stacking simulations for e+ Compton source

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	ILC-DR Snowmass '05 proposal	ILC 2008	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	8.7 MeV	0.803 MeV	0.803 MeV
longitudinal damping time $\tau_{\|\|}$	10 ms	12.8 ms	2 ms	2 ms

	ILC-DR Snowmass '05 proposal	ILC 2008	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	3.8 mm	3.8 mm	3.8 mm
rms energy spread at injection	0.14%	0.12%	0.28%	0.28%
final rms bunch length	6 mm	9 mm	5.12 mm	1.62 mm
final rms energy spread	0.14%	0.128%	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	24 MV	1.72 MV	17.2 MV
momentum compaction	3×10^{-4}	4.2×10^{-4}	1.69×10^{-3}	1.69×10^{-3}
2^{nd} order momentum compaction	1.3×10^{-3}	-	-	-
synchrotron tune	0.0356	0.067	0.0188	0.0596
bucket area	292 meV-s	150 meV-s	10 meV-s	61 meV-s
ICM=bucket area / long. edge emit. /π	133	66	4	30
RMIN=TI/ICM	0.75	5	15	2
IP/RMIN/$\tau_{\|\|}$	12	1.4	1.3	9.5
IP/RACT/$\tau_{\|\|}$	0.78	0.78	0.95	1.9
synchronous phase	15.58°	21.30°	26.47°	2.55°
separatrix phases 1&2	164.42°, -159.19°	158.70°, -124.19°	153.53°, -95.66°	177.45°, -140.11°
max. momentum acceptance	+/-2.7%	+/- 1.57%	+/- 1.0%	+/- 4.4%

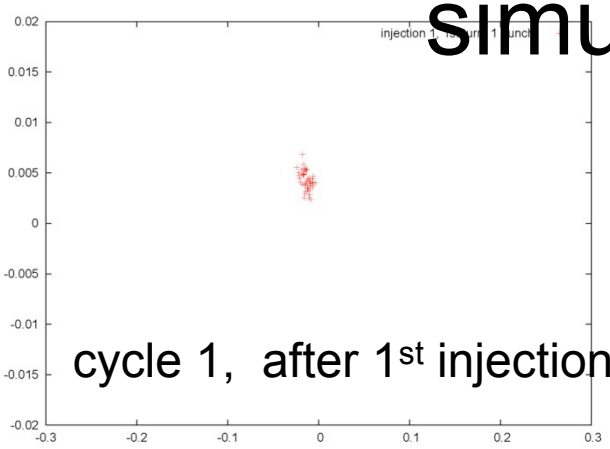
similar assumptions as for Snowmass'05

- stacking in longitudinal phase space
- sinusoidal rf, momentum compaction, radiation damping and quantum excitation
- injection septum placed at location with large dispersion; septum blade << transverse beam size
- between successive injections orbit at the septum is varied with fast bumper magnets
- energy of injected beam is ramped such that the transverse position of the septum always corresponds to a separation of 2 $\sigma_{\delta 0}$ from beam centroid of injected beam

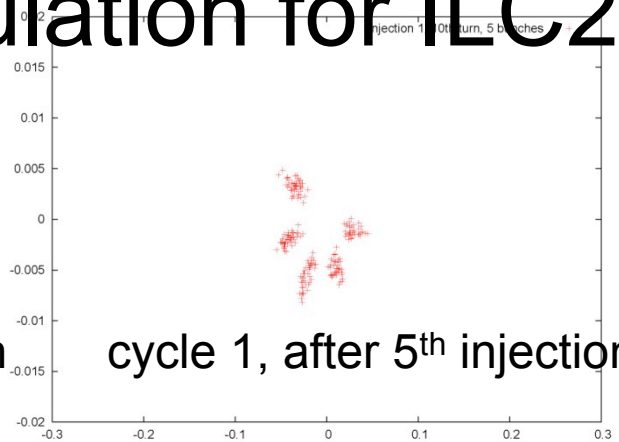
proposed injection scheme

- ILC 2008: inject every second turn (80 MHz ERL) into the same bucket - 30 times; then wait 10 ms (~450 turns, ~1 damping time) and repeat 9 times; total injections/bucket: 300; synchrotron phase advance between two injections: 0.134
- CLIC 2008: inject every 40^{th} turn (50 MHz ERL) into the same bucket - 6 times; then wait 3.8 ms (~4900 turns, ~2 damping times) and repeat 9 times; total injections/bucket: 60; synchrotron phase advance between two injections: 2.384

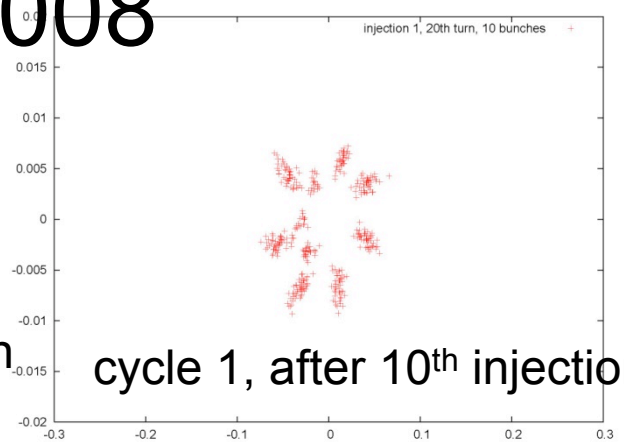
simulation for ILC2008



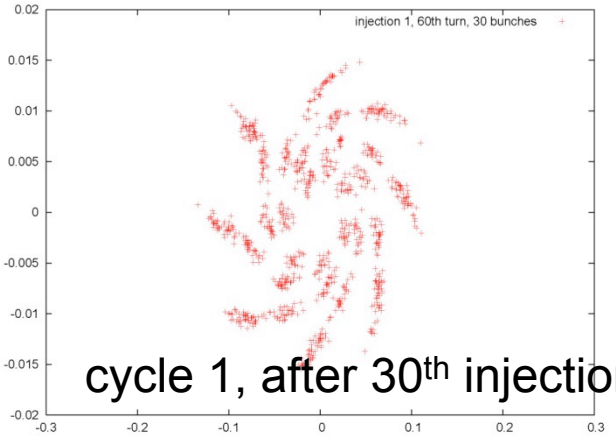
cycle 1, after 1st injection



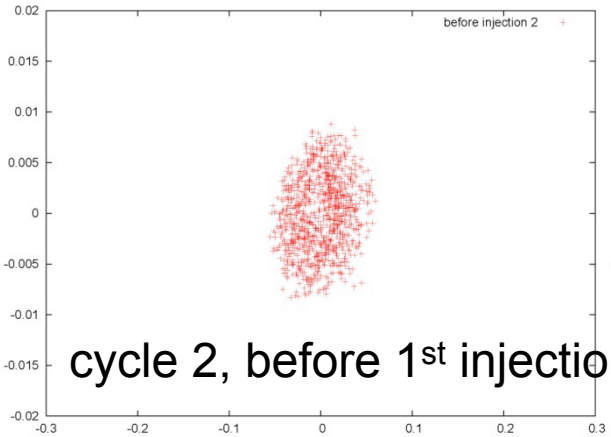
cycle 1, after 5th injection



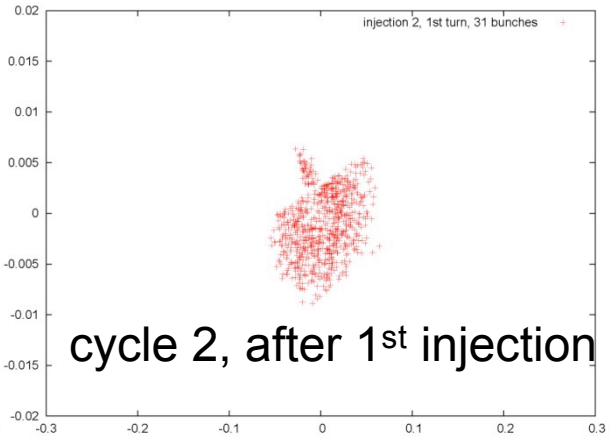
cycle 1, after 10th injection



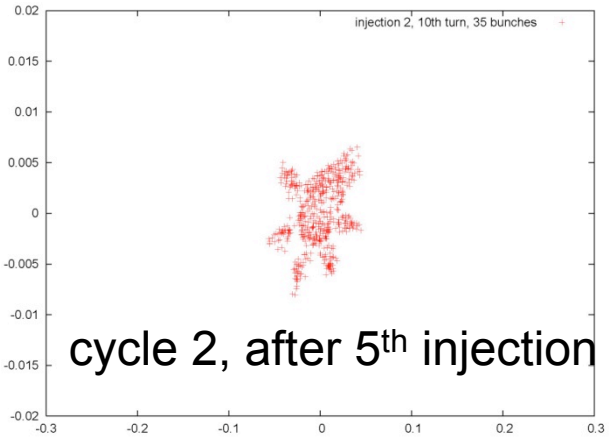
cycle 1, after 30th injection



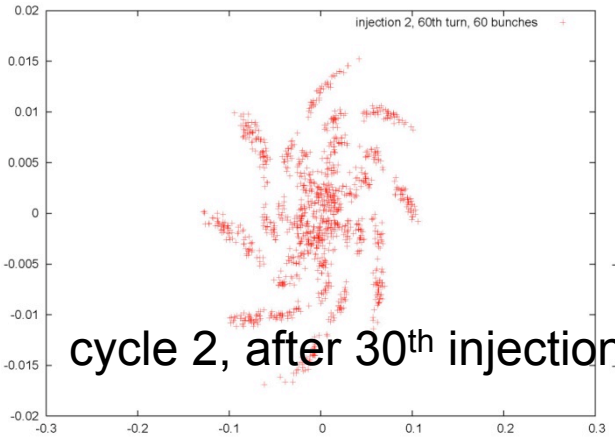
cycle 2, before 1st injectio



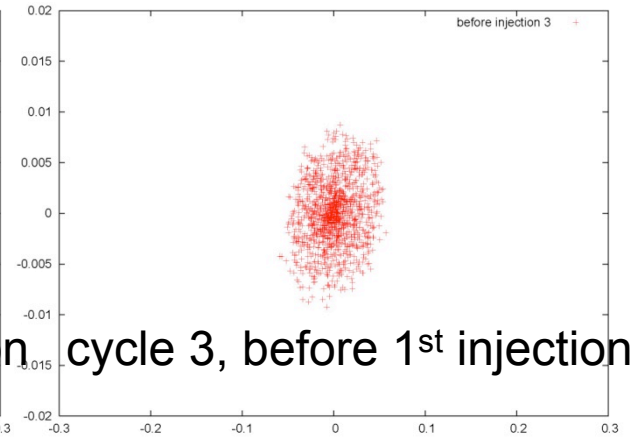
cycle 2, after 1st injection



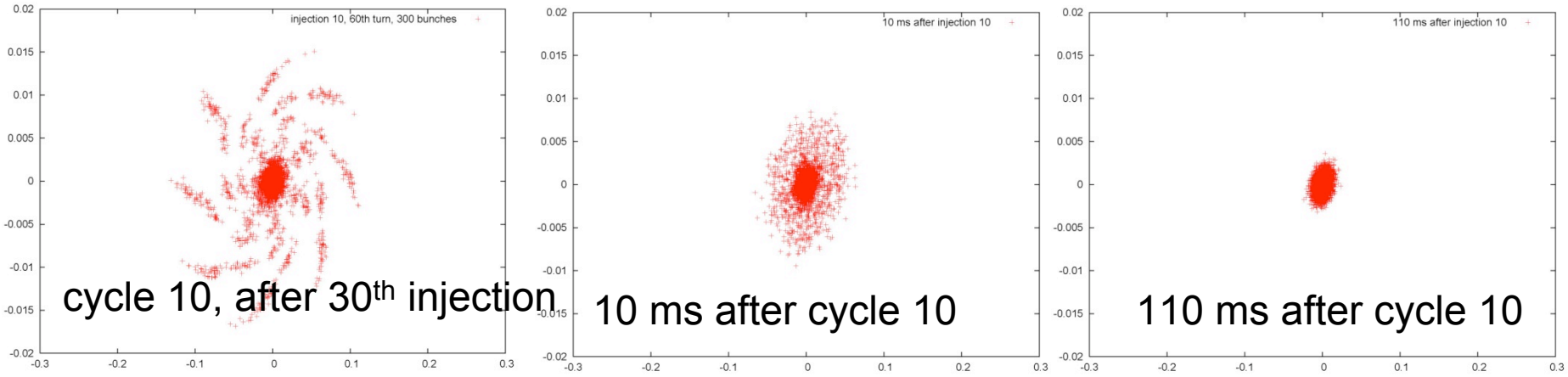
cycle 2, after 5th injection



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

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

why is it worse than in 2005?

- less e+ per injected bunch → more injections
- less momentum acceptance of damping ring
- larger damping time

possible remedies:

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