The little beam that could

Scientists at Los Alamos National Laboratory, in collaboration with researchers from the University of Nevada, Reno, Ludwig-Maximilian-University in Germany, and the Max-Planck-Institute for Quantum Optics in Germany, have developed a new method for using a laser beam to accelerate ions. The novel method may enable important advances in compact ion accelerators, medical physics and inertial confinement fusion.

In a paper published in a recent issue of the scientific journal *Nature*, a team led by Los Alamos scientist Manuel Hegelich describe their method for the laser acceleration of a monoenergetic ion beam. The carbon ion beam researchers created using the Trident laser facility at Los Alamos had an energy level of 3 Megaelectronvolt (MeV) per nucleon, or 36 MeV.

Scientists have known about laser-driven ion beams with energies in the MeV range for several years, but the Los Alamos team's experiment was the first to establish the basis for laser-driven acceleration of monoenergetic ion beams using specifically designed and treated targets. While the energy spread of laser-driven ion beams is still substantially larger than in conventional accelerators, in several respects they surpass conventional beams.

According to Hegelich, "Typically you need a very large accelerator, the kind that only fits in a research hall, and that accelerates particles over distances of around a hundred meters, to accelerate an ion beam to the energies reported in our paper. Even then, the resulting ion pulses are longer and have weaker currents (milli- or even microamps versus kiloamps). Because conventional accelerators are currently pushing the limits in size and cost, laser acceleration is a potential solution to these challenges. The laser-driven ion accelerator we've developed fits in a typical-sized laboratory and the accelerate ions over a distance of roughly 10 microns."

Because of its compact device size and unique beam characteristics, laser-accelerated ions have potential in the treatment of certain types of brain tumors, in lieu of conventional x-rays or protons. German medical researchers have already developed methods for using carbon ions to place almost all of the beam's energy in a tumor. Conventional tumor treatment methods typically deposit large amounts of radiation in the tumor as well as in surrounding healthy tissue. Producing the ion beams, however, has required large accelerator devices in the several hundred million-dollar range. The laser acceleration method has the potential to shrink both the size and cost of the required accelerator devices.

Laser acceleration also shows potential for use as a "sparkplug" in inertial confinement fusion (ICF). In conventional ICF, a fusion fuel is simultaneously compressed and heated by a laser driver until it reaches in its core the conditions needed for ignition. In an ICF concept called "fast ignition," the compression and ignition parts are separate and the long-pulse laser is first used to compress the fuel. Then, at the moment of maximum compression, the laser-driven ion beam is used as a "sparkplug" to ignite fusion. With very short pulse durations, laser-produced ions might possess the energy needed to ignite fusion at maximum compression.

Related story: Ion beams might one day fight cancer tumors

Source: Los Alamos National Laboratory