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Title: LANL Q2 2016 Quarterly Progress Report: Science Campaign and ICF

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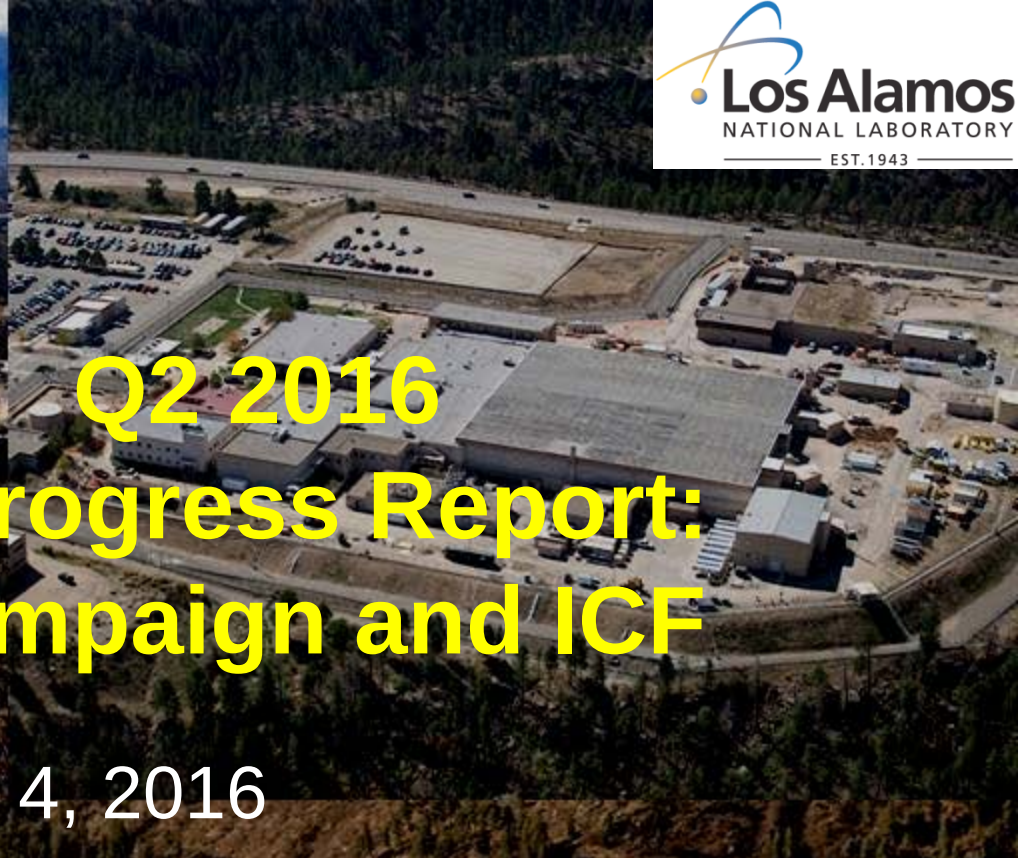


LANL Q2 2016 Quarterly Progress Report: Science Campaign and ICF

April 4, 2016

Los Alamos National Laboratory

Los Alamos, NM

LANL Science Campaign and ICF Technical Highlights for Q2 FY16. (1)

- **Advanced Certification and Assessment Methodologies**
  - Issued design release for first Certification Readiness Exercise (CRE-2) hydrotest 3677. This test is scheduled to be fired July 2017.
  - Executed a pRad experiment supporting the design for the first CRE-1 hydrotest 3666, scheduled to be fired September 2016.
  - Presented simulation studies for the proposed NDSE and ECSE radiography capabilities to the Predictive Science Panel and Weapon Capability Review held at LANL March 8.
- **Implosion Hydrodynamics (C-1, SCE)**
  - Executed the first shot in the joint US/UK HEKLA series of experiments at the LANSCE pRad facility. The experiments, which investigate a key weapons physics phenomenon, obtained a rich dataset and demonstrated the feasibility of joint operation of diagnostics.
  - Executed a series of single shock ejecta diagnostic validation experiments in support of upcoming Red Sage subcritical experiments. These experiments were designed to demonstrate the accuracy and precision of various ejecta diagnostics.
  - Executed the Renner experiment at the LANSCE pRad facility, moving from concept to executed experiment in less than three months. This experiment investigates performance issues related to the stockpile and future LEPs.
  - Released the Orpheus/3667 diagnostic data package, together with as-built engineering and diagnostic data reports, to weapon designers at LANL, LLNL, and AWE.

LANL Science Campaign and ICF Technical Highlights for Q2 FY16. (2)

- **Materials and Nuclear Science (C-1, C-2)**
  - Utilized SMARTS and HIPPO neutron diffraction diagnostics to determine residual stresses and texture variation in formed uranium parts.
  - Executed plutonium aging experiments at TA-55, which included two Kolsky bar experiments to measure the effect of aging on strength, and a 40 mm gun plate impact experiment to assess the influence aging has on dynamic performance.
  - Performed dynamic experiments on both wrought and additively manufactured 304L Stainless Steel in support of the science-based qualification GTS project.
  - Executed a series of reverse ballistic deep release experiments on epoxy, designed to define the products EOS. These data are important for modeling release and multiple shock waves in epoxy and will guide modeling efforts in tablular EOS.
- **Capabilities for Nuclear Intelligence**
  - A DP Award of Excellence was received by the LANL/SNL Practicum 2 team. The team was recognized for the quality and creativity of work as well as the excellent teaming between the different capabilities in developing the weapon system with the desired military characteristics.
  - Participated in the JOWOG-29 Proliferation Technology Working Group Meeting, with presentations on results of experimental and design efforts over the past year, a number of which were direct collaborations with the UK. Concepts for the Practicum 4 were identified.

LANL Science Campaign and ICF Technical Highlights for Q1 FY16. (3)

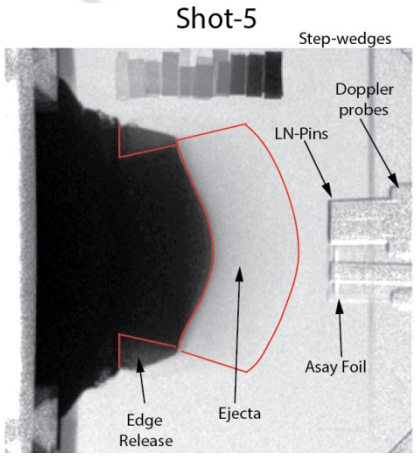
- **High Energy Density Science (C-1, C-4, C-10)**
  - Executed the first engineered macro-pore Marble capsule implosions on Omega with excellent data return. First demonstration of a Marble-like capsule configuration with additive manufacturing techniques.
  - Obtained Shock/shear data over 5 ns in a single NIF shot using the BABLon5 backlighter pulse, completing an edge-on copper dataset in just four shots taken during mini-campaigns. Advances in radiography have led to a 50% increase in data-taking rate compared to FY15.
  - Conducted high pressure/high temperature EOS measurements for U6%Nb at the LANSCE Lujan Center.
  - Completed build of new Clover detector system to be used for NIF experiments. This system will allow a number of new measurements of short(er)-lived activation products in LANLs radiochemical diagnostic efforts at NIF.

Ejecta Diagnostic Experiments provide valuable data for upcoming Red Sage experiments (SCE)

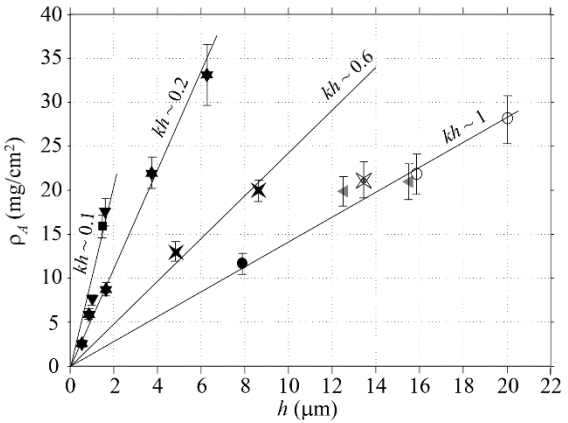
- Single shock ejecta experiments designed to demonstrate accuracy and precision of various ejecta diagnostics
- Simplified geometry allows validation and any needed improvements of diagnostics before moving to more complicated geometries
- Diagnostics will be used on Red Sage subcritical experiments

Fielded diagnostics included:
Soft x-radiography
6 $LiNbO_3$ piezoelectric pins
8 channels of PDV
1 channel of optical ranging
2 Asay foils (one LLNL design and one LANL design)

Shot	λ (μm)	*h* (μm)	*kh*	ρ_A^{pred}	ρ_A^{x-ray}	ρ_A^{LN}
1	50	2.31	0.29	12	11.6	$12-13$
3	50	4.09	0.5	12	7.7	12.6 ± 0.8
2	100	3.22	0.20	18	23.4	20.6 ± 1.1
5	100	6.84	0.43	23	17	22.2 ± 1.8
4	100	8.30	0.52	22	17.2	21.7 ± 0.6



ρ_A^{x-ray} were reduced from the x-ray data (NSTec/LAO)



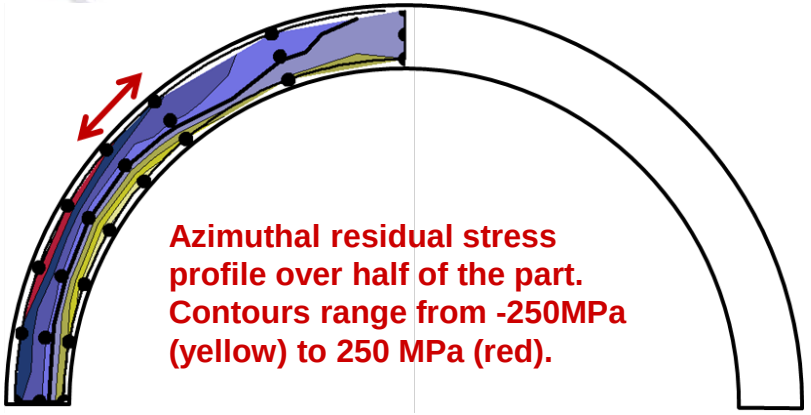
ρ_A^{pred} predictions are based on the Sn areal-density data (above) from S. K. Monfared *et al.*, J. Appl. Phys. **116**, 063504 (2014)

Renner experiment completed at LANSCE pRad facility (C-1)

- Concept first presented to a workshop audience on November 24, 2015
  - Investigates performance issue that is relevant to the current stockpile and future LEPs
- Experiment executed less than three months later – February 20, 2016
  - Development of drawings, fabrication, assembly, and proof shot and shot at pRad all completed within that time frame
- Detailed analysis of the results is underway – comparison of the pre-shot calculations has proven interesting.
- Follow-on experiments will be proposed for the next pRad run cycle.

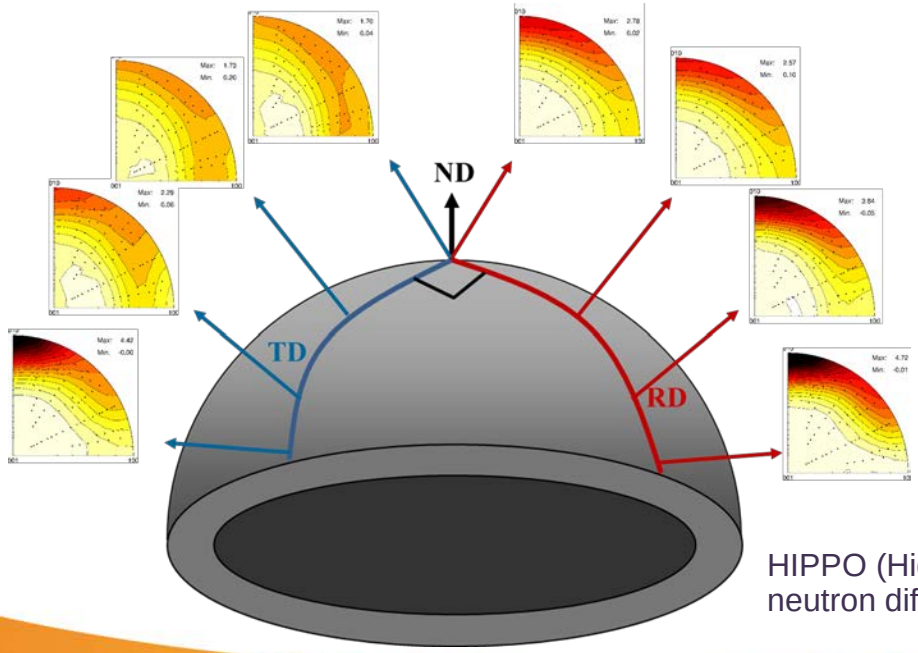
SMARTS and HIPPO at LANSCE are used to characterize formed Uranium parts(C-1)

- Large fraction of parts made for hydrotest program are scrapped due to distortions that occur during final machining
- Polar and azimuthal components of the residual stress measured by SMARTS are significant and will drive distortion during final machining and/or annealing.
- Crystallographic texture measured by HIPPO is shown to be a strong function of position. Coupled with anisotropic thermal expansion of orthorombic uranium, non-uniform thermal expansion will also cause distortion during annealing.



Azimuthal residual stress profile over half of the part. Contours range from -250MPa (yellow) to 250 MPa (red).

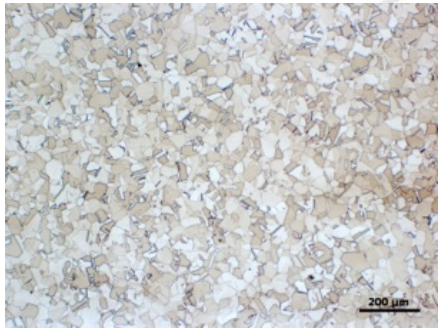
SMARTS (Spectrometer for Materials Research at Temperature and Stress) neutron diffractometer residual stress measurements



HIPPO (High Pressure/Preferred Orientation) neutron diffractometer texture measurements

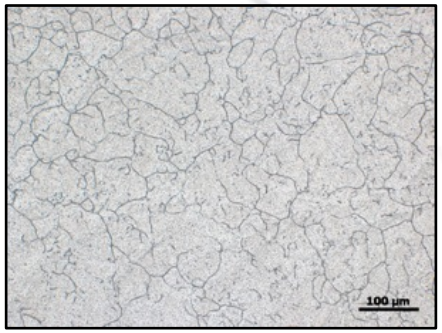
Data will validate a microstructure-aware plasticity model which will be used to guide processing optimization to minimize residual stress and texture variation, resulting in fewer scrapped parts.

Structure/strength, and damage relationships for both conventional and additively manufactured Stainless Steel are being investigated (C-2)

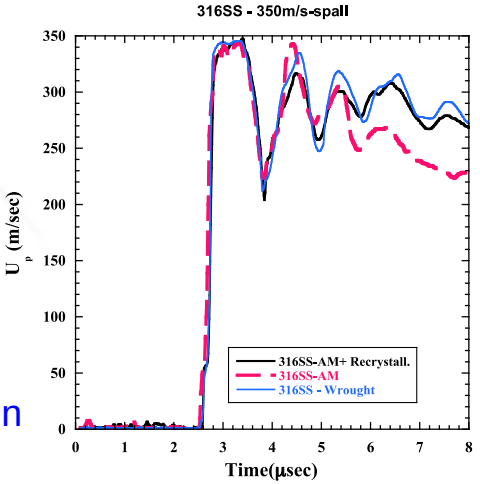


Fully-Annealed Wrought Plate

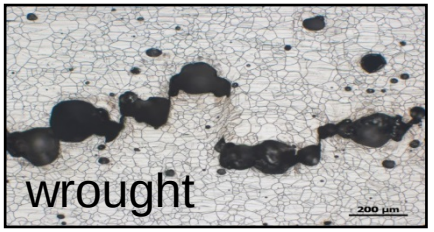
Additive – As-Built

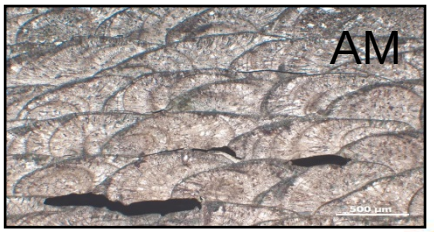


Additive after recrystallization



- Additive manufacturing will force a shift from “material” qualification to Science-based qualification
- A science-based approach is required for qualification:
  - Quantified process-structure-property-performance relationships
  - In-process monitoring and feedback control
- Additive manufacturing – 316L SS, initial spallation testing indicates significant dynamic ductility in AM-316L SS compared with wrought
- Insights from this project are transitioning to 304L SS to support “The Science-based qualification of a GTS Reservoir (U)” this FY





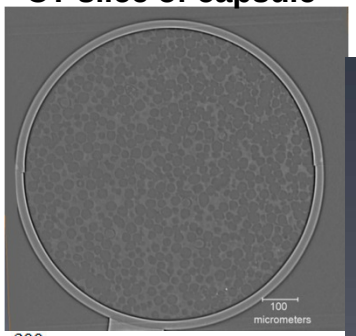
Spall of 316L SS

Marble engineered macro-pore foams have been characterized and fielded at Omega(C-1,C-4,C10)

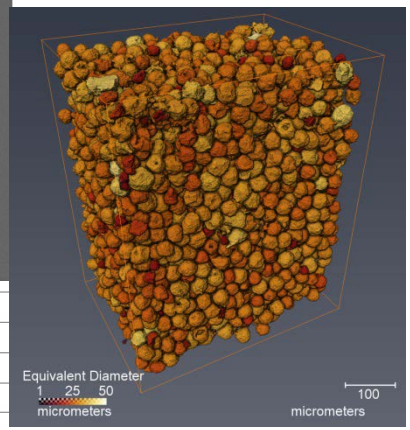
Foam characterization techniques: Radiography, Gravimetric, Density Characterization Station (DCS), Micro Computerized Tomography (CT)

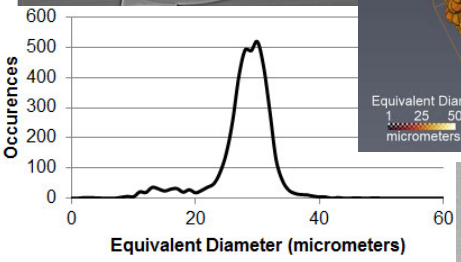
- The Marble campaign investigates heterogeneous mix on burn in ICF implosions
- CDH foam capsules containing nominal 30, 50, and 100 mm macro-pores have been shot on Omega with T_2/H_2 mixed gas fills (March)

CT slice of capsule

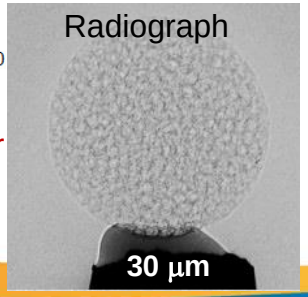


CT 3D visualization

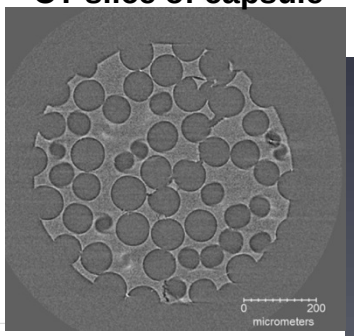


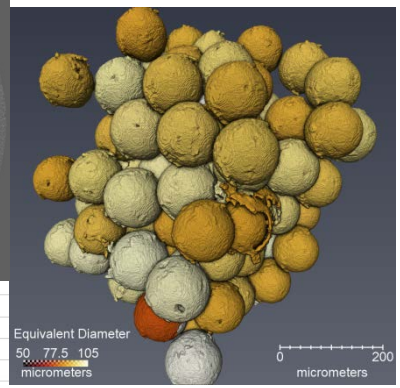


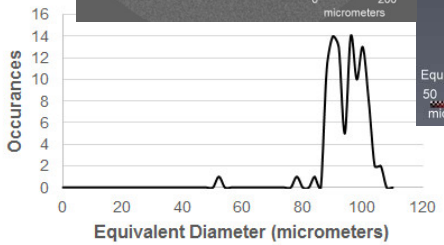
27 µm average void diameter
59.7% void volume



CT slice of capsule



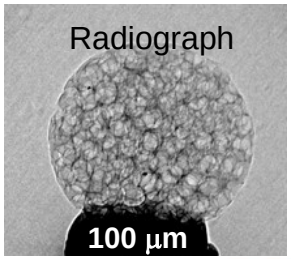




93.7 µm average void diameter
59.2% void volume

Experiments demonstrated:

- Ability to fabricate, characterize, and field Marble engineered capsules
- Relevance of using DT/DD ratios for comparison with simulations



New Cover detector system will be used for NIF HED experiments(C-1, C-10)

- A new Compton Suppressed Dual-Clover detector system, based on an existing LANL design, has been fully assembled in building 151 at LLNL.
- The new system, comprised of 8 HPGe crystals and a NaI Compton suppression annulus, will allow a number of new measurements of short(er) lived activation products in the joint LANL/LLNL RadChem diagnostic efforts at NIF.

- ^{206}Bi calibration sources were produced at LBNL on March 24 that are identical in geometry to those that will be used and counted at NIF. These will be used to calibrate the new clover system, and cross calibrate with another LLNL detector.
- Data will be collected from NIF shots supporting the HED Radiochemistry efforts to measure plasma stopping power as a probe of mix beginning in April 2016, and will compliment data collected on the dual clover system at LANL.

Upcoming Events

- **Meetings and Briefings:**
  - C4 L1 Review, LLNL, April 12-13.
  - Nevada Radiography Working Group Mtg., LANL, April 11-13.
  - Update on 3’ and 6’ confinement vessels for SCE at DOE NNSA, April 19.
  - Seminar on Recent results from the Matter in Extreme Conditions hutch at LCLS by Cindy Bolme at DOE NNSA, April 20.
  - Presentation on the SCE program to the NWC SSC AO, Pentagon, April 21.
  - Materials Capability Review, LANL, May 3-5.
  - Seminar on Production Science by Deniece Korzekwa and Dana Dattelbaum at DOE NNSA, May 19.
- **Experiments for April/May:**
  - NIF Marble experiments, April 4, May 3 & 22
  - Omega CoaxDiff experiments, April 28
  - NIF Shock/Shear experiments, April 7,10, 13, & 19
  - Omega Shock/Shear experiments, April 7
  - NIF Opacity experiments, May 8-9
  - Omega Marble Void Collapse experiments, May 12