



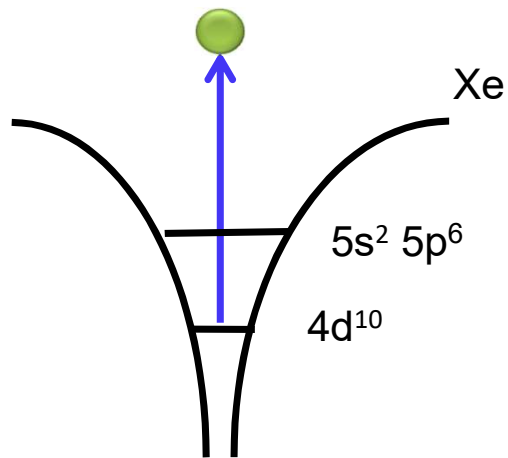
LUND
UNIVERSITY

Photoionization dynamics measured at the attosecond time scale

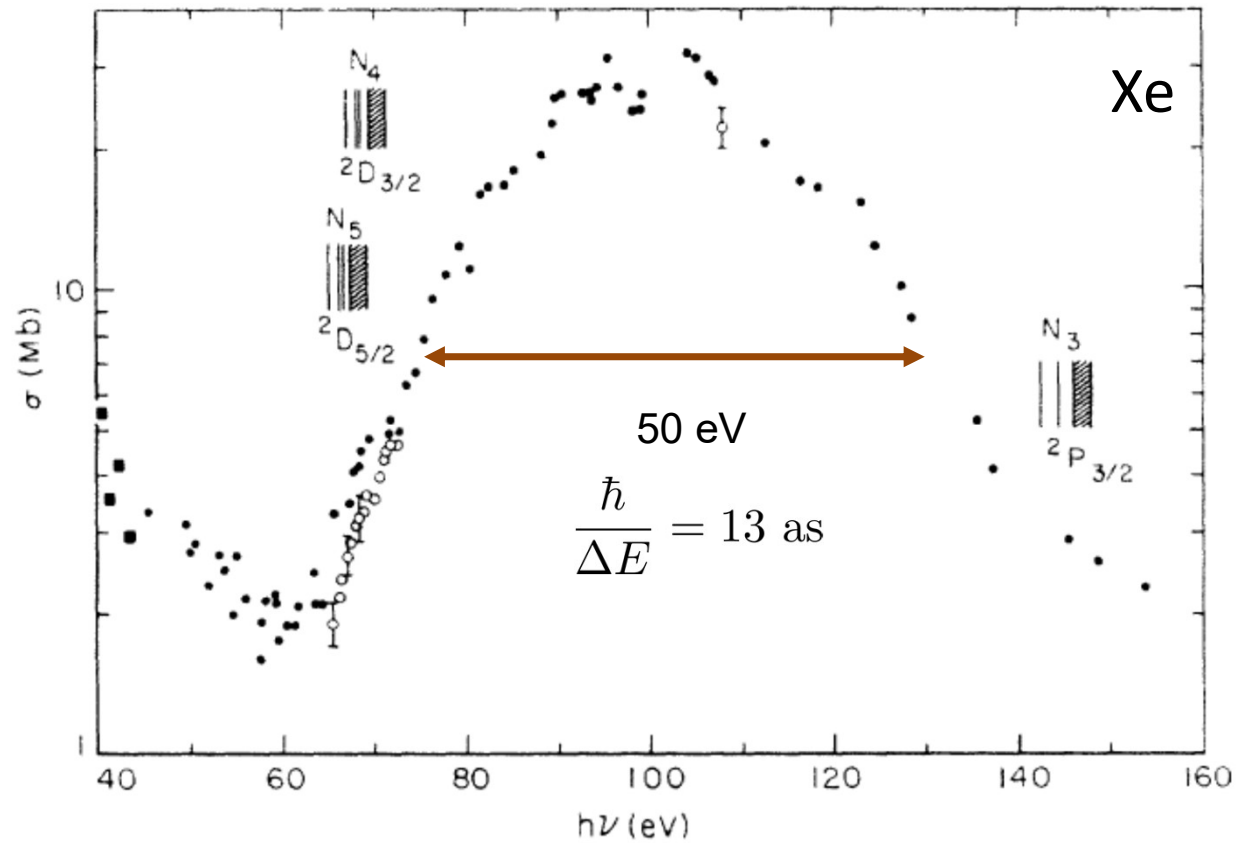
ANNE L'HUILLIER, PHYSICS DEPARTMENT



Photoionization of Xe in the 4d shell



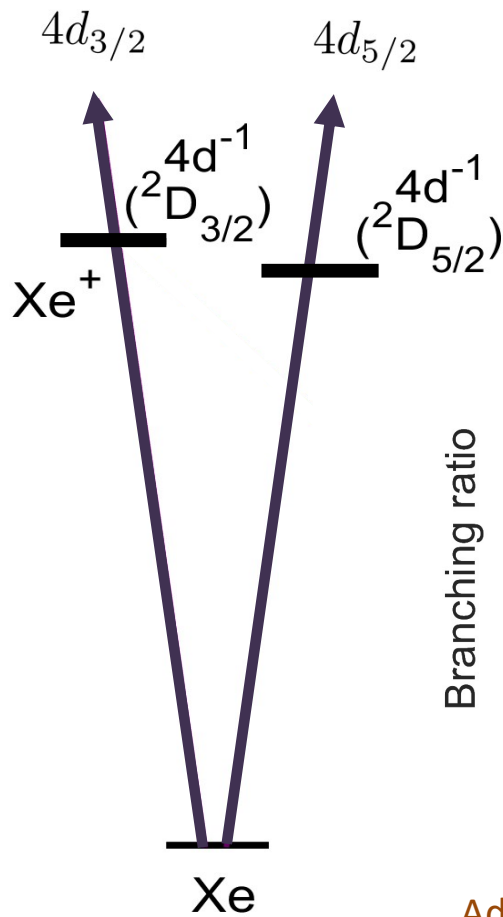
Dynamics of ionization ?



Ederer, PRL 1964
Mazza, Nat Comm 2015

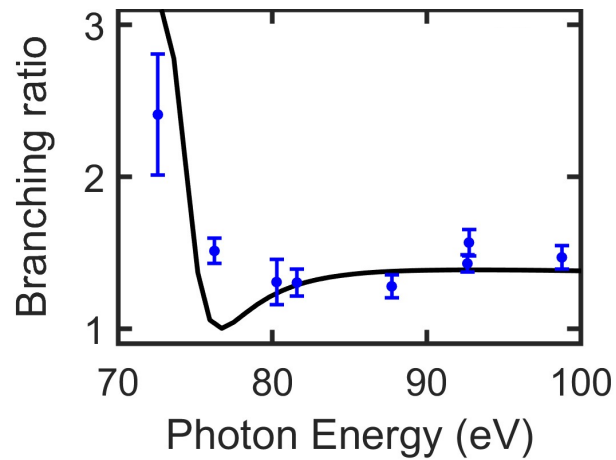
Giant dipole resonance in Xe 4d, Wendin, PRL, 1973

Photoionization of Xe in the 4d shell

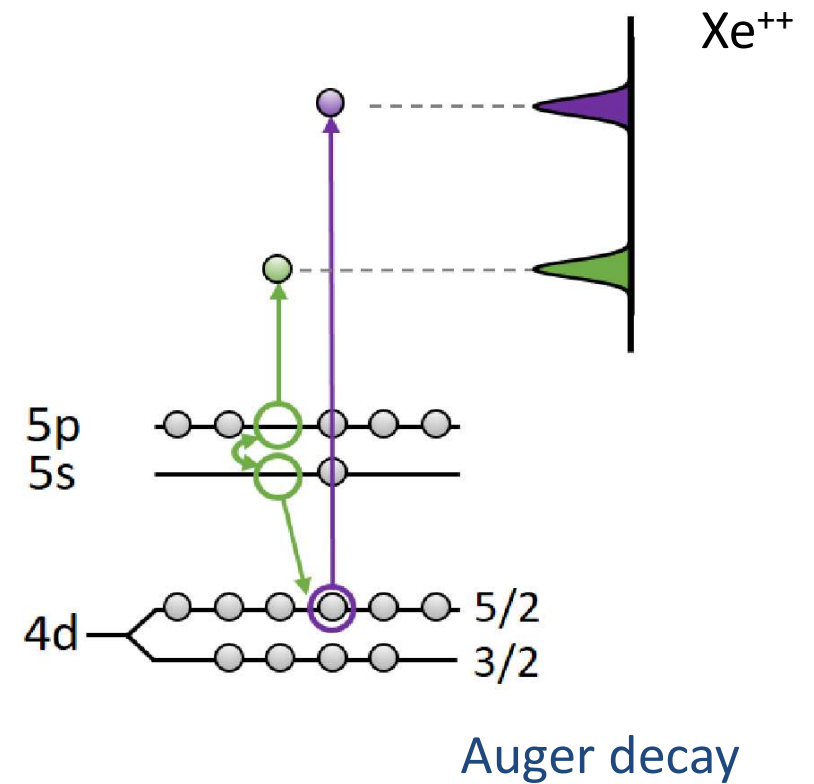


Spin-orbit interaction

Anomalous branching ratio between the spin-orbit channels at threshold

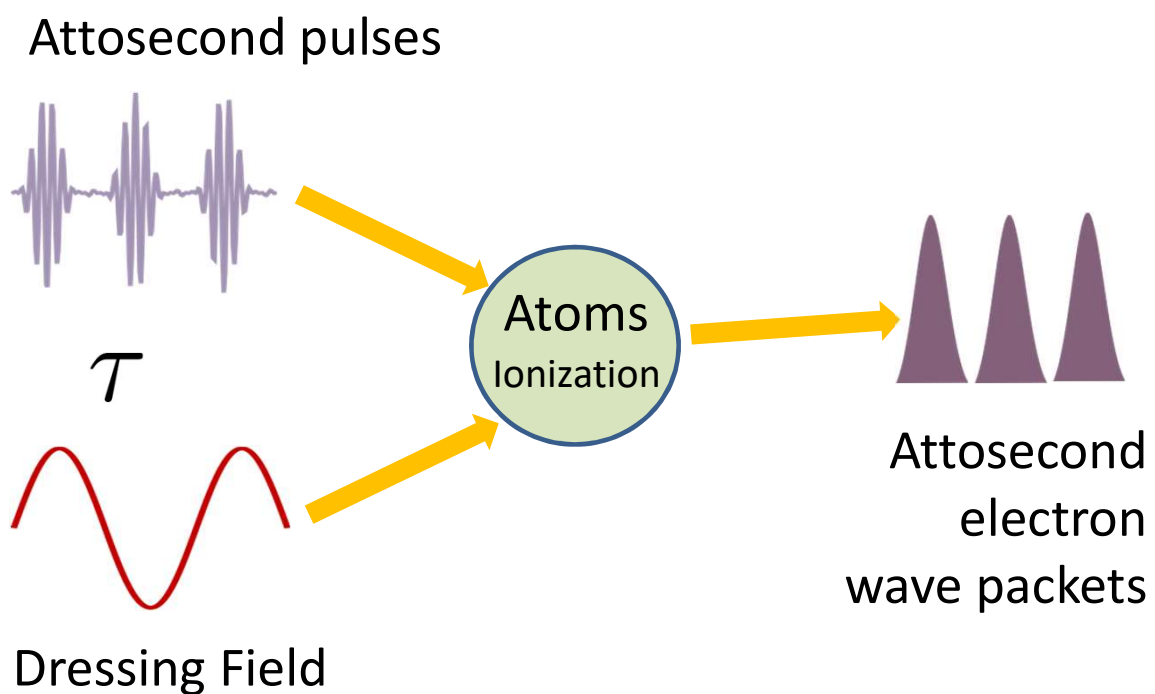


Adam et al., J. El. Spec. Rel. Phen. (1979)

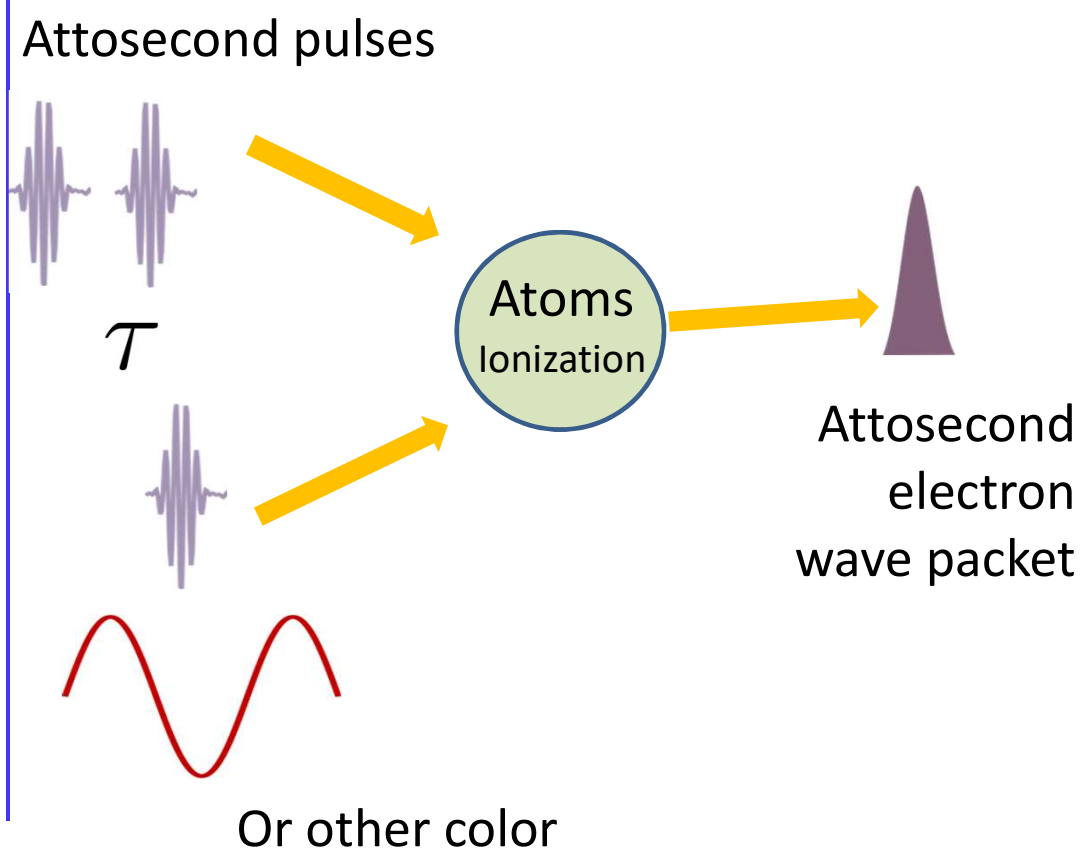


Drescher et al., Nature, 2002

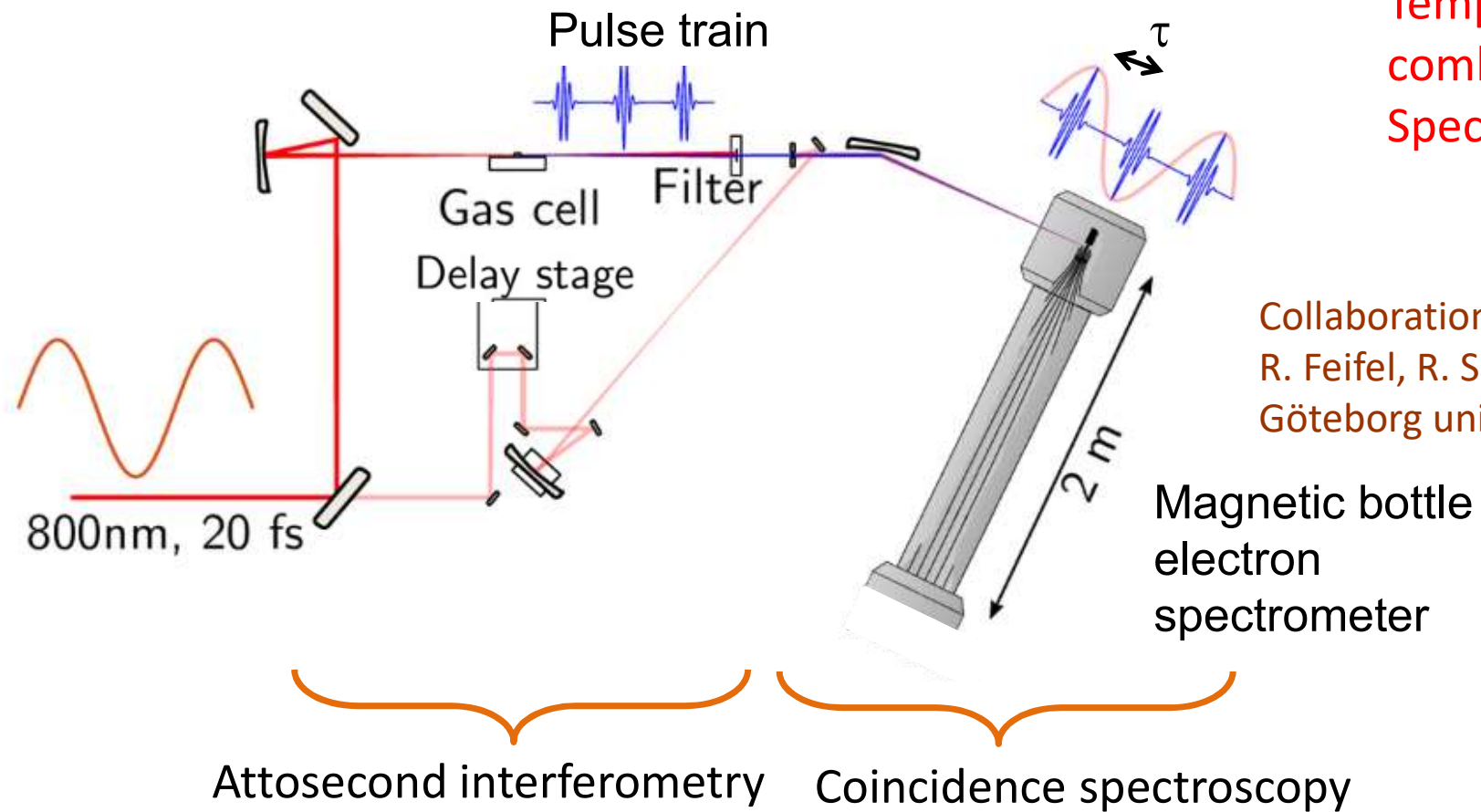
Laser-assisted photoionization



Pump/probe ?



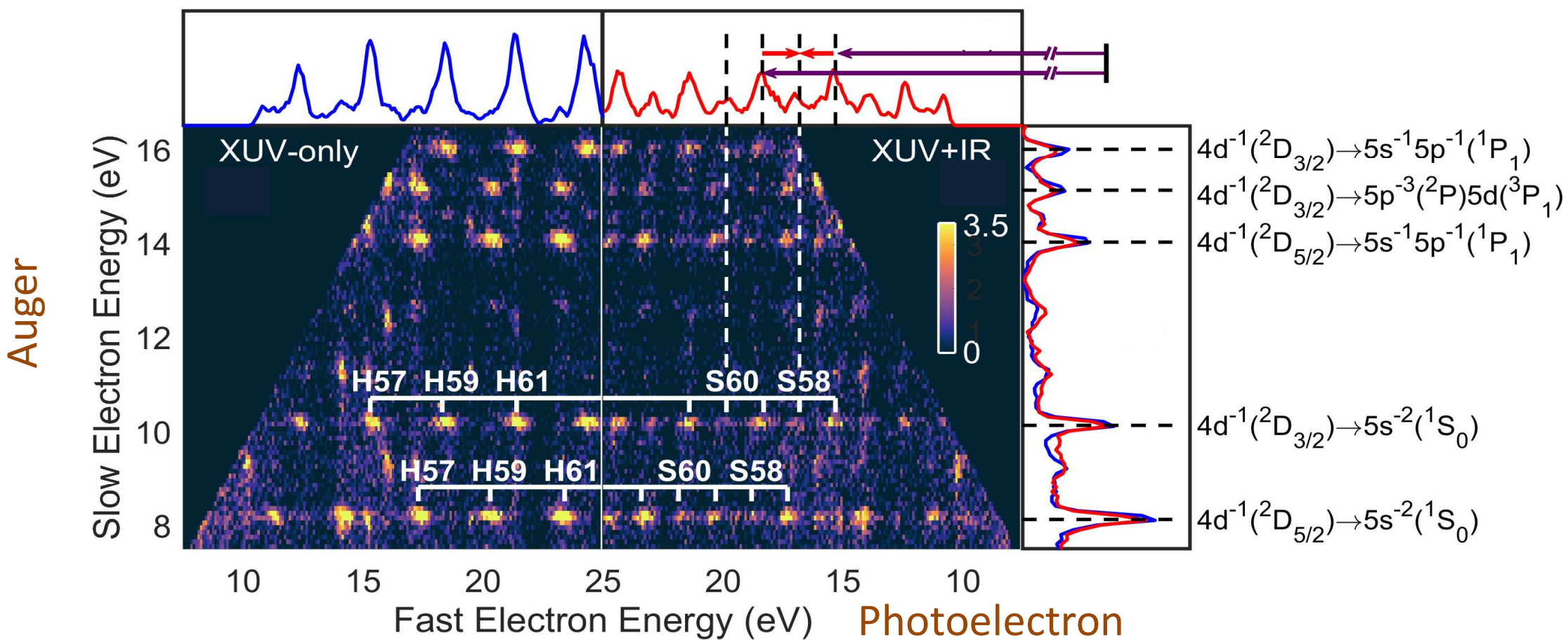
Experimental setup (with HHG)



Temporal resolution combined with Spectral resolution ?

Collaboration
R. Feifel, R. Squib,
Göteborg university

Coincidence spectroscopy



Attosecond interferometry

$$S \propto A + B \cos(2\omega T - \Delta\phi)$$

$$\frac{\Delta\phi}{2\omega} = \tau_{\text{XUV}} + \tau_{\text{A}}$$

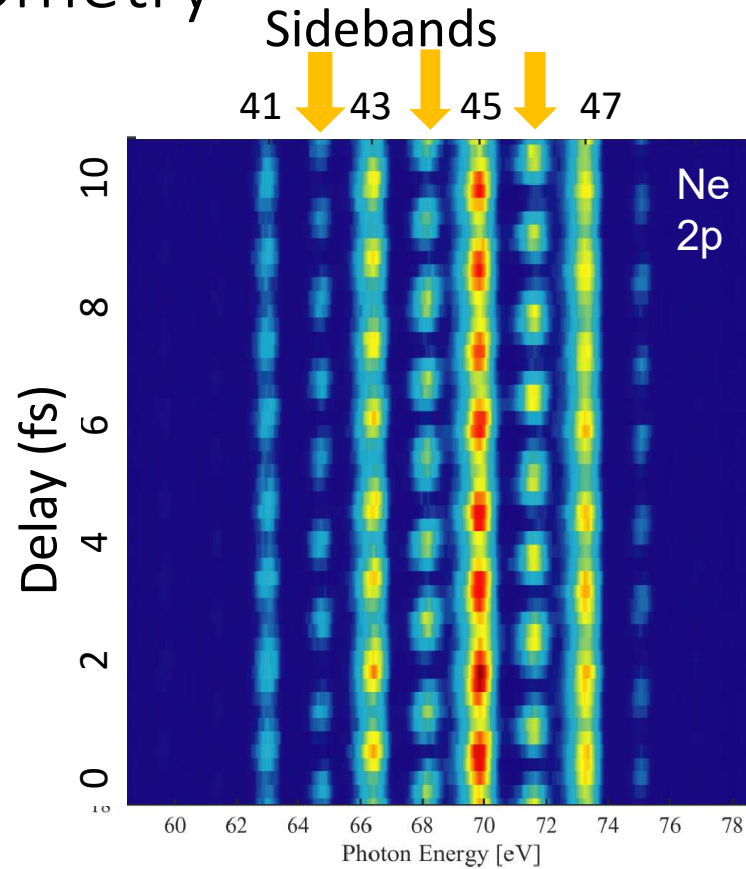
XUV
source

Atomic
ionization

$$\tau_{\text{A}} = \tau_{\text{W}} + \tau_{\text{cc}}$$

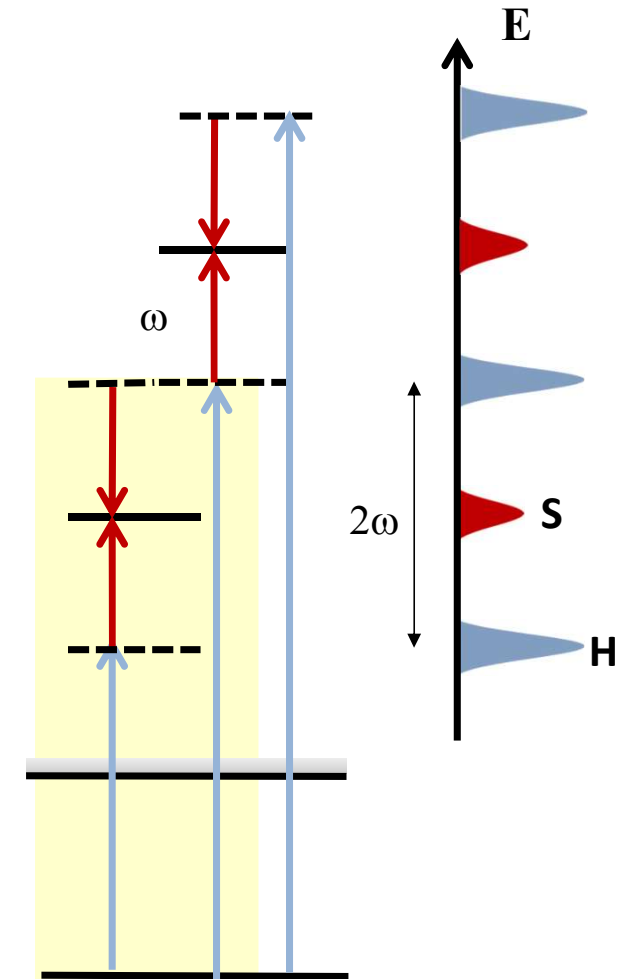
One-photon
ionization
Wigner
delay

Continuum-
continuum
transition

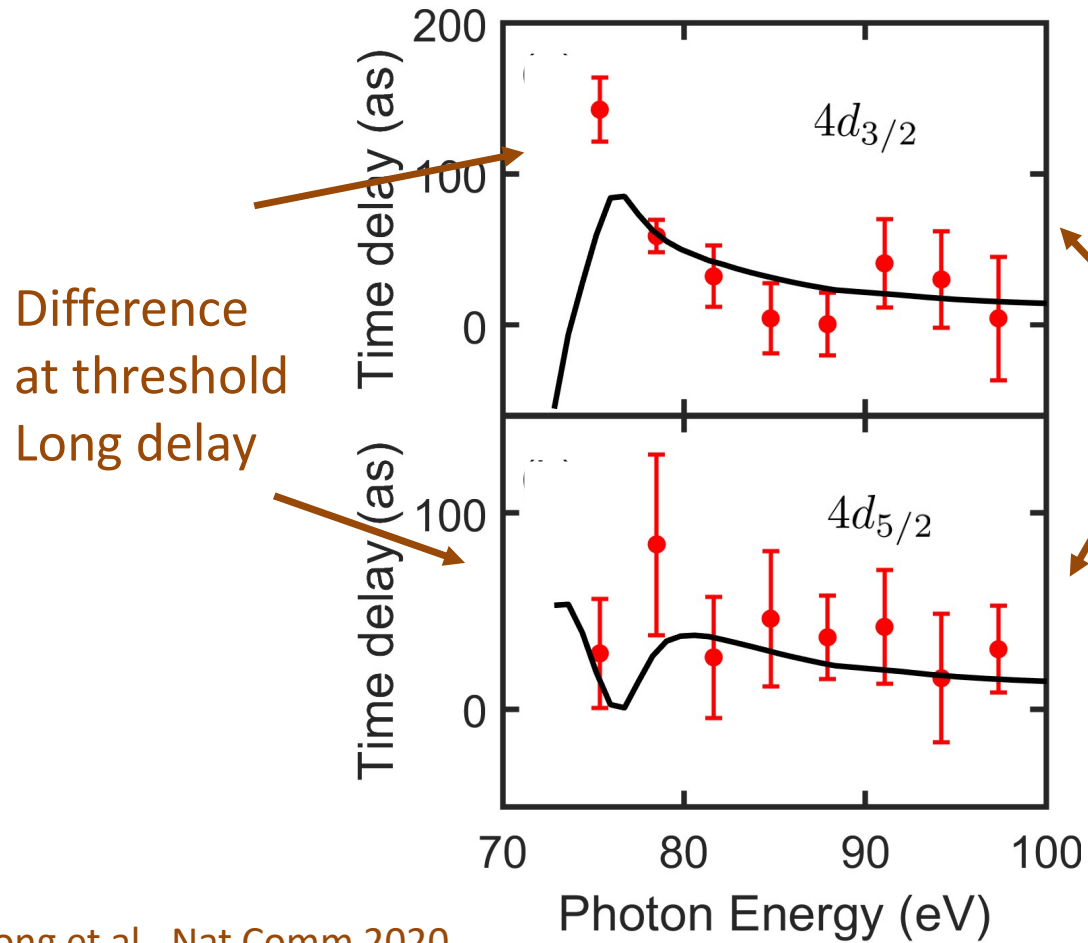


RABBIT

Paul et al., Science, 2001, Véliard et al., Phys. Rev. A 1996



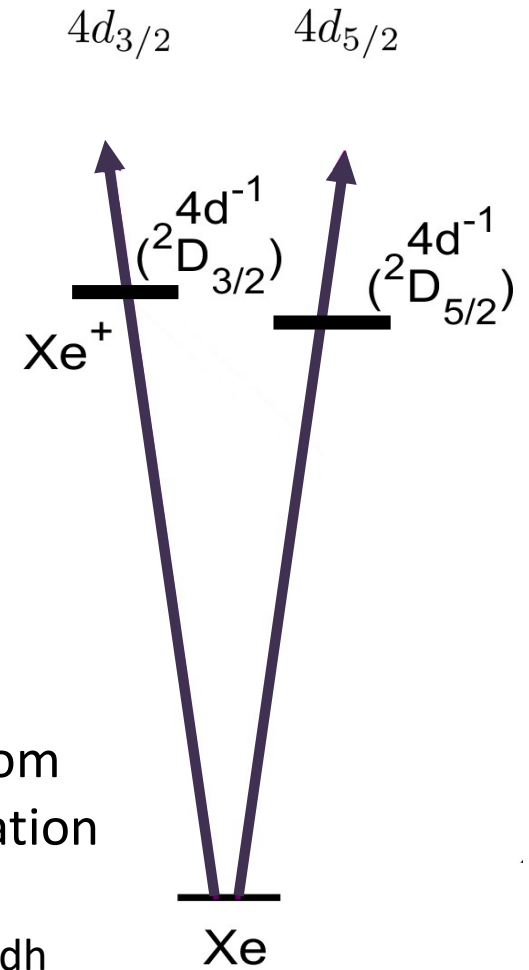
Photoionization time delays



Difference
at threshold
Long delay

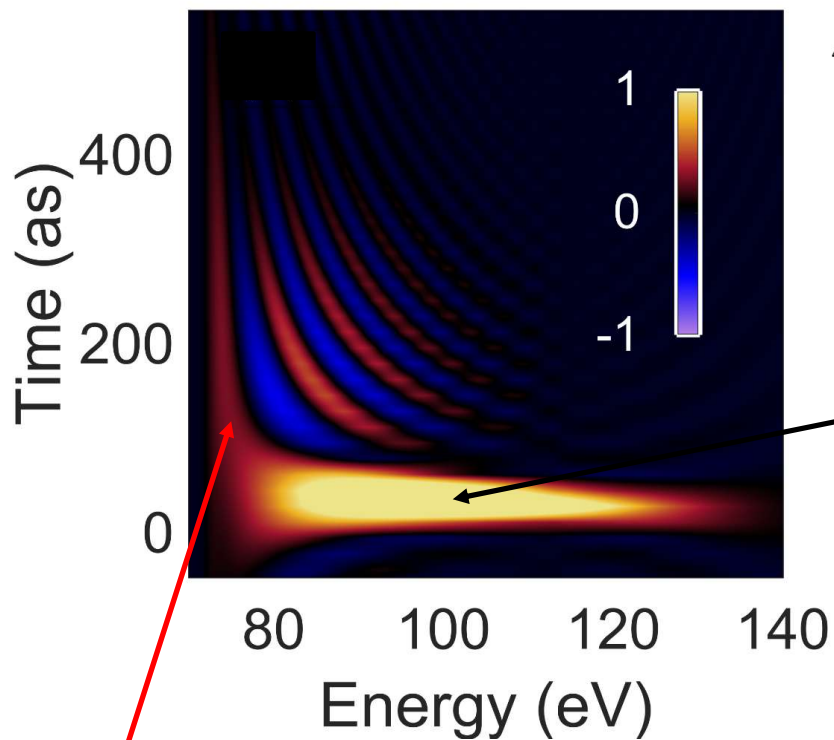
Positive
short
delay

Relativistic Random
Phase Approximation
(RRPA)
E. Lindroth, J. Vinbladh



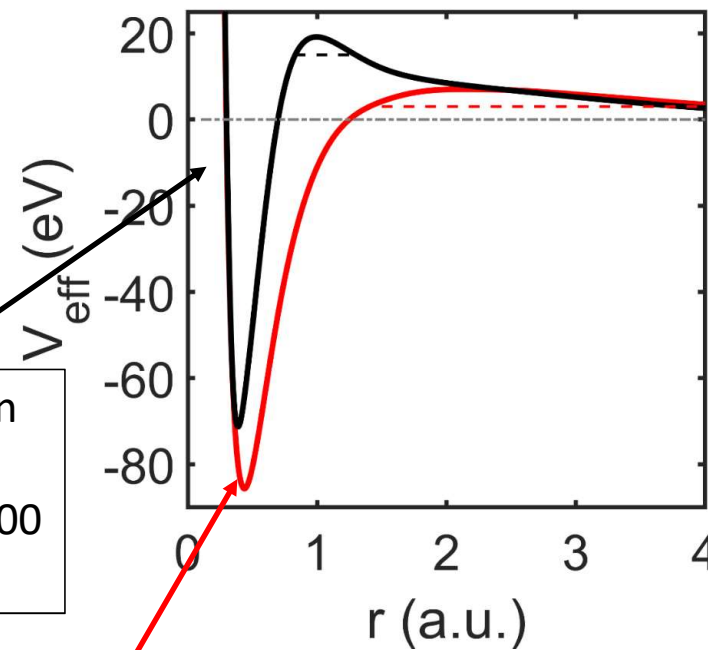
Ionization mechanisms and time scales

Wigner distribution



$4d_{5/2} \rightarrow \epsilon f_{5/2}$

Resonance due to electron correlation
A few tens of as, max at 100 eV, broadband



Resonance due to spin-orbit interaction
A few hundreds of as, 75 eV

$$W(E, t) = \int A\left(t + \frac{\tau}{2}\right) A^*\left(t - \frac{\tau}{2}\right) e^{-\frac{iE\tau}{\hbar}} d\tau$$

Conclusion

- Measurement of the phase, time delay, time-frequency representation
- Think beyond pump/probe
Spectral + temporal resolution
- Coincidences!
Also: angular resolution if multiple angular momentum channels
- Entanglement and decoherence