Proposal to the
University Consortium for a Linear Collider

August 28, 2002

Proposal Name

Investigation and prototyping of fast kicker options for the TESLA damping rings.

Classification (accelerator/detector: subsystem)

Accelerator: damping rings

Personnel and Institution(s) requesting funding

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Collaborators

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Project Overview

The large number of bunches (2820) and the relatively large inter-bunch spacing (337 ns) in the TESLA linear collider design give a bunch train which is more than 200 km long. A damping ring of this size would be very costly, and so the bunch train is damped in a compressed form, with a bunch spacing of 20 ns, leading to a damping ring with a circumference of 17 km.

In the TESLA baseline, the rise and fall time of the damping ring injection and extraction kickers determine the circumference of the ring. There is considerable leverage in developing faster kickers, as this translates directly into a smaller circumference ring. The baseline system for 500 GeV (cm) parameters has a 20 ns specification for the kicker pulse width; this becomes about 12 ns for the 800 GeV (cm) parameters. Designs and prototype results exist [1] for conventional kickers with widths of 7 ns, and design have been developed for more novel ultrafast schemes [2] using electron beams.

We propose to further explore the feasibility of the kicker designs described in the references cited above. We will also develop new ideas for fast kickers. For example, we will explore the possibility of the use of the ponderomotive force from a high-intensity laser pulse to provide a very short kick to the beam. We will work closely with our collaborators from the University of Illinois and Fermilab in exploring the novel fast kicker concept which is the subject of their proposal, *Investigation of Novel Schemes for Injection/Extraction Kickers*, to the LCRD consortium.

In the TESLA baseline design, both the injection and extraction kickers must be fast. The injection kicker is considerably more difficult than the extraction kicker, because of the larger beam size at injection. We will investigate the possibility of single-turn injection of beam into the damping rings, which would eliminate the need for a fast injection kicker.

It should be noted that, in addition to the small pulse width (of order ns) required for the kicker, extremely good pulse-to-pulse reproducibility is required in order to avoid beam jitter at the collision point. The fast intra-train feedback at TESLA cannot compensate for pulse–to-pulse jitter introduced by the extraction kicker. Part of the evaluation of the feasibility of any new kicker scheme must include an evaluation of the expected pulse-to-pulse jitter.

If a new fast kicker scheme is found to be technically feasible on paper, we propose to do an engineering design of a prototype, build the device, and test it using a high energy electron beam.

If the development of a fast kicker is successful and the ring size can be reduced, the average current will go up and at some point multibunch beam stability becomes the limiting factor to a further reduction in the ring size. This has been explored for two specific cases in prior work [3], for an earlier set of TESLA beam parameters. We propose to update and expand on these considerations, including our current understanding of critical stability issues such as the electron cloud, and to determine the minimum ring size permitted by beam dynamics considerations.

FY2003 Project Activities and Deliverables

During the first year, we will review fast kicker schemes which have been proposed in the past, and explore the feasibility of new kicker schemes. We will investigate the possibility of single-turn injection of beam into the damping rings. We will determine the minimum ring size permitted by beam dynamics considerations. This work will be done by one of the scientific staff members, together with a graduate student.

The first year deliverables will be 3 technical reports: on the feasibility of fast kicker schemes, the feasibility of single-turn injection for the TESLA damping rings, and on the minimum allowable ring size as set by the beam dynamics.

FY2004 Project Activities and Deliverables

Assuming that we have found a feasible design for a fast kicker scheme, in the second year we will execute an engineering design for a prototype kicker, and build the prototype. Although it may not be a full scale device, we will include in the prototype all the features needed to address the principal technical challenges of the device. The work will be done by scientific and engineering staff members, and the graduate student.

The second year deliverable will be the prototype kicker.

FY2005 Project Activities and Deliverables

In the third year, we will test the performance of the kicker. This will involve electrical measurements such as peak current, rise and fall time, and pulse-to-pulse reproducibility. We will also test the kicker in a high energy electron beam, either at CESR or a similar facility with an available beam. The work will be done by scientific and engineering staff members, and the graduate student.

The third year deliverable will be a technical report describing the results of the kicker prototype tests.

Budget justification

The first year's activities are limited to design studies, which will involve staff members and one graduate student (not included in the budget shown here). A minimal amount of travel funds is included to cover trips for consultations with collaborators.

During the second year, the design and construction of the prototype will be supported by 1/2 FTE of engineering and technician manpower. The graduate student support will continue.

During the third year, the testing of the prototype will be supported by 1/4 FTE of technician manpower, together with a graduate student.

Indirect costs are calculated at Cornell's 57% rate on modified total direct costs.

Three-year budget, in then-year K$

Institution: Cornell University

Item	FY2003	FY2004	FY2005	Total
Other Professionals	0	41	21	62
Graduate Students	0	0	0	0
Undergraduate Students	0	0	0	0
Total Salaries and Wages	0	41	21	62
Fringe Benefits	0	14	7	21
Total Salaries, Wages and Fringe Benefits	0	55	28	83
Equipment	0	0	0	0
Travel	2	2	5	9
Materials and Supplies	0	50	25	75
Other direct costs	0	0	0	0
Total direct costs	2	107	53	162
Indirect costs	0	14	14	28
Total direct and indirect costs	2	121	67	190

References

[1] B. I Grishanov et. al., Very Fast Kicker for Accelerator Applications, TESLA note 96-11 (1996)

[2] V. Shiltsev, Beam-beam Kicker for Superfast Bunch Handling, NIM A374, p. 137 (1996)

[3] V. Shiltsev, TESLA Damping Ring Impedances: Preliminary Design Consideration, TESLA note 96-02 (1996)