Center for Advanced Energy Studies (CAES)
Overview of Activities and Opportunities, Fall 2022

Presented by
Dave Rodgers, ISU Associate Director

Guests:
Phil Reppert, Director
Dave Estrada, BSU Associate Director
John Russell, UI Associate Director

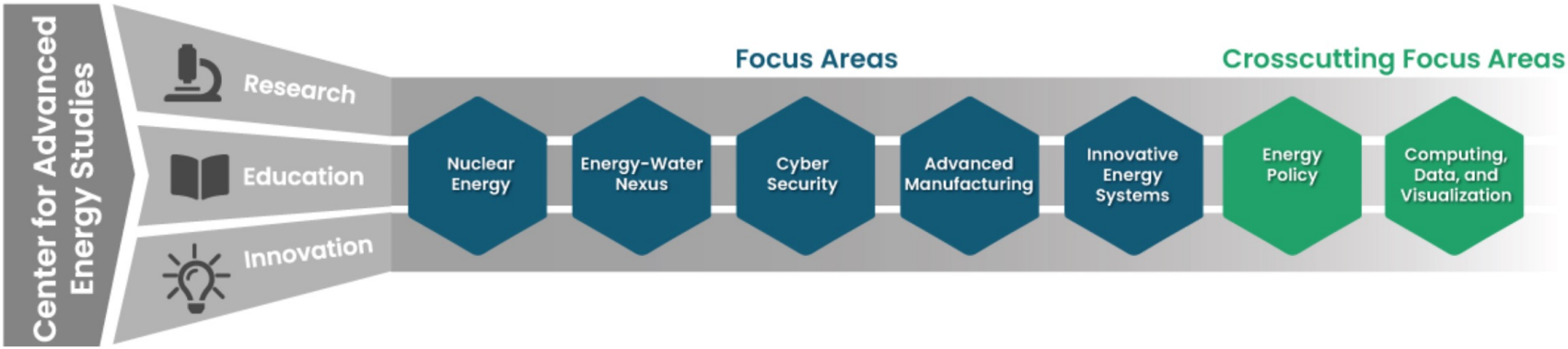
Idaho State University (Pocatello) acknowledges that it is located within the boundaries of the original Fort Hall Reservation on the traditional lands of the Shoshone and Bannock peoples.

What is CAES?

A Consortium of four institutions: INL, BSU, ISU, UI

A Vision of collaborative research/education/innovation in energy fields

A Strategic Plan that is evolving but in recent years has focused on seven energy-related themes:



A Building with access to offices and well-equipped laboratories

A Budget with discretionary funds to support CAES activities

How Can ISU Participate in CAES?

CAES Building (Idaho Falls)

- Six faculty offices plus cubicles for 20+ students
- Active Lab Research
  - Radiochemistry Lab
  - Thermal Hydraulics Lab
  - Microscopy and Characterization Suite (MaCS)
  - Advanced Manufacturing Lab

Collaborations

INL-supported CAES Activities

ISU-funded CAES Activities

Advanced Reactor Materials Research

- Molten Salt & Molten Sodium
- Structural Materials (Graphite)
- Fuel Materials (Metal, TRISO Compacts)
- Thermal Cycling & Fatigue to Support PWRs
- Advanced Sensors

- All projects either directly funded, or guidance provided, by INL/BEA

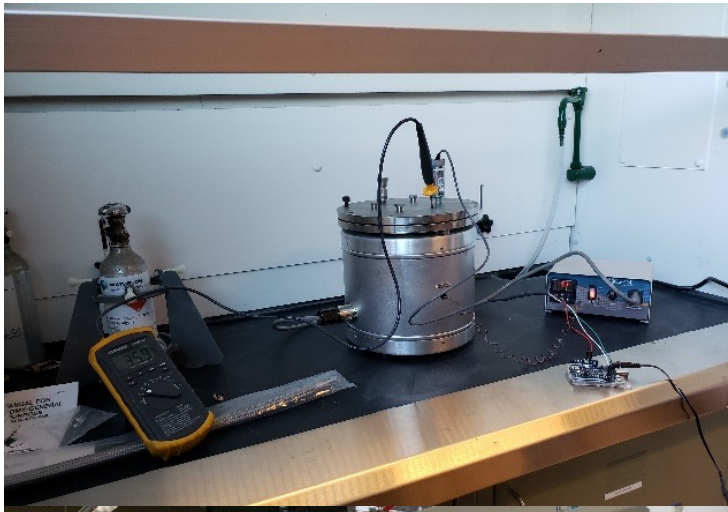
Projects include

Hands-on experimental work

Computational Design studies

Data Mining (Historical Efforts)

Pre- and Post-Test Analysis (Microscopy, e.g.)



Thermal-Hydraulics Research at CAES

CAES Center for Advanced Energy Studies

Recent and Active projects:

Scaling study on the heat transfer and fluid flow in FHR pebble bed reactors

Development of highly compact HX technology for non-water advanced reactors (computational & experimental)

Surface wettability and prediction of Critical Heat Flux (CHF) for chrome coated Zirc claddings

Database development for heat pipes in nuclear applications (INL)

Coupled CFD – RELAP5 analysis of in-vessel once-through steam generators

Surface Goniometer

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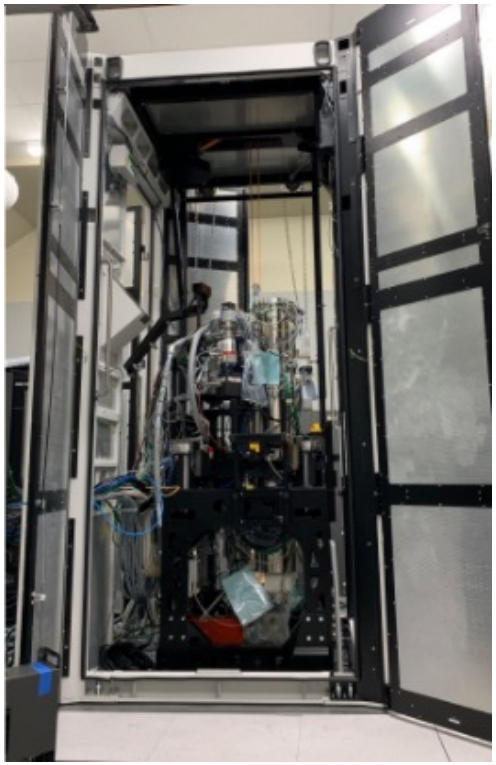
Microscopy and Characterization Suite

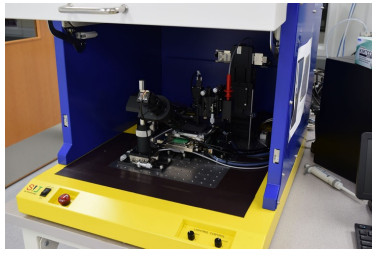


- **TEM: FEI Tecnai G^2 F30 STEM, 300 kV**
  - Analytical Scanning TEM with Field Emission Gun (FEG).
- **New TEM: FEI Spectra STEM, 300 kV**
- Energy resolution of < 0.2 eV compared to 0.8 eV with oldeer TEM
- Provides improved spatial resolution at low accelerating voltages, enabling analysis of light elements (Carbon, Nitrogen, and Oxygen for example)
- **LEAP: CAMECA LEAP 4000X HR**
  - 3-dimensional atom probe at near atomic resolution
  - UV laser, energy compensated reflectron, provides excellent mass resolution
- **FIB: FEI Quanta 3D FEG**
  - Dual beam FIB with Field Emission Gun (FEG) (FIB + SEM)
  - Omniprobe/minipulator – for TEM & LEAP samples
  - EDS, EBSD and STEM
- **SEM: JEOL JSM-6610LV**
  - EDS, EBSD and Cathodoluminescence
  - Variable chamber pressures
  - For both inorganic and organic materials
- **Rigaku SmartLab XRD**
  - Focusing and parallel beam geometries
  - Cu-Target, 20-60 kV, 2-60 mA
- **NIAFM: Hysitron TI-950 TriboIndenter**
  - Nanoindenter: nanometer scale indentation
  - Atomic Force Microscope (AFM)

Advanced Manufacturing Lab

3D Structural Additive Manufacturing (NSUF)

Electronic Materials Printers

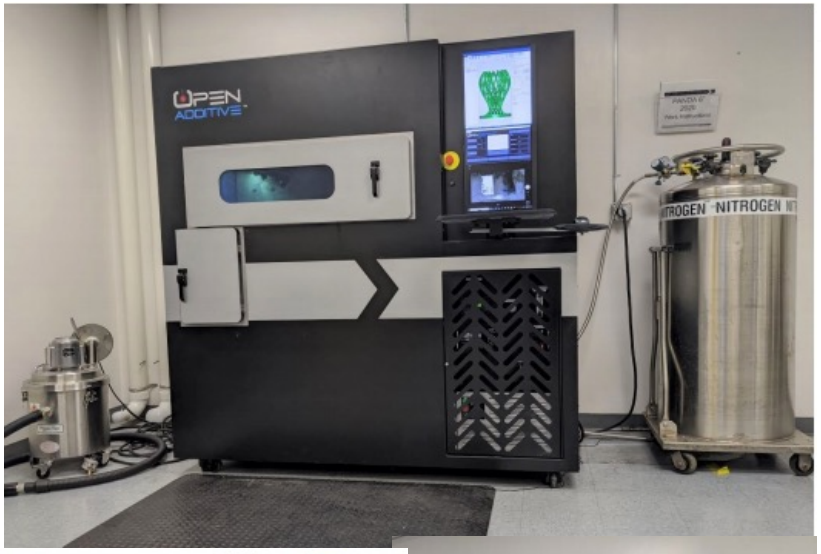


Spark Plasma Sintering

Ink / Feedstock Synthesis

- Approximately $1.4M in equipment to support materials development, printed sensors, and structural additive manufacturing for CAES
- Supports existing programs and opens new areas in printed and flexible electronics as well as trusted AI for advanced manufacturing
- Seeds investment in larger AM efforts and infrastructure (R2R, powder feedstock, benchmarking technologies, and custom printers)

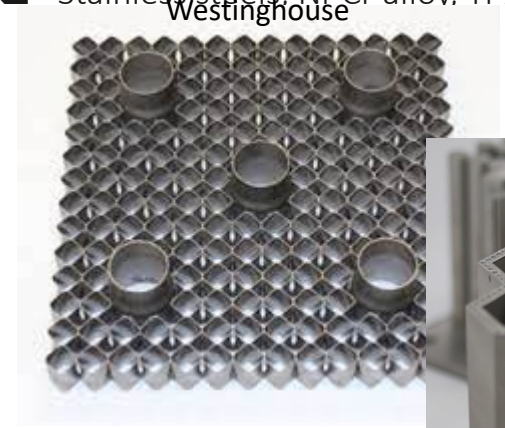
CAES – 3D Metal Printer



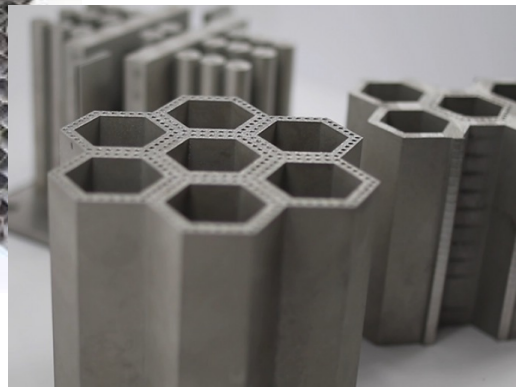
Open Additive Panda 3D Metal Printer (NSUF)

- Direct Metal Laser Sintering powder bed system
- 6 x 6 x 9 inch build volume
- 1000 W laser
- Custom access door with integrated dual gloves
- Thermal tomography sensor
- 30 gal flammable storage cabinet for powder
- Explosion proof vaccuum
- Materials research and technology development
- Stainless steels, Ni-Cr alloy, Ti-Al alloys, Al alloys

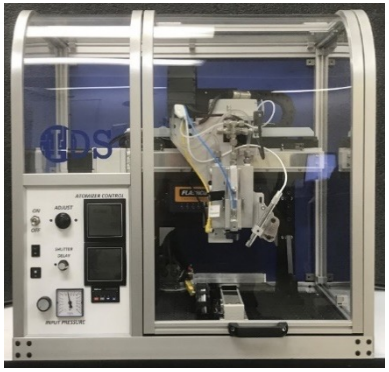
Westinghouse

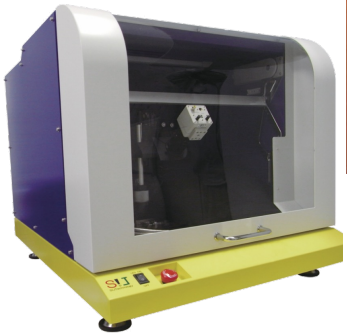


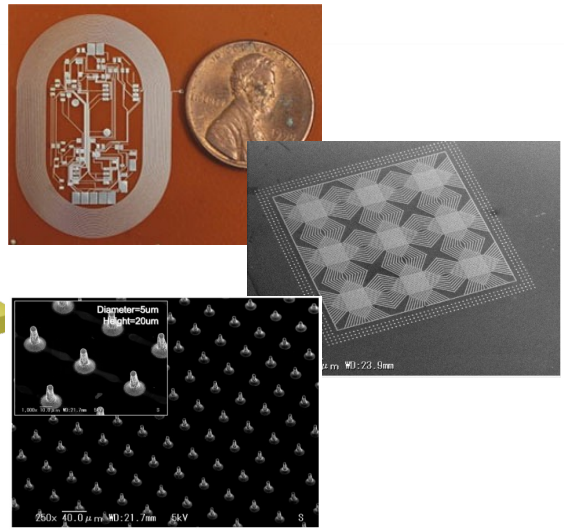
Oak Ridge



CAES – Ink Development and Printed Materials







- Located in the old ACL, we are installing an electrohydrodynamic inkjet printer, an aerosol jet printer, and suite of instruments to synthesis power feedstocks for ink development and characterization and/or 3D metal printing.
- A dynamic mechanical analyzer, creep tester, dilatometer, and materials microscope can also support analysis of mechanical properties and microstructure in printed materials.

How Can ISU Participate in CAES?

CAES Center for Advanced Energy Studies

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  - Advanced Manufacturing Lab

Collaborations, such as:

- NSF REU award (led by BSU) – from ISU: Dan LaBrier, Mustafa Mashal
- NSF Engines proposal (led by INL) – from ISU: Donna Delparte
- NSF ERC workshop (led by BSU) – from ISU: Marco Schoen, Dan LaBrier, Amir Ali

INL-supported CAES Activities

ISU-funded CAES Activities

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INL-supported CAES Activities

- Summer Visiting Faculty Program
- Collaboration Fund

ISU-funded CAES Activities

CAES Summer Visiting Faculty Program

Fosters collaboration between university faculty and INL researchers
PIs develop a jointly-funded external research proposal
Includes a $10K stipend for university faculty
Applications due in Winter, selections made in Spring
Over 5 years: 50+ university faculty participants including 17 ISU faculty

Summer 2022 ISU faculty:

Advanced Multiscale Thermal Properties Prediction in MOOSE via a General Boltzmann Solver	Jackson Harter (INL) Minhaz Zibran (ISU)
Multiphysics Modeling of Hydrogen Deflagration in the Event of a Severe Nuclear Accident	Ahmed Hamed (INL) Rajiv Mahamud (ISU)

CAES Collaboration Awards

Goal: to foster relationships between CAES researchers, leading to extramural funding
Awards of $10-50K funded by INL's CAES budget
Projects are led by INL researchers and must include faculty from the CAES universities
For 2022: 7 of 13 awards involved ISU researchers:

Net Zero: Utilization of Waste Products from Agricultural and Biomass Industries to Reduce Concrete Emissions	Kunal Mondal (INL) Mustafa Mashal (ISU)
Mobile Robot for Security Applications in Remotely Operated Advanced Reactors	Vaibhav Yadav (INL Mustafa Mashal (ISU)
Using Artificial Intelligence to Guide the Run-in of a Pebble Bed Reactor	Ryan Stewart (INL) Leslie Kerby (ISU)
Fundamentals of Computational Analysis of Thermal Systems: Curriculum Development	Joshua Fishler (INL) Amir Ali (ISU) Lan Li (BSU
Investigation on Designing a Framework of Utilizing Sensor Data in Virtual Training for Disaster Response Preparedness and Response	Xingyue Yang (INL) Rajiv Khadka (INL) John Koudelka (INL) Mustafa Mashal (ISU)
Improving the electron shuttling efficiency of activated carbon in relation to biological nitrogen removal during water treatment	Asef Redwan (INL) Anirban Chakraborty (ISU)
Developing Machine Learning based Force Field for Predicting Radiation Resistance of High Entropy Alloys	Md Riaz Kayser (INL) Ahmed Hamed (INL) Mostafa Fouda (INL)

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- NSF ERC workshop (led by BSU)

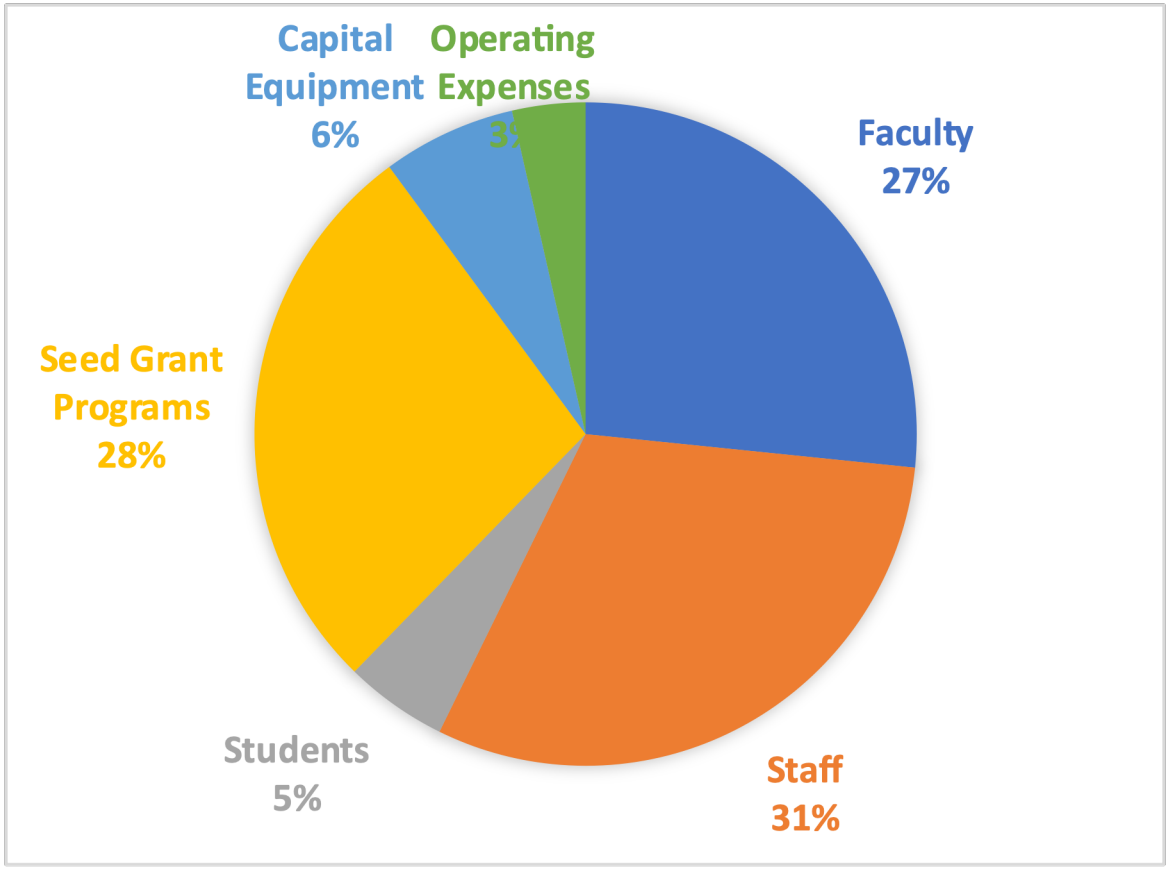
INL-supported CAES Activities

- Collaboration Fund
- Summer Visiting Faculty Program

ISU-funded CAES Activities

- Faculty/staff support
- Seed Grants (Research, MaCS)
- Student Support, Equipment

ISU-CAES Budget, FY23 $996K total funding



ISU-CAES Seed Grant Program

Funding for research projects led by ISU with collaborators from BSU, UI, INL

Research theme should correspond to CAES Strategic Plan

Prioritize projects that will lead to External Grant Proposals

At least $200K available annually, Individual awards of $20-30K

Successful Projects include the following.....

CAES Center for Advanced Energy Studies

ISU CAES Seed Grants CY 2021

ISU PI	ISU Department	ISU co-PIs	University co-PIs	INL co-PI	Project
Ali, Amir	NE		David Arcilesi (UI)	Piyush Sagharwall	Small-Scale Heat Exchanger Thermal Performance Facility
Jenkins, Cori	Chemistry	Josh Pak		Chris Zarzana Brittany Hodges	Urethane degradation analysis for upcycling and designing sustainable plastics
Leung Solomon	CE		Yaqiao Wu (BSU MaCS)	Don Wood	Sorption Removal of Gaseous Fission Products in Nuclear Fuel Reprocessing by MCM-41, TiO2, and their Functionalized Derivatives
Mashal, Mustafa	CE	Bruce Savage Jared Cantrell Roy Dunker		Rajiv Khadka Xingue Yang John Koudelka Maya Redden Bryon Marsh Shad Keele Michael Shurtliff	The Use of Emerging Technologies for Training of Emergency Responders
Murray, Kendra	Geosciences		Nick Bulloss (BSU MaCS)	Xiaofei Pu	Olivine phenocryst evolution in the Snake River Plain basalt flows that underlie the INL
Pashikanti, Srinath	Pharmacy/ Chemistry	Rene Rodriguez		Robert Fox Donna Baek	Synthesis of Conformationally-Rigid Tetralkyl phosphonium based Ionic Liquids for extraction of critical element Cobalt
van Woerden, Irene	Community & Public Health			Rae Moss	Perceptions of INL and Nuclear Energy in the local community

ISU CAES Seed Grants CY 2022

CAES Center for Advanced Energy Studies

ISU PI	ISU Department	ISU co-PIs	University co-PIs	INL co-PI	Project
Ali, Amir	Nuclear Engineering			Yasir Arafat	Performance optimization of MARVEL Microreactor power conversion system
Bodily, Paul	Computer Science			Rajiv Khadka	Application of Advanced Computational Theory to Facilitate Efficient Solutions to Real-World Combinatorial Problems
Forest, Tony	Physics			Chutiing Tan	A Neutron Generator for Materials Testing
Fouda, Mostafa	ECE			Ahmed Hamed	Smart Analytics of Biomass Images
Kalivas, John	Chemistry			John Koudelka	Virtual Reality for Dynamic Data Visualization of Analytical Chemical Data
Mashal, Mustafa	Civil Engineering	Dan LaBrier Jared Cantrell		Som Duhlipala Amit Jain	Machine Learning-Aided Validation of a Sustainable and Highly Durable Construction Technology for the Containment Facility of Advanced Reactors
Pashikanti, Srinath	Biomedical and Pharmaceutical Sciences	Rene Rodriguez		Robert Fox Donna Baek	Incorporation of Sterics in novel Phosphonium Ionic Liquid (PIL) and their Effect on Ligand Intermolecular Interactions and Chelation Properties
Savage, Bruce	Civil Engineering	Chikashi Sato Jim Mahar Mustafa Mashal	Karen Humes, UI Dakota Roberson, UI		Water Storage Infrastructure Viability using Repurposed Tires for Pumped Hydro
Weber, Keith	GIS TReC		Kathleen Araujo BSU Cassandra Koerner, BSU	Kelly Wilson Ryan Hruska Shiloh Elliot Chris Forsgren	The Power Grid/Wildfire Nexus: Using GIS and Satellite Remote Sensing to Identify Vulnerabilities
Xu, Danny	Biomedical and Pharmaceutical Sciences		Kenneth Cornell, BSU	Eric Whiting	Hearing Loss Prevention through Integrative High Performance Computing, Data Science, and Experimental Biology

MaCS Seed Grant Program

Funding for research projects that use instrumentation in the MaCS lab

$25K available annually,
Individual awards of $5K

Three applications received and funded:

Dan LaBrier, Nuclear Engineering:
Requisite Training for Characterization of Magnetic Powder

Dave Pearson, Geosciences: *Microstructural investigation of a shear zone in the northern Rocky Mountains*

Dan LaBrier, Nuclear Engineering: *Integration of Experiential Training with Traditional Classroom Instruction for an Introductory Material Science Course*

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  - Advanced Manufacturing Lab
  - Others: Fluids, Visualization, Electronics

Collaborative Proposals

- NSF REU, Engines, ERC, and others

INL-supported CAES Activities

- Collaboration Fund – Winter application, $10-50K
- Summer Visiting Faculty Program – Winter application, $10K

ISU-funded CAES Activities

- ISU CAES Seed Grant – November application, $20-30K
- MaCS Seed Grant – rolling application deadline, $5K
- Discretionary funds – rolling deadline: Student Support, Equipment

New Initiatives & Ideas

INL Net Zero by 2031 – reduce greenhouse gas emissions

Modified CAES Strategic Plan

Increased Coordination of CAES – C3 -- Cybercore

High Performance Computing

- Falcon Supercomputer donated by INL to BSU/ISU/UI
- New ISU staff position in HPC – Michael Ennis

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Overview of Activities and Opportunities, Fall 2022

More info:

https://www.isu.edu/research/centers-and-institutes/

https://caes.org/

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