CLIC Parameter working group

Update of Damping Ring parameters

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Original damping ring parameters

- Latest official parameters date back to 2005 (CLIC note 627)
- Further changes made during 2006, when considering super-conducting wigglers (optics optimisation, coupling correction)
- The strategy followed presently is to check the impact of the new parameters to the rings without re-optimising the optics

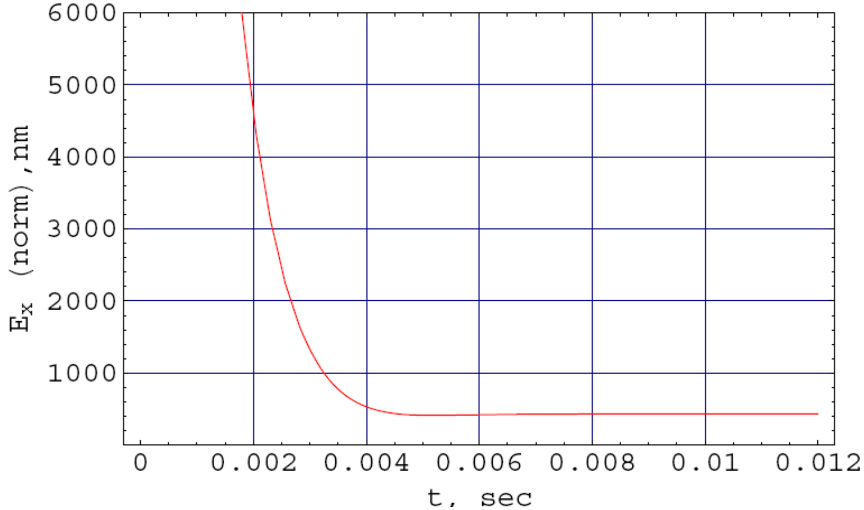
PARAMETER	2005	2006
energy [GeV]	2.424	2.424
circumference [m]	360	365.2
bunch population	2.56E+09	2.56E+09
bunch spacing [ns]	0.533	0.533
number of bunches/train	110	110
number of trains	4	4
store time/train [ms]	13.3	13.3
rms bunch length [mm]	1.547	1.51
rms momentum spread [%]	0.126	0.136
hor. normalised emittance [nm]	540	380
ver. normalised emittance [nm]	3.4	2.4
lon. normalised emittance [eV m]	4725	5000
coupling [%]	0.6	0.6
arc beam pipe radius [cm]	2	2
no. of arc bends	96	96
arc dipole field [T]	0.932	0.932
arc dipole length [m]	0.545	0.545
number of wigglers	76	76
wiggler field [T]	1.7	2.5
wiggler length [m]	2	2
wiggler period [cm]	10	5
hor.tune	69.82	69.82
ver.tune	34.86	33.8
energy loss/turn [MeV]	2.074	3.903
hor./ver./lon./ damping times [ms]	2.8/2.8/1.4	1.5/1.5/0.75
RF Voltage [MV]	2.39	4.25
number of RF cycles	2	2
repetition rate [Hz]	150	150
RF frequency [GHz]	1.875	1.875

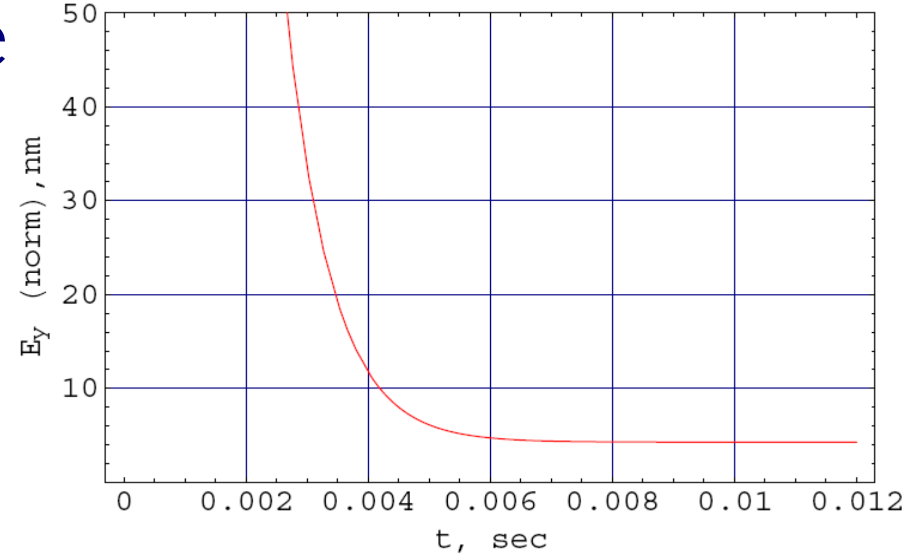
New parameters impact

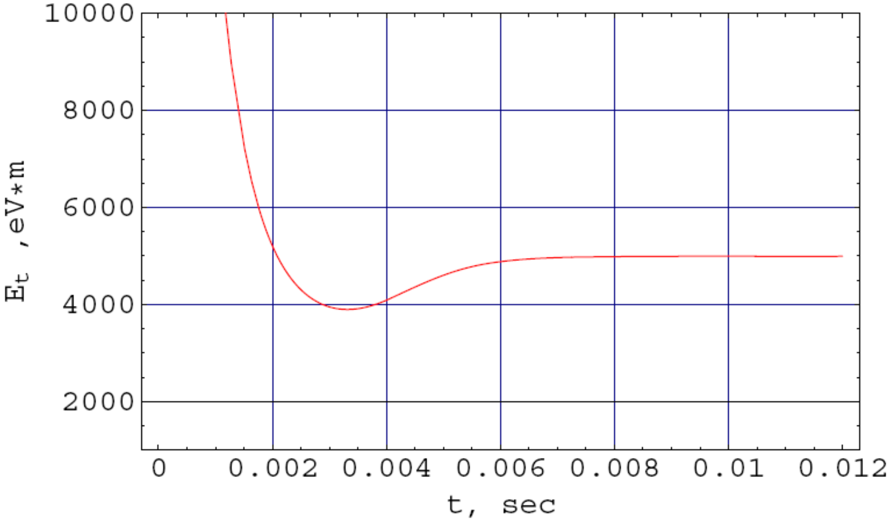
- Main changes:
  - Increased bunch population and bunch spacing (8RF cycles)
  - Number of bunches increase but still fit inside the ring (~1/6th of the circumference)
  - A non-interleaved scheme is considered (1 bunch train/RF cycle)
  - The reduced repetition rate increases the store time
- Longitudinal emittance of 5000eV.m considered (bunch compressor tolerance ?)
- Major impact: Increase in the transverse emittances (especially the vertical)

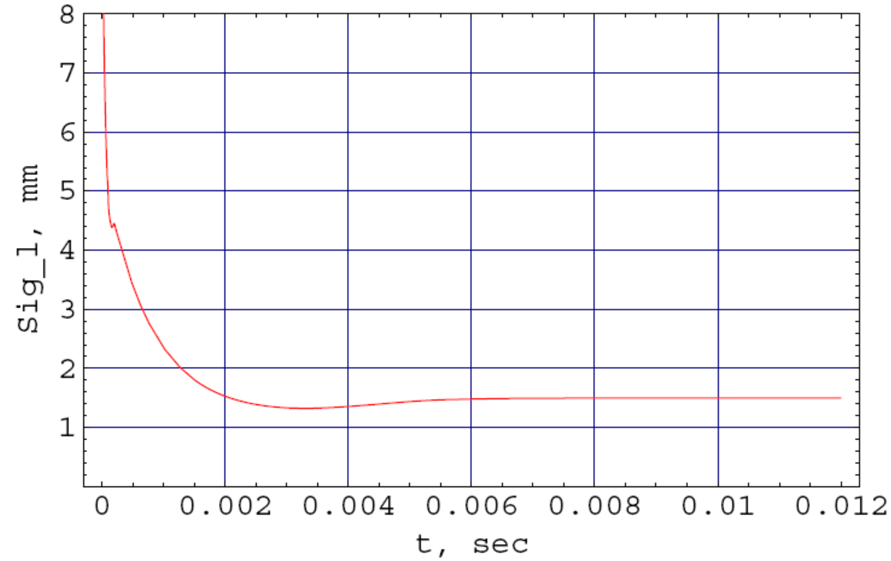
PARAMETER	2005	2006	NEW
energy [GeV]	2.424	2.424	2.424
circumference [m]	360	365.2	365.2
bunch population	2.56E+09	2.56E+09	5.20E+09
bunch spacing [ns]	0.533	0.533	0.667
number of bunches/train	110	110	311
number of trains	4	4	1
store time/train [ms]	13.3	13.3	20
rms bunch length [mm]	1.547	1.51	1.50
rms momentum spread [%]	0.126	0.136	0.137
hor. normalised emittance [nm]	550	380	432
ver. normalised emittance [nm]	3.3	2.4	4.3
lon. normalised emittance [eV m]	4725	5000	4993
coupling [%]	0.6	0.6	0.13
ver. dispersion invariant [um]	0	0	0.248
wiggler field [T]	1.7	2.5	2.5
wiggler period [cm]	10	5	5
energy loss/turn [MeV]	2.074	3.903	3.903
hor./ver./lon./ damping times [ms]	2.8/2.8/1.4	1.5/1.5/0.75	1.5/1.5/0.75
RF Voltage [MV]	2.39	4.25	4.345
number of RF cycles	2	2	1
repetition rate [Hz]	150	150	50
RF frequency [GHz]	1.875	1.875	1.499

Emittance vs. time



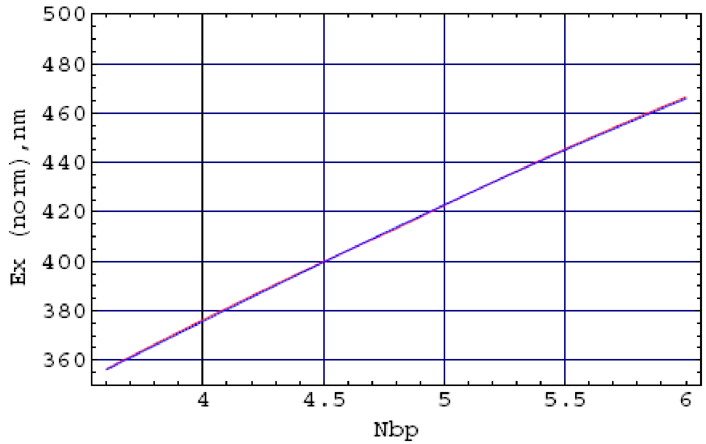


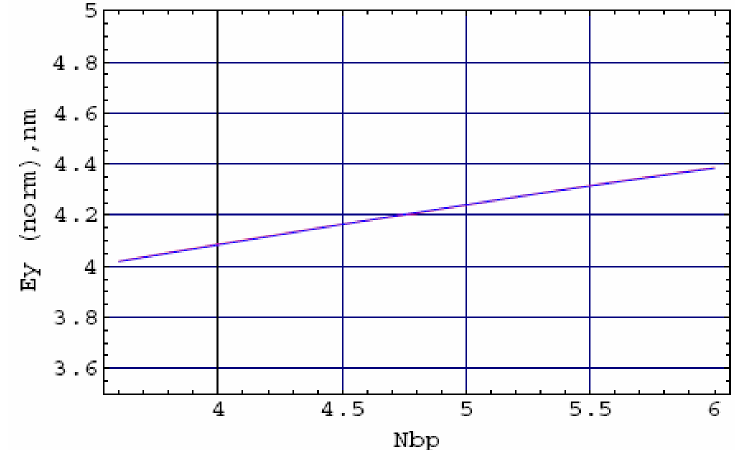


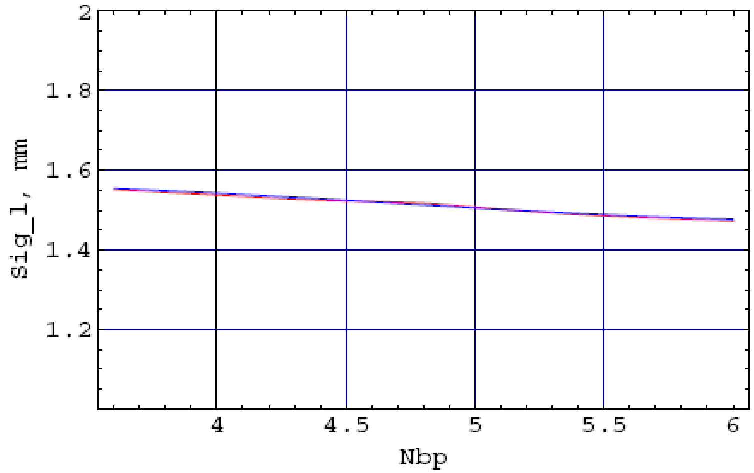


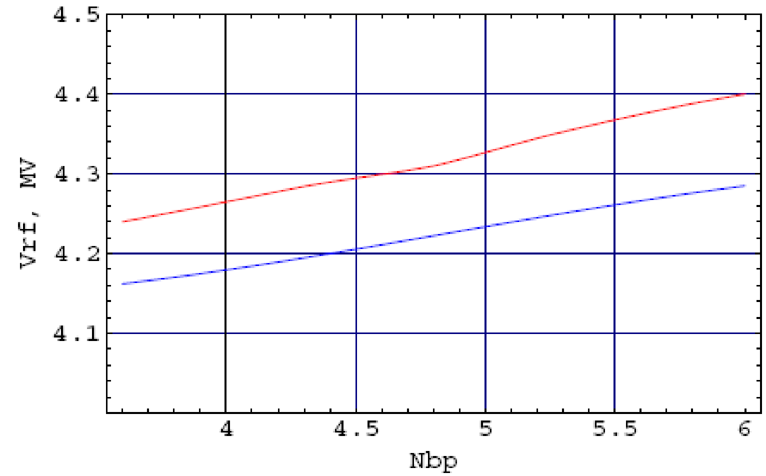
- Emittance evolution vs. time, including IBS based on modified Piwinski formalism

Emittance vs. bunch population









- Linear dependence of emittance, bunch length and required RF voltage on bunch charge (more pronounced on horizontal emittance)
- Two curves correspond to different bunch spacing (8 vs 7 RF cycles)

Dependence on bunch spacing

bunch spacing [ns]	0.667 (8RF cycles)	1.334 (16RF cycles)	0.334 (4RF cycles)	0.584 (7RF cycles)	0.75 (9RFcycles)
rms bunch length [mm]	1.5	1.5	1.56	1.51	1.50
rms momentum spread [%]	0.137	0.137	0.137	0.137	0.137
hor. normalised emittance [nm]	**432**	**431**	**423**	**432**	**432**
ver. normalised emittance [nm]	**4.27**	**4.27**	**4.24**	**4.27**	**4.27**
lon. normalised emittance [eV m]	4993	5000	5180	5000	5000
RF Voltage [MV]	4.345	5.450	4.000	4.245	4.450

- The transverse emittance stays almost constant when the bunch spacing is changed and keeping the longitudinal emittance almost unchanged
- Major impact on collective effects, as electron cloud and ion instabilities

Dependence on longitudinal emittance

lon. normalised emittance [eV m]	**4993**	**6337**	**8505**
bunch spacing [ns]	0.667	0.667	2 x 0.667
rms bunch length [mm]	1.5	1.9	2.7
rms momentum spread [%]	0.137	0.134	0.13
hor. normalised emittance [nm]	**432**	**381**	**328**
ver. normalised emittance [nm]	**4.27**	**4.1**	**3.9**
RF Voltage [MV]	4.345	4.05	4.05

- Reduction of the transverse emittance (especially the horizontal one) as the longitudinal emittance is increased
- Minimum RF voltage is limited by the energy loss per turn (wiggler parameters for minimising the emittance)

Remarks

- The increased bunch population has a degrading impact in the transverse emittance. Especially the vertical one is out of the required tolerances
- An increased longitudinal emittance reduces the emittance
- The transverse emittance is weakly depending on the bunch spacing
- A further optics optimisation is needed to achieve the required emittances (lattice, wiggler parameters)
- Clarification of the bunch compressor longitudinal emittance tolerance will be essential for damping ring optimisation
- Study of the impact of the new parameters to collective instabilities is on-going (e-cloud simulations by G. Rumolo)
- A further understanding and study of the emittance behaviour with IBS has to be followed (non-Gaussian beams, scattering simulations)