Optics of the Isolde Frontends

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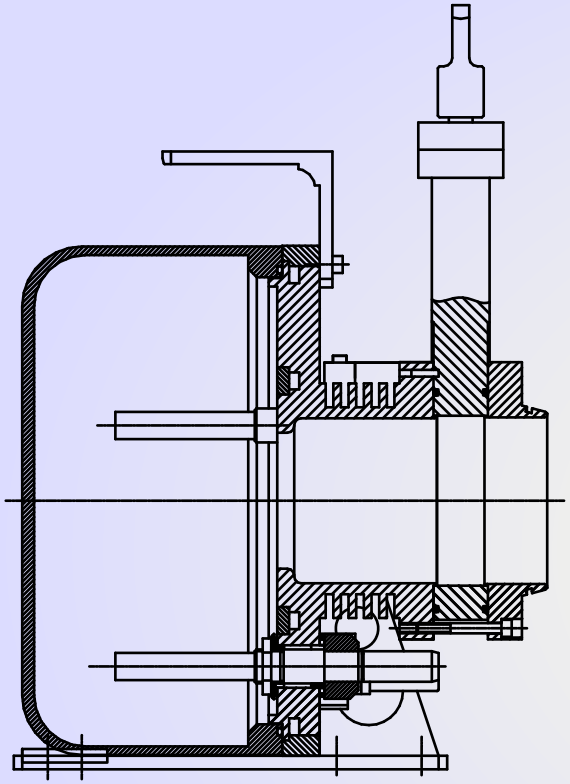
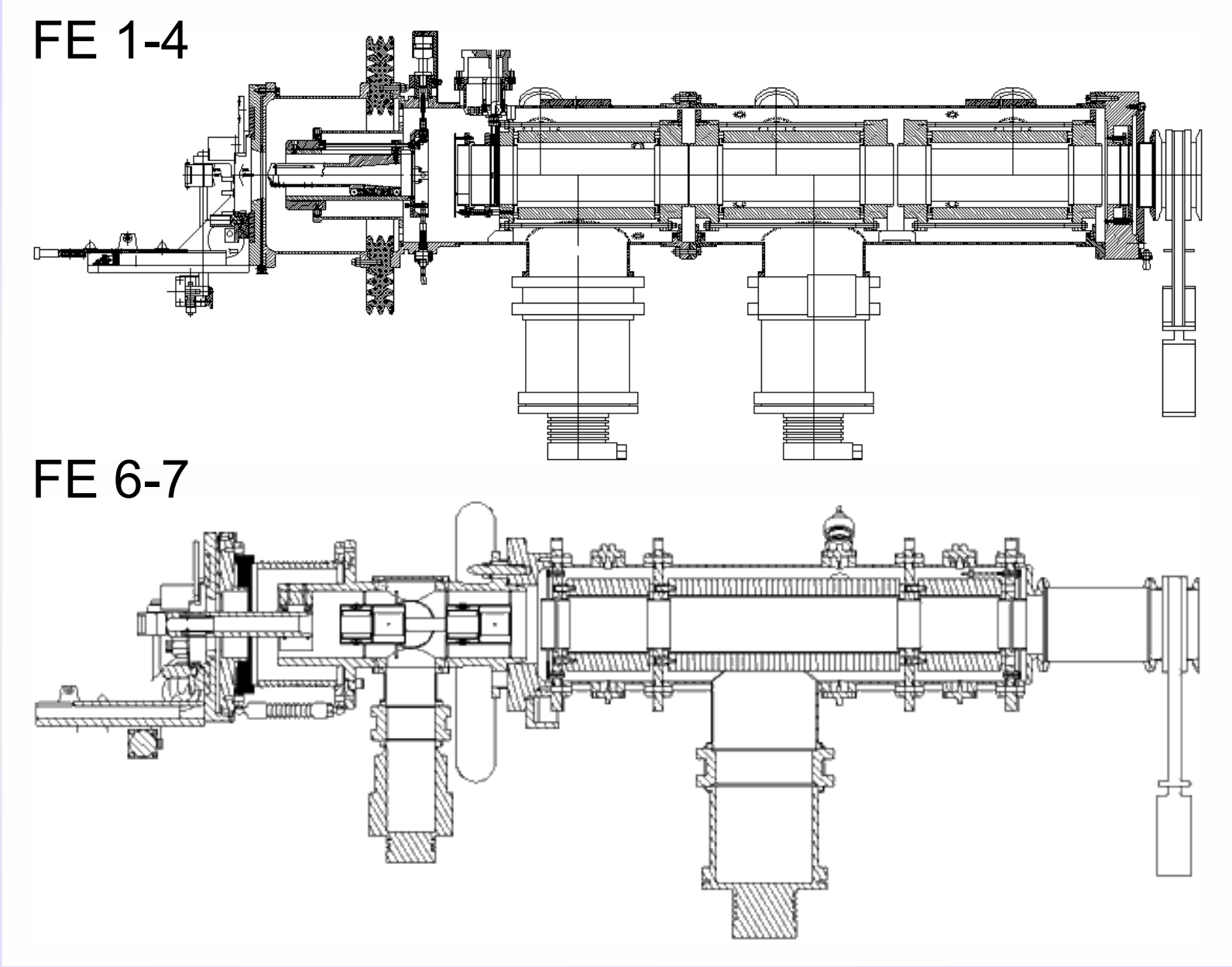
Nov 2009

The Isolde Frontends



Target unit
x2.5



FE6 test setup

Quadrupole triplet

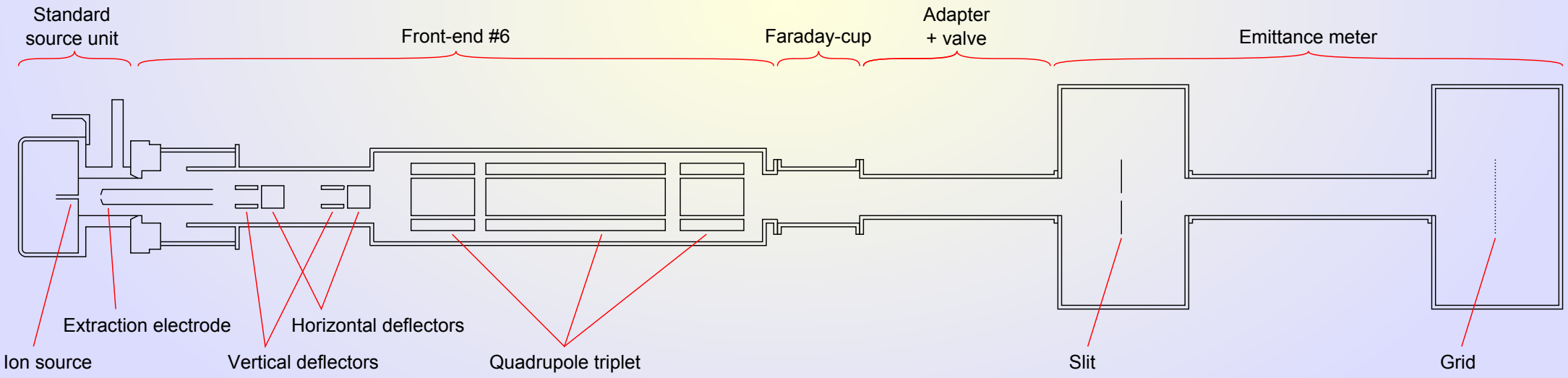
X/Y deflectors

Extraction electrode

Ion beam

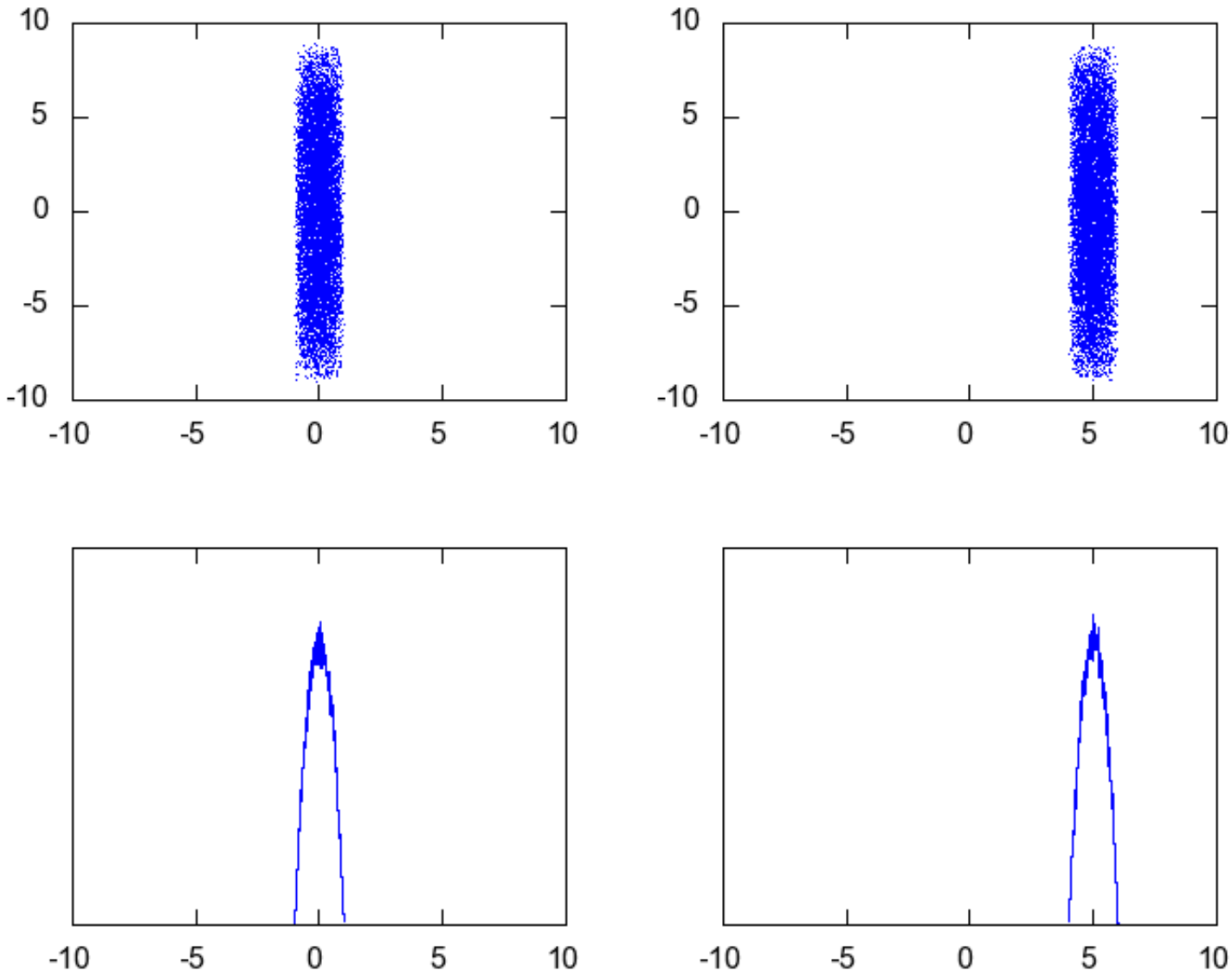
Ion source

Test beam-tunes matched to GPS and HRS separators

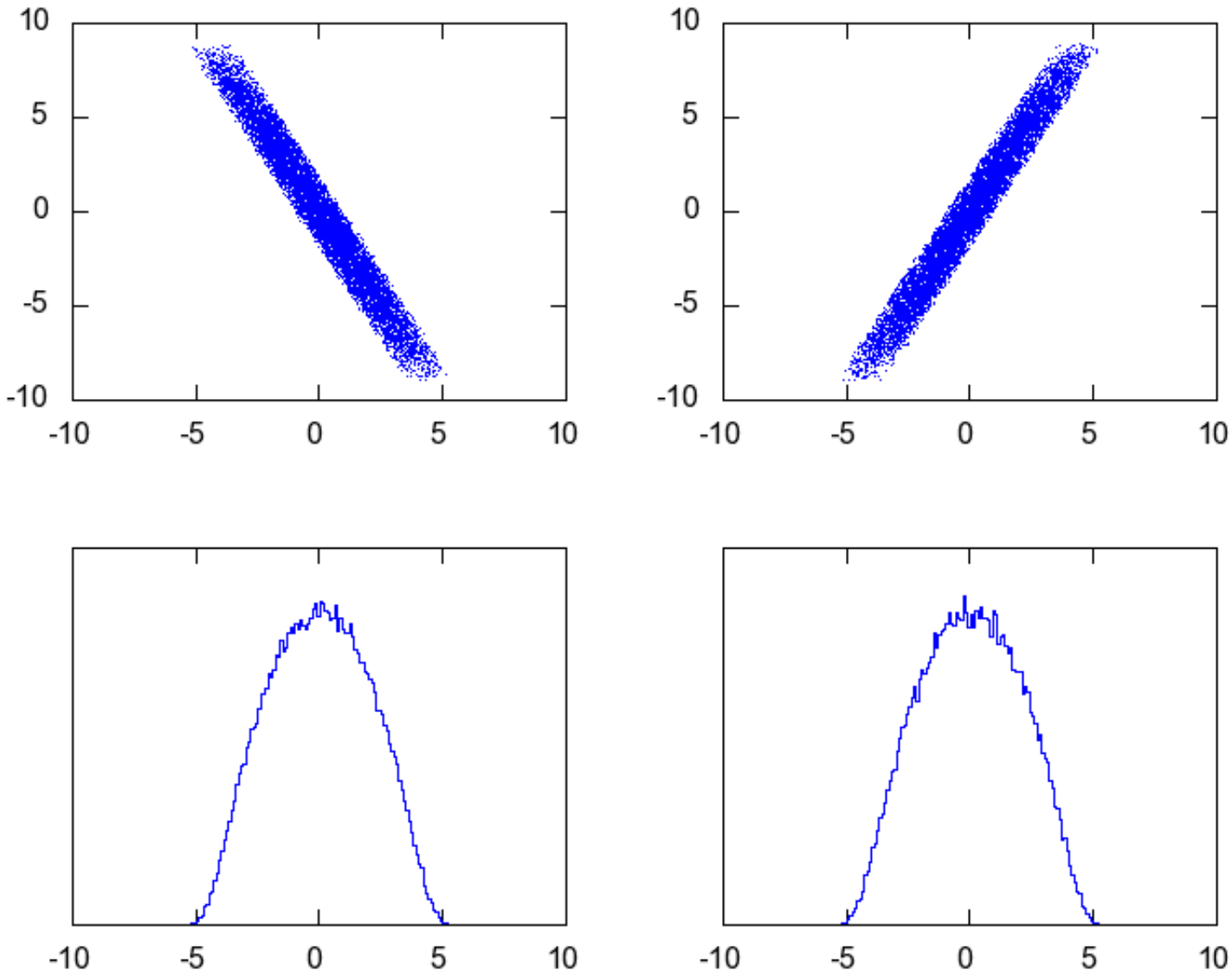


Lens Design

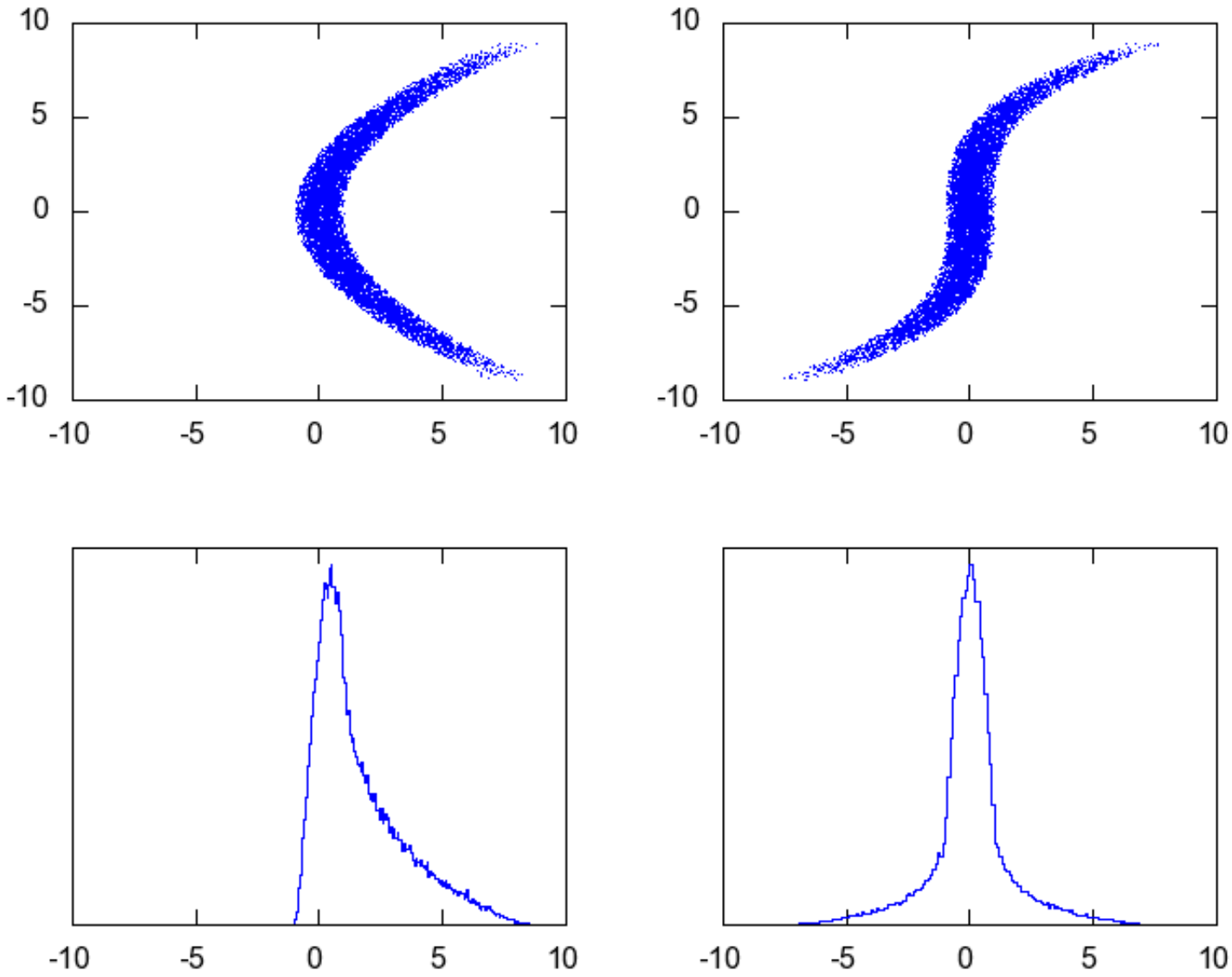
Effects of multipoles: 0th order (dipole)



Effects of multipoles: 1st order (quadrupole)

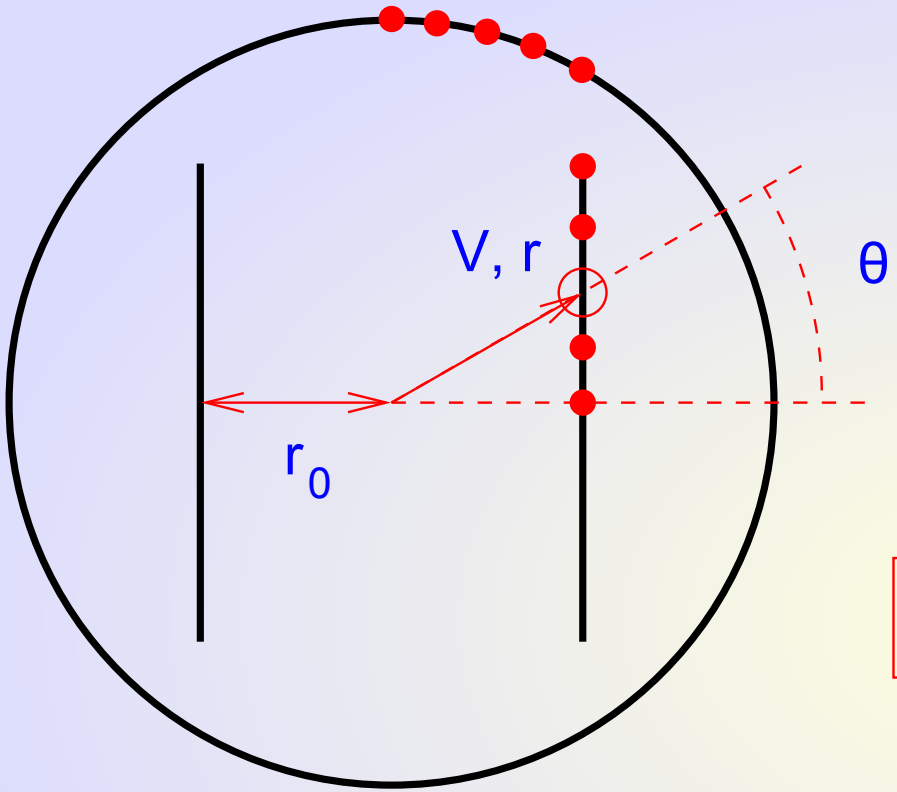


Effects of multipoles: 2nd and 3rd orders



Real Lenses and Distortions

Multipole Distortions



$$V = V_0 \sum_n a_n \frac{r^n}{r_0^n} \cos(n\theta)$$

For a dipole, n = 1, 3, 5 ...

For a quadrupole, n = 2, 6, 10 ...

Emittance growth $\varepsilon' = \varepsilon(1 + tol)$

Dipole

$$\frac{\varepsilon}{x_0 . tol} = \delta A_1 . \frac{a_n}{a_1} . n . \frac{x_0^{(n-1)}}{r_0^{(n-1)}}$$

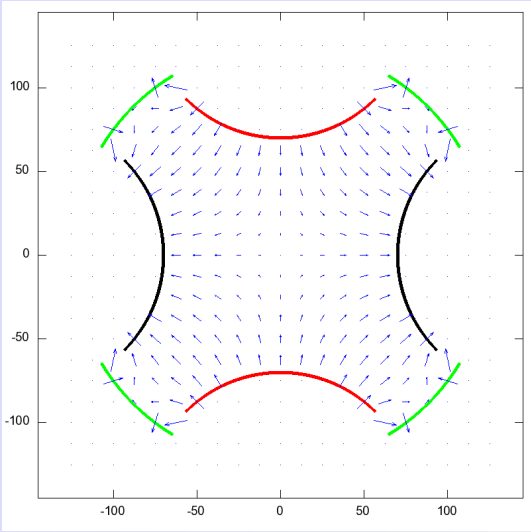
deflection angle

Quadrupole

$$\frac{\varepsilon}{x_0 . tol} = \delta A_2 . \frac{a_n}{a_2} . n . \frac{x_0^{(n-2)}}{r_0^{(n-2)}}$$

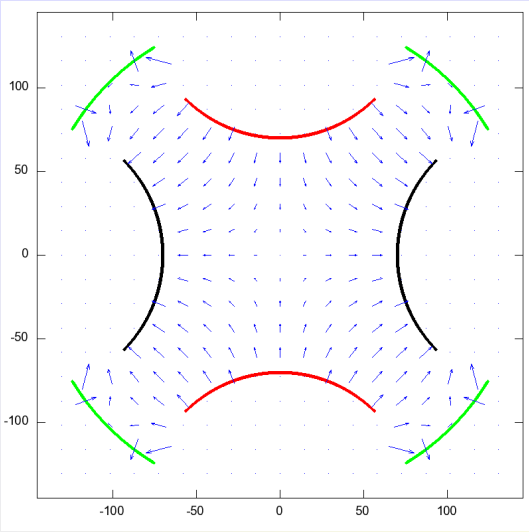
x_0 / focal length

Transverse Fields in Quadrupole Lenses



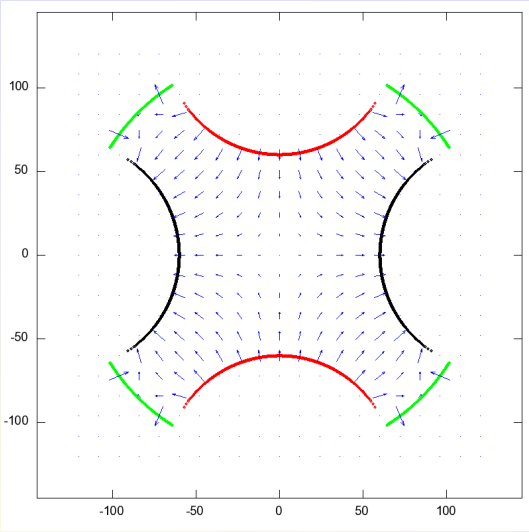
Beamline Quadrupole

a_2 = +1.004
a_6 = -0.0044
a_{10} = -0.0057
a_{14} = -0.0003



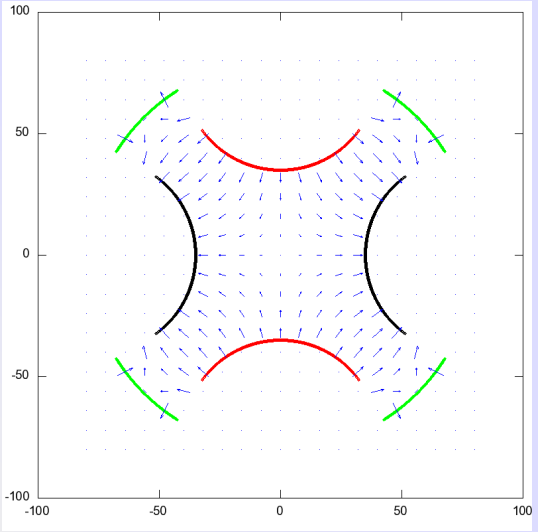
Frontend Quadrupole (old)

a_2 = +1.008
a_6 = +0.0062
a_{10} = -0.0012
a_{14} = -0.0000



Frontend Quadrupole (new)

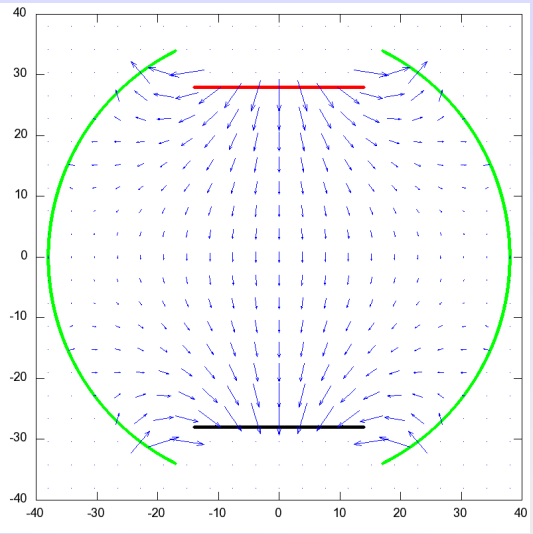
a_2 = +1.003
a_6 = +0.0012
a_{10} = -0.0019
a_{14} = -0.0001

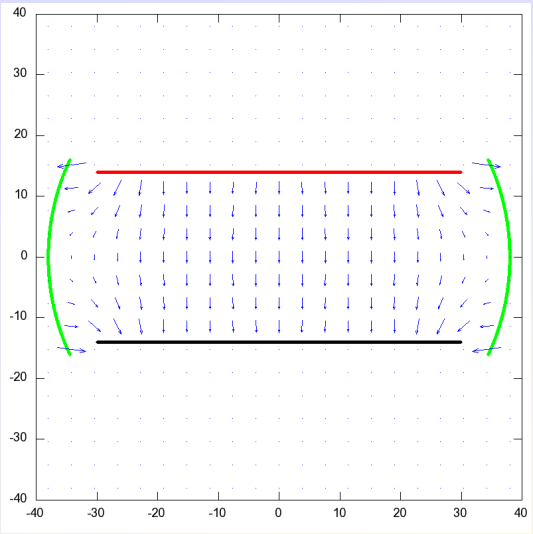


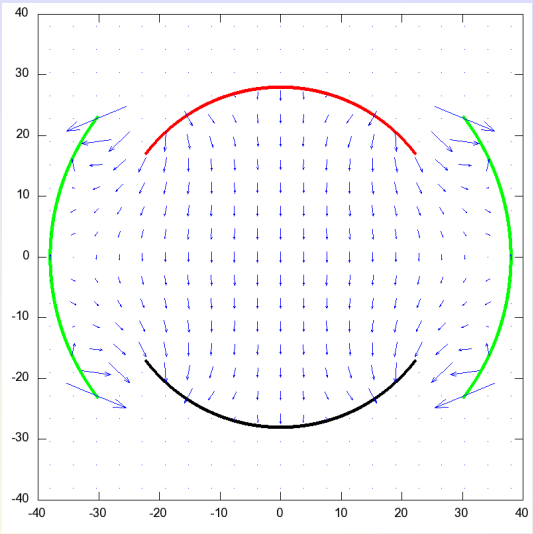
Compact Lens for RFQ Matching

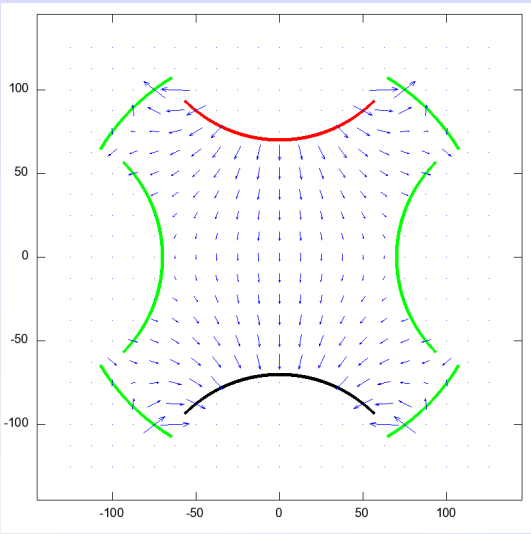
a_2 = +1.009
a_6 = +0.0076
a_{10} = -0.0004
a_{14} = -0.0000

Transverse Fields in Deflectors





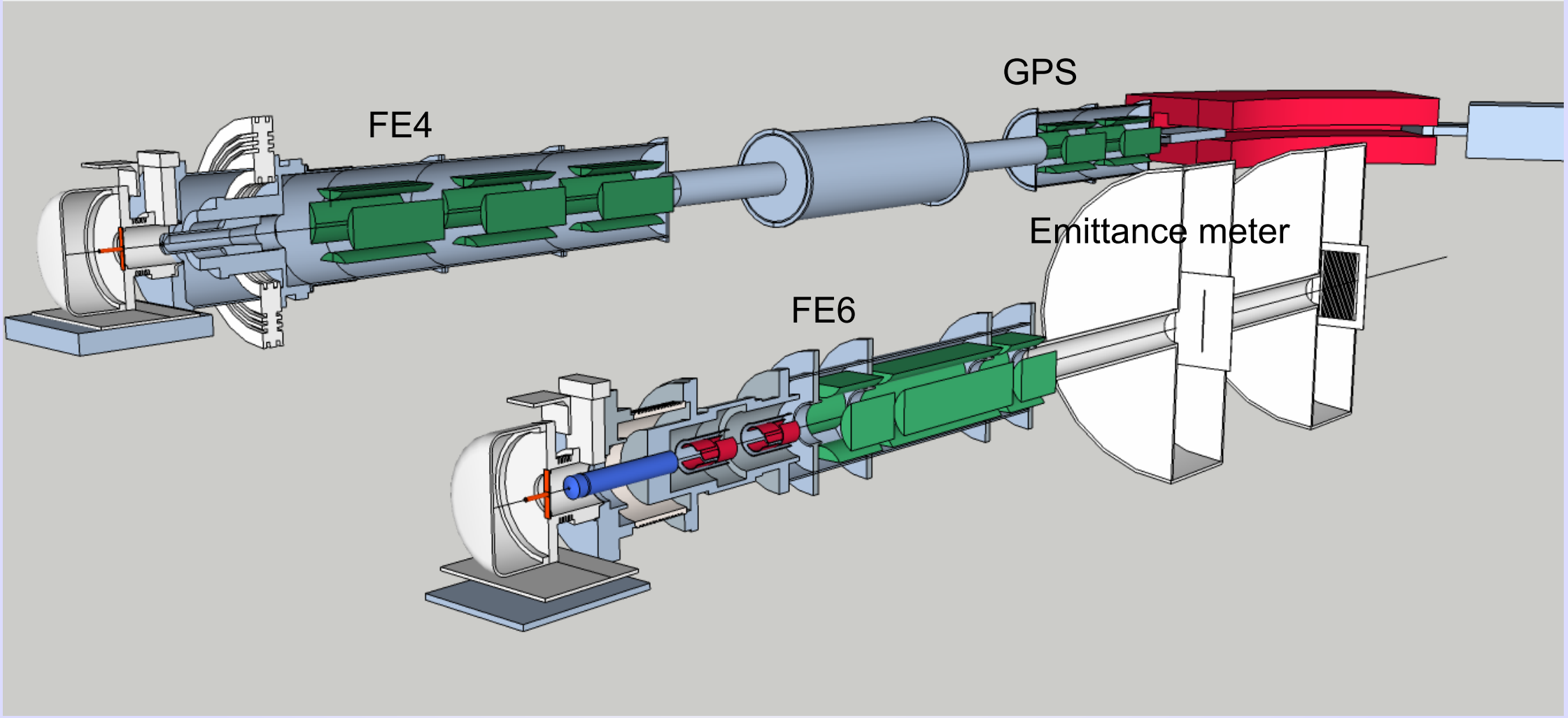




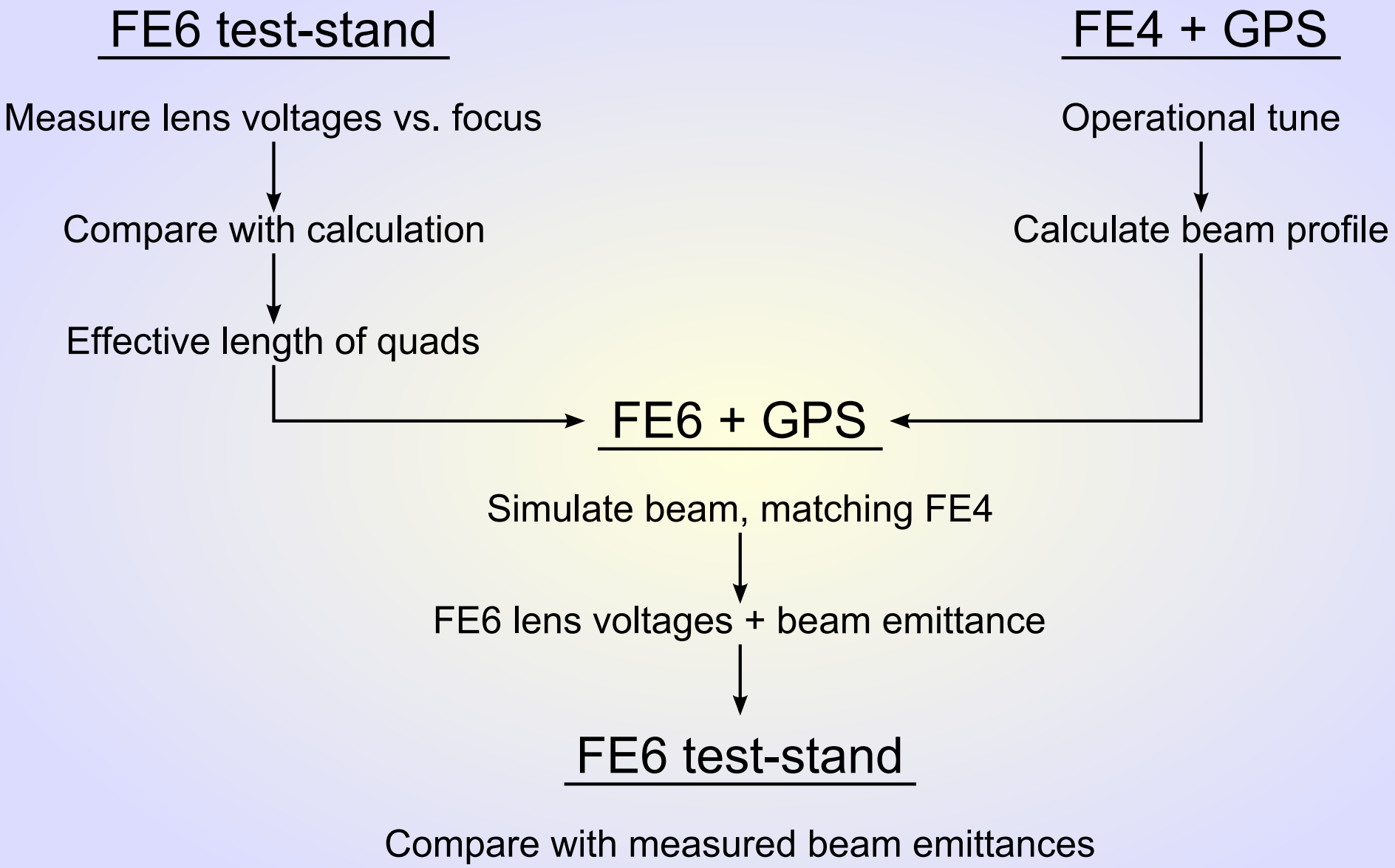
Wide Aperture	Narrow Aperture	Compact Curved (new frontend)	Quadrupole as Deflector
a_1 = +0.699	a_1 = +1.000	a_1 = +1.096	a_1 = +0.784
a_3 = +0.311	a_3 = +0.012	a_3 = -0.002	a_3 = +0.240
a_5 = +0.113	a_5 = +0.007	a_5 = -0.149	a_5 = +0.023
a_7 = +0.031	a_7 = +0.003	a_7 = +0.016	a_7 = +0.007
a_9 = +0.005	a_9 = +0.000	a_9 = +0.053	a_9 = -0.001
a_{11} = -0.001	a_{11} = +0.000	a_{11} = +0.018	a_{11} = -0.000

Tests and Results

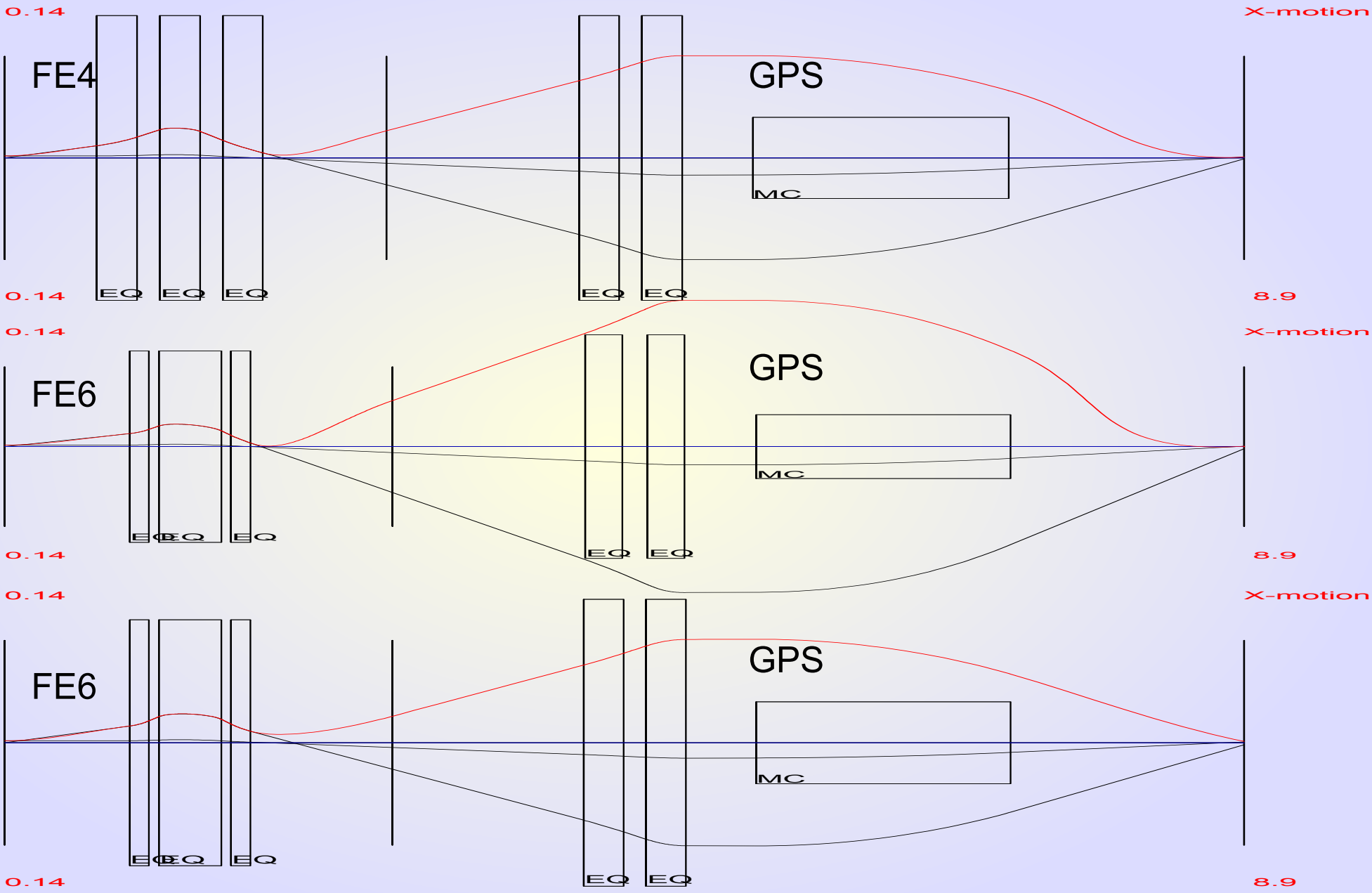
Tune testing method



Tune testing method



Tune testing method

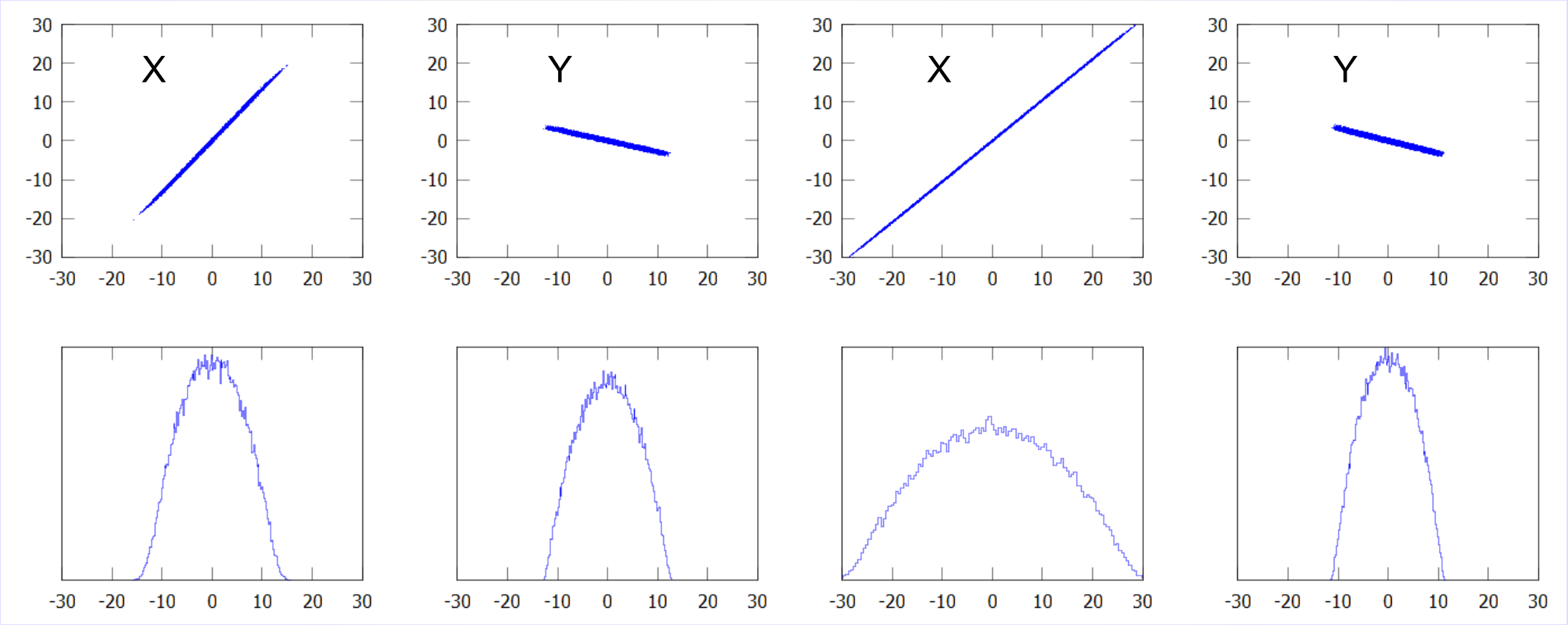


Tune testing method

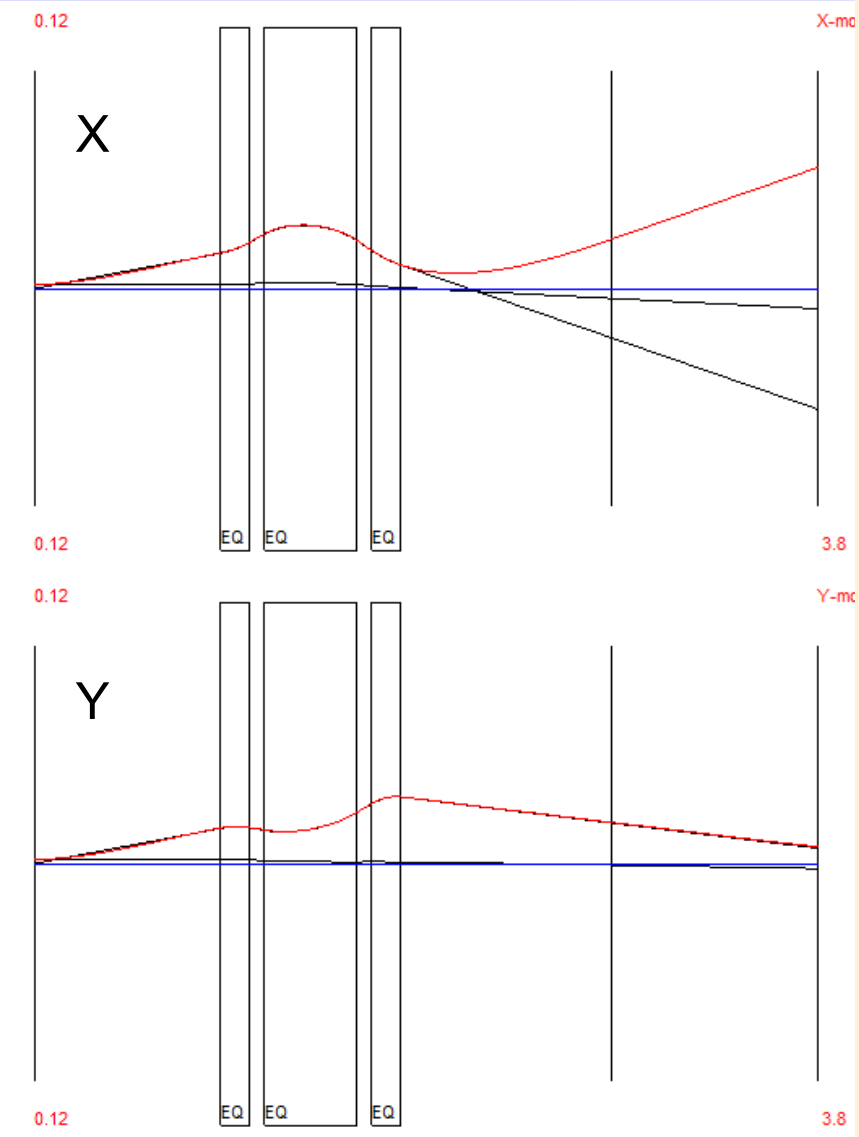
Calculated emittances

FE4 + GPS

FE6 + GPS



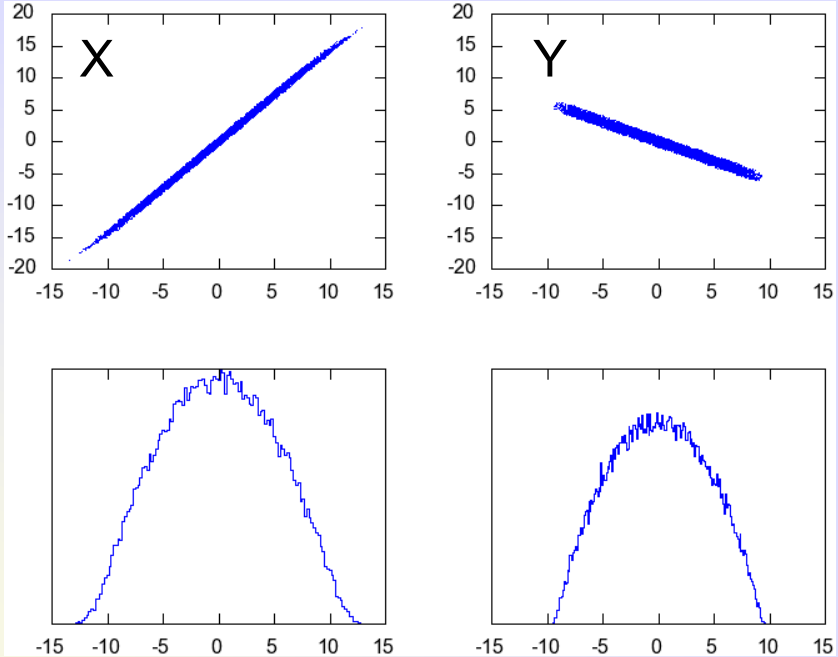
GPS tune #1



Simulation

α_x = -20.9
β_x = 14.5
γ_x = 30.2
Θ_x = -2.4
ρ_x = 59

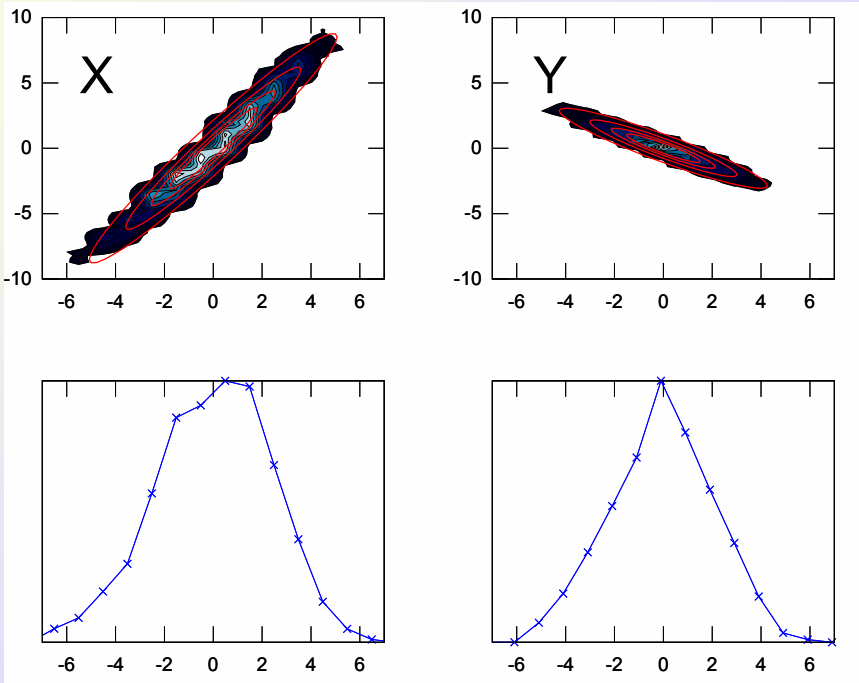
α_y = 6.0
β_y = 9.9
γ_y = 3.8
Θ_y = -2.2
ρ_y = 24



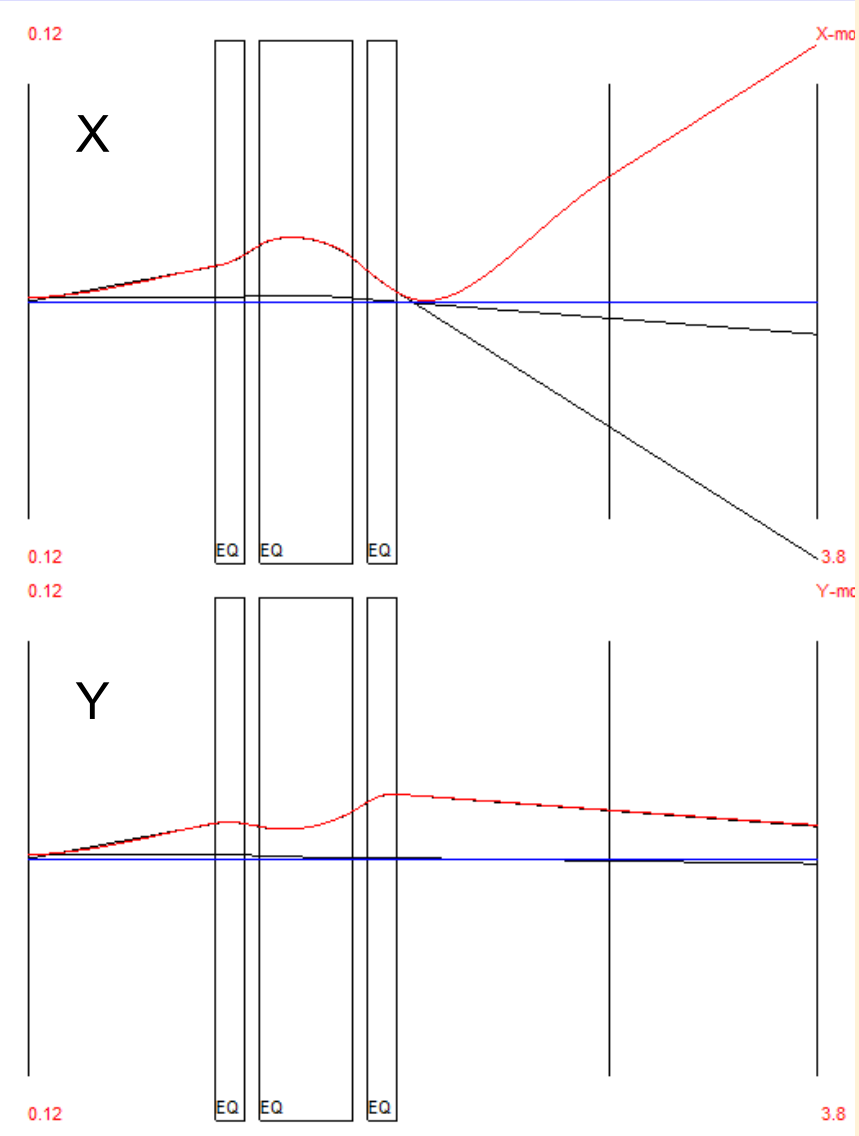
Measurement

α_x = -4.0
β_x = 2.4
γ_x = 7.1
Θ_x = -2.1
ρ_x = 12

α_y = 2.6
β_y = 3.9
γ_y = 2.0
Θ_y = -2.5
ρ_y = 10



GPS tune #2



Simulation

α_x= -97
β_x= 92
γ_x= 102

Θ_x= -3.0
ρ_x= 287

α_y= 4.4
β_y= 13.9
γ_y= 1.5

Θ_y= -1.2
ρ_y= 29

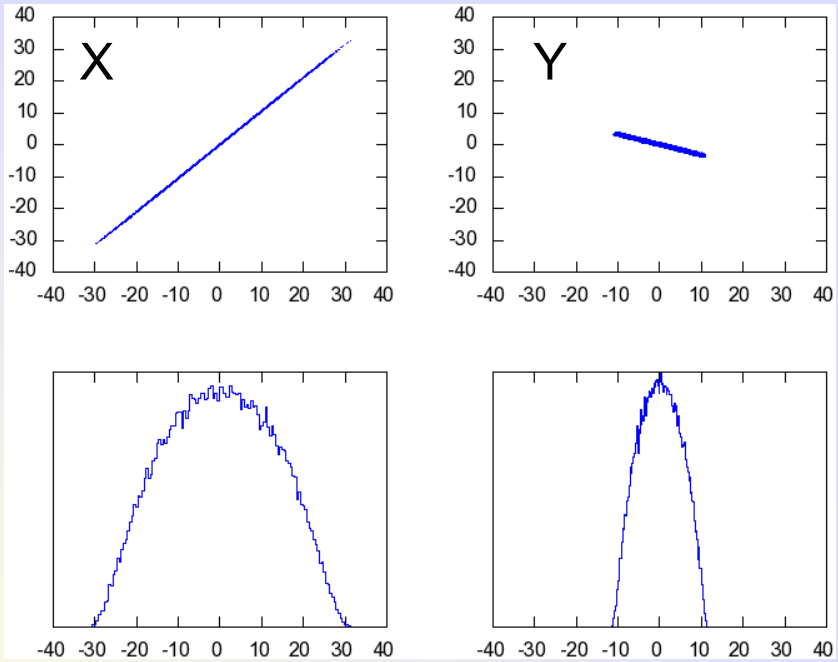
Measurement

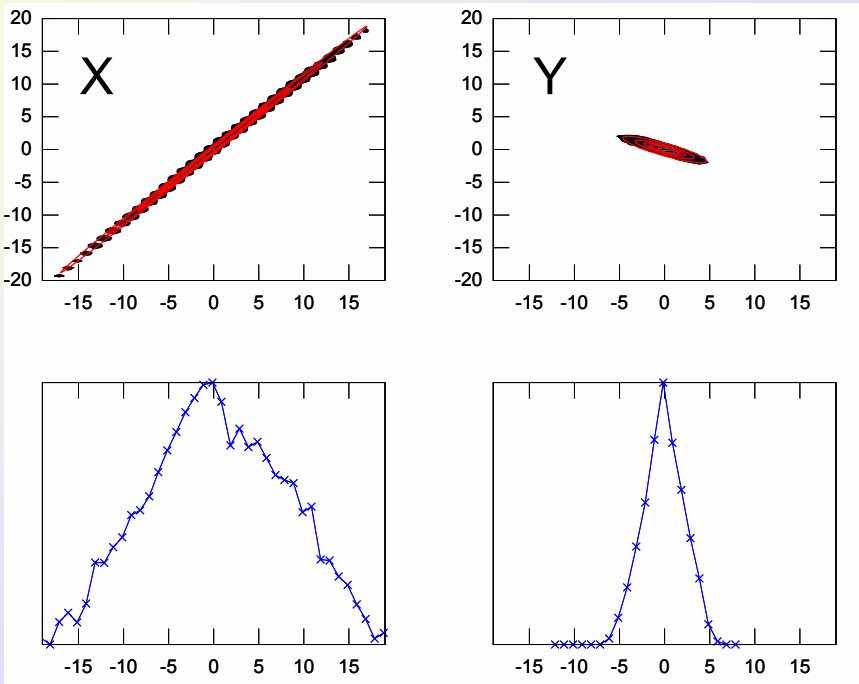
α_x= -25
β_x= 23
γ_x= 28

Θ_x= -2.9
ρ_x= 74

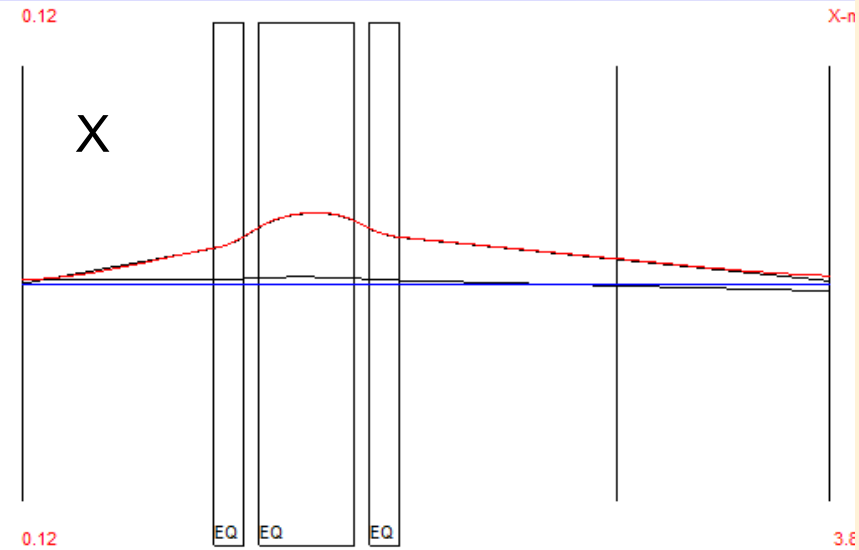
α_y= 1.8
β_y= 4.7
γ_y= 0.9

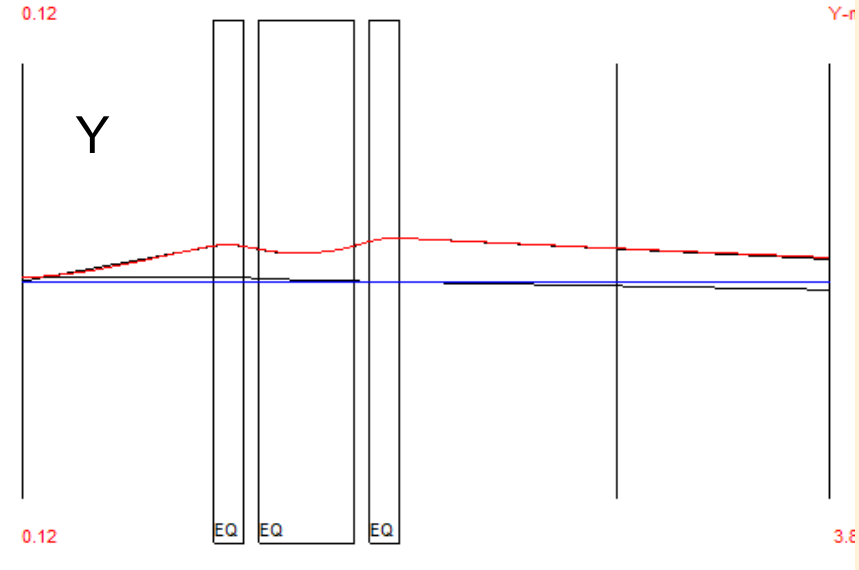
Θ_y= -1.5
ρ_y= 10





HRS tune





Simulation

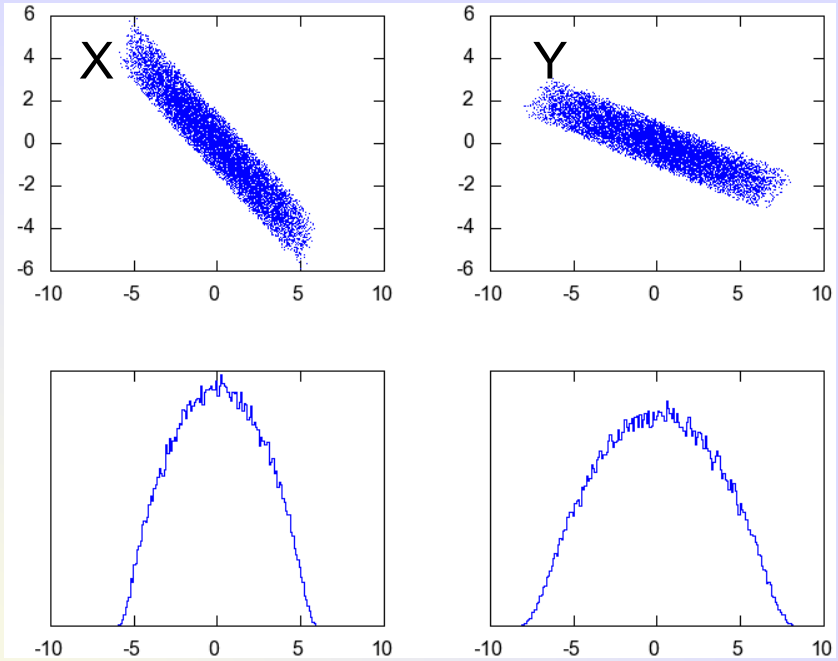
α_x = 3.0
β_x = 3.6
γ_x = 2.8
Θ_x = -2.9
ρ_x = 10

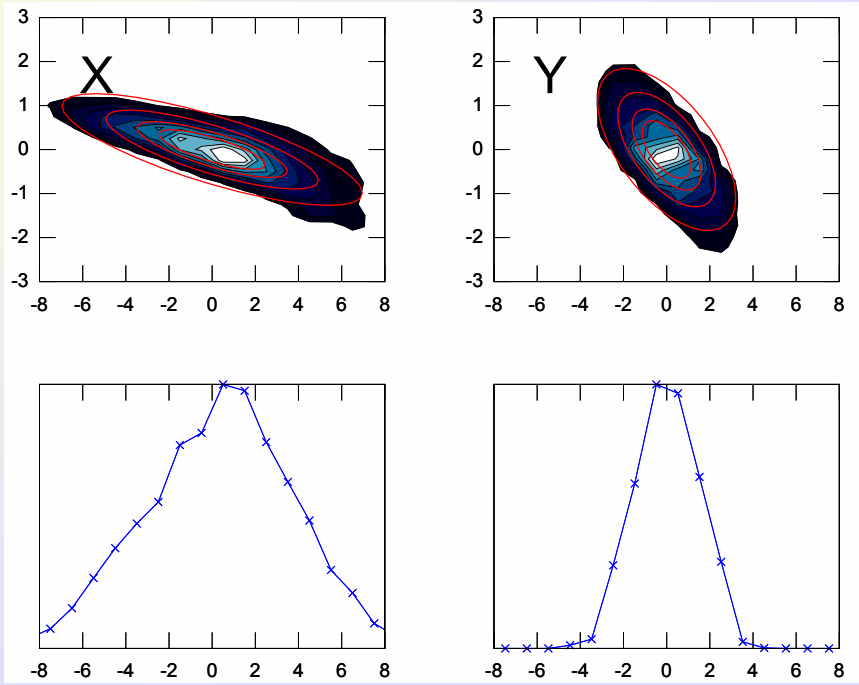
α_y = 1.9
β_y = 6.4
γ_y = 0.7
Θ_y = -1.2
ρ_y = 13

Measurement

α_x = 1.2
β_x = 8.8
γ_x = 0.3
Θ_x = -0.6
ρ_x = 18

α_y = 0.7
β_y = 2.2
γ_y = 0.7
Θ_y = -1.6
ρ_y = 5





Conclusions

- Frontend #6 is compatible with Isolde target units
- The new lenses operate as designed
- No appreciable distortion
- Capable of matching existing GPS and HRS

Online installation soon!