

A short note on high-intensity gold in AGS

C. Gardner

February 2021

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC), Nuclear Physics (NP) (SC-26)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-SC0012704 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

A short note on high-intensity gold in AGS

C.J. Gardner

February 6, 2021

In this short note we record the present state of affairs and rules for working with high-intensity gold beam in AGS.

Because Tandem is capable of delivering significantly more ions per pulse than EBIS [1], and because we now have more transfers from Booster to AGS (per AGS cycle) than in the past, it is easy with Tandem to exceed the maximum beam intensity previously achieved in AGS. That maximum was $7.4e9$ Au77+ ions circulating in AGS at 9.8 GeV per nucleon as reported in [2]. Going to the higher intensities needed during Run 20 required a review to ensure that measures were in place to prevent damage to the beam dump and the plunging stripping foil (PSF). These components, along with the closed orbit bump at the dump, ensure that any beam not extracted from AGS is put into the water-cooled copper absorber of the dump [3]. This is absolutely essential because the highly charged Au77+ ions can cause significant damage if lost on the vacuum chamber wall. (The amount of energy deposited is proportional to the square of the ion charge.) The review, followed by observations of the effect of higher intensities on the PSF, showed that with certain precautions and procedures it is reasonable to increase the maximum intensity to $9.6e9$ Au77+ ions per AGS cycle at 5.75 GeV per nucleon. Those precautions and accompanying procedures are given in [4]. As of this writing, a new document [5] allows the same maximum intensity for Au77+ ions at 3.85 GeV per nucleon. For all other gold ion energies, the maximum intensity currently allowed is $8e9$ Au77+ ions circulating in AGS at extraction.

Another component affected by the intensity of gold beam is the BTA stripper. The stripping foils used here are the aluminum-carbon foils described in [1, 6]. In order to get a given number of Au77+ ions circulating in AGS at extraction, one needs approximately twice as many ions passing through the foils. For the past decade the foils have given no indication of degradation when exposed to intensities of $12.0e9$ gold ions

per AGS cycle or less. However, when exposed to intensities ranging from 16.0×10^9 to 20.0×10^9 gold ions per AGS cycle, the foils accumulate damage and their performance suffers significantly. This has been quantified by careful measurements of stripping efficiency carried out by K. Zeno and documented in [2]. It is found that any area on a foil that is exposed to the higher intensities can have a useful lifetime of just hours. By moving the position of the beam on the foil or by moving the position of the foil itself, one can make use of any available undamaged area. Eventually all the undamaged area is used up and the foil is spent. Calculations of the heating and radiative cooling of the aluminum and carbon foils show that with 20.0×10^9 gold ions incident on the foils (per AGS cycle), the aluminum comes very close to its melting point. The carbon, on the other hand, does not melt and stays well below the temperature at which it sublimates.

In November 2020, the aluminum-carbon foils that had been in place since 2010 were removed from the foil changer and replaced with three new aluminum-carbon foils. These now occupy slots 5, 6, and 7 in the changer. (There are 8 slots which are labeled 0 through 7. Slot 0 is empty. Slots 1 and 2 contain nickel-aluminum foils that are used to strip uranium ions. Slots 3 and 4 contain new aluminum foils that will be used to strip oxygen ions.) Pictures of the old aluminum-carbon foils removed from slots 5 and 6 are shown in [2]. There one sees the significant damage done to the aluminum foils by the high-intensity beam. In order to conserve the new foils, they should be exposed to high-intensity beam only when high intensity is needed. This is normally during RHIC fills or when preparing for a fill. The transfer efficiency between Booster and AGS should be monitored to ensure that it is nominal. If lower than nominal, more beam is being put into the foil than necessary to produce a given intensity in AGS. This unnecessarily reduces the lifetime of the foils.

References

- [1] C.J. Gardner, et al, “Operation of the RHIC Injector Chain with Ions from EBIS”, Proceedings of IPAC2015, pp. 3804–3807.
- [2] K.L. Zeno, “The 2020 Low Energy Gold Run in the Injectors,” C-A/AP/Note 638, December 2020.
- [3] C.J. Gardner, L.A. Ahrens, and P. Thieberger, “Notes on Dumping Gold Beam in the AGS,” C-A/AP/Note 396, August 2010.
- [4] C.J. Gardner, H. Huang, and P.F. Ingrassia, “Temporary Procedure for increasing the intensity of Au⁷⁷⁺ ions circulating in AGS at energy 5.75 GeV per nucleon,” C-A-TPL 20-05, January 14, 2020.
- [5] C.J. Gardner and H. Huang, “Temporary Procedure for increasing the intensity of Au⁷⁷⁺ ions circulating in AGS at energy 3.85 or 5.75 GeV per nucleon,” C-A-TPL 21-01, January 2021.
- [6] P. Thieberger, et al, “Improved Gold Ion Stripping at 0.1 and 10 GeV/nucleon for the Relativistic Heavy Ion Collider”, Phys. Rev. ST Accelerators and Beams **11**, 011001 (2008).