety interlocks are in place, the slits will have stepper-motor drives for remote operation.

A system of slits and Soller collimators placed between the Fermi chopper and the sample will allow the incident beam divergence to be tailored to each experiment. There may be situations where the divergence delivered by the guide system is too large, particularly at lower energies, and slits will be adjusted to control where neutrons reach the guiding surfaces. Soller collimators after the Fermi chopper will absorb any neutrons that are too divergent, and eliminate scatter from the Fermi chopper itself. Although this Soller collimator may be exchanged, it is not anticipated to be a motorized operation. This region is critical for neutronic shielding, and a translation or rotation system to move such a device would possibly introduce leakage paths for background. Since the replacement or extraction of the collimator is expected to be a rare event it will be done manually.

2.1.6 Supermirror guide

Many experiments are restricted by low flux rather than by angular divergence. At energies below about 100 meV, a supermirror guide in the incident flight path serves to increase the flux at the expense of beam divergence. In principle the guide should extend as far back to the source as possible. The ARCS instrument will have three sections of guide totaling 8.1 m of the 13.6 m incident flight path — 2.0 m within the shutter itself, 3.0 m from the shutter to the T_0 and disk choppers, and 3.1 m from the disk chopper to the Fermi chopper. The cost estimate is for a state-of-the-art supermirror (m=3.6) guide.

Care will be taken in designing the guide mounting scheme so that background from the target will be minimized. The multilayers of the guide will be deposited on thin glass substrates held within steel jackets, allowing maximum shielding close to the reflecting layers. Neutron-absorbing fixed apertures of B_4C will be placed as needed to suppress the neutrons scattered where the beam hits the shield jacket. The guide sections will be evacuated for efficient transport of lower-energy neutrons.

2.2 Vacuum Vessel

The vacuum vessel serves three purposes. It provides an evacuated secondary flight path, its shielding provides a low background environment for the detector bank, and its vacuum provides thermal insulation for some sample environments. The inner volume of the vessel will be approximately 70 m^3, a massive structure that will require careful engineering for safe and reliable operation.

At present we anticipate that the detectors will be mounted in vacuum within the vessel. This eliminates the thin aluminum windows that must withstand many cycles of differential pressure between zero and one atmosphere. This is a safety issue because of the tremendous mechanical energy stored in the evacuated. Separation of the vessel structural integrity from the detector and window mounting also means that detector coverage can be almost continuous in angle. This is a prime consideration for single crystal spectroscopy. In collaboration with the SNS detector and data acquisition groups, the ARCS project will prototype detector modules using preamplifier and digitization electronics needed to operate linear-position-sensitive ^{3}He tubes in vacuum. Preprocessor boards will multiplex the signals from the 8-detector modules, reducing the need for complex vacuum feedthroughs of analog detector signals. Feedthroughs will be by fiber optic technology. Vacuum sensors will shut off the detector high voltage if the pressure in the vessel gets into a range where arcing could occur.

The design of the detector and sample tank will allow for the future use of large cryomagnets and possible polarizing elements. It should be possible to build the vacuum vessel of non-magnetic materials within 1 or 2 meters of the sample to avoid interactions with fringe fields of magnets in the sample region. The most promising technology for producing high-energy polarized neutrons are polarized He filters, which are sensitive to magnetic fields. The spectrometer design will be consistent with future installation of incident beam and analyzing filters so they can be installed once their design and usage becomes mature.

The best practice for inelastic neutron scattering measurements with chopper spectrometers is to eliminate any windows between the sample area and the detector flightpath (as has been done for the MAPS spectrometer at ISIS, for example). A method will be devised to isolate the sample area of the vessel from the main secondary flightpath area. This will eliminate fatigue problems from frequent cycling of the vacuum in the main part of the vessel, and save time in restoring a cryogenic vacuum at the sample (the internal neutron shielding, “crispy mix,” is somewhat hygroscopic). Sample changes will occur while the main vessel remains under vacuum, but the sample space will be opened to the main vacuum after the sample space is evacuated.

2.2.1 Shielding requirements

To improve dynamic range and sensitivity, the ARCS detector banks will be shielded from neutrons that would otherwise enter from outside the instrument. The vacuum vessel will be surrounded by at least a 30 cm shell of appropriate shielding material. Current practice is to use thin-walled steel containers filled with a mixture of wax and borax ($Na_2B_4O_7$) for moderation and absorption. At the SNS however there is an additional fire safety requirement that may preclude the use of these wax cans. The effectiveness of concrete walls will be investigated for this purpose. There will be shielding on all sides of the vacuum vessel, with special attention being paid to shielding around the incident beam path.

The interior of the vacuum vessel will be lined with a low-albedo neutron absorbing material. Currently boron-loaded epoxy ("crispy mix") is used, even though it has the undesirable property of possibly dropping B_4C granules in the vacuum and providing a large surface area for outgassing. A series of "baffles" of absorbing materials will keep the scattering from one area of the detector array from causing background in another region. The dead regions of the detectors at the ends provide an ideal location for horizontal planes of baffles. It is yet to be determined how many baffles will be needed to effectively reduce the instrument background.

2.2.2 Vacuum pumping system

The pumping system will have the following features.

1. It will be completely automated and equipped with interlocks for safety and to protect the investment in the spectrometer components.
2. It will be able to bring the entire vacuum vessel from ambient pressure to base pressure in 1 to 2 hours. This may be achieved by using the gate valve concept to only vent the smaller volume near the sample.
3. It will achieve a base pressure of 10^{-6} mbar in the sample and detector vacuum chamber.
4. It will avoid cryopumping of water and other material onto a sample held at 3.6 K.
5. It should not require service or regeneration during the period of a typical SNS beam cycle.

Rapid pump-down of the entire vessel will be provided by a Roots pump backed by a conventional rotary pump. Turbomolecular pumps will be used to reach a pressure of 10^{-6} mbar in the main vacuum. To avoid cryopumping onto the sample, the sample volume will also be pumped by a cryo-pump (poly-cold). Finally, a dry air venting system will be used to maintain a dry atmosphere in the vessel when it is not under vacuum.

2.3 Detectors

The detector array on ARCS will consist of approximately 900 1.0m 10-atmosphere ^{3}He linear position sensitive detectors (PSDs). The lengths of the detectors will be divided into pixels of ~1.5 cm length by the electronics, for a total of about 58,000 individual detector elements. Each pixel will subtend an angle of 0.5°. The detectors will be grouped into modules of eight, with the preamplifiers, neutron absorbing backing material and signal digitizing electronics mounted together on a mechanical frame. The identical modules will be mounted to a frame inside the vacuum vessel, and they in turn will feed data to more electronics for manipulation and histogramming as needed by the experiment. All electronics will be developed by the shared activities of the SNS Data Aquisition Group.

Since the decision to put such a large number of detectors into a vacuum vessel is key to the planning of the instrument, a strong prototyping effort is planned. The ARCS project will purchase a small vacuum system for testing of 2 8-detector modules, in order to confirm the reliability of the detectors in vacuum before committing to a vacuum vessel based on this idea. This test vessel will also be used to check the outgassing of the crispy mix in order to size the vacuum system.

2.4 Computer Hardware and Data Acquisition

The data acquisition and analysis systems will be built from commodity components following the standards under development at the SNS. Software for ARCS will benefit from (and provide benefits to) similar systems employed on other instrument. Software for data visualization is being developed by the SNS in a generic form, making it suitable for time of flight data obtained at any facility. By adhering to the emerging, HDF-based NeXus data format, portability of ARCS data to this (or any other) analysis package will be ensured.

The data acquisition hardware will be a modular system for performing the necessary event timing and positioning. An ethernet connection to the host UNIX computer will be sufficient for the data rates anticipated on ARCS (the full detector images are large, but for typical inelastic experiments counting times are long, so a delay of a few seconds is tolerable). The user interface to the data acquisition system will be through a web browser, decoupling the location and operating system of the spectrometer from those of the user. The sample environment will also be controlled via a standard under development by the SNS, which will allow different methods of communication between the beamline control computer and auxiliary equipment. Password-based security for a web-based control interface, specific to each experiment, will ensure safe and secure remote operation. Only systems that can be modified without compromising safe operation will be remotely controllable, although all relevant machine parameters should be viewable. These attributes for the data acquisition system are already among the specifications for the SNS data acquisition system, and the ARCS project will take advantage of these developments by the SNS.

2.5 Sample environment

In order to facilitate experiments on single crystals at ARCS, some type of manipulation of the sample orientation and its environment equipment is needed. The exact specifications for this manipulation are still being discussed by the IDT. In principle all motions, rotations and tilts, are needed. It is anticipated that sample environments will be provided by units that mount on a rotating stage atop the ARCS vacuum vessel. The stage will have a rotating vacuum seal large enough to enclose a bolt circle that will be standard at the SNS. The different systems for sample environment to be mounted with this bolt circle are:

1. Thimble, a thin-walled aluminum containment to separate the spectrometer vacuum from a cylindrical specimen region at ambient pressure. Specialized sample environments provided by users will fit within this thimble.
2. Low temperature heliplex system for experimentation from 3.6 K to 350 K. This unit is a closed-cycle refrigerator with enhanced low temperature capability provided by a Joule-Thompson heat exchanger.
3. Displex/heater unit for a temperature range of <30–650 K.
4. High temperature furnace unit capable of temperatures from 600–2073 K.

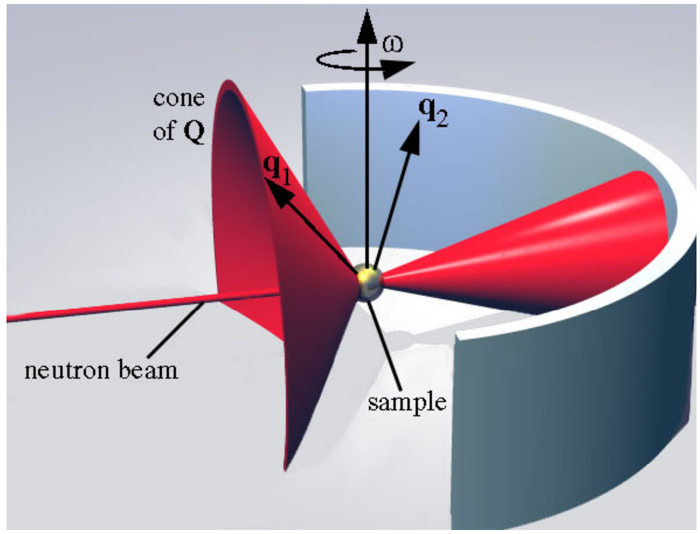

Figure 2: One degree of freedom allows $\boldsymbol{q}_1$ to intersect **Q** by rotation of ω. Another degree of freedom is required for both $\boldsymbol{q}_1$ and $\boldsymbol{q}_2$ to simultaneously intersect **Q**. (Here $\boldsymbol{q}_i$ points along the incident beam, $\boldsymbol{q}_f$ lies along the red cone at right.)

These units are described in detail below. An over-riding consideration in choosing these units was their ease-of-use. Especially in the early years of ARCS, all users will be inexperienced with its characteristics. Further risks to experiments from complexities of cryostat control, for example, are important to avoid. Displex units also provide for more convenient computer interfacing, and promise a greater degree of automatic control of data acquisition.

2.5.1 Sample rotation stage

Much of the science to be done on ARCS involves single crystal samples. For these experiments it is necessary to orient a particular direction in the reciprocal lattice of the sample, $\boldsymbol{q}$, with respect to the wavevector transfer, $\boldsymbol{Q} = \boldsymbol{q}_f - \boldsymbol{q}_i$, probed by the spectrometer. Figure 11 shows a case where the scattering of the (red) neutron beam involves a change in wavevector of $\boldsymbol{Q}$, which lies on a cone around the center of the sample. In many cases, a vector in the sample, $\boldsymbol{q}$, can be made to intersect this cone by a simple rotation by ω about a vertical axis. This degree of freedom is particularly simple to implement with a rotation stage. On the other hand, to probe several directions of $\boldsymbol{q}$ simultaneously, such as mapping dispersions in 3-dimensions, additional degrees of freedom for sample tilt will be required.

The rotation stage for the vertical rotation will include the flange for mounting the sample environment units atop the vacuum vessel. This requires the design of a rotating vacuum feedthrough. The diameter of the SNS standard bolt circle will set the size of the sample environment units. The sample rotation stage will be based on a commercial rotation table. A stepping motor and associated controller connected to the data acquisition software will control the angular setting of the rotation stage to within an accuracy of approximately 0.01 degrees. Mounting of this rotation stage on ARCS, with a flexible bellows coupling to the chamber, will be investigated. Having all sample motions on the spectrometer itself seems most practical for the standardization of data collection and subsequent analysis.

2.5.2 Thimble for specialized sample environments

While most sample environments will use the vacuum of the ARCS vacuum vessel to provide an evacuated scattering volume and thermal insulation, some special conditions require a separate sample vacuum. Examples of such cases are

1. When the ARCS vacuum vessel does not provide adequate thermal insulation, as for example in the case of a dilution refrigerator.
2. When there is a risk that the sample may disintegrate and contaminate the main vacuum vessel, as in the case of the high temperature furnace.
3. When a specialized sample environment is needed that cannot be mounted directly on the rotating vacuum flange.

For these cases and others there will be an ambient pressure thimble that can be mounted on the rotating vacuum flange to provide ambient pressure and temperature in the sample region of the spectrometer. The thimble will be made of aluminum tube stock and have a thin aluminum window at beam height to minimize scattering. The thickness of this window will be in the range of 1–2 mm as set by strength and safety considerations. All parts of the thimble outside of beam height will be coated with neutron-absorbing material such as boron-loaded epoxy on the side facing the vacuum vessel.

2.5.3 Oscillating radial collimator

Important parts of the scientific projects to be pursued on ARCS involve sample environments that necessarily place significant amounts of material in the incident beam path. Examples include the high-temperature furnace and various high-pressure cells to be used on the instrument. Owing to their different flight paths, neutrons that scatter elastically from material that is not at the sample position will in general arrive at the detector bank at different times than neutrons which scatter elastically from the sample. The result can be intense spurions that are difficult to distinguish from inelastic scattering from the sample itself.

To suppress these spurions and inelastic background from sample cells, ARCS will be equipped with an oscillating radial collimator. The collimator will be located in the detector vacuum vessel in such a way that it can be used in combination with any sample environment including the ambient pressure thimble. The collimator will cover the full angular range of the detector bank and the blade spacing will be chosen so as to define a cylindrical scattering volume at the sample with a diameter of order 1 cm. The radial collimator will be mounted on a rotation stage to provide the oscillating motion that prevents permanent shading of specific directions. Not only the collimator blades, but also the rotation stage and the frame from which the blades are suspended, will be coated with neutron-absorbing material to avoid spurious scattering. Provisions will be made to automatically lower or raise the collimator out of the beam path when it is not needed.

2.5.4 Low temperature closed-cycle refrigerator (3.6–350 K)

Since low temperatures are required for much of the scientific program, it is important to acquire a displex unit. Our preference is to obtain a unit with extended low temperature capability. One approach is taken by APD Cryogenics in their commercial Heliplex design. It uses a closed-cycle refrigerator in combination with a Joule-Thompson heat exchanger to achieve base temperatures below 3.6 K. A temperature controller dedicated to this device will be purchased.

2.5.5 High temperature closed-cycle refrigerator (<30–650 K)

Ross W. Erwin of NIST has modified a closed-cycle refrigerator to enable it to reach temperatures as high as 650 K. The trick is to use a sapphire spacer between the cooling head and heating stage. The thermal conductivity of sapphire is temperature-dependent so that it provides better heat conduction at low temperatures than at higher temperatures. The NIST group is agreeable to providing us with drawings and technical advice. We plan to build our own unit, however, which is based on a closed-cycle refrigerator unit from APD or Leybold, a heating stage from Air Products, and a sapphire link between them. Although the closed-cycle refrigerator has a base temperature of 6.5 K, we expect that with the sapphire spacer the base temperature should be between 25 and 30 K. A temperature controller dedicated to this refrigerator will be purchased.

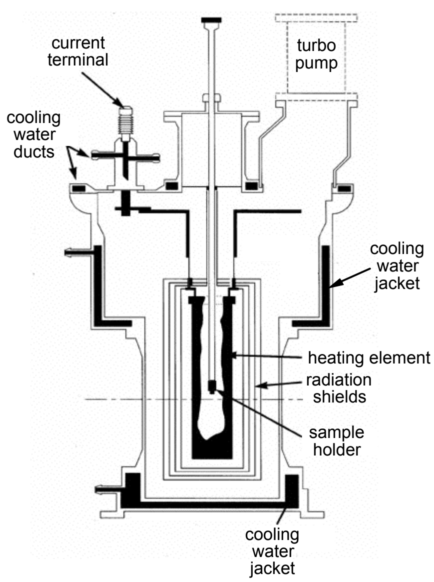

Figure 12: The ILL high temperature furnace. The thin Nb heating element and Nb radiation shields are in the neutron beam, but we have had little trouble with spurious scattering in reactor experiments with collimated beams at ORNL.

2.5.6 Furnace (600–2073 K)

We have evaluated the performance and reliability of several high temperature furnaces that have been used previously for neutron scattering work. The clear choice is the “ILL” furnace manufactured by AS Scientific Products, Abingdon, England, and shown in Figure 12. This unit uses a cylindrical Nb heating element around the sample, which can be as large as 4.5 cm diameter and 10 cm high. Cylindrical Nb radiation shields surround the heating element, and the water-cooled housing has thin Al windows for 360° neutron access around the sample. Neutron access is ±20° out of the horizontal scattering plane. This unit has relatively low background, but the background should be essentially negligible with incident beam collimation and the use of radial collimators in the ARCS vacuum vessel. The unit is reasonably priced, about 70 k$ with vacuum system, power supply, interlocks, and miscellaneous spare parts.

An important advantage of this ILL furnace is that it is a mature product, with an integrated vacuum system, temperature controller, power supply, and safety interlocks. It will likely be used with other instruments at the SNS.

2.5.7 Issues with pressure cells

Pressure experiments with a samples having masses of tens of grams and larger are often performed by mounting the sample in a canister that can be compressed in a hydraulic press, and then locked in a compressed position. Upon removal from the hydraulic press, the pressure is maintained in this compact “pressure cell”, which can be moved into the specimen region of the ARCS spectrometer, for example. An obvious feature of the pressure cell is that it is made of high-strength materials such as sapphire or steel, and typically contains more such material when higher pressures are required. For pressures of 10 kbar or higher, spurious scattering from the pressure cell can overwhelm the scattering from the sample itself, especially inelastic scattering from the sample. This problem can be alleviated considerably by collimation. The incident beam is collimated to have a width comparable to the sample, and the scattered beam is collimated with the oscillating radial collimators.