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EVALUATION TESTS OF TWO SPECIAL SECONDARY EMISSION CHAMBERS

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Collider Accelerator Department

Brookhaven National Laboratory

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USDOE Office of Science (SC)

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AGS DIVISION TECHNICAL NOTE

No. 136

EVALUATION TESTS OF TWO SPECIAL SECONDARY EMISSION CHAMBERS

Vassilis Agoritsas*

June 28, 1977

1. Introduction

Two special Secondary Emission Chambers were dynamically tested in two very different high energy proton beams in two laboratories. The tests were first started at Fermilab and later were continued at BNL/AGS.

It was found independently at SLAC,[1] at CERN,[2] at FNAL,[3] and here at Brookhaven,[4,5,6] that the relative efficiency or sensitivity of a number of secondary emission chambers varies with time or, rather varies with the total flux of protons or electrons that traversed them. These observed variations of the relative efficiencies were given the general name "Aging Phenomena". That is why the evaluation tests of the two special SECs were focused on their long-term stability.

The study, however, of the long term stability is a difficult enterprise. In order to study the "aging phenomena" of a SEC it is necessary to have:

a) A high intensity, high density pencil proton beam running for long periods of time so that very high integrated fluxes can be obtained,

b) A stable, accurate and reliable monitor which measures the beam intensity from pulse to pulse or measures the total beam flux during a number of pulses,

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c) A reliable beam size and beam position monitor,

d) Long term reliable and continuous data acquisition system,

e) Remote-controlled moving table in both vertical and horizontal planes on which the SEC can be fixed,

f) Free space in the beam as near as possible to a focusing point of the beam transport optics,

g) Available signal and HT interconnecting cables, between the location of the SEC in the beam and the location of the electronics.

2. The Two Special Secondary Emission Chambers

The two special SECs were constructed by LND, Inc.[7] following detailed specifications prepared by Miguel Awschalom and co-workers. These specifications are reproduced extensively in Appendix 1. The specification SSEM-2-73 and SSEM-3-73, each one taken together with SSEM-1-73, concern the special SEC #2 and special SEC #3, respectively.

The basic design of these two special SECs is similar to the design of a number of SECs constructed at CERN 10 years ago.[8] There is contradictory information about how effectively the two chambers were constructed and to what degree the specifications were followed. LND, Inc. confirms that the chambers were constructed following the specifications as closely as possible; however, some people who had the opportunity to inspect the LND, Inc. laboratories during the construction of the chambers think differently. It is not possible to find out what happened exactly, as the chambers were hermetically closed, and so considered as "black boxes". The external appearance of the chambers; however, indicates a careful and well-finished mechanical work. The color of the chambers also indicates that they were baked at high temperatures and for long periods of time.

2.1 The Special SEC #2

A simplified drawing of the special SEC #2 is shown in Fig. 1. The polarizing (bias) electrodes are shown in group 1. There are three groups of foils. Each group has 5 emitting foils and 6 corresponding bias foils.

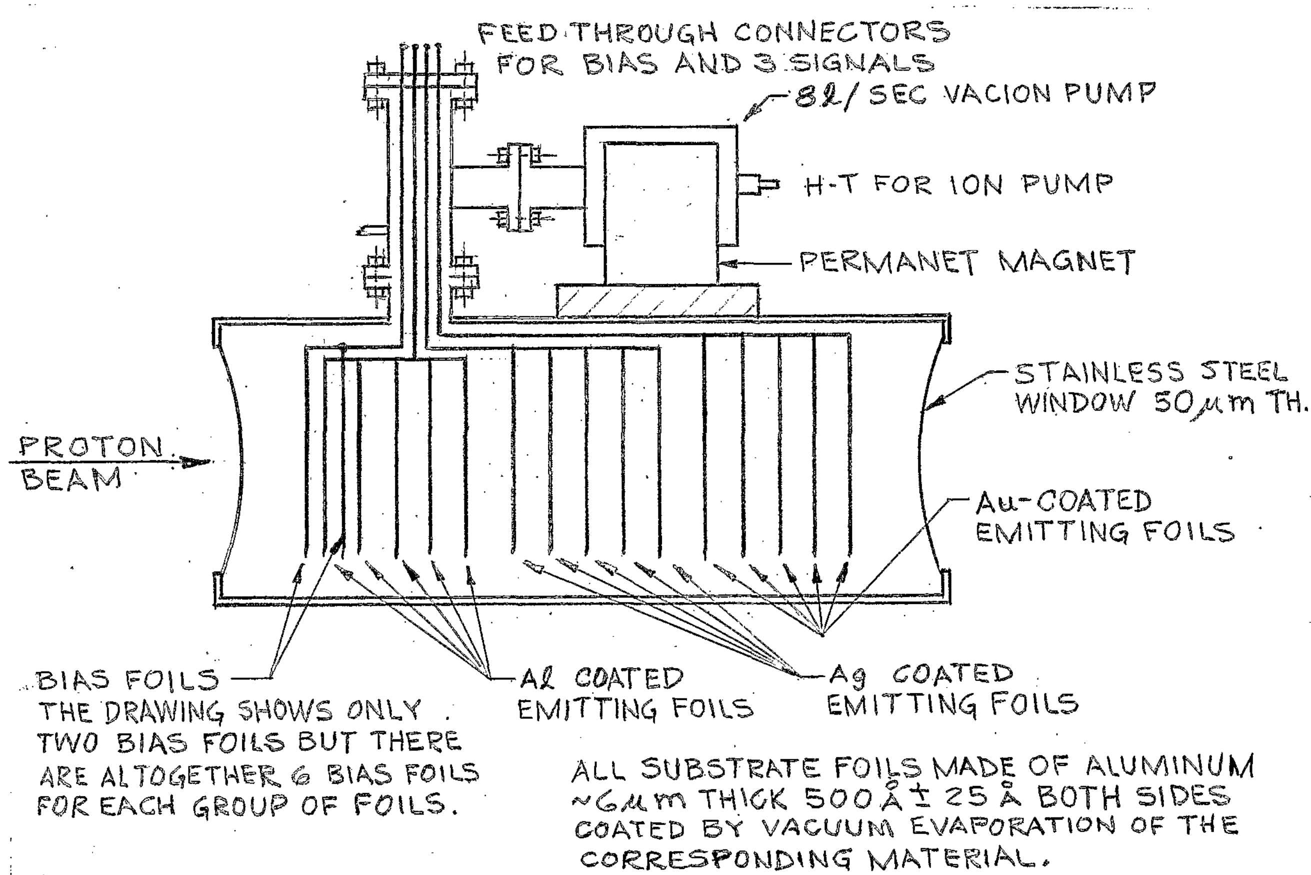

FIG.1 A SIMPLIFIED DRAWING OF THE SPECIAL SEC #2

The 5 emitting foils of each group are connected together through a feedthrough to a coaxial connector. All the foils are 6 μm thick aluminum foils 500 Å vacuum coated on both sides as follows:

Group 1 coated with aluminum, hereafter Special SEC #2 Aℓ

Group 2 coated with silver, hereafter Special SEC #2 Ag

Group 3 coated with gold, hereafter Special SEC #3 Au

The bias foils of all three groups of foils were connected through a feedthrough to a HT BNC connector.

2.2 Special SEC #3

The special SEC #3 is mechanically identical to the special SEC #2 but 10 cm longer. It also has three groups of foils. All the foils are also of 6 μm thick aluminum foils coated on both sides with 500 Å silver. The spacing between electrodes (foils) is now different for each group.

Group 1 spacing between foils 0.38 cm, hereafter Special SEC #3 Ag 1

Group 2 " " " 0.76 cm, " " " Ag 2

Group 3 " " " 1.52 cm, " " " Ag 3

The bias foils of the three groups were also connected together through a feedthrough to a HT BNC connector.

3. FNAL Tests

Even with the encouragement of the Accelerator Division and the warm cooperation of the Proton Department, we spent considerable time finding a location in an adequate proton beam. Finally, we were authorized to install the chambers in the P-East proton beam about 10 meters upstream of the target. In fact, it was a unique possibility. The chambers were installed at the end of June and taken out at the end of November.

Figure 2 shows a simplified drawing of the FNAL beams and target layout and the detailed layout of the beam upstream and downstream of the chambers. The special SEC #2 was fixed on a remote-controlled moving table which permits scanning of the beam vertically. The special SEC #3 was fixed on a rigid support.

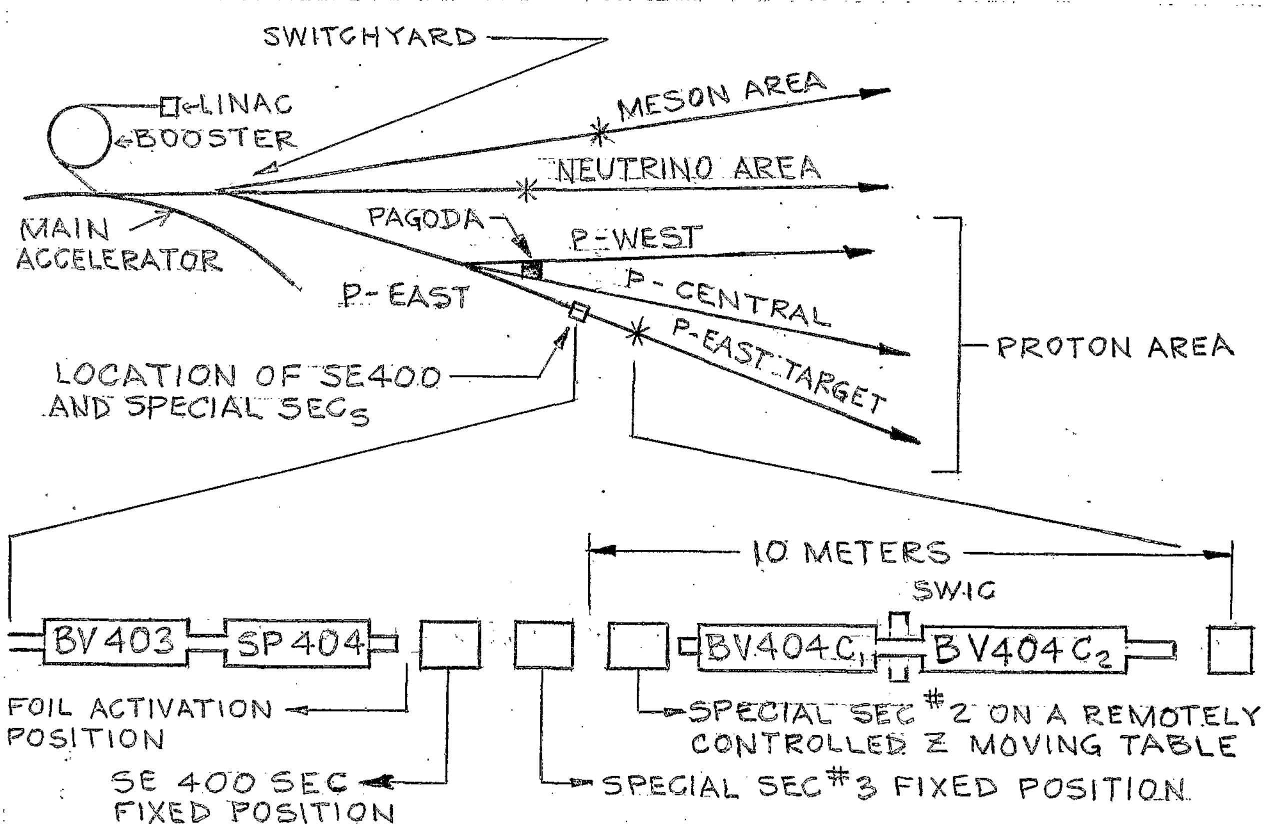

FIG.2 LOCATION OF THE TWO SPECIAL SECs AT FNAL

3.1 P-East Beam Characteristics

During the tests the P-East beam characteristics were as follows:

Energy: 400 GeV (for a short period 200 GeV & 400 GeV)

Machine repetition period: 9 - 15 sec.

Spill: 1-2 sec. (slow extracted beam)

Intensity: 10^{12} - 10^{13} protons per pulse

Beam position and size remained very stable during the five-month test. The beam profile was elliptic with area ~ 0.2 cm^2. This implies that the proton flux per pulse was 5×10^{12} - 5×10^{13} protons per cm^2.

The stability of the beam position and size are very well demonstrated by the spots the beam formed on the stainless steel windows of the SECs. Figure 3 shows the formed spot on the upstream window of the special SEC #2, as seen by a photographic lens. On the same figure we reproduce two autoradiographs of two different film exposure times of an activated aluminum foil. The activation took place on the 10th of August, 1976. The location of activation was about 1.5 meters upstream of special SEC #2. The P-East beam position and beam distributions in both vertical and horizontal planes were also continuously monitored by a number of SWICs (Segmented Wire Ion Chambers).[9,10,11] On the same figure a typical P-East beam spill is also shown.

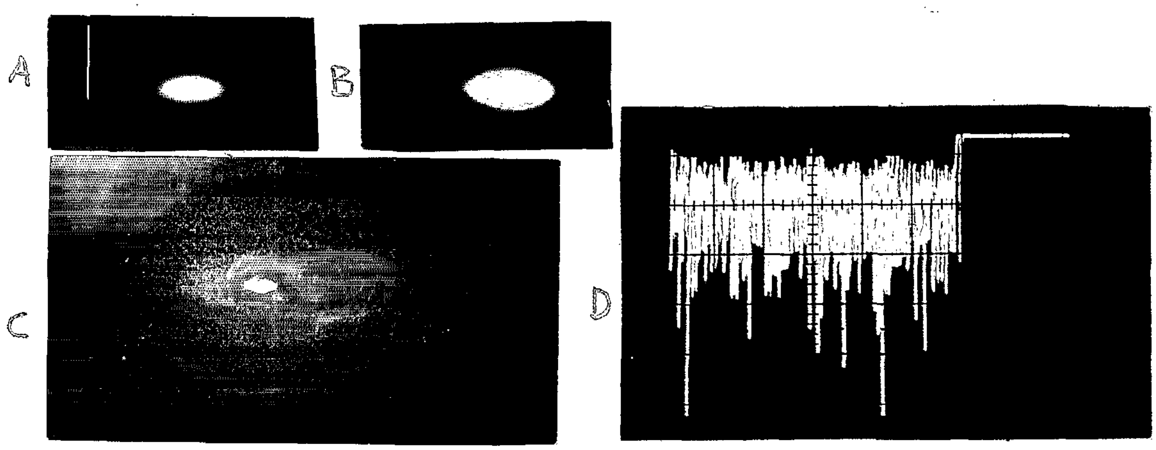

FIG. 3 P-EAST BEAM SHAPE AND TYPICAL SPILL

A AND B: AUTORADIOGRAPHS OF TWO DIFFERENT TIME EXPOSURES FOR THE SAME ACTIVATED THIN ALUMINUM FOIL LOCATED ONE METER UPSTREAM OF SPECIAL SEC#2.

C: PHOTOGRAPH OF THE BEAM SPOT FORMED ON THE UPSTREAM WINDOW OF THE SPECIAL SEC#2.

D: TYPICAL SPILL 200 mSEC PER DIVISION.

3.2 Electronic Chains and Interconnections

The block diagram of Fig. 4 represents the hook-up of the special SECs and associated apparatus used for performing long-term stability tests of these special SECs. The low level signal electrons and the control of the moving table were installed at the basement of the Pagoda where most of the Proton Area controls are also installed. Because of the lack of available high tension cables between Pagoda and SECs location, the power supply providing the bias for the special SECs was installed in another building. For the same reason the power supplies of the SEC Ion Pumps were left near the SECs. This split of the electronics introduced big earth loops which interfered unfavorably in the measurements of the very low level signal of the SECs.

The main part of the electronic chain is the Charge Integrator.[12] Only two charge integrators of a new type were available for our tests. That is why only two SEC signals of the six were treated simultaneously. The digital result of the two signals were displayed on a CRT video monitor through computer control. The collection of data, however, had to be taken by hand. All the effort of the Proton Department staff to automatize the collection of data failed because of the lack of needed equipment.

3.3 The Reference Intensity Monitor

The reference intensity monitor for the long term stability tests of the special SECs was another Secondary Emission Chamber, the SE400 which was installed in the P-East beam at the end of 1973. The construction specifications of this chamber are almost unknown. Fortunately, the operational history in its actual position in P-East is very well known.

Table I summarizes the proton flux and the integrated proton flux which traversed the SE400 chamber (measured by the SE400 chamber itself) from one foil activation to the next activation. The secondary emission chamber had been regularly calibrated against foil activation techniques.[14] One count of SE400 $\cong 10^9$ protons. All calibrations by FAT were based on the nuclear reaction

$$P_{400\ \mathrm{GeV}} + \mathrm{Cu} \rightarrow \Sigma_{xi} + {}^{24}_{11}\mathrm{Na}$$

using $\sigma = 3.5$ mb.[15,16]

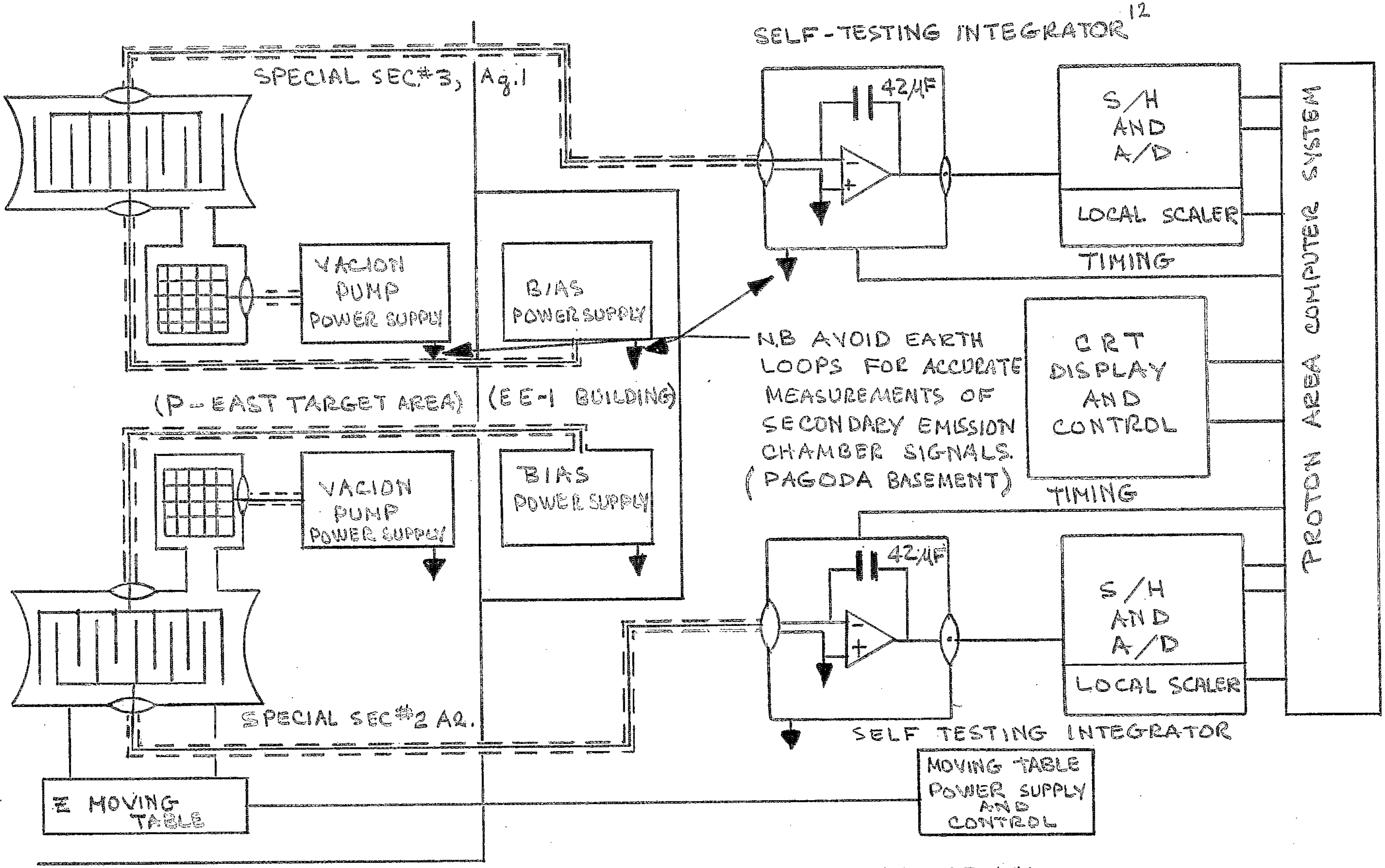

FIG 4. HOOK UP OF THE SPECIAL SECONDARY EMISSION CHAMBERS AT FNAL

Table 1

Date	Integrated Proton Flux × 10^{17}	Beam Size cm^2	Estimated Integrated Proton Flux per cm^2 × 10^{17}	Proton Energy GeV	Protons by FAT / Protons by SE400
Aug. 21, '73	0.6	0.2	3.0	200	0.945
Sept. 4, '73	1.3	0.2	4.5	200	1.01
Jan. 20, '74	2.8	0.2	14.0	300	1.00
Jan. 26, '74	3.0	0.2	15.0	300	1.01
Jan. 26, '74	3.0	0.2	15.0	300	0.99
May 1, '74	7.1	0.2	21.3	400	1.08*
May 16, '75	7.5	0.8	22.5	400	0.76*
Mar. 16, '76	28.15	0.2	142.5	400	1.00**
Aug. 18, '76	35.4	0.2	177	400	1.01**
Oct. 10, '76	40.0	0.2	200	400	1.02**
Oct. 10, '76	40.0	0.2	200	400	1.04**
Dec. 10, '76	45.5	0.2	227.5	400	0.97**
Feb. 2, '77	47.0	0.2	235	400	0.99**
Feb. 2, '77	47.0	0.2	235	400	0.99
Feb. 24, '77	65	0.2	325	400	1.00***
Feb. 24, '77	65	0.2	325	400	1.02***

*A new electronic chain was installed during that period.

** Foils activated downstream of SE400.

*** For this foil activation the SE400 was raised ~ 16 mm above its normal position.

The activities of the radioisotope ${}^{24}_{11}Na$ were always measured by the same Ge(li) detector and associated electronics. The counting efficiency of the Ce(li) detector was also regularly calibrated with a Bureau of Standards (radiation γ: 1172 and 1332 keV) source. Table 1 also summarizes the calibrations of the reference monitor SE400 against FAT. (We assume that something went wrong with the calibration done on 16 May, 1975.) Table 1 demonstrates that the reference monitor SE400 calibration tests remained stable during the period November '73 - February '77 (one SE400 count = 10^9 protons).

3.4 Results and Discussion

Data was taken almost day by day during the normal operation of the P-East beam. The results are presented in three plots as follows:

a) The relative efficiencies of the three groups of foils of the special SEC #2 against time or against integrated proton flux per cm^2. (Fig. 5)

b) The relative efficiencies of the three groups of foils of the special SEC #3 against time or against integrated proton flux per cm^2. (Fig. 6)

c) The relative efficiencies of the three groups of foils of the special SEC #2 against beam spot position in the vertical plane (vertical scanning of the special SEC #2 at the end of the tests). (Fig. 7)

We define the relative efficiency of a particular group of foils as the ratio of the counts of this particular group of foils over the counts of SE400. The secondary emission coefficient per emitting foil can be then calculated knowing the overall secondary emission coefficient ρ of the SE400, which is

$$\rho_{SE400} = \frac{\text{Number of emitted electrons of SE400}}{\text{Number of high energy protons traversing the SE400}} = 0.39.$$

(We cannot report the ρ_{SE400} per emitting foil as we do not know of what material the foils are made and how many emitting foils are in SE400 SEC.)

If we use the flat part of the plots in Fig. 5 and Fig. 6 the secondary emission coefficients per emitting foil of all the six groups of foils can be calculated. These coefficients are as follows:

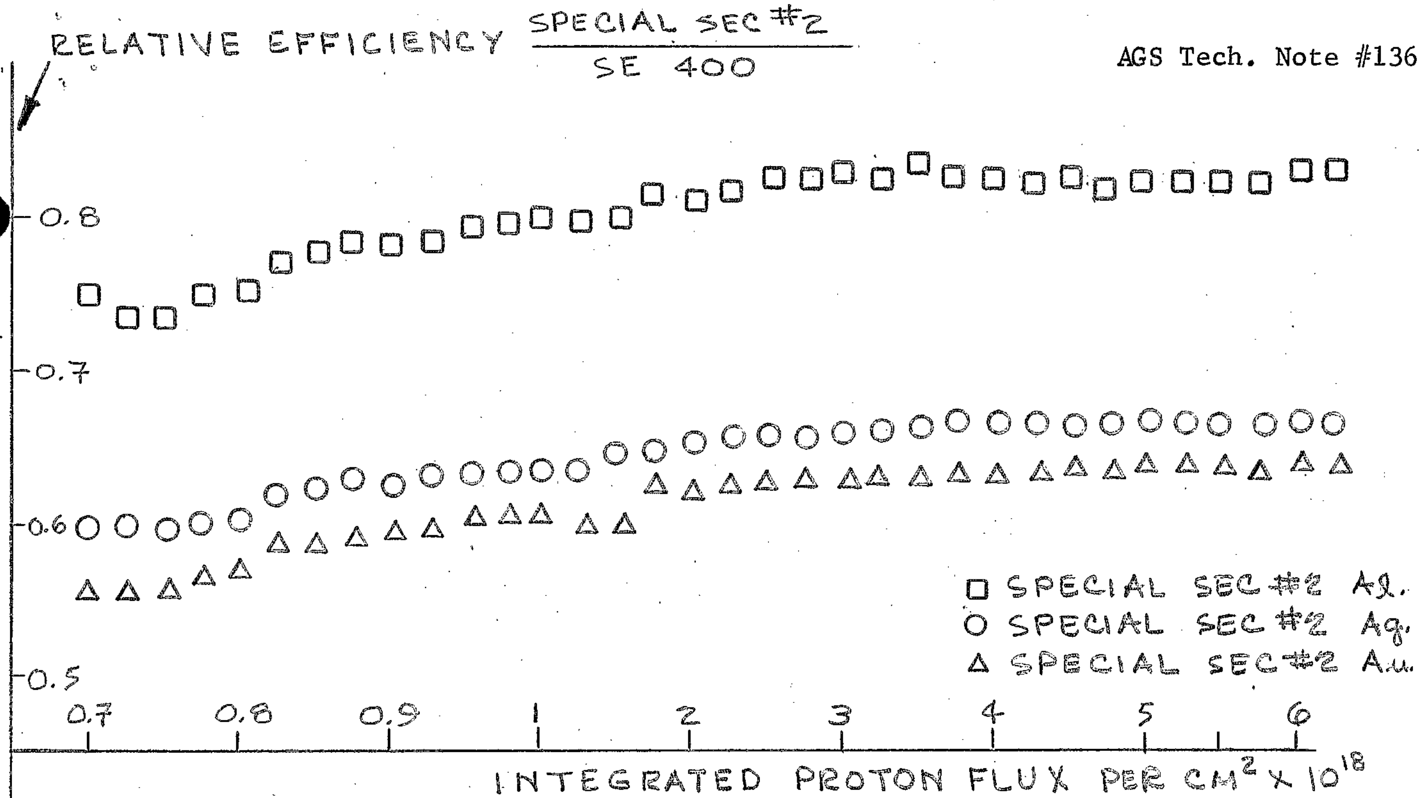

FIG. 5 RELATIVE EFFICIENCY OF SPECIAL SEC #2 AGAINST INTEGRATED PROTON FLUX PER CM² THAT TRAVERSED THE CHAMBER.

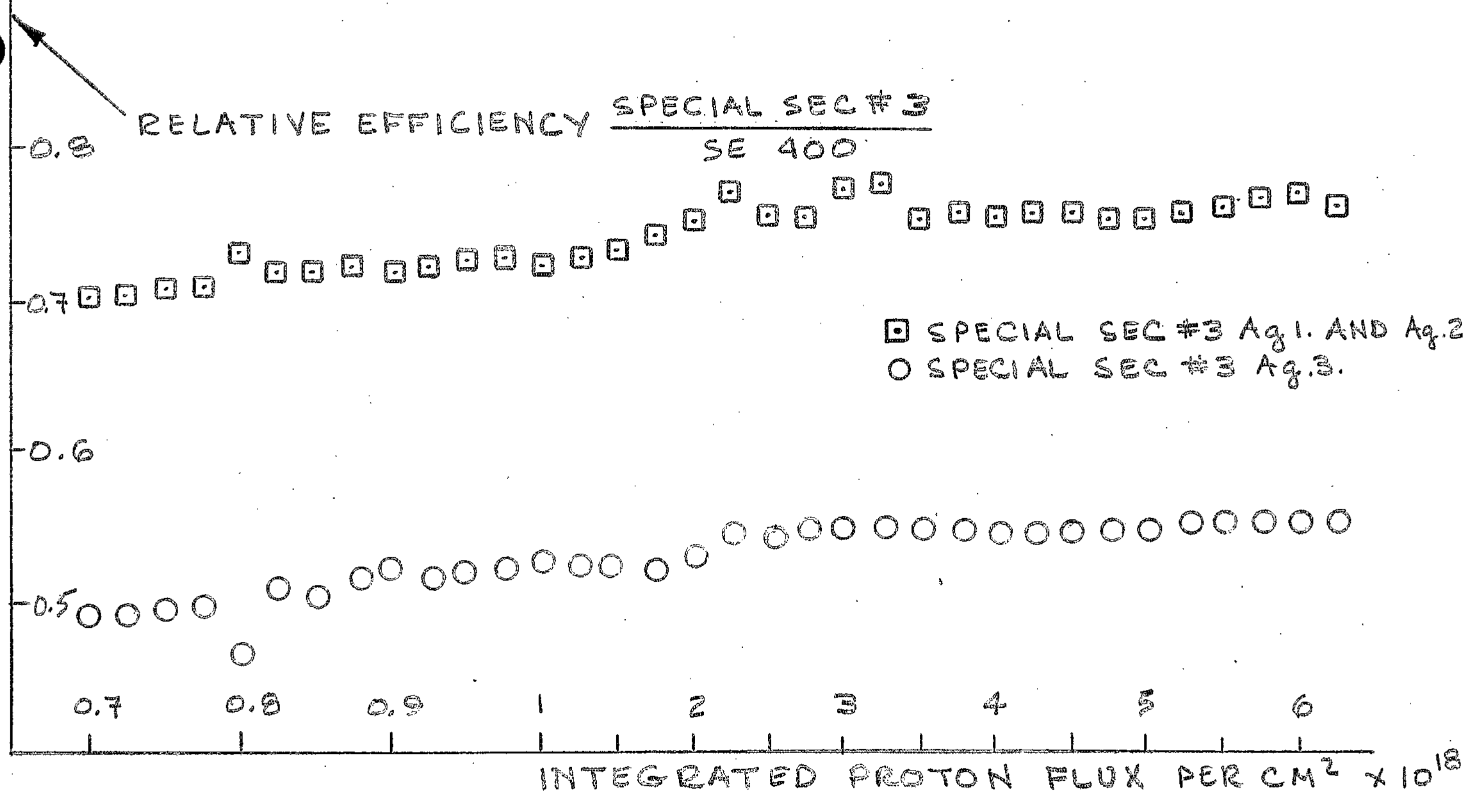

FIG 6 RELATIVE EFFICIENCY OF SPECIAL SEC #3 AGAINST INTEGRATED PROTON FLUX PER CM² THAT TRAVERSED THE CHAMBER.

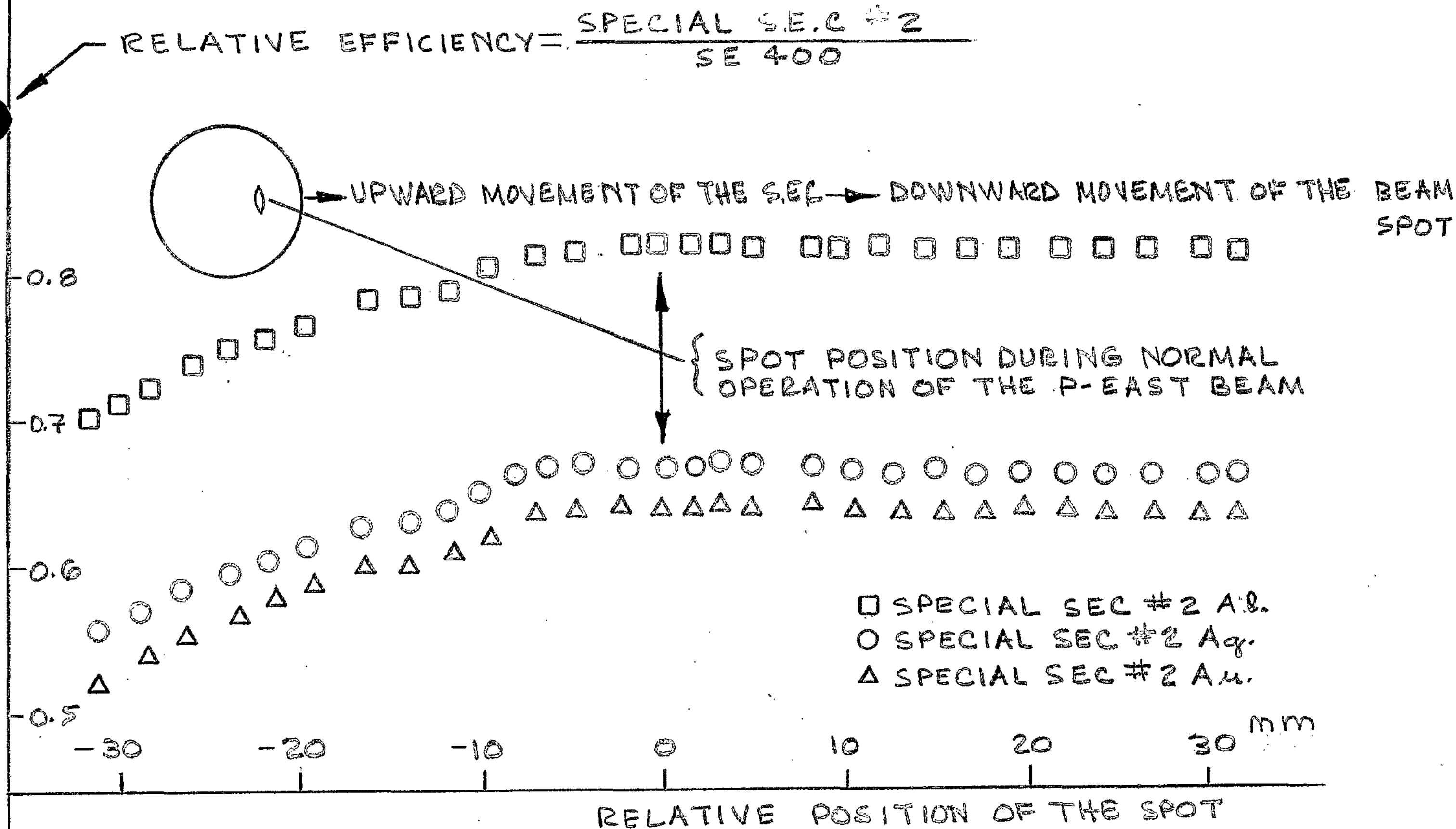

FIG. 7 RELATIVE EFFICIENCY OF SPECIAL SEC #2 AGAINST RELATIVE POSITION OF THE BEAM SPOT IN THE VERTICAL PLANE.

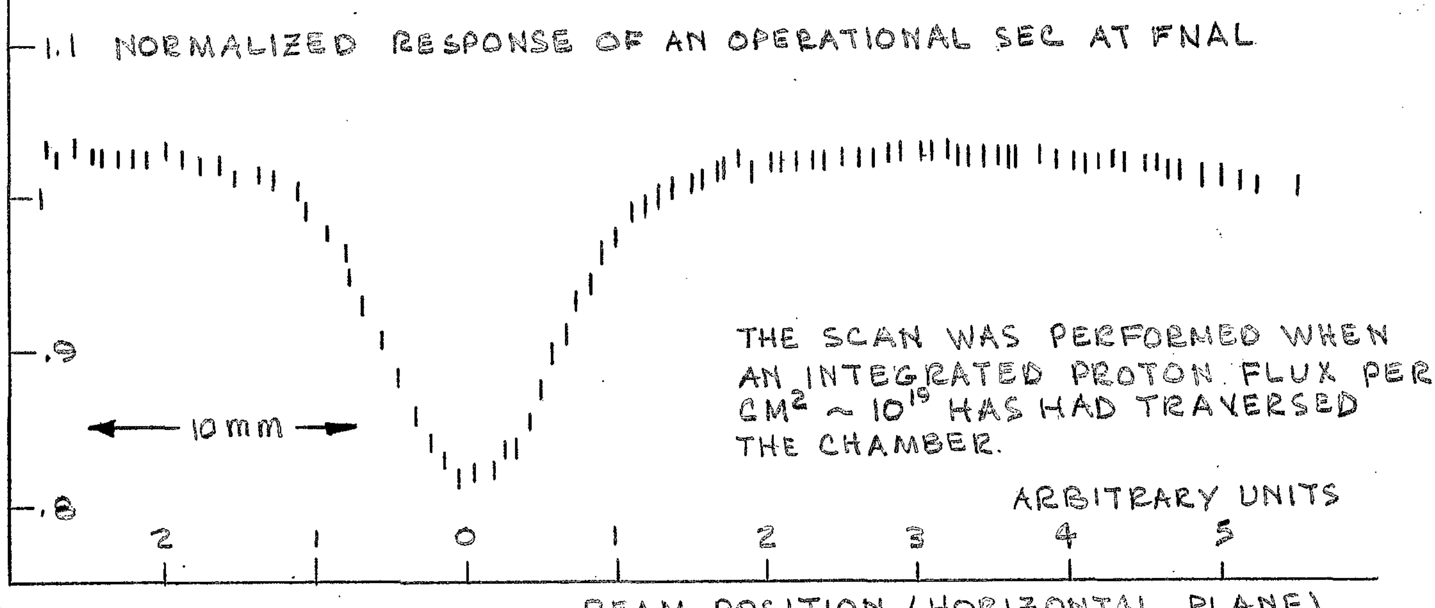

FIG. 8 NORMALIZED SEM(?) RESPONSE AGAINST RELATIVE POSITION OF THE BEAM SPOT IN THE HORIZONTAL PLANE. AS REPORTED BY F. HORNSTRA.[3]

$\rho_{\text{Special SEC \#2 Al}} = 0.041$ (emitted electrons per 400 GeV traversing protons)

$\rho_{\text{Special SEC \#2 Ag}} = 0.049$

$\rho_{\text{Special SEC \#2 Au}} = 0.037$

$\rho_{\text{Special SEC \#3 Ag1}} = 0.045$

$\rho_{\text{Special SEC \#3 Ag2}} = 0.045$

$\rho_{\text{Special SEC \#3 Ag3}} = 0.032$

A careful observation of plots in Fig. 5 and Fig. 6 indicates that all six groups of foils behaved astonishingly in the same manner with the integrated proton flux per cm^2 that traversed the SECs.

There is an apparent 10% increase of the relative efficiencies at the beginning of the tests. The integrated flux at that moment was less than 10^{18} protons per cm^2. If the relative efficiency of one group of foils is plotted against another group, for instance, special SEC #2 Al against special SEC #2 Ag1, then the plot is all the way flat. These considerations imply that there is no detected "aging phenomena" in both the special SECs under the conditions of the tests in Fermilab. We believe that the apparent increase in efficiency was due to some malfunctioning of the two used electronic chains and probably the timing circuit which was common to both integrators. The relative efficiency of the special SEC #3 Ag3 is only 2/3 of the relative efficiency of SEC #3 Ag1 or SEC #3 Ag2. This is because the electric field produced by the 1000 volts bias is not strong enough to collect all the emitted electrons. The interelectrode spacing for the group of foils SEC #3 Ag being 1.5 cm.

The plot of Fig. 7 is also strange. The normal position of the beam spot (see also Fig. 3) on the special SEC #2 was about 3 cm above the geometrical center of the SEC. Moving the table down, the spot goes up on the window. There is also an apparent decrease of the relative efficiencies of all the three groups of foils when the spot was hitting the upper part of the SEC. There is no change in the relative efficiencies in the other part of the chamber. We do not know to what these variation of the relative efficiency against spot positions are really due. An easy explanation is to suppose that all foils are somehow defective near their supports. However, we can assure that what we see is not due to the "aging phenomena" related to integrated proton flux per cm^2, as no proton beam hit this "defective" part of the SEC.

The tests at FNAL therefore show no "aging phenomena" for all the foil groups either against time or against integrated proton flux per cm^2. For comparison, we reproduce in Fig. 8 a normalized response of an operational SEC at FNAL, as reported by F. Hornstra.[3] The "aging phenomena" are very well demonstrated in this plot.

4. BNL/AGS Tests

Before final conclusions about the overall performance of the two special SECs we felt the need to continue the tests. No adequate beam was available in FNAL to continue the measurements for all 1977. That is why both special chambers were transported to BNL last February with the aim of pursuing the long term stability tests in an AGS high intensity beam. The most interesting beam for the tests around the AGS is the FEB. This is because the proton fluxes per cm^2 in this beam are higher than 10^{13} per machine pulse under normal operational conditions and because the intensity pulse by pulse is very well monitored by beam current transformers. The stability and accuracy of the beam current transformers are very good.[17] There are still some problems concerning the absolute calibration of these transformers, but for our measurements the absolute calibration is not necessary. Unfortunately, the scheduled FEB runs are rare and very limited in time. For a while we anticipated the possibility of using the BLIP line and test the SECs in a 200 MeV proton beam, but it turned out to be impossible in the available time.

The April-May 1977 FEB run was an opportunity and we tried to take maximum advantage of it. The available longitudinal space immediately upstream of the neutrino target was long enough for only one secondary emission chamber to be installed there. That is why we divided the FEB run into two periods. The first 6 weeks BNL operational SEC was installed and tested and the next 3 weeks the special SEC #2 was installed and tested. The special SEC #2 has suffered during the transportation from FNAL to BNL. Some of the internal connections of the electrodes were somehow lost. That is why the group of foils, special SEC #2 Al, were given no signal and the special SEC #2 Au was given half of the expected signal. The special SEC #2 Ag was, however, unaffected.

Figure 9 shows the simplified layout of the FEB and the location of the SECs tests. The FEB characteristics during the test were as follows:

Energy: 28 GeV

Repetition period: 1.6 sec.

Spill: $\sim 2.7\ \mu$sec (12-14 proton bunches)

Intensity: $(6\text{-}8) \times 10^{12}$ protons per pulse

Beam size: vertical = 6 mm, horizontal = 8 mm $\rightarrow \approx 0.36\ \text{cm}^2$

Protons fluxes per cm^2: $(1 - 1.6) \times 10^{13}$

However, from time to time the beam position was moving around the normal focusing point and an overall area of the spot, as seen for long periods of time, was $\sim 1\ \text{cm}^2$. The beam size and position was continuously monitored through a television camera on a flag immediately upstream of the neutrino target. The SEC was again fixed on a remote-controlled moving support which now permited scanning of the beam in both the vertical and horizontal planes. The block diagram of Fig. 10 shows the electronic chains used to acquire the data of the measurement. Both manual and computer acquisition of the data is now available. Thanks to a computer data acquisition program prepared by R. Witkover, a large amount of data was taken during the 15 days (12-27 May 1977) the special SEC #2 was in the FEB.

5. Results and Discussion

We summarize the measurements of the BNL/AGS tests using the relative efficiencies of the special SEC #2 Ag and special SEC #2 Au with reference to the beam current transformers as follows:

a) The plots of Fig. 11 represents the relative efficiencies of both groups of foils against beam spot position in the horizontal axis (horizontal scan of the SEC), at the beginning of the tests,

b) The plots of Fig. 12 represents the relative efficiency of both groups of foils against beam spot position in the horizontal axis at the end of the tests.

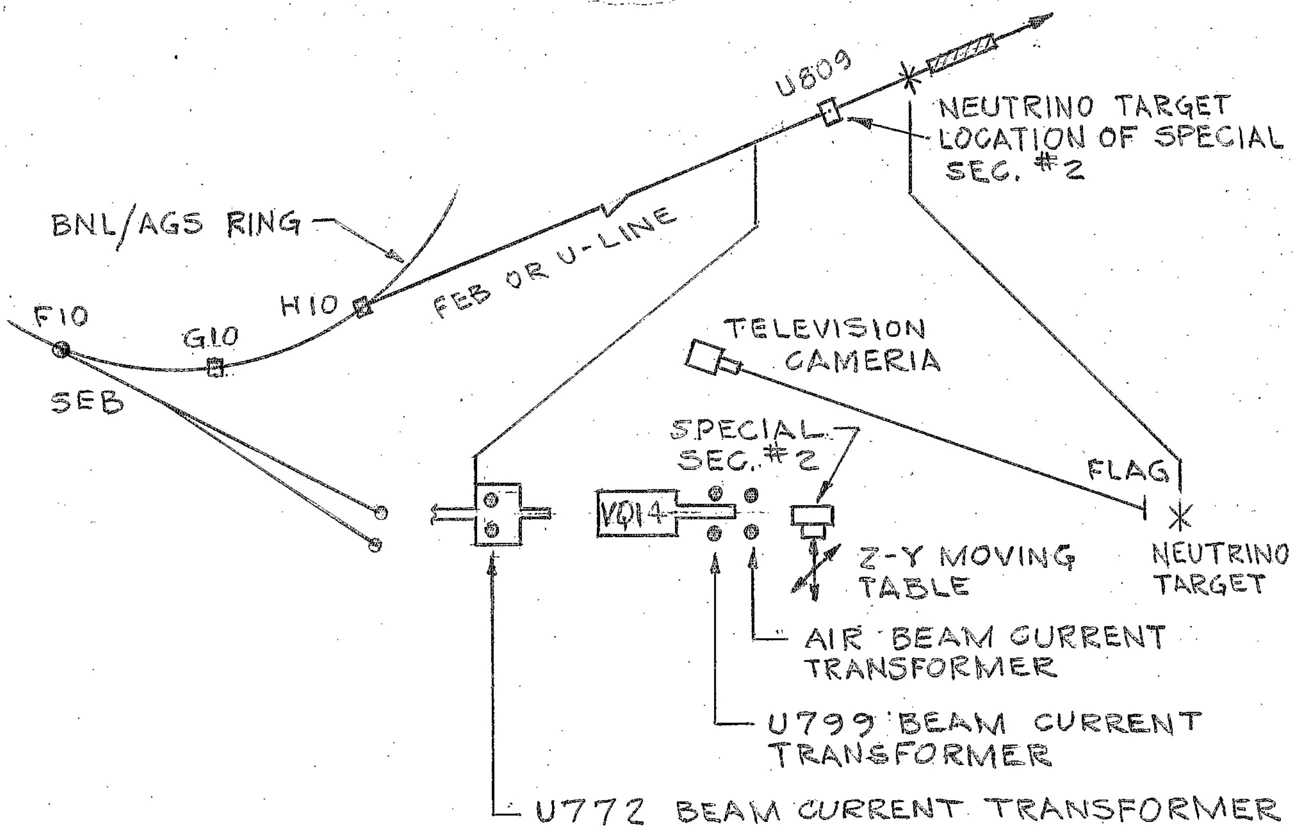

FIG. 9 LOCATION OF THE SPECIAL SEC #2 AT BNL/AGS

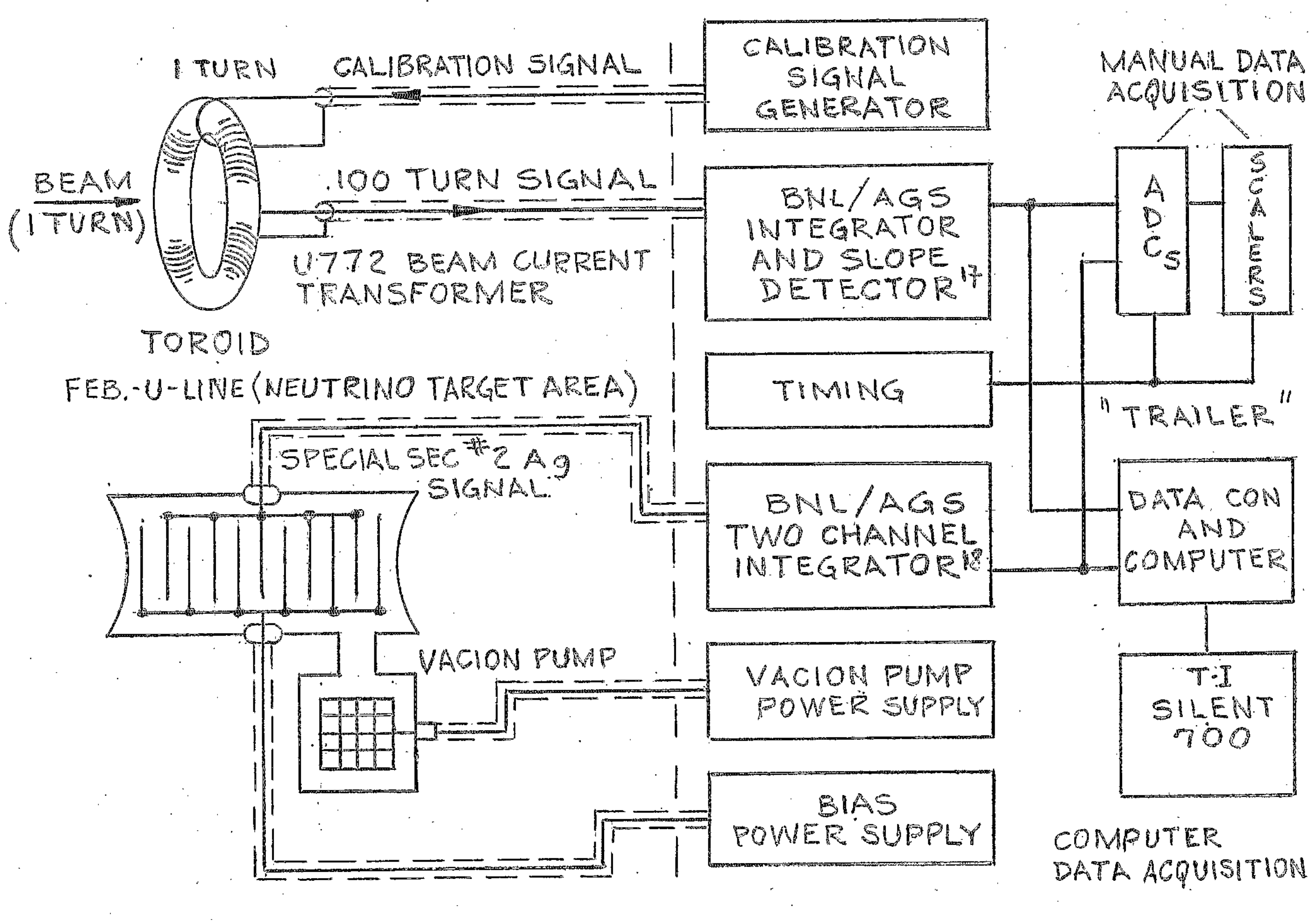

FIG. 10 HOOK UP OF THE TESTS AT BNL/AGS

DATE: 13-MAY-77 11:26   DATA FILE: AH1

VERTICAL POSITION: 1.692 INCHES

SECONDARY EMISSION COEFFICIENT (%) FOR 5 EMITTING FOILS
NORMALIZED TO U799

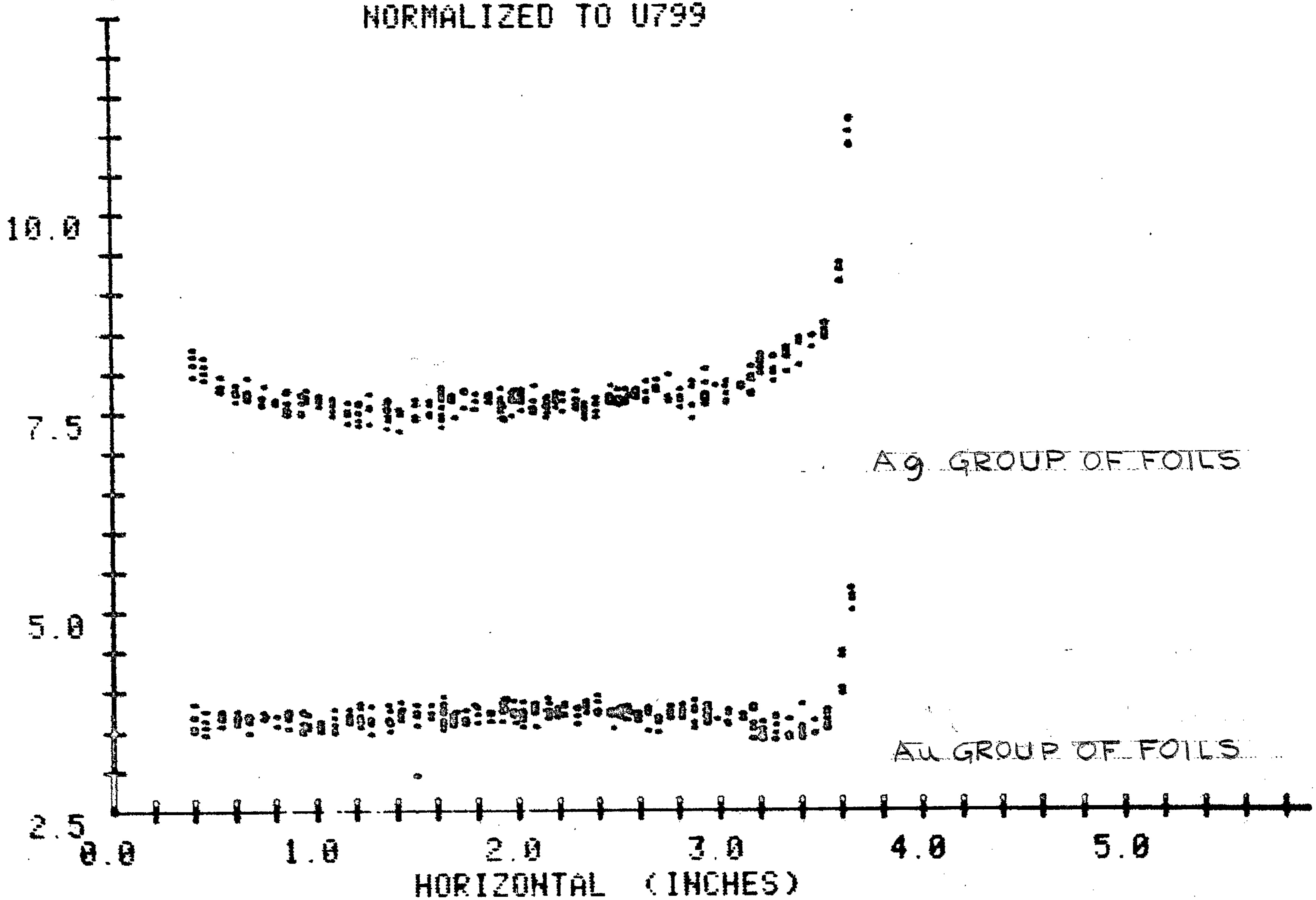

FIG. 11

DATE: 27-MAY-77 17:21   DATA FILE: RH4

VERTICAL POSITION: 1.695 INCHES

SECONDARY EMISSION COEFFICIENT (%) FOR 5 EMITTING FOILS
NORMALIZED TO U799

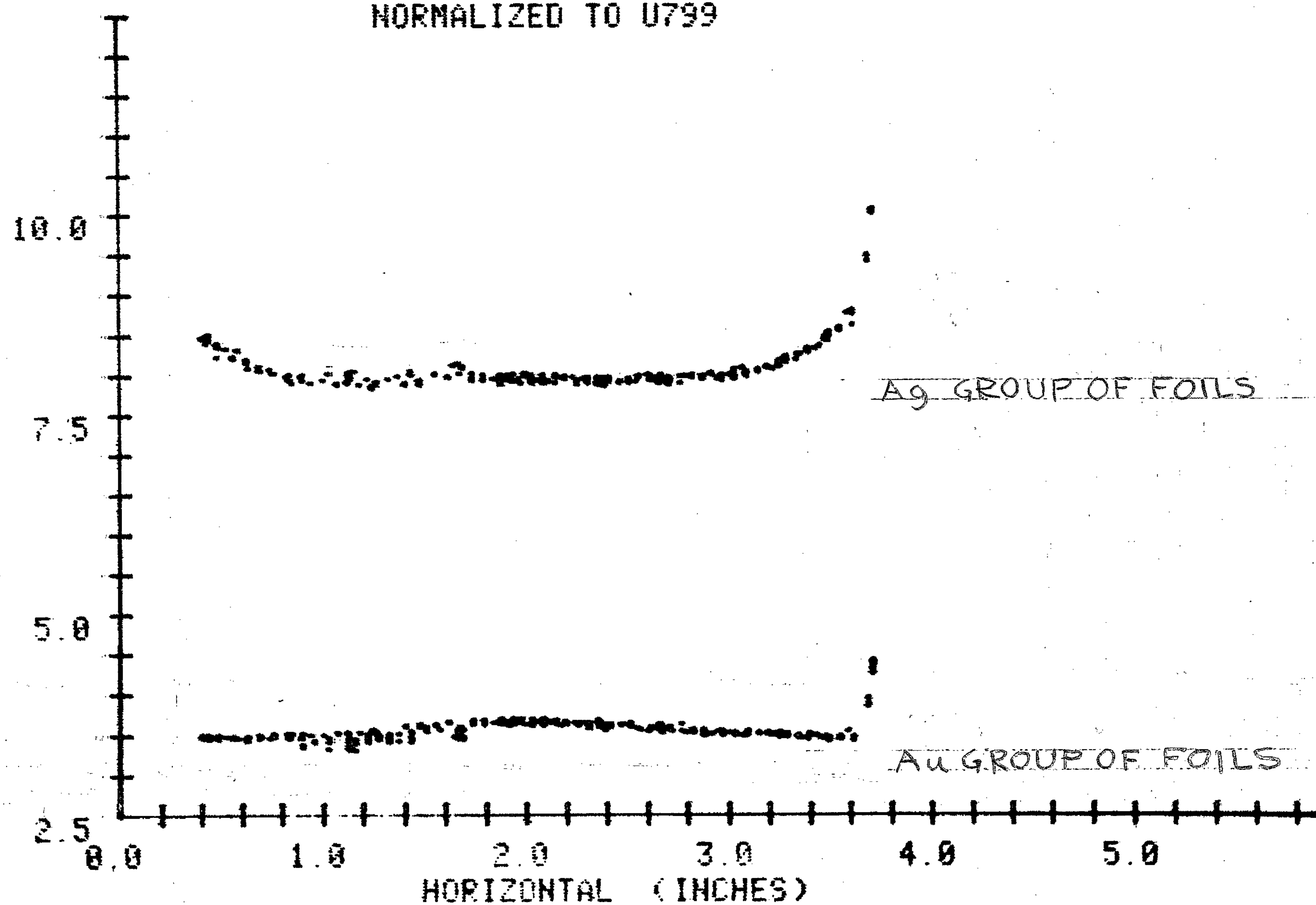

FIG. 12

Careful observation of the plots indicate very little variation in the relative efficiencies of both groups of foils. Scanning the SEC many times in different horizontal or vertical planes we did not detect any spot on the foils. Again, no detectable "aging phenomena" are present. For comparison we also show here two other plots of the relative efficiency of the operational BNL SEC tested in the same beam just before we started the measurements of the special SEC #2. The plots of Fig. 13 represent the relative efficiency of the BNL operational SEC against beam spot position in both vertical and horizontal axes of scanning.

The "aging phenomena" here are very well demonstrated. The integrated proton flux per cm^2 that had traversed the chamber at the moment of the scan was equal to $6 \cdot 10^{18}$ protons/cm^2.

We report here also an interesting observation of the Vacion current variations of the special SEC #2 and the Vacion pump variations of the operational BNL/AGS SEC during the tests in FEB. The Vacion Pump current of SEC #2 was less than 1 μA with the beam off and was increasing up to $\sim$ 2 μA with the beam on. The Vacion pump current of the operational BNL SEC was also of the order of 1 μA with the beam off but with the beam on the Vacion Pump current was as high as 20 μA. We attribute these variations of the pump currents to the "degassing" of the windows and foils due to the heat deposite of the proton beam itself.

6. Conclusions

The tests performed up to now of the two special secondary emission chambers are not complete. Before final conclusions can be formulated, further studies of performance of these chambers are necessary. However, the chambers behaved very well and very differently from the operational chamber at AGS, FNAL and at CERN.

The experience obtained during these tests will help in formulating constructional specifications of secondary emission chambers with no "aging phenomena".

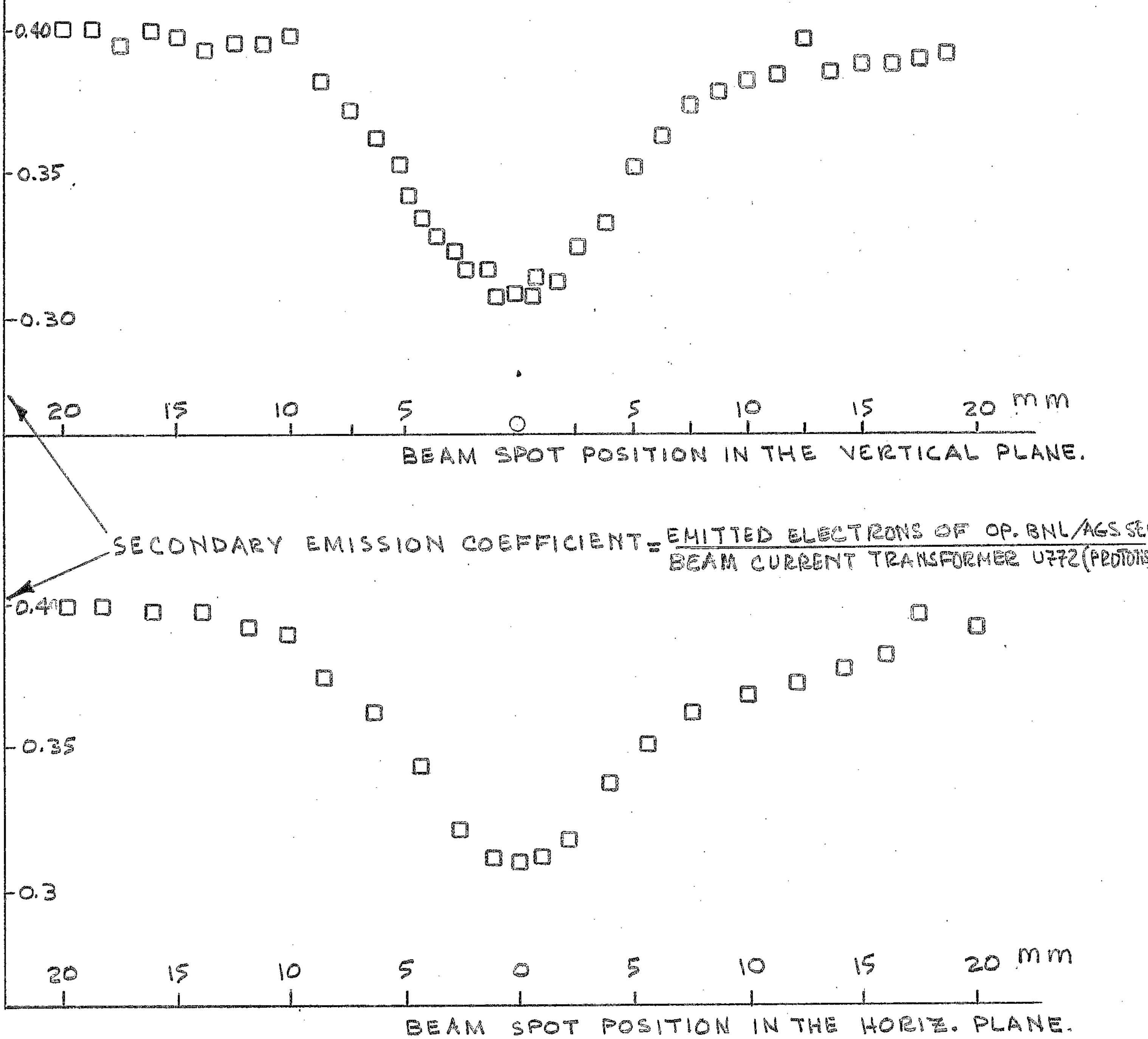

FIG. 13. SECONDARY EMISSION COEFFICIENT OF THE BNL/AGS OPERATIONAL SEC AGAINST BEAM SPOT POSITION IN FEB.

7. Acknowledgments

I am grateful to W. Yang and R. Witkover who were joint participants of the performance tests of the two special secondary emission chambers at FNAL and BNL/AGS, respectively. The tests would not have been possible without the valuable help of the Proton Department staff at FNAL and the AGS Division at BNL.

I am particularly indebted to Miguel Awschalom of FNAL who gave me the use of the two special secondary emission chambers and, in fact, suggested the long-term stability tests with these chambers at FNAL. I am also especially indebted to Lyle Smith, AGS Division Head, who warmly encouraged and supported tests at FNAL and BNL.

The tests at FNAL would not have been performed without the comprehensive and continuous help of Thornton Murphy and Brian Cox and Carmen Rotolo. I am very grateful to them and their co-workers.

I would also like to thank R. Adams, R. Dryden, D. Klein, A. Soukas and L. Repeta for their assistance I received installing interconnecting and test the chambers.

Distr: AGS Division Staff
Accel. Dept. S&P

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APPENDIX I

SPECIFICATIONS FOR A SECONDARY ELECTRON EMISSION MONITOR
SSEM-1-73
August 6, 1973

These specifications cover a hermetically sealed secondary electron emission monitor (SEM) equipped with a Varian #911-5001 vacuum pump.

The attached drawing NAL #1100-MD-17051 is part of the specifications. The SEM under consideration is marked OPTION #1.

1. There are 15 collector electrodes arranged in three groups of five each. Two groups of five collectors (C1's and C2's) shall have full foils, 0.00024 inch thick. One group of five collectors (C3's) shall have foils 0.002-0.003 inch thick, with three inch circular holes. These holes shall be concentric with the foil holder openings within ±0.020 inch.

2. There shall be a grounded holed electrode as described above, between the last full polarizing electrode and the first holed polarizing electrode.

3. There shall be twelve full polarizing electrodes and six holed polarizing electrodes in total.

4. In the accompanying drawing, full polarizing electrodes are marked with '*' and holed polarizing electrodes are marked '**'.

5. All electrodes shall be concentric within ±0.020 inch.

6. The foils of all electrodes shall be flat within ±0.005 inch.

7. Except for the thicknesses of the foils and the holes, all electrodes shall be equal.

8. The foils shall be aluminum, absolutely free of holes and defects. The manufacturer shall describe the method he uses to ascertain the integrity of the foils.

9. All electrodes and all other components that will reside inside the vacuum chamber shall be cleaned to vacuum tube standards. The manufacturer shall describe the proposed method to clean and degrease all such components.

SSEM-1-73

10. After final cleansing, the surfaces of all the electrode foils shall be silver-coated by vacuum evaporation to a thickness of 500 Å±25Å. The silver shall be 99.9999% (six nines) pure.

11. After silvering, the electrodes shall not be exposed to air for longer than 30 seconds. They shall be stored and worked on in an atmosphere of 99.99% pure argon.

12. The entrance and exit windows shall be stainless steel, 4 inches ±0.010 inch in diameter and 0.002 inch thick. The manufacturer shall show details of the proposed method to weld the foils to the end plates and provide them with relief after the SEM is evacuated.

13. The SEM shall be baked at 300°C for not less than 170 hours under hard vacuum.

14. The manufacturer shall guarantee that the SEM pressure shall be less than 10^{-7} torr after a period of two weeks with the pump turned off.

15. The electrical resistance between any one group of collector electrodes and all other electrodes and the body of the SEM shall be greater than 10^{14} ohms, at room temperature ($T \leq 35°C$) and an applied voltage of 10 volts between those collectors and the rest of the SEM. The grounded holed electrode is exempted from this specification.

16. The polarizing electrodes, feed-throughs and connectors shall be guaranteed to stand ±2000 V indefinitely without sparking.

17. The attached drawing leaves certain areas open to the manufacturer's initiative. Some guidelines are now given; all parts should be stainless steel, except for ceramic insulators and aluminum collector electrode foils. Should the manufacturer so desire, the electrode rings may may be made of heat-treated (normalized) stainless steel.

18. The air space between connectors and leads shall be carefully compartmentalized with grounded metalic surfaces, e.g., no air leakage path shall exist between any of the various signal and H.V. conductors.

SSEM-1-73

19. The signal connectors shall have either polyethylene or polystyrene insulators. The connectors shall be baked for 48 hours at 10°C below the softening point of the insulator. Then they shall be cooled off slowly over an 8 to 24 hour period.

20. The end plates shall have two standard O-ring grooves (0.205 to 0.220 inch wide and 0.086 to 0.096 inch deep), with inside diameters equal to 4.19 and 5.44 inch respectively.

21. The Buyer will supply to the manufacturer the parts listed below for each SEM ordered.

21.1 One (1) each Metal Bellows Corporation Part #60080-3.

21.2 Varian tee, flanges and nipples as required for installing the vacuum pump and electrical leads.

21.3 One (1) each Varian #911-5001 vacuum pump.

2.14 One (1) each High Voltage connector.

Acceptance Tests.

22. The SEM's shall be tested for sparking at (+) and (-) 2000 V for 24 hours each. Any one SEM sparking even once, shall be rejected.

23. The leakage current from each set of collectors to the rest of the SEM shall be measured at +10 V and -10V. This current shall be less than 0.10 pA. The test shall be made with a fully assembled SEM.

24. The vacuum pumps shall be turned off for one week. Then, upon turn on, the pump current shall be less than 10 μA.

SPECIFICATIONS FOR A SECONDARY ELECTRON

EMISSION MONITOR

SSEM-2-73

August 15, 1973

These specifications cover a special hermetically sealed Secondary Electron Emission Monitor (SEM) equipped with a Varian #911-5001 vacuum pump.

NAL Specifications SSEM-1-73 are part of these specifications.

1. This SEM shall be equal to the SEM specified in SSEM-1-73, except as listed below.

2. The grounded holed electrode shall not be built in.

3. All electrode foils shall be solid, made of aluminum 0.00024 inch thick.

4. There shall be three groups of five collector electrodes and six polarizer electrodes each.

5. The foils of all the electrodes of each group shall be vacuum coated as follows:

   5.a. Group 1, Aluminum,

   5.b. Group 2, Silver,

   5.c. Group 3, Gold.

   In all cases the purity shall be six nines (99.9999%) and all the precautions of SSEM-1-73 shall be observed rigorously, in particular the exposure to air of the coated foils.

6. The Buyer shall have the right to witness the coating of the foils and their transfer from evaporation jar to argon atmosphere.

7. All the signal connectors shall be properly identified as to group (a, b, c). They shall be UHF connectors.

NAL-Rad. Phys. Grp.

SPECIFICATIONS FOR A SECONDARY ELECTRON
EMISSION MONITOR
SSEM-3-73

August 15, 1973

These specifications cover a special hermetically sealed secondary electron emission monitor (SEM) equipped with a Varian #911-5001 vacuum pump.

NAL Specifications SSEM-1-73 are part of these specifications.

1. This SEM shall be equal to the SEM specified in SSEM-1-73, except as listed below.

2. The grounded holed electrode shall not be built in.

3. All the electrode foils shall be solid, made of aluminum 0.00024 inch thick.

4. There shall be three groups of five collector electrodes and six polarizer electrodes each.

5. All electrode foils shall be vacuum coated with silver as per SSEM-1-73.

6. The spacings between electrode foils shall be varied as follows:

I. 0.150 inch ± .005 inch

II. 0.300 inch ± .005 inch

III. 0.600 inch ± .005 inch.

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