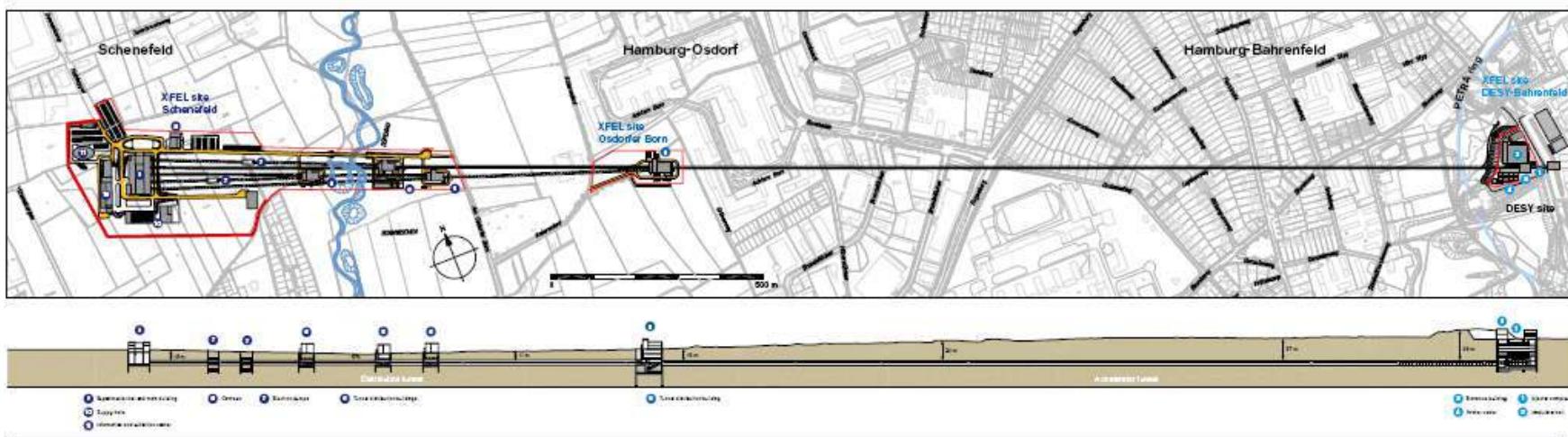


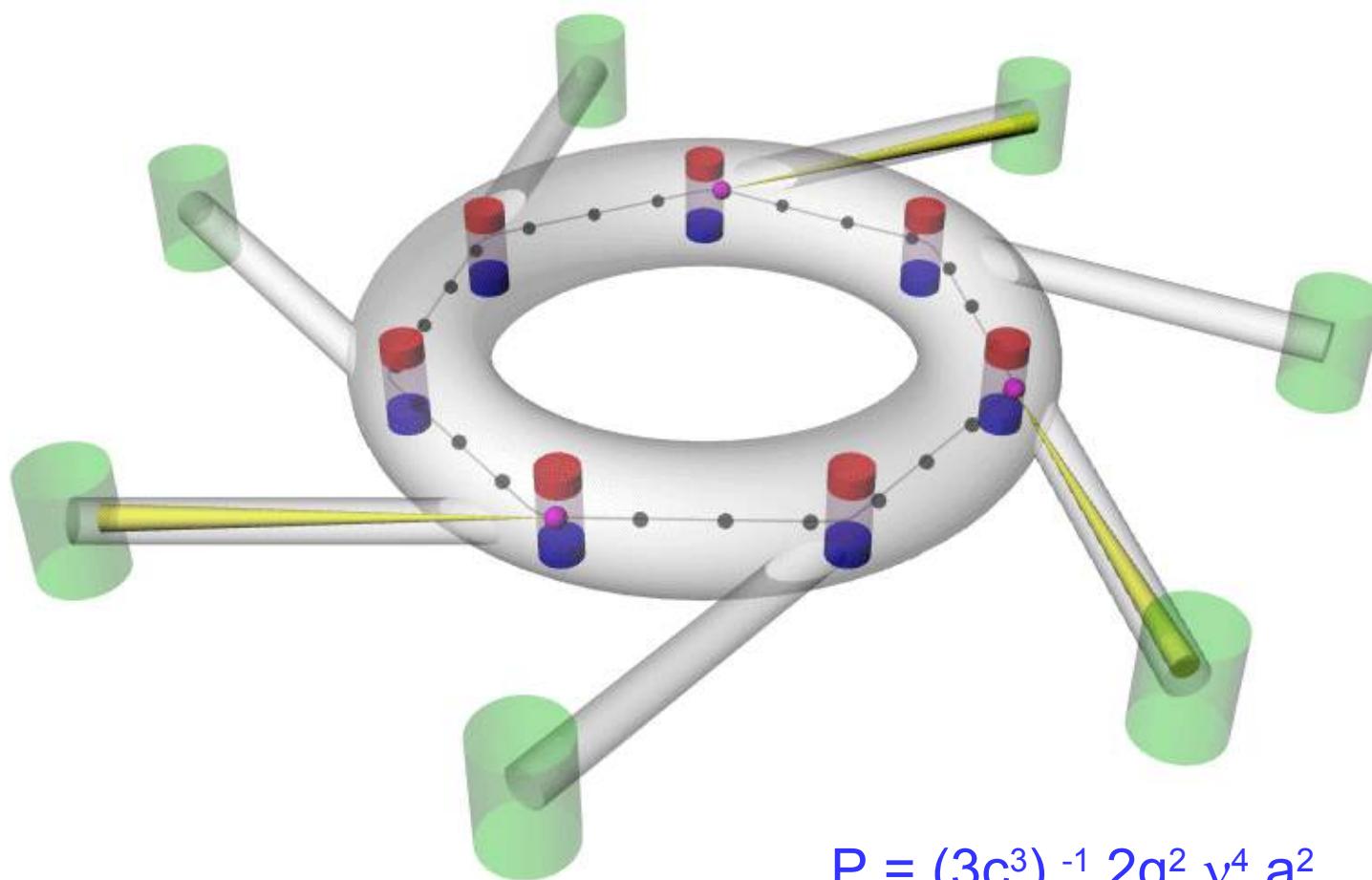
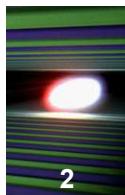


# *New Dimensions for Time- and Angle-Resolved PES at European XFEL*

Serguei L. Molodtsov, European XFEL, Hamburg



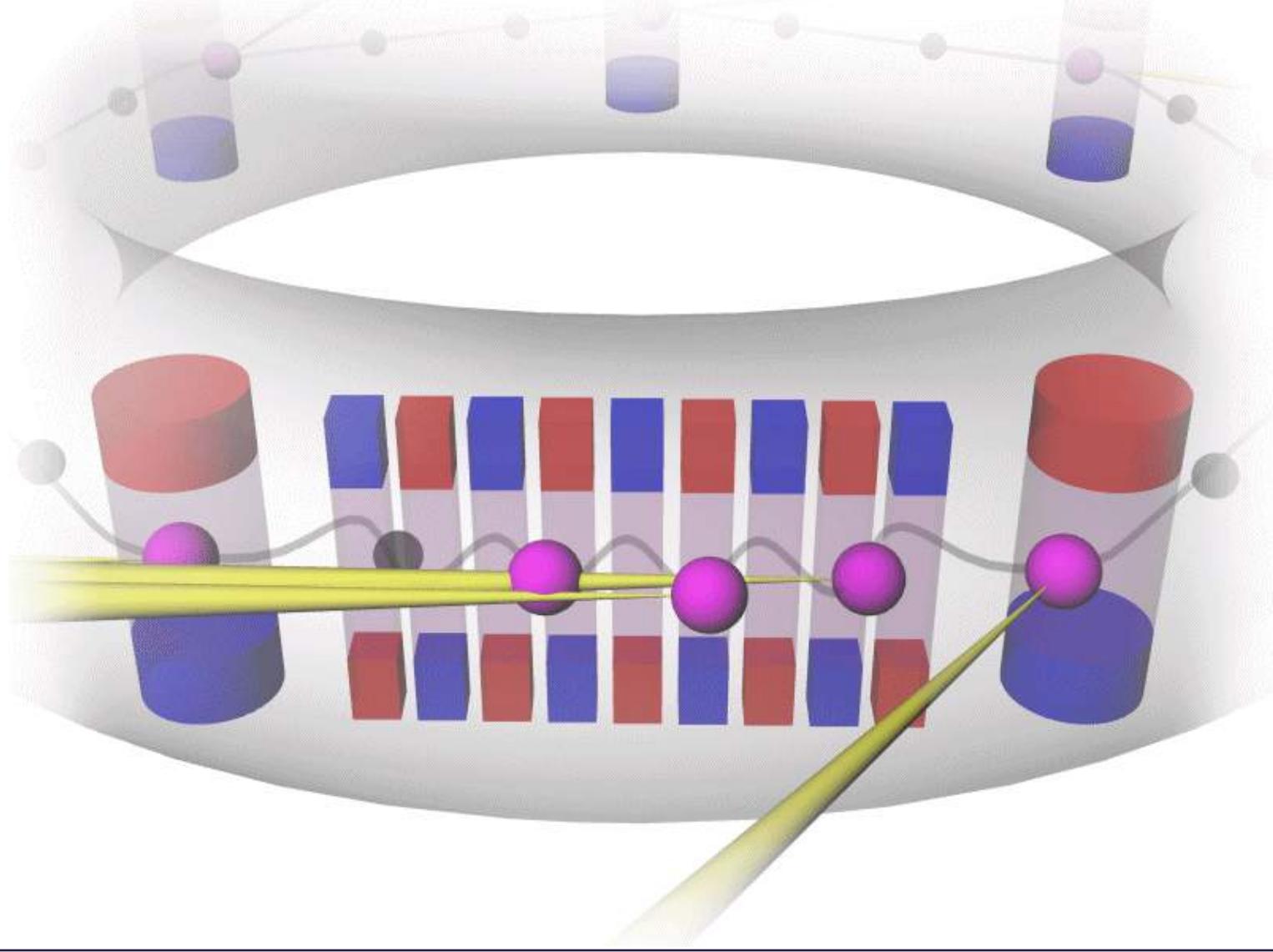
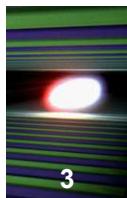
# Synchrotron radiation (dipoles)



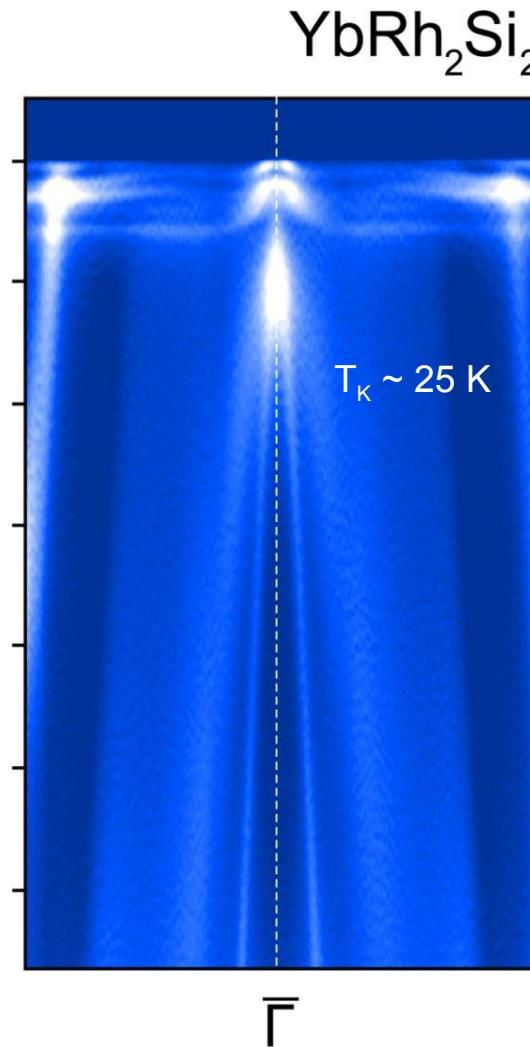
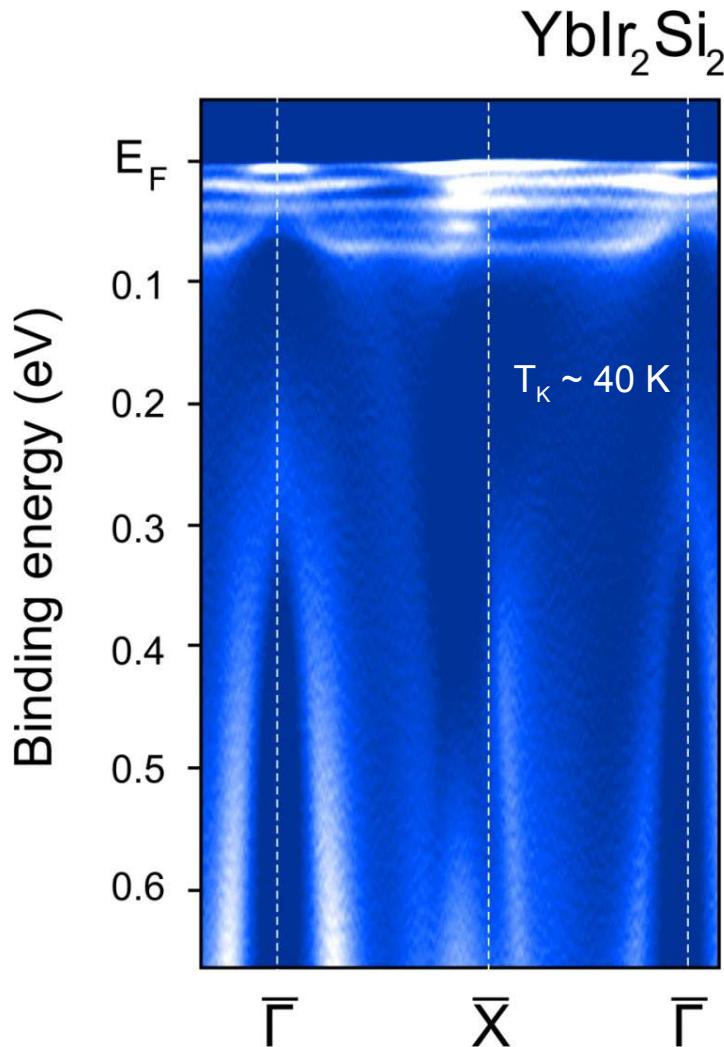
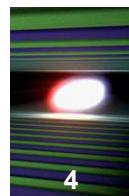
$$P = (3c^3)^{-1} 2q^2 v^4 a^2$$

P – radiated power; c – light velocity; q – particle charge; a – acceleration; v - normalized energy

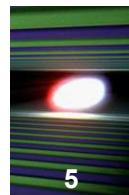
# Synchrotron radiation (undulators)



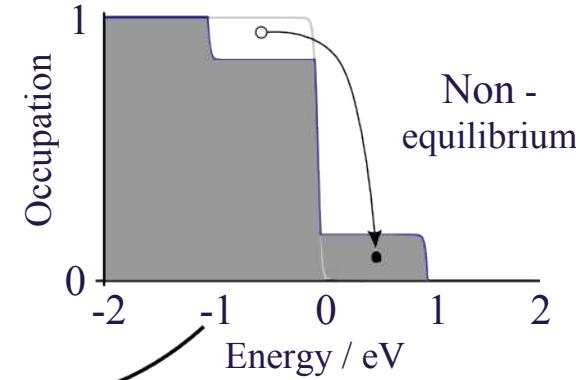
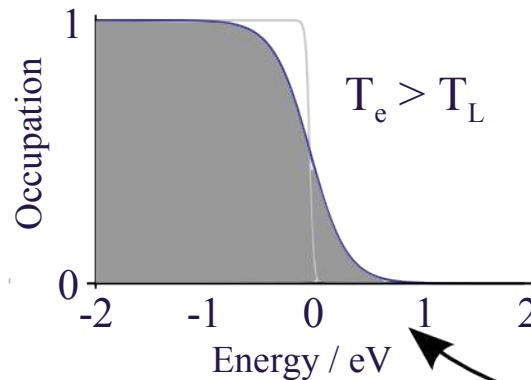
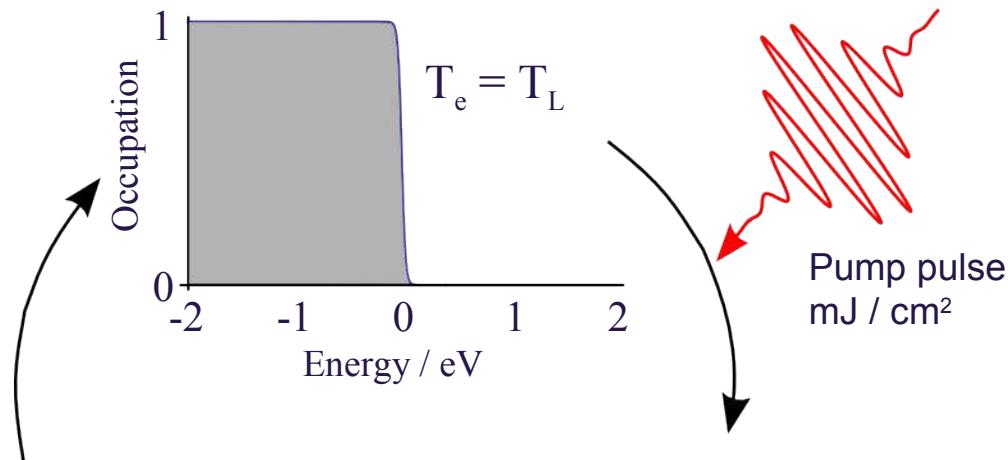
## Kondo (heavy-fermion) systems (D. Vyalikh, TU Dresden)



- effective mass mapping (transport phenomena)
- crystal field-split 4f states probing (magnetic properties)
- strength of electron states correlation (Kondo behavior)



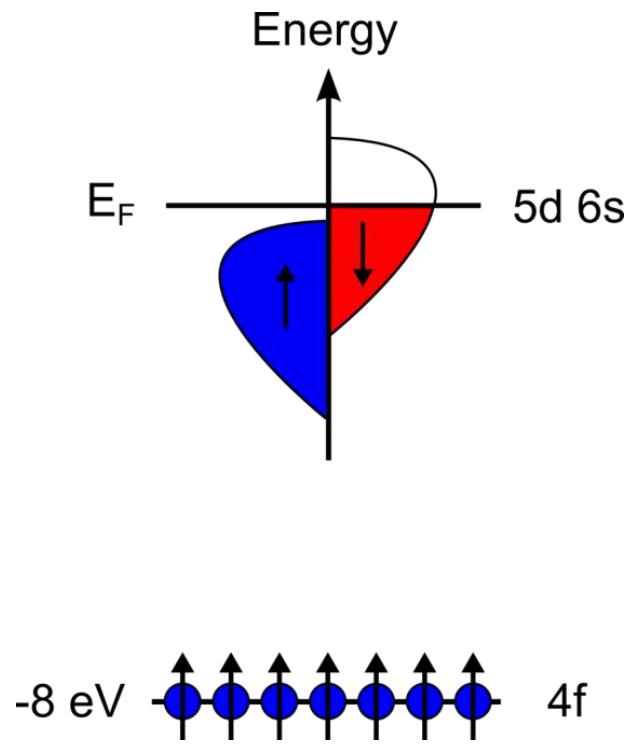
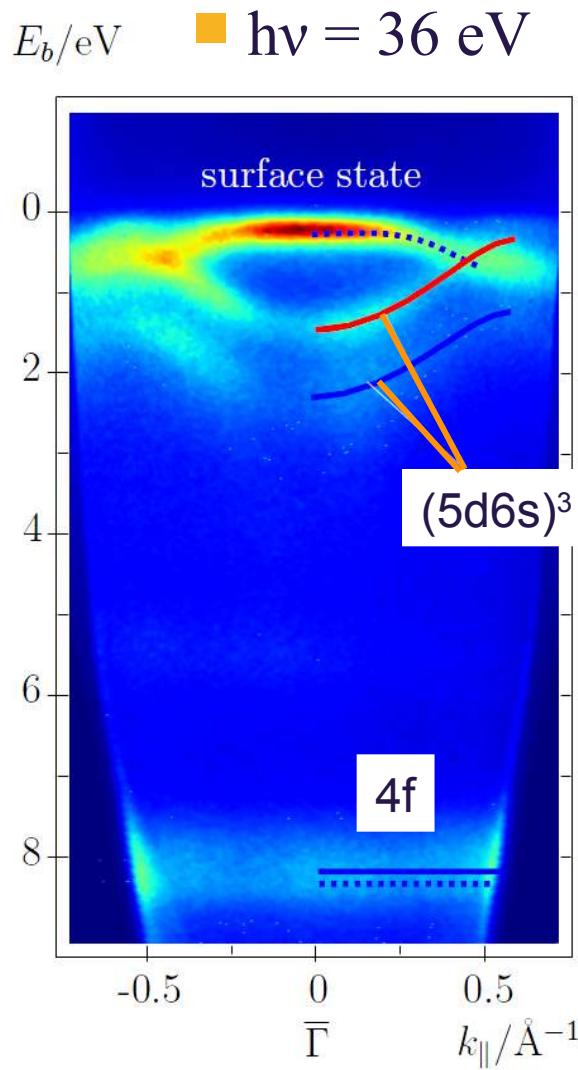
Electron-phonon coupling,  
Spin dynamics, ...  
0.1 to 100 ps



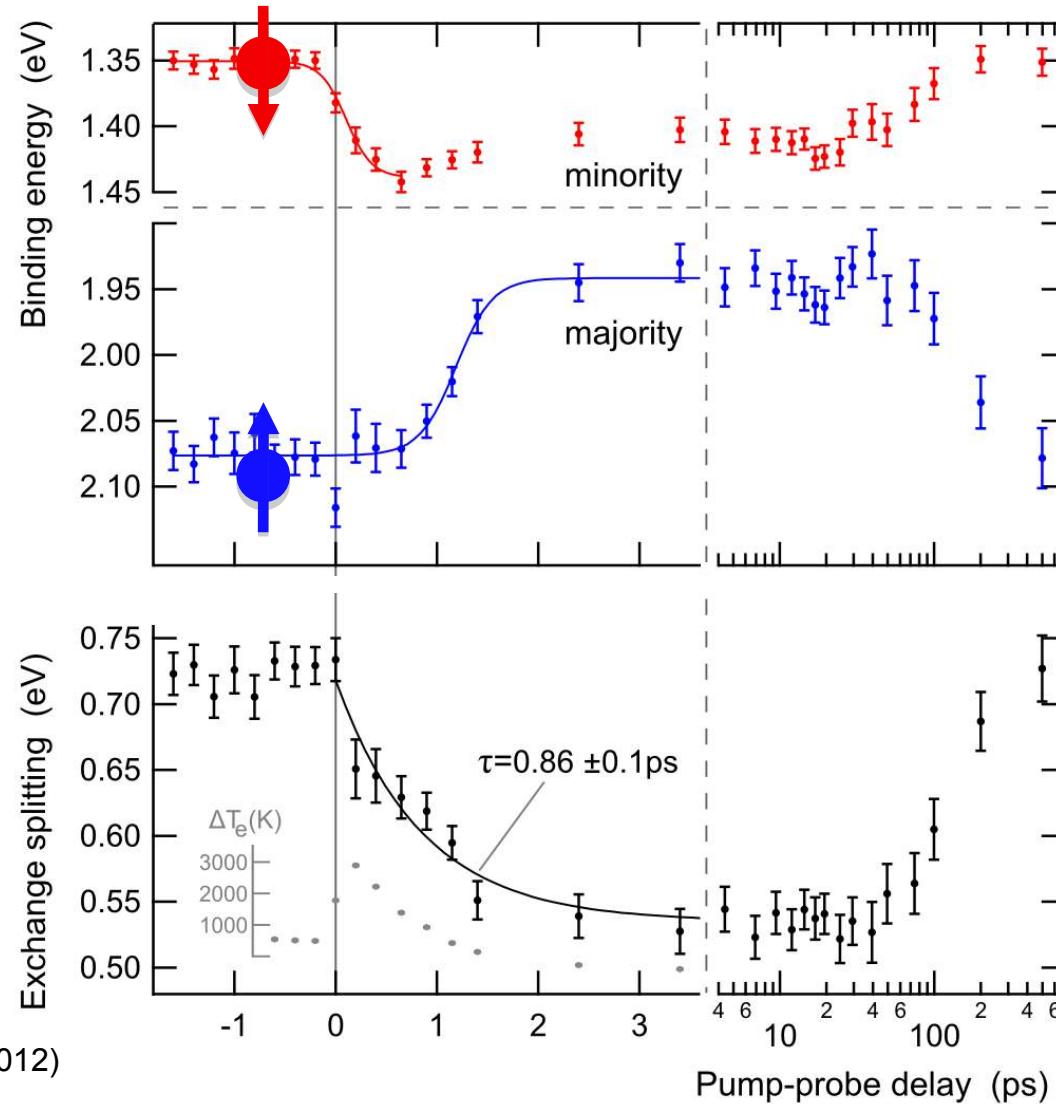
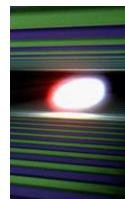
Basov *et al.* Rev.  
Mod. Phys. **83**,  
472 (2011)

Electron thermalization: 10 to 100 fs

# Ultrafast Magnetization Dynamics in Rare Earth Ferromagnets (group of M. Weinelt, FU Berlin)



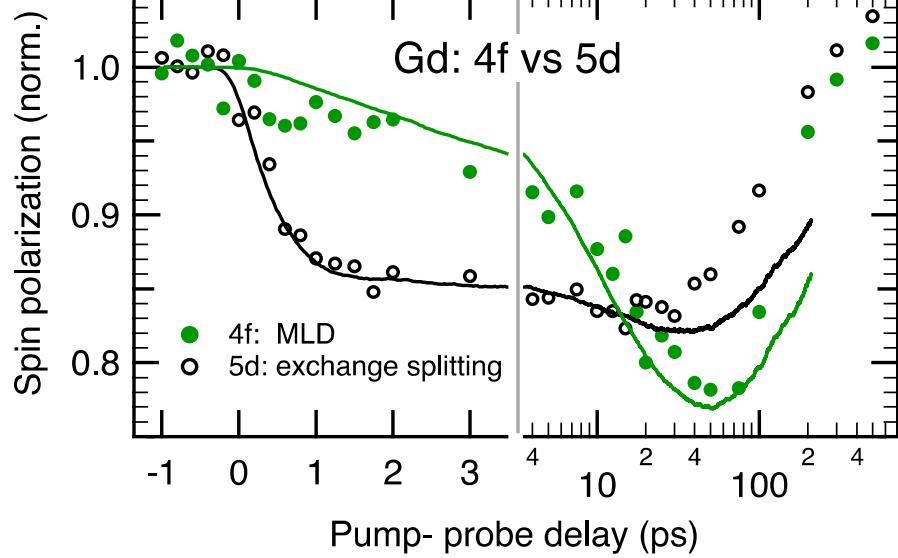
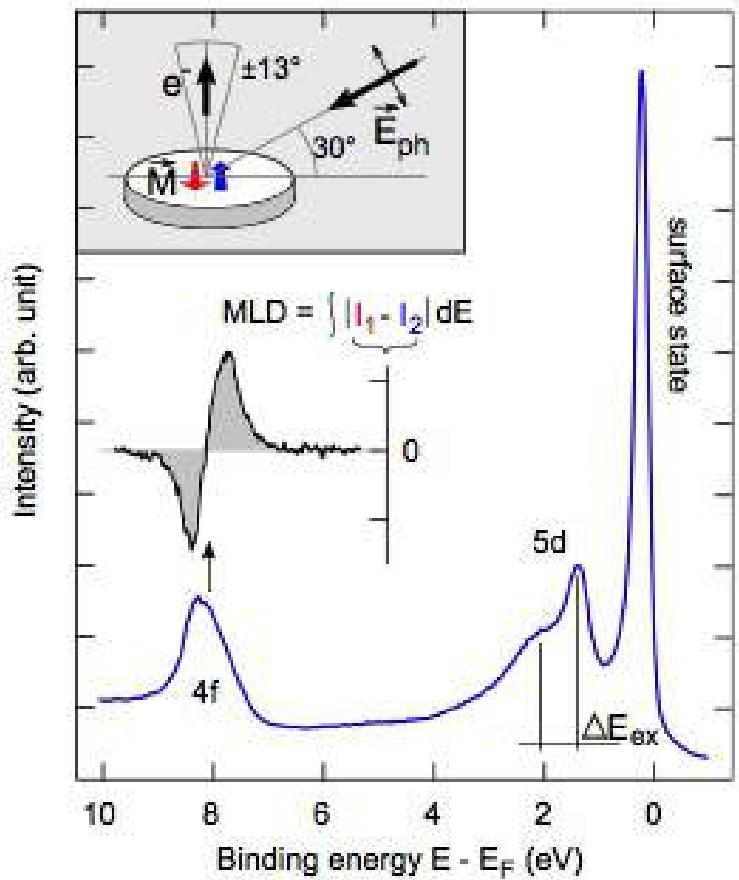
# Ultrafast Demagnetization of Gd Valence Bands



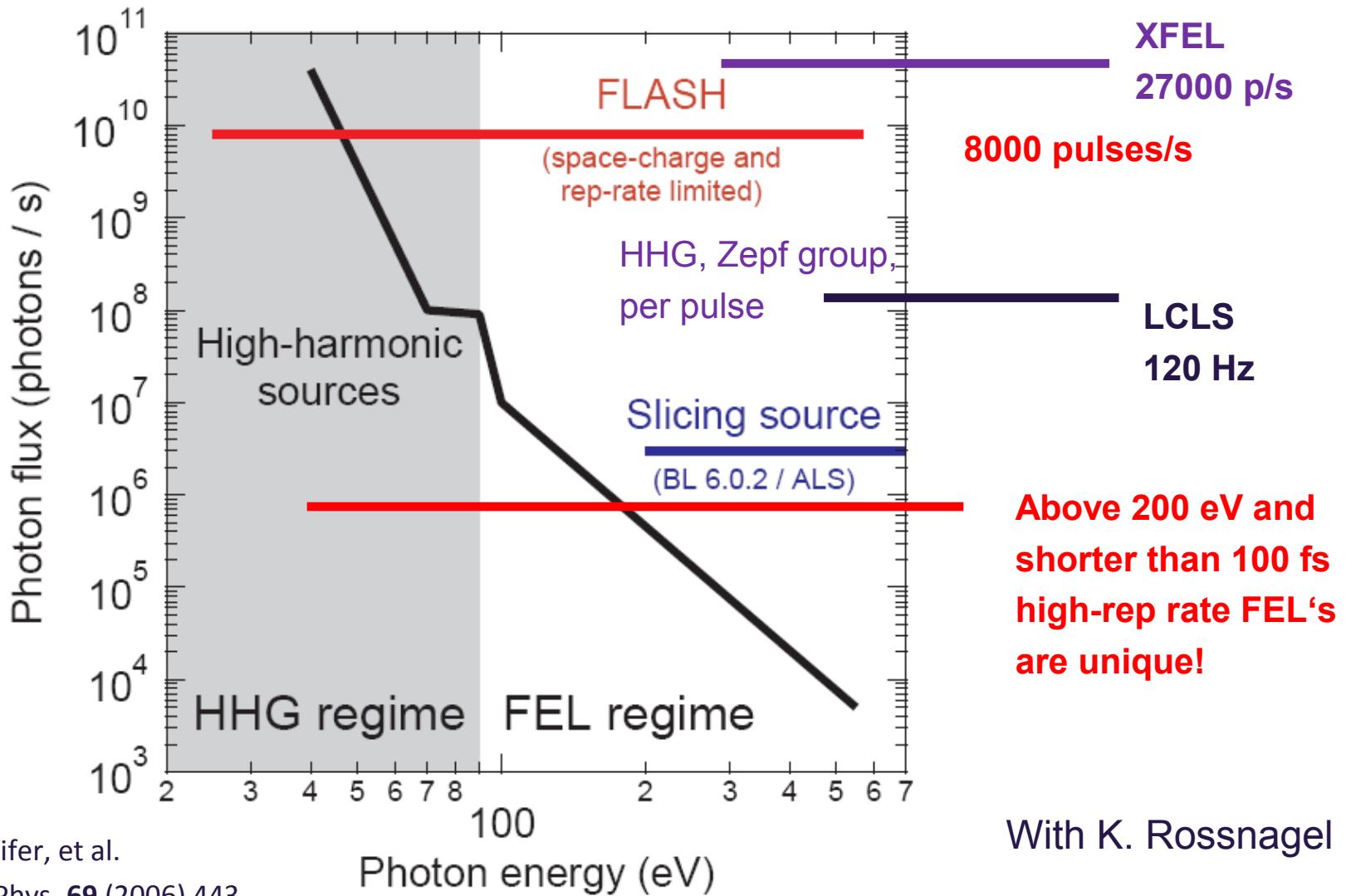
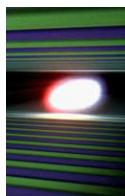
Carley et al.

PRL 109, 057401 (2012)

# Ultrafast 4f dynamics of Gd



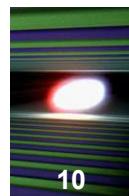
# Source comparison: Time-resolved PES



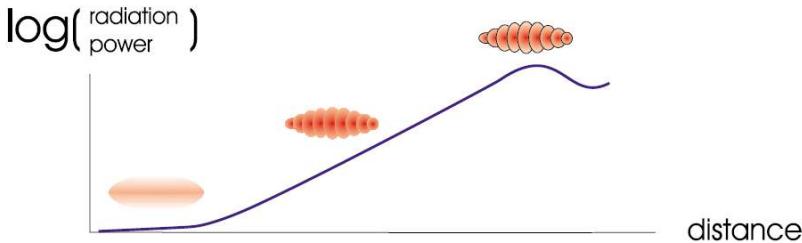
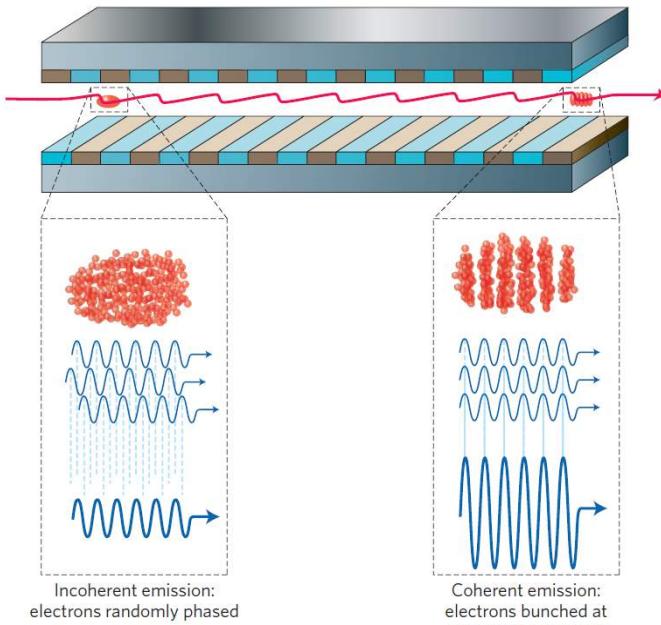
HHG, T. Pfeifer, et al.  
Rep. Prog. Phys. **69** (2006) 443

With K. Rossnagel

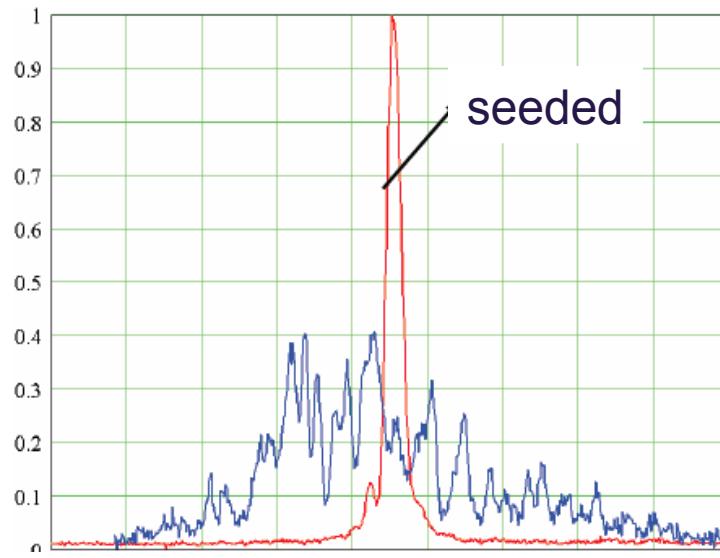
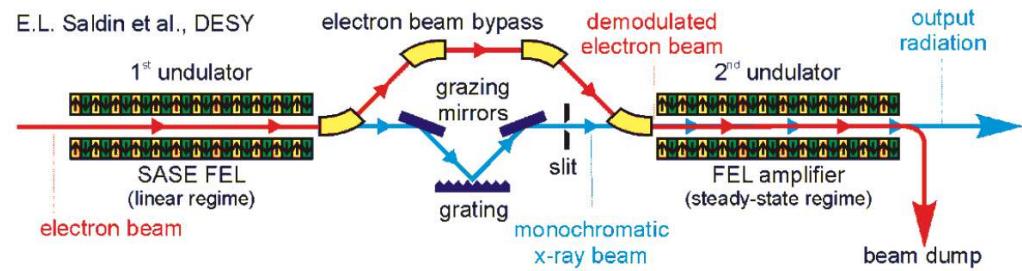
# Basics of SASE FEL process



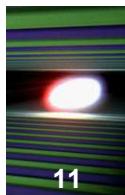
## SASE



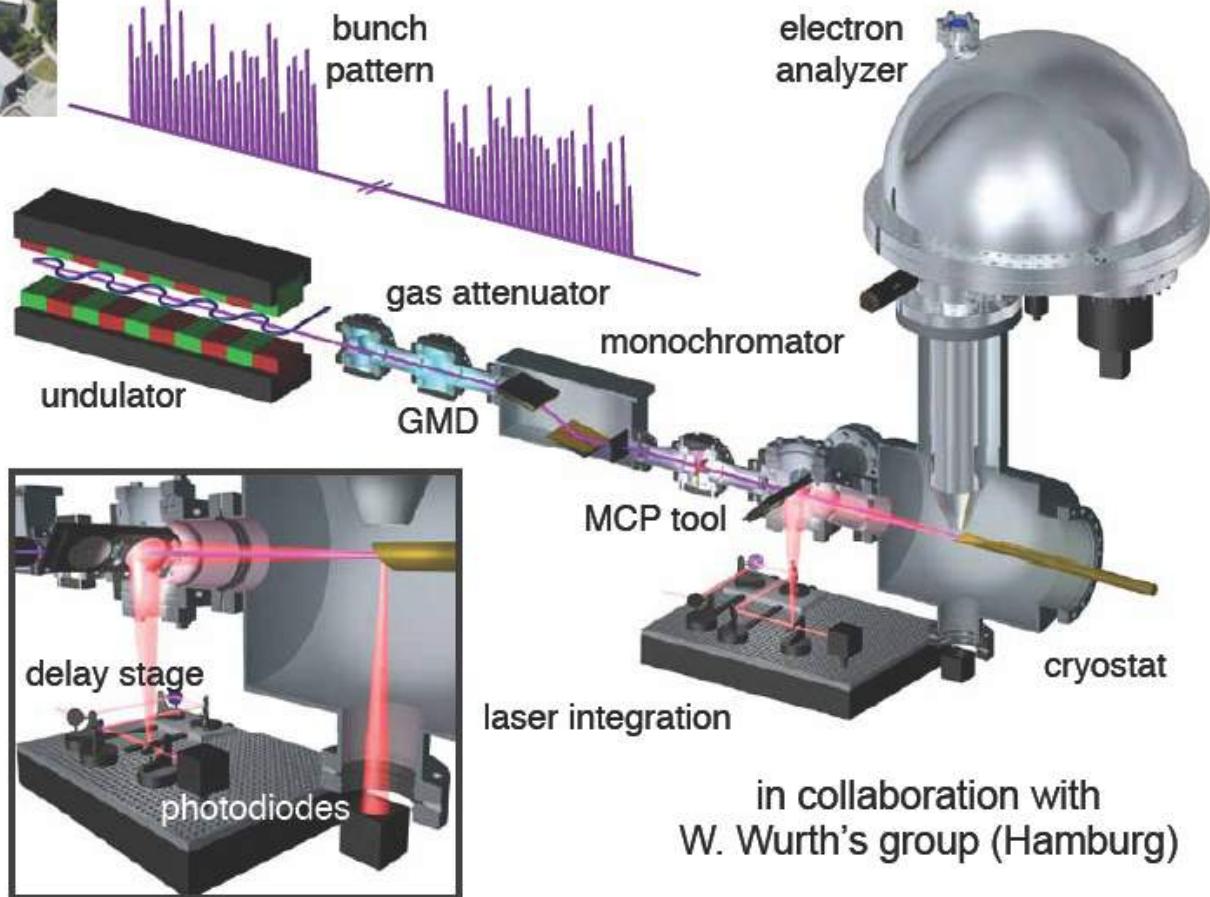
## Self Seeding



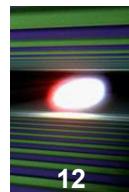
# Experimental set-up at FLASH (L. Kipp, Uni Kiel)



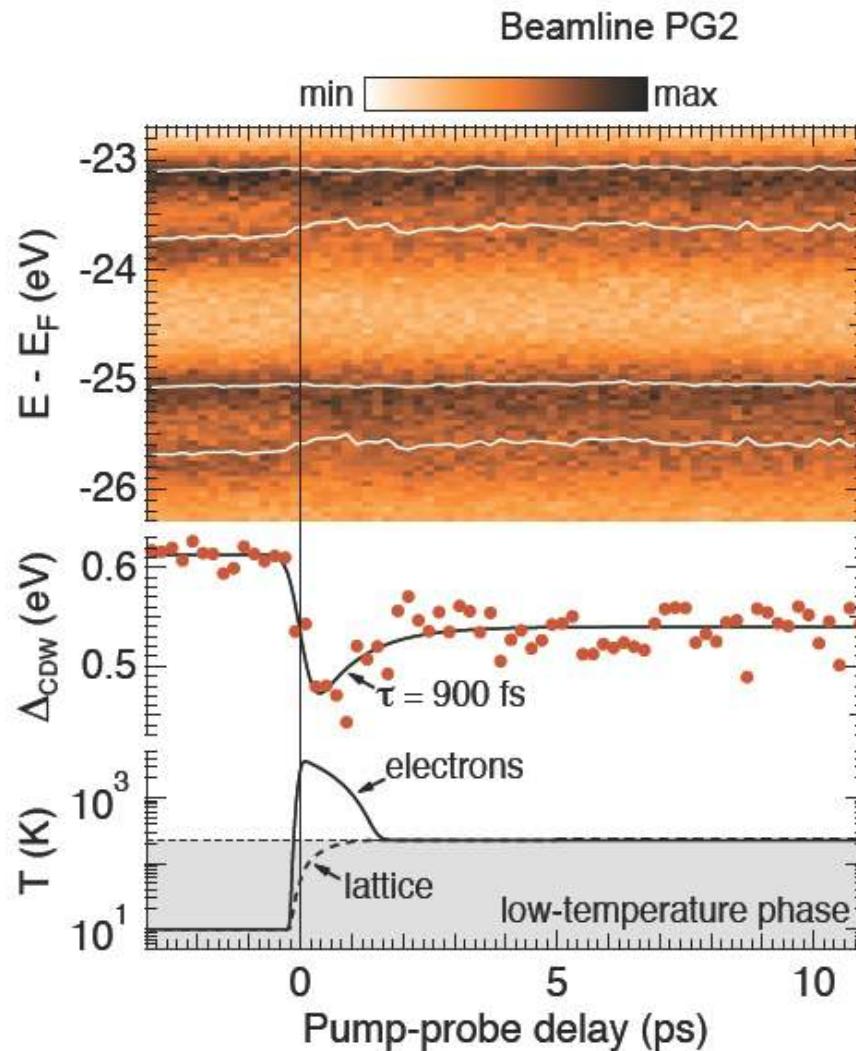
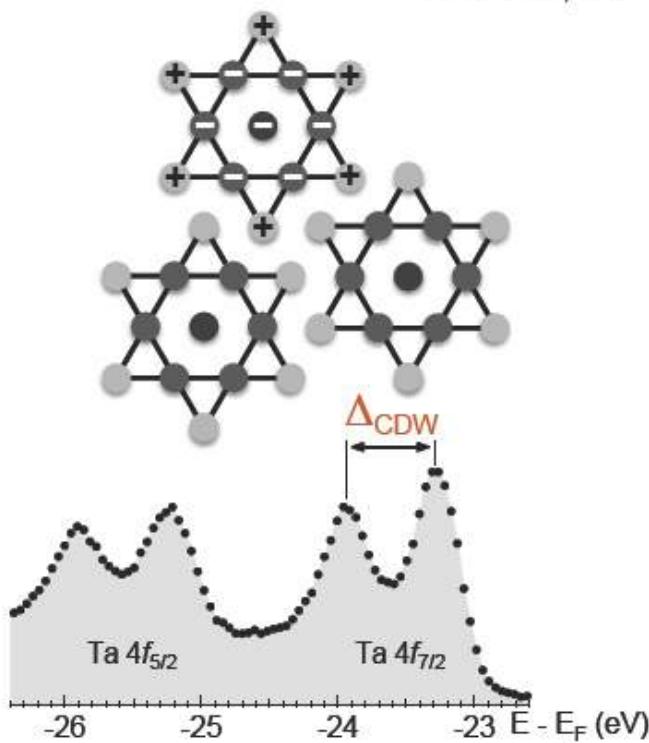
FLASH



Bundesministerium  
für Bildung  
und Forschung

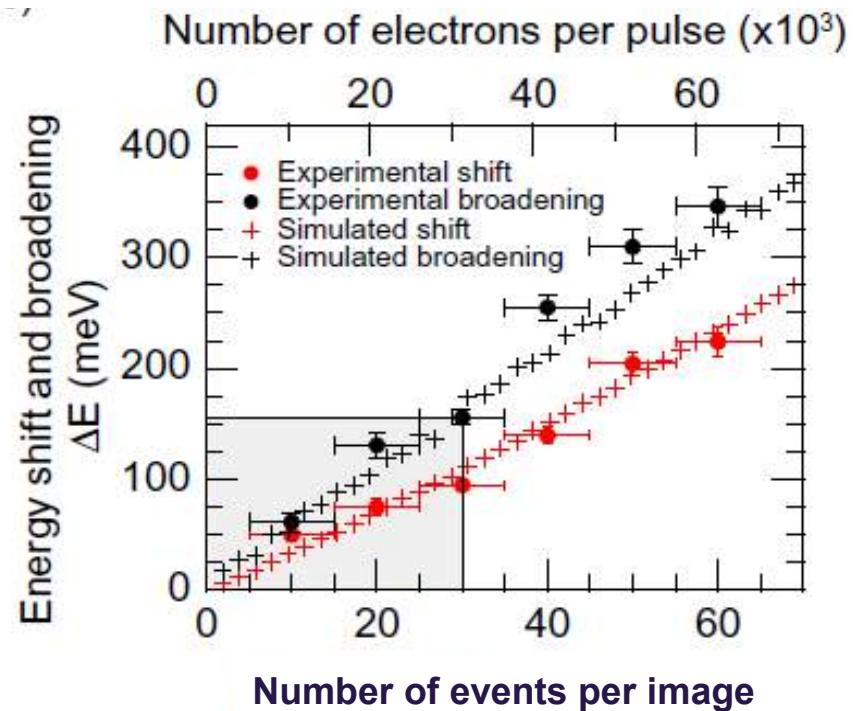
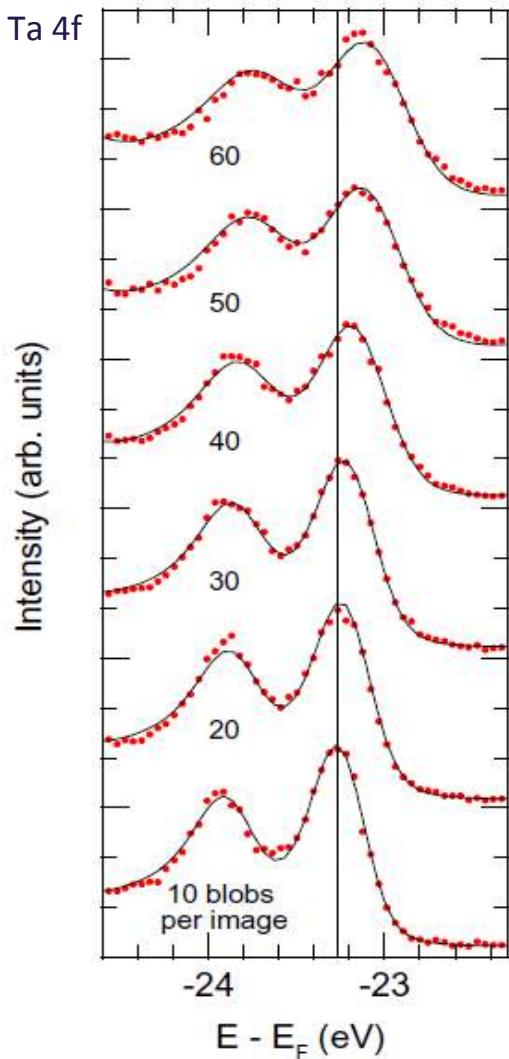
1  $T$ -TaSe<sub>2</sub>: tr-XPS using FLASH

$T = 10$  K  
 $h\nu_{pump} = 1.55$  eV.  $h\nu_{probe} = 156$  eV  
 $\Delta E \approx 300$  meV.  $\Delta t \approx 700$  fs  
 $F = 1.8$  mJ/cm<sup>2</sup>



Hellmann et al PRL 105, 187401 (2010)

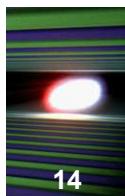
# Challenges for time-resolved (tr) PES: Space charge



Poses physical limits on number of electrons per pulse  
But can be controlled !

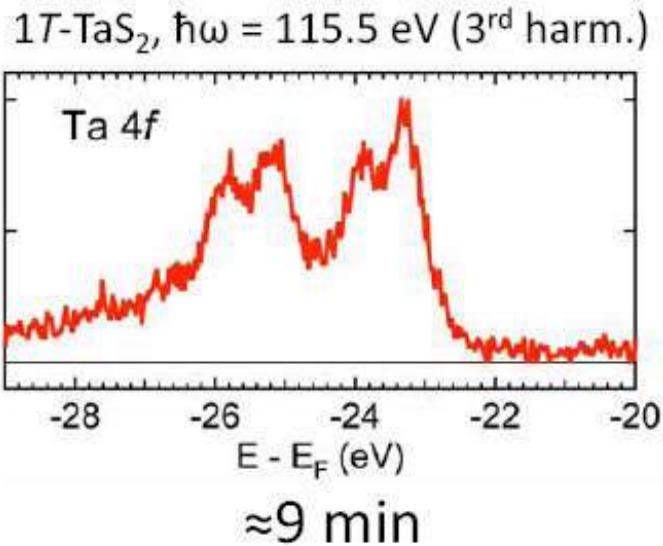
S. Hellmann et al.,  
New Journal of Physics 14 (2012) 013062

# What is feasible at FLASH (L. Kipp)



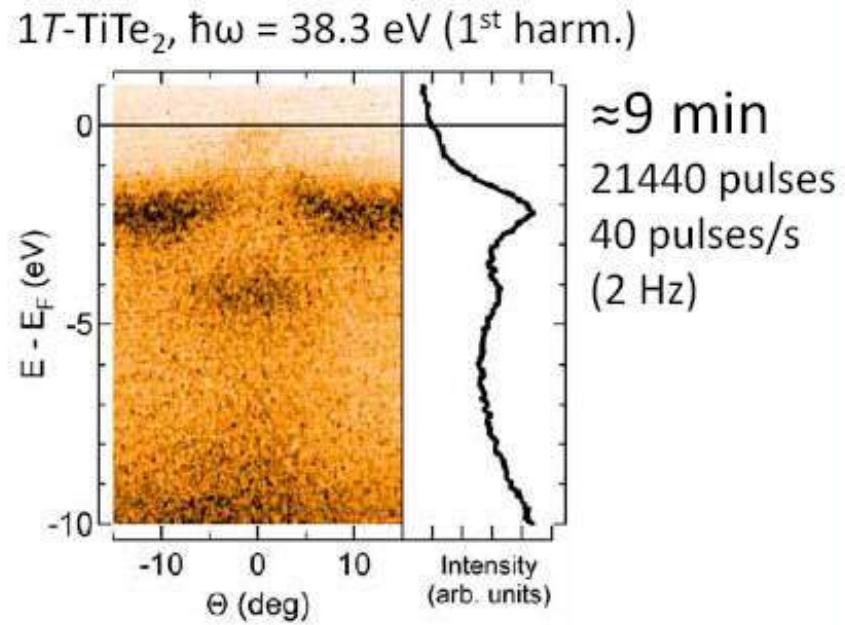
- Energy resolution: **<100 meV**
- Time resolution: **<500 fs**
- Time per spectrum: **<10 min**

### XPS

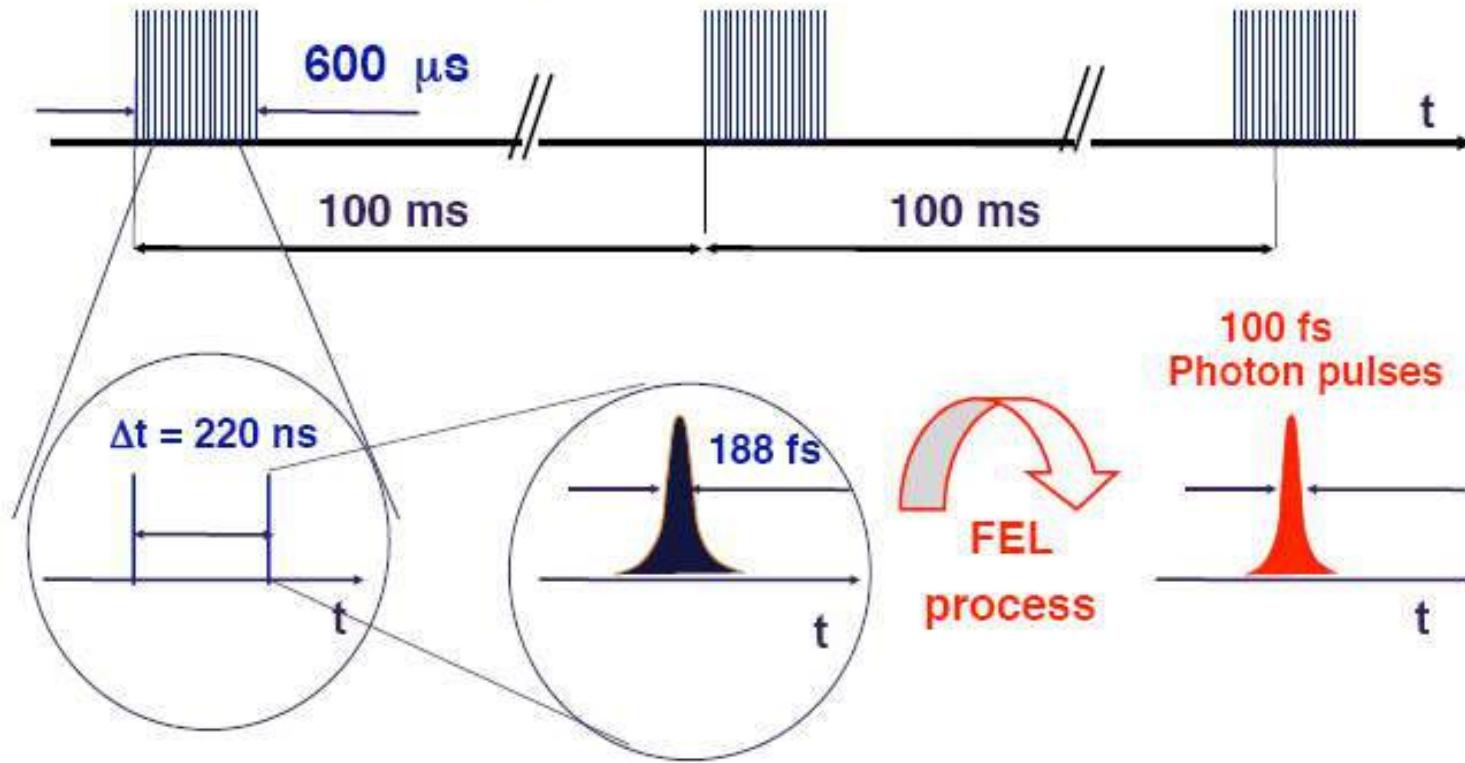


$\approx 9$  min  
56347 pulses, 100 pulses/s (5 Hz)

### ARPES

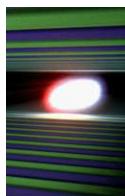


### Electron bunch trains (with up to 2700 bunches à 1 nC)

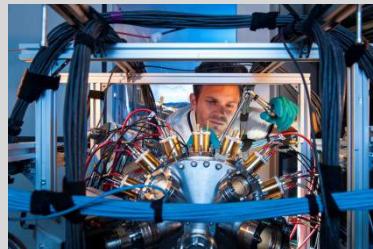


Superconducting LINAC technology provides 27.000 light pulses/s in burst-like structure. It makes XFEL.EU attractive for photon-hungry experiments.

# How it works – a closer look at the facility



Scientific instruments and instrumentation



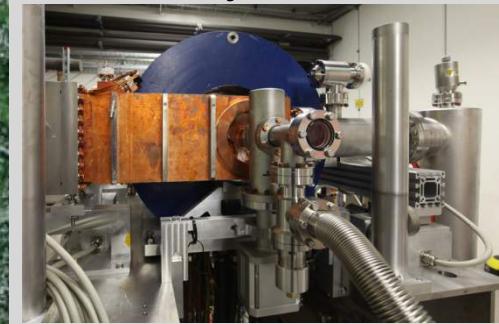
Undulator systems



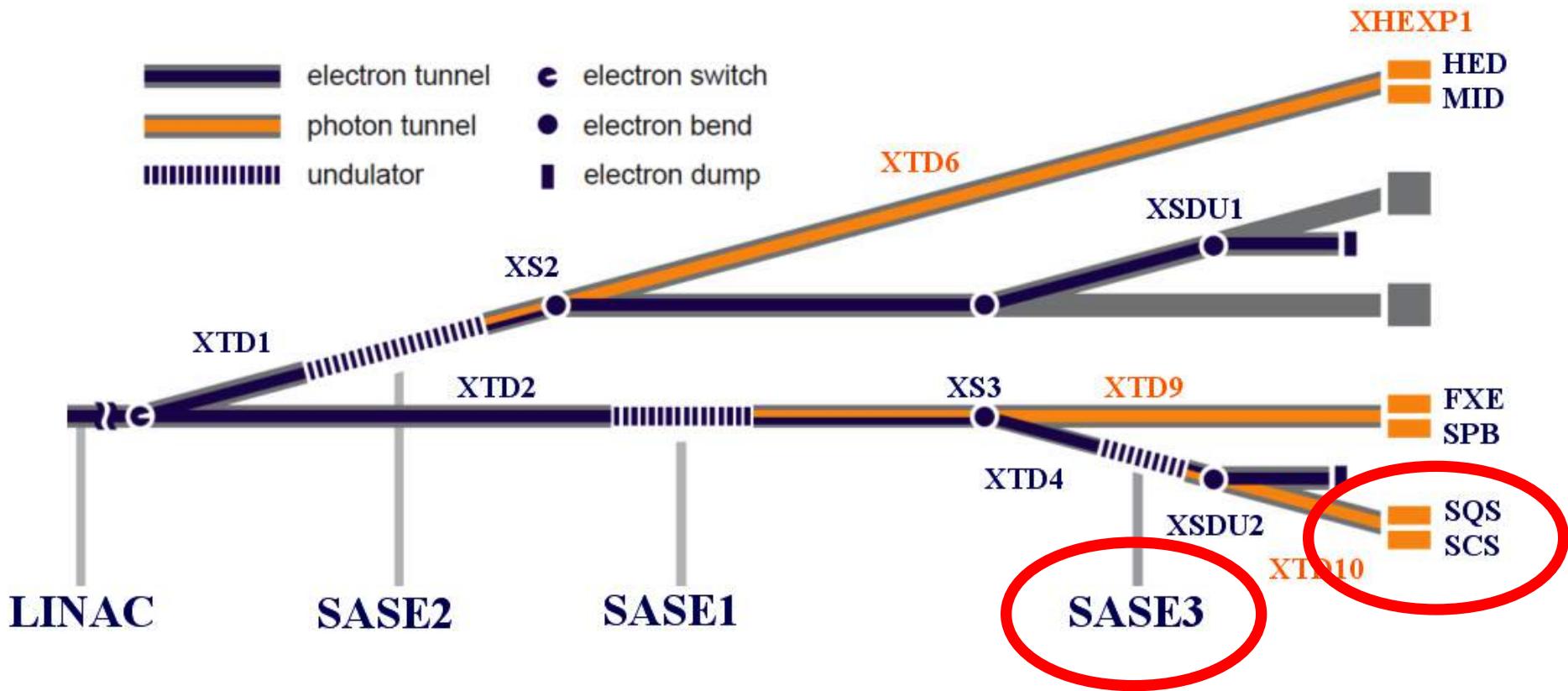
Superconducting electron accelerator



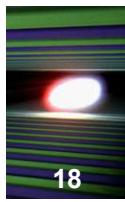
Electron injector



# Photon beam transport systems, soft X-rays



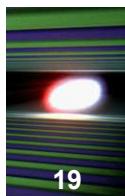
**SCS: Spectroscopy & Coherent Scattering**



# User Consortium

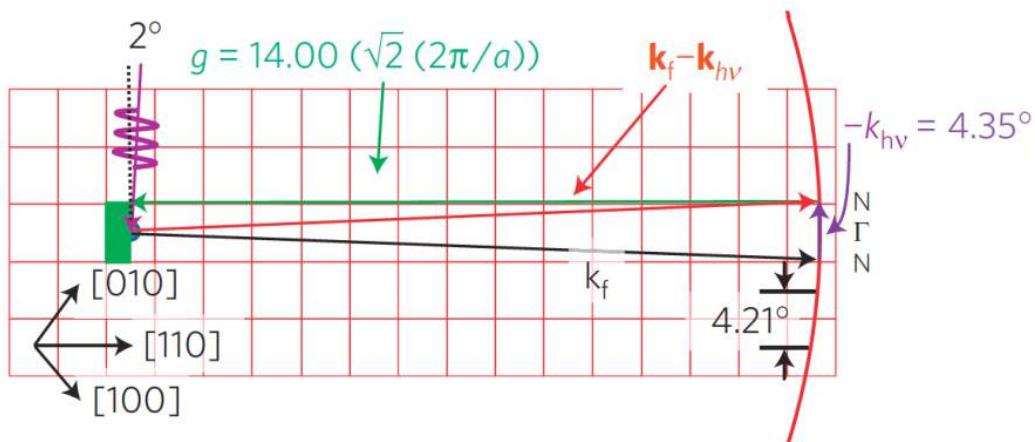
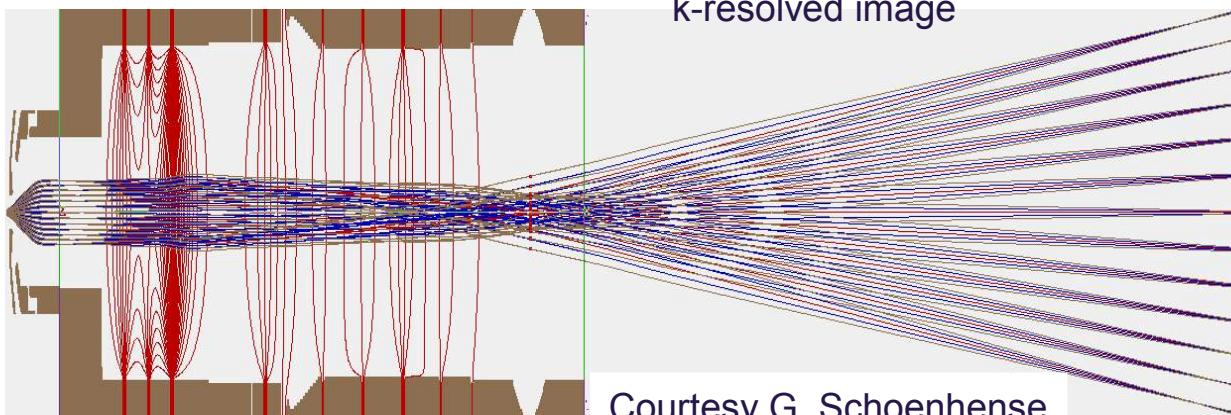
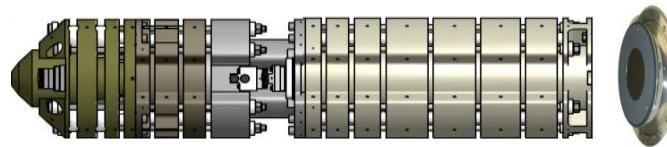
**tr-XPS and tr-ARPES**

# Choice of spectrometers

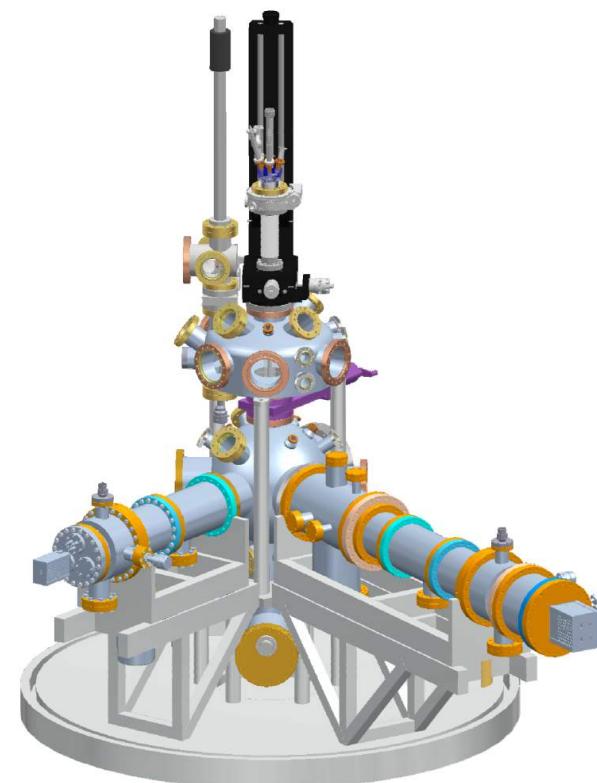


19

1000eV Start energy

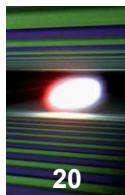
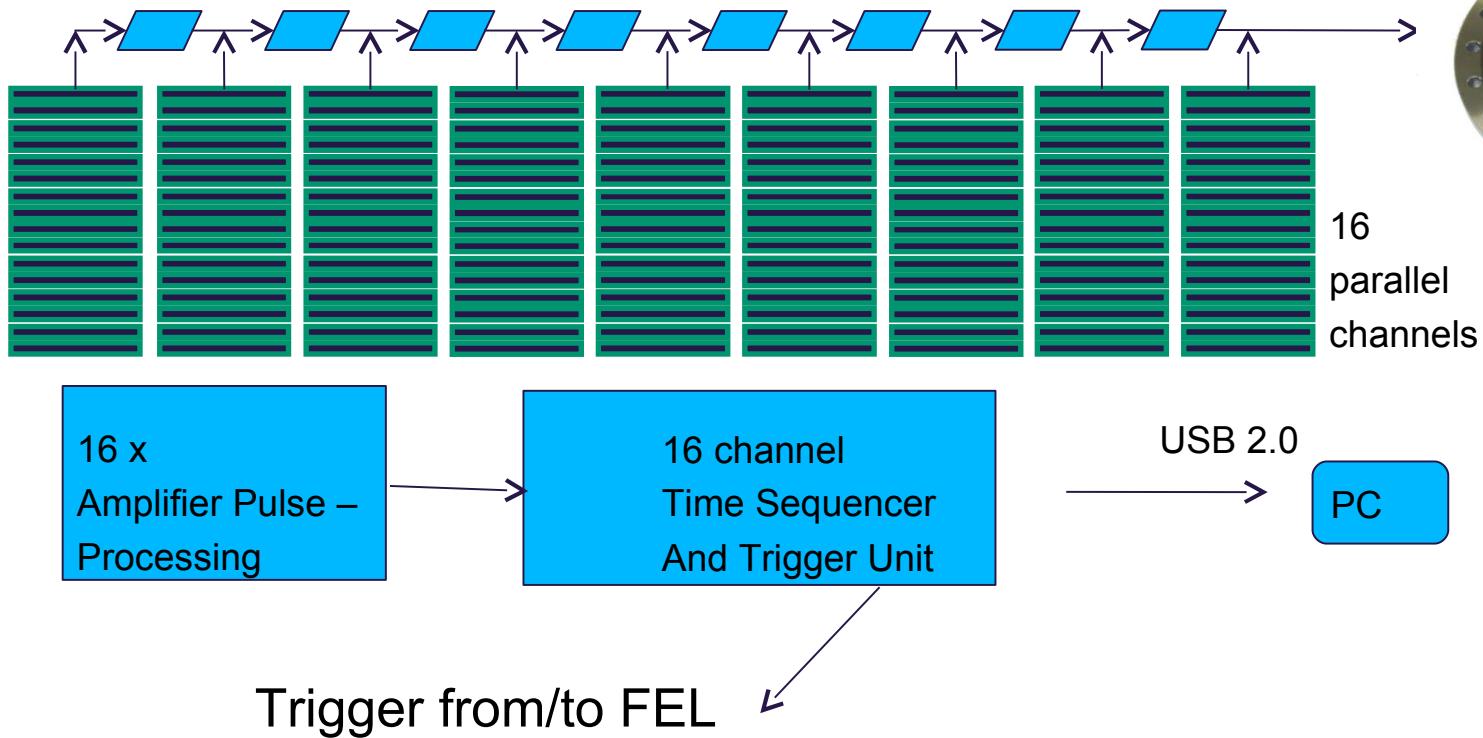


High angular resolution required  
for HARPES



## „Cluster DLD“: Capability for multiple event detection

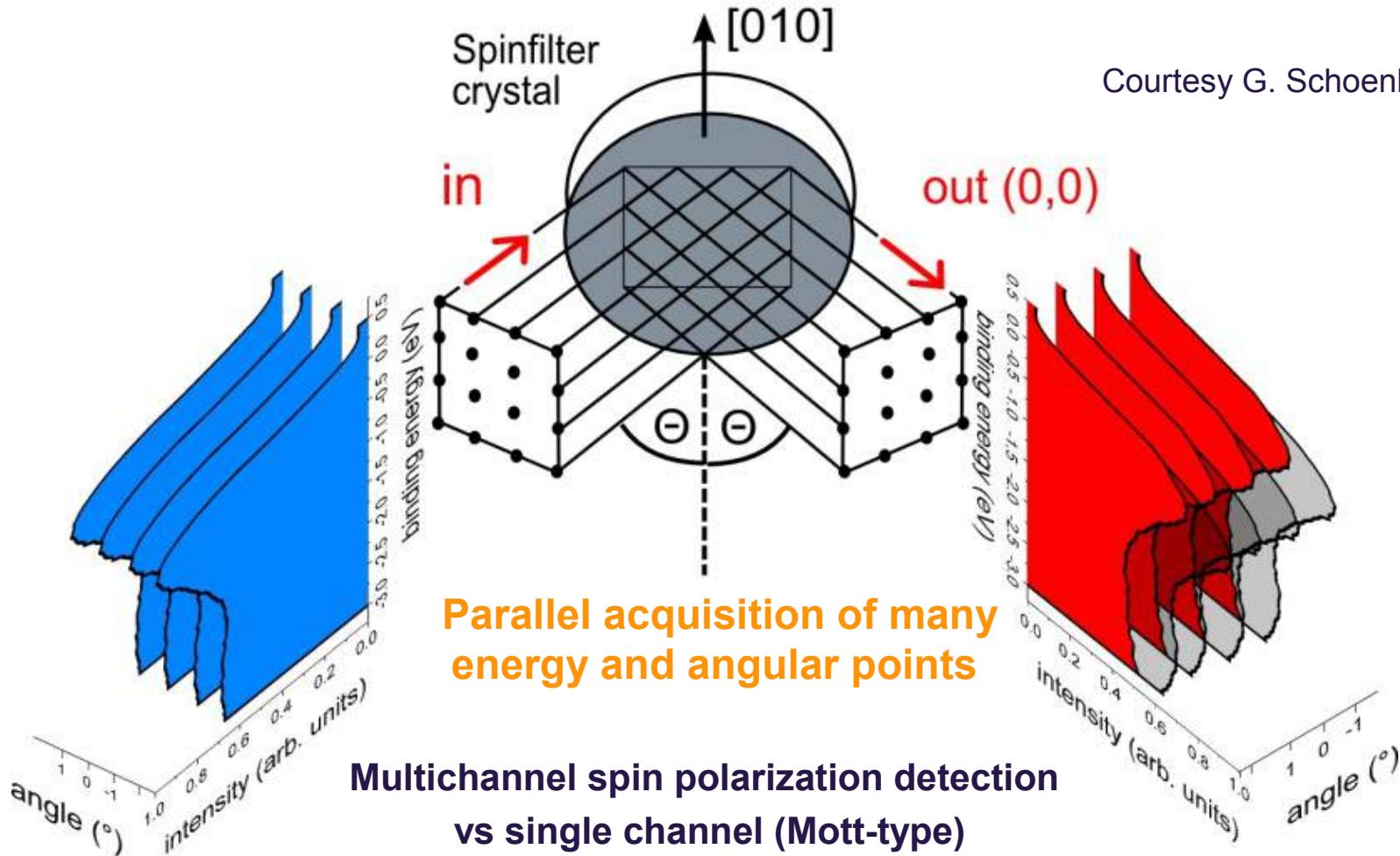
16 x 8 delays of 12 ns integrated into detector anode in vacuum



256 (may be 512) channel DLD in development (BMBF project with CFEL/UHH)

**SURFACE**  
CONCEPT

## Spin detection



„Established“ for hemispherical analyzers – concepts for TOF spectrometers

# Hamburg, 30.06.2010: Christening of the bending magnets and tunnels



100% of tunnels are excavated

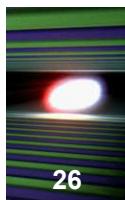


# Completion of underground construction (06.06.13)

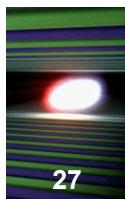




# European XFEL, Campus



# Experimental hall



# Main building: Architect's view



# Main building: Architect's view





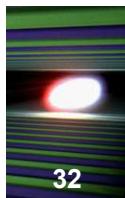
Together with DESY Photon Sciences Users' Meeting:  
822 registered participants, of which:

388 from Hamburg (DESY, XFEL.EU, University, CFEL,...)

434 from elsewhere than Hamburg

**You are very welcome  
to plan your experiments  
at European XFEL**

With thanks to...



32

**Martin Weinelt**  
**John Bowlan**  
**Kristian Döbrich**  
**Björn Frietsch**  
**Martin Teichmann**  
**Cornelius Gahl**

**Serguei Molodtsov**  
**Andreas Scherz**  
**Manuel Izquierdo**

