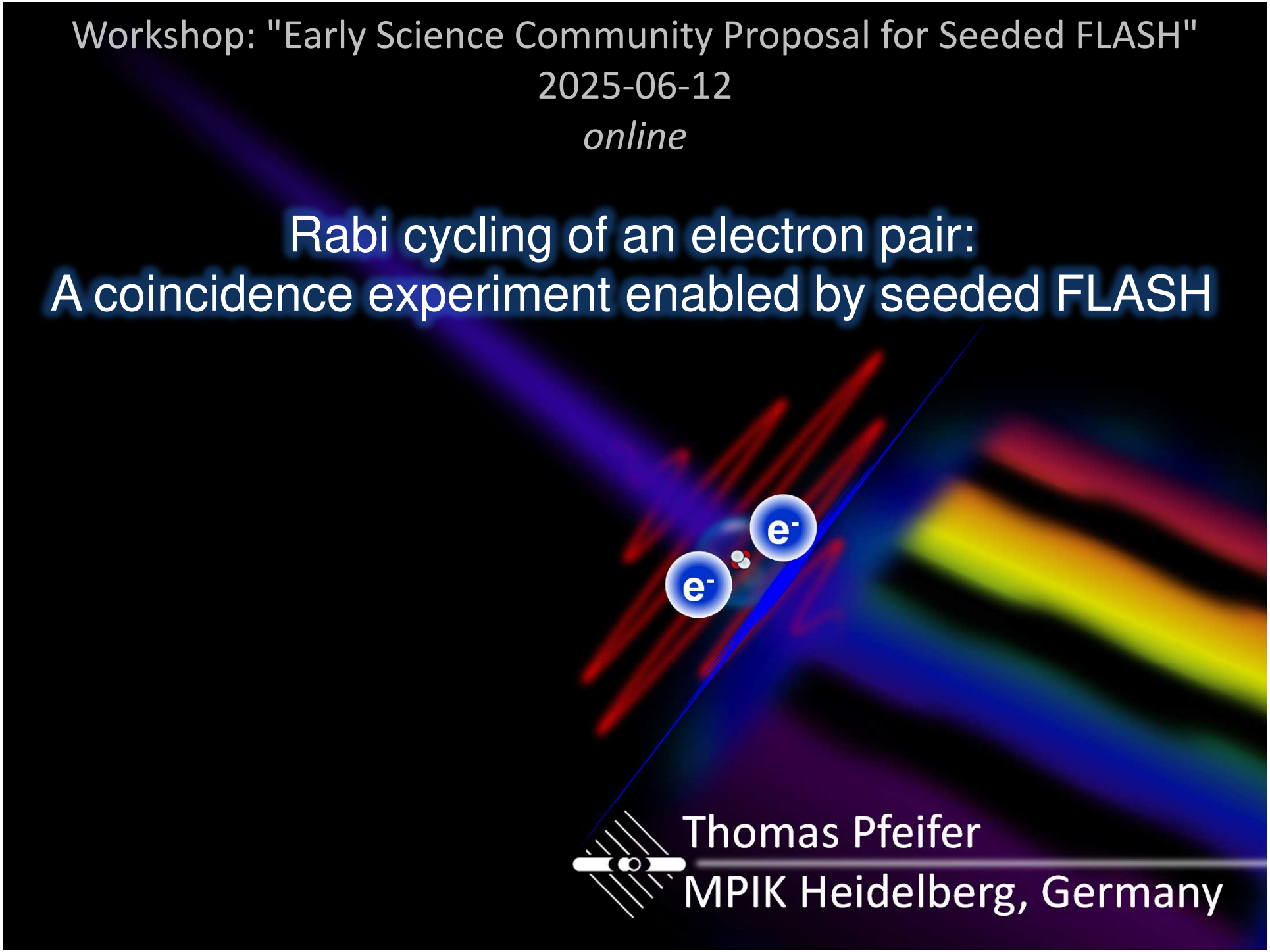
Workshop: "Early Science Community Proposal for Seeded FLASH"
2025-06-12
online

Rabi cycling of an electron pair:
A coincidence experiment enabled by seeded FLASH

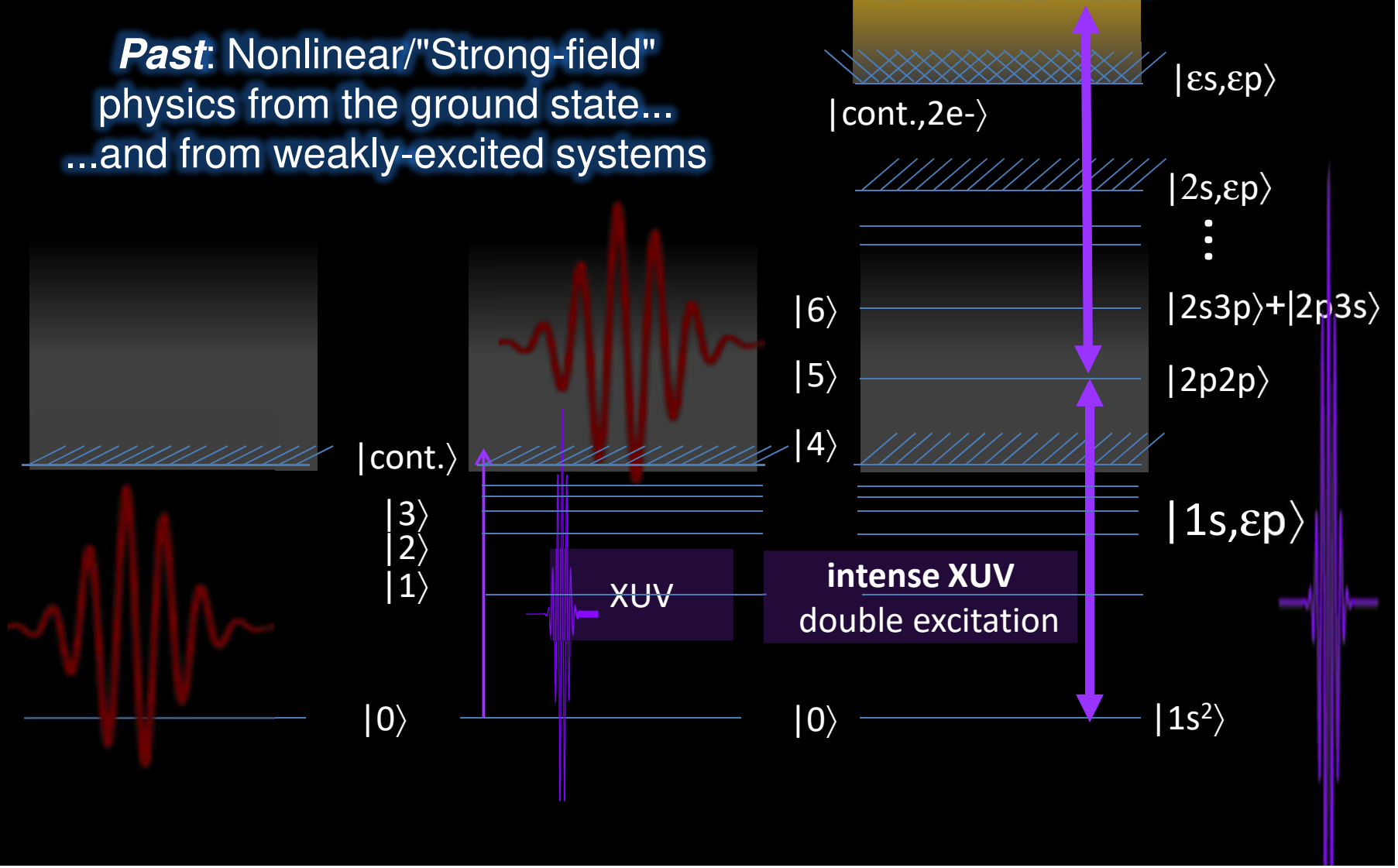


Thomas Pfeifer
MPIK Heidelberg, Germany

What's been done, and what not...

New: prepare excited states
and observe their response
to intense fields

Past: Nonlinear/"Strong-field"
physics from the ground state...
...and from weakly-excited systems



FELs can saturate bound quantum states (single-electron excitation)

Article

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Observation of Rabi dynamics with a short-wavelength free-electron laser

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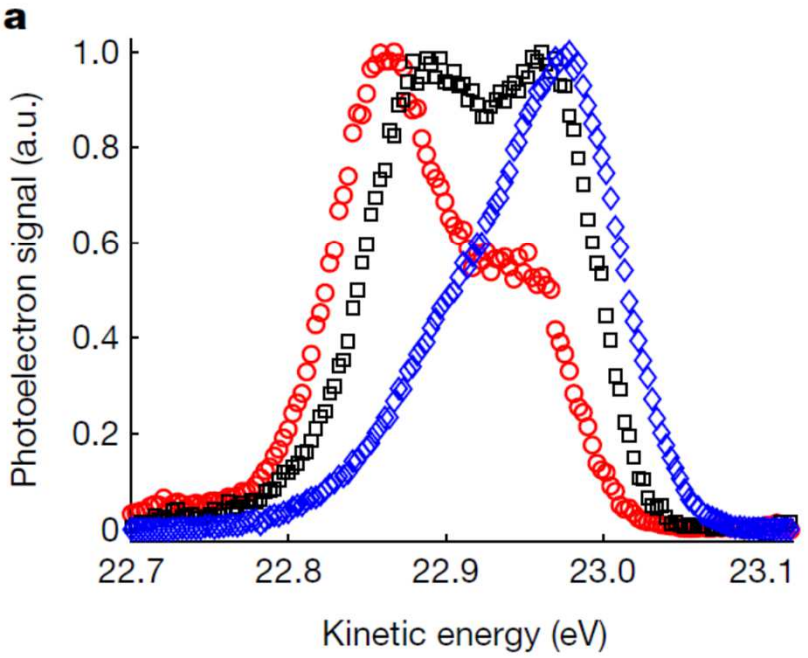

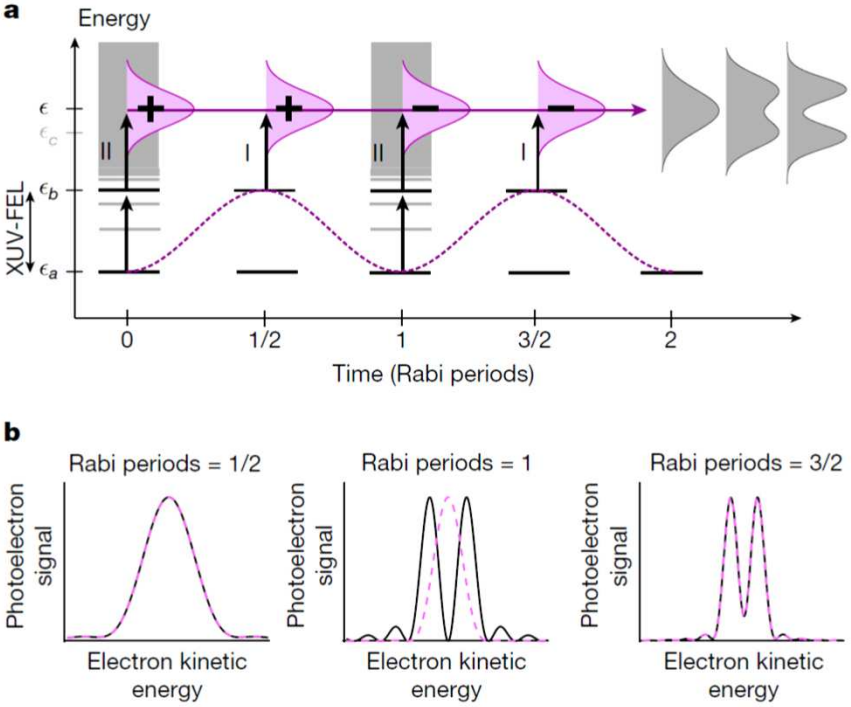

Article

Strong-field quantum control in the extreme ultraviolet domain using pulse shaping

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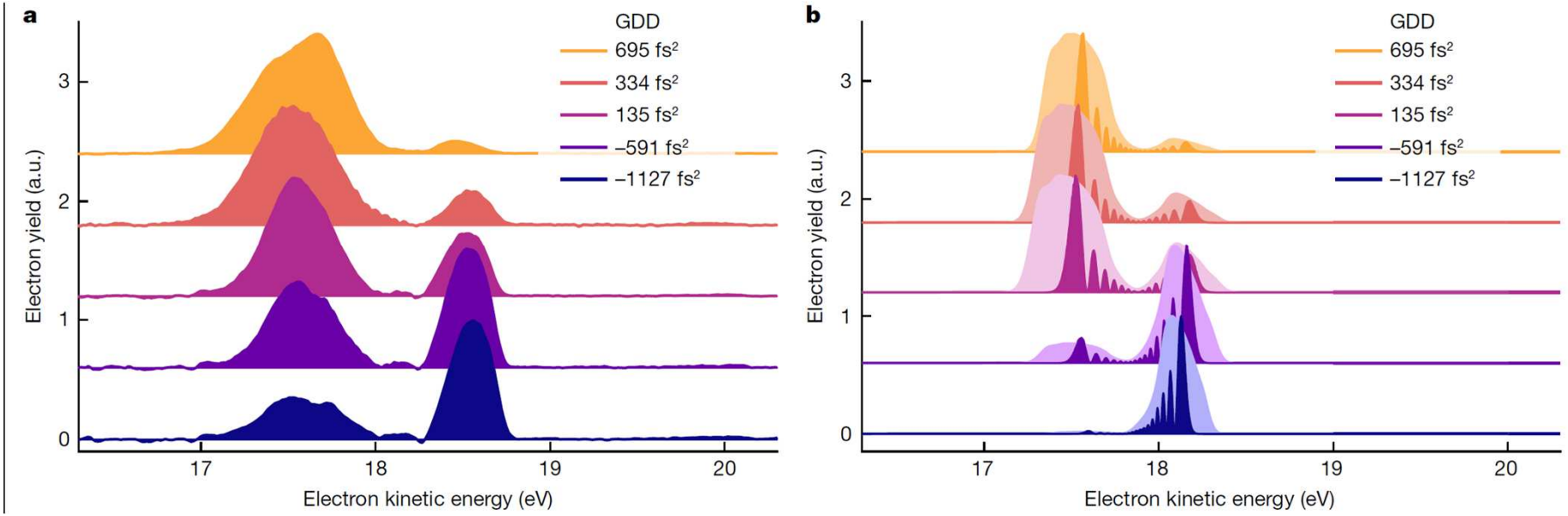
Check for updates

Fabian Richter[1], Ulf Saalmann[2], Enrico Allaria[3], Matthias Wollenhaupt[4], Benedetto Ardini[5], Alexander Brynes[3], Carlo Callegari[3], Giulio Cerullo[5], Miltcho Danailov[3], Alexander Demidovich[3], Katrin Dulitz[6], Raimund Feifel[7], Michele Di Fraia[3,8], Sarang Dev Ganeshamandiram[1], Luca Giannessi[3,9], Nicolai Gölz[1], Sebastian Hartweg[1], Bernd von Issendorff[1], Tim Laarmann[10,11], Friedemann Landmesser[1], Yilin Li[1], Michele Manfredda[3], Cristian Manzoni[12], Moritz Michelbach[1], Arne Morlok[1], Marcel Mudrich[13], Aaron Ngai[1], Ivaylo Nikolov[3], Nitish Pal[3], Fabian Pannek[14], Giuseppe Penco[3], Oksana Plekan[3], Kevin C. Prince[3], Giuseppe Sansone[1], Alberto Simoncig[3], Frank Stienkemeier[1], Richard James Squibb[7], Peter Susnjar[3], Mauro Trovo[3], Daniel Uhl[1], Brendan Wouterlood[1], Marco Zangrando[3,8] & Lukas Bruder[1]✉



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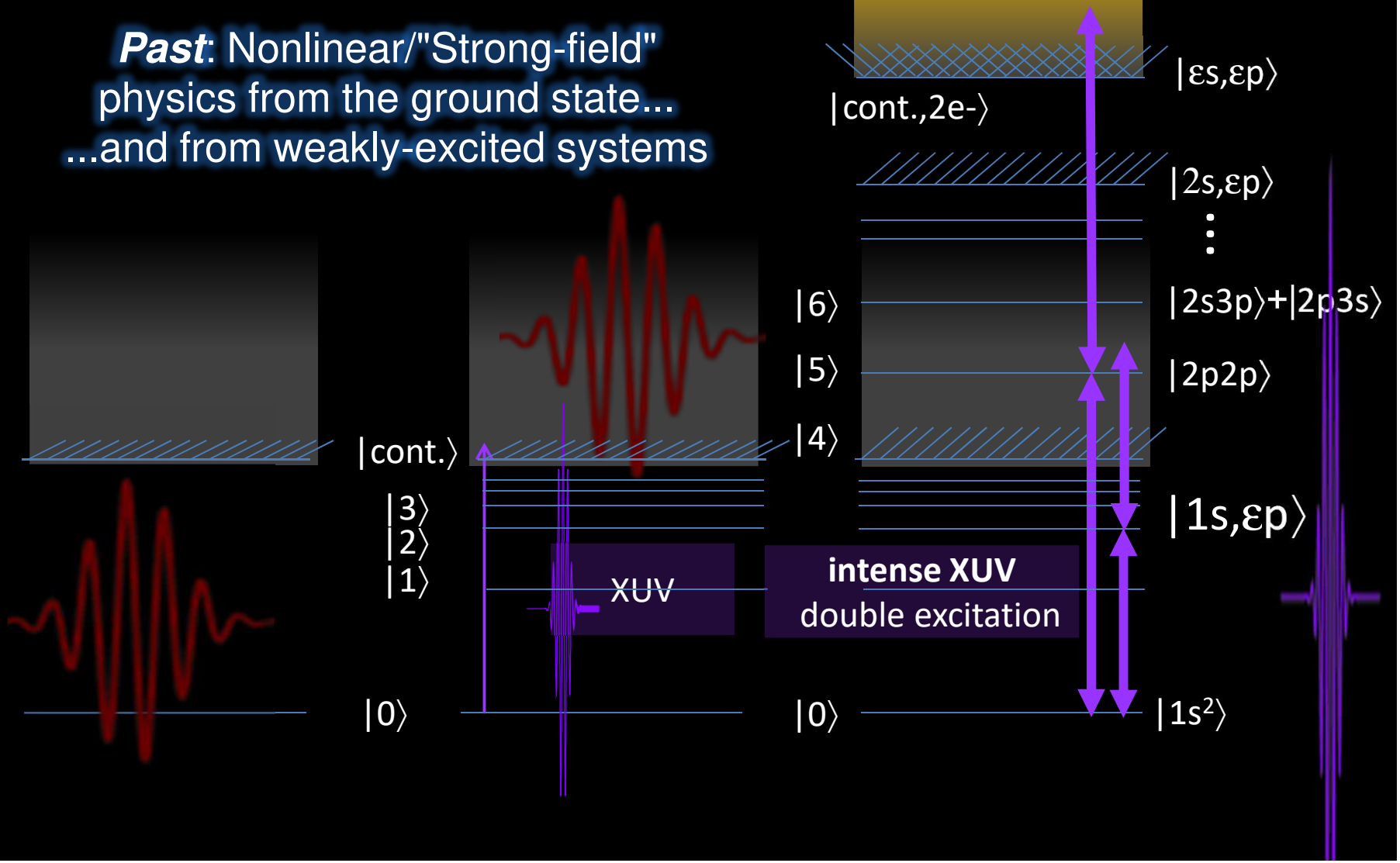
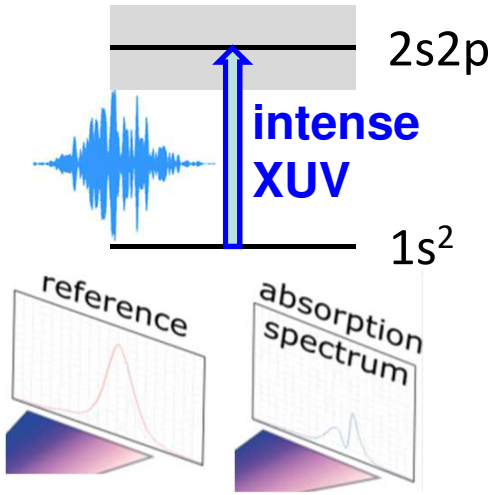
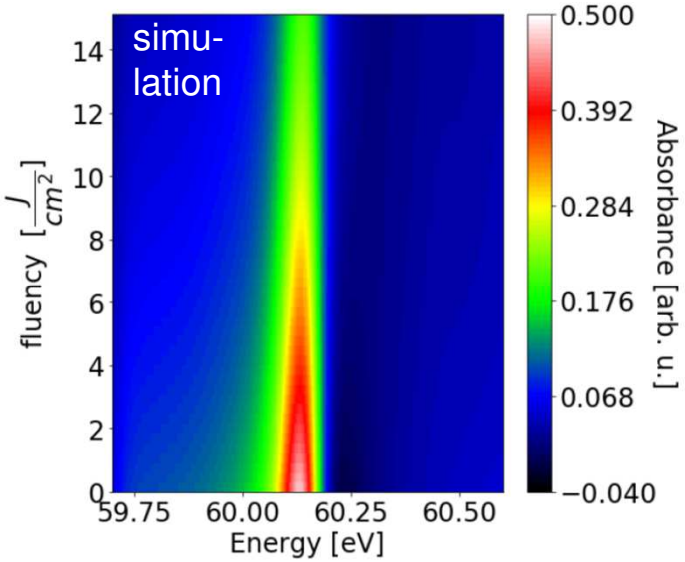


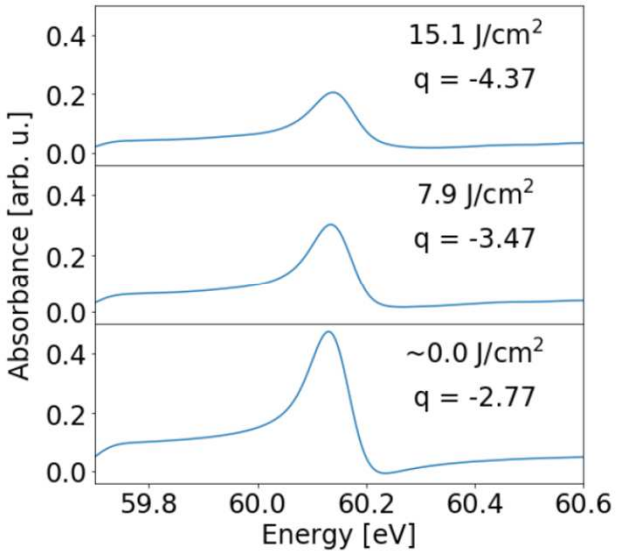
Strongly driven double excitation?

Christian Ott *et al.* PRL 2019

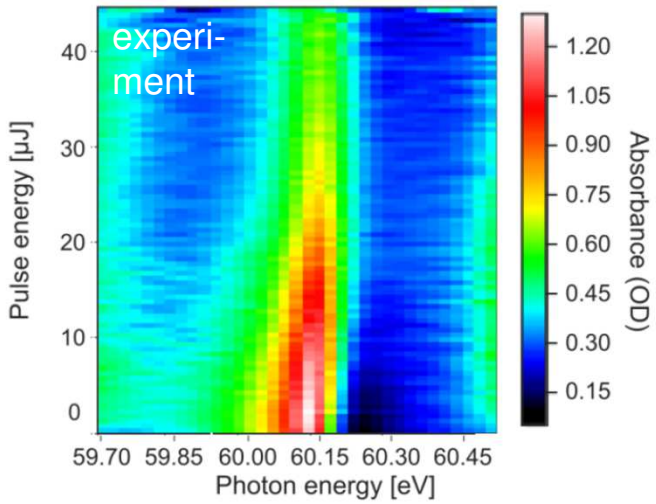
Collaboration:
C Ott, L Aufleger, T Ding, M Rebholz, A Magunia, M Hartmann, V Stooß, D Wachs, P Birk, G D Borisova, K Meyer, P Rupprecht, C da Costa Castanheira, R Moshammer, A R Attar, T Gaumnitz, Z H Loh, S Düsterer, R Treusch, J Ullrich, Y H Jiang, M Meyer, P Lambropoulos, T Pfeifer

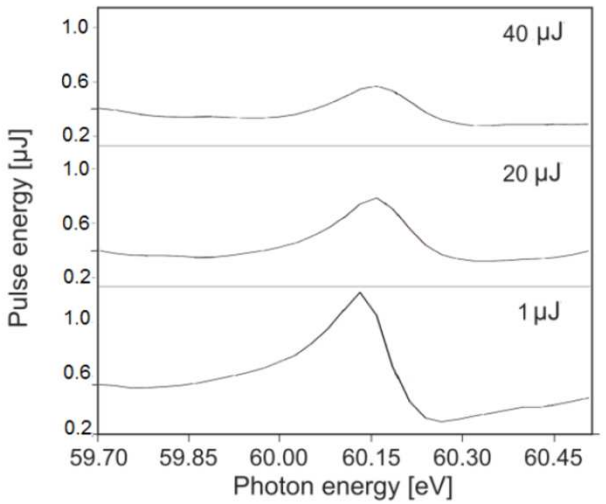






Two-level system interacting with typical noisy SASE FEL pulses, avg. over ~100 shots





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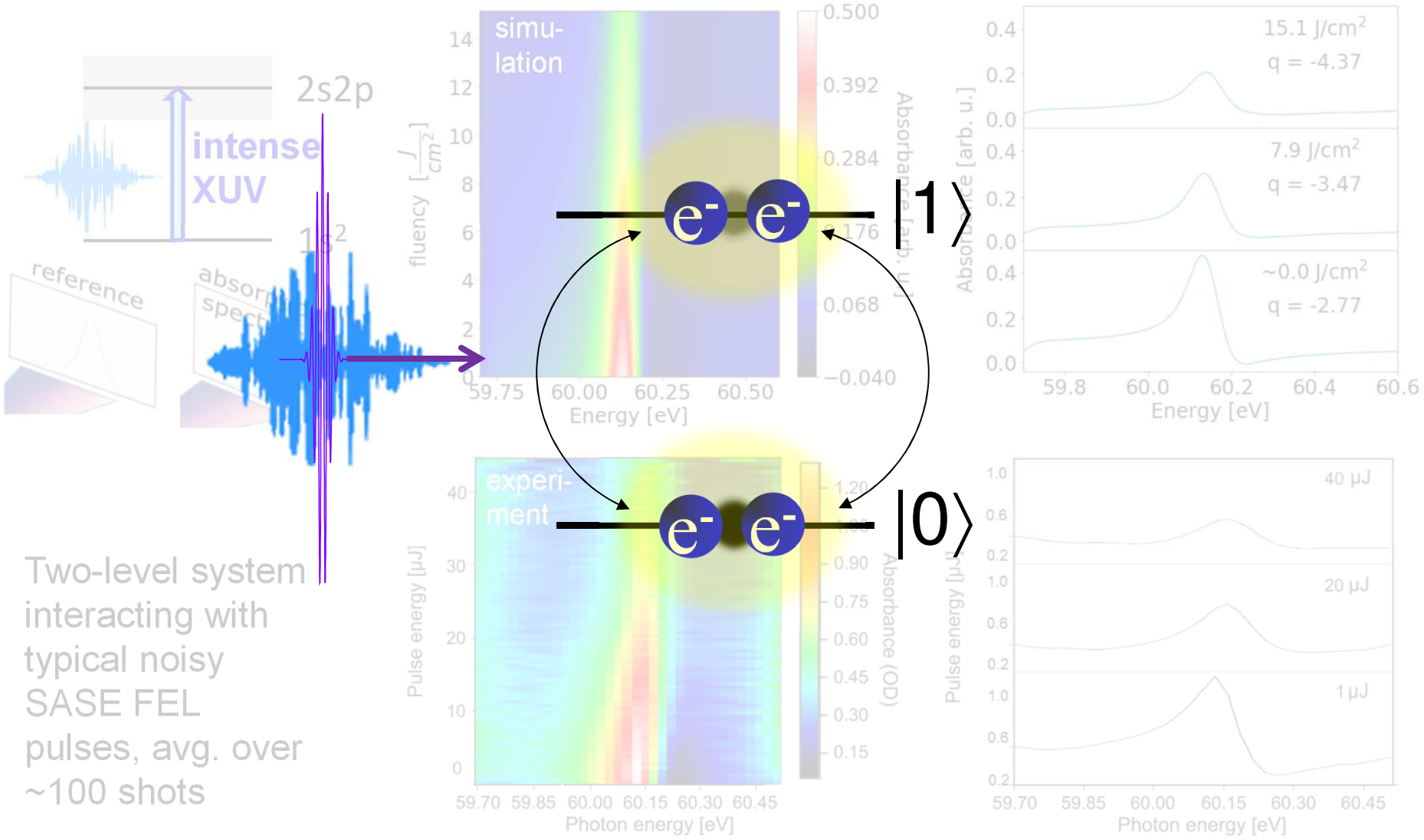

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Helium double excitation

two resonances of interest

Signal considerations (by Dr. A. Magunia, MPIK)

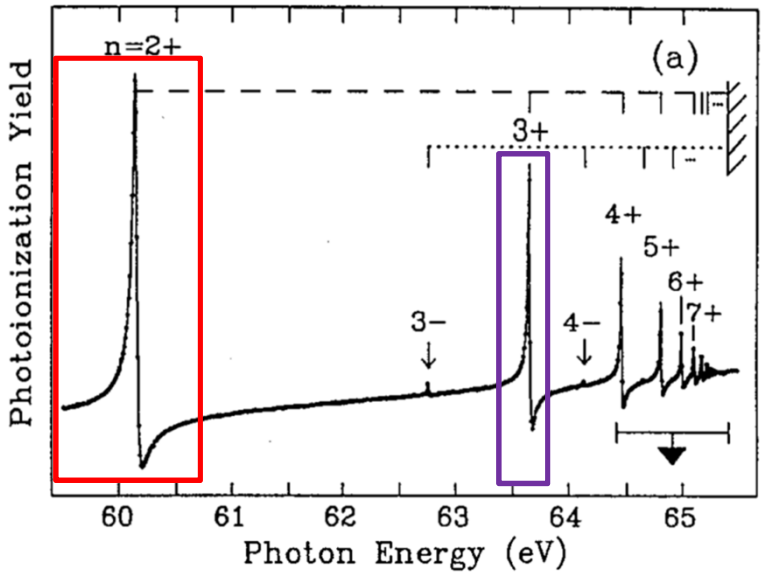
FEL properties:

- 10 µJ pulse energy
- 10 µm focus size
- fluence F= ~ 10^5 J/m^2

$\Rightarrow$ N = F/S = 10 (oversaturated)

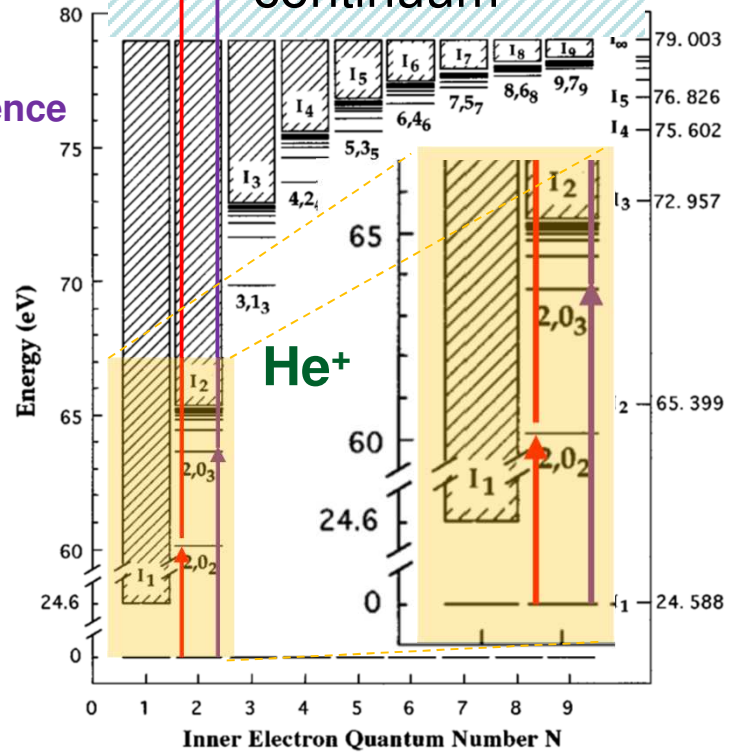
2s2p, 60.1 eV
10 Mb cross section
S ~ 10^4 J/m^2 saturation fluence
38 meV spectral width
18 fs lifetime

sp_{23+}: 63.655 eV
9 Mb cross section,
S ~ 10^4 J/m^2 saturation fluence
8 meV spectral width
90 fs lifetime



ion/electron detectors in coincidence @CAMP

He^{2+} double ionization continuum



M. Domke *et al.*, PRA **53** (1996) 1424

Impact and Outlook

Seeding advantages for gas-phase science:

- Fundamental physics of few-body quantum dynamics
- prepare/control specific excited states
- Technical: conincidence detection requires high repetition rate

A brief sketch of an experimental (atomic-physics) program:

- observe Rabi cycling of 2 correlated electrons
  (this proposal)
- from there (later): combination with IR laser: ultrafast quantum control of few-/multi-electron systems
- if available (later): attosecond time delays of (doubly-) excited states
- mid-term: correlation/entanglement measurement&control

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- mid-term: correlation/entanglement measurement&control
- mentioned by Tim Laarmann during discussion in meeting on 12 June 2025:
  also study chirped-pulse effects