

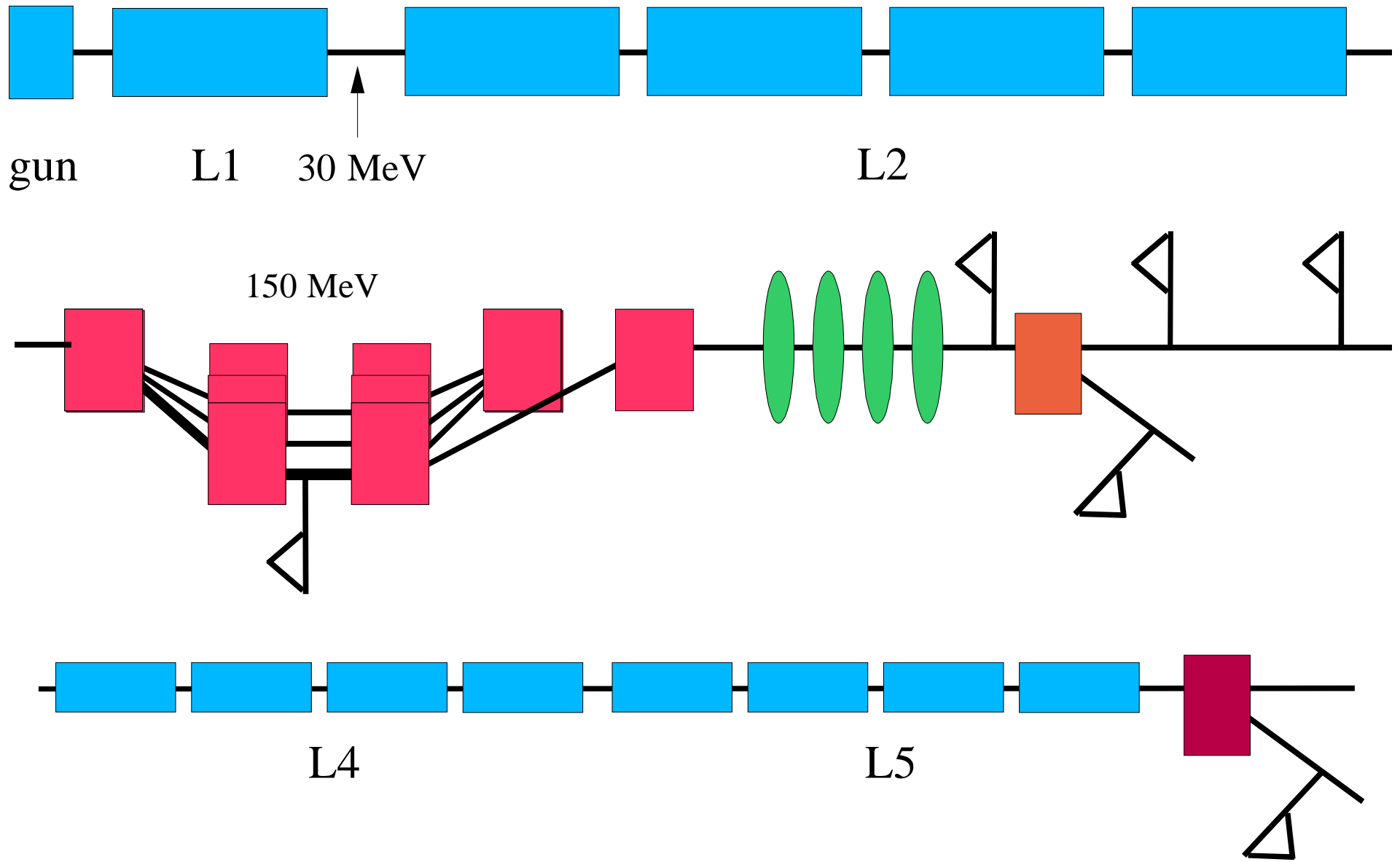
APS CSR Experiments and Comparison with Simulation

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Outline

- Overview of APS system
- System parameters
- Measurement techniques
- Experiments
 - Observations
 - Phase scan
- Comparison with simulation

APS Linac and Bunch Compressor



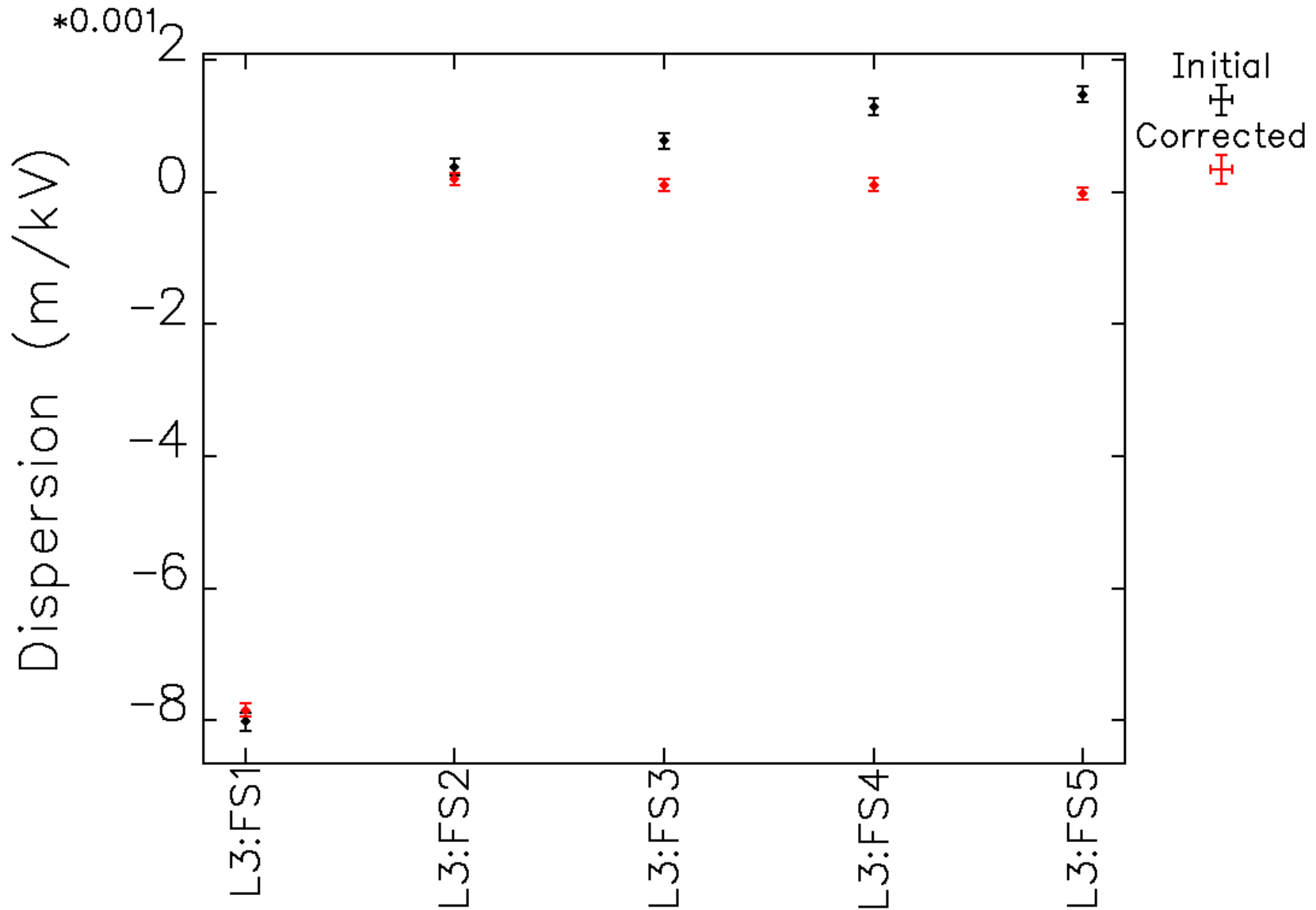
System Parameters

- Typical uncompressed beam parameters
 - normalized emittance: 3-5 μm
 - charge: 200-400 pC
 - rms bunch length: 1.5-2 ps
- Chicane parameters:
 - bending magnet: 0.19m length, $\theta < 13.4^\circ$
 - $|R_{56}| \leq 65\text{mm}$
 - $0.82\text{m} \leq L_{34} \leq 1.37\text{m}$
 - $100 \leq E \leq 200 \text{ MeV}$

Chicane Residual Dispersion

- If there is residual dispersion, the emittance will vary as the chirp of the beam is varied.
- The flags downstream of the chicane are used to measure the residual dispersion by looking at beam motion when L2 power is varied.
- Trajectory feedback is used in L2.
- Considerable residual dispersion is observed in both planes. The source is unknown.
- Horizontal dispersion can be corrected.

Chicane Residual Dispersion



Dispersion for dZ60-B4Nom with L3:QM3-6 at zero

Emittance Measurement

- Three screen system with separation of 0.93m and nominal 60° phase advance between flags
- Resolution is about $10\mu\text{m}$ in both planes
- Typically 30-60 profiles are acquired per plane per flag
- Statistics of the profile rms widths are used as input to a Monte Carlo process that estimates the sigma matrix and error bars.

Bunch Length Measurement

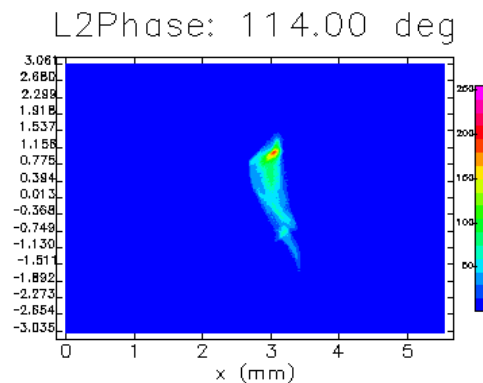
- Use rf 0/180° phasing with about 150 MV on L5
- L4 is used to cancel energy spread left from compression
- Resolution is about 0.15-0.2 ps rms

Dowell Diagnostic

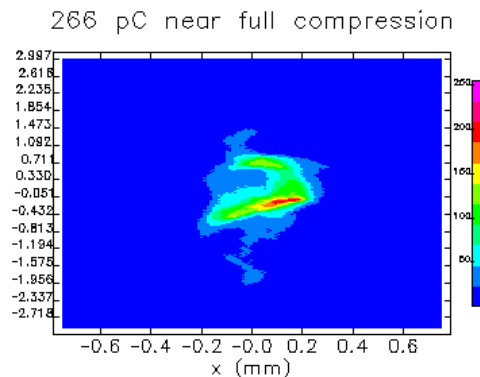
- CSR introduces correlations between x' and δ .
- A flag after a vertical dipole will image these correlations.
- Wakes and CSR should be distinguishable if head and tail can be identified.
- Problem: definitive determination requires
 - high charge (0.5 to 1 nC)
 - relatively smooth distribution

Dowell Diagnostic Data

- Images as L2 phase is varied from over-compression to decompression

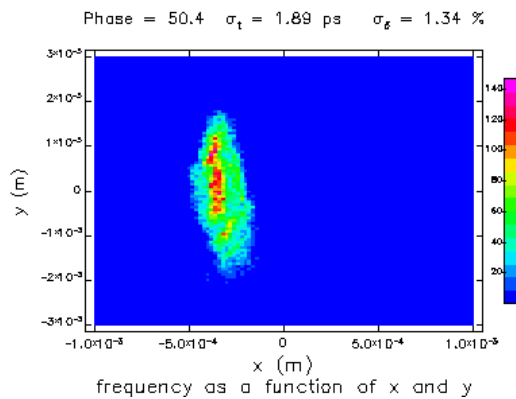


- Shot-to-shot variation in images at 266pC/bunch

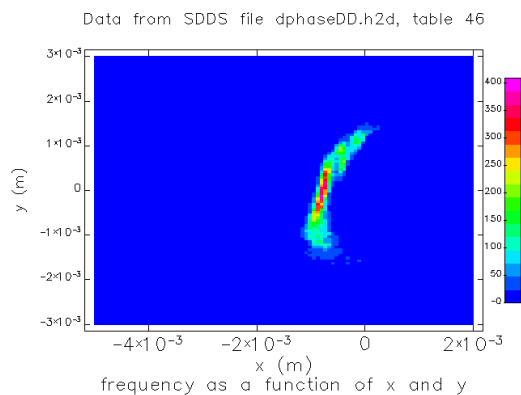


Dowell Diagnostic Simulation

- Simulation of a phase scan with 200pC beam, $R_{56} = -65\text{mm}$, B4 fully downstream.



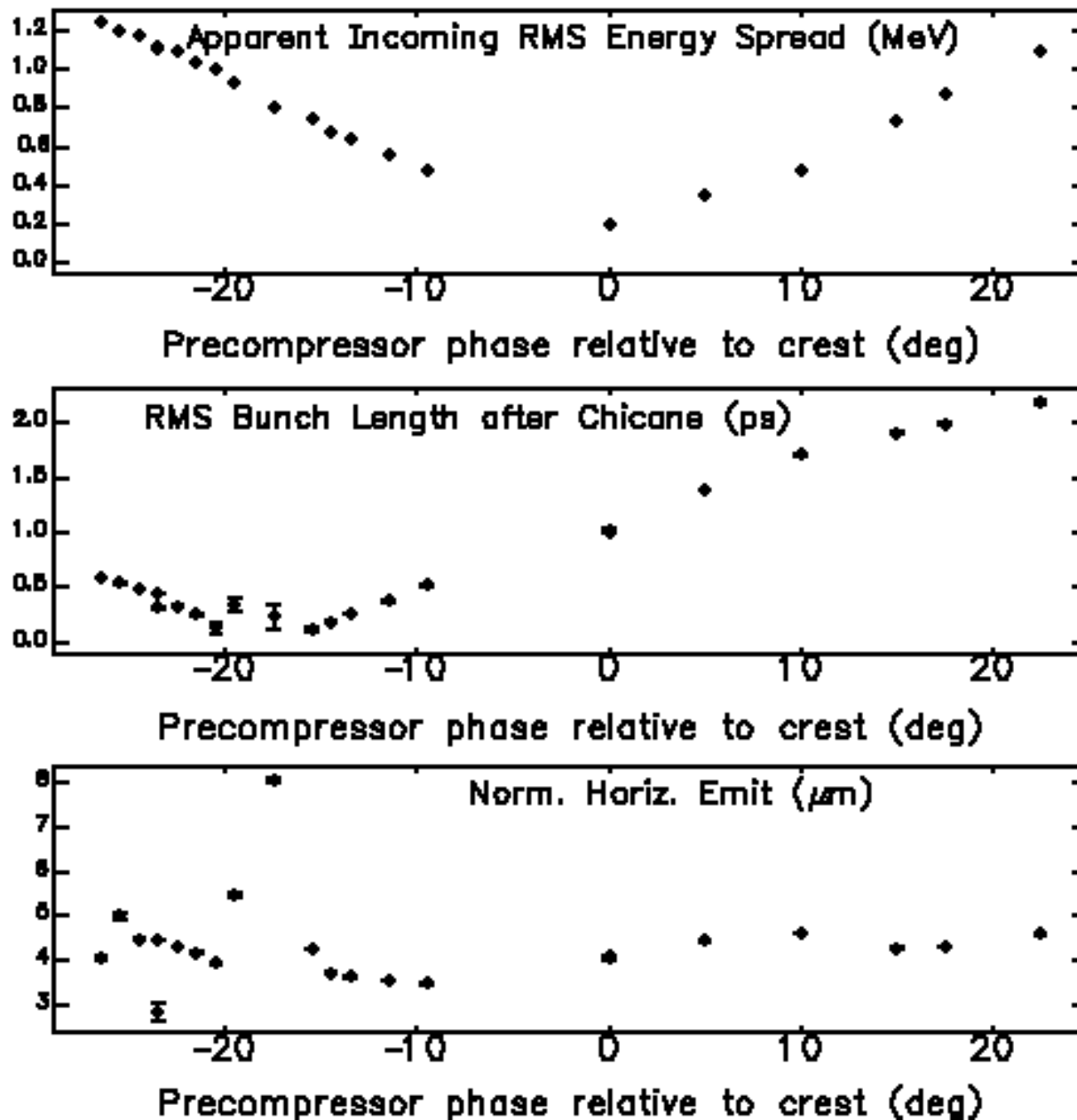
- Simulation with 1nC beam, same conditions



Phase Scan Experiment

- We vary the phase of L2 and change the voltage to keep the beam energy constant.
- This varies the chirp and hence the final bunch length.
- Measurements may include
 - energy spread at chicane center
 - energy spread at exit of chicane
 - emittance at exit of chicane
 - bunch length at end of linac

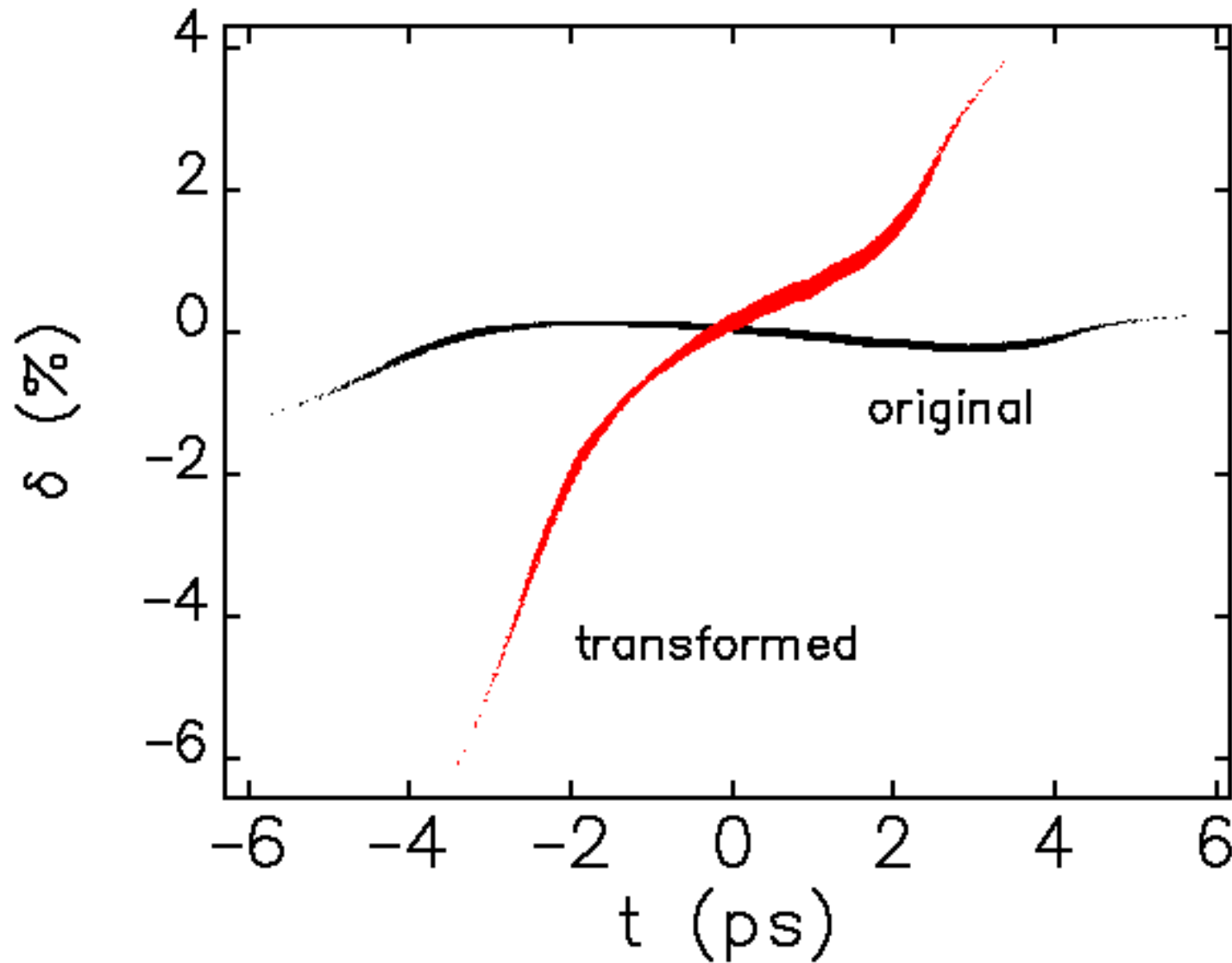
Phase Scan Data for 200pC



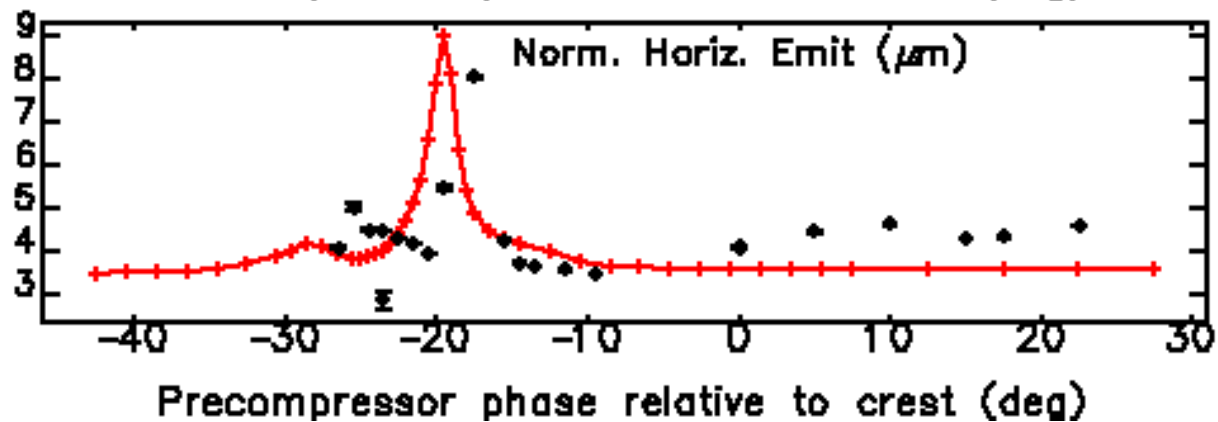
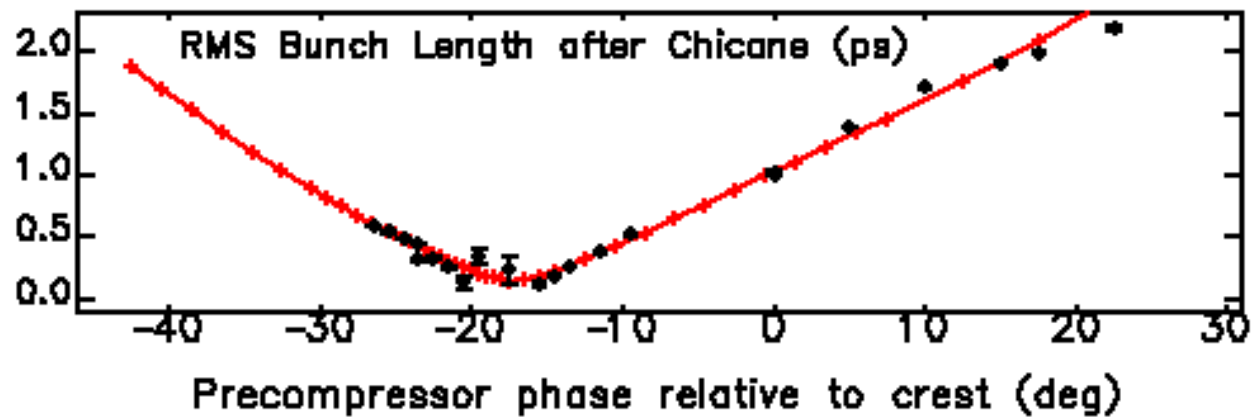
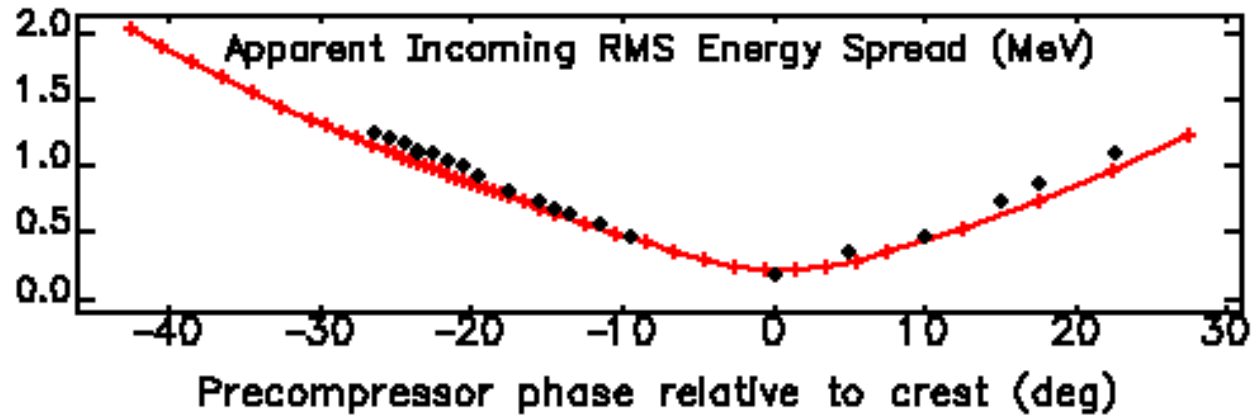
Phase Scan Simulation

- To simulate this experiment, the initial longitudinal phase space in simulation must match the experiment.
 - Start with the PARMELA-generated distribution.
 - Linearly transform it until the simulated energy spread and bunch length curves match the measurements.
 - Compare the emittance curves.

Matching of Longitudinal Phase Space



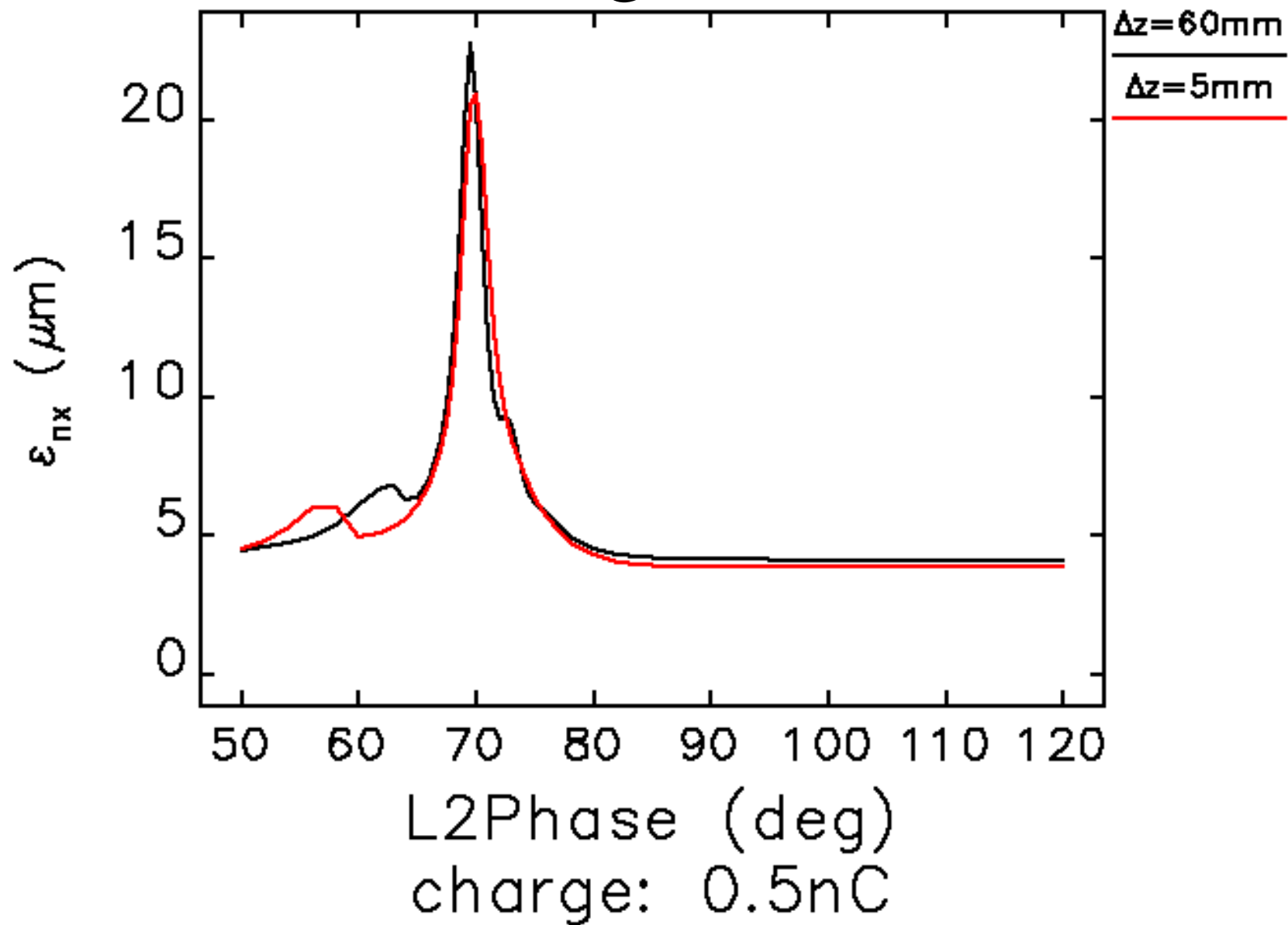
Phase Scan Simulation Result



Effect of Chicane Configuration

- Early simulations with simpler CSR models indicated ~20% differences should be seen between symmetric and asymmetric chicane configurations.
- Recent simulations show that differences should be much smaller.
- This is still being understood.

Simulation of Effect of Chicane Configuration



Planned Upgrades

- OTR/YAG screen at entrance to L2
 - sigma matrix measurement and matching
 - streak camera
- More BPMs in L1 and L2 to ease wakefield control.
- Retractable 50nm Al foil at exit of B3 to test blocking of CSR.
- Higher resolution bunch length measurement.

Planned Experiments

- Matching beam at the exit of the photoinjector.
- Figure out source of dispersion.
- Phase scans with various chicane geometries.
- Effect of scraper wakes (P. Emma suggestion).
- Dowell images with 0.5 to 1 nC.