

DAΦNE: results and consolidation activities

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on behalf of the DAΦNE Team

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The DAΦNE Team

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Other Contributors

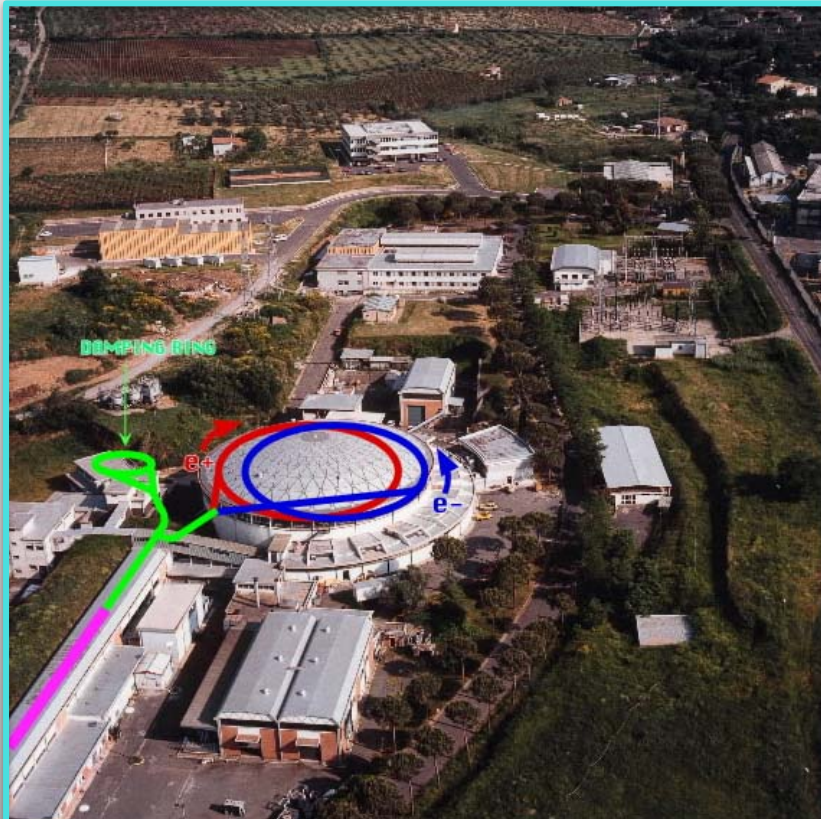
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Contents

DAΦNE commissioning and operation

- *Benefits from the consolidation activities*
- *Operations*
- *Latest luminosity results and future perspectives*
- *The KLOE-2 data taking*
- *Machine uptime*
- *Conclusions*

The DAΦNE Accelerator Complex



e^+e^-
 $C = 97\text{ m}$
 $E = 0.51\text{ GeV } (\Phi)$

LINAC

550 MeV e^+
800 MeV e^-

BTF

UV 2 - 10 eV

X-ray 900 - 3000 eV
X-ray

IR 1.24 meV - 1.24 eV

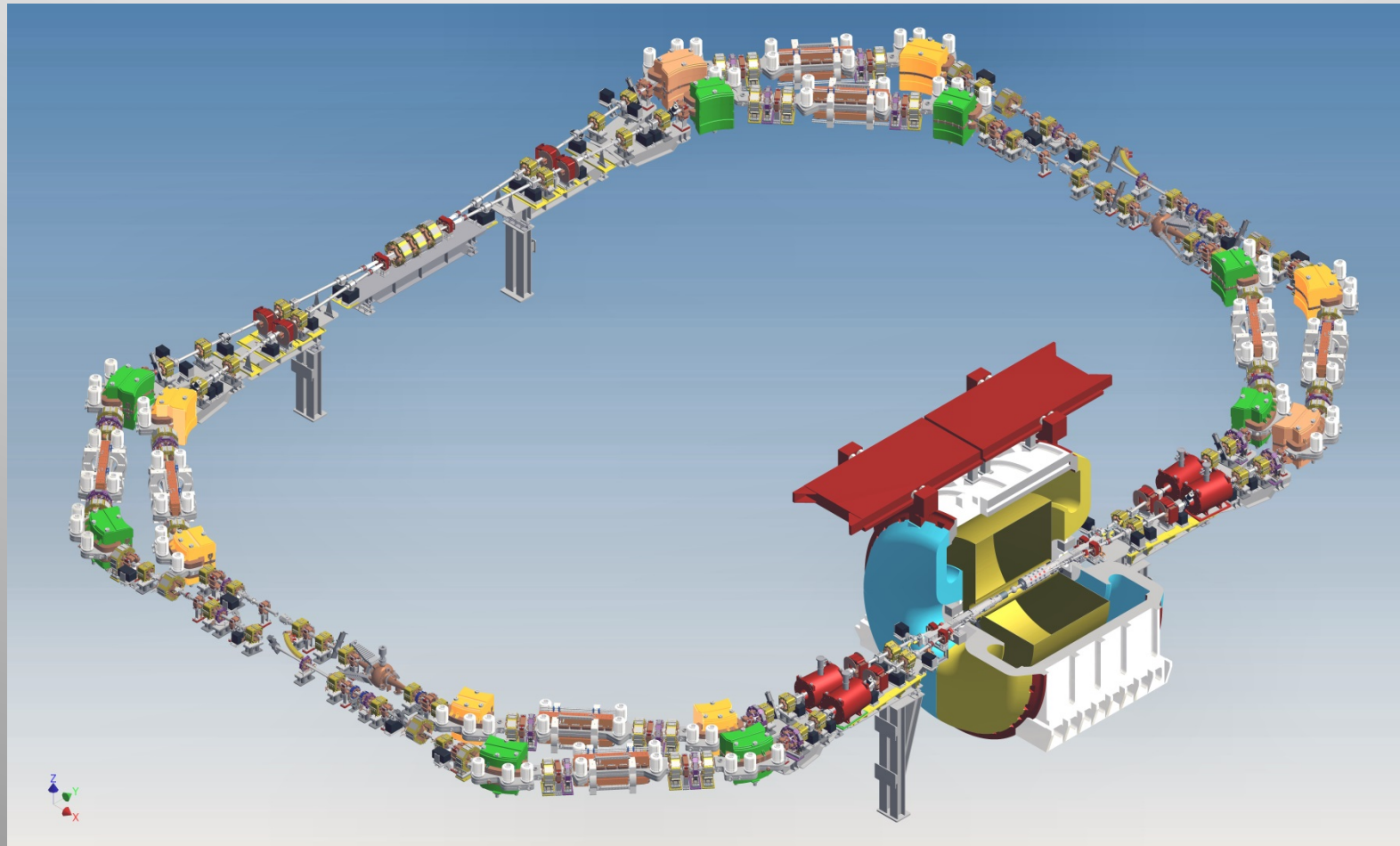
DAΦNE

KLOE

ACCUMULATOR
510 MeV

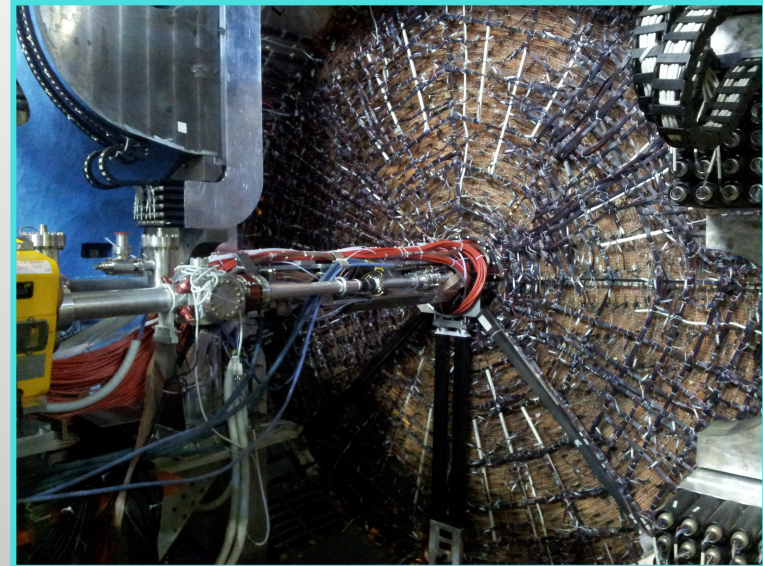
LNF are also part of the European
synchrotron light Infrastructures

DAΦNE and KLOE-2

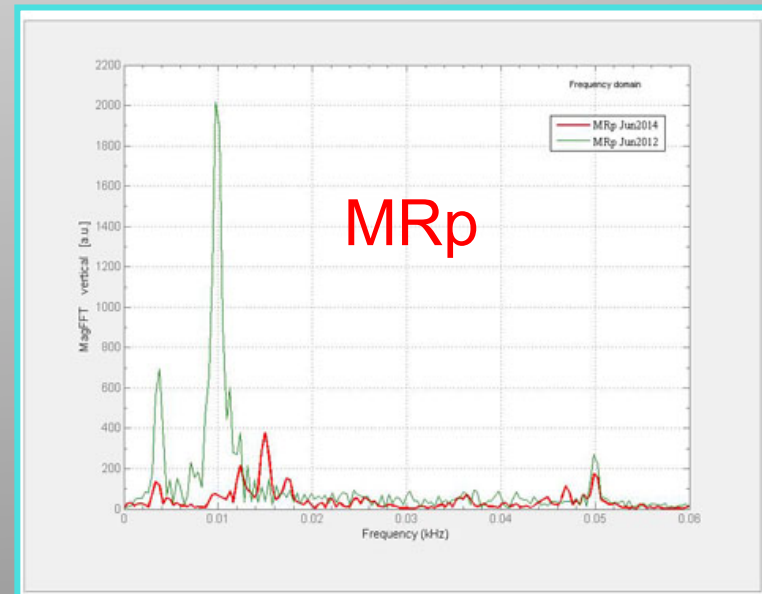


IR Structural Modifications

- 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.

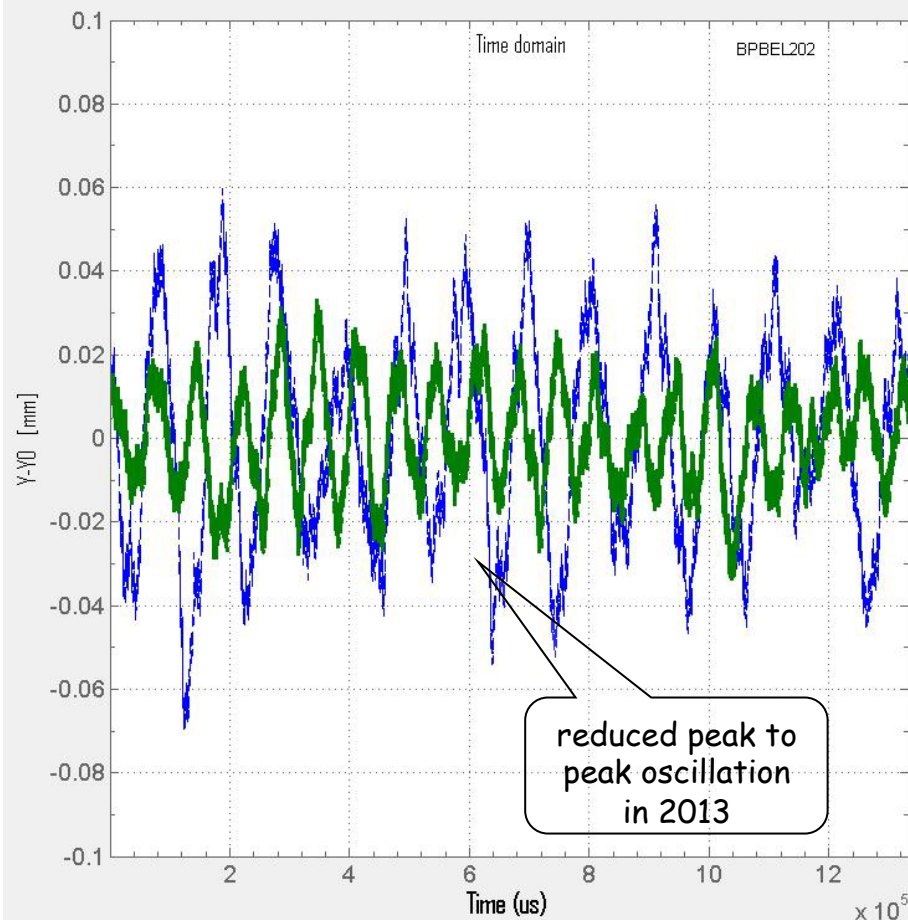


The spectrum of a previously observed vertical beam oscillation got modified. The main harmonic was shifted toward higher frequencies, ~ 15 Hz, and its amplitude reduced by a factor four

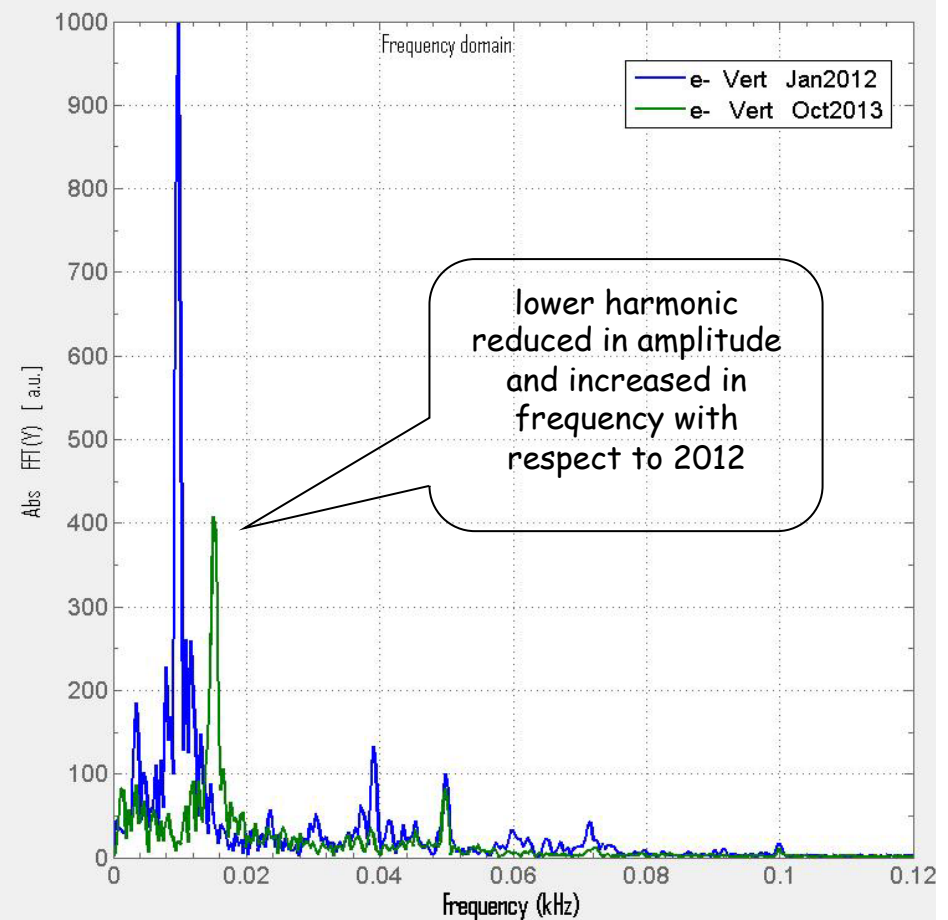


vertical orbit oscillation

recent measurements on e⁻ beam compared with 2012



time domain



FFT analysis

natural beam oscillation around the reference orbit as recorded at BPBEL202

Spherical Vacuum chamber

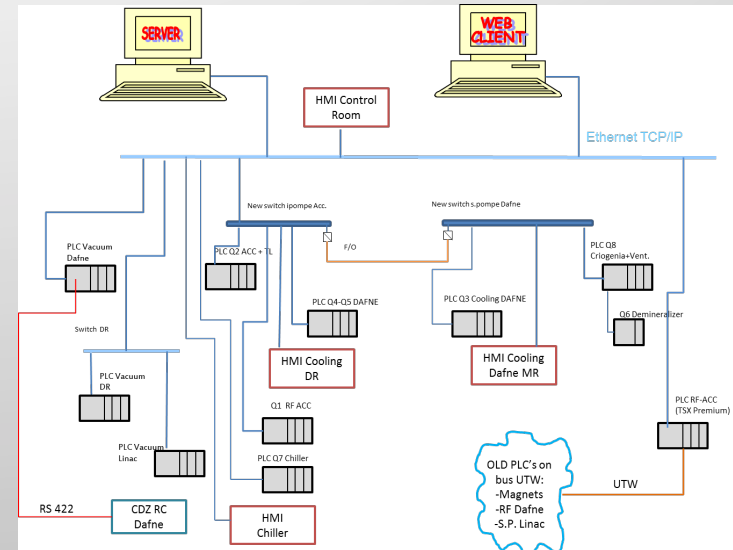
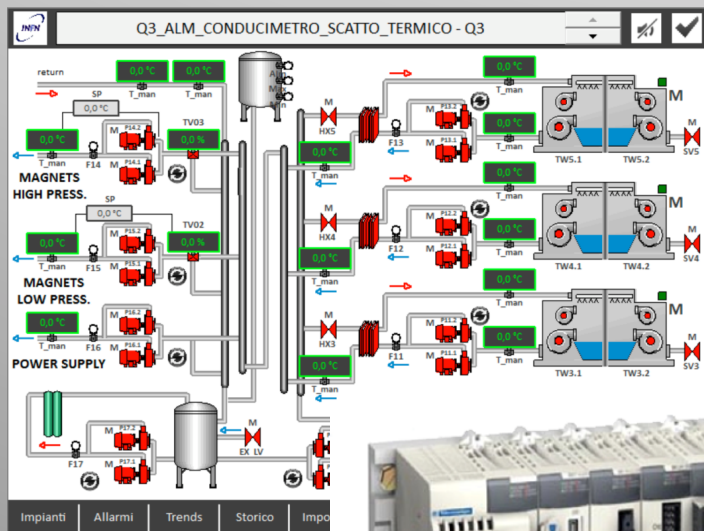


- Heating problem affecting the low- β defocusing quadrupole downstream the e-beam has been fixed
- working point stability in operations
- New BPMs allow more accurate beams overlap and transverse betatron coupling studies

Ancillary plants Control System

A new supervision and control system, based on an industrial SCADA MOVICON, performs a smarter management of the installation

The renewed PLC's and previous devices are under control of an unique supervision system.

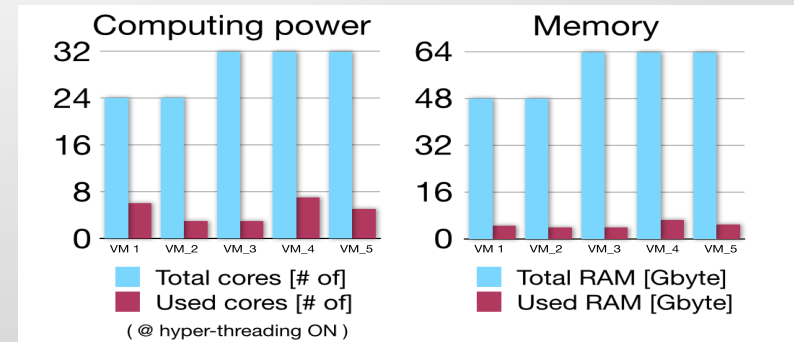


- Efficient and user friendly tools give access to subsystem information (data, alarm, faults) allowing a very useful data analysis
- Stability of the power supplies temperatures has been improved

Control System

The Control System architecture has been deeply modified:

- *Most of the VME bus platform have been dismissed*
- *The whole data flow has been redirected to the network*
- *An Object Caching service (Memcached) hosts the live data*
- *Large part of the front-end boards (serial, DAQs, ADCs, etc.) replaced by network devices, which allowed for the porting of many control programs to remote Linux virtual machines.*
- *Using serial device servers instead of serial communication boards, permitted to increment the number of daisy chain lines (RS-422) employed in connecting the magnets' power supplies.*
- *Almost all distributed front-end VME processors (forty-five 68030 custom boards) with Intel boards, run Linux.*
- *New Linux servers for the core services (NFS, DHCP, diskless boot, MySQL, memcached) and for the SunRay™ thin-clients employed as consoles.*



Computing and memory resources available for the virtual machines

- DCS is now more performable, **reliable** and its overall **uptime significantly increased**
- commutation of the injection system between the e^+ and the e^- operating modes is now considerably faster thanks to the increased number of daisy chain connecting the relative power supplies

Linear optics

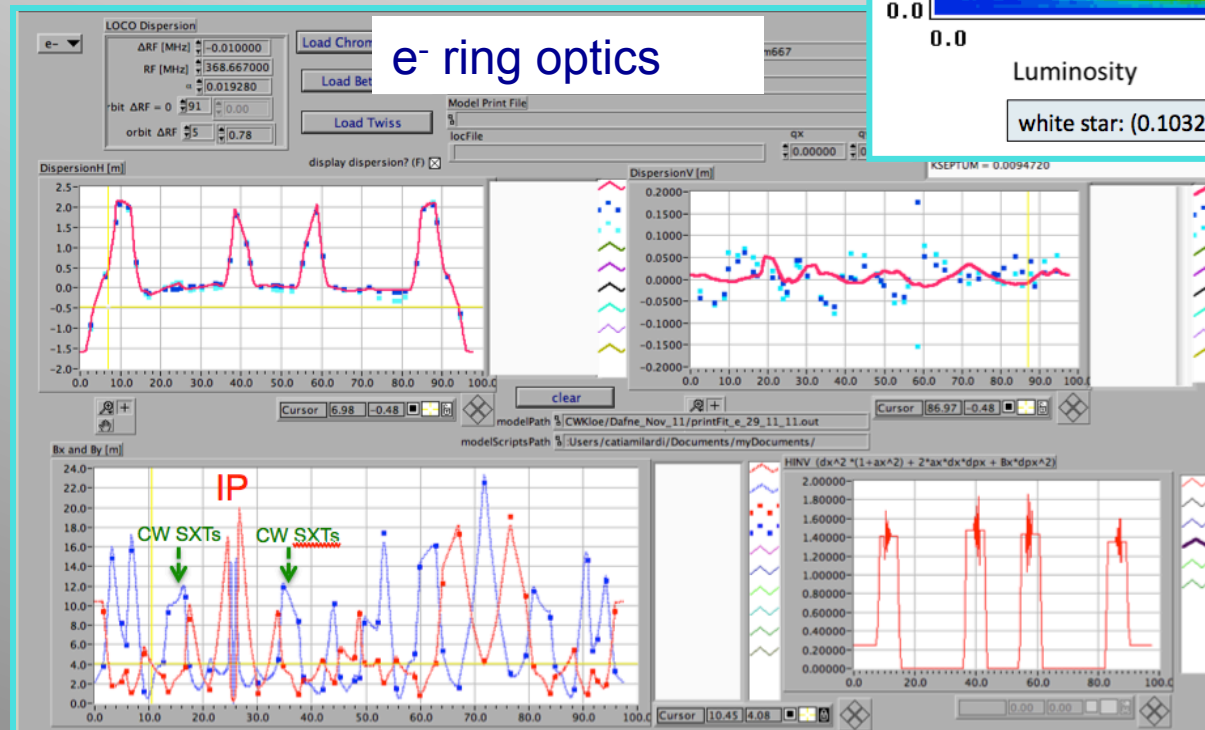
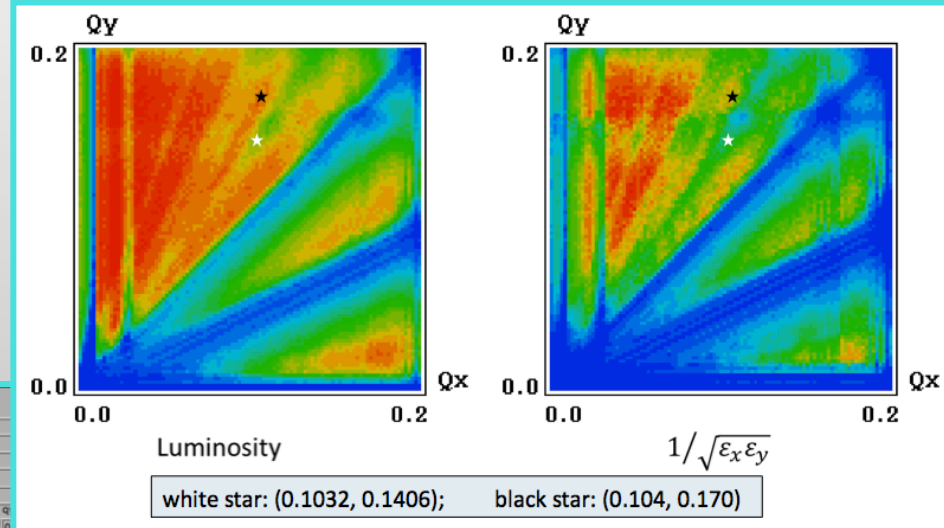
Commissioning started mainly by the end of January 2014, but it has been severely slowed down by 3 main interruptions due to external circumstances causing, in total, **two and half months of inactivity**.

working points adopted

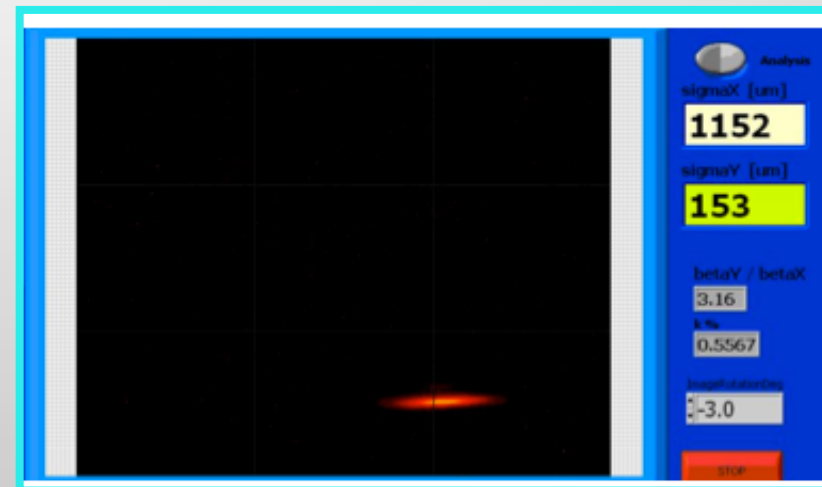
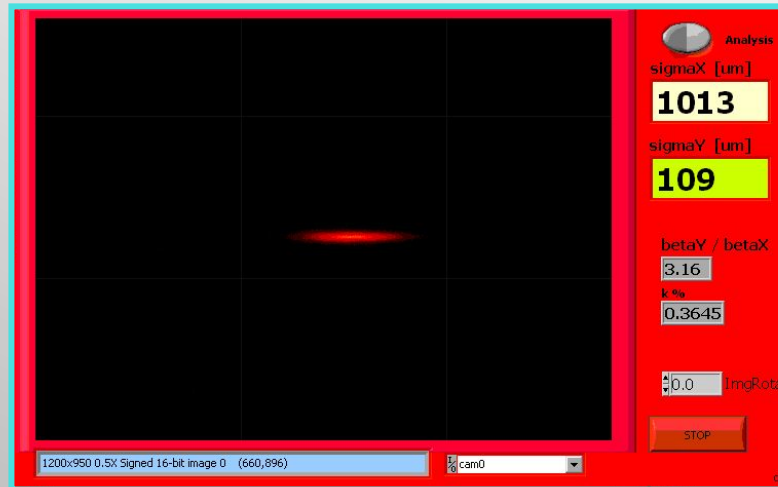
$$\nu_x^- = 5.098 \quad \nu_y^- = 5.164$$

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

according *LIFETRAC* simulations should provide good luminosity



Transverse betatron coupling optimization



Transverse betatron coupling all skew QUADs off:

$$\kappa^+ \sim 0.4\%$$

$$\kappa^- \sim 0.6\% \quad \text{not yet optimal}$$

Tuning the skew QUADs:

$$0.2\% < \kappa < 0.3\% \quad (\text{both beams})$$

Sextupoles alignment in MRe

Positioning of some sextupole magnets

SXPES101 (Crab-SXT)

SXPES203 (chromatic SXT)

Has been refined by using beam based alignment techniques

Beam Dynamics

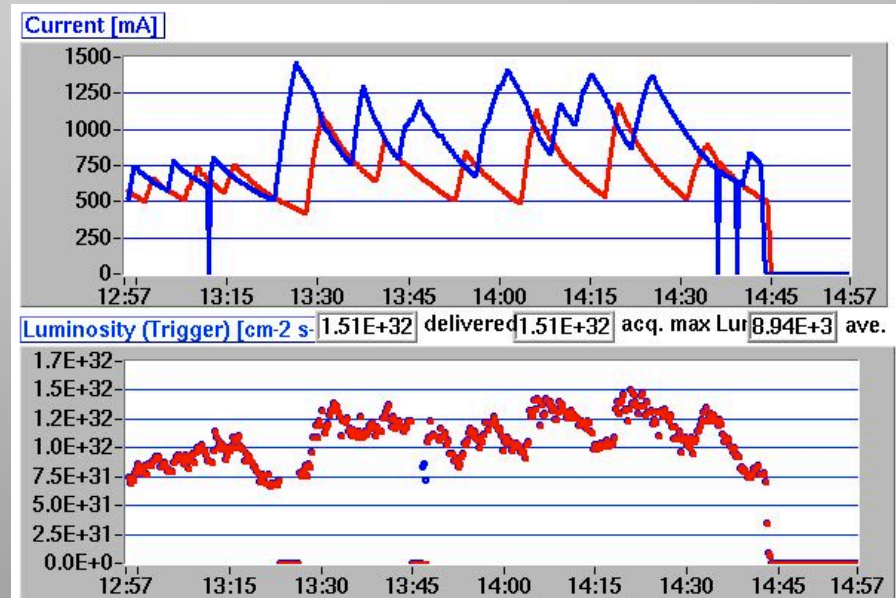
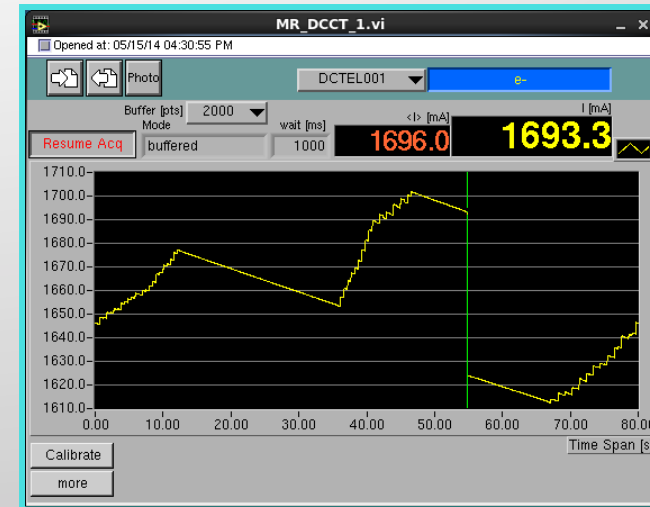
Highest currents stored, so far, in 98 bunches spaced by 2.7 ns are:

$$I^- = 1.85 \text{ A} \quad I^+ = 1.2 \text{ A}$$

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

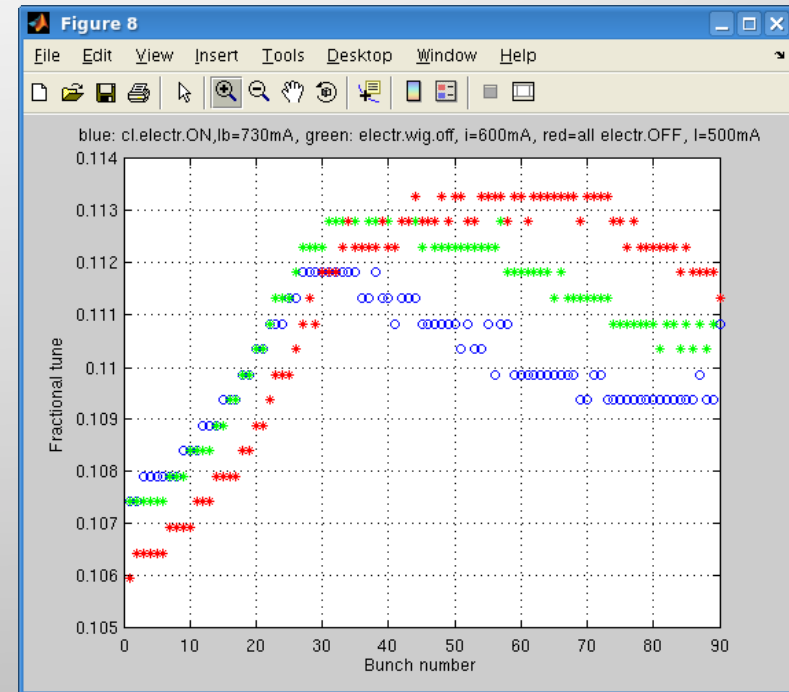
Simulations indicate that a factor two higher voltage is required to completely neutralize the e-cloud density due to a e^+ current of the order of 1 A

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

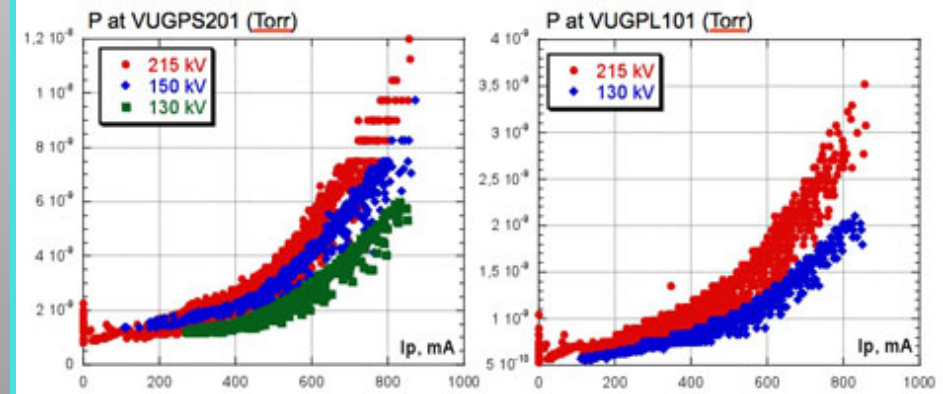
New setup test:

$I^+ = 700$ mA in 90 contiguous bunches

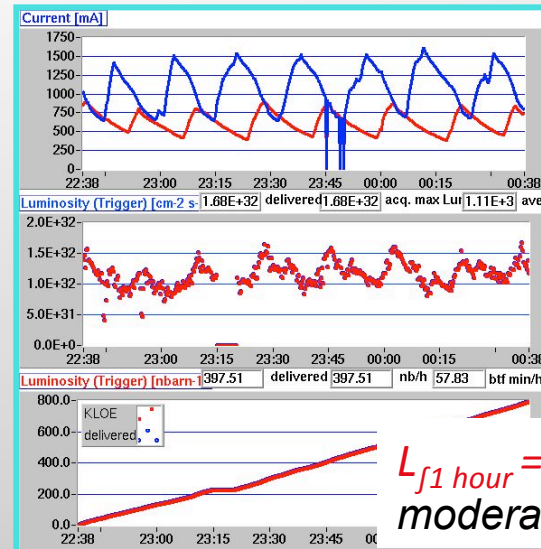
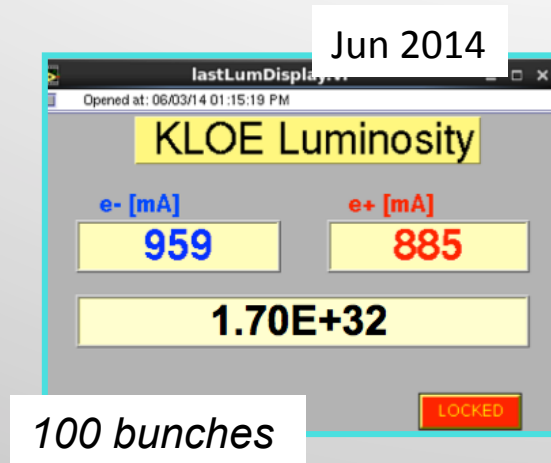


e-cloud induced effects have been mitigated also by:

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



Peak Luminosity



$L_{f1 \text{ hour}} = 0.4 \text{ pb}^{-1}$
moderate injection regime

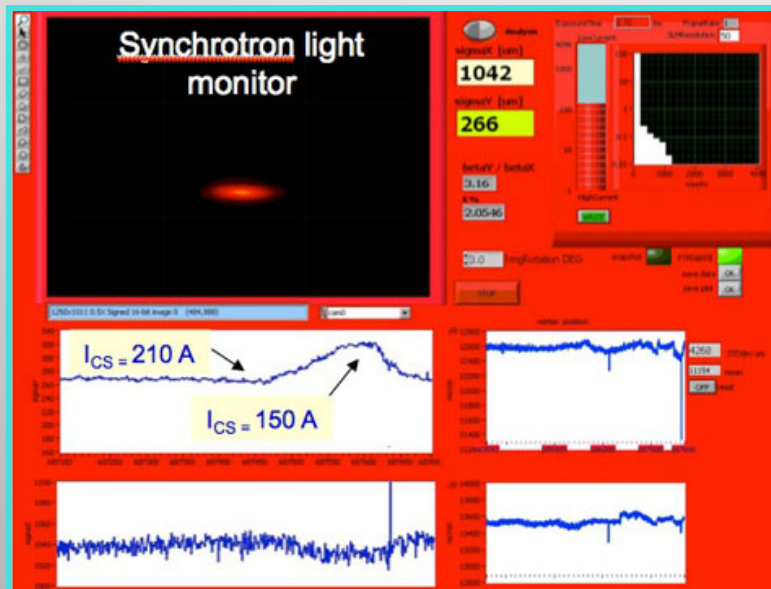
	DAΦNE CW upgrade SIDDHARTA (2009)	DAΦNE KLOE (2005)	DAΦNE (CW) KLOE (2012)	DAΦNE (CW) KLOE-2 (2014)
$L_{\text{peak}} [\text{cm}^{-2}\text{s}^{-1}]$	$4.53 \cdot 10^{32}$	$1.50 \cdot 10^{32}$	$1.52 \cdot 10^{32}$	$1.70 \cdot 10^{32}$
$I^- [\text{A}]$	1.52	1.4	0.93	0.96
$I^+ [\text{A}]$	1.0	1.2	0.72	0.89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

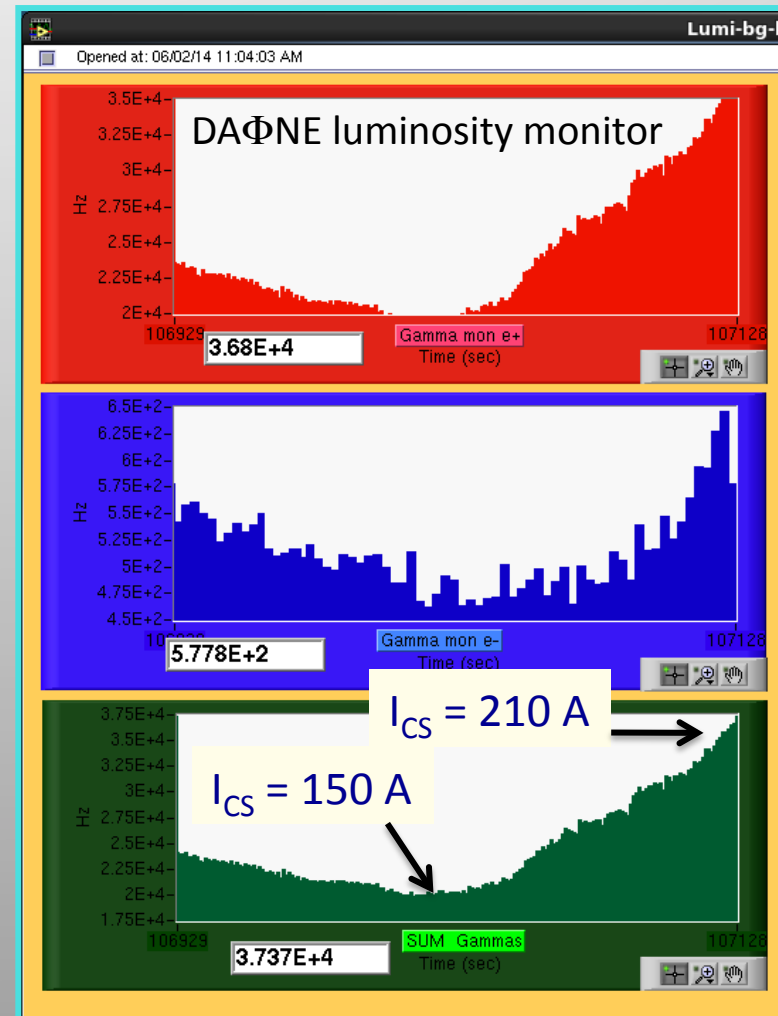
Background presently has been reduced to levels almost compatible with the detector data-taking

Crab-Waist Sextupoles

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

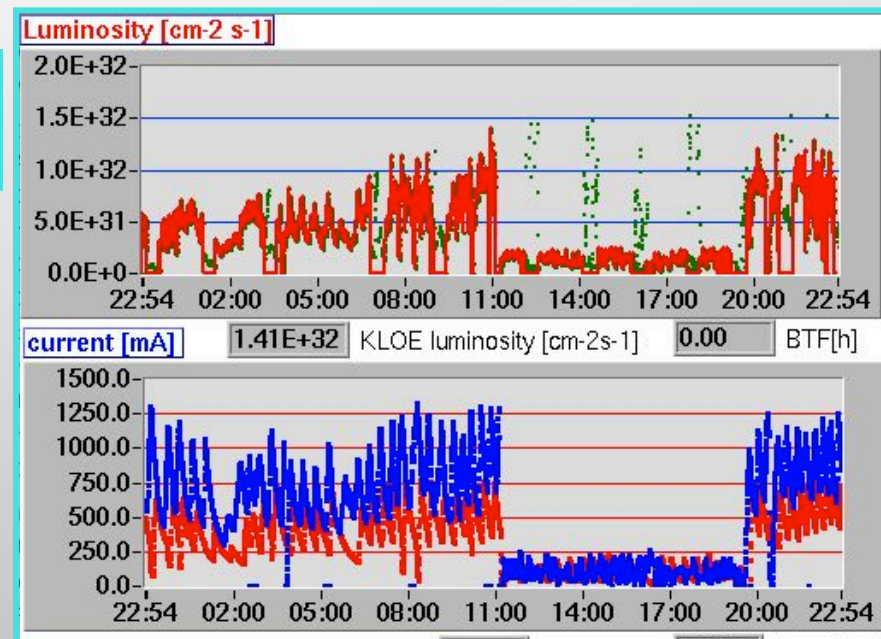
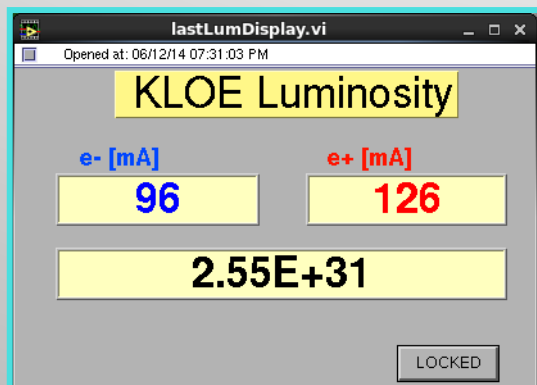


Crab-Waist Sextupoles strengths are 30% and 50% lower than the nominal ones for e^+ and e^- respectively.



10 Bunches Luminosity

Aiming at minimizing the impact of collective effects on L



$L_{peak} \sim 2.5 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$ might be achieved by using 100 bunches

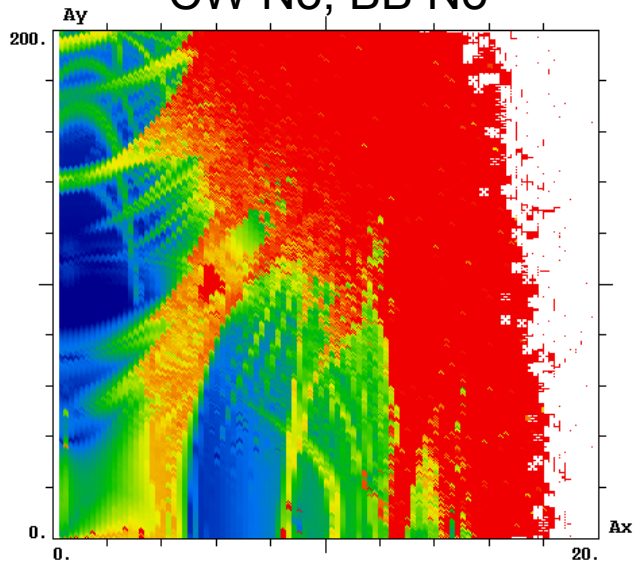
- Beam-beam is not a limiting factor
- Crab-Waist Sextupoles work (even at lower strength)

This result can be improved by:

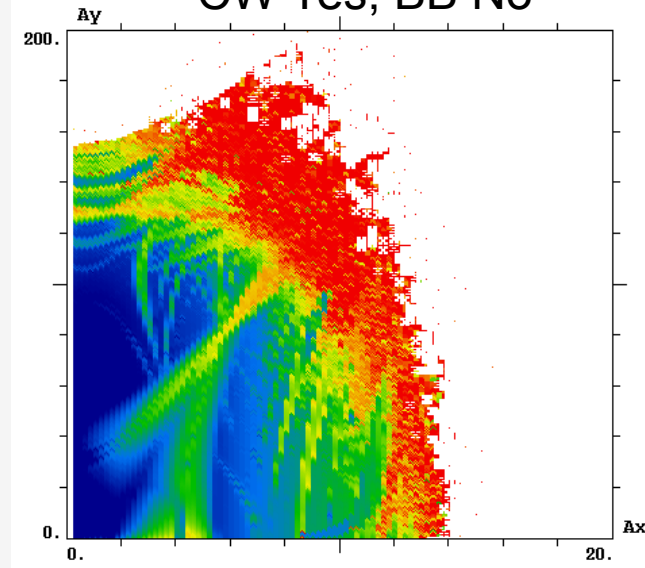
- optimizing dynamical vacuum
- perfecting colliding beams parameters
- tuning multi-bunch and high current operations

Electron ring dynamic aperture

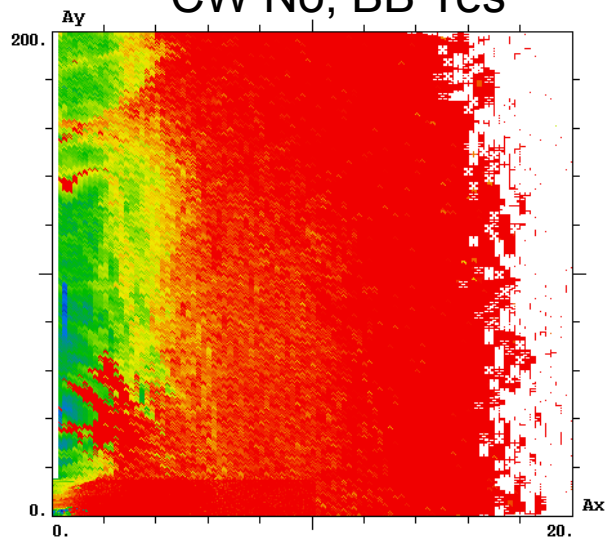
CW No, BB No



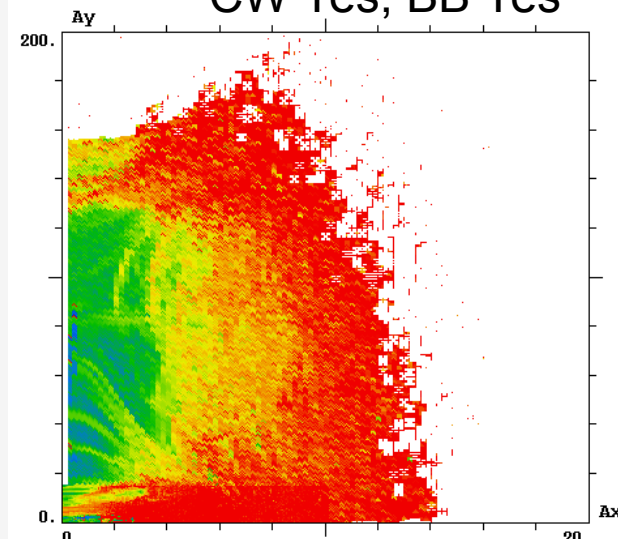
CW Yes, BB No



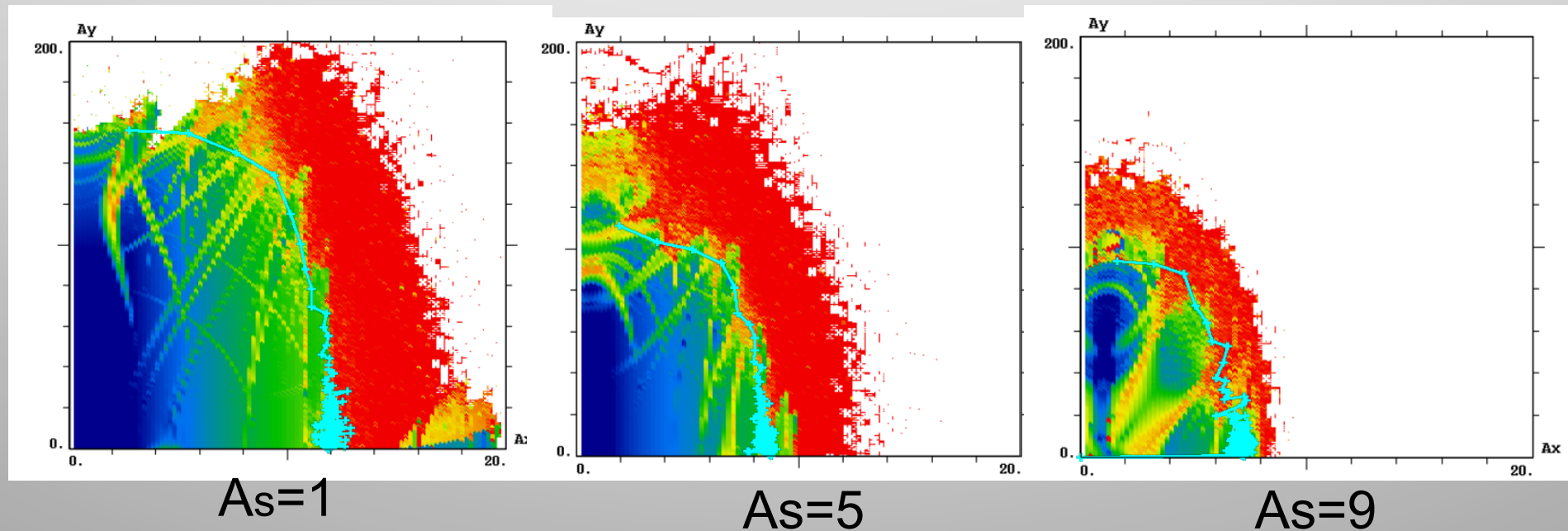
CW No, BB Yes



CW Yes, BB Yes



Electron ring dynamic aperture



Dynamic apertures have been simulated by using a new tool (*lifetrack* embedded in *MAD-X*) developed for HL-LHC and tested with the DAFNE optics

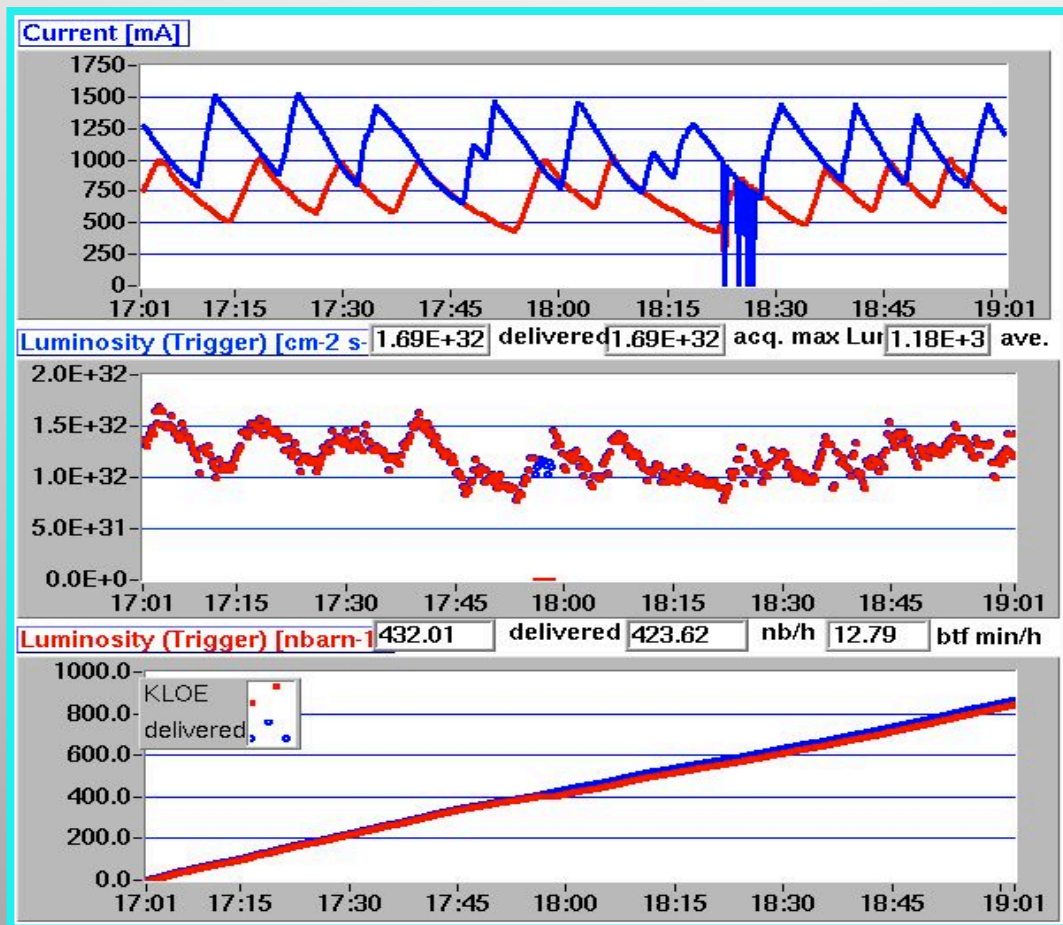
Pushing luminosity further

A considerably higher luminosity might be attained by:

- optimizing the present rings optics and working point
- Setting the CW-Sextupoles to the nominal values
- improving dynamic vacuum
- completing transverse betatron coupling optimization mainly in the e^- ring
- 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.

Best hourly integrated luminosity

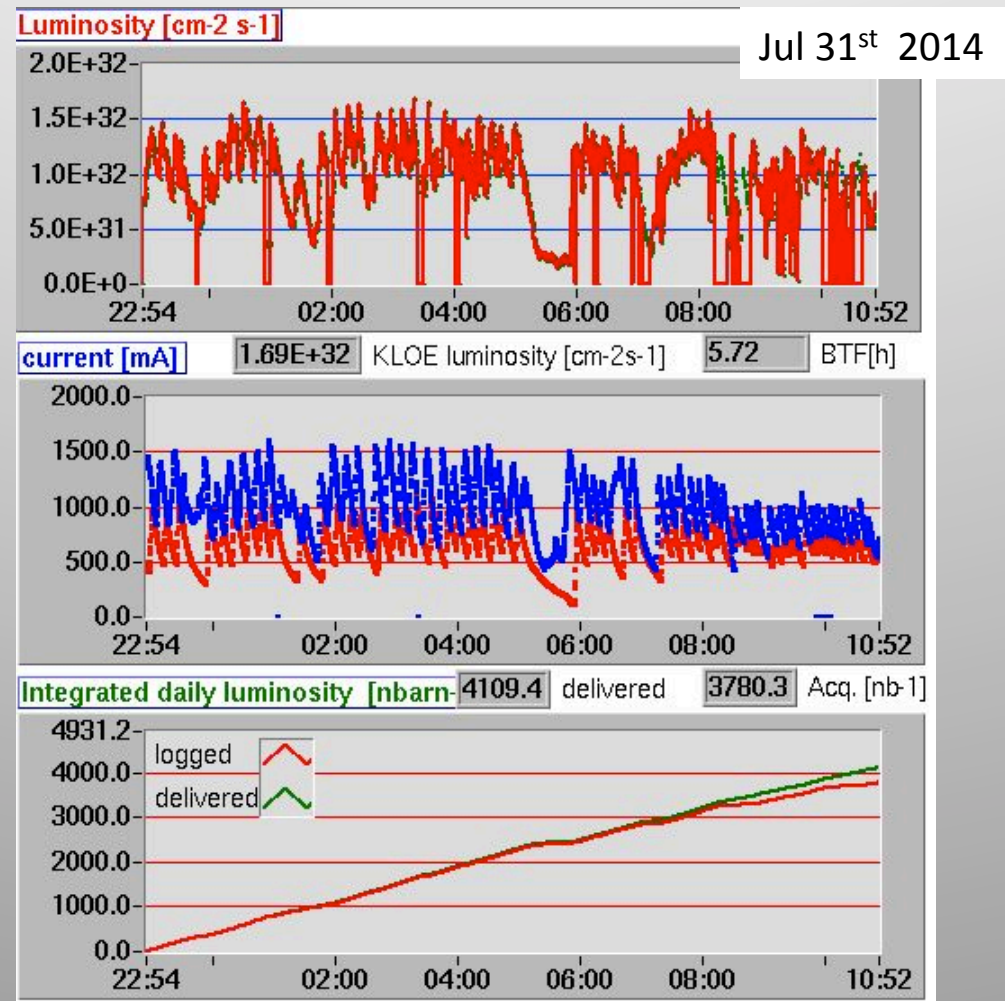


July 29th

$$L_{\text{peak}} = 1.69 \cdot 10^{32} \text{ cm}^{-2} \text{s}^{-1}$$

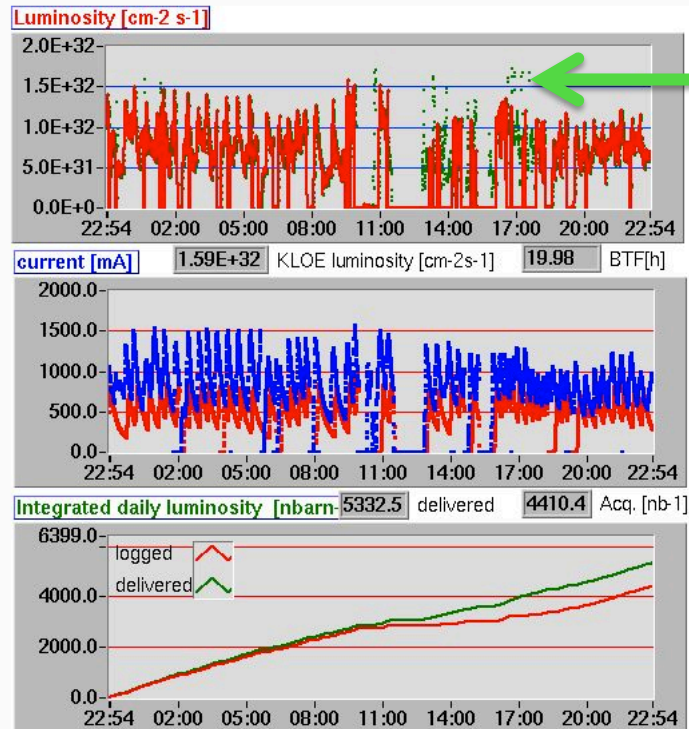
$$L_{\text{f1h}} = 432 \text{ nb}^{-1} \rightarrow L_{\text{fday}} > 10 \text{ pb}^{-1}$$

12 hour integrated luminosity

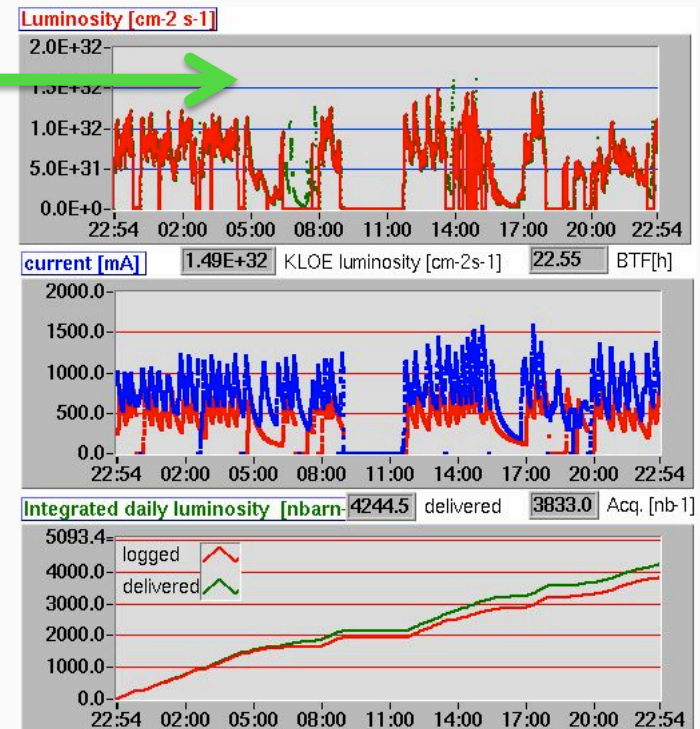


KLOE-2 data taking test

KLOE Luminosity History: 02/07/2014



KLOE Luminosity History: 03/07/2014



$$L_{f12 \text{ hour}} = 3.7 \text{ pb}^{-1}$$

KLOE-2 data taking test

Thursday 31st 2014

several injections moderate currents

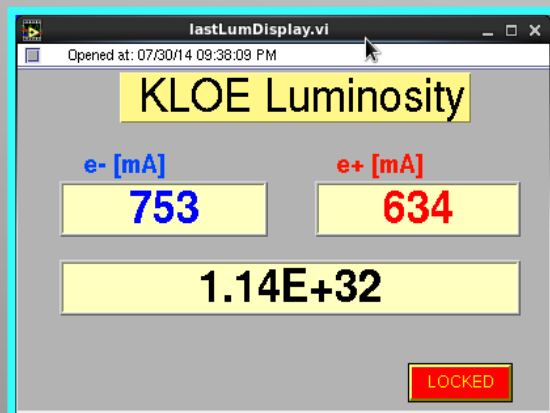
$$L_{\text{peak}} \sim 1.14 \cdot 10^{32}$$

$$L_{\text{f1h}} \sim 210 \text{ nb}^{-1} \text{ (stored on disk)}$$

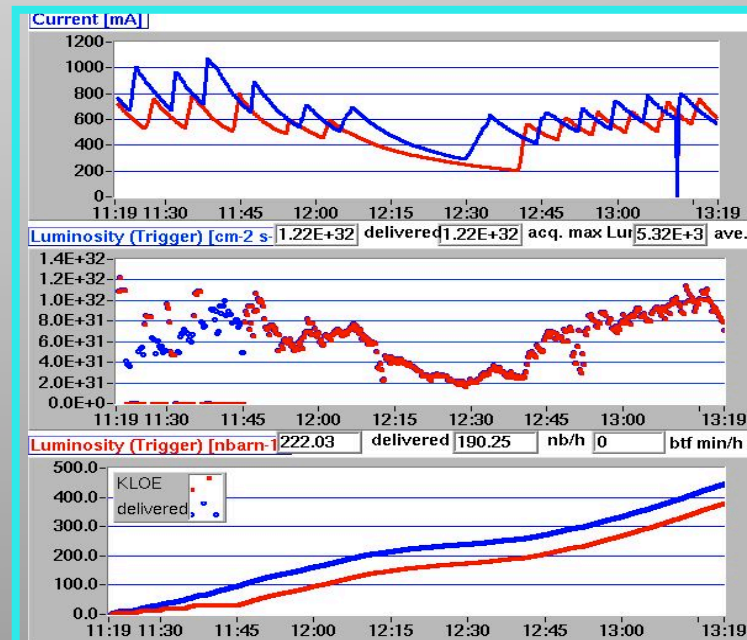
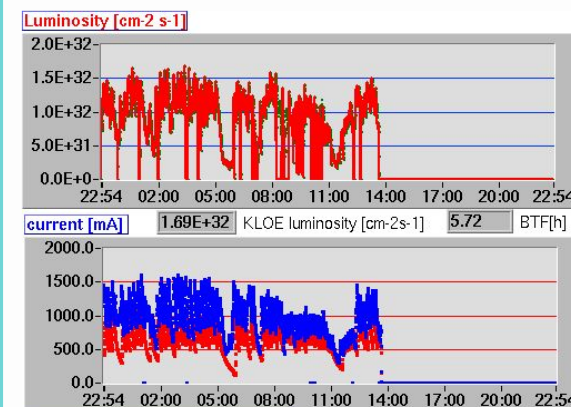
All detector components on

T_2 rate ~ 6 kHz

Hot rates ≤ 400 kHz



KLOE Luminosity History: 31/07/2014



Activity program

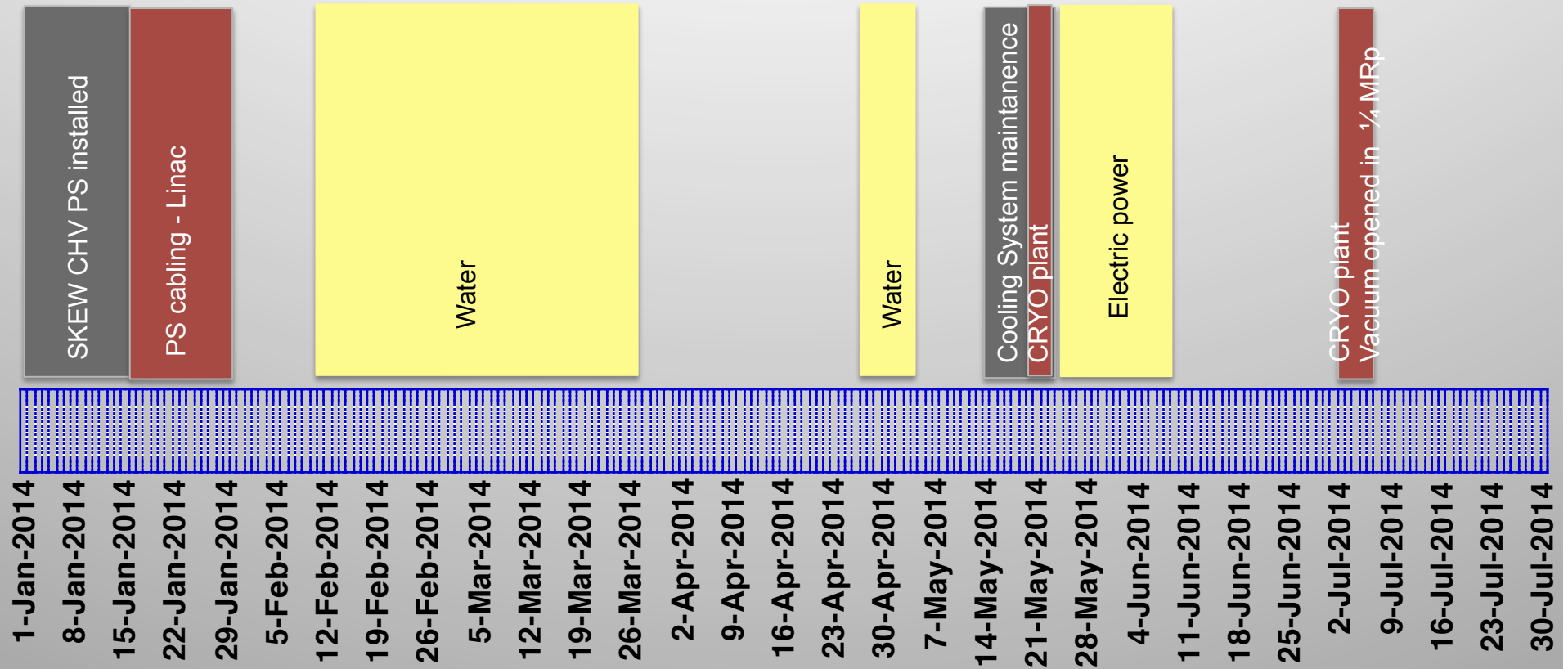
Four consecutive days a week dedicated to KLOE-2 data taking including:

- adiabatic collider optimization
- luminosity fine tuning
- background minimization (injection & costing)

Three days a week for machine studies and developments, if necessary

Aiming at delivering 1 fb^{-1} after 8 months operation

Commissioning



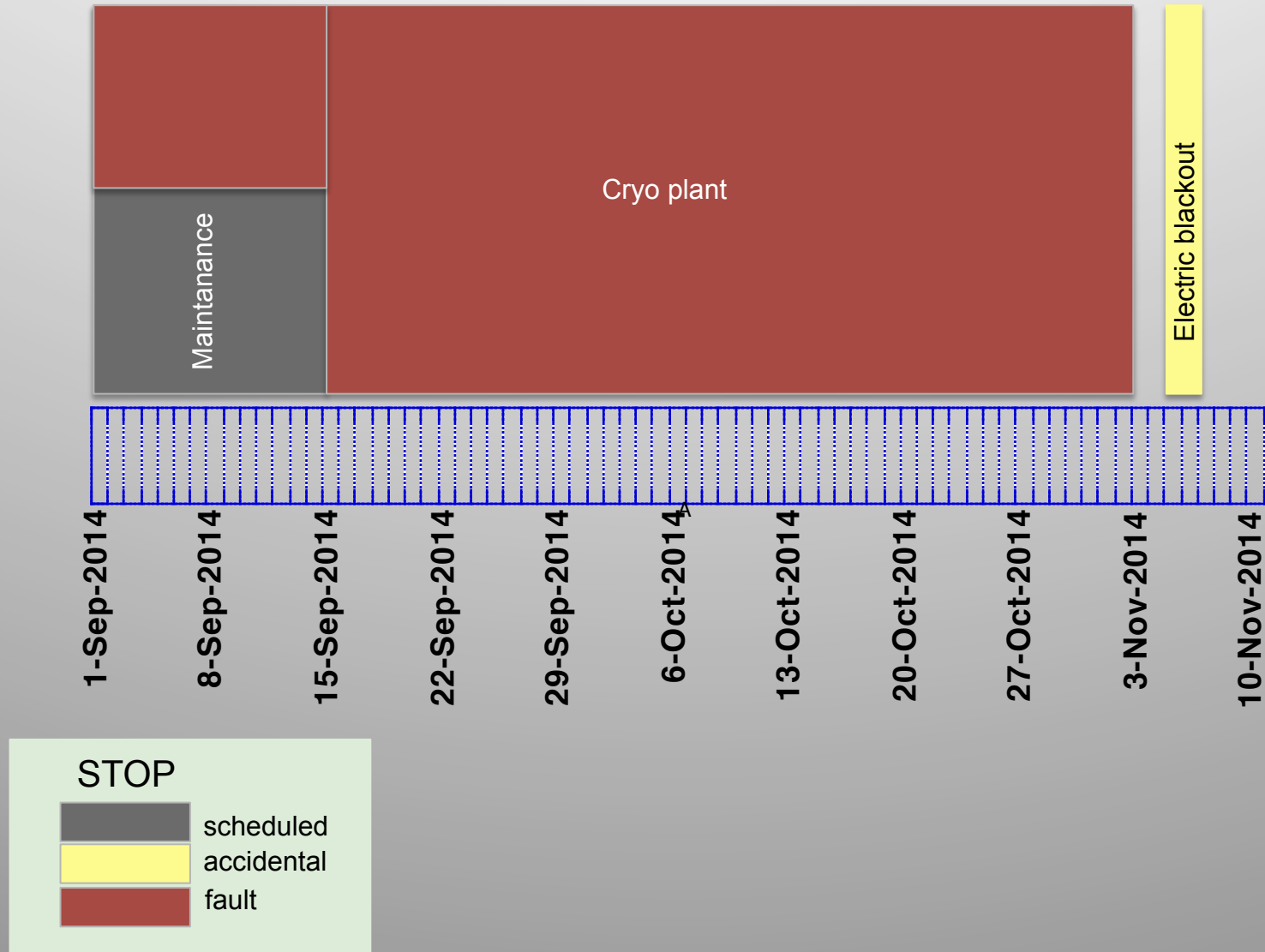
STOP



scheduled
accidental
fault

3 unscheduled interruptions due to external circumstances causing **two and half months of inactivity**
BTF operation has been assured

Commissioning



KLOE solenoid warmed up and cleaned (Aug 2014)

- some air leakage found and fixed after extensive checks
- seal of the compressor screw replaced
- oil contamination detected before the cold box first turbine imposing washing the Cold Box circuit by acetone
- oil contamination in the gas management system -> washing

Technical assistance and support from Linde

Summer shutdown activities

Intended mainly to fix a problem affecting the DAFNE CRYO plant becoming progressively more harmful

Also used to:

- fix faulty behaviours in the new power supplies of the skew correctors
- reduce the flow rate of the high pressure cooling water serving the MRs wiggler magnets
- Improve collimator system:
 - increased stroke for the collimator jaws around IP
 - new scraper at the end of TLe
- tune Linac for 50 Hz operations
- undertake ordinary maintenance

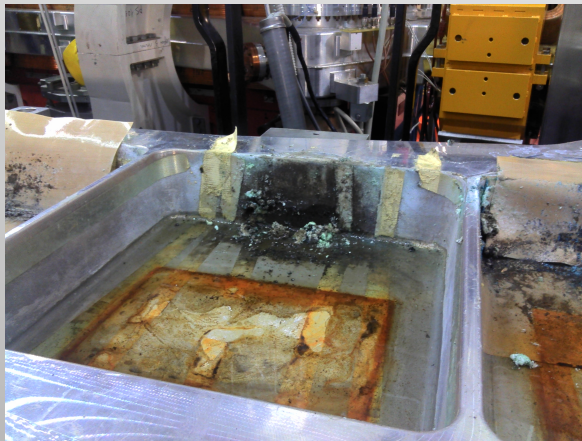
High pressure cooling water circuit

flow rate almost halved in order to prevent:

- holes in the wiggler coils

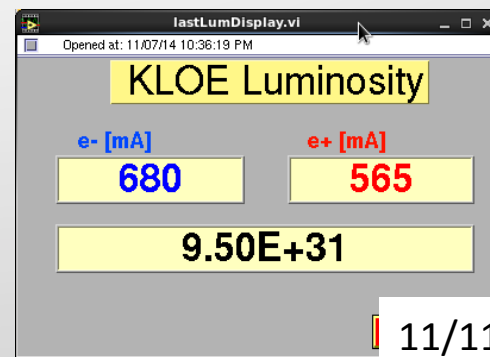
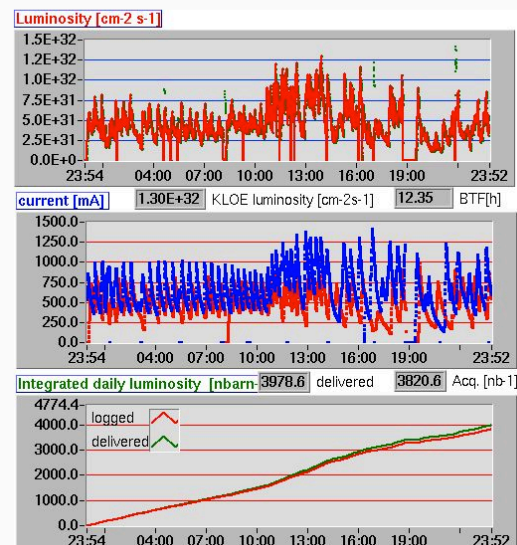
- rubber pipes damaging

In order to avoid destructive faults we experienced in the past

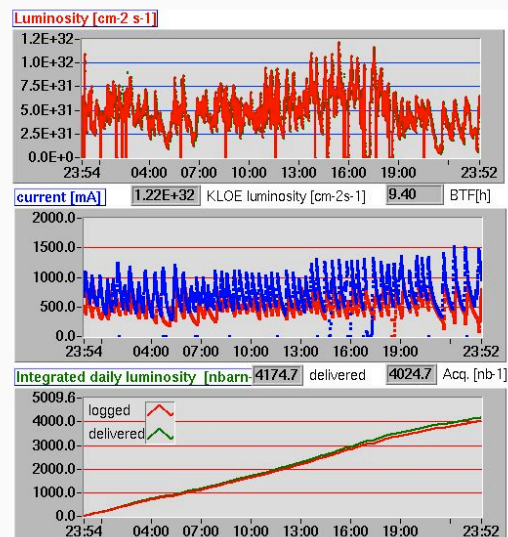


What is going on now

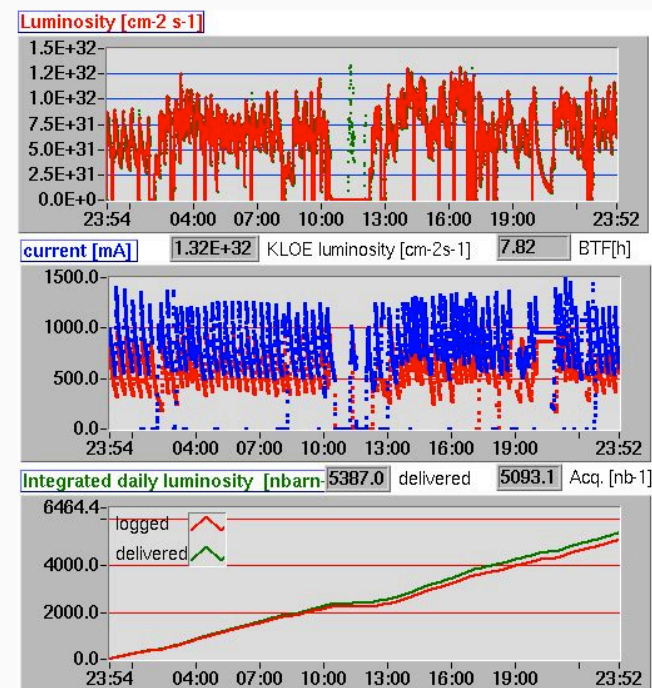
KLOE Luminosity History: 08/11/2014



KLOE Luminosity History: 09/11/2014



KLOE Luminosity History: 11/11/2014



Conclusions

There is clear evidence of a substantial continuous progress in the collider performances

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 first KLOE-2 data-taking tests have been successfully done and a plan has been done for the data taking

Some criticalities affecting specific subsystems have been cured during the summer shut-down

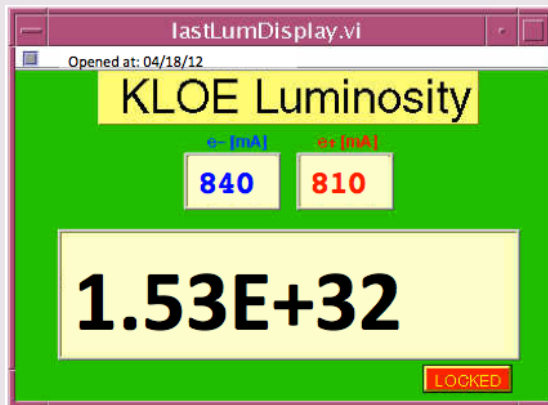
Concerning uptime and reliability of the DAFNE subsystems we are on the verge of inverting the negative trend, which requires a lot of efforts, quite long time and a proper framework.

Thank you for your attention

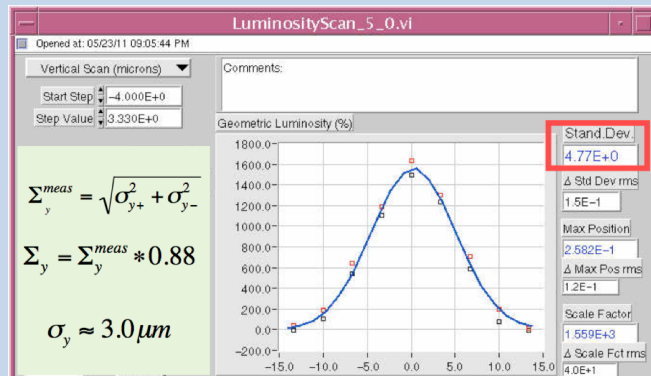
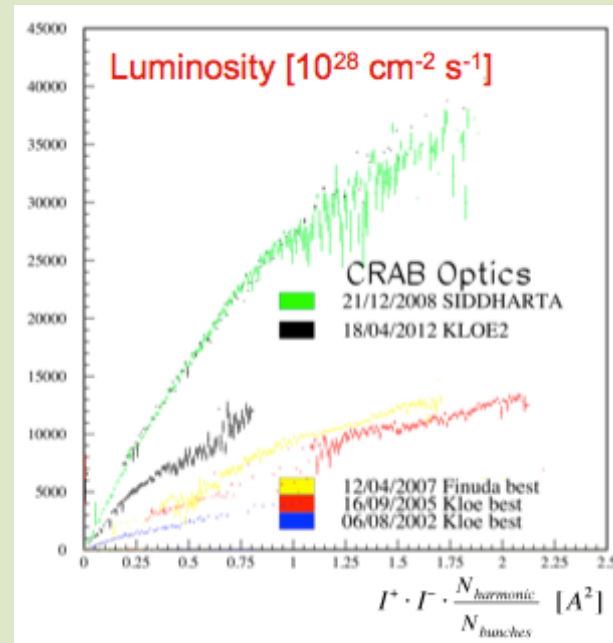
KLOE CW-IR preliminary test

2012 achievements

Peak Luminosity (100 bunches)

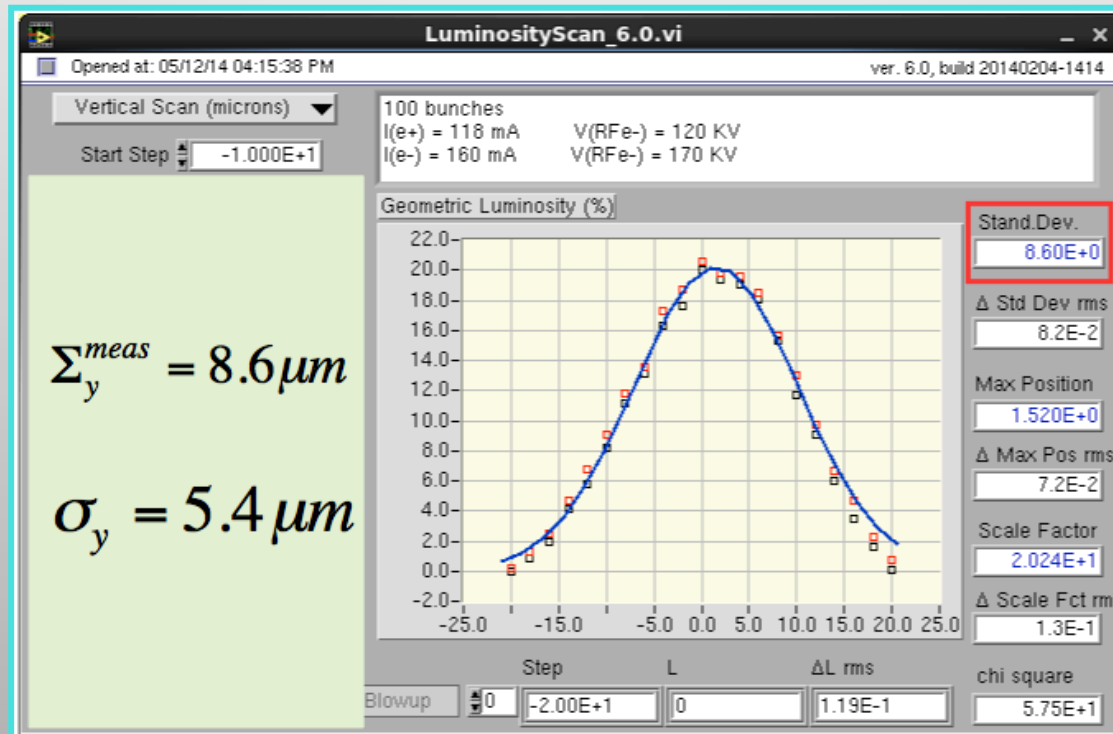


Comparison Among DAΦNE Best Runs with and without Crab-Waist



Vertical beam-beam scan

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

Dynamic vacuum in PS1

