Compression Studies at the ATF with the UCLA-BNL Chicane

Gerard Andonian
Particle Beam Physics Laboratory
University of California Los Angeles

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Collaboration

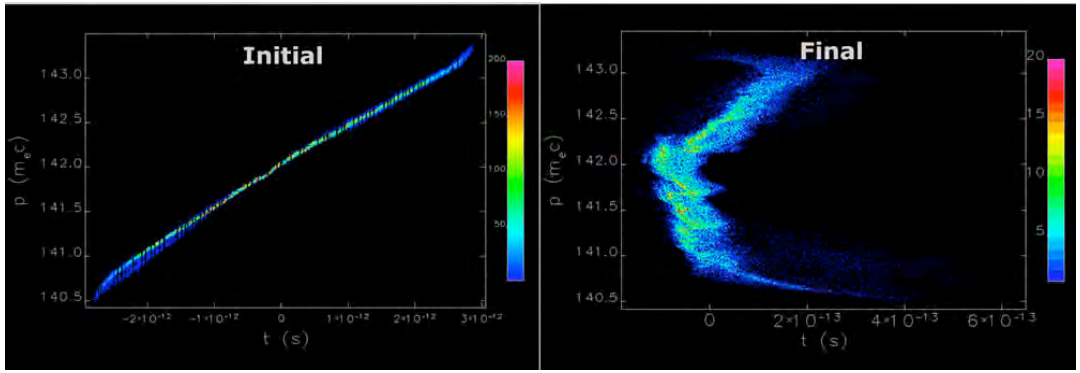
- UCLA
  - R. Agustsson, G. Andonian, A. Cook, P. Frigola, A. Murokh, S. Reiche, J. Rosenzweig, G. Travish, F. Zhou
- BNL-ATF
  - M. Babzien, I. Ben-Zvi, K. Kusche, R. Malone, M. Woodle, V. Yakimenko
- INFN-LNF
  - G. Palumbo, C. Vicario
- Univ. Milano
  - A. Flacco

Outline

- Motivation
- Technical Specifications
- Coherent Transition Radiation (CTR)
  - Recent Data
- Coherent Edge Radiation (CER)
  - Theory overview
  - Simulations
  - Preliminary Results
- Outlook

Motivation

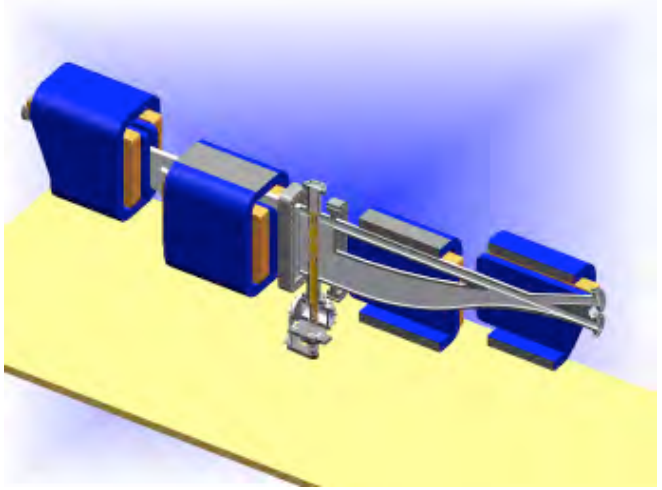
- Generation of compressed sub-micron beams
  - Study radiative effects (CSR, CER) emitted from short beams
  - Continue UCLA Neptune compressor physics studies in acceleration field dominated regime (space charge -> coherent radiation)
  - May greatly impact performance of future compressors and FELs (e.g. microbunching instability)
  - Use CER as non-destructive bunch length monitor



Parmela-Elegant simulation longitudinal phase space of beam, with compression from 50A to 1.5 kA.

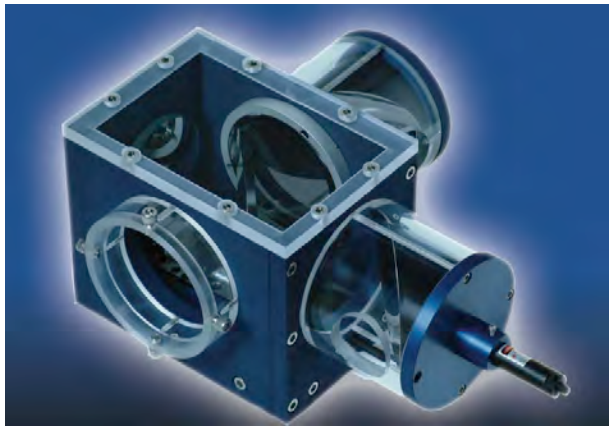
Compressor

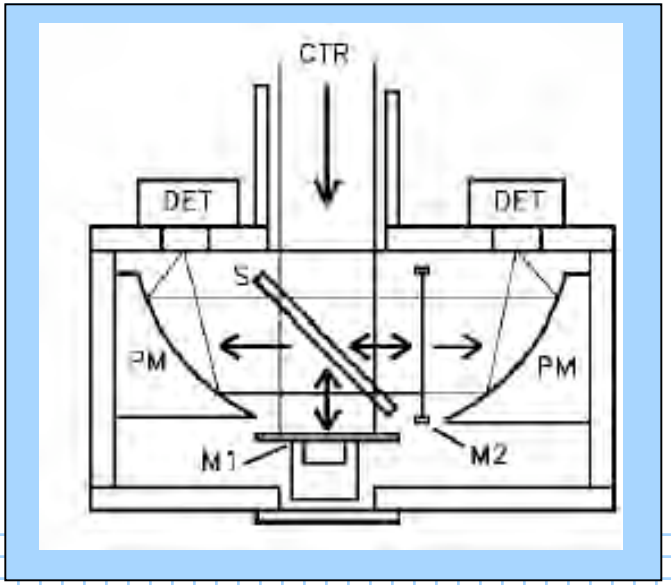
- Designed and Constructed at UCLA
  - Modeled with Amperes
  - Engineering + safety concerns addressed by ATF
- Installed and operational at ATF
  - Add to ATF core capabilities
  - Compress from 350 μm – 20 μm
- Extensive Simulation work
  - TREDI, Field-Eye, Parmela, Elegant



CTR Measurement

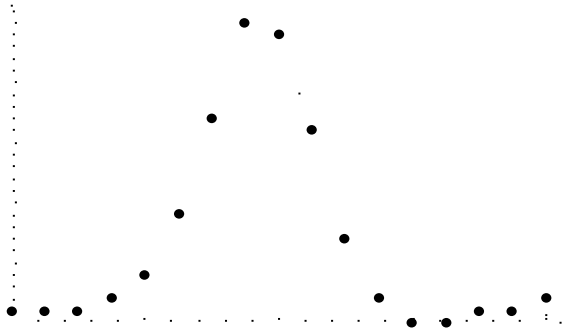
- Michelson Interferometer
  - Commercial Product
  - Compact Footprint
  - Convenient Alignment
  - Resolution : 10 μm – 1.5 mm (rms)
- Observe CTR from insertable foil
  - Golay Cell detectors
  - Autocorrelation
- UCLA time-domain methods (fitting) and data acquisition

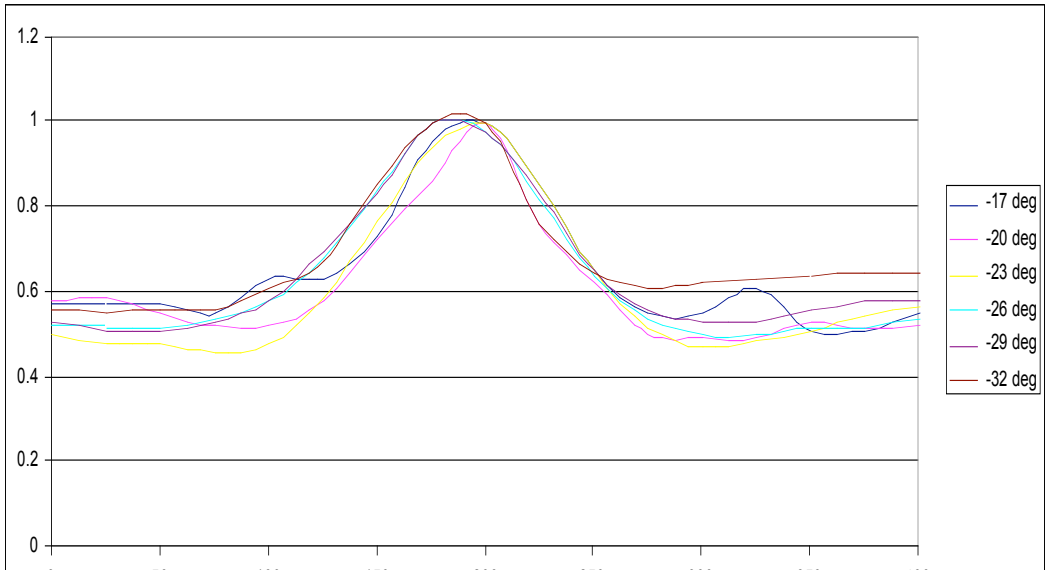


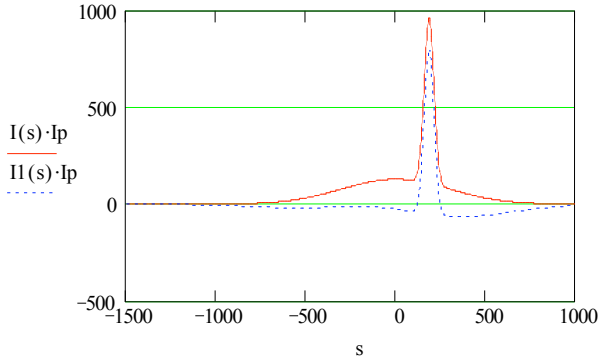


CTR Data

- Recent CTR data
  - Beam core compression not strongly dependent on phase
- UCLA Fitting technique
- σ = 27 μm (rms)
- Use double Gaussian
  - Reproduces expected pulse shape (ramped with tail)

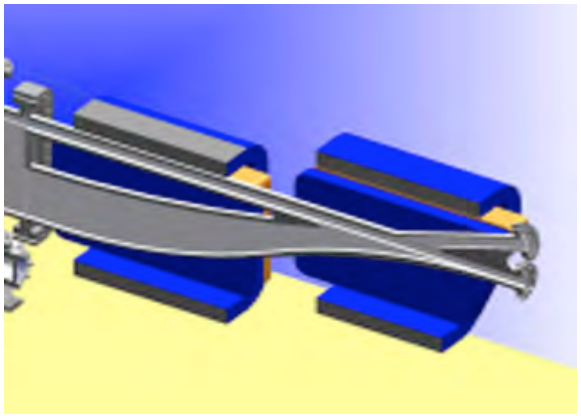


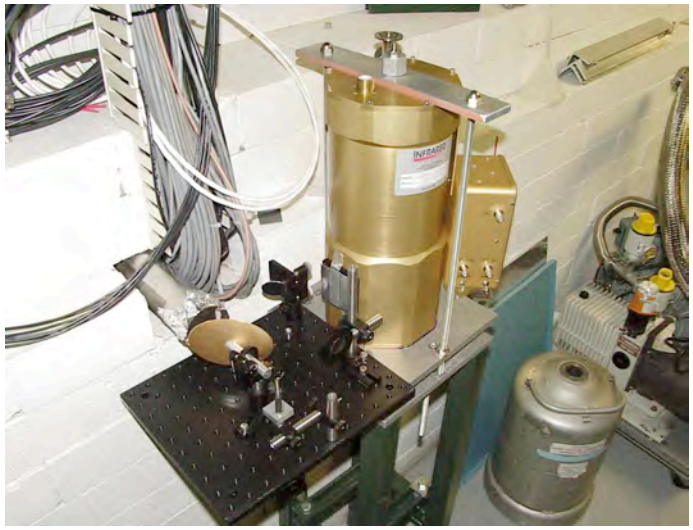




CER Experiment

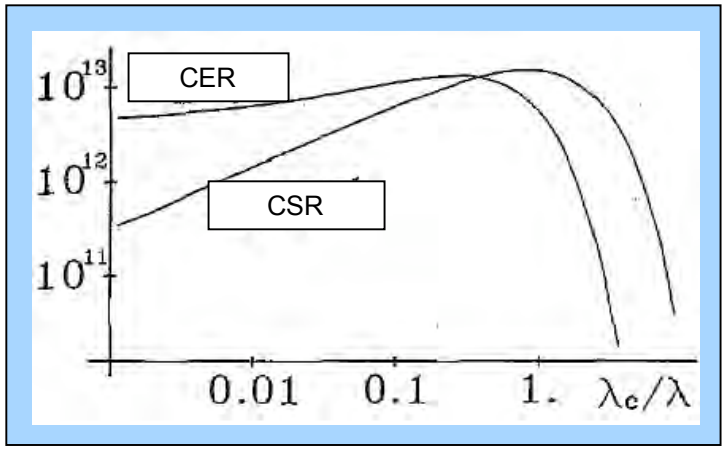
- Radiation collected from boundary region of dipoles 3-4
  - 7 m transport
- New regime for Edge Radiation
  - <50 micron wavelength
- Cold Bolometer
  - 4.2 K Si bolometer (IR Labs)





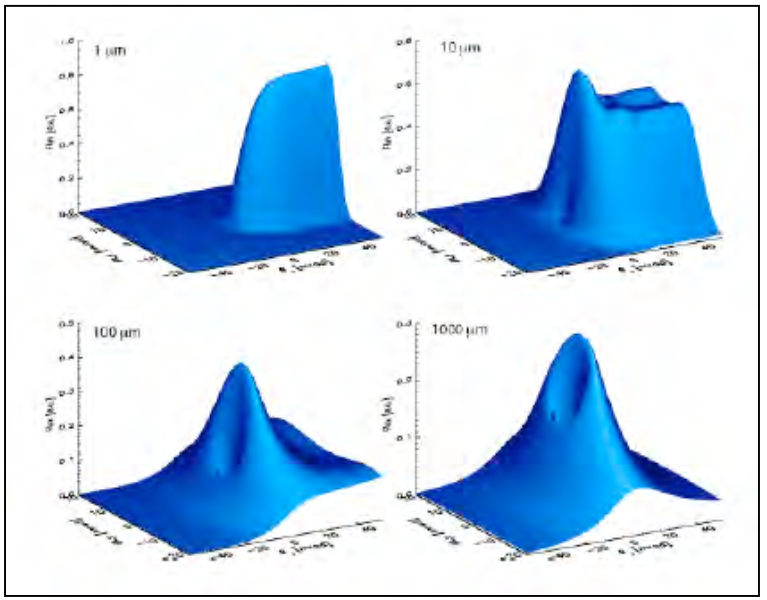
CER Overview

- Comparison to CSR
  - Not well distinguished from CSR at short wavelengths
  - Like CTR at long wavelengths
  - Radial polarization



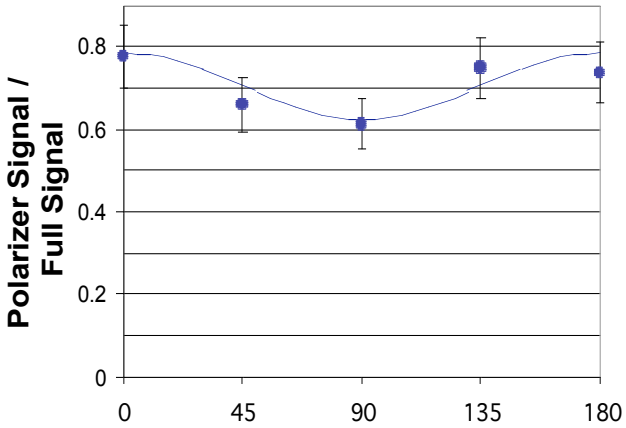
Chubard, Smolyakov, J. Optics 24 (1993) 117

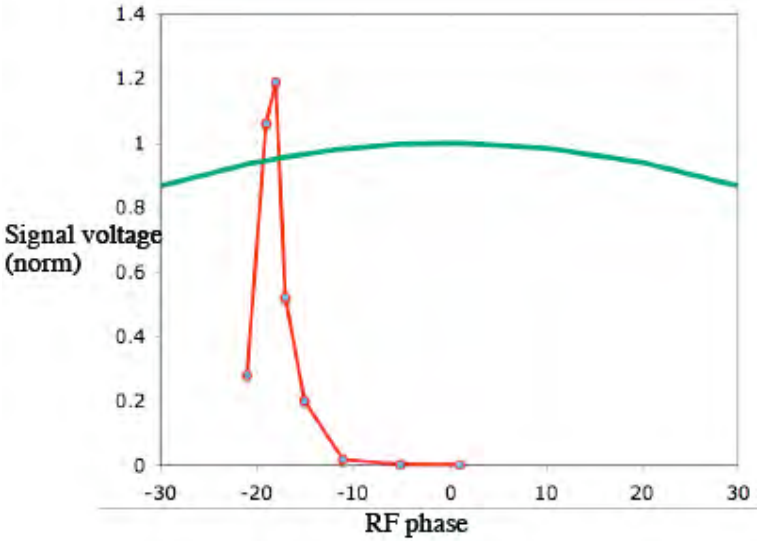
- CER calculations
  - Modeling with :
    - Semi-analytical
    - Field-Eye

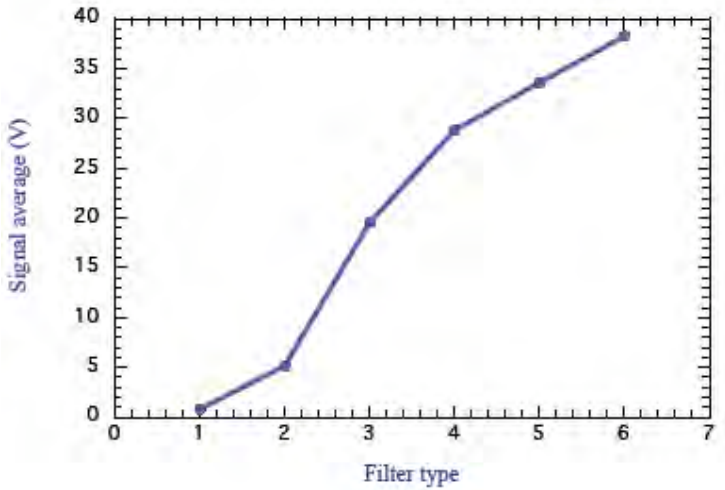


CER Results

- CTR+CER as a function of rf phase
  - Max signal -19 deg off crest
    - 11 deg forward of min momentum spread
- Polarizer
  - Radial polarization
- Filters
  - Reconstruct spectrum







Momentum Spread

- Observation of bifurcation
  - Momentum spectrum
    - Strong breakup of momentum distribution at phase of full compression
    - Currently being studied with TREDI code

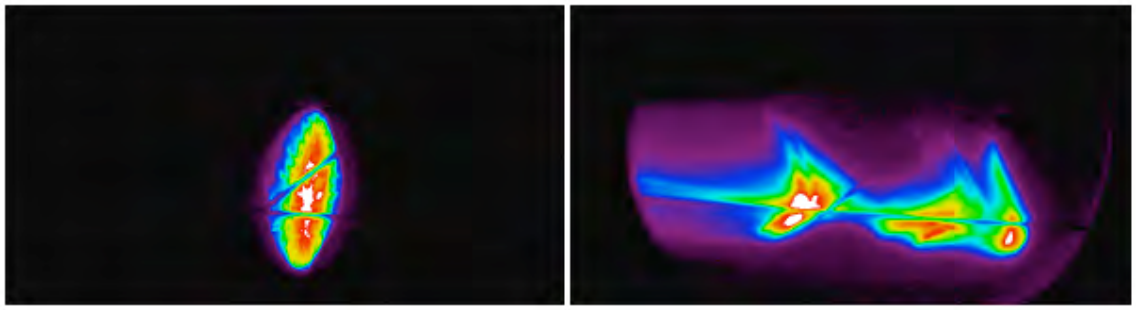
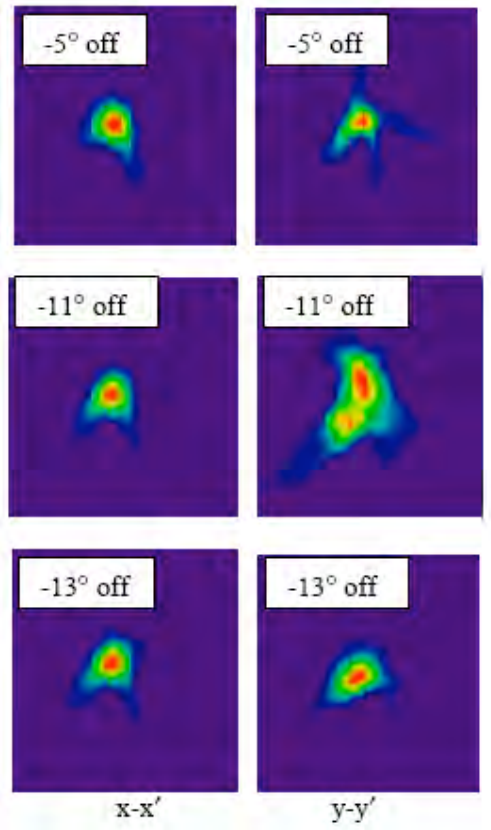


Image of beam in spectrometer (horizontal is bend plane).

Min. energy spread and no compression - 9 deg fwd of crest (left);
Max. compression -19 deg fwd of crest (right).

Transverse Effects

- Tomography
  - Quadrupole scanning tomography developed at ATF
- Operating parameters
  - Energy = 60 MeV
  - Charge = 200 pC
- Mild bifurcation observed
  - Space charge forces giving phase space bifurcation are alleviated at this energy



Bend plane is along vertical axis. Reconstructed phase space plots for under-, full-, and over- compression

F. Zhou *et al*., Experimental Characterization of 4-D Transverse Phase Space of a Compressed Beam, PAC 2005 Proceedings

Conclusions

- Summary
  - Chicane compressor installed and commissioned
  - Compressor provides a rich data set
    - CTR, CER, momentum spread, tomography
  - Simulations need to catch up
    - Microscopic physics model
- Future Run Plans
  - CER filter measurements
  - Improved CER polarizer measurements
  - Compare to models (Field-Eye)