stacking simulations for e+ Compton source - update 1

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Thanks to: Alessandro Vivoli, Tsunehiko Omori, Robert Chehab, Vitaly Yakimenko

10 March 2008

last meeting (ILC case):

76% of injected e+ are lost!
for a single cycle: 35% loss

addressing the comment by Vitaly

final ilc vertical normalized emittance is 0.017 micron rad;
initial rms emittance is 6 mm rad;
minimum store time follows from
0.017*exp(2 t/t_damp) micron rad=6000 micron rad
→ store time = 6.4 transverse damping time

how could we improve the situation?

remedies:

- ❑ smaller momentum compaction factor
- ❑ reduced synchrotron tune
- ❑ larger interval between cycles

  (but already too short for complete vertical damping – Vitaly Yakimenko)

…

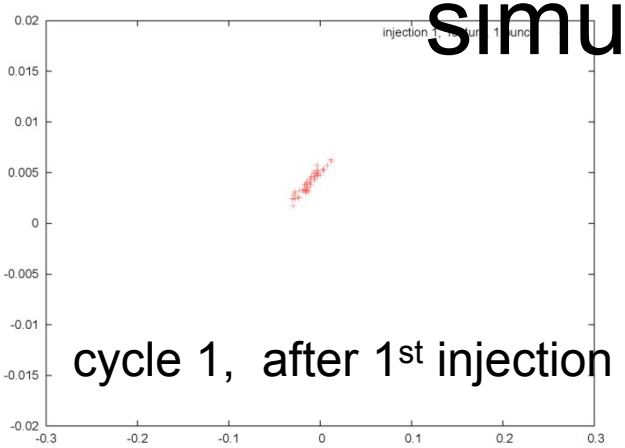
I am now trying

- ✓ energy pre-compression [x3] (R. Chehab)
- ✓ additional DR wigglers for faster damping [x2]
- ✓ larger rf voltage [x 1.5]

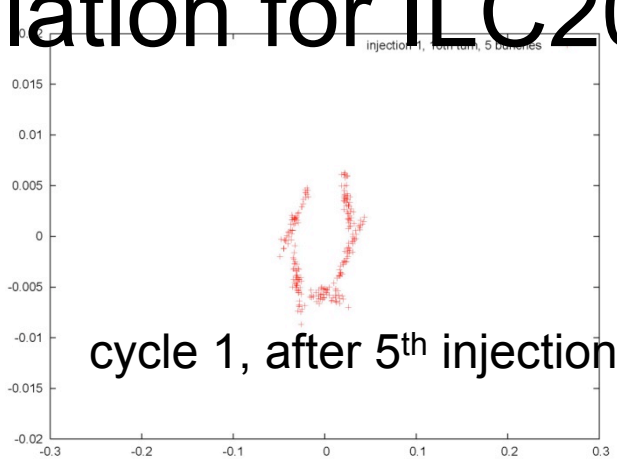
2	ILC-DR Snowmass '05 proposal	ILC 2008 – **Compton version**	pre-DR for CLIC (NLC 2004 design)	pre-DR for CLIC with higher Vrf
beam energy	5 GeV	5 GeV	1.98 GeV	1.98 GeV
circumference	3223 m	6695 m	230.93	230.93
particles per extracted bunch	2.4×10^{10}	2.0×10^{10}	4.0×10^{9}	4.0×10^{9}
rf frequency	650 MHz	650 MHz	2 GHz	2 GHz
harmonic number	6983	14516	1540	1540
no. trains stored in the ring	10 (10/pulse)	52.5 (52.5/pulse)	4 (1/pulse)	4 (1/pulse)
#bunches/train	280	50	312	312
bunch spacing	4.202 ns	6.15 ns	0.5 ns	0.5 ns
gap between trains	80 (336 ns)	~50 ns	73 (36.5 ns)	73 (36.5 ns)
#e+ / injection	2.4×10^{8}	6.65×10^{7}	6.65×10^{7}	6.65×10^{7}
#turns between injections in 1 bucket	1	2	40	40
injections/bucket per cycle	10	30	3	6
injection frequency	~240 MHz	80 MHz	~50 MHz	~50 MHz
full cycle length	200 ms	200 ms	80 ms	80 ms
time between injection periods	10 ms	10 ms	1.9 ms	3.8 ms
#turns between cycles	930	450	2470	4935
length of one injection period	0.107 ms	0.963 ms	0.046 ms	0.092 ms
TI=total # injections/bucket	100	300	60	60
ST=store time after last injection	110 ms	110 ms	42 ms	42 ms
IP=time interval with injection periods	90 ms	90 ms	38 ms	38 ms
energy loss/turn	5.5 MeV	**8.7x2 MeV**	0.803 MeV	0.803 MeV
longitudinal damping time $\tau_{\|\|}$	10 ms	**6.4 ms**	2 ms	2 ms

	ILC-DR Snowmass '05 proposal	ILC 2008-**Compton version**	pre-DR for CLIC (NLC 2004 design)	pre-DR for CLIC with higher Vrf
transv. normalized edge emittance at injection (10x rms)	0.05 rad-m	0.063 rad-m	0.063 rad-m	0.063 rad-m
transv. normalized dynamic aperture (Ax+Ay)gamma	>>0.05 rad-m?	0.4 rad-m	0.2 rad-m	0.2 rad-m?
rms bunch length at injection	3 mm	**11.4 mm**	3.8 mm	3.8 mm
rms energy spread at injection	0.14%	**0.04%**	0.28%	0.28%
final rms bunch length	6 mm	**5.2 mm**	5.12 mm	1.62 mm
final rms energy spread	0.14%	**0.091 %**	0.089%	0.089%
longit. "edge" emittance at inj.	0.7 meV-s	0.72 meV-s	0.72 meV-s	0.72 meV-s
rf voltage	20 MV	**36 MV**	1.72 MV	17.2 MV
momentum compaction	3×10^{-4}	4.2×10^{-4}	1.69×10^{-3}	1.69×10^{-3}
2nd order momentum compaction	1.3×10^{-3}	-	-	-
synchrotron tune	0.0356	**0.084**	0.0188	0.0596
bucket area	292 meV-s	**129 meV-s**	10 meV-s	61 meV-s
ICM=bucket area / long. edge emit. /π	133	**57**	4	30
RMIN=TI/ICM	0.75	5	15	2
IP/RMIN/$\tau_{\|\|}$	12	**2.8**	1.3	9.5
IP/RACT/$\tau_{\|\|}$	0.78	**1.56**	0.95	1.9
synchronous phase	15.58°	**28.97°**	26.47°	2.55°
separatrix phases 1&2	164.42 °, -159.19 °	**151.03 °, -82.64 °**	153.53 °, -95.66 °	177.45 °, -140.11 °
max. momentum acceptance	+/-2.7%	+/- 1.6%	+/- 1.0%	+/- 4.4%

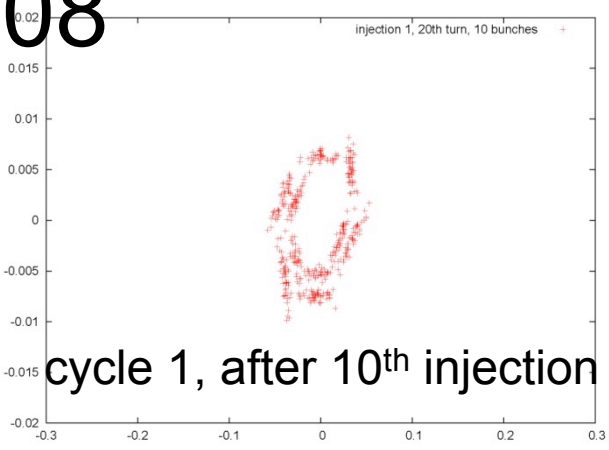
simulation for ILC2008



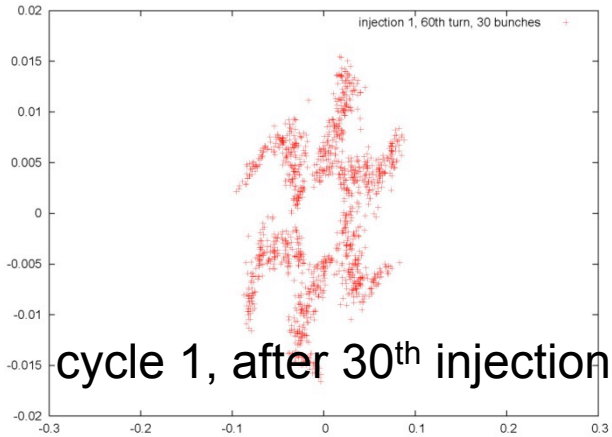
cycle 1, after 1st injection



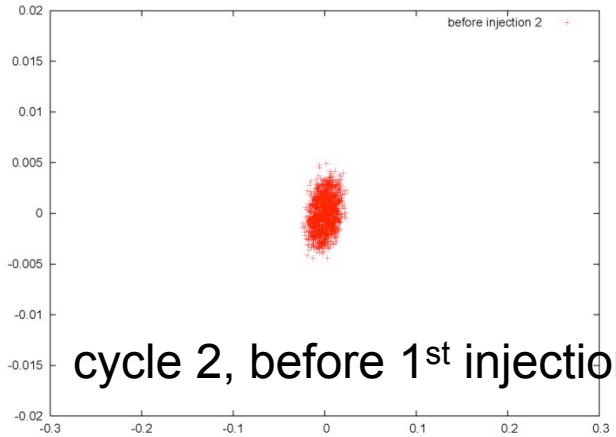
cycle 1, after 5th injection



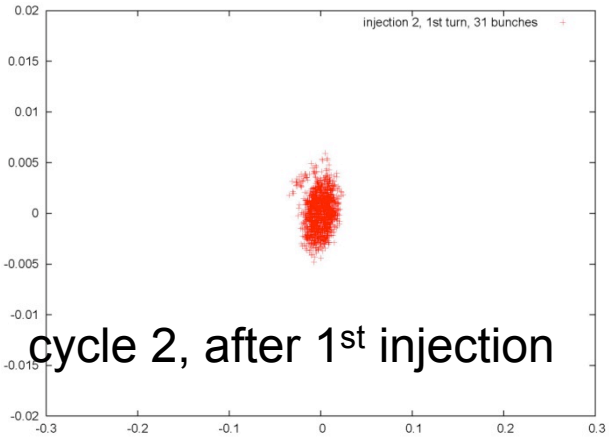
cycle 1, after 10th injection



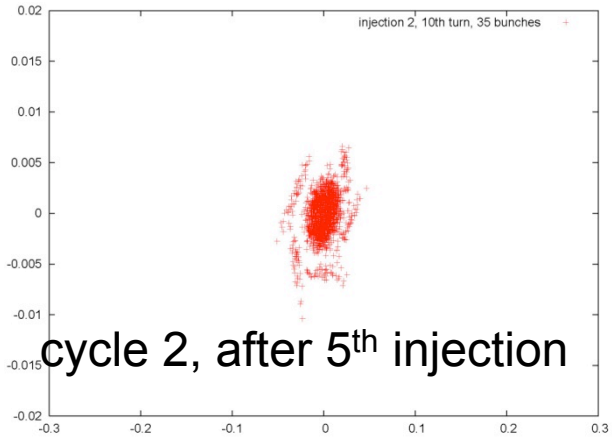
cycle 1, after 30th injection



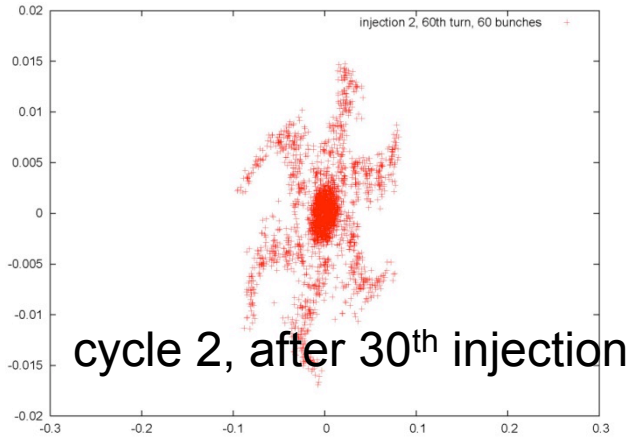
cycle 2, before 1st injection



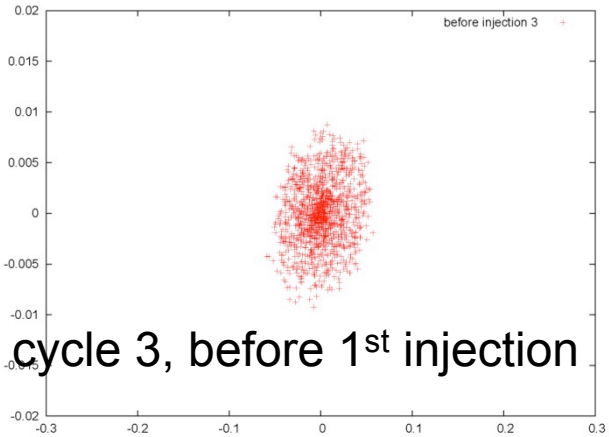
cycle 2, after 1st injection



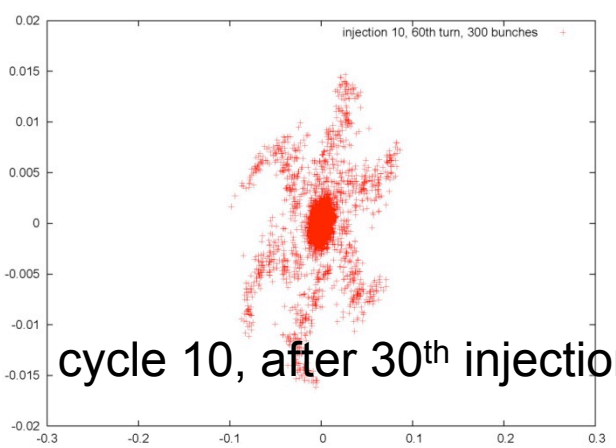
cycle 2, after 5th injection



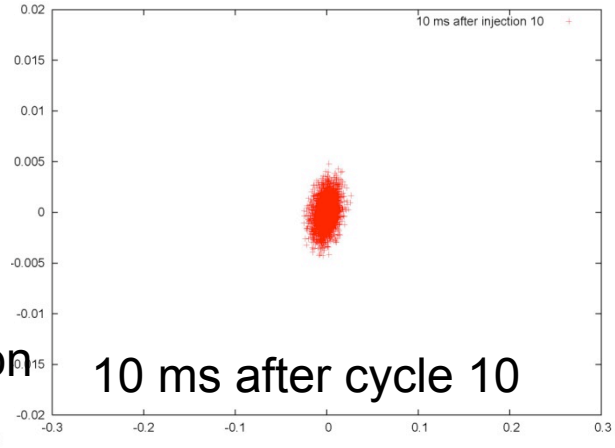
cycle 2, after 30th injection



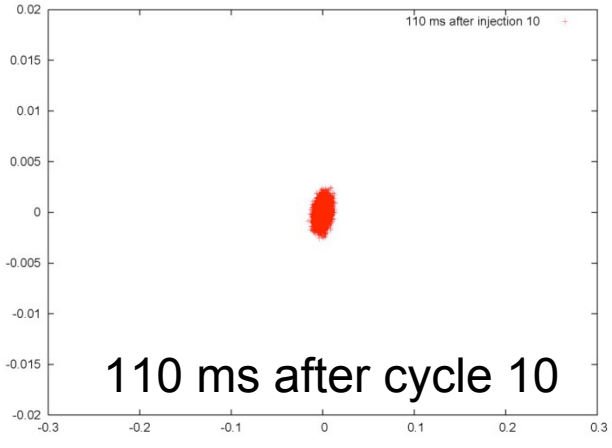
cycle 3, before 1st injection



cycle 10, after 30th injection



10 ms after cycle 10



110 ms after cycle 10

last meeting:

76% of injected e+ are lost!
for a single cycle: 35% loss

this meeting:

only 10.6% of injected e+ are lost!
loss fraction for single cycle similar

questions & comments

- there probably was a previous design of ILC or TESLA damping ring where the damping for e+ was twice stronger than for e-
- 2x3 km ring is option from Andy Wolski; it could reduce the damping times by factor 2, if we do not reduce the length of the wigglers
- ring parameters can be considered somewhat flexible; at present parameters are optimized for the undulator based source
- can we reduce initial energy spread to 2 MeV rms?
- option of pre-damping ring for ILC?