SBIR·STTR America's Seed Fund

U.S. DEPARTMENT OF ENERGY | SBIR/STTR Programs Office

A quarter-century-old polarized helium target continues to improve through multiple alliances, record-breaking innovations, and progressively more powerful lasers, like this 200W laser developed by Raytum Photonics.

DOE SBIR-FUNDED TECHNOLOGIES YIELD BETTER LASERS, BETTER TARGETS AND BETTER PHYSICS

Raytum Photonics is currently headquartered in Sterling, VA with a second laboratory facility in Columbia, MD. The company manufactures in the United States and has generated more than $6 million in revenue over the past 5 years by selling innovative, customized, state-of-the-art laser and electro-optic solutions, high-reliability-electronics and providing high-quality engineering services for scientific and military customers. The Raytum Photonics story, however, starts over a quarter-century ago …

FACTS

PHASE III SUCCESS
Raytum Photonics has achieved significant revenue targets leveraging DOE SBIR funding

IMPACT
Raytum breakthroughs have enabled leaps forward in the study of subatomic particles

DOE PROGRAM
Office of Nuclear Physics (NP)

http://www.raytum-photonics.com/

In 1998, a collaboration of researchers, including the Department of Energy's Thomas Jefferson National Accelerator Facility (Jefferson Lab), built a polarized helium-3 target to study the internal structure of the neutron, an important building block of the nucleus of the atom, for an upcoming experiment at Jefferson Lab. The target works by shooting electrons at it and examining how the electrons scatter from the nuclei of helium atoms. This tells the researchers things they want to know about the neutron. Almost 25 years later, physicists are still using the polarized helium-3 target to understand how quarks, the neutron's smaller constituent particles, combine to give the neutron its overall properties. The target is an integral part of neutron studies conducted at Jefferson Lab. According to Jian-Ping Chen, a senior staff scientist at Jefferson Lab who has been the coordinator of the target since its inception, "this target has been a very, very powerful tool to study how the neutron works."

The target has been especially useful for learning more about neutron spin. The target is made of helium-3, a form of helium that contains one neutron in every one of its atoms. To study the spin of a neutron and its constituent quarks, the neutrons in the helium-3 must begin the experiment with their spin oriented in the same direction, a state known as polarized. "The more neutrons whose spins are aligned, the better job we can do of studying the nuclear physics," said Todd Averett, a professor of physics at the College of William & Mary who helps develop technology to improve the polarization of the helium-3 target. That's where the lasers come in.

To polarize the helium, researchers shine laser beams into the hand-blown glass cell that holds it. This cell also holds potassium and rubidium, which are alkali metals. Lasers polarize the alkali atoms, which collide with the helium atoms, transferring their spin to the helium nuclei. But to do this, the lasers must be extremely powerful. While a laser pointer has a few milliwatts of laser power, the polarized helium-3 target needs 100 watts of laser power or more. "More laser power equals more polarized helium, and that equals better nuclear physics," Averett said.

Usually, making a high-power laser would sacrifice another property called linewidth, or the range of wavelengths of light a laser emits. Laser beams with a narrower linewidth polarize more helium, but increasing the power tends to broaden the linewidth. That is until 2007, when companies began to produce lasers exhibiting both high power and narrow linewidths. The polarized helium-3 target team tried the new technology as soon as they could obtain one of the new lasers. "It really helped!" Chen said. But the companies that produced these lasers soon stopped due to lack of demand. "We require lasers that no one else really cares about," Averett added.

Chen and his crew searched for a new company to build powerful, narrow linewidth lasers ultimately finding Raytum Photonics, a new startup interested in producing the lasers. Since providing their first laser to Jefferson Lab in 2017, Raytum Photonics has continued to improve the specialty lasers based on customer feedback and with critical SBIR funding. They've also improved on earlier generations of the lasers by increasing the power and narrowing the linewidth even more. “Both of those things are just critical to being able to have better targets,” Averett said. “Our niche field would be absolutely dead without the lasers that Raytum is producing. No other company is doing this.”

In 2017, Raytum Photonics applied for a highly competitive DOE Small Business Innovation Research (SBIR) grant and received an award to continue to develop their laser design to increase the quality of helium-3 experiments at Jefferson Lab. The grant was funded by the Office of Nuclear Physics on the topic of *Nuclear Physics Instrumentation, Detection Systems and Techniques,* with a sub-topic of *Specialized Targets for Nuclear Physics Research*. “The SBIR award is based on what our innovation can do to satisfy our customers’ current and future needs,” said Steven Lu, CEO of Raytum Photonics. “I’m thankful to the DOE for providing this opportunity, because the collaboration between the DOE, Raytum Photonics, and the universities is invaluable,” Averett said. All told, Raytum’s laser innovations have already increased target performance by more than a factor of five. Raytum Photonics, overall, has been awarded 19 SBIR grants totaling over $7 million across to DOE (15 awards, $6 million) and DoD (4 awards, $1.2 million).

Recently, Raytum Photonics reached another milestone, by building a powerful 200-watt laser with features particularly desirable for application in polarized targets. This one laser is intended to replace the four 50-watt lasers currently in use in the polarized helium-3 target. Operating just one laser is cheaper and simpler. According to Averett, pumping from both sides with 100 W by splitting 200W laser, which has never done before, a record polarization of 72% is achieved. “We have the responsibility to provide the help and tools needed by our physicists. It’s a great pleasure to see that what we have been doing plays a vital role in the nuclear physics research.” said Shukui Zhang, a laser scientist at Jefferson Lab, who has collaborated closely with both nuclear physicists and industry partners like Raytum to bring in innovation and improvement over the existing systems.

Since receiving its first DOE SBIR award in 2017, Raytum Photonics has expanded its research areas beyond just lasers. With support from DOE and DOD SBIR programs, the company has ventured into fiber lasers, high-end optics coating, high-power isolators, and AI technology. The commercialization of high-power fiber amplifiers has been successful, and the products have already been launched. The optical coating, which utilizes state-of-the-art atomic layer deposition (ALD) technology, has caught the attention of DOE and DOD due to its potential to coat large surface areas of irregular objectives and create extremely narrow band-pass filters. Additionally, the company has already realized the potential of AI technology in anomaly detection of particle accelerators and precise control of beam position. These developments, along with the contributions of others funded by other Programs within the Office of Science signal a bright future for AI technology in particle accelerator applications.