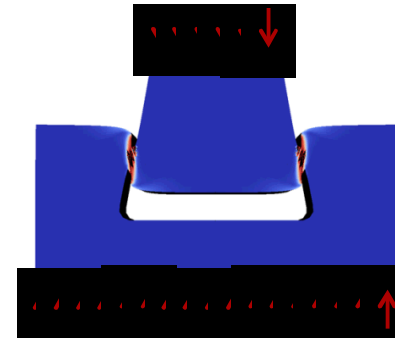
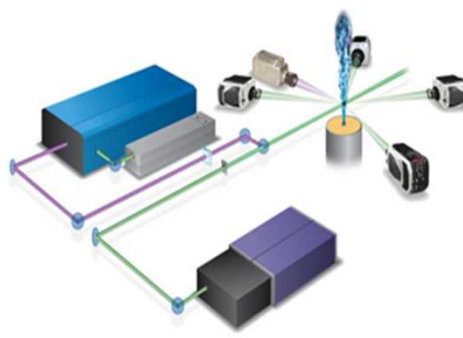


Exceptional service in the national interest



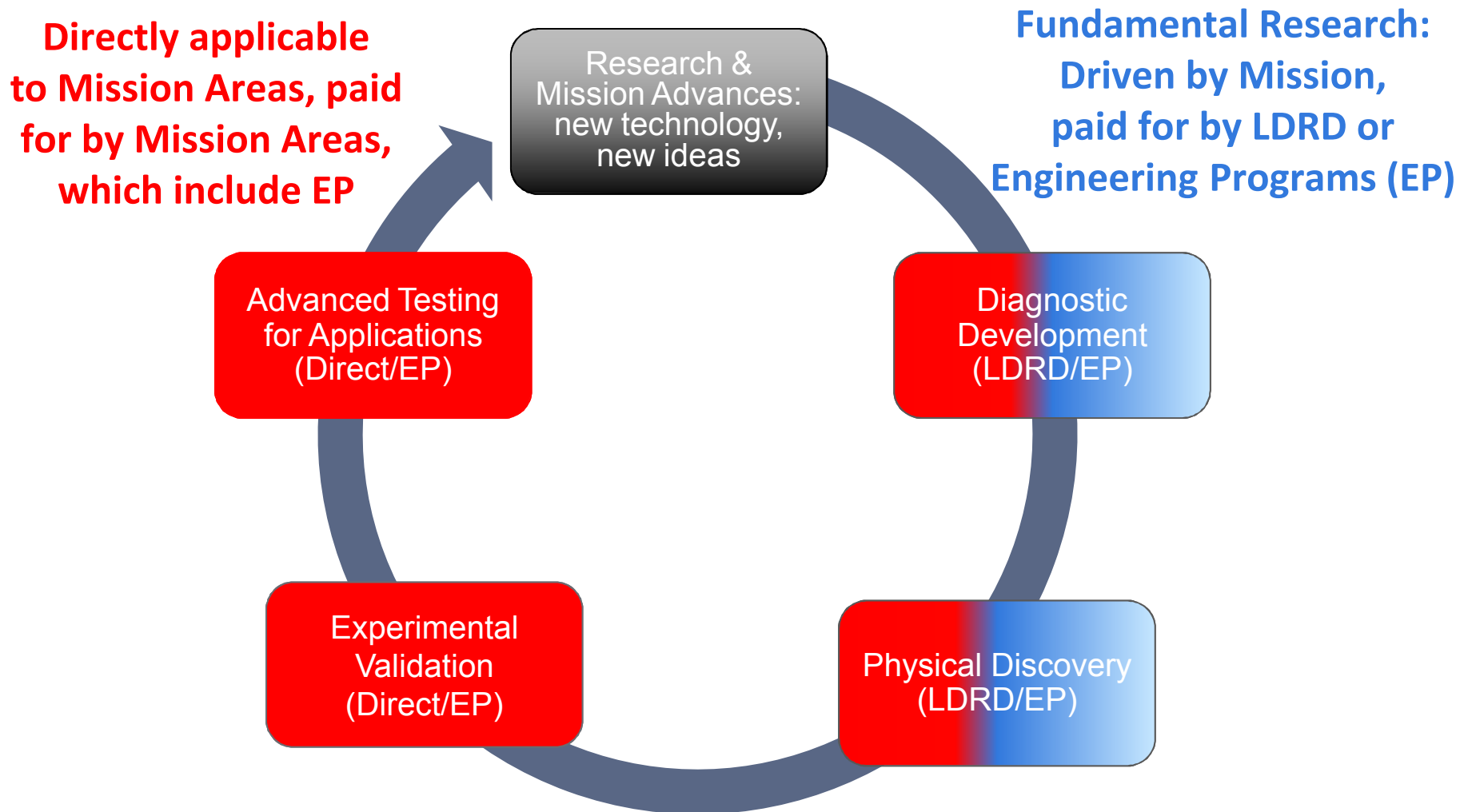
Diagnostics

Tracie L. Durbin, Manager
Diagnostic Science & Engineering Department

ESRF Panel Review
April 13, 2016

- **Engineering Sciences LDRD Call**
 - ***Novel diagnostics for experimental discovery, validation, and production testing:*** The development of predictive system-level models relies upon experimental data for phenomena discovery as well as validation of the multi-scale, multi-physics phenomena underlying the system behavior...
- **Adapted from 2014 ESRF Strategy Document:**
 - **Vision statement:**
 - Robust, well-maintained, and well-used ***experimental capabilities that advance the field in diagnostic techniques*** and facilitate experimental discovery.
 - **Implementation:**
 - *Objective 2:* Develop advanced diagnostic capabilities for experiments to improve our understanding of engineering phenomena.

LDRD and direct funding work together to advance diagnostic development and application

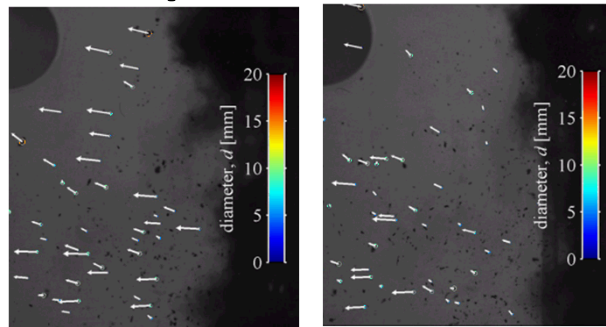


Many ESRF-LDRD projects have incorporated diagnostics and diagnostic development

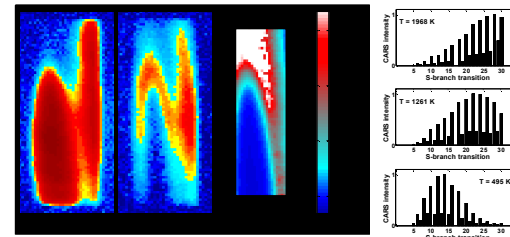
- **2000-2016**
 - 10% of the LDRD projects over the last 15 years were specifically focused on diagnostics
 - Many other projects require diagnostics to obtain the data needed for new physical understanding and validation
- **Current LDRD proposal season in mid-cycle**
 - 16/60 initial idea proposals were diagnostic focused
 - 6 have been selected to move forward to second round

ESRF contains many technical areas

- **ESRF spread across wide range of technical areas:**
 - solid mechanics, structural dynamics, combustion, thermal science, fluid mechanics, aerodynamics, energetics materials, electromagnetics, electrical circuit science, and shock physics
- **Two technical talks representative of diagnostic development in thermal/fluids**



D. Guildenbecher



C. Klierer

- **Following slides contain a brief subset of all diagnostic development efforts in engineering sciences**

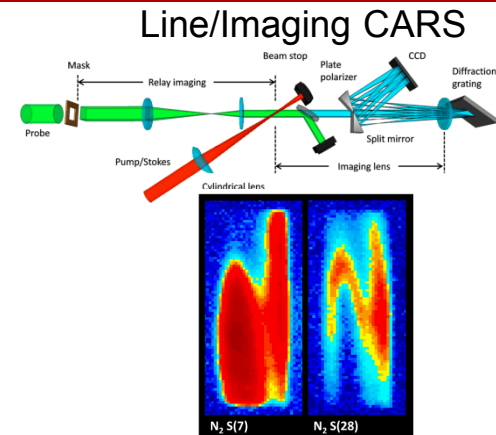
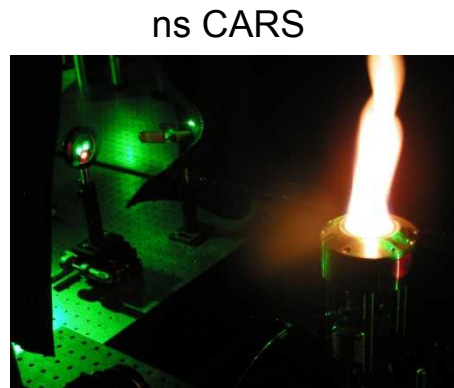
Common themes among the diagnostic examples to follow

- Sandia National Laboratories has developed a unique capability with state of the art equipment and facilities
- Partnerships with universities and other external collaborators to broaden our knowledge base
- Research is performed with a focus on our national security mission
- Engineering Sciences impacts all of SNL Mission Areas
 - NW = Nuclear Weapons
 - DSA = Defense Systems & Applications
 - EC= Energy & Climate
 - IHNS = International, Homeland, and Nuclear Security

Fire dynamics – Ground-breaking techniques for diagnostics of harsh environments

CARS =
Coherent anti-
Stokes Raman
spectroscopy

Temperature
and species
measurements



1990s

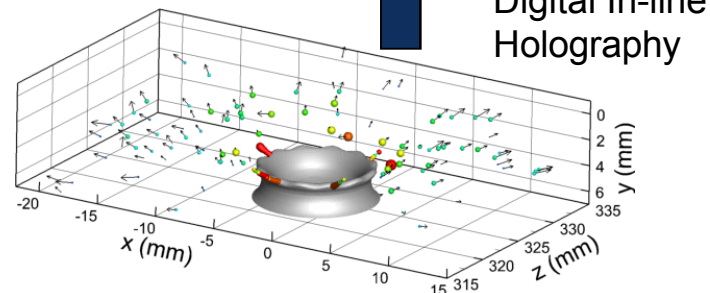
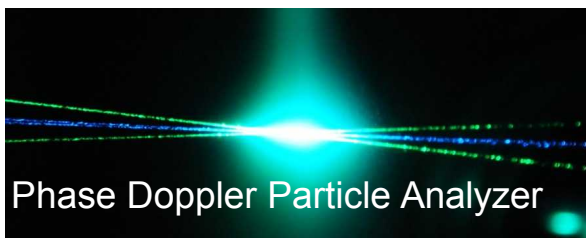
2005

2009

2011

2015

Multiphase
flow
diagnostics



Data collected using these techniques is useful for all SNL mission areas: NW, DSA, EC, IHNS.

X-ray diagnostics: Enabling vision in an opaque universe

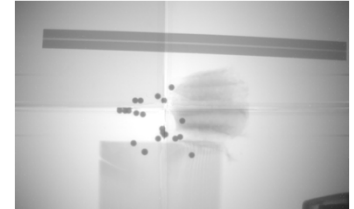
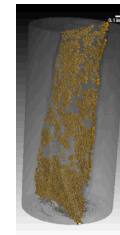
Image reconstruction software utilizes graphical processing units. Reconstructions now take minutes instead of hours



Radiographic signatures of home-made explosives (LDRD)



Proppant placement in fractured shale (LDRD)



Fragment tracking with high-speed and ultra-high speed x-ray imaging



2000-2005

2011

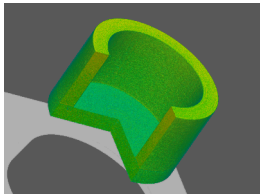
2012

2013

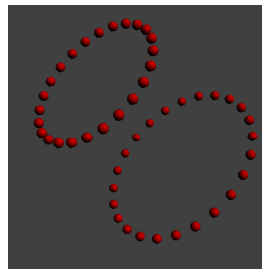
2014

2015

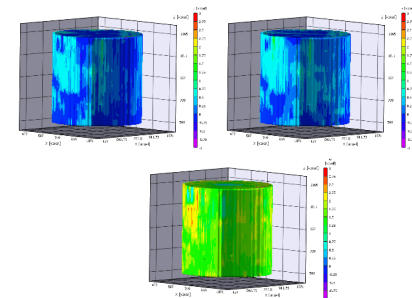
Complete implementation of computed tomography (CT)



Stereo X-ray Imaging –
2 x-ray machines,
2 detectors, 3-
dimensional
tracking



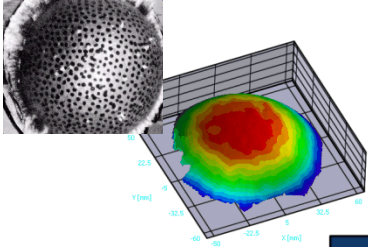
Digital Volume Correlation



X-ray is used for all mission areas from component level testing up through large scale testing.

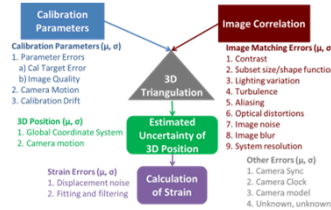
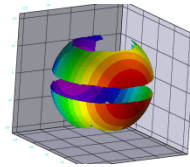
Solid Mechanics – A revolution in full-field engineering measurements

Displacement, velocity and strain



Stereo-DIC Uncertainty Quantification
From colors to metrology.

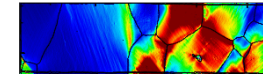
360° coverage



DIC for Material Properties

- Quantified Uncertainty
- More parameters per test
- Parameter interaction
- High-throughput
- Model validation

Grain Scale strain



2005

2007

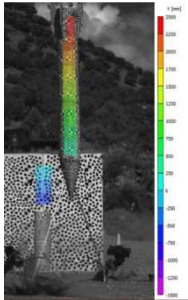
2009

2011

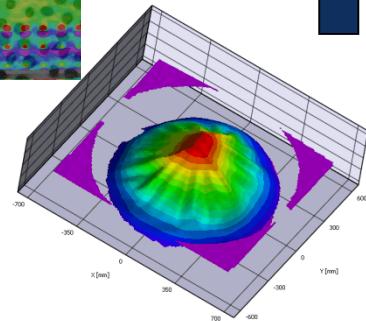
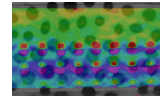
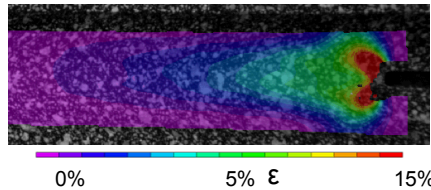
2013

2015

Introduction of
DIC to Sandia

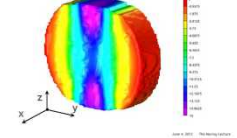


Crack-tip and Fracture Strain



Explosive Panel Deformation

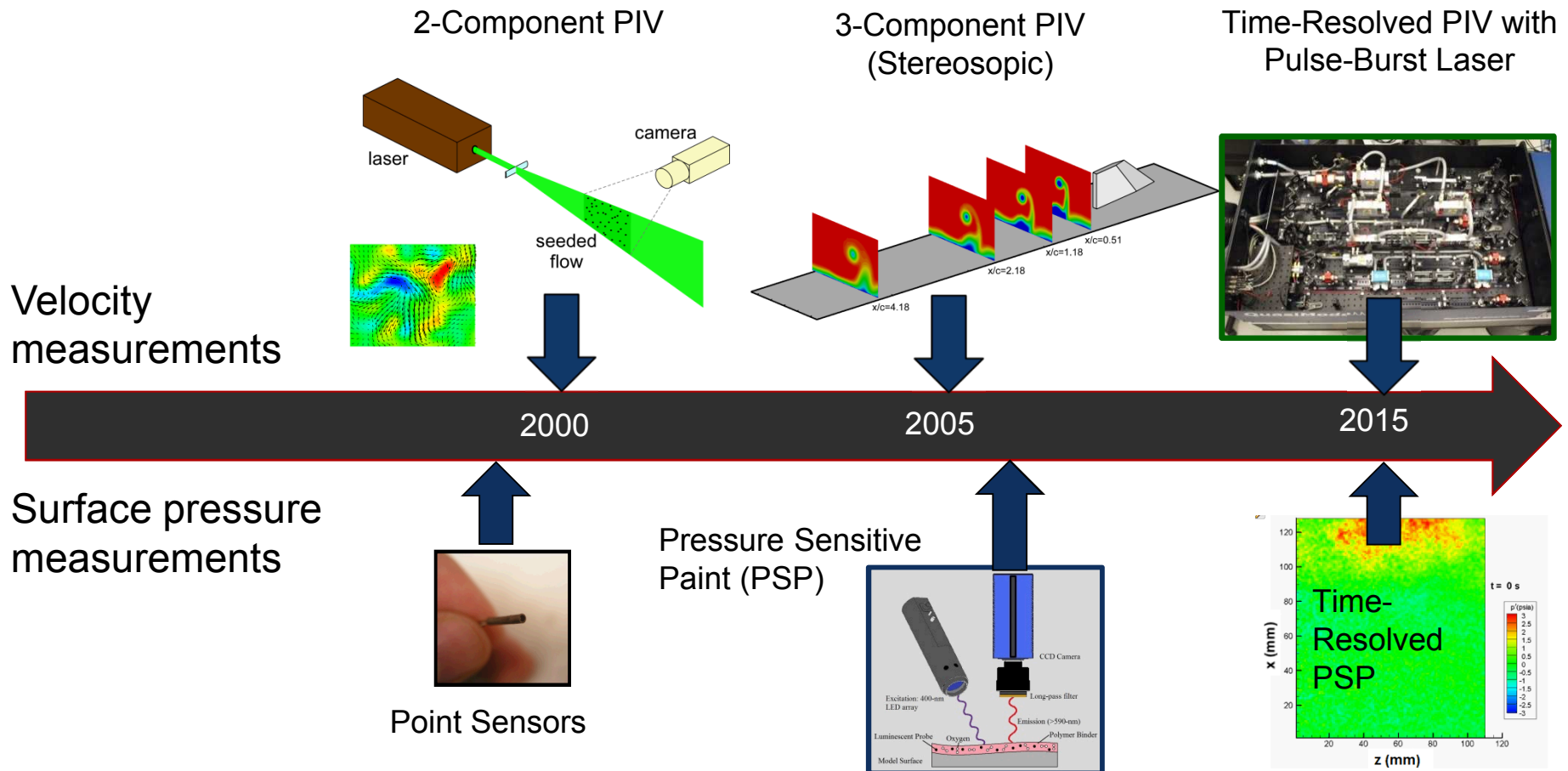
Distribution of strains in x-y planes, x-z planes and y-z planes



Volumetric DIC

Digital Image Correlation is used for testing in NW and DSA

Aerosciences – Pushing the limits of spatial and temporal resolution up to hypersonic speeds



Improving measurements for acoustical loading and qualification environments for NW, EC, and DSA Mission Areas.

Intentional Stewardship:

Development of ESRF Diagnostics Strategic Plan

Diagnostic Summit:
60 staff members
10 managers
6 hours



**Kick off of Engineering
Sciences Quarterly
Diagnostic Seminar Series**

4/2015

10/2015

5/2016

6/2016

10/2016

Initial Draft



**Identify five areas where
experimental gaps exist,
develop roadmaps.
(for example: metal
combustion & experimental
uncertainty quantification)**

**Fully Developed
Roadmaps Completed
in time to influence
2017 ESRF-LDRD Call**

**Continued investment in high-fidelity engineering
diagnostics is vital for discovery and validation**