



ULTRAFAST  STANFORD



Electrooptical Longitudinal Bunch Length Measurements

David A. Reis

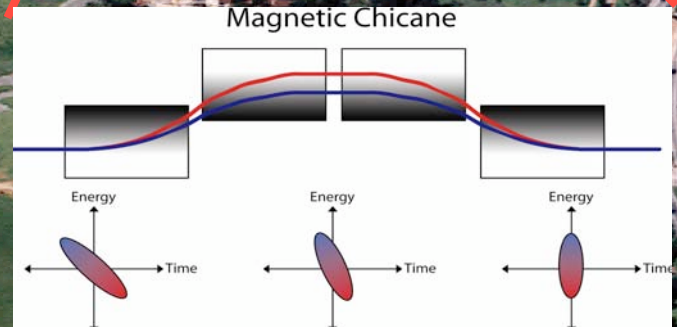
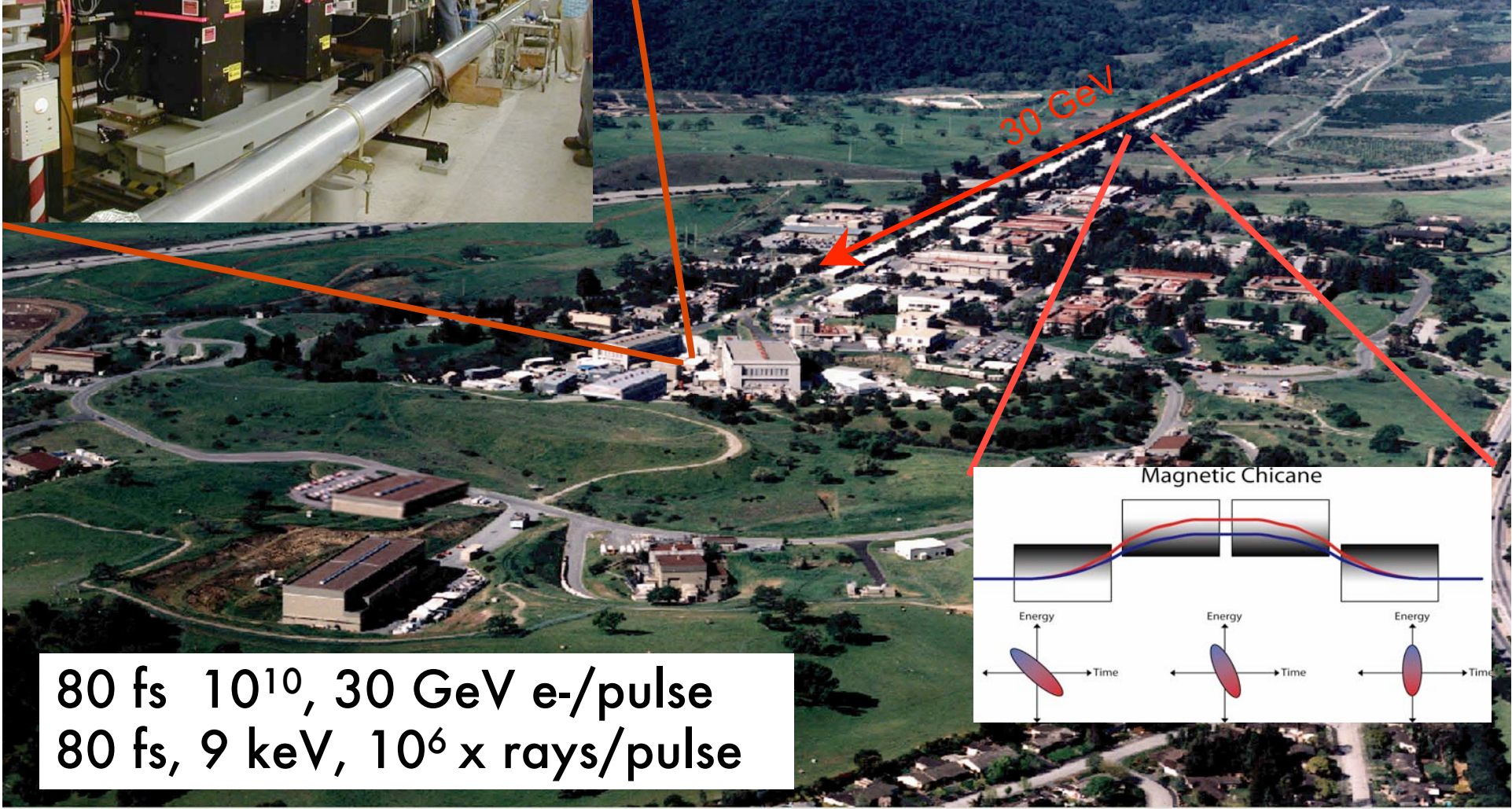
FOCUS Center and University of Michigan

Stanford PULSE Center

SNIC/International Symposium Detector Development April 3-6, 2006. Stanford Linear Accelerator Center

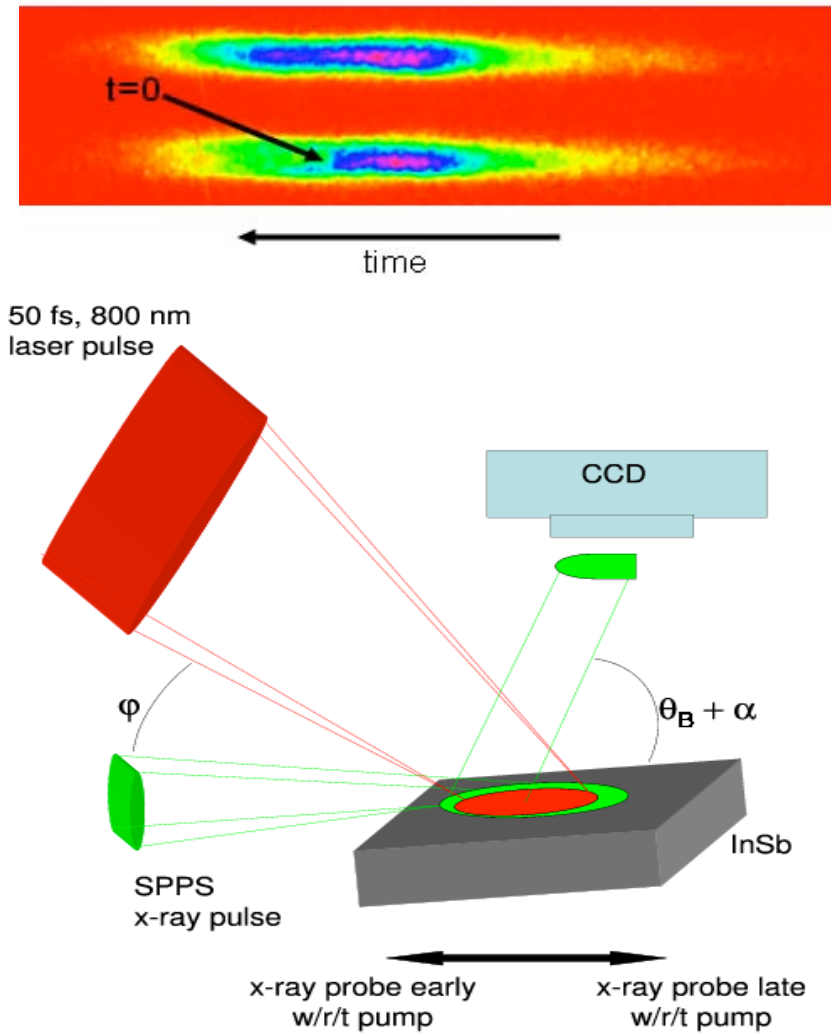
LINAC-based X-ray Source (SPPS)2003-2006

Ultrafast x-ray science and LCLS R&D

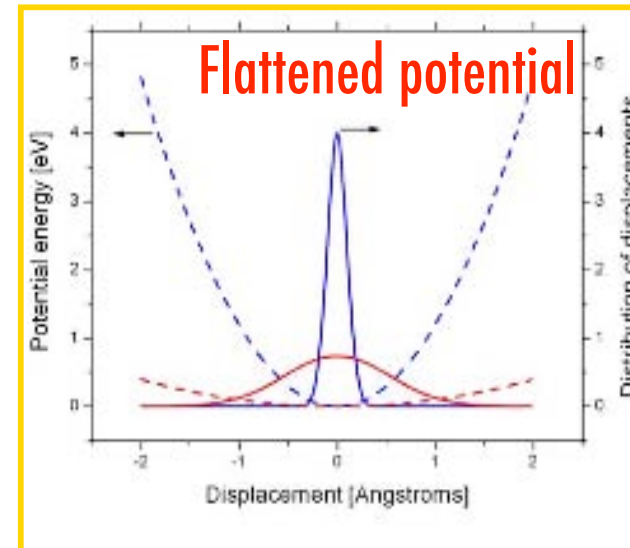
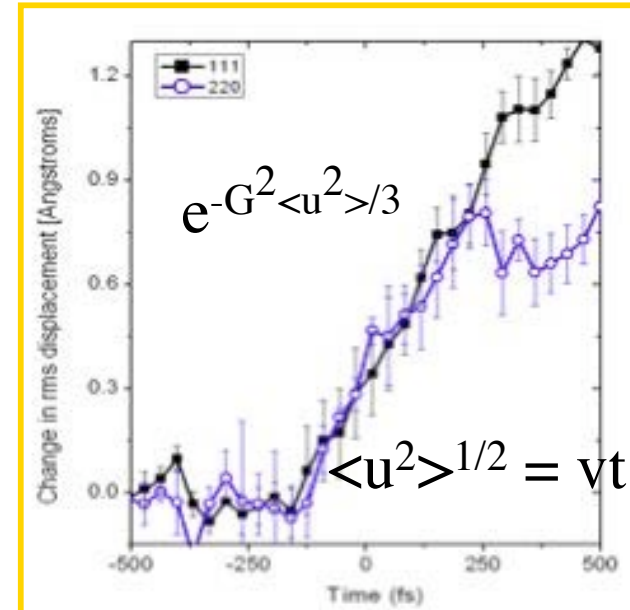


80 fs 10^{10} , 30 GeV e-/pulse
80 fs, 9 keV, 10^6 x rays/pulse

Single Shot X-ray Studies of Ultrafast Disordering In Solids

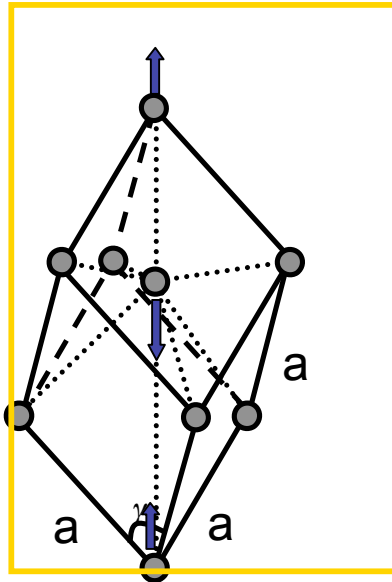


A. Lindenberg *et al.*, Science 308, 2005
 K. Gaffney *et al.*, PRL 95, 2005.

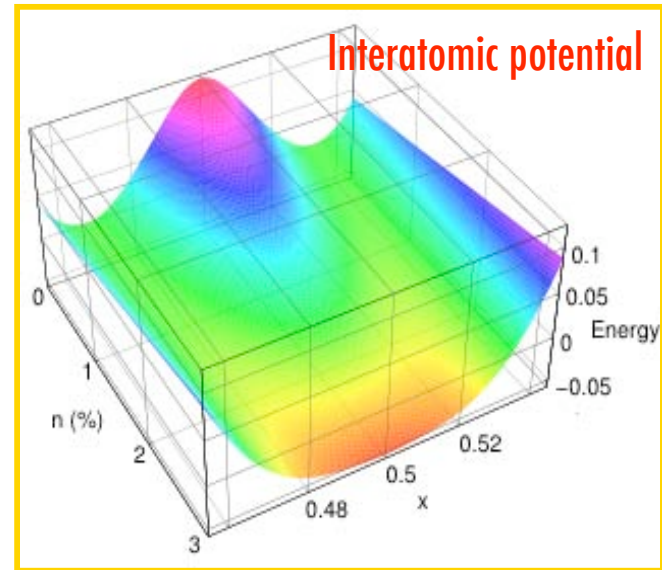


High amplitude atomic motion in photoexcited bismuth

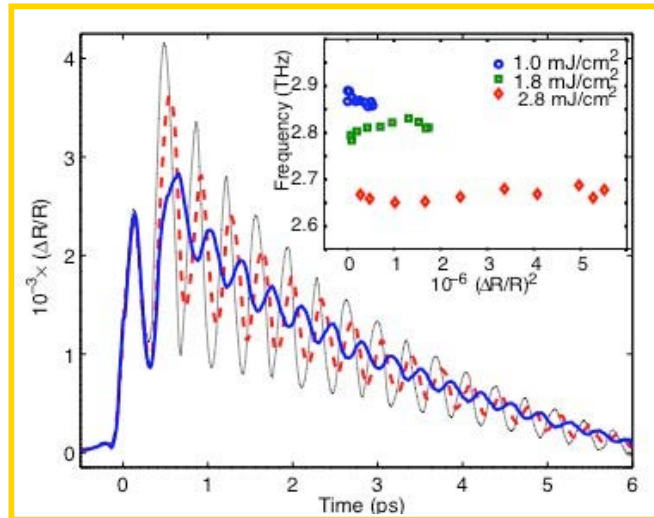
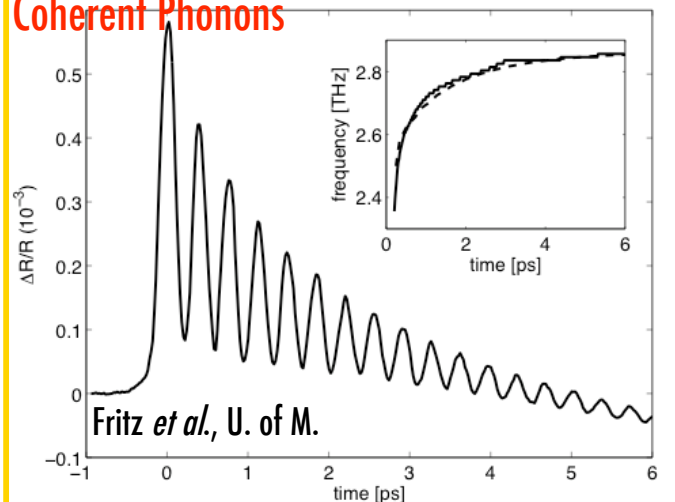
Bi structure



Interatomic potential

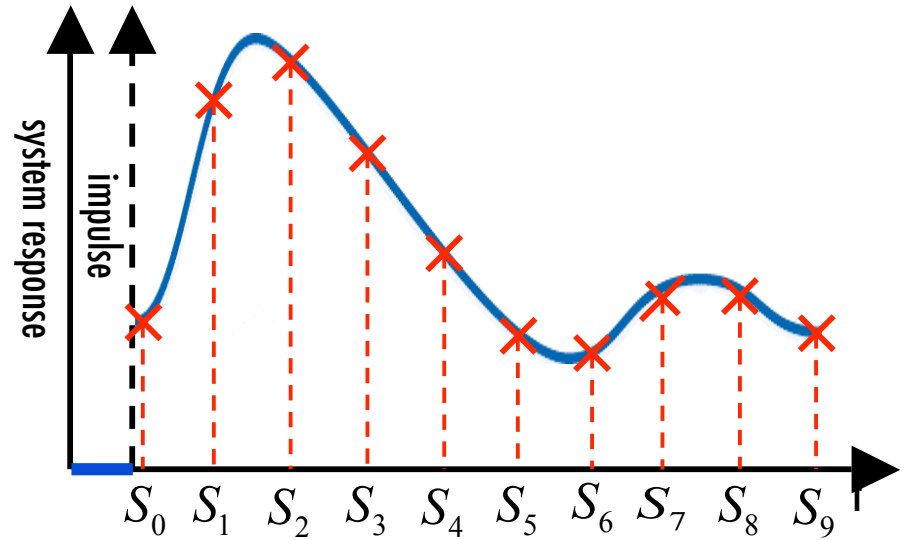
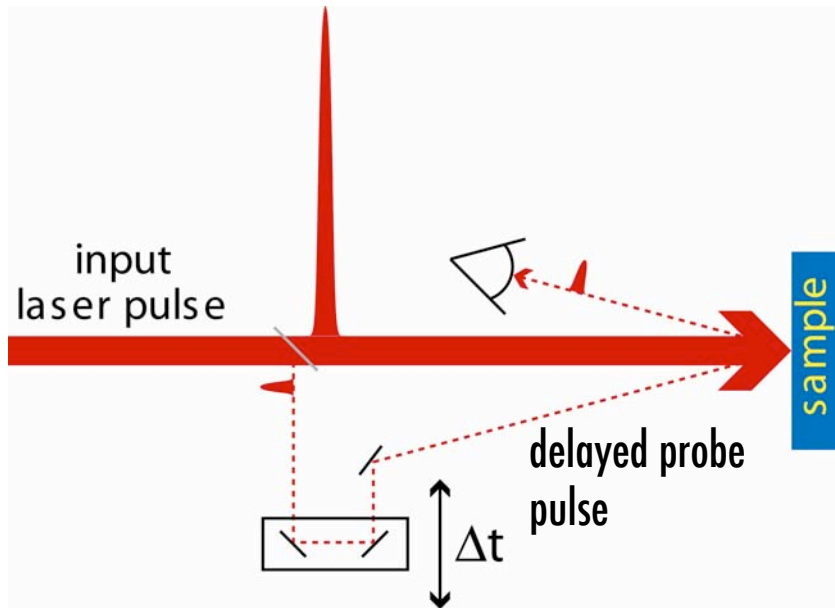


Coherent Phonons

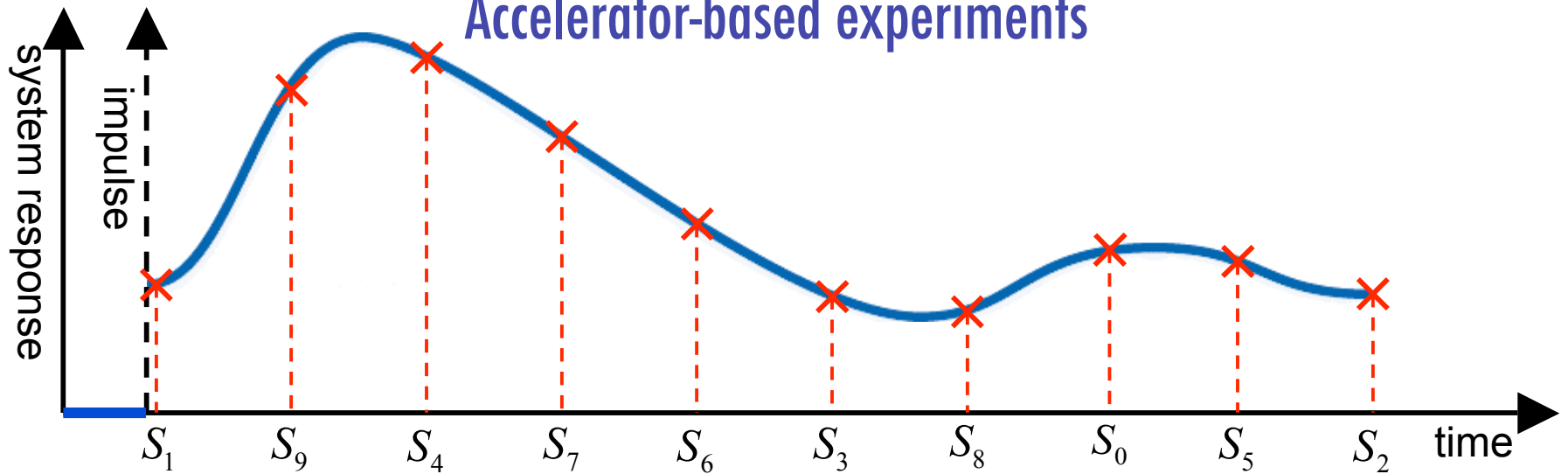


anharmonicity or electronic softening? (Fahy and Reis PRL 93 109701, 2004)
Murray *et al.* PRB 72, 060301 (R) 2005.

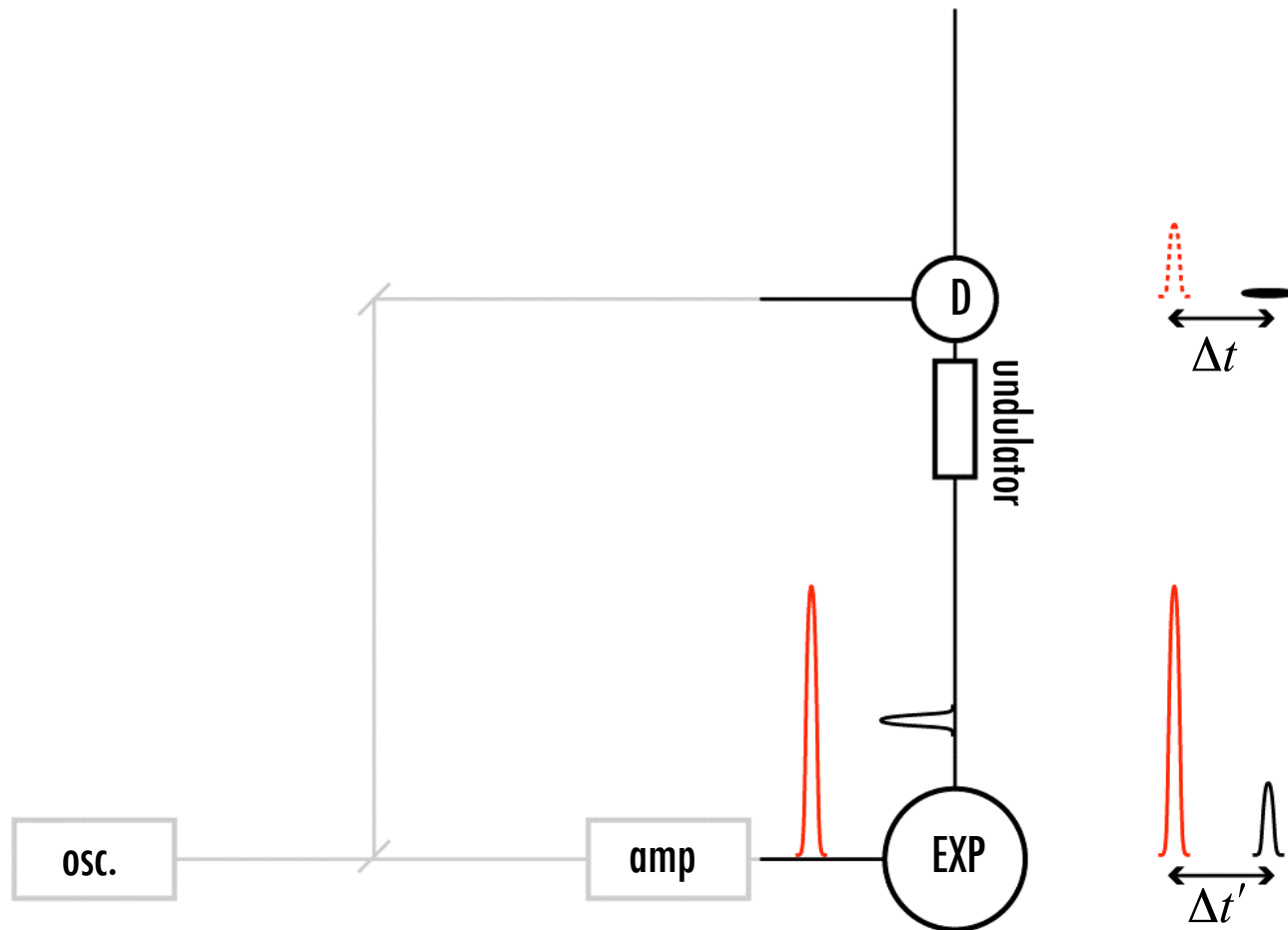
Standard Pump-probe experiments



Accelerator-based experiments



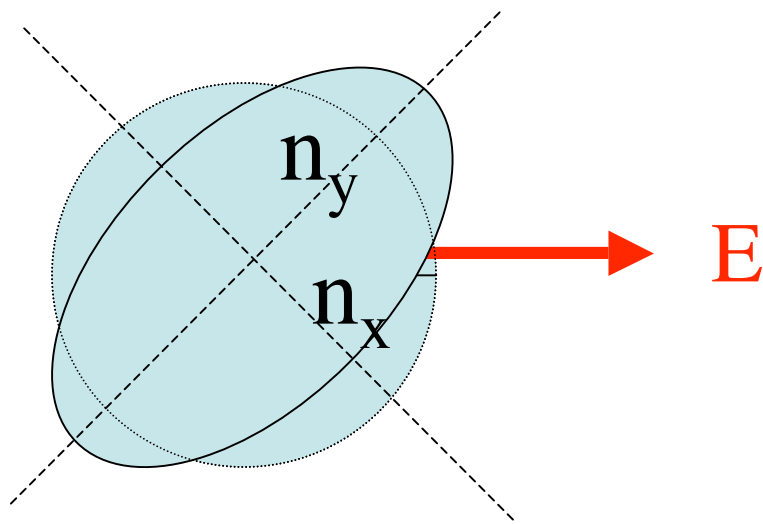
Indirect X-ray Pulse Arrival Time



S. H. Lee *et al.* Opt. Lett., 29(22):2602-2604, 2004

A. Cavalieri *et al.*, Phys. Rev. Lett. 94 144801, 2005

Pockels' effect (linear electrooptic)



$\bar{4}3m$, with E perpendicular to (110)

$$x' = [1/2, -1/2, 1/\sqrt{2}]$$

$$y' = [1/2, -1/2, -1/\sqrt{2}]$$

$$n'_x = n_0 - \frac{1}{2}r_{41}n_0^3E$$

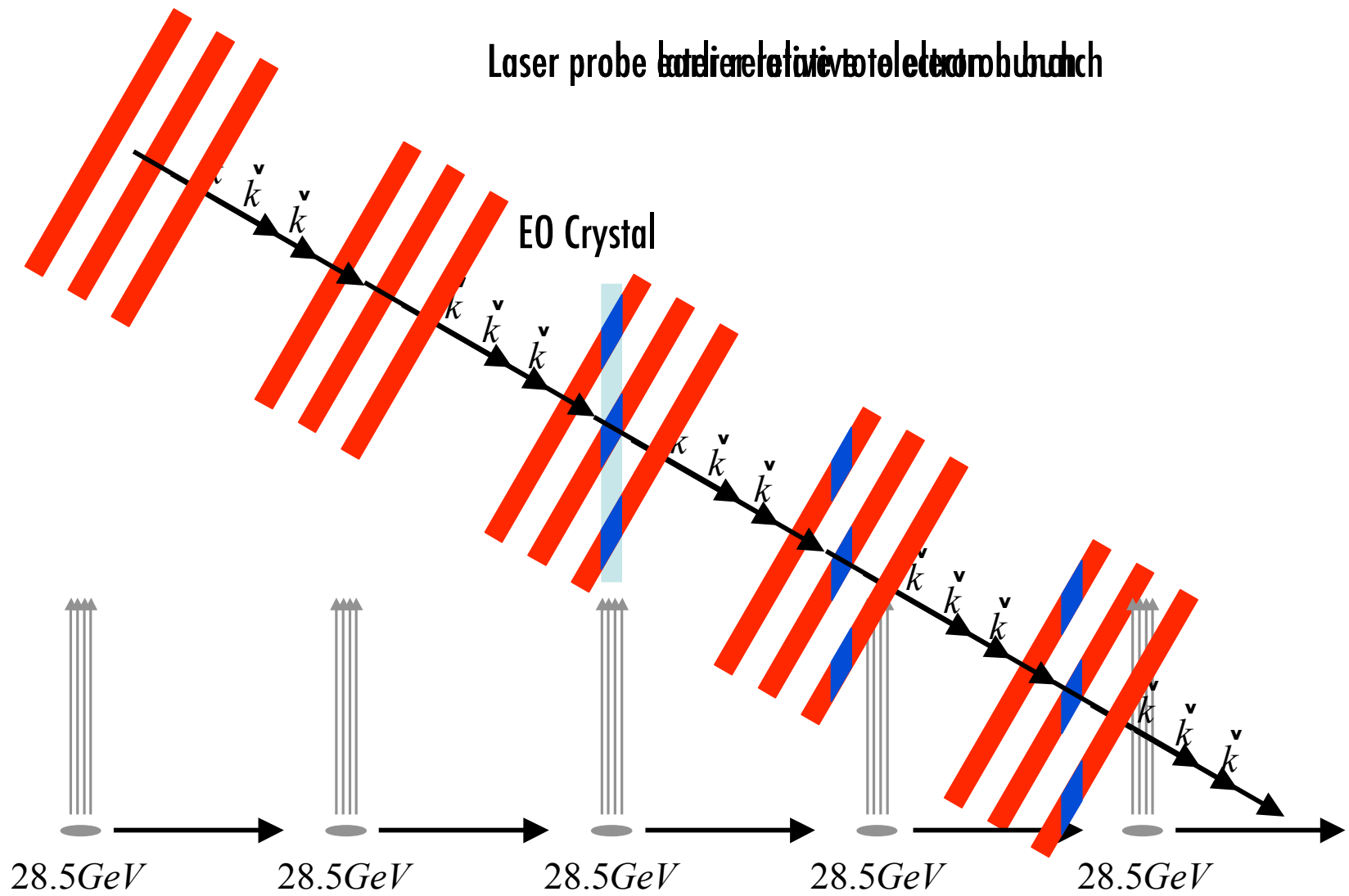
$$n'_y = n_0 + \frac{1}{2}r_{41}n_0^3E$$

Retardation:

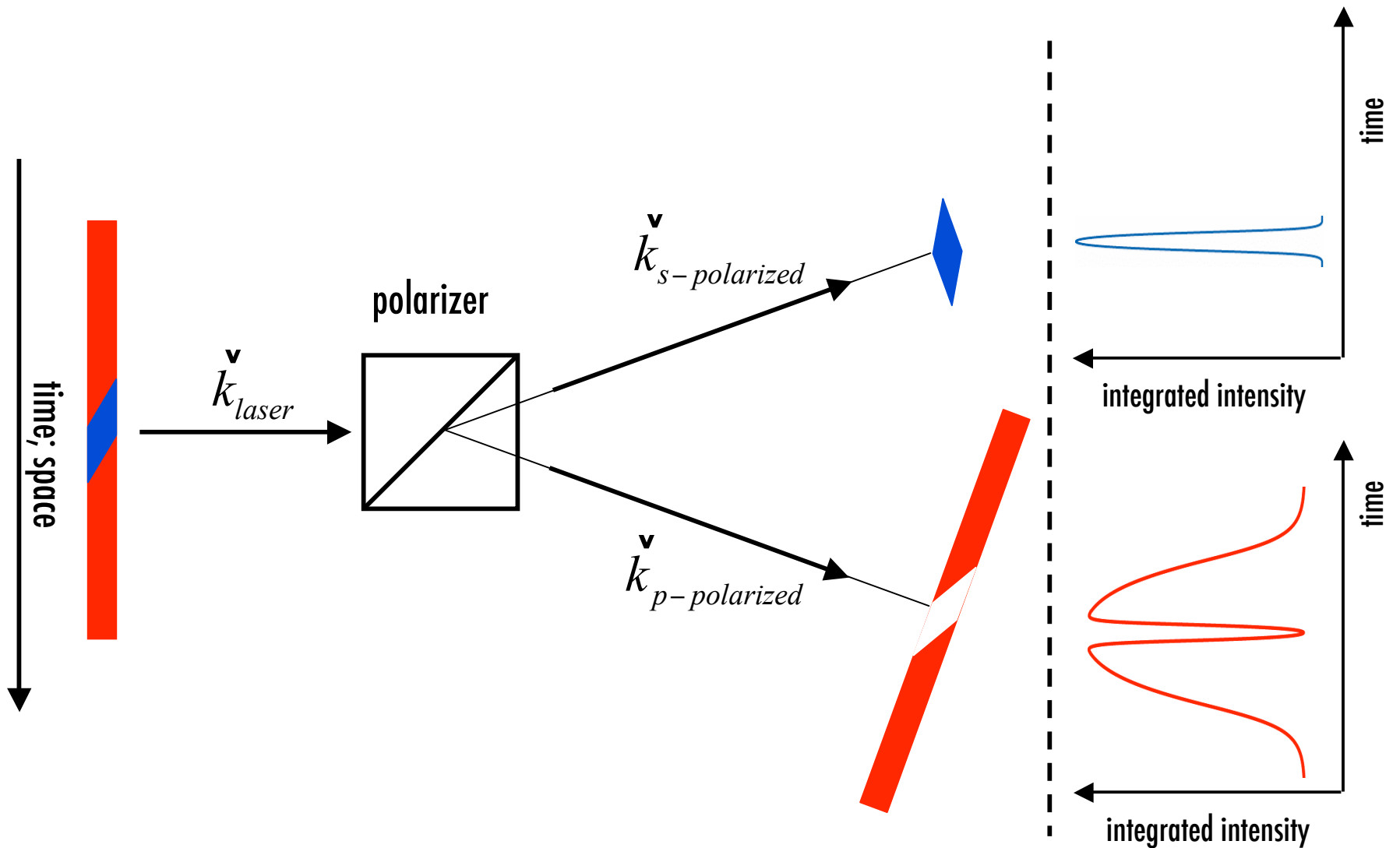
$$\Gamma = \frac{2\pi}{\lambda}r_{41}n_0^3EL$$

$$n \sim 3, r_{41} \sim 4 \text{ pm/V}$$

Spatially Resolved Electro-Optic Sampling (EOS)



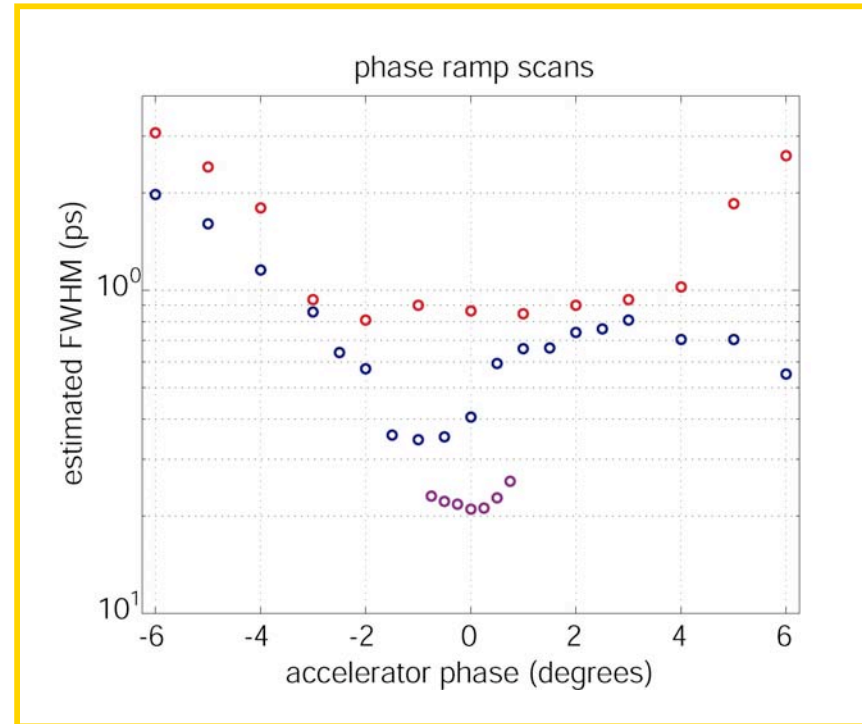
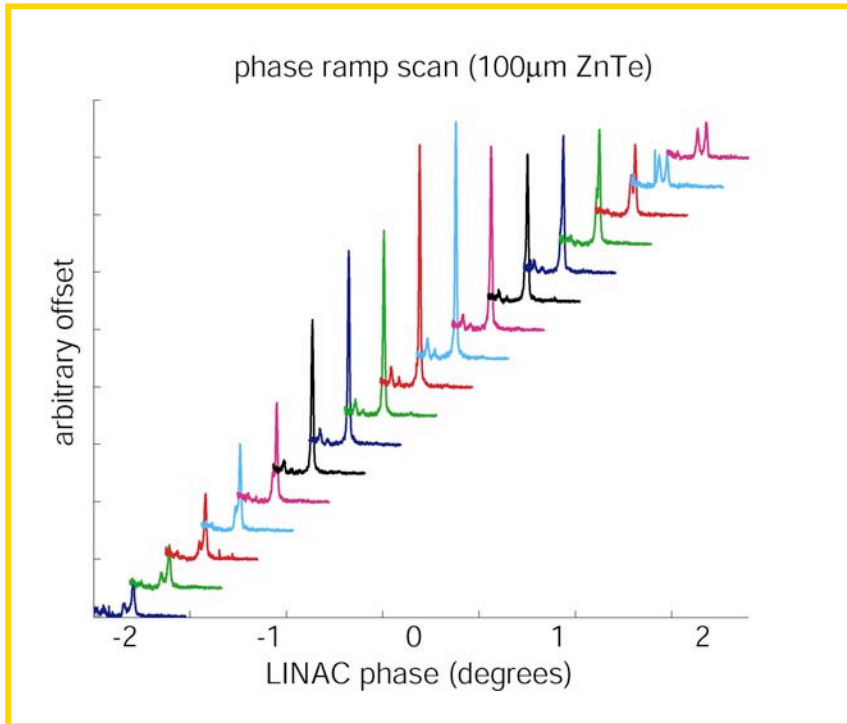
Arrival time and duration of bunch is encoded on profile of laser beam



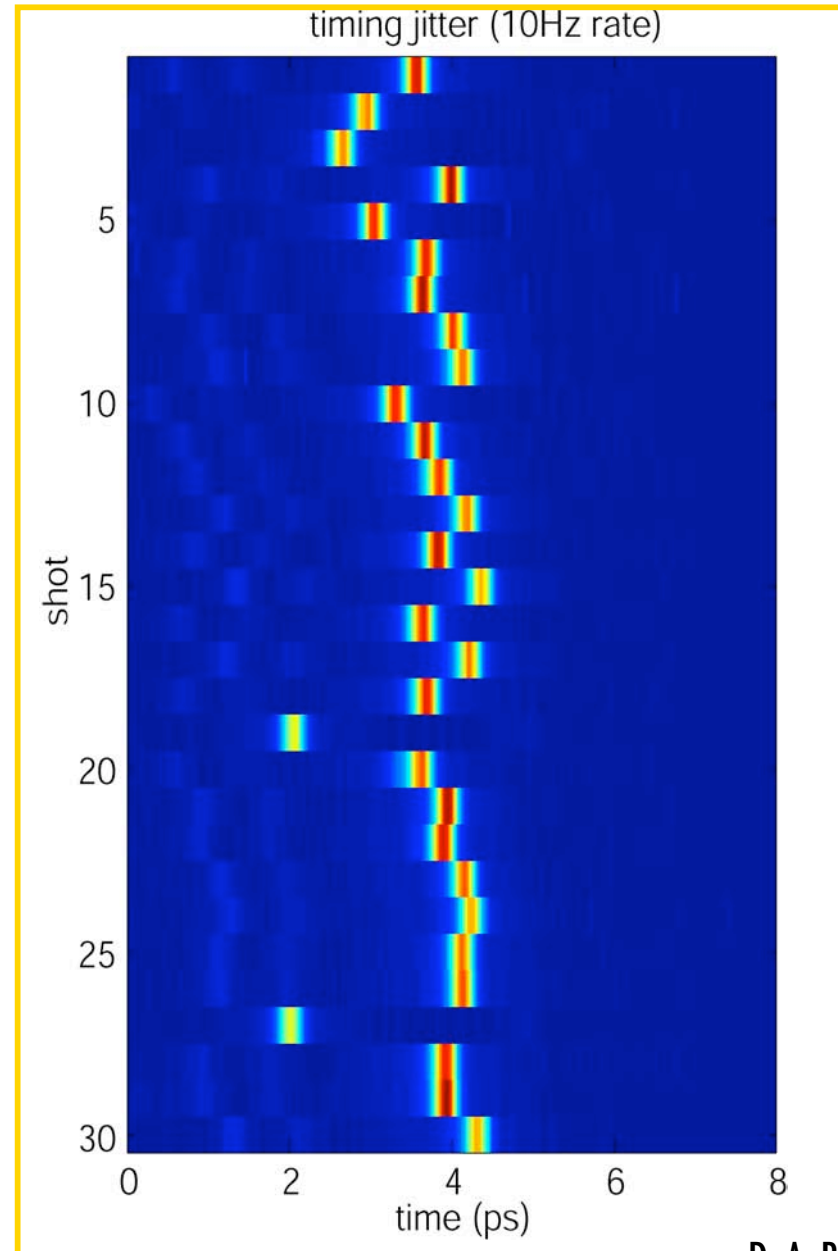
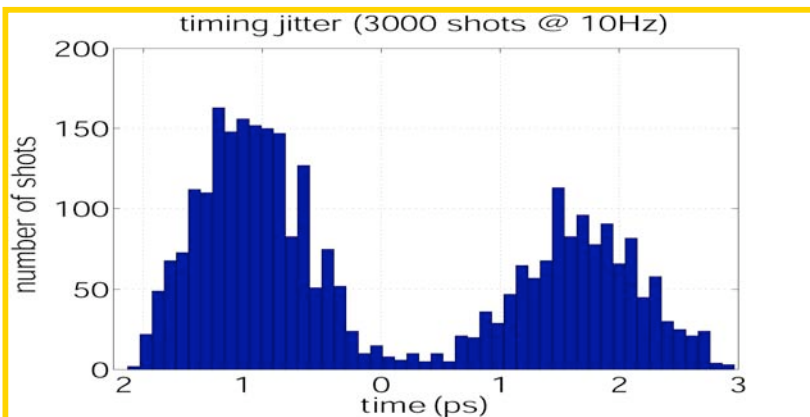
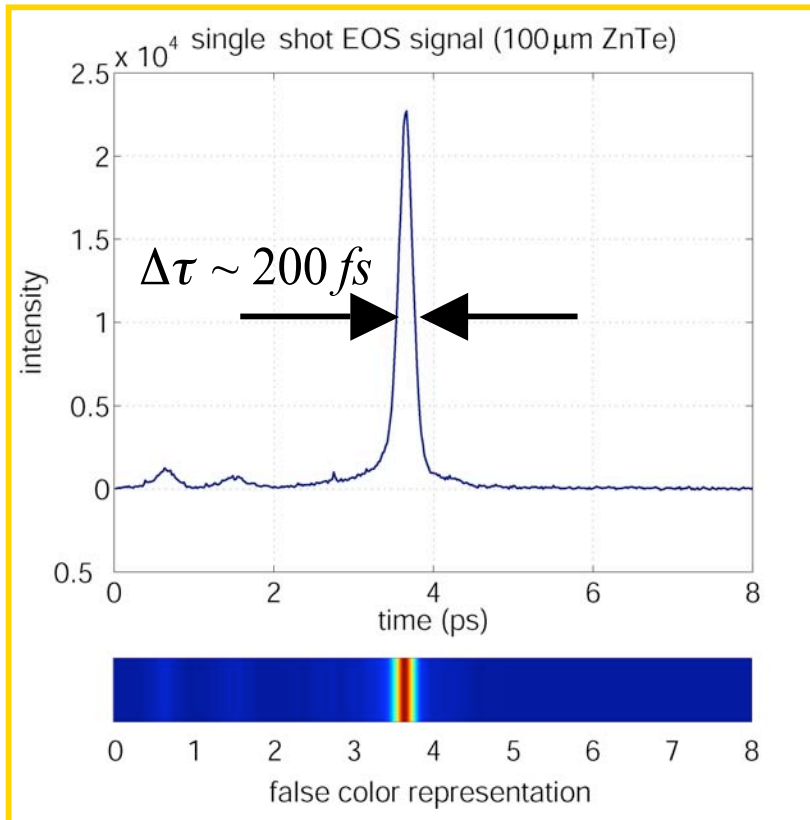
Considerations and limitations

- Phase matching (group velocity mismatch THz and optical)
- dispersion in index and pockels' coefficient.
- Interference between electronic and ionic susceptibility
- Phonon resonances
- Fabry-perot effects ("echos")
- Angular dependence.
- Laser pulse duration and bandwidth
- Complex field profile radiated from e-beam
(transition-, diffraction- and Cherenkov radiation, cavity modes of beam pipe....)

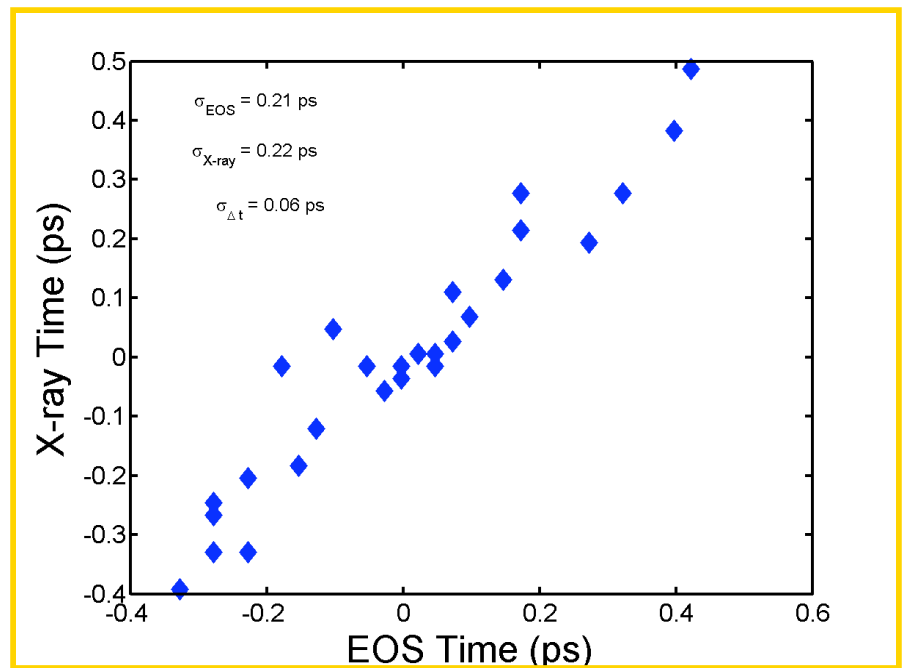
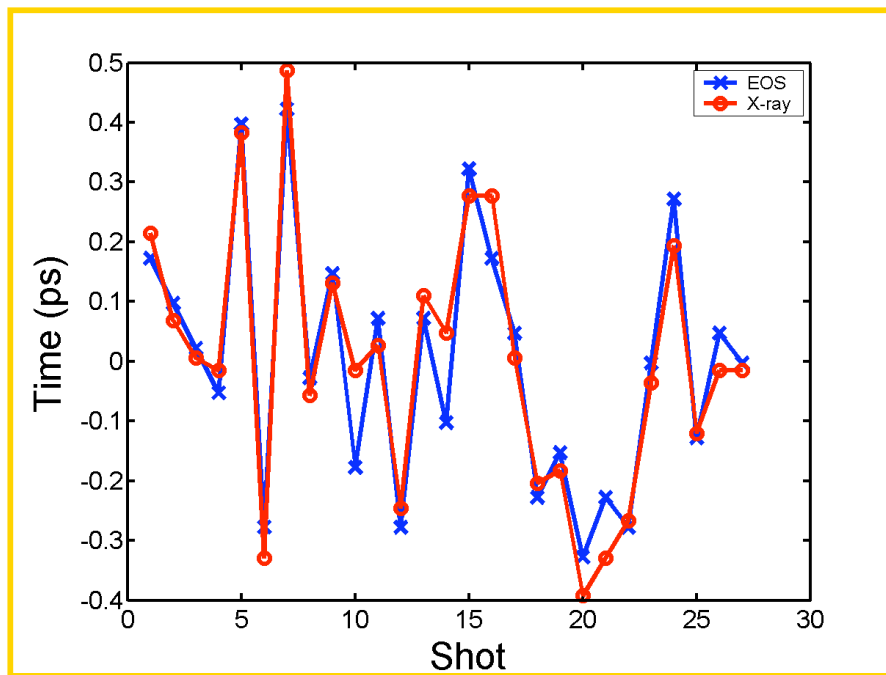
EOS measure of e^- beam bunch compression resolution limited by crystal



Single-Shot EOS Data at SPPS (100 μ m ZnTe)



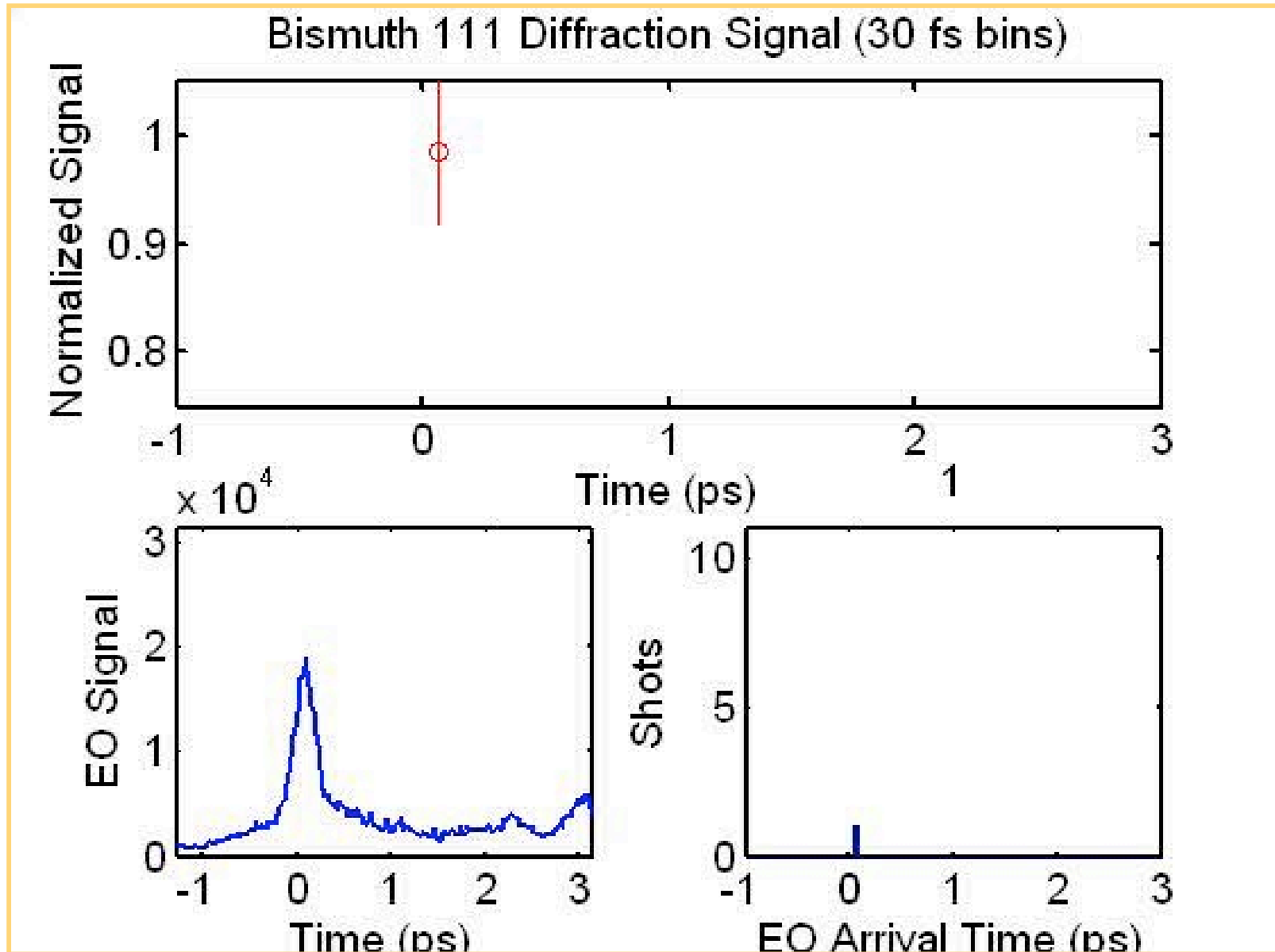
Electron beam–X-ray beam timing correlation: EOS and “Melting”



EOS and Melting $s = 60 \text{ fs}$, likely resolution limited.

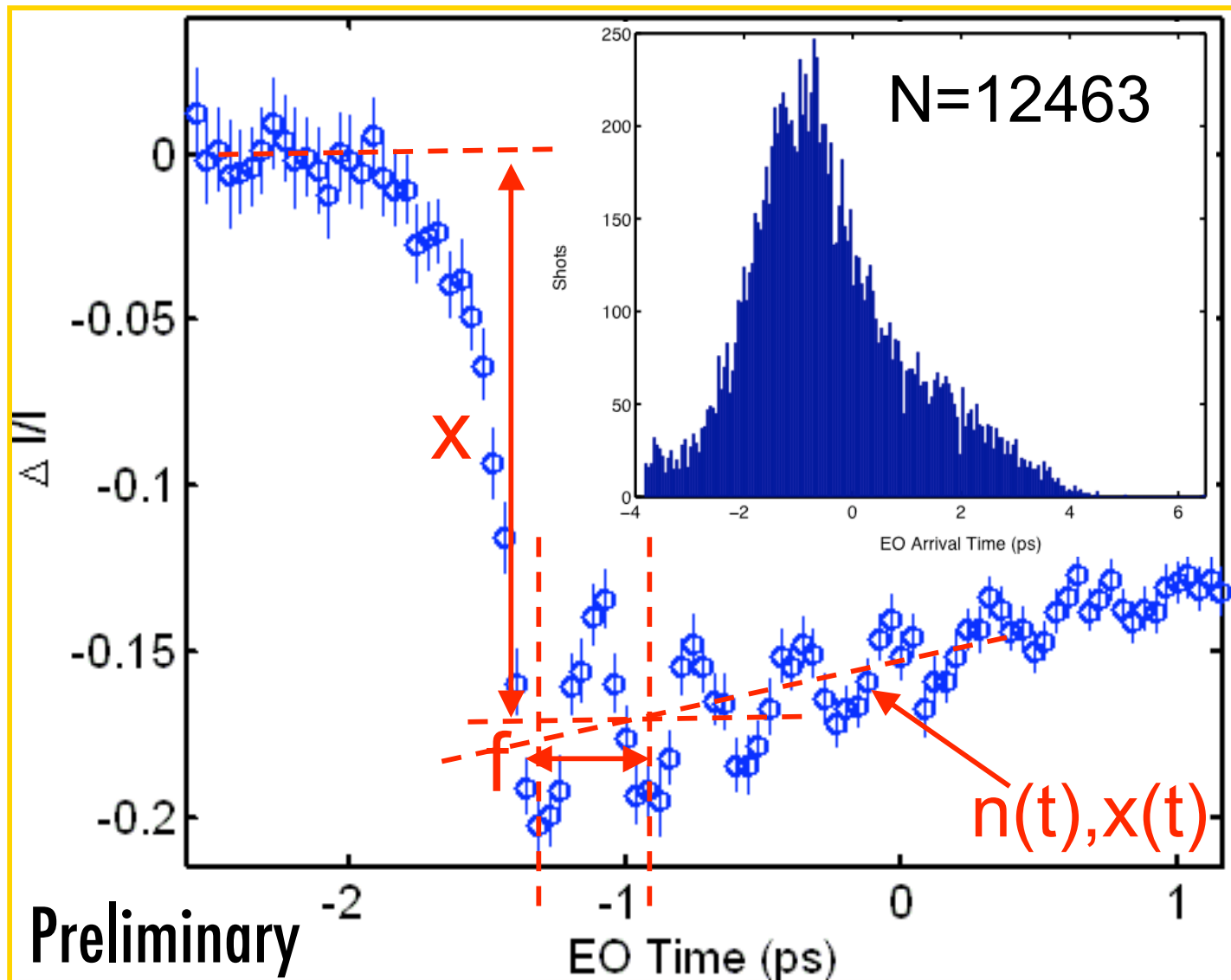
A. Cavalieri et al., Phys. Rev. Lett. 94 144801, 2005

Using Electrooptic sampling for Random sampling



D. M. Fritz *et al.* Preliminary Results!!!

Laser pump x-ray probe



1.74 mJ/cm² (absorbed), $\langle n \rangle \sim 1\%$; $f = 2.5$ THz; $\langle \Delta x \rangle = 5$ pm; $A > 0.92$ pm

SPPS Collaborating Institutions

Universities

UC Berkeley
U. of Chicago/BIOCARS
Copenhagen University
U. Of Michigan
Uppsala University
Chalmers University of
Technology
Lund University

Spokesperson

Prof. R. Falcone
Prof. K. Moffat
Prof. J. Als-Nielsen
Prof. P. Bucksbaum
Prof. J. Hajdu

Laboratories

ANL/APS and MSD
BNL/NSLS
DESY/HASYLAB
ESRF
LLNL/CMS
SLAC/SSRL

Spokesperson

Dr. Dennis Mills
Dr. D. Peter Siddons
Prof. J. Schneider
Dr. F. Sette
Dr. A. Nelson
Dr. J. B. Hastings

Approximately 50 scientists

D. M. Fritz^{1*}, B. Adams², C. Blome^{3*}, P. H. Bucksbaum^{1*}, A.L. Cavalieri^{4*}, S. Engemann^{5*}, S. Fahy⁶, P. H. Fuoss^{7*}, K. J. Gaffney^{5*}, P. Hillyard^{8*}, M. Horn von Hoegen⁹, M. Kammler¹⁰, J. Kaspar^{8*}, D. von der Linde^{9*}, A. M. Lindenberg^{5*}, S. H. Lee^{1*}, B. McFarland^{1*}, D. Meyer^{8*}, E. Murray⁶, M. Nicoul^{9*}, R. Pahl^{11*}, J. Rudati^{2*}, D. P. Siddons^{12*}, K. Sokolowski-Tinten^{9*}, J. K. Wahlstrand¹³, J. B. Hastings^{5*}, and D. A. Reis^{1*}

¹*FOCUS Center and Department of Physics, University of Michigan, Ann Arbor, MI 48109, USA*

²*Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439, USA*

³*Deutsches Elektronen-Synchrotron, Notkestrasse 85, 22607 Hamburg, Germany*

⁴*Max-Planck-Institut of Quantum Optics, Hans-Kopfermann-Str. 1 D-85748, Garching, Germany*

⁵*Stanford Synchrotron Radiation Laboratory, Menlo Park, CA, 94025, USA*

⁶*Department of Physics and Tyndall National Institute, University College, Cork, Ireland*

⁷*Materials Science Division, Argonne National Laboratory, Argonne, IL 60439, USA*

⁸*Department of Chemistry, Stanford University, Palo Alto, CA 94305, USA*

⁹*Institut fuer Experimentelle Physik, Universitaet Duisburg-Essen, Lotharstr.1, 47048 Duisburg, Germany*

¹⁰*Consortium for Advanced Radiation Sources, The University of Chicago, Chicago, IL 60637, USA*

¹¹*Institut fuer Halbleitertechnologie, Universitaet Hannover, 30167 Hannover, Germany*

¹²*National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY 11973, USA*

¹³*JILA and University of Colorado, Boulder, CO 80309, USA*

**Also Member Subpicosecond Pulse Source Collaboration*

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D. A. Reis