

**XFEL** European XFEL Project Team

The European X-ray Free Electron Laser Project in Hamburg

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**Properties of FEL radiation (0.2 - 14.5 keV)**

1. Ultra-high Brilliance ( $10^{24}$  average,  $10^{33}$  peak)
2. Ultra-short pulses (< 100 fs, with  $10^{12}$ - $10^{14}$  photons/pulse)
3. Spatially coherent

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**Linac-based Free-electron Lasers**

European XFEL Project, Hamburg →

Linear Coherent Light Source, SLAC, Stanford ←

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**Today:** study (structure) and dynamics on ns to ps timescale

**XFEL:** study (structure) and dynamics on a ps and fs timescale

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An approach to three-dimensional structures of biomolecules by using single-molecule diffraction images: **A simulation**

3-D structure (2.5 Å resolution) of rubisco molecule. (106 kDa)

Top view of a section ( $k_z=0$ ) of 3-D scattering pattern from  $10^6$  single molecules (of known relative orientation) each "exposed" by a single 10 fs XFEL pulse ( $\lambda=1.5\text{Å}$ ,  $0.1\mu\text{m}$  beamsize) containing  $2 \cdot 10^{11}$  photons.

Reconstructed 3-D pattern (from 250 2-D projections). Phasing by "oversampling" technique.

J. Miao, K.O. Hodgson and D. Sayre, PNAS, 98, 6641 (2001)

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Coulomb explosion of a small protein (lysozyme)

50 fs  
 $3 \cdot 10^{12}$  photons/100 nm spot  
 12 keV

Radiation damage interferes with atomic scattering factors and atomic positions

Heutsch, R., Weidt, R., van der Spoel, D., Weickert, E., Haeck, A. (2000) Biophys J 79:757

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- Isochoric heating of plasmas
  - Solid density plasmas
  - $T_e$  up to few 100 eV
  - Warm dense matter
  - Pressure up to Gbar
  - Plasma phase transitions

Plasma generation: X-ray FEL radiation → Laser interferometer → detector

Temperature (eV) and Pressure (Mbar) profiles for  $\lambda = 1.5406 \text{ \AA}$  and  $\lambda = 1.4814 \text{ \AA}$  with pulse durations of 100 fs and 10 fs. Source: Schlegel et al., (2000).

Al p-T phase diagram: Temperature (eV) vs. Density ( $\text{g/cm}^3$ ). Regions include classical plasma, dense plasma, and high density matter. Source: R.W. Lee & coworkers.

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### Memorandum of Understanding (MoU) on the Preparatory Phase of the European X-ray Free Electron Laser Facility

Signed by : France, Germany, Greece, Italy, Spain, Sweden, Switzerland, UK, Poland, Hungary, Denmark, Russia (and China on Nov. 24, 2005)

Timeline of the preparatory phase:

- 2004: preparation
- 2006: preparation
- 2009: LCLS start operation (SLAC)
- 2012/13: construction
- 2014/15: beam operation
- SASE1
- SASE2+3, spont. rad

Approva

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