

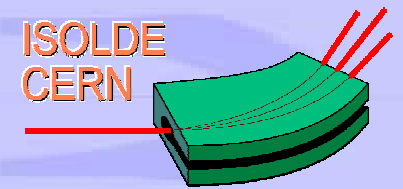
Ion Beam Optics at Isolde

Tim Giles 2 February 2005



Ion Optics at Isolde

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

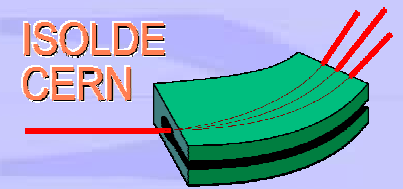
Definitions

The background of the slide is a photograph of a sunset or sunrise over a body of water. The sun is a large, bright, glowing orb on the right side of the frame, partially obscured by a dark, silhouetted horizon line. The sky is a deep, clear blue, and the water in the foreground is dark and calm, reflecting the light from the sun. The overall mood is serene and atmospheric.

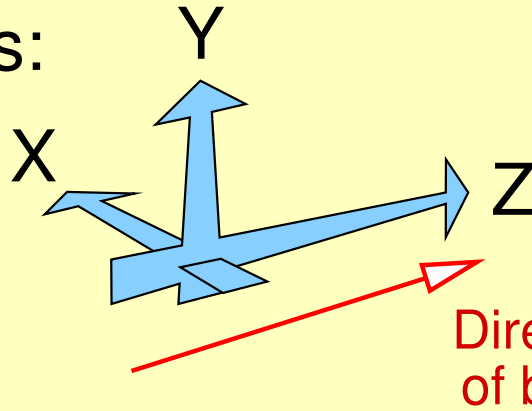


Some Definitions

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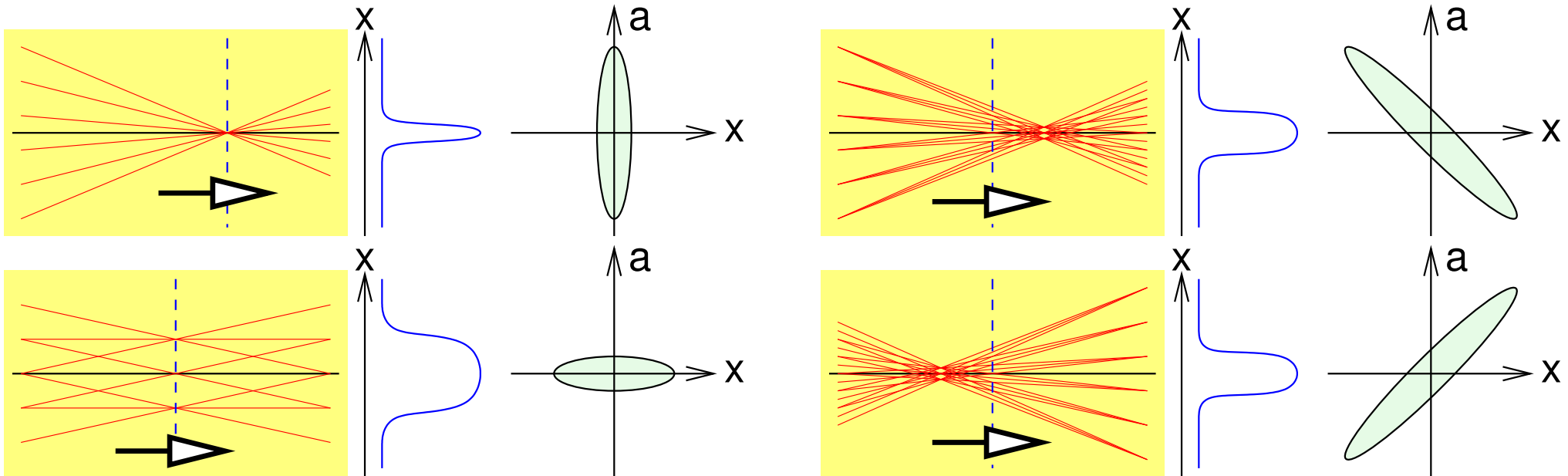
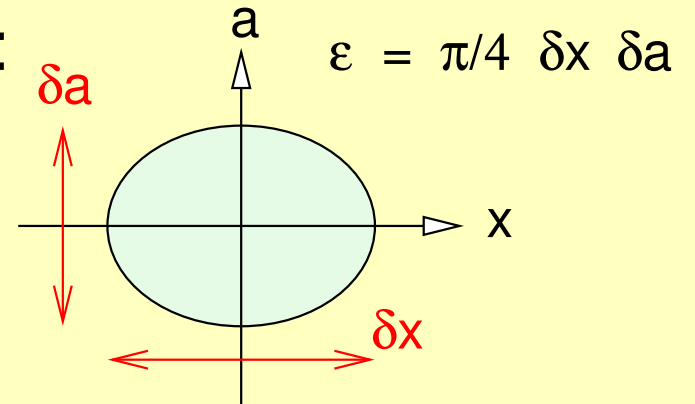


Axes:



$$a = dx / dz$$
$$b = dy / dz$$

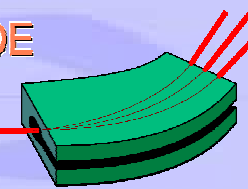
Emittance:



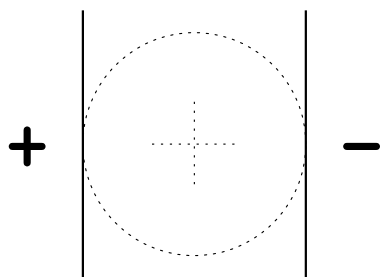


Electrostatic Multipoles

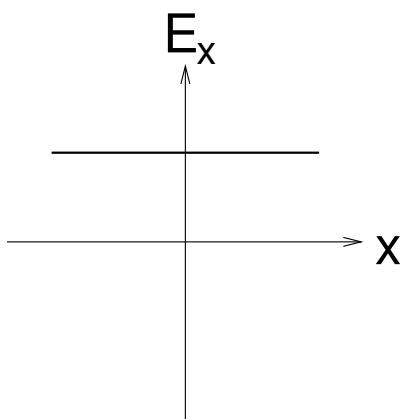
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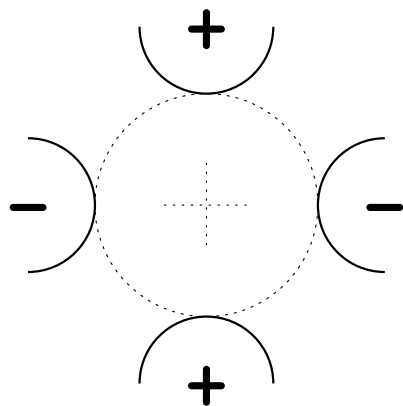
Dipole



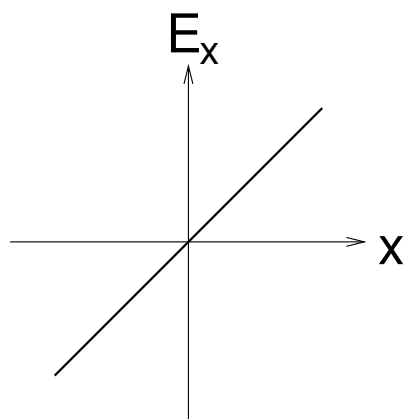
0th



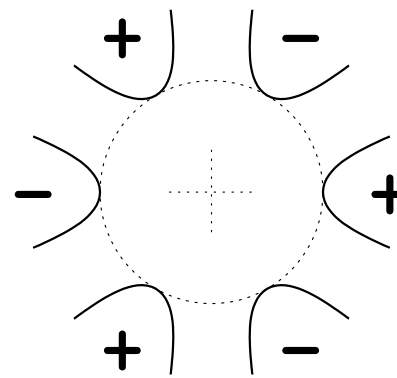
Quadrupole



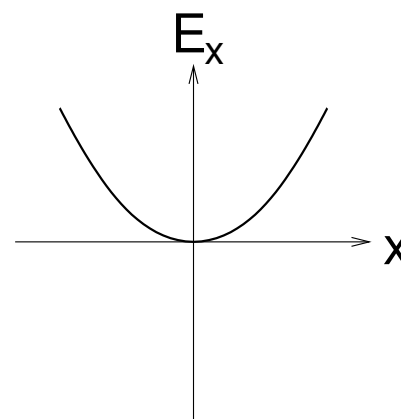
1st



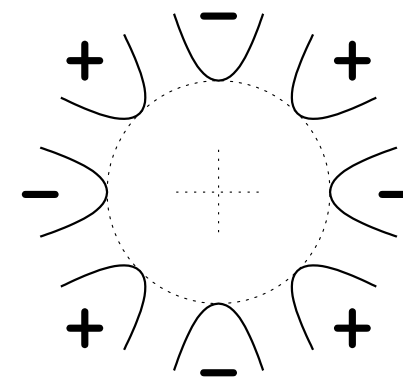
Hexapole



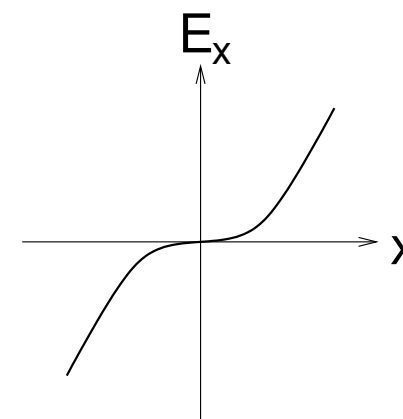
2nd



Octupole



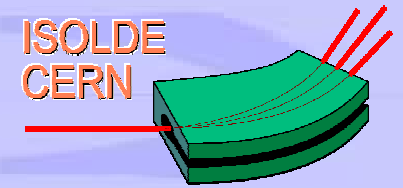
3rd



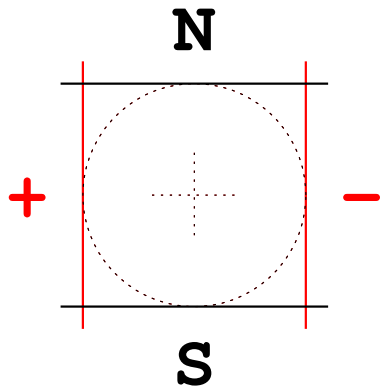


Magnetic Multipoles

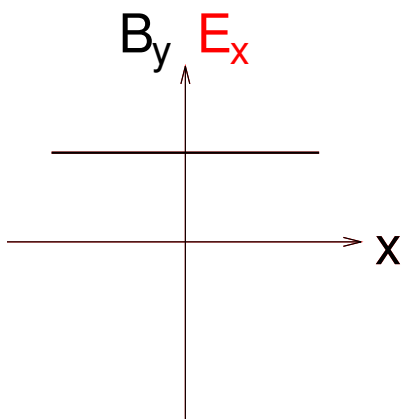
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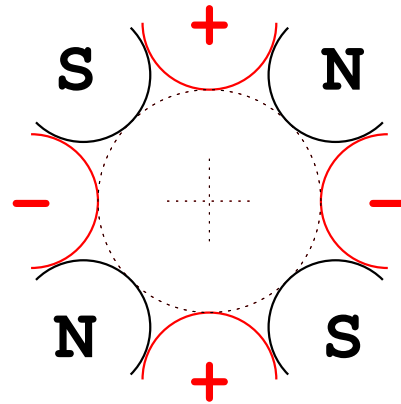
Dipole



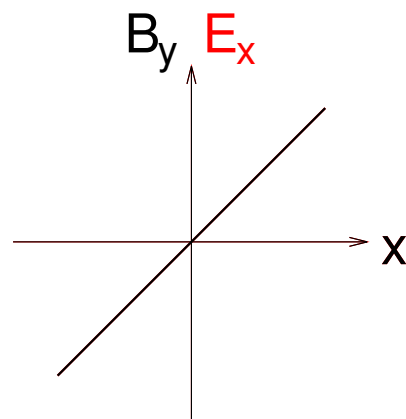
0th



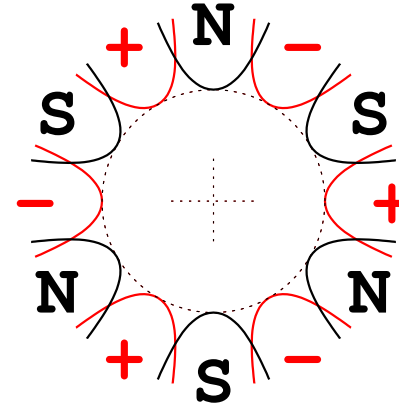
Quadrupole



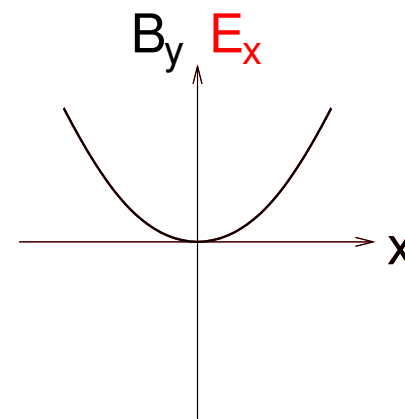
1st



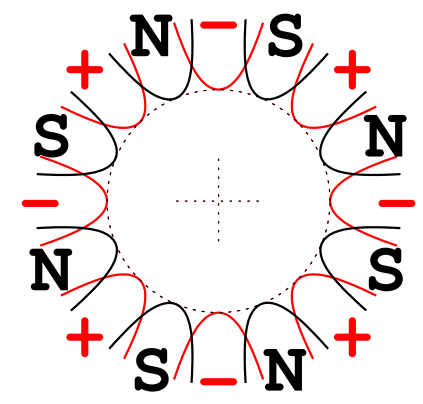
Hexapole



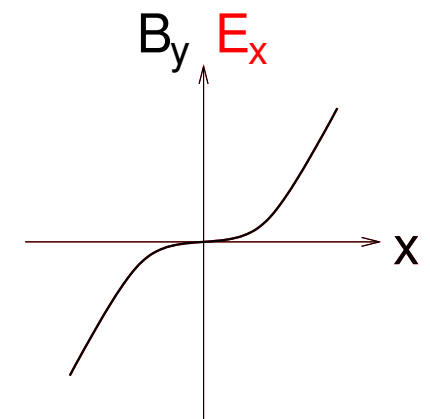
2nd

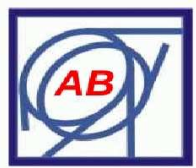


Octupole

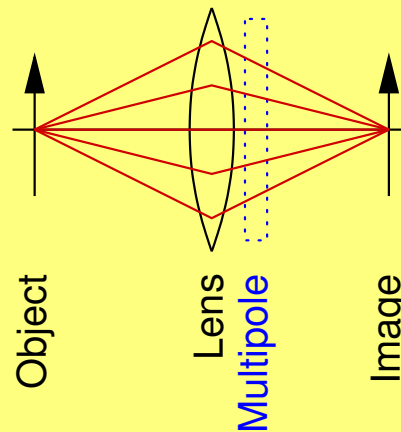


3rd

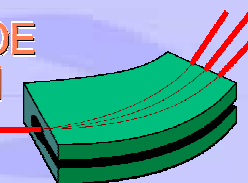




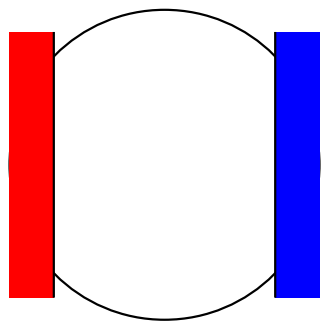
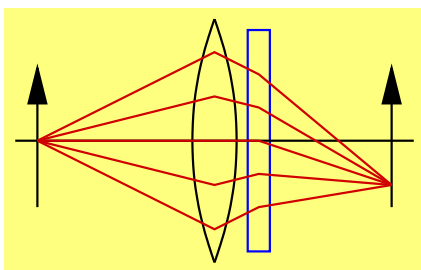
Effect:



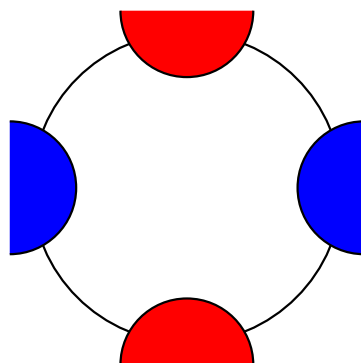
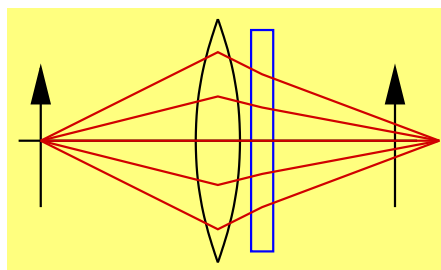
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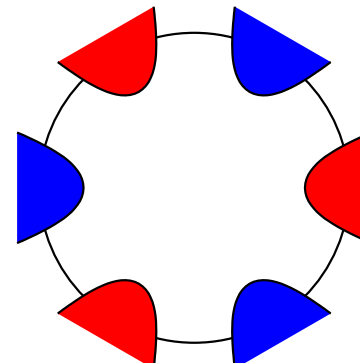
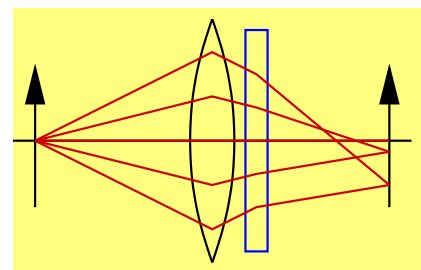
Dipole
0th



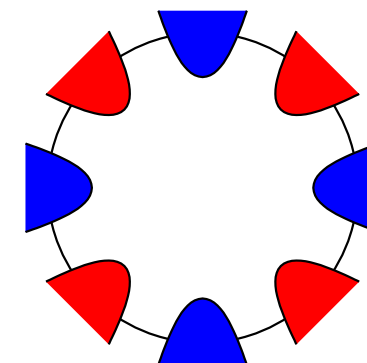
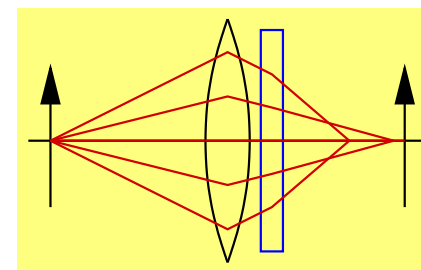
Quadrupole
1st



Hexapole
2nd



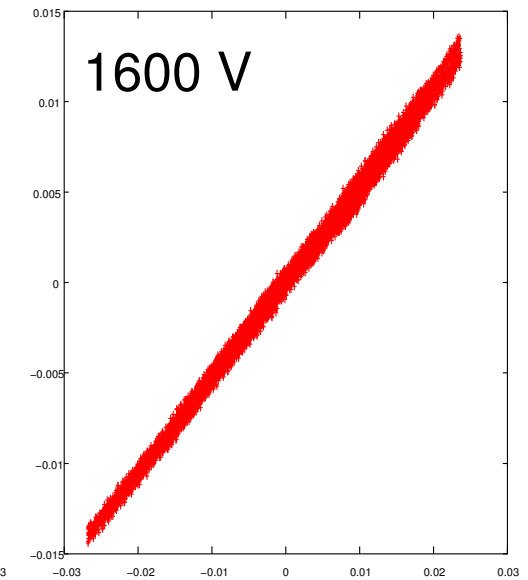
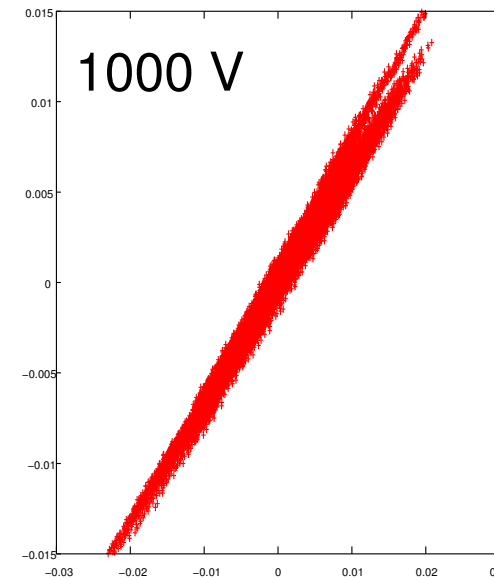
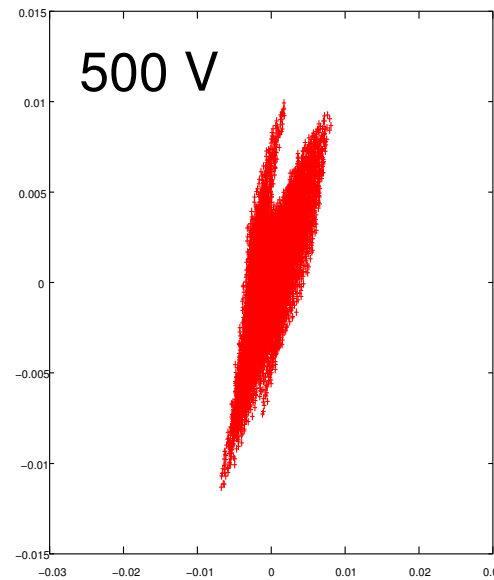
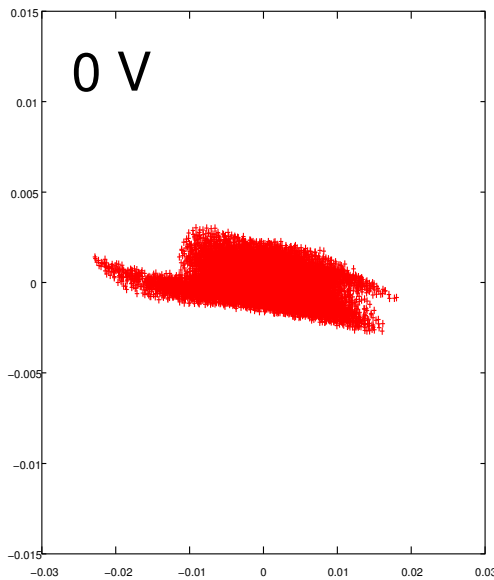
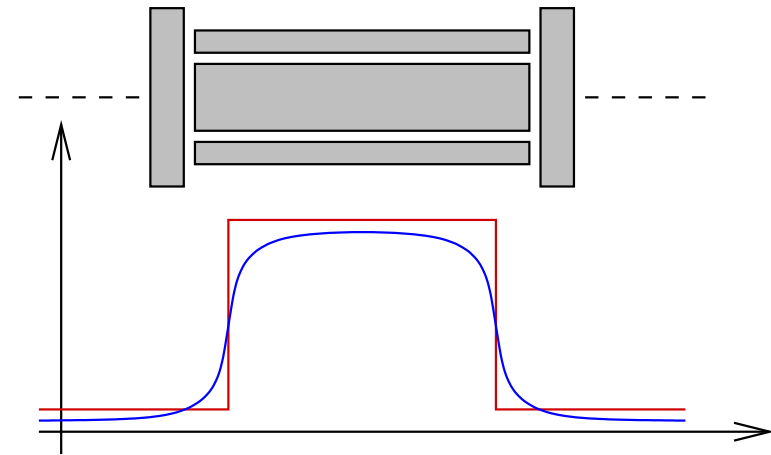
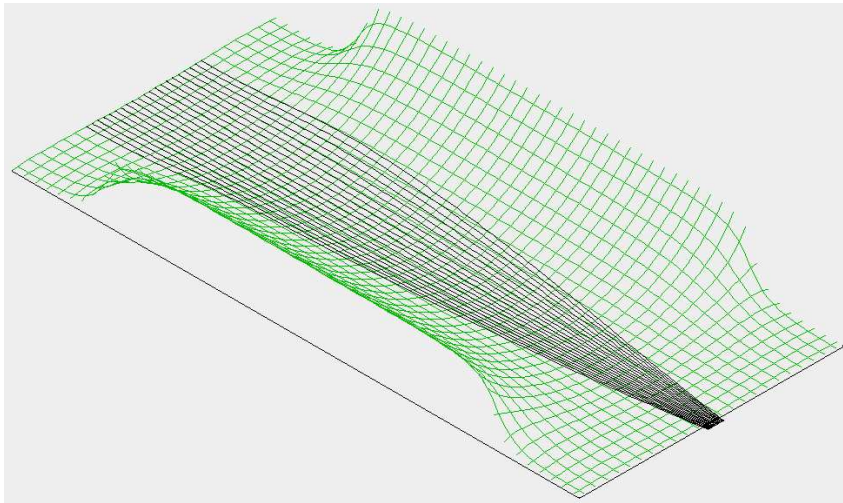
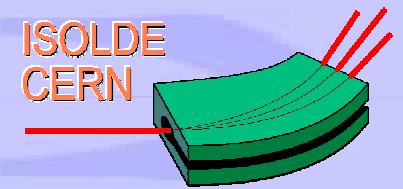
Octupole
3rd





Quadrupole length

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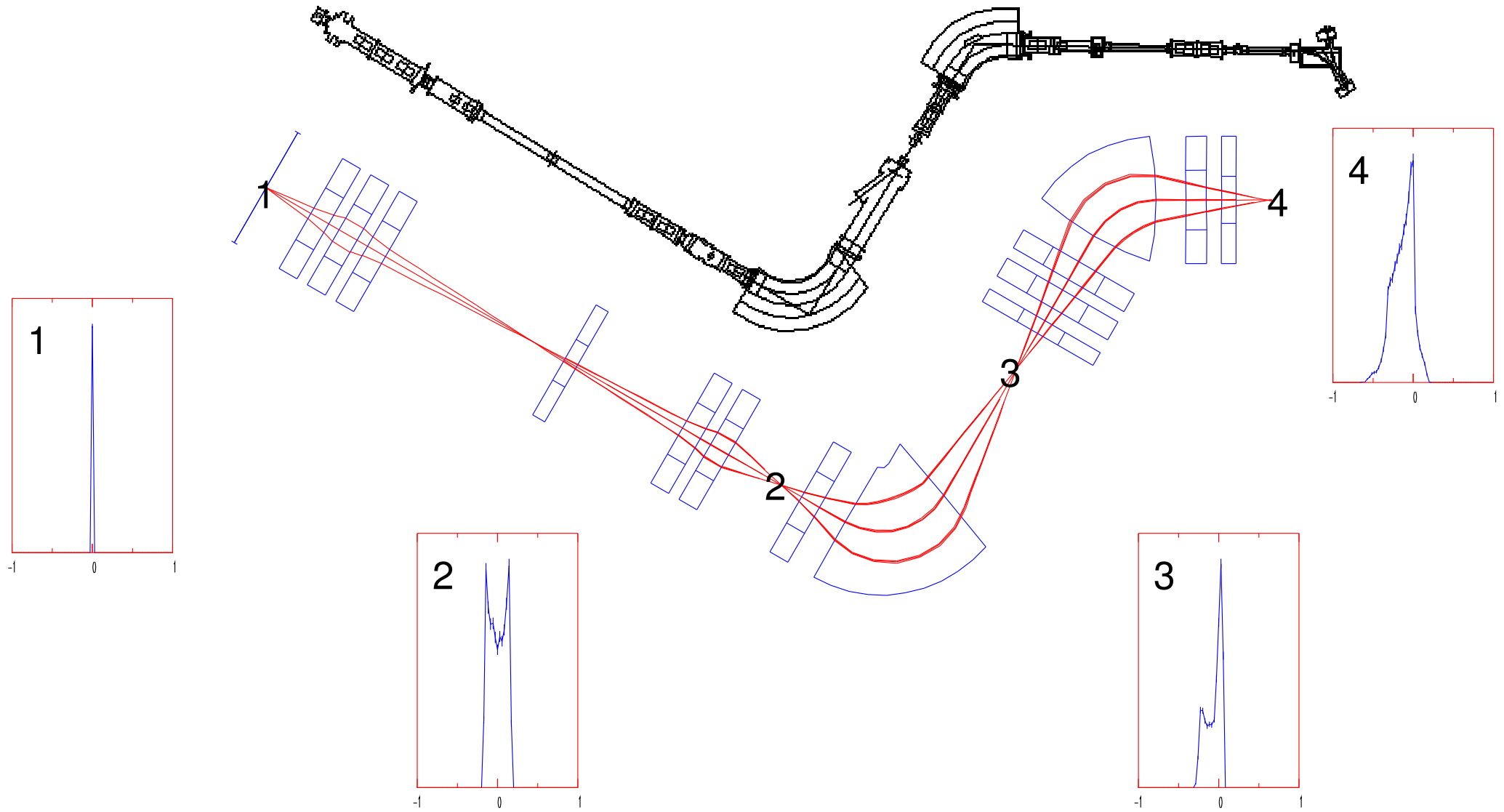
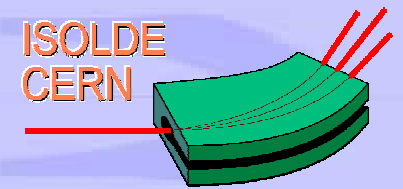
Examples

A photograph of a sunset or sunrise over a body of water. The sun is a large, bright, glowing orb on the right side of the frame, partially obscured by a thin layer of clouds. The water in the foreground is dark blue, while the sky transitions from a deep blue on the left to a lighter, hazy blue on the right. A bright, horizontal reflection of the sun stretches across the middle of the image, creating a shimmering path of light on the water's surface. The overall mood is serene and atmospheric.



Example 1: The HRS

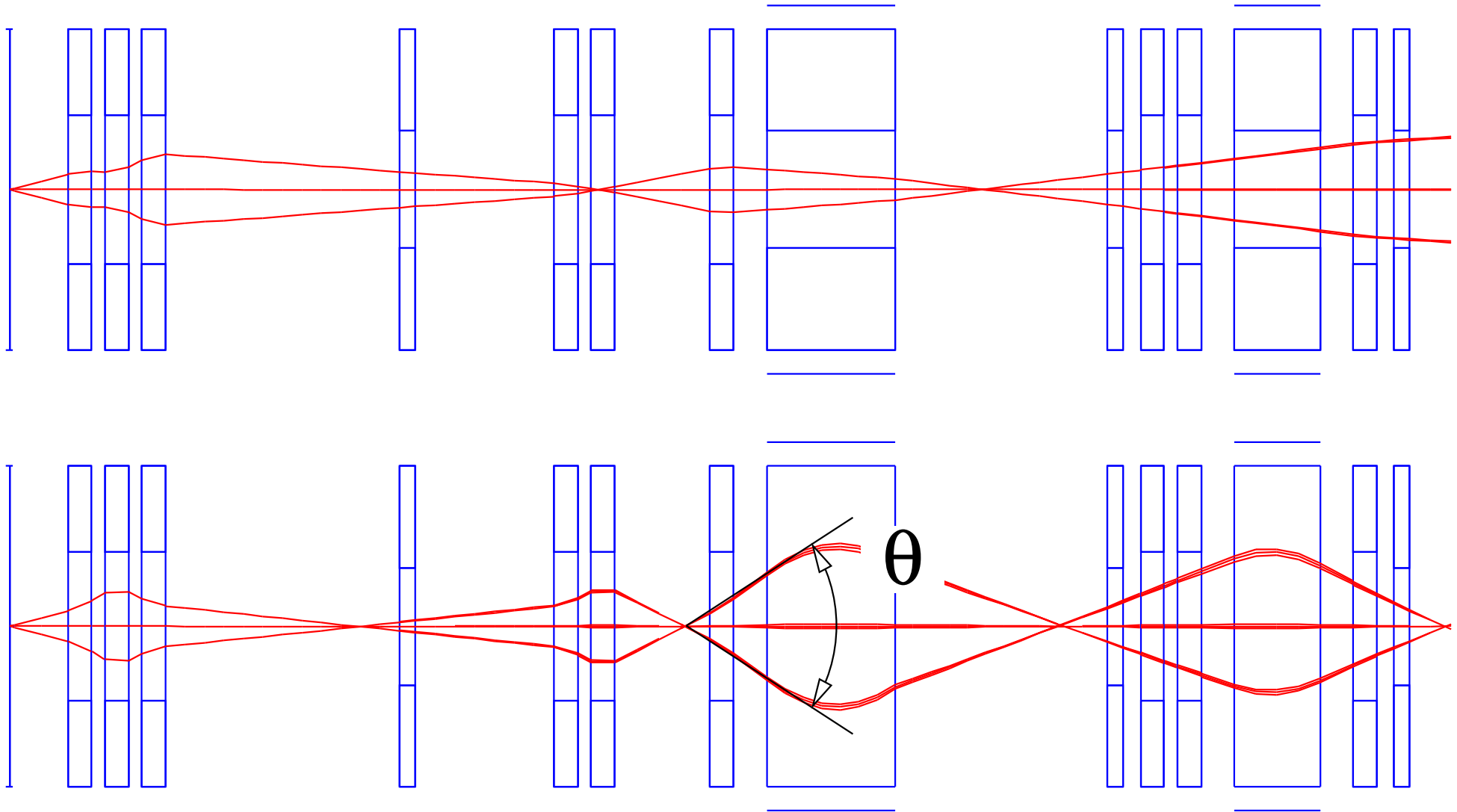
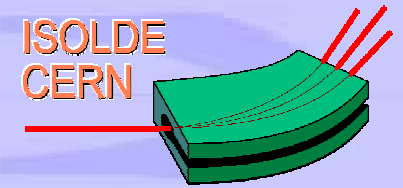
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Example 1: The HRS

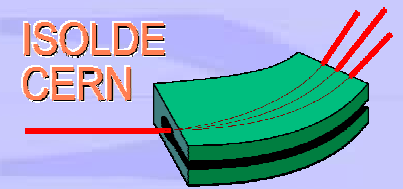
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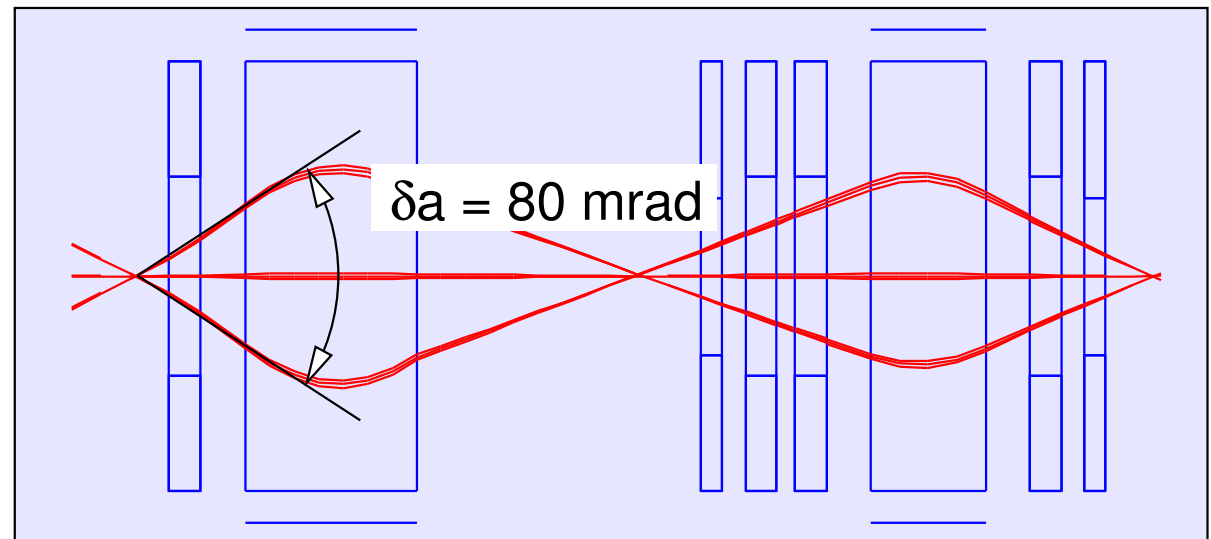
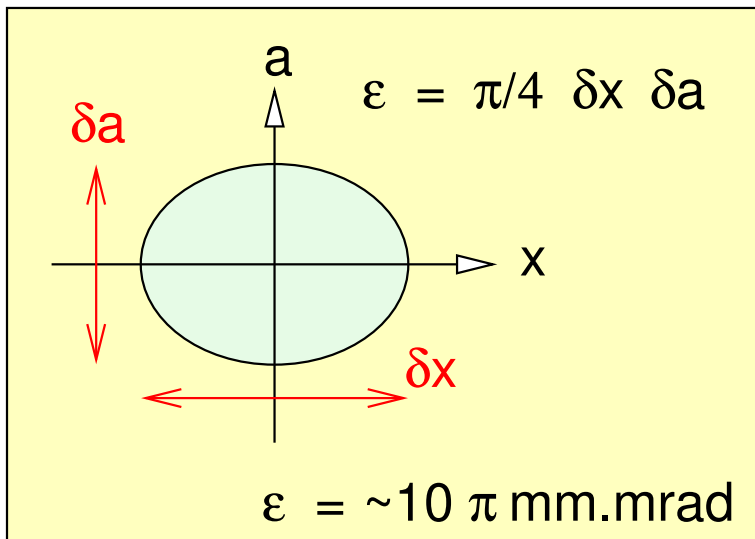


Mass Resolution

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

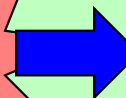


$\delta x = \sim 0.5 \text{ mm}$
 $D = 2700 \text{ mm}$

R = 5400

but:

Distortions

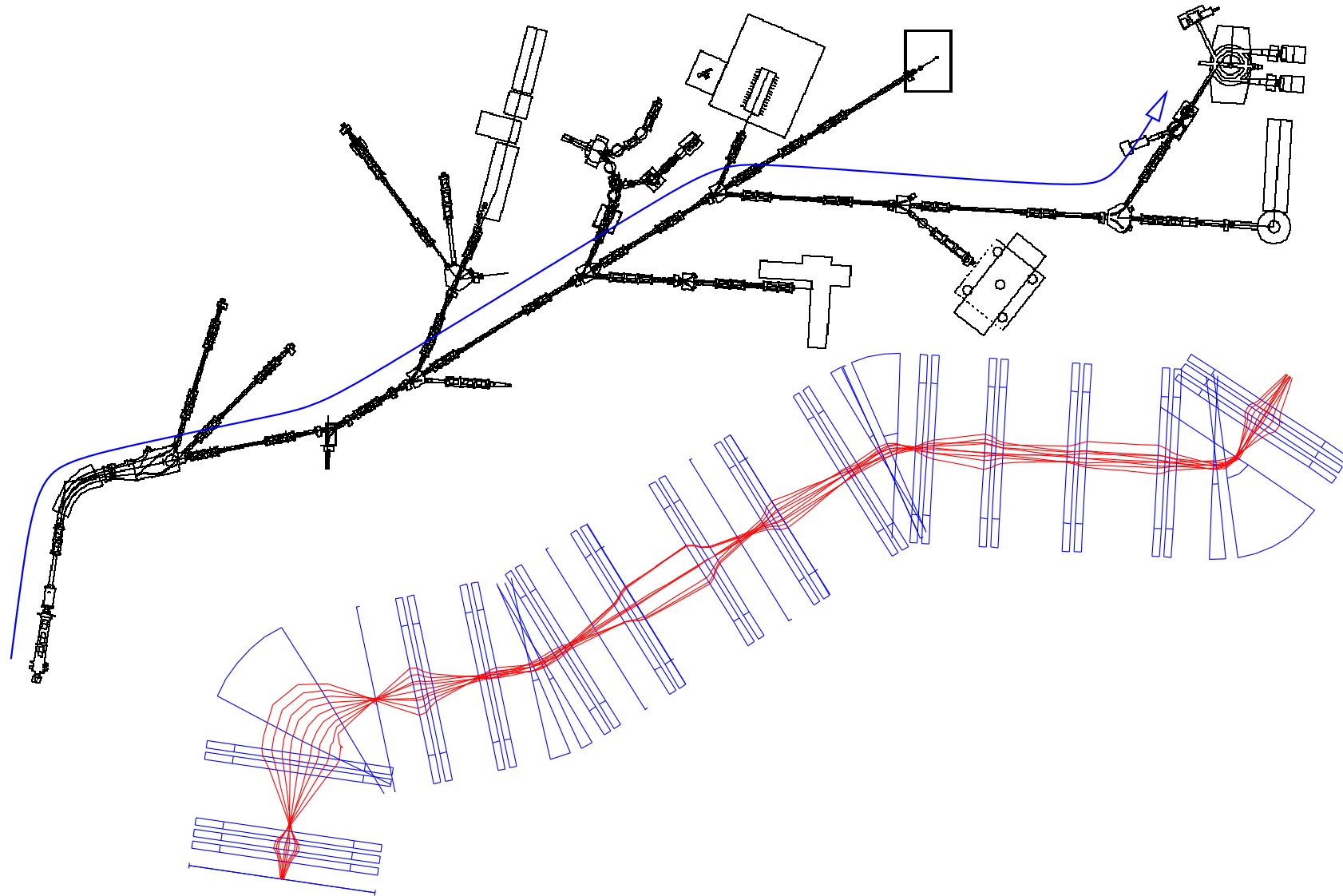
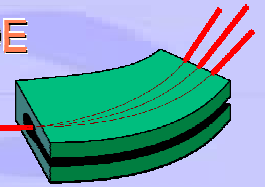


$\delta x > \sim 0.5 \text{ mm}$



Example 2: GPS to Mistral

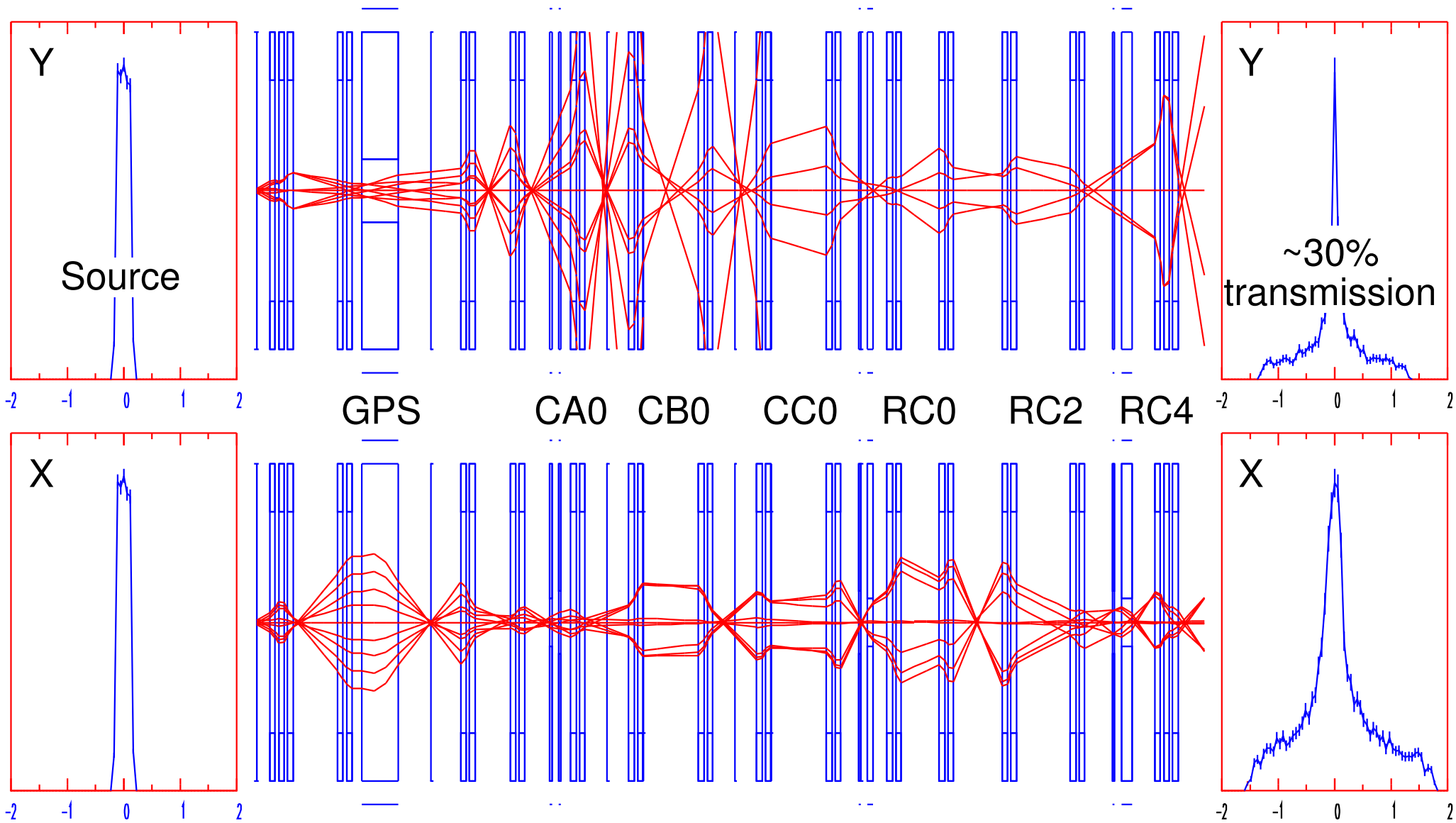
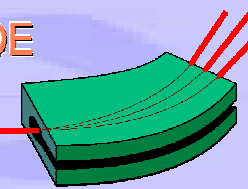
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Example 2: GPS to Mistral

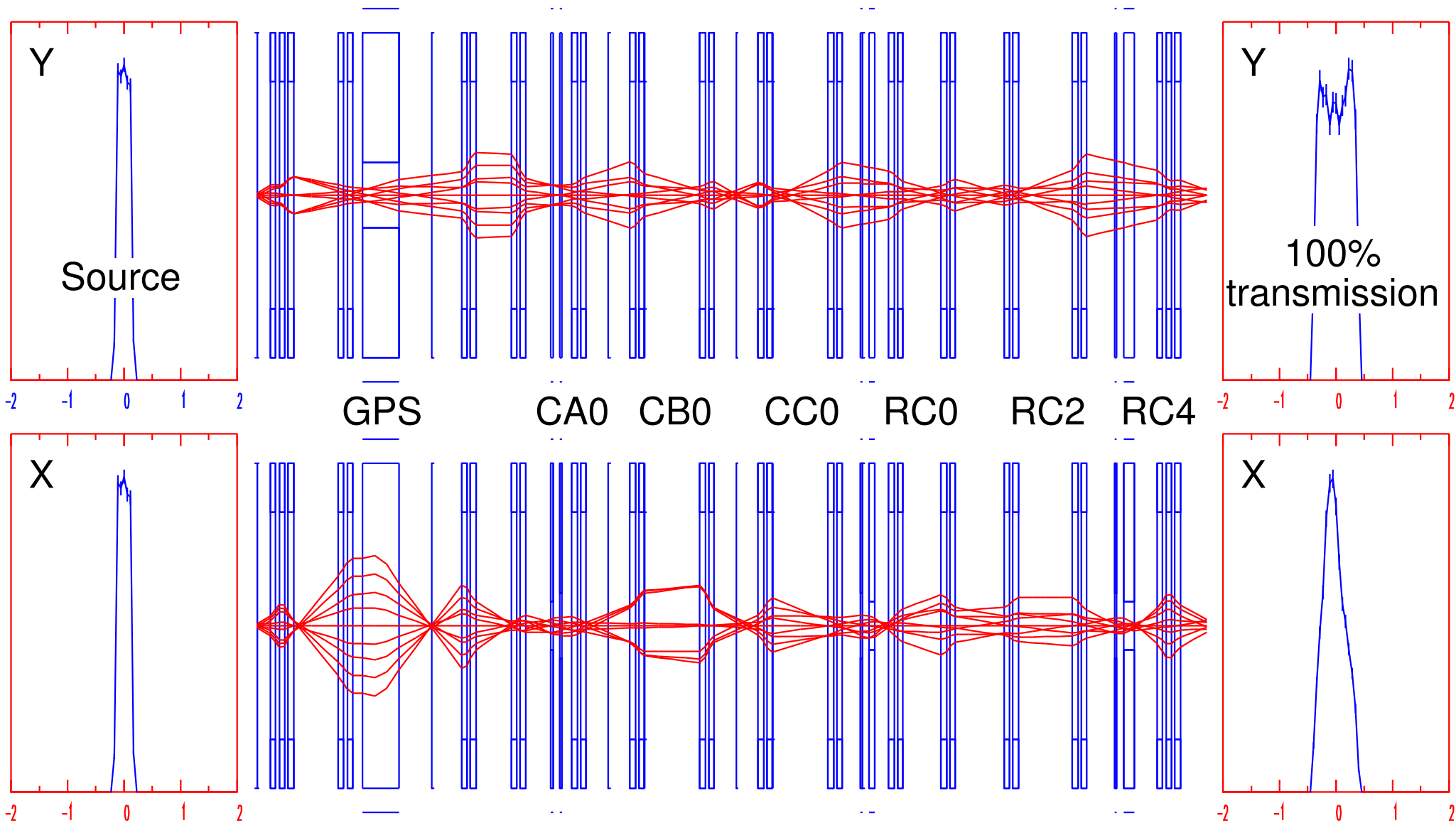
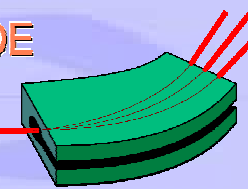
ISOLDE
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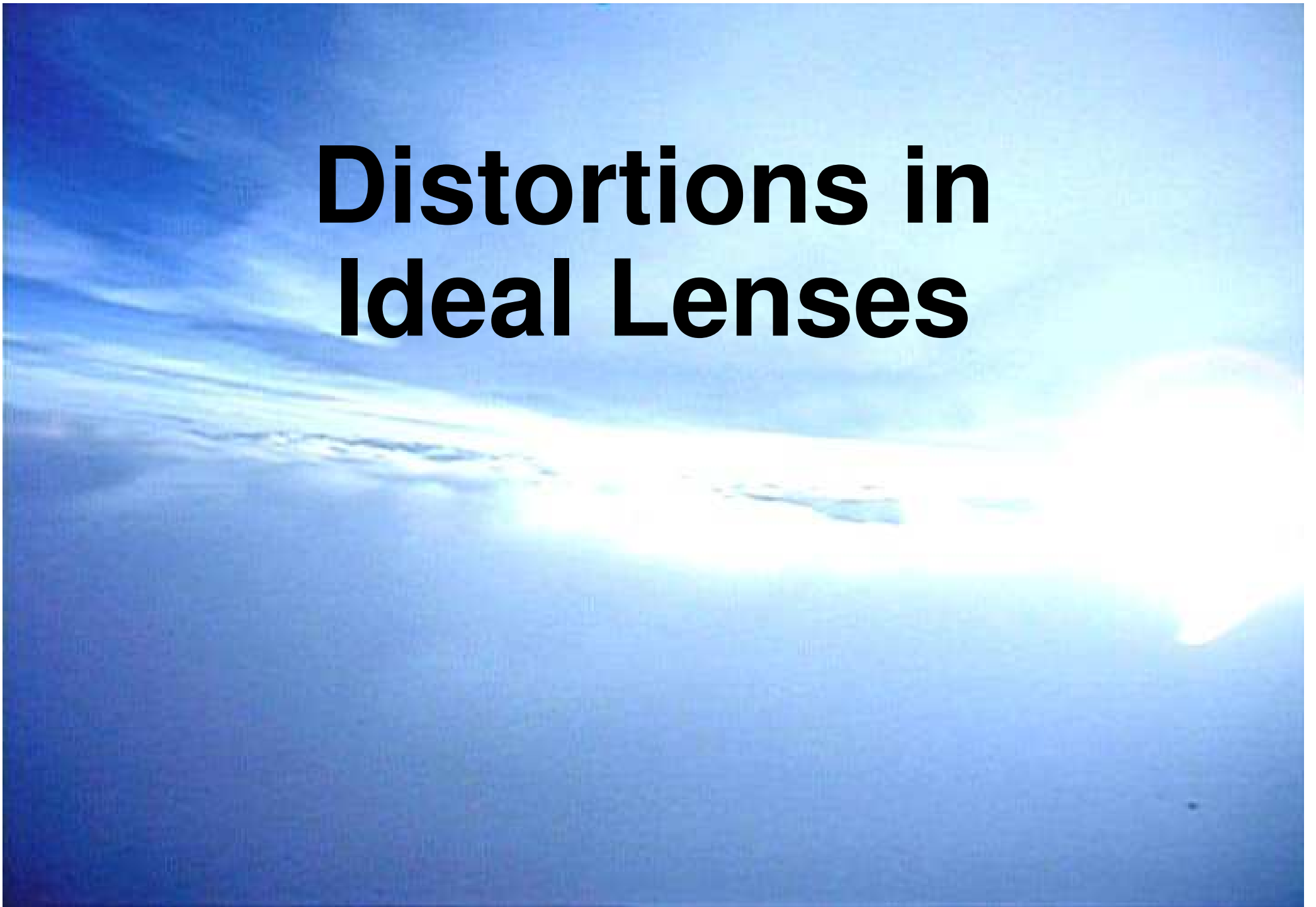


Example 2: GPS to Mistral

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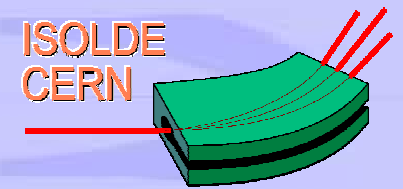
Distortions in Ideal Lenses





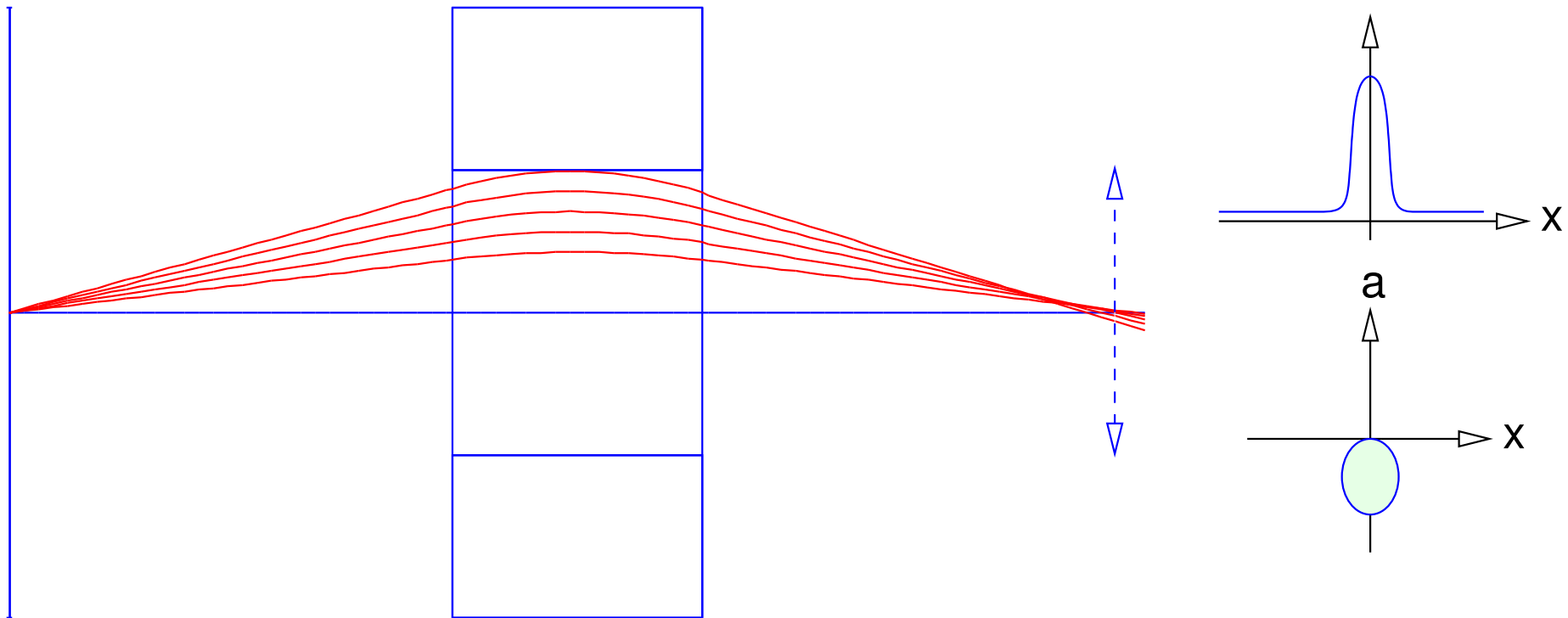
Distortions 1

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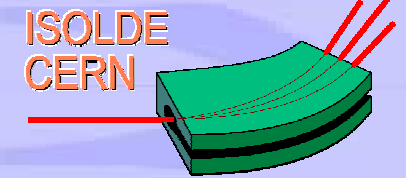
Beam steering in quadrupoles

Order mixing: 1st order adjustment \rightarrow 0th order effect



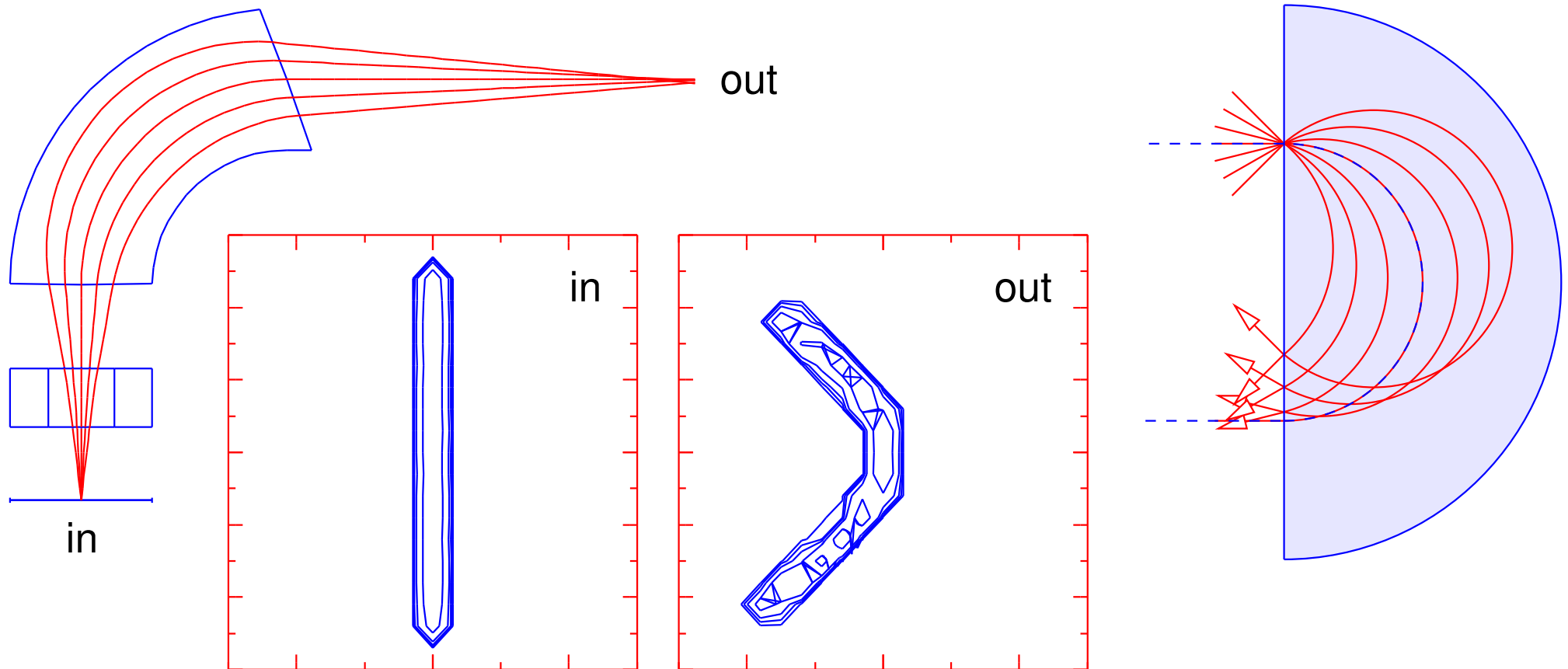


Distortions 2



Dipoles: separator magnets

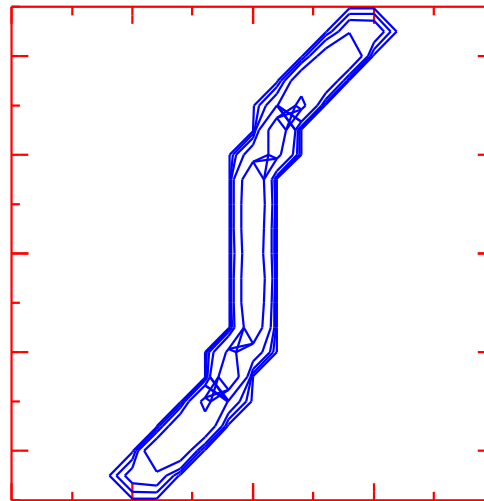
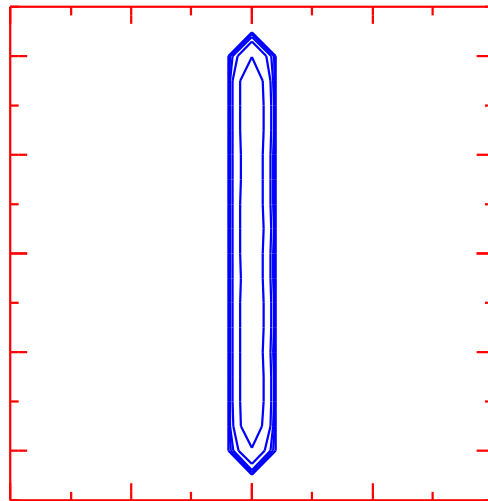
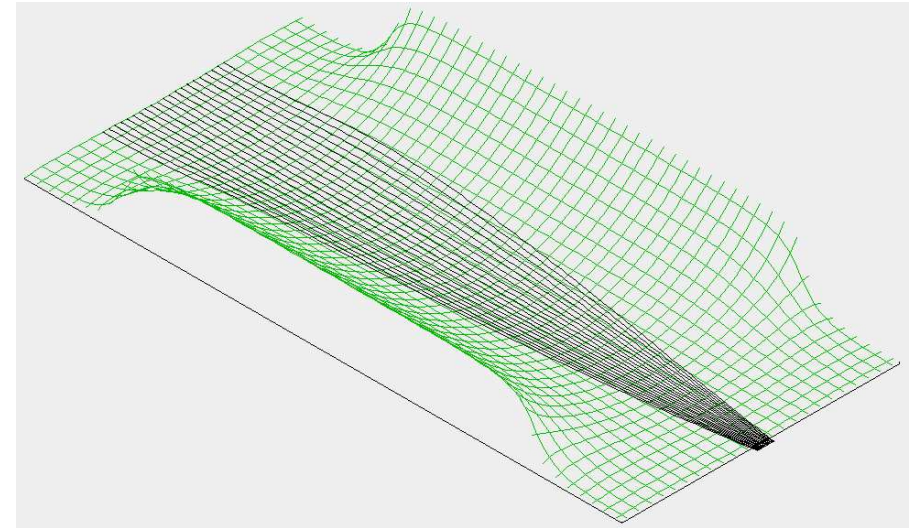
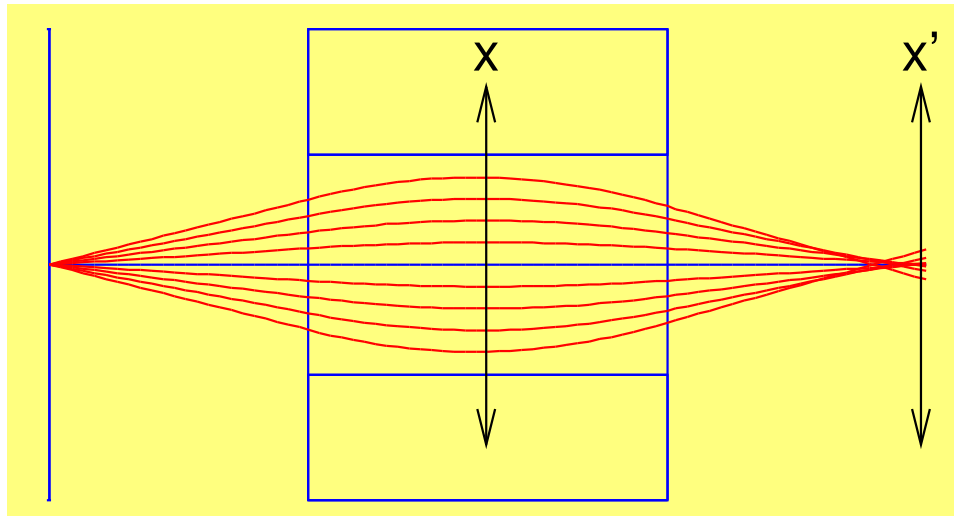
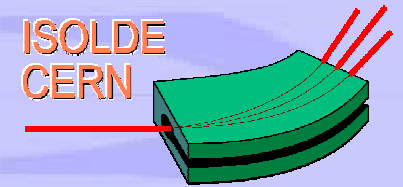
Order mixing: 0th order lens \rightarrow 2nd order effect





Distortions 3

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

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

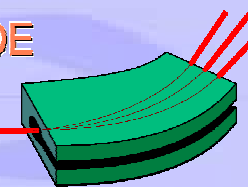
Real Lenses



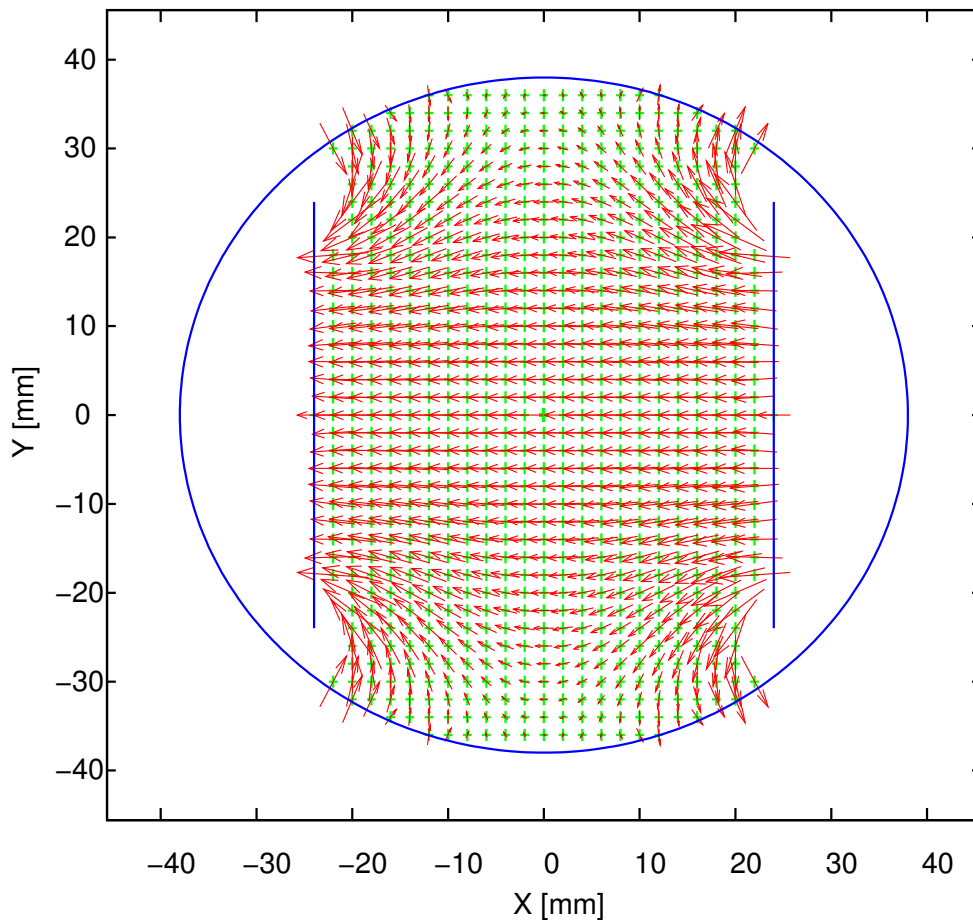


Field shaping: deflectors

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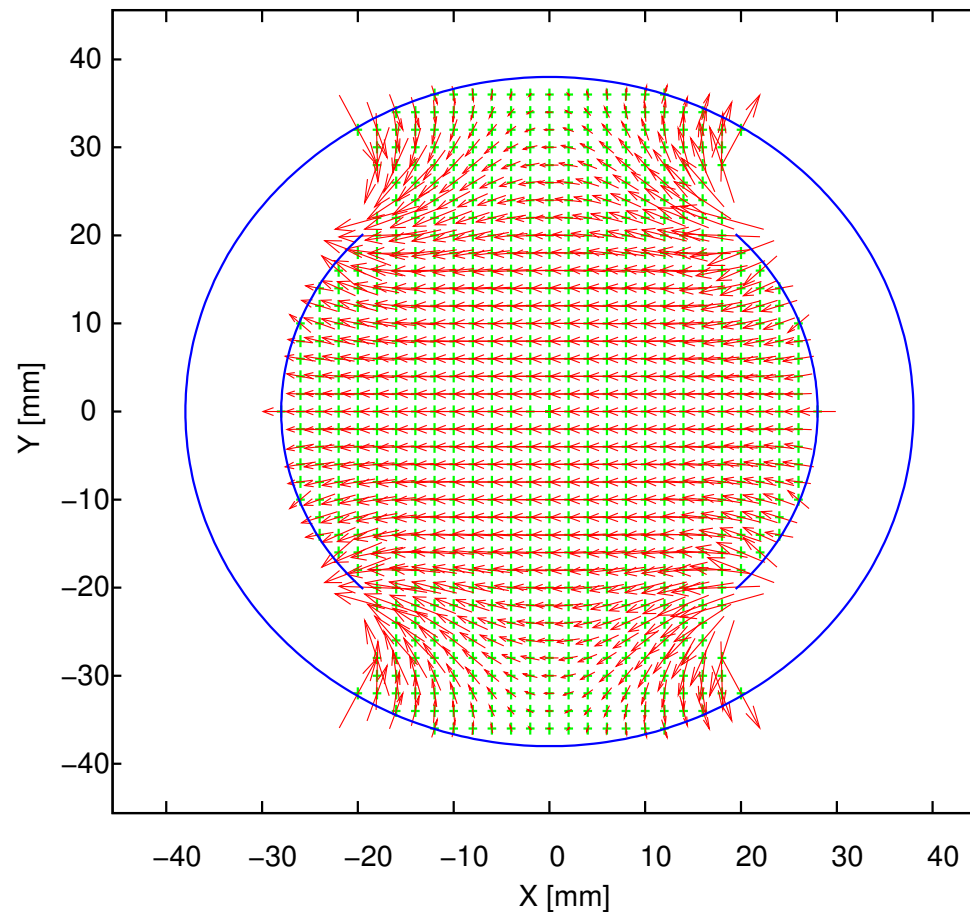


Deflector field, all components



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

Deflector field, all components

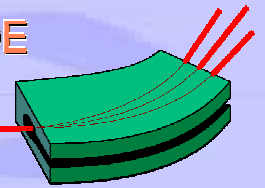


Dipole	Hexapole	10-pole	14-pole	18-pole
109 %	-0.3 %	-13 %	3.4 %	3.9 %

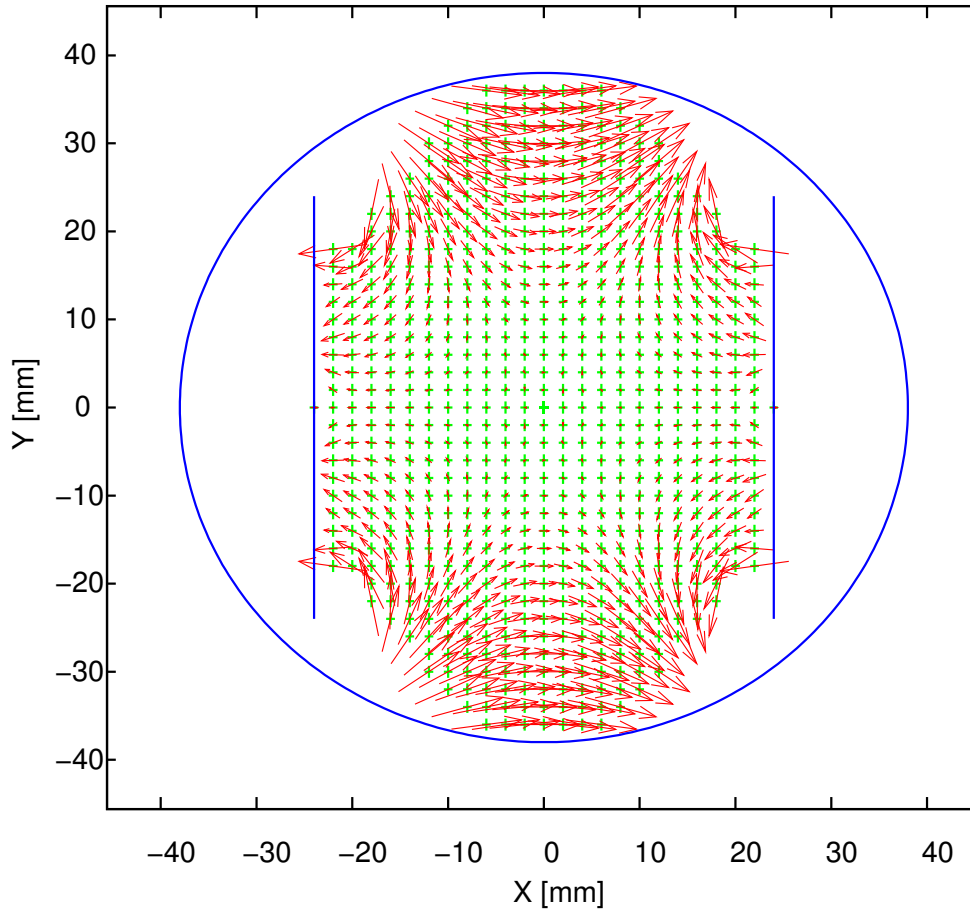


Field shaping: deflectors

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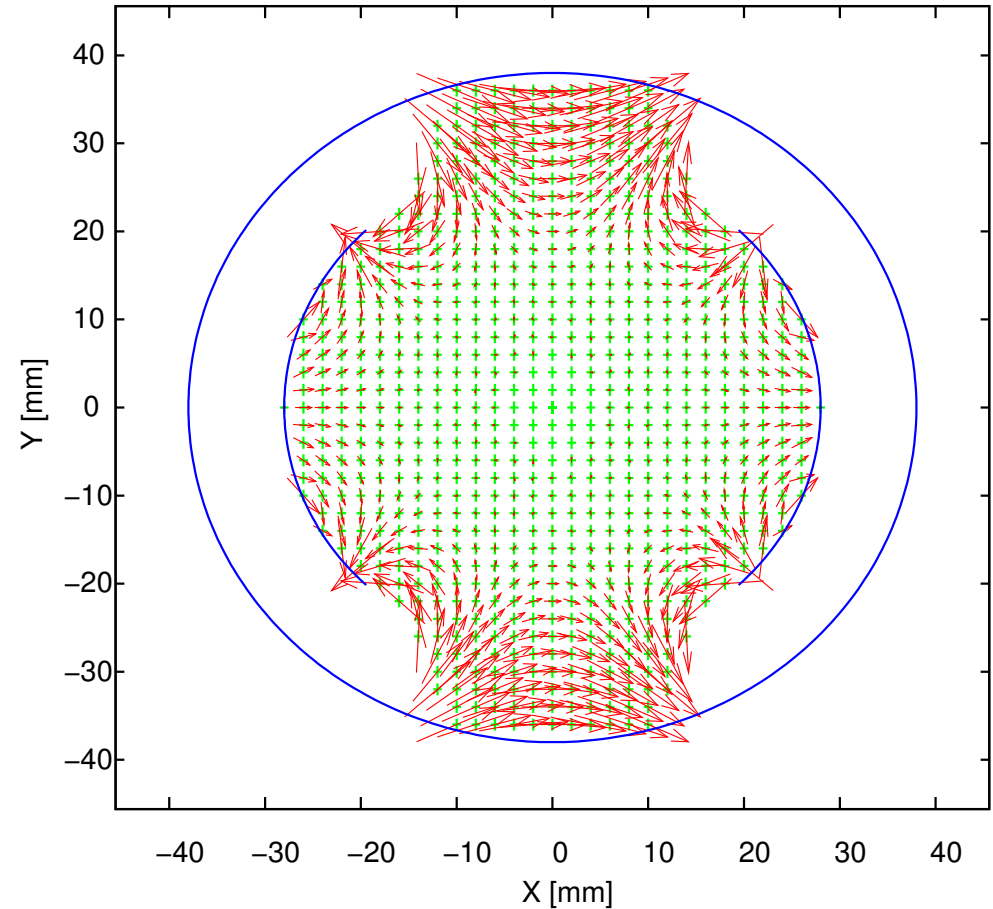


Deflector field, a1 component removed



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

Deflector field, a1 component removed

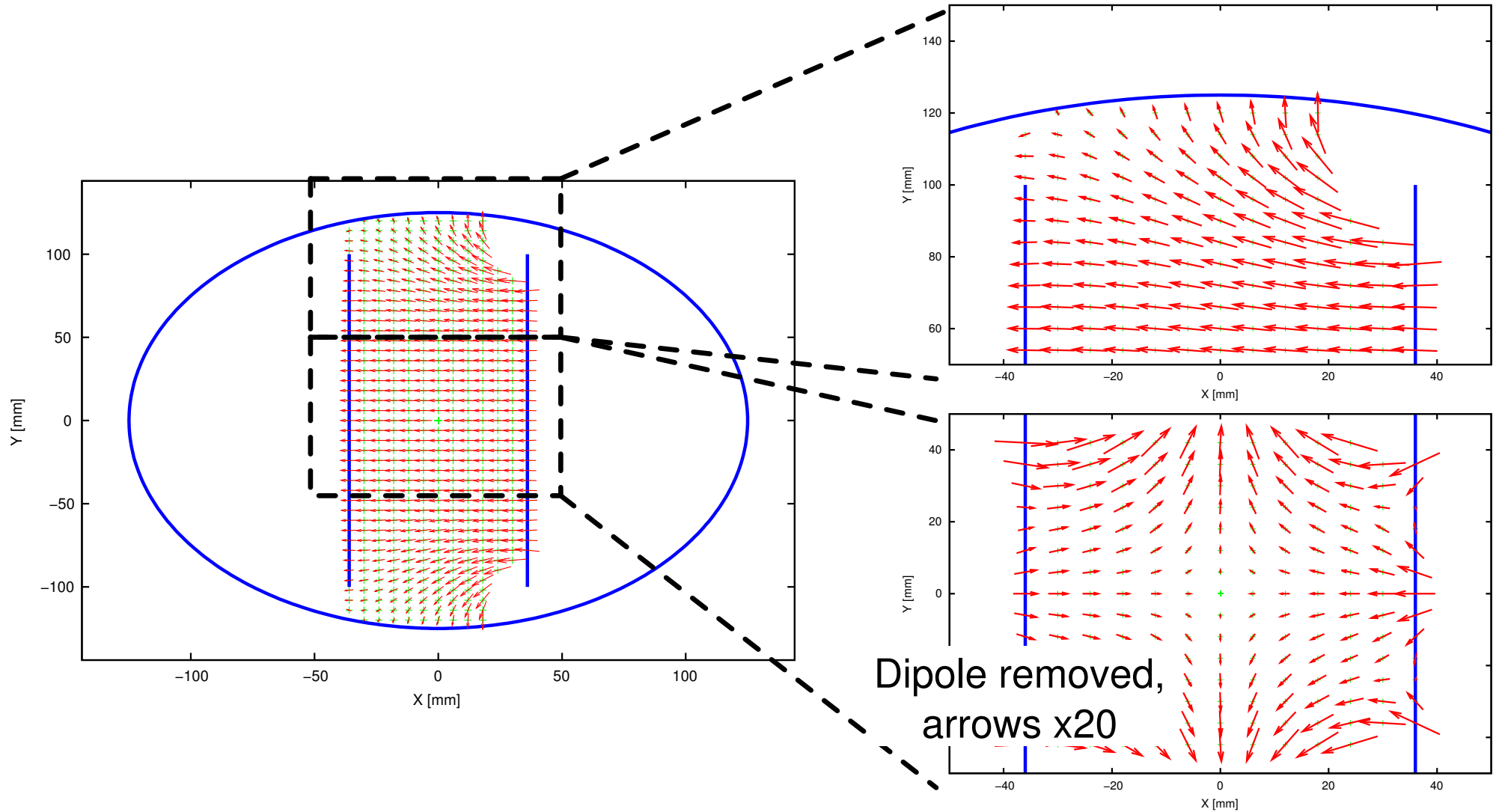
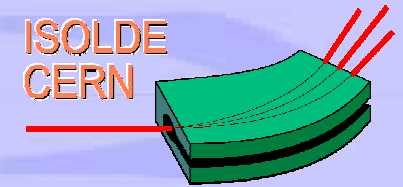


Dipole	Hexapole	10-pole	14-pole	18-pole
109 %	-0.3 %	-13 %	3.4 %	3.9 %



HRS deflectors

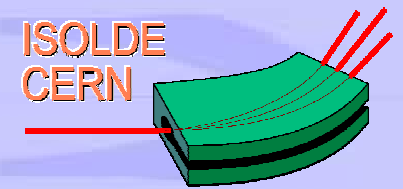
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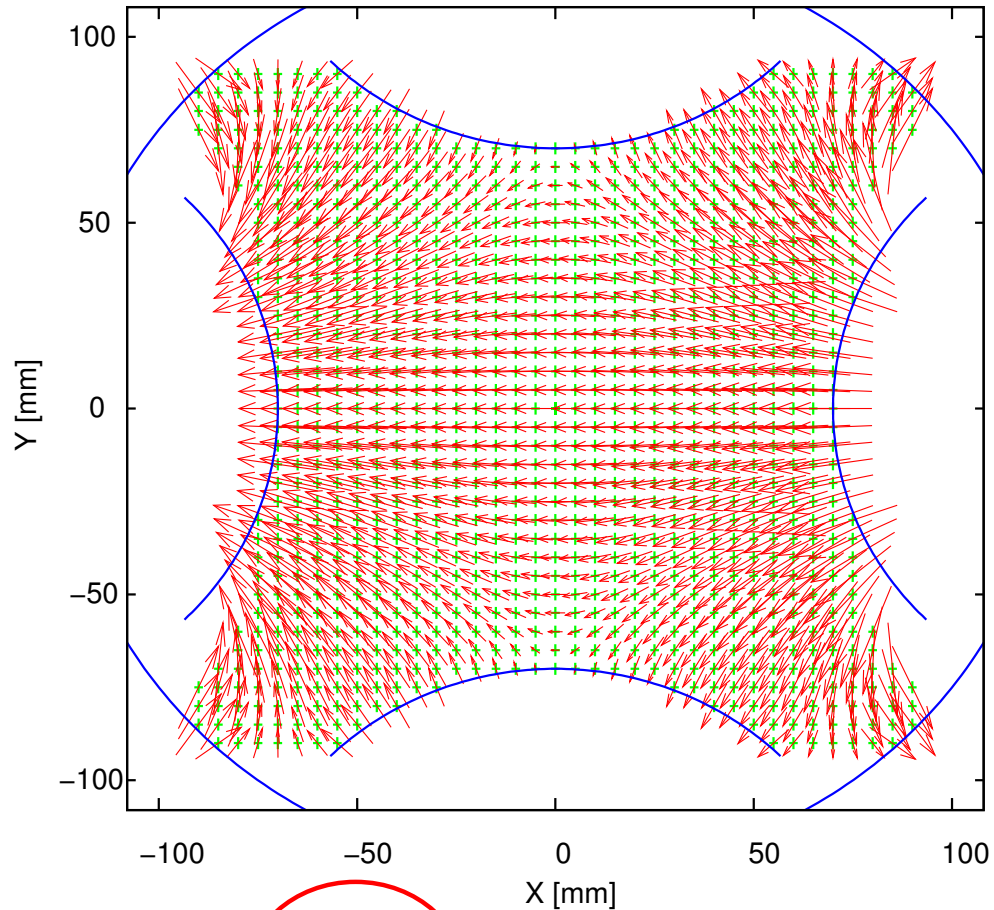


Quads as deflectors

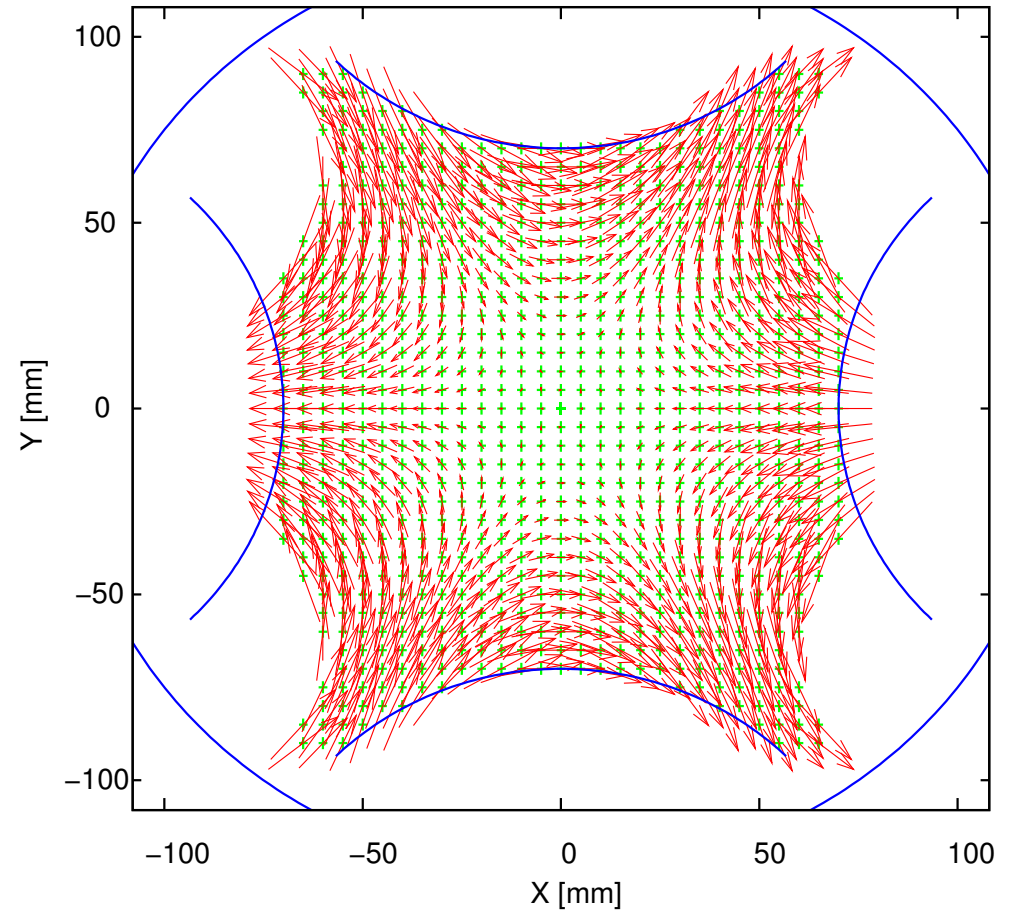
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Deflector field, all components



Deflector field, a1 component removed

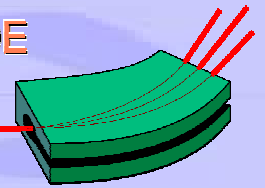


Dipole	Hexapole	10-pole	14-pole	18-pole
89 %	34 %	-1.5 %	0.4 %	-1.7 %

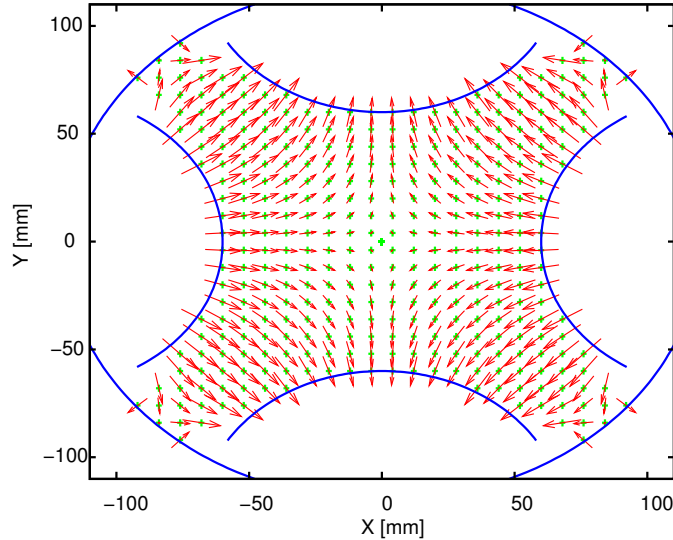


Quadrupole proportions

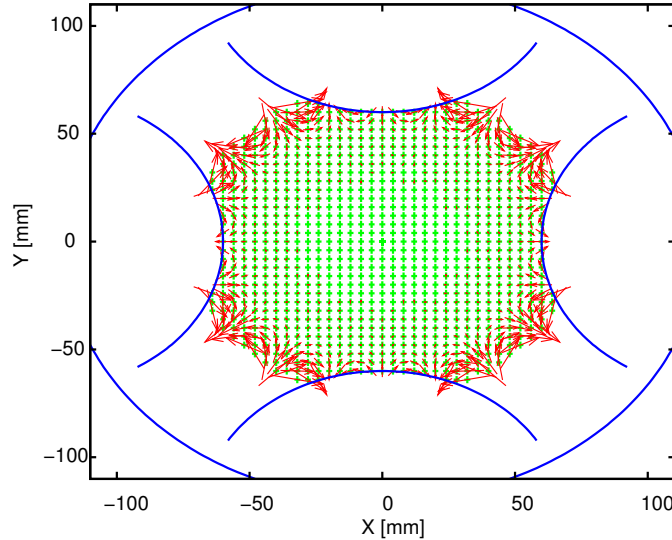
ISOLDE
CERN



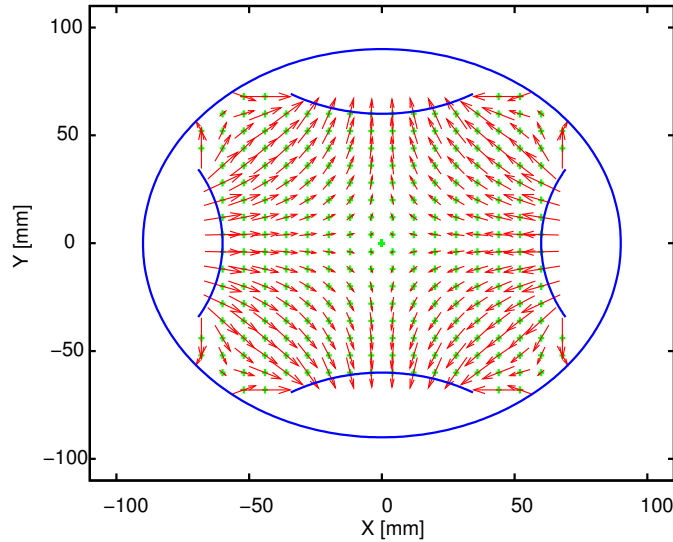
Q.Pole field, all components



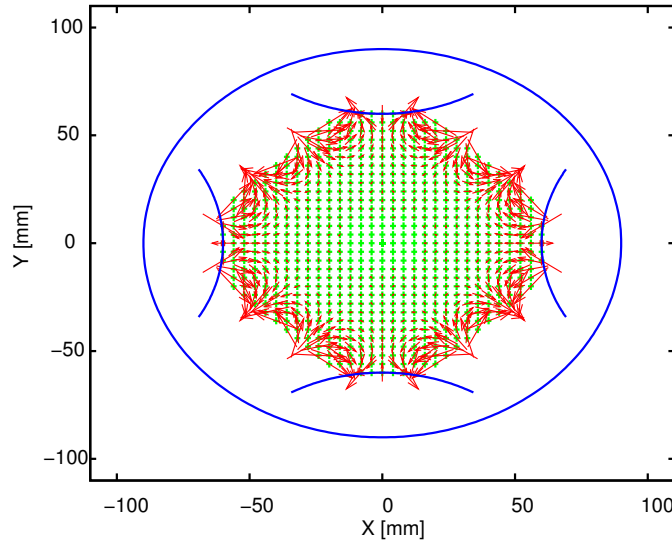
Q.Pole field, a1 component removed



Q.Pole field, all components



Q.Pole field, a1 component removed



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 %

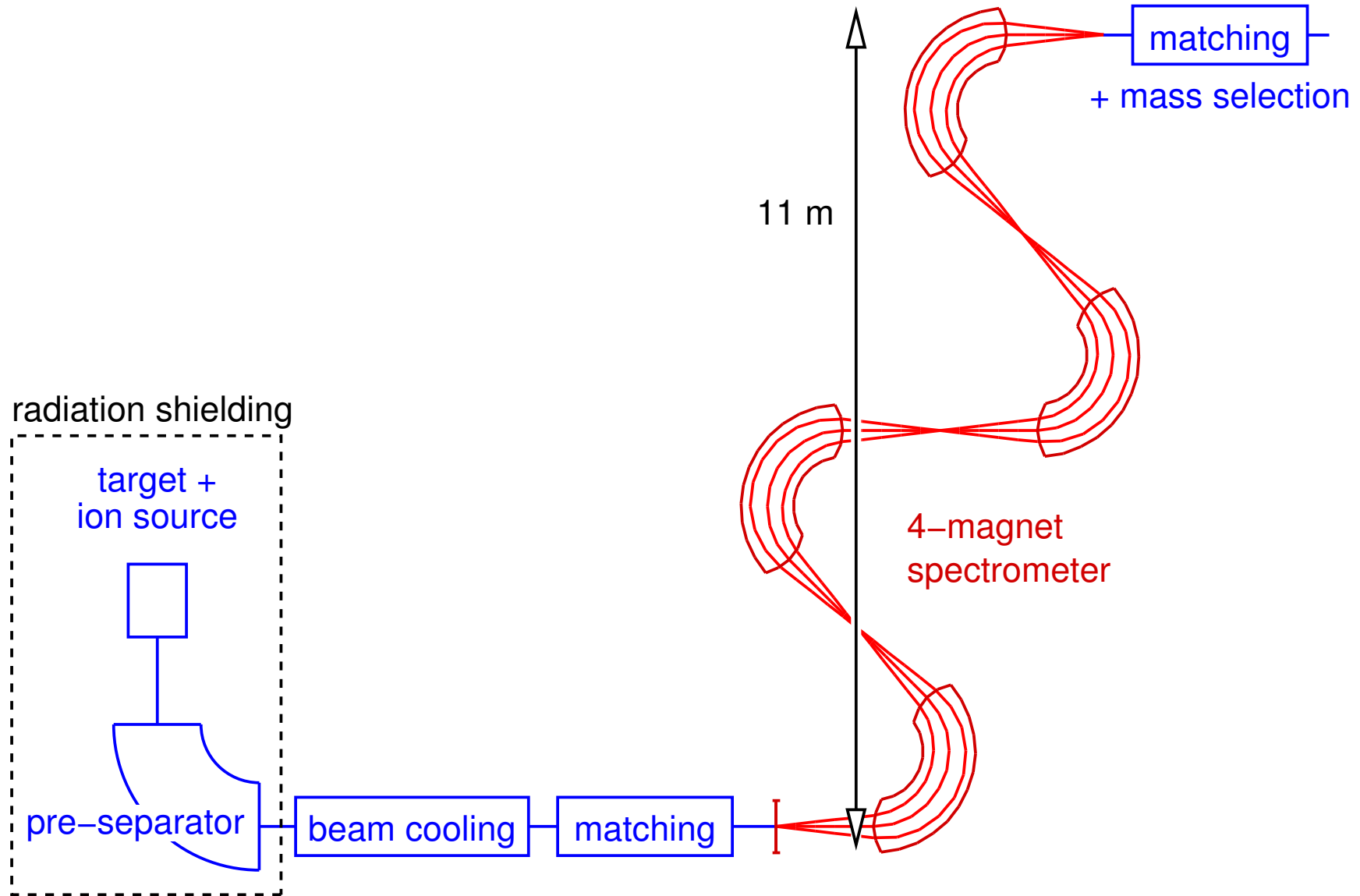
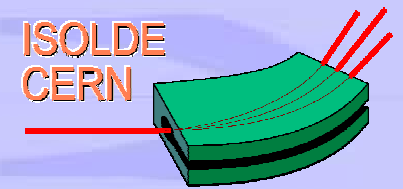
Ideas for the Future





A New HRS

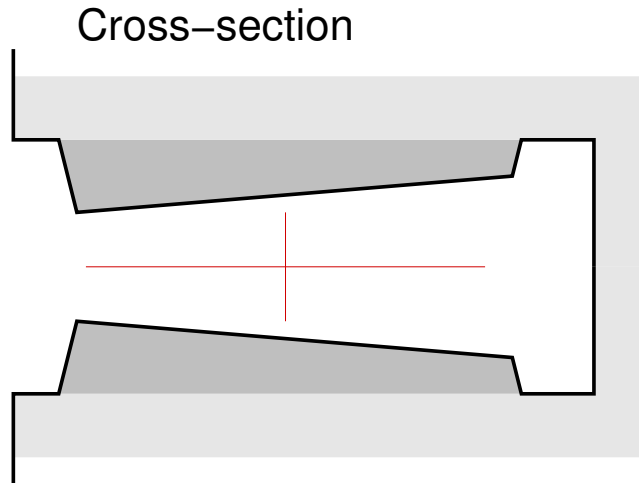
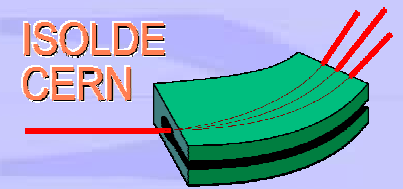
ISOLDE
CERN



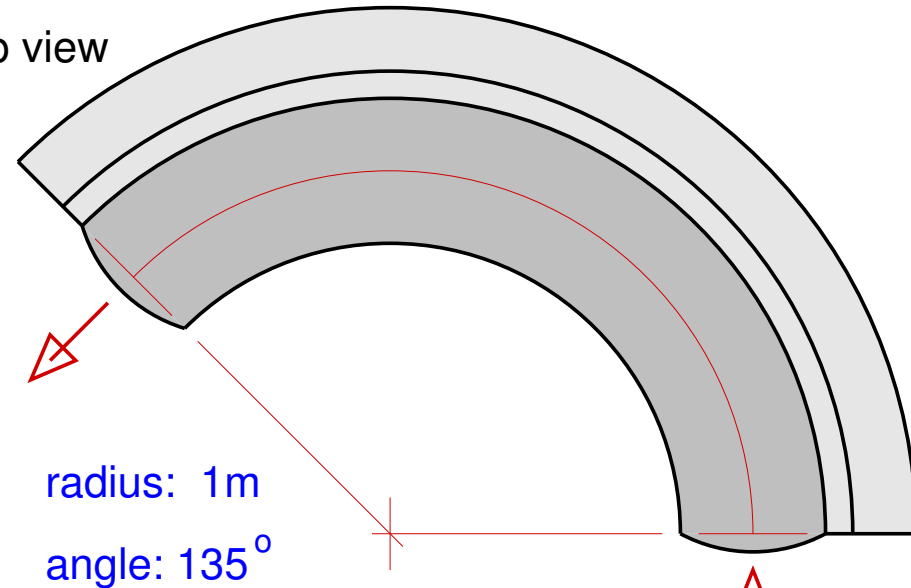


A New HRS

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Top view



radius: 1m

angle: 135°

Field shape:

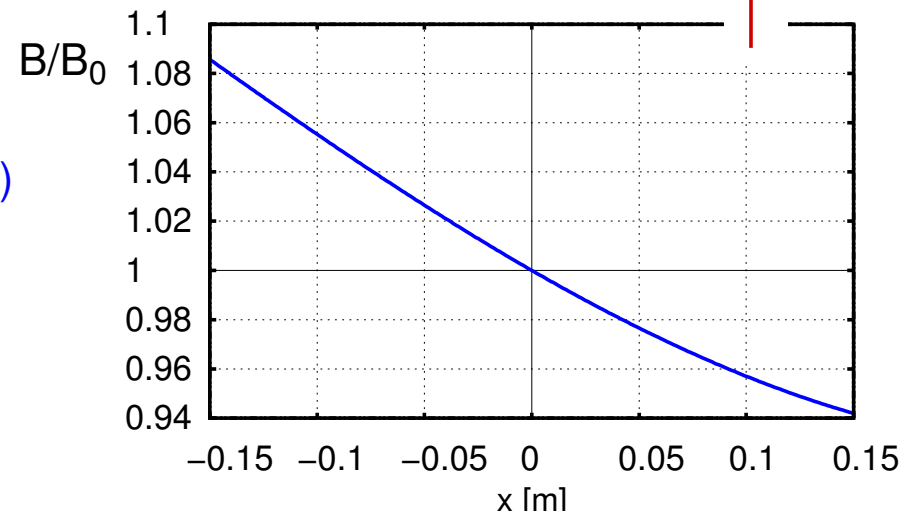
$$B_y = B_0 (1 - 0.5x + 0.61x^2 - 0.98x^3)$$

dipole

quadrupole

hexapole

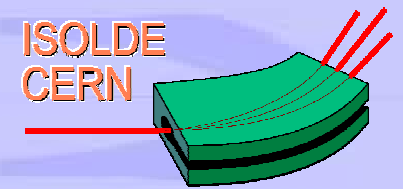
octupole



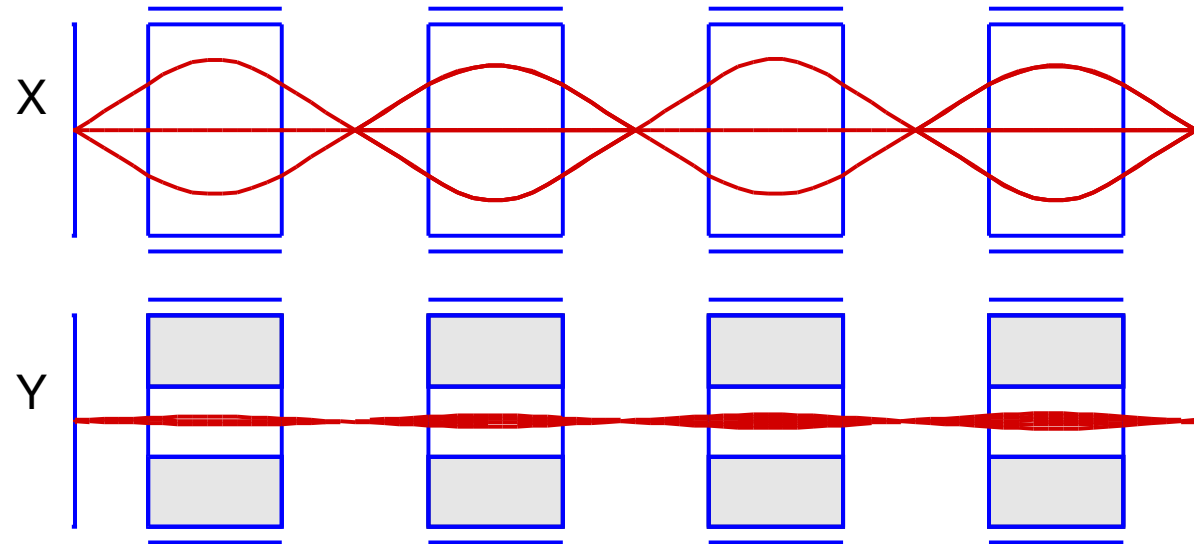


A New HRS

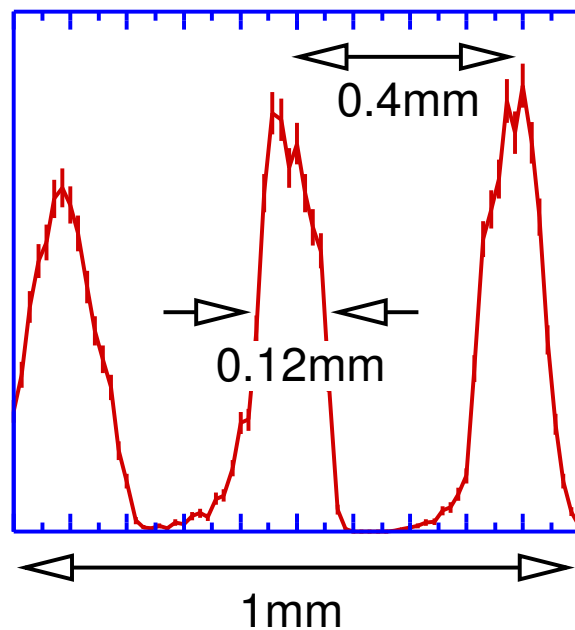
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Beam envelopes



Beam separation



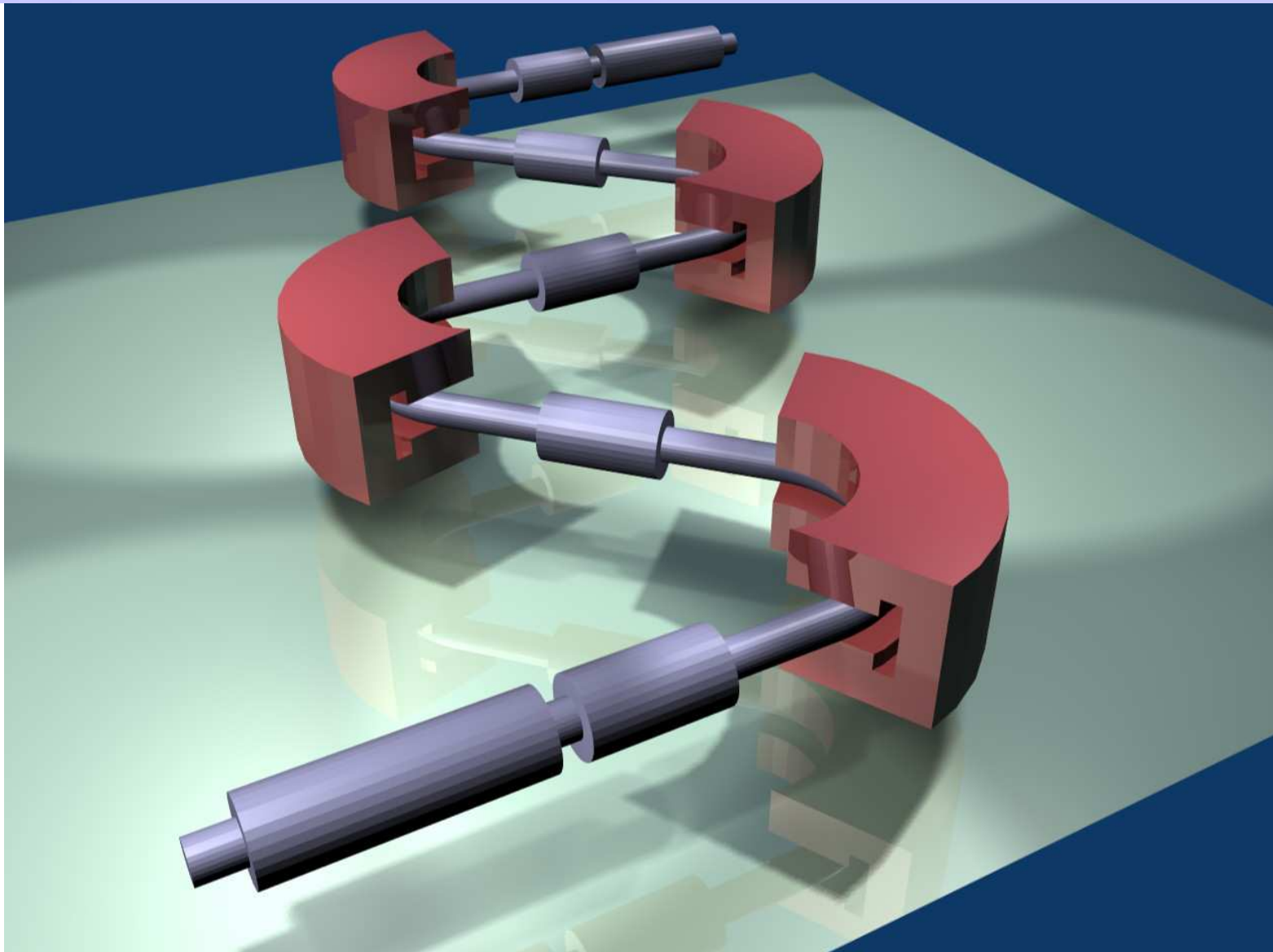
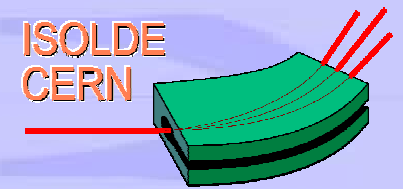
**Ultimate resolution:
64 000 for 3 pi.mm.mrad emittance**

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



A New HRS

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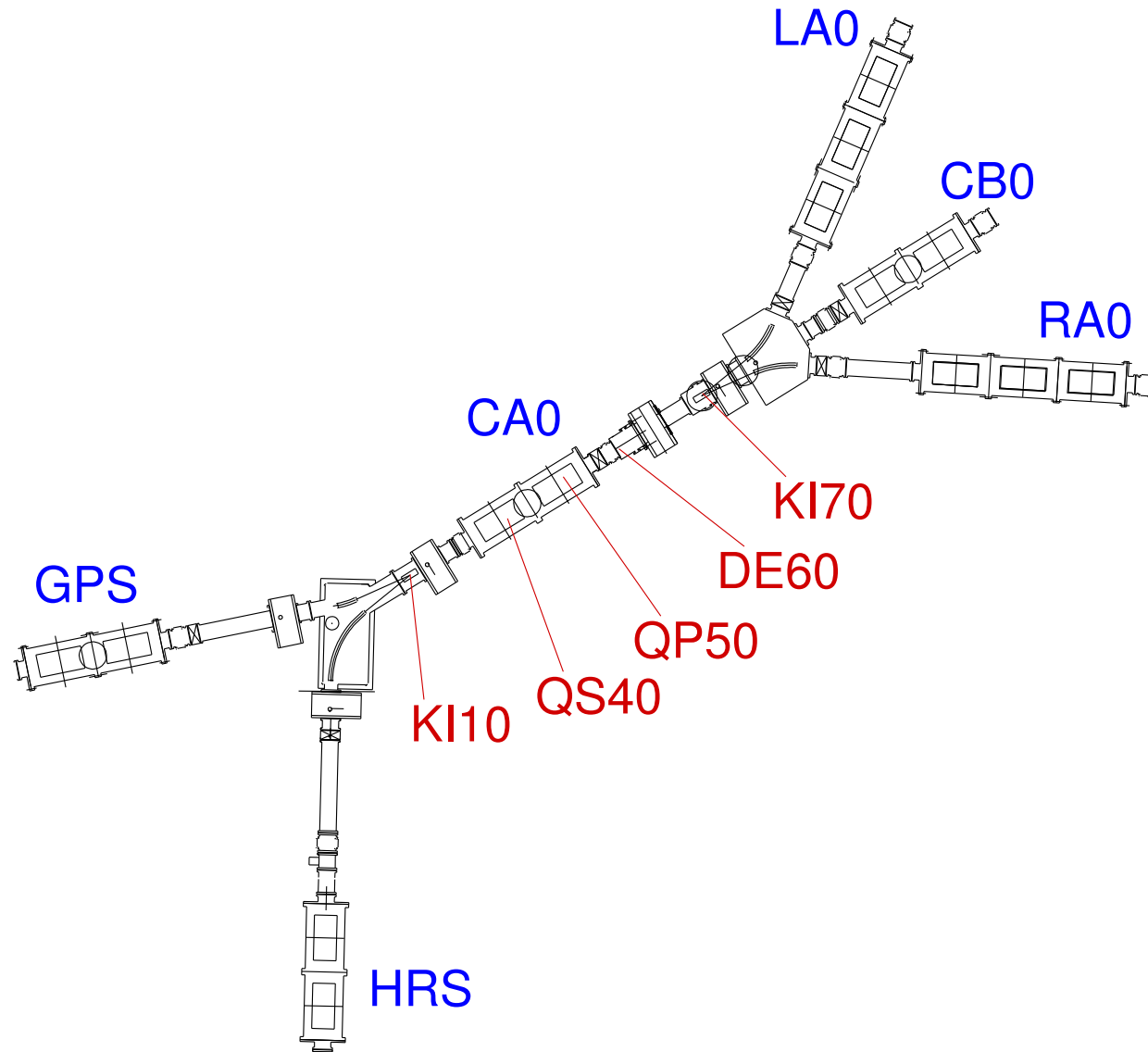
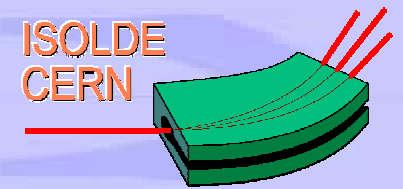


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Beam Optics At ISOLDE



The CA0 bottleneck

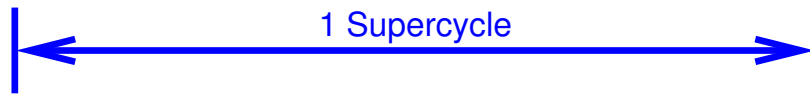
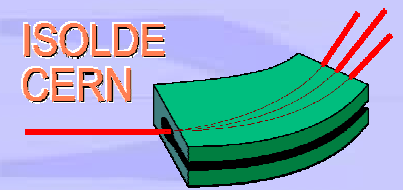
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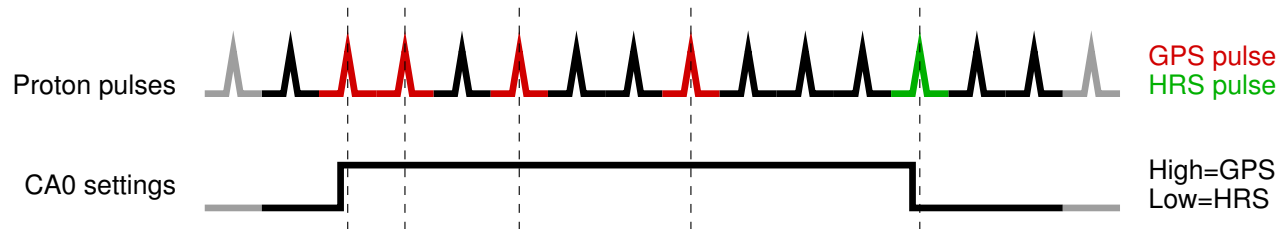
CA0 pulsing

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Scenario #1

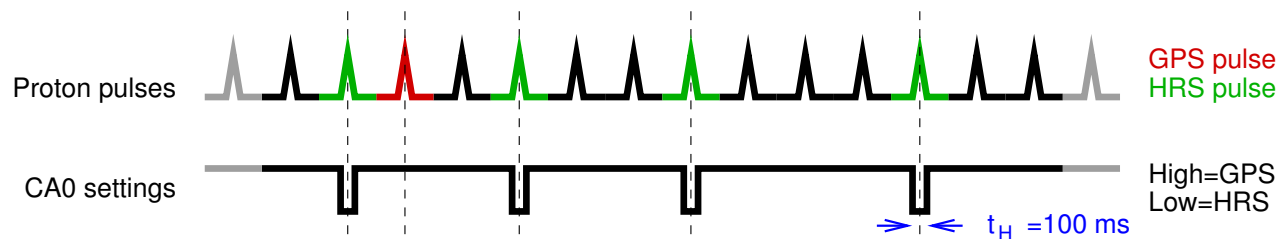
Experiment running on GRS
Proton-scan or yield test on HRS



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)



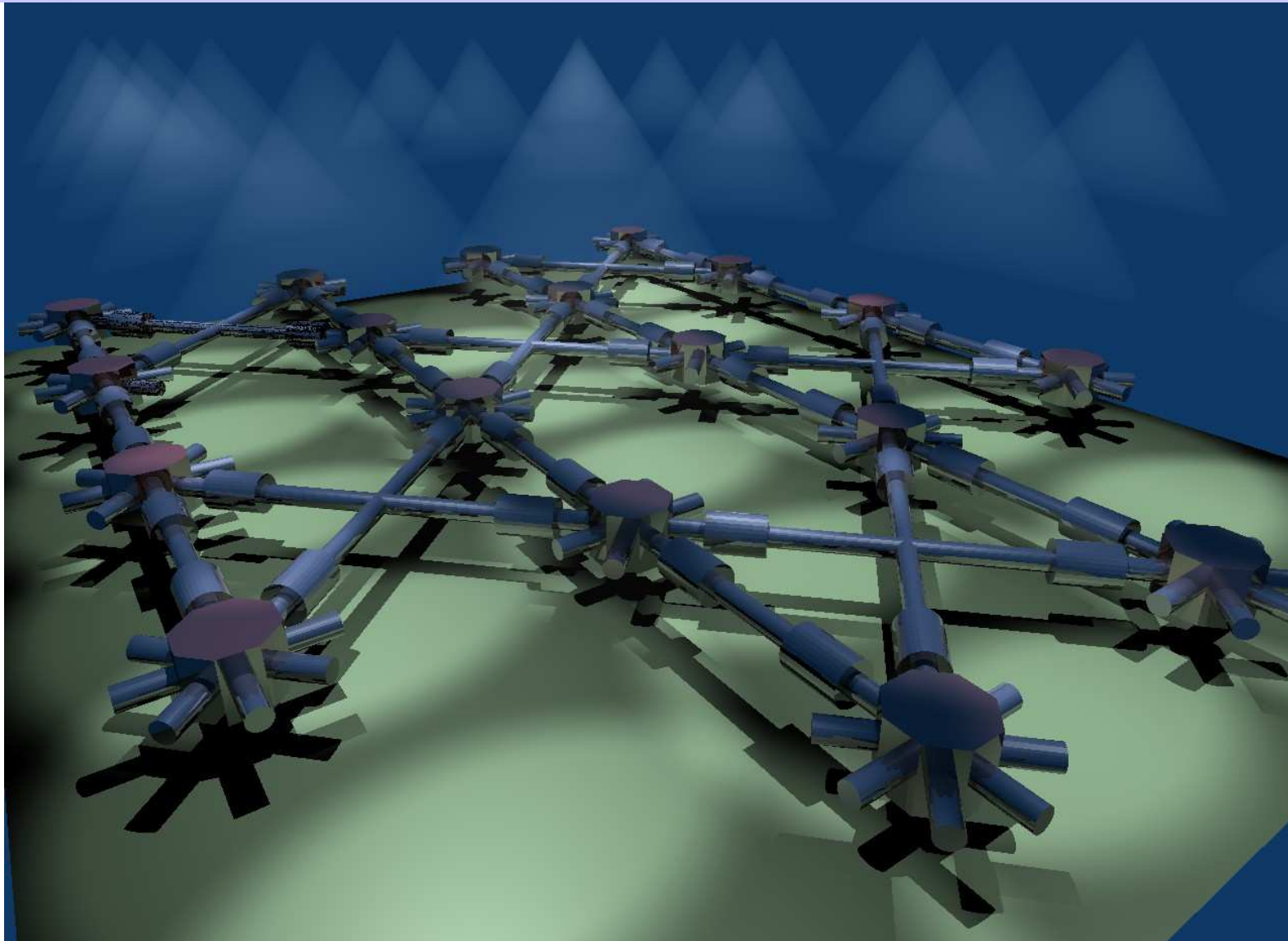
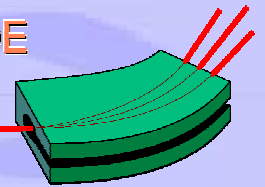
GPS-context trigger: (ISOGPS minus n1 milliseconds)
 GPS-context timeout: (None)
 HRS-context trigger: ISOHRS minus n2 milliseconds
 HRS-context timeout: t_H

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



A New ISOLDE

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