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H. N. Brown

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EP & S DIVISION TECHNICAL NOTE

No. 6

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DESCRIPTION AND USE OF SEPARATED BEAM 1a TO THE 31-in. BUBBLE CHAMBER

This technical note is intended to guide users of separated beam 1a in establishing initial conditions, tuning up, and monitoring the subsequent operation. Since a good understanding of the functioning of the beam transport and separation system is necessary to these ends, these matters will be presented in some detail for the benefit of those who have not previously had much experience with bubble chamber beams.

I. Layout and Functioning of Beam Components

Separated beam 1a is designed to transport particles from an internal target in the AGS to the 31-in. bubble chamber up to a maximum momentum of 4.0 BeV/c. The solid angle accepted at the target is presently 2 mrad vertically x 32 mrad horizontally as determined by the solid angle collimator C1. The vertical angle may be changed by opening the vacuum chamber.

The beam momentum is defined as follows. In the horizontal plane, quadrupoles Q1 through Q4 focus an image of the target at the momentum slit S_{P1}. This image is dispersed, according to momentum, by bending magnets D1, D2, and D3 (bending angles 5.5°, 8.5° and 12°) by the amount (320 inches) x $(\Delta p/p)$. The width of the slit is chosen to allow a momentum band of ± ½% to pass through. This slit is then refocussed by Q7 and Q8 and steered by D4 (bending 16°) onto the second momentum slit S_{P2}. This slit is slightly larger than the image and so does not further affect the primary momentum determination. Its purpose is to eliminate off-momentum particles which may have passed through S_{P1} as a result of scattering from the beam pipe walls or faces of the solid angle collimator. S_{P2} is refocussed in turn upon the final momentum slit S_{P3} by Q8, Q9 and Q10. Here again, magnet D5 (bending 15°) provides momentum selection at S_{P3} to eliminate any remaining off-momentum particles; it does not affect the primary momentum band when properly adjusted.

The mass separation process takes place in the vertical plane and is produced by the vertical electric field in the beam separator tank. In order to simplify the construction, by keeping the net deflection produced by the separator small, the net deflecting impulse imparted to a particle is balanced by a horizontal magnetic field. Thus the net force exerted is

$$F = e\,(E - \upsilon\, B)$$

assuming B is perpendicular to the particle's path. The net impulse on the particle is

$$\delta p_y = \int F dt = \int F \frac{d\ell}{\upsilon} = \int e\left(\frac{E}{\upsilon} - B\right) d\ell$$

$$= \frac{e}{c}\left(\frac{EL_E}{\beta} - BcL_M\right)$$ where L_E and L_M are the effective electric and magnetic field lengths.

The deflection angle, therefore, is

$$\delta\theta = \frac{\delta p_y}{p} = \frac{1}{\left(\frac{pc}{e}\right)}\left(\frac{EL_E}{\beta} - BcL_M\right)$$

For two particles of different mass, and hence of slightly different β (but the same p), the difference in this deflection angle is

$$\Delta_{12}\theta = \frac{EL_E}{(p\frac{c}{e})}\left(\frac{1}{\beta 1} - \frac{1}{\beta 2}\right) = \frac{EL_E}{(p\frac{c}{e})}\ \Delta_{12}\left(\frac{1}{\beta}\right)$$

In order to efficiently separate two types of particles, it is, therefore, necessary that the particle beam in the separator consist of particles whose vertical slopes are distributed within a range less than the separation angle $\Delta_{12}\theta$. This is accomplished in this beam by adjusting

Q1 through Q4 so that the beam is "parallel" (in the vertical plane) in the separator. More precisely, the source (target) is at the focal point of the lenses Q1 - Q4, and under this condition the range of slopes within the separator is

$$\Delta y' = \frac{h}{f_i}$$

where h is the vertical height of the target and f_i is the input focal length to the separator. After traversing the separator, the beam is refocussed (vertically) on the mass slit. If the output focal length is f_o, the image separations and widths are, respectively,

$$\Delta_{12} y = \frac{EL_E}{(p\frac{c}{e})} f_o \Delta_{12} \frac{1}{\beta} = \frac{V}{(p\frac{c}{e})} \frac{L_E}{g} f_o \Delta_{12} (\frac{1}{\beta})$$ where V=gap voltage in volts
g=gap dimension
$(p\frac{c}{e})$ in volts

$$\Delta y = h\frac{f_o}{f_i}$$

This description applies to the second separation stage as well as the first, of course, but with two changes to be borne in mind. The target width h is replaced by the wanted particle image width at SM_1, or by the slit width of SM_1, whichever is smaller. The width of the unwanted particle source for the 2nd stage is generally equal to the slit width, since this contamination is often distributed approximately uniformly across SM_1.

Beam separator #1 is a Berkeley separator. Its magnetic field is produced by a uniform current sheet within an iron "picture frame" yoke. The field length is 219". The electric field length is 232" and electrode gap is set at two inches. The target width h = .042" (Beryllium) and the input and output focal lengths are 1020" and 722" respectively. This gives a theoretical image size of .030" at SM_1.

Beam separator #2 is a BNL cylindrical type. Its effective magnetic field length is 179", produced by a Helmholtz coil arrangement outside the non-magnetic stainless steel tank. Here again, the electrode gap has been set to be two inches, and the electric field length is 182". For the second stage, the input and output focal lengths are, respectively, 730" and 665".

The beam is transported in vacuum most of the distance to the second mass slit. The AGS and beam pipe vacua are separated by a .005" aluminum window located 50" from the target. There are no windows at the ends of the separators. Mass slit SM_1 is located in air, between two 0.01" mylar windows spaced 18" apart. The final window is also .01" mylar, located 10" in front of SM_2 centerline. Beyond the final mass slit there is no vacuum system.

Quadrupole Q11, just behind SM_2, serves the purpose of expanding the beam vertically so that it will cover a region of 3"-4" in the bubble chamber. Despite the nearness to the vertical focus, this is accomplished by rotating Q11 about the beam axis through an angle of 15^o. This couples the vertical motion to the horizontal spread of the beam (about 1.5" at Q11), thus obtaining a larger vertical deflection than would otherwise be obtained due to the vertical spread of the beam alone (0.2").

P1 is a vertical pitching magnet just in front of the chamber, its purpose being to deflect the beam downward (upward) so that the visible arc of a beam track in the chamber is as nearly symmetric as possible. To do this, it is, of course, also necessary to lower (raise) the median plane of the chamber by the correct amount. This compensation cannot easily be made exact at lower momenta, due to the limited range of movement of the chamber, unless one is willing to employ less than maximum field in the chamber.

II. Instrumentation

All magnets in the beam are powered by regulated current power supplies which contain accurate (± 0.25%) shunts for measurement of the current. The shunt voltage in millivolts is read on a Dymec integrating digital voltmeter, which may be set to integrate over 0.1 or 1.0 seconds (the .01 second setting usually should not be used). The magnet current to be displayed is selected by switches, and the adjustment made by means of the Helipot on the corresponding remote control panel.

The total high voltage applied across the separator gap is the sum of the individual voltages (±) applied to the two plates. These voltages are read on Kiethley potentiometers which, when nulled, give the voltage in kilovolts from the dial settings. In checking certain fixed operating voltages on the electrodes, attention should be paid to the sensitivity setting of the instrument; e.g., on the 10 millivolt range, the null meter indicates a total range of ±1kV full scale.

There are various gauges and indicators associated with the vacuum system. Generally speaking, an experimenter need not be concerned with the pressure in the beam pipe as far as quality of the beam optics is concerned; if satisfactory voltage is maintained on the separators, the pressure is quite low enough. The one very important item to be checked is that all gate valves in the beam path (five in all) are open. The status of these valves is indicated on the vacuum control panel.

The Main Control Room distributes a measurement of the total number of accelerated protons. By request, the number of protons subtracted by one's particular target may also be obtained. The signal received consists of a train of pulses, one pulse for each 10^9 protons, which are counted by a scaler. (Usually a special beam monitor scaler is used, but almost any scaler will suffice.)

Main Control also distributes a timing pulse train - 2.0 μsec pulses spaced 1.0 milli-seconds apart. This 1 kc pulse train begins at T_0, the instant that voltage is applied to the AGS magnet. Most machine and monitoring timing functions of interest to the experimenter can be accomplished with reference to this signal by means of the Pre-Dets-scalers which can be set to give an output pulse when a pre-determined number of counts has been reached.

Scintillation counters are used as particle detectors for tuning and monitoring purposes. The time distribution and intensity of primary beam striking the target is observed on an oscilloscope. This signal comes from a scintillation counter located inside the AGS tunnel, near the target. The total charge reaching the photo-multiplier anode is integrated on the capacity of the coax cable leading to the scope. In addition to this monitor, there is a beam port in the AGS shield at $\pm 70^{\circ}$ with respect to the proton beam, through which individual secondaries from the target may pass and be counted by a set of scintillation detectors outside the shield. There are 4 such counters. M1 and M2 are in line and have scintillators 1" x 1". Coincidences between them (M1-M2) would typically be employed for a low intensity experiment such as a π^- exposure. In line with, and behind, M1 and M2, are M3 and M4. Their scintillators are ¼" x ¼". A high intensity run ($K^{\pm}$ or $\bar{p}$) would probably make use of M3-M4 coincidences for monitoring or normalizing the results obtained from the other separated beam detectors.

Just in front of SM_1, between the beam pipe window and slit face, there is a 4" space into which counters may be inserted. Counter C1 (do not confuse with floor layout drawings wherein C indicates a collimator) has a vertically thin (.015" x 1.4" wide x 0.5 thick) scintillator which is useful for exploring the vertical distribution of particles in the image at the mass slit. C2 is a 1" high x ¼" wide x 1" thick counter which can be moved across the beam to measure the horizontal distribution, or used in coincidence with C1 to measure the vertical distribution of a particular segment of the image. A third large counter, C2', may be placed in the beam here for a total flux measurement, or used with one edge placed just at the unwanted particle image above or below the slit for the purpose of detecting a shift in the beam separator fields.

At SM_2 there is another vertically thin counter, C3, which measures .042" x 1.4" wide x 1/2 " thick. C3 is used for scanning the vertical distribution (mass spectrum) of particles transmitted through SM_1 and BS2. Behind SM1 is located a large scintillator C5 (4" high x 6" wide x 1/4" thick) whose output would commonly be counted in coincidence with C6, as a measure of the flux directed to the chamber. C6 is placed between Q11 and P1, and measures 4" high x 4" wide x 1/4" thick.

Between C5 and C6, extending through the aperture of Q11, is a Čerenkov counter. Its active length is about 46 inches with a total gas path length of 54". The windows at each end are 3/8" laminated mylar. It can be pressurized to 250 psig, detecting pions down to ~1.5 BeV/c. In coincidence with the other two counters (C5-Č-C6) a measure of the fast particle (π,μ) contamination relative to the slow particle (K,p) flux (C5-$\bar{\check{C}}$-C6) can be obtained. (The efficiency of Č for this purpose has not been adequately studied as of this date.)

High voltages for the scintillation counters may be checked by means of the selector switch and panel meter at the top of the electronics rack. The current operating voltages are marked adjacent to the respective adjusting knobs.

Chronetics logic modules are utilized to handle the detector outputs. Each scintillation counter pulse is first passed through a pulse height discriminator, whose standardized output pulse is then sent to a coincidence unit or to a scaler. It is important that all unused inputs and outputs of any unit in use be terminated in 50 ohms, and that the maximum output frequency selector be set to the 100 megacycle position. The Chronetics scalers should be checked to be sure that they are set for negative input pulses at a discrimination level of 100 millivolts.

Gating during each AGS cycle is done at the scalers according to the start - stop times set up on the appropriate pre-det channels. Control switches allow each scaler to be reset manually only, or automatically during each machine pulse. Other switches permit selected scalers to count continuously, by manual control, or under control of a normalizing scaler. (These three choices are all subject to the recurrent gating period already mentioned.) A normalizing scaler is one of the six (determined by the normalizing scaler selector) which causes all scalers in the normalizing mode to stop counting when it reaches or exceeds a pre-set number of counts (set by the normalizing count selector switch). Commonly, the scaler to which the monitor pairs (M1-M2) or (M3-M4) are connected is employed for normalization. Alternatively, one might wish to normalize on the output of a large total flux counter just behind a thin scanning counter.

III. Initial Beam Set Up

A set of graphs is attached from which the required nominal current for each magnet may be obtained in terms of the shunt voltage (in millivolts) to be displayed on the DVM. On these graphs, the millivolt setting divided by the momentum (this ratio is almost constant) is plotted as a function of momentum. All of these settings should be calculated accurately from the curves in advance of starting the run.

Several parameters connected with the separators may also be established in advance from the attached curves. First, for the desired momentum and particle type, the necessary separator gap voltages for good separation in BS1 and BS2 may be estimated from the curves giving π-K and π-p separation vs. momentum, assuming that the image widths are about .04". Of course, one will have little choice for high momentum π-K separation, but at lower momenta it is usually advantageous, from the point of view of separator stability, to use less than maximum voltage where possible. (This choice might be over-ruled, however, by the necessity to maintain good conditioning of the separators for a subsequent high momentum experiment.) Having selected operating voltages, the required currents in the separator magnetic field coils may be obtained (to within a few percent) from the curves which show this current (again expressed in millivolts) as a function of total gap voltage. Note that BS1, having an iron yoke, exhibits a small remanent field. Since there will also be some hysteresis present, it may be important, in critical cases, to establish a (uni-directional) cycling procedure when changing the magnetic field by large amounts. Another useful quantity which has been plotted vs. momentum is the relative difference in magnetic field which is required to balance a given electric field for the π-K and π-$\bar{p}$ cases. There is also an attached sheet which gives various deflection sensitivities at the mass slits due to changes in separator or vertical steering magnet fields.

When the time comes to change over from the preceeding experiment, the bubble chamber crew should, of course, be notified, and if a change in momentum and/or particle charge is involved, the Target Desk should be called on the interphone (ivory colored) and the new values given. (The Target Desk is the point from which the Experimental Floor Watch personnel are dispatched to service magnets and power supplies in the event of experiment changes or malfunctions.) If a polarity change is required, the floor watch will reverse all magnets in the beam, by means of reversing switches, with the exception of the separator magnets whose polarity is set by the electric field direction. The bubble chamber crew should also be told of a polarity change since they must then reverse the chamber field.

At this time, Main Control should be informed that tuning for the next run is to commence and requested to set up a slow spill (~30 msec) on the F-20B target. The purpose of this is to circumvent the difficulties caused by high pion counting rates which would occur if the same rapid spill used for taking chamber pictures were employed. When a suitable spill pattern on the scope has been obtained, the counter start-stop gating times should be set to correspond, and should be within the target-up and target-down times set in the Main Control Room. Ask Main Control Room to adjust the spill until you observe ~200 counts per pulse from the monitor (M1-M2).

When the magnet power supplies are again ready for use, they may be switched on at the remote panels, and each Helipot set to about 080 and left to stabilize for a minute or so. The regulators in most supplies will then have taken hold, and the current then may be run up smoothly to the desired nominal value. On some supplies, it will be necessary to advance the Helipot to a higher setting to encourage the regulator to begin functioning. If it is advanced too far, there may be a considerable surge in current for a few seconds, which can occasionally trip the overload relay, in which case it is necessary to lower the Helipot, switch on, and try again.

When all magnets are set, the beam separator fields adjusted to balance, and a spill coming from the F-20B target, the large C2' counter, placed in front of SM1, should record a total pion flux of at least 5 times the (M1-M2) monitor counts. If this is not so, check calculation of all field settings, polarities, counter gates, target spill, etc. If the flux on C2' is satisfactory, one may assume that a beam is being propagated down the pipe, and tuning-up can begin.

IV. Tuning Process

There are many variations possible in the tuning of a separated beam. Here a fairly basic and obvious sequence of measurements will be described which will suffice in many instances, although the experimenter will probably think of other tests to perform as the job progresses. Of course, the more difficult high energy kaon runs will require the most detailed work in securing the best optical conditions for the beam.

The first step is to scan the vertical image at SM_1 by sweeping it across the thin counter C1. First, the image may be found by slowly changing BS1 current around the nominal point and observing the pulse to pulse counts from C1 and (M1-M2)(use automatic reset). When C1 jumps from a low value to several times (M1-M2), the π^- image is on the counter. It may now be systematically swept across C1 while recording the normalized counts; e.g., for 1000 counts on (M1-M2). Appropriate scaler switches should be set to Normalized Count and Manual Reset. The normalizing scaler switch is to be set on that scaler which records (M1-M2), usually scaler A. The sweeping field can be the separator magnetic field, or VSM1 (Vertical Steering Magnet 1) if an expanded, more detailed picture of the image is desired. It is advisable to plot the points as they are taken, if possible. The distribution obtained should exhibit a FWHM of .06" or less (refer to attached sheet for deflection sensitivities at SM_1).

If the image width should be as small as .035", only the more critical needs would require an attempt to improve the focussing. A broad image can, at this point, be improved by centering on C1 and then varying Q5 to increase the peak counting rate. However, since it is the "tail" of the pion distribution that is of most concern, a more exact procedure is to position the counter successively on both edges of the image, where the counting rate is 10-15% of the peak, and vary Q5 to seek minima in the rates at these two points as the image shrinks to its narrowest extent and then broadens again as it is defocussed. After an improved value for Q5 is selected, the whole image should be rescanned to see if there is indeed an improvement, particularly in the region where the separated K's or $\bar{p}$'s are to be found. If VSM1 is being used, be careful to correctly relate its direction of deflection to that of the separator magnetic field. The heavier particles are always displaced toward the high field side of the π peak when the separator magnetic field is swept.

Having optimized the image at SM_1, one could switch off VSM1 and attempt to scan over the mass spectrum at SM_1 by sweeping the BS1 field above the pion position. The presence or absence of a proton peak at $B_\pi \left[1+\Delta_{\pi p}\left(\frac{1}{\beta}\right)\right]$ (see attached graphs) of amplitude comparable to that of the pion peak is a good verification of the beam polarity. Generally, however, the K and $\bar{p}$ peaks will not be easily discernible against the background ($\sim$ a few percent of the pions) at SM_1. It will be more fruitful to now select a slit width based on the observed image size and calculated separation. Hevimet shims of thickness .04", .06", 0.1", and 0.15" are available to fix the image width. After centering the pion image on the slit, the second stage can be tuned for pions. All counters at SM_1 should be removed from the direct beam, since they cause appreciable loss at SM2.

First, the image should be located at SM_2 as was done at SM_1. Before proceeding to any focussing adjustments, it would be wise to verify that D4 is directing the beam centrally through the second momentum slit SP_2. This can be accomplished by centering the image on C3 and sweeping D4. Similarly, D5 can be swept to ensure that it centers the beam horizontally on SM_2, counting C5-C6 coincidences behind the slit.

With the bending magnets adjusted, the image at SM_2 may be scanned by means of BS2 or VSM3, and refocussed by adjusting Q9. After a final check of the image quality, VSM3 should be switched off and the BS2 setting necessary to center vertically on SM_2 determined using (C5-C6).

At this stage then, BS1 and BS2 currents are known which would transmit pions to the B.C. Magnetic field increments, $\Delta B = B_{\pi} \Delta (\frac{1}{\beta})$, can then be calculated from the attached graphs which, when added to $B\pi$, should allow the wanted particles only to pass. These values, of course, may not be quite optimum, so the recommended procedure is to set BS1 at the nominal value and then sweep BS2 to trace out the mass spectrum at SM2, counting on C3. Then, BS1 should be changed by a small amount and BS2 swept again. Three or four such passes should point fairly clearly to the best choice of operating point as regards separation, purity, and flux. A slit width for SM_2 can now be selected which gives a good compromise between beam purity and transmission efficiency. It is helpful to superimpose this slit on the graph of the mass spectrum. Note that it may be desirable to position the image slightly off the center of the slit in order to reject more of the light mesons. Finally, with the slit in place and leveled, the beam should again be swept over SM_2 and the transmitted mass spectrum observed on (C5-C6).

At this point, the beam is fully tuned. It remains only to stop the slow target spill and request that the RBD (rapid beam deflector) be turned on. This is a device which deflects the proton beam onto the target for about 50 μsec, then off again. In adjusting and maintaining the correct spill intensity, it is very helpful to send the (C5-C6) counts to the MCR for the operators to watch. This is probably the same signal which will be used to determine when there is an acceptable number of tracks in the B.C.

When the RBD spill is set up, it is worthwhile to rescan the K or $\bar{p}$ images to verify the final tuning. (M3-M4) should now be employed because of the high instantaneous counting rate occasioned by the RBD. If you attempt to re-examine the π peak, the scaler results will not be quantitatively reliable, but still the position of the edge of the peak, where the counting rate increases tremendously, can readily be located.

The beam is now ready for a test strip to be taken. The chamber crew should be informed of the RBD time, so that they can set the expansion time of the chamber. This first strip, besides being useful to the chamber crew for setting-up their operating conditions, will also show whether the beam is oriented satisfactorily in the chamber, and what changes in pitching magnet current and/or chamber elevation are called for.

In some cases, such as a pion run or a low energy run with easy separation, this tuning procedure can be simplified, and even done using an RBD spill throughout. This saves some set-up time, and allows the chamber to make a test strip check at some earlier point in the tuning.

V. Monitoring the Run

In order to be assured that the pion peak at SM_1 does not shift too close to the slit, it is convenient to position the edge of C2' just above the slit (for a negative beam) or just below it (for a positive beam) at the place where the pion image is located. This large counter's counting rate is then a step function as the pions are deflected onto it and away from the slit. If this rate, compared to the monitor, should drop below some value determined during tuning, it would be an indication of trouble.

At SM_2 it will usually be best to remove C3 during the run, and check the tuning as necessary by (C5-C6). Since remotely movable counters have not yet been installed, any tuning checks must be done by sweeping the separator. At SM_2 this can be done while taking pictures if one has clearly separated images, but for the high momentum cases, especially when checking at SM_1, the cameras should be stopped during this period.

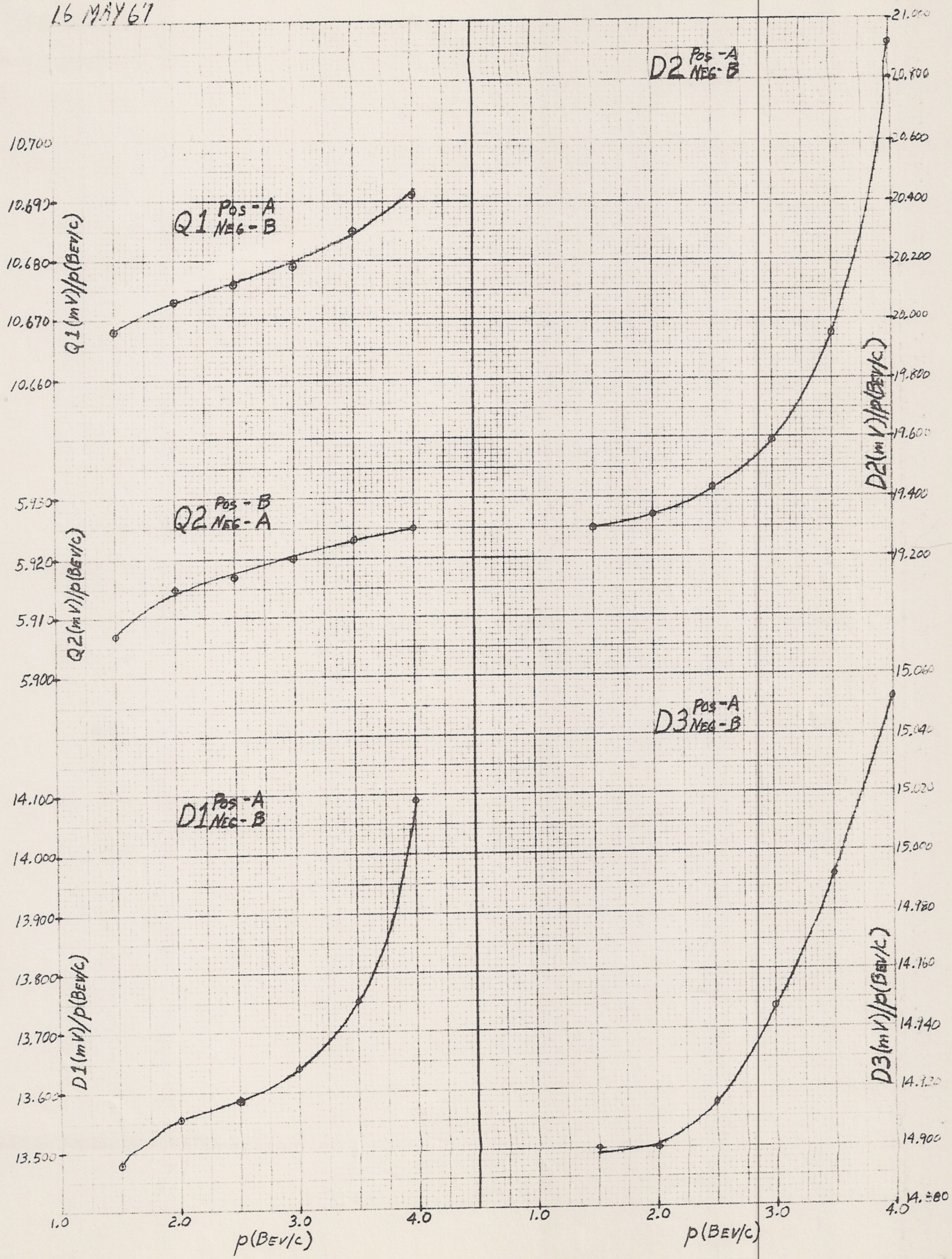
The experimenter is, of course, ultimately responsible for making sure that all parameters are correct during the run. To this end, the beam separator operator can assist in checking the high voltage and magnet settings, at least every 30 minutes, unless trouble at the other beam (Beam 2a) prevents him from doing so. If trouble is suspected, the chamber cameras should be stopped until the question has been resolved. Allowance is seldom made for a long series of pictures taken with an erroneous magnet current or other observable error.

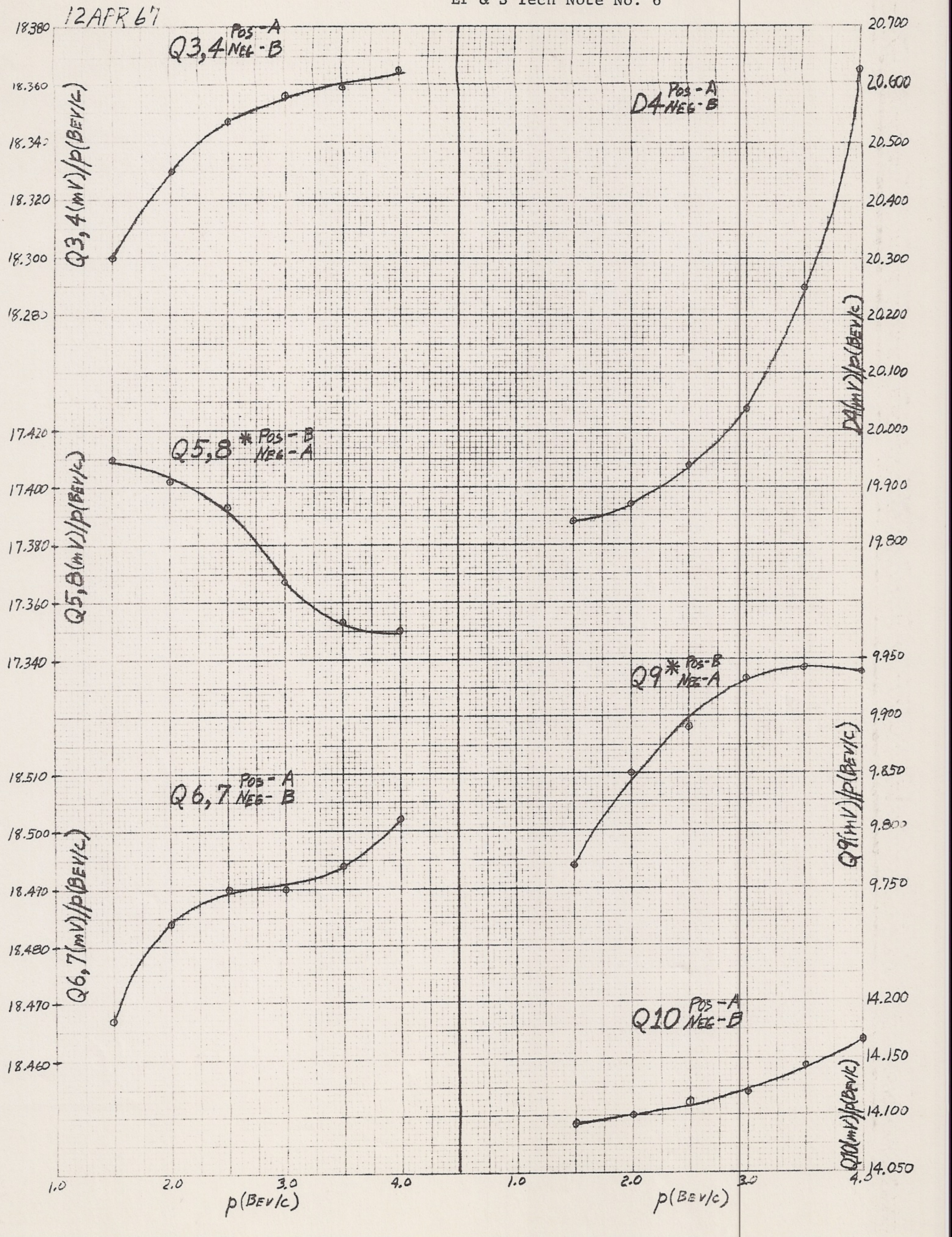
As mentioned earlier, it is a great help to send (C5-C6) counts to MCR to assist them in keeping that number within desired limits. Sometimes it is feasible for the experimenter to control the number of tracks against slow drifting by steering slightly off the slit center as required, but be sure that this is not done in such a way as to increase the contamination.

HNB/pam

Distribution:

Beam Separator Group
Experimenters


16 MAY 67
Q1 Pos - A Neg - B
Q2 Pos - B Neg - A
D1 Pos - A Neg - B
D2 Pos - A Neg - B
D3 Pos - A Neg - B
Q1(mV)/p(BeV/c)
Q2(mV)/p(BeV/c)
D1(mV)/p(BeV/c)
D2(mV)/p(BeV/c)
D3(mV)/p(BeV/c)
p(BeV/c)
p(BeV/c)


12 APR 67
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Q3,4(mV)/p(BeV/c)
D4 Pos-A Neg-B
D4(mV)/p(BeV/c)
Q5,8* Pos-B Neg-A
Q5,8(mV)/p(BeV/c)
Q9* Pos-B Neg-A
Q9(mV)/p(BeV/c)
Q6,7 Pos-A Neg-B
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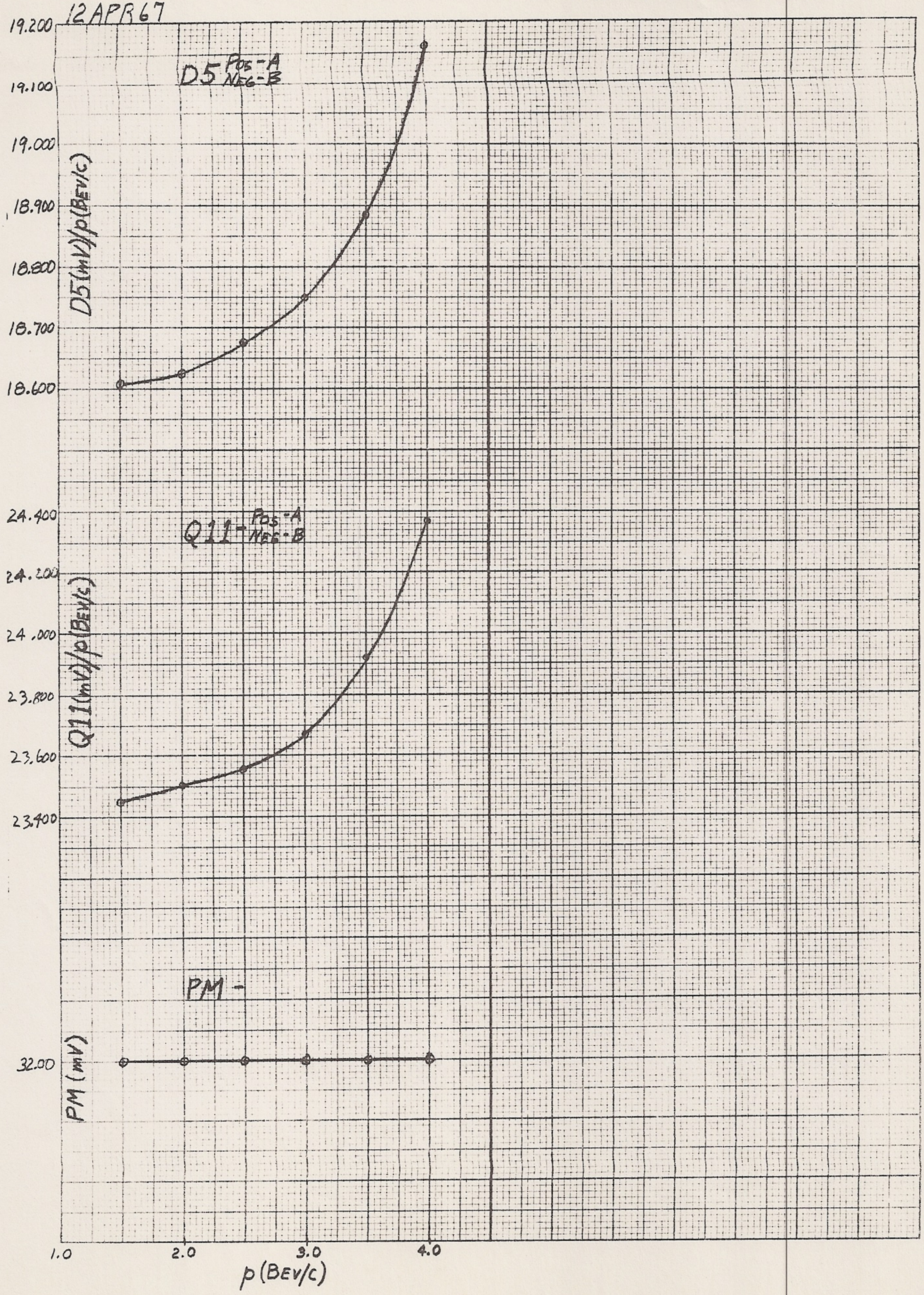
Q10 Pos-A Neg-B
Q10(mV)/p(BeV/c)
p(BeV/c)
p(BeV/c)


12APR67
19.200
19.100
19.000
18.900
18.800
18.700
18.600
D5(mV)/p(Bev/c)
D5 Pos-A Neg-B
24.400
24.200
24.000
23.800
23.600
23.400
Q11(mV)/p(Bev/c)
Q11- Pos-A Neg-B
PM -
32.00
PM (mV)
1.0
2.0
3.0
4.0
p(Bev/c)

BROOKHAVEN NATIONAL LABORATORY

BY________ DATE 4/12/67 SUBJECT MFSB 1a MAGNET SETTINGS SHEET No.____ OF____

CHKD. BY______ DATE______ JOB No.______

DEPT. OR PROJECT______

MAG	PS	R_s (μΩ)	2.0 Bev/c kG kG/in	2.0 Bev/c kA	2.0 Bev/c mV	3.0 Bev/c kG kG/in	3.0 Bev/c kA	3.0 Bev/c mV	4.0 Bev/c kG kG/in	4.0 Bev/c kA	4.0 Bev/c mV	POLARITIES Pos. Beam	POLARITIES Neg. Beam
FQ1		40	.6261	.5337	27.35	.9391	[illegible]	[illegible]	1.2522	[illegible]	[illegible]	A	B
Q2		40	-.3791	.2958	11.83	-.5687	.4439	17.76	-.7583	.5924	23.70	B	A
D1		25	-7.1958	1.0843	27.11	-10.7937	1.6366	[illegible]	-14.3916	2.2543	[illegible]	A	B
D2		40	-9.0470	.9670	[illegible]	-13.5705	1.4691	[illegible]	-18.0940	2.0915	83.66	A	B
X1													
D3		40	-6.9456	.7450	29.90	-10.4184	1.1211	[illegible]	-13.8913	1.5053	[illegible]	A	B
Q3		125	.3761	.2933	36.66	.5642	[illegible]	[illegible]	.7523	.5877	73.46	A	B
Q4			-.3761			-.5642		-	-.7523			B	A
Q5		125	-.3484	.2715	[illegible]	-.5226	[illegible]	52.18	-.6969	.5445	68.06	B	A
X2		125						6.0*					
Q6		66⅔	.7097	.5536	36.87	1.0645	.8321	55.47	[illegible]	1.1101	74.01	A	B
D4		40	-9.2477	.9935	39.74	-13.3715	1.5028	60.12	[illegible]	2.0667	82.[illegible]	A	B
Q7			.7097			1.0645		-	[illegible]			A	B
X3													
Q8			-.3484			-.5226		-	-.6969			B	A
Q9		66⅔	-.3887	.3032	19.45	-.5830	[illegible]	[illegible]	-.7773	.6074	[illegible]	B	A
X4		66⅔			20.21			30.15 9.0*			40.50		
Q10		40	.5799	.7049	28.20	.8699	1.0590	[illegible]	1.1523	1.4159	56.66	A	B
D5		40	-8.6731	.9313	37.25	[illegible]	1.4063	[illegible]	-17.3462	[illegible]	[illegible]	A	B
Q11		40	1.5000	1.1752	47.01	2.2500	1.7751	71.00	3.0000	2.4369	97.[illegible]	A	B
PM		40	-11.540	.8000	32.00	-11.540	.800	32.00	-11.540	.800	32.00		
VSM1					UP 13.00			UP 13.00					
VSM3					UP [illegible]			UP 3.50					

*- MILLIVOLT VALUES OBTAINED EMPIRICALLY BY TUNING: FIELD + CURRENTS DO NOT EXACTLY CORRESPOND; THEY ARE COMPUTER RESULTS

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BROOKHAVEN NATIONAL LABORATORY

BY________ DATE 4/12/67 SUBJECT________ SHEET No.____ OF____

CHKD. BY________ DATE________ JOB No.________

DEPT. OR PROJECT________

			1.5 BEV/c			3.5 BEV/c			2.5 BEV/c		
MAG	P.S.	R_s ($\mu\Omega$)	kG kG/IN	kA	mV	kG kG/IN	kA	mV	kG kG/IN	kA	mV
Q1		40	.4696	.9001	16.00	1.0957	.9349	37.40	.7826	.6673	26.69
Q2		40	.2844	.2214	8.86	.6635	.5182	20.73	.4739	.3698	14.79
D1		25	5.3968	.8088	20.22	12.5926	1.9251	48.13	8.9948	1.3586	33.965
D2		40	6.7852	.7238	28.95	15.8322	1.7458	69.83	11.3088	1.2145	48.58
X1											
D3		40	5.2092	.5586	22.35	12.1549	1.3118	52.47	8.6821	.9322	37.29
Q3		125	.2821	.2196	27.45	.6583	.5140	64.26	.4702	.3669	45.87
Q4			.2821			.6583			.4702		
Q5		125	.2613	.2033	25.41	.6098	.4761	59.51	.4356	.3399	42.49
X2		125									
Q6		$66\frac{2}{3}$	.5323	.4155	27.70	1.2420	.9710	64.73	.8871	.6934	46.22
D4		40	6.9358	.7440	29.76	16.1834	1.7718	70.87	11.5596	1.2461	49.84
Q7			.5323			1.2420			.8871		
X3											
Q8			.2613			.6098			.4356		
Q9		$66\frac{2}{3}$	.2915	.2270	14.65*	.6802	.5312	34.80*	.4858	.3791	24.72*
X4		$66\frac{2}{3}$									
Q10		40	.4350	.5286	21.14	1.0149	1.2375	49.50	.7249	.8819	35.28
D5		40	6.5048	.6977	27.91	15.1779	1.6525	66.10	10.8414	1.1673	46.69
Q11		40	1.1250	.8794	35.18	2.6250	2.0928	83.71	1.875	1.4722	58.89
PM		40	-11.540	.800	32.00	-11.540	.800	32.00	-11.540	.800	32.00

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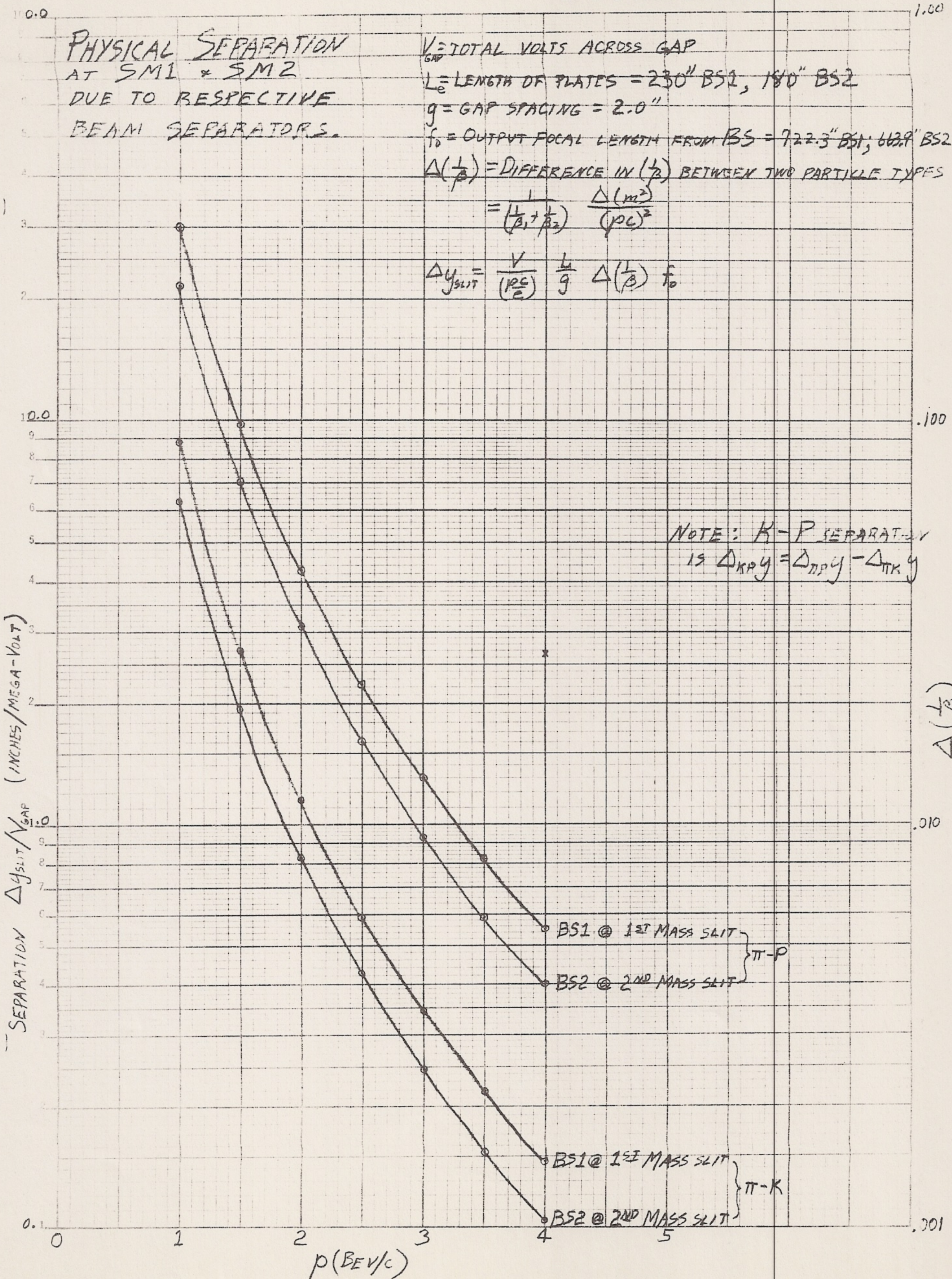
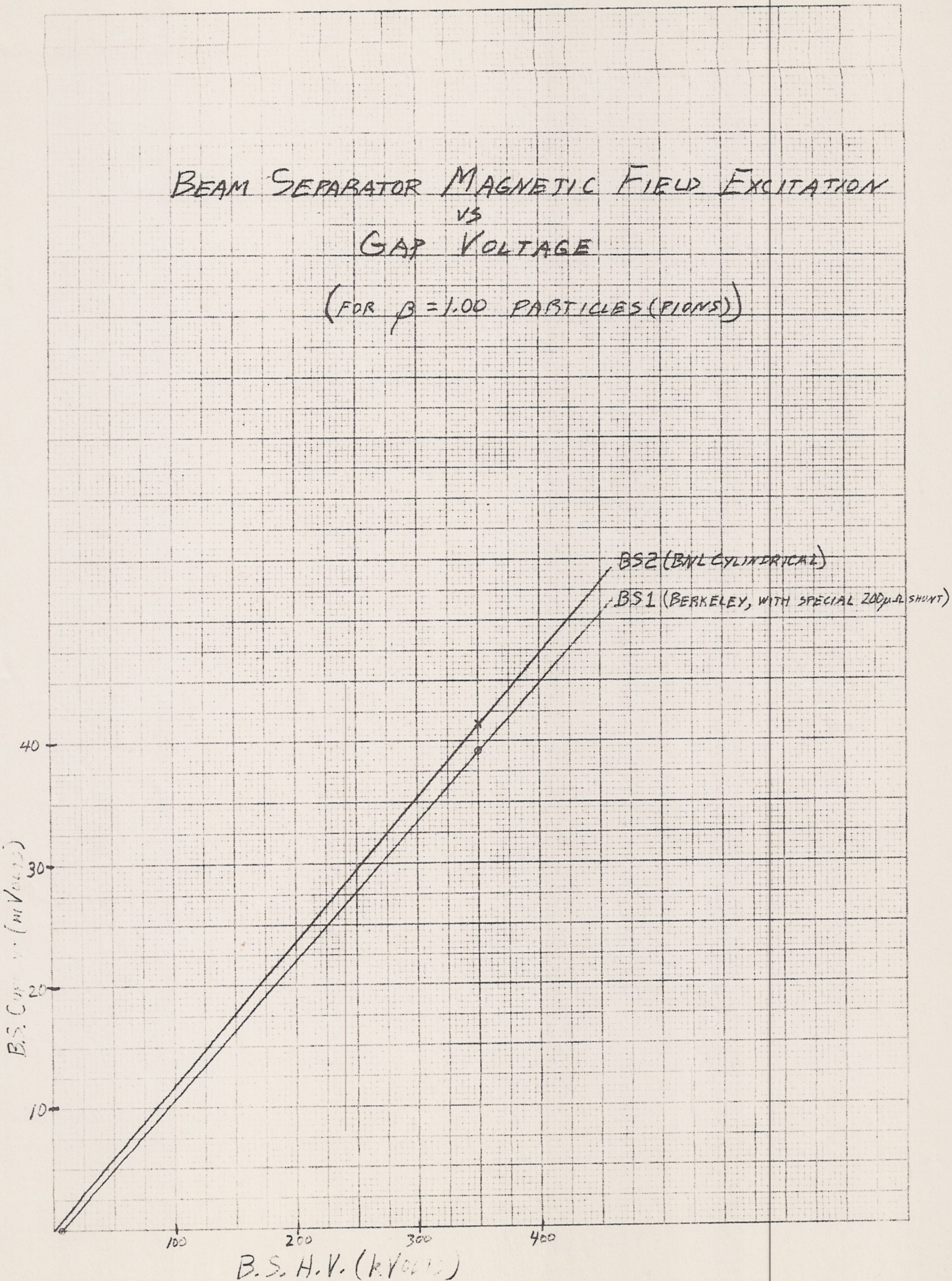
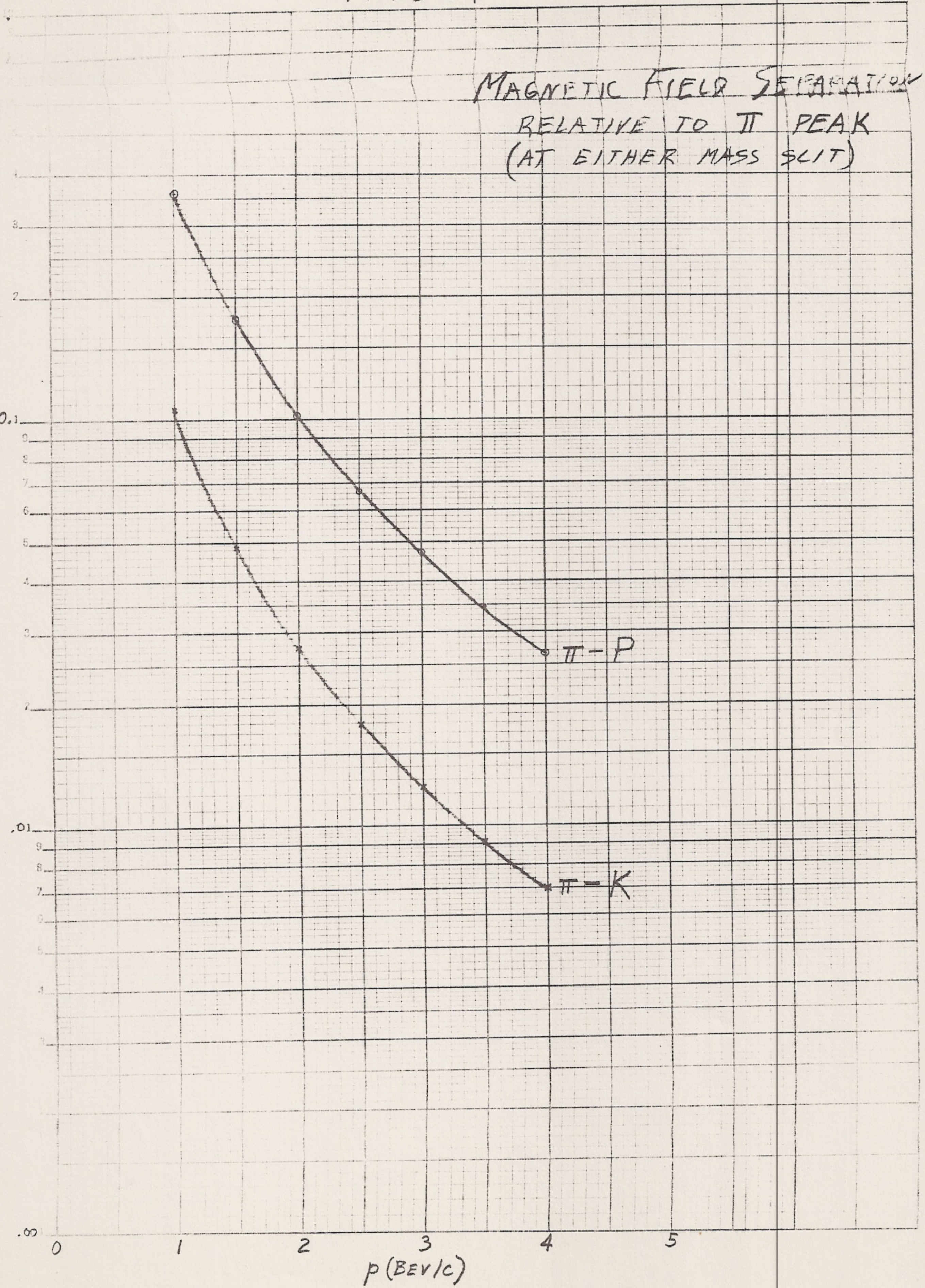
MESB - 1A EP & S Tech Note No. 6 31 MAY 67




BEAM SEPARATOR MAGNETIC FIELD EXCITATION
VS
GAP VOLTAGE
(FOR β = 1.00 PARTICLES (PIONS))
BS2 (BNL CYLINDRICAL)
BS1 (BERKELEY, WITH SPECIAL 200μΩ SHUNT)
40
30
20
10
100
200
300
400

MESB 1A EP & S Tech Note No. 6 7 JUN 67



5/31/67

EP & S Tech Note No. 6

BEAM SEPARATOR MAGNET CURRENTS TO BALANCE ELEC. FIELD + DEFLECTION SENSITIVITIES AT MASS SLITS

BS1: BERKELEY SEP. (IRON CORE - HYSTERESIS EFFECTS POSSIBLE)

$$I_\pi(\text{AMPS}) = 0.571\, V(\text{kVOLTS}) - 3.74 \text{AMPS}$$

$$I_\pi R_{SHUNT}(\text{mV}) = .1142\, V(\text{kVOLTS}) - .748 \text{ mV}$$

MAG. FLD. DEFLEC.: $\Delta y_{SM1}(\text{INCHES}) = \dfrac{0.735}{p(\text{BeV/c})} \Delta(IR_{SHUNT})(\text{mV})$

WITH SPECIAL 200μΩ SHUNT INSTEAD OF INTERNAL SHUNT.

ELEC. FLD. DEFLEC.: $\Delta y_{SM1}(\text{INCHES}) = \dfrac{.0831}{\beta p(\text{BeV/c})} \Delta V(\text{kV})$

VSM1: $\Delta y_{SM1}(\text{INCHES}) = \dfrac{.0508}{p} \Delta(IR_{SHUNT})(\text{mV})$

BS2: BNL CYLINDRICAL SEP. (AIR CORE)

$$I(\text{AMPS}) = 0.948\, V(\text{kVOLTS})$$

$$IR_{SHUNT}(\text{mV}) = 0.1185\, V(\text{kVOLTS})$$

WITH INTERNAL SHUNT IN PS #203.

MAG. FIELD DEFLEC.: $\Delta y_{SM2}(\text{INCHES}) = \dfrac{0.509}{p(\text{BeV/c})} \Delta IR_{SHUNT}(\text{mV})$

ELEC. FLD. DEFLEC.: $\Delta y_{SM2}(\text{INCHES}) = \dfrac{.0598}{\beta p(\text{BeV/c})} \Delta V(\text{kV})$

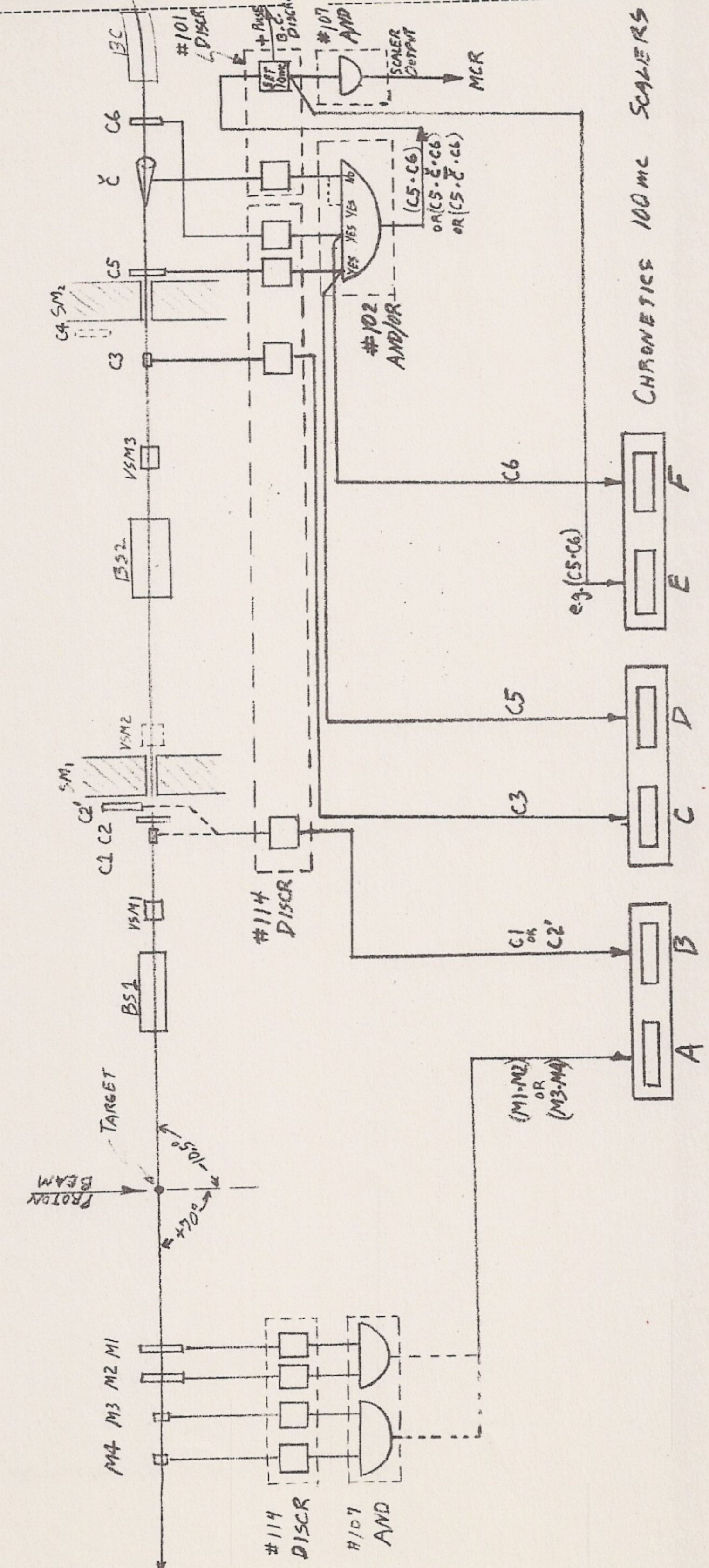
VSM3: $\Delta y_{SM2}(\text{INCHES}) = \dfrac{.0415}{p} \Delta(IR_{SHUNT})(\text{mV})$

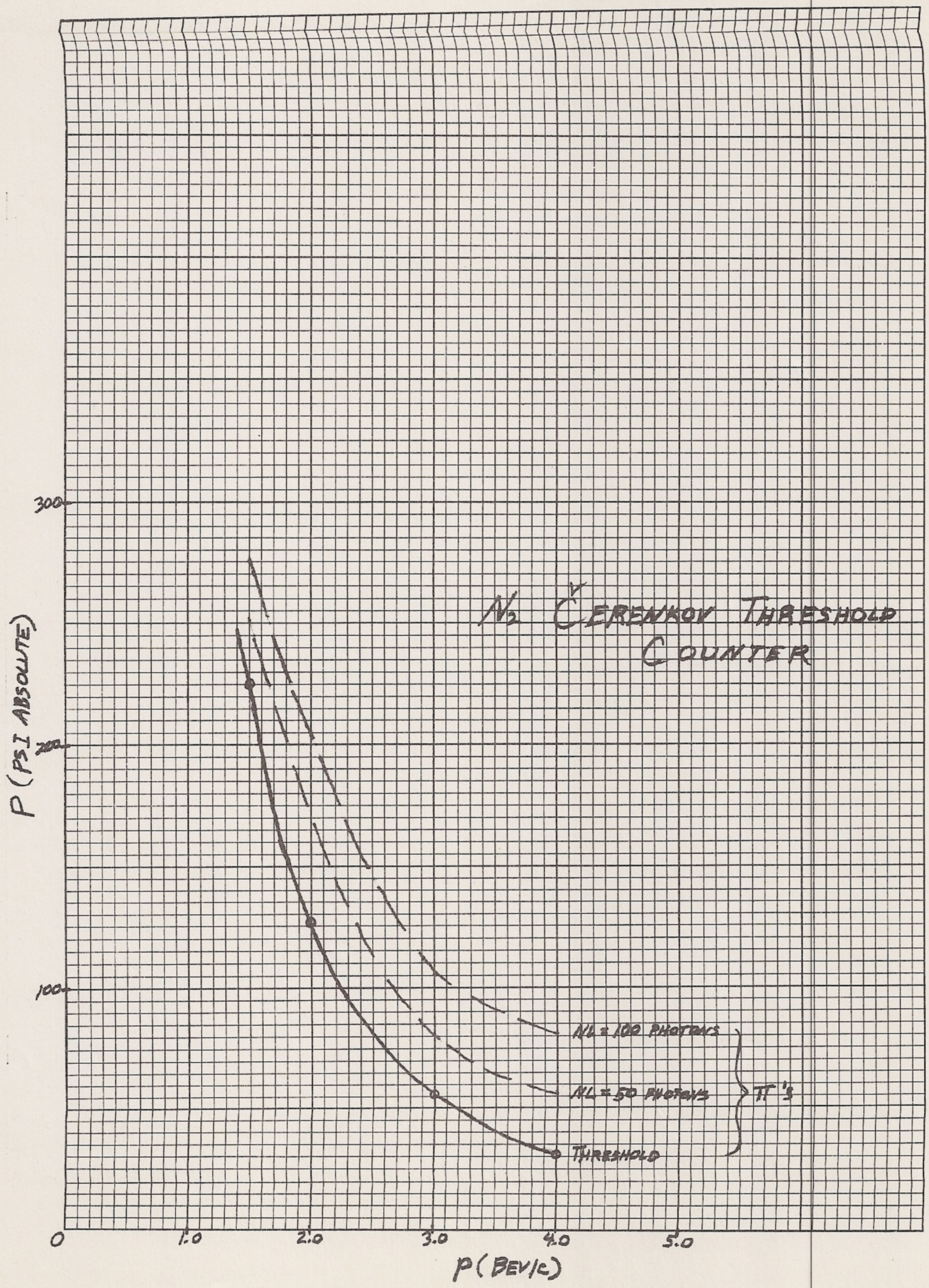
EP & S Tech Note No. 6

BY______________ DATE_________ SUBJECT____ SHEET NO.________OF______

CHKD. BY_______ DATE_________ JOB NO.____________________

REPRESENTATIVE COUNTER ARRANGEMENT




N2 ČERENKOV THRESHOLD COUNTER
P (PSI ABSOLUTE)
300
200
100
0
1.0
2.0
3.0
4.0
5.0
P (BEV/c)
NL = 100 PHOTONS
NL = 50 PHOTONS
THRESHOLD
π's

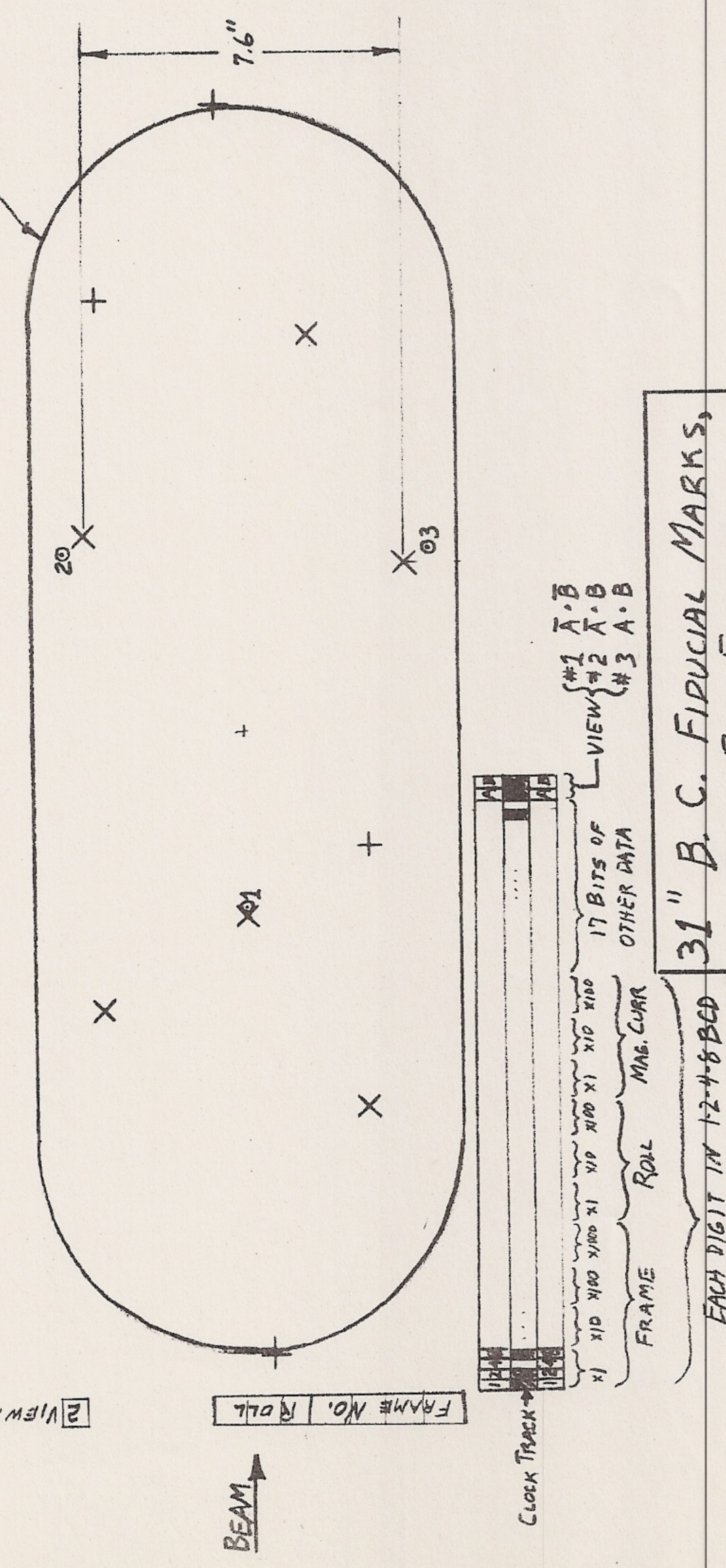
BY H.N.B. DATE 7 JUN 67 SUBJECT EP & S Tech Note No. 6 SHEET NO. ____ OF ____
CHKD. BY ____ DATE ____ JOB NO. ____

⊙ CAMERA LOCATIONS

× CHAMBER WINDOW FIDUCIALS

+ BACK WALL + RACETRACK FIDUCIALS

ORTHOGRAPHIC PROJECTION



31" B. C. FIDUCIAL MARKS, DATA BOX FORMAT, AND CAMERA LOCATIONS

(DIMENSIONS NOT EXACT: REFER TO B.C. GROUP FOR DETAILED LAYOUT)