MI-0082

LOCATION OF TEVATRON RF IN THE MAIN INJECTOR ERA AND CLARIFICATION OF THE TEVATRON F0 GEOMETRY

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MI NOTE: #0082

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1 Introduction

The question of the location of the Tevatron Rf cavities in the Main Injector Era has again surfaced. This is driven in part by the need to know the exact placement with respect to the new F0 enclosure, the new RF building, and existing brass plugs and markers so the that penetrations, transmission lines, cable trays, piping, etc. can be located and detailed Title II drawings may be detailed. (John Reid's request).

The location and spacing of the Tevatron RF cavities were specified in the Main Injector Conceptual Design Report (Rev. 1 March 1989 and Rev 2.3 April 1990). This is depicted in Figure 1. This had the centerline of the last cavity (A4) spaced a half-wavelength from the crossing point at F0. However, the location of the crossing point in reference to MR-F0 or TEV-F0 was not specified in this document.

There are two ancillary questions that must be answered to locate the cavities in the tunnel with respect to MR-F0 and TEV-F0 for Title II design. The first is where will the proton-pbar crossing point at F0 be located in the MI Era? And the second is, does the design of the P1 and A1 transfer lines require re-locating the cavities from there conceptual design location due to physical inteferences?

In trying to answer the first question there was a descrepancy between where John Reid and I had located the proton-pbar crossing point at F0. Consequently, we had the cavities located at different positions. I had the crossing point 6" upstream of TEV-F0 and John had the crossing point 7/8" downstream of TEV-F0. Obviously, this descrepancy had to be resolved. What follows was my attempt to find out where these numbers came from and determine what it should be for the MI Era.

2 A Little History:

To locate TEV-F0 with respect to the Tevatron lattice I utilized several lattice files containing the description of the Tevatron with markers for the straight sections. The lattice files of the Tevatron that I had been using (MAD lattice file tev_92.lat and a personal synch file) had a marker .F0 located 26.7494 m downstream of E49 99" quad and 26.4446 m upstream of the F11 99" quad. This marker, .F0, had been interpreted as TEV-F0.

The crossing point had been located symmetrically between the inner quads in the F0 location. More specifically, 26.597 m downstream of the magnetic end of the inner E49 99" quad. (The total separation between the magnetic end of the E49 and F11 99" quads is 53.194 m). The difference between the crossing point (midway between the quads) and the marker .F0 produces a crossing point which appears to be 6" upstream of the marker .F0 (i.e. 26.597 - 26.7494 = -0.1524 m).

3 A Little More History:

The synch file which "is a VAX version taken from Dave Johnson's synch file (CYBER version) for the double low beta design at B0 and D0" is shown in the Appendix. Note the values of LS1, LS2 and LSB1, LSB2. In this lattice file all straight section drifts are anti-symmentric with the upstream drift being 0.3048 m longer than the downstream drift. I have been unable to track down specific reasons for these unequal drifts. (I will not speculate here.) The end of LS1 had been taken as the center of the straight section (i.e. the Tevatron "0" marker). As will be pointed out this is NOT the Tevatron "0" marker. These unequal drift lengths (especially in the normal straight secthins) have been propagated for many years and are in many "current descriptions of the Tevatron". I questioned Norm Gelfand and his description in TEVLAT seens to be the only lattice file which currently utilized equal lengths for the up and downstream drifts in the "normal" straight sections.

According to TM-1032, "The Revised Great Doubler Shift", all Tevatron straight section markers are to be located at -10.308 inches in the Main Ring coordinate system. Additionally, the magnetic separation between the 49 and 11 99" inner quads of the normal straight section should be 2094.218". This places the "0" marker 1047.109" (25.5967 m) downstream of the downstream magnetic end of the 49 99" quad. Therefore, the straight section insertions (at least the inner quads are placed SYMMETRICALLY about the Tevatron "0" marker (in our case TEV-F0). This geometry is shown in Figure 3, which is page 7 of TM-1032. The magnetic length is 1.831" longer than the steel, so the steel-to-steel separation should be 2097.88". The steel-to-steel separation of the E49 and F11 99" inner quads was measured to be 2097.773" during a (re)survey of F0 in 3/'92. This is actually 113 mils shorter than the design reported in TM-1032.

The relative location of the origional B0 low beta insert was specified in Section 9.2.1 of the "Design Report of the Tevatron I Project". This had the insertion located symmetrically about the "long straight section B0". Furthermore, it states that the "maximum luminosity point (is) 0.9 inches downstream of Tevatron B0 for the final low beta of 1 m." This implies that the proton-pbar crossing point (longitudinally) at B0 is approx 7/8" downstream of the TEV-B0, defined to be at -10.313".

Furthermore, the location of the D0 collision hall and detector was specified in a memo by D. Finley (dated 10/19/84) to be -10.313 inches in the Main Ring coordinate system. This memo is included in the Appendix. He investigates the relative maximum luminosity points at B0 and D0 and points out that the "important point to keep in mind" is the relative locations of the RF cavities, B0 detector, and D0 detector. The implication here is that the proton-pbar crossing points at these locations should be each separated by 1/3 the circumference of the Tevatron.

The value for the crossing point at F0 of 7/8" downstream of TEV-F0 that was used by John Reid was obtained from meeting between H. Edwards and the RF group (12/6/83) specifying the locations of the Tevatron cavities for the Collider (see D. Finley memo in Appendix).

So, this 7/8" offset in the downstream direction of the crossing point at F0 and the maximum luminosity point at B0 are consistent with the separation being 1/3 the circumference.

4 CURRENT INSTALLATION:

During the shutdowns in Fall of 1990 (and early Spring 1992) the new B0 (and D0) low beta inserts were installed. These were designed as matched symmetric insertions centered about TEV-B0 and TEV-D0. Since the low beta insertions are symmetric, the maximum luminosity point isdefined to be at TEV-B0 and TEV-D0. The Tevatron RF was not moved and the crossing point at F0 remained 7/8" downstream of TEV-F0.

5 THE MAIN INJECTOR ERA:

When the location of TVE-60, and hence MI-60, was defined in MI note 00047, S. Peggs used the 26.4446 m drift as the separation between TEV-F0 and the F11 99" quad. The TEV-60 point was defined to bisect the 26.4446 m drift space, hence TEV-60 was defined to be 13.222 meters downstream of TEV-F0. This actually has little or no impact on the location of the MI or the beamline design but, we should be aware that MI-60 is not located at the bisector of the downstream half of Tevatron F0 straight section.

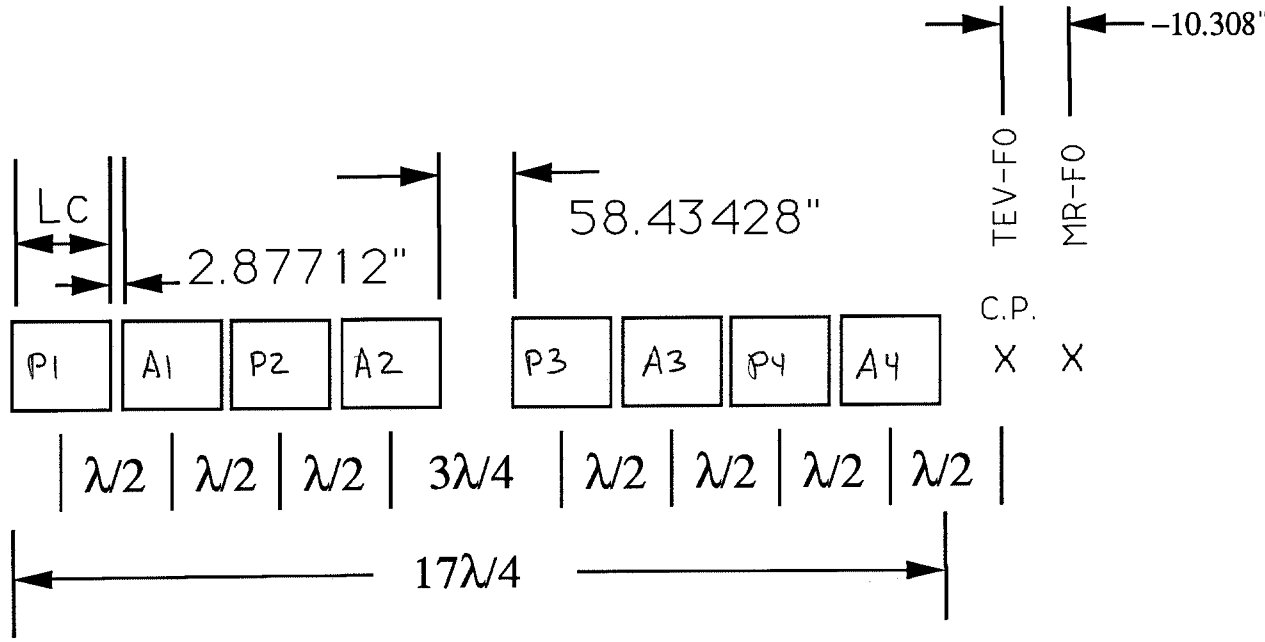
The location of the crossing points at B0, D0, and F0 should separated by exactly 1/3 the circumference of the Tevatron. This corresponds to 1113/3 = 371 wavelengths (buckets) or 2094.3951 m. Since the B0 and D0 inserts are centered on TEV-B0 and TEV-D0, the crossing point at F0 should be defined as TEV-F0.

The geometry of the Tevatron F0 region is shown in Figure 3. This shows the locations of MR-F0, TEV-F0, TEV-60, and the design location of the Tevatron RF.

The locations of the devices in the matching section of the current designs of the P1 and A1 beamlines is shown in Figure 4.

6 SUMMARY:

1. TEV-F0 is located 10.308 inches upstream of MR-F0.
2. The location of TEV-60 is 13.222 m downstream of TEV-F0.
3. The location of the proton-pbar crossing point at F0 should be defined as TEV-F0.
4. The location of the Tevatron RF cavities should be as specified in the MI Conceptual design report and as shown in Figure 1.
5. The current design of the P1 and A1 beamlines does not produce any physical inteferences with the cavities or Tevatron magnets and should not require the Tevatron RF cavities to be shifted from their design locations. The Tevatron F0 straight section with teh P1 and A1 beamlines is shown in Figure 4. (Note: the scale on this figure does not easily allow inteference checking by eye.)
6. To prevent confusion in the furture, the lattice files which describe the Tevatron straight sections should be modified to use equal upstream and downstream straight section drift lengths of 26.59657 meters such that the straight section markers acurately reflect the TEV "0" markers. If maximum luminosity points are found to not correspond to the "0" markers, additional markers "MAX_LUM" should be inserted in the lattice files.



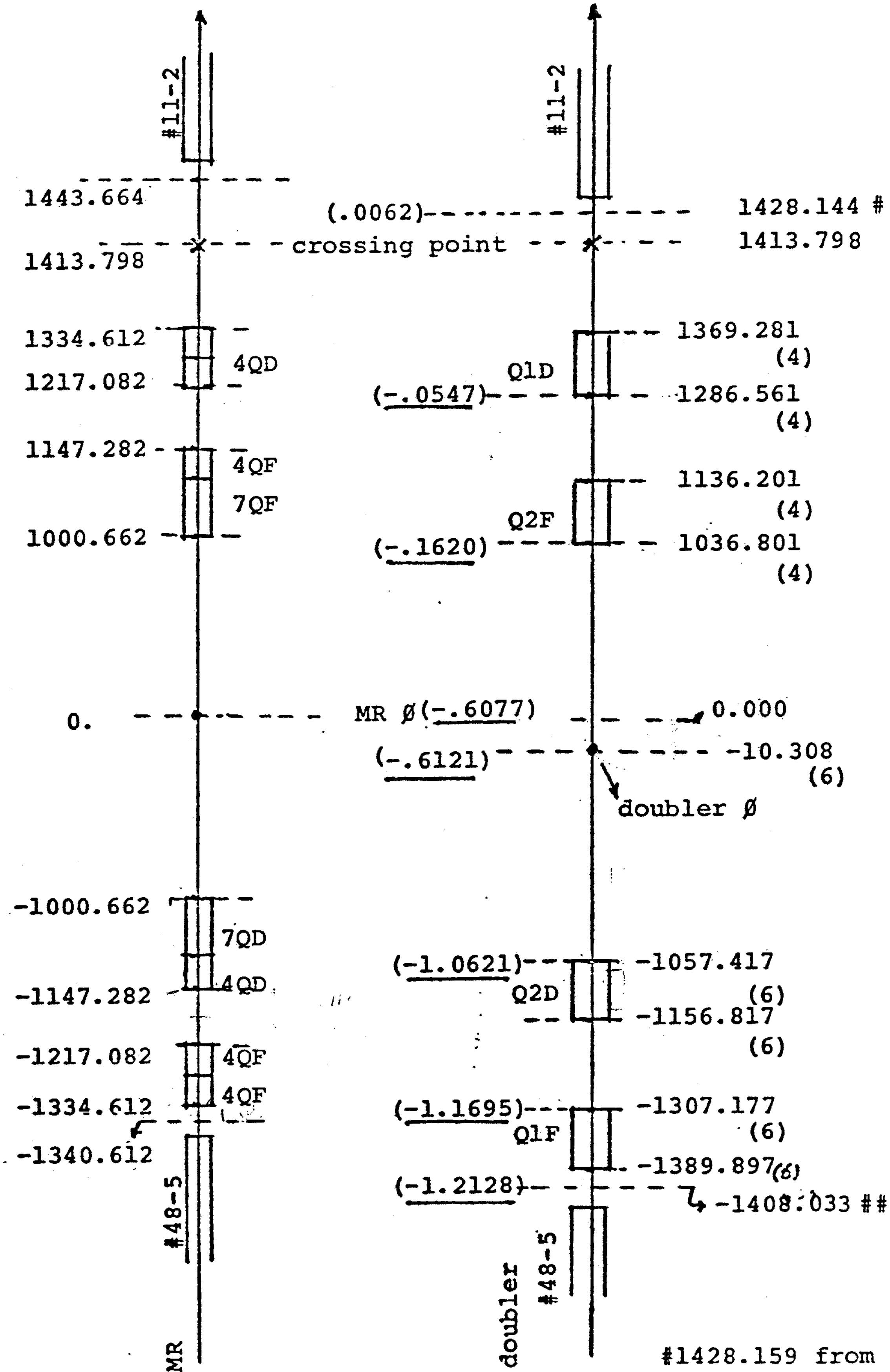
λ = c / RF freq = 2.99792458 E8 /53.1050716 E6
= 5.64526982 m = 222.245717inches.

$\lambda/2$ = 111.127359 inches

L c = 108.25 inches (physical length of cavity)

Figure 1: Tevatron RF spacing

normal long straight (BØ, CØ, EØ, FØ)



#1428.159 from SYNCH.
##1408.051 "

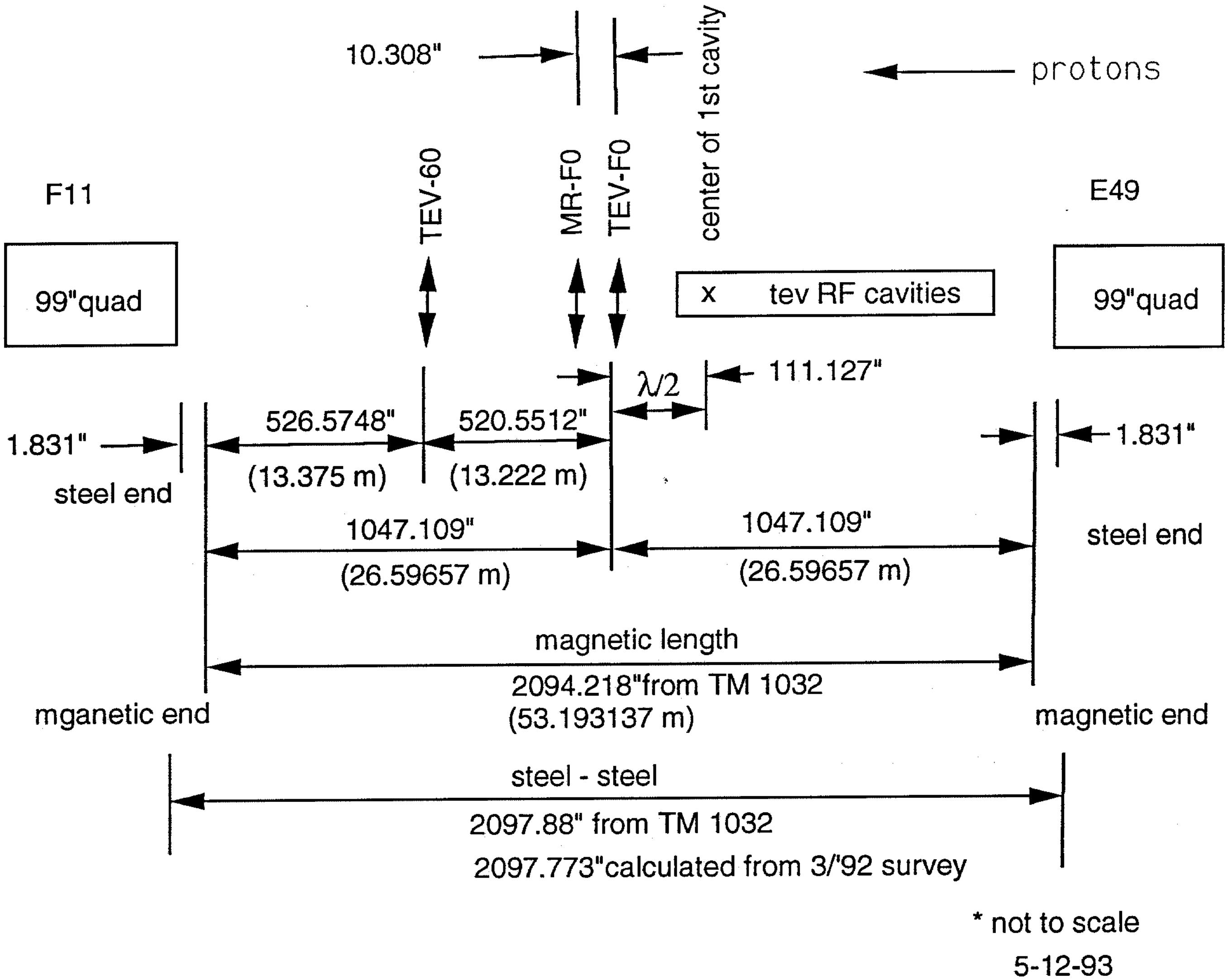
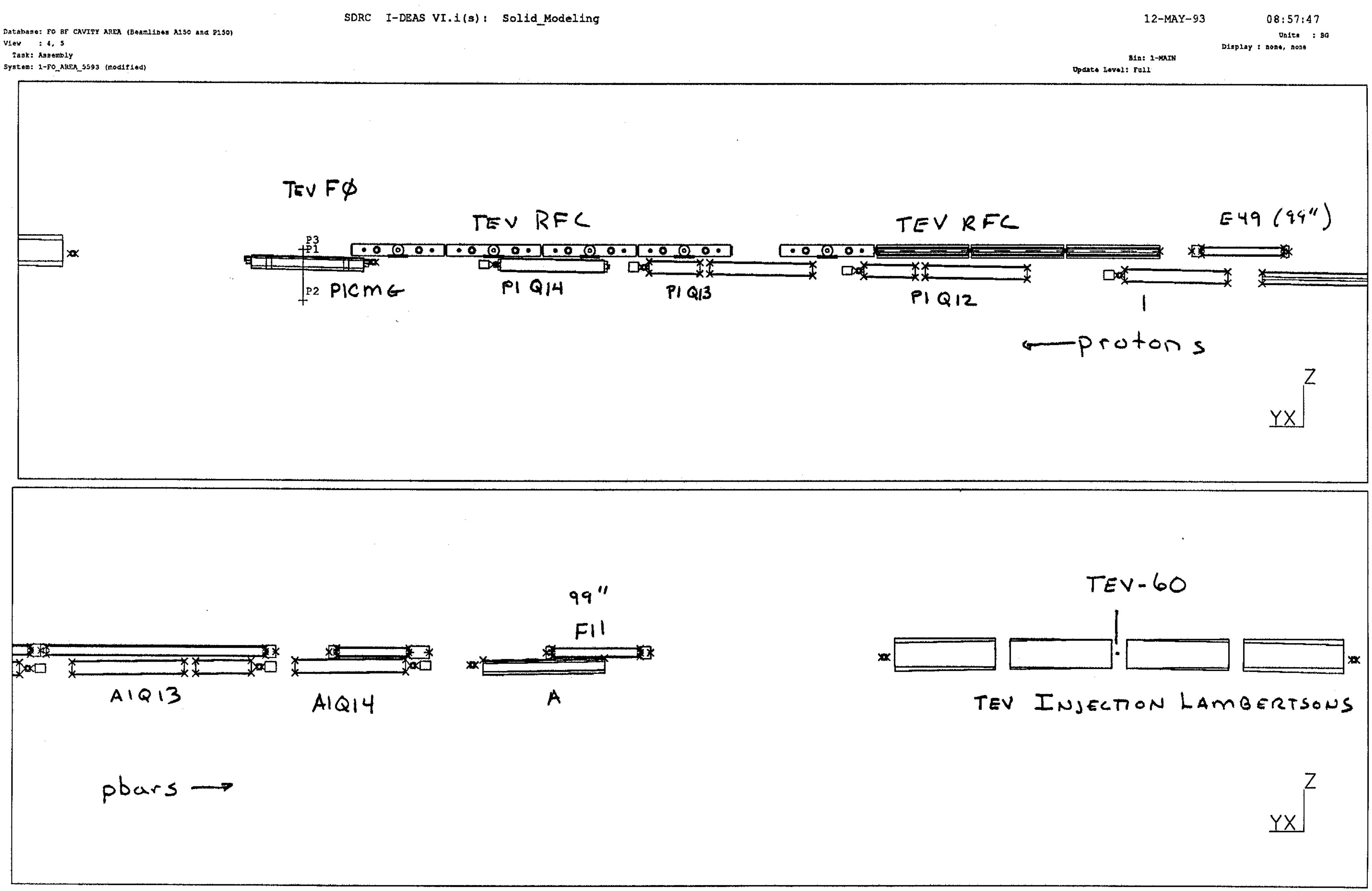


Figure 3: Geometry of the Tevatron F0 region



SDRC I-DEAS VI.i(s): Solid_Modeling
12-MAY-93
08:57:47
Database: FO RF CAVITY AREA (Beamlines A150 and P150)
View : 4, 5
Task: Assembly
System: 1-FO_AREA_5593 (modified)
Units : SG
Display : none, none
Bin: 1-MAIN
Update Level: Full
TEV FØ
TEV RFC
TEV RFC
E49 (99")
P3
P1
P2
P1CMG
P1 Q14
P1 Q13
P1 Q12
protons
Z
YX
99"
F11
TEV-60
A1Q13
A1Q14
A
TEV INJECTION LAMBERTSONS
pbars
Z
YX

FIGURE 4

```
SYNCH RUN       TEST OF SYNCH ON THE AD VAX
                TURN ON B0 AND D0 LOW B
                USED VALUES TAKEN FROM
                DAVE JOHNSON CYBER SYNCH

                7 OCT 1984 D. JOHNSON II

        MAGNET FIELDS

BRHO  =         33387.7020
BZ    =         44.276640
GF    =         760.32060
GD    =         -760.32060
GFC   =         -90.00
GDC   =         92.25

        MAGNET LENGTHS

BL    =         6.12140
QL    =         1.67894
QLC   =         .76200
QSL0  =         .81460
QSL1  =         2.10110
QSL2  =         2.52480
QHL0  =         .64770
QHL1  =         2.29080

        DRIFTS

O     DRF       .2794
OC    DRF       .2540
CO    DRF       2.14028
OOC   DRF       1.12428
OOO   DRF       .60038
OS1   DRF       .32098
OS3   DRF       .58496
OS4   DRF       1.55537
OSH3  DRF       .75184
OSH4  DRF       1.38844
D1    DRF       8.0355
D2    DRF       3.8191
D3    DRF       1.6348
DH1   DRF       7.98
DH2   DRF       3.8519
DH3   DRF       1.5792
LS1   DRF       26.7494
LS2   DRF       26.4446
MS1   DRF       13.50678
MS2   DRF       1.01948

        MAGNETS

B     MAG       BL      0.      BRHO    BZ      $
QF    MAG       QL      GF      BRHO
QD    MAG       QL      GD      BRHO
QFC   MAG       QLC     GFC     BRHO
QDC   MAG       QLC     GDC     BRHO

        QUADS WITH CORRECTION QUAD

QFN   BML       QF   OC   QFC
QDN   BML       QD   OC   QDC

        NORMAL LONG STRAIGHT QUADS
```

```
QS0   MAG       QSL0    GF      BRHO
-QS0  MAG       QSL0    GD      BRHO
QS1   MAG       QSL1    GF      BRHO
-QS1  MAG       QSL1    GD      BRHO
QS2   MAG       QSL2    GD      BRHO
-QS2  MAG       QSL2    GF      BRHO
C
C       HIGH BETA QUADS
C
QH0   MAG       QHL0    GF      BRHO
-QH0  MAG       QHL0    GD      BRHO
QH1   MAG       QHL1    GD      BRHO
-QH1  MAG       QHL1    GF      BRHO
QH2   MAG       QSL2    GF      BRHO
-QH2  MAG       QSL2    GD      BRHO
C
C       DIPOLE STRINGS
C
.HCN  BML       OOC  B  O  B  O  B  O  B  OOO
.HC2  BML       OOC  B  O  B  O  B  O  B  OS1
.HC3  BML       OS4  B  O  B  O  B  O  B  OOO
.HC4  BML       OSH4 B  O  B  O  B  O  B  OOO
HCN   MMM       .HCN
HCNS  MMM       .HC2
HCSS  MMM       .HC3
HCHS  MMM       .HC4
C
C       NORMAL LATTICE FROM 13-1 TO 46-5
C
.NC   BML        2( HCN  QDN  HCN  QFN   )
                MS1  B    O    B    MS2
                 12( QDN  HCN  QFN  HCN   )
C
C       NORMAL LONG STRAIGHT FROM 48 TO 12-5
C
.LSS  BML       O    QS0  D1   B    O    B    O    B    OOO
                QS1  D2   QS2  LS1  LS2  -QS2 D2   -QS1 D3
                B    O    B    O    B    O    B    OS1  O
                -QS0 OS3  HCSS
C
C       HIGH BETA LONG STRAIGHT FROM 48 TO 12-5
C
.LSH  BML       O    QH0  DH1  B    O    B    O    B    OOO
                QH1  DH2  QH2  LS1  LS2  -QH2 DH2  -QH1 DH3
                B    O    B    O    B    O    B    OS1  O
                -QH0 OSH3 HCHS
C
C       LOW-BETA AT B0
C
QIL2  =         4.57200
QIL3  =         3.65760
QIL4  =         3.65760
GB1   =         -861.1690
GB2   =         1002.332
GB3   =         -983.7353
GB4   =         1080.8935
DB1   DRF       7.45060
OB1   DRF       1.29540
OB2   DRF       0.87630
OB3   DRF       0.38100
LSB1  DRF       7.17560
LSB2  DRF       6.87050
L.1M  DRF       0.10000
QB1   MAG       QL      GB1     BRHO
QB2   MAG       QIL2    GB2     BRHO
```



```
QB3   MAG       QIL3    GB3     BRHO
QB4   MAG       QIL4    GB4     BRHO
-QB4  MAG       QIL4    -GB4    BRHO
-QB3  MAG       QIL3    -GB3    BRHO
-QB2  MAG       QIL2    -GB2    BRHO
-QB1  MAG       QL      -GB1    BRHO
LL    BML       L.1M L.1M L.1M L.1M L.1M L.1M
.LSB  BML       QB1  DB1       B    O    B    O    B
                QS1  D2   QS2  OB1
                QB2  OB2  QB3  OB3  QB3  OB2  QB4  LSB
                LL   LSB2 -QB4 OB2  -QB3 OB3  -QB3 OB2
                OB1  -QS2 D2   -QS1
                D3   B    O    B    O    B    O    B
                -QB1 OS4  B    O    B    O    B    O
                OOO
C
C       LOW BETA AT D0
C
C
GD1   =         -877.6291
GD2   =         736.03190
GD3   =         -866.3107
GD4   =         436.24370
DD1   DRF       7.22820
OD1   DRF       1.29540
OD2   DRF       0.87630
OD3   DRF       0.38100
LSD1  DRF       7.77560
LSD2  DRF       7.47080
QD1   MAG       QL      GD1     BRHO
QD2   MAG       QIL2    GD2     BRHO
QD3   MAG       QIL3    GD3     BRHO
QD4   MAG       QIL4    GD4     BRHO
-QD4  MAG       QIL4    -GD4    BRHO
-QD3  MAG       QIL3    -GD3    BRHO
-QD2  MAG       QIL2    -GD2    BRHO
-QD1  MAG       QL      -GD1    BRHO
.LSD  BML       QD1  DD1       B    O    B    O    B
                QH1  DH2  QH2  OD1
                QD2  OD2  QD3  OD3  QD3  OD2  QD4  LSD
                     LSD2 -QD4 OD2  -QD3 OD3  -QD3 OD2
                OD1  -QH2 DH2  -QH1
                DH3  B    O    B    O    B    O    B
                -QD1 OSH4 B    O    B    O    B    O
                OOO
C
C       THE SIX SECTORS
C
RING  BML       .NC  QDN  HCNS .LSH QFN
                .NC  QDN  HCNS .LSB QFN
                .NC  QDN  HCNS .LSS QFN
                .NC  QDN  HCNS .LSD QFN
                .NC  QDN  HCNS .LSS QFN
                .NC  QDN  HCNS .LSS QFN
C
C       DO IT
C
      CYC       RING
      FIN
      STOP
```

Finley

October 19, 1984

To: P. Koehler

From: D. Finley

Subject: Longitudinal Placements at DO

The DO experimental hall is to be centered at:

Z = -10.313 inches in the Main Ring coordinate system.

The DO detector is to be centered in the experimental hall.

This is based on several sources of information. All numbers are in inches in the Main Ring coordinate system unless noted otherwise.

1. TM-1032 "The Revised Great Doubler Shift" by T. Collins and S. Ohnuma. This TM has all Tevatron zeroes located at -10.308 inches, and is THE REFERENCE for the Tevatron.

2. 12/6/83 H. Edwards meeting with RF people. These notes give the locations of the RF cavities at FO and thus determine the p-pbar crossing point. These notes have TeV FO at -10.3 inches and the p-pbar crossing point at -9.425 inches. Thus, the p-pbar crossing point is 0.875 inch downstream of TeV FO.

3. K. Koepke print 2214-MD-187011 (3-28-83). This is what BO is based on. It has TeV BO located at -10.313 inches. The design intention is to center the collision hall, the detector, and the lattice at TeV BO.

4. September 1984 "Design Report Tevatron I Project". This report is based on a SYNCH run with low beta at BO only. This SYNCH knows nothing about RF. Section 9.2.1 says the arrangement of low beta quads has the result that the "maximum luminosity point is 0.9 inch downstream of Tevatron BO". Thus, the RF and the low beta quads agree that the best place is 0.875 to 0.9 inches downstream of TeV zero, when only BO low beta is on.

5. D. Johnson ran a SYNCH (under duress) which is dated 11 Oct 83 and has low beta at both BO and DO. Figure 1 is based on that SYNCH run. The X axis is in meters from the end of the G4 low beta quad on the 49 side. The minima indicated for BO and DO reflect the best location based on optics only. Converting to Main Ring coordinates and centering the lattice at Z= -10.313 inches, one obtains:

TeV 0	-10.313 inches
Best DO optics	-9.447 inches
Best BO optics	-8.266 inches

Thus, with both low betas on, the calculation indicates that the best place at DO is 0.856 inch downstream of TeV DO, and the best place at BO is 2.047 inches downstream of TeV BO.

A cursory glance at the figure should demonstrate that an inch means less than 0.1 percent change in maximum luminosity. If the lattice design changes for a very good reason, some things may change. However, I have no reason to suspect that items addressed in this note will significantly change.

A simple hand calculation to check the SYNCH run gives a parabolic dependence:

1 inch is 0.064 %

2 inches is 0.257 %

4 inches is 1.022 %

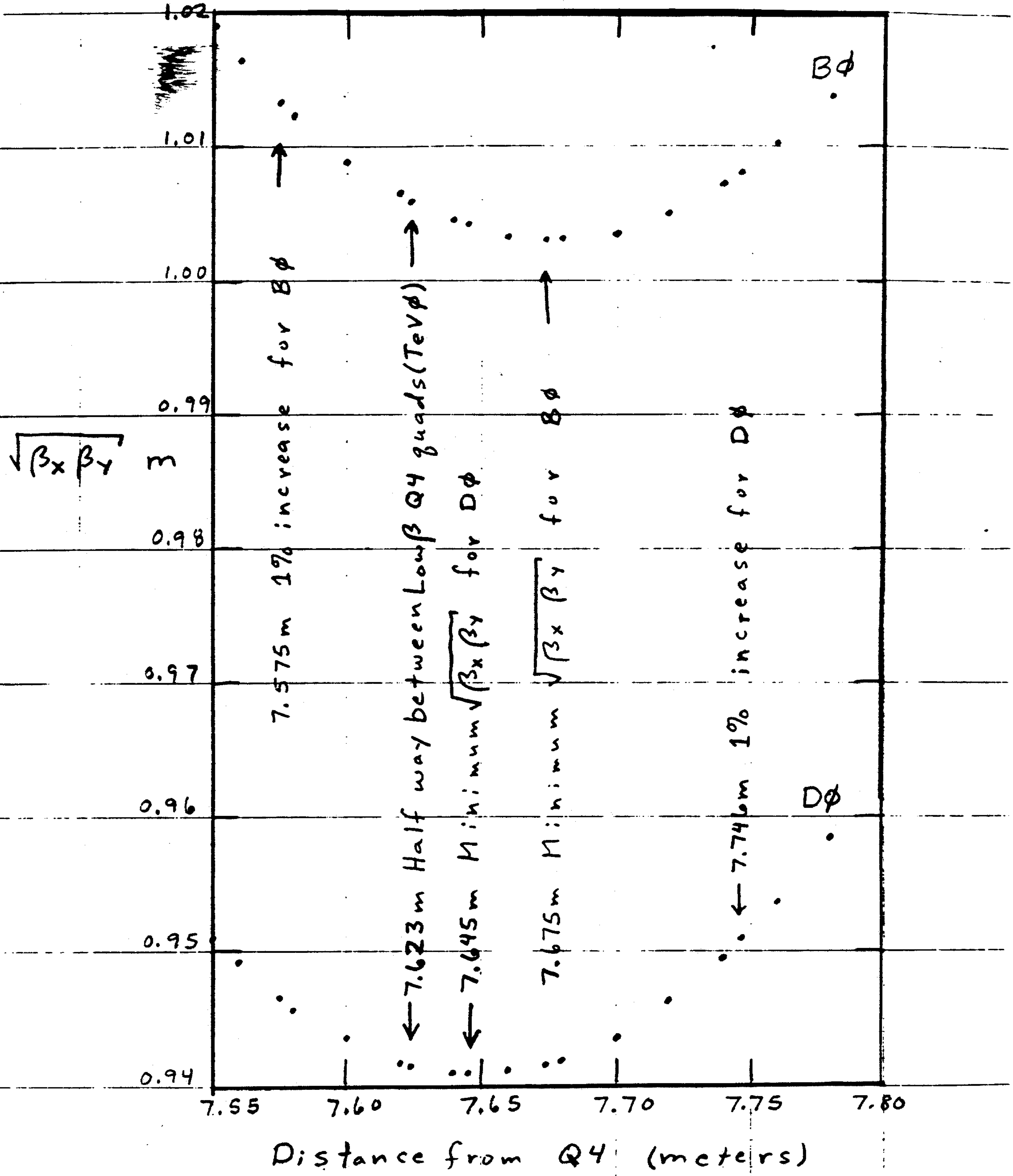
The figure shows 1 % points at about 0.1 meter, which agrees with the hand calculation.

Thus (on paper, at least), the effect of the lattice differences on the maximum luminosity points should be less than important. The important point to keep in mind is the locations of CDF relative to the DO detector. The figure shows that the ideal locations differ by a little more than an inch when both low betas are on. The actual locations of the RF cavities, CDF, BO lattice, DO detector and DO lattice will differ from their ideal values ... hopefully it will be no worse than the order of an inch. Adjustments to the RF should be able to compromise between BO and DO to give a best overall luminosity for both detectors -- if luminosity can be reliably measured that accurately.

Distribution

D. Edwards
H. Edwards
D. Johnson - Operations
D. Johnson - Tev I
S. Pruss

Bφ and Dφ $\sqrt{\beta_x \beta_y}$



From D.E. Johnson SYNCH 11 OCT 83.