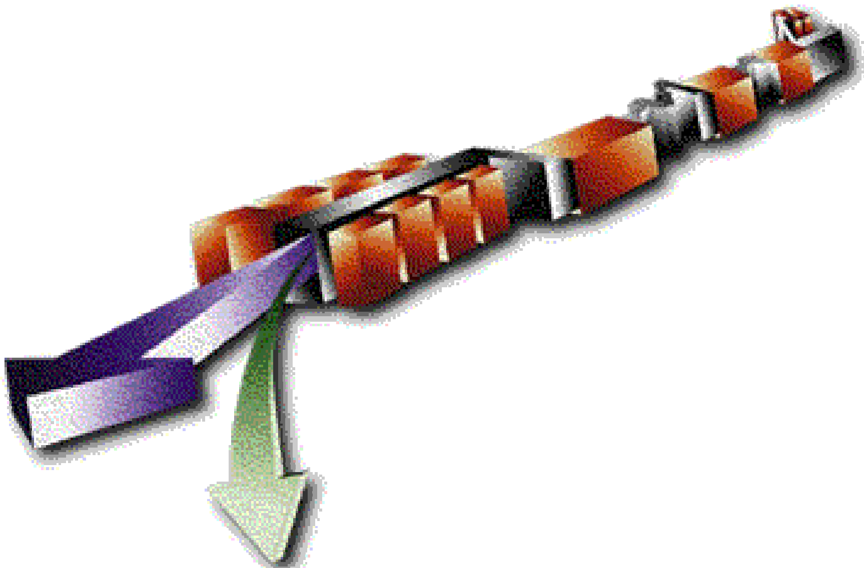
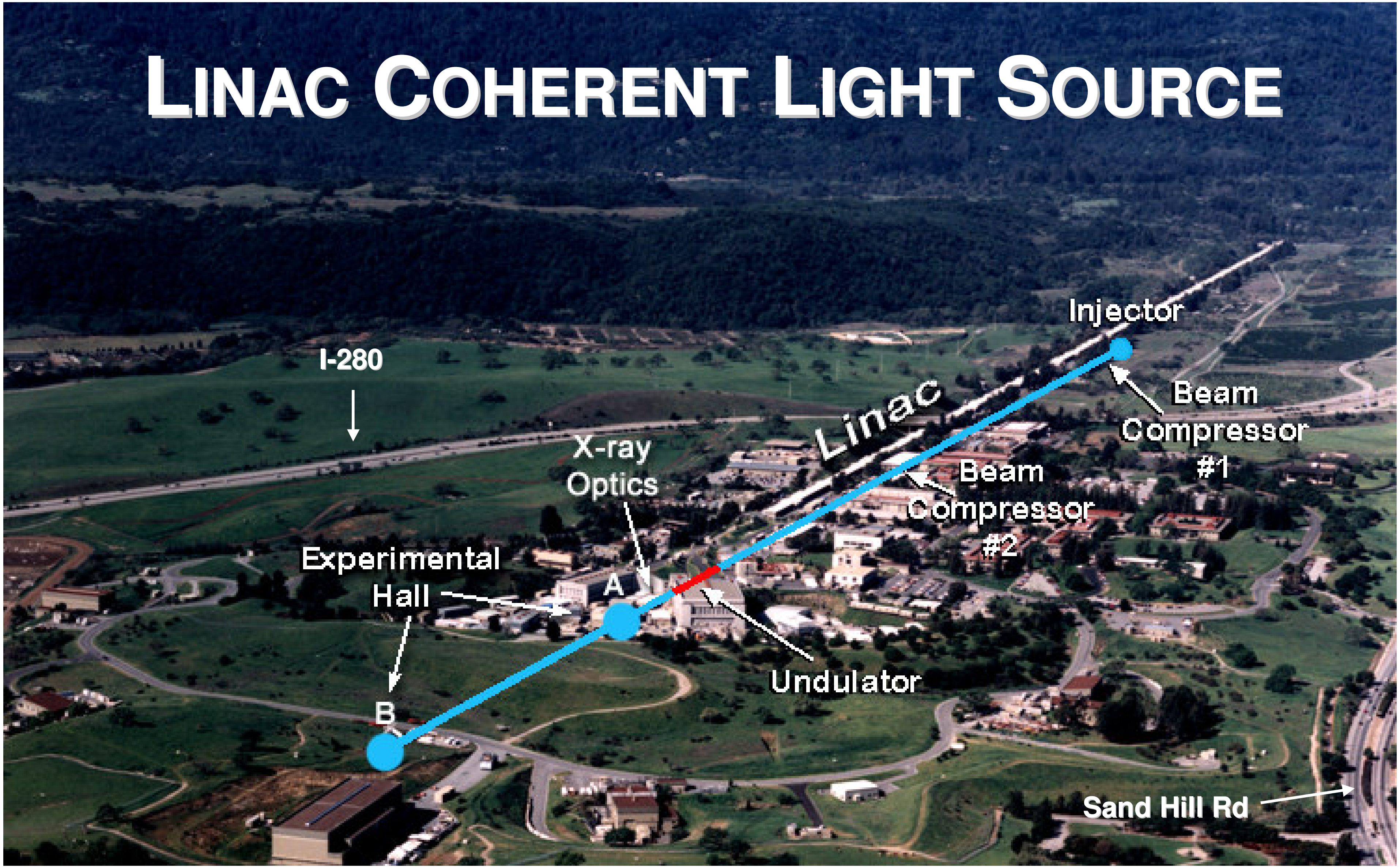
Linac Coherent Light Source Update

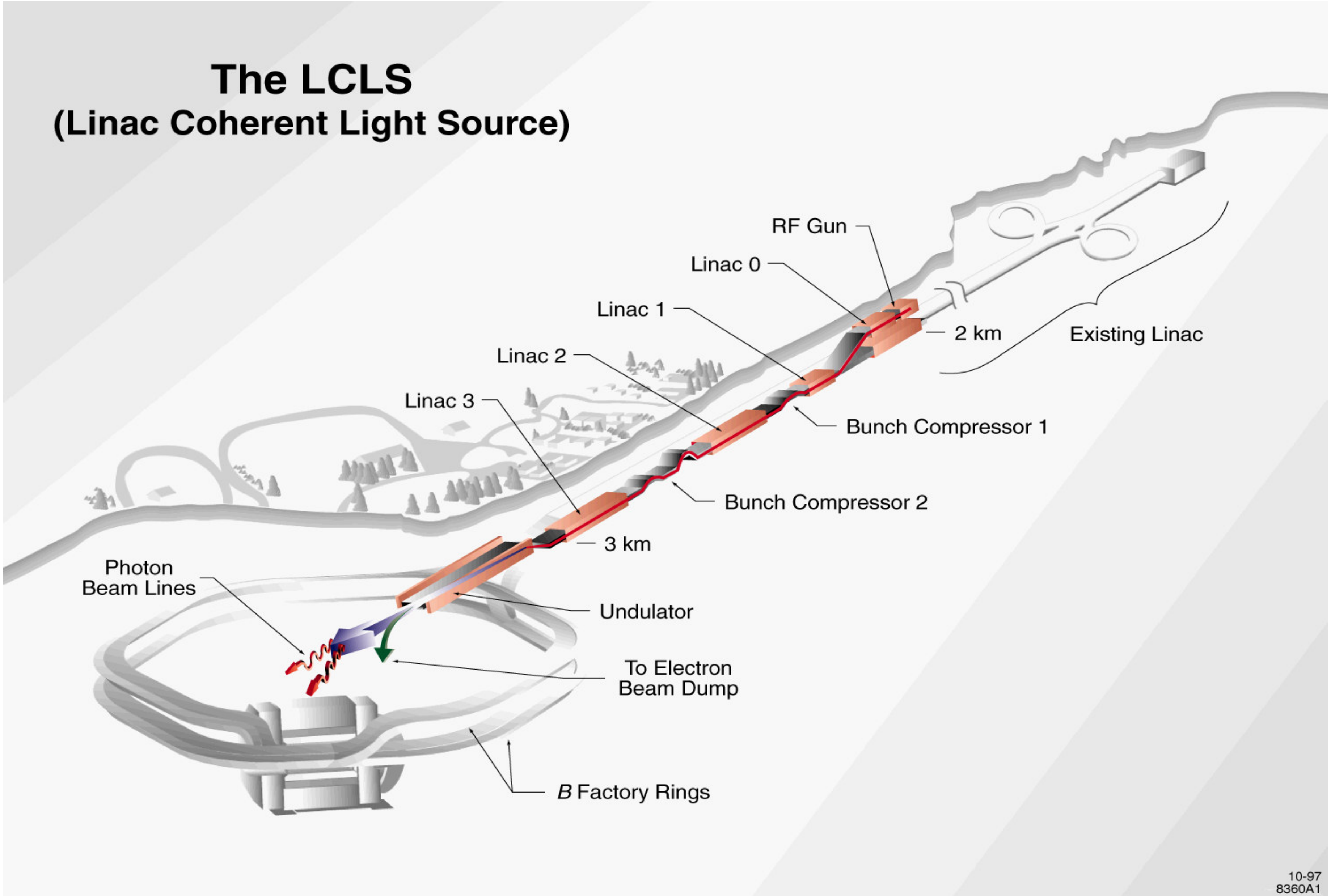


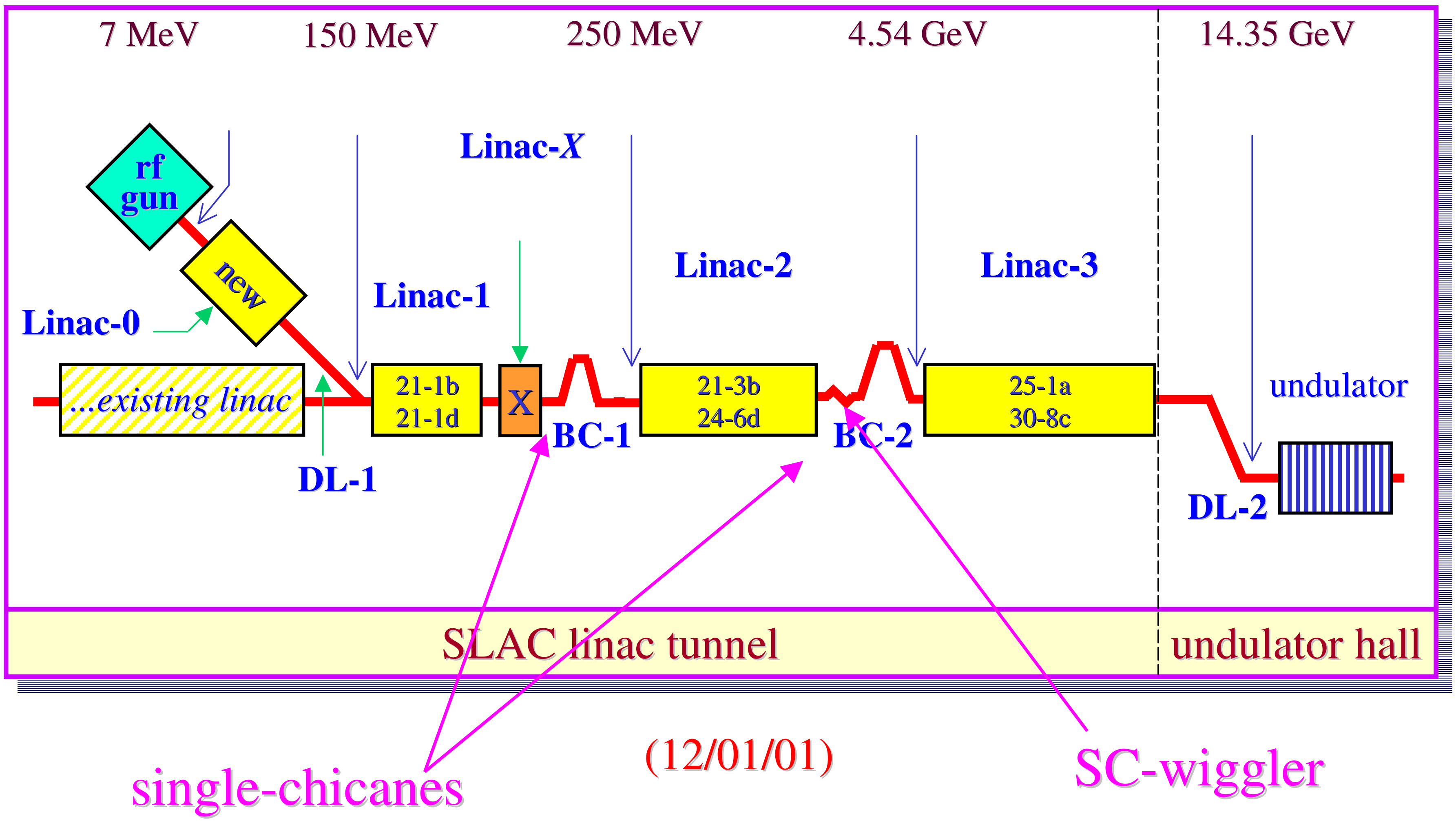
John N. Galayda
LCLS Project Director

Coherent Synchrotron Radiation Workshop
14 January 2002


LINAC COHERENT LIGHT SOURCE
Injector
I-280
Beam
Compressor
#1
Linac
X-ray
Optics
Beam
Compressor
#2
Experimental
Hall
A
B
Undulator
Sand Hill Rd

Conceptual View of LCLS at SLAC




7 MeV
150 MeV
250 MeV
4.54 GeV
14.35 GeV
rf gun
new
Linac-0
Linac-1
Linac-X
Linac-2
Linac-3
...existing linac
21-1b
21-1d
X
21-3b
24-6d
25-1a
30-8c
DL-1
BC-1
BC-2
DL-2
undulator
SLAC linac tunnel
undulator hall
(12/01/01)
single-chicanes
SC-wiggler

Parameters & Performance

FEL Radiation Wavelength	1.5	0.15	nm
Electron Beam Energy	4.54	14.35	GeV
Repetition Rate (1-bunch)	120	120	Hz
Single Bunch Charge	1	1	nC
Normalized rms Emittance	2.0	1.5	mm-mrad
Peak Current	3.4	3.4	kA
Coherent rms Energy Spread	<2	<1	10^{-3}
Incoherent rms Energy Spread	<0.6	<0.2	10^{-3}
Undulator Length	100	100	m
Peak Coherent Power	11	9.3	GW
Peak Spontaneous Power	8.1	81	GW
Peak Brightness *	1.2	12	10^{32}
Bunch Length	230	230	fsec

* photons/sec/mm^2/mrad^2/0.1%-BW

Stanford Linear Accelerator Center

Los Alamos
science serving society

SSRL

LCLS R&D is a collaboration of…

nsls
IR UV X

UCLA

Advanced Photon Source

R&D Progress – Gun

Excellent interaction between simulation effort and experiment

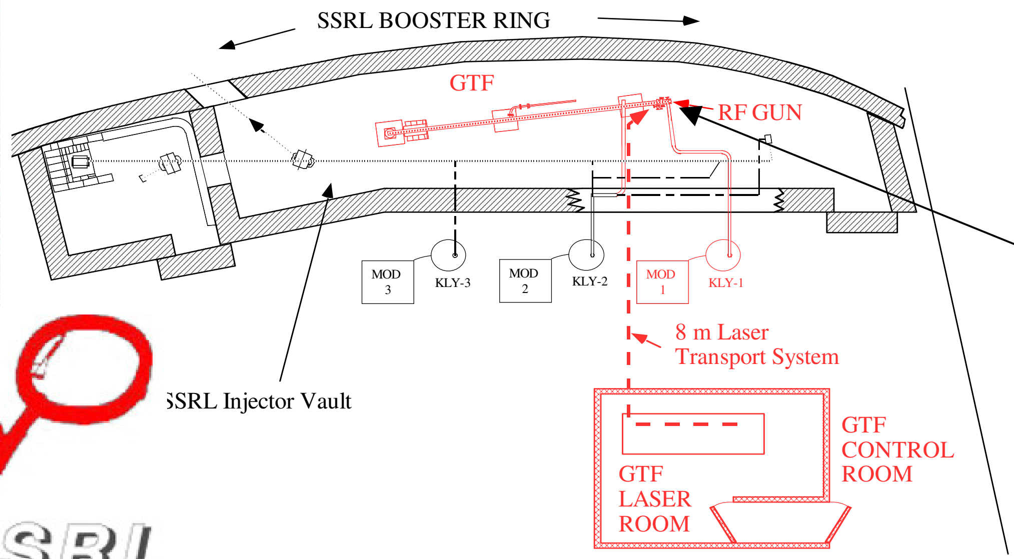
Excellent interaction between SSRL and TD

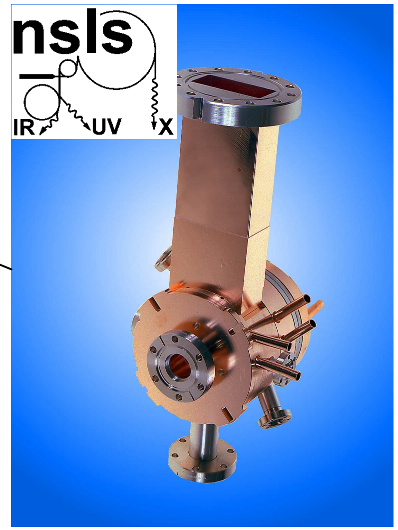
Computer simulations: Cecile Limborg; SSRL

E. Colby, V. Ivanov, P. Krejcik; TD

Gun Test Facility program: Jim Clendenin TD, John Schmerge SSRL,

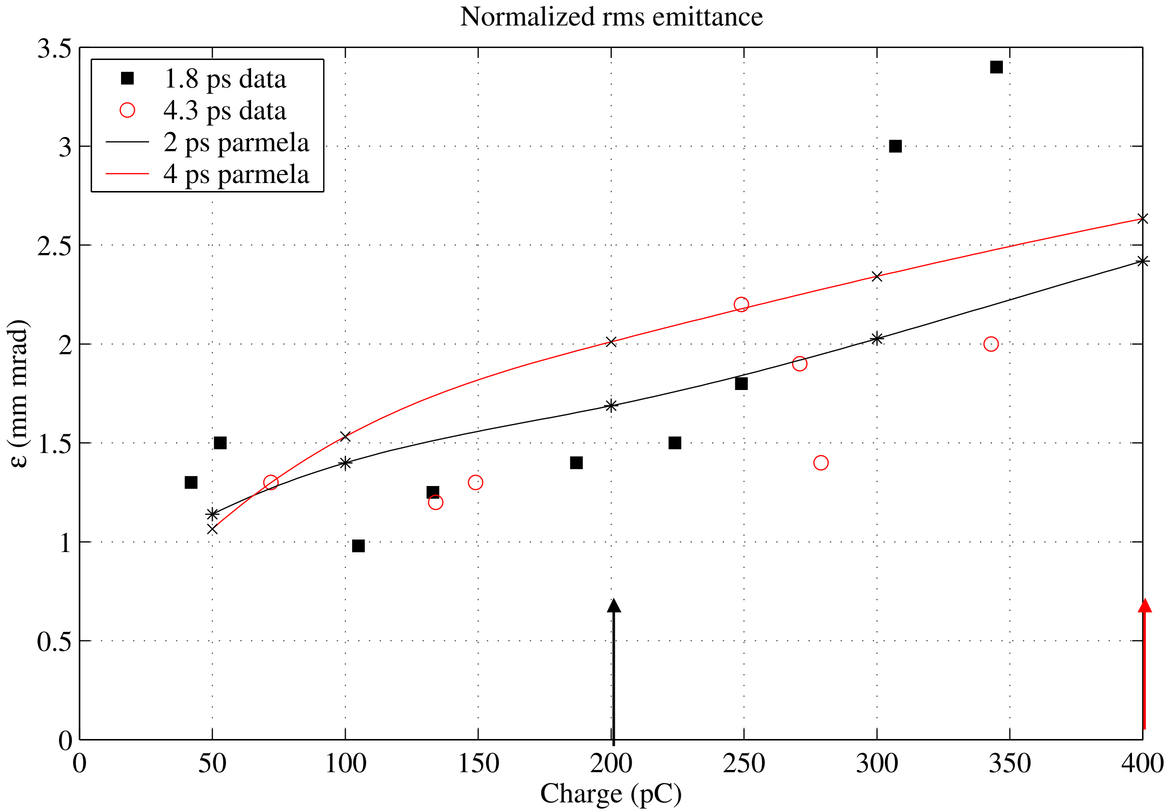
Paul Bolton, Steve Gierman, Brendan Murphy; TD





Simulations for GTF

Comparison to experimental results: ε vs. Q for 2ps-4ps pulses



Parameters

110MV/m

ϕ_{gun} = 40°

r = 1mm

$B_{solenoid}$ = 2kG

Linac 8.55 MV/m at 90 cm

- PARMELA computer code comparison to data
- Agreement is reasonable at target current of 100A
- SLAC is upgrading GTF to cover wider parameter range

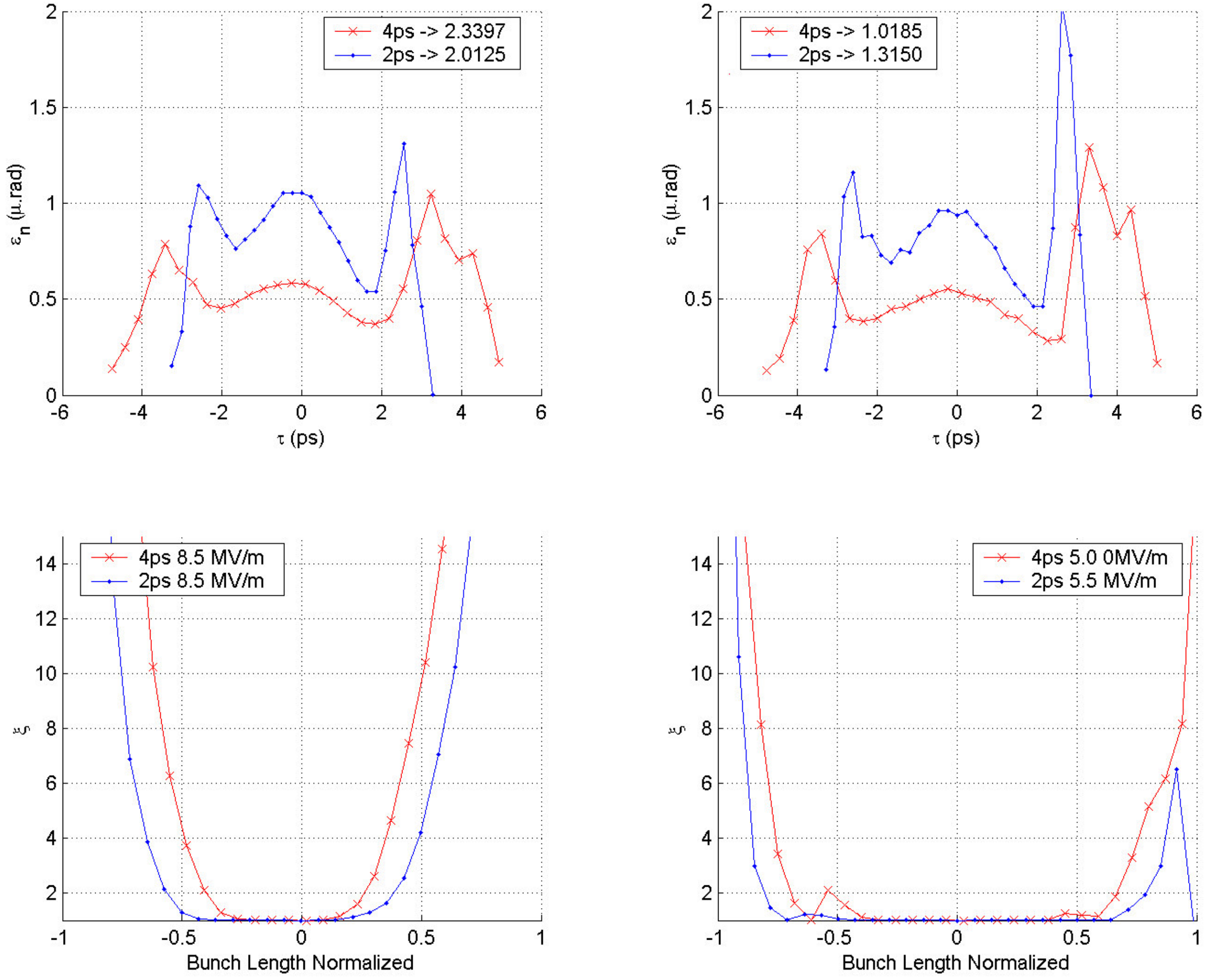
Why 2ps is lower than 4ps:

- 4ps core emittance lower than 2ps
- Matching of slices better for 2ps at standard booster gradient
- Matching is improved with lower gradient for both 4ps and 2ps
- With better matching

$\varepsilon_{4ps} < \varepsilon_{2ps}$

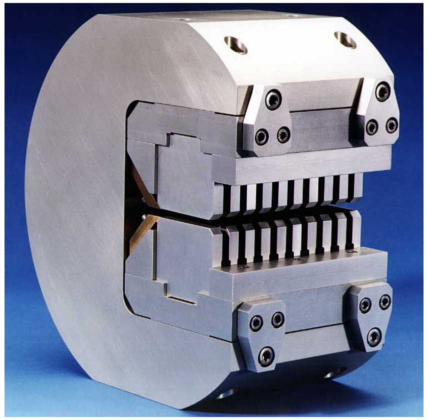
Mismatch parameter

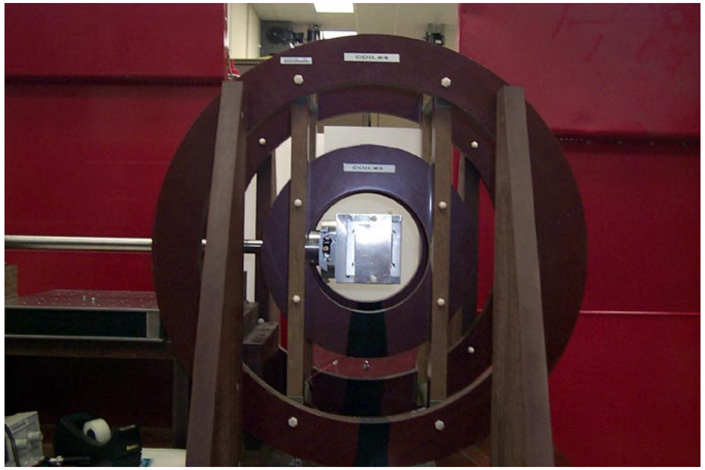
$$\xi = \frac{1}{2}(\gamma_o\beta - 2\alpha\alpha_o + \beta_o\gamma)$$



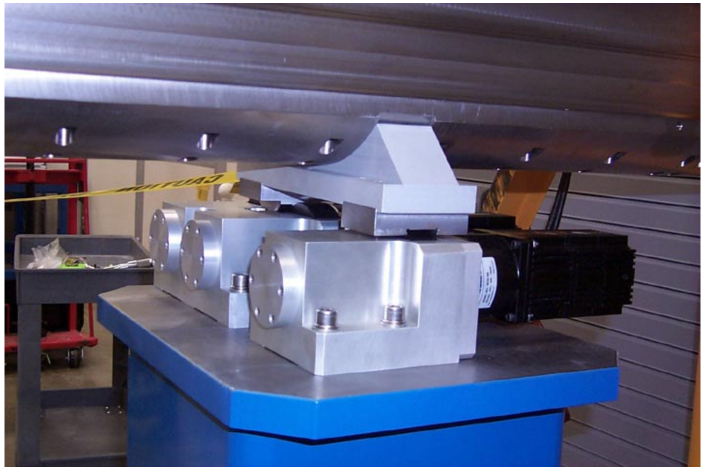
R&D Progress – Prototype Undulator

- Titanium strongback mounted in eccentric cam movers
- Magnet material 100% delivered
- Poles >90% delivered
- Assembly underway

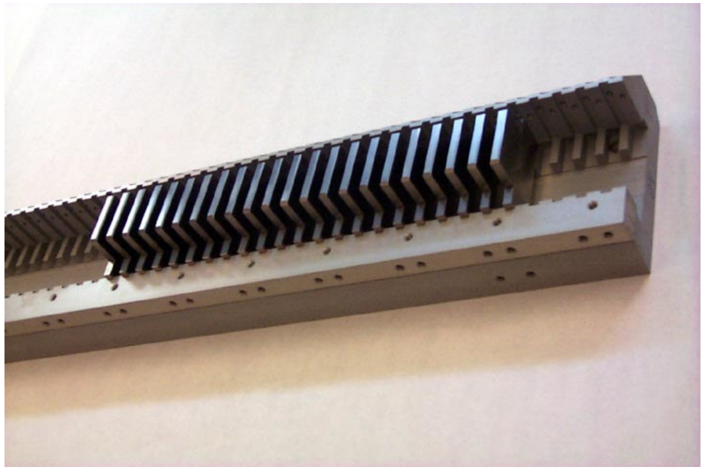




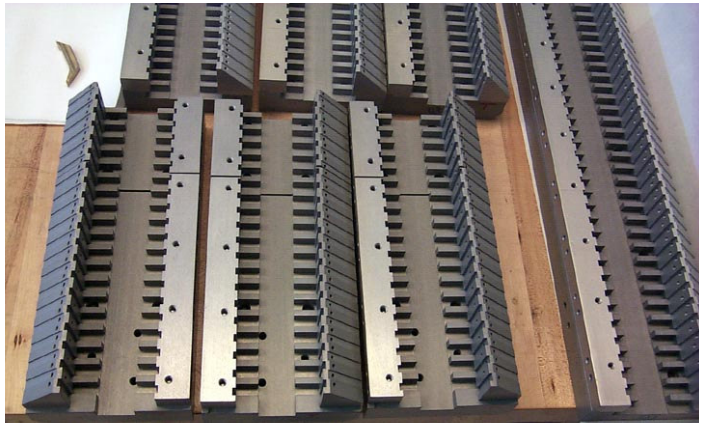
Helmholtz Coil – magnet block measurement



Translation stages for undulator segment

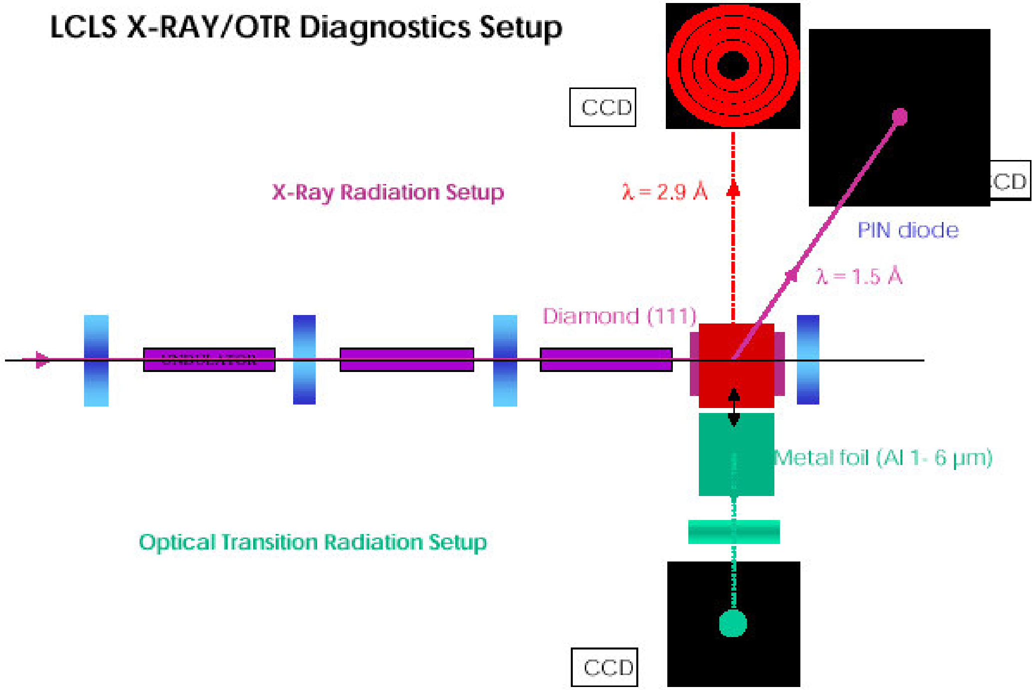


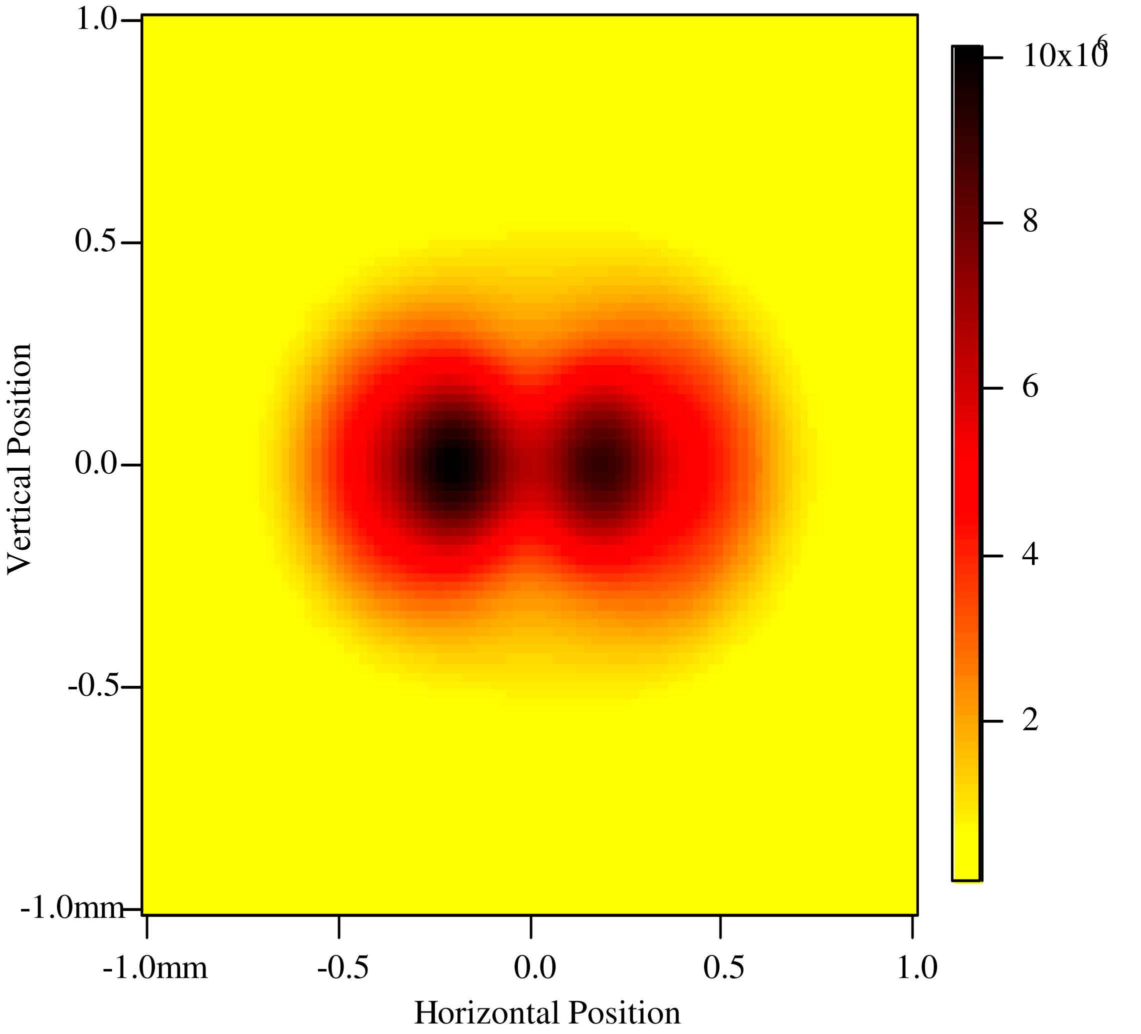
Poletip alignment fixture



Magnet block clamping fixtures

Planned beam diagnostics in undulator include pop-in C(111) screen
To extract and observe x-ray beam, and its superposition on e-beam

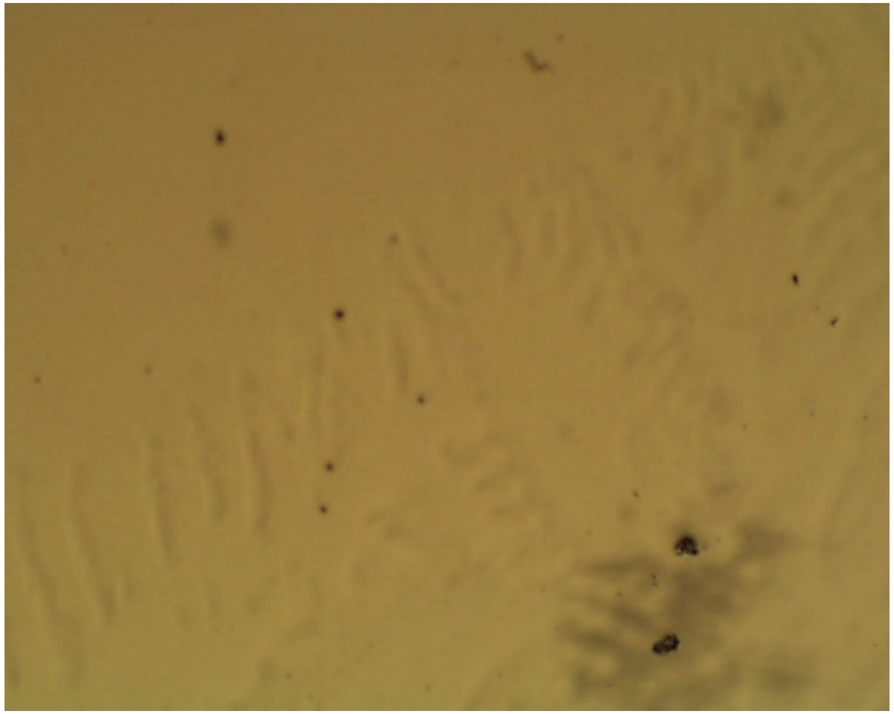




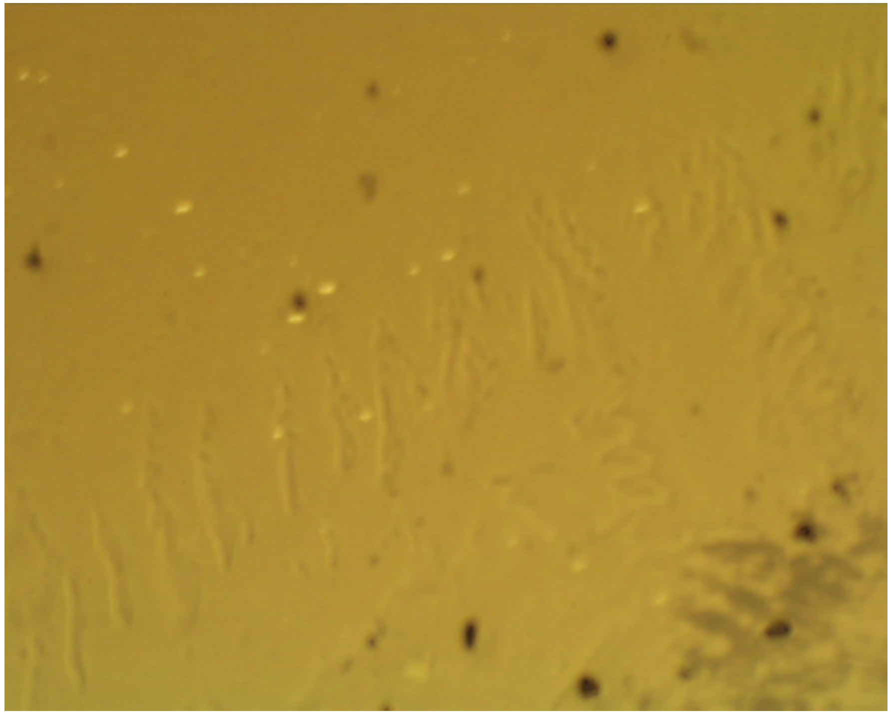
Calculated spatial distribution of the undulator radiation from a three-undulator cell with a missteering q_{mis} = 4 μrad, an electron beam emittance of 0.05 nm·rad, and a photon energy of 8.29 keV, at 60 m from the undulators.

R&D Progress – Undulator diagnostics

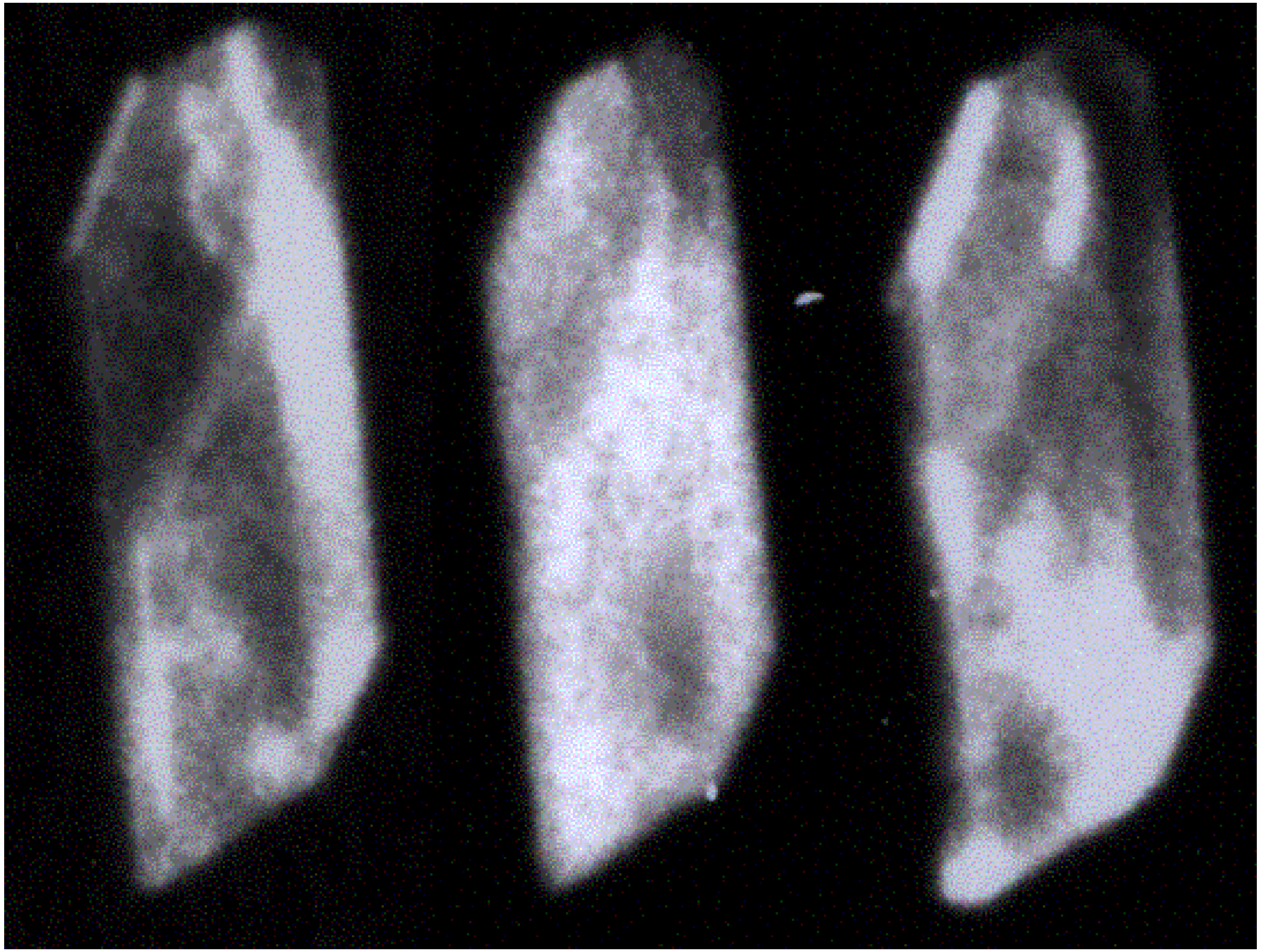
- P. Krejcik, W. K. Lee, E. Gluskin
- Exposure of diamond wafer to electron beam in FFTB-
- Same electric fields as in LCLS
- No mechanical damage to diamond
- Tests of crystal structure completed, crystal structure intact



Before



After



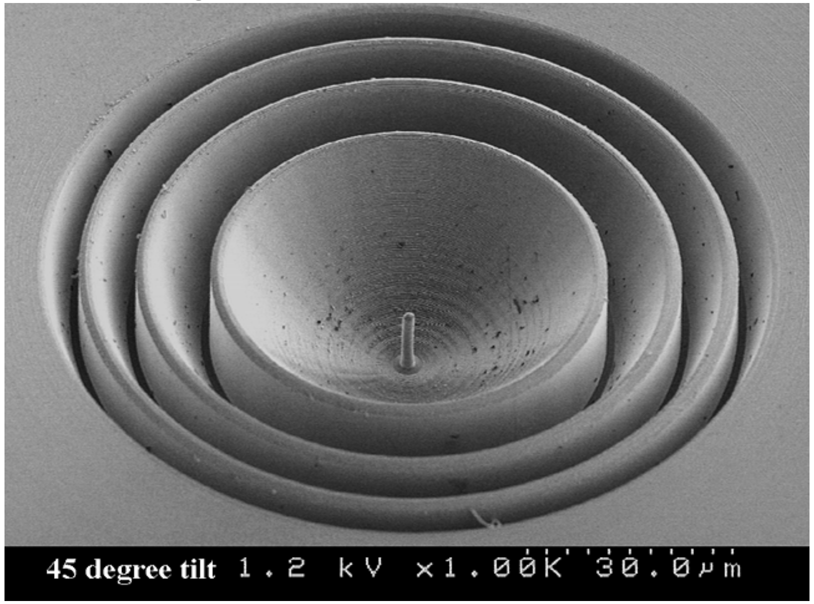
X-ray reflectivity shows no damage from exposure to electron beam

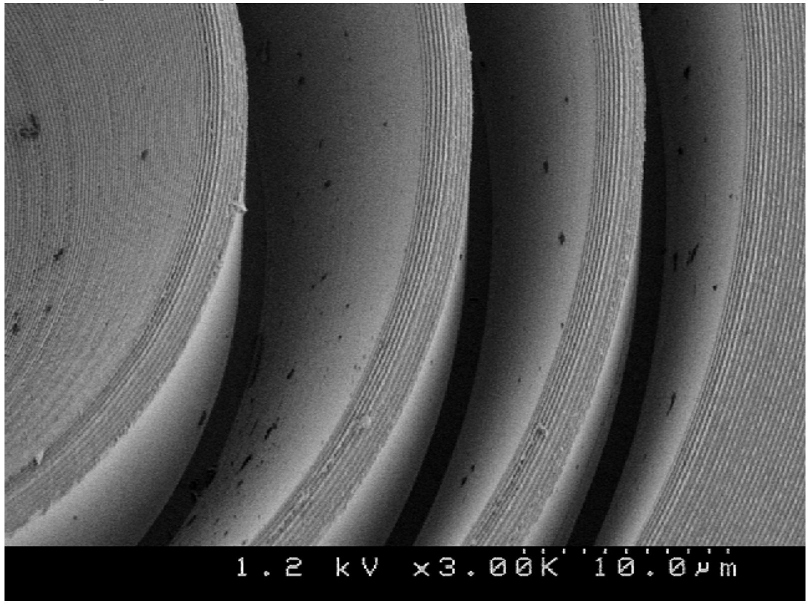
R&D Progress – X-ray optics

- LLNL tests of damage to silicon crystal
  - Exposure to high- power laser with similar energy deposition
  - Threshold for melting 0.16 J/cm^2, as predicted in model

- Fabrication/test of refractive Fresnel lens
  - Made of aluminum instead of carbon
  - Machined with a diamond point
  - Measurements from SPEAR presently under analysis

- Significant effort to estimate costs of experiments!





Two-Stage Chirped-Beam SASE-FEL for High Power Femtosecond X-Ray Pulse Generation

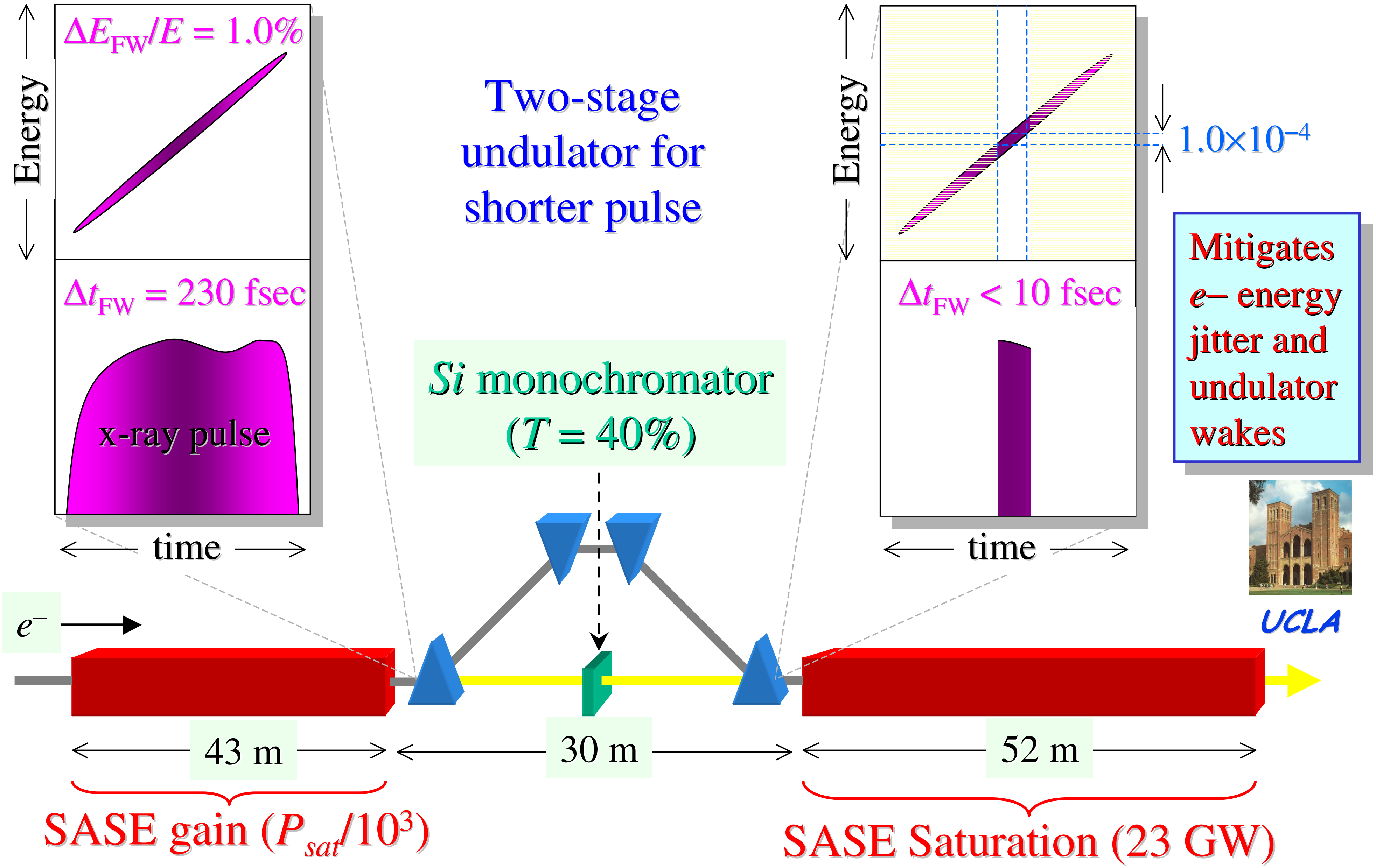
C. Schroeder*, J. Arthur^, P. Emma^, S. Reiche*, and C. Pellegrini*

^ Stanford Linear Accelerator Center
*UCLA

Strong possibility for shorter-pulse operation

UCLA

LCLS



Also a ***DESY*** scheme which emphasizes line-width reduction (B. Faatz)