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From Concept to Digital Twin: Holistic Modelling of High-Energy Laser Facilities with OPOSSUM

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In the worldwide pursuit of achieving energy production via inertial confinement fusion, the development of large laser infrastructures has experienced a renaissance. Advances in laser technology are being driven not only by the need to enhance laser performance and efficiency but also by the stringent requirements imposed by modern approaches to improve the overall efficiency of the fusion process. Given these increasing demands—and the sheer scale of laser facilities comprising hundreds to thousands of kilojoule beamlines—rigorous, holistic planning and design have become essential. Ideally, a digital twin of such a facility enables comprehensive analysis and optimization before significant resources are committed.

A tool whose development was initiated within the THRILL project (Technology for High-Repetition-Rate Intense Laser Laboratories) to support, guide, and evaluate designs for upcoming laser facilities at Eu-XFEL and FAIR addresses these challenges. This tool, called OPOSSUM (Open-Source Optics Simulation System and Unified Modeler), aims to provide a common software platform for the holistic modelling of large-scale laser facilities.

Following a flow-graph–based optical-design approach that mirrors laboratory build processes, OPOSSUM facilitates intuitive creation of digital optical setups and enables diverse analyses without the need to redefine configurations for each evaluation.

In this contribution, we present the latest developments, highlighting OPOSSUM's current modelling capabilities as well as ongoing and future enhancements.

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