Time- and spin-resolved ARPES at ATTOLAB

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photoelectron spectroscopy set-up (TOF-spin)

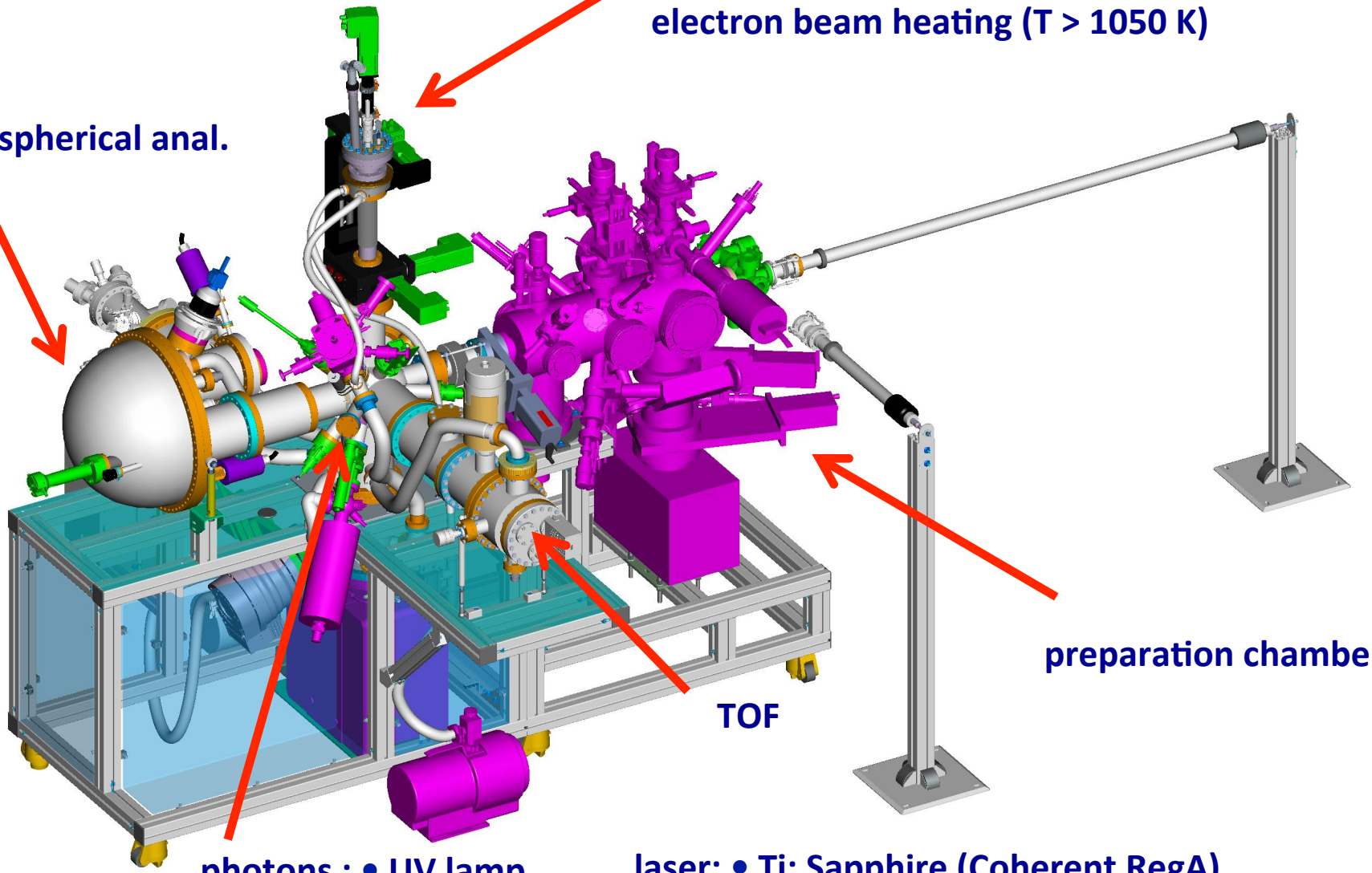
recent results on the Bi_2Se_3 topological insulator

currently in study: time resolved band structure of Fe(001)

perspective: influence of electronic correlation effects on the time scale of the photoemission process

TOF-SPIN configuration

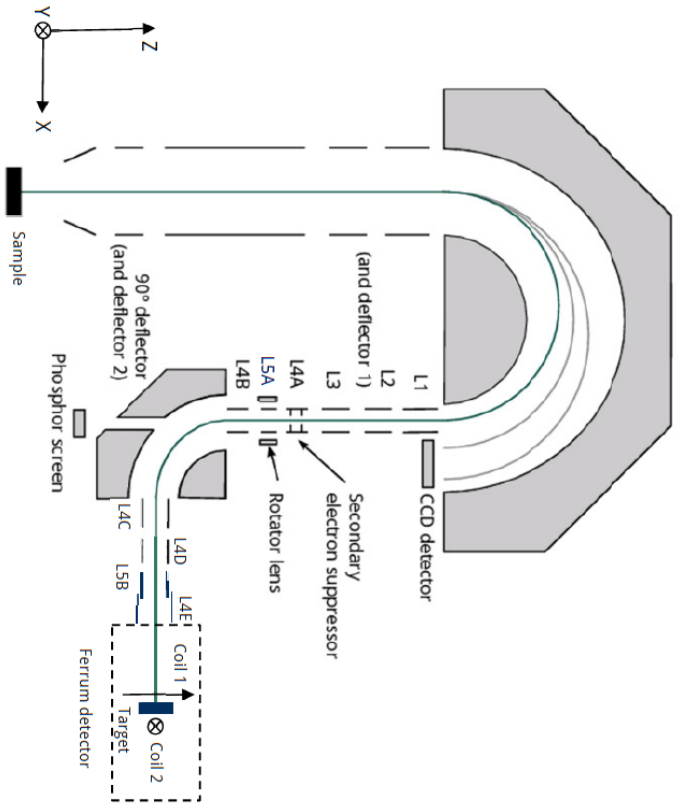
5- axis manipulator (x, y, z, θ, ϕ)
He-cooling (T < 20 K)
electron beam heating (T > 1050 K)



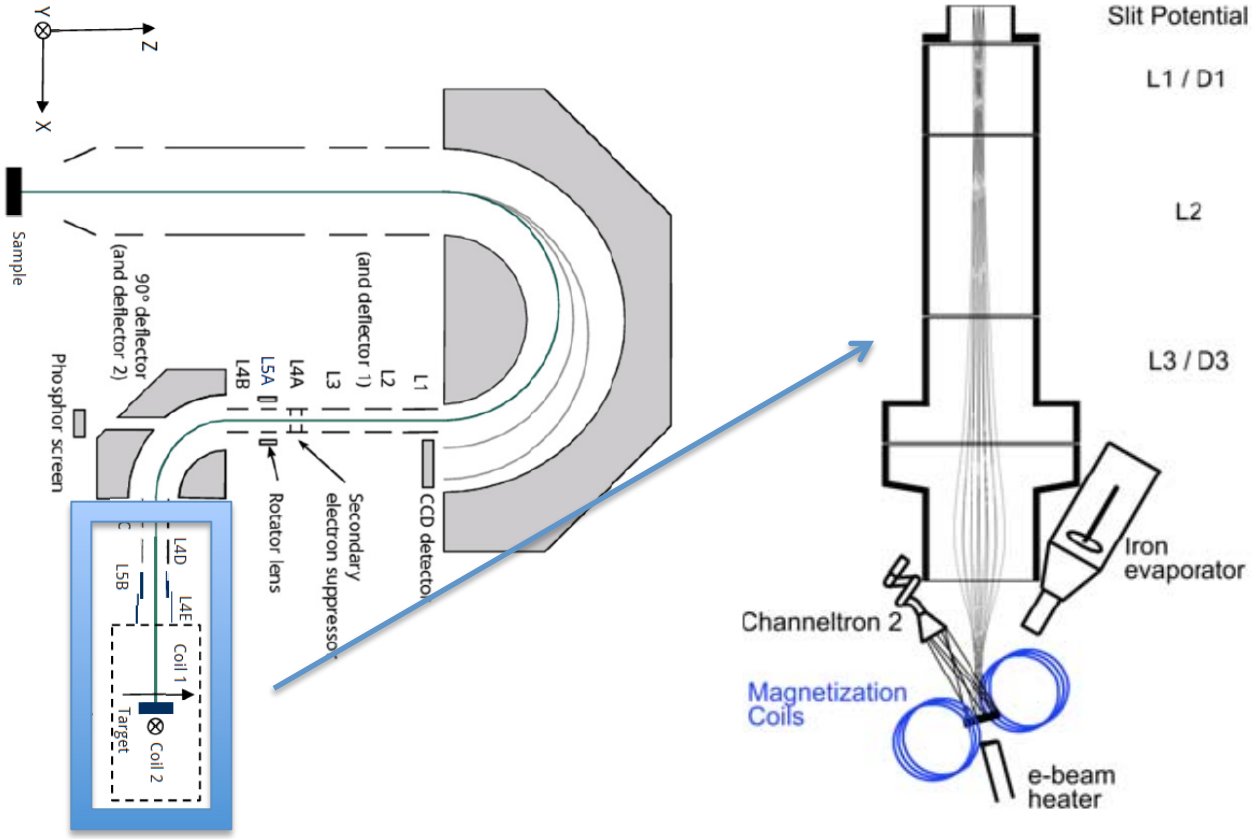
laser: • Ti: Sapphire (Coherent RegA),
• 780 nm (1.55 eV), 250 kHz/ 150 fs
• fourth harmonics (6.2 eV)

TOF-SPIN configuration at LPMS

spin analysis Ferrum, FOCUS

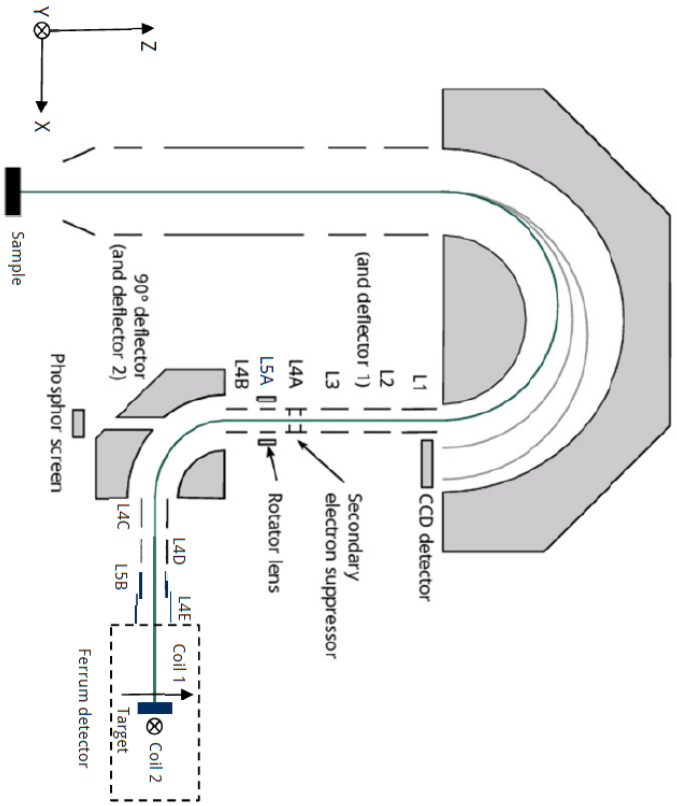


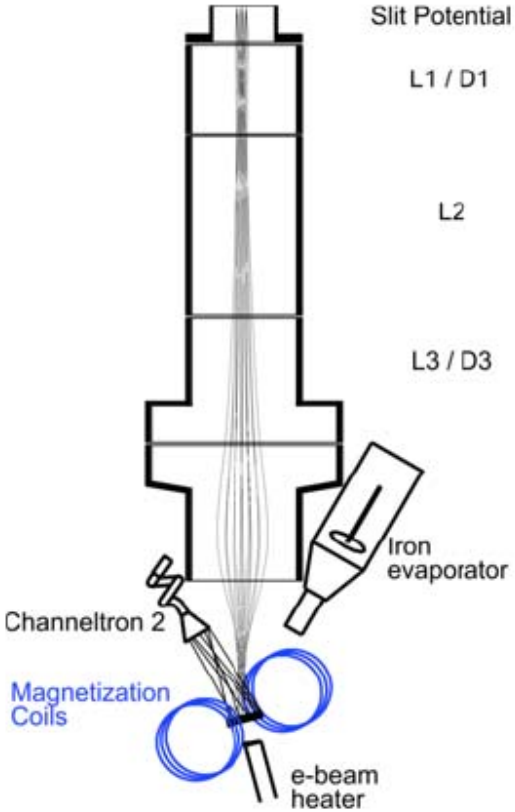
spin analysis Ferrum, FOCUS

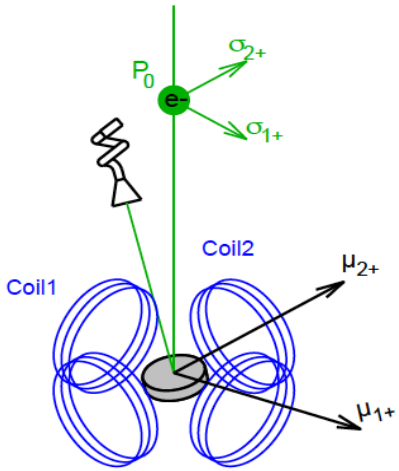


- low-energy exchange scattering

spin analysis Ferrum, FOCUS



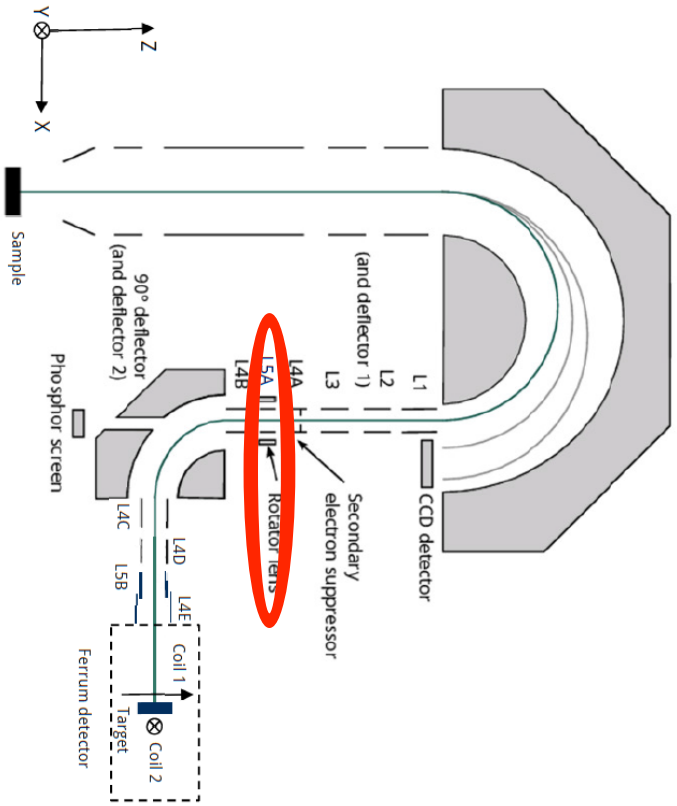


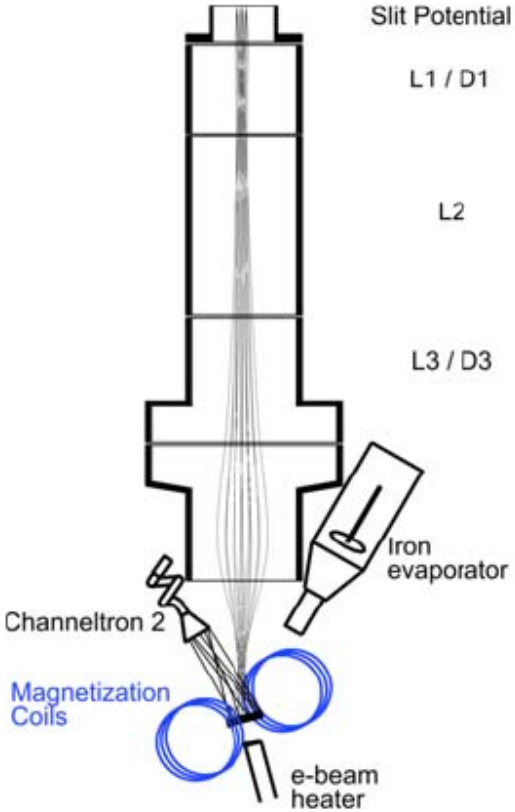


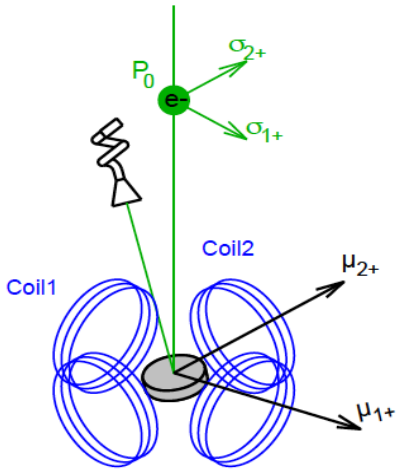
Fe-O

- low-energy exchange scattering

spin analysis Ferrum, FOCUS







Fe_3O_4

- low-energy exchange scattering
- access to 3 components of *P*

spin analysis

asymmetry
I_1 and I_2 :
scattering channels

$$A_m = \frac{I_1 - I_2}{I_1 + I_2}$$

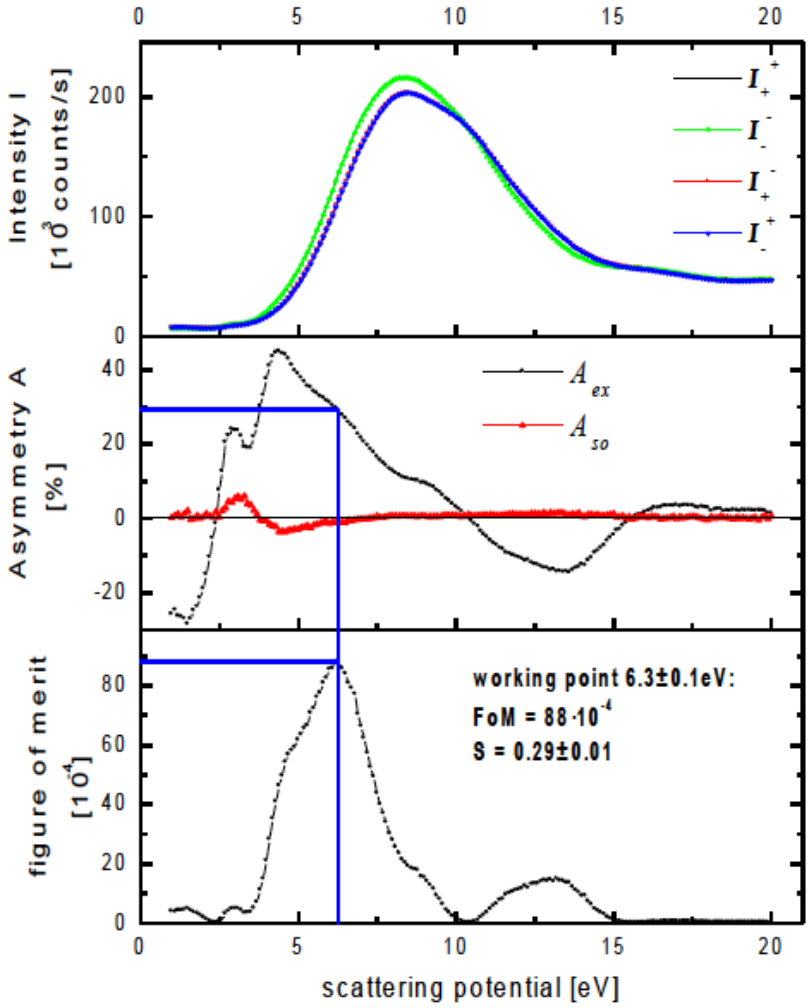
polarization
S_{eff} Sherman function

$$P = \frac{1}{S_{\text{eff}}} A_m$$

figure of merit

$$F = S_{\text{eff}}^2 \frac{I}{I_0}$$

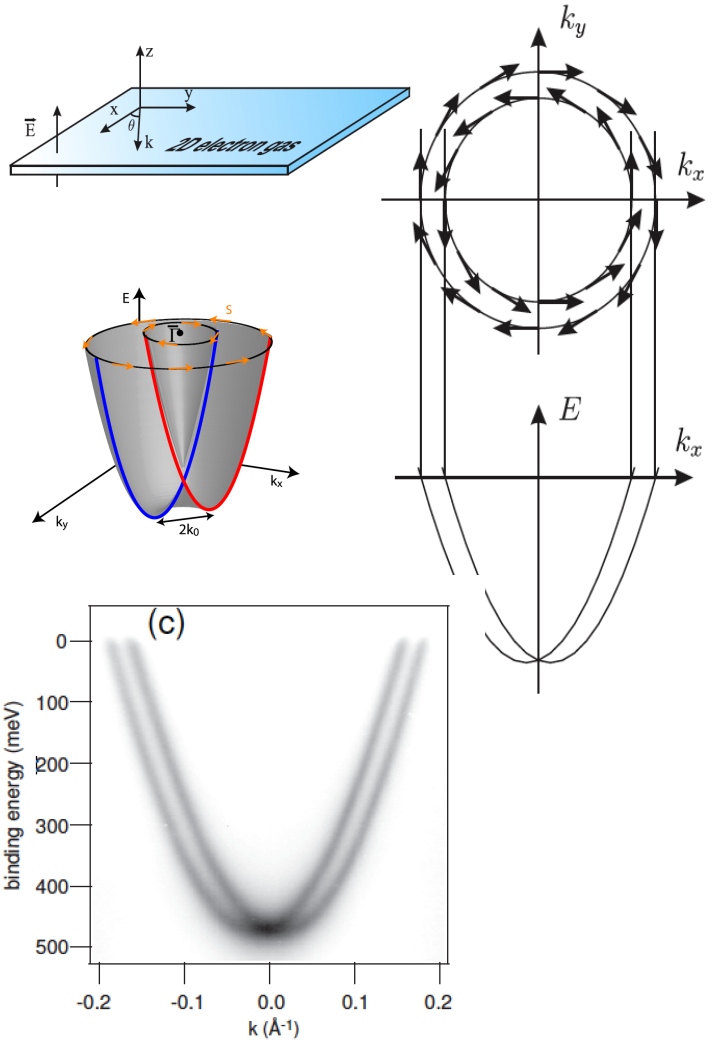
$$\Delta P_{\text{stat}} \approx \frac{1}{\sqrt{tI_0}} \frac{1}{\sqrt{F}}$$



Mott detector: F= 2.53 10^{-4}

acceptance measurements

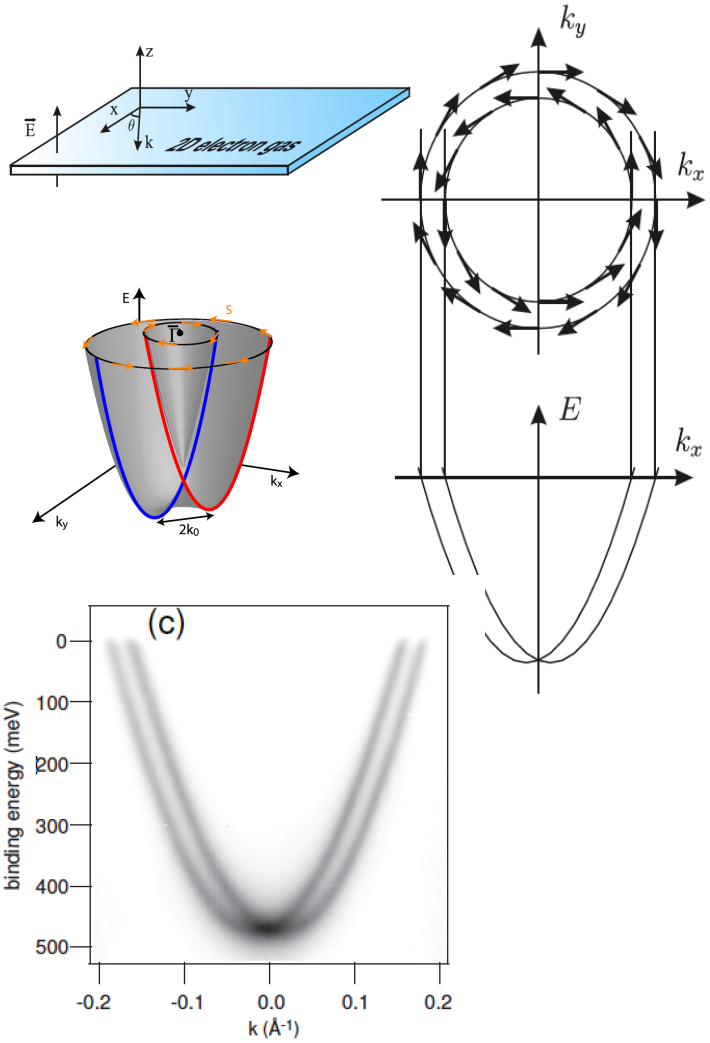
Au(111) Rashba state

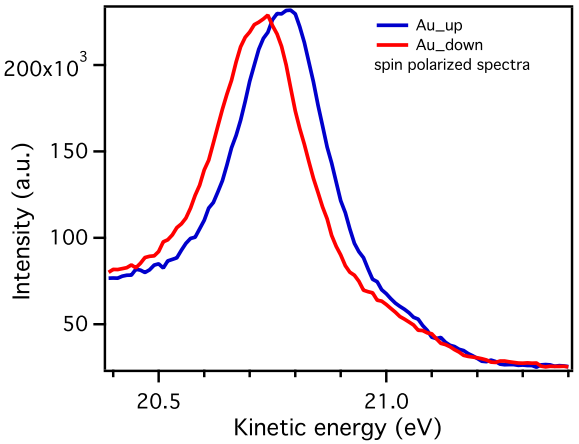


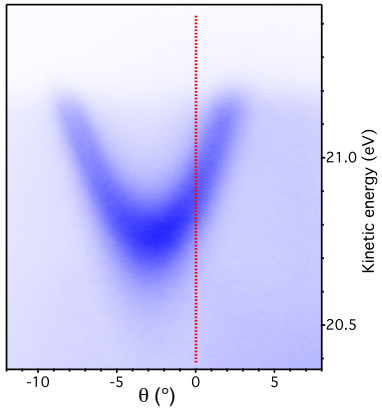
Nechaev, PRB 2009

acceptance measurements

Au(111) Rashba state





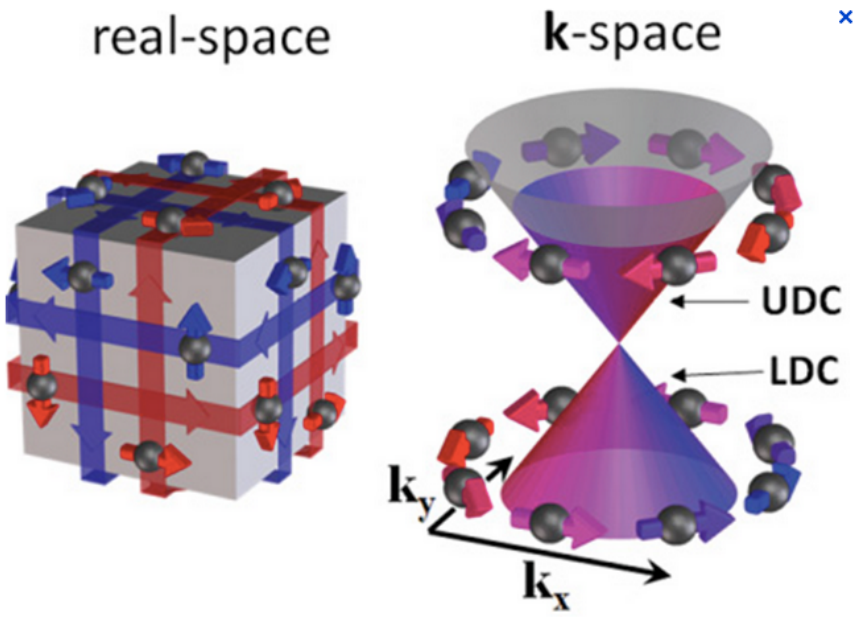


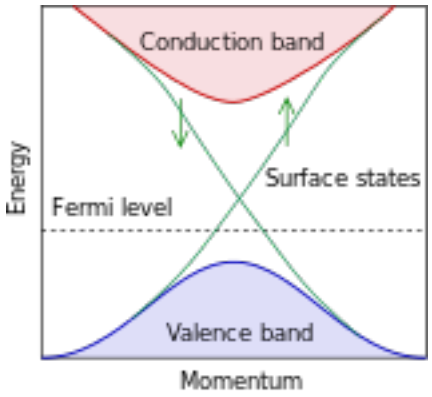
Nechaev, PRB 2009

recent results on the Bi_2Se_3 topological insulator

topological insulator insulator inside, conducting states at the surface

spin locked at a right-angle to their momentum





recent results on the Bi_2Se_3 topological insulator

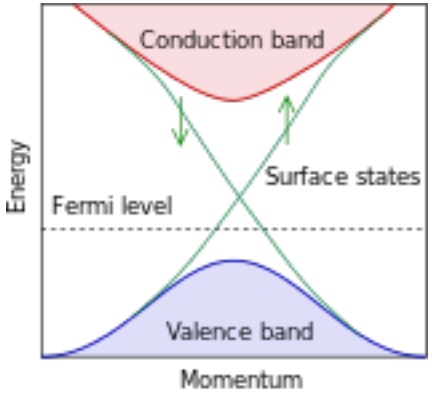
experiments: pump-probe

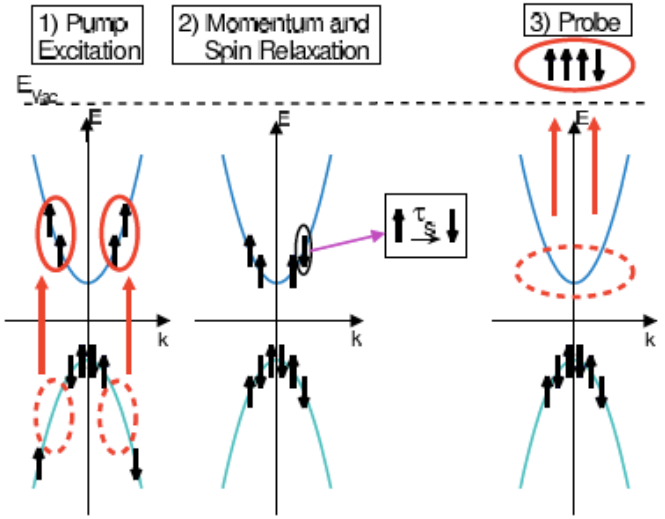
commercial Ti:Saphir regenerative amplifier (Coherent RegA),

pump: 780 nm (1.55 eV), 250 kHz/ 150 fs

probe: 4th harmonic 195 nm (6.2 eV) s-polarized

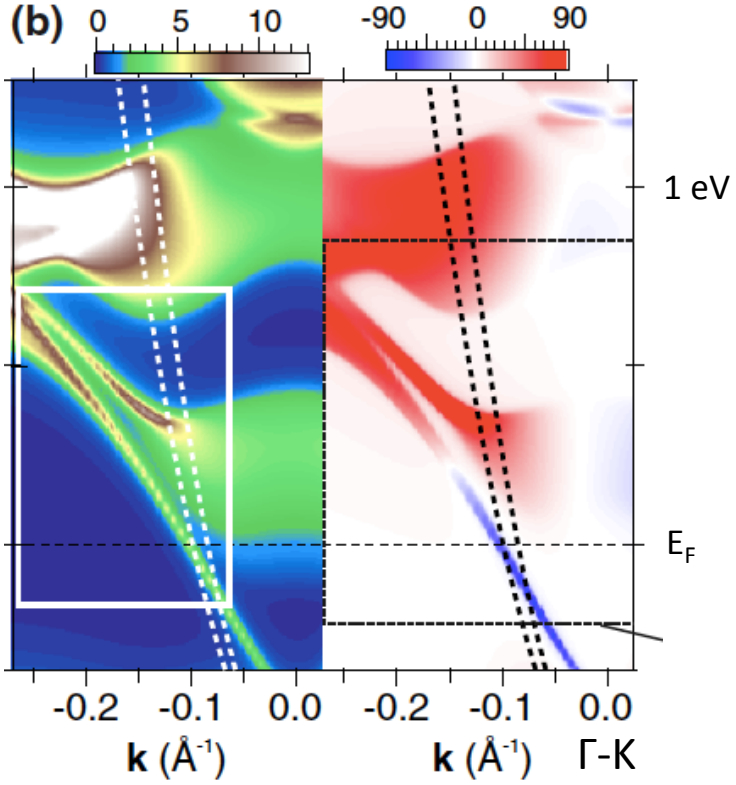
Diamond, RAL, GB



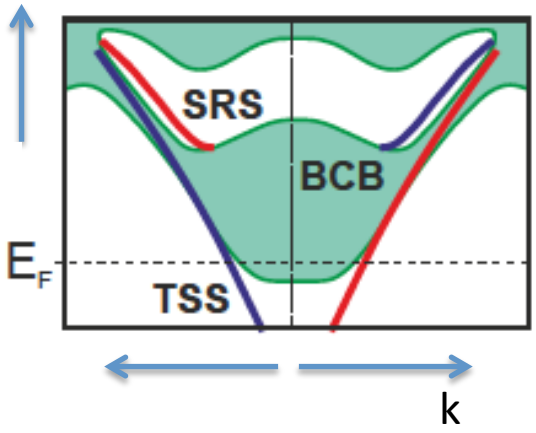


ab initio photoemission calculations

spin integrated spin resolved

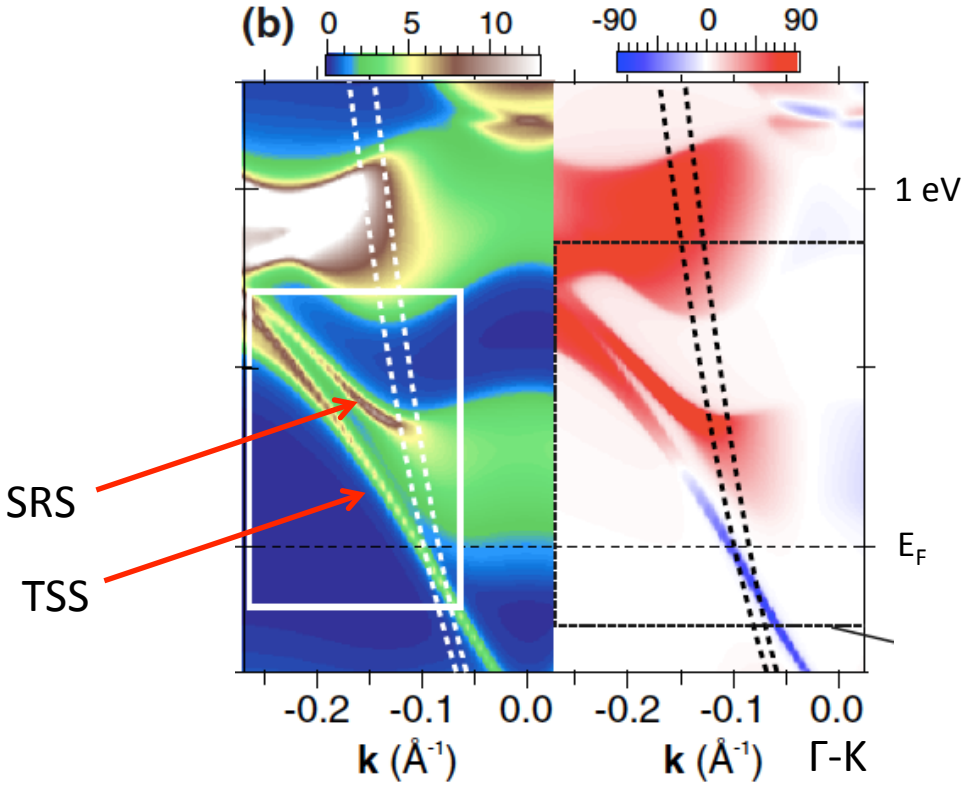


C. Cacho et al., PRL 2015



ab initio photoemission calculations

spin integrated **spin resolved**

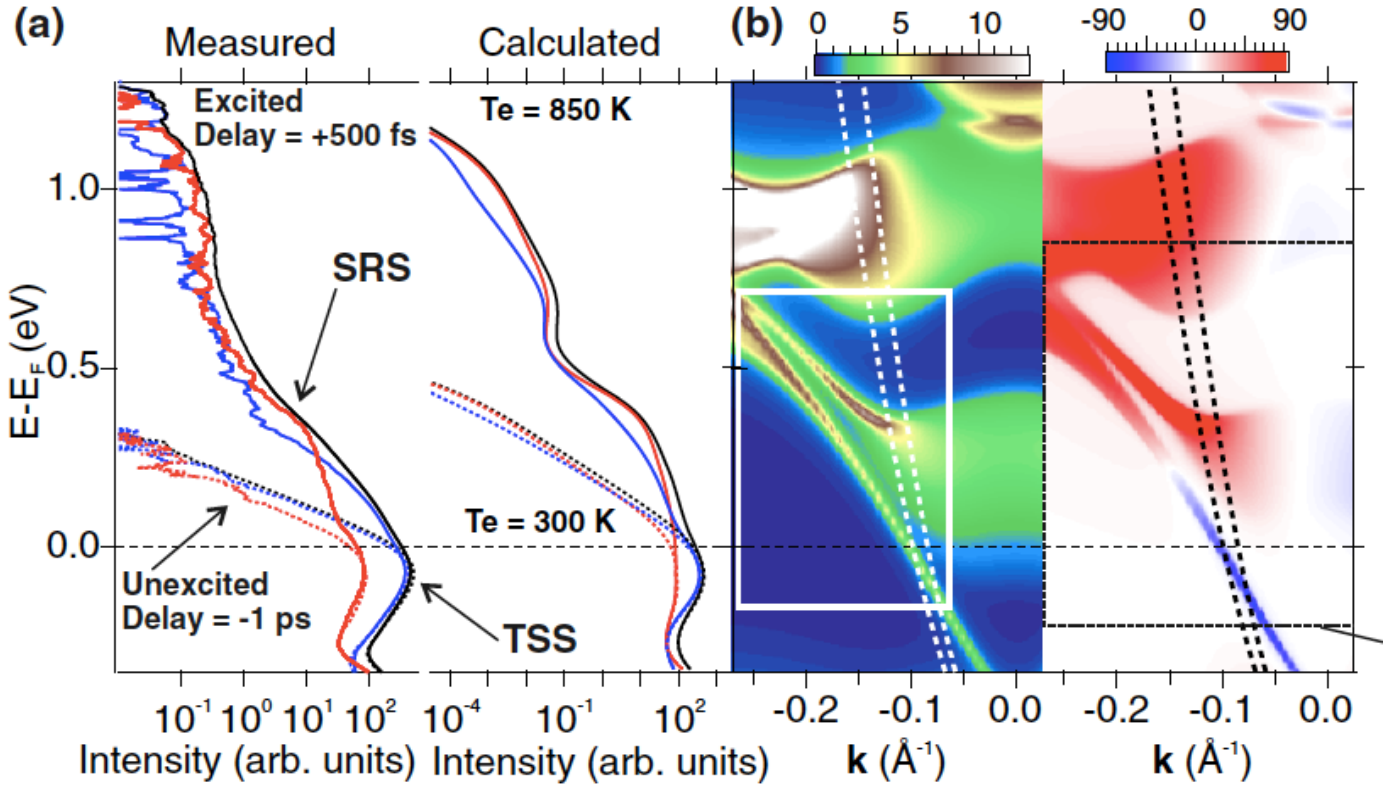


C. Cacho et al., PRL 2015

measured
-1 ps, 500 fs

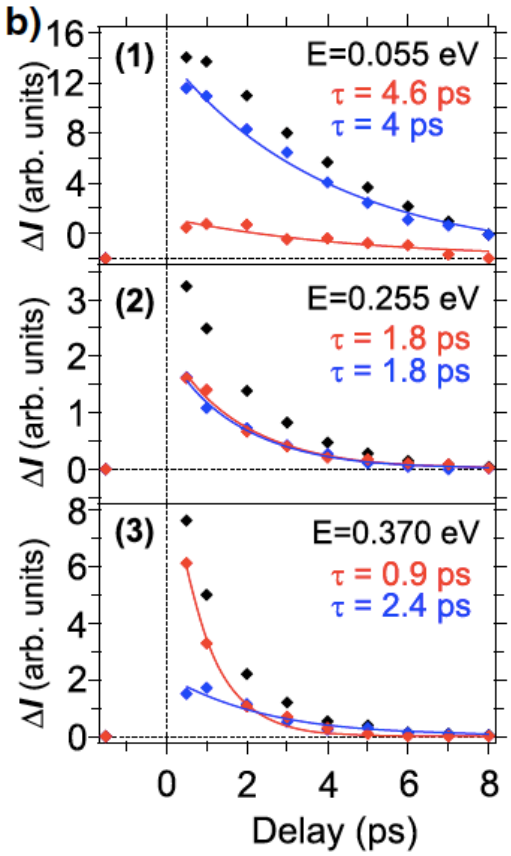
ab initio photoemission calculations

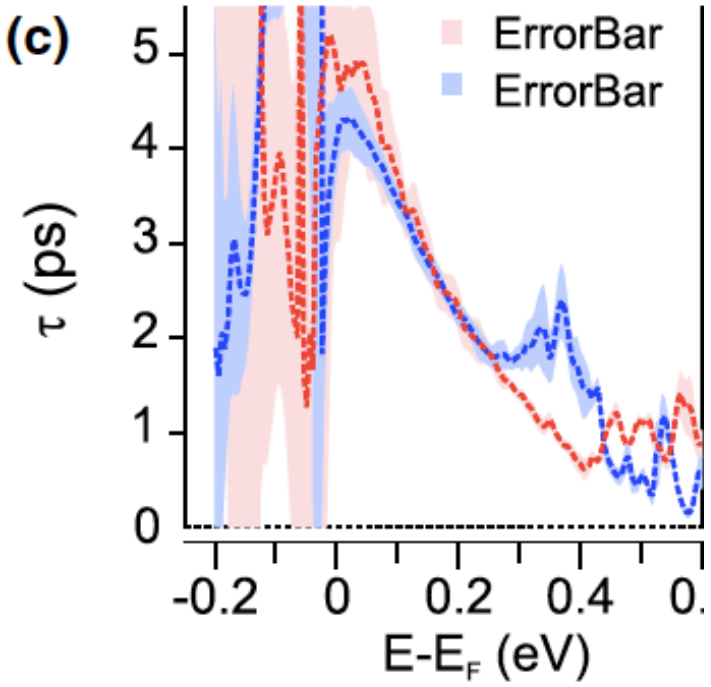
spin integrated spin resolved



simulation
thermalized electrons
300 K, 800 K

C. Cacho et al., PRL 2015





- surface and bulk states are weakly coupled even at room temperature
- within the first 8 ps : two independent electronic populations with different temperature and relaxation dynamics

C. Cacho et al., PRL 2015

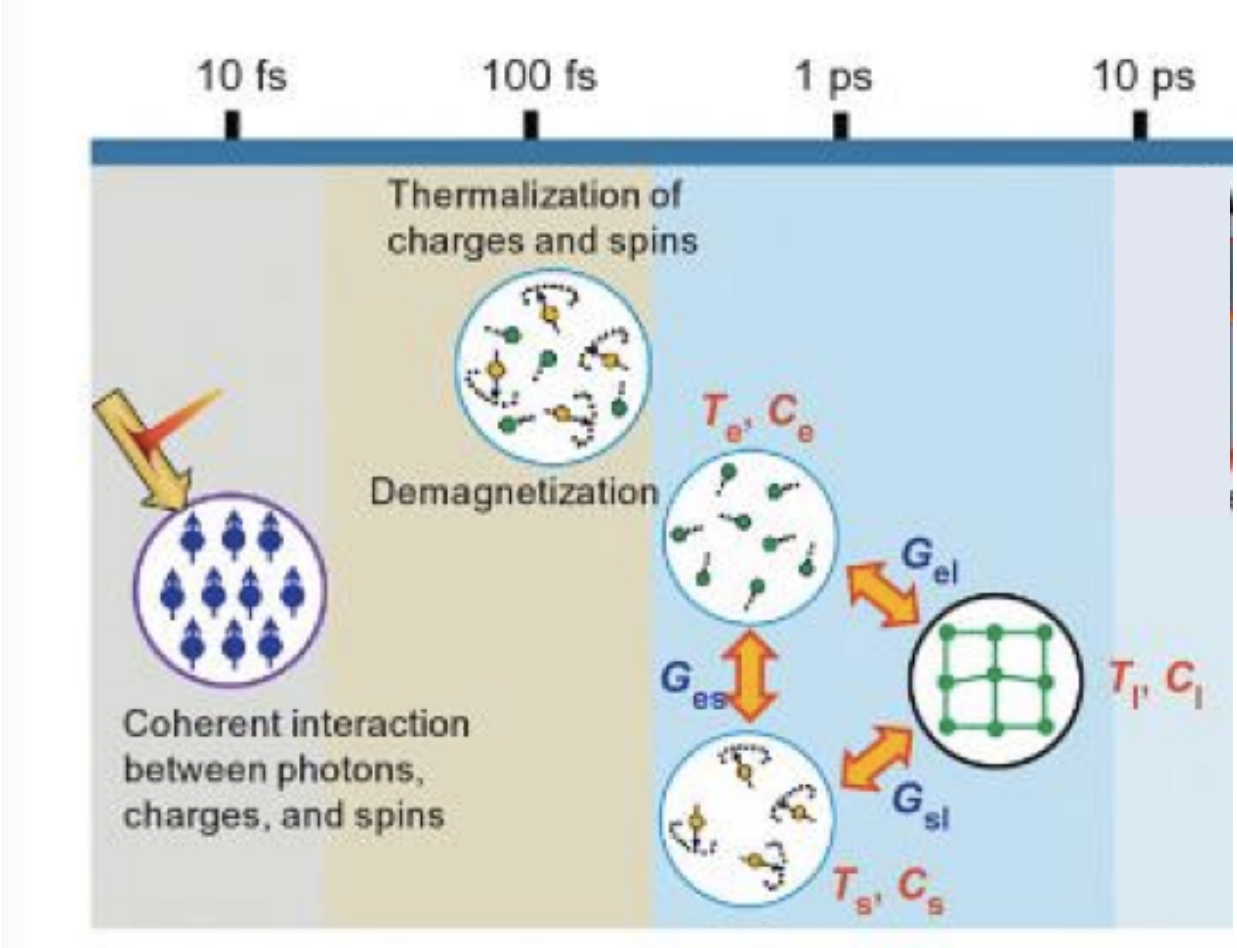
currently in study:

time resolved band structure of Fe(001)

Artemis/CLF /RAL GB

context:

- **demagnetization of Ni < 1 ps [Beaurepaire PRL 1996] with 40fs pulse**



currently in study:

time resolved band structure of Fe(001)

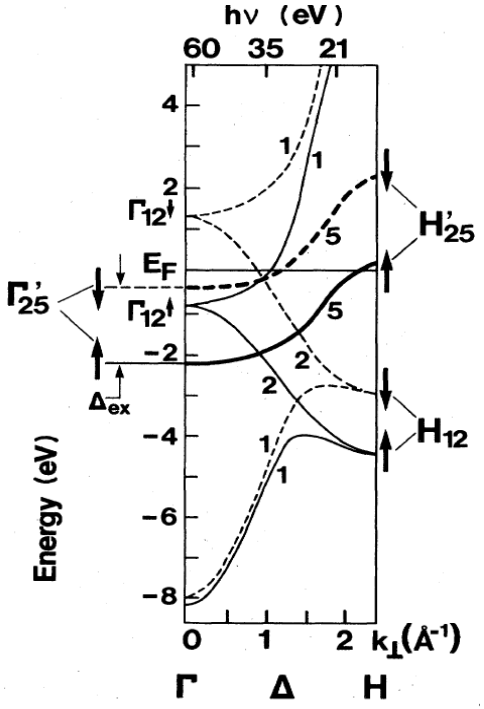
Artemis/CLF /RAL GB

context:

- demagnetization of Ni < 1 ps [Beaurepaire PRL 1996] with 40fs pulse
- microscopic processes involved to explain the dissipation of angular momentum remain debated

aim:

- follow the temporal evolution of the Fe(001) electronic structure



~ 2 eV exchange splitting

perspective:

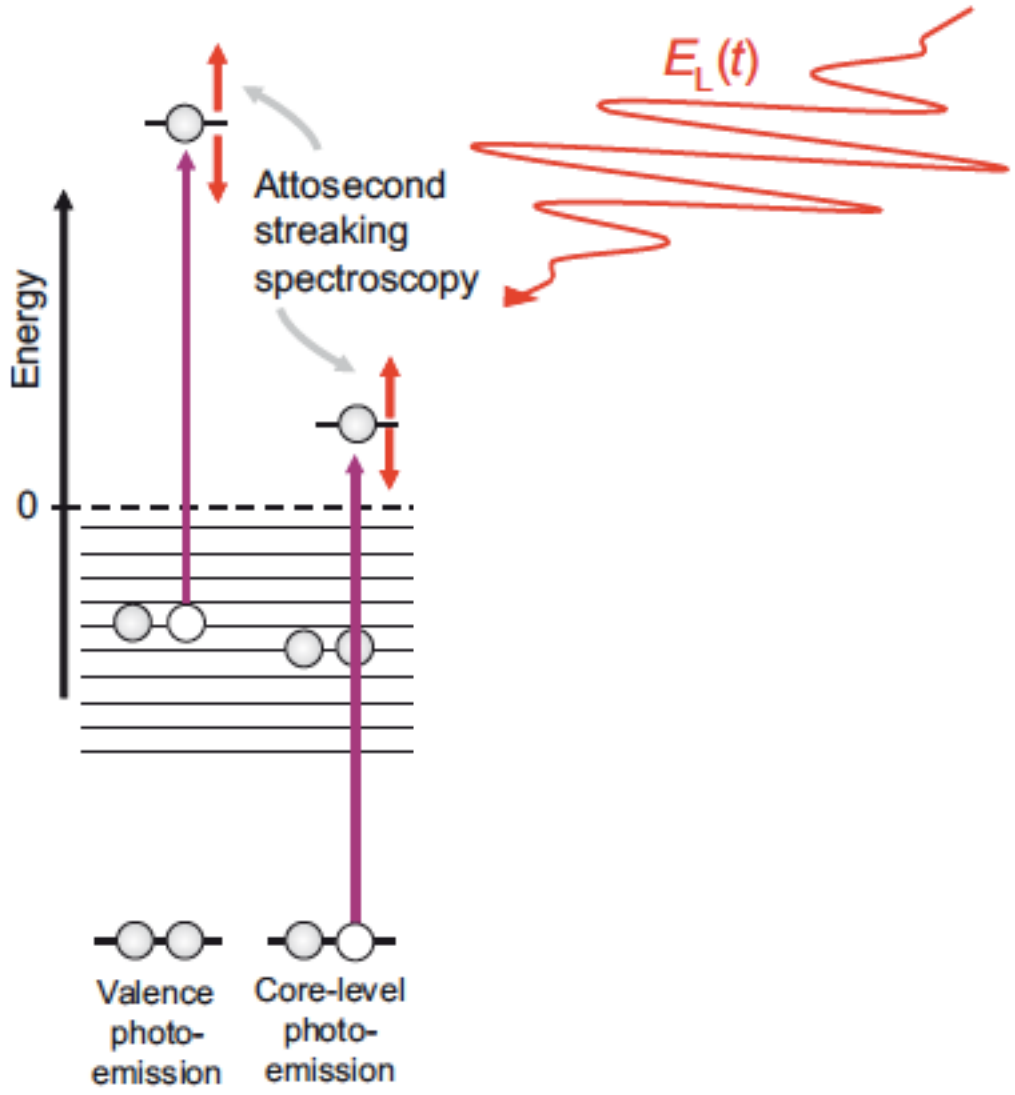
influence of electronic correlation effects on the time scale of the photoemission process

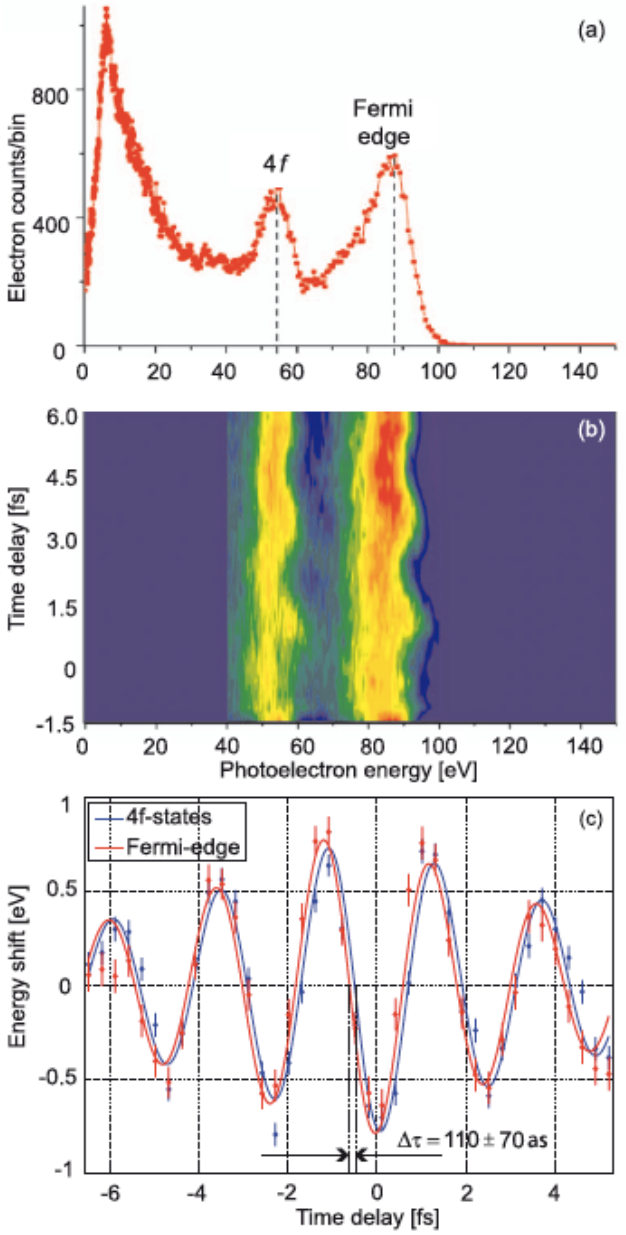
- **model system Cu, Au**
- **correlated system perovskite LSMO**

AST (attosecond streaking spectroscopy)
RABITT (reconstruction of attosecond beating by interference of two-photon transitions)

spin-polarisation of transitions under favorable conditions of matrix elements
-> access to phase-shifts of photoelectrons
-> phase-shifts correspond to time delays of photoemission determined by attosecond spectro

AST: Attosecond streaking spectroscopy

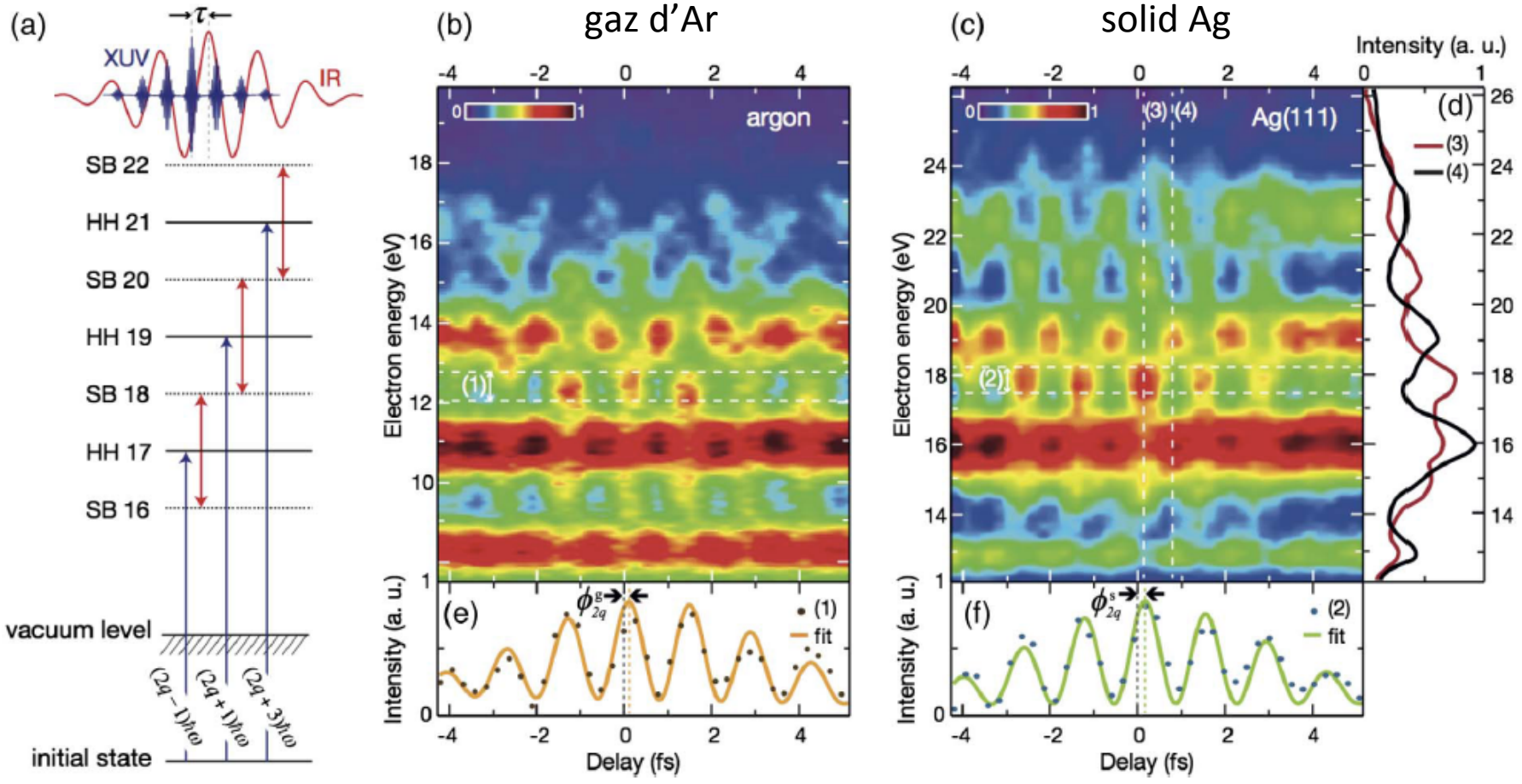


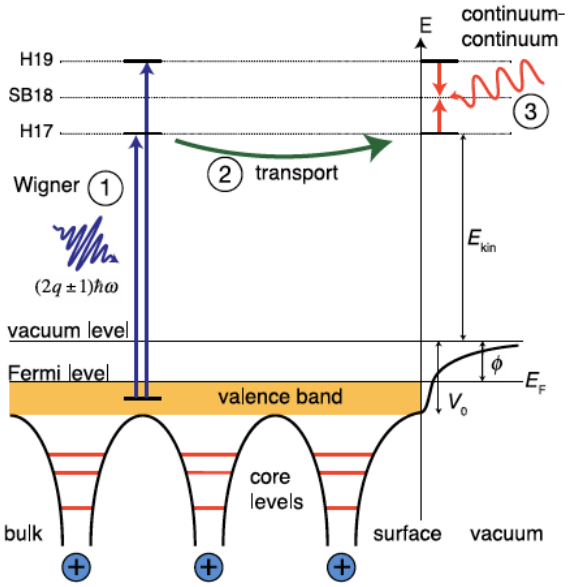


Cavalieri et al., Nature 2007

RABBITT: reconstruction of attosecond beating by interference of two-photon transitions

Interaction of the outgoing electron emitted by the attosecond extreme ultraviolet (XUV) pulse with an intense few-cycle infrared (IR) field leads to the formation of sidebands (RABBITT) or changes in the electron momentum (streaking)





Locher 2015, Optica