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REQUIREMENTS OF INSTRUMENTATION DURING THE FY 1987 HEAVY ION RUN

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During the FY 1987 SEB run, we will begin external heavy ion beam commissioning. We will first extract 10^{10} Oxygen into the switch yard. After the initial commissioning period, we will run the quark search experiment in the D-line and the emulsion and track etched plastic experiments in the B1 or A1 line. In addition, the B1 line will be used by Exp. 802. The A-line will be used by the MPS experiment, Exp. 810. If we use the A1 line for the emulsion experiment, then Exp. 802 can run simultaneously with it.

Before we go into details of how we accommodate the heavy ion experiments, let us first summarize the existing instrumentation and its performance.

I. The existing switch yard instrumentation

A. The loss monitors

There are two lengths of loss monitors installed in the switch yard. The long loss monitor, generally 10 feet long, is mounted on the switch yard wall. The short loss monitor, 2 feet long, is placed under the magnet to monitor the localized loss. With the addition of the 10x amplifier, these devices are capable of monitoring the beam loss of 10^{10} primary protons.

B. Flags

During the high intensity operation, i.e. 10^{12}, the aluminum oxide flag was used. When intensity was reduced to about 10^{10}, as in the polarized proton run, we have to use the Radelin flag instead of the aluminum oxide flag. In some areas the camera must also be changed to increase the light collection. During the polarized proton run, a special arrangement was made in front of the MPS so that the flag was

sensitive to 10^6 protons/few mm^2. There are 15 flags with their cameras and drive boxes distributed in the switch year and in individual beam lines. In addition to the plunging flag, each target station has one flag in front of the production target. These do not include the U-line which is used for fast extraction only.

C. The intensity monitors

1. The SEC

In addition to the C-10 SEC, there is one SEC per primary beam line to monitor the incident intensity on each target. With the existing electronics, they are usable down to 10^9 proton per sec. The C-10 SEC was used as an intensity monitor and the beam spill servo for Siemens. During the polarized proton run, we used the argon filled SEC. For 10^{10} operations, the signal is too large and we have to reduce the gain of the electronics by a factor of 6.

2. Ion chamber

The ionization chamber we now use was obtained from Argonne National Laboratory. It has 6 inches operation aperture and 4.3 cm active length. The sensitivity of the ion chambers is about 10^4 more than the SEC. The lower limit of the ion chamber sensitivity is about 10^6. The limitation is due to the noise of the electronics and the device. At the lower limit the noise count becomes a significant fraction of the beam count.

D. SWICs

The SWICs are used to monitor the beam profile at various points of the beam transport system. The wire spacing and wire diameters are dictated by the beam size and the beam intensity. They are categorized in the following four types:

1. Mini SWICs

These SWICs are used in front of the target. The beam size is, in general, less than 100 mil and the intensity of the beams are high, about 10^{12}. The wire spacings are 25 mil with 2 wire planes offset by half of the wire spacing to achieve 12.5 mil effective wire spacing. The SWIC is operated in the high radiation area; they are constructed so that they can be easily removed and disposed.

2. Maxi SWICs

These SWICs are a variation of the mini SWIC. The wire size is 3 mil and the wire spacing is 1 mm. We use this type of SWIC in the

area where the beam size is not too small. They are used in D2 target, U-line and B5 line. The intensity of the upcoming Exp. 791 test run is 10^{10}. To accommodate this experiment, we made 3 Maxi SWICs with 0.7 mil wire to increase the sensitivity of the SWIC.

3. PWC SWICs

The gain of the proportional chamber depends strongly on the field strength near the anode wire. The critical field strength is around 10^5 volt/cm. In order to achieve this, the anode wires were were made very small, typically less than 1 mil in diameter. We used .7 mil gold plated tungsten wire. We have various types of PWC SWICs used in the switch yard.

a. Plunging SWICs

There are 4 stations in the switch yard. They are located at C39, C100, C223, and D146. They were originally designed for high intensity running. We had replaced the anode wire with the .7 mil wire. During the polarized proton run, the DW146 operated satisfactorily with 10^{10} proton per pulse. We will replace the remaining 3 with the new design. They should be able to operate down to 10^9 level when required. The wire spacing of these SWICs is 50 mil; the total active area is 1.5 inches.

b. The Argonne SWIC

We have some SWICs obtained from Argonne National Laboratory. These SWICS are used in D-line for the polarized proton run and the low intensity D-line running. The basic design is very similar to the plunging SWIC: .8 mil wire, 2 mm wire spacing. We have 6 installed in D-line. Two of them are used for beam servo. Presently we have used all the available Argonne SWICs.

c. Proportional SWIC

We developed these SWICs in 1978. The construction of this SWIC is identical to regular proportional chambers typically used in high energy experiments. The wire spacing is 2 mm with a typical 1/4 inch G-10 frame. There are two 12 inch types used in C1 line and the function at $\sim 10^7$ level. We also made 2 more of this type with 6 inch apertures. Their performance is similar to the 12 inch type.

D. Beam Servo System

In the high intensity mode of running, we use the STAC for the beam servo. For the lower intensity mode, such as 10^{10} in the D-line, we used the split SWIC as the servo device. The electronics were not changed; only the gain of the devices was changed. The present lower limit is $\sim 10^8$, using the PWC SWIC as the servo device.

II. Initial requirements of the heavy ion run

Since the experiment uses the primary beam on the experimental target, the traditional primary and secondary beam distinctions are no longer applicable. On the other hand, the experiment requires low intensity, 10^4 to 10^6 ions per pulse, while the intensity of the extracted beam is 10^9 to 10^{10} oxygen per pulse. The present thinking is to split the beam in the switch yard and collimate the beam in the individual beam lines. The collimator will, in general, reduce the intensity by a factor of 100. These factors can be adjusted by varying the size of the collimator and/or beam tuning. In this type of arrangement, the beam intensity upstream of the collimator is about a factor of 100 of that of the desired intensity.

A. The Switch Yard

As shown in Section I, the existing instrumentation can properly monitor the beam intensity of 10^{10} proton per pulse. With the help of the Z^2 effect, 10^9 oxygen beam can be effectively monitored. The split beam may present some problems. For the low intensity split, we may have to tune up the beam line with high intensity and then reduce the beam intensity after the beam line is set up. Some low intensity air SWICs should be added in the individual beam lines to monitor the final beam. This will require an air break in the beam line. The amount of material of the air SWIC is about 60 mg/cm^2, which is less than two 5 mil aluminum windows. The effect of these windows and SWICs should be studied during the commissioning period. If we cannot tolerate the contamination, then we have to replace the air SWIC with the plunging type.

B. D-Line

The quark search experiment will be located downstream of the polarized target. It will take up to the maximum intensity of the extracted beam. The instrumentation of this line is capable of monitoring 10^{10} proton beam. There should be no special new device needed. We will have to rearrange the SWIC for the profile monitor and the beam servo. The intensity monitor can be either the SEC or the ion chamber, depending on the beam intensity.

C. B1-Line

The intensity reduction collimator will probably be located upstream of the B target. The reduction factor is most likely to be about a factor of 100. The emulsion experiment will run at 10^4 per pulse while Exp. 802 will run at 10^6 or lower. We are designing 4 plunging PWC SWICs to be used in this line. The requirement of 10^4 per pulse is probably achievable with the help of adding integrators on each wire. The other requirements are listed below.

1. Experiment 802

In addition to the 4 plunging SWICs, the experiment will need a servo at their target. There is no definitive solution yet. In principle, we can place a PWC SWIC before or after the experimental, target to servo the beam. The experimenters prefer using their own device, such as the halo counter, etc. The detail and rate problem has to be defined before we can proceed. I consider it is the experimenter's responsibility to come up with a solution to his liking. The servo at the B target will not be needed if the collimator was placed upstream of B target and there are no bending magnets between them. We will need a flag, SWIC, ion chamber and beam servo SWIC just upstream of the collimator. The intensity at this point will be 10^8. The instrumentation needed to transport the beam to this point will be adequate with the exception of the loss monitor. Since the intensity is low, the problem may not be serious.

2. The Emulsion Experiment

This experiment shares the same 4 SWICs for the B1 beam line monitor. The desirable intensity for these experiments is 10^4/ pulse. The spot size is about 10 cm x 10 cm and the experimenters prefer parallel beam in the vertical plane. In order to monitor the purity and parallelism in the vertical plane, a hodoscope and/or plastic Cerenkov counter will be needed. The details must be worked out by the experimenter and Dana Beavis. The upstream transport will be a problem. If we assume the collimator will only reduce the intensity by a factor of 100, then the B line has to transport 10^6 per pulse. There are no plunging SWICs in this region and the existing cameras are not sensitive enough. Since we will have a small pin hole collimator downstream, we probably can stand a substantial beam loss in the B line. Also, if we tune the B line with higher intensity, say 10^8, then the existing flag will be adequate, provided we use the Radelin material and possibly higher sensitivity cameras. A low intensity PWC plunging SWIC should be added to help the diagnostics of the beam line without changing the beam sharing.

D. A Line

Experiment 810 will run with 10^4 ions per pulse. This requirement is very similar to the emulsion experiment. Although the experiments are not ready to run during the first period of heavy ion run, they are prepared to do beam study in the MPS. The area is instrumented with beam chambers and counters, and also they are linked up to an existing computer system. These will make the startup for the emulsion easier. We will run this line modeling after Exp. 817 (Roberts). The collimator will be placed downstream of A target. There are 24 feet of air break in this region. Since the collimator is very small (1/16" x 1/16"), we will need to tune the beam parallel to the collimated beam line. In order to do this we will need two SWICs to monitor the beam incident angle on the collimator. In order to transport 10^6 heavy ions to the A target, we will need some low intensity SWICs to monitor the beam tuning. There are 3 flags in the beam line between A target and AD3 magnet. They can be upgraded and used for initial tuning of the A line with high intensity beam, about 10^8/pulse.

III. Summary

For the initial run, we assume the extracted beam will be greater than 10^9 per pulse and we will run A, B, and D lines. The minimum requirements of instrumentation are summarized below:

A. Switchyard

1. Flags: replacing all the pertinent flags with Radelin flags.

2. Plunging SWICs: Upgrade the existing 1.5" plunging SWIC.

3. Scintillating counter for loss monitor: To be specified by the extraction group.

B. D Line

Rearranging the existing instrumentation. Will need one new ion chamber.

C. B1 Line

Assuming the emulsion experiment is in A line:

1. Upstream of the B collimator: 1 ion chamber, 1-2 air SWICs and possibly 1 servo SWIC.

2. Downstream of B collimator: 4 new plunging PWC SWICs. Beam servo for the experimental target.

D. A Line

1. Upstream of A target collimator: 1 flag, 1 servo SWIC, 1 ion chamber, and 2-3 low intensity air SWICs.

2. Downstream of A target collimator: Use the MPS instrumentation (their beam chamber and counter). Special counter for the emulsion experiment is to be specified.