

Photon Sciences at SLAC / Stanford University

Matthias Kling, Professor in Photon Science, contact: kling@stanford.edu

Stanford campus

Photon Science faculty and scientists at SLAC lead interdisciplinary research teams driving internationally leading research

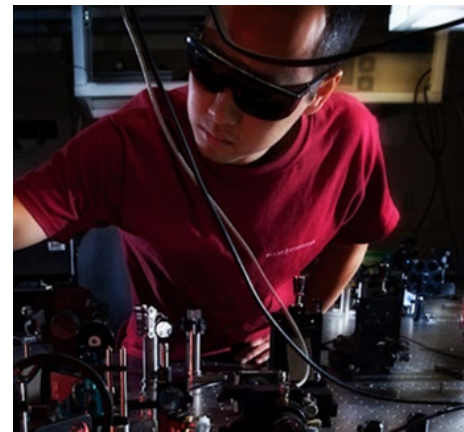
Photon Science has 42 faculty over diverse disciplines

Applied Physics, Physics, Chemistry, Materials Science, Chemical Engineering, Electrical Engineering, Geosciences, Structural Biology, Bioengineering, ...

Chair: Phil Bucksbaum

Latest appointments:

James Cryan: Attosecond Science
Angelo Dragone: Microelectronics and Detectors



- **Joint Research Institutes:**
PULSE, SIMES, SUNCAT
- **Unique Facilities:**
LCLS, SSRL, UED, FACET, cryo-EM, ASC-labs, etc.

Faculty offering core courses in x rays, lasers and ultrafast science

Examples

APPPHYS 283: Ultrafast Quantum Physics (PHOTON 283)

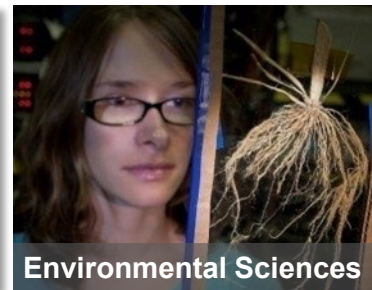
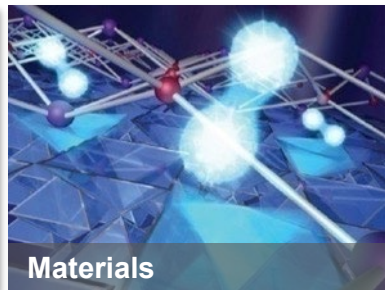
Intended for first-year graduate students who are interested in understanding the basic concepts of ultrafast quantum science to prepare for research in AMO physics, condensed matter physics, physical chemistry or quantum information science.

APPPHYS 325: Synchrotron Radiation and Free Electron Lasers: Principles and Applications. (PHOTON 325)

Synchrotron radiation sources for scientific exploration, and x-ray FELs for studies of ultrafast processes at the atomic scale.



SLAC's unique facilities enable high-impact scientific discoveries addressing national challenges in energy, critical materials and AI



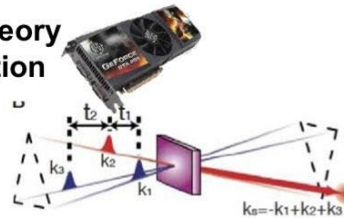
PHOTON SCIENCE

Stanford **SLAC**
NATIONAL ACCELERATOR LABORATORY

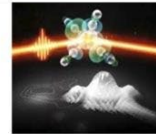
Research conducted in the **PULSE Institute** is driven by the opportunities introduced by ultrafast science with X-rays.

Engaging in work at LCLS, SSRL, and auxiliary laser labs

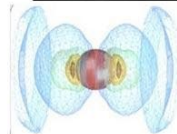
- Ultrafast Theory and Simulation



- Attosecond science



- Ultrafast Chemistry

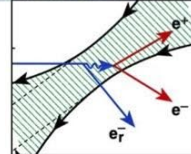


- X-ray Movies of Molecules in Motion

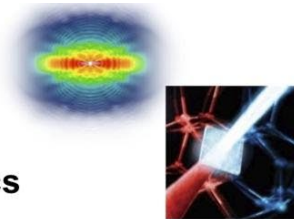


- High Energy Densities

- QED at the Schwinger limit



- Strong Field AMO Physics

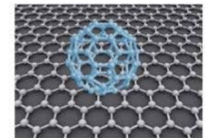


- Solid State High Harmonics

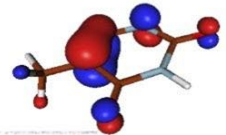
- Nonlinear X-ray interactions



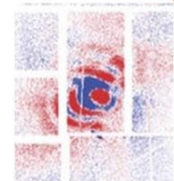
- Electron Dynamics on the Nanoscale



- Ultrafast X-Ray Spectroscopy



- Ultrafast Materials Science



Director: Prof. Matthias Kling, kling@stanford.edu

Website: <https://ultrafast.stanford.edu>

UXSS

2026

PULSE

20th Anniversary

June 15-19, 2026



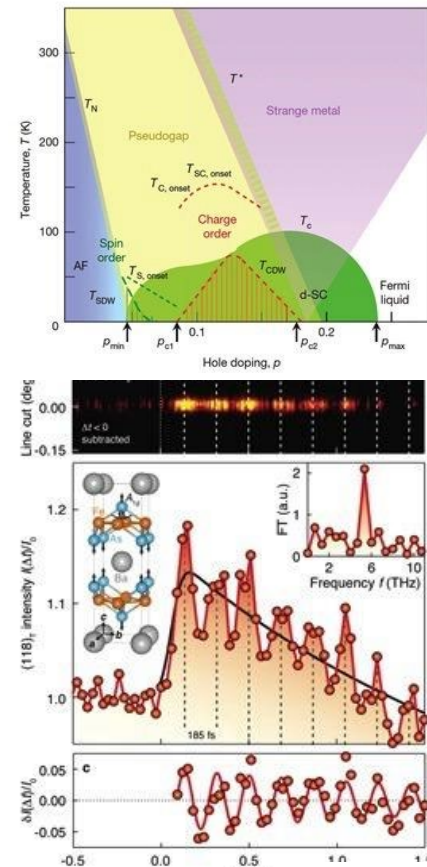
PHOTON SCIENCE

Stanford **SLAC**
NATIONAL ACCELERATOR LABORATORY

Stanford Institute for Material and Energy Sciences (SIMES)

Addressing grand challenges in the science of energy-related materials

- Why do **quantum electronic materials** have unique emergent properties?
- What are **pathways to convert** photons into energy and to store energy chemically?
- How can we **design and synthesize materials**, both physically- and bio-inspired, that exhibit these amazing quantum and energy transformative properties?
- How can we **best measure, probe, and simulate** the ultrafast photonic and electronic processes that drive all of the above?



Director: Prof. Harold Hwang, hyhwang@stanford.edu,

Website: <https://simes.stanford.edu>

There are world-class X-ray facilities at SLAC for ground-breaking science

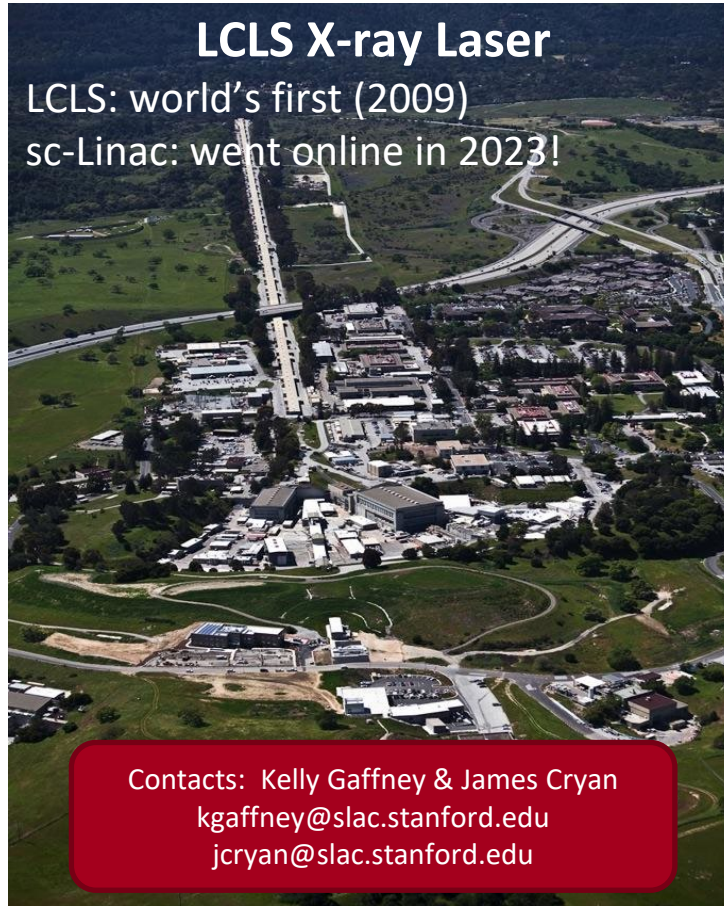
SSRL Synchrotron Radiation



Contacts: Paul McIntyre & Piero Pianetta
pcm1@stanford.edu
pianetta@stanford.edu

LCLS X-ray Laser

LCLS: world's first (2009)
sc-Linac: went online in 2023!



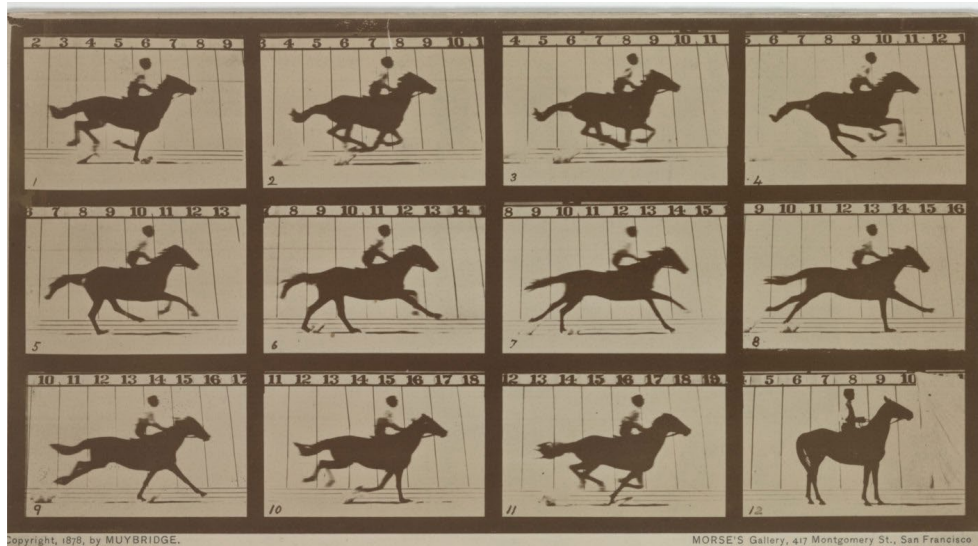
Contacts: Kelly Gaffney & James Cryan
kgaffney@slac.stanford.edu
jcryan@slac.stanford.edu

Then: The time axis – recording

fast movies

Ultrafast Imaging @ Stanford

The first movie (recorded at Stanford)



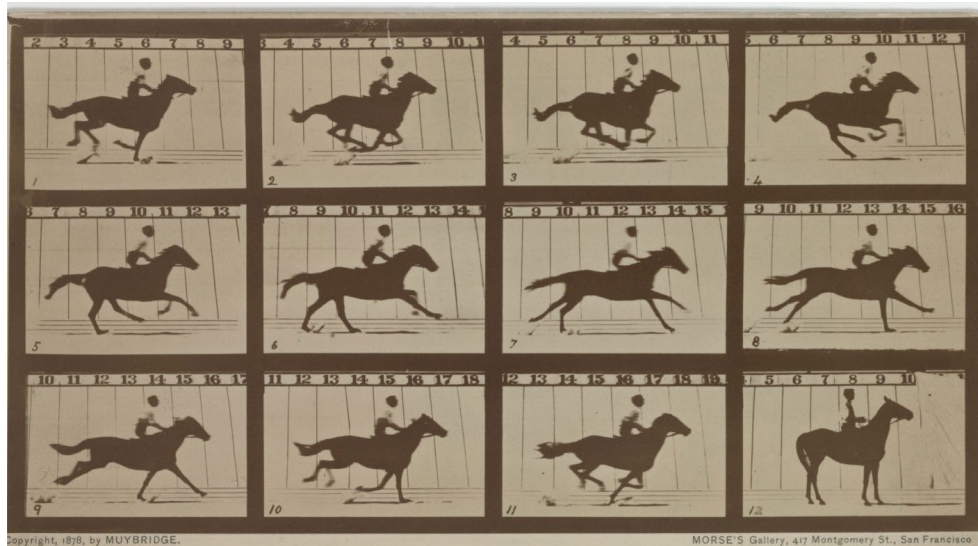
*The Horse in Motion ("Sallie Gardner," Owned by Leland Stanford;
Running at a 1:40 Gait Over the Palo Alto Track, 19th June 1878)*

E. Muybridge

Now: The time axis – recording (ultra) fast movies

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The Horse in Motion ("Sallie Gardner," Owned by Leland Stanford;
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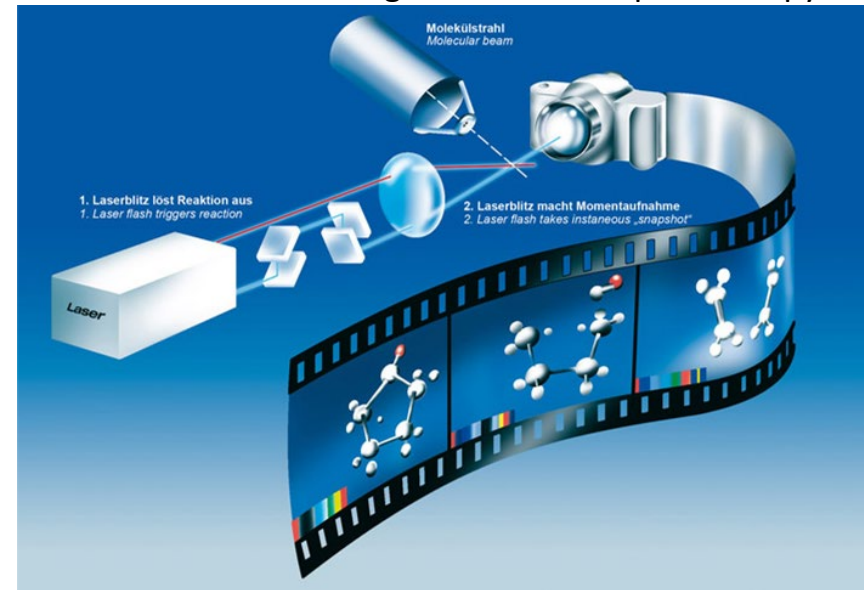
E. Muybridge



Nobel Prize
in chemistry
1999



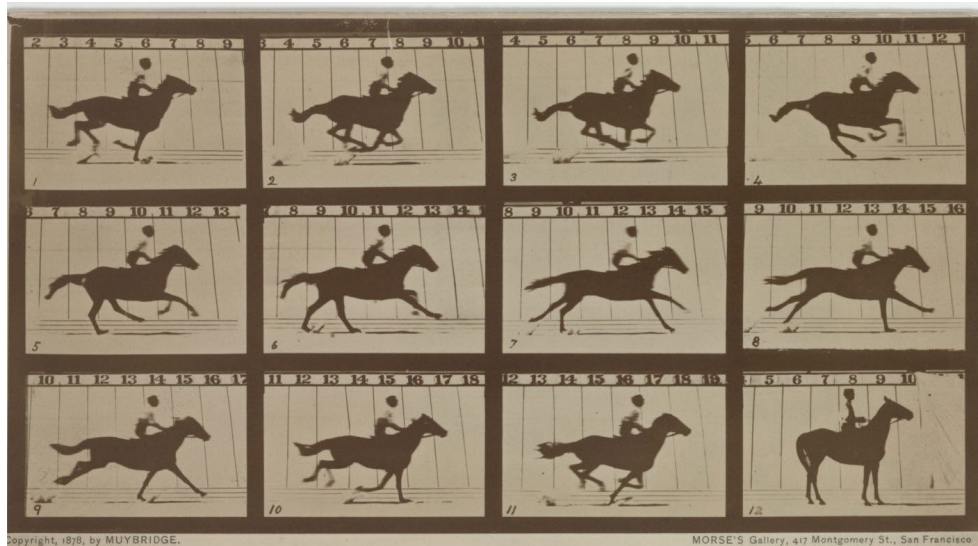
Ahmed H. Zewail for „for his studies of the transition states
of chemical reactions using femtosecond spectroscopy”



Now: The time axis – recording (ultra) fast movies

Ultrafast Imaging @ Stanford

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Copyright, 1878, by MUYBRIDGE.

MORSE'S Gallery, 417 Montgomery St., San Francisco

*The Horse in Motion ("Sallie Gardner," Owned by Leland Stanford;
Running at a 1:40 Gait Over the Palo Alto Track, 19th June 1878)*

E. Muybridge

State-of-the-art: femtosecond flashes of light

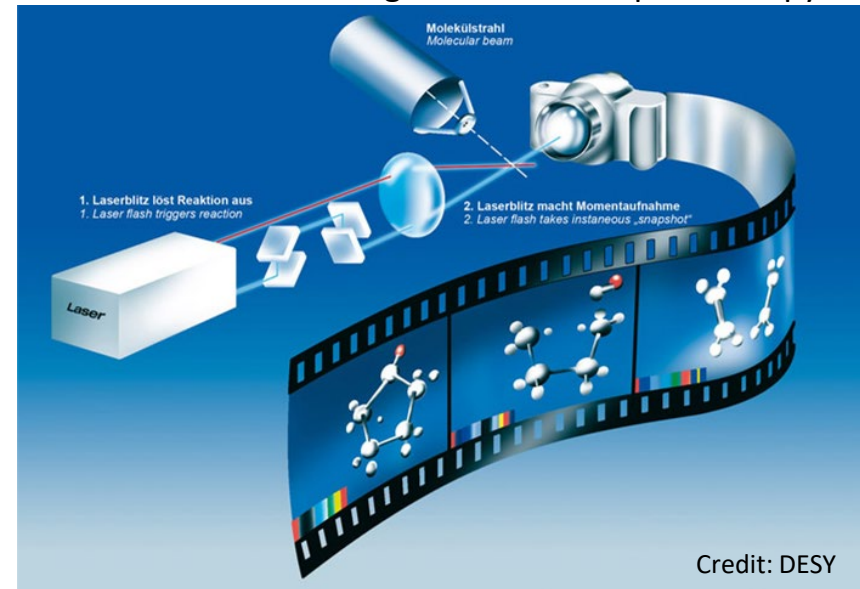
1 fs = 0.000 000 000 000 001 s (10^{-15} s)



Nobel Prize
in chemistry
1999



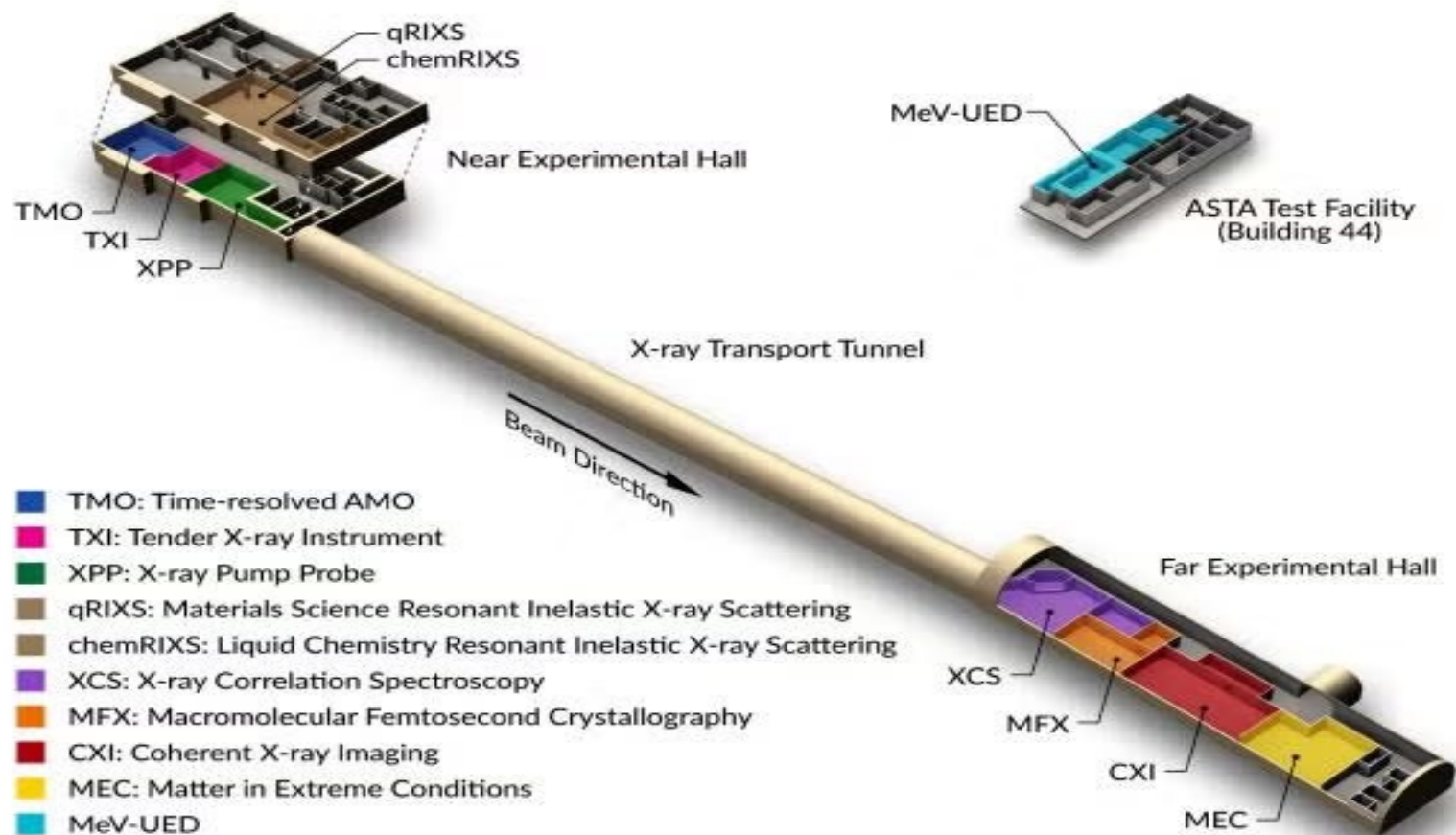
Ahmed H. Zewail for „for his studies of the transition states
of chemical reactions using femtosecond spectroscopy”



Credit: DESY



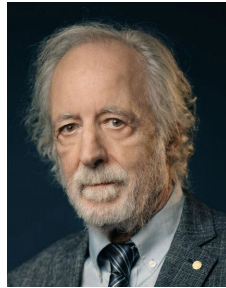
Experimental Infrastructure at LCLS incl. MeV-UED



Beyond! Measuring and harnessing electron dynamics



Nobel Prize
in Physics 2023

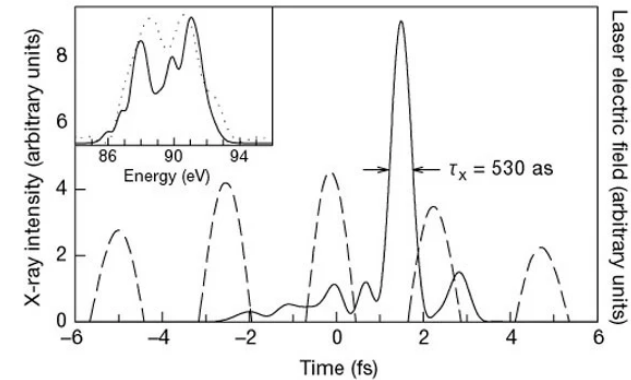
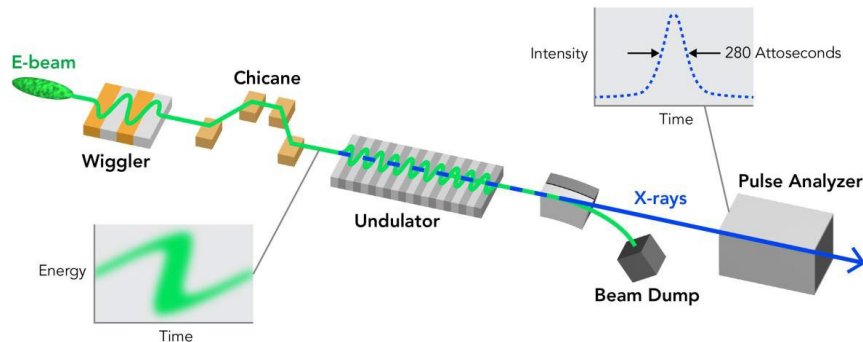


**Pierre Agostini, Ferenc Krausz,
and Anne L'Huillier**

„for experimental methods that generate
attosecond pulses of light for the study of
electron dynamics in matter”

Now: Attosecond flashes of light at Stanford

1 as = 0.000 000 000 000 000 001 s (10^{-18} s)

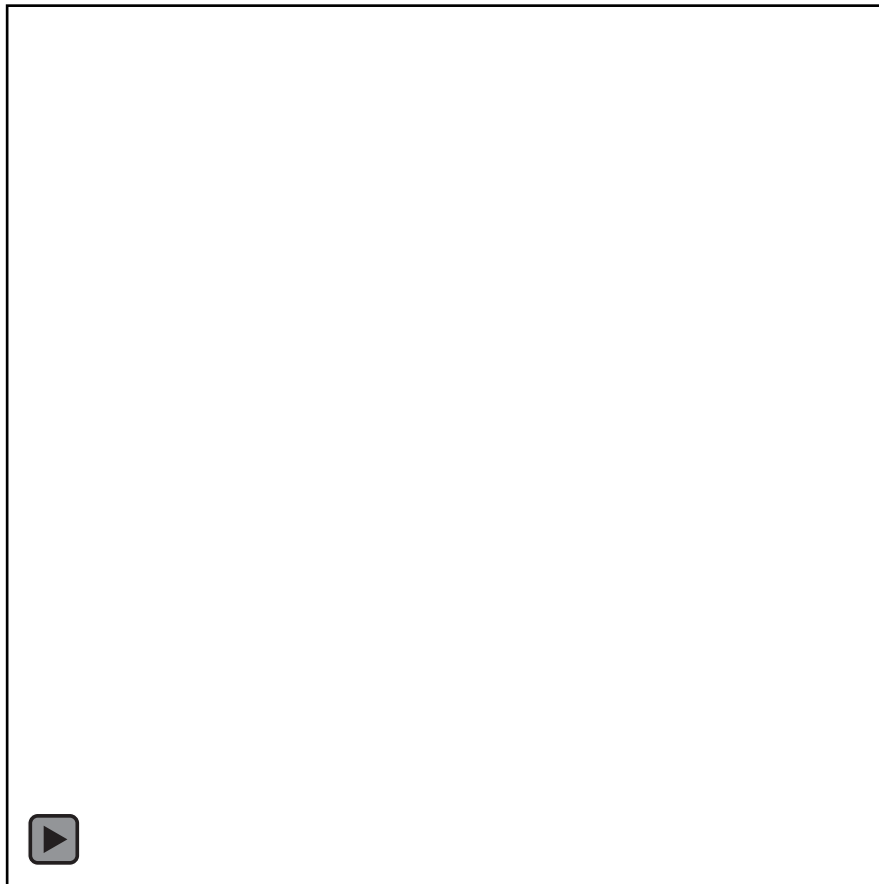


Hentschel, M. *et al.*, Attosecond metrology,
Nature **414**, 509–513 (2001).

Greg Stewart/SLAC National Accelerator Laboratory

Attosecond Science with X-ray Free Electron Lasers

Probing the ultrafast motion of electrons with atomic precision



AI as an accelerator for your PhD

1

From data firehose to insight

Facilities such as LCLS create 100,000 X-ray pulses per second. Every pulse gives us information about our target molecule, solid, nanosample, etc.

AI/ML tools are developed to analyze the data, perform simulations, and achieve a deeper understanding of the underlying photon science.

A PhD today looks very different from a PhD just last year ago. We work at the forefront of AI for Science.

2

From supercomputer-months to minutes

Quantum molecular dynamics is accurate but scales as $O(N^3)$. The reactions we care about are out of reach.

A machine-learned force field reproduces the same forces at classical-MD cost and can be told how much charge is driving the chemistry.

Simulation finally reaches the size and timescale the experiment probes.



Come and join us – Photon Science at SLAC/Stanford

Rotation opportunities

