Argonne's CARIBU charge breeder breaks world record for efficiency

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Engineer Richard Vondrasek installs a new turbo pump on the Californium Rare Isotope Breeder Upgrade (CARIBU). CARIBU reached world record efficiencies for ionization efficiency of solids.

(PhysOrg.com) -- Scientists at the U.S. Department of Energy's Argonne National Laboratory have pushed the limits of charge breeding and broken a long-standing world record for ionization efficiency of solids.

Argonne's Californium Rare Isotope Breeder Upgrade (CARIBU) project has reached 11.9 percent efficiency with metallic particles of rubidium. The previous metal record was 6.5 percent, using potassium, achieved at Laboratory of Subatomic Physics and Cosmology (LPSC) in Grenoble.

"There have been several improvements made that increased efficiency

little by little until we finally reached record numbers, and we foresee even higher efficiencies in the future," said senior accelerator physicist Richard Pardo.

Beams of stable isotopes from elements across the entire periodic table have been used at the Argonne Tandem-Linac Accelerator System (ATLAS) for research in nuclear physics for many years.

But when additional protons or neutrons are added to originally stable isotopes, the nuclei eventually become 'particle unstable', emitting excess protons or neutrons. Neutrons, unlike protons and electrons, have no charge; therefore, many more can be added to a nucleus before it becomes unstable.

The CARIBU project will extend ATLAS's reach to include potentially hundreds of previously unstudied isotopes.

CARIBU will use californium-252 to create neutron-rich heavy fission fragments at a rate of more than one billion per second. These fragments are thermalized in helium gas and converted into a low-energy beam of singly charged ions.

The charge breeder, an electron cyclotron resonance (ECR) ion source, takes these beams, stops them in the plasma and strips them to higher-charged states for reacceleration in ATLAS.

Scientists used two radio frequencies (RF) to excite the plasma in the ECR source. This resulted in the creation of higher charge states and improved efficiency. They also injected the RF radially into the source using an open—versus a closed—hexapole structure. This allowed for higher magnetic confinement of the hot plasma, as well as more uniform field gradients.

“Fundamentally, there are limits to how high an efficiency you can get in a charge breeder, but we can expect a 20-30 percent improvement of current numbers,” said Argonne principal engineer Richard Vondrasek.

So far, CARIBU has only used stable metal ions for charge breeding, but testing has just begun using the radioactive isotopes from the californium source.

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