# ATF2 Q magnets

## FF magnets

| Qname | length[m] | K1[1/m] | # | T/m |
|---|---|---|---|---|
| QM16 | 0.2 | -0.366 | 1 | -7.93 |
| QM15 | 0.2 | 0.564 | 1 | 12.22 |
| QM14 | 0.2 | -1.664 | 1 | -36.053333 |
| QM13 | 0.2 | 0.52 | 1 | 11.2666667 |
| QM12 | 0.2 | 0.882 | 1 | 19.11 |
| QM11 | 0.2 | -0.0019 | 1 | -0.0421633 |
| QD10 | 0.2 | -0.314 | 2 | -6.8033333 |
| QF9 | 0.2 | 0.374 | 2 | 8.10333333 |
| QD8 | 0.2 | -0.56 | 1 | -12.133333 |
| QF7 | 0.2 | 0.6 | 1 | 13 |
| QD6 | 0.2 | -0.56 | 1 | -12.133333 |
| QF5 | 0.2 | 0.374 | 2 | 8.10333333 |
| QD4 | 0.2 | -0.314 | 2 | -6.8033333 |
| QD2B | 0.2 | 0.588 | 1 | 12.74 |
| QF3 | 0.2 | -0.25 | 1 | -5.4166667 |
| QD2A | 0.2 | -0.274 | 1 | -5.9366667 |
| QF1 | 0.4 | 0.914 | 1 | 9.90166667 |
| QD0 | 0.5 | -1.494 | 1 | -12.948 |
| | | | 22 | |

## EXT→FF magnets

| Qname | length[m] | K1[1/m] | # | T/m |
|---|---|---|---|---|
| Q1C | 0.2 | 1.59 | 1 | 34.45 |
| Q2C | 0.2 | 0.894 | 1 | 19.37 |
| Q3C | 0.2 | -0.64 | 1 | -13.86667 |
| Q4C | 0.2 | 0.894 | 1 | 19.37 |
| Q5C | 0.2 | 1.59 | 1 | 34.45 |

Field gradient T/m is estimated at E=1.3 GeV.
All the Q has its bore 32ϕ.
B'=45T/m → pole-tip field of 0.72T @r=16mm.

? Tolerance for stability
multipole comp.

# Estimation of SX component limit in Q

Calculate $\Delta\sigma$, untill $\Delta\sigma > 0.5\ \sigma 0$ increasing K2 by factor10 for each Q.

Then $d\sigma/dK2 = \Delta\sigma / 10^n$

beam size

| | |
|---|---|
| sigx[m] | 2.37E-06 |
| sigy[m] | 3.36E-08 |

| | | | K2 for 10% beam size increase | | | | | |
|---|---|---|---|---|---|---|---|---|
| Qname | dsigx/dK2 | dsigy/dK2 | x | y | minK2 | B2@r=10mm | K1 | B2/B1@r=10mm |
| QM16 | 2.36E-08 | 3.02E-10 | 1.00E+01 | 1.11E+01 | 1.00E+01 | 1.09E-02 | -0.366 | -1.37E-01 |
| QM15 | 6.87E-10 | 1.39E-11 | 3.45E+02 | 2.42E+02 | 2.42E+02 | 2.62E-01 | 0.564 | 2.14E+00 |
| QM14 | 5.75E-09 | 1.44E-10 | 4.12E+01 | 2.33E+01 | 2.33E+01 | 2.53E-02 | -1.664 | -7.02E-02 |
| QM13 | 8.44E-09 | 1.25E-10 | 2.81E+01 | 2.69E+01 | 2.69E+01 | 2.91E-02 | 0.52 | 2.58E-01 |
| QM12 | 1.03E-08 | 2.33E-09 | 2.30E+01 | 1.44E+00 | 1.44E+00 | 1.56E-03 | 0.882 | 8.17E-03 |
| QM11 | 2.40E-09 | 1.01E-08 | 9.89E+01 | 3.31E-01 | 3.31E-01 | 3.59E-04 | -0.002 | -8.29E-01 |
| QD10 | 6.09E-08 | 1.19E-07 | 3.89E+00 | 2.83E-02 | 2.83E-02 | 3.07E-05 | -0.314 | -4.51E-04 |
| QD10A | 1.60E-07 | 1.79E-07 | 1.48E+00 | 1.88E-02 | 1.88E-02 | 2.04E-05 | -0.314 | -2.99E-04 |
| QF9 | 2.39E-06 | 1.10E-07 | 9.91E-02 | 3.05E-02 | 3.05E-02 | 3.30E-05 | 0.374 | 4.08E-04 |
| QF9A | 2.19E-06 | 5.35E-08 | 1.08E-01 | 6.28E-02 | 6.28E-02 | 6.80E-05 | 0.374 | 8.39E-04 |
| QD8 | 8.66E-08 | 1.40E-08 | 2.74E+00 | 2.40E-01 | 2.40E-01 | 2.60E-04 | -0.56 | -2.14E-03 |
| QF7 | 5.41E-09 | 9.79E-11 | 4.38E+01 | 3.43E+01 | 3.43E+01 | 3.72E-02 | 0.6 | 2.86E-01 |
| QD6 | 9.21E-08 | 1.35E-08 | 2.57E+00 | 2.50E-01 | 2.50E-01 | 2.71E-04 | -0.56 | -2.23E-03 |
| QF5 | 2.59E-06 | 5.37E-08 | 9.16E-02 | 6.26E-02 | 6.26E-02 | 6.78E-05 | 0.374 | 8.37E-04 |
| QF5A | 2.26E-06 | 1.10E-07 | 1.05E-01 | 3.06E-02 | 3.06E-02 | 3.31E-05 | 0.374 | 4.08E-04 |
| QD4 | 1.91E-07 | 1.77E-07 | 1.24E+00 | 1.90E-02 | 1.90E-02 | 2.05E-05 | -0.314 | -3.02E-04 |
| QD4A | 5.70E-08 | 1.14E-07 | 4.16E+00 | 2.96E-02 | 2.96E-02 | 3.20E-05 | -0.314 | -4.71E-04 |
| QD2B | 3.83E-08 | 3.93E-09 | 6.19E+00 | 8.56E-01 | 8.56E-01 | 9.27E-04 | 0.588 | 7.28E-03 |
| QF3 | 6.08E-08 | 1.30E-09 | 3.90E+00 | 2.59E+00 | 2.59E+00 | 2.80E-03 | -0.25 | -5.17E-02 |
| QD2A | 1.34E-07 | 2.14E-09 | 1.77E+00 | 1.57E+00 | 1.57E+00 | 1.70E-03 | -0.274 | -2.87E-02 |
| QF1 | 1.51E-05 | 3.18E-07 | 1.57E-02 | 1.06E-02 | 1.06E-02 | 5.72E-06 | 0.914 | 5.78E-05 |
| QD0 | 4.43E-07 | 3.57E-07 | 5.36E-01 | 9.42E-03 | 9.42E-03 | 4.08E-06 | -1.494 | -3.15E-05 |

SX component might be corrected by SEXT magnets.

The above estimation does not include the correction.

# Estimation of 12-pole component limit in Q

Calculate Δσ, untill Δσ >0.5 σ0 increasing K5 by factor10 for each Q.

Then dσ/dK5= Δσ /10^n

beam size

| | |
|---|---|
| sigx[m] | 2.40E-06 |
| sigy[m] | 3.46E-08 |

| | | | K5 for 10% beam size increase | | | | | |
|---|---|---|---|---|---|---|---|---|
| Qname | dsigx/dK5 | dsigy/dK5 | x | y | minK2 | B5@r=10mm | K1 | B5/B1@r=10mm |
| QM16 | 5.63E-23 | 8.38E-25 | 4.26E+15 | 4.13E+15 | 4.13E+15 | 7.82E+05 | -0.366 | -6.16E+06 |
| QM15 | 6.64E-21 | 3.38E-21 | 3.61E+13 | 1.02E+12 | 1.02E+12 | 1.94E+02 | 0.564 | 9.90E+02 |
| QM14 | 1.64E-23 | 3.05E-24 | 1.46E+16 | 1.13E+15 | 1.13E+15 | 2.15E+05 | -1.664 | -3.72E+05 |
| QM13 | 5.52E-20 | 4.22E-22 | 4.35E+12 | 8.20E+12 | 4.35E+12 | 8.23E+02 | 0.52 | 4.57E+03 |
| QM12 | 1.36E-20 | 6.28E-21 | 1.77E+13 | 5.51E+11 | 5.51E+11 | 1.04E+02 | 0.882 | 3.41E+02 |
| QM11 | 3.79E-21 | 3.46E-20 | 6.33E+13 | 9.99E+10 | 9.99E+10 | 1.89E+01 | -0.002 | -2.73E+04 |
| QD10 | 4.89E-19 | 1.34E-18 | 4.90E+11 | 2.58E+09 | 2.58E+09 | 4.88E-01 | -0.314 | -4.48E+00 |
| QD10A | 1.01E-17 | 9.05E-18 | 2.38E+10 | 3.82E+08 | 3.82E+08 | 7.24E-02 | -0.314 | -6.65E-01 |
| QF9 | 1.37E-15 | 4.68E-17 | 1.76E+08 | 7.39E+07 | 7.39E+07 | 1.40E-02 | 0.374 | 1.08E-01 |
| QF9A | 1.05E-15 | 2.96E-17 | 2.28E+08 | 1.17E+08 | 1.17E+08 | 2.21E-02 | 0.374 | 1.70E-01 |
| QD8 | 2.92E-18 | 3.13E-19 | 8.22E+10 | 1.11E+10 | 1.11E+10 | 2.09E+00 | -0.56 | -1.08E+01 |
| QF7 | 5.45E-20 | 2.72E-22 | 4.40E+12 | 1.27E+13 | 4.40E+12 | 8.33E+02 | 0.6 | 4.01E+03 |
| QD6 | 3.32E-18 | 4.32E-19 | 7.24E+10 | 8.01E+09 | 8.01E+09 | 1.52E+00 | -0.56 | -7.81E+00 |
| QF5 | 2.32E-15 | 5.03E-17 | 1.03E+08 | 6.88E+07 | 6.88E+07 | 1.30E-02 | 0.374 | 1.00E-01 |
| QF5A | 8.60E-16 | 5.32E-17 | 2.79E+08 | 6.50E+07 | 6.50E+07 | 1.23E-02 | 0.374 | 9.49E-02 |
| QD4 | 1.81E-17 | 9.62E-18 | 1.33E+10 | 3.60E+08 | 3.60E+08 | 6.81E-02 | -0.314 | -6.25E-01 |
| QD4A | 1.80E-18 | 1.58E-18 | 1.34E+11 | 2.19E+09 | 2.19E+09 | 4.15E-01 | -0.314 | -3.82E+00 |
| QD2B | 2.03E-18 | 1.26E-19 | 1.18E+11 | 2.76E+10 | 2.76E+10 | 5.22E+00 | 0.588 | 2.56E+01 |
| QF3 | 9.54E-19 | 4.35E-21 | 2.52E+11 | 7.95E+11 | 2.52E+11 | 4.76E+01 | -0.25 | -5.50E+02 |
| QD2A | 2.48E-17 | 9.02E-19 | 9.67E+09 | 3.83E+09 | 3.83E+09 | 7.26E-01 | -0.274 | -7.64E+00 |
| QF1 | 4.03E-14 | 1.03E-15 | 5.95E+06 | 3.35E+06 | 3.35E+06 | 3.17E-04 | 0.914 | 2.00E-03 |
| QD0 | 5.47E-17 | 3.52E-17 | 4.39E+09 | 9.84E+07 | 9.84E+07 | 7.45E-03 | -1.494 | -3.60E-02 |

# Estimation of 20-pole component limit in Q

Calculate Δσ, untill Δσ >0.5 σ0 increasing K9 by factor10 for each Q.

Then dσ/dK9= Δσ /10^n

beam size

sigx[m] 2.38E-06

sigy[m] 3.55E-08

| | | | K9 for 10% beam size increase | | | | | |
|---|---|---|---|---|---|---|---|---|
| Qname | dsigx/dK9 | dsigy/dK9 | x | y | minK2 | B9@r=10mm | K1 | B9/B1@r=10mm |
| QM16 | 5.81E-41 | 2.00E-41 | 4.10E+33 | 1.78E+32 | 1.78E+32 | 7.30E+11 | -0.366 | -5.75E+12 |
| QM15 | 1.30E-40 | 2.66E-42 | 1.83E+33 | 1.33E+33 | 1.33E+33 | 5.48E+12 | 0.564 | 2.80E+13 |
| QM14 | 1.31E-42 | 1.48E-42 | 1.82E+35 | 2.40E+33 | 2.40E+33 | 9.86E+12 | -1.664 | -1.71E+13 |
| QM13 | 1.33E-36 | 4.43E-38 | 1.78E+29 | 8.02E+28 | 8.02E+28 | 3.29E+08 | 0.52 | 1.82E+09 |
| QM12 | 2.77E-37 | 1.46E-37 | 8.59E+29 | 2.43E+28 | 2.43E+28 | 9.99E+07 | 0.882 | 3.27E+08 |
| QM11 | 1.77E-35 | 3.05E-36 | 1.34E+28 | 1.16E+27 | 1.16E+27 | 4.77E+06 | -0.002 | -6.88E+09 |
| QD10 | 1.85E-34 | 6.19E-34 | 1.29E+27 | 5.73E+24 | 5.73E+24 | 2.35E+04 | -0.314 | -2.16E+05 |
| QD10A | 4.32E-32 | 1.26E-31 | 5.51E+24 | 2.82E+22 | 2.82E+22 | 1.16E+02 | -0.314 | -1.06E+03 |
| QF9 | 5.13E-29 | 6.42E-30 | 4.64E+21 | 5.53E+20 | 5.53E+20 | 2.27E+00 | 0.374 | 1.75E+01 |
| QF9A | 2.15E-29 | 1.57E-30 | 1.11E+22 | 2.26E+21 | 2.26E+21 | 9.27E+00 | 0.374 | 7.15E+01 |
| QD8 | 3.67E-33 | 3.53E-34 | 6.48E+25 | 1.00E+25 | 1.00E+25 | 4.12E+04 | -0.56 | -2.12E+05 |
| QF7 | 3.60E-37 | 5.26E-39 | 6.60E+29 | 6.75E+29 | 6.60E+29 | 2.71E+09 | 0.6 | 1.30E+10 |
| QD6 | 6.33E-33 | 5.71E-34 | 3.76E+25 | 6.22E+24 | 6.22E+24 | 2.55E+04 | -0.56 | -1.31E+05 |
| QF5 | 8.53E-28 | 4.62E-30 | 2.79E+20 | 7.69E+20 | 2.79E+20 | 1.14E+00 | 0.374 | 8.83E+00 |
| QF5A | 1.28E-28 | 6.66E-30 | 1.86E+21 | 5.33E+20 | 5.33E+20 | 2.19E+00 | 0.374 | 1.69E+01 |
| QD4 | 4.71E-32 | 6.51E-32 | 5.05E+24 | 5.45E+22 | 5.45E+22 | 2.24E+02 | -0.314 | -2.06E+03 |
| QD4A | 1.25E-33 | 1.49E-33 | 1.90E+26 | 2.38E+24 | 2.38E+24 | 9.75E+03 | -0.314 | -8.96E+04 |
| QD2B | 2.71E-33 | 5.54E-34 | 8.77E+25 | 6.41E+24 | 6.41E+24 | 2.63E+04 | 0.588 | 1.29E+05 |
| QF3 | 1.81E-33 | 2.03E-36 | 1.32E+26 | 1.75E+27 | 1.32E+26 | 5.40E+05 | -0.25 | -6.23E+06 |
| QD2A | 1.62E-31 | 5.86E-33 | 1.47E+24 | 6.06E+23 | 6.06E+23 | 2.48E+03 | -0.274 | -2.62E+04 |
| QF1 | 7.86E-26 | 1.20E-27 | 3.03E+18 | 2.95E+18 | 2.95E+18 | 6.05E-03 | 0.914 | 3.82E-02 |
| QD0 | 4.18E-31 | 7.51E-31 | 5.70E+23 | 4.73E+21 | 4.73E+21 | 7.76E+00 | -1.494 | -3.75E+01 |

# Stability of Q

Calculate Δσ, untill Δσ >0.5 σ0 increasing dK1 by factor 2 for each Q.
Calculate Δσ, untill Δσ >0.5 σ0 decreasing dK1 by factor 2 for each Q
Then dσ/dK1= Max(Δσ /dK1)

| | | | dK1/K1 for 10% beam size increase | | | | |
|---|---|---|---|---|---|---|---|
| Qname | dsigx/(dK1/K | dsigy/(dK1/K | x | y | minK2 | sigx | sigy |
| QM16 | 1.47E-06 | 1.01E-07 | 1.61E-01 | 3.33E-02 | 3.33E-02 | 2.36E-06 | 3.36E-08 |
| QM15 | 4.71E-06 | 1.30E-07 | 5.01E-02 | 2.59E-02 | 2.59E-02 | 2.36E-06 | 3.36E-08 |
| QM14 | 6.53E-06 | 1.27E-06 | 3.62E-02 | 2.65E-03 | 2.65E-03 | 2.36E-06 | 3.36E-08 |
| QM13 | 3.20E-05 | 3.03E-07 | 7.38E-03 | 1.11E-02 | 7.38E-03 | 2.36E-06 | 3.36E-08 |
| QM12 | 3.73E-05 | 1.02E-05 | 6.33E-03 | 3.29E-04 | 3.29E-04 | 2.36E-06 | 3.36E-08 |
| QM11 | 1.62E-08 | 2.31E-07 | 1.46E+01 | 1.46E-02 | 1.46E-02 | 2.36E-06 | 3.36E-08 |
| QD10 | 4.61E-05 | 1.02E-04 | 5.12E-03 | 3.29E-05 | 3.29E-05 | 2.36E-06 | 3.36E-08 |
| QD10A | 1.54E-04 | 9.10E-05 | 1.53E-03 | 3.69E-05 | 3.69E-05 | 2.36E-06 | 3.36E-08 |
| QF9 | 8.02E-04 | 2.59E-05 | 2.94E-04 | 1.30E-04 | 1.30E-04 | 2.36E-06 | 3.36E-08 |
| QF9A | 8.25E-04 | 1.09E-05 | 2.86E-04 | 3.08E-04 | 2.86E-04 | 2.36E-06 | 3.36E-08 |
| QD8 | 9.89E-05 | 2.05E-05 | 2.39E-03 | 1.64E-04 | 1.64E-04 | 2.36E-06 | 3.36E-08 |
| QF7 | 2.27E-05 | 1.68E-07 | 1.04E-02 | 2.00E-02 | 1.04E-02 | 2.36E-06 | 3.36E-08 |
| QD6 | 1.18E-04 | 2.01E-05 | 1.99E-03 | 1.67E-04 | 1.67E-04 | 2.36E-06 | 3.36E-08 |
| QF5 | 7.71E-04 | 1.17E-05 | 3.06E-04 | 2.88E-04 | 2.88E-04 | 2.36E-06 | 3.36E-08 |
| QF5A | 7.69E-04 | 2.66E-05 | 3.07E-04 | 1.27E-04 | 1.27E-04 | 2.36E-06 | 3.36E-08 |
| QD4 | 1.61E-04 | 8.78E-05 | 1.47E-03 | 3.83E-05 | 3.83E-05 | 2.36E-06 | 3.36E-08 |
| QD4A | 4.63E-05 | 9.96E-05 | 5.10E-03 | 3.37E-05 | 3.37E-05 | 2.36E-06 | 3.36E-08 |
| QD2B | 7.50E-05 | 1.38E-05 | 3.15E-03 | 2.44E-04 | 2.44E-04 | 2.36E-06 | 3.36E-08 |
| QF3 | 3.96E-05 | 8.01E-07 | 5.96E-03 | 4.20E-03 | 4.20E-03 | 2.36E-06 | 3.36E-08 |
| QD2A | 1.56E-04 | 9.52E-07 | 1.51E-03 | 3.53E-03 | 1.51E-03 | 2.36E-06 | 3.36E-08 |
| QF1 | 0.0071257 | 9.60E-05 | 3.31E-05 | 3.50E-05 | 3.31E-05 | 2.36E-06 | 3.36E-08 |
| QD0 | 0.0011439 | 6.31E-04 | 2.06E-04 | 5.32E-06 | 5.32E-06 | 2.36E-06 | 3.36E-08 |