DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **BM-11**

REPORT ON DAΦNE MD OF 14/01/2004

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1. Introduction

This note summarizes the results obtained in the DAΦNE Machine Development (MD) of 14/01/2004. The measurements have been addressed to:

1) investigate the e^+ current threshold due to the horizontal instability;

1) measure the chromaticity in the e^+ ring in the Single Bunch (SB) mode and in the Multi Bunch (MB) mode;

1) measure the c_{11} coefficient in the e^+ ring as a function of the octupole OCTPL101 and OCTPL202 currents.

2. e^+ current threshold measurements

Presently the current in the e^+ ring is limited by a horizontal instability. The mechanism of this instability and, therefore, the possible causes are not yet well understood. From the phenomenological point of view, in previous measurements, we have observed that the threshold current depends on:

a1) the injection condition;

a2) the bunch pattern;

a3) the RF frequency.

Moreover, for a given injection condition, bunch pattern and RF frequency set, we have observed that:

b1) the growth rate of the instability has a very sharp threshold;

b2) the bunch oscillations are not uniform along the train. In particular, in the case of a gap in the bunch filling pattern (typically we operate with 90/120 bunches), the bunches ahead do not oscillate while the bunches at the tail of the train oscillate strongly.

This phenomenology lets us suspect of a possible "beam-breakup" instability [1] caused by a medium range wake field.
Two possible ways to fight this instability can be addressed:

c1) to find the element(s) in the ring that causes this medium range wake field. This can be done, for example, by measuring the current threshold as a function of localized bumps (horizontal or vertical) in the suspected device(s);

c2) to try varying the machine parameters to increase the current threshold.

The results obtained on the MD of 14/01/2004 are summarized in the following.

2.1 Current threshold as a function of the localized bumps on bellow n.5

The bellow n.5 localized near the Y of IP2 (Fig. 1) from x-rays pictures [2] seems to be damaged.
Localized horizontal and vertical bumps on this device (Fig. 2) have been done to investigate if it is the cause of the beam instability.
The results are summarized in Table I.

Table I: e^+ current threshold as a function of the localized bump in bellow n.5 (90/120 bunches)

		I_{MAX} [mA]
X bump [mm]	+2	600
	+4	570
	+6	570
	-6	600
Y bump [mm]	2	570
	5	570
	-5	540

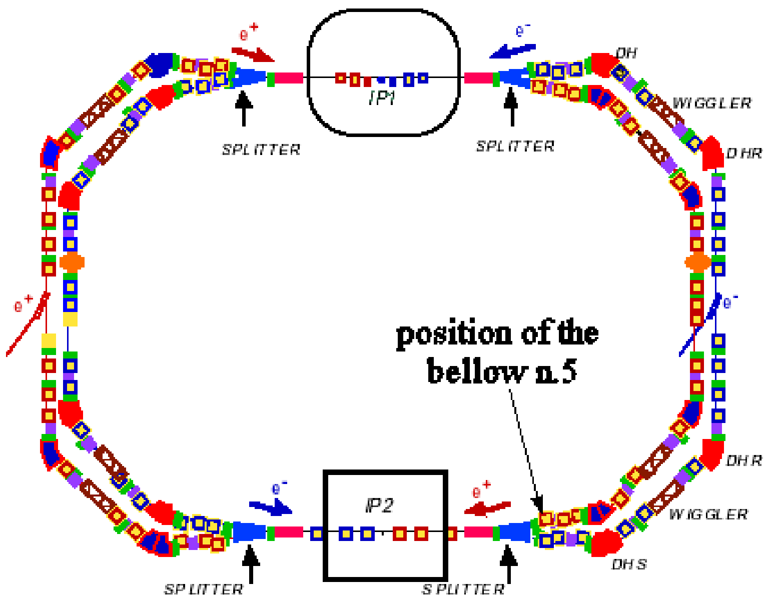

Fig. 1: Position in DAΦNE of the suspected damaged bellow

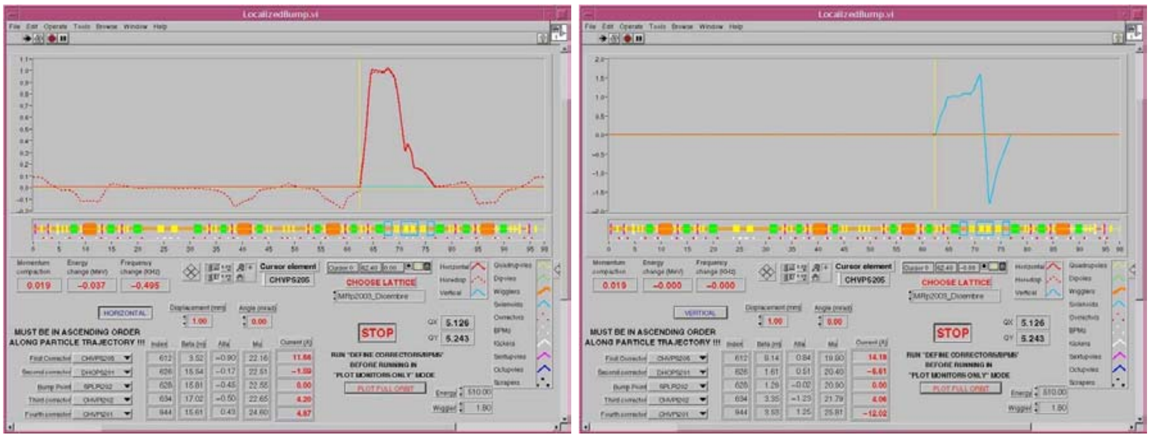

Fig. 2: x and y localized bumps on bellow n.5

2.2 Current threshold as a function of the RF frequency

The current threshold is strongly dependent on RF frequency as observed before in previous measurements. We have repeated this measurement and the results are reported in Table II. The variation of the RF frequency with respect to the nominal one (368.278 MHz) changes both the energy of the beam and the orbit in the machine. The dispersion orbit and the orbit obtained with Δf_{RF}=-10kHz are reported in Fig. 3.

Table II e+ current threshold as a function of Δf_{RF} (90/120 Bunches)

Δf_{RF} [kHz]	I_{MAX} [mA]
-5	720
-10	940
-15	960
+5	700
+10	760

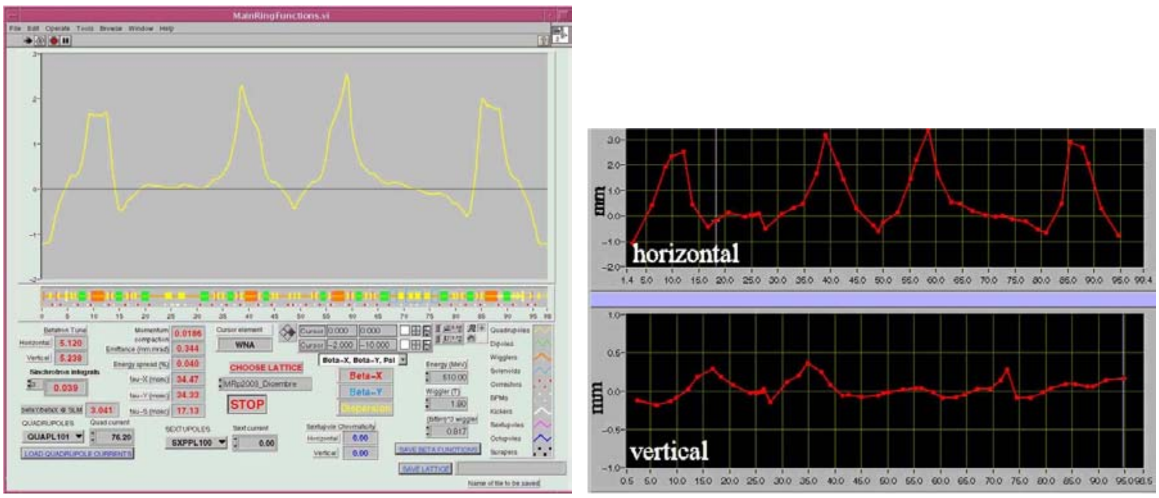

Fig. 3: a) Dispersion of e^+ ring; b) orbit with Δf_{RF}=-10 kHz

The fact that the current threshold changes with f_{RF} can be due orbit in the ring or beam energy variation.

The effect of the energy in the current threshold is not yet clear, while the orbit distortion can have two possible effects:

d1) different magnet non-linearities acting on the beam;

d2) different beam position in element(s) that causes the horizontal instability.

To investigate separately the two effects we have done the following measurements:

e1) c_{11} measurements as a function of Δf_{RF}.. The results, plotted in Fig. 4, yield c_{11}=-220 at nominal condition and with Δf_{RF}=-10kHz it does not change.

e2) at the unperturbed f_{RF} we have reproduced the orbit obtained with Δf_{RF}=-10kHz by means of horizontal dipole correctors. It is important to remark that, in this case, there is a variation of the beam energy. The measure has shown that, in this case, the current threshold is 800 mA.

2.3 Chromaticity measurements in SB and MB regime and current threshold as a function of the sextupole PS203 current

A further measurement as been done to measure the variation of the chromaticity in the e^+ ring in the Single Bunch (SB) mode and in the Multi Bunch (MB) mode. The results are plotted in Fig. 5.
The current threshold as a function of sextupole PS203 current has been also measured. From simulation this sextupole seems to strongly affect a non linear sextupole resonance. The result is reported in Table IV.

Table IV: e+ current threshold as a function of the sextupole PS203 current (90/120 Bunches)

I_{SEXT} [A]	I_{MAX} [mA]
55	600
75	570

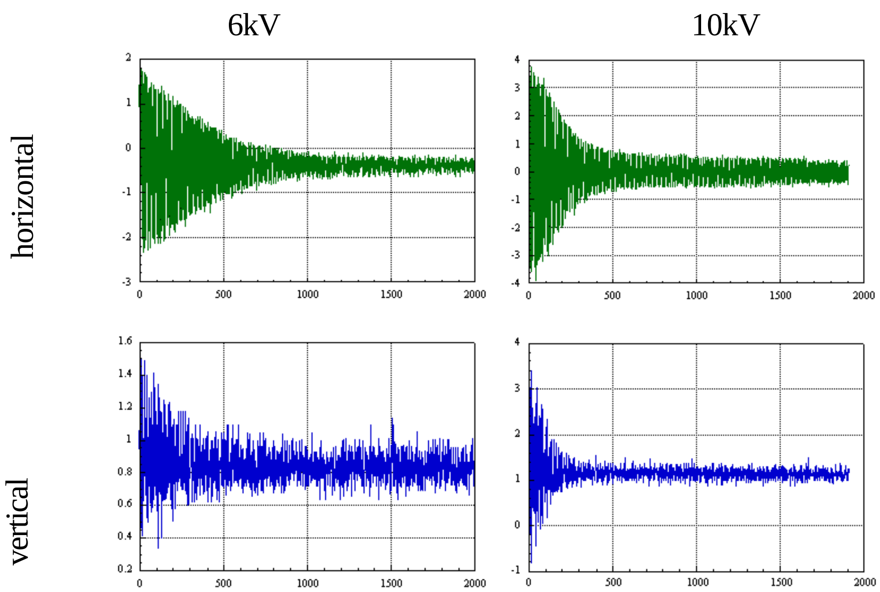

Fig. 4: horizontal bunch oscillations amplitudes as a function of the number of turn for an horizonthal kick of 6 kV and 10 kV @ nominal condition.
The result obtained with Δf_{RF}.=-10 kHz is the same.

a b

c

Fig. 5: Chromaticity measurement result in SB mode and MB mode: a) SB 10 mA; b) MB 200mA; c) MB 630 mA.

2.4 Other current threshold measurements

We have also measured the current threshold:

- f1) with all scrapers out and 90/120 bunches: the threshold is 570 mA;
- f2) with 45/120 bunches: the threshold is 500 mA;
- f3) with 30/120 bunches + 30/120 bunches with a gap of 30/120 bunches: the threshold is 570 mA;

3. c_{11} measurements as a function of octupoles PL101 and PL201 current

We have measured the beam decoherence varying the octupoles strength in order:

- g1) to understand their strong influence on the lifetime in beam-beam collisions;
- g2) to define their sign and contribution in c_{11}.

The tracked horizontal oscillations as a function of octupoles PL101 and PL201 currents are reported in Fig. 6.
The obtained c_{11} are summarized in Table V.

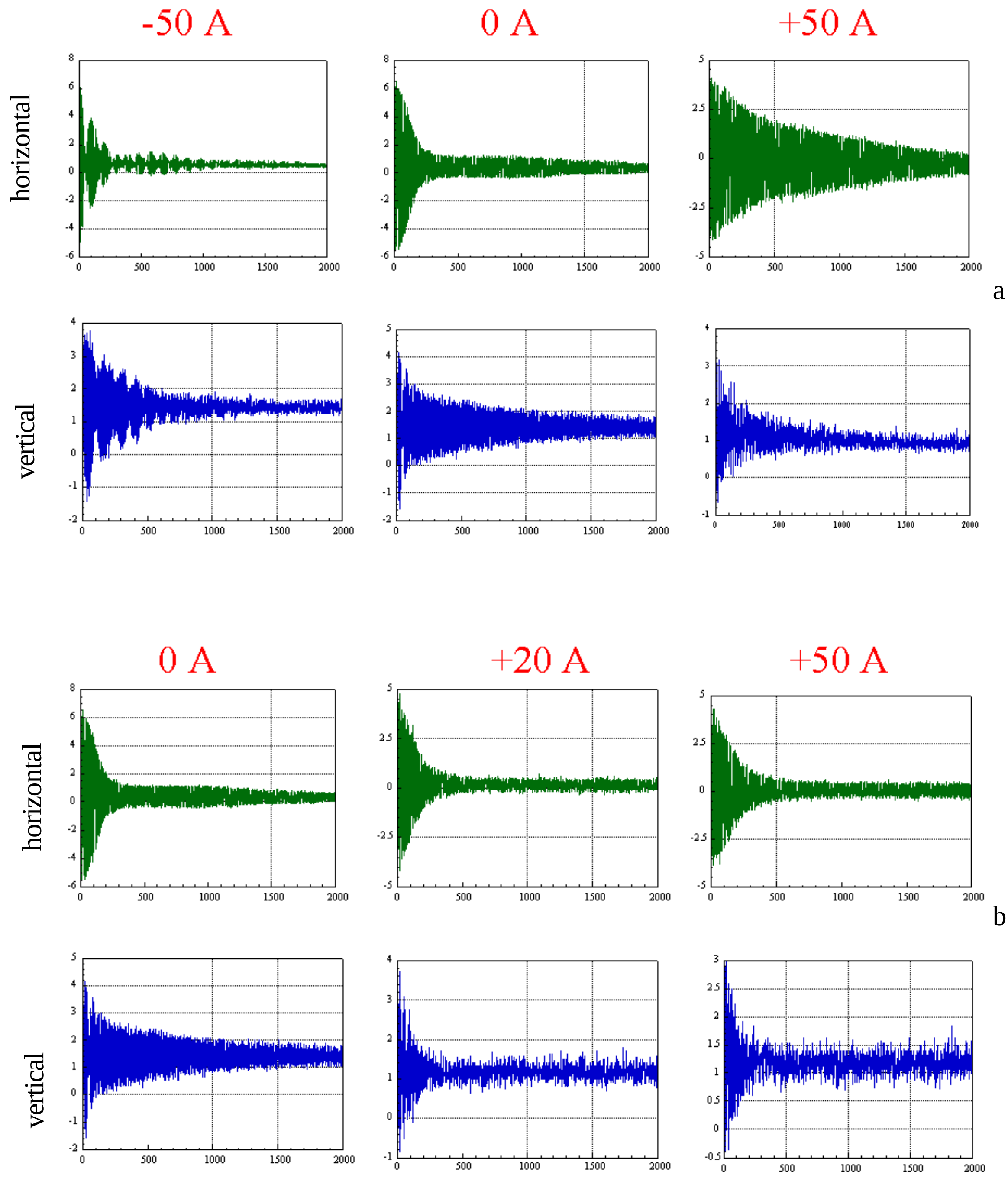

Fig. 6: Tracked horizontal oscillations as a function of the octupole PL 101(a) and PL 201(b) currents

Table V: c11 measurements as a function of the octupoles PL101 and PL202 currents

File	V [kV]	I [mA]	PL101 [A]	PL201 [A]	Δf [kHz]	Δx [mm]	Turns	ΔQx	C11	comments
160338	6	1	21	0	0	1.7125	545	0.11229	-221	Good fit
160108	8	1	21	0	0	2.6909	392	0.11178	-195	
155948	10	1	21	0	0	3.4300	271	0.11066	-221	Long trace
155618	10	1	21	0	0	3.4243	272	0.11069	-221	Short trace
160956	4	0.95	21	0	-10	0.7019	698	0.11256	-420	$\Delta x \sim \sigma x$
160556	6	1	21	0	-10	1.7344	551	0.11231	-215	Good fit
160722	8	0.97	21	0	-10	2.6824	394	0.11173	-195	
160838	10	0.95	21	0	-10	3.392	275	0.11069	-221	
161133	12	0.95	21	0	-10	3.8701	188	0.1091	-283	Bad fit
164012	10	1.32	-100	0	0	5.5115	46	0.08947	-812	Before resonance
161731	10	0.53	0	0	0	3.7771	171	0.1080	-318	After resonance
155618	10	1	21	0	0	2.6064	272	0.11069	-221	
161452	10	0.8	50	0	0	2.9200	1071	0.11330	-66	
161731	10	0.53	0	0	0	3.7771	171	0.1080	-318	
161934	10	0.53	0	20	0	3.7154	187	0.1097	-296	
162051	10	0.53	0	50	0	3.5788	244	0.11063	-236	

4. Conclusions

1) Concerning the e^+ current threshold, it seems that the change of f_{RF} increases the threshold because of the change of the orbit in the machine. Moreover changing the orbit in the suspected bellow does not change the scenario.
2) Concerning the c_{11} measurements:
   a) positron ring cubic nonlinearity c_{11} = -220 is at a limit of the acceptable range;
   b) changing the RF frequency by –10 kHz does not change the beam decoherence. If it were so the positron instability threshold variation could be explained only by the impedance change due to the dispersive orbit.
   c) the octupole PL101 changes substantially c_{11}. The decoherence dependence on the octupole strength is magnified by the fact that the present working point is close to the resonance 2Qx =Qy. This explains the strong influence of the octupole on the beam-beam lifetime.
   d) The octupole PL201 does not change much the horizontal decoherence, but may be useful to correct the vertical nonlinearity, intoduced by the octupole PL101 (the sign of PL201 has to be changed for this purpose).

References

[1] R. L. Gluckstern et al, Phys. Rev. E, Vol. 52, p. 1026, 1995.

[2] A. Clozza, private communications.