

ILC Damping Rings Lattice Evaluation

ALCPG11

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I. Introduction to the Lattice Evaluation

A primary deliverable for the ILC Damping Rings (DR) Working Group in early 2011 is the selection of a baseline lattice for the remainder of the ILC Technical Design Phase (TDP). A number of modifications have been incorporated to the DR design planning since the preparation of the ILC Reference Design Report in 2007 and the subsequent choice of the DCO4 lattice as the baseline lattice at the beginning of the TDP. Key design updates for the 2011 evaluation include:

- 3.2km ring circumference
- Lower momentum compaction resulting in a smaller required RF complement to achieve a 6mm bunch length
- Increased energy acceptance ($\pm 1\%$) to ensure adequate quantum lifetime
- Space for a wiggler complement capable of shorter damping times for 10Hz operation
- An RF system design compatible with 10Hz operation and with a 50% duty cycle for the positron DR
- Incorporation of shorter straight sections optimized for the 3.2km circumference

In contrast to the baseline lattice choice carried out at TILC08 in March 2008, several key evaluation criteria for the lattice designs have been maintained as fixed features of each of the lattices being evaluated at this time. As a result, a somewhat more limited set of evaluation criteria will be used. The 2008 evaluation criteria included:

- *Lattice Design and Dynamical Properties*
- *Conventional Facilities and Layout*
- *Magnets, Supports and Power Supplies*
- *Vacuum System and Radiation Handling*
- *RF System*
- *Injection and Extraction Systems*
- *Instrumentation and Diagnostics*
- *Control System, Availability and Reliability*

For the present evaluation, we are assuming that the conventional facilities and layout issues are fixed between the lattices, that the injection and extraction systems are identical, and that there are no significant differences in the control system requirements, nor in the availability and reliability issues. Thus the present evaluation will cover the following areas:

- *Lattice Design and Dynamical Properties*
- *Magnets, Supports and Power Supplies*
- *Vacuum System and Radiation Handling*
- *RF System*
- *Instrumentation and Diagnostics*

II. Lattice Evaluation Criteria

The following provides a more detailed description of the issues that need to be evaluated in each evaluation area:

1. Lattice design and dynamical properties.

- a) Is the design complete? Does it include all necessary systems, such as injection/extraction optics, RF, wiggler, circumference chicane, tune trombone, etc?
- b) Is there sufficient margin in general dynamical parameters (damping times, equilibrium emittance and energy spread, etc.)?
- c) Does the momentum compaction factor provide a good compromise between RF requirements, at 6 mm bunch length, and instability thresholds?
- d) How does the lattice compare with others in terms of sensitivity to collective effects (such as impedance-driven instabilities, intrabeam scattering, space charge, ion effects, and electron cloud)?
- e) How much flexibility is there in tuning the momentum compaction factor?
- f) Is the dynamic aperture sufficient?
- g) Are there any particular benefits or concerns with the dynamics, specific to the lattice?

2. Magnets, supports and power supplies.

- a) How does the number of magnets, and the number of different styles of magnet, compare with the other lattices?
- b) Are the magnet parameters (length, field strength or gradient, spacing) reasonable?
- c) Compare the degree of magnet optimization required for the various lattices?
- d) How do the alignment and stability sensitivities compare with other lattices? In particular, what is the sensitivity of emittance dilution due to these effects.
- e) How do the numbers and types of supports required for the magnets compare with other lattices?
- f) How do the numbers and types of individually powered magnets compare with the other lattice options?
- f) Are there any particular benefits or concerns with the magnets, supports and power supplies, specific to the lattice?

3. Vacuum system and radiation handling.

- a) How do the aperture requirements compare with other lattice designs?
- b) How does the difficulty of handling the radiation from the dipoles and wigglers compare with other lattice designs?

- c) Are there any particular benefits or concerns with the vacuum system, specific to the lattice?

4. RF system.

- a) How feasible is the RF voltage required, over the range of possible momentum compaction factors, to provide a bunch length of 6 mm?
- b) Is there sufficient space in the lattice for all required RF cavities (allowing some margin for klystron failure)?

7. Instrumentation and diagnostics.

- a) Can the BPMs and other instrumentation and diagnostics be readily accommodated?

III. Ranking System

A ranking system with values 1-5, 5 being the best, the same system as was employed in 2008, is proposed for each key question in each topic. For questions where absolute evaluations were required, the following scoring criteria will be used:

- 5 – Item has been addressed in the lattice design and fully meets the DR specifications. In cases where lattice flexibility is required, the range of parameters has been thoroughly explored and meets the DR specifications for the entire parameter range. In cases where technical systems impact is being evaluated, the lattice design results in a technically feasible design with minimum cost.
- 4 – Item has been addressed in the lattice design but some refinement is still required to meet the DR specifications. In cases where lattice flexibility is desired, work remains to ensure that the DR specifications can be met for the entire parameter range. In cases where technical systems impact is being evaluated, the lattice design results in a technically feasible design, but technical issues remain and/or cost is not the minimum. In all cases, there is a high expectation that a successful design can be completed.
- 3 – Item has only been partially addressed. Significant work remains in order to meet the DR specifications. In cases where technical systems impact is being evaluated, significant technical issues remain and/or significant cost optimization is required. In all cases, there is a reasonable expectation that a successful design can be completed.
- 2 – Item has not been directly addressed in the lattice design. There is a reasonable expectation that a successful design can be achieved which meets DR specifications. In cases where technical systems impact is being evaluated, there is a reasonable expectation that technical and/or cost issues can be successfully addressed.
- 1 – Item has not been directly addressed in the lattice design. Significant questions exist about achieving a successful design which meets DR specifications. In cases where technical systems impact is being evaluated, there are significant uncertainties that technical and/or cost issues can be successfully addressed.

For questions where relative rankings are required, the ranking of the *best* lattice will be calibrated with the above absolute rating scale. For cases where insufficient information exists to make an evaluation, an entry of “Ins.” will be recorded.

Within each major evaluation item, a weighted average of the rankings for each sub-item will be used to generate the overall ranking for that item. Setting the weights of each sub-item was carried out as part of the TILC08 evaluation process and we propose to maintain the same weights for the present evaluation. In order to obtain an overall score for each lattice, each of the overall item rankings will be summed.

IV. Evaluation Table

The following table will be filled in as part of the evaluation process. As was already noted, the weights that are used are those that were determined at TILC08.

Evaluation Item	Weight	DMC3	DSB3	Other	----
1. Lattice design and dynamical properties.					
Completeness	1.0				
Margin - general parameters	1.0				
α_p choice	1.0				
Compare lattice sensitivities to collective effects	1.0				
α_p flexibility	1.0				
Dynamic aperture	1.0				
Particular benefits/concerns	1.0				
Overall					
2. Magnets, supports and power supplies.					
Compare magnet counts and types	1.0				
Reasonableness of magnet parameters	1.0				
Compare degree of optimization needed	1.0				
Compare alignment & stability sensitivities	1.0				
Compare support counts and types	1.0				
Compare individual PS counts and types	1.0				
Particular benefits/concerns	1.0				
Overall					
3. Vacuum system and radiation handling.					
Compare aperture requirements	1.0				
Compare radiation load issues (dipole/wiggler regions)	1.0				
Particular benefits/concerns	1.0				

Overall					
4. RF system.					
RF voltage requirements	1.0				
Space in lattice for RF cavities	1.0				
Overall					
5. Instrumentation and diagnostics.					
Accommodation of diagnostics	1.0				
Overall					
Grand Total					

Appendix A. Other Criteria from the 2008 Evaluation

The following items describe the additional evaluation criteria that were used in the March 2008 discussions that are not being evaluated in the present evaluation.

1. Conventional facilities and services.

- a) Is the layout technically feasible from point of view of:
 - i) civil construction;
 - ii) distribution of services, including air, water, cryogenics, power;
 - iii) installation;
 - iv) access for maintenance and repair.
- b) How would the cost for construction and installation compare with other lattices?
- c) Are there any particular benefits or concerns with the conventional facilities, distribution of services, or installation, specific to the lattice?

Appendix B. March 2008 Evaluation Table

Evaluation Item	Weight	OCS8	FODO4	FODO5	DCO
1. Lattice design and dynamical properties.					
Completeness	1.0	4	4	4?	4
Margin - general parameters	1.0	5	5	5	5
α_p choice	1.0	4	4	5	5
Compare lattice sensitivities to collective effects	1.0	Ins.	Ins.	Ins.	Ins.
α_p flexibility	1.0	4	5	5	5
Dynamic aperture	1.0	4	4	4	3
Particular benefits/concerns	1.0	-	-	-	-
Overall		4.2	4.4	4.6	4.4
2. Conventional facilities and services.					
Technical feasibility	1.0	4	4	4	4
Compare costs	1.0	Ins.	Ins.	Ins.	Ins.
Particular benefits/concerns ¹	1.0	3	3	3	4
Overall		3.5	3.5	3.5	4
3. Magnets, supports and power supplies.					
Compare magnet counts and types	1.0	3	4	4	4
Reasonableness of magnet parameters	1.0	5	5	5	5
Compare degree of optimization needed	1.0	5	4	4	5
Compare alignment & stability sensitivities	1.0	Ins.	Ins.	Ins.	Ins.
Compare support counts and types	1.0	3	4	4	4
Compare individual PS counts and types	1.0	3	4	4	4
Particular benefits/concerns	1.0	-	-	-	-
Overall		3.8	4.2	4.2	4.4
4. Vacuum system and radiation handling.					
Compare aperture requirements	1.0	Ins.	Ins.	Ins.	Ins.
Compare radiation load issues (dipole/wiggler regions)	1.0	Ins.	Ins.	Ins.	Ins.
Particular benefits/concerns	1.0	-	-	-	-
Overall		0	0	0	0
5. RF system.					
RF voltage requirements	1.0	2	2	4	4
Space in lattice for RF cavities	1.0	5	5	5	5

¹ A particular benefit was identified which was the ability to cluster all major components residing in alcoves within a few hundred meters of the two main access shafts. This is a distinguishing feature of the DCO design

Overall		3.5	3.5	4.5	4.5
6. Injection and extraction systems.					
Suitability of inj/ext optics	1.0	5	4	4	4
Space in lattice for inj/ext components	1.0	4	4	4	4
Particular benefits/concerns ²	0.5	3	3	3	4
Overall		4.2	3.8	3.8	4
7. Instrumentation and diagnostics.					
Accommodation of diagnostics	1.0	4	4	4	4
Overall		4	4	4	4
8. Control system, availability and reliability, other.					
Compare cost and complexity	1.0	4	4	4	4
Compare availability and reliability	1.0	4	4	4	4
Particular benefits/concerns ³	0.5	3	3	3	4
Overall		3.8	3.8	3.8	4
Grand Total		27.0	27.2	28.4	29.3

² A particular benefit that was identified was the ability in the lattice to cluster the entire complement of injection or extraction kickers in a single location in the lattice, thus easing the injection/extraction region design.

³ The ability to concentrate control nodes at locations near the main access shafts is expected to improve the overall machine availability as well as to simplify maintenance.