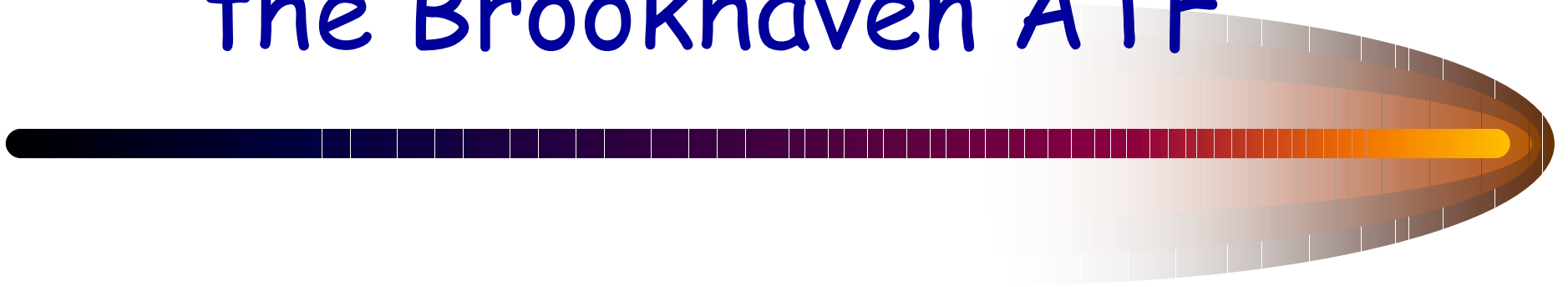


Longitudinal Beam Dynamics at the Brookhaven ATF



J.B. Rosenzweig

UCLA Department of Physics and Astronomy

BNL, April 30, 2001

Overview



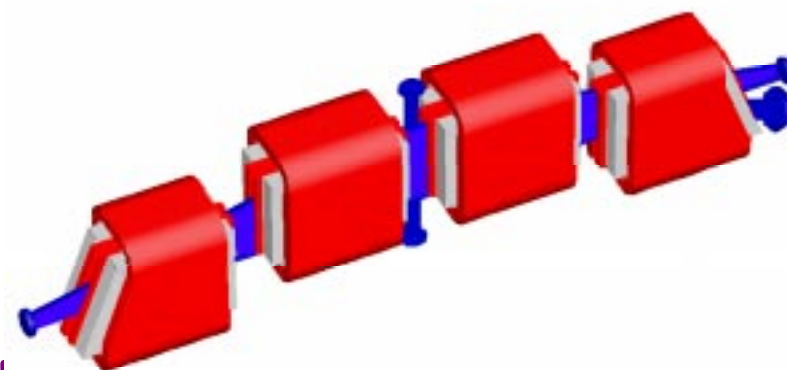
- Dual purpose: compressor update, and analysis of VISA beam brightness anomalies
- UCLA Chicane compressor
 - Compatibility with existing beam transport
- Study of combined chicane+double dogleg systems
 - Example: Beamline 1
 - Example: Beamline 3
- VISA performance: compression in Beamline 3
- Measuring the pulse length in the undulator line



UCLA chicane compressor for ATF

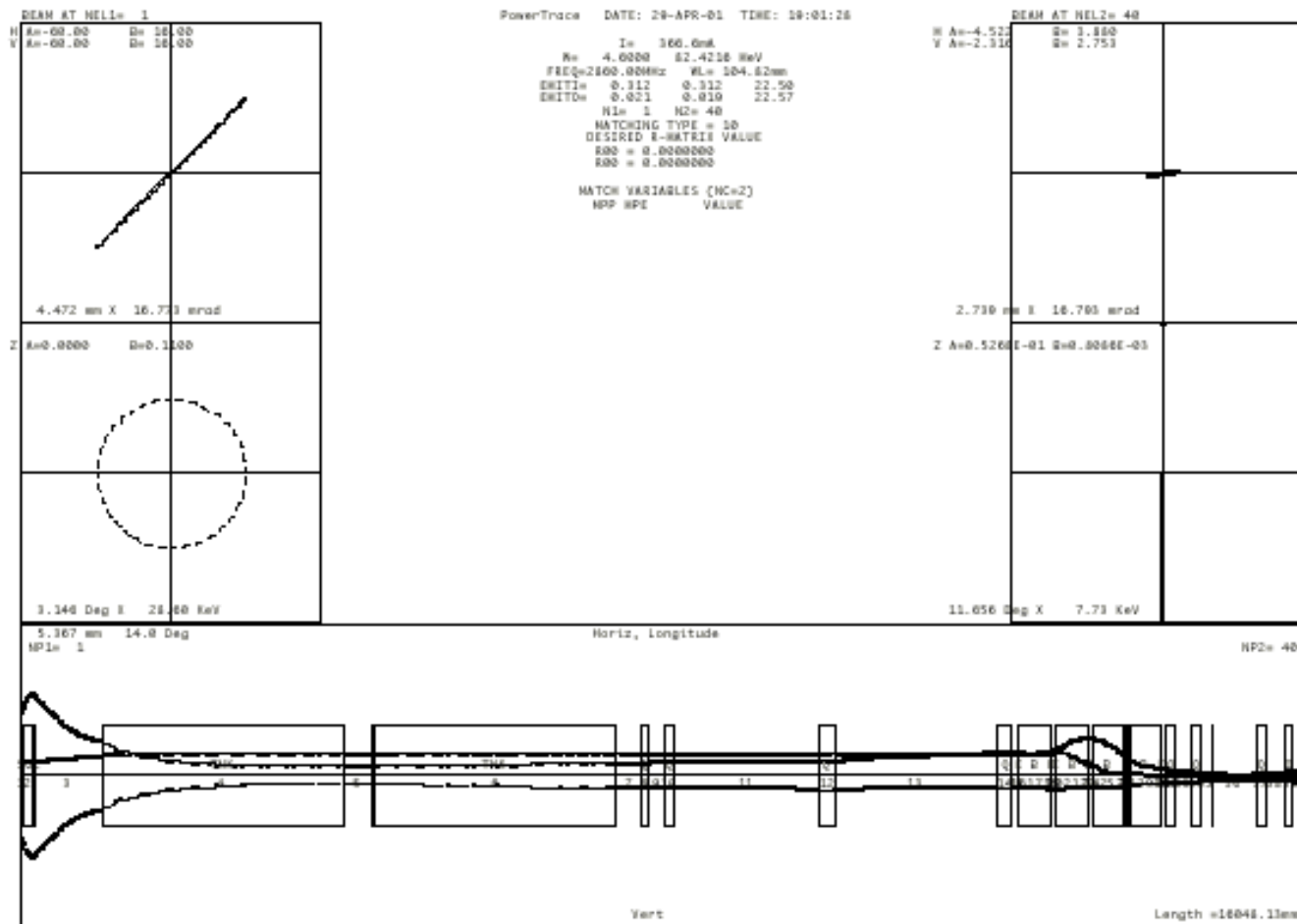
- Double focusing system
- Nominal parameters

| | |
|--------------------------------|------------------|
| Rms energy spread $\delta U/U$ | 0.1% |
| Bend angle θ | 20 degrees |
| Radius of curvature R | 1.2 m |
| Final pulse length σ | 25 μm |
| Charge Q | 150 pC |



- Possible use for CSR, SASE FEL and plasma experiments
- Status: magnets complete; vacuum vessel under construction, stands/electricals designed

TRACE3D simulation of chicane (compression by factor of 11)

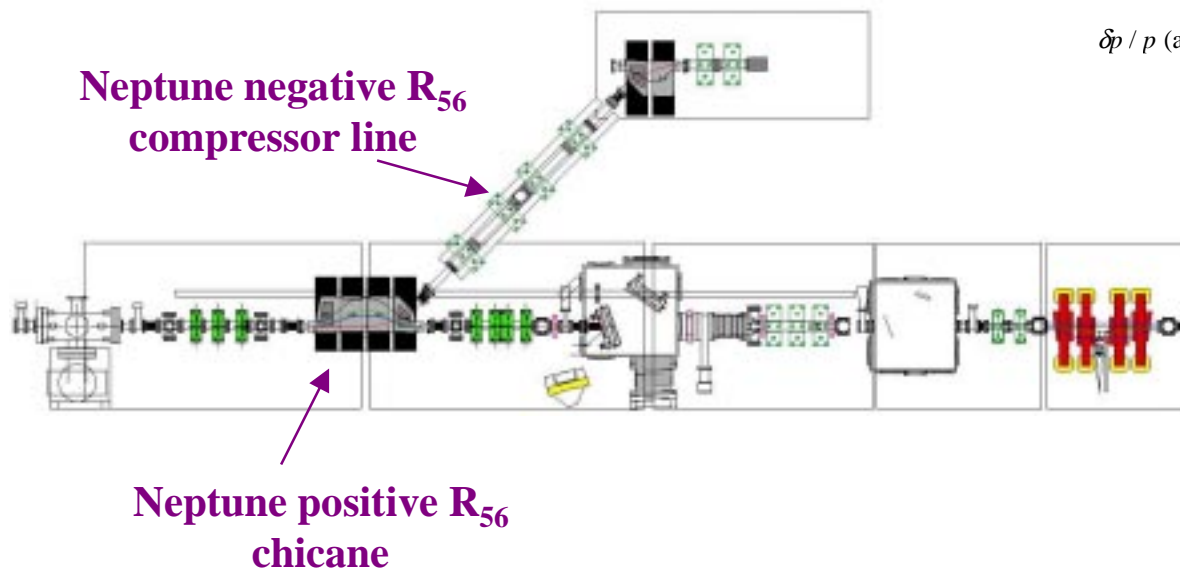


BNL beamlines

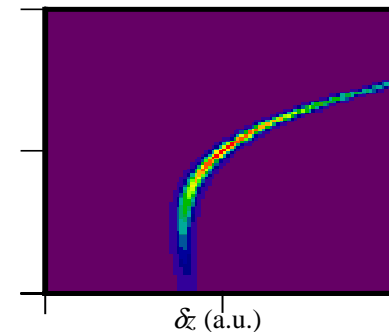
Recent issue: compatibility of beamlines with chicane



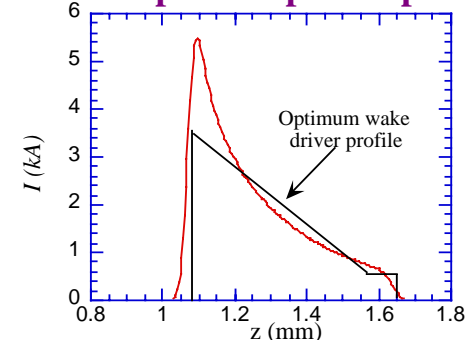
- Energy spread ("bandwidth")
- Opposing R_{56} parameters
- Timely issue: impacts Neptune and ORION design/implementation



$\delta p / p$ (a.u.)



Compressed phase space



Projected current profile

BNL beamlines



Chicanes v. "S-bends"

- Chicane longitudinal "drift" parameter $R_{56} \equiv \partial z / \partial (\delta p / p)$

$$R_{56,Ch} = 4R[\tan \theta - \theta] - \frac{L}{\gamma^2} \cong \frac{2}{3} R \theta^3$$

- Need to run linac roughly 20 degrees forward
- S-bend parameter

$$R_{56,S} = 2R[\theta - \sin \theta] - \frac{L}{\gamma^2} \approx -\frac{1}{3} R \theta^3$$

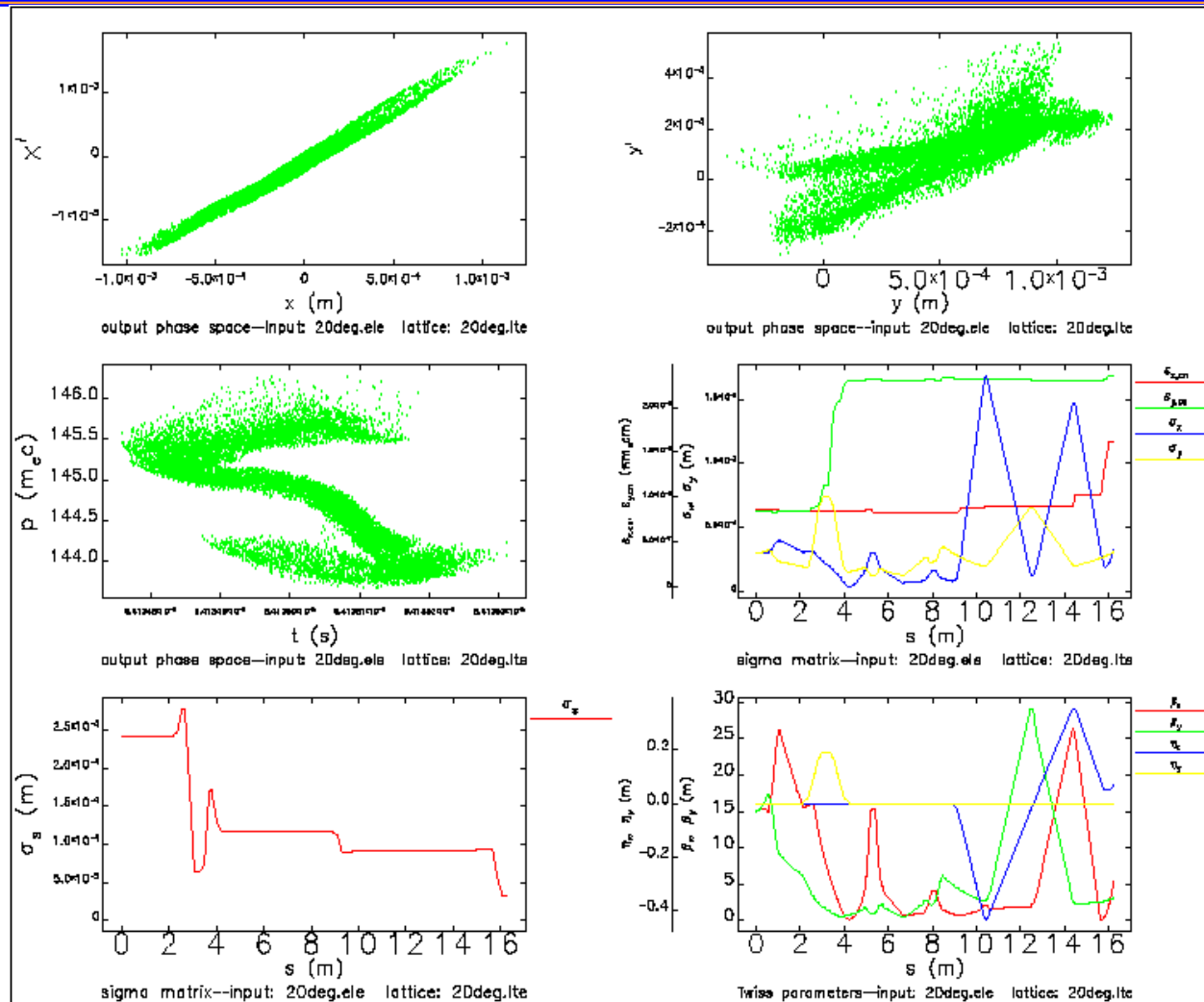
- Need to run linac roughly 45 degrees backward...
- For the ATF, the nominal radii of curvature and bend angle are the same; the beamlines remove nearly half of the compression!
- Overcompression in chicane needed (more energy spread or more bend...)

ATF Beamline Studies



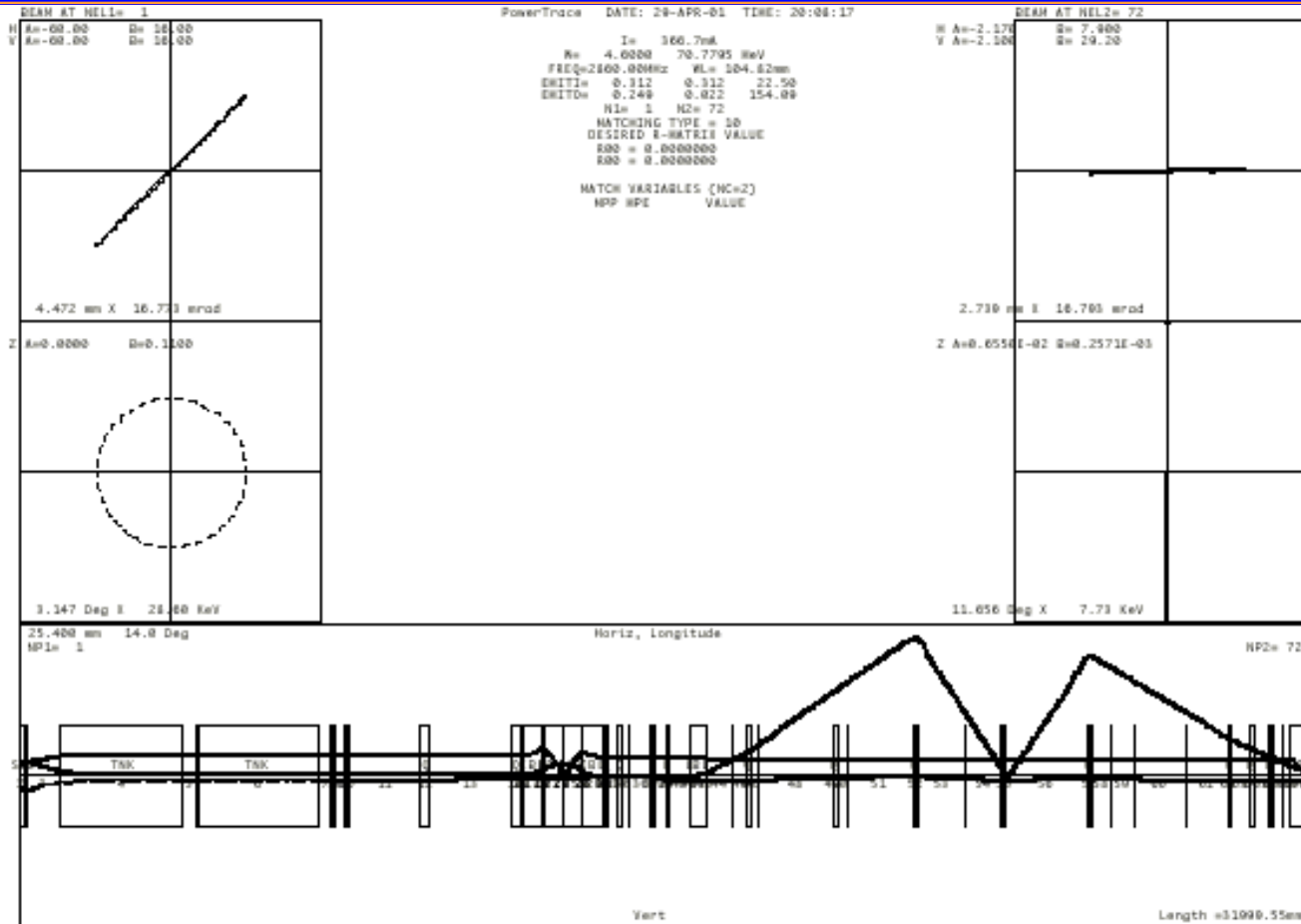
- Beamline 1 (for Compton...)
 - TRACE 3D (linear space-charge)
 - ELEGANT (Coherent synchrotron radiation)
- Beamline 3 (VISA)
 - TRACE 3D
 - Present beamline tune
 - Modified tune for lower dispersion
 - Energy error analysis

Beamline 1: ELEGANT simulation



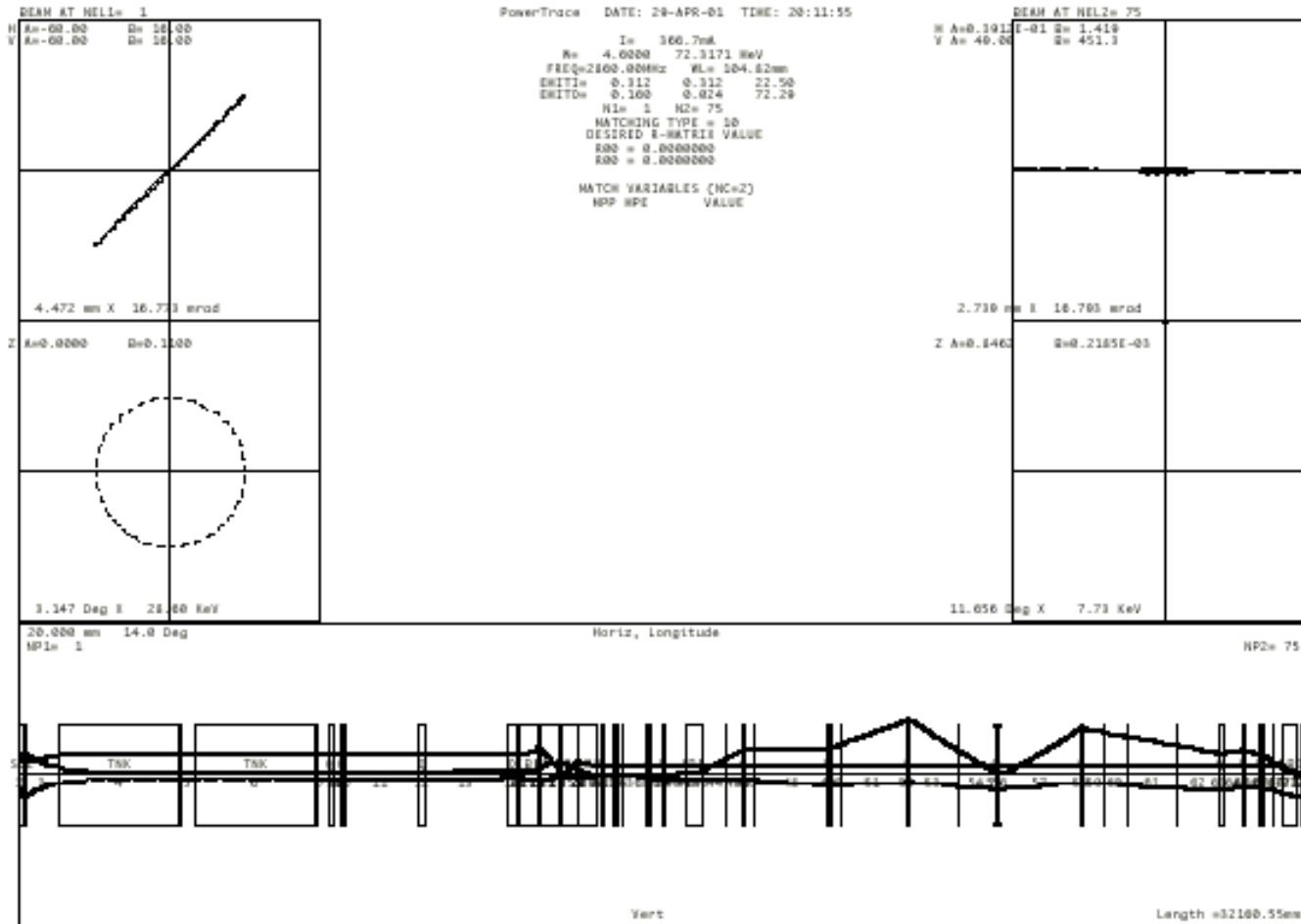
BNL beamlines

Beamline 3: Present tune



Excessive dispersion/beam size
BNL beamlines

Beamline 3: Modified tune



Controlled dispersion/beam size. Capable of FEL operation?

BNL beamlines



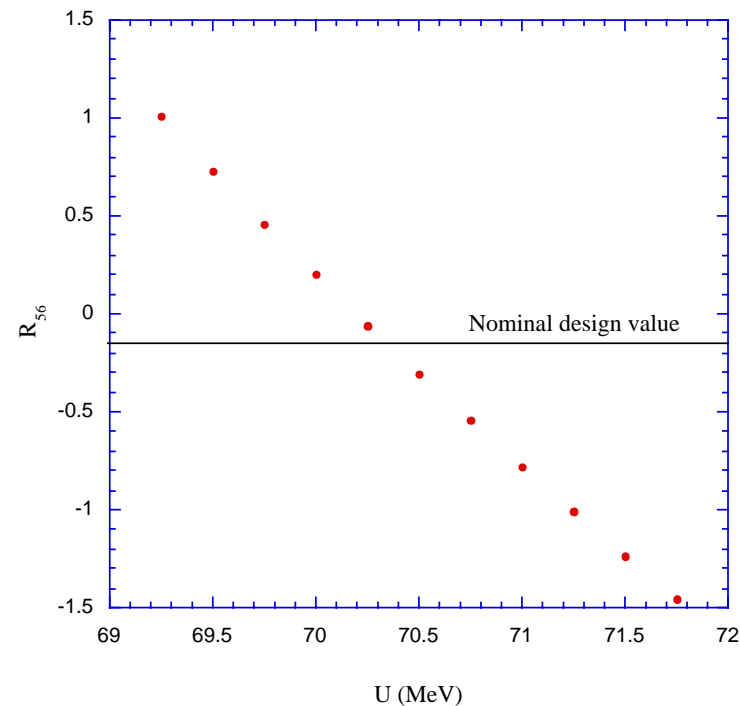
Beamline 3: VISA operation

- Operational anomalies ("hints")
 - Gain length short
 - Single spectral peak in saturating cases
 - Need to tune linac phase ($\sim 4-5$ degrees) to obtain highest gain
- 5 degrees not sufficient for significant compression
- Examine off-energy operation

Off-energy operation

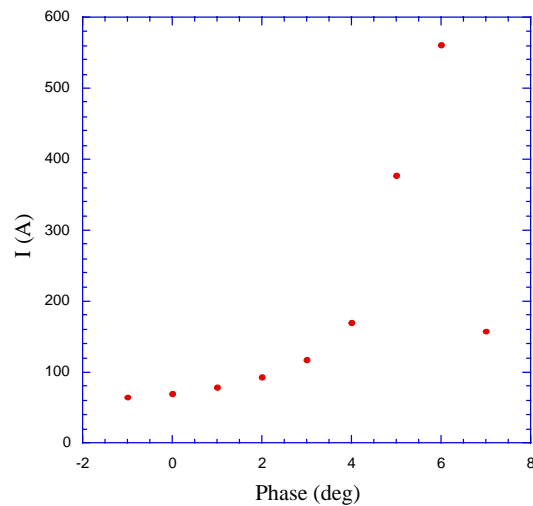
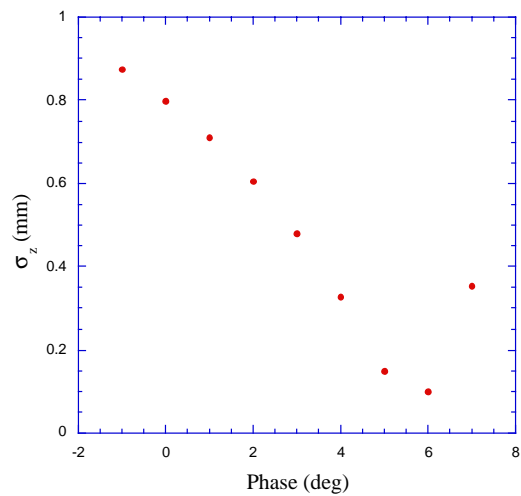
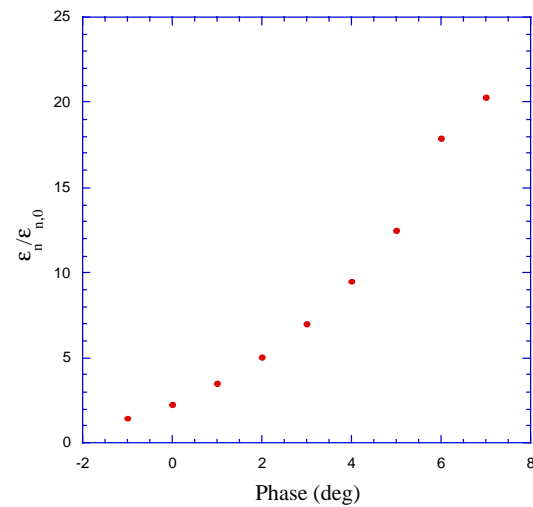
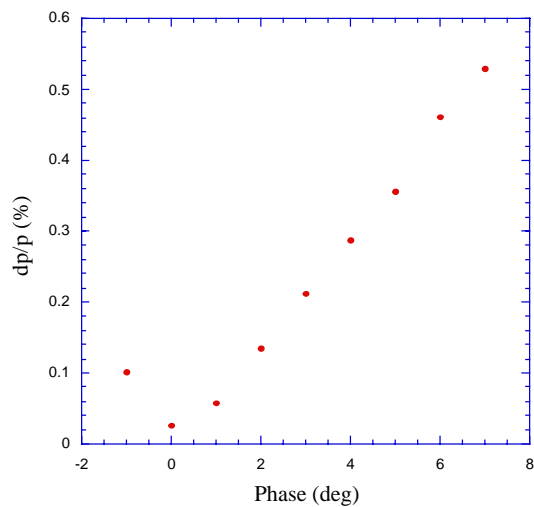


- Beamline 3 is a widely spaced triplet
- Very unstable with respect to central energy
- R56 can vary radically



R56 from TRACE 3D

Example: Positive R56 Compression with 200 pC at 69 MeV



BNL beamlines

Outlook for VISA



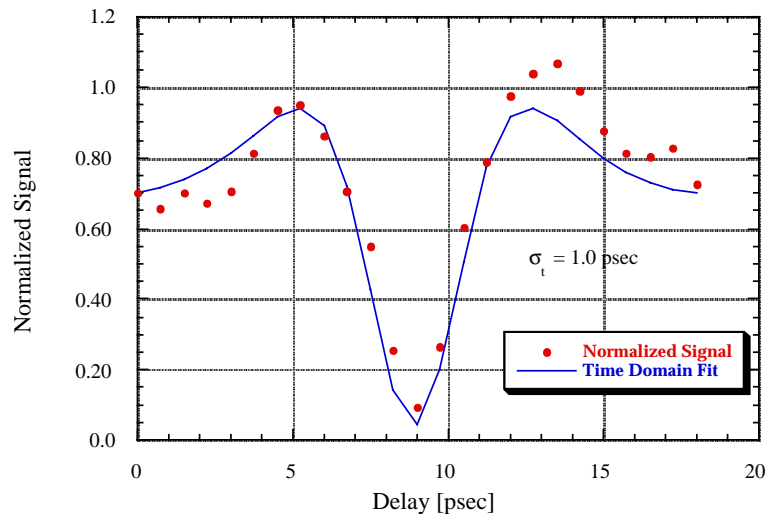
- *After H-line, current is in the range of 50-70 A*
- *Current may vary (upwards!) widely for nearby conditions*
- *Compression gives enhanced gain, single spike, less spectral structure, but...*
- *We must measure the pulse length in BL3*

Possible pulse length measurements



- Streak camera
- Coherent transition radiation (CTR) interferometer
- CTR radiation polychromator
- CTR power spectrum with filters
- Single shot autocorrelation with SASE signal
- Resonant cavity bunch length monitor?

CTR interferogram

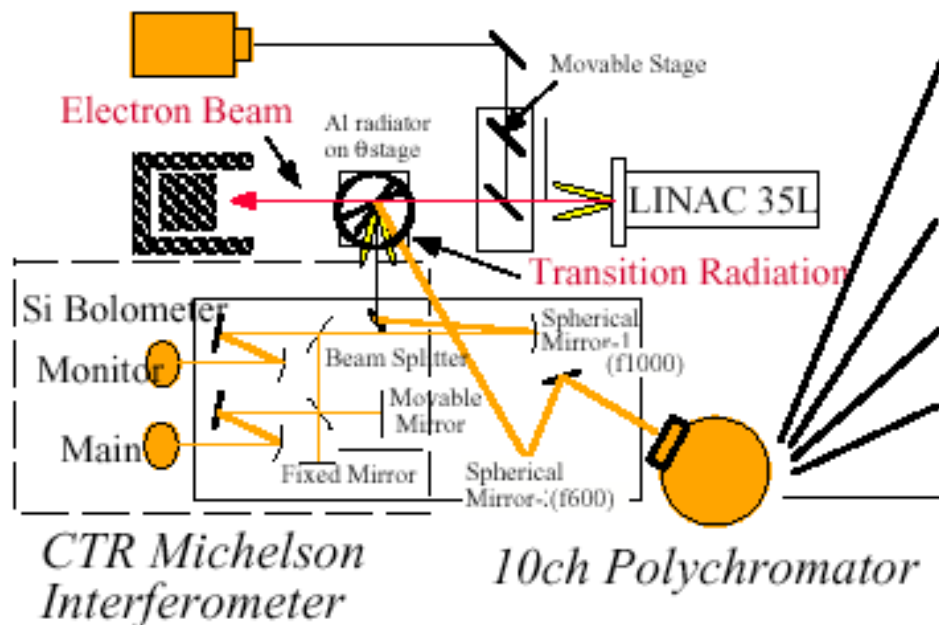


Neptune CTR Michelson signal
Compressor Bend Angle = 22.5°

- Martin-Puplett interferometer
- 0.5 psec resolution (at Neptune)
- Multi-pulse measurement
- Not available from Neptune at present

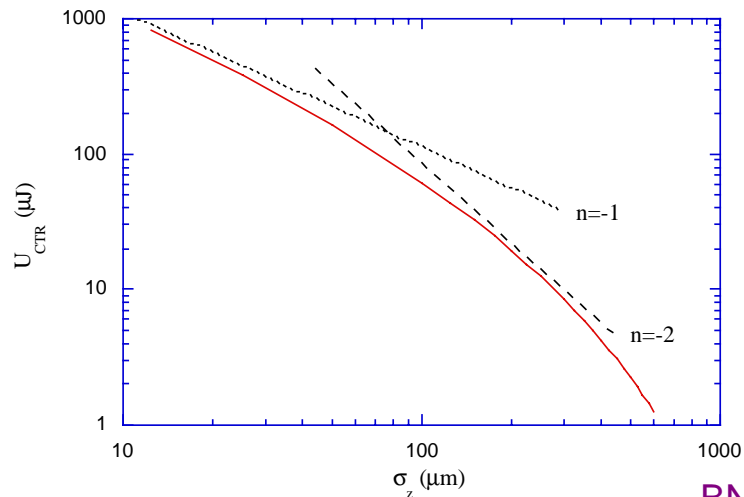
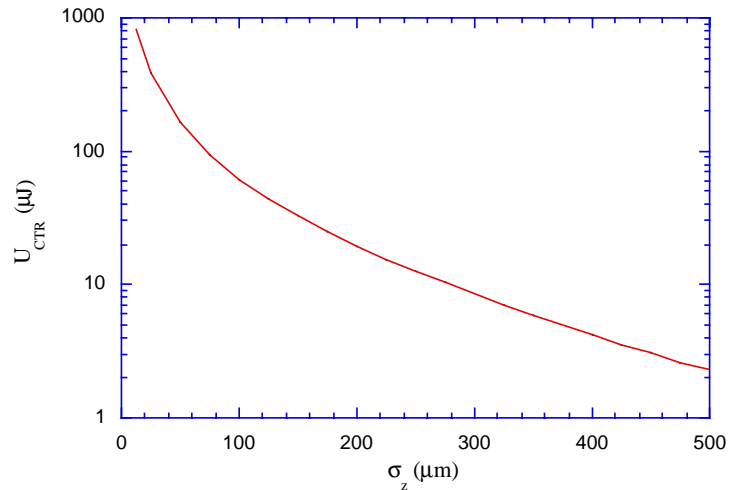
Polychromator

Femtosecond streak camera



- Technique developed by Shibata
- In use at Tokyo
- Proposed for Neptune BWA experiment
- Older, sophisticated system at PPPL
 - Wrong spectral range
 - Very large piece of equipment!
 - Not fast...

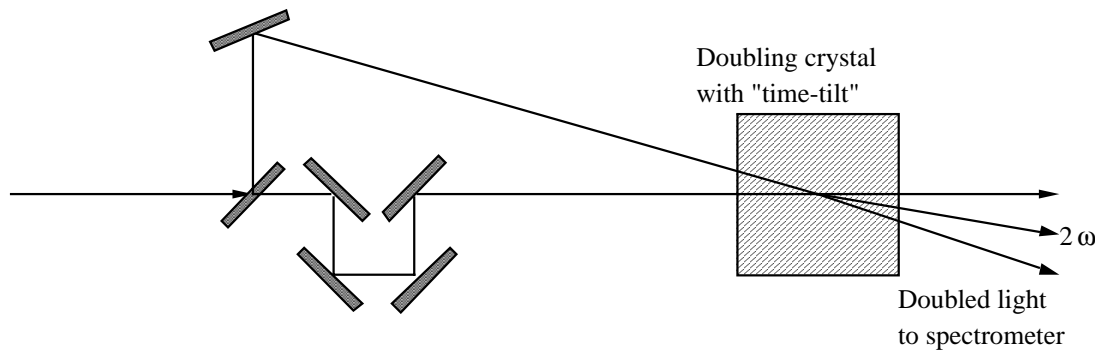
CTR power spectrum



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- We have ONE Golay cell purchased last fall
- Can we make a poor man's bunch length monitor?
- CTR power spectrum is a strong function of bunch length
 - Inherent power law inverse with bunch length
 - Finite radiator effects
- We are evaluating cheap filters

Single shot autocorrelation of SASE light



Single shot autocorrelation, first step in FROG

- Autocorrelation planned as part of FROG setup
- Developed by Greg LeSage, commissioned by Alex Murokh
- Existing expertise at BNL ATF
- Very short length scales
- Not a direct measure of bunch length...