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AGS Main ring loss monitor systems/External beam loss monitor systems

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EXTERNAL BEAM LOSS MONITOR SYSTEMS

I. Introduction

This technical note describes the beam loss monitor systems presently in use in the AGS. The main impetus is to give the uninitiated an overview of what systems exist, some of the rationale behind them, and some of the places (both physical and programmatical areas) in which they are used.

There are several major reasons why we are concerned about the measurement of beam loss in the AGS. The first is to be able to account for the beam that has not reached its goal (e.g., during the processes of acceleration, extractions, transport, etc.). Where this lost beam goes is most important in several ways. It not only subtracts from the ultimate or final beam intensity, but it also activates equipment in the vicinity where it is lost. The second reason for beam loss measurement is as a potential diagnostic of what may be going wrong in the AGS if we cannot accelerate "smoothly" to high energies, or in the beam lines if we can't, for example, split the beam readily. The third reason is that as one gets the "output" beam closer to the "input" beam (i.e., close to 100% acceleration, extraction, etc.) it becomes increasingly difficult to measure absolute quantities of "input" and "output" with enough accuracy to be able to take a ratio or a difference of the two to determine the efficiency or the beam lost. Measurement of the lost beam quantity directly however, can be accomplished with much lower resolution or accuracy, and still give better efficiency and loss percentages.[1-2]

II. Loss Monitor Systems in Use

The loss monitor systems currently in use in the accelerator complex are based on the ionization principle. All the schemes are very similar in operation. They use an electric field to drift the ions to a collector and then convert the current flow into an analog voltage signal and digitize it in some fashion. The differences in the various systems arise from: [1] geometrical considerations (basically the loss monitor length and its orientation to the beam loss), [2] the biasing scheme (floating or ground-based power supply), [3] the electronic readout system, and [4] their time response to the character of the pulsed beam radiation they are trying to measure (e.g., the linac 300 microsecond beam pulse or the SEB 1 sec pulse).

The systems that will be described in section III of this note are: [1] the AGS Ring Long Loss Monitor, [2] the AGS Ring Short Loss Monitors, and [3] the SEB and FEB line Long and Short Loss Monitors. The other systems in operation are the Linac Long Radiation monitor system[3] (which also performs a fast beam interrupt function), and the AGS Ring Long Radiation Monitor[4] (a segmented system in which each loss monitor encompasses two AGS magnets). These systems are described in the references cited and will not be covered here.

III. Detailed System Descriptions

As mentioned in section II, the loss monitor systems are based on the ionization of a gas mixture contained in a given volume by stray high energy particles. The electron/ion pairs will drift (in opposite directions) in the presence of a bias-potential and will create a current signal that is proportional to the incident high energy beam. If we avoid saturation and do not have a large amount of recombination, the signal we obtain is directly proportional to the beam loss.[5] For reasons of economy, the gas volume is contained in as simple a container as possible and preferably available commercially, since large numbers of individual loss monitors are required to fully instrument a large accelerator and its associated beam lines. In our case, we chose to use a commercially available coaxial cable which comes in different diameters. The size in predominant use is the 7/8 inch cable, although other sizes are in use. The cables have a solid inner conductor and an outer conductor separated by a spiral insulator. This space forms the volume through which we flow our gas mixture. The cable is Andrew Corp. Heliax type HJ5-50 coaxial cable. Fittings for electrical and gas connections are also available (types 75AV and 75 XV). Thus, once a diameter and a length of cable are chosen one has a loss monitor. It is then physically mounted and clamped in place at the desired location (usually a quadrupole magnet or downstream of a known aperture or potential beam loss point of the accelerator or beam line). Gas connections are made to a gas supply, which in our case is a 95% Argon, 5% CO_2 mixture. The gas flows through the loss monitor volume and is returned to a valve and gas bubbler systems (several inches of liquid) so that control and visual indication of the gas flow is available.

The electronic biasing and readout systems for the loss monitors covered in this Technical Note are very similar. The typical loss monitor system consists of a loss monitor, an interconnecting cable, a floating dc bias power supply, an integrator, a multiplexer/analog-to-digital converter (11 bits and sign or 12 bits) and a computer connection. A simplified schematic diagram is shown in Fig. 1. This scheme assures that loss monitor data is available to an AGS operations computer as digital data or to a viewer in the MCR via the analog multiplexer system.

The following paragraphs present some specific details for each of the systems.

A. AGS Ring Long Loss Monitor

This system consists of a long coax cable that covers the entire AGS ring circumference in four (4) sections. The four sections cover from A10 to G1, G1 to G10, G10 to H3, and H3 to A10. (See drawing number D11-E611-3.) Existing cables carry the signals to the second floor (above the MCR) where the electronics is set-up. The electronics consists of a 4-channel isolated power supply, a 4-channel integrator and the necessary digitization and analog multiplexing. Both the individual section values and the sum of all 4 (hence the total for the AGS Ring) are made available.

B. AGS Ring Short Loss Monitors

This system consists of short (usually 24 inches long) "point" type loss monitors (of coax cable), that are mounted at specific locations to monitor the loss more closely coupled with a device. The types of devices include items such as septum magnets, ejector magnets, the beam catcher, injection points, known limiting machine apertures, etc. A specific application would, for example, be to install one 2 foot device at the upstream end and one 2 foot device at the downstream end of the H20 electrostatic septum used during SEB. By taking both absolute values and difference of the two devices into account, both the position (traverse) and the angle (skew) of the septum can be optimized. Also, in this case, an additional application of the loss monitor signal comes into service. Because of the sensitivity of the electrostatic septum wires to beam impinging on them (during injection, acceleration, and extraction, hence heating them up), the loss monitor signal is used as a beam abort trigger via rf turnoff or Main Magnet P.S. flattop slope control. In both cases the beam moves to the inside of the AGS and away from the sensitive septum wires.

C. External Beam Loss Monitors

These systems consist of combinations of both long (10-30 ft.) and short (2 ft.) point loss monitors, that cover a large fraction of the SEB switchyard, the SEB target caves and stations, some secondary beam lines and the FEB U-line. Layouts of the lengths and locations of these systems exist in the MCR. Except for the loss monitor length and the size of the integrating capacitance (hence the gain or overall sensitivity), all of these units are handled in a similar fashion. The loss monitors are physically mounted along the cable trays of the beam line or on the magnet stands. Gas is hooked up to them from a gas distribution valve panel. The gas supply for the beam line monitors is located at one place by the switchyard Mid-C gate. The units are cabled to their associated electronics racks in their vicinity usually just outside of the beam caves (this is done to cut down on cabling costs as well as to reduce noise pickup). The monitor electronics consist of 4-channel isolated power supplies, 4-channel integrators, and the digitizing modules. The digitizing (Analog Mux + A to D converter) and digital communication (crate controller) to the AGS control computer is via standard Datacon hardware. The Datacon devices are documented elsewhere (see CAOS hardware and software notes).

The control of the integrators consists of a reset trigger usually at T_0, and then either a T_{HOLD} trigger followed by a T_{READ}, or they are read "on the fly" at a specified T_{READ} time. The data is then usually normalized to the circulating beam intensity (L20 transformer) or to a specific beam line intensity (SEC's). It is then displayed in a tabular or graphic form.

IV. Computer Programs and Data Presentation

Application software exists for the AGS PDP-10 computer that utilizes the loss monitor data obtained from the various systems. After possible subtraction and normalization, the data is displayed via location and as efficiencies or as inefficiencies.

For the SEB operating mode, two programs labeled BONNIE and CLYDE (one for data acquisition and one for display) are used to calculate the performance of the SEB via the utilization of loss monitor data and other data (e.g. SEC's). This is then displayed in the MCR via TEC's and is distributed via the closed circuit TV system.

For the FEB operation the programs used for the same functions are called NITTY and GRITTY.

These programs access individual loss monitor units or entire files. AGAST type files exist also where raw numbers are displayed. Some existing files are ULMON, LOSMO, LOSLG, LOSSB, DLOSM, etc.

The above programming information is presented briefly to indicate what type of readouts and displays are available and is not intended to be all inclusive.

References

1. AGS Division Technical Note 112, SEB Efficiency Measurement using Calibrated Loss Monitors, September 1974, F. Hornstra, L. Blumberg, J.W. Glenn, J. Keane, Y.Y. Lee, L. Smith, A. Soukas.

2. AGS Division Technical Note 113, Beam Loss Due to G10 Targetting, September 1974, L. Blumberg, J.W. Glenn, F. Hornstra, J. Keane, Y.Y. Lee, M. Month, L. Smith, A. Soukas.

3. Long Radiation Detector System for Beam Loss Monitoring. IEEE Trans. on Nucl. Sc., NS-24, No. 3, June 1977, J. Balsamo, N. Fewell, D. Klein, R. Witkover.

4. Microprocessor Based Beam Loss Monitor System for the AGS. R. Witkover, IEEE Trans. on Nucl. Sc., NS-26, No. 3, June 1979 (3313-3315).

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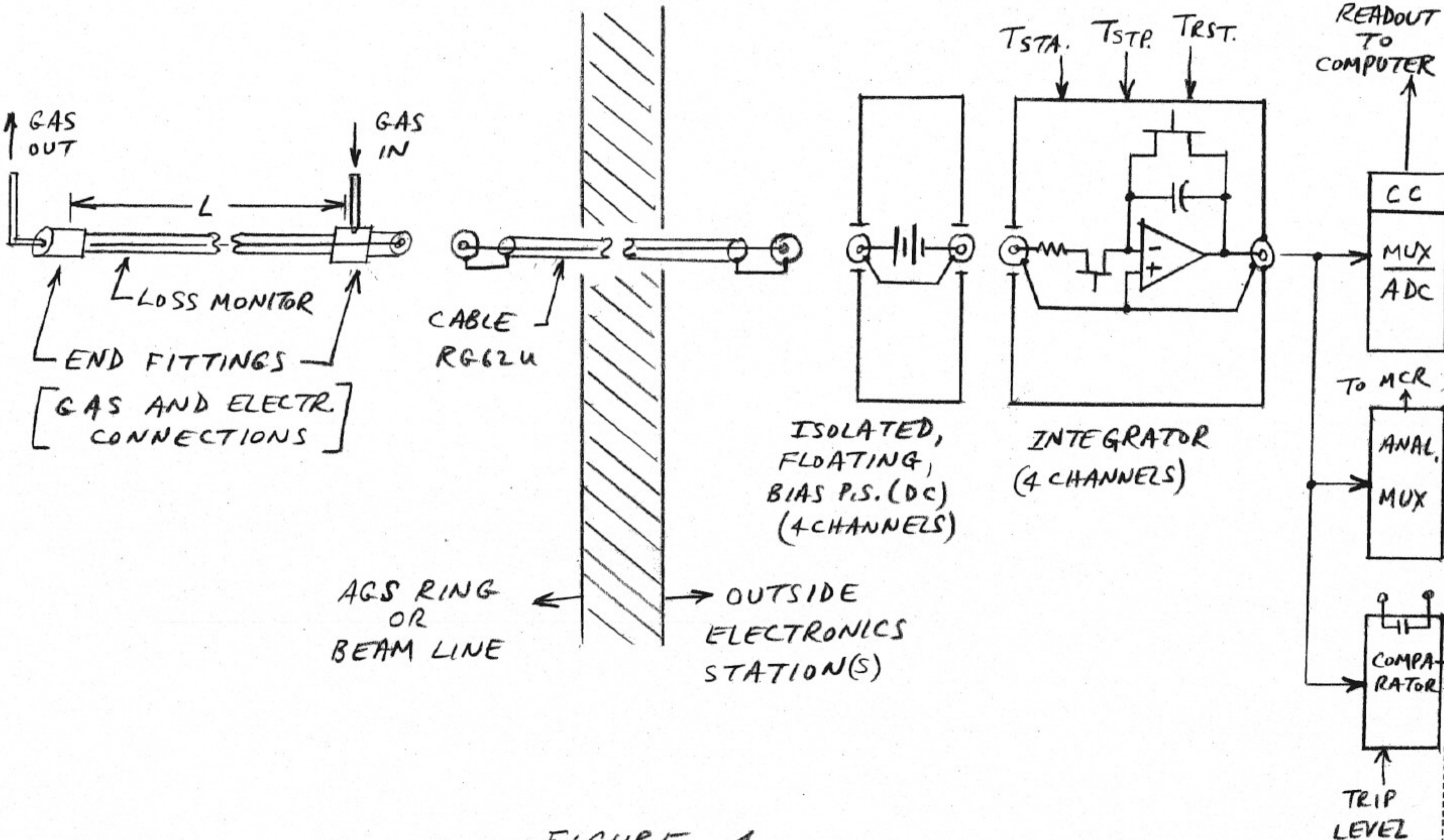

FIGURE 1.

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BY ________ DATE 4/22/87 SUBJECT TYPICAL SIMPLIFIED LOSS MONITOR SCHEMATIC SHEET NO. 1 OF 1

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