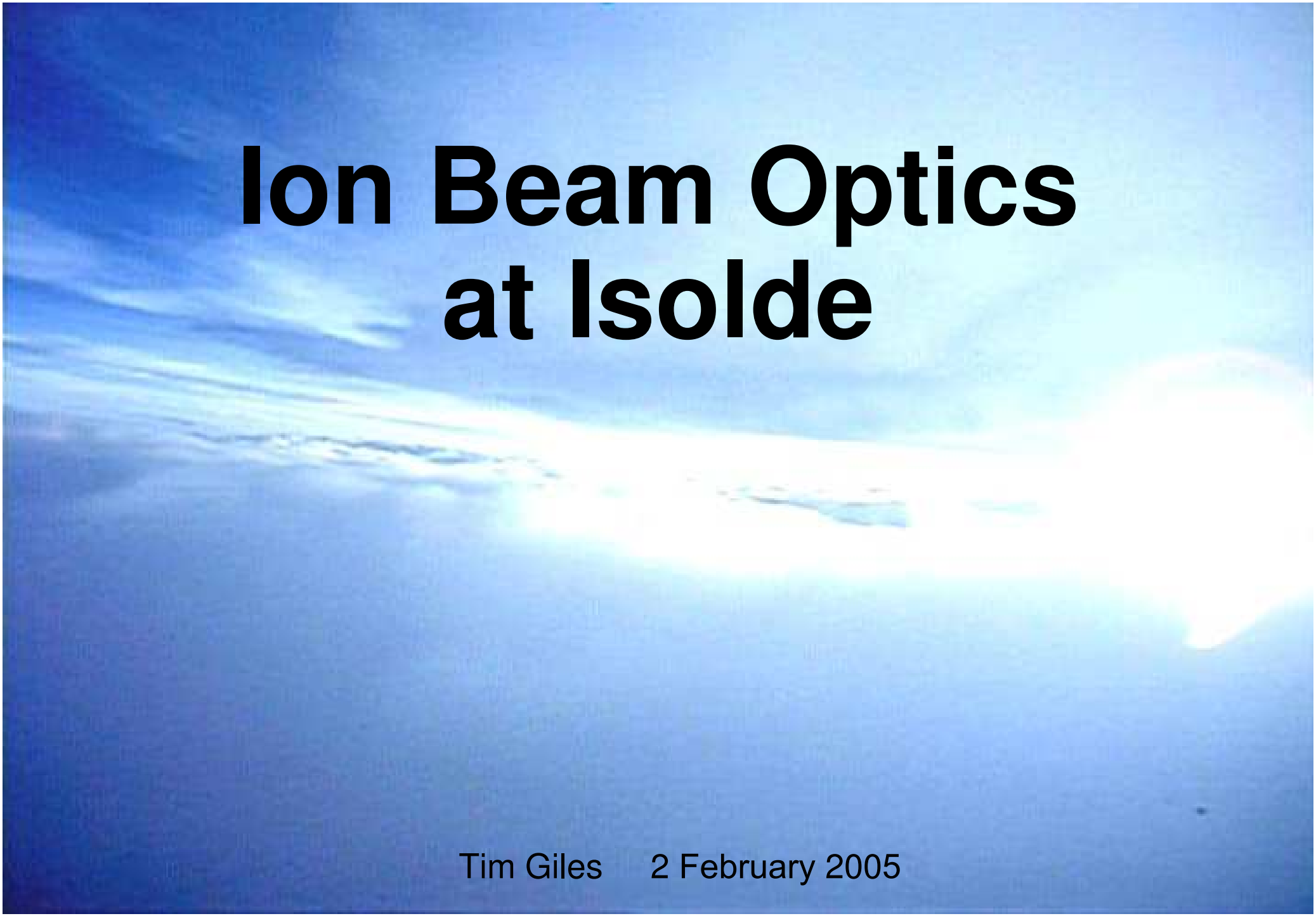
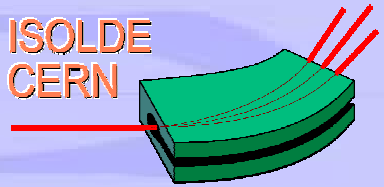


Ion Beam Optics at Isolde

Tim Giles 2 February 2005

Ion Optics at Isolde

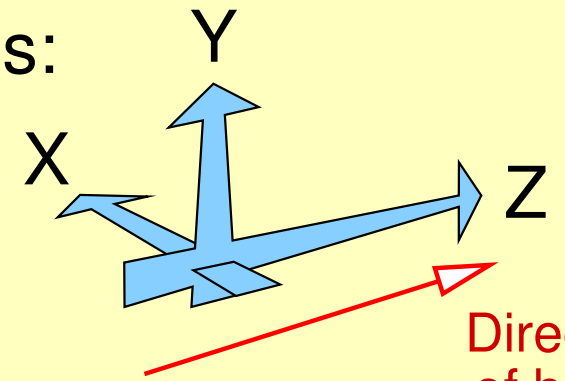


- Some Definitions
- Some Examples
- Distortions in Ideal Lenses
- Design of Real Lenses
- Ideas for the Future


Definitions

Some Definitions

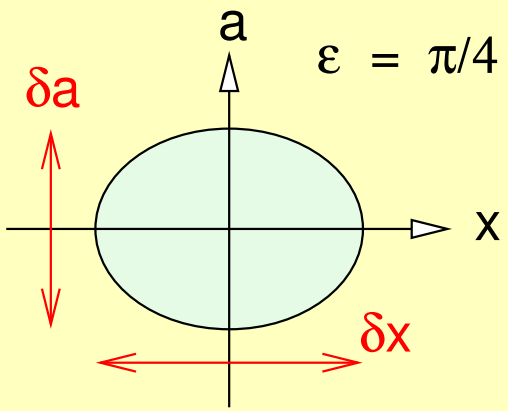
Axes:



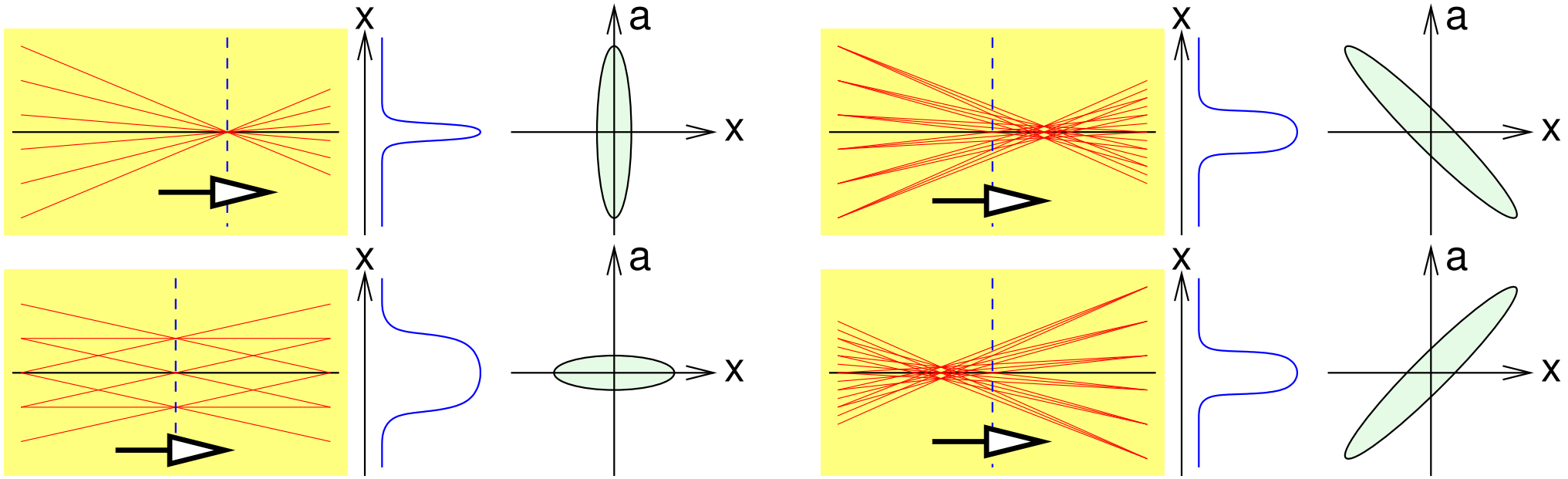
a = dx / dz

b = dy / dz

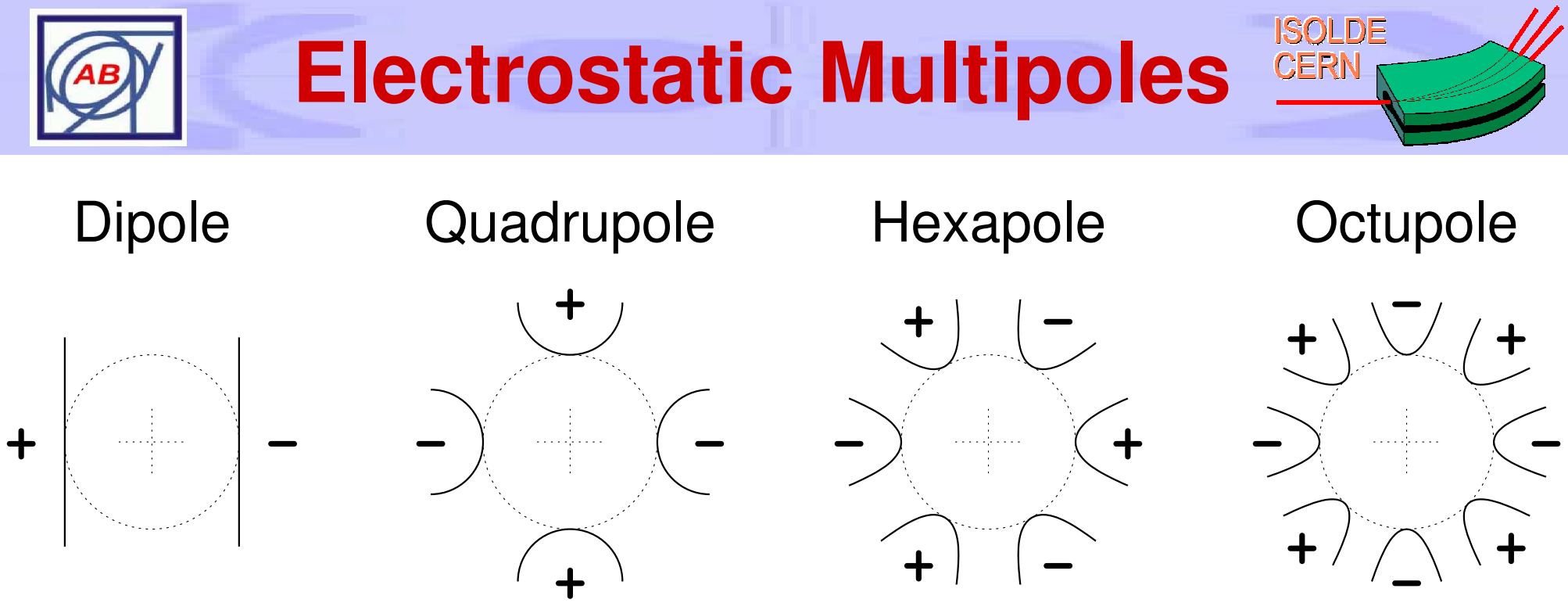
Emittance:



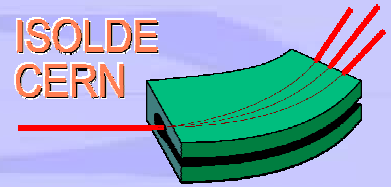
$\varepsilon = \pi/4 \ \delta x \ \delta a$

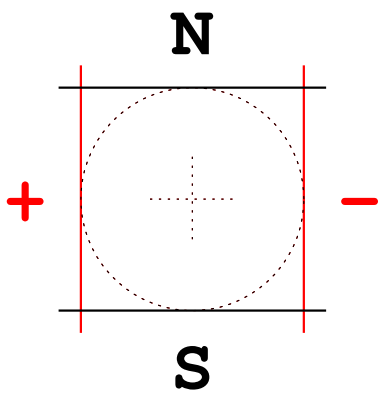
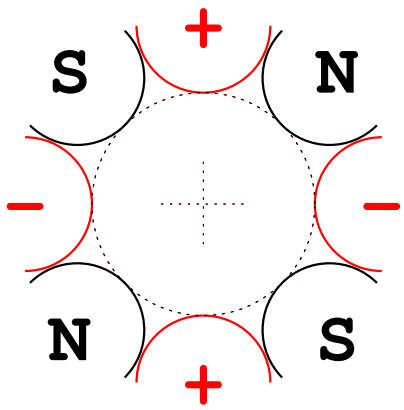
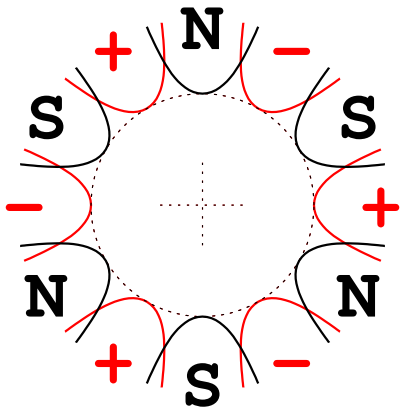
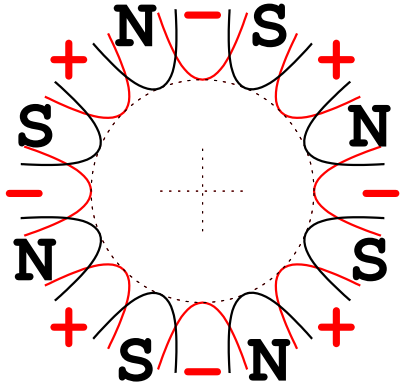
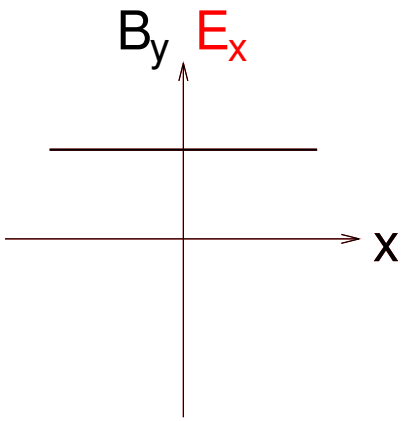
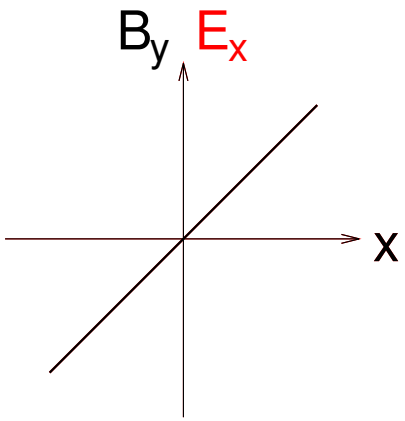
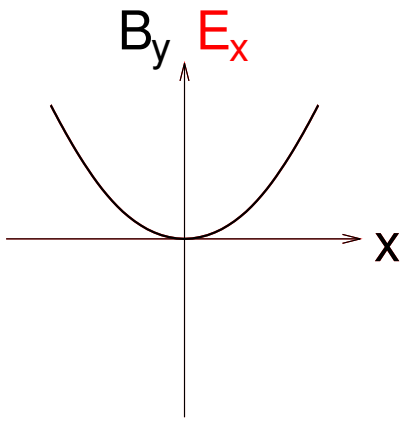
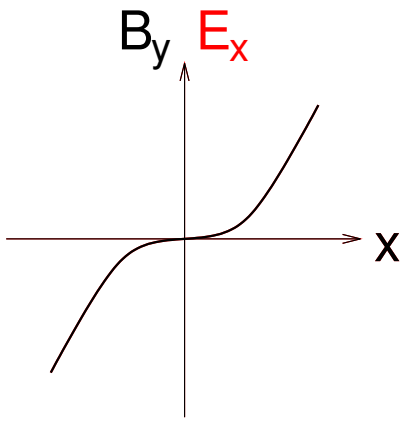


Electrostatic Multipoles

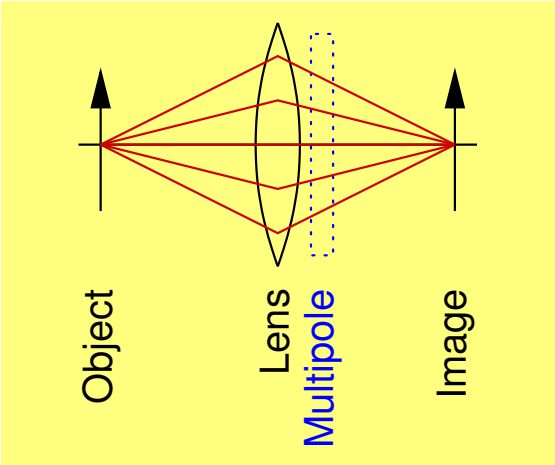


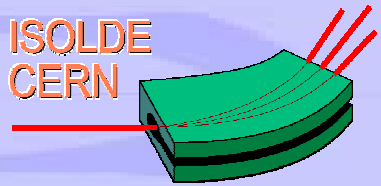
Magnetic Multipoles

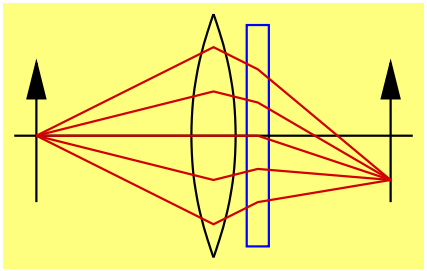
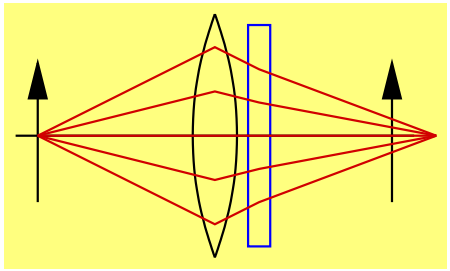
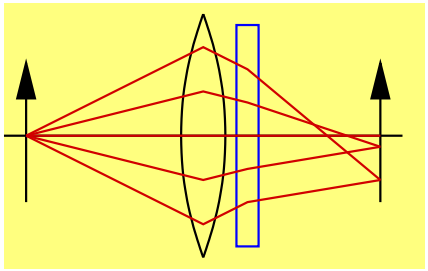
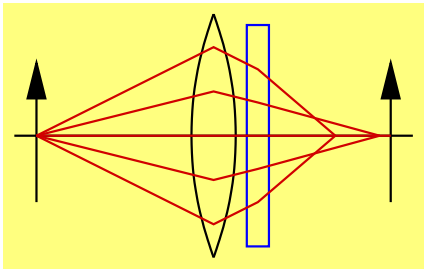
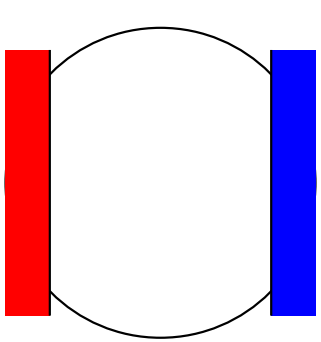
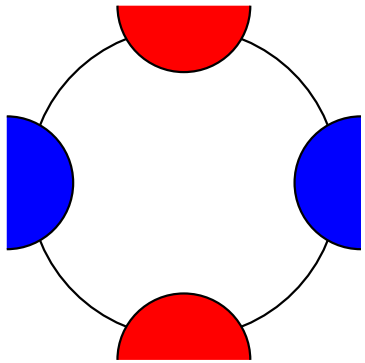
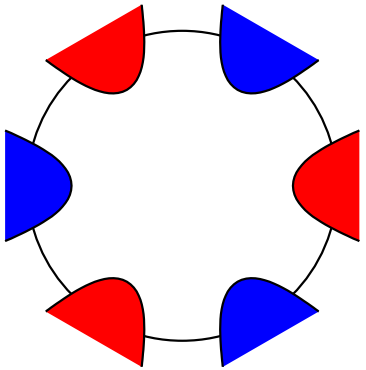
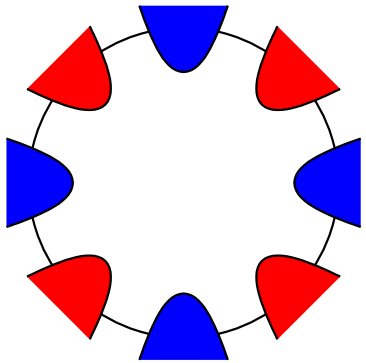


Dipole	Quadrupole	Hexapole	Octupole
			
0th	1st	2nd	3rd
			

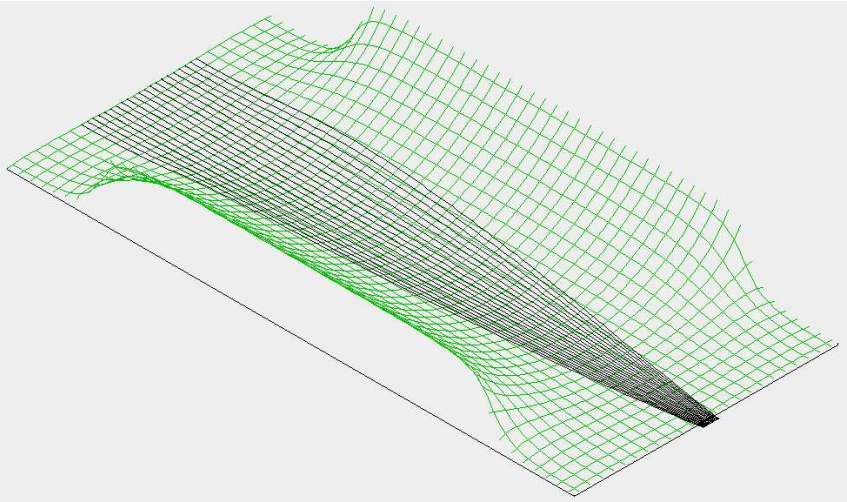
Effect:

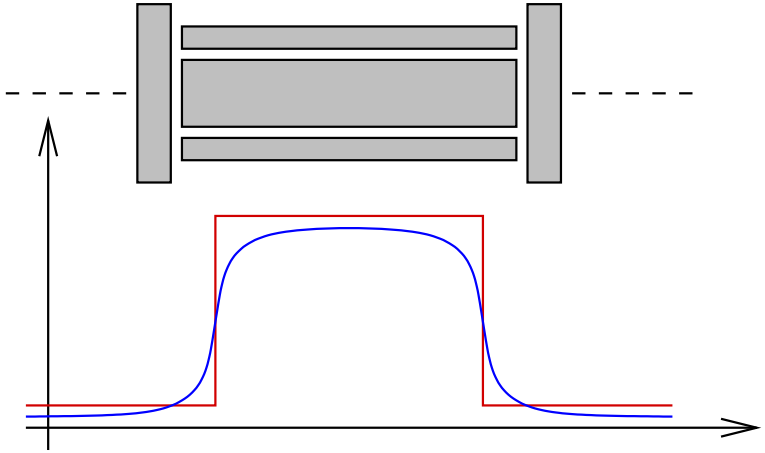


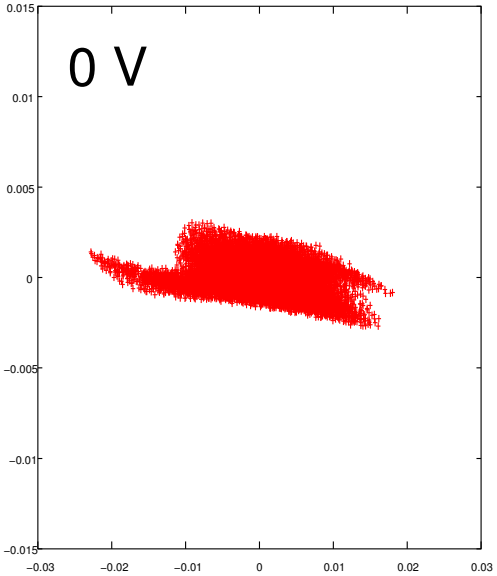


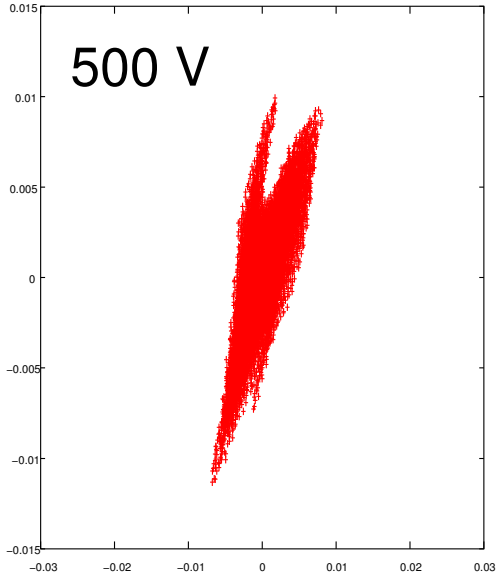
Dipole 0th	Quadrupole 1st	Hexapole 2nd	Octupole 3rd
			
			

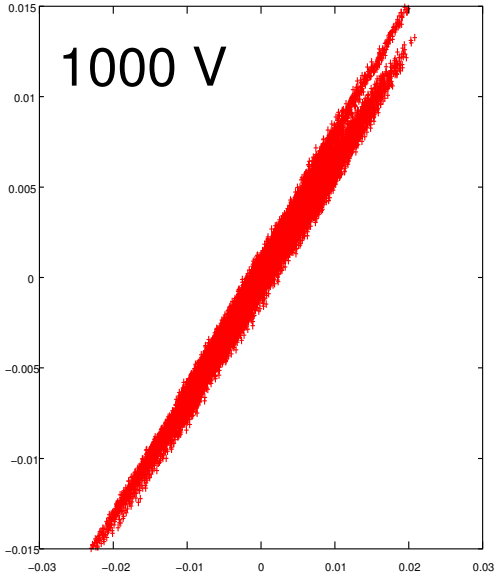
Quadrupole length

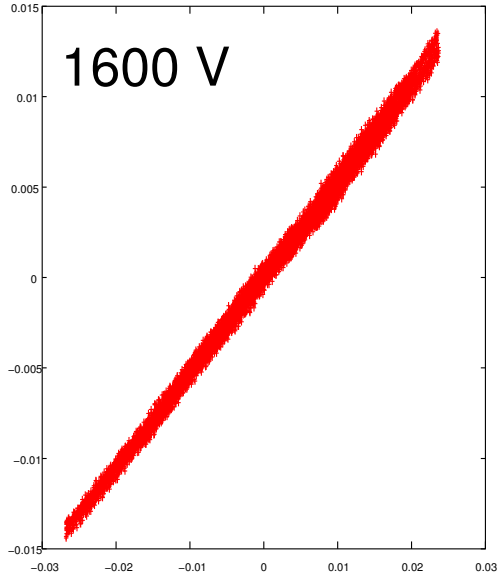


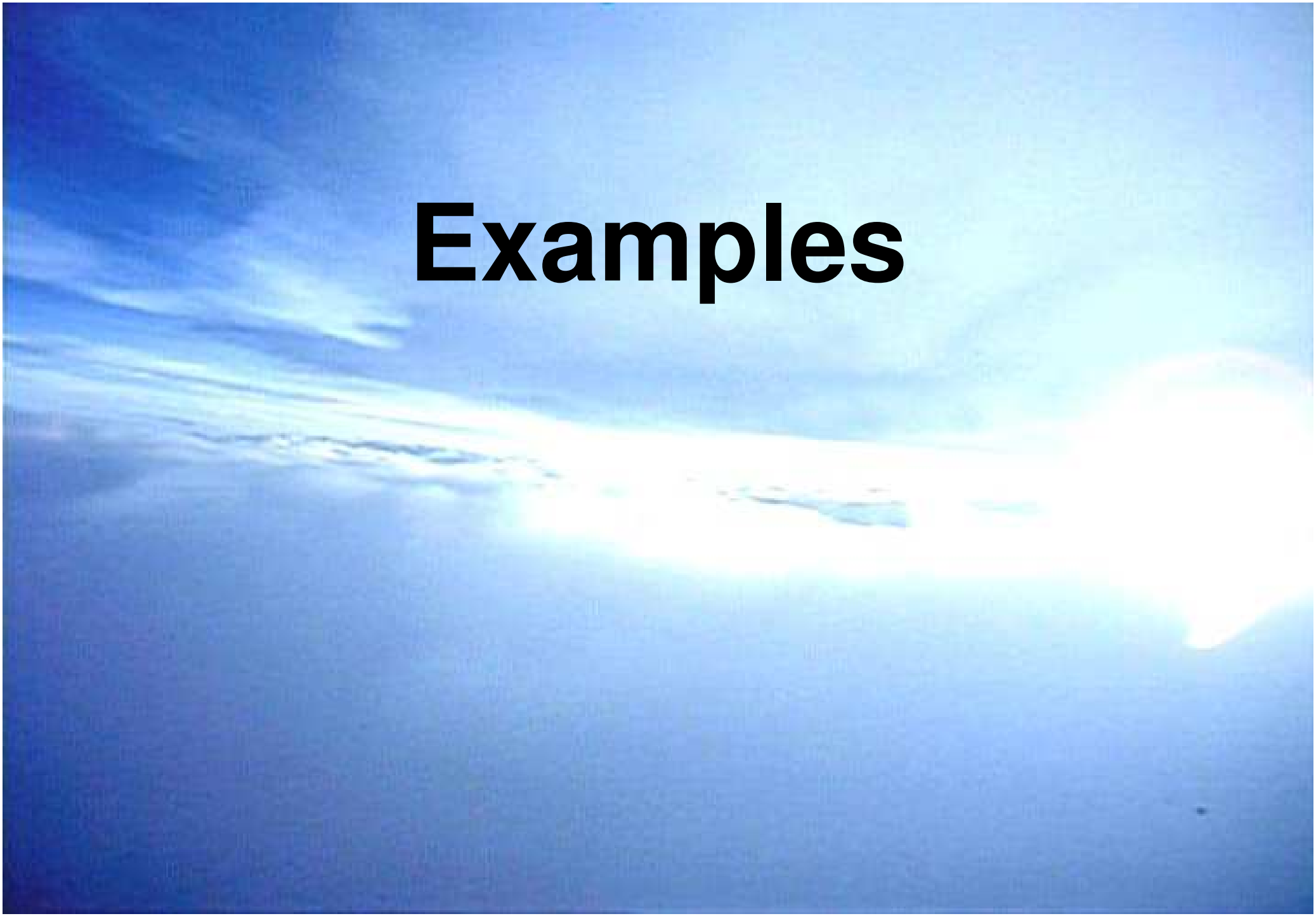




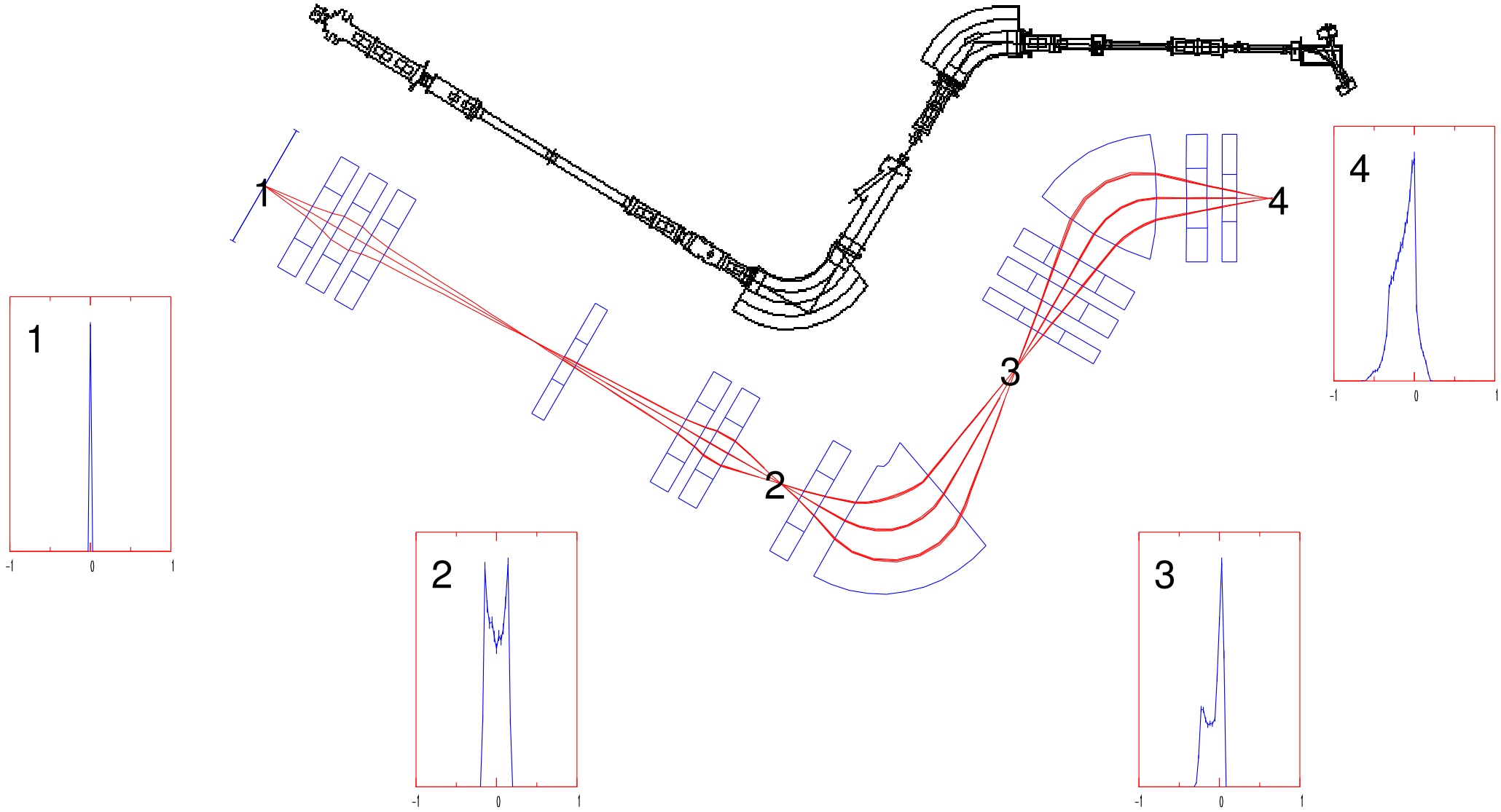




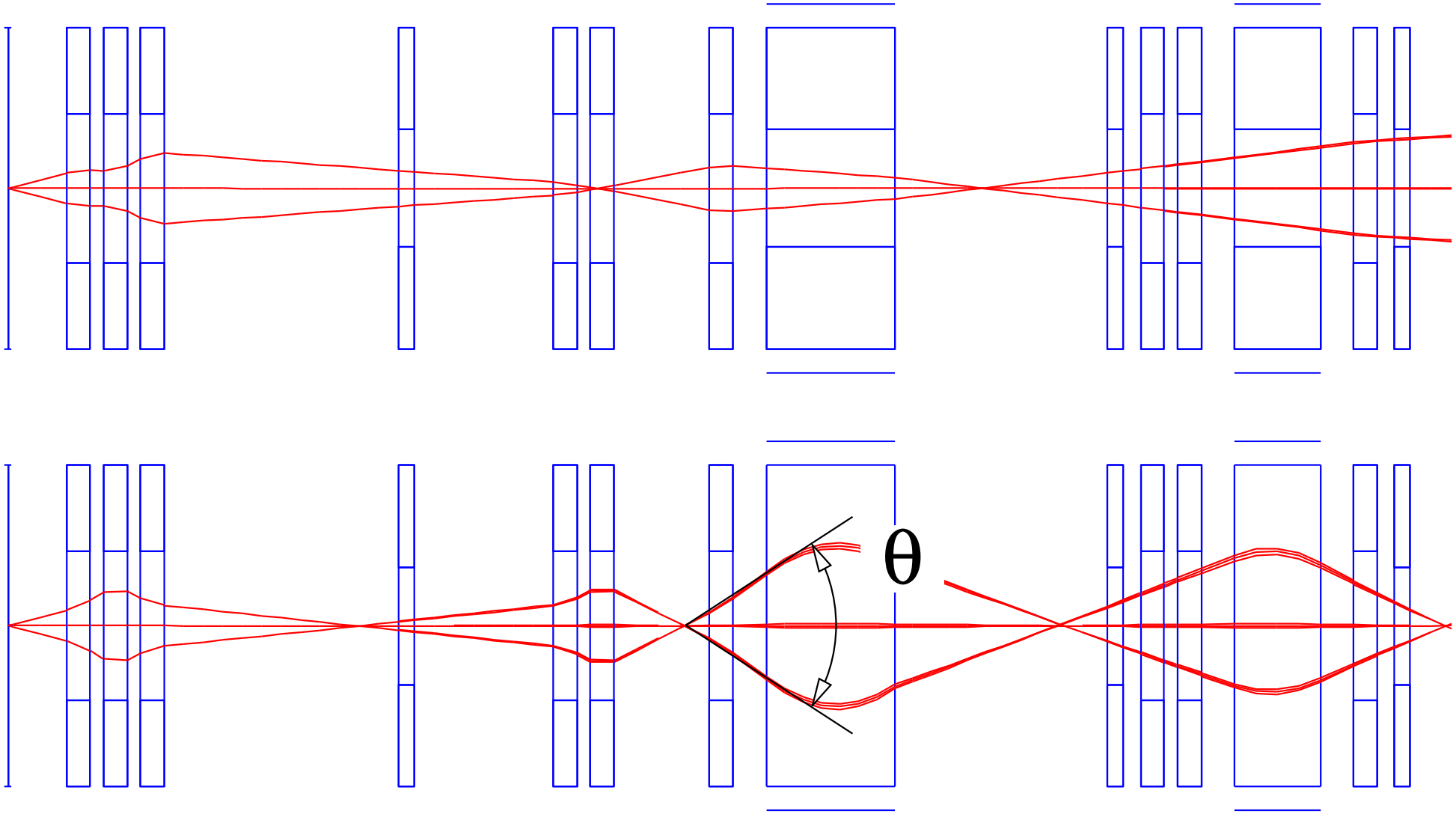



Examples

Example 1: The HRS

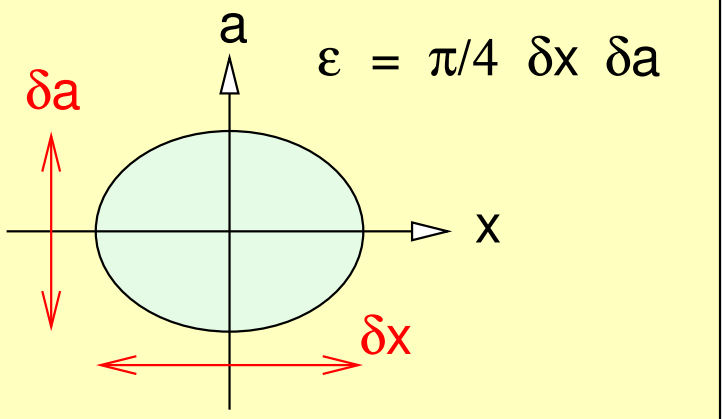


Example 1: The HRS



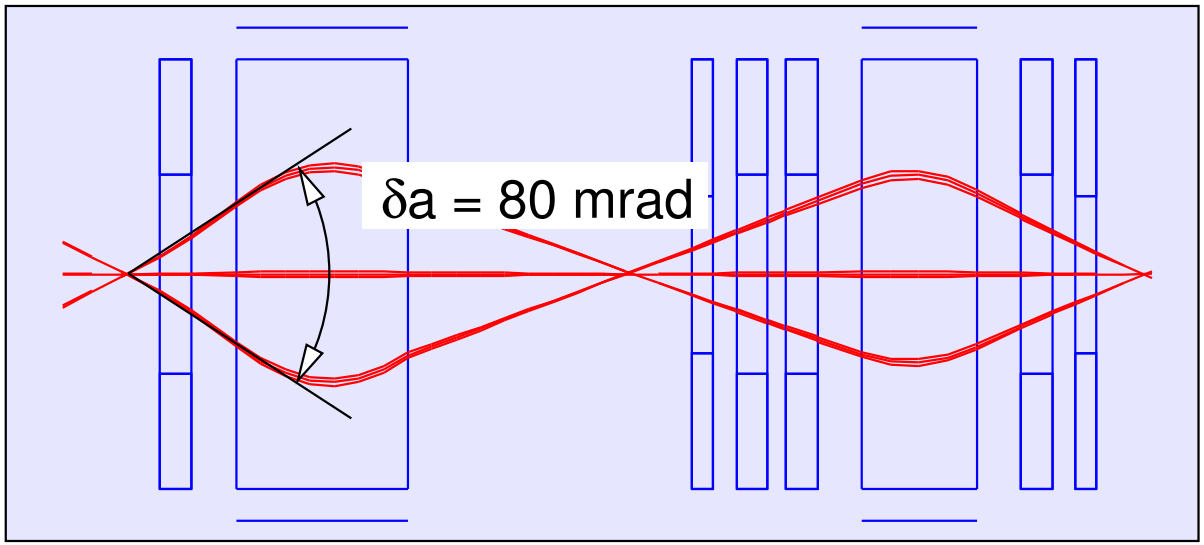
Mass Resolution

δx	:	width of beam at final focus
D	:	dispersion $D / dx = m / dm$
R	:	resolution $R = D / \delta x$



$\varepsilon = \pi/4 \; \delta x \; \delta a$

$\varepsilon = \sim 10 \; \pi$ mm.mrad



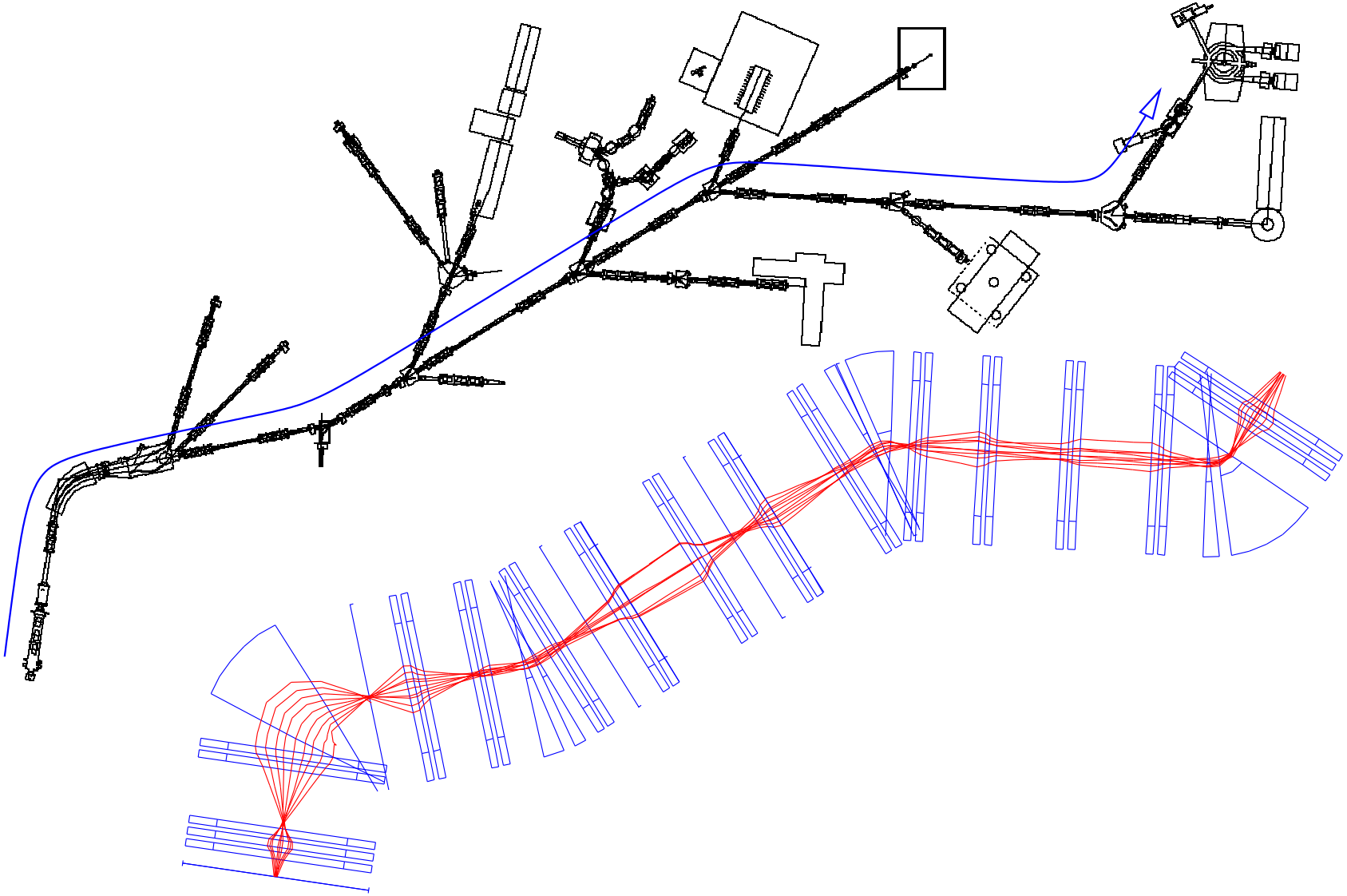
$\delta x = \sim 0.5$ mm

D = 2700 mm

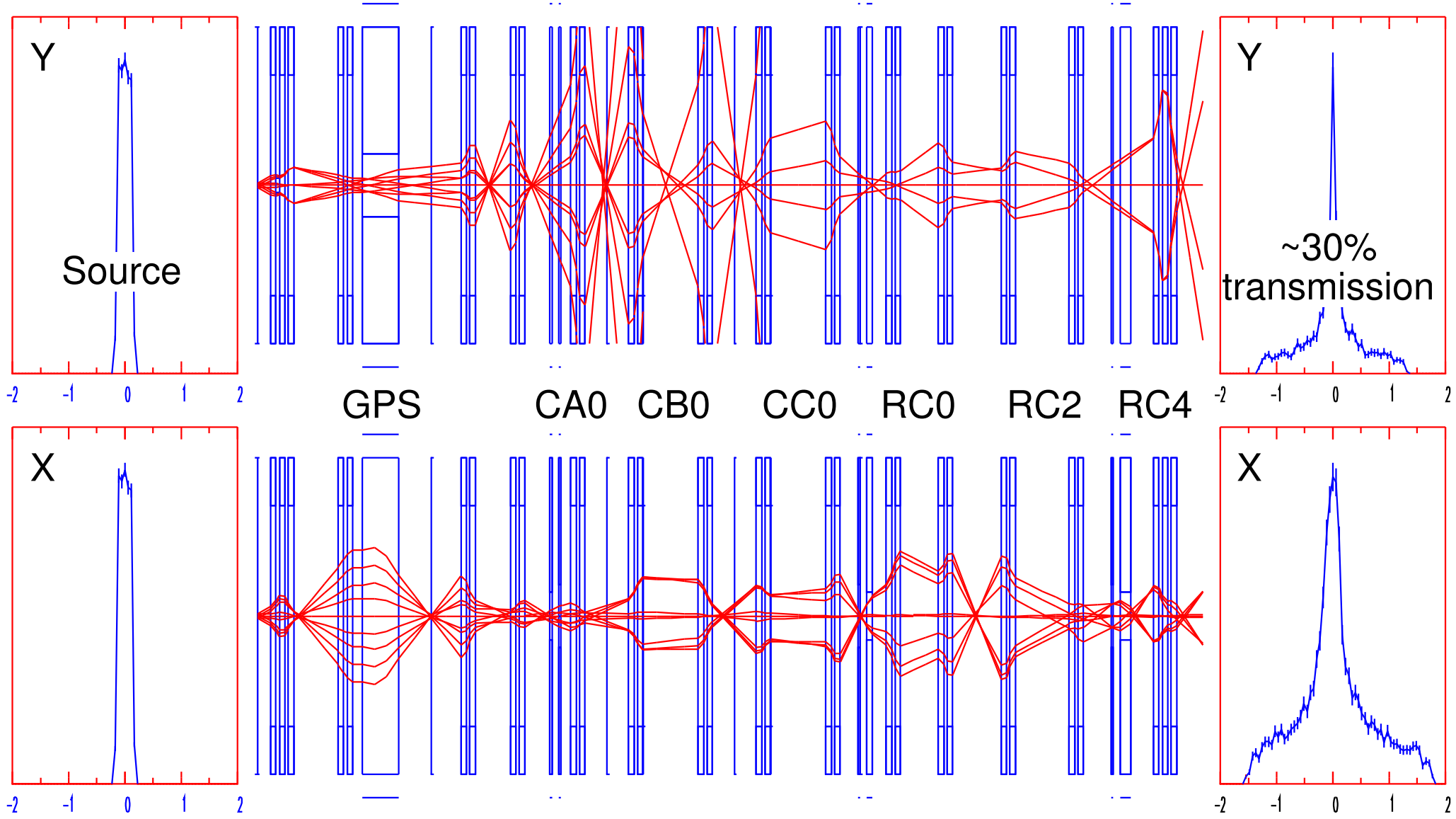
R = 5400

but: Distortions → $\delta x > \sim 0.5$ mm

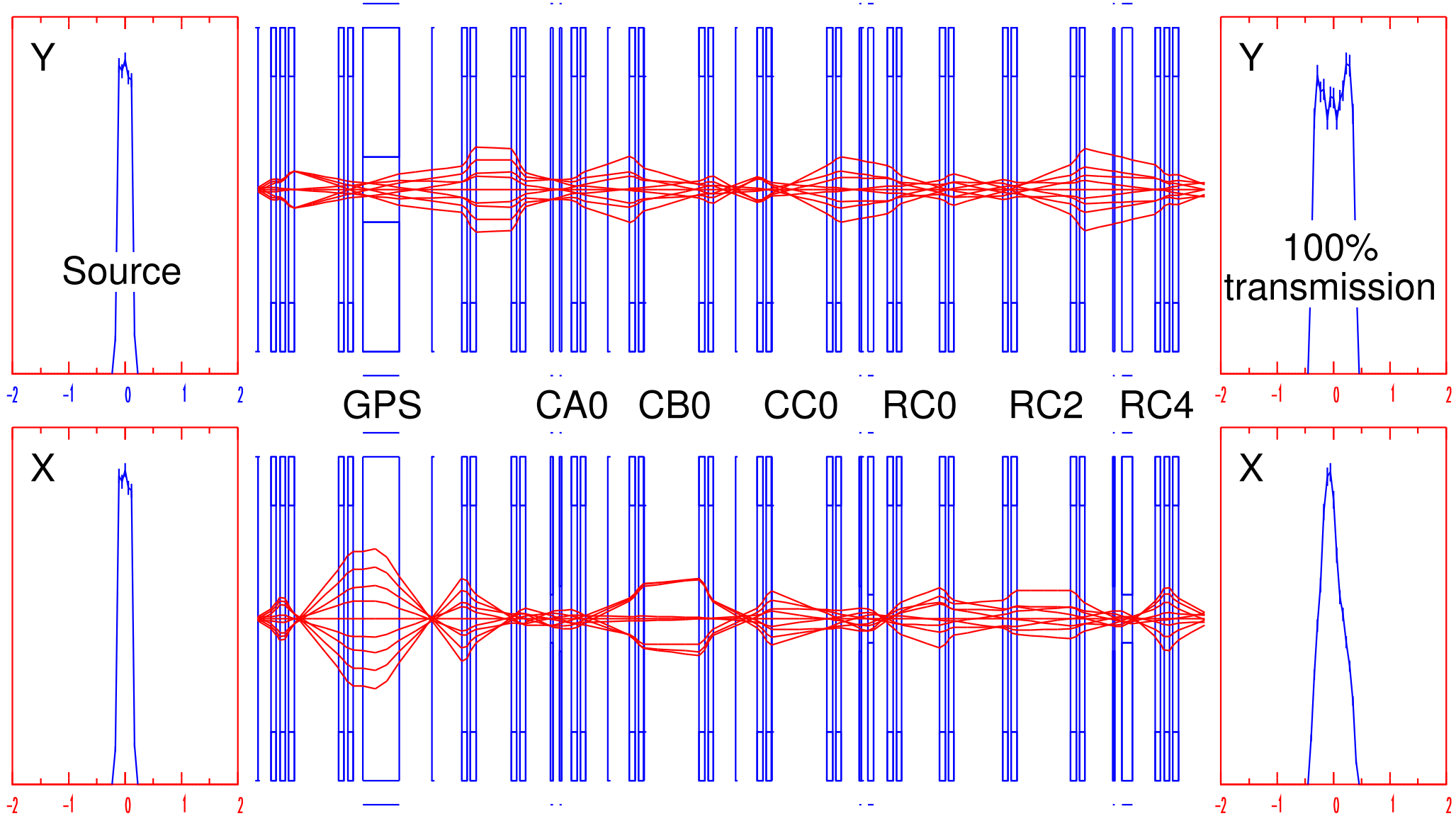
Example 2: GPS to Mistral

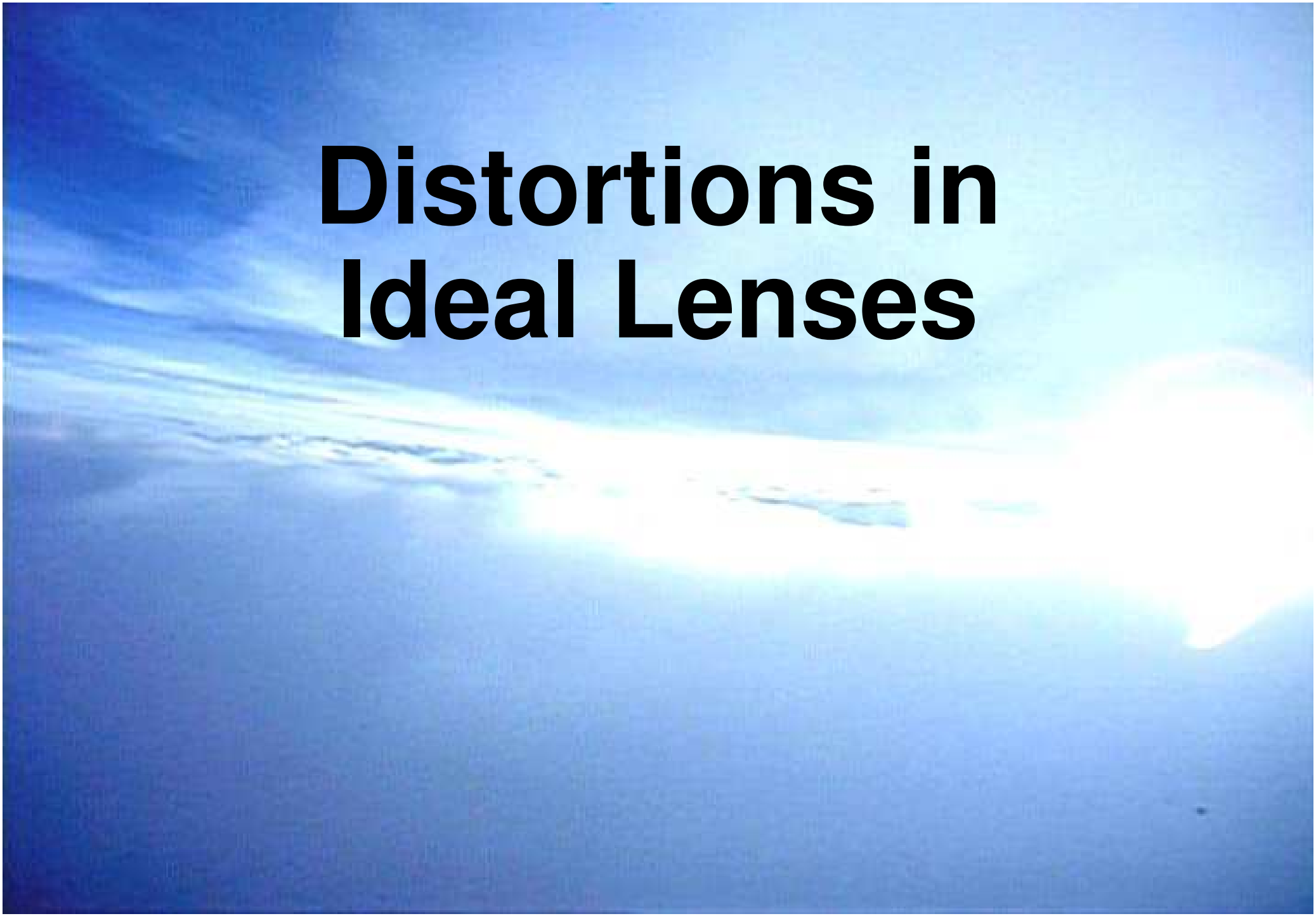


Example 2: GPS to Mistral



Example 2: GPS to Mistral

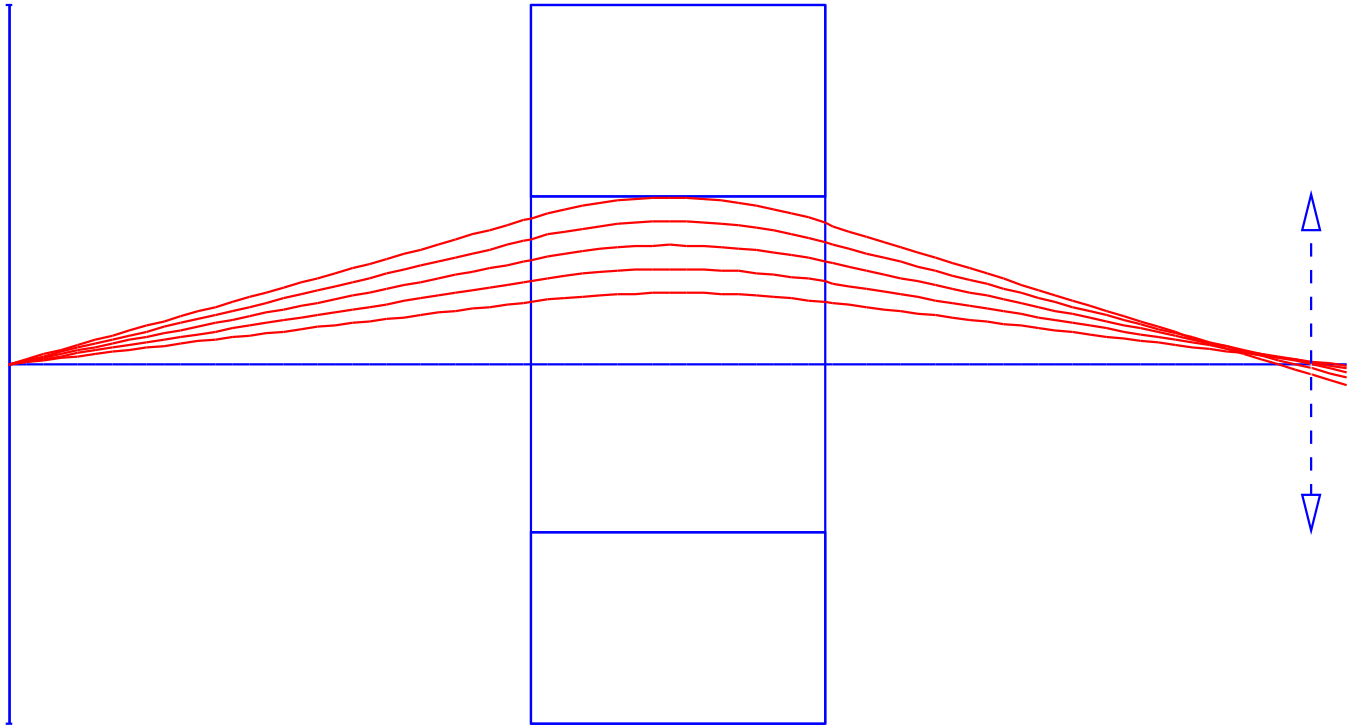


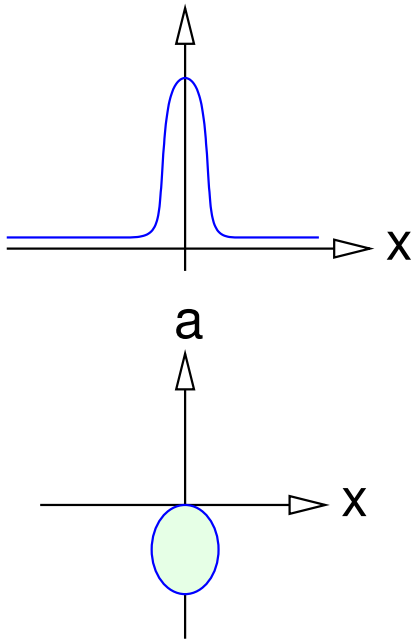

Distortions in
Ideal Lenses

Distortions 1

Beam steering in quadrupoles

Order mixing: 1st order adjustment –> 0th order effect

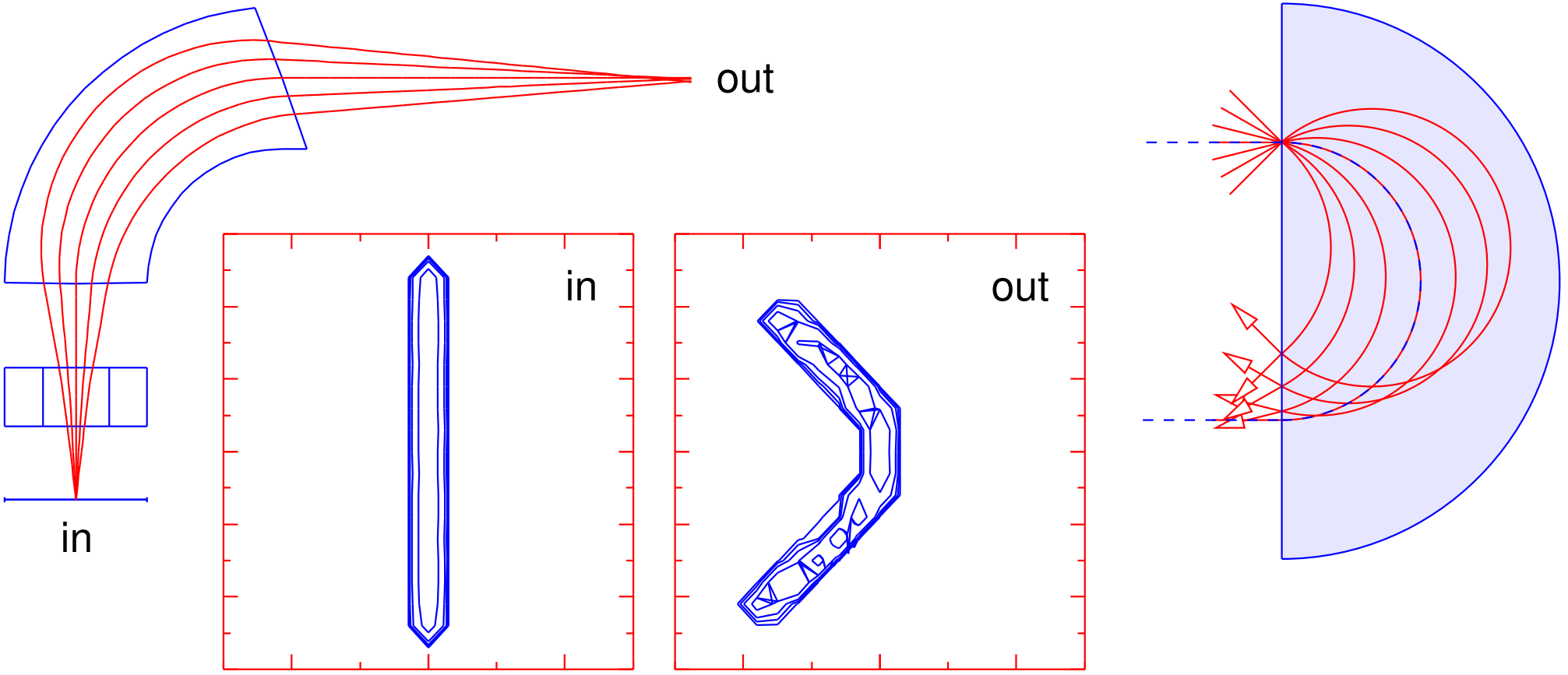




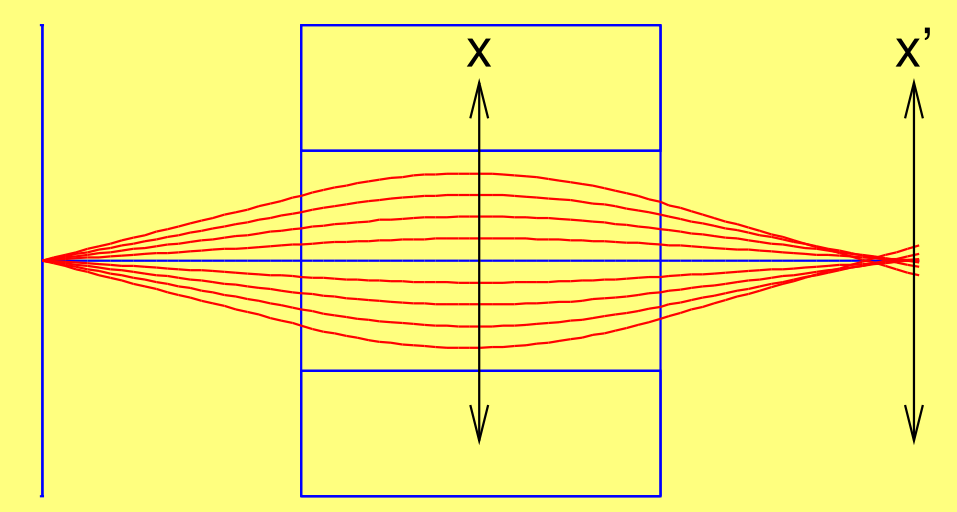
Distortions 2

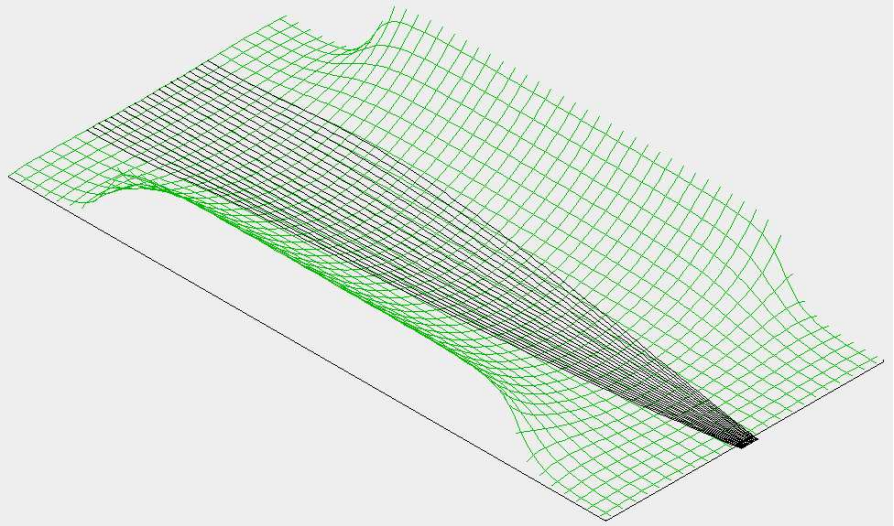
Dipoles: separator magnets

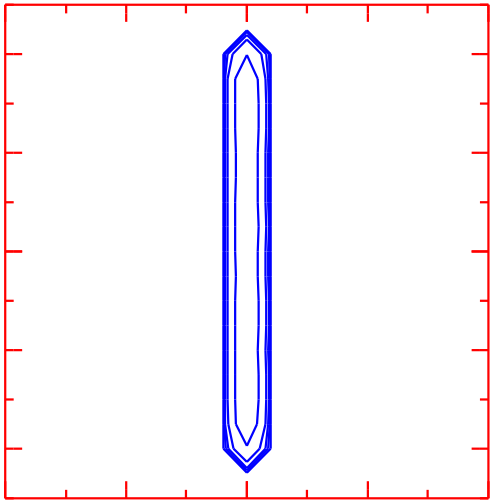
Order mixing: 0th order lens –> 2nd order effect

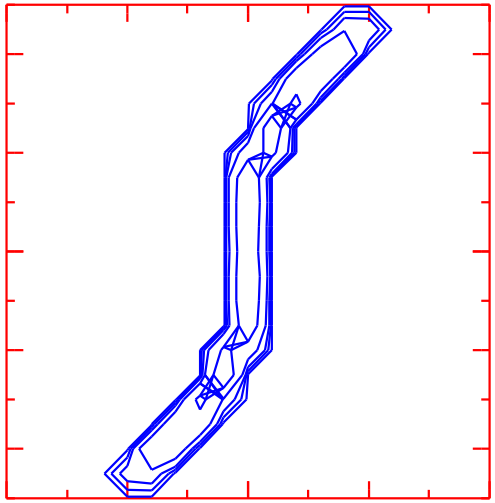


Distortions 3







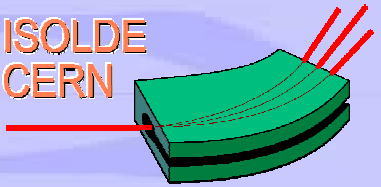


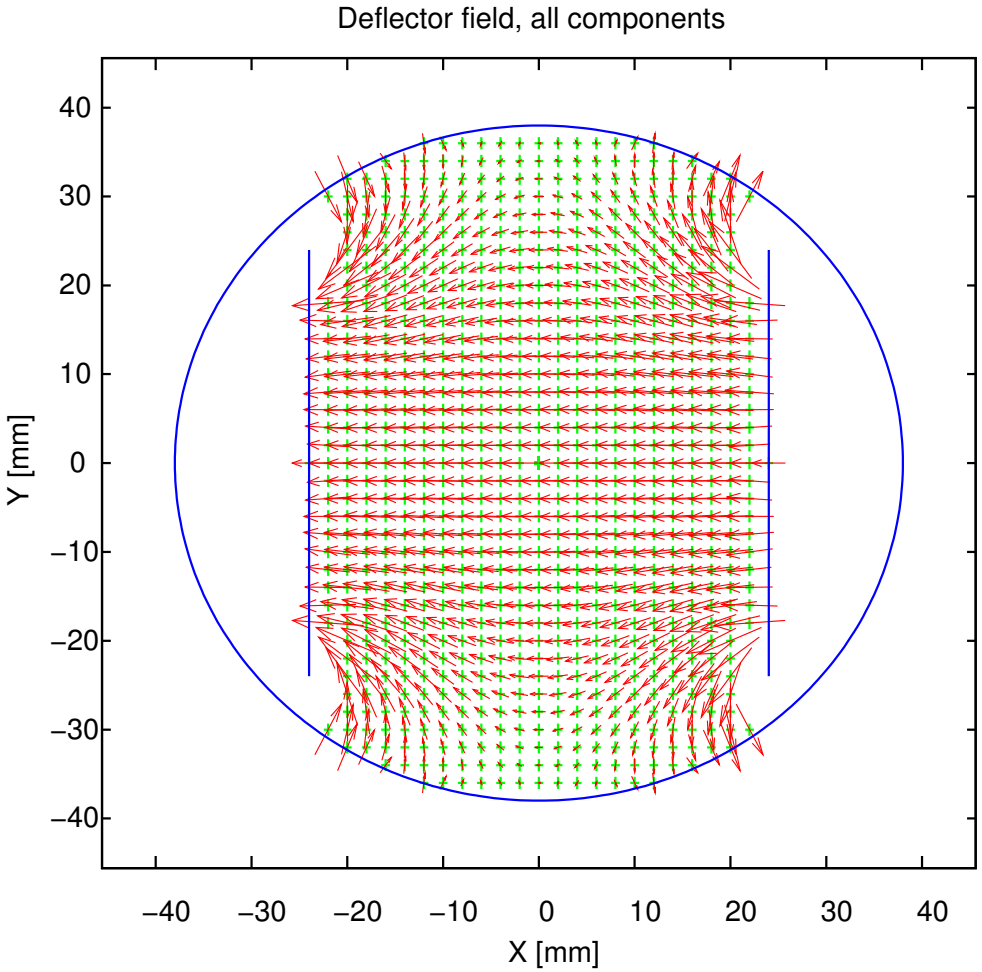
$$f = f_0 \left(1 - \frac{k x^2}{Q_0} \right)$$

$$x' = - \frac{k x^3}{Q_0}$$

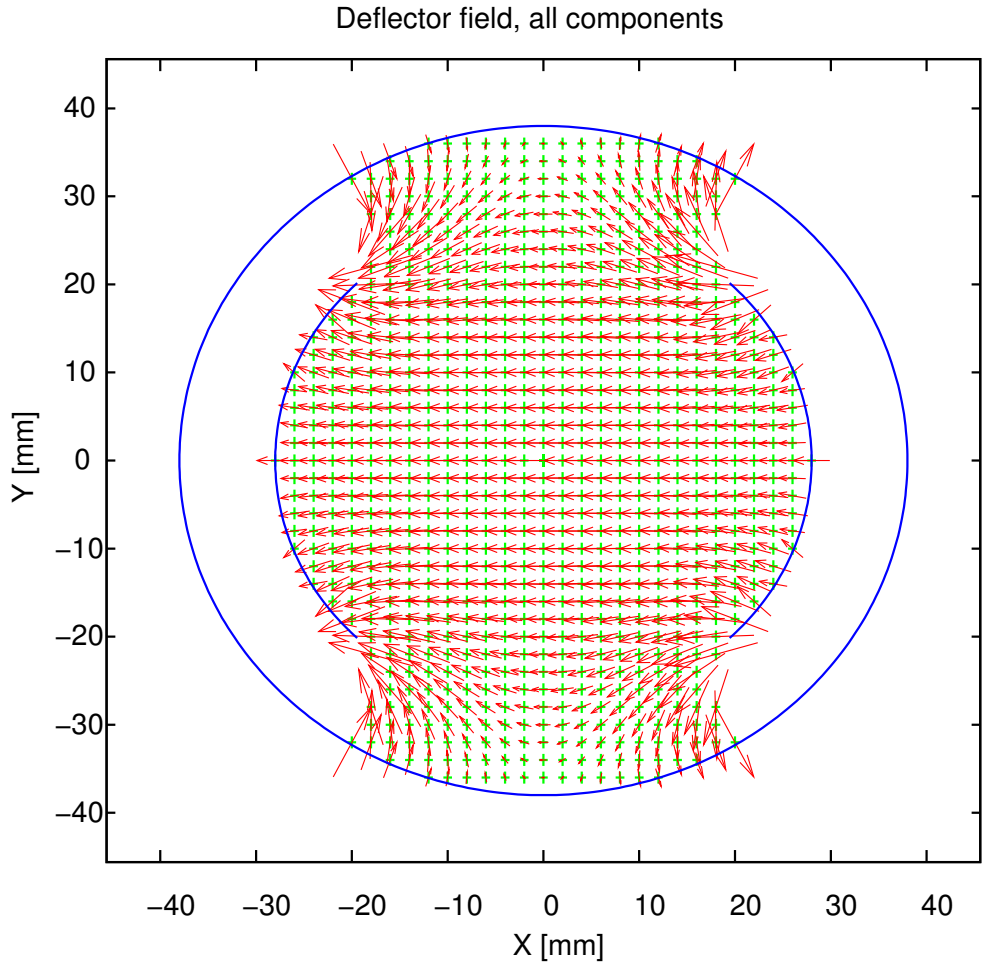

Real Lenses

Field shaping: deflectors



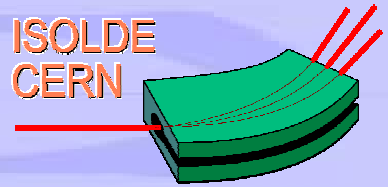


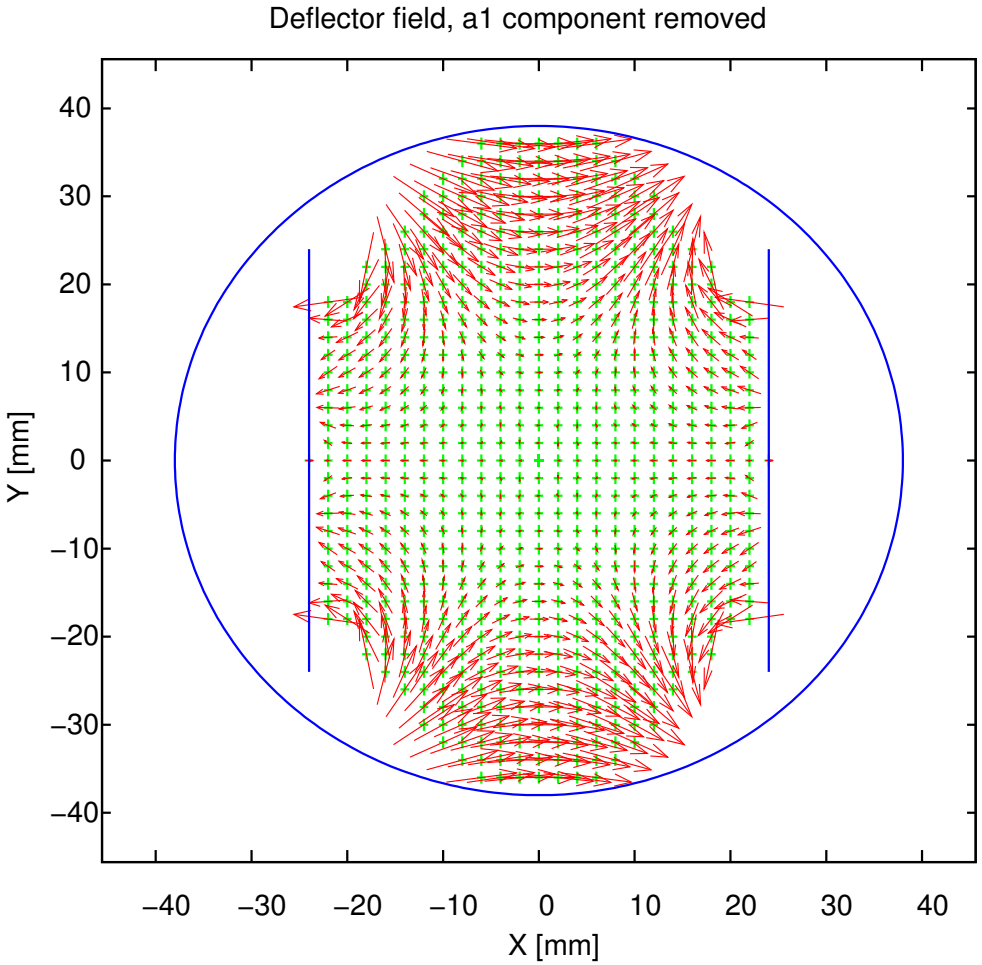
Dipole	Hexapole	10–pole	14–pole	18–pole
93 %	11 %	−3.5 %	−0.8 %	0.003 %



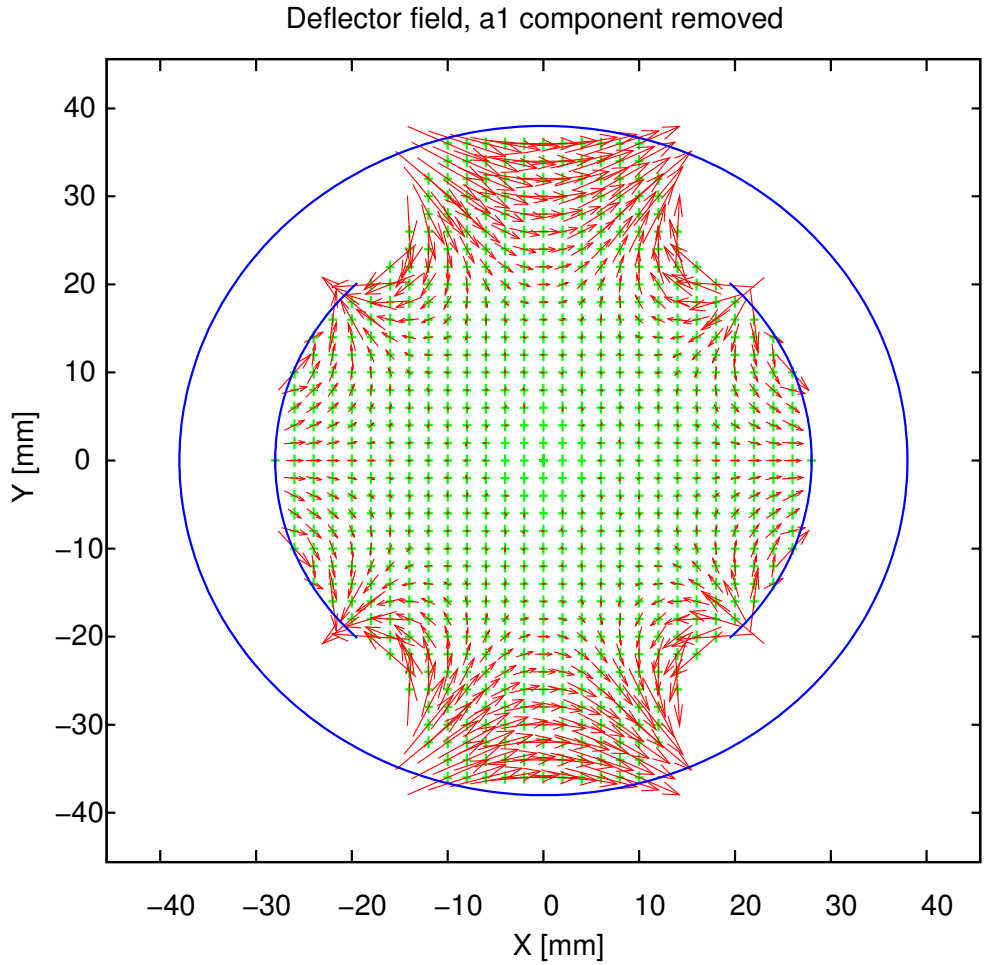
Dipole	Hexapole	10–pole	14–pole	18–pole
109 %	−0.3 %	−13 %	3.4 %	3.9 %

Field shaping: deflectors



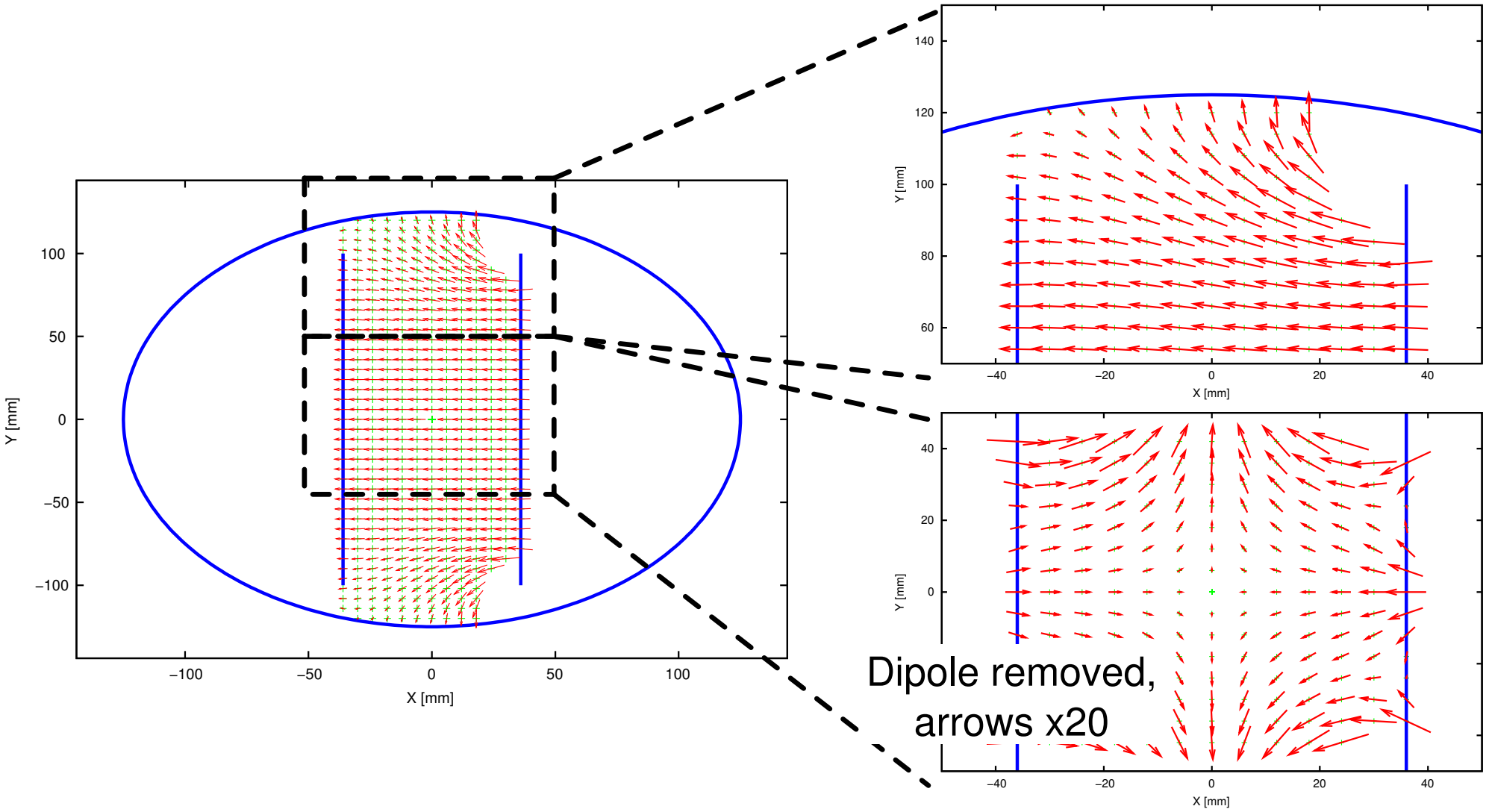


Dipole	Hexapole	10–pole	14–pole	18–pole
93 %	11 %	−3.5 %	−0.8 %	0.003 %

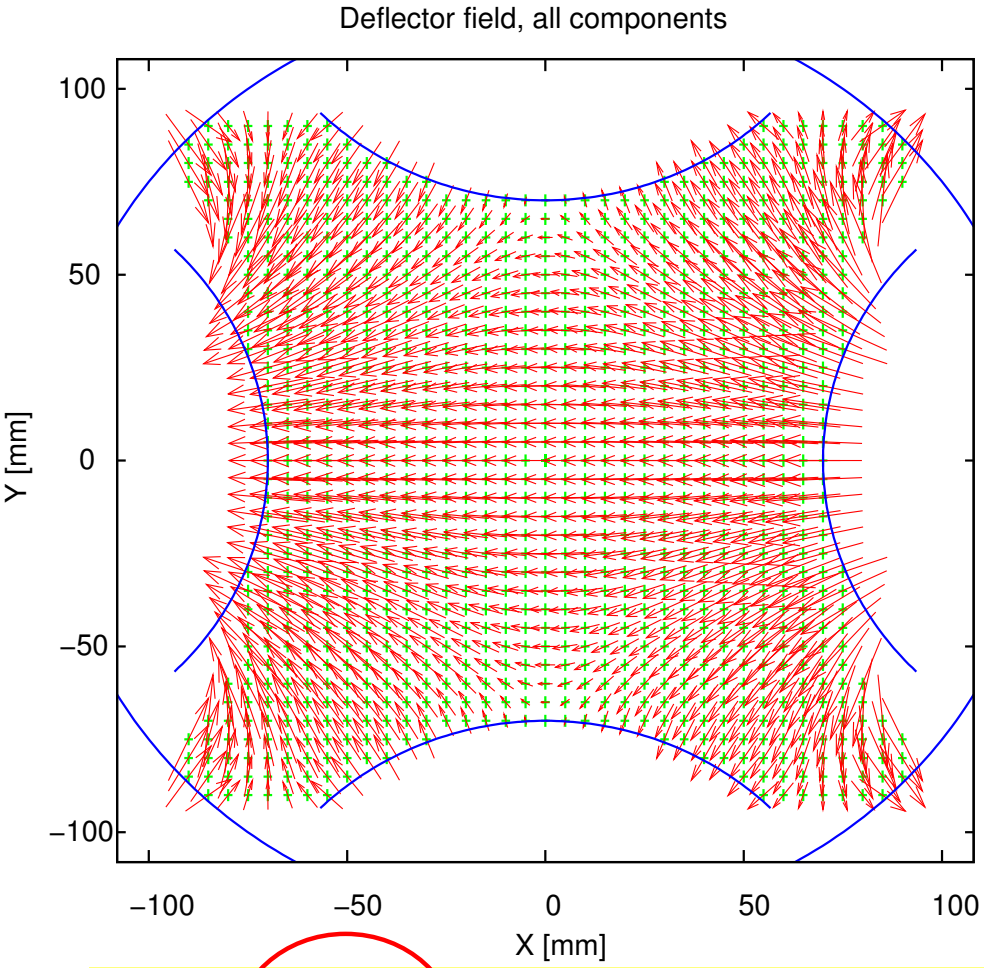


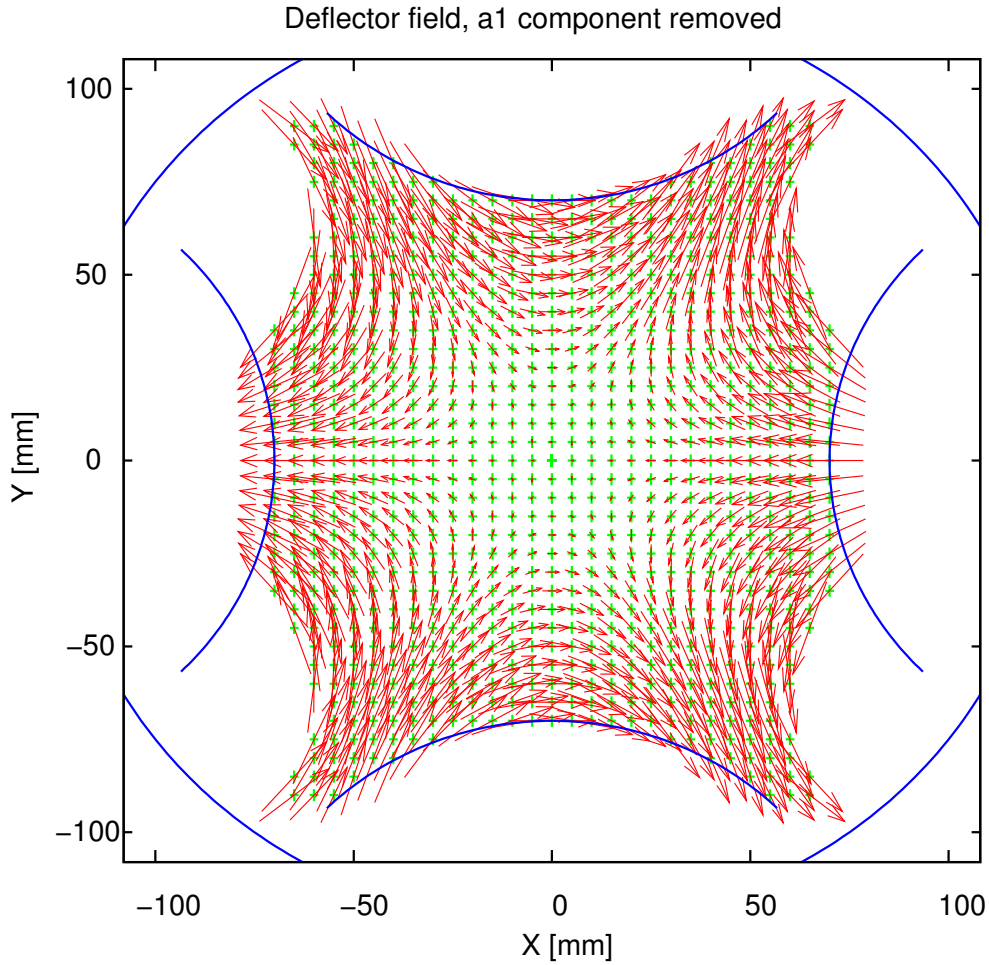
Dipole	Hexapole	10–pole	14–pole	18–pole
109 %	−0.3 %	−13 %	3.4 %	3.9 %

HRS deflectors



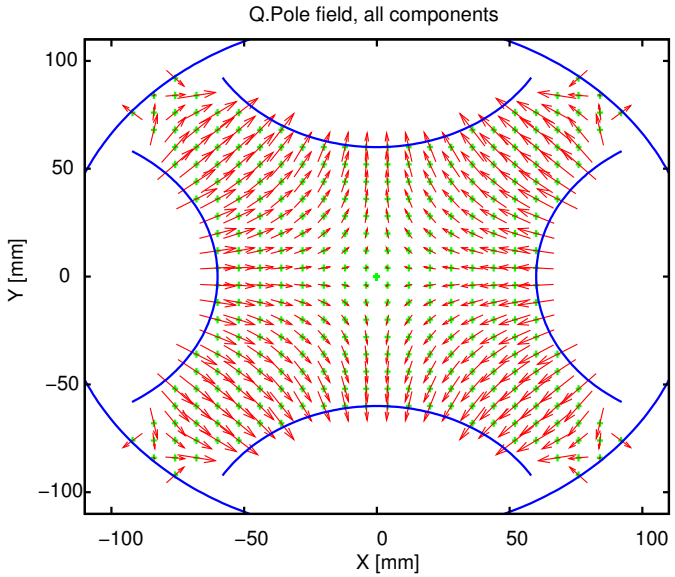
Quads as deflectors

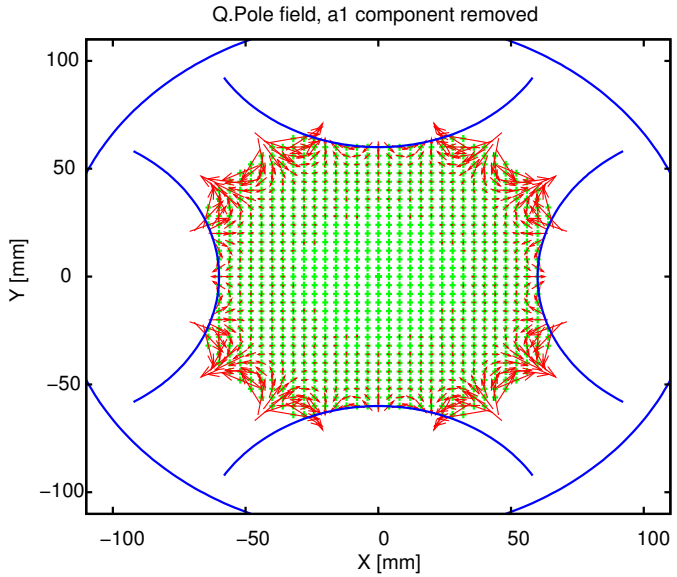




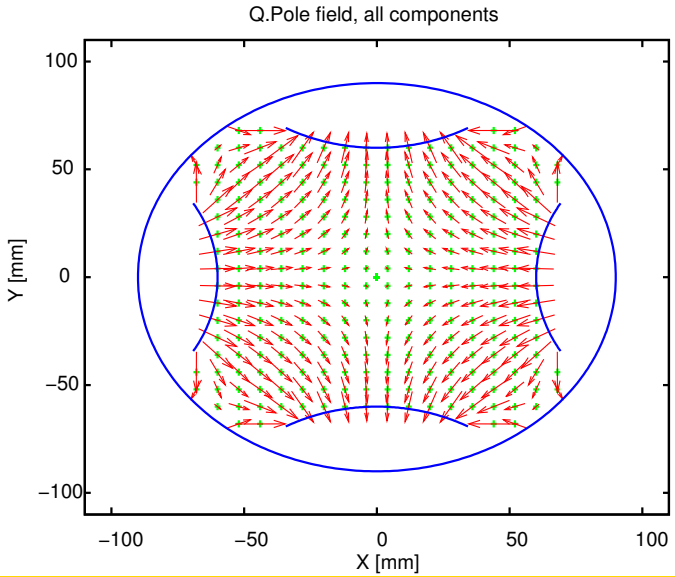
Dipole	Hexapole	10–pole	14–pole	18–pole
89 %	34 %	−1.5 %	0.4 %	−1.7 %

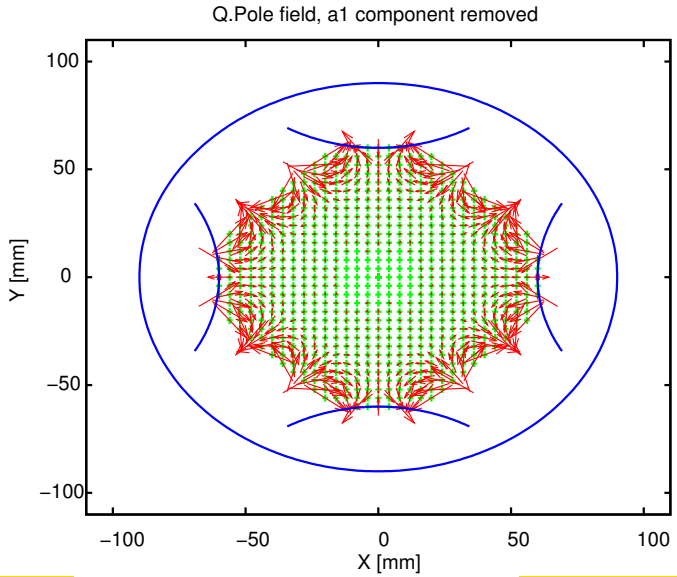
Quadrupole proportions





Quad	12–pole
100 %	0.007 %
20–pole	28–pole
–0.3 %	–0.04 %

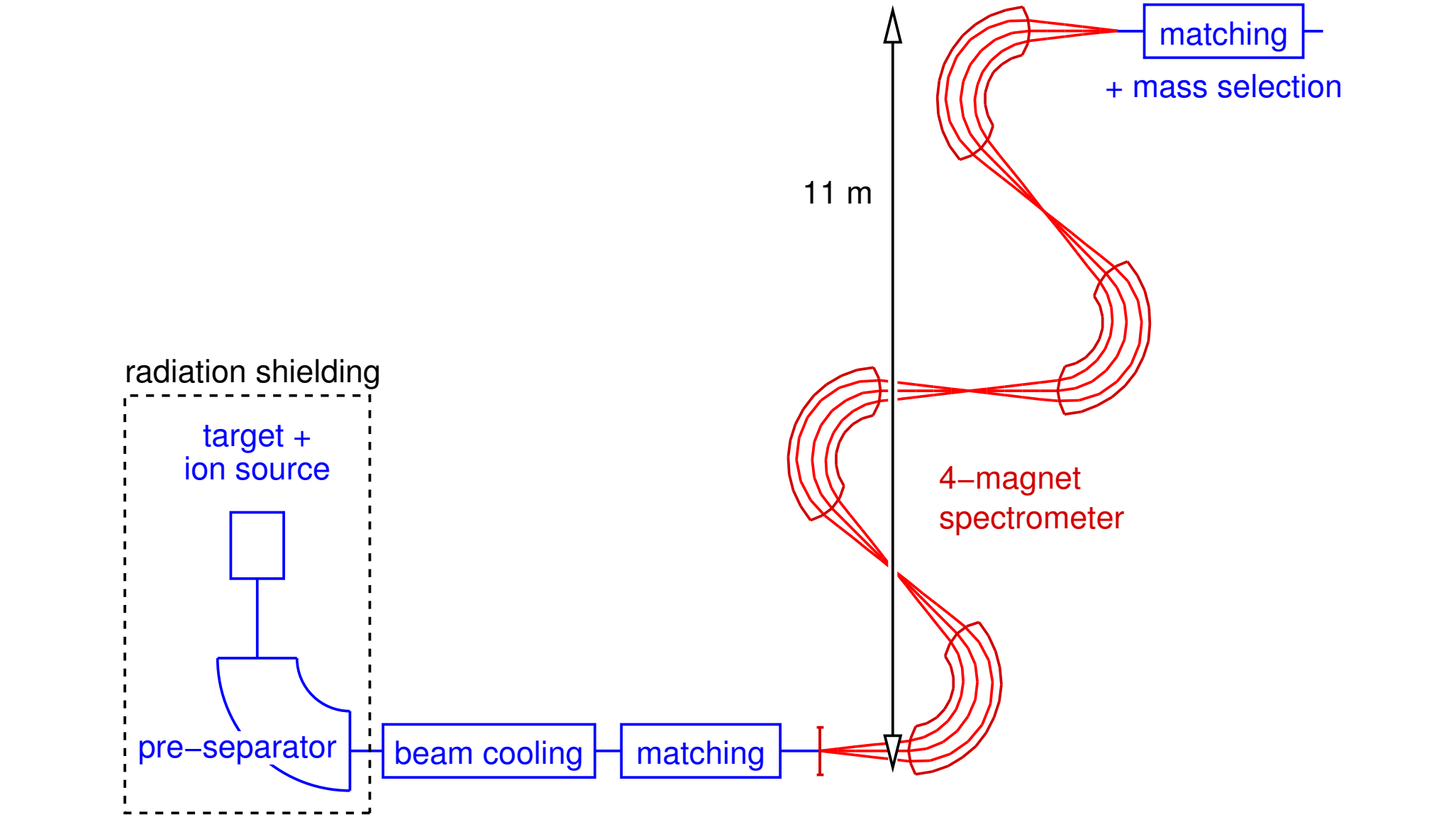




Quad	12–pole
99 %	1.9 %
20–pole	28–pole
–1.2 %	–0.02 %

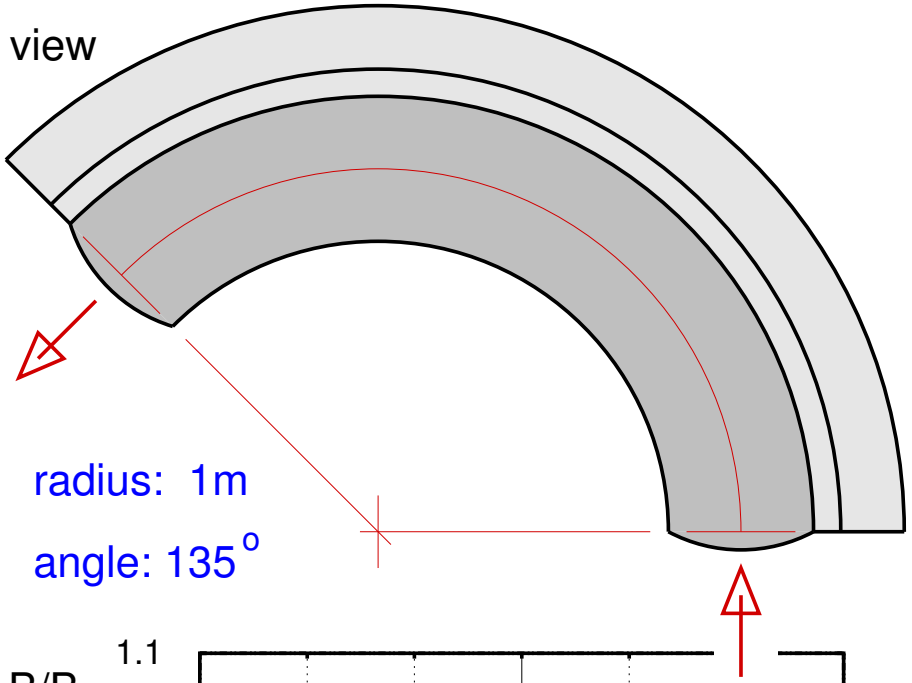

Ideas for the Future

A New HRS

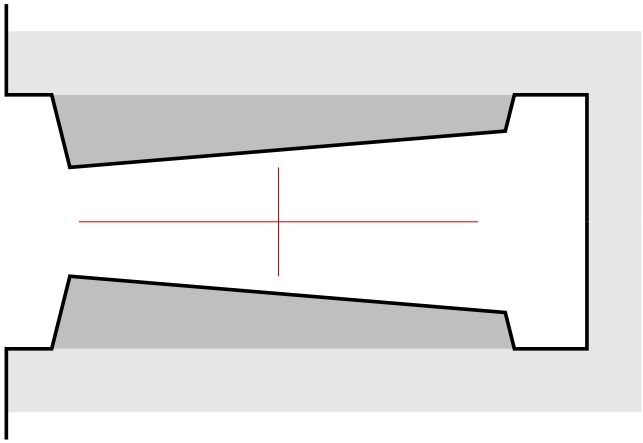

matching
+ mass selection
11 m
radiation shielding
target +
ion source
4–magnet
spectrometer
pre–separator
beam cooling
matching

A New HRS

Top view



Cross–section



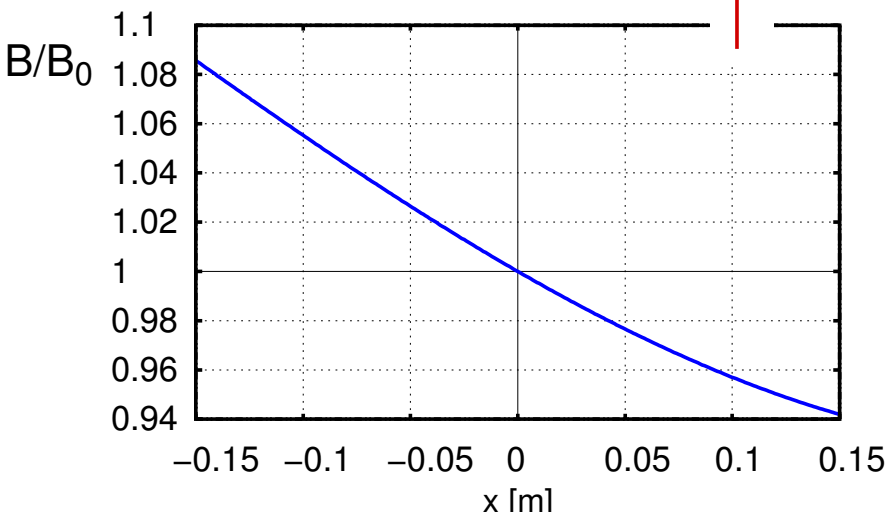
radius: 1m

angle: 135°

Field shape:

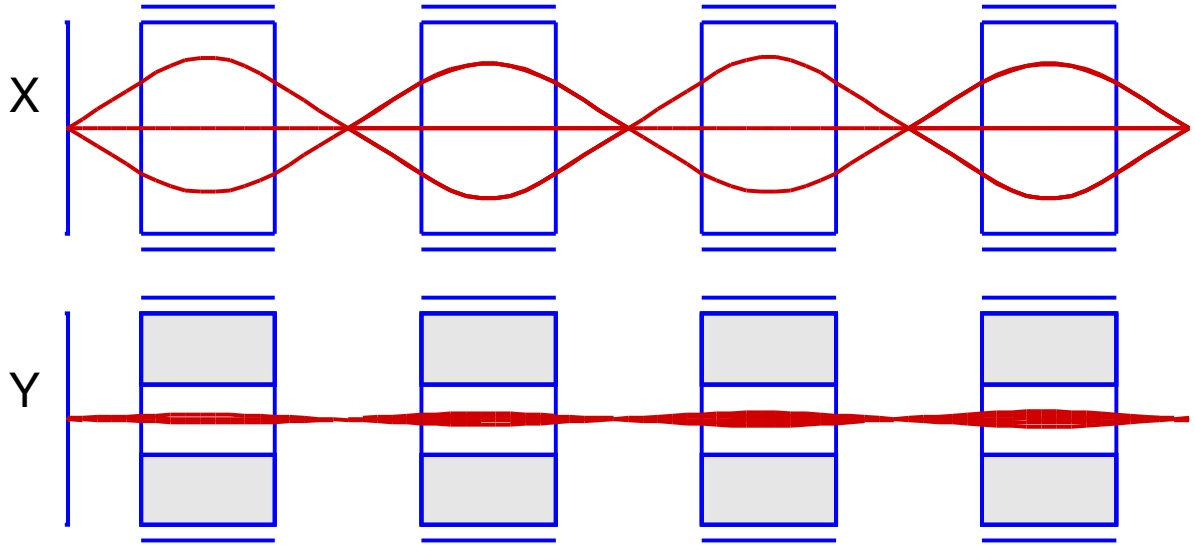
$B_y = B_0 (1 - 0.5\, x + 0.61\, x^2 - 0.98\, x^3)$

dipole quadrupole hexapole octupole

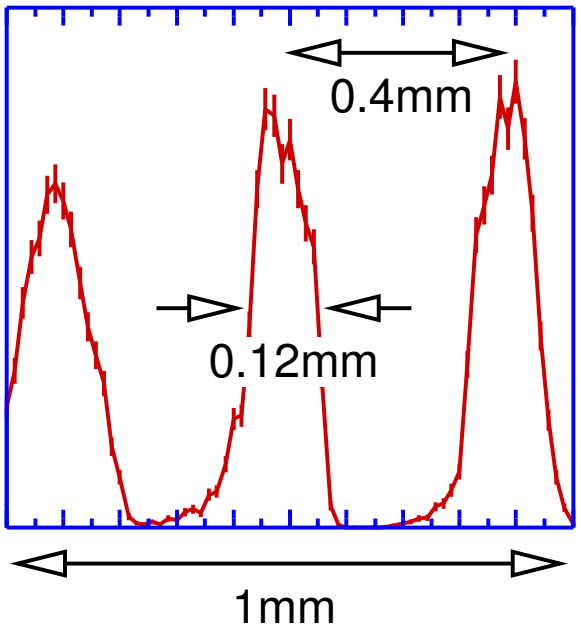


A New HRS

Beam envelopes



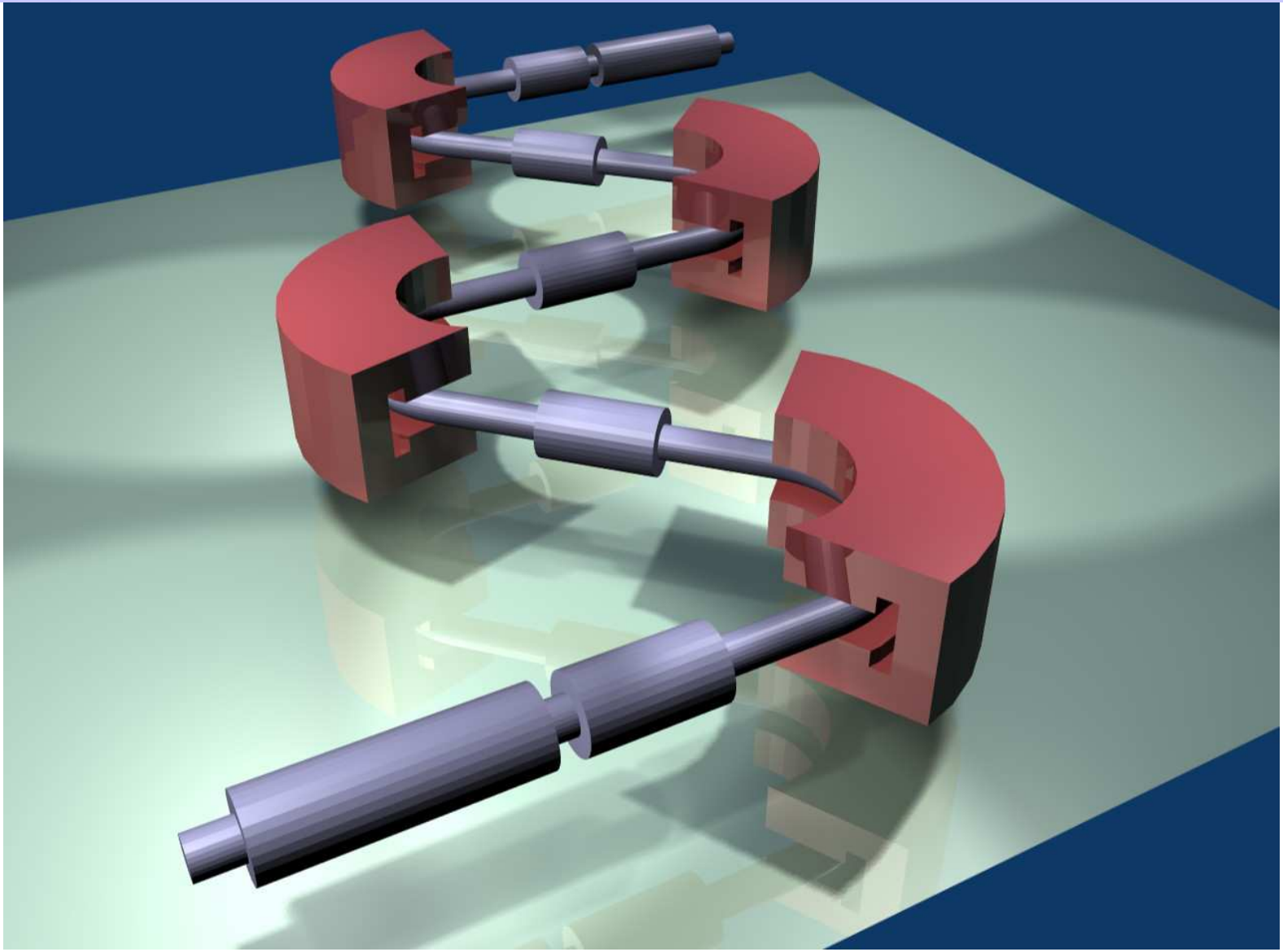
Beam separation



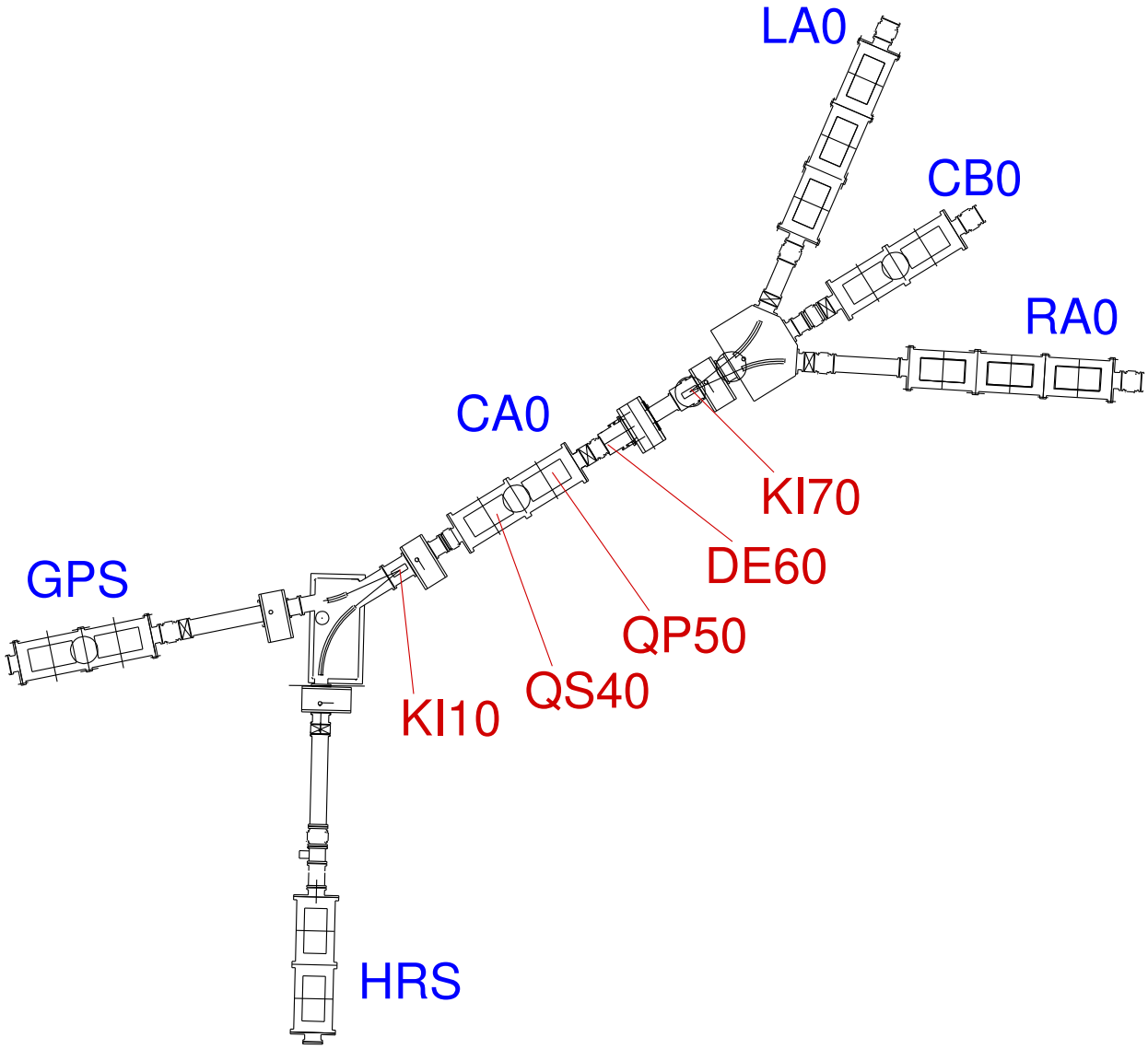
Ultimate resolution:
64 000 for 3 pi.mm.mrad emittance

eg. ^{126} In / Cd Q_β = 5.5 MeV $\frac{M}{\Delta M}$ = 20 000

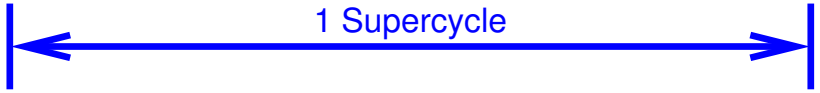
A New HRS



The CA0 bottleneck

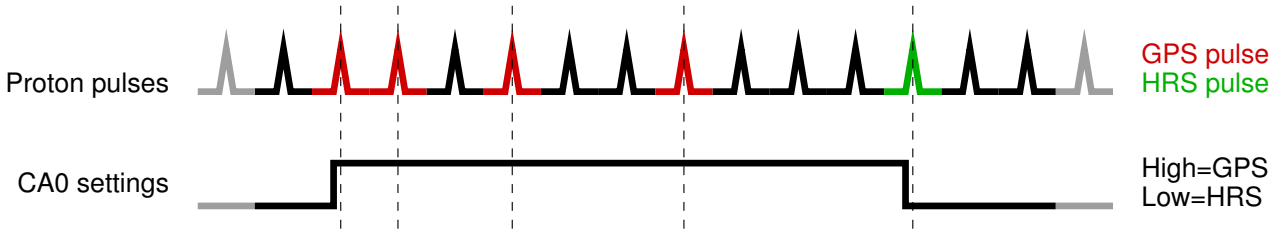


CA0 pulsing



Scenario #1

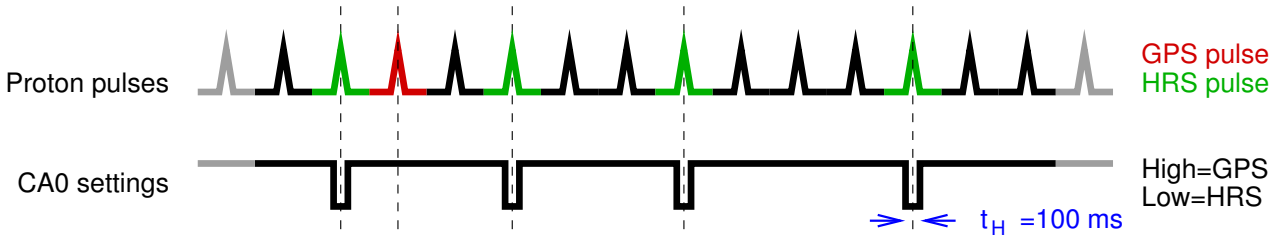
Experiment running on GRS
Proton–scan or yield test on HRS



GPS–context trigger: ISOGPS minus n1 milliseconds
GPS–context timeout: (None)
HRS–context trigger: ISOHRS minus n2 milliseconds
HRS–context timeout: (None)

Scenario #2

Experiment running on GRS (long–lived isotope)
Experiment running on HRS (short lived species)



GPS–context trigger: (ISOGPS minus n1 milliseconds)
GPS–context timeout: (None)
HRS–context trigger: ISOHRS minus n2 milliseconds
HRS–context timeout: tH

- "Context" driven controls
- Synchronisation of scanners & faraday cups
- Synchronisation of beamgates
- Fast switching of power supplies

A New ISOLDE