Fermilab Users Meeting

Nigel Lockyer
August 2, 2021
COVID and the Future of Work

- About 75% of staff vaccinated (one work related COVID case, recovered)
- Red lanyard says vaccinated and no need to social distance and no mask (but this has changed….. Delta variant, expect to hear from DOE this week)
- Lab is still closed to the public and staff are in maximal telework

- DOE is expected to release a framework on the “future of work” soon
- Staff survey indicates a desire for hybrid work model by ~80% of staff
- Three work arrangements: fully on-site, hybrid and fully remote
- Likely a phased approach to transition back to work on-site September
- Open to Public after that
Reopening to the public… not as open as before

• Receiving requests to come on-site by bikers, birders, and groups (e.g.; Fermi Natural Areas)

• Our opening, public spaces, and hours open to public must be approved by the Fermi site office (discussions beginning with site office)

• Very different: Public visitors 18 and over, and unaccompanied minors -- including cyclists, walkers, and all adults in a vehicle -- will be required to show an ID at the gate for site access. (new)

• New and limited site access hours,

• New Wilson Hall public areas: ground, 1\textsuperscript{st} and 2\textsuperscript{nd} floors limited hours
Welcome new Secretary of Energy

- On an irreversible path to carbon net zero
- Clean energy, climate, environmental justice
- EDI, industries of the Future
Fermilab Plan Emerging

- Fermilab a leader in Industries of the Future—quantum computing and sensors, microelectronics, and real time AI/ML
- Fermilab is also building a portfolio of projects with diverse applications
- Themes:
  - Co-locating with Industry…. E.g., Building quantum computer with Rigetti, Lockheed Martin, Keysight
  - Opportunities of real-time AI/ML with Agriculture, John Deere
  - Advance building a portable high-power electron accelerator for replacement of Cobalt-60 sterilization (working with Baxter, J&J)
  - Collaboration with Microsoft on cold ASIC design
P5 Science Drivers of Particle Physics

- Higgs boson
- Neutrinos
- Dark matter
- Dark energy and inflation
- Exploring the unknown

• Achieving science goals requires technology innovation
  - All easy experiments have been done
  - Pushing boundaries of technology enables new experiments
P5 endorsed a global particle physics program

• The future of U.S. particle physics relies on successful international engagements
• CERN is our strongest partner
• Seeking worldwide participation in LBNF/DUNE/PIP-II
  – Not only resources, but also expertise
  – Strong international interest in PIP-II technology and the science of DUNE
• Fermilab has developed leading partners and a broad coalition for LBNF/DUNE/PIP-II, working with DOE High Energy Physics/Office of Science
Implementing the Vision - Deep Underground Neutrino Experiment

Currently: 1,347 collaborators from 204 institutions in 33 countries (plus CERN)

- **Origin of matter.** Investigate leptonic CP violation. Are neutrinos the reason the universe is made of matter?
- **Neutron star and black hole formation.** Ability to observe neutrinos from supernovae events and perhaps watch formation of black holes in real time.
- **Unification of forces.** Investigate nucleon decay.

*LBNF and PIP-II will enable the United States to host the global high energy physics community to advance world class discovery science into the fundamental nature of matter*
South Dakota: Excellent performance by project team

- 2 years of construction completed
- Lost 3 months (COVID)
- Reliability projects done
- Pre-excavation done
- All on budget & schedule
- ~ 6% contingency used
- Near site prep completed on time and budget
Excavation has begun in South Dakota

Drill holes
Explosives
Blast
Muck Rock
Repeat for 2.5 years
Mucking over Grizzly
Thanks to CERN for Neutrino Platform and its great success

- CERN is our major partner
- DUNE constructed detectors around the world and transported successfully to CERN
- Detector performance exceeded specifications and is published

Marzio Nessi, CERN, Head neutrino platform
Other LBNF/DUNE Updates

• Project working to add second far detector module to baseline scope
  – Attracting additional international partners, France lead, plus Italy, UK, CERN

• Gina Rameika elected as DUNE Co-Spokesperson (DOE project experience)

• Stefan Soldner-Rembold
  DUNE Co-Spokesperson
CERN HL-LHC

• Science goal
  - Study the Higgs, search for new particles

• Recent Achievements
  - 1039 collider papers as of April 4th, 2021

• Nb3Sn hi-field magnets with LBNL and BNL

• Mass storage is foundation of Fermilab’s computing capability

• CMS 1.6 exabytes for HL-LHC by 2030 at Fermilab
The big push for HL-LHC: Accelerator Upgrade Project and CMS Detector Upgrades

AUP baselined and moving ahead:
• First 4 production magnets for HL-LHC successfully passed acceptance testing at BNL
• Assembly of the first 2-magnet production Cold Mass in progress at FNAL
• Testing of second prototype Crab Cavity planned for mid-August

CMS upgrades moving ahead:
• Project team working with the Lab and DOE and CERN to enable project baselining in the coming calendar year
• Wide variety of technical progress at Fermilab and the ~ 40 HEP institutes involved in the upgrades

CMS utilizing High Performance Computing
• > 5 billion CMS events generated on HPCs in FY21
Mu2e will be re-baselined end of the year

Science goal

x10,000 sensitivity improvement to \( \mu^+ \mathrm{N} \rightarrow e^- \mathrm{N} \)

Will be world leading lepton violation experiment

Magnets from Italy all delivered and work well
Three detectors with one mission: are there more than 3 types of neutrinos? New regime with millions of detected $\nu$ per year

Nobel Prize winner Carlo Rubbia leads ICARUS and invented liquid argon as a detection medium.
Short Baseline Neutrino Program: ICARUS detector started

Three detectors with one mission: are there more than 3 types of neutrinos?

New regime with millions of detected $\nu$ per year

ICARUS Vessel with Cryogenics and detector electronics installation

Event display of an ICARUS BNB $\nu\mu$ interaction candidate

Event display of an ICARUS NuMI $\nu\mathrm{e}$ interaction candidate
NOvA Science

Addresses important questions in the physics of neutrino mass and mixing

- What is the neutrino-mass ordering?
- Do neutrinos violate CP symmetry?
- What is the flavor composition of the 3rd neutrino mass state ($q_{23}$ octant)
- Excellent progress in past year
- 3s sensitivity to hierarchy for 30-50% of $d_{CP}$ range by 2024
World’s leading dark energy telescope…3 (of 6) years released

- Dark Energy Survey makes public catalog of nearly 700 million objects (226 million galaxies)
  - International collaboration led by Fermilab released the largest ever maps of galaxy shapes and traced ordinary & dark matter out to 7 billion years on Jan 2021
  - Hints that matter is less clumpy than expected
  - Over 300 papers published to date
SPT-3G Cosmic Microwave Background

SPT-3G camera (16,000 detectors), and operating at South Pole

CMB-S4 being led by Berkeley (500k detectors)

DOE and NSF funded
World’s first demonstration of optical stochastic cooling

IOTA is a unique accelerator science platform

Unique facility: stored a single electron
Fermilab researchers are making substantial steps towards compact superconducting accelerators for applications like wastewater treatment, medical isotope production.

Current result: $\text{Nb}_3\text{Sn}$ cavity + cryocooler + conduction cooling

Next step: compact accelerator prototype

- $e$- gun
- 2 x 2 W cryocooler
- Cryostat
- RF Coupler
Leveraging FRA, LLC and Corporate Parents

• **FRA** corporate, selected contributions
  – Board support critical in many areas (international, safety, construction, EDI, cyber)
  – Business and operations performance improvement assistance

• **UChicago**, selected contributions
  – COVID-19-related support and testing coordination
  – Continuing education and leadership training for Fermilab and Argonne
  – Joint Task Force Initiative

• **URA**, selected contributions
  – Annual Graduate Thesis award, Post-doc Award, Early Career Award
  – Visiting Scholars program: research awards
  – Annual Users trip to Washington and letters to Congress in support of DOE/HEP
Muon g-2 experiment: impact

- More than 150 research papers since April 7 proposing to explain the result
- Possible explanations involve new forces and particles
- Could be related to the cosmic controversy over the Hubble expansion rate of the universe
- Spokesperson Chris Polly will present the 2021 Manne Siegbahn Memorial Lecture sponsored by the Nobel Committee for Physics and the Royal Swedish Academy of Sciences
Muon g-2 experiment: impact

Front page of the New York Times

Editorial Board

Why Congress Should Care About the Laws of Physics

Recent research seems to challenge the fundamentals of the field. The U.S. should support the quest for answers.

By Michael Bloomberg
May 7, 2021, 1:44 PM EDT

“The most extraordinary event of the year” - Michael Bloomberg

To Observe the Muon Is to Experience Hints of Immortality

Attempting to model the universe as precisely as possible is to try to see the one thing that even the strictest atheist agrees is everlasting.

Evidence is mounting that The Force has been with us... ALWAYS.

In a major breakthrough for particle physics, Fermilab facilitated discoveries indicating an entire new realm in physics

- May 11 letter signed by 20 U.S. Senators
Muon g-2 experiment: strategy for discovery

Fermilab hosting an international collaboration

- Critical hardware and expertise provided by Italy and the UK
- More than half of Muon g-2 scientists are from outside the U.S.
- Hosting of Muon g-2 scientific community: Fermilab Village housing, Global Services office, computing support, ES&H
- DOE Intensity Frontier fellowships, URA Visiting Scholars program
Proton Improvement Plan – II (PIP-II)
Bottom Line Up Front – PIP-II Status

► In the past year, three Critical Decisions (CD) were approved
► CD-2/3 of Early Conventional Facilities (ECF) subproject – Jul 2020
► CD-3a for Long Lead Procurements – Mar 2021
► Beam tests at PIP2IT successfully completed, critical technologies demonstrated
► International partner engagement is strong
► Cryogenic plant building construction is advancing well
► Project is focused on execution:

**PIP-II is blazing a new trail in major accelerator projects in DOE/SC with international partners**
**800 MeV SRF Linac**

Cryoplant 2.5kW @ 2K

H- Ion source

RFQ

CDS

HWR 162.5 MHz

Single Spoke 1

pSSR1 X 2

325 MHz

Beam energy 800 MeV

Beam current 2 mA

CW-compatible

**Superconducting**

Elliptical

HB650 X 4

650 MHz

Elliptical

LB650 X 9

650 MHz

Single Spoke 2

SSR2 X 7

325 MHz

**Room Temperature**

**PIP-II is the world’s highest energy and highest power CW proton linac, and the first U.S. accelerator project to be built with major international contributions**
PIP-II Injector Test (PIP2IT) – Testbed for PIP-II Technologies

PIP2IT is a near-complete Front End of PIP-II with first two cryomodules.
PIP-II Cryogenic Plant Building – 6 June 2021

✓ Construction contract award – July 2020
✓ Construction ~60% complete – June 2021
• Authorization for Use and Possession – December 2021
Linac Complex Design is Complete – Ready to Execute Civil Construction

Linac Complex design enables PIP-II multi-user capability and upgrade/expansion to 2 GeV linac in support of 2.4 MW program
Equity, Diversity, and Inclusion (EDI)

- Fermilab is inclusive, transparent and open to discussion and recommendations from every level of the organization and user community
- Fermilab culture is very much like a university physics department
- The EDI Task Force broadly represents the lab. It has endorsed a shared leadership model, that was recommended by the APS TeamUp Report. Everyone has the opportunity to have their voices heard. This takes time.
- Led by Sandra Charles, Chief EDIO
Diverse Leadership Team

Nigel Lockyer
Laboratory Director

Joe Lykken
Deputy Director for Research

Kate Gregory
Chief Operating Officer

Chris Mossey
Deputy Director for LBNF/DUNE-US

Lia Merminga
PIP-II Project Director

Anna Grassellino
SQMS Center Director

Hema Ramamoorthi
Chief of Staff and Special Assistant for Intl. Engagements

Sandra Charles
Chief Equity, Diversity and Inclusion Officer

Kevin Pitts
Chief Research Officer

Jacqueline Bucher
Head of the Office of Communication

Doug Glenzinski
Chief Project Officer

Anju Jain
Chief Human Resources Officer

Amber Kenney
Chief Safety Officer

Mike Lindgren
Chief Accelerator Officer

Alison Markovitz
Chief Strategic Partnerships Officer

Vanessa Peoples
Chief Financial Officer

Alex Romanenko
Chief Technology Officer

Liz Sexton-Kennedy
Chief Information Officer
Chief of EDI Sandra Charles creating New Workforce Pipelines

- PIP-II ASPIRE Fellowship
  (Accelerator Science Program to Increase Representation in Engineering)
- LBNF/DUNE Far Site Internship
- SQMS Internship (17 students)
- Carolyn B. Parker Fellowship
- Vet Tech Program (Department of Labor Award)

- Plus, long established intern programs

Current S&T Workforce Demographics

- White: 77%
- Asian: 13%
- Black or African American: 4%
- Hispanic/Latino: 6%
- Native Hawaiian or Other Pacific Islander: 0%
- Two or More Races: 0%

Targets
- Black/AA representation to 15%
- Hispanic/Latino to 18%
A DOE National Quantum Information Science Research Center

20 Institutions
>250 Collaborators

Fermilab
rigetti
Northwestern University
AMES LABORATORY
Northwestern University
NASA
Stanford University
INFN
University of Illinois
Rutgers
University of Colorado
University of Arizona
Goldman Sachs
Lockheed Martin
JANIS
Unitary Fund
Building a diverse quantum workforce: 22 new SQMS hires at Fermilab

37% of the new SQMS hires are women and URM, eight different nationalities, QIS materials, devices, physics/sensing, algorithms experts
Building a diverse quantum workforce: SQMS schools, internships, fellowships

SQMS Summer Internship for undergraduate students
18 students, more than 50% URM and women
https://internships.fnal.gov/sqms-quantum-undergraduate-internship/

New Carolyn B. Parker postdoctoral fellowship for under-represented minorities
Currently accepting applications
https://news.fnal.gov/2021/05/fermilabs-quantum-center-announces-carolyn-b-parker-fellowship-for-postdocs/

SQMS QIS Summer School hosted by the Galileo Galilei Institute (Florence)
84 student Admitted, 7 different countries
https://www.ggi.infn.it/showevent.pl?id=402
Quantum Internet

- Now commissioning the second node of the Fermilab Quantum Network, and the Illinois Express Quantum Network
- Collaboration has already achieved the world’s first sustained high-fidelity quantum teleportation system
- Supported by DOE HEP QuantISED, ASCR, and BES
- Collaborations with universities, industry, and other labs towards a Quantum Internet
Hiring in Computing: March 2020 - March 2021

Field is transitioning to more AI/ML and using HPC

Core Computing Division, Scientific Computing Division and the Office of the Chief Information Officer

Aleksandra Ciprijanovic
Research Associate

Yesenia Gonzales
Computer Security Analyst

Sharwari Ramesh Joshi
Applications Developer

Gauri Pradhan
Artificial Intelligence Associate

Jonathan Daniel
Eisch
Applications Physicist

Benjamin Hawks
Artificial Intelligence Associate

Balu Kattera
Application Developer & Systems Analyst

Carlos Salazar
Communications Associate

Juan Favela
Network Analyst

Travis Hountondji
Systems Administrator

Jovan Pavle Mitrevski
Applications Physicist

Divya Sirikonda
Detector Electronics Engineer

Alan Thomas Varghese
IT Associate

Tammy Walton
Associate Scientist
New Theory Division

• Marcela Carena will lead the new division, consisting of
  – three departments: astroparticle, particle, and quantum
  – 18 scientists, 22 postdocs, 10 theory associates, 5 students and 5 emeriti
• National programs: Neutrino Theory Network, USQCD, QuantISED Theory Consortia
Future Colliders Group formed

• Develop Fermilab’s engagement plans in future collider projects,
• Develop roadmap for further (design) studies R&D for future colliders
  • Work with US universities and other national labs
  • Near-term focus: robust proposals as input to Snowmass
• Members: Pushpa Bhat (Lead), Sergo Jindariani (Deputy), liaisons from divisions
Fermilab earned media top coverage
Fermilab is the most followed national lab on YouTube, Facebook, LinkedIn, and Twitter.

**Fermilab is the second most followed lab on Instagram, trailing NREL by about 3000 followers.
Recent Award Winners…. Congratulations to all

- **Farah Fahim**
  2021 DOE Early Career Research Award
  Front-end implementation of AI/ML neural networks for on-detector radiation-hard edge compute

- **Brian Nord**
  2021 DOE Early Career Research Award
  Simulation-based inference for cosmological parameter estimation and discovery

- **Jonathan Jarvis**
  2020 DOE Early Career Research Award
  Development of next-generation particle beam cooling and control with optical stochastic cooling

- **Robert Ainsworth**
  2020 DOE Early Career Research Award
  Ensuring bunch stability in multimegawatt accelerated particle beams

- **Steve Brice**
  2021 Secretary’s Honor Award

- **Joe Lykken**
  2021 Secretary’s Honor Award

- **Aria Soha**
  Servant Leadership Award, Society of Hispanic Professional Engineers

- **Jeny Teheran**
  2020-21 Excellence in Leadership Award, Society of Hispanic Professional Engineers

- **Josh Frieman**
  2021 AAS Fellow

- **Anna Grassellino**
  2020 APS Fellow

- **Kevin Burkett**
  2020 APS Fellow

- **Panagiotis Spentzouris**
  2020 APS Fellow

- **Jay Theilacker**
  Samuel C. Collins Award

- **Javier Tiffenberg**
  2021 New Horizons in Physics Prize co-awardee
  Advances in the detection of sub-GeV dark matter, especially in the SENSEI experiment
  2020 URA Early Career Award

- **Juan Estrada**
  2020 American Physical Society Division of Particles and Fields Instrumentation Award
  Creation and development of novel applications for charge-coupled devices
Vibrant Fermilab Users Executive Committee and recent advocacy efforts

UEC members are elected for a two-year term to support users in their research and their relationship with the lab.

- This year's HEP advocacy effort had over 70 participants, including delegates from US LUA, SLUO and APS DPF, who organize the effort alongside UEC.
- Some key themes included training the next generation STEM workforce, everyday applications of HEP, and equity, diversity and inclusion efforts – including VetTech
- Sponsored by URA.

- Thanks to entire HEP advocacy team.
Thanks to UEC for organizing this meeting and to DOE and NSF for their support