SAND2021-10255PE

Sandia National Laboratories

HED research at Sandia

Discussion with NASEM panel for National Assessment of HED Science

Daniel Sinars

Director, Pulsed Power Sciences Center

Program Executive, Office of Experimental Sciences

Chair, REHEDS Research Foundation

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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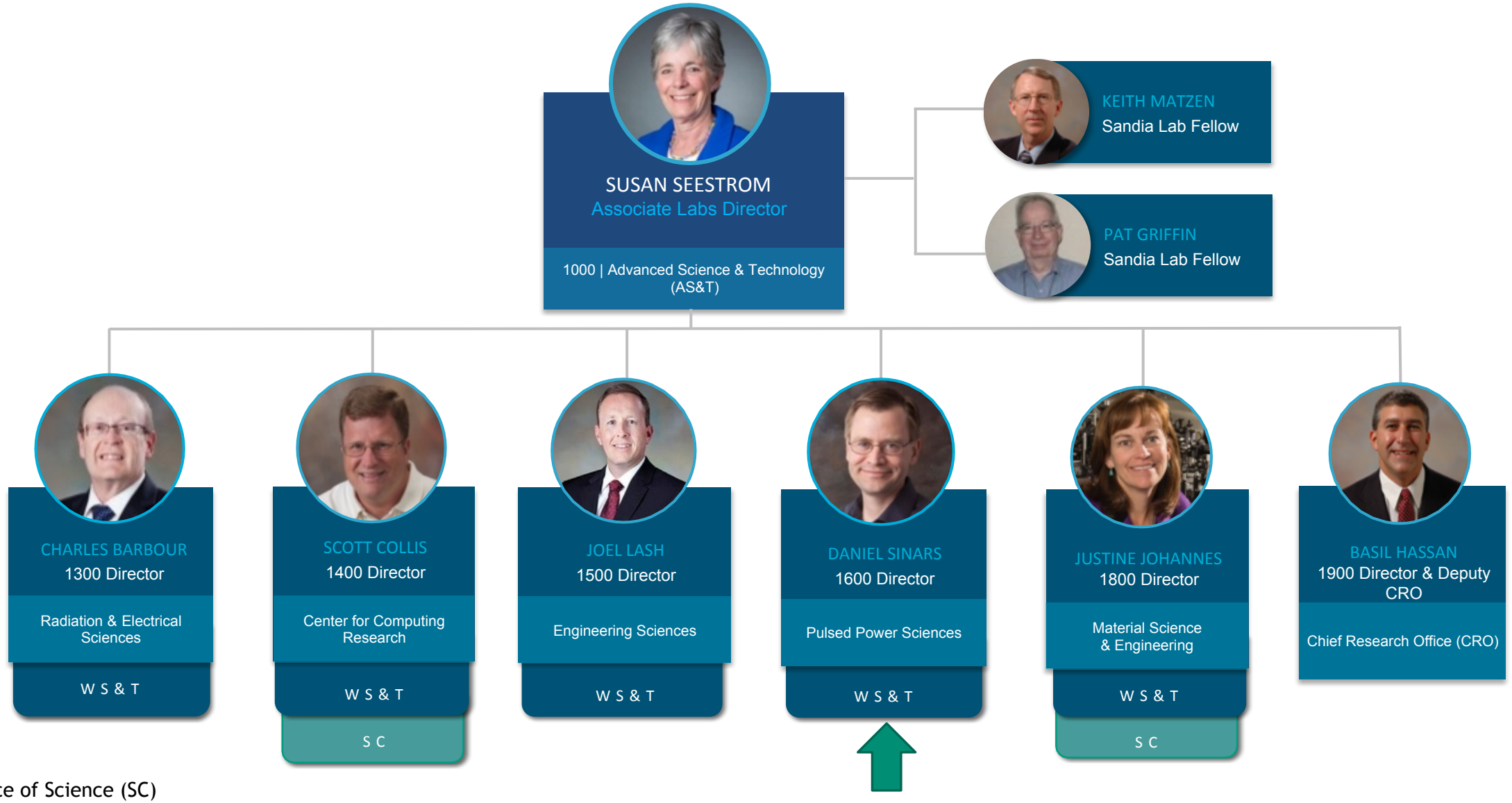
Talking points for Susan to open NASEM site visit

- Introduction of Susan's roles at the laboratory (ALD for AS&T and CRO)
- Sandia is a multi-mission laboratory
- Nuclear Deterrence is a key program area
- HED science plays an important role in both Sandia's and the national ND efforts
  - Sandia maintains intellectual leadership in pulsed power, a key driver technology for HED
  - At Sandia, HED science supports understanding of high-pressure materials and development of bright neutron and radiation sources for radiation effects of non-nuclear systems.
  - Nationally, the HED science conducted at Sandia supports understanding of high-pressure nuclear materials (e.g. Pu), radiation flow and hydrodynamic processes in nuclear weapons, and development of laboratory fusion sources on the path to high yield.
- Sandia manages the HED science at Sandia through both the AS&T portfolio (WS&T) and the REHEDS research foundation within the Chief Research Office.
  - Dan will talk more about the organization and plans of these efforts at the lab

Sandia's Advanced Science and Technology Division



Office of Science (SC)

ND Weapons Science & Technology (WS&T) ORG 400

Most HED Science is done here

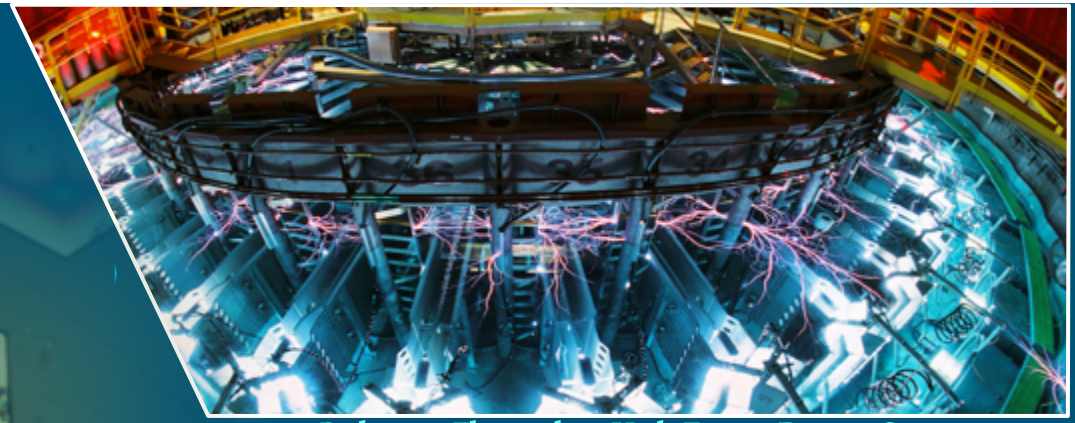
Date of last revision 1/30/21

Discipline-based Research Foundations steward core science & technology capabilities

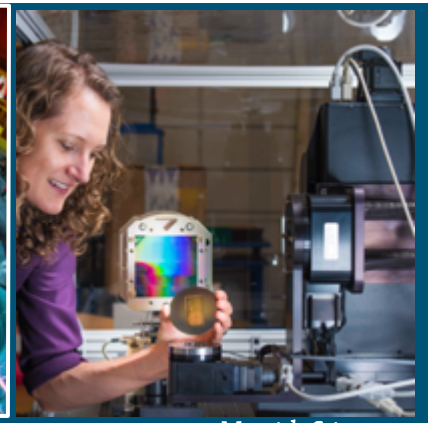
Purpose: Conduct fundamental/discovery research and use-inspired research in disciplines germane to, and inspired by, national security mission needs to advance the frontiers of knowledge, explore innovative solutions, and build/maintain technical capability.

Nanodevices & Microsystems

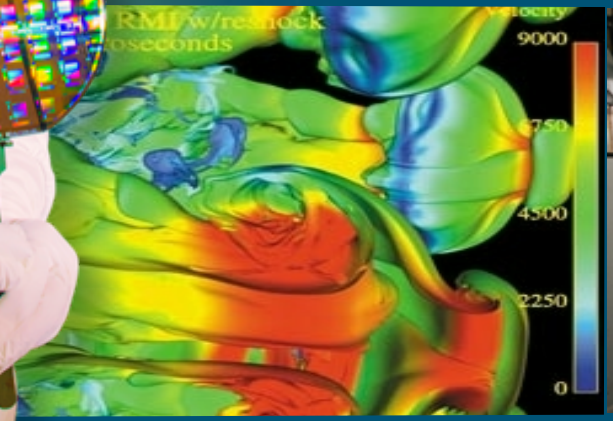
Computing & Information Science



Radiation, Electrical, & High Energy Density Science



Materials Science



Engineering Science

Earth Science

Bioscience

The REHEDS RF stewards four key research disciplines at Sandia

Research Disciplines

Radiation Effects Science (RES)

- Focused on understanding the effects caused by single and combined radiation environments.
- These effects impact materials, devices, components, and systems and can cause complex physical and chemical responses in electrical and mechanical systems.

Electrical & Electromagnetic Science (EES)

- Focused on understanding the effects of electromagnetic radiation (EMR), with a particular focus on electrical and electro-optical circuits.
- Research, development, and application of computational and physical simulation capabilities will assure that electrically susceptible systems and components operate as intended in normal, abnormal, and hostile environments.

High Energy Density Science (HEDS)

- Focused on the study of material properties, inertial confinement fusion, radiation transport, and other physical processes at extreme temperatures, densities, and pressures.
- A nuclear explosive package operates almost exclusively in this high energy density regime.
- HED plasmas are efficient and powerful sources of fusion neutrons and of x rays that are applicable to RES studies.

Pulsed Power Science & Technology (PPS&T)

- Focused on understanding the physical principles that underlie the efficient creation and application of electrical energy through pulsed power technologies.
- REHEDS is known for its use of large-scale terawatt-to-petawatt pulsed-power systems to support its work.
- REHEDS also conducts fundamental pulsed power science and engineering over a wide range of scales.

REHEDS is chartered by the Chief Research Office, and has substantial interactions with the Advanced Science & Technology (AS&T) Programs

AS&T PROGRAM PORTFOLIO (Susan Seestrom & Grant Heffelfinger)

Program management direction of work in support of the Department of Energy (DOE) including Office of Science (SC) and the Weapons Science & Technology (WS&T) programs

CHIEF RESEARCH OFFICE (CRO) (Susan Seestrom & Basil Hassan)

Stewards Sandia Labs-wide research enterprise including LDRD, the research strategy, capabilities, partnerships, and tech transfers.

LDRD

Program invests in high-risk, potentially high-payoff activities that enable national security missions and advance the frontiers of science and engineering.

REHEDS LDRD IA ($8M FY21, $9.5 FY22)

RESEARCH FOUNDATIONS

Fundamental discovery research in disciplines germane to and inspired by national security mission needs to advance the frontiers of knowledge, explore innovative solutions, and build/maintain technical capability.

REHEDS "Base program" (~$245M in FY21) + ECSE

MISSION CAMPAIGNS

Portfolios of LDRD-funded projects that are designed to bridge between science, technology, and engineering and broad mission demands.

RAD ($32M over FY20-24)
ASAP ($40M over FY21-26)

GRAND CHALLENGES

Bold, ambitious, and large scale projects that advance the frontiers of science and engineering.

Plasma ($15M over FY18-20)

EXPLORATORY EXPRESS

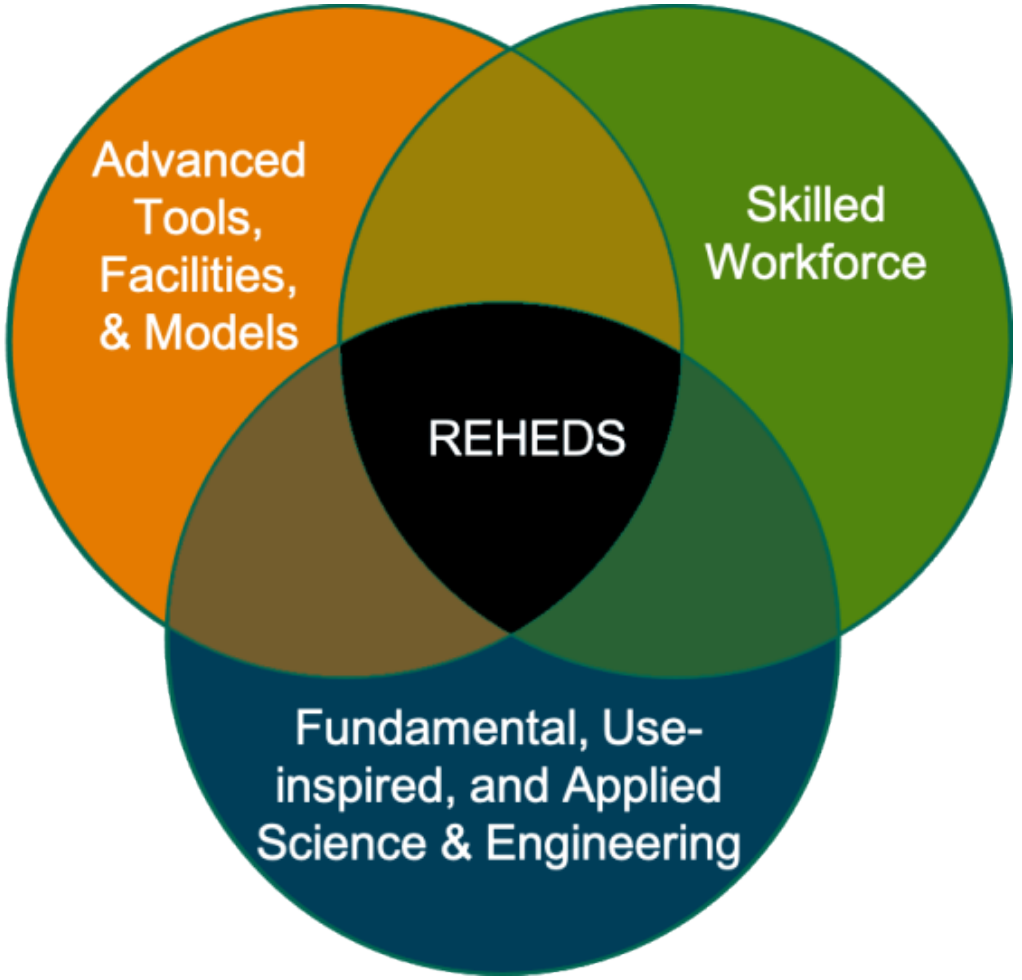
Short-term projects formulated to answer a single key R&D question in an area of current or future strategic importance to Sandia.

($0.14M in FY21)

REHEDS initiatives highlight specific needs along the general themes of workforce, tools, and science/engineering

Strategic Initiatives

- Provide discipline-based technical expertise to the national nuclear deterrence program
- Provide capabilities to identify, assess, and respond to changes in nuclear weapon environments
- Collaborate to provide stewardship science capabilities for nuclear weapon design changes
- Advance and sustain our critical experimental capabilities
- Improve the integration of experimental and computational simulation capabilities



We have identified major strategic initiatives within REHEDS

Strategic Initiatives

Provide discipline-based technical expertise to the national nuclear deterrence program

Invest in our current workforce

Cultivate strategic university and partner institution relationships

Provide capabilities to identify, assess, and respond to changes in nuclear weapon environments

Understand effects and response of electrical components & materials in combined and complex environments

Improve the fidelity of the effects and responses generated by relevant environments

Collaborate to provide stewardship science capabilities for nuclear weapon design changes

Provide high-quality, timely materials, transport, and hydrodynamics science to support high-consequence decisions

Understand the physics of fusion sources today, applications to stockpile science, and scaling to high yield (>100 MJ)

Advance and sustain our critical experimental capabilities

Execute major capital acquisition and facility refurbishment projects

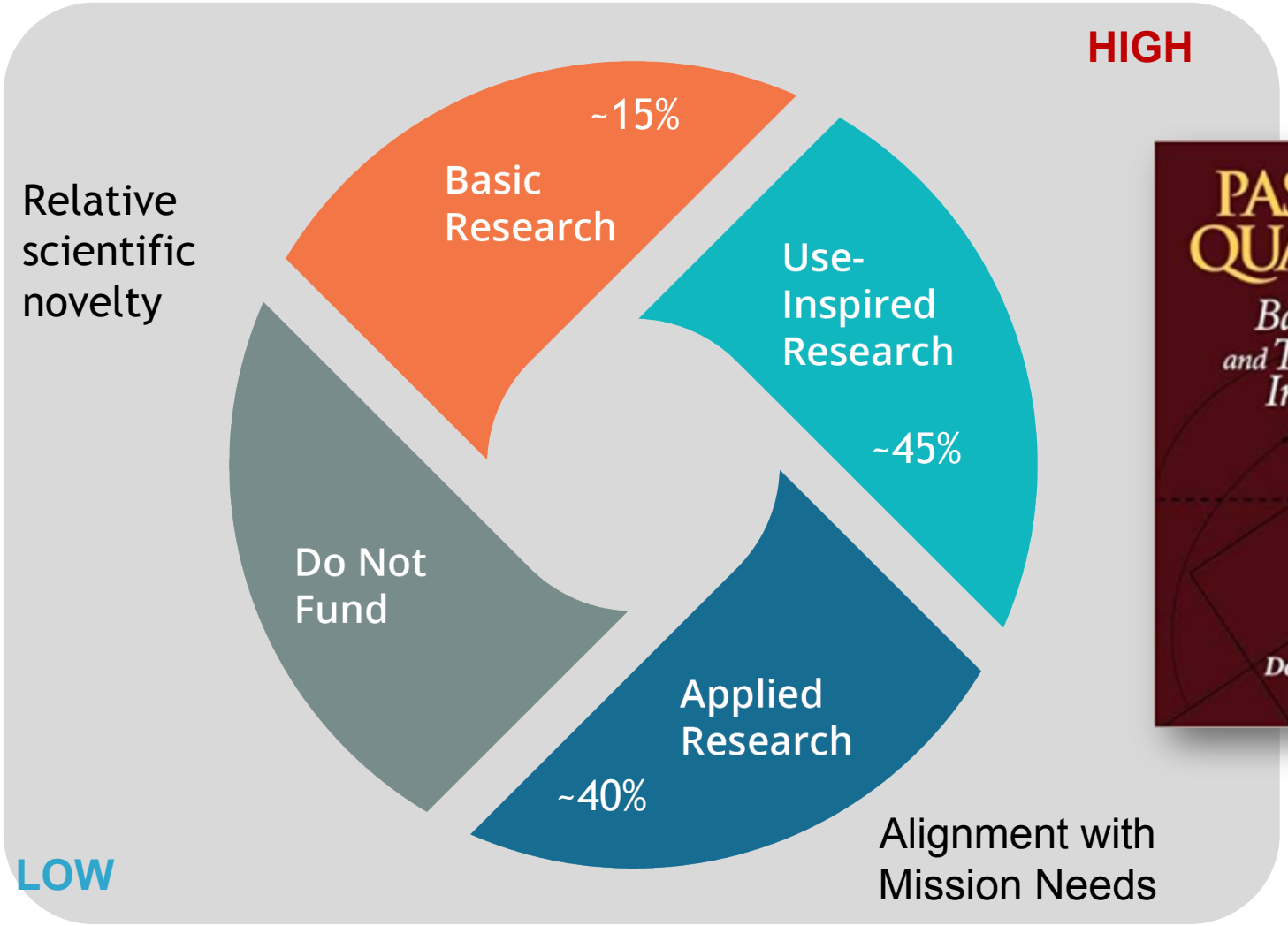
Advance the technology readiness of next-generation pulsed power

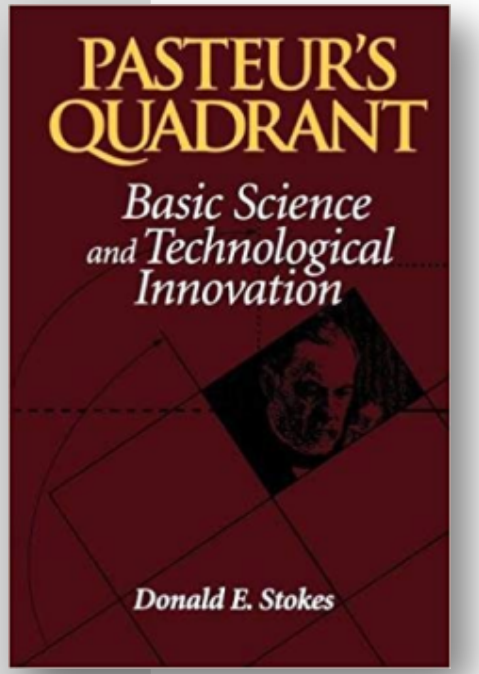
Understand the behavior of plasma formation and power flow on current and future pulsed power facilities

Improve the integration of experimental and computational simulation capabilities

Majority of Z research is “use-inspired”

Conducting open, novel science in the pursuit of applications benefiting the mission of the NNSA





The Z facility is supported by the multi-kJ Z-Beamlet & Z-Petawatt lasers, which can also be operated independently

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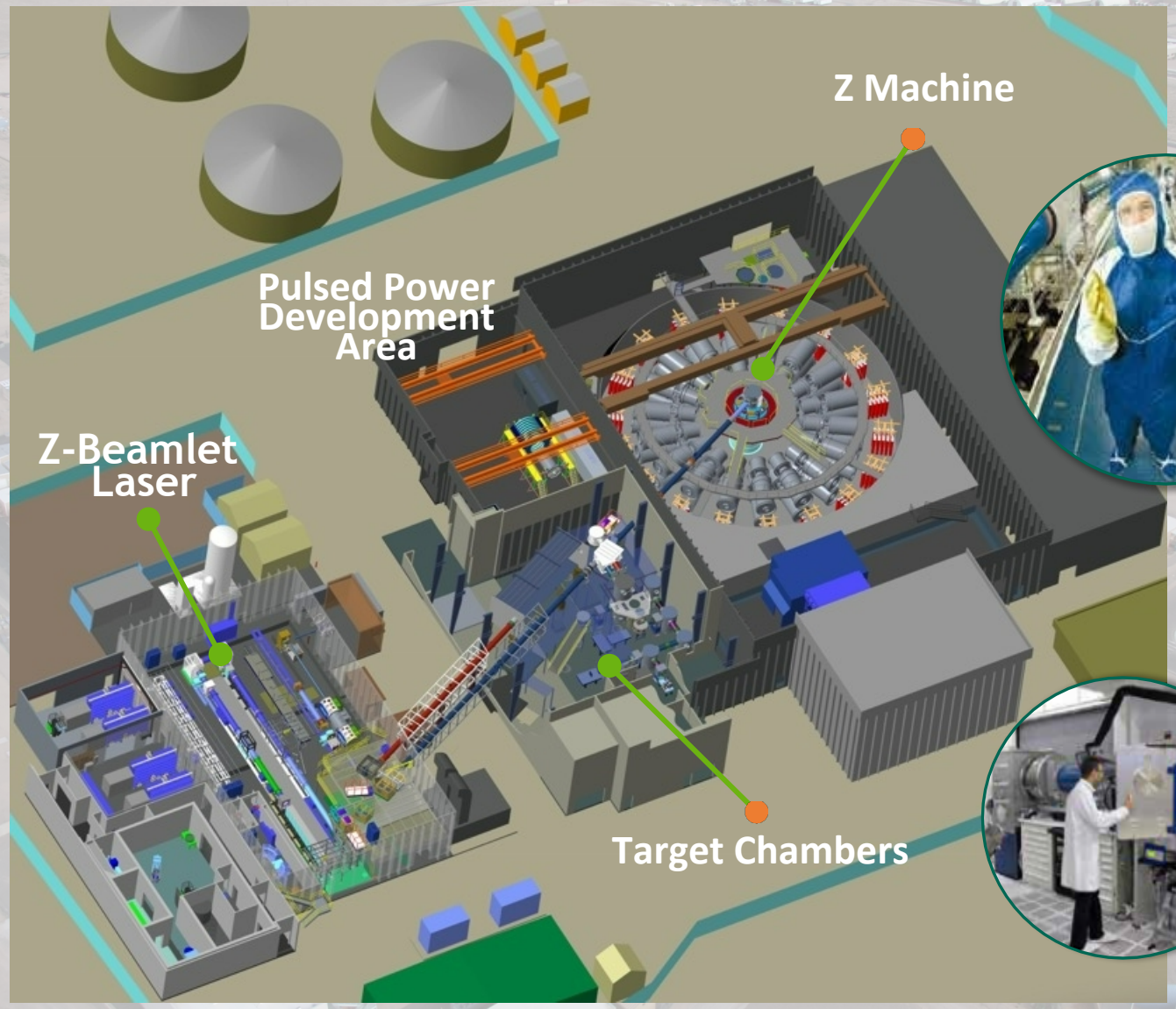


P.K. Rambo *et al.*, Applied Optics 44 (2005); P. Rambo *et al.*, Proc. SPIE 10014 (2016).

Purpose: Exceptional science and pulsed-power technology in the National interest

Mission: *We develop and apply pulsed-power technology to expand the frontiers of high-energy-density science, fusion, and extreme radiation environments with the primary goals to provide essential data for the Nation's nuclear stockpile, to inform present and future stockpile decisions, and to be an engine of discovery for national security.*

ICF & Assessment Science Integrated Roadmap

Sandia National Laboratories

Mission Priority	Objective
Thermo-nuclear Burn	Realize and apply magnetic-direct-drive fusion platforms for stockpile applications
Material Properties	Be the world leader in multi-Mbar material and opacity science for the stockpile
Survivability	Realize the world's brightest x-ray and fast neutron environments for weapon survivability
Pulsed-Power	Be the world leader in pulsed-power science and technologies for key national security applications.

2021

- *Pu Aging*
- *MagLIF Integration 2*

2022

- *Plasma Transport Requirements*
- *Vulcan Operational*
- *Z-NIF Opacity Comp.*
- *Engineering Materials Assessment*

2023

- *25 MA transmission line models*
- *Warm x-ray scaling*
- *3D MIF Modeling*

2024

- *High-pressure SNM (tiny stripline)*
- *High-Yield Facility Requirements*
- *Advanced Insulator Technology*

2025

- *Multi-MJ Fusion Scaling*
- *60 MA power-flow model*
- *Next-Gen Pulsed-Power Designs*

2026

- *Pre-heated SNM*
- *Fast-neutron Effects*
- *Production 3D xMHD Design*

2027-30

- *Outputs opacity*
- *Fusion Assessment at Max Z-Scale*
- *Enhanced Integrated Testing*
- *SNM Diffraction*

Extra Slides

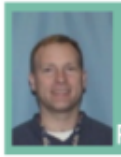
Center 1600
Pulsed Power Sciences

Most of the HED science at Sandia is managed and executed out of Center 1600

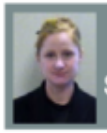
Daniel Sinars
01600
Pulsed Power Sciences Center

T. McCollum
Senior Mgmt Assistant

Center Support Team



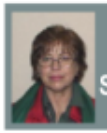
Kyle Peterson
01601
PP Strategic Planning & Dev



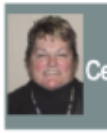
S. Hansen
Snr Scientist

M. Knudson
Snr Scientist

M.A. Sweeney
DMTS



C. Wiuff
Senior Admin



D. Kao
Center Business Manager

L. Shreve
Center Business Admin

Thomas Mattson
01640
HED Material Physics

Luke Shulenburger
01641
HEDP Theory

Chris Seagle
01646
Dynamic Material Prop

Scott Alexander
01647
Solid Dynamics Experiments

Mike Cuneo
01650
Pulsed Power Accelerator S&T

Kate Bell
01651
Advcd Acclrtr Phys

Jon Custer
01656
Advd Rad Tech

Dan Bozman
01656-1
Nevada Sppt

George Laity
01659
Advd Capabil for PP

Chris Bourdon
01670
Z Experimental Capability Mgmt

Mark Kiefer
01670
Z Experimental Capability Mgmt

Nathan Joseph
01671
Z Expmt Plan & Exec

Andrew Biller
01671-1
Z Cntr Section Execution

Scott Beatty
01672
Z Pulsed Power Systems

Jason Petti
01673
Syst Design & Ops Practices

Greg Rochau
01680
Radiation & Fusion Physics

Michael Jones
01681
Capab Intgrtn & Strategy

John Porter
01682
Laser Ops & Engineering

David Ampleford
01683
Fusion Experiments

Kris Beckwith
01684
Radiation & ICF Target Design

Jens Schwarz,
actg
01688
Rad Exprnts

Randy McKee
01690
PP Engineering & Design

Albert Owen
01691
Z, ZBL & PP Dev Eng

Alex Barrows
01692
Load Diag & Containment

Ben Cook
01693
Maj. PP Syst Engineering

Office of Experimental Sciences (NA-113) - Sandia Program Roles

The majority of the HED Science at Sandia is funded by the NNSA ICF and Assessment Science Programs ($131M in FY21)

ICF and Assessment Science program managers are also line managers in 1600

Daniel Sinars (1600)
NA-113 Program Executive

Greg Rochau (1680)
Deputy, Inertial Confinement Fusion Program

Thomas Mattsson (1640)
Deputy, Assessment Science Program

Chris Bourdon (1670)
Lead, ICF Facility Ops

Luke Shulenburger (1641)
Lead, Primary Assessment Technologies (PAT)

Michael Jones (1681)
Lead, ICF Diagnostics

Chris Seagle (1646)
Lead, Dynamic Material Properties (DMP)

Greg Rochau (1680)
Lead, ICF Science

Michael Cuneo (1650)
Lead, Advanced Diagnostics

Brent Jones (1688)
Lead, Secondary Assessment Technologies (SAT)