Vamos a Fermilab

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Fermilab
28 Jan 2022

Fermilab

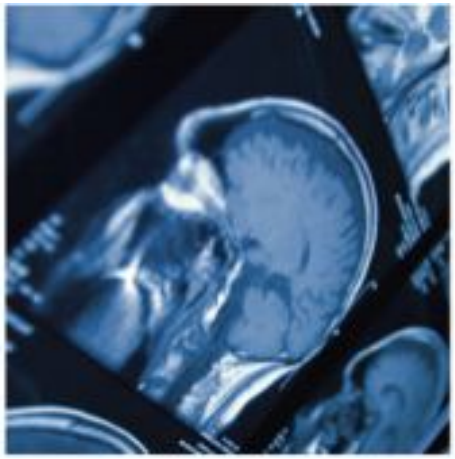
Fermilab is American's particle physics and accelerator laboratory

What we do:

- Particle physics
- Particle accelerator
- Detectors
- Computing
- Quantum science and technology
- Emerging technologies
- Theoretical physics

Fermilab science programs are performed by people from different STEM careers including: Physics, math, computer science, electrical engineering, mechanical engineering, electronics …

Particle Physics is used Everywhere



- The pharmaceutical industry used X-ray beams created by particle physics accelerators to develop more effective drugs to fight disease
- Cancer treatments use gamma rays and protons
- Medical implants are manufactured using electron beam
- Tomography
- Microwaves!

- Sensors and security:
- Particle physics technology improves homeland security

Fermilab Builds Proton Accelerator to Treat Cancer

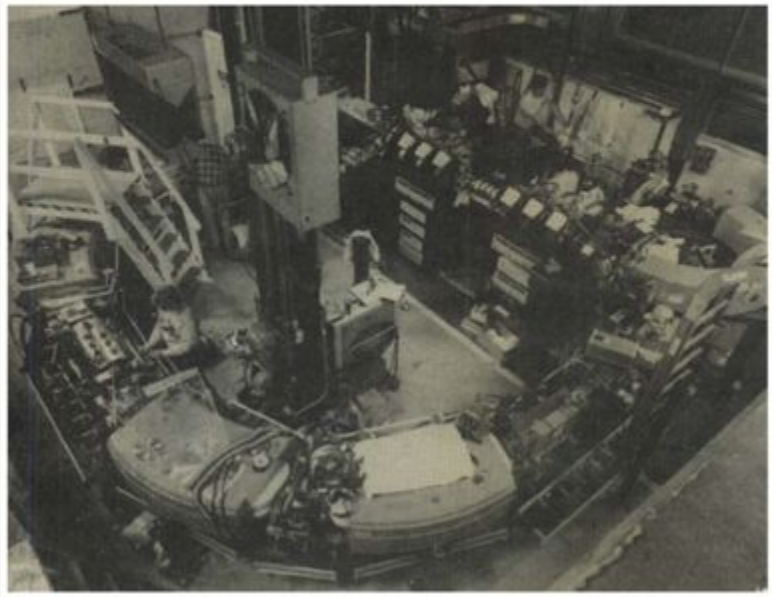
Source: Batavia Chronicle, January 4, 1989

The U.S. Department of Energy's Fermi National Accelerator Laboratory at Batavia has announced the first successful operation of a small proton accelerator to treat rare cancers. It was designed and built at Fermilab for Loma Linda University Medical Center in California, where it will be used to treat cancer and other diseases by focusing a beam of protons to eradicate diseased cells.

The first operation is an important step in a 1986 agreement between the medical center and Fermilab, according to Fermi officials.

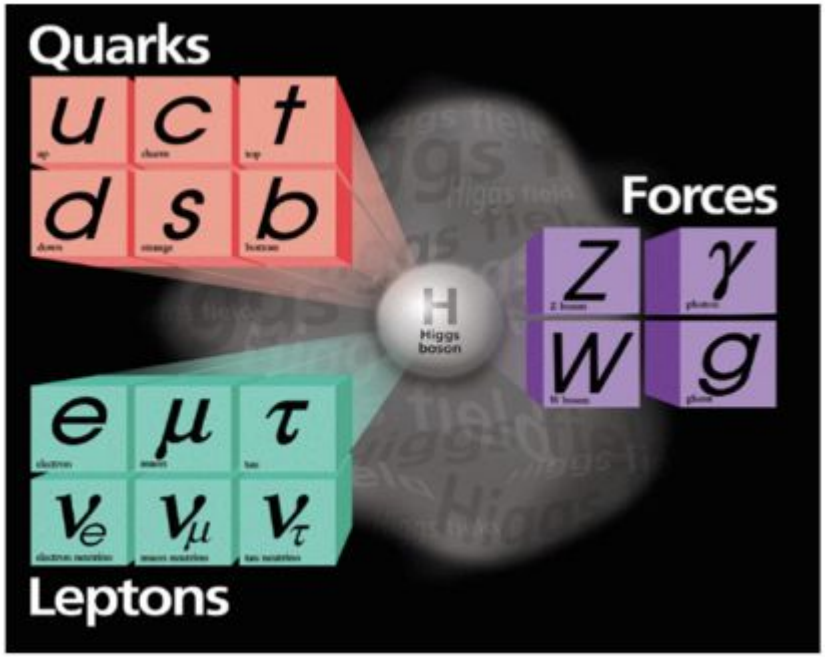
Under the agreement the accelerator will be disassembled and moved to Loma Linda during the summer of 1989 when the critical facilities for the treatment of patients are ready. In the interim Fermilab will continue start-up procedures although it will not be used to treat patients, Fermilab will continue accepting patients in its neutron therapy facility.

The proton therapy accelerator is 20 feet in diameter -- the world's smallest proton synchrotron -- and will deliver a variable energy of 70 to 250 MeV (million electron volts). In comparison, the Fermilab Tevatron -- the world's largest -- is 4 miles in circumference and delivers energies of approximately I trillion electron volts.



Standard Model of Elementary Particles

Standard model of elementary particles, everything known in this world is made of these particles



b: Bottom quark was discovered at Fermilab in 1977

t:Top quark was discovered at Fermilab in 1995

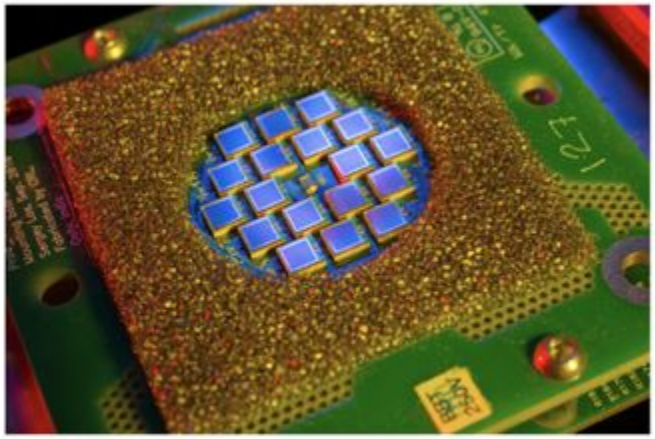
τ:Tau was discovered at Fermilab in 2000

Is the standard model complete?

- Neutrinos in the standard model has no mass
- However neutrino mass has been observed, and it is much smaller than all other particles

Fermilab Science

Detectors, Computing and Quantum



Neutrino experiment

CMS experiment found the Higgs Boson

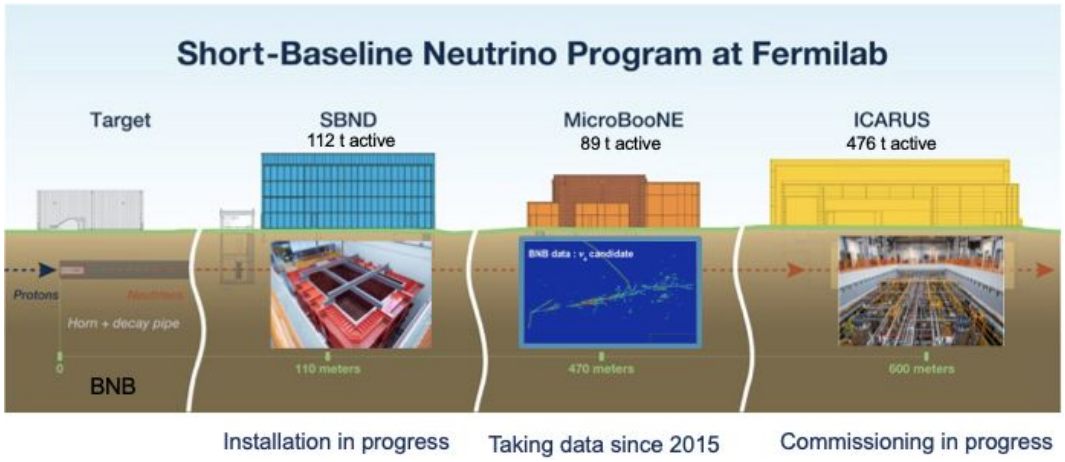
Dark Energy Search

Mu2e will search for muon to electron

Construction of the Mu2e detector

Neutrinos

- Fermilab produces powerful neutrino beams and hosts many neutrino experiments
- Neutrino have puzzlingly low masses when compare to other elementary particles and they are able to oscillate or change from one type of neutrino to another when they travel
- Many experiments under construction and operation

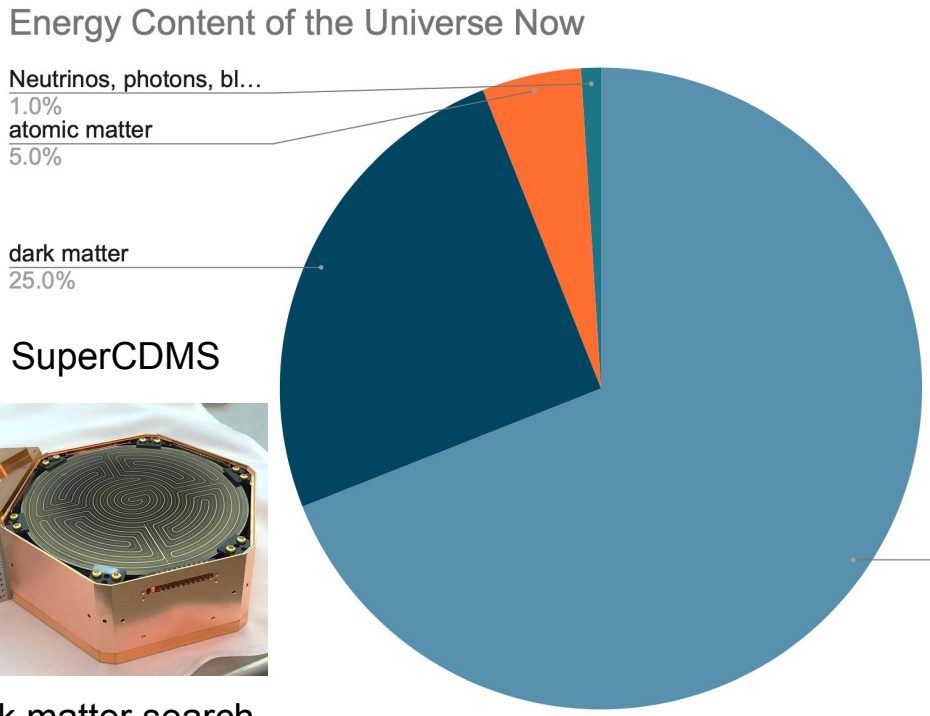


NOvA Experiment

My first experience building a detector
Helped to ensemble the modules
Installation, commissioning and data analysis

Astrophysics

- Fermilab's astrophysics advances dark matter searches, dark energy, cosmic microwave background, large scale structure of the universe and cosmology.



Dark Energy Survey
Dark Energy Spectroscopic Instrument

SuperCDMS

direct dark matter search

South Pole Telescope

Fermilab

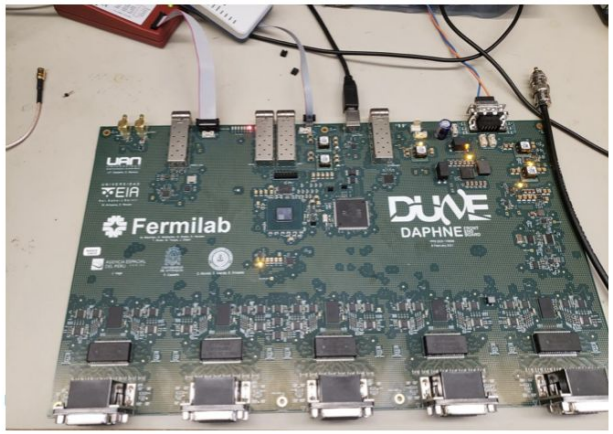
Astrophysics

- The astrophysics program at FNAL is building the next generation of experiments to explore the unknown components of the Universe : Dark Matter and Dark Energy.
- We also operate several ongoing experiments (superCDMS, ADMX, SENSEI, DES, SPT…) and produce science with their data.
- The experiments involve astronomical observations in optical and microwaves from mountains in Chile and the South Pole.
- Direct Dark Matter searches involve cryogenic detectors (down to temperatures below 1 Kelvin) operated at the surface and also 1 mile underground.
- The exploration of unknown components of the universe is continuously pushing our technological limits and demanding novel ideas.
- Several engineering, computing and science opportunities exist for exciting careers in Astrophysics.

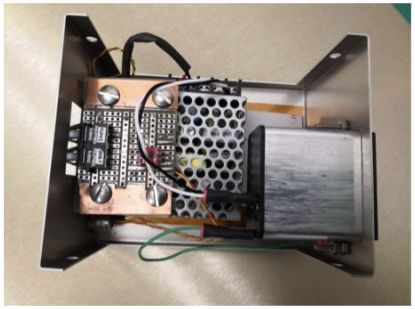
Electrical Engineering

- Electrical engineers at Fermilab work on challenging projects to make detector electronics or tests key components of the experiments
  - Detector electronics: how to detect and readout particle hits, design and testing

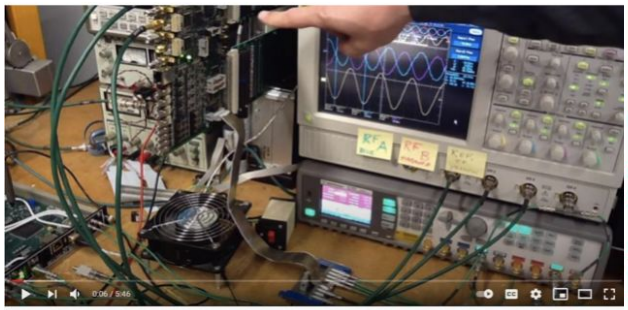
Detector electronics

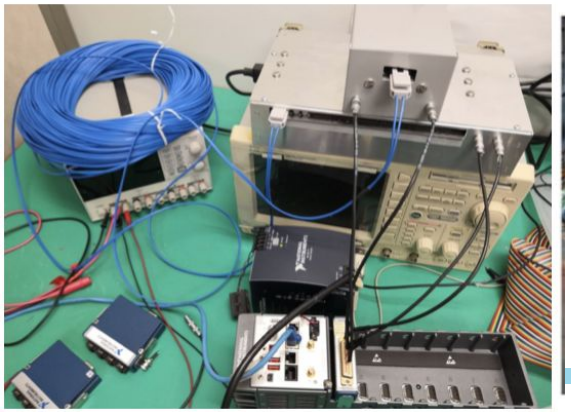


30kA power supply control and current distribution

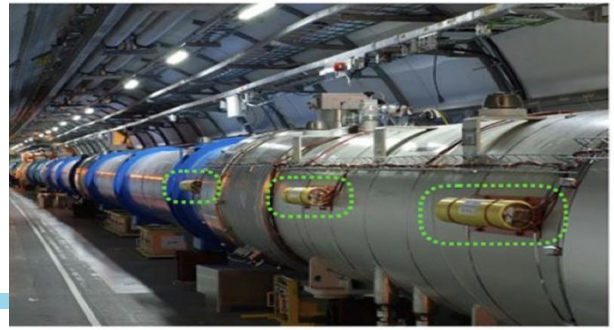


Superconducting





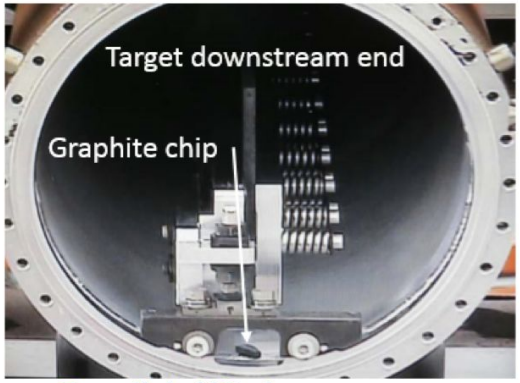
Beam Loss Monitoring System



Mechanical Engineering

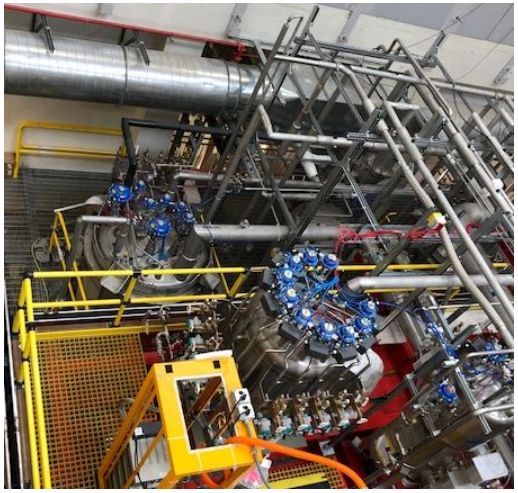
- Mechanical engineers at Fermilab design many systems to do the experiments
- Examples:
  - Fluid systems that cools heat loads in operating equipment, such as magnets, horns, pumps…
  - Design targets that can sustain very high energy and high intense beams
  - Cryogenic for neutrino liquid argon detectors and dark matter

Ejector prototype cooling system



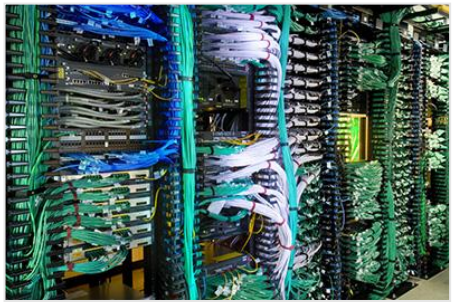
Fermilab-NOvA target autopsy

Cryogenic for neutrino detector



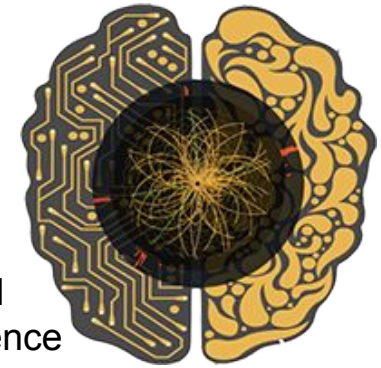
Software and Computing

- Fermilab develops software to operate accelerators, detectors, and process physics data in modern computing systems
- Examples:
  a. Data acquisition and controls
  b. Cloud storage
  c. Software to extract physics results
  d. Data transport (networking)
  e. Big data analysis
  f. Artificial intelligence applications
  g. Quantum computing for HEP

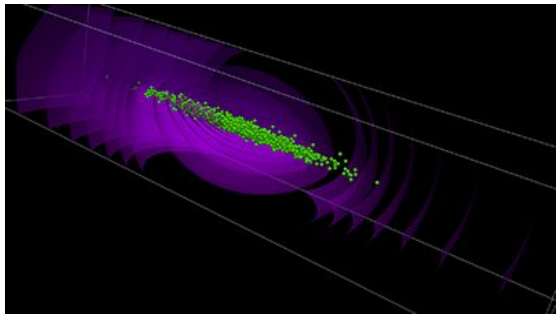


Networking

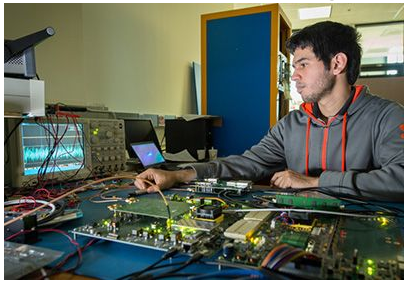
Cloud computing



Artificial Intelligence



Accelerator beam simulation



R&D

Examples of Shadowing Activities

- Shadow a neutrino physicist to test electronics of the neutrino detector readout
- Shadow a physicist to install or test a component of a detector
- Shadow a electrical engineering to test electronics
- Shadow a mechanical engineering to monitor fluid or cryogenic systems
- Shadow an astrophysicist to optimize new imaging detectors for astronomical instruments.
- Shadow a computational physicist programing and integrating software within an experiment framework
- Shadow a physicist analyzing data from the experiments

The Vamos a Fermilab program

Initial goal (WDTS DOE funding): Increase the number of Hispanic/Latinx postsecondary students applying successfully to the DOE CCI and SULI summer internship programs

Long-term goal: Establish a pipeline program that leads up to employment at Fermilab

Partnership with Chicagoland Hispanic-serving institutions

Focus on initial goal during 2022:

- Student selection and establishment of mentoring teams
- Vamos a Fermilab summer in-person 3-days recruitment event
  - Talks about CCI and SULI followed by tours of Fermilab facilities, shadowing, personalized advice about the application process
- Conéctate a Fermilab nationwide 1-day online recruitment event
  - Keynote speaker, STEM panelists, CCI/SULI application process

Nothing could come in the way of such a nice plan … unless

The Vamos a Fermilab program

… unless … a pandemic strikes but, what are the chances?

Vamos a Fermilab in COVID times

Flexibility is the key to success in times of COVID

A proposal for your consideration:

- The 3-days summer event will evolve with a high probability into a series of events conducted asynchronously
  - Talks/lectures would take place via zoom on a single day
  - Application guidelines to SULI, CCI programs would be also be discussed remotely on a different day
  - Tours of Fermilab facilities would be arranged in small groups according to the student interests on different days
  - The shadowing experience would take place in person at the Fermilab site on days and times determined by each mentoring team (assigned teacher and STEM professional) and the student

Vamos a Fermilab in COVID times

Flexibility is the key to success in times of COVID

A proposal for your consideration:

- The in-person session devoted to networking and collaboration opportunities among partner institutions would be held remotely on a day/time convenient for the participating individuals
- Students and teachers would be granted the status of Fermilab visitors/affiliates with flexibility to access the lab on the days and times agreed upon with the STEM professionals and the tour guides
  - Optimal solution offering plenty of flexibility and opportunities towards the future
  - There is paperwork involved which may take up to 3 months - More from Juan next

Student and Mentoring Team

- Match each student with a Fermilab professional according to the student's career interest. We expect that each FNAL professional will mentor only 1 student.
- The mentoring team is completed with a faculty member at the academic institution. This faculty member will help design the activities for the student based on their academic background, interest and schedule availability.

- Fermilab STEM professional role :
  - Support the 3-day shadowing activity.
  - Guide the student through the application process for DOE internships.
  - In some cases (perfect match) this could develop into a longer term partnership with the student engaged in projects at the lab beyond the 3-day event.

…comments/suggestions welcomed!

Matching student to STEM Professional at FNAL

- Student selection will be done by academic institution.

  We will not have strict academic requirements for the students. We expect academic partners to be the best judges of the likelihood of success of the student.

- This is how we imagine the process (comments welcomed):
  1. Fermilab team provides a description of the STEM opportunities (as started earlier in these slides).
  2. Faculty members discuss with students the opportunities. If there is interest Fermilab can have more detail conversations about the opportunities with students (talks).
  3. Iterate between FNAL/Faculty/student to design the program for each case. Schedule, activities, needed background. We expect the FNAL mentors to start getting directly involve at this step.

Becoming a FNAL User

All the student and faculty participating in this program will become Fermilab Users. This has several advantages:

- Easy to get access to FNAL computers.
- Flexibility to access the FNAL site.
- Facilitates any longer term engagement with FNAL.

Becoming a FNAL user takes time. It involves completing some online training (<3hrs) and waiting for signatures.

We should plan for 3 month.

<u>Students need to start this process in April to be ready for summer.</u>

Guidance for Mentoring team

- We expect the Daniel, Minerba and Juan will start iterating after this meetings with the academic institutions on any questions that could come up about the STEM opportunities. Giving whatever support is needed from you to engage students.

- Once initial matching between mentors and student is done Fermilab mentors will be have an initial training session with the FNAL project team (Daniel, Minerba and Juan).

- We will also arrange a meeting between Fermilab mentors and the faculty members to discuss student programs. This will be on smaller groups, probably short meetings to understand expectations from everyone.

- Any additional suggestions here?

Next steps

- FNAL team:
  - Available for detailed discussions with Universities/Colleges to help with student selection.
  - Identify potential mentors.
  - Match mentors to student candidates.

- Faculty partners:
  - identity student candidates
  - discuss with FNAL student interest to match with mentors

- Initial list of students and mentors/projects February 28th.
- Final student/mentor matching in March 31th.
- Fermilab onboarding to start on first week of April, and will take up to three months.

https://docs.google.com/spreadsheets/d/1Ku4eMNtf94jCQ6HfVFjUv2SLknTfC0NtOsFUnDqkLFA/edit?usp=sharing