BNL-104219-2014-TECH
AGS.SN347;BNL-104219-2014-IR

Booster Loss Monitor Sensitivity

L. Ahrens

July 1996

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Science (SC)

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AGS Complex Machine Studies **(AGS Studies Report No. 347)** **Title: Booster Loss Monitor Sensitivity**
Study Period: July 6, 1996; 1100-1300
Participants: L. Ahrens
Reported by: L. Ahrens
Machine: Booster and BtA
Beam: Low Intensity Proton (0.4 TP/Booster cycle)
Tools: Booster loss monitor system (which monitors the BtA line as well as the Booster itself), Booster current transformer, BtA multiwire, AGS A20 current transformer, and of course the Booster, accelerating and extracting low intensity 0.35 x 10^{12} protons per Booster cycle) beam.
Aim: To measure the response from the Booster and BtA loss monitors for a known beam loss (answer from this data: 100000 F superperiod L.M. counts/TP @ Booster extraction, 34000 long monitors sum L.M. counts/TP @ B.A. line.

Procedure

Measure beam intensity at Booster extraction. (Check Booster current transformer using calibrate pulse). Crash this beam in various ways and measure the response from the Booster and BtA loss monitors. In Booster we are using the normal ring loss monitor system: 48 monitors covering the ring with one loss monitor cable extending from the center of each (quad-dipole) unit to the center of the next. In BtA we use the "equivalent" set of long cables which cover the entire line except for the section in the shielding between machines and the final section near L20 in the AGS. The BtA loss monitors are identified by their "average" location down the line; BTA023 is the first monitor in the line with its center 23 feet down the line, BTA206 lies 206 feet down the line slightly before entry into the AGS. Figure 1, which is a part of Booster drawing D36-M-1896-5 rev B, gives an overview of the relevant piece of the accelerator complex. The electronics associated with all of these monitors produce integrated loss outputs. The same integration time intervals (windows) are applied to all the monitors. For this exercise the normal extraction window, "window #4" which extended from 50ms to 61ms in the Booster cycle, with extraction at about 58.5ms, was used. Although the tails of losses extend into the next (the fifth) window, the counts observed in window five were small enough to be neglected for this work. The Booster loss monitor system, in

low sensitivity mode, is in fact very sensitive given the typical beam loss associated with the high intensity operation. To avoid saturation, with the objective of losing the entire beam, an intensity of less than .5 TP must be used. This requirement, and the fact that the magnets in BtA are not "ppm" implied that this be a dedicated study. An "AGS extraction power supply failure" provided two hours during normal running time to carry out the measurements described below.

First the beam was "crashed" at Booster extraction by putting the F6 septum to standby. Then with extraction reestablished the crash was moved into the BtA line. The BtA crash was accomplished several ways; first by missteering the extracted beam with the first vertical dipole in the line, (DV007). Multiwire 125(which is on the AGS side of the wall in B.A.) was used to observe the effectiveness of this dipole in removing the beam. The multiwire profile moved about 5 mm on the wires (not to the edge of the flag) and then disappeared. Four other crashes were accomplished by mistuning the beam using the quadrupoles just upstream of the shield wall between Booster and AGS. A clear diagnostic to measure how much of the beam was lost in BtA for these four setups was not found. The multiwire downstream of MW125 were not functioning. Also the last current transformer in BtA did not give consistent beam information. However, a current transformer a A20 in AGS could see the injected beam albeit in a fuzzy fashion. The reduction of this current transformer signal as the quads were changed was used to gauge the effectiveness of the "kill". For each of the four cases the quad current was changed until the current transformer signal was reduced to near noise level - perhaps to 20% of its initial value.

The objective was to measure the signal size from the loss monitors for several loss "geometries" for a known beam loss. The hope was that the result will allow determination of a sensitivity (counts per Teraproton) for the loss monitors which could be applied to a situation where the geometry of the loss is not explicitly known. And of course what one really will take from this, without full justification, is a very small set of calibration numbers to apply to all situations.

Results

Table 1 gives all the loss monitor data for the various conditions. The BtA data has the "beam off" readings subtracted. For the complete kill of the beam using the F6 septum, the reported losses occurred nearly entirely in the F superperiod (for a .35TP loss, we see 37000 counts from all the monitors in the Booster ring, with 36000 of these in F superperiod , and 33200 of these in monitors F6 and F7. In this situation there only 220 counts from all of the BtA). This gives a calibration of 100000 cnts/TP lost, which is slightly high than the 85000 cnts/TP measured several years ago. The present measurement was for a "fast" loss - a loss occurring in a single turn - which in the past has been shown to give somewhat lower loss monitor counts than a "slow" loss - a loss occurring over milliseconds (e.g. when beam is scraped off as the extraction bump ramps up to value). During HEP, and judging from analog loss monitor signals, fast losses usually dominate at Booster extraction. The 20% increase in sensitivity relative to the past may reflect slight changes in the geometry of the loss, though this is a particularly simple case. It may also indicate that the sensitivity of the cable detectors has changes. The gas inside these coaxial cables is not flowing. At any rate, a 20% uncertainty is not unusual, and indeed is acceptable for loss monitor beam loss measurement.

The distribution of losses for the BtA beam "kills" described above are shown in figure 2. The vertical dipole loss is well contained - as it must be given the setup. Some lost beam could be avoiding the monitors because of the lack of coverage inside the shield wall section of the line. The first monitor in the line does not contribute to the pattern; we learn nothing about its sensitivity. This monitor is not "dead" as is clear from the BtA loss pattern when the F6 septum is turned off (shown for completeness in figure 3). For the four loss patterns resulting from the quadrupole swings the dump patterns are somewhat varied, with losses traded off between BTA114 and BTA160. However, again from figure 2, it is clear that these four dumps are not completely contained in BtA. Again this was probably built in to the method, since some beam appeared to survive to the A20 current transformer, The leakage may be covered adequately by our 80% beam loss assumption, but in retrospect, given the high agreement among these results, more variation in the loss pattern and a more complete beam loss would have strengthened the results.

The loss numbers are given in table 1. For the vertical dipole loss, summing over the monitors in the BtA line gives 11700 counts for .35 TP or 33500 cnts/TP. The same drill can be applied to the other four situations. If we assume that 80% of the beam is in fact lost in the line, then the results give (11300+/-700) cnts/.32 TP or about 35000 cnts/TP, The consistency over the four runs is high. It is certainly true that for this geometry less than .4 TP loss caused 11300 counts in the loss monitors, or equivalently that the sensitivity is greater than 28000 counts per TP.

<u>Discussion</u>

One reason for determining these sensitivity numbers is to attempt to pin down the locations of the (huge) apparent BtA beam losses which occur when we accelerate high intensity beam in the complex. These losses are implied from the difference between the current transformers in the Booster and AGS. Given the response times of those current transformers, the losses are not immediately assignable to Booster, to the BtA line or to early loss in AGS. The above numbers allow an estimate (and with greater certainty a minimum estimate) for the part of the loss occurring at Booster extraction and in the BTA line, to be combined with other measures in coming to an overall estimate for the loss amounts and locations. The question of variation with geometry is not explored thoroughly. The rather similar measured sensitivities for the upstream and down stream losses encourages the hypothesis that different loss geometries would give similar total loss monitor counts. The loss distributions actually seen for normal running are similar to those seen here except that for normal losses the first monitor in the line is a significant player.

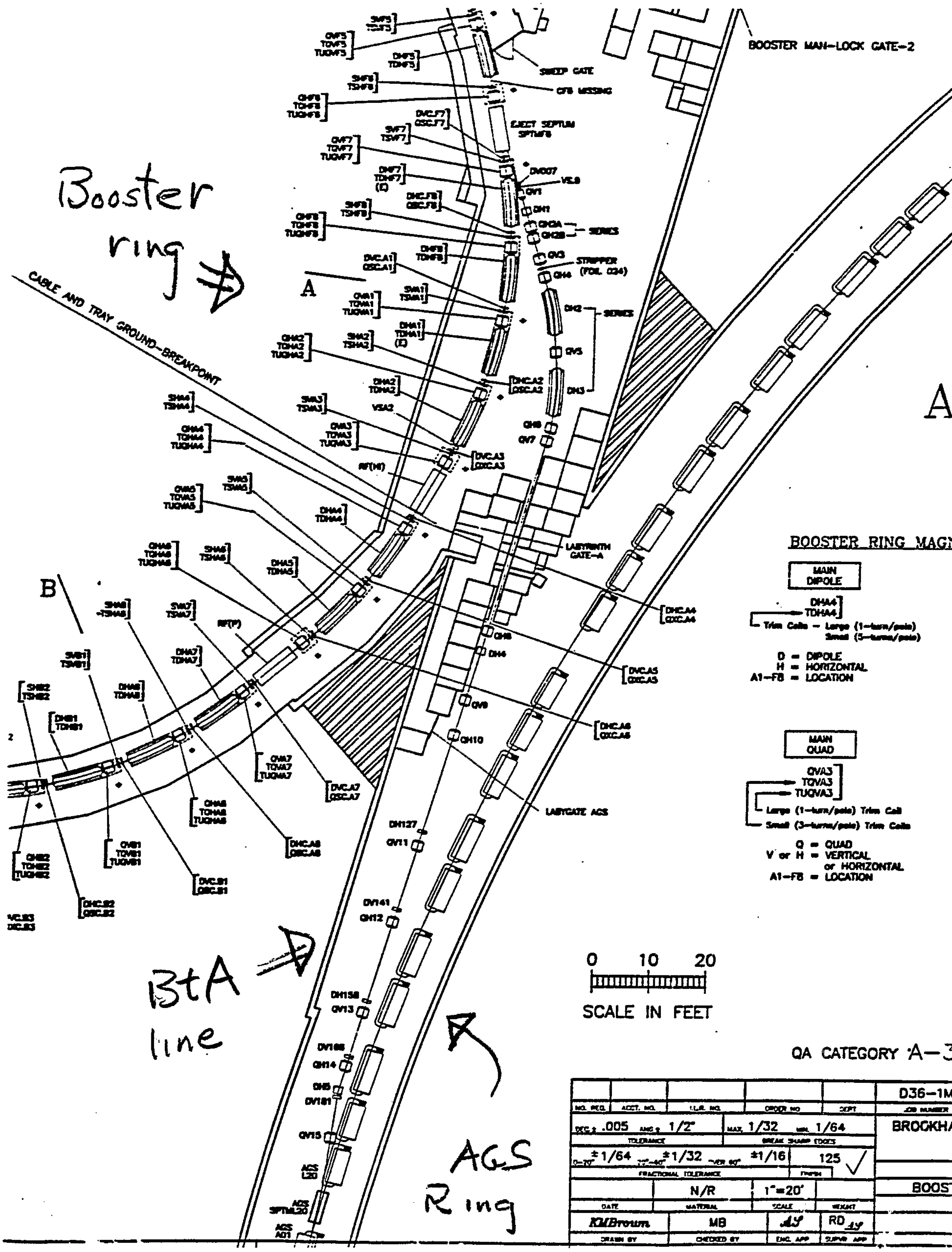
Booster ring
BtA line
AGS Ring
A
B
CABLE AND TRAY GROUND-BREAKPOINT
BOOSTER MAN-LOCK GATE-2
SWEEP GATE
EJECT SEPTUM
STRIPPER
SERIES
LABYRINTH GATE-A
LABYGATE AGS
BOOSTER RING MAGN
MAIN DIPOLE
D = DIPOLE
H = HORIZONTAL
A1-F8 = LOCATION
MAIN QUAD
Q = QUAD
V or H = VERTICAL or HORIZONTAL
A1-F8 = LOCATION
0 10 20
SCALE IN FEET
QA CATEGORY A-3
D36-1M
BROOKHA
BOOST
KMBrown
MB
1"=20'
N/R

Figure 1

		Booster	Ring	Loss	Monitor	Counts		
condition	intensity (Tp)	A	B	C	D	E	F	SUM
beam off	0.00	7	19	26	90	301	140	583
p910 run	3.00	2473	90	94	277	403	23694	27031
F6@stby	0.35	706	25	39	97	326	36239	37432
&F3lower(18.5)	0.35	2681	50	50	2861	503	27065	33210
&F3@17kV	0.35	2449	90	73	5998	947	19893	29450
normal ext	0.35	18	19	33	78	320	362	830

			BtA	Line	Loss	Monitor	Counts			
	intensity Tp	BtA023	BtA045	BtA067	BtA114	BtA137	BtA160	BtA183	BtA206	SUM
p910 run	3	454	69	49	1190	436	348	152	70	2768
F6@stby	0.35	168	24	20	0	0	10	-10	5	217
&F3lower(18.5)	0.35	843	211	79	0	0	10	-20	5	1128
F3@17Kv	0.35	537	147	59	-20	0	0	0	5	728
normal ext	0.35	5	-15	-5	250	88	69	5	5	402
wipe DV007	0.35	33	6831	3268	1010	240	167	59	85	11693
QH6200A	0.40	-5	-38	-5	3350	990	3856	1980	1875	12003
QH6-200A	0.40	-5	-33	-10	930	1127	4489	2043	2025	10566
QV7350A	0.40	-5	-29	-10	1730	1401	4057	1798	1855	10797
QV70A	0.40	-7	-29	15	5770	1504	1999	1142	1565	11959

Table 1

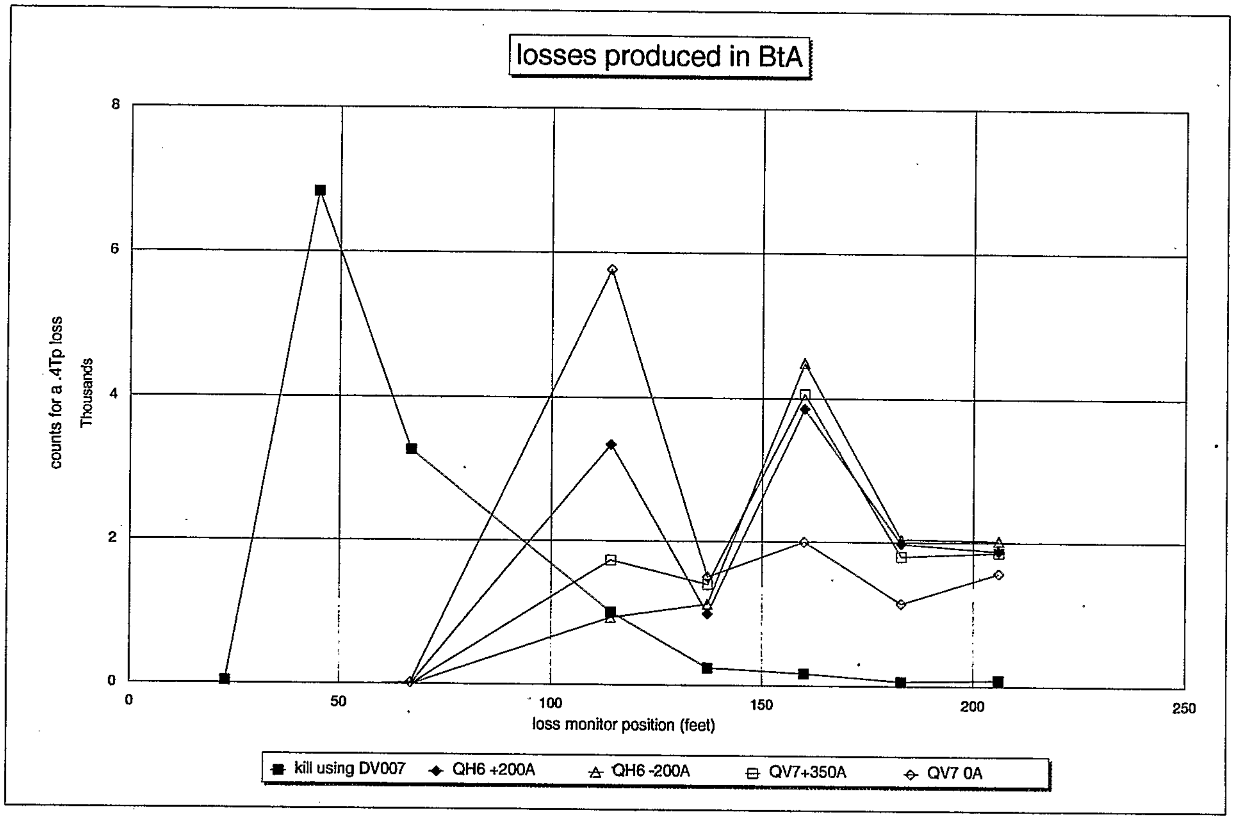

Figure 2 Losses for beam kills in BtA

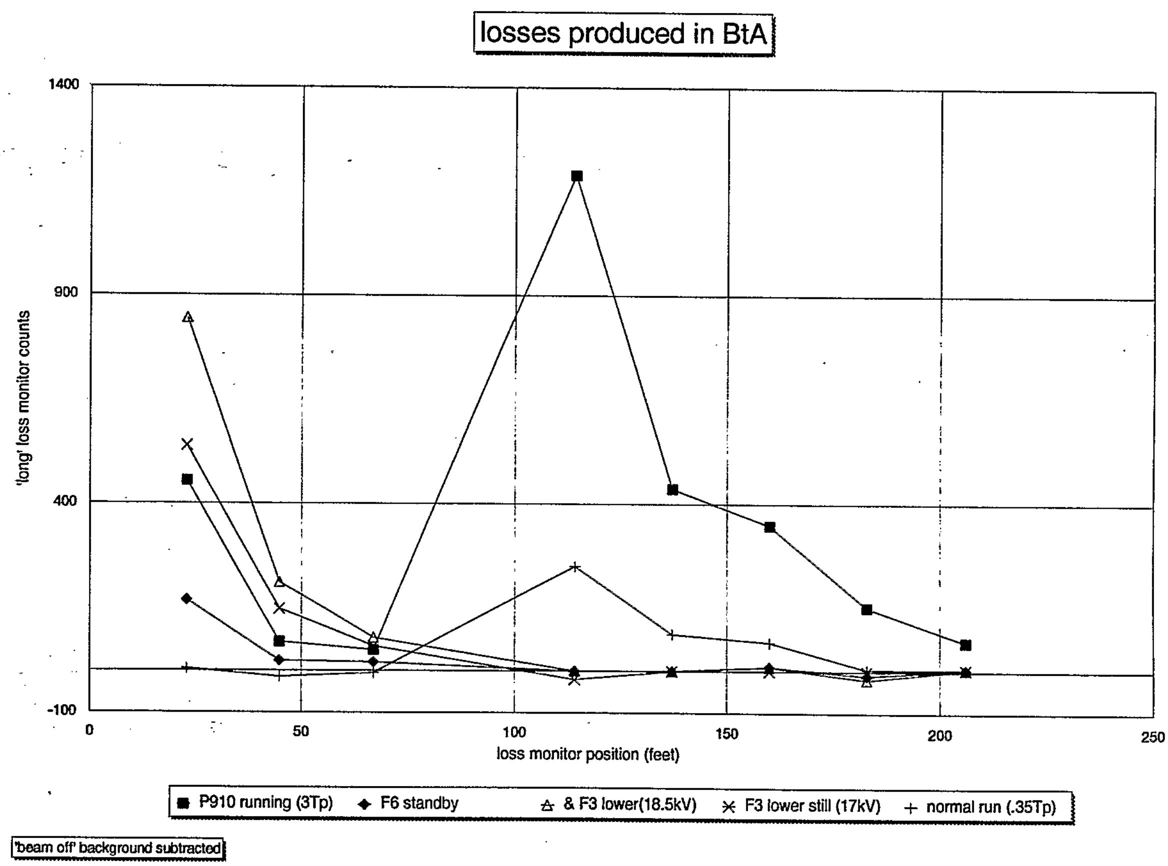

Figure 3 Losses for beam kills at Booster extraction