

OVERVIEW OF PROGRESS ON THE IMPROVEMENT PROJECTS FOR THE LANSCE ACCELERATOR AND TARGET FACILITIES

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Abstract

Three projects have been initiated since 1994 to improve the performance of the accelerator and target facilities for the Los Alamos Neutron Science Center (LANSCE). The LANSCE Reliability Improvement Project (LRIP) was separated into two phases. Phase I, completed in 1995, targeted near-term improvements to beam reliability and availability that could be completed in one-year's time. Phase II, now underway and scheduled for completion in May 1998, consists of two projects: a) implementation of direct H^- injection for the Proton Storage Ring (PSR) and b) an upgrade of the target/moderator system for the short pulse spallation neutron (SPSS) source. The latter will reduce the target change-out time from about 10 months to about three weeks. The third project, the SPSS Enhancement Project, is aimed at increasing the PSR output beam current to 200 μA at 30 Hz and providing up to seven new neutron scattering instruments.

1 INTRODUCTION

During the years 1993-1995 the focus of the program based on the 1 mA, 800 MeV proton linac at Los Alamos shifted from basic research in intermediate energy nuclear and particle physics to neutron science. The accelerator and target facility improvement projects are being undertaken to facilitate this transition from the Los Alamos Meson Physics Facility (LAMPF) to LANSCE. The centerpiece for LANSCE and its neutron science program is the short-pulse spallation neutron source comprising the PSR, the neutron production target facility, and the suite of instruments incorporated in the Manuel Lujan Jr Neutron Scattering Center (MLNSC). When the improvements are completed, LANSCE will provide the US neutron science community with access to a world-class, short-pulse spallation neutron source. The main goals for beam delivery improvements are:

- Operation with > 85% neutron beam availability for up to 8 months per year with <5% down time from intervals > 8 hours.
- 100 μA @ 20 Hz from PSR with acceptable losses in the ring at the end of the LANSCE Reliability Improvement Project.
- 200 μA @ 30 Hz from PSR with acceptable losses in the ring at the end of the SPSS Enhancement Project.

2 THE RELIABILITY IMPROVEMENT PROJECT

High neutron beam reliability (as measured by neutron beam availability with respect to established schedules) has been of paramount concern to the users of LANSCE. Neutron beam availability prior to and including 1993 operations was in the range of 50-75%. This level of availability along with access restrictions to experimental rooms (ER-1) surrounding the neutron production target were major impediments to a successful user program in neutron scattering. The reliability improvement project was undertaken in 1994 to address these issues.

2.1 Phase I – Near-term Reliability Improvements

A large list of potential improvements were identified and prioritized by their expected contribution to improved beam availability. However, average down time is not a complete measure of the impact on users. For the typical neutron scattering experiment of 2 or 3 days duration, the distribution of the length of down time intervals is also highly significant. The impact of short down times is often equivalent to a reduction in average current while longer down times can seriously disrupt the experimental plan. Therefore, in the final selection, greater priority was given to treating the sources of long down time intervals, especially those greater than 8 hours.

The main improvements of Phase I are listed below:

- Several H^- source and injector reliability improvements
- Upgrade of the “soft-vacuum” for tank 1 of the linac
- Several linac rf reliability/availability improvements
- DC beam switching (H^-) to replace the pulsed kicker switching
- PSR reliability/maintainability improvements
 - Reconfigured extraction region of PSR for improved maintainability
 - Refurbished H^0 line and vacuum system
 - PSR Pulsed-Power Improvements (upgrade of ring injection line kicker modulator and improvements to the extraction kicker modulators)
- Upgrade of the extraction line beam position monitoring (BPM) system
- Some PSR controls converted to EPICS

- Measures to improve operability and serviceability of MLNSC target/moderator cooling systems
- Improved MLNSC target cell shielding
- Improvements to the Radiation Security System (RSS) which in conjunction with improved shielding allows access to ER-1 by trained experimenters under limited access conditions

Phase I was 95% completed by the start of beam operations in July of 1995. One measure of success, but not solely attributable to the Phase I hardware improvements, is the improved neutron beam availability of 83% and 84% (and greatly reduced fraction of down time from intervals greater than 8 hours) which was experienced in 1995 and 1996, respectively. Further characterization of improvements in reliability and availability is shown in the graph of Figure 1 where the unavailability for major subsystems during the period 1988 – 1992 is compared to the year 1995, the first year after the completion of Phase I. Similar results were obtained for 1996 operations.

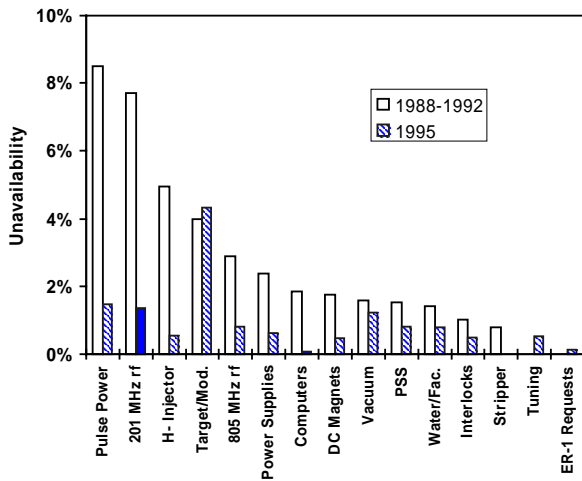


Figure 1. Main contributors to down time.

2.2 Phase II – Longer-term Reliability Improvements

Two projects requiring extensive preparations and a lengthy installation period constitute Phase II of the reliability improvement project. The first project, conversion of the beam injection into PSR from the present two-step process (H^- to H^0 to H^+) to direct injection of H^- beam in one step (H^- to H^+), addresses the root cause of beam losses in the ring. [1] The second, an upgrade of the spallation neutron production target system, will lead to a target that can withstand 200 μ A average current and can be replaced in three weeks instead of the 10 months needed for the existing target/moderator system. [2]

2.2.1 PSR Injection System Upgrade

Beam losses at PSR and the resulting radio-activation of ring components are the dominant factors

limiting average beam current, a significant cause of equipment failure, and a major element in repair times. Present radiation levels in the injection and extraction regions of the ring are at the limit for practical hands-on maintenance. Reducing the beam loss rate is key to improving maintainability, raising beam current and limiting radiation exposure to personnel who must work on ring components.

Beam losses at PSR are now well understood. First turn losses are now known to arise from the production of excited states of H^0 produced in the stripper foil [3,4]. Stored beam losses are the most prevalent and arise from nuclear and large angle Coulomb scattering as stored beam traverses the stripper foil [5,6]. Reduction of stored beam losses would result from measures that reduce foil traversals but the present H^0 injection scheme severely constrains injection painting. The direct H^- injection upgrade for PSR, first proposed in 1987, avoids these constraints and allows optimum injection painting. [7,8]

The PSR injection upgrade starts with a reconfiguration of the injection line to bring H^- beam to a low-field DC merging magnet placed in the injection section of the ring which functions to merge the H^- and the stored H^+ orbits. The H^- beam is converted to H^+ in a stripper foil located after the merging magnet. A programmed, closed-orbit vertical bump at the foil moves the injected beam off the foil for nearly optimal injection painting. Painting in the horizontal plane is achieved by offsetting the injection point. Important details of the injection upgrade are covered in other papers in these proceedings. [1,8,9]

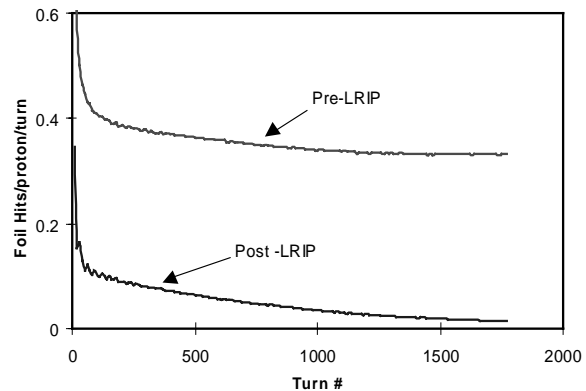


Figure 2. Simulation of foil hits in PSR injection systems.

The main benefit of the new injection system, a large reduction in the foil hits, is computed in ACCSIM simulations to be a factor of 10. This can be seen in more detail in Figure 2 which compares calculated curves of the foil hits per turn per proton for the present and the new injection systems. After optimizing foil thickness to reduce total losses, the overall reduction in beam losses is estimated in the simulations to be a factor 4.5.

2.2.2 Target and Moderator System Upgrade

Replacement of components of the existing target, moderator or reflector system is an intensive, lengthy (~10 months), hands-on operation that results in very significant radiation dose to workers. Failure rates of target system components are rather uncertain but the risk of a long down time is considerable. To date there have been no failures of the tungsten target. However, there have been two failures of the liquid hydrogen moderators in the past 5 years that had a very serious impact on the programs dependent on cold neutrons. For these reasons, upgrade of the target system for faster replacement is of high priority.

The concept of the target upgrade is a single-piece assembly that can be removed remotely in one operation. The assembly will contain a water-cooled target, moderators, reflectors, beam diagnostics and some shielding that fits into a vacuum chamber in the bulk shielding. An overhead crane and access port through the target cell roof will be added so that the target module can be lifted remotely into a shielded cask. For more details see reference [2] in these proceedings.

3 SPSS ENHANCEMENT PROJECT

The US neutron scattering community strongly supports higher beam intensity (both peak and average) from the short pulse spallation neutron source. After LRIP is successfully completed the opportunity exists to reach 200 μA @ 30 Hz with further modest upgrades of the SPSS at LANSCE.

3.1 H⁻ Ion Source and Injector Upgrade

The present H⁻ ion source limits the H⁻ current from the linac to ~ 6.5 mA averaged over the PSR chopping pattern. To reach the goal of 200 μA @ 30 Hz requires about 50 % more peak current from the H⁻ ion source and injector. More current, up to the 17 mA capacity of the linac, is desirable to reduce storage time (hence beam losses in the ring) and to reduce the bunch length in PSR.

A source with twice the intensity and half the emittance of the present surface conversion source is desired. A project to develop the needed source and injector modifications is underway in collaboration with experts at LBNL. Progress is reported in reference [10] of these proceedings.

3.2 RF Buncher Upgrade for PSR

To reach the peak intensity of 4.2×10^{13} protons per pulse required for 200 μA @ 30 Hz one must deal with the limits imposed by the PSR instability. The preponderance of evidence to date supports the e-p hypothesis for this instability i.e., coupled oscillations of low-energy electrons trapped in the potential well of the circulating proton beam. [11,12] The threshold intensity for the instability is most strongly influenced by rf

buncher parameters, especially the buncher voltage, as is shown in Figure 3. This behavior is consistent with the e-p hypothesis and is the basis for the buncher upgrade to control the PSR instability.

A project is underway to upgrade the existing rf buncher in PSR to produce a wave form with up to 18 kV peak voltage at the fundamental of the revolution frequency. When this is completed a second buncher that produces 15 kV at the second harmonic will be added to produce a better bunching factor.

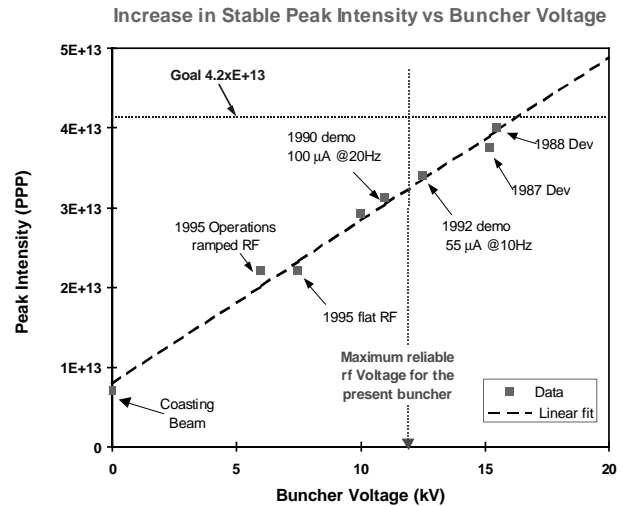


Figure 3. Threshold intensity vs Buncher Voltage.

REFERENCES

- [1] D. H. Fitzgerald, *et al.*, 'Overview and Status of the Los Alamos PSR Injection Upgrade Project', these proceedings.
- [2] J. B. Donahue, *et al.*, 'LANSCE Short-Pulse Spallation Source Target Upgrade', these proceedings.
- [3] R. Hutson and R. Macek, Proceedings of the 1993 Particle Accelerator Conference (1993) 363.
- [4] R. J. Macek, *et al.*, Proceedings of ICANS XII, (1993) Volume 2, A-25.
- [5] R. Macek, *et al.*, Proceedings of the European Particle Accelerator Conference (1988) 1252.
- [6] R. J. Macek, *et al.*, Proceedings of the 1993 Particle Accelerator Conference (1993) 3739.
- [7] R. J. Macek, Proceedings of ICANS X, (1988) 91.
- [8] Barbara Blind and Andrew Jason, 'PSR Injection Line Upgrade', these proceedings.
- [9] C. R. Rose, *et al.*, 'Overview of the Bump Magnet System at the Los Alamos Proton Storage Ring', these proceedings.
- [10] A. B. Wengrow, *et al.*, 'Development of a High Duty Factor, Surface Conversion H⁻ Ion Source for the LANSCE Facility', these proceedings.
- [11] D. Neuffer *et al.*, NIM, A321 (1992) 1-12.
- [12] M. Plum, *et al.*, 'Recent Experimental Evidence for the Los Alamos Proton Storage Ring Instability', these proceedings.