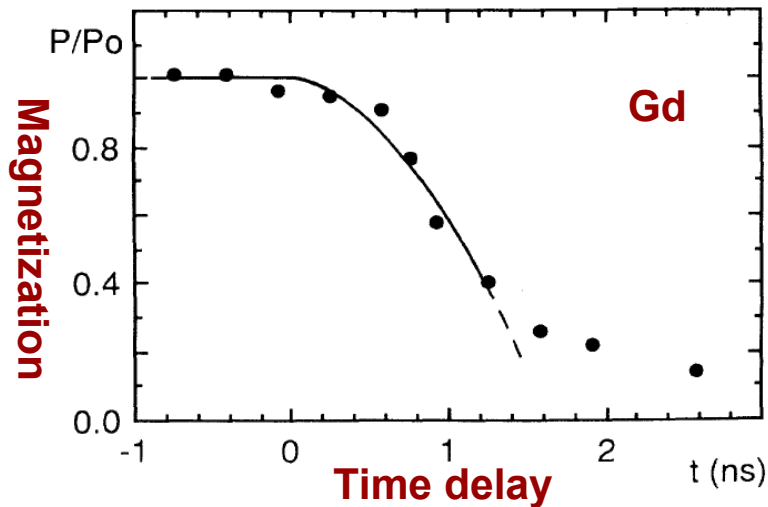


Spatially resolved ultra-fast magnetization dynamics tracked via resonant magnetic scattering at FLASH

Bastian Pfau, TU Berlin

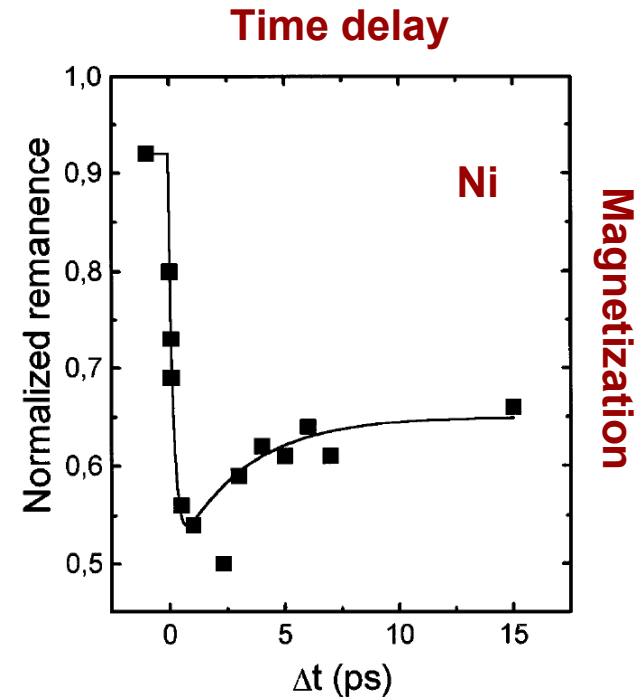
Ultrafast demagnetization



Time-resolved photoemission

Gd: 100 ± 80 ps

A. Vaterlaus et al., PRL **67**, 3315 (1991)



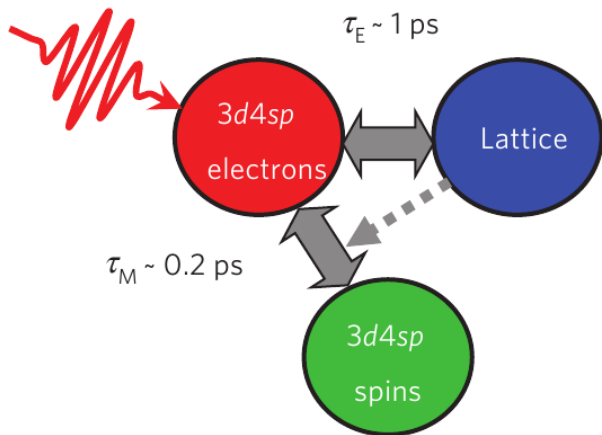
Time-resolved MOKE

Ni: 120 fs

E. Beaurepaire et al., PRL **76**, 4250 (1996)

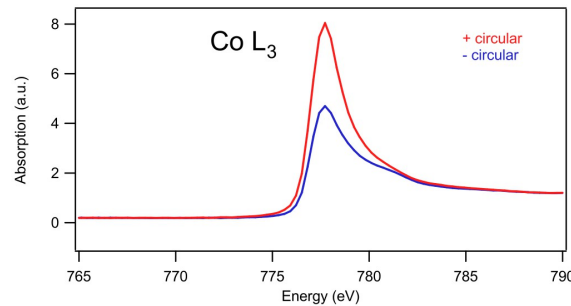
Magnetic scattering at free-electron lasers

Time resolution (fs)



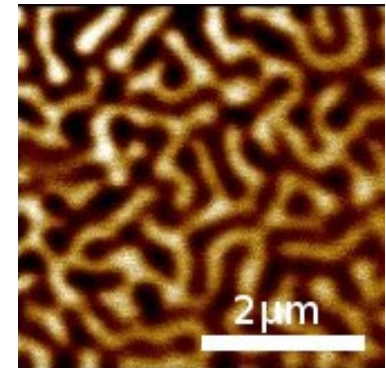
three-temperature model

Sensitivity



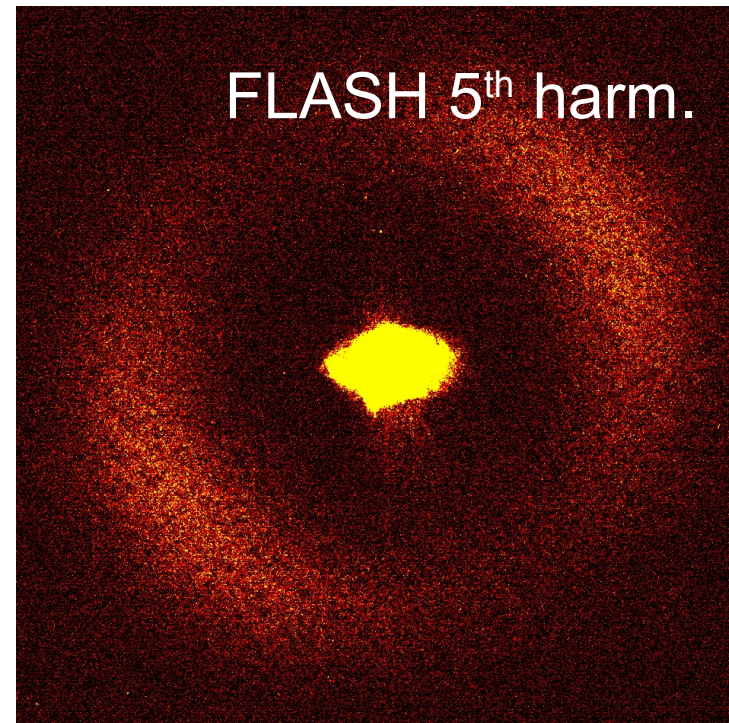
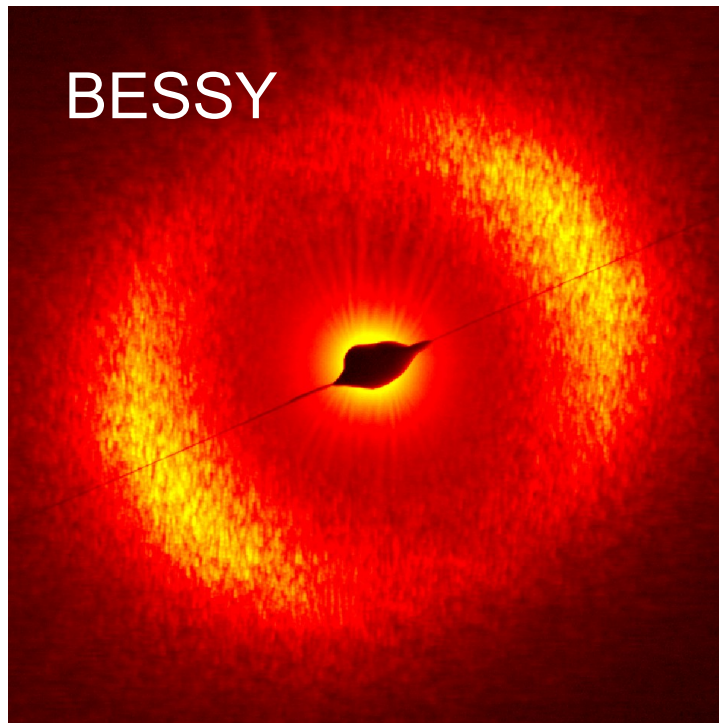
- Magnetic (XMCD)
- Element
- Spin and orbital momentum

Structure (nm)



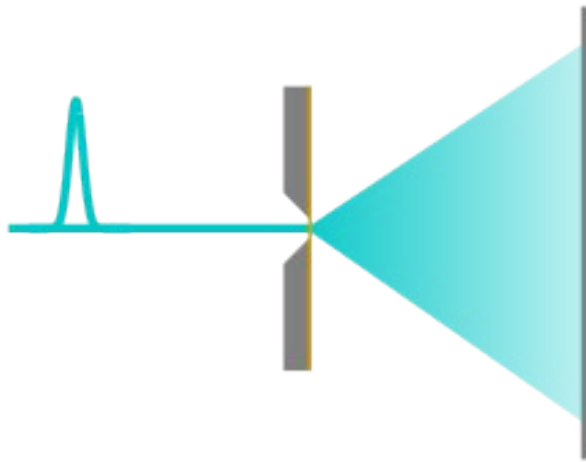
[Co(m)/Pt(n)]_x
 $m, n < 10 \text{ \AA}$
 $5 < x < 50$

Magnetic small-angle scattering @ 1.6nm (L-edge)



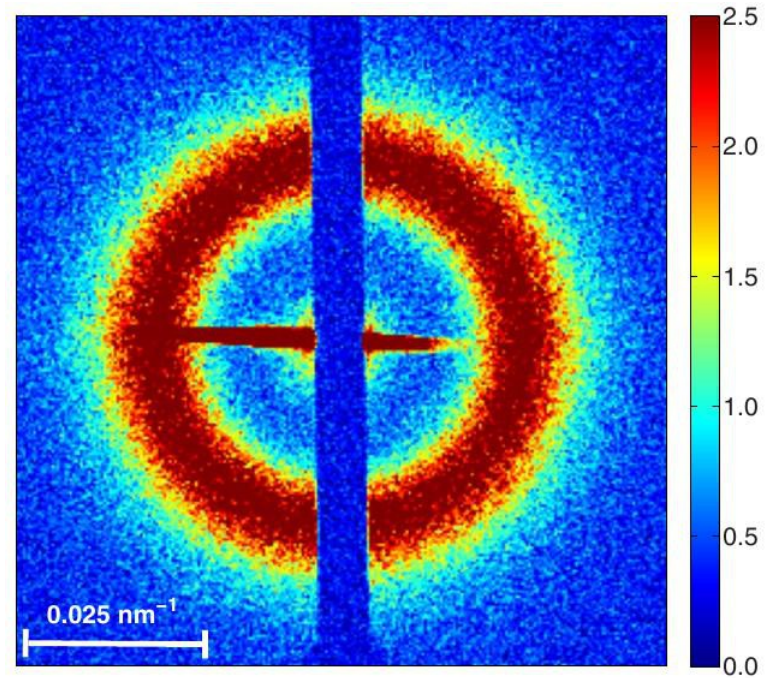
C. Gutt et al., PRB **79**, 21240 (2009)

Magnetic Scattering at FLASH @ 20.8nm (M-edge)



30 fs single shot

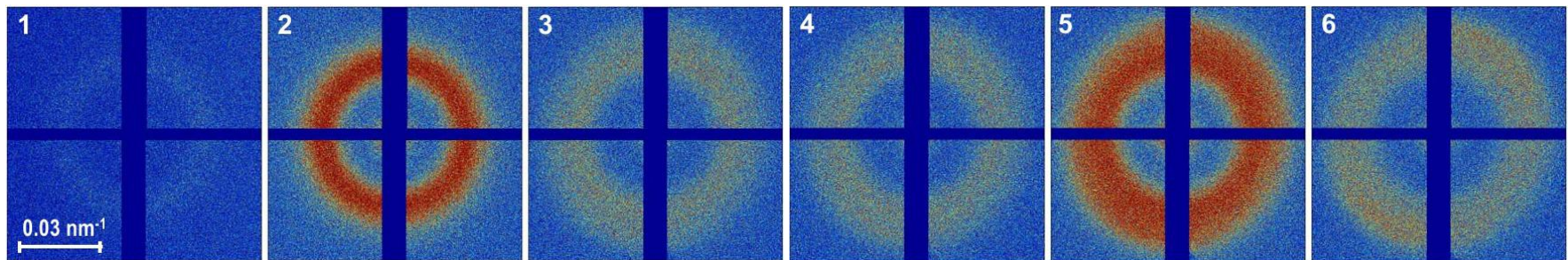
Destructive or non-destructive



C. Gutt et al., PRB **81**, 100401(R) (2009)

Magnetic Scattering at FLASH @ 20.8nm (M-edge)

Series of single shots 30 fs



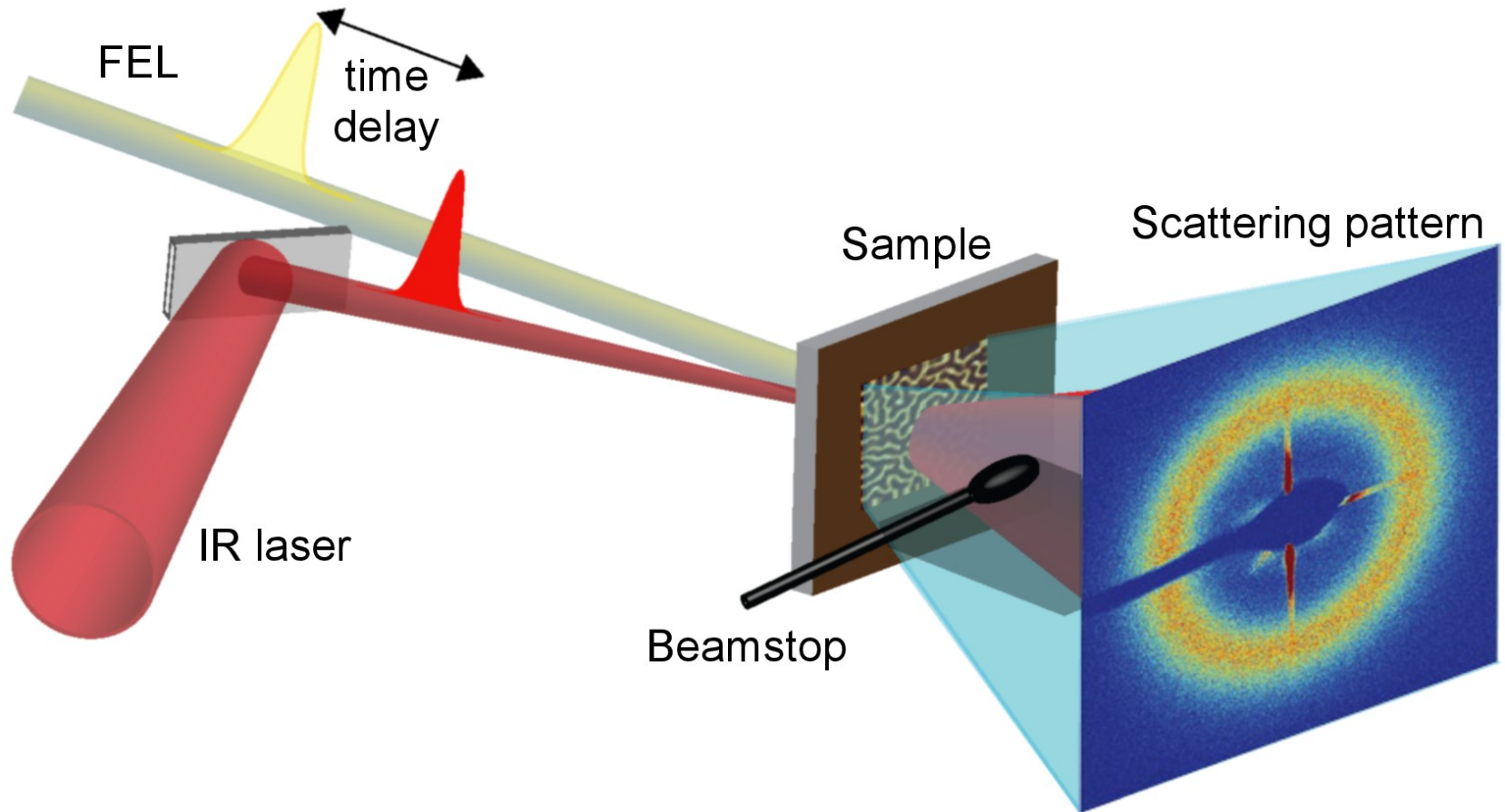
Magnetic moments are not quenched during exposure

Sample comes back to equilibrium

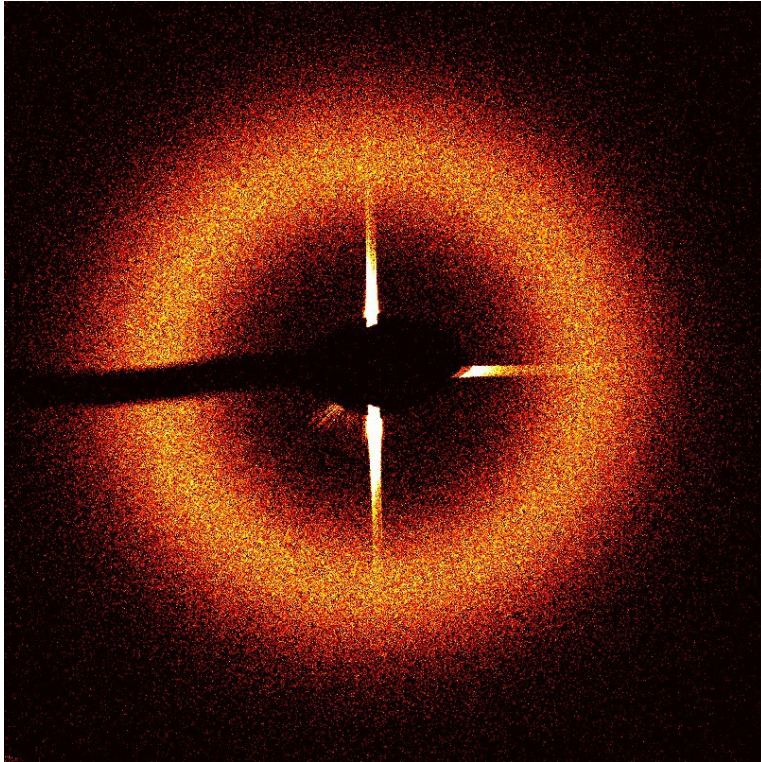
FEL pulse can induce irreversible sample changes

FEL pulse can serve as pump

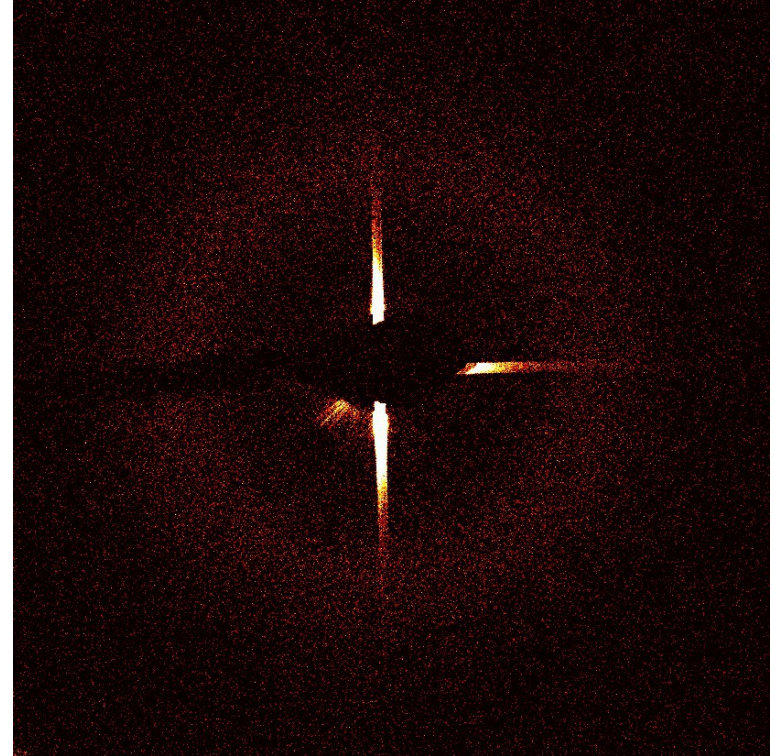
IR-pump X-ray probe



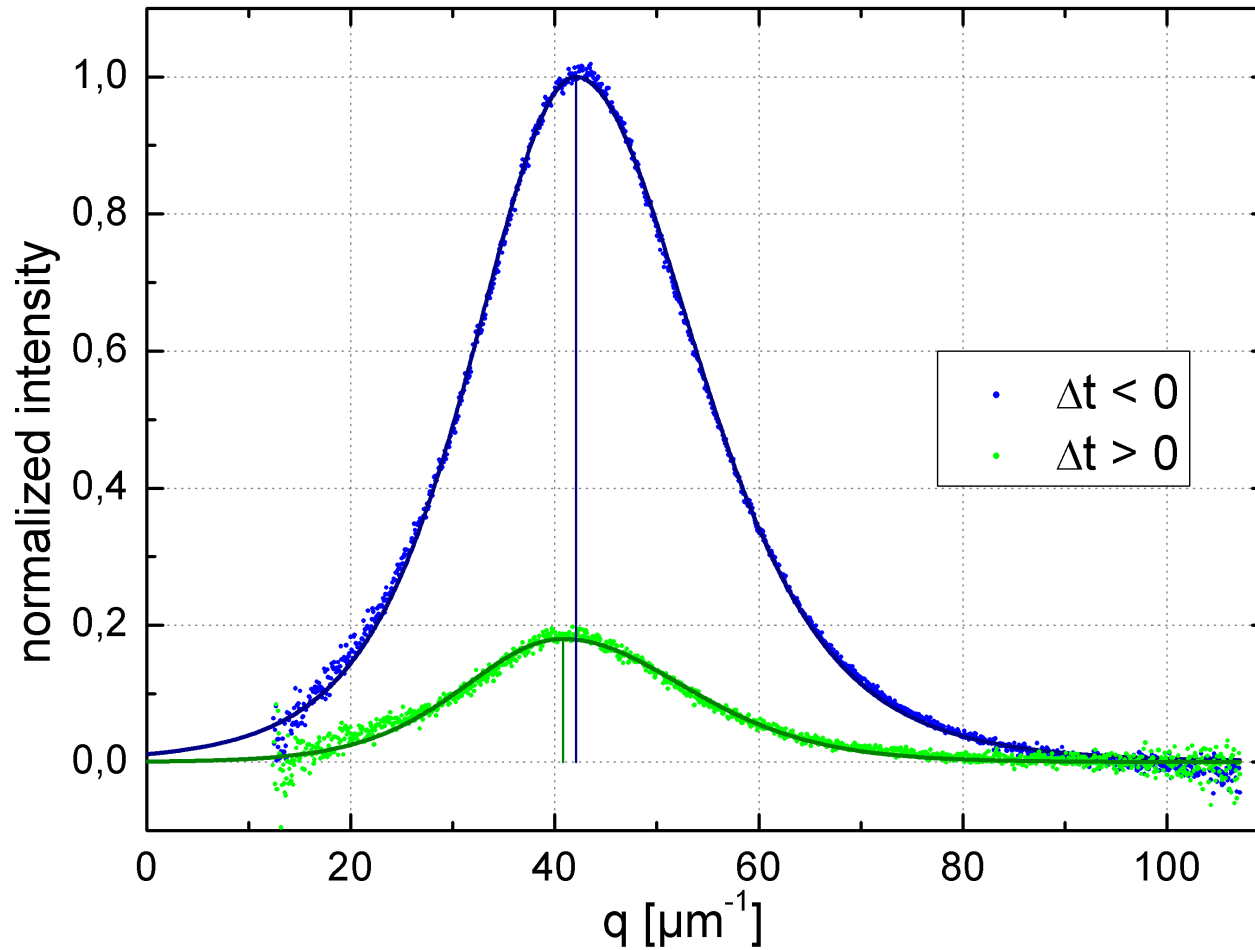
before pump



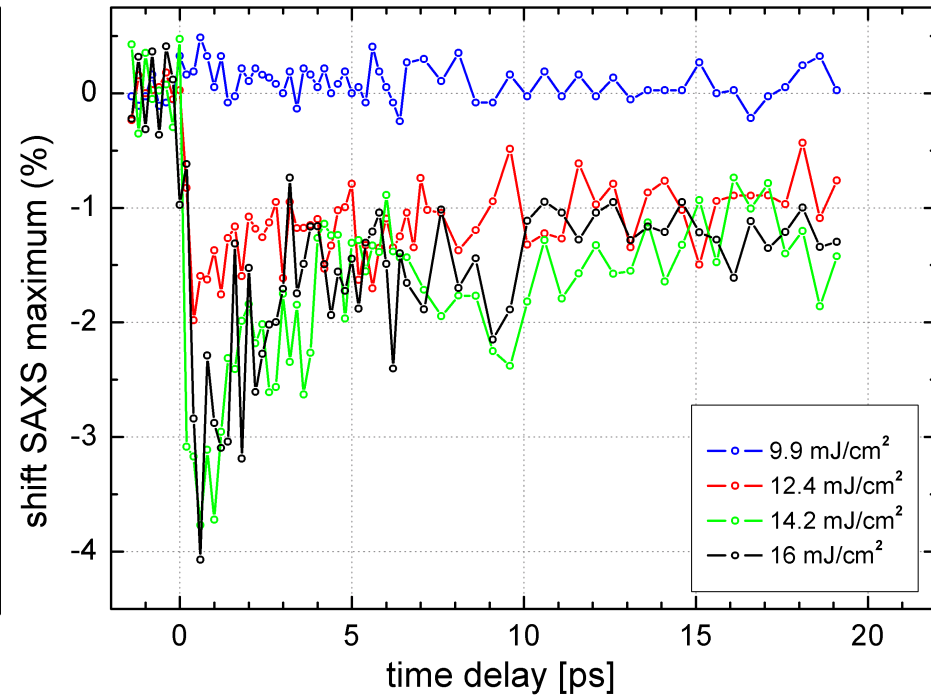
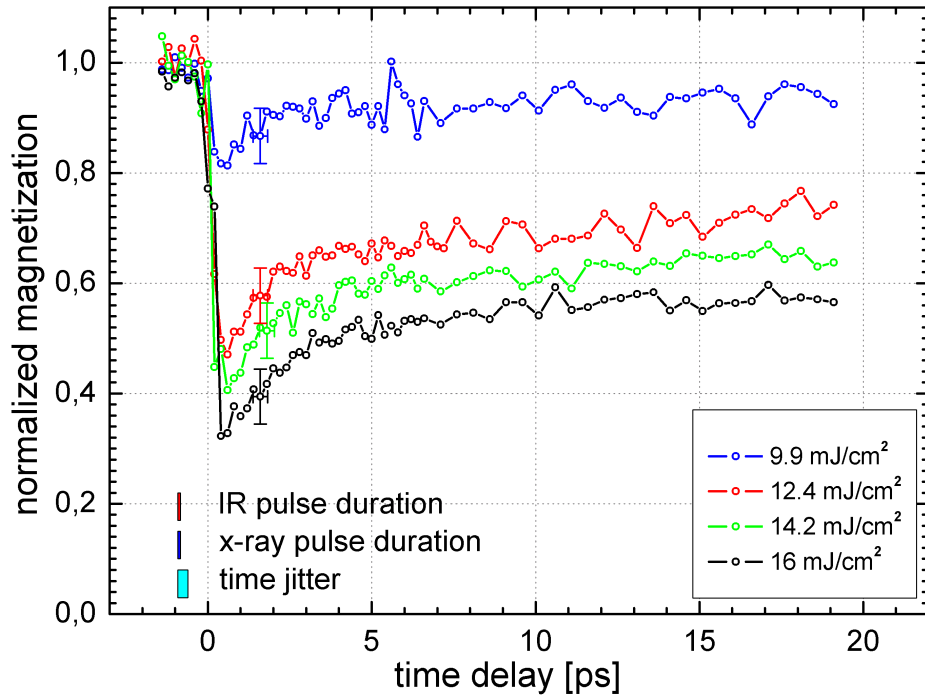
after pump ($\sim 0.5\text{ps}$)



Spatially resolved ultrafast magnetization dynamics at FLASH



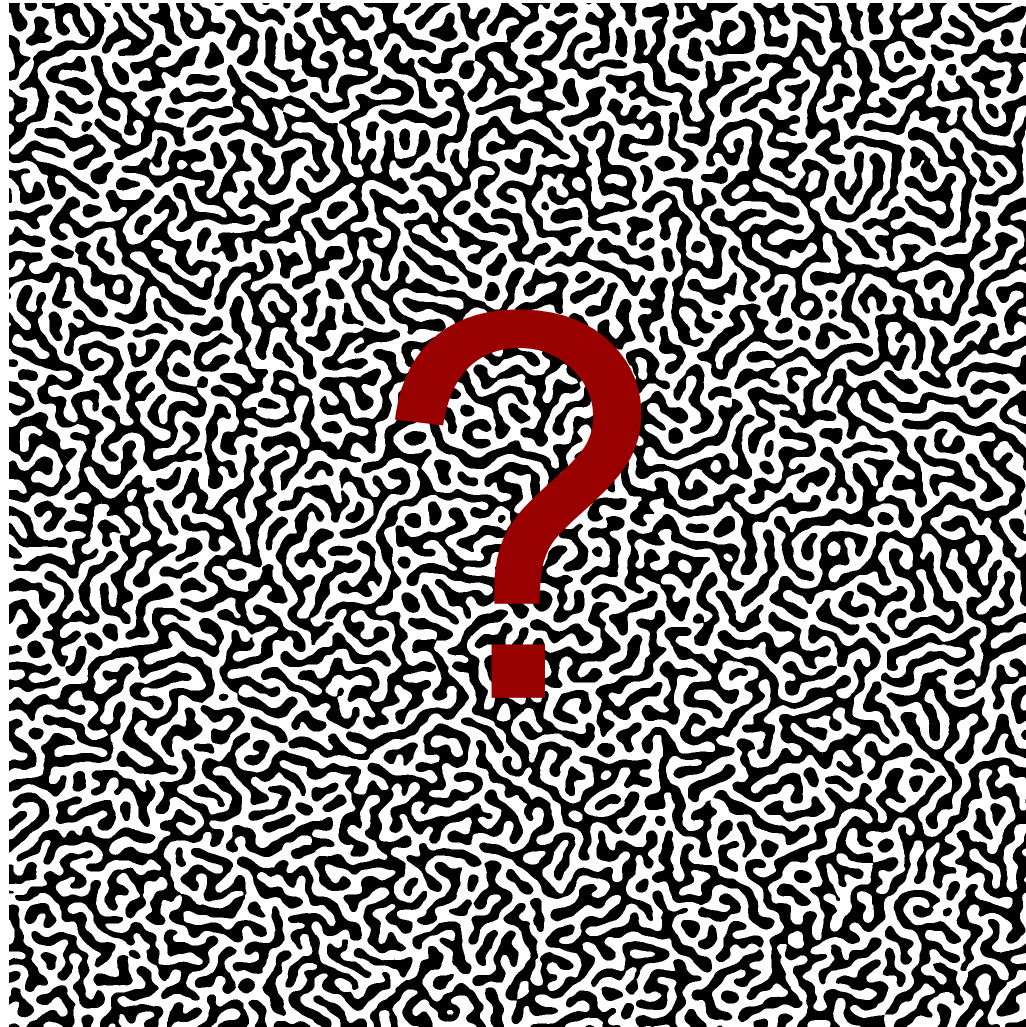
IR-pump X-ray probe



Ultrafast demagnetization

Ultrafast magnetic domain structure changes

Spatially resolved ultrafast magnetization dynamics at FLASH

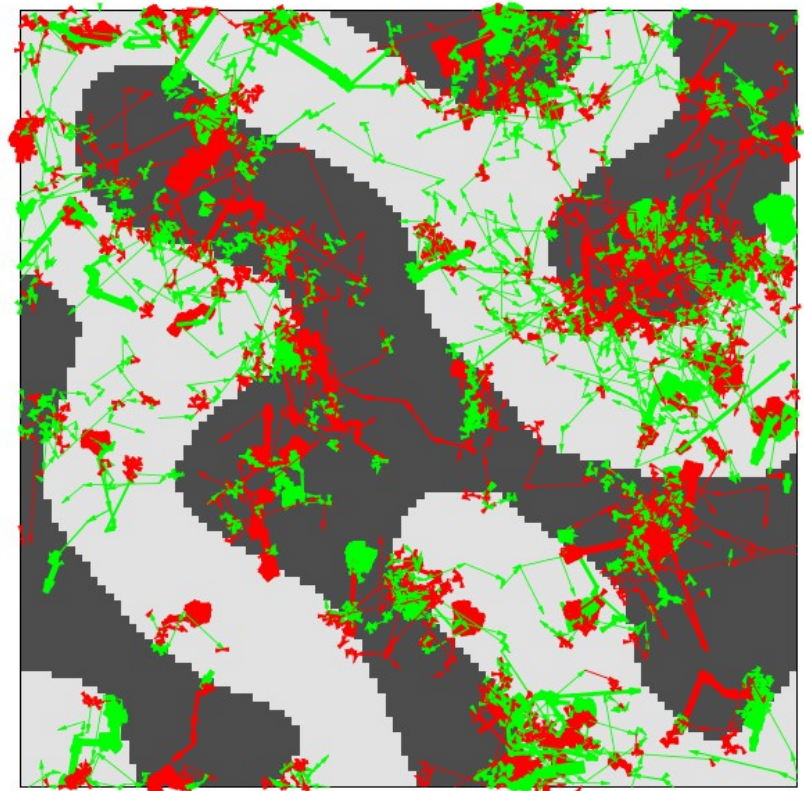
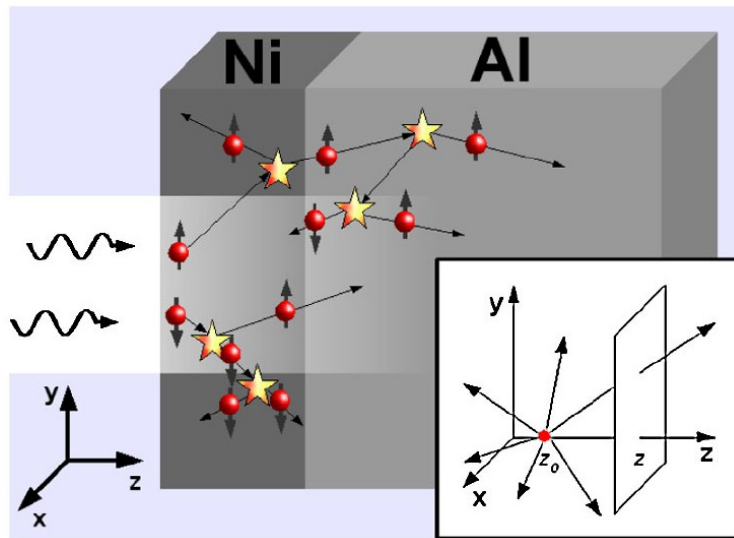


Superdiffusive Spin Transport as a Mechanism of Ultrafast Demagnetization

M. Battiato,* K. Carva,† and P. M. Oppeneer

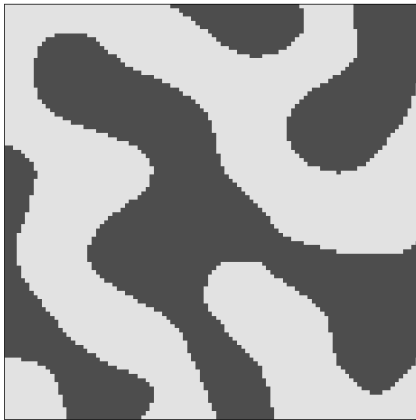
Department of Physics and Astronomy, Uppsala University, Box 516, SE-75120 Uppsala, Sweden

(Received 31 March 2010; published 9 July 2010)

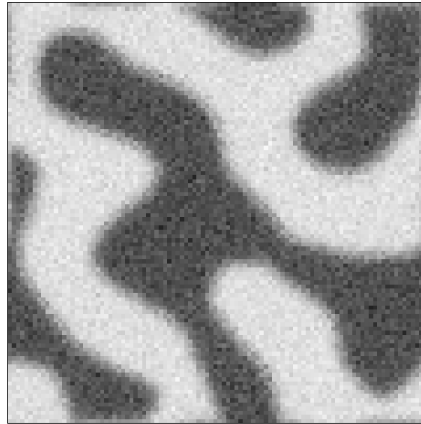


Monte-Carlo Simulation

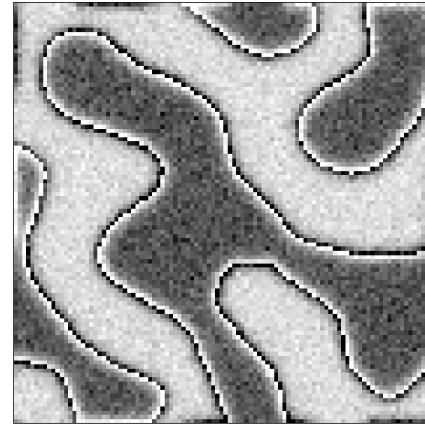
0 fs



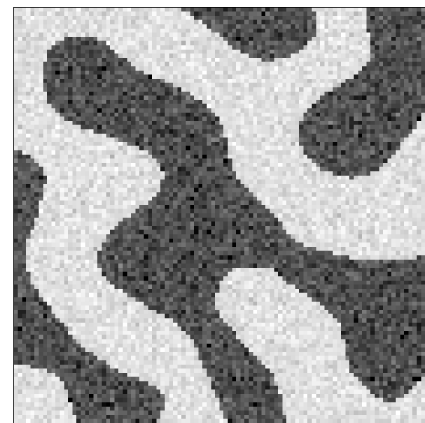
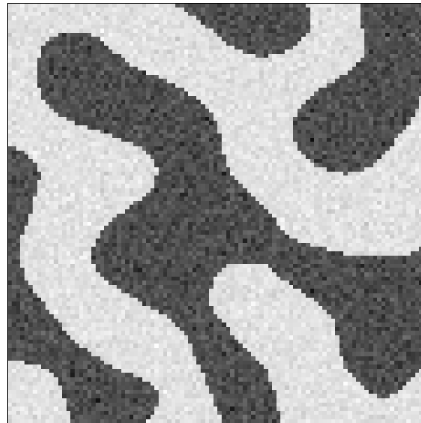
300 fs



500 fs

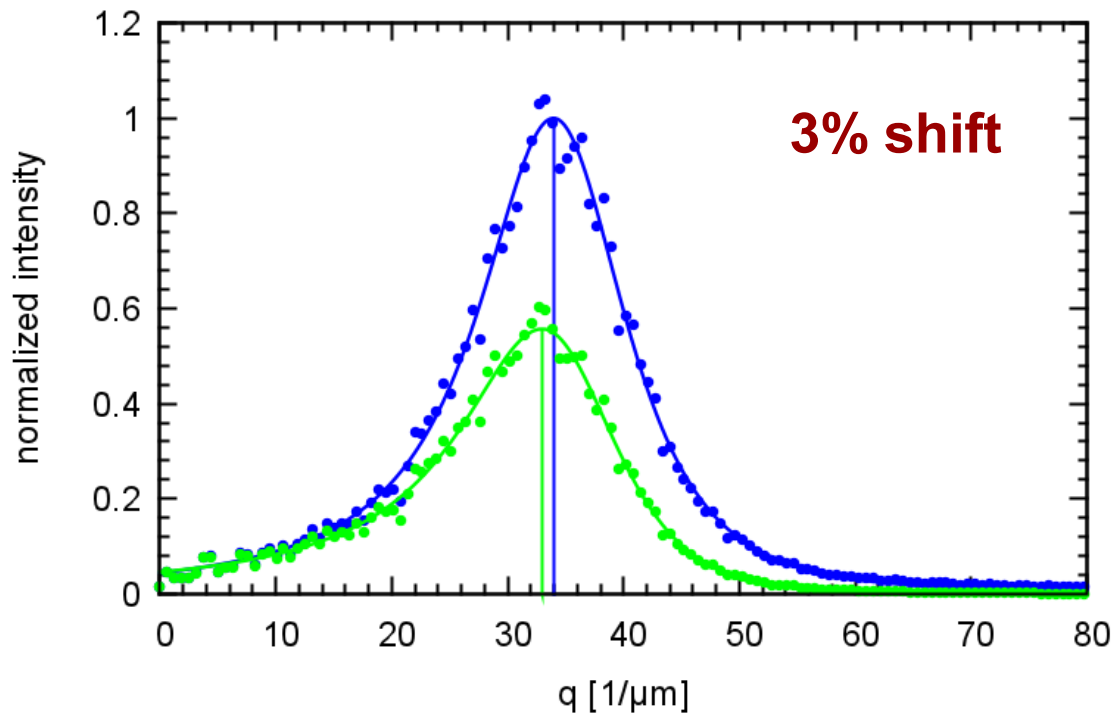


spin-
polarized

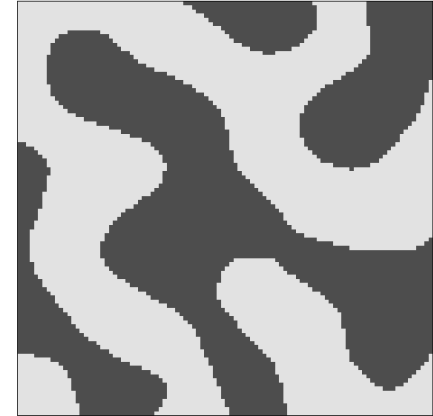


unpolarized

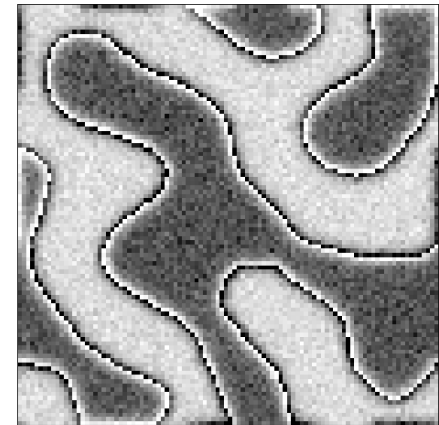
Monte-Carlo Simulation



0 fs



500 fs



Acknowledgements



HZB Helmholtz
Zentrum Berlin



Universität Hamburg

Stefan Eisebitt
Sam Flewett
Jan Geilhufe
Erik Gührs
Christian Günther
Stefan Schaffert
Jyoti Mohanty
Torbjörn Rander

Gerhard Grübel
Christian Gutt
Leonard Müller
Simone Streit-Nierobisch
Lorenz Stadler
Michael Walter

Hans Peter Oepen
Robert Frömter
Matthias Hille
André Kobs
Daniel Stickler

Rolf Treusch
Stefan Düsterer



HITACHI
Inspire the Next
Olav Hellwig

Jan L ning
Boris Vodungbo

Nicolas Jaouen
Horia Popescu

Christmas Wish List

Yes, we want variable polarization!

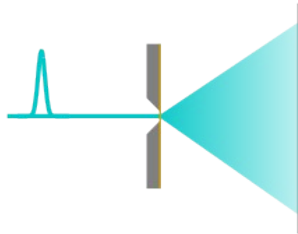
Photon energies up to the L3 edges of 3d elements

Better temporal resolution, esp. lower jitter

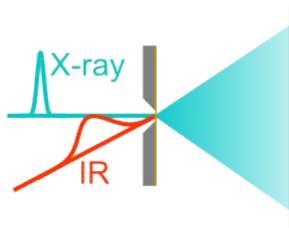
Spectral analysis (shot-to-shot)

Split and delay line

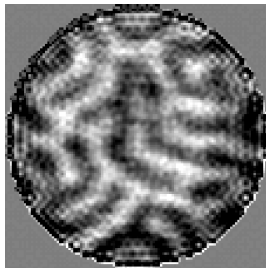
Summary



Resonant FEL pulses can serve as probe for detecting ultrafast magnetization dynamics.



We detected ultrafast demagnetization in combination with changes in the domain structure.



For future, we need circular polarization, e.g. for single-shot imaging