• Experimental Investigation of the Longitudinal Beam Dynamics In a Photoinjector Using a Two-Macroparticle Bunch

• Manipulation of the Drive Laser Longitudinal Profile at the Fermilab/NICADD Photoinjector Laboratory
Pulse-stacker is used to get a quasi-flattop pulse in a time domain by stacking four Gaussian pulses.
BUNCH LENGTH VERSUS CHARGE

Electron bunch length vs. charge
Astra simulation and experimental results

Gaussian, laser rms=2.4ps

Stacked, laser rms=6.6ps
EMITTANCE VERSUS SOLINOID CURRENT

- ASTRA simulation (solid lines) and experimental data (circles and diamonds); blue—flattop, and red—Gaussian.
MAGNETIC BUNCH COMPRESSION THEORY

• An electron with coordinate \((t_i, d_i)\) in the longitudinal phase space within the bunch is mapped downstream the bunch compressor following:

\[
ct_f = ct_i + R_{56} \delta_i - \frac{3}{2} R_{56} \delta_i^2, \quad \delta_i = \delta_f, \text{ where } \delta_i = \frac{\varepsilon_i - \langle \varepsilon \rangle}{\langle \varepsilon \rangle}
\]

• the minimum bunch length is achieved provided the incoming chirp and momentum verify:

\[
\frac{c}{R_{56}} = \frac{d \delta_i}{dt_i}
\]
MAGNETIC BUNCH COMPRESSION THEORY

• We note that in the case of two macroparticles, the evolution of the macroparticle separation downstream of the bunch compressor can be written as:

\[
\Delta \tau_f = \Delta \tau_i + \frac{R_{56}}{c} \frac{\Delta \varepsilon}{\varepsilon} \left[ 1 - \frac{3}{2} \frac{\Delta \varepsilon}{\varepsilon} \right]
\]

• To calculate \( R_{56} \) we need the best compression phase \( f \) only

\[
-R_{56} = 3.67 \frac{\varepsilon_0 + \varepsilon_0^{cav} \cos \phi}{\varepsilon_0^{cav} \sin \phi - \frac{1}{\pi} \varepsilon_0} \text{ (cm)}
\]
EXPERIMENTAL SET-UP

• The photoinjector laser beam is split into two and then recombined in such a way that a time-delay is introduced between the two pulses

• The delay can be remotely varied from 7 to 35 ps
Example of data set for measurement of energy separation between the two macroparticles. a): beam density on dispersive viewer, b): corresponding projection
RESULTS

• **EMITTANCE MEASUREMENTS:** The lowest emittance for the Gaussian was measured to be 3 mm mrad; for the flat-top it is 2.5 mm mrad. This agrees well with the ASTRA simulation.

• **MAGNETIC BUNCH COMPRESSION:** The measured energy was 12.9 MeV and the macroparticle energy spread was 0.84 MeV. The time separation between the two macroparticles was: 17.8 ps. This yields the value for the momentum compaction of 9.1 cm. The theoretical value is 8.3 cm.