TM-805
2960.0

Fermilab

REPORT ON A DESIGN STUDY FOR UPGRADING THE N7/N5 HADRON BEAMLINE

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I. Introduction

The N7/N5 hadron beamline was originally built as a beamline to the Fermilab 15 foot Bubble Chamber[1]. As such, an acceptance of .3μstr% was adequate. However, with the construction of Lab E in that beamline, a more demanding program of hadron physics was begun. In order to meet the requirements of E-595, a pion experiment to be conducted in Lab E, a beam of approximately 10^6 π^-'s in the energy range from 200 to 300 GeV will be needed. The existing beamline cannot provide this. Recent yield measurements[2] suggest that an improvement of about a factor of ten in acceptance is required if a maximum of 3×10^{11} protons/pulse are to be targeted.

Modifications of two types are recommended to meet the requirements ot E-595. The first is a change to the optics of the beam, in particular, a revamping of the front end which will improve the solid angle by about a factor of ten, along with a minor modification of Enclosure 113. These modifications are described in detail here. The second consists of radiation hardening of Enclosure 100, the N7/N5 target hall, and also providing a larger beam dump, so that higher intensity may be targeted. Details of this second modification will appear elsewhere.

II. Description of the New Beam

The acceptance of the existing N5 beamline is $\Delta\Omega$ = .3μstr, with $\frac{\Delta p}{p}$ ~ 1%. The reason for the small solid angle is the large distance between the target, in Enclosure 100, and the first quads, in Enclosure 101, a distance of about 300 ft. In the proposed design, the target is moved upstream of its present location in order to make room for quads close to the target, inside Enclosure 100.

For a visual comparison of these two arrangements, see Figure 1. The new arrangement provides a potential solid angle of 3.7μstr. Unfortunately, the toroidal muon spoilers recently installed in Enclosure 100 have only a 3-inch hole for the N5 to pass through and constitute a horizontal aperture which reduces the solid angle to 2.7μstr. A 5-inch hole would provide no obstruction. Naturally, since the bends are unchanged, the momentum bite is about the same.

In the new arrangement, a doublet at the upstream end of Enclosure 100 focuses the primary beam onto the target. Studies show that this doublet can provide a spot on target of 2mm x 1mm. The 1 mr. east bend provided in the past by the "7H00" verniers has been eliminated. Consequently, the secondary beamline views the target at a angle of 4 mr., instead of 3 mr. However, 0^{o} production can be achieved with a dipole after the target. Also, a dipole prior to the target is recommended since it will allow cleaner dumping of the primary protons when running positive secondaries.

The change in Enclosure 113 consists of replacing the existing 3Q84 quad at Z=7748.10 ft. with a 4Q120 quad to be placed slightly farther downstream. This arrangement allows the beam, which is large from Enclosure 109 to Enclosure 113, to be focused in Lab E in such a way that the beam fits through both the 5E13 bending magnets and the PWC's to be used in E-595.

The principal trajectories of the secondary beam are shown in Figure 2. The beam is brought to parallel out of Enclosure 100. There is a vertical focus between Enclosures 101 and 103, and a horizontal focus in Enclosure 103 where the momentum bite is controlled by a horizontal collimator. There are both horizontal and vertical foci between Enclosure 107 and 109. Out of Enclosure 109, the beam is parallel to accommodate Cerenkov tagging. The quads in Enclosure 113 control the spot size in Lab E.

A couple of comments are in order: First, one would prefer to have all the foci inside enclosures, as in the past. However, the optics of the new beam are heavily constrained by the cost-motivated decision to use existing enclosures and, where possible, existing magnets in their present locations. Second, the proposed design is capable of transporting 500 GeV secondaries. However, above 440 GeV the quad doublet in Enclosure 113 lacks the ability to focus the beam early enough to fit vertically through 5E13 or the E-595 PWC's. This is not viewed as a problem for E-595.

The details of the new arrangement in Enclosure 100 are given in Table I. This table shows magnet types, position coordinates, etc. Since, for the new doublet downstream of the target, some freedom exists in the choice of quadrupole types, both possible arrangements are given. The choice is between three 3Q120's or three 3Q84's for the upstream (defocusing) part of the doublet. The advantage of 3Q120's is that power consumption is less.

The details of the new arrangement in Enclosure 113 are given in Table 2. Table 3 contains a list of new quads that must be obtained.

The field gradients and currents for the N7/N5 quads for 400 GeV operation are given in Table 4.

Figures 3 through 6 are DECAY TURTLE generated histograms. Figure 3 shows the solid angle acceptance assuming no obstruction from the toroids. Figure 4 shows the solid angle including the 3 inch holes as an aperture. Figure 5 shows $\frac{\Delta p}{p}$ vs. x at the momentum dispersed focus. Figure 6 shows the angular divergence of the beam in the parallel region.

III. Potential Problems

The N5 has a history of being a "Lossy" beamline. The most likely explanation of this is a combination of magnet mis-alignments between enclosures and "hidden" apertures. The N5 is considerably longer than most of Fermilab's secondary beamlines, stretching almost 3000 ft. from target to Lab E. The beam enclosures are far apart, in the worst case 570 ft. (Enclosure 101 to 103). Thus, the beamline is sensitive to shifts, especially the sinking of "heavy" enclosures relative to lighter ones. Enclosure 100, formerly the site of a peat bog, is a particularly notorious offender. Unless great care is taken to make sure that the beamline magnets are properly positioned, even as the enclosures drift away, it will be impossible to reproduce a calculated beam in practice.

"Hidden" apertures are beam pipes buried in the neutrino berm. The pipe between Enclosures 100 and 101 was known to be seriously distorted as of 4 years ago (although the information was not widely diseminated). Profile studies of this pipe, and the much longer one between Enclosures 101 and 103 are underway. Depending on the outcome of these studies, corrective action may be required.

An additional concern is the alignment of the beam pipes between Enclosures 109 and 113. These pipes will be used as Cerenkov counter radiators, so that it is important that the beam travel along the center of these pipes. This is apparently not the case for the present N5 and is a matter which must be investigated. It may be necessary to relocate one or both of these pipes, or the beamline itself.

IV. Scheduling

The modifications described here should be implemented on the shortest timescale possible. It is important that the new optics be in place before the fall check-out run of E-595. This time will be needed to study the real life properties of the new beam, and such hands-on experience will be invaluable in evaluating the need for higher targeting intensity, with its associated heavier beam dump and shielding, which can be put in place in the spring of 1979. Also, such experience will indicate whether drilling larger holes in the Enclosure 100 toroids should be considered.

Acknowledgement

Valuable advice from members of the Research Division and Neutrino Department is much appreciated. Also, without the efforts of the authors of Transport and DECAY TURTLE, an amateur could not perform the calculations upon which this report is based.

REFERENCES

1. J.Lach and S.Pruss, TM-285.

2. L.Stutte, letter to A.Bodek.

TABLE 1

Proposed Arrangement of Enclosure 100*

Element	Position Code	Z (Cent.) Ft.	X (Cent.) Ft.
Profile Wire Chamber	7WCØØ-1	4822.00	-1.877
3Q120 Quad	7FØØ-1	4829.00	-1.877
3Q120 Quad	7FØØ-2	4840.00	-1.878
3Q120 Quad	7DØØ-1	4865.00	-1.880
3Q120 Quad	7DØØ-2	4876.00	-1.881
3Q60 Quad	7DØØ-3	4884.50	-1.882
3Q60 Quad	7DØØ-4	4890.50	-1.882
Vern. 4-4-30 Horiz.	7HØØ-1	4897.00	-1.883
Vern. 4-4-30 Horiz.	7HØØ-2	4900.71	-1.883
Vern. 4-4-30 Horiz.	7HØØ-3	4904.42	-1.883
Vern. 4-4-30 Vert.	7VØØ-1	4908.13	-1.884
Vert. Collimator	7CØØV	4915.00	-1.884
Ion Chamber	5SØION	4923.00	-1.885
5-1.5-120 Bend	7BØØT	4930.00	-1.886
Profile Wire Chamber	7WCØØ2-1	4935.50	-1.886
Profile Wire Chamber	7WCØØ2-2	4936.00	-1.886
Target	5T	4938.67	-1.886
5-1.5-120 Bend	5BØØT	4946.00	-1.892

* For all elements listed, Y (Cent.) = 744.998 ft.

TABLE 1 (continued)

Plan A (using three 3Q120 quads)

Element	Position Code	Z (Cent.) Ft.	X (Cent.) Ft.
Beam Dump	7DMP	4973.00	-1.987
3Q120 Quad	5DØØ-1	4984.00	-2.027
3Q120 Quad	5DØØ-2	4995.00	-2.068
3Q120 Quad	5DØØ-3	5006.0	-2.108

Plan B (using three 3Q84 quads)

Element	Position Code	Z (Cent.) Ft.	X (Cent.) Ft.
Beam Dump	7DMP	4980.67	-2.015
3Q84 Quad	5DØØ-1	4991.17	-2.054
3Q84 Quad	5DØØ-2	4999.17	-2.083
3Q84 Quad	5DØØ-3	5007.17	-2.113

Upstream End Tor.		5015.32	-2.143
Downstream End Tor.		5039.67	-2.233
3Q84 Quad	5FØØ-1	5043.50	-2.247
3Q52 Quad	5FØØ-2	5049.49	-2.269

TABLE 2

Proposed Arrangement of Enclosure 113

Element	Position Code	Z (Cent.) Ft.	X(Cent.) Ft.
3Q52 Quad	5F13-1	7703.00	-17.695
3Q52	5F13-2	7710.10	-17.367
4Q120 Quad	5D13	7759.27	-15.099
4-2-240 Bend	5E13-1	7807.50	-12.594
4-2-240 Bend	5E13-2	7829.00	-12.019

TABLE 3

List of New Quads Needed

	Number Needed	Type
Plan A	3	3Q120
	1	3Q84
	1	3Q52
	1	4Q120*
Plan B	4	3Q84
	1	3Q52
	1	4Q120*

* This magnet replaces a 3Q84 in Enclosure 113. Thus, one 3Q84 is "free". Also, in both plans, an existing 3Q60 quad is left over.

TABLE 4

Quad Tune for 400 GeV Primary

Quad Position Code	Field Gradient Kg/in	Current Amps.
7DN	0.0	0.0
7FN	0.0	0.0
7FØØ	3.367	71.38
7DØØ	-3.852	-81.66

Quad Tune for 400 GeV Secondary

Quad Position Code Old	New	Field Gradient Kg/in	Current Amps.
----	5DØØ (Plan A)	-3.816	-80.90
----	5FØØ (Plan A)	5.047	3680
----	5DØØ (Plan B)	-5.046	-3679
----	5FØØ (Plan B)	5.179	3776
3DØ1*	5FØ1	2.815	2052
3FØ1*	5DØ1	-3.619	-2639
3QØ3	3QØ3	4.800	3500
5FØ5	5FØ5	3.703	2700
5DØ5	5DØ5	-4.800	-3500
5FØ6	5FØ6	3.000	640.9
5FØ9	5FØ9	4.231	3085
5DØ9	5DØ9	-3.449	-2515
5D13*	5F13	4.247	3096
5F13*	5D13	-4.966	-1061

*Note that these quads have their polarity reversed.

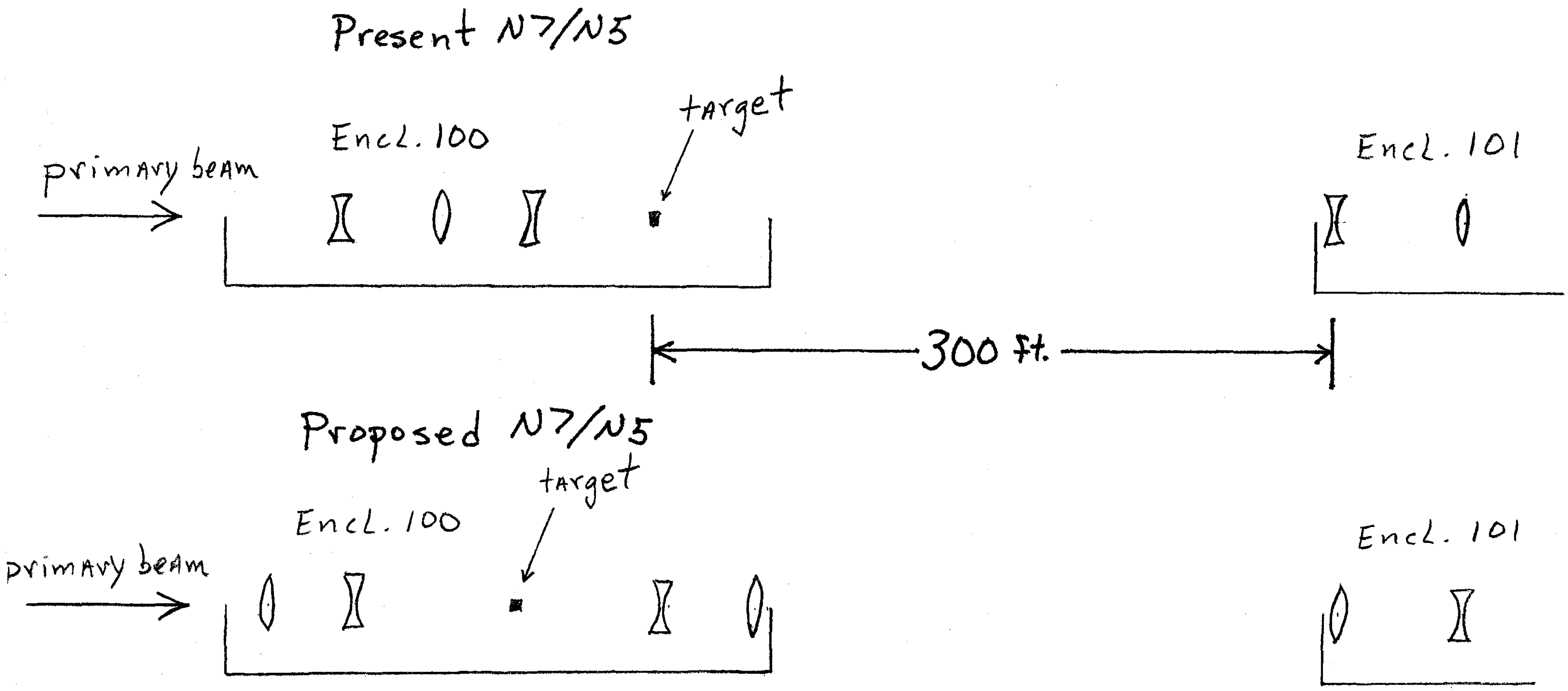

Figure I. Contrast between the small acceptance front end of the existing beam and the large acceptance front end of the proposed beam.

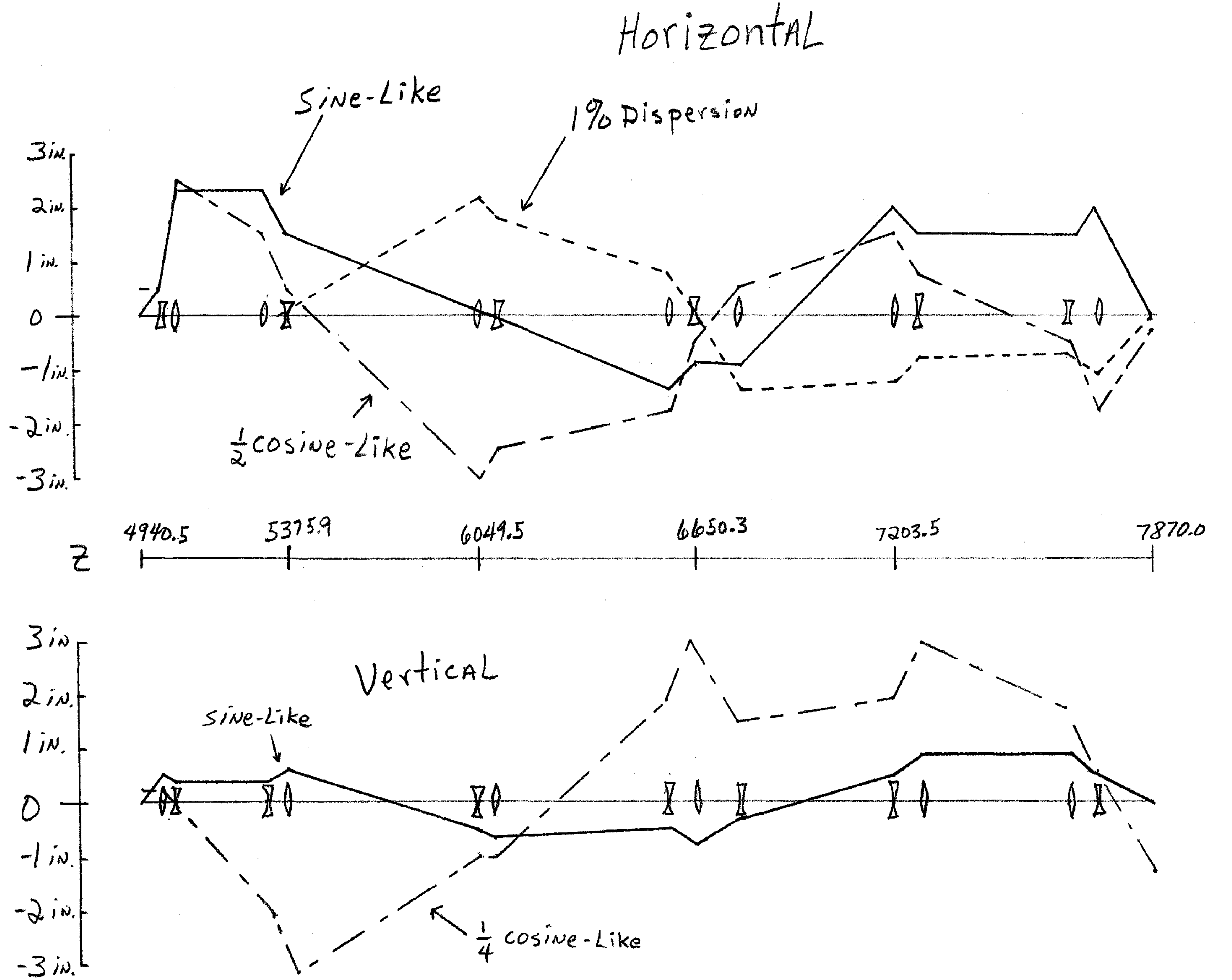

Figure 2. Principal trajectories. Note that both the horizontal and vertical cosine-like trajectories are scaled for ease of display.

```
HISTOGRAM NO  1
HORIZONTAL AXIS    X↑ IN MR                          0.000 FT   FROM THE TARGET
VERTICAL AXIS      Y↑ IN MR                          0.000 FT   FROM THE TARGET, FLAG AT      2933.000 FT
```

Lab E

```
                    -2.000    -1.000     0.000     1.000     2.000 TOTALS
                     I**---**---**---**---**---**---**---**---**I--------
  -2.000 TO  -1.900 I                                          I        0
  -1.900 TO  -1.800 I                                          I        0
  -1.800 TO  -1.700 I                                          I        0
  -1.700 TO  -1.600 I                                          I        0
  -1.600 TO  -1.500 I                                          I        0
  -1.500 TO  -1.400 I                                          I        0
  -1.400 TO  -1.300 I                                          I        0
  -1.300 TO  -1.200 I                                          I        0
  -1.200 TO  -1.100 I           11 1123133211211 1             I       25
  -1.100 TO  -1.000 I          44989CB838CF88644A2             I      145
  -1.000 TO   -.900 I          49ABDEGCNKHEBJEFDC62            I      255
   -.900 TO   -.800 I          7IEKPJKKJMLNECJWKME3            I      364
   -.800 TO   -.700 I          1D9OPKJPJQWUMRJMJFG3            I      386
   -.700 TO   -.600 I          BALJRURQKRVSPLSGJDC6            I      417
   -.600 TO   -.500 I          5HIKQPERJIVRQIMNLKD6            I      396
   -.500 TO   -.400 I          57MKLNBJXTORYWOOPQK4            I      430
   -.400 TO   -.300 I          7HFVIMONXOSVUOLEFMD3            I      417
   -.300 TO   -.200 I          6BFNOEVNHLTIUUIOLM78            I      392
   -.200 TO   -.100 I          8MEPVMSPV$NSKJRULJI6            I      453
   -.100 TO    .000 I          5IGBJPSONTSVMLUGV9A5            I      401
    .000 TO    .100 I          7IOQNQQWNKPNRQPMGLI5            I      433
    .100 TO    .200 I          3DMNPLPUGNKLRWHLJKK9            I      407
    .200 TO    .300 I          8GDDIIQNRUTLPVNMEN94            I      393
    .300 TO    .400 I          6AKFKRLUSNQIOMWRKDE5            I      401
    .400 TO    .500 I          7IJKOKRUMPTTPFNIGNJ7            I      416
    .500 TO    .600 I          2CCIPJPJPPUJRIROSLI5            I      399
    .600 TO    .700 I          49EJGGCGIOTXPJLPHFK3            I      355
    .700 TO    .800 I          6FKHJQTTPNMONMJMCCD6            I      384
    .800 TO    .900 I          4DLIMKJDORSTUNFGHD84            I      353
    .900 TO   1.000 I          788DLDIHIDLFEDGAA9A2            I      259
   1.000 TO   1.100 I          135C8G9F99E78D755332            I      154
   1.100 TO   1.200 I           1 23 2216  31  21              I       24
   1.200 TO   1.300 I                                          I        0
   1.300 TO   1.400 I                                          I        0
   1.400 TO   1.500 I                                          I        0
   1.500 TO   1.600 I                                          I        0
   1.600 TO   1.700 I                                          I        0
   1.700 TO   1.800 I                                          I        0
   1.800 TO   1.900 I                                          I        0
   1.900 TO   2.000 I                                          I        0
                     I**---**---**---**---**---**---**---**---**I--------
                    I                                          I
                    I                                          I
                    I          12344444455555444332            I
                    I          18406479715006538689            I
          TOTALS    I 0000000000862839017122195364480000000000 I     8059

     TOTAL NUMBER OF ENTRIES =        8059 INCLUDING UNDERFLOW AND OVERFLOW AS FOLLOWS

                         UNDERFLOW        OVERFLOW
               ACROSS        0                0
               DOWN          0                0
```

solid angle for 5 inch hole in torroids

Page 12

Fig. 3


```
HISTOGRAM NO  1
HORIZONTAL AXIS    X↑ IN MR                          0.000 FT   FROM THE TARGET
VERTICAL AXIS      Y↑ IN MR                          0.000 FT   FROM THE TARGET, FLAG AT      2933.000 FT
```

```
HISTOGRAM NO  1
HORIZONTAL AXIS    X↑ IN MR                                0.000 FT    FROM THE TARGET
VERTICAL AXIS      Y↑ IN MR                                0.000 FT    FROM THE TARGET, FLAG AT      2933.000 FT
```

Lab E

```
                   -2.000    -1.000     0.000     1.000     2.000 TOTALS
                    I**---**---**---**---**---**---**---**---**I--------
 -2.000 TO  -1.900 I                                          I     0
 -1.900 TO  -1.800 I                                          I     0
 -1.800 TO  -1.700 I                                          I     0
 -1.700 TO  -1.600 I                                          I     0
 -1.600 TO  -1.500 I                                          I     0
 -1.500 TO  -1.400 I                                          I     0
 -1.400 TO  -1.300 I                                          I     0
 -1.300 TO  -1.200 I                                          I     0
 -1.200 TO  -1.100 I               1123133211211              I    22
 -1.100 TO  -1.000 I              69CB838CF886421             I   113
 -1.000 TO   -.900 I              9DFGCNKHEBJEFA              I   207
  -.900 TO   -.800 I              DPJKKJMLNFCJWB              I   270
  -.800 TO   -.700 I              IPKJPJQWUMRJMH              I   321
  -.700 TO   -.600 I             1DRURQKRVSPLSGH              I   337
  -.600 TO   -.500 I             1EQPERJIVROIMNH              I   308
  -.500 TO   -.400 I              GLNBJXTORYWOOK2             I   339
  -.400 TO   -.300 I             2SIMONXOSVUQLF82             I   334
  -.300 TO   -.200 I              KOEVNHLTIUUIOI1             I   318
  -.200 TO   -.100 I             1LVMSPV$NSKJRUJ1             I   362
  -.100 TO    .000 I             19JPSONTSVMLUGO              I   330
   .000 TO    .100 I             2JNQQWNKPNRQPMF              I   334
   .100 TO    .200 I             1KPLPUGNKLRWHLH1             I   317
   .200 TO    .300 I              AIIQNRUTLPVNMC3             I   318
   .300 TO    .400 I             3CKRLUSNQIOMWRI1             I   332
   .400 TO    .500 I              IOKRUMPTTPFNI9              I   314
   .500 TO    .600 I             1GPJPJPPUJRIROK1             I   321
   .600 TO    .700 I              DGGCGIOTXPJLPC              I   279
   .700 TO    .800 I              DJQTTPNMONMJM9              I   305
   .800 TO    .900 I              EMKJDORSIUNFGA              I   279
   .900 TO   1.000 I              8LDTHIDLFEDGA6              I   203
  1.000 TO   1.100 I              58G9F99F78D752              I   127
  1.100 TO   1.200 I              23 2216   31  1             I    21
  1.200 TO   1.300 I                                          I     0
  1.300 TO   1.400 I                                          I     0
  1.400 TO   1.500 I                                          I     0
  1.500 TO   1.600 I                                          I     0
  1.600 TO   1.700 I                                          I     0
  1.700 TO   1.800 I                                          I     0
  1.800 TO   1.900 I                                          I     0
  1.900 TO   2.000 I                                          I     0
                    I**---**---**---**---**---**---**---**---**I--------
                    I                                          I
                    I                                          I
                    I              3444444555554442            I
                    I              1164797150065391            I
          TOTALS    I 0000000000003739017122195353000000000000 I   6411

      TOTAL NUMBER OF ENTRIES =       6411 INCLUDING UNDERFLOW AND OVERFLOW AS FOLLOWS

                           UNDERFLOW       OVERFLOW
                ACROSS          0              0
                DOWN            0              0
```

Solid angle for

3 inch holes in torroids

Fig. 4

```
HISTOGRAM NO  1
HORIZONTAL AXIS    X↑ IN MR                                0.000 FT    FROM THE TARGET
VERTICAL AXIS      Y↑ IN MR                                0.000 FT    FROM THE TARGET, FLAG AT      2933.000 FT
```

```
HISTOGRAM NO  3
HORIZONTAL AXIS     X IN IN                                  1123.330 FT    FROM THE TARGET
VERTICAL AXIS   DP/P IN PC                                   1123.330 FT    FROM THE TARGET

                     -3.000    -1.500     -.000     1.500     3.000 TOTALS
                      I**---**---**---**---**---**---**---**---**I--------
-1.500 TO  -1.350 I                                           I       0
-1.350 TO  -1.200 I      3                                    I       3
-1.200 TO  -1.050 I     4$X5                                  I      92
-1.050 TO   -.900 I     4$$$$6                                I     384
 -.900 TO   -.750 I      3$$$$$4                              I     704
 -.750 TO   -.600 I        1R$$$$6                            I     704
 -.600 TO   -.450 I           R$$$$2                          I     649
 -.450 TO   -.300 I             F$$$$                         I     716
 -.300 TO   -.150 I               R$$$$3                      I     762
 -.150 TO   -.000 I                 5$$$$                     I     702
 -.000 TO    .150 I                   6$$$$4                  I     724
  .150 TO    .300 I                     1$$$$C                I     709
  .300 TO    .450 I                       5$$$$E              I     659
  .450 TO    .600 I                         5$$$$01           I     674
  .600 TO    .750 I                           3$$$$X          I     686
  .750 TO    .900 I                             A$$$$U2       I     681
  .900 TO   1.050 I                               C$$$$3      I     443
 1.050 TO   1.200 I                                 F$$4      I     167
 1.200 TO   1.350 I                                   E8      I      22
 1.350 TO   1.500 I                                           I       0
                  I**---**---**---**---**---**---**---**---**I--------
                  I                                           I
                  I                                           I
                  I      11233333333333333333233333221        I
                  I      2982641323576334643539513458271      I
           TOTALS I 0000817492340447034916092595926166050000  I    9481

      TOTAL NUMBER OF ENTRIES =       9481 INCLUDING UNDERFLOW AND OVERFLOW AS FOLLOWS

                            UNDERFLOW        OVERFLOW
              ACROSS             0               0
              DOWN               0               0

HISTOGRAM NO  3
HORIZONTAL AXIS     X IN IN                                  1123.330 FT    FROM THE TARGET
VERTICAL AXIS   DP/P IN PC                                   1123.330 FT    FROM THE TARGET
```

Momentum dispersed horizontal focus in Encl. 103

Fig. 5

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HISTOGRAM NO  4
HORIZONTAL AXIS    X* IN MR                         2517.330 FT   FROM THE TARGET
VERTICAL AXIS      Y* IN MR                         2517.330 FT   FROM THE TARGET

                    -.200     -.100     -.000      .100      .200 TOTALS
                   I**---**---**---**---**---**---**---**---**I--------
 -.200 TO  -.190  I                                          I      0
 -.190 TO  -.180  I                                          I      0
 -.180 TO  -.170  I                                          I      0
 -.170 TO  -.160  I                                          I      0
 -.160 TO  -.150  I                                          I      0
 -.150 TO  -.140  I                                          I      0
 -.140 TO  -.130  I                                          I      0
 -.130 TO  -.120  I                                          I      0
 -.120 TO  -.110  I                                          I      0
 -.110 TO  -.100  I                                          I      0
 -.100 TO  -.090  I                                          I      0
 -.090 TO  -.080  I                                          I      0
 -.080 TO  -.070  I                                          I      0
 -.070 TO  -.060  I                                          I      0
 -.060 TO  -.050  I                                          I      0
 -.050 TO  -.040  I                                          I      0
 -.040 TO  -.030  I              116DJMDFC441                I    111
 -.030 TO  -.020  I              1CN$$$$$$N85                I    650
 -.020 TO  -.010  I             12S$$$$$$$$D62               I   1162
 -.010 TO   .000  I               B$$$$$$$$$M71              I   1400
  .000 TO   .010  I              9U$$$$$$$$$M83              I   1426
  .010 TO   .020  I              5L$$$$$$$$B6                I   1117
  .020 TO   .030  I              46L$$$$$$F52                I    627
  .030 TO   .040  I              134BIMHCC921                I    112
  .040 TO   .050  I                     11 11                I      4
  .050 TO   .060  I                                          I      0
  .060 TO   .070  I                                          I      0
  .070 TO   .080  I                                          I      0
  .080 TO   .090  I                                          I      0
  .090 TO   .100  I                                          I      0
  .100 TO   .110  I                                          I      0
  .110 TO   .120  I                                          I      0
  .120 TO   .130  I                                          I      0
  .130 TO   .140  I                                          I      0
  .140 TO   .150  I                                          I      0
  .150 TO   .160  I                                          I      0
  .160 TO   .170  I                                          I      0
  .170 TO   .180  I                                          I      0
  .180 TO   .190  I                                          I      C
  .190 TO   .200  I                                          I      0
                  I**---**---**---**---**---**---**---**---**I--------
                  I                                          I
                  I                   1111                   I
                  I                 12602 1062               I
                  I                349661801683              I
          TOTALS  I 0000000000000014261386062866000000000000 I   6609

      TOTAL NUMBER OF ENTRIES =        6609 INCLUDING UNDERFLOW AND OVERFLOW AS FOLLOWS

                           UNDERFLOW        OVERFLOW
                ACROSS         0               0
                DOWN           0               0
```

Beam divergence in parallel region

Fig. 6

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HISTOGRAM NO  4
HORIZONTAL AXIS    X* IN MR                         2517.330 FT   FROM THE TARGET
VERTICAL AXIS      Y* IN MR                         2517.330 FT   FROM THE TARGET
```

Fermilab

ADDENDUM TO TM-805

REPORT ON A DESIGN STUDY FOR

UPGRADING THE N7/N5 HADRON BEAMLINE

JACK RITCHIE

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August 22, 1978

TM-805 describes a proposed upgrade of the N7/N5 beamline. The limited availability of new quads, as well as difficulties associated with providing power to the main ring quads recommended in TM-805, has led to the evolution of a new arrangement which calls for fewer quads and no new main ring quads. The effect of this is to reduce the maximum momentum of the system. However, both the pre-target doublet and the doublet downstream of the target are adequate for 400 GeV running. The Neutrino Department has been instrumental in the development of this "economy plan", and has agreed to implement it. The details are described here. Also, this opportunity will be taken to clarify how 7HØØ, 7BØØT and 5BØØT are to be operated in dumping the primary proton beam.

I. The Economy Plan

The optics of the beam is as described in TM-805. The solid angle acceptance is reduced to 2.6μstr because of the 3 inch aperture of the 3Q120 and 3Q60 quads downstream of the toroids. The arrangement of Enclosure 100 is given in Table A1. It may be found in practice that an additional vertical vernier is needed to provide adequate control over the primary beam. The arrangement in Enclosure 113 is given in TM-805. In order to avoid the need for a new 4Q120 quad, it is recommended that the 4Q120 in Enclosure 106 and the 3Q84 in Enclosure 113 be interchanged. Table A2 gives the field gradients and currents for the N7/N5 quads for 400 GeV operation.

II. Dumping the Primary Beam

The secondary beamline views the target at 3.7 mr. This fact is exploited in dumping the primary beam. When running negative secondaries, 5BØØT alone is used to split the two beams. See Figure A1 for details. Note that 0^{o} production is accessible at all secondary momenta.

When running positive secondaries, 7HØØ, 7BØØT and 5BØØT are used. By bending the primary beam west upstream of the target with 7BØØT, the east bend in 5BØØT is increased, thereby increasing the split between the 400 GeV protons and the lower energy secondary particle. See Figure A2 for details.

TABLE A1

Arrangement in Enclosure 100

Element	Position Code	Z (Cent.) Ft.	X (Cent.) Ft.
Profile Wire Chamber	7WCØØ-1	4821.00	-1.877
3Q120 Quad	7FØØ-1	4928.00	-1.877
3Q120 Quad	7FØØ-2	4839.00	-1.878
Vern. 4-4-30 Horiz.	7HØØ-1	4846.50	-1.879
Vern. 4-4-30 Horiz.	7HØØ-2	4850.50	-1.879
Vern. 4-4-30 Horiz.	7HØØ-3	4854.50	-1.879
Vern. 4-4-30 Vert.	7VØØ-1	4859.00	-1.879
Profile Wire Chamber	7WCØØ-2	4862.00	-1.880
3Q120 Quad	7DØØ-1	4868.00	-1.880
3Q120 Quad	7DØØ-2	4879.00	-1.881
3Q60 Quad*	7DØØ-3	4887.50	-1.882
Ion Chamber	7SØION	4926.50	-1.885
5-1.5-120 Bend	7BØØT	4933.00	-1.886
Profile Wire Chamber	7WCØØ-3	4939.00	-1.886
Target	5T	4940.00	-1.886
5-1.5-120 Bend	5BØØT	4947.00	-1.892
Beam Dump	7DMP	4972.00	-1.984
3Q120 Quad	5DØØ-1	4983.00	-2.025
3Q120 Quad	5DØØ-2	4994.00	-2.065
3Q60 Quad	5DØØ-3	5002.50	-2.097
Upstream End Tor.		5008.00	-2.117
Dowsntream End Tor.		5033.00	-2.209
3Q120 Quad	5FØØ-1	5039.00	-2.231
3Q120 Quad	5FØØ-2	5047.50	-2.262

* This quad should be replaced by a 3Q120 in order to focus 480 GeV protons on target.

TABLE A2

Quad Tune for 400 GeV Primary

Position Code	Field Gradient Kg/in	Current Amps.
7DN	0.0	0.0
7FN	0.0	0.0
7FØØ	3.209	68.03
7DØØ	-4.392	-93.11

Quad Tune for 400 GeV Secondary

Position Code	Field Gradient Kg/in	Current Amps.
5DØØ	-4.748	-100.66
5FØØ	3.779	80.11
5FØ1	2.815	2052
5DØ1	-3.619	-2639
3QØ3	4.800	3500
5FØ5	3.703	2699
5DØ5	-4.800	-3500
5FØ6 (3Q84)	4.270	3113
5FØ9	4.227	3082
5DØ9	-3.441	-2509
5F13	4.247	3096
5D13 (4Q120)	-4.966	-1061

Dumping Scheme for Negative Secondaries

(not to scale)

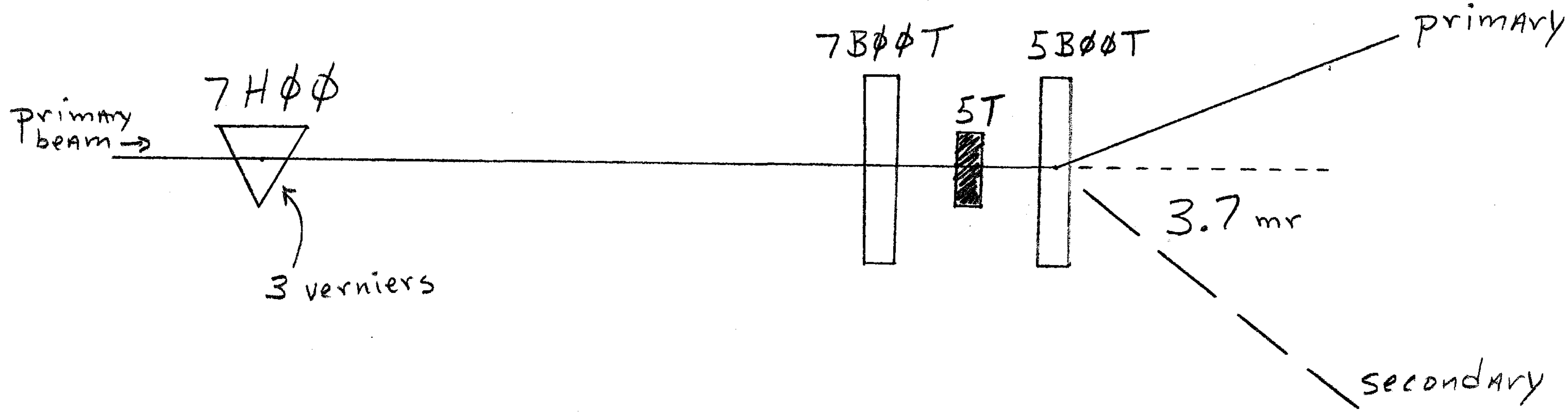

Figure A1. The positive primary and negative secondary beams are split by 5BØØT. Both 7HØØ and 7BØØT are off. For 200 GeV secondaries the field in 5BØØT should be -8.1 Kg., which is obtained with a current of -765 amps. This value may be scaled linearly to other momenta. In practice, it may be necessary to sweep 7HØØ in order to maximize transmission.

Dumping Scheme for Positive Secondaries

(not to scale)

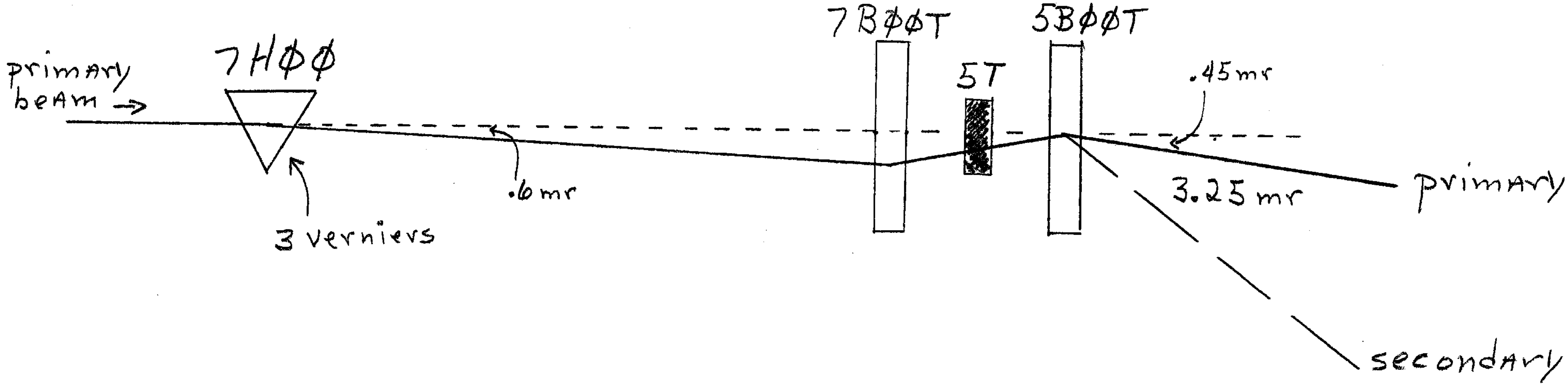

Figure A2. Shown is the scheme which allows 0° production for 200 GeV positive secondaries. The fields and currents are given below. For secondary momenta below 200 GeV/c, these values may be scaled linearly. Above 200 GeV/c, the values given should be used, resulting in non-0° production (of course, 0° may be reached by reducing the field in 7BØØT, but at the expense of clean dumping). In practice, it may be necessary to sweep 7HØØ in order to maximize transmission.

	Field (Kg.)	Current (amps.)
7HØØ	3.5	140
7BØØT	-15.0	-1688
5BØØT	14.23	1344