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Results from Beam-Fault Studies #30 performed along the Y-arc of the ATR Line Using Polarized Proton Beam

Beam fault studies were performed over the Thompson Road area, and along the Y arc of the ATR transfer line, to assess the effectiveness of the shielding material below Thompson Road area when a bunch of polarized protons is transported down the Y-arc under fault conditions.

The study was performed on Sept. 8 2000 at ~13:00.
A summary of the results of the study is presented below.

The written procedure of the study was reviewed by Dana Beavis and the approved and signed copy is attached in the page 141 of the Fault Studies Book FE.304.0.09701 which is kept in the MCR of AGS.

A photo-copy of the AGS-OPM 9.1.9 document which ensures the "approval of the execution" of the fault studies, is complete with all signatures, and is attached in the page 140 of the Fault Studies Book FE.304.0.09701 which is kept in the MCR.

After establishing "normal beam transport" (minimum beam losses as read by the Y-arc BLM's) along the Y-arc, five fault conditions were generated by setting the magnet current of the Y-arc to 99.5, 99, 98, 96 and 94% of the current corresponding to the "normal beam transport".

For the "normal beam transport" and for each fault condition, the following measurements were obtained:

a) Radiation readings using HPI-1010 monitors placed at six "specified points" on the surface along the along the Y-arc. A schematic diagram of the Y-arc magnets showing these "specified points is attached on the page 142 of the previously mentioned fault studies book.
The location (in meters) of these "points" along the Y-arc with respect to the beginning of the switching magnet is shown in the Table 1 below.
For each of these points, two additional radiation measurements were obtained, but at points 10 feet to the Left and 10 feet to the Right transversely to the Y-arc direction.
The measurements were recorded on a page which is signed by the HP (Mike) involved in the study, and is attached on the page 142 of the previously mentioned fault studies book. (L=Radiation measured on the Left point looking downstream C=Radiation measured on the Center point, R=Radiation measured on the Right point looking downstream).
The Radiation readings of the HPI-1010 radiation monitors, for each fault condition, appear in TABLE 2.
The maximum reading of the HPI-1010 was 0.4 μrad and this corresponded to the fault condition of 99% were the beam (as the BLM's of the Y-arc indicate) scrapes the beam pipe during its transport down to the Y-line.

The three HPI-1010 used in the measurements were source calibrated by the HP involved in the studies, an hour before the studies.

The background radiation readings (no beam) as measured with the monitors HPI-1010 are ~0.3 μrad.
These readings appear as sudden bursts every 4-5 minutes and are unrelated to the beam.

b) The beam current of the transported beam was measured by the uxf1, uxf3, wxf1, and yxf1 current transformers.
The beam current during the fault studies maintained a value of ~$5x10^{10}$ protons/pulse. The value of the beam current for each fault condition is shown on GPM plots which are attached on pages 143 to 145 of fault studies log-book mentioned earlier.
The current transformer yxf1 provided reading for the 0% and 0.5% beam-fault conditions only. The rest of the fault conditions did not allow the transport of beam at the location of the yxf1 current transformer.

c) The readings of the BLM's along the Y-arc[1]. Plots of the BLM's readings vs BLM location, for each fault condition, are attached on pages 143 to 145 of fault studies log-book.
The radiation readings of the BLM's for the 0.5% fault condition were identical to those of the "normal beam transport". This indicates that there are no beam losses for 0.5% beam-fault condition.

d) The 30 seconds interval readings of NMO216 for each fault condition is plotted and attached on pages 143 to 145 of fault studies log-book..

TABLE 1

LOCATION #	1	2	3	4	5	6
DIST. FROM SWM (m)	43.0	48.6	53.4	61.4	67.6	76

TABLE 2

Fault % ΔI/I	Locat. #1			Locat. #2			Locat. #3			Locat. #4			Locat. #5			Locat. #6		
	L	C	R	L	C	R	L	C	R	L	C	R	L	C	R	L	C	R
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0.2	0	0	0.2	0	0	0	0	0	0.4	0	0	0.2	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0	0	0	0
4	0.2	0.2	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0	0	0
6	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8		0			0													

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[1] The BLM's are used to detect relatively small radiation levels due to low beam losses during beam transport along the transport lines, and their electronic gains therefore are set for these levels (<160 mrem). High radiation levels, as those produced during fault conditions, will saturate the BLM's which, in this case, loose any quantitative information about the beam losses.
In addition, neighboring BLM's along the transport lines are chained together, and some "position resolution" on the location of the radiation is lost.

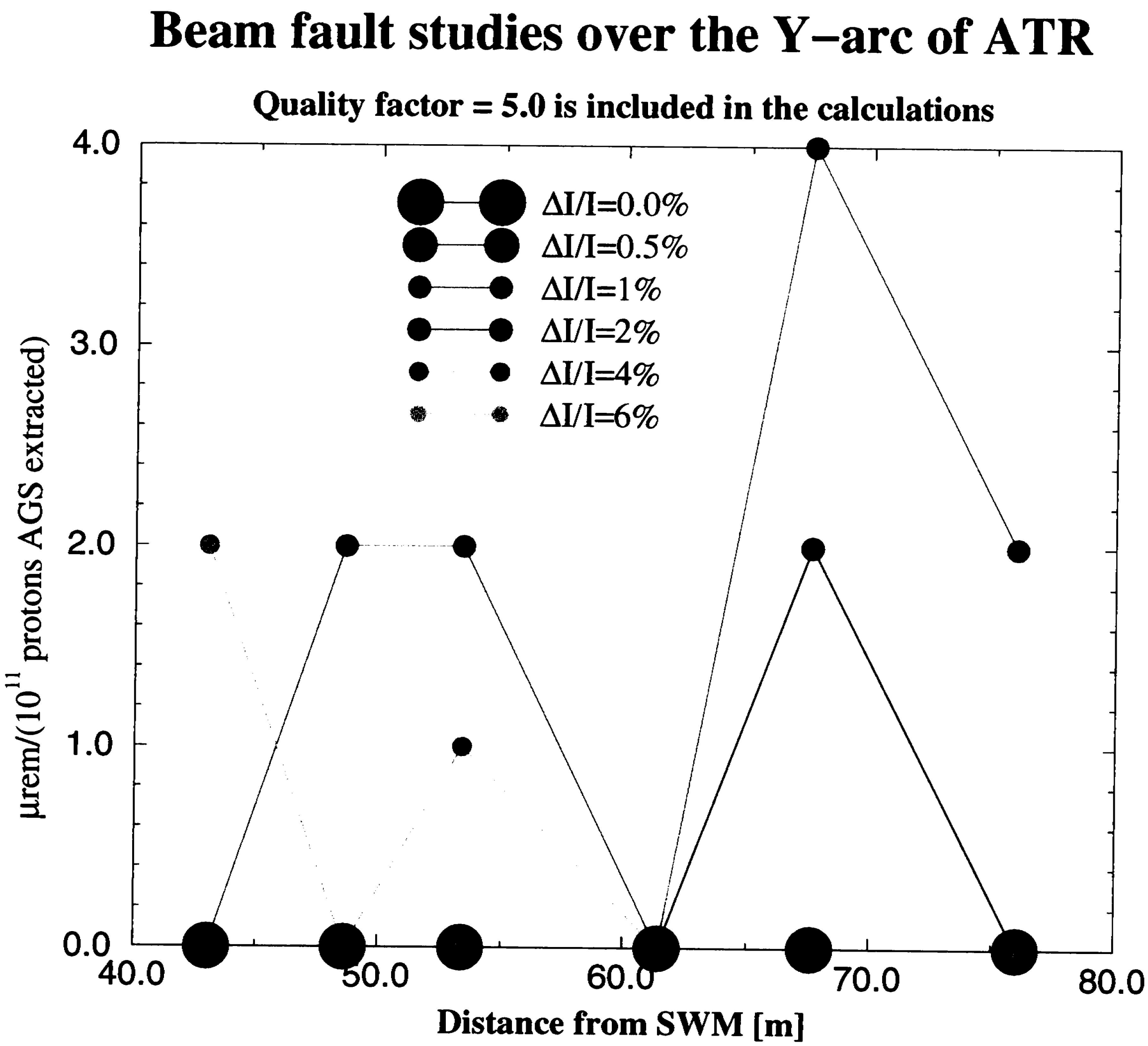

Figure 1. The radiation levels in µrem per 10^{11} protons, for a given fault condition, at the location "points" shown in TABLE 1 as function of distance of the "points" from the switching magnet.

Presentation of the results

The results showing the radiation levels along the Y-arc under fault conditions described earlier in the text, are presented in Figure 1.

Interpretation of the results

1. The "**normal beam transport**" and the "**99.5% fault condition**" show no radiation levels above background, as detected by both the HPI-1010 (see Figure 1) over the Thompson Road, and the BLM's which are located inside the tunnel of the Y-arc. In addition the yxf1 current transformer indicates "**normal beam transport**" under both conditions.
2. The "**99% fault condition**" yields radiation levels along the Y-arc (see figure 1). The radiation is due to beam scraping along the Y-arc as the BLM's of the Y-arc indicates.
3. The "**96% and 94% fault conditions**" generate no significant radiation levels (<0.1 µrem/10^{11} protons) beyond 60 m from the switching magnet (see figure 1). These radiation levels are receding upstream as the fault condition increases. The BLM's of the Y-arc demonstrate similar behavior.

4. Theoretical calculations (Alan Stevens) show that fault conditions that stop a beam of 10^{11} protons at ~24 GeV/nucleon will generate 50 μrem on the surface of Thompson Road.
The calculations are based on fault condition where the beam stops within the radiation length. Such an assumption may not be valid under the conditions the fault-studies were conducted where the beam which is deflected horizontally only will interact with the vacuum chamber before it stops in the iron of the magnet. (see Figure 2). This may explain the difference between the observed (Figure 1) and calculated (50 μrem) radiation levels.

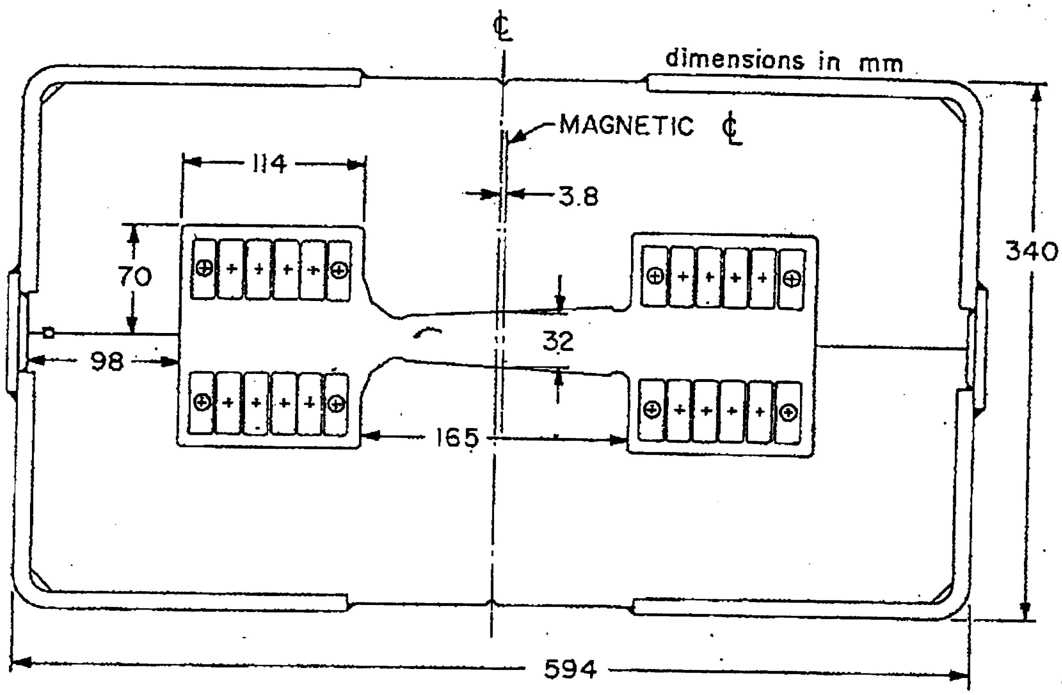

Figure 2 The cross Section of the "B type" combined function magnet. There are 26 such dipoles along the Y-arc. The vacuum chamber (not shown) is located within the gap of the maget.