DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **BM-8**

Report of DEAR shifts

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Introduction

A new optics for DEAR has been studied in the December shifts (10÷20 Dec 01). The main difference with respect to the optics adopted during April-June shifts is the value of β_y^* reduced from 7 cm to 3 cm. Two shifts have been dedicated to a lattice with an intermediate value β_y^* = 4 cm. All the measurements performed on the two rings are reported in the following, in order to have a complete scenario for the next shifts.

Optics measurements

Measured β functions, compared with the model (MRpDEAR01), are shown in Fig. 1 for the e^- ring. For the e^+ ring the β functions, measured in the DEAR IR only, are shown in Fig. 2.

The dispersion function measured by a 5KHz frequency shift has been fitted with the model and the results are shown in Figs. 3,4 for e^- and e^+ respectively.

The parameters of the machine model for DEAR are in a dxcalc file:

/exp/dafne/soft/optics/mad8/susanna/p_dear_dec_01.loc.

The chromaticity has been measured and corrected by increasing the strengths of the vertical (SD) sextupoles. The central RF frequency for DEAR is 368.260. The behavior of tunes vs. energy for the two beams is shown in Figs. 5, 6 for the lattice with β_y^* = 4 cm. The two curves show a parabolic behavior: the term m_1 is the chromaticity, m_2 is the second order coefficient and, δ^+ and δ^-, are the maximum energy deviations before fast lifetime decrease. Chromaticities, together with values of m_2, δ^+ and δ^- , for different lattices and both beams are listed in Table I. All the data in the table depend on the value of the momentum compaction. Here the value calculated by machine model, and listed in the table, has been used. From the fit of the dispersion function (see Figs. 3, 4) the momentum compaction can be estimated by scaling the value of the model with the ratio of the applied frequency shift and the fitted one. This gives a smaller momentum compaction i.e. smaller m_2 and larger δ^+, δ^-. A measure of bunch length vs. RF voltage at low current is needed to check the momentum compaction value. Three DEAR lattices, which differ for the β_y^* value at IP2, are shown; for comparison the KLOE lattice corresponding to the maximum luminosity is also reported. All the measurements are performed with sextupoles except for two lattices, DEAR June (β_y^* = 7cm) and KLOE for which the measurement without sextupoles is also shown.

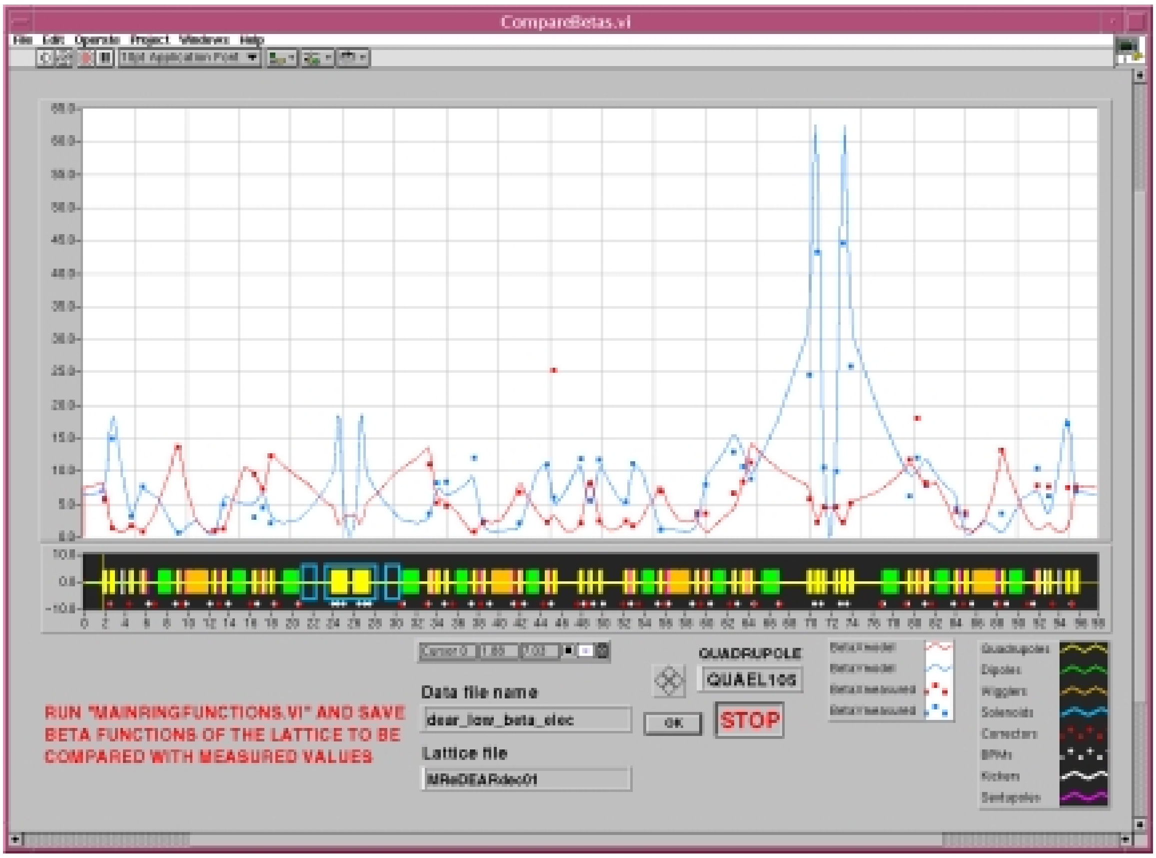

Figure 1 - Measured β functions for e⁻

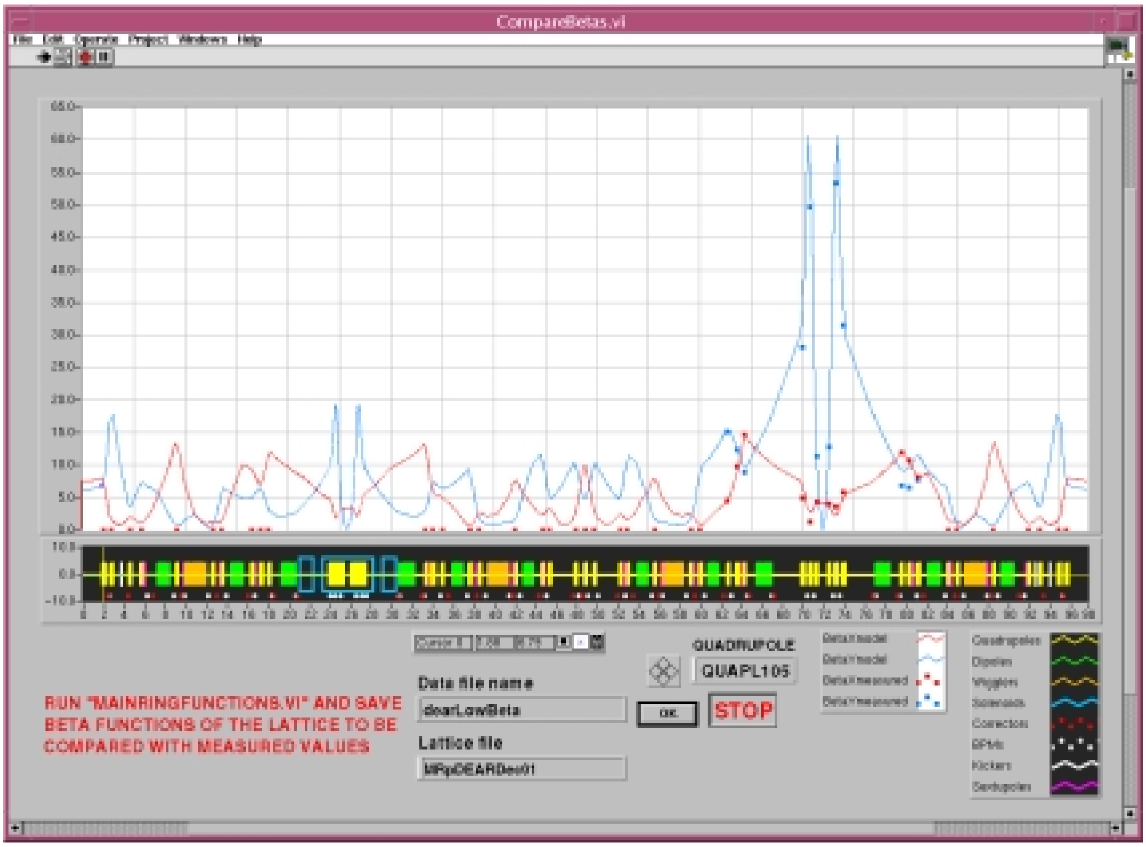

Figure 2 - Measured β functions for e⁺.

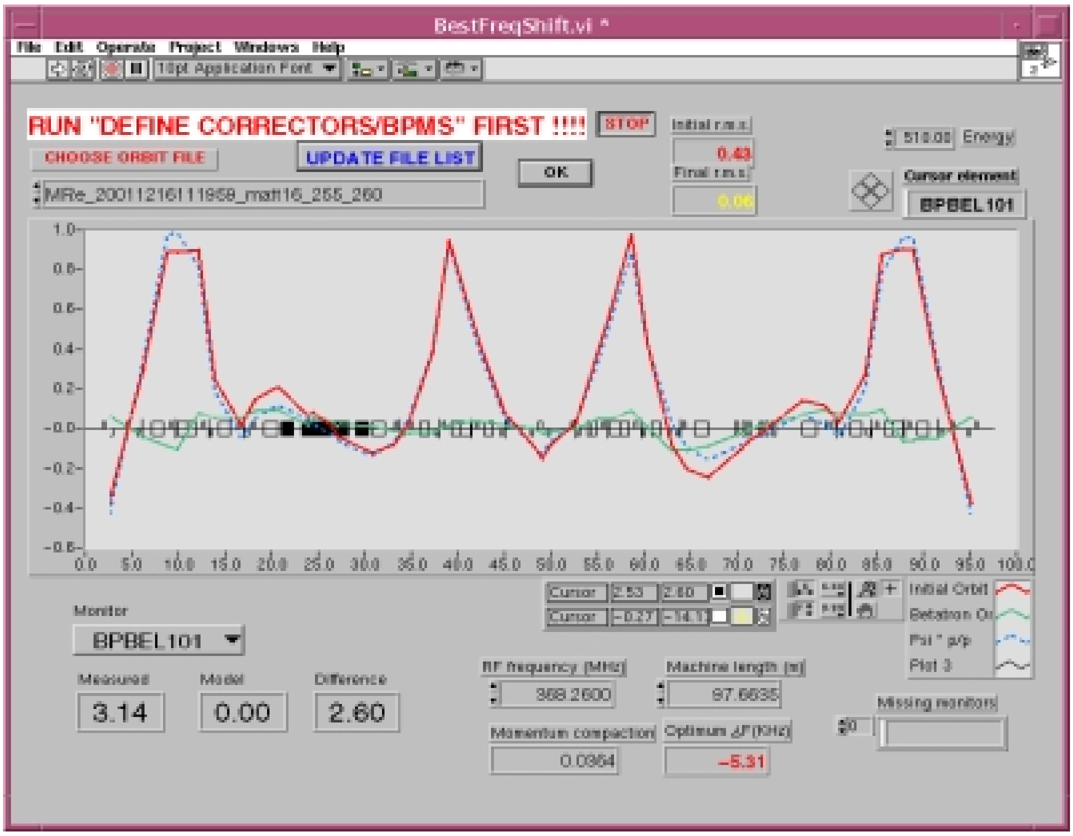

Figure 3 - Measured dispersion function for e$^-$ (Δf_{RF} = 5 KHz).

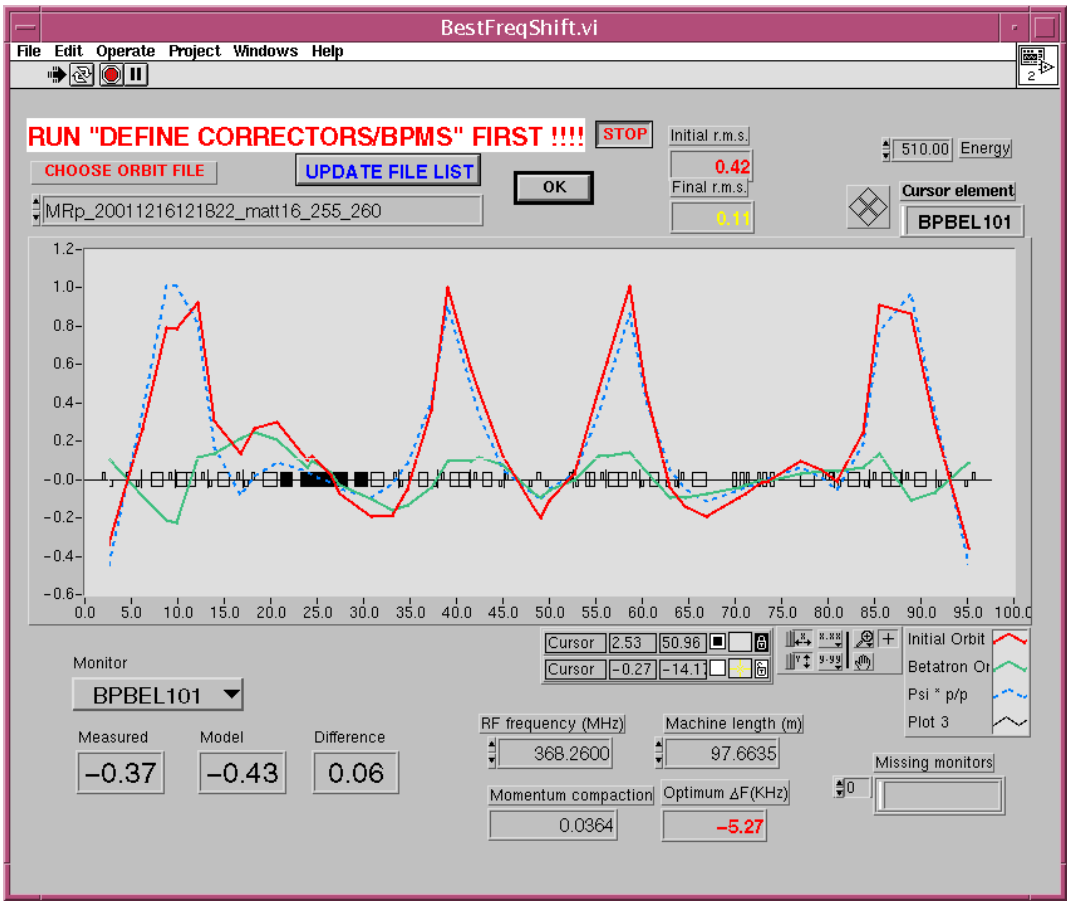

Figure 4 - Measured dispersion function for e$^+$ (Δf_{RF} = 5 KHz).

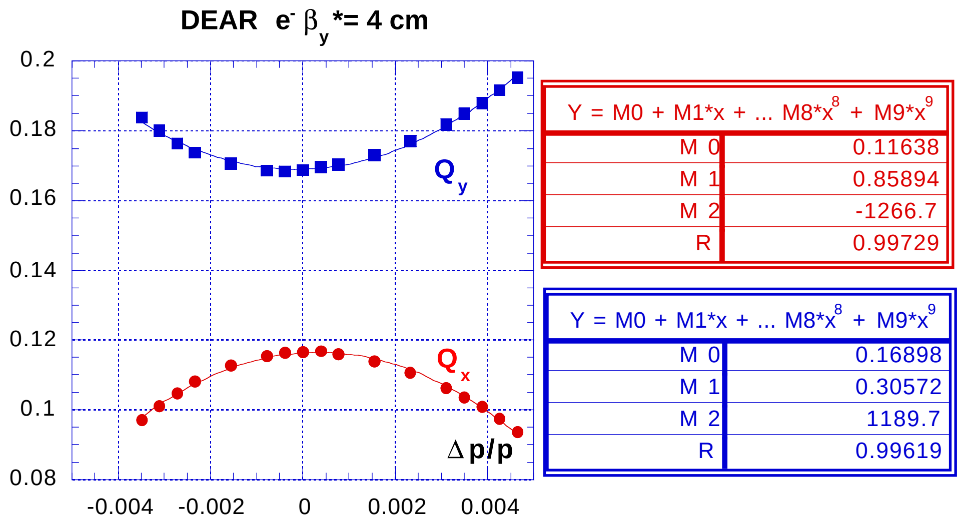

Figure 5 - Tunes vs. relative energy deviation for the e$^-$ ring.

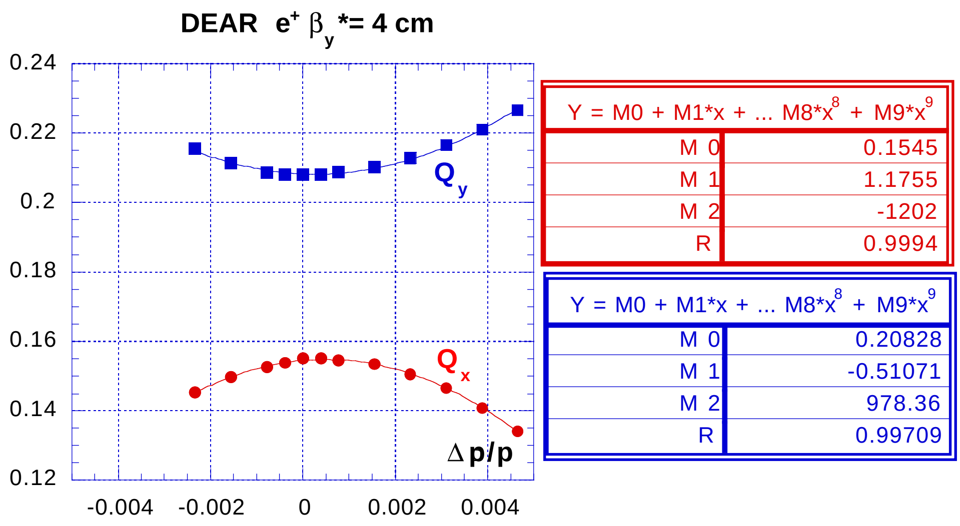

Figure 6 - Tunes vs. relative energy deviation for the e$^+$ ring.

The second order dependence of the tune on energy is produced by octupole terms in the machine and by the combination of strong chromaticity correcting sextupoles. A large dependence of the tune on energy can affect the beam-beam behavior of the machine and limit the maximum luminosity. A few considerations can be done looking at Table I:

- The m_2 coefficients are influenced in a different way by the sextupoles. Studies will be dedicated to find a proper sextupole configuration that reduces these coefficients.
- The table shows that reduction of the β_y^* value at the IP increases the parabolic coefficient in the vertical plane. This might counteract the luminosity increase due to the β_y^* reduction.

- The m_2 coefficients of the three DEAR lattices are always larger than those of the KLOE one, which corresponds to the maximum luminosity. This can be explained by the smaller chromaticity of the KLOE lattice which has only one low beta in the KLOE region, while the DEAR lattice (due to the permanent magnet quadrupoles in KLOE) has a low beta in both interaction regions (β_y^* = 7cm in KLOE IP). Moreover the KLOE lattice is used since April 2001 and the sextupole configuration has been optimized during operation.

Three octupole magnets will be installed in each ring in January. They will allow to compensate, at least in part, the second order terms in the tune dependence on energy and on amplitude. We aspect that, after an optimization of the octupole strengths, the lifetime and luminosity will improve both for KLOE and DEAR.

Table I

β_y^* **(cm)**	α_c	C_x	C_y	m_{2x}	m_{2y}	δ^+	δ^-
DEAR e^+							
3 sext. on	.036	-.97	.22	-1045	1414	2.3e-3	3.8e-3
4 **sx on**	.035	1.2	-.50	-1202	978	2.3e-3	4.7e-3
7 **sx on**	.036	-.5	-2.2	-1009	614	4.9e-3	6.8-3
7 **sx off**	.036	-8.4	-16	-1323	933	1.9e-3	3.0e-3
KLOE e^+							
3 **sx on**	.032	-.55	1.77	-788	786	3.4e-3	3.8e-3
3 **sx off**	.032	-8.7	-17.6	-996	949	3.0e-3	4.2e-3
DEAR e^-							
3 **sx on**	.036	-.23	.32	-1118	1345	1.5e-3 1)	1.5e-3 1)
4 **sx on**	.035	.86	.31	-1267	1190	3.5e-3	3.5e-3
7 **sx on**	.036	-1.6	-.22	-1244	880	3.8e-3	4.5e-3
7 **sx off**	.036	-8.0	-16.5	-1271	958	3.0e-3	3.0e-3
KLOE e^-							
3 **sx on**	.032	-1.4	.22	-611	716	3.4e-3	5.9e-3
3 **sx off**	.032	-8.8	-20.8	-1417	951	2.1e-3	1.7e-3

1) Range of measure, not lifetime limit.

Another measurement of machine nonlinearity is the coefficient of the tune shift with betatron amplitude. This can be obtained by decoherence measurements performed at low current by kicking the beam in the horizontal plane and registering the position turn by turn. Measurements for both beams (DEAR optics, $\beta_y^* = 3$ cm) with sextupoles on and off are shown in Table II. The values obtained are only slightly different from the KLOE ones (-170 at the maximum luminosity).

Table II

Kick (KV)	x (mm)	turns	Q_x	C_{11}	sextupoles
			e^+		
2	185	289	0.1531	166	on
3	329	190	0.1523	143	on
4	459	134	0.1512	145	on
5	584	100	0.1494	153	on
			e^-		
3	4.72	153	.1177	173	on
4	6.39	111	.1166	176	on
5	8.48	82	.1148	180	on
3	4.60	191	.1187	142	off
4	6.30	137	.1175	145	off
5	8.13	101	.1158	152	off

Single beam lifetime

The beam lifetime measured at three different currents, for the positron beam, is shown below, together with the corresponding beam roundness.

I (mA)	r	τ (s)
15.11	.097	803
13.15	.095	910
10.51	.095	1044

Colliding beams

Collisions at low current have been done to adjust the overlap of the two beams. The currents of the compensating solenoids are: -72, +73. The effective vertical beam size at IP2 ($\Sigma = \sqrt{\sigma_{y+}^2 + \sigma_{y-}^2}$) has been measured by means of luminosity scans at three different longitudinal positions. The results are given in Table III.

Table III

s (cm)	**Σ (μm)**	**Lpeak (a. u.)**
-3.0	18.8	38.8
0	13.8	55.9
3.0	17.6	44.4

Assuming emittance and beta values from machine model:

$\varepsilon = .92\ 10^{-6}$ m rad

$\beta_y^* = .03$ m,

these values of Σ correspond to a coupling $\kappa = 3.5\text{e-}3$ for equal beam sizes of the two beams and are well consistent with $\beta_y^* = .03$ m and the waists of the two beams in the same position.

At the synchrotron light monitor we measure the ratio $r = \sigma_y/\sigma_x$ and calculate the corresponding value of the coupling, assuming a ratio of the betas $\beta_y/\beta_x = 1.6$. We have:

e^+ $r = .093$ $\kappa = 5.4\text{e-}3$

e^- $r = .155$ $\kappa = 1.5\text{e-}2$.

The reason why these values are higher than that obtained from the luminosity scan needs further studies. The main reason might be the finite resolution of the synchrotron light monitor.

Other parameters, which are important for the beam-beam behavior, are the separation at the second IP and at the parasitic crossing points.

The vertical separation at the KLOE IP, taking the mean value of the two bpms adjacent to the IP, is 2.5 mm (-2.5 e^+, 0 e^-). A larger separation is needed, to improve beam-beam behavior, but when we increase the separation also the coupling increases and this reduces the luminosity. A systematic work to try and increase the separation should be planned in the next shifts in order to find the optimal solution.

The model optical functions at the first parasitic crossings (for 120 and 60 bunch filling) are listed below:

S (m)	β_x (m)	β_y (m)	Δ_x (mm)	n_b
.4	4.26	5.36	10.0	120/120
.8	3.47	24.9	18.4	60/120

Runs for Dear have been performed with this optics for a few days. During these runs the electron current was limited due to a problem of the RF cavity. Currents and luminosity for a typical run are shown in Figs. 7, 8. The scrapers have been optimized in this configuration and DEAR people have carried out extensive background measurements.

This optics has a larger luminosity, at the same current, than June optics, consistently with the reduction of the β_y^* at the IP. Injection is less efficient than in June and requires further optimization.

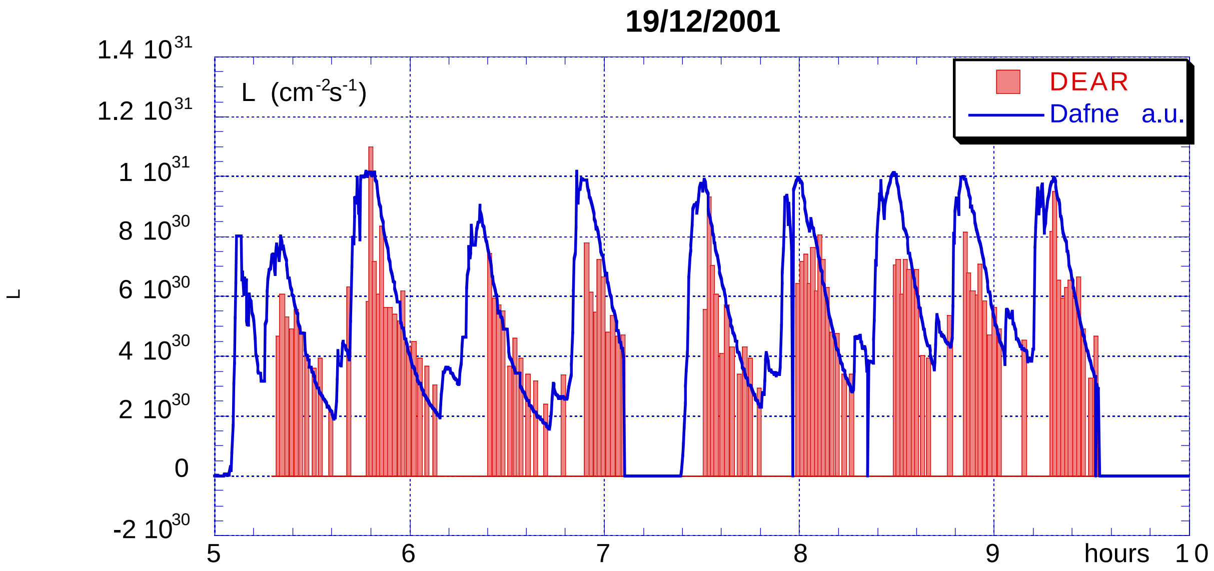

Figure 7

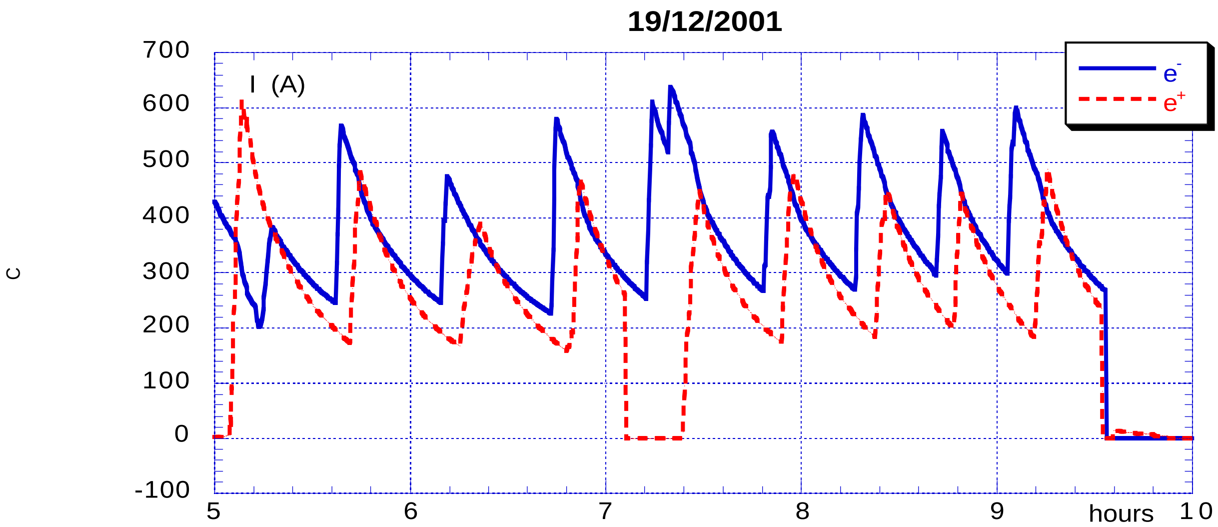

Figure 8

Only two shifts have been dedicated to an optics with an intermediate β_y^* value (β_y^* = 4 cm) between June optics and the one above. With respect to the optics described above (β_y^* = 3 cm) chromaticity and sextupole strengths are lower. Injection is easier and more efficient but luminosity is lower. Currents and luminosity for 5 hour runs are shown in Figs. 9, 10. Luminosity measured by the DAΦNE monitor, normalized to be superimposed, is also shown.

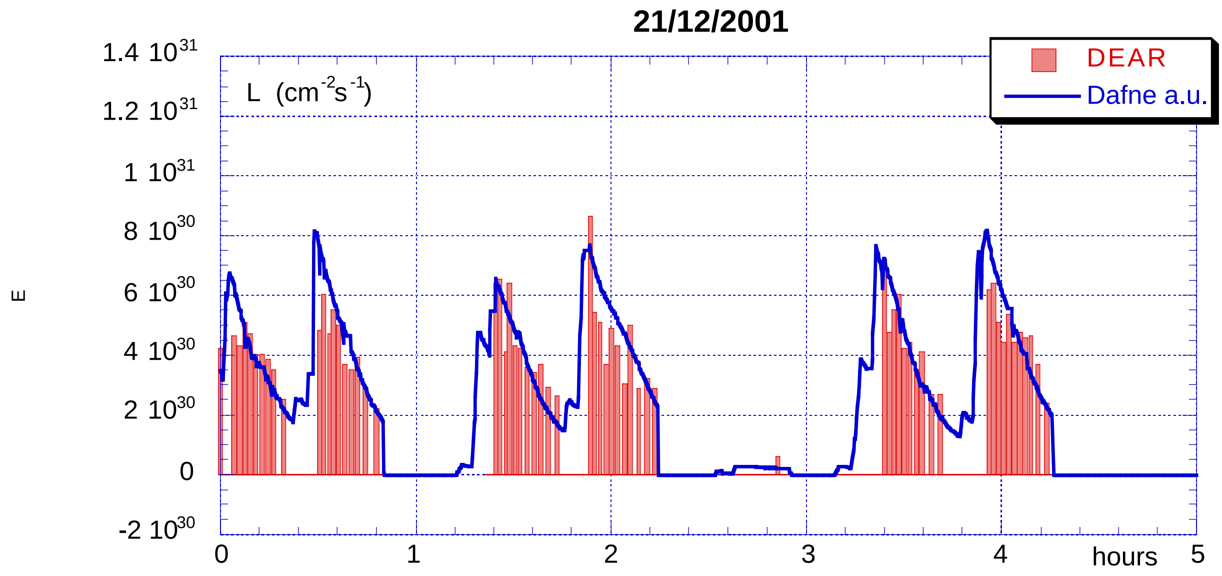

Figure 9

Figure 10