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Development of the Transverse Residual Gas Ionization SWIC for High Intensity Proton Beam*

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March 9, 1990

I. Introduction.

In preparation for the AGS Heavy Ion program, a new type of Segmented Wire Ionization Chamber (SWIC) was developed. These SWICs were designed to be plunged in and out of the beam line and operated in the vacuum environment. Subsequently the design evolved from the normal proportional chamber construction to the presently-called universal construction. The original goal was to use the SWIC can to house the SWIC and ion chamber and accommodate future expansion for secondary emission-type devices for profile and intensity monitor for high intensity operations. During the first test, the vacuum was not good enough to void the residual ionization effect. In addition, the SWIC at B510 was used by E791 for high intensity running and later was not suitable for the low intensity running of E802 (a residual profile of the proton beam persists when high gain electronics were added to the system). The goal of using the same device for both high and low intensity running mode was abandoned. We continue to look for a better way to monitor the high intensity beam to augment the flag.

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* Also known as EPM.

Tests of the universal SWIC for high intensity reveal that our present electronics can detect the residual ionization in the 10-micron vacuum, and our switchyard vacuum is operated in this range. A simple calculation shows we can detect the beam profile by using transverse collecting plates to increase the active volume. The additional aadvantage of transverse design is that the material is out of the path of the primary proton beam. If we assume the residual gas is air, the primary ionization is estimated to be around 13 ion pairs/cm at the atmosphere pressure. At 10 microns, 10^{12} proton will produce

$$13 \times 10^{12} \times \frac{10}{760000} = 1.7 \times 10^{8} \text{ ions per cm of active area.}$$

The total calculated charge produced is about 2.7×10^{-11} Coulomb. This is about the lowest sensitivity limit of our present integrator/scanner system. The residual gases are composed normally of H_2O and Hydrocarbon. The ion pair/cm are in general higher than air.

II. Test of EPM.

A test device was constructed to be mounted in the vacuum plunger at C370 (present location of the C-line heavy ion plunging SWIC). The device consists of two G-10 boards with one side covered with copper plate(a normal G-10 board for electronic PC board). Figure 1 shows the construction. The wires were strung along the proton beam axis and the wire spacing is 2 mm. The signal and high voltage planes are separated by 4 inches so that they will not intercept the proton beam. The active area is 10 cm in length and 6 cm in width. If the residual gas in the vacuum is as expected, the total charge produced by 7×10^{12} proton will be:

$$7 \times 1.7 \times 10^{8} \times 1.6 \times 10^{-19} \times 10 = 1.9 \times 10^{-9} \text{ Coul.}$$

The integrator capacitor value is 10^{-9} farad; the resulting voltage of the output should be 1.9 volts. The scanner gain was set to 2 so that the total display should be about 3.8 volts-bin.

Figure 2 shows the profile of the beam at C370. The device shows the beam motion during test. In addition the signal disappeared when the device was plunged out of the beam. This shows the device is working and can be used as a beam profile monitor. The origin of the uniform background is not understood yet. If we subtracted the flat background, the

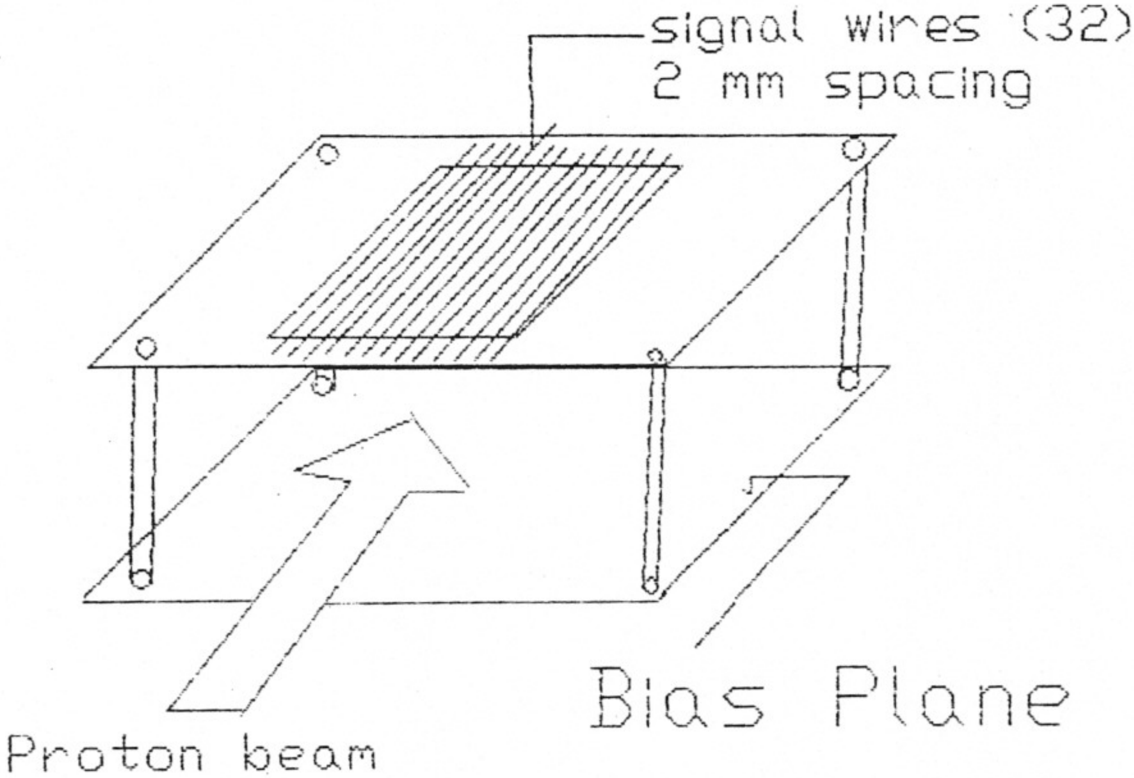
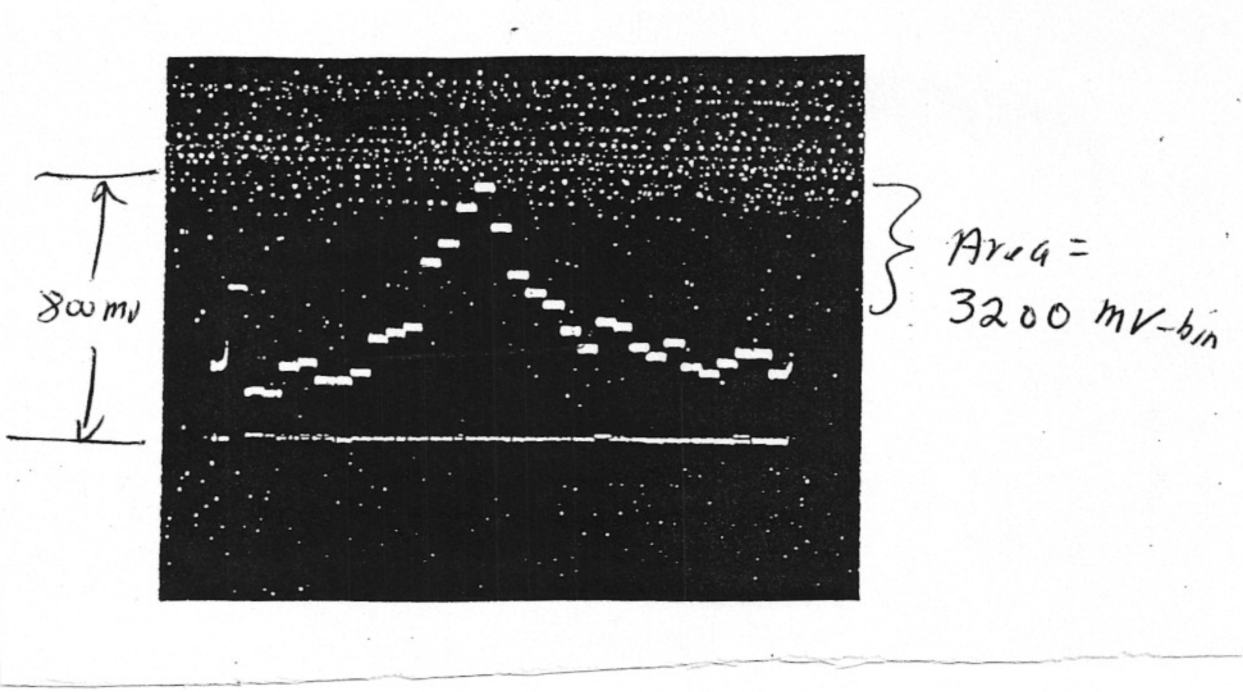
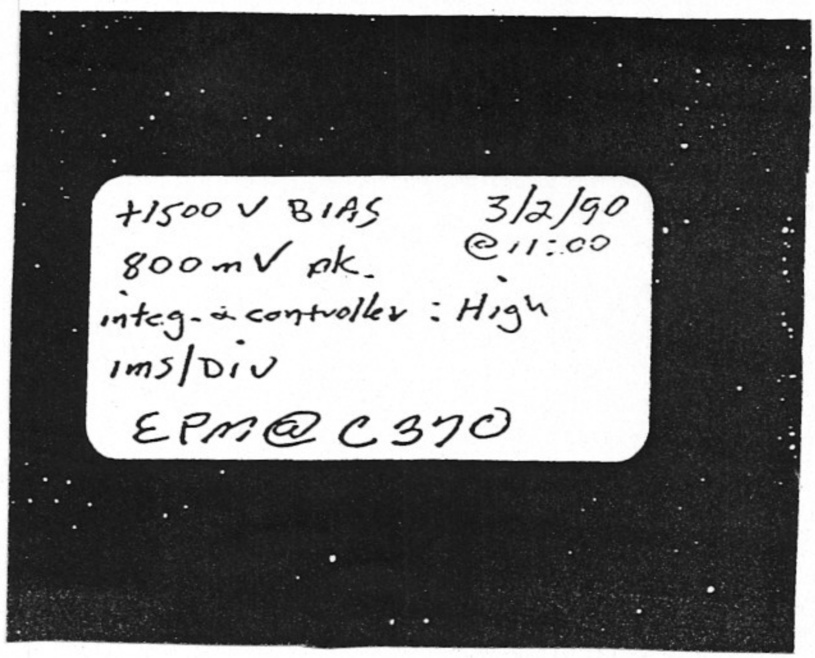


Figure 1





Beam intensity 7 x 10^{12}, each bin represents the voltage on one wire, and the bin with wire spacing is 2 mm.

Figure 2

the integral of the beam profile is 3.2 volt-bin, which is consistent with the calculation, 3.8 volt-bin. Figure 3 shows the profile of 1.6 x 10^{12} beam (with a 50 mV/div). The beam signal is clearly visible and the profile is similar to that of Fig. 2 (with 7 x 10^{12} proton).

The device now being tested by J.W. Glenn and AGS operations personnel. The name EPM (External Profile Monitor) was chosen because an IPM (Internal Profile Monitor) has operated in the AGS for many years.

The advantage of this type of device is that it presents no additional material in the beam line and the beam profile can be monitored continuously. The drawback is that the signal strength is linearly proportional to the vacuum. If the vacuum is reduced by a factor of 10, the signal will be reduced by a factor of 10 and electronic improvement will be necessary. If the vacuum was spoiled to the torr range, the glow discharge will limit the bias voltage and the profile will not resemble that of the beam. On the other hand, a 10 μm vacuum range can be generally maintained without much effort. In the Booster operation, the beam intensity will be increased by a factor of 4. This device will be very useful for beam tuning and monitoring.

III. Prototype Construction.

To further test the device, four prototypes will be made to be used in the D-line. This line was rearranged to accommodate the new 2 GeV/c separated beam. The EPM will be placed adjacent to the flag and SWIC for comparison. Figure 4 shows the assembly drawing. The basic parameters are:

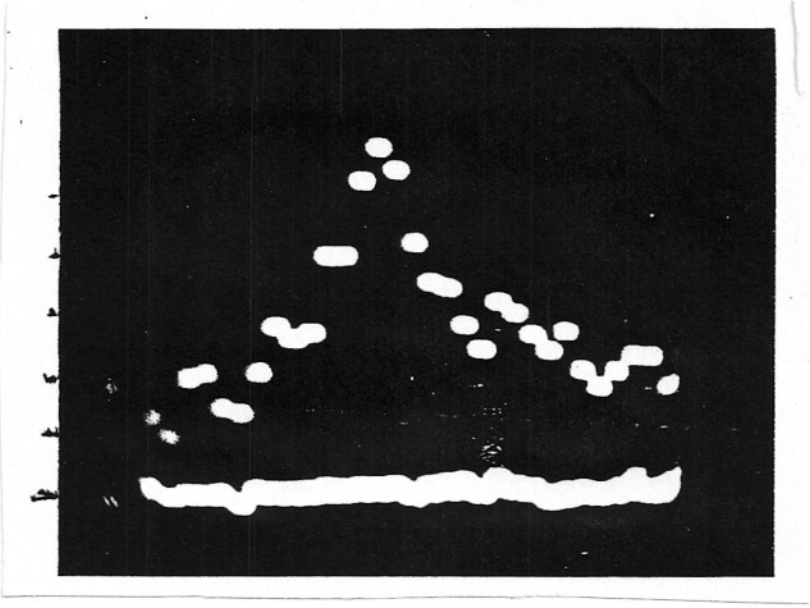
a. <u>Center Body</u>:

It is made from a 12-inch aluminum beam pipe, 21 inches in length. The length can be changed easily without affecting the basic design.

b. <u>End Plate</u>:

These two plates serve as alignment and supporting fixture. All the electronic feed-throughs are located on one plate and the same plate has four supporting rods to mount the electrodes. The beam opening is four inches.

c. <u>Beam Pipe Coupling</u>:



Beam intensity 1.6×10^7

50 mV/div

Figure 3

ITEM NO	QTY.	DESCRIPTION	MAT'L. DWG. NO. OR SHT. NO
21	64	WASHER FLAT FOR 3/8 BOLT SST	T-84140
22	24	NUT PLAIN HEX 3/8-16NC-2B SST	T-81616
23	24	SCR.SOC.HD.3/8-16NC-2A X 2 1/2LG. SST	T-95764
24	24	WASHER LOCK FOR 3/8 BOLT SST	T-86736
25	4	SET SCR.SOC.HD.1/4-20NC X 1"LG.SST	T-64159
26	4	SET SCR.SOC.HD.#10-24NC X 1/2LG SST	T-64123
27	16	SCR.SLOT.RD.HD.#8-32NC X 1/2LG. SST	T-58504
28			
29			
30	2	O-RING #3/16XS-1/4ID X 5-5/8 OD VITON	H-30626
31	2	O-RING #1/4X12 ID X 12-1/2 OD VITON	H-30695
32	2	GROUNDED SHIELD CERAMASEAL #	809A9263-01-A
33	2	CONNECTOR 37 PIN "D" HERMETIC CANNON	DCH-37P-002
34	4	SCREWLOCK ASS'Y FEMALE 205817-1	BNL#A-66505
35	2	GASKET	D13-M-5775-1
36	4	SCR SLOT.RD HD #4-40NC X 1/4LG.SST	T-58164
37	4	WASHER FLAT 1/8 ID X 5/16 OD X 1/32 THK SST	T-84104
38	8	SPECIAL WASHER	D13-M-5984-1

ITEM NO.	QTY.	DESCRIPTION	MAT'L. DWG. NO. OR SHT. NO
1	1	SUPPORT FLANGE	D13-M-6138-4
2	1	SUPPORT FLANGE	D13-M-6139-4
3	2	#8 5/8 CLAMPING FLANGE	D13-M-6140-3
4	2	#6 1/8 MATING FLANGE	D13-M-6141-3
5	2	#14 1/8 MATING FLANGE	D13-M-6142-3
6	8	WIRE BOARD BRACKET	D13-M-6143-3
7	16	FASTENER	D13-M-6144-2
8	4	SPACER "SHORT"	D13-M-6145-2
9	4	SPACER "LONG"	D13-M-6146-2
10	4	SPACER "LOCKING"	D13-M-6149-2
11	4	#1/2 HANGER ROD	D13-M-6150-2
12			
13	4	3MM WIRING BOARD	D11-E831-4
14	1	TUBE #12 OD X .250 WALL X 20 LG.	AL 6061-T6
15			
16	4	ROD CONT.THD.1/2-13UNC-2A X 25LG. STL.	T-08750
17	8	NUT PLAIN HEX 1/2-13NC-2B STL.	T-79804
18	8	WASHER FLAT FOR #1/2 BOLT STL.	T-83928
19	8	WASHER LOCK FOR #1/2 BOLT STL.	T-86352
20	16	SCR.SOC.HD.3/8-16NC-2A X 2LG. SST	T-95760

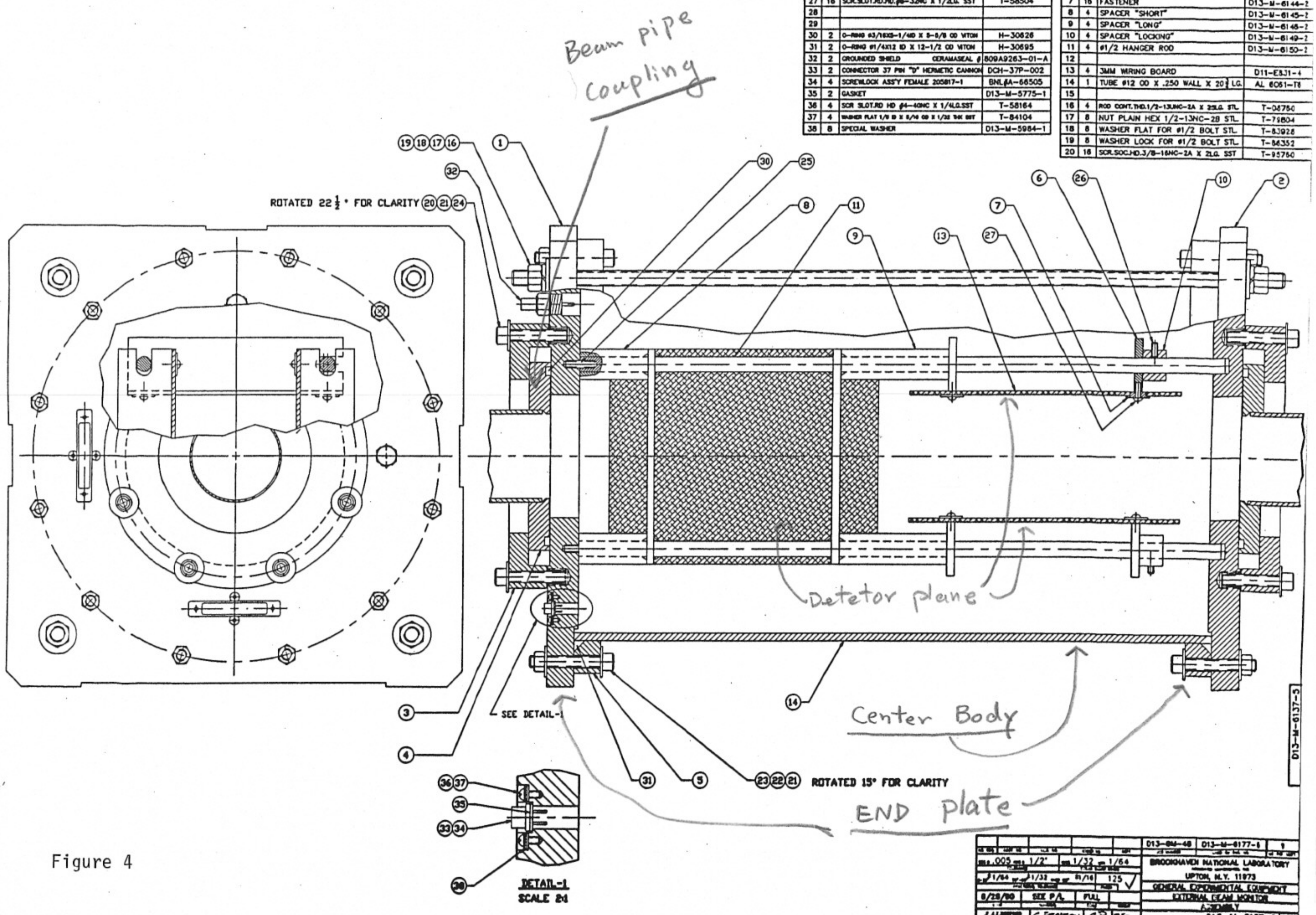


Figure 4

D13-DM-48 | D13-M-6177-5
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GENERAL EXPERIMENTAL EQUIPMENT
EXTERNAL BEAM MONITOR
ASSEMBLY
D13-M-6137-5 A

The coupling design allows the beam pipe to move laterally relative to the end plate so that we can maintain the device position without a bellows. The present coupling will adapt to a beam pipe of up to four inches in diameter. The D-line beam has a three-inch beam pipe.

d. Detector Plane:

Two sets of planes were used for collecting the residual ionization. They are mounted four inches apart and one is for horizontal and the other is for vertical. The wire spacing is 2 mm. The active region is six inches.

IV. Future Plans:

These EPM will be tested during the 1991 SEB run. Their profile will be compared with that of flag and SWIC. We did not add field shaping plane to the open side of the detector. The resistor chain to shape the field may cause glow discharge and add the complication of the design. If need be we can add it; the design is very flexible.

One more possible application for this device is a high intensity servo detector. The signal is quite small, 27 pico Coulomb per 10^{12} proton per cm of active area. A more sensitive electronic will be tried out to study the feasibility of this scheme. If successful, it can be employed in the switchyard to stabilize the primary beam.

V. Acknowledgement.

The authors would like to thank Joan Depken, Phil Pile and Gary Smith for reading the draft and making suggestions. The background subtraction was suggested by Phil Pile.