

Streaking the ultra-short electron beams at optical frequencies

(preliminary studies, comments please)

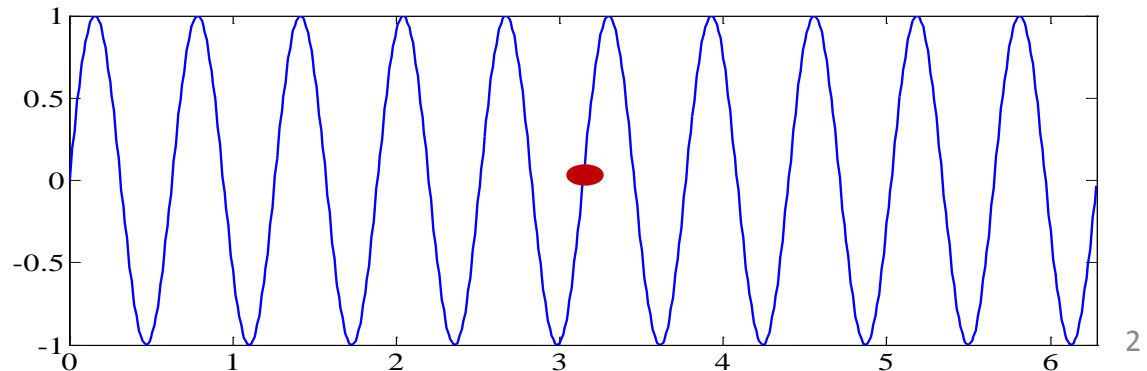
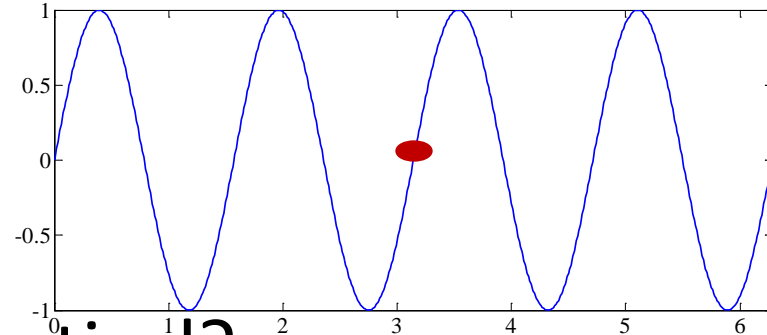
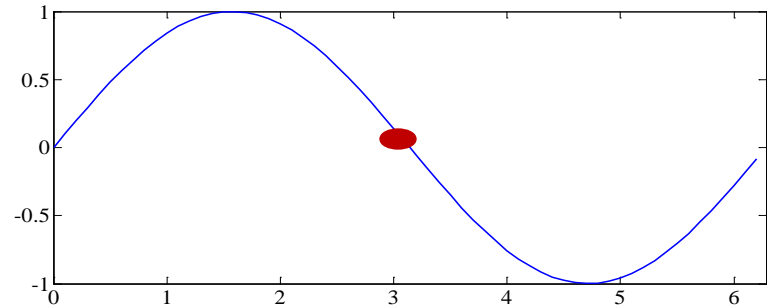
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FLS2010, Menlo Park, California

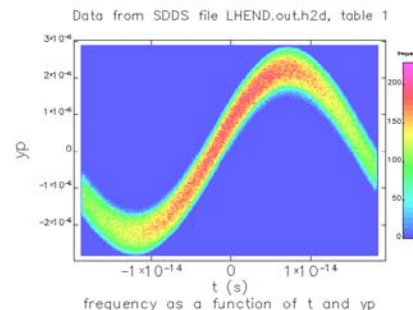
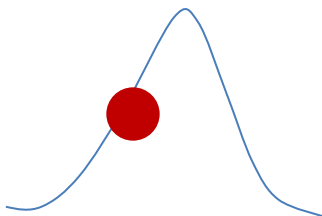
RF deflector \rightarrow optical deflector

- S-band RF deflector
resolution ~ 20 fs
- X-band RF deflector
resolution ~ 2 fs
- How about going to optical?



Modulation with CO2 laser

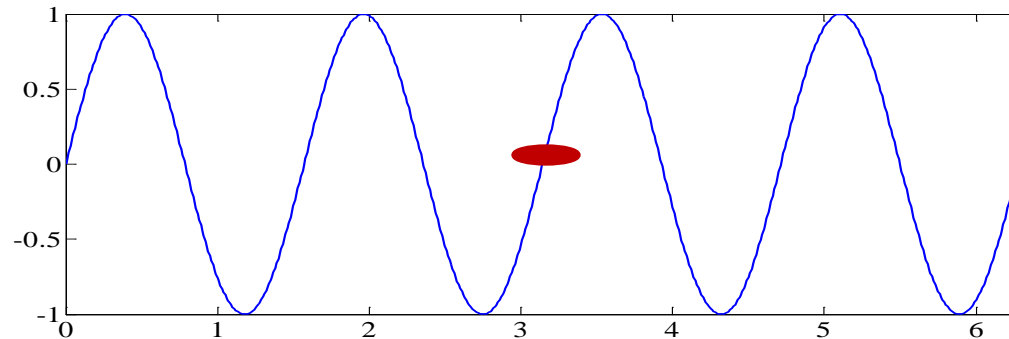
- **optical zero-phasing:** (M. George, P. Emma et al)
 - ✓ need a wiggler, and a spectrometer;
 - ✓ random laser phase -> have to calibrate with multishots;
 - ✓ analyze the chirp effects;
 - ✓ requires CO2 laser of > 50GW for 4.3 GeV beam.
- **optical deflector:**
 - ✓ need a wiggler;
 - ✓ random laser phase -> have to calibrate with multishots;
 - ✓ use a special laser transverse mode TEM01, or use a fundamental mode with a transverse offset;
 - ✓ requires CO2 laser of >10 GW for 4.3 GeV beam, 0.5 um emittance.



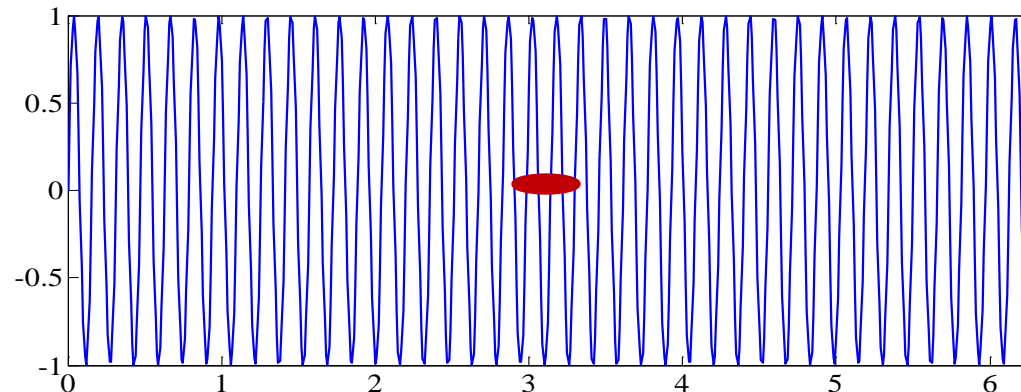
CO2 laser → Ti:sapphire laser

- CO2 laser is not easy to operate, why do we still choose that?
→ we need the laser wavelength $>$ electron bunch length

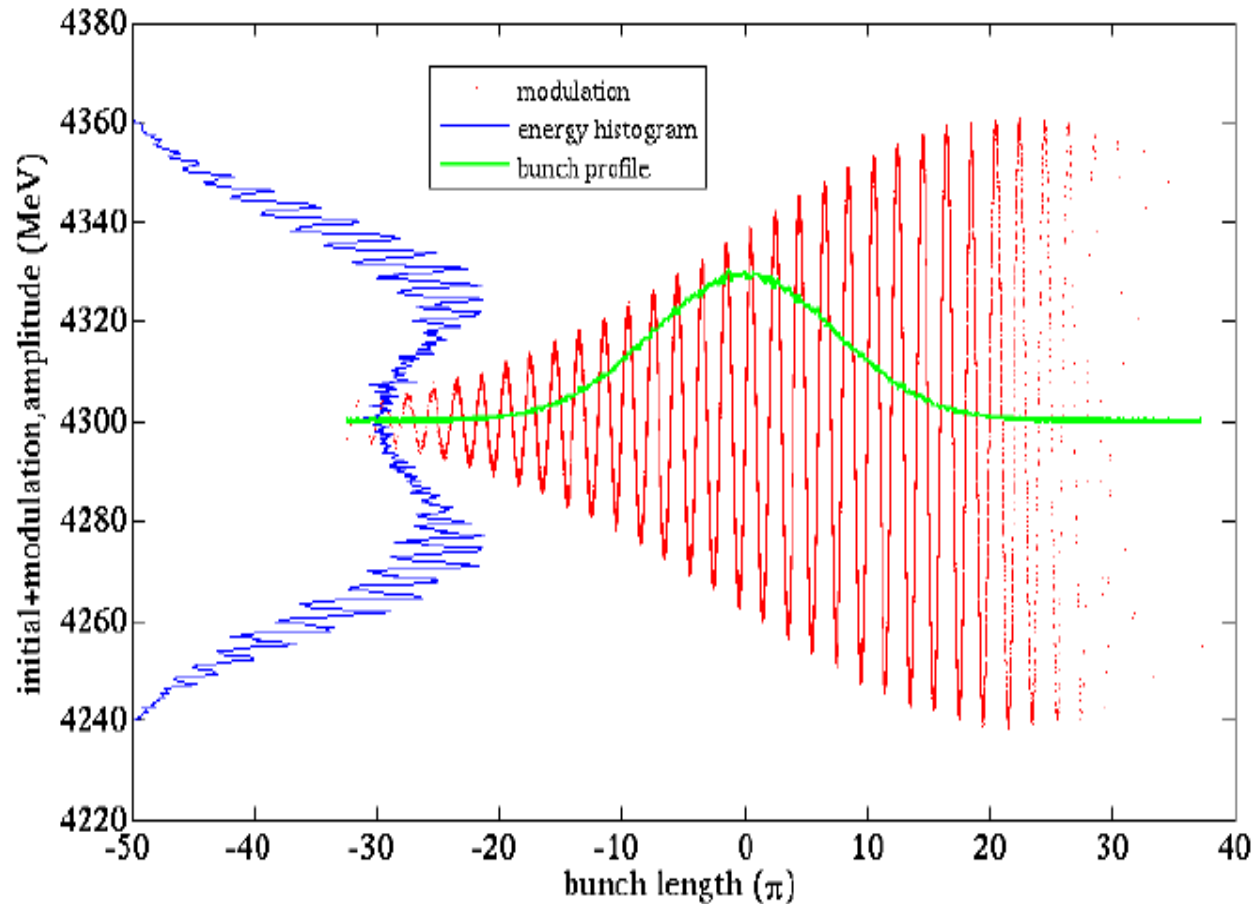
CO2 laser



Ti:Sapphire laser



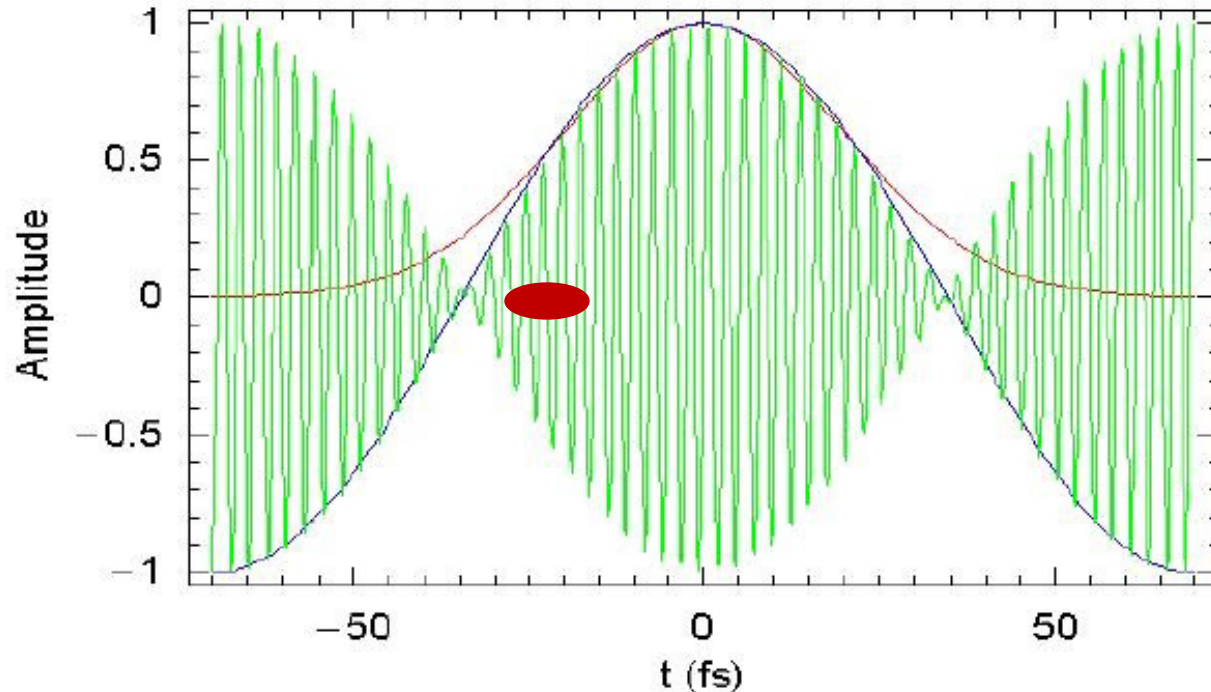
Using laser envelope to separate the different periods



Single shot (though not every shot);
Self-calibrated;
Can get bunch shape information.

More effective, use beating wave from two lasers (Suggested by J. Frisch)

800 nm + 770 nm
laser peak power: 0.5 TW (add together)



System Setup

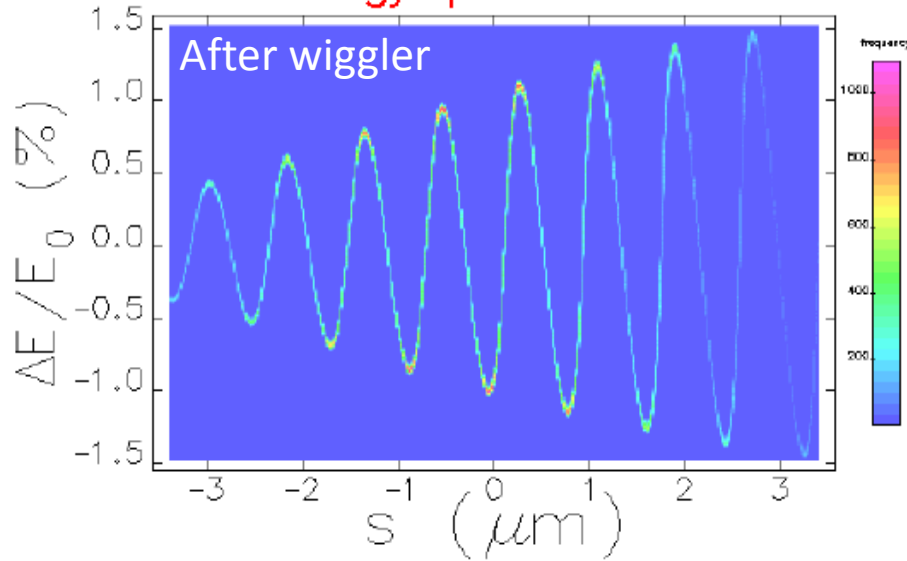
- laser system: beating 800nm+770nm, 0.5TW
- a 10-period wiggler
- a spectrometer



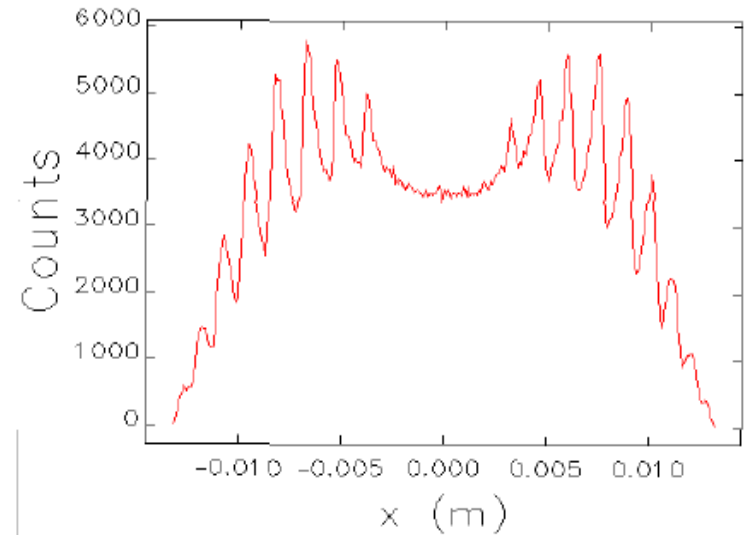
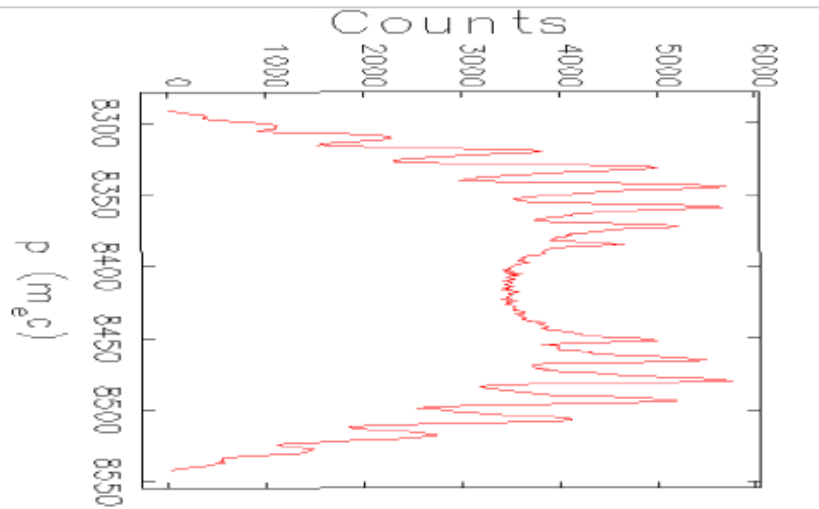
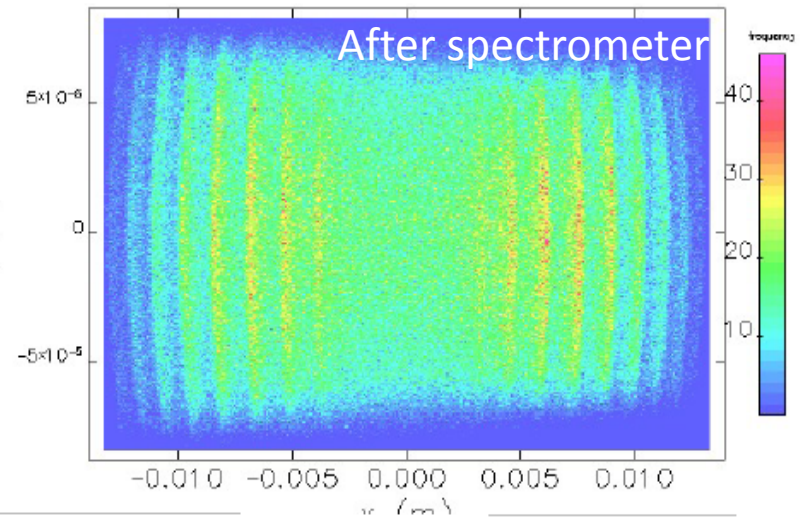
- **Simulation examples with Elegant:**
 - electron 4.3GeV, 2-10 fs rms, Gaussian shape;
 - including longitudinal chirp.
 - slippage included.
 - optimization is still on the way.

Electron 5fs rms, without chirp (1)

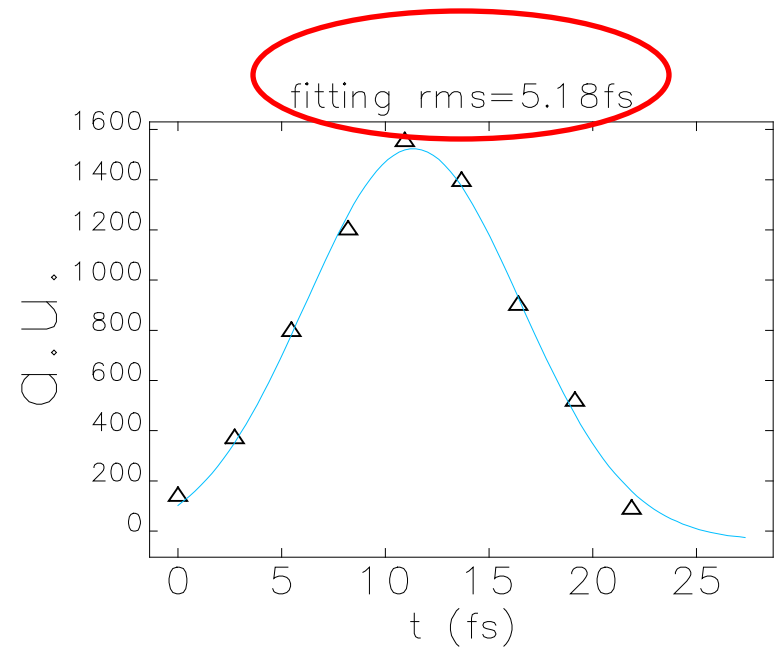
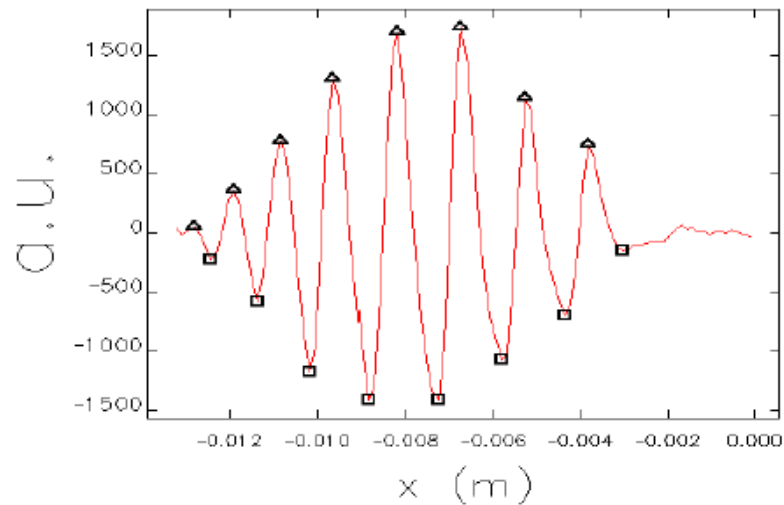
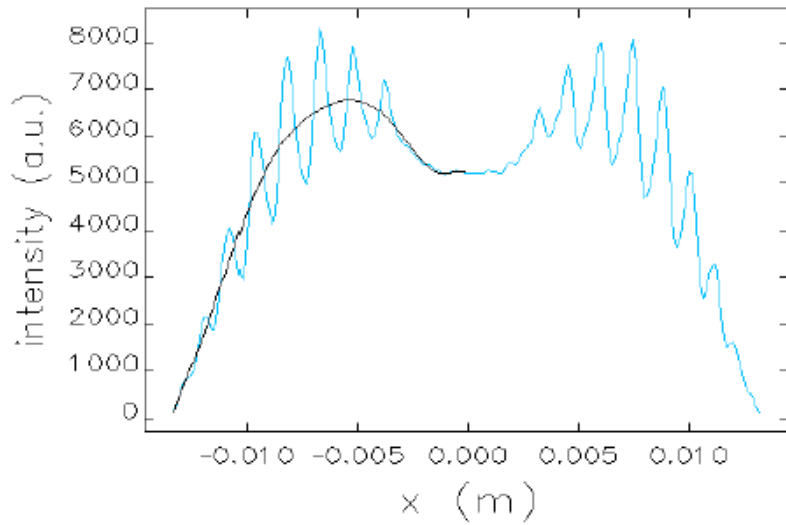
Slice energy spread 0.5 MeV



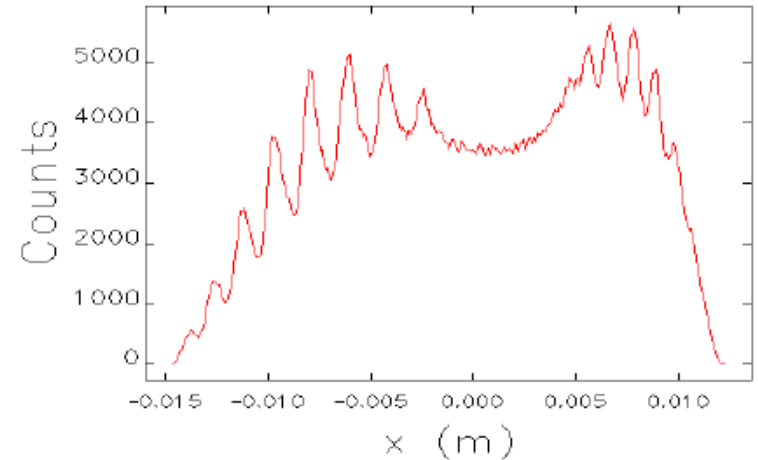
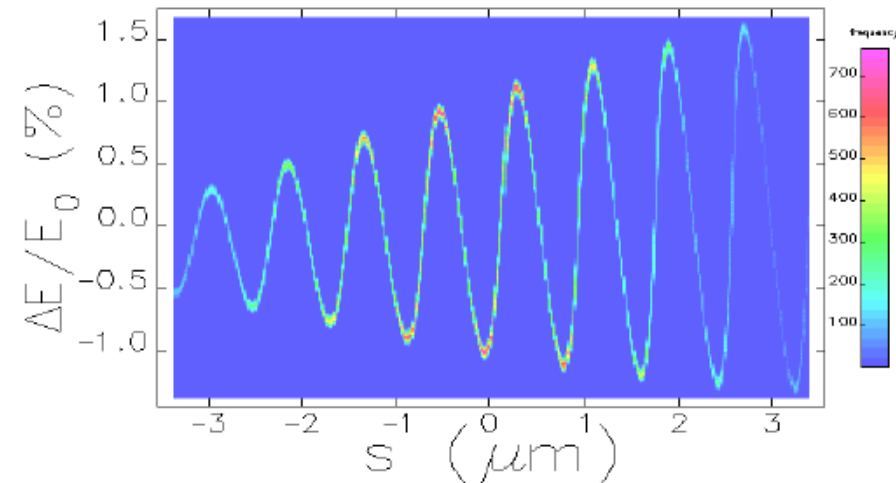
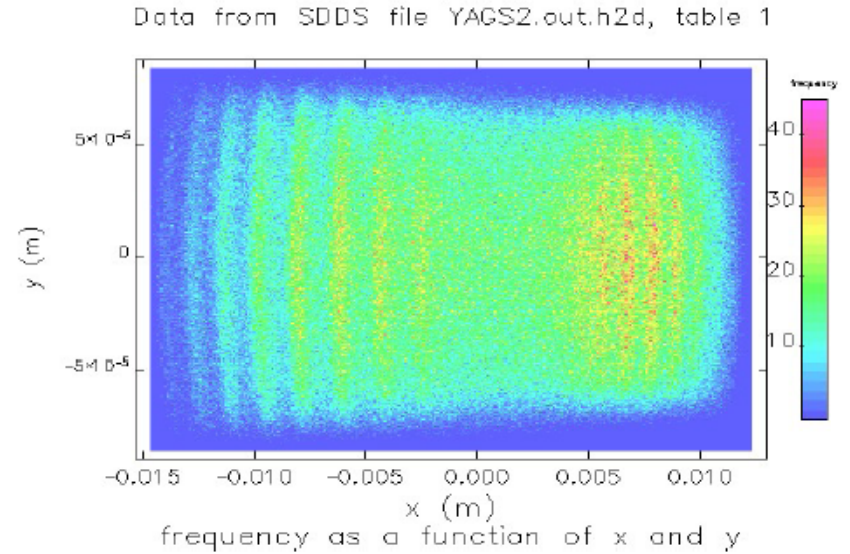
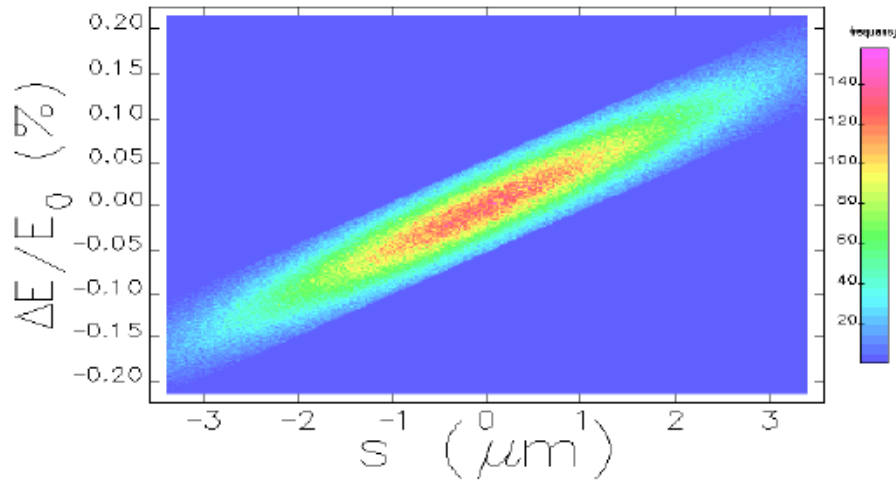
Data from SDDS file YAGS2.out.h2d, table 1



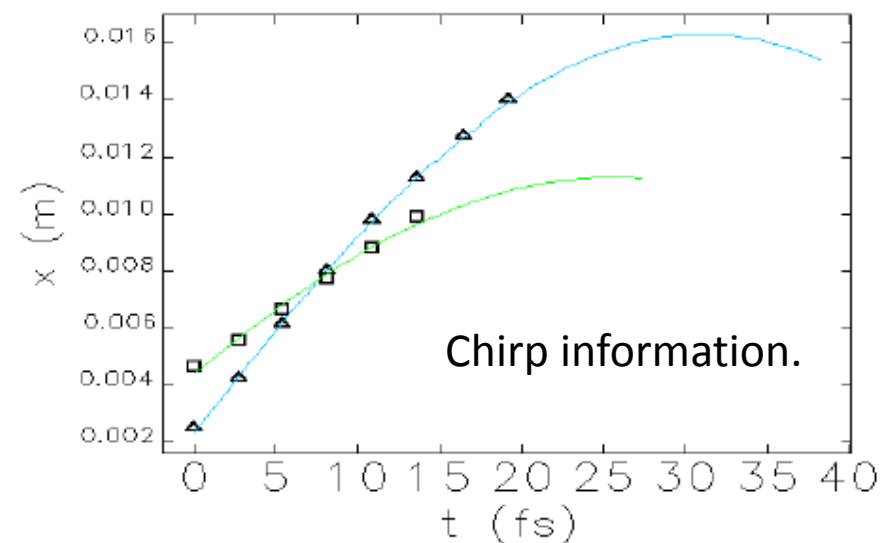
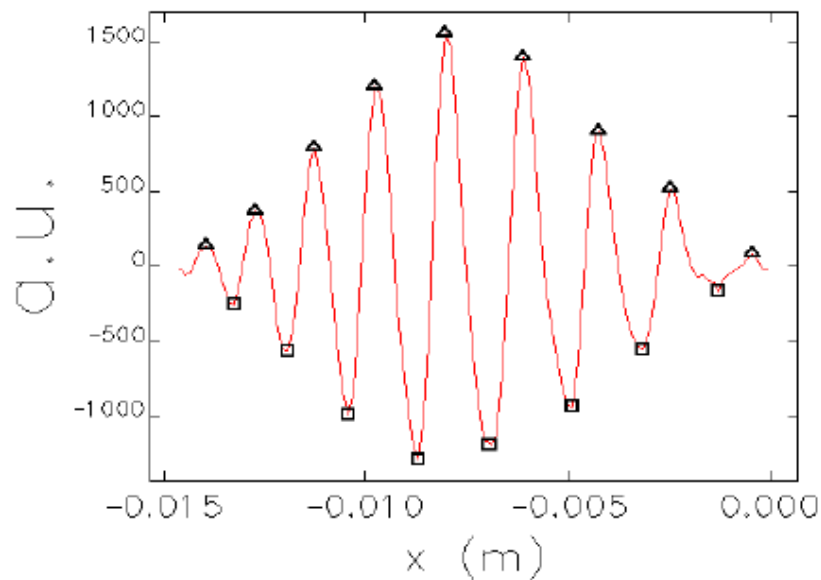
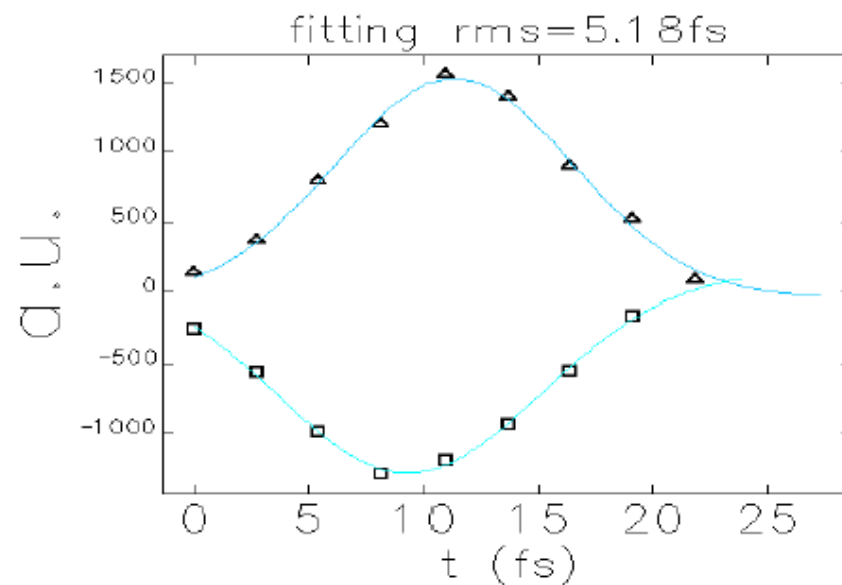
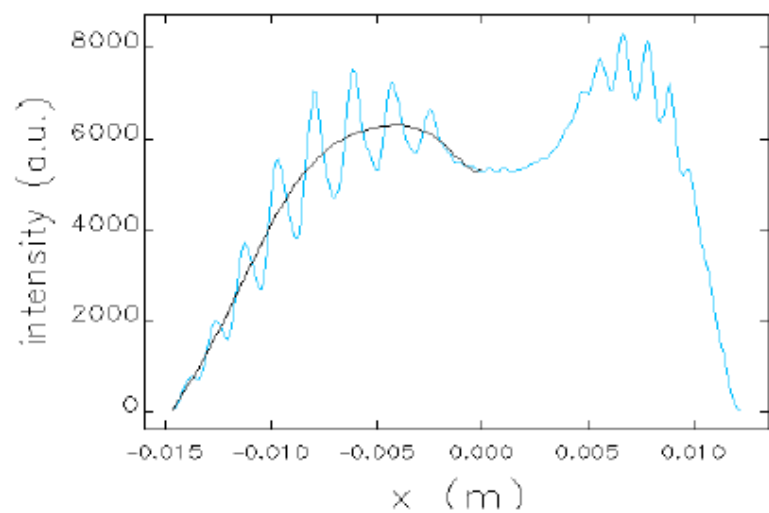
Electron 5fs rms, without chirp (2)



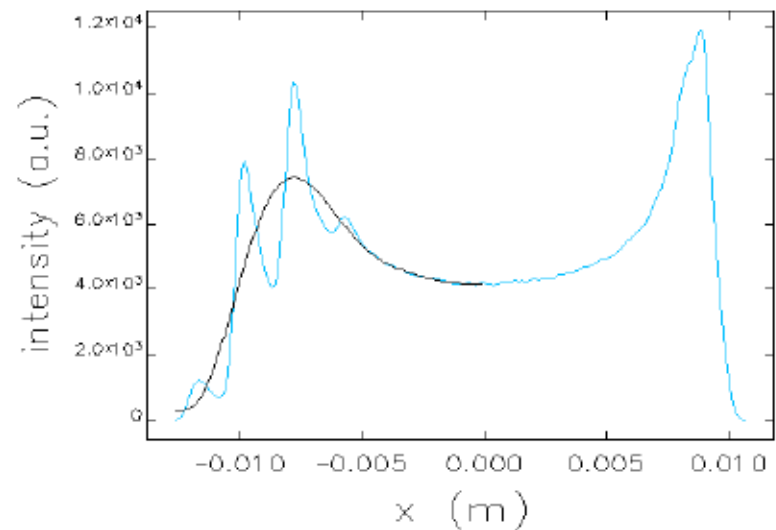
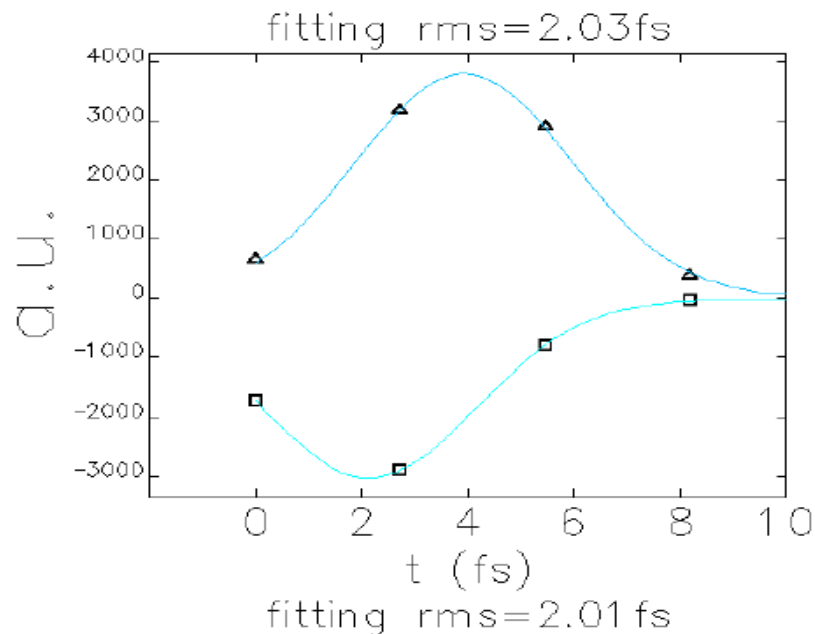
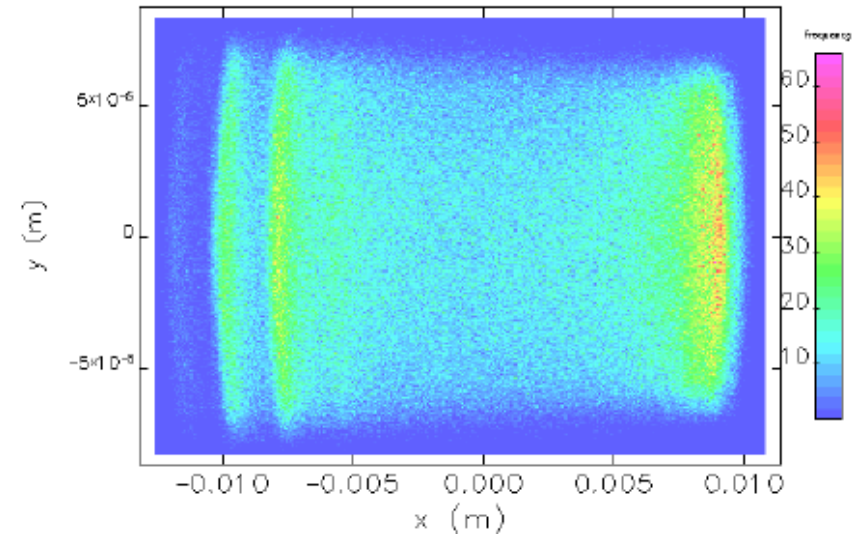
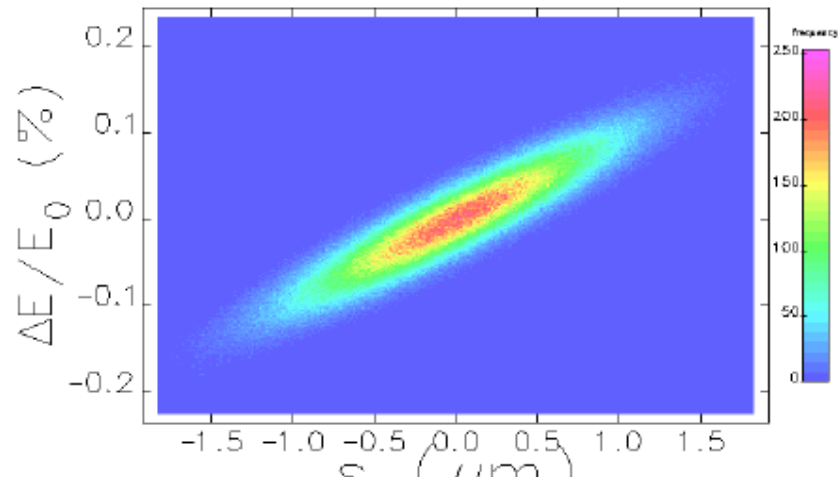
Electron 5fs rms, with chirp-1, energy spread 1 MeV



Electron 5fs rms, with chirp-1, energy spread 1 MeV



An example of 2 fs beams



Discussions

- Optical streaking with help of the laser envelope:
 - ✓ single shot
 - ✓ self-calibrated
 - ✓ possible to deduce the shape and chirp
- Use minimum energy spread information based on multi-shots (J. Frisch). Slippage effects, optimization on the way.
- other methods.....
- Thanks many discussions with my SLAC colleagues, and you...