Damping Ring Specifications

S. Guiducci

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Nominal parameters of beams injected into damping rings

	Low Power		High Power
Train rep. rate	5 Hz	10 Hz	5 Hz
Number of bunches/train	1300	1300	2600
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:

$$A_x + A_y < 0.09m$$

with:

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

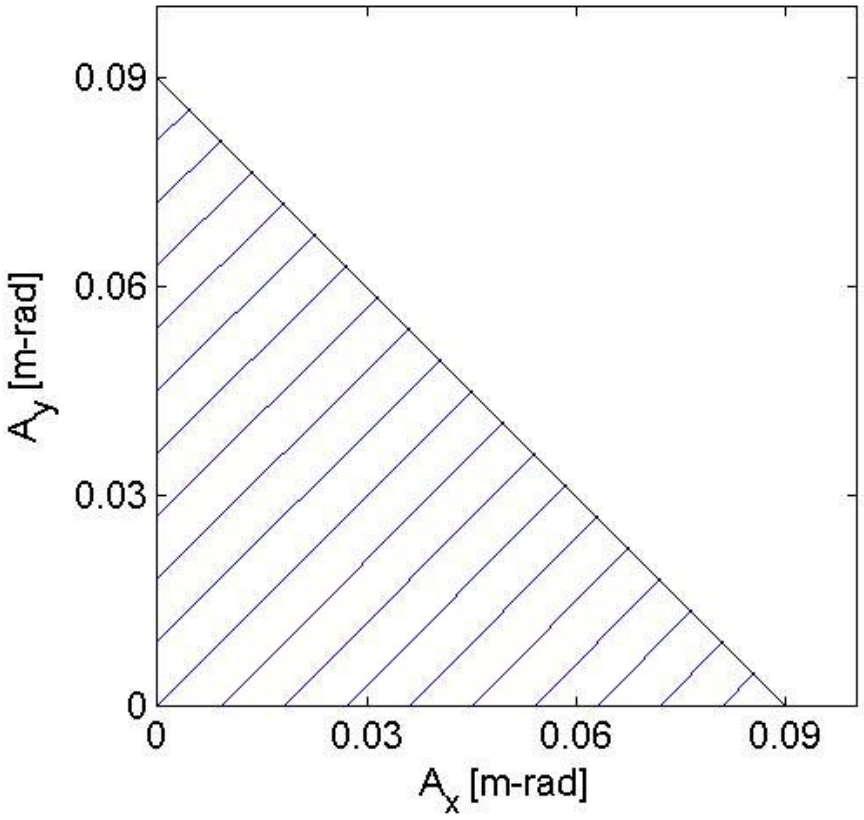
The equivalent rms beam size and emittance are:

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

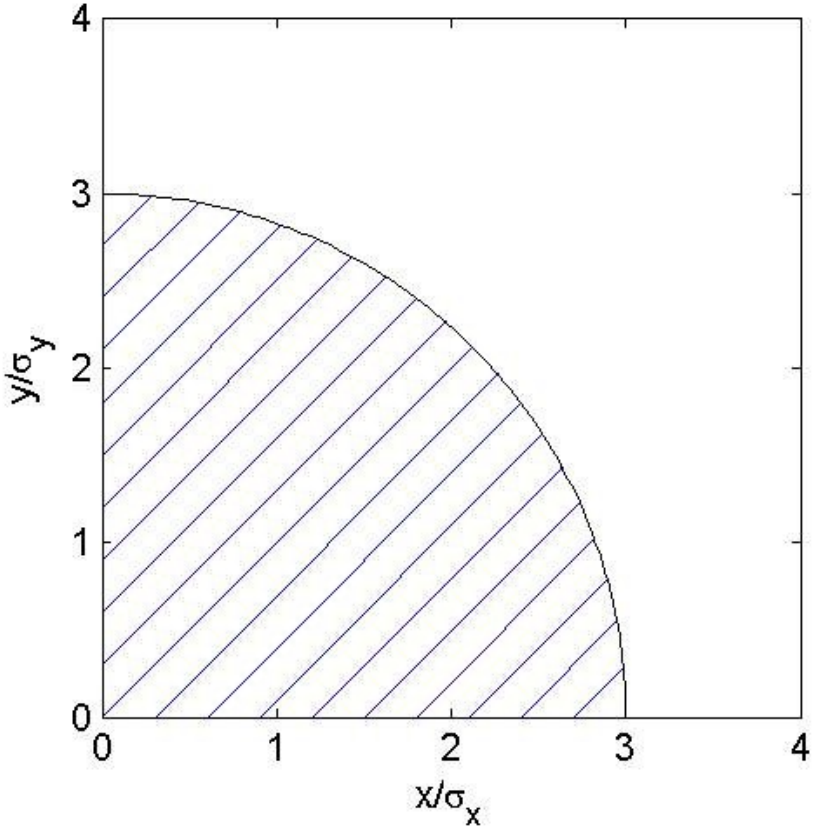
$$\varepsilon_x = \sigma_x^2/\beta_x = A_x/9 < 1\cdot 10^{-6} m$$

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

	Low Power		High Power
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From RDR
Check with positron source

RDR Longitudinal acceptance

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

- Max bunch length for δ_{max} = ±5e-3

$$\Delta l_{\max} = \frac{c}{2\pi f_{RF}} \frac{\alpha_c h}{Q_s} \delta_{\max} = 23mm$$

Check with positron source

- Energy acceptance for Δl_{inj} = 34 mm

δ_{max} = ±7.4e-3

Energy acceptance and lifetime

- Injection acceptance $\delta_{max} = \pm 5e\text{-}3$

- Energy acceptance gives quantum lifetime:

  $\delta_{max} = 5e\text{-}3$ and $\sigma_p = 1.3e\text{-}3$ ➔ $\delta_{max} = 3.9\sigma_p$ ➔ 2-3 sec lifetime

- For emittance tuning ~ 30min is needed ➔

  $\delta_{max} \geq 5.5\sigma_p \geq 7e\text{-}3$

- also consider Touschek lifetime, less critical since tuning can be done at low current
- Energy acceptance should be at least

  $\delta_{max} = \pm 0.75\%$

Nominal parameters of beams extracted from damping rings

	Low Power		High Power
Train rep. rate	5 Hz	10 Hz	5 Hz
Number of bunches/train	1300	1300	2600
Number of particles/bunch	$2x10^{10}$		
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	13 ms	24 ms
e^- Vertical damping time	24 ms	18 ms	24 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)
  - RF cavities upstream of wigglers
- Wigglers
  - Space for synchrotron radiation absorbers >0.75 m
  - Use present RDR CESR-c type wigglers
  - Or new optimization of field and period for the shorter damping time

RF system and momentum compaction

- It's an expensive system, cost containment is important
- RF has to be sufficient for 5Hz Low Power and High Power, and 10 HZ Low Power
- 6 mm bunch length
- Overvoltage $V_{RF}/U_0 \leq 2$ 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 is preferred:

$$\alpha_c < 2 \cdot 10^{-4}$$

DSB3 RF parameters options

	SB2009 Low Power 5Hz	SB2009 High Power 5Hz	SB2009 Low Power 10Hz	
Particle	e^+/e^-	e^+/e^-	e^+	e^-
Circumference (m)	3238	3238	3238	3238
N bunches	1305	2610	1305	1305
N part./bunch	2×10^{10}	2×10^{10}	2×10^{10}	2×10^{10}
Damp. time τ_x (ms)	24	24	13	18
Emittance ε_x (nm)	0.53	0.53	0.57	0.45
Emittance ε_y (pm)	2	2	2	2
En. loss/turn (MeV)	4.5	4.5	8.4	6.2
Energy spread	1.2×10^{-3}	1.2×10^{-3}	1.5×10^{-3}	1.4×10^{-3}
Momentum comp.	1.3×10^{-4}	1.3×10^{-4}	1.3×10^{-4}	1.3×10^{-4}
B wiggler (T)	1.6	1.6	2.4	2.0
Wiggler period (m)	0.4	0.4	0.28	0.28
Wiggler length (m)	2.45	2.45	1.72	1.72
Tot. wigg. len.(m)	78	78	75	75
Numb. of wigglers	32	32	44	44
Bunch length (mm)	6	6	6	6
Overvoltage	1.7	1.7	1.6	1.7
RF Voltage (MV)	7.5	7.5	13.4	10.4
Average curr. (A)	0.39	0.78	0.39	0.39
Beam Power (MW)	1.76	3.51	3.28	2.42
N. of RF cavities	6	12	12	9
Power/cavity (kW)	293	292	273	269
Voltage/cav. (MV)	1.25	0.63	1.12	1.16
Klystron/ring	2	4	4	3
Power/klystron (kW)	880	880	820	807

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