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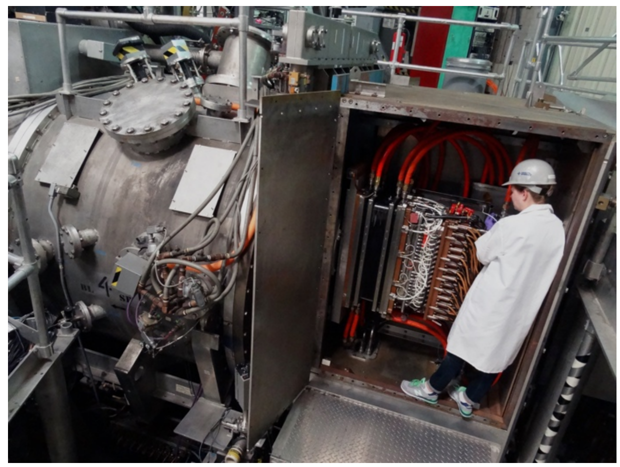
New Breakthrough Enables Scientists Greater Control of Fusion Energy

Unique Particle Beams Bring Fusion Experiments to New Heights

SAN DIEGO – Researchers working at the DIII-D National Fusion Facility at General Atomics (GA) have created an important new tool for controlling energy-producing plasma in fusion devices. GA led the research in collaboration with scientists from the University of California-Irvine and Princeton Plasma Physics Laboratory.



***NEW BREAKTHROUGH IN FUSION, DIII-D FUSION FACILITY**: GA technician Ashley Harris, of the Neutral Beam Team, works on the beam used for plasma control to increase fusion power (Photo by GA)*

Research in the field of magnetic confinement fusion energy is focused on developing fusion as a new, carbon-free energy source – essentially bringing the energy of the sun to Earth. The most common magnetic confinement device is the tokamak in which immensely powerful particle beams heat plasma to temperatures hotter than the center of the Sun. Scientists and engineers at DIII-D, the nation's largest magnetic fusion facility, have recently succeeded in developing new flexibility for the particle beam system, enabling a dramatic increase in the ability to both create and control hotter plasmas in the tokamak. Their work will be published in the January 2017 edition of *Nuclear Fusion*, a leading journal founded by the International Atomic Energy Agency (IAEA).

"This project involved two years of engineers and physicists working hard to create something new, and it's wonderful to see it working successfully on DIII-D," said Dr. David Pace, a physicist who led the neutral beam project for the GA Energy Group, which focuses on developing innovative energy solutions to meet global demands. "Now we get to focus on the next exciting step, which is demonstrating all the ways these variable voltage beams can improve magnetic fusion in machines across the world."

The increase in beam flexibility improves plasma control by allowing precise variation of the beam parameters during the approximately six-second plasma shots and, in the process, demonstrating unprecedented control of plasma behavior. The neutral beam system injects up to 20 megawatts of power – equivalent to the power use of ~15,000 homes. Changing the way this system operates is a significant effort, considering the size and complexity of each beam system (there are four truck-sized housings and eight beams at DIII-D).

Until this breakthrough, neutral beams have operated by accelerating ions through high voltage (~90,000V) that is fixed in time, and then passing them through a chamber of dense gas where they neutralize and fly into the tokamak plasma. The high acceleration voltage is necessary to maximize the velocity of the resulting neutral atom and beam heating power. Experiments in recent years have shown that the velocity of the beam particles can produce or amplify electromagnetic plasma waves that then kick those particles out of the plasma and cause them to smash into the walls of the tokamak. This presents a dilemma: high beam power is necessary to produce high plasma temperatures, but the beam particle loss reduces the plasma temperature and can lead to costly damage along the tokamak walls.

The solution: varying the beam voltage in real-time allows for both a reduction of beam particle losses due to plasma waves and the maximization of input beam power. As the plasma is heated, the behavior of the plasma waves changes such that beam particles of different velocities interact with the waves. The DIII-D neutral beams can be given preprogrammed voltage profiles that minimize wave-particle interactions. This limits interference, allowing the beam particle voltage to later increase to maximum levels, thereby increasing the potential for producing fusion energy.

Future work will extend the voltage range and speed of the neutral beam system. DIII-D experiments will then be capable of applying this new technique to an even wider range of plasmas, taking advantage of the control and diagnostic opportunities it provides. Ultimately, these experiments are intended to unravel some of the physics mysteries behind wave-particle interactions and other plasma behaviors in fusion-relevant regimes.

Tim Scoville, head of the Neutral Beam Group at DIII-D, will present the initial results at the annual meeting of the American Physical Society Division of Plasma Physics, Oct. 31 – Nov. 4.

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