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Laser-induced ultrafast demagnetization and perpendicular magnetic anisotropy reduction in a $\text{Co}_{88}\text{Tb}_{12}$ thin film with stripe domains

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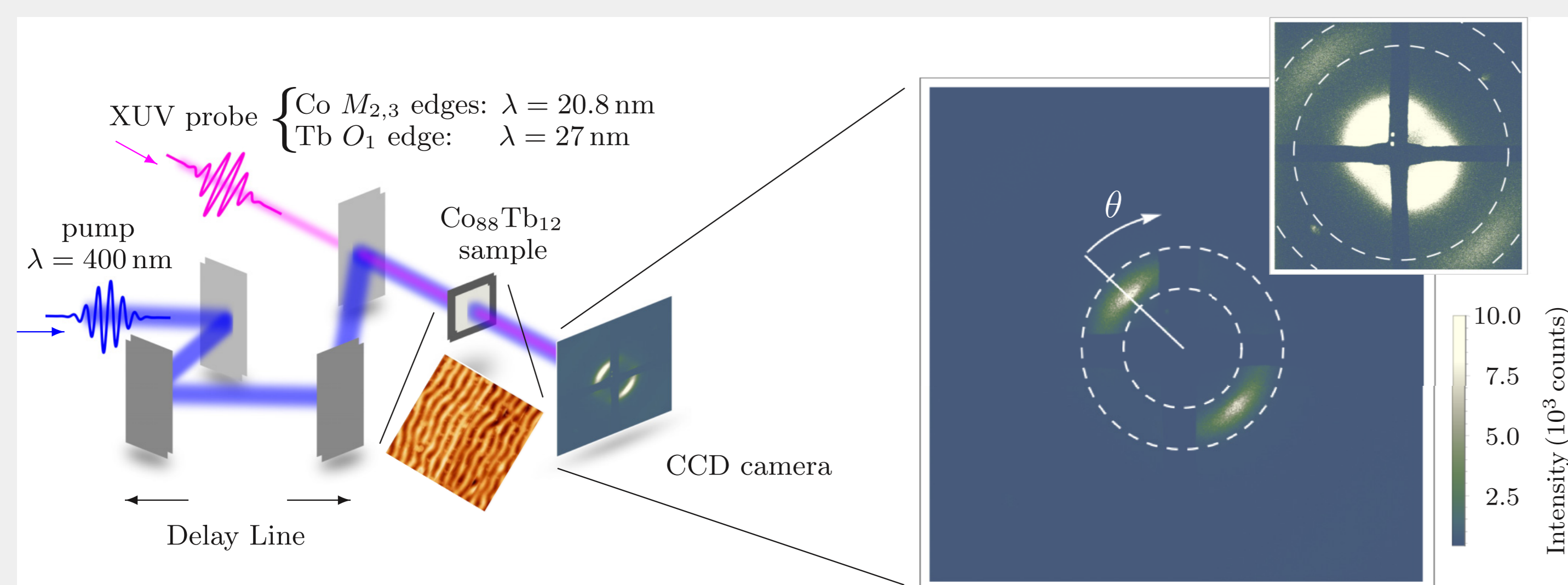
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Abstract

We use time-resolved x-ray resonant magnetic scattering (TR-XRMS) at the Co $M_{2,3}$ and Tb O_1 edges to study ultrafast demagnetization in an amorphous $\text{Co}_{88}\text{Tb}_{12}$ alloy with stripe domains. Combining the femtosecond temporal with nanometer spatial resolution of our experiment, we demonstrate that the equilibrium spin texture of the thin film remains unaltered by the optical pump pulse on ultrashort timescales (< 1 ps). However, after 4 ps, we observe the onset of a significant domain wall broadening, which we attribute to a reduction of the uniaxial magnetic anisotropy of the system, due to energy transfer to the lattice. Static temperature-dependent magnetometry measurements combined with analytical modeling of the magnetic structure of the thin film corroborate this interpretation.

X-ray resonant magnetic scattering [1]

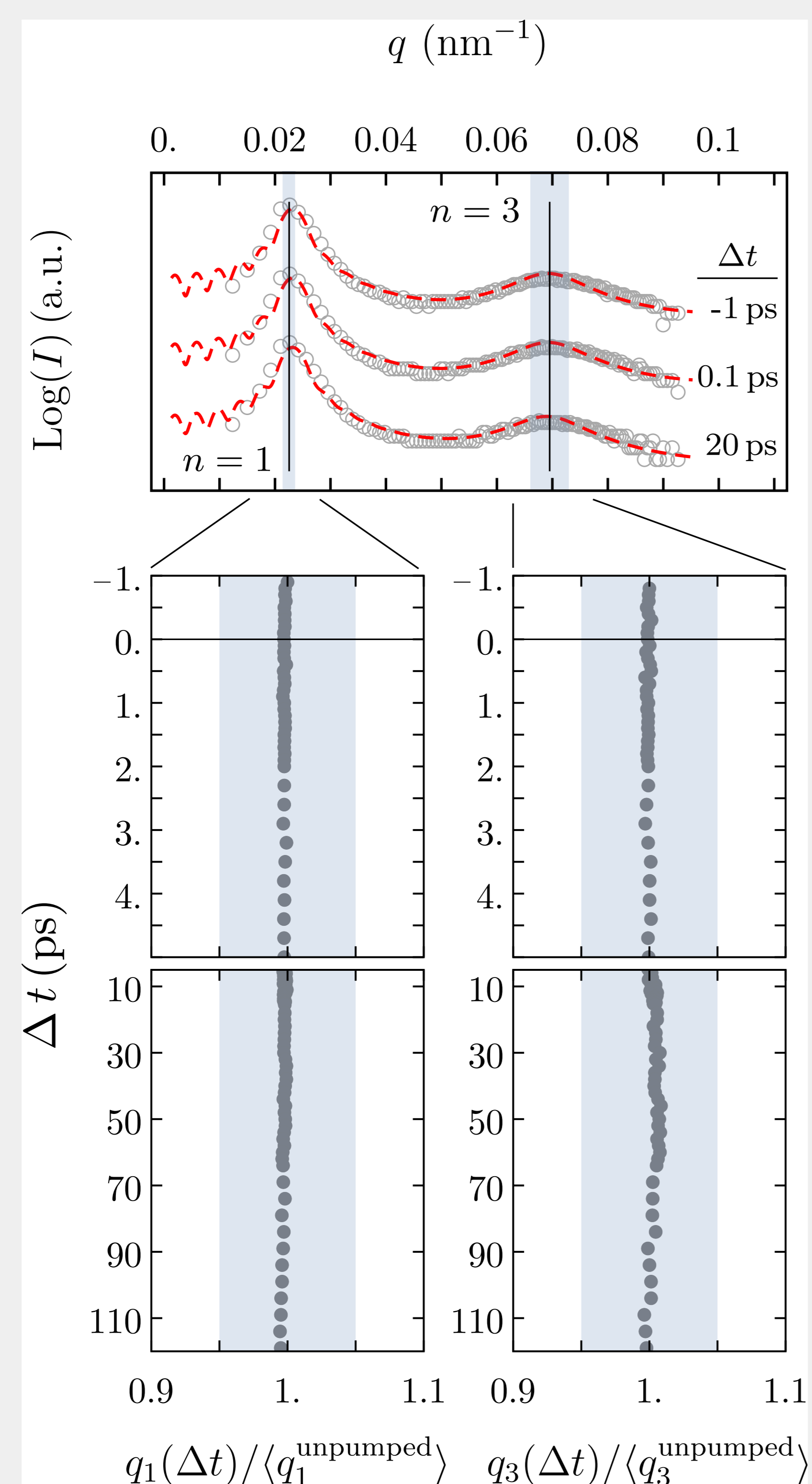


Experiment realized at FERMI free electrons laser

$\text{Co}_{88}\text{Tb}_{12}$ sample presenting a stripe domains structure

Observing intensity of scattering orders (1st and 3rd) as a function of time delay

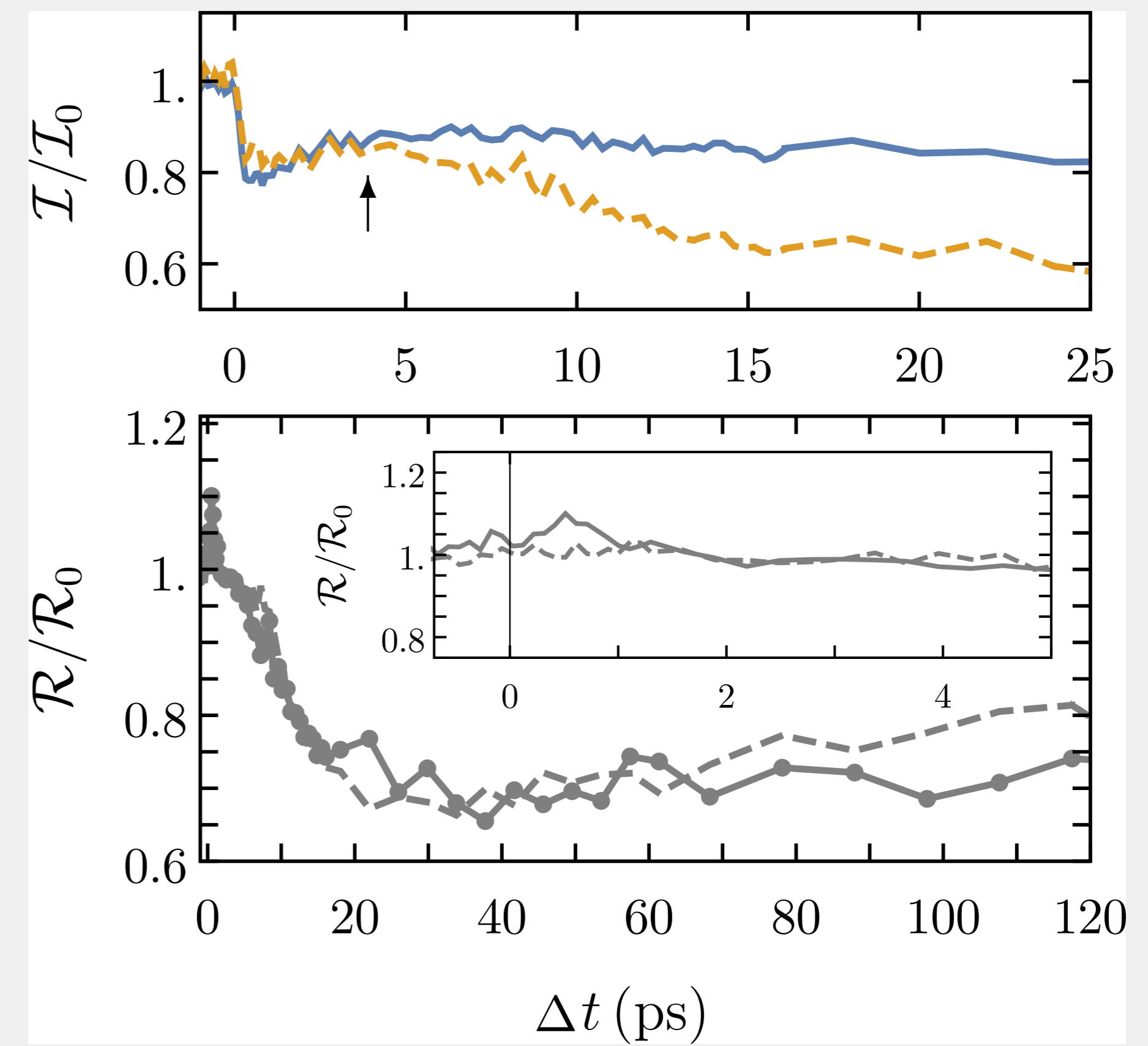
Azimuthal integration of scattering pattern (along θ)



1st and 3rd peaks remain fixed as function of time

No modification of the domain structure periodicity

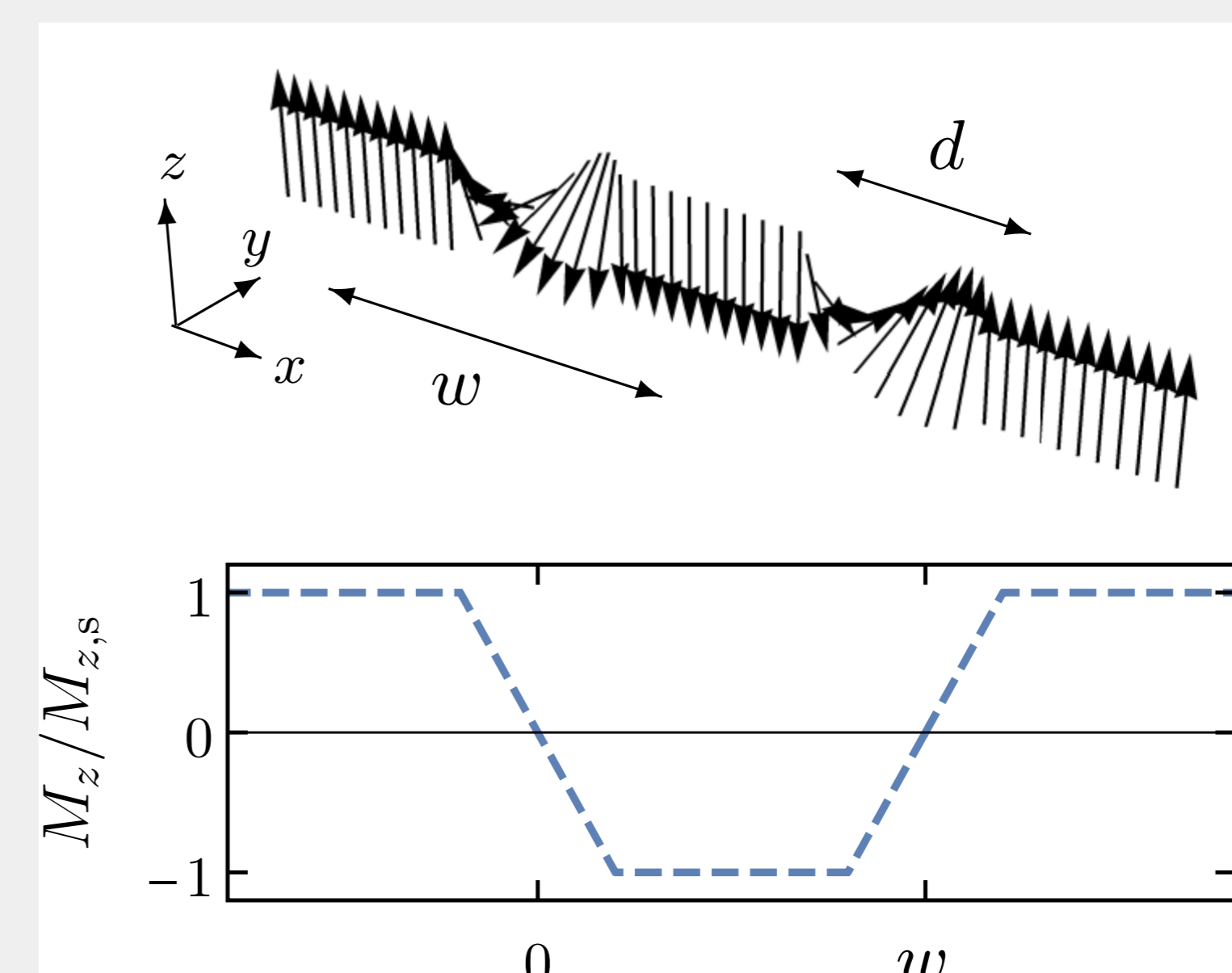
Scattering intensity as function of time delay



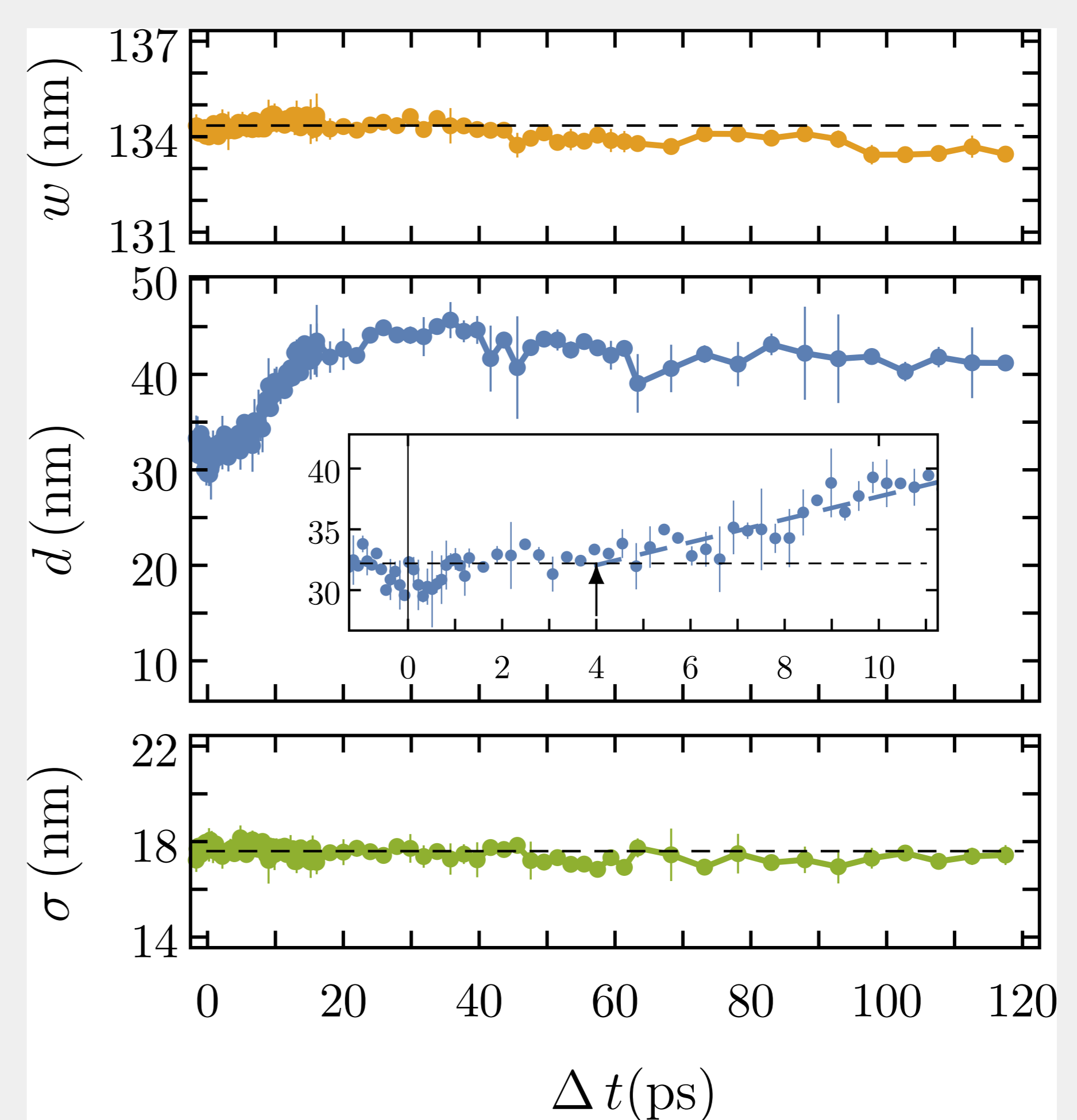
1st and 3rd orders intensity have very different dynamics

This reveals a modification of the domain wall region

Fit to domain wall model [2]



Magnetic domain structure describe with linear domain wall



The domain wall width increases on the picosecond timescales

Conclusion

We attribute this increase in domain wall width to a modification of the magnetic anisotropy since $d \propto \sqrt{\frac{A}{K_u}}$, where A is the exchange stiffness (which we suppose mostly constant) and K_u is the magnetic anisotropy.

References

- 1 B. Vodungbo et al., Nat. Commun. 3, 999 (2012).
- 2 O. Hellwig et al., Phys. B: Condens. Matter 336, 136 (2003).
- 3 M. Hennes et al., Phys. Rev. B 102, 174437 (2020).