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New Capabilities for Hostile Environments on Z Grand Challenge LDRD – Final Status

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The purpose of this project was to develop new physical simulation capabilities in order to support the science-based qualification of nonnuclear weapon components in hostile radiation environments. The project contributes directly to the goals of maintaining a safe, secure, and effective US nuclear stockpile, maintaining strategic deterrence at lower nuclear force levels, extending the life of the nuclear deterrent capability, and to be ready for technological surprise.

This LDRD project invested $17.2 M over 3 years and succeeded in the development of new fast neutron and warm x-ray sources and improved testing platforms on the Z Pulsed Power Facility that are now ready for program use. These platforms improve our ability to efficiently provide science-based qualification arguments for the nation's nuclear stockpile to hostile radiation requirements. These advances have enabled, for the first time, useful SGEMP and TMS testing for x-ray energies above 10 keV and 20 keV. We also developed the ability to investigate fast neutron displacement damage equivalence on HED facilities, for the first time. This project led the development of new platforms for neutron damage on all large HED drivers (Z, NIF, and Omega).

This project demonstrated record x-ray yields at >10 keV, >20 keV, and > 40 keV, increased by 2 – 3X compared to the pre-project levels. We developed six new warm x-ray diagnostics to better characterize the photon source. With these diagnostics, we greatly improved our understanding of the role of thermal ionization in producing warm x-ray sources and now understand the relative contribution from thermal and non-thermal ionization. Advanced x-ray cassette designs provided a fluence increase ~4.6X for x-ray SGEMP experiments and ~2.7X for TMS testing. Neutron yields were increased by a factor of 2 – 4X to record levels. Advanced neutron cassette designs enable moving test objects closer to the target, providing a fluence increase of 9.1X.

We established a safety basis for use of tritium at Z and were able to field a trace tritium experiment with a 0.1% tritium fill in an ICF target on Z. This is the first use of tritium in a pulsed power experiment since the 1980's, and first ever on Z. This work paves the way for post-project program expansion of tritium from the demonstrated 0.1% level, perhaps up to 50%, and a future potential increase of neutron yields by 60-90X. This exceeds the project goals.

We demonstrated nearly lossless coupling of currents to x-ray and neutron sources by decreasing the inductance of the target hardware to below 3 nH. This resulted in peak currents for neutron targets that were increased from 21.1 to 25.3 MA. Peak currents to X-ray targets were increased from 22.1 MA to 28.8 MA. These large increases of current of 4-7 MA were a key element of increasing the x-ray and neutron source yields by 2-4X. We also developed a new type of plasma discharge system that was more suitable for *in-situ* cleaning on Z and demonstrated that this discharge could clean test coupons as well as full-scale convolute and feed hardware. A full scale *in-situ* cleaning system was commissioned on Z and tested and will be evaluated in the coming year on program experiments to lower current loss for higher inductance loads, through control of contaminant plasma formation on electrode surfaces.

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