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# Spallation Neutron Source

## Workshop Report

# VULCAN INSTRUMENT DEVELOPMENT TEAM MEETING #1

*held on November 18-19, 2001 at Spallation Neutron Source*


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# VULCAN INSTRUMENT DEVELOPMENT TEAM MEETING #1

SNS Building, Scarboro Rd., Oak Ridge, Tennessee

November 18-19$^{th}$ 2002

## 1. Introduction

The purpose of the meeting was to inform the Instrument Development Team (IDT) members as well as the wider VULCAN team of the present design status of VULCAN and the cost model for the instrument. In view of the assembled expertise, several discussion sessions were held on topics such as “Bringing the North American engineering community together at VULCAN”, “Access to VULCAN” and “Speculation on new areas of science, expertise and novel equipment”. The successful application for an NSF grant to fund an “International Materials Institute” by the University of Tennessee was also described. The Spallation Neutron Source (SNS) site was visited on the afternoon of Nov 19$^{th}$ to give the participants an idea of the scale of the undertaking. The meeting agenda is included in Appendix 1 and the attendees and their affiliation are listed in Appendix 2.

## 2. Present Status

### 2.1 Canada Foundation for Innovation Perspective

Bruce Gaulin presented the building of VULCAN as a transformative opportunity for the Canadian neutron scattering community: to be part of the best initiative in the world. Funding was announced in June 2002 subject to four conditions addressed in a Memorandum of Understanding between McMaster University and Battelle. The conditions are to have an inter-institutional agreement as regards money flow, to have operating and maintainence budgets secure for 10 years from SNS, to have no cost over-runs and guaranteed access for Canadians. Two further conditions on funding included the selection of scientists to be part of the IDT and the existence of a strategy of outreach to the Canadian community. The members of the formal IDT are listed in Appendix 2. 75% of the running time is devoted to the general user program, 20% is devoted to the IDT split equally between the Canadian users and Metals and Ceramics Division (ORNL) users, and 5% is devoted to discretionary time for the instrument scientist.

In addition, the Canadian capital cost contribution translates to access for Canadian users of 10% of time on a high -resolution chopper and 10% over the remaining suite of instruments. Bruce Gaulin as Principal Investigator has overall responsibility for scientific oversight, budget control and outreach.

## 2.2 The Spallation Neutron Source

Ian Anderson, head of Experimental Facilities Division at the SNS, welcomed participants and gave an overview of the SNS. The SNS is designed to run at a target power of 1.4MW, producing a neutron flux which exceeds that at the ISIS source in England, the nearest competitor, by a factor of eight. The SNS will have a peak flux which is 50-100 times higher than the steady flux at the reactor at the Institut Laue-Langevin (ILL) which is the world's most intense steady source. The target is liquid mercury. It is expected that the cavitation spalling of the target windows due to pressure waves generated by the pulsed proton beam will be manageable. The civil construction of the linac building, the proton storage ring and the tunnel to the target is nearly complete. The front end of the accelerator, the ion source, has been delivered by Lawrence Berkeley Laboratory and is producing 30mA out of the 35mA specified current. Electrical services to the klystrons that feed the linac are being installed. The basement of the target room is completed and the steel liner of the target station is in place. Currently there are 600 construction personnel on site.

Of 24 possible beam lines, 14 have been assigned to instruments, of which one is VULCAN. The scheduled start-up date is 2006. After 2 years of testing and commissioning, the neutron flux delivered will be equivalent to the ISIS source and it will take a further 2 years to ramp to full power.

## 2.3 VULCAN

Xun-Li Wang, the instrument scientist and project manager, presented the current VULCAN design. The VULCAN beam line views a decoupled water moderator. This provides a beam with a maximum intensity of around $8x10^7$ neutrons $cm^{-2}sec^{-1}Å^{-1}$ between 1 and 2Å and a pulse width of 10μsec. The neutron beam leaves the target through a collimator, a chopper to reduce background and tune the wavelength range, and into a 20m curved guide. The curved guide reduces the number of fast neutrons in the beam and prevents the γ-flash from reaching the sample. The curved guide is followed by a 12m straight guide and a 5m straight section with 5 interchangeable 1m long guides and collimators. This interchangeable section allows tuning of the resolution and intensity to match the needs of the experiment. The calculated peak fluxes at the sample position in the high resolution ($\Delta d/d = 0.2x10^{-2}$) and low resolution ($\Delta d/d = 0.4x10^{-2}$) modes are 2 and $8x10^7$ neutrons $cm^{-2}sec^{-1}$ respectively. This compares with the estimated flux of $5x10^7$ neutrons $cm^{-2}sec^{-1}$ at the upgraded D20, a high-intensity diffractometer, at the ILL. The number of neutrons counted depends on the area of the counter bank, which, for the fully featured VULCAN, will be 2 steradians. The resolution at VULCAN is comparable with other time-of-flight diffractometers. For example, the NPD at Los Alamos has a resolution of $0.25x10^{-2}$, SMARTS at Los Alamos has $0.4x10^{-2}$ and ENGIN-X at ISIS has $0.2x10^{-2}$. (Note ENGIN the predecessor of ENGIN-X has $0.7x10^{-2}$). A resolution of $0.4x10^{-2}$ can readily resolve 23 different peaks in an hcp structure such as zirconium and will be adequate for most applications.

## 2.4 VULCAN cost model

George Rennich, the design engineer for VULCAN, gave a breakdown of the cost model for VULCAN based on the standard procedure adopted for all SNS instruments. This differs in detail from the cost model presented to the expert committee that reviewed VULCAN for the Canada Foundation for Innovation (CFI). However, the bottom line is nearly the same. The November 2002 cost model is given in Appendix 3. In summary, procurements are 4.9M$, scientific and technical support is 0.9M$, engineering design is 1.7M$ and travel is 0.3M$ for a total of 7.8M$ in US dollars. Assuming an escalation of 1.025 over 5 years the total cost is 8.9M$. The department of Energy (DOE) requires a 20% contingency. 0.9M$ of this has been assigned to labour and materials and 0.7M$ to scope contingency. This puts the load frame and furnace potentially at risk. This is an unsatisfactory situation since the load frame and furnace are essential items of the diffractometer. This point should be considered in the light of the NSF instrument proposal to be re-submitted by the University of Tennessee in January 2003.

The November 2002 cost model calls for sums of 1.9, 1.7, 1.5,2.0 and 0.5M$ to be spent in the fiscal years 2003 to 2007. The immediate tasks are to develop the schedule fully, to refine the budget by line-item and to refine the funding profile. The first item on the critical path is the core vessel and shutter inserts to be installed in May of 2004. Table 1 shows time lines for installation of essential parts of the diffractometer.

Table 1

| Job | Time (Financial Year) |
|---|---|
| Management, oversight , installation | 2003-2007 |
| Neutron guide purchase | 2003 |
| Data acquisition | 2004-2007 |
| Detectors | 2004-2006 |
| Shielding | 2003-2007 |

The question was raised of who decides on de-scoping, if necessary, and it was agreed that the expert group X.-L. Wang, B. Gaulin, T.M. Holden, the Canadian IDT and their counterparts in Metals and Ceramics Division at ORNL would make such decisions.

## 2.5 Anticipated areas where our efforts will need to be concentrated.

Tom Holden presented a first cut at areas of the detailed design of VULCAN where advice is needed from the VULCAN team. The following points were identified.

2.5.1 Guide alignment. Who will align the guides and what benchmarks will be left in place? Is the shielding covering the guides easy to remove to do repairs?

2.5.2 Incident beam definition. Design of slit carriage? Ease of optical alignment of slit carriage with the beam line? Independent computer control of the left and right sides of the slits?

2.5.3 Sample Table. What is the distance of the top of the table to the sample position when the table is fully down? (This gives a measure of the maximum size of component that may be handled.) What is the range of motion, accuracy and load capacity? Is there a way to centre the table to 0.1mm across the beam? What ancillary rotating tables and high precision linear tables, alignment fixtures and calibration fixtures will be needed?

2.5.4 Scattered beam definition. Mounting, manipulation and precision alignment of the radial collimators? Set of sizes of radial collimators? How will the radial collimators be shielded? Will there be collimator coverage of the complete counter bank?

2.5.5 Counters. Type of counter ($He^3$ versus scintillator)? How will the counter be shielded to minimise background? Is there a means to position the counters equidistantly from the sample to within 0.5mm?

2.5.6 Enclosure. What will be the size and design of enclosure? How will hanging fixtures such as radial collimators be supported. Will the walls be coated with neutron absorbers? What is the access for major pieces of equipment? What services (gas and exhaust manifolds, hydraulics, electricity, TV, air-conditioning, temperature stabilisation, safety features) will be needed?

2.5.7 Set-up facilities. What theodolites, feeler gauges, optical bench locations and soft-ware will be needed for set up?

2.5.8 Peripherals. Stress rig, fatigue rig, corrosion cell, furnaces, cryostats, texture goniometer, carousels for multiple samples.

2.5.9 Collision avoidance. Should there be both soft-ware CAD-CAM defence and hard-ware defence such as proximity switches, light curtains etc. M. Bourke believes proximity switches are the most effective way to avoid collisions.

Several logic components were also identified.(a) What is the from of the control file (menu-driven or spread-sheet?), (b) What is the mode of control of the peripherals? (c) In a high data acquisition respect what is the robustness as regards crashing? Will there be automatic recovery after crashing? Will there be extensive testing well ahead of time at a beam line test-bed to iron out the inevitable bugs? (d) Careful choice of routing of data between counters/electronics, time-stamping devices and storage to ensure speed and reliability? (e) Quick-look facility, continuous updating of the intensity versus d-spacing spectrum, automatic single-peak fitting and whole pattern fitting? (f) Rapid output of analysed data to spread-sheets and graphics packages? (g) How will the "SmartsExpert" system for of input/ output , data gathering and data analysis developed by Los Alamos be incorporated?

## 3 Technical Developments

### 3.1 Counters

Ron Cooper, detector-team leader for SNS, described counter options for VULCAN. The requirement is for $10m^2$ of counters at a distance of 1.5m from the sample with a time resolution of about 5μsec. The time resolution is needed to count 20 neutrons in a 100μsec long pulse corresponding to the powder scattering from the (110) peak of iron. The position resolution required is 25mm (vertical) and 5mm (horizontal).
The options are (1) the use of straight $He^3$ tubes with a length to give the desired angular and time resolution or (2) the use of linear position sensitive $He^3$ tubes to give high angular resolution and (3) the use of LiF/ZnS:Ag 0.4mm thick scintillators of ISIS design.
For a $He^3$ tube the position resolution is at least 13mm in the horizontal plane, being the tube diameter. The position resolution can, however, be achieved with scintillators. $He^3$ tubes are more efficient than scintillators. For example the efficiencies of $He^3$ tubes at 1.5, 1.0 and 0.7Å are 66, 57 and 48% while the comparable figures for scintillators are 62, 50 and 40% . The maximum count rate of $He^3$ counters is usually reckoned to be 70kHz which corresponds to 7 neutrons in a 100μsec. Scintillators can count up to 40 counts in 100μsec without losing pulses. $He^3$ counters are straightforward to set up whereas scintillators with the necessary photo-tubes are more complex. The typical cost of a single $He^3$ tube plus electronics is \$1500 or 120k\$ per $m^2$ plus installation cost. The cost of the ISIS design of scintillator counter (a vee-shaped arrangement to optimise efficiency in a $0.1m^2$ module with14 photo-tubes) is 225k\$ per $m^2$.

Generally the intention at the SNS is for inelastic neutron scattering spectrometers to use $He^3$ tubes since the cross sections and count rates are lower and powder diffractometers to use scintillators.

The cost of a SANS detector, which could be added after VULCAN is built, would be 700k\$. This would give a 2-d cross-wire $He^3$ position sensitive detector with $5x5mm^2$ spatial resolution. However, the requirement is for $1x1mm^2$ spatial resolution.

For a Bragg-mirror imaging detector, also an add-on to the basic VULCAN instrument, the requirement is for 0.1mm spatial resolution in one dimension to match the imaging capability of the Bragg mirror. A Brookhaven design exists with 0.4 mm resolution over a $50x50mm^2$area. Higher efficiency detectors, such as a solid state detector have only 10% efficiency so one of the obstacles to achieving the aims of a Bragg-mirror device is the counter development.

### 3.2 Data acquisition: what SNS provides

Steve Hicks, on behalf of Rick Riedel, presented an overview of the data acquisition system (DAQ) which will be provided by the SNS. The DAQ will take data from the counter electronics. SNS is responsible for bringing the data all the way to a central depository which provides standardised pulse shapes from the recorded counts. These pulses are then time-stamped in a pre-processor with a signal from the $T_0$ chopper that defines the initial burst of thermal neutrons. The data then passes to a control computer as well as a data analysis computer. From the control computer the data goes to storage. Further analysis of the data from storage is customised for each instrument and is the responsibility of the instrument scientist. The customised analysis package would include, for example, single peak analysis of the data as well as a Reitveld analysis of all the peaks in the spectrum. The analysis computer will allow close to real time visualisation of the data based on a number of standard 1d, 2d, 3d graphical presentations.

The system is based on PC's with a WINDOWS 2000 operating system. The network connecting the electronics components and the computers is a G link TCP-IP private network with commercial 2G fibre channel links. The data rate which may be handled is expected to be 80Megabytes $sec^{-1}$.

The heart of the system is the "data sockets" network governed by the control computer which tells the other "satellite" computers what to do. The satellite computers control the sample environment (furnaces, cryostats, stress-rigs, sample stages etc.) the beam-shaping choppers, ancillary control (for moving counters or guides or checking vacuum monitors) as well as any "user" computer brought in to control special equipment provided by the user.
The detector calibration and control software and the run-file set-up software and the data visualisation software will be provide by SNS since these are common to all the instruments

## 4 Planning for the use of VULCAN

### 4.1 Plans for implementing the NSF infrastructure grant by the Materials Science and Engineering Group at the University of Tennessee

Peter Liaw of the Materials Science and Engineering Department at the University of Tennessee described plans for implementing the International Materials Institute (IMI) which is expected to be funded in January 2003. The IMI allows for exchange of personnel between the United States and other countries leading to International collaboration. It provides money for short-term study groups, workshops and symposia as well as internet resources. Twenty-five facilities were named in 8 countries (USA, Canada, UK, Germany, France, Japan, Korea and China). Research work will include in-situ studies of mechanical properties of materials and real-time measurements. The first phase will include interactions between the USA and Canada. In the second phase interactions with France, Germany and Japan will be added and in the third phase Korea and China will be added. It is expected that two or three new faculty positions will be advertised in materials science and engineering at the University of Tennessee principally in the area of computational materials science. It is also expected that undergraduate courses will be set up on the fundamentals of neutron scattering and on the applications of neutron scattering. The following milestones are anticipated: 2003 recruitment of senior level faculty at the University of Tennessee: 2004 Neutron Diffraction course level 1: 2005 International Summer School on mechanical properties as studied with neutrons, Neutron Diffraction Course Level 2, graduate seminars: 2006 American Conference on Neutron Scattering, workshop, neutron scattering school: 2007 Program assessment.

4.2 Application for NSF funds for tensile testing equipment

Peter Liaw informed the workshop that an application for National Science Foundation funding will be submitted in January 2003 for tensile testing equipment at VULCAN. Many of the scientists and engineers working in the field are named in the application as well as engineers working at Boeing, General Electric and Haynes International among others. The principal facility will be able to apply uniaxial and torsional loads in a static or cyclic fashion. The maximum uniaxial load will be 250kN, the maximum torsional load will be 2500N-m. The maximum frequency will be 200Hz. The associated furnace is expected to be operated at 2000ºC under stand-alone conditions and 1800ºC under load. A corrosion cell will be designed for the equipment to allow hydrogen charging and other electrolytic changes. A question was raised that it might be appropriate to achieve multiaxial load conditions with multiple actuators rather than the torsion/tension approach. The second instrument will be a small sample load-frame with a maximum load of 4kN but high resolution.
The proposed equipment differs from the SMARTS load-frame, commissioned in 2001, with the addition of torsional stress, automatic centering of the sample, a fatigue capability, a higher temperature capability (1800ºC versus 1500ºC) and the addition of a corrosion cell.

Two of the members of the VULCAN team, S. Agnew and M. Gharghouri are experts in the design and use of tensile testing equipment and offered to help with the detailed design of the load frames.

4.3 Design Experience from SMARTS at Los Alamos National Laboratory

Mark Bourke summarised his experience in building and running the SMARTS difractometer which was the first purpose-built spectrometer for materials science and engineering at a spallation source. Many of the principles first explored at SMARTS are incorporated in the design of VULCAN. The mandate at SMARTS is for testing new materials (such as shape memory alloys), new processing methods (such as equal channel angular extrusion) and solving problems related to defence needs in the USA. Of major importance is his belief that four qualified scientists plus a dedicated technician are needed to maintain the throughput at SMARTS and to answer the subtle questions needed to run the equipment efficiently.
SMARTS views a chilled water moderator and has a resolution of $\Delta d/d = 0.4 \times 10^{-2}$. The intensity is about 8 times more intense than that at NPD which was designed as a high resolution powder diffractometer. The complete spectrum for a sample of $1000mm^3$ can be obtained in about 10 minutes. A measure of strain in a gauge volume of $1mm^3$ of iron of thickness 10mm can be obtained in about 60min. The sample table capacity is 1500kg and has translational ranges of 300mm in the horizontal plane and 600mm vertically. The

sample table is 30m from the target and $2\theta_c$ supermirror guides are used outside the 5m thick bulk shield.
Mark Bourke commented on the design difficulty and costing of a number of the components of SMARTS which thus provide useful guidelines for VULCAN. (a) Mercury shutter and associated collimation. The design time was 3 months, the cost 200k$ (US) and the “aggravation” was medium. (b) Floor modifications to isolate the guide supports from the lab floor and to get the needed distance between the sample position and the top of the sample table in its lowest position. The cost was 200k$ and the “aggravation” was high. (c) Procuring and installing the neutron guides. The time between starting talking to the vendor (CILAS, France) and installation was 24 months. The cost including installation was 500k$. The aggravation” was low. (d) Procuring shielding to minimise background at the sample, personnel exposure and cross-talk between instruments. The design (laminates of boron loaded polyethylene, steel and polyethylene) and procurement took 24 months, the cost was 500k$ and the “aggravation” was high. The shielding must be designed to be ergonomically removable. (e) Spectrometer enclosure. The cave is $6x6m^2$ in section and 2m high with a removable roof. The 25cm thick walls are of steel and borated polyethylene. The cost was 300k$ and the aggravation was low. (f) Detectors. The detectors are single ended $He^3$, 12mm diameter, 250mm long. There are 192 detectors arranged about ±90°. The total cost of the detectors and electronics was 400k$ and the “aggravation” medium. (g) Translator. The translator was designed and built by “Advanced Design Consulting” (ADC) at a cost of 120k$ over a 12 month time span. ADC also designed and built the adjustable slit system in the incident beam. It is vital to have full documentation of these kinds of components from the vendor. The “aggravation” was low. (h) Radial collimators. The collimators have mylar vanes coated with GdO. They are heavy and must be supported from above to avoid the sample table. The collimators vary in focal length between 100 and 200mm and define gauge volumes of 1, 2, 3, and 4mm. The collimators were procured from JJ Industries (Denmark) for 120k$. The “aggravation” was low. (i) Load-frame. The load frame, procured from Instron and Materials Research Furnaces, took 24 months from starting discussions to commissioning. The “aggravation” was high and required a great deal of interaction between the manufacturers and two members of the SMARTS team. The cost of the load frame was 300k$ and the furnace 200k$ and required an additional 200k$ in personnel time.

Mark Bourke gave the breakdown of users and the breakdown of equipment used to date at SMARTS. Of the users, 55% were academic, 20% were from defence, 16% were from Los Alamos and 9% were from industry. 38% of the users used the load frame, 29% also used the furnace, 24% of users did spatially resolved measurements and 9% did other experiments. He offered several points from the perspective of hindsight. Make certain that tests are conducted well ahead of time on the data acquisition system. Make certain that data visualisation and automatic calibration routines are in place on day one. Place strong emphasis on shielding and signal to noise. Get the staffing levels right. Watch for “scope of work creep”. The major cost risk in building a diffractometer is the time spent by the designer. Often this is over-optimistic. Designer time should be treated like procurement.

## 5 Discussion Sessions

### 5.1 "Bringing the North American engineering community together at VULCAN: what we have to do. Moderator A. Krawitz (University of Missouri)

Many ideas for achieving this end were noted such as holding workshops, training courses, giving talks at engineering conferences such as the Canadian Materials Science Conference in Halifax in 2003. Have a North American round robin exercise analogous to the VAMAS international round robin and the RESTAND European round robin. Take VULCAN on tour to Universities and Industries across Canada and the United States. Produce a "white paper" identifying problem areas in Materials Science and Engineering. Produce a "living" web page connected to the SNS web page. (This matches the University of Tennessee IMI initiative for web-based information). Produce a VULCAN Newsletter on a regular basis. Carry out trial experiments at existing spallation sources to introduce new users prior to VULCAN commissioning. Prepare reports for the general public.

An attempt was made to define "Who is the Community?" Four segment were identified: (a) industry in sub-categories of research, manufacturing and service, (b) government, the National Laboratories in Canada and the USA, the funding agencies CFI and DOE and (c) universities in sub-categories of faculty, students and faculty consulting with industry. Several points were brought up which will be looked at in detail in future meetings. What represents adequate staffing? What is the best way of eliciting and judging proposals for VULCAN and the nature of the proposal form, number of review periods per year etc. Should there be a mail-in sample service? Should there be remote-access to VULCAN to run the equipment?

### 5.2 "Discussion on user access" Moderator A. Ekkebus (User co-ordinator, SNS)

Al Ekkebus explained the user policy to be used for both the HIFIR reactor and SNS at Oak Ridge National Laboratory as regards proposal forms, evaluation mechanisms and entrance requirements to the neutron sources. Efforts are in hand to improve the ORNL internal processes including the US Export Control Regulations, ORNL security issues and sample storage. There will be a conference of representatives of the major North American neutron sources in January 2003 to lay out the development of future capabilities, to examine operations schedules to see whether they can be dove-tailed as regards shut-downs, to maximise training which can be common between laboratories and generally to eliminate barriers to wider use.

A discussion of industrial access for proprietary research was initiated. The need for proprietary access is likely to be restricted to a few instruments at the SNS. The concept, however, has been used extensively to justify both the neutron source and instruments around it. It is important to address the issue since industrial problems often lead to further basic advances and research work is likely to give North Americans an economic advantage. The following idea was introduced, but many discussions with a number of parties are needed to come up with a workable scheme. It was suggested that some "fast access" time-slots be left available in the 75% of general user time. This would reflect the need for fast turn-around for paying industrial customers distributed over the calendar year. If there is no industrial demand for these time-slots, local users with approved proposals could be scheduled for this time at relatively short notice. The question of who would do the tests for industrial clients also needs discussion.

5.3 "Speculation on New Areas of Science" Moderator C. Hubbard (ORNL)

A short session on this topic was held. An effective way to keep up to date on new areas of science was proposed by S. Agnew. He suggested that areas of materials science and engineering should be divided up with members of the VULCAN team volunteering to report on developments in their fields in subsequent meetings. S. Agnew and M. Gharghouri volunteered to cover the area of constitutive modelling. Xun-Li Wang, S. Spooner and P. Liaw volunteered to cover physical metallurgy and processing. A volunteer is needed to cover strain-mapping and comparison with finite element modelling

In the area of new techniques the following were mentioned: Bragg-edge measurements, synchrotron strain measurements, beam compression with Kirkpatrick-Baez mirrors to examine strain grain by grain by Laue diffraction (this is analogous to recent advances in Synchrotron X-ray measurements), beam compression by neutron lenses and the Bragg-mirror method of getting 0.1mm resolution in one dimension by imaging a point in a sample onto a detector and using the time-of –arrival to determine d-spacing. It was felt that efforts were needed now to begin figuring out how to do in-situ measurements on operating engines or cyclical welding operations.

5.4 "Our areas of expertise" Moderator L.Clapham (Queens' University, Kingston)

Lynann Clapham volunteered to co-ordinate a VULCAN newsletter on a once a year basis from Queens' University. This would be sent to Universities and out to industry. There is a need to compile lists of names and addresses for the newsletter. There should be a VULCAN web site linked to the SNS. R. Rogge (National Research Council of Canada, Chalk River) volunteered his services for this task. X-L. Wang and G. Rennich indicated their interest in guide design. Volunteers are needed to cover the areas of incident beam definition and scattered beam definition. R. Rogge and C. Hubbard expressed interest in the design of the sample table and the fixtures securing the sample to the sample table. T. Holden expressed an interest in background mitigation. C. Hubbard and T. Holden expressed an interest in the design of theodolite sytems for fast and accurate alignment of samples. Hahn Choo, P. Liaw, S. Agnew and M. Gharghouri volunteered to work on the options for load frames and furnaces for VULCAN.
C. Hubbard volunteered expertise in Euler cradles for computer controlled orientation of samples. R. Rogge and M. Gharghouri volunteered expertise in collision avoidance methods.

APPENDIX 1

VULCAN Instrument Development Team Meeting

November 18-19, 2002
Room 101B, 701 Scarboro Road, Spallation Neutron Source
Oak Ridge, TN 37922, USA

Monday, November 18

| Time | Topic | Speaker |
|---|---|---|
| 8.30-9.00 ” | “Welcome and “Overview of SNS | Ian Anderson |
| 9.00-9.30 | “Canada Foundation for Innovation perspective” | Bruce Gaulin |
| 9.30-10.00 | “Present Status of Design” part1 | Xun-Li Wang |
| 10.00-10.30 | Break | |
| 10.30-11.00 | “Present Status of Design” part2 | Xun-Li Wang |
| 11.00-11.30 | “Cost model” | George Rennich/Randy Summers |
| 11.30-12.00 | “Data acquisition… what SNS provides” | Steve Hicks/Rick Riedel |
| 12.00-13.00 | Lunch | |
| 13.00-14.00 | “Plans for implementing the NSF Infrastructure grant and plans for the NSF equipment grant” | Peter Liaw |
| 14.00-15.00 | “Anticipated areas where our efforts need concentrating” | Tom Holden |
| 15.00-15:30 | Break | |
| 15.30-16.00 | “Experience with SMARTS” | Mark Bourke |
| 16.00-17.00 | “Bringing the North American engineering community together at VULCAN….. what we have to do!” | Aaron Krawitz moderator |
| 17.00 | Finish | |
| 18.30 | Dinner at the Bleuhound | |

Tuesday, November 19

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|---|---|---|
| 8.30-9.00 | “Detectors Options” | Ron Cooper |
| 9.00-9.30 | “Our favourite areas of expertise…. Jobs for the team members” | Lynann Clapham moderator |

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|---|---|---|
| 9.30-10.00 | “Discussion on access…..Canada, instrument development team, general user, industrial” | Al Ekkebus moderator |
| 10.00-10.30 | Break | |
| 10.30-11.30 | “Speculation on new areas of science, new areas of expertise and novel equipment” | Cam Hubbard moderator |
| 11.30-12.00 | Wrap-up session | |
| 12.00-13.00 | Lunch | |
| 13.00-15.00 | Visit to SNS site | |

APPENDIX 2

Attendees

Formal IDT members
Bruce Gaulin (McMaster University, Principal Investigator), Thomas M. Holden (Northern Stress Technologies, Deep River, leader), Lynann Clapham (Queen's University, Kingston), Michael Gharghouri (Dalhousie University), Ronald Rogge (National Research Council of Canada, Chalk River, Ontario), Xun-Li Wang (Instrument Scientist, SNS) and Camden Hubbard (Metals and Ceramics Division at Oak Ridge National Laboratory).

VULCAN (advisory) team
Aaron Krawitz (University of Missouri), Sean Agnew (University of Virginia), Mark Bourke (Los Alamos National Laboratory). Peter Liaw and Hahn Choo (University of Tennessee), George Q. Rennich (Engineering Design, SNS)

Ian Anderson (Director of Experimental Facilities Division,  SNS), Kent Crawford (Instrument System Group Leader), Ron Cooper and Lowell Crowe (Counter Development ,SNS), Rick Riedel (Data acquisition, SNS), Alan Ekkebus (User affairs, SNS), Judy Pang and Stephen Spooner (ORNL)

## Appendix 3

### November 2002 cost summary

Available upon request from Instrument Scientist, Xun-Li Wang