

# Introduction and Monte Carlo Transport Project Software Engineering Practices

University of Michigan Software Engineering Class Lecture

Patrick S. Brantley



# Patrick Brantley

- University of Tennessee B.S. in Nuclear Engineering
- University of Michigan NERS Ph.D. in Nuclear Engineering and Scientific Computing
  - Worked with Prof. Ed Larsen on “Spatial and Angular Moment Analysis of Continuous and Discretized Particle Transport Problems”
- Started working at LLNL in 1998
  - I’ve been doing Computational Transport/Physics at LLNL for almost 27 years, and I still love it!
- American Nuclear Society Mathematics and Computation Division
  - Chair 2016 – 2017
  - Technical Program Chair 2010 – 2012



# I currently lead the Monte Carlo Transport Project



## ■ Software Engineering:

- Approx. 370k lines of C++ code with embedded Python interpreter
- Parallelism: MPI, OpenMP, Cuda, HIP
- Git version control, repositories hosted on GitLab, branch development with merge request reviews, pre-merge testing, automated nightly testing on multiple platforms with multiple configurations including use of sanitizer tools
- Requirements gathering via ongoing customer interactions and annual program planning
- Regular production releases and nightly development releases



## ■ Staffing: 6 nuclear engineers/computational physicists and 5 computer scientists

- LLNL software projects are typically multidisciplinary with computer scientists as an integral component
- Computer scientists contribute to novel algorithm development including for GPU supercomputers, advance software engineering practices for multiple computing platforms, understand and improve code parallel scaling and performance, support code releases and process, etc.
- Some computer scientists also contribute significantly to physics development
  - Multiple CS staff have obtained Ph.D. degrees
- More broadly at LLNL computer scientists are involved in AI/ML, computational math & science, HPC systems and software, cybersecurity, etc.
- Most recent project hire is a Michigan Nuclear Engineering Ph.D. graduate

# LLNL hires staff and interns in Engineering, Computer Science, Physics, etc.

- LLNL is a recipient of the Glassdoor 2022 Best Places to Work award
- General LLNL jobs site:
  - <https://www.llnl.gov/join-our-team/careers>
- LLNL has various student internship programs
  - Defense Science & Technology Summer Student Internship applications due in January each year
  - <https://sd.llnl.gov/careers/students>

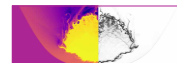


## Defense Science & Technology 2025 Summer Student Internships

We have opportunities for student interns to conduct research in fields such as nuclear physics, radiation transport, hydrodynamics, astrophysics, plasma dynamics, numerical methods, and computer science supporting national security for the Strategic Defense Directorate.

Research projects combine theory with computation and are geared to further the student's educational goals. During the summer, students work directly with laboratory mentors in their fields of research. Internship opportunities are available for highly qualified candidates of all levels of undergraduate or graduate education. Internships are for 8 months, during the summer. Students must arrive in May or June, work for three months and depart in August or September.

**Lawrence Livermore National Laboratory**  
LLNL (www.llnl.gov) applies science and technology to important problems related to national security including nuclear weapons (stockpile stewardship, nonproliferation, and homeland security). In support of the mission, the Laboratory has a history of and continues to pioneer technical innovations in many areas including high-energy-density physics, high-performance scientific computing, and inertial confinement fusion. LLNL is one of the country's largest and finest research and engineering laboratories, and is located in beautiful Northern California.



### Student Project

When the nose shock of a hypersonic aircraft strikes a windship, it deposits baroclinic vorticity on the surface, leading to fast dynamic instabilities, which subsequently break up the droplet. When the droplet hits the nose of the aircraft, it can damage the vehicle's thermal protection system. The above image shows the trade of a droplet shortly after passing through a Mach 30 shock. PhD student Calvin Young of Texas A&M University in collaboration with Andy Cook of LLNL, is investigating the response of atmospheric droplets to shocks of various Mach numbers.

### Application Deadline: Jan. 20, 2025



<https://sd.llnl.gov/careers/students>  
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