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Transforming Laser-Driven Proton Beams into Application-Ready Sources

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Laser-plasma acceleration (LPA) generates ion beams with extraordinary properties. The inherently high number of accelerated ions, delivered in ultrashort bunches, makes LPA ion sources ideal for high-dose-rate applications such as radiobiology. However, these bunches exhibit high divergence and broad energy spectra, necessitating spatial and spectral shaping before utilization.

To address these challenges, we introduce the pulsed power technology platform ALBUS –Advanced Laser-driven Beamlines for User-specific Studies. ALBUS uses pulsed magnets, adapted from high-field laboratories, as tunable beam optics with large apertures and short focal lengths, enabling efficient beam capture, transport, and energy selection.

We demonstrate its capability using the two-solenoid beamline ALBUS-2S as an example. Designed to shape LPA proton beams for homogeneous dose delivery to volumetric radiobiological samples, it has been implemented at the DRACO PW laser, where we performed the world's first controlled tumor irradiations in a dedicated mouse model using LPA protons.

Looking ahead, we outline our plans to further advance the unique combination of pulsed power technology and LPA by developing high-repetition-rate beamline magnets alongside targetry capable of similarly high repetition rates. Coupled with advanced real-time diagnostics and automated feedback systems, these developments will pave the way for application-ready LPA proton sources.

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