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Spectral characterization of hard X-rays emitted from a Laser Wakefield Accelerator

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Laser-plasma-driven X-ray sources based on betatron oscillations and inverse Compton scattering offer unique properties, including femtosecond duration, milliradian divergence, and high photon flux. These very properties, however, impose limitations on their spectral characterization, particularly for single-shot detection of X-ray energies up to 100 keV. Conventional semiconductor and scintillator-based detectors face challenges due to limited quantum efficiency at higher energies and susceptibility to overexposure from intense photon fluxes. Our approach employs a filter pack comprising metallic elements of varying thicknesses and atomic numbers, paired with a pixelated CsI(Tl) scintillator array imaged onto a CCD camera. By analysing the spatially resolved transmission through the filter pack and solving the related inverse problem, we reconstruct the X-ray spectrum using probabilistic optimization algorithms. We validate the accuracy of this method by reconstructing spectra from conventional X-ray tubes and demonstrate that it is able to retrieve single-shot betatron spectra from laser-wakefield experiments without the need for assumptions about their spectral shape.

Primary author: TRAVAC, Enes (PhD)

Co-authors: DÖPP, Andreas (LMU Munich); IRSHAD, Faran (Center of Advanced Laser Applications at Ludwig Maximilian University of Munich); PEÑA, Felipe (University of Oslo and Ludwig Maximilian University of Munich); HABERSTROH, Florian (LMU Munich); ZIRKELBACH, Johannes; VON GRAFENSTEIN, Katinka (Ludwig-Maximilians-Universität); ZEUNER, Maurice (LMU Munich); FOERSTER, Moritz (LMU Munich); WEISSE, Nils (LMU Munich); Prof. KARSCH, Stefan (LMU München)

Presenter: TRAVAC, Enes (PhD)

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