Damping Rings R&D Plan: Low-Emittance Tuning

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Objectives

S3 WBS	Objective	Priority
2.1.4.1	Develop strategies for low-emittance tuning	High
2.1.4.2	Specify requirements for survey, alignment and stabilization	High
2.1.4.3	Demonstrate < 2 pm vertical emittance	Very High
2.1.4.4	Specify support schemes for damping rings magnets	High
2.1.4.5	Specify orbit and coupling correction scheme	High

Low-emittance tuning strategies

- Emittance specification of 2 pm is a factor of two lower than the lowest emittance achieved to date.
- Achieving the specification will require:
  - **attention given to alignment sensitivities in the lattice design (e.g. choosing a working point away from coupling resonances);**
  - **precise initial survey and alignment;**
  - **correction of residual coupling using beam-based techniques;**
  - **appropriate instrumentation and diagnostics.**
- Tasks will include evaluation of lattice sensitivities, development of new tuning techniques, and systematic comparison of a range of tuning techniques.

Low-emittance tuning strategies

The required input includes:

- **Latest damping rings lattice designs; and lattices for existing storage rings to be used for benchmarking and tests.**
- **Data from previous studies of low-emittance tuning.**
- **Estimates of anticipated survey alignment precision and diagnostics performance (BPMs, beam size monitors etc.)**

The main deliverables will be:

- **Guidance on requirements for the damping rings lattice design to ease sensitivity to magnet alignment errors.**
- **Guidance on the requirements for survey, alignment and stabilization of magnets (Objective 2.1.4.2), and the configuration of the orbit and coupling correction scheme (specification and layout of the diagnostics, and orbit and coupling correction magnets – Objective 2.1.4.5).**
- **Optimized tuning methods that can be applied to demonstrate vertical emittance of less than 2 pm in existing facilities (Objective 2.1.4.3).**

Survey, alignment and stabilization

- Achieving and maintaining the specified vertical emittance of 2 pm will place demanding requirements on the survey, alignment and stabilization of the damping ring magnets.
- The required input will include:
  - **Results from studies of low-emittance tuning techniques (Objective 2.1.4.1) showing the dependence of the final achieved vertical emittance on the initial alignment accuracy.**
  - **Information from survey and alignment experts, for the implications (in time and cost) of specifications for different levels of alignment accuracy.**
- The deliverables will be:
  - **Guidance for work on lattice design, instrumentation and diagnostics, low-emittance tuning techniques etc., on whether further work is needed to ease requirements on initial alignment of the damping ring magnets.**
  - **Specifications for the survey and alignment accuracy required for the damping ring magnets.**

Demonstrate < 2 pm vertical emittance

- Required to validate simulation studies.
- Will require the following tasks to be accomplished:
  - **Evaluation of the availability of facilities (for example, ATF, CesrTA, APS, ALS etc.), and their capability to meet the requirements of low-emittance tuning techniques.**
  - **Upgrade to diagnostics, orbit and coupling correction systems, etc.**
  - **Implementation of low-emittance tuning techniques, and evaluation of the results (and implications for the damping rings).**
- Deliverables will include:
  - **Demonstration that the vertical emittance goal of 2 pm in the damping rings is achievable.**
  - **A range of essential information and data for improving the completeness of low-emittance tuning simulations, for optimising low-emittance tuning techniques (Objective 2.1.4.1), and for specifying design requirements for the lattice, coupling correction schemes (2.1.4.5), instrumentation and diagnostics performance, and survey and alignment accuracy (2.1.4.2).**

Specify magnet support schemes

- Vibrations (10 ~ 100 Hz) and slow ground motion (hours, days and weeks) are a concern.
- Magnets may be placed on individual stands, or grouped on girders.
- Technical designs for support stands will be needed for the Engineering Design Report.
- The following tasks must be completed:
  - **Identify different options for support schemes. Evaluate the impact of the different options on low-emittance tuning.**
  - **Complete a detailed specification for a particular choice of support scheme.**
  - **Prepare technical designs for the magnet supports, which will allow modeling of the magnet vibration and long-term magnet alignment stability.**
  - **Construct prototype supports, and evaluate stability performance.**

Specify magnet support schemes

The deliverables will include:

- **Specification of baseline magnets support scheme, consistent with alignment and stability requirements (Objective 2.1.4.2) and low-emittance tuning techniques (Objectives 2.1.4.1 and 2.1.4.3).**
- **Models of magnet vibration and stability for input to studies of low-emittance tuning (Objective 2.1.4.1) and beam stability.**
- **Prototype magnet supports, ready for final engineering design.**

Specify orbit and coupling correction

- Need to specify quantities, locations, functionality and performance of diagnostics and instrumentation (particularly BPMs) and orbit and coupling corrector magnets.
- BPM specifications have impact on lattice design and machine impedance.
- Tasks will include:
  - **Identify the options for coupling and correction schemes, including variable numbers and positions of monitors and correctors.**
  - **Evaluate the performance of the various schemes.**
- The main deliverable will be:
  - **Specification of the coupling and correction scheme for the baseline configuration, including quantities, functionality, performance and locations of the diagnostics and instrumentation, and the orbit and coupling correction elements.**

Required Resources

Staff Effort (FTE)
Excludes operational support for Facilities.

	2007	2008	2009
Low-emittance tuning techniques	2.0	2.0	2?
Survey, alignment, stabilization	0.5	0.5	0.5?
Demonstrate 2 pm	2.0	2.0	2?
Specify support schemes	2.0	2.0	2?
Specify orbit and coupling correction	1.0	1.0	1?

M&S (US$k)
Excludes operating costs for Facilities

	2007	2008	2009
Low-emittance tuning techniques	0	0	0
Survey, alignment, stabilization	0	0	0
Demonstrate 2 pm	350	350	350?
Specify support schemes	0	0	100?
Specify orbit and coupling correction	0	0	0

Potential Investigators

ANL
- Louis Emery
- Vadim Sajaev
- Aimin Xiao

Cockcroft Institute
- James Jones
- Kosmas Panagiotidis
- Andy Wolski

Cornell
- Scott Chapman
- Don Hartill
- Richard Helms
- Mark Palmer
- David Rubin
- Maury Tigner

KEK
- Kiyoshi Kubo
- Junji Urakawa

LBNL
- Gregg Penn
- Ina Reichel
- Marco Venturini
- Mike Zisman

Oxford University
- Armin Reichold
- David Urner

SLAC
- Yunhai Cai