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E-890 (Rosenzweig) **Advanced Accelerator Test at the Fermilab Electron Source Facility**

UCLA, Fermilab

Status: *No Data Yet*

A new set of experiments is proposed which uses accelerator facilities now under construction at Fermilab to accomplish several scientific objectives. The core of the facility is a short-bunch, long-pulse photoinjector, which can produce a train of intense electron bunches. Owing to the uniqueness and versatility of this facility, it can be used for multiple purposes in both accelerator and basic physics research.

There is widespread interest in developing high-gradient accelerating structures to pave the way toward more compact and affordable high energy accelerators. However, high-gradient acceleration is by nature faced with three problems to be solved: 1) to find a suitable structure or medium to support a high electric field for accelerating test particles using immediately available power sources; 2) to find methods to manipulate and synchronize intense beams for acceleration once the electric field is produced; and 3) to develop efficient compact power sources to couple energy from the external world to the accelerating structure, allowing staging of acceleration sections. In this proposal, we outline an experiment that can be performed at Fermilab, where staging of GeV/m accelerating sections can be demonstrated for the first time, using wakefields in plasmas driven by ultra-high brightness electron beams[1].

The plasma wakefield accelerator (PWFA) concept is based on the excitation of a steep field gradient in a plasma due to the injection of an intense drive electron beam, followed by a witness bunch which is to be accelerated. A promising regime which offers the most freedom from sources of instability and includes intrinsic linear focussing properties can be realized by the injection of an intense drive electron bunch into an underdense plasma, creating a symmetric focussing channel, the so-called electron blowout regime. Recent experimental work by the UCLA team at Argonne has shown effective generation of such channels, along with a significant acceleration gradient[2].

Perhaps the most important experiment to be undertaken in this area is that of synchronization of the witness bunch with the wakefields generated by the excitation bunch. Recently, it has been proposed that magnetic compression of an rf photoinjector beam can be applied to effectively reduce injection jitter from the witness beam that has plagued previous attempts at acceleration[3]. Such a scheme (shown schematically in the figure) would enable a first real attempt at synchronization and low-emittance, low-energyspread acceleration - with the possibility, currently unique to the Fermilab facility, of staging the accelerating sections.

The components of the experimental program envisioned are:

a) Demonstrate synchronization of a witness beam with the beam-generated wakefields in the blow-out regime of the PWFA, using an rf photoinjector with a bunch compression system;

b) Demonstration of GeV/m acceleration;

c) Understand the beam matching physics between successive modules of a multiple stage scheme. This includes the development of effective kickers or other schemes for merging drive and witness beams, and understanding of the beam dynamics; and

d) Demonstrate multiple stage acceleration using the PWFA; determine physics of intensity and gradient scaling, diagnose beam quality after each accelerating section.

The physical demands on the Fermilab facility for this project would be minimal. The basic experimental setup, as shown in the figure, consists of a plasma chamber at the end of the photoinjector/linac section. The primary diagnostics for the experiment are based on the Compton scattering apparatus described in E-886. It is envisioned that the work will proceed in two phases: the first phase will be the diagnosis of the accelerating channels produced by the drive beam, including demonstration of acceleration. A second phase would involve the demonstration of successful coupling of two stages.

References

1. J. B. Rosenzweig, Proc. Linear Accelerator Conference, Chalk River, AECL-10728, (1993).

2. N. Barov, et al., Proc. Particle Accelerator Conference, Dallas (1995).

3. J. B. Rosenzweig, N. Barov, and E. Colby, IEEE Trans. Plasma Science 24, 2, (1996).

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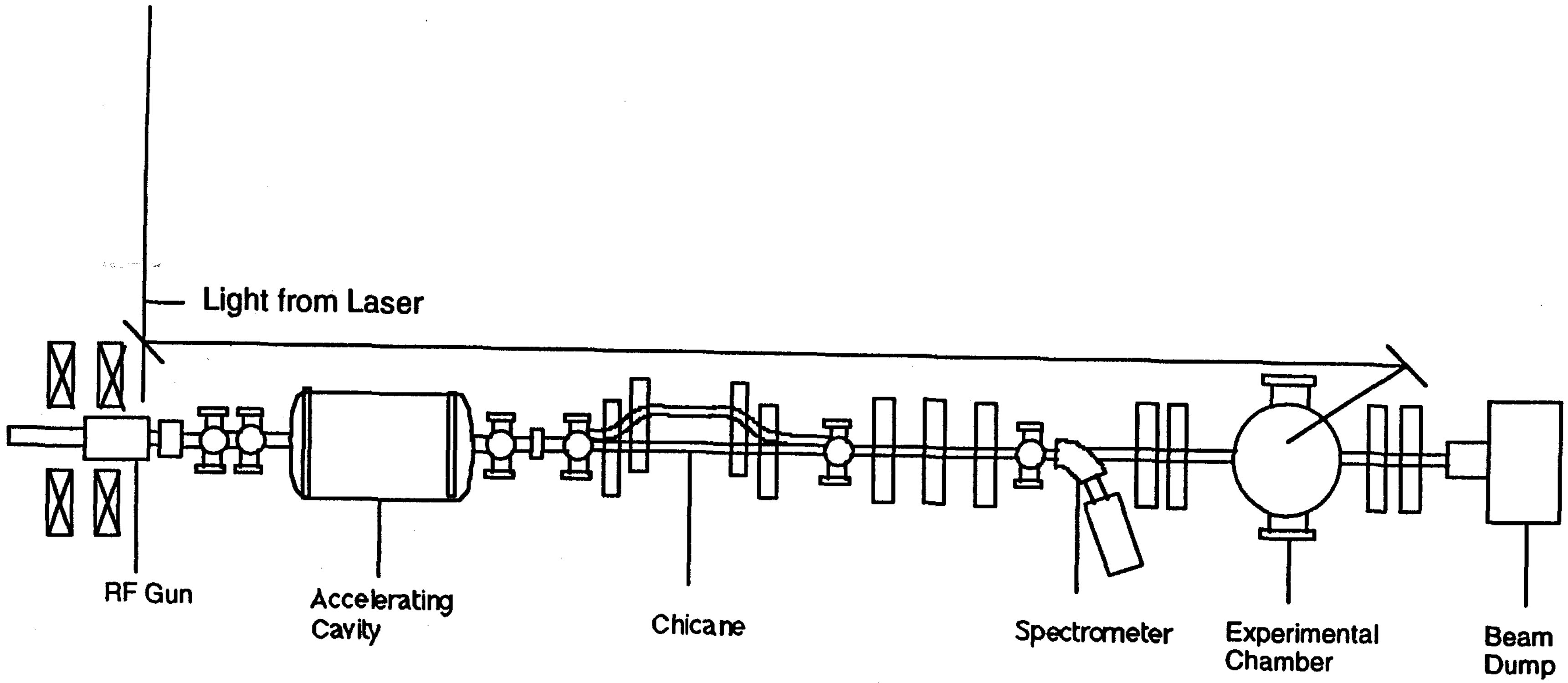

Schematic diagram of the electron source facility. A laser-driven photocathode produces short electron bunches which are accelerated by a superconducting cavity. A magnetic chicane is used to compress the bunches longitudinally, which are then focussed into the experimental chamber.

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