

# REVIEW OF THE MECHANICAL ENGINEERING CHALLENGES ASSOCIATED WITH THE SNS\* POWER RAMP UP

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## Abstract

Since commissioning of the SNS in April 2006 the beam power has been steadily increasing towards the design power intensity of 1.4 MW. Several areas of the accelerator have been shown to require modifications, upgrades or new designs of mechanical equipment to support the power ramp schedule. This paper presents mechanical engineering design work implemented since initial commissioning along with a review of current projects and discussion of mechanical engineering issues being addressed that are a direct result of design decisions made early in the project.

## INTRODUCTION

First beam to the SNS target was achieved on April 28, 2006 with  $10^{13}$  protons delivered, followed by formal construction project completion in June 2006. Immediately after this the SNS project concentrated on ramping-up the accelerator power and improving performance towards the full design capability. The goal is set at 1.4 MW of beam power, operating 5000 hours per year and an availability of >90% all within a three year period. The SNS power ramp-up curve is shown in Figure 1.

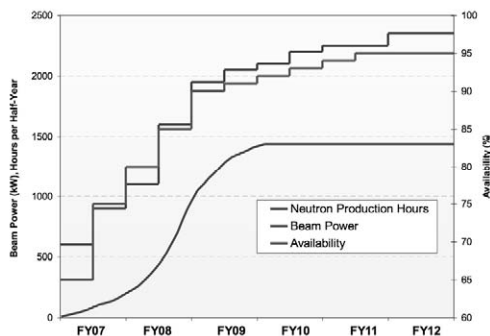


Figure 1: SNS Power Ramp-Up Curve.

To date the maximum beam power on target has exceeded 500 kW and is tracking the project goal but as expected the push to higher beam power exerts a larger load on the accelerator components and many areas of the accelerator have now been identified as requiring modifications or upgrading to a more robust design.

This of course impacts heavily on the mechanical engineering function that has the responsibility for design,

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procurement and initial testing and commissioning of these components. At present there are 18 engineers and designers working solely on accelerator design engineering with a design task list that extends many years into the future.

The engineering design work undertaken since April 2006 can be categorized into three areas:

- Design work that has been instigated due to breakdowns, design limitations of installed equipment and the addition of de-scoped components e.g. diagnostic equipment.
- Design work required to allow removal of activated components and installation of new.
- Accelerator development work.

The scope of this work covers most areas of the accelerator complex and involves close collaboration with the cognizant accelerator physicist and area manager.

## MECHANICAL DESIGN ENGINEERING

### Design Work in Support of Operations

Support to beam operations is the highest priority of both the Research Accelerator and the Neutron Facilities Development (NFDD) Divisions. The mechanical engineering group within NFDD supports these design activities with individual system engineers typically leading a team of design engineers who are responsible for providing design support following breakdowns or the identification of a limiting component. During the last two years there has been a substantial amount of work falling into this category.

The front-end of the accelerator required a modified electrostatic low energy beam transport (LEBT) system; excessive sparking destroyed the LEBT chopper electronics contributing to much of the accelerator downtime in 2007. Improved chopper electronics protection in conjunction with the re-design of the mechanical LEBT chopper resolved the weakness. Figure 2 shows the re-designed electrostatic LEBT

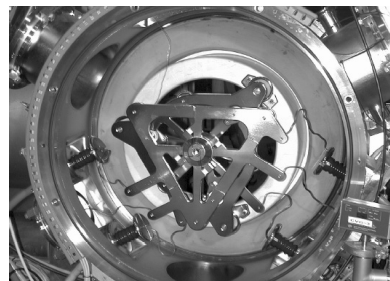


Figure 2: Re-designed Electrostatic LEBT.

A new medium energy beam transport (MEBT) beam-stop and MEBT chopper were also designed, manufactured and installed; the beam stop allows higher powered tune-up beams and the chopper is a test base for proof of principle prior to a final design. The assembled MEBT chopper is shown in Figure 3.

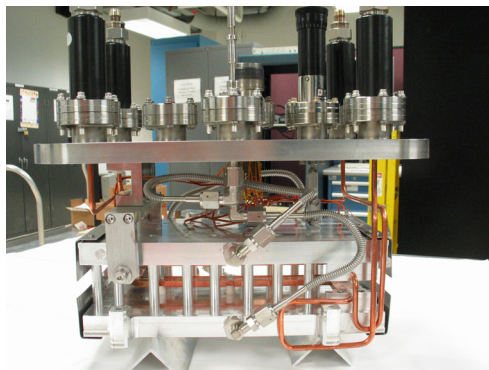


Figure 3: Assembled MEBT Chopper.

The ring injection region of the storage ring has also been problematic with high losses in and around the injection point and the ring injection dump beam-line. To improve losses and beam transport to the ring injection dump (RID) a modified injection septum magnet has been installed which includes a larger vacuum vessel and modified pole tips and a new 'C' magnet has been added in the RID beam-line [1].

This region of the machine has also had a view-screen and wire scanners installed for beam diagnostic purposes and a gamma blocker to block shine from the RID during maintenance activities. Figure 4 shows the view-screen and a wire scanner installed in the RID beam-line.

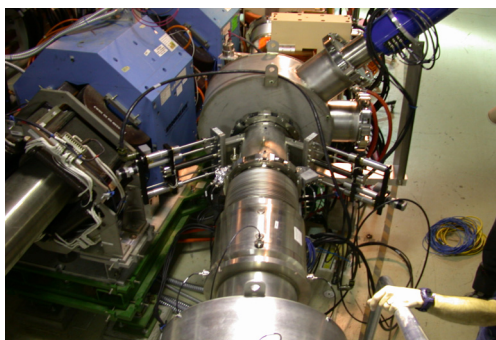


Figure 4: RID Diagnostic Installation.

The primary and secondary foil regions of the storage ring have also been identified as areas for concern and requiring engineering design. A new primary foil changer mechanism and vacuum vessel are now in design the motivation being to improve the active handling capabilities, streamline the foil change process and the addition of a radiation hard gate valve that will allow the region to be isolated from the injection straight during foil changes. The secondary foil stripper mechanism is being designed in parallel and will include a modified vacuum

vessel with quick release vacuum clamps, an enlarged viewport and new actuator design. Figure 5 shows the 3-D concept of the primary foil mechanism.

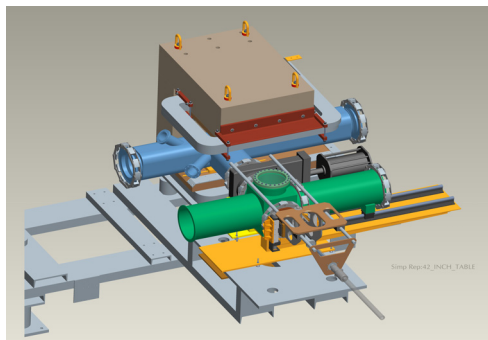


Figure 5: Primary Foil Mechanism Conceptual Design.

In the ring to target beam transport (RTBT) beam-line the final diagnostic (HARP) is also problematic and requires upgrading. The HARP itself has several broken wires and the mechanism that drives the HARP does not operate as expected. A new mechanism has been designed that includes a radiation hard drive system incorporating an air motor, gear box, acme threaded drive shaft and stainless steel guide rails. The original mechanism was designed with active handling in mind and therefore has many features that will simplify the replacement process however, this is an activated area of the accelerator and removal of the component is not a trivial task. This is discussed in more detail later.

An EVAC<sup>®</sup> Cefix<sup>®</sup> vacuum sealing system was chosen as the standard across the accelerator, most likely due to the availability of quick release chain clamps from the same vendor. This choice in the most part has not caused too many problems however; during construction and many of the regular maintenance activities since, several areas of the machine have exhibited problems in obtaining a good vacuum joint. The problem was traced to the socket flanges being warped during the welding process. Also, the seal design does not lend itself to working in activated areas; it is difficult to position and align when flanges are in the vertical orientation. Both issues have been resolved through the development of a welding procedure that dictates strict parameters for welding these flanges onto new components to a flatness of  $\pm 0.06\text{mm}$  and in conjunction with this an aluminum diamond seal that locates on the EVAC flange has been designed; this seal is more forgiving of un-parallel flange faces and will now be used as the default seal.

### *Design in Support of Active Handling*

Active component handling encompasses not only designing for removal of existing components but also designing handling features into new components. Any component now being installed in the accelerator is assessed as to whether there are special requirements with respect to dose rate in that area of the machine. An example of this is the primary foil mechanism and the re-

design of the aluminum vacuum seals, features that are included to help reduce dose rates to maintenance personnel.

In line with this thinking remote vacuum clamps have been utilized on one of the three collimator regions in the storage ring. The design is based on an existing design already in use at SNS [2]. The plan is to extend the use of these systems to the other collimator regions as budget permits but before the areas become too activated.

As discussed earlier the RTBT HARP assembly will be replaced with a new mechanism and most likely an updated diagnostic, to achieve this ~180 tonnes of potentially activated shield blocks need to be removed, therefore a specialized lifting fixture has been designed and is now in manufacture. In parallel with this activity work is underway to plan the tooling required to safely remove and replace the HARP assembly along with a detailed procedure of activities. This is a difficult task that will require sound planning including methods to shield the activated components when they are removed. Figure 6 shows a 3-D design of the components at the end of the RTBT tunnel with the new HARP assembly midway between its vacuum vessel and shielded cask. There is still some ambiguity regarding dose rates in this area; during a maintenance repair outage one year ago the levels were lower than expected but with the beam power ramping up it's expected that these residual rates will be closer to the calculated values.

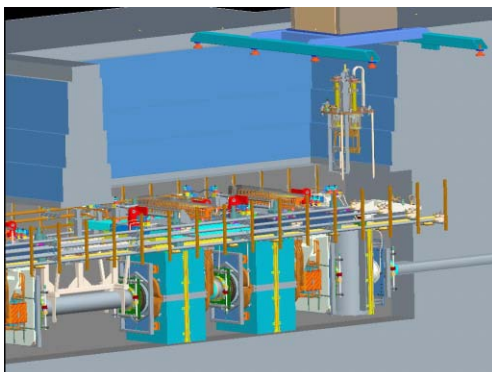


Figure 6: HARP Assembly Removal Concept.

### *Design in Support of Accelerator Development*

During the past eighteen months there has been a substantial design development effort in the front-end region of the accelerator. Two areas where mechanical engineering is heavily involved are design of an external antenna ion source and a new magnetic LEBT to replace the current electrostatic LEBT discussed earlier.

Difficulty with routinely achieving the peak ion source current required for the ramp-up prompted an aggressive testing program that included the design of an external antenna source [3]. After many months of design and testing the final design parameters were completed and the engineering design finalized. Figure 7 shows the 3-D model of the external antenna source and the actual manufactured source ready for testing. This source will now be fully tested on the ion source test stand.

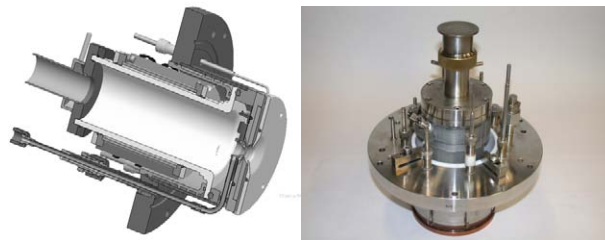


Figure 7: External Antenna Source.

Development and design of a magnetic LEBT is also well underway this will replace the electrostatic LEBT once it has been fully tested and characterized on the ion source test stand. The new LEBT will include a new ion source vacuum vessel, two solenoid magnets and a suite of beam diagnostics to troubleshoot the H<sup>-</sup> beam. Figure 8 shows a 3-D model of the engineering concept.

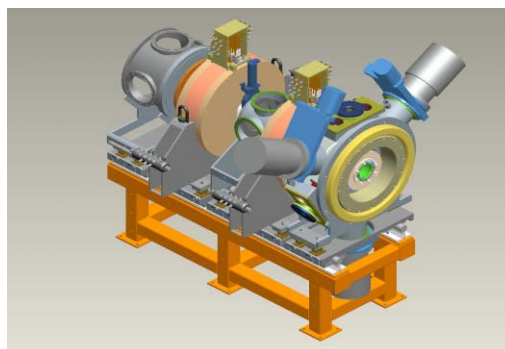


Figure 8: Conceptual Design of Magnetic LEBT.

## SUMMARY

Since initial commissioning of SNS in April, 2006 the accelerator design engineering requirements have increased dramatically in support of operations and the push to increase beam power on target, designing equipment to handle activated components and supporting the continued development activities. Staffing has increased to accommodate this workload and there is now a talented team of engineers and designers working on designs in most areas of the accelerator.

## REFERENCES

- [1] Wang J.G. "Modifications of a Spare Septum Magnet for SNS Ring Injection Dump Beam Line", This Conference.
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