ELI-ALPS and the high-intensity ReMi project

Albert-Ludwigs-Universität Freiburg

UNI FREIBURG

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Historical overview

Über Elementarakte mit zwei Quantensprüngen

Von Maria Göppert-Mayer

(Göttinger Dissertation)

(Mit 5 Figuren)

Einleitung

The Nobel Prize in Physics 1963

https://www.nobelprize.org/prizes/physics/1963/mayer/biographical/

Göppert-Mayer, M. (1931). "Über Elementarakte mit zwei Quantensprüngen." Annalen der Physik **401**(3): 273-294.

First example of multiphoton process: second harmonic generation

- Generation of second harmonic using a Ruby laser (E~10^7 V/m) in crystal quartz:

VOLUME 7, NUMBER 4 PHYSICAL REVIEW LETTERS AUGUST 15, 1961

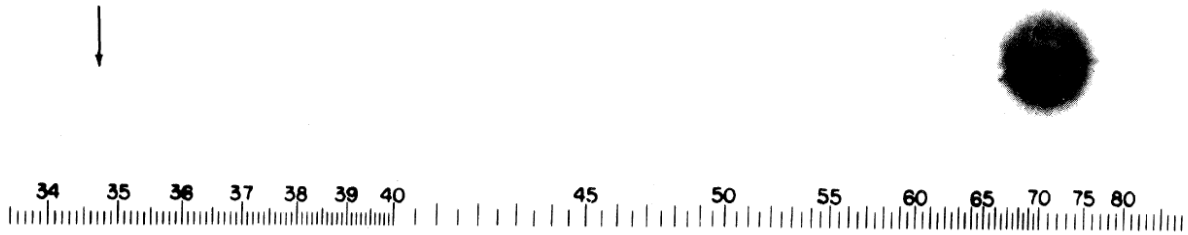


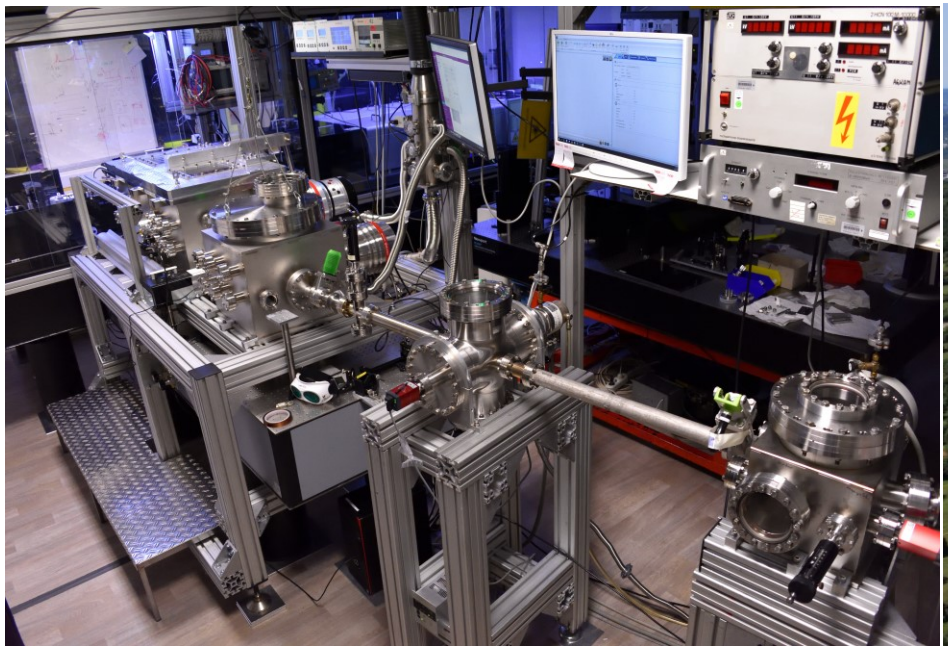
FIG. 1. A direct reproduction of the first plate in which there was an indication of second harmonic. The wavelength scale is in units of 100 A. The arrow at 3472 A indicates the small but dense image produced by the second harmonic. The image of the primary beam at 6943 A is very large due to halation.

"Ironically, the faint spot did not appear in the figure in Physical Review Letters because someone at the printing company thought it was a blemish and erased it, says Weinreich."

P. Franken *et al., Phys. Rev. Lett.* **7**, 118 (1961)
D. Lindley *Physics* **7**, 112 (2014)

Intense soft X-ray sources

Attosecond laboratory *(Freiburg 10.11.2020)*



~ 1-10m

Attosecond time resolution

Low photon flux

Free Electron Laser *(FERMI@Elettra)*

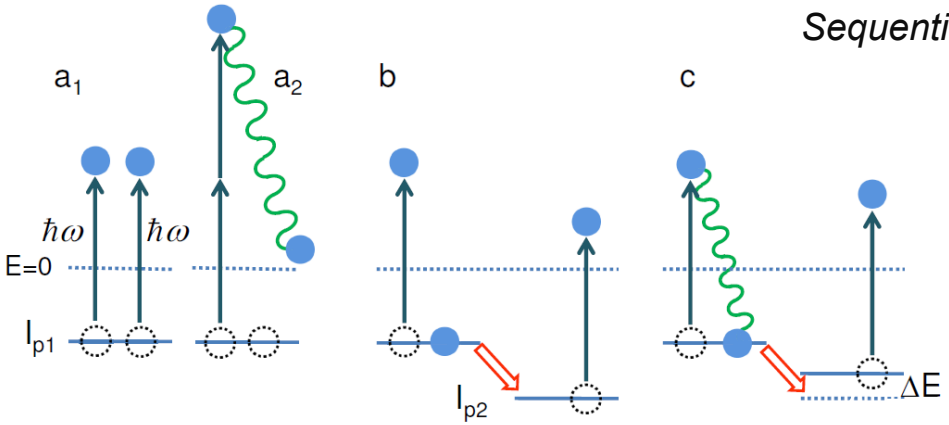
~0.1-1 km

Femtosecond time resolution

High photon flux-> nonlinear effects

Electronic correlation in real time: *attosecond timescale*

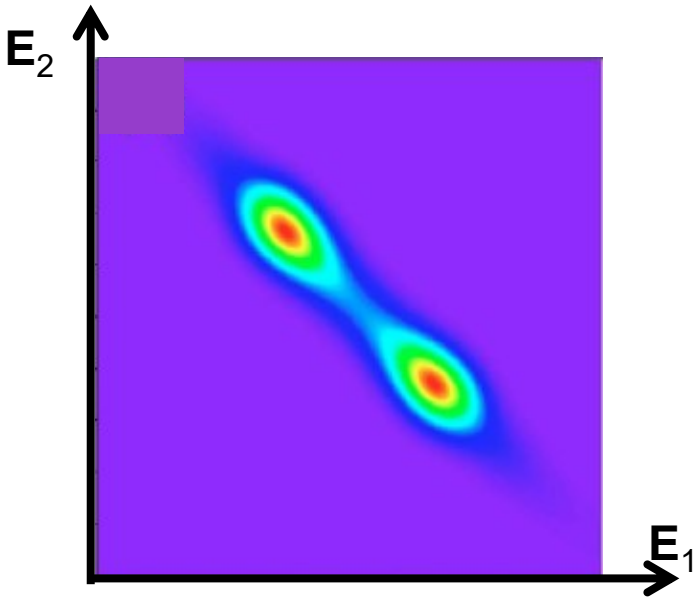
- Electronic correlation beyond mean-field



$$\Delta t = \frac{\hbar}{I_{p2} - I_{p1}} = 22\ as$$

Correlated two-electron measurements ($\mathbf{p}_1$ and $\mathbf{p}_2$)

Sequential vs non-sequential double ionization of helium



K. Ishikawa and K. Midorikawa Phys. Rev. A **72**, 013407 (2005)

Electronic correlation in real time: *coincidence spectroscopy*

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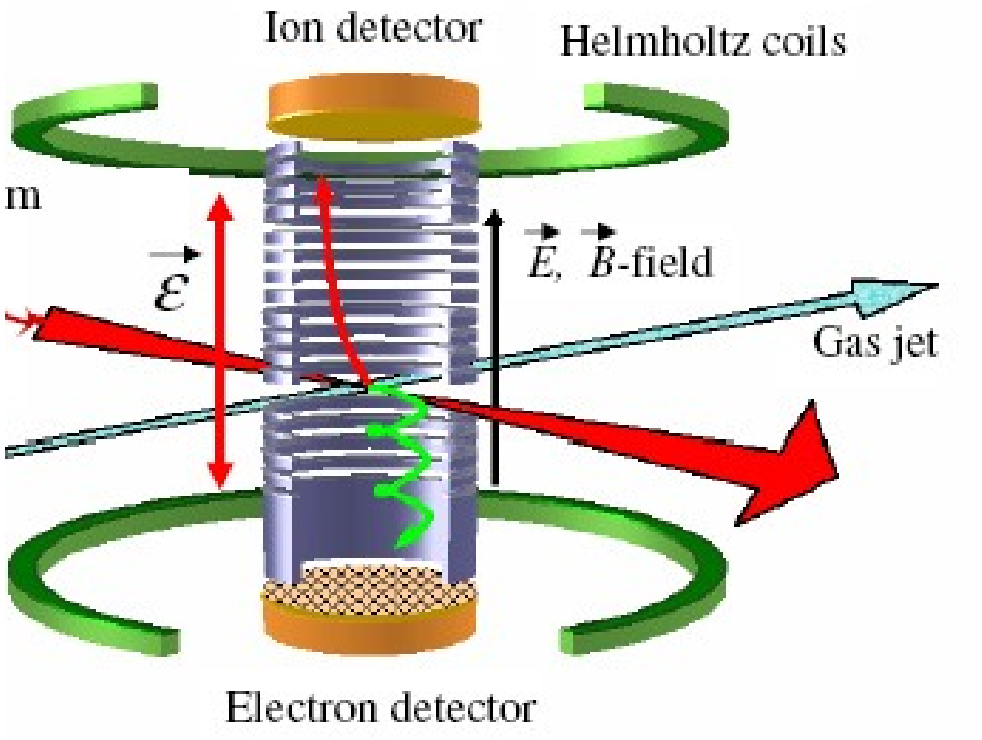
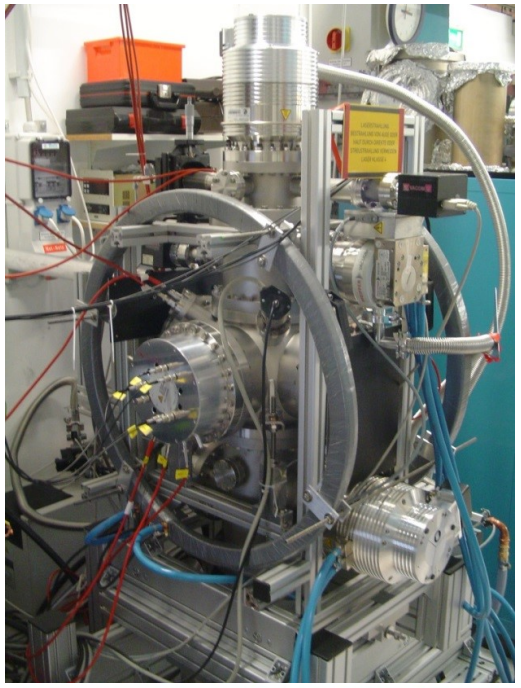
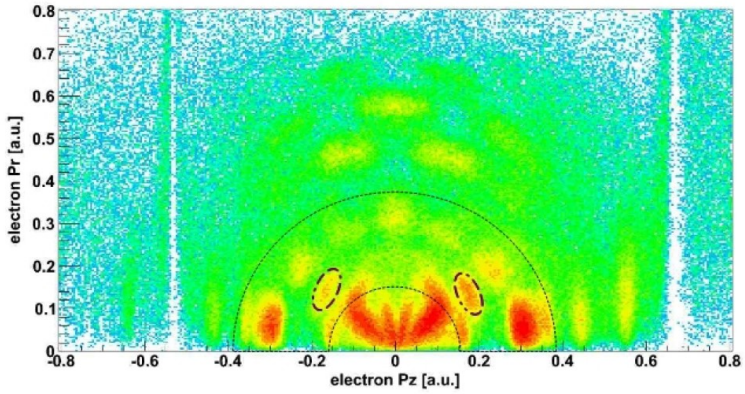
Reaction Microscope







Electronic correlation in real time: *requirements*

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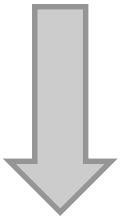
- Nonlinear effects→ high intensities
- Electronic timescale → attosecond pulses
- Coincidence spectroscopy → high repetition rates



- No source available worldwide can meet these conditions!
- SYLOS Laser system at ELI-ALPS (10^{15}-10^{16} W/cm^2; < 500 as; 1 kHz)
- (seeded FEL in the soft-Xray?)

BMBF: Nonlinearatto project

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Untersuchung der korrelierten elektronischen Dynamik mit Attosekunden Pulsen

Objectives

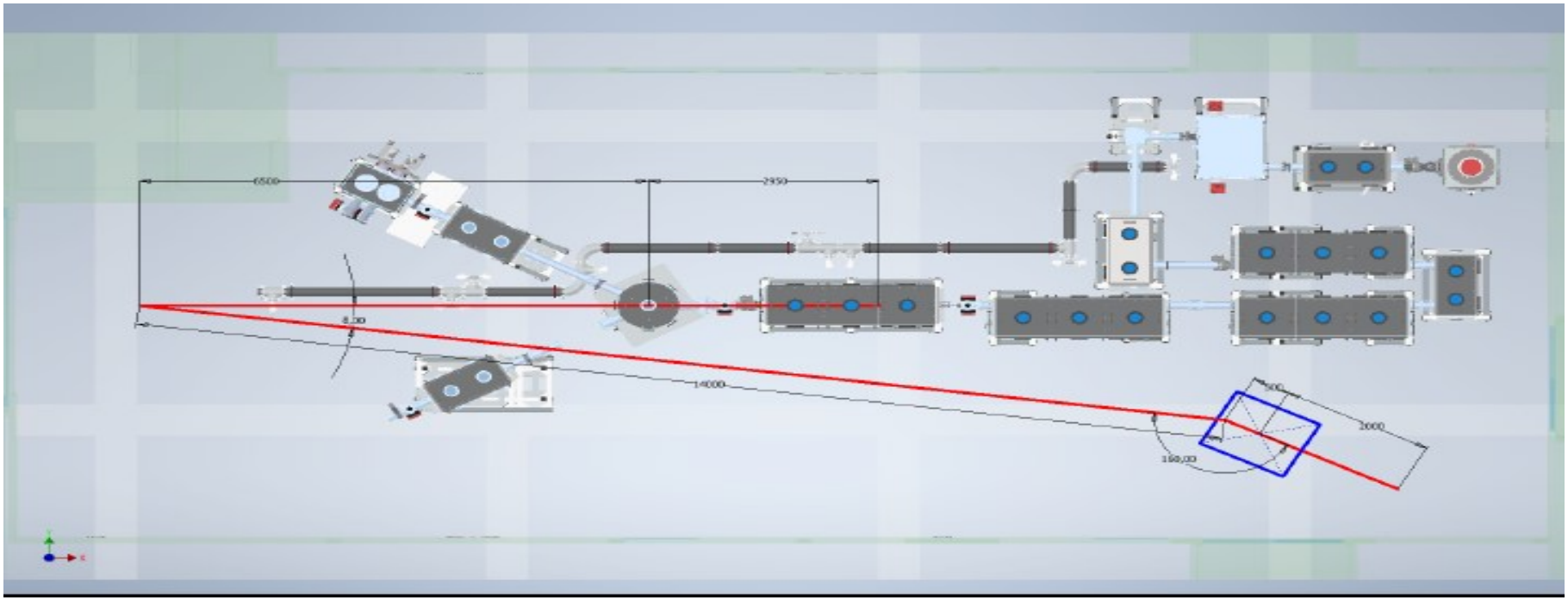
a. Characterization of trains and isolated attosecond pulses: comparison between XUV-IR cross-correlation and XUV nonlinear autocorrelation techniques
b. Two-photon double ionization of helium (TPDI)
c. XUV-pump-XUV probe attosecond spectroscopy in molecules

Team

- **Albert-Ludwigs- Universitaet Freiburg**
- Max-Planck Institut für Kernphysik Heidelberg
  (Robert Moshammer, Thomas Pfeiffer, Claus-Dieter Schroeter)
- FORTH, Greece (Dimitris Charalambidis, Paris Tzallas)
- CNR-Padua, Italy (Luca Poletto, Fabio Frassetto)

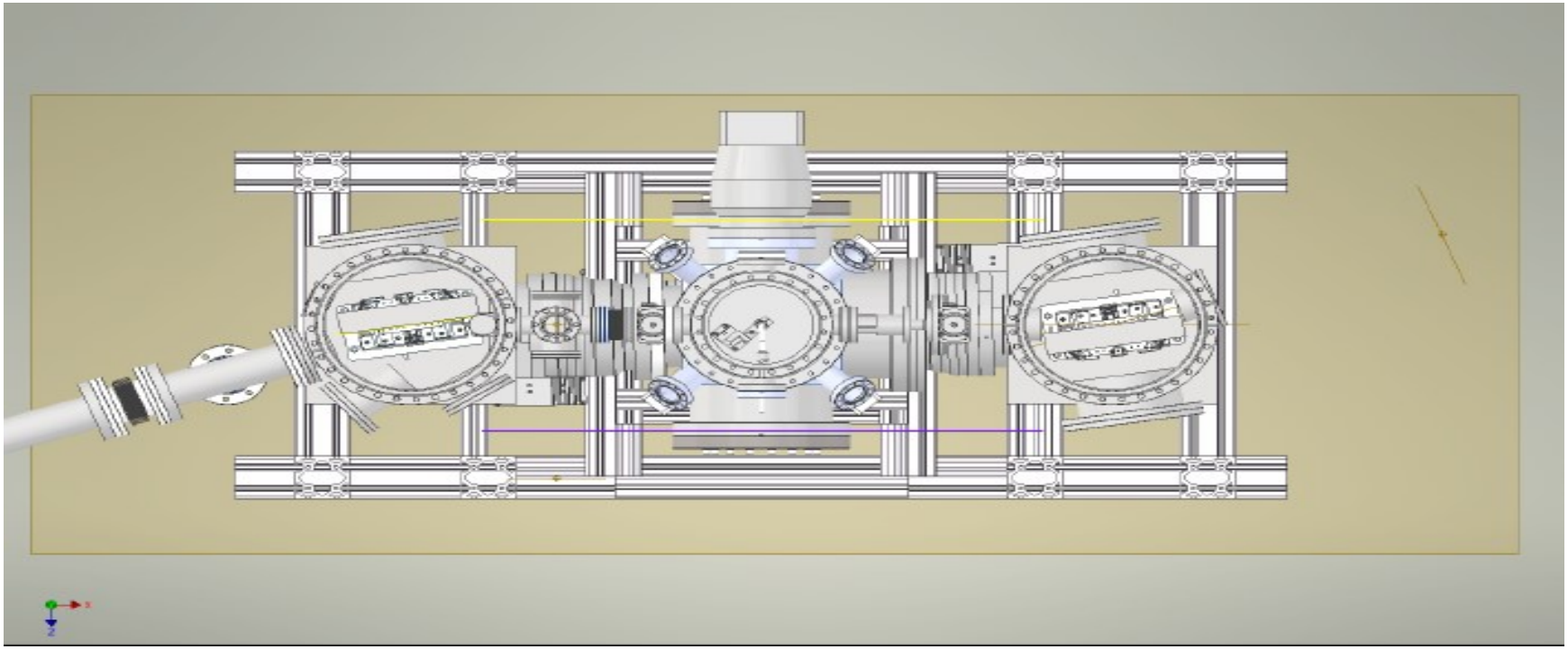
Implementation (1)

- PhD Student (Samuel Kellerer 01.11.2019)
- Postdoc (Ioannis Makos 01.12.2020) (delay due to the pandemic)
- Optical and technical design of the system
  - ray-tracing (focusing of the XUV radiation; imaging of the XUV focus)
  - positioning on the SYLOS-driven beamline



Implementation (2)

- Acquisition of different components (vacuum pumps, detectors, electronics, mirrors, translation stages, et.)
- Installation and testing of the system in Freiburg
- Shipment of the system to ELI-ALPS



Thank you for the attention

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A milestone in laser technology

- First demonstration of chirped pulse laser amplification (CPA)

Volume 56, number 3 OPTICS COMMUNICATIONS 1 December 1985

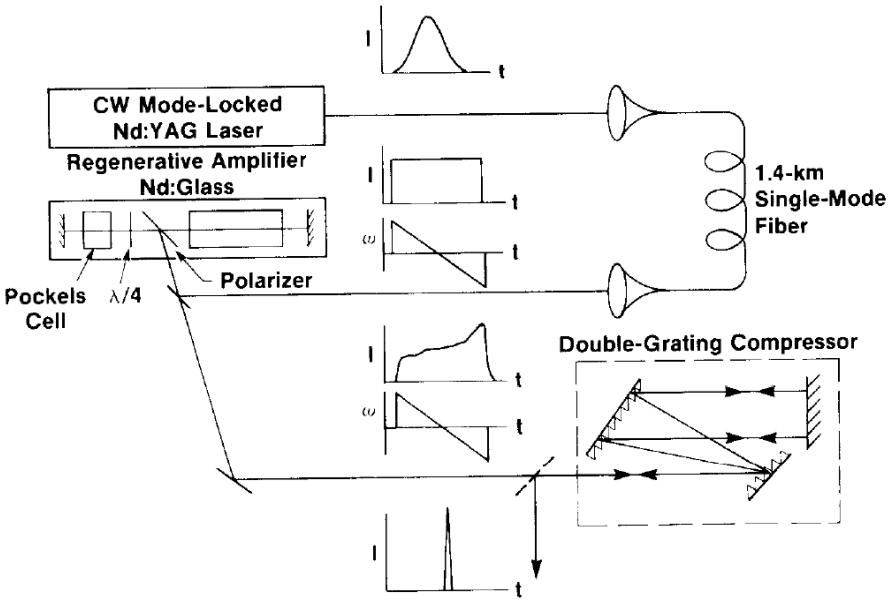


Fig. 1. Amplifier and compression system configuration.

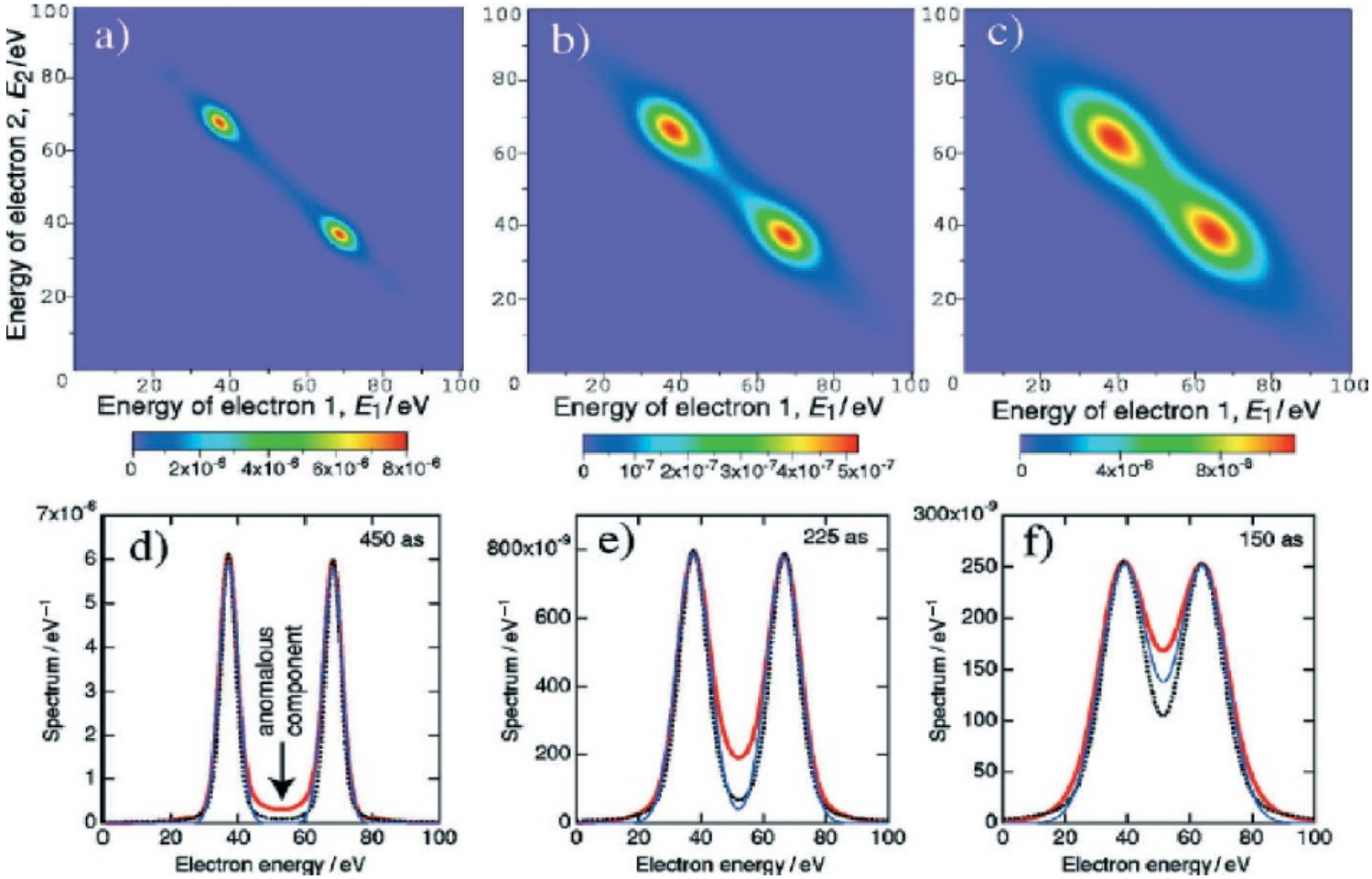
D. Strickland and G. Mourou, *Opt. Commun.* **56**, 219 (1985)

Chirped pulse amplication

D. Strickland and G. Mourou
Optics Communications **56**, 219 (1985)

The Nobel Prize in Physics 2018
Gérard Mourou and Donna Strickland "for their method of generating high-intensity, ultra-short optical pulses."

Electronic correlation in real time



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