IR-Parameters-5

File 190125-IR.pdf and txt

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01/25/2019

This design made after the pCDR greatly reduces the required gradients by keeping e and hadron magnets side by side instead of alternating them.

Significant Changes since last meeting (01/11):

- Choice of strongly tilted proton forward Q2pF
- Abandonment of special electron forward for baseline
- Increase in electron rear bending B2eR

Conventions

The tables use Brett Parker's conventions:

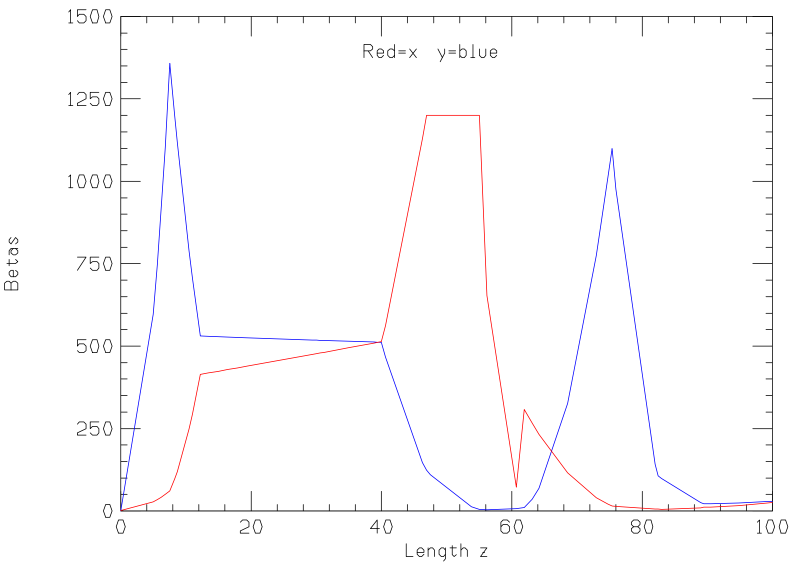
- "rad1" is the minimum inside magnet aperture at the IP end of magnets. "rad2", if tapered, is the larger aperture father from the IP.
- "center-x", "center-y", "center-z" are the horizontal, vertical and distance along the beam, of the magnet centres, with respect to a Z axis passing through the IP parallel with the hadron beam at the IP. x=y=z=0 is at the IP.
- "angle" is the horizontal angle between the magnet axis and the Z axis

Gradients given are only approximate because:

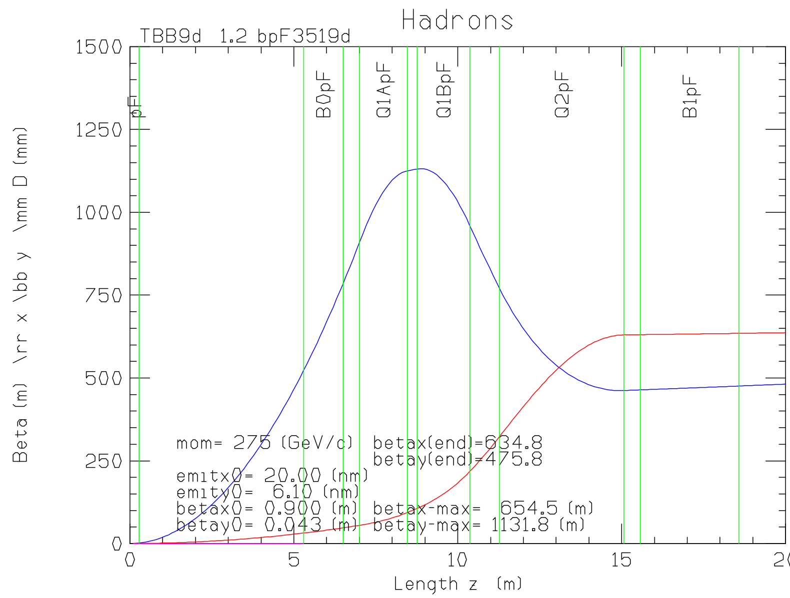
- Matching will likely change them
- My program is not exact

The term "Baseline" is used for 140 GeV c of m, High Divergence, No Cooling. Apertures for other cases estimated by their greater divergences

Protons Forward

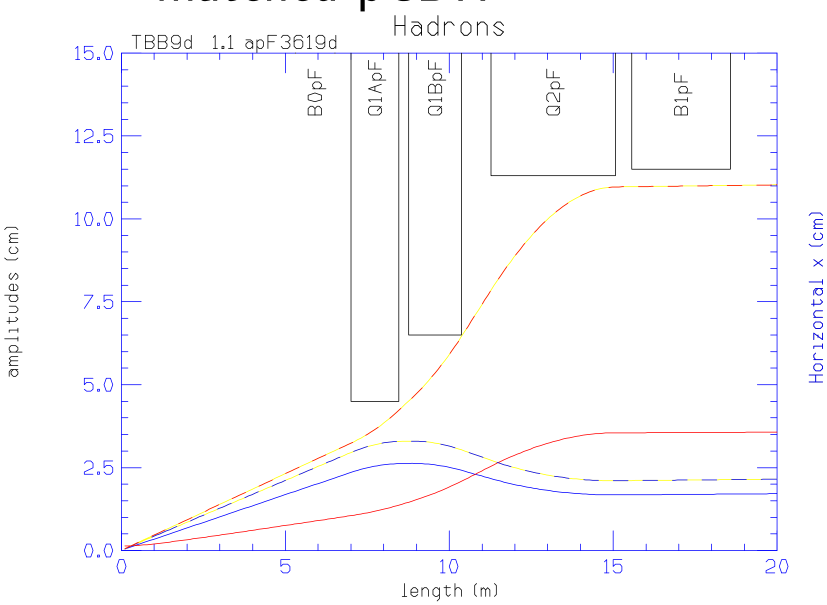


matched pCDR



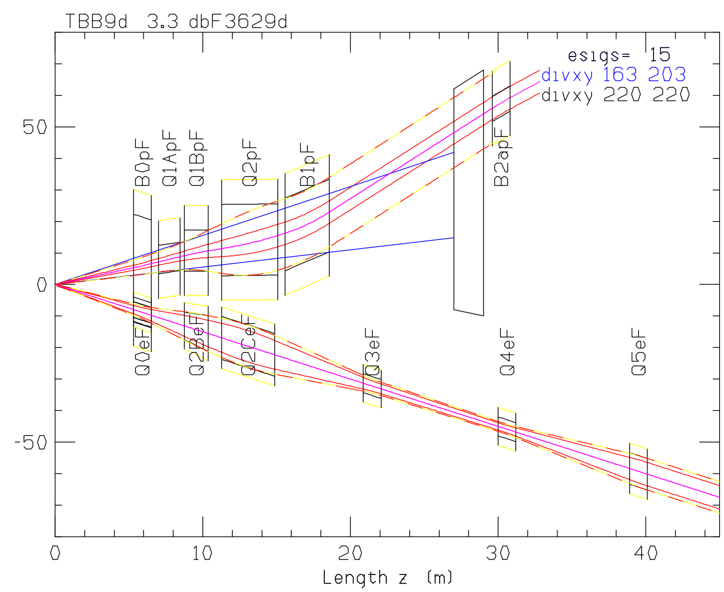
current

Red lines are for x, Blue lines for y



Amplitudes

Red=x Blue=y

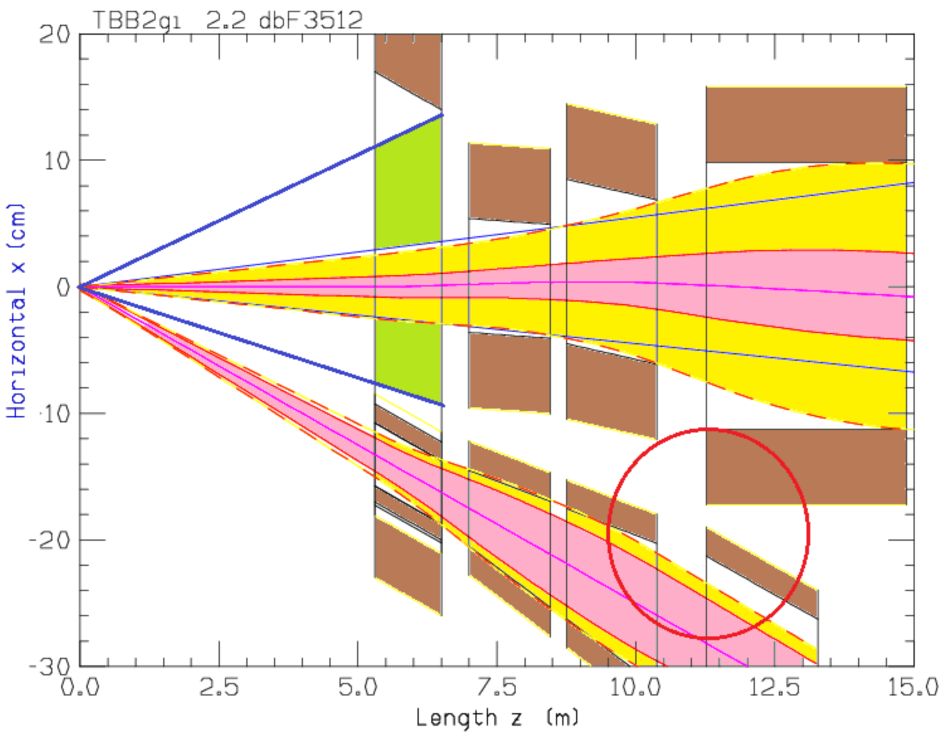


x-z Layout

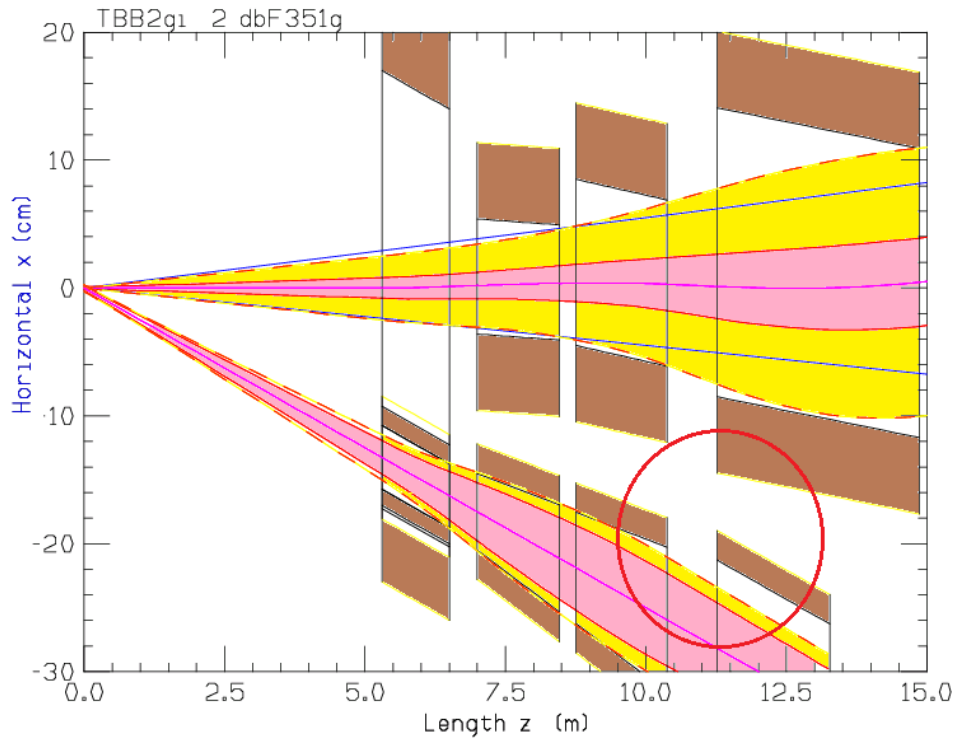
Red=beams Blue n cone

Lines are for the baseline beam Dash lines are for apertures for out-going tracks up to B2ApF for protons, or for larger divergence cases with cooling or lower energies.

Discussion of tilting Q2pF



Untilted Q2pf



Tilted Q2

The more tilted design increases the space between Q2pF and Q2CeF, but increases the aperture of Q2pf by 5%

The more tilted Q2pF was chosen

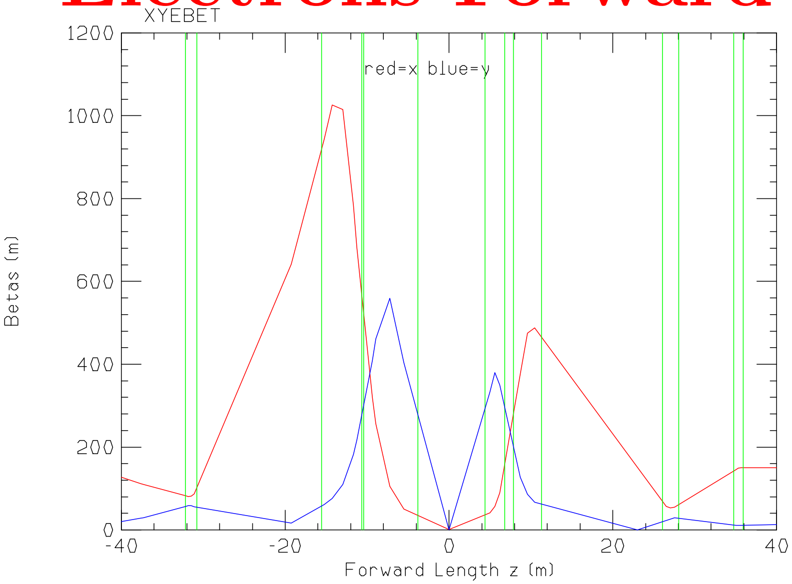
```
#
# ------------------------------------
# zpF3529d  Hadron forward  275
#
# beta*_x   beta*_y  gm emit_x gm emit_y  angle_x  angle_y    mom
#  [m]       [m]       [nm]      [nm]      [mrad]    [mrad]     GeV/c
 0.9000   0.0430     20.0000    6.1000      25       0        275
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad   alphax    betax    alphay      betay
#           [m]      [m]     {m}   [m]    [m]   [mrad]    [T]    [T/m]     [T]               [m]                  [m]
  B0pF    5.900  -0.0150  0.170  0.170   1.20  -25.0  -1.30     0.000     0.000    -6.553    39.574  -108.929   647.365
  Q1ApF    7.730   0.0067  0.045  0.045   1.46   -3.2   0.00   -77.903    -0.035   -12.861    70.148   -75.814  1061.777
  Q1BpF    9.565   0.0119  0.065  0.065   1.61  -10.0   0.00   -66.180    -0.043   -33.823   150.758    55.871  1092.779
  Q2pF   13.170   0.0100  0.113  0.113   3.80   -9.5   0.00   37.327     0.042   -44.571   539.185    36.872   525.824
  B1pF   17.070   0.0180  0.115  0.115   3.00   10.0  -4.57     0.000     0.000    -0.673   632.796    -1.954   469.936
  B2apF   30.200   0.2710  0.040  0.040   1.20   17.0   3.30     0.000     0.000    -0.703   650.856    -2.088   523.004
#-----------------------------------
```

We note that the betas in pCDR matched case, and ours stay relatively flat at ≈ 500 m out to 35 m. This is required to allow Roman Pot detectors to be sensitive to the angles of outgoing tracks.

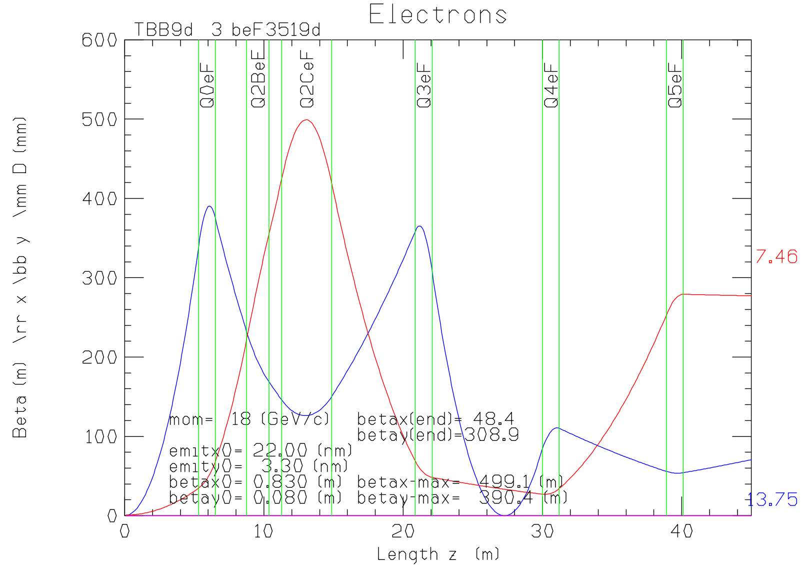
This differs from all the other cases in which the betas drop to much lower values by the next element.

Q1BpF and Q2pF are tilted to increase the space between the fronts of each from the electron magnets Q2BeF and Q2CeF that are close by them. The tilt of Q1BpF bends the p beam closer to the electrons, but the stronger Q2pF bends it by a greater angle away.

Electrons Forward

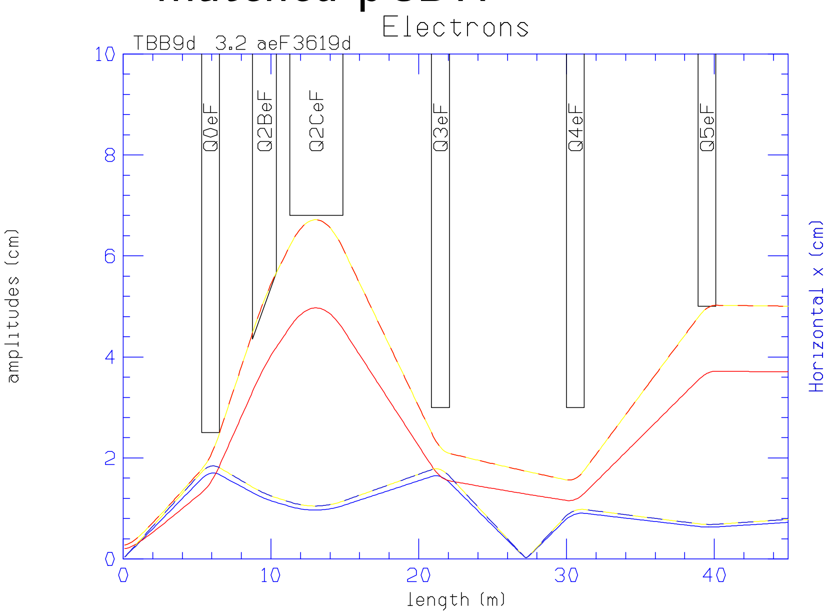


matched pCDR

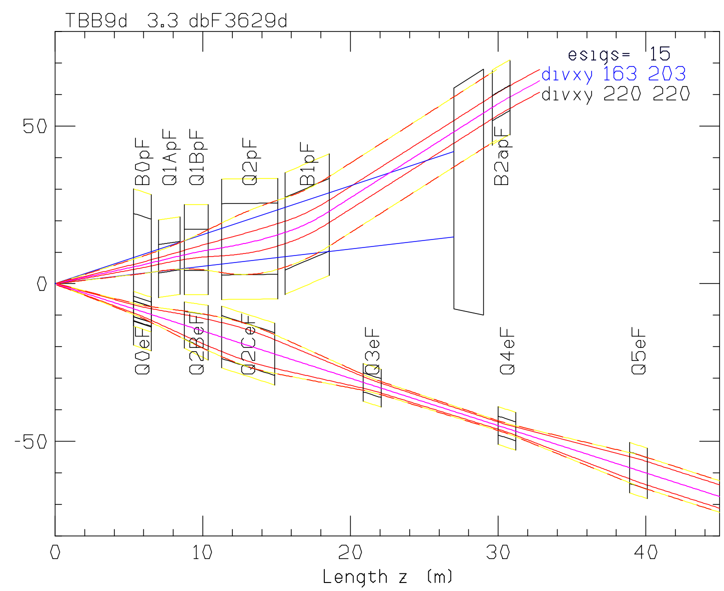


current

Red lines are for x, Blue lines for y



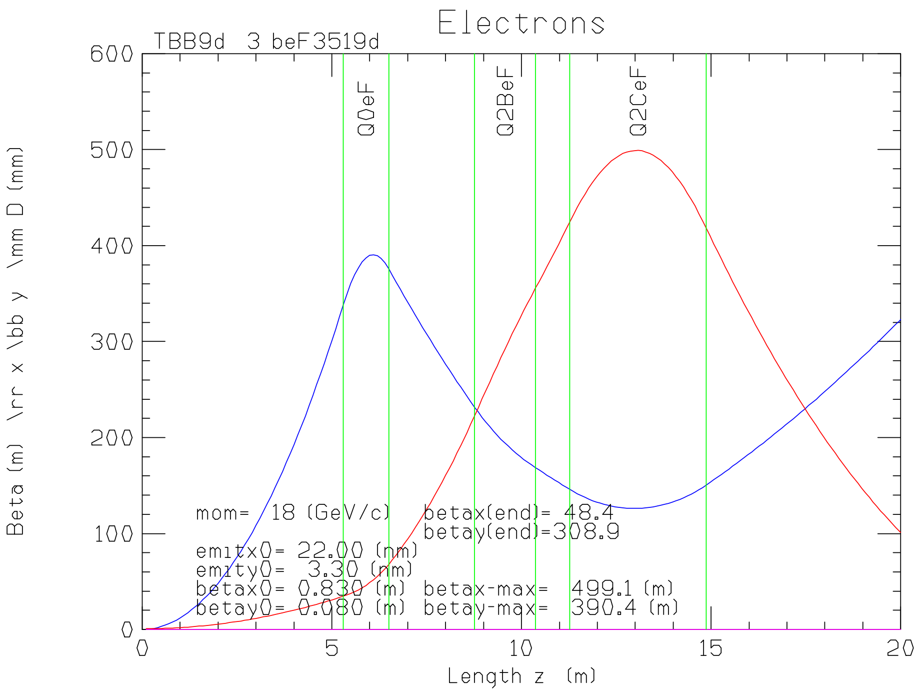
Amplitudes
Red=x Blue=y



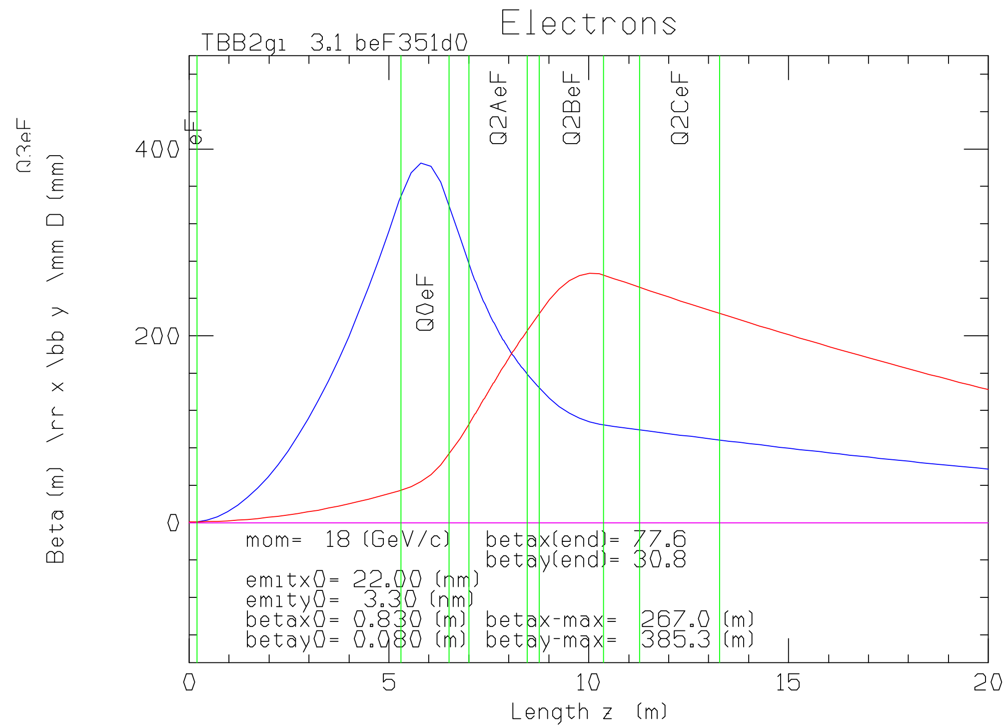
x-z Layout
Red=beams Blue n cone

Lines are for the baseline beam
Dash lines are for apertures for out-going tracks up to B2ApF for protons, or for larger divergence cases with cooling or lower energies.

Alternative for baseline only (not used)



Current design



baseline option

The current design is used for baseline and worst cases.

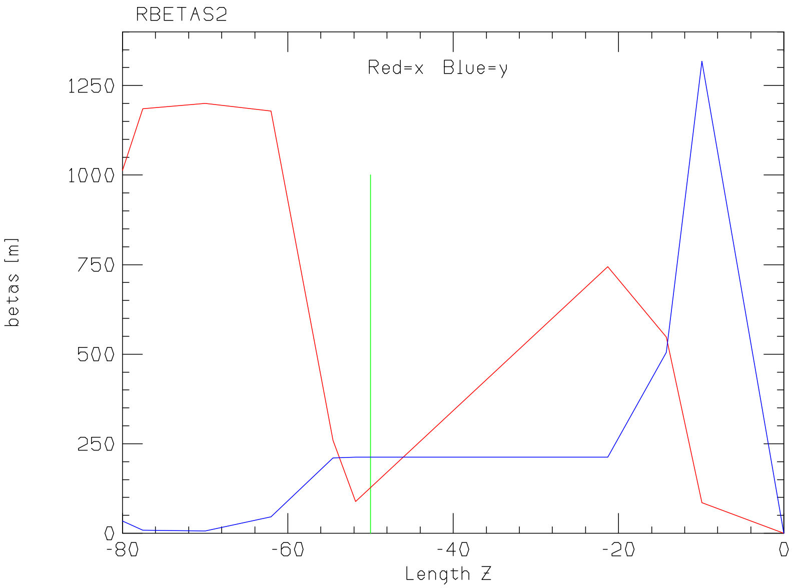
This option, for the baseline only, lowered the betamax from 499 to 267 m.

It would have required an additional magnet Q1AeF and a significant increase in gradients for Q0eF which, being inside the forward spectrometer B0pF, appeared difficult.

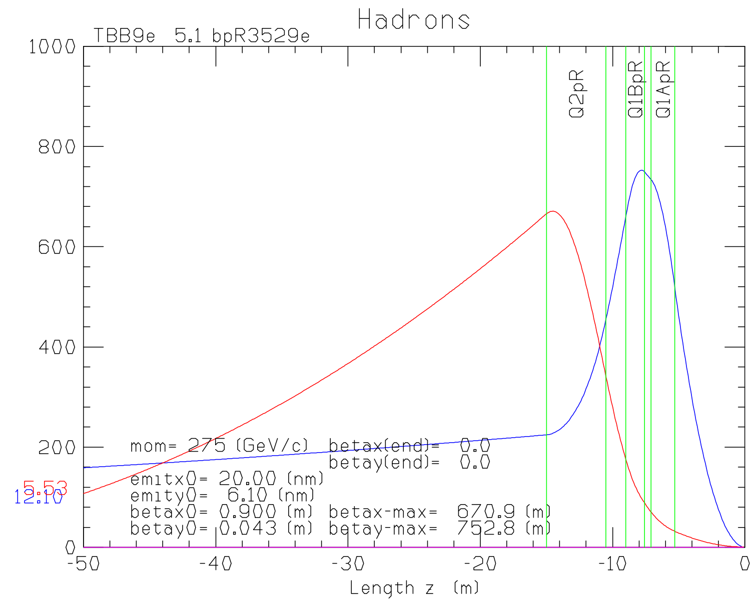
```
#
# -------------------------------------
# zeF3519d  Electron forward  18
#
# beta*_x   beta*_y  gm emit_x gm emit_y  angle_x  angle_y    mom
#  [m]       [m]      [nm]      [nm]     [mrad]    [mrad]     GeV/c
 0.8300   0.0800    22.0000    3.3000      25      0        18
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad   alphax    betax    alphay      betay
#           [m]      [m]     {m}   [m]     [m]   [mrad]    [T]     [T/m]     [T]                 [m]                 [m]
  Q0eF    5.900   0.0000  0.025  0.025   1.20   25.0   0.00   -13.540    -0.003   -13.160    46.051   -16.165   387.278
  Q2BeF    9.565   0.0000  0.044  0.057   1.61   25.0   0.00     2.553     0.001   -41.727   292.544    19.130   194.024
  Q2CeF   13.070   0.0000  0.068  0.068   3.60   25.0   0.00     3.043     0.002     1.213   499.042    -0.618   126.296
  Q3eF   21.470   0.0000  0.030  0.030   1.20   25.0   0.00   -12.012    -0.004     8.026    54.079    22.255   358.648
  Q4eF   30.600   0.0000  0.030  0.030   1.20   25.0   0.00   -13.860    -0.004    -2.807    28.137   -10.836   105.963
  Q5eF   39.500   0.0000  0.050  0.050   1.20   25.0   0.00     4.023     0.002   -10.842   272.621     0.647    53.669
#------------------------------------
```

The matching shown to the crab cavities at 40 m is seen to be significantly different from that in the pCDR, and includes the addition of Q3eF. This was needed to constrain the aperture of Q2CeF. Alternative and simpler designs may be possible. It is shown as an example of possible matching and should not be seen as a constraint in detail.

Protons Rear

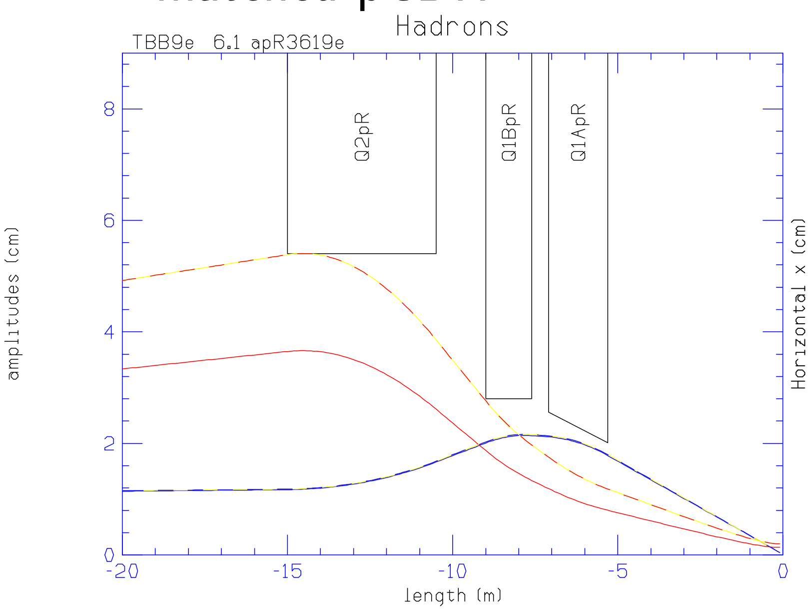


matched pCDR

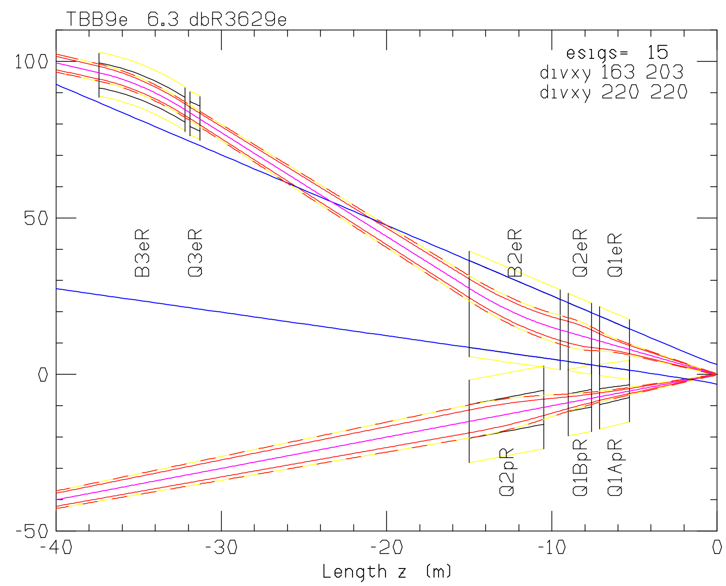


current

Red lines are for x, Blue lines for y



Amplitudes
Red=x Blue=y



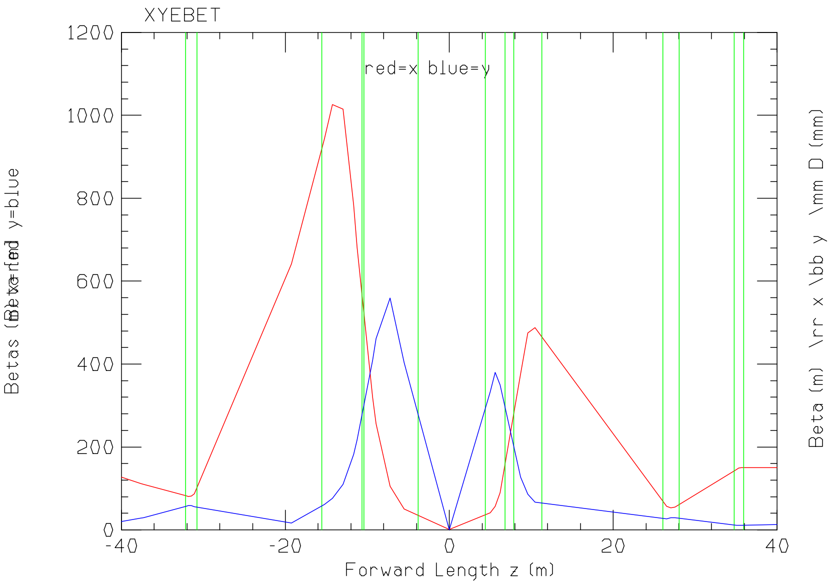
x-z Layout
Red=beams Blue SR fan

Lines are for the baseline beam
Dash lines are for apertures for out-going tracks up to B2ApF for protons, or for larger divergence cases with cooling or lower energies.

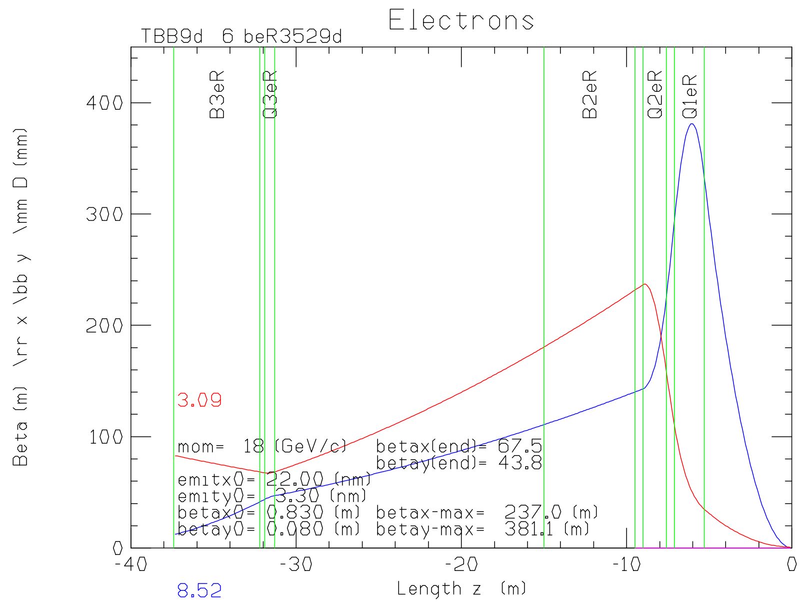
```
#
# ------------------------------------
# zpR35239d  Hadron Rear  275
#
# beta*_x   beta*_y  gm emit_x gm emit_y  angle_x  angle_y    mom
#  [m]       [m]       [nm]      [nm]     [mrad]    [mrad]     GeV/c
 0.9000   0.0430     20.0000    6.1000      25       0       275
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad   alphax    betax    alphay      betay
#           [m]       [m]     {m}   [m]     [m]   [mrad]    [T]    [T/m]     [T]                [m]                 [m]
  Q1ApR   -6.200   0.0000  0.020  0.026   1.80    0.0   0.00   -84.150    -0.022   -10.408    46.563   -60.940   665.600
  Q1BpR   -8.300   0.0000  0.028  0.028   1.40    0.0   0.00   -84.150    -0.024   -29.993   123.074    32.917   737.069
  Q2pR  -12.750   0.0000  0.054  0.054   4.50    0.0   0.00    33.843     0.018   -40.819   594.541    22.648   275.049
#----------------------------------
```

Because the e and p beams are so close, the first proton focus is broken into two: Q1ApR and Q1BpR. Q1ApR is shown tapered, but it could also be straight with the larger aperture throughout, but with less space between them. The magnet builders can choose.

Electrons Rear

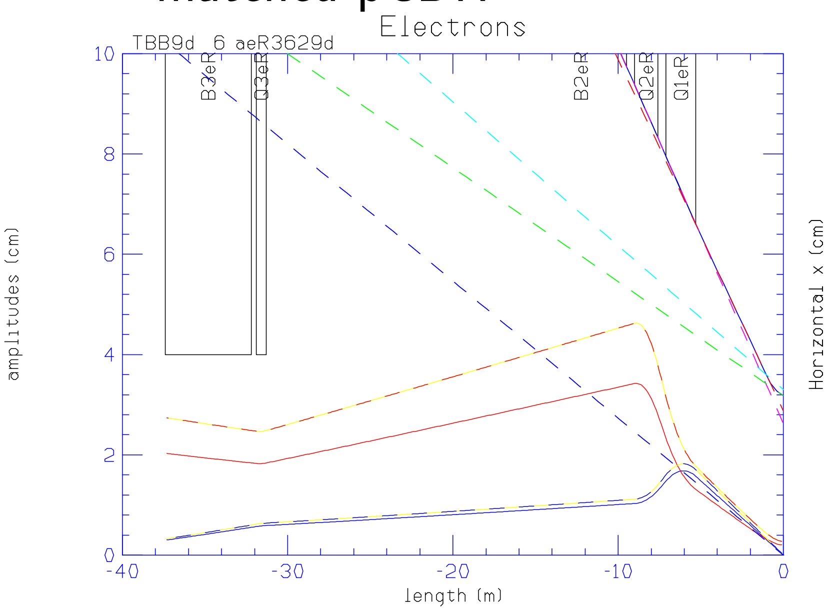


matched pCDR

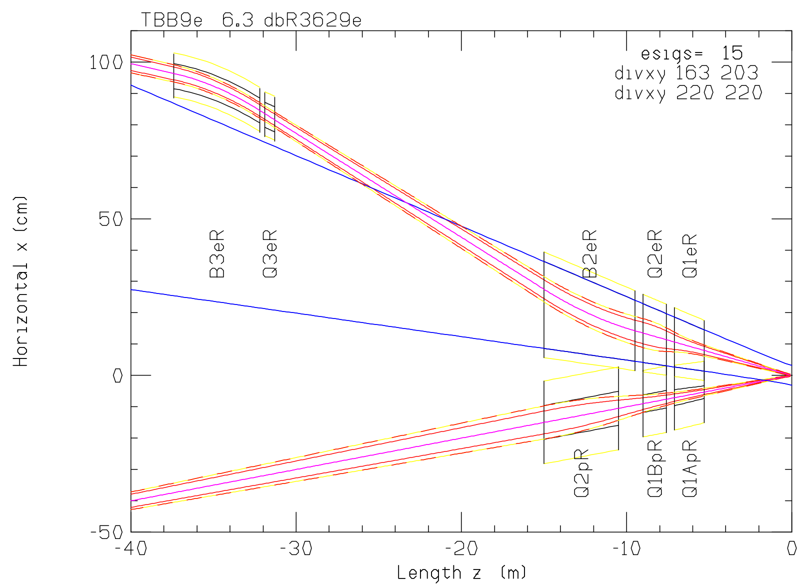


current

Red lines are for x,
Blue lines for y



Amplitudes
Red=x Blue=y



x-z Layout
Red=beams Blue SR fan

Lines are for the baseline beam
Dash lines are for apertures for outgoing tracks up to B2ApF for protons, or for larger divergence cases with cooling or lower energies.

```
#
# -----------------------------------
# zeR35239d  Electron Rear  18
#
# beta*_x  beta*_y  gm emit_x gm emit_y  angle_x  angle_y    mom
#  [m]      [m]      [nm]      [nm]      [mrad]    [mrad]     GeV/c
 0.8300   0.0800     22.0000    3.3000      25       0        18
#
# name    center_z center_x rad1  rad2  length  angle     B      grad  ap x grad   alphax    betax    alphay     betay
#            [m]      [m]     {m}   [m]     [m]   [mrad]    [T]    [T/m]      [T]                 [m]                 [m]
  Q1eR   -6.200   0.0000  0.066  0.079   1.80   25.0   0.00   -15.038    -0.012   -18.779   56.141   13.931  378.985
  Q2eR   -8.300   0.0000  0.083  0.094   1.40   25.0   0.00    14.290     0.013   -29.468  218.668   26.914  163.168
  B2eR  -12.250   0.0000  0.097  0.139   5.50   25.0  -0.20     0.000     0.000     4.641  205.234    2.663  124.969
  Q3eR  -31.600   0.3503  0.040  0.040   0.60   34.0   0.00    -6.000    -0.002     0.558   67.334    2.748   45.753
  B3eR  -34.800   0.3780  0.040  0.040   5.20   31.1   0.25     0.000     0.000    -1.427   75.497    2.826   24.207
#----------------------------------
```

The electron magnets are very large to transport the synchrotron SR radiation fan to beyond the magnets, and possibly to 26 m where the beam sepaates from the fan. The further the absorber is fro the IP, the less of any reflected radiation comes back to the detector absorber.

Since their fields are low, it is assumed that all the electron rear magnets are tapered.

The parameters and locations given for Q3eR and B3eR will be determined by the overall matching and those given here are only for illustration. There has been talk of bringing them closer to the IP, hence:

The field in B2eR has been increased to bring the separation of the beam and synchrotron fan further from the next magnet (Q3eF). This will ease the design of the synchrotron absorber.

Corrections

The pCDR hadron rear beta plot was incorrect. To match the hadrons to the corrected plot, the gradients in Q1ApR, Q1BpR, and Q2pR were reduced.

After the step sizes in the tracking program were reduced to reduce errors, several focus gradients were adjusted.

Quadrupole gradient changes since 12/1 4/2018

name	12/14 T/m	01/25 T/m	dif %	
Q1ApF	77.9	66.18	0	
Q1BpF	63.0	66.18	+5	
Q2pF	39.7	37.3	-6	
Q0eF	-12.7	-13.54	+7	
Q1eF	1.155	2.55	+64	was very low
Q2eF	3.85	3.04	-21	
Q1ApR	83.4	84.15	+1	
Q1BpR	83.4	84.5	+1	
Q2pR	77	33.8	-56	magnet now longer
Q1eR	-14.46	-15.04	+4	
Q2eR	13.46	15.04	+4	

Conclusion

- The only significant changes since 12/14/2018 are:
    1. The choice of the strongly tilted forward proton quads Q1BpF and Q2pF to maximize the space between them and the electron magnets close by. The resulting 5% increase in Q2pF aperture is accepted.
    2. The abandonment of modified parameters with lower maximum electron betas that can accommodate the baseline (140 GeV c of m, High Divergence, no cooling) case, but not other cases with larger divergences at lower energies or with cooling. The magnet Q1AeF is eliminated.
    3. An increased bending field in B2eR by 39% (from 0.144 to .2 T) to separate the beam from the synchrotron fan by a location further from the next component Q3eF. This should simplify the SR dump design. This also helps the electron tagging. This change has no effect on any of the other components and should be brought up in a meeting on the SR dump design.
- We conclude that these parameters and choices have settled to the point that only designs of the required matching and layout in the tunnel should yield any significant changes.