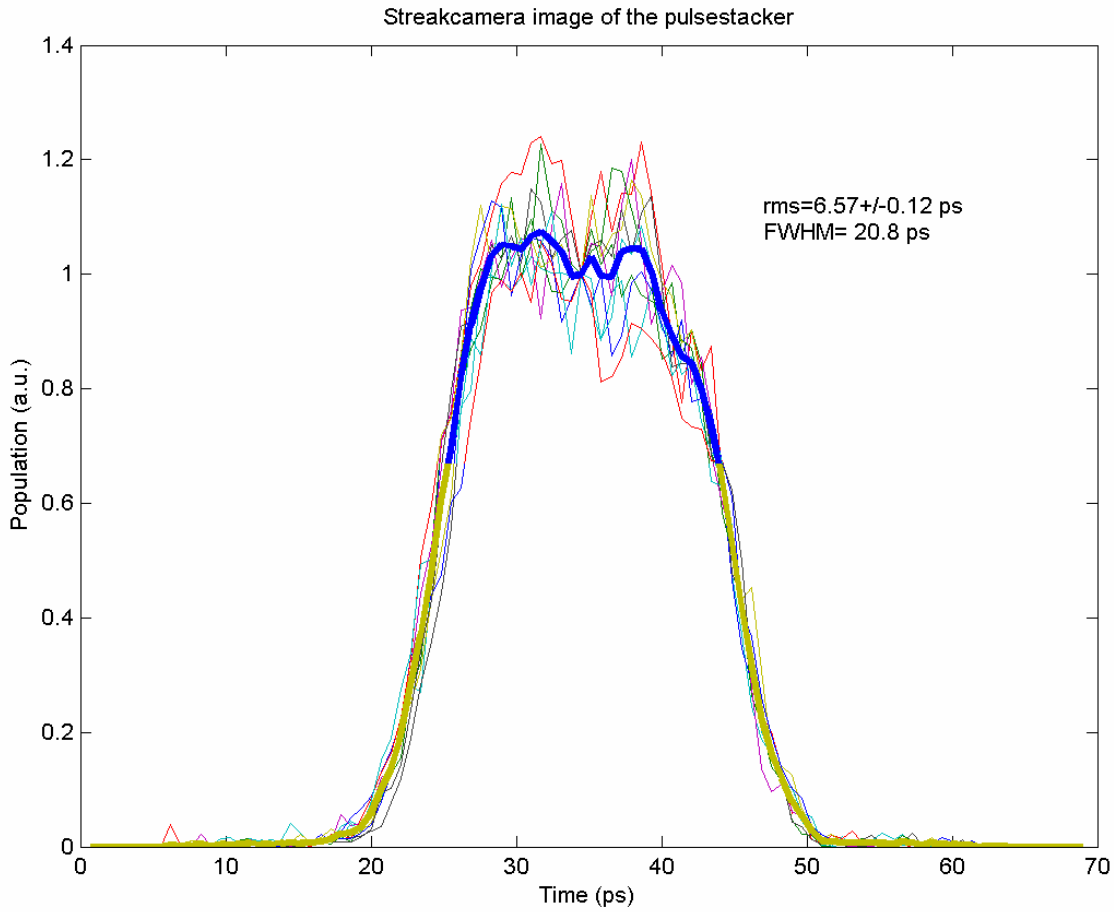
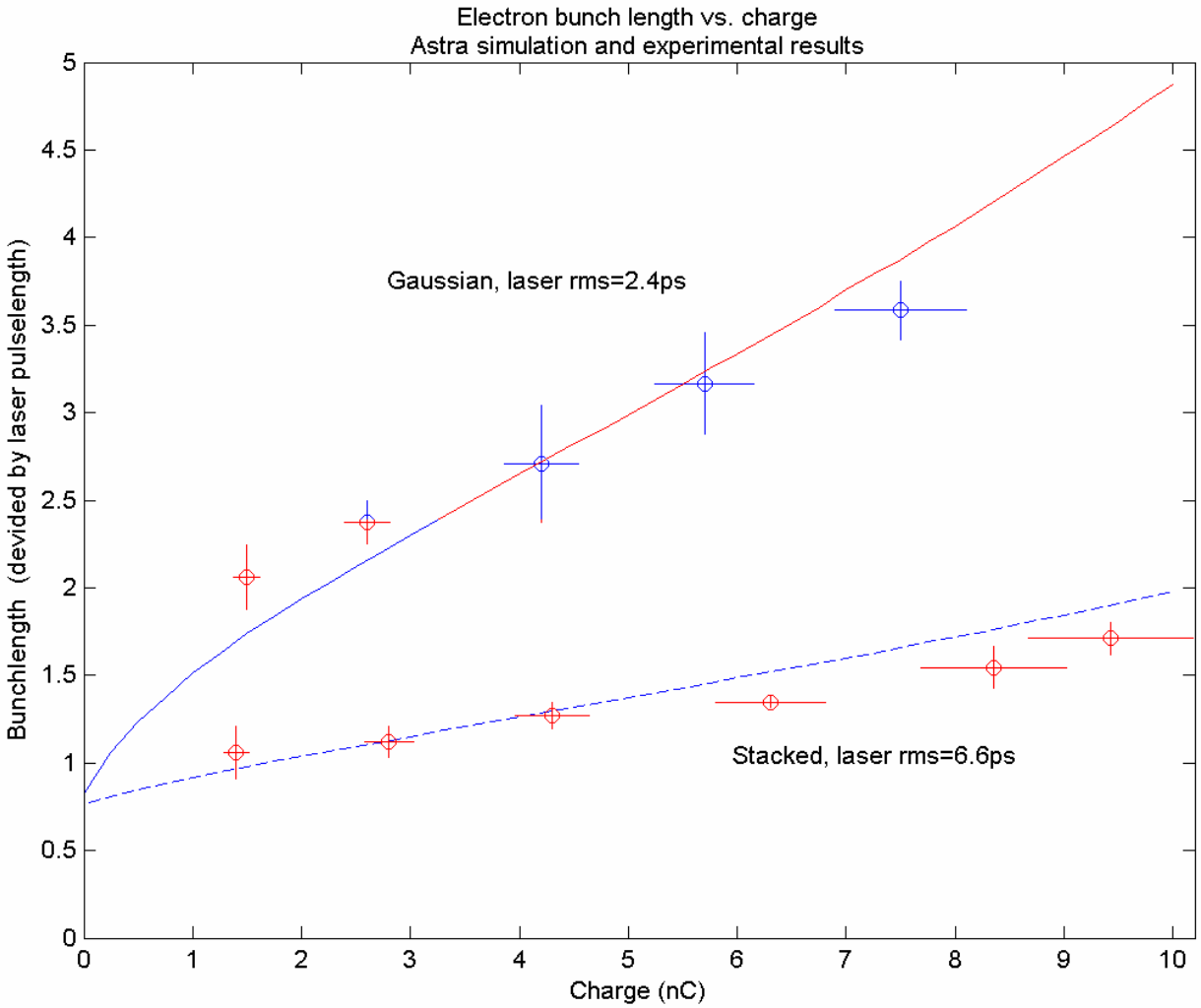
- **Experimental Investigation of the Longitudinal Beam Dynamics In a Photoinjector Using a Two-Macroparticle Bunch**
- **Manipulation of the Drive Laser Longitudinal Profile at the Fermilab/NICADD Photoinjector Laboratory**

STACKED PULSED

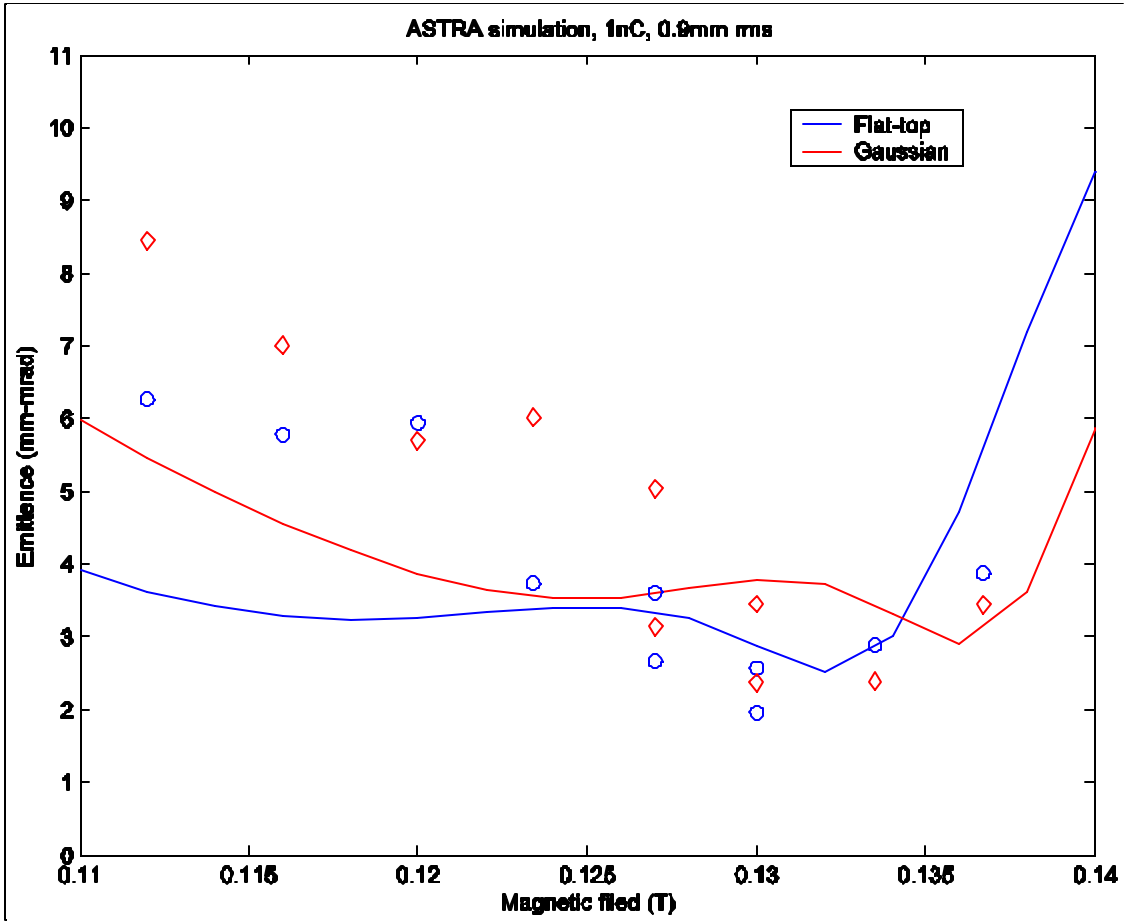


Pulse-stacker is used to get a quasi-flattop pulse in a time domain by stacking four Gaussian pulses.

BUNCH LENGTH VERSUS CHARGE



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:

$$ct_f = ct_i + R_{56} d_i - \frac{3}{2} R_{56} d_i^2,\ d_i = d_f, \text{ where } d_i = \frac{e_i - \langle e \rangle}{\langle e \rangle}$$

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

$$\frac{c}{R_{56}} = \frac{d d_i}{d t_i}$$

MAGNETIC BUNCH COMPRESSION THEORY

- We note that in the case of two macropaticles, the evolution of the macropaticle separation downstream of the bunch compressor can be written as:

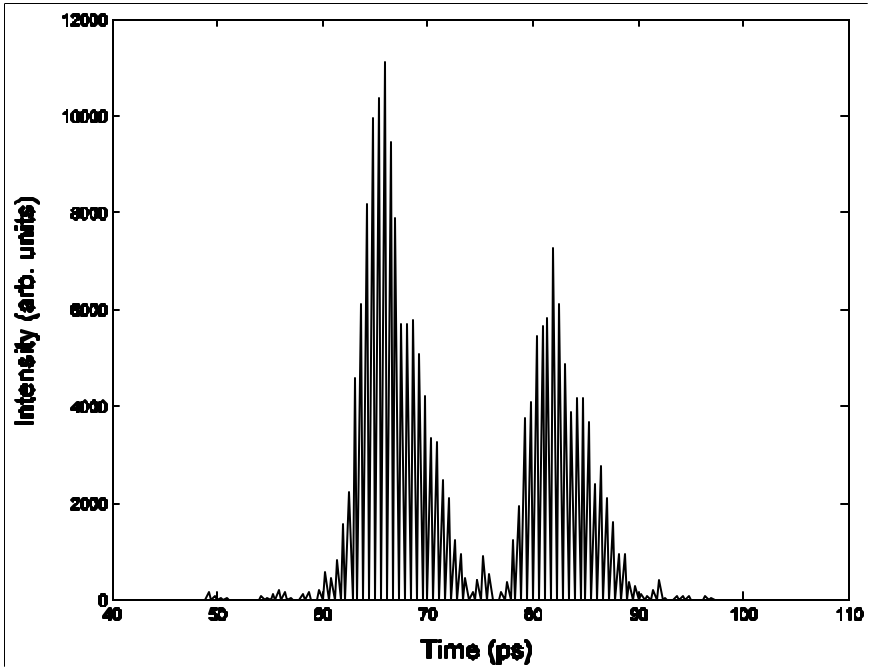
$$\Delta t_f = \Delta t_i + \frac{R_{56}}{c}\frac{\Delta e}{e}\left[1 - \frac{3}{2}\frac{\Delta e}{e}\right]$$

- To calculate R_{56} we need the best compression phase f only

$$-R_{56} = 3.67\,\frac{e_0 + e_0^{cav}\cos f}{e_0^{cav}\sin f - \frac{1}{p}e_0}\ \text{(cm)}$$

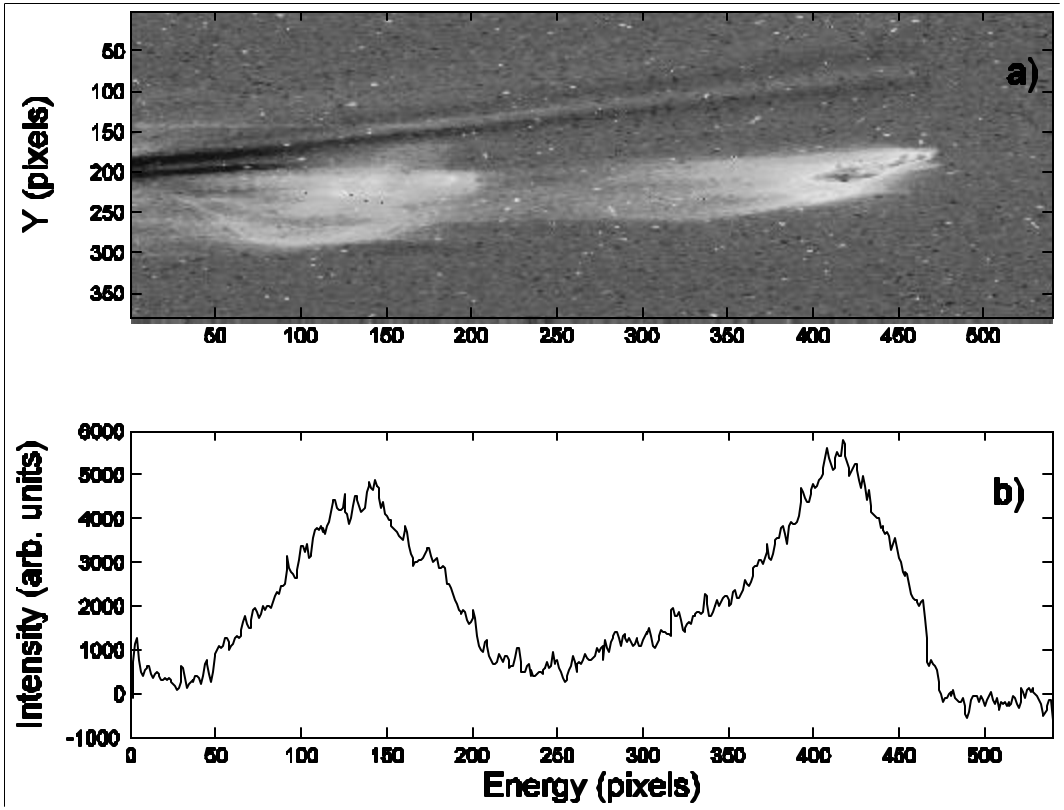
EXPERIMENTAL SET-UP

- 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

EXPERIMENTAL SET-UP



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.