**Project name**

Investigation of Novel Schemes for Injection/Extraction Kickers

**Classification (accelerator/detector:subsystem)**

Accelerator

**Institution(s) and personnel**

University of Illinois at Urbana-Champaign, Department of Physics:
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**Project Overview**

The injection/extraction kicker systems for damping rings in both the NLC and TESLA linear collider designs pose interesting challenges of speed, stability, and reproducibility.

The NLC damping ring design presently requires kickers with rise/fall times of ~60 ns, and "flat top" fields which are stable for ~270 ns in order to inject, and then extract, a train of 192 bunches from the main damping ring. The entire train will orbit inside the damping ring with the same 1.4 ns bunch spacing as when the train travels down the NLC linac.

The 2820 bunches of a TESLA pulse would require an unacceptably large damping ring if the 337 ns linac bunch spacing were used in the damping ring. As a result, the TESLA 500 GeV design calls for 20 ns bunch separation in a 17 km circumference damping ring; a fast kicker will deflect individual bunches on injection or extraction, leaving the orbits of adjacent bunches in the damping ring undisturbed. A number of the kicker designs which have been considered involve the creation of individual magnetic field pulses of sufficiently short duration so that only one bunch is influenced by a pulse. The demands of short rise/fall times and pulse-to-pulse stability are challenging. A system capable of generating shorter pulses would allow the construction of a smaller damping ring.

We propose to investigate the feasibility of novel designs for damping ring kicker systems.

One class of designs to be considered would replace the pulsed kicker system with an oscillator (for NLC) or set of oscillators (for TESLA) whose (oscillating) fields could be charged rapidly and then maintained while kicking bunches from the damping ring.

The TESLA kicker might be built from a set of oscillators whose frequencies and phases were chosen to kick every $n^{th}$ bunch in a train while leaving undisturbed the train's other ($n$ - 1) bunches. Injection (or extraction) of the entire train would be completed by the end of the $n^{th}$ orbit after the kicker was energized.

The total field integral (as a function of time) for a 17-element system appropriate for a TESLA damping ring bunch spacing of 10.21 ns and linac bunch spacing of 337 ns is shown in Figure 1. Individual oscillators run at frequencies which are integral multiples of the linac bunch frequency so that

$$\int_{\substack{entire \\ train}} Bdl = 10 \text{ Gauss-m} \times \left[ \frac{1}{2} + \sum_{k=1}^{k=16} \cos\left( \frac{2\pi k}{337 \text{ ns}} t \right) \right].$$

Bunches 0, 33, 66,… are kicked but other bunches pass through while the field integral is zero. The highest frequency element oscillates at 48.97 MHz.

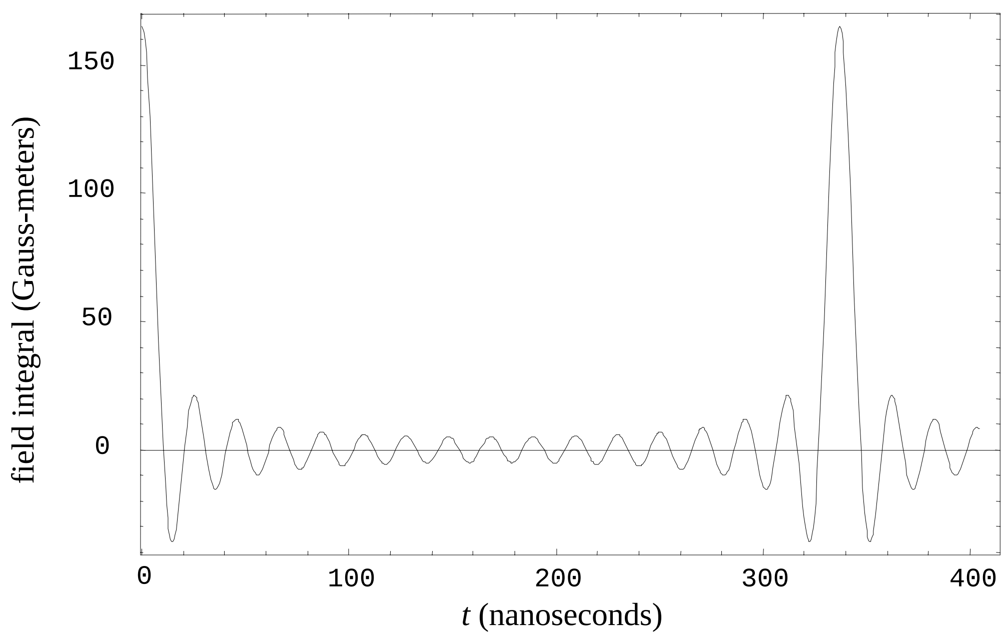


Figure 1. Field integral (Gauss-meters) *vs*. time (ns) in a 17-element system. Bunches 1 and 34 are kicked, while damping ring bunches 2 through 33 pass through the kicker during the zeroes of the field integral.

It is conceivable that such a system could be built from rf cavities driven in an appropriate mode; rapid excitation of the cavities, or the invention of some other scheme to avoid disturbing the beam during cooling must be investigated. The stability issues are likely to be different for a system of oscillators than they are for the pulsed stripline systems currently being considered.

A number of other ideas for kicker systems have been described in the accelerator physics literature and will also be studied.

The proposed work could lead to the design of a feasible, stable kicker system; in the case of the TESLA kicker it might permit the construction of a much smaller damping ring at considerable savings to the project.

**Description of first year project activities**

During the first year we will explore the prospects of building the NLC and TESLA damping ring kicker systems with some of the novel approaches described in the accelerator physics literature, as well as pursuing studies of the approach briefly described above. The end product of the first year's activities will be a technical report discussing the feasibility of several approaches to the design of the damping ring kickers for NLC and TESLA.

The budget is modest since the first year's activities are limited to design studies to be performed by staff already at the participating institutions. It contains requests for a small amount of materials as well as travel associated with conferring with collaborators.

Future work is likely to involve the engineering studies which would be necessary to construct a prototype element of a kicker system. After the first year, this is likely to be an ideal project for student participation so we would expect to request a modest amount of support for a senior undergraduate physics major in addition to funds associated with prototype construction.

**Budget**

| Institution | Item | Cost |
|---|---|---|
| Illinois | Travel | $1,500 |
| Illinois | Boorum and Pease ESS16021215Q laboratory notebook | $44 |
| Illinois | Indirect costs | $818 |
| Illinois | Illinois total | $2,362 |
| other institutions | | $0 |
| | Grand total | $2,362 |