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Continued Search for the Source of the North Conjunction Area Muon Radiation--Shielding the H20 Electrostatic Septum

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Continued Search for the Source of the North Conjunction Area Muon Radiation -- Shielding the H20 Electrostatic Septum

Study Period: July 12-14, 1994	
Participants: L. Ahrens & J.W. Glenn	
Reported by: L. Ahrens	
Machine: AGS	
Beam: Normal HEP	
Tools: Digital Oscilloscope, AGS Loss Monitors	
Aim: Understand source for North Conjunction Area radiation.	

Introduction:

Early on during the present HEP run, unexpectedly high "chronic" levels of ionizing radiation, with a quality factor consistent with muons as the ionizing particles were found outside the North Conjunction Area (NCA) adjacent to the AGS ring. The word chronic means these losses were occurring with a normal AGS setup - nothing about the AGS setup was obviously unusual. There is no indication that subsequent evolution in the AGS setup during the run changed the source term for this radiation in a fundamental way, though the addition of external shielding adequately reduced the chronic radiation levels.

The geometry of the North Conjunction area (see figure 1) is such that particle trajectories nearly tangent to the ring over most of a superperiod end at the North Conjunction Area shield wall having passed through rather minimal shielding prior to hitting the wall. The geometry would allow pions created in this superperiod at the beam pipe and traveling in roughly the forward direction relative to the circulating beam to decay to muons traveling into the North Conjunction Area. Of course the geometry could also be characterized simply as relatively thin shielding in the forward direction allowing a "chronic" muon "beam" associated with the normal losses around the synchrotron and transported by the synchrotron magnets albeit in a very inefficient manner to be observed.

The demands on the shielding required to eliminate radiation outside of the area would be greatly reduced if some fraction of the shielding were placed so as to interact with the source pions thereby reducing the flux of subsequently produced muons at the high energy end. The problem is to identify the pion production sites and, if the region is accessible (outside of the vacuum chamber) and if only a few such regions exist, to add very local shielding at these spots.

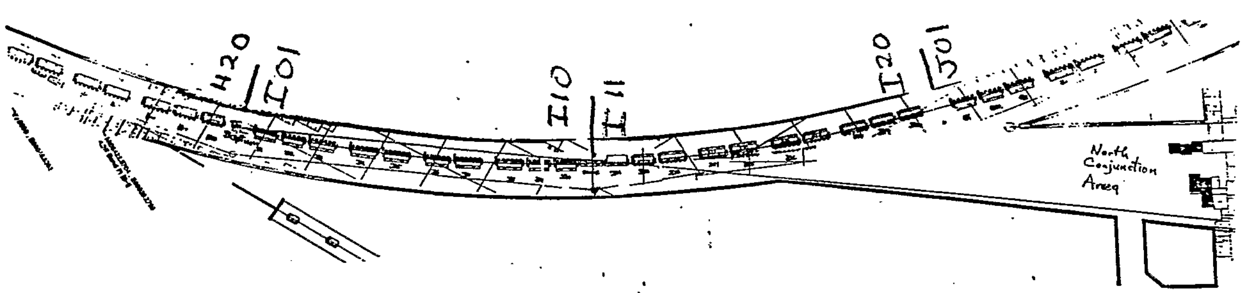

Figure 1 The AGS Ring Near the North Conjunction Area

A prime candidate for a radiation source is the H20 electrostatic septum. There is measurable loss in this area under normal running conditions (i.e. chronic loss see table 1), and a straight line can be drawn from H20 to the NCA shield wall which only intersects material where that line crosses the vacuum chamber at about the I10 straight section. The present attempted to affect a hypothetical H20 pion source and measure a resulting change in NCA radiation.

U-P SET UP: MODE=1 1700 TO 3000MS PLOT NUMBER 1 DISPLAYED
14-JUL-94 TIME=13:21 49.6

A	B	C	D	E	F	G	H	I	J	K	L	S
3	3	3	3	3	3	1893	0	81	-4	3	3	1634
3	3	3	3	3	69	233	10	3	-4	3	3	1716
3	3	3	3	3	4188	8	3	3	3	3	3	3647
3	3	3	3	3	416	3	3	3	3	3	3	-4
3	3	-1	3	3	420	3	3	3	3	3	3	1926
3	3	-5	3	3	3058	3	3	3	3	3	3	1897
3	3	3	3	3	874	3	3	3	3	3	3	1875
3	4	3	3	3	-4	3	3	3	3	3	3	3
3	3	3	3	3	255	3	3	3	3	3	3	
3	3	3	3	24	985	3	19	3	3	3	3	

Table 1 Chronic Losses during Extraction from the AGS

Each number in this table gives the integrated radiation seen by a 2 AGS magnet long loss monitor. The electronics is set up to give a small positive output if no detectable radiation is present. For this integration window, the "no beam" output is about 3 counts. For example the first "3" under "A" indicates that the monitor at AGS magnets A1-A2 saw less than one count of radiation. The "24" in the column under "E" indicates that the monitor at AGS ring magnets E19-E20 saw 24-3=21 counts of radiation. Negative numbers (C9-C10), (C11-C12), indicate (in code) specific problems associated with the Datacon transmissions for those channels. This particular data set represents an integration across most of the extraction period (1700ms - 3000 ms from AGS T0). One fact the data shows is that the I superperiod is clean - a conclusion consistent with the relatively low activation in this superperiod and an indication of the basic dilemma associated with the external North Conjunction Area radiation.

Setup:

The basic approach in the search for the NCA radiation source is to look for correlations between the NCA radiation and losses measured elsewhere in the ring. The beam loss occurring at H20 can be measured using the analog signal from the "I02" ring loss monitor located at I01 - I02 (the analog version of the signal integrated and displayed in Table 1). This monitor is located at larger radius than the beam, below the top of the magnet support girder. The analog signal is proportional to the "instantaneous" loss in this location. For the present study the analog signal is "integrated" using the capabilities of a digital oscilloscope in MCR. The loss beyond the shield wall in the NCA is monitored using a short ion chamber located adjacent to the radiation sensing "chipmunk" (NMO77). This chipmunk was positioned to sense radiation near the G-2 beam line outside of the NCA. The electronics attached to the ion chamber are inherently integrating. Figure 2 shows typical signals from these monitors as well as from the similar ring loss monitors from the F5-F6 section and the F11-F12 section. These last two monitors are sensitive to losses at the F5 septum magnet and the F10 ejector magnet, which (table 1) are the ring spots with highest losses during extraction. The ramping portion of the signals corresponds to the time period when the proton beam was being slowly extracted from the AGS. When this data was taken there was no significant signal from the NCA at any other time in the acceleration cycle. The data summarizing the losses for this particular cycle are the numbers in the right hand column (59.4 mV for the NCA monitor and 8.95 mVs for the I02 monitor. These numbers are used as measures of the relative losses at these different locations with all the data clearly coming on the same AGS cycle. From comparison with figure 1 (not the same cycle however) one count in the digital system corresponds to about .1 mVs in this analog system.

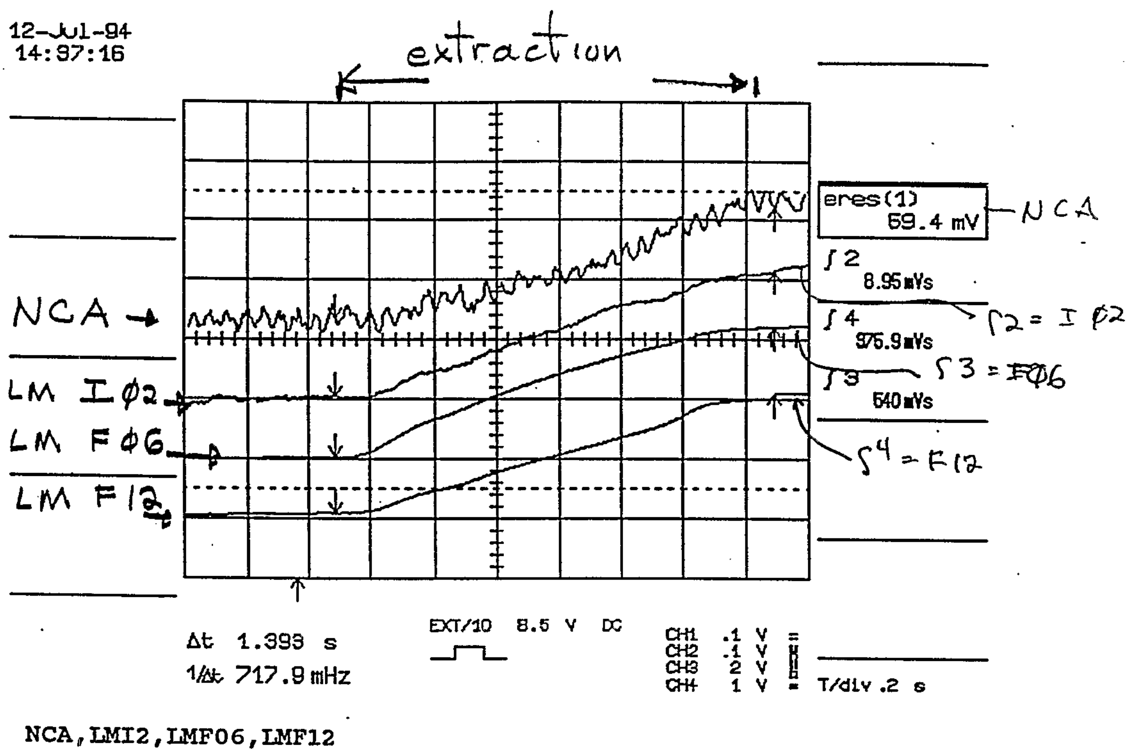

Figure 2   Integrated Analog Signals from AGS Loss Monitors

The specific experiment is to look for a change in the correlation between loss at the I02 loss monitor and the NCA monitor when some additional material is inserted downstream of the H20 electrostatic septum. The "material" was added to the gap of the I01 magnet during an interruption to the program on 13 July 94. Figure 3 gives a cross section of the I01 magnet and the added material. The beam travels into the paper. The material consisted of two 1.5 inch diameter rods of "G-10" and eight 1.5 inch diameter rods of Phenolic material. The specific gravity of the phenolic is given as 1.26, the G-10 as 1.7. The rods extend nearly the full length of the magnet (about 75 inches). The conjecture is first that some pions (presumably created just upstream of I01 in the H20 electrostatic septum straight section) traveling through the (apriori empty) volume defined by the plastic material decay into muons which find their way to the ion chamber by the NCA chipmunk; and that with the plastic added some of these pions interact in this chunk of plastic ultimately yielding lower energy muons which range out in the shield wall and hence do not get to the ion chamber. If a Collision length of 60 g/cm^2 is assumed, and average density 1.4 g/cm^3; the collision length is 43 cm or 17 inches. Therefore, for pions in the magnet gap outside of the vacuum chamber and traveling nearly forward, there is a large probability of at least one nuclear interaction.

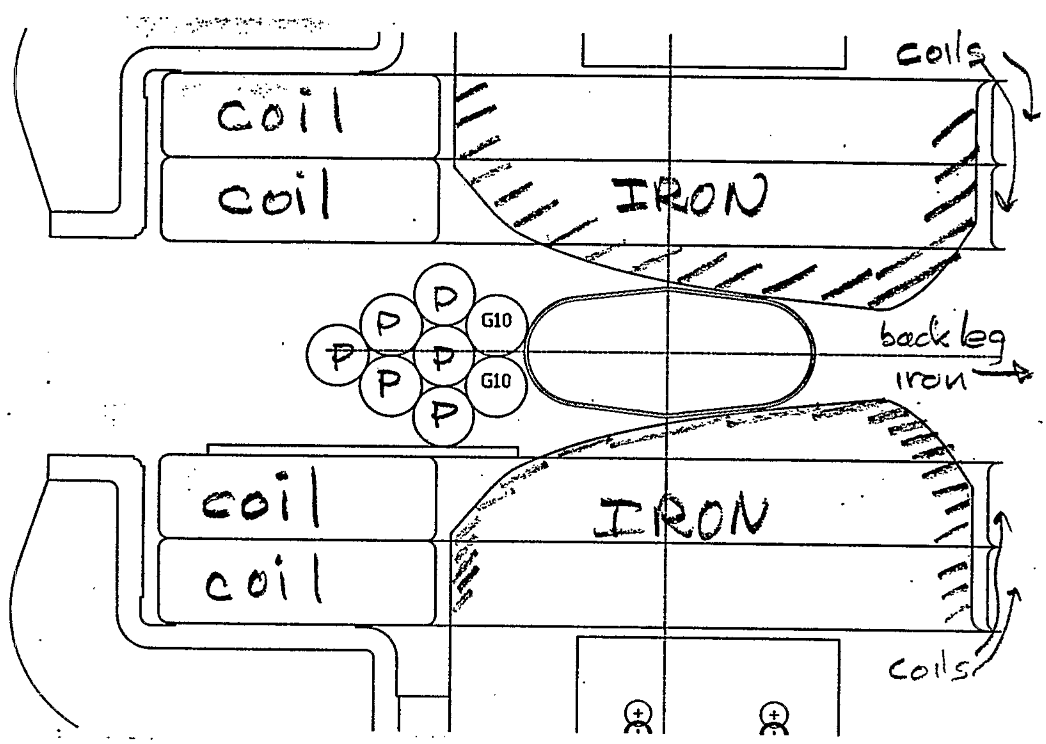

Figure 3 Cross Section of the I02 AGS Main Ring Magnet, and Added Material.

Summary of Results:

Figure 4a gives the "before" data taken on July 12. A lot of "chronic" shots were measured. In addition the H20 flag was inserted into the extracting beam to create a larger loss at H20 and I02 with the response of the NCA chamber documented. In fact inserting the flag caused a very pronounced effect at the NCA monitor (and at the NM077 chipmunk. Following the insertion of the material in magnet I01 on the 13th, the experiment was repeated. Again data was taken with the H20 flag out and inserted and again a strong correlation was measured. Figure 4b gives this data. The slope or "transfer function" is not significantly changed by the addition of the material. The line in the figure just displays unity slope.

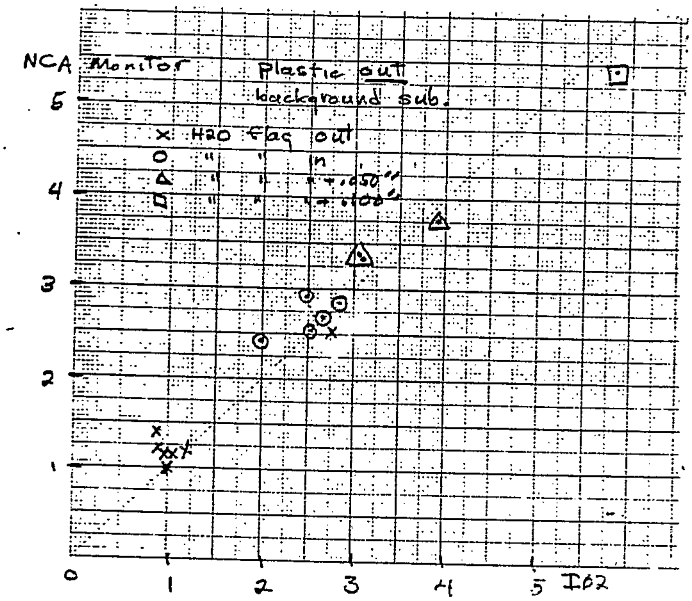

Figure 4a

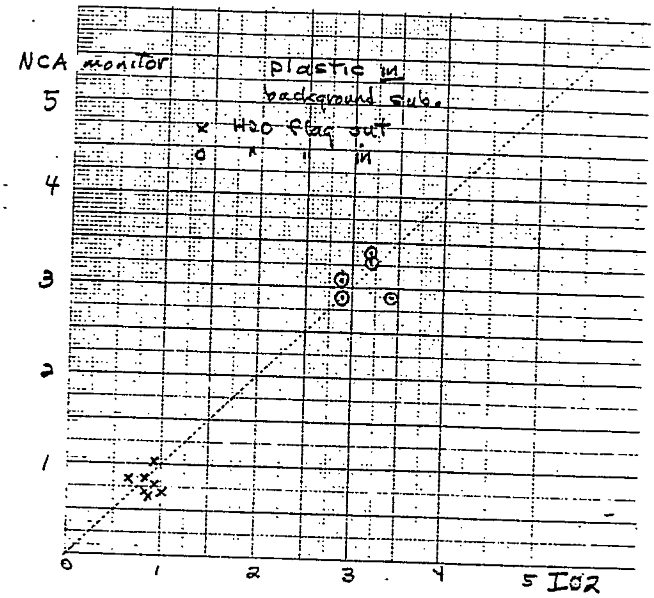

Figure 4b

NCA Monitor Signal vs I02 Loss Monitor Signal. a) without and b) with material in the I01 Magnet Gap.

All of the data is "normalized" by the values obtained on one arbitrary shot - which then shows up as a point at (1,1) in Figure 4a. This is done only to make the scales simple. The x's are chronic loss shots. The circles are taken with the H20 flag creating additional loss. The triangles and square in 4a are losses with the flag pushed still further into the extracting beam. The apparently linear sensitivity to loss at H20 together with the additional observation (not shown) that the measured losses at both F05 and F10 did not change as the flag was inserted encourage the hypothesis that loss at H20 is directly associated with NCA chronic radiation. The lack of a change in this transfer function with the addition of the I01 material indicates that some other assumption in the above conjecture is not correct.

This note is not at all a complete statement of understanding about the NCA radiation, but just about the study of adding material to the I01 magnet gap. As an indication, figure 5 is included showing chronic loss in the NCA at an earlier time (late June) in the run. The top trace again shows loss measured in the NCA. The ion chamber is at a different physical location the NCA-associated shielding is slightly different than for the other data presented in this note. The second trace shows local losses at H20, a different monitor than I02, but presumably carrying the same information. The lowest trace gives (instantaneous) loss downstream of the "catcher" at E20 - far upstream of the NCA. The point is that the step in the NCA loss at the end of the spill - representing more than a quarter of the NCA loss on this shot occurred with no correlation, not even a hint to losses seen at H20 and with high correlation to losses at the "catcher".

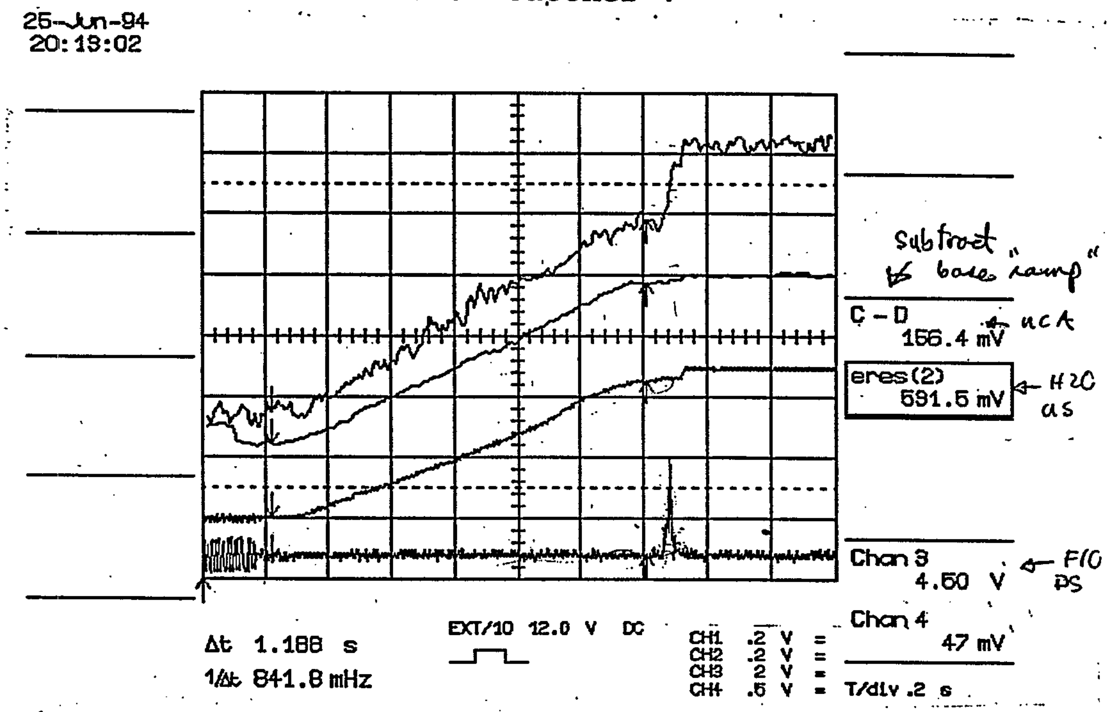

Figure 5. A Different Source: Losses during Extraction at NCA (top), H20 (second), F10 downstream, and the E20 "Catcher" (bottom trace)