Chick Keller Postdoctoral Fellowship

The additional required memo included in a Chick Keller Postdoc Fellow candidate package provides you the opportunity to highlight the research the candidate will be doing, and specifically how it aligns with one or more of the CSES research areas and their Focused Science Topics identified below.

Astrophysics and Cosmology

We emphasize advanced research in observation, theory, simulation, and instrumentation that strives to achieve fundamental understanding of the universe. In addition, this focus area benefits from and in turn strengthens its strong overlap with many on-going Laboratory programs in areas such as nuclear physics, particle physics, weapon physics, plasma physics, and condensed matter physics. It further utilizes and leverages the facilities and observatories both inside and outside of the Laboratory. We are interested in proposals that are innovative and forward-looking, especially those with strong potential leading to new capabilities and research directions.

It is strongly encouraged that proposals exploit unique resources at Los Alamos National Laboratory is involved:

1. Facilities such as the HAWC, Raptor, ZTF, etc.
2. Computational techniques, codes and resources, such as VPIC, RAGE, etc.
3. Broad knowledge base in a full range of physics that tie together theory, simulation, experiments, and observations.

<u>Specific Topics for new projects starting in FY19:</u>

Overall theme is to conduct cutting-edge research that enables breakthroughs in our understanding of Astrophysical Transients through innovative uses of unique LANL observational, theoretical, numerical and experimental capabilities. The area of Astrophysical Transients is a rapidly developing field in astrophysics, e.g., discoveries of gravitational wave sources, fast radio bursts, etc. The likely engines for such transients are astrophysical compact objects such as black holes, neutron stars and stellar explosions. Most of these subjects are tied closely to LANL expertise, some of which are quite unique (e.g., HAWC, Raptor).
Transients connect much of the natural phenomena observable in our universe to similar physical processes in LANL programmatic areas of the high temperature and pressure, often turbulent physical regimes, while being at the forefront of current astrophysical research, and having the capability of attracting the brightest minds to Los Alamos.

1. **Advancing theory and modeling capabilities.** Development that sheds light on understanding Astrophysical Transits will be emphasized. Some examples include:
    a. Center for Theoretical Astrophysics (CTA), such as modeling progenitors, engines and signals of transients, nuclear, particle and plasma physics processes
    b. Simulation codes that are suitable for Exascale Computing platforms to study systems with radiation magnetohydrodynamics, charge particle energization and transport connecting fluid and kinetic regimes
    c. Close collaboration between theory/modeling and observations of astrophysical transients.
    d. Potential applications include neutron stars, pulsar wind nebulae, supernovae, fast radio bursts, gamma-ray bursts, gravitational wave sources, black hole formation,

jets and flares, signatures from exoplanetary systems and protoplanetary disks, etc.

2. **Developing new technologies and tools.** Support activities that will develop new technologies and tools that contribute to new missions and facilities. These new missions and facilities should be strongly connected with Astrophysical Transit sciences. Some examples include:
    a. HAWC data mining; other ground-based gamma-ray experiment development
    b. Optical, X-ray and gamma-ray transient detections (possible NASA missions)
    c. Laboratory plasma experimental innovations investigating astrophysical processes
3. **Supporting upcoming NASA Astrophysical Mission participation**. Work that supports mission participation from either a theoretical or preferably an instrument development angle, for upcoming missions of interest to LANL (e.g., AMEGO, the All-sky Medium Energy Gamma-ray Observatory, TAP - Transient Astrophysics Probe, LOX - Lunar Occultation Explorer, Astrophysical Transient Probe).

In addition, proposals that demonstrate strong collaborations (both internally and externally) as well as branch out to new Astrophysical Transit science areas are particularly encouraged.

Space Science

We particularly encourage proposals that lead to new capabilities for mission participation, new technologies, and/or innovative new uses of unique LANL data, simulation, or modeling capabilities. We recognize that LANL has a long history of research in space sciences that covers many diverse specialties. While that expertise and sustainment of capability is essential to future success, the CSES space science focus for this cycle emphasizes research that supports innovation and creativity leading to new capabilities for missions, new technologies, or new scientific discovery. New space science missions are the 'ultimate prize' because they lead to large, sustained research activities, high profile publications, recruitment and training opportunities, etc. Often, the path to new missions is paved with smaller projects involving the development of new instruments or new measurement capabilities. Those, in turn, often rely on numerical studies that identify the most important open scientific questions and establish the foundational basis for measurements and missions needed to answer such questions.

<u>Specific Topics for new projects starting in FY19:</u>

Overall theme is to conduct cutting-edge research that enables fundamental breakthroughs in our understanding of the space environment through new missions, new technologies, and innovative uses of unique LANL data or numerical modeling resources.

1. **New Missions**. The first priority will be to support LANL's intensifying efforts to participate in new NASA space missions, both for those in the current pipeline (e.g. CONNEX) and for new concepts. Foundational proposals enabling and/or supporting mission concept developments are encouraged.
2. **New Technologie**s. Technology development and demonstration with an emphasis on technologies that can be applied to basic and national security research objectives:
    a. Instrument and measurement concepts
    b. Laboratory demonstrations
    c. Instrument performance studies that enhance our existing sensors
3. **Innovative uses of unique LANL data or numerical modeling resources**. Release of GPS and LANL-Geo data provides new (or renewed) opportunities for collaboration and

recruitment. We particularly encourage studies using limited-access data sets that can have open publications (e.g. GPS lightning data). We encourage new numerical model development or use of current model capabilities for completely different applications – particularly those leading to creative and innovative measurement, instrument, and mission concepts.

Proposals are solicited for theoretical, computational, and/or observational research. It is strongly encouraged that proposals exploit unique resources at Los Alamos National Laboratory which include:

a. LANL satellite experiments
b. LANL satellite data
c. LANL space science computer simulation codes, and algorithms.

Geophysics

The Geophysics focus area supports basic and applied research concerning the Earth's surface and lithosphere. This research includes numerical, experimental, and field studies of the structure, properties, processes, and dynamics of the Earth. It is strongly encouraged that proposals exploit unique resources at Los Alamos National Laboratory which include:

a. Los Alamos National Laboratory high-performance computing resources
b. The Los Alamos Neutron Science Center (LANSCE)
c. Geochemical analyses facilities resident in EES and C divisions
d. Sensor technology capabilities resident in C, EES, ISR, and N divisions

We are particularly interested in innovative and collaborative research projects in areas of current, strong international scientific interest.

<u>Specific Topics for new projects starting in FY19:</u>

Overall theme for the Geophysics Focus Area is research to help our understanding of natural systems that are perturbed by human actions. Studies that integrate theoretical, experimental, modeling and simulation efforts to address the fundamental technical changes in understanding the earth's subsurface are of particular interest. Geoscience topics that play a fundamental role in supporting LANL's core mission include understanding the state of stress in the subsurfaces, the dynamics of rock fracturing and how it affects permeability, and how fluid (gas and liquid) flow through fractured rock. A thorough understanding of these topics is critical for LANL mission in evaluating underground explosions, characterizing oil/gas reservoirs, and developing geothermal resources. The following four subtopics underpin this mission:

1. **Geodynamics**. The state of stress in the crust, earthquake seismology, seismoacoustics, and seismotectonics. Understanding critically stressed faults and their use for mitigating seismic hazard. Development of Quantitative Geomorphology techniques and analysis to understand the dynamic interaction between climate, tectonics, and the character of the Earth's topographic surface. New techniques in remote sensing and digital data analysis that provide information for geologic framework models used in numerical modeling of subsurface processes.

2. **Evaluation of Geomaterials**. Strain localization, dynamics and elasticity of Earth geomaterials. The development of realistic material models for use in numerical simulations (Abaqus). Upscaling of material properties for use in numerical models.
3. **Geomechanics of the Subsurface**. Computational geomechanics; dynamic subsurface processes in porous and fractured media; transient and steady-state behavior in geologic and hydrologic processes, including multi-phase fluid flow in porous and fractured media. Advanced finite-element and fluid-flow modeling.
4. **Low-Magnitude Signals for Subsurface Investigations**. Development of techniques to characterize background signals; HPC and quantum computing approaches for prompt (real-time) evaluation of signals (events/leaks); and development of a machine-learning-based multi-physics method for an accurate characterization of the subsurface.

In these topical areas, proposals that address the following future challenges are particularly encouraged:

- **Big Data.** The volume of data collected has grown exponentially Growing need to interpret data in real time (minutes to hours instead of days to weeks Increased emphasis on decision-making based on evaluation of problem complexity and uncertainty. Use Data Analytics to minimize data paralysis and eliminate interpretation bias.
- **Extracting Relevant Information from a Noisy World.** Typical problems of interest for the Lab/Sponsors are data collected from a large area (100's of km), small signals, lots of noise, keep costs down, and provide feedback in real time. Relevant questions: Are there new signatures we are not using? How to optimize existing signatures? Can the analysis of multi-phenomenological data help solve our problems? Two drivers: "**did** something happen" vs "**is** something happening"?
- **The Earth as a Filter.** Important for building learning sets. All signals and signatures are recorded after passing through a heterogeneous Earth. How can we use upscaling to improve our physics models of geoscience phenomenology?

Earth Systems

The Earth System focus area emphasizes process to predictive level understanding of the coupled atmosphere, ocean, hydrosphere, terrestrial, biogeosphere, and anthroposphere of planet Earth by studies at multiple scales. This focus area examines fundamental climate processes and the impacts of climate change. It also supports projects that improve our understanding of mechanisms from microbe to plant, aerosol to cloud, eddy to global circulation scale, including targeted laboratory and field studies, aimed toward the improvement of models. This focus area promotes understanding of the interactions between natural and human systems and developing capabilities to strengthen security and resilience. Integration of measurements and models to fill outstanding gaps, particularly in sensitive regimes and high impact regions (e.g. Arctic) are encouraged.

It is recommended that proposals exploit unique Los Alamos National Laboratory resources, which include:

a. LANL high performance computing
b. DOE-sponsored process-resolving to global scale models (e.g. HiGrad/Firetec, Amanzi-Advance Terrestrial Simulator, CICE, and E3SM)
c. Experimental data sets (e.g. NGEE Arctic and ARM)
d. Climate monitoring systems (e.g. SUMO, Pinon-Juniper woodland, and CAFÉ)

Specific Topics for new projects starting in FY19:

Overall theme is to conduct cutting-edge research that enables fundamental breakthroughs in our understanding of Earth Systems signatures and impacts and secure and resilient response strategies, through integration of LANL's theoretical, experimental, measurement, and numerical modeling resources.

1. **Signatures.** Transforming technologies and methods for identifying or attributing Earth System change.
    a. Revolutionary sensors and integrated sensor networks.
    b. Innovative analytical methods, including cross disciplinary data fusion, data analytics, and integrative assessment.
2. **Impacts.** Advancing fundamental understanding of Earth Systems interactions and impacts to improve the application of models to energy, water, food, and health security problems.
    a. Extreme or catastrophic events (e.g. drought, fire, epidemics, or storm surge).
    b. Influences on regional stability.
3. **Secure and resilient responses.** Development and demonstration of information and tools for integrated decision support capabilities.
    a. Integration of Earth System models, assessment models, and response models, incorporating uncertainty quantification.
    b. Regional predictions on seasonal to multi-decadal time scales.