DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **BM-15**

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1. Introduction

In the week 14-21 June 2004 two days were devoted to implement in both rings a new lattice with a negative momentum compaction. The bunch lengthening at high bunch currents is expected to be less dramatic for negative α_c lattices and this could allow for further reducing the value of the β_y^*. At present β_y^* is 1.9 cm with a measured bunch length, at 10 mA bunch current, of about 2.3 cm for electrons and 1.9 cm for positrons. This reduces the achievable luminosity due to the hourglass effect.

Measurements of bunch lengthening and dispersion were performed on both rings with the new lattice. The results were very promising; however this lattice will need more MD time to adjust the theoretical model in the electron ring, to correct orbits and to fine tune all the parameters to be able to successfully collide.

Moreover in the standard lattice configuration for KLOE, with positive α_c, the bunch length at two different RF voltages and betatron functions in the electron ring were also measured.

2. Electron ring bunch length measurement for negative α_c lattice

The negative α_c lattice was first applied to the electron ring. The bunch length at different bunch currents was measured with a streak camera for a RF voltage of 165 kV, the present operation value. Horizontal and vertical dispersion functions were also measured. The lattice turned out to be slightly different from the model, so further measurements are needed in order to adjust the model. Figure 1 shows the electron bunch profiles as measured for 0.43, 0.8, 1, 7.7, and 10 mA bunch currents.

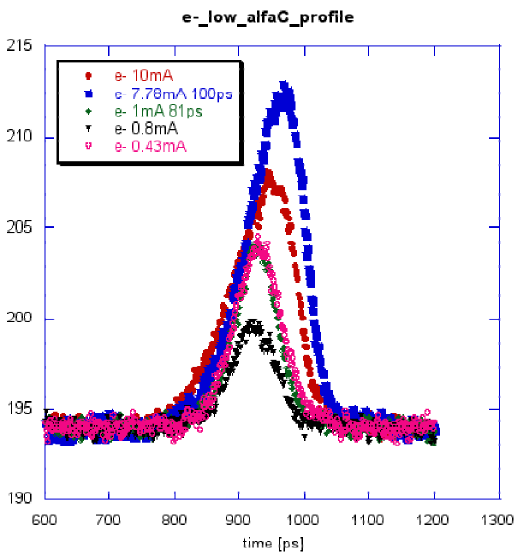

Figure 1 – Electron bunch profile at different bunch currents (V_{RF}=165 kV)

The synchrotron frequency was also measured, f_s = 31.5 kHz at 165 kV, giving a momentum compaction value of 0.017. The sign of α_c can be derived by the measured orbit change when moving the RF frequency.

Figure 2 shows the bunch profile (in ps) for the lowest bunch current values: 0.43 and 0.8 mA. From both Figs. 1 and 2 the deformation of the profiles, which, as theoretically predicted, become asymmetric for increasing bunch current, although much less than for positive ac, can be observed.

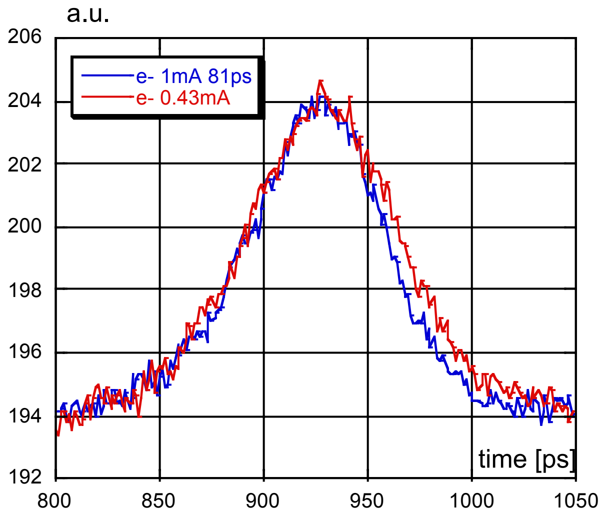

Figure 2 – Electron rms bunch length (in ps) at 0.43 and 1 mA/bunch (V_{RF}=165 kV)

The computed rms bunch length, in ps, is plotted in Fig. 3 as a function of the bunch current. It is evident from the measurements that, as predicted by theory, for bunch currents below 4 mA, before reaching the microwave instability threshold, the bunch actually shortens with respect to its design (zero current) value.

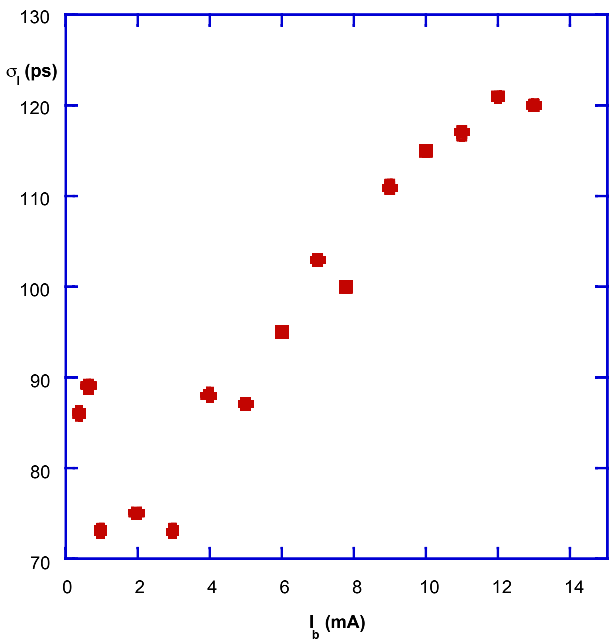

Figure 3 – Electron rms bunch length (in ps) vs bunch current (V_{RF}=165 kV)

Finally, a comparison between measured rms bunch length for positive and negative α_c is plotted in Fig. 4. The gain in bunch lengthening for the negative α_c lattice with respect to the positive one is striking (about 40 %).

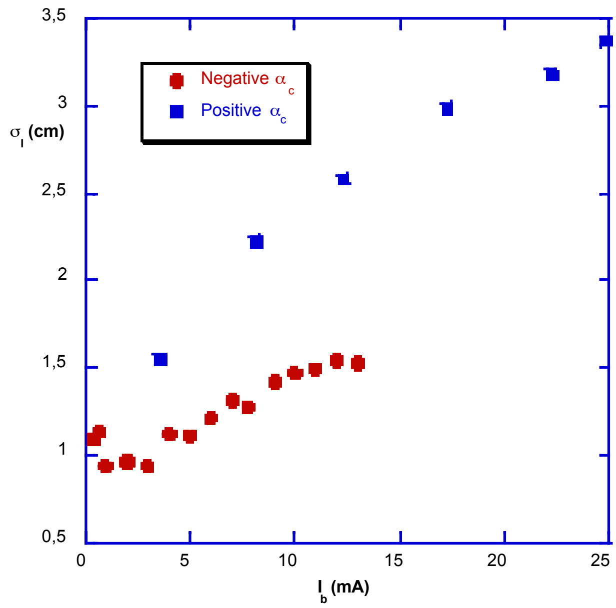

Figure 4 – Comparison of electron rms bunch length for $\alpha_c > 0$ and $\alpha_c < 0$ (V_{RF}=165 kV)

3. Electron ring dispersion measurement for negative α_c lattice

The dispersion function was measured as usual by recording the beam orbit at different RF frequency values. The computed horizontal dispersion is plotted in Fig. 5 (red line) as compared to the model one (blue line) for +10 kHz RF frequency displacement. The measurement shows that small adjustments to the model should be performed.

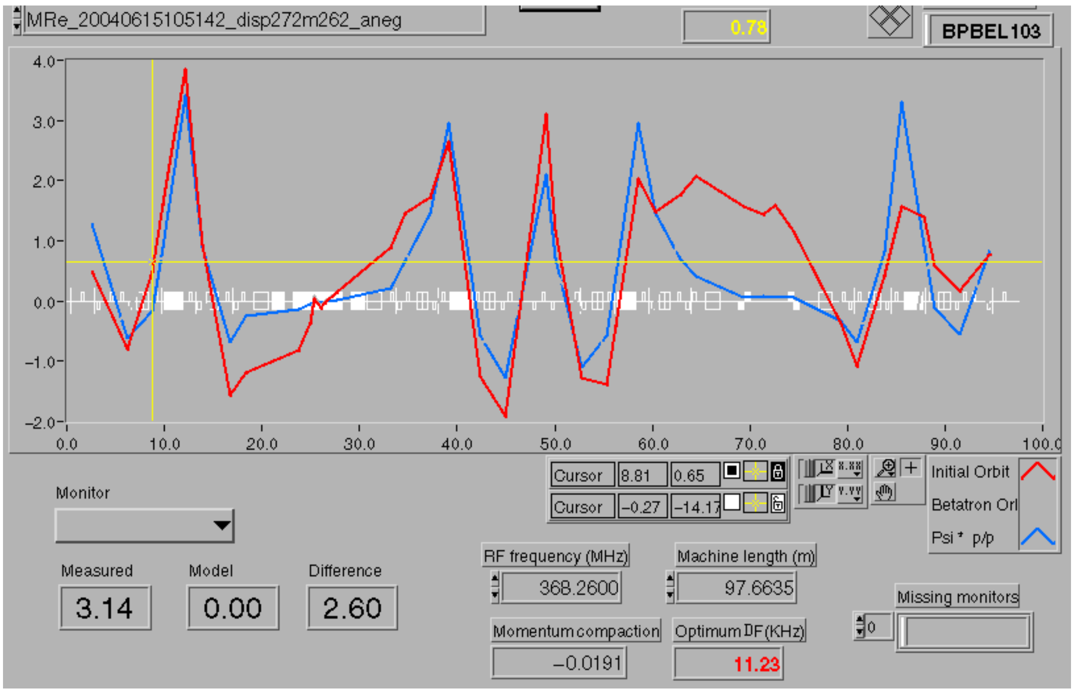

Figure 5 – Comparison of measured and model horizontal dispersion function in the e- ring

4. Positron ring bunch length measurement for negative α_c lattice

The bunch length in the positron ring was unfortunately measured, for lack of time, at a RF voltage of 120 kV only. The bunch profiles at different bunch currents are shown in Fig. 6. The profiles are asymmetric as for the electron beam.

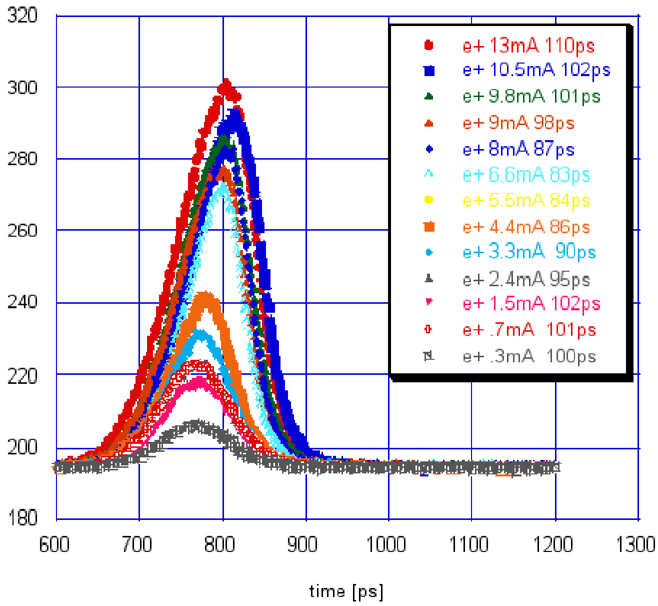

Figure 6 – Positron bunch profile at different bunch currents

A comparison between the previously measured bunch length for positive α_c at 110 kV, with the standard KLOE lattice, and for negative α_c at 120 kV, is reported in Fig. 7. As observed for the electron beam there is a net gain in bunch lengthening at our normal running current of 10 mA/bunch, and a bunch shortening with respect to the zero current bunch length, as predicted by theory, is observed for low bunch currents. This "threshold" is higher (10 mA) with respect to the electron ring, being the positron ring impedance smaller.

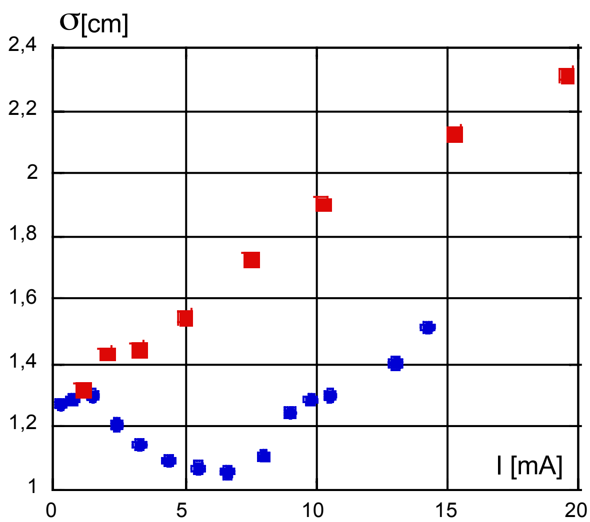

Figure 7 – Comparison of positron bunch length (in cm) for $\alpha_c > 0$ (V_{RF} =110 kV, red squares) and $\alpha_c < 0$ (V_{RF} =120 kV, blue dots)

5. Positron ring dispersion measurement for negative α_c lattice

For the positron ring the agreement between model and actual lattice was much better than for the electron ring. The measured dispersion function was very close to the theoretical one, as can be seen from Fig. 8.

The measured synchrotron frequency was f_s = 33.2 kHz at 167 kV and 28.8 kHz at 120.6 kV, yielding a momentum compaction value between -0.0187 and -0.0195.

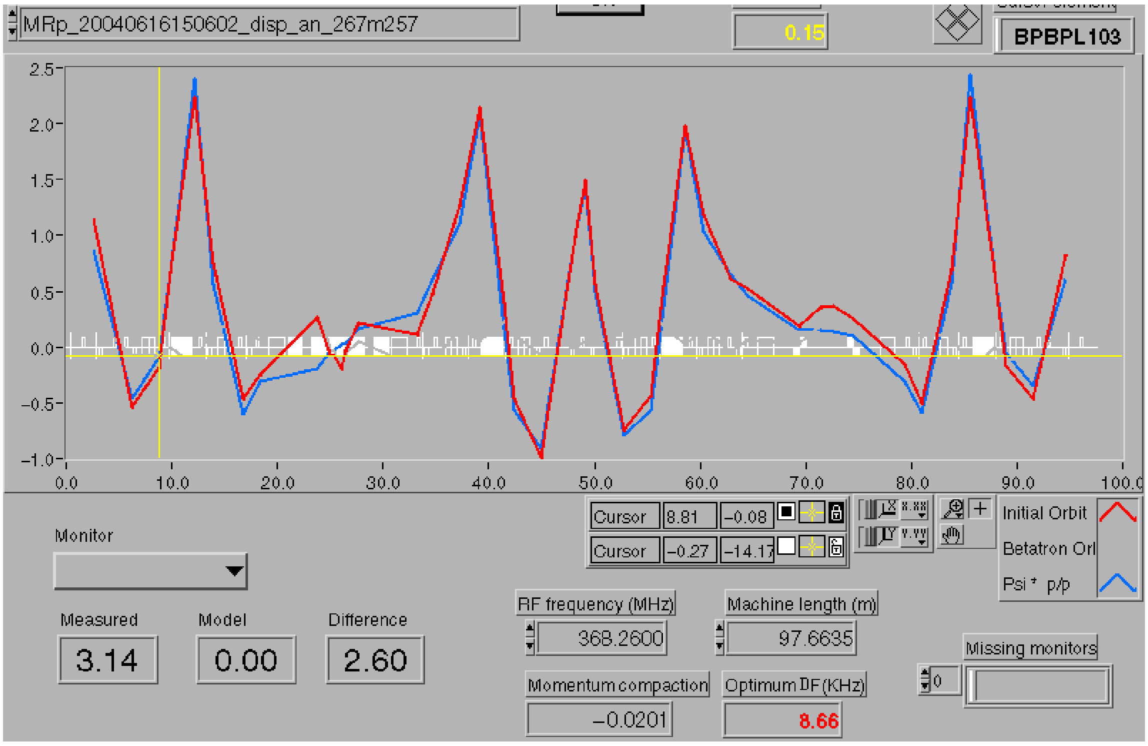

Figure 8 – Comparison of measured and model horizontal dispersion function in the e^+ ring

6. Standard KLOE lattice measurements (positive α_c)

Measurements of the electron ring bunch length at different RF voltages and of betatron functions in the electron ring were also performed.

6.1 Electron ring bunch length measurement

The bunch length was measured at two different RF voltages to check the possibility of working with shorter bunch length at higher RF voltage. Two different bunch length measurements are plotted in Fig. 9 as a function of the bunch current: one with 165 kV (blue squares, measurements taken on June 11) and one with 220 kV (red dots, measurements taken on June 14, with 100 bunches).

There is a net decrease in bunch lengthening for our working bunch current. These results led to the measurements described in the following section.

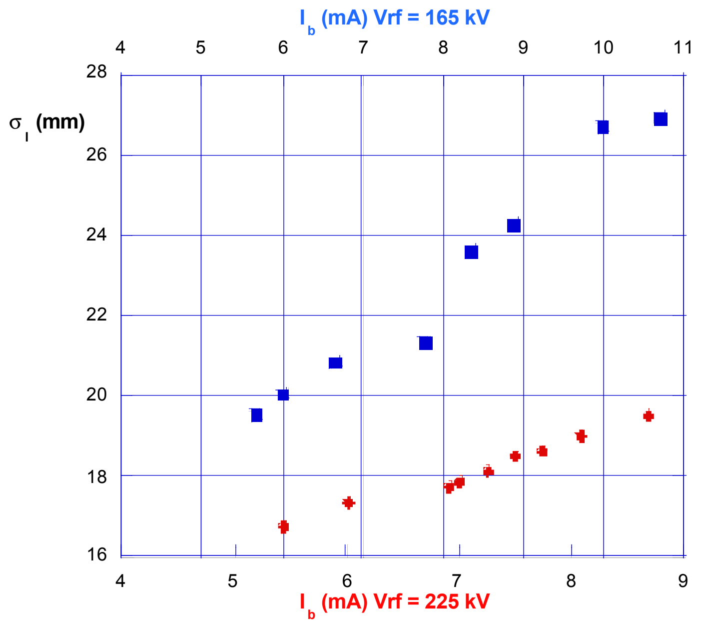

Figure 9 – Electron bunch length vs bunch current(red: 225 kV, blue: 165 kV)

6.2 Electron ring beam sizes measurement at higher RF voltage

Since with higher RF voltage the observed bunch lengthening is shorter, thus decreasing the luminosity reduction due to the hourglass effect, beam sizes measurements in single beam for different RF voltages were performed.

The RF voltage was changed while recording the beam sizes at the Synchrotron Light Monitors and the beam lifetime, starting at 900 mA with tune settings: frac(ν_x) = 0.1013, frac(ν_y) = 0.1778. Unfortunately the beam showed an increase of its transverse beam sizes for higher RF voltage leading presumably to a loss in luminosity when colliding. For completeness this measurement is documented in the following Table and in Fig. 10.

Table I

V_{RF} (kV)	I (mA)	σ_x (mm)	σ_y (mm)	τ (sec)	Notes
168	895	1.20	0.21	3040	
178	890	1.25	0.21	3100	
188	850	1.29	0.21	2500	Starts to die
198	832	1.25	0.22	2950	Starts to die
208	825	1.25	0.21	3000	
218	816	1.24	0.21	2900	
168	792	1.25	0.18	2850	
158	780	1.23	0.18	2850	
148	762	1.23	0.20	3200	
138	750	1.25	0.18	3050	
128	750	1.21	0.18	3100	
118	740	1.20	0.17	3100	
108	740	1.20	0.18	3300	
208	703	1.25	0.20	2700	
218	696	1.25	0.20	2650	
168	1009	1.23	0.23	3300	New injection
188	991	1.27	0.23	2700	
148	970	1.13	0.22	3800	

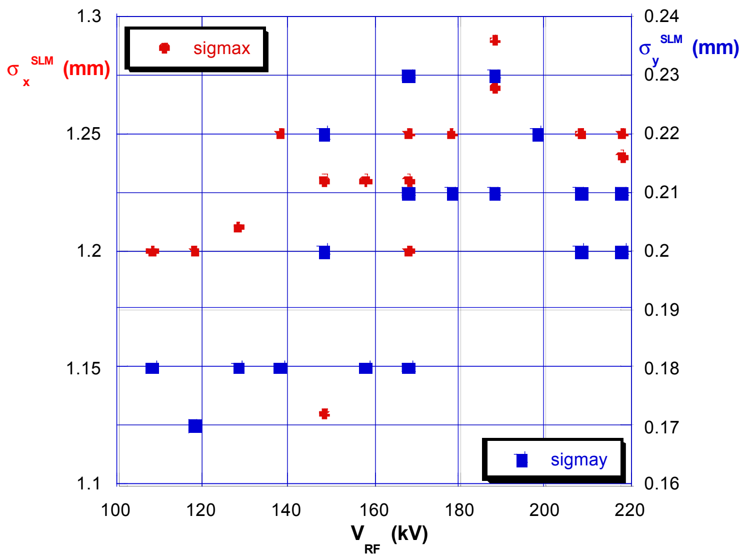

Figure 10 – Electron transverse beam sizes vs RF voltage

6.3 Electron ring betatron functions measurement

To check the model accuracy the betatron functions in the electron ring were measured. The comparison between the model (solid lines) and the measurements (dots) is shown in Fig. 11.

The agreement is excellent, except for the "FINUDA" Interaction Region were the orbit change due to the quadrupole setting changes was not corrected.

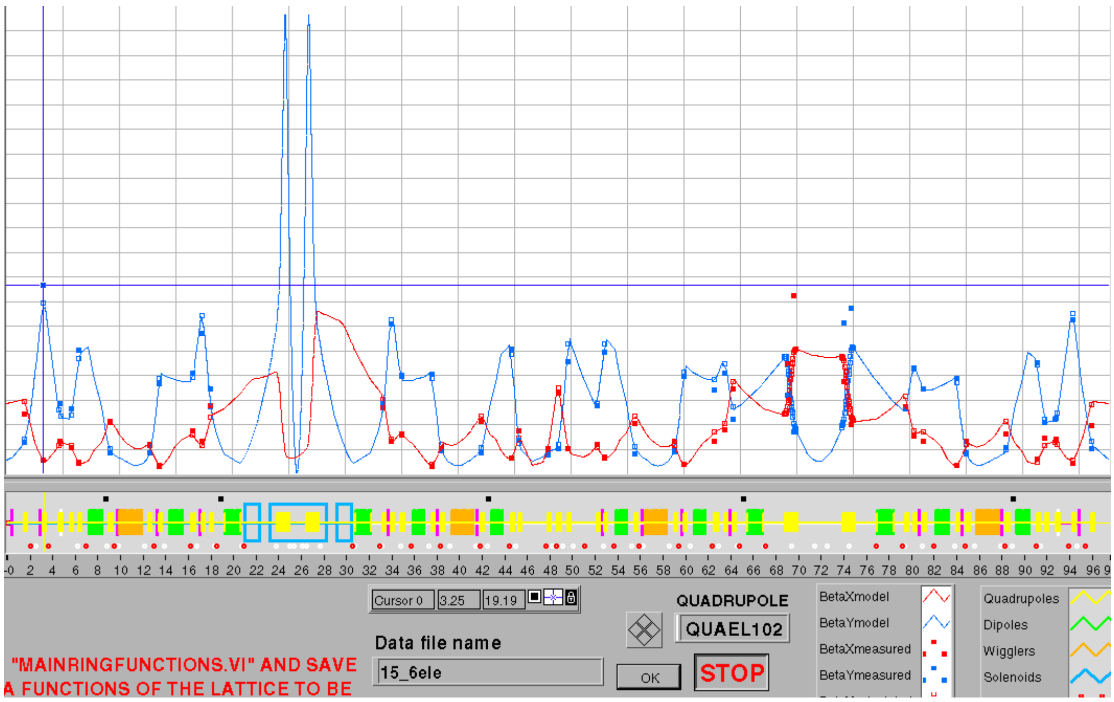

Figure 11 – Comparison of measured and model betatron function in the e- ring (horizontal red, vertical blue)