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Gold Beam Loss at the Booster

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DISCLAIMER

AGS Complex Machine Studies **(AGS Studies Report No.373)** **Gold Beam Loss at the Booster**
Study Period: April 28, 1998
Participants: L. Ahrens, S.Y. Zhang
Reported by: S.Y. Zhang
Machine: Booster
Beam: Gold
Tools: Bumps, Injection transformer
Aim: To Study the Booster Gold Beam Losses

I. Summary

1. Scraping the Gold beam at a 800 Gauss porch in the Booster, it is demonstrated again that the Gold beam life time at the Booster injection is affected by the beam loss, rather than the circulating beam intensity.

2. The beam life time immediately after the scraping is shorter for the larger beam loss.

3. The beam life time is recovered in 100 ms after the scraping, which is consistent with the 35 ms time constant of the vacuum pressure created by the beam loss, reported in AGS Studies Report No. 370, 1998.

II. Experiment

To study further on the Gold beam scraping effect, a 800 Gauss porch is created at the Booster. This set-up is similar to the AGS Study Report No.354 [1]. However, there are several important differences.

1. At 800 Gauss, the magnetic field set-up is easier than the one at 600 Gauss [1], which is at the injection energy.

2. The typical beam life is increased from 150 ms to 950 ms, allowing better observation of the beam loss structure.

3. The porch length is extended from 170 ms to 900 ms, allowing observation of the change of the beam life time after the scraping, which might be in a range of 100 ms [2].

The beam intensity of the user 1 at the time was typically 3.8×10^9 Au^{31+} ions injected, and the Booster early was 1.9×10^9 ions. The user 2 used for the study had about half of that intensity. Therefore, the typical Booster early intensity relevant to the study was about 10^9 ions, similar to the one in [1]. The beam intensity is, of course, reduced significantly during the acceleration and also at the long porch.

The normal cycle and five scraped beam cycles are shown in Fig. 1. All the beam intensities have the background signal subtracted. One may observe that, from the intensity level before the injection, in the cases A, B, and C, the subtraction of the background signal is near perfect. In the other three cases, it is not, but still acceptable. The beam was scraped at C7, C5, and D1, at the time of 400 *ms* and 250 *ms* in the cycle, with the bumps strength ranged from 6 *mm* to 11 *mm*.

III. Results

A simple logarithmic plot of the beam intensity gives rise to better view, as shown in Fig. 2.

The normal cycle is shown in Fig. 2A, where we observe that from 350 *ms* to the end of the cycle, the linear life time of $\tau = 950$ *ms* has a perfect fit.

Other main results from the observation are as follows.

1. Using the same life time to fit all the cases, we find that the beam life time is not affected by the beam intensity. The lowest intensity is in the end of the cycle in the case B, and the highest is at 300 *ms* in the case A. The net difference of $e^{1.8}$ implies that the variation of the intensity in a factor of 6, yet the life time is the same.

2. The beam life time immediately after the scraping is significantly reduced. This can be seen from the cases B to F in Fig.2. Since the three cases of the C7 bump scraping only differ by the bump strength, these cases are replotted in Fig. 3. It is estimated that the scraped beam intensities in the cases B, F, and C are 2.3×10^8, 1.8×10^8, and 1.3×10^8 ions, respectively. As shown in Fig. 3, the beam life time immediately after the scraping approximately fit the lines of $\tau = 250$ *ms*, 350 *ms*, and 450 *ms*, respectively. The larger the beam loss, the shorter the beam life time after the loss.

3. In all the cases, the beam life time is recovered in about 100 *ms* after the scraping. This can be observed from Fig. 2, and also from Fig. 3. In [2], it is reported that the vacuum pressure created by the beam loss has a decay time constant of 35 *ms*. Therefore, the result of this study is in agreement with that conclusion.

A more detailed comparison between the scraped beam of the case C and the normal cycle is shown in Fig. 4, where the C7 bump voltage is also shown. From 550 ms to 900 ms in the cycle, the beam life times are identical and the pattern of the shorter life time after the scraping is shown clearly.

IV. Discussion

1. In the experiment reported in [3], for different Tandem beam intensities, the Booster injection efficiency is studied using the comparison between the cases. It was also concluded that the injection efficiency is affected by the beam loss, rather than the circulating beam intensity.

2. It is also interesting to mention that in the set-up at the 600 Gauss porch, the typical beam life time is 150 ms, whereas in the 800 Gauss porch, the beam life time is 950 ms. In [4], it is suggested that for Au^{31+} Booster injection, the capture loss is dominant. Using the KMJ model, the electron capture cross sections are $\sigma_c = 10^{-16.8}$ cm^2 and $10^{-17.76}$ cm^2, for $\beta = 0.044$ and $\beta = 0.056$, respectively. These are corresponding to 600 and 800 Gauss porches. Let the nitrogen equivalent capture cross section be 10 times of the electron impact cross section, then we consider the beam life time

$$\tau = \frac{1}{10\sigma_c \times 3.3 \times 10^{16} \times \beta cp}$$

   where c is the light speed in cm, and p is the vacuum pressure in $Torr$. Taking the average vacuum pressure in the ring to be 10^{-9} $Torr$, then we arrive at that the beam life time at $\beta = 0.044$ is 145 ms, and at $\beta = 0.056$, it is 1,038 ms.

V. References

1. L.A. Ahrens, AGS Study Report No.354, Feb. 1997.

2. S.Y. Zhang, AGS Study Report No.370, May 1998.

3. S.Y. Zhang and L.A. Ahrens, AGS Study Report No.369, Feb. 1998.

4. S.Y. Zhang, AGS Tech. Note, No.482, Dec. 1998.

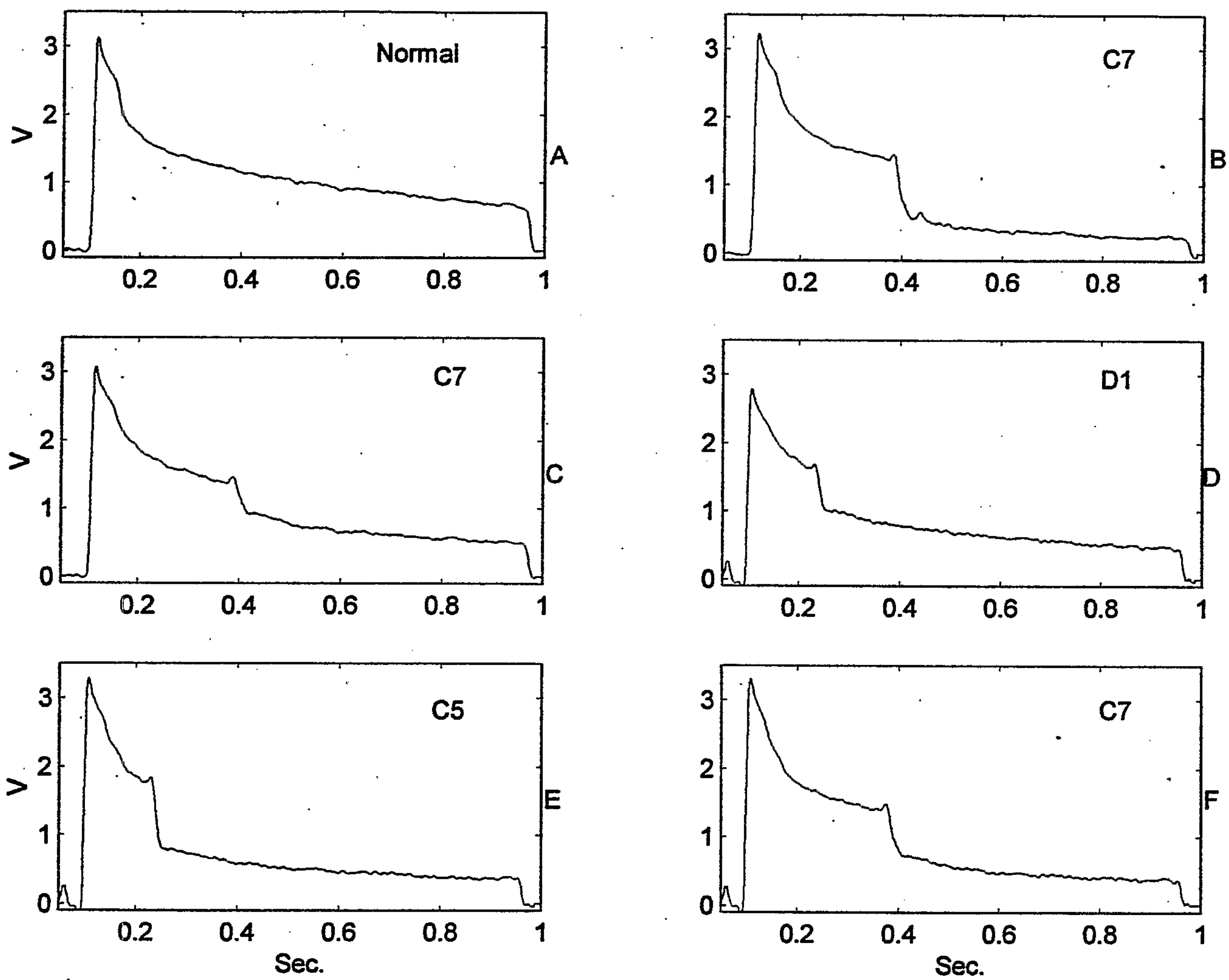

Fig.1. *Beam scraped at C7, C5, and D1. The case A is a normal cycle.*

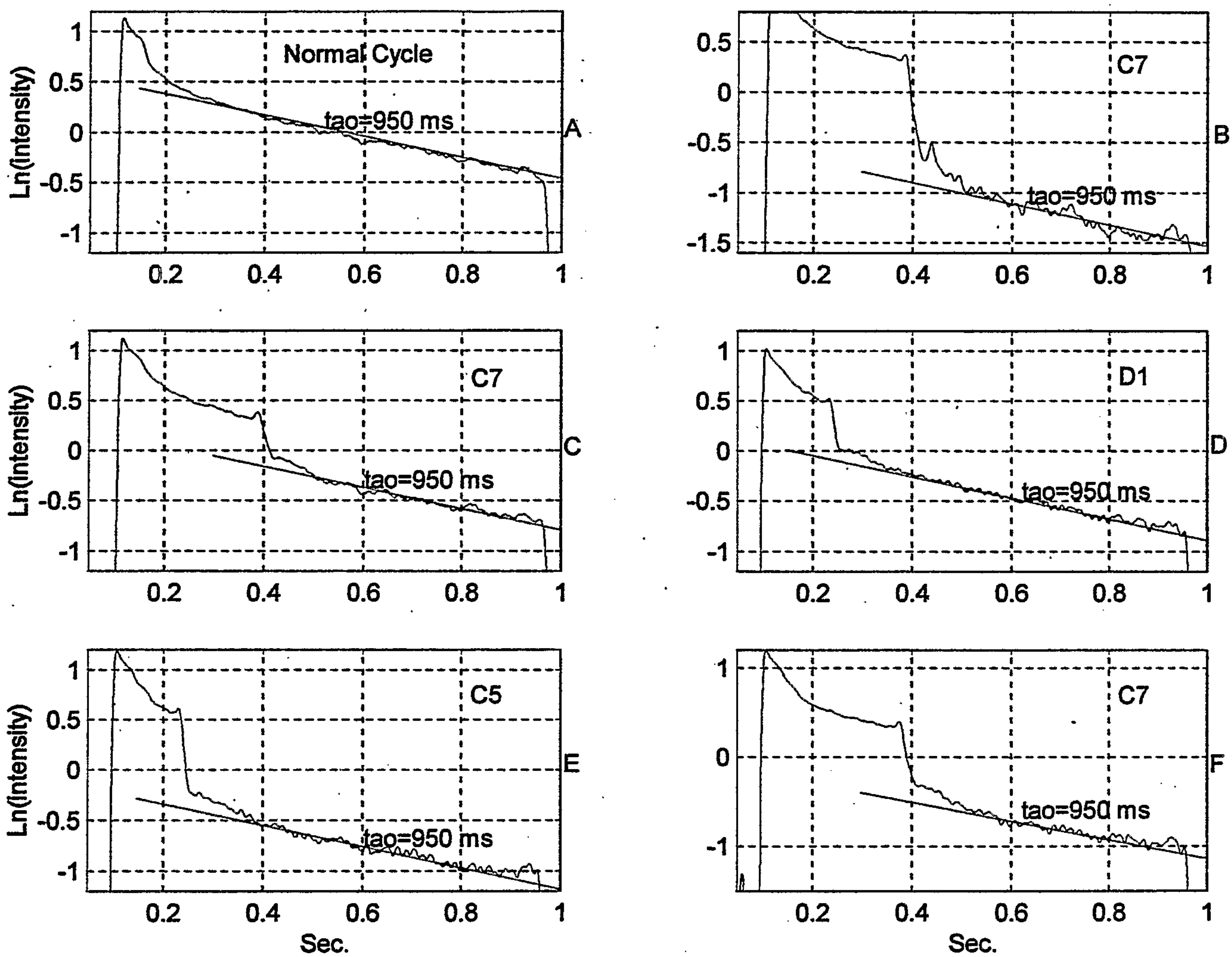

Fig.2. *Logarithmic plot. Use 950 ms life time to fit all cases.*

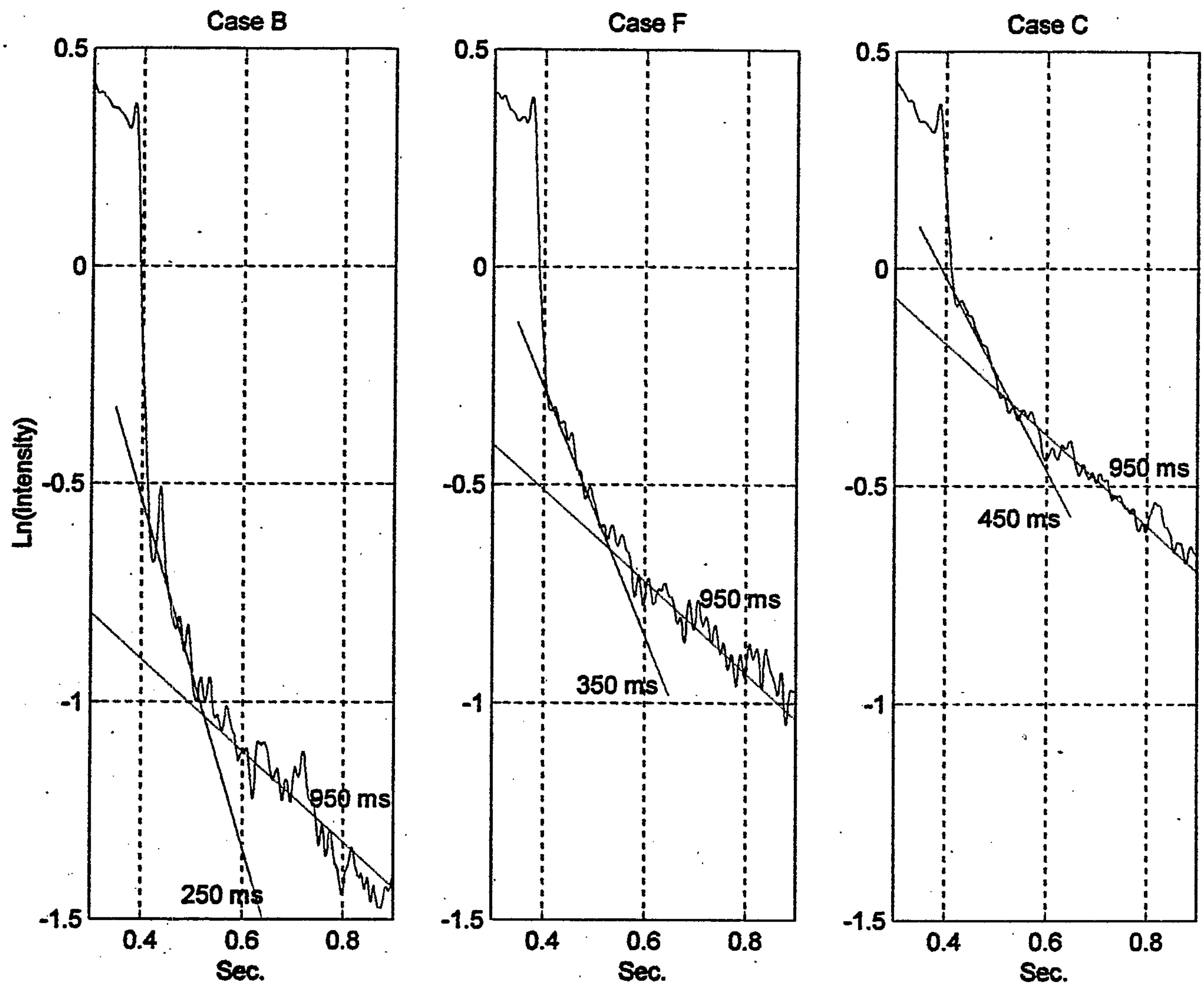

Fig.3. *The larger the beam loss, the shorter the beam life time after scraping.*

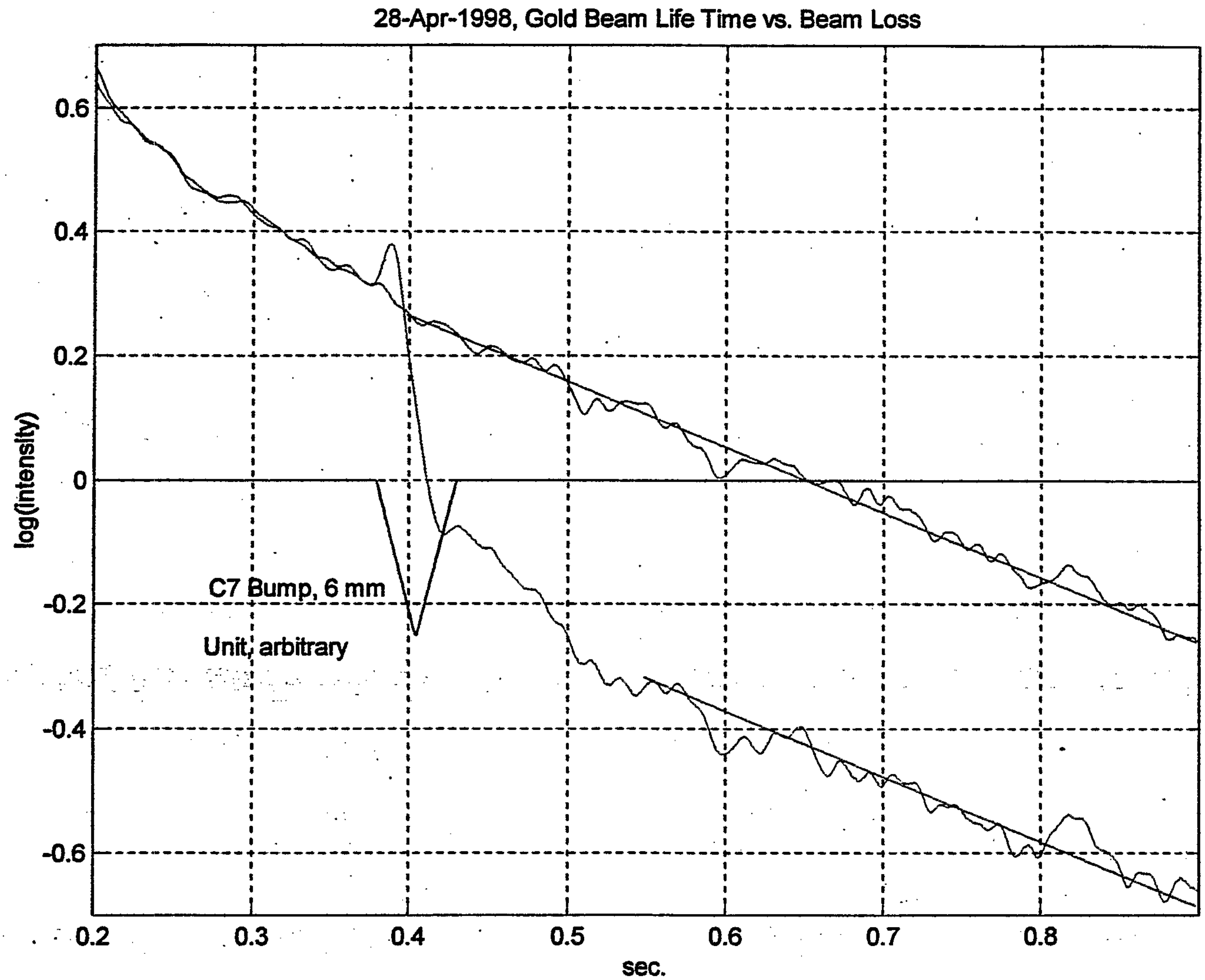

Fig.4. *Close look at the case C. The beam life time is recovered in 100 ms.*