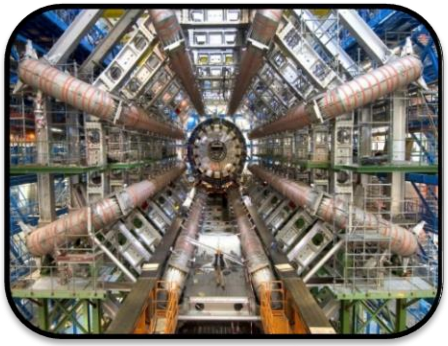
Jan Tyler
Program Manager
Office of Workforce Development for Teachers and Scientists

https://science.osti.gov/wdts
Jan.tyler@science.doe.gov

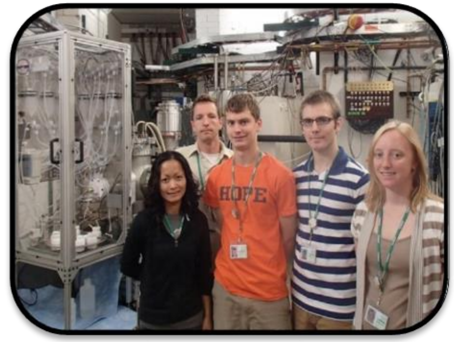
Office of Science (SC) at a Glance

FY 2021 Enacted budget: $7B



Largest Supporter of Physical Sciences in the U.S.

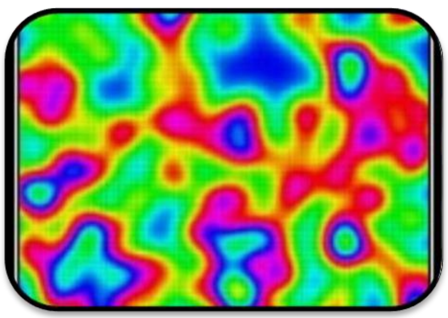
Funding at >300 Institutions including all 17 DOE Labs



Over 22,000 Scientists Supported

Nearly 32,000 Users of 26 SC Scientific Facilities

~40% of Research to Universities



Research: 40%

Facility Operations: 39%,

Projects/Other: 21%,

17 DOE National Laboratories

Office of Science Laboratories

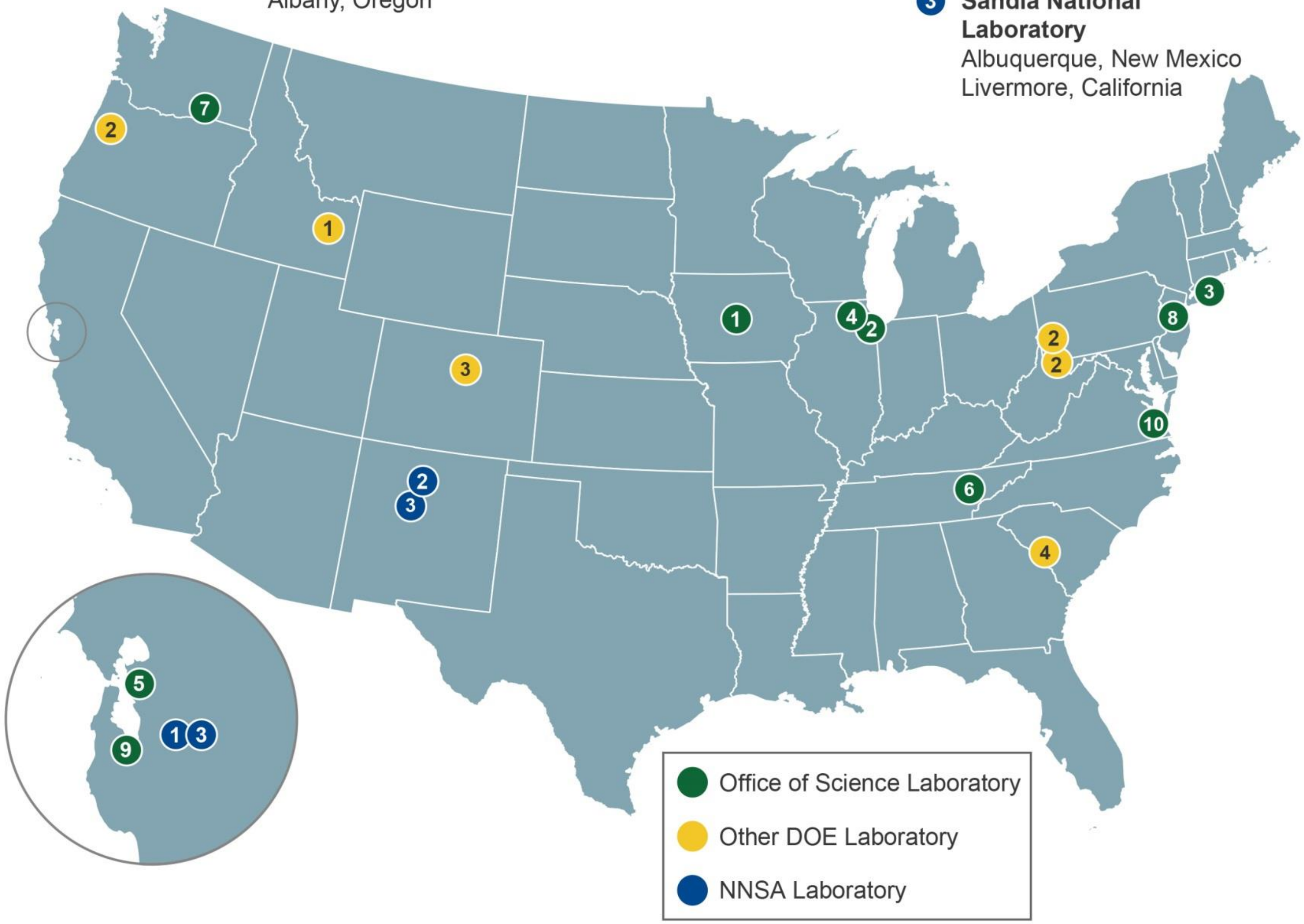
1. **Ames Laboratory**
   Ames, Iowa
2. **Argonne National Laboratory**
   Argonne, Illinois
3. **Brookhaven National Laboratory**
   Upton, New York
4. **Fermi National Accelerator Laboratory**
   Batavia, Illinois
5. **Lawrence Berkeley National Laboratory**
   Berkeley, California
6. **Oak Ridge National Laboratory**
   Oak Ridge, Tennessee
7. **Pacific Northwest National Laboratory**
   Richland, Washington
8. **Princeton Plasma Physics Laboratory**
   Princeton, New Jersey
9. **SLAC National Accelerator Laboratory**
   Menlo Park, California
10. **Thomas Jefferson National Accelerator Facility**
    Newport News, Virginia

Other DOE Laboratories

1. **Idaho National Laboratory**
   Idaho Falls, Idaho
2. **National Energy Technology Laboratory**
   Morgantown, West Virginia
   Pittsburgh, Pennsylvania
   Albany, Oregon
3. **National Renewable Energy Laboratory**
   Golden, Colorado
4. **Savannah River National Laboratory**
   Aiken, South Carolina

NNSA Laboratories

1. **Lawrence Livermore National Laboratory**
   Livermore, California
2. **Los Alamos National Laboratory**
   Los Alamos, New Mexico
3. **Sandia National Laboratory**
   Albuquerque, New Mexico
   Livermore, California



SC's Major Programmatic Responsibilities

Support of Fundamental Research

SC funds programs in physics, chemistry, materials science, biology, environmental science, applied mathematics, and computer computational sciences, and is the Federal steward for several disciplines within these fields such as high energy physics and nuclear physics; fusion sciences; high performance computing science and technology; and accelerator and detector science and technology. SC is also the largest Federal supporter of fundamental research relevant to future solutions for clean energy. Sponsored research at ~300 US institutions.

Support of 21st Century Tools for Science

SC supports the planning, design, construction, and operation of 26 state-of-the-art scientific user facilities considered the most advanced tools of modern science. More than 31,000 investigators perform research at these open-access facilities each year. Large facilities can have costs in excess of $1B and can be in design and construction for a decade. Most of our facilities are at DOE labs, but increasingly we engage in international cooperation as the cost of some facilities becomes well in excess of $1B.

Oversight of 10 DOE Laboratories

SC oversees the operation of 10 DOE national laboratories. SC conducts a formal laboratory strategic planning process annually with its labs to understand future directions, immediate and long-range challenges, and resource needs. SC also conducts an annual evaluation of the scientific, technological, managerial, and operational performance of the M&O contractors of its labs. In addition, SC funds mission-ready infrastructure and investments that foster safe and environmentally responsible operations at the labs.

R&D coordination and integration

SC coordinates its activities with the DOE technology offices, the National Nuclear Security Administration, and of other federal agencies. This occurs through SC and DOE program manager-driven informal working groups and joint activities, Under Secretary-level commissioned working groups, and interagency working groups. Example areas of recent targeted focus are advanced materials, exascale computing, cybersecurity, subsurface technology R&D, and electrical energy storage. Other efforts have included biofuels, solar energy utilization, superconductivity for grid applications, and vehicle technologies.

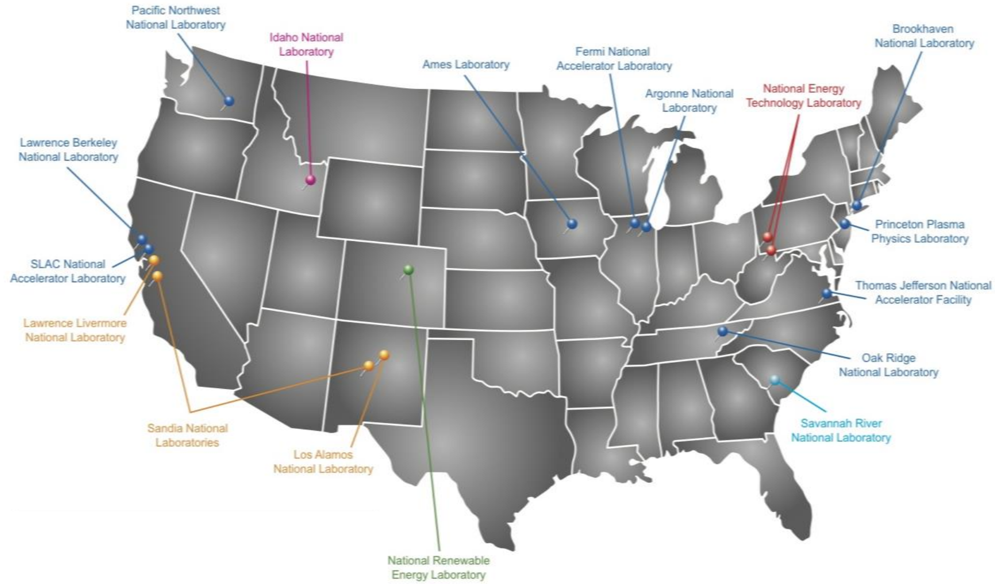
The Office of Science research portfolio

Advanced Scientific Computing Research	• Computational and networking capabilities to extend the frontiers of science and technology
Basic Energy Sciences	• Understanding, predicting, and controlling matter and energy at the electronic, atomic, and molecular levels
Biological and Environmental Research	• Understanding complex biological, climatic, and environmental systems
Fusion Energy Sciences	• Matter at very high temperatures and densities and the scientific foundations for fusion
High Energy Physics	• Understanding how the universe works at its most fundamental level
Nuclear Physics	• Discovering, exploring, and understanding all forms of nuclear matter

STEM Workforce Training Opportunities at DOE National Laboratories

WDTS manages the following programs via partnership with DOE national laboratories (>70% budget):

- **Science Undergraduate Laboratory Internships - SULI**
- **Community College Internships - CCI**
- **Visiting Faculty Program - VFP**
- **Office of Science Graduate Student Research Program - SCGSR**



The DOE system of National Laboratories is a unique asset for training and workforce development:

- DOE Labs employ >30,000 scientists and engineers (~14,000 at SC Labs)
- World-class scientific user facilities, capabilities, and resources
- Culture of team science, mentoring, and learning through discovery

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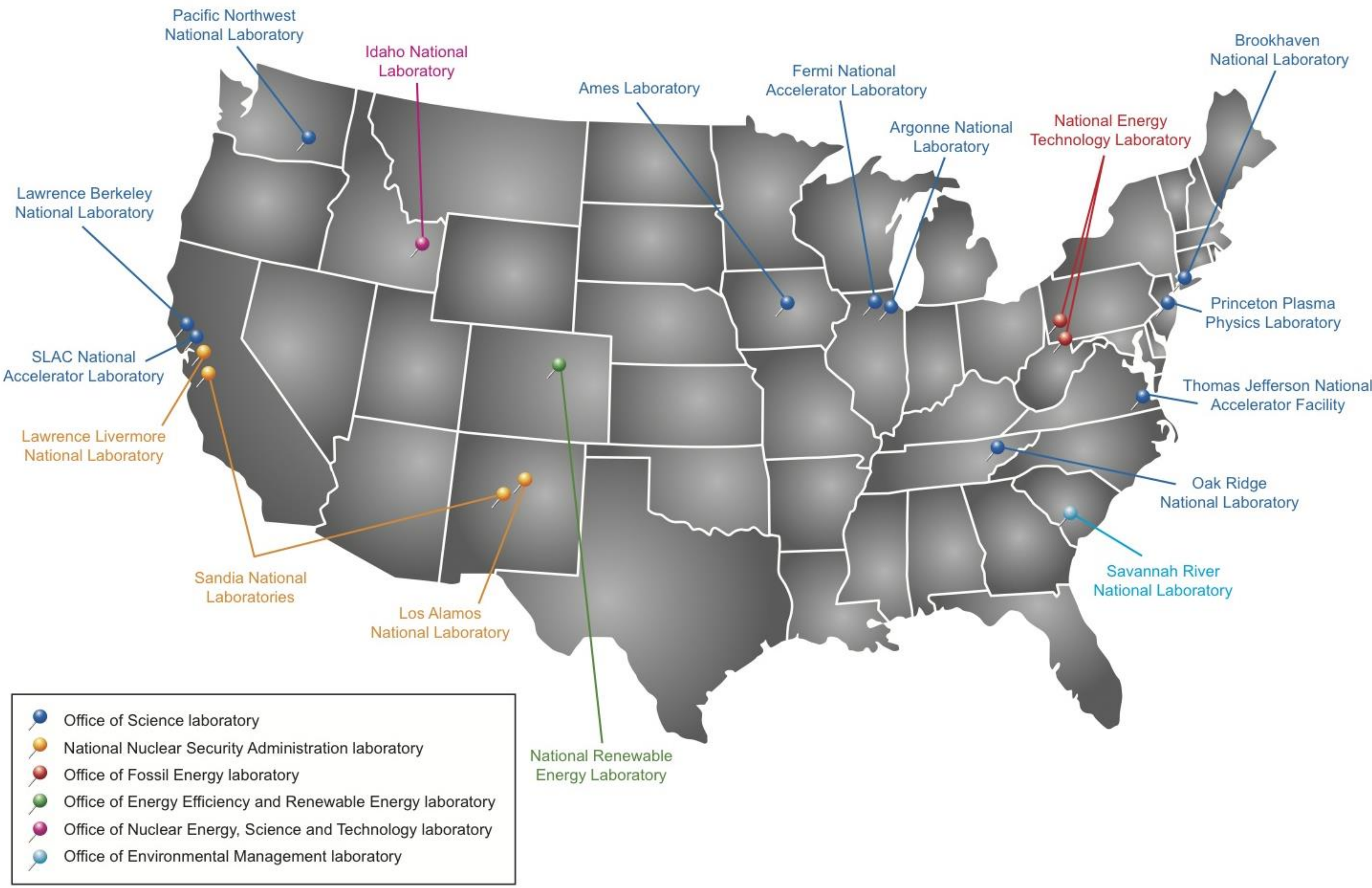
Find details at https://science.osti.gov/wdts

DOE Labs Employ >30,000 Scientists and Engineers (~14,000 at SC Labs)

The DOE system of labs is a unique asset for training and workforce development



Workforce Development for Teachers and Scientists (WDTS)

Goal: To help develop the next generation of scientists and engineers to support Department missions, administer its programs, and conduct the research that will help realize the Nation's science and innovation agenda.

WDTS programs:

- Student and faculty programs at the DOE laboratories - approximately 70% of the budget - placing more than 1,100 participants annually:
  - **Science Undergraduate Laboratory Internship - SULI**
  - **Community College Internship - CCI**
  - **Visiting Faculty Program - VFP**
  - **Office of Science Graduate Student Research Program - SCGSR**
- The **National Science Bowl®** (NSB) is managed by WDTS, also sponsoring NSB's finals competition – NSB
- The **Albert Einstein Distinguished Educator Fellowship** program for K–12 STEM teachers, administered by WDTS for DOE, and other participating federal agencies (established under P.L. 103-382) – AEF

https://science.osti.gov/wdts

Albert Einstein Distinguished Educator Fellowship (AEF)

AEF brings K-12 teachers to DC for 11 months to support Federal agencies and Congressional offices to:

- Learn roles of Federal agencies and Congress in STEM education and take experience, new networks, and knowledge of Federal programs back to their districts
- Gain significant knowledge and understanding in areas of national issues, policy, legislation, grant-making, and STEM programs and resources
- Participate in discussions hosted by leading authorities on STEM
- Develop substantial skills as educators and leaders
- Make bonds and professional contacts with their cohorts, offices, and agencies, AEF Alumni, and a broad range of professionals from other organizations

2020-2021 Fellows

Top Row: Suzanne Otto (DOD)

Second Row: Rachael Arens (NASA), David Locket (NASA), Kathleen Lanman, Rachel Benzoni

Third Row: Jennifer Stimpson, Machin Norris (Smithsonian), Kama Almasi (USGS), Michael Vargas (DOD), Laura Larkin (DOD)

Bottom Row: Kelly Day (DOE), Chanda Jefferson, Michael Guarraia (NASA), Peter DeCraene (Library of Congress), Shakiyya Bland

DOE National Science Bowl®

- **The U.S. Department of Energy (DOE) National Science Bowl®** encourages middle and high school students to **expand their knowledge of math and science, expose students to careers relevant to DOE's mission, and raise the visibility of academic achievement in the sciences** through a nationally prestigious academic event.

- The Department of Energy (DOE) created the National Science Bowl in 1991 to encourage students to excel in mathematics and science and to pursue careers in these fields. More than 325,000 students have participated in the National Science Bowl® throughout its 31-year history, and it is one of the nation's largest science competitions.

- Middle and high school student teams from diverse backgrounds face off in a fast-paced question-and-answer format on a range of science disciplines including biology, chemistry, Earth science, physics, energy (DOE-lab research and facilities), and math.

2021 National Champion for High Schools
North Hollywood High School, North Hollywood, CA

2021 National Champion for Middle Schools
Jonas Clarke Middle School, Lexington, MA

Community College Internships (CCI)

(~**175** CCI interns)

The CCI program seeks to support community college students who are interested in pursuing technical careers or furthering their educational aspirations relevant to the DOE mission by providing technical training experiences at the DOE laboratories. Selected students participate as interns appointed at one of 16 participating DOE laboratories.

- CCI interns work on science and engineering technical projects with laboratory scientists, engineers, or technical staff who serve as mentors.
- Student deliverables include a research report, an oral or poster presentation, and pre- and post-participation surveys.
- 10 weeks during the Summer term (May-August), and some labs offer flexible Fall and Spring schedules in which 400 work hours may be distributed over 16 weeks.

Award Benefits:

- Paid internships ($600 weekly stipend, dedicated funding for travel and lodging).
- Labs provide training seminars and professional development opportunities.

Eligibility:

- U.S. citizen or legal permanent resident
- At least 18 years old at time of application
- Minimum cumulative GPA 3.0
- May participate in CCI twice; may apply up to three times

2021 Fall Application Due May 27, 2021; 2022 Spring Term Application Started July 15, 2021
2022 Summer Term – Application to Start October 19, 2021

Full details, requirements, FAQs, and link to application at: https://science.osti.gov/wdts/CCI/

Program Contact : sc.cci@science.doe.gov

Science Undergraduate Laboratory Internships (SULI)

(~1100 SULI interns)

The SULI program encourages undergraduate students and recent graduates to pursue science, technology, engineering, and mathematics (STEM) careers by providing research experiences at the Department of Energy (DOE) laboratories.

- SULI participants work on science and engineering research projects with laboratory scientists and engineers who serve as mentors.
- Student deliverables include a research report, an oral or poster presentation, a peer review, a general audience abstract, and pre- and post-participation surveys.
- 10 weeks during the Summer term (May-August); 16 weeks during the Fall (August-December) or Spring (January-May) terms

Award Benefits:

- Paid internships ($600 weekly stipend, dedicated funding for travel and lodging).
- Labs provide training seminars and professional development opportunities.

Eligibility:

- U.S. citizen or legal permanent resident
- Undergraduates from 2- or 4-year colleges, freshmen through senior year or recent graduates
- At least 18 years old at time of application
- Minimum cumulative GPA 3.0
- May participate in SULI twice; may apply up to three times

2021 Fall Application Due May 27, 2021; 2022 Spring Term Application Started July 15, 2021
2022 Summer Term – Application to Start October 19, 2021

Full details, requirements, FAQs, and link to application at: https://science.osti.gov/wdts/SULI/

Program Contact : sc.suli@science.doe.gov

Jefferson Lab 2019 Undergraduate Students

https://youtu.be/wsnk-yk4OQE

Implementation of Monte Carlo Algorithms for Error Quantification of Parton Distribution Functions

C. Aldridge[1], W. Melnitchouk[2], N. Sato[2]

Abstract

Monte Carlo algorithms are a class of computational tools which use statistical analysis and random sampling to return the most likely result for a given scenario along with uncertainty. The project used a variety of these algorithms to best calculate parameters for parton distribution functions (PDFs). PDFs are universal functions which characterize the internal quark and gluon structure of a hadron. While there are many variations of Monte Carlo algorithms, the two used in this project were the Markov-Chain Monte Carlo algorithm (MCMC) and the Hamiltonian Monte Carlo algorithm (HMC). MCMC focuses on Bayesian inferences and posterior and prior functions, while HMC focuses on the Hamiltonian of the selected system and uses that as the framework to build an analysis. The project's main goal was to implement the HMC and MCMC algorithms in tandem with the Data Resampling and Hessian algorithms, to ensure the best fit with the prescribed PDFs. The main body of the project focused on fitting the two Monte Carlo algorithms to an initial "toy data" set. Then the Monte Carlo algorithms were compared and analyzed against the Data Resampling and Hessian algorithms to ensure the outputs had no dependency on the algorithm of choice. The project found that algorithms were able to produce values for the parameters of the PDFs to an equal caliber. The implementation of these algorithms in future scenarios will allow the error of a PDF to be smaller than previously calculated. Since PDFs are universal functions, the PDF will remain the same, no matter the scattering interaction of the hadron. This finding will help further the description of the quark and gluon structure of matter with greater confidence and improve calculations which rely on PDFs.

Methods

The main goal of this project was to compare algorithms and their ability to determine the parameters of PDFs. This goal was accomplished through the implementation of the HMC and MCMC algorithms along with the Data Resampling and Hessian algorithms, which were already in use.

To start, we began with toy PDFs, with known parameters, and the algorithms were installed, and the PDFs were run through it. The two PDFs used in the project (shown below) were simplified models of the up and down quarks.

$$PDF_u = x^a(1-x)^b$$

$$PDF_d = 0.1x^c(1-x)^d$$

The libraries used for the MCMC algorithm was *emcee*, and the library used for the HMC was *pyhmc*. After implementing these algorithms into our Toy Example, they were compared to the Data Resampling and Hessian algorithms through a variety of graphing and analytical processes.

[1]Washington and Lee University, Lexington, VA 24450
[2]Thomas Jefferson National Accelerator Facility, Newport News, VA 23606

Results

Figure 1

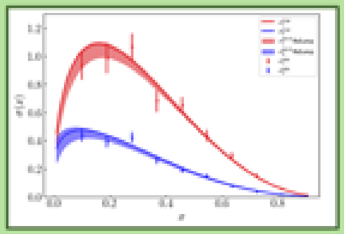
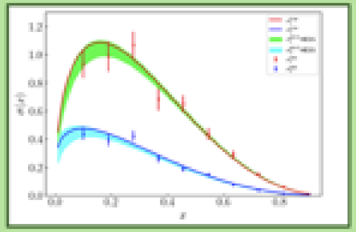


Figure 2



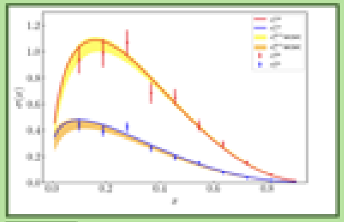


Figure 3

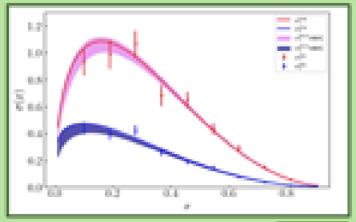


Figure 4

Figures 1-4 are graphs of the Data Resampling, Hessian, MCMC, and HMC algorithms respectively, showing the parton momentum fraction (x) verses cross section (sigma)). Each graph shows the "True" curves in a solid red or blue, with the algorithms' outputs shown in a colored band. As one can see each algorithm fits the "toy data" within one standard deviation.

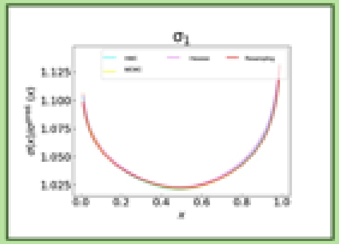


Figure 5

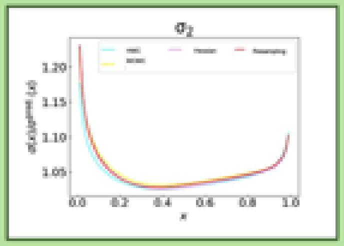


Figure 6

Figures 5 and 6 are comprehensive graphs showing all results completed during this project. Figure 5 shows the comparison of the algorithms for the sigma 1, or the proton, while Figure 6 shows the same comparison except for sigma 2, the neutron. As one can see, all the algorithms follow similar distributions and are all within one standard deviation.

Conclusion

Throughout this project, we were able to implement two types of Monte Carlo algorithms and compare them with the traditional Hessian and Data Resampling algorithms. We were able to create one code which ran all four algorithms simultaneously and produced valuable graphs which made the comparison between the algorithms quite easy. While the project is ongoing, we were able to create a strong foundation on which future research can be conducted. With this strong foundation one can continue work into the errors of PDFs. Since PDFs are universal functions, they are one of the keys into understanding how partons (quarks and gluons) interact with each other and themselves.

Acknowledgements

I would like to thank the many people who helped with this project. First and foremost, my amazing mentors, Wally Melnitchouk, and Nobou Sato; without their guidance this project would never have left the ground. Secondly my partner W. Henry Mills, who was the best fellow intern I could have worked with. I would also like to thank Dr. Gail Dodge and Dr. Xiaochao Zhen, who provided me with much needed background research. Finally, I would like to thank the Science Education Team at Jefferson Labs, specifically Jalyn Dio, Steve Gagnon, and Lisa Surles-Law, without whose guidance, I would have been a very lost intern.

This project was made possible by the following grant from the National Science Foundation: 1950141.

Contact

Email: aldridgec23@mail.wlu.edu

Jefferson Lab: Local & State Educational Outreach

K-12 programs annually serve >12,000 students and >940 teachers

BEAMS - Becoming Enthusiastic About Math and Science

- 5th and 6th grade students spend 2-4 days at Jefferson Lab
  1,200 inner-city students, 60 teachers

Community Outreach Programs

- Physics Fest (two-hour activity at JLab)
  5,000 students, 175 teachers
- SPARK: (Summer Program for Arts, Recreation and Knowledge)
  staff interact with ~125 students each year
- High School Student Honors Program
- Other school visits and workshops
  5,000 students, 600 teachers

Web-based Activities

- Frostbite Theater
- Jefferson Lab's YouTube Channel has >230,000 subscribers
- Puzzles and games used as study and exploration guides

Jefferson Lab: Teachers' Workforce Development

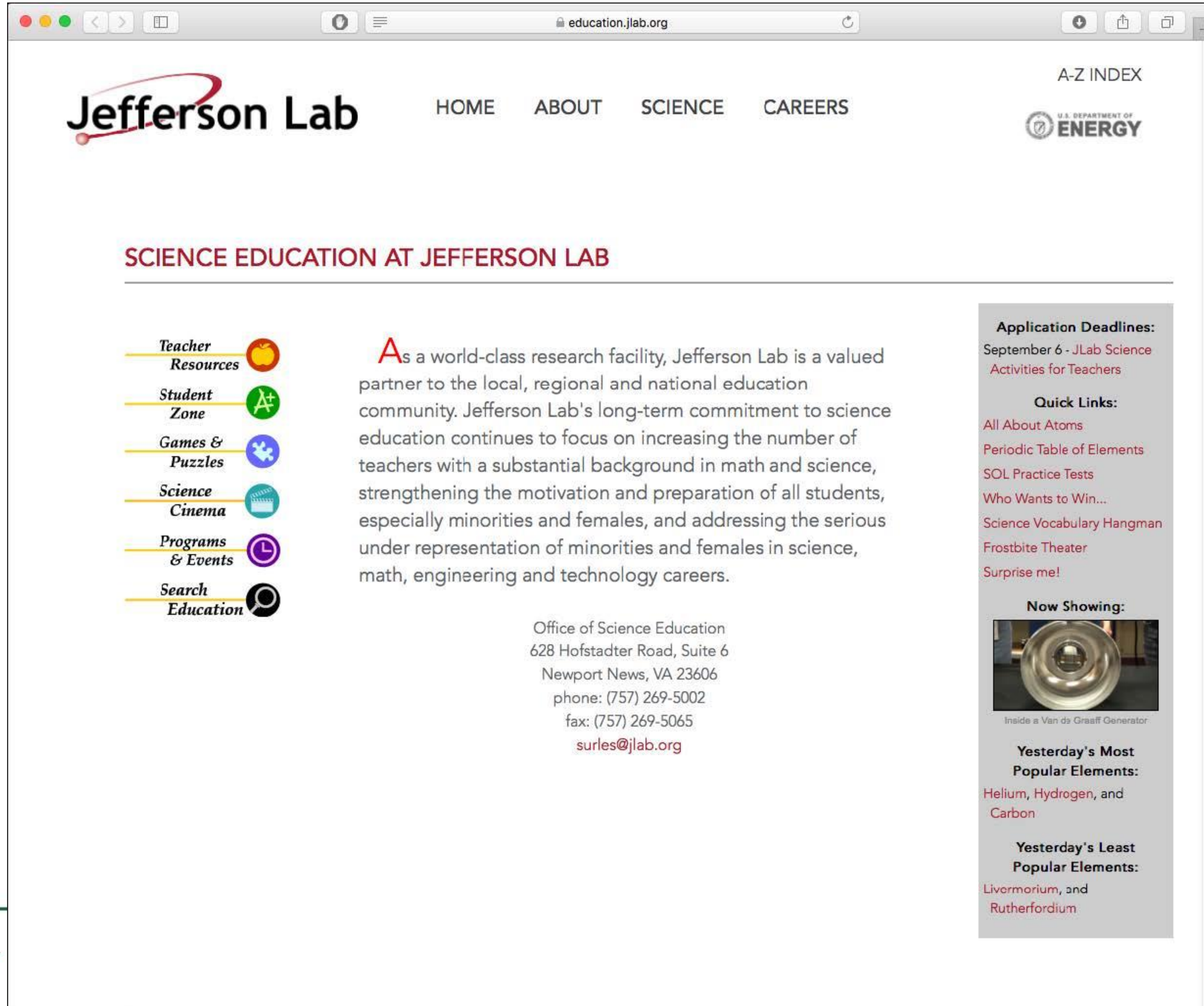
JSA Teacher Development Initiative: JSAT (JLab Science Activities for Teachers)

- Through the JSA Initiatives Fund proposal, started in 2006 with 20 teachers
- Sixty teachers learn content and applications at JLab throughout the school year (18 two-hour sessions) => positively impacts ~6,000 students every year
- JSAT places JLab as the community's leader in providing needed professional development for local teachers

- JLab continues to build on the core JSAT program by:
  - Having JLab education staff spend several hours co-teaching with and supporting each JSAT teacher in his or her classroom
  - Offering former participants opportunities to actively participate in events, such as the JLab Open House, JSA Teacher Night, and VIP visits
  - Encouraging teachers who have completed at least one year of JSAT to participate in the BEAMS (Becoming Enthusiastic About Math and Science) program
- Hosts the Annual JSA Teacher Night in April
- Numerous teachers from the Hampton Roads community have been recognized by local schools and National Education Foundation for excellence in teaching

Jefferson Lab: Science Education Website

Over <u>3.5 billion</u> page views since inception; currently about 200 million each year



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STEM Pipeline: Today’s students are tomorrow’s STEM Workforce

Through these combined outreach efforts, Jefferson Lab intentionally creates pathways for students to return to the lab and contribute to our scientific mission as:

- **Undergraduate students**
- **Graduate students**
- **Post-doctoral students**
- **STEM career professionals**