Subject: Two-Bunch Polarized Proton Injection/extraction of the AGS, extraction of single protons bunches from the AGS on the ramp, and faults under Thompson Road.


The committee reviewed several issues related to new methods of operating the AGS for polarized protons.

Two-Bunch Proton Injection of the AGS

The new source for polarized protons has the potential to produce injection intensities for the Booster of $10^{12}$ to $2*10^{12}$ per bunch. The present operational intensity is approximately the same as that in the FY12 polarized proton run with the previous source. The intensity delivered to the Booster was approximately $5*10^{11}$ protons per bunch. It is expected that as the new source is commissioned the intensity will increase with the long term goal of providing a single bunch of $2*10^{12}$ protons into the booster. The Booster would then inject 1.4 GeV (kinetic energy) protons into the AGS with two bunches of $5*10^{11}$ polarized protons. The AGS accelerates the proton bunches (23 GeV is typical kinetic energy) and extracts the desired number of bunches to RHIC. A PowerPoint presentation¹ was delivered by V. Schoefer for this mode of operation.

The linac to Booster injection does not increase the risk of BLIP pulses being accidently sent into the booster. The interleaving of BLIP and Booster pulses is the same as previous years.

During RF capture the Booster RF will split the single linac pulse into two pulses. The pulses will have half the injected intensity but with half the longitudinal emittance. A portion of the polarized proton beam is scrapped horizontally and vertically in the Booster. The scrapping removes portions of the bunch with poorer polarization. A portion of the beam will be transverse scrapped in the Booster. The horizontal scrapping is done at the beam scrapper/dump at B6. This area has a large soil cap. The vertically scrapping occurs at several locations around the Booster ring. With the increased intensity coupled
with the one to two bunch splitting the loss patterns should be examined to ensure that vertically scrapping is not occurring in a location that could impact soil activation. The Booster has soil caps over B6, D6 which is attached to the NSRL cap, and portions of building 914 serve as a soil cap. The soil under the caps are not sensitive to beam scrapping at reasonable levels.

The Booster LP will examine the losses with the new mode of operations and review them with RSCC and ESSHQ. Periodic updates should be provided throughout the FY13 run with polarized protons.

**Review Booster Losses**

ATS-C. Gardner – Booster-Feb. 21, 2013.

Placement of soil samples in unprotected areas where losses are expected to occur should be considered.

**Placement of Removable soil samples**

ATS-C. Gardner – Booster – Feb. 21, 2013

No additional operating procedures are required for this mode of operation in the Booster.

The Booster bunches are injected into and extracted from the AGS in an identical manner as previous polarized proton operations. The B15 current transformer will provide the same protection as for single bunch operations. The previous operation of polarization protons had either zero or one bunch extracted. If the beam in the AGS was being used for studies then no bunch would be extracted and the bunch would terminate on the J10 scrapper. If beam was required for AtR or RHIC then the bunch would be extracted. The two-bunch mode will have either zero, one or two bunches extracted depending on the requirements of the program. The RHIC users may require polarization patterns in RHIC that can only be achieved with one-bunch injection. In addition there may be times when one RHIC ring is filled with single bunches and two-bunch injection in used in the other ring. These variations in RHIC injection do not introduce any new hazard. The only condition in the AGS is that there will be twice the beam from previous polarized proton operations and eventually four times the total beam when the bunch intensity increases. The J10 dump was designed for $5 \times 10^{12}$ protons per second which is well above the operations levels being discussed presently. Periodic surveys are conducted by RCTs at the AGS. The AGS Liaison Physicist, RCD Rep., RSCC, and ESSHQ will review the surveys to ensure no new loss pattern has developed around the AGS ring.

**Review AGS loss pattern.**

ATS-H. Huang-AGS-Feb. 21, 2013

The extraction of the two AGS bunches is nearly identical to previous polarization proton extraction. The only difference is after flat top is achieved the first bunch is extracted and then the second bunch will be extracted about 150 ms later. 100 ms or more is required for the G10 kicker to be ready for extracting the second bunch. The AtR BLMs are updated at 60 HZ (16.7 ms) so that the 150 ms between pulses will not impact their response to beam losses. Heavy ion operations uses four-bunches transfers from the AGS
to RHIC. Thus, multi-bunch extraction to RHIC is not new, but for polarized protons it is a new mode.

The only issue for the two-bunch proton extraction into AtR up to the W-dump is the rate at which beam losses can occur. The same loss pattern is expected as in previous polarized proton operations. The LP for AtR will examine the beam loss procedure to determine if any updates are necessary due to the higher transfer rate. The LP for AtR will provide his recommendations to the head of operations, RSCC, and the ESSHQ so that they become implemented.

**Examine AtR Loss Procedure**

**ATS-V. Schoefer-U-multi-bunch extraction-Feb. 21, 2013**

Single turn extraction at not possible for operations at the nominal energies for RHIC injection. An ATS item has been entered to examine any special operations that might use single turn extraction at low energy.

With increasing intensity in proton transfers and now with the request of two bunches per AGS cycle the committee needs to recommend how Thompson Road should be treated during proton operations.

The X and Y injection arcs transport the beam under a portion of Thompson Road. Thompson Road is an Uncontrolled Area. The potential exposure on Thompson Road has been discussed in previous RSC Minutes. A single bunch with upgraded intensity produces 0.07 mrem at the peak of the dose distribution. For two-bunch injection of RHIC the maximum dose would be 0.14 mrem per AGS cycle. The committee had not previously considered multi-bunch proton injection of RHIC. An entire fill with the upgraded intensity would great a maximum possible dose of 7.7 mrem over a three minute period. With single bunch injection the fill time for a ring is twice as long.

Early RHIC operations occurred at the time of high intensity proton operations to g-2 (in the U line) and the SEB program. Thompson road was fenced off and posted as a Controlled Area as a precaution. Since that time there have been improvements including two added chipmunks (a total of four at the road), two added TLD monitors (a total of four at the road), loss monitoring procedures to alarm on beam losses in the injection ARCs, and review of past operational experience. All indications are that there is essentially no dose at Thompson road. The road has been open during RHIC operations for a number of years and is an uncontrolled area.

The C-AD shielding policy states that no more than 20 mrem of exposure can occur to people in an uncontrolled area during a maximum credible beam incident. Operations monitors RHIC fills very closely not for safety but the quality of the injected pulses into RHIC have a dramatic impact on the physics program. Fills are often stopped with poor transport or missed pulses due to the impact on the program and not losses under Thompson Road. Most losses in the arcs typically occur near the end in the RHIC tunnel.
The minimum transfer efficiency\(^1\) for RHIC fills during the FY12 polarized proton operations was 93%. The average was 98-99%. The accuracy of the numbers are a few percent. In a few cases we can see that there are transfers exceeding 100%, which indicates a minor difference in the calibration and performance of the current transformers.

There was additional discussion on the impact of closing Thompson Road. It was noted that at least once in the past an employee hit the closed gate, so that closing the road can create other safety consequences. C-AD staff often use Thompson Road as the most efficient means to travel to NSRL, EBIS, and the PHENIX support building on the outside of the ring. In the past they have voiced the desire to have the road remain open. Thompson Road is also considered desirable to be open for emergency response.

**The committee recommended that Thompson Road remain open and continue to be an Uncontrolled Area.**

The LP for AtR will examine the loss monitor procedure for faults in the X and Y arcs and establish a 25% beam loss alarm and a 50% beam loss alarm for full beam fills with polarized protons. The LP for AtR will modify the procedure with appropriate responses and reviews so that we proceed with caution. It is not expected that a BLIP pulse can be transmitted through the accelerator systems to Thompson Road. However, the dual transformers could allow one pulse. Should it be suspected that such a BLIP pulse is extracted out of the AGS the AtR loss procedure must have operations halt to determine the cause of the fault. The RSCC, MCR group leader, and ESSHQ will review the procedure for Thompson Road.

**Review RHIC Injection Loss Procedure**  
ATS-V. Schoefer-RHIC-Feb. 21, 2013

A process must be in place so that personnel from F&O are not dispatched to this section of Thompson Road to conduct stationary work during RHIC operations.  

**Work planning for Thompson Road**  
ATS-P. Cirigliaro-RHIC-Feb. 15, 2013

The arcs are tuned with single cycles an often low intensity to establish the operational parameters of the transport.

**Single-Bunch AGS Proton Extraction on the Ramp**

H. Huang gave a brief presentation\(^4\) on a mode to extract polarized protons on the AGS magnet ramp. It is expected that this mode of operation could increase the polarization by 3-5%. Spin-spin physics goes as the fourth power of the polarization and therefore this could provide a substantial increase in the spin-spin physics output.

Extraction on the AGS magnet ramp has never been conducted for the U line. Typically, there is a flat top to the magnetic field before extraction begins. This mode of operation will only be conducted with single bunches of polarized protons in the AGS. A different
user function will be used for extraction on the ramp verses two-bunch operation. Potential variations of the magnetic field and shifts in timing could cause losses to occur in AtR. The loss procedures for AtR are well developed and have been used successfully for several years. The RSC considers the types of faults are within the scope considered by the AtR loss procedure. The AGS LP and the ATR LP are responsible to work with operations to ensure that stable extraction and low losses are achieve before this mode is allowed to be used routinely. They will review the initial tests results for transfers to the W-dump with the RSCC and ESSHQ before the mode is used for delivering beam into the RHIC arcs.

**Review stability of ramp extraction before used routinely.**

ATS-H. Huang & V. Schoefer-U-Feb. 21, 2013


References

1) V. Schoefer and H. Huang, PowerPoint presentation, Jan. 22, 2013; “RHIC Polarized Proton Operation with Two Bunches per AGS Cycle”
2) Reference to J10 design
4) H. Huang, PowerPoint presentation, Jan. 22, 2013; “Extraction-on-the-fly”

CC:

Present
RSC
RSC Minutes e-File
A. Pendzick
A. Dress
C. Gardner
D. Passarello