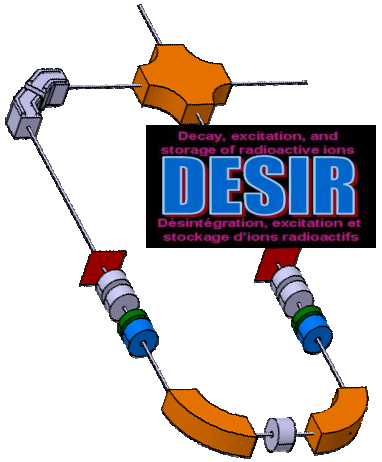


Status of the HRS

Teresa Kurtukian-Nieto
CEN Bordeaux-Gradignan

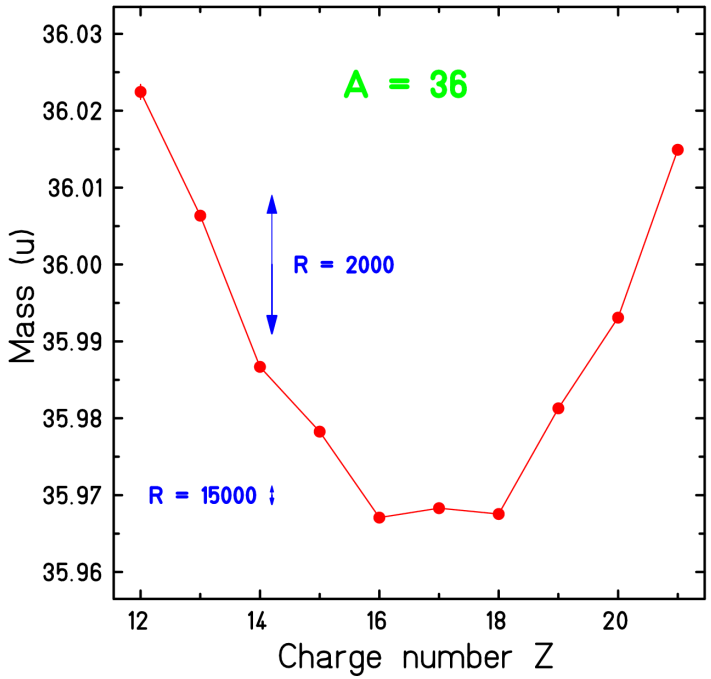
SPIRAL2-WEEK
Caen, January 28th 2010

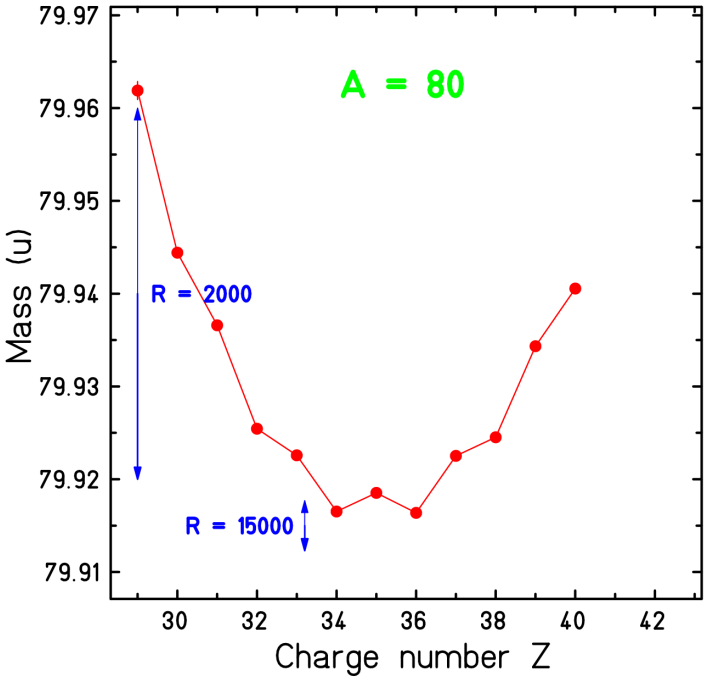
High Resolution Separator HRS
Outline

- HRS: Design Goal
- Initial Implementation
- New design: HRS-U180
- Ion optics:
  - COSY Infinity calculations
  - Optics discussion
- Performance study using Raytracing Turtle
- Summary and outlook

HRS: Design goal

High resolution separator with enough mass resolving power to allow isobaric separation.



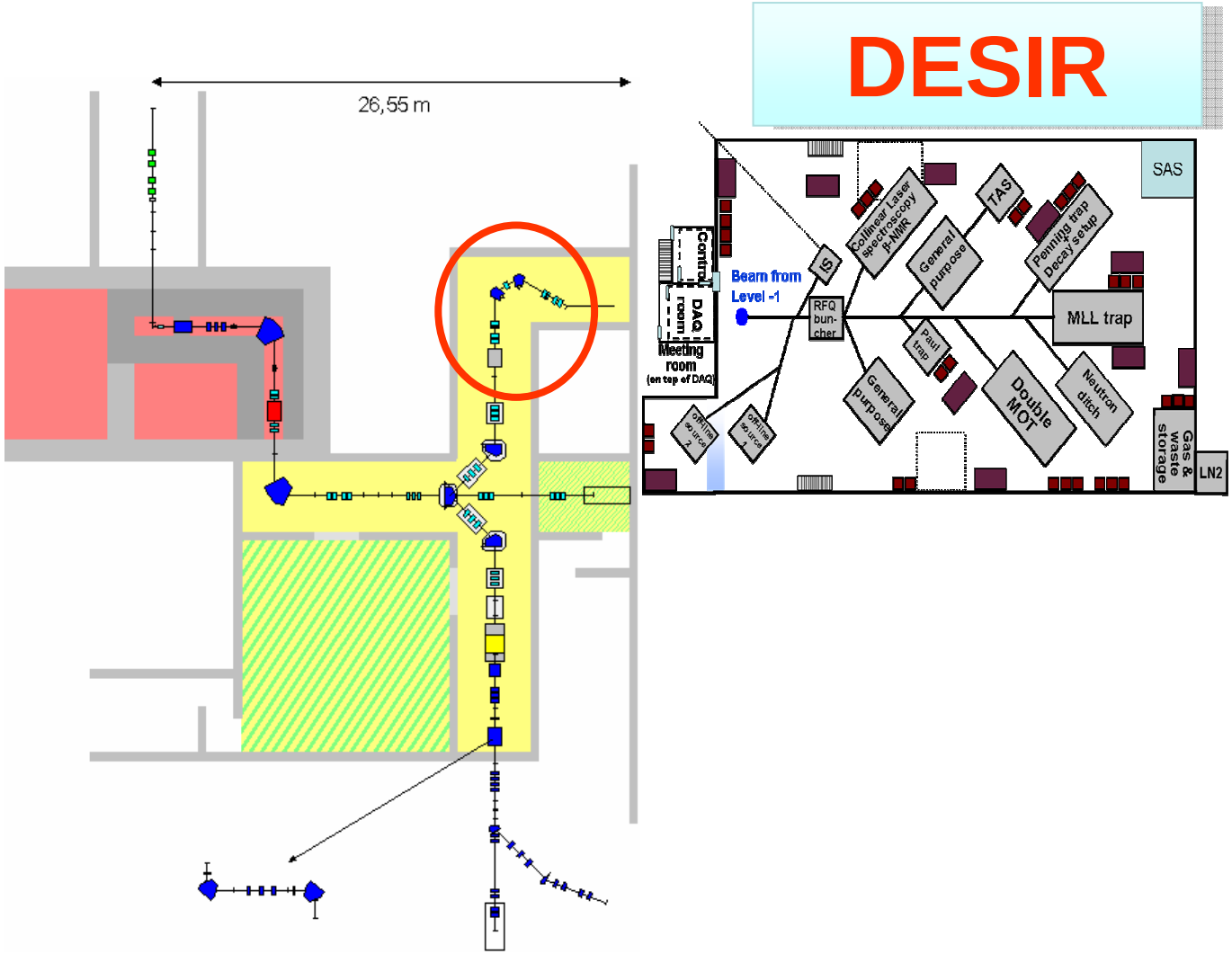


Resolving Power

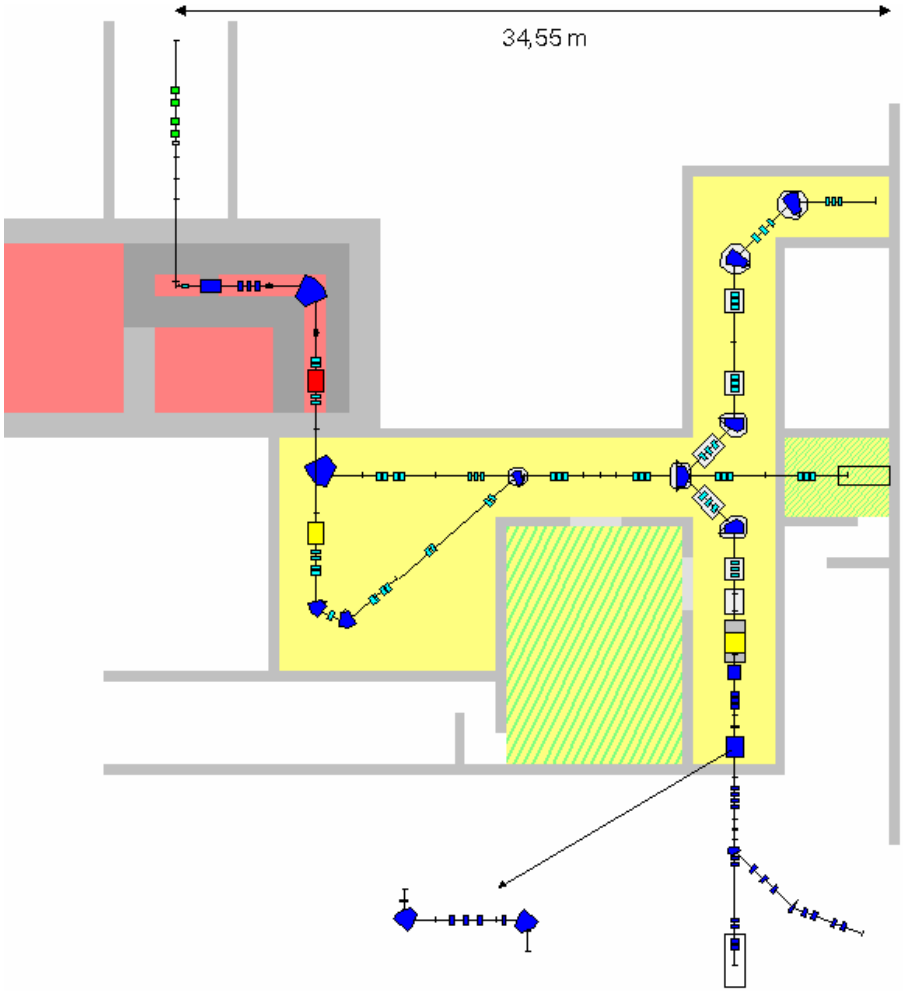
$$R = \frac{m}{\Delta m} \sim 20000$$

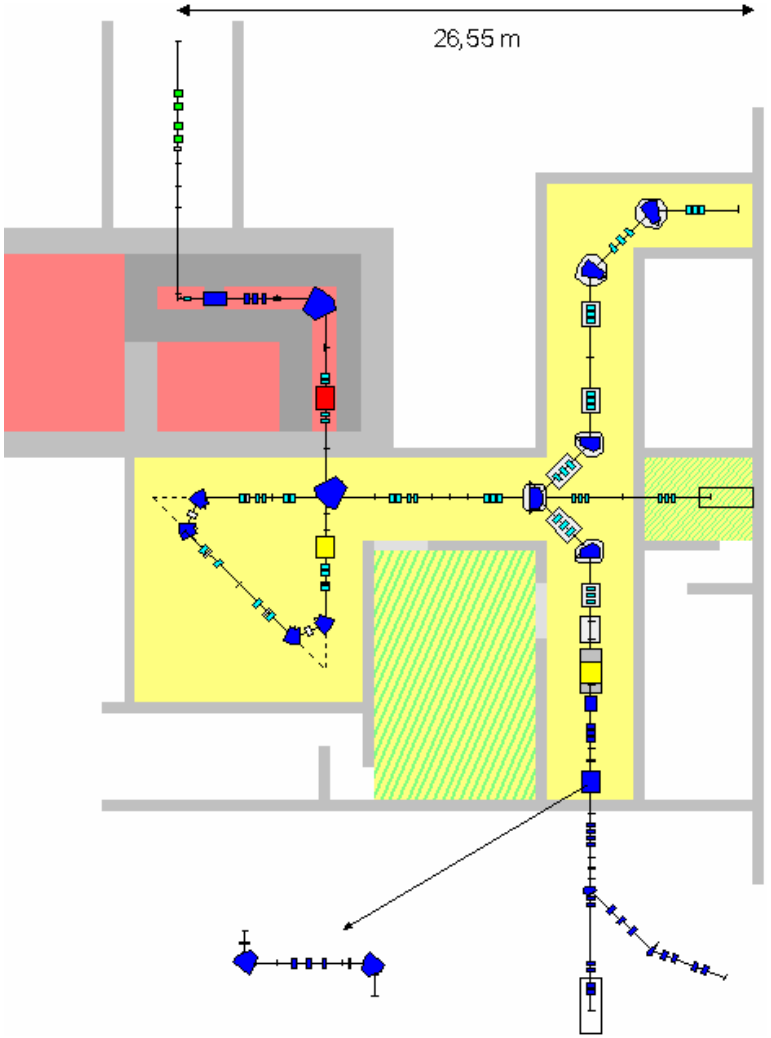
$$R = \frac{(x \mid \delta)}{2x_{00}(x \mid x) + \Delta}$$

HRS: initial conception



HRS: "C" and "Alpha"



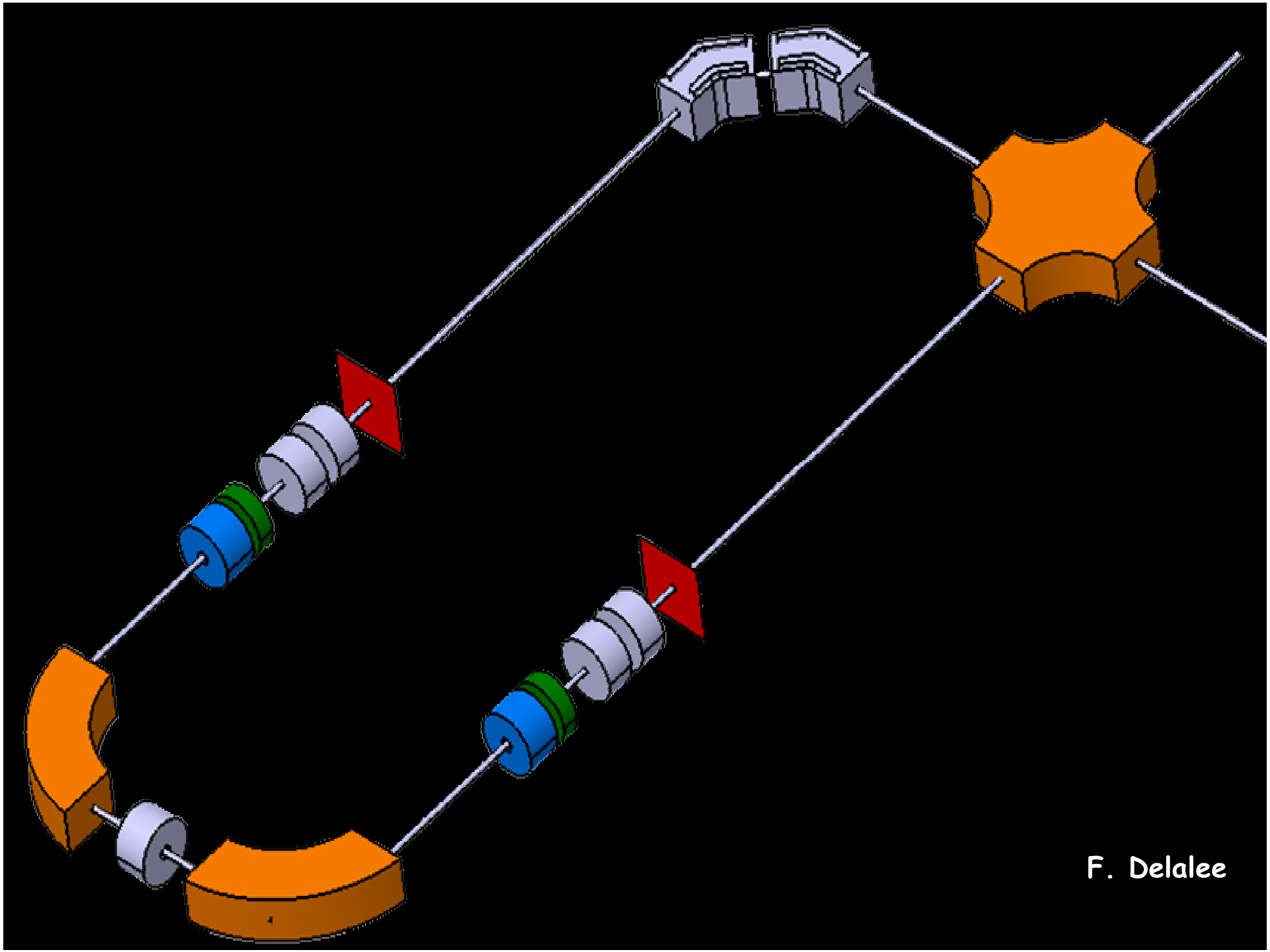


http://www.cenbg.in2p3.fr/desir

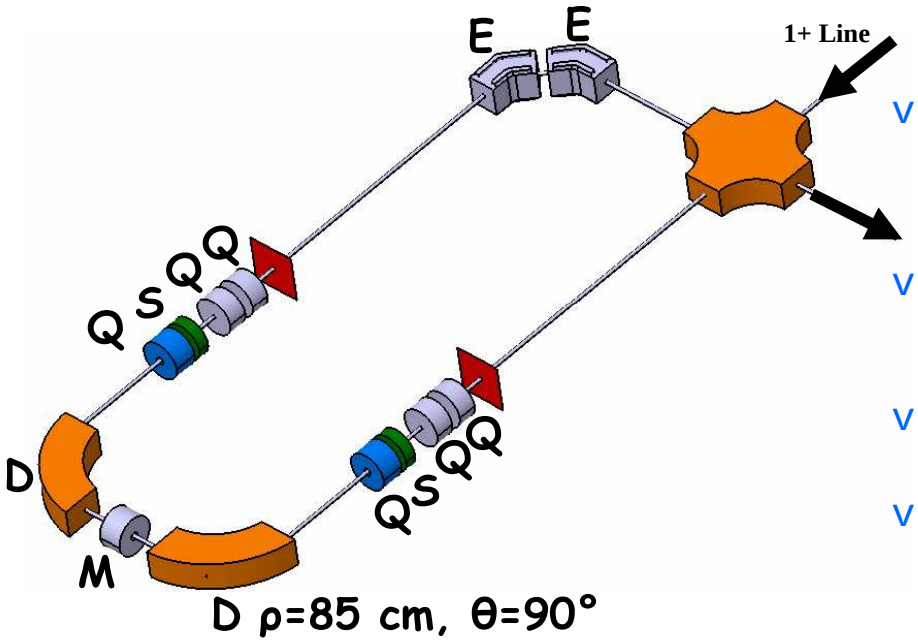
FIRST DESIR-HRS WORKSHOP

- November 12th-13th 2009, CENBG

- Participants:
  - Cary Davids ANL, USA
  - Rich Baartman TRIUMF,Canada
  - Helmut Weick, GSI, Germany
  - François Méot, Grenoble, France
  - Maurice Duval, GANIL, France
  - Franck Varenne, GANIL, France
  - David Lunney, CSNSM, France
  - DESIR-HRS Bordeaux Team

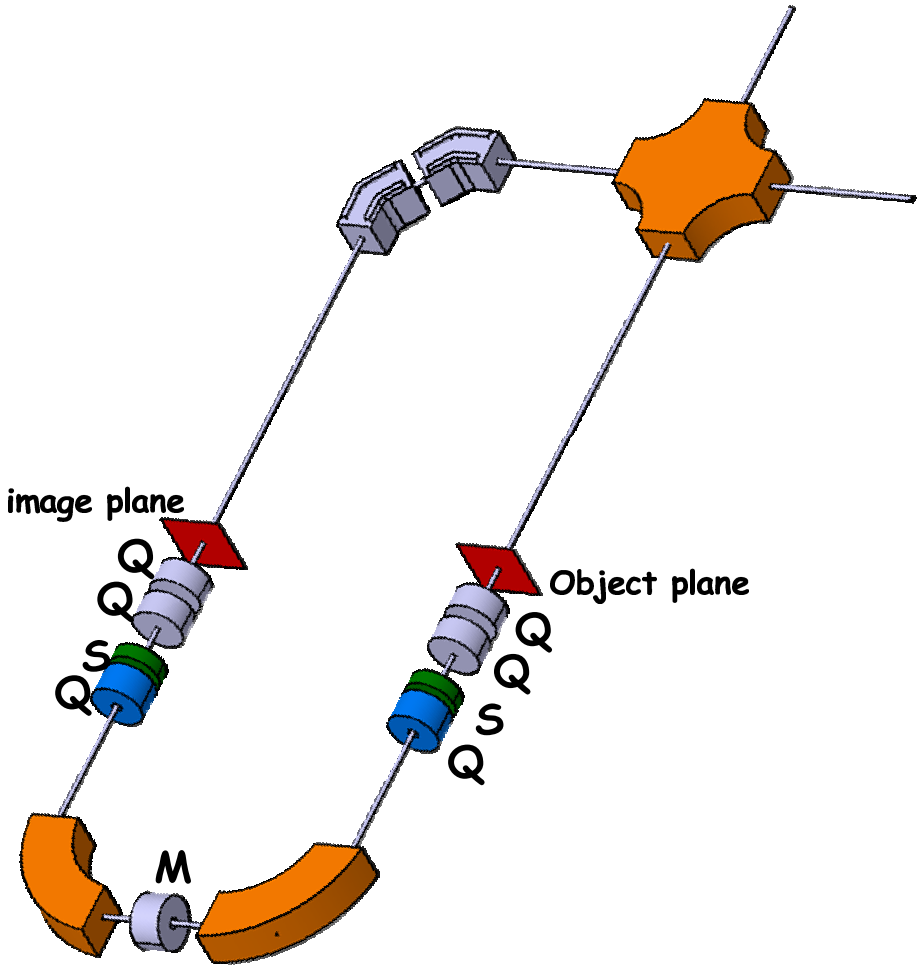

F. Delalee

HRS: "U180"



- The quadrupole doublet matching section produces a ribbon-shaped beam, so y-angles are small, minimizing *b* aberrations
- The first quadrupole diverges in *x* and converges in *y*, giving a small y size which minimizes y aberrations
- The large x area in the magnets gives mass dispersion
- Focus conditions in centre: *(a|a)=(y|b)=(b|y)=0*
- The reverse matching section transforms the ribbon-shaped beam back to a circular cross-section, allowing a 1 mm x-selection slit at the focal plane
- The 2 sextupoles and 1 multipole to correct aberrations to 5th order
- The two electrical benders transport the beam back to the 1+ Line

HRS U180



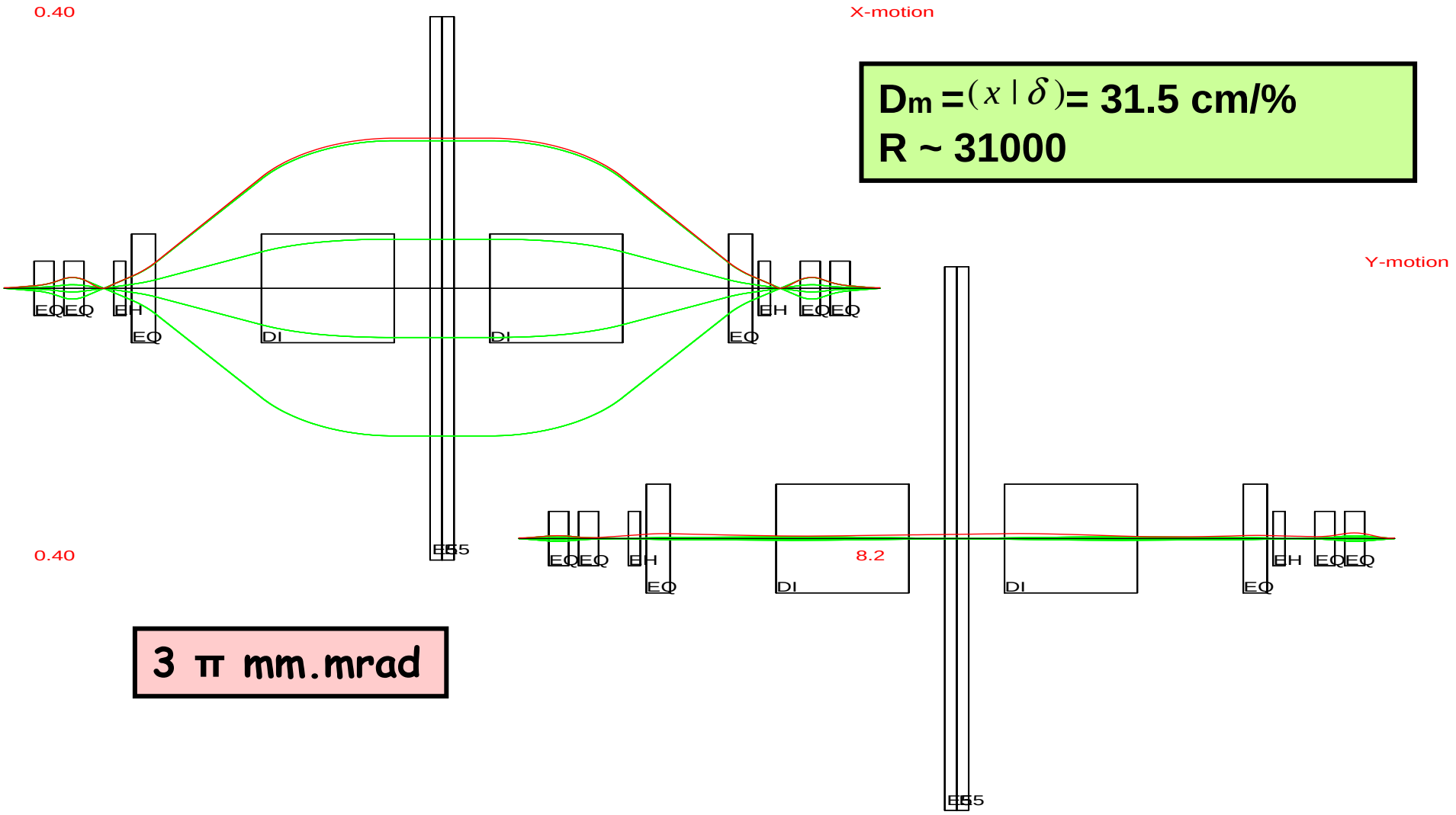
Transfer matrix

	(x,)	(a,)	(y,)	(b,)
x	**-1.0**	-4.5	0.0	0.0
a	0.3E-7	**-1.0**	0.0	0.0
y	0.0	0.0	**1.0**	23.2
b	0.0	0.0	-0.2E-7	**1.0**
δm	**-31.5**	-70.9	0.0	0.0

- ü **(x|δ) = -31.5 cm/%**
- ü **Mirror symmetric**
- ü **point-to-point both x and y**

R ~ 31000

COSY INFINITY X and Y motion



$D_m = (x \mid \delta) = 31.5$ cm/%
R ~ 31000

3 π mm.mrad

Ion optics discussion

- Symmetric design helps to minimize aberrations.

- Large mass dispersion ($x|\delta$) and small aberration coefficients are obtained by increasing the incident and exit angles at the boundary of a magnetic sector.
  - ü 36.5° was chosen for the 90° bending dipoles

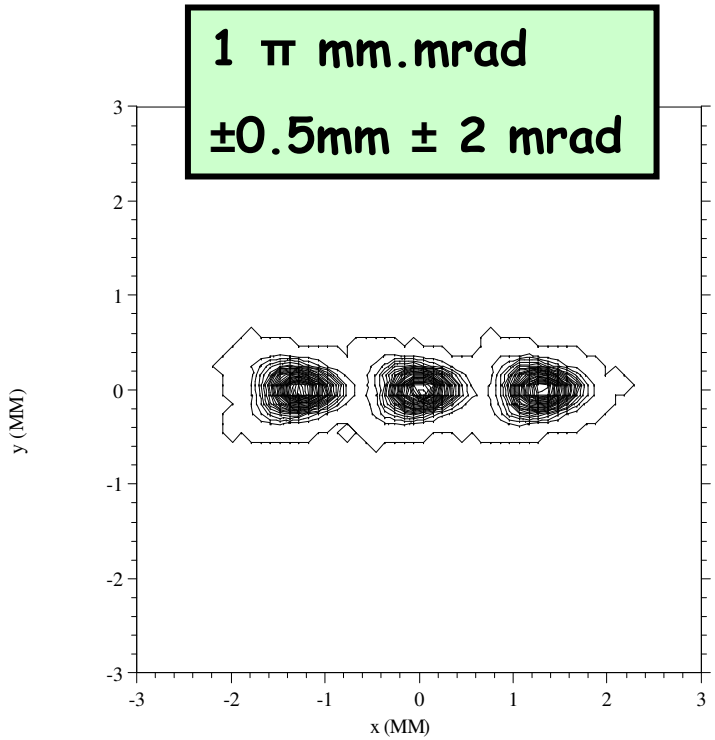
- Quadrupoles are used as the focusing mode in the y-direction and the defocusing mode in the x-direction.

  - ü By choosing suitable distances and fitting the quadrupole strengths, a beam profile in the dipole gap can be made very wide in the x-direction and narrow in the y-direction, attaining two advantages simultaneously:

    - * High transmission
    - * Small image magnification ($x|x$) to attain high resolution

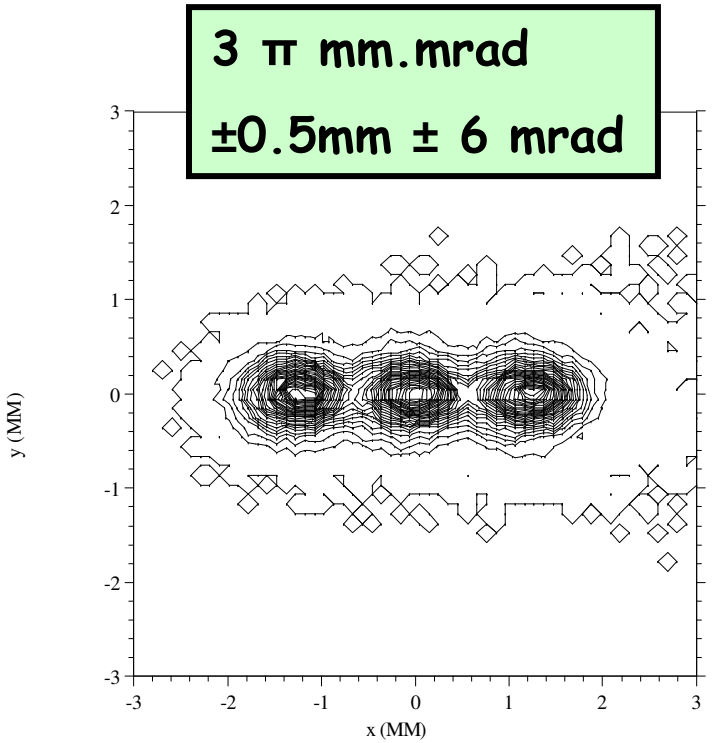
Performance study using Raytracing Turtle

X-Y phase space for isobars with mass deviations
-1/20000, 0, +1/20000



97% transmission in 1 mm^2

0.09% cross-contamination



77% transmission 1 mm2

1.4% cross-contamination

Laurent Serani

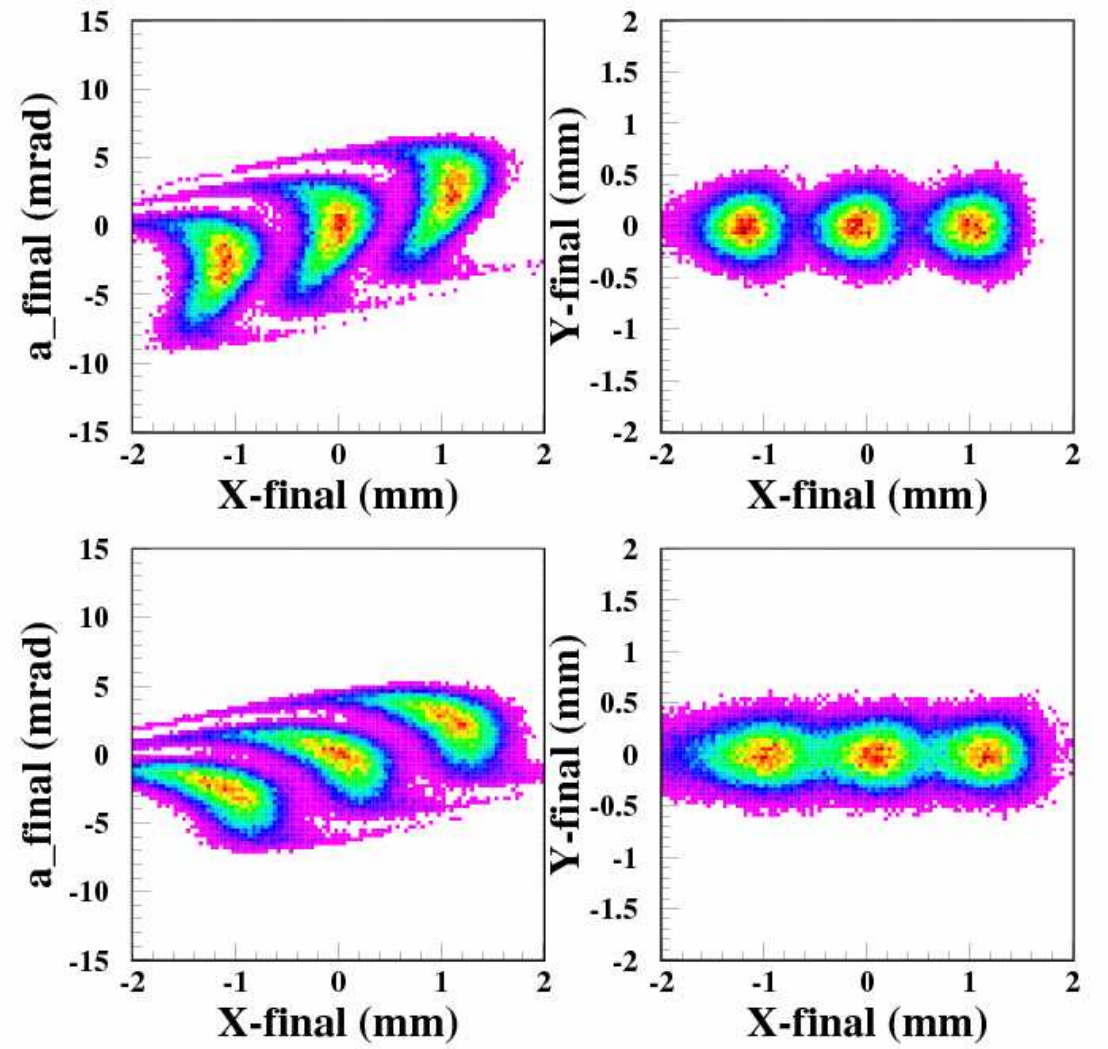
Cost Estimation

The Cost Estimation is shown in the following table:

concept	number	total cost (€)
Dipole	2	388.744,08
Long quadrupoles	4	278.121,03
Short quadrupoles	2	156.636,31
Sextupoles	2	100.533,15
Multipoles	1	66.481,58
Vacuum chambers	3	92.087,15
Vacuum system	1	130.200,00
Electrostatic correctors	1	56.875,00
Power sources	6	302.709,33
TOTAL VAT EXCLUDED		**1.572.387,63**

Prices include conceptual design, manufacturing design and manufacturing. Turnkey

Misalignment effects on mass resolution



Phase spaces calculated to 5th order

50000 particles with mass deviations -1/20000, 0, +1/20000

A shift in the multipole of 0.2 mm in the x-direction induces a deformation in the x-a phase space which is responsible for the blur in the final mass separation.

Summary

- A new ion-optical design concept for the HRS, the HRS-U180, is currently under study as a result of the discussion with experts at the First HRS Workshop held at CENBG last November.

- This design gives a compact configuration, high transmission and high resolving power, providing monoisotopic beams of exotic nuclides.

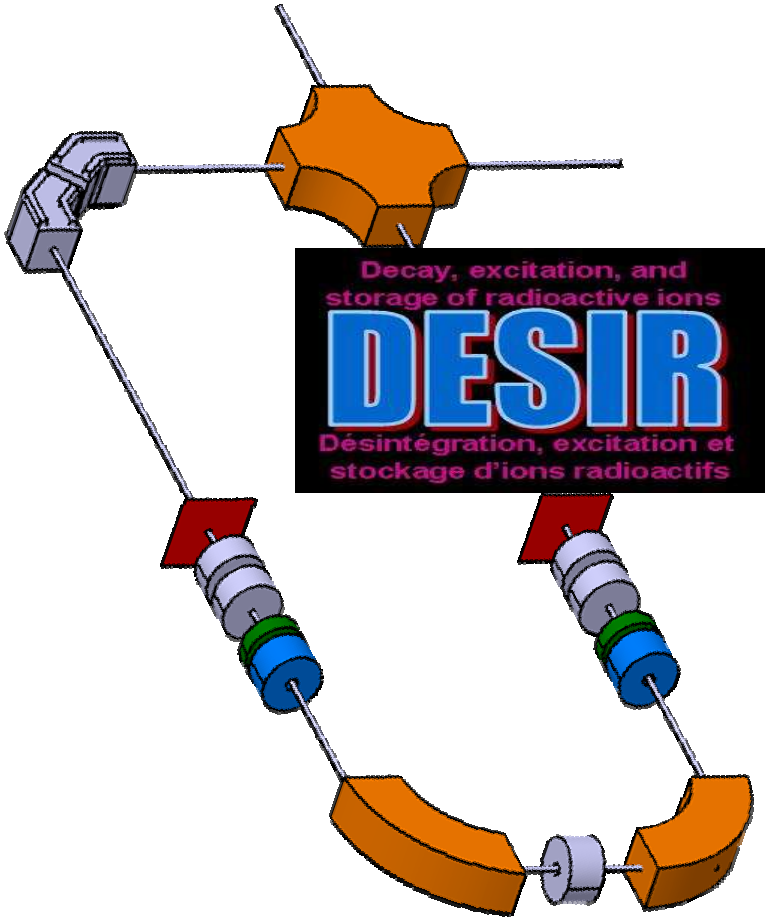
- This compact configuration is less expensive, concerning both installation and operation costs.

- A beam emittance of the order of <3 π mm mrad and an energy dispersion of about 1 eV are needed. These requirements will be fulfilled with the RFQ cooler SHIRAC.

Next steps

- By the end of the next week the specifications for the dipole magnets will be sent to M. Duval who will calculate the corresponding 3D TOSCA maps.
- We estimate to have this calculations ready by the end of February and start the raytracing evaluation to study the performance of the system.
- End of march: first document on the definition of the size envelope of the HRS.
- October: we expect to have the final design.
- End of 2010 Technical Specifications finished. Order dipole magnets 2011.
- Beginning of 2013 mounting and test of the HRS at Bordeaux.

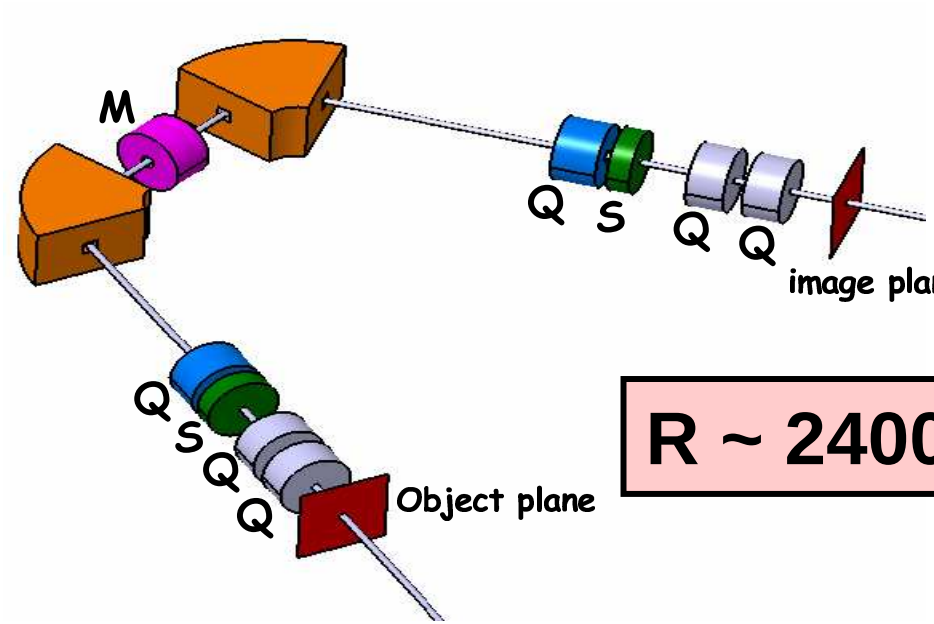
DESIR-HRS working group @CENBG



- ü Blank, Bertram
- ü Delalée, Franck
- ü Kurtukian-Nieto, Teresa
- ü Serani, Laurent

Backup slides

HRS C135

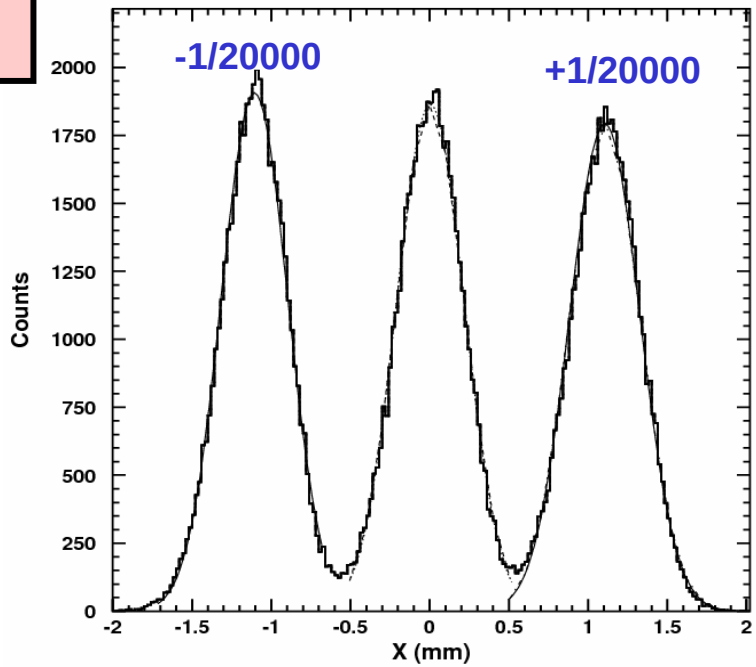


- ü (x|δ) = -24 cm/%
- ü Mirror symmetric
- ü point-to-point both x and y

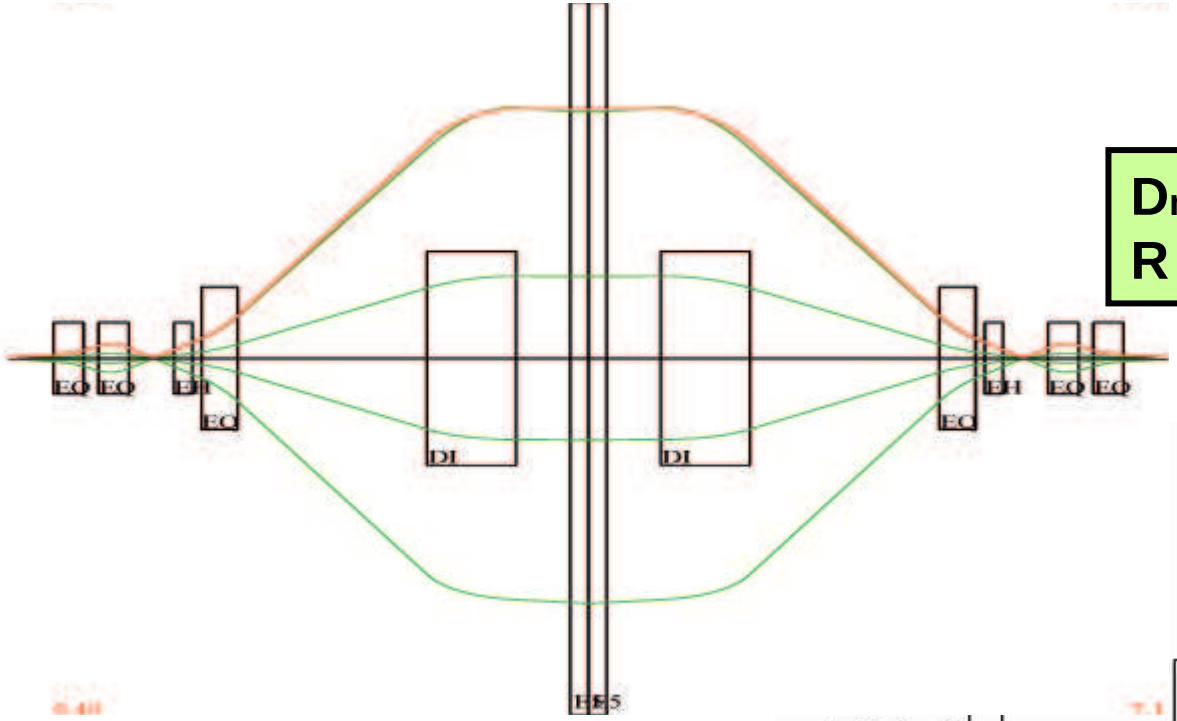
R ~ 24000

Transfer matrix

	(x,)	(a,)	(y,)	(b,)
x	**-1.0000**	-4.5202	0.0000	0.0000
a	0.28E-7	**-0.9999**	0.0000	0.0000
y	0.0000	0.0000	**1.0000**	0.25E-7
b	0.0000	0.0000	-0.12E-8	**1.0000**
δm	**-24.10**	-54.47	0.0000	0.0000

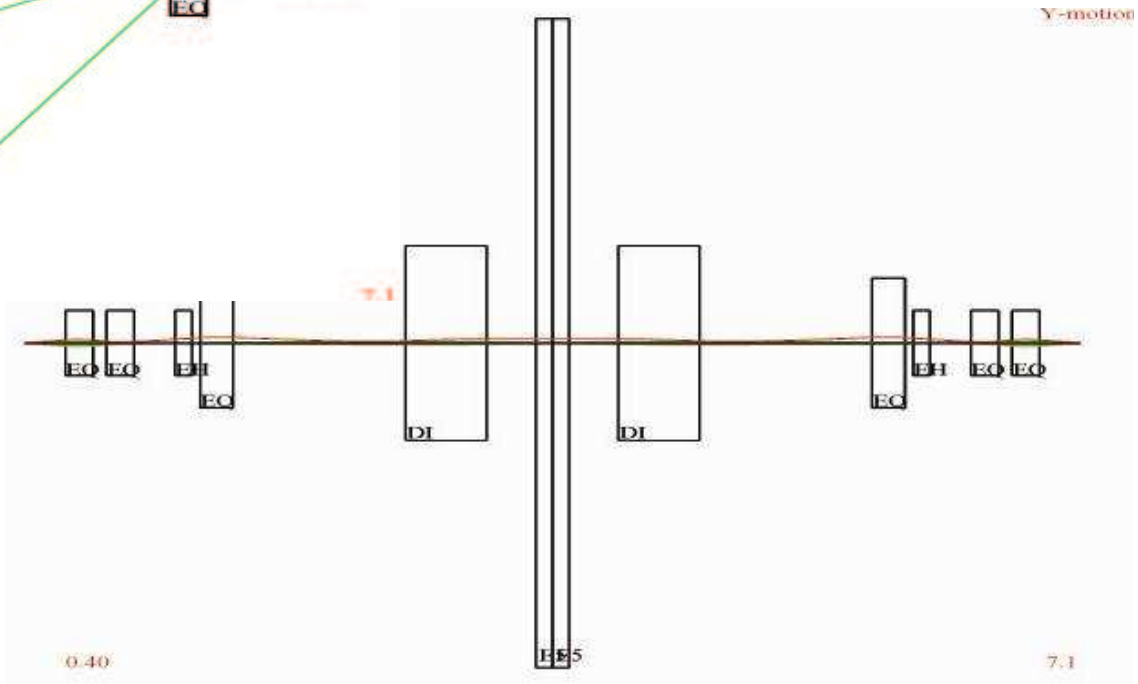


COSY INFINITY X and Y motion

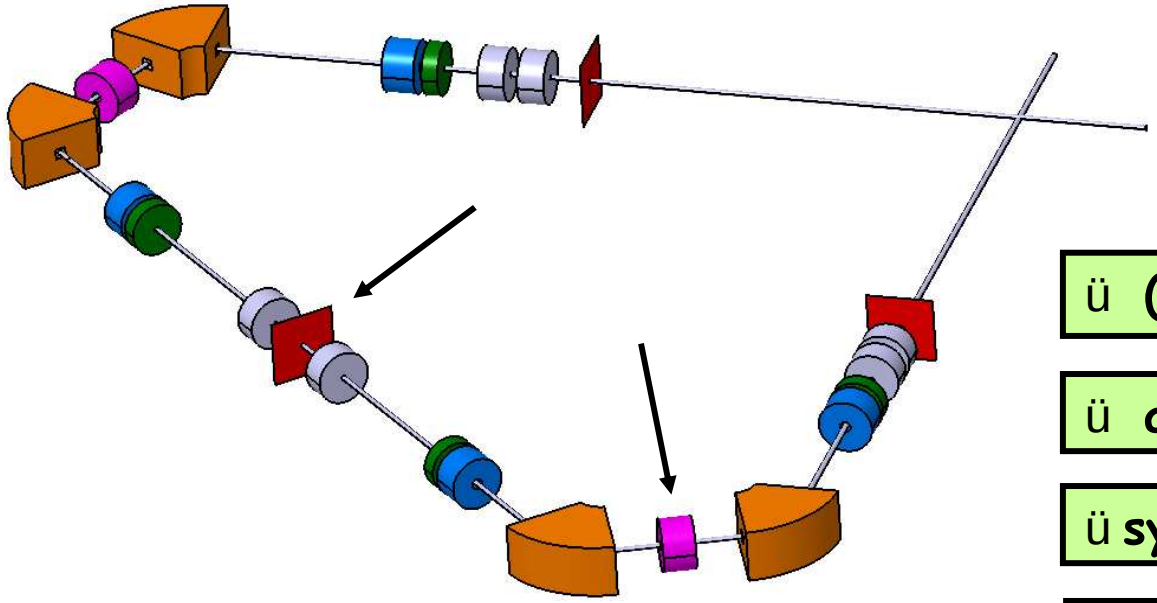


$D_m = (x \mid \delta)$ = 24.10 cm/%
R ~ 24000

3 π mm.mrad



HRS Alpha Asymmetric: short



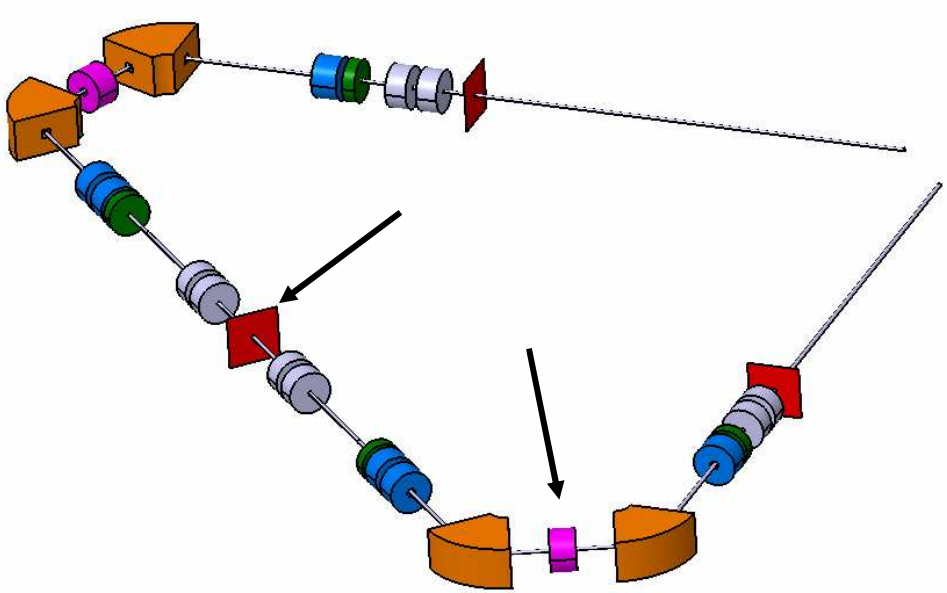
Transfer matrix :

	(x,)	(a,)	(y,)	(b,)
x	**0.4004**	5.9434	0.0000	0.0000
a	0.10E-6	2.4972	0.0000	0.0000
y	0.0000	0.0000	**1.7245**	4.5850
b	0.0000	0.0000	-0.53E-7	**0.5799**
δm	**8.66**	-0.13E-6	0.0000	0.0000

- ü **(x|δm) ~ 9 cm/%**
- ü **asymmetric for M plane**
- ü **symmetric for mid-plane**
- ü **(x|x) ~ 0.4**
- ü **point-to-point both x and y**

R ~ 21750

HRS Alpha Asymmetric: Large



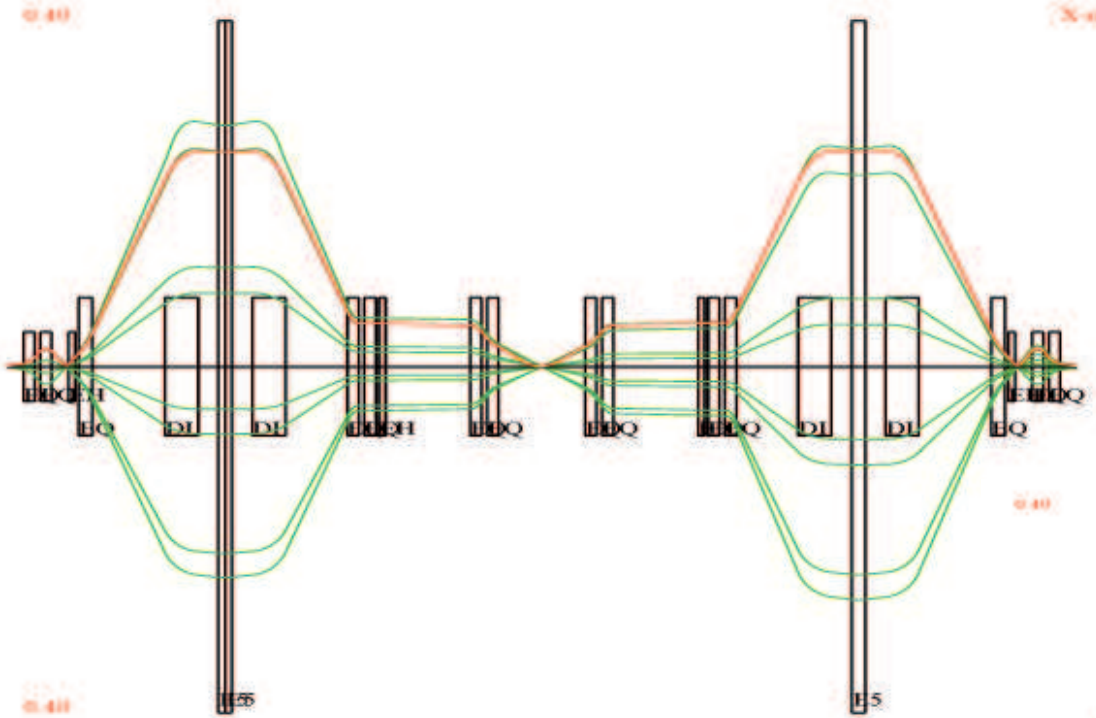
Transfer matrix :

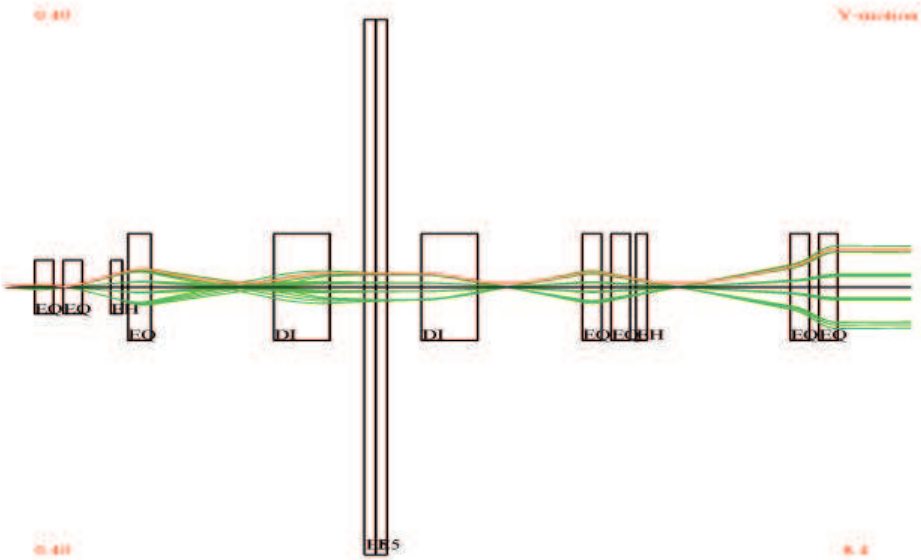
	(x,)	(a,)	(y,)	(b,)
x	**0.4043**	5.8394	0.0000	0.0000
a	-0.53E-7	2.4732	0.0000	0.0000
y	0.0000	0.0000	**26.19**	-0.2400
b	0.0000	0.0000	4.1672	**-0.16E-10**
δm	**10.23**	0.49E-8	0.0000	0.0000

- ü **(x|δm) ~ 10 cm/%**
- ü **asymmetric for M plane**
- ü **symmetric for mid-plane**
- ü **(x|x) ~ 0.4**
- ü **point-to-point in x**

R ~ 25500

COSY INFINITY X and Y motion

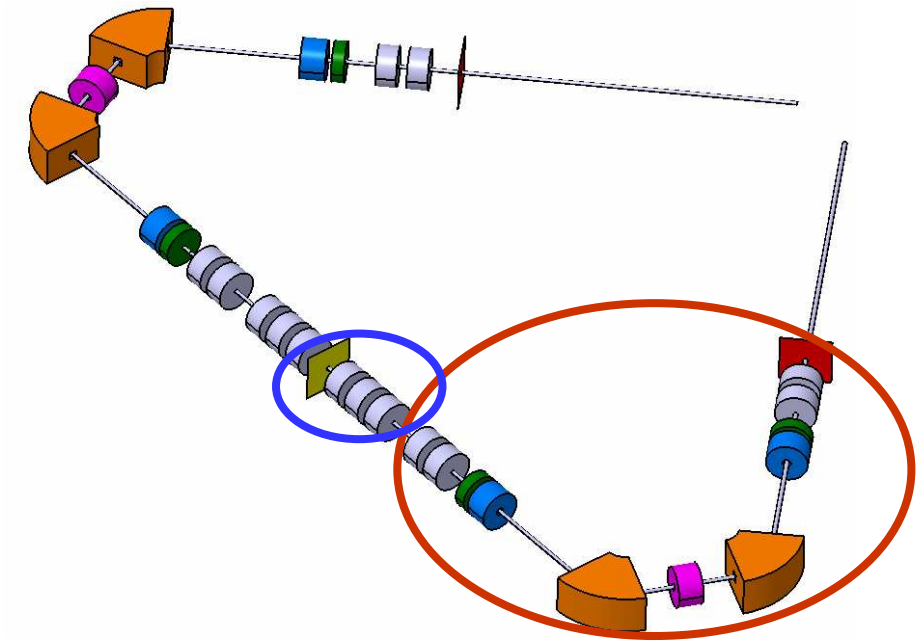




$D_m = (x \mid \delta)$ ~ 10 cm/%

R ~ 25500

HRS Alpha Symmetric



- ü Same as HRS C135
- ü Compensation triplet
- ü Doubly symmetric

R ~ 24000

Transfer matrix

	(x,)	(a,)	(y,)	(b,)
x	**-1.0000**	-4.5202	0.0000	0.0000
a	0.28E-7	**-0.9999**	0.0000	0.0000
y	0.0000	0.0000	**1.0000**	0.25E-7
b	0.0000	0.0000	-0.12E-8	**1.0000**
δm	**-24.10**	-54.47	0.0000	0.0000

Transfer matrix

	(x,)	(a,)	(y,)	(b,)
x	**0.3787**	-5.9685	0.0000	0.0000
a	-0.11E-7	**2.6407**	0.0000	0.0000
y	0.0000	0.0000	**-0.8472**	-4.3693
b	0.0000	0.0000	0.2289	0.38E-6
δm	**9.1254**	0.34E-5	0.0000	0.0000