Electron Beam Microbunching and Coherent Radiation Observations

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Microbunching of the electron beam at 100 fs and shorter timescales is observed at BNL's Source Development Lab.

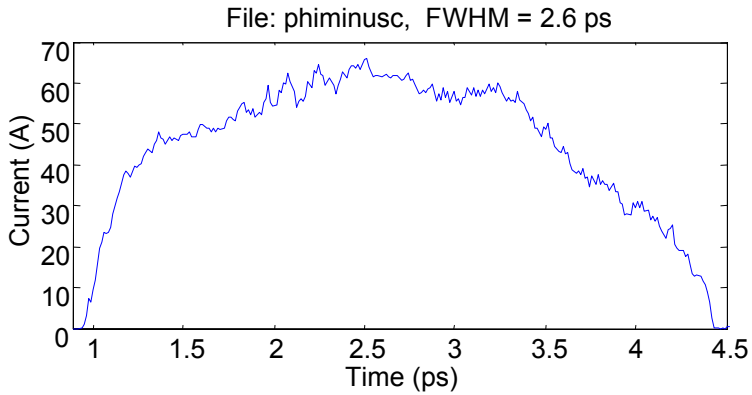
An initially smooth time profile becomes more modulated as the compression is increased. The causes are not yet fully understood. We believe that time modulations in the UV photoinjector drive laser perturb the energy-time distribution of the electron beam, and that this small perturbation is amplified by coherent synchrotron radiation emission in the bunch compression chicane magnets.

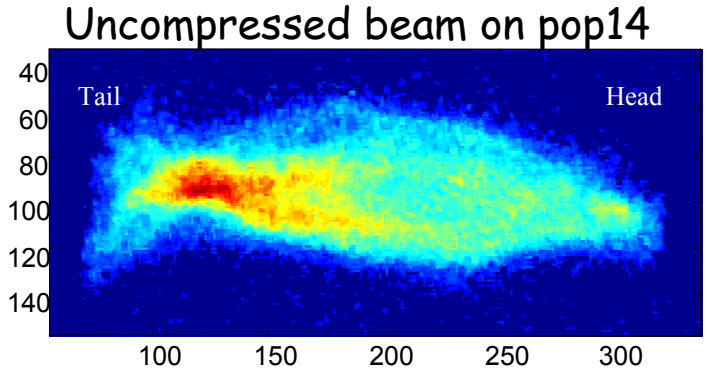
The following slides present measurements of the electron beam time profile using the RF zero phasing method, and frequency domain measurements using a far IR interferometer to estimate the power spectrum. The two complementary methods are in good agreement on the microbunch structure.

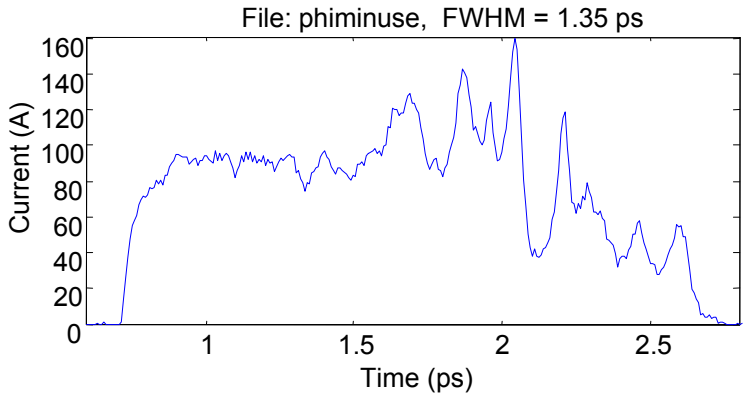
Cross-correlation measurements of the UV laser time profile are also presented that show the dependence of the time modulations on the phase matching angle of the BBO harmonic generation crystals.

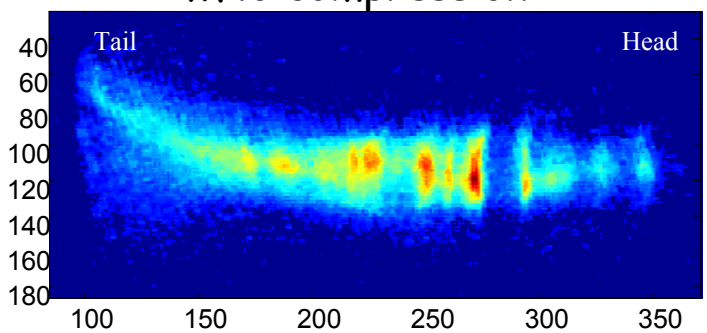
Each of these measurement methods has resolution < 200 fs, which is required to resolve the various modulations.

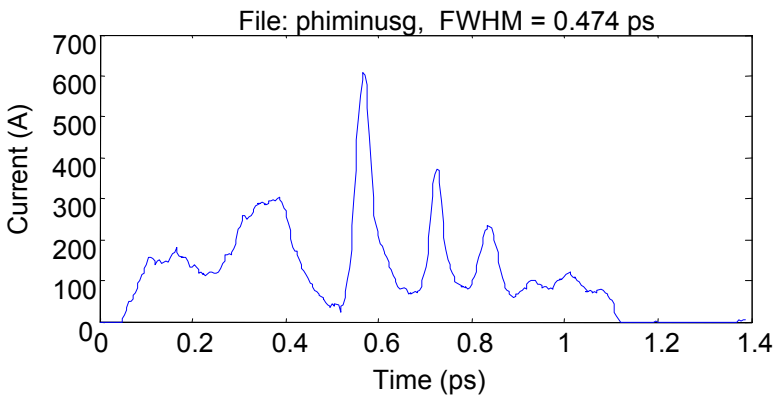
Microbunching at high compression

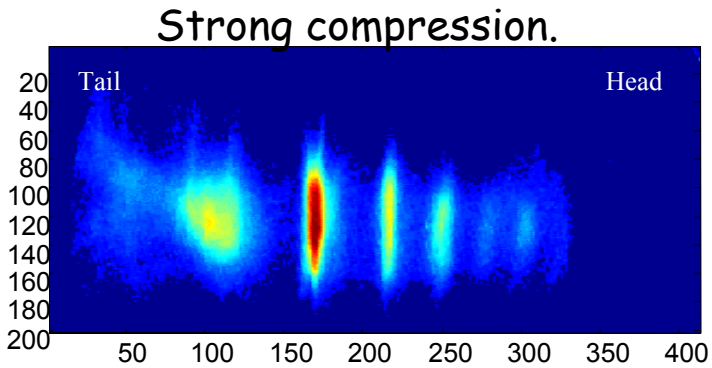










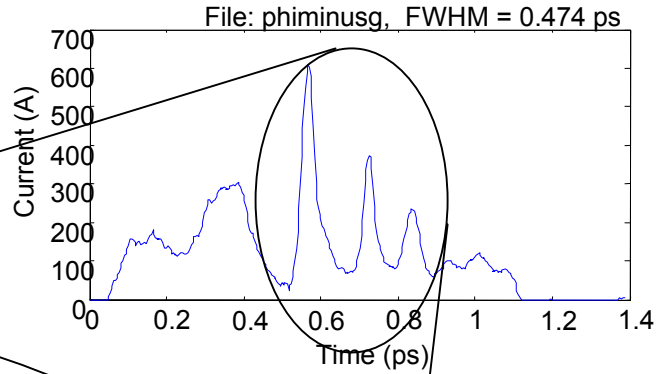


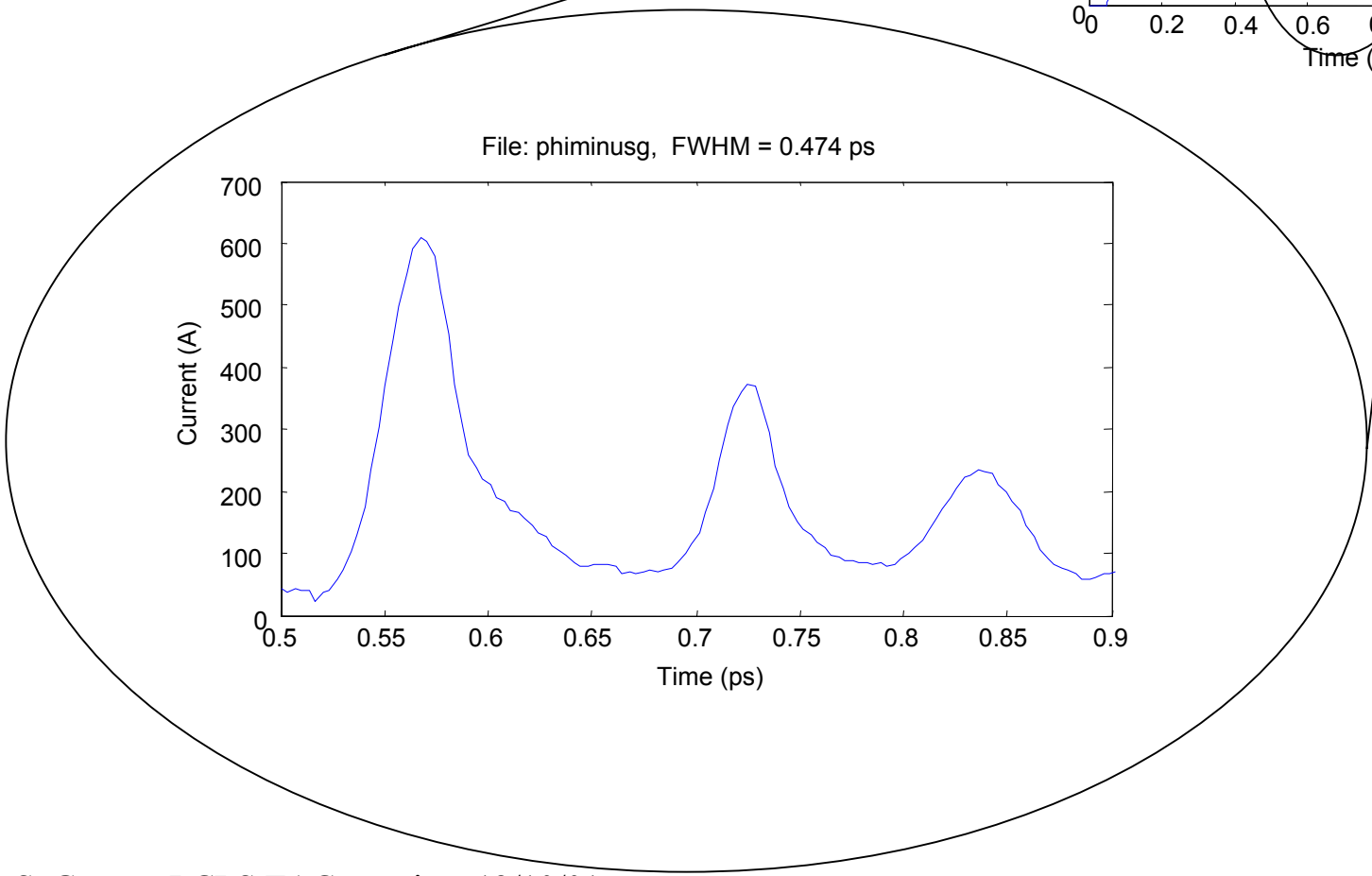
RF Zero Phase Bunch Length Measurement

Time resolution < 50 fs.

Peak spacing is 140 fs (42 um).

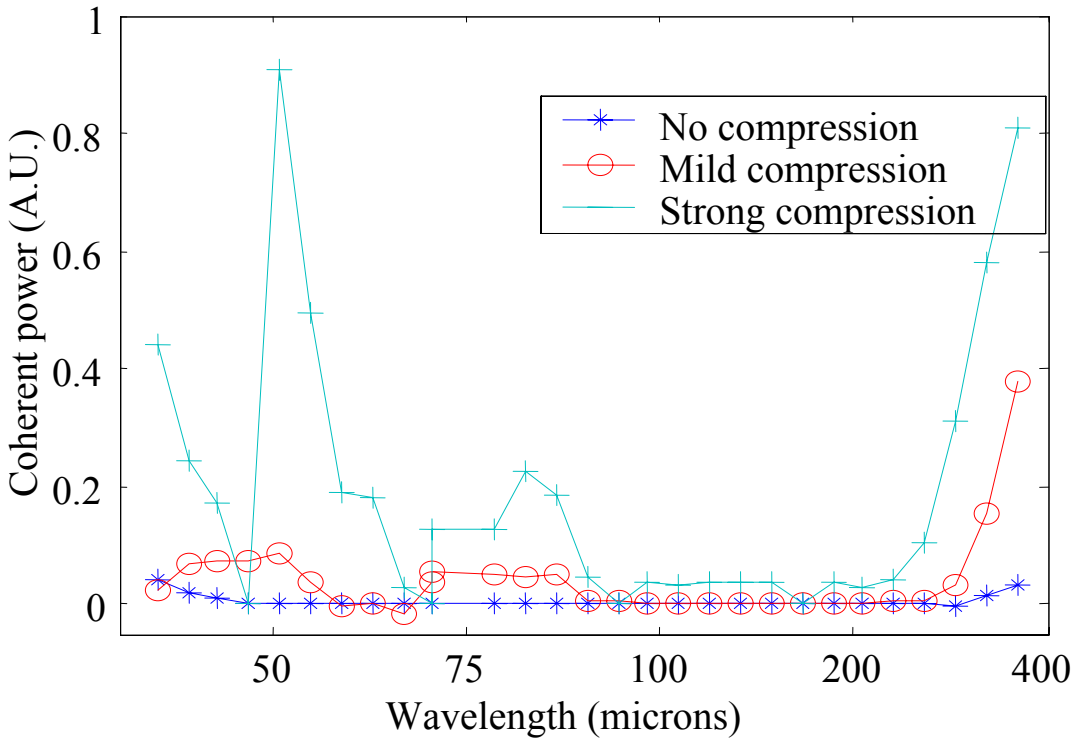
Peak full-width is 50 fs (15 um).





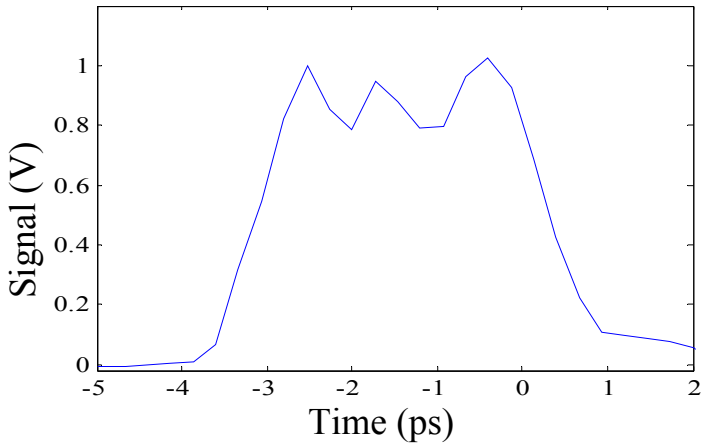
Coherent Infrared Spectra

Data and analysis from Larry Carr



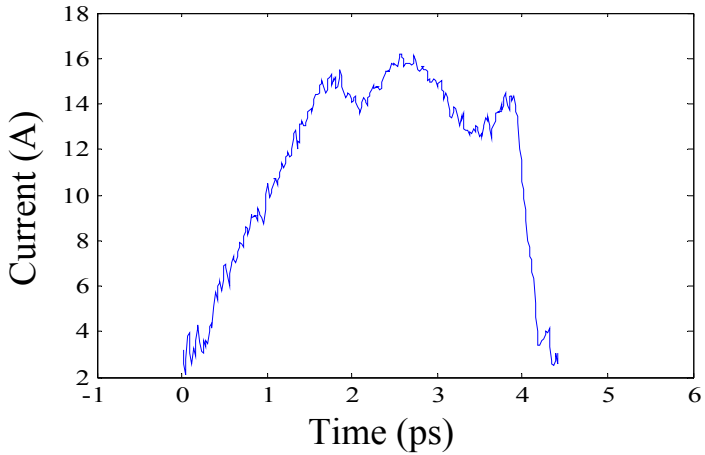
These spectra were recorded concurrently with the three RF zero-phasing time profiles.

Modulations on photoinjector drive laser may seed CSR microbunching.



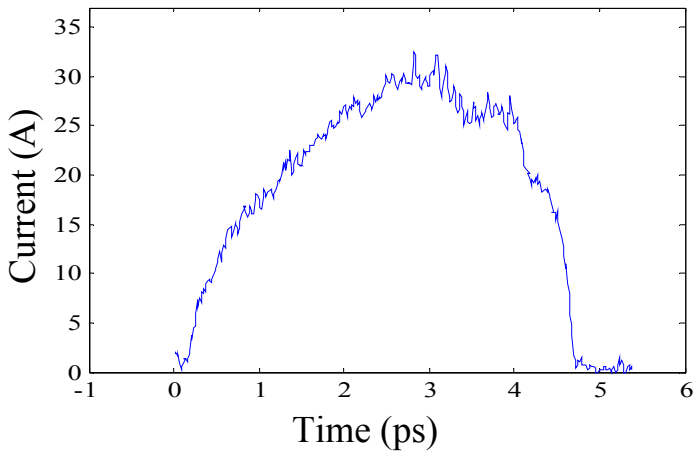
UV laser time profile

Resolution = 200 fs, RMS length = 0.97 ps



Uncompressed e-beam time profile (50 pC)

Resolution = 200 fs, RMS length = 1.05 ps.



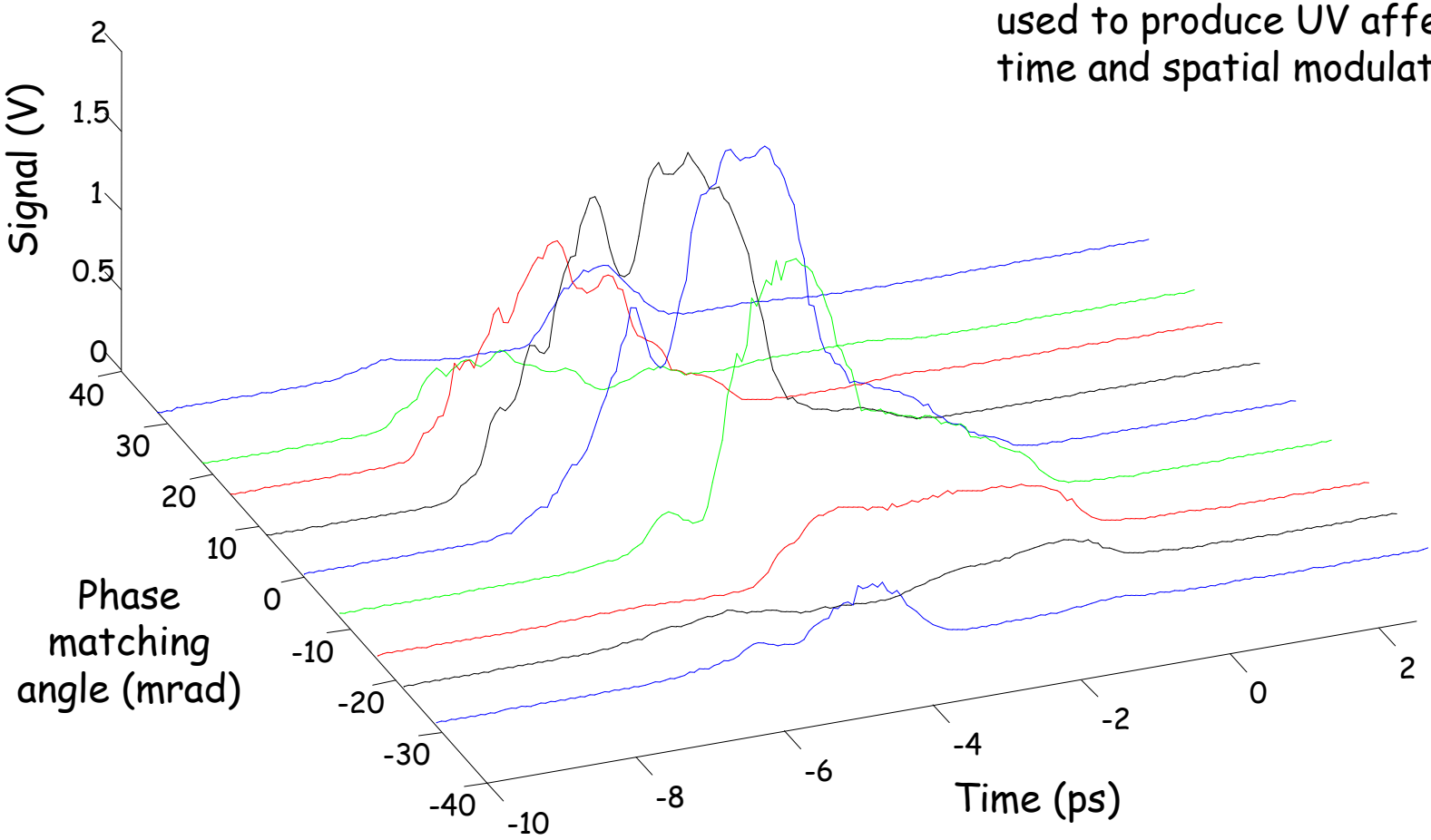
Uncompressed e-beam time profile (100 pC)

Resolution = 200 fs, RMS length = 1.13 ps.

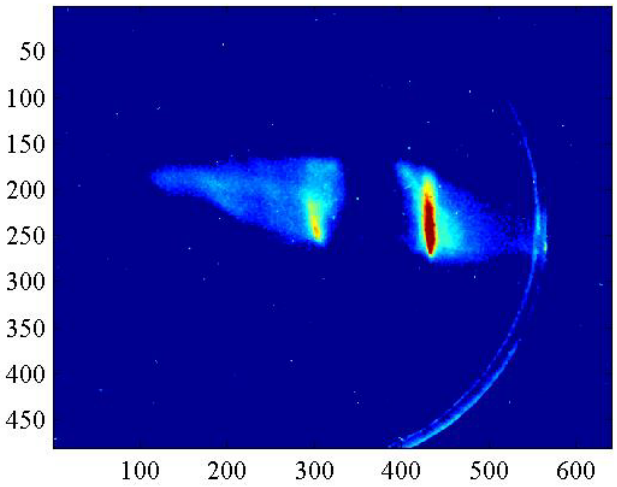
Time structure smooths out as charge increases, due to space charge. However, local energy modulations are produced that can seed microbunching.

Time modulations on UV laser pulse

Phase matching angle of harmonic generation crystals used to produce UV affects time and spatial modulations.

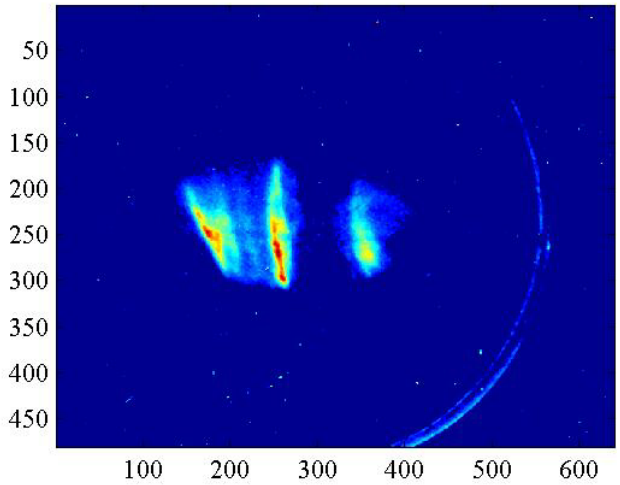


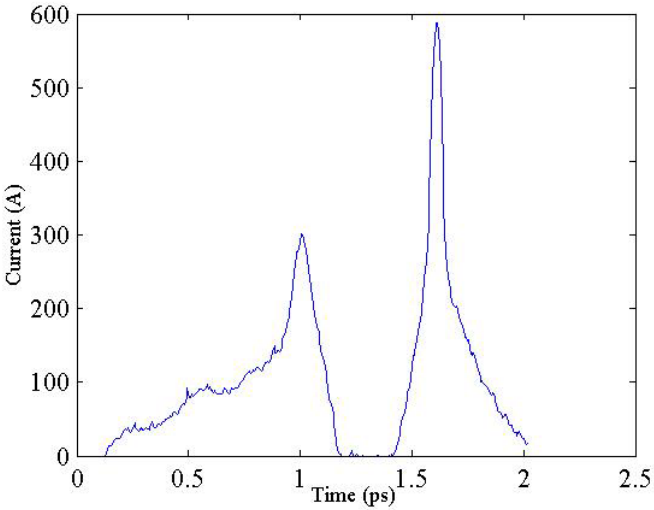
Recent Microbunching Measurement



Images of chirped, compressed ebeam from scintillator in dispersive section.

(RF zero phasing measurement)





Projection of above images onto time axis.

Compression phase is 26 degrees from crest…just before max compression.