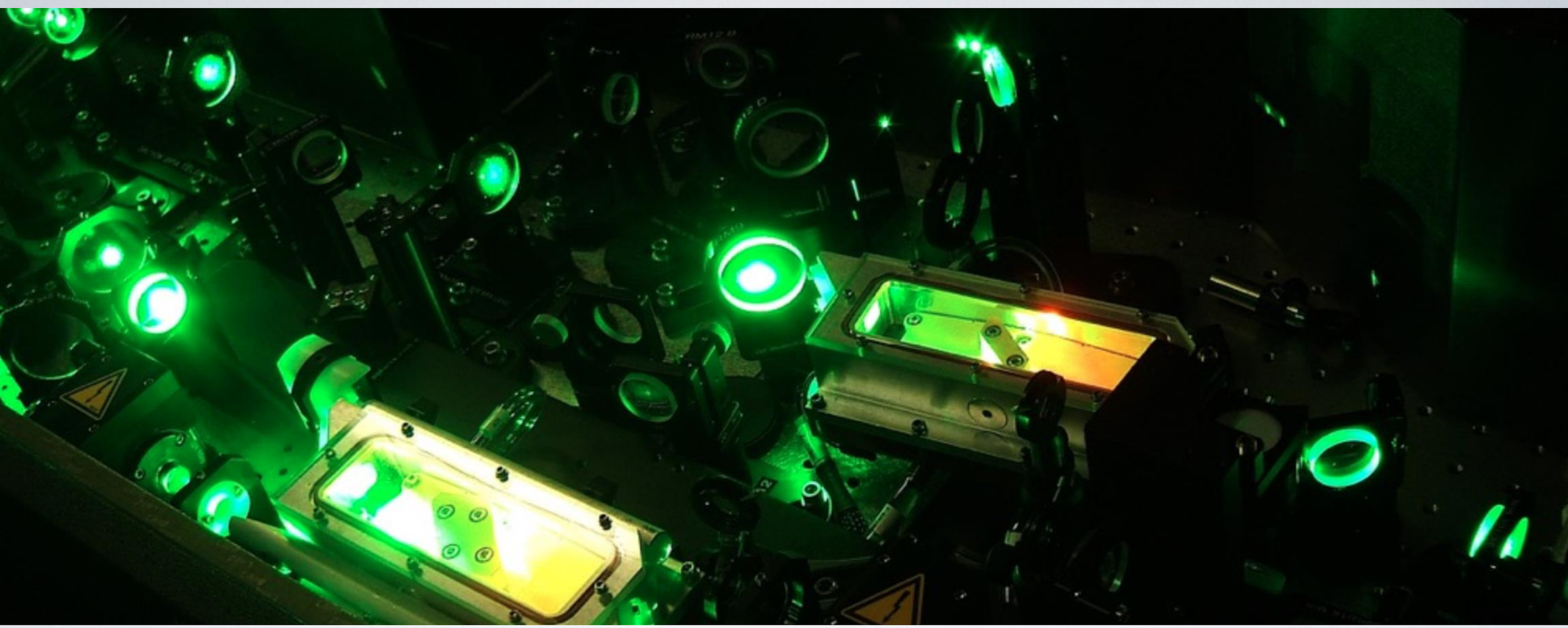


TIME-RESOLVED PHOTOEMISSION EXPERIMENTS WITH LASER BASED HHG SOURCES

Barbara Ressel

Laboratory of Quantum Optics

University of Nova Gorica, Slovenia

Frascati, 6.12.2024

OUTLINE

CITIUS light source

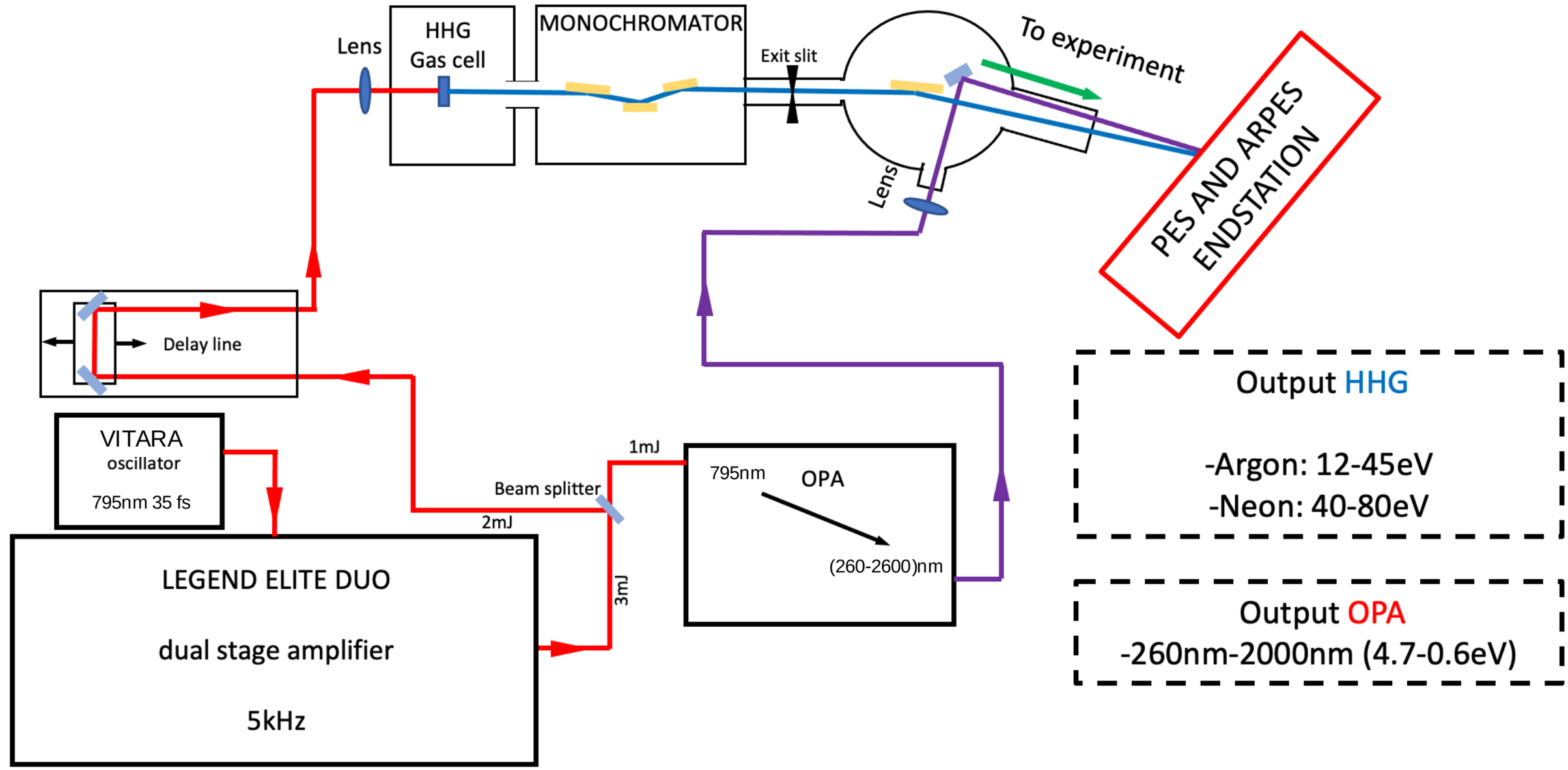
High order Harmonic Generation (HHG)

Applications:

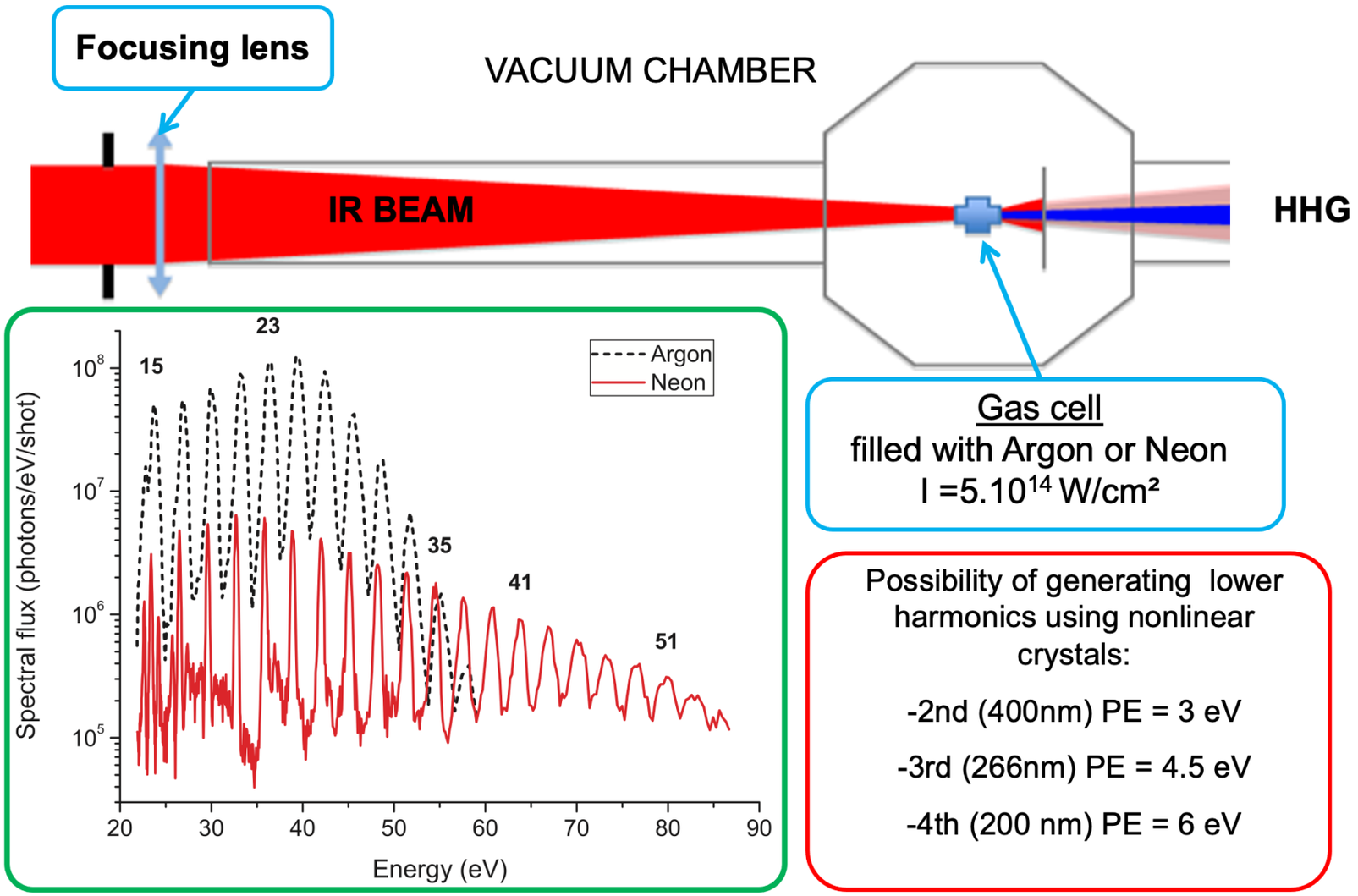
Time resolved photoemission

Challenges and examples

CITIUS LIGHT SOURCE



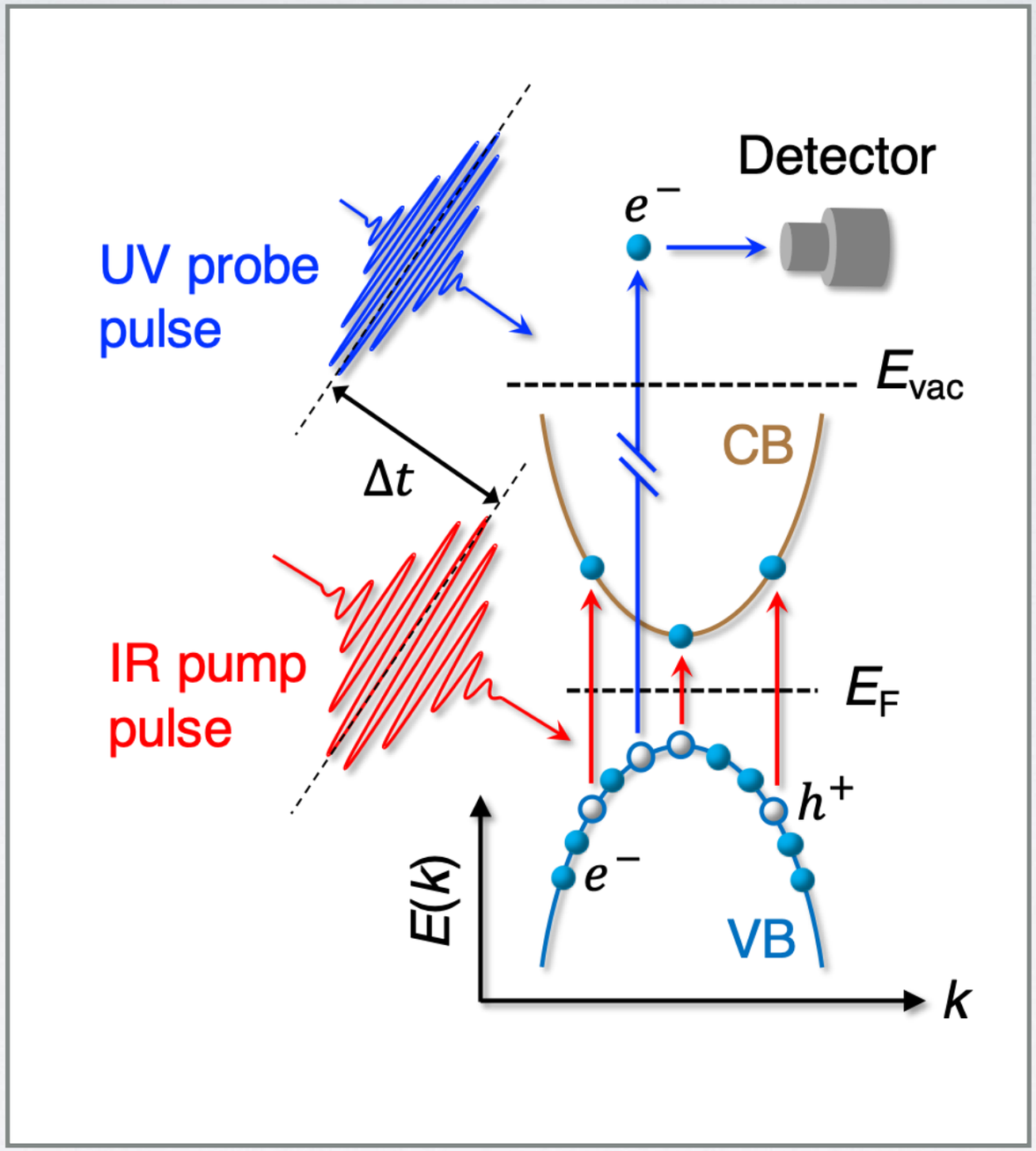
HHG GENERATION



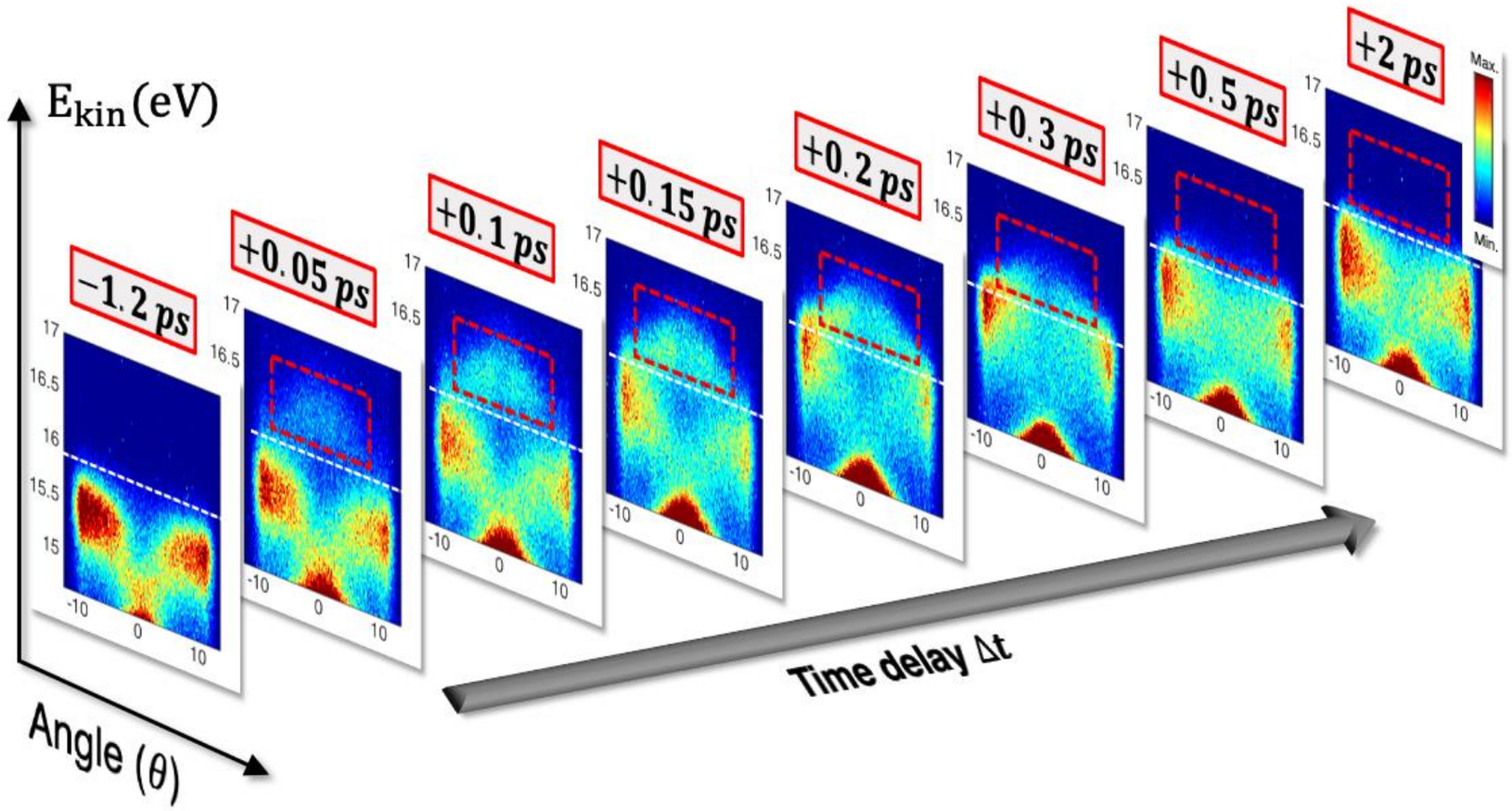
FERMI FEL-1		CITIUS	
Energy range	12.4 — 120 eV	Energy range	14 — 80 eV
Pulse duration	20 — 40 fs	Pulse duration	35 fs
Rep rate	10/50 Hz	Rep rate	5 kHz
Photons/pulse	10^{12} — 10^{14}	Photons/pulse	10^{5} — 10^{8}

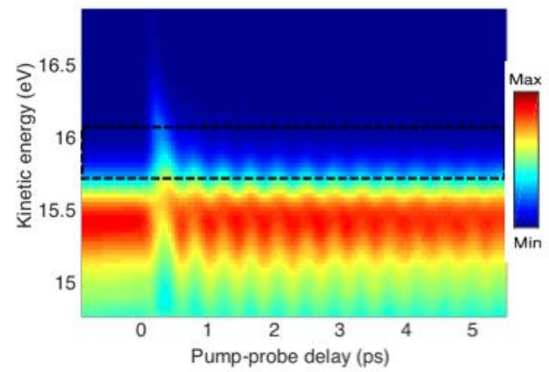
Grazioli et al., *Rev. Sci. Instrum.* 85, 023104 (2014)

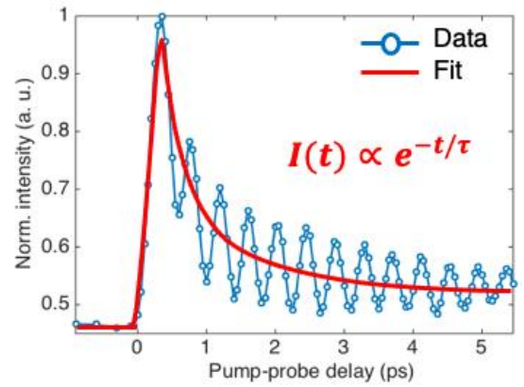
TIME RESOLVED PHOTOEMISSION



TYPICAL DATA SET



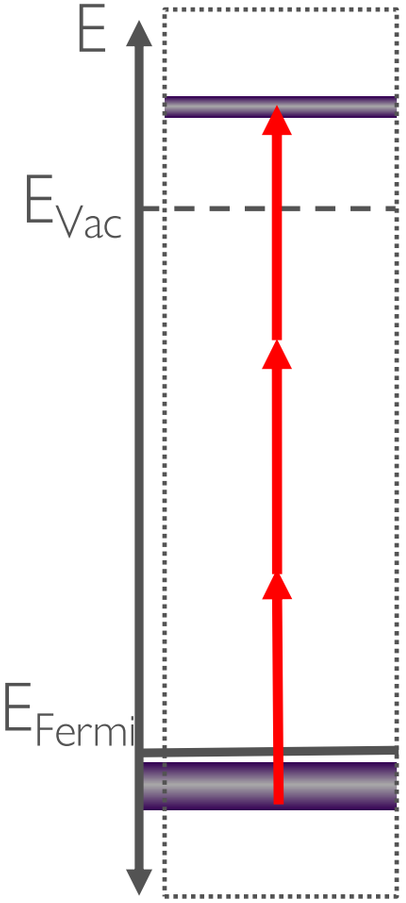




CHALLENGES

- ✓ LIMITED ENERGY RESOLUTION
- ✓ REPETITION RATE
- ✓ MULTIPHOTON ELECTRON EMISSION
- ✓ SPACE CHARGE EFFECT
- ✓ LASER ASSISTED PHOTOEMISSION (LAPE)

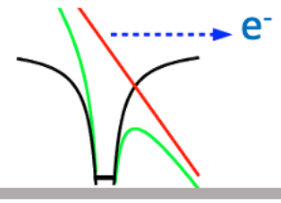
MULTIPHOTON EMISSION



CAUSES

-THERMIONIC EMISSION or HOT EMISSION:
just like emission from a hot filament, but the electrons are heated with the laser.

- FIELD EMISSION or COLD EMISSION: the potential of the atom is perturbed by the lasers electric field so that the electrons are ripped from the parent atom.



EFFECTS

- BACKGROUND

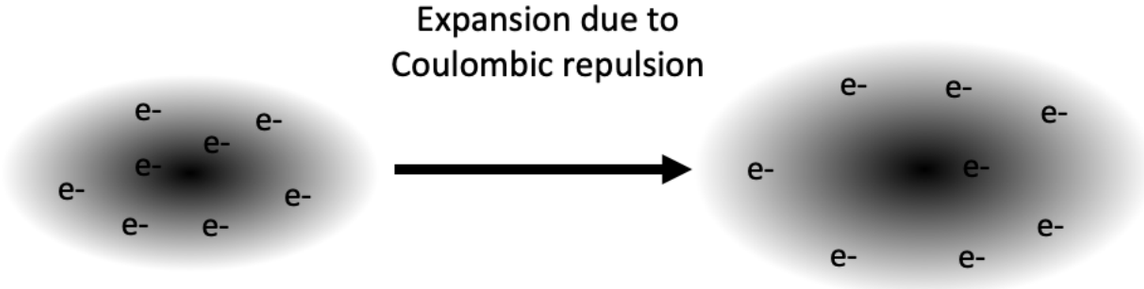
- ENERGY SPREAD AND SHIFTS (due to the resulting space charge effect)

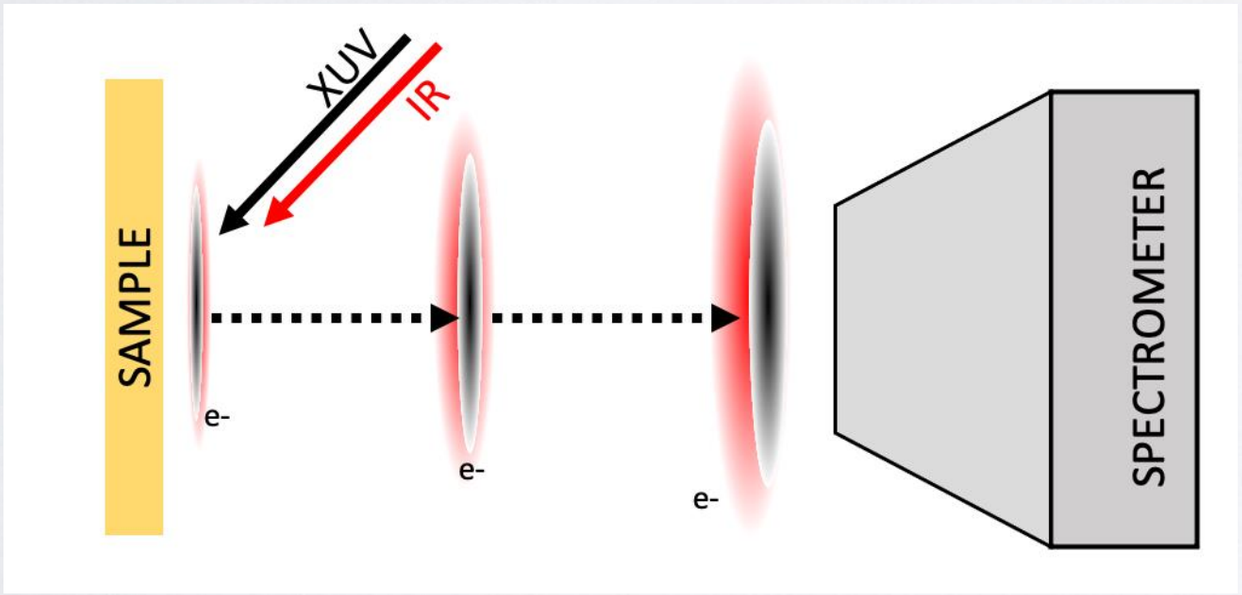
REMEDIES

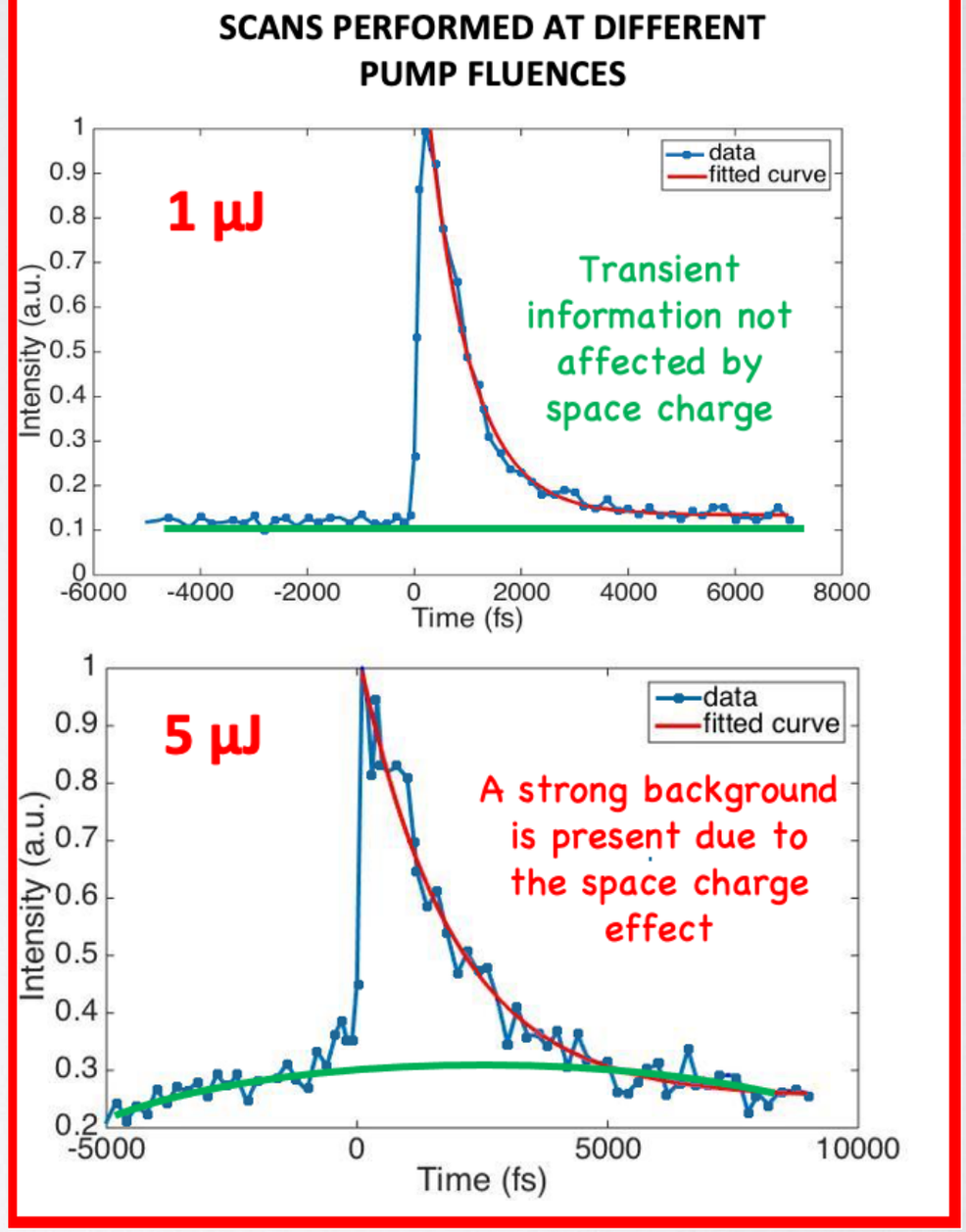
- Reduction of laser energy flux

- Alignment and sample preparation to avoid illuminating facets and defects

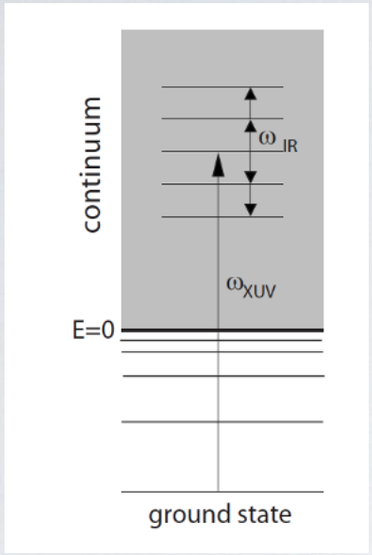
SPACE CHARGE EFFECT





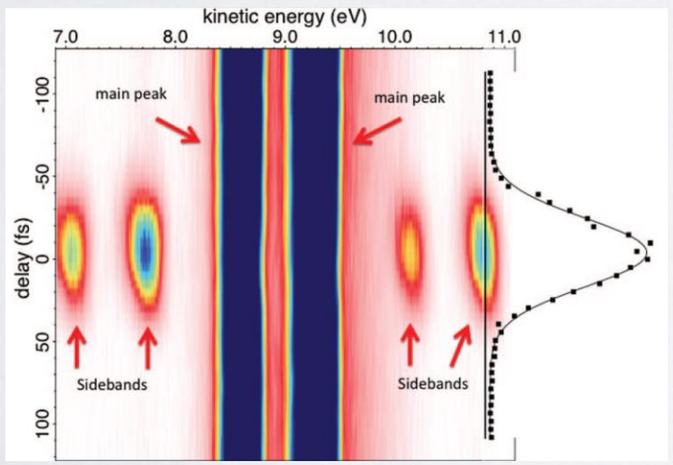


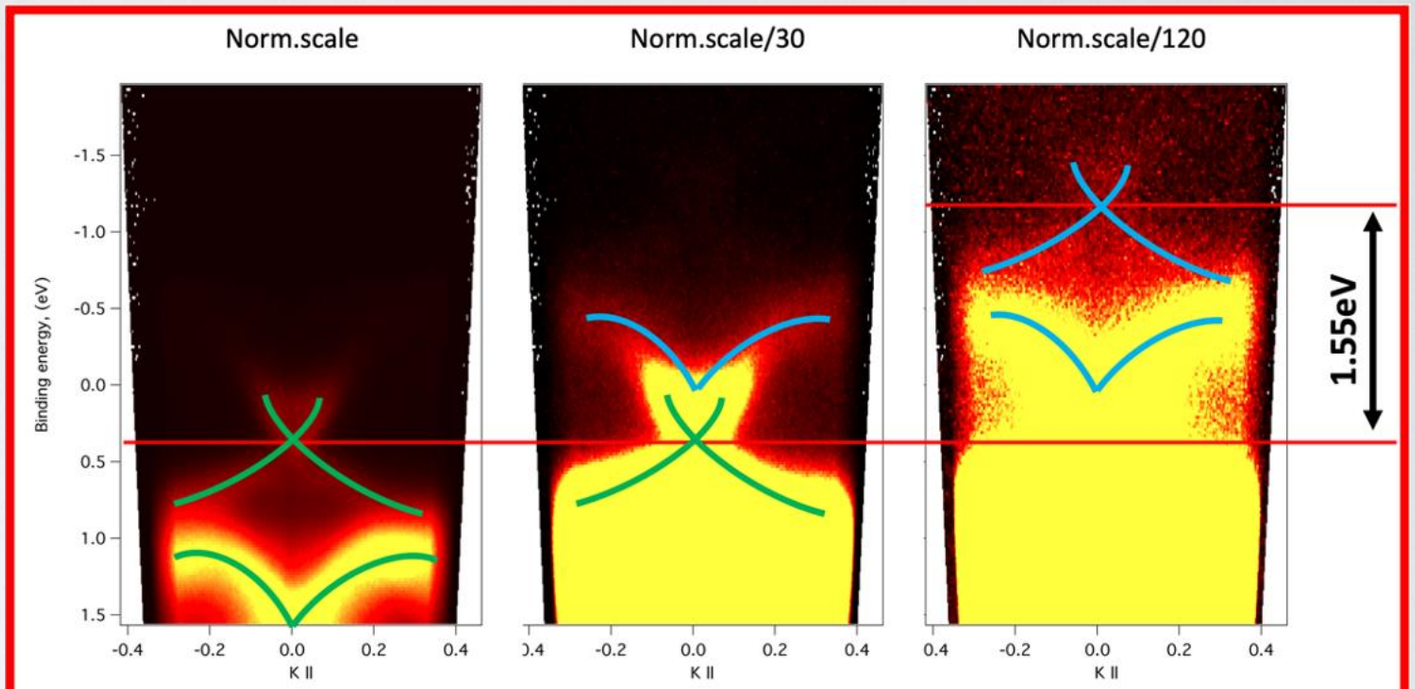
LASER ASSISTED PHOTOEMISSION

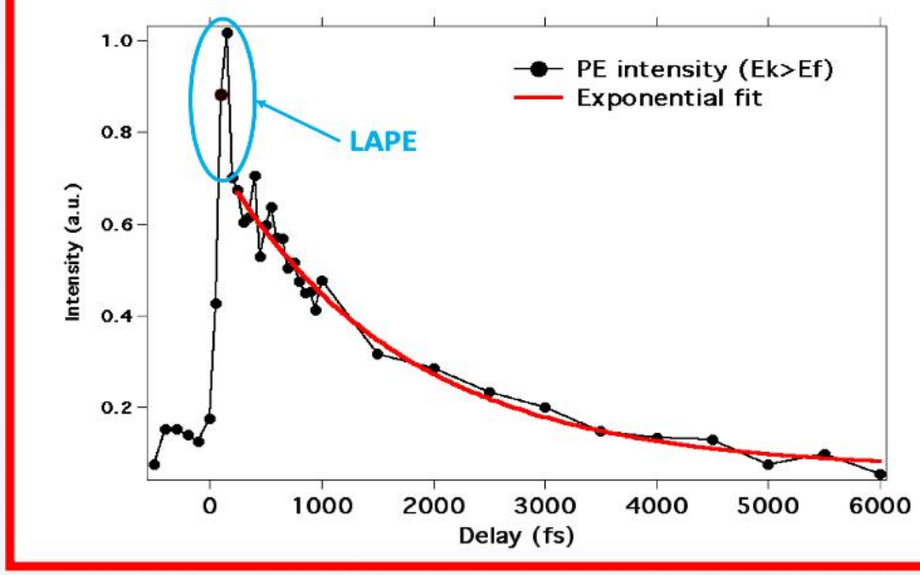


In a LAPE process additional photon can be absorbed or emitted by the electron, resulting in sidebands.

LAPE can be very useful as a tool for the characterization of XUV pulse duration.



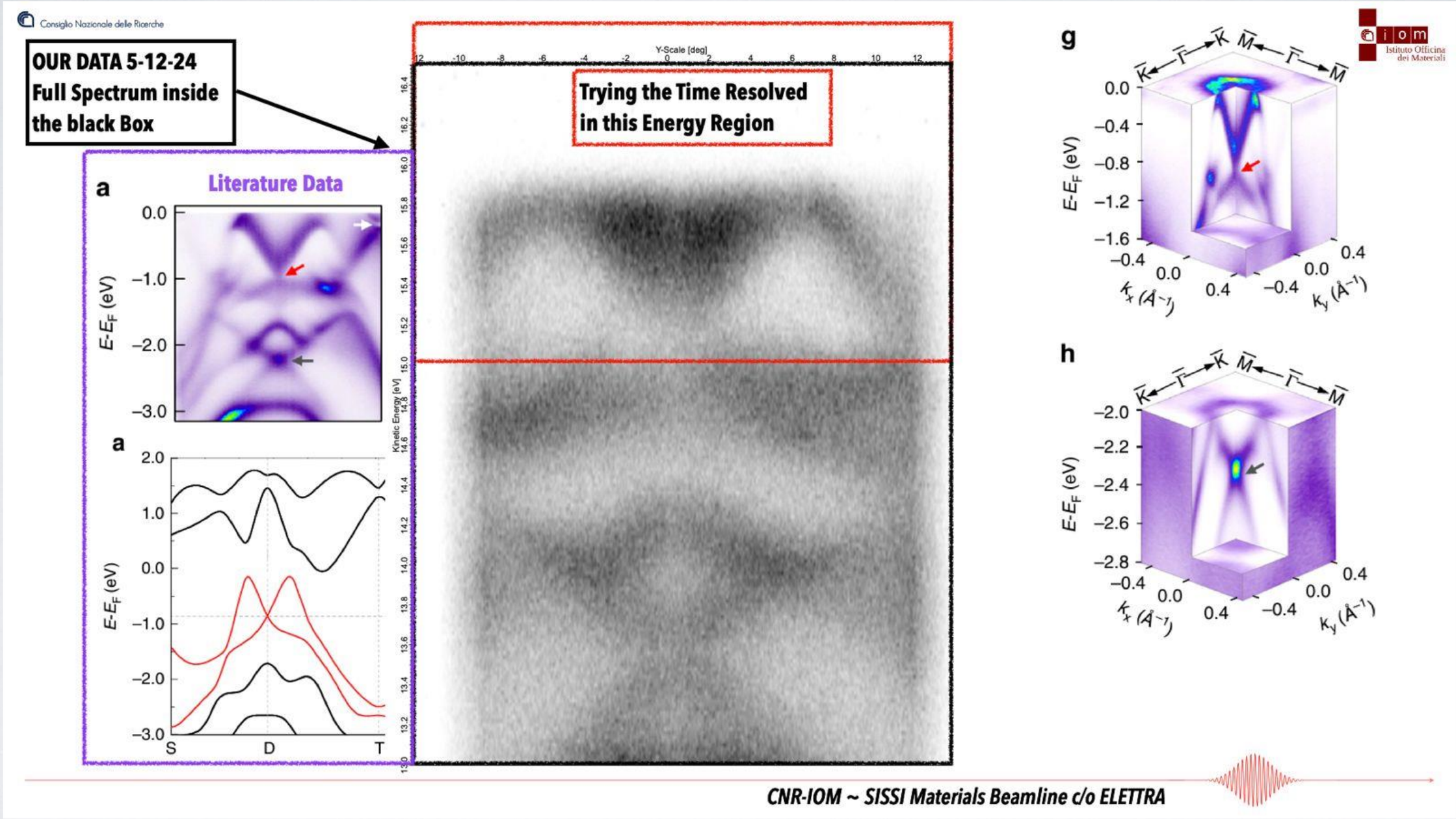




Can form replicas of spectral features in a PES experiment.

Can induce features not related to the response of the material.

ENERGY RESOLUTION



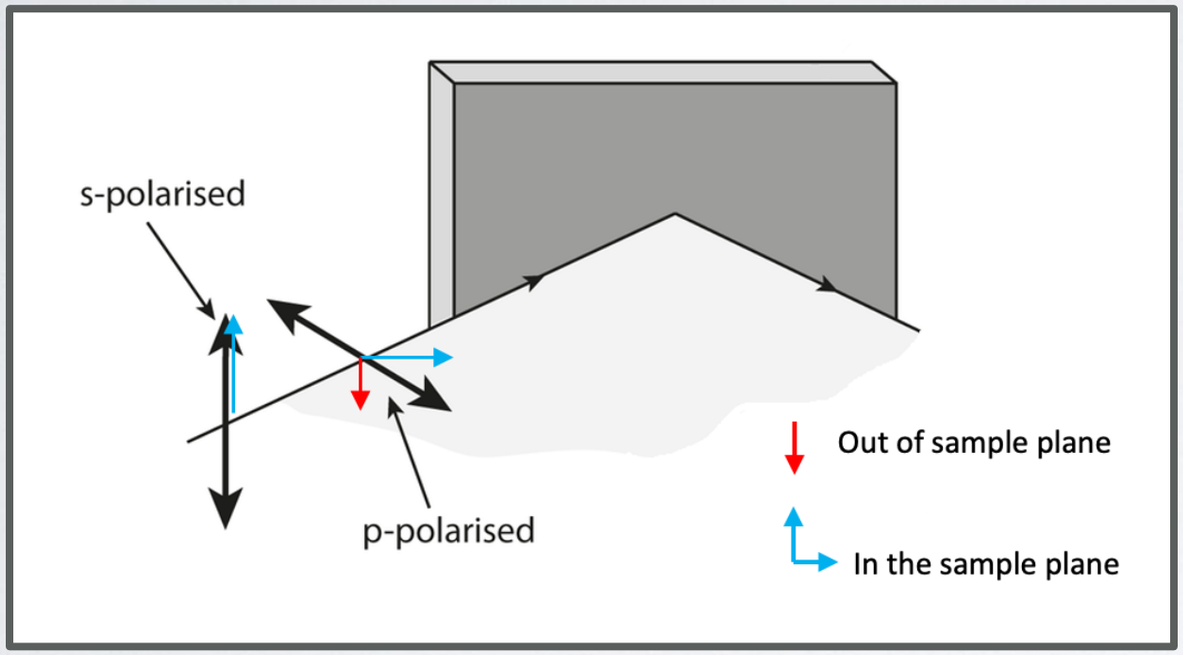
PtTe$_2$ ARPES data - Courtesy of dr. Zacchigna (CNR-IOM)

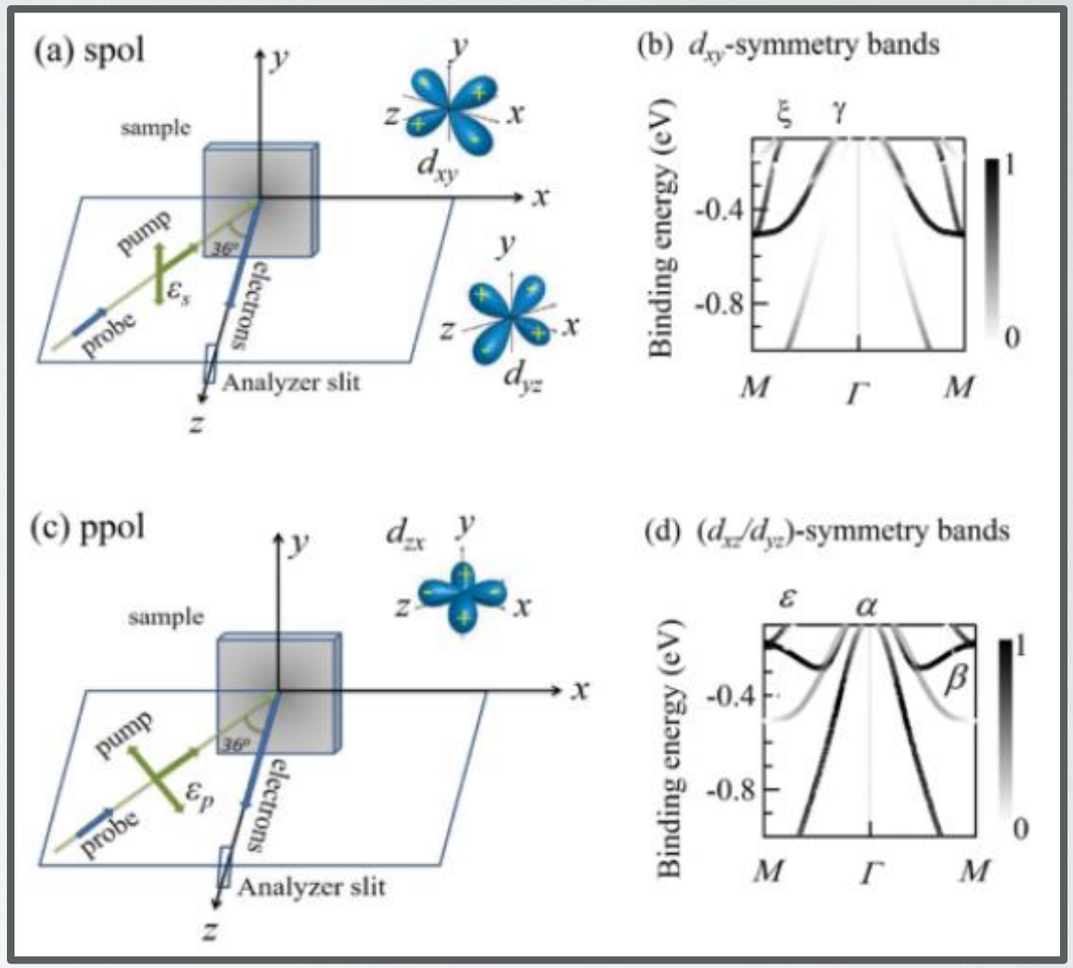
THE “GOOD” SIDE

- ✓ Straight forward control on the linear polarization
- ✓ Possibility of further compression of pulses (hollow fiber compressor)
- ✓ GAS PHASE PHOTOEMISSION - ref. dr. Marcello CORENO

SELECTIVE ORBITAL EXCITATION

Both pump (IR) and probe (XUV) beams allow for easy manipulation of their linear polarizations





PHYSICAL REVIEW B **98**, 205142 (2018)

Orbital-dependent electron dynamics in Fe-pnictide superconductors

Ganesh Adhikary,[1,*] Barbara Ressel,[1] Matija Stupar,[1] Primož Rebernik Ribič,[2] Jurij Urbančič,[1] Giovanni De Ninno,[1,2,†] D. Krizmancic,[3] A. Thamizhavel,[4] and Kalobaran Maiti[4,‡]

Using polarization to selectively excite orbitals in $EuFe_2As_2$ pnictide

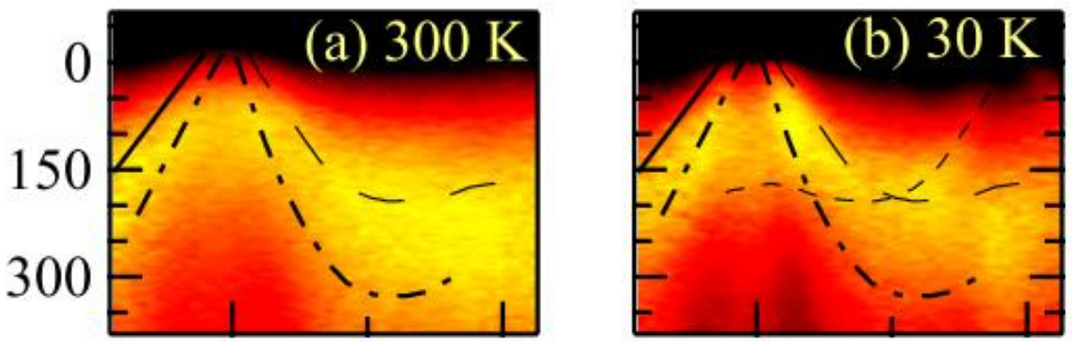
UNIVERZA V NOVI GORICI
SCIENTIA VINCES
1995

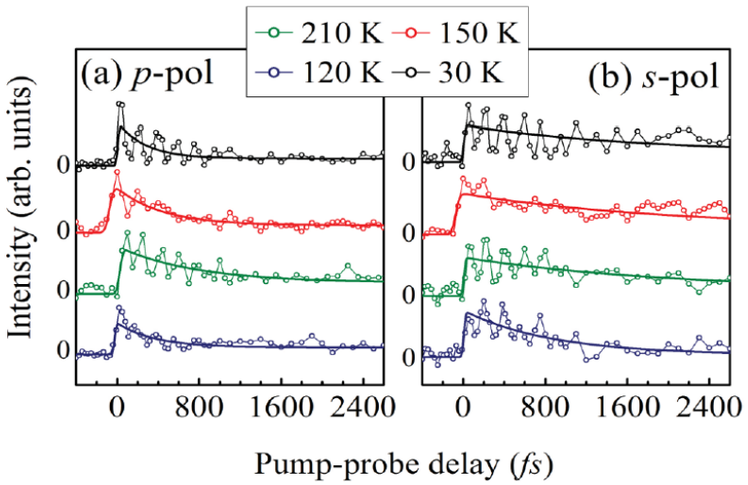
SELECTIVE ORBITAL EXCITATION

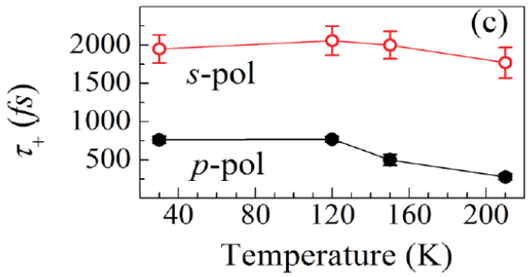
Europium pnictide - $EuFe_2As_2$

✓ Parent compound to Fe superconductors

✓ Study of electron correlation

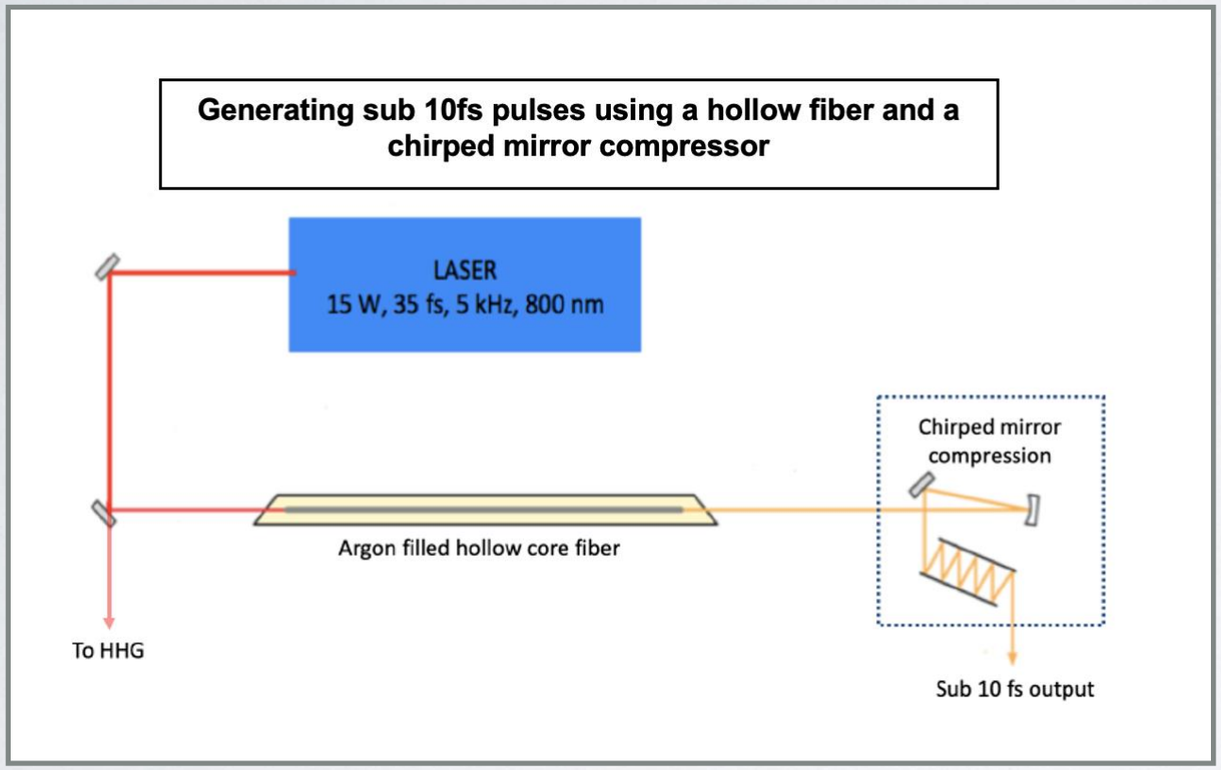


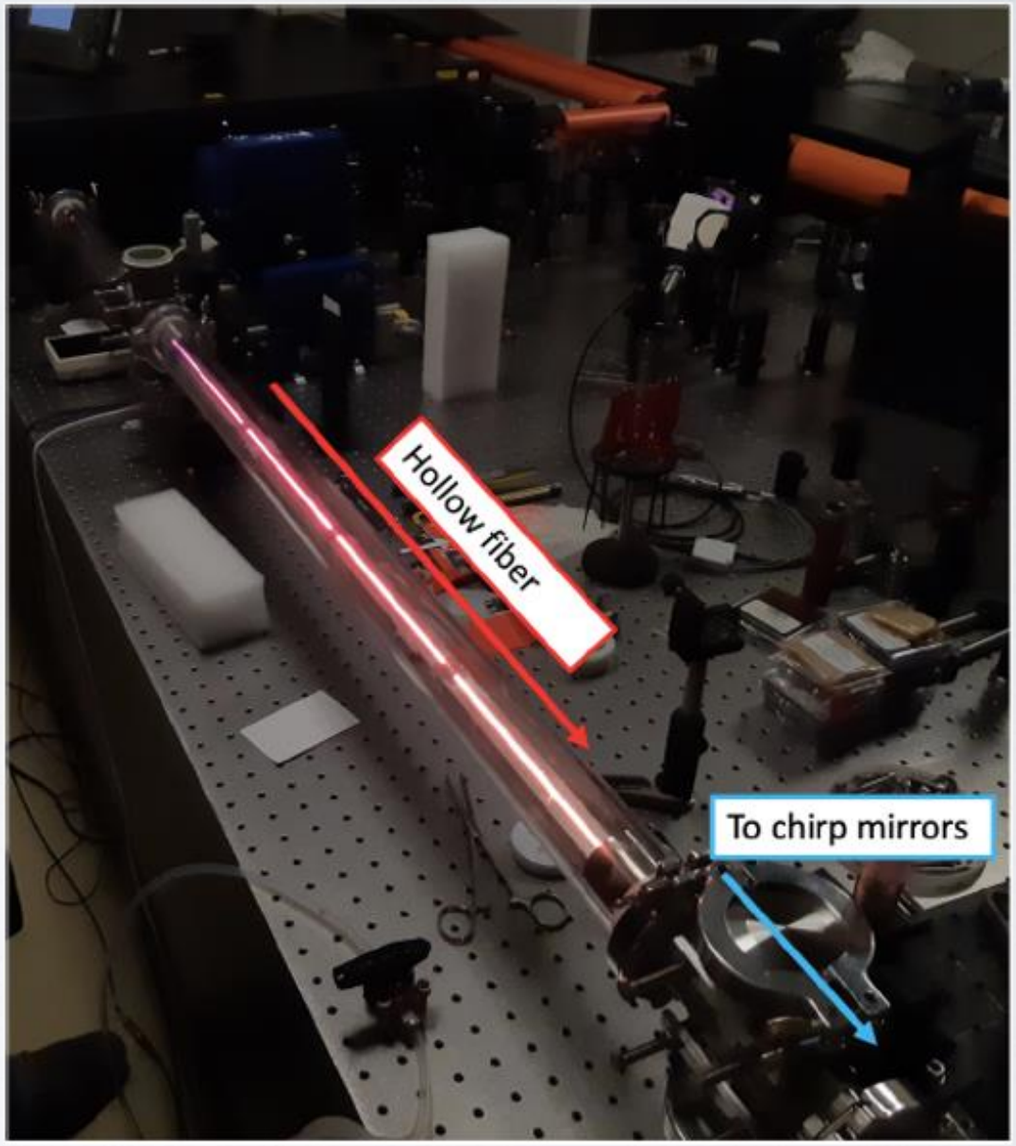




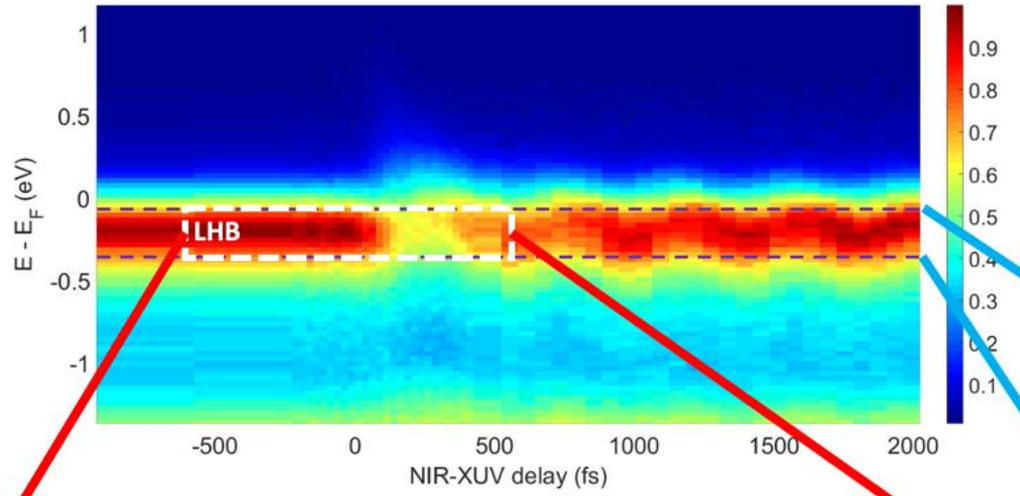
Different dynamics for different symmetry bands are fingerprint of different interactions and localizations of bands

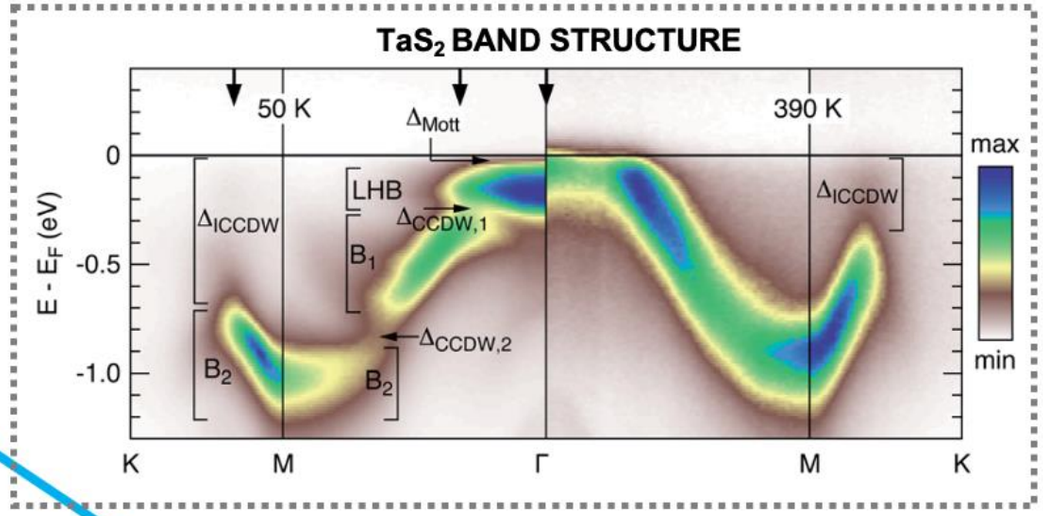
HOLLOW FIBER COMPRESSOR

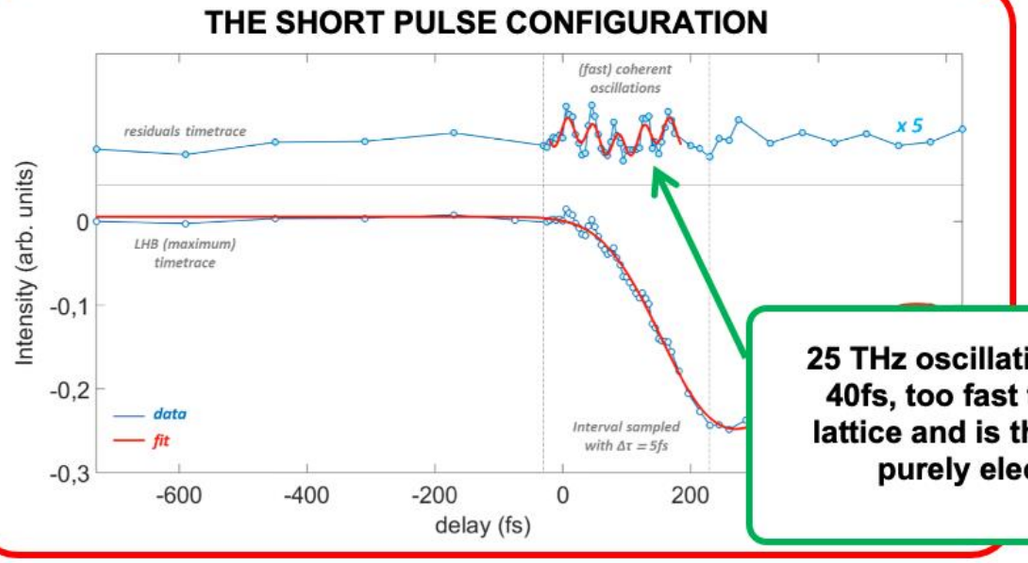


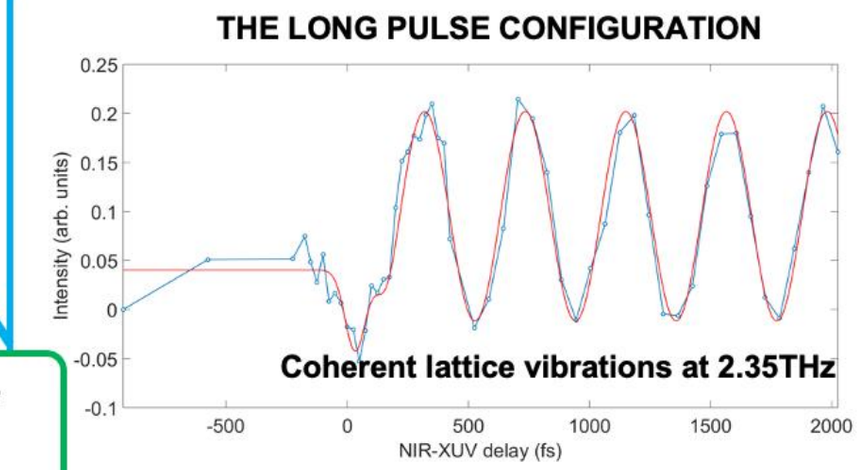


ULTRAFAST OSCILLATIONS IN TaS_2









25 THz oscillations with a period of 40fs, too fast to be related to the lattice and is therefore related to a purely electronic process

Simoncig A., et al., Phys. Rev. B **103**, 155120

CONCLUSIONS

CITIUS novel light source providing ultrashort light pulses in the XUV soft X ray spectral region

TR photoemission pros and cons

Access through proposal submission

- NEP (NFFA Europe Pilot), call every 3 months

https://www.nffa.eu

- Elettra Sincrotrone Trieste - Fermi, call every 6 months

https://www.elettra.eu/userarea/access-request.html

LKO GROUP AND COLLABORATORS

LKO @ University of Nova Gorica
Prof. Dr. Giovanni De Ninno
Izr. Prof. Dr. Barbara Ressel
Dr. Johannes Schmidt

Ph.D. students:
Rokaya Osama
Arun Ravindran
Luka Novinec

Sincrotrone Trieste S.C.p.A.
Prof. Dr. Giovanni De Ninno
Dr. Primož Ribič Rebernik
Dr. Carlo Spezzani
Luka Novinec

Dr. Alberto Simoncig

Dr. Marcello Coreno (ISM-CNR)

CNR- IFN (Padova, Italy)
Dr. Luca Poletto
Dr. Fabio Frassetto

Dr. Paolo Miotti