Report on DAΦNE activity

Catia Milardi

(on behalf of the DAΦNE Commissioning Team)

3rd EuCARD Steering Committee Meeting
Nov. 5th 2009 LNF, Frascati, Italy.

DAΦNE Commissioning Team

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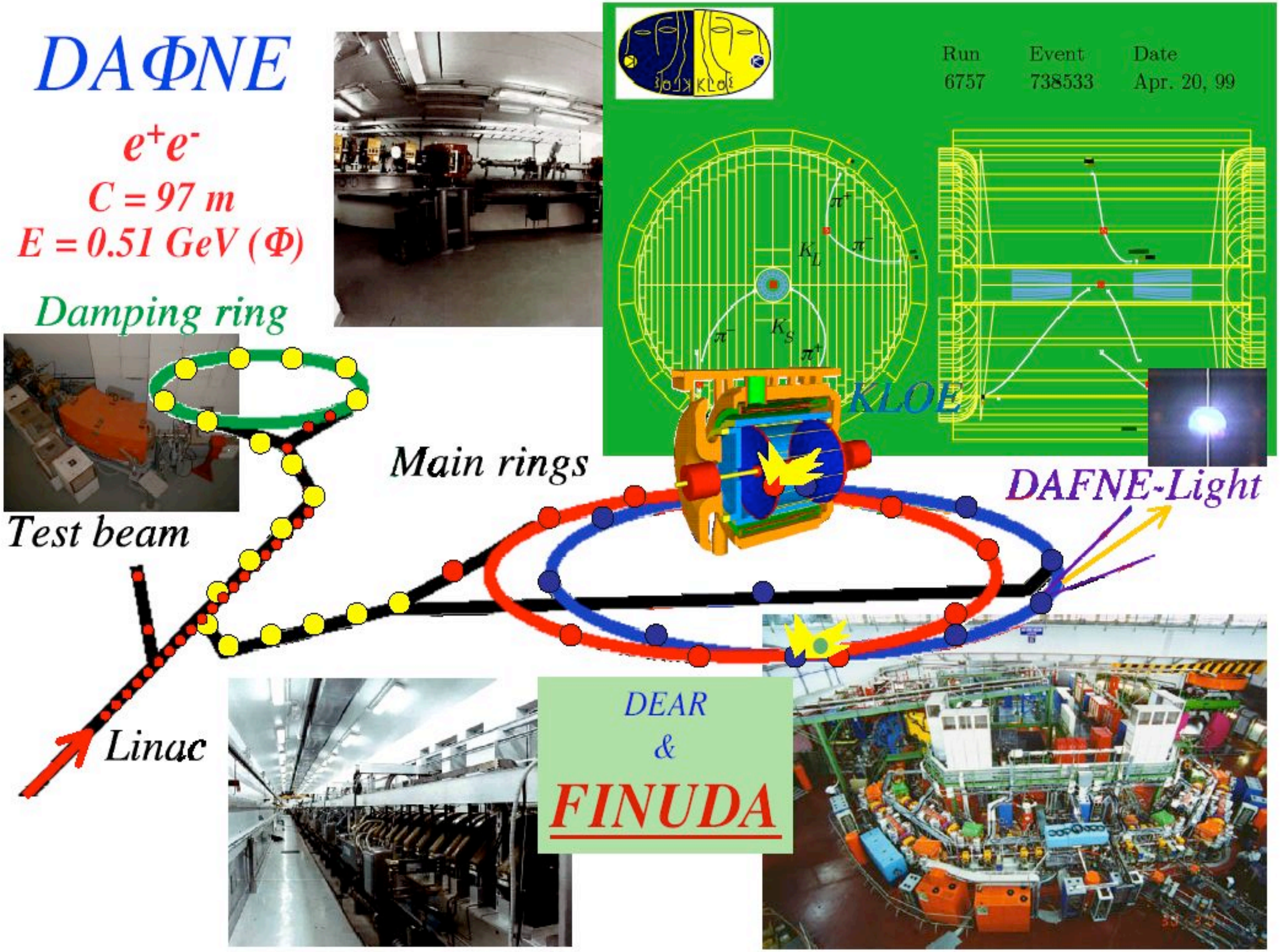
Outline

- *DAΦNE in general*

- *DAΦNE performances after the upgrade*
  - *Beam test measurements about the new collision scheme*
  - *latest Luminosity results*

- *The new run with the KLOE detector*
  - *The new KLOE IR*
  - *Further upgrade involving all the accelerator complex*

- *Conclusions*


DAΦNE
e+e-
C = 97 m
E = 0.51 GeV (Φ)
Damping ring
Test beam
Linac
Main rings
Run 6757
Event 738533
Date Apr. 20, 99
KLOE
DAFNE-Light
DEAR
&
FINUDA

DAΦNE upgrade

•*In 2007 the DAΦNE accelerator complex has been upgraded in order to implement a new collision scheme based on* ***large Piwinski angle****,* ***low–β*** *and* ***Crab-Waist compensation*** *of the synchrobetatron resonances*

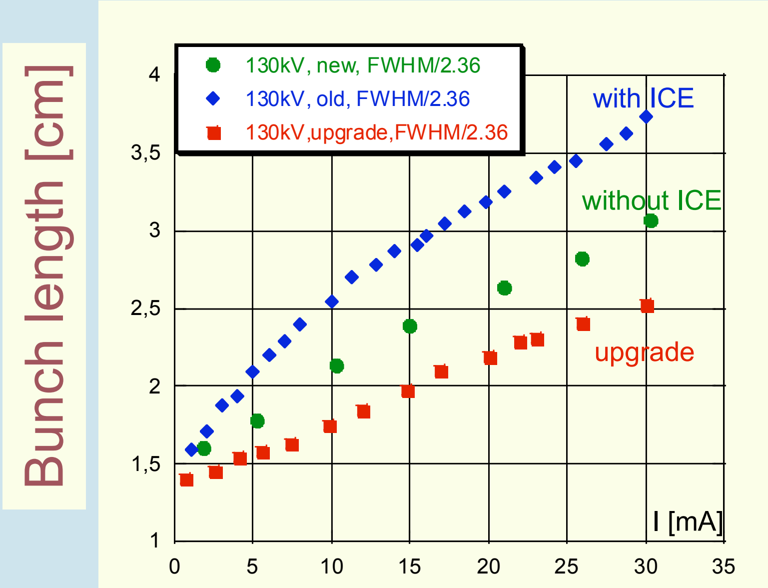
•*The upgrade took ~* ***five months***

•***Since May 2008*** *DAΦNE is delivering luminosity to the SIDDHARTA experiment.*

Beam optics parameters

	DAΦNE KOE	DAΦNE Upgrade
$\theta_{cross}/2$ (mrad)	12.5	25
ε_x (mm mrad)	0.34	0.26
β_x^* (cm)	150	26
σ_x^* (mm)	0.70	0.26
$\Phi_{Piwinski}$	0.6	1.9
β_y^* (cm)	1.80	0.9
σ_y^* (μm) low-current	5.4	3.1
Coupling %	0.2÷0.3	0.3
I_{bunch} (mA)	13	>10
σ_z (mm)	25	20
N_{bunch}	111	105
L ($cm^{-2}s^{-1}$) x10^{32}	1.6	4.53 (5.)

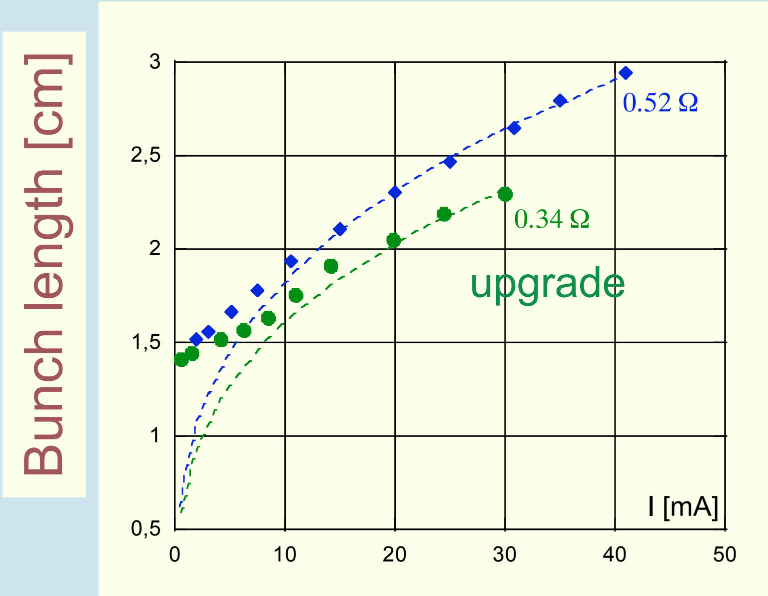
Bunch Lengthening in the Main Rings



e⁻

20% bunch length reduction @ I_{bunch} ~ 10 mA due to:

- ICE removal
- new injection kickers
- new bellows



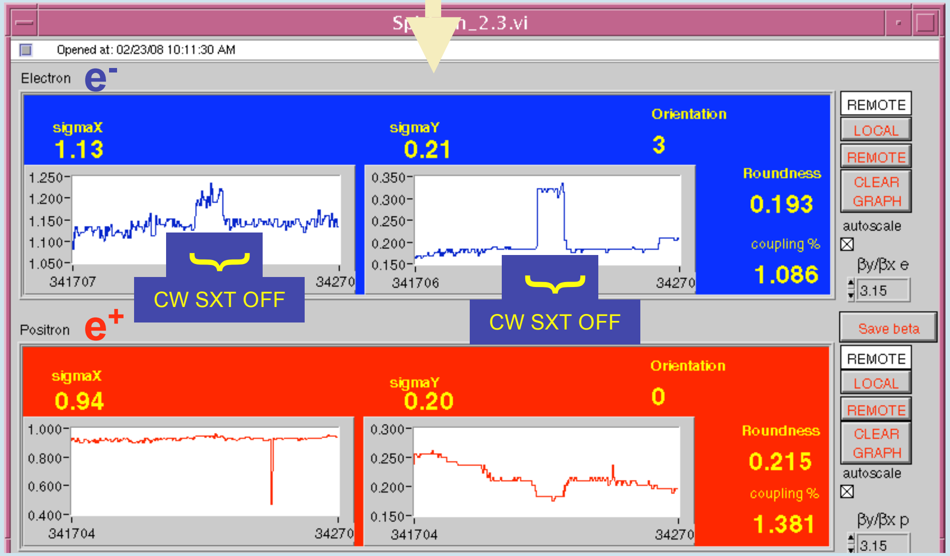
e⁺

Few % reduction in bunch length due to:

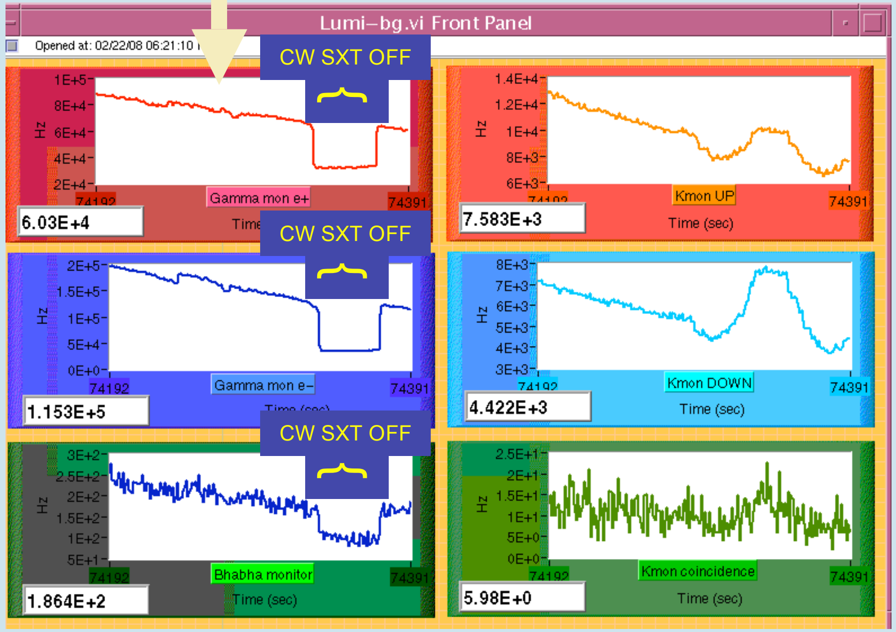
- new injection kickers
- new bellows

Crab-Waist compensation first experimental evidence

Beam transverse size measured at the synchrotron light monitor



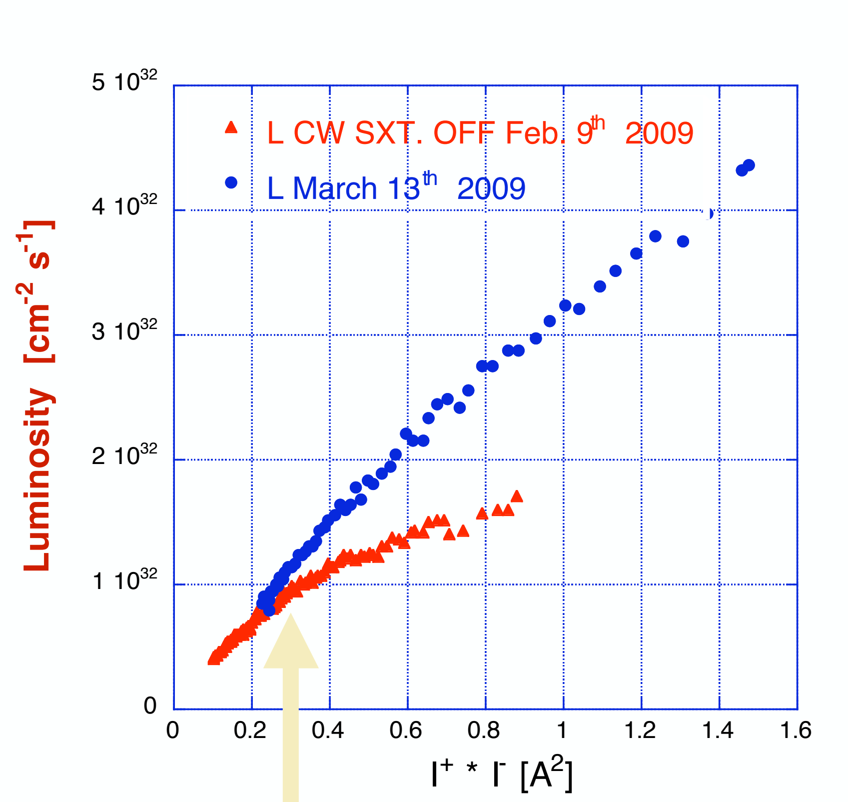
Luminosity measured by 2 different monitors

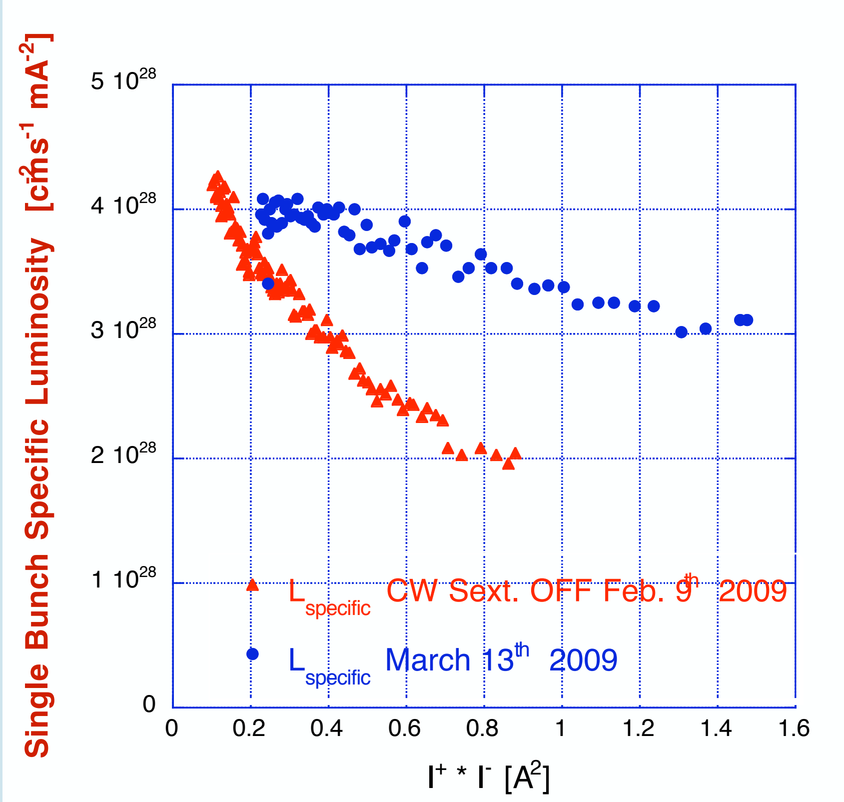


Transverse size (left) and luminosity dependence (right) on the CW sextupole excitation in the e^- ring

Crab Sextupoles are working since the first time they have been tested

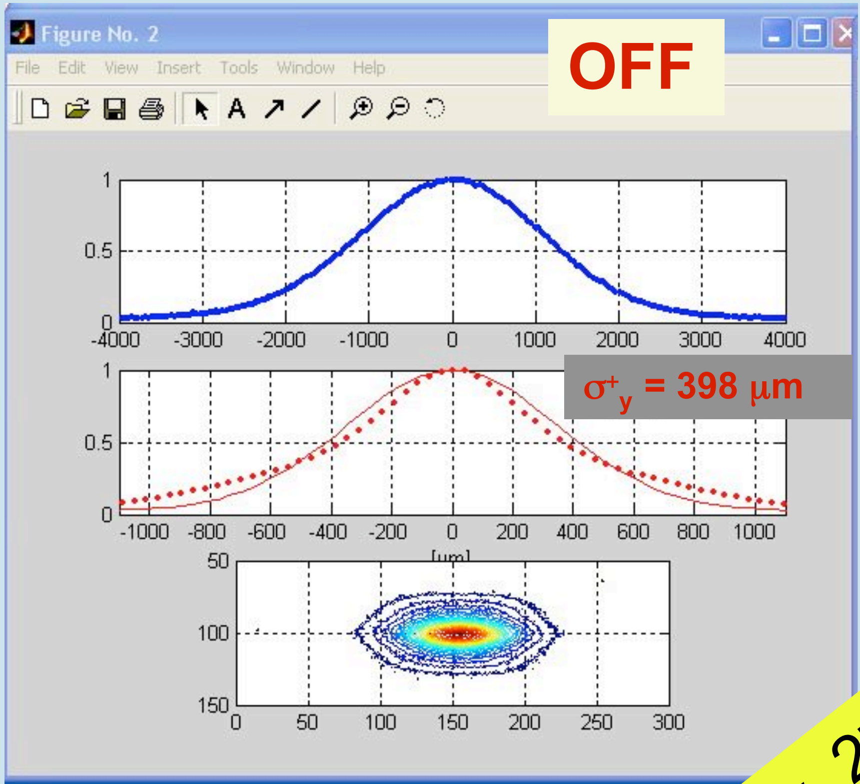
Crab-waist compensation and luminosity

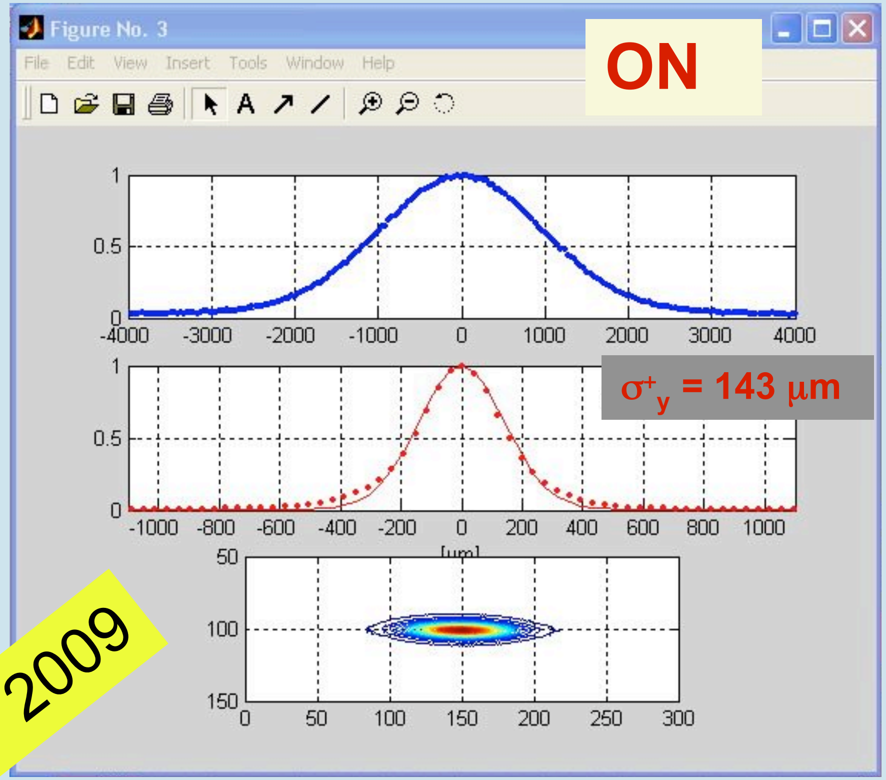




- Transverse beam blow-up
- Lifetime reduction

Transverse Beam profile measurements versus *Crab-Waist SEXTUPOLES*





Nov. 2nd 2009

$I^- = 1$ A
$I^+ = 0.09$ A

105 colliding bunches

$I^- = 0.8$ A
$I^+ = 0.15$ A

Peak luminosity

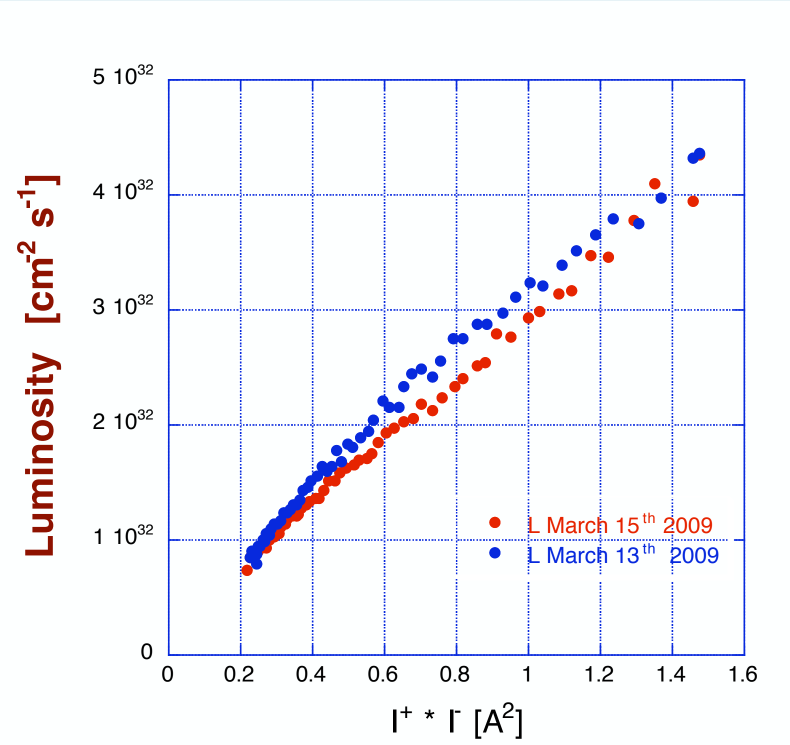
105 bunches

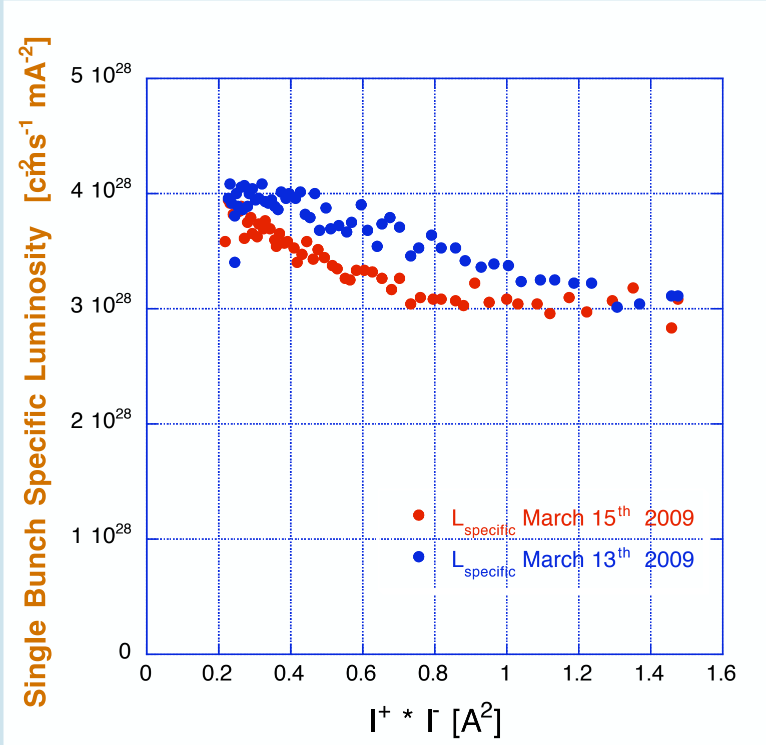
A luminosity in excess of $4 \cdot 10^{32}$ $cm^{-2}s^{-1}$ is measured almost in every run when operating the collider in optimized conditions.

ξ_y (MAX) ~ 0.0443

ξ_y(MAX) is a factor ~1.5 higher than the best achieved without Crab-Waist compensation
The collider has the same damping time as in the past

Luminosity during two of the best runs





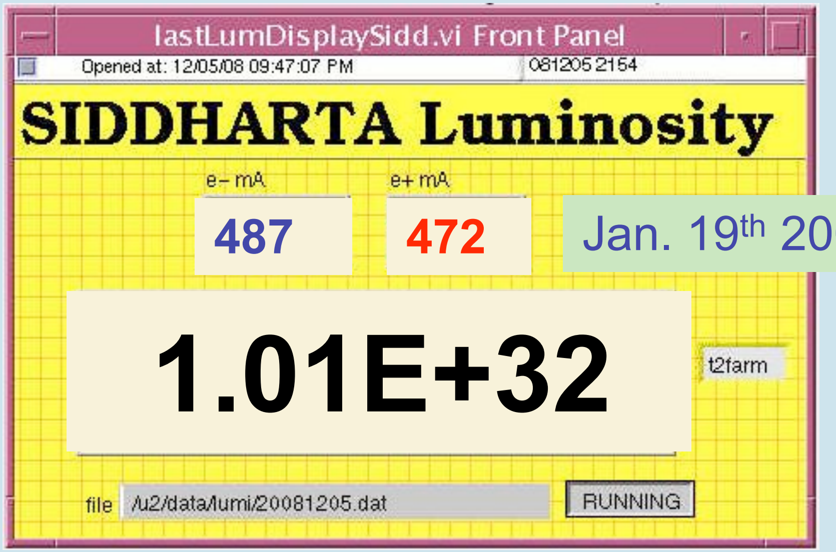
$L_{specific}$

- Drops with the product of the colliding currents due to:
  - beam-beam blow up
  - bunch lengthening
- At low currents is four times higher than in the past
- The reduction is underestimated since collisions are optimized mainly at high ***I***, it has been considerably reduced during the collider commissioning

Luminosity in weak-weak and strong-weak regime

Specific luminosity at intermediate currents is a factor of four higher than in the past

ξ_y (MAX) ~ 0.020



Jan. 19th 2009

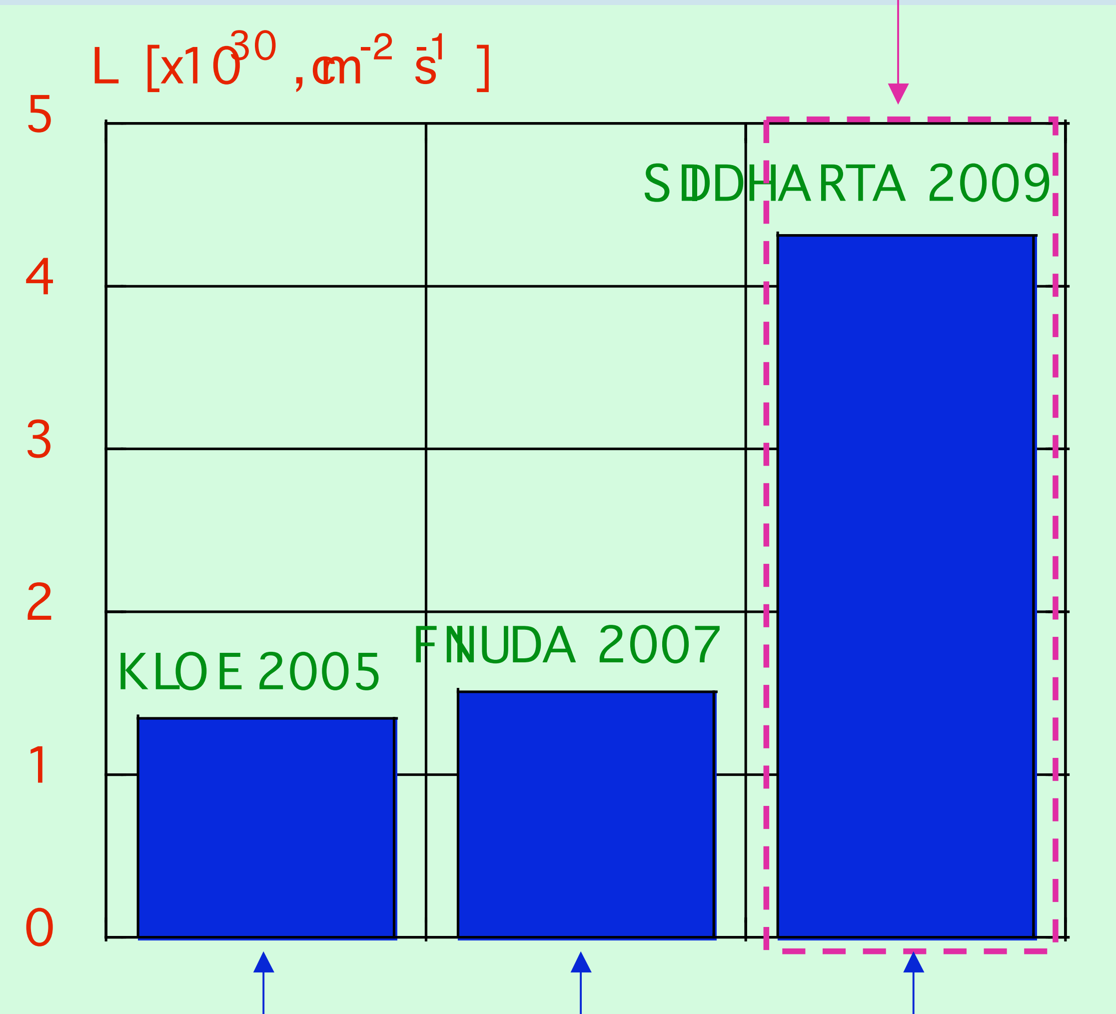
Asymmetric currents

ξ_y(MAX) ~ 0.074

Crab-Waist compensation works in weak-strong regime

Jan. 9th 2009

Single Bunch Luminosity

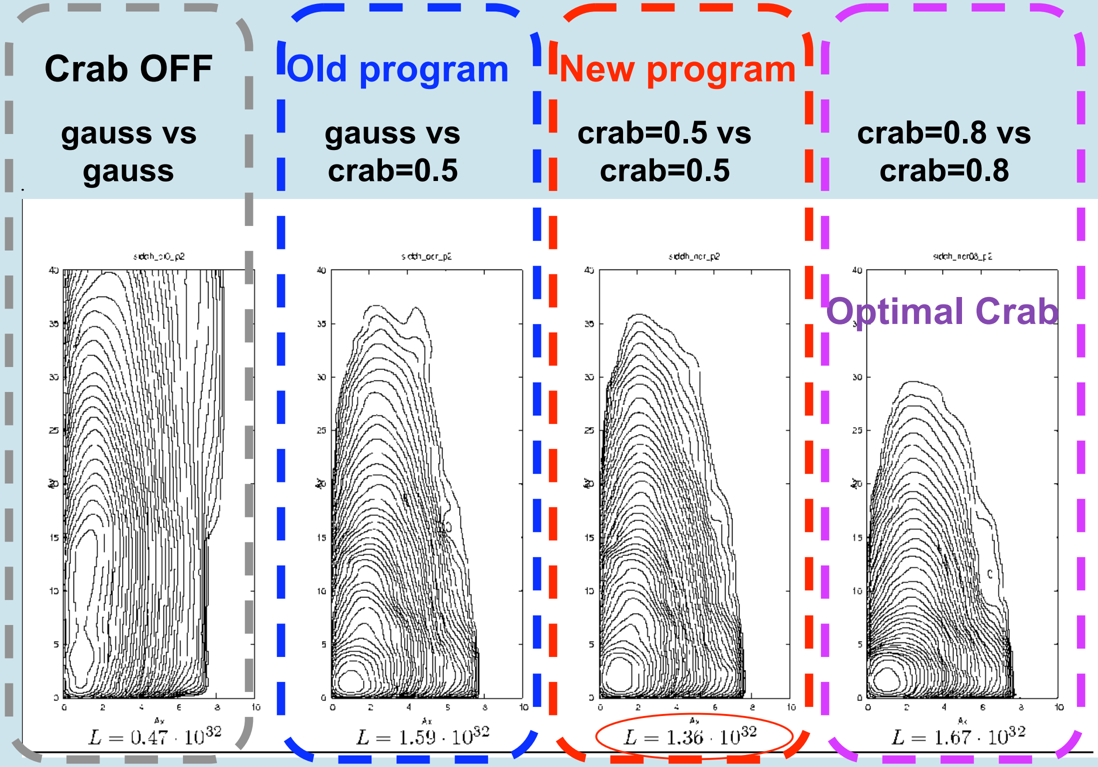


Collision with 20 bunches

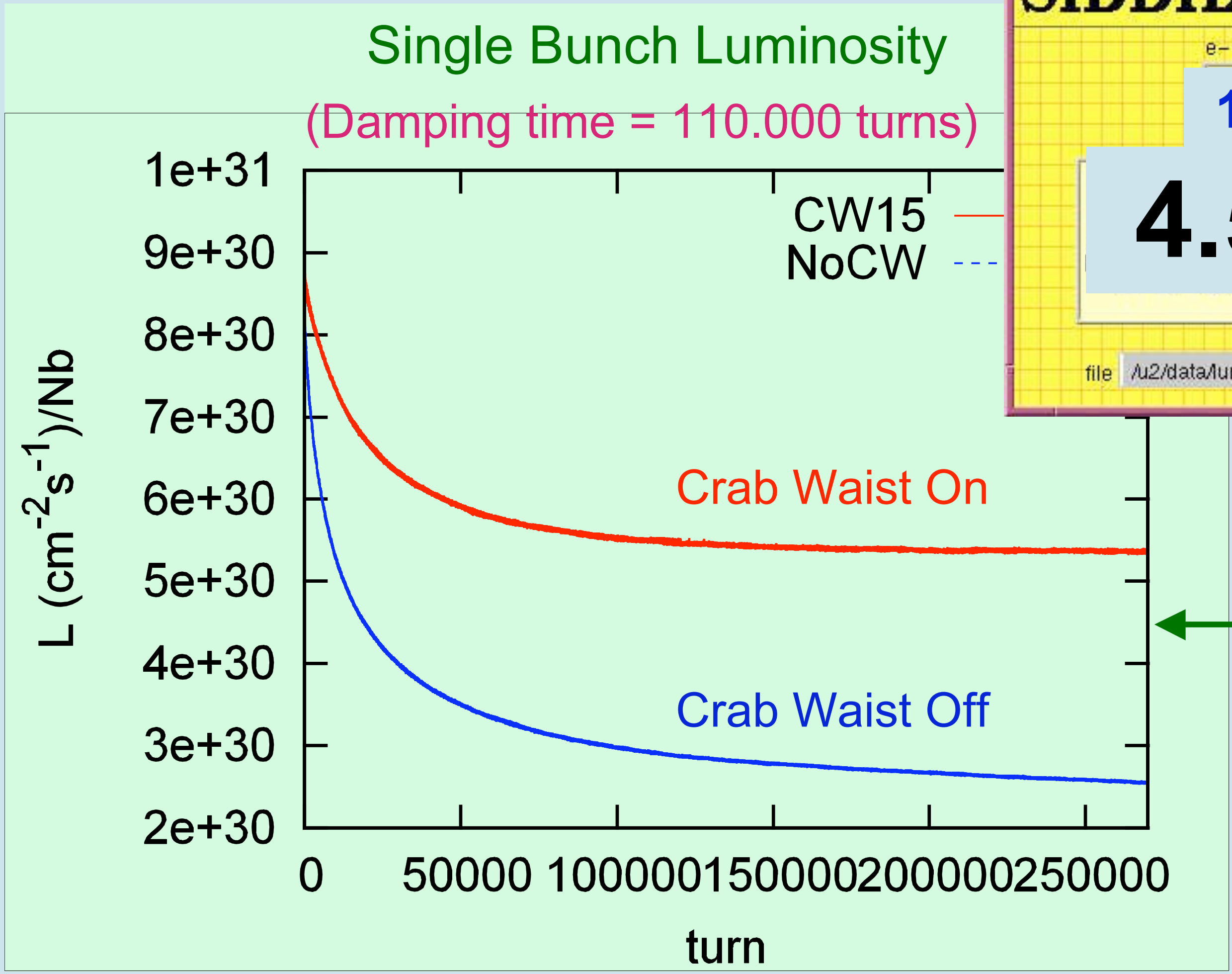
Normal Operating Conditions with > 100 bunches

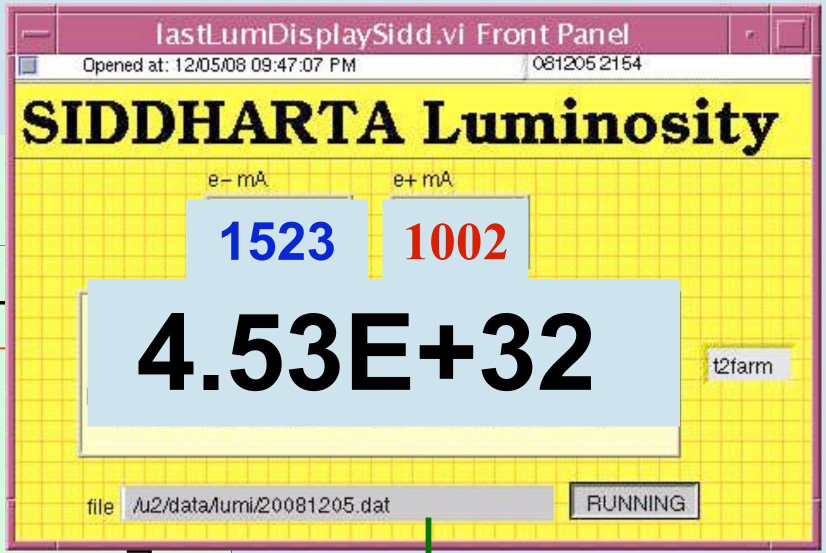
Weak-Strong Simulations

$\xi_y = 0.074$



Strong-Strong Beam-Beam Simulations

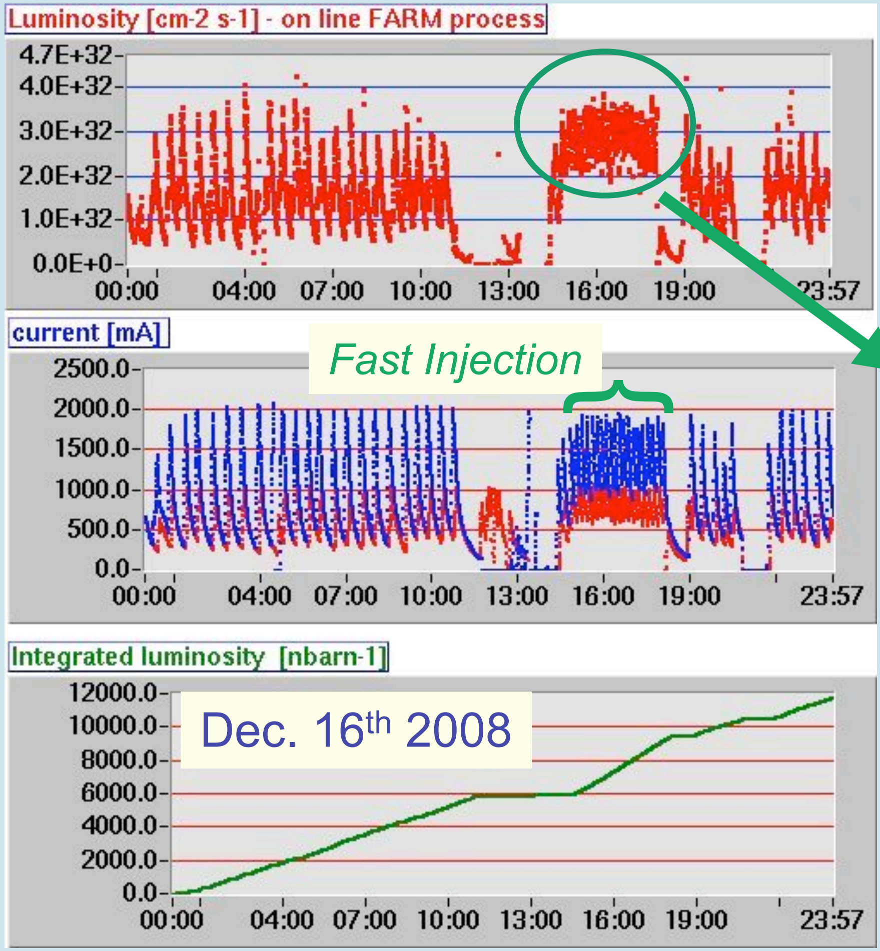




105 bunches

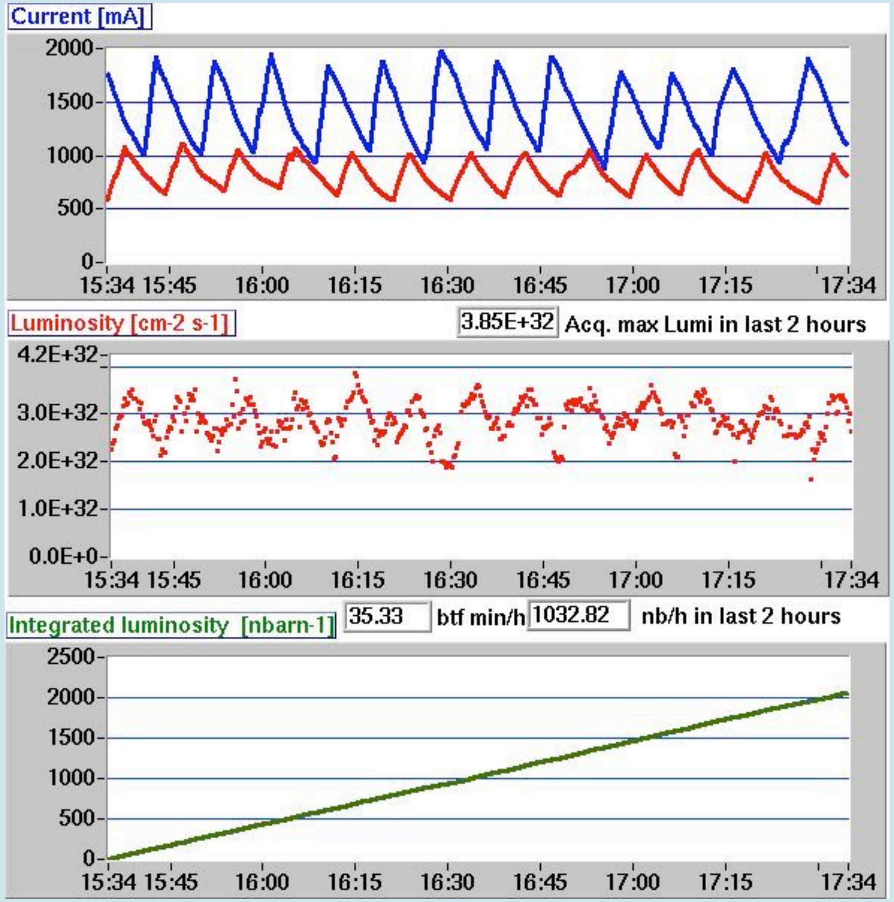
about 20% lower

Best hourly integrated luminosity



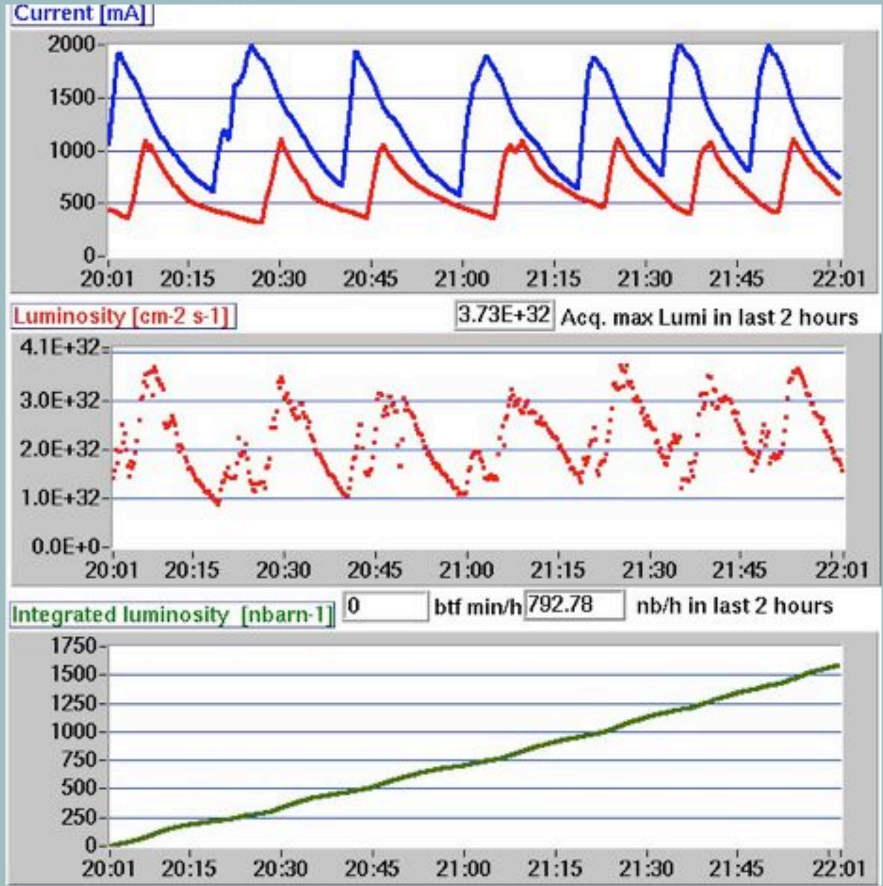
$L_{\int 1\ hour} = 1.033\ pb^{-1}$

- *High rate injection regime*
- *105 colliding bunches*
- *Very* ***useful for a future KLOE run***



Fast injection is not compatible with the SIDDHARTA operations!

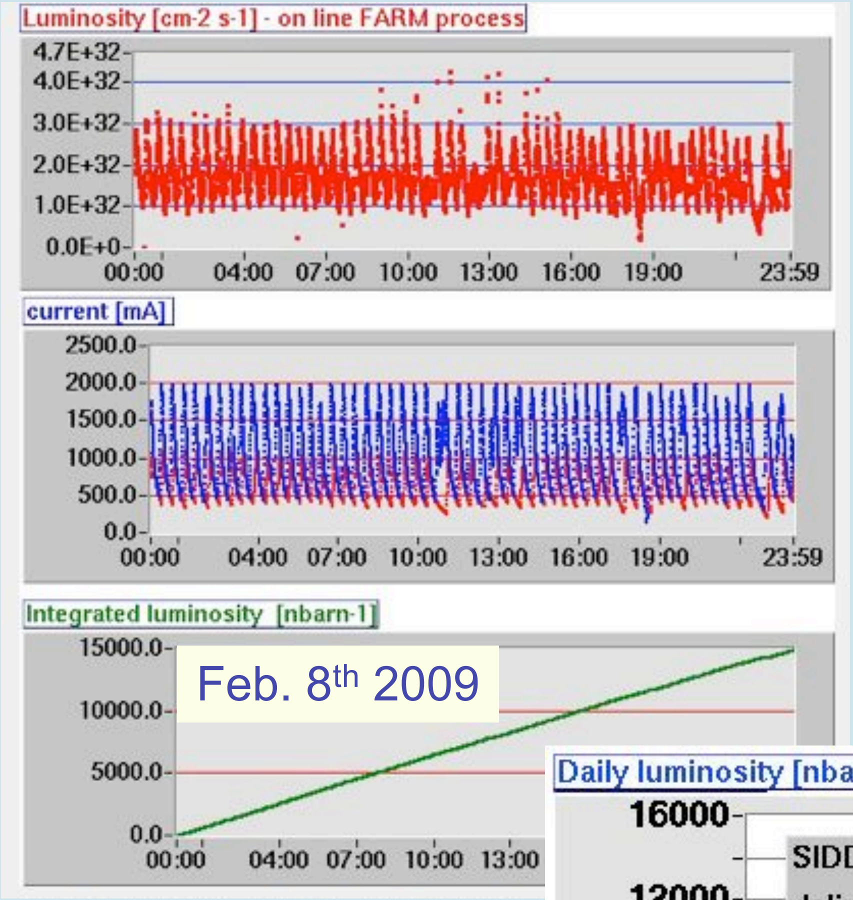
Best hourly integrated luminosity during the SIDDHARTA data-taking



$L_{\int 1\ hour} = .79\ pb^{-1}$

- *Best hourly integrated luminosity* ***compatible with the SIDDHARTA data taking***
- *moderate injection rate regime*
- *105 colliding bunches*

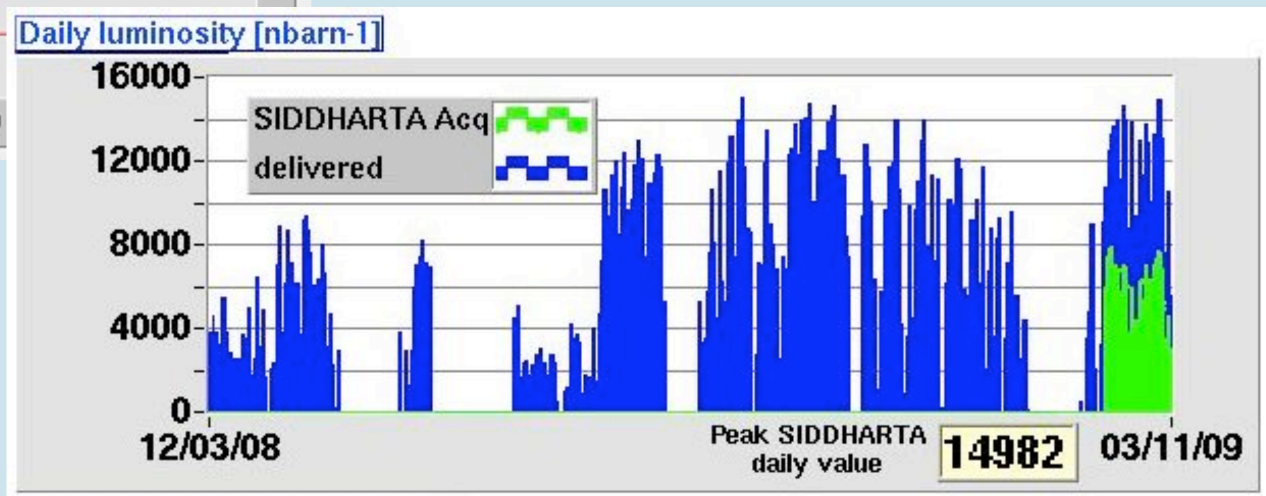
Best daily integrated luminosity



$L_{\int day} = 15.\ pb^{-1}$

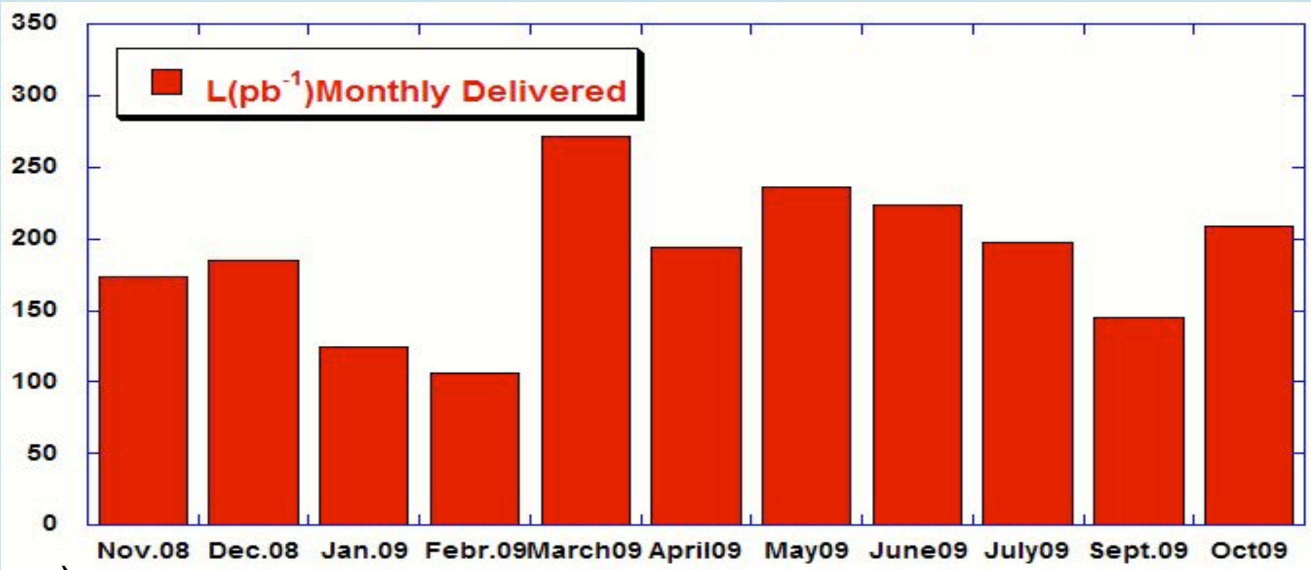
- *moderate injection rate regime*
- *105 colliding bunches*
- $L_{\int hour} = 0.62\ pb^{-1}$

+ 60 % FINUDA 2007

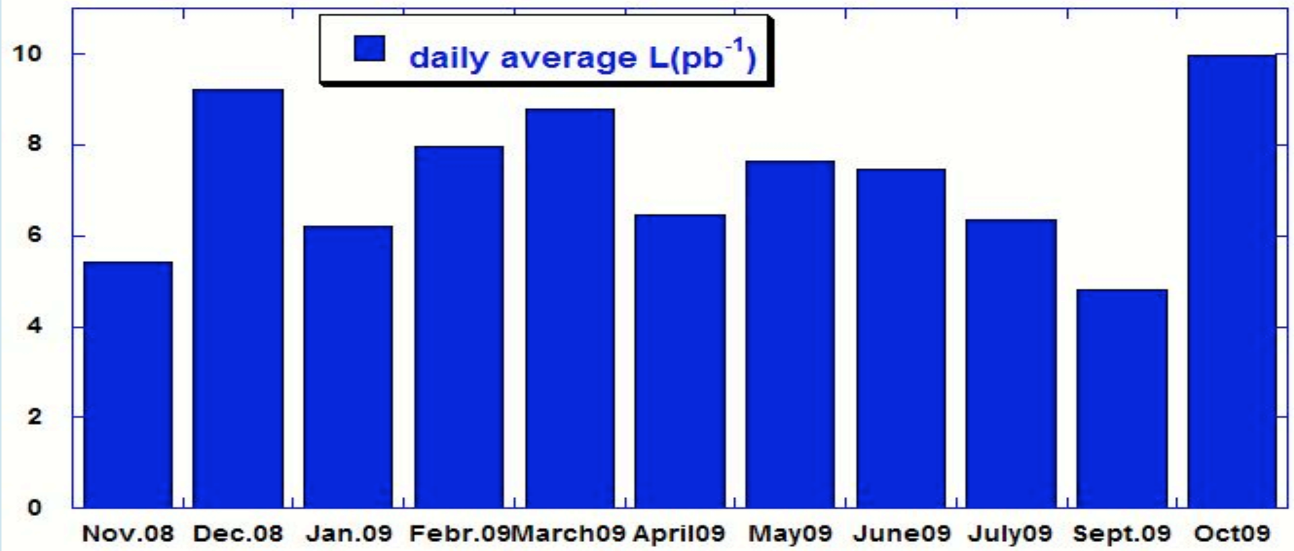


Monthly performances

November 1st 2008 – October 23th 2009



(Days of run) (20) (20) (24) (23)



tot. # running days 297

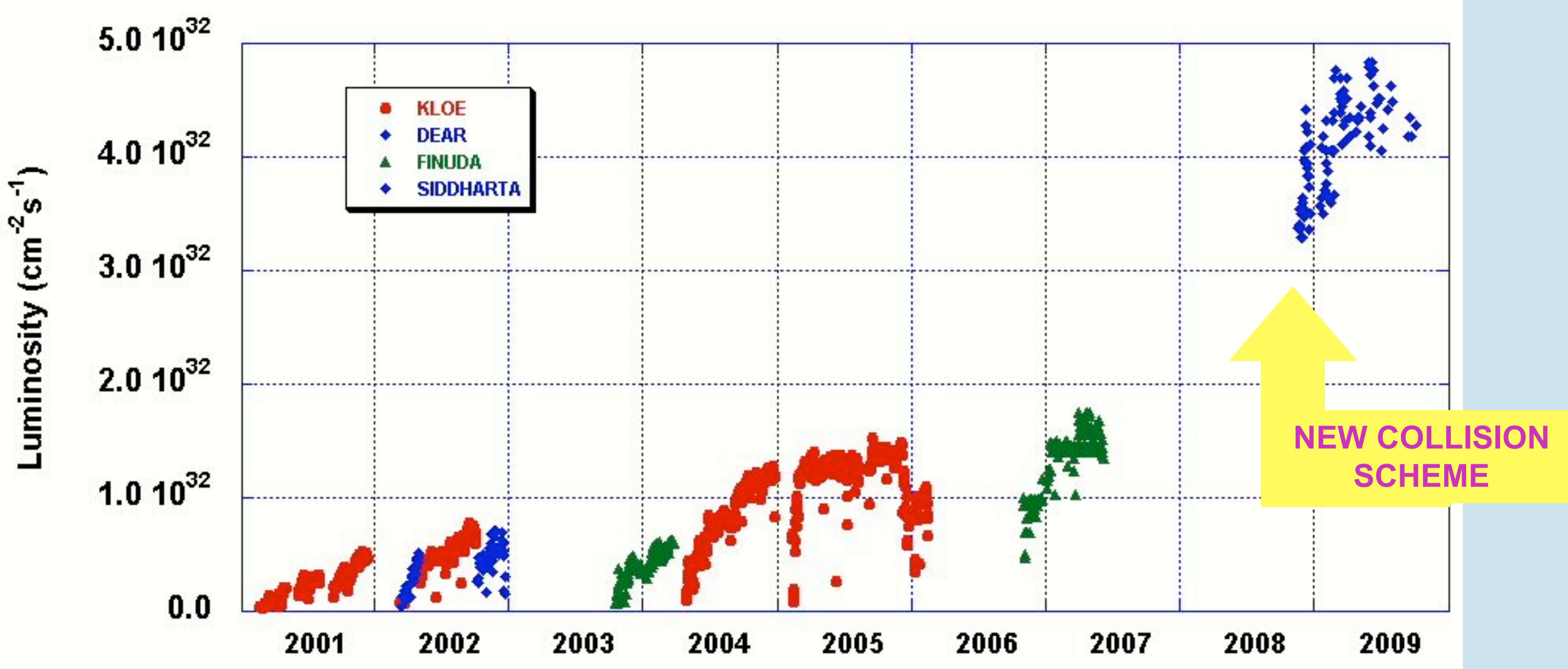
DAΦNE present achievements

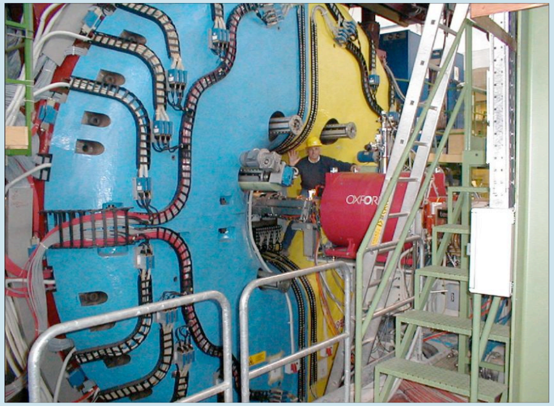
	DAΦNE upgrade SIDDHARTA	DAΦNE KLOE	DAΦNE FINUDA
L_{peak} [$cm^{-2}s^{-1}$]	**$4.53 \cdot 10^{32}$ ($5.0 \cdot 10^{32}$)**	$1.5 \cdot 10^{32}$	$1.6 \cdot 10^{32}$
$L_{\int day}$ [pb^{-1}]	**14.98**	9.8	9.4
$L_{\int 1\ hour}$ [pb^{-1}]	**1.033**	0.44	0.5
I^{-}_{MAX} in collision [A]	**1.52**	1.4	1.5
I^{+}_{MAX} in collision [A]	**1.0**	1.2	1.1
$N_{bunches}$	**105**	111	106
ξ_y	**0.0443** (0.074)	0.025	0.029

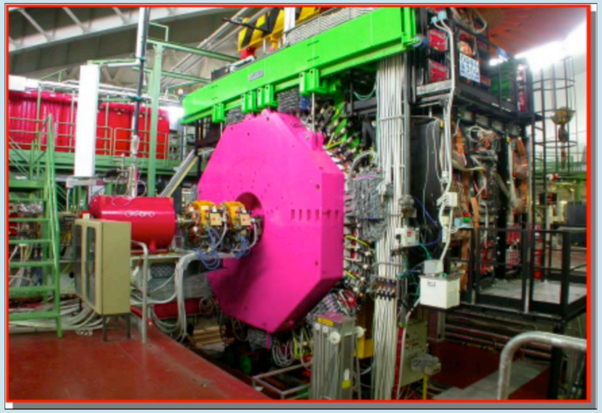
However collider performances are still limited by:

- *e-cloud*

L_{peak} at DAΦNE 2001 ÷ 2009







L_{logged} (fb^{-1}) 2001÷2007

KLOE	3.0
FINUDA	1.2
DEAR	0.2

Perspectives

Scaling the present data from the luminosity monitor:

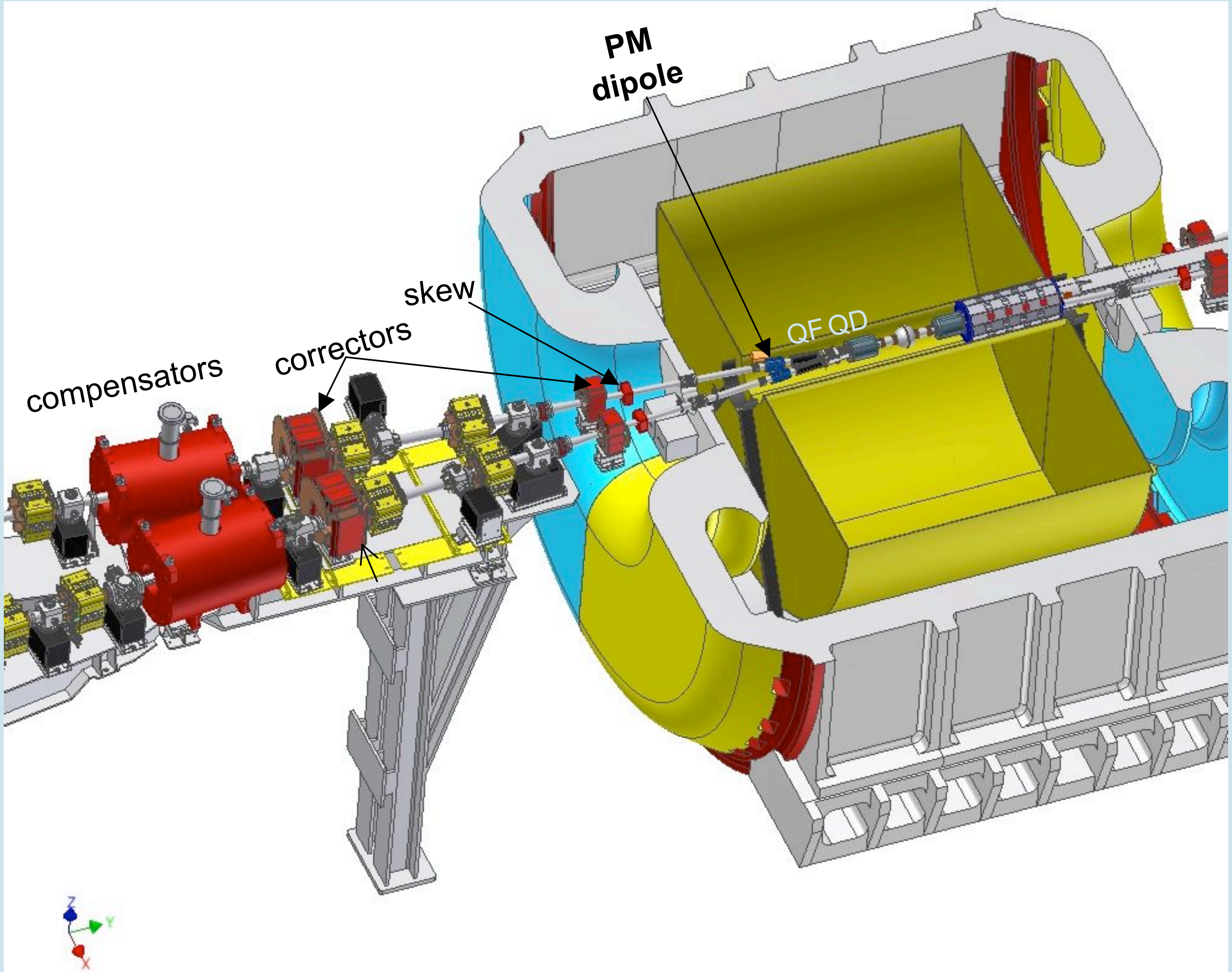
$L_{\int 1\ hour} = 1.033\ pb^{-1}$

$L_{\int day} \geq 20.\ pb^{-1}$ ***seems possible!***

Assuming 80% collider uptime $\Rightarrow$ $L_{\int month} \sim .5\ fb^{-1}$

….. in fact a new KLOE run has been approved, the detector will roll back in the next months.

The new KLOE IR



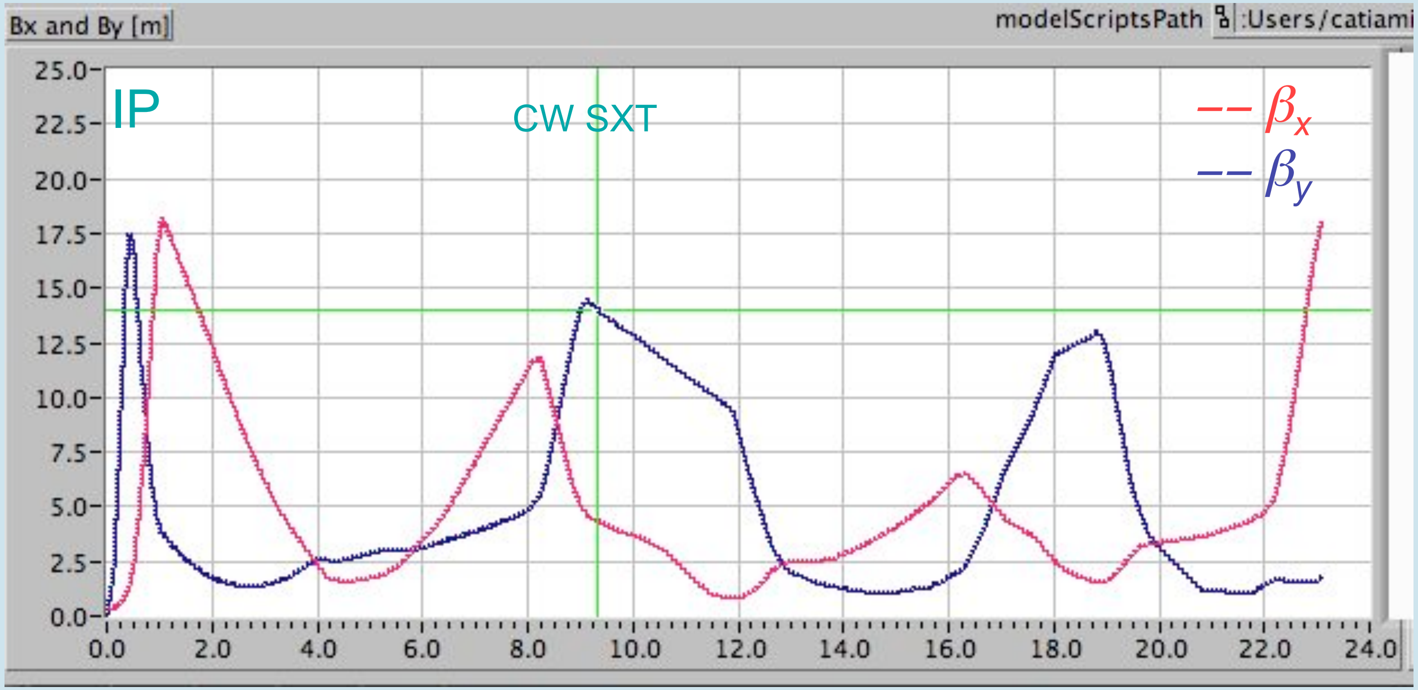
IR optics for the new KLOE run

IR design criteria:

- *Coupling matrix = 0 before CW SXT*
- $\Delta\nu_x = \pi$
- $\Delta\nu_y = 3\pi/2$
- *highest* β_y *at the CW sextupole*
- $\int_{KLOE} B \bullet dl$ *canceled by 2 compensator solenoids for each beam*

Low-β parameters:

- β^*_x = 26.5 cm
- β^*_y = 8.5 mm
- θ_{cross} = 26 mrad



Z from IP [m]

Coupling correction

	Z from IP	Rotazioni QUADs +Comp [rad] **(Sept. 2009)**	Rotazioni QUADs +Comp [gradi] **(Sept. 2009)**
PMQD	.415	0	0
PMQF	.9503	-0.0794	-4.548
QSKPS100	3.46	for tuning	
QUAPS100	4.1391	-0.23974	-13.736
QUAPS101	5.2591	-0.23974	-13.736
QUAPS102	8.2408	0.01491	0.854
QUAPS103	9.0059	-0.01491	-0.854
Compensator [A]	6.9808	72.319	72.319

Fixed QUAD rotations
K is expected to be lower than for KLOE past
K_{KLOE1} = 0.2 ÷ 0.3 %

$$\int_{KLOE} B \cdot dl = 2.048 \quad [Tm] \quad \rightarrow \quad I_{KLOE} = 2300. \quad [A]$$

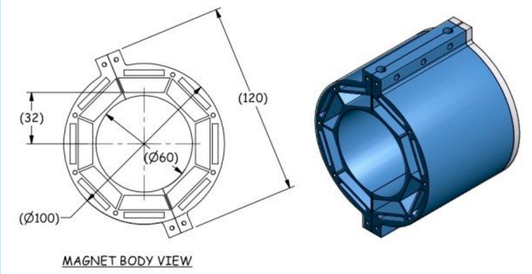
$$\int_{comp} B \cdot dl = \pm 1.024 \quad [Tm] \quad \rightarrow \quad I_{comp} = 86.7 \quad [A]$$

In order to have coupling compensation also for off-energy particles

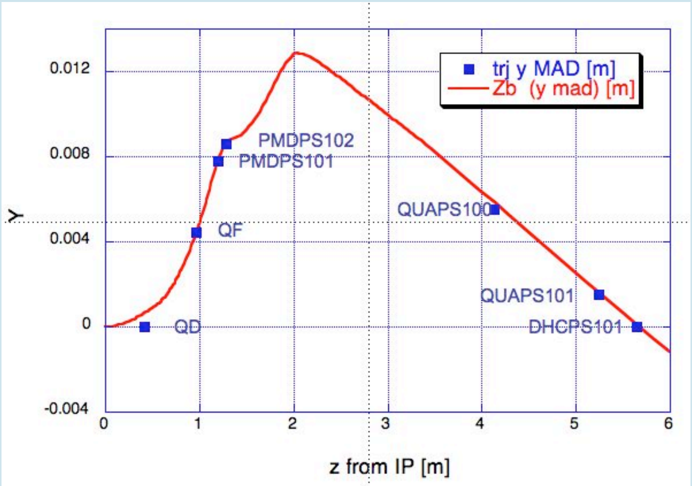
Beam Trajectory in the new IR

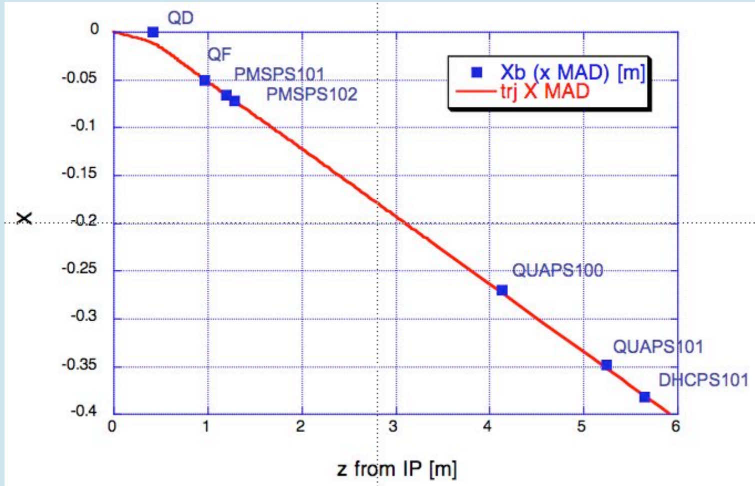
•*Due to the* ***larger crossing angle*** *and the* ***stronger first low-β quadrupole (PMQD)****, the vertical displacement of the beam in the IR is an order of magnitude larger than in the past KLOE run.*

•*A* ***permanent magnet dipole*** *is used to keep under control the vertical beam trajectory.*



Magnetic length (mm) 75
field (T) 0,22933
Good field region radius (mm) 15
Magnet material type Nd-Fe-B

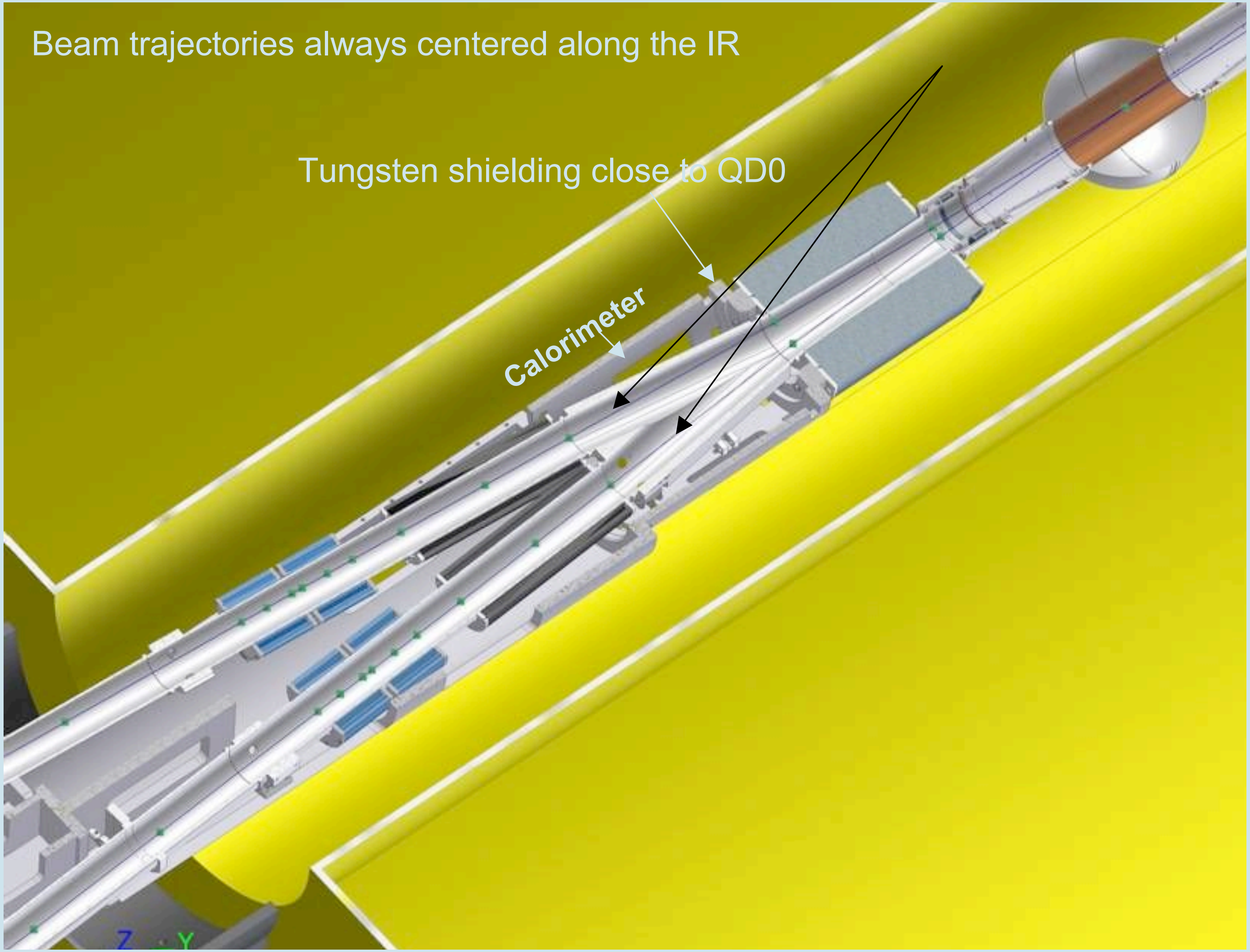




QUADs are centered as much as possible on the beam trajectory to improve beam acceptance.

Vacuum chamber design is very much simplified: straight sections and few bellows

Radial section of the KLOE IR pipe



Wigglers modification

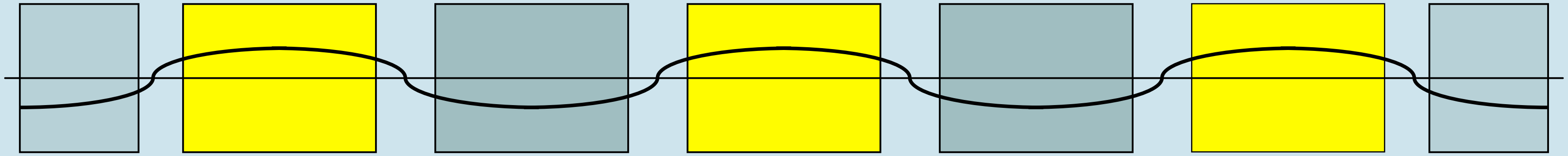
The 8 Wigglers are going to be modified in order to:

- *Improve by more than a factor 2 the good field region*
- *Increase the B_{max} for a given current*
- *Reduce the higher order components in the B*
- *Decrease the wall plug power*
- *Eliminate 8 additional power supplies used for the terminal poles*

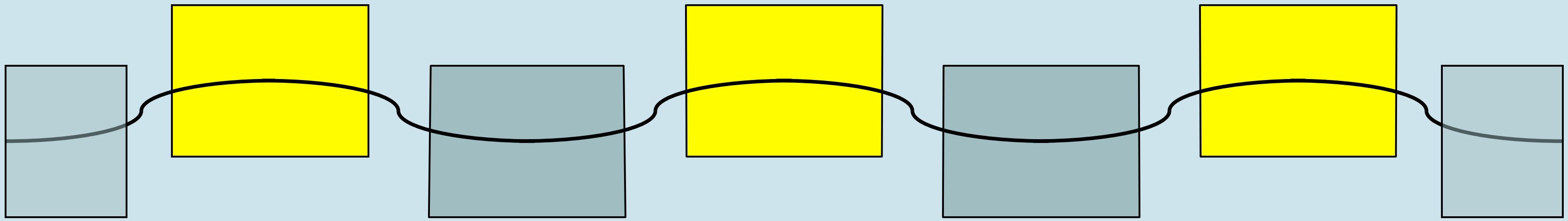
⇓

– **Improved beam dynamics**
– **longer beam lifetimes**
– 500KW **power reduction with same B_{max}** (0.5ME/Year)
– **Less histeresys** better reproducibility

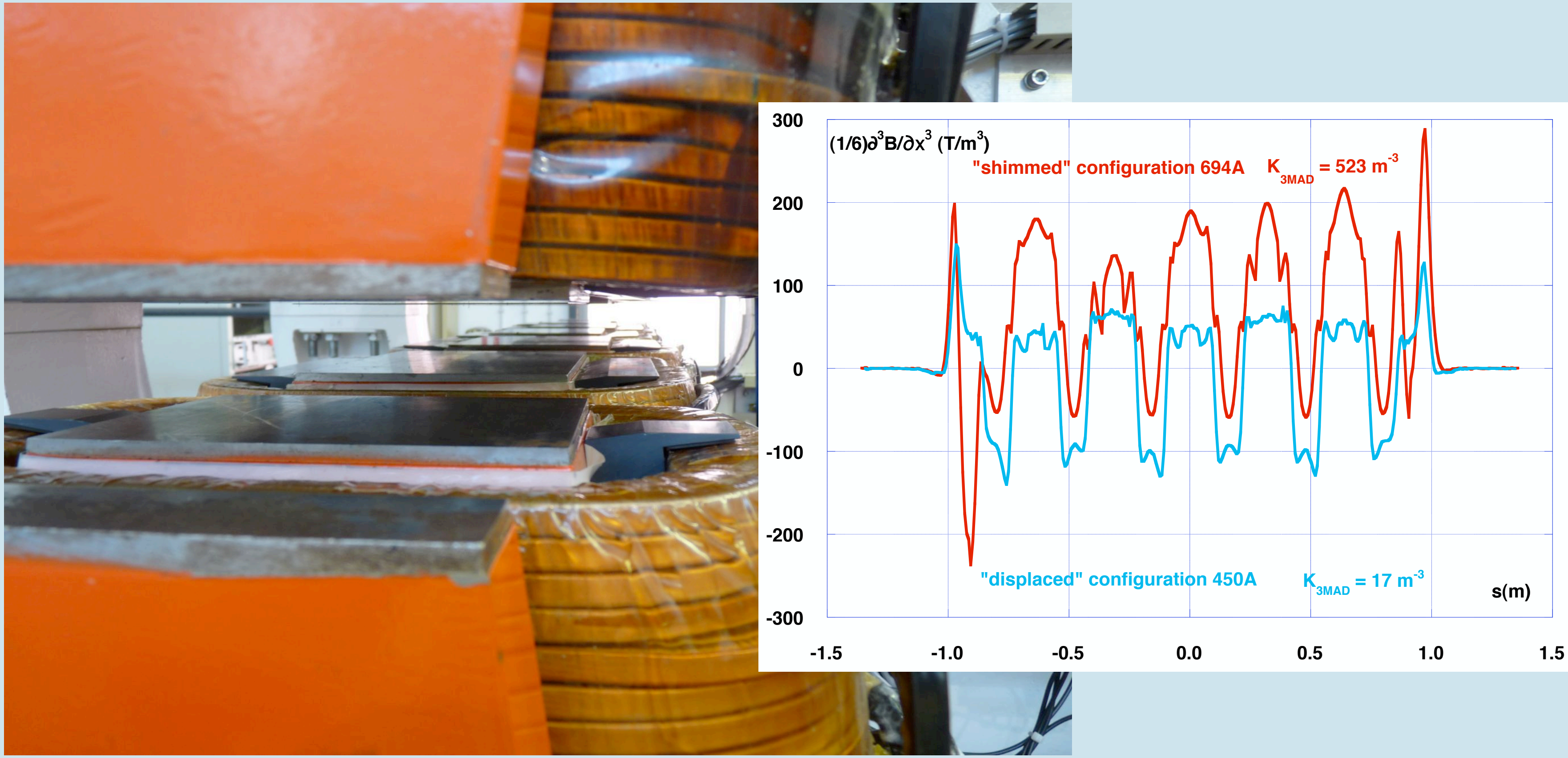
Present wiggler



Modified wiggler



In the modified wiggler the beam trajectory passes always near the pole center: in this way the higher order terms in the magnetic field are significantly reduced.

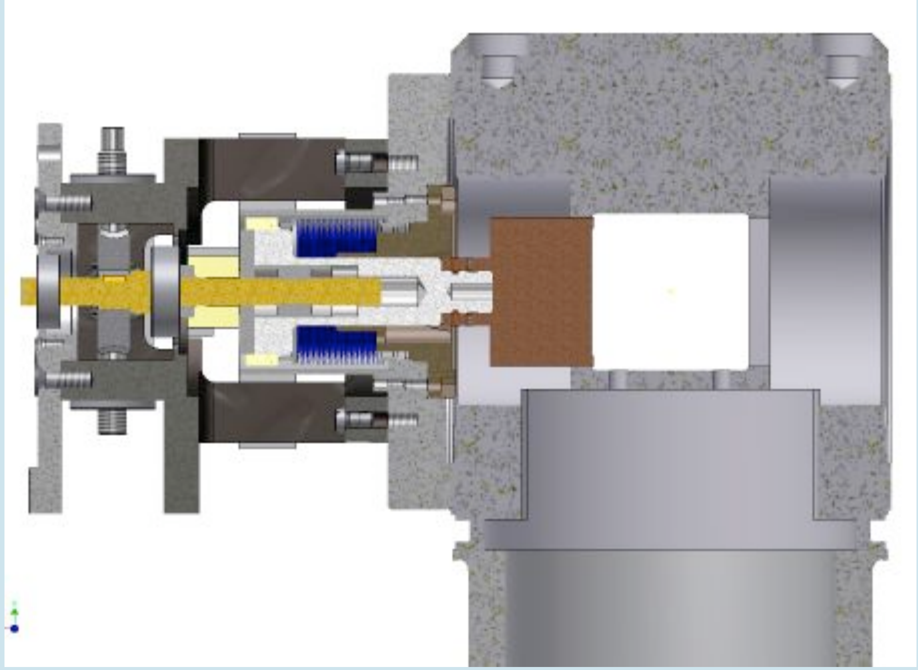


The pole axis is displaced in such a way that it leaves the beam trajectory approximately half on the right and half on the left: in this way ***even terms still cancel from pole to pole****, while* ***odd terms cancel inside each pole****.*

Scrapers

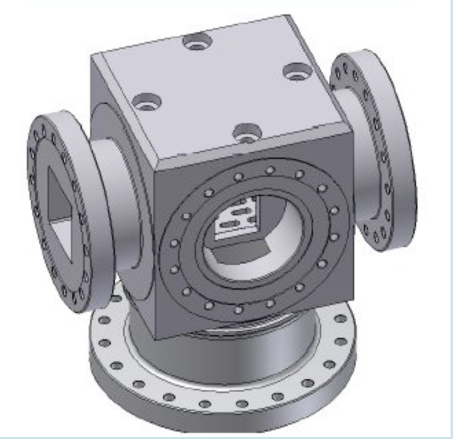
Scrapers will be modified to

- improve their effectiveness
- reduce their contribution to the ring impedance



NEW SCRAPER

new scrapers chamber



New kicker for horizontal feedback

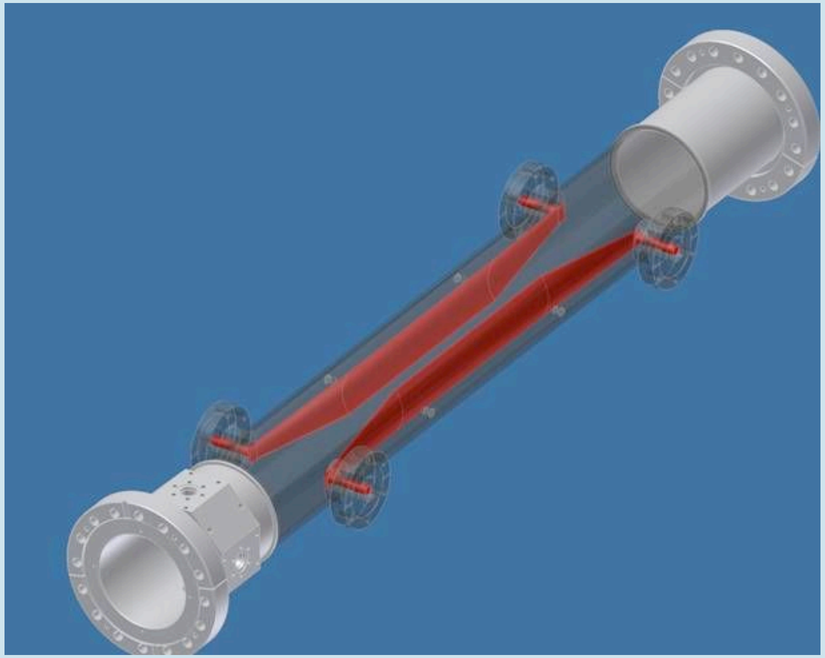
A new kicker is under design to be used

- for transverse horizontal feedback in the e+ ring
- as beam dumper (less detector trips and radiation level)

The new kicker differs from the old one having:

- *double Stripline length*
- *reduced stripline separation in the horizontal plane:*
  88 mm -> 60 mm

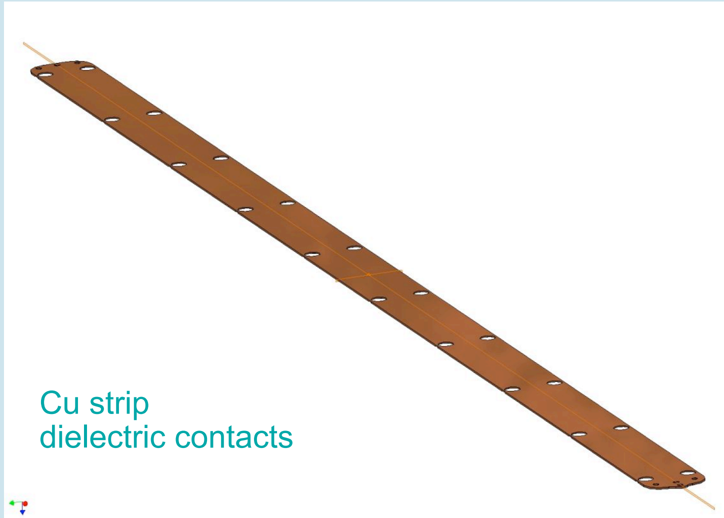
These features will improve ***the kick strength by a factor ≈3*** *(with the same amplifier power).*

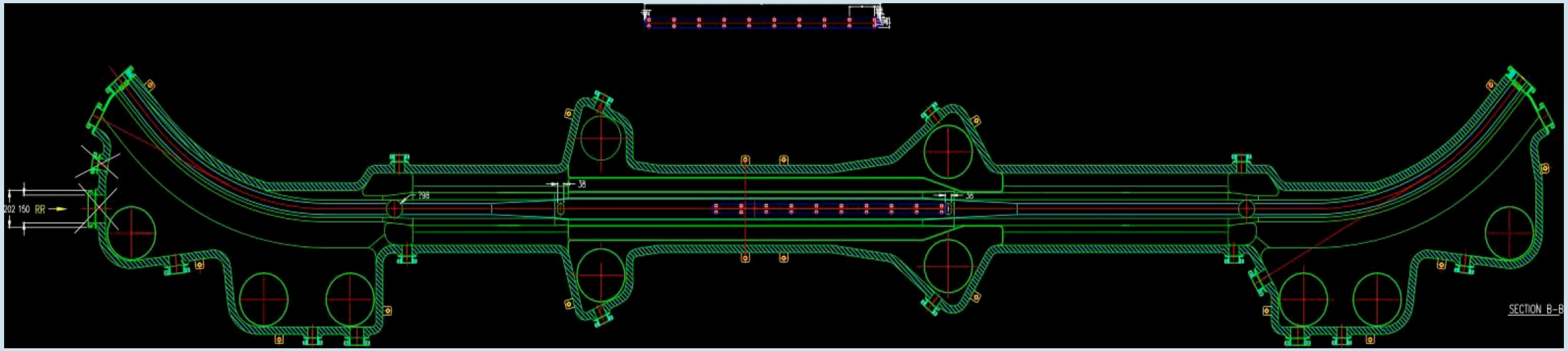


Stripline electrodes for e-cloud clearing

e-cloud *in the wiggler and dipole chambers can be removed by means of stripline electrodes kept at a moderate voltage. The electrodes have been mechanically designed.*

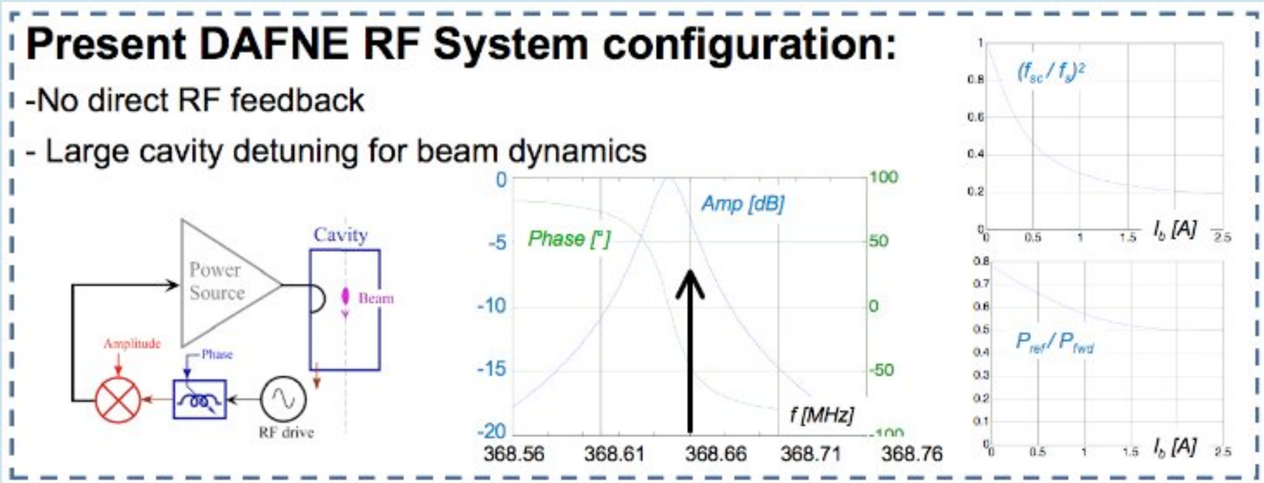
Studies on coupling impedance contribution, thermal and mechanical stresses, insertion and extraction techniques are well advanced

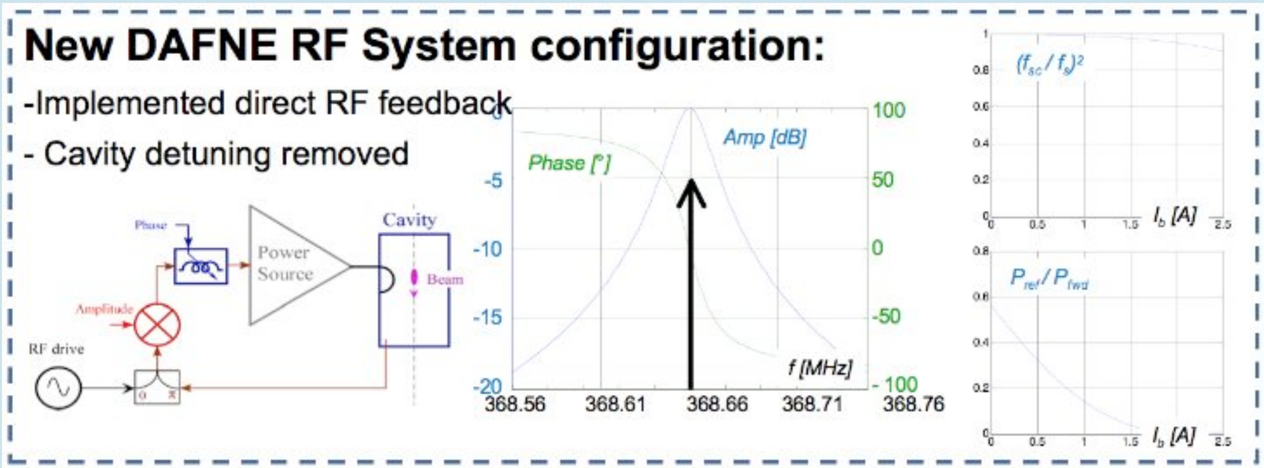




RF low level feedback

The low level RF feedback will allow to reduce the reflected power in the cavity and to improve the beam dynamics by limiting the reduction of the ***coherent 0-mode synchrotron frequency*** *with beam current.*

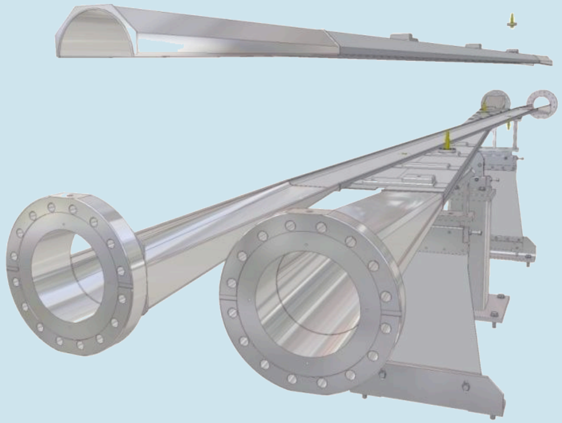


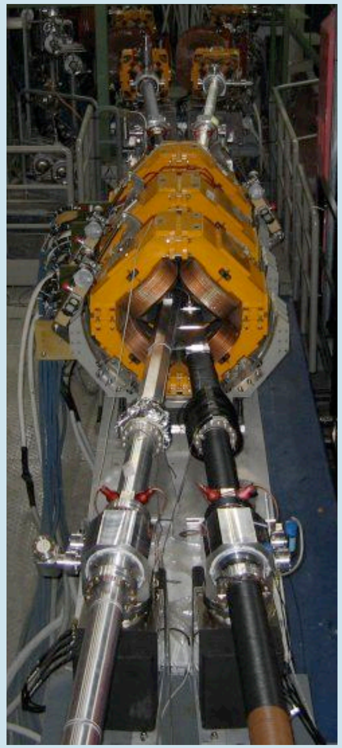


Ring Crossing Region (old IR2)

- *RCR half-moon chamber will be refurbished since an imperfect welding caused a 5 mm deviation from straightness.*
- *Minor adjustment involving the quadrupole positions is also foreseen*

  - *RCR beam stay clear will improve by about 50%*
  - *Less background*





Linac Maintenance & upgrade

- **Linac gun cathode,** almost exausted, will be replaced with a new one
- **Modulators:** capacitors, thyratron replacement → test set
- **New Power Supplies** installation for steering magnets + control system insertion
- **BPM** digitalization for orbit control
- **Flag** cameras mirror system installation
- **New klystron** procurement (delivery by end 2010)

- Another accelerating section will be added at the end of the Linac to increase the energy overhead (~20 MeV gain)

⬇

  - More positrons from the Linac
  - More stable performances

Other Hardware developments

- *Control system*
- *Cryogenic plant upgrade (4 compensator solenoids in the IR)*
- *All the old style bellows will be replaced with the new ones having lower impedance and better mechanical behaviour*
- *The Ion Clearing Electrodes still present in the e- ring will be removed*
- *Horizontal feedback power will be doubled providing 500 W. This item, together with the improved feedback kickers and the electrodes installed in the Wiggler and the dipole of the e^+ ring, should allow to control the e-cloud instability and, as a consequence, to increase the maximum e^+ storable current.*

Conclusions

- *The DAΦNE collider, based on a new collision scheme including Large Piwinski angle and Crab-Waist, has successfully delivered luminosity to the SIDDHARTA detector.*

- *Large crossing angle and Crab-Waist compensation proved to be effective in:*
  - *Increasing luminosity, now a factor 2.7 higher than in the past*
  - *controlling transverse beam blow-up due to the beam-beam*

- *Work is in progress to test the new configuration with a large experimental detector.*