GICOSY Calculations for HRS

Helmut Weick, GSI
DESIR HRS Meeting
Bordeaux, 17+18th Nov. 2011

- **Fringe Fields**
- **Hexapole Corrections**
- **Misalignments**

Fringe Fields + Effective Lengths

**We still don’t have the real FF distributions,
but they can be calculated with SIMION or TOSCA.**

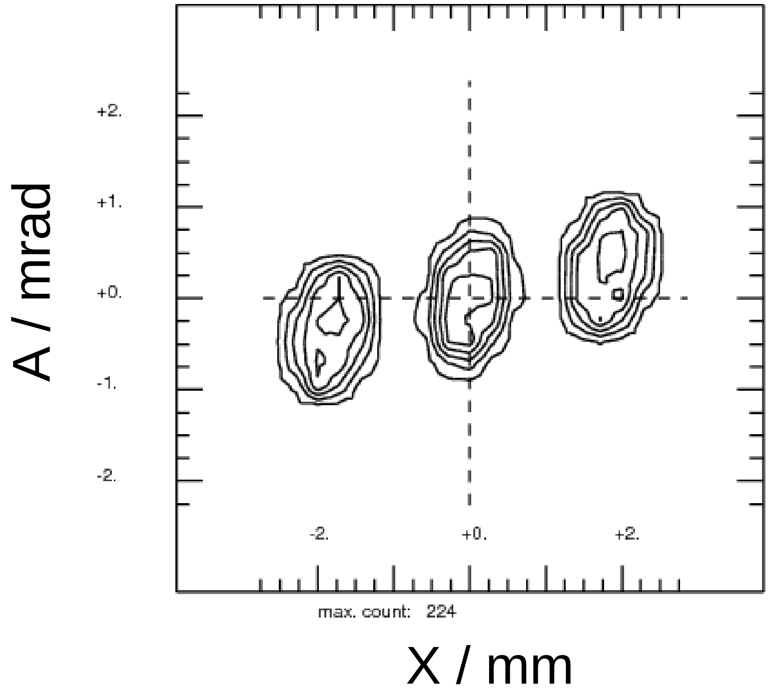
Still the design is good enough because even assuming the largest possible variation of fringe field extension just requires a small readjustment of quadrupoles + multipole, and all optical properties are restored.

The effective lengths of quadrupoles and dipoles need to be calculated. They will differ from geometrical lengths. This effect is much larger than that coming from the fringe fields.

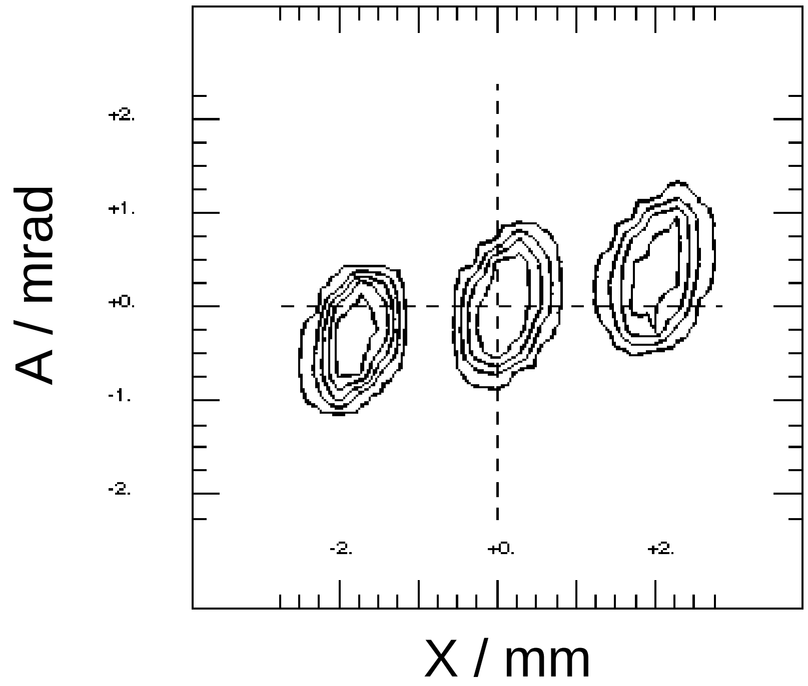
Phase Space after all Multipole Corrections

phase space $X_0 * A_0$ = 0.5mm * 7 mrad, $\delta_m = \Delta m/m$ = 1/ 20000

1st order



3rd order

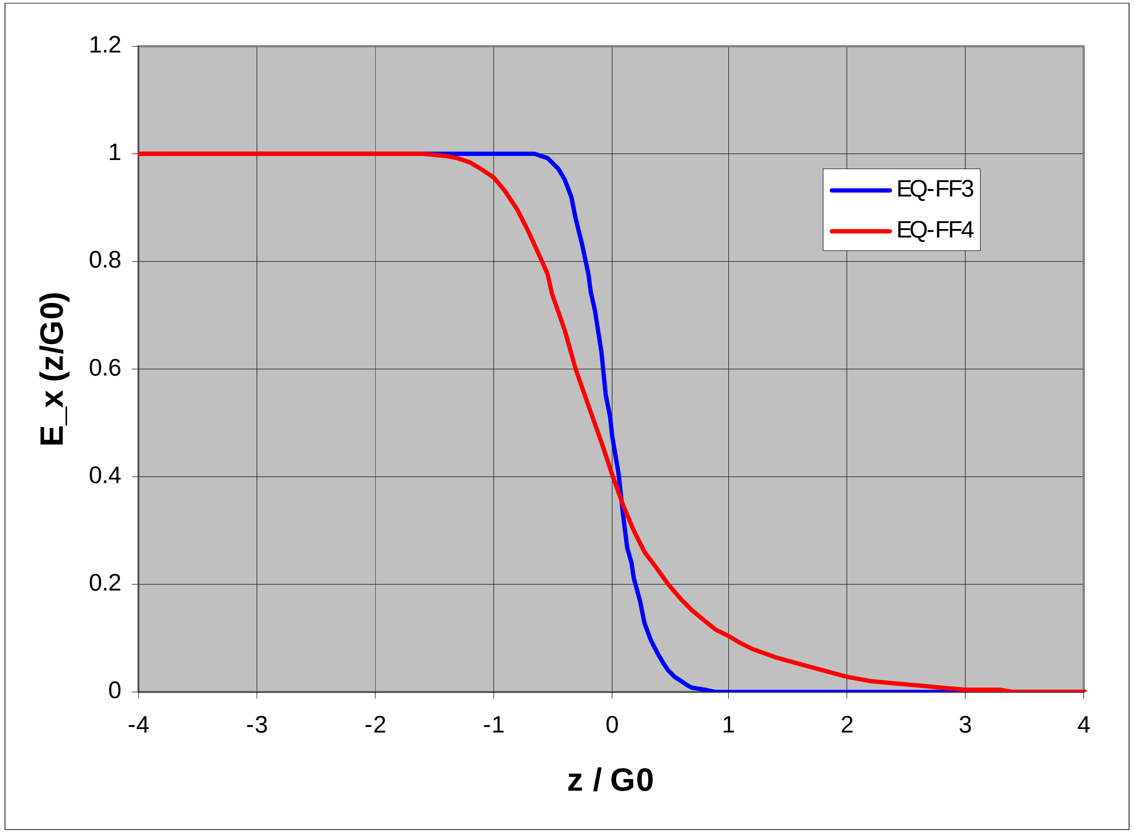


In perfect system

Just to verify the calculations

Possible Fringe Field Distributions

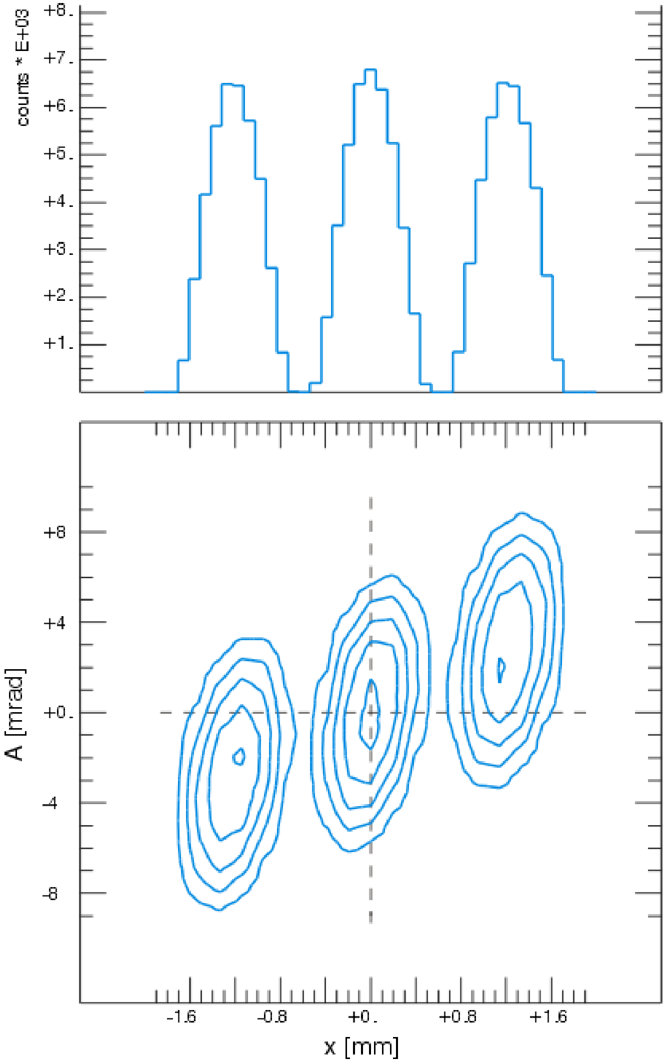
Two extreme cases for EQ from GICOSY list, FF3 and FF4, different Enge coefficients (field shape) but same effective length (field integral).



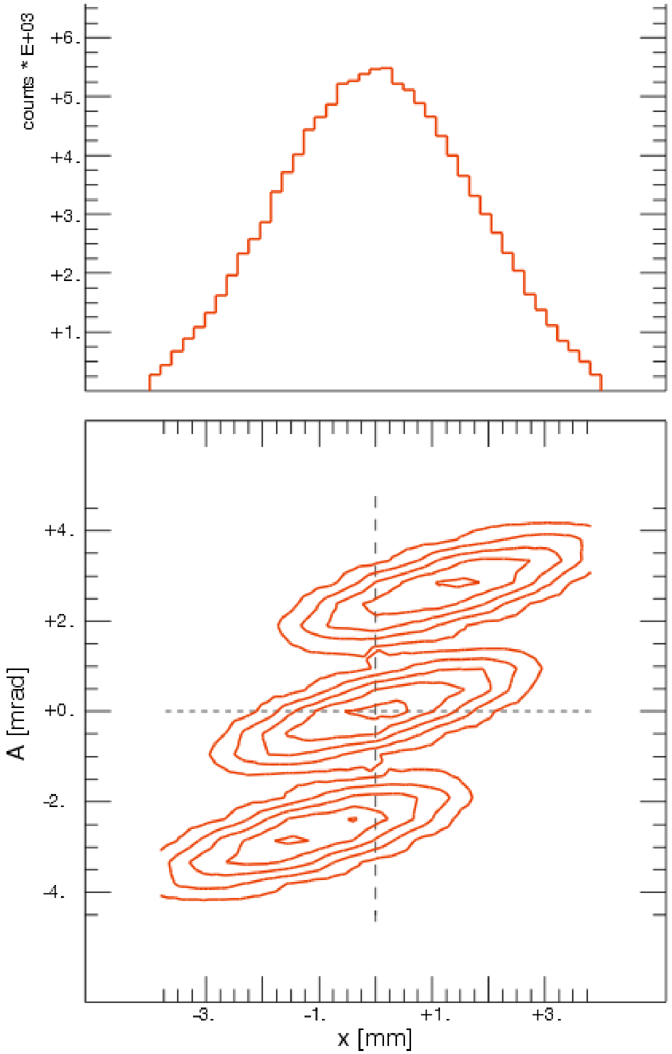
Depends much on environment: beam pipe, neighboring elements

At Image Plane

FF3 for all quads



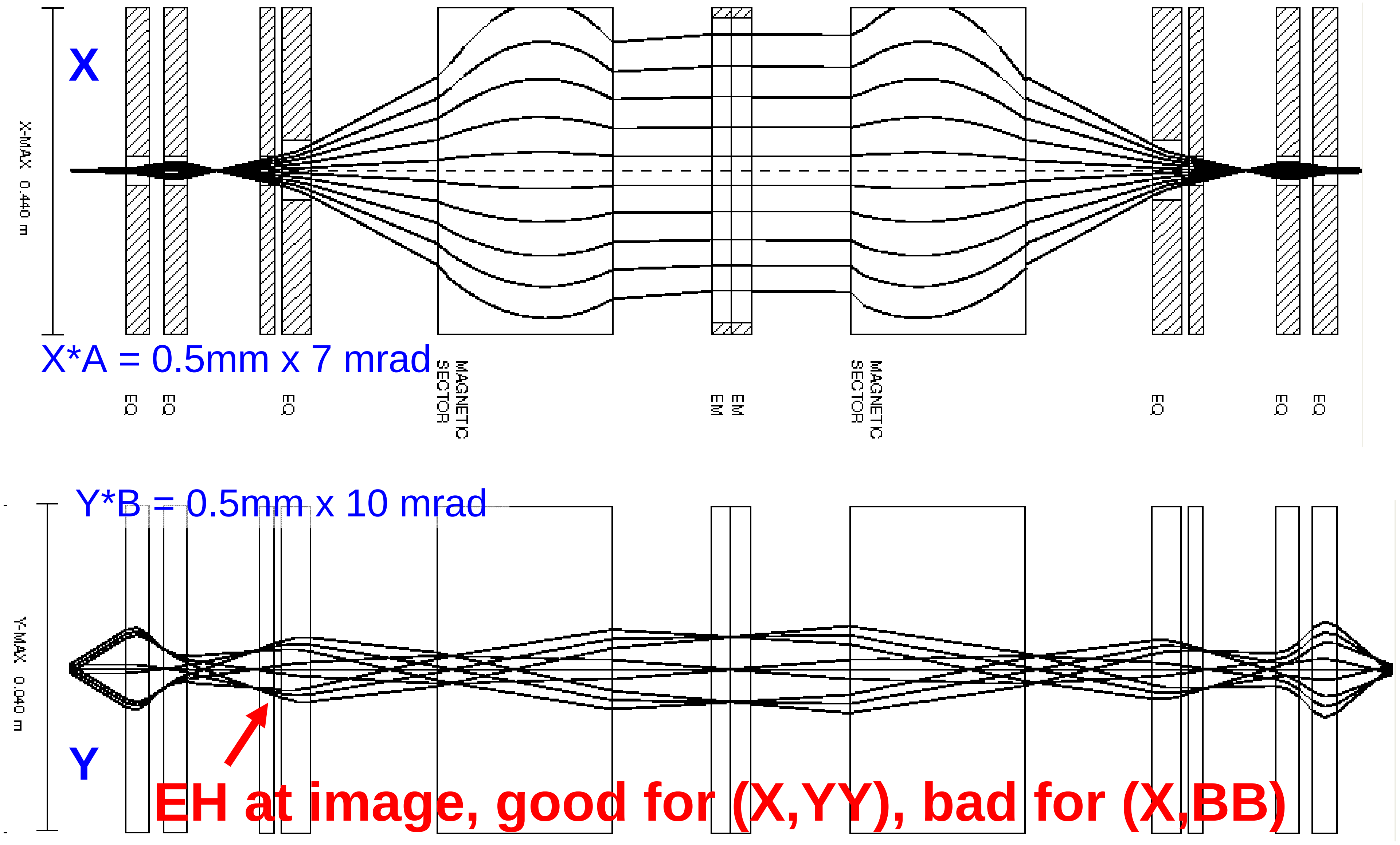
FF4 for all quads



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

MQ1, + 1%
MQ2, +1%
FQ1, -2%

Trajectories (3rd order)



Effect of first and third Hexapole

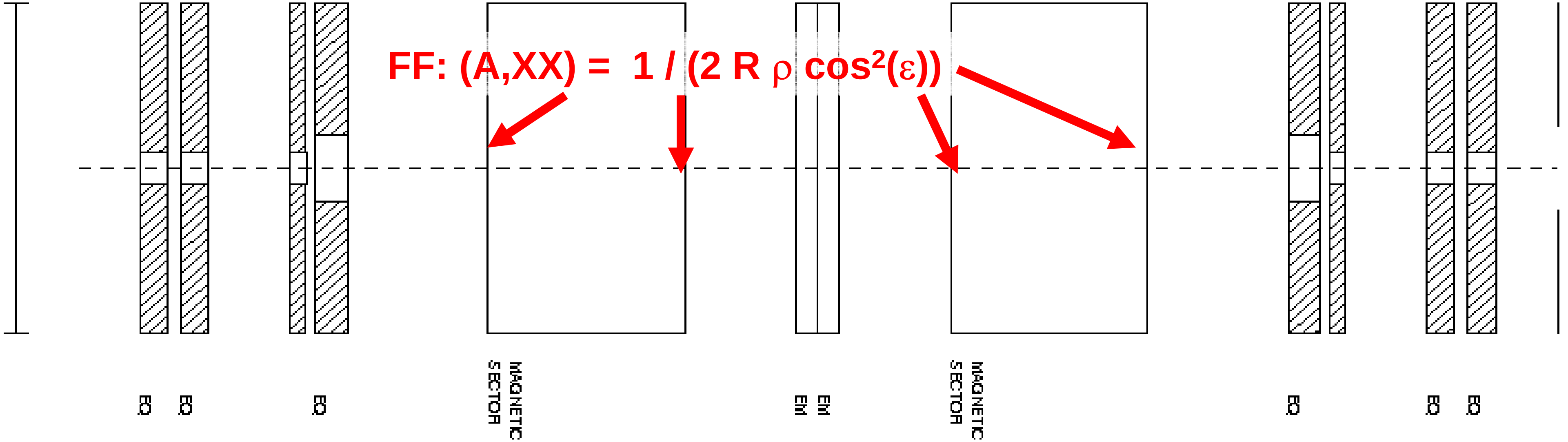
Assume symmetric operation,
but also opposite polarity checked, values for 60 keV

U = 0.00 kV, 0.00 kV --> (X,BB)= 1.17m, (X,YY)= 1237/m, (X,AA) = 0 m
U = 0.10 kV, 0.10 kV --> (X,BB)= 1.16m, (X,YY)= 895/m, (X,AA) = 54 m
U = 0.10 kV, -0.10 kV --> (X,BB)= 1.17m, (X,YY)= 1225/m, (X,AA) = 0 m
U = 0.36 kV, 0.36 kV --> (X,BB)= 1.14m, (X,YY)=   0/m, (X,AA) =195 m

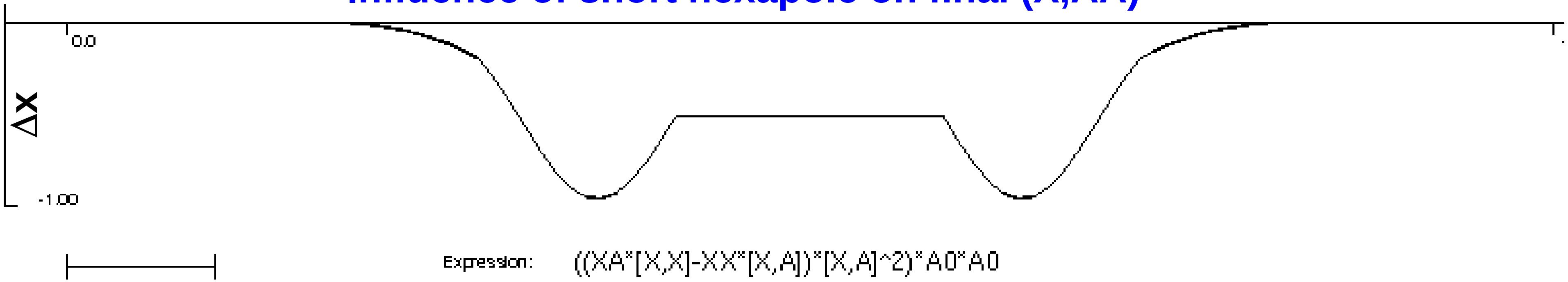
$\Rightarrow$ **(X,YY) can be corrected (no small Y slit needed)**
(X,AA) needs only small retuning with central multipole

(X,BB) cannot be corrected,
but it is compensated by symmetry,
here (X,BB)*B_0*$B_{0\ max}$ = 0.056 mm, with B_0 = 7 mrad
requires large deviation from symmetry to be disturbing.

Coupling Coefficient for (X,AA)



Influence of short hexapole on final (X,AA)



Curvature = ρ / R = 0.85m / 5.76m on all sides makes overall (X,AA) zero.

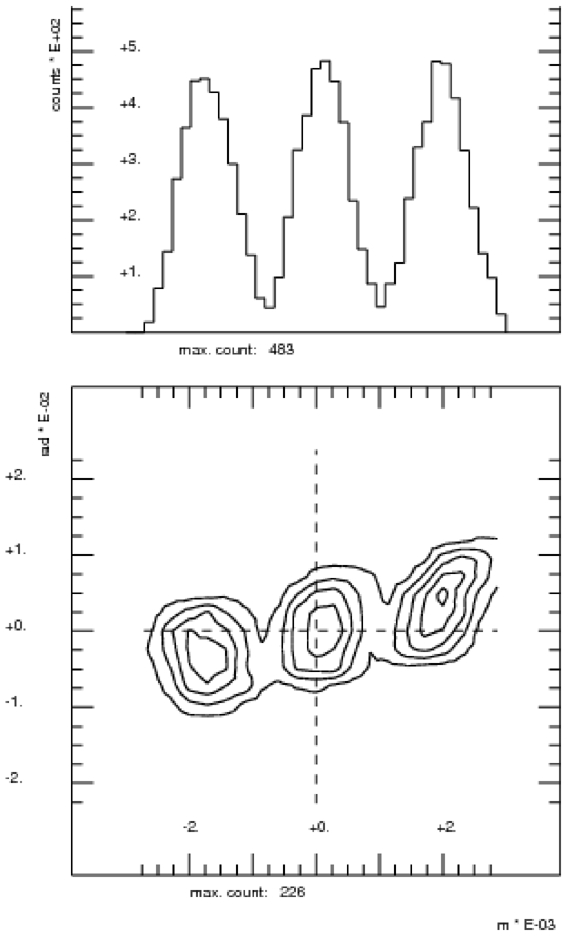
It may be easier to use only the much more sensitive inner sides.

R = 3m would overcorrect the aberration by far!

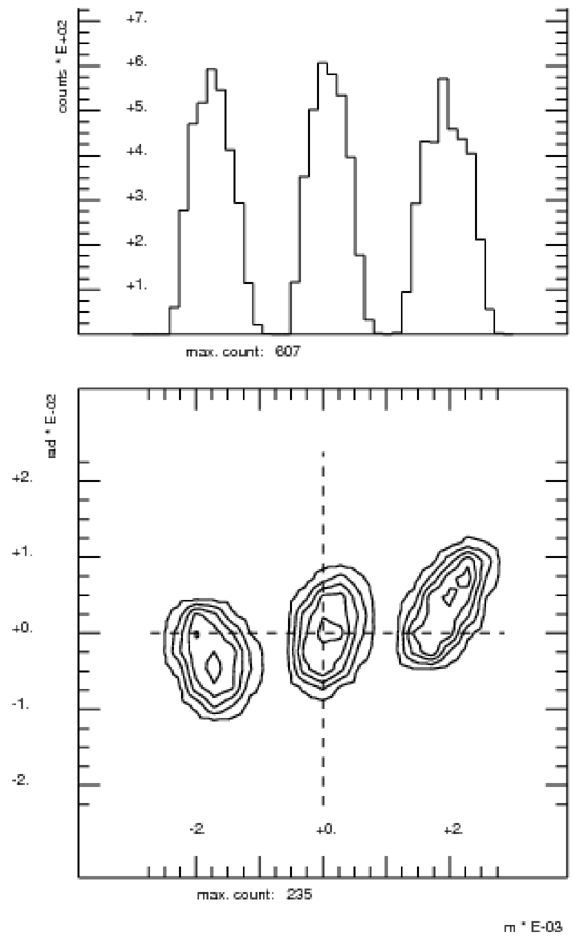
Phase space with some quads rotated a bit

3rd order GICOSY calculation

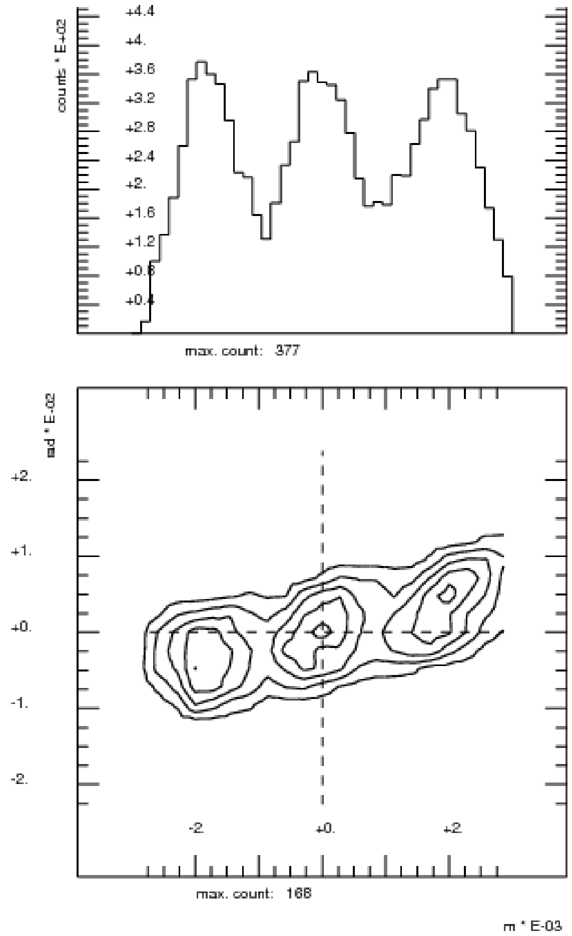
1st quad rot. by 1°



1st + 2nd quad rot. by 1°



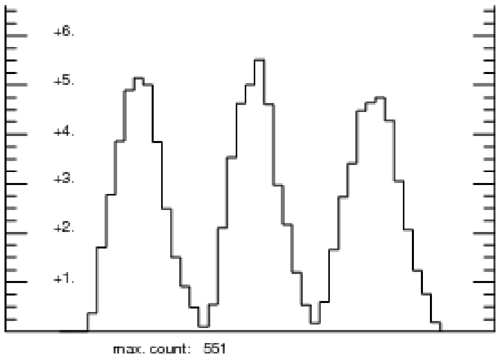
1st- 3rd quad rot. by 1°

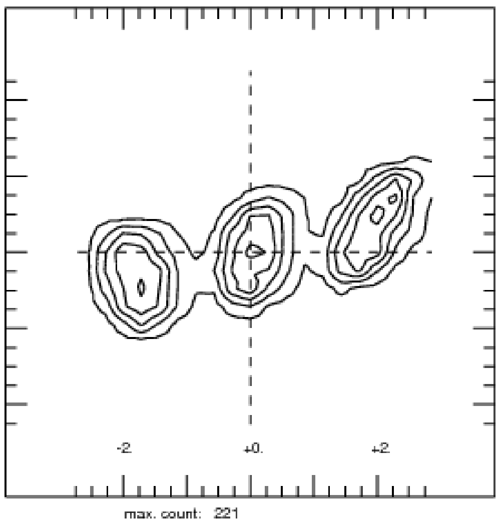


Similar result for rotation of quadrupoles behind dipoles

Rotation in 1st module can be compensated by 3rd

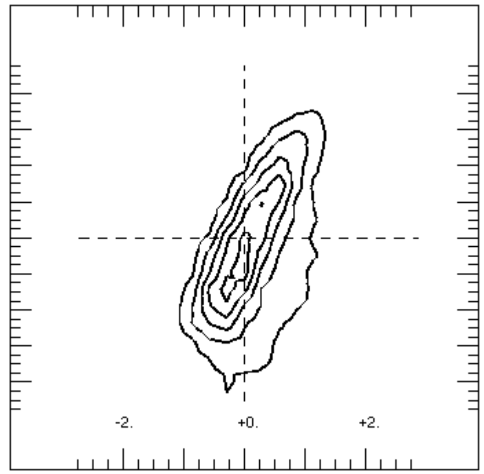
1st- 3rd quad rot. by 0.5°





Well aligned and adjusted system

(X,B) = 0, (X,Y) = 0,
and
(X,AA) = 0



1st+ 3rd quad rot. by 1°
Size of contributions

(X,B)*B_0 = -0.56 mm
(for B_0=10 mrad)

but also (X_0=Y_0= 0.5mm, A_0=7 mrad)
(X,AA)*A_0*A_0 = 0.28 mm
(X,AY)*A_0*Y_0 = 0.41 mm
(X,AB)*A_0*B_0 =-0.19 mm
(X,YY)*Y_0*Y_0 = 0.24 mm

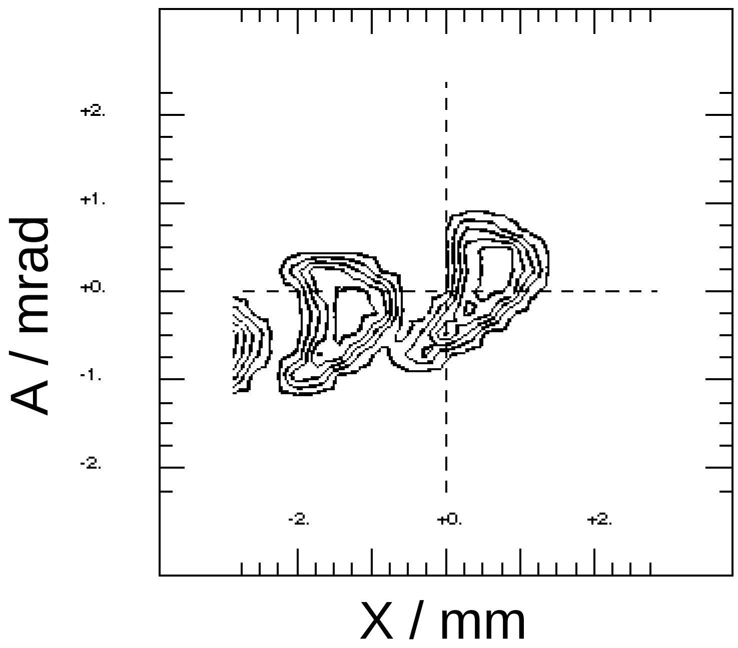
numbers are maximal values not peak widths

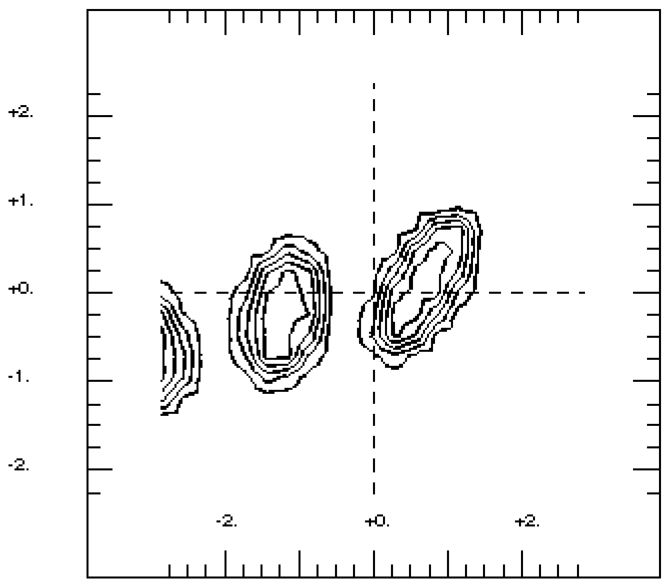
Influence of Shifts, X

1st module shifted by Δx = 0.1mm

old hexapole value

hexapole +1.4%

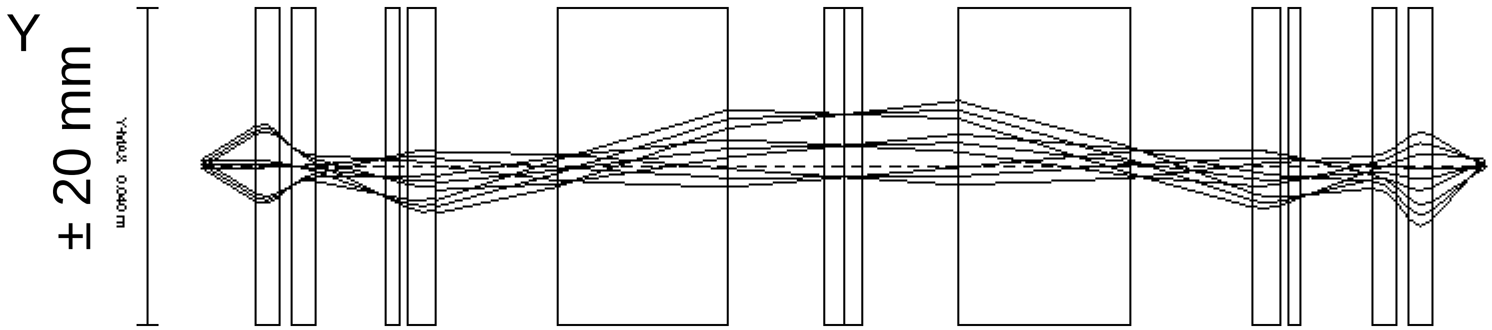


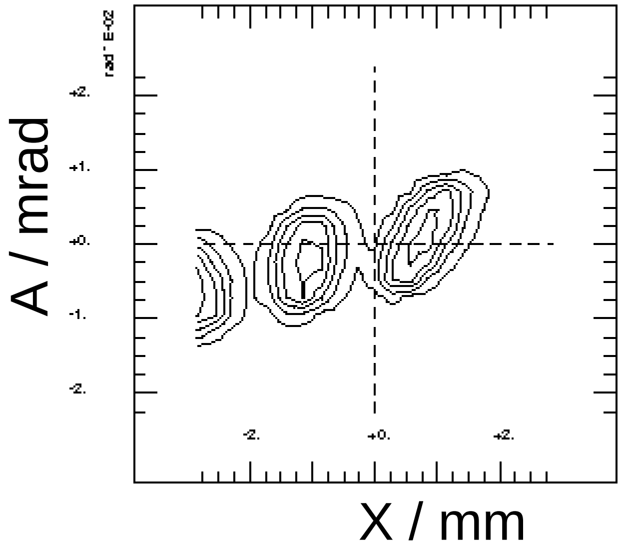


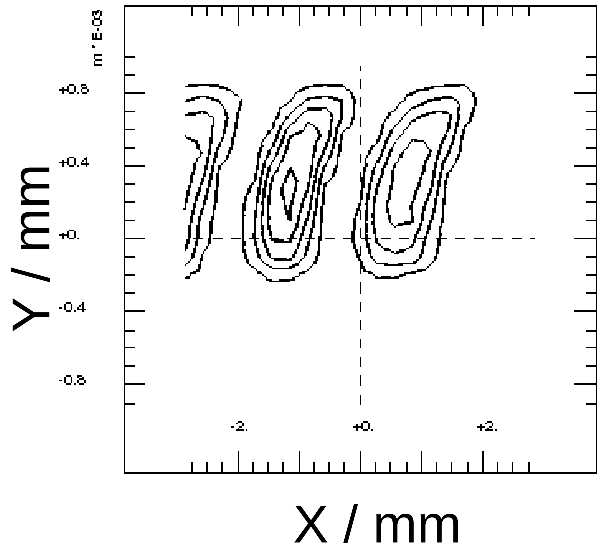
(X,AA) and some (X,BB),(X,XA)

Influence of Shifts, Y

1st module shifted by Δx = 0.1mm, Δy = 0.5mm







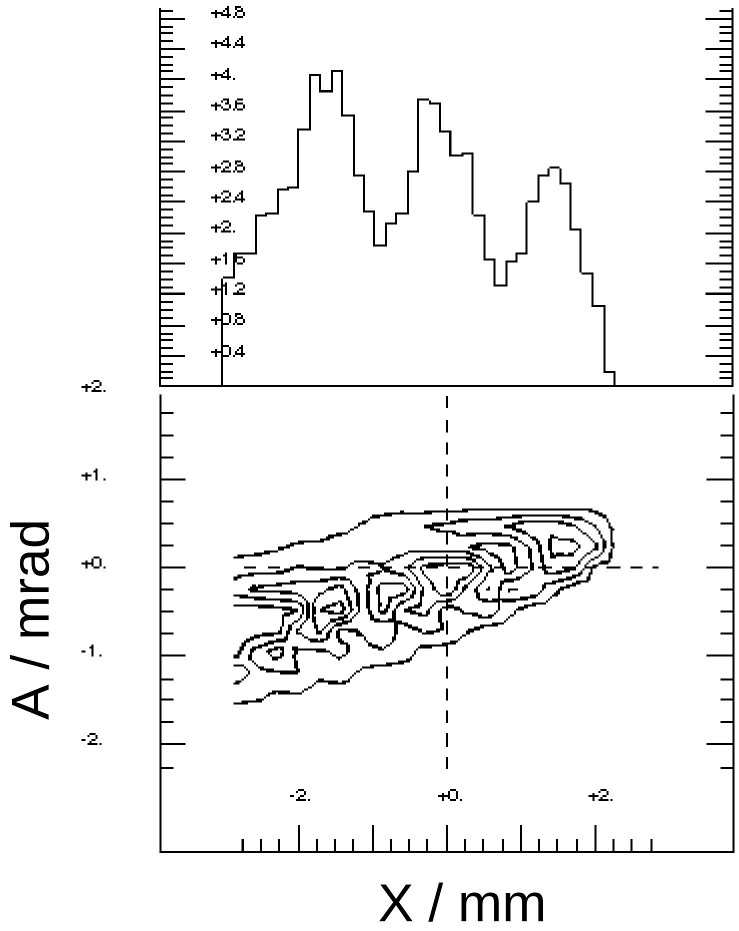
some (X,Y)

X, Y independent
for small shifts

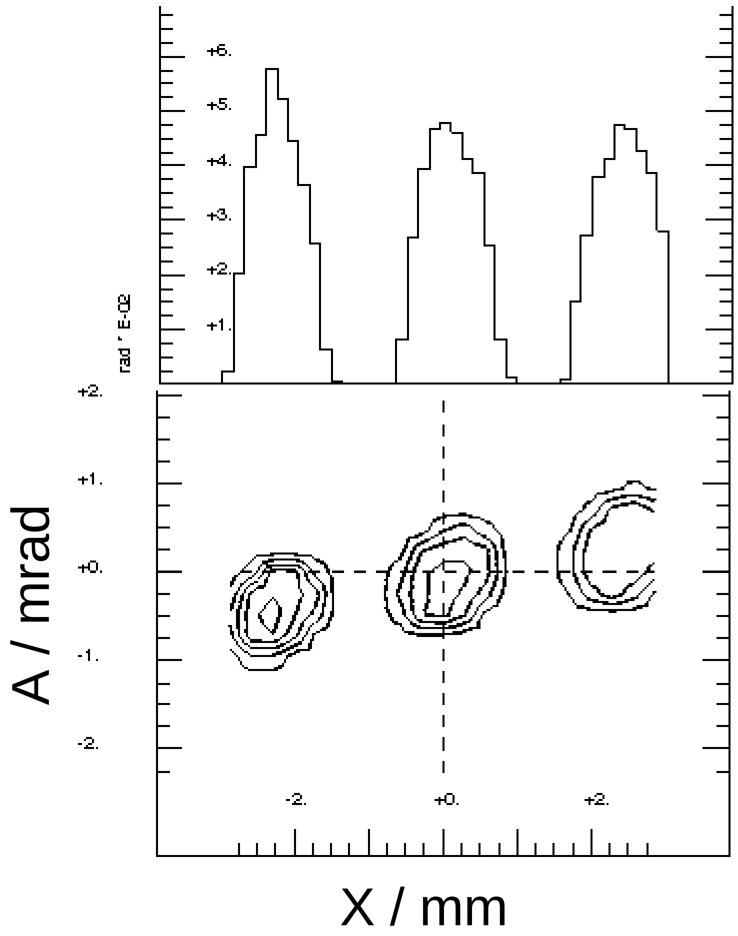
Initial Beam Direction

Angle in y is uncritical, but angle in X is critical.

assume ΔA = 1 mrad uncompensated



assume ΔA = 1 mrad, but central multipole hex +10% and final image shifted by Δz = 14 cm



For even larger shifts use steerers