DAΦNE TECHNICAL NOTE

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Note: **BM-6**

FIRST RESULTS OF LUMINOSITY ON THE 'DETUNED LATTICE'

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Introduction

I will briefly describe the measurements carried out at DAFNE on the 'detuned lattice' [1] in the five dedicated machine shifts in the period from 4 to 9 March. The most important result is the achievement of $\sim 1 \cdot 10^{30}$ cm^{-2} sec^{-1} single bunch luminosity. It is the first time since the KLOE detector installation that single bunch luminosity values comparable with the ones obtained in "day one configuration" are measured. This is a very important milestone for DAFNE and therefore adequate study time must be spent in order to fully exploit the luminosity limits of this machine configuration.

Ring Optics

Both rings have been set on the tunes (5.15, 5.21), with the quadrupole settings of [1].

The orbits have been corrected without using 'C' and Lambertson correctors. The splitters settings have been adjusted by correcting the orbit, leading to values slightly different from those computed with the calibration measurements.

The RF frequency has been increased by 40 kHz, going to 368.30 MHz, to correct the dispersion-like orbit distortion.

For both rings the measured parameters, the measured dispersion and betatron functions compared with the calculated ones are shown in Tab. I and Fig. 1.

The chromaticity correction has been done by using the sextupoles of Ref. [1], increasing by 10 % one of the focusing families to correct the residual chromaticity. The measured tunes with energy deviation without sextupoles are shown in Fig. 2.

The horizontal betatron function at the wigglers has been lowered in order to minimize the effect of the wiggler-nonlinearity. The curvature of the tune on energy (see Fig. 2 and Tab. I) is a factor two below the expected one.

Table I – Main Parameters of both rings

	design	e+	e-
Q_x	5.15	5.18	5.16
Q_y	5.21	5.23	5.19
Q'_x	-5.5	-5.1	-6.3
Q'_y	-14.9	-14.4	-12.5
Q''_x	-1154 *	-501	-515
Q''_y	1188 *	566	323
α_c	0.028	0.024	0.024
ε_x (mm mrad)	0.80	0.81	0.79

°computed with an octupole lens in the centre of each wiggler with K_3L = -1000 m^{-3}

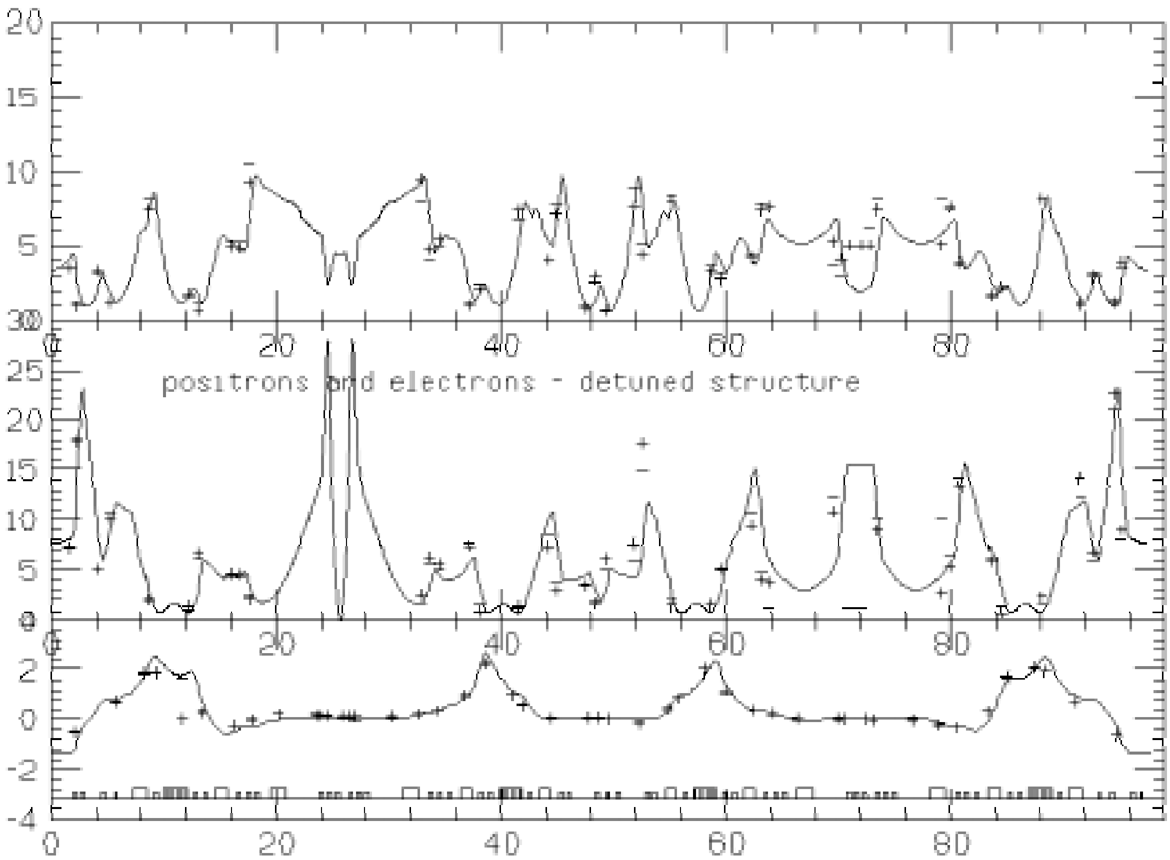

Figure 1 – Measured betatron functions and dispersion on positron (+) and electron ring (-).

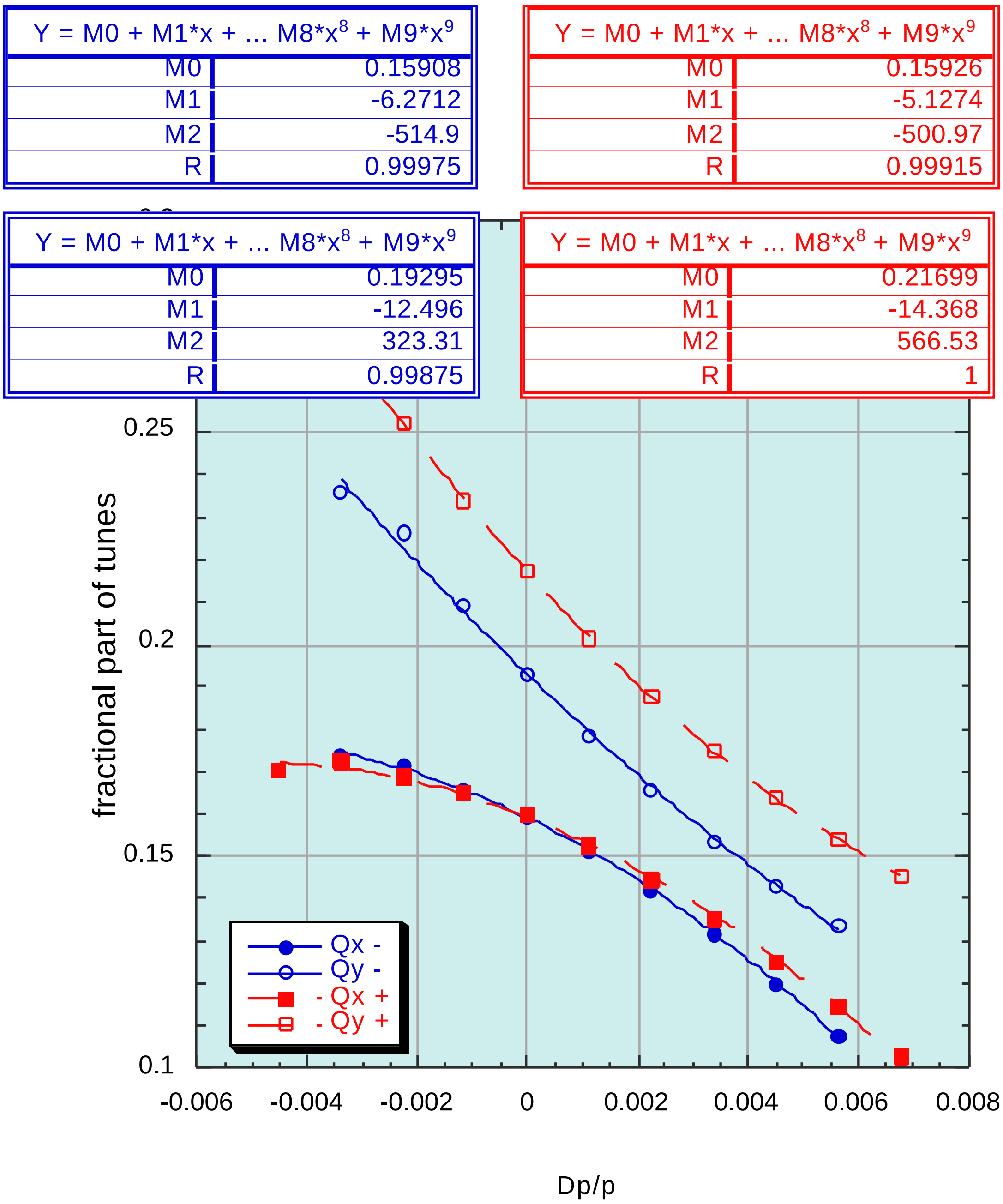

Figure 2 – Tunes vs. energy variation with sextupoles off in electron (left equations, full lines) and positron (right equations, dashed lines) rings.

Coupling

The coupling has been corrected on both rings by tuning the shared solenoids. After a first correction of the orbit within ± 5 mm in the horizontal plane and ±3 in the vertical plane, sextupoles, 'C' correctors, Lambertson correctors, and skew quadrupoles have been switched off in order to eliminate all so far known coupling sources.

The coupling (ratio between mode 2 and mode 1 emittance) on the ring depends quadratically on the field of the KLOE solenoid. Let's call $K^{\pm}_{min}$ the current of the KLOE solenoid power supply corresponding to the minimum coupling for a given ring configuration in the positron (+) or electron (-) ring, and C_1 and C_2 the currents of the two compensator power supplies.

A first scan with the set of compensators used in normal operation (C_1 = -77A, C_2 = 77A) (Fig. 3) has shown that K^{+}_{min} was higher than K^{-}_{min} by about 40 A.

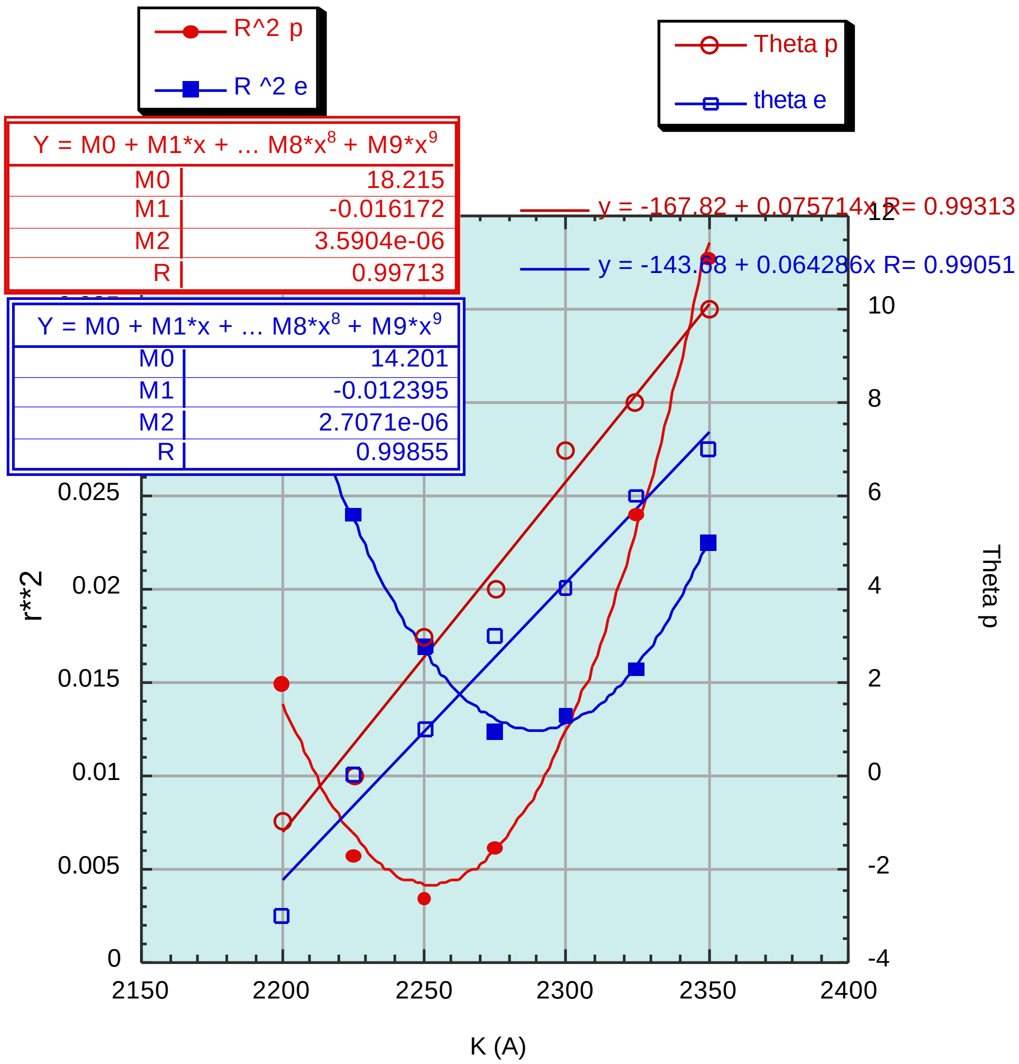

Figure 3 – Coupling and orientation at the SLM as a function of KLOE field with C_1 = -77 and C_2 = 77A

Scans done keeping the two compensators at the same current with different values of the compensators have shown on both rings that $K^{\pm}_{min}$ increase as the compensator field decreases (Fig. 4).

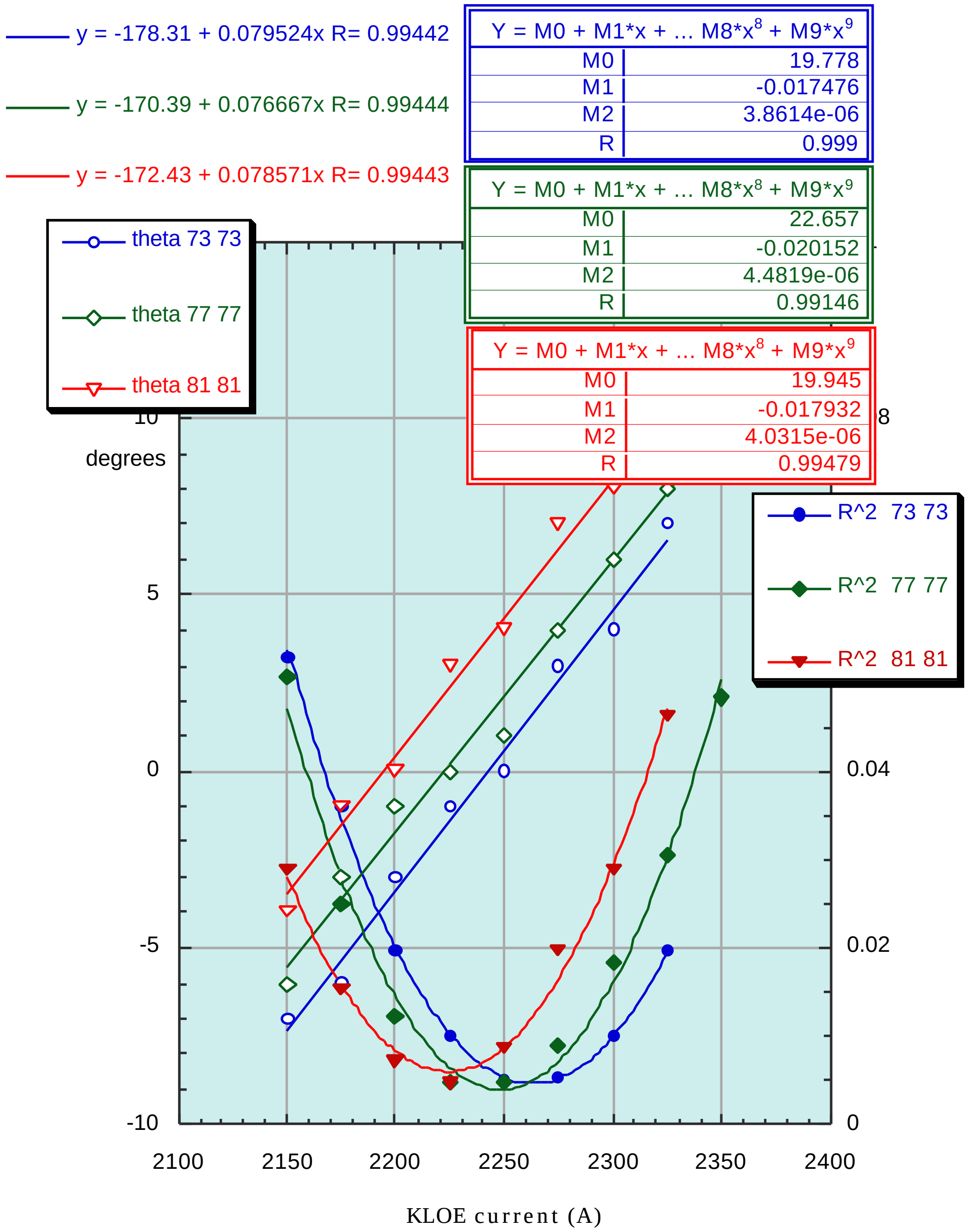

Figure 4 – Coupling and orientation at the SLM as a function of KLOE field with C_1 = -C_2 at different currents on positron ring

Powering the two compensators with different currents changes the relative position of K^+_{min} and K^-_{min}. The set of currents which lead to

$$K^-_{min} = K^+_{min} = 2300 \text{ A}$$

has been found and corresponds to C_1 = –74.5 A and C_2 = 71.5 A (Fig.5). The relative difference between the two compensators coincides with the computed one [2], while the absolute value of both $K^{\pm}_{min}$, C_1 and C_2 are all lower, which could be due to other coupling sources in the rings.

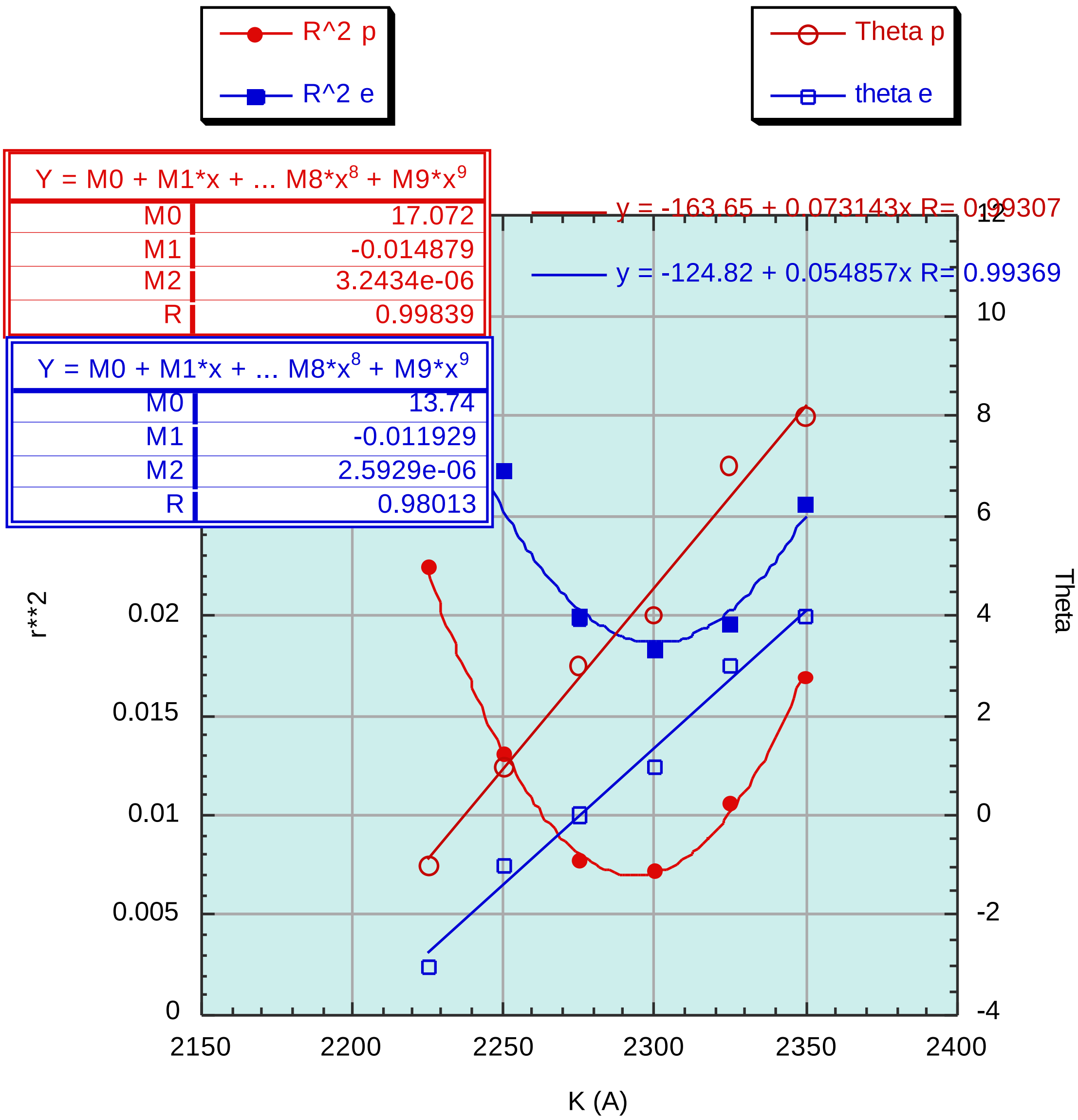

Figure 5 – Coupling and orientation at the SLM as a function of KLOE field with C_1 = -74.5 and C_2 = 71.5A

An extra correction of the coupling has been done by powering the skew quadrupoles: the coupling on the positron ring, according to the measurement of betatron functions and at the SLM, corresponds to less than 0.2%. In the electron ring it would correspond to 0.7% if the measurements at the SLM had the same resolution, and to better than 0.5% taking into account the different resolution.

Set-up for Collision

The overlap of the two beams has been done with single bunch at low current (5 to 3 mA) per bunch, with no evidence of blowup. The measured vertical sigma at the IP, Σ, is 12 μ, which for the nominal value of β^* corresponds to an average coupling of both rings of 0.3%.

The vertical orbit in the second IP has been displaced by ±1cm. The bump has been done using 'C', Lambertson and skew correctors, in a combination which minimize the coupling change. The vertical aperture has been checked by increasing the separation at the IP: in the positron ring the beam lifetime dropped for a vertical orbit of 4 cm, in the electron ring for 3.5 cm.

Single Bunch Luminosity

The first collisions have been done with the same tunes for both beams: (5.15, 5.21). The electron beam has soon shown to be weaker on these tunes, so they have been changed toward the usual e- tunes, (5.12, 5.19). On these values it has been possible to collide with ~16 mA per bunch, with a luminosity (measured by KLOE) of 6~7 10^{29} cm^{-2} sec^{-1}.

The electron ring lifetime was still critical with the vertical tune. Lowering it and going to (5.12, 5.16) the beam-beam conditions were less critical, currents of 20mA per bunch could be put in collision, and the maximum luminosity measured by KLOE was $1 \cdot 10^{30}$ cm^{-2} sec^{-1}. Figure 6 shows the first day collisions, while Fig. 7 shows the second trial.

Beam lifetime of the order of 1 hour at the maximum luminosity was obtained. There was no evidence of effective saturation, and there are margins to improve both luminosity and beam lifetime.

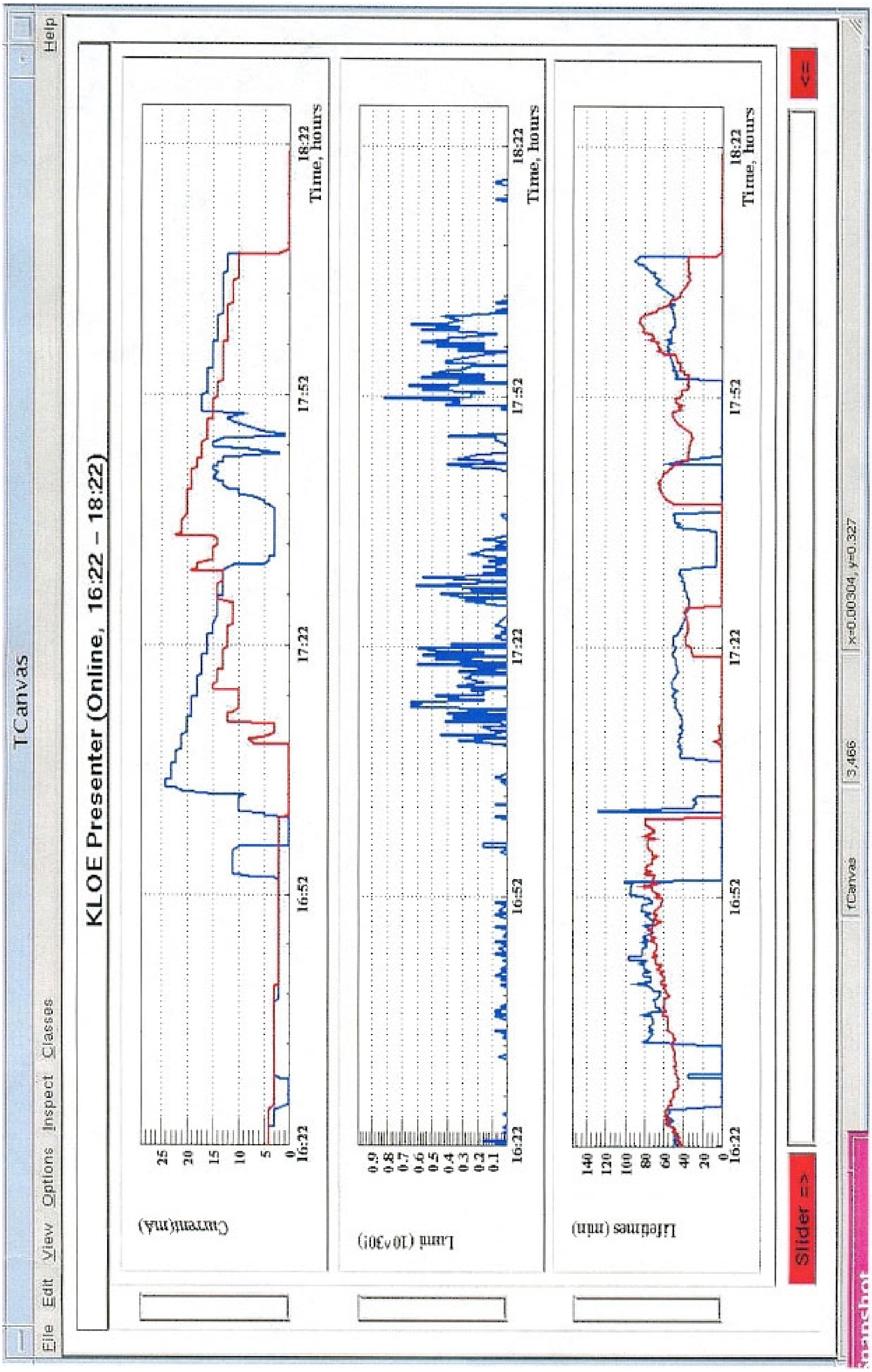

Figure 6 – First single bunch collisions on the detuned structure.

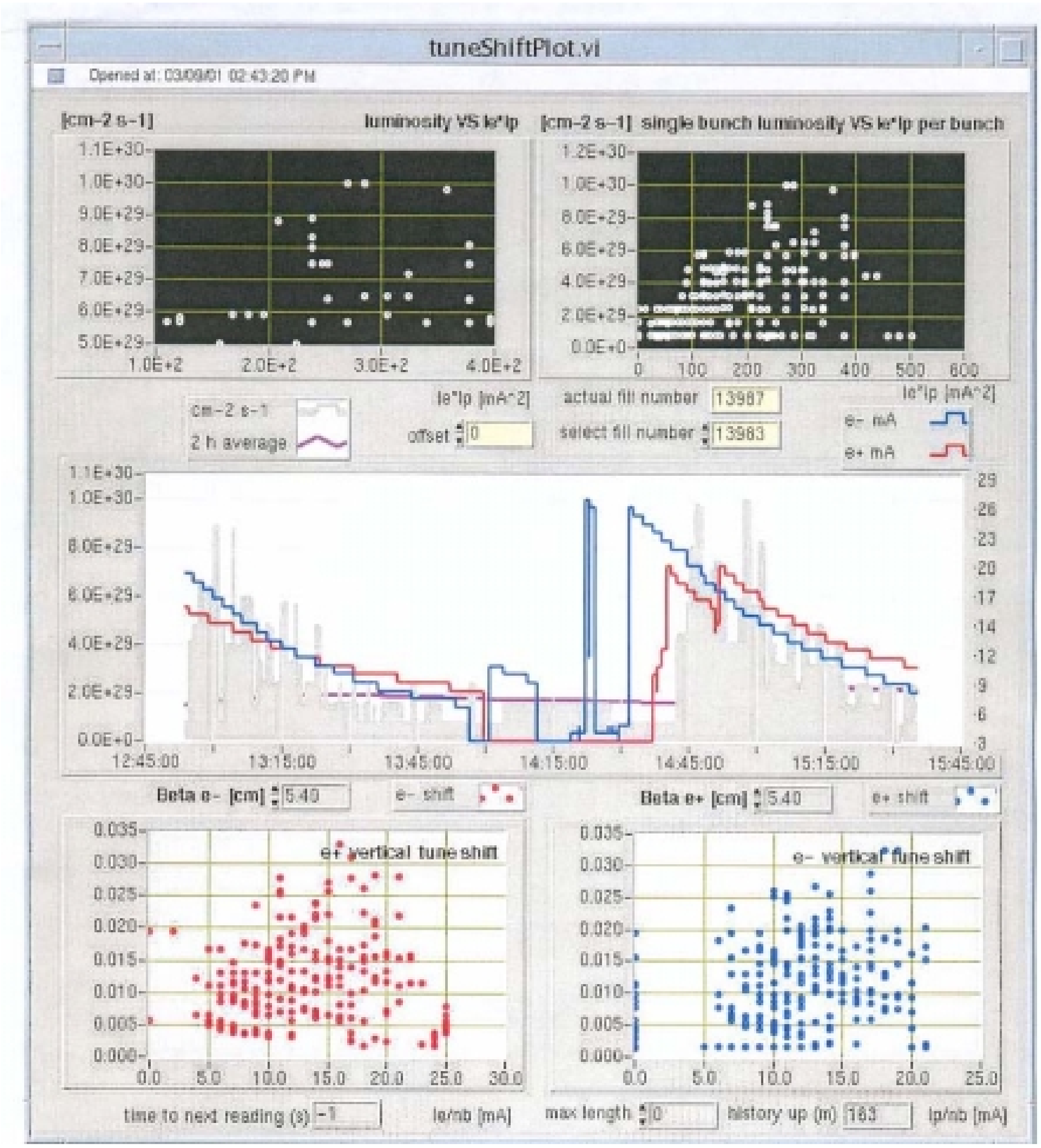

Figure 7 – Second day of collisions reaching luminosity of 10^{30} cm^{-2} sec^{-1}

General Considerations

For the first time since the KLOE installation, a single bunch luminosity of the order of the one obtained in the day-one configuration has been measured, with better lifetime.

The background on the KLOE end caps is high with this optics. In fact the observation of the beam-loss monitors around the rings shows that most losses are concentrated in the two IRs, especially on the second one. There are two possible reasons: one is the lower beta function at the wigglers and at the nearby quadrupole, which in the usual optics are beam-loss positions. The second is the lower horizontal betatron function in the zone near to the second IR, which correspond to the position of one of the scrapers.

Another unwanted effect of the smaller beam size in the wiggler is that the Landau damping provided by the wiggler octupole is decreased, and a transverse horizontal instability appears in multibunch configuration, at a current of the order of few hundreds of mA.

Due to a slightly lower momentum compaction the longitudinal quadrupole instability has appeared in multibunch configuration at about 15 mA per bunch with 20 bunches.

To understand better the tools which have given this good result on the luminosity, a different optics has been applied on both rings [3], in which the detuning and high vertical separation at the second IP have been maintained, while the betatron functions at the wiggler position are higher. The optimized injection section (high horizontal beta at the septum position and exactly π horizontal phase advance between the kickers) allows very efficient injection.

The background on the KLOE end-caps is lower by a factor ~7 with respect to the first optics. However, the beam lifetime is lower and the dynamic aperture suffers from the effect of the wiggler-non linearity. Collisions done with this configuration have shown, as expected, that the lifetime in collision is not good.

From all the above considerations it can be concluded that a further step towards the enhancement of luminosity/background ratio could be done if the following ‘recipes’ are followed:

- detune the second IR, which implies no beam-beam effect of the second IP, plus correction of the coupling at the best we have done so far;
- momentum compaction higher than 0.03;
- high horizontal betatron function at the position of the scraper near the second IR to make the scraper more effective;
- emittance invariant in the short sections higher than in the long one, so that the arcs nearer to the KLOE experiment produce less large amplitude particles and therefore less background on the experiment;
- horizontal betatron function at the wiggler position in the long arcs higher than in the short ones. The average value must be balanced in such a way that the octupole of the wigglers still provides Landau damping, the dynamic aperture is affected but not excessively decreased and the two long arcs can scrape some of the background produced in the short arcs.

Acknowledgment

I want to thank the technical staff for their competence and tireless support.

References

[1] C. Biscari – ‘ Detuned lattice for DAFNE main rings ‘ - DAFNE Technical Note L-32, March 2001

[2] C. Biscari – ‘More about Coupling in DAFNE’ - DAFNE Technical Note L-31, March 2000.

[3] DAFNE logbook – 13, 15 and 16 March 2000.