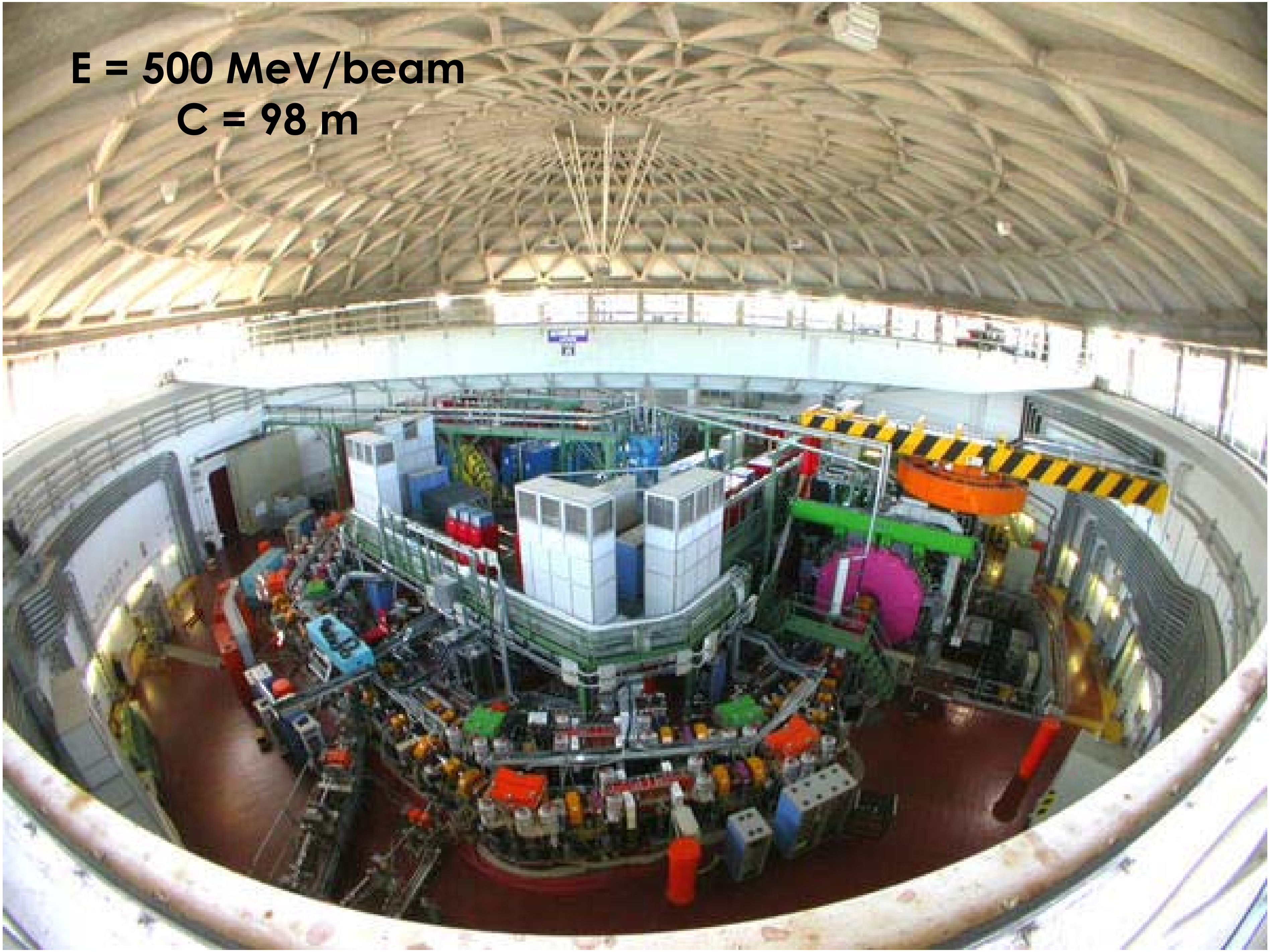
DAΦNE Interaction Regions

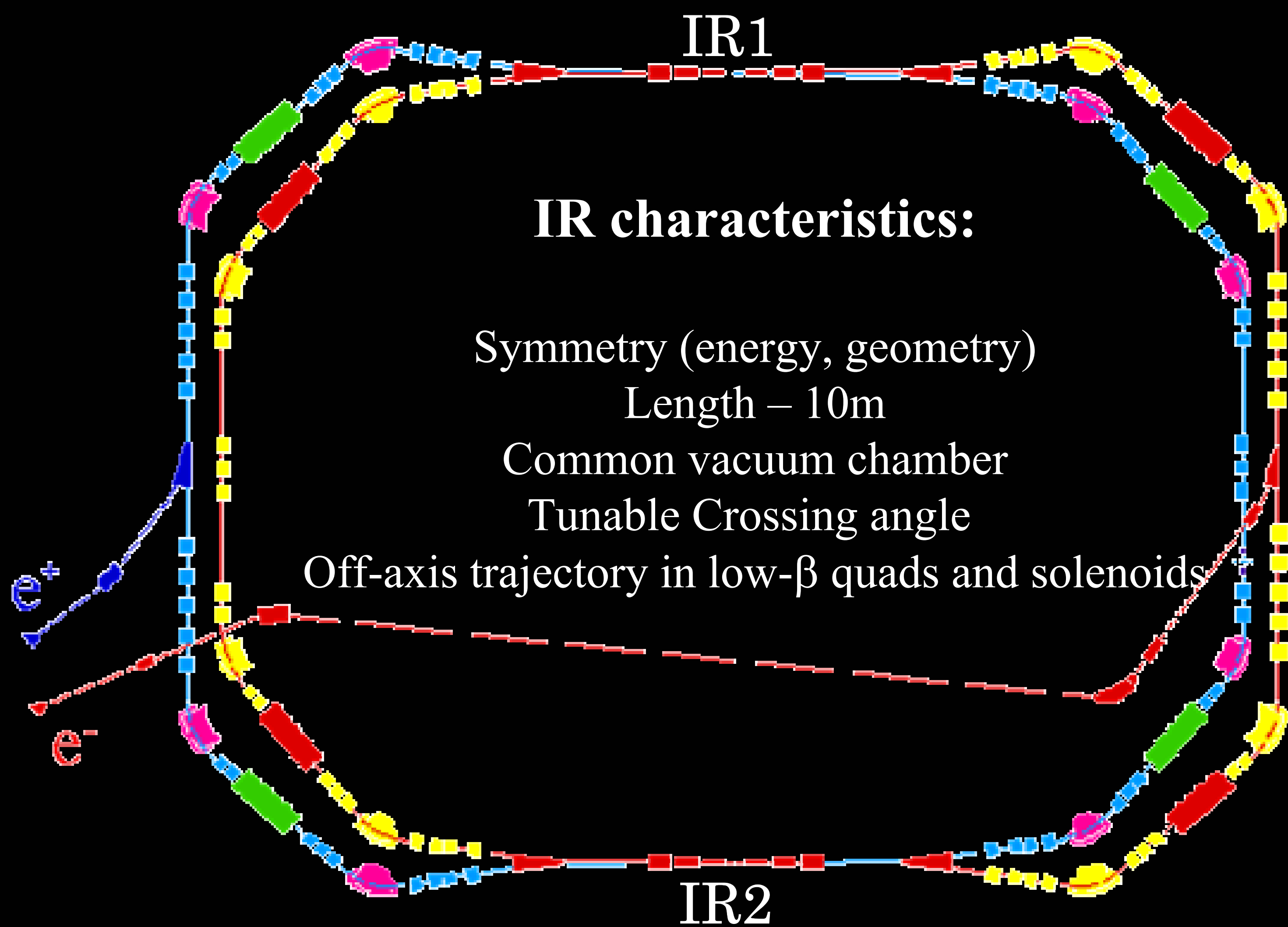
C. Biscari
LNF, INFN

Beijing, January 2004


DAΦNE
building
STOP

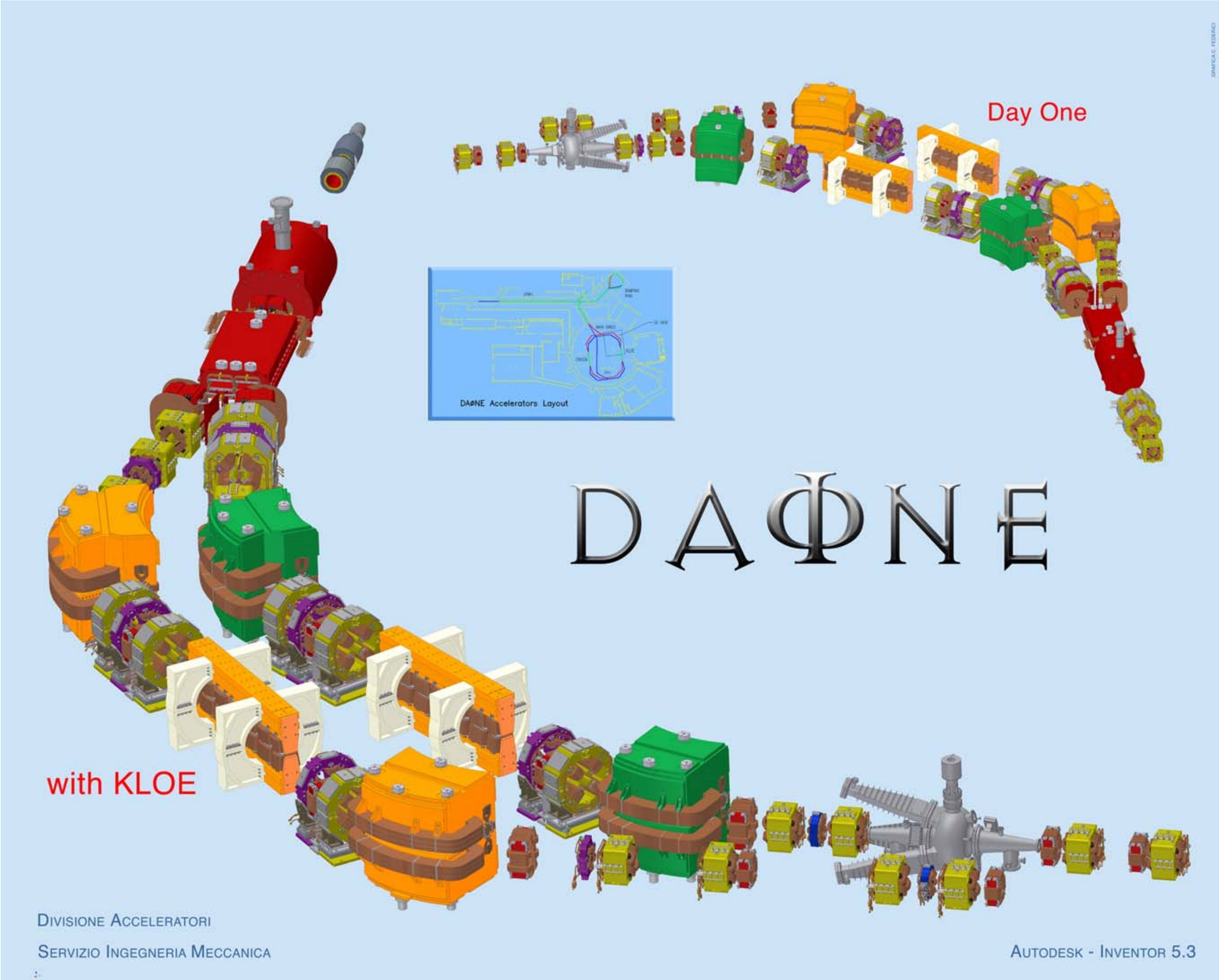

E = 500 MeV/beam
C = 98 m

DAΦNE layout

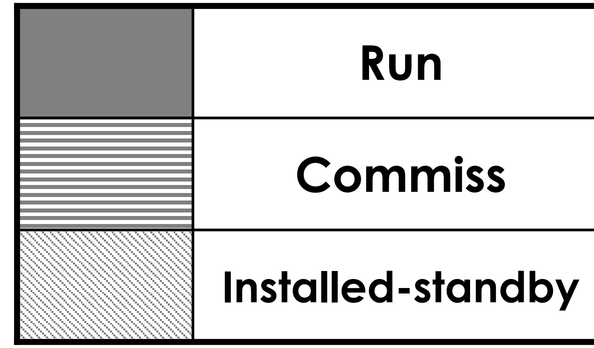


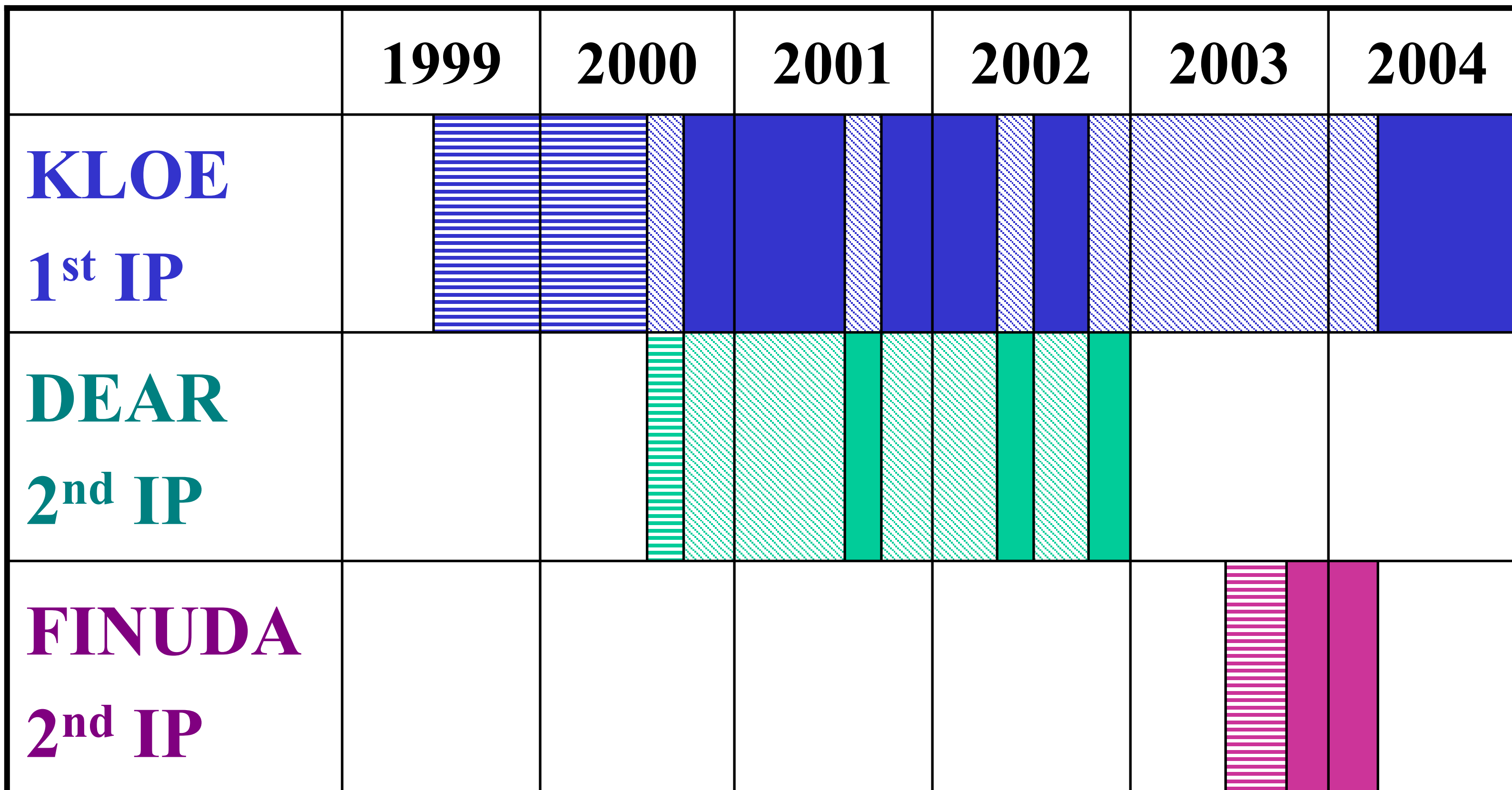
IR characteristics:

Symmetry (energy, geometry)
Length – 10m
Common vacuum chamber
Tunable Crossing angle
Off-axis trajectory in low-β quads and solenoids


Day One
DAΦNE Accelerators Layout
DAΦNE
with KLOE
Divisione Acceleratori
Servizio Ingegneria Meccanica
Autodesk - Inventor 5.3

DAΦNE experiments





From design considerations*

To work with **different IR configurations** an approach defined ***transparency*** has been adopted in the ring design:

the structure of the regular lattice, the **arcs**, remains as much as possible unchanged whatever is the experiment or the magnetic structure in the two IRs because the **IR designs have almost the same transfer matrix and are easily interchangeable**. Almost the same phase advance between sextupoles is kept in all the different lattices, in order to have similar sextupole configurations and dynamic apertures even with different chromaticities.

In all the IRs there is the possibility to create a vertical orbit bump and separate the two beams. When only one experiment is running, the beams can be separated at the other IP to optimize the luminosity.

- **REVIEW OF DAΦNE LATTICES**

M.E. Biagini, C. Biscari, S. Guiducci, J. Lu, M.R. Masullo, G. Vignola
DAΦNE TECHNICAL Note: **L-9,** October 12, 1993

Design single bunch luminosity and tune shifts

$$\xi_x = \frac{r_e}{2\pi\gamma}\frac{N\beta_x}{\sigma_x(\sigma_x+\sigma_y)} \approx \frac{r_e}{2\pi\gamma}\frac{N\beta_x}{\sigma_x^2} = \frac{r_e}{2\pi\gamma}\frac{N}{\varepsilon_x}$$

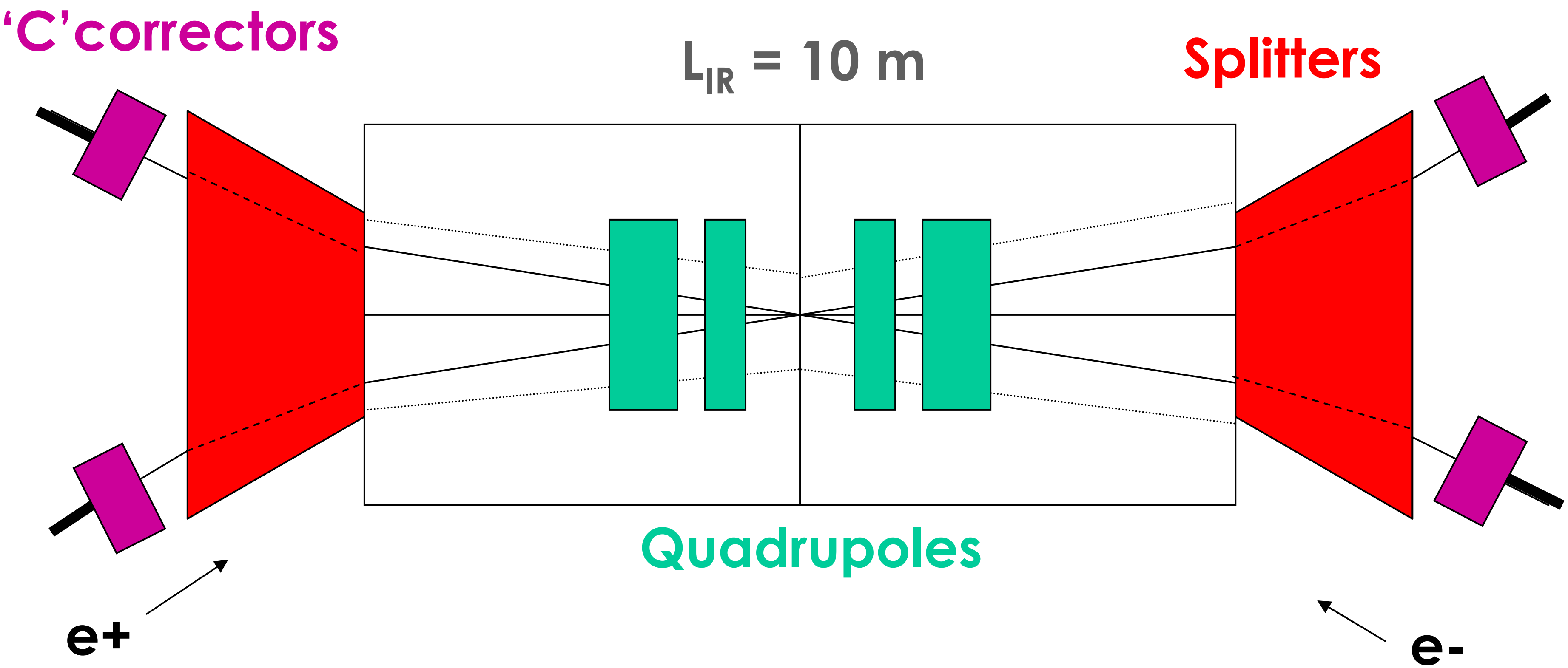
$$\xi_y = \frac{r_e}{2\pi\gamma}\frac{N\beta_y}{\sigma_y(\sigma_x+\sigma_y)} \approx \frac{r_e}{2\pi\gamma}\frac{N\beta_y}{\sigma_x\sigma_y}$$

If: $$\kappa = \frac{\varepsilon_y}{\varepsilon_x} = \frac{\beta_y}{\beta_x} = \frac{\sigma_y}{\sigma_x}$$

Then: $$\xi_x = \xi_y$$

	H	V
ε (mm mrad)	1	0.01
β* (m)	4.5	0.045
σ (mm)	2.1	0.021
ξ (N = 8.9 10^{10})	0.04	0.04

Tunable crossing angle



Design: 10-15 mrad
In operation: 10-20 mrad

IR configurations

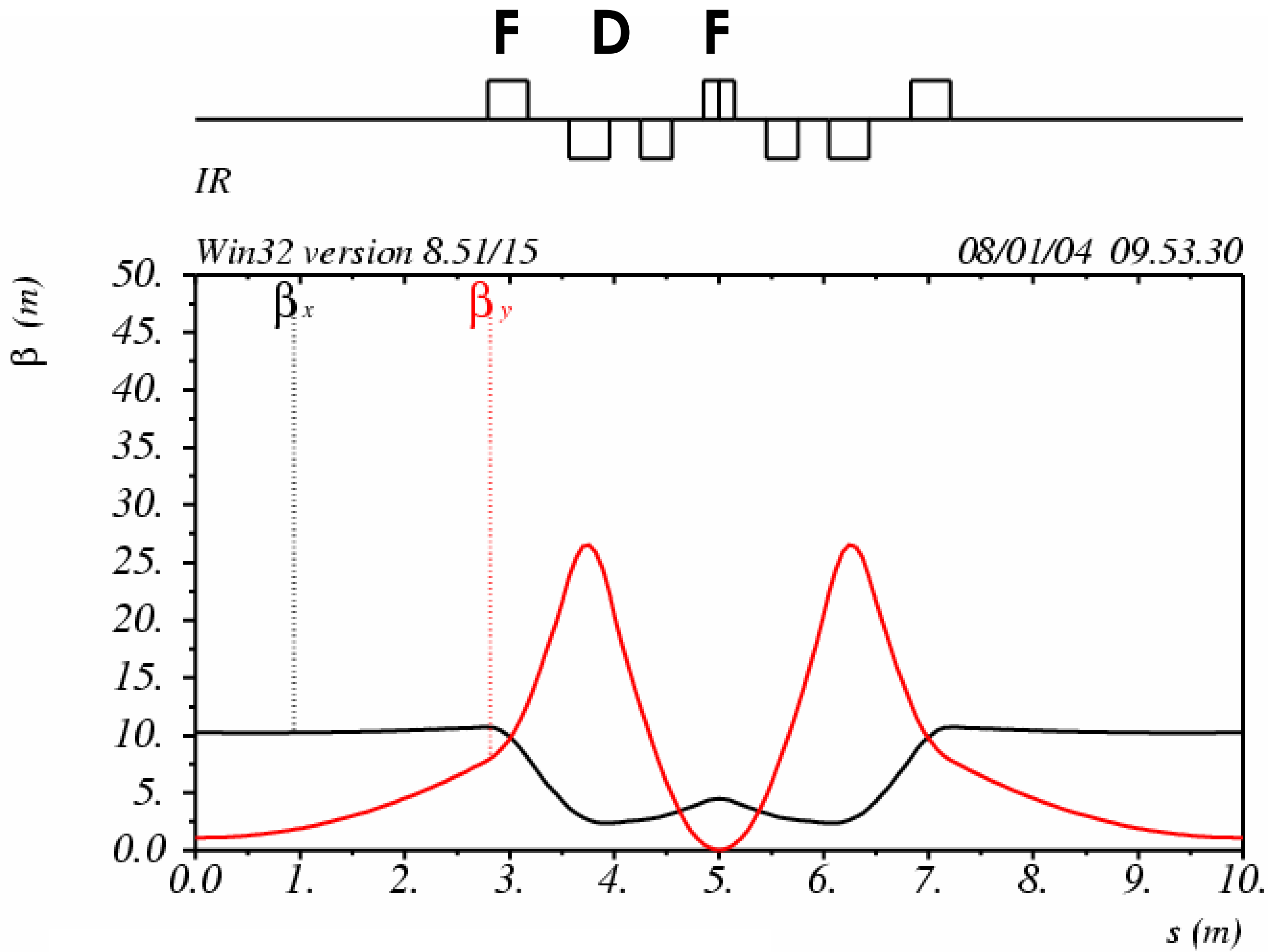
No solenoids

- Day-one
- DEAR
- Detuned

With solenoids

- FINUDA
- KLOE I
- KLOE II

No solenoid IRs



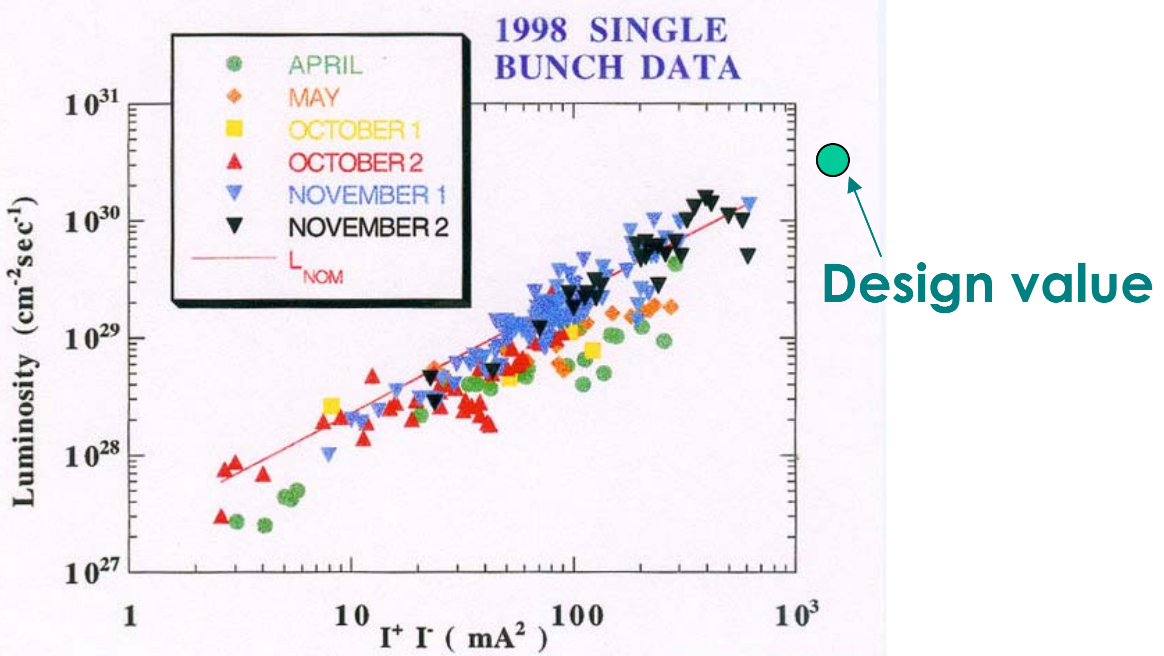
DAY-ONE – commissioning

β^*_x = 4.5 m
β^*_y = 4.5 cm

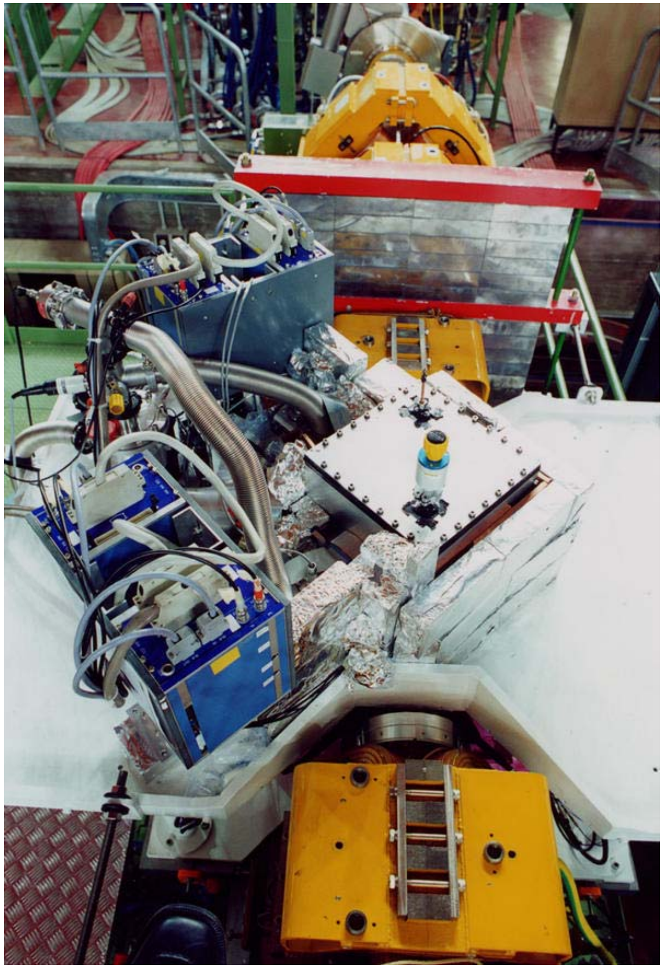
Normal conducting quads

Design values

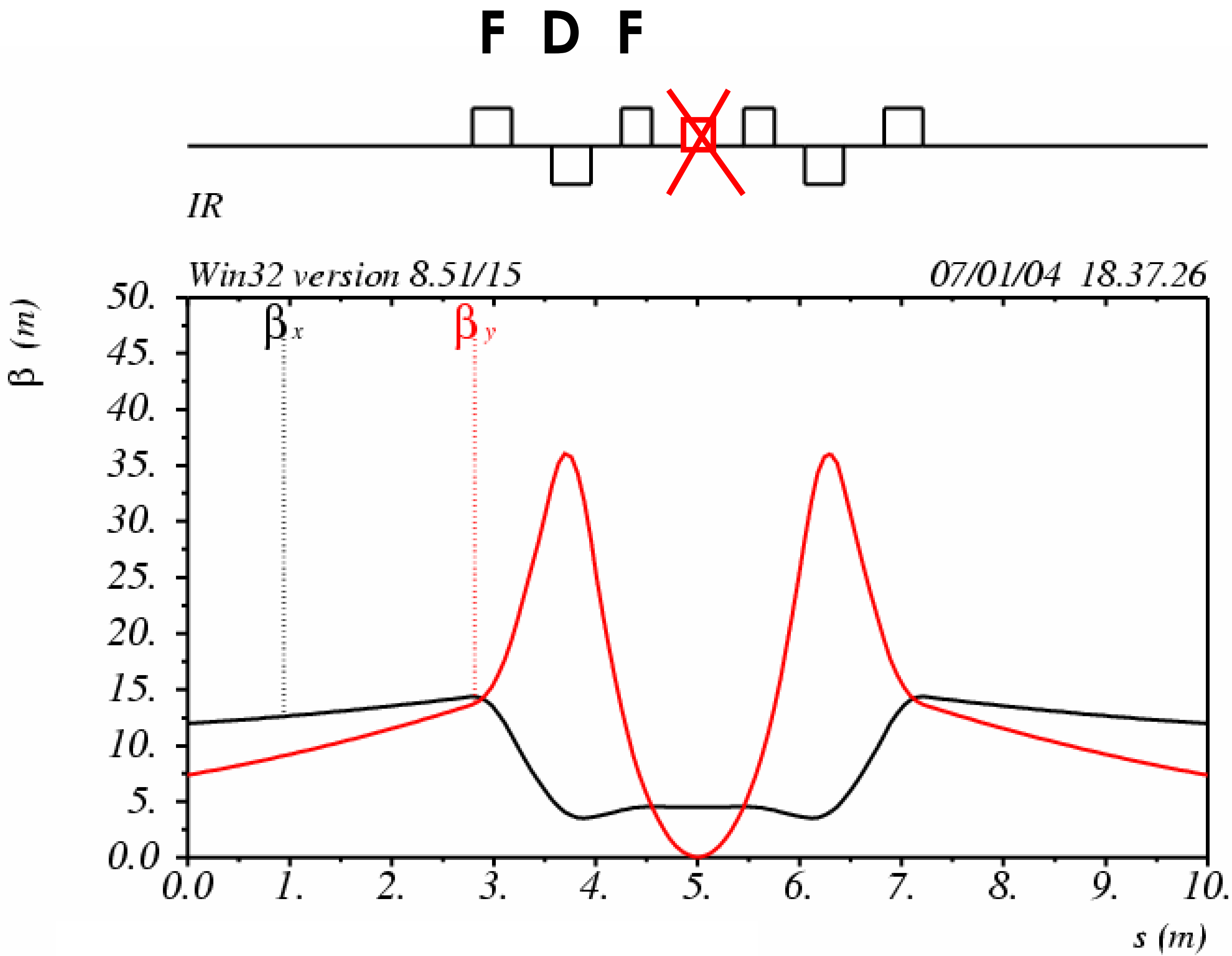
Day-one Luminosity Results



DEAR experiment

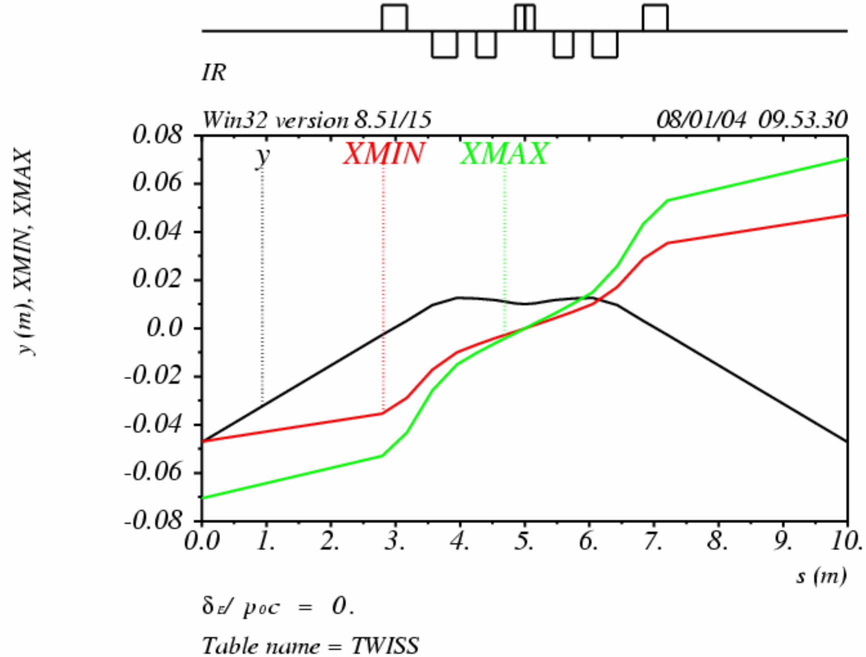


Target around the vacuum chamber
for exothic athoms research:
No effect on the beam optics



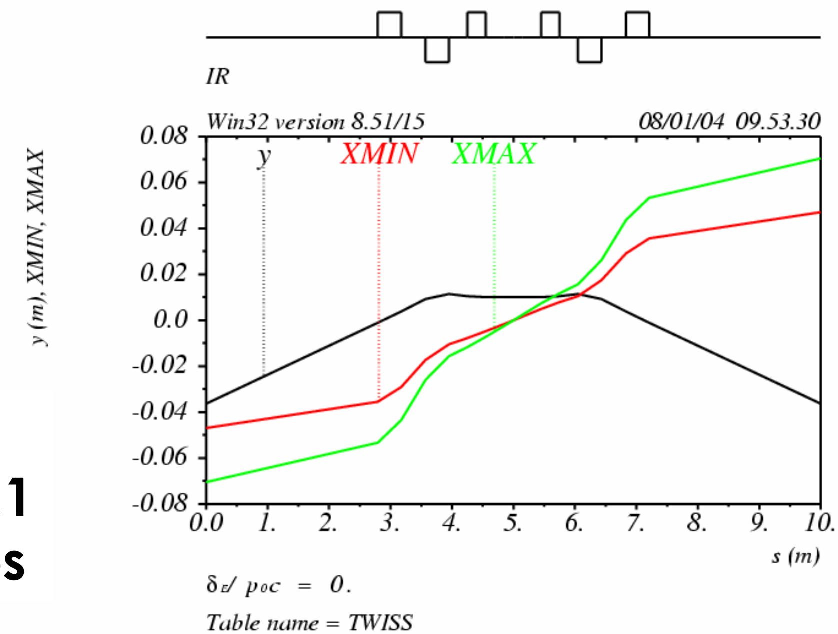
DEAR -1

β^*_x = 4.5 m
β^*_y = 4.5 cm
Design values

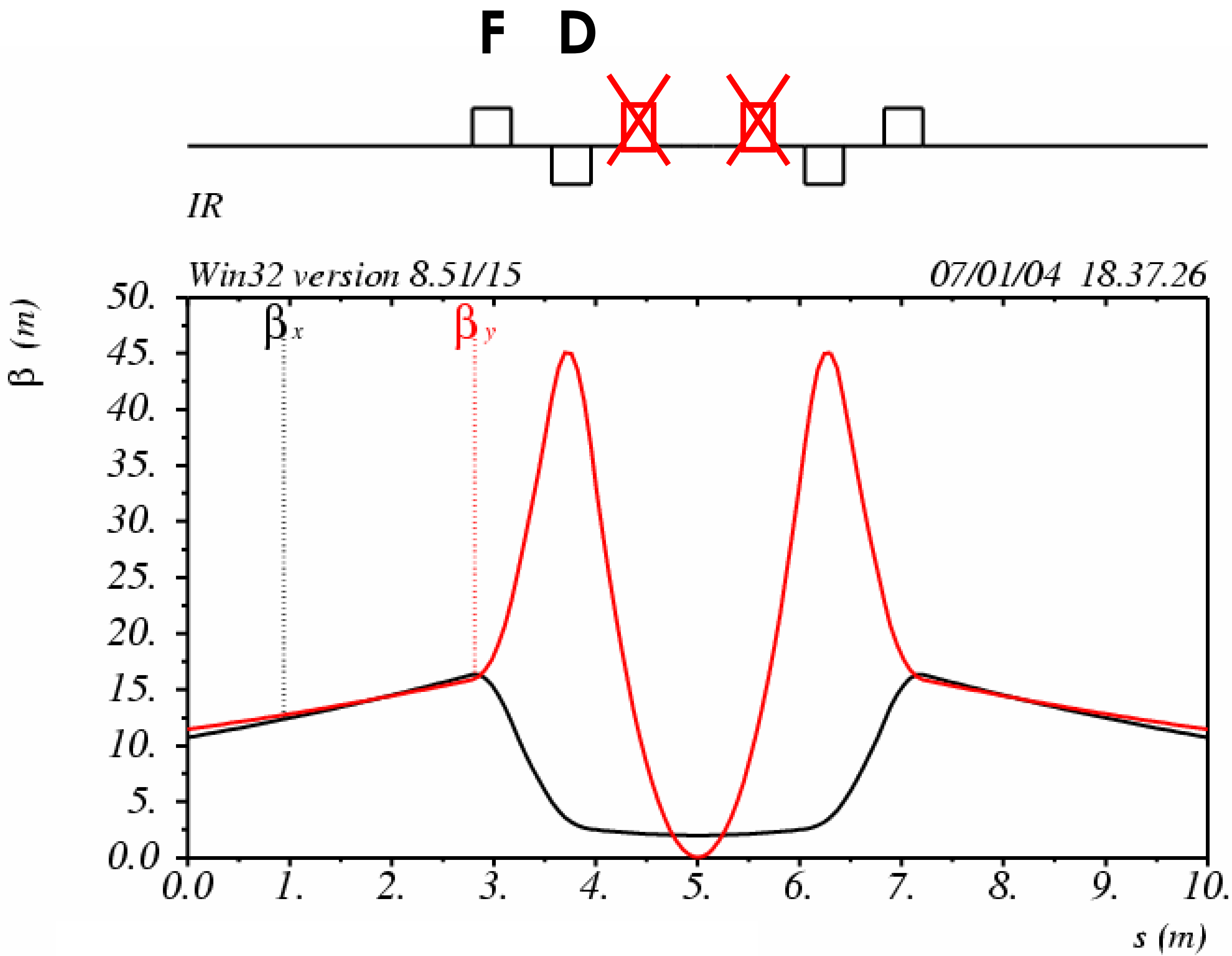


DAY-ONE
θ (mrad): 9.1 to 13.6

Beam trajectories



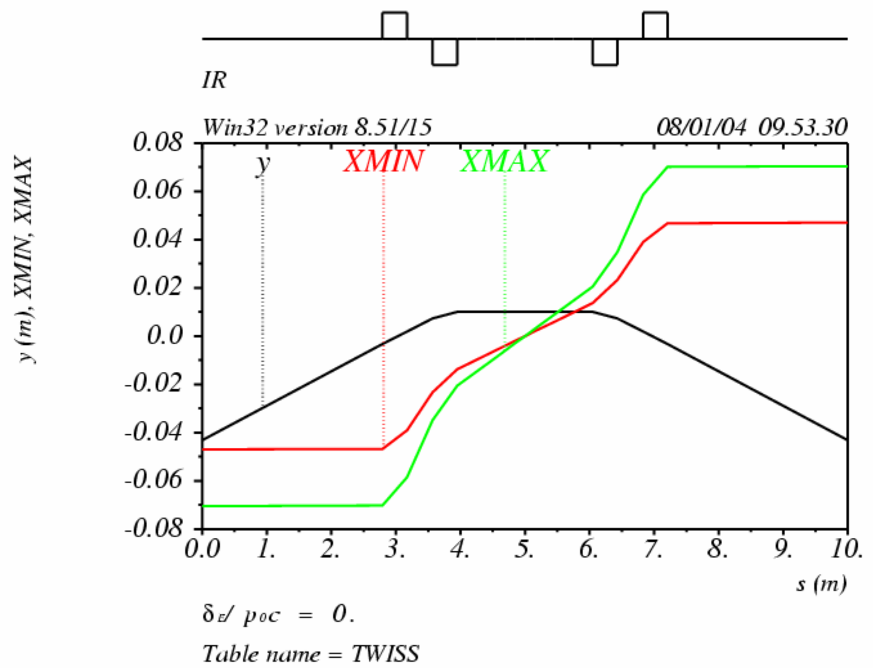
DEAR-1
θ (mrad): 10.8 to 16.1
Run with 50 bunches



DEAR -2

β^*_x = 2 m
β^*_y = 3 cm
Lower than design

Beam trajectories

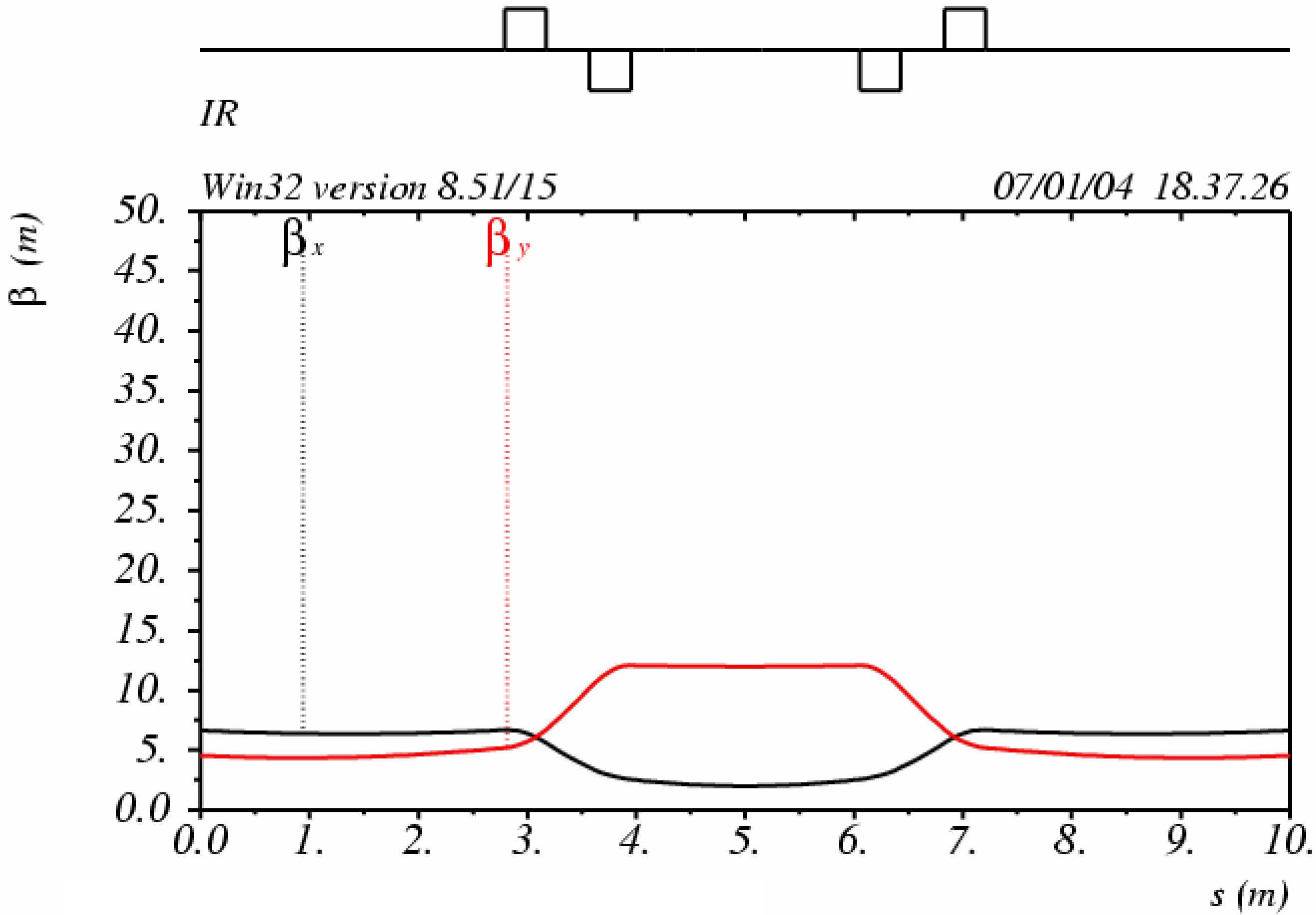


DEAR-2

θ(mrad): 13.0 to 19.6

Run with 100 bunches

With weaker parasitic crossings effects



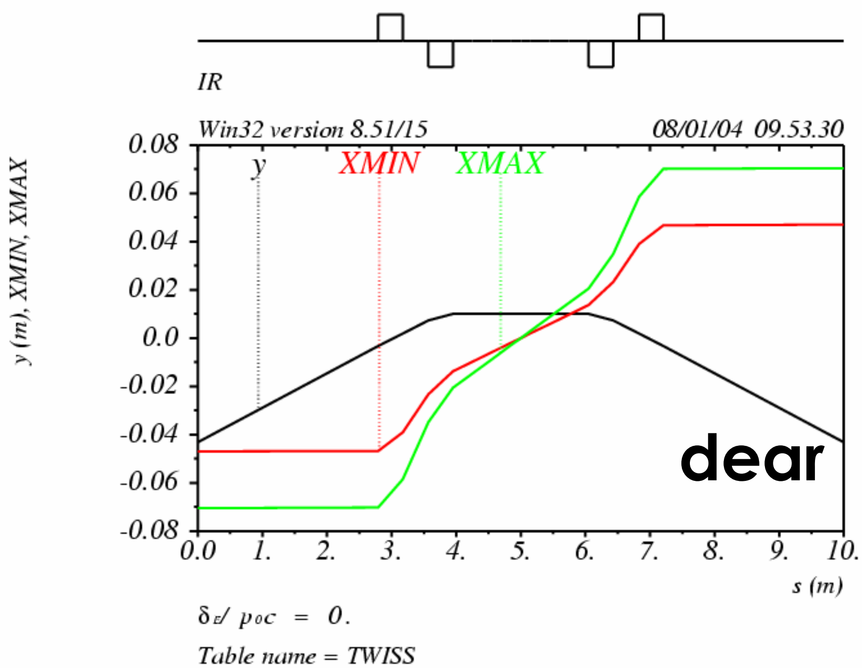
**DETUNED for 2nd IP
While colliding on 1st
one for KLOE**

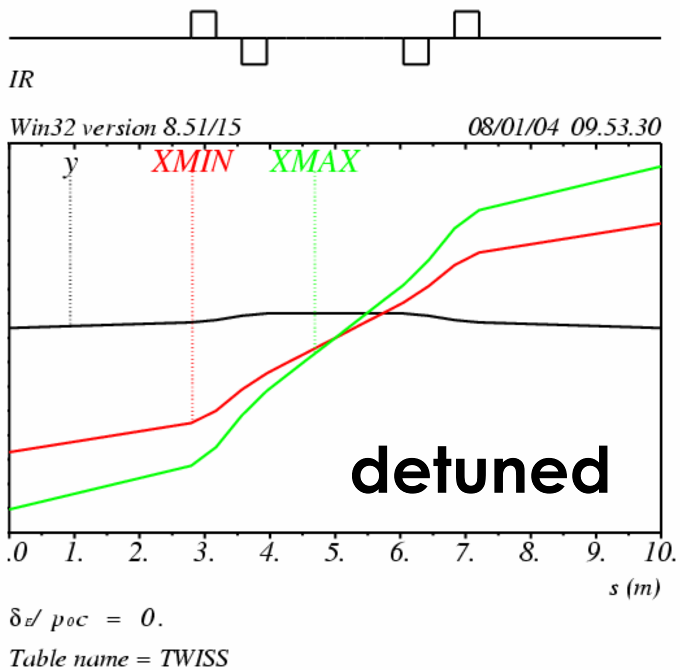
β^*_x = 2 m
β^*_y = 12 m

DETUNED
θ (mrad): 13.8 to 20.8

Advantages:
Only 1 low-beta (lower chromaticity)
Beam vertical separation = bump
Does not introduce coupling

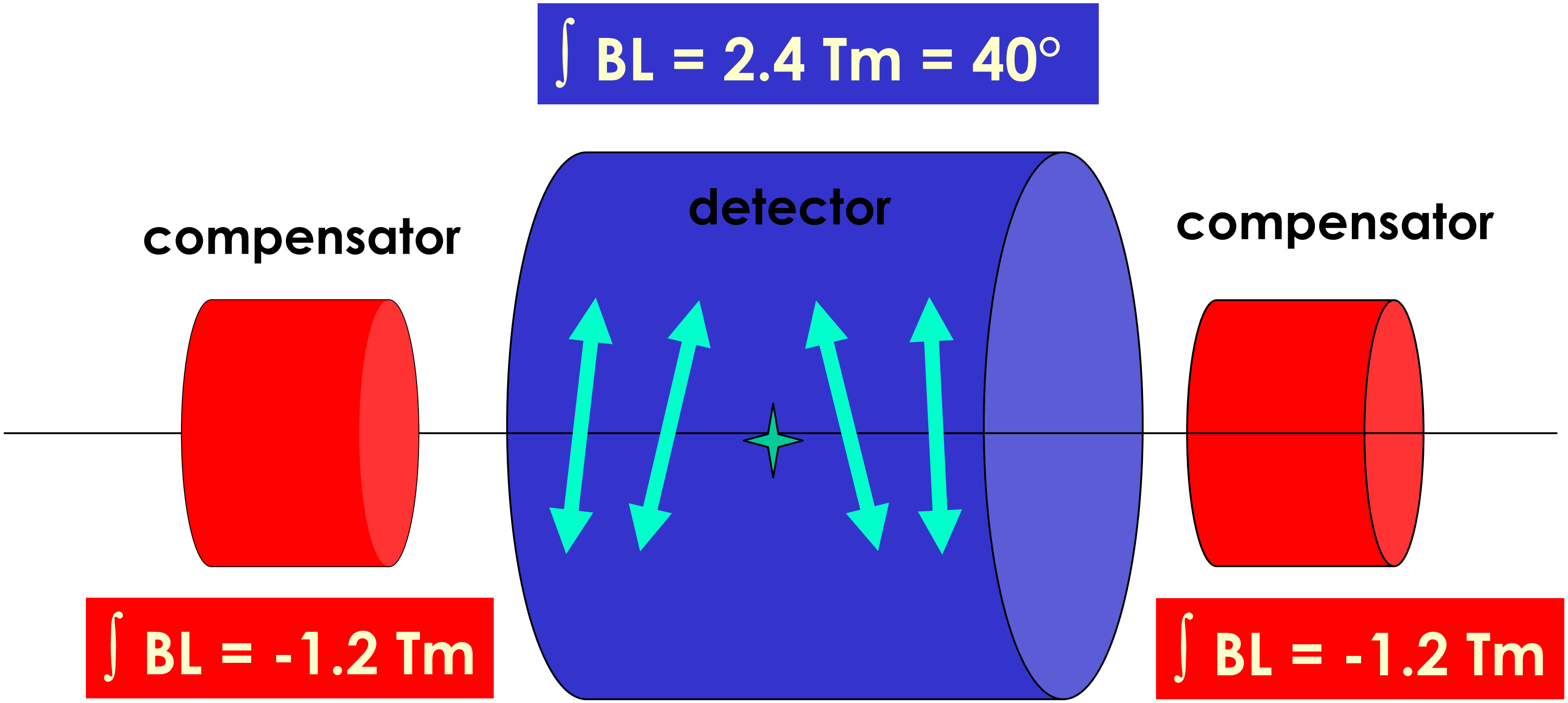
Beam trajectories





IRs with solenoids

Solenoid compensation



Quads tilted by $$\frac{1}{2B\rho}\int_{IP}^{s_q} B\,ds + \delta\theta_q$$

Exact coupling cancellation

$$\vec{x} = \begin{pmatrix} x \\ px \end{pmatrix}$$

$$\begin{pmatrix} \vec{x} \\ \vec{y} \end{pmatrix}_1 = \begin{pmatrix} X & XY \\ YX & Y \end{pmatrix}_{IR} \begin{pmatrix} \vec{x} \\ \vec{y} \end{pmatrix}_o$$

Coupling terms

4x4 matrix

Simplectic transport matrix:

4 parameters for cancelling XY and YX

Additional rotation of quads $\delta\theta_Q$

plus small modifications to solenoid fields δB_S

Solenoid: rotation and focusing (H,V)

$$\mathbf{S} = \begin{pmatrix} \cos K_s L_s & \dfrac{\sin K_s L_s}{K_s} \\ -K_s \sin K_s L_s & \cos K_s L_s \end{pmatrix} R(\theta_S)$$

$$K_s = \frac{B_s}{B\rho} \qquad \theta_S = \frac{1}{2B\rho}\int B_s ds$$

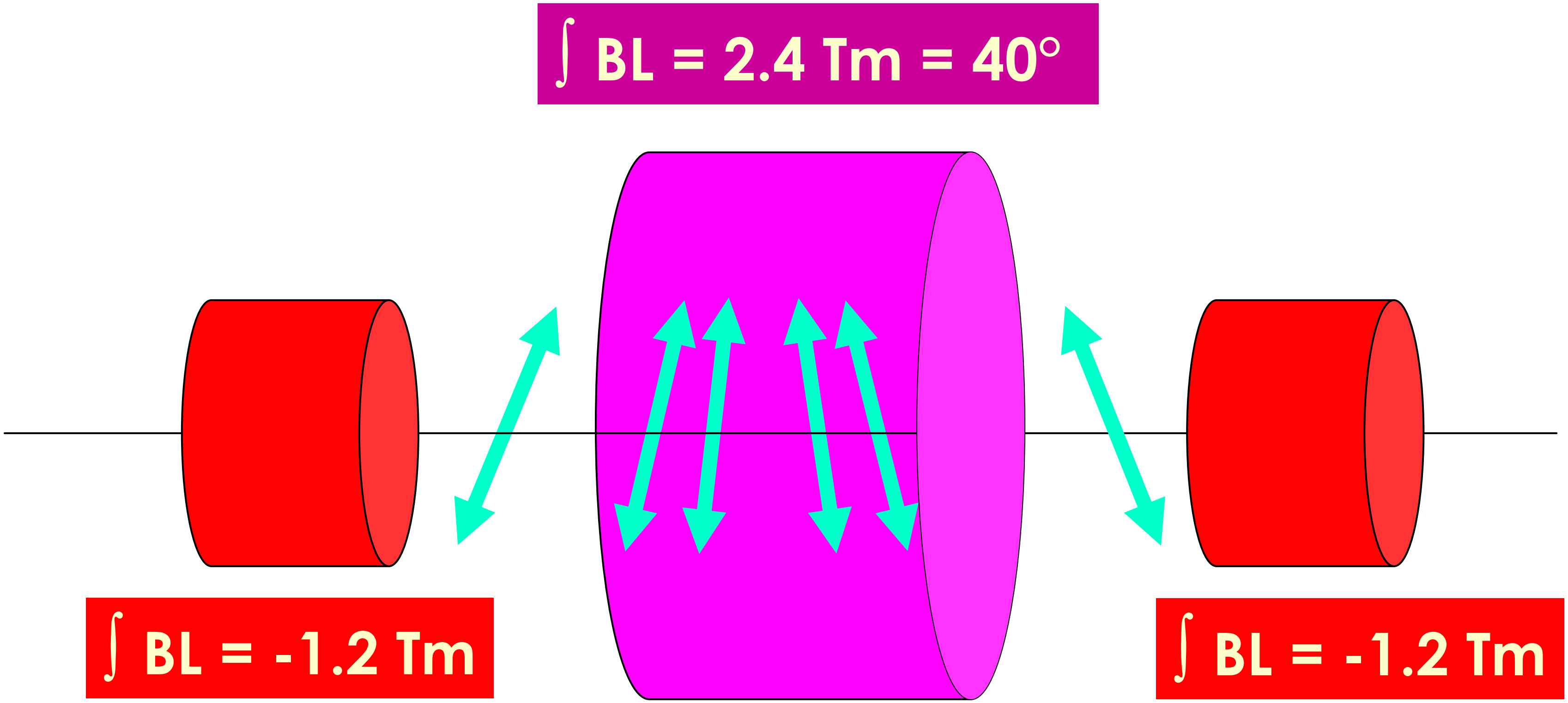
The solenoid is more chromatic by a factor 2 with respect to a quadrupole with the same focusing strength, because of the different energy dependence

$$K_s L_s = 2\theta_s$$

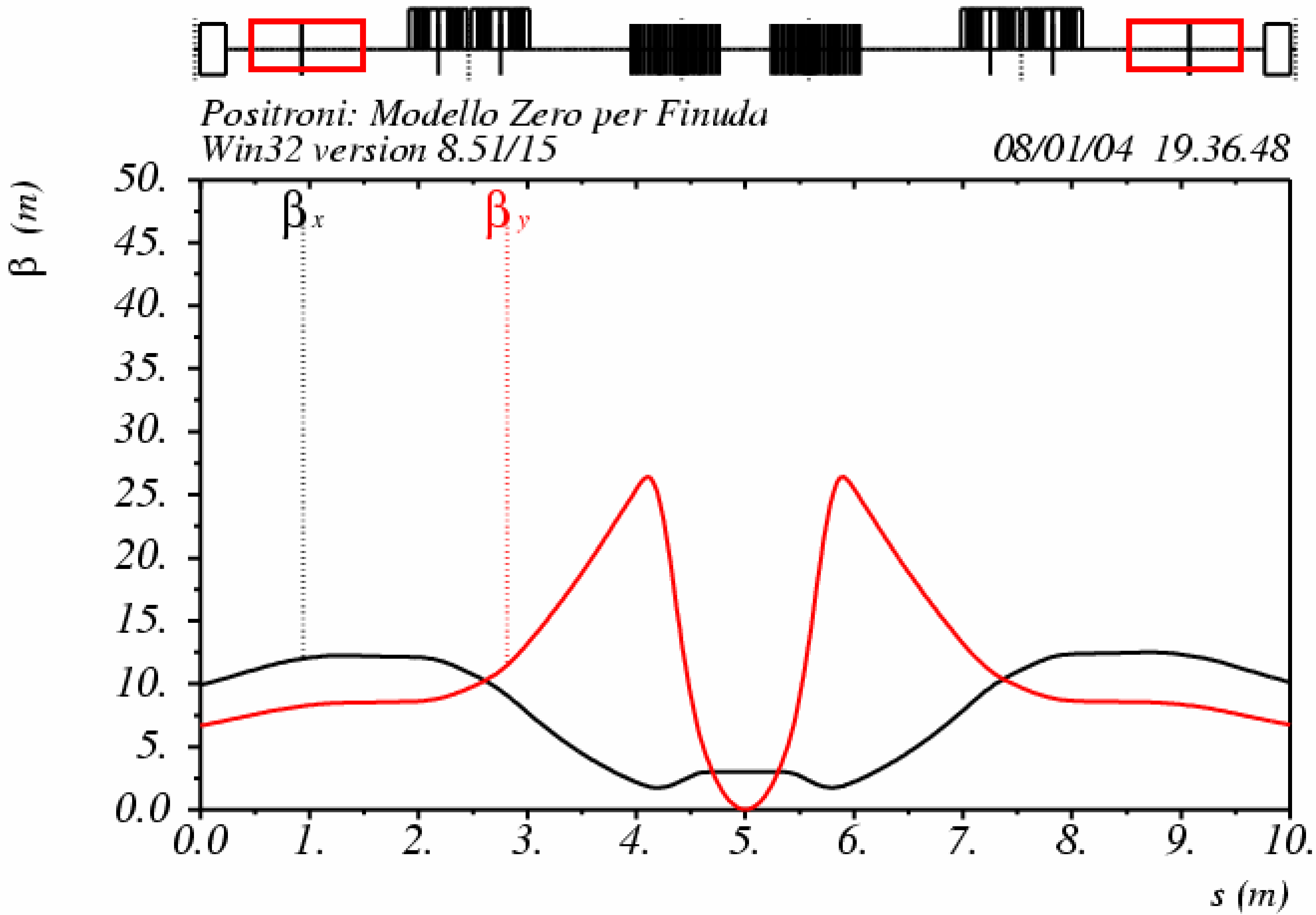
θ_s depends only on the integral of Bs, the focusing strength, once fixed θ_s, is inversely proportional to Ls.

The focusing properties of the compensator are relevant, while those of the detector with the same absolute value of θ_s are negligible

FINUDA In operation now



Two permanent + two normal quads



$\delta_E/\ p_0c\ =\ 0.$

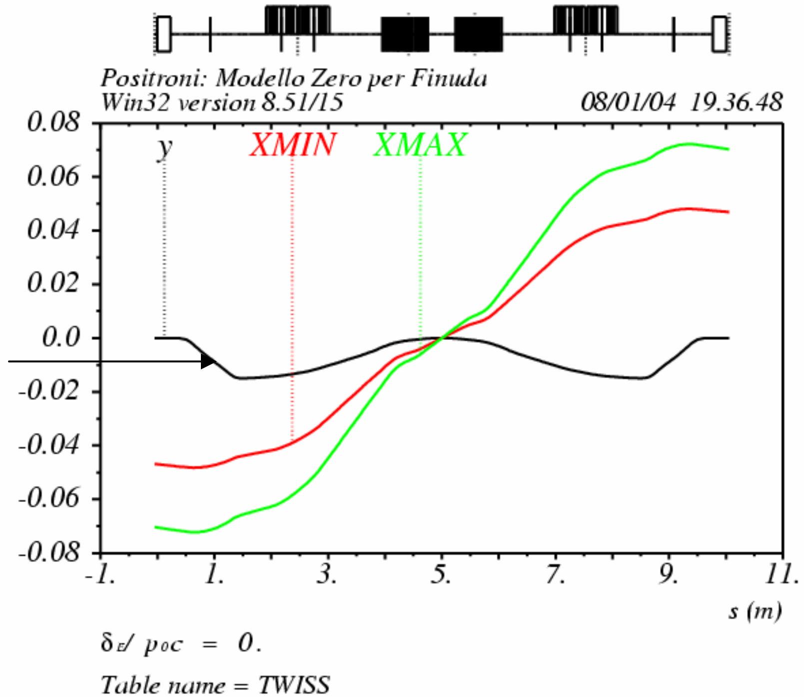
Table name = TWISS

β^*_x = 3 m

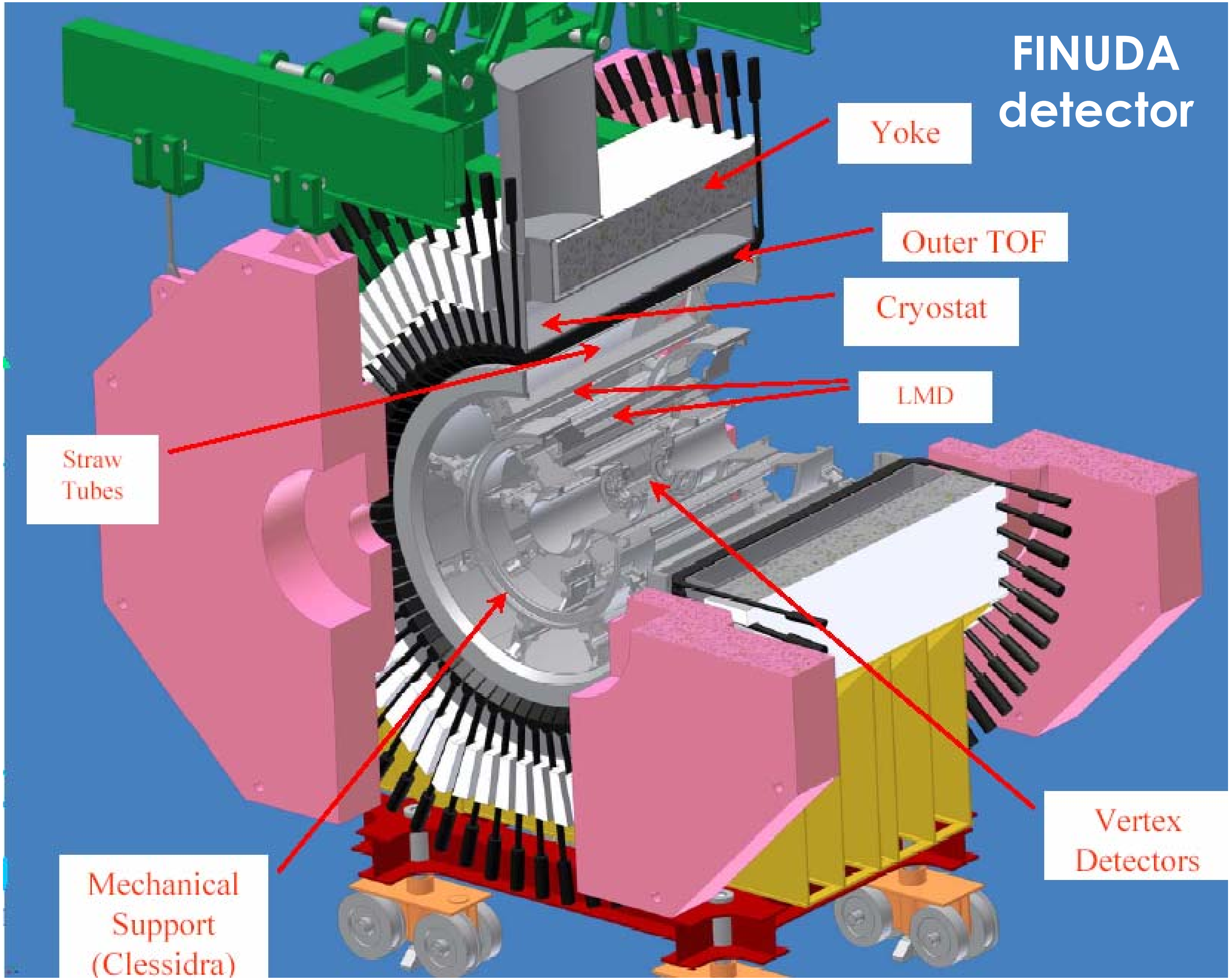
β^*_y = 3 cm

Beam trajectories

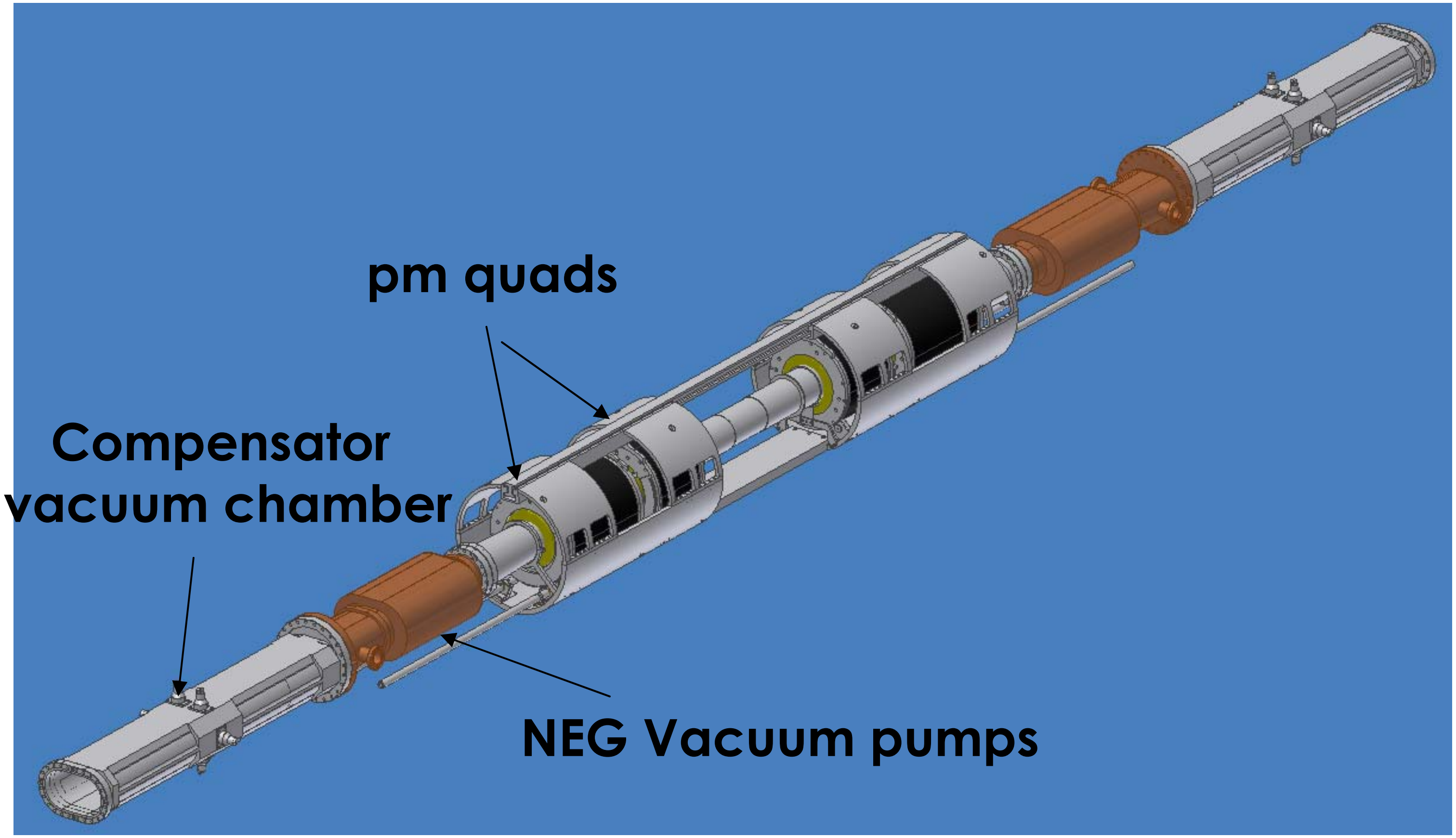
Vertical orbit due to off-axis trajectory Insde the solenoid



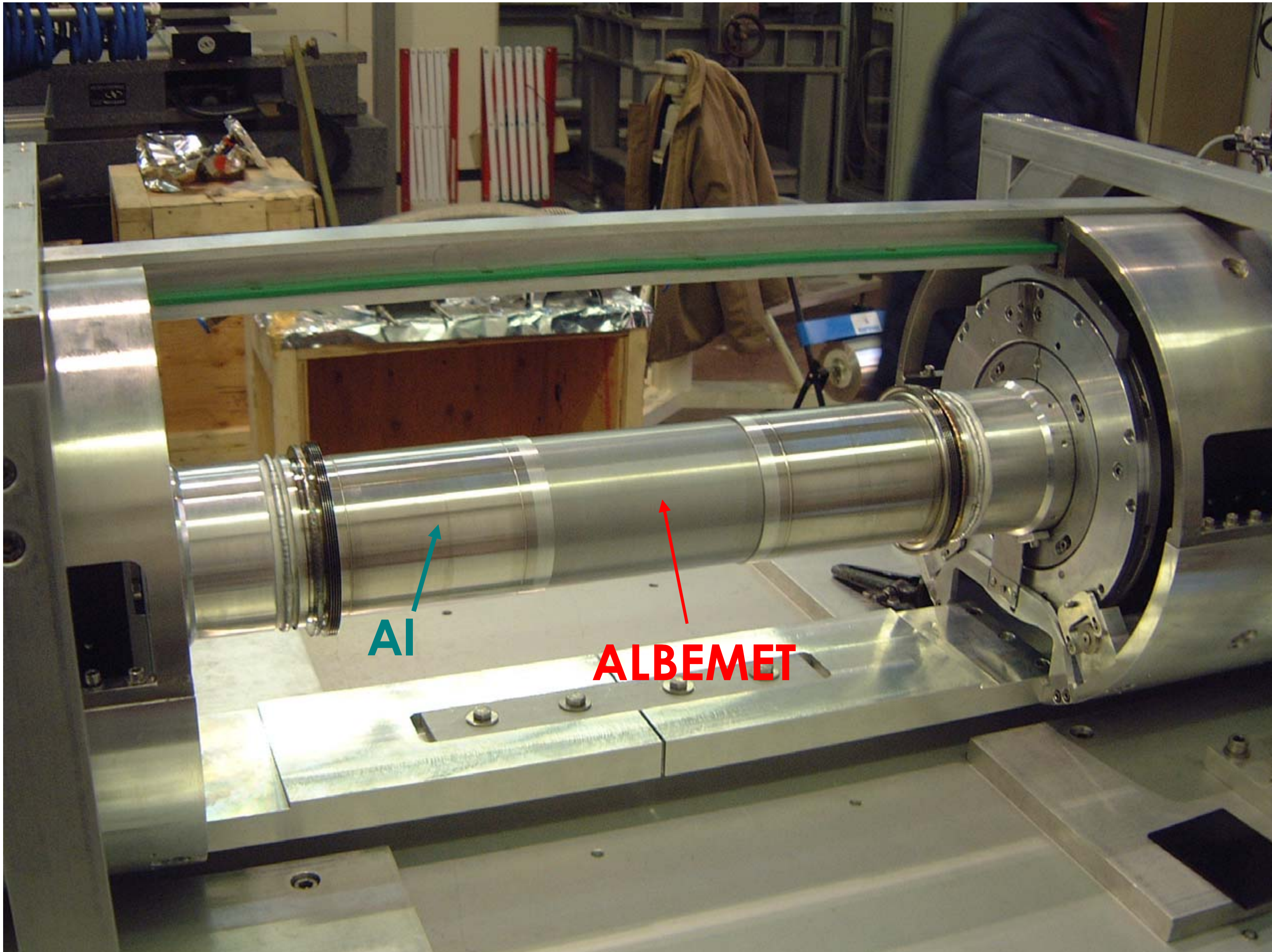
Crossing angle between 10.7 – 16.1 mrad


FINUDA detector
Yoke
Outer TOF
Cryostat
LMD
Straw Tubes
Vertex Detectors
Mechanical Support (Clessidra)

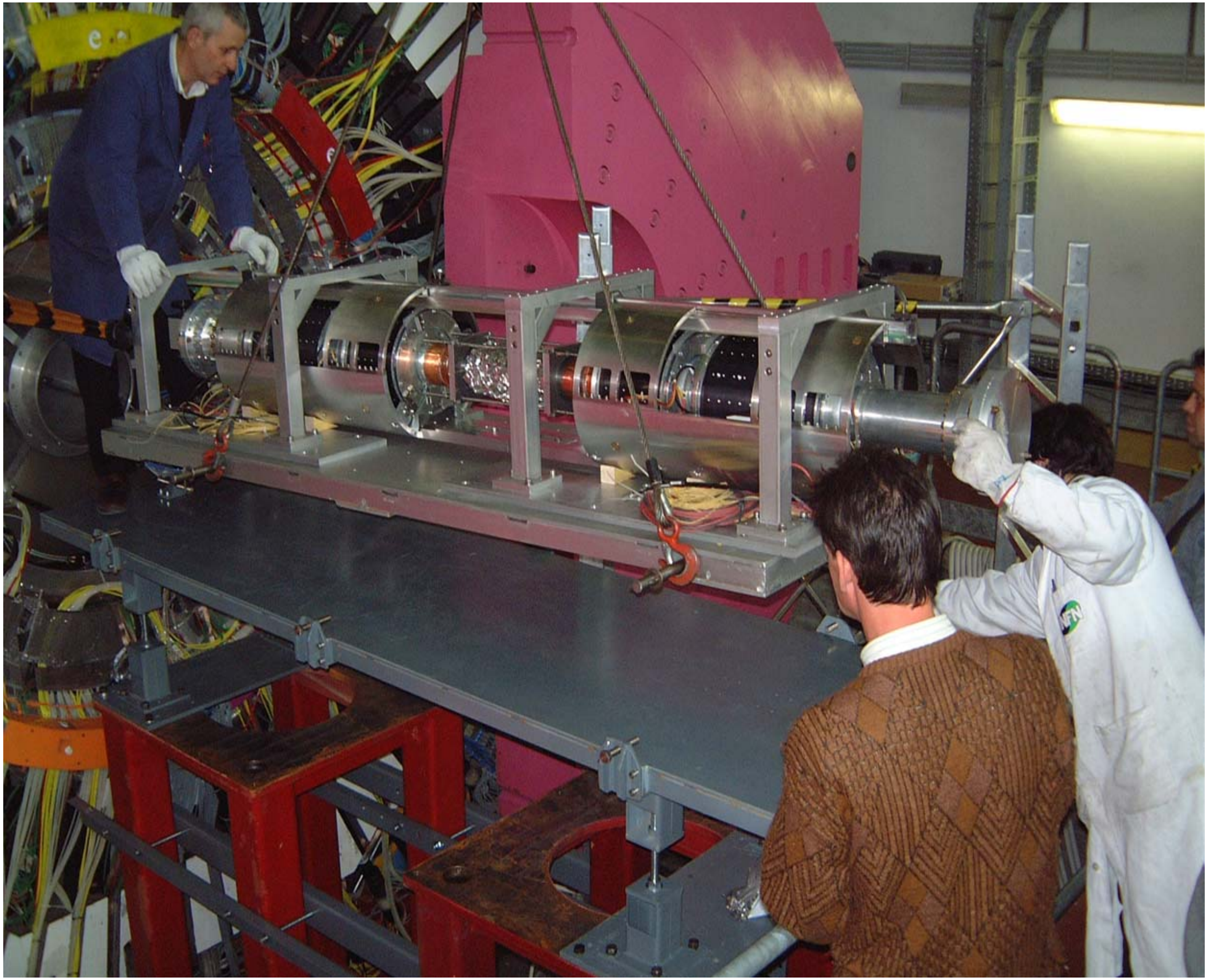
FINUDA IR
vacuum chamber and pm quads



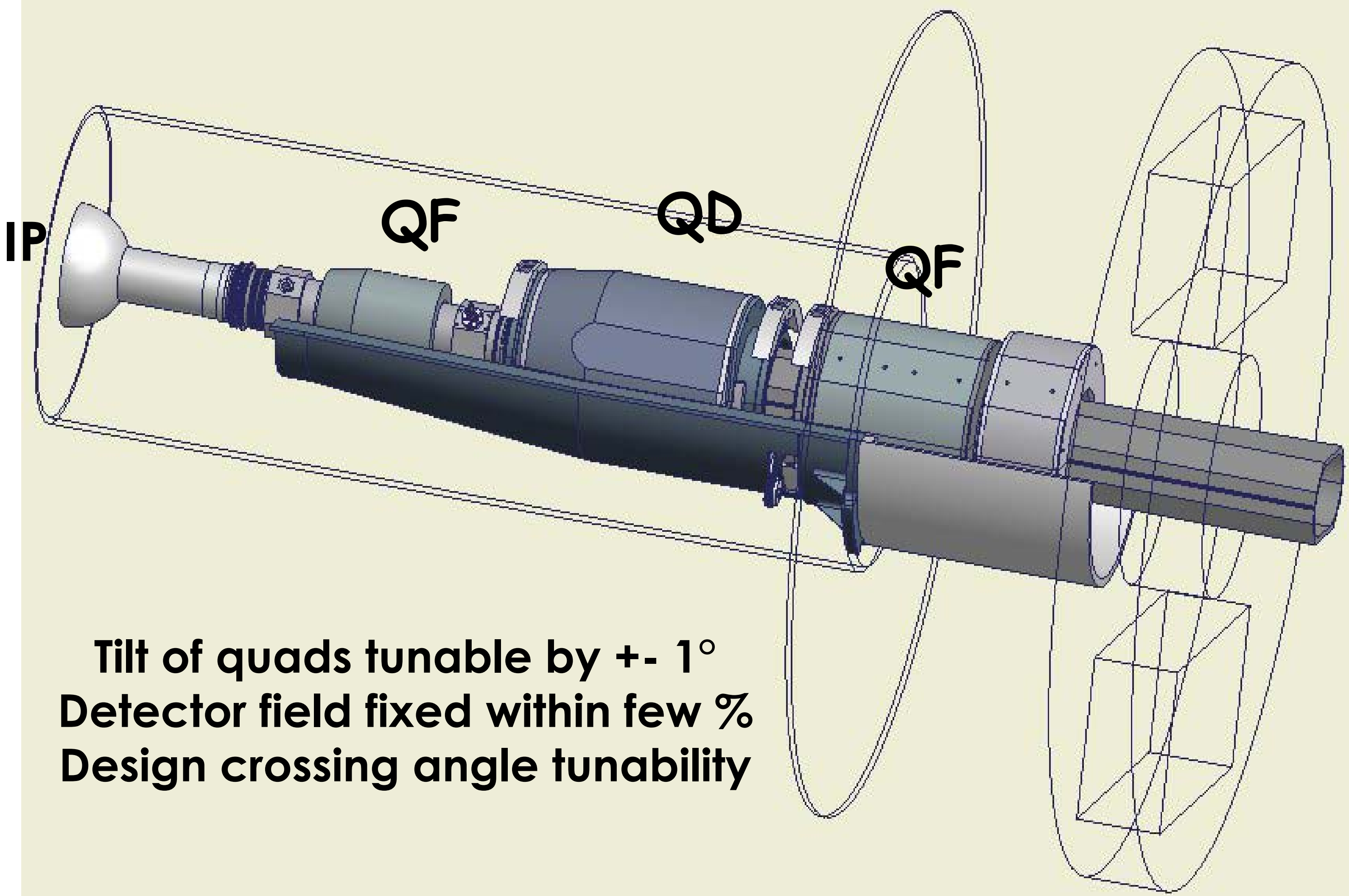
FINUDA IR Vacuum chamber



Finuda I.R. installation (spring 03)

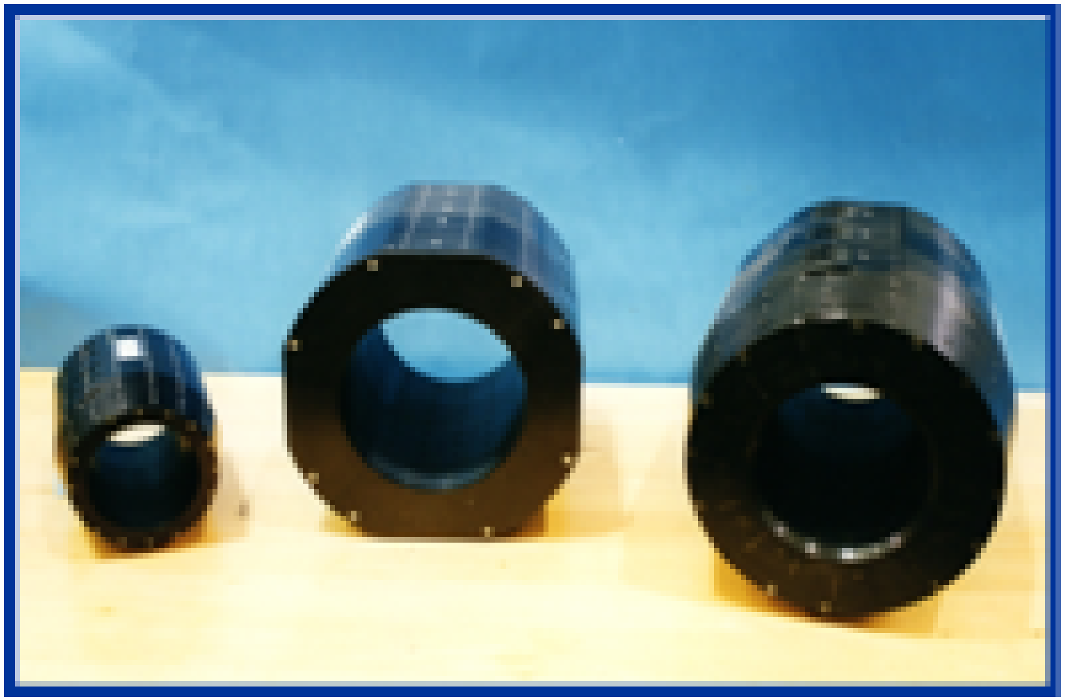


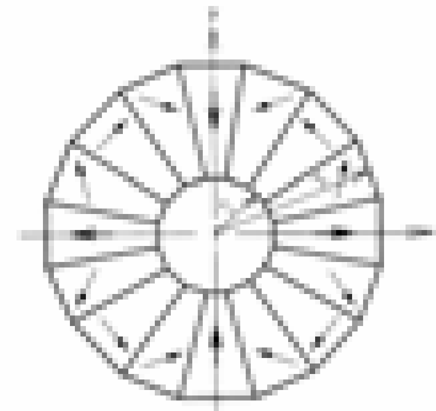
KLOE-I (run until 2002)



Tilt of quads tunable by +- 1°
Detector field fixed within few %
Design crossing angle tunability

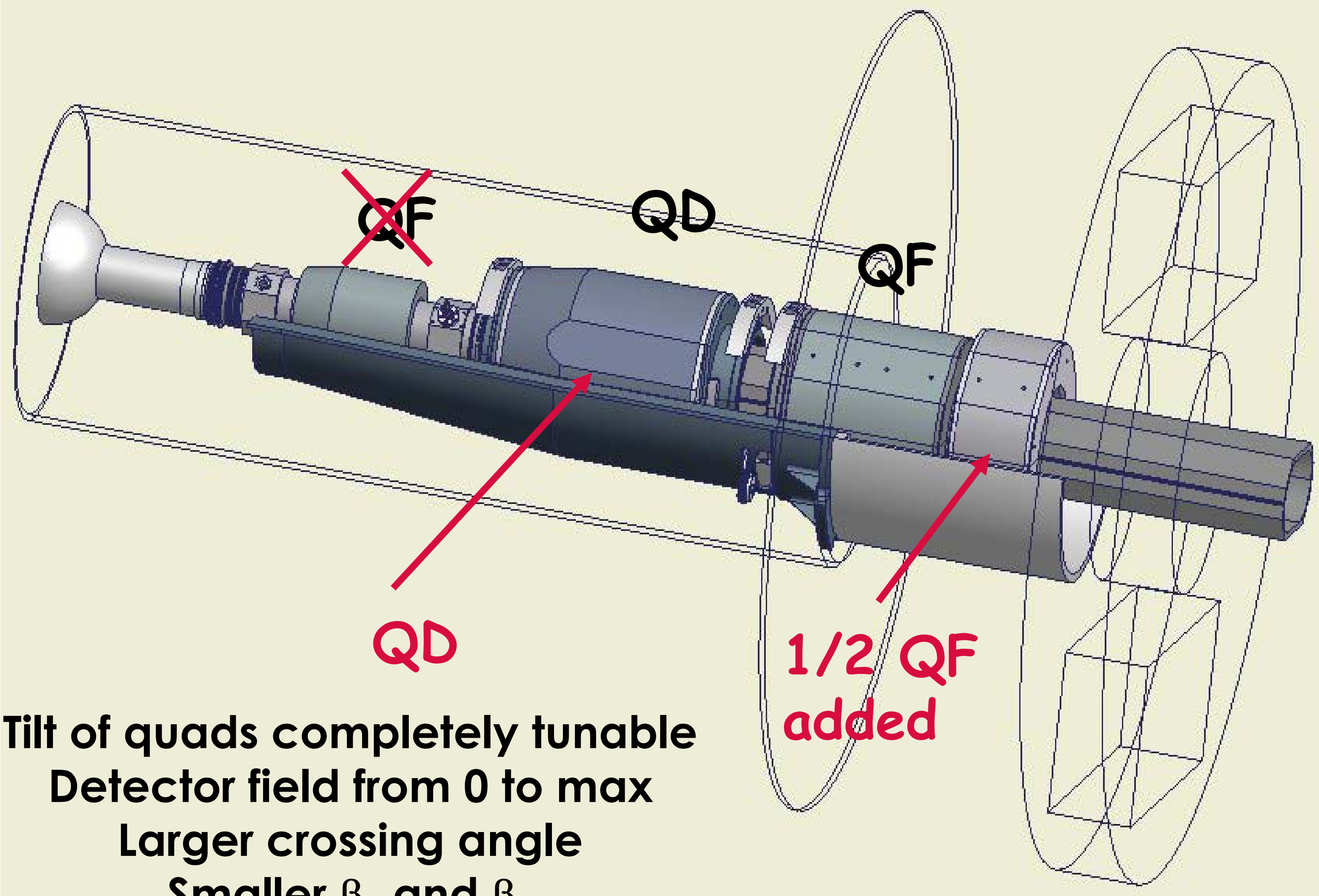
KLOE IR low beta quads



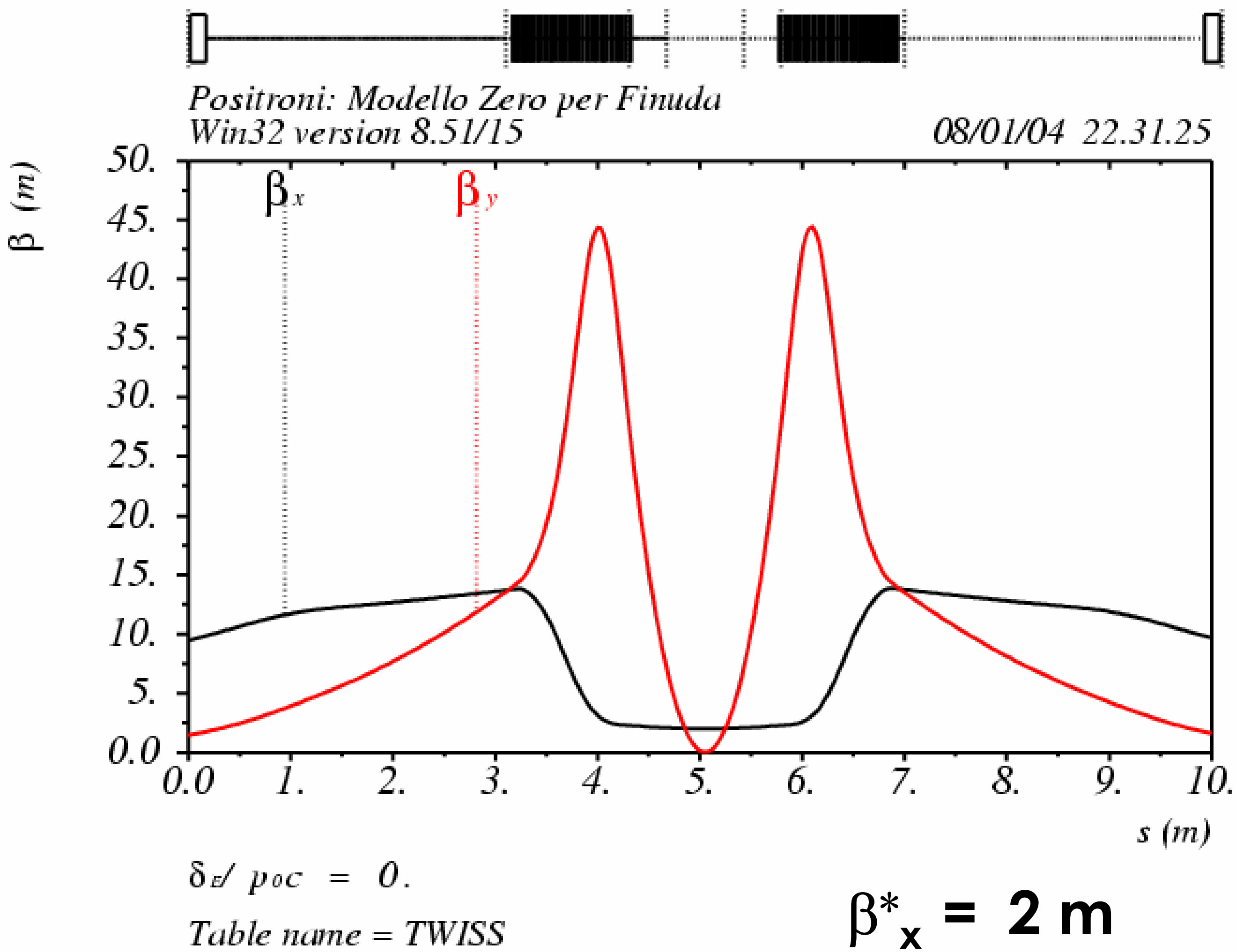


	1st F	2nd F	D
G(T/m)	6.0	5.3	10.3
GL (T)	1.2	1.4	3.6

KLOE-II (to be commissioned this year)



Tilt of quads completely tunable
Detector field from 0 to max
Larger crossing angle
Smaller β_x and β_y

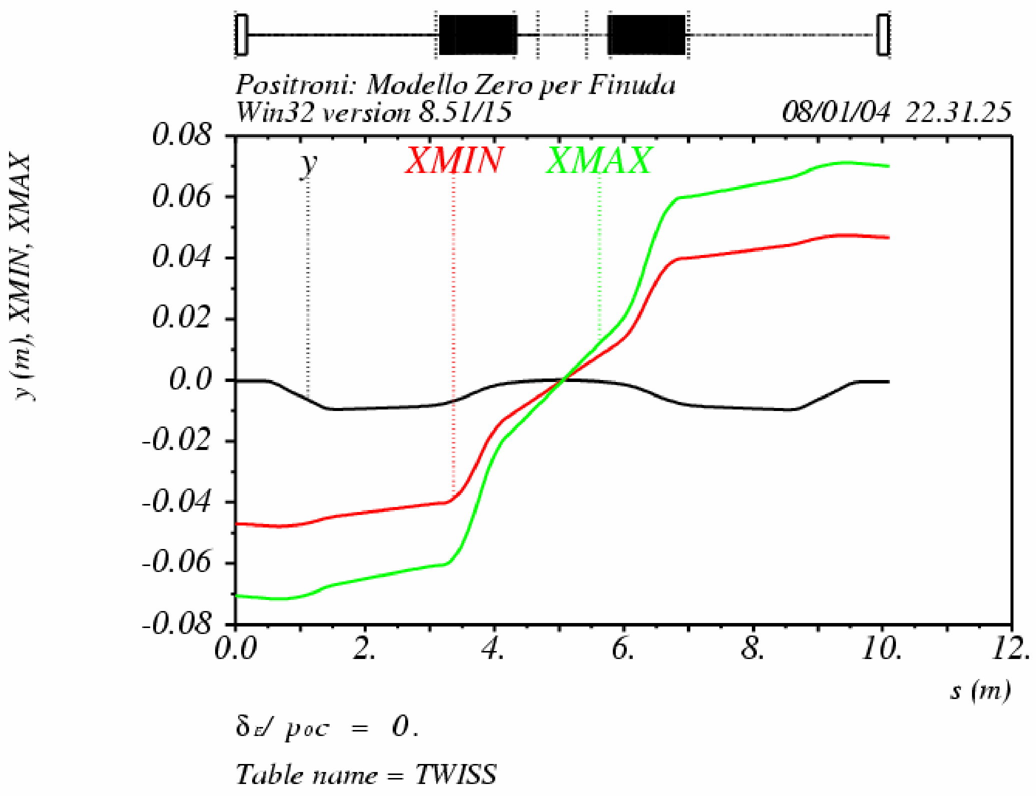


KLOE II

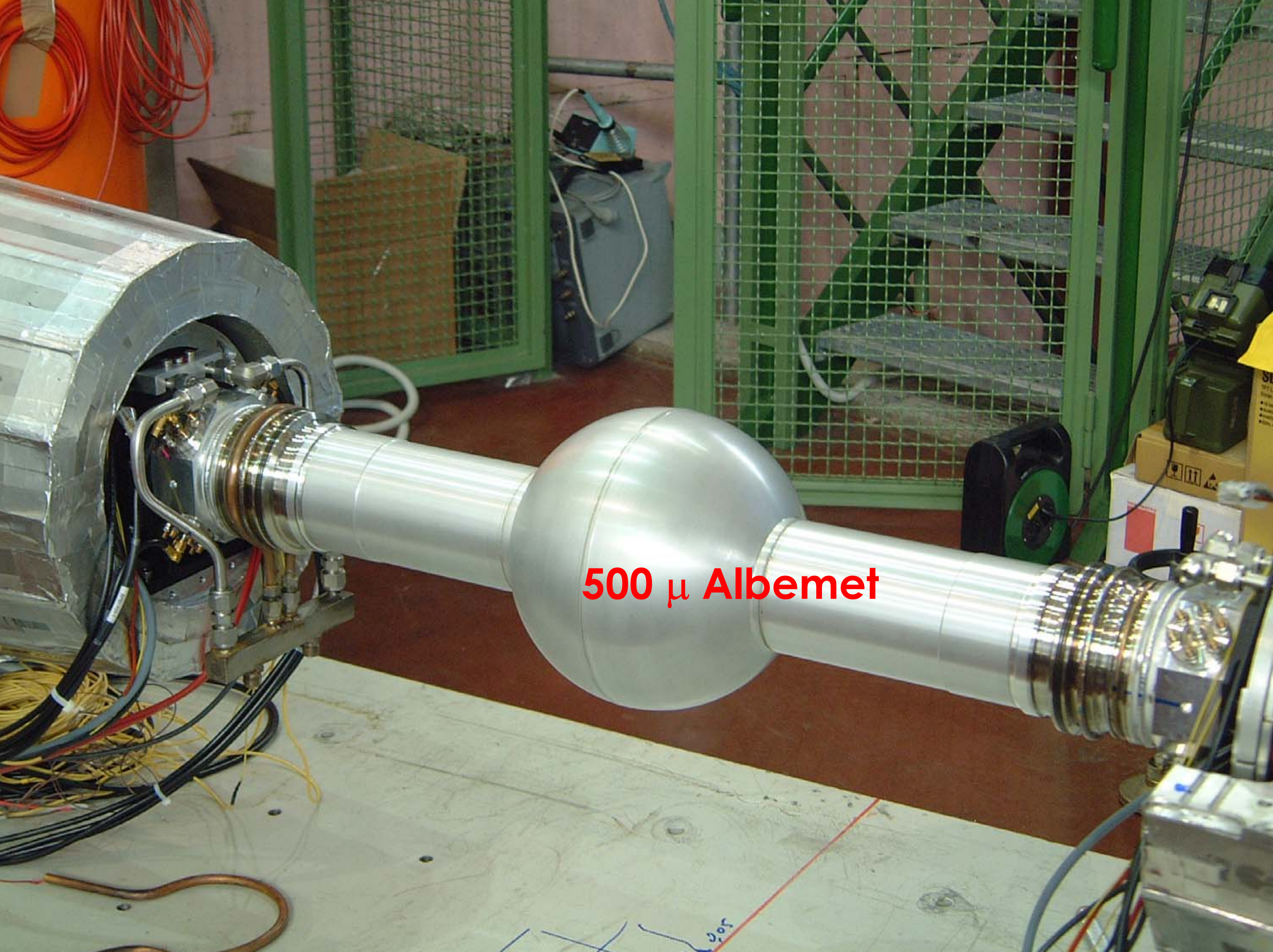
β^*_x = 2 m

β^*_y = 2 cm

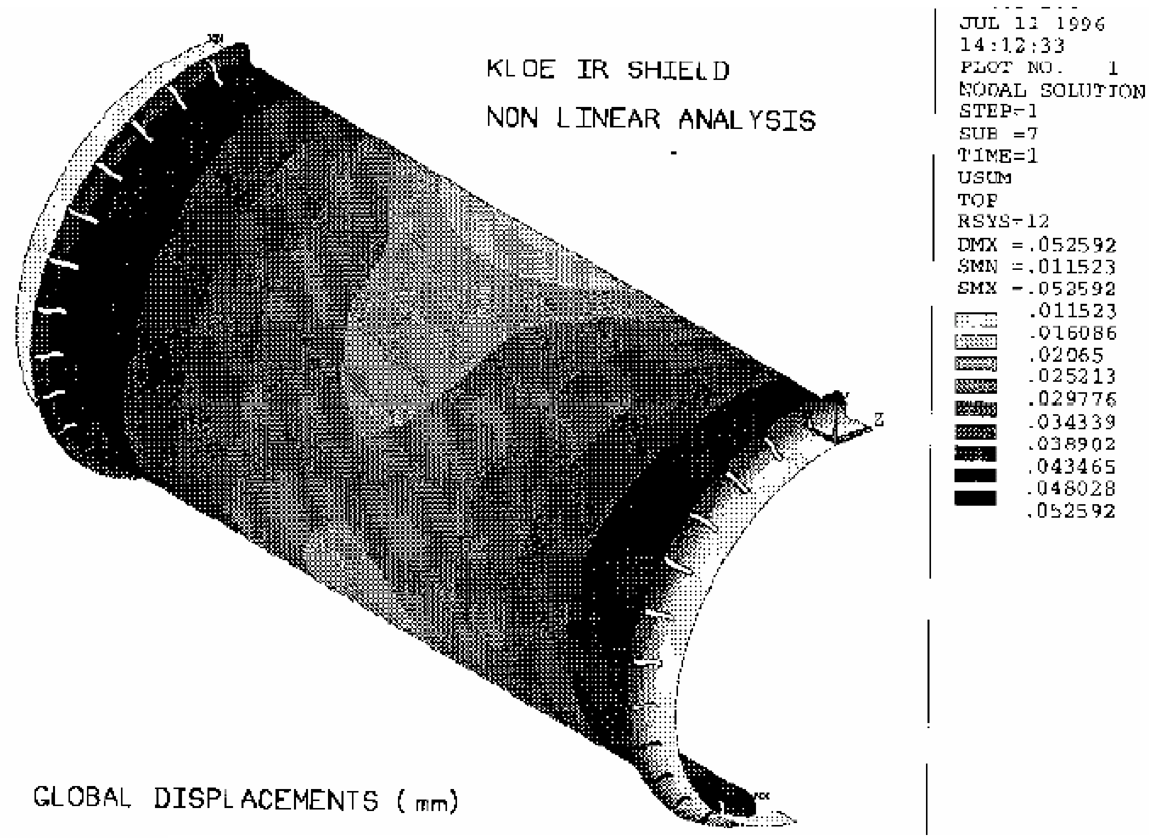
Beam trajectories inside IR

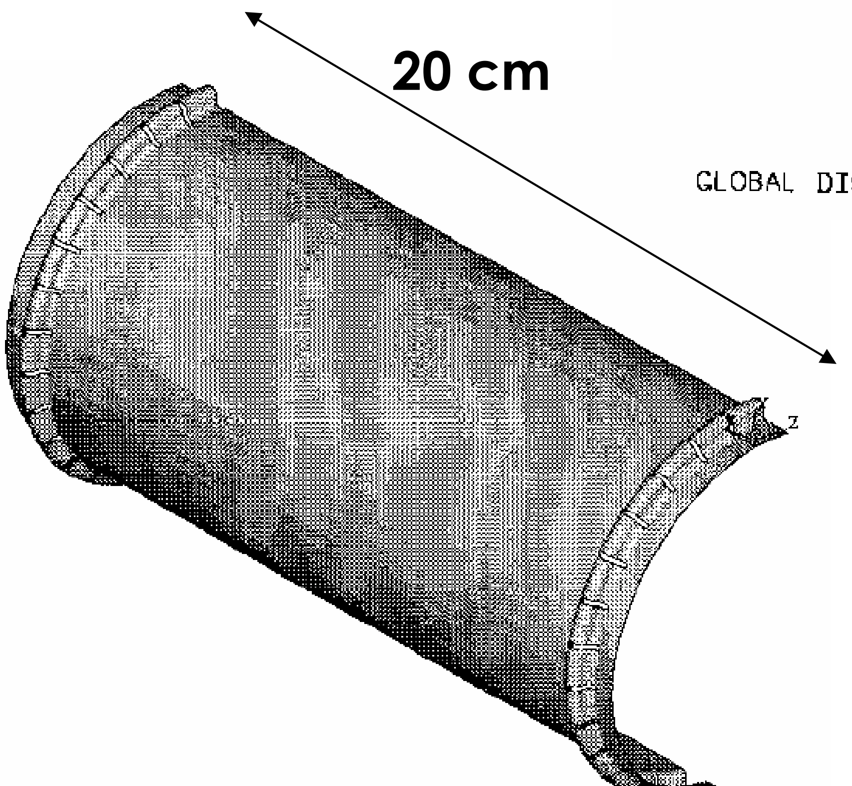


Crossing angle between 12.1 – 18.1 mrad

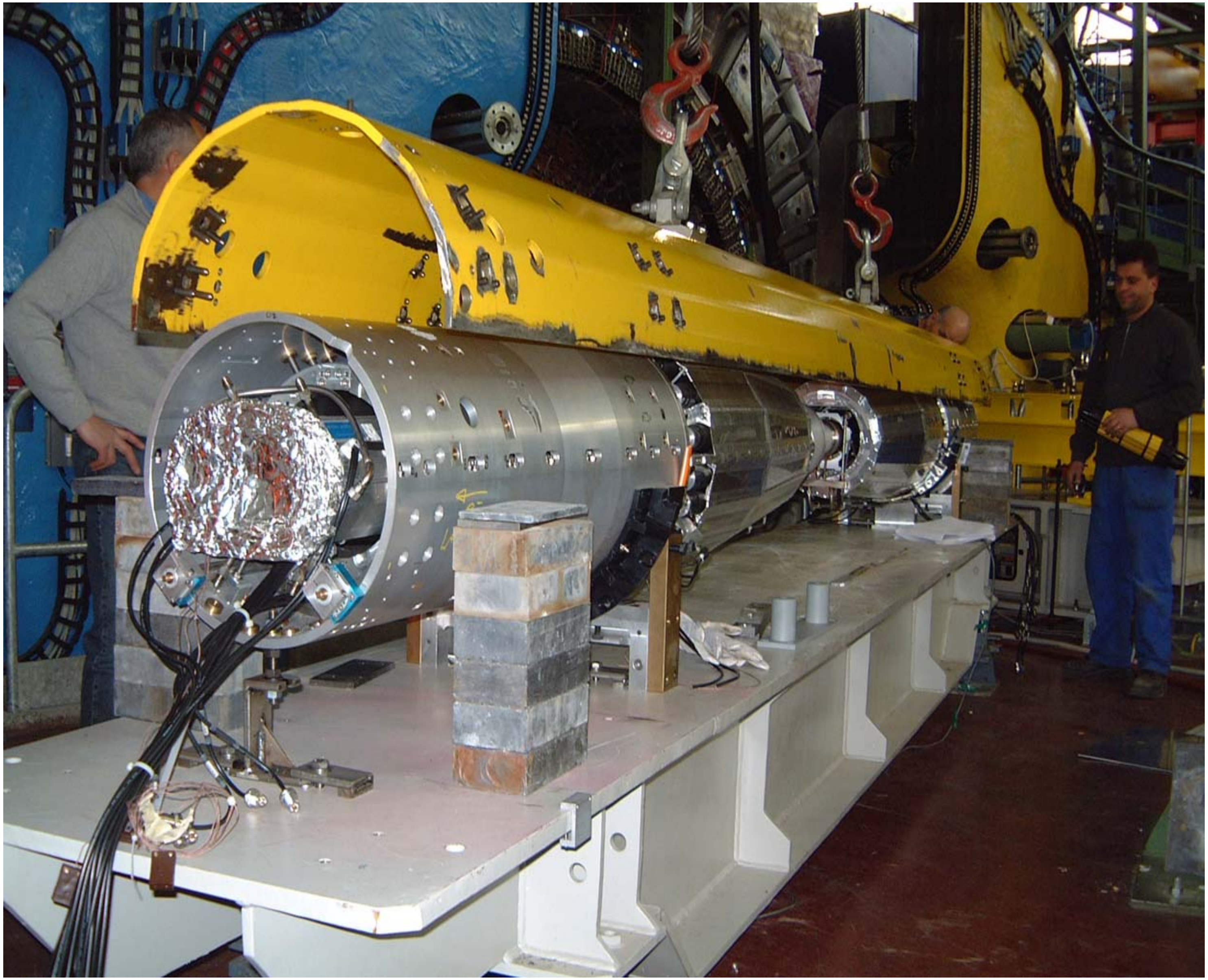

500 μ Albemet

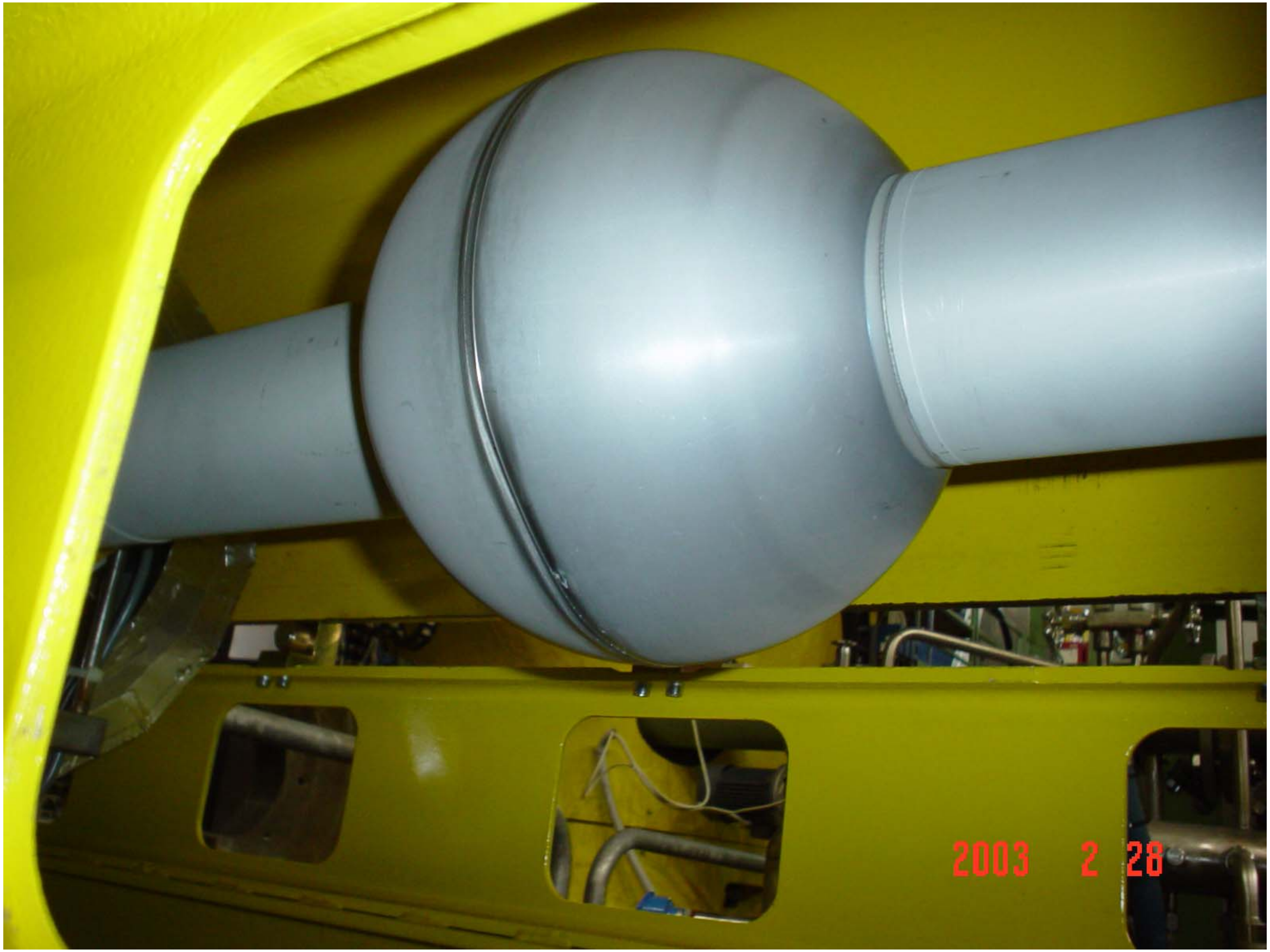
RF shield inside the sphere (50 μ)





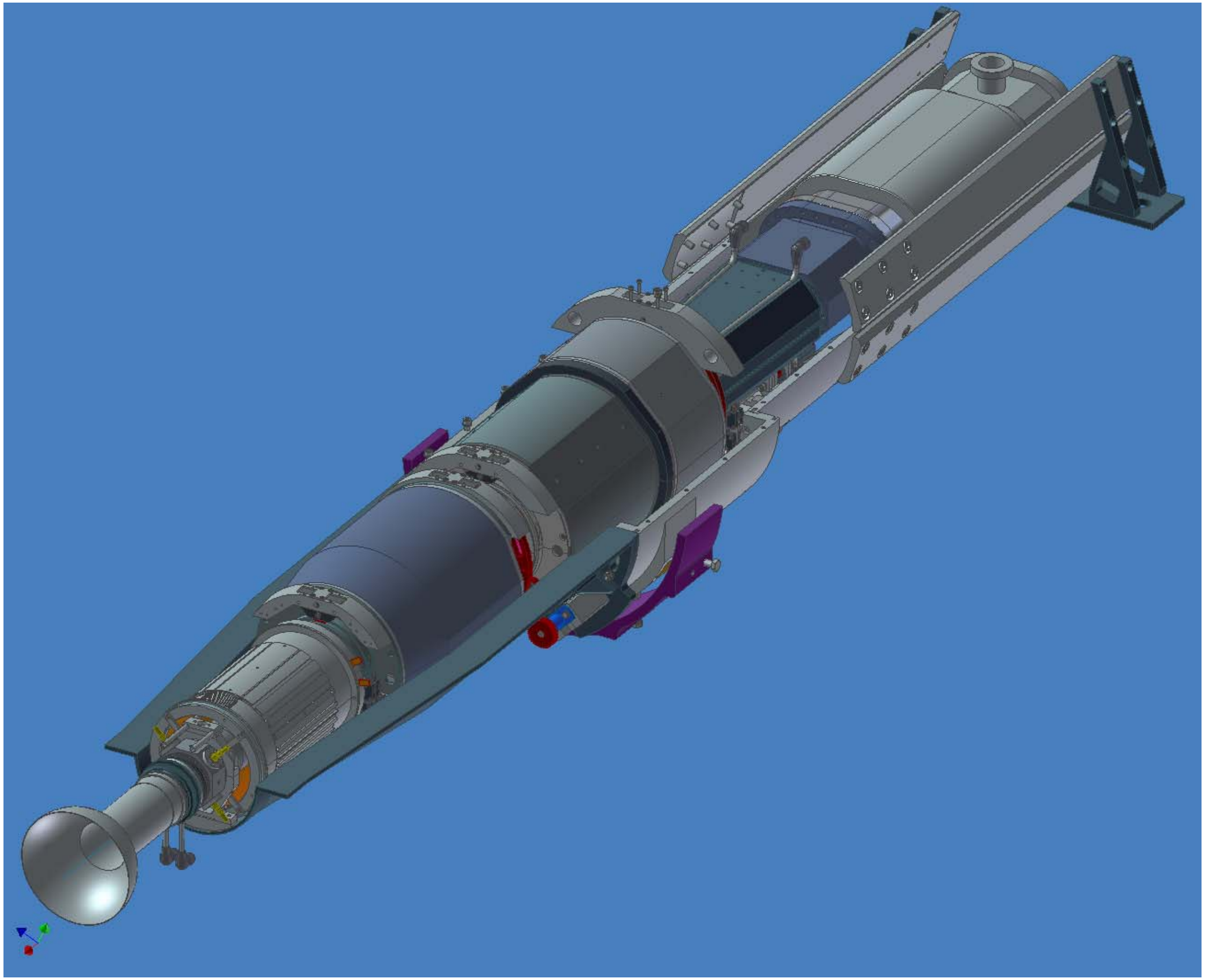
Kloe I - I.R. removal (spring 03)



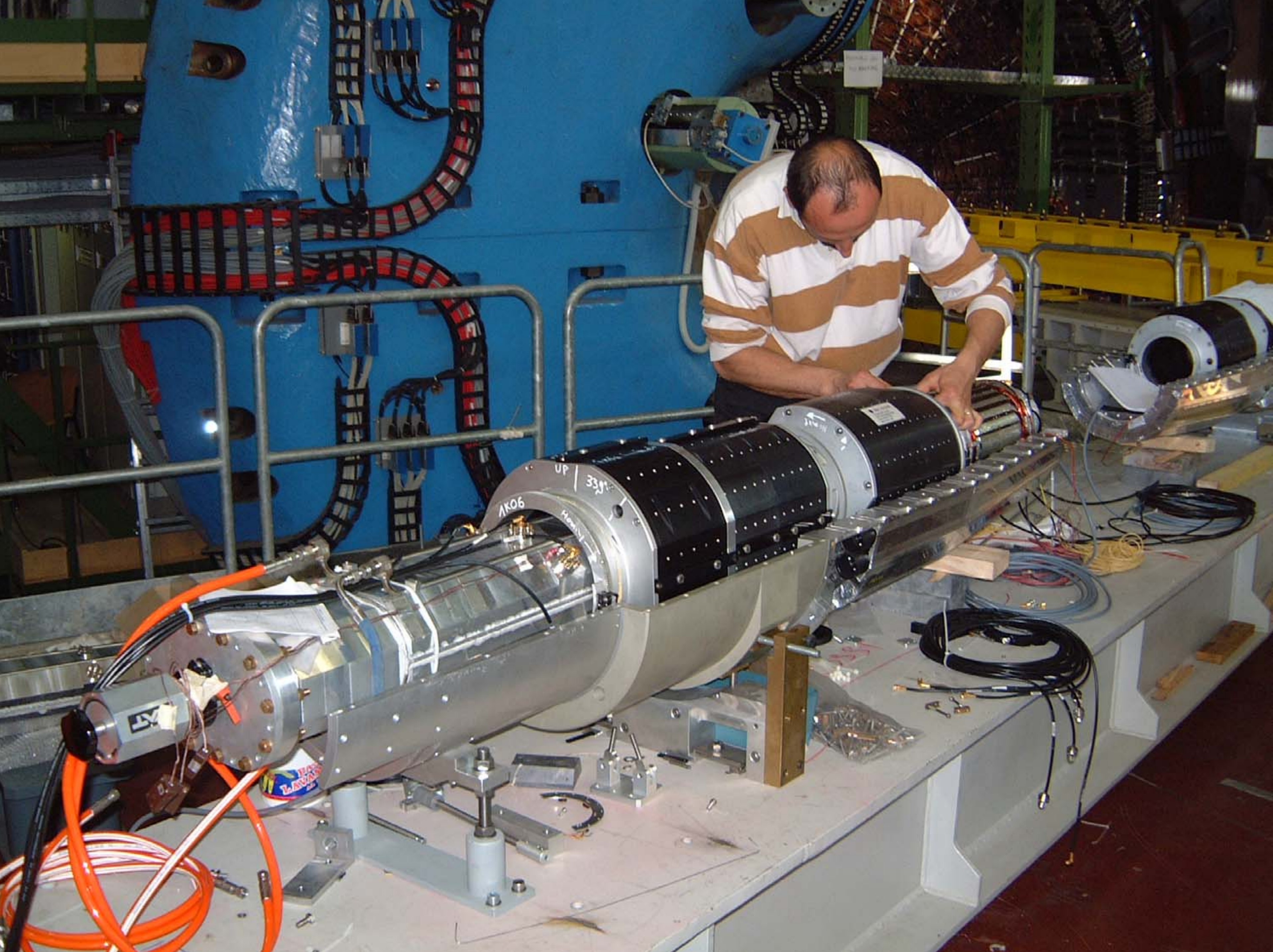

2003 2 28

Kloe I.R. installation hardware

KLOE IR

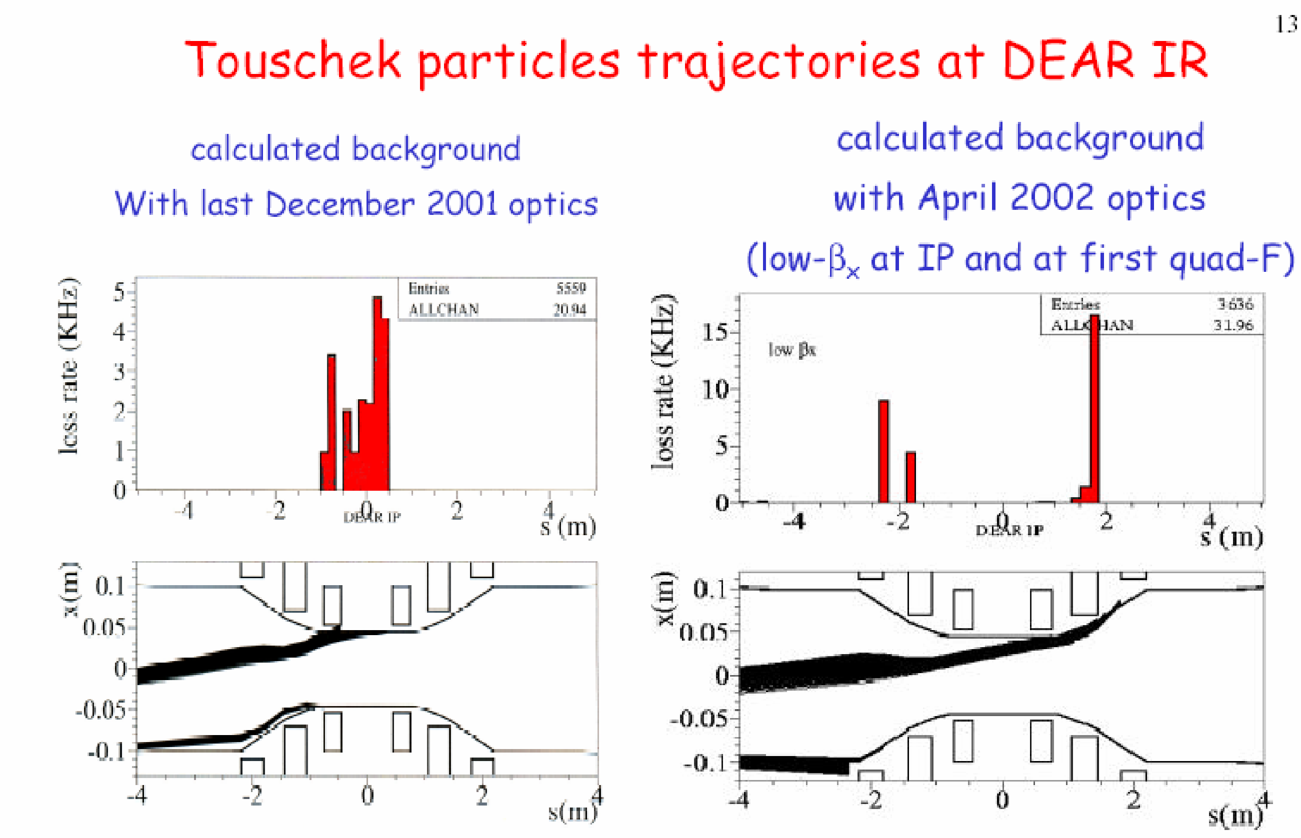



Beta

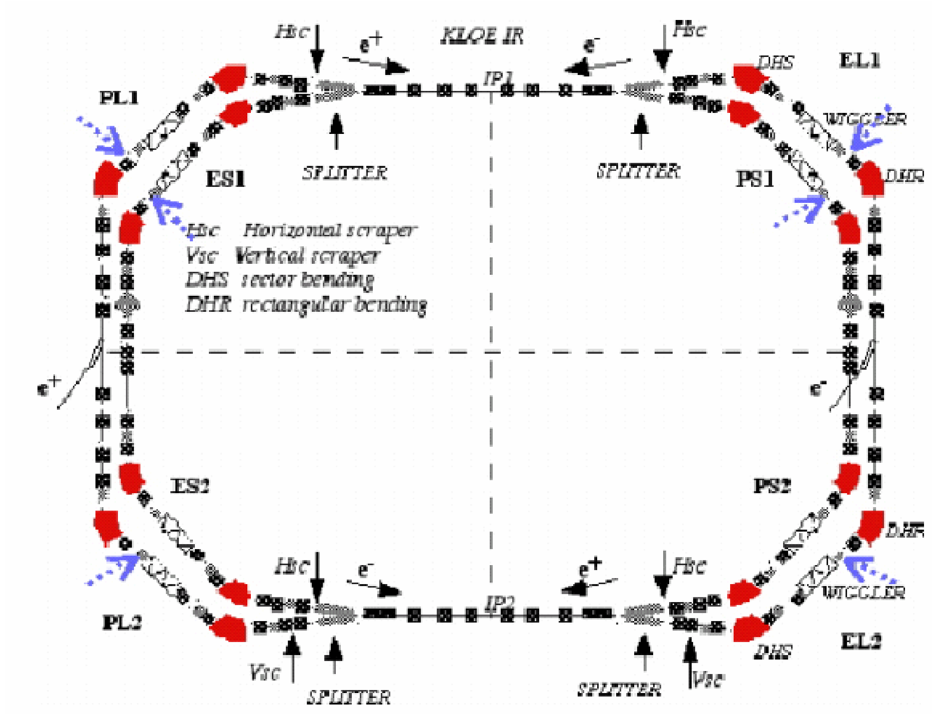

UP
AK06

Background

- **Dominated by Touschek losses**
- **Depending on dynamic aperture, coupling, beam lifetime, optics**

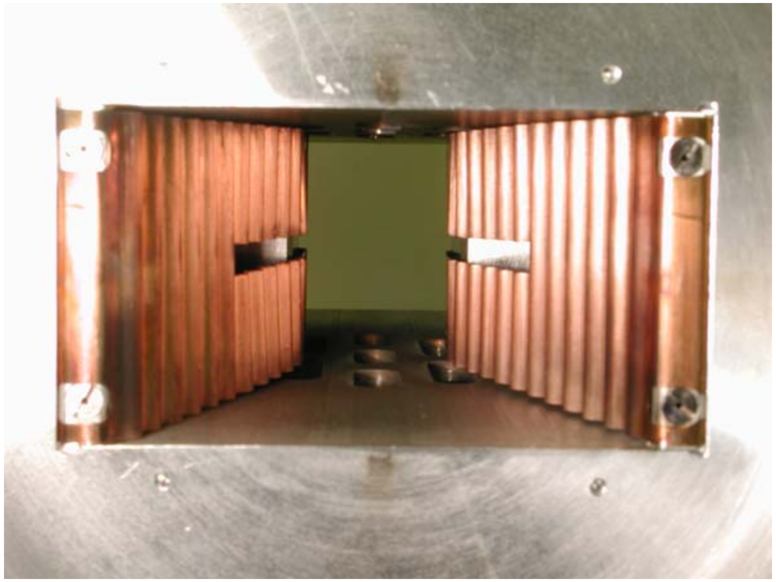


Intercepted with scrapers

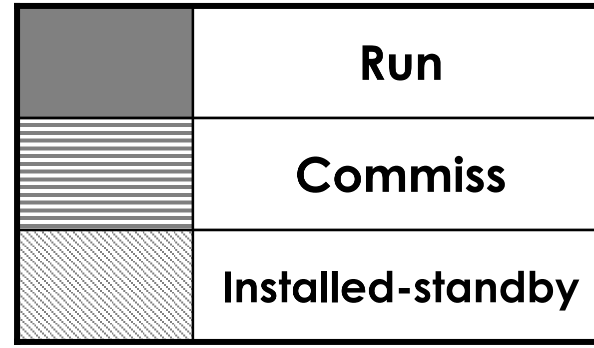


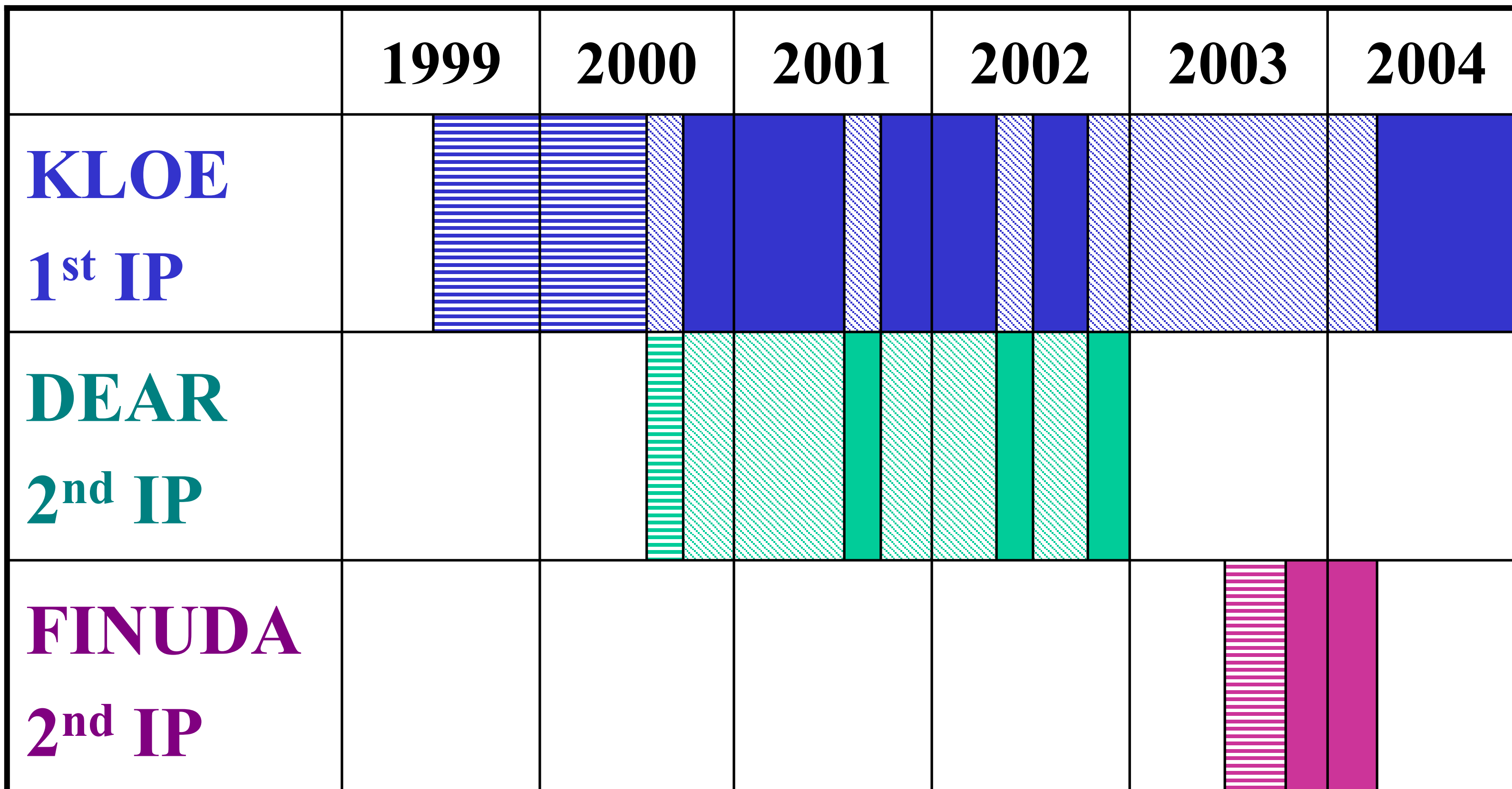
Vertical scraper

horizontal scraper



DAΦNE experiments





DAΦNE peak luminosity 2000-2003