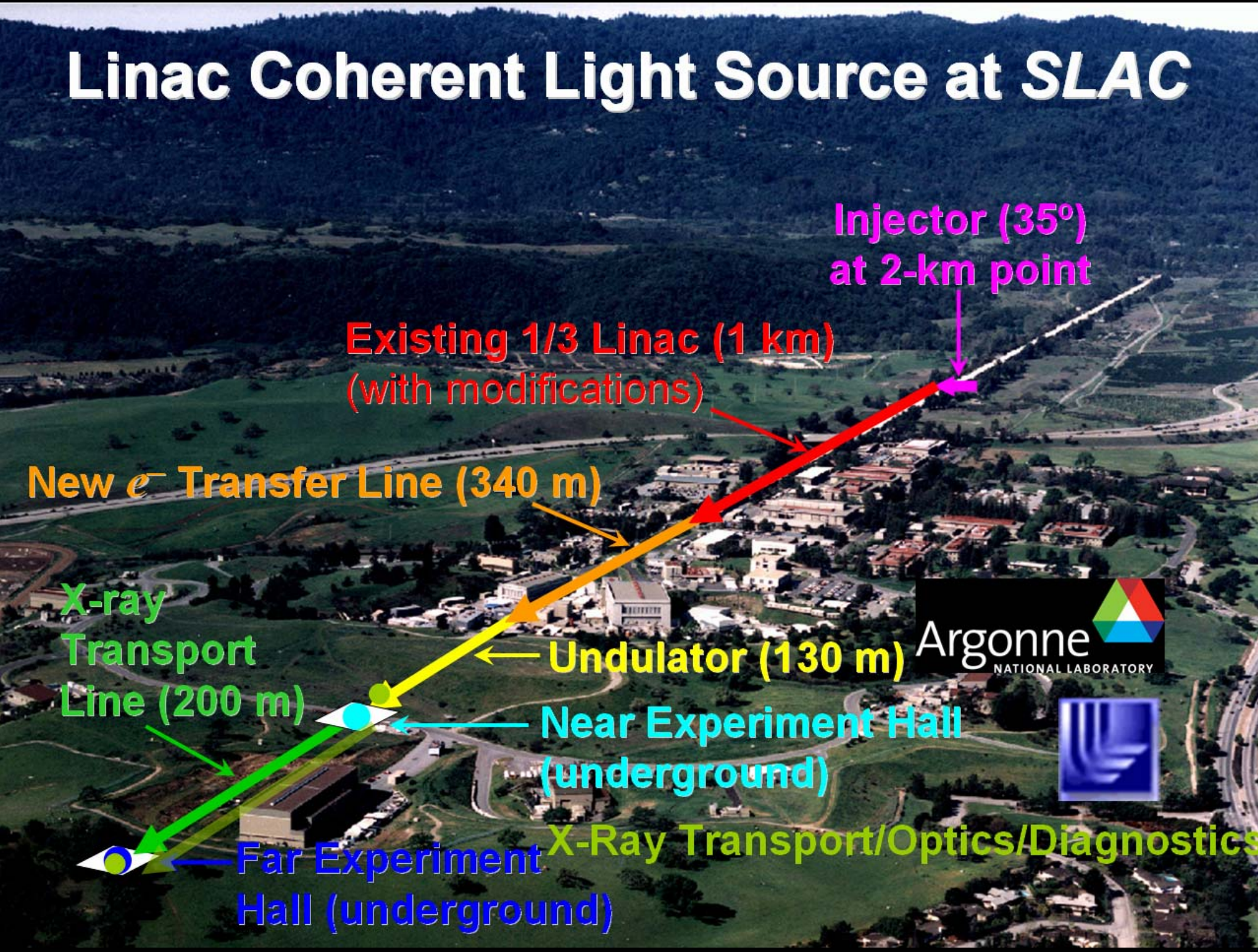
LCLS Project Status

25 June 2008

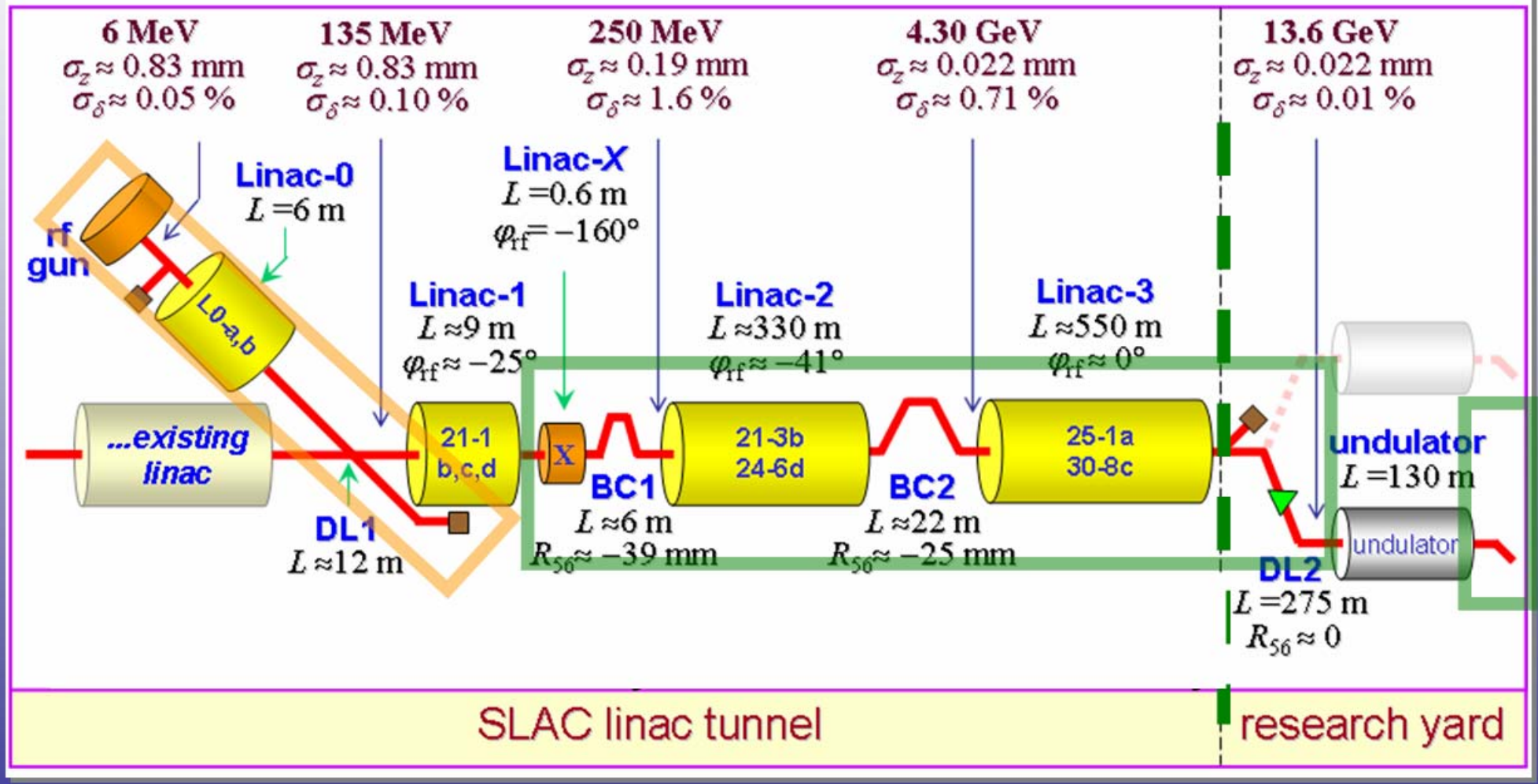
- Project Description
- Project Status
- Commissioning
- Future

John N. Galayda
galayda@slac.stanford.edu


Linac Coherent Light Source at SLAC
Injector (35°)
at 2-km point
Existing 1/3 Linac (1 km)
(with modifications)
New e⁻ Transfer Line (340 m)
X-ray
Transport
Line (200 m)
Undulator (130 m)
Near Experiment Hall
(underground)
Far Experiment
Hall (underground)
Argonne
NATIONAL LABORATORY
X-Ray Transport/Optics/Diagnostics

LCLS Injector
100% Complete

LCLS Linac
86% Complete



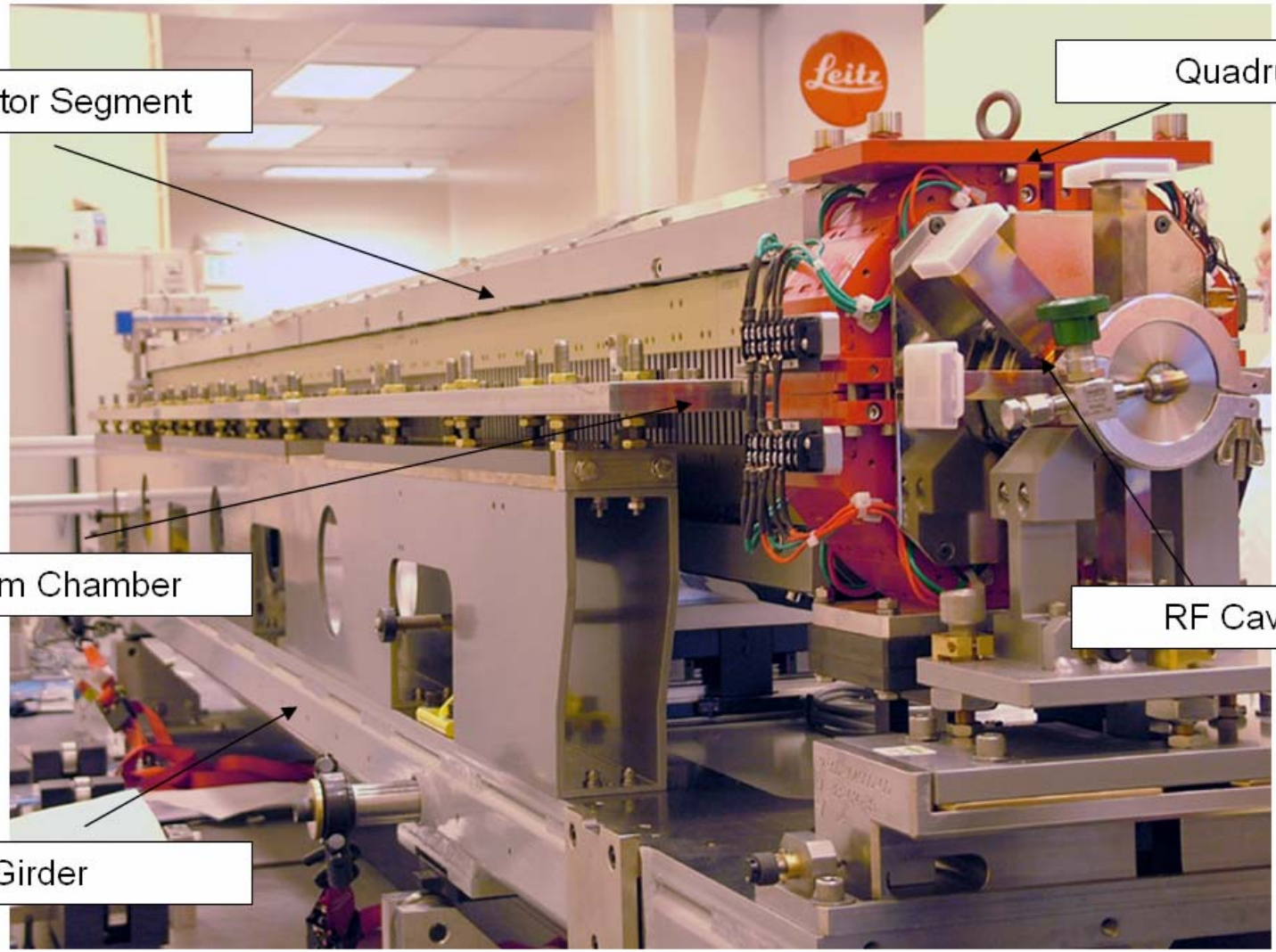
John N. Galayda
galayda@slac.stanford.edu

Linac-to-Undulator system installation

6/10/08

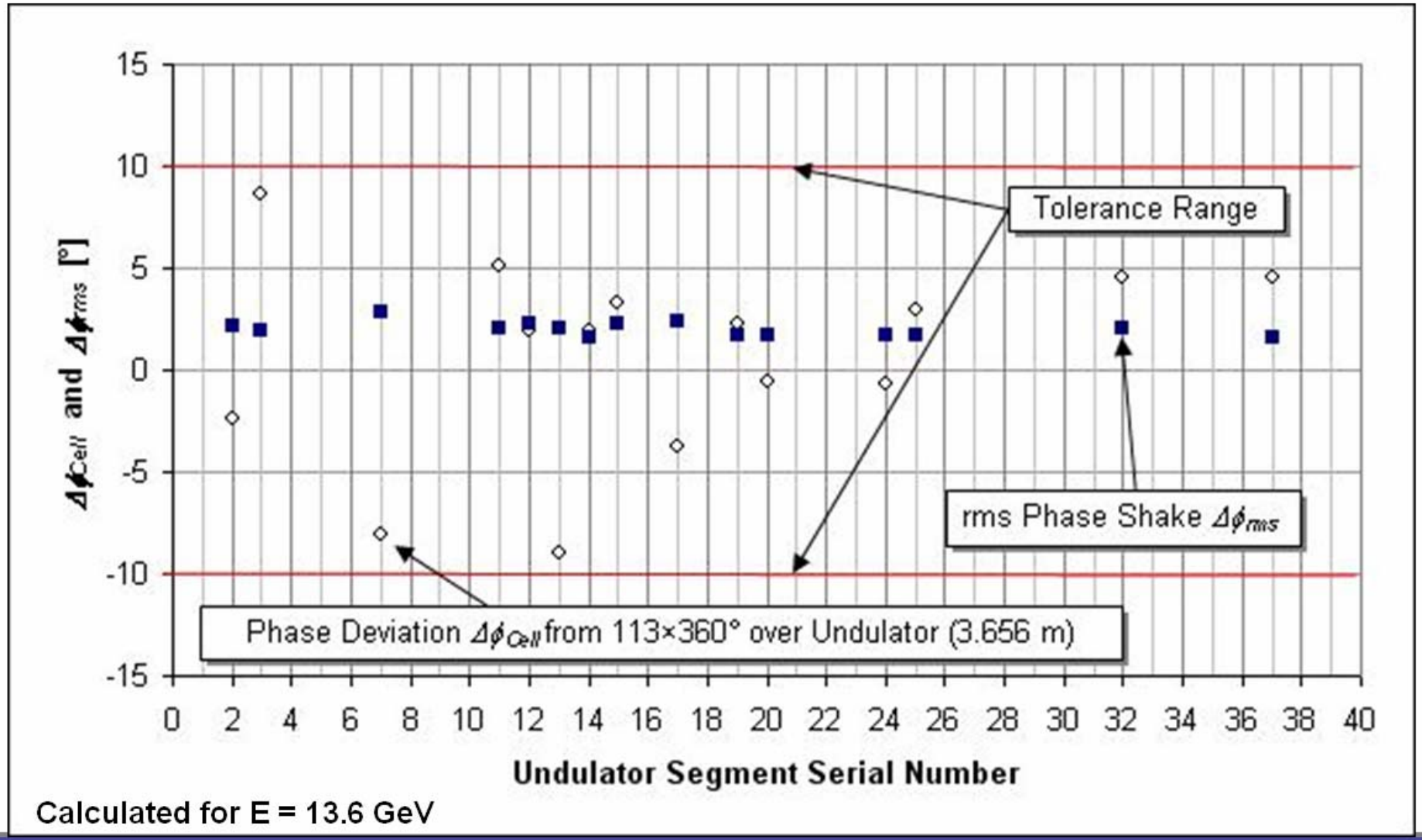
John N. Galayda
galayda@slac.stanford.edu

Fully Assembled Girder



John N. Galayda
galayda@slac.stanford.edu

Tuning Results: Phase Difference well within Tolerance

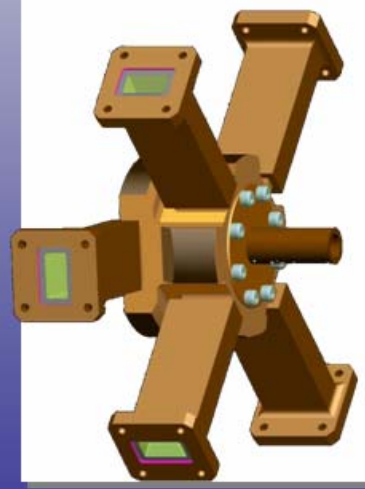


Calculated for E = 13.6 GeV

John N. Galayda
galayda@slac.stanford.edu

Undulator System Key Components

- RF BPM
  - 1 micron Resolution spec met: (09/27/07) < 0.6 micron
  - Long term drift spec for 1 hour spec met
  - Gain stability spec met
  - 1 hour temperature stability spec met
  - 24 hour temperature stability spec met electronics with simulated beam

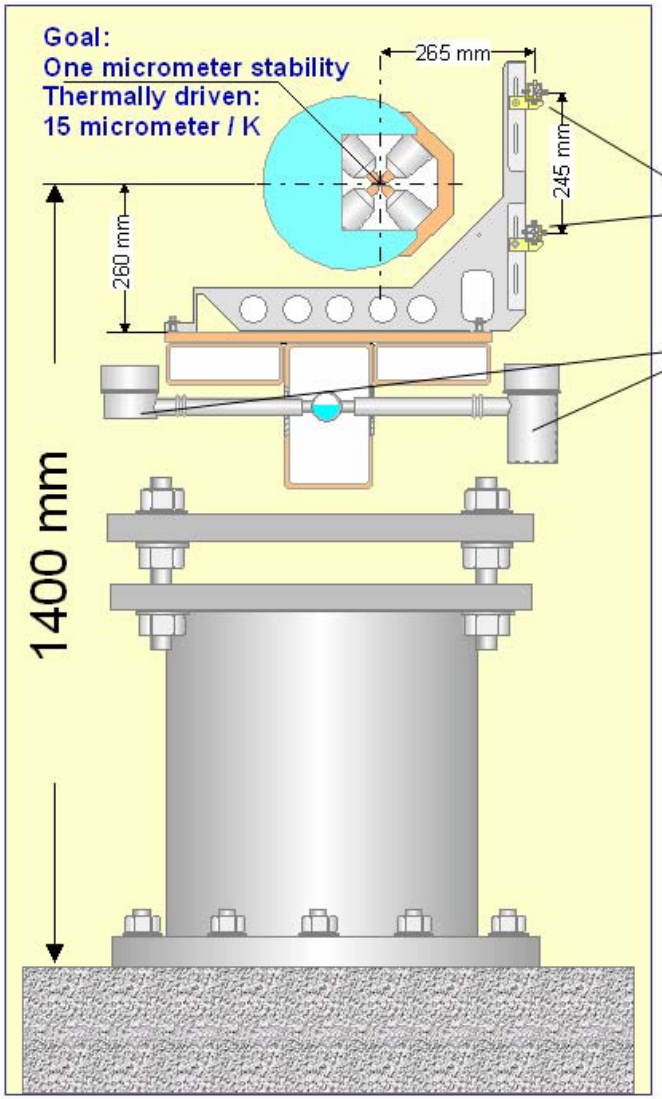


Argonne NATIONAL LABORATORY

- Undulator Vacuum Chamber
  - Machining tests successful
  - Dimensional tolerance met
  - Polishing tolerance met

John N. Galayda
galayda@slac.stanford.edu

Undulator Alignment Diagnostics System



WPM & HLS will operate as one Alignment Diagnostic System, ADS

WPM measures:
X & Y- Positions relative to two stretched wires

HLS measures:
Y - Positions relative to the water surface

Common Task:

- X & Y Positon monitoring of U-Segments
- Resolution: < Micrometer
- Data rate: Every few minutes
- Operation: Continously, no drifts

Courtesy F. Peters/G. Gassner

Undulator supports installed in the tunnel

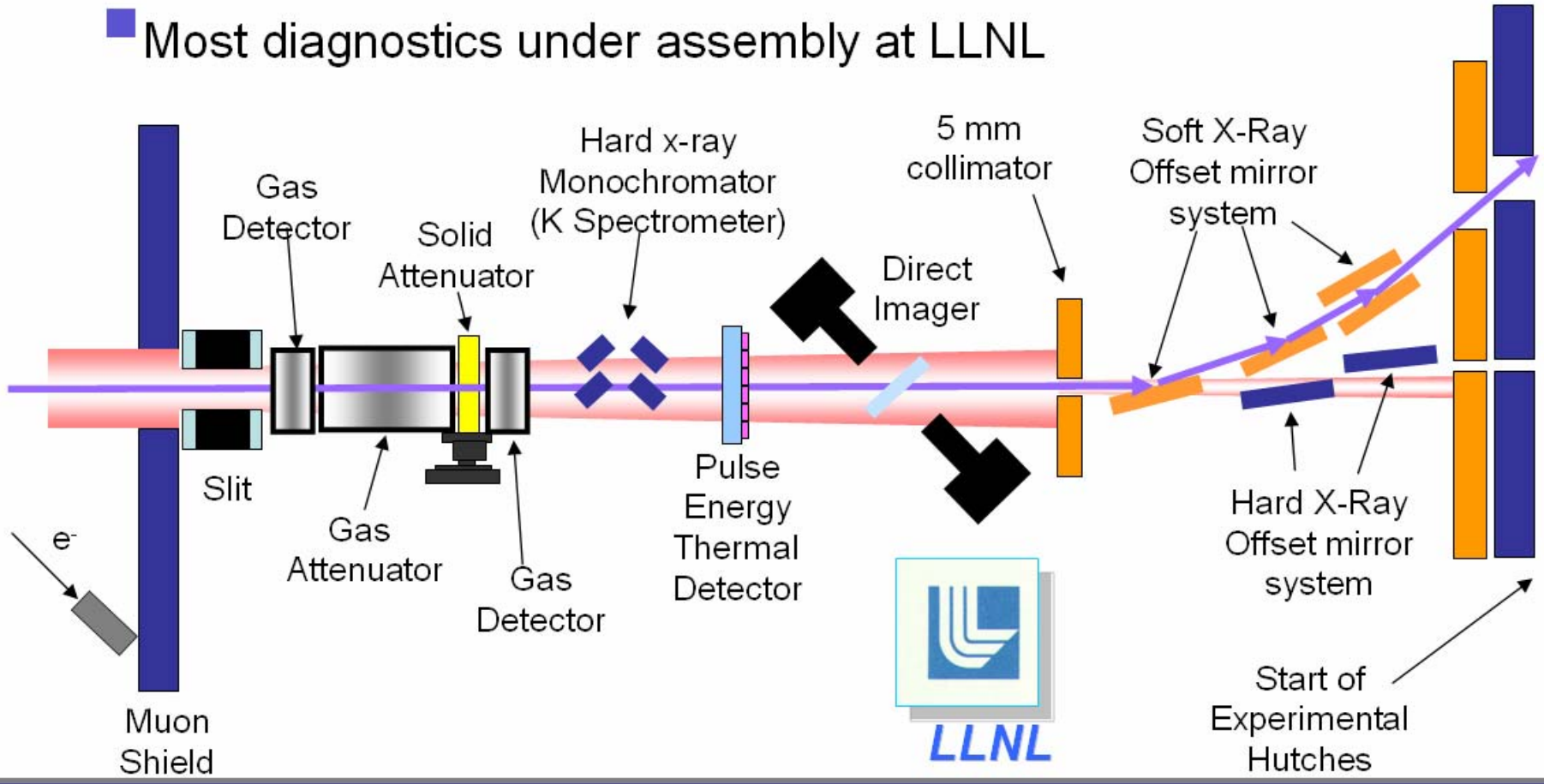
64 pedestals installed,
26 aligned

6/13/08

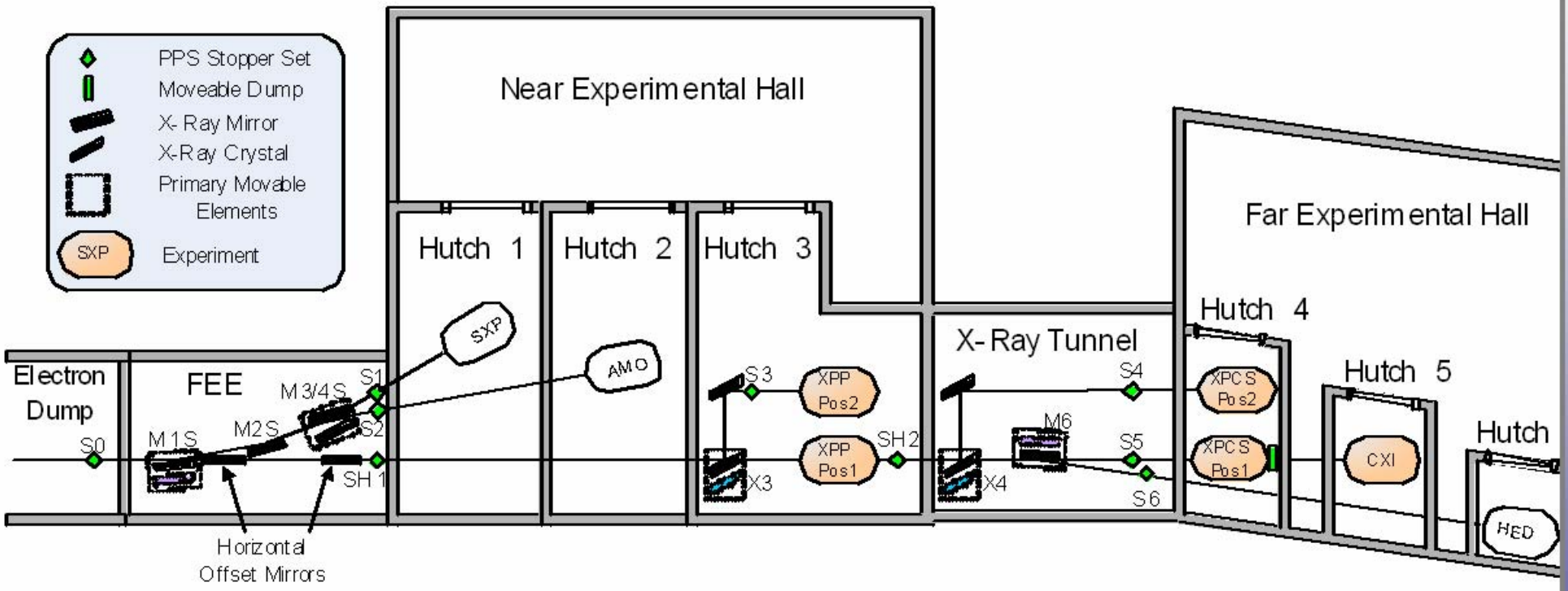
John N. Galayda
galayda@slac.stanford.edu

X-ray front end

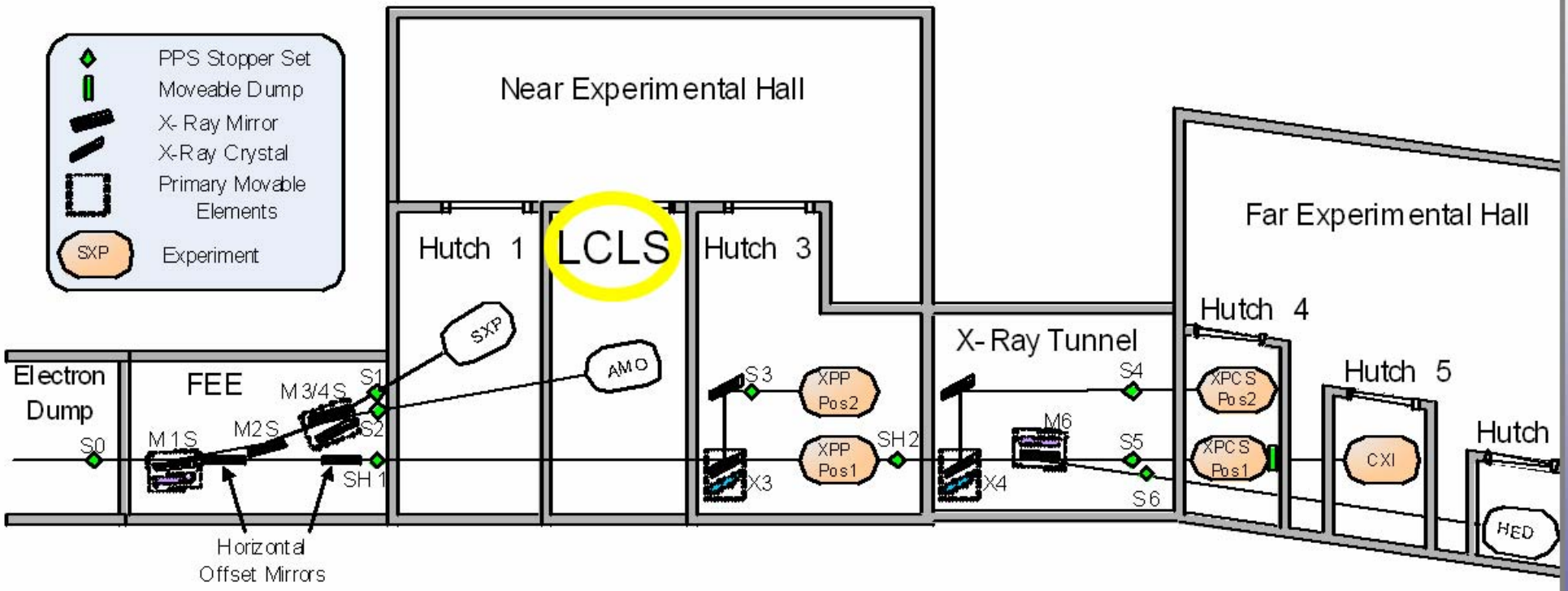
- ***Front end X-ray optics being assembled***
  - All mirrors ordered; soft X-ray mirror figure meets spec
  - Most diagnostics under assembly at LLNL



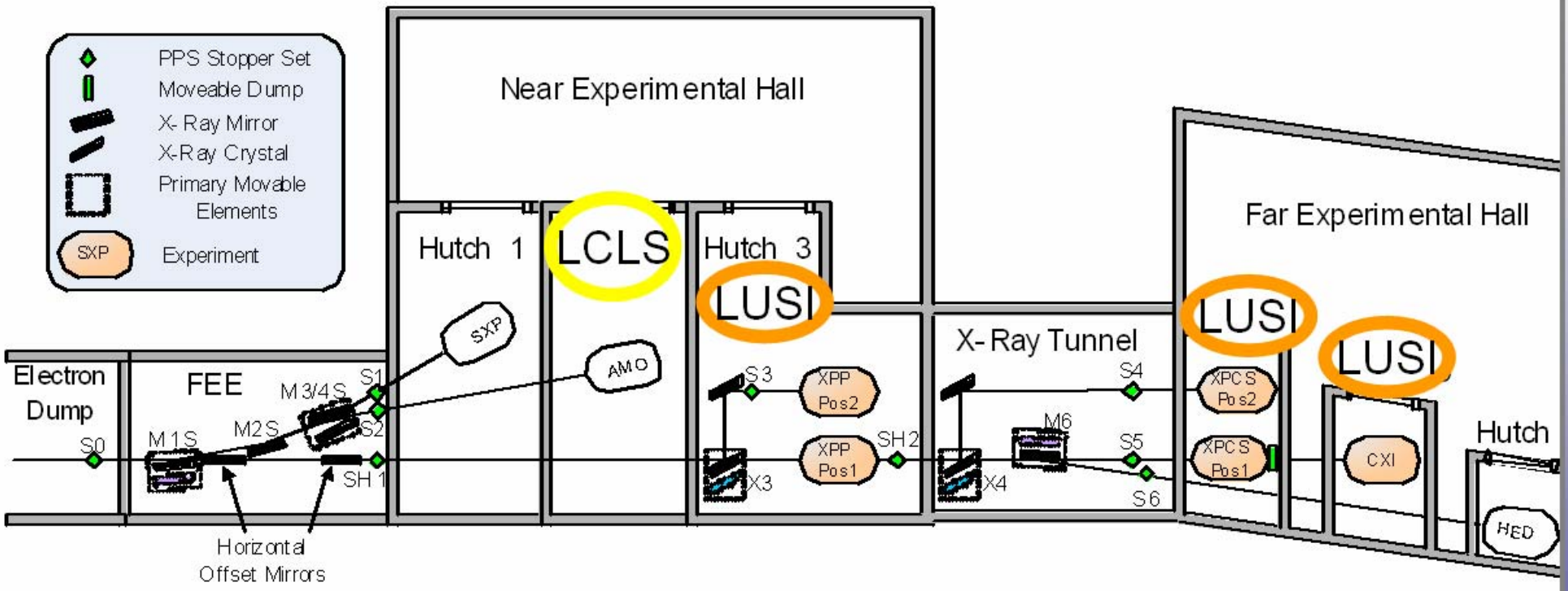
XR End Stations



XR End Stations



XR End Stations



Design and typical electron beam parameters @ 0.25 nC

Parameter	symbol	design	measured	unit
Final linac e^- energy	γmc^2	4.3 - 13.6	4.3 - 13.6	GeV
Bunch charge	Q	1	0.25	nC
Final bunch length (rms)	σ_{zf}	0.02	0.01	mm
Final peak current	I_{pk}	3.4	2 - 2.5	kA
Final slice energy spread (rms)	σ_{Ef}/E_0	<0.01	-	%
Projected x emittance (linac)	$\gamma\varepsilon^L_x$	1.5	1.2 - 1.6	μm
Projected y emittance (linac)	$\gamma\varepsilon^L_y$	1.5	0.8 - 1.2	μm
Single bunch rep. rate	f	120	10 - 30	Hz
Final rel. energy jitter (rms)	σ_E/E	0.1	0.03	%
Final timing jitter (rms)	σ_t	<120	50	fs
Bunch charge jitter	σ_N/N	2	1.5	%
Hor. pointing jitter (rms)	$\langle x^2\rangle^{1/2}/\sigma_x$	10	10 - 15	%
Peak current jitter	σ_I/I	<12	9	%

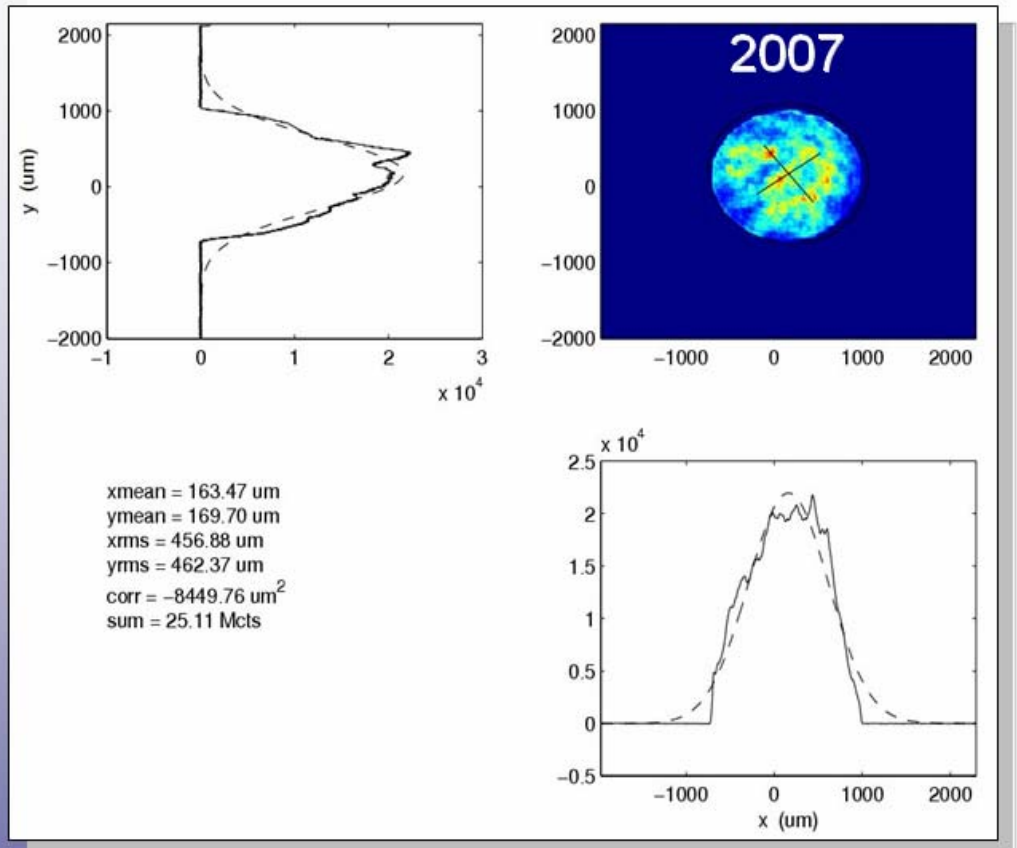
John N. Galayda
galayda@slac.stanford.edu

Estimated 2009 FEL Performance

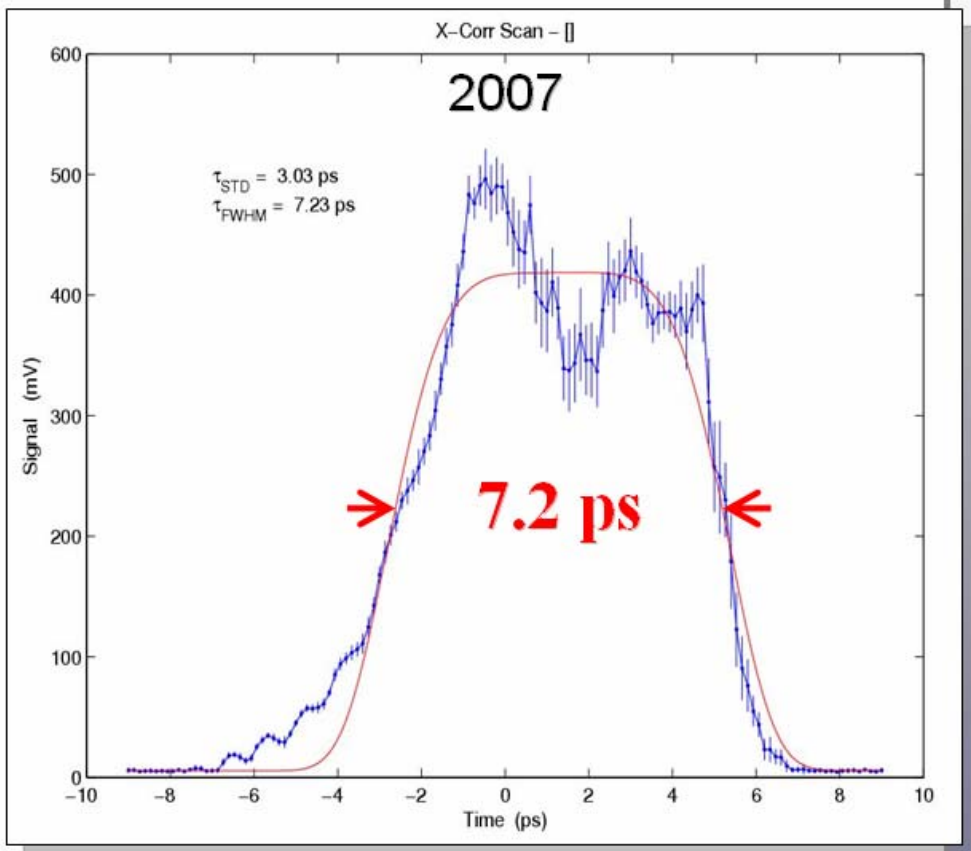
Parameter	symbol	15 Å FEL	5 Å FEL	units
Electron energy	E_0	4.3	7.5	GeV
Single bunch rep. rate	f	30	30	Hz
Norm. rms emittance	$\gamma\varepsilon_{x,y}$	1.2 - 2	1.2 - 2	μm
Peak current	I_{pk}	2	2.5	kA
Photon energy	$\hbar\omega$	0.84	2.5	keV
FEL power gain length	Lg	1.6 - 2.1	2.5 - 3.5	m
FEL fundamental power	P_{FEL}	6 - 9	8 - 13	GW
Rel. FEL bandwidth (FWHM)	$\Delta\omega/\omega$	0.3	0.2	%
Photon pulse duration (FWHM)	$\Delta\tau$	100	80	fs
Energy per pulse	E_{FEL}	0.6 - 0.9	0.6 - 1	mJ
Number of photons/0.1%-BW	N_γ	1.6 – 2.3	0.8 - 1.3	10^{12}
Peak brightness (0.1%-BW/s/mm^2/mmrad^2)	B_{pk}	3 - 4	16 - 26	10^{31}
Average brightness (at 30 Hz)	B_{avg}	0.8 – 1.2	4 - 6	10^{20}
Relative power in 3rd harmonic	P_3/P_1	~ 1	~ 1	%
Relative power in 5th harmonic	P_5/P_1	~ 0.1	~ 0.1	%

John N. Galayda
galayda@slac.stanford.edu

Laser Spatial and Temporal Shaping

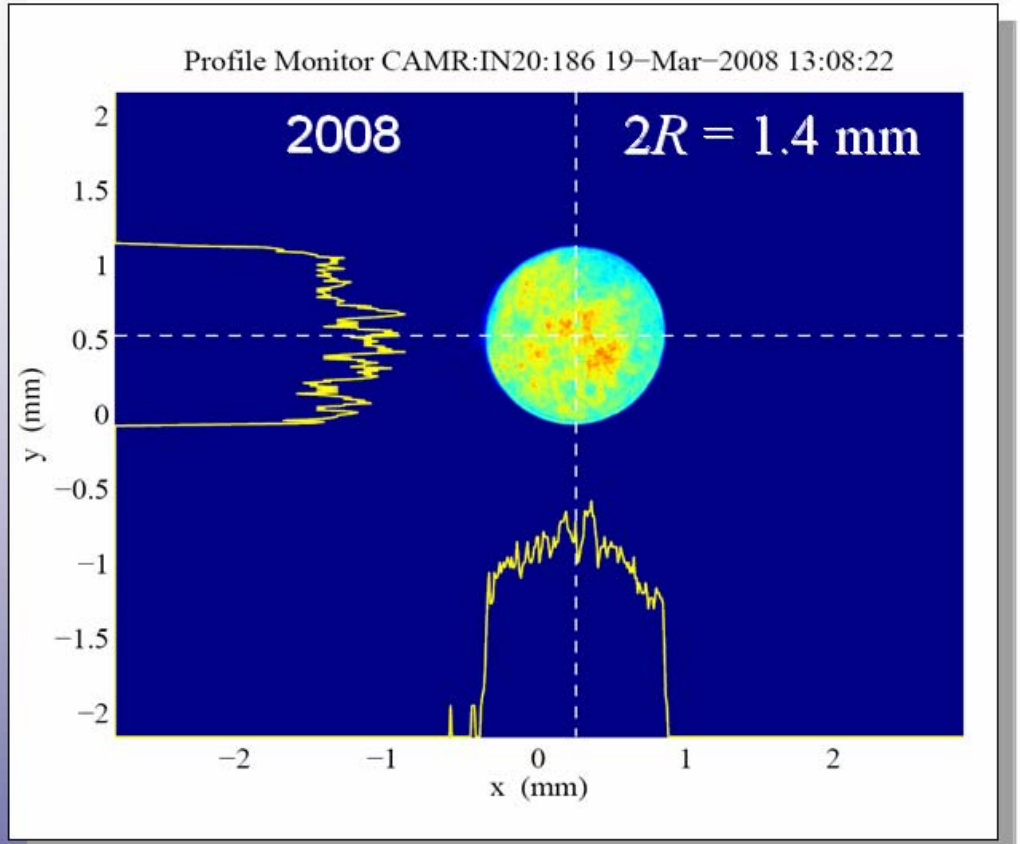


Spatial shape on cathode using iris

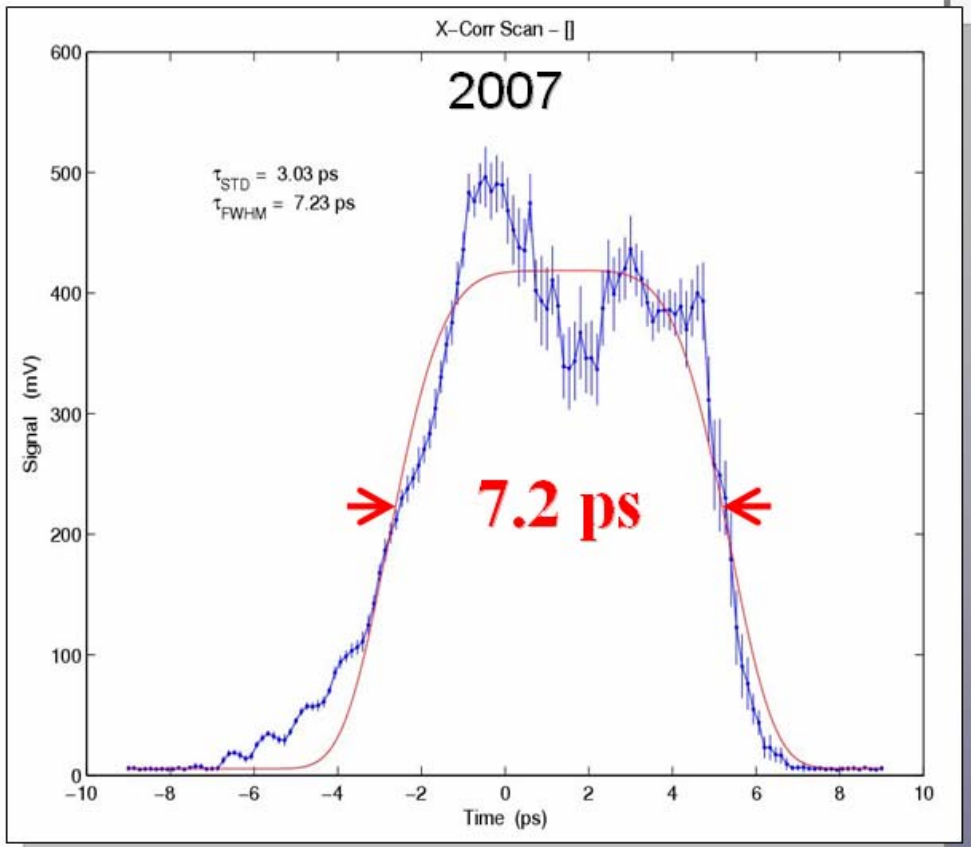


Temporal shape (6.6 ps FWHM)

Laser Spatial and Temporal Shaping

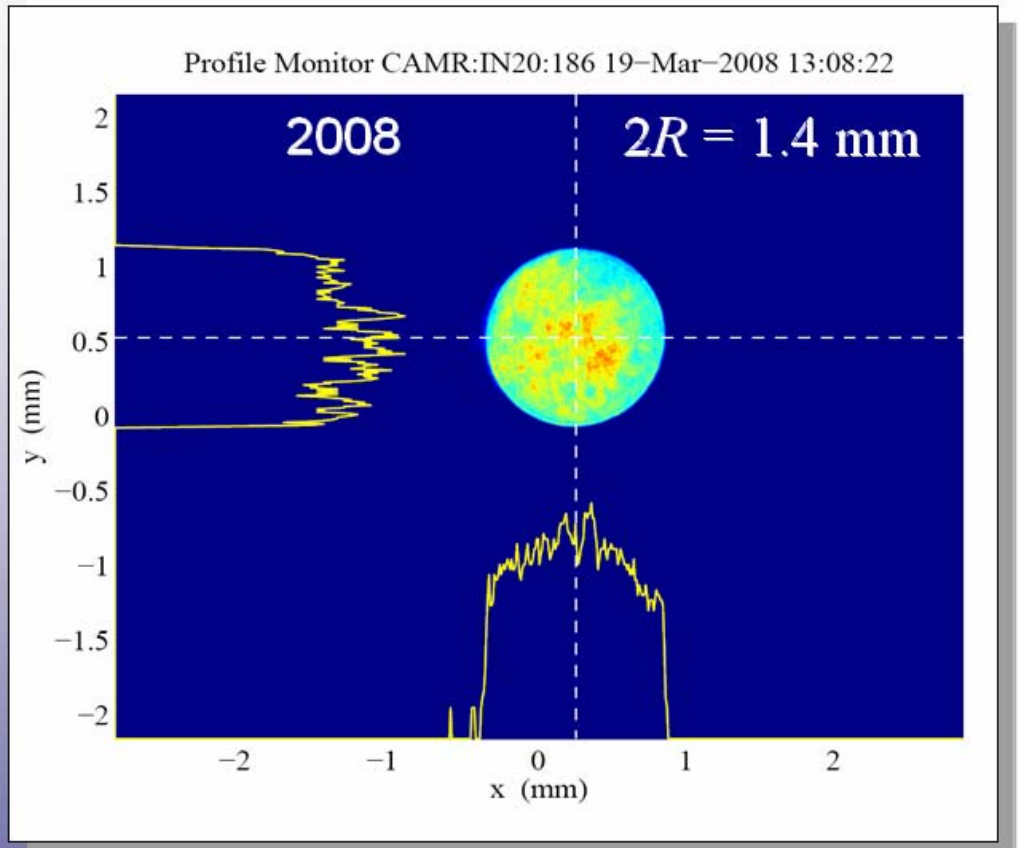


Spatial shape on cathode using iris

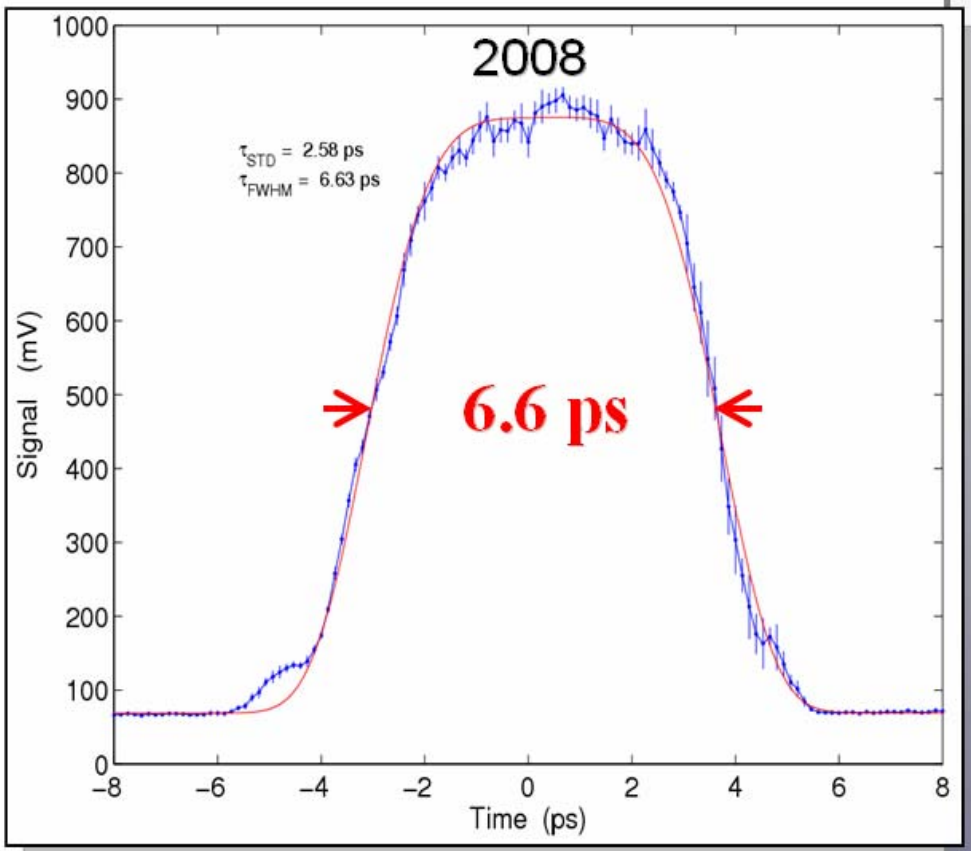


Temporal shape (6.6 ps FWHM)

Laser Spatial and Temporal Shaping



Spatial shape on cathode using iris



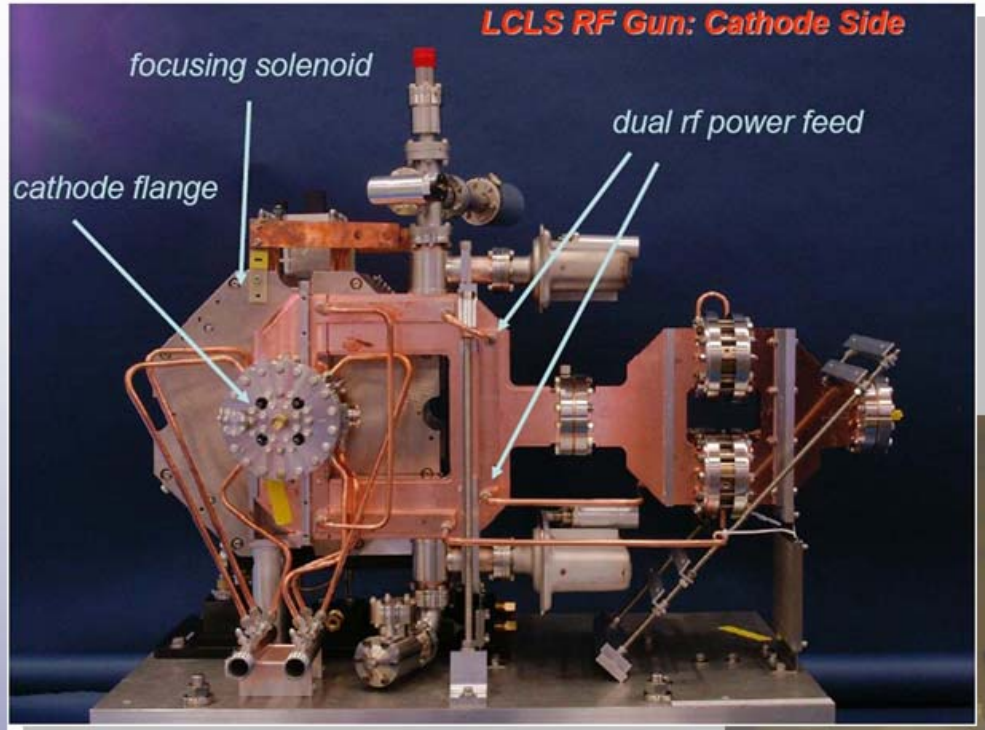
Temporal shape (6.6 ps FWHM)

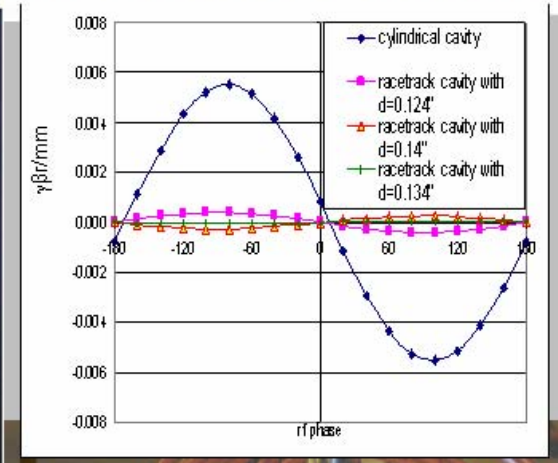
99% Drive Laser up time!

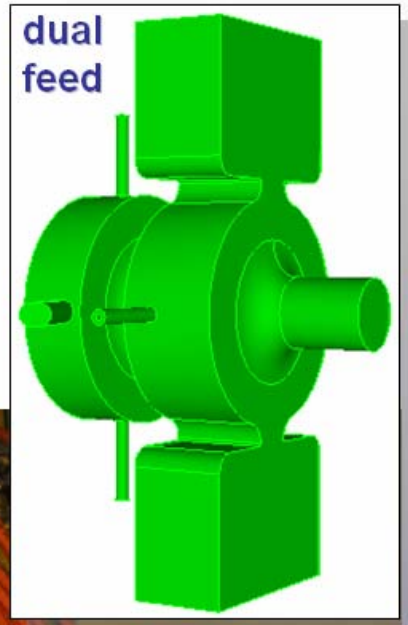
S. Gilevich, G. Hays, P. Hering, A. Miahnahri, W. White

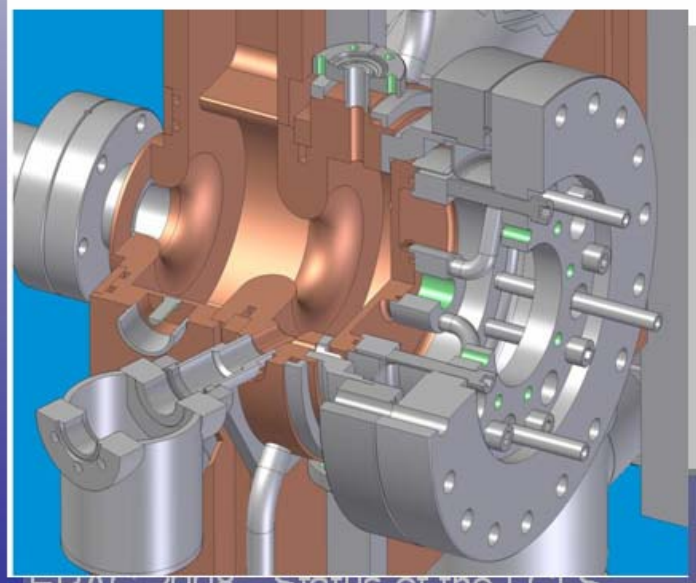
John N. Galayda
galayda@slac.stanford.edu

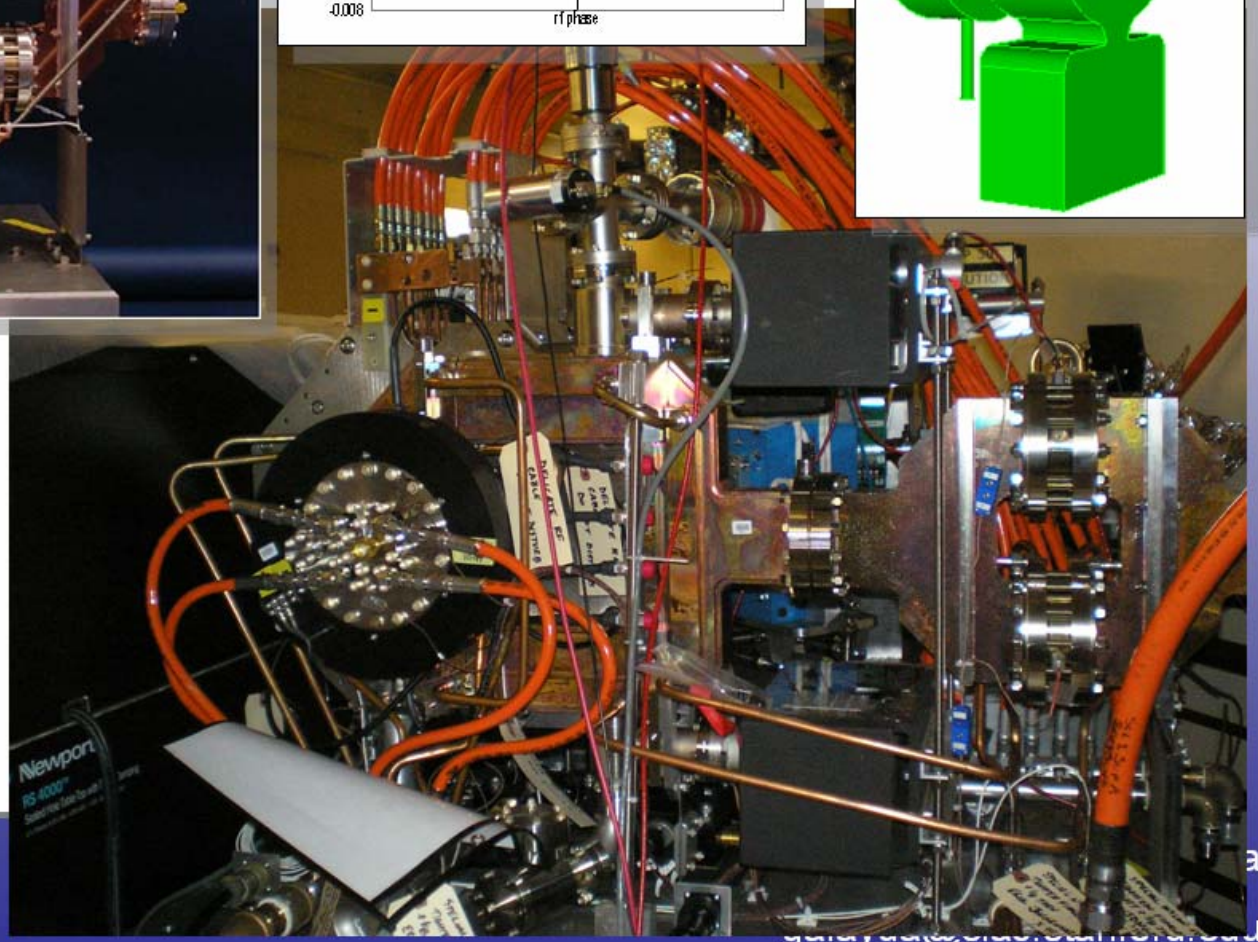
RF Gun Installed in March 2007



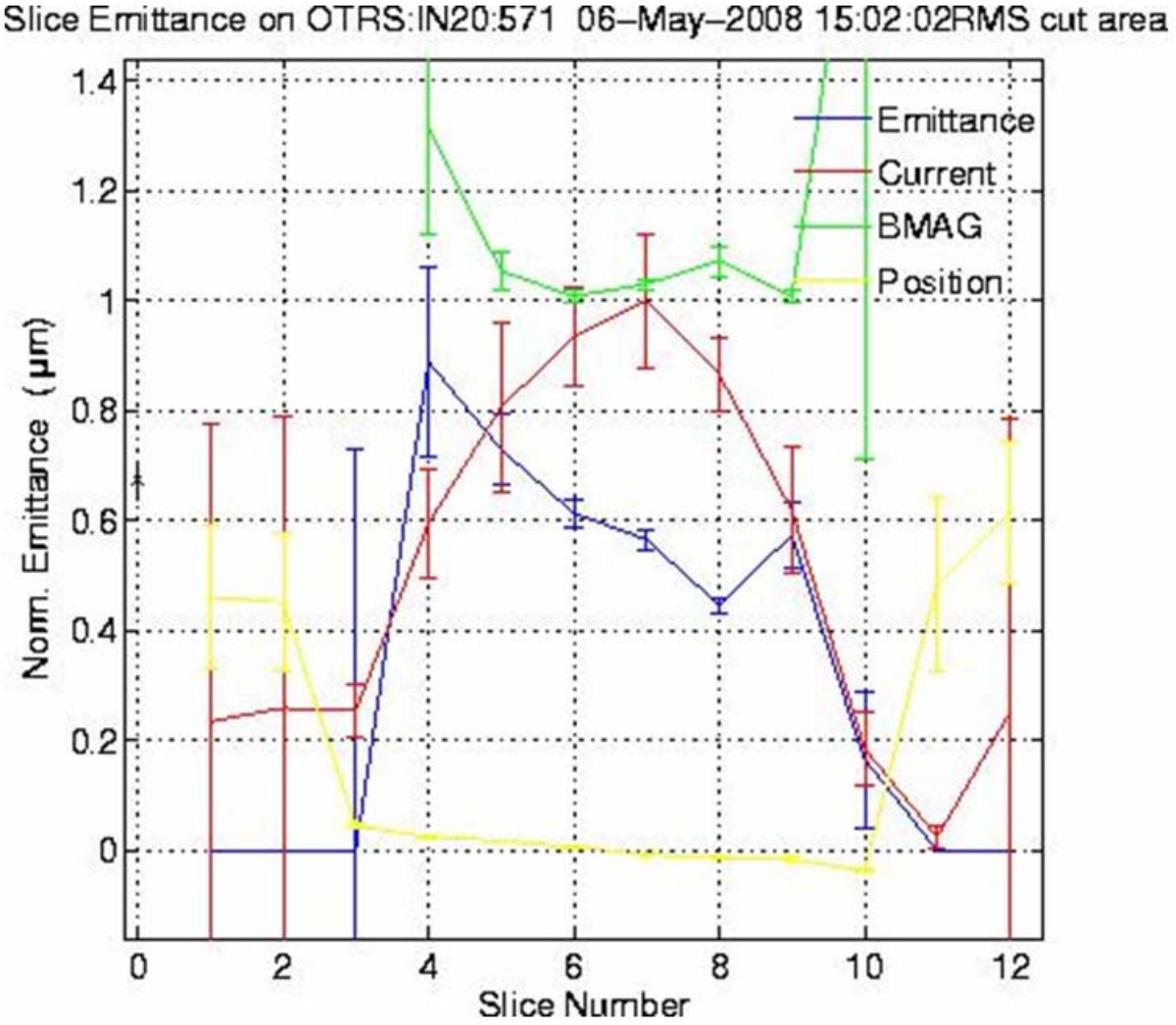




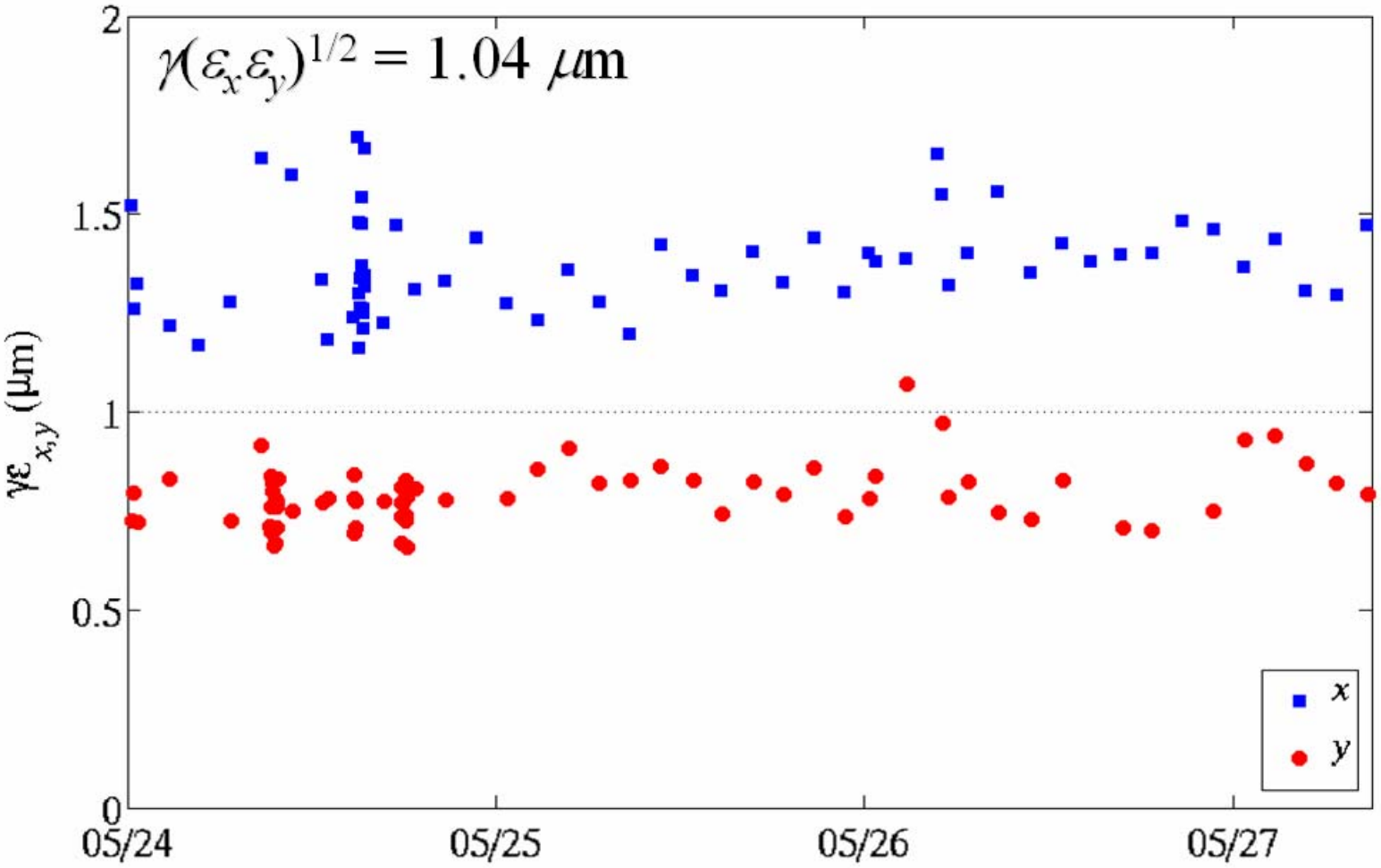




Slice Emittance at 135 MeV



Emittance Near End of Linac Over Long Weekend



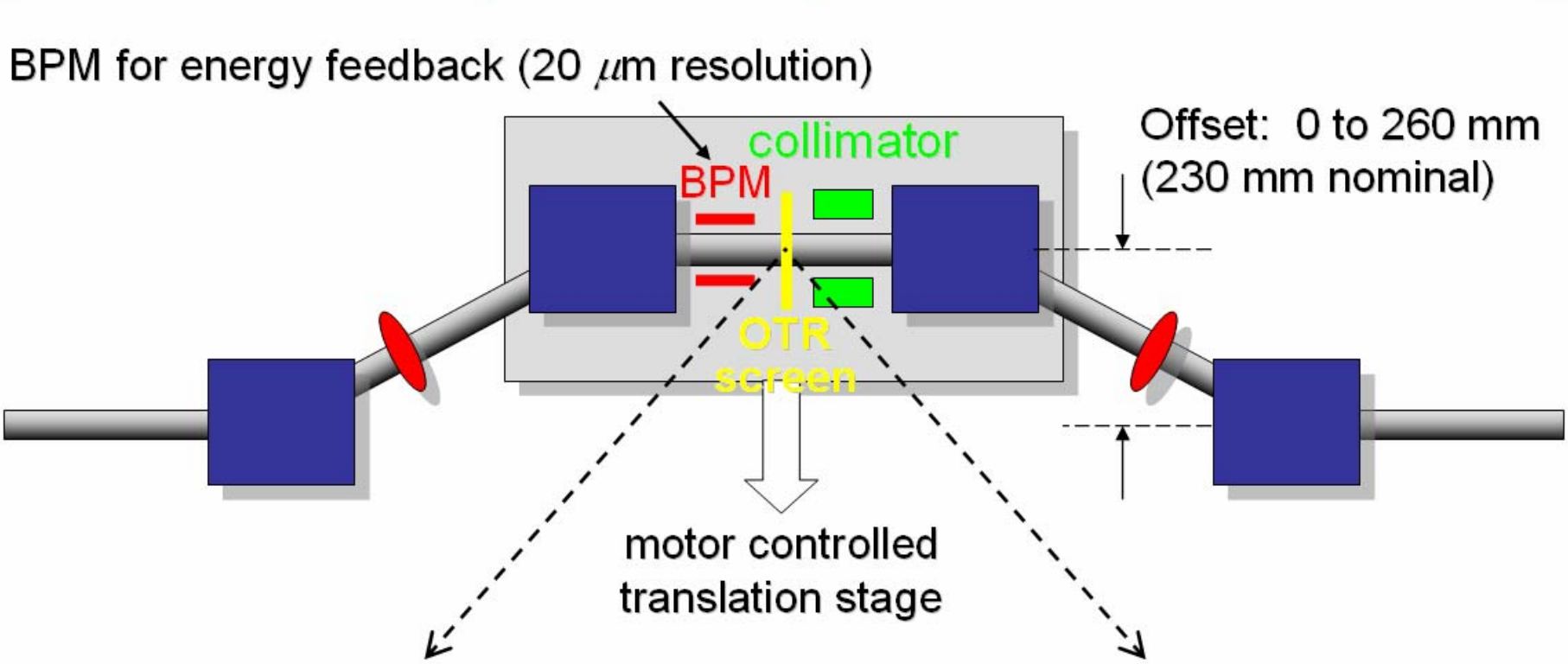
(3.3 days) May 24, 2008 00:01 to May 27 09:00

weekend run at 0.25 nC, with no tuning

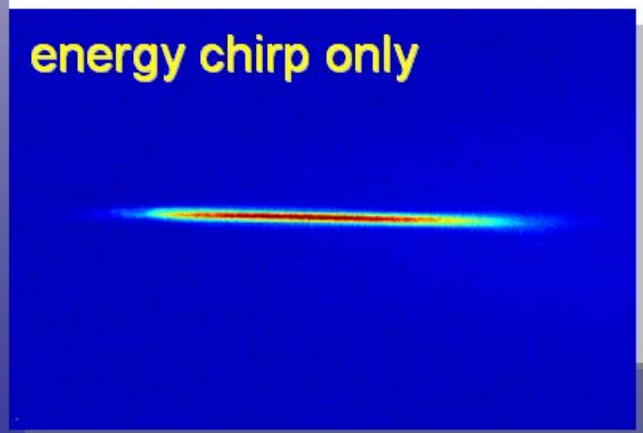
Saturation at 1.5 Å in 100 m (assuming BBA, etc)

John N. Galayda
galayda@slac.stanford.edu

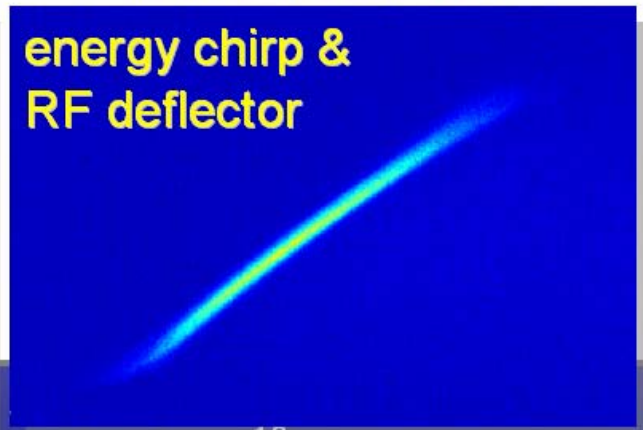
X-Band RF (11.4 GHz) and BC1 Chicane



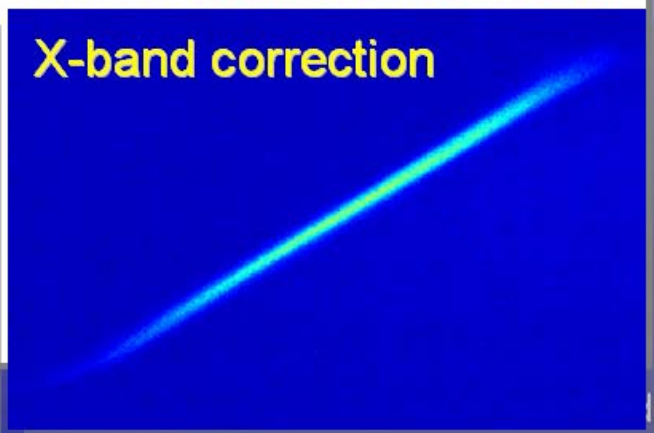
RF deflector **OFF**



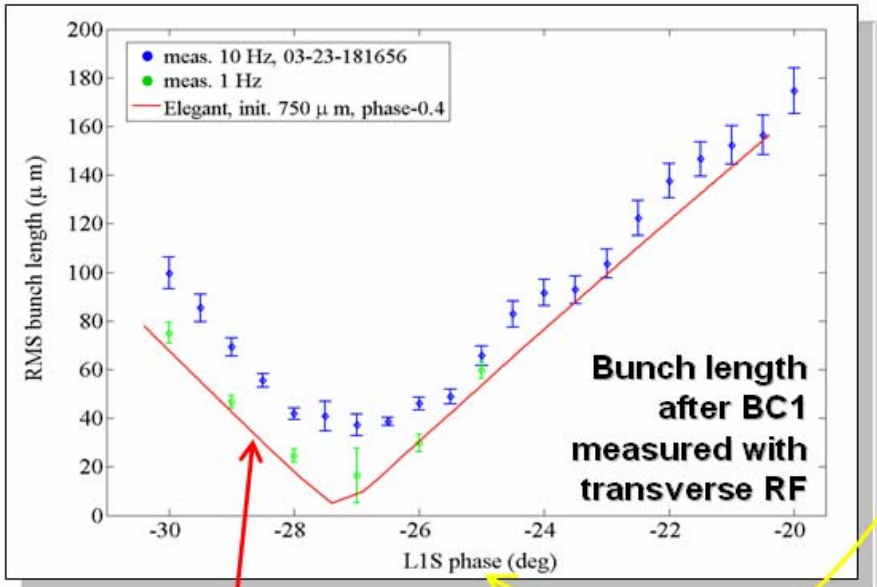
RF deflector **ON**

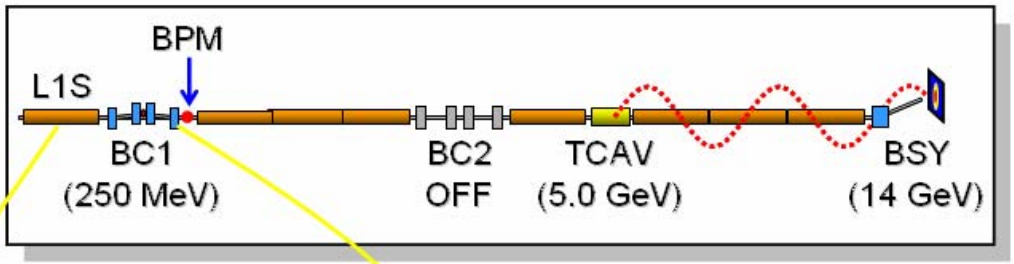


Deflector **ON** & X-band **ON**

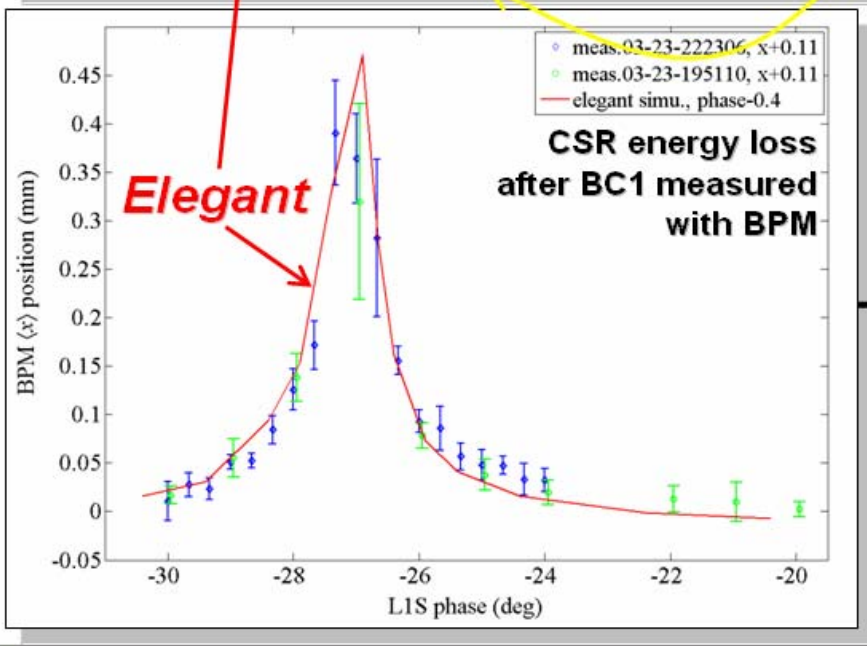


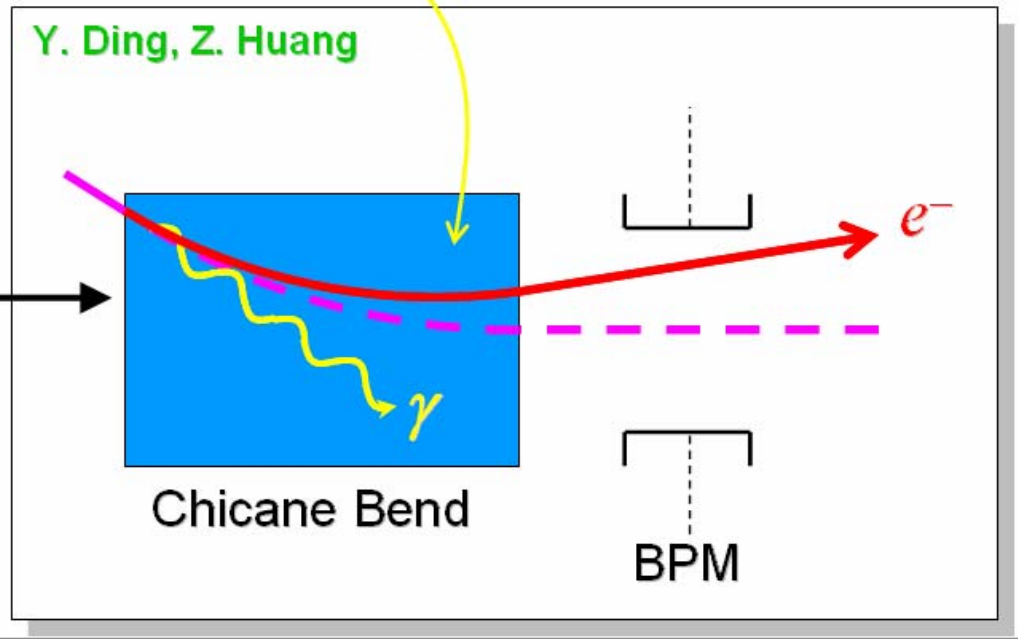
BPM-Measured CSR Energy Loss in BC1 at 0.25 nC (compares well with tracking)





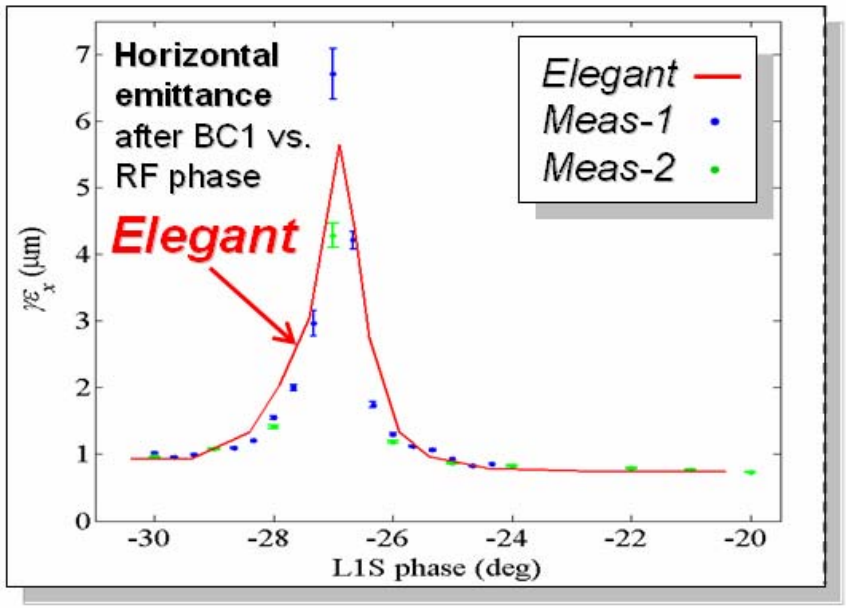
A Phase shift of –0.4 deg is added to the *Elegant* curves



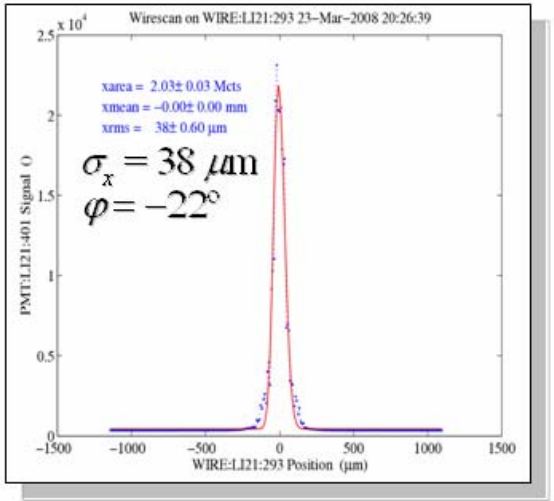


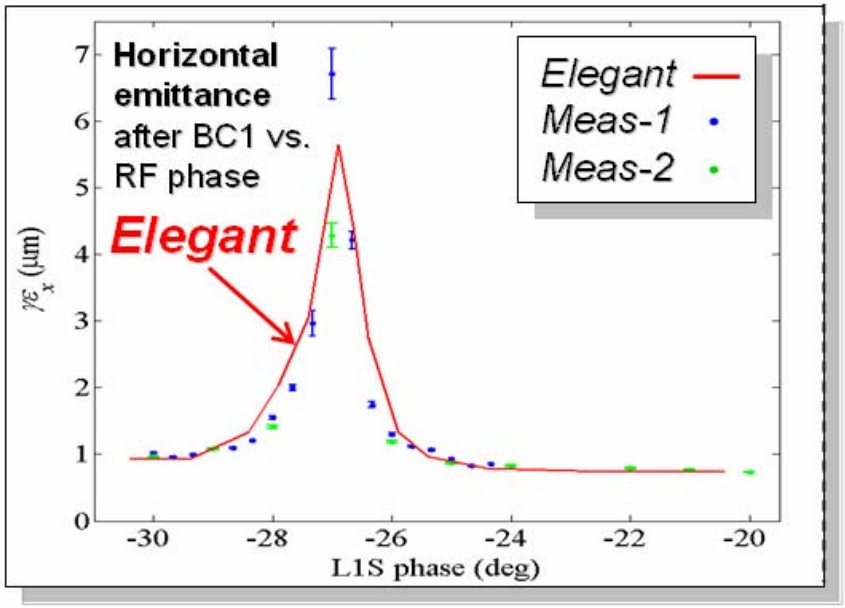
Hor. CSR Emittance Growth after BC1 (250 MeV, 0.25 nC)

Now plot horizontal emittance after BC1

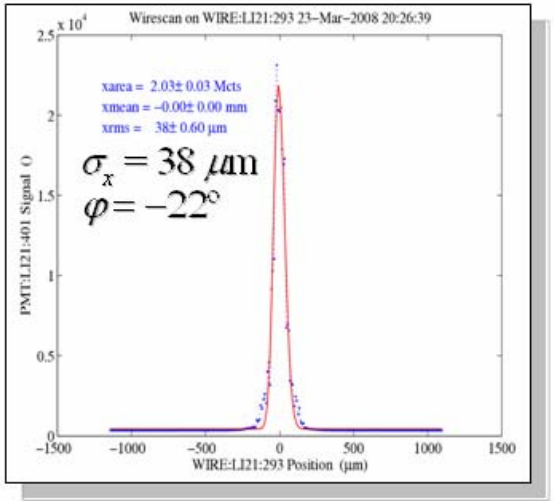


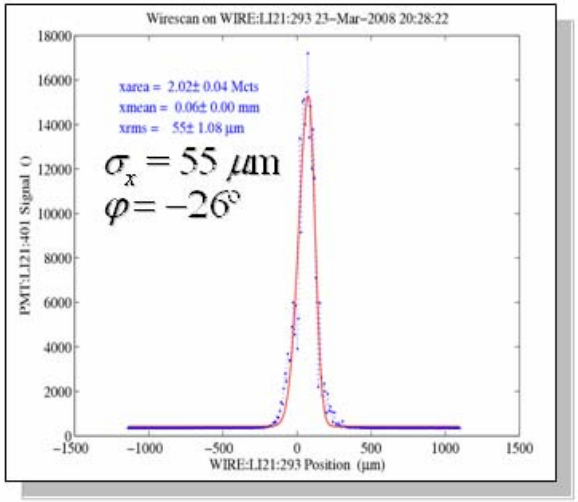
Hor. CSR Emittance Growth after BC1 (250 MeV, 0.25 nC)

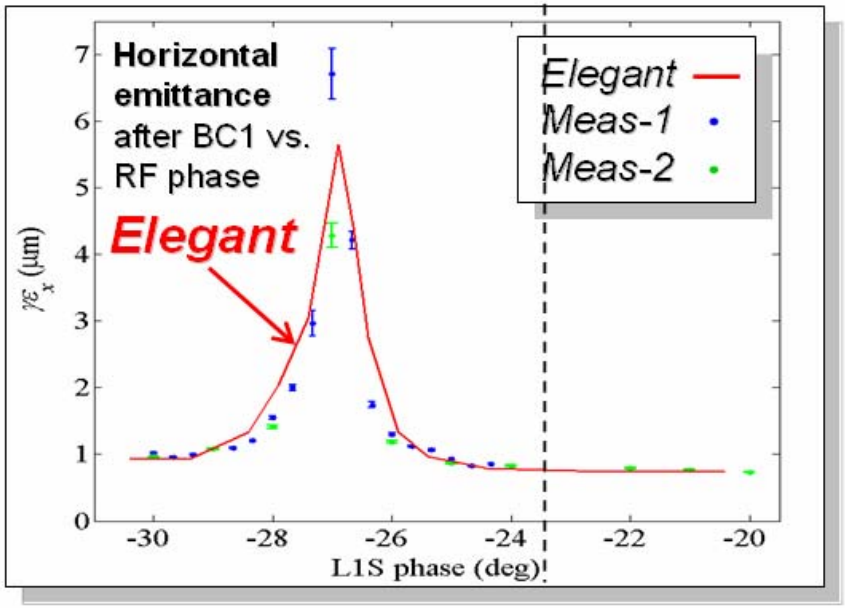




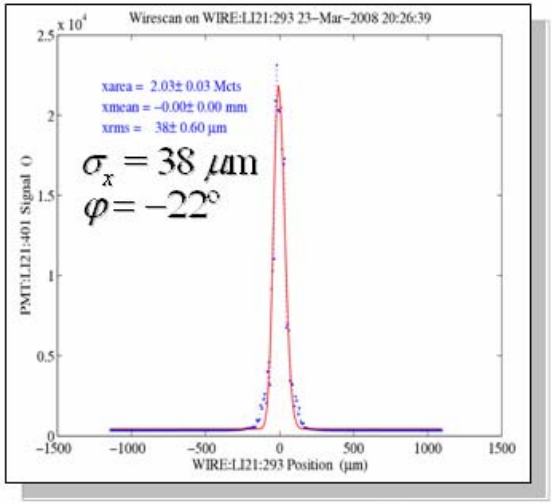
Hor. CSR Emittance Growth after BC1 (250 MeV, 0.25 nC)

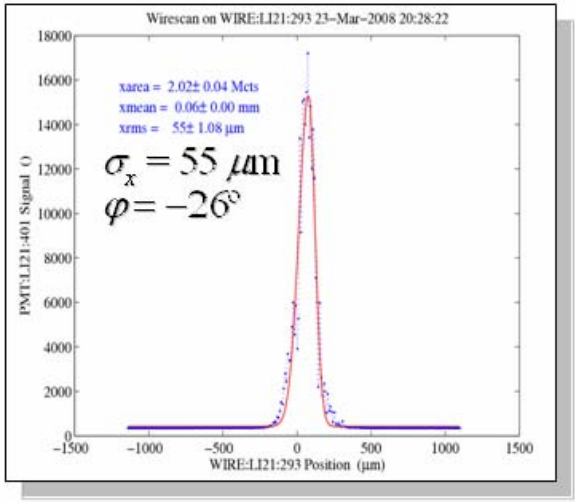


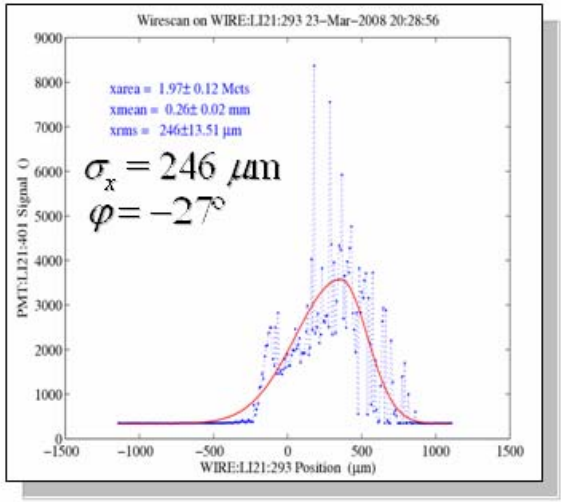


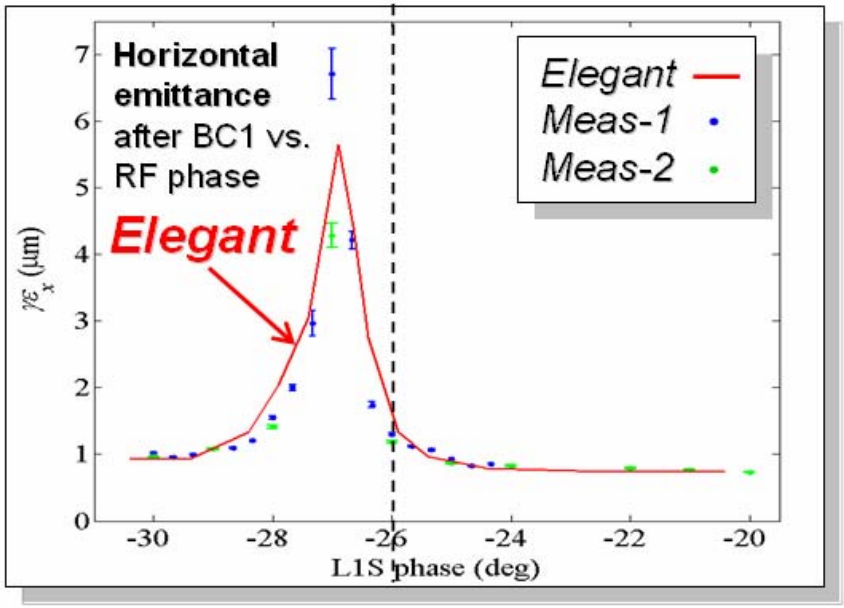


Hor. CSR Emittance Growth after BC1 (250 MeV, 0.25 nC)

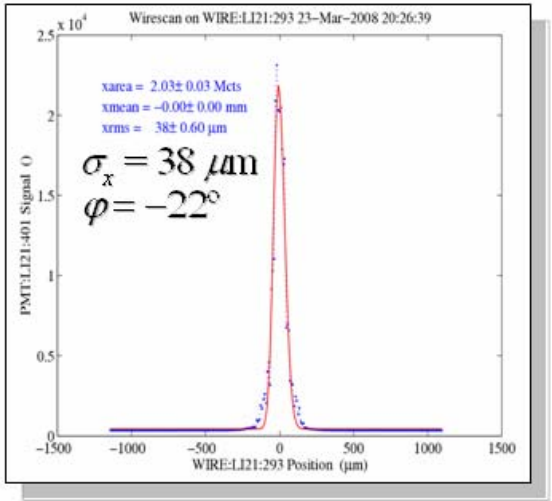


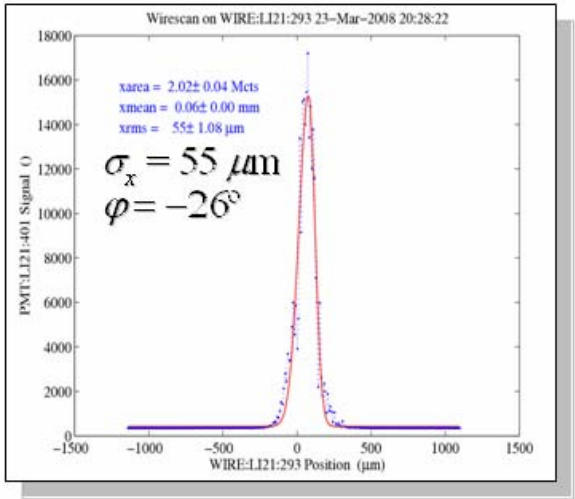


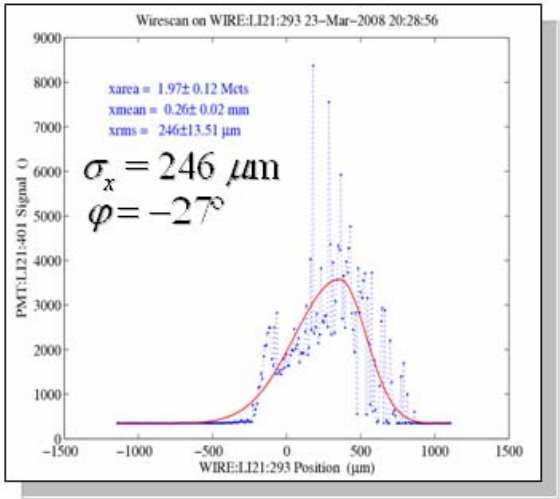


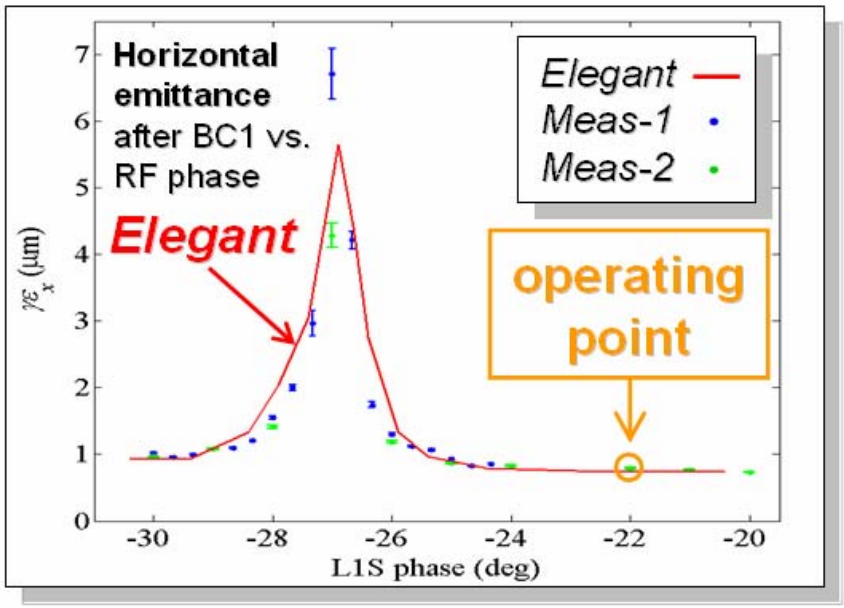


Hor. CSR Emittance Growth after BC1 (250 MeV, 0.25 nC)

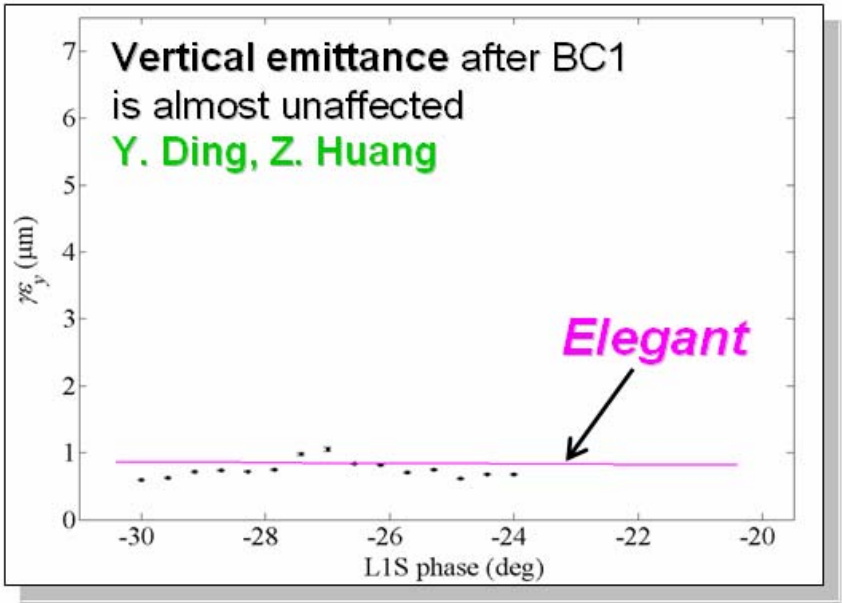






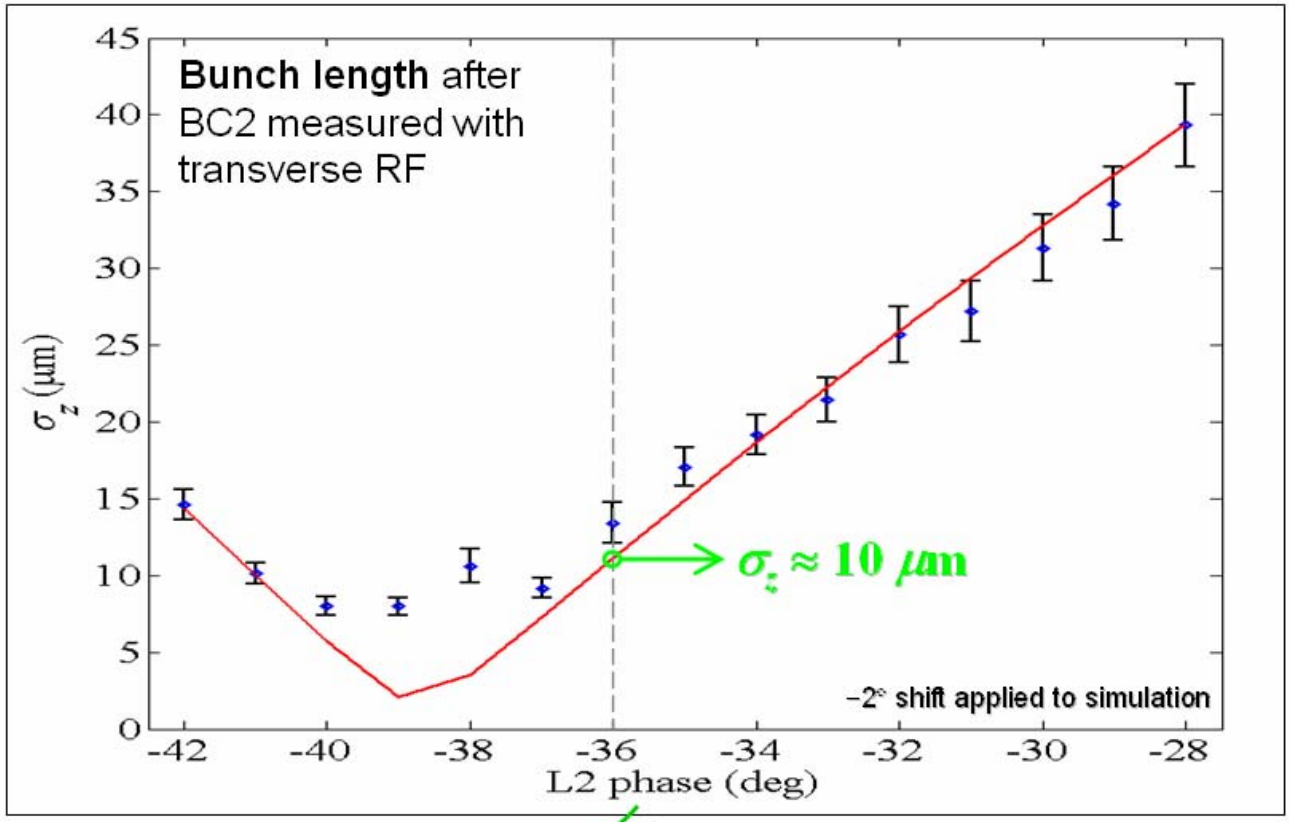


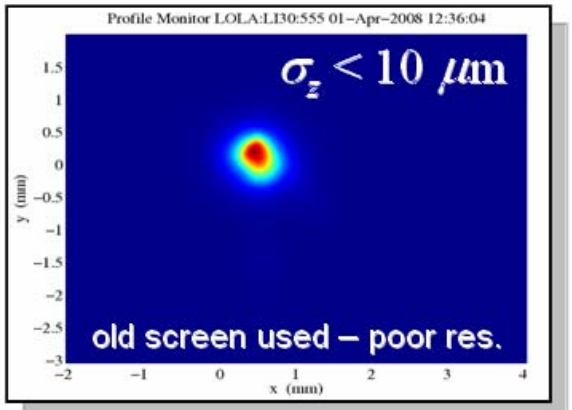
Data also exists at 1 nC and BC2 data (0.25 nC) also shows decent results

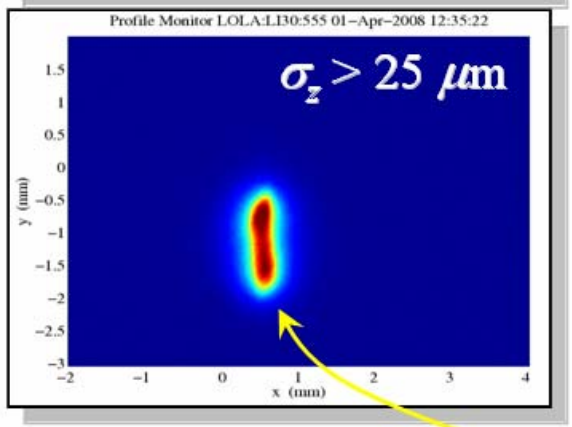


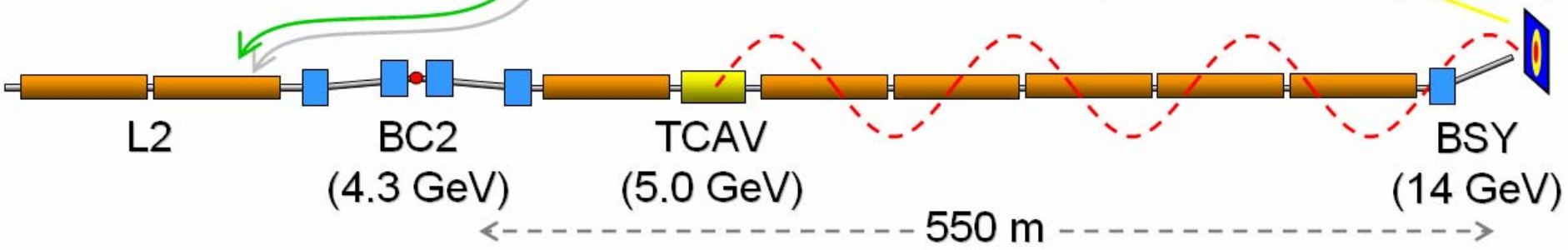
John N. Galayda
galayda@slac.stanford.edu

Bunch Compression Measured after BC2 (0.25 nC)



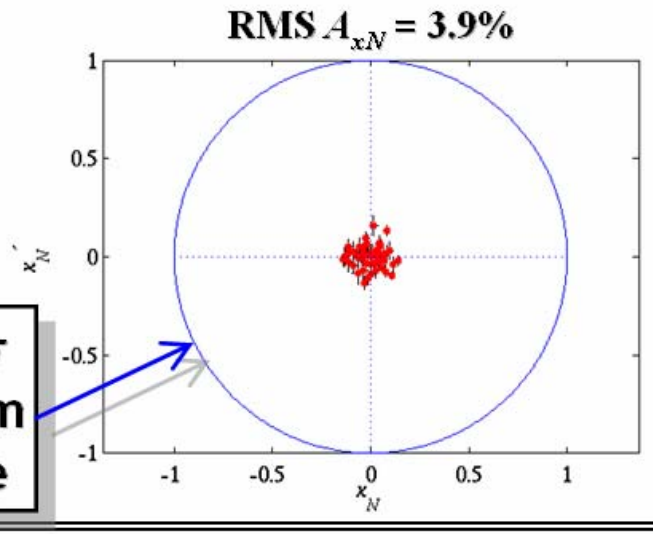


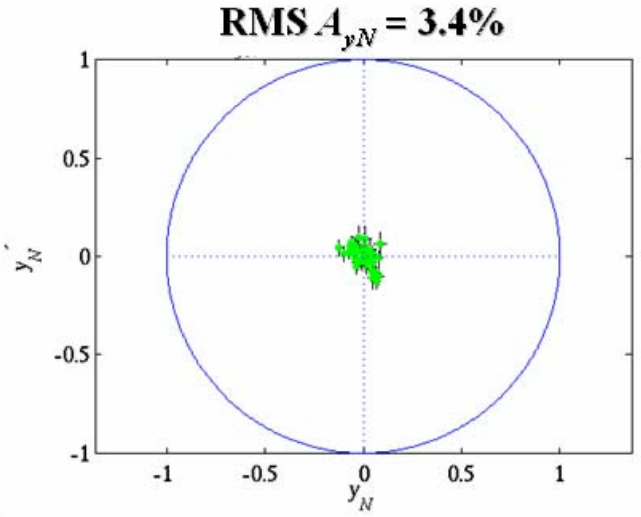




John N. Galayda
galayda@slac.stanford.edu

Normalized phase space centroid jitter after BC1 (~4% of rms beam size)





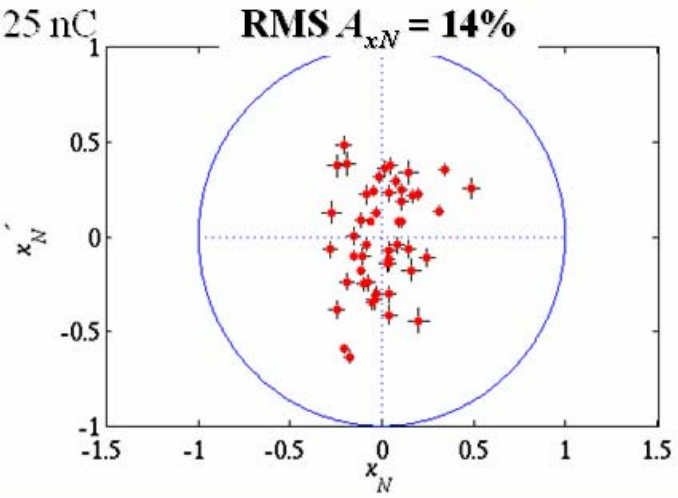
1-σ beam size

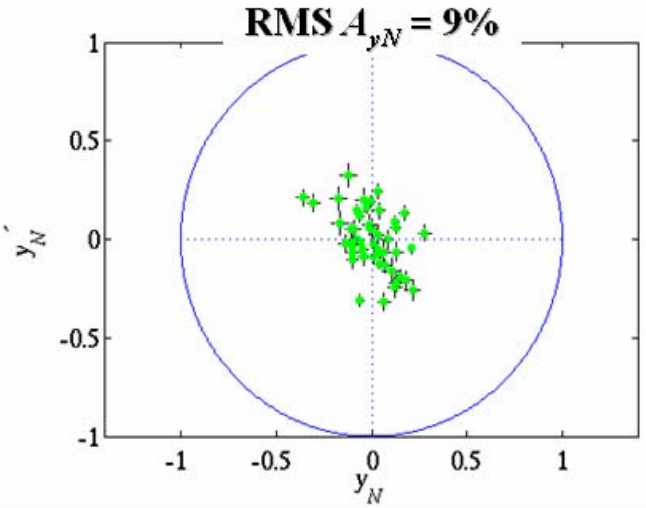
Stability is not so far off of our goals (~10%)

D. Ratner

… near end of linac (~12% of rms beam size, but sometimes larger)

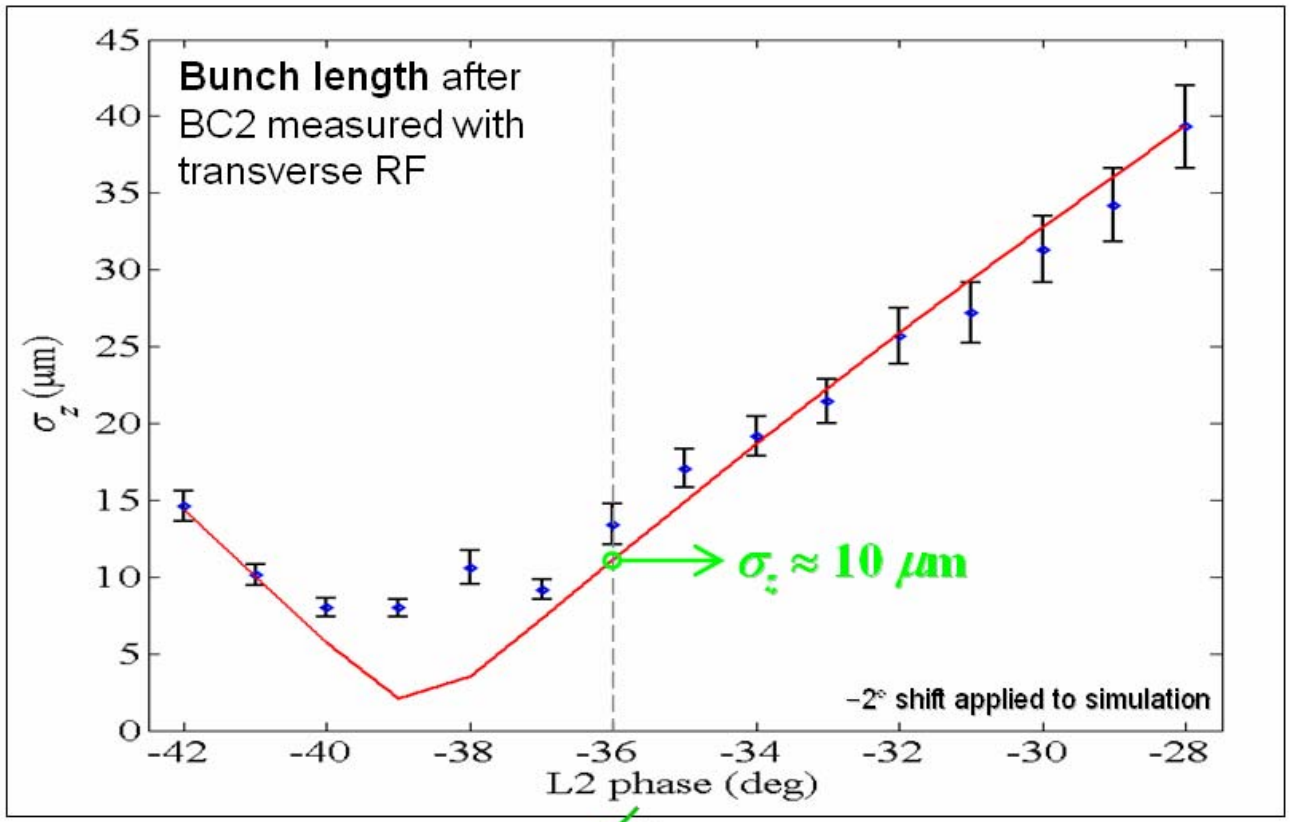
$Q = 0.25$ nC

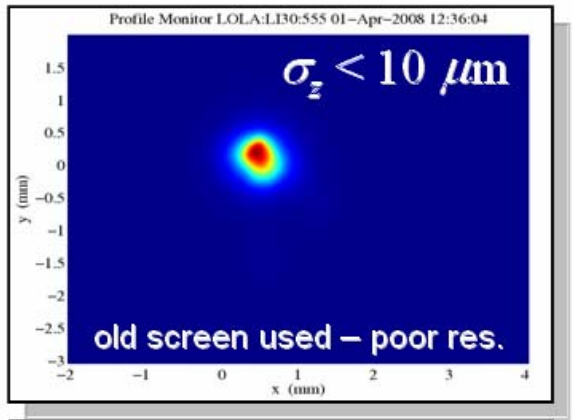


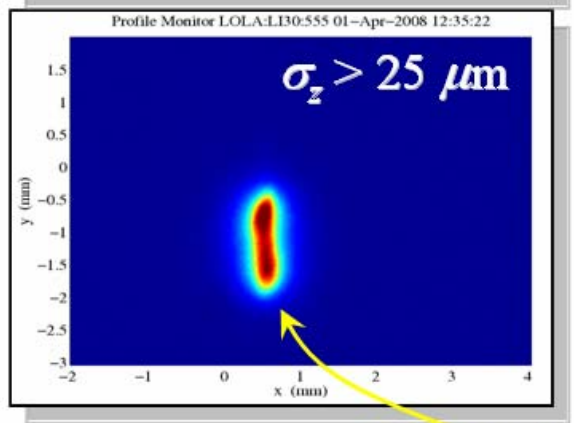


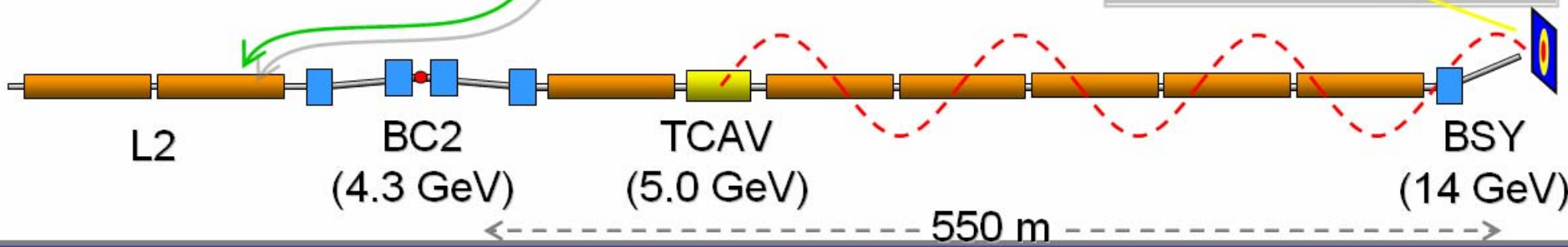
$\Delta E/E$ jitter ≈ 0.03%
$\Delta Q/Q$ jitter ≈ 1.5%

Bunch Compression Measured after BC2 (0.25 nC)



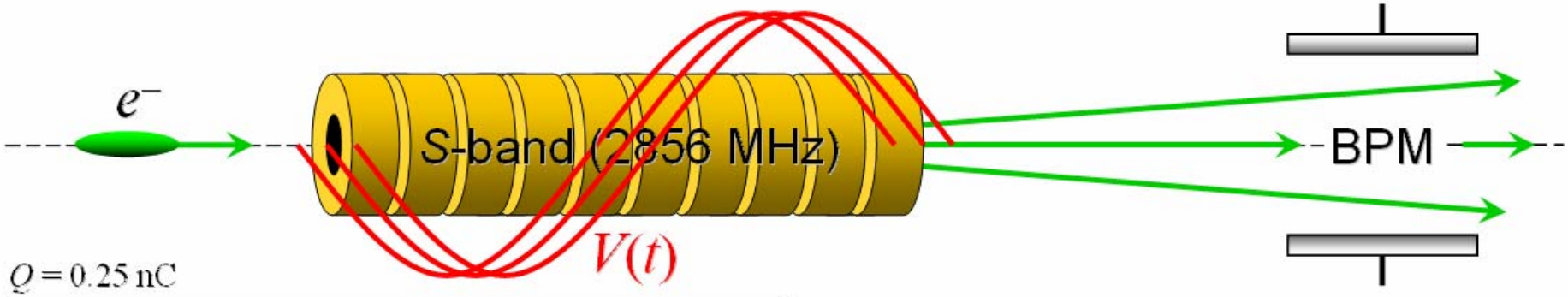




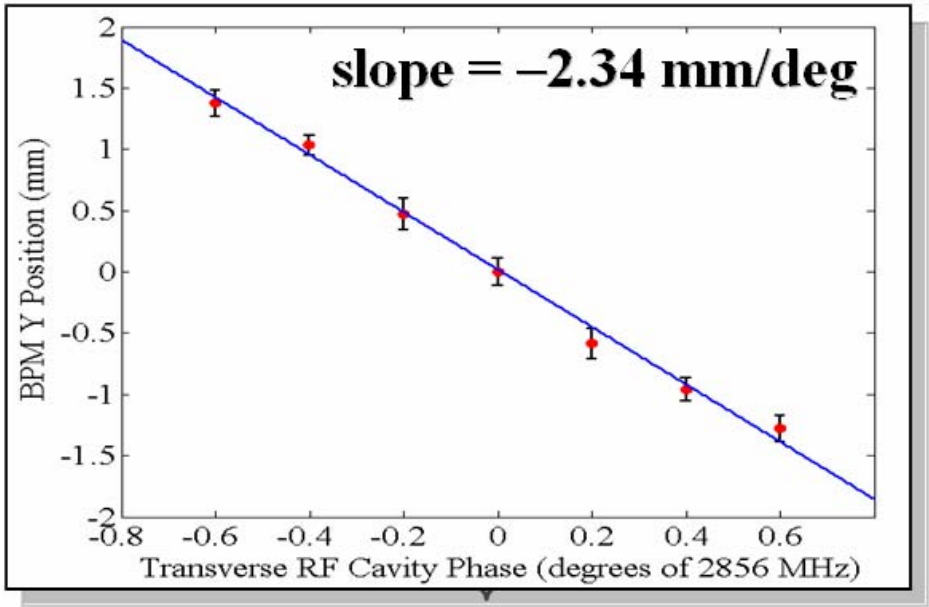


John N. Galayda
galayda@slac.stanford.edu

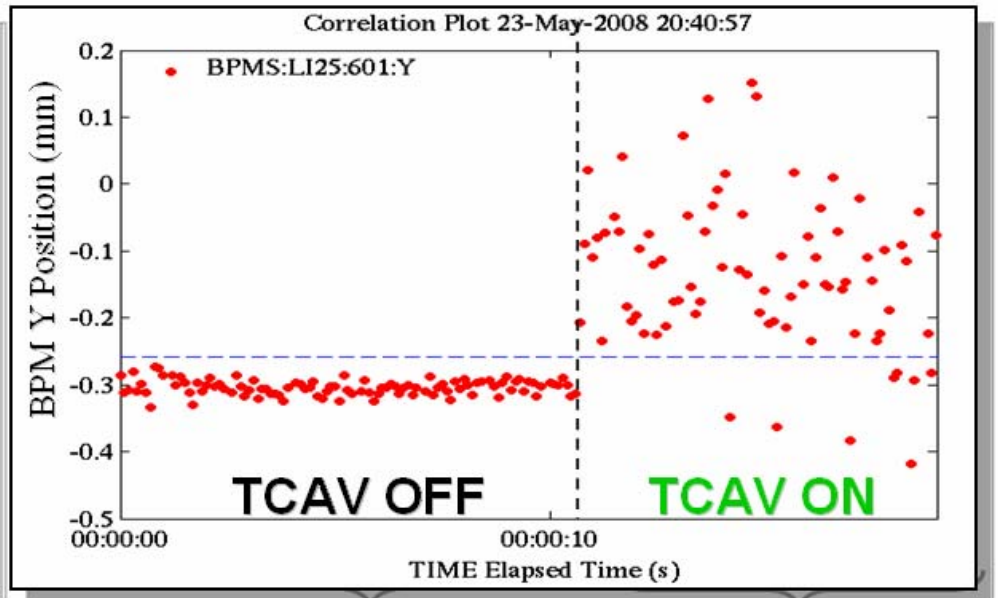
Measuring Bunch Arrival Time Jitter



$Q = 0.25$ nC



$\Delta t \approx \pm 0.6$ ps

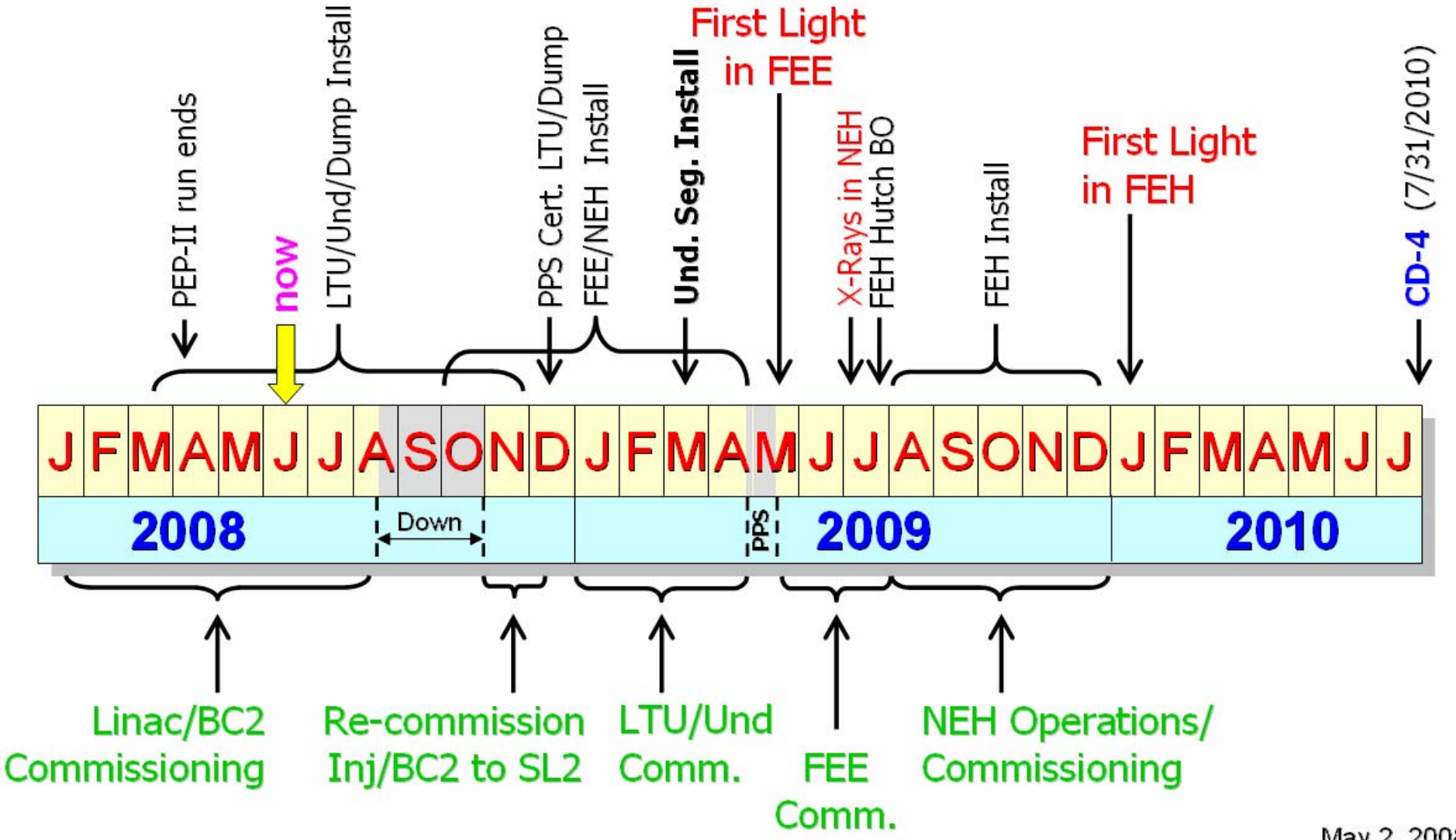


9 μm rms

110 μm rms

John N. Galayda
galayda@slac.stanford.edu

LCLS Installation and Commissioning Time-Line



May 2, 2008

FAR EXPERIMENTAL HALL 14 January 2008

SSRL/LCLS User Meeting in Far Hall 10/2008

John N. Galayda
galayda@slac.stanford.edu

End of Presentation

Thanks to:

SLAC
Jess Albino
John Arthur
Paul Emma
Tom Fornek
Mark Reichanadter
David Saenz
David Schultz

ANL
Geoffrey Pile
Bill Berg
Marion White

LLNL
Richard Bionta
Donn McMahon

John N. Galayda
galayda@slac.stanford.edu