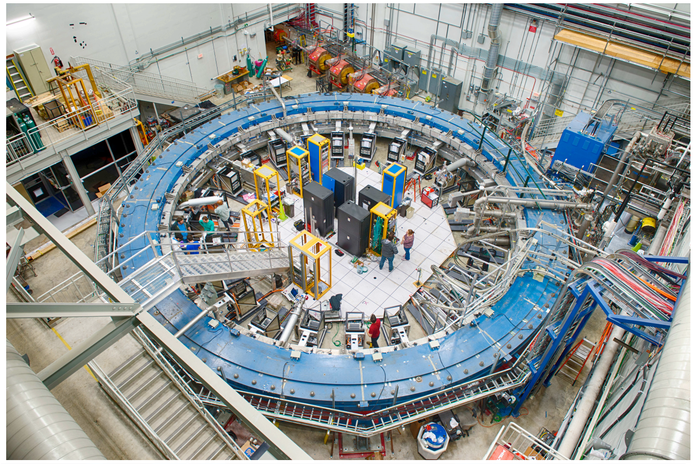
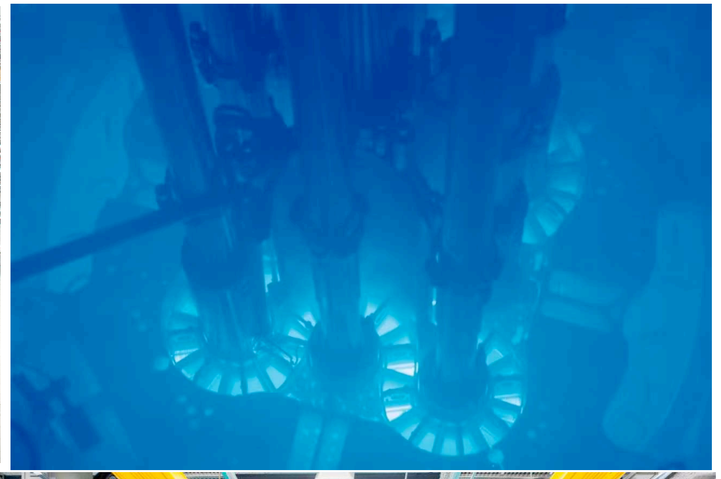
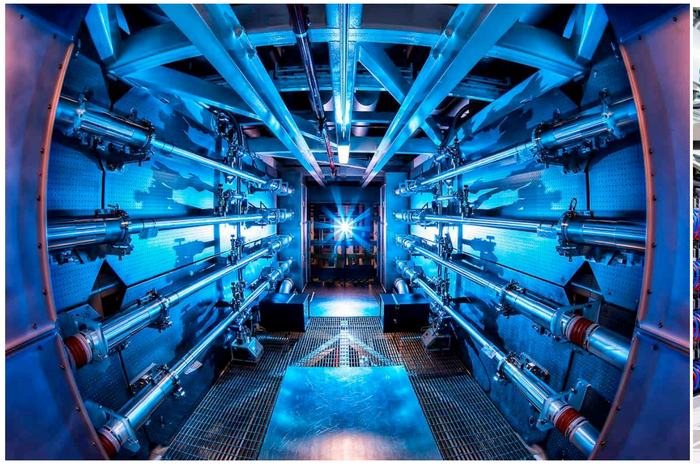
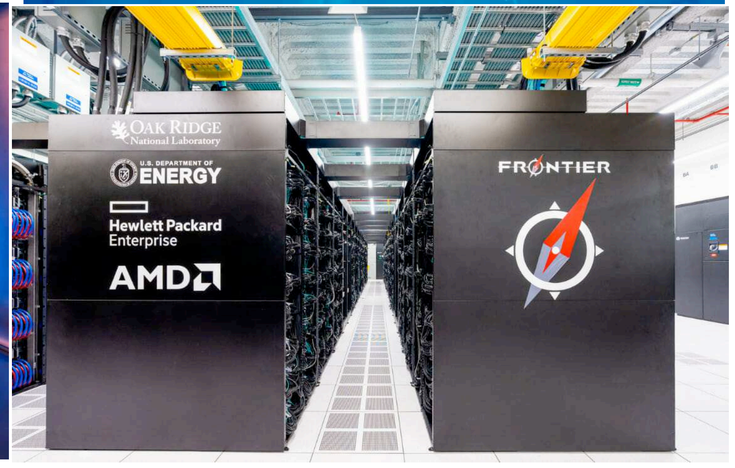
Navigating Career Opportunities at the DOE National Laboratories

U.S. DEPARTMENT OF ENERGY









Steven Gardiner

FSPA Early Career Seminar

4 May 2023

Outline

- Overview of the DOE national laboratories
- Case study: my career trajectory so far
- University vs. National Lab vs. Industry research positions
- Some practical thoughts/advice as you navigate your own journey
- **Want to work for Fermilab? My group is hiring a postdoc!**

National laboratories overview

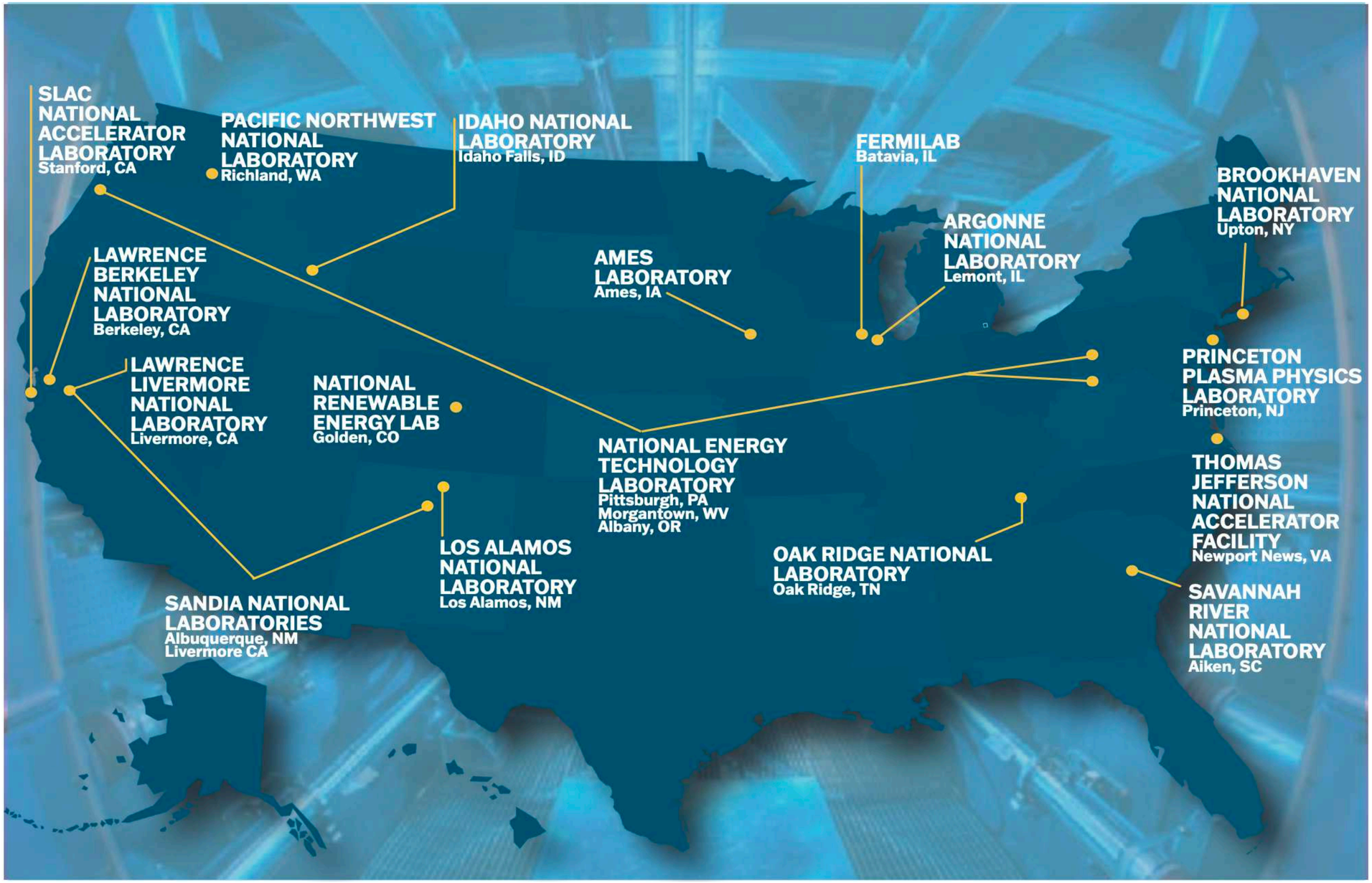
- Four basic missions of the US Department of Energy:
  - Clean energy innovation
  - **Scientific leadership & discovery**
  - Nuclear security
  - Environmental stewardship of the nuclear weapons complex

- Nationwide system of 17 DOE laboratories
  - Federally-funded Research and Development Centers (FFRDCs)
  - All but NETL are government owned, contractor operated
  - Example: I am employed by Fermi Research Alliance, which operates Fermilab on behalf of DOE

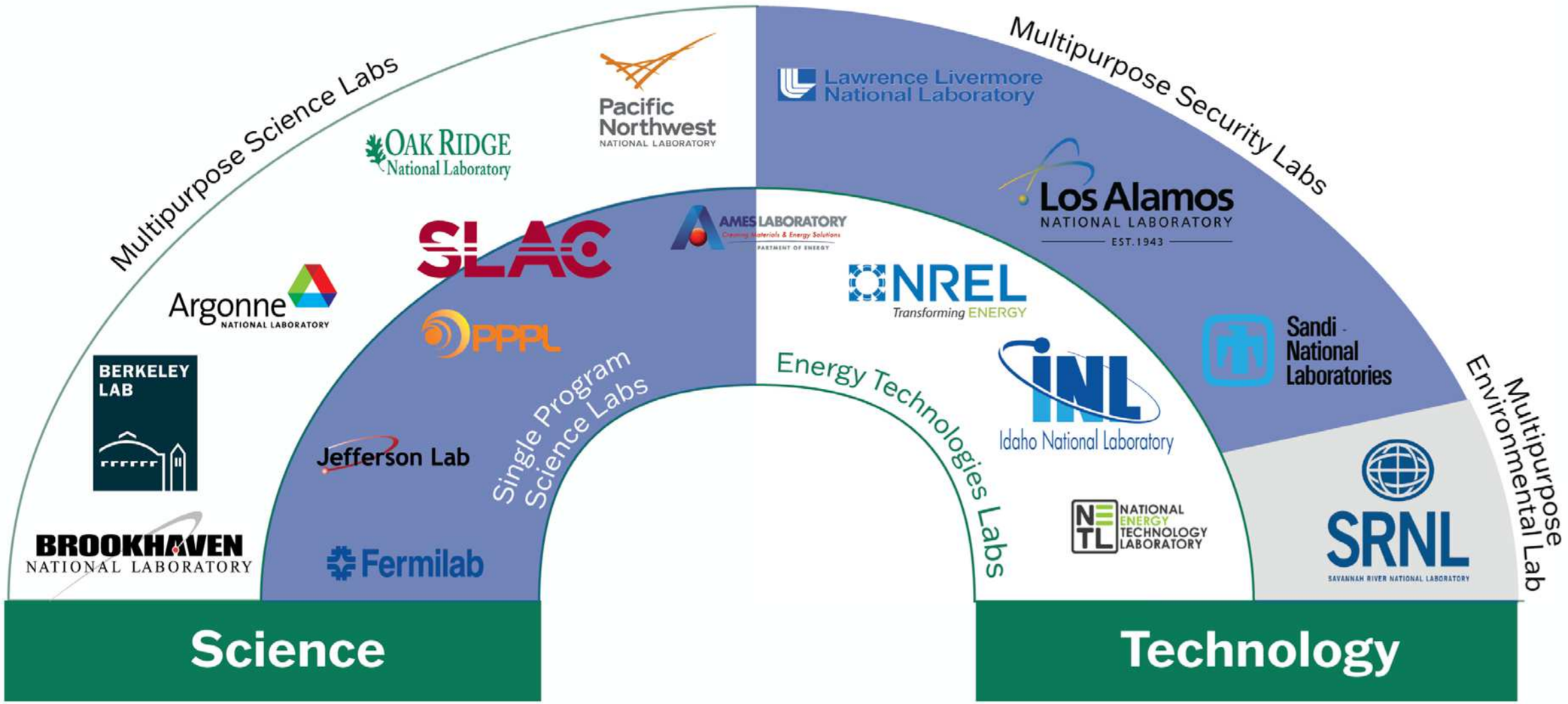
Slide adapted from https://www.youtube.com/watch?v=RyUbU-r_Wt8

Map of the DOE national laboratory system

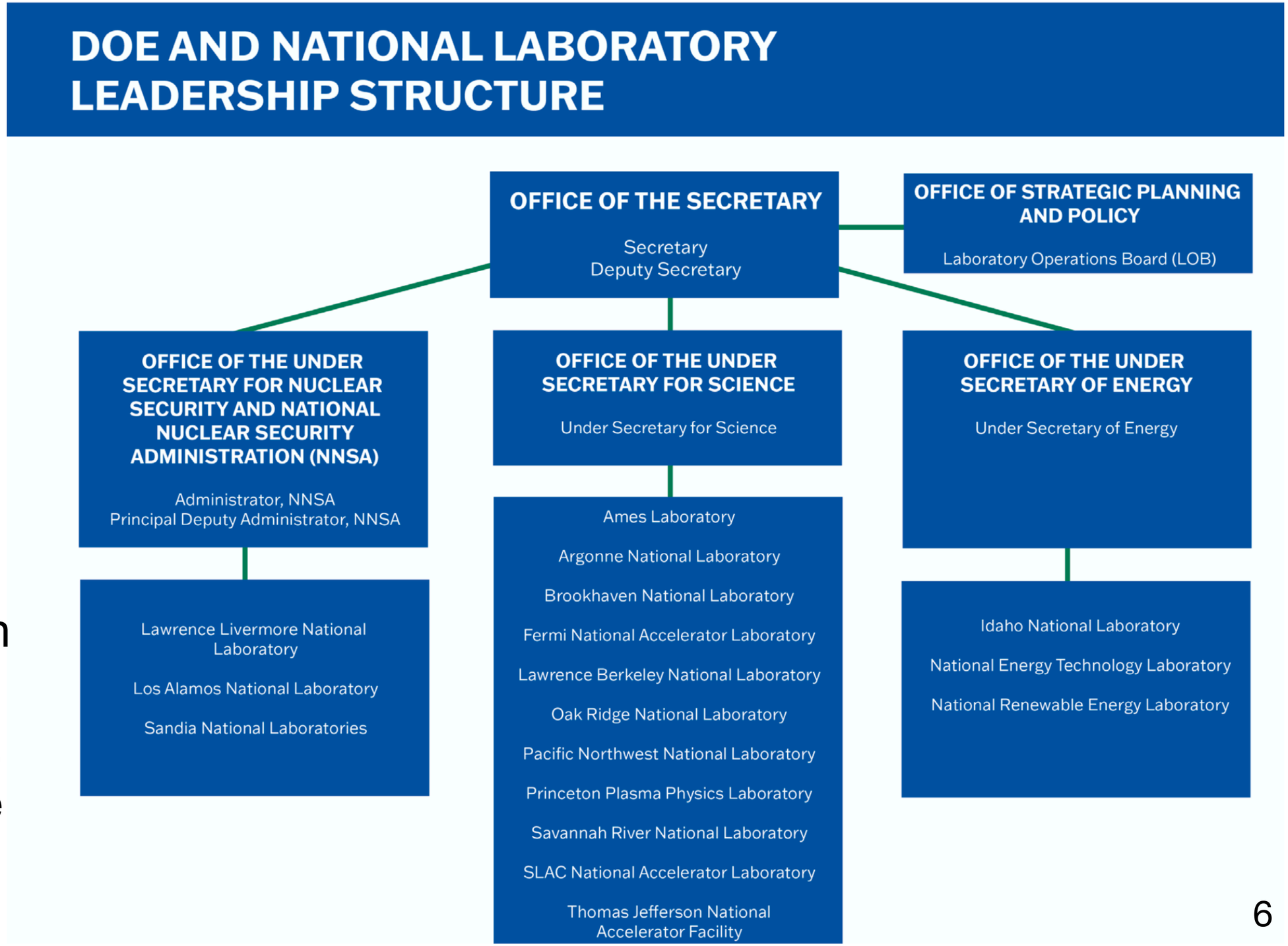
- More near the coasts, Chicagoland has two
- Two labs have multiple campuses (Sandia, NETL)



DOE EXECUTES ITS MISSIONS THROUGH DIVERSE NATIONAL LABS



- Fermilab is overseen by the DOE Office of Science
- Some fundamental physics research happens at the NNSA labs (e.g., neutrino science at Los Alamos)

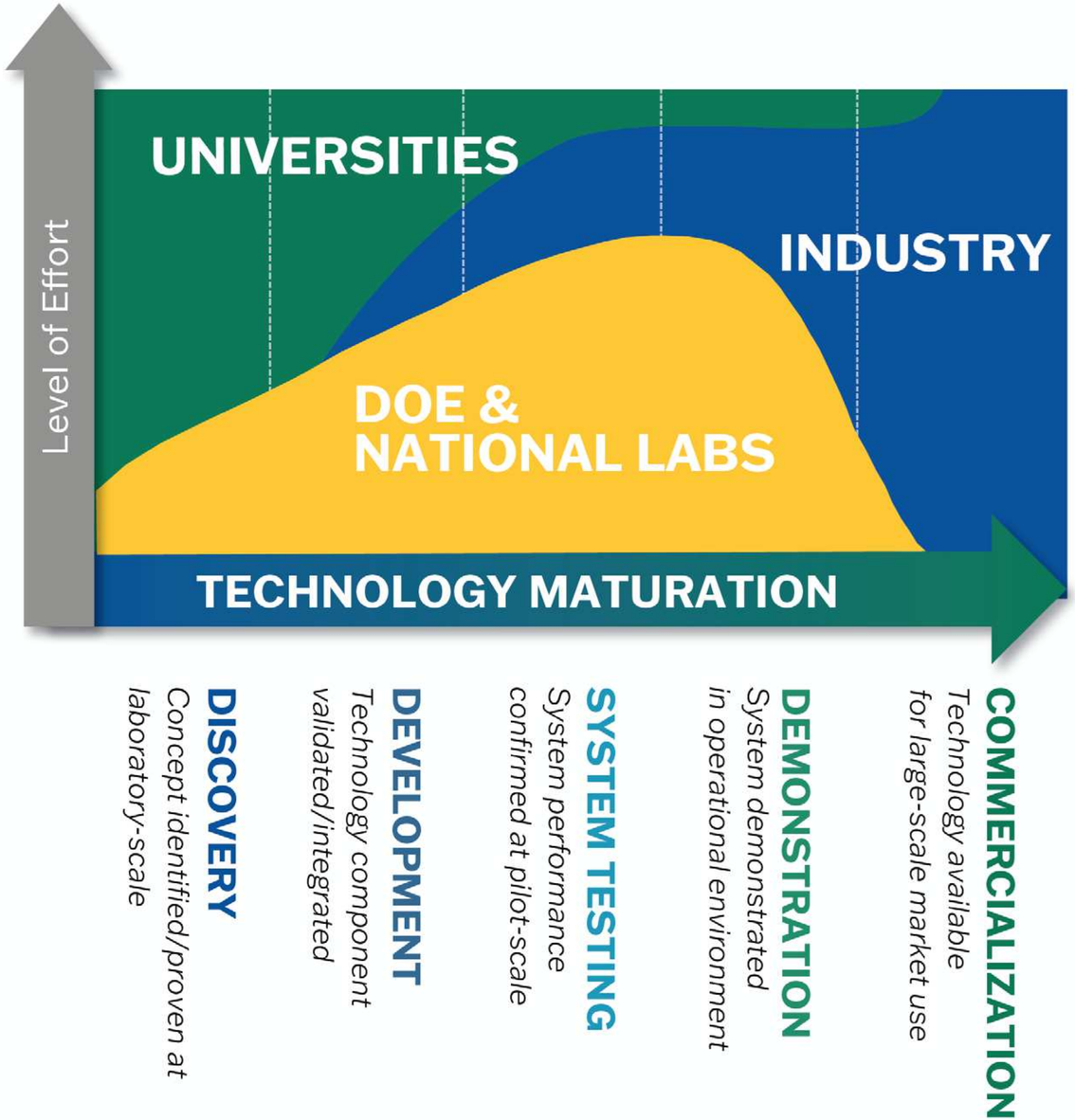


DOE NATIONAL LABORATORIES' RELATIONSHIP TO UNIVERSITIES & INDUSTRY IN THE INNOVATION SYSTEM

- National laboratories are an important part of the US technology development ecosystem

- Diagrams from this part of the talk taken from 2020 DOE labs report:

  https://www.energy.gov/articles/state-doe-national-laboratories-2020-edition



My journey to a staff position at Fermilab

- Bachelors degree in physics at Brigham Young University, 2012
  - Designing new neutron detectors for security applications
  - Very applied research, felt like nuclear engineering
- Postbaccalaureate researcher at Los Alamos, 2012-2013
  - Initially through DOE SULI internship program
  - Producing and testing neutron cross-section data tables for simulations
- PhD in physics at University of California, Davis, 2018
  - Simulations of supernova neutrino interactions
  - Neutron background measurement for the ANNIE experiment at Fermilab
- Fermilab postdoc, 2018-2022
  - Simulation and analysis work for the MicroBooNE experiment
- Promoted to staff in 2022, currently Group Leader in the Physics Simulation Department

Post Helium-3 Neutron Detection at BYU

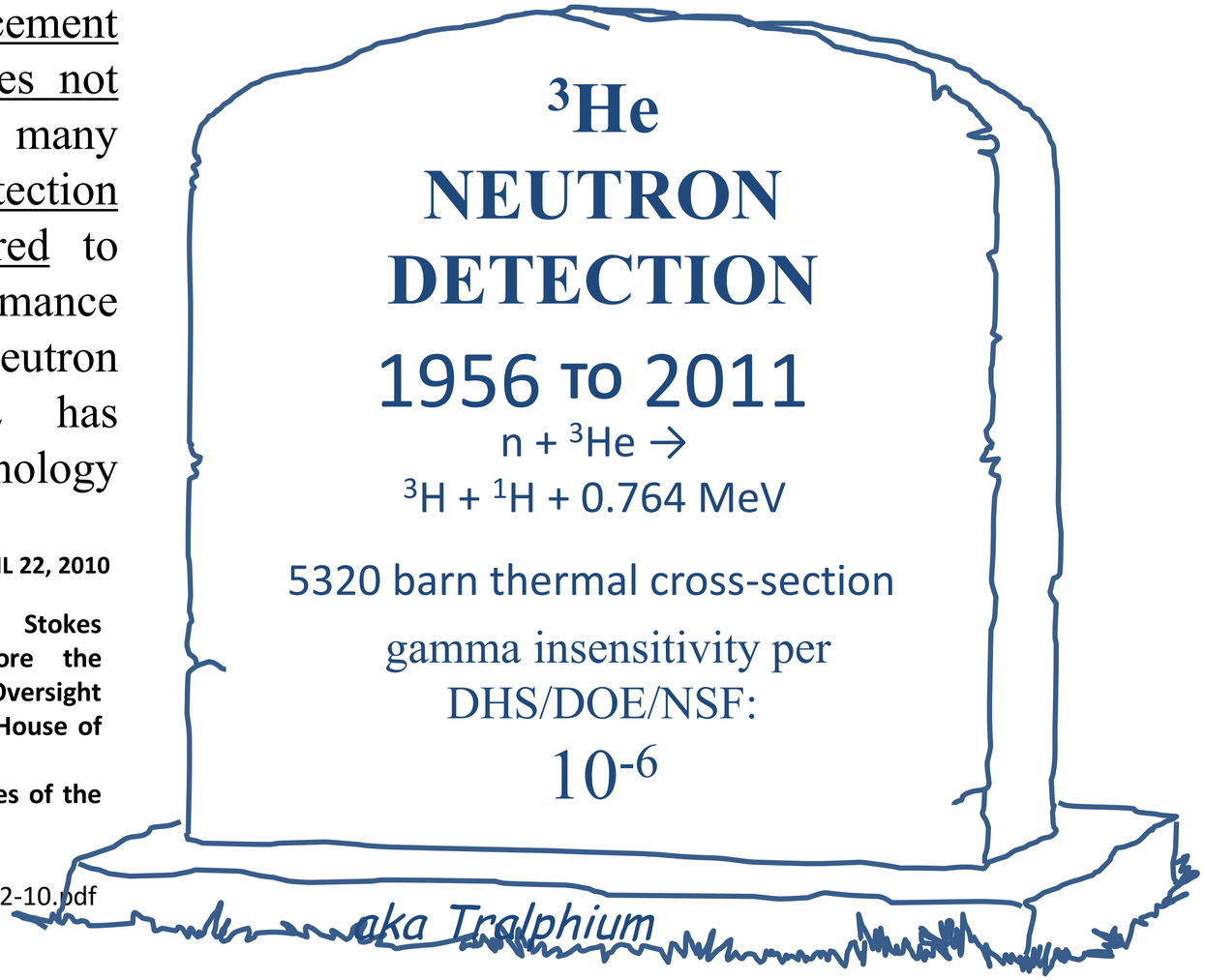
John E. Ellsworth

Inventions of J. Bart Czirr and Lawrence Rees

"… a drop-in replacement technology for Helium-3 does not exist today. Furthermore, as many as six different neutron detection technologies may be required to best address the performance requirements of the neutron detection applications GE has served historically with technology using Helium-3."

THOMAS R. ANDERSON, APRIL 22, 2010

Product Line Leader, GE Energy, Reuter Stokes Radiation Measurement Solutions Before the Subcommittee on Investigations and Oversight Committee on Science and Technology, U.S. House of Representatives Hearing on
"Caught by Surprise: Causes and Consequences of the Helium-3 Supply Crisis"
http://www.parttec.com/Helium-3_Congress_Hearing_Anderson_Testimony_4-22-10.pdf



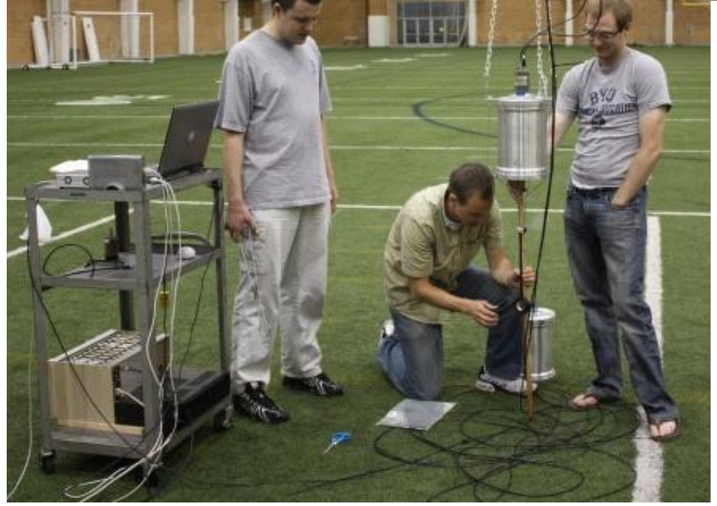
some tools

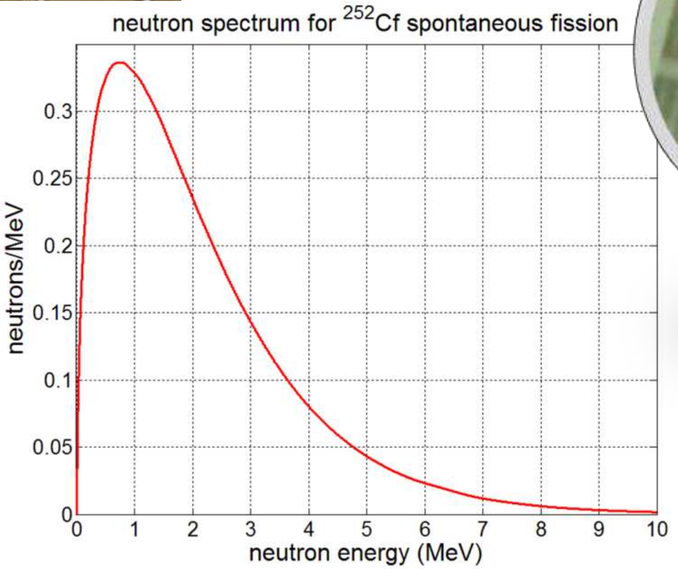
low room return testing, BYU Indoor Practice Field (IPF)

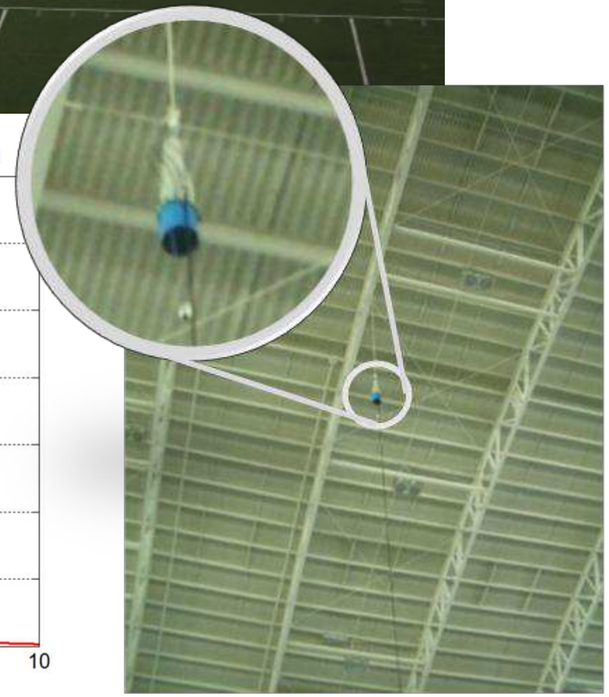
Graduated in August 2012, took a year off

Had learned MCNP simulation code, good fit for LANL Nuclear Data Team

- Detector suspended in the air 45 feet from all structural materials (concrete, ground, steel, etc)







nuclear@byu.edu

Nuclear Data Team: maintain cross-section tables needed to simulate neutron transport (reactors, detectors, weapons ...)

Group XCP-5

NNSA lab: tanks!

Release of ENDF/B-VII.1-based Continuous-Energy Neutron Cross-Section Data Tables for MCNP

Jeremy Lloyd Conlin Steven J. Gardiner D. Kent Parsons A. C. Kahler
M. Beth Lee Morgan C. White

Los Alamos National Laboratory
PO Box 1663, Los Alamos NM 87544

June 4, 2013

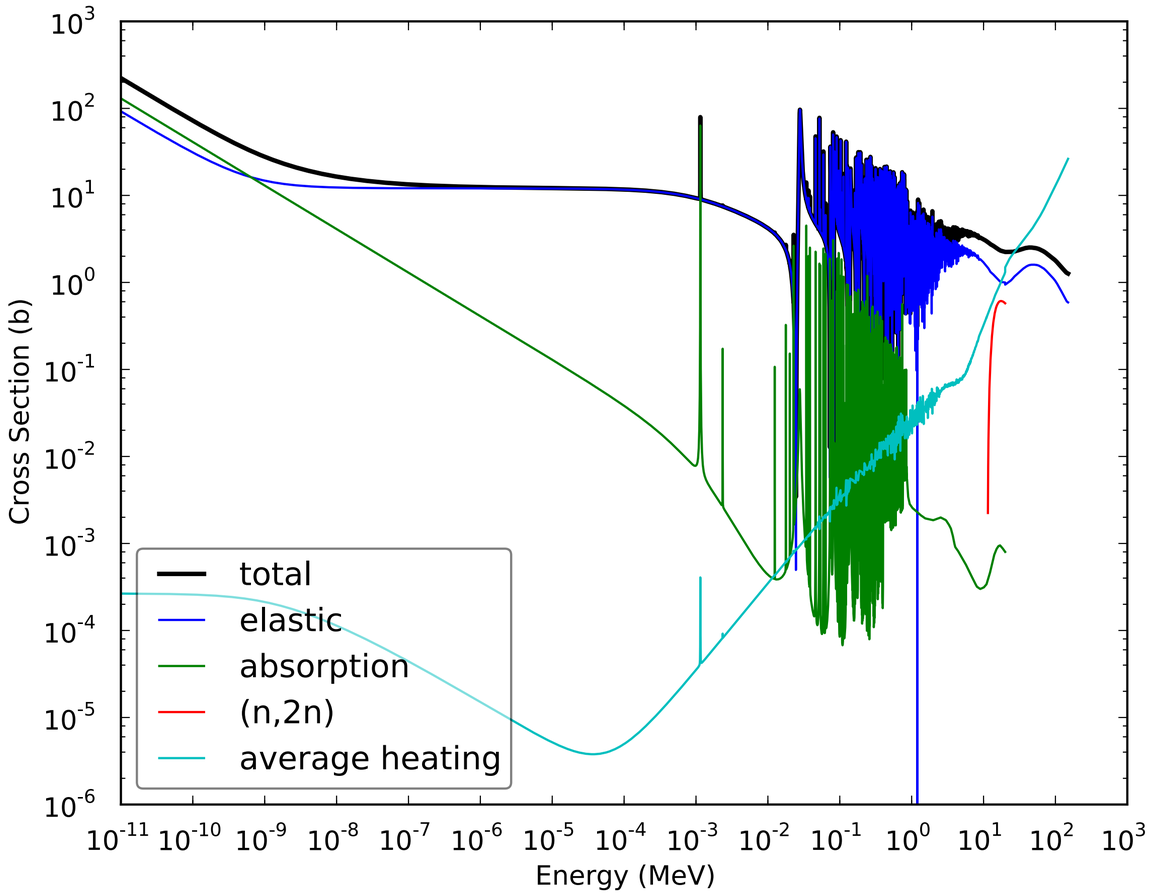
Visual Inspection of Major Cross Sections

Wrote code to inspect and test data libraries

Unphysical errors (e.g., discontinuities) sometimes found and corrected

Also uncovered a rare but significant bug in MCNP itself

LANL = Vatican of Fortran 😂



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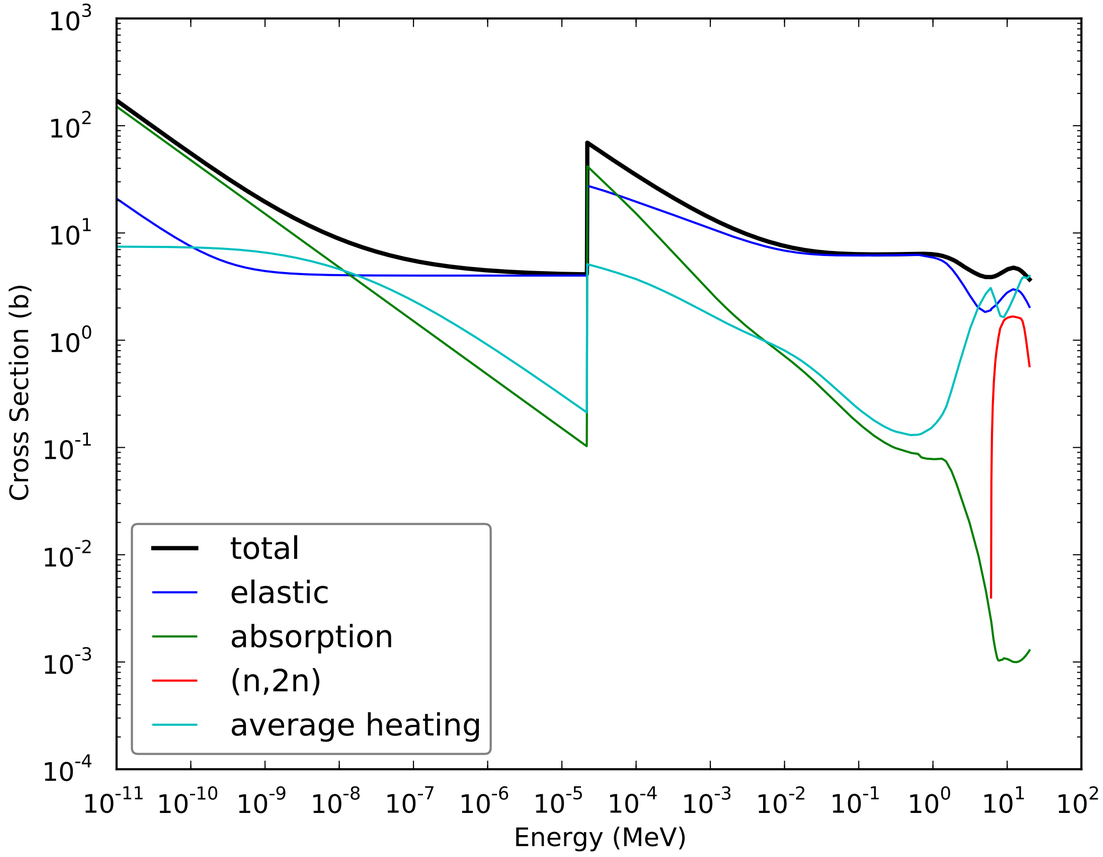

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Mechanical Testing

- 4 cm sphere
- One isotope
- Nominal density for element
- $1 \times 10^{-11}\,\text{MeV} \leq E \leq 20\,\text{MeV}$
- Three energy distributions:
  1. Uniform
  2. Watt fission spectrum
  3. Room temperature Maxwellian

- `mode n p`
- 1×10^{9} histories
- Tallies:
  - `F1` Outer surface current
  - `F2` Outer surface flux
  - `F4` Volume flux
- 500 logarithmically-spaced energy bins

Mechanical Testing—(Too) Many Secondaries

Wrote code to inspect and test data libraries

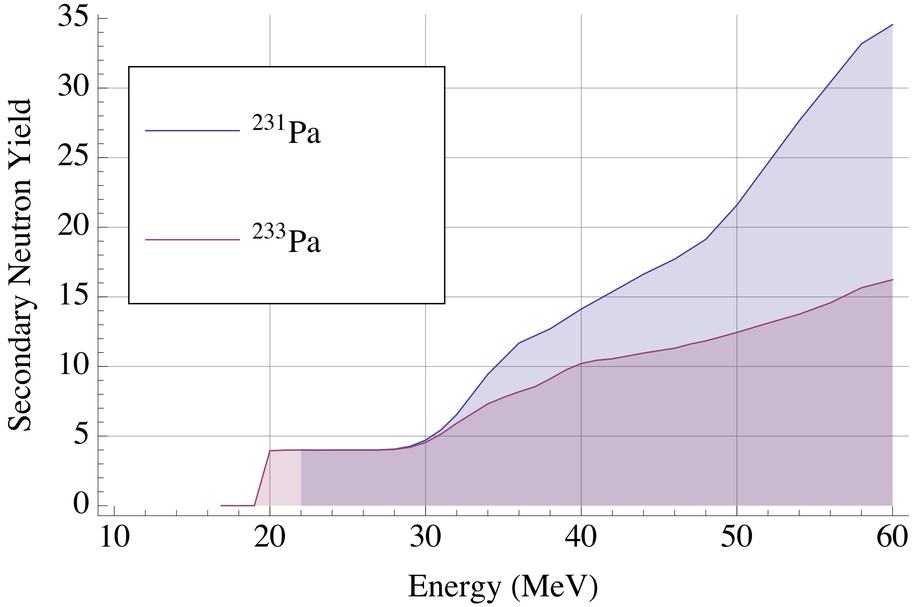
Unphysical errors (e.g., discontinuities) sometimes found and corrected

Also uncovered a rare but significant bug in MCNP itself

LANL = Vatican of Fortran 😂

- `MT=5`, $(n, *)$ ^{231,233}Pa
- < 12 secondaries assumed
- If ≥ 12 secondaries:
  - Array bounds exceeded
  - Unknown quantities changed
  - (very) Negative energies

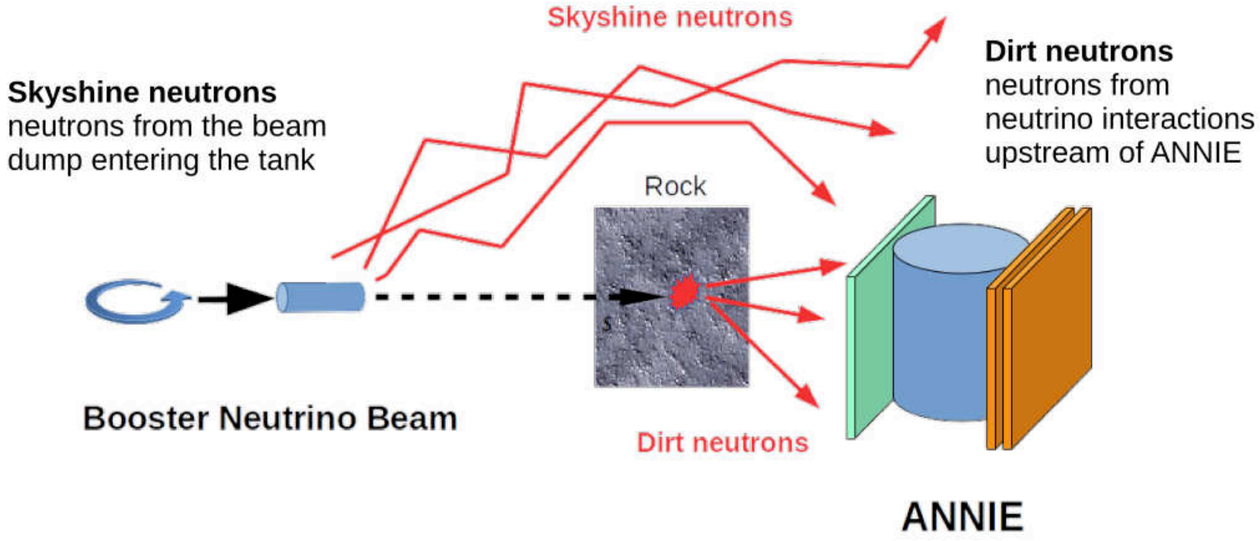
This has *not* been fixed in `MCNP`



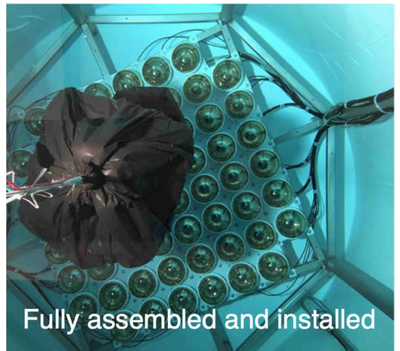
PhD research brought me to Fermilab for the first time

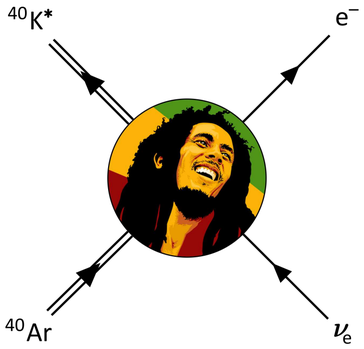
ANNIE Phase I: neutron background measurement

"measure and understand beam-induced neutron backgrounds to the physics measurement to be conducted in Phase II"

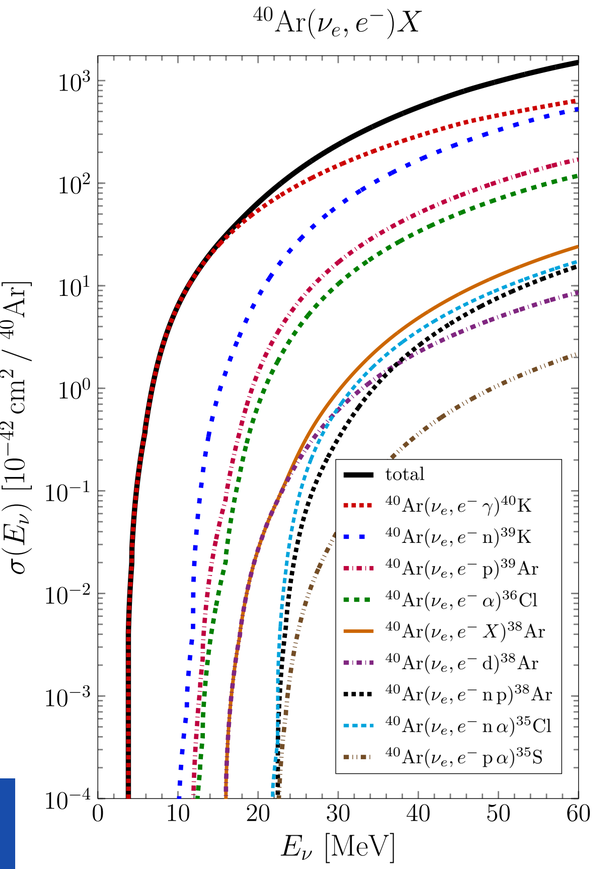


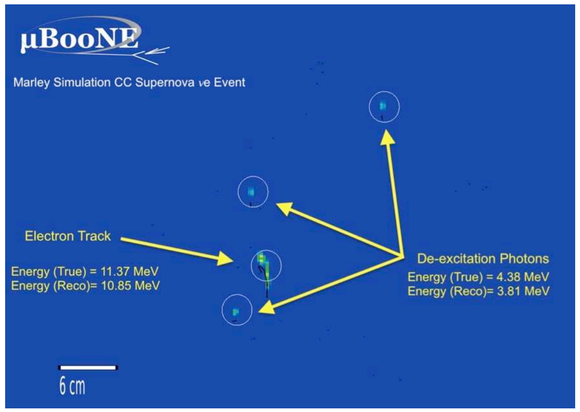
ANNIE collaboration, [J. Instrum. 15 P03011 (2020)]

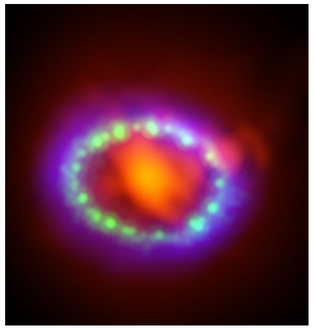




Model of **A**rgon **R**eaction **L**ow **E**nergy **Y**ields



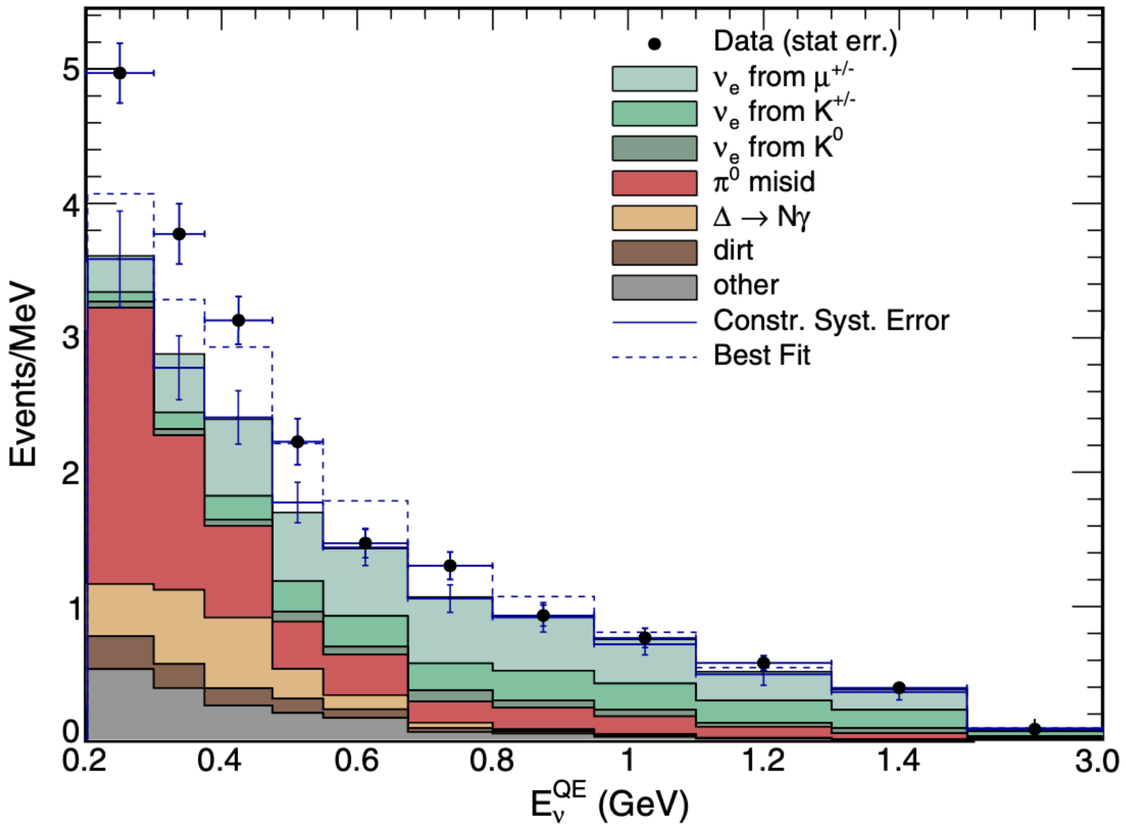




S. Gardiner, [Phys. Rev. C 103, 044604 (2021)]

S. Gardiner, [Comput. Phys. Commun. 269, 108123 (2021)]

Postdoctoral work on simulations and analysis for MicroBooNE



MiniBooNE collaboration,
Phys. Rev. Lett. 121, 221801 (2018)

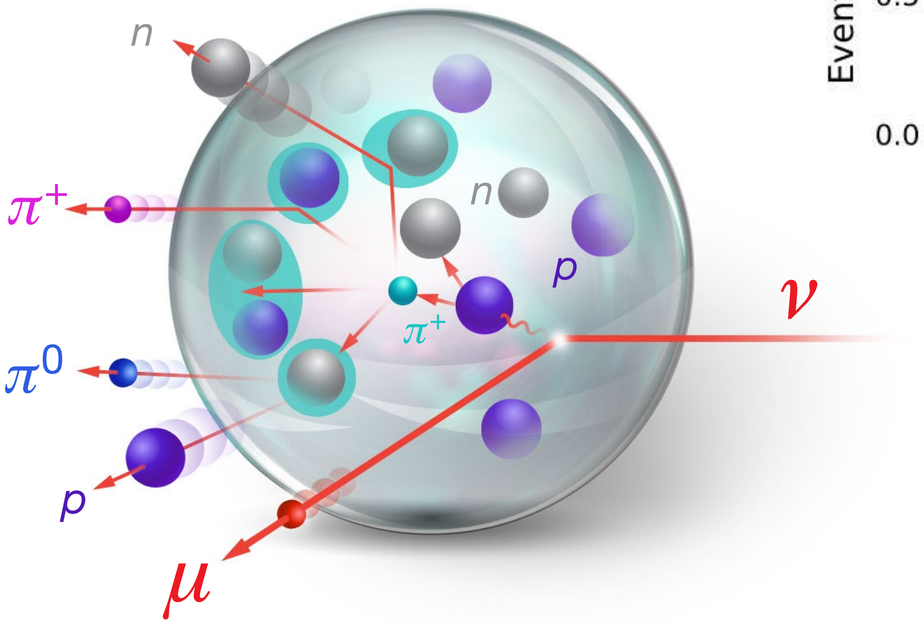
MiniBooNE saw more ν_e-like events at low energies than expected

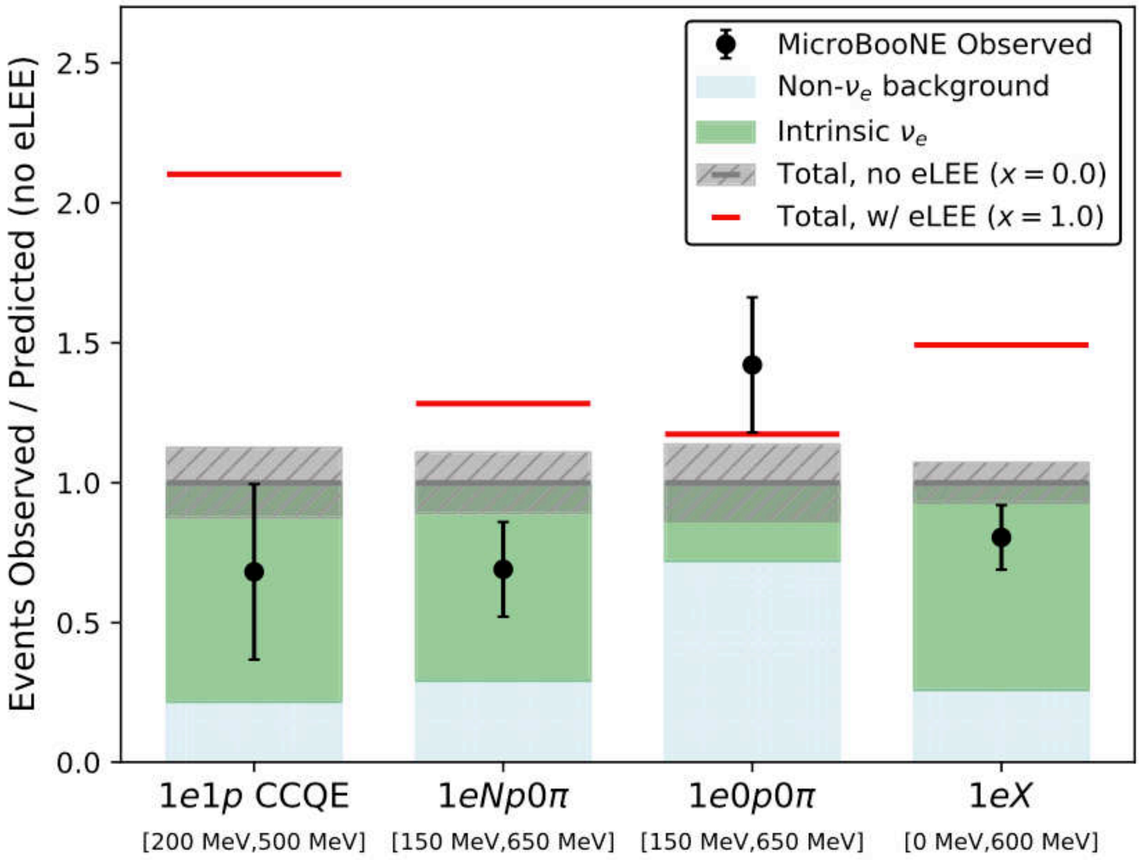
MicroBooNE designed to investigate using multiple channels

Postdoctoral work on simulations and analysis for MicroBooNE

Interpretation of MicroBooNE results requires comparison to simulation

I led development of the interaction simulation for MicroBooNE by improving the GENIE code





Also co-led the MicroBooNE cross-section working group, tasked with making measurements to benchmark GENIE and similar simulations

My faculty/staff job search

- Began permanent job applications as I was starting my 4th postdoc year
- Applied to 10 positions, all in neutrino physics
  - 8 universities, all primarily research-focused
  - 2 national laboratories: Fermilab (Wilson), SLAC (Panofsky)
- Long-list remote interviews for two universities, ended there
- Short-list interviews for both national labs
  - Internal offer of promotion (no advertised search) came before I officially heard back from Wilson Fellowship committee
  - Negotiated with Fermilab, ultimately withdrew SLAC application before decision announced

Three scientific career paths

- Universities: “teaching and PI-directed research”

- National laboratories: “big science as a team”

- Private industry: “delivering value to the customer”

University	National lab	Industry
• High research freedom (“whatever you can get funded”)	• Medium freedom (broad opportunities, may be limited by mission of lab)	• Limited freedom (scope restricted by practical objectives of company)
• Formal teaching required via traditional courses, mentoring in research	• Mentor postdocs and visiting students. Limited formal opportunities (e.g., summer schools)	• Mentoring junior employees, perhaps student interns

University	National lab	Industry
• Tenure-track (~5 years)	• “Staff” positions (~5 years) sometimes considered tenure-equivalent	• Typically no tenure
• Department Chair, Dean, Provost	• Group / Department / Division Leader	• Various management positions
• Might teach same courses over & over	• Might work with same facility / instrument over & over	• Might work on same kind of project over & over

University	National lab	Industry
• Mostly indifferent to nationality	• Depends, but sometimes very sensitive	• Varies, mostly indifferent
• Foreign travel “easy”	• Foreign travel carefully reviewed	• Foreign travel “easy”
• Few or zero other local professors may work in the same subfield	• May be hard to find collaborators outside of the lab (less true for Fermilab)	• Trade secrets, etc. may restrict opportunities for external collaboration

University

- Start-up package, then become self-sustaining via grants
- Cheap access to labor (students!), expensive equipment/ facilities

National lab

- Less effort from individual staff to “keep lights on,” but external funding encouraged
- Cheap access to equipment/facilities, expensive labor (postdocs+, overhead)

Industry

- Often less need to worry about the details of where your salary comes from

University

- Close relationship with students
- Intellectual freedom (extends beyond science)
- Some geographic flexibility (especially long-term)

National lab

- World-class local collaboration
- In the “room where it happens” (and everyone else visits you)
- National mission (e.g., nuclear security)

Industry

- Greatest flexibility (location, career change/growth)
- Pay and benefits can be excellent
- Direct impact of work on customers/society can be more apparent

How much can I move from one path to the other?

- The boundaries are porous, but ease of movement varies

- I personally know multiple national lab staff scientists who became university professors
  - All tenure-equivalent positions → tenured professorship at same level
  - All in particle physics

- Some items to consider
  - Publication record typically needed to transition out of industry
  - Classified activities can make your career outputs hard to review
  - Can often move between subfields at the same national lab (e.g., neutrinos → quantum information science)

There are multiple kinds of “staff” positions at national labs

- All permanent employment, but different expectations for the job
  - Details vary between laboratories

- Worthwhile to investigate for any particular position you’re considering

- Examples at Fermilab
  - Associate Scientist / Scientist / Senior Scientist: perform self-directed research. Considered equivalent to Assistant / Associate / Full Professor
  - Applications Physicist: contribute scientific and technical expertise to the lab’s mission and operations. Time for self-directed research more limited.
  - Computational Physics Developer: develop and maintain scientific software tools needed by the Fermilab community

The interview process

- I interviewed in person for postdoc jobs at LANL and Fermilab
- Virtual interviews for staff fellowships at Fermilab and SLAC (COVID)
- Broadly similar, but every lab does it a little differently
  - Research seminar (~1 hour), emphasize your contributions and future plans at the institution (the latter especially for staff jobs)
  - Committee includes staff from multiple subfields (and typically experiment + theory), understand how broad your audience is!
  - One-on-one or two-on-one discussions (details of technical topics, “behavioral” questions, etc.)
  - Often a tour as a fun break
  - Fermilab sent me to dinner with a current postdoc uninvolved in the hiring decision

Some practical tips (1)

- Senior scientists in your subfield are the best guides for where to find jobs, but here are a few pointers:
  - Every lab has a dedicated web page for job postings (e.g., **fermilab.jobs**) and they are typically searchable
  - **AcademicJobsOnline.org** and **inspirehep.net** are good for particle physics
  - For nuclear security, subscribe to this email newsletter: **https://nssc.berkeley.edu/about_nssc2/nssc-opportunities-mailing/**
- Don’t be afraid to negotiate, especially if you have multiple written offers
  - Big mistake in my postdoc search
  - Learned my lesson as I looked for permanent employment
  - Seek advice from senior people you trust. A new skill for many of us!

Some practical tips (2)

- Postdoctoral positions can often lead to staff jobs at the labs
  - Retention rate varies with lab and subfield, but you have a “home field advantage”
  - Postdoc jobs at nearby universities (e.g., UT Knoxville for ORNL) or long-term visits can also raise your odds of success if you build a strong reputation
- Tailor your research statement to the lab’s environment (use the facilities in an interesting new way, etc.) and needs for its future science program
  - Shows strong interest in a particular lab and its mission
- Feedback on application materials
  - Fairly easy to get from staff not involved in the hiring decision
  - Valuable, but you have to start early (easier said than done, of course!)

We're hiring!

- I lead the recently-formed **Event Generators Group** here at Fermilab
  - Physics Simulation Department; Data Science, Simulation, and Learning Division; Computational Science and AI Directorate

- We have an opening for a postdoctoral researcher to work on neutrino event generators and liquid argon experiments
  - **https://inspirehep.net/jobs/2632750**

- C++ coding skills essential, but no prior generator/neutrino experience is required
  - Candidates from experiment/theory/computation will all be considered

- Please advertise the job ad and refer interested candidates to me (**gardiner@fnal.gov**) if they have questions

Some final thoughts

- The DOE national labs offer a broad range of scientific career opportunities
  - Unique advantages/disadvantages compared to universities & industry
  - It depends what you find most exciting / fulfilling

- Job searches are stressful in general, and academic ones are particularly competitive
  - Random fluctuations play a significant role, and the signal-to-noise can be poor
  - Your worth as a scientist and a human being doesn’t depend on the outcome of this process

- I wish you success and luck whether you choose the national lab path or a completely different one!