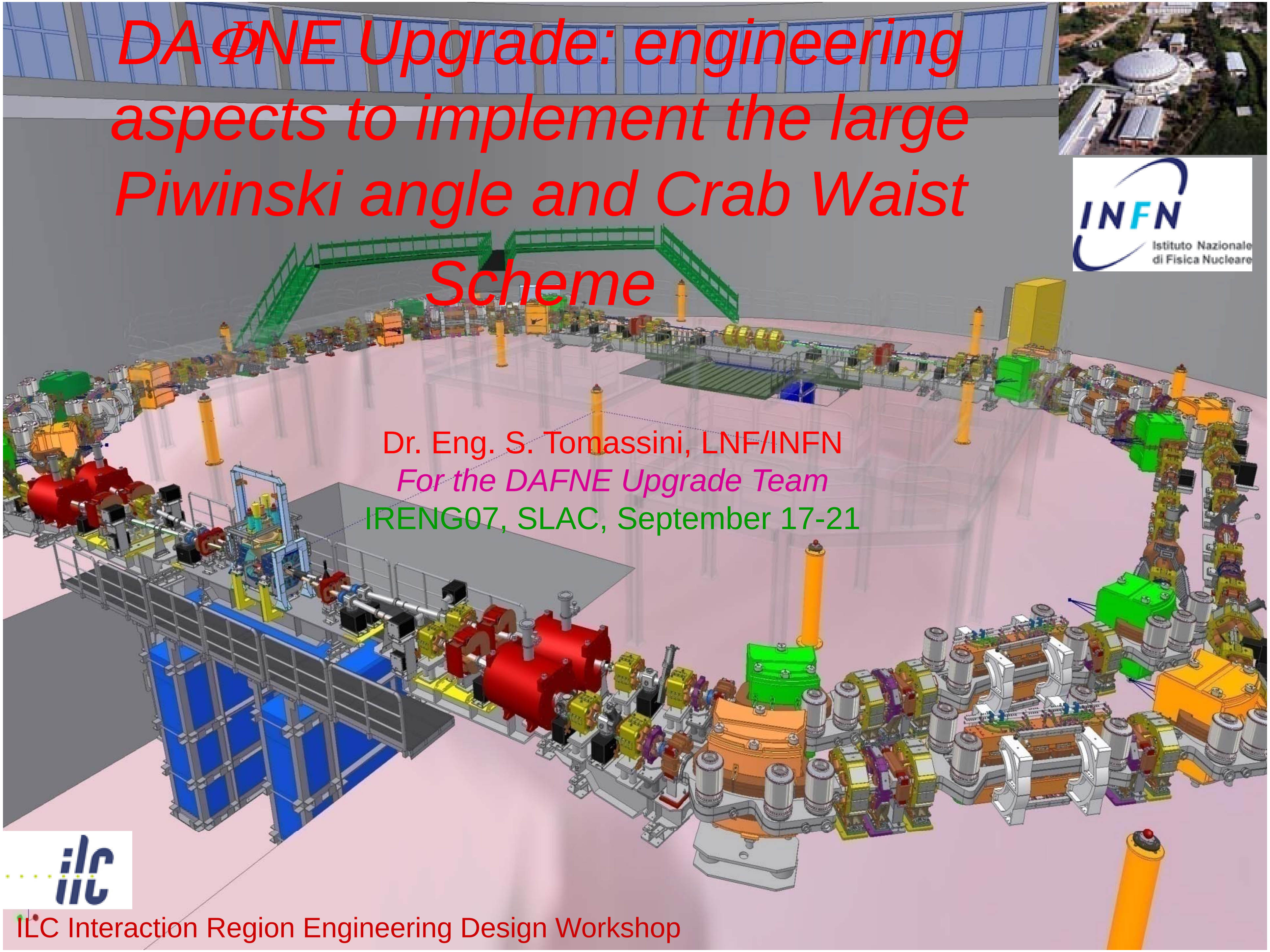

DAΦNE Upgrade: engineering aspects to implement the large Piwinski angle and Crab Waist Scheme

Dr. Eng. S. Tomassini, LNF/INFN

For the DAFNE Upgrade Team

IRENG07, SLAC, September 17-21

DAΦNE Upgrade Team

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WHY A NEW COLLIDING SCHEME?

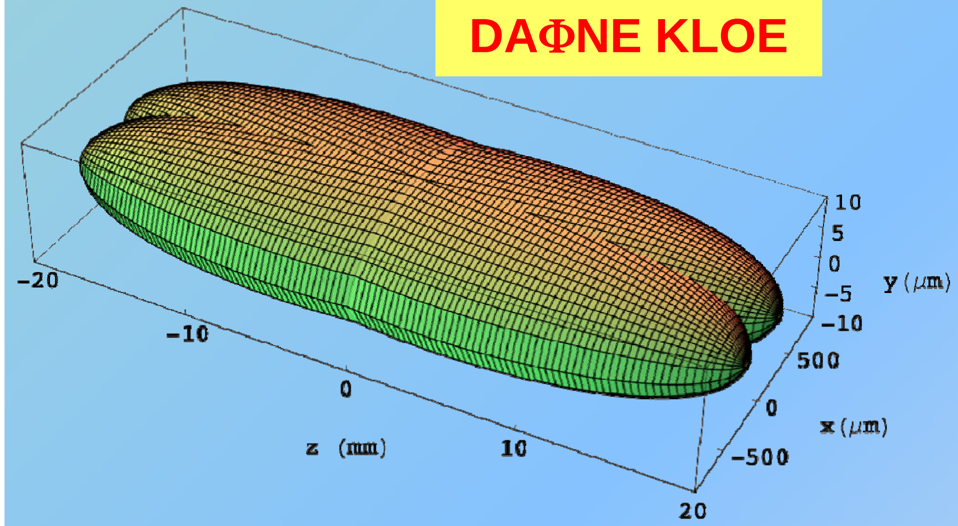
1. **The key requirements in high luminosity colliders is a very small β_y^* at the IP. However, β_y^* cannot be much smaller than the bunch length without incurring in a "hourglass" effect, and this sets a stringent requirement on the bunch length σ_z.**

2. **Indeed it is very difficult to shorten σ_z in a high current ring, as proposed in standard upgrade plans for Factories, without the problem of High Order Mode heating, coherent synchrotron radiation, excessive power consumption and instabilities.**

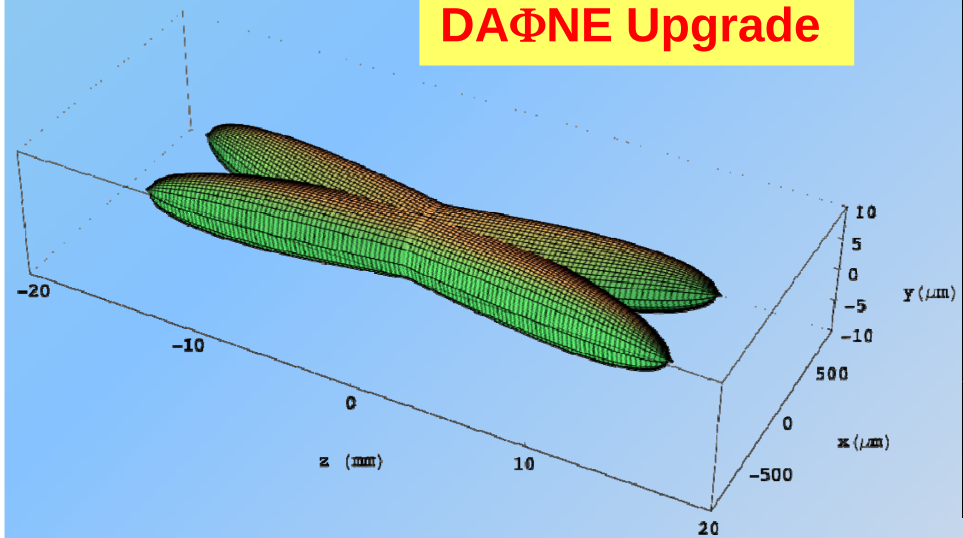
3. **The recently proposed large Piwinski angle and Crab Waist scheme for collisions holds the promise of increasing the luminosity of storage-ring colliders by more than two orders of magnitude beyond the current state-of-the-art, without any significant increase in beam current and without reducing the bunch length.**

DAΦNE Beam distributions @ IP

DAΦNE KLOE



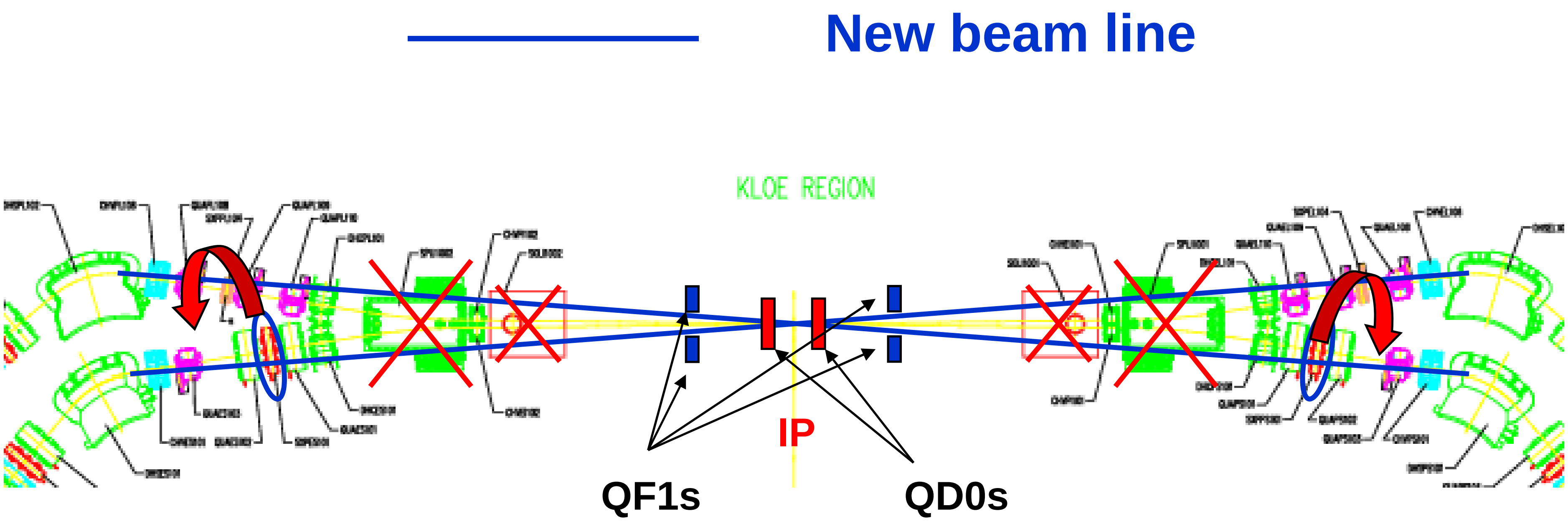
DAΦNE Upgrade



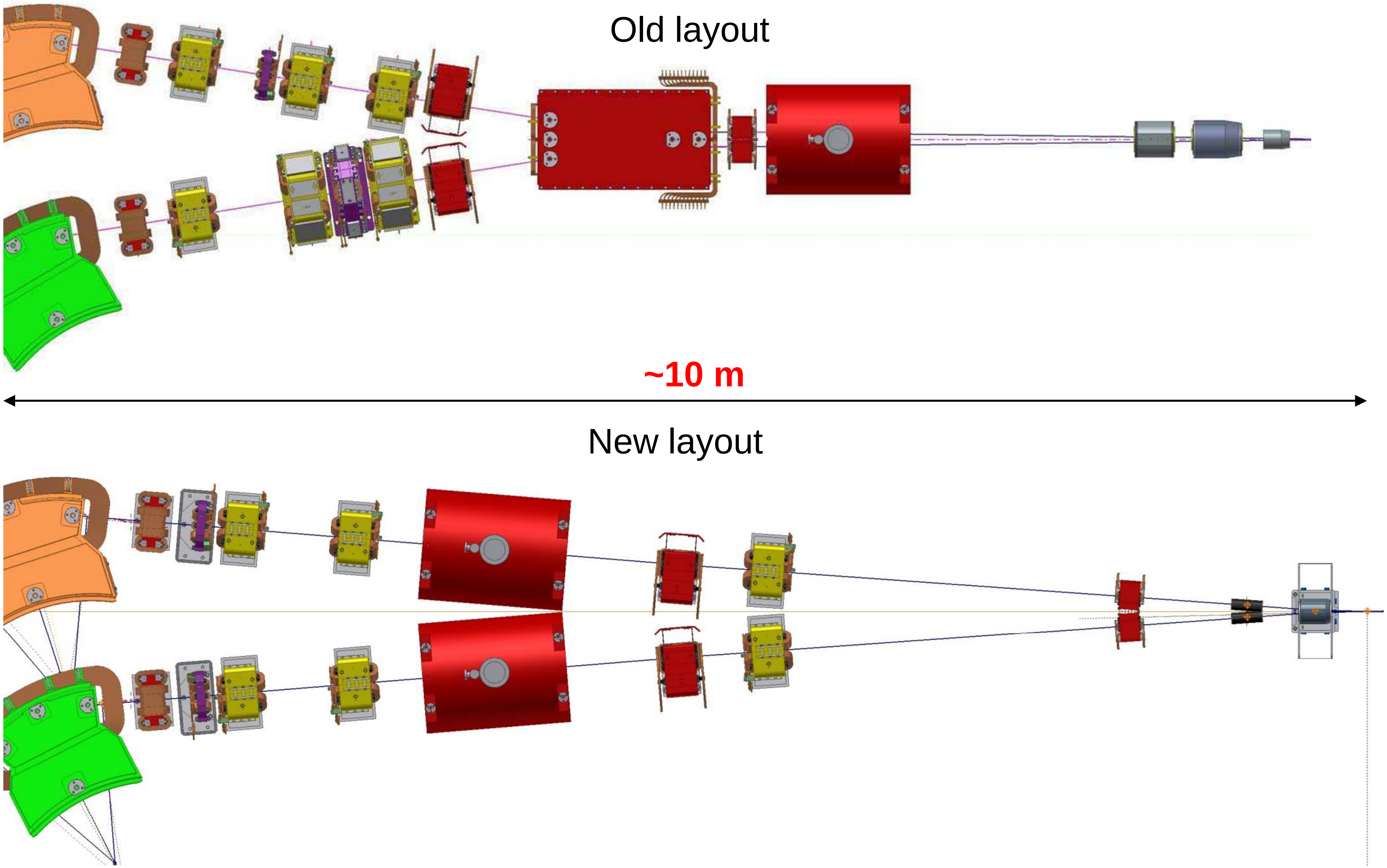
	DAΦNE KLOE	DAΦNE Upgrade
I_{bunch} (mA)	13	13
N_{bunch}	110	110
β_y* (cm)	1.7	0.65
β_x* (cm)	170	20
σ_y* (μm)	7	2.6
σ_x* (mm)	0.7	0.2
σ_z (mm)	25	20
$\theta_{cross}/2$ (mrad)	12.5	25
$\Phi_{Piwinski}$	0.45	2.5
L ($cm^{-2}s^{-1}$) x10^{32}	1.5	>5

Interaction Region Sketch

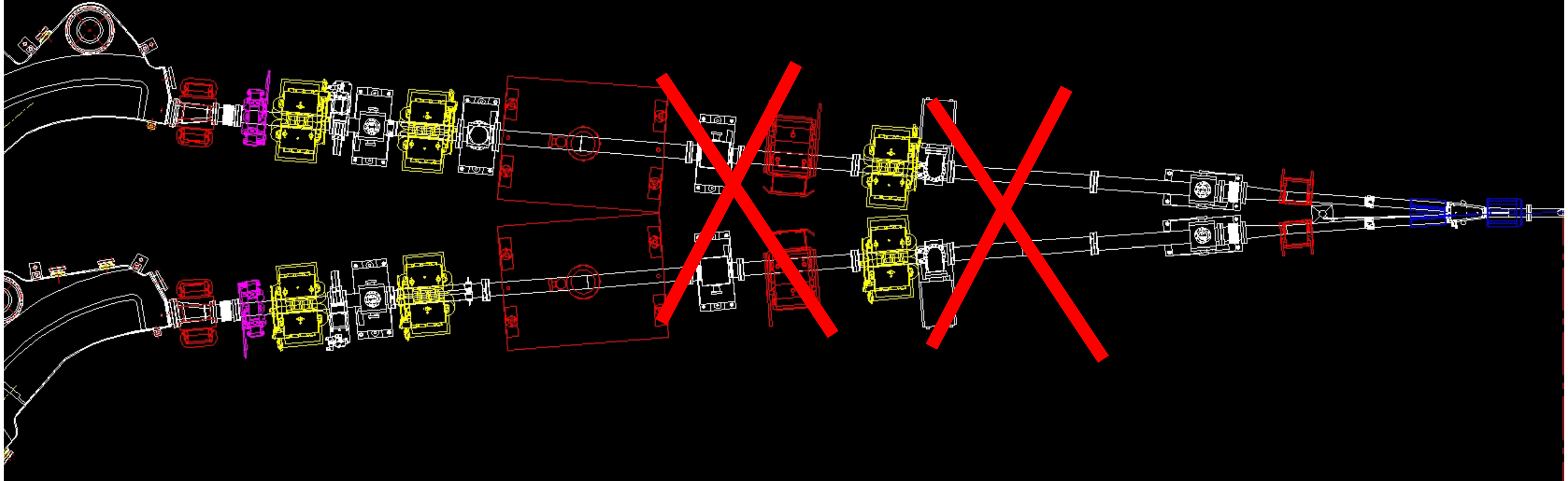
- Removed splitter dipoles (on both interaction regions)
- Designed a new vacuum chambers for IP regions
- Adjusted field and position of dipoles facing the IP
- Designed new permanent magnets at the IP1 region
- Relocated all the other elements (quads, sexts etc)
- Designed new components (bellows, etc)
- Upgraded the vacuum system for the crossing regions

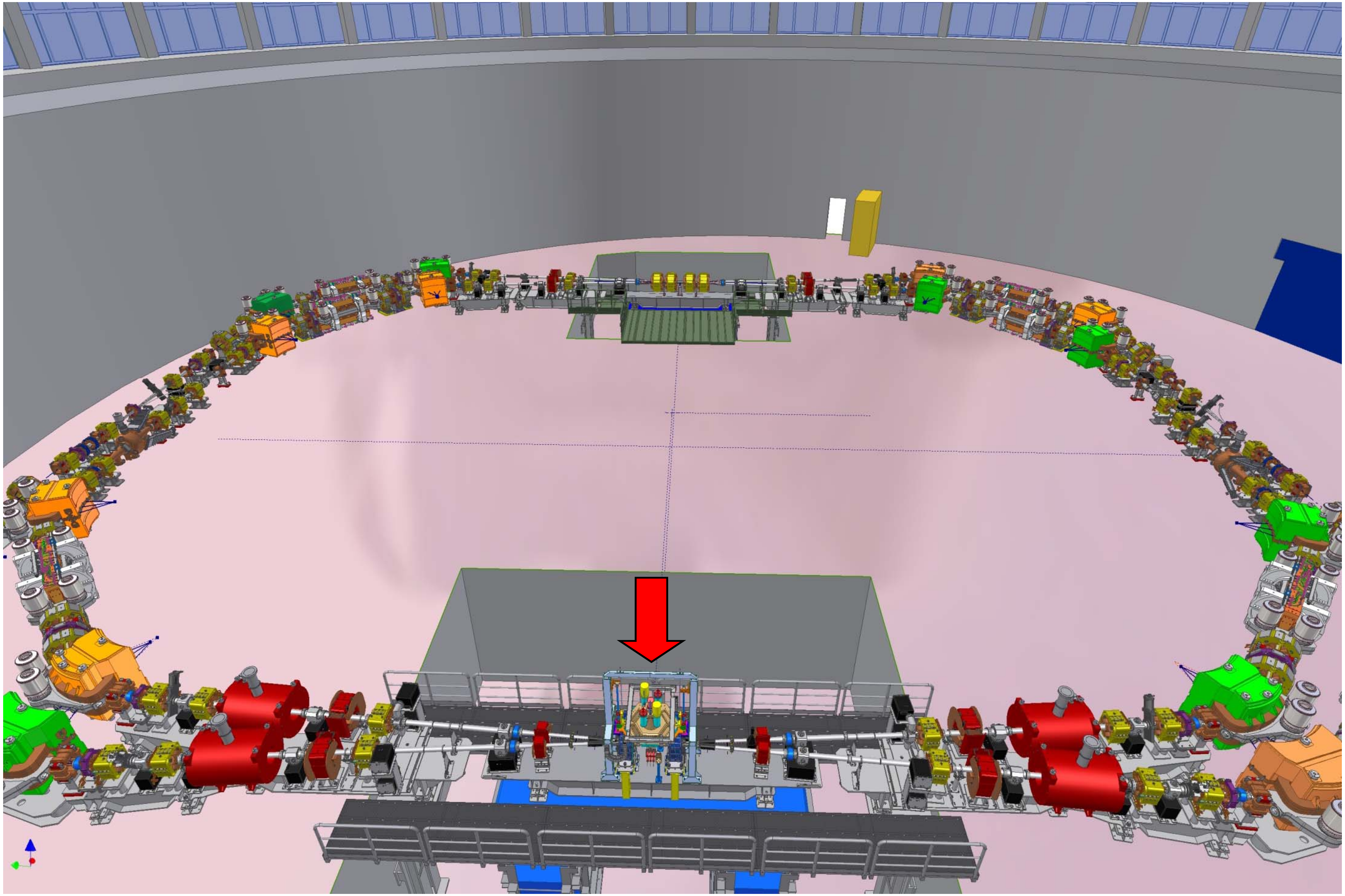


IR Magnetic Layout: old & new (half)

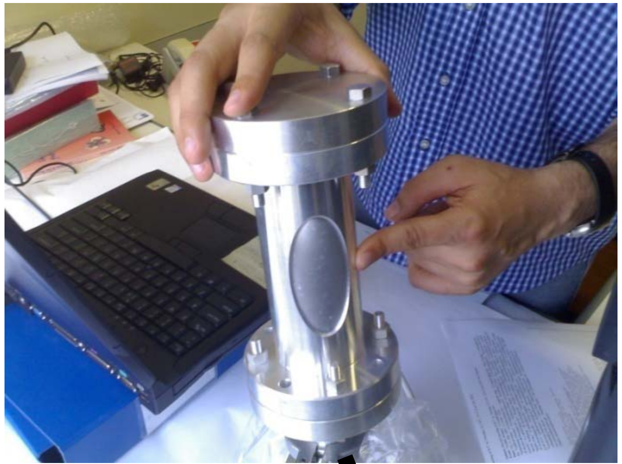


Crossing Region Layout

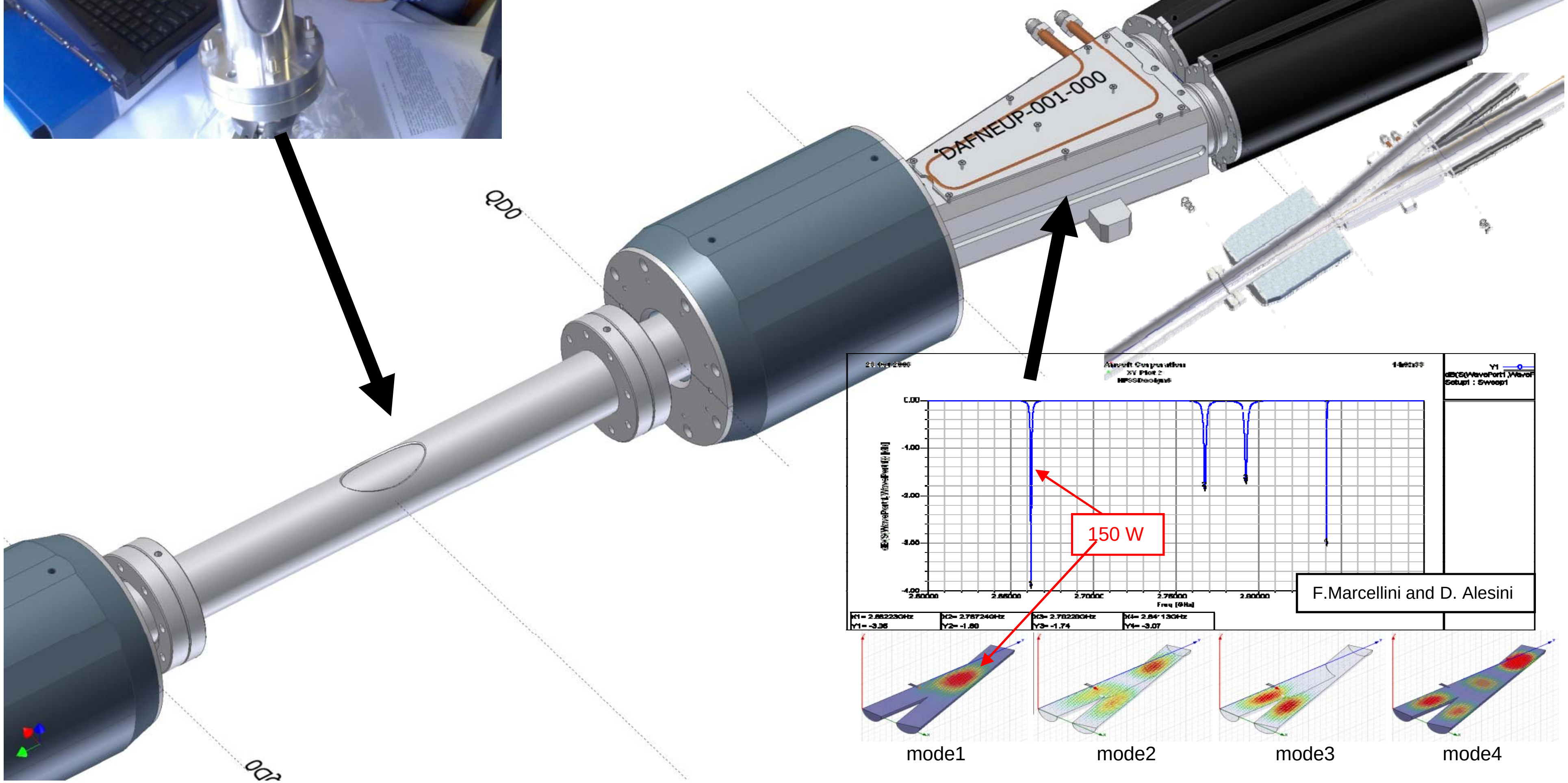




IP for SIDDHARTA Experiment

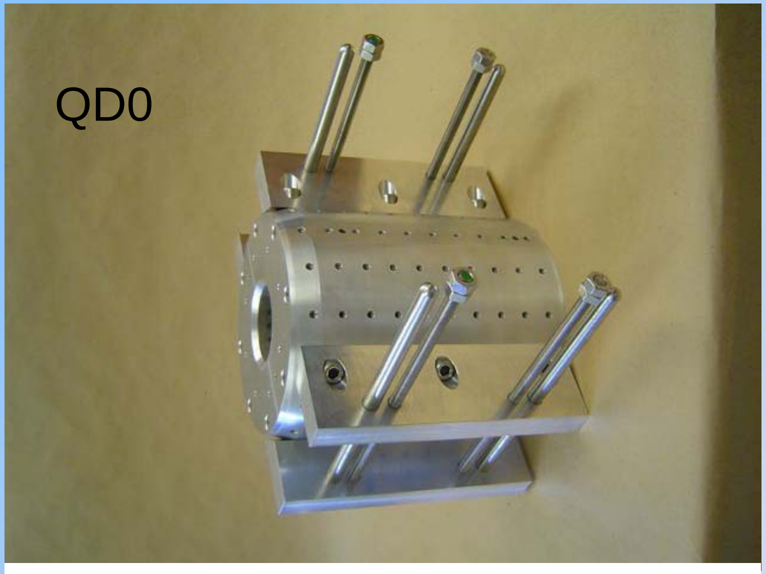


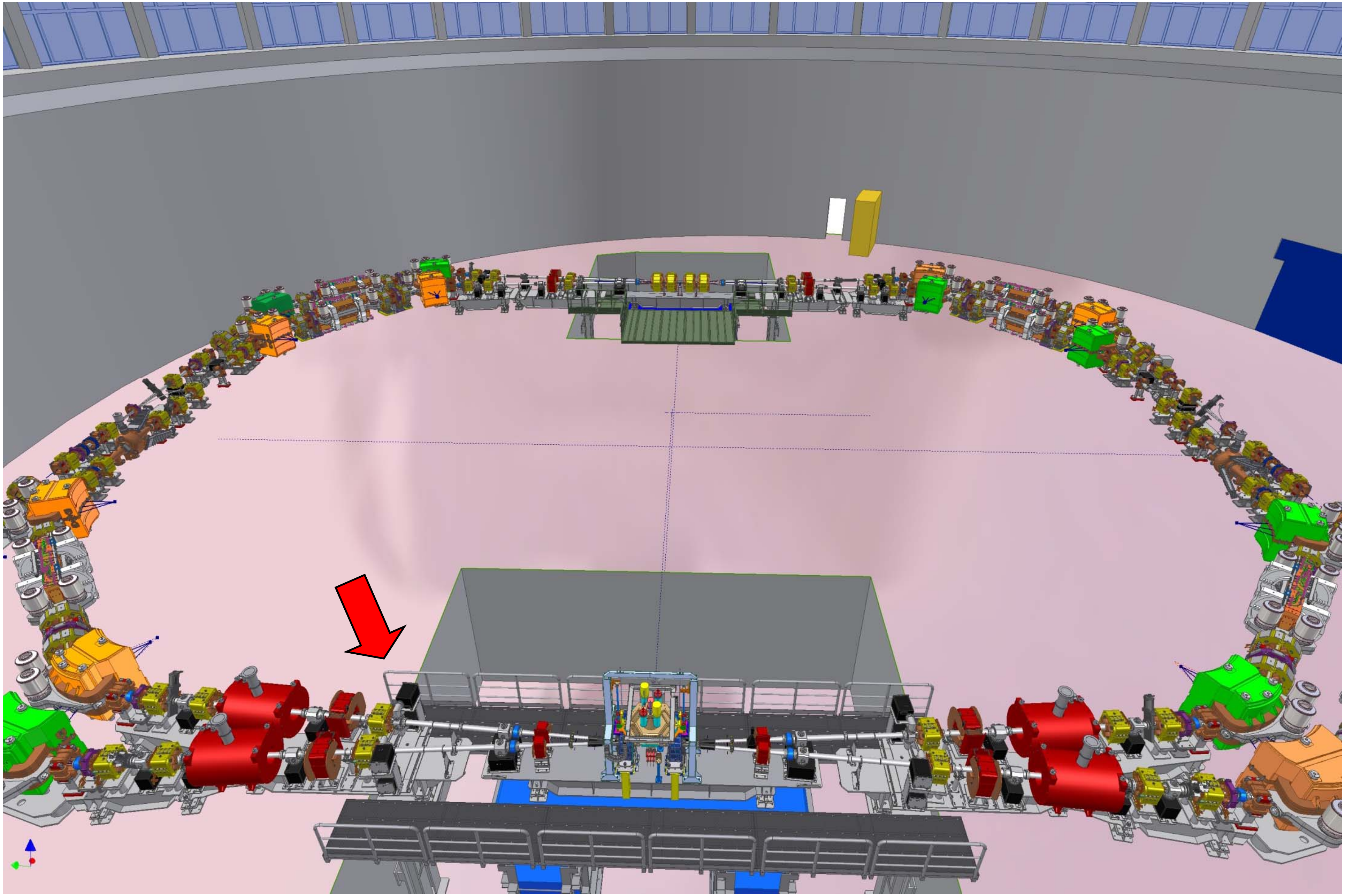
- Aluminum made (AL6082) (very cheap)
- Thin window thickness= 0.3 mm
- Mechanical and Vacuum test done
- Delivery by the end of September

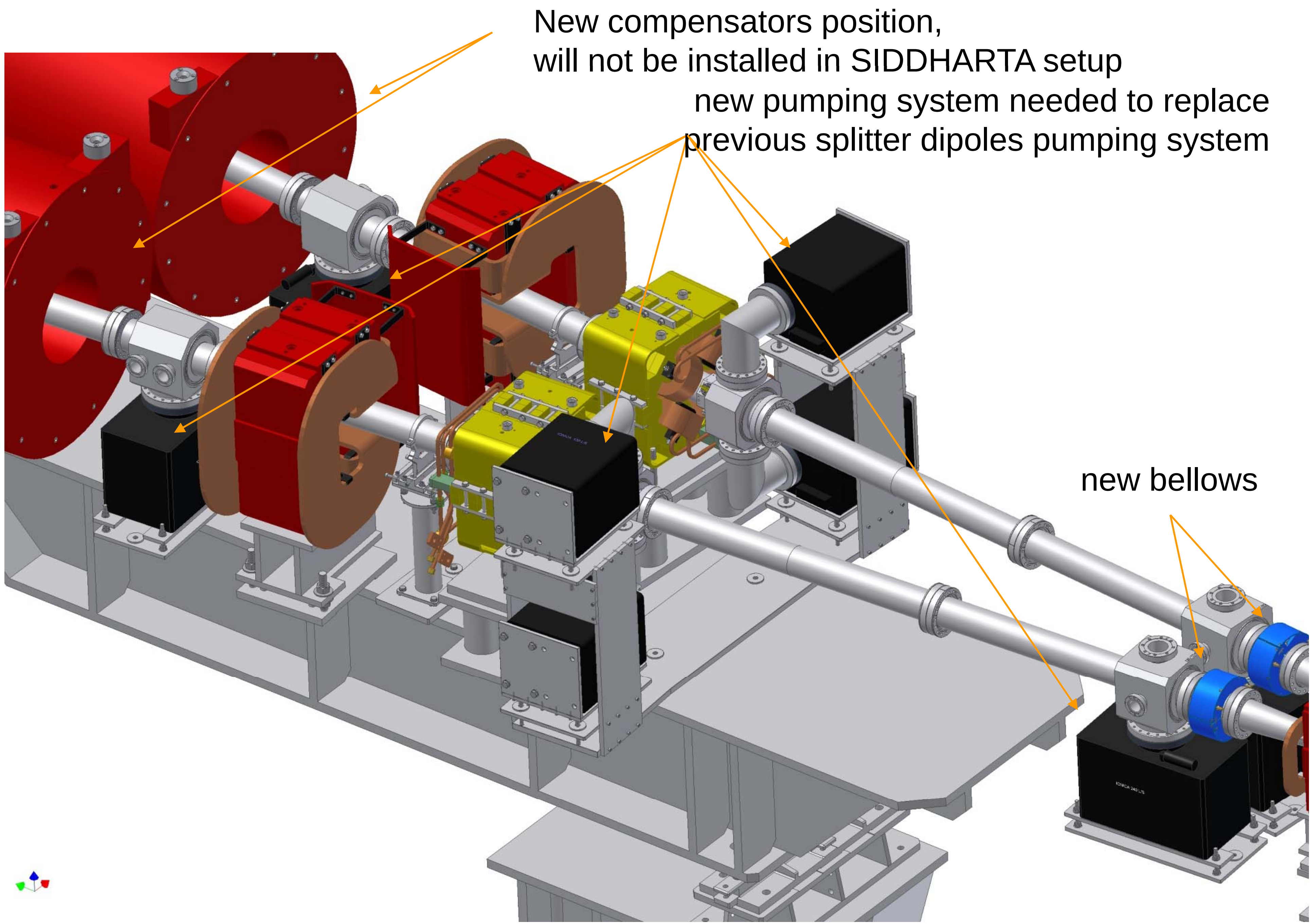


Low-β PM Quadrupole

Parameters	**QD0**	**QF1**
Quantity	2	4
Minimum clear inner radius (mm)	33	30
PM inner radius (mm)	34	30.5
Maximum outer radius (mm)	100	45
Magnetic length (mm)	230	240
REM physical length (mm)	230	240
Maximum mechanical length (mm)	240	250
Nominal gradient (T/m)	29.2	12.6
Integrated gradient (T)	6.7	3.0
Good field region radius (mm)	20	20
Integrated field quality |dB/B|	5.00E-04	5.00E-04
REM stabilization temperature (°C)	150	150
Magnet material type	SmCo2:17	SmCo2:17
Magnet construction	2 halves	2 halves

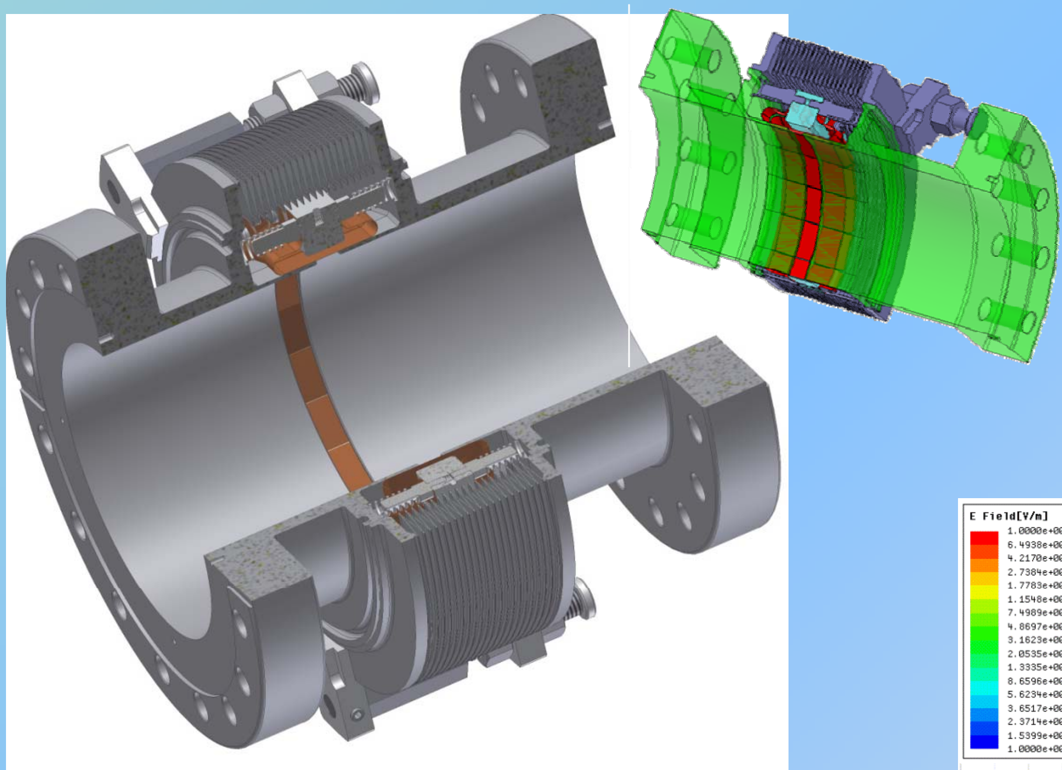


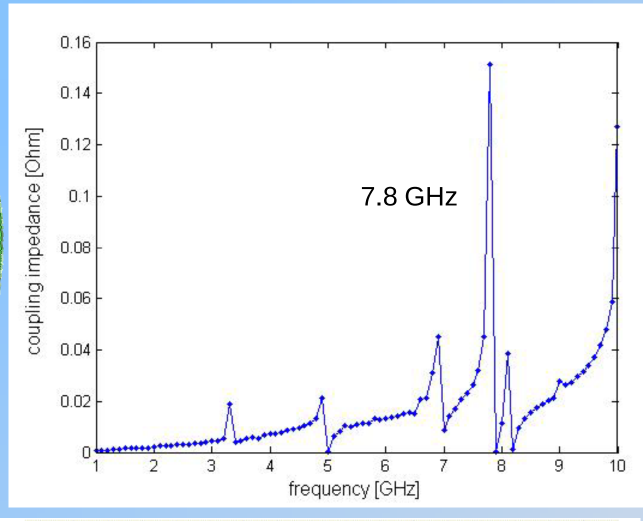




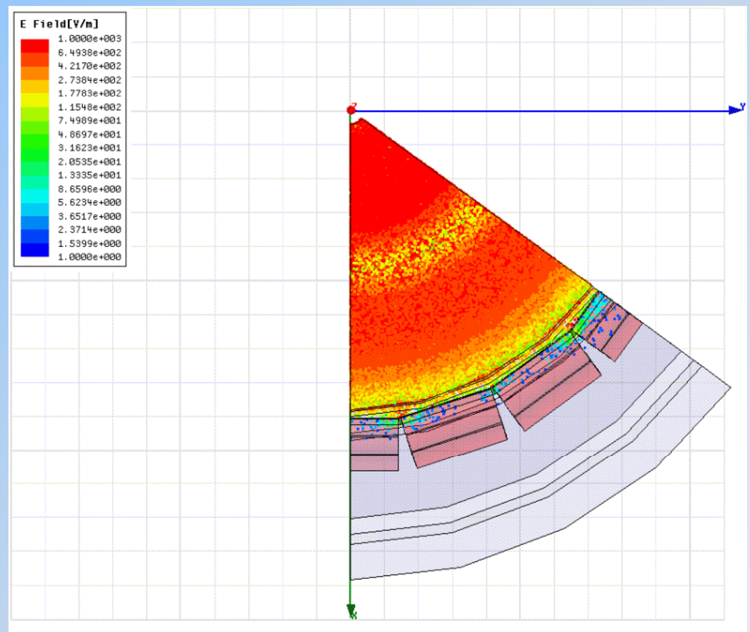
New compensators position,
will not be installed in SIDDHARTA setup
new pumping system needed to replace
previous splitter dipoles pumping system
new bellows

Ω Shielded Bellows





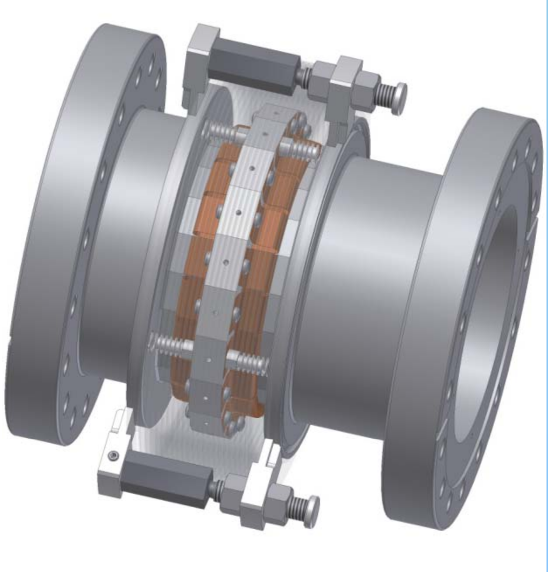
Axial working stroke = ±7 mm
Radial offset = ±3 mm

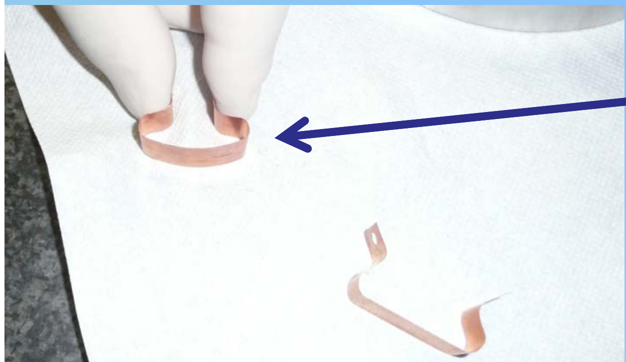


HFSS simulation

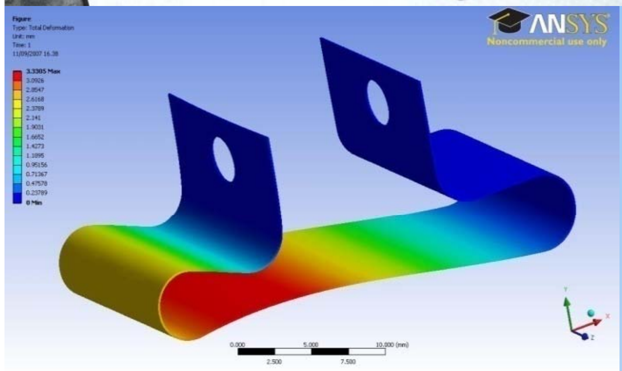
- Beam excited fields in the bellows structure
- No significant fields in the volume beyond the shield @ resonance

Ω Shielded Bellows

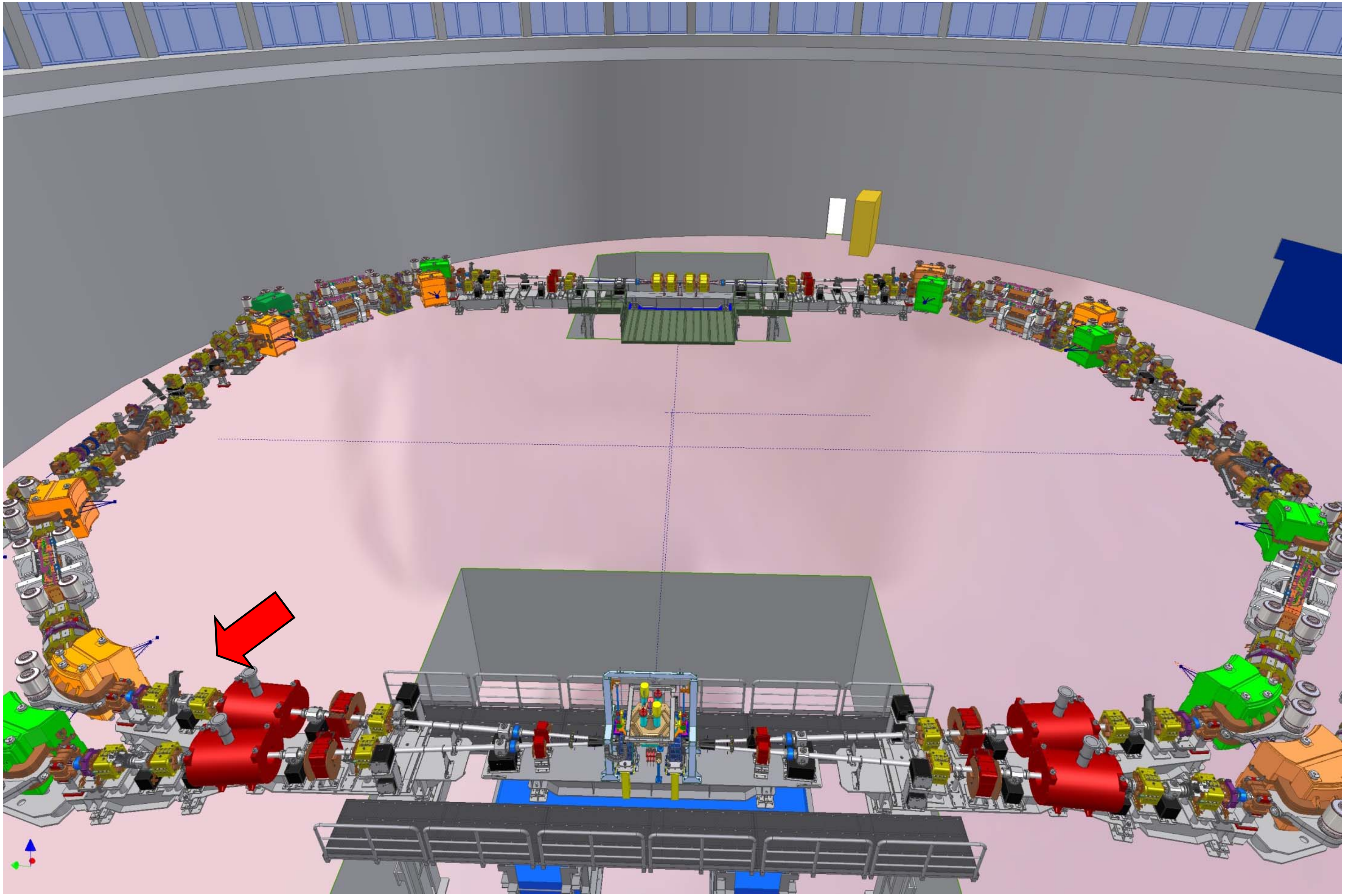


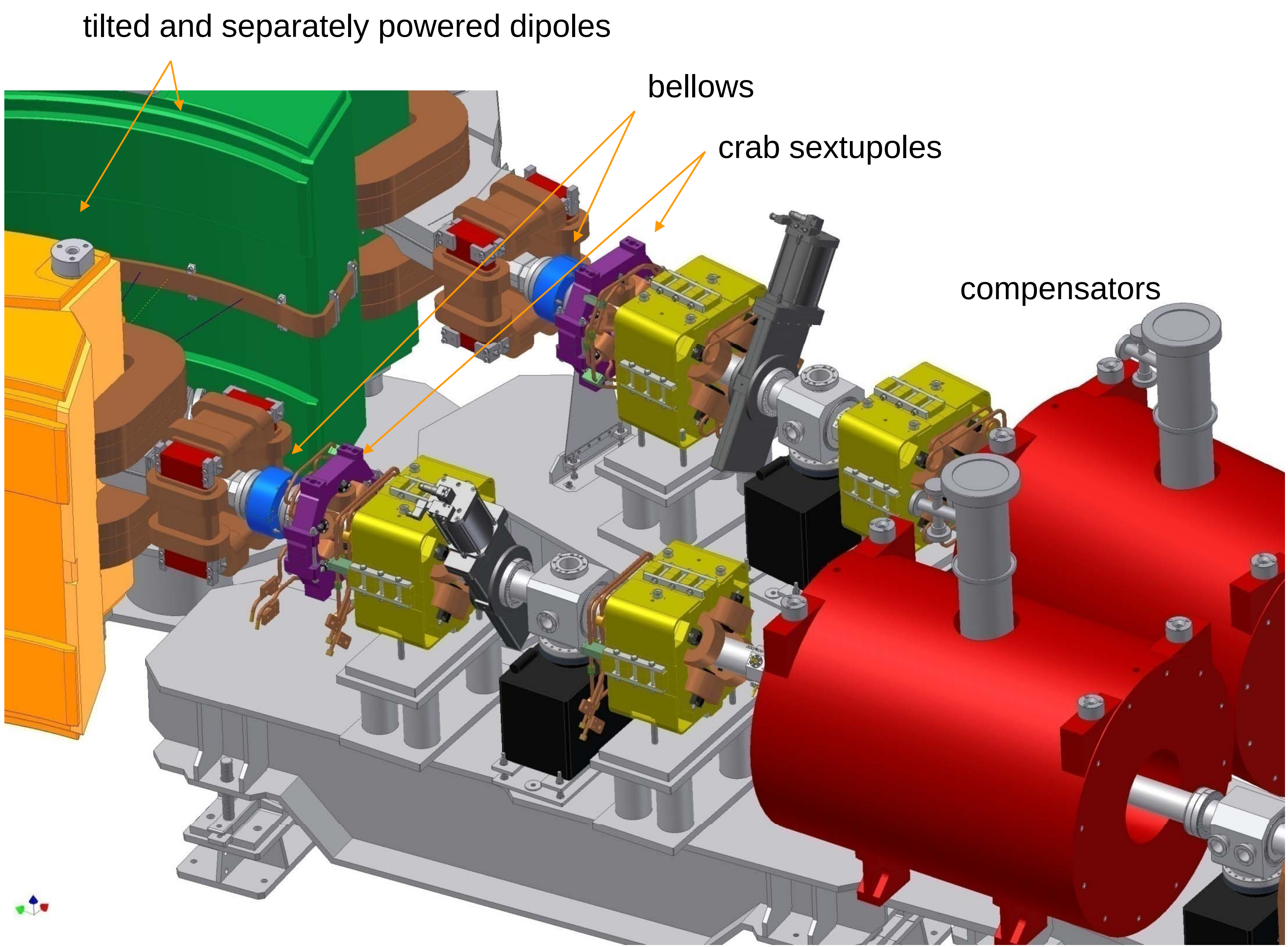


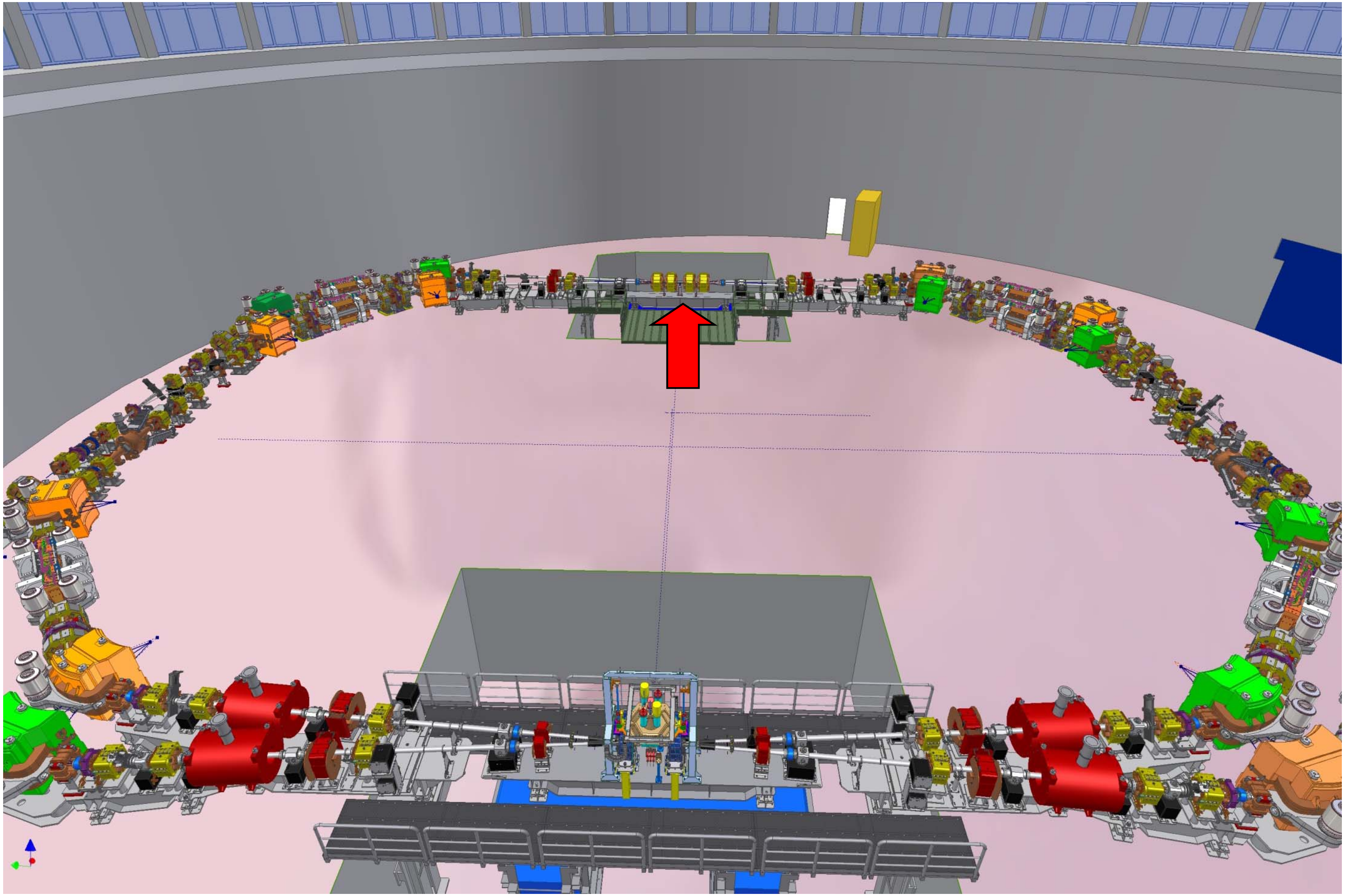
Be-Cu Ω strip



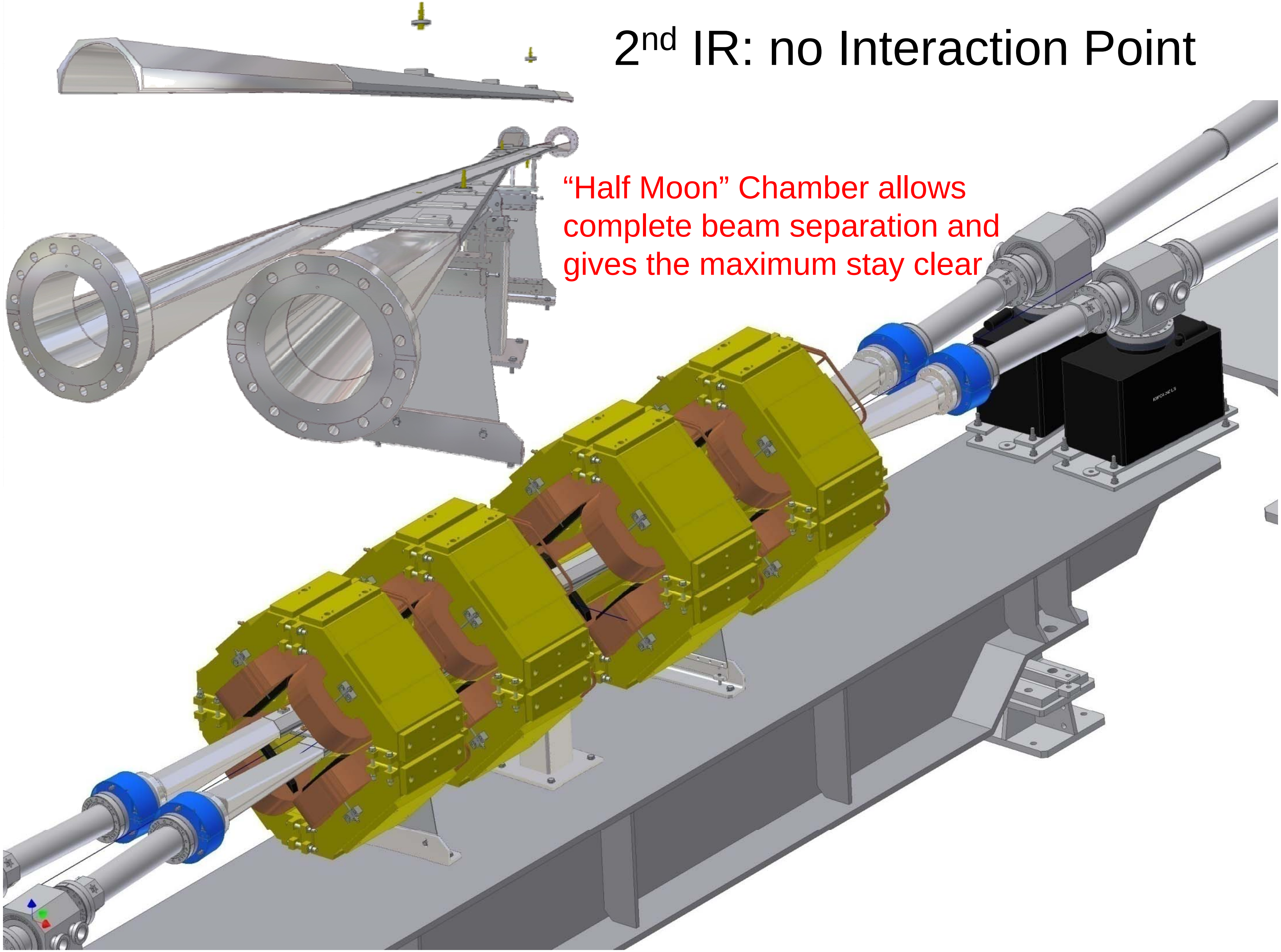
- Shielding based on Be-Cu Ω strips 0.2 mm thickness

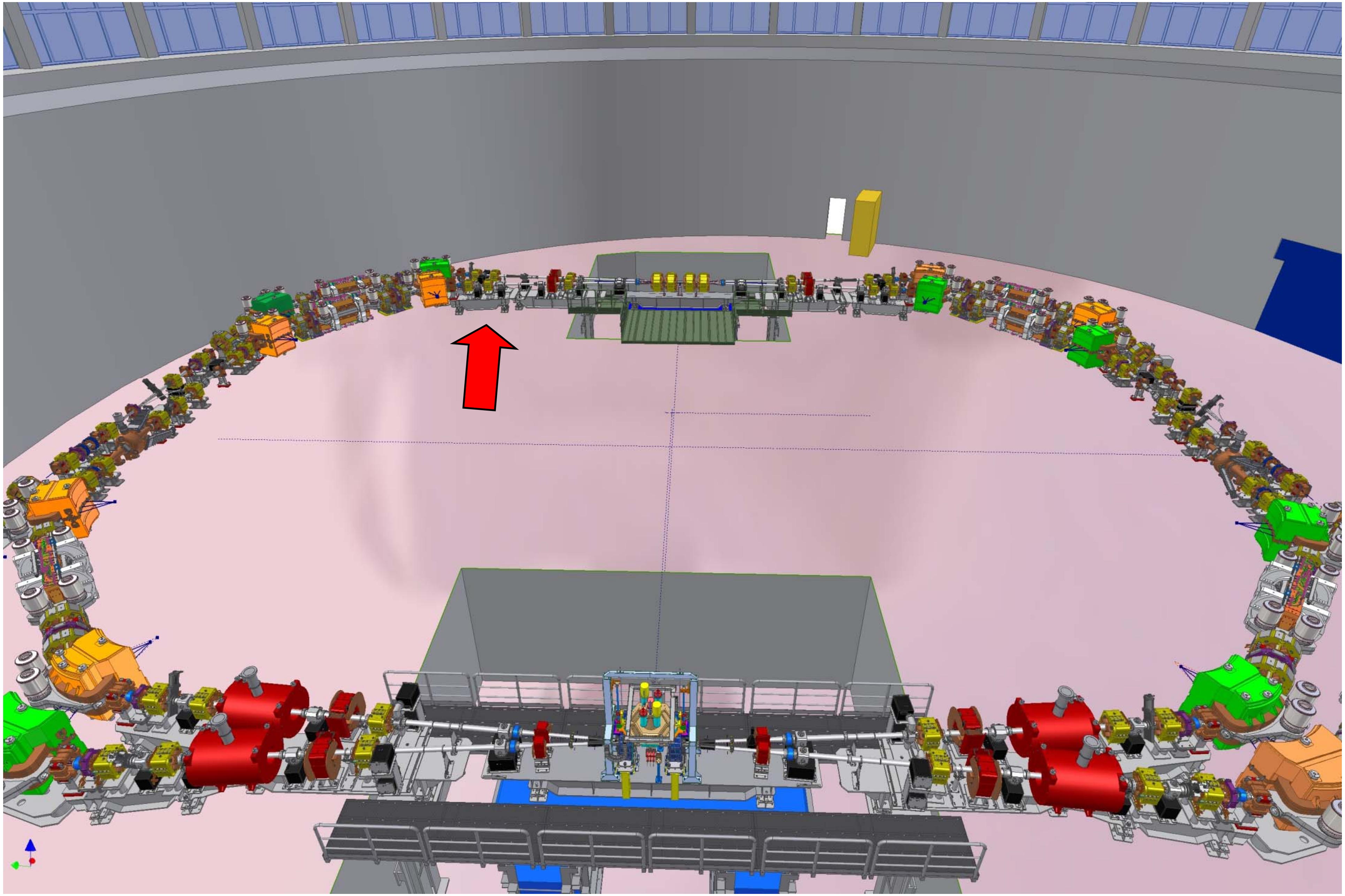



tilted and separately powered dipoles
bellows
crab sextupoles
compensators



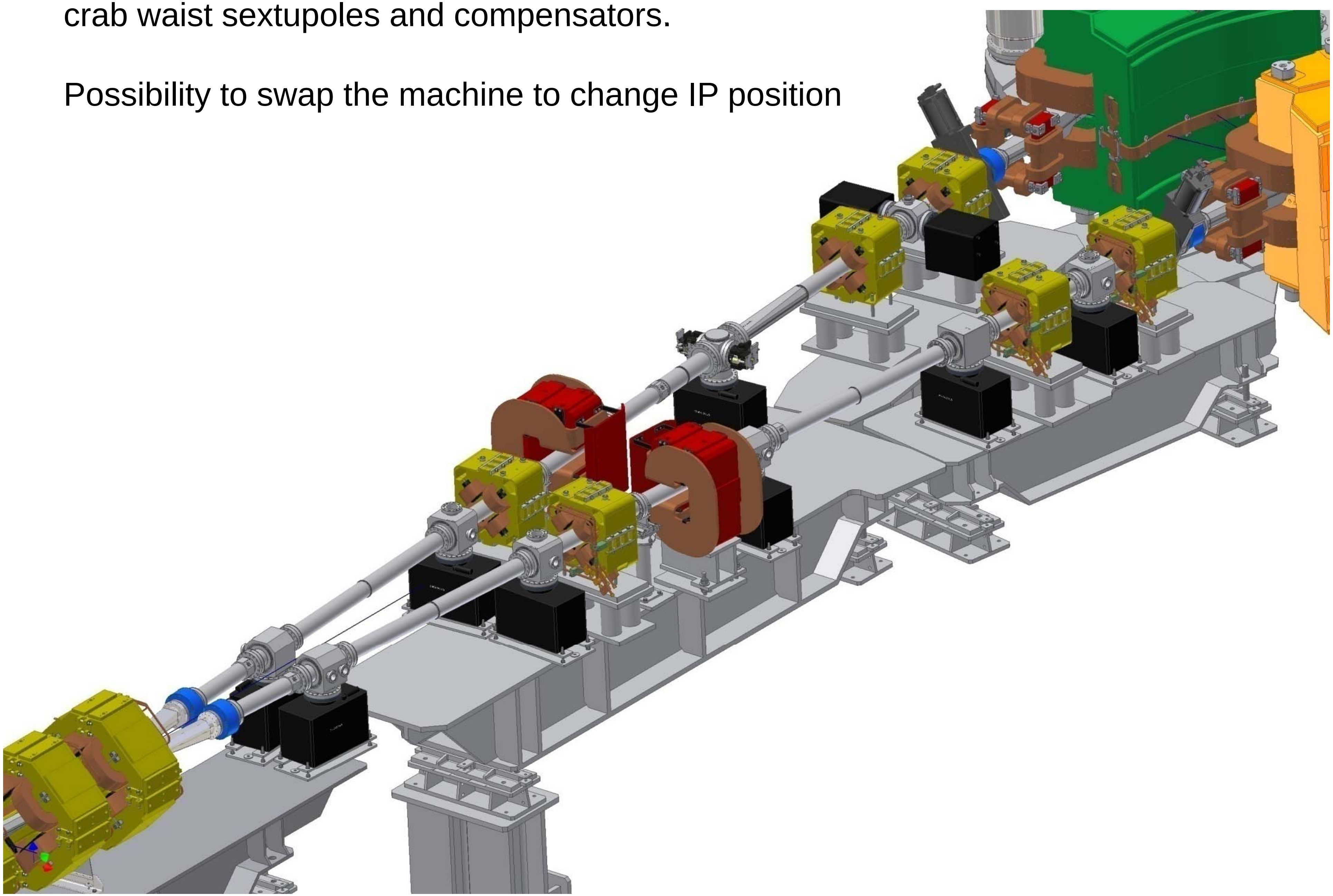
2^{nd} IR: no Interaction Point

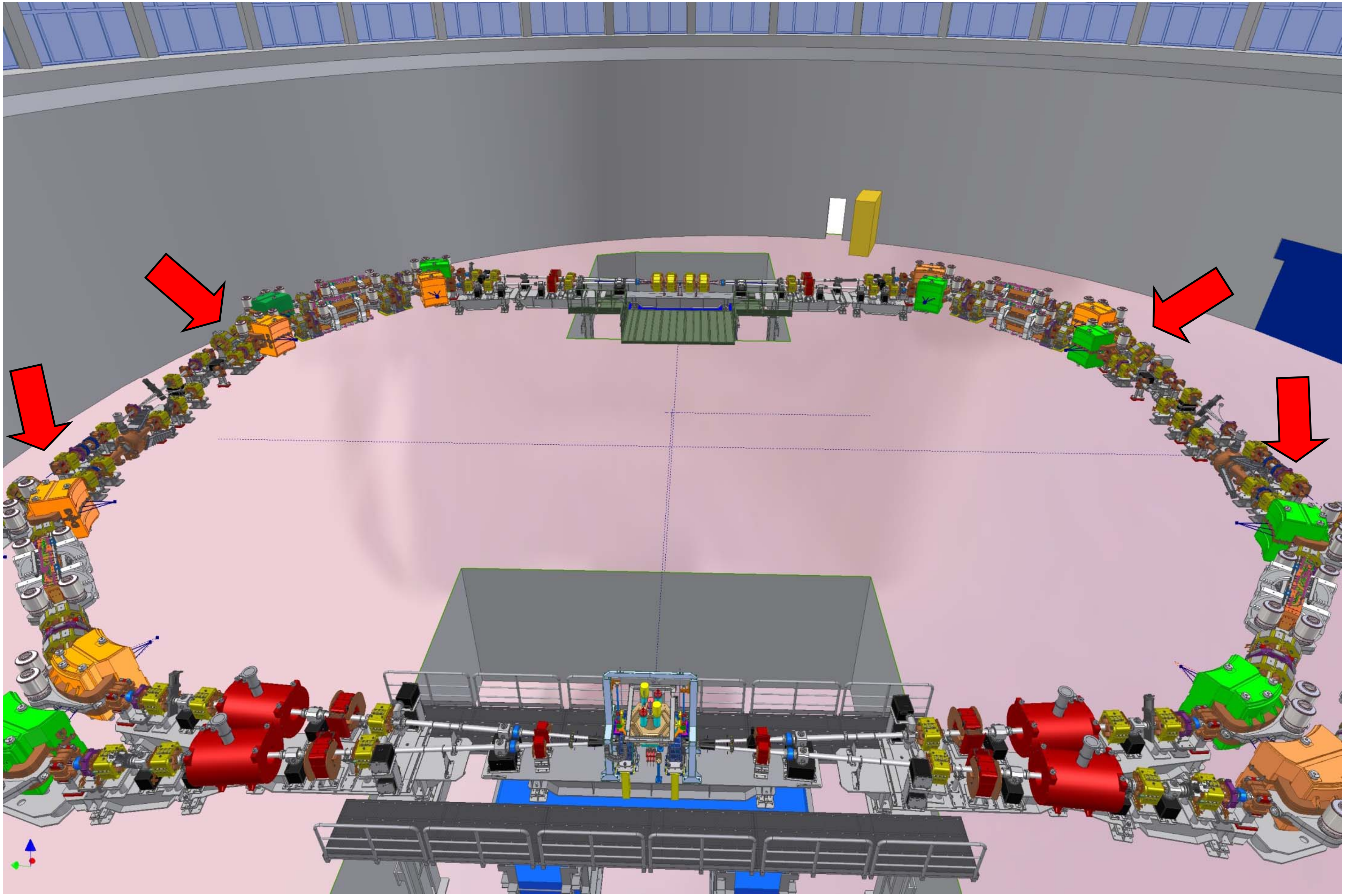


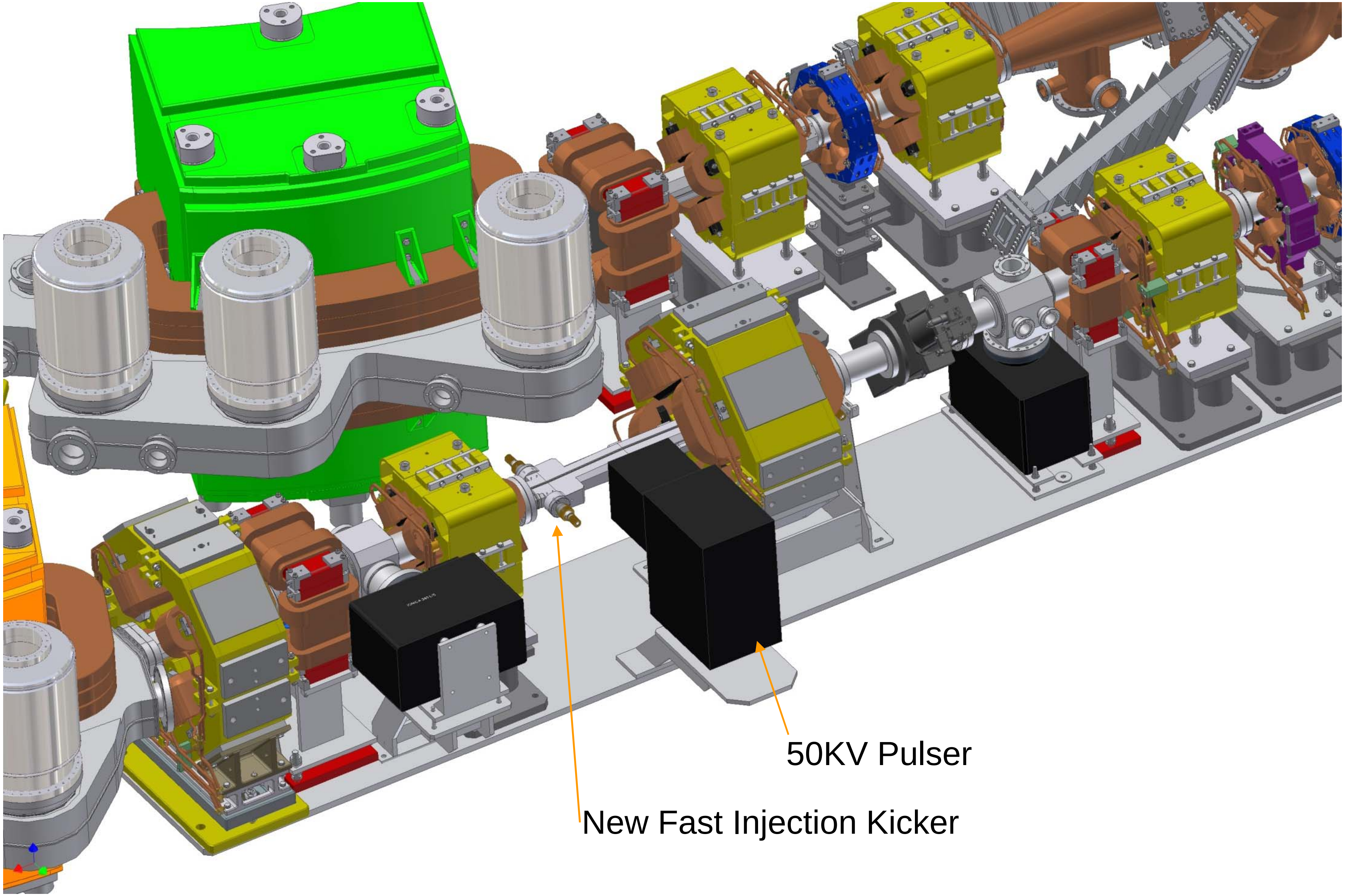


IR2 Y is completely symmetric to IR1 except for crab waist sextupoles and compensators.

Possibility to swap the machine to change IP position

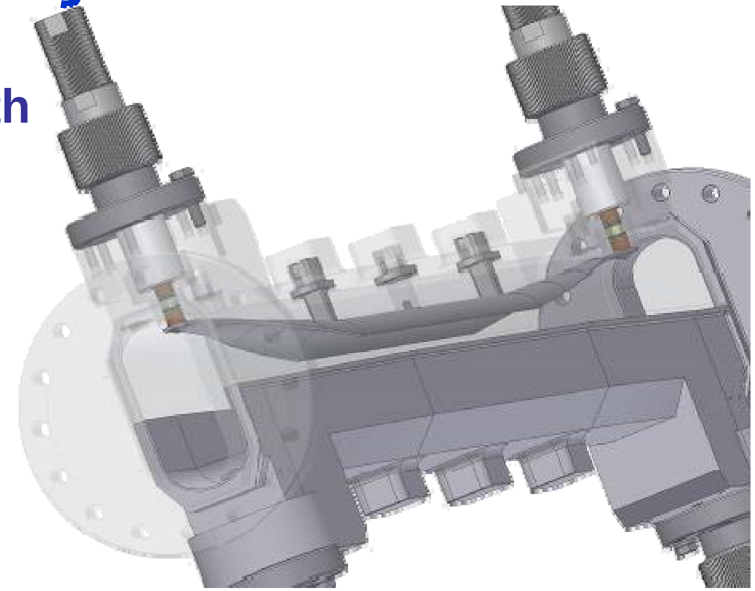


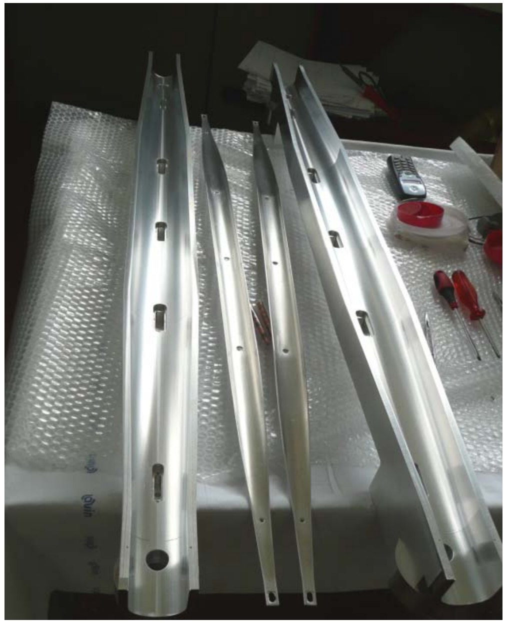


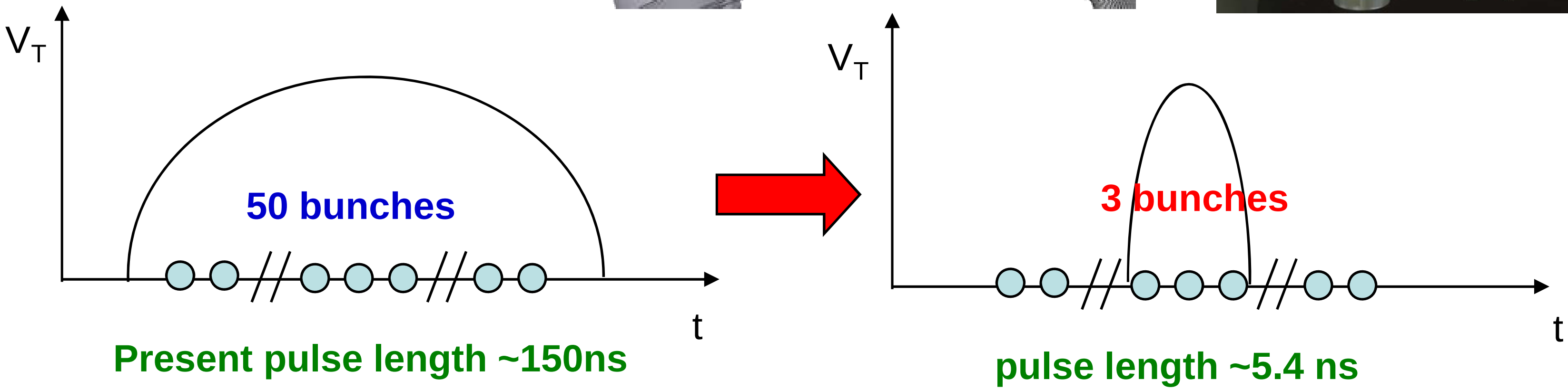

50KV Pulser
New Fast Injection Kicker

New Fast Injection Kickers

New stripline kicker with **5.4 ns flat top pulse length** to reduce perturbation on stored beam



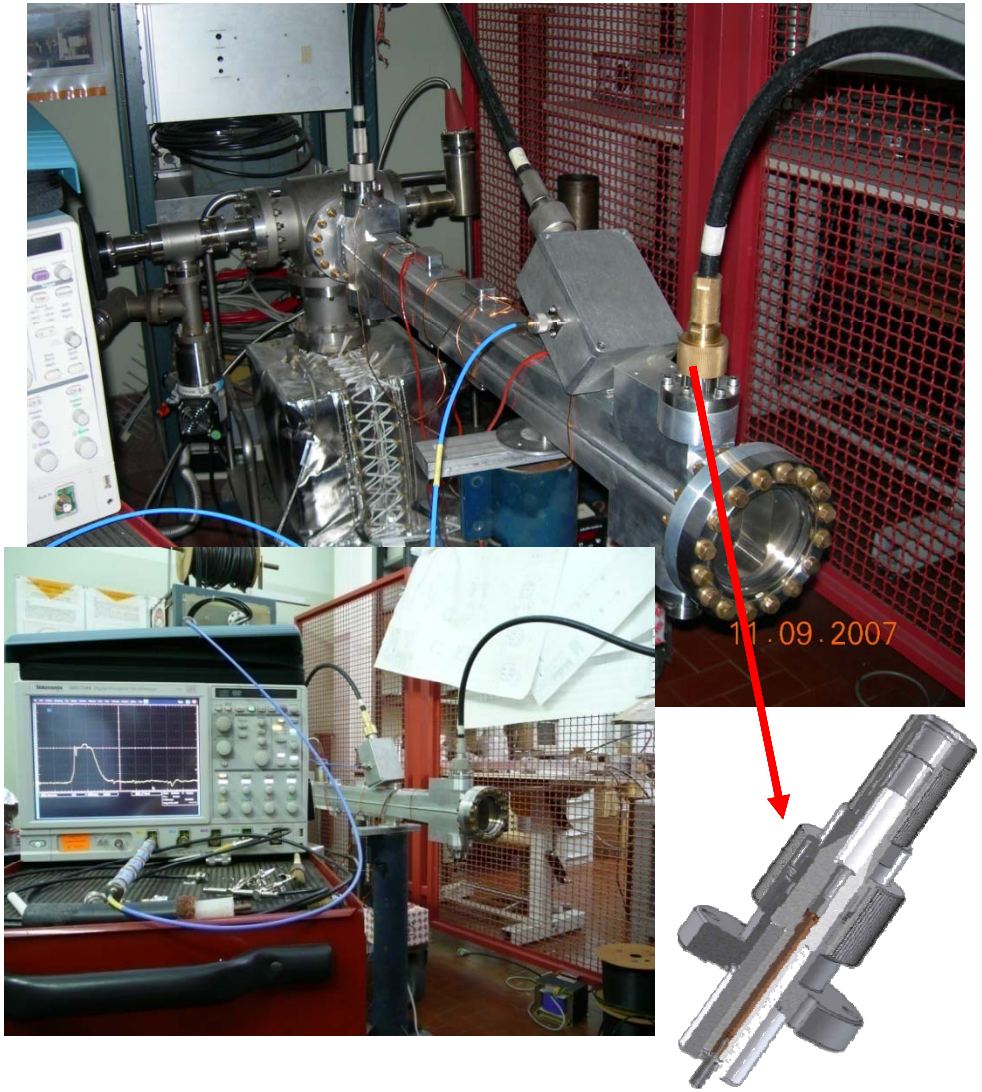




Expected benefits:

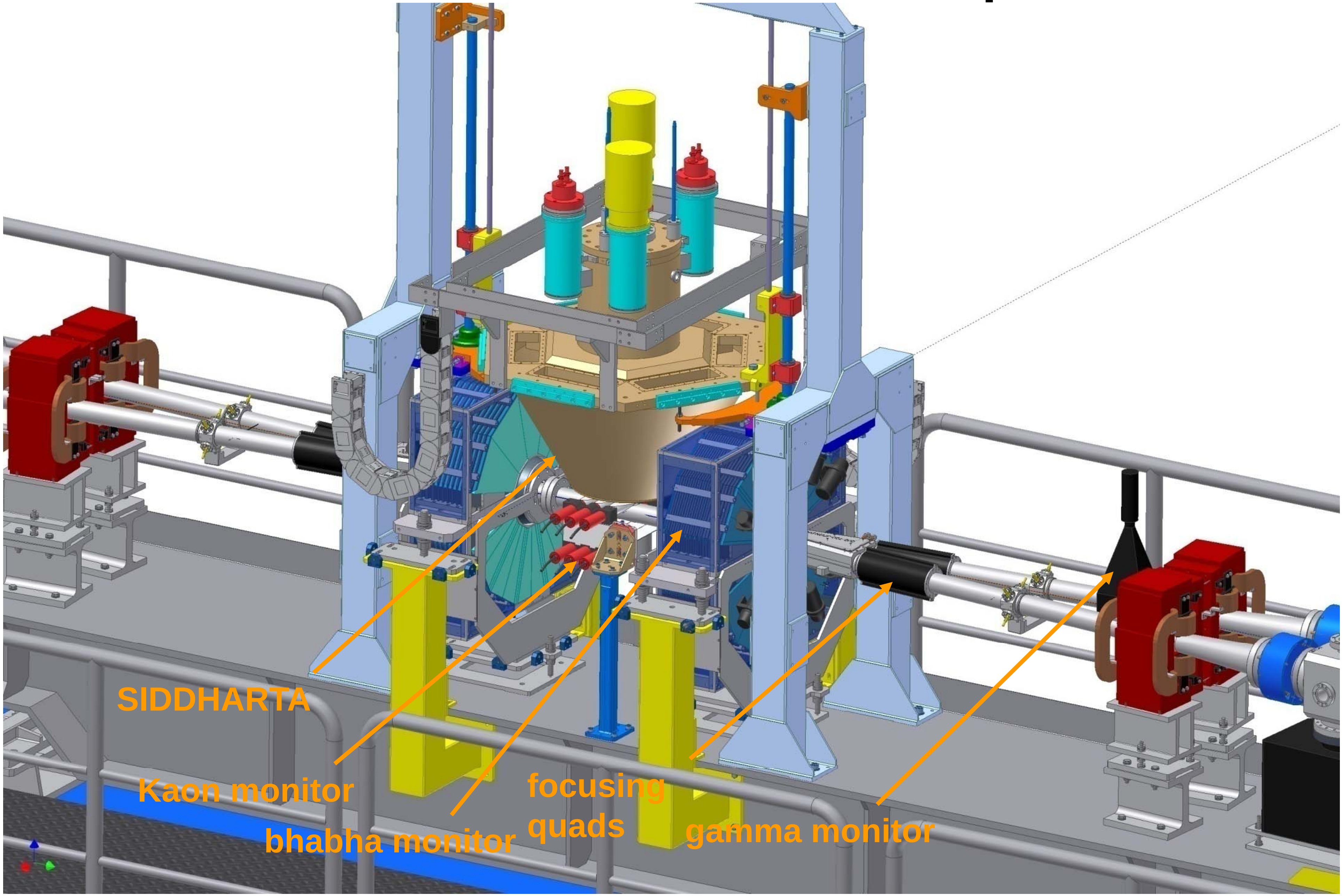
- higher maximum stored currents
- Improved stability of colliding beams during injection
- less background allowing data acquisition during injection

New Fast Injection Kickers

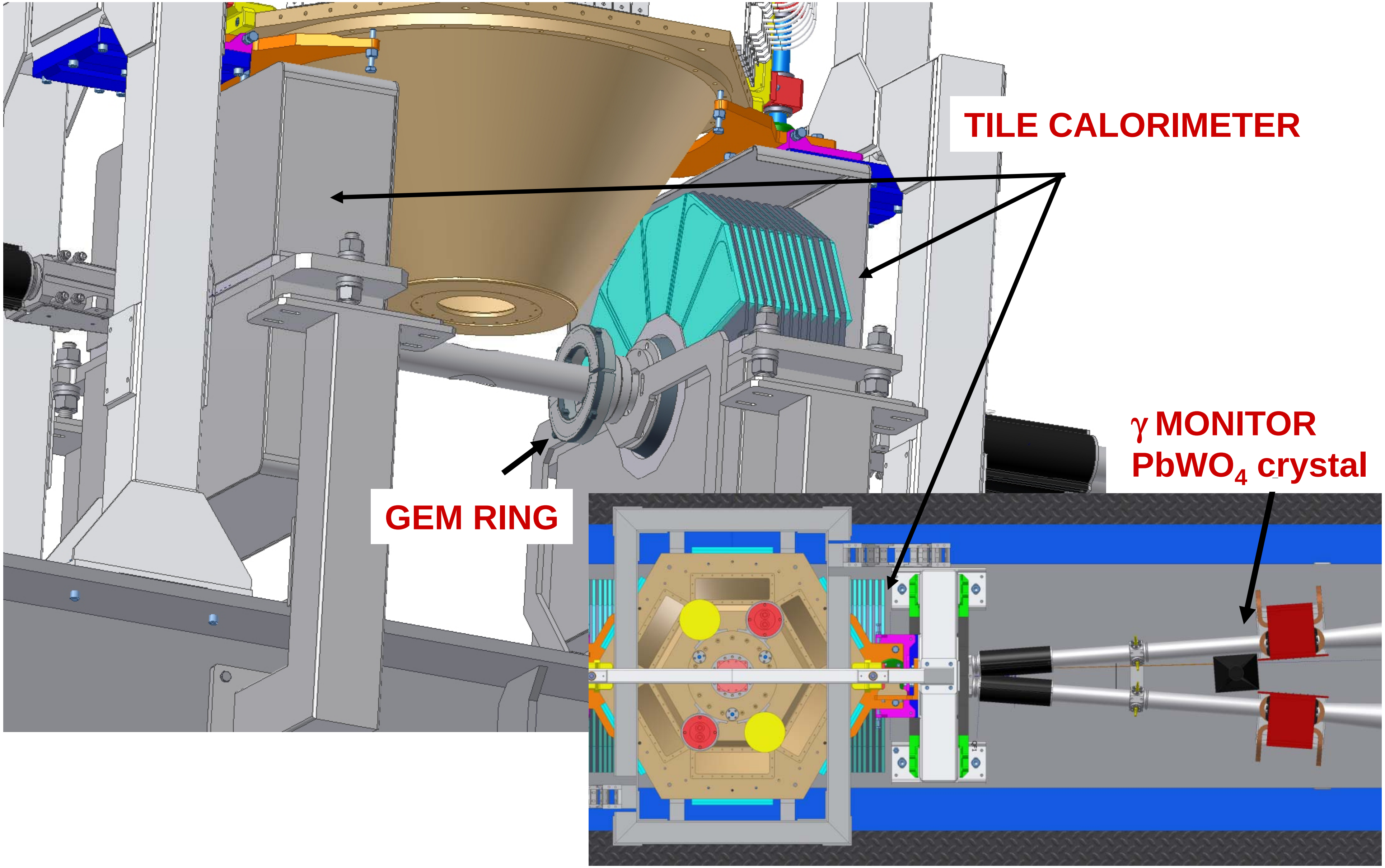


- Kicker final design completed at end of April
- Pulse generator prototype successfully tested and the final version ordered
- 50 KV final feed-through successfully tested and manufactured
- First Kicker was delivered at the end of June; vacuum and electrical test were successfully performed
- Other 5 kickers will be delivered by the end of September and installed in DAΦNE

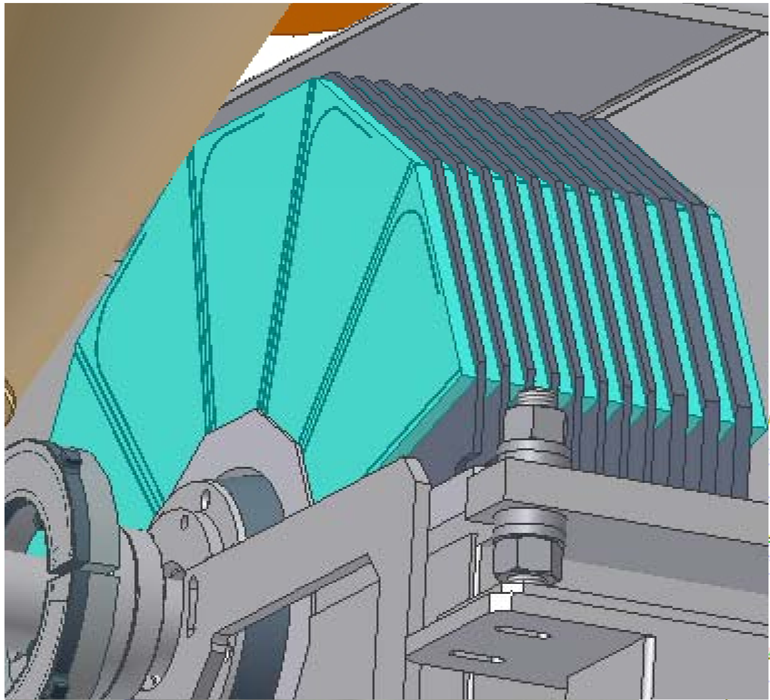
SIDDHARTA Setup



Luminosity monitor for SIDDAHRTA run

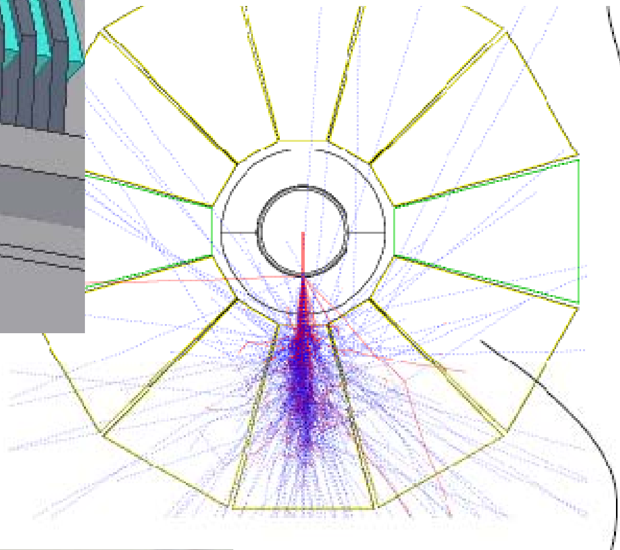


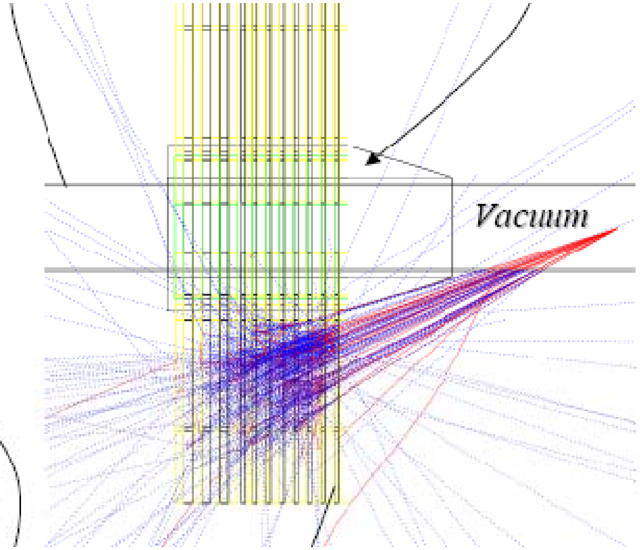
Tiles Bhabha calorimeter (lumi)

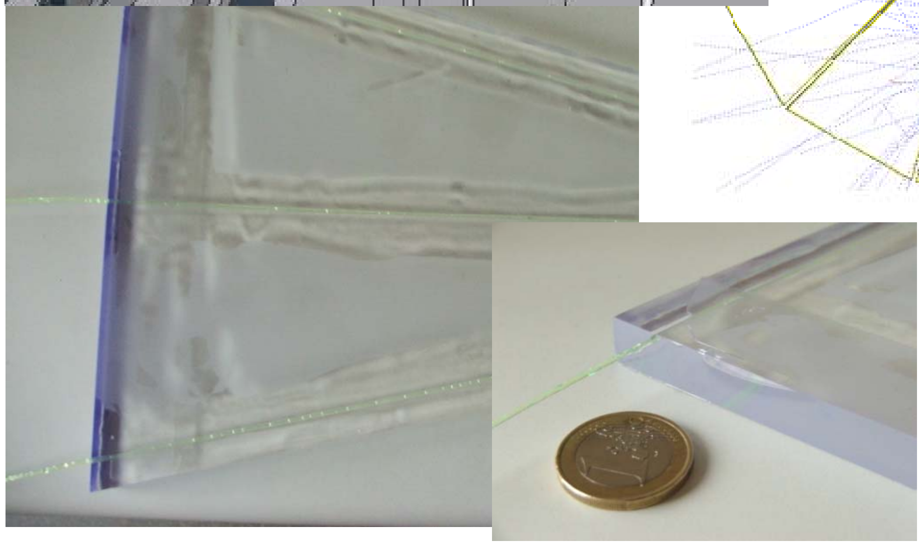


- 4 calorimeter composed by 5 sectors of 30 deg
- 7 lead sheet 5mm - 3 final lead sheet 10mm
- 12 Scintillating tiles a sector

12.5 X_0 15% resolution @ 510 MeV

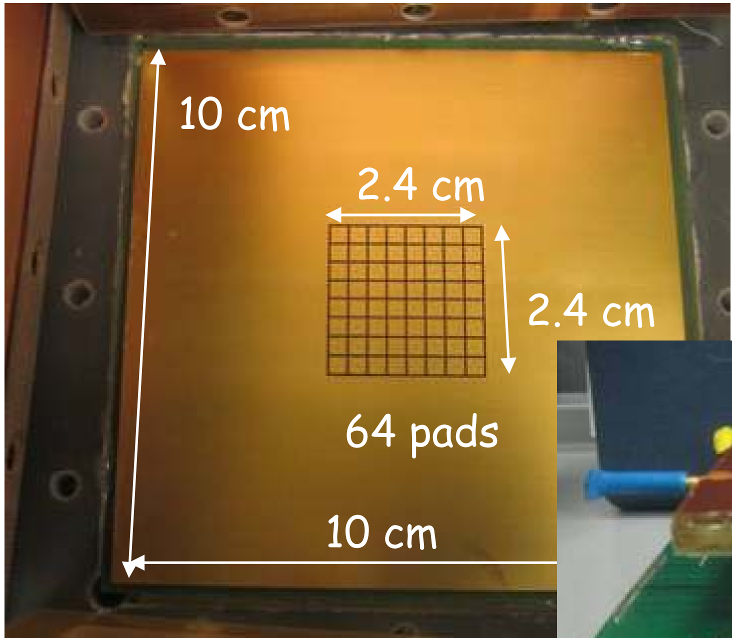


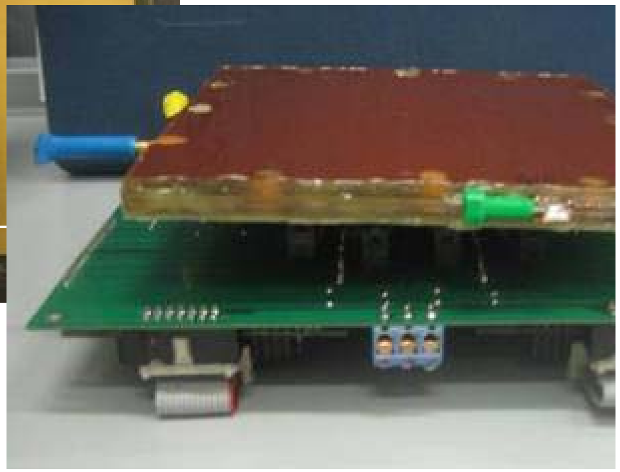




- First Russian tail sample arrived
- BTF test planed for October

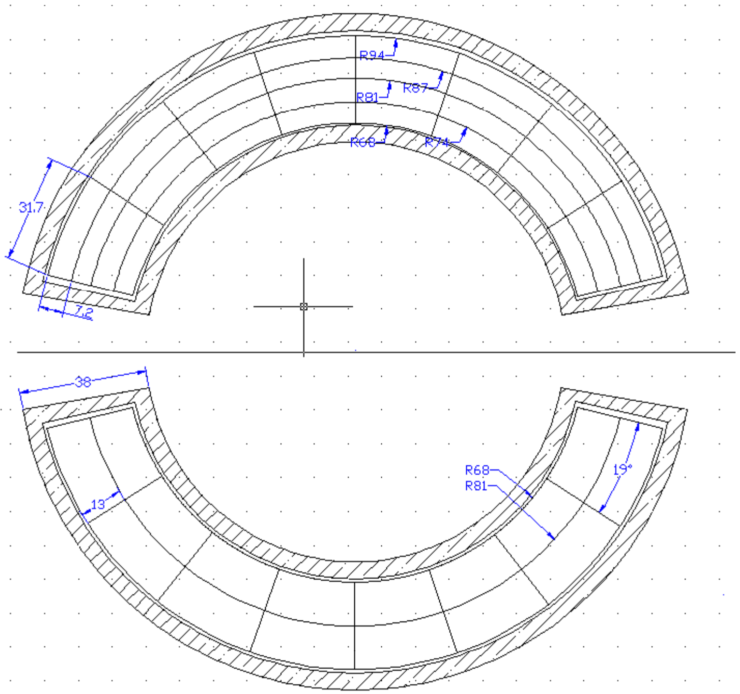
A 3GEM Monitor for DAΦNE





rectangular GEM prototype was tested @ DAFNE

Annular gem foil design
for bhabha detector
@ DAFNE

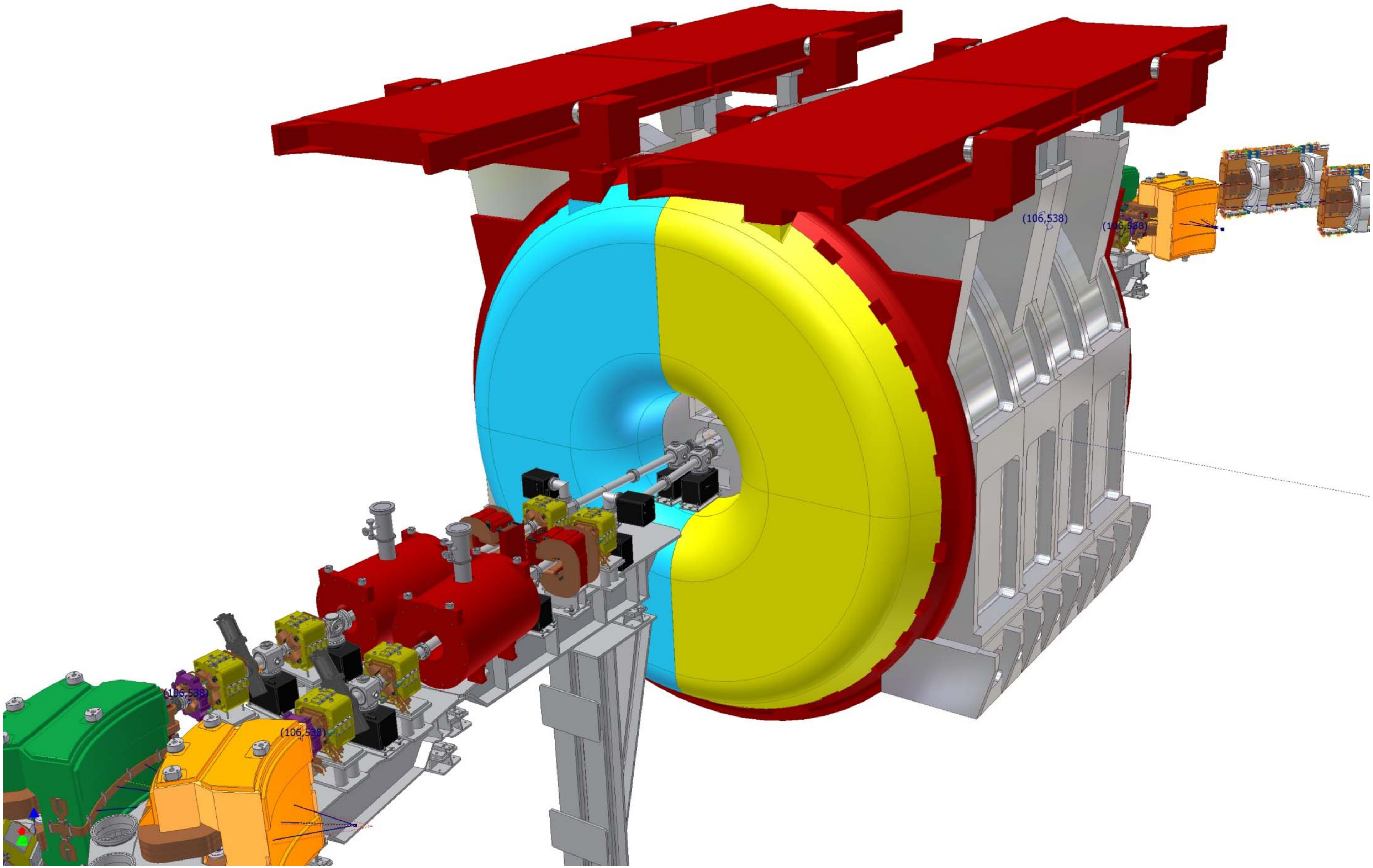


The read out has been realized using
8 chip ASDQ (8 channel each)

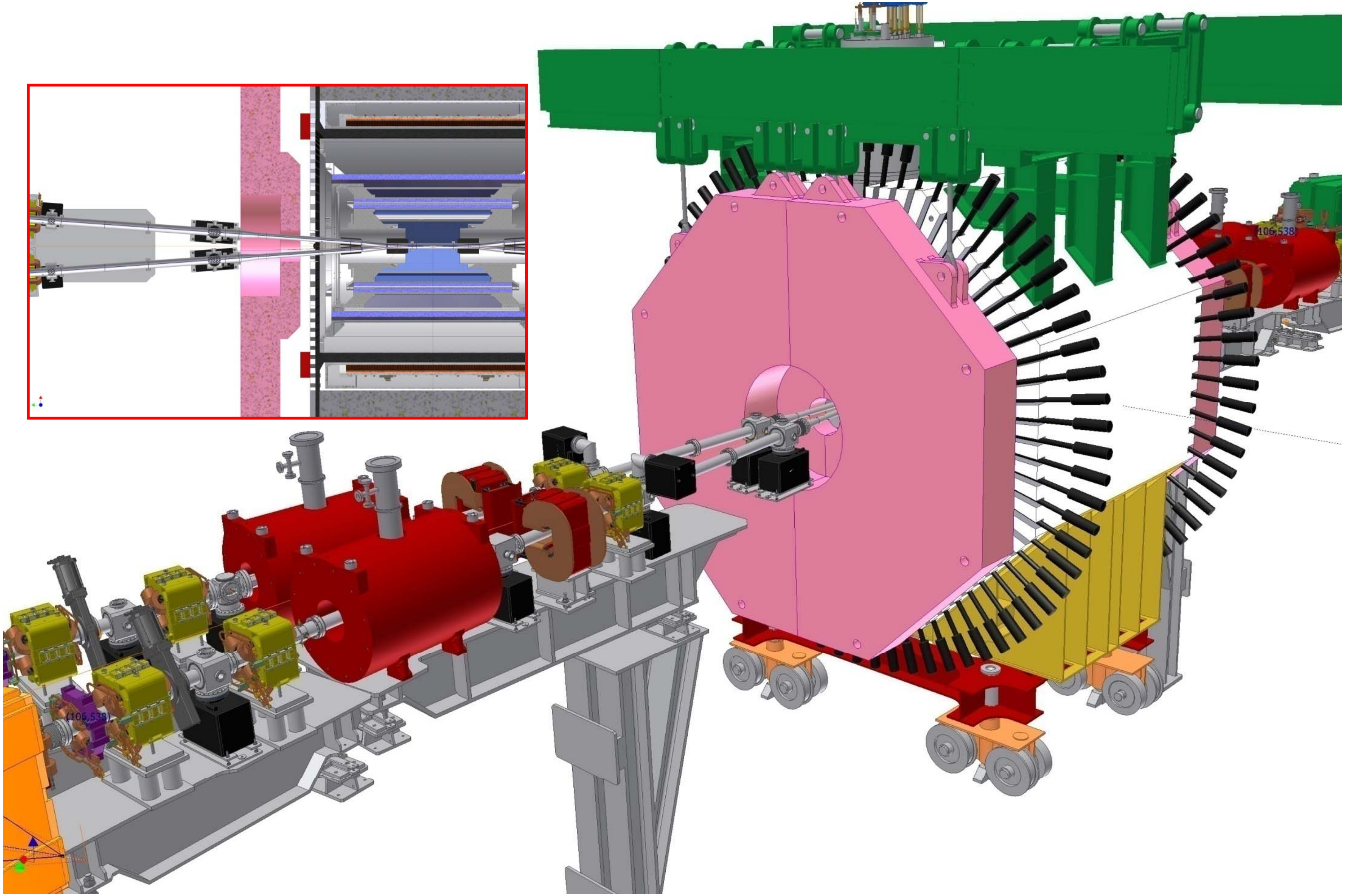
Test at BTF
99% efficiency for electron (signal in bhabha measure)
~ 1% efficiency for photons (background in bhabha measure)

32 + 32 channels

DAΦNE-UP & KLOE2 (end of 2008)



DAΦNE-UP & FINUDA2



DAΦNE Upgrade Installation

DAΦNE IR1 decommissioning started on mid June

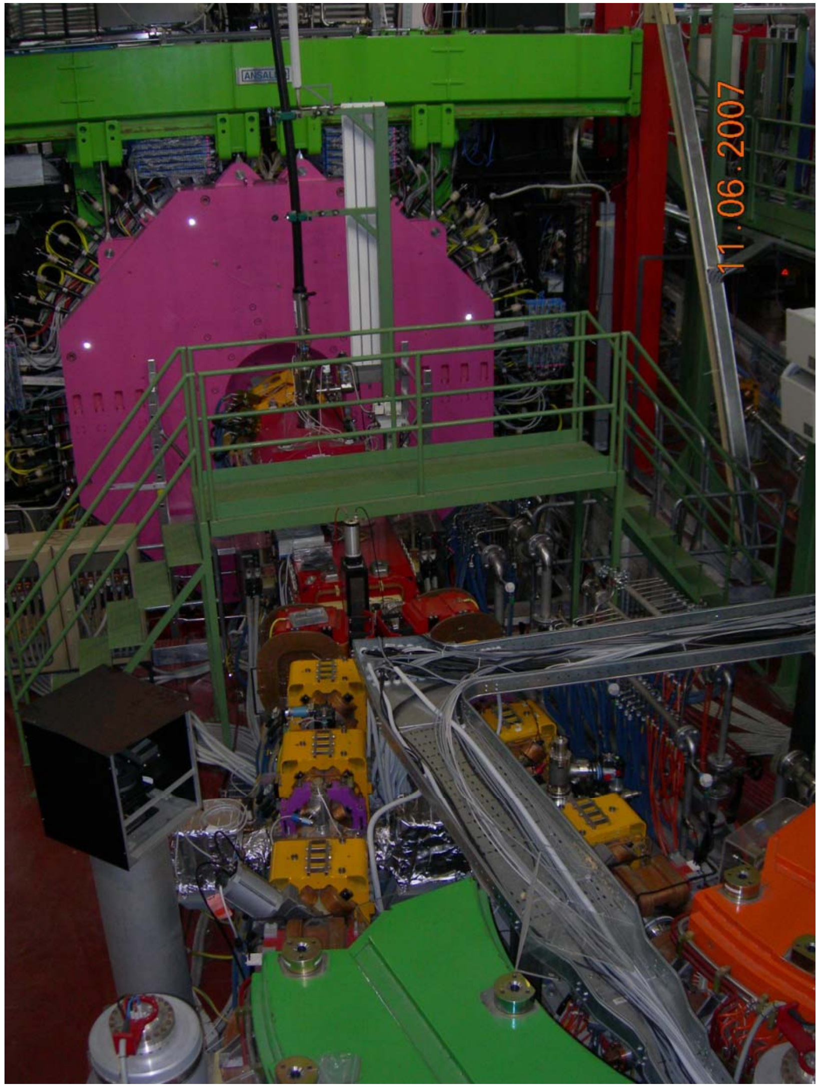
DAΦNE Upgrade Installation

DAΦNE IR1 magnet installation was concluded (not permanent magnets)

- Cabling and piping concluded
- Alignment in progress
- Vacuum chambers installation in progress
- Permanent magnets delivered by the manufacturer

DAΦNE Upgrade Installation

DAΦNE IR2 decommissioning started on mid June



- FINUDA was rolled out

DAΦNE Upgrade Installation

We Expect to conclude the installation by November

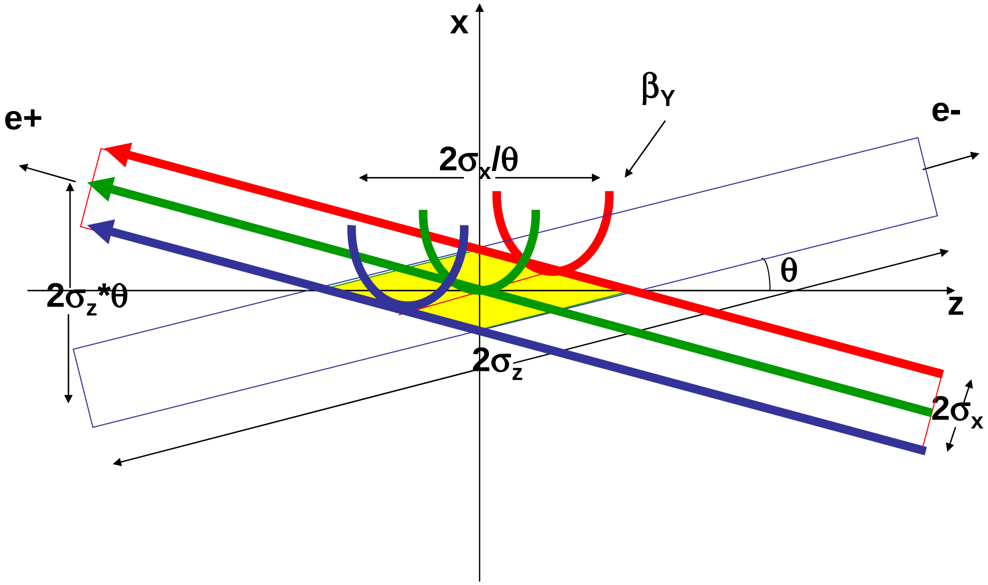
Thank you for your attention

Crab Waist @ DAΦNE main items

1. Large Piwinski's angle $\Phi = tg(\theta)\sigma_z/\sigma_x$

2. Vertical beta comparable with overlap area $\beta_y \approx \sigma_x/\theta$

3. Crabbed waist transformation $y = xy'/(2\theta)$



Crabbed waist is realized with a sextupole in phase with the IP in X and at π/2 in Y

P. Raimondi, November 2005

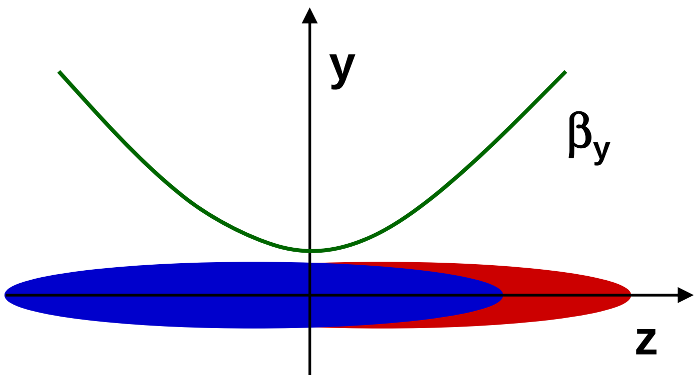
Luminosity and crossing angle

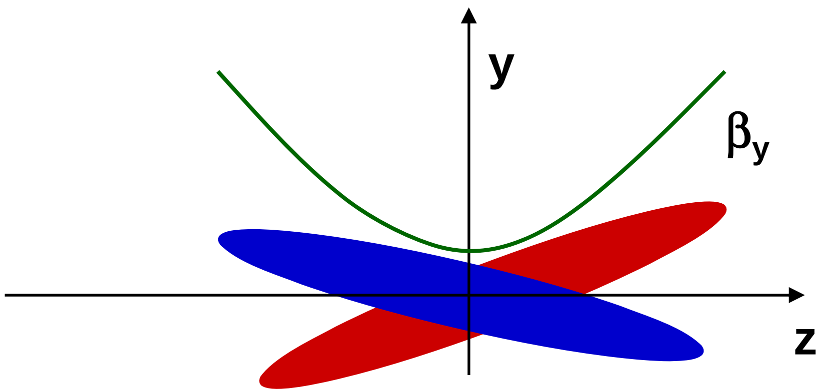
$$L \propto \frac{N^2}{\sigma_x \sigma_y} \quad + \quad \Phi \approx \frac{\sigma_z}{\sigma_x}\frac{\theta}{2} \quad \Rightarrow \quad L \propto \frac{N^2}{\sigma_x \sqrt{\beta_y (1+\Phi^2)}}$$

luminosity is limited by hourglass and tune-shift effects

crossing angle θ (Piwinski angle Φ)

high density N
low β_y
low σ_x





The introduction of a crossing angle do NOT improve luminosity

luminosity and tune-shift

but allows to play with transversal dimension σ_x and β_y optical function, kipping limited the vertical tune-shift and strongly depressing horizontal tune-shift

$$\xi_y \propto \frac{N\sqrt{\beta_y}}{\sigma_x\sqrt{1+\Phi^2}} \qquad \xi_x \propto \frac{N}{\sigma_x^2(1+\Phi^2)}$$

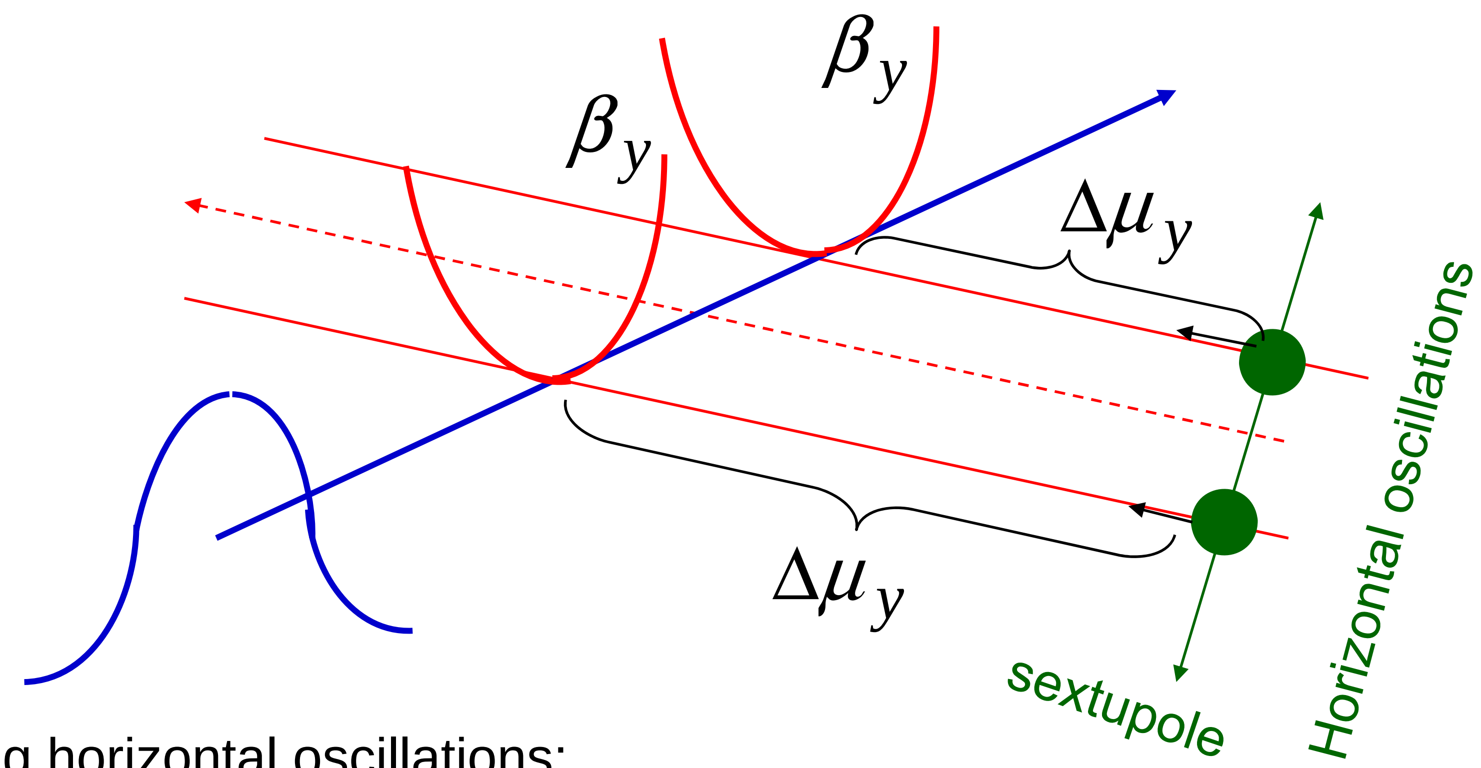
$$\Phi \approx \frac{\sigma_z}{\sigma_x}\frac{\theta}{2}$$

$\theta\sigma_z$ large
σ_x small ⇒

$$\beta_y \approx \frac{\sigma_x}{\theta} << \sigma_z$$

but a large Piwinski angle can generate strong sincro-bethatron oscillation

Suppression of X-Y Resonances



Performing horizontal oscillations:

1. Particles see the same density and the same (minimum) vertical beta function
2. The vertical phase advance between the sextupole and the collision point remains the same ($\pi/2$)