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791 Neutral beam

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I. The concern of the neutral beam is to try to define a 5 mrad (horizontal) x20 mrad (vertical) beam with little halo which will accept 10^{13} protons per pulse on the production target. There are several differences from the present A3 beam:

1. The collimators are taped with a focus at the upstream face of the first sweeping magnet. The production target is pulled upstream from this focus so that no particle produced there sees a collimator face. Monte Carlo simulations by the experimenters indicated that these faces would be a significant source of halo.

2. The beam can be pitched onto the target from 1° to 4.5° in a vertical plane. This will allow the experimenters to control, somewhat, the K_L/n ratio. A vertical plane was chosen so that the target would more easily fit within the cone formed by the collimator apex described in 1. This allows the target to be closer to the collimator focus. A disadvantage is that the collimator solid angle will see a significant variation in production angle, so rates will be different over the 20 mrad angle. However, the vertical pitch results in our being able to use narrower magnet gaps.

3. The beam will be dumped <u>after</u> the first sweeper, 10 cm from the neutral channel. CASIM calculations show that it is important to dump the beam as far from the hole as possible, but it is also important to have considerable shielding along the proton direction. The first sweeper field will be 27 kgauss to spread the charged beam as far from the neutral beam as is possible.

4. The two magnets used for sweepers will have their coils spread apart with telescoped poletips to focus the field on the neutral beam region. This will protect the coils (8" lead will be placed between the coils) and give considerably more shielding on the median plane. Gordon Danby pointed this out: an H-magnet would be better as a sweeper than a window-frame magnet.

5. There will not be a middle sweeping magnet, as in A3. Tests in A3 indicate that the second magnet helps very little. Advantages are that the shielding in the area where the beam dumps can be much tighter and that there will be no dynamic element there which can break.

6. There will be considerably more iron than for A3 and the region just downstream of the collimators will be shielded by light concrete to absorb slow neutrons.

Figures 1 and 2 show the neutral beam area. The side view indicates the path of 28.5 GeV/c protons which are dumped at about 3 meters into steel. For 1° targetting the beam is dumped at a point 15 cm from the neutral beam hole. For a 4.5° incident proton angle the dump point is 30 cm from the hole. Longitudinally, the beam sees about 6 meters of steel and 1 meter of concrete in the dump.

Figure 3 is a copy of a flux contour plot taken from CASIM notes. The contours are proportional to hadron flux for 30 GeV/c protons dumped in an iron cylinder, a function of radius and depth. The neutral beam hole for 1° protons is shown superimposed on the plot. At the exit of the neutral beam the star density is about 10^{-12} per incident proton. One can see the effect of dumping later: it has the advantage of getting further from the hole, but there would be less steel depth available. An example is shown on the figure where the beam is dumped instead at 5 meters on Fig. 1, which gives a 25 cm distance to the hole (radius) and 4 meters of steel depth. The star density at the exit of the collimator is 10^{-9}, three order of magnitude higher than for our design. Also shown on Fig. 3 is a contour for Exp. 780 in the A3 line. The proton beam is dumped at a radius of about 1 cm (in brass and lead) and has a steel depth of approximately 6 meters. At the exit of the neutral beam, 780 would have a comparable "direct flux" to 791.

One can also use Fig. 3 to estimate fluxes from indirect sources. If we assume that low energy neutrons which reach the neutral channel then scatter isotropically, a fraction then are scattered down the hole into the experimental area. The relative contributions along the collimator are weighted by the effective solid angle of the hole exit as viewed from each source position. A source about 2 meters from the beginning of the dump dominates for the 791 design. For the 780 collimator this position has a factor of ten larger star density than for 791 and there are very much higher hadron densities further upstream. It would appear that the 791 design should result in a greater than 1 order of magnitude improvement in the number of slow neutrons boiling out of the hole into the experimental area.

The comments above all use CASIM to give relative fluxes. The conversion to absolute hadrons per cm^3 depends on whether the dump is "thin" (a factor of 500) or "thick" (a factor of 10^5). Furthermore, it is assumed that the very low energy neutrons have been absorbed by concrete, or else the appropriate factor would be much higher (P. J. Gollon, Fermi report TM-6641100.5). So, I do not think that absolute predictions are worth much.

II. Beam size calculations used in the collimator design are given here.

A. Beam divergence (V) is ±2 cm/7 m = ±3 mrad (Transport, 90% of beam) for no scattering the B target. It is ±4 mrad for the thick B target case.

B. Multiple scattering in the target is ±2 mrad.

C. Beam width is tiny (~ ±1 mm).

D. Typical scattering cone is $\sim \frac{200 \text{ MeV}}{30 \text{ GeV}} = \pm 7$ mrad.

Added in quadrature, this is ±8 mrad. A 10 mrad cone is shown for the 1° beam in Fig. 1. The dump is 3.5 meters from the target so the beam spot there is 2.8 cm radius. The horizontal beam divergence is similar to this.

III. The first sweeper (18D72 coils, SREL iron) will run at 27 kgauss, so θ_{bend} = 53 mrad. Figures 4 and 5 are from John Jackson's calculations (the magnet coils will be split 8 inches).

IV. There will be three collimators, each tapered, the first two made of brass and the third stainless (to accommodate the vacuum). The first two will be on the 5 x 20 mrad cone, the third (in the downstream sweeper) slightly off the line. Material (steel) with less strict tolerance will be between the collimators. The experimental vacuum will start with a window just in front of the 2nd collimator. A 1 to 2 inch lead plug will be in the neutral beam in the first sweeper, positioned to avoid the proton beam. It will be inserted from upstream. Tolerances have been determined by Bill Molzon. They are:

- 1/64" to 1/32" for collimator positions (offset and roll)
- 1/64" or better on machined faces
- chambers will come with reference center lines and adjustments for 1/32" tolerance
- all collimators should be within these limits.

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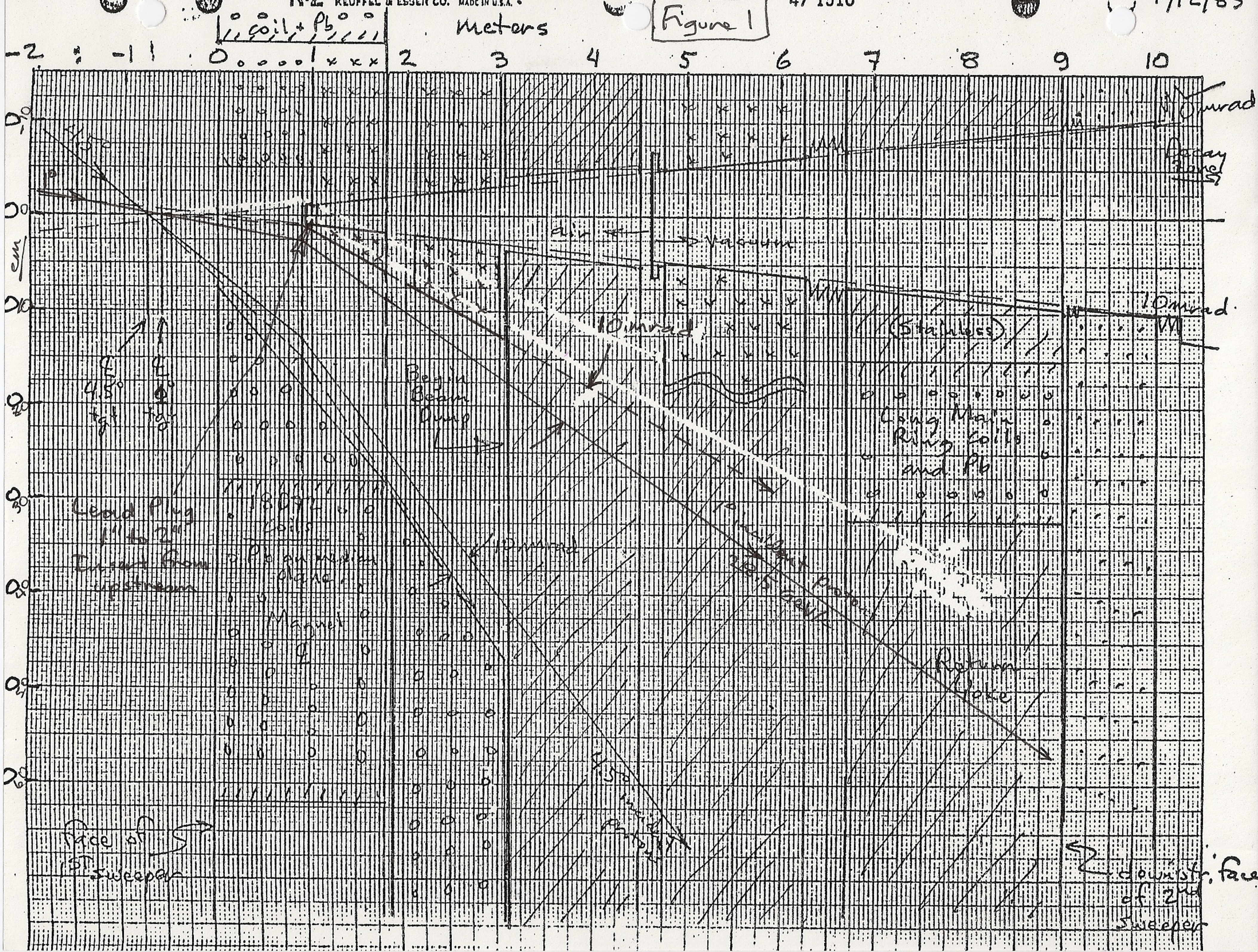
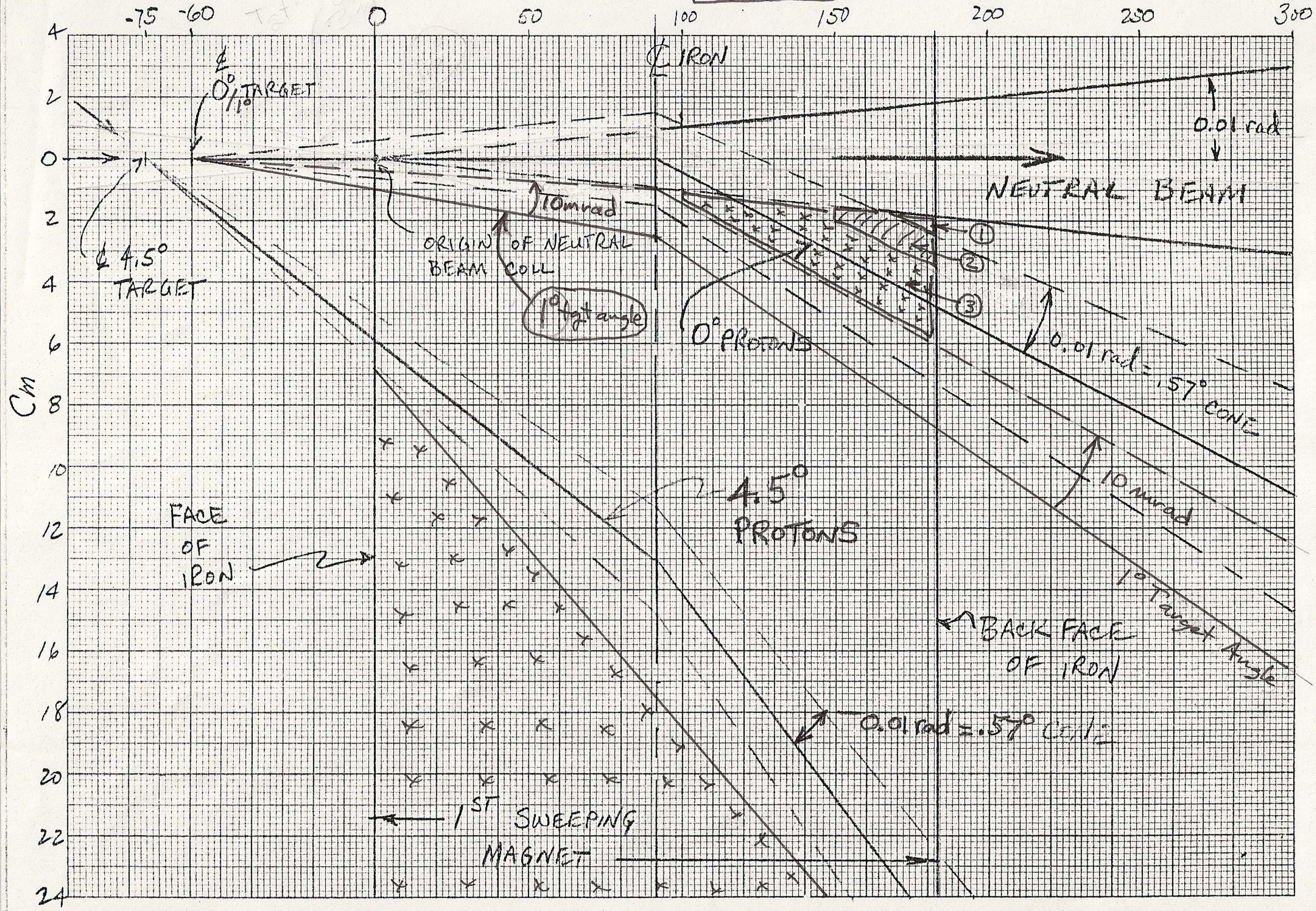


Figure 2



cm
-75
-60
0
50
100
150
200
250
300
4
2
0
2
4
6
8
10
12
14
16
18
20
22
24
Cm
℄ IRON
℄ 0°/1° TARGET
℄ 4.5° TARGET
10 mrad
ORIGIN OF NEUTRAL BEAM COLL
1° tgt angle
0° PROTONS
NEUTRAL BEAM
0.01 rad
0.01 rad = .57° CONE
10 mrad
1° Target Angle
4.5° PROTONS
FACE OF IRON
BACK FACE OF IRON
0.01 rad = .57° CONE
1ST SWEEPING MAGNET
1
2
3

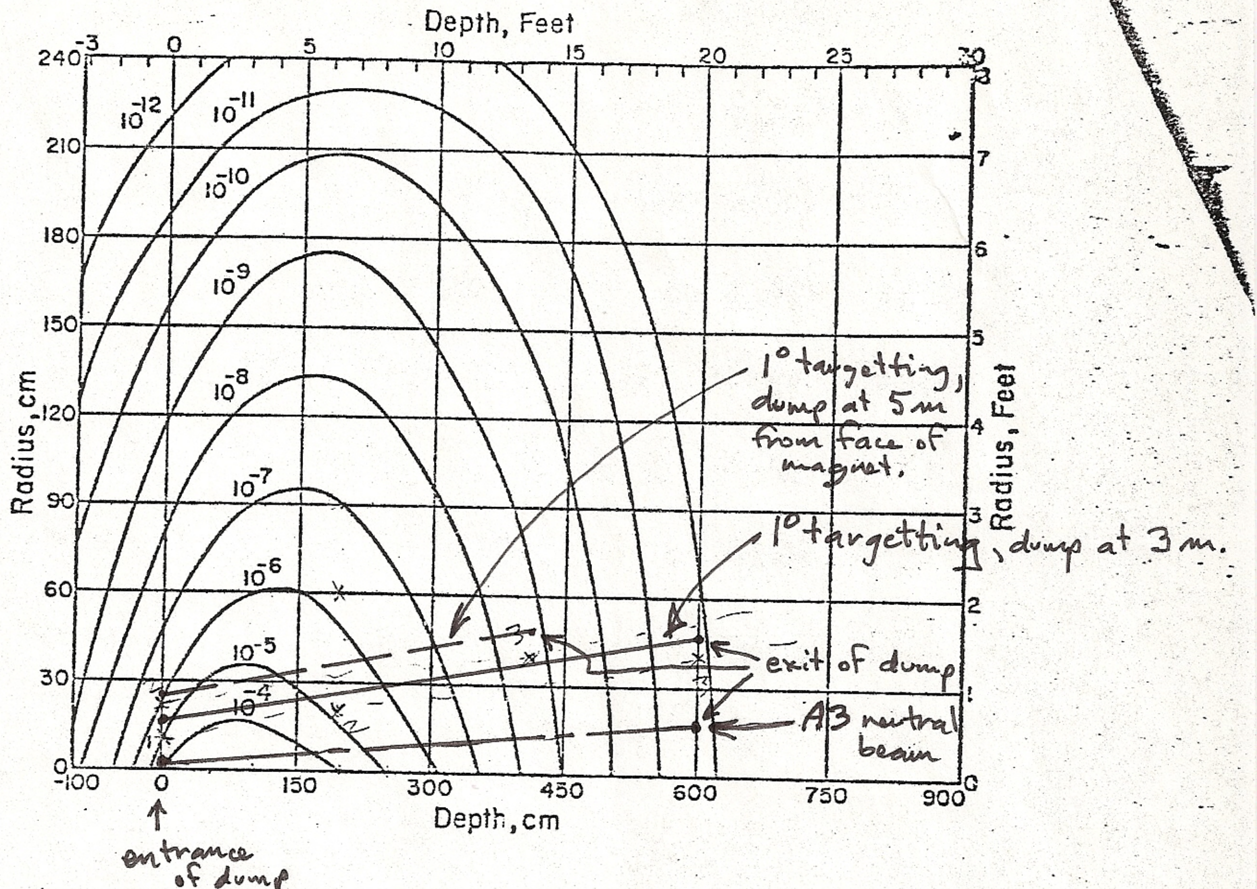


Fig. VIII.1. 30 GeV/c protons incident on a solid iron cylinder. Contours of equal star density (stars/cm^3 · inc. proton). The beam of 0.3 × 0.3 cm cross section is centered on the cylinder axis and starts to interact at zero depth. The star density includes only those due to hadrons above 0.3 GeV/c momentum. Contours of higher star density are not shown for clarity of the plot, those of lower star density are not included due to statistical uncertainty.

Figure 3.

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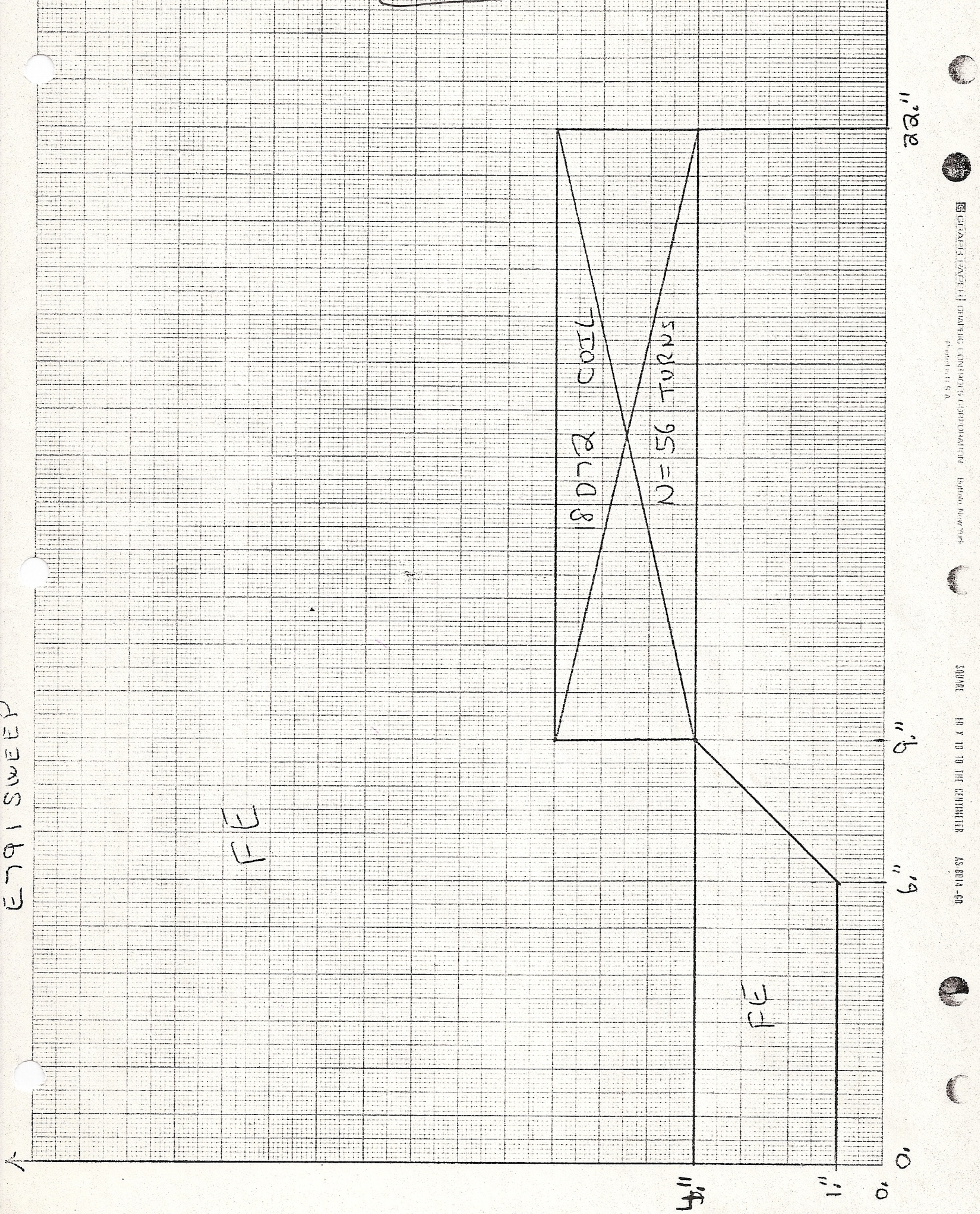
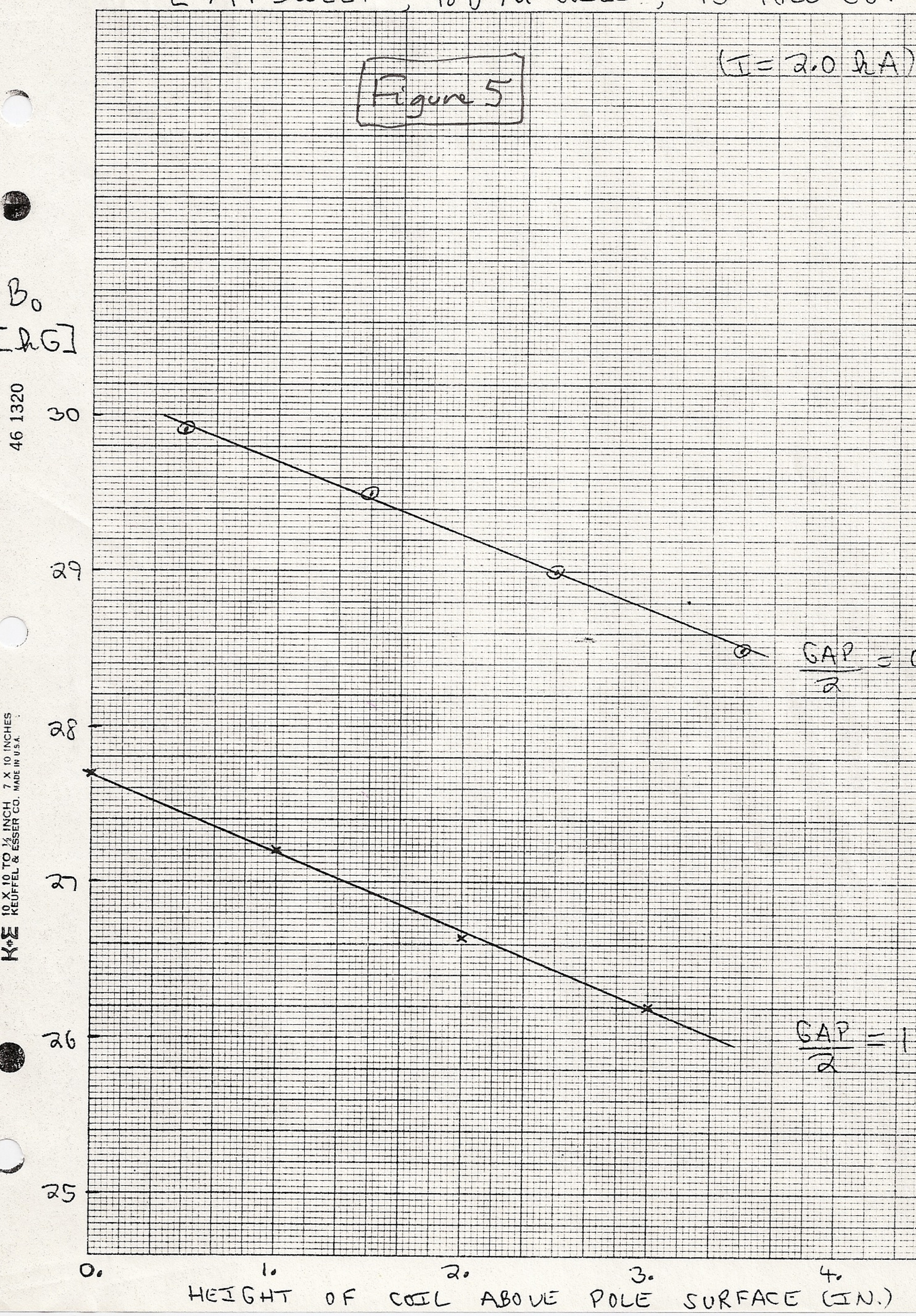
Figure 4



E791 SWEEP, 18D72 COILS, 45° POLE CUT

(I = 2.0 kA)

Figure 5



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