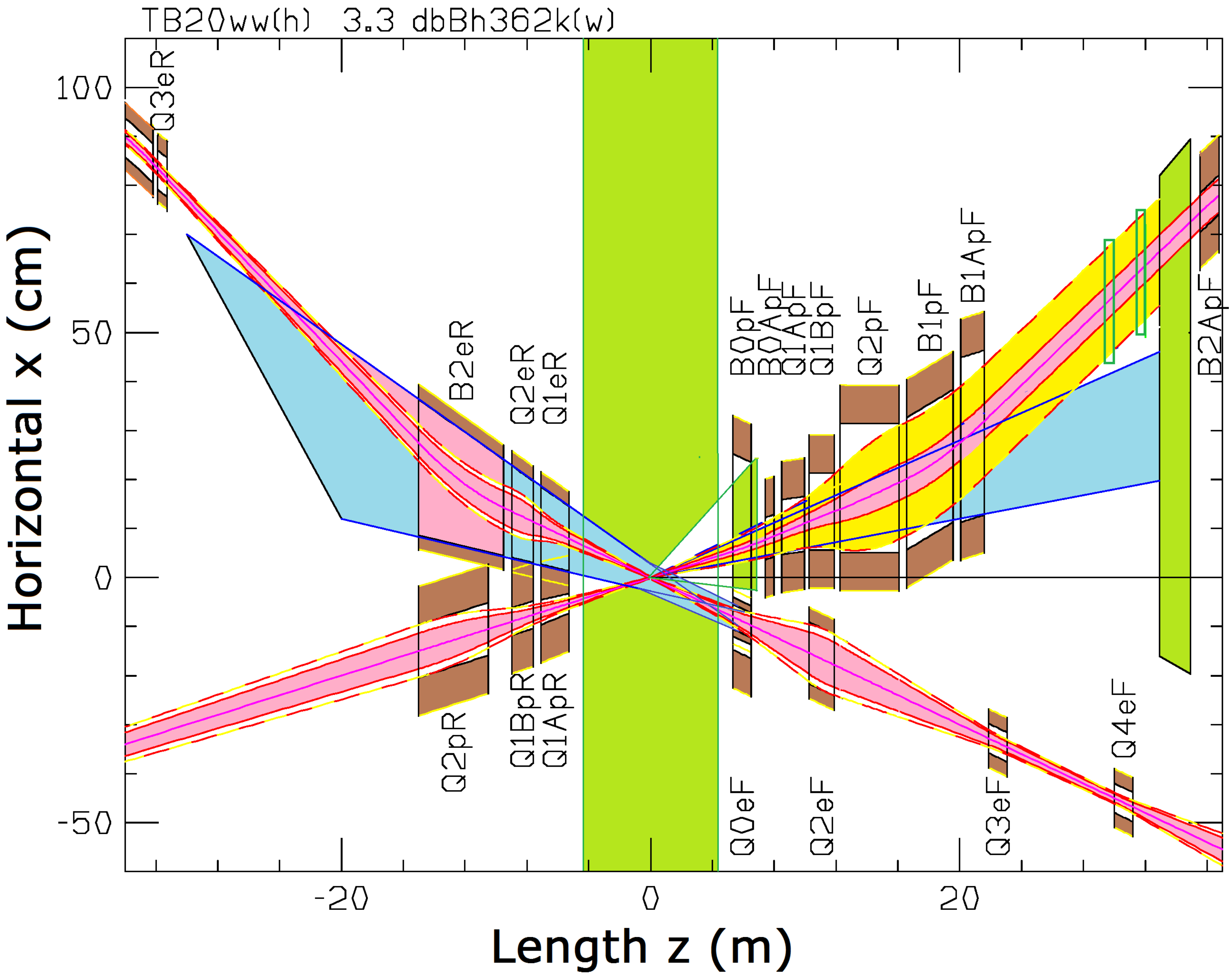
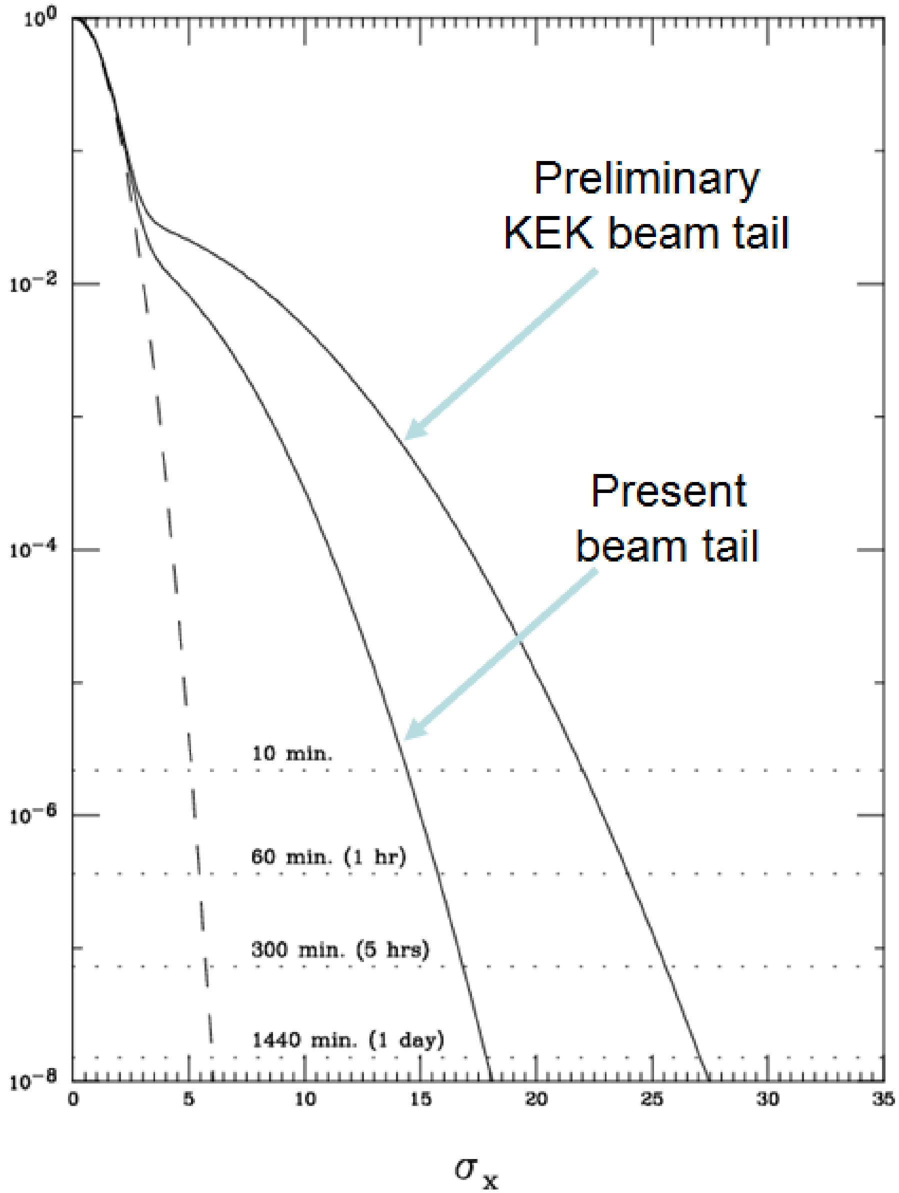
190617-Magnet parameters 6.4

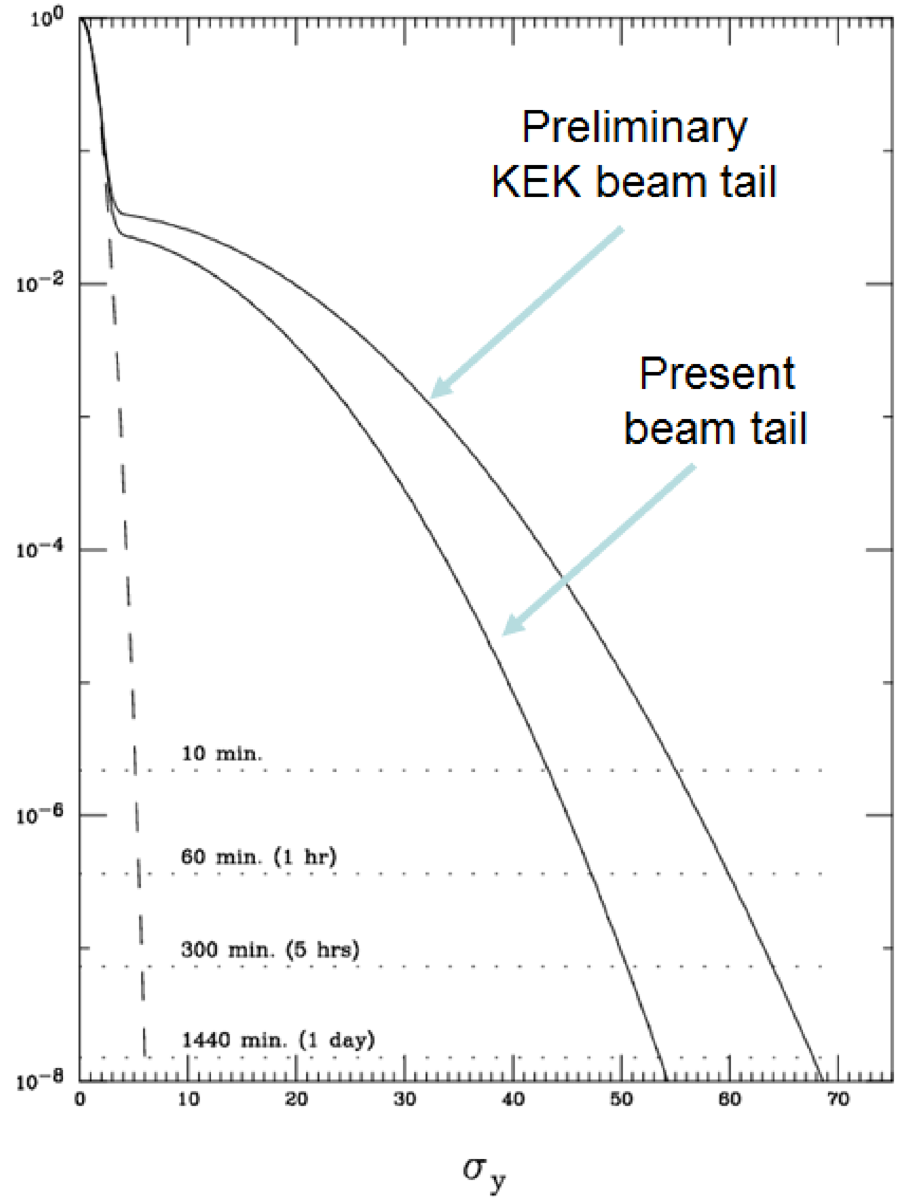
Bob Palmer 6/17/19
Corrected slides shown 6//14/19

1. Discussion of tails and required electron apertures
2. Modified vacuum system dimensions
3. Summary of IR magnet parameters


TB20ww(h) 3.3 dbBh362k(w)
Horizontal x (cm)
Length z (m)
100
50
0
-50
-20
0
20
Q3eR
B2eR
Q2eR
Q1eR
Q2pR
Q1BpR
Q1ApR
B0pF
B0ApF
Q1ApF
Q1BpF
Q2pF
B1pF
B1ApF
B2ApF
Q0eF
Q2eF
Q3eF
Q4eF

Observed tails at KEK



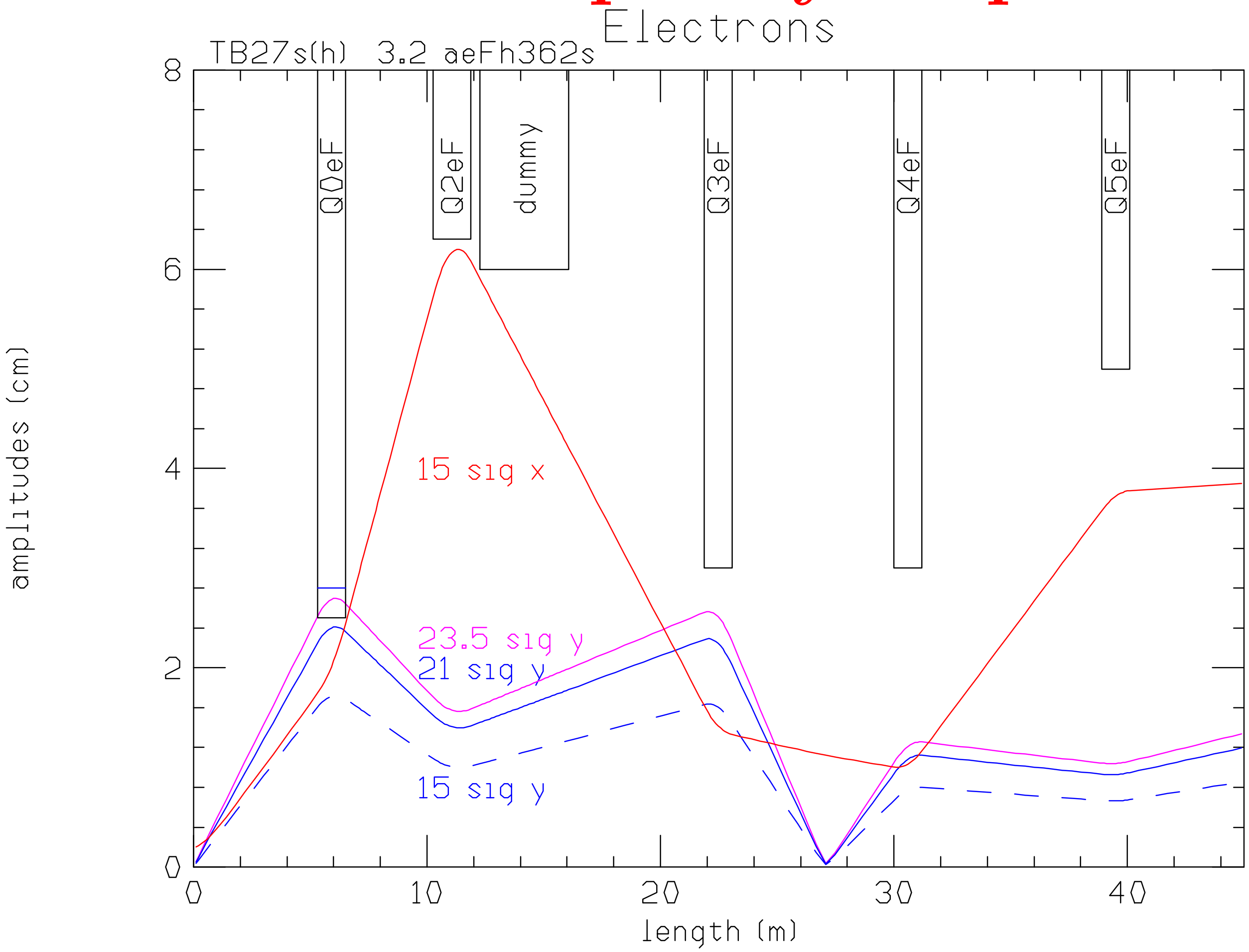


Note difference of horizontal scalebox y is 3 times as wide as x

KEK, like us, are using flat beams with smaller y (vertical) than x (horizontal) emittances. They find, in a simulation, that, as a result, the beam tails are almost 3 times greater in y then x. This believed to be primarily due to beam-bam effects, but even gas scattering giving transvers kicks independent of x or y will, in terms of multiples of the asymmetric beam emittances, will give the same result. Our emittances are not as asymmetric as KEK's, but it is still likely that our y tails are likely to be greater than those in x.

These y tails, as the beam passes through quadrupoles near the IR, will generate synchrotron radiation fans with divergencies almost entirely given by the electron divergences of electrons in those magnets.

Maximum accepted y amplitudes, worst case



21 sigmas in y is transmitted with current 25 mm Q0eF

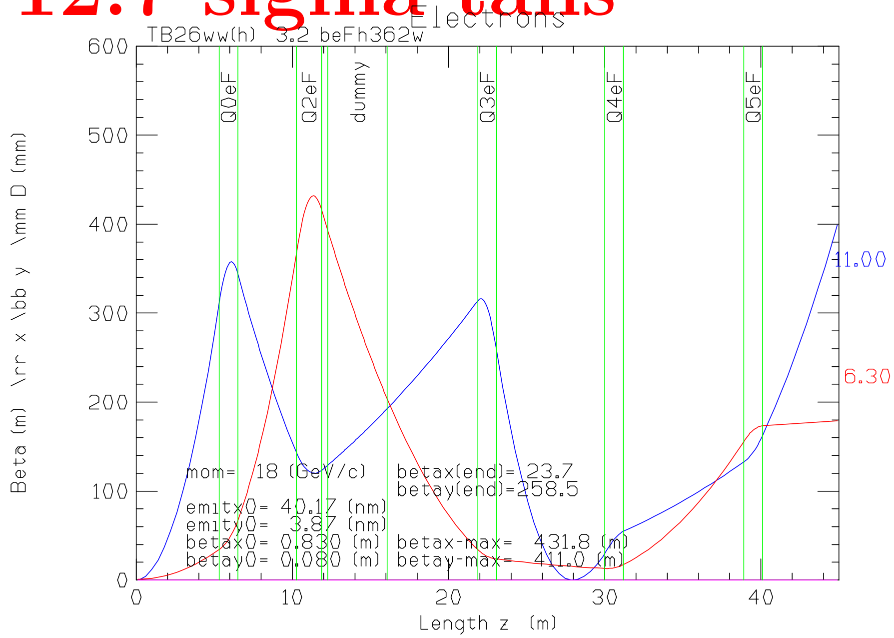
23.5 sigmas if 28 mm Q0eF

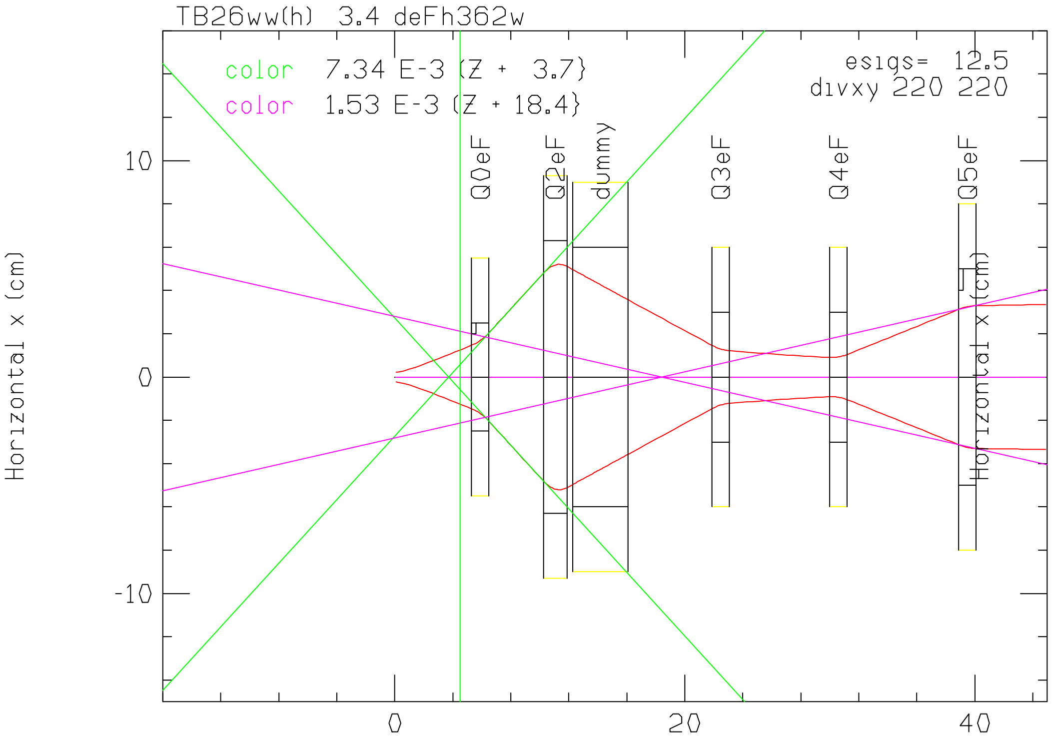
After 15% collimation (85% transmitted), SR from 12.8 sig in x and 21 sig in y should not hit pipe or later magnets

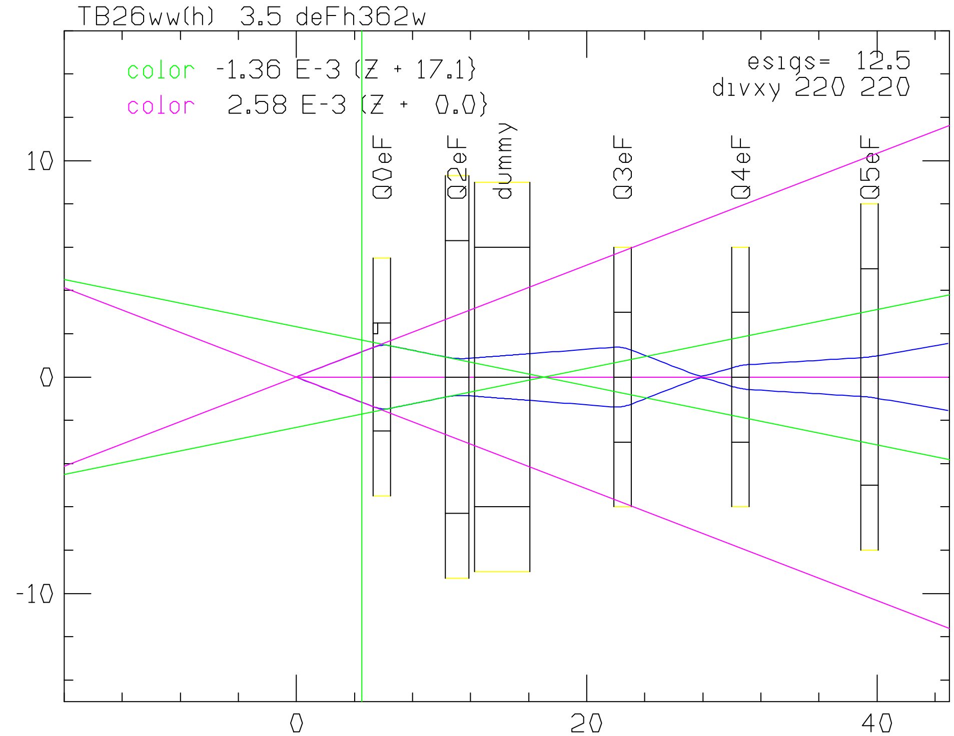
Synchrotron Fans from 12.7 sigma tails

From electron Forward design

This has not yet been matched into the ring







SR fan discussion

In x there are two serious quadrupole fans: x_1 (from Q0eF and Q2eF) dominating at longer distances from the IP (negative z); x_2 (from Q5eF) dominating at shorter ones; with the cross-over approximately at the IP.

The magnet apertures of the first 3 electron magnets in the rear have been designed to transmit the fans for x = 12.7 sigma electrons:

$$x_1 = 7.5\ 10^{-3}\ (-Z + 3.7) \qquad \mathrm{(m)}$$

$$x_2 \approx 1.53\ 10^{-3}\ (-Z + 18.4) \qquad \mathrm{(m)}$$

In y there are also two serious fans, but smaller than those in x: y_1 (from Q0eF) dominating at longer distances from the IP, and y_2 (from and Q2eF at shorter ones, with the cross-over approximately at the IP:

$$y_1 \approx 2.58\ 10^{-3}\ (-Z) \qquad \mathrm{(m)}$$

negligable near the IP; and

$$y_2 = 1.36\ 10^{-3}\ (-Z + 17.1) \qquad \mathrm{(m)}$$

At the IP y_2 is 2.22 cm, which is less the 2.8 cm in x, and much less than Mike Sullivan's recommended 4.0 cm, that would be reached only at $12.7 \times 4/2.22 = 22.8$ sigma for the worst cases.

These fans correspond to beams collimated to 12.7 sigma. At the IP it is ≈ 2.2

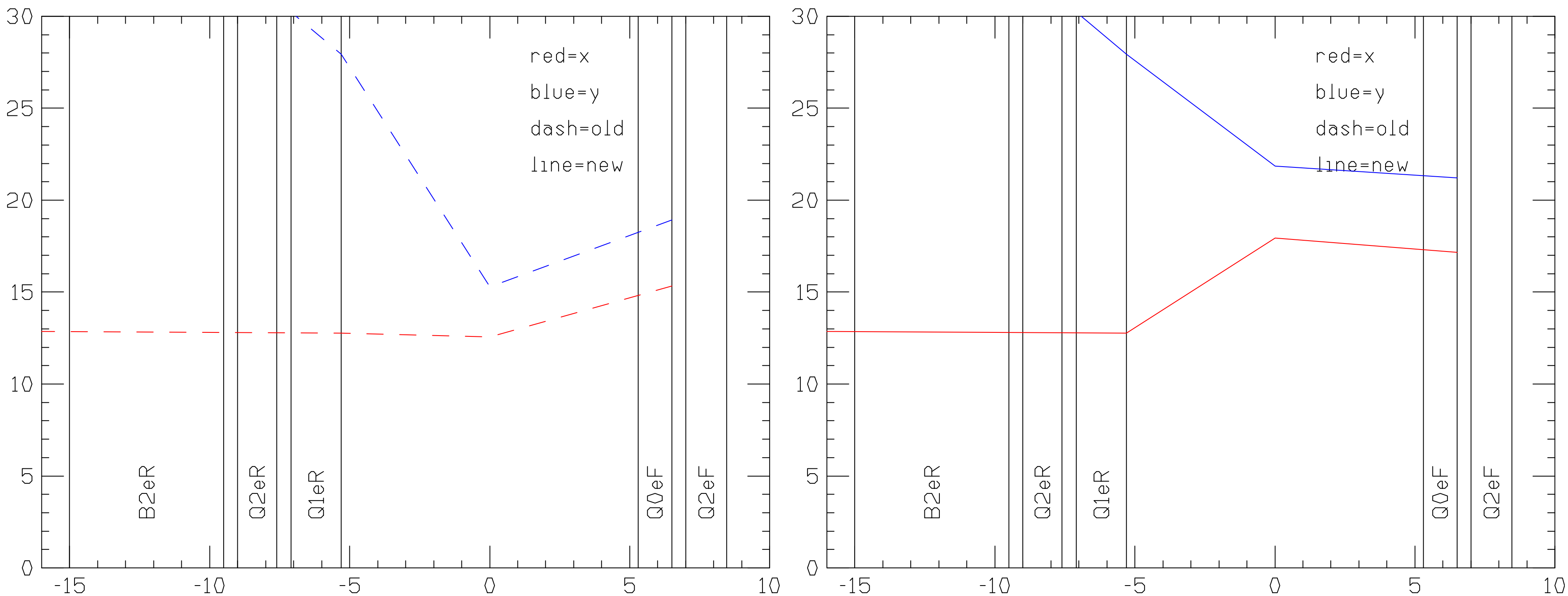
The maxima of x1 and x2 (X) and of y1 and y2 (Y) are given at a number of Z are given below and in the following figure. The pipe radius at the IP is set at 4 cm as recommended by Mike Sullivan, and the number of sigmas transmitted at each location are also given.

The apertures in y are always above 20 sigma.

Sigmas of electrons whose SR fans would pass

- After increasing pipe at IP from 3 to 4 cm round
- meets 12.8 sigma x criterion and 21 sigma y criterion

Z m	R cm	$X_{12.7}$ cm	$Y_{12.7}$ cm	σ_x	σ_y
6.5	2.8	2.07	1.68	17.2	21.2
0	4	2.8	2.3	17.9	21.8
-5.3	6.7	6.66	3.05	12.8	27.9
-16	14.7	14.58	4.50	12.8	41.6



Strong Cooling cases

The above estimates are based on beams whose electron divergencies were 220 μrad from the IP, the largest divergencies allowed for any operating case, defied as a "worst" case. Individual cases often have lower diverencies, making the number of accepted sigmas in their tails.

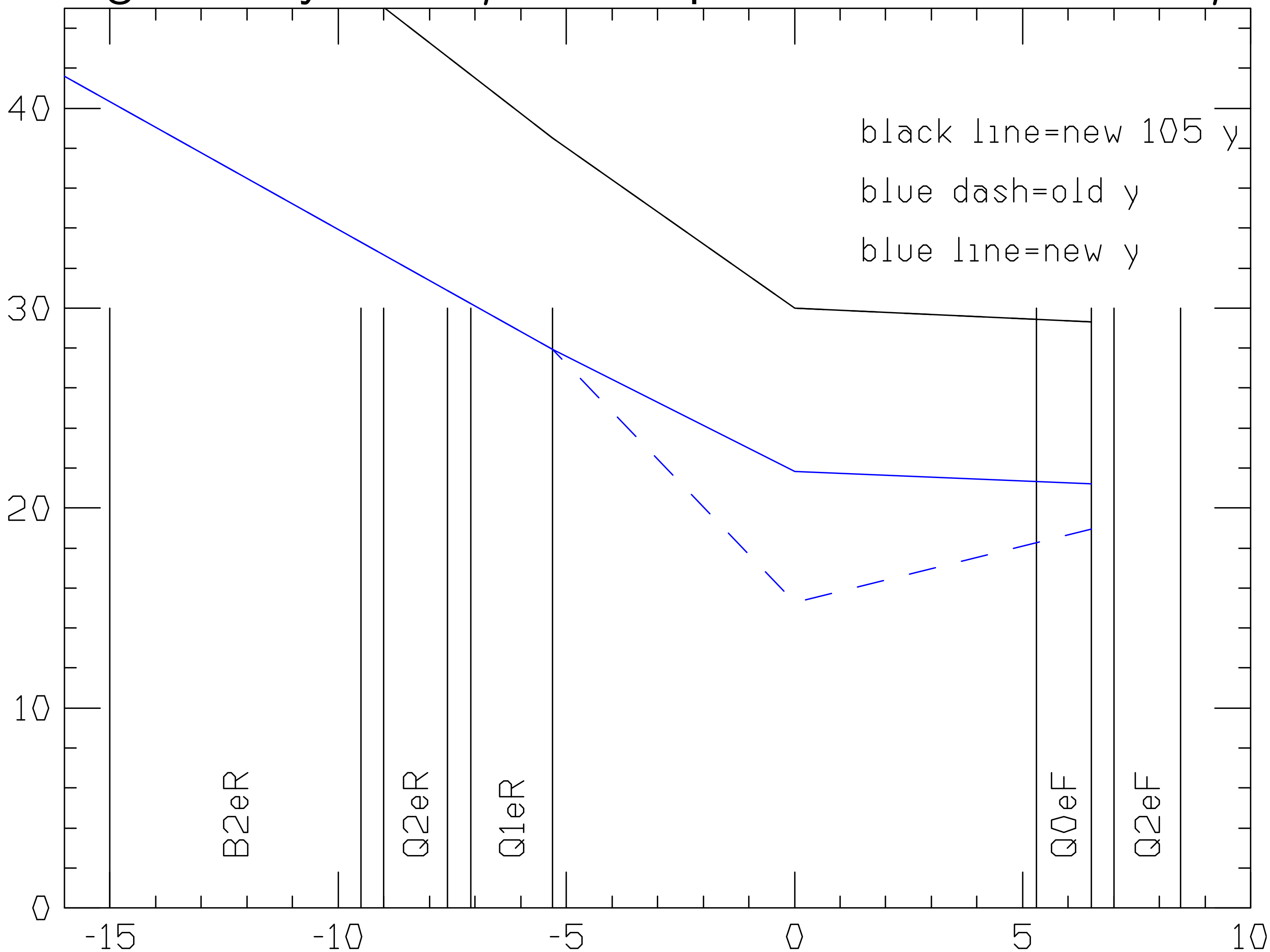
For instance, in the important 105 GeV highest luminosity case with cooling the rms electron divergencies are 220 μrad in x but only 159 μrad in y.

For this case the number of sigmas for which the fan in y are transmitted is $220/159 \times 21 = 30.6$ sigmas.

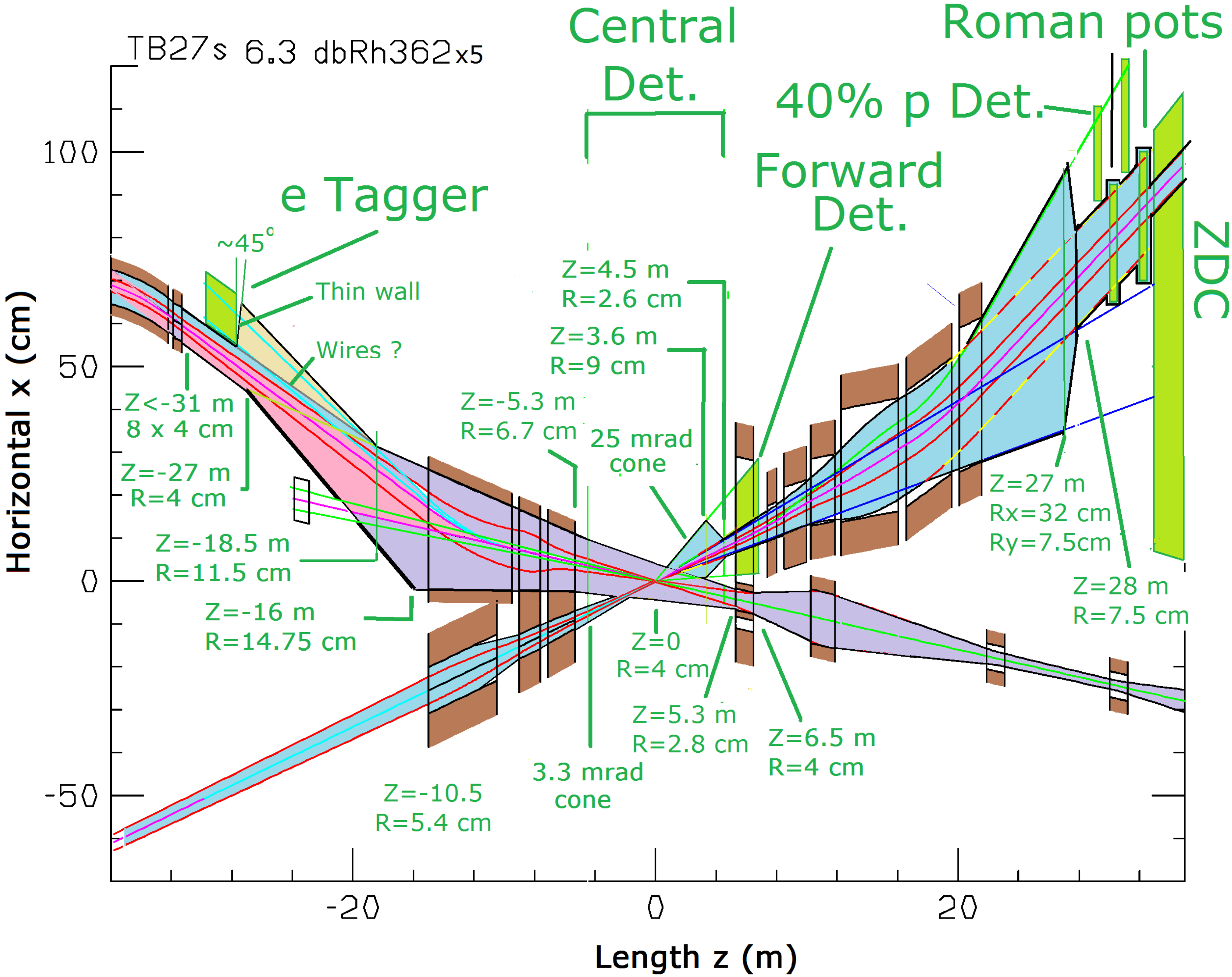
A study is underway to see how seriously performances in other cases would be restricted to such a divergence.

For 105 GeV with cooling

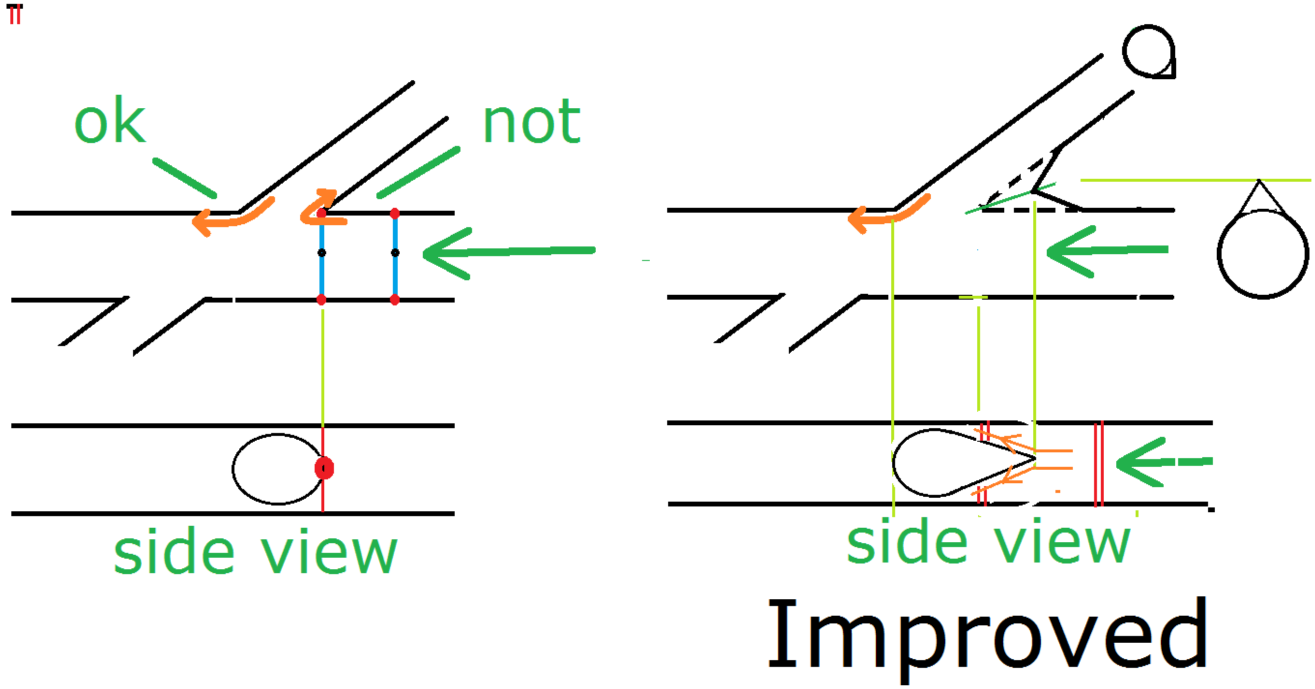
divergence in y is 159 μrad compared with worst of 220 μ rad



Modified vaccum system



Sharp edge crossing problem & droplet solution



Sharp edge in elliptical hole is bad because the induced wall charge from a short (high frequency) relativistic bunch does not know in time to go around the hole. The resulting pile up or sudden change in direction of the charge radiates rf. The resulting energy loss corresponds to an increase of the impedance.

Simulations needed to confirm this hypothesis.

Parameters

These are the most up to date parameters I know of. The forward hadrons are those once named "w" in which all acceptances were increased by 2 mm to ensure that all design criteria were met.

```
pF from 190510

# TB20ww(h)  zpFh361w Hadron forward  275 GeV/c
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad    x1       x2       cc1      cc2
#            [m]      [m]     {m}   [m]     [m]   [mrad]    [T]     [T/m]     [T]     [m]      [m]      [m]      [m]
  B0pF    5.900  -0.0150  0.200  0.200   1.20  -25.0  -1.30     0.000     0.000  0.0000  -0.0300   0.1325   0.1325
  B0ApF    7.700   0.0055  0.043  0.043   0.60    0.0  -3.30     0.000     0.000  0.0055   0.0055   0.1905   0.2055
  Q1ApF    9.230   0.0140  0.056  0.056   1.46   -5.5   0.00   -72.608    -4.066  0.0180   0.0100   0.2305   0.2590
  Q1BpF   11.065   0.0238  0.078  0.078   1.61  -10.0   0.00   -66.180    -5.162  0.0319   0.0158   0.2884   0.3126
  Q2pF   14.170   0.0407  0.131  0.131   3.80  -10.2   0.00   40.737     5.357  0.0601   0.0213   0.3668   0.4231
  B1pF   18.070   0.0390  0.135  0.135   3.00    9.0  -3.40     0.000     0.000  0.0255   0.0525   0.4397   0.5418
  B1ApF   20.820   0.0800  0.168  0.168   1.50    0.0  -2.70     0.000     0.000  0.0800   0.0800   0.5817   0.6192
====================================================================

# -------------------------------------
# TB20ww(h)  zpFh362b Hadron forward  100 GeV/c
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad    x1       x2       cc1      cc2
#            [m]      [m]     {m}   [m]     [m]   [mrad]    [T]     [T/m]     [T]     [m]      [m]      [m]      [m]
  B0pF    5.900  -0.0150  0.200  0.200   1.20  -25.0  -1.300     0.000     0.000  0.0000  -0.0300   0.1325   0.1325
  B0ApF    7.700   0.0055  0.043  0.043   0.60    0.0   1.014     0.000     0.000  0.0055   0.0055   0.1905   0.2055
  Q1ApF    9.230   0.0140  0.056  0.056   1.46   -5.5   0.000   -26.403    -1.479  0.0180   0.0100   0.2305   0.2590
  Q1BpF   11.065   0.0238  0.078  0.078   1.61  -10.0   0.000   -24.065    -1.877  0.0319   0.0158   0.2884   0.3126
  Q2pF   14.170   0.0407  0.131  0.131   3.80  -10.2   0.000   14.813     1.948  0.0601   0.0213   0.3668   0.4231
 B1pF   18.070   0.0390  0.135  0.135   3.00    9.0  -0.587     0.000     0.000  0.0255   0.0525   0.4397   0.5418
  B1ApF   20.820   0.0800  0.168  0.168   1.50    0.0  -0.402     0.000     0.000  0.0800   0.0800   0.5817   0.6192
#

#================================
```

```
#
# ------------------------------------
# TB20ww(h)  zpFh362c Hadron forward  41 GeV/c
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad    x1      x2      cc1      cc2
#           [m]      [m]     {m}   [m]    [m]   [mrad]    [T]    [T/m]     [T]     [m]     [m]     [m]      [m]
  B0pF    5.900  -0.0150  0.200  0.200   1.20  -25.0  -1.299     0.000     0.000   0.0000  -0.0300   0.1325   0.1325
  B0ApF    7.700   0.0055  0.043  0.043   0.60    0.0   2.464     0.000     0.000   0.0055   0.0055   0.1905   0.2055
  Q1ApF    9.230   0.0140  0.056  0.056   1.46   -5.5   0.000   -10.825    -0.606   0.0180   0.0100   0.2305   0.2590
  Q1BpF   11.065   0.0238  0.078  0.078   1.61  -10.0   0.000    -9.867    -0.770   0.0319   0.0158   0.2884   0.3126
  Q2pF   14.170   0.0407  0.131  0.131   3.80  -10.2   0.000     6.073     0.799   0.0601   0.0213   0.3668   0.4231
  B1pF   18.070   0.0390  0.135  0.135   3.00    9.0  -0.587     0.000     0.000   0.0255   0.0525   0.4397   0.5418
  B1ApF   20.820   0.0800  0.168  0.168   1.50    0.0  -0.402     0.000     0.000   0.0800   0.0800   0.5817   0.6192
  #
=====================================================
eF from 190322

# ------------------------------------
# TB19w2(g)  zbFg362 Electron Forward  18 GeV/c
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad    x1      x2      cc1      cc2
#           [m]      [m]     {m}   [m]    [m]   [mrad]    [T]    [T/m]     [T]     [m]     [m]     [m]      [m]
  Q0eF    5.900  -0.1475  0.025  0.028   1.20   25.0   0.00   -13.540   -0.338   0.0000   0.0000   0.1325   0.1625
  Q2AeF    7.730  -0.1933  0.030  0.042   1.46   25.0   0.00     0.000     0.000   0.0000   0.0000   0.1750   0.2115
  Q2eF   11.065  -0.2766  0.063  0.063   1.61   25.0   0.00     8.008     0.505   0.0000   0.0000   0.2565   0.2968
  Q3eF   22.470  -0.5617  0.030  0.030   1.20   25.0   0.00   -11.627   -0.349   0.0000   0.0000   0.5468   0.5767
  Q4eF   30.600  -0.7650  0.030  0.030   1.20   25.0   0.00   -15.400   -0.462   0.0000   0.0000   0.7500   0.7800
  Q5eF   39.500  -0.9875  0.050  0.050   1.20   25.0   0.00     4.023     0.201   0.0000   0.0000   0.9725   1.0025
#
==============================================
```

Rear

```
pR from tb27

#
# -------------------------------------
# TB27s(h)  zbRh362s Hadron Rear  275 GeV/c
#
# name    center_z center_x rad1  rad2  length  angle     B       grad  ap x grad    x1       x2       cc1       cc2
#            [m]       [m]      {m}   [m]     [m]   [mrad]    [T]     [T/m]      [T]     [m]      [m]       [m]       [m]
  Q1ApR   -6.200   0.0000  0.020  0.026   1.80    0.0   0.000   -78.375    -2.005   0.0000   0.0000   0.1325   0.1775
  Q1BpR   -8.300   0.0000  0.028  0.028   1.40    0.0   0.000   -78.375    -2.194   0.0000   0.0000   0.1900   0.2250
  Q2pR  -12.750   0.0000  0.054  0.054   4.50    0.0   0.000    33.843     1.828   0.0000   0.0000   0.2625   0.3750
#
# -------------------------------------
# TB27s(h)  zbRh362s Electron Rear  18 GeV/c
#
# name    center_z center_x rad1  rad2  length  angle     B       grad  ap x grad    x1       x2       cc1       cc2
#            [m]       [m]      {m}   [m]     [m]   [mrad]    [T]     [T/m]      [T]     [m]      [m]       [m]       [m]
  Q1eR   -6.200   0.1550  0.066  0.079   1.80   25.0   0.000   -13.980    -1.111   0.0000   0.0000   0.1325   0.1775
  Q2eR   -8.300   0.2075  0.083  0.094   1.40   25.0   0.000    14.100     1.322   0.0000   0.0000   0.1900   0.2250
  B2eR  -12.250   0.3063  0.097  0.139   5.50   25.0  -0.198     0.000     0.000   0.0000   0.0000   0.2375   0.3750
#
```