Phase Transfer Measurements at the Jefferson Lab Recirculated Linacs

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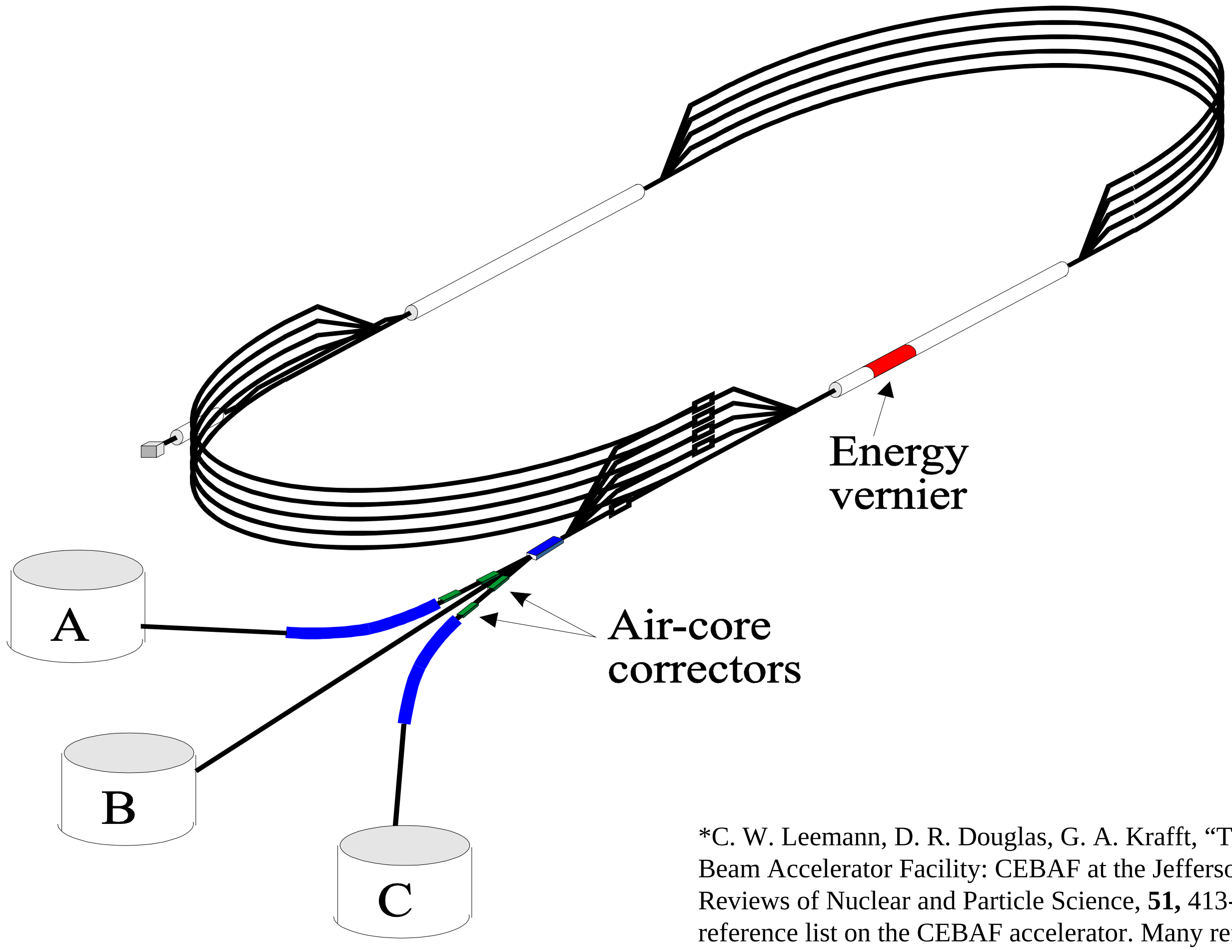
CEBAF Accelerator Layout*

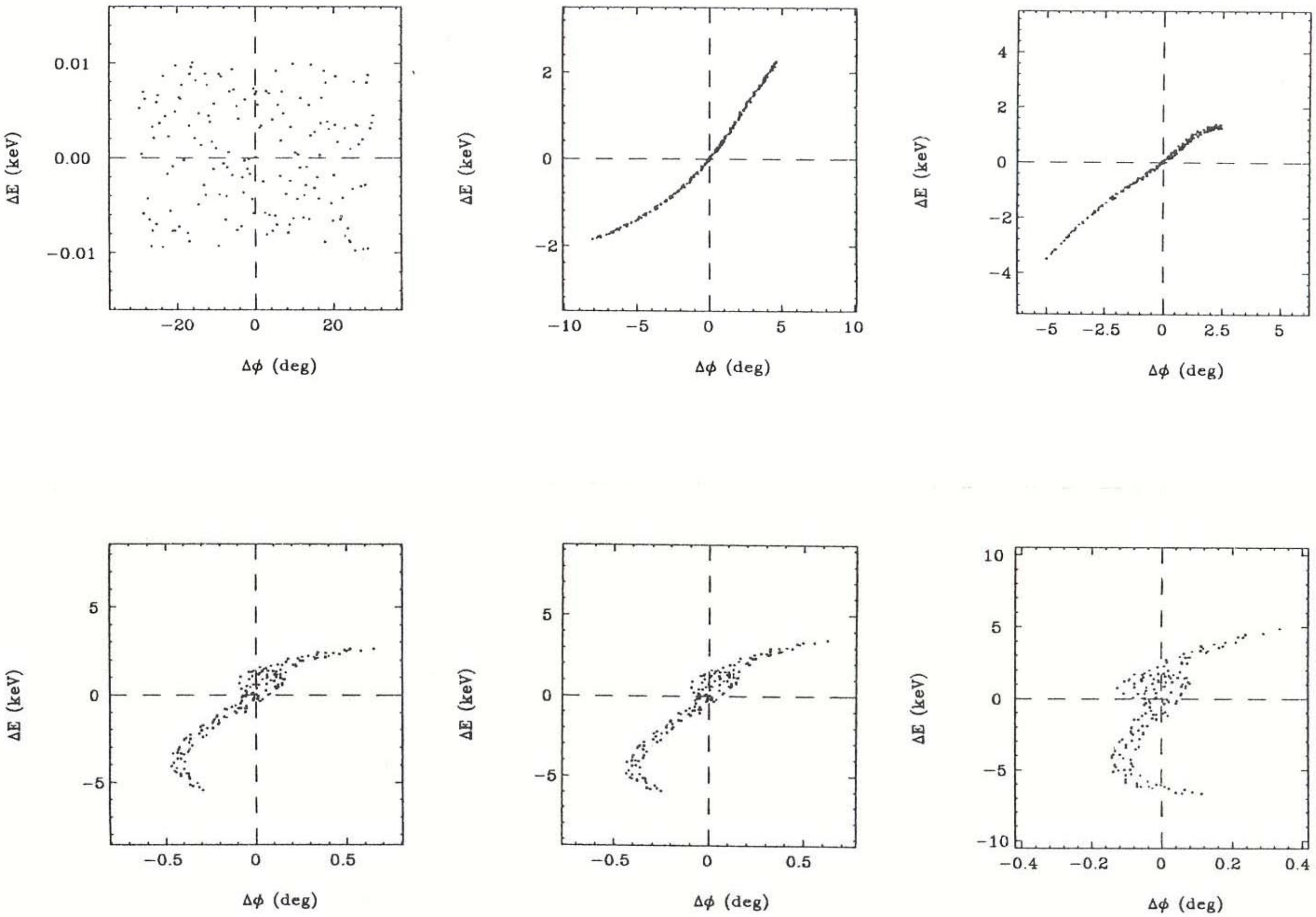


*C. W. Leemann, D. R. Douglas, G. A. Krafft, "The Continuous Electron Beam Accelerator Facility: CEBAF at the Jefferson Laboratory", Annual Reviews of Nuclear and Particle Science, **51,** 413-50 (2001) has a long reference list on the CEBAF accelerator. Many references on Energy Recovered Linacs may be found in a recent ICFA Beam Dynamics Newsletter, #26, Dec. 2001: http://icfa-usa/archive/newsletter/icfa_bd_nl_26.pdf

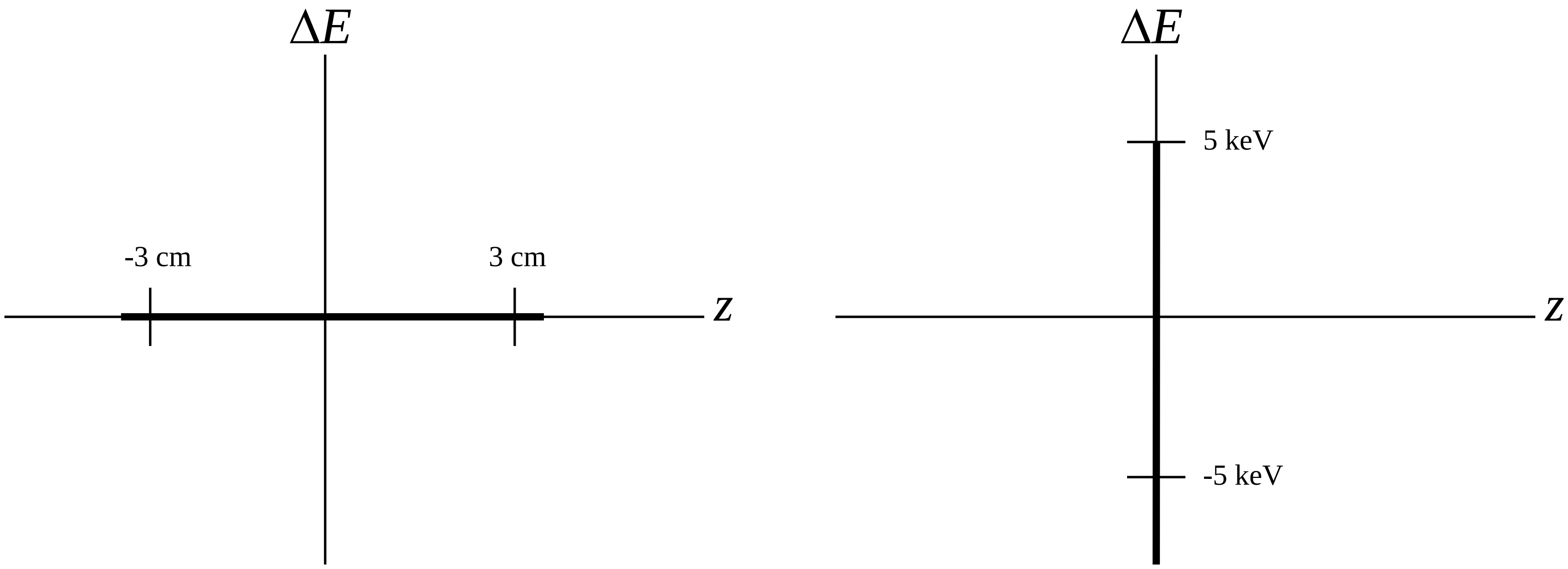
CEBAF Beam Parameters

Beam energy	6 GeV
Beam current	A 100 μA, B 10-200 nA, C 100 μA
Normalized rms emittance	1 mm mrad
Repetition rate	500 MHz/Hall
Charge per bunch	< 0.2 pC
Extracted energy spread	$< 10^{-4}$
Beam sizes (transverse)	< 100 microns
Beam size (longitudinal)	100 microns (330 fsec)
Beam angle spread	$< 0.1/\gamma$

Calculated Longitudinal Phase Space

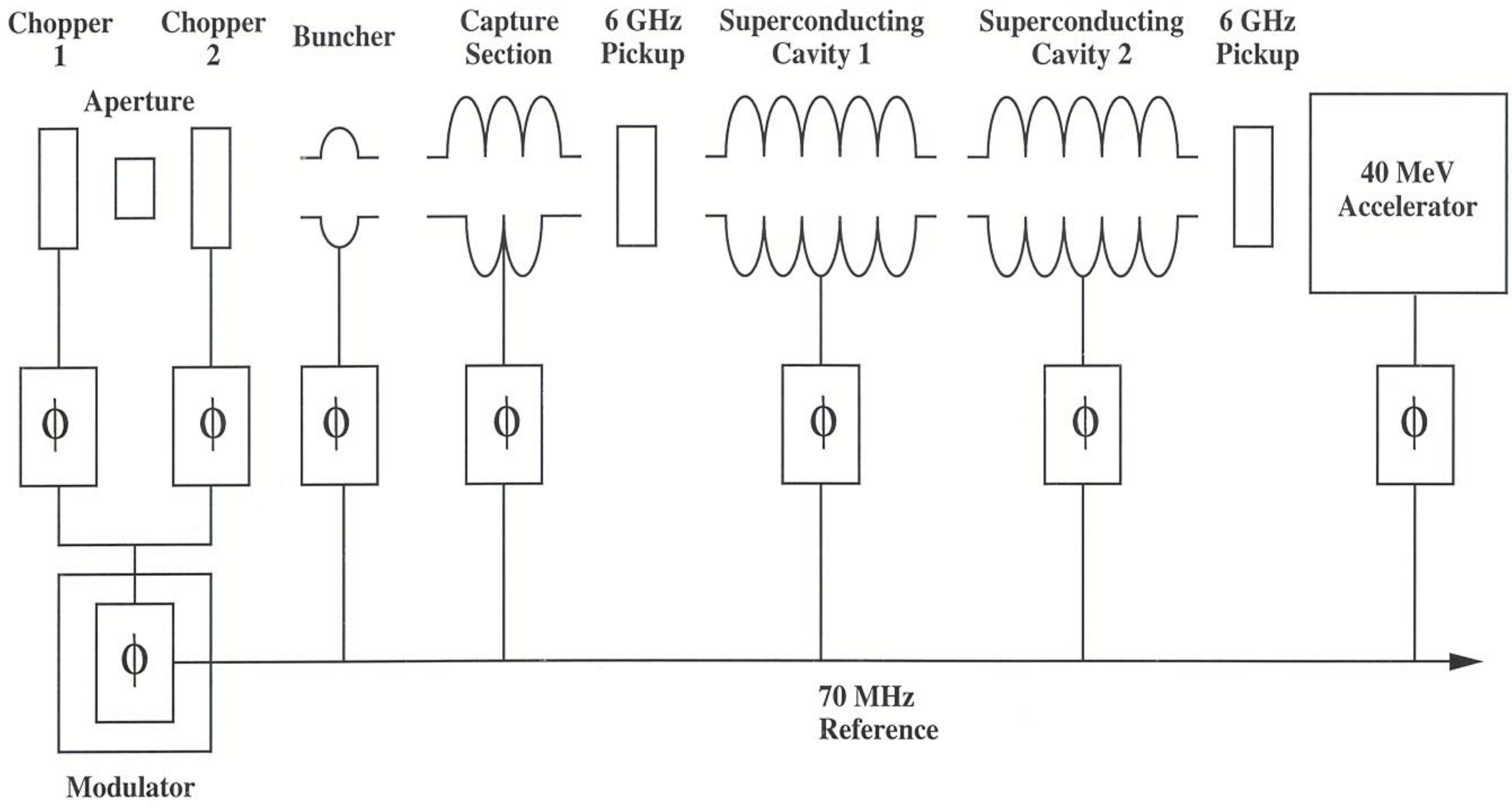


Phase Space from CEBAF Bunching



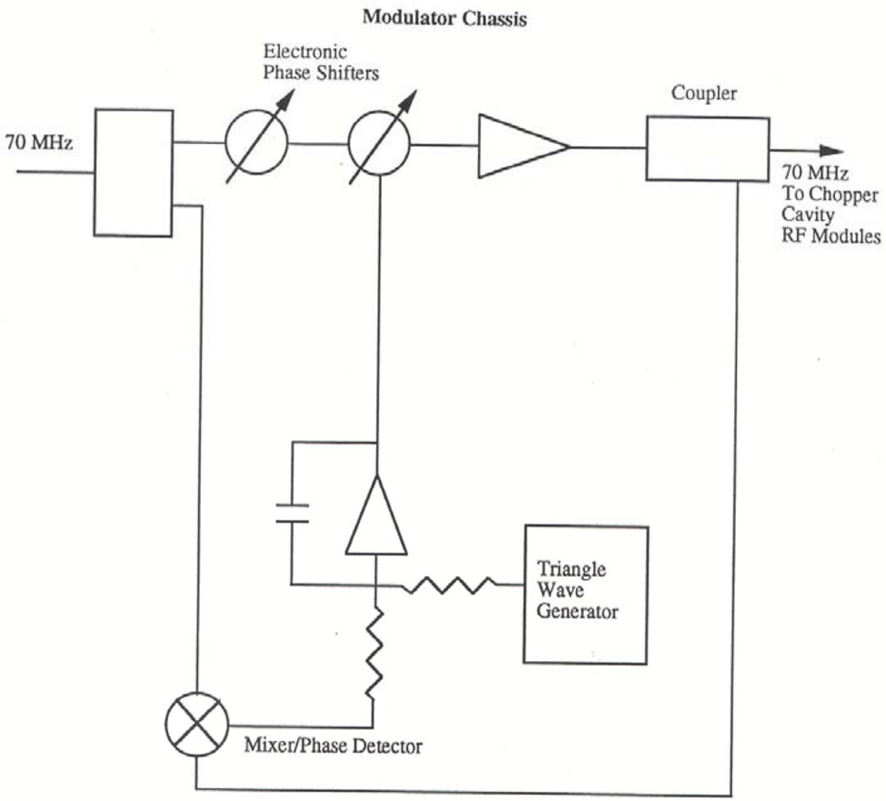
>100 bunching factor!

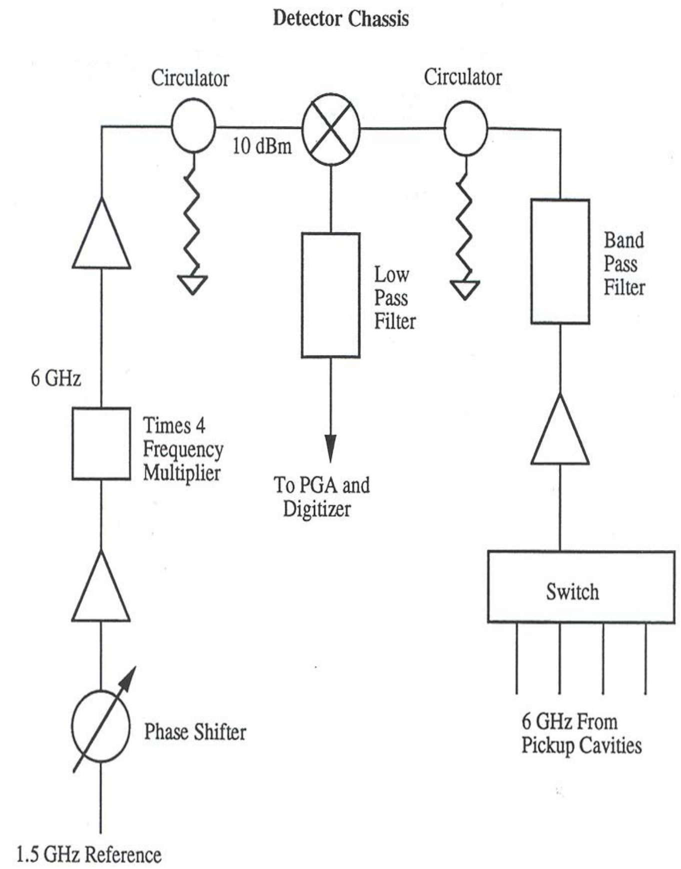
Schematic of CEBAF Injector Phase Distribution



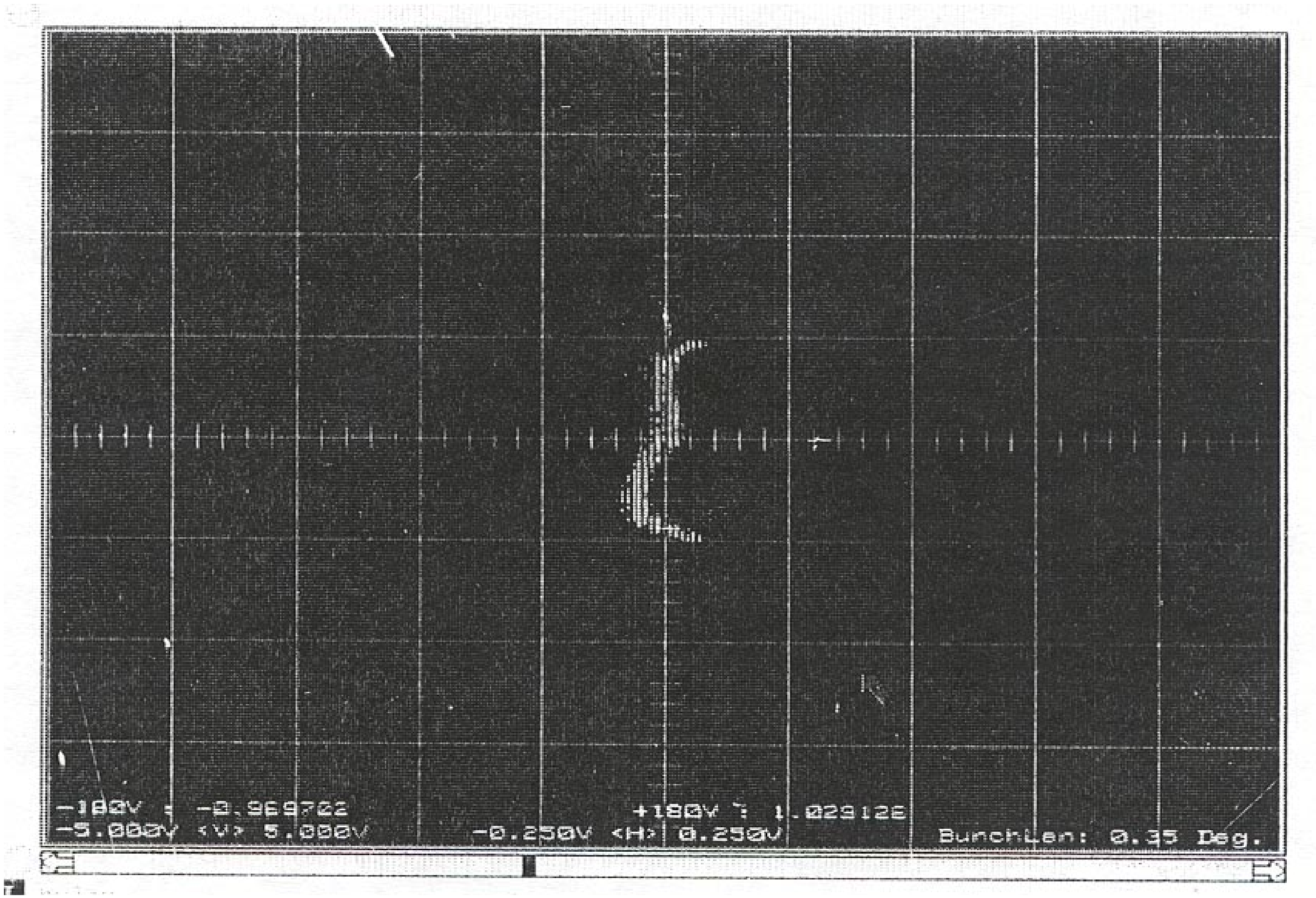
Phase Transfer Technique

Simultaneously, digitize phase modulation and arrival time determined by a phase detector

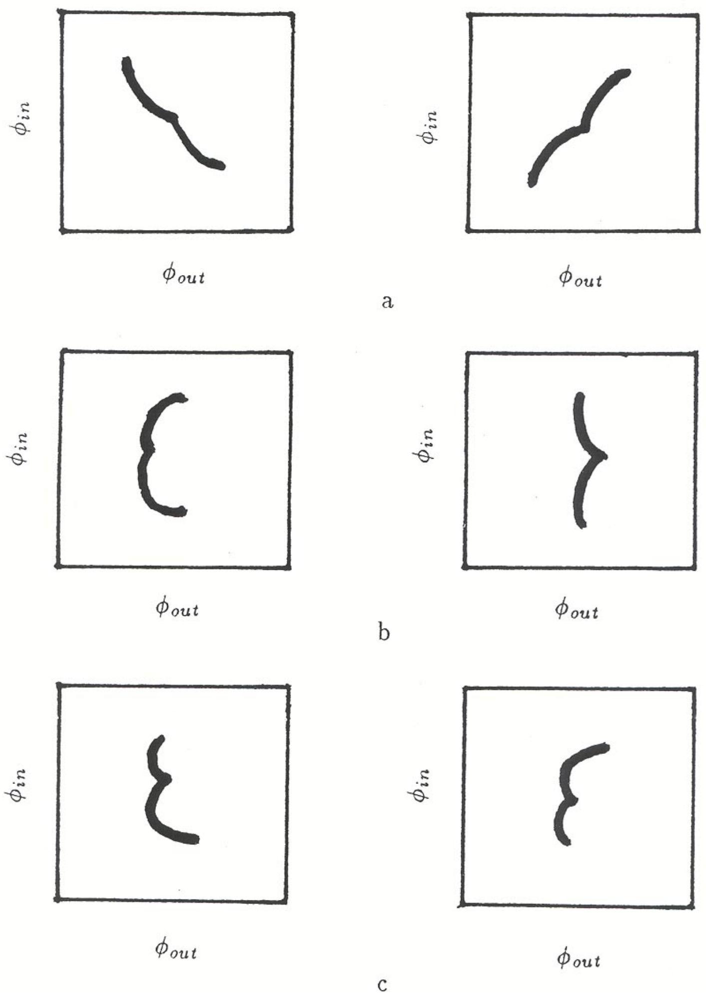




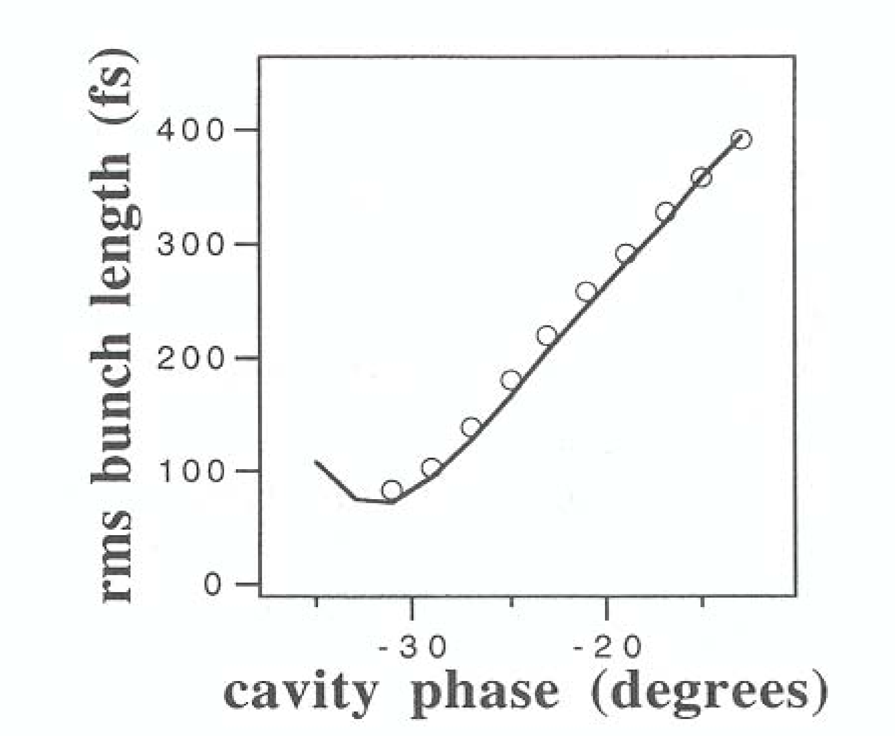
Some Early Results



Phase Space Correction Scheme

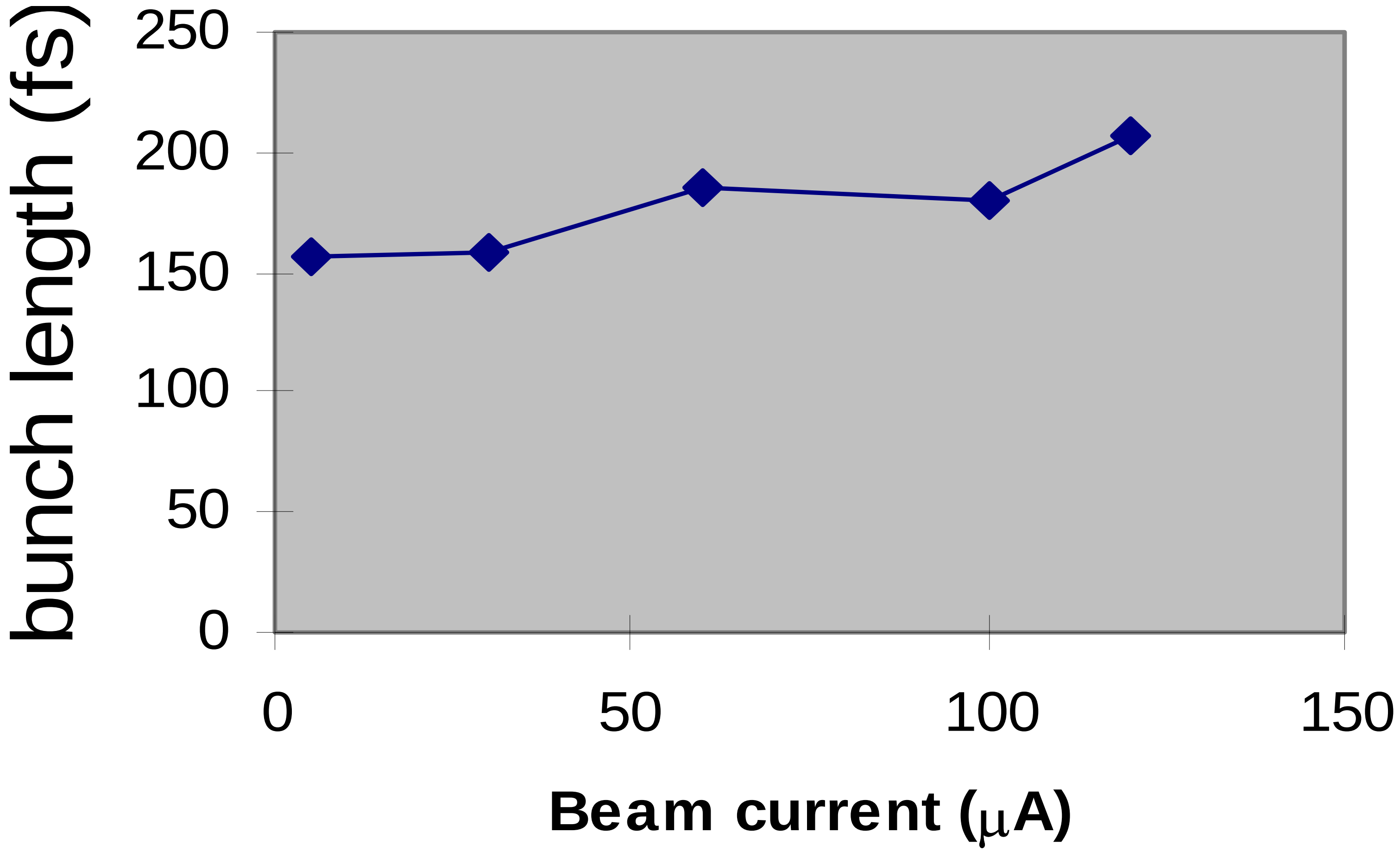


Short Bunches in CEBAF



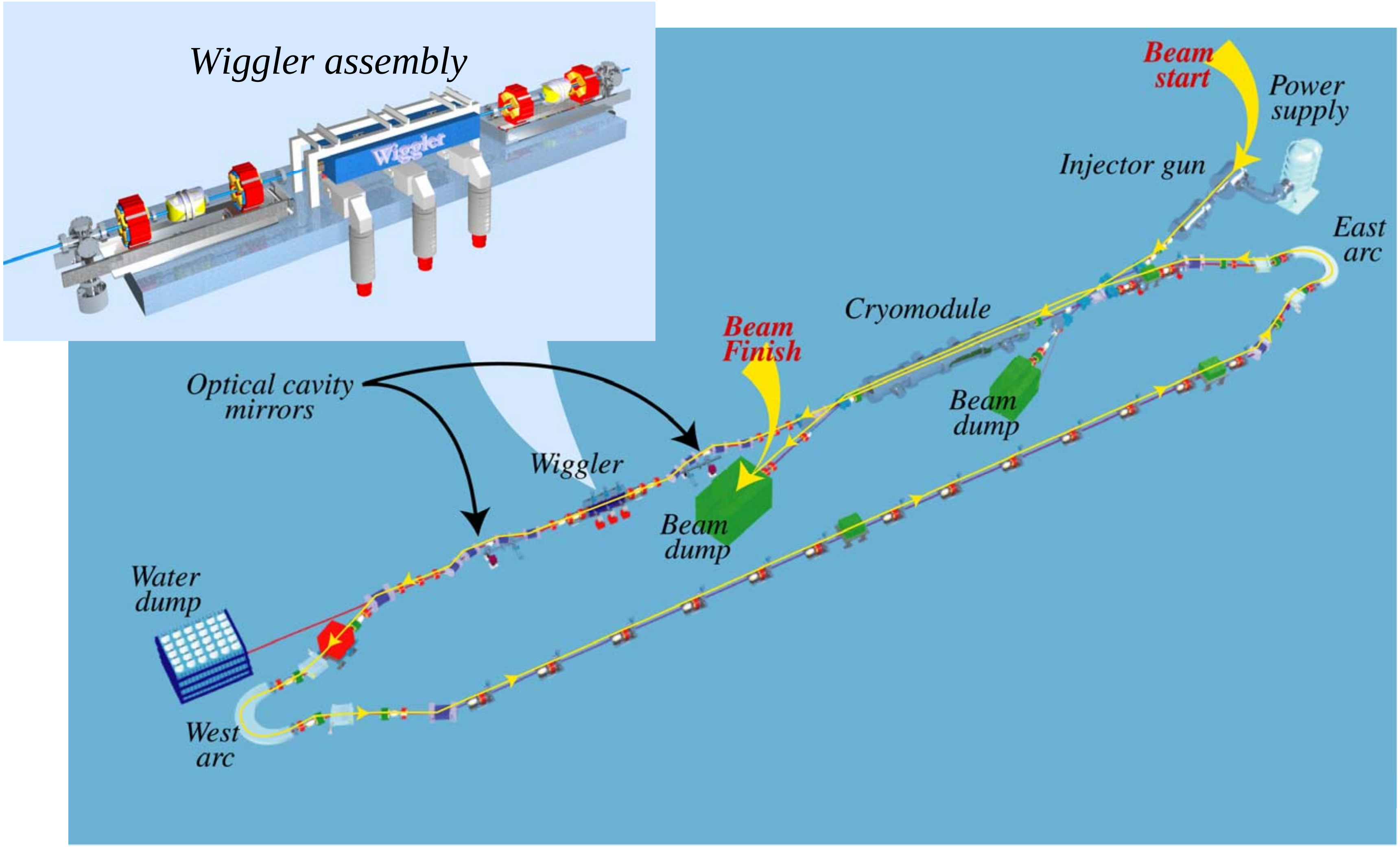
Wang, Krafft, and Sinclair, Phys. Rev. E, 2283 (1998)

Short Bunch Configuration

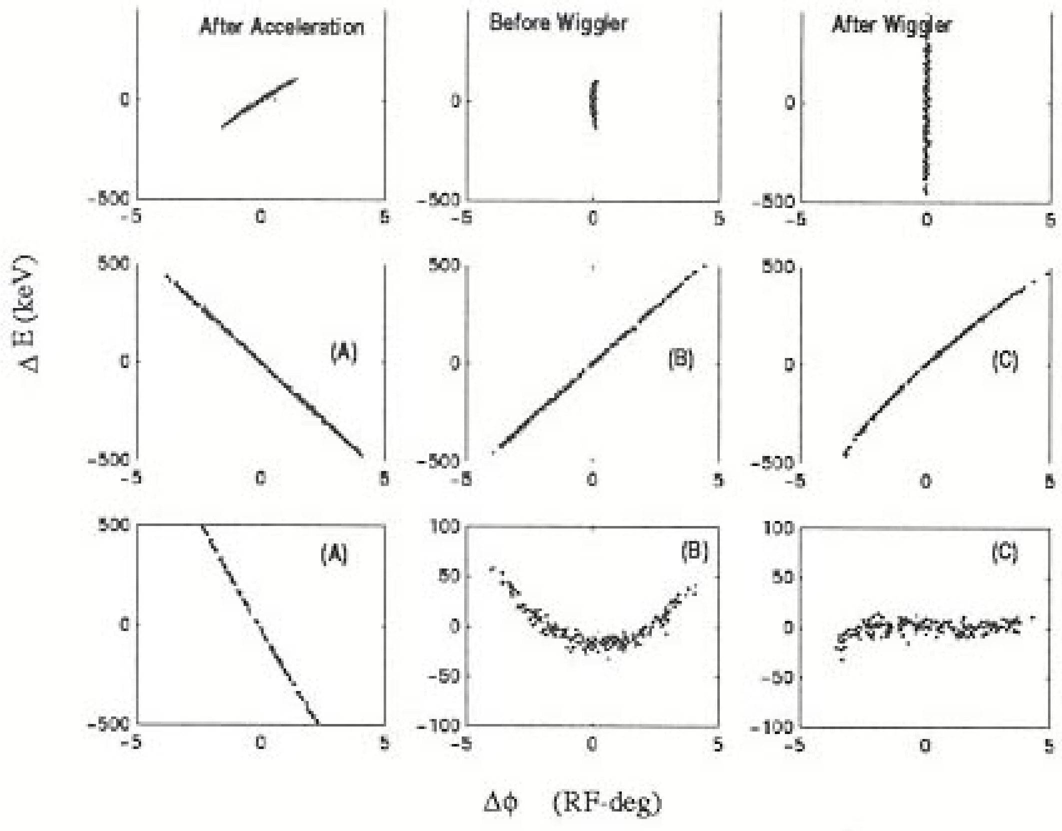


Kazimi, Sinclair, and Krafft, *Proc. 2000 LINAC Conf.*, 125 (2000)

The Jefferson Lab IR Demo FEL

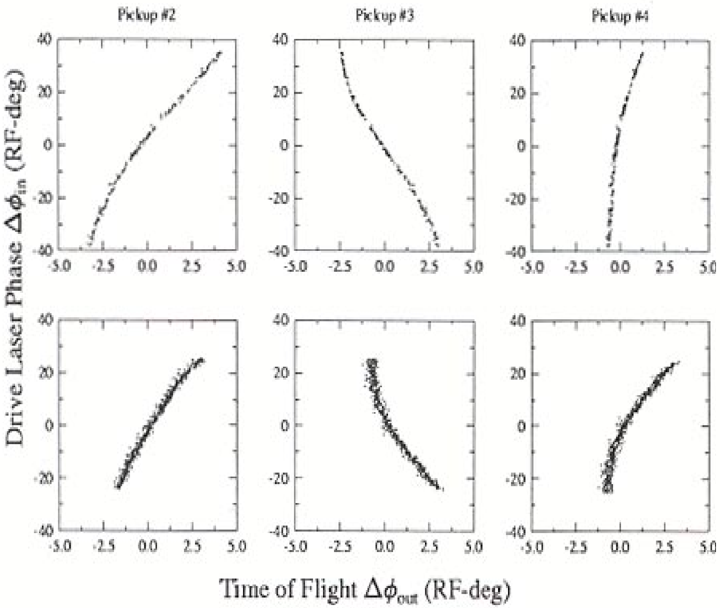


Longitudinal Phase Space Manipulations



Simulation calculations of longitudinal dynamics of JLAB FEL

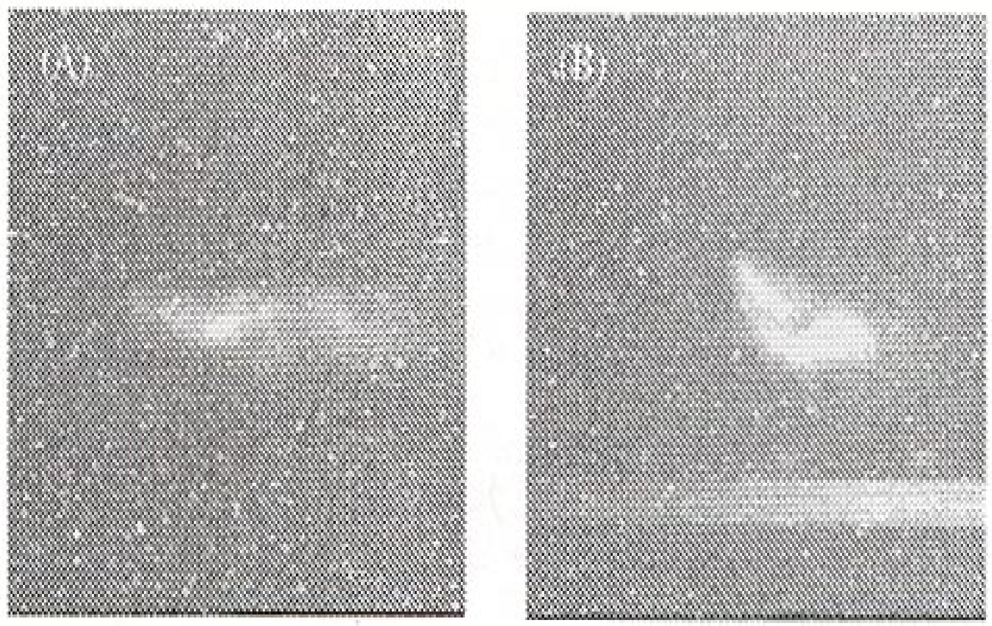
Transfer Function Measurements



Experiment		
# 2	0.1172	0.0008
# 3	-0.0801	0.0016
# 4	0.0911	0.0006
Simulation		
# 2	0.1070	0.0007
# 3	-0.0834	0.0003
# 4	0.0256	0.0004

Piot, Douglas, and Krafft, *Phys. Rev. ST-AB*, **6**, 0030702 (2003)

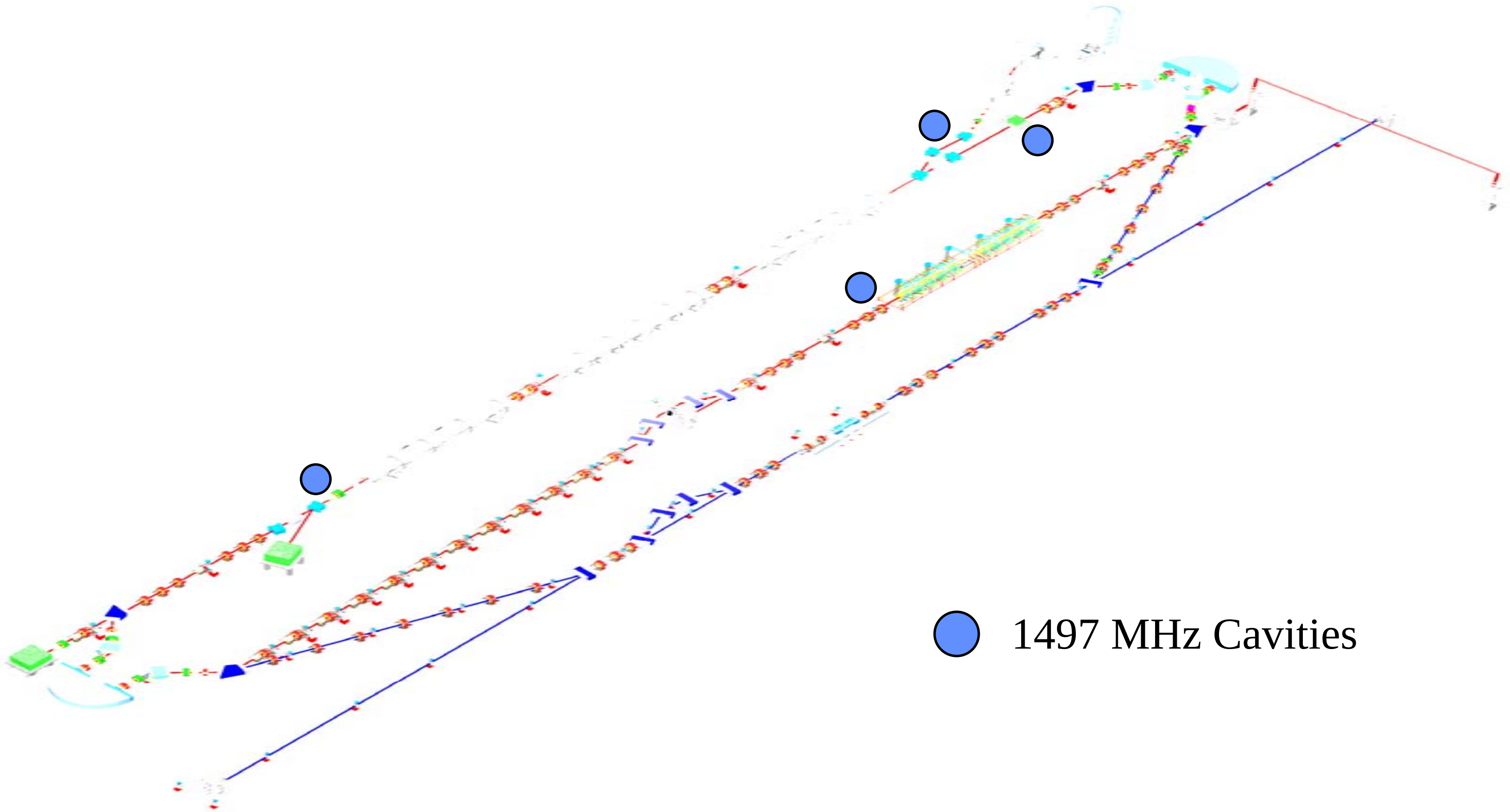
Longitudinal Nonlinearities Corrected by Sextupoles



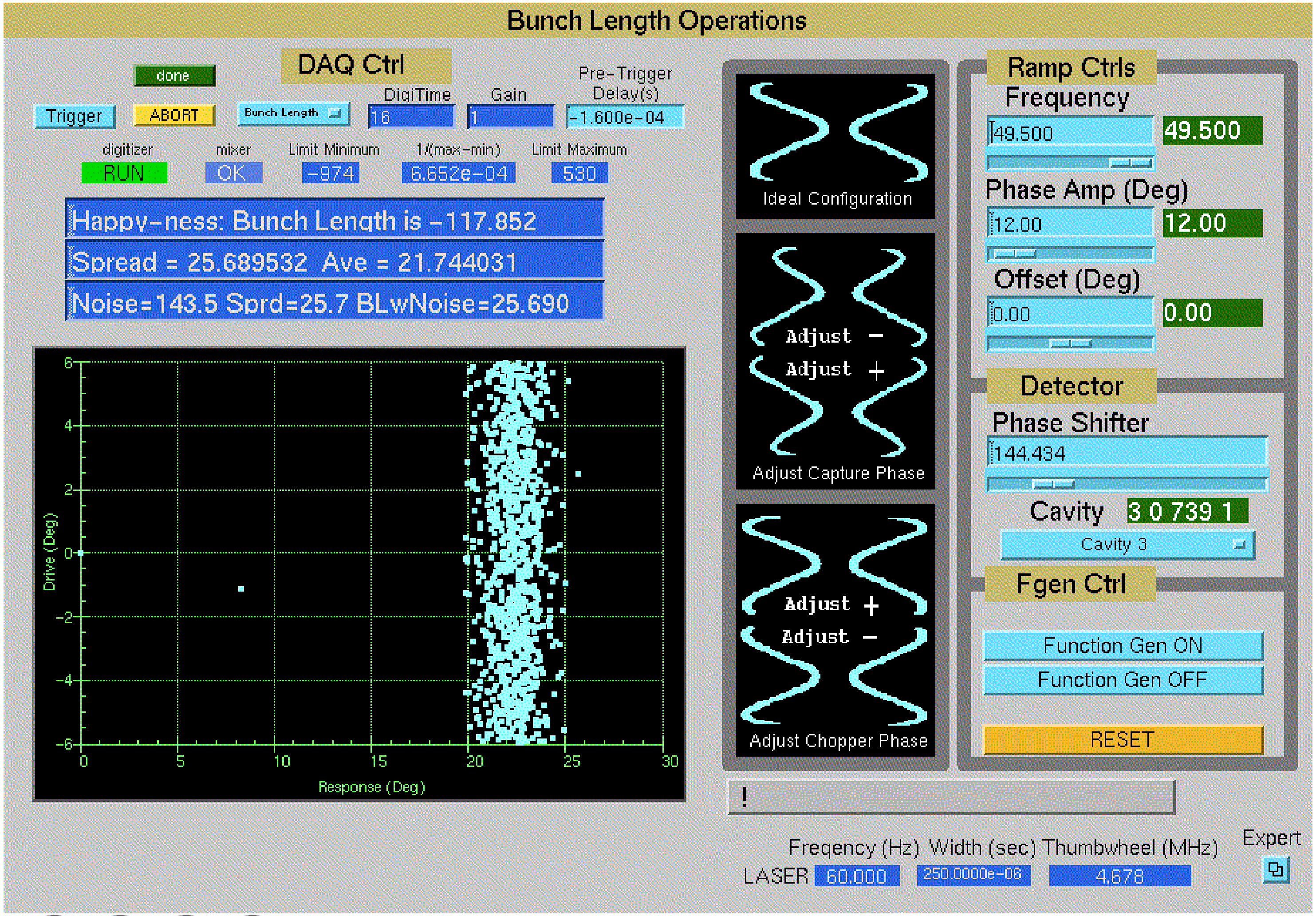
Sextupoles Off   Nominal Settings

Basic Idea is to use sextupoles to get T_{566} in the bending arc to compensate any curvature induced terms.

IR FEL Upgrade

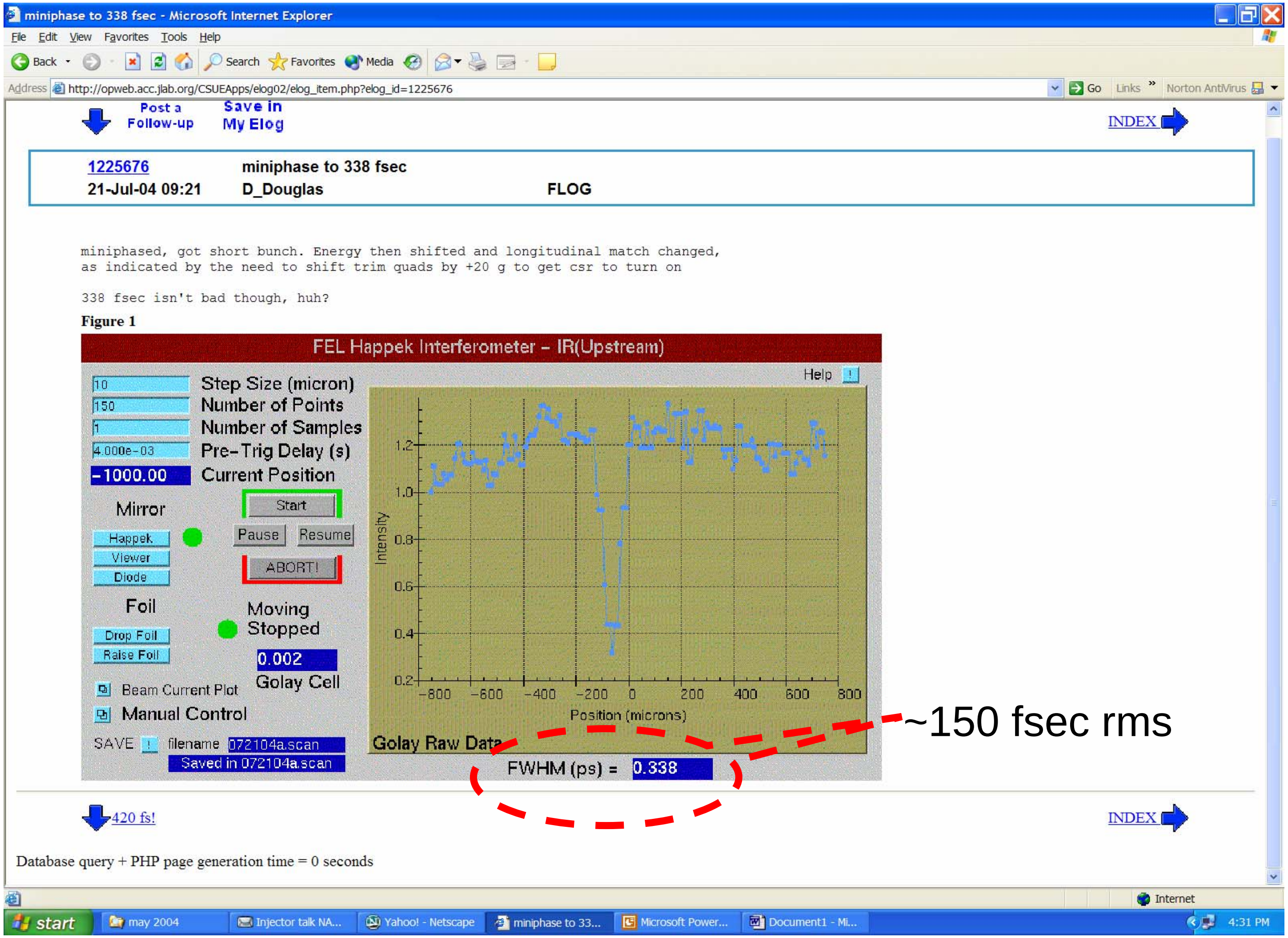


Injector to Wiggler Phase Transport



Courtesy Dave Douglas, S. Benson

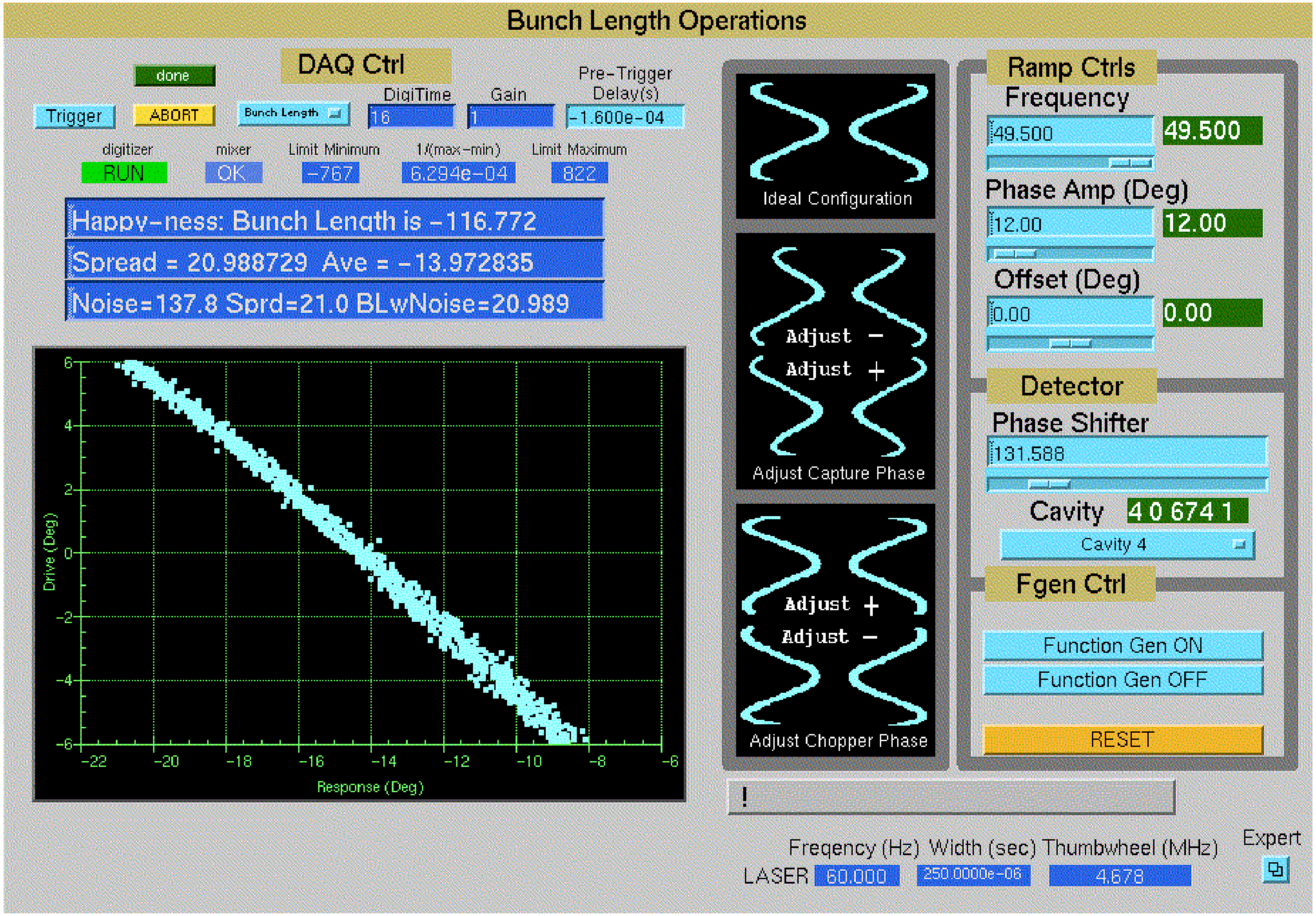
Bunch Length at Wiggler



~150 fsec rms

Courtesy Dave Douglas, S. Benson

Injector to Reinjection Phase Transport



Courtesy Dave Douglas, S. Benson

Controlling nonlinearities with sextuples and octupoles is validated by high order transport measurement

Figure 1: initial optimized setup

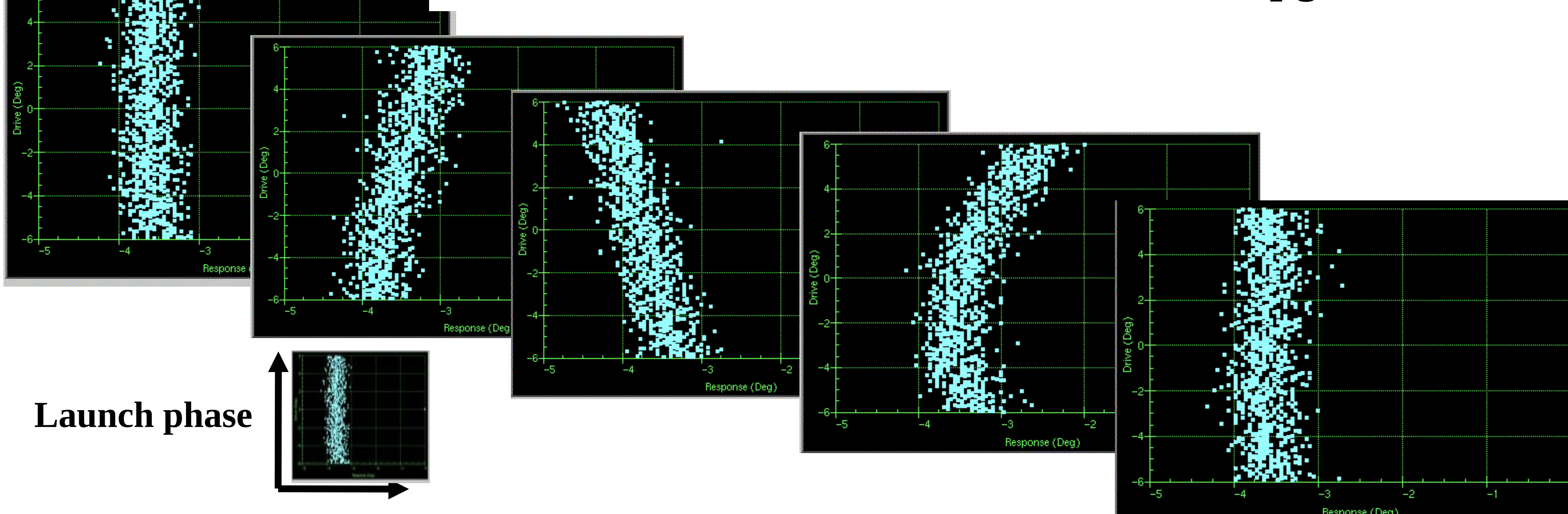
Figure 2: lower trim quads to -185 g from initial -215 g

Figure 3: raise trim quads to -245 g

Figure 4: quads back at -215, but sextupoles 2000 g below design, at 10726 g-cm

Figure 5: back to start: trim quads -215 g sextupoles at 12726 g-cm

Transfer Function Measurements on IR Upgrade



Launch phase

Arrival phase

Courtesy Dave Douglas, S. Benson

Conclusions

- In this talk I've introduced the idea of the phase transfer function measurement, and demonstrated some of its commissioning uses.
- Practical implementations have been made in all on the Jefferson Lab Recirculated Linacs.
- These techniques were instrumental in allowing reproducible production of short bunches in these accelerators.
- They allow *beam based measurements* of non-linear beam optical effects.