Parameters (Tech note to follow)

Bob Palmer 12/3/2018

Beam parameters for a "baseline" with High Divergences (HD) and without cooling:

E(hadron)=275 GeV; E(electron)= 18 GeV
β^*(hadron) x/y = 90/4.3 (cm)
β^*(electron) x/y = 83/8.0 (cm)
ϵ(hadron) x/y = 20/6.1 (nm)
ϵ(electron) x/y = 22/3.3 (nm)

To allow for the larger beams at other energies, divergences, and cooling, magnet apertures are increased by the ratio of maximum divergences over the baseline divergences.

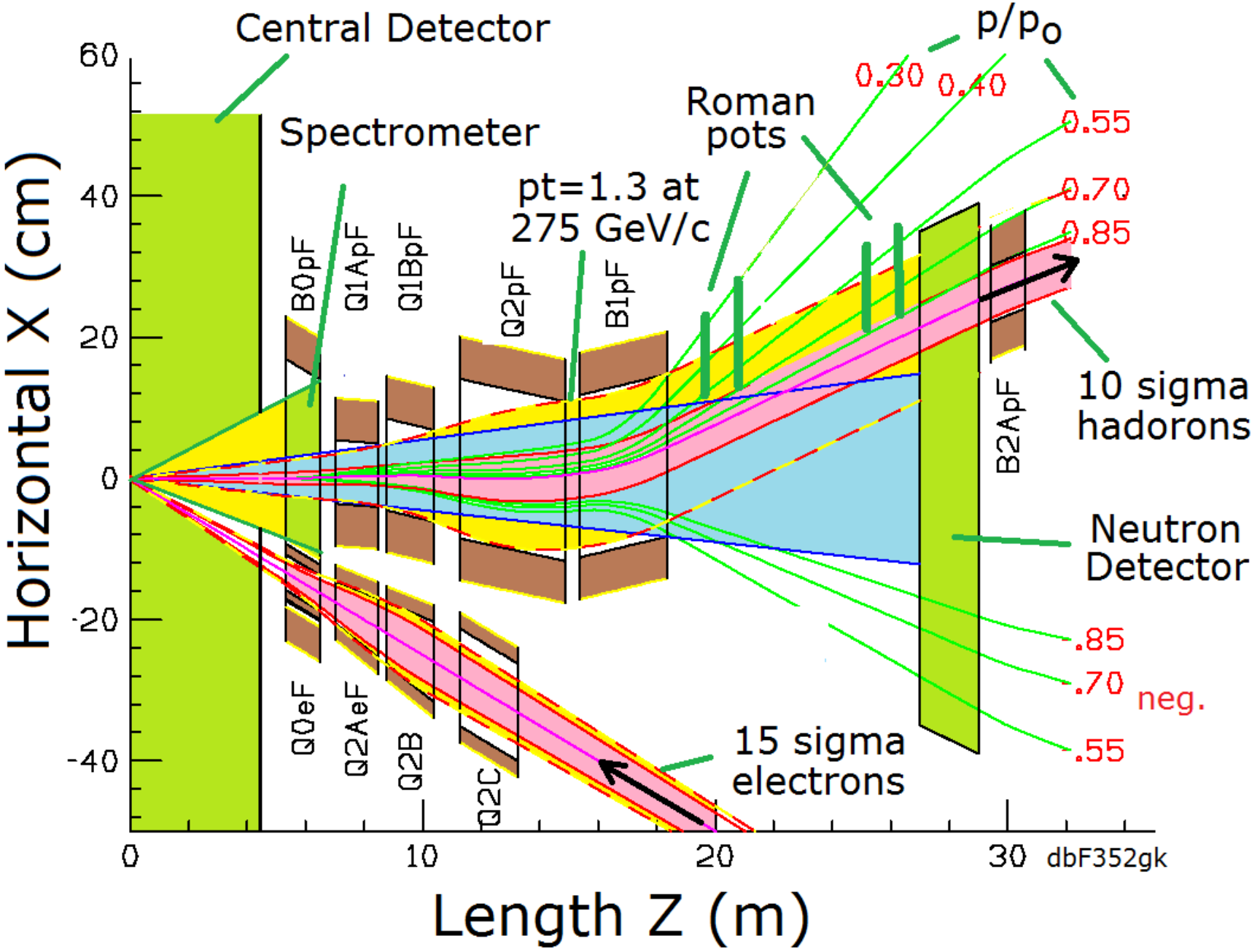
Magnet parameters are given in two formats:

1. The tables in boxes use my old conventions:
   - L1 is the location of the magnet end closest to the IP
   - X is the horizontal position of the magnet ends closest to the IP, with respect to a Z axis passing through the IP parallel with the electron beam at the IP
   - "Grad1" is the field gradient at the end nearest the IP, Grad2 at the other end (all the same in these cases).
   - IR1 is the minimum inside radius closer to the IP; IR2 is that further from the IP.
   - B1 and B2 are the magnet apertures $\times$ the field gradients.
   - θ is the horizontal angle between the magnet axis and the Z axis

2. The text tables use our newer conventions:
   - "gm emit" is a geometric emittance.
   - "rad1" is the minimum inside magnet aperture at the IP end of magnets.
   - For straight magnets, "rad2" is given as 0
   - For tapered magnets "rad2" 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

Forward systems



FORWARD Proton Magnets

mom = 275 GeV/c

		L1 m	DL m	gap m	x cm	θ mrad	IR1 cm	IR2 cm	OR cm	B1 T	B2 T	B T	Grad1 T/m	Grad2 T/m
B0	3	5.30	1.20	0.50	13.3	0.00	17.00	17.00	0.0	0.000	0.000	-1.300	0.000	0.000
Q1A	5	7.00	1.46	0.30	18.4	21.85	4.50	4.50	0.0	3.506	3.506	0.000	-77.903	-77.903
Q1B	7	8.76	1.61	0.90	23.9	15.00	6.50	6.50	0.0	4.097	4.097	0.000	-63.028	-63.028
Q2	9	11.27	3.60	0.50	31.0	16.11	11.30	11.30	0.0	4.490	4.490	0.000	39.736	39.736
B1	11	15.37	3.00	11.03	38.7	35.00	11.50	11.50	0.0	0.000	0.000	-4.570	0.000	0.000

```
# ------------------------------------------------------------------------
# zpF3513g  Hadron forward  275
#
# beta*_x  beta*_y  gm emit_x gm emit_y  crossing_x  crossing_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 center_y rad1  rad2   length   angle      B      gradient
#           [m]      [m]      [m]     [m]    [m]     [m]     [mrad]    [T]     [T/m]
  B0pF    5.900  -0.0150    0.00    0.1700   0    1.200   -25.00   -1.300     0.000
  Q1ApF    7.730   0.0067    0.00    0.0450   0    1.460    -3.15    0.000   -77.903
  Q1BpF    9.565   0.0119    0.00    0.0650   0    1.610   -10.00    0.000   -63.028
  Q2pF   13.070   0.0120    0.00    0.1130   0    3.600    -8.89    0.000    39.736
  B1pF   16.870   0.0180    0.00    0.1150   0    3.000    10.00   -4.570     0.000
# ------------------------------------------------------------------------
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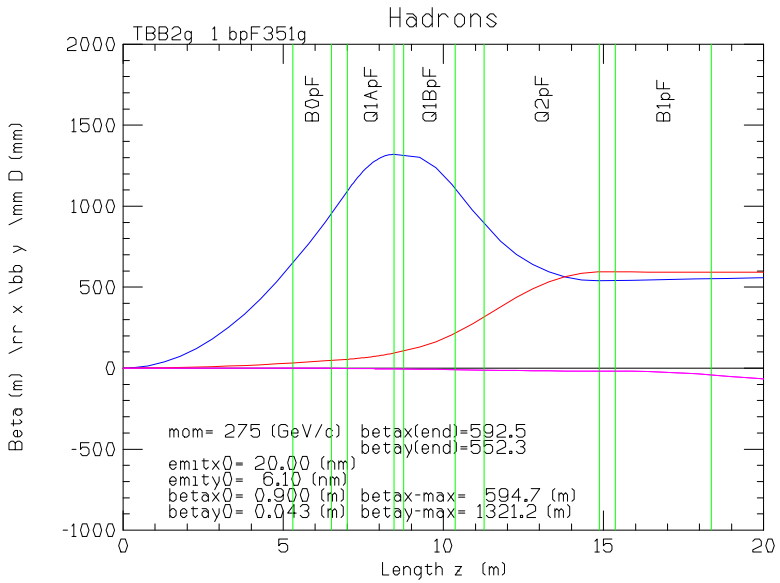
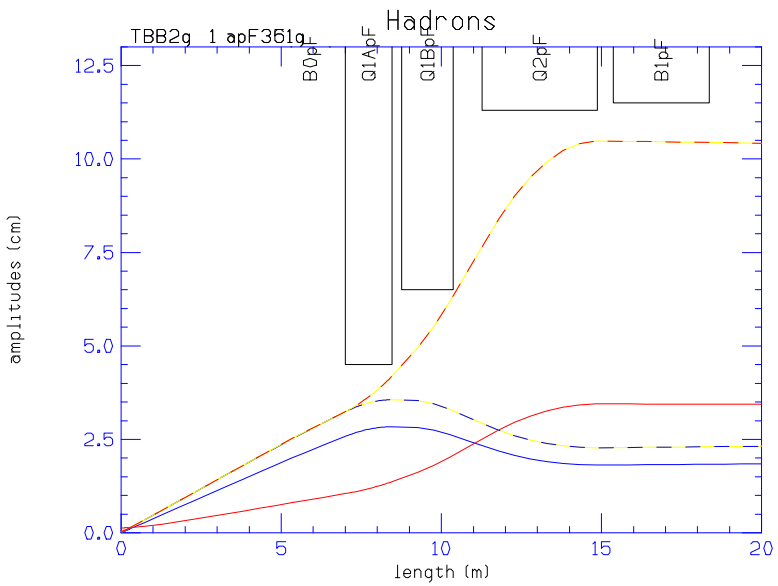
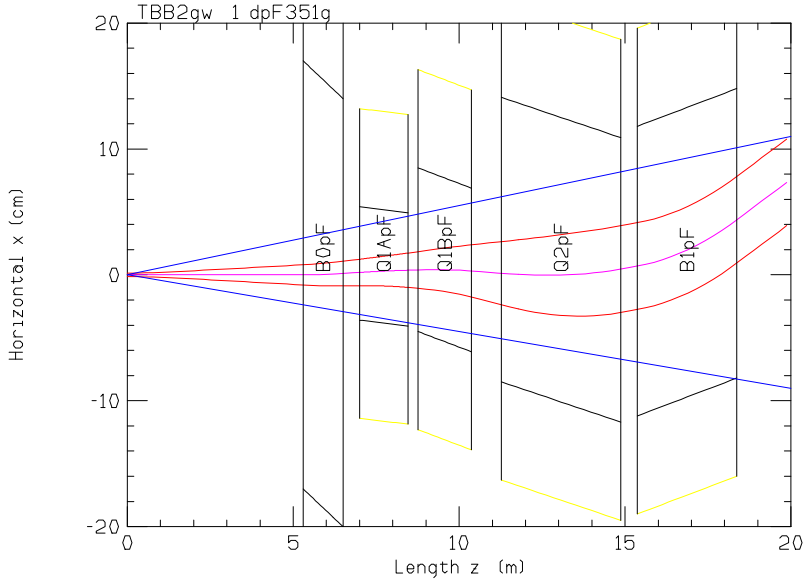
The next magnet (B2A?) should not start before 29.4 m to allow sufficient separation between the proton beam and neutron cone. A greater distance would be preferred.


Hadrons
TBB2g 1 bpF351g
B0pF
Q1ApF
Q1BpF
Q2pF
B1pF
mom= 275 (GeV/c) betax(end)=592.5
betay(end)=552.3
emitx0= 20.00 (nm)
emity0= 6.10 (nm)
betax0= 0.900 (m) betax-max= 594.7 (m)
betay0= 0.043 (m) betay-max= 1321.2 (m)
Beta (m) \rr x \bb y \mm D (mm)
Length z (m)


Hadrons
TBB2g 1 apF351g
B0pF
Q1ApF
Q1BpF
Q2pF
B1pF
amplitudes (cm)
length (m)


TBB2gw 1 dpF351g
B0pF
Q1ApF
Q1BpF
Q2pF
B1pF
Horizontal x (cm)
Length z (m)

FORWARD Electron Magnets

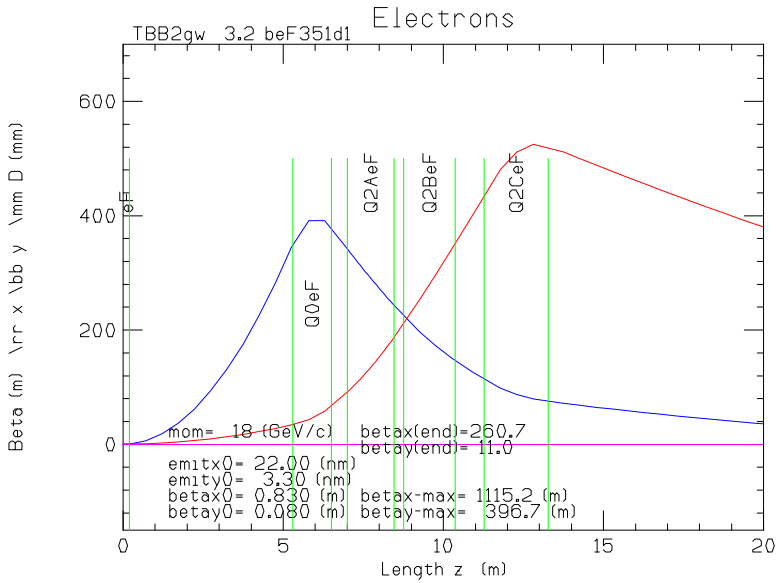
"Worst case" solution

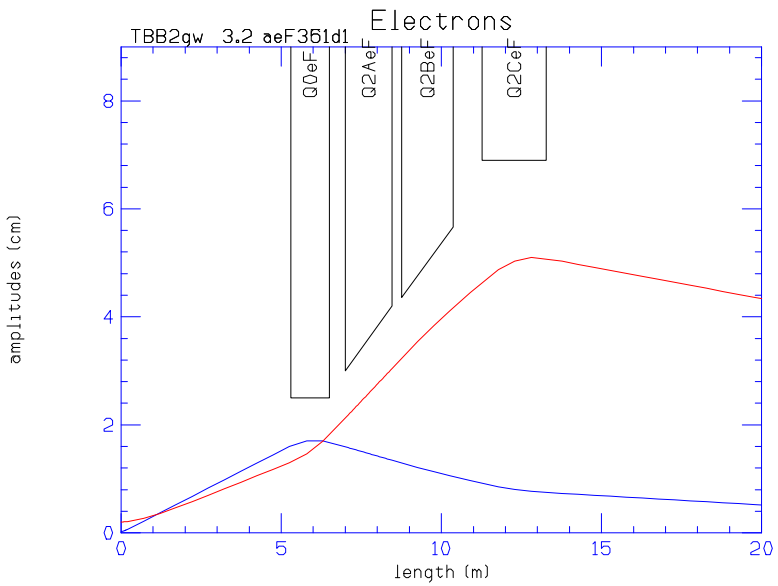
Because the "Worst case" has larger beam divergences the synchrotron fan must be reduced by a weaker Q0eF and greater space to the following quads that give a higher beta max of 520 m. This solution does not use Q2AeF.

mom = 18 GeV/c

		L1 m	DL m	gap m	x cm	θ mrad	IR1 cm	IR2 cm	OR cm	B1 T	B2 T	B T	Grad1 T/m	Grad2 T/m
Q0	3	5.30	1.20	0.50	0.0	0.00	2.50	2.50	0.0	0.318	0.318	0.000	-12.705	-12.705
Q2A	5	7.00	1.46	0.30	0.0	0.00	3.00	4.20	0.0	0.000	0.000	0.000	0.000	0.000
Q2B	7	8.76	1.61	0.90	0.0	0.00	4.36	5.66	0.0	0.050	0.065	0.000	1.155	1.155
Q2C	9	11.27	2.00	13.53	0.0	0.00	6.90	6.90	0.0	0.266	0.266	0.000	3.850	3.850

```
# ------------------------------------
# zeF3513d1  Electron forward High beta 18
#
# beta*_x  beta*_y  gm emit_x gm emit_y  crossing_x  crossing_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 center_y rad1  rad2    length   angle      B      gradient
#           [m]      [m]      [m]    [m]    [m]      [m]    [mrad]     [T]     [T/m]
  Q0eF    5.900  -0.1475    0.00   0.0250    0      1.200    -25.00    0.000   -12.705
  Q2AeF    7.730  -0.1933    0.00   0.03   0.042   1.460    -25.00    0.000     0.00
  Q2BeF    9.565  -0.2391    0.00   0.0436 0.0566  1.610    -25.00    0.000     1.155
  Q2CeF   12.270  -0.3067    0.00   0.0690   0      2.000    -25.00    0.000     3.850
# ------------------------------------
```


Electrons
TBB2gw 3.2 beF351d1
Beta (m) \rr x \bb y \mm D (mm)
Length z (m)
eF
Q0eF
Q2AeF
Q2BeF
Q2CeF
mom= 18 (GeV/c)
betax(end)=260.7
betay(end)= 11.0
emitx0= 22.00 (nm)
emity0= 3.30 (nm)
betax0= 0.830 (m)
betay0= 0.080 (m)
betax-max= 1115.2 (m)
betay-max= 396.7 (m)


Electrons
TBB2gw 3.2 aeF351d1
amplitudes (cm)
length (m)
Q0eF
Q2AeF
Q2BeF
Q2CeF

Baseline case

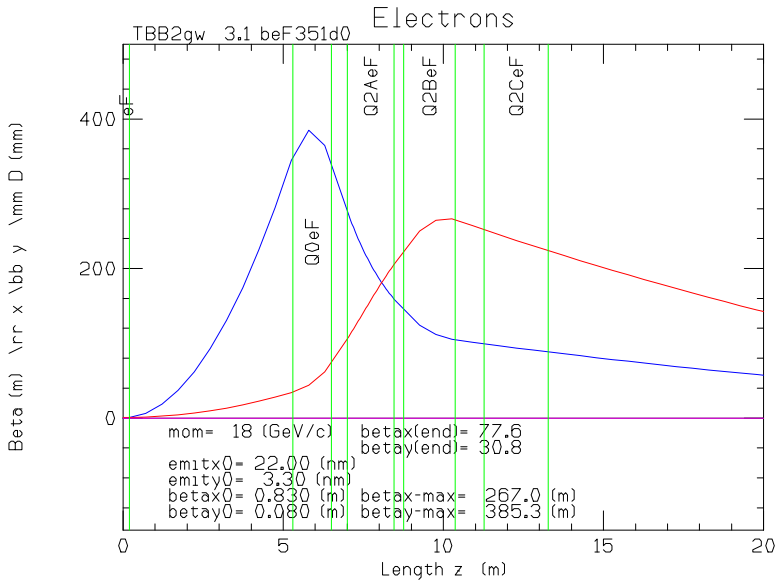
mom = 18 GeV/c

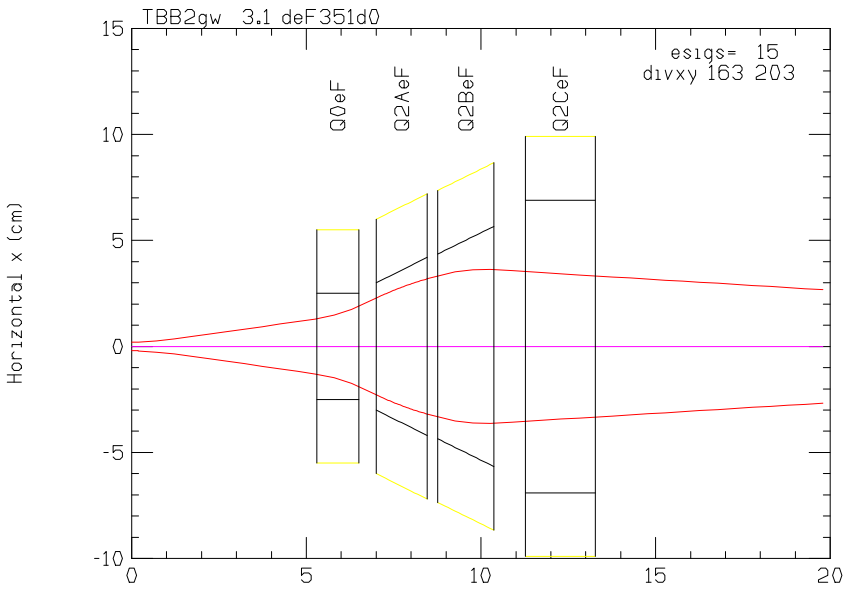
		L1	DL	gap	x	θ	IR1	IR2	OR	B1	B2	B	Grad1	Grad2
		m	m	m	cm	mrad	cm	cm	cm	T	T	T	T/m	T/m
Q0	3	5.30	1.20	0.50	0.0	0.00	2.50	2.50	0.0	0.433	0.433	0.000	-17.325	-17.325
Q2A	5	7.00	1.46	0.30	0.0	0.00	3.00	4.20	0.0	0.167	0.234	0.000	5.582	5.582
Q2B	7	8.76	1.61	0.90	0.0	0.00	4.36	5.66	0.0	0.297	0.386	0.000	6.814	6.814
Q2C	9	11.27	2.00	13.53	0.0	0.00	6.90	6.90	0.0	0.000	0.000	0.000	0.000	0.000

```
# ------------------------------------
# zeF3523d2  Electron forward  Low beta 18
#
# beta*_x  beta*_y  gm emit_x gm emit_y  crossing_x  crossing_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 center_y rad1  rad2  length   angle      B      gradient
#           [m]      [m]      [m]     [m]   [m]    [m]     [mrad]    [T]     [T/m]
  Q0eF    5.900  -0.1475    0.00   0.0250    0    1.200   -25.00    0.000   -17.325
  Q2AeF    7.730  -0.1933    0.00  0.03    0.042  1.460   -25.00    0.000     5.582
  Q2BeF    9.565  -0.2391    0.00  0.0436  0.0566 1.610   -25.00    0.000     6.814
  Q2CeF   12.270  -0.3067    0.00   0.0690   0     2.000   -25.00    0.000     0.000
# ------------------------------------
```

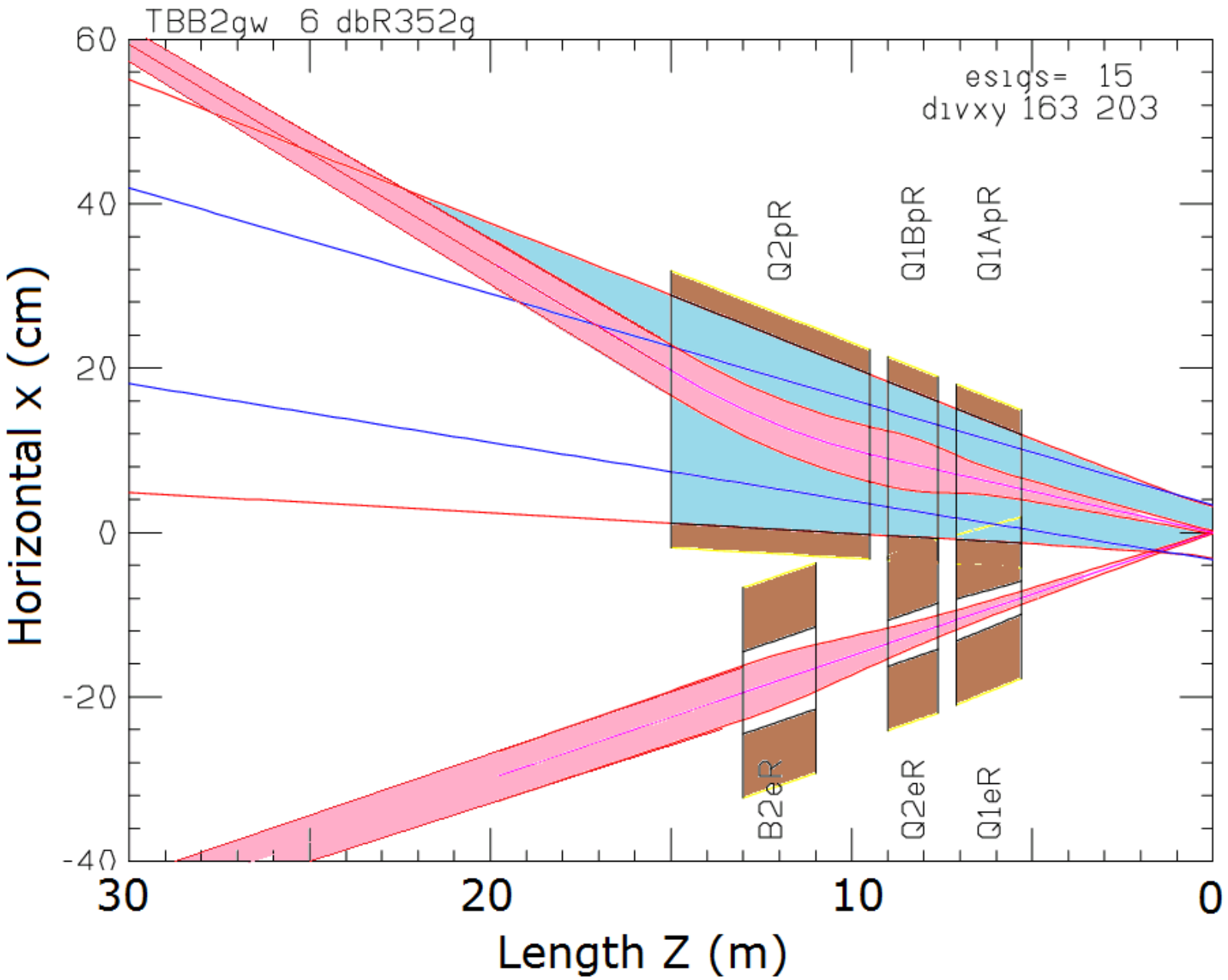
With the smaller divergences in the baseline case, a stronger Q0eF can be used, with following quads closer in, giving a lower beta max of 267 m.

The magnets should be designed for the larger of the gradients in the two cases:
5.582 , 6.814, and 3.85 T/m for Q2AeF, Q2BeF, and Q2CeF respectively.


Electrons
TBB2gw 3.1 beF351d0
Beta (m) \rr x \bb y \mm D (mm)
Length z (m)
QeF
Q0eF
Q2AeF
Q2BeF
Q2CeF
mom= 18 (GeV/c)
betax(end)= 77.6
betay(end)= 30.8
emitx0= 22.00 (nm)
emity0= 3.30 (nm)
betax0= 0.830 (m)
betax-max= 267.0 (m)
betay0= 0.080 (m)
betay-max= 385.3 (m)


TBB2gw 3.1 deF351d0
esigs= 15
divxy 163 203
Horizontal x (cm)
Q0eF
Q2AeF
Q2BeF
Q2CeF

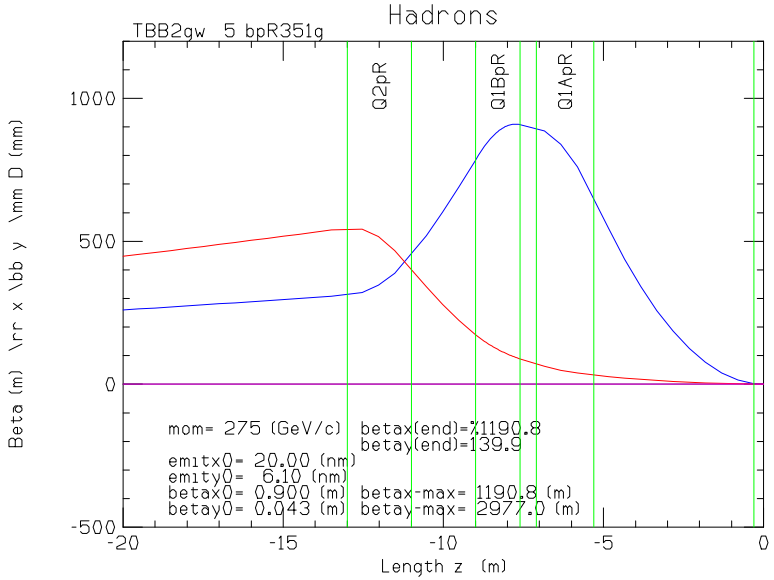
Rear Systems

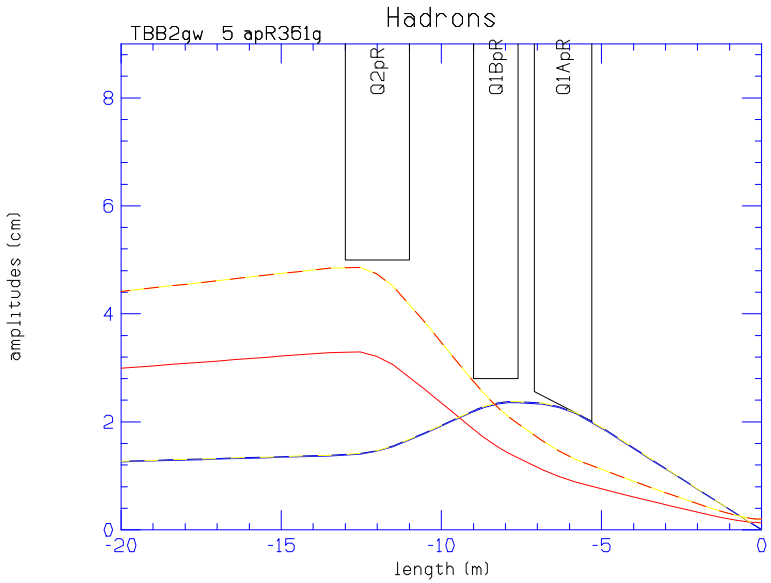


REAR Hadron Magnets with Tapered Q1ApR

		L1	DL	gap	x	θ	IR1	IR2	OR	B1	B2	B	Grad1	Grad2
		m	m	m	cm	mrad	cm	cm	cm	T	T	T	T/m	T/m
Q1A	3	-5.30	1.80	0.50	13.25	25	2.01	2.56	0.0	1.680	2.134	0.000	-83.417	-83.417
Q1B	5	-7.60	1.40	2.00	19.00	25	2.80	2.80	0.0	2.336	2.336	0.000	-83.417	-83.417
Q2	7	-11.00	2.00	39.80	27.50	25	5.00	5.00	0.0	3.850	3.850	0.000	77.000	77.000

```
# ------------------------------------------
# zpR3513g  Hadron Rear  275
#
# beta*_x  beta*_y  gm emit_x gm emit_y  crossing_x  crossing_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 center_y rad1    rad2   length   angle      B      gradient
#         [m]     [m]      [m]      [m]     [m]     [m]     [mrad]     [T]     [T/m]
Q1ApR   -6.200   0.00     0.00    0.0201   0.0256   1.800     0.00    0.000    -83.417
Q1BpR   -8.300   0.00     0.00    0.0280     0      1.400     0.00    0.000    -83.417
Q2pR   -12.000   0.00     0.00    0.0500     0      2.000     0.00    0.000     77.000
# ------------------------------------------
```





As seen in the right hand plot, Q1ApR could be un-tapered with a fixed aperture of .024 m, instead of the taper from .0201 to .0256 m. But,at the IP end, this reduces the space between the e and p beams and increases the pole tip fields. The magnet designer should choose.

Electron Rear

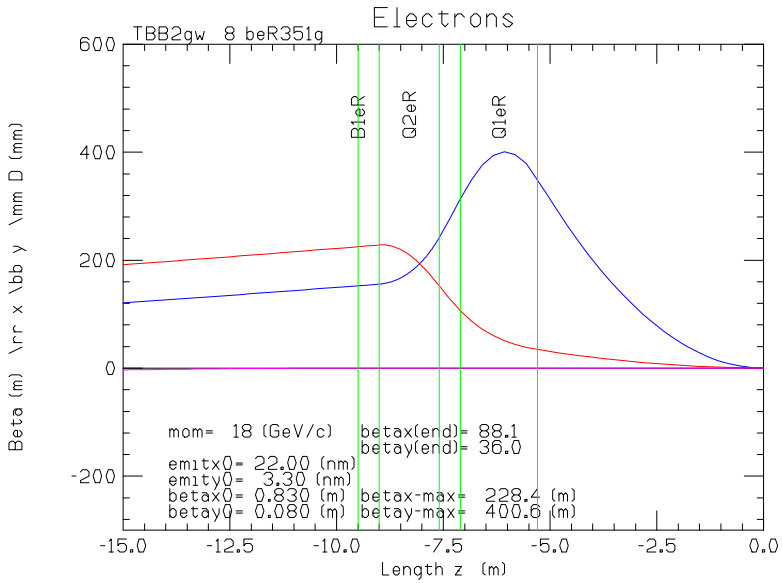
mom = 18 GeV/c

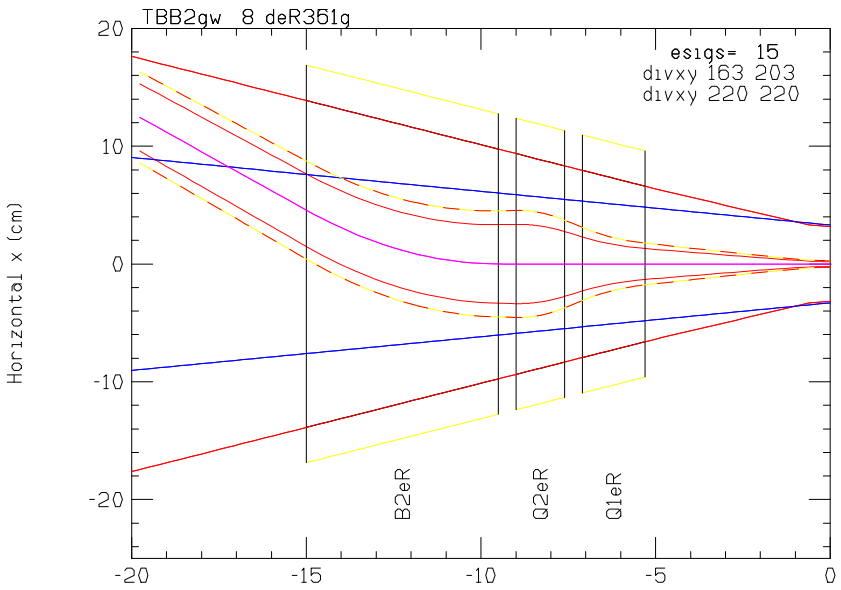
		L1	DL	gap	x	θ	IR1	IR2	OR	B1	B2	B	Grad1	Grad2
		m	m	m	cm	mrad	cm	cm	cm	T	T	T	T/m	T/m
Q1	3	-5.30	1.80	0.50	0.0	0.00	6.60	7.95	0.0	0.954	1.150	0.000	-14.460	-14.460
Q2	5	-7.60	1.40	0.50	0.0	0.00	8.32	9.38	0.0	1.144	1.288	0.000	13.740	13.740
B2	9	-9.50	5.50	16.59	0.0	0.00	9.75	13.88	0.0	0.000	0.000	-0.180	0.000	0.000

```
# ------------------------------------
# zeR3513g  Electron Rear  18
#
# beta*_x  beta*_y  gm emit_x gm emit_y  crossing_x  crossing_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 center_y rad1  rad2   length    angle      B     gradient
#           [m]      [m]      [m]     [m]   [m]     [m]      [mrad]    [T]     [T/m]
  Q1eR   -6.200   -0.1550    0.00  0.066  0.0795   1.800    -25.00    0.000   -14.460
  Q2eR   -8.300   -0.2075    0.00  0.0832 0.0938   1.400    -25.00    0.000    13.740
  B2eR  -12.250   -0.3063    0.00  0.0975 0.1388   5.500    -25.00   -0.18     0.000

# ------------------------------------
```

The next magnet (B3?) should not start before 31.6 m to allow a separation of the electron beam from the synchrotron fan. A greater distance or stronger B2eR would be preferred.


Electrons
TBB2gw 8 beR351g
B1eR
Q2eR
Q1eR
mom= 18 (GeV/c)
betax(end)= 88.1
betay(end)= 36.0
emitx0= 22.00 (nm)
emity0= 3.30 (nm)
betax0= 0.830 (m)
betax-max= 228.4 (m)
betay0= 0.080 (m)
betay-max= 400.6 (m)
Beta (m) \rr x \bb y \mm D (mm)
Length z (m)


TBB2gw 8 deR351g
esigs= 15
divxy 163 203
divxy 220 220
B2eR
Q2eR
Q1eR
Horizontal x (cm)