Damping Ring Parameters and Interface to Sources

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Configuration Options

	Baseline	Luminosity update	10 Hz mode
Train rep. rate	5 Hz	5 Hz	10 Hz
Number of bunches/train	1300	2600	1300

- For the" Luminosity update" operation of the positron ring we need to store twice the nominal current with 3.1 ns bunch spacing.
- In case the electron cloud mitigations that have been recommended are not sufficient to achieve the required performance for this configuration it has been foreseen as risk mitigation the possibility of installing a second positron ring in the same tunnel.
- The "Luminosity update" configuration shown in the tables corresponds to 1 e+ ring and 1 e- ring.
- In the case with 2 positron rings both the e+ rings have the baseline parameters.

Operation @ 10 Hz, Collisions @5 Hz

- e^- linac runs at 10 Hz :
  - **t_1** e- accelerated at high energy for positron production
  - **$t_2 = t_1 + 100$ ms** e- accelerated at low energy for collisions
- e^- DR always at full current:
  1. **t_1 and t_2** simultaneous injection and extraction, beam stored 100 ms for damping
- e^+ linac runs at 5 Hz:
  - **t_2** e^+ accelerated at low energy for collisions
- e^+ DR is empty half of the time (100 ms):
  - **t_1** e^+ are produced and injected into DR in ~1ms
  - Beam stored 100 ms for damping
  - **t_2** beam extracted in ~1 ms for acceleration and collisions

Nominal parameters of beams injected into damping rings

	Baseline	Luminosity update	10 Hz mode
Train rep. rate	5 Hz	5 Hz	10 Hz
Number of bunches/train	1300	2600	1300
Number of particles/bunch	2×10^{10}		
e^+ max. transverse amplitude A_x+A_y	0.09 m.rad		
e^+ max. energy error δ_{max}	±0.5%		
e^+ max bunch length	±34 mm		
e- normalized injected emittance	45 μm		
e^- rms relative injected energy spread	0.1%		

Positron Acceptance

The injected positron beam has a normalized betatron amplitude:

$$A_x + A_y < 0.09\,m$$

with:

$$\frac{A_x}{\gamma} = \gamma_x x^2 + 2\alpha_x x x' + \beta_x x'^2$$

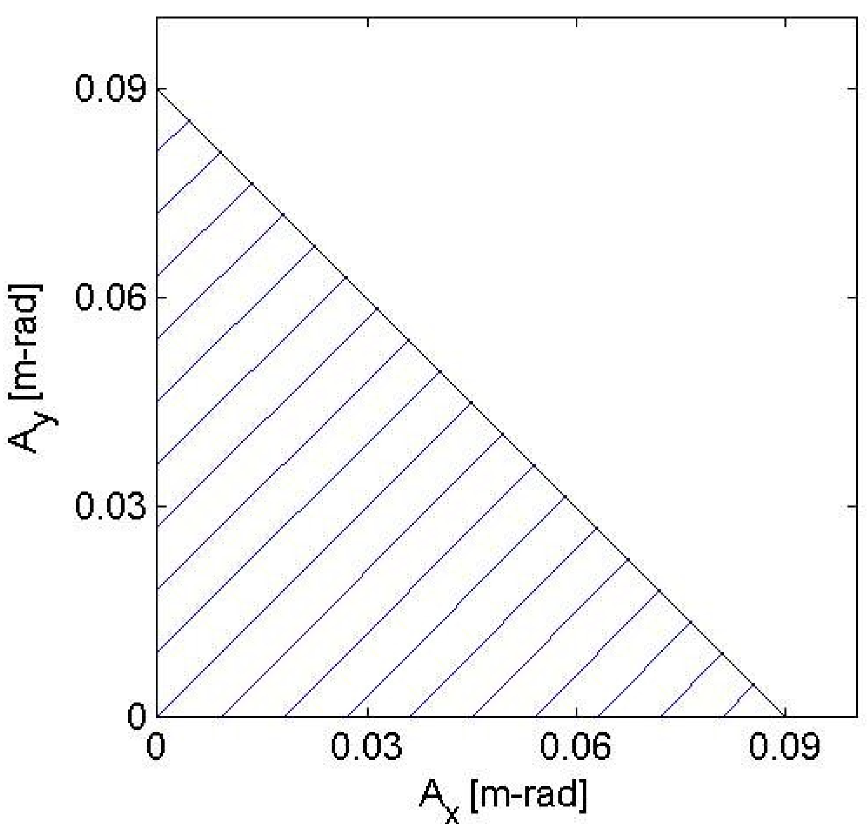
The equivalent rms beam size and emittance are:

$$3\sigma_x = x_{\max} = \sqrt{\beta_x \frac{A_x}{\gamma}}$$

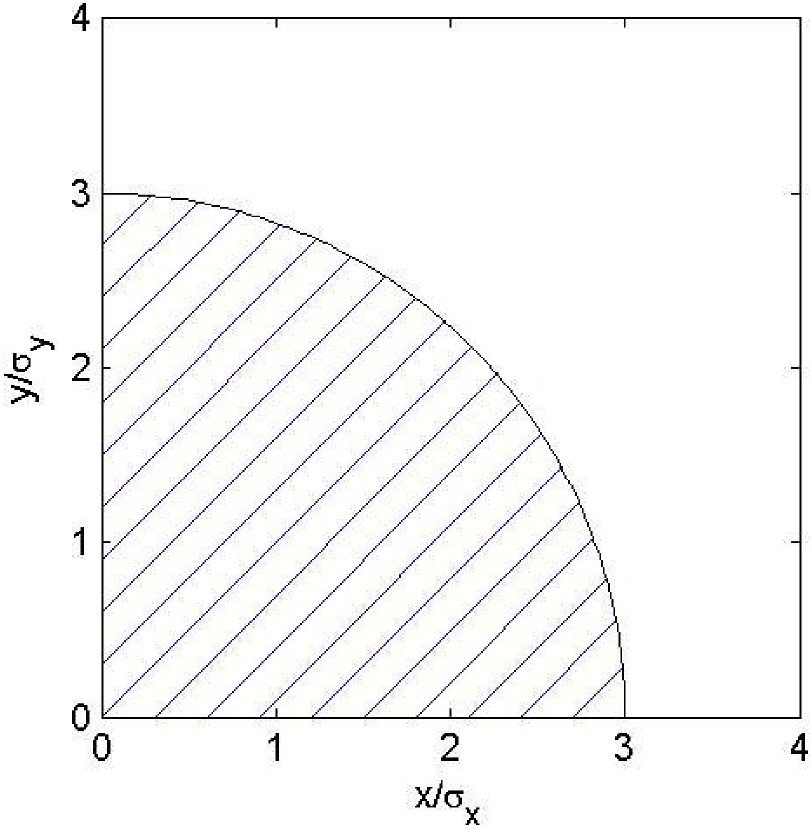
$$\varepsilon_x = \sigma_x^2 / \beta_x = A_x / (9\gamma) = 1 \cdot 10^{-6}\,m$$

Configuration Studies and Recommendations for the ILC Damping Rings, ILC-NOTE-2009-051
http://ilcdoc.linearcollider.org/record/25788/files/

All particles in the injected positron beam should lie within the shaded areas



specification on betatron amplitudes



specification in coordinate space

$\varepsilon_x = \varepsilon_y = 1 \bullet 10^{-6}$ m

Longitudinal acceptance

	Baseline	Luminosity update	10 Hz mode
Train rep. rate	5 Hz	5 Hz	10 Hz
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From RDR
Check with positron source

Longitudinal acceptance

- Injection energy acceptance δ_{max} = ±5e-3
- Max injected bunch length Δl_{inj} = 34 mm

- The max accepted bunch length depends on: energy acceptance δ_{max}, momentum compaction and synchrotron tune (i.e. RF voltage)

$$\Delta l_{\max} = \frac{c}{2\pi f_{RF}} \frac{\alpha_c h}{Q_s} \delta_{\max}$$

Energy acceptance and lifetime

- The ratio between energy acceptance and energy spread gives the quantum lifetime
- The energy spread is determined by the wiggler peak field and is $\sigma_p \sim 1.3\ 10^{-3}$
- For emittance tuning 30min is needed ➔

  $\delta_{max} \geq 5.5\ \sigma_p \geq 7e\text{-}3$
- A larger energy acceptance also improves Touschek lifetime (less critical since tuning can be done at low current)
- We aim at an energy acceptance

  $\delta_{max} \sim 1\%$

Nominal parameters of beams extracted from damping rings

	Baseline	Luminosity update	10 Hz mode
Train rep. rate	5 Hz	5 Hz	10 Hz
Number of bunches/train	1300	2600	1300
Number of particles/bunch	2×10^{10}		
Energy	5 GeV		
Horizontal emittance	$<8.0\ 10^{-10}$ m.rad		
Vertical emittance	$2.0\ 10^{-12}$ m.rad		
rms relative energy spread	<0.15%		
rms bunch length	6 mm		
e^+ Vertical damping time	24 ms	24 ms	13 ms
e^- Vertical damping time	24 ms	24 ms	18 ms
Horizontal/vertical jitter	$<0.1\sigma_x/\sigma_y$		

Layout and Components

- Racetrack
  - Injection/extraction in straight section 1
  - RF and wigglers in straight section 2
- Magnets (reduce cost with respect to RDR)
  - Reduce number of magnets, strenghts, number of different types
- Injection/extraction as DCO4
  - $\beta_x \cong 70$m, $\beta_y \cong 10$m at kickers
  - $\beta_x \cong 70$m at septum, phase advance between kickers and septum $\Delta\mu_x=\pi/2$
  - Space for kickers and septa as DCO4
- Phase adjustment in the straights
  - DCO4: $\Delta Q_x = \pm 0.5$ and $\Delta Q_y = \pm\ 0.25$ per straight section
  - *Minimum:* $\Delta Q_x = \pm 0.25$ *and* $\Delta Q_y = \pm\ 0.25$ *per ring*
- Chicane
  - *DCO4 (6.4 km):* $\Delta C/C = \pm\ 10^{-6}$ ➔ $\Delta C = \pm 6.4$ *mm*
  - *For 3.2 km ring:* $\Delta C/C = \pm\ 10^{-6}$ ➔ $\Delta C = \pm 3.2$ *mm*

Layout and Components

- RF section
  - Longitudinal space per cavity 3.5 m
  - Leave space for a number of cavities sufficient to cover all the options (5 Hz, 1310 bunches – 10 Hz, 1310 bunches – 5 Hz, 2620 bunches)
  - In case of second positron ring avoid cavities vertically superimposed
  - RF cavities upstream of wigglers
- Wigglers
  - Space for synchrotron radiation absorbers >0.75 m
  - Use optimized version of CESR-c type wigglers

RF system and momentum compaction

- It's an expensive system, cost containment is important
- RF has to be sufficient for the Baseline and also for the Luminosity update and the 10Hz mode.
- 6 mm bunch length
- Overvoltage $V_{RF}/U_0 \sim 2$ is desirable for 50% duty cycle operation of the e^+ ring at 10Hz (100 ms full current, 100 ms empty ring)
- A low momentum compaction allows a lower RF voltage
- A high momentum compaction makes the lattice less sensitive to various instabilities at high current
- With the present parameters the number of RF cavities needed is determined more by the beam power than by the voltage. Therefore the same number of cavities can be used for values of momentum compaction in the range:

$$1.5\ 10^{-3} < \alpha_c < 3.5\ 10^{-3}$$

Interface to e^+ Source

Nominal parameters of beams injected into damping rings

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Interface to e^+ Source

- We increased the DR energy acceptance to

$$\delta_{max} = 1\%$$

- The corresponding bunch length for the nominal RF voltage is

$$\Delta l_{max} = 54 \text{ mm}$$

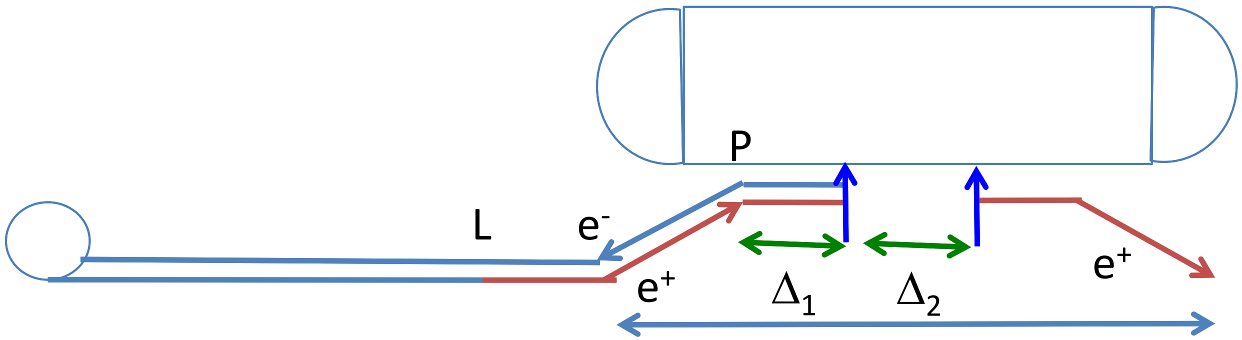
- How does it scale the transverse acceptance?

Interface to e^+ Source

- The interface point is in the DR tunnel at the location of the splitter for injection in 2 rings (the splitter will be installed only if the second ring is needed)
- The transfer line from the interface point to the injection septum is not yet defined

Back up

Self-reproducing fills



L = distance for extracted e- going from P trough the RTML and Main Linac to e^+ source and for e^+ going from source to point P

Δ_1 = distance between P and e^- extraction (e^+ injection) septum

Δ_2 = distance between e^+ injection and extraction septum

Condition for self-reproducing fills:

$$L + 2\Delta_1 + \Delta_2 = nC$$

The position of the injection/extraction septa in the long straight can be chosen to satisfy this condition, for example:

L = 30 km, C = 3.24 km, n=9 ➔ Δ_1 =0; Δ_2 =160 m

$L + 2\Delta_1 + \Delta_2$ = 30.16 ; nC = 29.25 ➔ C = 30.16/9 = 3.35 km

DTC lattice parameters options

Parameter	10 Hz(Low)	5 Hz (Low)	5 Hz (High)
Circumference	3.2 km	3.2 km	3.2 km
RF frequency	650 MHz	650MHz	650 MHz
τ_x/τ_y [ms]	13.5	24.1	24.1
σ_s [mm]	6	6	6
σ_δ	0.134%	0.11%	0.11%
α_p	3.3×10^{-4}	3.3×10^{-4}	3.3×10^{-4}
$\gamma\varepsilon_x$ [μm]	2.7	4.4	4.4
RF [MV] (16 cavities)	19.7	14	14
ξ_x/ξ_y	-51.5/-44.6	-51.5/-43.9	-51.5/-43.9
Wigglers- N_{cells}@B[T]	27@2.1	27@1.5	27@1.5
Energy loss/turn [MeV]	8.0	4.5	4.5
sextupoles	3.41/-4.34	3.41/-4.34	3.41/-4.34
Power/RF coupler @400mA [kW]	200	112.5	225

References

- Configuration Studies andRecommendations for the ILC Damping Rings, February 2006 https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/ConfigStudy
- ILC RDR Report, August 2007 http://www.linearcollider.org/?pid=1000437
- Specifications for the ILCDamping Rings EDR baseline lattice, A. Wolski, December 2007 https://wiki.lepp.cornell.edu/ilc/pub/Public/DampingRings/LatEvalPage/EDRLatticeSpecifications.pdf
- DCO4: ILC-NOTE-2010-057 http://ilcdoc.linearcollider.org/record/30937/files/ILC-NOTE-2010-057.pdf
- "Parameters and scope for low-power option discussions" N. Walker , AD&I meeting: BAW-2 preparation, 07 January 2011, http://ilcagenda.linearcollider.org/getFile.py/access?subContId=0&contribId=0&resId=0&materialId=slides&confId=4962