DR 10 Hz Repetition Rate

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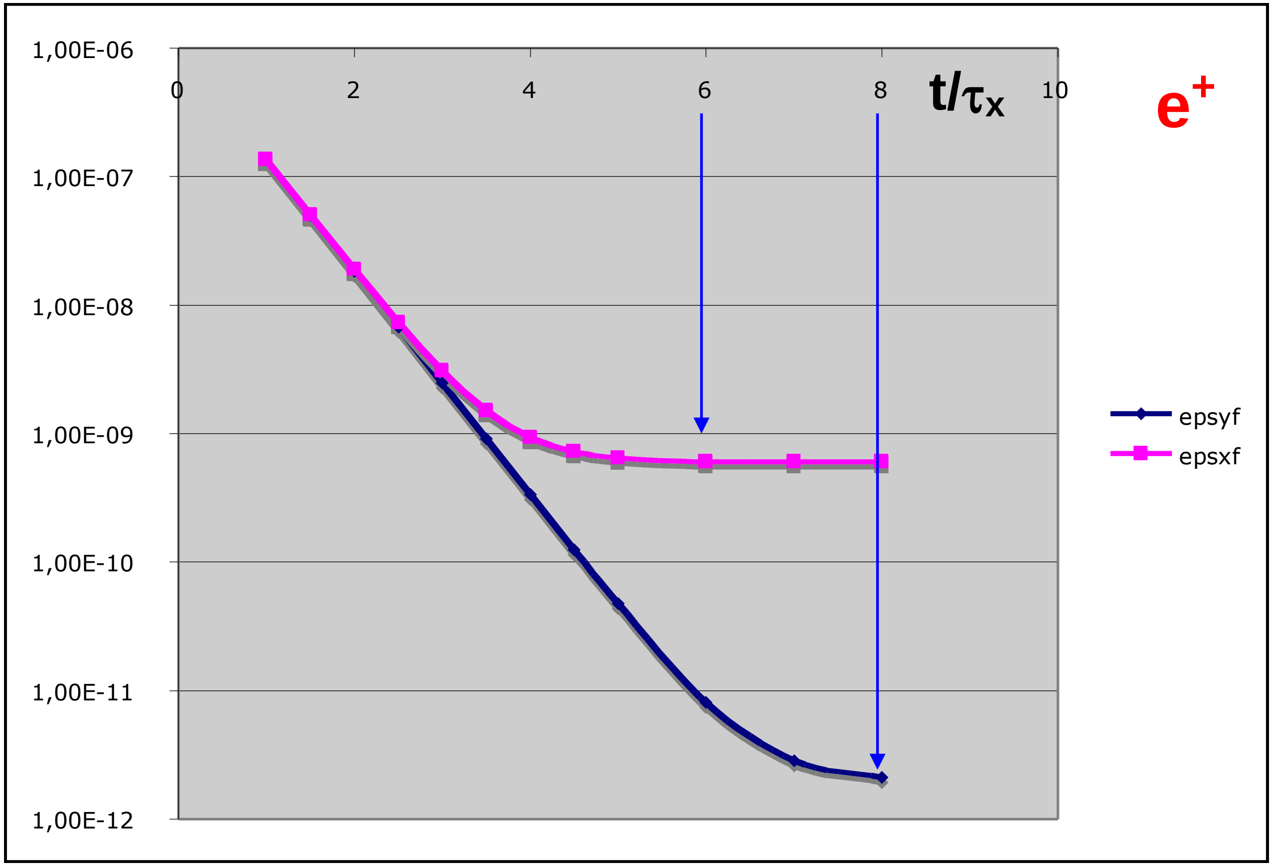
Positron emittance damping

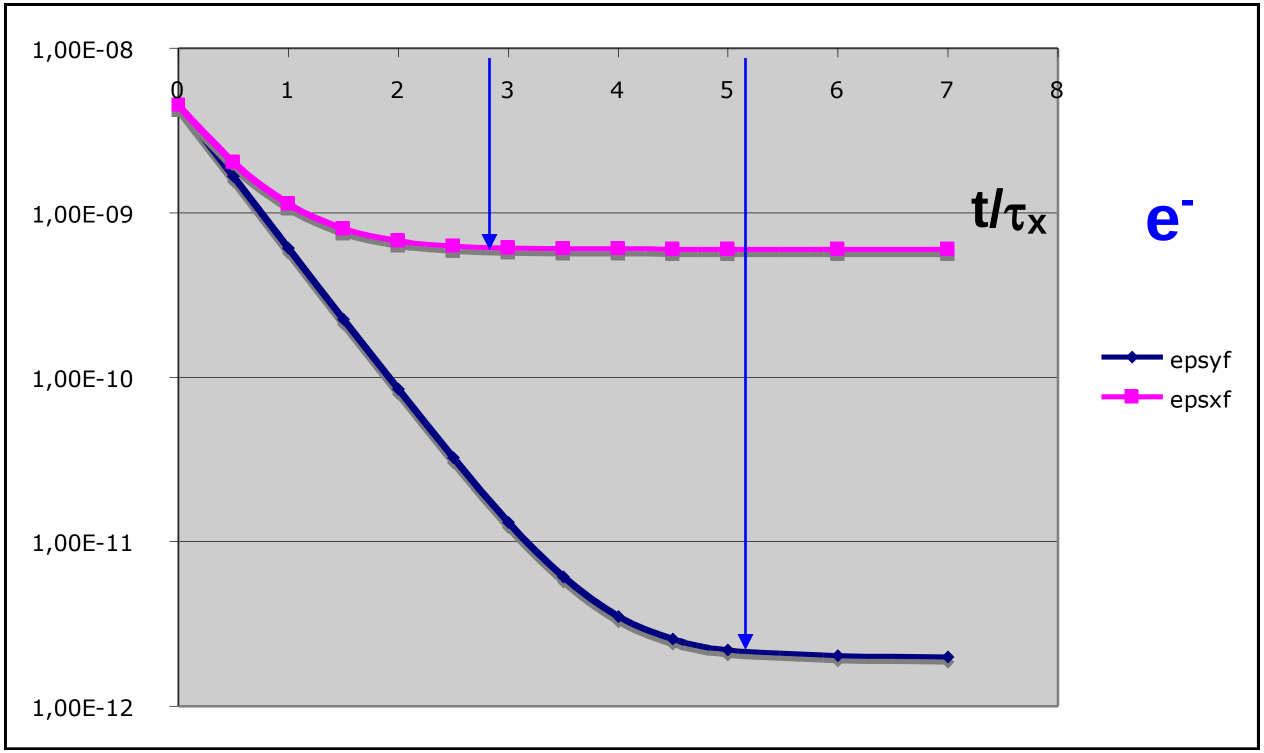


~8 damping times are needed for the vertical emittance

5 Hz ⇒ $\tau_x \leq 26$ ms

10 Hz ⇒ $\tau_x \leq 13$ ms

Electron emittance damping



~5 damping times are needed for the vertical emittance

5 Hz ⇒ $\tau_x \leq$ 36 ms

10 Hz ⇒ $\tau_x \leq$ 18 ms

The evaluation is done only for the positron ring which is more demanding

SB2009 - 3.2 km ring

DR Parameters for positron ring
10 Hz operation

	SB2009	10 Hz e^+
Circumference (m)	3238	3238
Number of bunches	1305	1305
Damping time τ_x (ms)	24	13
Emittance ε_x (nm)	0.53	0.57
Emittance ε_y (pm)	2	2
Energy loss/turn (MeV)	4.4	8.4
Energy spread	1.2×10^{-3}	1.5×10^{-3}
Bunch length (mm)	6	6
RF Voltage (MV)	7.5	13.4
Average current (A)	0.43	0.43
Beam Power (MW)	1.9	3.6
N. of RF cavities	8	16
Bwiggler (T)	1.6	2.4
Wiggler period (m)	0.4	0.28
Wiggler length (m)	2.45	1.72
Total wiggler length (m)	78	75
Number of wigglers	32	44

8 damping times needed to reduce vertical e^+ emittance

5 Hz $\Rightarrow \tau_x \leq 26$ ms

10 Hz $\Rightarrow \tau_x \leq 13$ ms

Increase wiggler field

Reduce wiggler period

Double the number of RF cavities

Cost related modifications

RF voltage	7.5 ⇒ 13.4 MV
Beam power	1.9 ⇒ 3.6 MW
N. of RF cavities	8 ⇒ 16
Wiggler field	1.6 ⇒ 2.4 T
Wiggler period	0.4 ⇒ 0.28 m
Wiggler length	2.45 ⇒ 1.72 m
N. of wigglers	32 ⇒ 44
Total wig. sect. length	136 ⇒ 176 m
SR power per wiggler	40 ⇒ 63 kW

Comments on wiggler modifications

- Some engineering design work is needed
- Lattice and dynamic aperture tuning
- SR copper absorbers* (not included in RDR costs) 0.5 m long, 40 kW; with modified wigglers there is space to increase the length to 0.75 m to absorb 60 kW
- The SR power passing through all modules and continuing downstream to the fist arc dipole is 256 kW. This is expected to by ~ 1.5. A solution is to leave some space for more absorbers
- Cryogenic load to be reevaluated

* O. B. Malyshev, et al. “Mechanical and Vacuum Design of the Wiggler Section of the ILC Damping Rings”, ID: 2596 - WEPE092, IPAC10

DCO4* - 6.4 km ring

DR Parameters for positron ring
10 Hz operation

	DCO4 (90deg)	10 Hz e^+
Circumference (m)	6476	6476
Number of bunches	2610	2610
Damping time τ_x (ms)	21	13
Emittance ε_x (nm)	0.44	0.56
Emittance ε_y (pm)	2	2
Energy loss/turn (MeV)	10.2	16.6
Energy spread	1.3×10^{-3}	1.6×10^{-3}
Bunch length (mm)	6	6
RF Voltage (MV)	21	32
Average current (A)	0.43	0.43
Beam Power (MW)	4.4	7.1
N. of RF cavities	18	30
B wiggler (T)	1.6	2.4
Wiggler period (m)	0.4	0.28
Wiggler length (m)	2.45	1.72
Total wiggler length (m)	216	162
Number of wigglers	88	94

8 damping times needed to reduce e^+ vertical emittance

5 Hz $\Rightarrow \tau_x \leq$ 21 ms

10 Hz $\Rightarrow \tau_x \leq$ 13 ms

Increase wiggler field

Reduce wiggler period

Increase the number of RF cavities 18 $\Rightarrow$ 30

DCO4 has 3 options with different momentum compaction, I used the intermediate one with α_c = 1.6e-4

* DCO4 is new baseline after Sendai TILC08 meeting

Preliminary Costs

	SB2009 @ 10 Hz	DCO4 @ 10 Hz
N. of bunches	1305	2610
Added RF cavities	8	12
Cost (k$)	12000	18400
Added wigglers	12	6
Cost (k$)	3600 - 5000	1800 - 2500

- Costs based on RDR 2007 numbers
- 50% duty cycle not considered
- The lower cost for the wigglers is scaled with the wiggler length
- SR absorbers are not included
- Extra quadrupoles are not included

Preliminary Costs

	SB2009 @ 10 Hz	DCO4 @ 10 Hz
N. of bunches	1305	2610
Added RF cavities	8	12
Cost (k$)	12000	18400
Added wigglers	12	6
Cost (k$)	3600 - 5000	1800 - 2500

	SB2009 @ 10 Hz	
	single ring	2 rings
N. of bunches	2610	2610
Added RF cavities	16	2x8
Cost (k$)	24000	24000
Added wigglers	12	2x12
Cost (k$)	3600 - 5000	7200 - 10000

Comparison with SB2009 2610 bunches options

- 1 or 2 positron rings in the same tunnel

Alternate 10Hz Cycle DR RF Operation

- In consultation with Sergey Belomestnykh (Cornell)
- Normal Operations:
  - **Reactive beam loading is large**
  - **Cancelled by appropriate cavity de-tuning**
  - **Beam-loaded cavity then represents a matched load for the klystron**
- Issues
  - **With no beam, the cavity is detuned far from resonance**
  - **For DR parameters, ~365kW would be required to maintain the voltage in each cavity**
  - **This exceeds available power from klystron in our present specification**
- Potential Solutions
  - **Fast Frequency Tuner with either feedforward or feedback system ⇨ Tune cavity as beam is injected/extracted**
    - Tristan utilizes a piezo tuner on their SCRF cavities
    - CESR cryomodules also equipped with piezos for microphonics (not enough range for large detuning)
    - Requires an R&D effort to implement for this application, but millisecond timescale seems quite reasonable.
  - **Fast Waveguide Tuner**
    - Under development at several laboratories, but not presently used in operations
    - Probably not sufficient by itself as ower requirements will still be high
    - May be useful in conjunction with a Fast Frequency Tuner (particularly if frequency tuner has limited range)
  - **Other?**
- Conclusion: Significant R&D will be required for the alternating 10Hz scenario ***OR*** a significant cost increase to deal with the additional power overhead

Wiggler Photon Stop Issues

- In consultation with Yulin Li & Xianghong Liu
- 10 Hz Operation
  - **Higher power load in each wiggler requires adjustments to design**
  - **Expect that a technical solution is possible**
- Alternating 10Hz Cycle Operation
  - **Average power load is lower than previous case**
    ⇨ no issues for cooling system
  - **Rapid cycling will lead to added thermal stress at the photon absorbing surfaces**
    - Some concern about ability of standard tools to model this (optimized for steady state calculations)
    - General recommendation is to provide additional operating margin relative to the steady state yield point
    - Assuming that baseline design is for full duty cycle 10Hz operation, the factor of 2 reduction in average power load likely satisfies the previous recommendation.
- Conclusion: No serious issues are likely