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Time-of-arrival detection for time-resolved STXM imaging

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The quest for faster and more efficient magnetic data storage devices has recently ignited numerous studies of sub-ns magnetodynamical processes such as e.g. antiferromagnetic spintronics [1], high frequency spin waves [2], and ultrafast SOT-induced processes [3]. Time-resolved scanning transmission X-ray microscopy (STXM) is a popular technique for the investigation of such processes, as it combines a high spatial resolution with the possibility to efficiently carry out pump-probe experiments. Up to now, time-resolved STXM imaging relies on the assumption that the X-ray photon flashes generated by the synchrotron light source illuminate the sample at a specific, infinitesimally small, time point. This is, however, not the case, as the X-ray flashes generated by the synchrotron light source exhibit, at the SLS, a FWHM on the order of 70 ps, having the consequence that high frequency excitations (above 6 GHz) are inaccessible. A possible workaround to this problem is to employ shorter X-ray pulses, offered e.g. by operating the synchrotron with low-alpha optics, but this approach is both not practical and not sustainable in the long term: with the upcoming upgrade to the diffraction-limited source SLS 2.0, the operation with low-alpha optics will no longer be possible, and it is expected that the X-ray bunch length will remain unvaried from the current 70 ps value. Therefore, we present here a different solution, based on the measurement of the time-of-arrival of the X-ray photons. This will enable the measurements of high frequency excitations (with "low alpha performance") using the normal optics. Faster measurements at high excitation frequencies will therefore be possible, thanks to the higher photon flux offered by the standard optics and, with the upgrade to SLS 2.0 in sight, such a solution would guarantee the long-term competitiveness of the SLS in time resolved studies down to 1-10 ps resolutions.

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[1] C.H. Marrows, Science 351, 558 (2017)
[2] G. Dieterle et al., Physical Review Letters 122, 117202 (2019)
[3] M. Baumgartner et al., Nature Nanotechnology 12, 980 (2017)

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