DAΦNE operation with the upgraded KLOE-2 detector

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on behalf of the DAΦNE Team

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The DAΦNE Team

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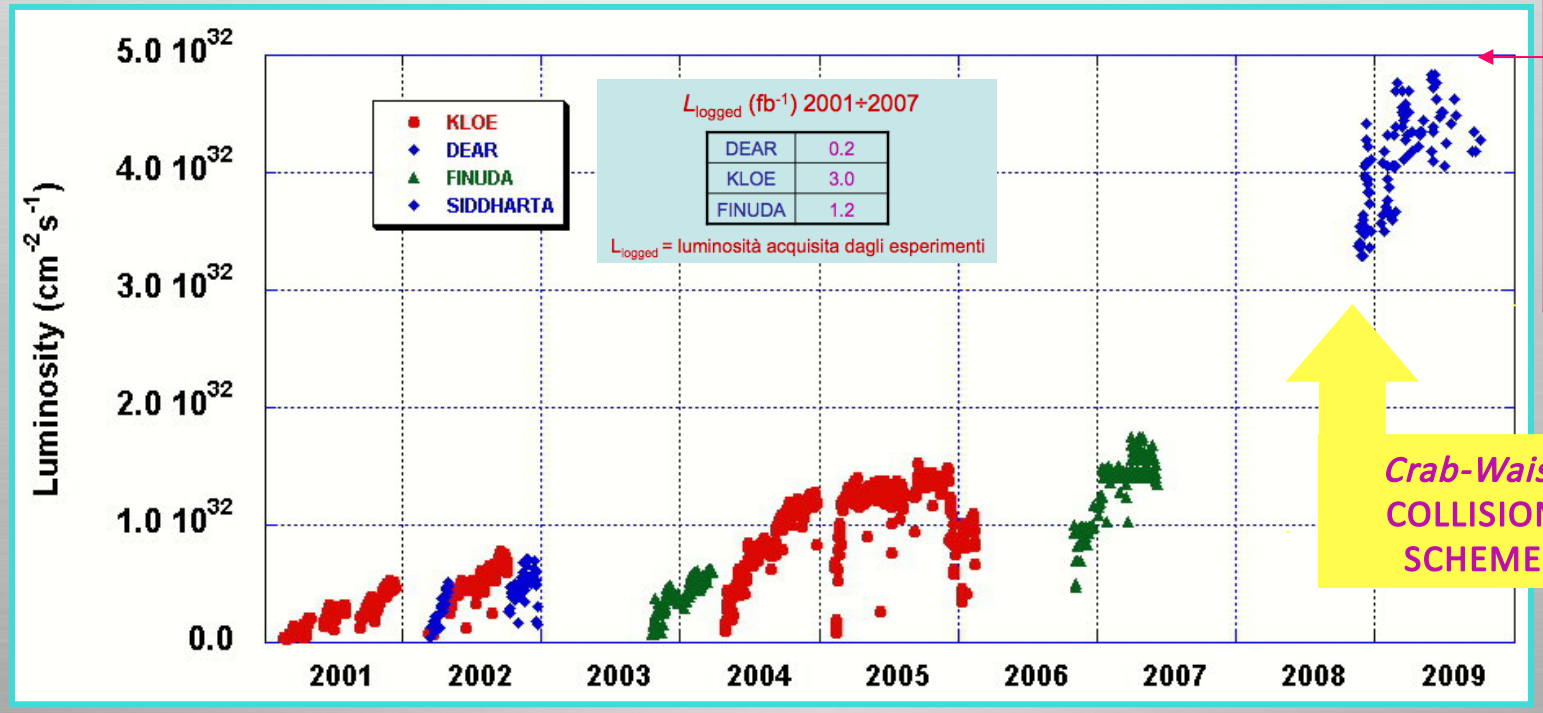
Outline

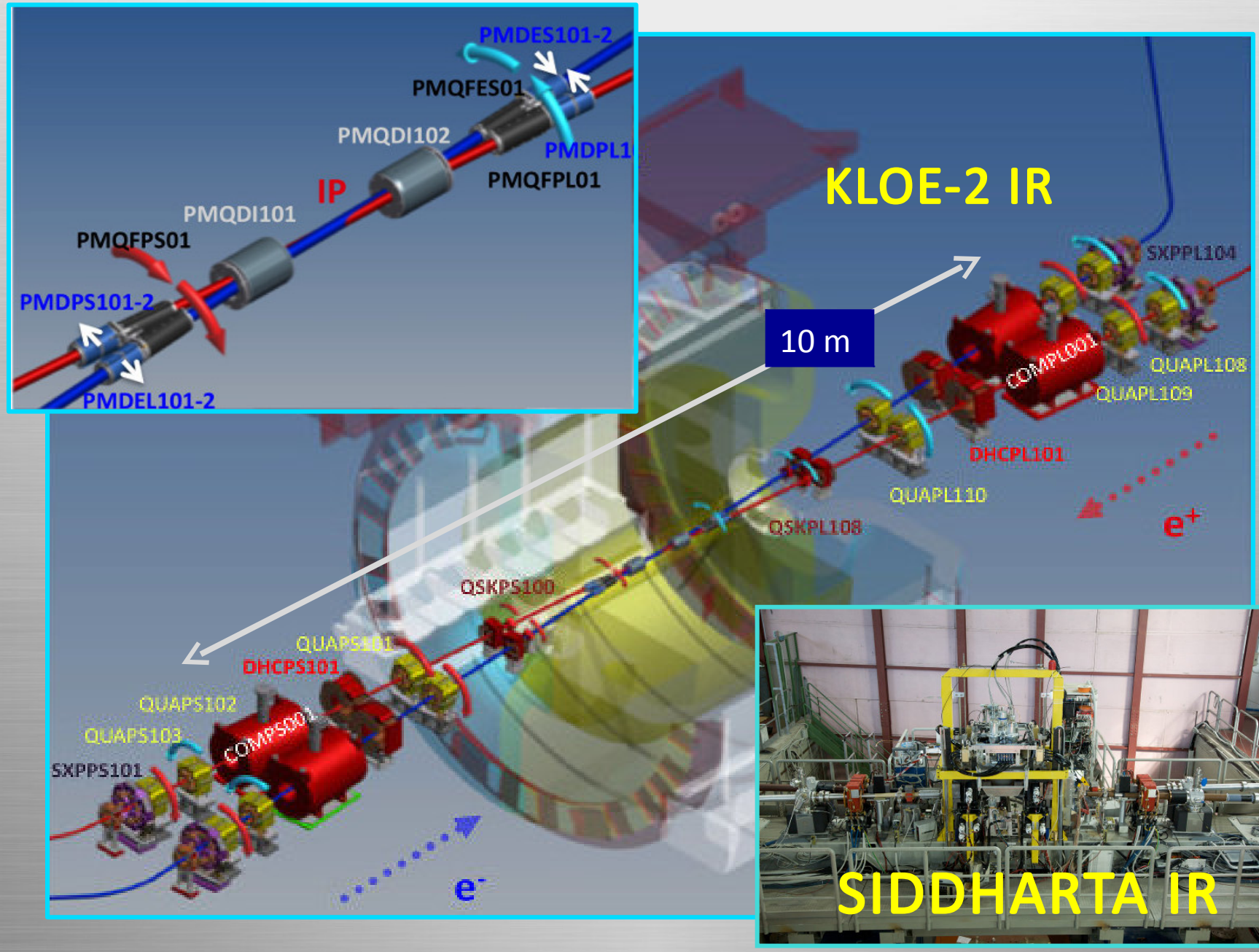
- *Overview on DAΦNE*
- *Some relevant activities from the 2013 shut-down*
- *DAΦNE commissioning*
- *Latest luminosity results*
- *Pushing luminosity even further*
- *Conclusions*

The DAΦNE Accelerator Complex

LNF are also part of the European synchrotron light Infrastructures

Luminosity at DAΦNE 2001 ÷ 2009




PMDES101-2
PMQFES01
PMQDI102
PMDPL1
PMQFPL01
IP
PMQDI101
PMQFPS01
PMDPS101-2
PMDEL101-2
KLOE-2 IR
10 m
SXPPL104
COMPL001
QUAPL108
QUAPL109
DHCPL101
QUAPL110
QSKPL108
e+
QSKPS100
QUAPS101
DHCPS101
QUAPS102
QUAPS103
COMPS001
SXPPS101
e-
SIDDHARTA IR

DAΦNE Consolidation Activities

DAΦNE shut-down was intended mainly to upgrade the experimental detector (KLOE became KLOE-2), moreover it has been very useful to consolidate the entire collider.

December 16th 2012 - mid July 2013

Activities involved almost all the components and the subsystems of the DAΦNE accelerator complex:

- IR mechanical structure and IP vacuum chamber
- auxiliaries' automation and control system
- Control system
- Vacuum installation (windows, scrapers)
- Cooling system
- Cryogenic plant
- Magnets and power supplies
- Modification of the LLRF controllers
- Linac
- E-cloud electrode power supplies
- new horizontal kicker for the MRe feedback
- Additional BPMs and improved tools for beam profile measurements

Posters:

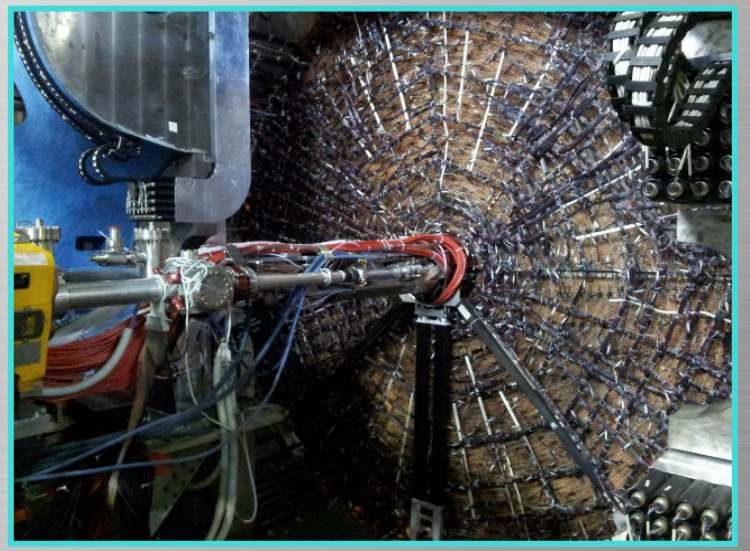
C. Milardi et al,THPRI002
A. De Santis et al,THPRI015
F. Guatieri et al,TUPRI089

IR Structural Modifications

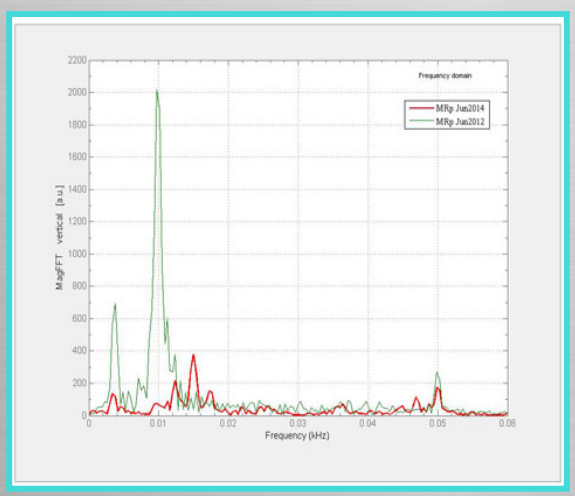
The supports design of vacuum chambers, equipment, magnetic elements and diagnostic have been revised to:

- host the new detector components
- stand additional weight
- improve alignment precision

A pair of carbon fiber composite legs have been added to the existing ones
Some rubber pads previously inserted below the cradle support have been removed, thus strengthening the structure and increasing its rigidity.



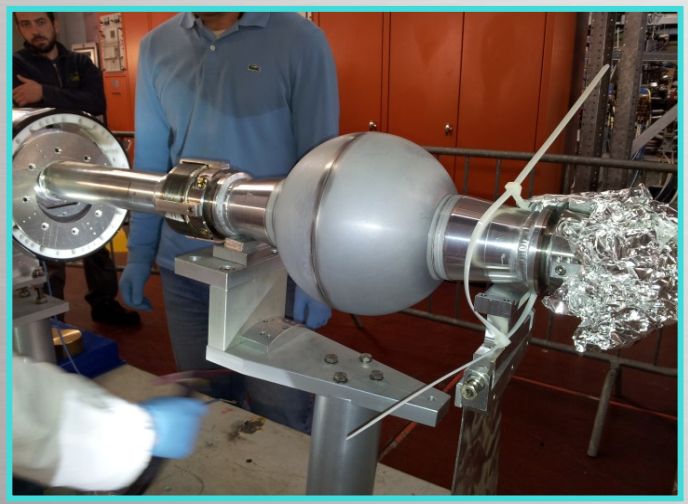
The spectrum of a previously observed vertical beam oscillation got modified. The main harmonic was shifted toward higher frequencies, ~15 HZ, and its amplitude reduced by a factor four

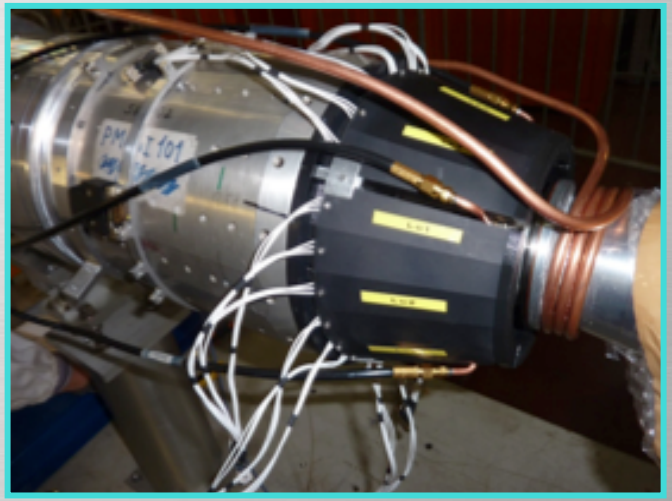


Interaction Point Vacuum Chamber

The vacuum chamber around the Interaction Point (IP) has been redesigned:

- new ALBEMET spherical chamber
- tapered transition between the sphere and the Al beam pipes
- new bellows with new designed RF contacts
- Two cooling pipes added on the tapers
- semi-cylindrical thin (35 μm) beryllium shields replaced inside the sphere
- two additional BPMs installed on both sides of the IP





- Heating problem affecting the low-β defocusing quadrupole downstream the e- beam has been fixed
- working point stability in operations
- New BPMs allow more accurate beams overlap and transverse betatron coupling studies

Commissioning

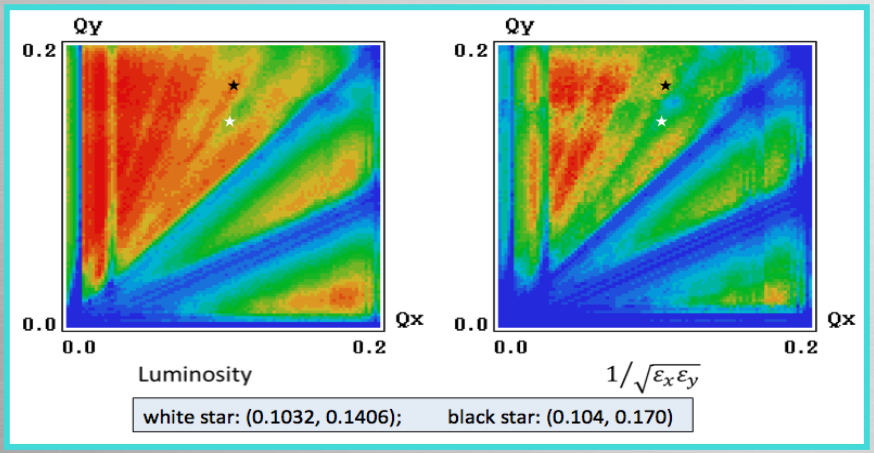
Commissioning started mainly by the end of January 2014, but it has been severely slowed down by three main interruptions due to external circumstances. A drastically reduction of the water supply, and an electric blackout imposed three shut-down costing, in total, **two and half months of inactivity.**

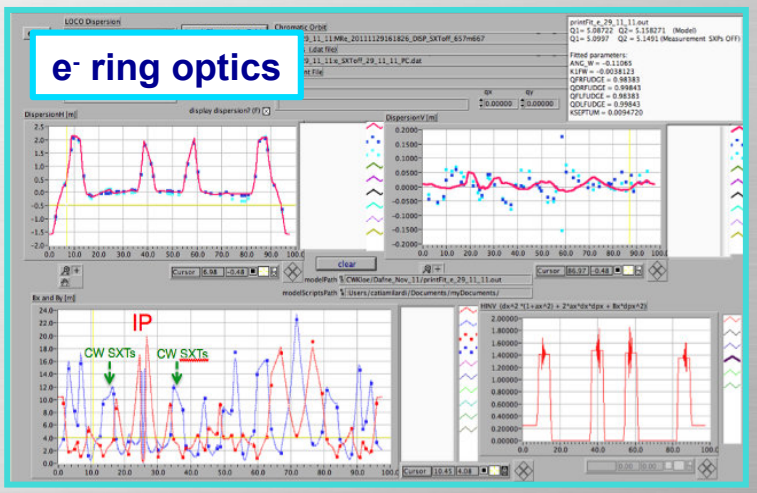
working points adopted

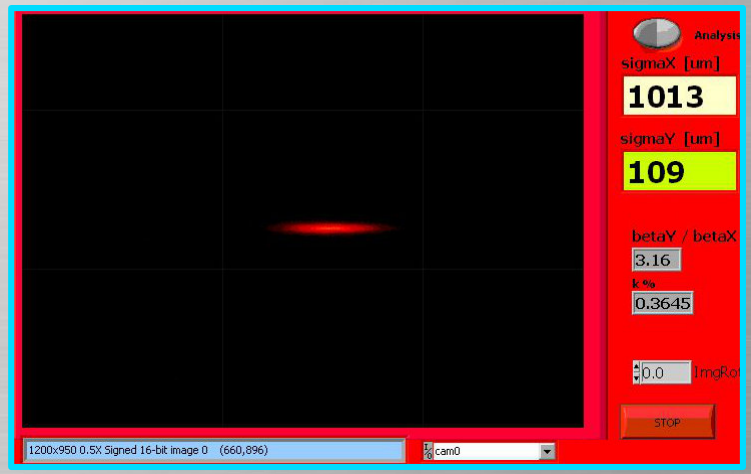
$\nu_x^- = 5.098 \quad \nu_y^- = 5.164$

$\nu_x^+ = 5.102 \quad \nu_y^+ = 5.139$

which *LIFETRAC* simulations should provide good luminosity.







Transverse betatatron coupling with all skew QUADs off:

$\kappa^+ \sim 0.4\%$

κ^- not yet optimal

Tuning the skew QUADs:

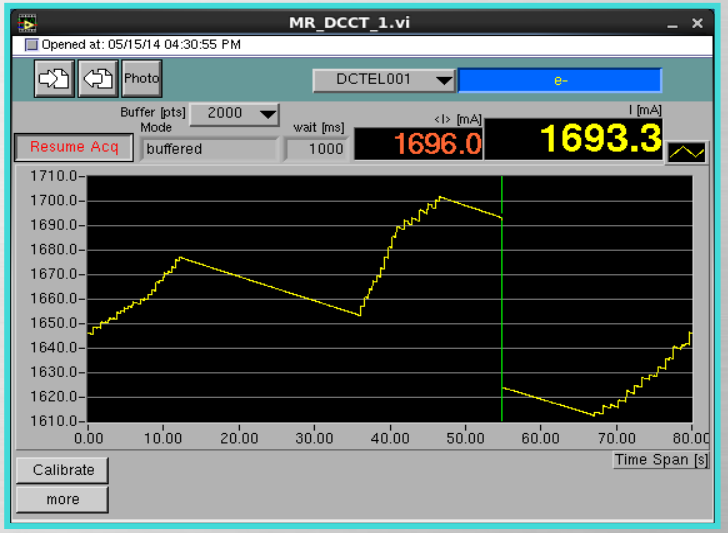
$0.2\% \leq \kappa \leq 0.3\%$ (both beams)

Beam Dynamics

Highest currents stored, so far, in 98 bunches spaced by 2.7 ns are:

$I^- = 1.7$ A $I^+ = 1.15$ A

These currents are the highest ever achieved after installing the new IR for the KLOE-2 detector, based on the *Crab-Waist* collision scheme.



The three independent bunch-by-bunch feedback systems installed on each ring are essential for high current multi-bunch operations.

The e^+ vertical feedback is now using a new ultra-low noise front-end module, designed in collaboration with the SuperKEKB feedback team, aimed at reducing the noise contribution to the transverse vertical beam size in collision.

e^+ Beam Dynamics

Beam dynamics in the e^+ ring is clearly dominated by the **e-cloud** induced instabilities which are kept under control by:

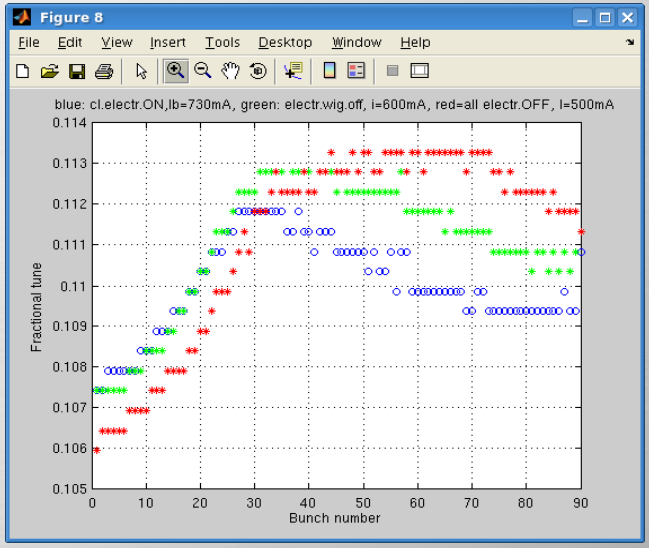
- powerful bunch-by-bunch transverse feedback systems
- solenoids wound all around the straight sections
- electrodes installed inside dipole and wiggler vacuum chambers.

Electrodes effectiveness has been already proved in 2012 polarizing the stripline with a positive voltage in the range 0÷250 V
Simulations indicate that a factor two higher voltage is required to completely neutralize the e-cloud density due to a e^+ current of the order of 1 A

e-cloud Mitigation

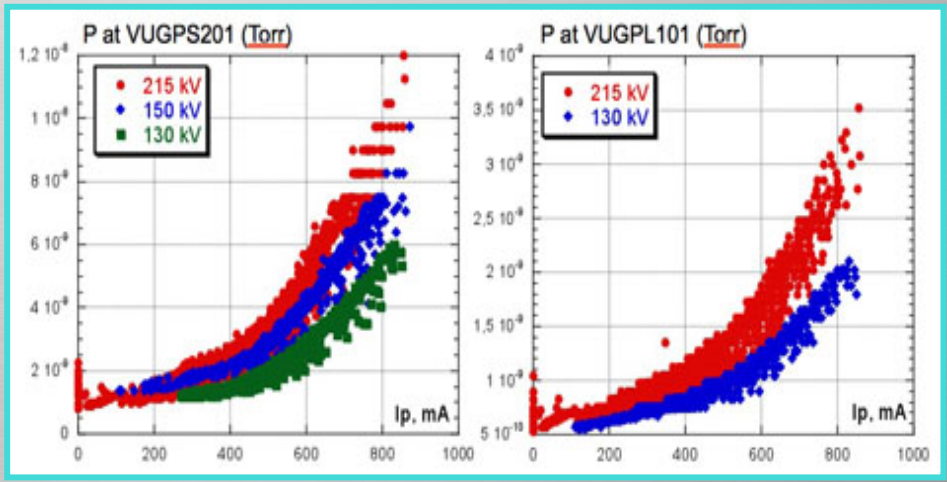
The electrode power supplies have been replaced with devices providing a maximum negative voltage of 500 V, the change of polarity was intended to limit the current delivered by the power supplies

New setup test:
I^+= 700 mA in 90 contiguous bunches.

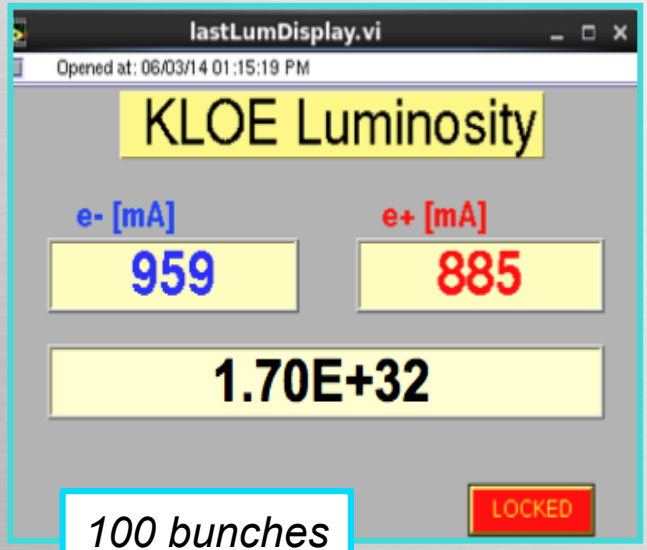


e-cloud induced effects have been mitigated also by :

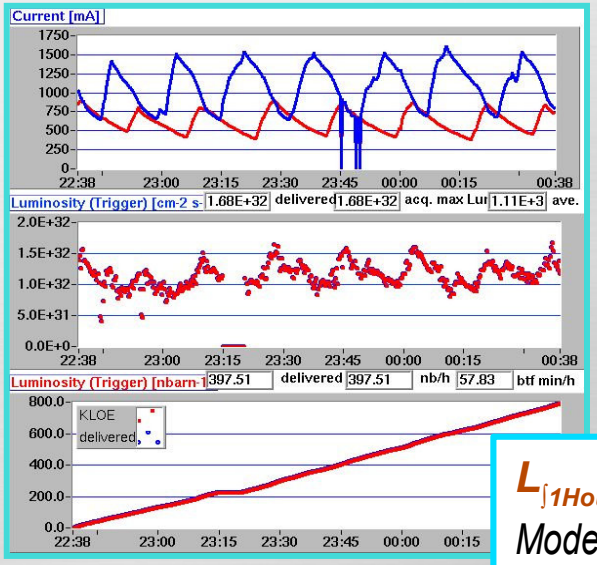
- Moving ξ_x ξ_y to higher positive values
- Lengthening the bunch by reducing the RF cavity voltage



Peak Luminosity



100 bunches



$L_{\int 1Hour} = 0.4\ pb^{-1}$

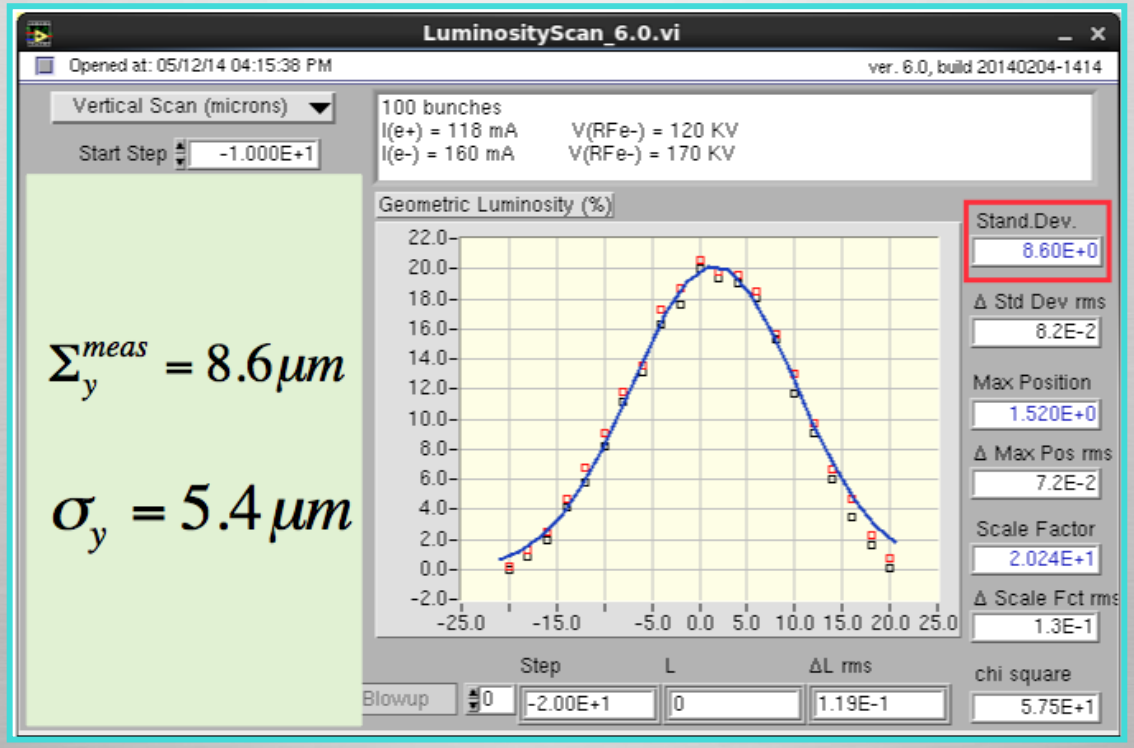
Moderate injection regime

	DAΦNE CW upgrade SIDDHARTA (2009)	DAΦNE KLOE (2005)	DAΦNE (CW) KLOE (2012)	DAΦNE (CW) KLOE-2 (2014)
L_{peak} [$cm^{-2}s^{-1}$]	**$4.53 \cdot 10^{32}$**	$1.50 \cdot 10^{32}$	$1.52 \cdot 10^{32}$	**$1.70 \cdot 10^{32}$**
I^- [A]	**1.52**	1.4	0.93	**0.96**
I^+ [A]	**1.0**	1.2	0.72	**0.89**
$N_{bunches}$	**105**	111	100	**100**

L_{peak} exceeds by a 13% the best luminosity ever achieved, at DAΦNE, during operations for an experimental apparatus including high field detector solenoid.

Background presently has been reduced to levels almost compatible with the detector data-taking

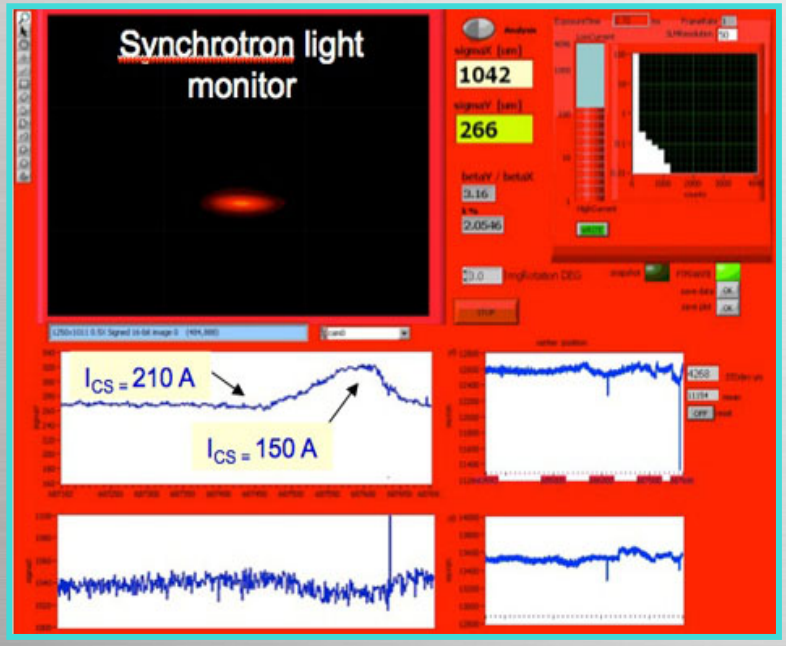
Vertical beam-beam *Luminosity scan*

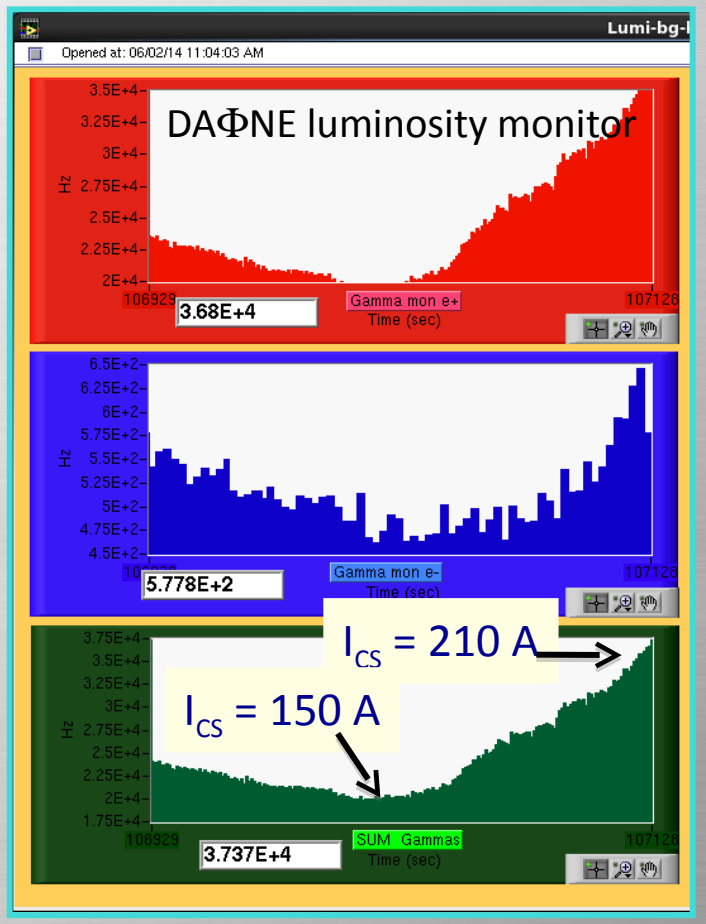


Σ_y^{meas} is still considerably high since the transverse betatron coupling in the e^- ring is not yet properly corrected

Crab-Waist Sextupoles

Crab-Waist Sextupoles effectiveness has been tested on the e^+ ring

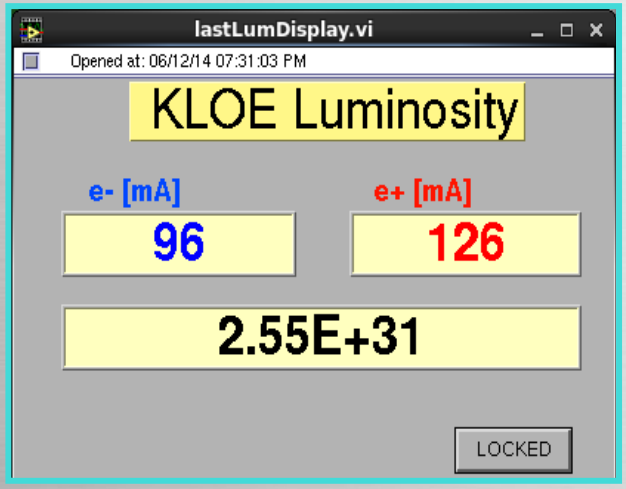


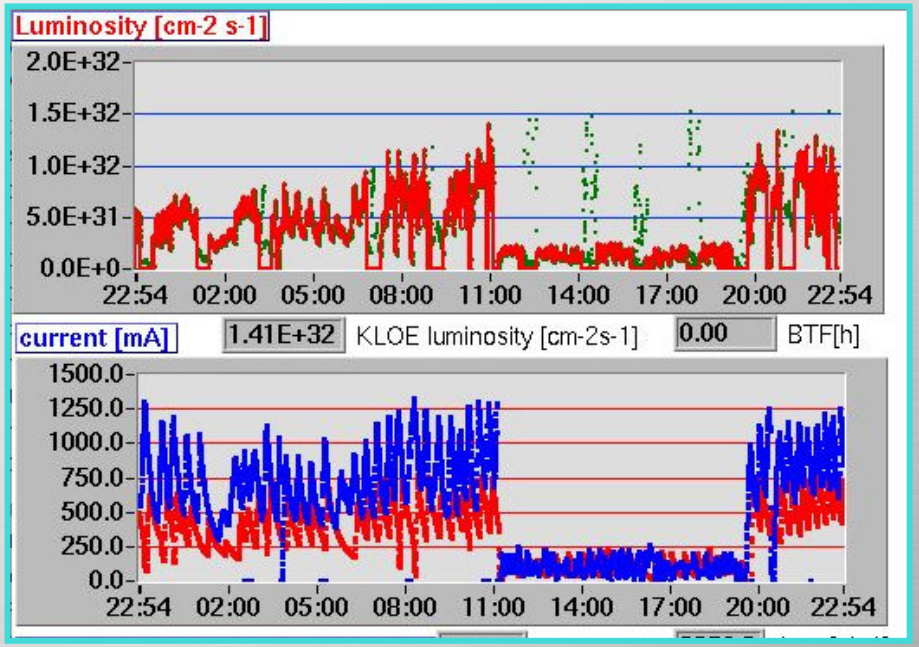


Crab-Waist Sextupoles strengths are 30% and 50% lower than the nominal ones for e^+ and e^- respectively.

10 Bunches Luminosity

Aiming at minimizing the impact of collective effects on L





L_{peak} ~ 2.5 10^{32} cm^{-2} s^{-1} might be achieved by using 100 bunches

- *Beam-beam is not a limiting factor*
- *Crab-Waist Sextupoles work (even at lower strength)*

This result can be improved by:

- *optimizing dynamical vacuum*
- *perfecting colliding beams parameters*
- *tuning multi-bunch and high current operations*

Pushing luminosity further

A considerably higher luminosity might be attained by:

- Improving the transverse betatron coupling correction in the e^- ring
- optimizing the present rings optics and working point
- Setting the *CW*-Sextupoles to the nominal values
- improving dynamic vacuum
- Increasing stored currents and number of colliding bunches

Further contributions might come also from exploring new optics configuration with higher α_c and from extensive beam dynamics studies.

Conclusions

The DAΦNE collider is operational again.

Despite the adverse circumstances several clear results have been achieved: the instantaneous luminosity and the maximum stored beam currents are now the highest ever achieved in operations with an experimental apparatus including high field detector solenoid.

Limiting factors have been well understood and still many parameters can be ameliorated to further improve the collider performances

The KLOE-2 data taking can start

Thank you for your attention