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A short note on high-intensity gold in AGS

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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 16.0e9 to 20.0e9 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 20.0e9 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

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