ILC Damping Rings R&D Status

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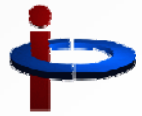


The Damping Rings R&D Context

The RDB has outlined a set of “ideal” R&D goals.

- For the damping rings, these goals include things like:
  - Develop electron-cloud suppression techniques.
  - Develop a high-power fast pulser.
- The list is available from:
  - http://www.linearcollider.org/wiki/doku.php?id=rdb:rdb_external:rdb_external_home

The list of “ideal” R&D goals should provide strong guidance for labs planning damping rings R&D activities, but the reality is that the program is driven by proposals from the labs.

So far, the GDE has not had strong control over the damping rings R&D program, and its role has been very much one of trying to provide information and facilitate communication.

A more active approach to DR R&D coordination is needed

In this presentation, I shall…

…first consider the "methodology" for developing an R&D plan:

- How can we arrange the multitude of R&D goals into a coherent *structure*?
- How do we *prioritize* the R&D goals?
- How do we estimate required *resources* and assign realistic *schedules*?

…then consider the "organization":

- What are the *current activities* that people are actually doing?
- How do we *plan* and *coordinate* future activities?
- How do we *monitor progress* and *ensure accountability*?

…and finally summarize the R&D plans presented at this meeting by the various labs and universities, and discuss the next steps.

I shall *not* discuss in any detail the technical status of any R&D items.

Methodology

An R&D database has been set up to manage the information on the various damping rings R&D goals. This includes the “ideal” objectives, and (separately) the actual activities.

The information is categorized within an R&D “WBS”:

1. Parameter optimization.

   This provides an interface with the overall machine parameters. An example of a recent activity was the study of the timing issues in ILC.

2. Beam dynamics studies.

   Includes theoretical and experimental studies.

3. Technical subsystem or component development.

4. Test facilities.

   This category is not well developed. It is intended to categorize goals associated with development and operation of the test facilities themselves: i.e. the support of other damping rings R&D goals, rather than the direct goals for the ILC damping rings.

Very High Priority R&D Objectives (from the database)

2.1.3 Beam Dynamics Studies: Single-Particle Dynamics: Low-Emittance Tuning

3 Demonstrate < 2 pm vertical emittance

2.2.1 Beam Dynamics Studies: Multi-Particle Dynamics: Single-Bunch Impedance

2 Characterize single-bunch impedance-driven instabilities

2.2.3 Beam Dynamics Studies: Multi-Particle Dynamics: Electron Cloud

1 Characterize electron-cloud build-up

2 Develop electron-cloud suppression techniques

4 Determine electron-cloud instability thresholds

2.2.4 Beam Dynamics Studies: Multi-Particle Dynamics: Ion Effects

1 Characterize ion effects

2 Specify techniques for suppressing ion effects

3.5.1 Technical Subsystem or Component Development: Kickers: Damping Ring Injection/Extraction Kickers

1 Develop a fast high-power pulser for injection/extraction kickers

Very High Priority R&D Items: Status in Brief (1)

Low-emittance tuning

We are still a factor of 2 away from demonstrating our goal of 2 pm. Encouraging results that were obtained at the KEK-ATF and LBNL-ALS have been difficult to reproduce.

Single-bunch impedance

Beam stability is a critical issue. The present baseline lattice has a relatively large momentum compaction factor to raise the instability thresholds, but this leads to a requirement for a very large RF voltage.

Electron cloud

Still a major concern. Promising approaches (low SEY coatings, grooved chambers, clearing electrodes) need to be developed and carefully evaluated.

Ion effects

Still a concern. Effects may perhaps not be very severe, but work is needed to achieve the understanding necessary to make reliable predictions of the consequences.

Very High Priority R&D Items: Status in Brief (2)

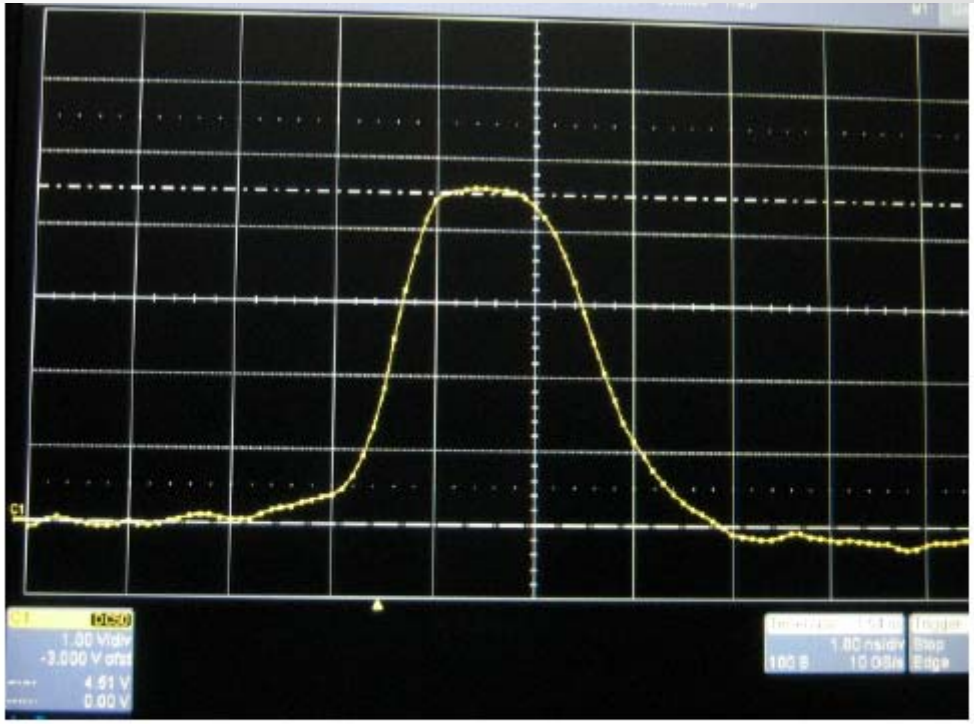
Injection/extraction kickers

Low-*Q* parameter set will require 3 ns bunch spacing (hence 3 ns kicker rise/fall time for the injection and extraction kickers) in the damping rings. This looks extremely challenging for the injection and extraction kickers. The high-*Q* parameter set relaxes the specification on the rise/fall time to 6 ns.

Several different technologies appear to come close to meeting the specifications, and are being tested.

Concerns include stability and reliability as well as the rise/fall time.

Very High Priority R&D Items: Status in Brief (3)



A_out = 4.5 x 600 = 2,700 V

Horizontal scale: 1 ns / div

Waveform: by the LeCroy osc., 10GS/s

Voltage output from Drift Step Recovery Diode, July 2006.
Alexei Kardo-Sysoev (Ioffe PTI, St Petersburg), Anatoly Krasnykh (SLAC).

High Priority R&D Objectives 1 (from the database)

2.1.1 Beam Dynamics Studies: Single-Particle Dynamics: Lattice Design

- 1 Lattice design for baseline positron ring
- 2 Lattice design for baseline electron ring
- 5 Lattice design for injection/extraction lines

2.1.2 Beam Dynamics Studies: Single-Particle Dynamics: Acceptance

- 1 Characterize damping rings acceptance

2.1.3 Beam Dynamics Studies: Single-Particle Dynamics: Low-Emittance Tuning

- 1 Develop strategies for low-emittance tuning
- 2 Specify requirements for survey, instrumentation etc.
- 4 Specify support schemes for damping rings magnets

2.2.1 Beam Dynamics Studies: Multi-Particle Dynamics: Single-Bunch Impedance

- 1 Develop single-bunch impedance models

2.2.2 Beam Dynamics Studies: Multi-Particle Dynamics: Multi-Bunch Impedance

- 1 Develop long-range wakefield models
- 2 Characterize multi-bunch instabilities

High Priority R&D Objectives 2 (from the database)

2.2.3 Beam Dynamics Studies: Multi-Particle Dynamics: Electron Cloud

3 Develop modeling tools for electron-cloud instabilities

2.2.5 Beam Dynamics Studies: Multi-Particle Dynamics: Other Collective Effects

1 Characterize space-charge effects

3.1.1 Technical Subsystem or Component Development: Vacuum: Vacuum Chamber

1 Specify vacuum chamber material and geometry

2 Develop engineering design of principal vacuum chamber components

3 Characterize vacuum system performance

3.5.1 Technical Subsystem or Component Development: Kickers: Damping Ring Injection/Extraction Kickers

2 Develop physics designs for kicker striplines

3.6.1 Technical Subsystem or Component Development: Damping Ring RF Systems: RF Cavities

1 Develop physics design for 650 MHz RF cavities

3.6.3 Technical Subsystem or Component Development: Damping Ring RF Systems: RF Controls (Low-Level RF)

1 Develop RF controls

High Priority R&D Objectives 3 (from the database)

3.7.2 Technical Subsystem or Component Development: Instrumentation and Diagnostics: Beam Position and Phase Diagnostics

2 Develop feedforward for extraction kicker stabilization

3.7.3 Technical Subsystem or Component Development: Instrumentation and Diagnostics: Beam Size and Bunch Length Diagnostics

1 Develop high-precision beam size monitor

4 Develop instrumentation for monitoring emittance damping

3.10. Technical Subsystem or Component Development: Supports and Alignment Systems: Normal-Conducting Magnet Supports

1 Specify alignment and stabilization hardware

3.13. Technical Subsystem or Component Development: Multiple Systems: Systems Integration

1 Develop integrated mechanical design

Prioritization, Resources, Schedule

We do have a structure that can be used for categorizing the various R&D objectives.

- How should the objectives be reviewed and updated?

Prioritization so far has been done “informally”, based on personal judgement and a small amount of discussion within the RDB.

- We need to formalize the process somehow.
- Should priorities be set by the RDB? Or by the Damping Rings Area Systems Group? Or both?
- How should the priorities be reviewed and updated?

Resources and schedule have not been properly addressed so far.

- This aspect of the technical issues is closely connected to the organizational issues.
- So far, for practical reasons, the approach has been to let the labs take the lead: each lab puts together a proposal (we hope guided by the priorities list, and in consultation with the community) which is submitted to a funding agency.

Organizational Issues

So far, “coordination” of the R&D has been limited to trying to collect information on activities that people are either pursuing, or plan to pursue.

This is imperfect: it is a passive approach that relies on people taking the initiative to provide accurate information.

The information that has been collected has been included in the damping rings R&D database, and cross-referenced against the R&D objectives.

Example: Activity 3.5.1.A (fast kickers)

3.5 Kickers

3.5.1 Damping Ring Injection/Extraction Kickers

3.5.1.A Development of high-availability injection/extraction kicker

Required for Baseline Status as at 4/12/2006: In progress

An initial prototype has been created and tested at the ATF in FY05. Work in FY06 will involve the design and test of new circuits for improved performance with the goal of updating the prototype.

Addresses Objectives:

3.5.1.1 Develop a fast high-power pulser for injection/extraction kickers

Investigators:

Ed Cook, LLNL

Craig Brooksby, LLNL

Chris Pappas, SLAC

Richard Cassel, SLAC

Anatoly Krasnykh, SLAC

Minh Nguyen, SLAC

* Marc Ross, SLAC

Junji Urakawa, KEK

Takashi Naito, KEK

Ray Larsen, SLAC

Example: Activity 3.5.1.B (fast kickers)

3.5.1.B Development of fast injection/extraction kicker

Required for Baseline Status as at 6/1/2006: In progress

Addresses Objectives:

3.5.1.1 Develop a fast high-power pulser for injection/extraction kickers

Investigators:

* Mark Palmer, Cornell
  Bob Meller, Cornell
  Gerry Dugan, Cornell

The list of activities at different labs runs to three pages

ANL			
2.1.1.C	Damping ring lattice characterization and optimization	*In progress*	*12-Apr-06*
3.7.3.A	Development of time-resolved photon diagnostics	*In progress*	*12-Apr-06*
ASTeC			
2.2.1.B	Develop single-bunch impedance models	*Proposed*	*28-Apr-06*
3.1.1.B	Specification for damping rings vacuum system components	*Proposed*	*02-May-06*
Cornell			
2.1.3.B	Develop low-emittance tuning strategies	*In progress*	*01-Jun-06*
2.1.3.C	Specify requirements for alignment and stabilization	*Proposed*	*02-May-06*
2.2.3.D	Model electron-cloud build-up and instabilities	*Proposed*	*28-Apr-06*
2.2.4.E	Studies of fast ion instability	*Proposed*	*28-Apr-06*
2.2.5.G	Estimate the impact from CSR	*Proposed*	*28-Apr-06*
2.2.5.H	Determine the Touschek lifetime	*In progress*	*01-Jun-06*
3.4.6.A	Develop physics design for damping wigglers	*In progress*	*28-Apr-06*
3.5.1.B	Development of fast injection/extraction kicker	*In progress*	*01-Jun-06*
3.7.3.B	Develop instrumentation for monitoring emittance damping	*In progress*	*01-Jun-06*
3.7.5.A	Develop instrumentation for fast dispersion measurements	*In progress*	*01-Jun-06*
DESY			
2.2.3.C	Model electron-cloud build-up and instabilities	*Proposed*	*28-Apr-06*
2.2.4.D	Studies of fast ion instability	*In progress*	*28-Apr-06*
FNAL			
2.2.5.B	Self-consistent modeling of space-charge effects	*In progress*	*12-Apr-06*
2.2.5.C	Self-consistent modeling of CSR effects	*In progress*	*12-Apr-06*

Planning and Coordination

We need to develop a more coherent and pro-active approach to planning and coordination of damping rings R&D. It will probably be necessary to hold face-to-face meetings at regular intervals.

We made a start at this workshop. We asked representatives to present (in 10 minutes each) their plans for taking responsibility for different topics of damping rings R&D, including statements of:

- the scope of responsibility envisioned
- the goals of the proposed R&D program
- the resources needed (compared with present resources)
- the timescale (with a comparison against the overall project timescale)
- how the resources will be provided
- potential or agreed collaborators and partners

The question now is how to move forward. There are areas of duplication that can be avoided: resolving the variety of R&D proposals into a single integrated plan will require patience, understanding and cooperation.

Overview of R&D plans beyond the RDR

	ANL	CI	Cornell	DESY	FNAL	IHEP	KEK	LBNL	LNF	SLAC
kickers			•		•		•	•	•	•
e-cloud			•	•	•			•	•	•
ions				•			•			•
low-ε_y	•	•					•	•		•
impedance	•	•						•		•
vacuum		•				•		•		
lattice design	•				•	•		•		•
acceptance	•		•					•		•
RF system			•							
RF controls								•		•
align/support			•					•		
mech.integration								•		
instrumentation	•		•				•	•		
feedback system								•	•	•
wiggler			•	•					•	
main magnets						•		•		

Overview of R&D plans beyond the RDR

There are existing, planned and proposed test facilities that can fulfill a variety of roles.

- KEK-ATF
  - Largest linear collider test facility; has carried out a highly successful program of studies on beam dynamics and instrumentation over the past several years. Will still be essential for damping rings studies (e.g. kicker development) but the focus of activities will move more towards ATF2 and beam delivery system issues in the future.
- CESR-TF
  - Hope to start operation from April 2008. Will provide opportunities for a range of important studies, including electron cloud mitigation techniques.
- HERA-DR
  - Under discussion. Could go beyond an R&D facility, if developed over several stages into a full system test and demonstration, and ultimately into one of the ILC damping rings.

The R&D program needs to take full account of the opportunities provided by the test facilities; but the test facilities should be driven by the R&D program, not the other way around.

Development of a Coordinated Global R&D Plan

What:	Who:	When:
Where necessary, clarify objectives, timescales and resources.	Laboratory Contacts & Area System Leaders	by early August
Update damping rings R&D database.	A. Wolski	by the middle of August
Identify gaps and duplications.	Area System Leaders	by the end of August
Negotiations to resolve duplications and cover gaps.	Laboratory Contacts & Area System Leaders	from now through to middle of September
Draft damping rings R&D plan with objectives, resources, schedule and role of test facilities.	Area System Leaders	by the end of September
Discuss, amend and agree damping rings R&D plan.	Laboratory Contacts & Area System Leaders	by the end of October

Development of a Coordinated Global R&D Plan

Cooperation is better than competition.

By preparing a well-coordinated R&D plan, we reduce the risks associated with decisions made by the funding agencies.

Flexibility is essential to adapt to the changing availability of resources.

Join the Damping Rings R&D Effort

We are in the fortunate position of having proposals that provide good coverage of most, if not all, of the very high and high priority R&D items.

However, there may still be specific items that need focused effort from expert groups.

For example:

alternative pulser technologies for the injection/extraction kickers;
instrumentation and diagnostics.

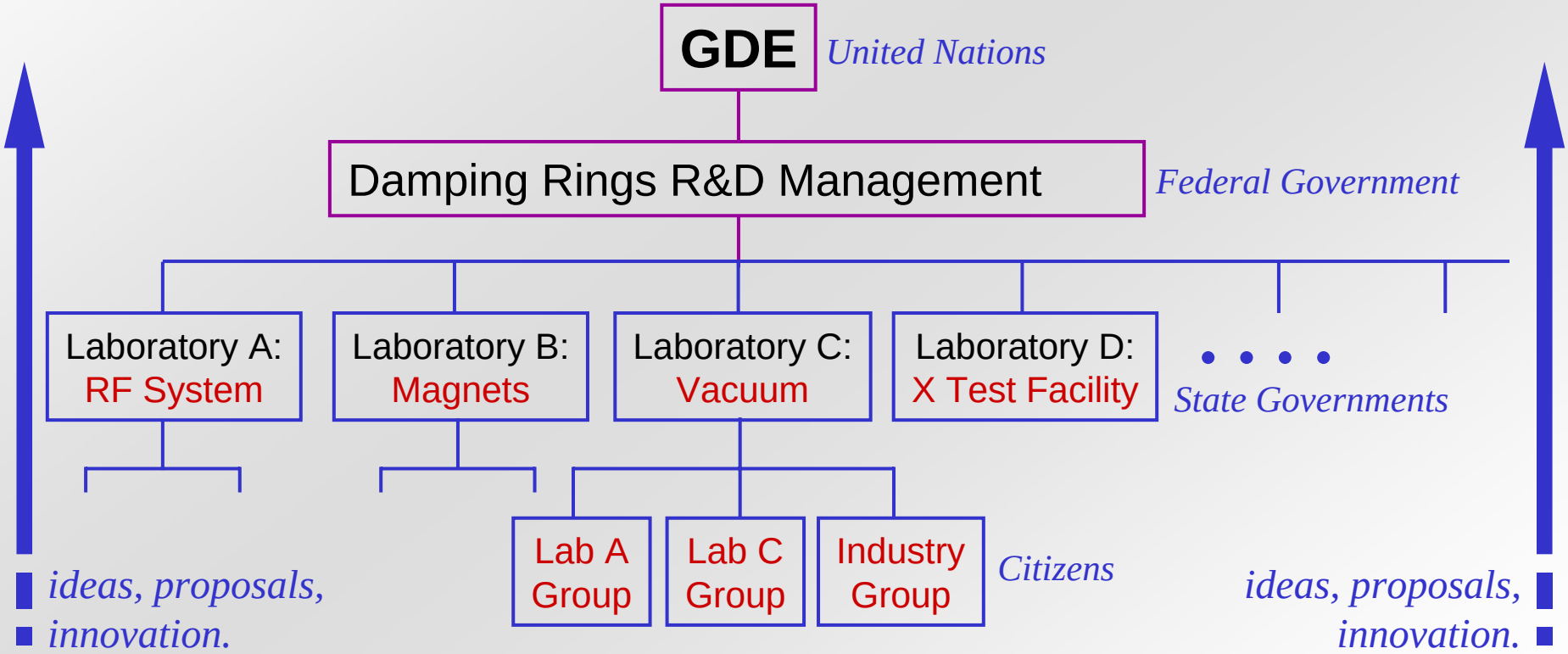
Please look at the existing R&D database, and the R&D plan as it is developed.

https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/WebHome

If you feel that you are able and interested to contribute, please contact one of the Area System Leaders (Jie Gao, Susanna Guiducci, Andy Wolski, Mike Zisman).

A vision for the R&D organisation

It would be helpful to have an organization for the damping rings R&D activities that reflects the R&D Plan. For example, different institutions have defined responsibilities for specific subsystems. We then establish a “federal” organization.



“He would allow nothing that was harmful, nor prevent anything that was helpful.”

Andrew Bolkonsky on General Kutuzov, leader of the Russian army before the Battle of Borodino, 1812. (Leo Tolstoy, “War and Peace”).