The Q2pF B1pF and other IR Problems

File: 190322-IR8.pdf March 22, 2019

This work was done in close collaboration with Holger with ideas from Brett. It was intended to address the problems Holger & others had seen in Version 5A used in the cost review.

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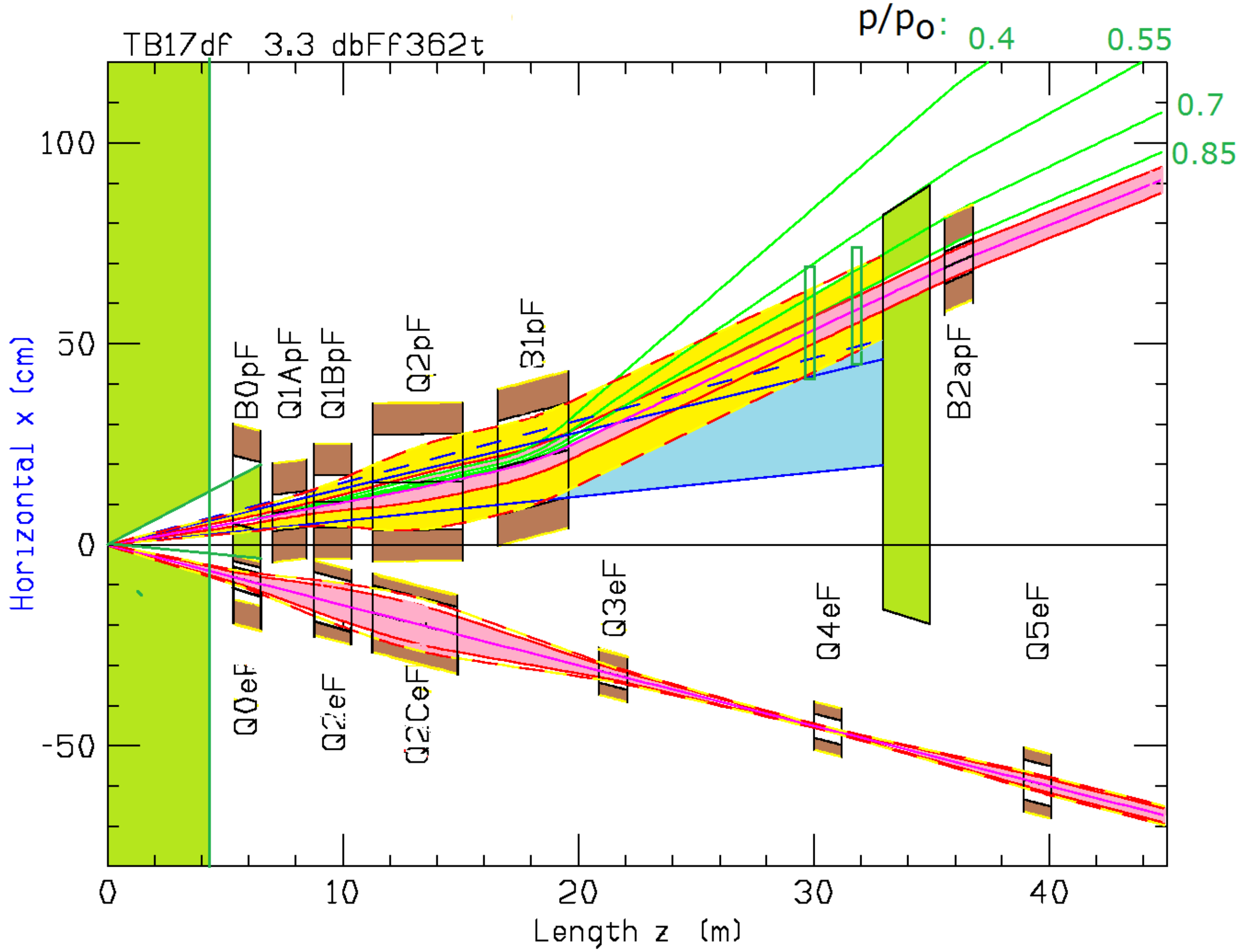
Lattice Requirements

1. Achieve required betas at IP:
   down to 4 cm in y, and down to 50 cm in x
2. Transmit hadrons with angles between 5 and $\approx$ 20 mrad to a forward spectrometer.
3. Transmit 275 GeV, pt $\leq$ 1.3 GeV/c hadrons to Roman pots.
4. Transmit $p/p_o \geq 0.4$ hadrons to a detector.
5. Provide locations for crabs with β_x=1200 m for p, and 250 m for e
6. Minimize all other betas to control chromaticity
7. Minimize fields in all magnets to allow NbTi at 4 K
8. Adequately shield between e and p beams
9. Minimize fan of synchrotron Radiation SR in IP and beyond (REAR)

Parameter Sets

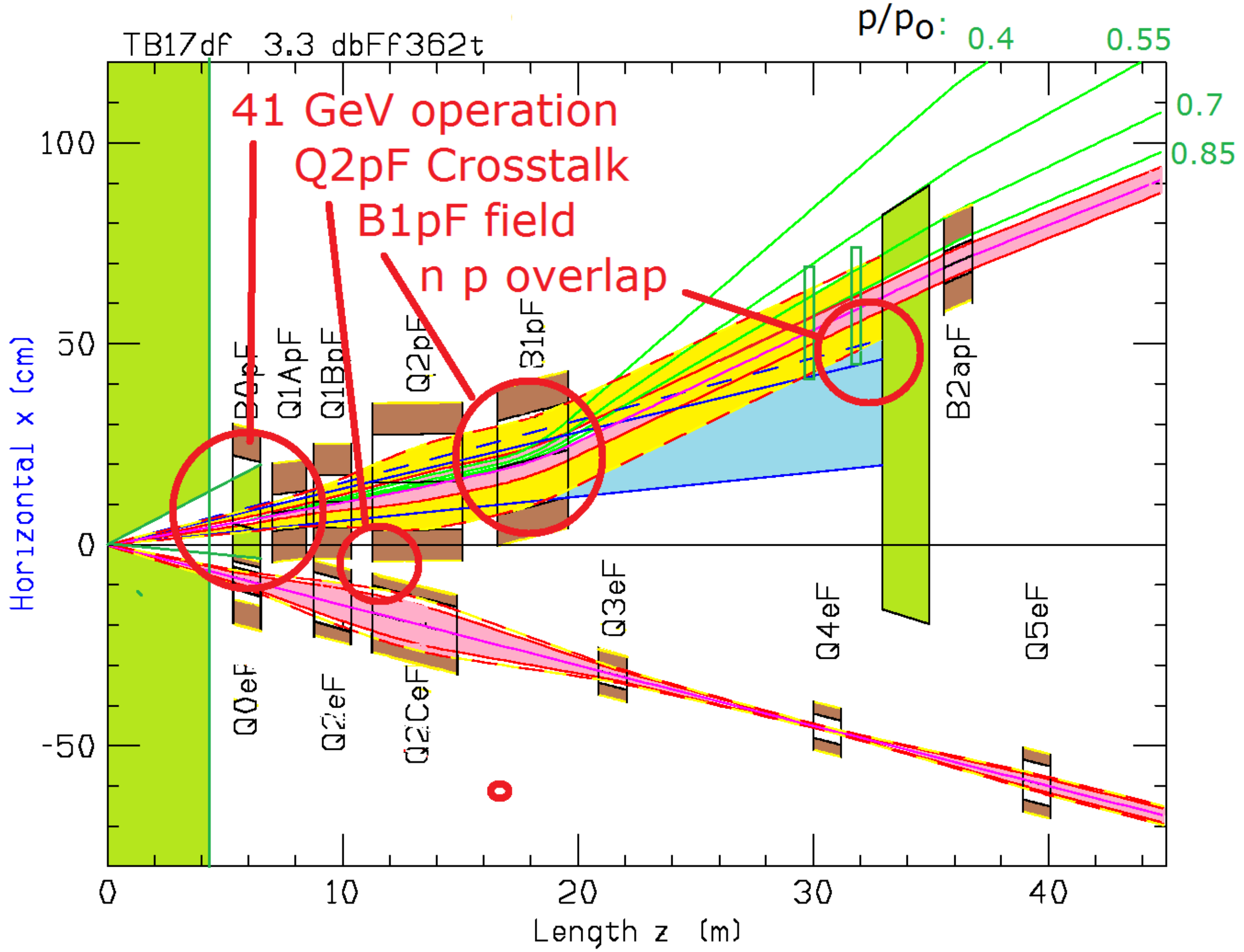
Version 5 file: 190125-IR.pdf, circulated Jan 25, 2019, and used for **Cost Review**. After fixing a program bug, the specifications changed little. Corrected parameters (IR-Parameters 5A) circulated Feb. 18, and given in Appendix 1.



Blue lines define ± 4 mrad. Blue dashes define +5.5 mrad also accepted

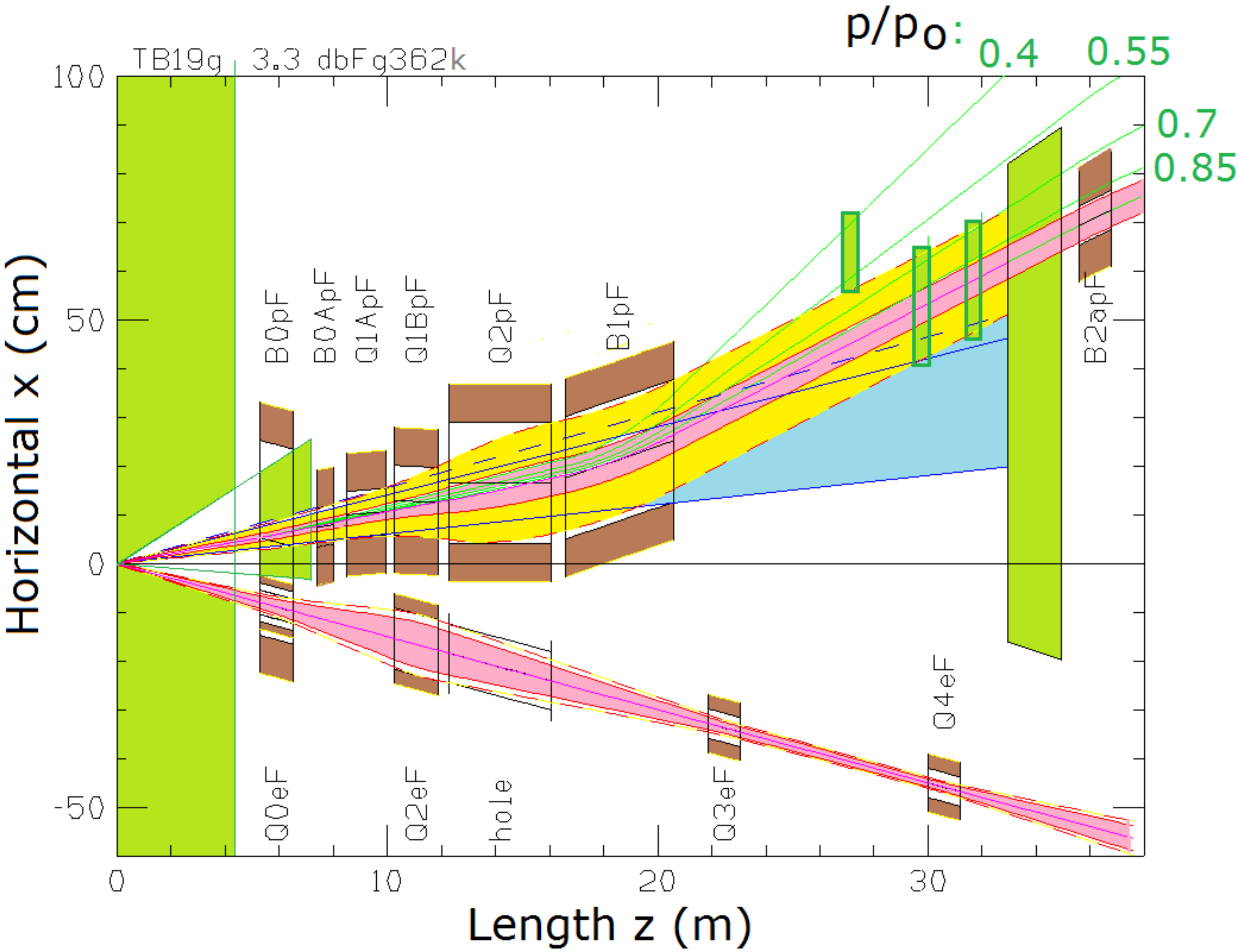
Parameter Sets

Version 5 file: 190125-IR.pdf, circulated Jan 25, 2019, and used for **Cost Review**. After fixing a program bug, the specifications changed little. Corrected parameters (IR-Parameters 5A) circulated Feb. 18, and given in Appendix 1.



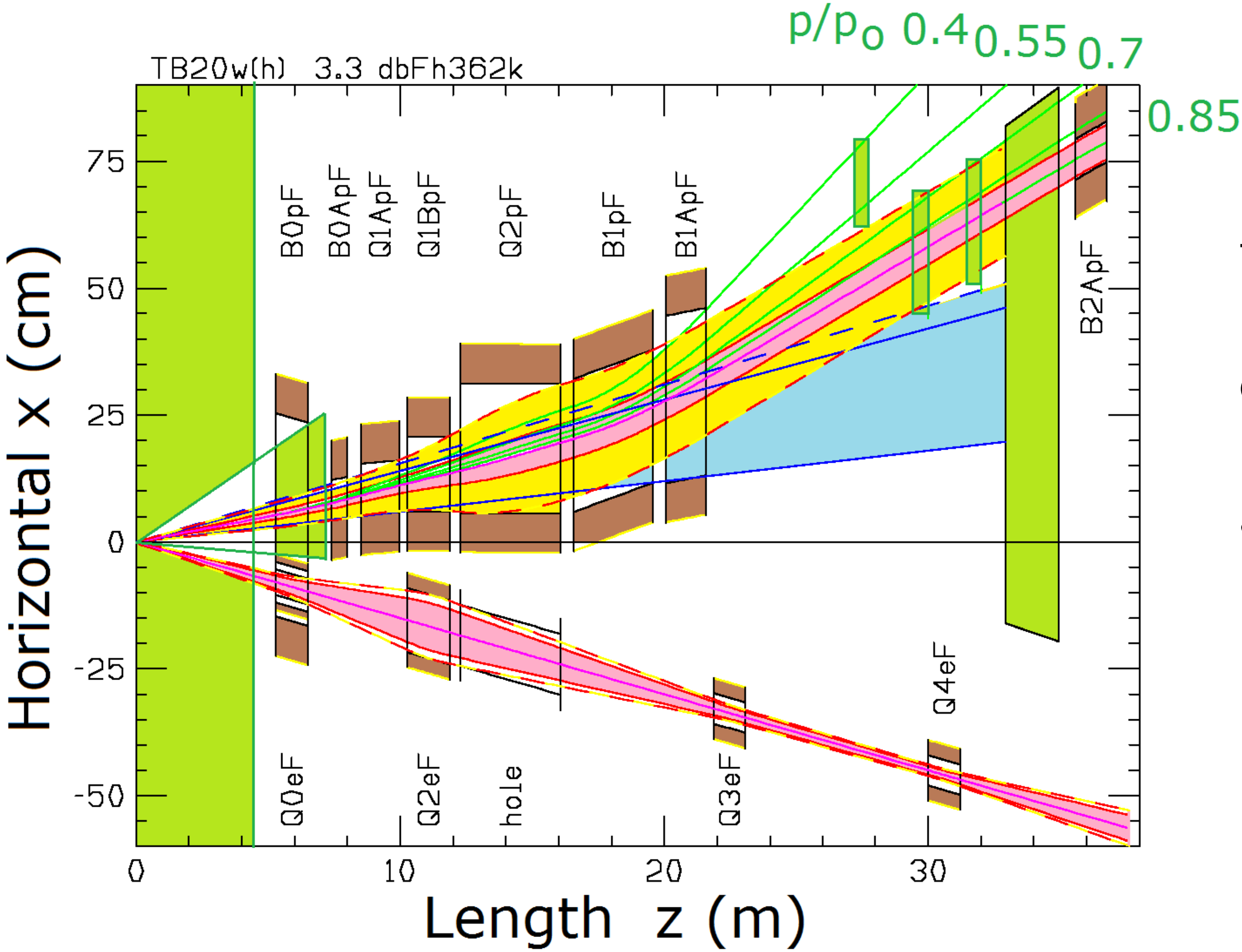
Blue lines define ± 4 mrad. Blue dashes define +5.5 mrad also accepted

Version 6.2, is discussed here: File 190226-IR8.pdf . It has increased L* in response to Holger's concerns with Q2pF. Its parameters are given in Appendix 2.



Blue lines define ± 4 mrad. Blue dashes define +5.5 mrad also accepted

Version 6.3, is discussed here: File 190226-IR8.pdf . It has easier B1pF specifications and better separation between the hadron beams and neutron cone. B1pF has been divided into two. Its parameters are given in Appendix 3.



Blue lines define ± 4 mrad. Blue dashes define +5.5 mrad also accepted

The Problems in Version 5A

1. **Q2pF-Q2CeF crosstalk**

   Excessive crosstalk between Q2pF and its side by side electron Quad Q2CeF at the IP end of the magnets.

2. **B1pF field and aperture**

   Compared with RHIC D0 & DX, B1pF appeared to Holger to be unreasonable.

3. **Displaced orbits at Low momenta**

   Orbits at 100 & 41 GeV with a fixed 1.3 T B0pF spectrometer field were excessively displaced, requiring reductions in B0pF field and lower momentum accuracy.

4. **Separation between hadrons and neutrons**

   Elke had complained that the Version 5A Hadron Neutron separation of 29.75 cm at the start of the neutron detector was inadequate, because Roman pot detectors need to be inside the neutron cone (-4 to +5.5 mrad).

Q2pF approaches considered

1. **Further Increasing the crossing angle.**

   Each additional mrad increases the e-p space 1.13 cm. Several extra mrad would probably be required. Not proposed

2. **Q0eF inside detector**

   If Q0eF is inside the detector, then Q2eF is well short of Q2pF (no side-by side) and the electron beam at Q2pF $<$ 4 cm ($\approx$ 5 cm less than that V 5A) and solving the q2pF problem without increasing L*.

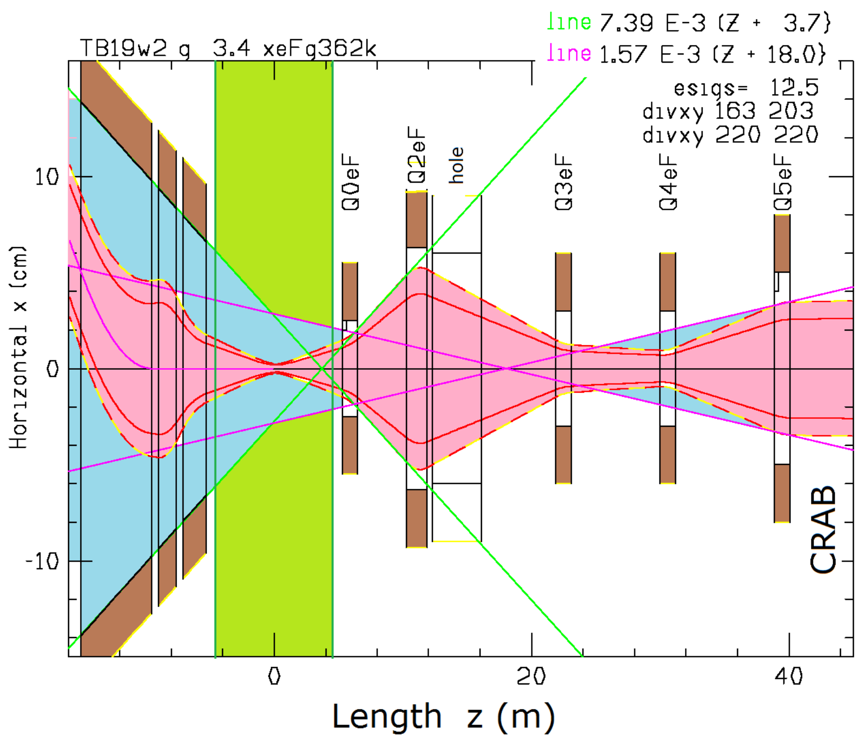
   The design of an inside quad, operating in the central detector solenoid, would be challenging. And Elke objected to it. Not proposed

3. **Versions with increased L***

   Removing electron focus elements from side-by-side of Q2pF, required moving all hadron focus magnets away from the IP - increasing L*, hadron $\beta_y(max)$ and chromaticity. The aperture to aperture space is increased by at least 5 cm, apparently solving the problem. Proposed here

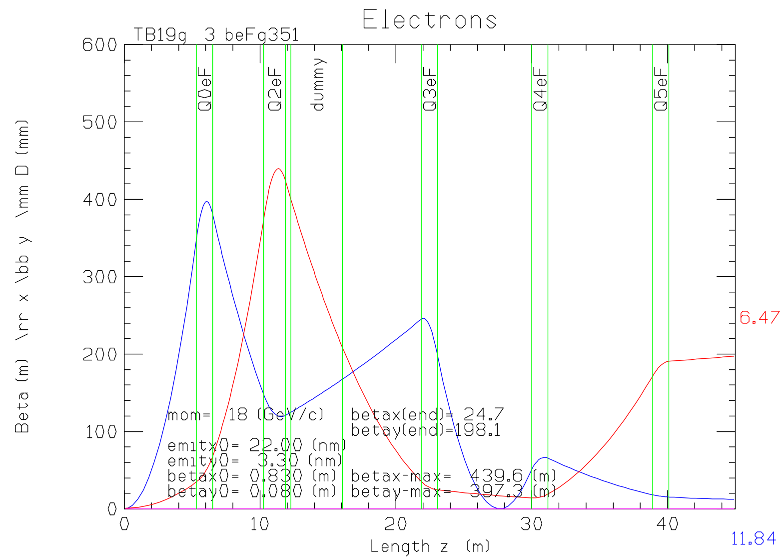
Step 1) No e quad beside Q2pF & SR constraint

To avoid a large e beam size at Q2pF, Q2eF needed to be located before Q2pF. Not trivial because of the constraint on Q1eF strength from the synchrotron radiation fan divergence of 7.5 mrad that defined the rear electron magnet apertures..

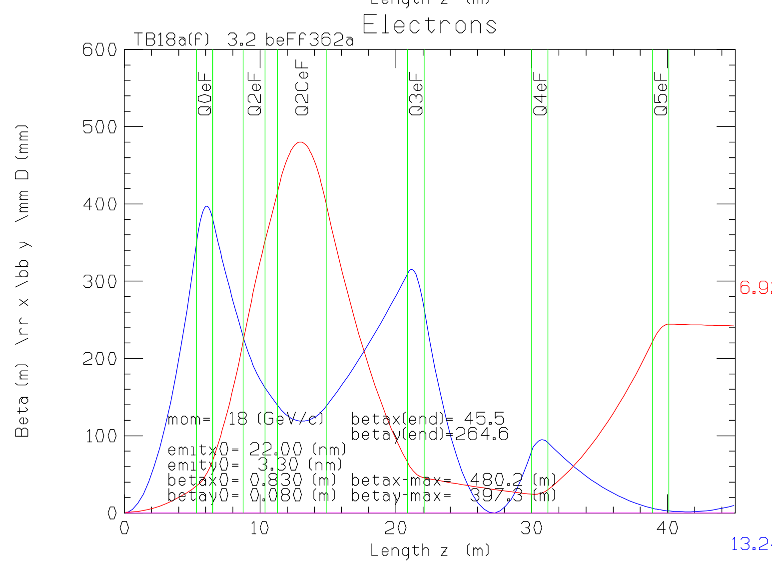


6

Shown matching to the crab beyond 20 m attempts to follow the PCDR lattice. Probably not optimum.



5A



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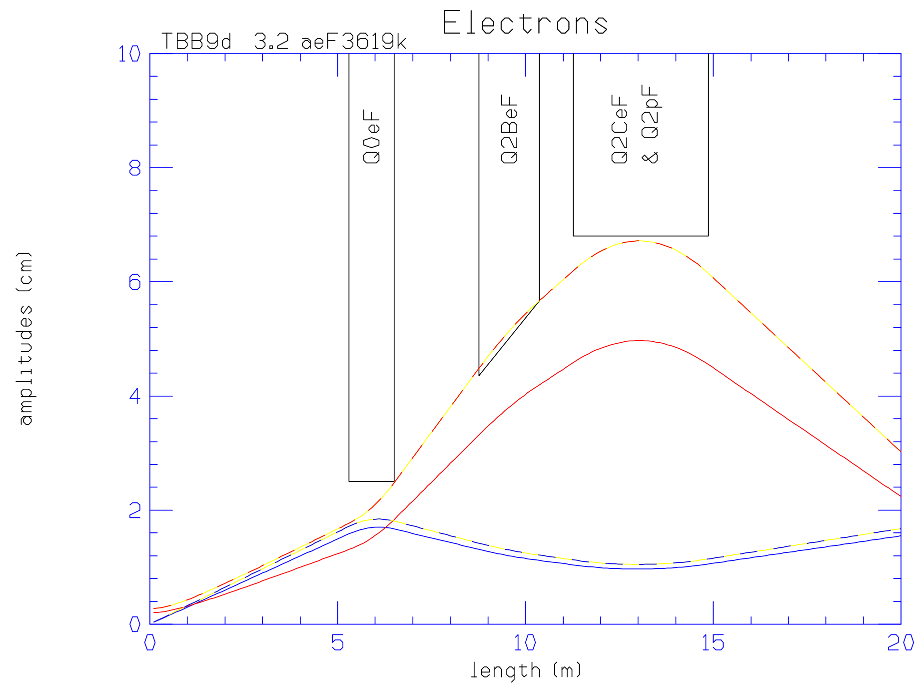
Step 2) Move Q2pF beyond the new Q2eF

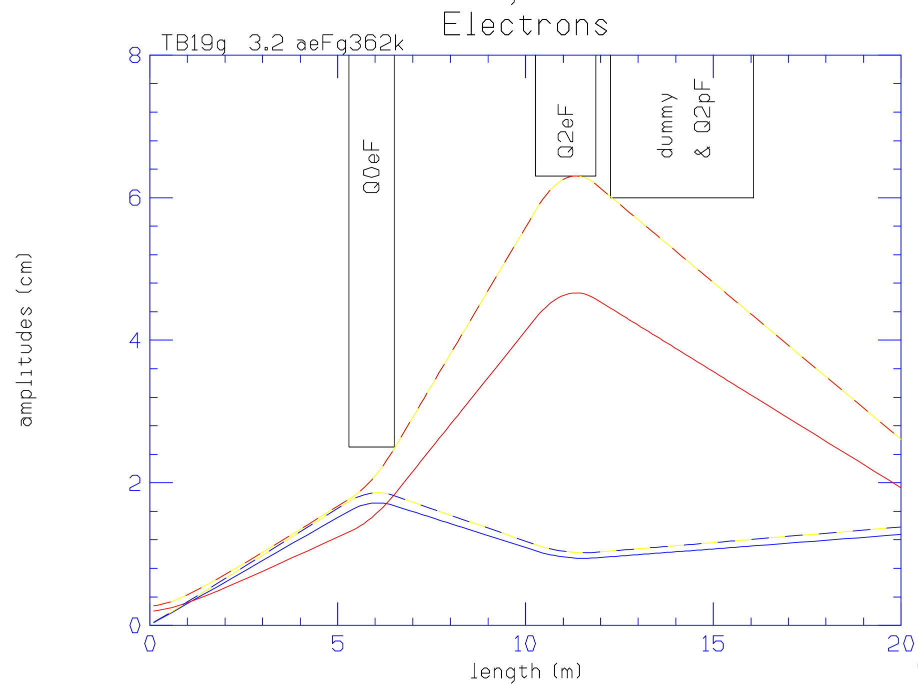
The new electron lattice has the end of Q2eF at 11.87 m compared with V 5A start of Q2pF at 11.27 m.

Q2pF has to move back to avoid a side-by-side situation, and also increases the spacing between beams at Q2pF.

Dashed lines are 15 sigma beam envelope with cooling.



5A



6.2

Step 3) Q1ApF and Q1BpF

An earlier study rejected a single Q1pF unless tapered. They were then split into stepped Q1ApF & Q1BpF. This is used here.

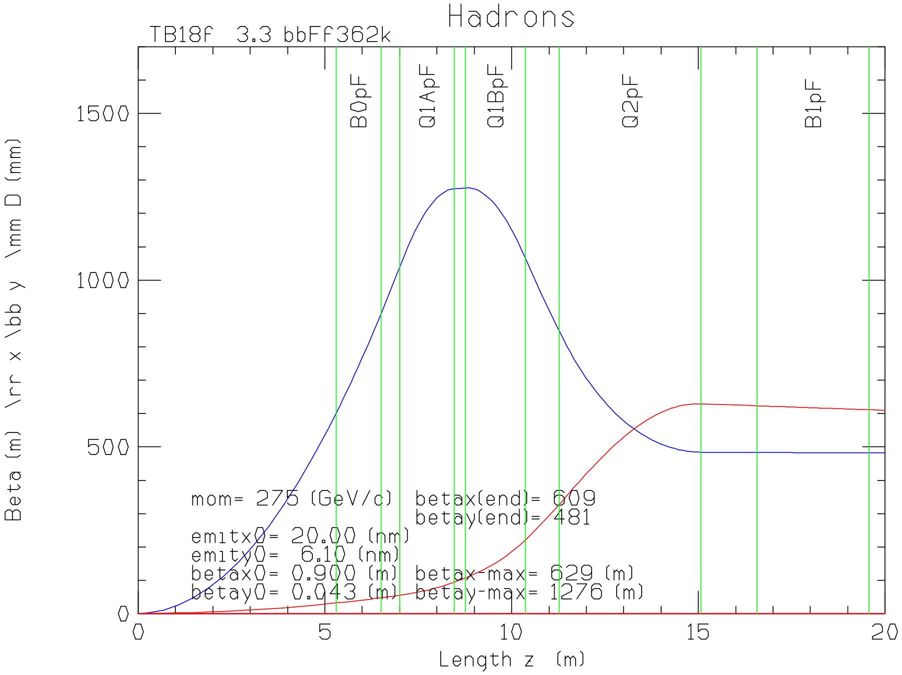
Now Q2pF is back, where to locate Q1ApF & Q1BpF?

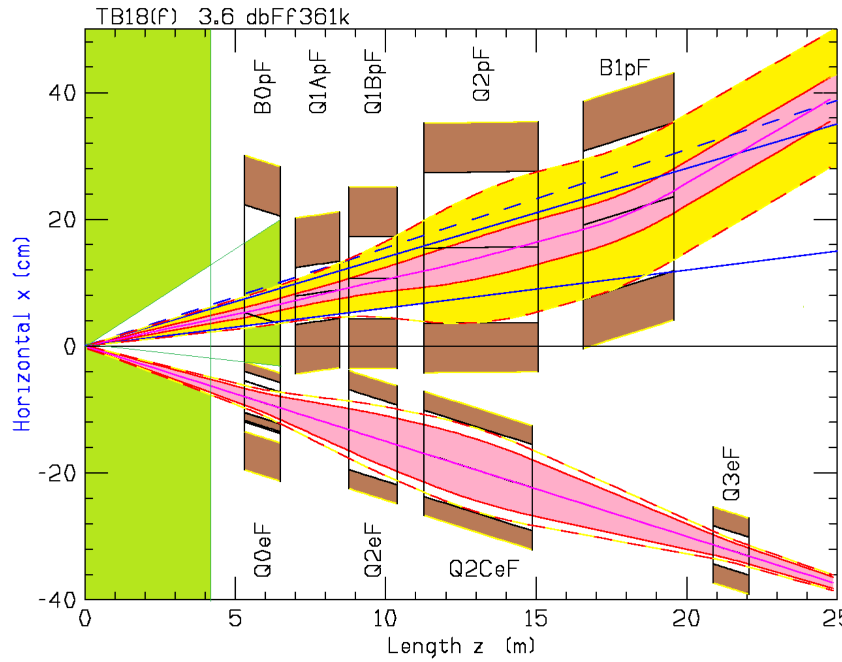
Minimizing Q1BpF-Q2pF spacing (moving Q1ApF & Q1BpF away from IP) minimizes Q2pF aperture, decreases the hadron-electron space and allows doubling spectrometer resolution and better correction of low E orbits.

It raises L*, $\beta_y(max)$, and y chromaticity (by 20% from V 5A, 13% from Brett$'$s current). But it is reasonable that some price must be paid to mitigate the Q2pF & other problems.

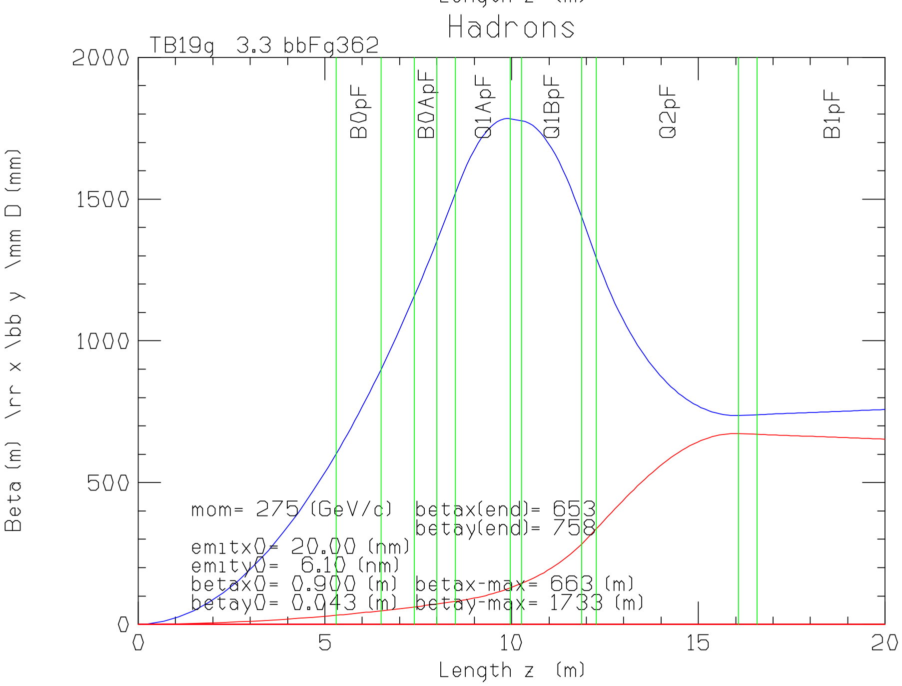
Version	$\hat{\beta}_{py}$ m	chrom$_{py}$	$\hat{\beta}_{ex}$ m	chrom$_{ex}$	chrom$_{ey}$
5A	1276		500	7.46	13.85
6	1783		440	6.47	11.84
factor	1.4	1.2	0.88	0.87	0.85

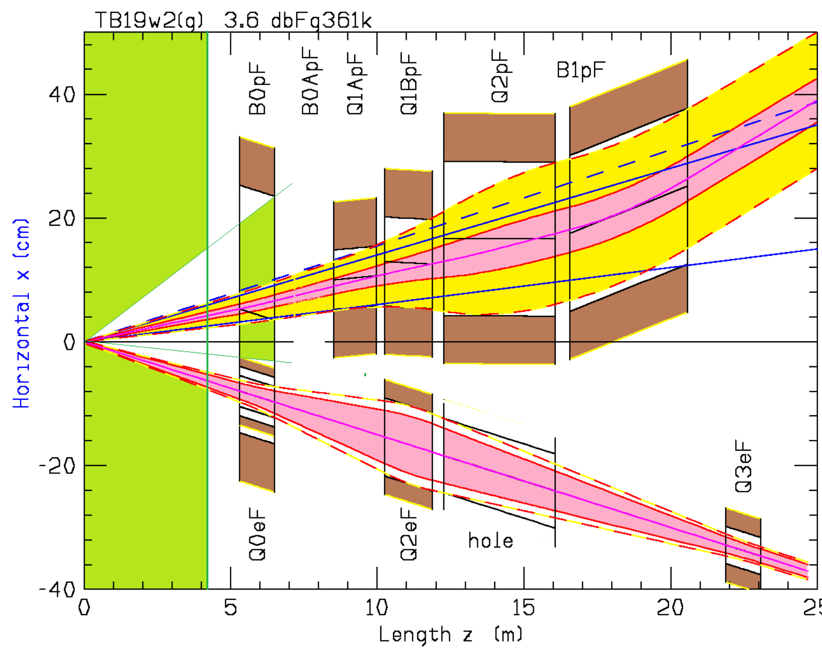
Beta$_p$(x & y) for 5A and new





5A





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4) Uses for space between B0pF and Q1ApF

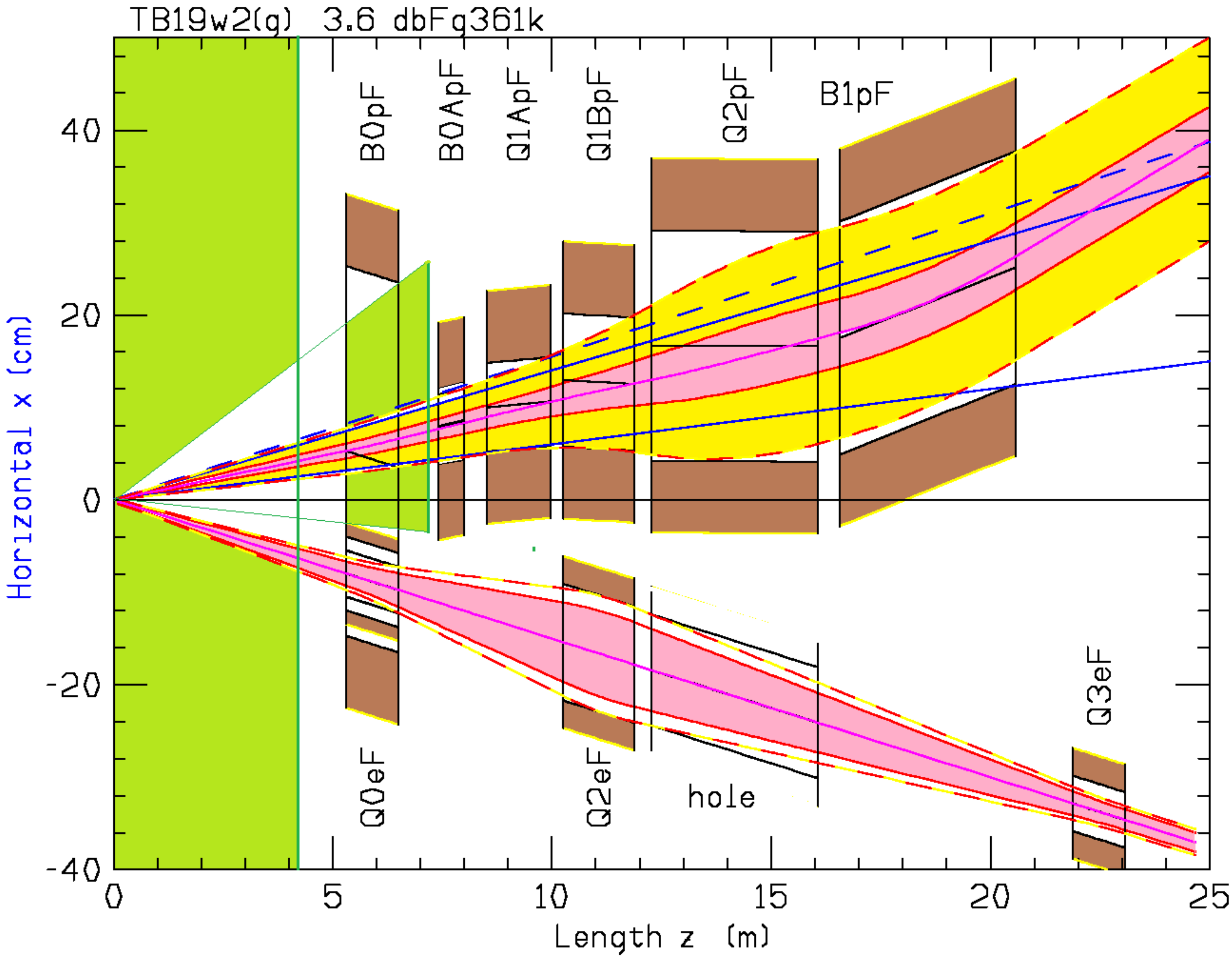
The increased space between B0pF and Q1Apf now allowed three improvements:

4a The spectrometer detectors associated with B0pF could be extended at least 60 cm beyond the end of B0pF. The displacement and momentum measured accuracy is doubled.

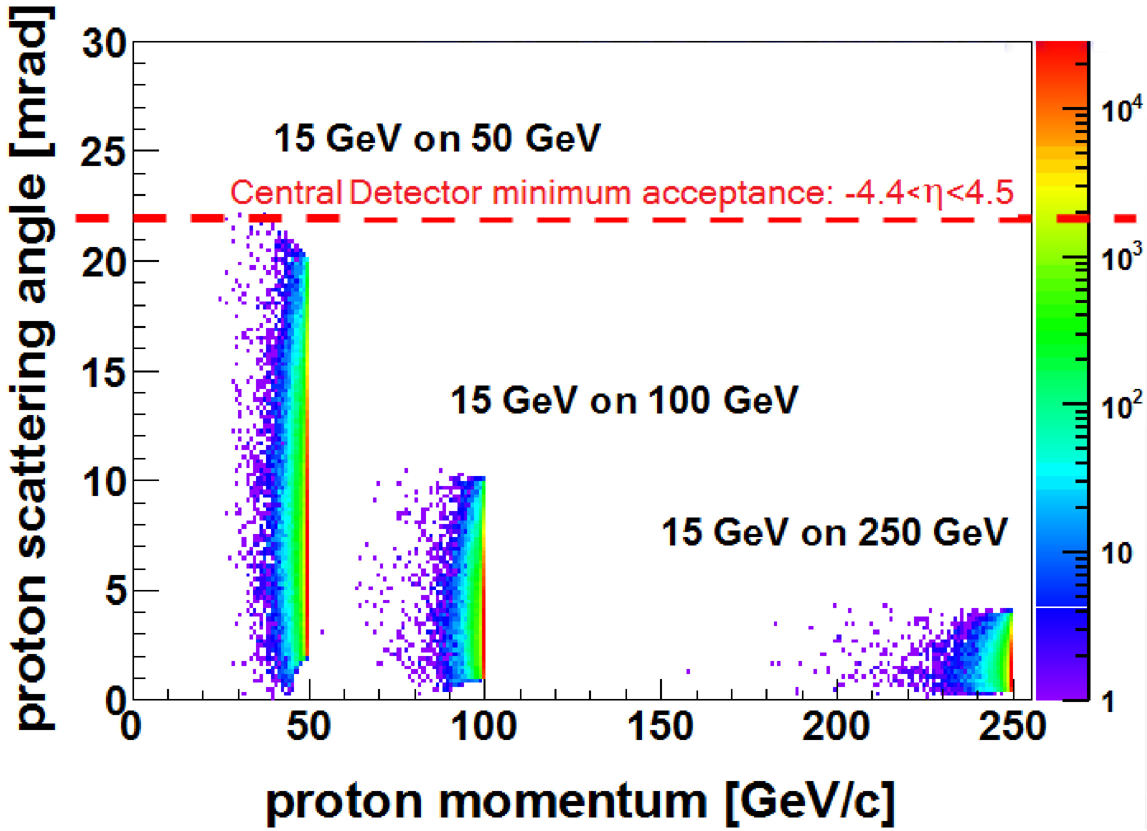
4b A corrector dipole B0ApF can be inserted before Q1ApF to correct, close to its source, the strong upward deflections by B0pF (operating at 1.3 T) at the lower momenta of 100 and 41 GeV/c.

4c This early corrector dipole B0ApF can also be used (in V 6.3) to give upward deflections at all momenta, increasing the electron and protons separation at Q1ApF, Q1BpF, and Q2pF. This was NOT done in version 6.2 because it greatly increased the aperture of B1pF that must accept both the upward displaced protons and the un-displaced neutron cone and exceeded the criterion for what is practicable (see slides 22 & 23).

Layout of V 6.2 (with spectrometer extension and B0ApF)

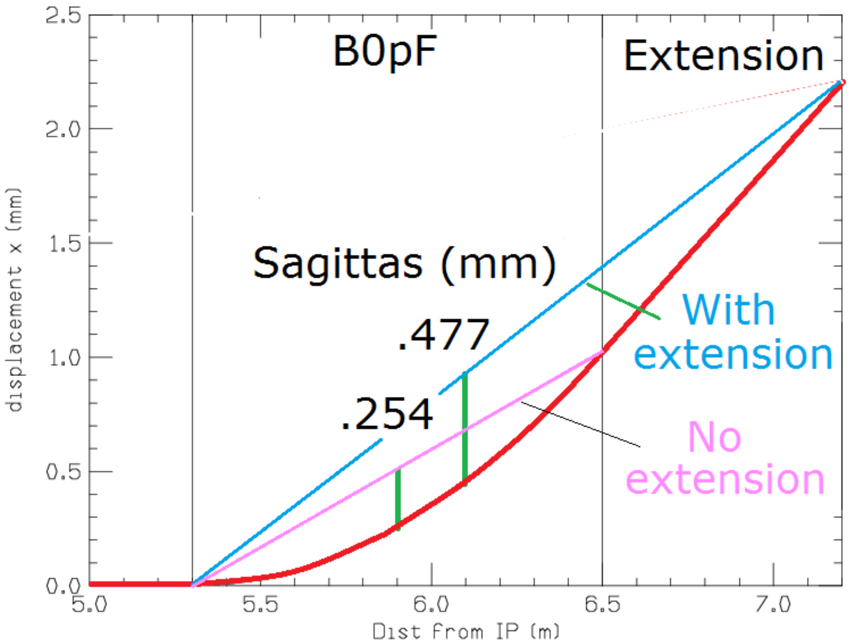


4a) Diffractive Physics



- Forward protons at 275 GeV/c will be observed in Roman Pots.
- Forward protons at 100 and 41 GeV/c will be observed in Roman Pots below 5 mrad and in the forward spectrometer under B0pF above that.
- Momentum spreads $\approx$ 20 % so desired resolution is $\leq \quad \approx$ 2%.
- With 25 micron resolution and Version 5A , the 100 GeV resolution is 6% (2.5% at 41 GeV) and appears inadequate.

Extended detectors after B0pF

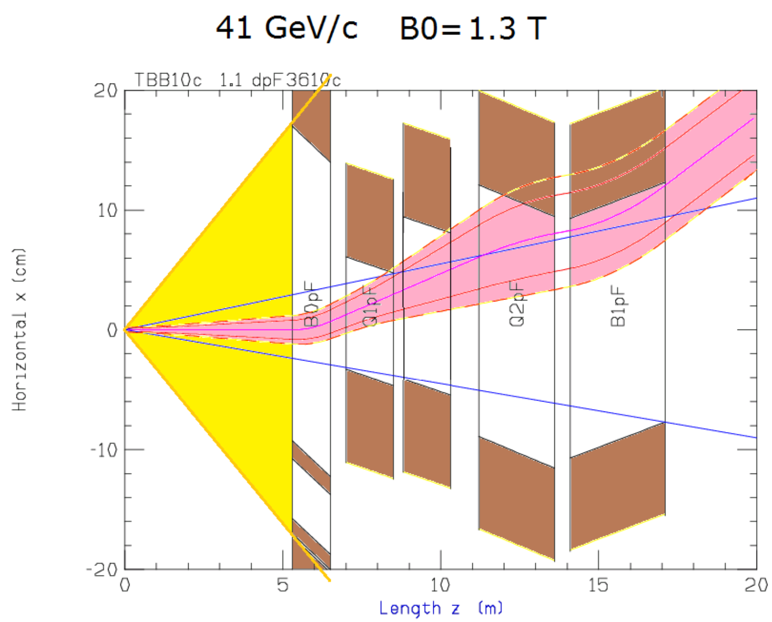


Assuming 3 point measurement to 25 microns, momentum resolution in 1.2 m B0pF at 100 GeV/c is only 6.2%. This can be reduced to 3.3 % if the detector is extended 70 cm beyond the magnet.

Mom		No extension	With extension
275 GeV/c	Sagitta (mm)	0.25	0.48
	rms dp/p (%)	**17**	**9**
100 GeV/c	Sagitta (mm)	0.69	1.32
	rms dp/p (%)	**6.2**	**3.3**
41 GeV/c	Sagitta (mm)	1.68	3.22
	rms dp/p (%)	**2.5**	**1.3**

4b) Correction of orbits for lower Energies

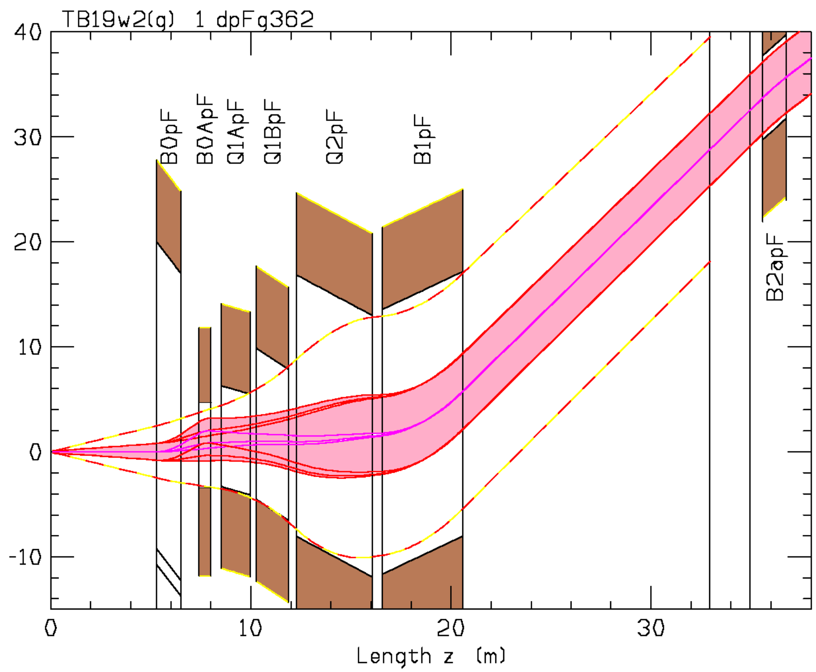
- The deflection in B0pF at 275 GeV/c is 1.3 mrad, but at 41 GeV/c it is 8.8 mrad: a difference of 7.5 mrad.
- If uncorrected, the beam at 41 GeV/c soon leaves the beam pipe.



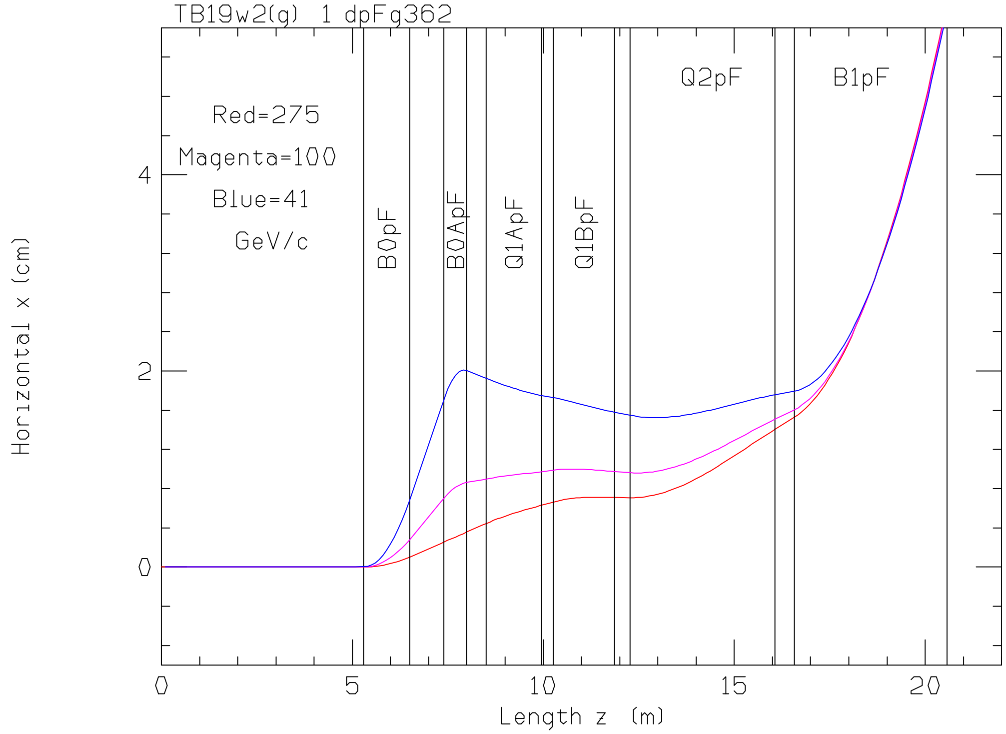
- If corrected only after Q1ApF the beam′s maximum displacement is 2.5 cm.
- If corrected before Q1ApF it is reduced to 1.3 cm.
- Correcting near the source helps.

Orbits vs Energy

Superimposed 41, 100, 275 GeV for V 6.2. Orbits identical after B1pF.



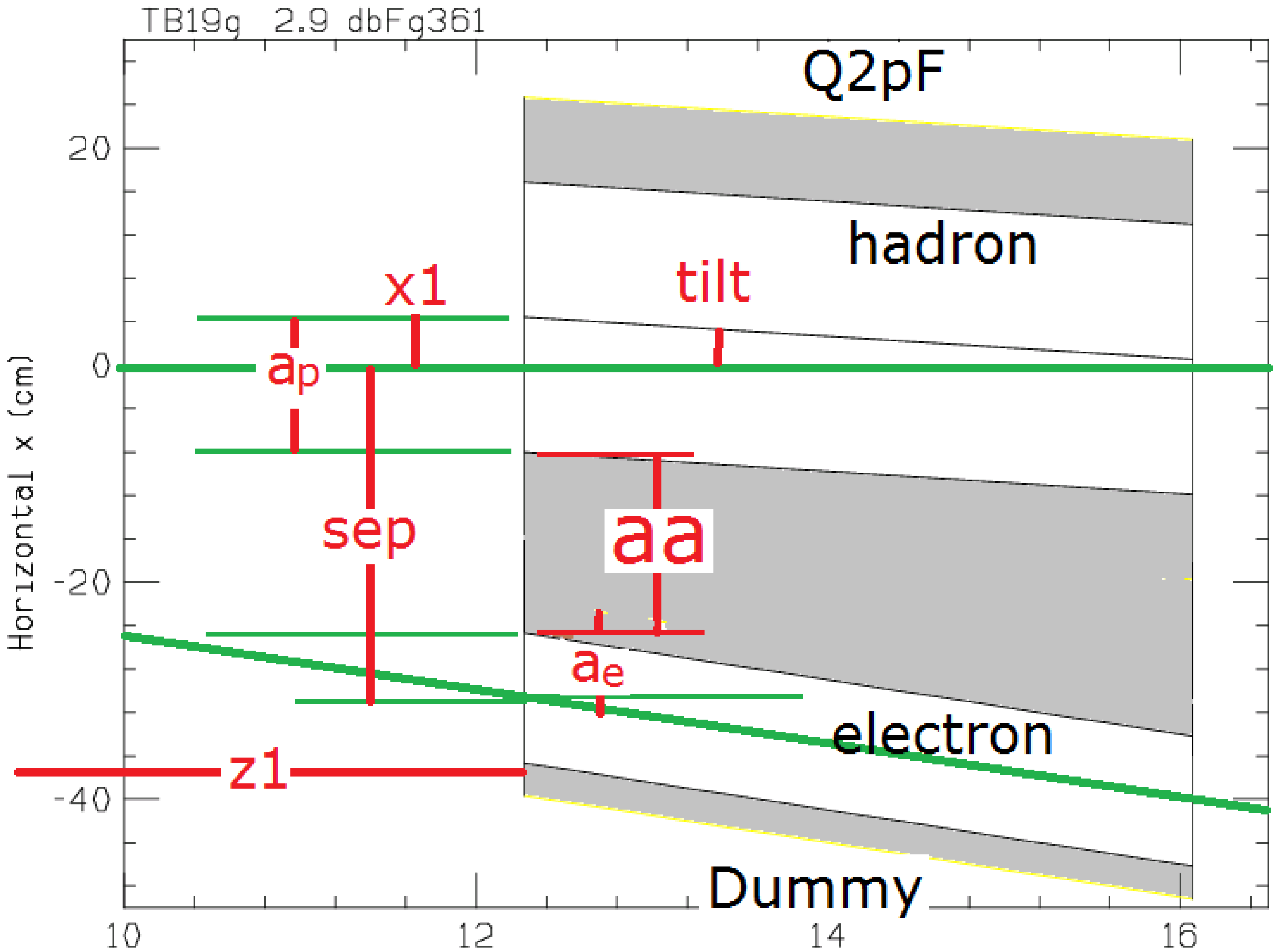
10 sigma beams



beam axes

Momentum GeV/c	Max offset cm	B0pF T	B0ApF T	B1pF T
275	0	1.3	-3.3	-3.4
100	.51	1.3	+1.03	-1.30
41	1.68	1.3	+2.49	-0.589

Results 1) Q2pF Aperture-aperture separation



a-a = sep + x1 - a_p - a_e sep = z1 x 0.025

Gains in aperture separation (aa) in Q2pF

	L1	L2	sep	x1	e app	p app	grad	B_{pt}	aa	gains
	m	m	m	m	m	m	T/m	T	m	cm
5A	11.27	15.07	.2817	0.042	0.087	0.119	38.7	4.60	0.1177	**0**
6.2	12.27	16.07	30.67	0.044	0.06	0.124	40.7	5.07	0.1668	**4.9**
6.3	12.27	16.07	30.67	0.062	0.06	0.127	40.7	5.07	0.1847	**6.7**

Larger separation aa (proton aperture to electron hole aperture) eases cross-talk and allows space for correctors or vacuum insulation.

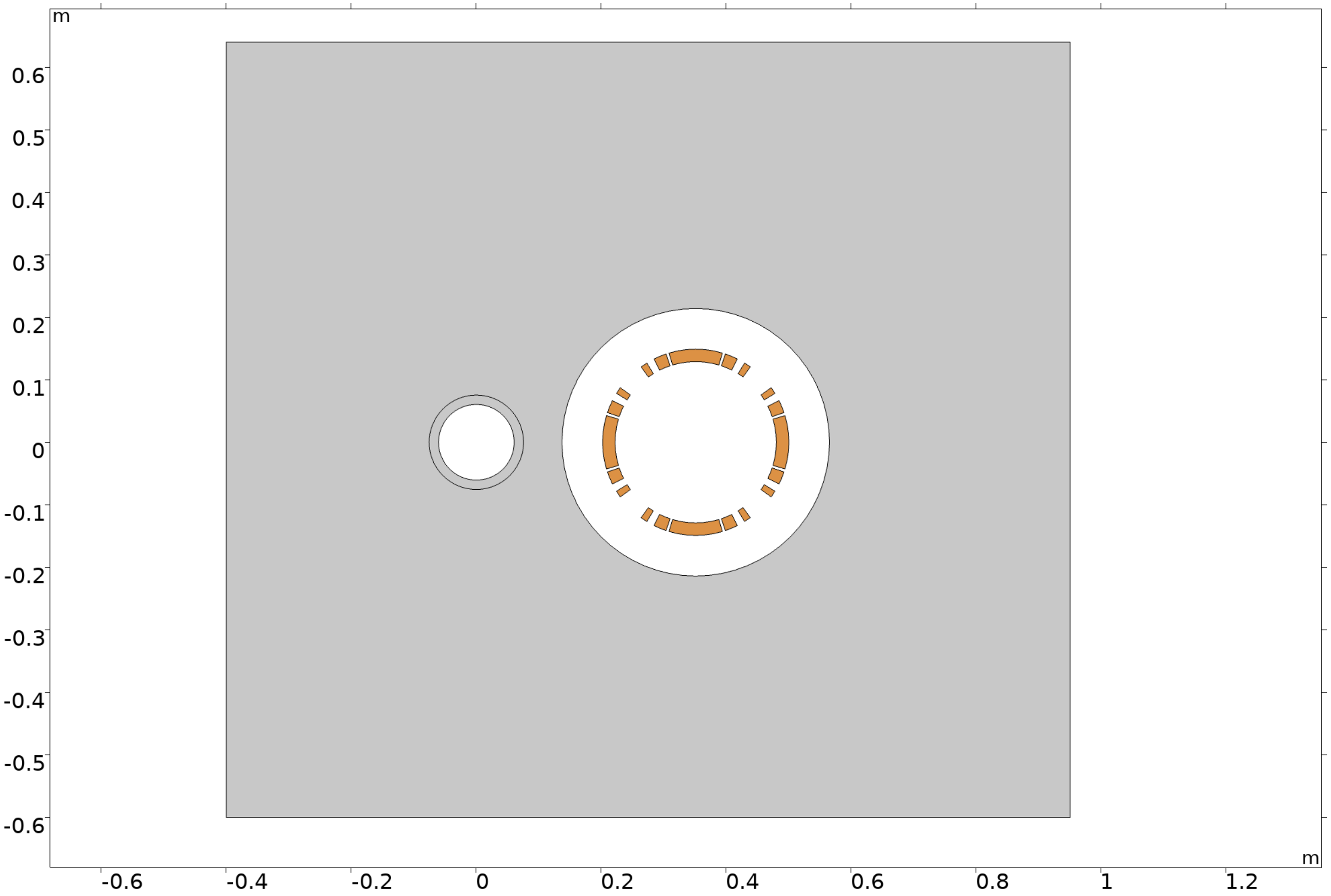
aa Gain in V 6.2 (4.9 cm) is ≈ equally from greater beam-beam separation (2.5 cm) and smaller e beam (2.7 cm).

In V6.3 the gain increases by almost another 2 cm from the greater vertical beam shift (X1) from B0ApF.

Note that not tilting Q2pF would lose 4.4 cm: almost all the V 6.2 gain and 2/3 of 6.3 gain. Probably not viable

V 6.2 Q2pF Holger Design

At IP end of Q2pF



Easier with V 6.3 allows correctors/vacuum insulation etc.

Dipole magnet criteria of difficulty

Possible criteria are: the mid-plane azimuthal force per unit length (related to azimuthal motion and pre-compression) $\propto D1 = B^2A$;

and the stored energy per unit length $\propto D2 = (BA)^2$.

Both are given for the maximum performances of RHIC D0 and DX.

	A m	B T	$(BA)^2$ $(Tm)^2$	B^2A $T^2\ m$
D0 maximum	.05	5.35	.07	**1.43**
DX maximum	.09	4.72	.18	**2.0**

The greater similarity of B^2A for the two magnet sizes suggests that this is the better criteria to use.

For this we assume a safe operating value of **D2≈1.43.**

Results 2) Criteria applied to B1pF (& B1ApF)

Using the above criterion, B1pF in Version 5A is clearly beyond what can be specified without significant study and possible R&D.

Version 6.2 is better but still challenging.

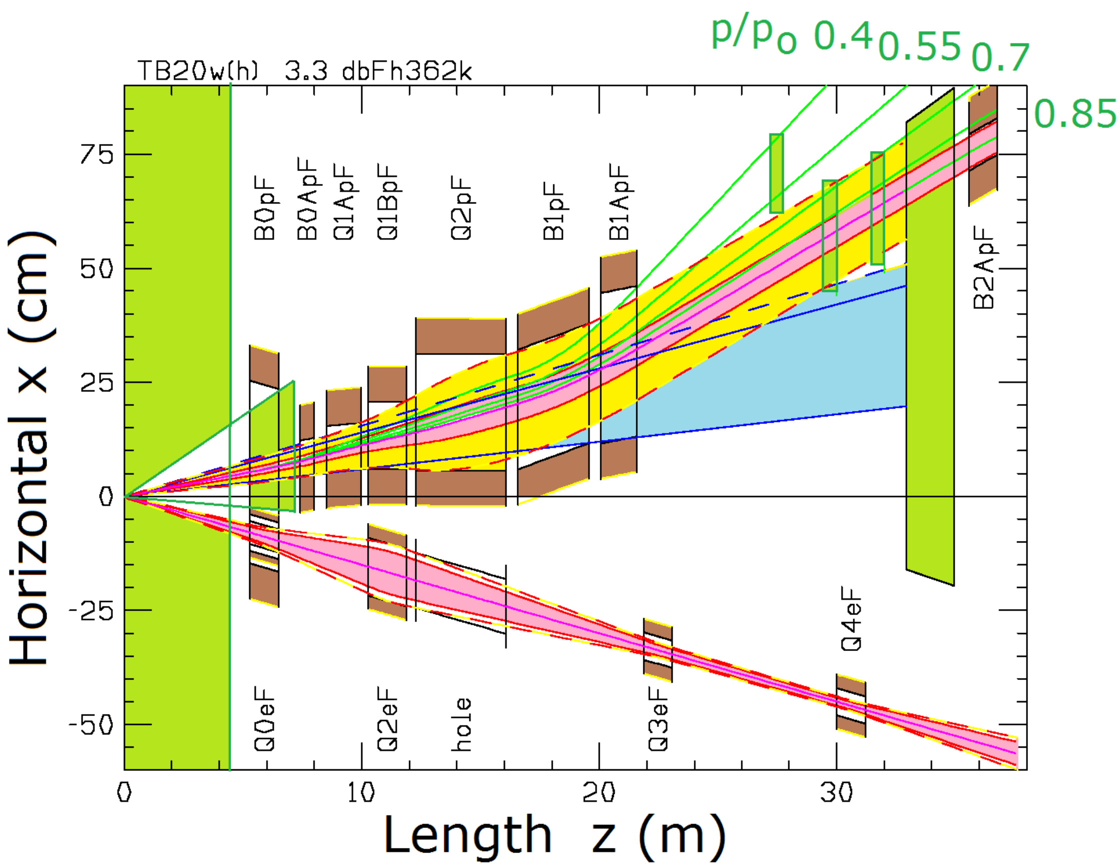
In Version 6.3, if balanced, both magnets meet the criterion.

	A m	B T	$(BA)^2$ $(Tm)^2$	$B^2\ A$ $T^2\ m$	
V 5A B1pF	.119	4.57	.3	**2.5**	**X**
V 6.2 B1pF	.126	3.71	.2	**1.73**	**?**
V 6.3 B1pF	.136	3.4	.22	**1.57**	**?**
V 6.3 B1ApF	.165	2.7	.20	**1.2**	**ok**
V 6.3 balanced			0.21	**1.45**	**ok**

2 magnets, vs. 1, could cost more but easier magnets less.

Results 3) Hadron-Neutron separation

Version	sep cm	sep-sep(5A) cm	
5A	**29.7**	**0**	After correction
6.2	**31.63**	**1.9**	Increased L* solution
6.3	**35.8**	**6.1**	B1pF split to B1pf and B1Apf



This was not the primary aim of versions 6.2 and 6.3, but surely welcome to Elke et al.

Conclusion

- The cost review IR had 2 magnet, and 2 other, problems
- Moving Q2pF beyond the earliest placed Q2eF avoids side-by side magnets for Q2pF
- Moving Q1Apf and Q1Bpf close to Q2pF (in V 6.2) :
  1. Minimized aperture of Q2pF
  2. Allowed spectrometer extension halving errors
  3. Allowed Corrector dipole B0ApF for low E orbits
  4. But raised hadron y chromaticity by 20% (13% from Brett)
- Breaking B1pF (in V 6.3) into an initial lower aperture, and later larger aperture but lower field, magnets:
  1. Reduced the difficulty criteria of these magnets to that of D0 & DX RHIC magnets
  2. Allowed an increased e-p separation in all quads, and increased the p-n separation at the Roman pots.

Appendix 0: Parameter list 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 Z axis
- The term "Baseline" is used for 140 GeV c of m, High Divergence, No Cooling. Apertures for other cases estimated by scaling their greater divergences.
- Gradients given are only approximate because:
  - Matching will likely change them
  - My program is not exact

Appendix 1: Parameters 5A

```
#
# ------------------------------------
# TB18f  zpFf362 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    x1       x2
#            [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  0.0000  -0.0300
  Q1ApF    7.730   0.0067  0.045  0.045   1.46   -3.2   0.00  -80.251    -3.611   0.0090   0.0043
  Q1BpF    9.565   0.0119  0.065  0.065   1.61  -10.0   0.00  -66.180    -4.302   0.0200   0.0039
  Q2pF   13.170   0.0239  0.119  0.119   3.80   -9.5   0.00   38.700     4.605  0.0420   0.0059
  B1pF   18.070   0.0325  0.117  0.117   3.00    5.0  -4.57    0.000     0.000  0.0250   0.0400
  B2apF   36.170   0.3430  0.040  0.040   1.20   15.6   3.30    0.000     0.000   0.3336   0.3523
  B2bpF   47.370   0.5120  0.040  0.040   1.20   20.0  -0.00    0.000     0.000   0.5000   0.5240
#
# name    center_z    x(beam)  theta    Bdist1   Bdist2    alphax     betax    alphay      betay
#            [m]         [m]     (mrad)    (T)      (T)                 [m]                    [m]
  B0pF    5.900     0.0003     0.851    0.000     0.000    -6.546    39.567  -123.503   742.602
  Q1ApF    7.730     0.0030     1.359    0.431     0.163  -12.980    70.208   -82.829  1209.340
  Q1BpF    9.565     0.0050     0.574    0.746     0.181  -34.295   151.798    67.998  1225.264
  Q2pF   13.170     0.0087     2.504   -1.008    -0.137  -44.062  544.792    43.254   563.182
  B1pF   18.070     0.0281    10.265    0.000     0.000     1.973  617.389     0.239   482.849
  B2apF   36.170     0.3430    15.583    0.000     0.000     1.830   548.553     0.199   474.921
  B2bpF   47.370     0.4940    13.424    0.000     0.000     1.741   508.560     0.175   470.734
#------------------------------------
```

Appendix 2: Parameters 6.2

```
#
# ------------------------------------
# TB19w2(g)  zbFg362 v 6.2 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    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   0.0080  0.040  0.040   0.60    0.0  -0.00     0.000     0.000  0.0080   0.0080   0.1930   0.2080
  Q1ApF    9.230   0.0110  0.048  0.048   1.46   -5.5   0.00   -72.608    -3.485  0.0150   0.0070   0.2275   0.2560
  Q1BpF   11.065   0.0168  0.072  0.072   1.61  -12.5   0.00   -66.180    -4.765  0.0269   0.0068   0.2834   0.3035
  Q2pF   14.170   0.0247  0.124  0.124   3.80  -10.2   0.00    40.737     5.072  0.0441   0.0053   0.3508   0.4071
  B1pF   18.570   0.0275  0.126  0.126   4.00    9.0  -3.71     0.000     0.000  0.0095   0.0455   0.4238   0.5598
  B2apF   36.170   0.3474  0.040  0.040   1.20   17.0   3.00     0.000     0.000  0.3372   0.3576   1.2264   1.2768
  B2bpF   47.370   0.5126  0.040  0.040   1.20   14.7   0.00     0.000     0.000  0.5037   0.5214   1.6730   1.7206
#
# name    center_z    x(beam)  theta   Bdist1   Bdist2    alphax    betax    alphay      betay
#           [m]         [m]     (mrad)    (T)      (T)                [m]                  [m]
  B0pF   B0   5.900    0.0003    0.851     0.000     0.000    -6.546    39.567  -123.503   742.602
  B0ApF   B0A   7.700    0.0031     1.702     0.000     0.000    -8.541    66.722  -160.477   1253.766
  Q1ApF   Q1A   9.230    0.0055     1.240     0.580     0.222   -15.888    99.301   -91.099   1722.641
  Q1BpF   Q1B  11.065    0.0071     0.197     0.987     0.308   -41.763   198.363   109.055   1680.591
  Q2pF   Q2  14.170    0.0094     2.166    -1.080    -0.136   -49.176   578.695    65.625   850.979
  B1pF   B1  18.570    0.0283    10.535     0.000     0.000     2.444   660.513    -2.651   750.176
  B2apF   B2a  36.170    0.3474    16.659     0.000     0.000     2.258   577.751    -2.839    846.797
  B2bpF   B2b  47.370    0.5126    14.696     0.000     0.000     2.140   528.490    -2.959    911.735
#------------------------------------
#
```

```
# ------------------------------------
# TB19w2(g)  zbFg362 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    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  0.025   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
  14.170  -0.3543  0.060  0.060   3.80   25.0   0.00     0.000     0.000   0.0000   0.0000   0.3067   0.4017
  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
  B2beF   45.700  -1.1425  0.040  0.040   1.20   25.0   0.00     0.000     0.000   0.0000   0.0000   1.1275   1.1575
#
# name    center_z    x(beam)  theta   Bdist1   Bdist2    alphax    betax    alphay      betay
#           [m]         [m]    (mrad)    (T)      (T)                [m]                  [m]
  Q0eF    5.900    0.0000     0.000    0.000    0.000   -13.149    46.060   -14.487   394.869
  Q2AeF    7.730    0.0000     0.000    0.000    0.000   -35.034   140.924    33.430   292.532
  Q2eF   11.065    0.0000     0.000    0.000    0.000   -16.194   434.984     7.913   123.004
  dummyeF   14.170    0.0000     0.000    0.000    0.000    25.221   296.272    -5.623   145.425
  Q3eF   22.470    0.0000     0.000    0.000    0.000     4.244    27.792    20.747   237.235
  Q4eF   30.600    0.0000     0.000    0.000    0.000    -1.859    15.152    -5.930    64.370
  Q5eF   39.500    0.0000     0.000    0.000    0.000    -8.172   185.403     1.192    16.335
  B2beF   45.700    0.0000     0.000    0.000    0.000    -0.698   198.366     0.038    12.359
#-----------------------------------
#
```

Appendix 3: Parameters 6.3

```
#
# ----------------------------------
# TB20w(h)  zpFh362 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    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   0.0080  0.040  0.040   0.60    0.0  -3.30     0.000     0.000   0.0080   0.0080   0.1930   0.2080
  Q1ApF     9.230   0.0140  0.051  0.051   1.46   -5.5   0.00   -72.608    -3.703   0.0180   0.0100   0.2305   0.2590
  Q1BpF    11.065   0.0228  0.073  0.073   1.61  -10.0   0.00   -66.180    -4.831   0.0309   0.0148   0.2874   0.3115
  Q2pF    14.170   0.0427  0.127  0.127   3.80  -10.2   0.00    40.737     5.194   0.0621   0.0233   0.3688   0.4251
  B1pF    18.070   0.0380  0.131  0.131   3.00    9.0  -3.40     0.000     0.000   0.0245   0.0515   0.4387   0.5408
  B1ApF    20.820   0.0800  0.165  0.165   1.50    0.0  -2.70     0.000     0.000   0.0800   0.0800   0.5817   0.6192
  B2ApF    36.170   0.8907  0.040  0.040   1.20   20.0   3.00     0.000     0.000   0.8787   0.9027   1.7680   1.8220
  B2bpF    47.370   1.3064  0.040  0.040   1.20   35.8   0.00     0.000     0.000   1.2850   1.3279   2.4542   2.5271
#
# name     center_z    x(beam)  theta   Bdist1   Bdist2    alphax    betax    alphay      betay
#            [m]         [m]    (mrad)    (T)      (T)                [m]                  [m]
  B0pF   B0   5.900    0.0006     2.127     0.000     0.000    -6.546    39.567  -123.503    742.602
  B0ApF   B0A   7.700    0.0081     6.955     0.000     0.000    -8.541    66.722  -160.477   1253.766
  Q1ApF   Q1A   9.230    0.0225     9.827    -0.086    -0.413   -24.917   105.267    50.341   1620.662
  Q1BpF   Q1B  11.065    0.0419    11.265    -0.281    -0.736  -114.333   323.374   319.290    769.026
  Q2pF   Q2  14.170    0.0804    11.497     0.267     0.930   -80.214  1543.746   -57.891     62.188
  B1pF   B1  18.070    0.1220    20.607     0.000     0.000   141.072   533.862  -485.845   2087.753
  B1ApF   B1A  20.820    0.2087    40.052     0.000     0.000    38.552    39.891  -796.763   5614.975
  B2ApF   B2A  36.170    0.9046    40.659     0.000     0.000    -7.968  7024.967  %-2532.243  %56715.930
  B2bpF   B2b  47.370    1.3064    35.750     0.000     0.000    -8.071  7204.611  %-3798.502  %127620.227
#----------------------------------
#
```

Electron parameters for V 6.3 the same as for V 6.2