Two radiation generators mark major milestones

September 8 2011, By Neal Singer

Saturn, Sandia's workhorse pulsed-power machine, delivers hard radiation during one of its milestone shots. The scarcity of jagged, lightning-like arcing between different water/metal interfaces means that the machine's water insulation is effective, and that relatively much of its electrical pulse is traveling on its intended path from the machine's circular exterior to its central target. Credit: Randy Montoya

Two remarkable pulsed-power machines used to test the nation's defenses against atomic weapons have surpassed milestones at Sandia National Laboratories: 4,000 firings, called 'shots,' on the Saturn accelerator and 9,000 shots on the HERMES III accelerator.

Saturn — originally projected to last 5 to 10 years — began operating in 1987. Its major function has been to produce X-rays to test the effectiveness of countermeasures used to protect electronics and other materials against X-ray radiation from nuclear weapons. The machine, used broadly as a physics research testbed , provides data that can be used either directly or as input for computer simulations. The machine can fire twice a day. All these characteristics make it a spry source for data.

HERMES (High-Energy Radiation Megavolt Electron Source) III, which can fire six to eight times daily, is used primarily to demonstrate the effect of gamma ray radiation -- another component of a nuclear weapon burst -- on electronics and larger military hardware. First fired in 1988, it is still the world’s most powerful gamma ray generator.

“The continued operation of these facilities is a testament to the ingenuity and dedication of personnel and management,” said Sandia manager Ray Thomas.

Saturn is a predecessor to Sandia’s more awesome Z machine, but still fills a significant niche. Though it operates at roughly one-third the power of Z, Saturn can accelerate electrons at voltages and amperages that allow materials to be tested for so-called hard X-ray effects; the Z facility is not configured to produce X-rays in this critical range of frequencies.

Twenty-one years ago, in what proved to be one of Saturn’s most high-profile endeavors, it hosted its first wire-array tests, which pulsed millions of amperes in nanoseconds through a number of wires each thinner than a human hair. The success of these tests led to installation of wire-array hardware on the larger Z machine, with gains in X-ray output that astonished the world and led to Z’s consideration as a potentially reliable way to create electricity essentially from seawater, the world’s largest natural resource.

Technicians service the linear HERMES pulsed-power machine — the most powerful gamma ray producer in the world — for its next shot. Because of Sandia's nuclear responsibilities, HERMES and Saturn are kept in "warm, standby mode" for immediate testing of components. Credit: Randy Montoya

In those early tests, the wires of course disintegrated like overstressed fuses from the great flood of electricity. But the powerful magnetic field always associated with a powerful electric current grabbed the floating ions created from the shorted-out wires and pulled them together at great speeds. When the ions ran out of room to travel, they stopped suddenly, confronting each other along a relatively vertical axis that was the hub of the magnetic field. Their sudden braking led them to release X-ray energy, similar to the release of heat from a car's tires when the driver jams on the brakes. The scientific process, called a z-pinch by geometrical reference, caused an extraordinary increase of X-ray energy output over previous methods. Such intense X-rays can be used to compress a BB-sized hydrogen capsule, fusing its contents to release enormous energies that eventually could be used to drive an electrical power plant on very little fuel.

Unlike Saturn and Z, whose modules are each arranged in a circular pattern that resembles a wagon wheel, with electrical transmission lines like spokes leading to the target at the axle, HERMES uses 20 inductively isolated modules coupled to a linear transmission line that resembles a short subway train in size, shape and amount of metal. The output voltage from each module is added in series, the reason for the very high voltage achieved. Saturn's outdoor test facility is large enough to accommodate military tanks.

Continued improvements on both machines have enhanced their capabilities to map portions of the X-ray spectra previously unattainable, and to reach radiation dose rates never before achieved by an accelerator
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Provided by Sandia National Laboratories

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