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Title:

High Current L-band Linac

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Abstract. The Sub-Picosecond Accelerator (SPA) at the Los Alamos National Laboratory is an L-band photoinjector. Using magnetic compression, the SPA routinely compresses 8 MeV, 1 nC per bunch electron beams from an initial temporal FWHM bunch length of 20 ps to less than 1 ps. In recent plasma wakefield accelerator experiments, we have compressed a 2 nC per bunch electron beam to an approximate temporal length of 1 ps.

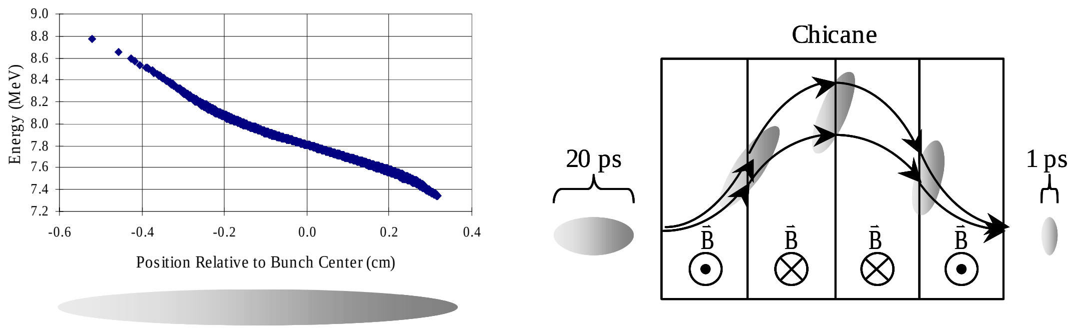
1. Introduction

The Sub-Picosecond Accelerator facility (SPA) at Los Alamos National Laboratory is an 8 MeV, radio-frequency photoinjector operating at 1300 MHz[1]. The SPA has compressed electron pulses containing 1 nC of charge to sub-picosecond lengths[2].

Recent experiments on the SPA have used its very short, high peak current beam as the drive beam in an electron beam driven plasma wakefield accelerator (PWFA) experiment. In these experiments, we have compressed electron pulses containing 2 nC of charge to lengths of approximately 1 ps FWHM and generated plasma wakefields as high as 60 MV/m in a 3 mm long plasma.

2. Experiment

Magnetic bunch compression is a well-understood process. By injecting our electron beam at the appropriate phase in the rf cycle, we obtain an energy versus longitudinal position correlation like that shown in Figure 1a. Subsequently, when the beam travels through the chicane, Figure 1b, the electron pulse is compressed.



a) b)

Figure 1: a) Plot of energy versus electron position in bunch. b) Diagram of electron motion in chicane.

2.1 Pulse length measurements

At low charge, 0.1 nC per bunch, we measured a bunch length less than 0.25 ps FWHM using an rf deflecting cavity to streak the beam on an OTR screen[2]. At higher charge (1 nC) we were unable to use this technique because space charge expansion of the beam limited our resolution. Instead, we inferred the bunch length from the space charged induced energy spread[2].

Figure 2a shows a plot of the beam energy spread versus the chicane bending angle for a 2/3 nC per bunch beam. As the angle is increased, we see the energy spread decrease up to the point of maximum bunching, at which point the energy spread of the beam increases dramatically. Figure 2b shows a plot of

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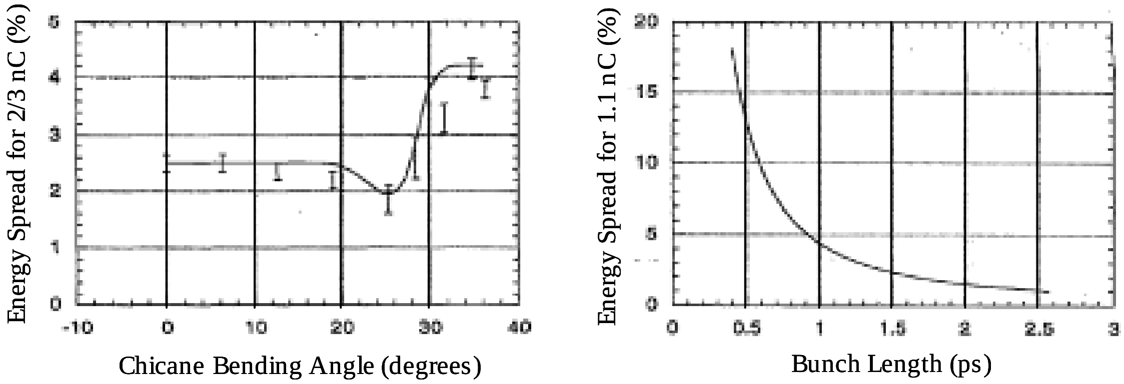
energy spread versus bunch length as calculated by PARMELA for a 1.1 nC per bunch beam. From this type of calculation we can infer a minimum bunch length of 0.4 ps for the 2/3 nC beam in Figure 2a.



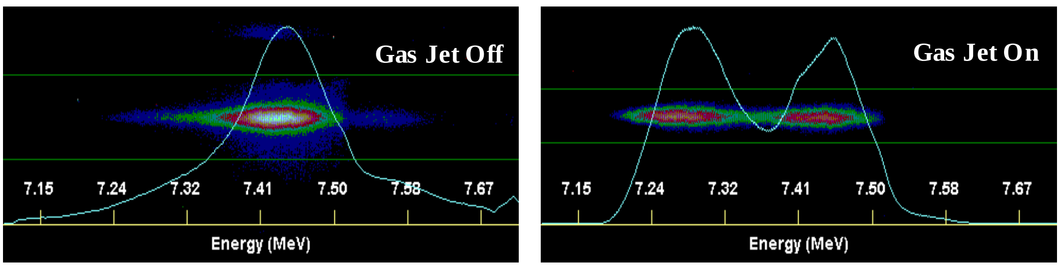
a) b)

Figure 2: a) Plot of beam energy spread versus chicane bending angle for 2/3 nC per bunch beam. Solid line is from a PARMELA[3] simulation. Maximum beam compression occurs at about 30 degrees. b) Energy spread versus bunch length for a 1.1 nC per bunch beam as simulated by PARMELA[3].

2.2 Plasma wakefield accelerator experiment

A recent experiment used the SPA electron beam as the drive beam in a PWFA experiment[4], [5]. The bunched electron beam was directed into a plume of xenon gas generated by a rectangular gas jet built by Northrop-Grumman. The gas jet is 3 mm long and 0.7 mm wide. The electron beam passes 200 microns above the jet opening along the long axis of the jet. The neutral gas density is 5 x 10^{17} atoms/cc.

In our experiments, we observed that the first two electron pulses in the beam cause the jet to ionize, forming a 3 mm long plasma. Subsequent beam pulses experience plasma wakefields as high as 60 MV/m. Figure 3 shows the energy spectrum of the beam for a five bunch beam with 2 nC per bunch and a FWHM temporal length of approximately 1 ps. Figure 3a shows the energy spectrum with the gas jet off. Figure 3b shows the energy spectrum for the same beam, but with the gas jet on.



a) b)

Figure 3: a) Energy spectrum of five-pulse beam, 2 nC per bunch, gas jet off. b) Energy spectrum of five-pulse beam, 2 nC per bunch, gas jet on (plasma present).

3. Acknowledgements

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