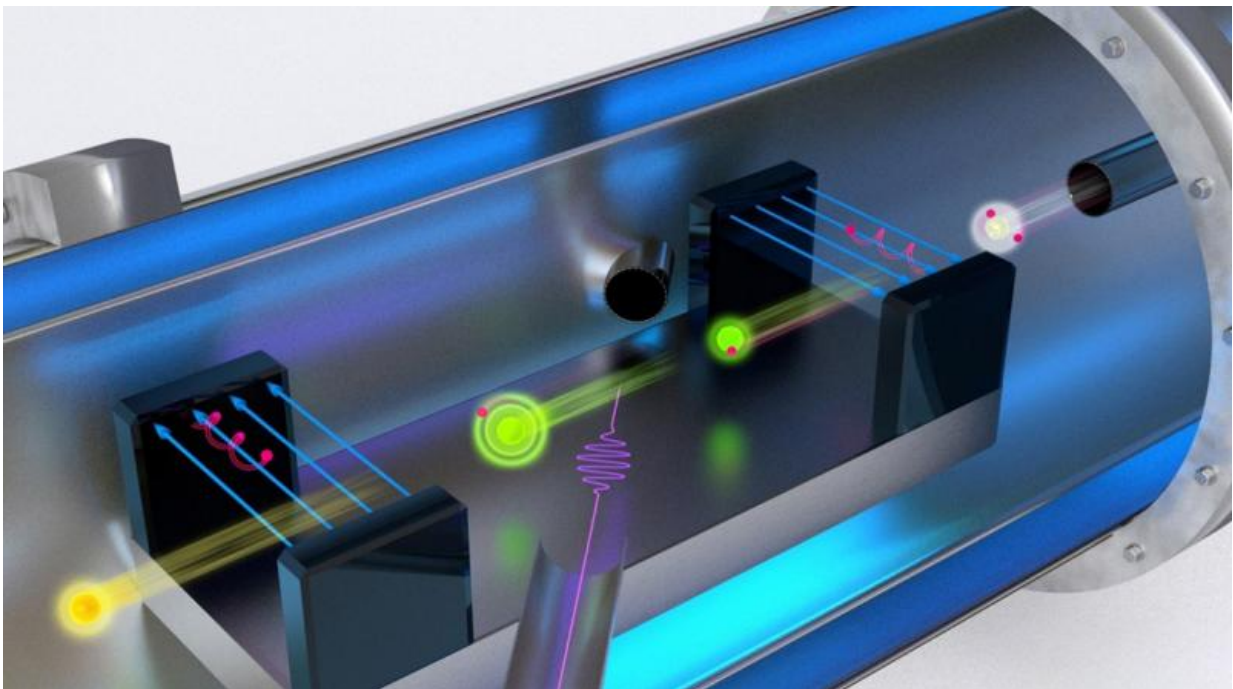


# Technique could lead to significantly higher power proton beams used to answer tough scientific questions

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An artistic representation of the laser stripping method. Shown from right to left: the incoming hydrogen particle with two electrons (red) (right), the first electron stripped in a magnetic field, the excitation (purple beam) of the remaining electron by the laser (center), and finally the remaining electron stripped off by a second magnetic field and the resulting proton particle (yellow) (left). Credit: US Department of Energy

Many large-scale accelerators deliver short, powerful pulses of proton beams. Creating the beams involves accumulating multiple lower power beam pulses to produce a single high-power beam pulse. Today, the achievable proton beam powers are limited by the technology used to merge the incoming pulses into a final beam pulse. To resolve this limitation, scientists demonstrated a new technique, called laser stripping. The approach uses a high-power laser and two magnets.

The new approach could revolutionize how high-power [proton](#) beams are generated in accelerators. Scientists use the beams to answer tough questions about materials. Industry uses the beams in medical and security applications. Laser stripping means next-generation accelerators with significantly higher [beam](#) powers. Higher beam powers result in increased rates of particle production and higher particle collision rates.

The conventional method of merging beam pulses starts with an incoming [pulse](#) of energized hydrogen ions, H-, or a proton with two electrons, merges the ions with a circulating proton beam in a ring, then strips the H- ions of their electrons to leave only protons in the beam. The electron stripping is performed by passing the just-merged, dual-species beam through a micrometer-thin film made of a low atomic number, high melting point material, called a stripper foil. These stripper foils degrade at high temperatures. The degradation limits the achievable proton-beam [power](#) density. The laser stripping technique is a novel method of removing the electrons from an energized H- beam without any material interaction.

As a result, it is scalable to arbitrarily high beam powers. In the laser stripping method, a magnet removes the weakly bound outer electron from the H- ion, turning it into a neutral hydrogen atom. The tightly bound inner electron is then excited by a laser to a loosely bound state where it can be stripped by a second dipole magnet to produce a proton.

In the experiment recently conducted at the Spallation Neutron Source [accelerator](#), scientists demonstrated the laser stripping technique for a 10-microsecond pulse of a 1 gigaelectronvolt energy H- beam using commercial [laser](#) technology. The achieved electron stripping efficiency was greater than 95 percent, comparable to typical efficiencies in the conventional foil-based method. This was the first demonstration of the technique for realistic time-scale beams in an accelerator. The [technique](#) was a factor of 1000 increase in pulse duration compared to a previous demonstration where less realistic scales were used.

**More information:** Sarah Cousineau et al. First Demonstration of Laser-Assisted Charge Exchange for Microsecond Duration H- Beams, *Physical Review Letters* (2017). [DOI: 10.1103/PhysRevLett.118.074801](https://doi.org/10.1103/PhysRevLett.118.074801)

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