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BtA Losses 25 June 96 at 8PM

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AGS Complex Machine Studies (AGS Studies Report No. 349) Title: "BtA" Losses 25 Jun 96 at 8 pm
Study Period: 2000-2100 25 Jun 96
Participants: L. Ahrens
Reported by: L. Ahrens
Machine: AGS
Beam: High Intensity Proton
Tools: "Machine Efficiencies" Labview Program (Tamminga author) with Booster and AGS current transformers as inputs, AGS Loss Monitor system
Aim: To document where the beam is lost in going from Booster to AGS

I. Introduction

(Conditions and motivation)

We present a set of beam intensities and loss measurements associated with the "high intensity" AGS complex as it happened to be running on the evening of 25 Jun 96. The situation is not optimal in terms of intensity or losses for this running period, it is not unusual however. From the scalars in MCR, the "late" intensity for AGS was about 56Tp (10^{12} protons), the intensity in the AGS just after the last Booster transfer, was about 62 Tp, the intensity at Booster extraction was 86Tp. Our objective is to further quantify the losses associated with the transfer of beam between the Booster and AGS - how much and where. The tools to be used are the AGS and Booster current transformers and loss monitors with associated application codes.

II. Data to be presented

Although the intensities in the two machines are already listed above, for this note we evaluate beam intensity using the same current transformers, but as captured on a digital scope in MCR, with the signals coming from their sources via the mux system. The calibration of these signals is carried out independently, using the available calibration pulses as seen by the same scope display. The time dependence of beam intensity during the acceleration cycle, especially in the AGS, is evaluated using the "Labview" program developed by Bonnie Tamminga this year. This program quantifies the beam losses presented by the calibrated current transformers, breaking them up into losses "seen" in the AGS (which are further divided into the "slow" losses occurring on a millisecond time scale around the four transfers and "drool" losses occurring during the rest of the 133 ms between transfers) and losses not seen in AGS - implied from the difference between the late Booster intensity and the upward steps in AGS. This type of loss is referred to as "BtA" loss in the program. It could occur at Booster extraction, in the BtA line itself, or in AGS over the first few (maybe ten) turns. It might not exist at all - if the relative calibrations of the transformers in the two machines is flawed.

For about the same machine conditions the "new" AGS loss monitor system was asked to measure the losses occurring across the AGS injection porch. A first pass at a "calibration" for this system at injection is used to compare these numbers with the current transformer data.

Data was not taken from the Booster (BtA) loss monitors at this time. The AGS loss monitor data and the current transformer data were for different AGS cycles. The cycles occurred within the same hour, and machine conditions were stable.

III. The Data - a Summary

The current transformer data claims nearly equal amounts of a) "visible" loss in AGS and b) "between machines" loss, both 3 (+/-1) Tp for each Booster cycle. Of the visible loss in AGS, 1Tp is "slow" , 2 Tp is drool. (In retrospect, the data we took has what seems a large and uncharacteristic drool component - showing what might be steps on the porch between transfers. It is not impossible that some of this could be instrumentation, even the particular mux connection, but never mind). To facilitate comparison both with the loss monitor numbers and with the scalar current transformer numbers we eliminate the final drool after the last transfer in this analysis. So then we have the Tamminga program claiming 12.1Tp BtA loss, and (less the last drool) 9.4Tp of visible loss in AGS; 21.5 Tp lost in all.

The AGS loss monitors accumulate 10250 counts across the porch. A nontrivial portion of this (estimated at 2100 counts - from 1st turn kill pattern but with a large uncertainty) has the appearance of cross talk from the BtA line and is subtracted. The sensitivity of the AGS system to "slow" losses at injection is estimated from some study work (S.N. 348) at about 400-500 counts per Tp. Taking the 500cnts/Tp number, and assuming all the loss is "slow", the (10250-2100)=8150 counts would correspond to 16.3Tp lost; 400cnts/Tp would require 20.4Tp lost. The transformer data says 21.5 Tp are available.

If a portion of the "BtA" loss is in fact "first turn" loss in AGS, the counts/Tp generated by the AGS loss monitor system are expected to be much lower. The loss monitor sensitivity for all geometries explored went down dramatically for fast losses (to 150 cnts/Tp for a single turn loss). The trade off between slow and fast loss mechanisms then would allow more protons to be lost in AGS without increasing the loss monitor counts seen. Unless some anomalously sensitive loss monitor(s) dominate the AGS result, the data has little room for large single turn losses and for large losses upstream of AGS. The AGS loss monitor data is then easily made consistent with the hypothesis that all of the loss reported from the current transformers actually happens in the AGS.

Going the other way, if there were little “low sensitivity” fast loss in AGS, and the higher sensitivity number (the 500 counts/Tp) is taken for the AGS system, then (21.5-16.3=5.2)Tp of beam could be lost upstream of the AGS over the four transfers or 1.3 Tp/transfer. This much loss cannot be ruled out from what we know of loss monitor data. About .4 Tp loss would create 40000 Booster Loss Monitor counts in the F superperiod and the rest would make 31000 counts in the long monitors in the line. We don’t have Booster loss monitor numbers taken at this particular time, but know these magnitudes are not ridiculous. During the run the F6 and F7 monitors frequently ran close to saturation, which would correspond to 40000 counts in F, and some numbers in “store” for the long monitors in BtA are nearly as high as 30000 counts.

Results from the Tamminga program for current transformer dumps for two AGS cycles:

IX data	cycle 2 (Tp)	cycle 3 (Tp)	cycle 4 (Tp)	cycle 5 (Tp)	sum (Tp)
BtA	3	1.8	2.9	3.7	11.4
Slow	.7	1.2	.5	1.2	3.5
Drool	1.0	2.3	2.5		5.7
BtA	2.5	2.3	3.3	4.7	12.8
Slow	1.6	1.4	.4	.7	4.1
Drool	.6	2.5	2.3		5.4

The average beam seen being lost in AGS through the last transfer is then 9.4Tp, the beam lost after Booster late and before the AGS current transformer is 12.1 Tp. The following table results from weighting these losses by various sensitivities for the AGS loss monitor system with the assumption that all of the beam in fact gets into the AGS. The observed loss monitor counts were 8150. At the high sensitivity end, half of the “BtA” type current transformer losses still need to happen in the AGS - but then nearly half would happen upstream of the AGS.

assumed Fast (BtA) sensitivity (cnts/Tp)	assumed slow (AGS) sensitivity (cnts/Tp)	“BtA” type beam loss (in AGS) <12.1Tp>	“AGS” type beam loss (in AGS) <9.4Tp>	Predicted loss monitor sum	excess, (prediction over observation)
150	500	1815	4700	6515	-1635
150	400	1815	3760	5575	-2575
500	500	6050	4700	10750	2600
		<6.9Tp>	<9.4Tp>		
500	500	3450	4700	8150	0

Below we include two pictures from this work. The first (figure 1) is one of the displays from the "Machine Efficiencies" Labview program showing the beam intensity 'scope data as collected by the program, and the extracted beam losses for the various intervals. Figure 2 shows the measured AGS losses across the injection porch. With losses occurring in BtA subtracted as best we can, the loss leaders (and l.m. cnts) by superperiod are F (2295), L (1710), A (1205), H (1090), I (520), G(350). Sixty percent of the loss (count-wise) occurs in just 9 monitors: L6(890), F12(880), A2(760), F14(530), H12(505), F16(480), L14(360), L20(355), and L12(300). A given monitor (e.g. L6 covers two AGS main magnets and the straight section in between (e.g. L5 and L6).

runningplot0430.vi

Running Plot

	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle Average
Booster	2.82	2.49	3.36	3.06	2.93
BTA	1.88	1.84	2.40	3.77	2.47
Pre Transfer	0.30	0.43	0.04	0.22	0.25
Post Transfer	1.25	0.95	0.39	0.52	0.77
Drool	0.60	2.54	2.28	1.16	1.64

X E12 particles

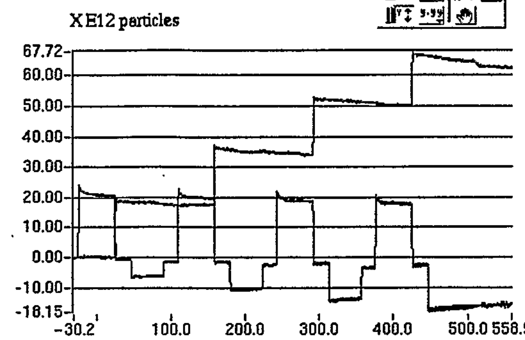

Figure 1 Machine Efficiencies Output, Current Transformers in Booster and AGS

DATA: SAVED FILE typical_25jun96 - REFERENCE FILE injoff ACQUISITION DATE: Tue Jun 25 20:56:17 1996
GAIN SETTING: LOW AGS CYCLE: 11845 11846 11847

WINDOWS:	475 ms.	625 ms.*	750 ms.*	1200 ms.*	2200 ms.*	3000 ms.*
SUMS:	10261 cts.	1442 cts.	8248 cts.	614 cts.	9307 cts.	7788 cts.
SIGMAS:	382.2 cts.	132.5 cts.	459.6 cts.	82.5 cts.	118.4 cts.	83.5 cts.
XFORMER:	5875 cts.	5568 cts.	5441 cts.	5403 cts.	2274 cts.	-76 cts.
SIGMAS:	41.4 cts.	57.6 cts.	42.8 cts.	34.2 cts.	18.4 cts.	17.2 cts.

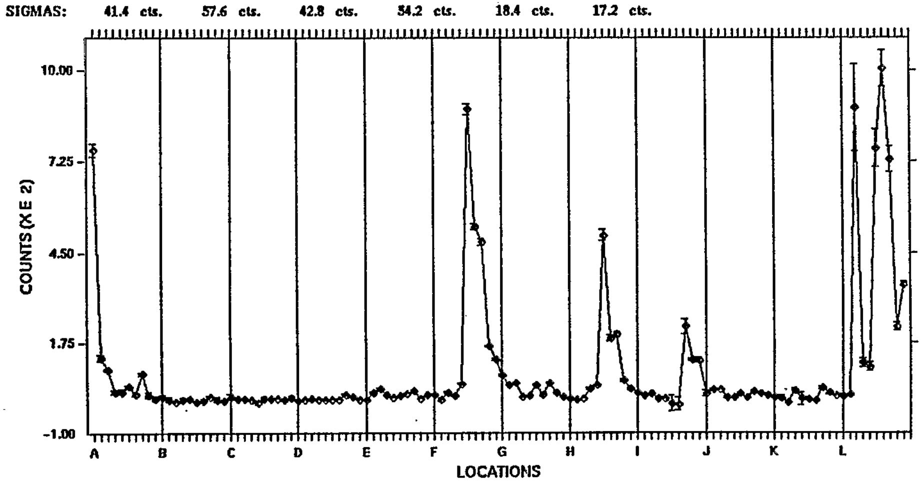

Figure 2 AGS Loss Monitor Report for the Injection Porch

IV. Discussion and Conclusions

Both tools (the AGS loss monitor system and the "Machine Efficiencies" Labview program) used in this analysis are still "work in progress" to some degree, but mature enough for use. More details on the loss monitor system can be found in other recent study notes. The "Machine Efficiencies" program requires the setting of many parameters (data "smoothing"optimization, widths for time windows, determination of calibrations for the two contributing current transformers) to allow extraction of the processed numbers. Exploring the sensitivity of the results to the setting of these parameters is work in progress. The first pass on this suggests that while for example the allocation of losses between slow and drool categories in AGS is sensitive, the total "visible" loss in AGS - which is the relevant piece for this work - is rather insensitive to the details.

This work claims that at least 70% of the "BtA" loss occurs in the AGS, and the fraction could be higher.