Sanford Underground Research Facility

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Deep Thoughts

Notes from the underground by Communications Director Constance Walter

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Science in a vacuum

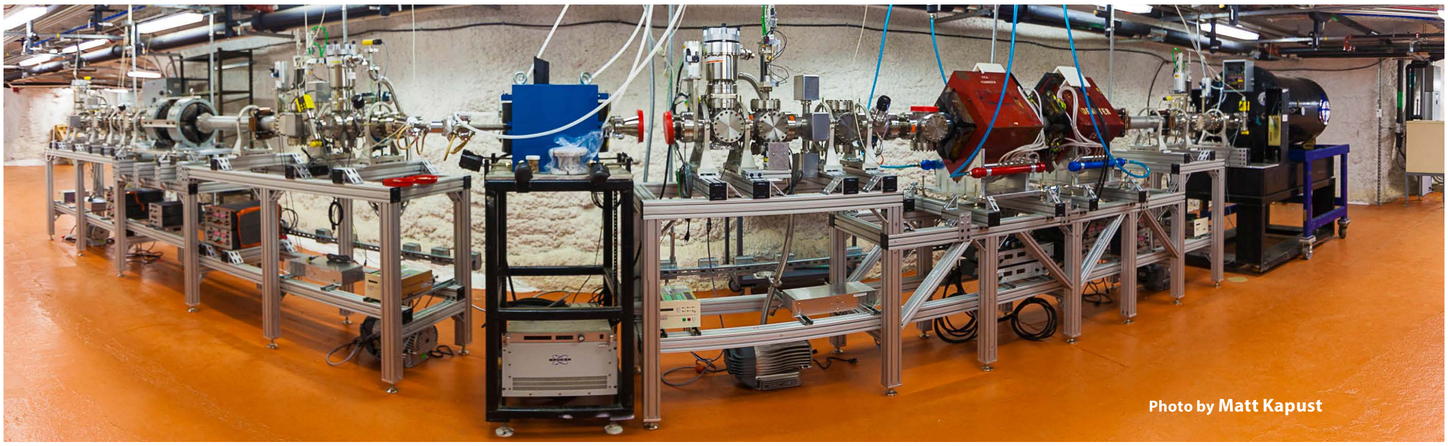

Photo by Matt Kapust

Accelerators rely on an ion or plasma source to produce charged particles. CASPAR uses radio-frequency energy to produce a beam of protons or alpha particles from hydrogen or helium gas. The electric field speeds up the beam of particles, which are steered and focused with magnets through the beam pipe in a vacuum. A 25-degree bending magnet ensures that only particles with the right energy are directed to the target.

Life may not operate in a vacuum, but particle accelerators certainly do.

Whether a cathode ray tube built in the late 19th Century, a cyclotron invented at Berkeley in the 1930s by South Dakota native Earnest Lawrence, or CERN's 27-kilometer Large Hadron Collider, particle accelerators have one critical thing in common: a vacuum system.

"If you shoot a beam without a vacuum system, it will travel a very short distance—maybe one foot," said Frank Strieder, principal investigator for CASPAR (Compact Accelerator System for Performing Astrophysical Research).

Particle accelerators use electric fields to speed up a beam of particles, which are steered and focused by magnetic fields to ensure they hit the target. The beam travels through the beam pipe in a vacuum, which removes any obstacles that can cause friction. "That allows the beam to travel much longer distances," said Strieder, professor of physics at South Dakota School of Mines and Technology.

Accelerators are most commonly associated with fundamental research as is the case with CERN, Fermilab and CASPAR, Strieder said, but they have a wide range of applications in other areas. "For example, they are used in carbon dating and the authentication of paintings, as well as cancer treatment."

Modeled on the Van de Graaff accelerator, CASPAR uses a motorized insulated rotating belt to transport a positive charge from ground to a high-voltage terminal to help accelerate charged particles up to 1 million Volts (the LHC can accelerate particles up to almost 7 trillion Volts). A combination of mechanical pumps remove air from the beamline tubes and a vacuum gauge measures pressure per unit, or Torr. The low-energy accelerator will allow researchers to study nuclear fusion in stars.

The CASPAR collaboration, which also includes researchers from Notre Dame and the Colorado School of Mines, began installing the accelerator on the 4850 Level of Sanford Lab in 2015. The team is now testing different beam components.

"We've completed the vacuum system and the pumps are running," Strieder said. Currently, the vacuum/pressure is less than 10^{-7} torr, which is sufficient enough to allow the accelerated particles to travel more than 50 feet, the length of CASPAR. (For comparison, atmospheric pressure is approximately 760 torr, while accelerators that are several miles in length require a vacuum of 10^{-12} torr. In outer space, the vacuum is up to 10^{-17} torr.)

"Things are looking very good for the CASPAR team as we move into the accelerator testing phase," said Dan Robertson, a member of CASPAR and researcher with the Nuclear Science Laboratory Institute for Structure and Nuclear Astrophysics at Notre Dame. "Very soon we will be firing up the control system and components in the accelerator. With the completion of the vacuum test, we are mechanically ready to produce particle beams into the evacuated beamline."

CASPAR collaborators hope to begin operating in earnest by late spring/early summer. "We would have loved to be further along and taking data already," Robertson said. "But we are assuming the secrets of the stellar environments will wait for us."