SNS 100000000-PN0004-R00

# Spallation Neutron Source Commissioning Program Plan

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# Spallation Neutron Source
# Commissioning Program Plan

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# 1.0 Introduction

The Spallation Neutron Source (SNS) Facility commissioning from Front End to Critical Decision 4(CD-4), the end of the construction project and the transition to operations, will take place under the Department of Energy Accelerator Safety Order, DOE O 420.2 A.

Commissioning refers to the activities, which take place after installation and integrated testing, which require the use of the beam to determine operational parameters and verify equipment performance.

The Commissioning Program Plan contains a brief technical description of SNS systems and details the administrative and technical Safety systems which are required for commissioning under the DOE Accelerator Safety Order DOE O 420.2A . The SNS has chosen the modular approach to commissioning. is described in the Draft Guidance for DOE O 420.2A in the following paragraph:

"Commissioning an accelerator facility incrementally can be advantageous, particularly when the contractor desires to operate portions of the facility while others are still under construction. Typically the facility construction will be delineated into modules such as the beam particle source, particle injector, main accelerator, storage ring, experimental halls, etc. As each module is completed and tested, a Commissioning ARR is conducted on that particular module. The commissioning activity for each separate module requires DOE approval before it is initiated unless the contractor receives DOE approval for an overall commissioning program. The development of an overall commissioning program plan tends to focus better the required approval by DOE and lessen the likelihood of delays in obtaining a number of discrete approvals. A commissioning program plan should include:

- a description of the content of each module;
- identification of any additional administrative and technical controls and contingency plans beyond those established for prior modules;
- a description of the content of that portion of the overall facility ARR that is needed for each module; and,
- the schedule for each module."

The Commissioning Program Plan also contains the Standards Based Management System roles, responsibilities, accountabilities & authorities as detailed for the commissioning process

Other documents supporting SNS commissioning is the SNS Accelerator Readiness Review Plan of Action, the SNS Safety Assessment Document and the Accelerator Safety Envelope. The SNS Accelerator Readiness Review Plan of Action is a high level document which describes the SNS plan to achieve readiness for commissioning and operation consistent with the Accelerator Safety Order DOE O 420.2A,

SNS commissioning is also supported by the Accelerator Systems Division Technical Commissioning Plan, which consists of a sequence of one page summaries of technical commissioning activities. These activities begin with system and subsystem integrated testing and end with systems commissioned to the Critical CD-4 requirements.

## 1.1 Accelerator Systems Commissioning

### 1.1.1 Accelerator Commissioning Organization

Commissioning of the SNS accelerator requires detailed planning and close coordination of installation, test and check-out, and accelerator system conditioning activities. Commissioning refers specifically to those activities involving the use of the beam. All other activities not using the beam are installation, testing, processing and conditioning etc.

The SNS Accelerator Systems Division (ASD) is composed of approximately 120 physicists, engineers and technicians available to support the effective and efficient commissioning of each accelerator system.

ASD has established a Commissioning Team structure (Fig. 1.a) consisting of Managers for each major technical area, drawing team resources from the Accelerator System Division. This structure will provide day-to-day and weekly coordination of commissioning activities. This group will ensure efficient use of machine resources and time.

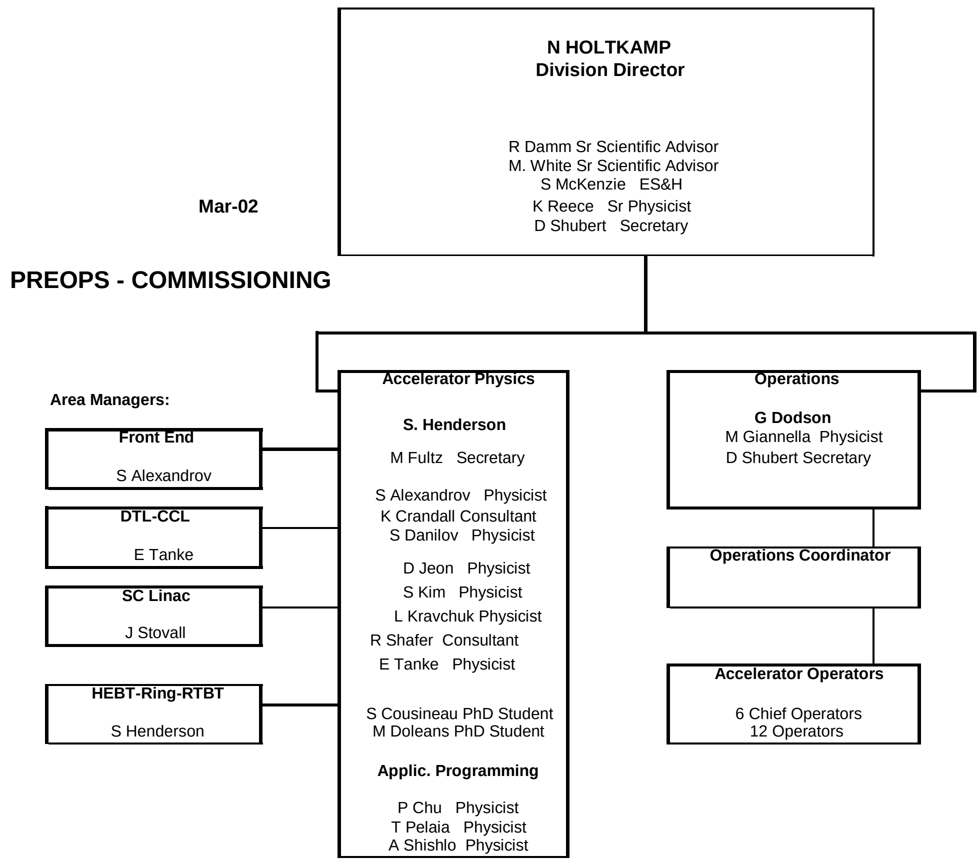



**Figure 1.a Commissioning Organization**

Each of the ASD technical groups will provide technical leads and specialists to supervise commissioning work, under the guidance and direction of the Commissioning Team.

The SNS Environmental Safety and Health (ES&H) Manager provides guidance and advice pertaining to SNS adherence to ORNL, DOE and Federal regulations.

### 1.1.2 Accelerator Systems Commissioning

The SNS Commissioning Program plan was developed over a period of about thirteen months. The process began with one of two SNS Accelerator Systems Commissioning Workshops held at LANL. These workshops concentrated primarily on the Front End and Linac. In addition to the workshops, a number of conference papers and visits by commissioning team members to partner laboratories added to a basic understanding of the commissioning process. A series of regular Accelerator Commissioning Team videoconferences were established. These weekly meetings alternated focus between the Front End and Linac. Recently the Ring Commissioning Team was added to the videoconference rotation.

For each of the commissioning teams, an Area Manager (see Fig. 1.a) was named to act as the team leader and to assume overall responsibility for the technical commissioning process and beam delivery to the “treaty points” between systems. The overall goal of the commissioning process is the delivery, to the spallation target, of a beam consistent with the requirements of Critical Decision 4 (CD-4), which defines the successful completion of the SNS project. The CD-4 requirements are listed in the SNS Project Execution Plan, Document SNS_1999_00004 ORNL/M6661/R0A.

The SNS Commissioning Program Plan is intended to work in concert with the SNS Accelerator Systems Division Installation Plan (document SNS 100000000-PN002-R00) and the SNS Integrated Project Schedule, since the installation, test and check out, and conditioning of the accelerator components ("pre-beam") will be interleaved with commissioning ("with beam").

A high level schedule for the installation, testing and commissioning of the SNS accelerator systems is shown in the SNS Accelerator Readiness Review Plan of Action(ARRPOA), SNS Document number 100000000-PN005-R00. It can also be found in the SNS Integrated Project Schedule (IPS), which can be found at http://it.sns.ornl.gov/project_controls/IPSR250.pdf.

The commissioning of an accelerator system is a critical step in the transition from the fabrication and installation phases to the operational phase. Accelerator commissioning includes a sequence of accelerator physics measurements, and the test and check-out and tuning of accelerator systems with beam, in order to characterize the actual operational parameters of the accelerator systems. The information gained from commissioning studies is used to endorse the operation of those systems as they were measured, or as a basis by which to modify the systems to provide a beam with different qualities. The sequence of measurements constitutes the Technical Commissioning Program Plan. As discussed in Section 1.0, the Commissioning Program Plan describes administrative and technical safety systems which are essential elements in the Accelerator Readiness Review (ARR) process as described in Draft Guidance for DOE O 420.2A.

According to the Draft Guidance for DOE O 420.2A:

"Commissioning a facility incrementally can be advantageous, particularly if it is desirable to operate portions of the facility while other portions are still under construction. Facilities can be delineated into modules such as the beam particle source, the accelerator, beam lines, accumulator ring, etc. As each module is completed and tested, a commissioning ARR can be conducted for that module. The commissioning activity for each separate module requires DOE approval before it is initiated unless approval from DOE is received for an overall commissioning program. The development of an overall commissioning program plan tends to focus better on the required approval by DOE and lessen the likelihood of delays in obtaining a number of discrete approvals."

It is our plan to commission the SNS accelerator systems as a sequence of modules, beginning with the Front End and DTL. The accelerator will then be commissioned module by module, as the modules become available, as described in the ARRPOA. We plan to conduct an Accelerator Readiness Review for each module, with Readiness Assessments for each element of the module to formalize the "punch list" signoff prior to approval for each element and include "lessons learned" from prior commissioning studies.

The Commissioning Modules and their constituent elements consist of:

- Front End and the Drift Tube Linac
- Coupled Cavity Linac and the Superconducting Linac
- High Energy Beam Transport (HEBT) - Ring – Ring to Target Beam Transport (RTBT) to Extraction Dump
- Ring to Target Beam Transport to Target and Instruments

The commissioning of the RTBT will be in two distinct modules. The portion of the RTBT from the Ring to the extraction dump will be commissioned with Ring systems. The dipole magnet (DH13), which directs the beam from the extraction dump beam line of the RTBT into the second portion and to the target, will be physically disabled, under configuration control, until it is needed. Following the commissioning studies to the extraction dump, DH13 will be enabled. After completion of the RTBT to Target and Instruments ARR, the beam will be directed to the target through the downstream section of the RTBT.

Chapters 2 through 6 of this plan reflect the modular structure of the ARR plan for commissioning.

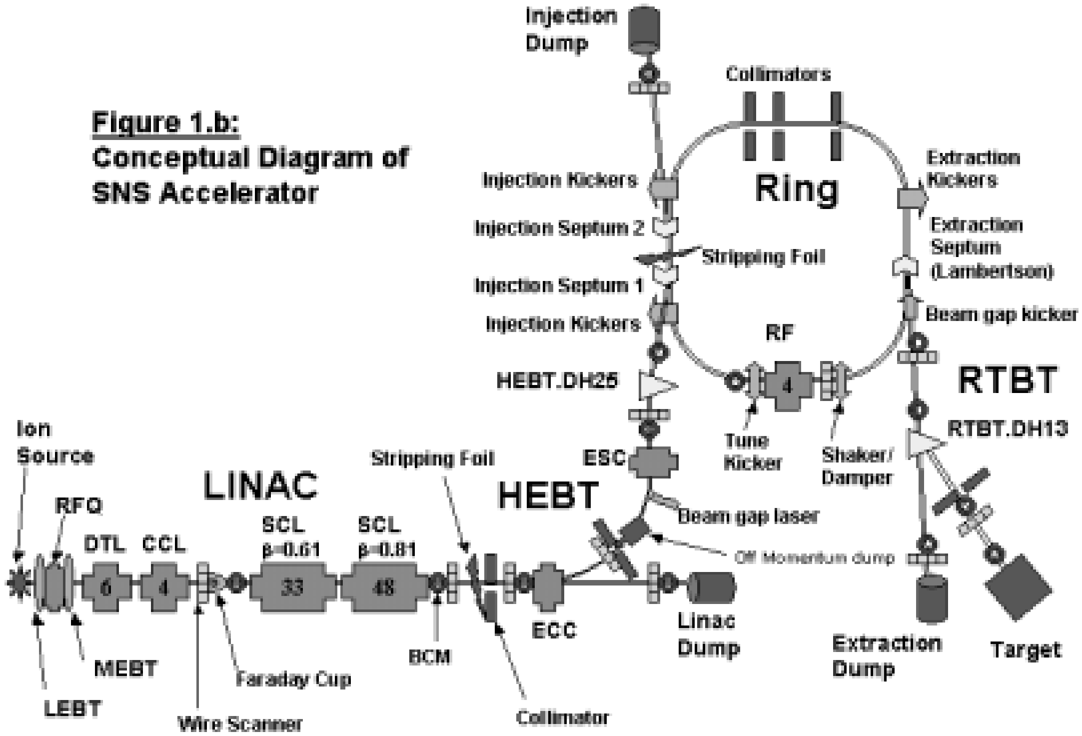
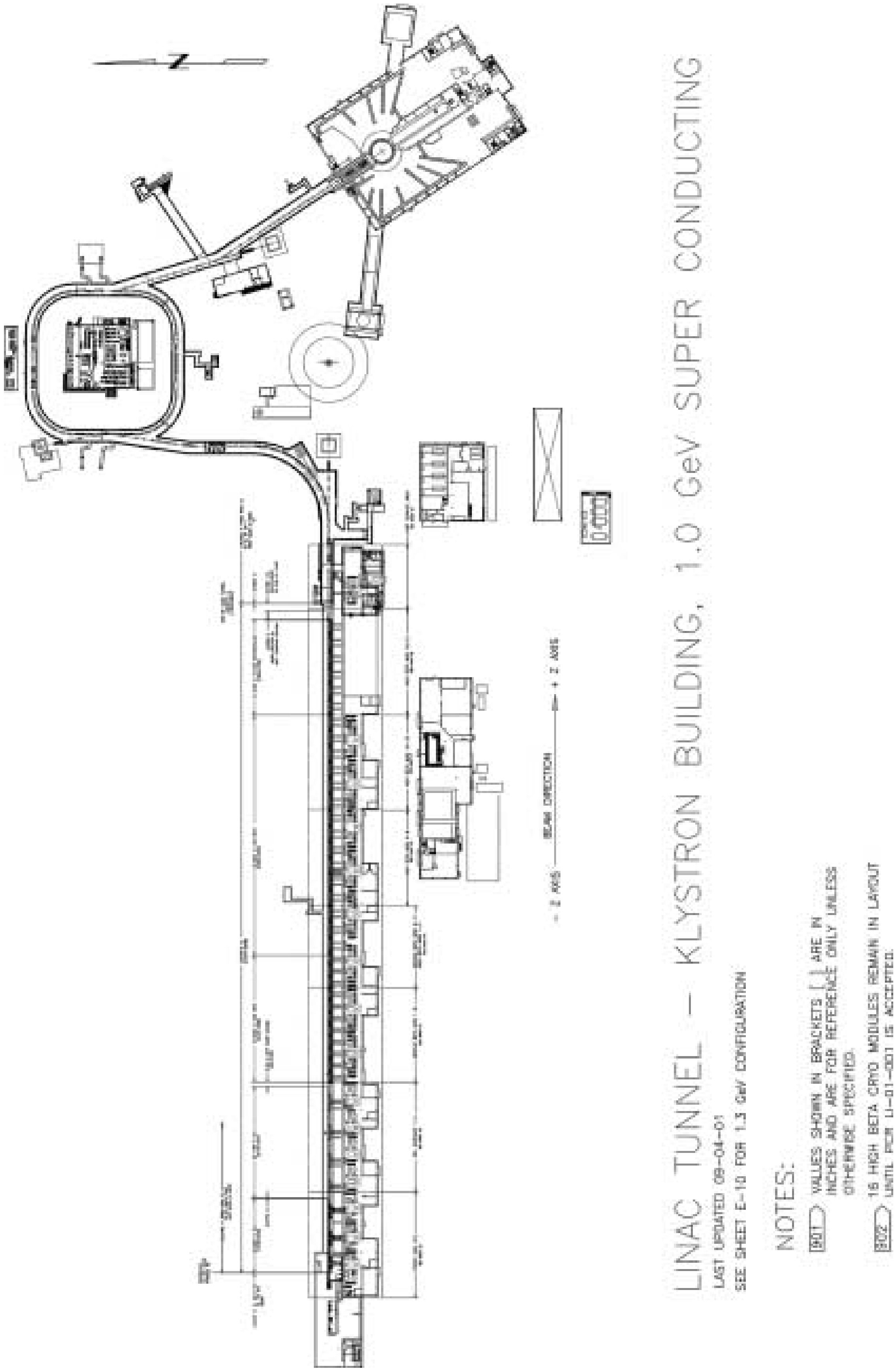



**Figure 1.b: Conceptual Diagram of SNS Accelerator**

The Target will be commissioned under the Accelerator Safety Order DOE O 420.2A as an Accelerator Facility. In order for the Accelerator Safety Order to apply, we will maintain a radionuclide inventory in the Target less than the threshold for a Category 3 Nuclear Facility. The methodology for compliance with this limit is described in Section 5.2.2.

**Fig. 1.c Overall SNS Facility**



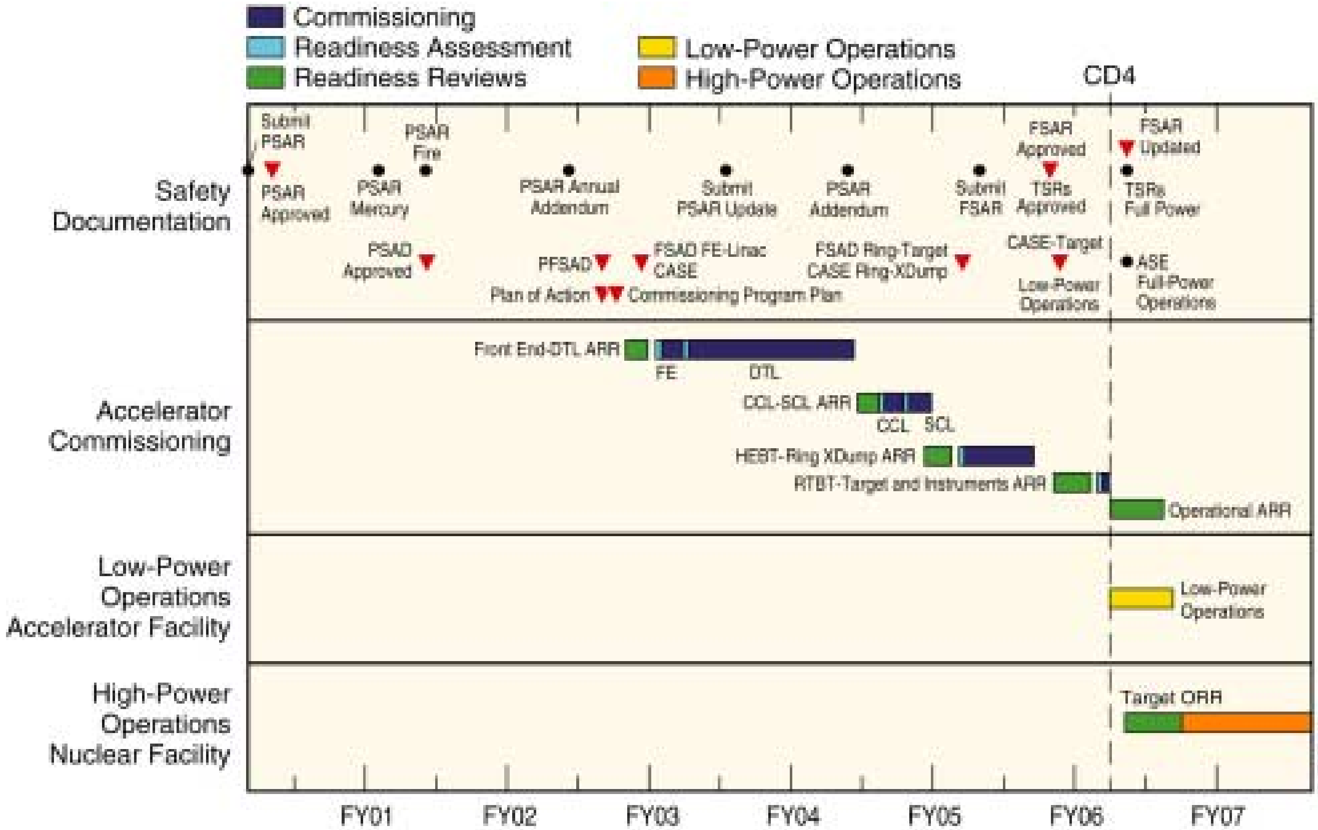



**Figure 1.d Schedule for Reviews, Commissioning, and Operations**

The commissioning program plan that is presented will include, for each module:

- A technical description of the module
- Identification of any additional administrative and technical controls and contingency plans.
- A description of the content of that portion of the overall facility ARR that is needed.
- The schedule for each module.

## 1.2 Target and Instrument Commissioning

This document includes a chapter describing the Experimental Facilities Division (XFD) plan for achieving full power operations of the Spallation Neutron Source (SNS) Target Facility. Commissioning of the Target Facility beginning in FY 06 is planned as the culmination of a series of accelerator commissioning modules, starting with the front end.

The XFD Chapter addresses necessary interfaces with other SNS groups and the Oak Ridge National Laboratory (ORNL). Target Systems and Instrument Systems are both discussed. Necessary baseline utilities are assumed to be in place to support systems testing and integrated systems testing. It is assumed that the accelerator ring-to-target beam transfer (RTBT) line will have been successfully commissioned through to the RTBT Extraction beam dump before target commissioning is initiated. Commissioning of the RTBT extension to the actual target interface will be completed concurrently with target commissioning.

To simplify the drive to full-power operations, the target will initially be operated as an Accelerator Facility for the purpose of low-power testing. The Target will be commissioned following an Accelerator Readiness Review (ARR) conducted under the Accelerator Safety Order, DOE O 420.2A. During low power operations, the target proton bombardment will be limited in order to maintain radionuclide inventories less than a Category 3 Nuclear Facility. The methodology for compliance with this limit is described in Section 5.2.2.

After installation of the Target Systems monolith and hot cell equipment, their components and systems will be thoroughly tested, both individually and as integrated systems. As testing nears completion, the Target ARR will be initiated with the goal of commissioning the Target for low-power operations.

The next step in the process will be to have the target commissioned. Information obtained during Target commissioning will be used to satisfy the Project Acceptance Tests milestone, which will in turn provide the basis for DOE to reach Critical Decision 4 (CD-4). Target commissioning and attainment of the CD-4 is addressed in Section 5.

Figure 1-e shows the overall chronology of events from installation through commissioning, to high power operation. The schedule presented is consistent with both the Integrated Project Schedule and the Project Commissioning Strategy (as presented in the May 2001 DOE Review).

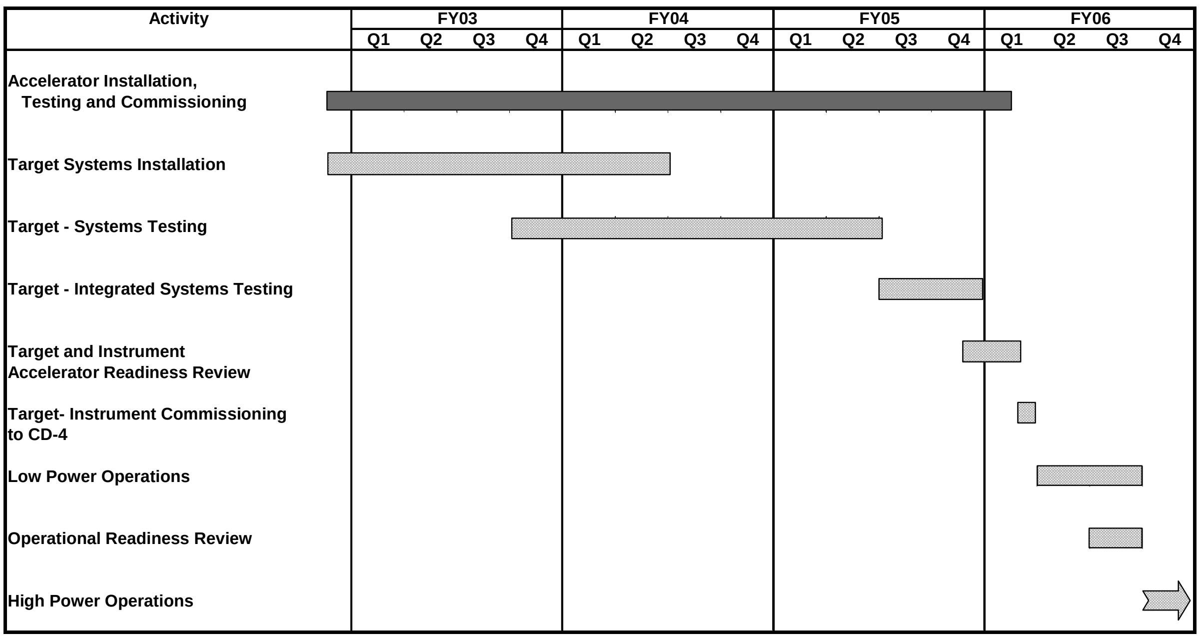



**Figure 1-e Schedule for the Target from Installation, through Commissioning to High Power Operation**

Instrument Systems will progress under a separate review and approval process that is mostly independent of the Target commissioning process. At least one instrument (possibly a temporary instrument) must be installed, tested, reviewed, and approved for use in conjunction with target commissioning. Plans for Instrument commissioning are presented in Section 6. Instruments that are not needed for completion of target commissioning will be brought on line after commissioning, and a separate readiness review will be held for each.

# 2.0 Front End and Drift Tube Linac Systems

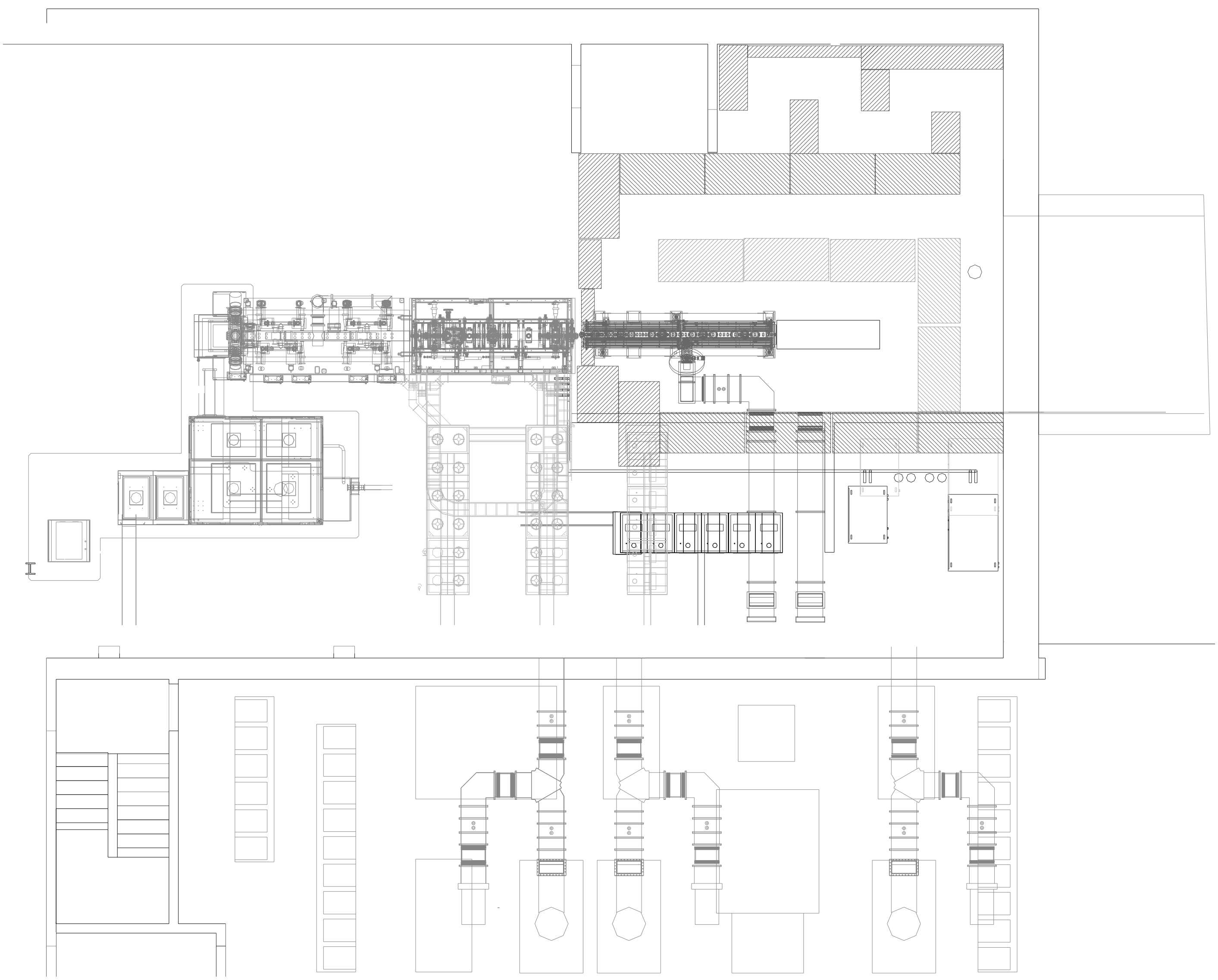
## 2.1 System Description

### 2.1.1 Introduction to the Front End

The primary function of the Spallation Neutron System Front End System (FES) is to produce an appropriate beam of $H^-$ ions and inject it at 2.5 MeV into the Linac for further acceleration. (See conceptual map in Fig. 1.b and detailed layout in Fig. 2.a). The principal front-end beamline components include:

- $H^-$ Ion source
- Low Energy Beam Transport system (LEBT)
- Radio-Frequency Quadrupole Linac (RFQ)
- Medium Energy Beam Transport line (MEBT)

**Fig. 2.a Front End and DTL Tank 1**



Supporting technical components satisfy the associated instrumentation and control requirements. Also required are local water systems (for cooling and temperature stabilization), vacuum subsystems, and support and alignment capabilities. Beam chopper systems are required in the front end to create a train of 645 nS mini-pulses with gaps of approximately 300 nS in the beam to accommodate the rise time of the extraction kicker in the accumulator ring. Chopping is performed in a distributed fashion with chopping provided in both the LEBT and MEBT.

The Front End Systems will be developed and produced as an integrated package and beam-tested at LBNL prior to delivery and installation at the SNS site.

### 2.1.1.2 Front End Performance

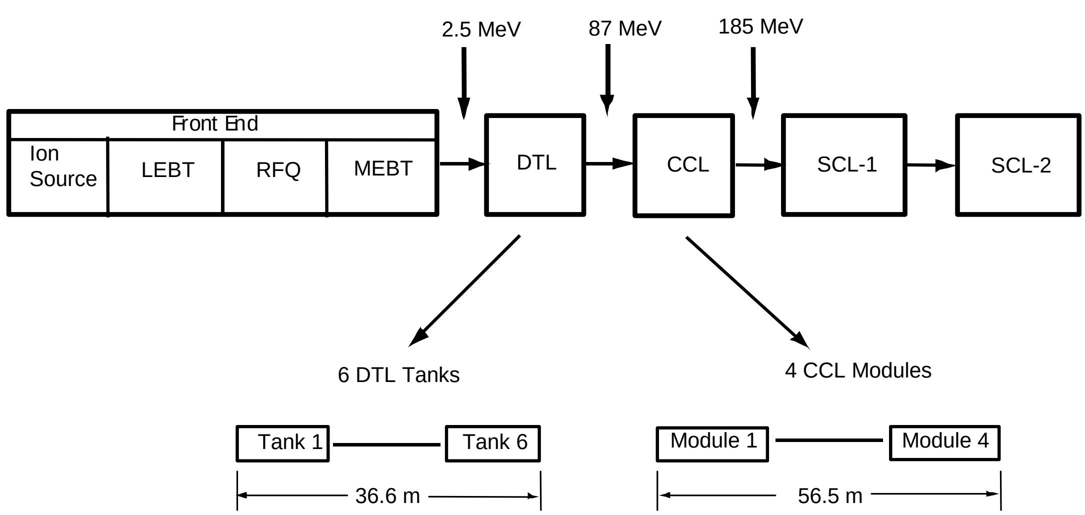
The requirements for the front end are established by the 1.4MW overall specification for operation of the neutron source and by the associated requirements of the other major accelerator systems. Operation must be extremely reliable and commensurate with routine operation as part of a major user facility.

The ion source is a multi-cusp, RF-driven, volume source similar to the device successfully developed by LBNL for the Superconducting Super Collider (SSC), but designed and engineered to provide increased peak $H^-$ beam current at the required emittance and duty factor. The LEBT is a compact, split electrode, all-electrostatic transport system. It is required to provide for transverse matching of the beam into the acceptance of the RFQ. The RFQ structure incorporates design concepts developed in earlier LBNL RFQ's, but is required to operate at more than 6% duty factor. The RFQ is required to bunch the beam and provide acceleration from 65 keV to 2.5 MeV. The MEBT is required to transport the beam from the RFQ to the drift-tube Linac (DTL) and provide proper beam matching in both transverse and longitudinal phase space. The MEBT incorporates a fast chopper system developed and built by LANL. The LANL design is based on the traveling wave chopper successfully operated at LANSCE, but designed and engineered to meet the rise/fall time requirement for the SNS.

### 2.1.2 Introduction to the DTL

The performance, design, development, and test requirements for the Linear Accelerator are described in this document. The Linac follows the MEBT and accelerates the $H^-$ beam from an energy of 2.5 MeV to 1 GeV. (See conceptual maps in Fig.1.b and Fig.2.b). Four types of RF structures, two normal conducting and two superconducting, perform this task. The first structure is a 402.5-MHz Drift Tube Linac (DTL) that accelerates the beam to 87 MeV. Figure 2.b shows a general schematic of the Spallation Neutron Source (SNS) Front End and Linac System Layout.

**Figure 2.b SNS Front End and Linac System Layout**



### 2.1.3 The DTL

The DTL is the first of two normal conducting accelerators that comprise the Linear Accelerator of SNS. It accelerates the beam from 2.5 MeV to 87 MeV. The DTL RF system is composed of six modules each powered by a 2.5 MW, 402.5 MHz klystron. The accelerating structure is based on the $TM_{010}$ Alvarez design. Cells are of length $\beta\lambda$ and the transverse focusing period is $6\beta\lambda$ in length. Focusing is accomplished with permanent magnet quadrupoles (PMQ's) positioned within specific drift tubes. The focusing lattice is FFODDO, i.e. consisting of two drift tubes containing focusing magnets followed by an empty drift tube followed by two drift tubes containing defocusing magnets ending with an empty drift tube. Some empty drift tubes will incorporate electromagnet dipoles (EMD's) for beam steering or beam position monitor (BPM) diagnostics. In some cases the empty drift tubes will incorporate EMD’s in the last four empty drift tubes of each DTL tank. Beginning with DTL tank 2 the first two empty drift tubes in each tank will incorporate a BPM. See the physics design criteria document SNS-104050000-DC-R00 for general magnet locations. The DTL will have post couplers to stabilize and tune the longitudinal field distribution.

A map of the DTL beam diagnostics layout is at:
http://www.sns.gov/APGroup/refTables/drawings/DTL_diag.pdf

## 2.2 Administrative and Technical Controls and Contingency Plans for Front End and DTL Systems

### 2.2.1 Technical Controls and Safety Systems

Accelerator specific safety systems, which must be in place, tested and certified for operation prior to commencement of commissioning studies for Front End Systems include the Personnel Protection System (PPS) and the Machine Protection System (MPS)

**PPS**
The Personnel Protection System that provides radiation protection for **Front End Systems** commissioning includes the following:

The equipment will operate standalone in the PPS Phase 0 mode.
Operating modes provided are:

- Off
- Ion Source 65 kV power supply on
- Ion Source RF Plasma power supply on
- Full operation (Ion Source HV, RF and the RFQ)

During commissioning and operation, high radiation levels will be detected by the Fermilab standard ionization chambers (Chipmunks), which will shut off the Ion Source 65 kV power supply and the RF drive to the RFQ at the Transmitter as well as the Transmitter HV supply. High radiation trips will require evaluation and approval by the Chief Operator prior to the manual reset for commissioning restart.

Activation of the Emergency-Stop pushbutton on the operator panel shuts off all critical devices including the Ion Source 65 kV power supply and the RF drive to the RFQ at the transmitter and the transmitter high voltage power supply. Emergency-Stop shutdowns require evaluation and approval by the Chief Operator prior to the manual reset for commissioning restart.

The Personnel Protection System radiation protection for **DTL Systems** commissioning includes the following:

The DTL Tank 1 will be commissioned with a variation of the standalone PPS Phase 0 design that was used in the Front End commissioning. DTL Tank 1 is expected to produce significant amounts of dark current X-ray radiation during conditioning and commissioning. Additionally, the 7.5 MeV beam is directed to the Diagnostic Plate beam dump, as well as any beam scraped off and not reaching the full energy, will produce significant neutron radiation. DTL Tank1, the Diagnostic Plate and the Diagnostic Plate beam dump will reside in a shielded enclosure with shielding sufficiently thick so that installation work can proceed in the Linac while low intensity beam commissioning activities are ongoing. This version of the PPS will include a minimum of five Chipmunk radiation detectors outside the DTL shielding hut. The hut will have an interior search station, a beam shutdown station and a stack light status indicator. A search zone door will be used to secure the hut. All interlocks will be applied to the 65 kV In Source high voltage supply as well as the RF for the RFQ. The RFQ RF interlock also controls the high voltage supply for the RFQ and DTL Tanks 1 and 2.

For DTL Tanks 2-6 commissioning, the shielding enclosure around DTL Tank 1 will be disassembled and a shielding wall will be fabricated as needed downstream of the CCL. During this mode the beam will be dumped on the internal diagnostic Faraday cups in the DTL tanks. The equipment will operate in PPS Phase 1 mode, i.e. equipment will be installed to secure the warm Linac. The normal PPS operating modes will be available, i.e.,

- Restricted Access (RWP Access, Magnets and RF OFF)
- Controlled Access (RWP and Key Access, Magnets and RF OFF)
- Controlled Access (RWP and Key Access, Magnets ON, RF OFF)
- Power Permit (No Access, Magnets and RF On)
- Beam Permit (No Access, Full Operation)

During commissioning and operation, high radiation levels will be detected by the Fermilab standard ionization chambers (Chipmunks), which will shut off the Ion Source 65 kV power supply and the RF drive to the RFQ at the Transmitter as well as the Transmitter HV supply. High radiation trips will require evaluation and approval by the Chief Operator prior to the manual reset to restart commissioning.

During DTL Systems commissioning, a radiation producing beam is only allowed in the “Beam Permit” mode. The detection of an open PPS interlocked door will terminate the “Beam Permit” operating mode, and will shut down two independent critical devices necessary to create the radiation producing beam, i.e. The Ion Source (via the 65 kV power supply) and the RFQ (via the RF drive to the transmitter and the transmitter high voltage power supply). In addition, the PPS operating mode will drop down to “Restricted Access”, removing the “Power Permit” and thus turning off both the Magnet and RF Power within the violated PPS area(s). Such PPS area(s) violation will require evaluation by the Chief Operator, and a sweep and reset of the area(s) before commissioning restart.

Activation of the Emergency-Stop pushbutton on the operator panel or the Beam Shutdown Station (BSS) shuts off all critical devices including off the Ion Source 65 kV power supply and the RF drive to the RFQ at the transmitter and the transmitter high voltage power supply. Emergency-Stop or Beam Shutdown Station (BSS) shutdowns require evaluation and approval by the Chief Operator prior to the manual reset for commissioning restart.
The PPS will be re-certified at least once per year and when significant modifications are made.

**MPS**

The Machine Protection System (MPS) runs in two modes.

- If the MPS Latched system is tripped, the Ion Source 65 kV power supply and the RFQ Transmitter HV power supply are disabled. This will require evaluation and approval by the Chief Operator prior to the manual reset for commissioning restart.
- If the MPS Auto Reset system is tripped, the LEBT Chopper is directed not to allow beam to exit the LEBT and the RFQ RF drive is inhibited for the duration of the macropulse.

The MPS will be re-certified at least once per year and when significant modifications are made.

A full description of the MPS can be found at:
http://www.sns.gov/projectinfo/ics/192/1923/MPS_FDR/

Machine Protection software/hardware planned for the **Front End** commissioning includes:

- EPICS device support for the MPS PMC module,
- Manual mode-mask definitions,

- MPS hardware modules,
- Fast Protect Latched shutdown hardware,
- Fast Protect – Auto Reset shutdown hardware,
- Differential current monitor,
- Integrated current monitor,
- Run-permit and Fast-Protect display screens for Source, LEBT, RFQ, and MEBT, and
- Beam Power Select Switch.

The Machine Protection System (MPS) for DTL systems includes those systems previously described for the Front End Commissioning, but additional Machine Protection software/hardware that should be in place for the DTL commissioning includes:

- Automatic file creation from Oracle Database,
- Configuration verifier,
- 2 MHz, RFQ RF Vetoing circuits,
- All PS, Vacuum, RF, Beam Loss Monitors, Differential current loss monitors, Diagnostic MPS Inputs, and
- Run-permit and Fast-Protect display screens for DTL.

**Beam Power**

During Front End commissioning, the beam power will be limited to an amount less than that which is specified for each system in the Commissioning Accelerator Safety Envelope. The SNS Operational Envelope and Safety Envelope are specified in the SNS ASD Operations Procedures Manual Chapter 2 Section B-1. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html.

**Safety**

**Radiation Safety**

Radiation safety during Front End System commissioning is ensured by strict compliance with the relevant policies and procedures of the ORNL Standards Based Management System (SBMS) (http://eshtraining.ornl.gov/SBMS/), specifically:

- ORNL Radiological Protection Management System (RPMS) (http://eshtraining.ornl.gov/sbms/SBMSearch/Msd/RPS/RPS_MSD.cfm),
- ORNL Radiological Control Policy and Radiological Protection Procedures (http://eshtraining.ornl.gov/sbms/SBMSearch/ORNLProc/ORNL-RP-110.htm), and
- ORNL ALARA Program (http://eshtraining.ornl.gov/sbms/SBMSearch/ORNLProc/ORNL-RP-138.htm),

which are in compliance with 10CFR835 (Occupational Radiation Protection).

Lockout-Tagout safety during commissioning is ensured by compliance with the ORNL-SNS LOTO policy, which is OSHA compliant. This policy can be found at:

http://www.internal.sns.gov/esh/standards/lockout_tagout.pdf

**Fire safety**

Fire safety is ensured during commissioning. A fire alarm system will be in place and operational in the building which is compliant with NFPA Standard 72. A sprinkler system will be in place and operational in the building that is compliant with NFPA Standard 13. Where construction activities prevent a required fire safety feature from being operational, compensatory measures in general accordance with NFPA 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations, will be identified and implemented.

**Emergency Response**

Emergency response procedures are specified in the SNS ASD Operations Procedures Manual Chapter 5 Section B. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html. These policies and procedures are consistent with the ORNL SBMS Emergency Management System which can be found at: http://eshtraining.ornl.gov/sbms/SBMSearch/MSD/EPS/EPS_MSD.cfm

### 2.2.2 Administrative Controls

Administrative controls are described in **Appendix A – Personnel, Training, Certification, Procedures and Records.**

## 2.3 The Portion of the Overall Facility ARR Needed for Front End and DTL Systems

Portions of the overall ARR that are needed for Front End and DTL Systems commissioning include an approved Commissioning Accelerator Safety Envelope (CASE) and an approved Safety Assessment Document (SAD).

The SNS Operational Envelope and Safety Envelope are specified in the SNS ASD Operations Procedures Manual Chapter 2 Section B-1. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html

The SNS Preliminary Final Safety Assessment Document is available at: http://www-internal.sns.gov/esh/safdoc/Final_Draft_to_reviewees_1_17_02.pdf

## 2.4 The Schedule for Front End and DTL Systems Commissioning

Front End and DTL System Systems commissioning schedule is shown in the SNS Accelerator Readiness Review Plan of Action(ARRPOA), SNS Document number 100000000-PN005-R00. It can also be found in the current Integrated Project Schedule. The IPS can be found at: http://it.sns.ornl.gov/project_controls .

# 3.0 The Coupled Cavity Linac and Superconducting Linac Systems

## 3.1 System Description

### 3.1.1 The CCL

The Coupled Cavity Linac (CCL) is the second of two normal conducting sections of accelerator that comprise the Linear Accelerator. It accelerates the beam from 87 MeV to 185 MeV. The CCL RF system is composed of four klystrons, each of 5 MW, 805-MHz RF capacity. It is a conventional side coupled cavity structure having 8 cells per segment and 12 segments per module. Each module is assembled onto a steel support structure with the segments supported by the steel structure, the bridge couplers and electromagnetic focusing quadrupoles located between the segments. The 8-cell segments are of length 4 $\beta\lambda$ and the 3-cell bridge couplers are of length 2.5 $\beta\lambda$ each. The spacing between successive quadrupole focusing elements is thus 6.5 $\beta\lambda$, which gives a focusing period of 13$\beta\lambda$at 805 MHz for the FODO array. A focusing period spans two segments and two bridge coupler sections. The electromagnet quadrupoles have integral dipole steering coils for steering correction of the beam as required. The spaces between accelerator segments also contain beam diagnostic elements to determine beam centroid position, current and profile.

The CCL RF structure consists of accelerating cavities, side coupling cavities, bridge coupler cells, and the waveguide transition and iris assemblies. The RF Structure is composed of two main types of components, the segment assemblies and the bridge coupler assemblies. The segments provide the basis of RF focusing and acceleration of the beam. The bridge couplers provide a mechanism for resonant coupling of the segments to form an RF assembly that can be powered with a single RF amplifier. The four SNS CCL modules are powered by 5 MW RF klystrons split into two WR-975 wave guide feeds that connect to each module at roughly the one-quarter and three-quarter points along the assembly. Power flows through and fills the resonant structure and the resonant coupling between components is sufficient to prevent unacceptable field variation along the structure between the RF feed points. All powered components are actively water-cooled to control the RF resonance frequency to 805 MHz. Each module has a common water cooling system (Resonance Control Cooling System, RCCS) and a vacuum pumping system. All RF cavities are connected to a common vacuum plenum running the length of the module. The plenum is actively pumped during operation to maintain the cavities at or below a specified pressure as required to prevent beam stripping and activation of the components.

A map of the CCL beam diagnostics layout is at:
http://www.sns.gov/APGroup/refTables/drawings/CCL_diag.pdf

### 3.1.2 The SCL

The Super Conducting Linac (SCL) makes up the third and fourth sections of the SNS Linear Accelerator. It consists of a Medium Beta part, taking the beam energy from 185 MeV to 387 MeV, followed by a High Beta part, further accelerating the beam to 1 GeV. The 805 MHz SCL design is based on elliptical Niobium six-cell cavities with warm sections between a total of 23 cryomodules. These warm sections house quadrupoles in a doublet focusing arrangement. The cryomodules are based on the CEBAF CM with improvements borrowed from LHC, TESLA, and the JLab 12 GeV upgrade and uses the frequency scaled KEK fundamental power coupler (FPC).

The Medium Beta part consists of 11 cryomodules containing three cavities each and achieving peak electric fields of 27.5 MV/m (± 2.5 MV/m). Cavities are powered by individual klystrons, rated at 0.55 MW peak power. With an average macro pulse beam current of 26 mA, this allows for a 33% margin for control of effects including Lorentz force detuning, microphonics and uncertainty in peak field.

The High Beta part consists of 12 cryomodules containing four cavities each and achieving peak electric fields of 35 MV/m (+ 2.5 / -7.5 MV/m). This higher gradient, with respect to the Medium Beta, might be obtained through electro-polishing of the cavities. The High Beta cavities are also powered by individual klystrons, rated at 0.55 MW peak power, but have a 40% margin for an average macro pulse beam current of 26 mA. The output average beam power thus obtained would be 1.4 MW.

Behind the SCL, space is left for 9 more cryomodules, intended for a possible future upgrade in beam energy from 1 GeV to 1.3 GeV. As there is some uncertainty to what extent electro-polishing will be successful, part of this space can be used to install 3 extra cryomodules. In this back-up plan, the High Beta cavities would all operate at 27.5 MV/m, thus obtaining a beam energy of 975 MeV.

A map of the SCL beam diagnostics layout is at:
http://www.sns.gov/APGroup/refTables/drawings/SCL_diag.pdf

## 3.2 Administrative and Technical Controls and Contingency Plans for CCL and SCL Systems

### 3.2.1 Technical Controls and Safety Systems

Accelerator specific safety systems that must be in place, tested and certified for operation prior to commencement of commissioning studies for CCL and SCL Systems include the Personnel Protection System (PPS) and the Machine Protection System (MPS).

**PPS**

The Personnel Protection System which provides radiation protection for Linac Systems will evolve through a number of phases as Linac commissioning proceeds.

During CCL and SCL Systems commissioning, a radiation producing beam is only allowed in the "Beam Permit" mode. The detection of an open PPS interlocked door will terminate the "Beam Permit" operating mode, and will shut down two independent critical devices necessary to create the radiation producing beam, i.e.,

- the Ion Source (via the 65 kV power supply), and
- the RFQ (via the RF drive to the transmitter and the transmitter high voltage power supply).

In addition, the PPS operating mode will drop down to "Restricted Access", removing the "Power Permit" and thus turning off both the Magnet and RF Power within the violated PPS area(s). Such PPS area(s) violation will require evaluation by the Chief Operator, and a sweep and reset of the area(s) before commissioning restart.

Activation of the Emergency-Stop pushbutton on the operator panel or the Beam Shutdown Station (BSS) shuts off all critical devices including off the Ion Source 65 kV power supply and the RF drive to the RFQ at the transmitter and the transmitter high voltage power supply. Emergency-Stop or Beam Shutdown Station (BSS) shutdowns require evaluation and approval by the Chief Operator prior to the manual reset for commissioning restart.

During CCL commissioning of Modules 1,2 and 3, the PPS Phase 1 will be extended to the end of the Linac. Appropriate shielding will already be in place at the downstream end of the CCL to protect SCL components immediately downstream and personnel in the HEBT.

During CCL Module 4 and SCL commissioning, the equipment will operate in the PPS phase 2 mode, i.e. equipment will be installed to secure the Linac and the HEBT. The beam will be directed into the Linac beam dump. The normal PPS operating modes will be available, i.e.,

- Restricted Access (RWP Access, Magnets and RF OFF)
- Controlled Access (RWP and Key Access, Magnets and RF OFF)
- Controlled Access (RWP and Key Access, Magnets ON, RF OFF)
- Power Permit (No Access, Magnets and RF On)
- Beam Permit (No Access, Full Operation)

The PPS will be re-certified at least once per year and when significant modifications are made.

**MPS**
The Machine Protection System (MPS) is the same as previously described for the DTL Commissioning, but additional Machine Protection software/hardware that should be in place for the CCL-SCL commissioning includes:

- automatic file creation from Oracle Database,
- configuration verifier,
- two MHz, RFQ RF Vetoing circuits,
- all PS, Vacuum, RF, Beam Loss Monitors, Differential current loss monitors, Diagnostic MPS Inputs, and
- run-permit and Fast-Protect display screens for CCL, SRF, and Linac Dump.

**Beam Power**
During Linac commissioning, the beam power will be limited to an amount less than that which is specified for each system in the Commissioning Accelerator Safety Envelope. The SNS Operational Envelope and Safety Envelope are specified in the SNS ASD Operations Procedures Manual Chapter 2 Section B-1. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html

**Safety**
Policies for Radiation Safety, Lockout-Tagout and Fire safety during Linac Systems commissioning are the same as for the Front End and DTL Commissioning – described in Section 2.2.1 Technical Controls and Safety Systems.

### 3.2.2 Administrative Controls

Administrative controls are described in **Appendix A, Personnel, Training, Certification, Procedures and Records.**

## 3.3 The Portion of the Overall Facility ARR Needed for CCL and SCL Systems

Portions of the overall ARR that are needed for Linac Systems commissioning include an approved Commissioning Accelerator Safety Envelope (CASE) and an approved Safety Assessment Document (SAD) for CCL and DTL Systems. The SNS Operational Envelope and Safety Envelope are specified in the SNS ASD Operations Procedures Manual Chapter 2 Section B-1. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html

The SNS Preliminary Final Safety Assessment Document is available at:
http://www-internal.sns.gov/esh/safdoc/Final_Draft_to_reviewees_1_17_02.pdf

## 3.4 The schedule for Linac Systems Commissioning

CCL and DTL Systems commissioning is shown in the SNS Accelerator Readiness Review Plan of Action (ARRPOA), SNS Document number 100000000-PN005-R00. It is also listed in the current Integrated Project Schedule. The IPS can be found at http://it.sns.ornl.gov/project_controls.

# 4.0 High Energy Beam Transport to Accumulator Ring to Ring to Target Beam Transport to Extraction Dump

## 4.1 System Description

### 4.1.1 Introduction

Three major accelerator systems are included.

- High Energy Beam Transport (HEBT) system (Fig.4.a),
- Accumulator Ring (AR) system (Fig.4.b), and
- Ring to Target Beam Transport (RTBT) system (Fig.4.c).

(See also conceptual map in Fig. 1.b).

The purpose of the Beam Transport and Ring system is to convert the incoming Linac beam of about 1 ms length into a beam of 695ns length and transport this final beam onto the neutron target.

**Figure 4.a  Detailed Layout of HEBT**

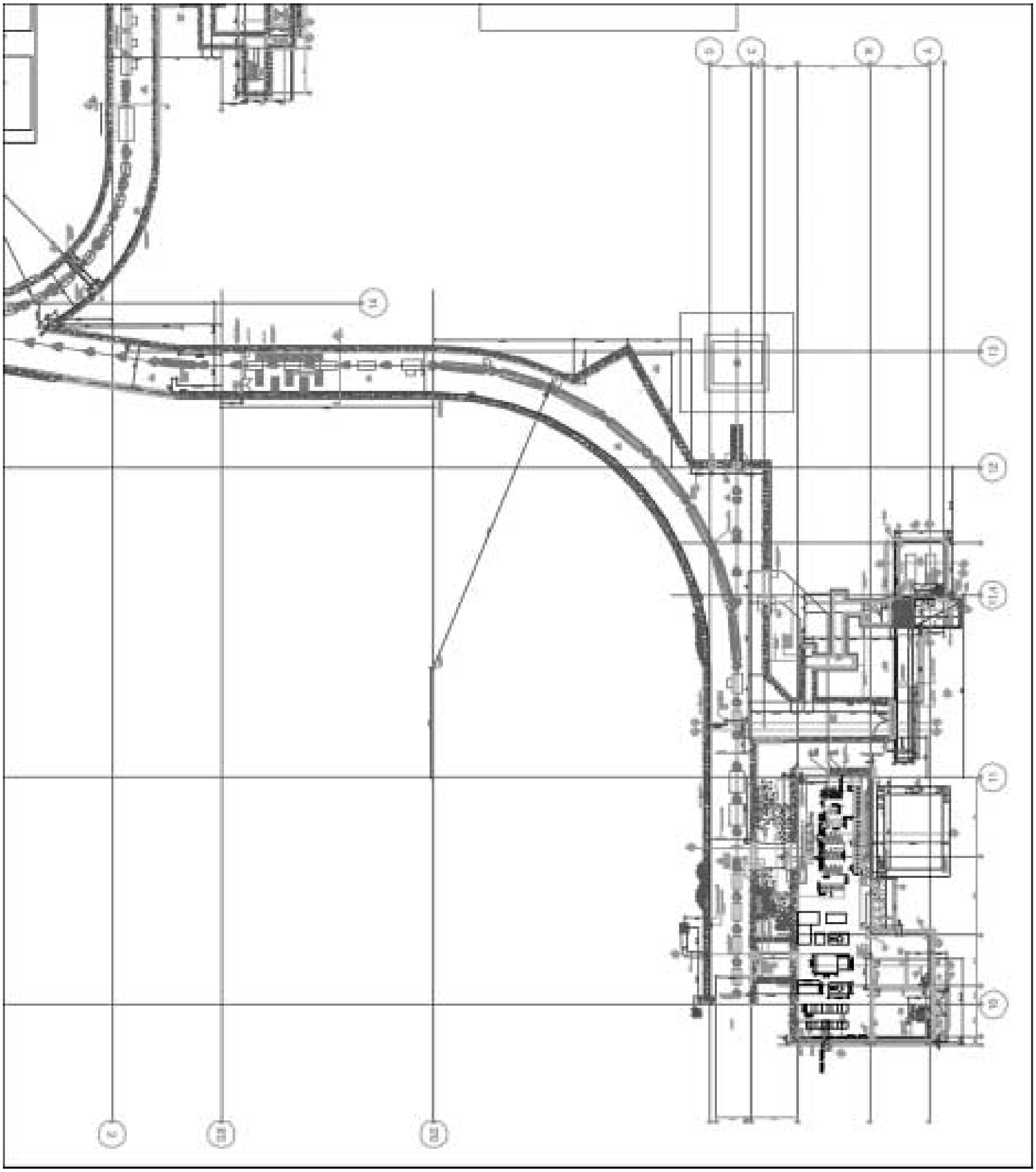


**Figure 4.b Detailed Layout of Ring**

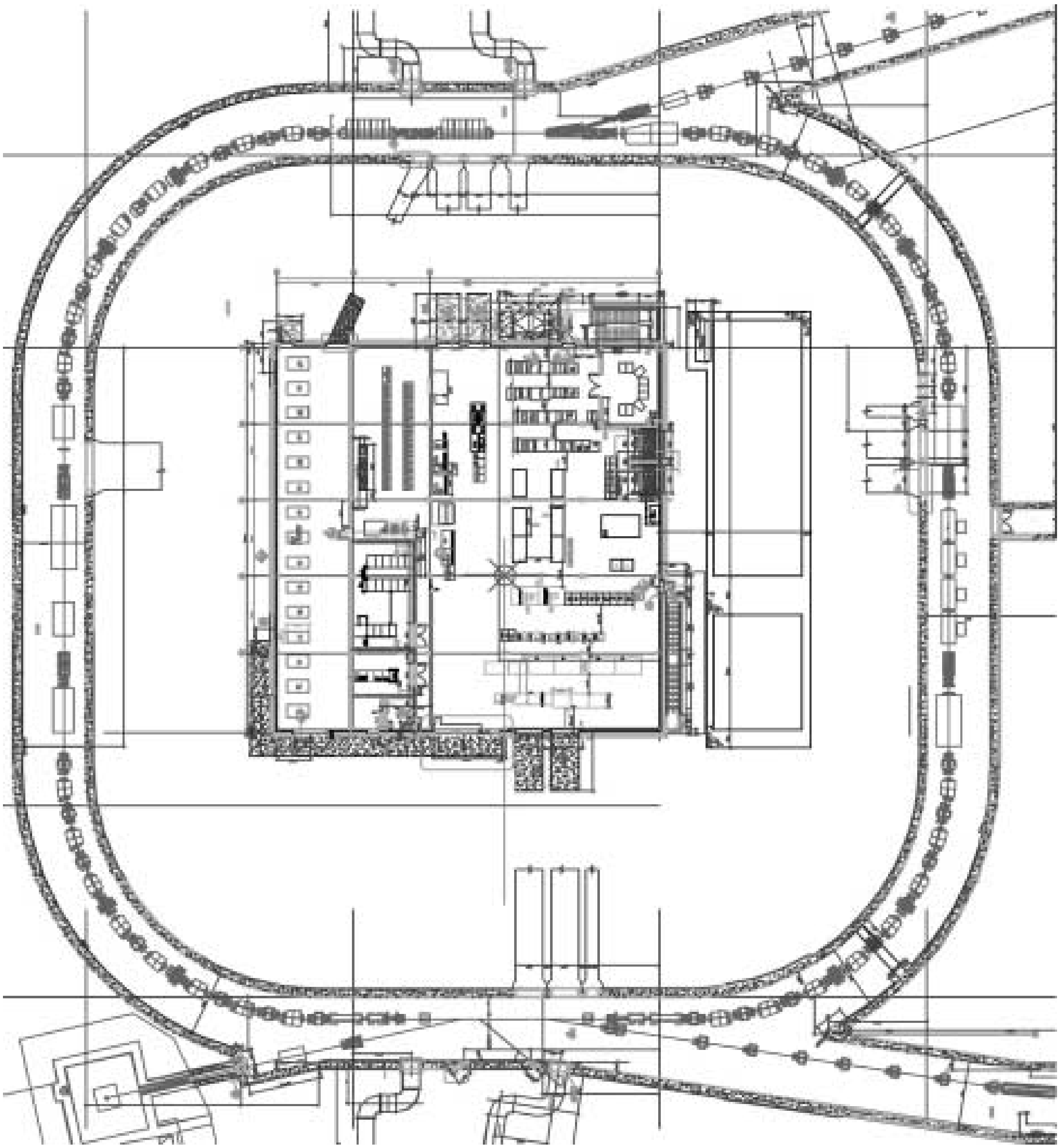
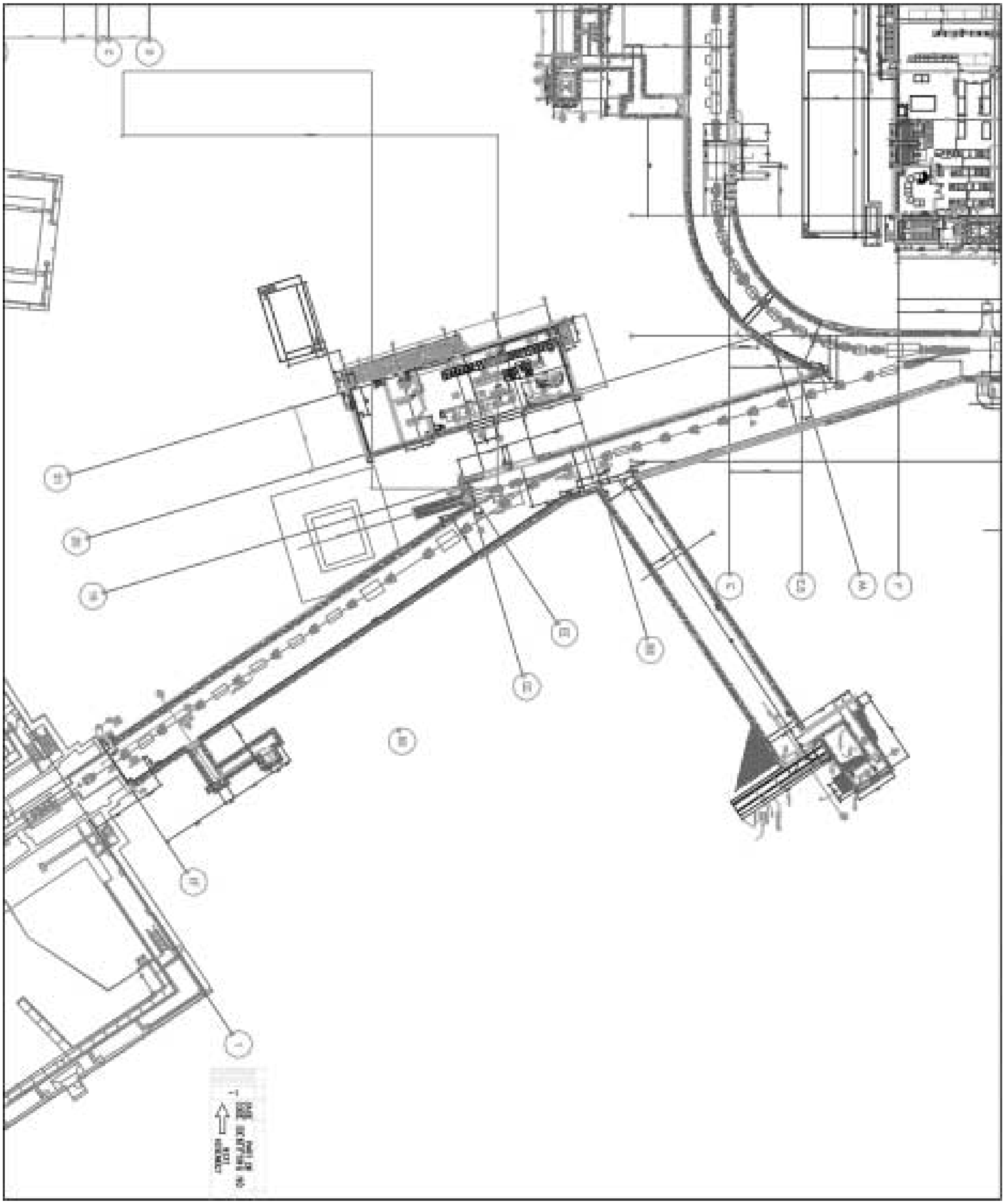


**Figure 4.c Detailed Layout of RTBT**



To maximize the performance and lifetime of the neutron target, a beam spreading system will create a beam on target of 20 cm (H) x 7 cm (V) size with the ratio of peak density to that of the average density no larger than two. Another major performance requirement will be to hold the average uncontrolled particle loss during the accumulation time to less than $2 \times 10^{-4}$ of total protons. This stringent requirement will hold down the residual radiation to a level that will permit hands-on maintenance except in a few localized areas, such as the injection, extraction, and collimation systems. To achieve this goal, special care has been exercised in the design of the $H^-$ stripping, the RF stacking, and the collimator systems. Ongoing accelerator R&D and computer tracking studies of the space-charge effects and halo formation will ensure the achievement of this performance goal.

### 4.1.2 High Energy Beam Transport (HEBT)

The HEBT system provides the link between the Linac and the accumulator ring. The beam coming out of the Linac is a 1 GeV $H^-$ beam, approximately 1 ms long, with an 805-MHz microstructure, chopped into minipulses of length 645ns with 300ns gaps, each of peak current 26 mA. The transverse rms un-normalized emittance of the Linac beam will be 0.14 $\pi$ mm mrad in both planes, and the longitudinal emittance will be 300 $\pi$ keV degrees. The total length of the HEBT line is 170 m (excluding the beam dumps), and the total bending angle will be 90°. The line will provide locations for beam scraping of the halo particles from the Linac in both betatron and momentum phase space. An energy corrector/spreader system will be provided for the proper control of the momentum spread of the beam injected into the accumulator ring. At the injection point, the Linac beam will be matched to the ring lattice for the $H^-$ injection process.

A map of the HEBT beamline layout is at:
http://www.sns.gov/APGroup/refTables/drawings/hebt.pdf

### 4.1.3 Accumulator Ring (AR)

The proton accumulator ring is one of the major systems in the design of the SNS. The primary function of the AR is to take about 1 ms long 1GeV $H^-$ beam from the Linac and compress it into a 695 ns long beam by accumulating it in the AR in 1060 turns. The final beam will have $\sim 2 \times 10^{14}$ protons per pulse, meeting the design specification of 1.4-MW design average beam power at a 60-Hz repetition rate. Provisions have been reserved for a future upgrade to run the ring with up to 1.3 GeV injection energy with only a minimal change of hardware; namely, two dipoles in the injection straight. The lattice structure of the AR is a fourfold symmetric hybrid of FODO lattice arc with a matching doublet straight section. The betatron phase advance for the arc is adjusted so that the straights are dispersion free. The total circumference of the ring is 248 meters. The transition gamma is about 4.95, much higher than the operating energy of 1 GeV.

#### 4.1.4 Ring to Target Beam Transport (RTBT)

The Ring to Target Beam Transport system takes the extracted beam from the AR and transports it to the neutron target. The extraction starts with two 7 module kicker arrays to deflect the circulating beam vertically by 16.8 mrad followed by a Lambertson magnet to bend the beam out of the ring. The magnet apertures in this line have been sized to allow for malfunctions of one of the extraction kickers, protecting the line against excessive losses. A beam shape control section is being provided for the final beam profile tuning for the target. Additional focusing control provides compensation for the window scattering before the target. The total length of the RTBT line is 150 meters (excluding the beam dump line) and the total horizontal bend angle is 16.8 degrees

## 4.2 Administrative and Technical Controls and Contingency Plans for HEBT-Ring-RTBT Systems

### 4.2.1 Technical Controls and Safety Systems

Accelerator specific safety systems that must be in place, tested and certified for operation prior to commencement of commissioning studies for HEBT-Ring-RTBT Systems include the Personnel Protection System (PPS) and the Machine Protection System (MPS).

This commissioning module will include the first half of the RTBT up to the Extraction Dump, but not the portion of the RTBT downstream of DH-13, which is the bend leading to the Target. For personnel safety in the Target building during commissioning DH-13 will not be installed, making it impossible to direct the beam to the Target building.

**PPS**
The Personnel Protection System radiation protection for HEBT-Ring-RTBT Systems commissioning includes the following:

The equipment will operate in the fully operational PPS mode with equipment installed to secure the Linac and the HEBT-Ring-RTBT. The normal PPS operating modes will be available, i.e.,

- Restricted Access (RWP Access, Magnets and RF OFF),
- Controlled Access (RWP and Key Access, Magnets and RF OFF),
- Controlled Access (RWP and Key Access, Magnets ON, RF OFF),
- Power Permit (No Access, Magnets and RF On),
- Beam Permit (No Access, Full Operation).

During commissioning and operation, high radiation levels will be detected by the Fermilab standard ionization chambers (Chipmunks), which will shut off the Ion Source 65 kV power supply and the RF drive to the RFQ at the Transmitter as well as the Transmitter HV supply. High radiation trips will require evaluation and approval by the Chief Operator prior to the manual reset to restart commissioning.

During HEBT-Ring-RTBT Systems commissioning, the Beam Permit mode, Access controls, radiation monitor interlock trips, Emergency-Stop pushbutton and PPS Certification all function in the same manner as previously described for the Linac Commissioning in section 3.2.1 Technical Controls and Safety Systems.

**MPS**
The Machine Protection System (MPS) is the same as previously described for the Linac Commissioning in section 3.2.1 Technical Controls and Safety Systems, but additional Machine Protection software/hardware that should be in place for the HEBT-Ring-RTBT commissioning includes:

- Automated run-permit checker.
- Run-permit and Fast-Protect display screens for HEBT, Injection Dump, Ring, RTBT, and extraction dump.
- All PS, Vacuum, RF, Diagnostic MPS Inputs
- Foil, Injection Kickers, Extraction Kickers, Ring RF, Collimator protection inputs.

**Beam Power**
During HEBT-Ring-RTBT commissioning, the beam power will be limited to an amount less than that specified for each system in the Commissioning Accelerator Safety Envelope. The SNS Operational Envelope and Safety Envelope are specified in the SNS ASD Operations Procedures Manual Chapter 2 Section B-1. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html

**Safety**
Policies for Radiation Safety, Lockout-Tagout and Fire safety during HEBT-Ring-RTBT Systems commissioning are the same as before and are described in Section 2.2.1 Technical Controls and Safety Systems.

### 4.2.2 Administrative Controls

Administrative controls are described in **Appendix A, Personnel, Training, Certification, Procedures and Records.**

## 4.3 The Portion of the Overall Facility ARR Needed for HEBT-Ring-RTBT Systems

Portions of the overall ARR that are needed for HEBT-Ring-RTBT Systems commissioning include an approved Commissioning Accelerator Safety Envelope (CASE) and an approved Safety Assessment Document (SAD) for Linac Systems. The SNS Operational Envelope and Safety Envelope are specified in the SNS ASD Operations Procedures Manual Chapter 2 Section B-1. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html

The SNS Preliminary Final Safety Assessment Document is available at:
http://www-internal.sns.gov/esh/safdoc/Final_Draft_to_reviewees_1_17_02.pdf

## 4.4 The Schedule for HEBT-Ring-RTBT Systems Commissioning

The schedule for HEBT-Ring Systems commissioning is listed in the current Integrated Project Schedule. The IPS can be found at http://it.sns.ornl.gov/project_controls

This commissioning is done in two modules. The first module includes the first half of the RTBT up to the Extraction Dump, but not including DH-13, which will be physically disabled and shielding installed in the beam line downstream of DH-13 for the safety of personnel in the Target building. This timeline is described in the Accelerator Readiness Review Plan of Action, SNS 1000000000-PN005-R00.

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# 5.0 Ring to Target Beam Transport to Target Commissioning

## 5.1 Description of Systems

### 5.1.1 Introduction

The purpose of the RTBT to Target Commissioning Phase is to demonstrate operability of the SNS facility to DOE. Information obtained in target commissioning will be used to satisfy the Project Acceptance Tests milestone, which will provide the basis for DOE to reach Critical Decision 4 (CD-4). CD-4 is a Level 0 milestone, which designates that the project has been completed. For Target Systems, the pertinent CD-4 criterion is that SNS produces moderated neutrons at or above a determined flux per incident proton.

Commissioning of the RTBT to the Extraction Dump will be the final in a series of accelerator segments to be commissioned before the beam is transported to the target. Upon completion of the Target ARR and with approval of the SNS management, all prerequisites to final RTBT and target commissioning will have been met and target commissioning can begin. The Target and final RTBT Commissioning will be done concurrently. This project phase will constitute the first fully integrated operation of the SNS as a combined Accelerator/Target/Instruments Facility. Integrated operations will require careful coordination between Target and Accelerator personnel. A detailed, integrated commissioning plan will be developed that assures a coordinated team approach to completing required RTBT to Target commissioning activities.

### 5.1.2 Criteria for Success

One DOE Level 0 milestone and two DOE Level 1A milestones are associated with Target commissioning. Initiation of Target commissioning meets the Level 1A milestone "Start Target Commissioning." Completion of this milestone is defined as the issuance of a memorandum, with supporting technical documentation to the project office. Completion of commissioning provides the last component of the Level 1A "Project Acceptance Tests" milestone. This milestone is described in section A, page A-9 of the SNS Project Execution Plan. The criteria for the performance test is to demonstrate that a pulse of $1 \times 10^{13}$, 1-GeV protons can be accumulated in the storage ring, extracted in a single turn, transported to the target and that there is an integrated neutron flux of $5 \times 10^{-3}$ neutrons per steradian solid angle per incident proton measured viewing a moderator face. Completion of the "Project Acceptance Tests" is a prerequisite for CD-4. CD-4 is defined as a Secretarial Decision Memorandum from DOE confirming the completion of the milestone. The Instrument commissioning portion of this plan is discussed in Chapter 6.

In addition to the basic physical measurements needed to confirm performance meets CD-4 criteria, other measurements and observations will be made during target commissioning. Even though these will not be formal commitments or deliverables, a considerable amount of valuable information may be gained during initial operations with regard to areas such as preliminary shielding assessments and target systems behavior.

### 5.1.3 Target Systems

The Target facility has been designed to ultimately operate as a Hazard Category 2 Nuclear Facility. Consequently, operation of the Target Systems will be ultimately conducted under the FSAR. However, until completion of the Operational Readiness Review (ORR), the facility will be operated as an Accelerator Facility under the FSAD. Even though the XFD target and support systems will initially be approved for operation as an Accelerator Facility, it is intended that all safety related Structures, Systems, and Components (SSCs) necessary for a Category 2 Nuclear Facility will be in place and fully functional at this time. The accelerator safety envelope developed for target commissioning and low power operations will specify how operations will be restricted in order to keep the facility within the accelerator facility category.

Prior to Target Commissioning, the Target Integrated Systems Tests will be performed. In the integrated systems tests all systems will be operated in an integrated manner duplicating the conditions for target operations as close as possible but without proton beam.

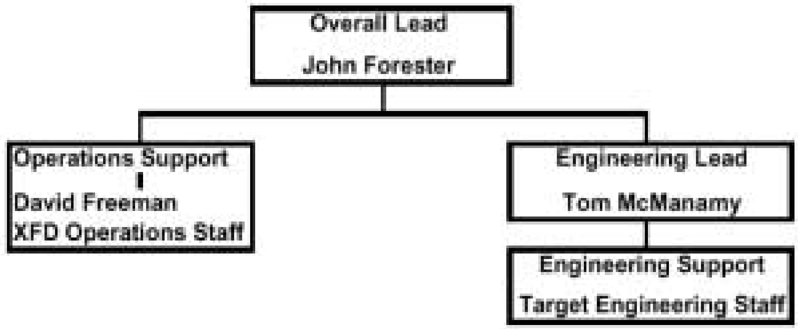


**Figure 5-a Organizational Chart for Target Commissioning**

Throughout these tests Target Systems Engineers will provide support as needed for any engineering modifications or adjustments required to make the systems operate properly. By the end of the Integrated Tests, operating procedures will have been finalized and operations personnel will be trained and qualified. Commissioning with proton beam will follow the Integrated Systems Tests and the Target ARR. Commissioning will be accomplished with the same organization, personnel and operating procedures that were used in the Integrated Systems Tests and reviewed in the ARR. The Organizational Chart for Target Commissioning is shown in Figure 5-a.

For the first operations it is expected that the proton beam will be at full energy (~1 GeV) but with a low intensity per pulse and low pulse repetition rate. The first beam may be delivered on a pulse-on-demand basis. With each pulse, target parameters, neutron production measurements, and radiation measurements can be observed. Beam on target can be suspended as necessary in response to unexpected conditions.

Striking the target with high energy protons for target commissioning will provide the first opportunity to assess the adequacy of radiation shielding. Radiological surveys of areas in and around the Target Building will be conducted. It will be important to determine both prompt radiation and residual radiation. Prompt radiation is directly associated with each pulse and residual radiation is due to the build up of radioactive isotopes. Most residual radiation will be associated with the target. Even though the Target Commissioning phase will be short in duration and will be done with proton pulses and duty cycles much less than maximum, the radioactive isotope inventory in the mercury will be substantial. Radiation levels from the mercury target material may become large enough to begin to identify shielding deficiencies if they exist.

Radiation monitoring instruments will be in place to remotely measure radiation levels around the target. Detailed radiation surveys with hand held instruments will be conducted. The first areas to be measured will be those that are to be occupied during commissioning operations. When it is determined safe for personnel to be in place, personnel may then occupy the areas. If shielding problems are discovered, operations will be adjusted as appropriate to provide protection for personnel.

The neutronic effectiveness of the target, moderator, and reflector assembly will be verified by measuring the brightness of a moderator face using standard neutron beam monitor detectors in one of the neutron beam lines. Time-of-flight detectors will be calibrated using simultaneous foil activation measurements. The results will indicate the energy-dependent spectral brightness of the moderator over the energy range accessible to the neutron scattering instruments. To satisfy the requirements associated with CD-4, we plan to demonstrate the spectral brightness meets or exceeds the spectral brightness associated with a 1-eV moderator coupling of $5 \times 10^{-4}$ neutrons per steradian per eV per proton incident upon the target and a Maxwellian flux distribution with a thermal ratio of 0.5 at a spectral temperature appropriate to the moderator.

## 5.2 Administrative and Technical Controls and Contingency Plans for RTBT to Target

### 5.2.1 Technical Controls and Safety Systems

Accelerator specific safety systems that must be in place, tested and certified for operation prior to commencement of commissioning studies for RTBT and Target Systems include the Personnel Protection System (PPS), the Machine Protection System (MPS) and the Target Protection System (TPS)

**<u>TPS</u>**

Target Protection System (TPS).The TPS is a high integrity system that employs highly reliable analog components to automatically initiate cutoff of the proton beam when the following two pre-determined conditions are met:

- .High mercury temperature
- Low mercury flow

Also included in the general heading of Target Safety are Target System Safety Significant Instruments. This refers to target instruments that are not a part of the TPS but that have been credited as performing or helping to perform a Safety Significant function. These instruments, or instrument features, are described in more detail in Chapter 4 of the SNS PSAR. They include the following:

- Monitoring and alarm associated with the core vessel inerting system (CVIS)
- Hydrogen safe barriers for electronic or instrumentation systems that are routed into the core vessel
- Monitoring and alarm associated with the cryogenic moderator helium inerting system (CMHIS)
- Target plug position switch

The TPS is described in the SNS Preliminary Safety Analysis Report (PSAR), which can be found as SNS Document Number: 102030102-ES0001-R00.

The Target Protection System will be in place and operating for Target commissioning. Operating modes for the TPS for Target System commissioning are;

- Target Ready
- Target Not Ready

**<u>PPS</u>**

The Personnel Protection System radiation protection for RTBT to Target Systems commissioning includes the following:

The equipment will operate in the fully operational PPS mode with equipment installed to secure the Linac and the HEBT-Ring-RTBT. The normal PPS operating modes for the accelerator will be available, i.e.,

- Restricted Access (RWP Access, Magnets and RF OFF)
- Controlled Access (RWP and Key Access, Magnets and RF OFF)
- Controlled Access (RWP and Key Access, Magnets ON, RF OFF)
- Power Permit (No Access, Magnets and RF On)
- Beam Permit (No Access, Full Operation)

**PPS operating modes for Target systems are**:

The Basement Utility area in the Target Building is protected by the PPS. The PPS modes for this area are:

- Restricted Access
- Search
- Beam Permit

During commissioning and operation, high radiation levels will be detected by the Fermilab standard ionization chambers (Chipmunks), which will shut off the Ion Source 65 kV power supply and the RF drive to the RFQ at the Transmitter as well as the Transmitter HV supply. High radiation trips will require evaluation and approval by the Chief Operator prior to the manual reset to restart commissioning .

During RTBT to Target Systems commissioning, the Beam Permit mode, Access controls, radiation monitor interlock trips, Emergency-Stop pushbutton and PPS Certification all function in the same manner as previously described for the Linac Commissioning in section 3.3.1 Technical Controls and Safety Systems.

**MPS**
The Machine Protection System (MPS) is the same as previously described for the HEBT-Ring-RTBT Commissioning in section 4.2.1. Technical Controls and Safety Systems, but additional Machine Protection software/hardware that should be in place for the RTBT to Target commissioning includes:

- Automated run-permit checker.
- Run-permit and Fast-Protect display screens for HEBT, Injection Dump, Ring, RTBT, and extraction dump.
- All PS, Vacuum, RF, Diagnostic MPS Inputs
- Foil, Injection Kickers, Extraction Kickers, Ring RF, Collimator protection inputs.

**Beam Power**
During RTBT to Target commissioning, the beam power will be limited to an amount less than that specified for each system in the Commissioning Accelerator Safety Envelope. The SNS Operational Envelope and Safety Envelope are specified in the SNS ASD Operations Procedures Manual Chapter 2 Section B-1. This is available at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html

**Safety**
Policies for Radiation Safety, Lockout-Tagout and Fire safety during RTBT to Target Systems commissioning are the same as before and are described in Section 2.2.1 Technical Controls and Safety Systems.

### 5.2.2 Administrative Controls

In order for the target to be commissioned as an accelerator system the radionuclide inventory must remain below the Category 3 threshold limit. The SNS approach to compliance with this limit is described in SNS 11004000-TR0002-R00 Methodology for Demonstrating Compliance with Category 3 Threshold Activities.

Additional administrative controls are described in **Appendix A, Personnel, Training, Certification, Procedures and Records.**

## 5.3 The Portion of the Overall Facility ARR Needed for RTBT to Target Systems

Portions of the overall ARR that are needed for RTBT to Target Systems commissioning include an approved Commissioning Accelerator Safety Envelope (CASE) and an approved Safety Assessment Document (SAD) for Accelerator and Target Systems.

The SNS Preliminary Final Safety Assessment Document is available at:
http://www-internal.sns.gov/esh/safdoc/Final_Draft_to_reviewees_1_17_02.pdf

## 5.4 The schedule for RTBT to Target Systems Commissioning

Target Systems commissioning is listed in the current Integrated Project Schedule. This commissioning will include the second half of the RTBT to and including the high power Hg Target. The IPS can be found at: http://it.sns.ornl.gov/project_controls. It can also be found in the Accelerator Readiness Review Plan of Action, SNS 1000000000-PN005-R00.

# 6. Instrument Commissioning

## 6.1 System Description

### 6.1.1 Overview of Neutron Beam Instrument Commissioning

The SNS target station has 18 beam ports and will ultimately support up to approximately 24 neutron beam instruments, but several of these beam ports will not be instrumented initially. The instruments will be installed and commissioned at varying times, and it is not expected that all 24 will be in place until several years after CD-4. Instrument commissioning cannot occur until after neutron production has reached the level meeting the criteria for CD-4, so instrument commissioning is not a part of the SNS Line Item construction project but will instead occur after the construction project is complete and SNS is operational. Each of these instruments is largely independent of any of the others, and instruments will be commissioned on an individual basis. Commissioning of each of these instruments will commence following a Readiness Review for that instrument, and will proceed at a pace appropriate to that instrument independently of the status of the other instruments. Thus, instrument commissioning will be an ongoing process with one or more instruments in various stages of commissioning at any given time.

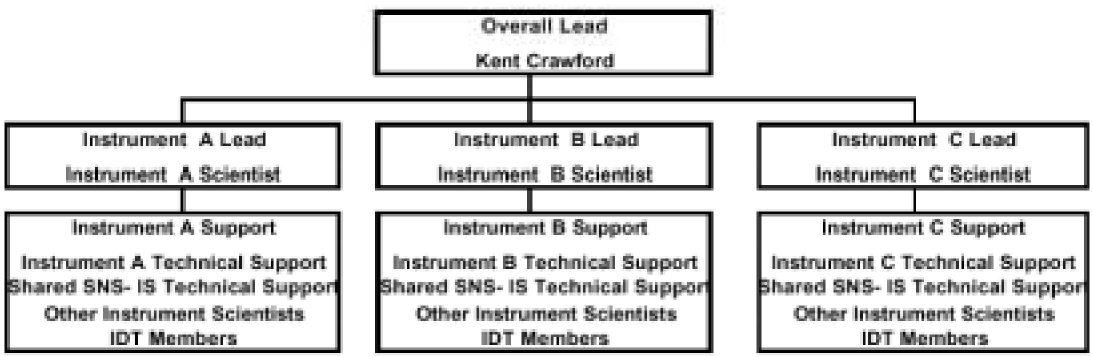


**Figure 6-a Organization Chart for Instrument Commissioning**

Commissioning of each of the instruments is largely independent of the commissioning of any of the others. Each instrument commissioning group will be lead by an instrument scientist and may contain one or more additional scientists, some of whom may not be SNS employees. Each instrument commissioning group will also include the technical support personnel attached to that instrument. Each commissioning group will proceed with the commissioning plan for that instrument, and several different instruments will be in different stages of commissioning at the same time. Shared technical resources such as detector or data acquisition expertise will be called on as needed. The Organizational Chart for the commissioning of three instruments labeled, A B and C is shown in Figure 6-a.

Five neutron scattering instruments are being constructed with Line Item funding as part of the Spallation Neutron Source Project. In addition, there are at least three more instruments being constructed by Instrument Development Teams (IDTs) with external funding. It is anticipated that additional externally-funded IDT instruments will begin design and construction from time-to-time, and that additional instruments will also be funded by SNS out of the SNS operating budget starting in FY2006. Three of these current SNS Line Item instruments are planned to be installed as part of the Line Item baseline and are expected to complete acceptance testing and Instrument Readiness Review prior to CD-4. These three instruments will be ready to begin commissioning immediately following CD-4. The other two SNS Line Item instruments may be installed concurrently if supplemental funds become available, otherwise these two instruments will be installed as part of the SNS operating budget starting in FY2006. Three instruments are currently being funded by IDTs. Two of these three instruments are on a schedule to complete installation within FY2006, and so could begin commissioning by the end of FY2006.

The five initial SNS-funded instruments are:

| | |
|---|---|
| WBS 1.7.4 | Backscattering Spectrometer – Installed and ready for commissioning at CD-4 |
| WBS 1.7.5 | Magnetism Reflectometer – Installed and ready for commissioning at CD-4 |
| WBS 1.7.6 | Liquids Reflectometer – Installed and ready for commissioning at CD-4 |
| WBS 1.7.8 | SANS Diffractometer – Installation requires supplemental funds, so commissioning may not start until well after CD-4 |
| WBS 1.7.10 | Powder Diffractometer – Installation requires supplemental funds, so commissioning may not start until well after CD-4 |

The three currently funded IDT instruments are:

Cold Neutron Chopper Spectrometer (CNCS) – Installed and ready for commissioning by the end of FY2006

Wide Angle Chopper Spectrometer (ARCS) – Installed and ready for commissioning by the end of FY2006

Engineering Diffractometer (VULCAN) – The installation and commissioning schedule is being developed.

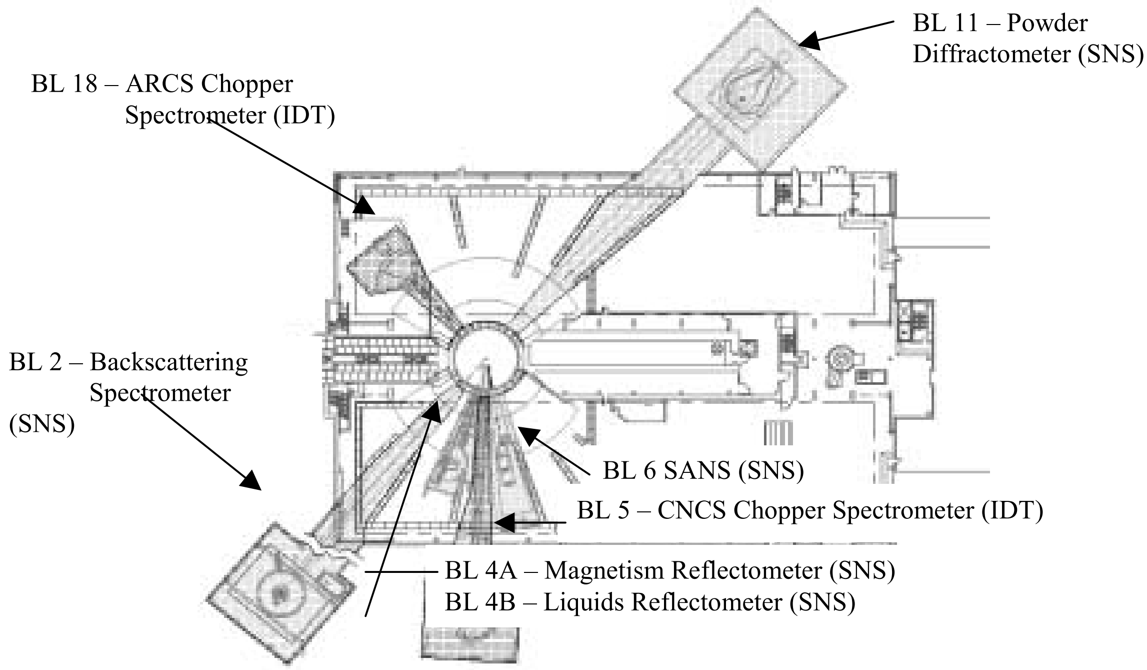


**Figure 6.1 Initial Instrument Layout in the Target Building**

## 6.1.2 Typical Commissioning Steps for Each Instrument

Initial stages of commissioning will involve a series of test measurements to be carried out by the instrument operations staff (instrument scientist(s) and technicians, supported by health physics personnel as appropriate). These tests and measurements will determine at a minimum:

1. That radiation doses in accessible areas are within acceptable limits.
2. That all instrument components are functioning neutronically as designed.
3. That instrument backgrounds (unintended signals measured by the detectors) are within acceptable limits.
4. That performance (resolution and range for the variables of interest) is within acceptable limits.
5. A calibration for the instrument.
6. That measurements on known samples produced the expected results.

It is anticipated that some of these tests will indicate the need for modifications to the instrument, so that the actual early parts of the commissioning program will consist of alternating periods of testing and modification until the desired results are achieved. Many of these tests can be completed entirely or at least in part during low-power operation.

## 6.2 Administrative and Technical Controls and Contingency Plans - Instrument Systems

## 6.2.1 Technical Controls and Safety Systems

Safety systems that must be in place, tested and certified for operation prior to commencement of Instrument commissioning. This includes the Personnel Protection System (PPS).

**PPS**
In addition to the PPS previously described for Accelerator Systems and Target Systems, the Personnel Protection System for Instrument Systems commissioning includes the following:

The equipment will operate in the fully operational PPS mode with equipment installed to secure the Instrument Systems. The normal PPS operating modes will be available, i.e.,

Instrument Open
Instrument Sweep (if required for the particular instrument)

Instrument Ready

During commissioning and operation, high radiation levels will be detected by the Fermilab standard ionization chambers (Chipmunks), which will shut off the Ion Source 65 kV power supply and the RF drive to the RFQ at the Transmitter as well as the Transmitter HV supply. High radiation trips will require evaluation and approval by the Chief Operator prior to the manual reset to restart commissioning.

During Instrument Systems commissioning, the Beam Permit mode, Access controls, radiation monitor interlock trips, Emergency-Stop pushbutton and PPS Certification all function in the same manner as previously described for the Linac Commissioning in section 3.2.1 Technical Controls and Safety Systems.

**Beam Power**
All neutron beam instruments approved for commissioning will be certified for operation up to the full neutron source design power. Instrument commissioning will not provide any additional constraints on accelerator operations except in cases where a limit period of reduced accelerator operations is approved for a particular instrument test.

**Safety**
Policies for Radiation Safety, Lockout-Tagout and Fire safety during Instrument Systems commissioning are the same as before and are described in Section 2.2.1 Technical Controls and Safety Systems.

### 6.2.2 Administrative Controls

Administrative controls are described in **Appendix A, Personnel, Training, Certification, Procedures and Records.**

## 6.3 The Portion of the Overall Facility ARR Needed for Instrument Systems

Portions of the overall ARR that are needed for Instrument Systems commissioning include an approved Commissioning Accelerator Safety Envelope (CASE) and an approved Safety Assessment Document (SAD) for Accelerator and Target Systems.

The SNS Preliminary Final Safety Assessment Document is available at:
http://www-internal.sns.gov/esh/safdoc/Final_Draft_to_reviewees_1_17_02.pdf

## 6.4 The schedule for Instrument Systems Commissioning

As described in section 6.1.1, each neutron beam instrument will be commissioned independently. At least three neutron beam instruments will begin commissioning immediately following CD-4 and several others will begin commissioning soon thereafter.

The generic requirements to be achieved before commissioning of an instrument is complete have been described in section 6.1.2. Commissioning of an instrument typically takes 6-12 months. Thus it is expected that up to three instruments could have completed commissioning within 6-12 months after CD-4. The staged nature of instrument construction, installation, and commissioning means that additional instruments will still be being commissioned at that time, and that at any given time thereafter it is likely that at least one instrument will be undergoing commissioning.

# Appendix A - Personnel, Training, Certification, Procedures and Records

**Current Procedures**

Only current, approved operating procedures are to be used in the accelerator commissioning program. A copy of the current, approved Operations Procedures Manual can be found at: http://www-internal.sns.gov/operations/SNS-OPM_Folder_Tree/TOC.html

**Personnel, Staffing, Training and Certification**

Operation of accelerator systems during commissioning will proceed with the chain of command and the personnel specified in the SNS Operations Procedures Manual, SNS-OPM Chapter 6, Section A-2.

It is the responsibility of the Operations Coordinator, as Group Leader of the Central Control Room (CCR), to direct and supervise the Chief Operators - providing guidance, reviewing and proposing procedures, and resolving any conflicts in operational judgment among the Chief Operators - following the directives and approved procedures by the Operations Manager.

It is the responsibility of the Operations Manager to review and approve all operational procedures and work planning, and to direct operational efforts for quality assurance, reliability and safety.

It is the responsibility of the on-shift operating crew to safely operate the accelerator through adherence to written procedures and sound operating practices. The authority for accelerator operations is vested in the on-duty Chief Operator (CO) and transferred only through formal turnover to a qualified Chief Operator. If a special test, or abnormal condition arises, accelerator personnel shall be aware that the responsibility and authority to determine corresponding operating conditions, system alignments, or equipment manipulations rests fully with the on-duty Chief Operator. The CO shall not permit any individual to bypass or overrule their operational judgment. If this happens, the CO shall bring the matter to the attention of higher line authority for operations.

A minimum of two Accelerator Operations personnel will be present during commissioning. Of these there will be one Chief Operator (CO), at least one accelerator operator (AO). A Health Physics representative (HP) will be present or on-call.

Chief Operators and Operators will be trained and certified in accordance with the SNS Operations Procedures Manual Chapter 4, Training and Certification.

**Critical Records**

Critical records will be maintained and kept current in accordance with DOE standards and “Best Practice”. These include:

- Training and Certification,
- Radiation Dose,
- PPS/MPS Design, Calibration, Maintenance and Test,
- Fire protection evaluation, and
- Operations and Health Physics Logbooks, see SNS-OPM Chapter 1, Section B-1.