GICOSY Calculations for HRS

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HRS Meeting

Bordeaux, 12+13th Nov. 2009

- **Different Fringe Fields**
- **Alpha Short-2**

Achromatic Separator with Combined Magnetic and Electrostatic Fields

Only magnetic dipoles, but acceleration between first and second stage (EXCYT, ORNL)

or

Magnetic Dipole and Electrostatic dipole (TRIUMF)

But that was 15 years ago !
Today beam cooling,
only limited by beam intensity.

Calculate Fringe Fields

Methods:

1.) Raytracing
general form or TURTLE, RAYTRACE in optical coord. system
2.) Differential Algebra (COSY IINFINITY, GICOSY)
in principle for arbitrary fields but for our purpose in
Field described by multipole expansion along optical axis
3.) Fringe Field Integrals (GIOS, TRIO,GICOSY)
Also based on multipole expansion, for fields that drop relatively fast

Field input:

a) Magnetic fields from calculation (Poisson, Opera, other FEM program)
or from mapped field distribution
b) Electrostatic field from calculation
(finite differences SIMION, surface charge method)
measurement is difficult

Fringe Field Integrals

Approximative solution of equation of motion.
Stepwise integration method by Picard + Lindelöf is usually not very practical as we get more and more complicated integrals.
But for well shaped fringe field fast convergence, only 1 (2,3) integration steps needed.

We can move geometric scaling factors in front of the integrals.
Remaining Integrals depend only on shape not on absolute size.
Of course also scaling with absolute field strength / rigidity (k_0).

e.g. $(X|A)_{\_FF\_Quad} = -2\, k_0\ I_{2a}$,

$$I_{2a} = k_0^{-1} \int s \int k\, d^2 s - \frac{1}{6} s_b^3$$

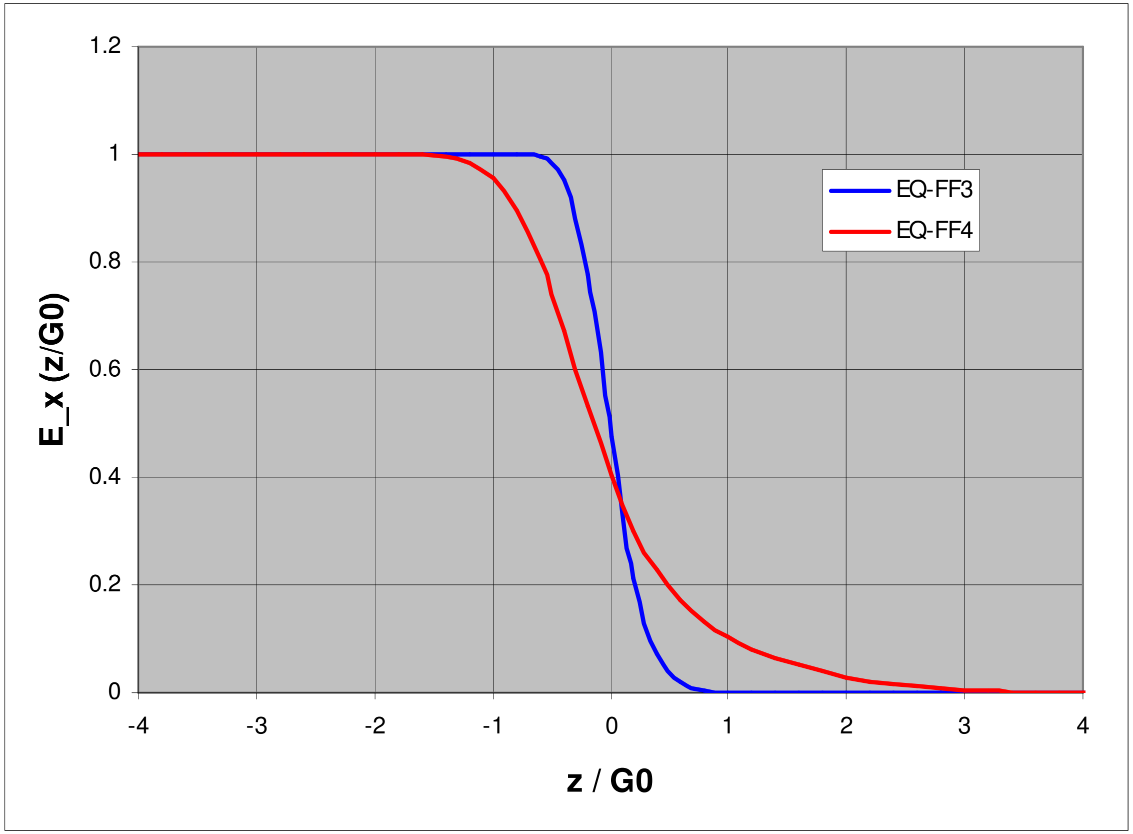
scales with G_0^3

➔ Scaling behavior with gap size, fast calculation.

For fringe fields of otherwise homogenous standard elements good agreement with **Raytracing** or **Differential Algebra**.

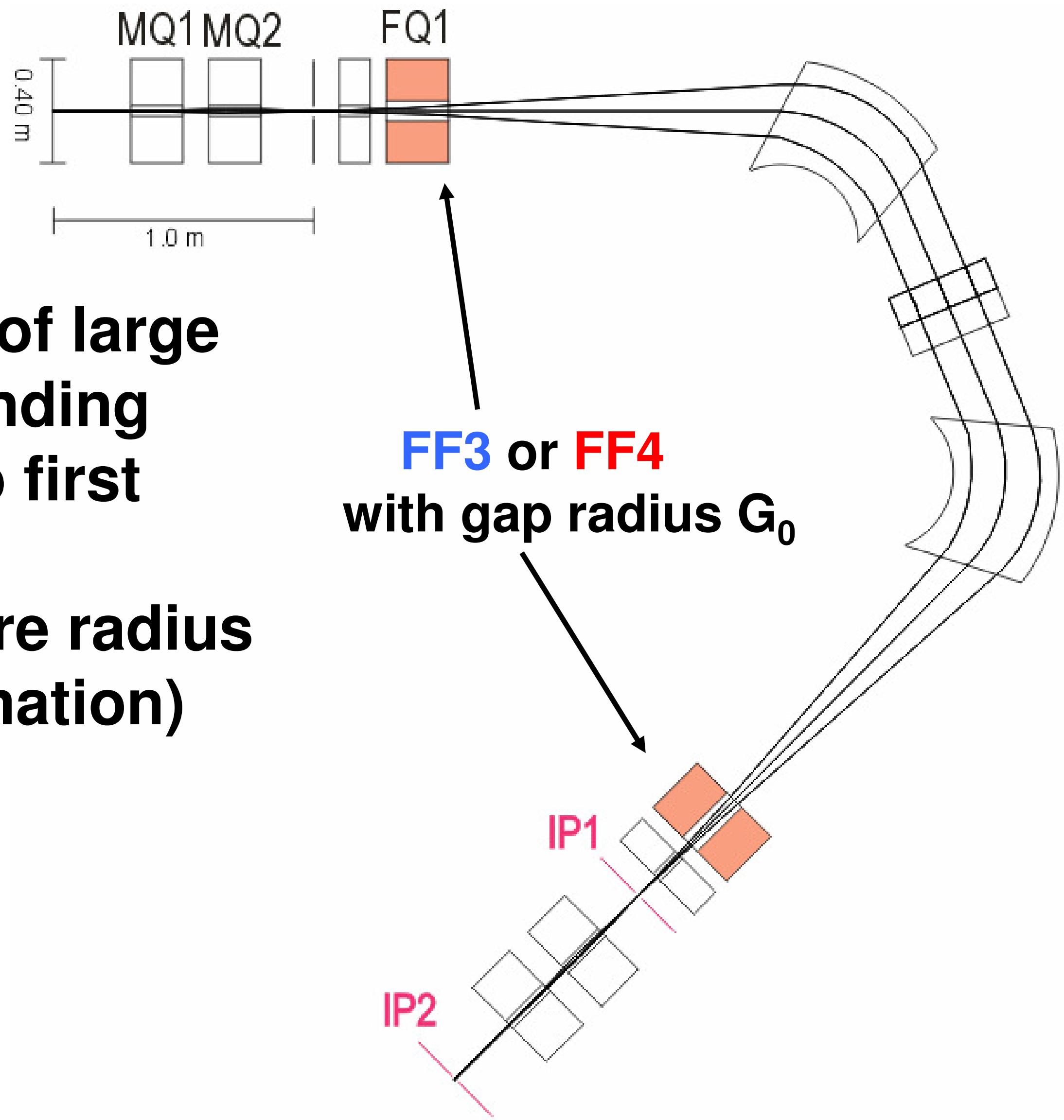
Possible Fringe Field Distributions

Two cases for EQ from GICOSY list, FF3 and FF4, different Enge coefficients (field shape) but same effective length (field integral).



Depends much on environment: beam pipe, neighboring elements

Scheme of HRS

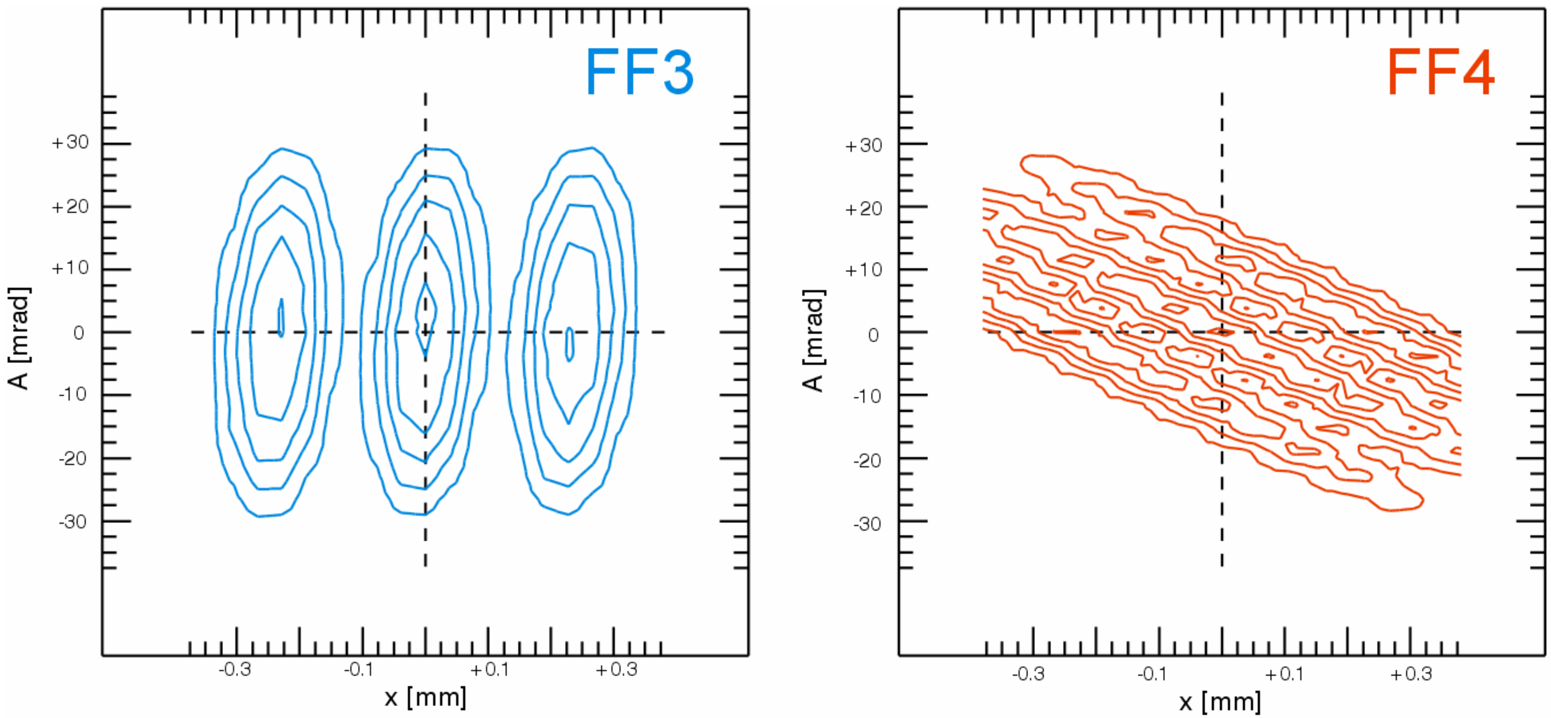


FQ1 is critical because of large aperture. The corresponding transfer matrix has also first order terms.
Scaling law with aperture radius (leading order approximation)

$$(A|X)_{FF\text{-}Q} = k_0 \; I_{3a} \; G_0^3$$
$$(X|A)_{FF\text{-}Q} = -2k_0 \; I_{2a} \; G_0^3$$

Influence of FF on Image Position at IP1

Quadrupole FQ1 adjusted with FF3 model.
Then changed fringe field to FF4.

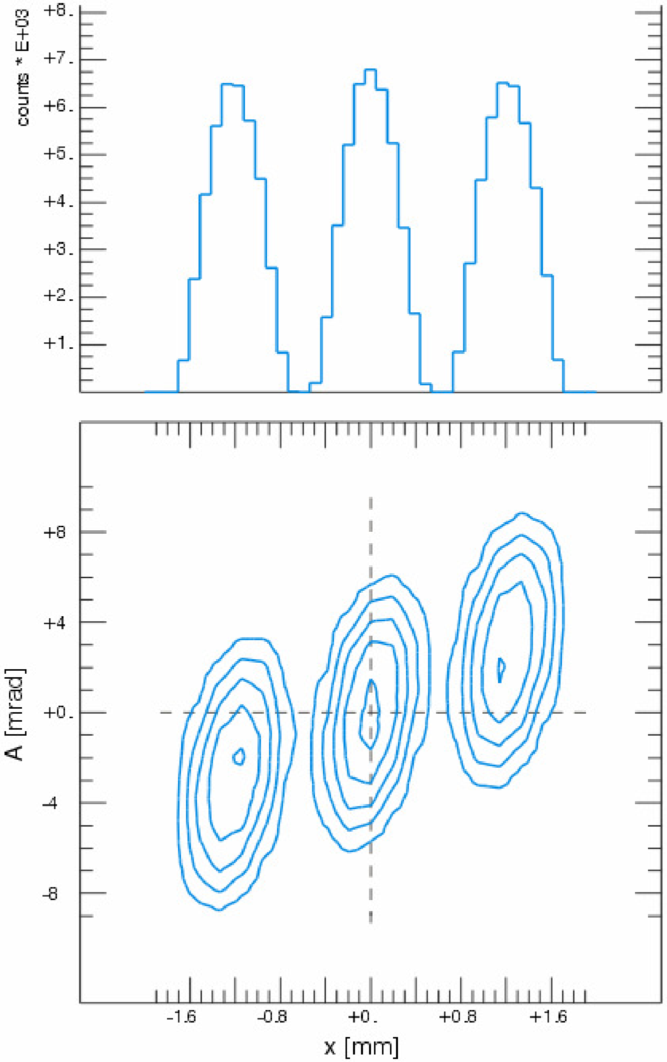


Shift of image plane Δf_x = -0.020 m.

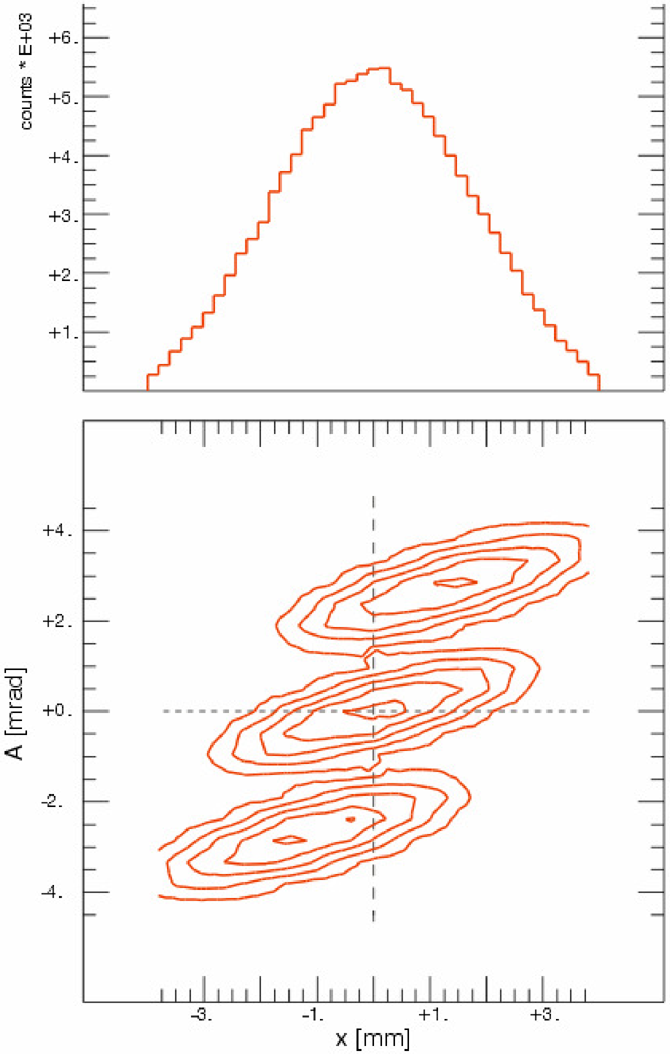
Can be adjusted by tuning FQ1, U = 1.002 kV --> 0.983 kV

At 2nd Image Plane (IP2)

FF3 for all quads



FF4 for all quads



Shift of image plane Δf_x = 2.9 m, but with refit we get the same picture as before.

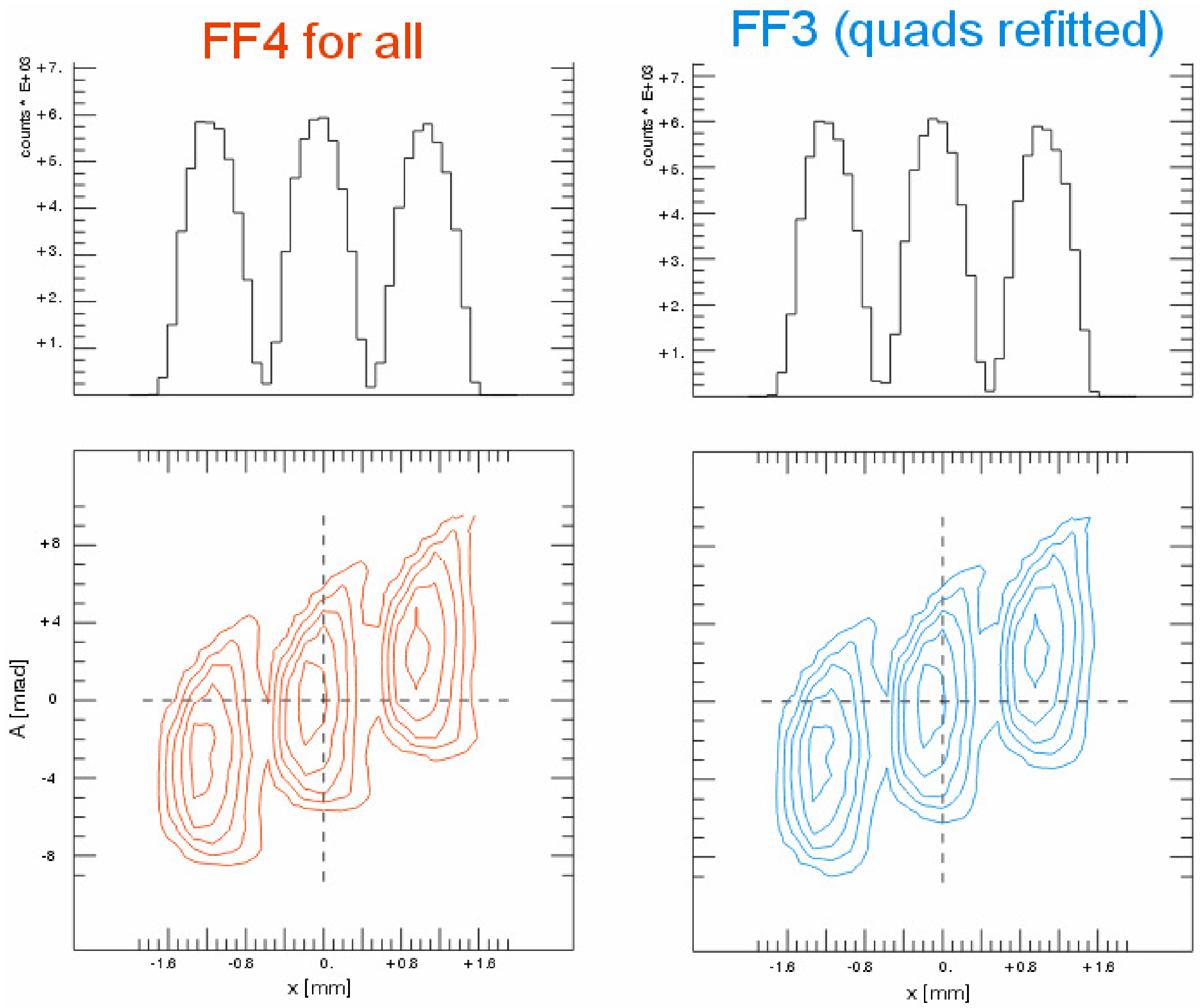
MQ1 = -0.7570 kV
MQ2 = 0.8809 kV
FQ1 = -1.0023 kV

→

MQ1 = -0.7641 kV
MQ2 = 0.8893 kV
FQ1 = -0.9831 kV

Higher Order Differences

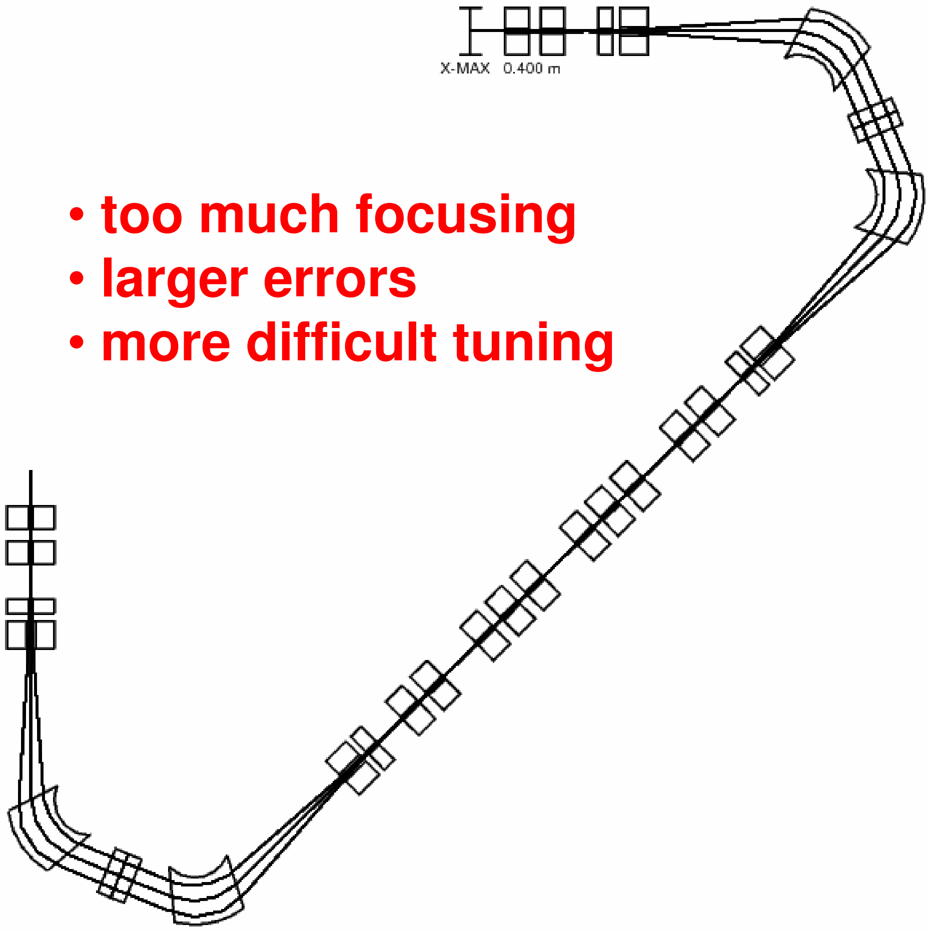
Optimize hexapoles and octupole component for FF4.



Alpha Modes

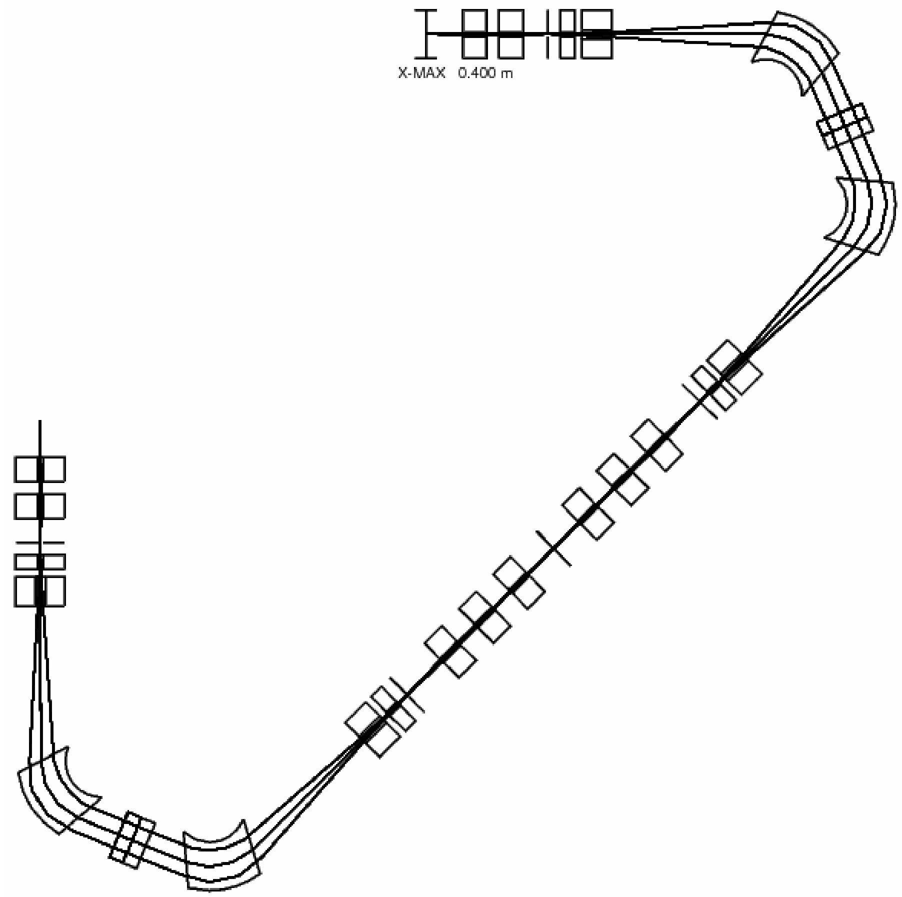
with 3 images to be achromatic

HRS-ALPHA-C135
like in report, 5 images

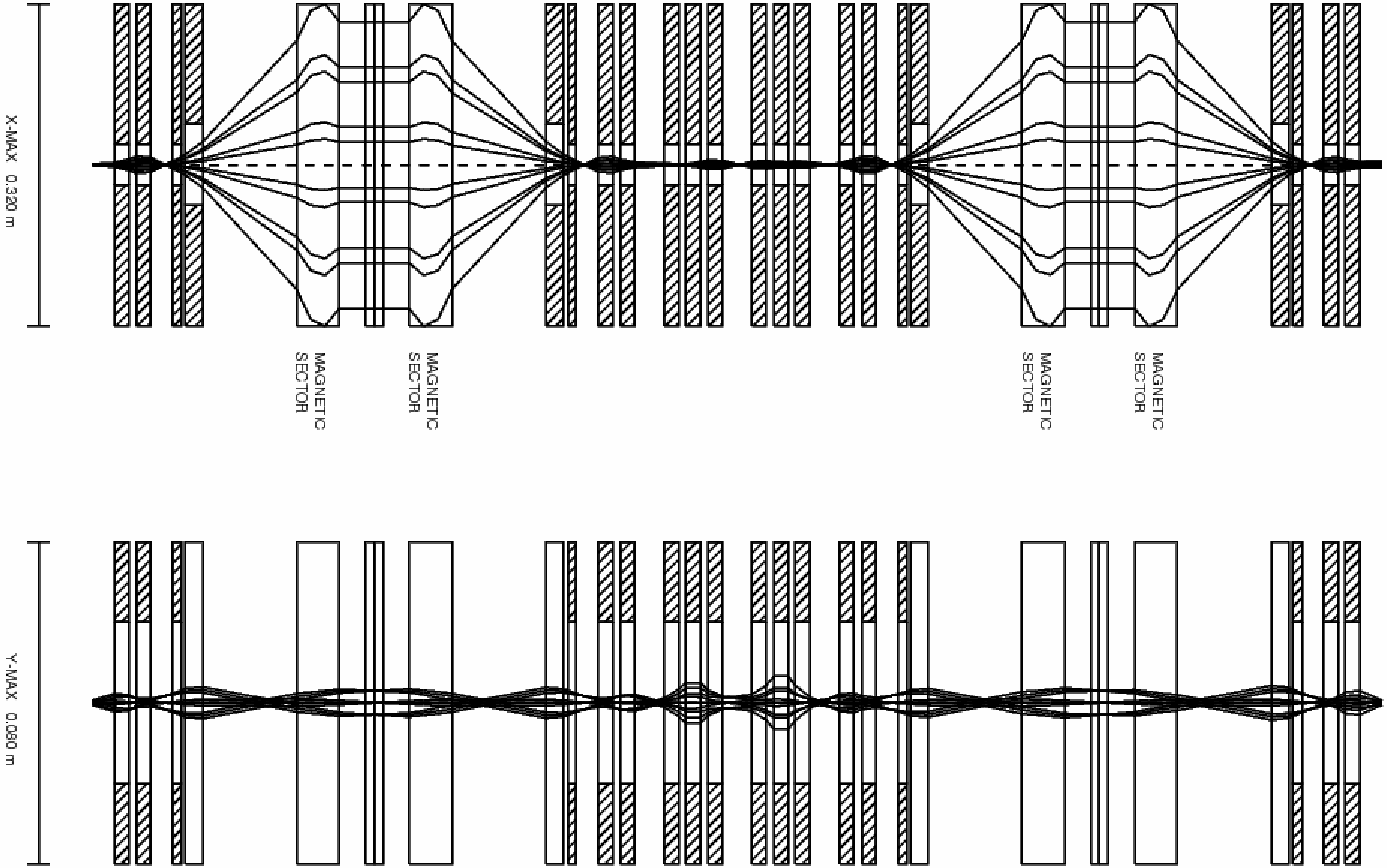


- too much focusing
- larger errors
- more difficult tuning

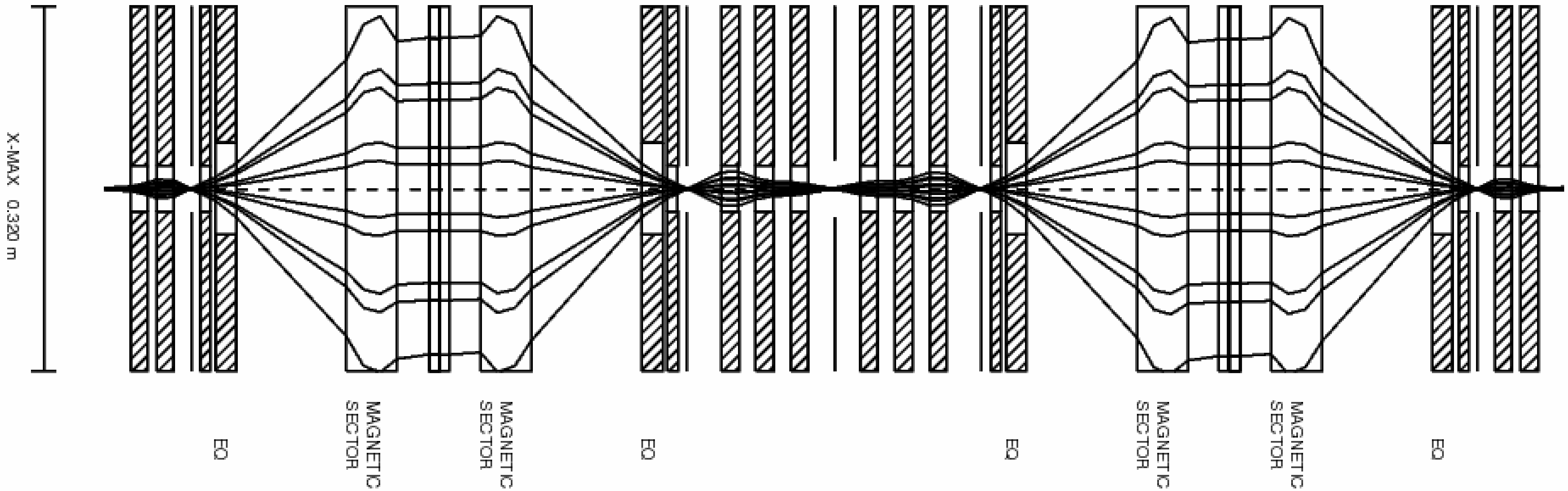
HRS-ALPHA-C135 short-2
only 3 images, L = 16.84 m
4 quads less



HRS alpha C135



HRS alpha C135 short-2



In midplane :(X|D) = -11.2 m, (X|X) = -0.46

waist but no image in Y, ΔY = ±3.3 mm (for ε_y = 1mm x 10 mrad)