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SDC
SOLENOIDAL DETECTOR NOTES

IRON-SCINTILLATOR CONFIGURATIONS FOR SDC MUON TRIGGERS

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I) INTRODUCTION

The following is a preliminary study of the Pt thresholds that can implemented with magnetized iron and scintillator configurations in SDC. Figure 1 shows the assumed layout of the iron and scintillators. Further dimensional details are given in figs 2 and 3. The central region covers -1.0<eta<1.0, and the forward region 1.56<eta<2.5. The intermediate region from 1.0 to 1.56 in eta was not studied in detail, but would be conceptually similar to the forward region.

The scintillators are segmented so as to define narrow roads in theta. Since the iron magnets bend tracks in theta, this sets Pt thresholds in the trigger. The scintillators should have a time resolution that permits the identification of beam crossings. Figure 4 shows length segmentations that limit variations in light transit times to about 16 nsec or less. The segmentation in theta is shown in fig 5. The two layers ("B" and "C") outside the iron define the allowed muon bend-angle limits. To avoid overlapping counters in layer C, a trigger requires the coincidence of a theta segment in layer B with the appropriate OR of two contiguous counters in layer C. Layer A is not shown in fig 5 but would be similar to layer C in its segmentation and trigger coincidence requirement. Layer A does not influence the Pt acceptance but allows a robust 3-fold coincidence that requires tracks to traverse the iron magnets.

II) CALCULATIONS

A simple Monte Carlo program was written that traces muons through the SDC. The program takes into account the finite (Gaussian) p-p source size, dE/dx losses in the calorimeter and iron magnets, and multiple scattering according to the prescription summarized in the 1988 Particle Data Booklet on pages 95-96. Bremstrahlung was not included, but is not expected to have a serious impact in the momentum region of interest here (<100 GeV/c). The calculation is essentially one-dimensional (polar) and ignores azimuthal effects which are not large within an octant. The programs and sample outputs are shown in appendices 1 and 2.

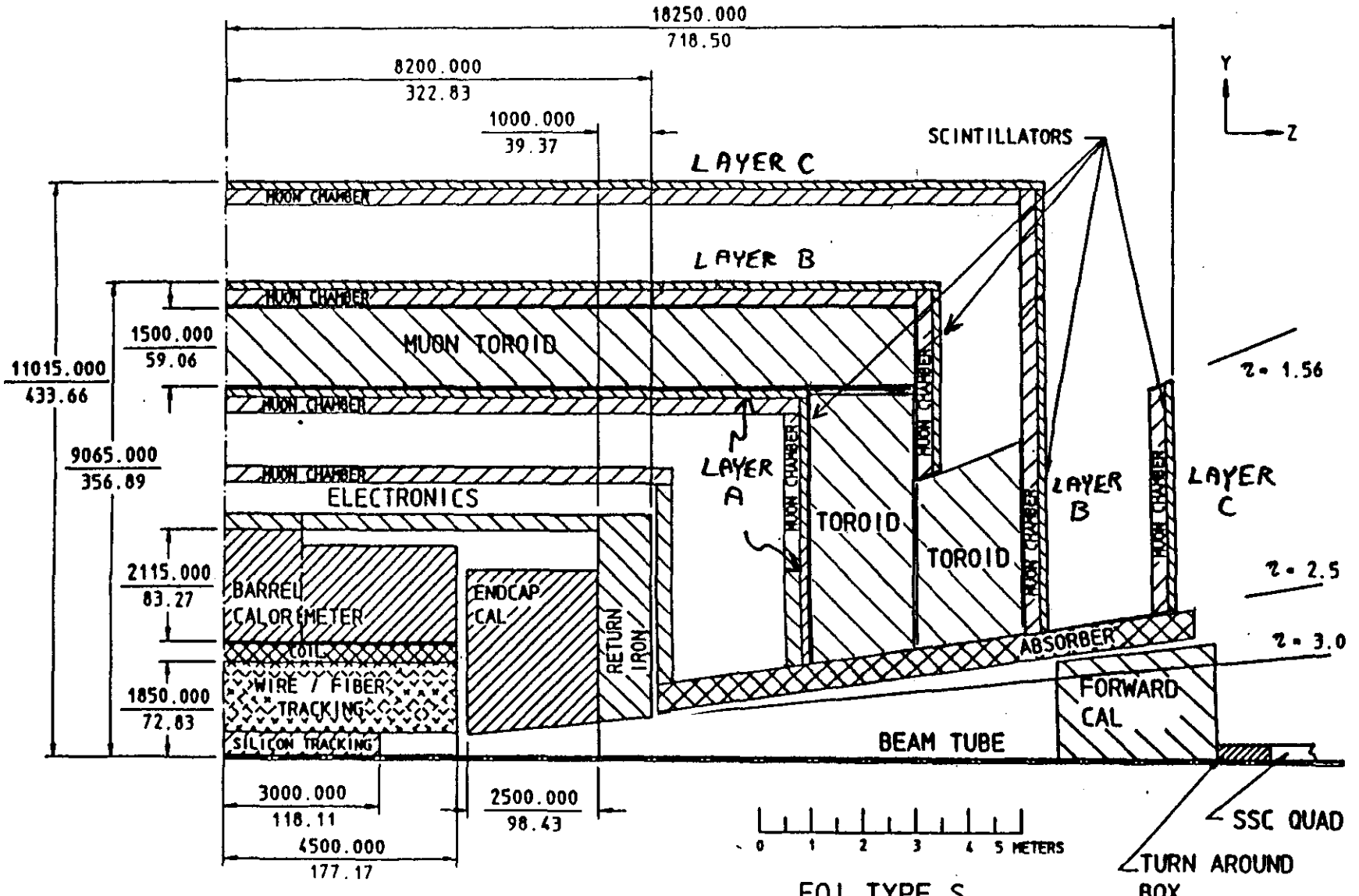
As shown in fig 6, one expects a scintillator counter width which varies as 1/(sin(theta))**2 to give Pt thresholds that are independent of theta in the central region. This was indeed confirmed by the Monte Carlo results (figs 7-8). In the forward region, one expects that uniform Pt thresholds require the width to be proportional to sin(theta)/(cos(theta))**3. As shown in fig 9, this was only approximately consistent with Monte Carlo results. At larger angles, dE/dx losses in the calorimeter and iron represent a bigger Pt bite. Figure 10 shows that the sin(theta)/(cos(theta))**3 parametrization works well when dE/dx losses are excluded. It was found empirically that a width that varies as (sin(theta))**1.35 gave Pt thresholds independent of eta in the forward region when dE/dx effects are properly included (figs 11-12).

As a point of information, we note that counter widths that subtend constant d(eta) would be proportional to 1/sin(theta) in the central region, and to sin(theta)/(cos(theta))**2 in the forward region.

III) RESULTS

Figure 7 shows the trigger efficiency in the central region as a function of Pt for counters that have a width that varies as 0.10m/(sin(theta))**2. Figure 8 shows the results for 0.15m/(sin(theta))**2. One can expect that a "reasonable" scintillator-iron geometry will provide a Pt cut-off at around 10 GeV/c and attain good (>90%) trigger efficiencies above 20 to 30 GeV/c. Figures 11-12 show similar results for two different configurations in the forward region.

For the segmentation shown in fig 4 with counter widths given by 0.15m/(sin(theta))**2, one requires a total of 7600 counters in the central region. The forward region (both ends) requires about 2200 counters if the scintillator width varies as 0.10m*(sin(theta))**1.35. The intermediate region was not examined in detail but would probably require another 2000 counters, for an overall total of approximately 12,000 counters.



NOTES: 1. ALL DIMENSIONS ARE IN MM OVER INCHES.

FIG 1 VERSION WITH FORWARD IRON TOROIDS

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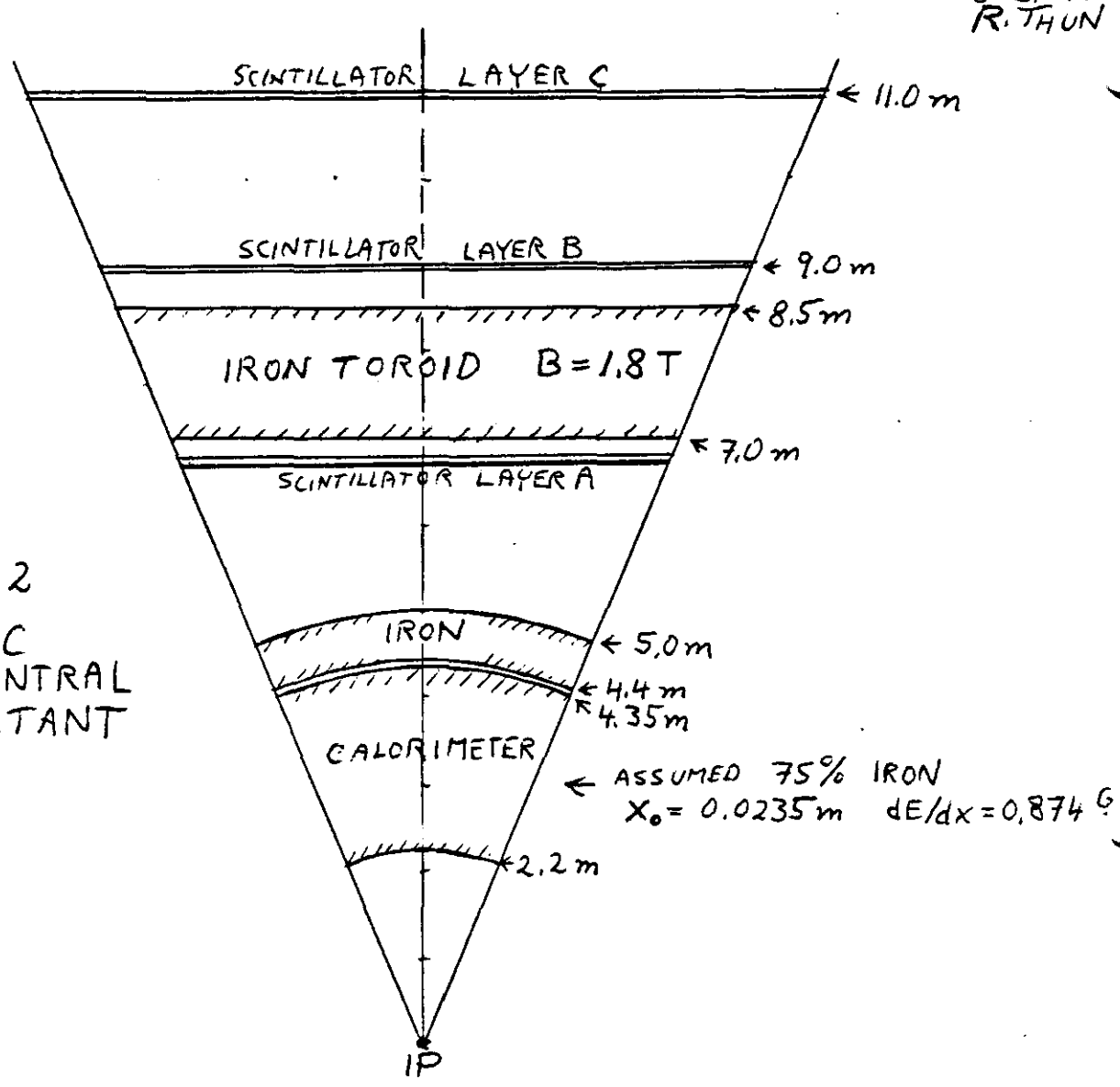

FIG 2

SDC CENTRAL OCTANT

FIG 3

SDC FORWARD GEOMETRY

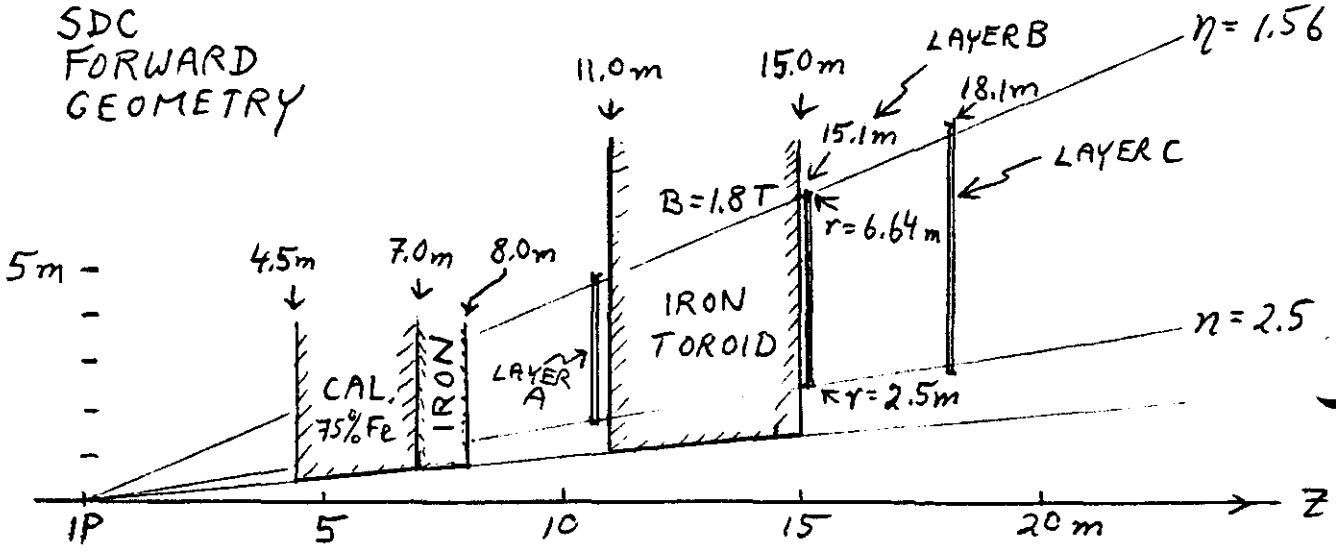

FIG 4 POSSIBLE COUNTER SEGMENTATION

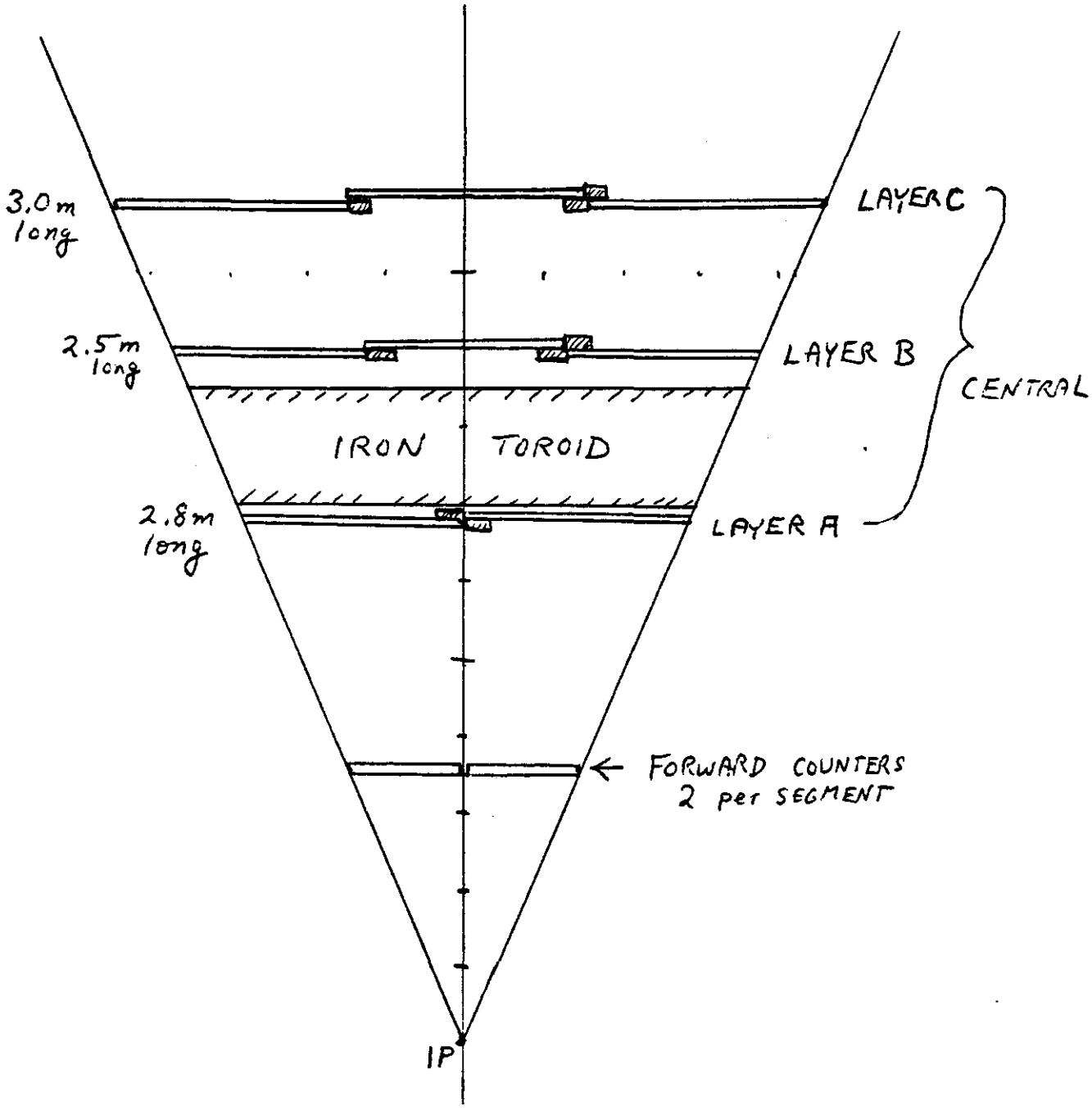

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FIG 5 CENTRAL MUON TRIGGER SCINTILLATORS
(FORWARD LAYOUT IS SIMILAR)

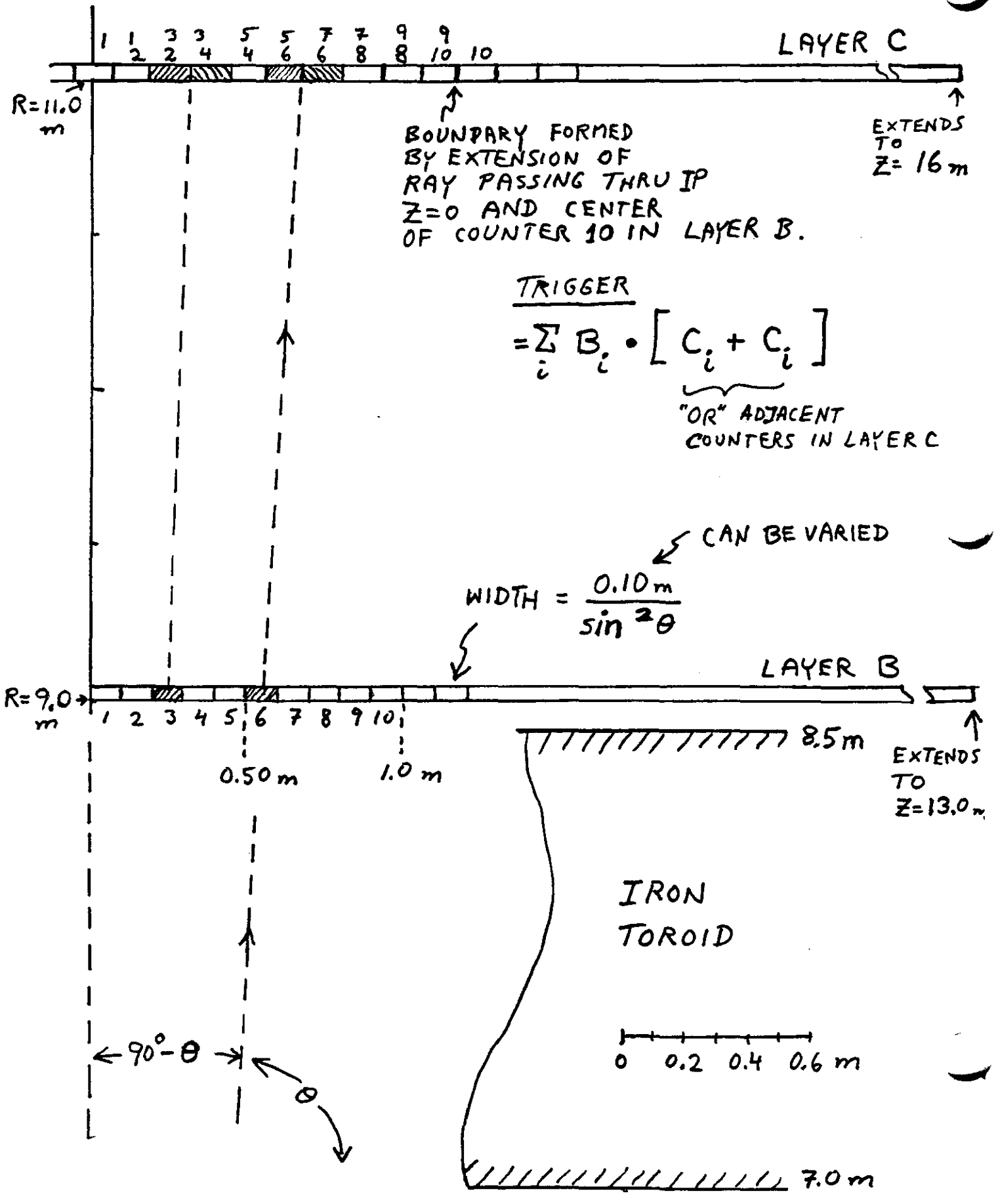
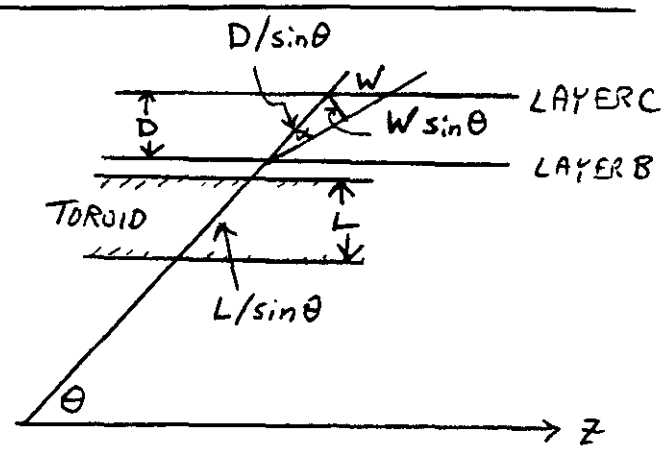


FIG 6

Scintillator Segmentation for Uniform $P_\perp$ Thresholds

Naively:



1.) CENTRAL REGION

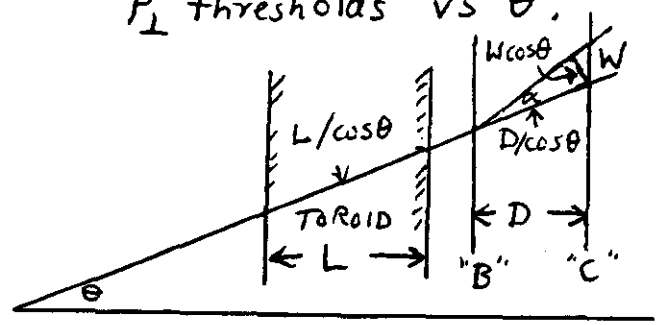
Counter width W defines a bend-angle

$$\alpha \approx \frac{W\sin\theta}{D/\sin\theta} = \frac{W}{D}\sin^2\theta$$

$$P_\perp = P\sin\theta \approx \frac{0.3B\frac{L}{\sin\theta}}{\alpha}\sin\theta = \frac{0.3BLD}{W\sin^2\theta}$$

so want $\boxed{W \approx \frac{0.3BLD}{P_\perp \sin^2\theta}}$

In the Monte Carlo $W = \frac{\text{const}}{\sin^2\theta}$ does give uniform $P_\perp$ thresholds vs θ.



2.) FORWARD REGION

$$\alpha \approx \frac{W\cos\theta}{D/\cos\theta} = \frac{W}{D}\cos^2\theta$$

$$P_\perp = P\sin\theta \approx \frac{0.3B\frac{L}{\cos\theta}}{\frac{W}{D}\cos^2\theta}\sin\theta = \frac{0.3BLD}{W}\frac{\sin\theta}{\cos^3\theta}$$

or $\boxed{W \approx \frac{0.3BLD}{P_\perp}\frac{\sin\theta}{\cos^3\theta}}$

In the Monte Carlo, this gives a somewhat non-uniform response. Empirically $W \approx [\sin\theta]^{1.35}$ works ok.

FIG. 7

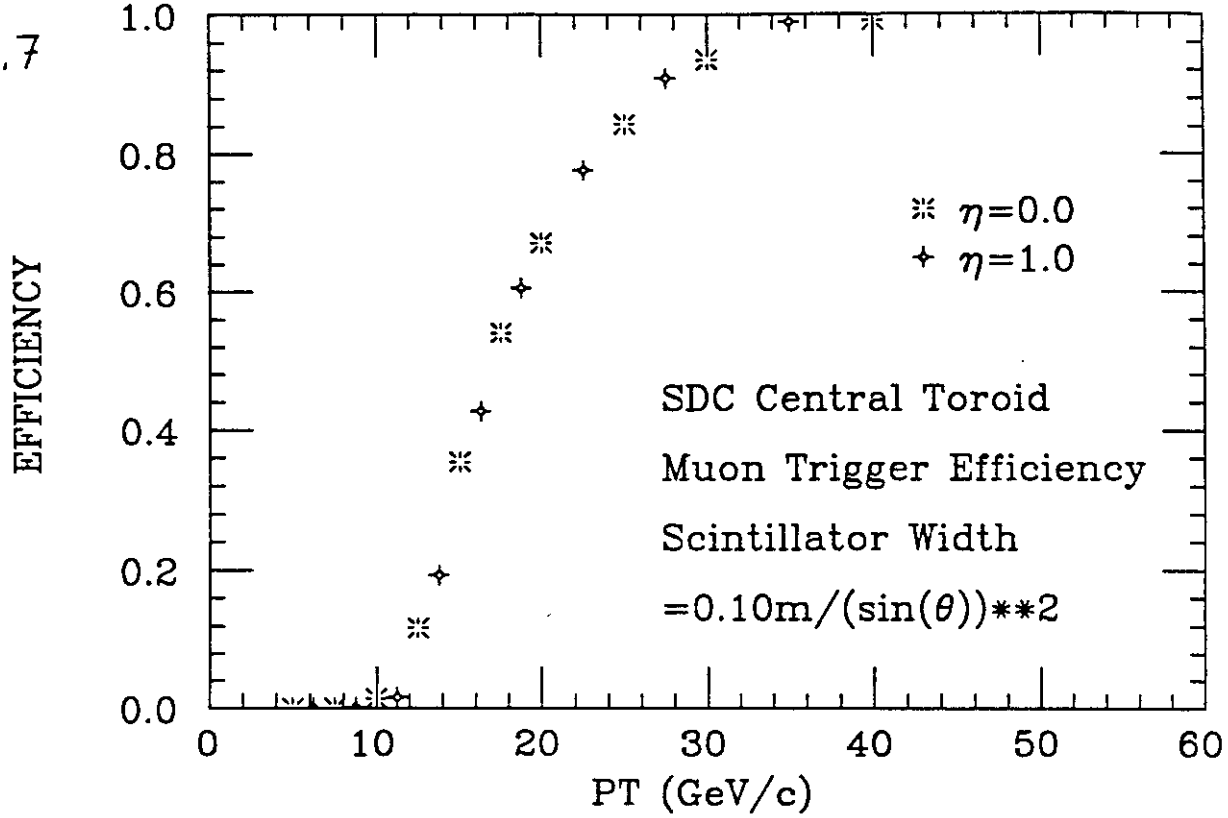

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=0.0
η=1.0
SDC Central Toroid
Muon Trigger Efficiency
Scintillator Width
=0.10m/(sin(θ))**2

FIG. 8

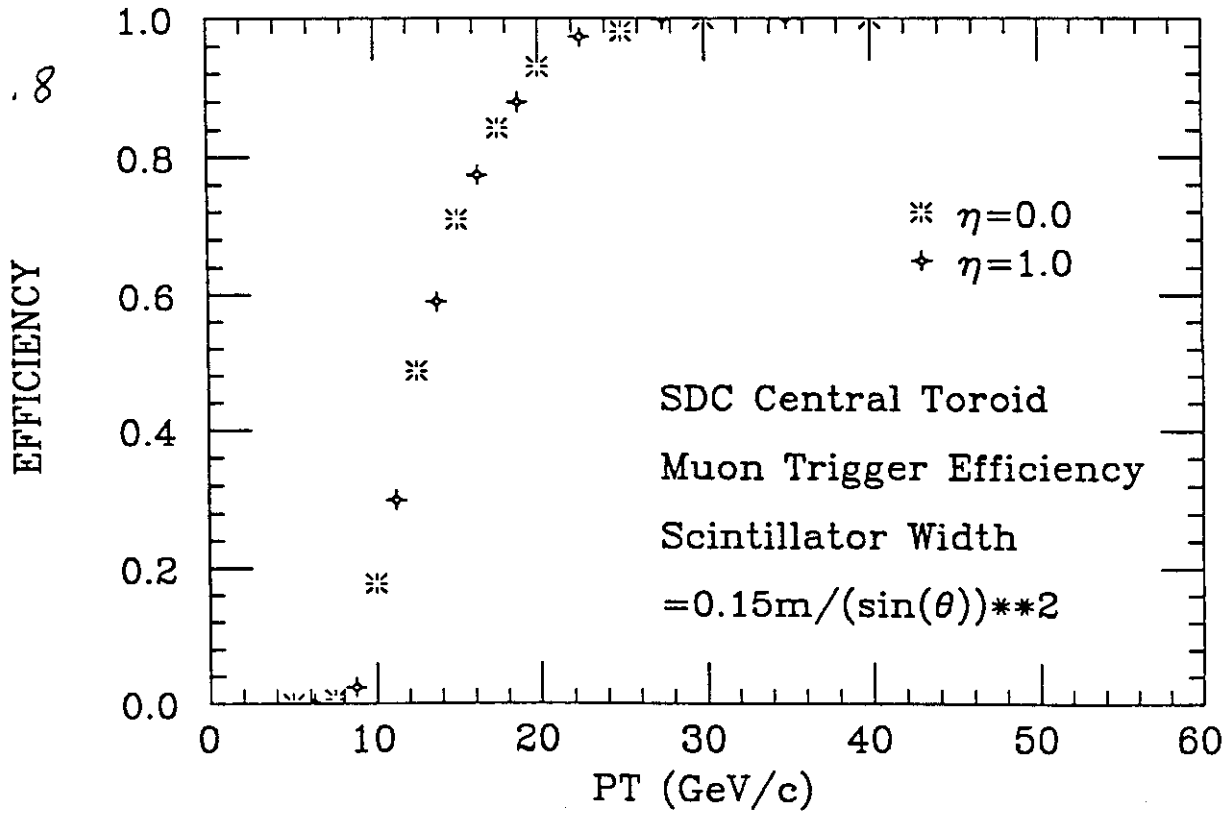

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=0.0
η=1.0
SDC Central Toroid
Muon Trigger Efficiency
Scintillator Width
=0.15m/(sin(θ))**2

FIG 9

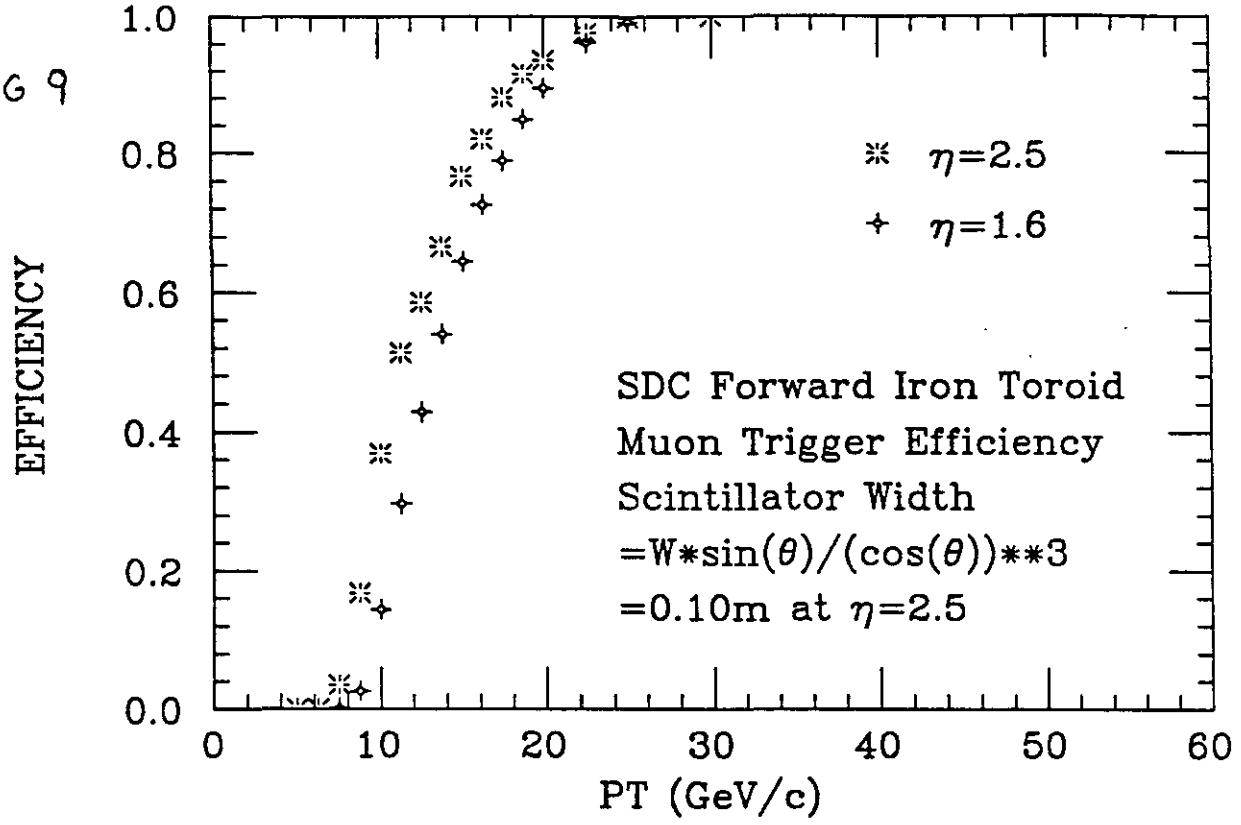

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*sin(θ)/(cos(θ))**3
=0.10m at η=2.5

FIG 10

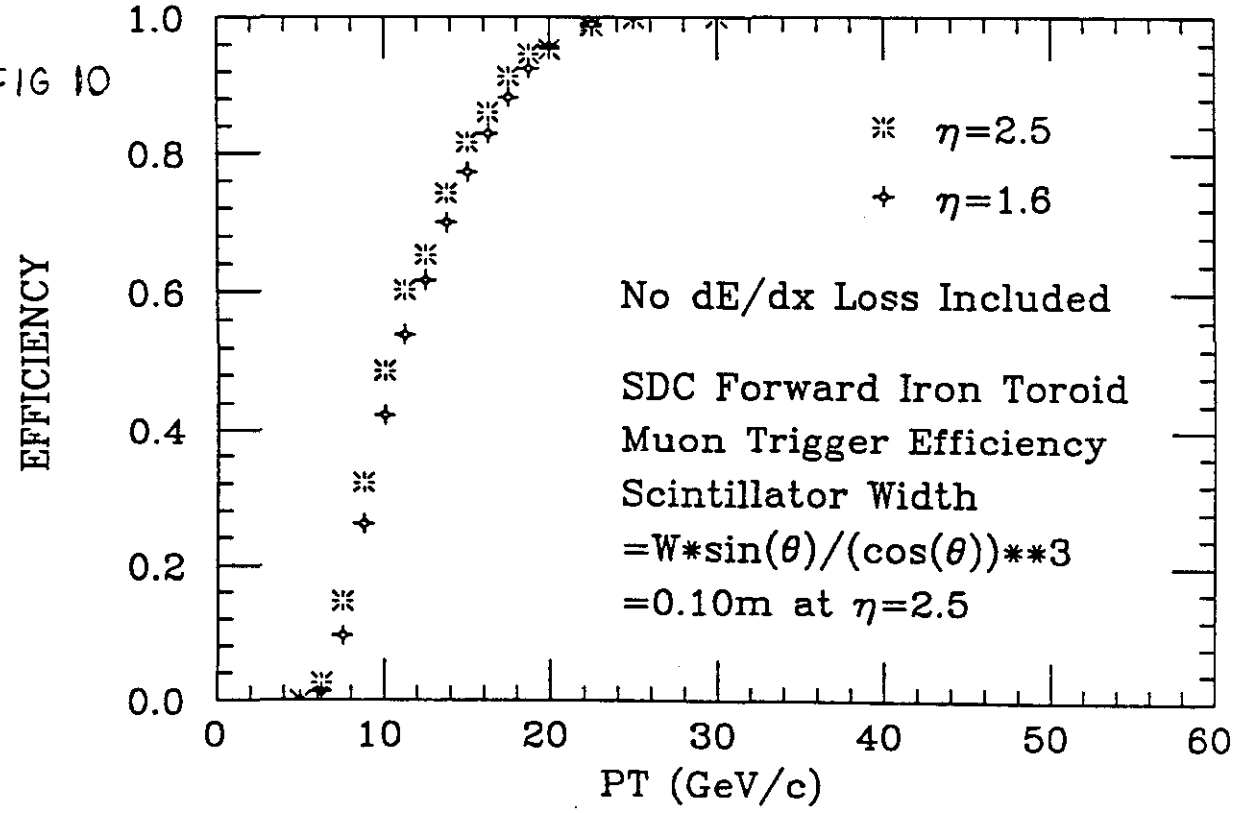

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
No dE/dx Loss Included
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*sin(θ)/(cos(θ))**3
=0.10m at η=2.5

FIG. 11

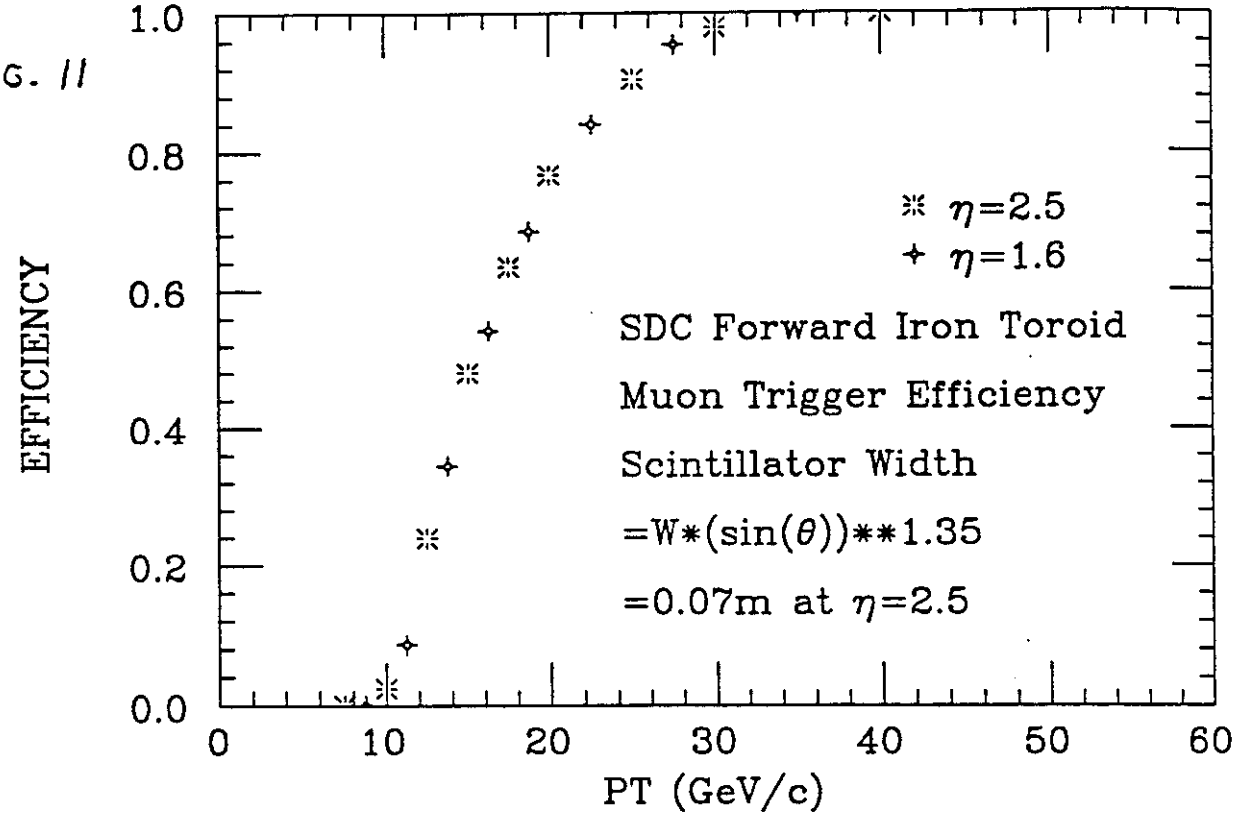
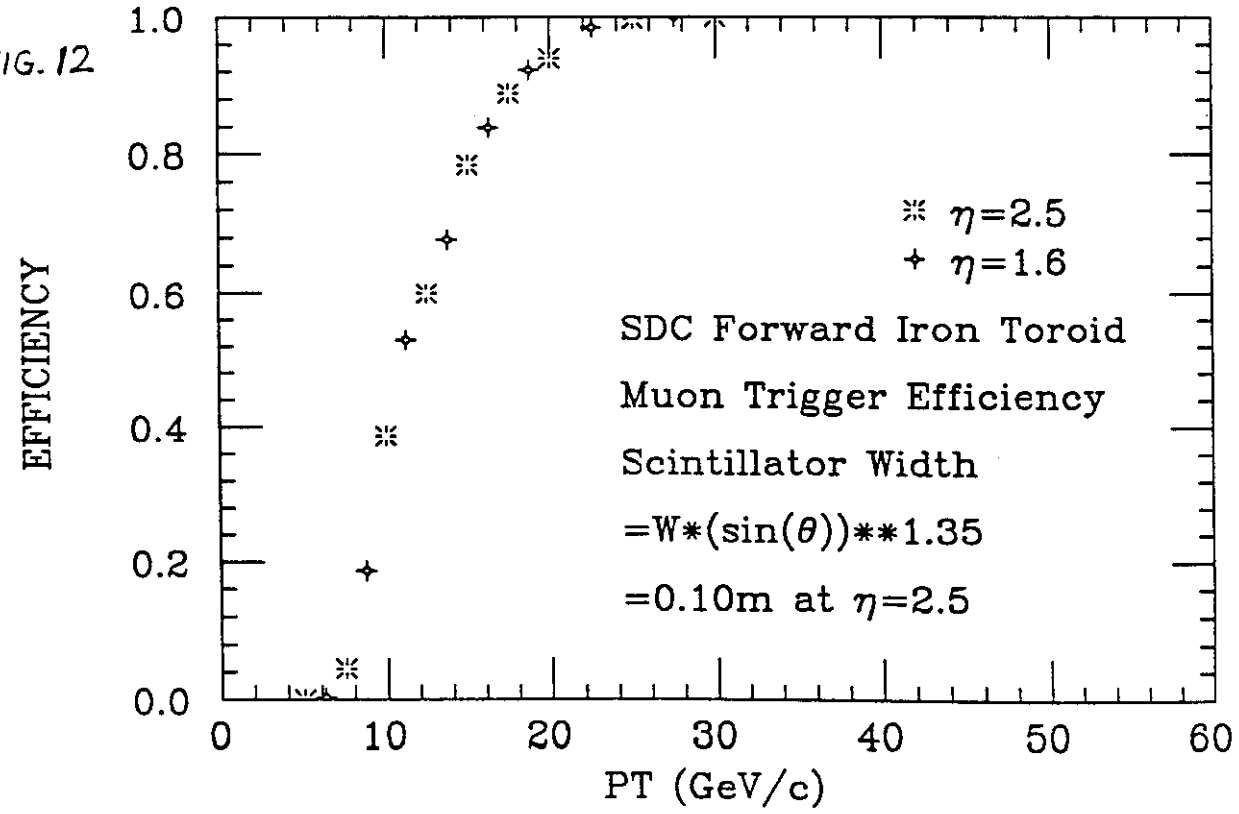

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*(sin(θ))**1.35
=0.07m at η=2.5

FIG. 12


1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*(sin(θ))**1.35
=0.10m at η=2.5

APPENDIX 1 : PROGRAM FOR CENTRAL TOROID

```
C       MUONC1.FOR
C       Program for calculating muon trigger efficiencies in central region.
C       This uses contiguous counters in both layers.
C
C       Input constants (meter, tesla, GeV)
C       L1N=left edge of scintillator layer 1.  L1P=right edge
C       same for layer 2 ( L2N, L2P )
C       N1(I) = number of tracks hitting counter I in layer 1
C       N12(I) = number of tracks striking counters I of both layers
        REAL L1N,L1P,L2N,L2P,L2C,LR1,LR2
        DIMENSION L1N(400),L1P(400),L2N(400),L2P(400),L2C(400)
        DIMENSION NHIT1(400),NHIT12(400),RATIO(400)
        DIMENSION N1(10),N12(10),R12(10)
        DIMENSION PTS(10)
        IPRINT=0
        NBIN=20
        NSTART=100
        DO 10 I=1,400
        L1N(I)=99.999
        L1P(I)=99.999
        L2N(I)=99.999
        L2P(I)=99.999
        NHIT1(I)=0
        NHIT12(I)=0
10      RATIO(I)=-1
C       Tracks generated at fixed PT and charge sign
        SIGN=1.0
        PTS(1)=5.0
        PTS(2)=7.5
        PTS(3)=10.0
        PTS(4)=12.5
        PTS(5)=15.0
        PTS(6)=17.5
        PTS(7)=20.0
        PTS(8)=25.0
        PTS(9)=30.0
        PTS(10)=40.0
        NEVT=10000
        SQRT12=SQRT(12.0)
C       SBEAM = rms z-dimension of beam-beam interaction region
C       WL1 = width of layer 1 counters at z=0
C       FSB = factor taking into account finite source size
        SBEAM=0.05
        WL1=0.15
C       DWL2 not used anymore (3 Sep 90)
        DWL2=0.0
        FSB=3.0
        EXPSIN=2.0
        NL1=400
C       Radiation lengths and dE/dx for iron and calorimeter
        XFE=0.0176
        EFE=1.165
        XCAL=0.0176/0.75
        ECAL=0.75*1.165
C       Field in toroid
        BFIELD=1.8
C       Inner and outer radii of calorimeter, return flux iron, toroid,
C       and trigger layers.
C       The following represents the SDC geometry as of 3 Sep 90.
        CR1=2.2
        CR2=4.35
        SR1=4.4
        SR2=5.0
        TR1=7.0
        TR2=8.5
        LR1=9.0
        LR2=11.0
        WRITE(6,1330)SBEAM,WL1,DWL2,EXPSIN,FSB
        WRITE(6,1340)XCAL,ECAL,BFIELD,CR1,CR2
        WRITE(6,1350)SR1,SR2,TR1,TR2,LR1,LR2
C       Define detector edges at layer 1
        ZLIM=13.0
        DLIM=SQRT(LR1**2+ZLIM**2)
        COSLIM=ZLIM/DLIM
C       Calculate counter edges
        ZP=FSB*SBEAM
        D12=LR2-LR1
        L1N(201)=0.0
        L1P(201)=WL1
        ITEST=0
        DO 20 I=201,NL1
        SINTH=1.0
        IF(I.EQ.201) GO TO 19
        Z=L1P(I-1)
        SINTH=LR1/SQRT(LR1*LR1+Z*Z)
        COSTH=SQRT(1.0-SINTH*SINTH)
C       SEGMENTATION WITH EXPSIN=1.0 GIVES CONSTANT D(ETA)
        DZ=WL1/(SINTH**EXPSIN)
        L1N(I)=L1P(I-1)
        L1P(I)=Z+DZ
19      CONTINUE
        L1P(NL1-I+1)=-L1N(I)
        L1N(NL1-I+1)=-L1P(I)
        IF(ITEST.EQ.1) GO TO 22
        IF(L1N(I).GT.ZLIM) ITEST=1
20      CONTINUE
22      NMAX=I
        NMIN=401-NMAX
        F=0.5*LR2/LR1
        DO 25 I=NMIN,NMAX
25      L2C(I)=F*(L1N(I)+L1P(I))
        NMAX=NMAX-1
        NMIN=NMIN+1
        DO 30 I=NMIN,NMAX
        L2N(I)=L2C(I-1)
        L2P(I)=L2C(I+1)
30      CONTINUE
        DO 2000 IPT=1,10
        NACC=0
        PT=PTS(IPT)
        DO 1000 I=1,NEVT
C       GAUSSIAN BEAM-BEAM Z-DISTRIBUTION
        R=RG32(X)
        Z=R*SBEAM
C       UNIFORM ILLUMINATION OF FIRST SCINTILLATOR LAYER AT LR1
        R=RN32(X)
        ZR=-ZLIM+2.0*R*ZLIM
        COSTH=ZR/SQRT(ZR*ZR+LR1*LR1)
        SINTH=SQRT(1.0-COSTH**2)
        TANTH=SINTH/COSTH
C       GO THROUGH CALORIMETER
        Z=Z+CR2/TANTH
        D=(CR2-CR1)/SINTH
        XN=D/XCAL
        P=PT/SINTH
        PN=P-ECAL*D
        IF(PN.LT.0.0) GO TO 900
        PAV=(PN+P)/2.0
        SA=0.015*SQRT(XN)/PAV
        R2=RG32(X)
        A=SA*R2
        IF(A.GT.1.0) GO TO 900
```

```
      COSA=COS(A)
      SINA=SIN(A)
      COSB=COSTH
      SINB=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) GO TO 900
      TANTH=SINTH/COSTH
      R1=RG32(X)
      DZ=D*SA*(R1/SQRT12+R2/2.0)
      Z=Z+DZ/SINB
      Z=Z+(SR2-CR2)/TANTH
C     GO THROUGH YOKE IRON
      D=(SR2-SR1)/SINTH
      P=PN
      PN=P-EFE*D
      IF(PN.LT.0.0) GO TO 900
      PAV=(PN+P)/2.0
      XN=D/XFE
      SA=0.015*SQRT(XN)/PAV
      R2=RG32(X)
      A=SA*R2
      IF(A.GT.1.0) go to 900
      COSA=COS(A)
      SINA=SIN(A)
      COSB=COSTH
      SINB=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) go to 900
      TANTH=SINTH/COSTH
      R1=RG32(X)
      DZ=D*SA*(R1/SQRT12+R2/2.0)
      Z=Z+DZ/SINB
C     GO THROUGH IRON TOROID......FIRST BEND..THEN MULTIPLE SCATTER
      ZTR1=Z+(TR1-SR2)/TANTH
      D=(TR2-TR1)/SINTH
      P=PN
      PTR1=P
      PN=P-EFE*D
      IF(PN.LT.0.0) GO TO 900
      PAV=(PN+P)/2.0
      RP=SIGN*PAV/(0.3*BFIELD)
      A=ZTR1+RP*SINTH
      B=TR1-RP*COSTH
      C=RP*RP-(TR2-B)**2
      IF(C.LT.0.0) GO TO 900
      Z=A-SIGN*SQRT(C)
      DN=SQRT((Z-ZTR1)**2+(TR2-TR1)**2)
      DE=(DN-D)*EFE
      PN=PN-DE
      IF(PN.LT.0.0) GO TO 900
      SINB2=DN/(2.0*RP)
      COSB2=SQRT(1.0-SINB2**2)
      SINB=2.0*SINB2*COSB2
      COSB=SQRT(1.0-SINB**2)
      COSA=COSTH
      SINA=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) GO TO 900
      PAV=(PN+PTR1)/2.0
      XN=DN/XFE
      SA=0.015*SQRT(XN)/PAV
      R2=RG32(X)
      A=SA*R2
      IF(A.GT.1.0) GO TO 900
      COSA=COS(A)
      SINA=SIN(A)
      COSB=COSTH
      SINB=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) GO TO 900
      TANTH=SINTH/COSTH
      R1=RG32(X)
      DZ=DN*SA*(R1/SQRT12+R2/2.0)
      Z=Z+DZ/SINB
C     CHECK HITS IN SCINTILLATOR LAYERS AT LR1 AND LR2
      ZL1=Z+(LR1-TR2)/TANTH
      ZL2=Z+(LR2-TR2)/TANTH
      IF(ZL1.LT.-ZLIM) GO TO 900
      IF(ZL1.GT.ZLIM) GO TO 900
      J1=NMIN
      IF(ZL1.GT.0.0) J1=201
      Do 800 J=J1,NMAX
      IF(ZL1.LT.L1P(J)) GO TO 810
800   CONTINUE
810   I1=J
      NHIT1(I1)=NHIT1(I1)+1
      IF(ZL2.LT.L2N(I1)) GO TO 900
      IF(ZL2.GT.L2P(I1)) GO TO 900
      NHIT12(I1)=NHIT12(I1)+1
      NACC=NACC+1
      GO TO 1000
900   CONTINUE
1000  CONTINUE
      WRITE(6,1231) PT,SIGN,NEVT,NACC
      IF(IPRINT.NE.1) GO TO 1011
      WRITE(6,1200)
      WRITE(6,1100) (NHIT1(I),I=1,400)
      WRITE(6,1210)
      WRITE(6,1100) (NHIT12(I),I=1,400)
      DO 1010 I=1,400
      IF(NHIT1(I).LT.1) GO TO 1010
      A=FLOAT(NHIT1(I))
      B=FLOAT(NHIT12(I))
      RATIO(I)=B/A
1010  CONTINUE
      WRITE(6,1220)
      WRITE(6,1110) (RATIO(I),I=1,400)
1011  CONTINUE
      IA=1-NBIN+NSTART
      IB=NSTART
      DO 1015 I=1,10
      N1(I)=0
      N12(I)=0
      R12(I)=-1.0
      IA=IA+NBIN
      IB=IB+NBIN
      DO 1012 J=IA,IB
      N1(I)=N1(I)+NHIT1(J)
      N12(I)=N12(I)+NHIT12(J)
1012  CONTINUE
1015  CONTINUE
      Do 1016 I=1,10
      IF(N1(I).LT.1) GO TO 1016
      A=FLOAT(N12(I))
      B=FLOAT(N1(I))
      R12(I)=A/B
1016  CONTINUE
      WRITE(6,1300) (N1(I),I=1,10)
```

```
      WRITE(6,1310)  (N12(I),I=1,10)
      WRITE(6,1320)  (R12(I),I=1,10)
      DO 1018 I=1,400
      NHIT1(I)=0
      NHIT12(I)=0
1018  CONTINUE
2000  CONTINUE
      WRITE(6,1240)
      WRITE(6,1120)  (L1N(I),I=1,400)
      WRITE(6,1250)
      WRITE(6,1120)  (L1P(I),I=1,400)
      WRITE(6,1260)
      WRITE(6,1120)  (L2N(I),I=1,400)
      WRITE(6,1270)
      WRITE(6,1120)  (L2P(I),I=1,400)
1100  FORMAT(1X,10I7)
1110  FORMAT(1X,10F7.2)
1120  FORMAT(1X,10F7.3)
1200  FORMAT(1H1,5HNHIT1)
1210  FORMAT(1H1,6HNHIT12)
1220  FORMAT(1H1,5HRATIO)
1231  FORMAT(1H0,3HPT=,F6.1,3X,5HSIGN=,F4.1,3X,5HNEVT=,I5,3X,
     1 5HNACC=,I5)
1240  FORMAT(1H1,3HL1N)
1250  FORMAT(1H1,3HL1P)
1260  FORMAT(1H1,3HL2N)
1270  FORMAT(1H1,3HL2P)
1300  FORMAT(1X,3H N1,10I7)
1310  FORMAT(1X,3HN12,10I7)
1320  FORMAT(1X,3HR12,10F7.3)
1330  FORMAT(1H0,6HSBEAM=,F5.3,3X,4HWL1=,F5.3,3X,5HDWL2=,F5.3,
     1 3X,7HEXPSIN=,F5.2,3X,4HFSB=,F3.1)
1340  FORMAT(1X,5HXCAL=,F6.4,3X,5HECAL=,F5.3,3X,7HBFIELD=,F4.2,
     1 2X,4HCR1=,F6.3,2X,4HCR2=,F6.3)
1350  FORMAT(1X,4HSR1=,F6.3,2X,4HSR2=,F6.3,2X,4HTR1=,F6.3,2X,
     1 4HTR2=,F6.3,2X,4HLR1=,F6.3,2X,4HLR2=,F6.3)
      END
```

R12 = detection efficiency

SAMPLE OUTPUT

```
SBEAM=0.050   WL1=0.150   DWL2=0.000   EXPSIN= 2.00   FSB=3.0
XCAL=0.0235   ECAL=0.874   BFIELD=1.80  CR1= 2.200  CR2= 4.350
SR1= 4.400  SR2= 5.000  TR1= 7.000  TR2= 8.500  LR1= 9.000  LR2=11.000

PT=   5.0   SIGN= 1.0   NEVT=10000   NACC=    0
 N1      0      0   1889   1441   1196   1157    926     42      0      0
N12      0      0      0      0      0      0      0      0      0      0
R12 -1.000 -1.000  0.000  0.000  0.000  0.000  0.000  0.000 -1.000 -1.000

PT=   7.5   SIGN= 1.0   NEVT=10000   NACC=   35
 N1      0      0   2254   1450   1202   1135   1478   2266      0      0
N12      0      0      7      8     10      4      6      0      0      0
R12 -1.000 -1.000  0.003  0.006  0.008  0.004  0.004  0.000 -1.000 -1.000

PT=  10.0   SIGN= 1.0   NEVT=10000   NACC= 1448
 N1      0      0   2276   1558   1174   1262   1442   2195      0      0
N12      0      0    267    224    216    213    213    315      0      0
R12 -1.000 -1.000  0.117  0.144  0.184  0.169  0.148  0.144 -1.000 -1.000

PT=  12.5   SIGN= 1.0   NEVT=10000   NACC= 4776
 N1      0      0   2266   1595   1230   1132   1436   2273      0      0
N12      0      0   1025    780    584    564    736   1087      0      0
R12 -1.000 -1.000  0.452  0.489  0.475  0.498  0.513  0.478 -1.000 -1.000

PT=  15.0   SIGN= 1.0   NEVT=10000   NACC= 6935
 N1      0      0   2294   1474   1219   1162   1542   2256      0      0
N12      0      0   1546   1020    843    842   1096   1588      0      0
R12 -1.000 -1.000  0.674  0.692  0.692  0.725  0.711  0.704 -1.000 -1.000

PT=  17.5   SIGN= 1.0   NEVT=10000   NACC= 8365
 N1      0      0   2317   1517   1184   1198   1525   2226      0      0
N12      0      0   1940   1271   1003   1002   1270   1879      0      0
R12 -1.000 -1.000  0.837  0.838  0.847  0.836  0.833  0.844 -1.000 -1.000

PT=  20.0   SIGN= 1.0   NEVT=10000   NACC= 9211
 N1      0      0   2293   1519   1165   1209   1532   2246      0      0
N12      0      0   2093   1397   1080   1128   1422   2091      0      0
R12 -1.000 -1.000  0.913  0.920  0.927  0.933  0.928  0.931 -1.000 -1.000

PT=  25.0   SIGN= 1.0   NEVT=10000   NACC= 9835
 N1      0      0   2343   1437   1229   1170   1492   2300      0      0
N12      0      0   2314   1415   1208   1144   1474   2280      0      0
R12 -1.000 -1.000  0.988  0.985  0.983  0.978  0.988  0.991 -1.000 -1.000

PT=  30.0   SIGN= 1.0   NEVT=10000   NACC= 9976
 N1      0      0   2302   1561   1246   1165   1472   2234      0      0
N12      0      0   2302   1561   1246   1162   1471   2234      0      0
R12 -1.000 -1.000  1.000  1.000  1.000  0.997  0.999  1.000 -1.000 -1.000

PT=  40.0   SIGN= 1.0   NEVT=10000   NACC= 9982
 N1      0      0   2215   1482   1217   1271   1500   2297      0      0
N12      0      0   2215   1482   1217   1271   1500   2297      0      0
R12 -1.000 -1.000  1.000  1.000  1.000  1.000  1.000  1.000 -1.000 -1.000
```

$-\eta \longleftarrow \longrightarrow +\eta$

$\eta = 0$

L1N

99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999

L2N

99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
-17.069	-16.474	-15.908	-15.366	-14.849	-14.353	-13.878	-13.422	-12.983	-12.560
-12.153	-11.760	-11.381	-11.014	-10.658	-10.314	-9.979	-9.655	-9.339	-9.032
-8.733	-8.442	-8.158	-7.880	-7.609	-7.344	-7.085	-6.831	-6.582	-6.337
-6.098	-5.862	-5.631	-5.403	-5.179	-4.959	-4.741	-4.527	-4.315	-4.106
-3.900	-3.696	-3.494	-3.294	-3.096	-2.900	-2.706	-2.513	-2.322	-2.131
-1.942	-1.754	-1.567	-1.381	-1.195	-1.011	-0.826	-0.642	-0.458	-0.275
-0.092	0.092	0.275	0.458	0.642	0.826	1.011	1.195	1.381	1.567
1.754	1.942	2.131	2.322	2.513	2.706	2.900	3.096	3.294	3.494
3.696	3.900	4.106	4.315	4.527	4.741	4.959	5.179	5.403	5.631
5.862	6.098	6.337	6.582	6.831	7.085	7.344	7.609	7.880	8.158
8.442	8.733	9.032	9.339	9.655	9.979	10.314	10.658	11.014	11.381
11.760	12.153	12.560	12.983	13.422	13.878	14.353	14.849	15.366	15.908
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
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99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999

L2P

99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
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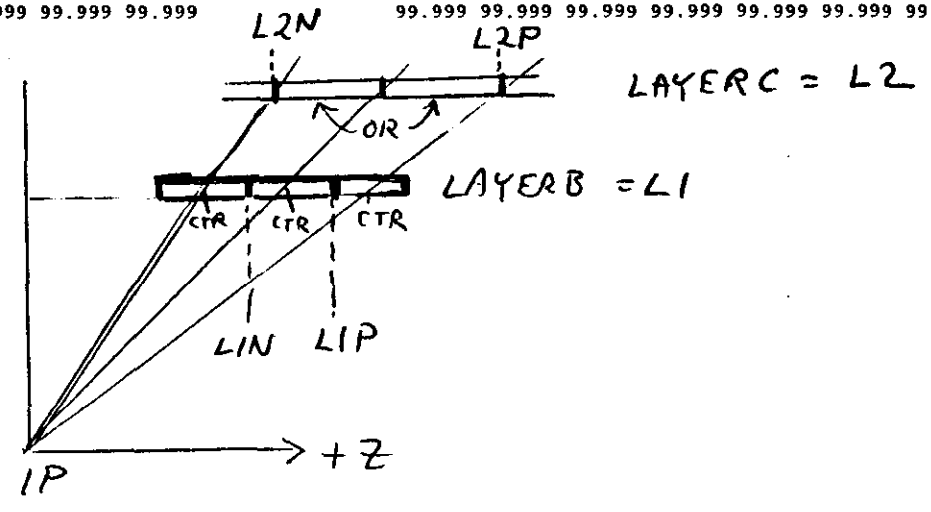
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
-15.908	-15.366	-14.849	-14.353	-13.878	-13.422	-12.983	-12.560	-12.153	-11.760
-11.381	-11.014	-10.658	-10.314	-9.979	-9.655	-9.339	-9.032	-8.733	-8.442
-8.158	-7.880	-7.609	-7.344	-7.085	-6.831	-6.582	-6.337	-6.098	-5.862
-5.631	-5.403	-5.179	-4.959	-4.741	-4.527	-4.315	-4.106	-3.900	-3.696
-3.494	-3.294	-3.096	-2.900	-2.706	-2.513	-2.322	-2.131	-1.942	-1.754
-1.567	-1.381	-1.195	-1.011	-0.826	-0.642	-0.458	-0.275	-0.092	0.092
0.275	0.458	0.642	0.826	1.011	1.195	1.381	1.567	1.754	1.942
2.131	2.322	2.513	2.706	2.900	3.096	3.294	3.494	3.696	3.900
4.106	4.315	4.527	4.741	4.959	5.179	5.403	5.631	5.862	6.098
6.337	6.582	6.831	7.085	7.344	7.609	7.880	8.158	8.442	8.733
9.032	9.339	9.655	9.979	10.314	10.658	11.014	11.381	11.760	12.153
12.560	12.983	13.422	13.878	14.353	14.849	15.366	15.908	16.474	17.069
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999

Z - coordinates of counter edges



APPENDIX 2: PROGRAM FOR FORWARD TOROID

```
C       MUONF1.FOR
C       Program for calculating muon trigger efficiencies in forward region.
C       ( NOTE: this is modified version of muonc.for )
C
C       Program was modified on 2 SEP 90 for contiguous counters in
C       layer 2 similar to program muonc1.for
C
C       Input constants (meter, tesla, GeV)
C       L1N=left edge of scintillator layer 1.  L1P=right edge
C       same for layer 2 ( L2N, L2P )
C       N1(I) = number of tracks hitting counter I in layer 1
C       N12(I) = number of tracks striking counters I of both layers
        REAL L1N,L1P,L2N,L2P,L2C,LR1,LR2
        DIMENSION L1N(400),L1P(400),L2N(400),L2P(400),L2C(400)
        DIMENSION NHIT1(400),NHIT12(400),RATIO(400)
        DIMENSION N1(10),N12(10),R12(10)
        DIMENSION PTS(10)
        IPRINT=0
        DO 10 I=1,400
        L1N(I)=99.999
        L1P(I)=89.999
        L2N(I)=99.999
        L2P(I)=89.999
        NHIT1(I)=0
        NHIT12(I)=0
10      RATIO(I)=-1
C       Tracks generated at fixed PT and charge sign
        SIGN=1.0
        PTS(1)=5.0
        PTS(2)=7.5
        PTS(3)=10.0
        PTS(4)=12.5
        PTS(5)=15.0
        PTS(6)=17.5
        PTS(7)=20.0
        PTS(8)=25.0
        PTS(9)=30.0
        PTS(10)=40.0
        NEVT=10000
        SQRT12=SQRT(12.0)
C       SBEAM = rms z-dimension of beam-beam interaction region
C       WL1 = width of layer 1 counters at ZLIM1 (inner radius)
        SBEAM=0.05
        WL1=0.07
        DWL2=0.0
        FSB=3.0
        EXPSIN=0.0
        EXPCOS=1.35
        NL1=400
C       Radiation lengths and dE/dx for iron and calorimeter
        XFE=0.0176
        EFE=1.165
        XCAL=0.0176/0.75
        ECAL=0.75*1.165
C       Field in toroid
        BFIELD=1.8
C       Inner and outer radii of calorimeter, return flux iron, toroid,
C       and trigger layers.
C       Dimensions below reflect iron option for SDC as of 2 Sep 90.
        CR1=4.5
        CR2=7.0
        SR1=7.0
        SR2=8.0
        TR1=11.0
        TR2=15.0
        LR1=15.1
        LR2=18.1
        WRITE(6,1330)SBEAM,WL1,DWL2,EXPSIN,EXPCOS,FSB
        WRITE(6,1340)XCAL,ECAL,BFIELD,CR1,CR2
        WRITE(6,1350)SR1,SR2,TR1,TR2,LR1,LR2
C       Define detector edges
C       Correspond to eta range 1.56 to 2.5
        ZLIM1=2.50
        ZLIM2=6.64
        ZDIF=ZLIM2-ZLIM1
        SINTH=LR1/SQRT(LR1*LR1+ZLIM1*ZLIM1)
        COSTH=SQRT(1.0-SINTH**2)
C       Note that SINTH=cos(theta) and COSTH=sin(theta) where
C       theta is direction with respect to beams. (Sorry about that!)
        WL1=WL1*(SINTH**EXPSIN)/(COSTH**EXPCOS)
C       Calculate counter edges
        L1N(1)=ZLIM1
        DO 20 I=1,NL1
        Z=L1N(I)
        SINTH=LR1/SQRT(LR1*LR1+Z*Z)
        COSTH=SQRT(1.0-SINTH**2)
C       SEGMENTATION WITH EXPSIN=2.0 AND EXPCOS=1.0 GIVES CONSTANT D(ETA)
        DZ=WL1*(COSTH**EXPCOS)/(SINTH**EXPSIN)
        L1P(I)=Z+DZ
        IF(I.EQ.NL1) GO TO 19
        L1N(I+1)=L1P(I)
19      CONTINUE
        IF(L1N(I).GT.ZLIM2) GO TO 21
20      CONTINUE
21      CONTINUE
        NMAX=I-1
        F=0.5*LR2/LR1
        DO 23 I=1,NMAX
23      L2C(I)=F*(L1N(I)+L1P(I))
        IMAX=NMAX-1
        DO 25 I=2,IMAX
        L2N(I)=L2C(I-1)
        L2P(I)=L2C(I+1)
25      CONTINUE
        L2N(1)=2.0*L2C(1)-L2C(2)
        L2P(1)=L2C(2)
        L2N(NMAX)=L2C(IMAX)
        L2P(NMAX)=2.0*L2C(NMAX)-L2C(IMAX)
        DO 2000 IPT=1,10
        NACC=0
        PT=PTS(IPT)
        DO 1000 I=1,NEVT
C       GAUSSIAN BEAM-BEAM Z-DISTRIBUTION
        R=RG32(X)
        Z=R*SBEAM
C       UNIFORM ILLUMINATION OF FIRST SCINTILLATOR LAYER AT LR1
        R=RN32(X)
        ZR=ZLIM1+R*ZDIF
        COSTH=ZR/SQRT(ZR*ZR+LR1*LR1)
        SINTH=SQRT(1.0-COSTH**2)
        TANTH=SINTH/COSTH
        Z=Z*COSTH
C       GO THROUGH CALORIMETER
        Z=Z+CR2/TANTH
        D=(CR2-CR1)/SINTH
        XN=D/XCAL
        P=PT/COSTH
        PN=P-ECAL*D
        IF(PN.LT.0.0) GO TO 900
        PAV=(PN+P)/2.0
        SA=0.015*SQRT(XN)/PAV
        R2=RG32(X)
```

```
      A=SA*R2
      IF(A.GT.1.0) GO TO 900
      COSA=COS(A)
      SINA=SIN(A)
      COSB=COSTH
      SINB=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) GO TO 900
      TANTH=SINTH/COSTH
      R1=RG32(X)
      DZ=D*SA*(R1/SQRT12+R2/2.0)
      Z=Z+DZ/SINB
      Z=Z+(SR2-CR2)/TANTH
C     GO THROUGH YOKE IRON
      D=(SR2-SR1)/SINTH
      P=PN
      PN=P-EFE*D
      IF(PN.LT.0.0) GO TO 900
      PAV=(PN+P)/2.0
      XN=D/XFE
      SA=0.015*SQRT(XN)/PAV
      R2=RG32(X)
      A=SA*R2
      IF(A.GT.1.0) go to 900
      COSA=COS(A)
      SINA=SIN(A)
      COSB=COSTH
      SINB=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) go to 900
      TANTH=SINTH/COSTH
      R1=RG32(X)
      DZ=D*SA*(R1/SQRT12+R2/2.0)
      Z=Z+DZ/SINB
C     GO THROUGH IRON TOROID......FIRST BEND..THEN MULTIPLE SCATTER
      ZTR1=Z+(TR1-SR2)/TANTH
      D=(TR2-TR1)/SINTH
      P=PN
      PTR1=P
      PN=P-EFE*D
      IF(PN.LT.0.0) GO TO 900
      PAV=(PN+P)/2.0
      RP=SIGN*PAV/(0.3*BFIELD)
      A=ZTR1+RP*SINTH
      B=TR1-RP*COSTH
      C=RP*RP-(TR2-B)**2
      IF(C.LT.0.0) GO TO 900
      Z=A-SIGN*SQRT(C)
      DN=SQRT((Z-ZTR1)**2+(TR2-TR1)**2)
      DE=(DN-D)*EFE
      PN=PN-DE
      IF(PN.LT.0.0) GO TO 900
      SINB2=DN/(2.0*RP)
      COSB2=SQRT(1.0-SINB2**2)
      SINB=2.0*SINB2*COSB2
      COSB=SQRT(1.0-SINB**2)
      COSA=COSTH
      SINA=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) GO TO 900
      PAV=(PN+PTR1)/2.0
      XN=DN/XFE
      SA=0.015*SQRT(XN)/PAV
      R2=RG32(X)
      A=SA*R2
      IF(A.GT.1.0) GO TO 900
      COSA=COS(A)
      SINA=SIN(A)
      COSB=COSTH
      SINB=SINTH
      COSTH=COSA*COSB-SINA*SINB
      SINTH=SINA*COSB+SINB*COSA
      IF(SINTH.LT.0.0) GO TO 900
      TANTH=SINTH/COSTH
      R1=RG32(X)
      DZ=DN*SA*(R1/SQRT12+R2/2.0)
      Z=Z+DZ/SINB
C     CHECK HITS IN SCINTILLATOR LAYERS AT LR1 AND LR2
      ZL1=Z+(LR1-TR2)/TANTH
      ZL2=Z+(LR2-TR2)/TANTH
      IF(ZL1.LT.ZLIM1) GO TO 900
      IF(ZL1.GT.ZLIM2) GO TO 900
      Do 800 J=1,NL1
      IF(ZL1.LT.L1P(J)) GO TO 810
800   CONTINUE
810   I1=J
      NHIT1(I1)=NHIT1(I1)+1
      IF(ZL2.LT.L2N(I1)) GO TO 900
      IF(ZL2.GT.L2P(I1)) GO TO 900
      NHIT12(I1)=NHIT12(I1)+1
      NACC=NACC+1
      GO TO 1000
900   CONTINUE
1000  CONTINUE
      WRITE(6,1231) PT,SIGN,NEVT,NACC
      IF(IPRINT.NE.1) GO TO 1011
      WRITE(6,1200)
      WRITE(6,1100) (NHIT1(I),I=1,400)
      WRITE(6,1210)
      WRITE(6,1100) (NHIT12(I),I=1,400)
      DO 1010 I=1,400
      IF(NHIT1(I).LT.1) GO TO 1010
      A=FLOAT(NHIT1(I))
      B=FLOAT(NHIT12(I))
      RATIO(I)=B/A
1010  CONTINUE
      WRITE(6,1220)
      WRITE(6,1110) (RATIO(I),I=1,400)
1011  CONTINUE
C     Sum over bins
      IA=-4
      IB=0
      DO 1015 I=1,10
      N1(I)=0
      N12(I)=0
      R12(I)=-1.0
      IA=IA+5
      IB=IB+5
      DO 1012 J=IA,IB
      N1(I)=N1(I)+NHIT1(J)
      N12(I)=N12(I)+NHIT12(J)
1012  CONTINUE
1015  CONTINUE
      Do 1016 I=1,10
      IF(N1(I).LT.1) GO TO 1016
      A=FLOAT(N12(I))
      B=FLOAT(N1(I))
      R12(I)=A/B
1016  CONTINUE
```

```
      WRITE(6,1300)  (N1(I),I=1,10)
      WRITE(6,1310)  (N12(I),I=1,10)
      WRITE(6,1320)  (R12(I),I=1,10)
      DO 1018 I=1,400
      NHIT1(I)=0
      NHIT12(I)=0
1018  CONTINUE
2000  CONTINUE
      WRITE(6,1240)
      WRITE(6,1120)  (L1N(I),I=1,400)
      WRITE(6,1250)
      WRITE(6,1120)  (L1P(I),I=1,400)
      WRITE(6,1260)
      WRITE(6,1120)  (L2N(I),I=1,400)
      WRITE(6,1270)
      WRITE(6,1120)  (L2P(I),I=1,400)
1100  FORMAT(1X,10I7)
1110  FORMAT(1X,10F7.2)
1120  FORMAT(1x,10F7.3)
1200  FORMAT(1H1,5HNHIT1)
1210  FORMAT(1H1,6HNHIT12)
1220  FORMAT(1H1,5HRATIO)
1231  FORMAT(1H0,3HPT=,F6.1,3X,5HSIGN=,F4.1,3X,5HNEVT=,I5,3X,
     1 5HNACC=,I5)
1240  FORMAT(1H1,3HL1N)
1250  FORMAT(1H1,3HL1P)
1260  FORMAT(1H1,3HL2N)
1270  FORMAT(1H1,3HL2P)
1300  FORMAT(1X,3H N1,10I7)
1310  FORMAT(1X,3HN12,10I7)
1320  FORMAT(1X,3HR12,10F7.3)
1330  FORMAT(1H0,6HSBEAM=,F5.3,2X,4HWL1=,F5.3,2X,5HDWL2=,F6.4,
     1 2X,7HEXPSIN=,F5.2,2X,7HEXPCOS=,F5.2,2X,4HFSB=,F3.1)
1340  FORMAT(1X,5HXCAL=,F6.4,3X,5HECAL=,F5.3,3X,7HBFIELD=,F4.2,
     1 2X,4HCR1=,F6.3,2X,4HCR2=,F6.3)
1350  FORMAT(1X,4HSR1=,F6.3,2X,4HSR2=,F6.3,2X,4HTR1=,F6.3,2X,
     1 4HTR2=,F6.3,2X,4HLR1=,F6.3,2X,4HLR2=,F6.3)
      END
```

R12 = detection efficiency

SAMPLE OUTPUT

```
SBEAM=0.050  WL1=0.100  DWL2=0.0000  EXPSIN= 0.00  EXPCOS= 1.35  FSB=3.0
XCAL=0.0235   ECAL=0.874   BFIELD=1.80  CR1= 4.500  CR2= 7.000
SR1= 7.000  SR2= 8.000  TR1=11.000  TR2=15.000  LR1=15.100  LR2=18.100

PT=   5.0   SIGN= 1.0   NEVT=10000   NACC=     0
 N1    839   1522   2041   2611   1148      0      0      0      0      0
N12      0      0      0      0      0      0      0      0      0      0
R12  0.000  0.000  0.000  0.000  0.000 -1.000 -1.000 -1.000 -1.000 -1.000

PT=   7.5   SIGN= 1.0   NEVT=10000   NACC=  239
 N1   1026   1666   2107   2781   1331      0      0      0      0      0
N12     46     70     66     49      8      0      0      0      0      0
R12  0.045  0.042  0.031  0.018  0.006 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  10.0   SIGN= 1.0   NEVT=10000   NACC= 3266
 N1   1137   1691   2230   2912   1365      0      0      0      0      0
N12    439    609    820    997    401      0      0      0      0      0
R12  0.386  0.360  0.368  0.342  0.294 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  12.5   SIGN= 1.0   NEVT=10000   NACC= 5858
 N1   1134   1767   2300   2813   1499      0      0      0      0      0
N12    680   1109   1447   1718    904      0      0      0      0      0
R12  0.600  0.628  0.629  0.611  0.603 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  15.0   SIGN= 1.0   NEVT=10000   NACC= 7419
 N1   1211   1700   2238   2968   1442      0      0      0      0      0
N12    949   1315   1761   2310   1084      0      0      0      0      0
R12  0.784  0.774  0.787  0.778  0.752 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  17.5   SIGN= 1.0   NEVT=10000   NACC= 8653
 N1   1233   1766   2255   3013   1443      0      0      0      0      0
N12   1095   1571   2014   2706   1267      0      0      0      0      0
R12  0.888  0.890  0.893  0.898  0.878 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  20.0   SIGN= 1.0   NEVT=10000   NACC= 9293
 N1   1202   1747   2276   3056   1435      0      0      0      0      0
N12   1129   1664   2198   2939   1363      0      0      0      0      0
R12  0.939  0.952  0.966  0.962  0.950 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  25.0   SIGN= 1.0   NEVT=10000   NACC= 9754
 N1   1319   1693   2257   3000   1495      0      0      0      0      0
N12   1315   1692   2255   2998   1494      0      0      0      0      0
R12  0.997  0.999  0.999  0.999  0.999 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  30.0   SIGN= 1.0   NEVT=10000   NACC= 9825
 N1   1240   1796   2402   2966   1421      0      0      0      0      0
N12   1240   1796   2402   2966   1421      0      0      0      0      0
R12  1.000  1.000  1.000  1.000  1.000 -1.000 -1.000 -1.000 -1.000 -1.000

PT=  40.0   SIGN= 1.0   NEVT=10000   NACC= 9870
 N1   1217   1712   2324   3113   1504      0      0      0      0      0
N12   1217   1712   2324   3113   1504      0      0      0      0      0
R12  1.000  1.000  1.000  1.000  1.000 -1.000 -1.000 -1.000 -1.000 -1.000
```

decreasing η → increasing θ

$\eta = 2.5$ $\eta = 1.56$

L1N

2.500	2.600	2.705	2.816	2.933	3.056	3.186	3.324	3.468	3.621
3.783	3.954	4.135	4.326	4.529	4.743	4.970	5.210	5.465	5.734
6.019	6.321	6.640	6.978	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
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99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
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99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999

L1P

2.600	2.705	2.816	2.933	3.056	3.186	3.324	3.468	3.621	3.783
3.954	4.135	4.326	4.529	4.743	4.970	5.210	5.465	5.734	6.019
6.321	6.640	6.978	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
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89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
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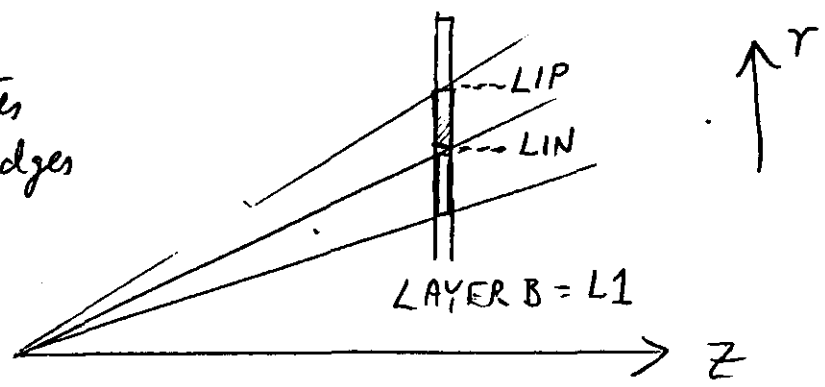
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999

r coordinates
of counter edges



L2N

2.934	3.057	3.180	3.309	3.446	3.590	3.741	3.902	4.071	4.249
4.438	4.637	4.848	5.071	5.307	5.557	5.821	6.101	6.398	6.712
7.044	7.396	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
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99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999
99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999	99.999

L2P

3.180	3.309	3.446	3.590	3.741	3.902	4.071	4.249	4.438	4.637
4.848	5.071	5.307	5.557	5.821	6.101	6.398	6.712	7.044	7.396
7.768	8.141	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999	89.999
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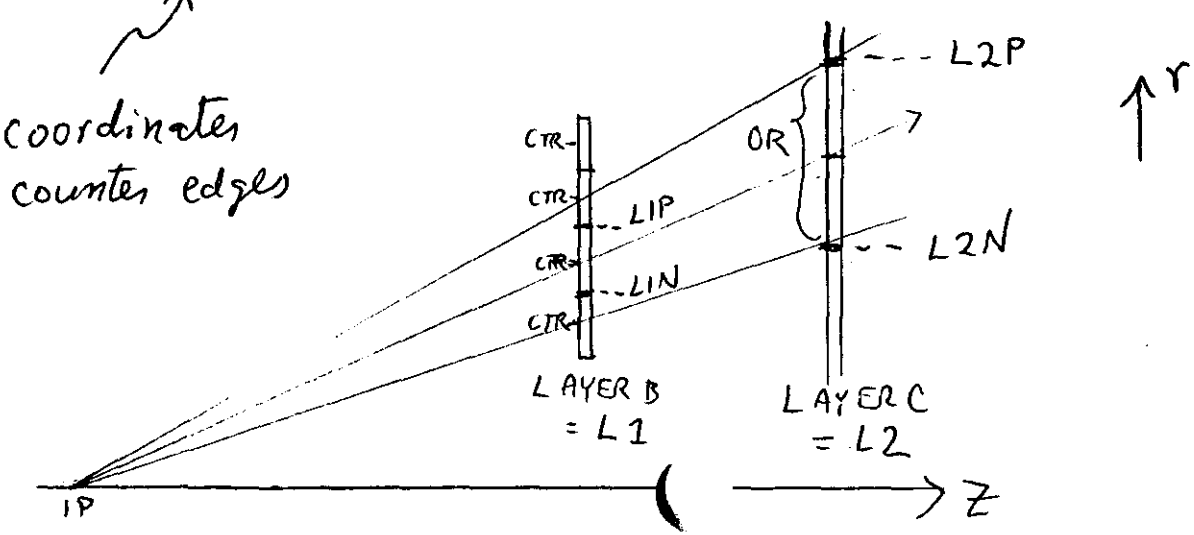
r coordinates of counter edges