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Observations of ultrafast light-induced processes in proteins using time-resolved serial femtosecond crystallography

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XFELs with their ultrashort and highly intense pulses open the sub-ps time domain for time-resolved crystallography using small crystals that can be efficiently photolyzed. This is particularly appealing for the study of photosensitive proteins, which contain a light-absorbing chromophore that allows exploitation of light energy as a resource or as a carrier of information initiating intra- or intercellular signaling. The ultrafast light-induced events comprising double-bond isomerization have been the subject of intense research for decades and have been spectroscopically well characterized. However, direct structural information on the excited state and intermediate structures necessary to understand the underlying mechanisms has been inaccessible until recently. We present recent insight on the initial events in photoisomerization obtained by time-resolved serial femtosecond crystallography experiments in combination with time-resolved spectroscopy and quantum chemical calculations. This comprehensive mechanistic insight is not only important for the fundamental understanding of light-driven processes but has practical impact on future developments of fluorescent proteins for optical nanoscopy or retinal proteins for optogenetics.

Primary author: NASS KOVACS, Gabriela (Max Planck Institute for Medical Research, Heidelberg, Germany)

Presenter: NASS KOVACS, Gabriela (Max Planck Institute for Medical Research, Heidelberg, Germany)

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