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Anomalous Beam Motion in the TTB Line, and the Getter-Strip Hypothesis

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AGS Complex Machine Studies   **(AGS Studies Report No. 371)**   **Title: Anomalous Beam Motion in the TTB Line, and the "Getter-Strip" Hypothesis**
Study Period: June 19, 1998
Participants: L. Aherns, J. Benjamin, R. Burkhardt, J. Donohue, C. Gardner, P. Thieberger, K. Zeno
Reported by: C. Gardner
Machine: Tandem, TTB Line, Booster
Beam: Gold Au $_{13+}$ and Fe $_{10+}$
Tools: TTB Beam Profile Monitors
Aim: To investigate the anomalous motion of the beam in the TTB line.

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1 Beam Profiles on 29MW141 Monitor

1.1 Observations

(See Logbook No. AG.303.2.9803—"FY 98 HIP SETUP Booster/AGS Book III")

- 30 April 1998: Gardner finds that the horizontal and vertical beam profiles at 29MW141 vary as peaker is varied. The width of the horizontal profile varies, but not its center. The center of the vertical profile varies and so does its width to some extent. Changing the injection fast bump and the C3 vertical three-bump in the Booster has no effect on the profiles.
- 4–5 May 1998: Zeno finds that tuning dipole correctors in the Booster ring has no effect on the profiles at 29MW141; however, changing the tune quads has the same effect as changing peaker. Moreover, putting the Booster main magnet to dwell and scanning pseudo-peaker has the same effect as changing peaker. Zeno concludes that the *time* of injection is the factor that leads to the variation seen at 29MW141.
- 6 May 1998: Zeno finds small variation of profiles at 29MW090 as pseudo-peaker is varied. Also looked for changes at 29MW141 as various magnetic elements in Booster were varied but found none.

- 7 May 1998: Gardner looks for variations of profiles at 29MW090, 28MW132, 27MW154, 26MW042, 25MW152, and 12MW165 as peaker is varied. Small variation seen at 29MW090 but none seen upstream of this monitor.
- 7 May 1998: Ahrens finds that variation of 29MW141 profiles has 16.6666 ms periodicity as pseudo-peaker is varied.
- 7–8 May 1998: Zeno looks for TTB Line elements that have significant 60 Hz ripple; none found.
- 10 May 1998: With Booster Main Magnet OFF, Ahrens finds same variation of 29MW141 profiles with pseudo-peaker.

1.2 Comments

The above observations seem to indicate that some magnetic or electric element near the end of the TTB line has enough 60 Hz ripple to produce the observed variation of the beam profiles at 29MW141. However, TTB and Booster magnetic elements are exonerated by the observations of Zeno on 7–8 May and by those of Ahrens on 10 May.

2 Getter ("Neg") Strip Hypothesis

Upon hearing of the above results, Peter Thieberger suggests that the getter ("neg") strip that runs along the bottom of the TTB beam pipe may be the culprit. This strip is electrically insulated from the beam pipe and sits slightly above the floor of the pipe. It is periodically (about once every two years) "activated" by passing a current (at 120 VAC) through it to heat it up. The current is controlled by a variac, and, even if the variac is adjusted so that no current flows through the strip, the strip will float at 120 VAC with respect to the beam pipe if the breaker for the strip is left ON. Mike Mapes of the vacuum group believes that the breaker for the 50-foot-long strip that runs between 29MW090 and 29MW141 has been ON since 1995 when the last activation took place.

An AC potential difference between the getter strip and the beam pipe could explain several of our observations. The electric field would deflect the beam vertically and would have horizontal components that increase from zero as one moves away from the vertical plane that bisects the pipe. This would explain the vertical deflection and horizontal focusing or defocusing of the beam. The 60 Hz voltage would, of course, explain the time-periodicity of the profile variation. The variation of the electric field (stronger at the bottom of the pipe and weaker at the top) would also be consistent with the observation that the beam "likes" to be high vertically on the 29MW090 and 29MW141 profile monitors.

Following is a simple-minded calculation of the vertical deflection expected for a Au^{31+} ion moving in a uniform vertical electric field, E, due to a potential difference, V, of 100 Volts between the top and bottom of the beam pipe.

2.1 "Back-of-the-Envelope" Calculation

The vertical deflection of a beam particle under constant vertical acceleration, a, is

$$\Delta y = \frac{1}{2} a t^2 \tag{1}$$

where

$$a = QE/m, \quad t = L/v, \quad E = V/d. \tag{2}$$

Thus

$$\Delta y = \frac{1}{2}\left(\frac{QV}{mv^2}\right)\left(\frac{L^2}{d}\right) = \frac{1}{4}\left(\frac{QV}{W}\right)\left(\frac{L^2}{d}\right) \tag{3}$$

where $W = mv^2/2 = 182$ MeV and $Q = 31$ for Au^{31+} ions in the TTB Line. Here $L = 50$ feet $= 1524$ cm is the distance from MW090 to MW141, and $d = 10$ cm is the diameter of the beam pipe. Taking $V = 100$ volts we get

$$\Delta y = \frac{1}{4}\left(\frac{3100}{182 \times 10^6}\right)\left(\frac{1524^2}{10}\right) = 1.0 \text{ cm}. \tag{4}$$

2.2 Other Supporting Evidence

Consulting the various log books for the heavy-ion runs since 1993 we find that until 1995, the beam "wanted" to be centered vertically at 29MW090 and 29MW141. Moreover, the peak Booster injection efficiency during the 1993 and 1994 runs was close to 60%, but was at most 50% for all runs since 1995.

2.3 Comments

All of the observations and evidence are consistent with the getter-strip hypothesis. The "back-of-the-envelope" calculation of vertical deflection gives a number consistent with the observed deflection.

We will probably not have a chance to test the hypothesis with beam until the next scheduled heavy-ion run (about one year from now). It is very important that we remember to do this at that time.