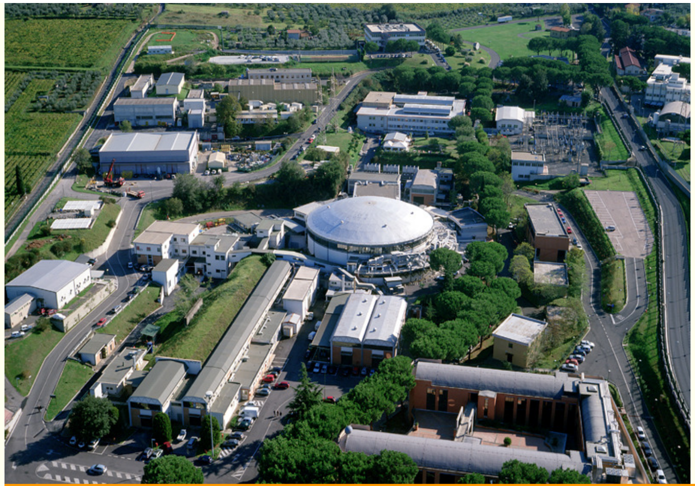

DAΦNE: Status Report and Plans

M. Boscolo

on behalf of the DAΦNE Team

Frascati, 39th Scientific Committee, October 26th 2009

INFN
Istituto Nazionale di Fisica Nucleare

DAΦNE Upgrade Team

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OUTLINE

- Present DAFNE performance
- Summary of the SIDDHARTA run
- Plans for the hardware activities:
    - KLOE IR: machine new layout & installation plans
    - machine upgrades
    - ordinary & extraordinary maintenance
- Conclusions with KLOE run perspective

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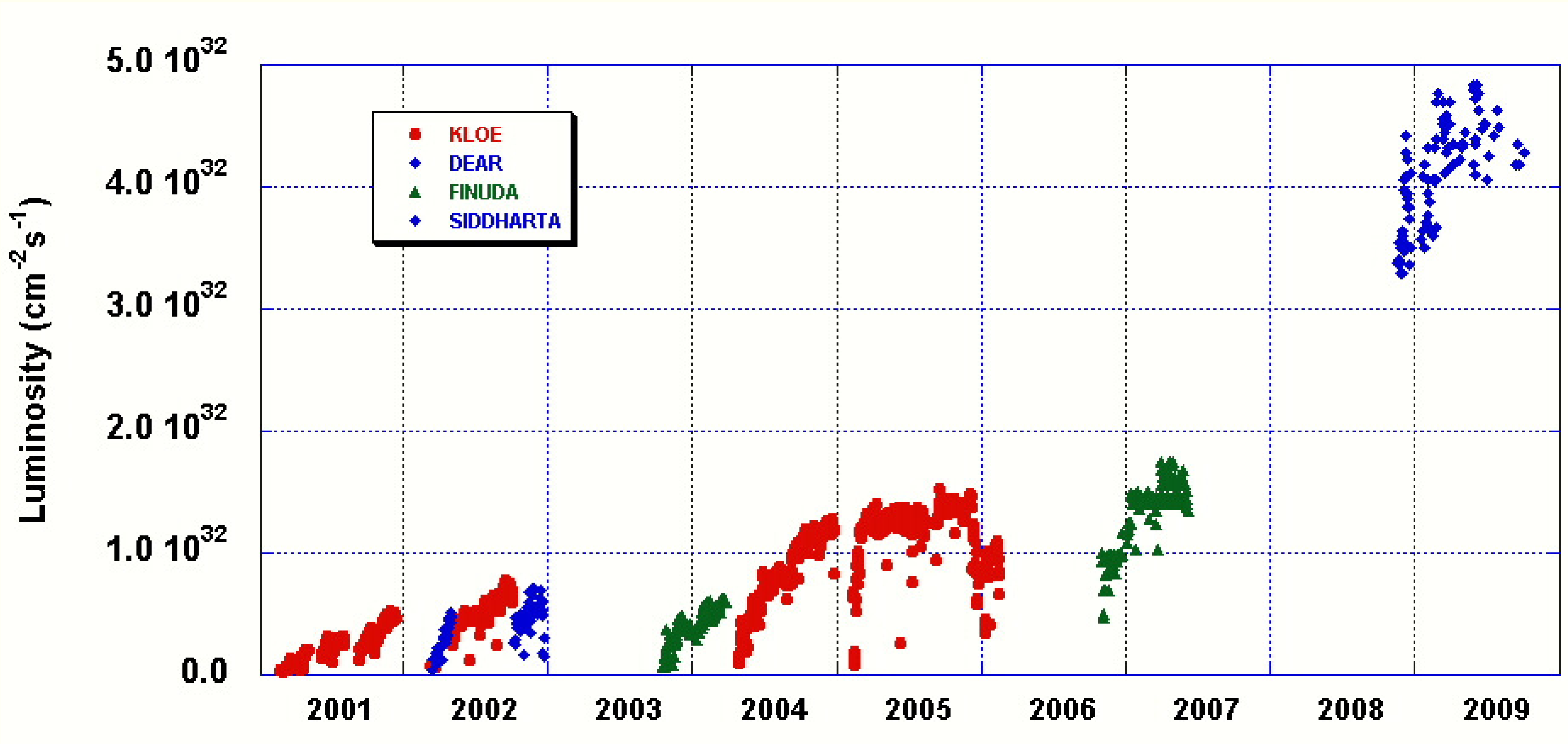
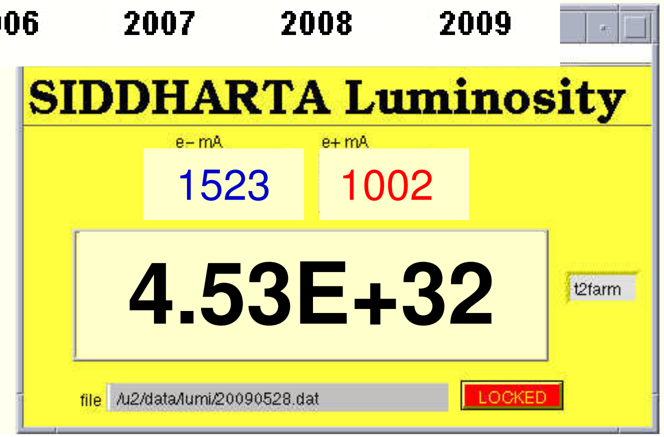
DAFNE Peak Luminosity



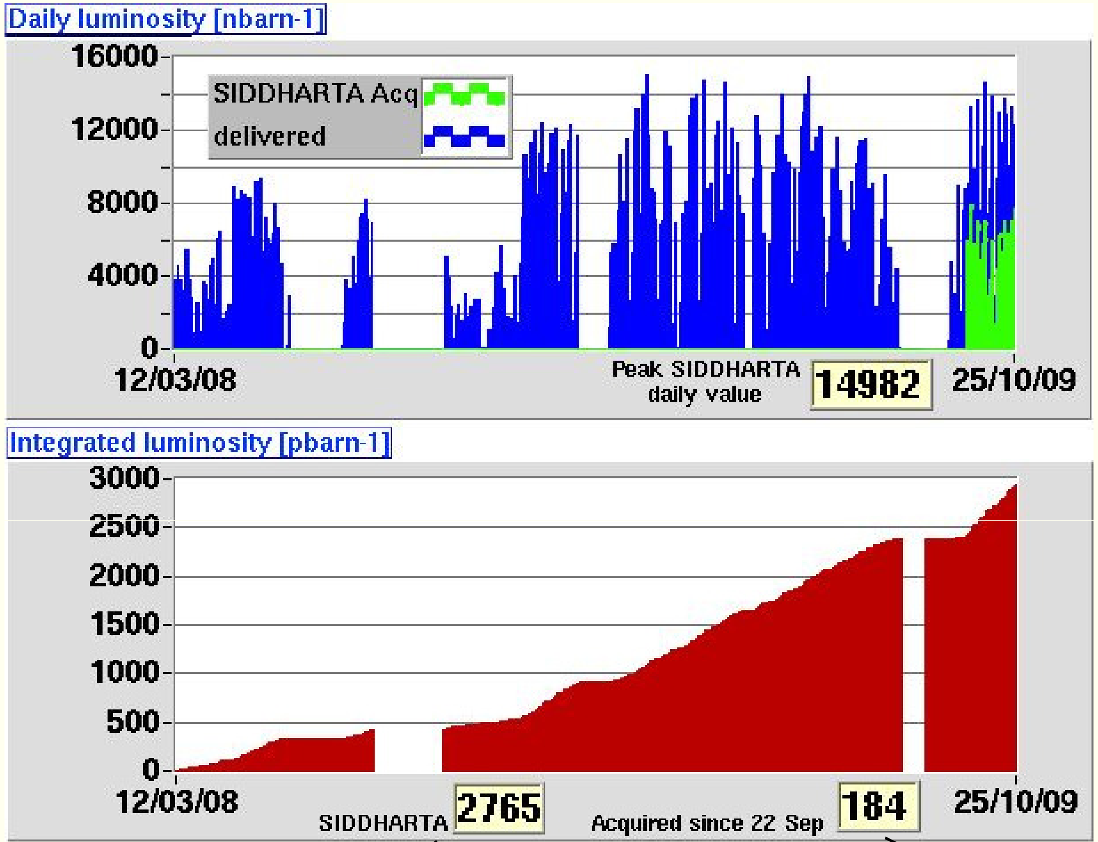


Present Schedule

- SIDDHARTA data taking ended on July, as planned.
- During summer shutdown ordinary and extraordinary maintenance has been done on the:
  - Cooling system
  - Linac power supplies
  - Feedthrough e- kicker replacement
- Machine operation restarted last September 9th

  and on Sept. 22th SIDDHARTA started data taking with Deuterium.
- According to SIDDHARTA requests and as agreed with the KLOE collaboration the run as been extended until Nov. 9th, by then we expect to reach an acquired integrated luminosity of about 200 pb^{-1}, as requested.

Total SIDDHARTA Integrated Luminosity



totally **delivered** (pb^{-1})
since 12/03/08 up today

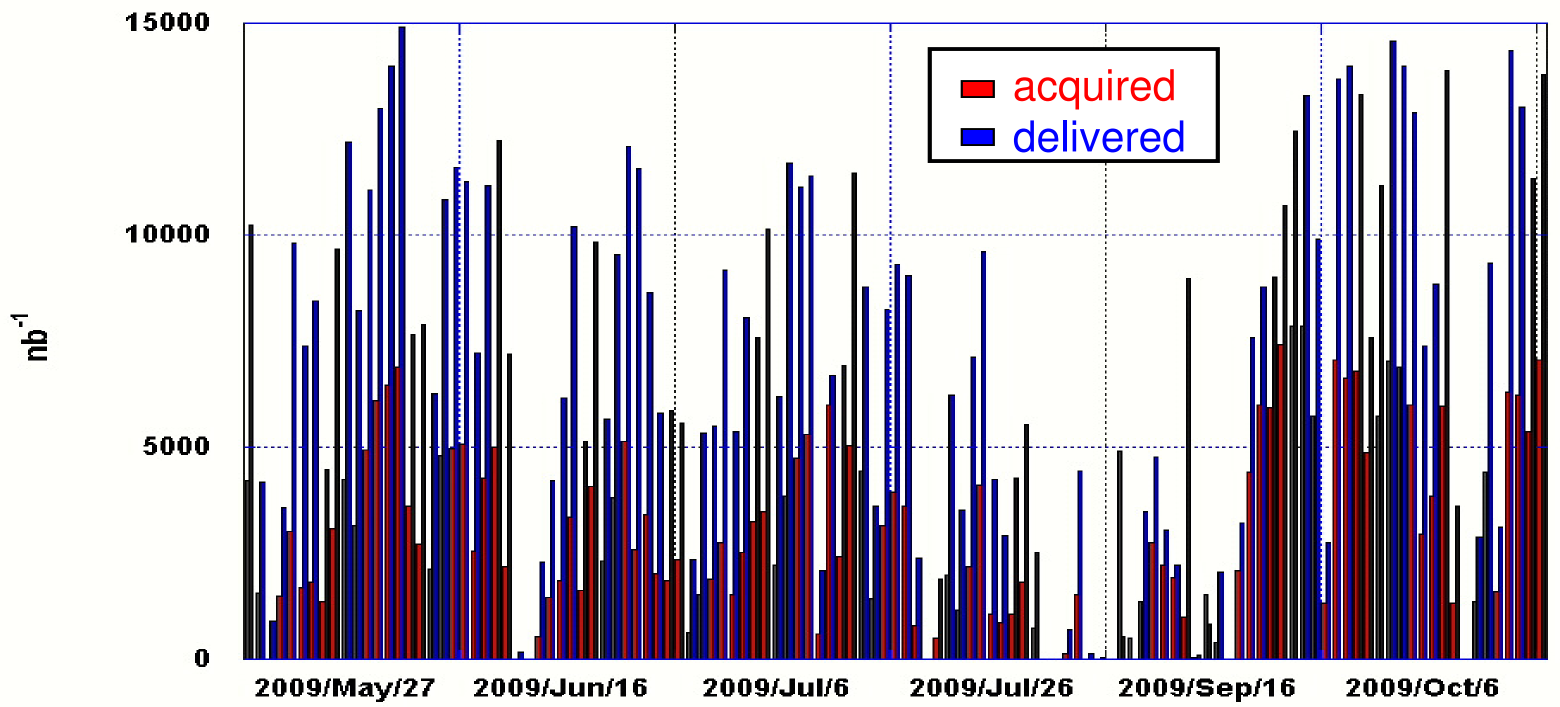
acquired (pb^{-1}) by
Siddharta since 22/09/09
up today

A 2 months extension (Sept. 9th -Nov. 9th) of the SIDDHARTA run has been agreed with all the experiments

Delivered/Acquired Luminosity since May 18th 09

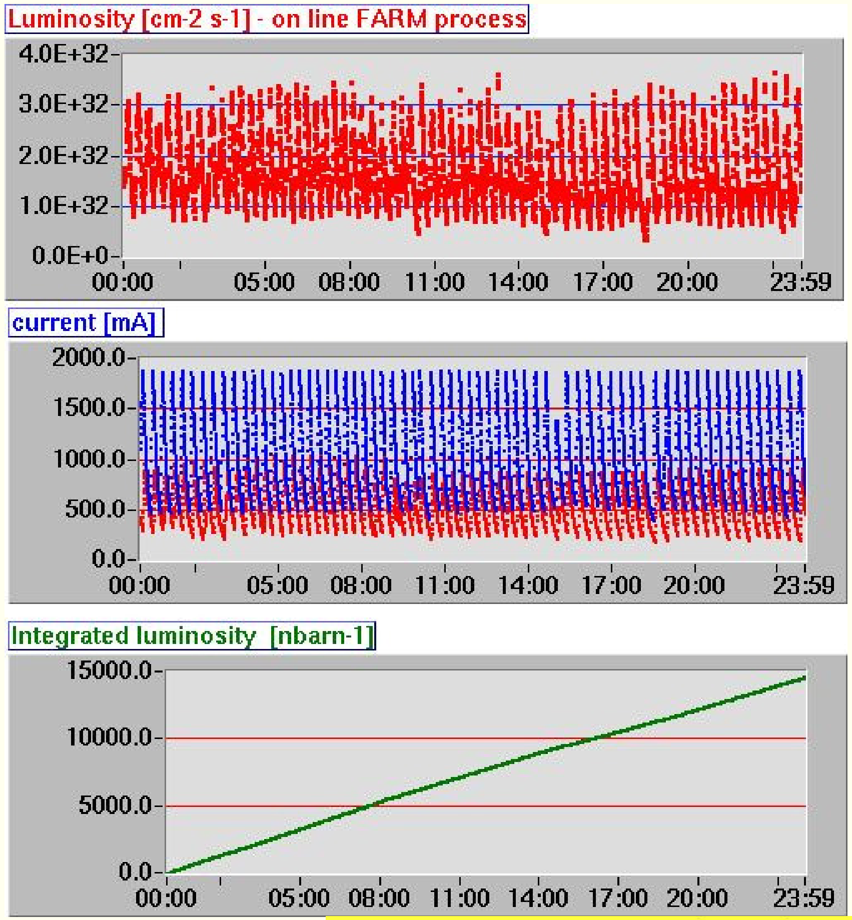
(day when SIDDHARTA began to provide us the detector uptime)

	Total 120 days	Average
Delivered	**850** pb^{-1}	**7023** nb^{-1}/day
Acquired	**369** pb^{-1}	**3046** nb^{-1}/day
efficiency	**43 %**	

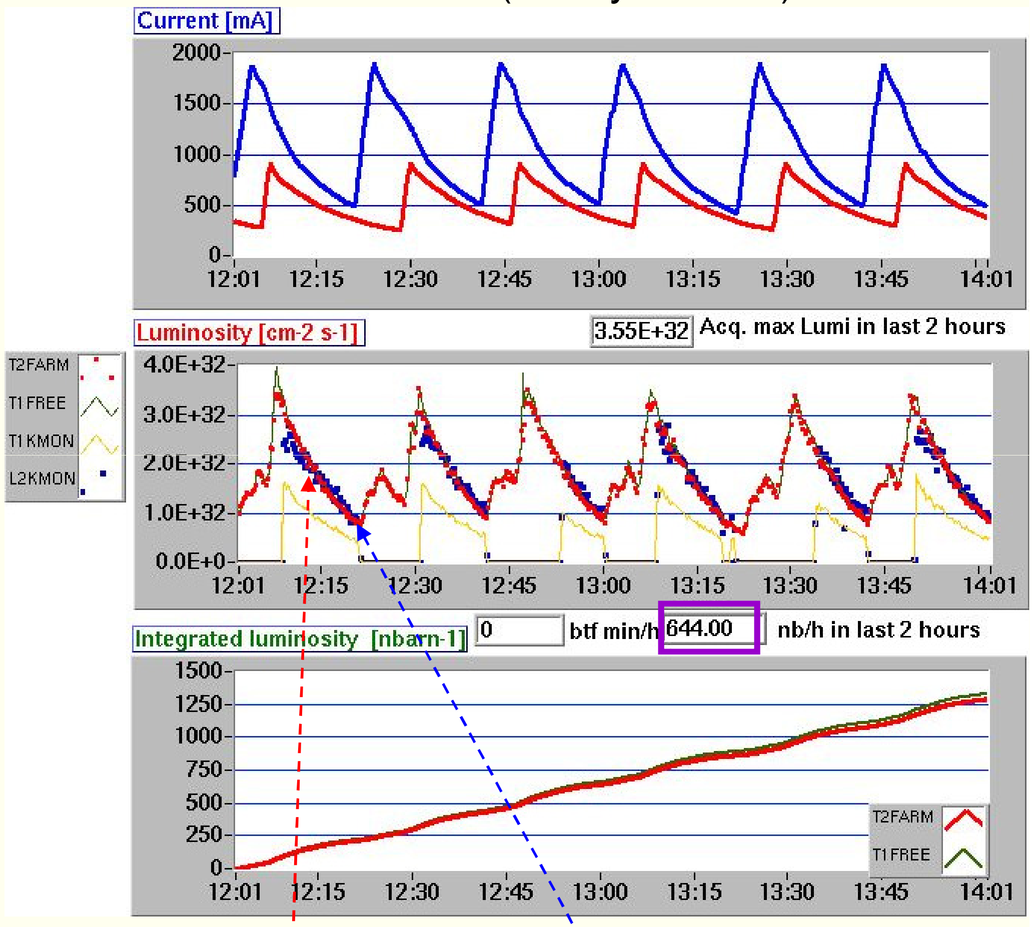


Present machine Status

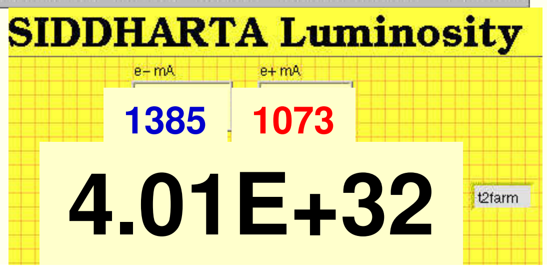
October 4th 2009



2 hours (Friday 23 Oct.)



Peak L

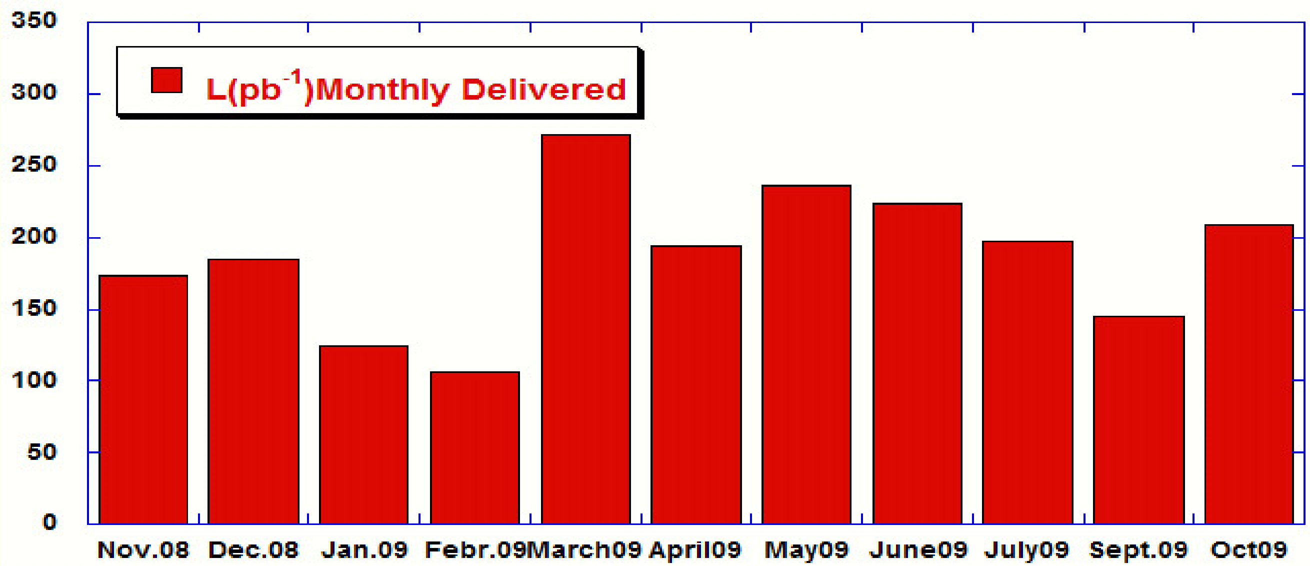


red dots: our luminometer

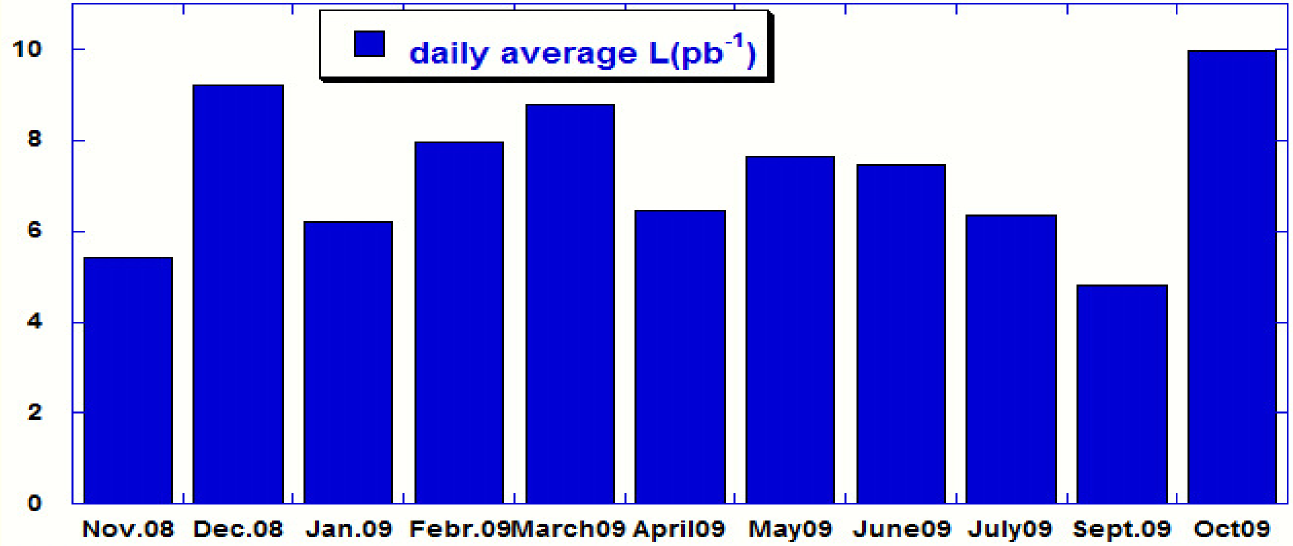
blue dots: Siddharta luminosity measurements

Monthly performances

November 1st 2008 – October 23th 2009

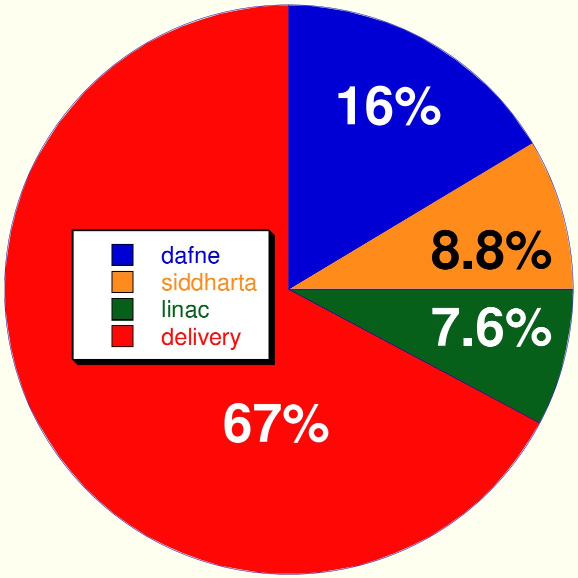


(Days of run) (20) (20) (24) (23)

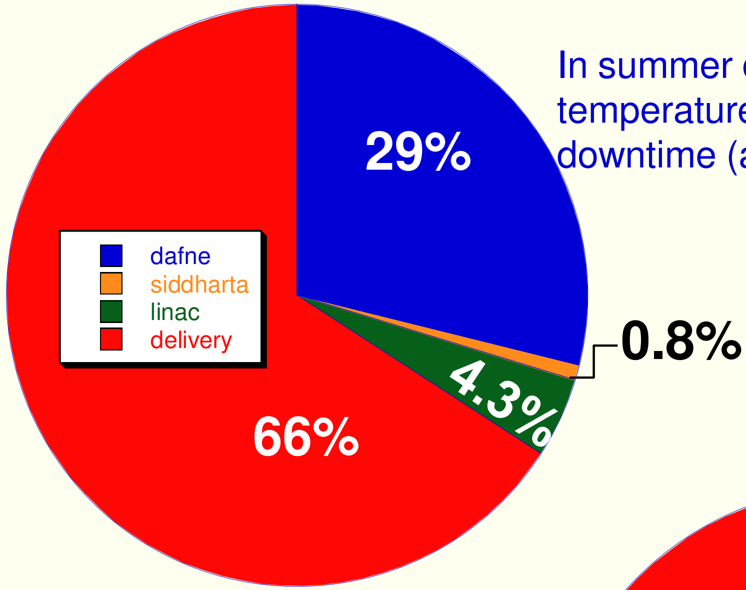


tot. # running days 297

Machine uptime/downtime* 2009



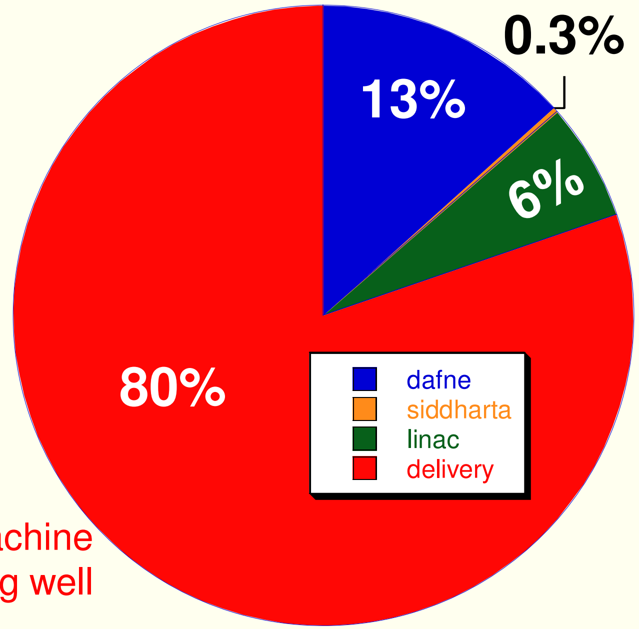
January-May09



June-August 09

In summer due to high temperatures we had a larger downtime (almost doubled)

dafne
siddharta
linac
delivery



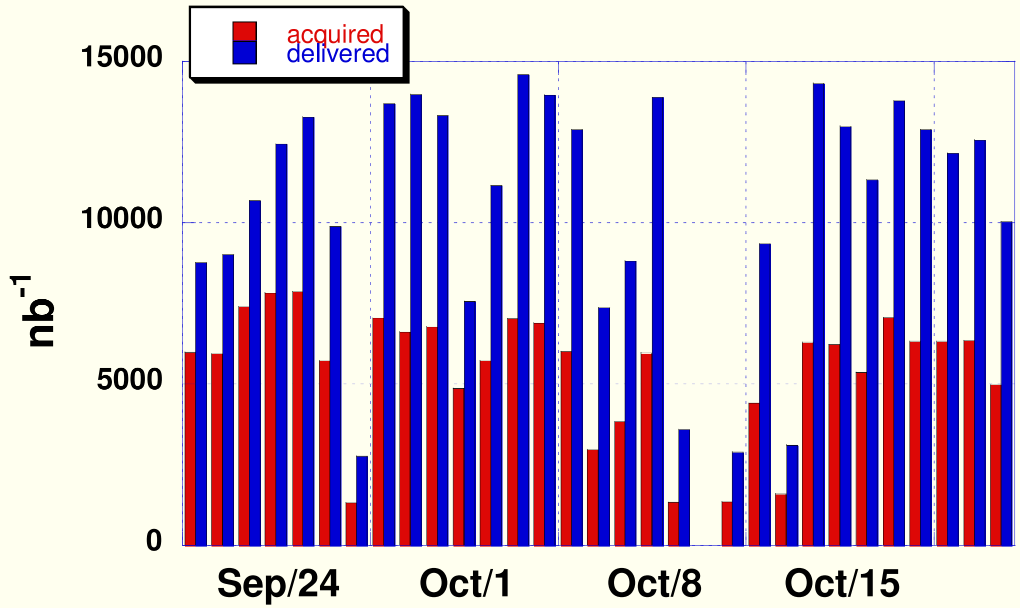
Presently the machine is working well

Sept.22th– Oct 22th 09

*Values with % uncertainty

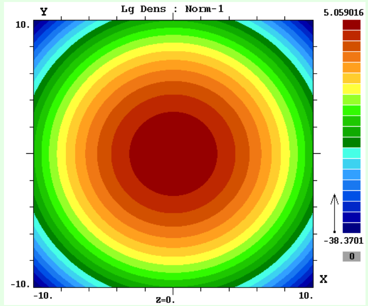
22^{th} September – 22^{th} October

	Total (30 days)	Average
Delivered	**317 [pb^{-1}]**	**10233 [nb^{-1}/day]**
Acquired	**164 [pb^{-1}]**	**5275 [nb^{-1}/day]**
efficiency	**52 [%]**	



Update on Beam-Beam Simulations for Crab Waist Scheme

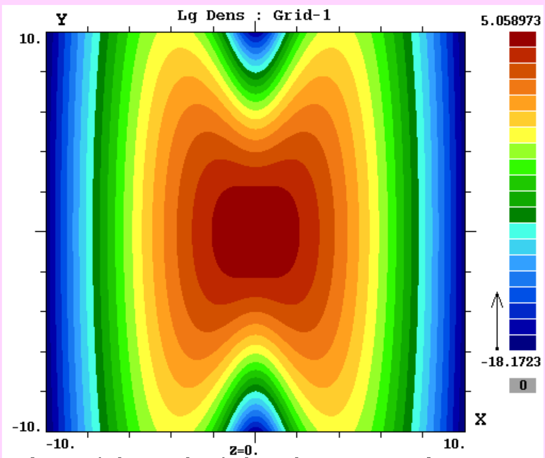
- **Beam distribution is non-Gaussian due to the crab sextupoles, even without beam-beam, so the Bassetti-Erskine formulae are not valid.** In the old simulations these formulae have been used. So, the “weak” beam was crabbed, while the “strong” one was Gaussian. Imperfections of this approach were recognized from the very beginning.



Log(density) in the x-y plane at the IP (z=0) of the **Gaussian** strong bunch

- **Correct simulations with the crabbed “strong” beam require that the beam-beam kicks are calculated using the grids**, as there are no corresponding analytical formulae.

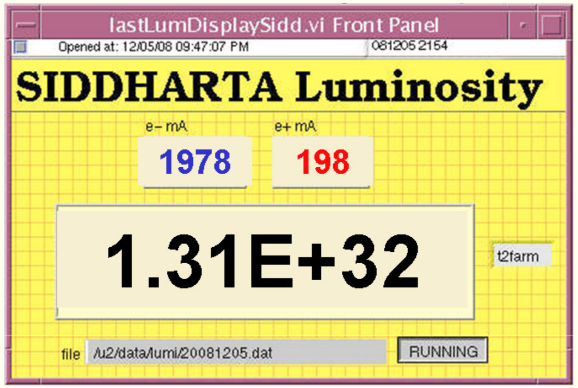
- **Recently this new feature has been implemented in LIFETRAC**. In principle it allows calculating beam-beam kicks from arbitrary “strong” bunch distribution, and can be used in future for quasi strong-strong simulations.

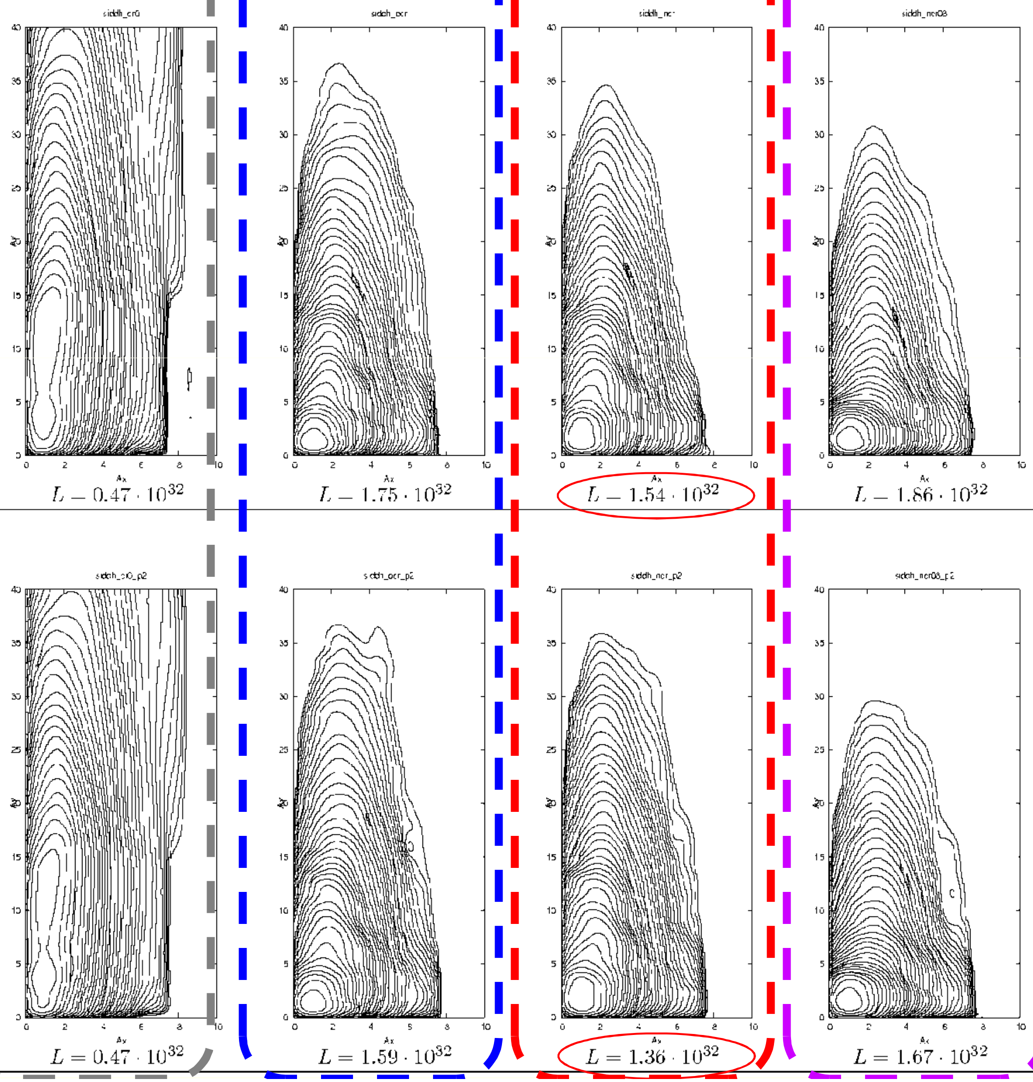


Log(density) in the x-y plane at the IP (z=0) of the **crabbed** strong bunch

Weak-Strong Simulations vs. Experiment

Crab OFF	Old program	New program	Optimal Crab
gauss vs gauss	gauss vs crab=0.5	crab=0.5 vs crab=0.5	crab=0.8 vs crab=0.8





$\xi_y = 0.074$

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New KLOE IR

- Interaction Region **design complete** and several components of the **new hardware** already **acquired** and/or **in construction**
- Main **improvements** w.r.t. the present optics and Kloe1 are:
  - Increased beam stay clear (+σ_x) at IR w.r.t. Siddharta
  - Better shielding

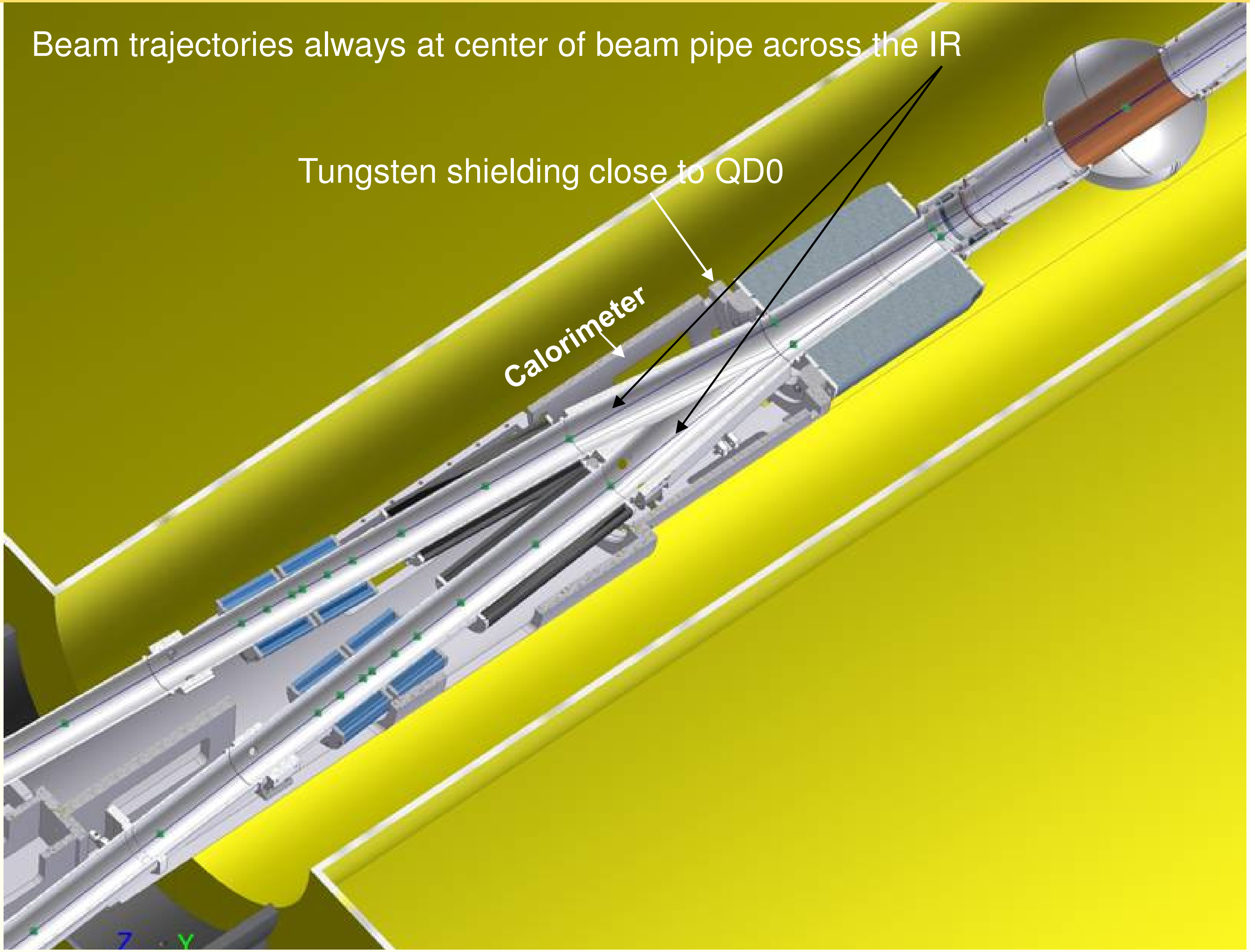
    → **Less Background**

  - Additional skew quad added across QF1
  - Independent pair of solenoids for each beam
  - Skew quad placed at the Crab-Sextupole location

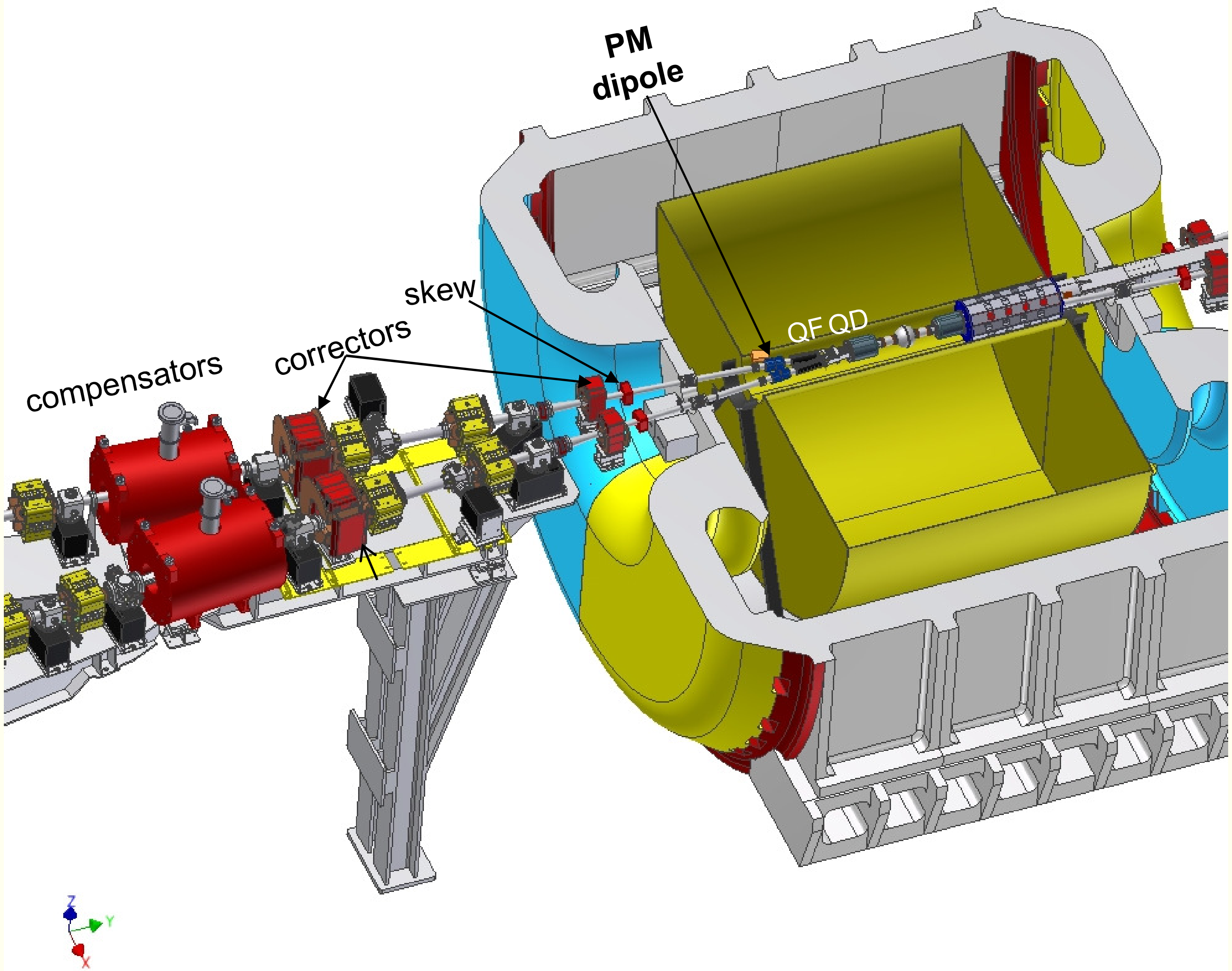
    → **Dector Solenoid Coupling correction better than Kloe1** (where it had been achieved 0.2-0.3%)

    → **No need of rotating quads** for fine adjustment

Radial section of the KLOE IR pipe



View of the new KLOE IR

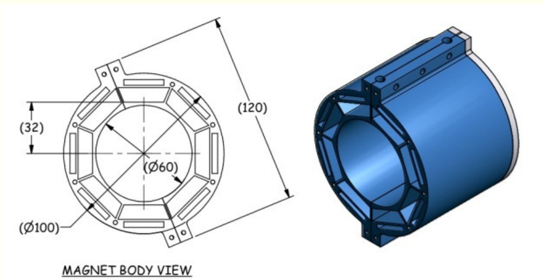


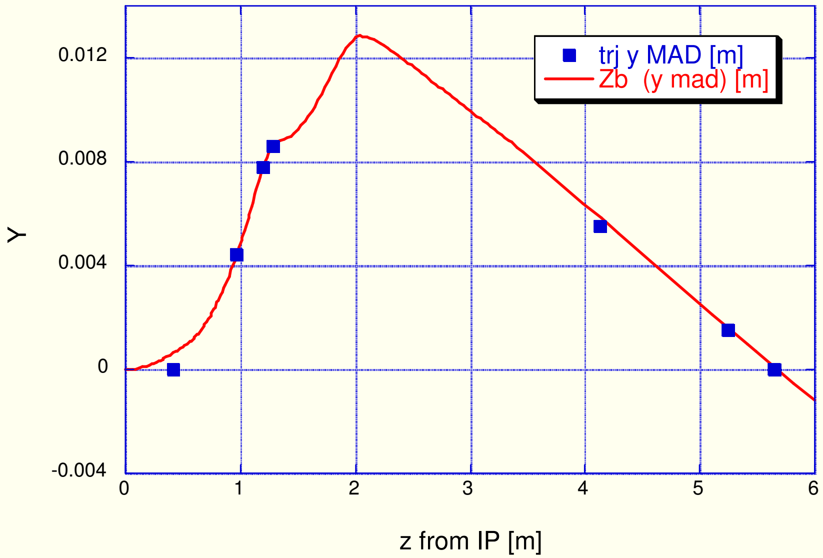
New KLOE IR

- PM dipole added after QF1

Due to the **larger crossing angle**, the vertical displacement of the beam in the IR is about 2.5 times w.r.t. the last KLOE run.

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





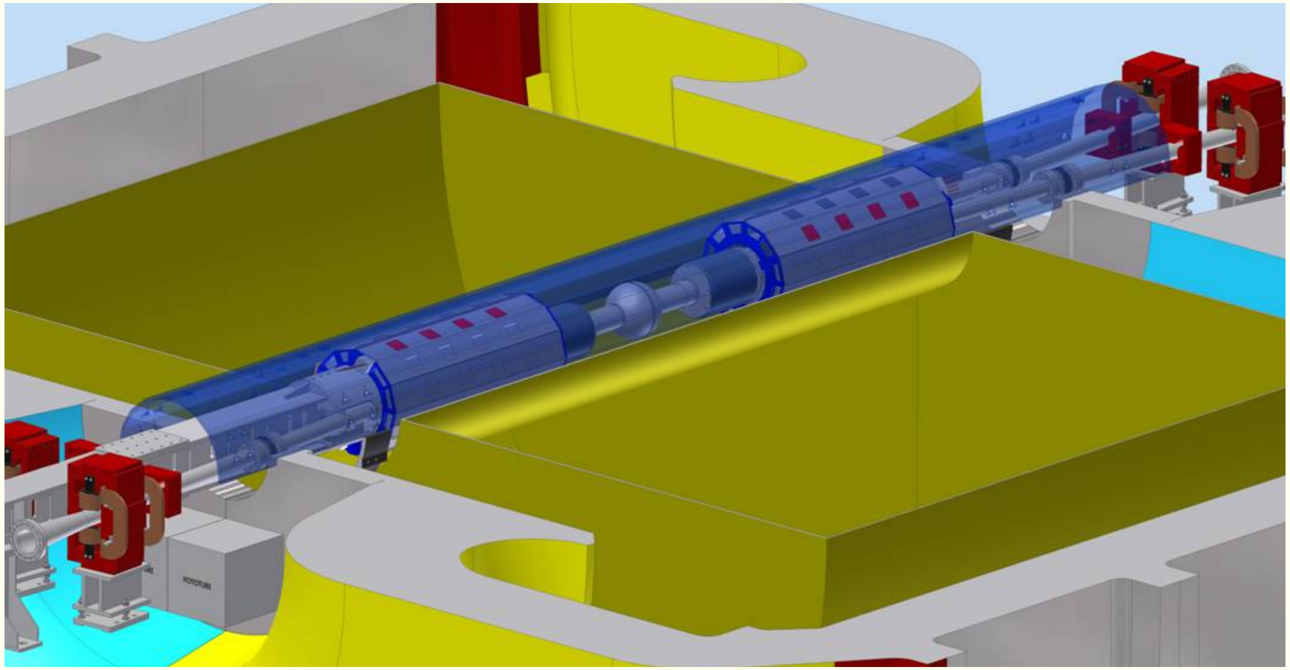
PM designed, built, measured and ready to be installed.

KLOE IR design is flexible, allowing different solenoid field values in the experiment (PM dipole design can be split in two; QD0 rotation null)

Plans for KLOE IR installation

Interaction Region **design complete** and several components of the **new hardware acquired** and/or **in construction**

The IR will be installed following the well established procedure defined for KLOE-1, using the iron shell



DAFNE Plans for KLOE roll-in

Kloe Roll-in allows us to further improve the DAΦNE performances and gives us a chance to reduce some of the limits to the achievable peak luminosity and integrated luminosity

Present main limits come from:

- Maximum positron current
- Short beam lifetimes
- Hardware reliability

Hardware activities

Positron peak current and vertical beam sizes limited by electron cloud

- **Stripline electrodes** will be installed in all wigglers and dipoles vacuum chambers for electron cloud clearing

- **Horizontal feedback power** will be doubled, providing 500 W output (now 250 W)
- **Horizontal feedback kicker** will be modified to further improve the feedback effectivness
  - Higher e+ current
  - More stable e+ beam
  - Smaller e+ vertical size
  - Weaker e+ sextupoles
  - Longer e+ lifetime

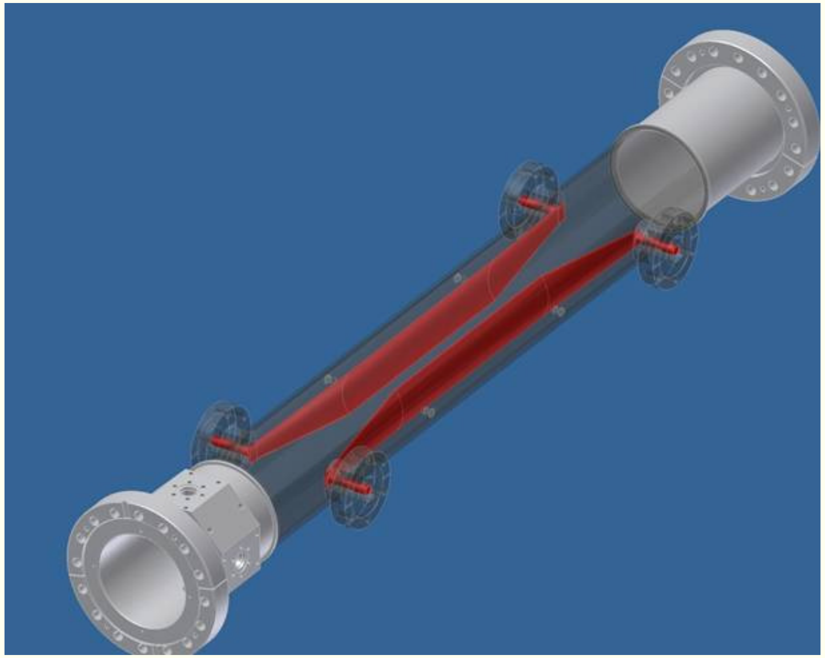
New kicker for horizontal feedback in e+ ring

Work in progress for adding a new dedicated kicker for the second transverse horizontal feedback in a position with higher β_x

- e.m. design ready, mechanical design almost completed
- Same design criteria adopted for the new injection kickers (tapered stripline) to reduce the beam impedance.

Features of new kicker w.r.t. present one:

- Stripline length doubled.
- Minimum stay clear (stripline separation in horizontal plane) 60mm instead of 88mm.
- Larger Beta
- These 3 modifications will have the effect **of increasing the kick strength delivered to the beam by a factor ≈3** (considering the same power from amplifiers).



Wigglers modification

Wigglers will be modified according to a novel technique that will:

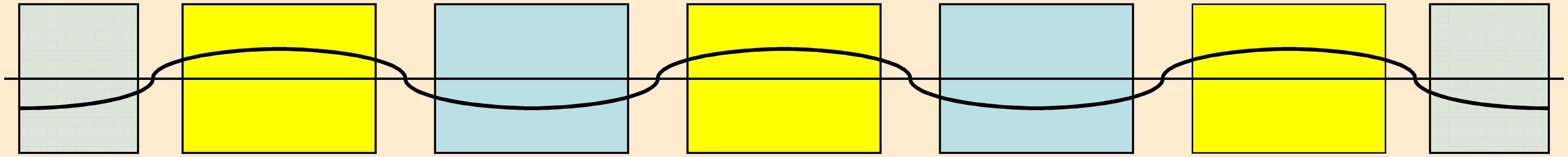
- Improve by more than a factor 2 the good field region
- Increase the B_{max} for a given exitation (current)
- Decrease the wall plug power
- Eliminate 8 critical power supplies

⇓

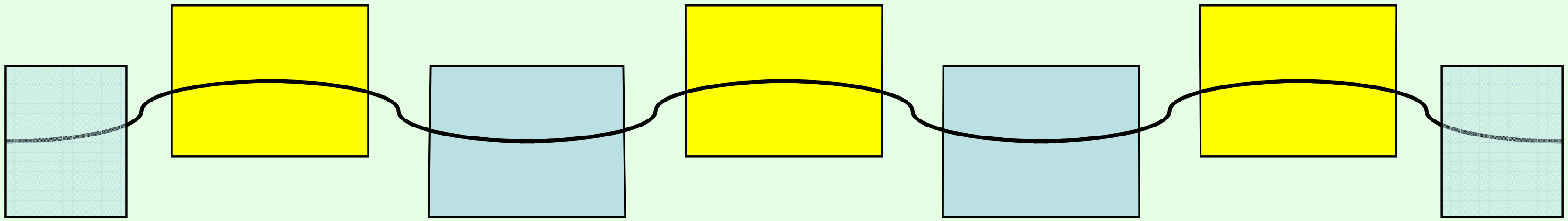
- **50% longer beam lifetimes**
- 500KW **power reduction with same B_{max}** (0.5ME/Year)
- **Less histeresys**, better reproducibility
- **Increase machine reliability**

Wigglers modification

Present wiggler

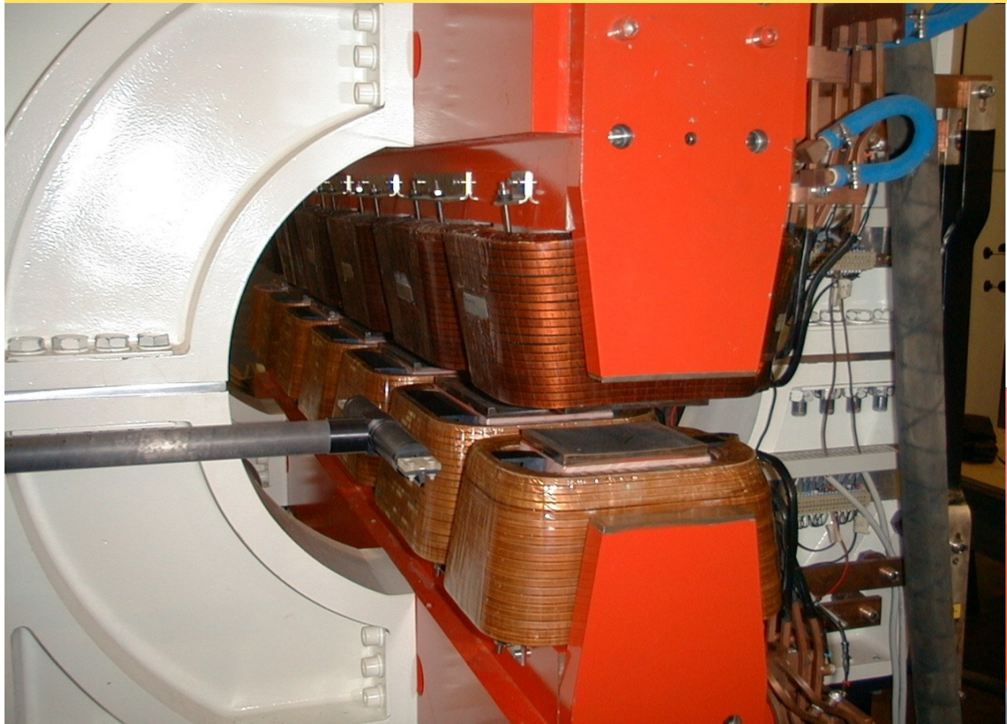


Modified wiggler



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.

Before modification

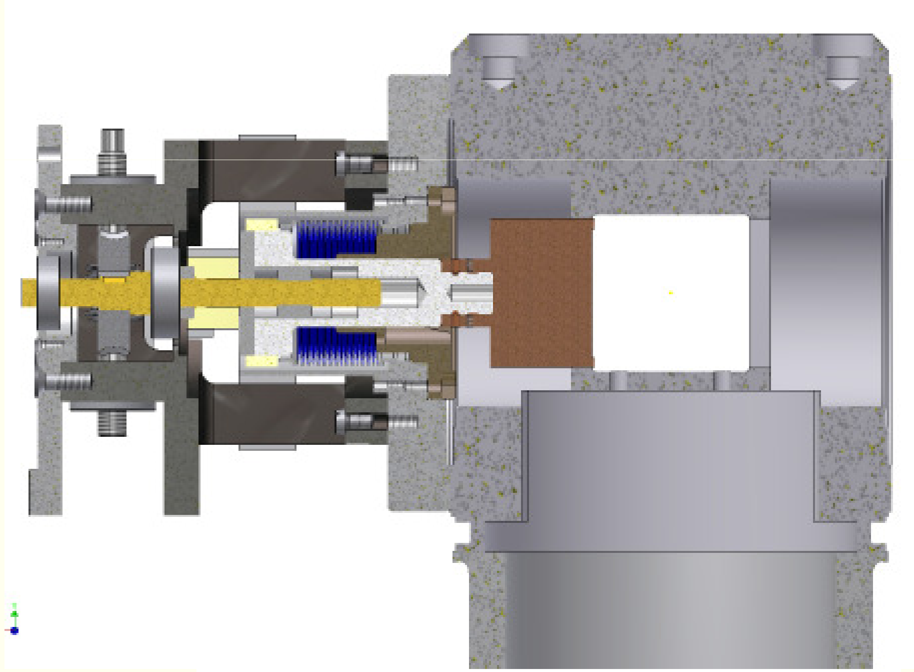


After modification

Hardware activities

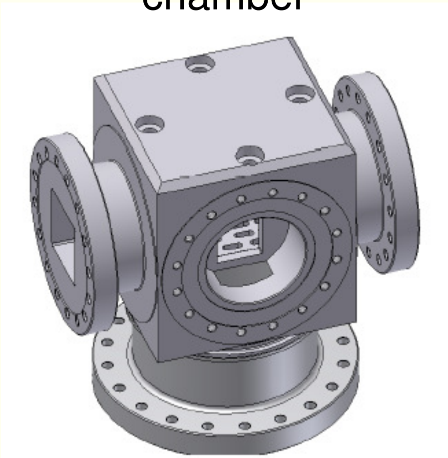
Scrapers will be modified to

- improve their background reduction effectiveness and
- reduce their contribution to the ring impedance



Picture of a new scraper

new scrapers chamber



Hardware Activities

- All remaining old type **bellows** (12) will be replaced with the new ones
  - new ones have lower impedance and better mechanical performance

- All remaining ions **clearing electrodes** in the e- ring will be removed

⇓

  - Less microwave instability
  - Smaller vertical e- beam sizes
  - Shorter bunches and less dependence by the beam currents
  - Better vacuum

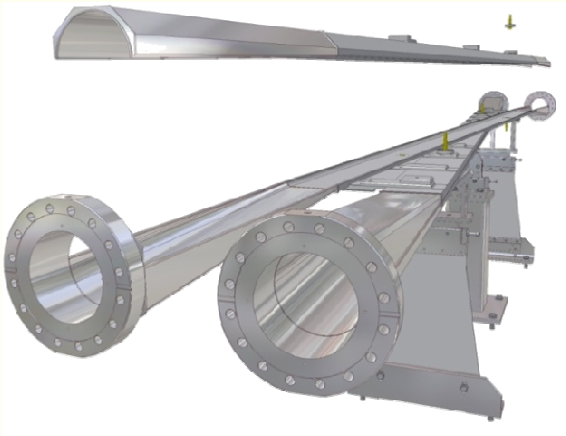
Hardware Activities: IP2 region

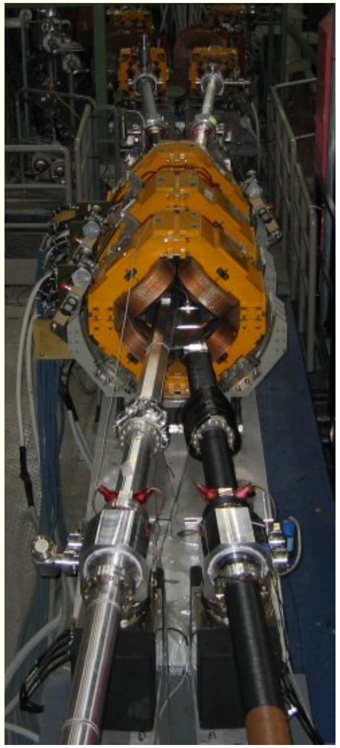
- IP2 X-chamber will be refurbished to improve its straightness (an imperfect welding caused a 5 mm deviation from straightness)

- Some minor adjustment of the quadrupoles position in the area is also foreseen

⬇

  - IP2 beam stay clear will improve by about 50%
  - Less background
  - Better beam lifetimes





Additional Fast Kickers (beam dumper)

Fast kickers are able to dump the beam(s)
on a single turn basis

Fast kickers will be installed to cleanly dump the beam:

- When needed by the operators
- When background exceeds a dangerous level
- When there is some hardware failure

⇓

- Less detector trips
- Less radiation and less radiation interlocks

Linac Maintenance & upgrade

- **Linac gun cathode** (presently 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

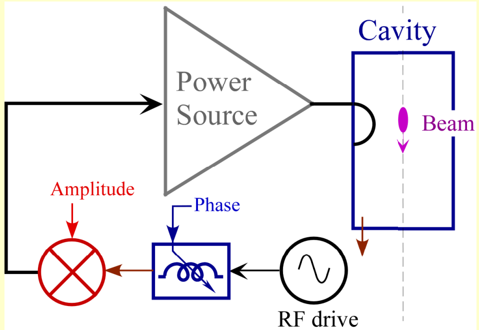
RF low-level and High-Power will be modified

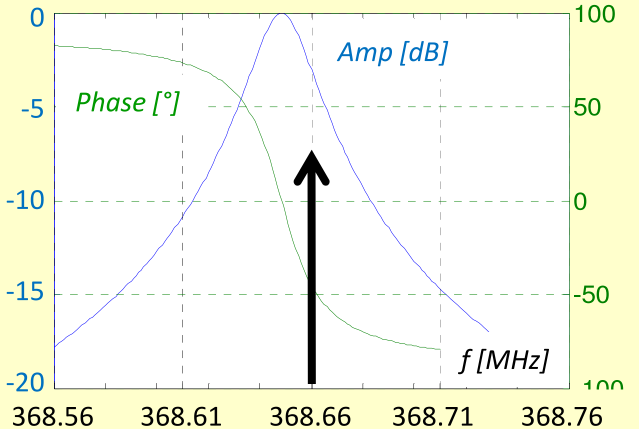
Less Wall-Plug Power (200KW 0.2ME/Year); Improved Longitudinal Stability

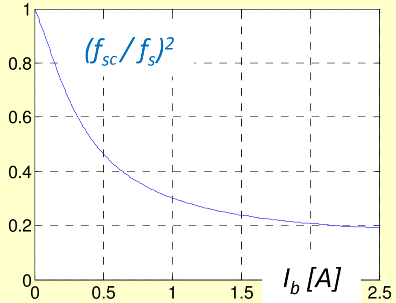
Present DAFNE RF System configuration:

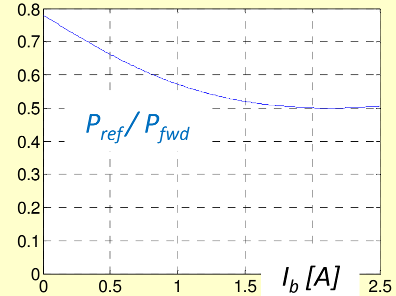
-No direct RF feedback

- Large cavity detuning for beam dynamics





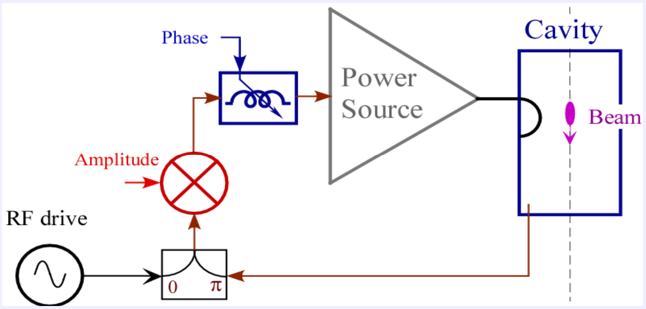


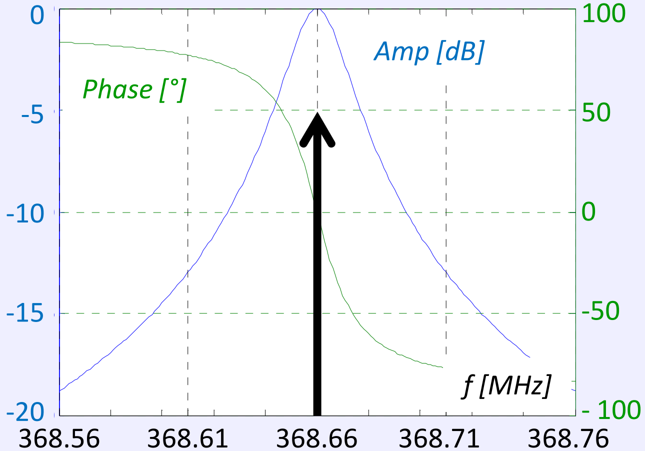


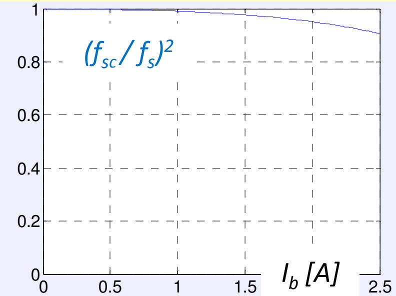
New DAFNE RF System configuration:

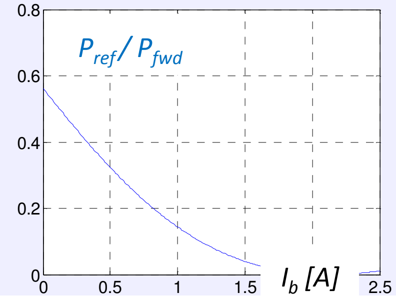
-Implemented direct RF feedback

- Cavity detuning removed









DAFNE Hardware Maintenance

Ordinary and Straordinary maintainance of all the subsystems (Linac, Power Supplies, Cooling etc...)

- More improvements (Controls System, …) will take place as well

  - Recover overall Dafne Uptime
  - Improve average performances

- More windows of the Dafne Dome will be shielded with concrete

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Dafne perspective for new Kloe run

- At regime (about 3 months of commissioning) we expect an overall improvement on the Dafne Peak Luminosity of the order of 20% w.r.t. the Siddharta one

  → L_{peak} about $5.5 \cdot 10^{32}$ $cm^{-2}s^{-1}$

  Integrated luminosity about 0.5 fb^{-1}/month

- Wall Plug Power should decrease by 10-20% w.r.t. Siddharta (0.25 MW increase due to Cryogenics included in the estimate) and almost a factor 2 w.r.t. Kloe1

Conclusions

- SIDDHARTA experiment is smoothly taking data with a good Luminosity–to-Background ratio

- The machine will run for the SIDDHARTA experiment up to its completion (November 9th 2009)

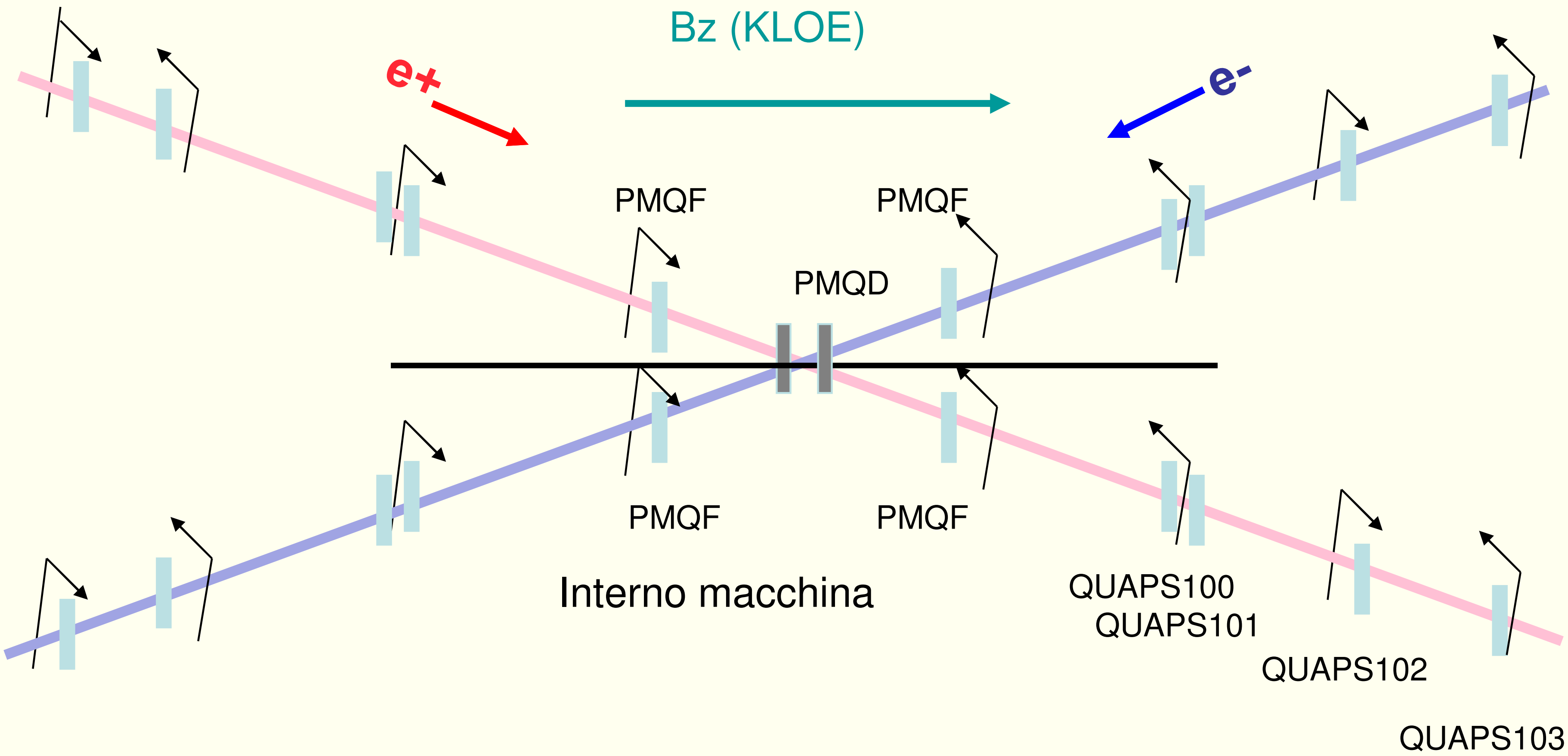
- The shutdown for the KLOE installation will start immediately on Nov. 9th and DAFNE should restart on March 2010

- KLOE runs should last about 10 consecutive months to maximize the data taking efficiency

Back-up

Quadrupole Rotations

	Z from IP (m)	Rotations [degrees]
QD	.415	0
QF	.9503	-4.548
QUAPS100	4.1391	-13.736
QUAPS101	5.2591	-13.736
QUAPS102	8.2408	0.854
QUAPS103	9.0059	-0.854



IR optics for the new KLOE run

Beam optics design criteria:

$\beta^*_x = 26.5$ cm

$\beta^*_y = 8.5$ mm

Coupling matrix = 0 after QUAPS103

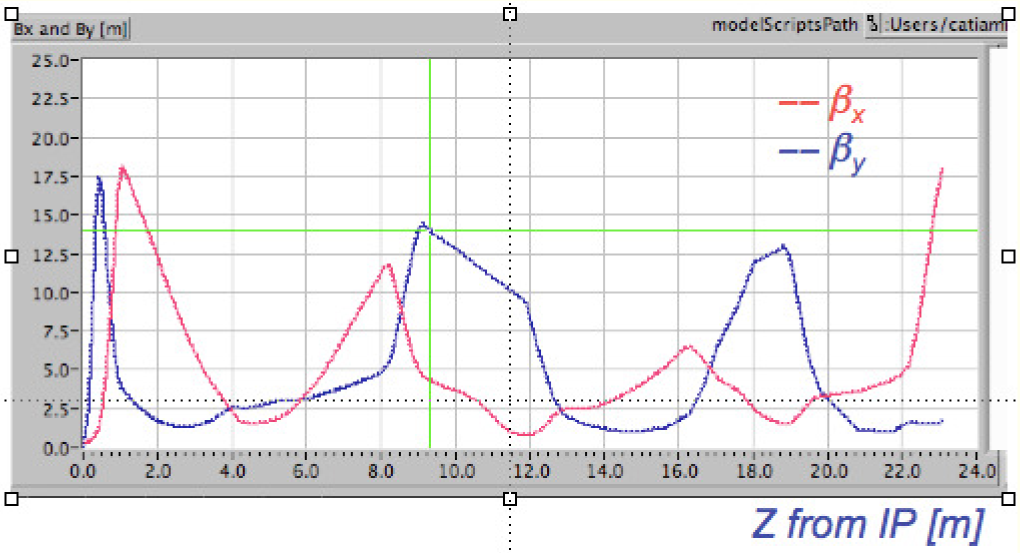
$\Delta\nu_x = \pi$

$\Delta\nu_y = 3\pi/2$

highest β_y at the CW sextupole

$$\int_{KLOE} B \cdot dl = 2.048\,[\mathrm{Tm}]$$

$$I_{KLOE} = 2300\,[\mathrm{A}]$$



Monthly performances

November 1st 2008 – October 23th 2009

Date (# run days)	e^- (Ah)	e^- (Ah)	delivered $\int_{month} \mathbf{L}$ (pb^{-1})	acquired $\int_{month} \mathbf{L}$ (pb^{-1})	ave delivered $\int_{day} \mathbf{L}$ (pb^{-1})
Nov 08	12.5	7.8	173.4		5.42
Dec (20)	17.2	9.3	184.6		9.23
Jan (20)	13.5	6.9	124.0		6.20
Febr.	16.7	8.9	106.5		7.95
March	**17.4**	**8.7**	**271.8**		8.77
April	14.9	6.7	194.1		6.47
May	20.2	8.2	236.7		7.63
June	18.8	7.5	224.0	84.6	7.47
July	17.3	7.1	197.0	76.5	6.36
Aug (4)	1.2	0.1	5.3	1.7	0.38
Sep (24)	10.4	5.2	144.7	85.7	4.82
Oct **(23)**	20.1	8.9	209.3	100.9	**9.97**
tot. # running days = 297			**2024.0**	**325.5** →counting only from June09	

DAFNE Updated performances

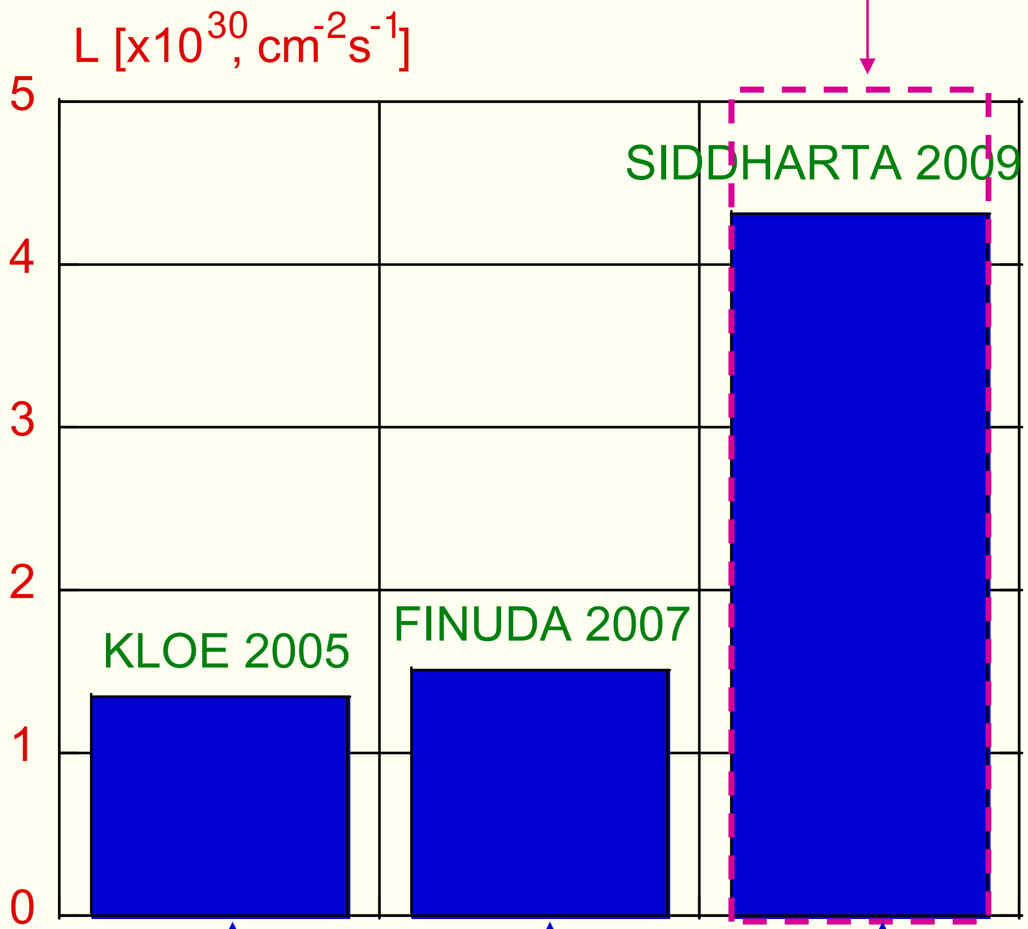
39th sci.com. 38th sci.com. ~20% better than now

	SIDDHARTA (Oct. 26th 09)	SIDDHARTA (May 11th 09)	FINUDA	KLOE-1	*GOAL* *KLOE-2*
L_{peak} [$cm^{-2}s^{-1}$]	**$4.53 \cdot 10^{32}$**	**$4.36 \cdot 10^{32}$ ($5.0 \cdot 10^{32}$)**	$1.6 \cdot 10^{32}$	$1.5 \cdot 10^{32}$	***$5.5 \cdot 10^{32}$***
$\int_{month} L$ [pb^{-1}]					***500***
$\int_{day} L$ [pb^{-1}]	14.98	**14.98**	9.4	9.8	*16.5*
$\int_{1hour} L$ [pb^{-1}]	1.033	**1.033**	0.5	0.44	*0.7*
I^{-}_{MAX} [A] (in collision)	**1.52**	**1.47**	1.5	1.4	
I^{+}_{MAX} [A] (in collision)	1.00	**1.00**	1.1	1.2	
$n_{bunches}$	105	**105**	106	111	
ξ_y	**0.0443**	**0.042**	0.029	0.025	
β_y^* [mm]	8.5	8.5	1.70		*8.5*
β_x^* [cm]	27(e^-)/24(e^+)	27(e^-)/24(e^+)	170		*26.5*

DAFNE Luminosity and Tune Shifts

	KLOE	*FINUDA*	*SIDDHARTA*
Date	Sept. 2005	Apr. 2007	June 2009
Luminosity, $cm^{-2}\ s^{-1}$	1.53×10^{32}	1.60×10^{32}	4.53×10^{32}
e- current, A	1.38	1.50	1.52
e+ current, A	1.18	1.10	1.00
Number of bunches	111	106	105
ε_x, mm mrad	0.34	0.34	0.25
β_x, m	1.5	2.0	0.25
β_y, cm	1.8	1.9	0.93
ξ	0.0245	0.0291	0.0443(0.074)

Single Bunch Luminosity



Collision with 20 bunches

Normal Operating Conditions with > 100 bunches

Basic Idea for wigglers modification

- In the **original** wiggler with flat poles the field is symmetric in the horizontal direction with respect to the pole axis, while the derivative of the field is antisymmetric.

- **Even terms** in the magnetic field (dipole, sextupole, decapole ….) have the same symmetry as the field, and therefore they tend to cancel each other because the field changes sign from pole to pole.

- **Odd terms** (quadrupole, octupole, dodecapole….) have instead the symmetry of the field derivative, and therefore they add coherently from pole to pole, because both the beam position and the field change sign from pole to pole, leaving the derivative always the same.

- In the **modified wiggler** 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**.

First Wigglers modification: shims on poles

- The original wiggler had flat poles and a gap of 40 mm. In order **to reduce the octupolar component** **shims were glued on the poles** and **the octupole was decreased by a factor slightly larger than 2**.

- However, the length of the magnetic circuit had to be increased to allow the insertion of the shims and the peak field **at the nominal current of 694 A** dropped from 1.782 T to 1.610 T. The minimum gap (37 mm) and the thickness of the shims were then reduced and **the final peak field reached 1.712 T**.

- A complete map of the field was measured on a spare wiggler in the “shimmed” configuration at an excitation current of 694 A. All the wigglers were modified in this configuration and they are **presently running** in DAFNE **at a current of** **550A**, in order to save on the power bill. Magnetic measurements at this current are unfortunately not available. An estimate based on previous measurements in different configurations gives a field of **1.60 T**

Proposed wigglers modification with shifted poles

- The **new configuration with shifted poles** has been tested on the spare wiggler. There are **no shims** and the **gap** has been kept at **37 mm**. The measured peak field at **550 A** was **1.726 T**. It was therefore decided to decrease the current further to save more on the power bill. At **450 A** the field was **1.644 T**, still larger than the present peak value in the rings at 550 A.

- **Since the power scales roughly with the square of the excitation current, the overall saving with respect to the original configuration at 694 A is more than a factor 2**.

- **An additional gain in power has been obtained by short-circuiting one of the five coils of the terminal poles winding**: in this way the field integral of the whole wiggler is almost perfectly compensated with central and terminal coils powered in series (they are now independent). In this way **8 big power supplies will not be used** and the **power loss** in the long cables **between the power supplies hall and the ring will be avoided**. The residual field integral in the wiggler (≈27 Gm) will be compensated by means of the standard orbit correctors placed on both sides of each wiggler.

DAΦNE Upgrade Parameters

	DAΦNE FINUDA	DAΦNE Upgrade
$\theta_{cross}/2$ (mrad)	12.5	25
ε_x (mm x mrad)	0.34	0.20
β_x^* (cm)	170	20
σ_x^* (mm)	0.76	0.20
$\Phi_{Piwinski}$	0.36	2.5
β_y^* (cm)	1.70	0.65
σ_y^* (μm)	5.4 (low current)	2.6
Coupling, %	0.5	0.5
I_{bunch} (mA)	13	13
N_{bunch}	110	110
σ_z (mm)	22	20
L ($cm^{-2}s^{-1}$) $x10^{32}$	1.6	5

Larger Piwinski angle

Lower vertical beta

Already achieved

Optical parameters (July 2008)

	electrons design	electrons achieved	positrons design	positrons achieved
emittance (mm.mrad)	0.20	0.25	0.20	0.25
β_x @IP (m)	0.20	0.27	0.20	0.24
β_y @IP (m)	0.0065	0.0085	0.0065	0.0085
coupling (%)	0.5	0.2	0.5	0.2
σ_x @ IP (mm)	0.20	0.26	0.20	0.25
σ_y @ IP (μm)	2.6	3.2	2.6	3.2
Piwinski angle (10mA)	2.5	1.6	2.5	1.7

Beam-beam simulations update- summary

- Crabbed strong beam has been implemented in LIFETRAC and tested. There is a good agreement between simulations and DAΦNE experimental data.

- In general, with the crabbed "strong" beam (new feature) the optimum for "crab" value is increased, but the luminosity and beam tails in the optimum are almost the same as in the old simulations, or even better. It means all the previous simulations are relevant in assumption that the "crab" value (crab sextupole strength) is slightly increased.

- The road towards improved quasi strong-strong simulations (actually, it will be *strong-strong without coherent effects*) is opened and has been already passed by more than 50 %.