Microbunching and CSR experiments at BNL's Source Development Lab

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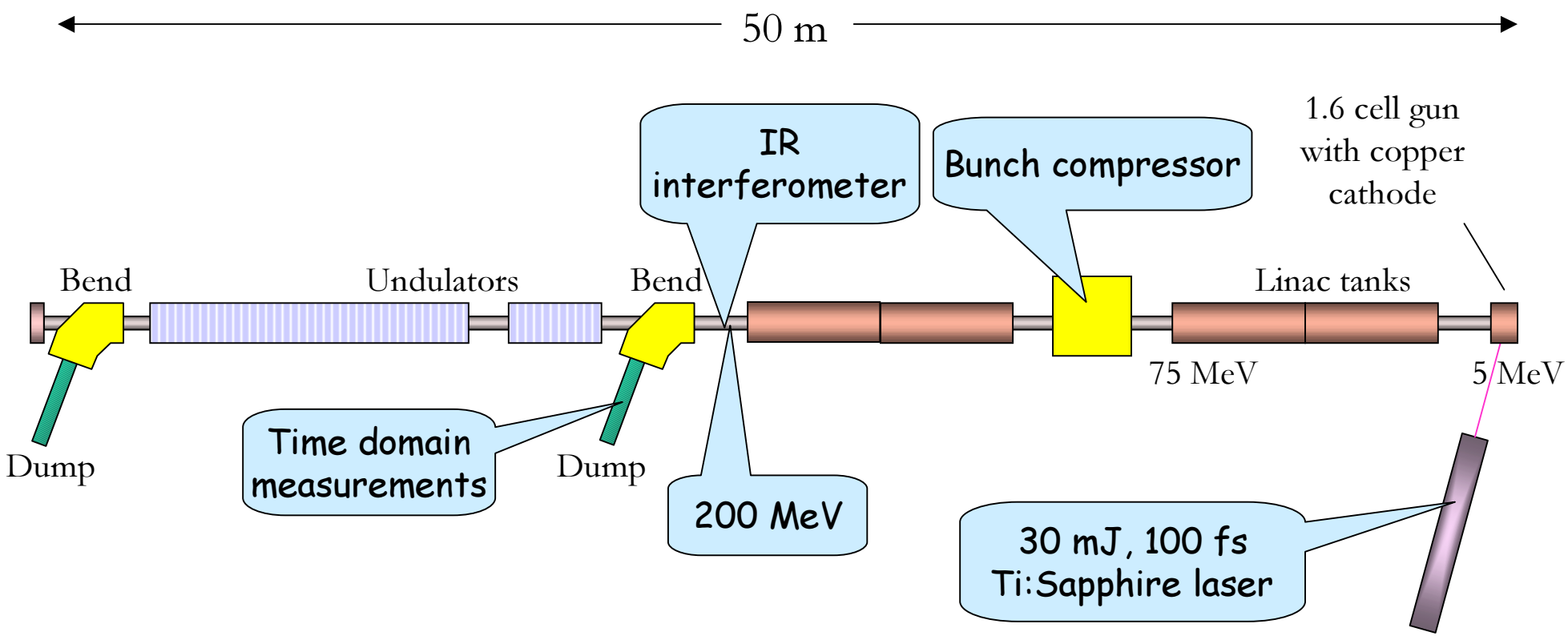
ICFA CSR Workshop

Berlin, Jan., 2002

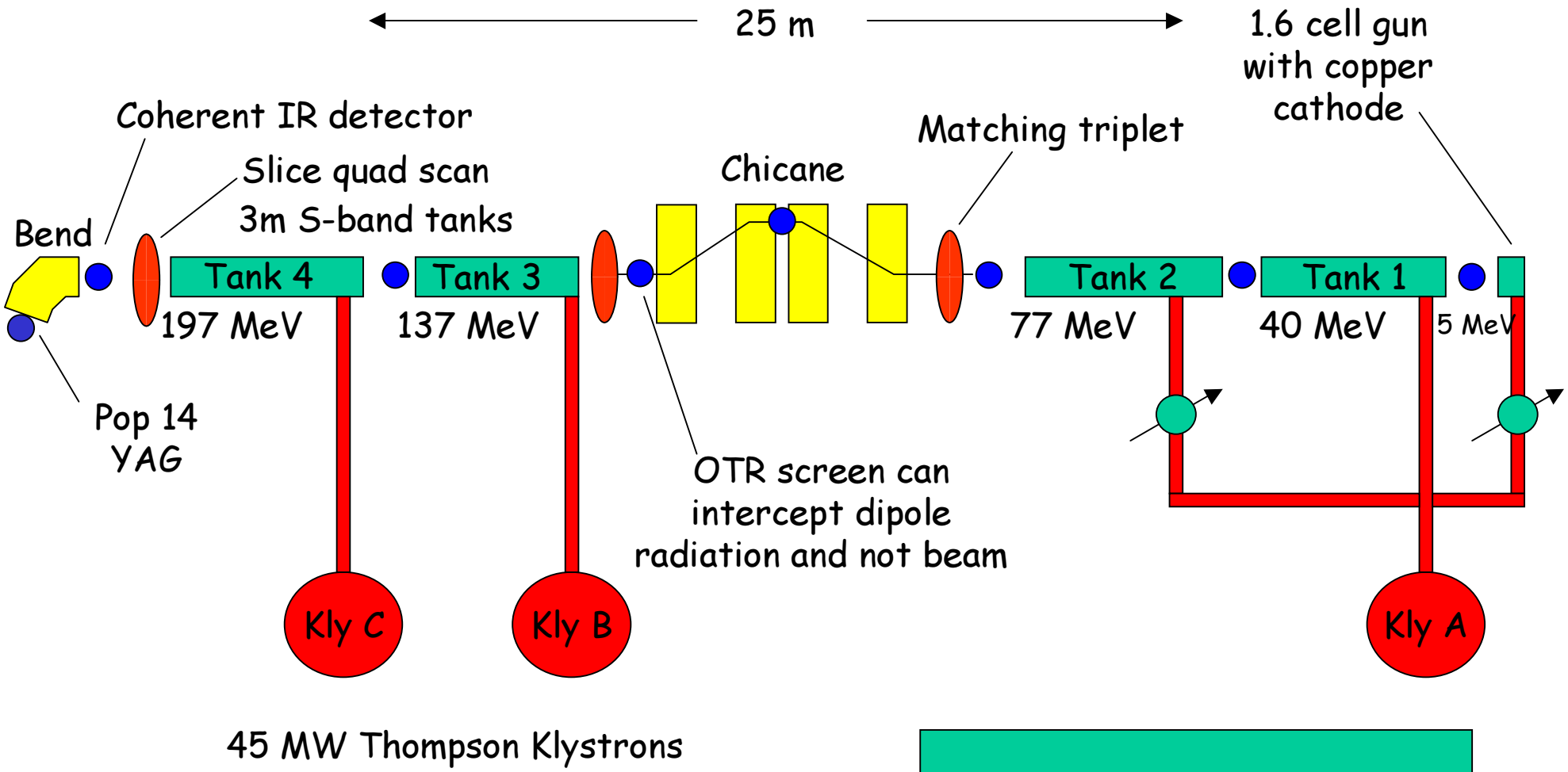
SDL FACILITY



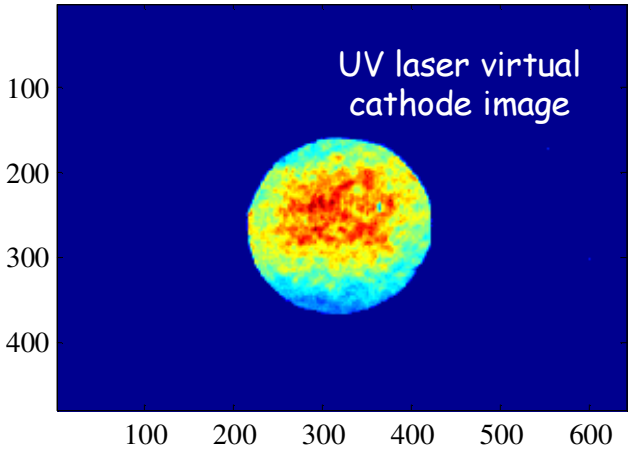
Goal is to reach deep UV wavelength using High Gain Harmonic Generation (HGHG) process seeded by conventional laser for full longitudinal coherence.

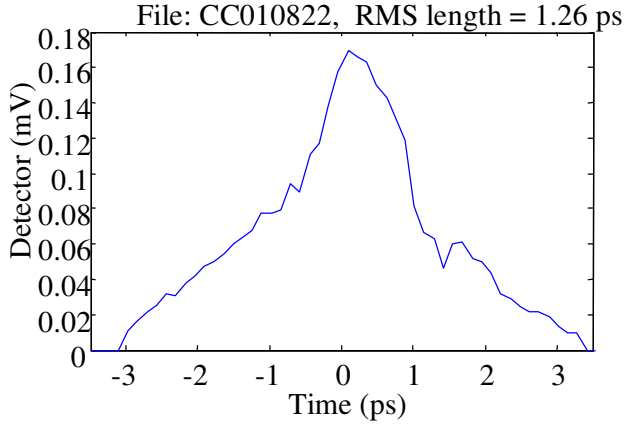
Currently commissioning undulator with SASE at 400 nm.

DUVFEL Accelerator

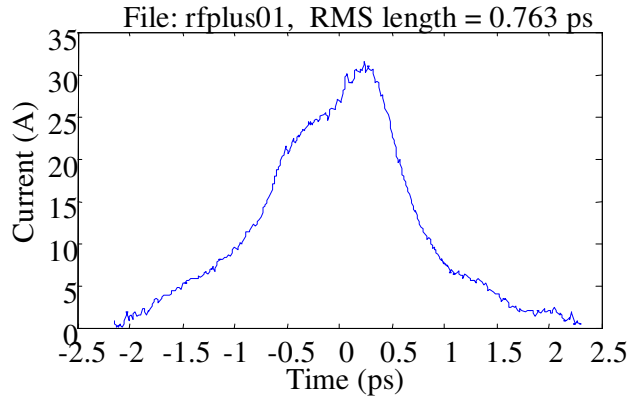


SDL data from 1/8/2002

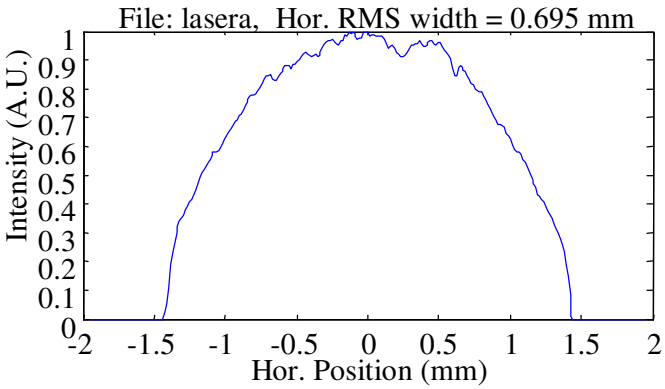




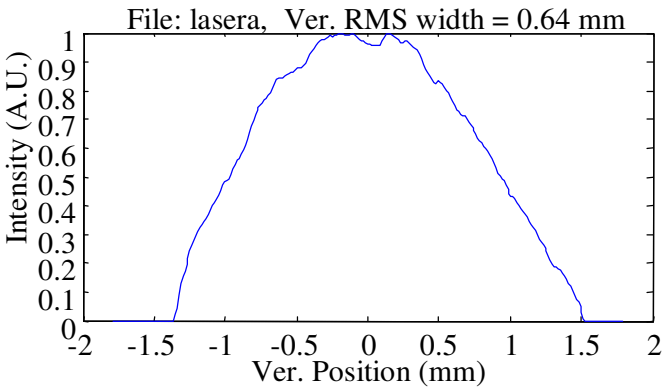
UV laser time profile



Ebeam time profile



Horizontal projection



Vertical projection

Technical Data

Gun energy: 5.37 MeV

Gradient: 114 MV/m.

E-beam parameters at chicane entrance: Emitnx = 1.08 um, Alphax = -0.78, Betax = 3.1 m, Emitny = 1.30 um, Alphay = -1.78, Betay = 3.1 m

Initial phase: leading edge of beam at 30 degrees from phase of zero crossing.

RMS laser size on cathode: 0.695 mm hor, 0.640 mm ver.

Charge: 50 pC

Pop14: pixel size: 28.8 um (all electron beam profiles are from pop14), image size: 640 X 480, dispersion: 1.1 m

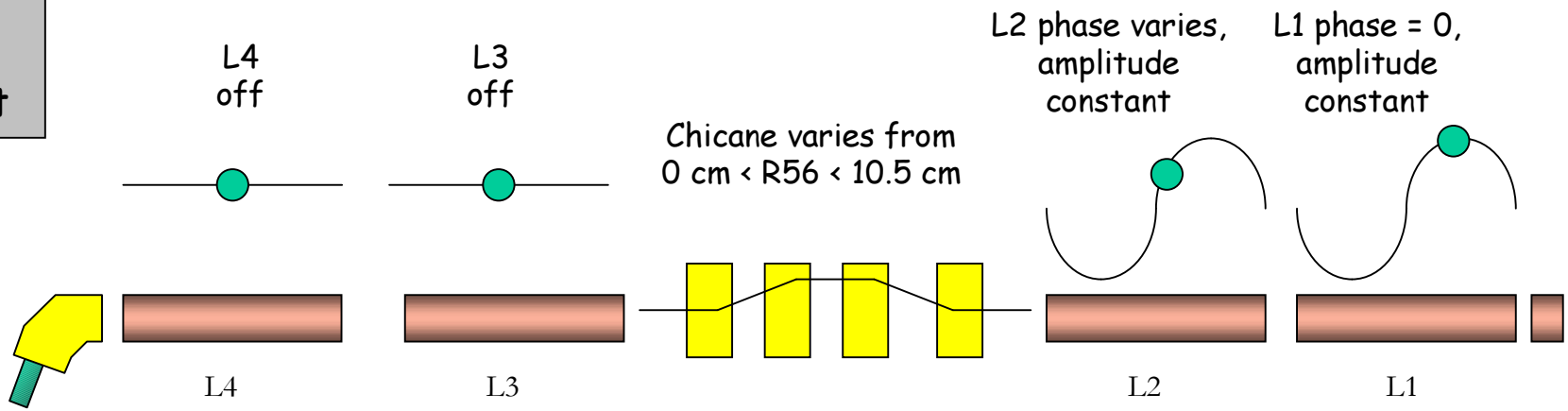
Cathode pix.el size: 13.75 um

Linac gradient approx. 11.89 MV/m.

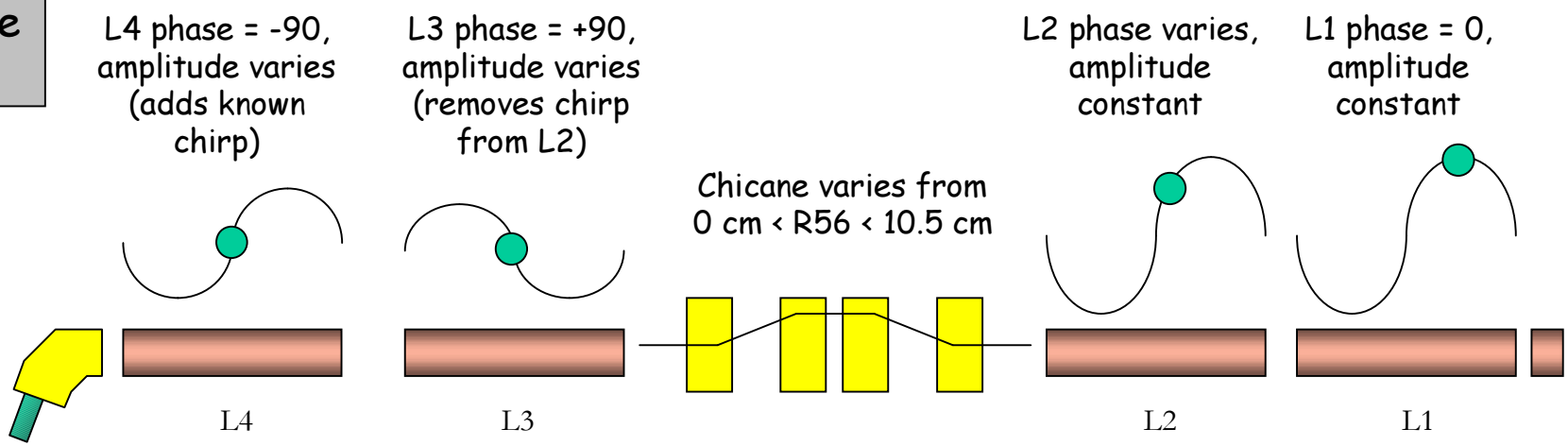
Final max energy: 76.7 MeV

Chicane angle at 50 A, 75 MeV: .2097 rad

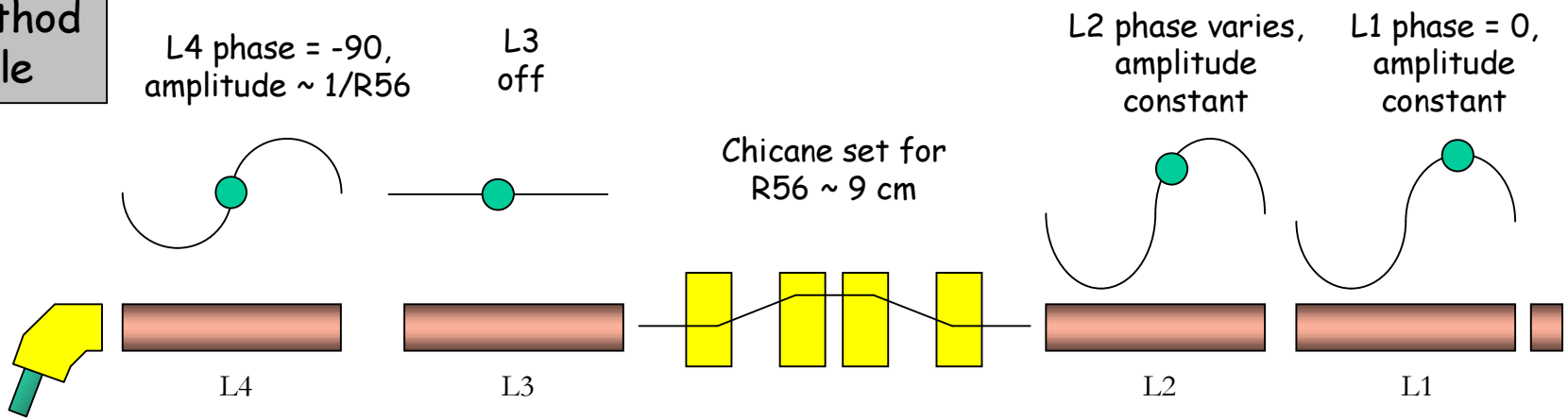
Energy spectrum measurement



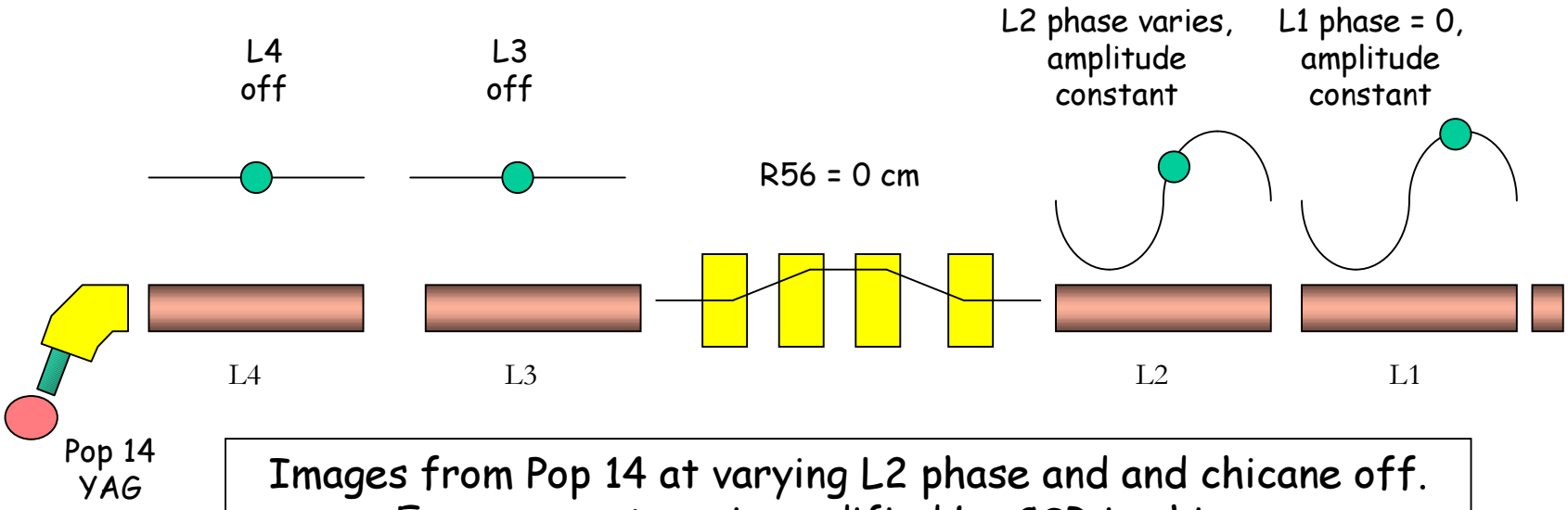
RF zero-phase time profile



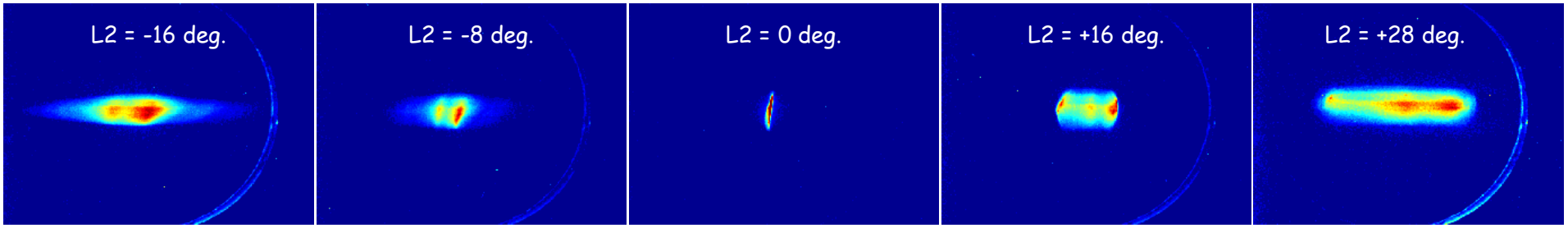
T. Smith method time profile

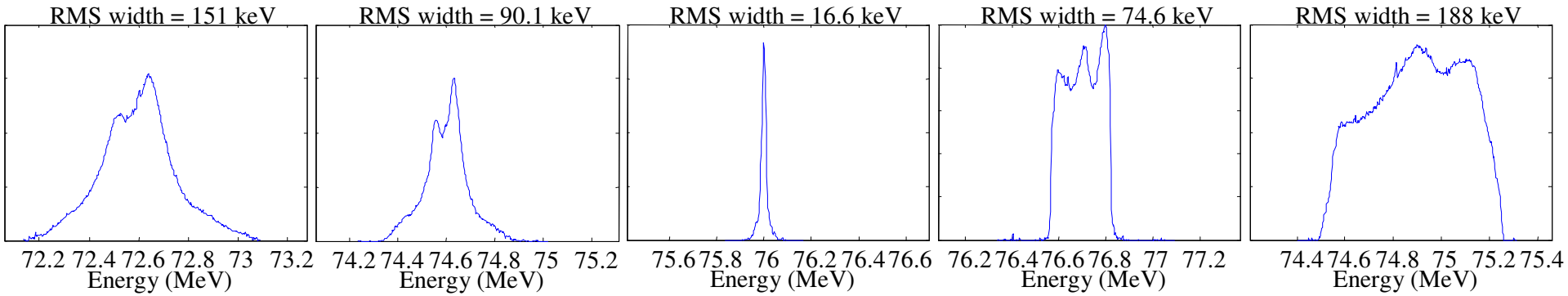


Energy spectrum measurement with chicane off.



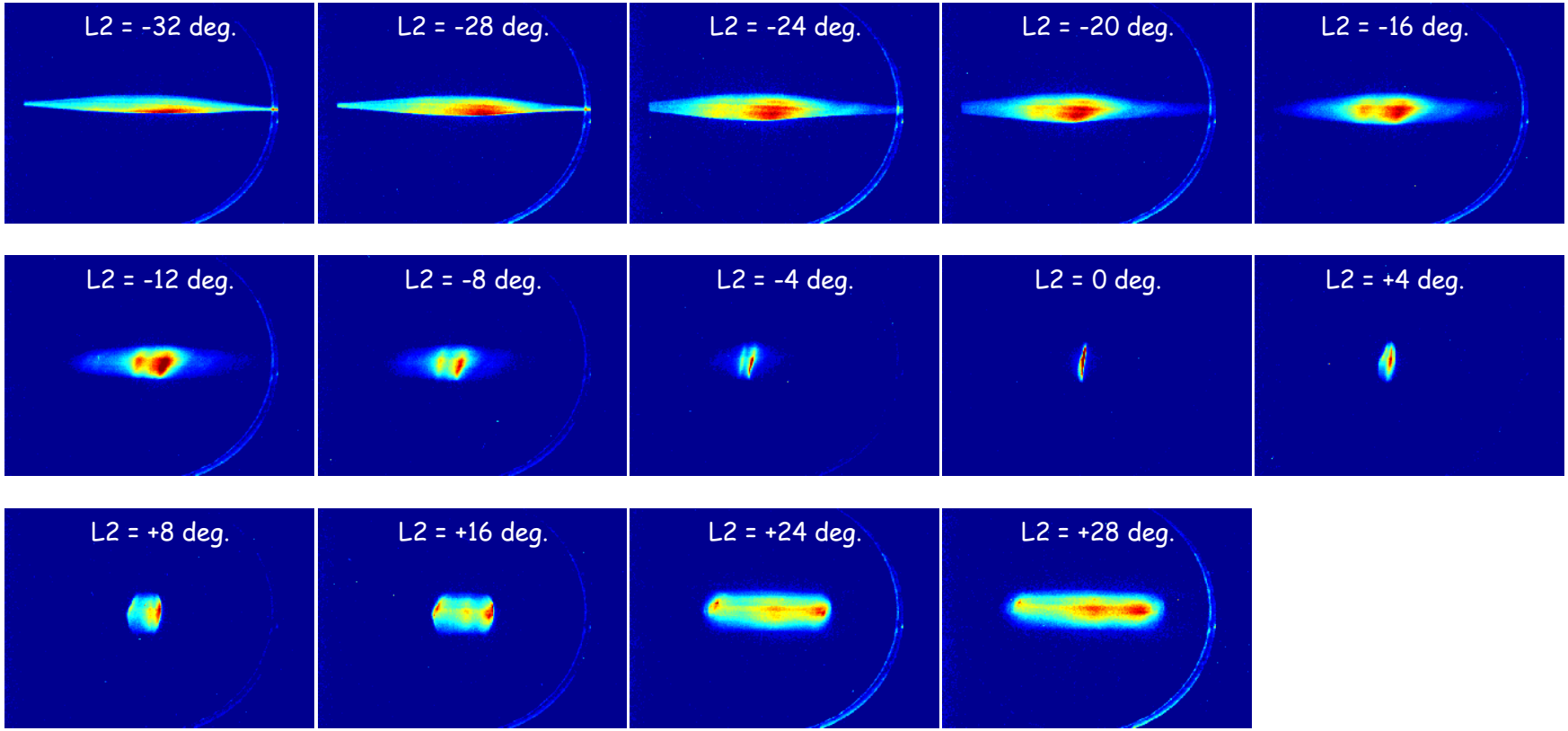
Images from Pop 14 at varying L2 phase and and chicane off.
Energy spectrum is modified by CSR in chicane.



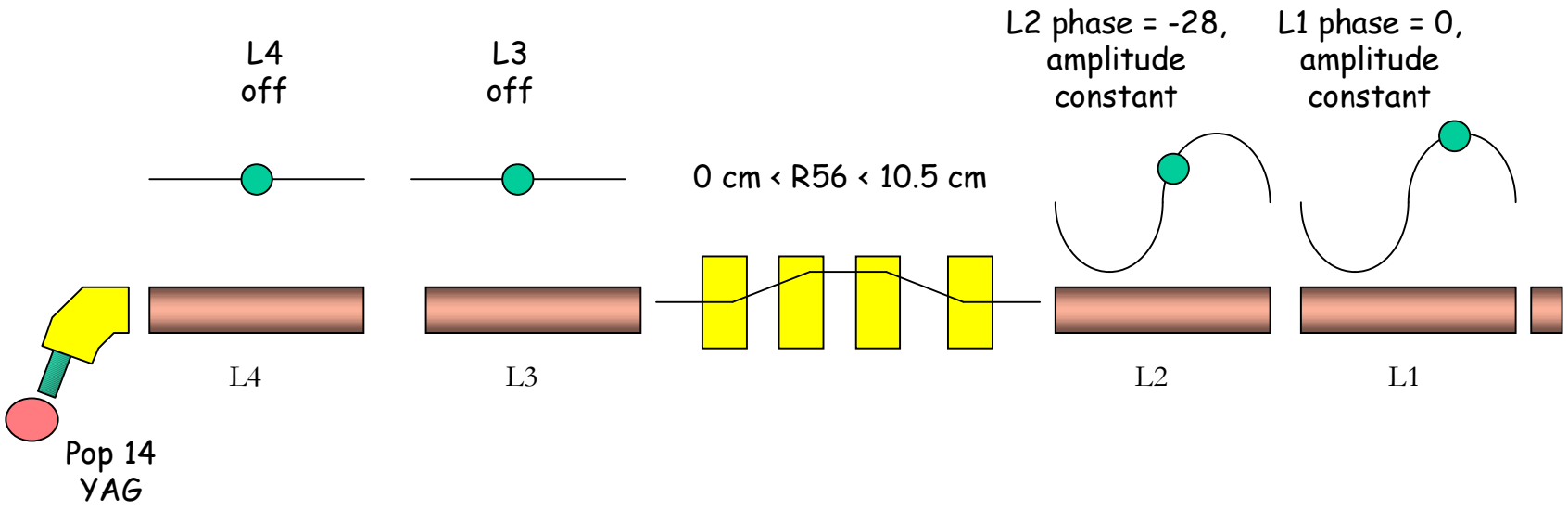


Energy profiles at many L2 phases

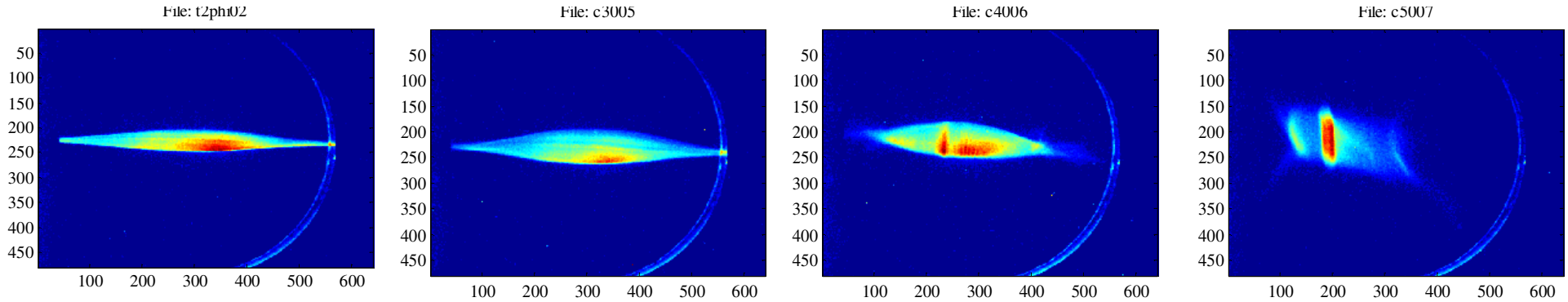
L2 phase varying. Chicane, L3, and L4 off.



Energy spectrum measurement with chicane on.



Images from Pop 14 at fixed L2 phase and increasing chicane strength. Energy spectrum is modified by CSR in chicane.



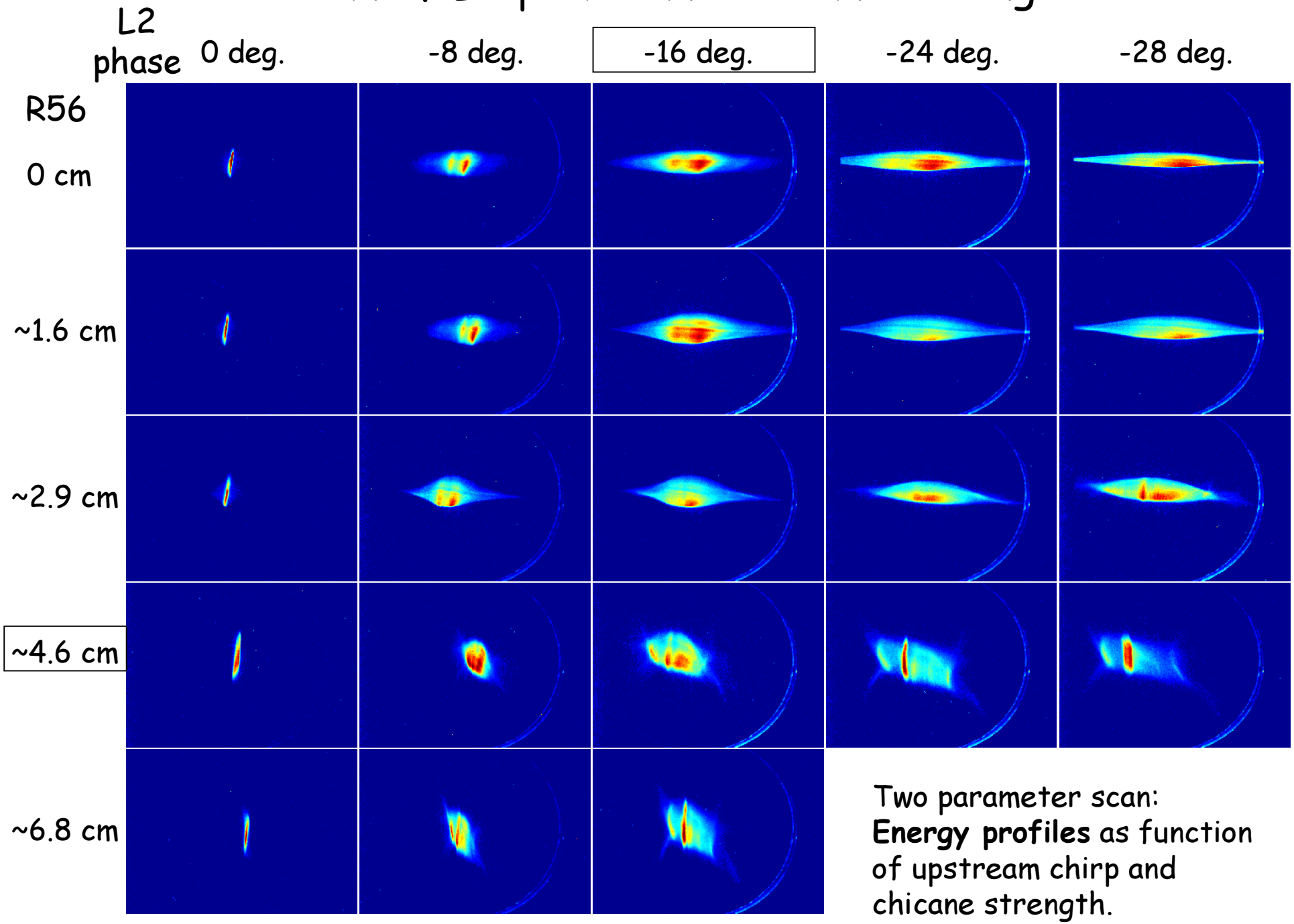
R56 = 0 cm,
L2 = -28 deg.

R56 = 1.8 cm,
L2 = -28 deg.

R56 = 3.3 cm,
L2 = -28 deg.

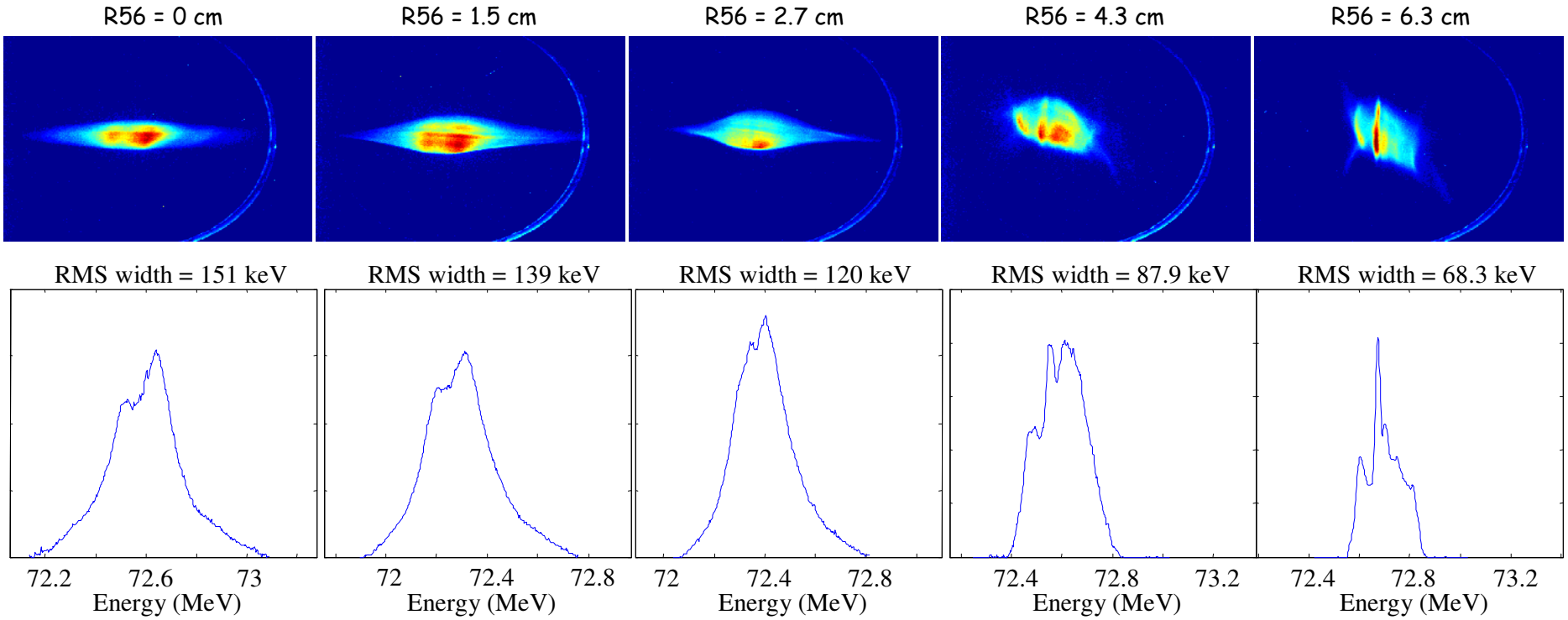
R56 = 5.2 cm,
L2 = -28 deg.

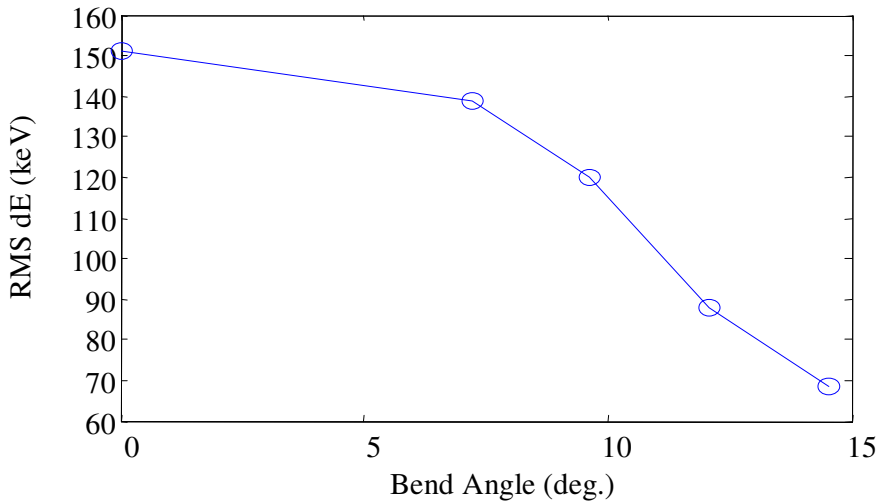
Scan of L2 phase and chicane strength



Two parameter scan:
Energy profiles as function of upstream chirp and chicane strength.

Energy spectrum measurement vs chicane strength





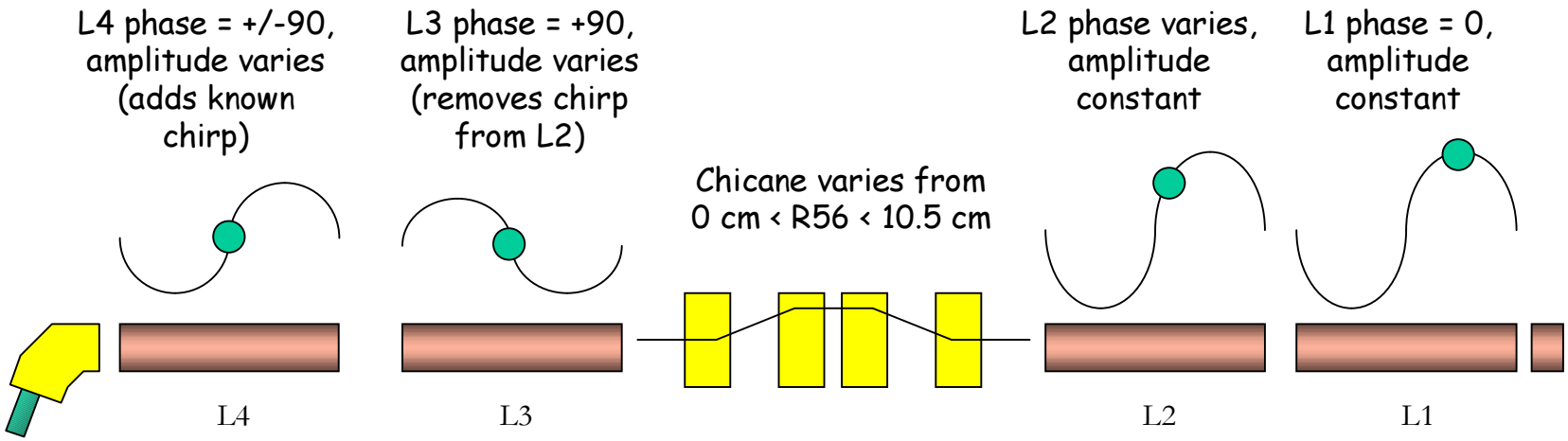
Bunch is compressing with increasing chicane strength.

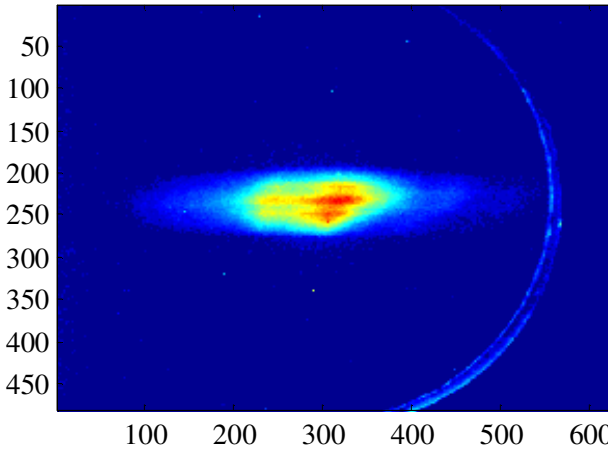
Energy spectrum can only be modified by CSR and wakes. Charge = 50 pC.

L2 phase = -16 degrees.

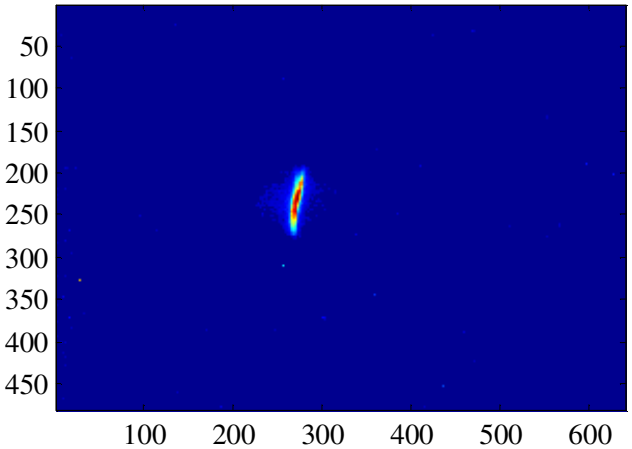
L3, L4 are off.

RF zero-phase time profile

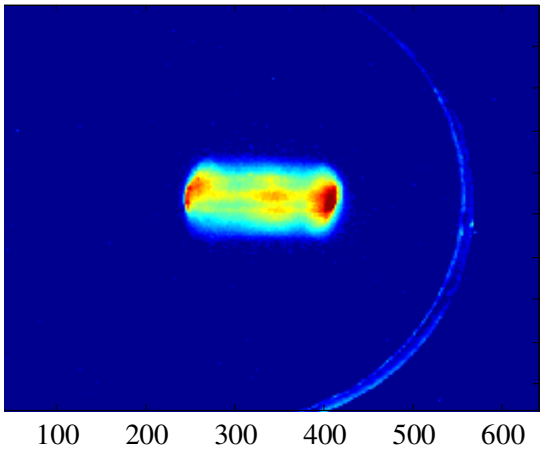




L4 phase = -90 degrees

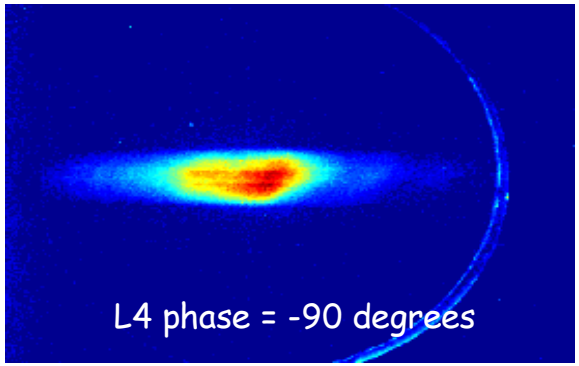


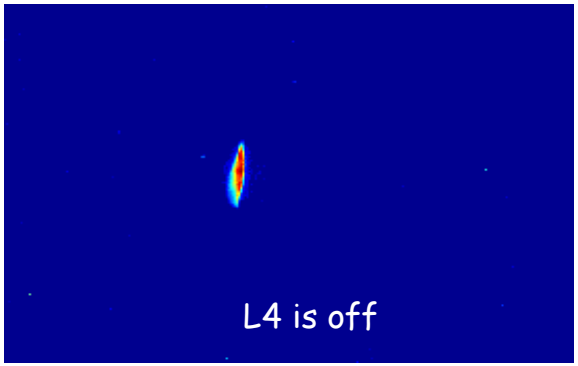
L3 corrects residual chirp, L4 is off

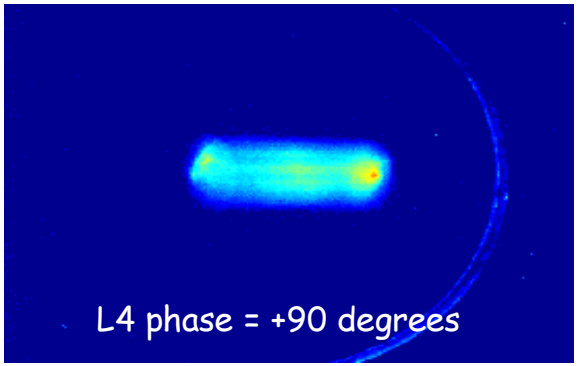


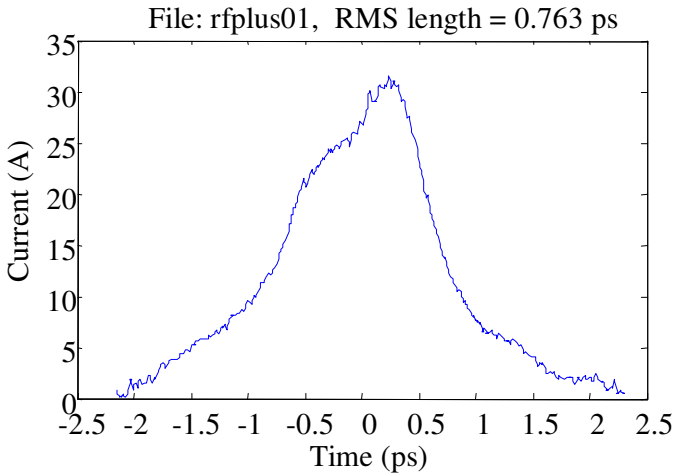
L4 phase = +90 degrees

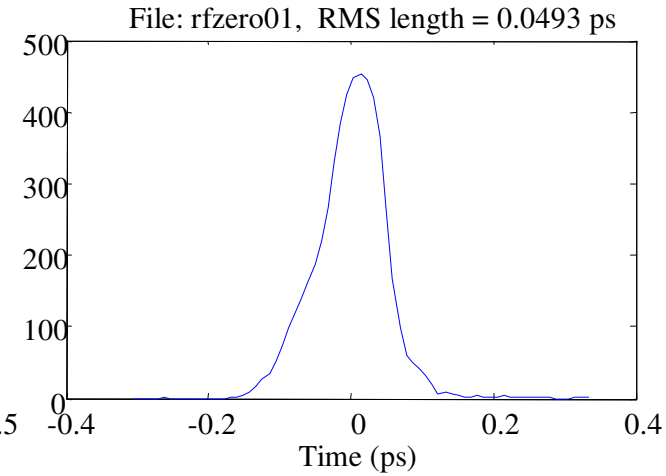
RF zero-phase time profiles

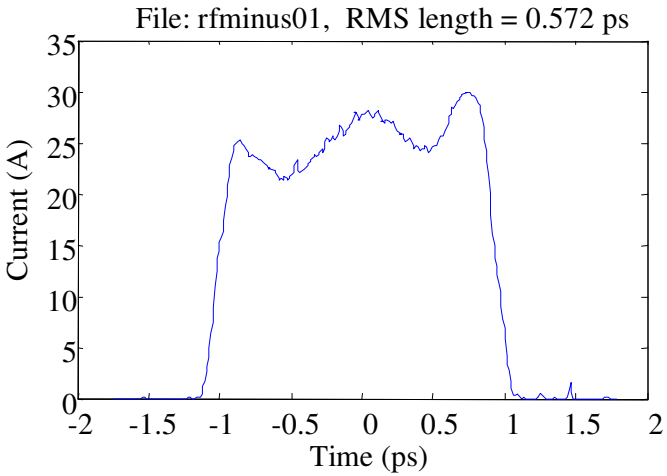


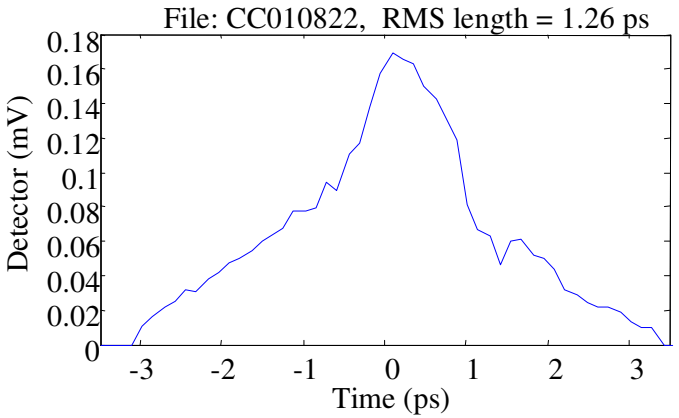






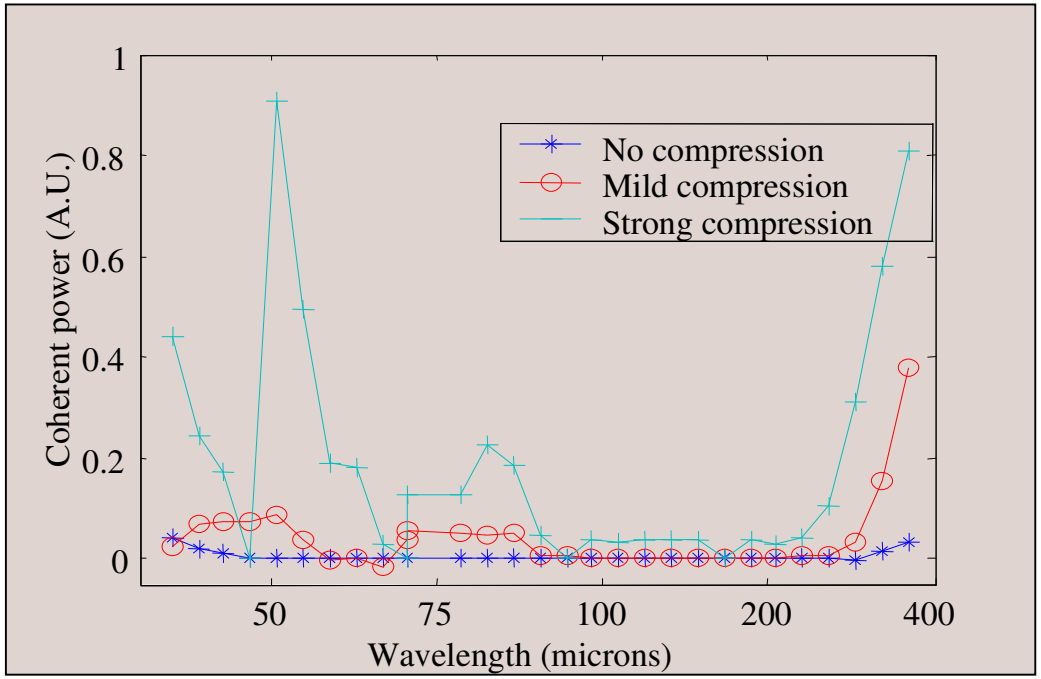




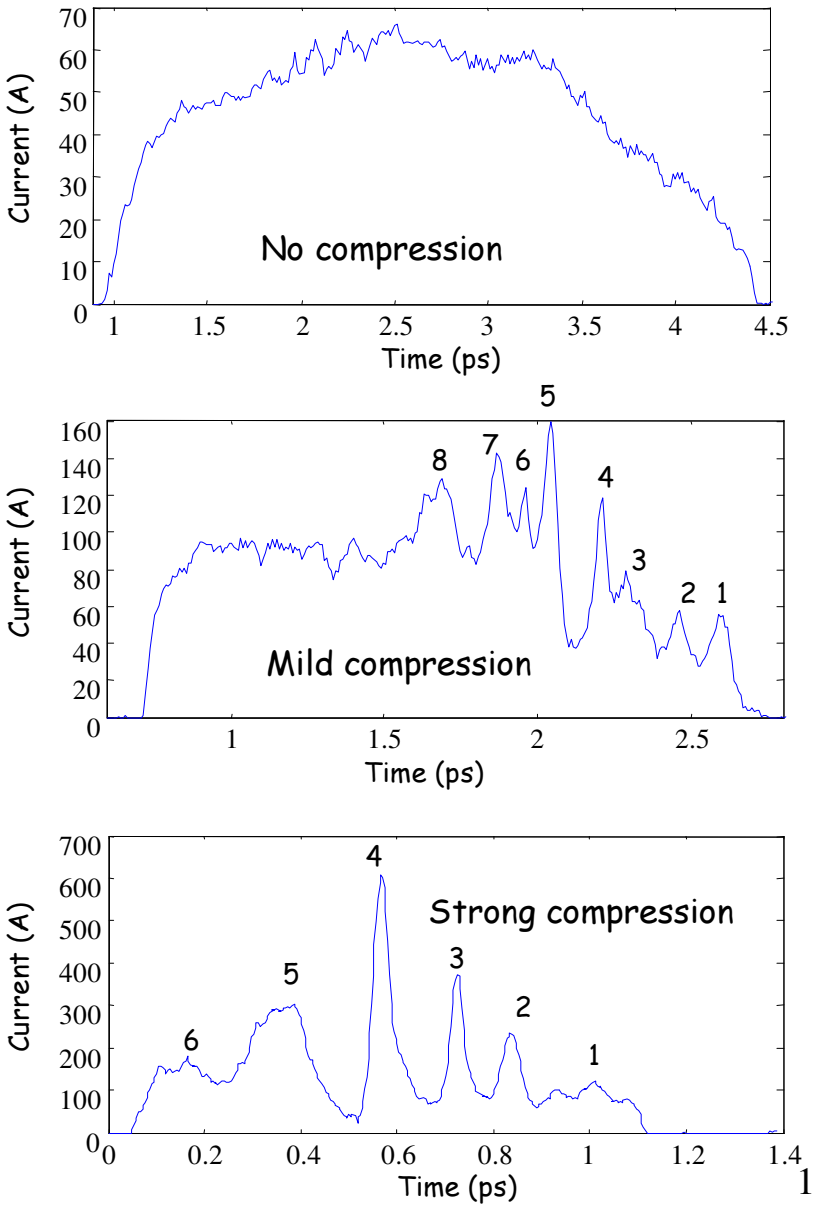


UV laser profile from scanning cross-correlation with laser IR pulse. Resolution ~200 fs.

IR Spectrum from scanning interferometer courtesy of L. Carr (10 minutes/scan).



RF zero phasing measurement of electron beam time profile.

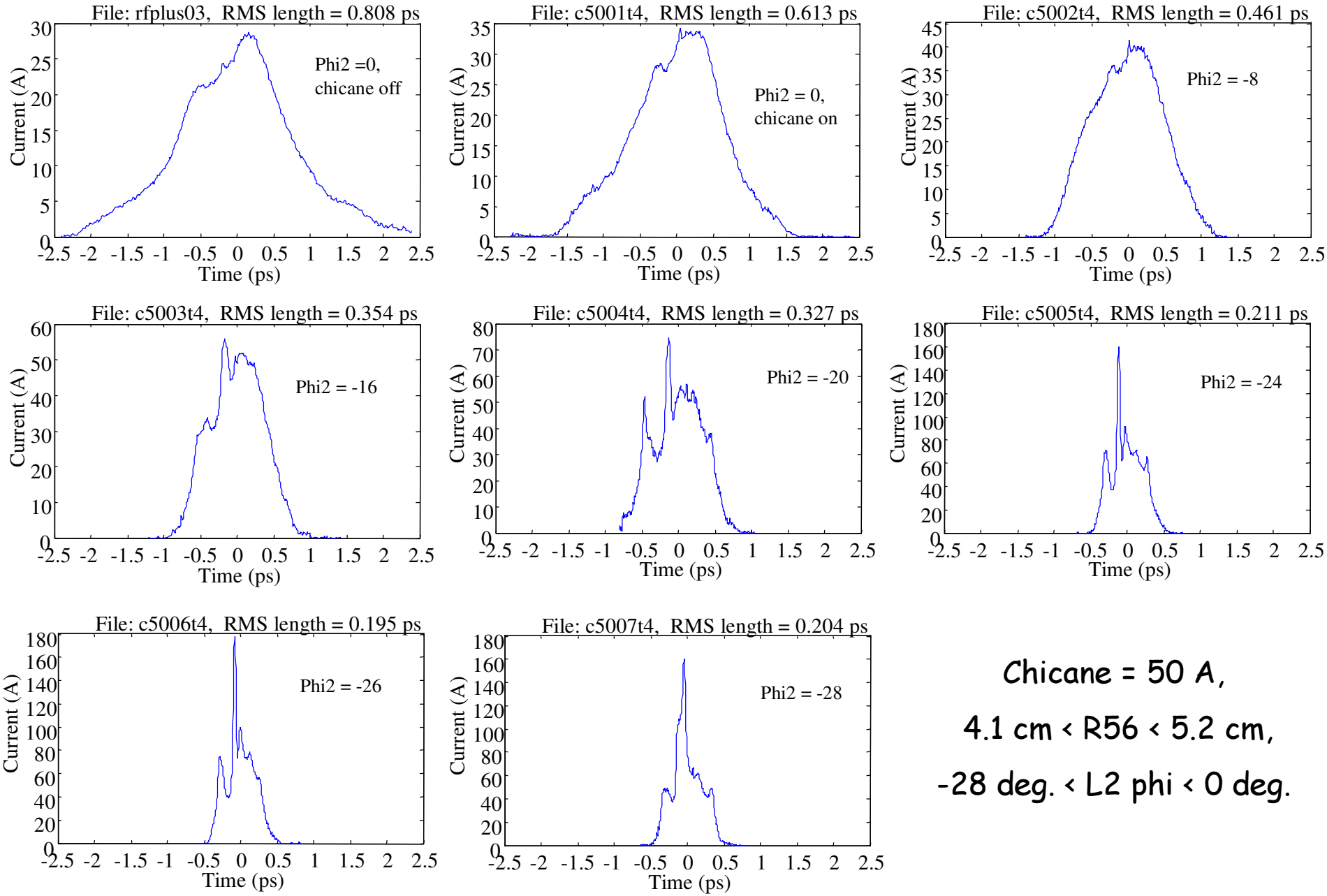


Mild compression case shows ~7 periods in ~1 ps = 45 um wavelength.

Strong compression case shows ~5 periods in 0.8 ps = 60 um wavelength.

Data from March, 2001. Charge = 250 pC.

RF zero-phase time profiles vs chirp



Chicane = 50 A,

4.1 cm < R56 < 5.2 cm,

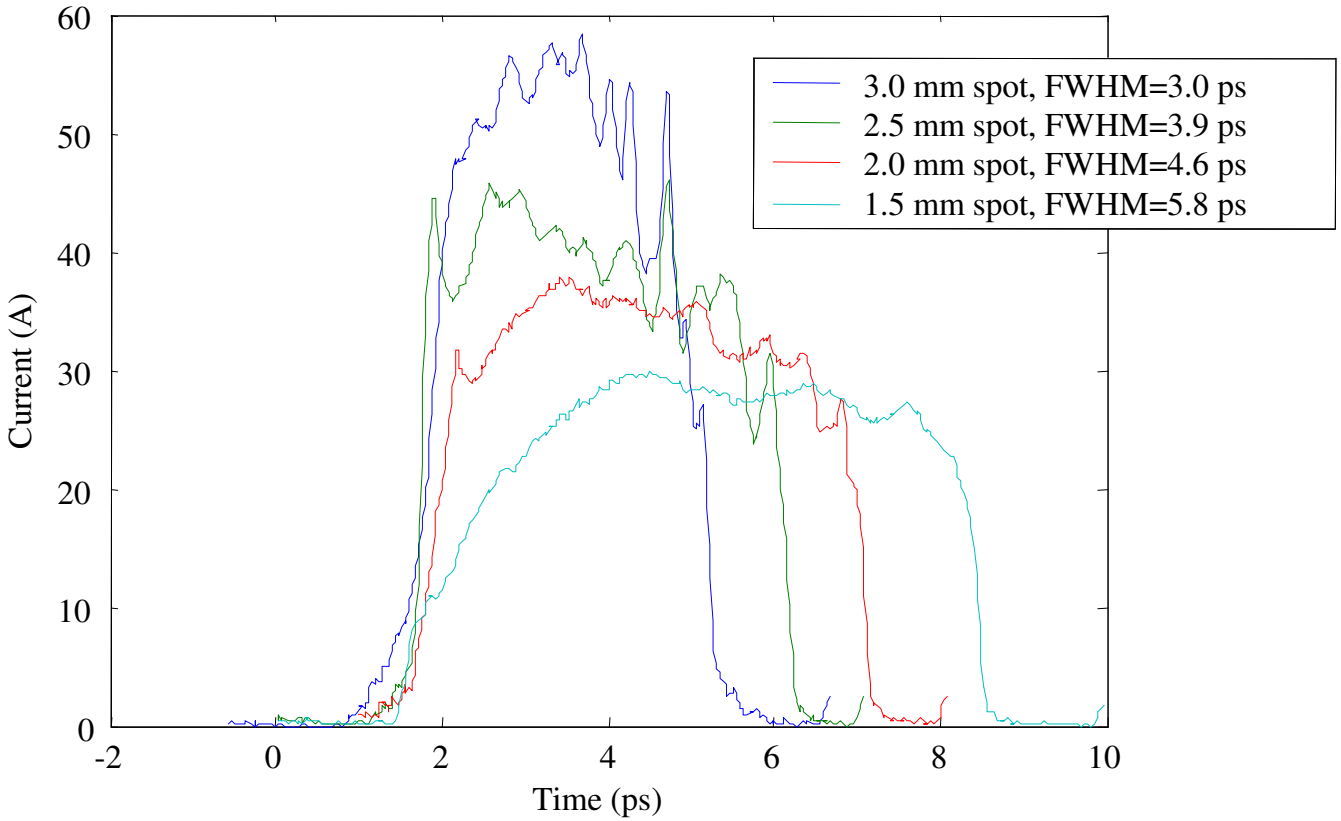
-28 deg. < L2 phi < 0 deg.

Time profiles vs cathode diameter

RF zero-phasing data from March, 2001 before gun upgrade and laser cross-correlation measurements.

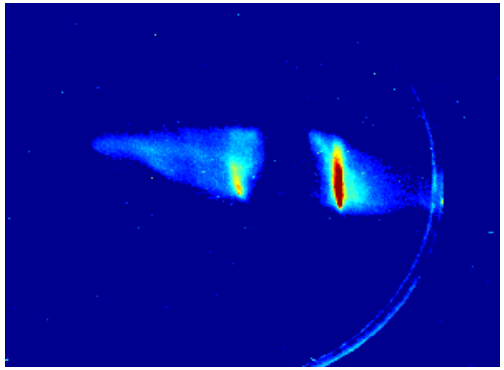
Gradient ~95 MV/m, charge = 200 pC, chicane off.

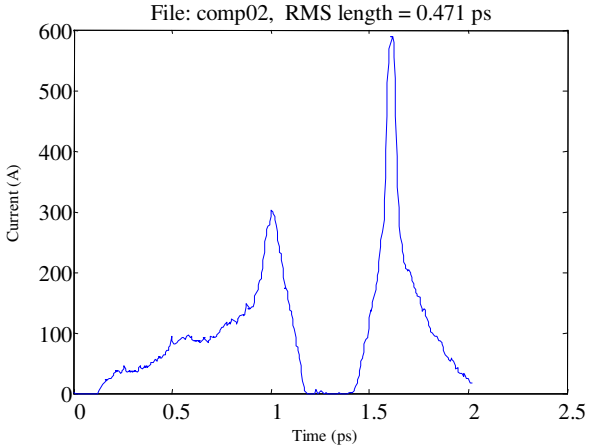
Structure is due to laser. At high charge density structure smears (and pulse lengthens) due to space charge near cathode. Speculate that structure is shifted from time to energy.



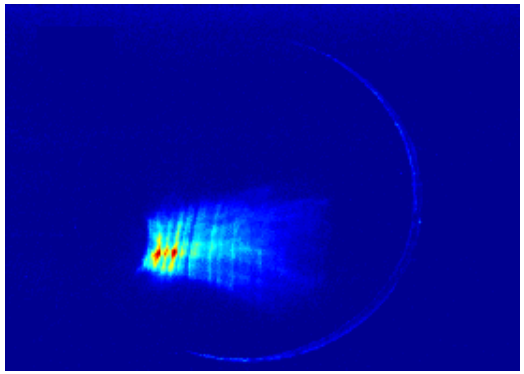
Interesting observations

Single pulse beam break-up at full compression of 300 pC



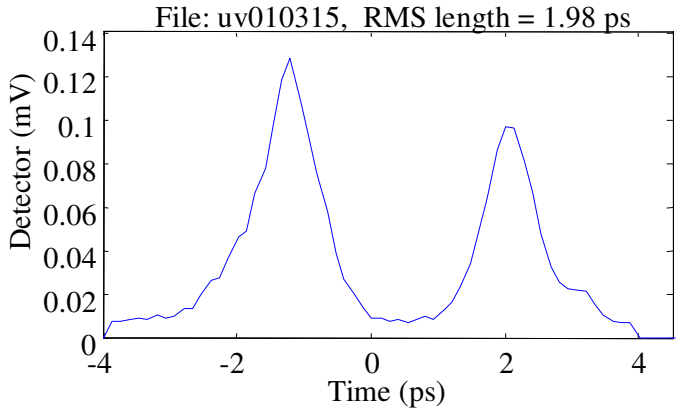


Single-frequency perturbation

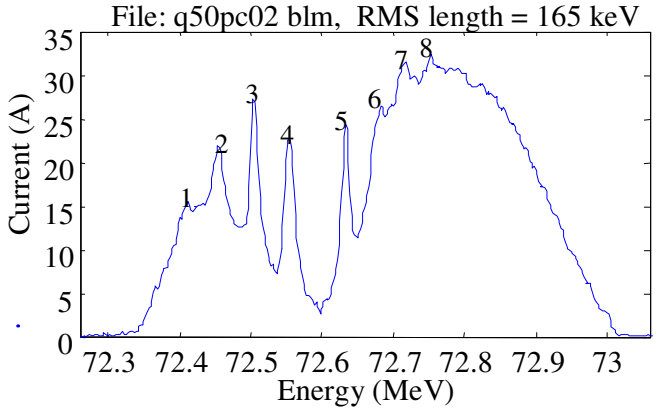


Two-pulse studies

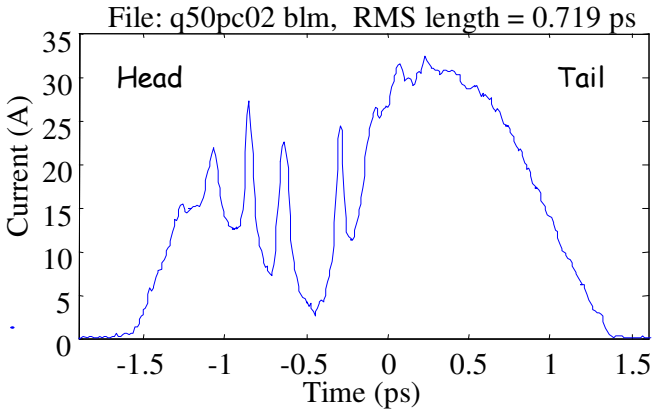
UV laser time profile from cross-correlation measurement. Fourier-plane mask produces two closely spaced pulses.



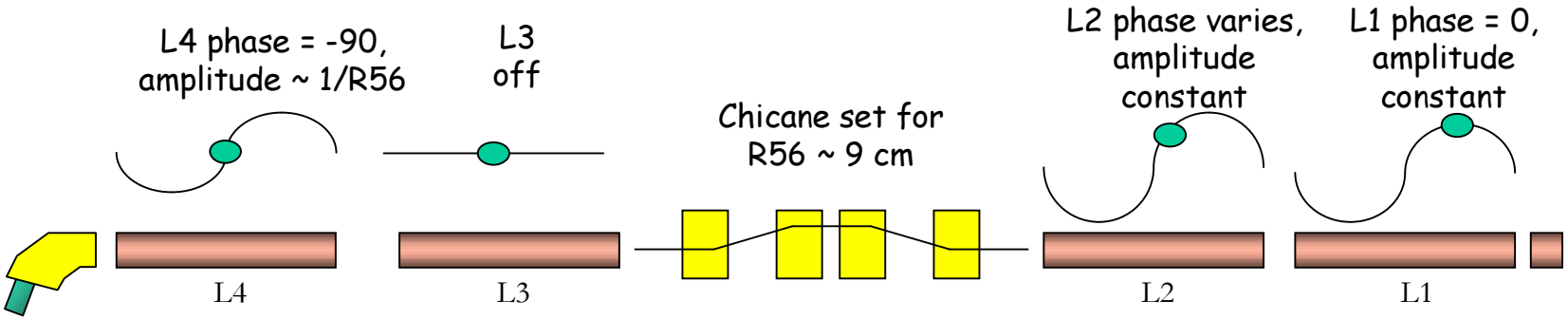
Energy distribution using T. Smith method. R56 = 9.5 cm, upstream chirp near zero (~no compression).

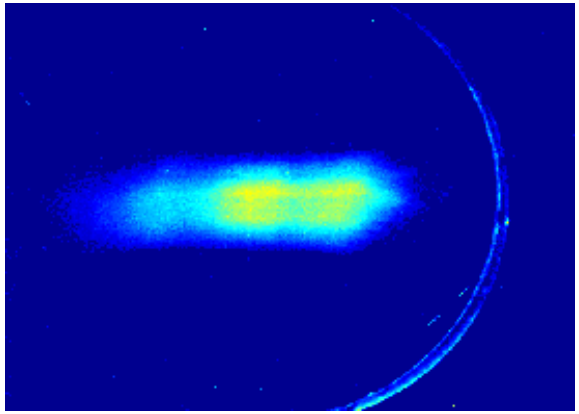


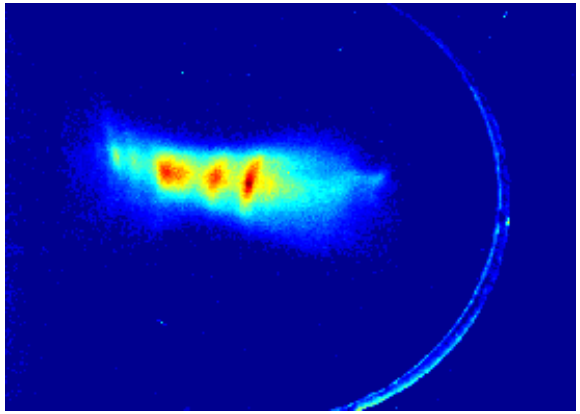
Peak spacing ~64 um.

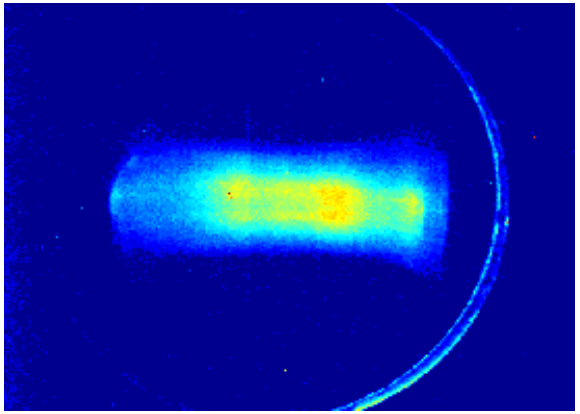


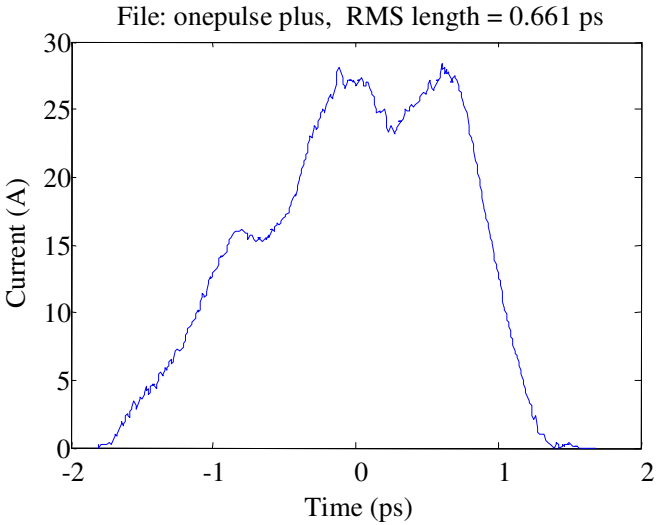
T. Smith method time profile measurement

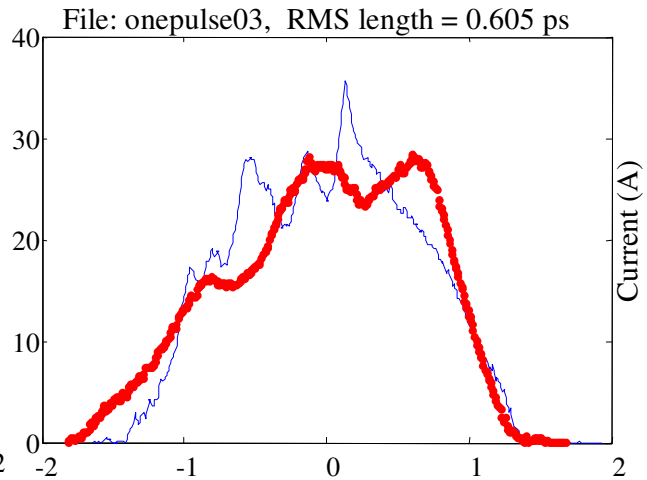


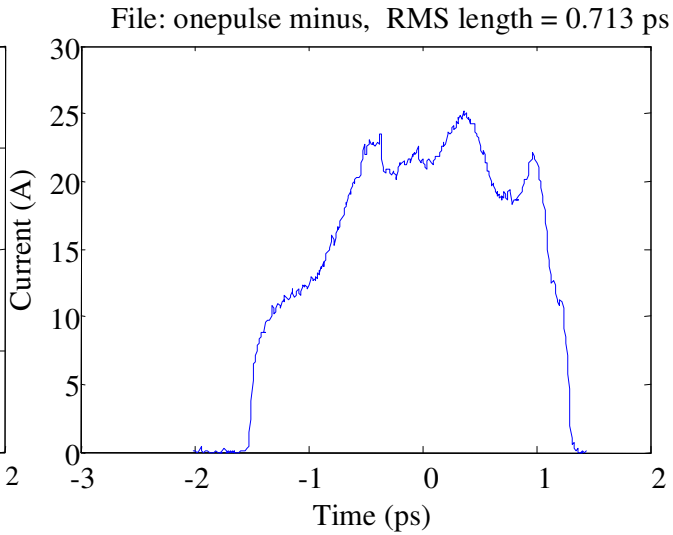








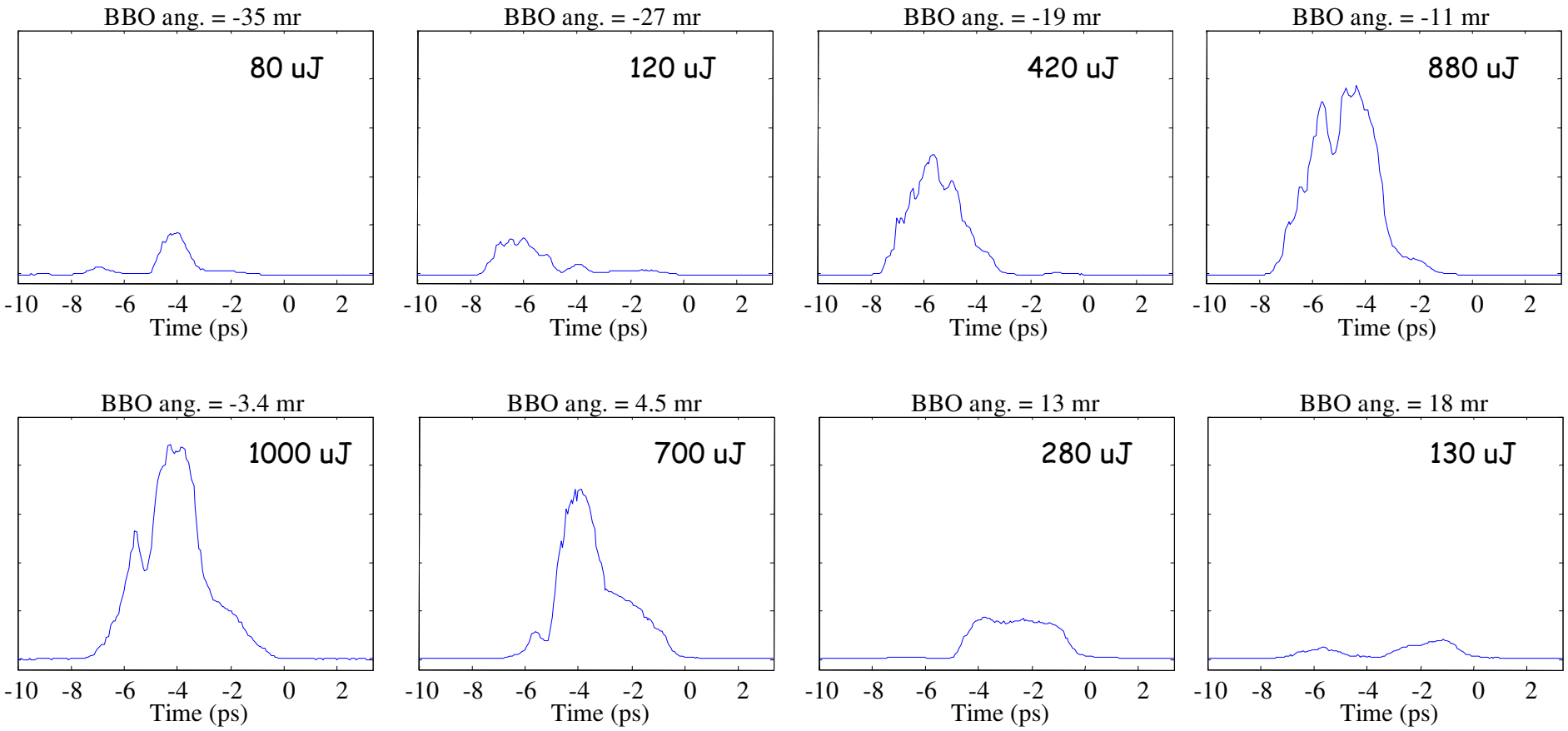




Laser time profiles

Time profiles measured by scanning cross-correlation (difference frequency generation) of few ps UV cathode pulse with 100 fs IR oscillator pulse. Time resolution is 200 fs FWHM. Data from B. Sheehy and H. Loos. ~5 minutes/scan.

Different plots are for different matching angles in BBO harmonic generation crystal.



RF zero-phase compared to 'sub-ps' streak camera

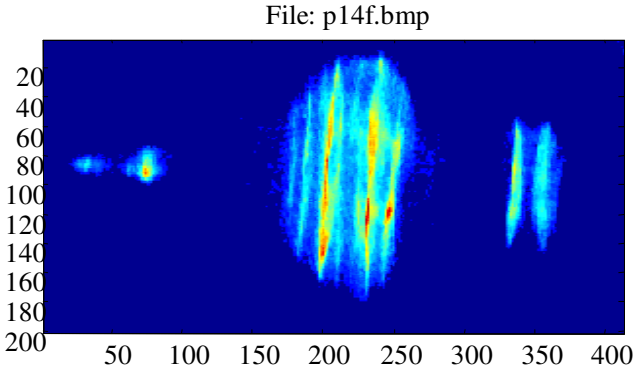
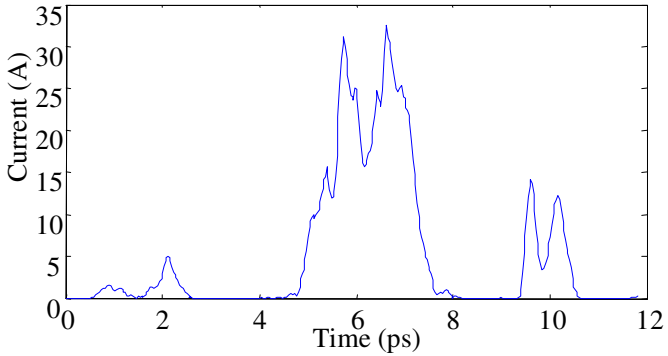
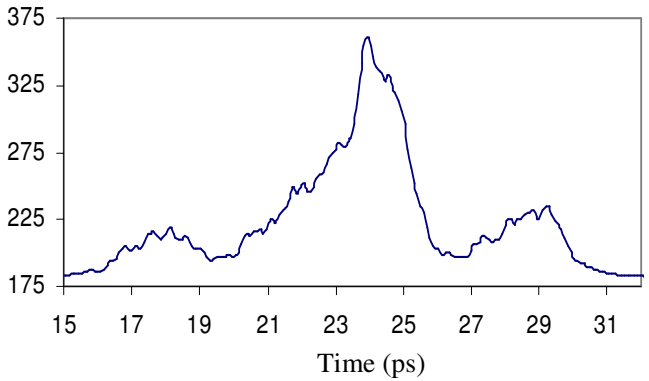


Image of electron beam on pop14. Horizontal axis is time. Laser BBO crystal deliberately detuned to produce structure.



Bunch time profile from YAG image. Structure is due to laser…chicane off.



Streak camera measurement of UV light. Hamamatsu FESCA 500 streak camera with reflective input optics, sub-ps synch, and wide-response cathode.

Measured FWHM time resolution is **760 fs** repetitive mode, **1.0 ps** single-shot at 800 nm, and **2.4 ps** single-shot at 266 nm.

Next steps…

Tomography: Use existing RF and chicane to measure complete 2D longitudinal distribution upstream of chicane. Currently under test.

IR spectrum: Installing new interferometer to measure CSR spectrum.

RF Deflector: Would provide unambiguous single-shot 2D longitudinal distribution upstream and downstream of chicane.

Simulation: Continue to build detailed comparison with experiment.

Benchmark different codes against experiment.