



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, 1st and 2nd 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



Secretary of Energy
Jennifer Granholm

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



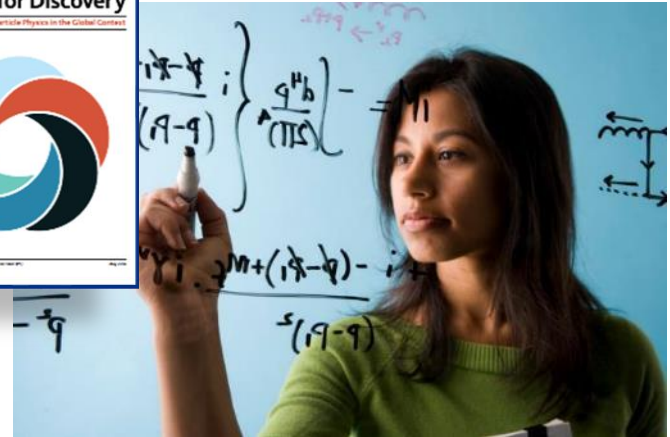
Dark matter



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



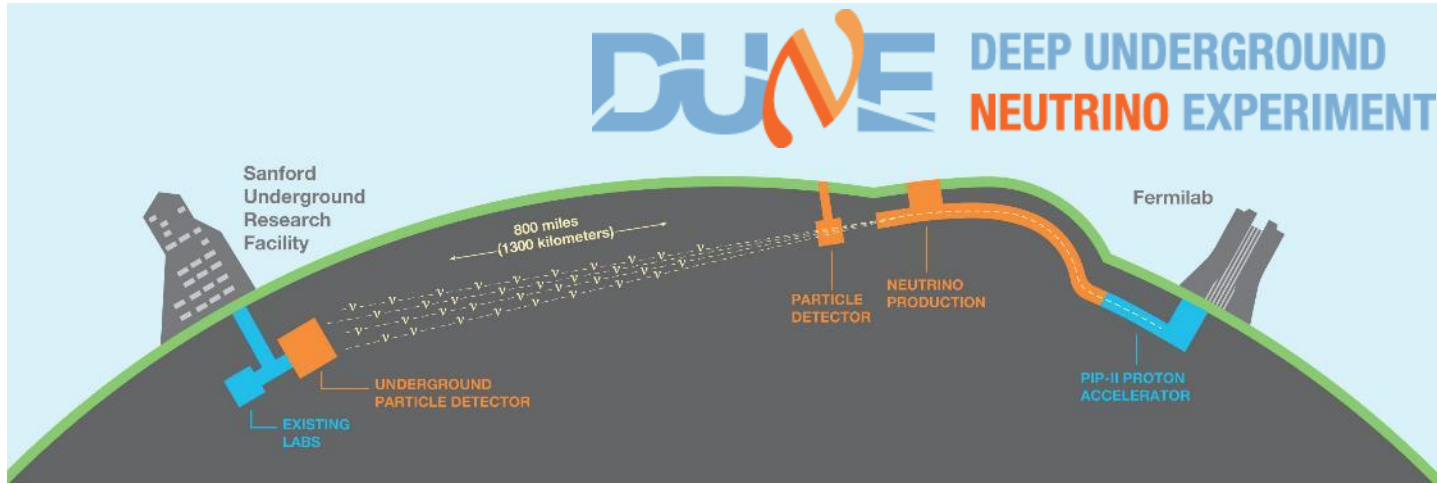
P5 endorsed a global particle physics program

- 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

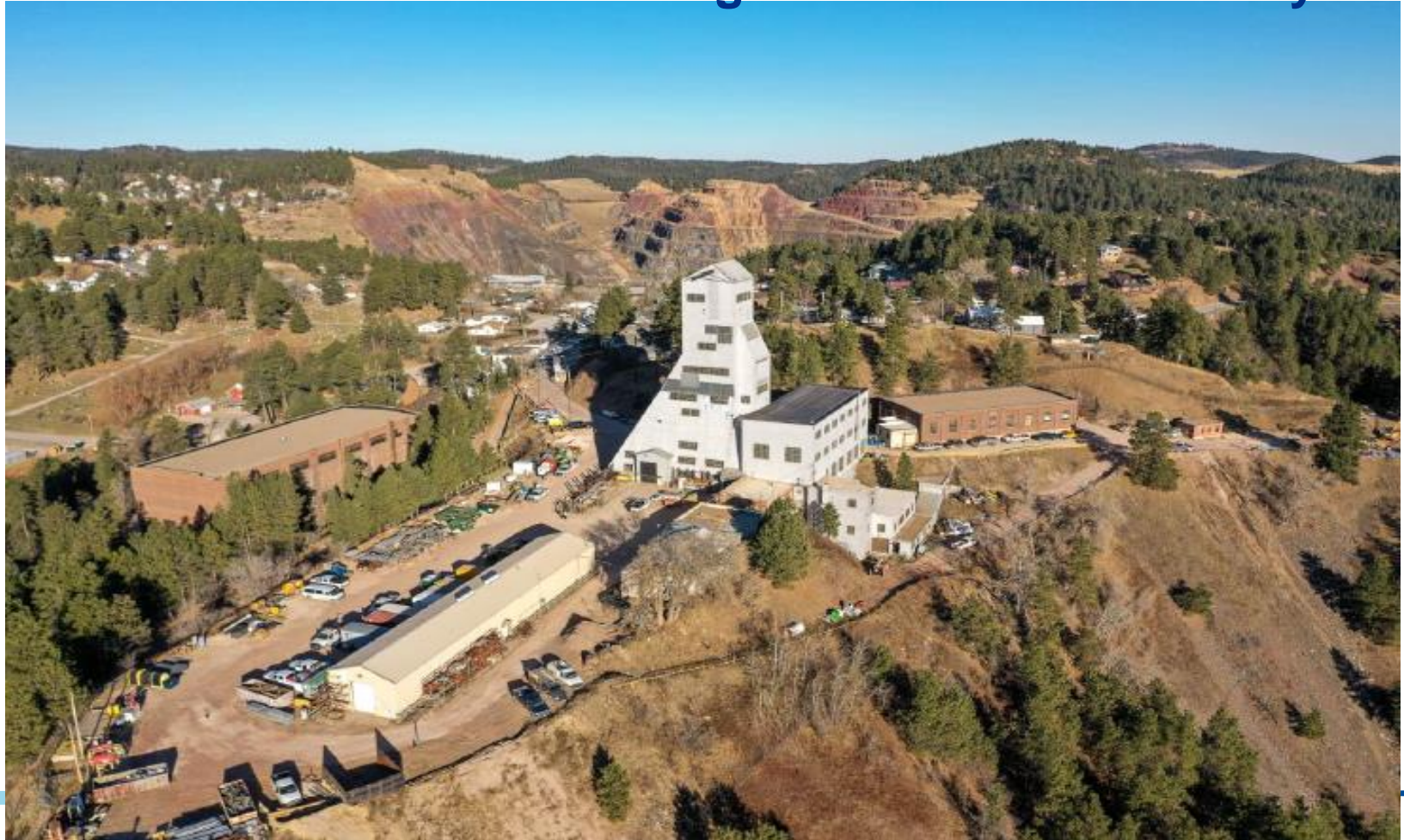
Currently: 1,347 collaborators from 204 institutions in 33 countries (plus CERN)



- **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

Homestake Mine: Sanford Underground Research Facility



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



"Jumbo" drilling blasting hole

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

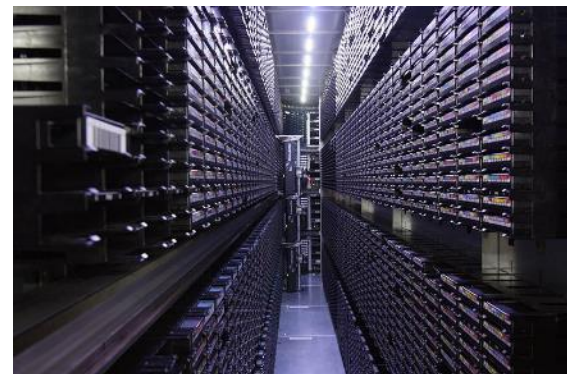
- Science goal
 - Study the Higgs, search for new particles
- Recent Achievements
 - 1039 collider papers as of April 4th, 2021



- Nb3Sn hi-field magnets with LBNL and BNL



New Wilson Fellow, AI/real-time intelligent detectors

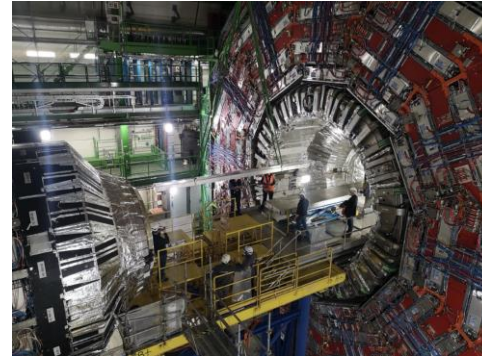


- Mass storage is foundation of Fermilab's computing capability
- CMS 1.6 exabytes for HL-LHC by 2030 at Fermilab

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

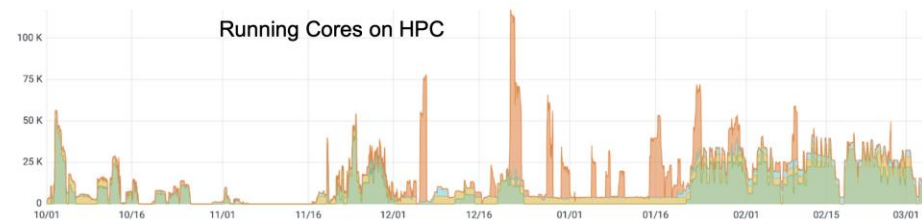


CMS upgrades moving ahead:

- 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

$\times 10,000$ sensitivity improvement to $\mu\tau$ N $\rightarrow e\tau$ N

Will be world leading lepton violation experiment

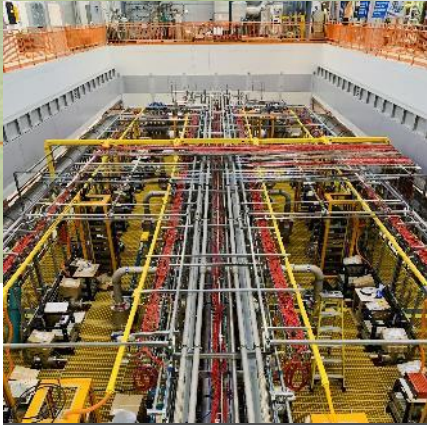


Magnets from Italy all delivered and work well



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 ν per year



ICARUS Vessel with Cryogenics and detector electronics installation



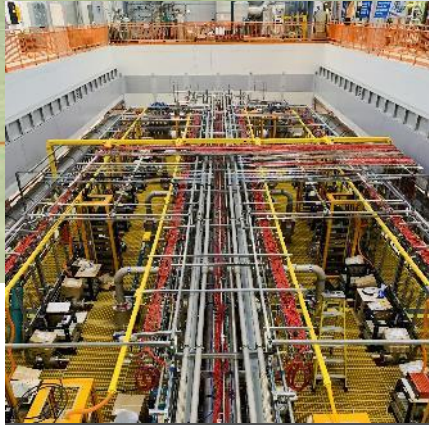
Nobel Prize winner Carlo Rubbia leads ICARUS and invented liquid argon as a detection medium



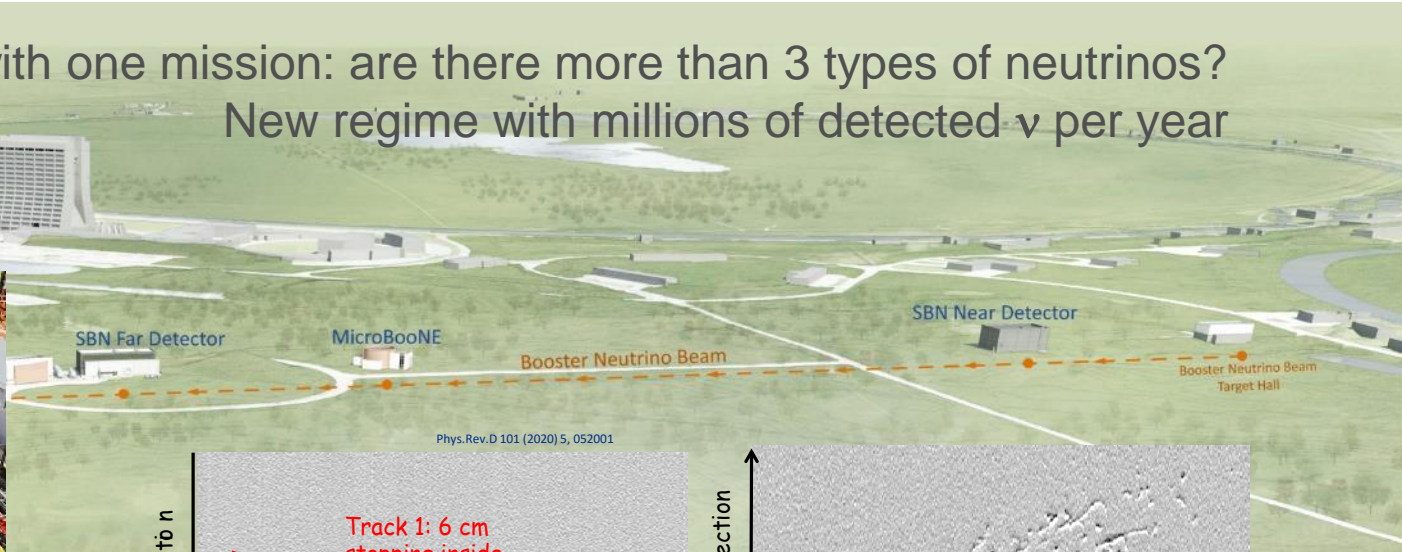
SBND Building with Cryostat Steel Structure

Short Baseline Neutrino Program: ICARUS detector started

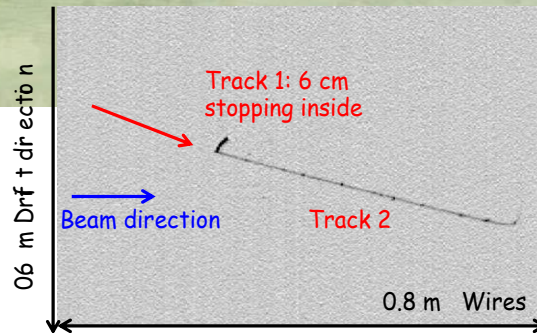
Three detectors with one mission: are there more than 3 types of neutrinos?
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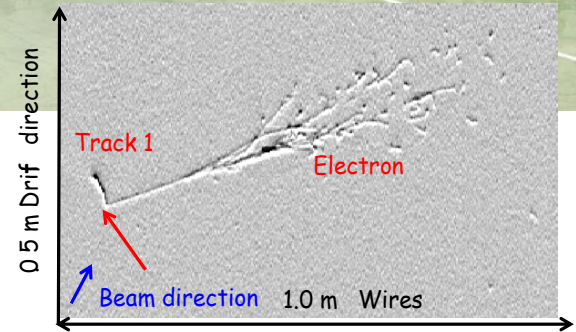
ICARUS Vessel with Cryogenics and detector electronics installation



Phys.Rev.D 101 (2020) 5, 052001



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

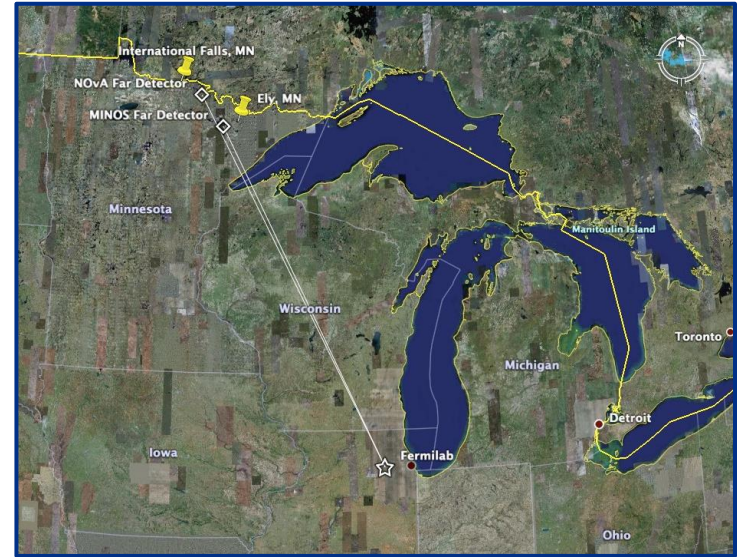


Event display of an ICARUS NuMI νe interaction candidate

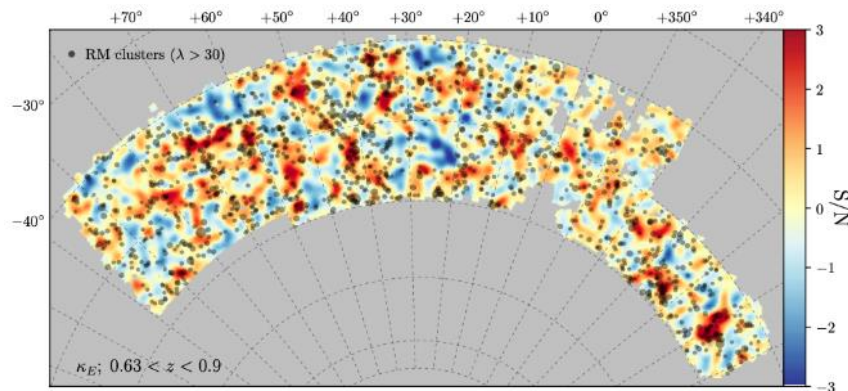
NOvA Science

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

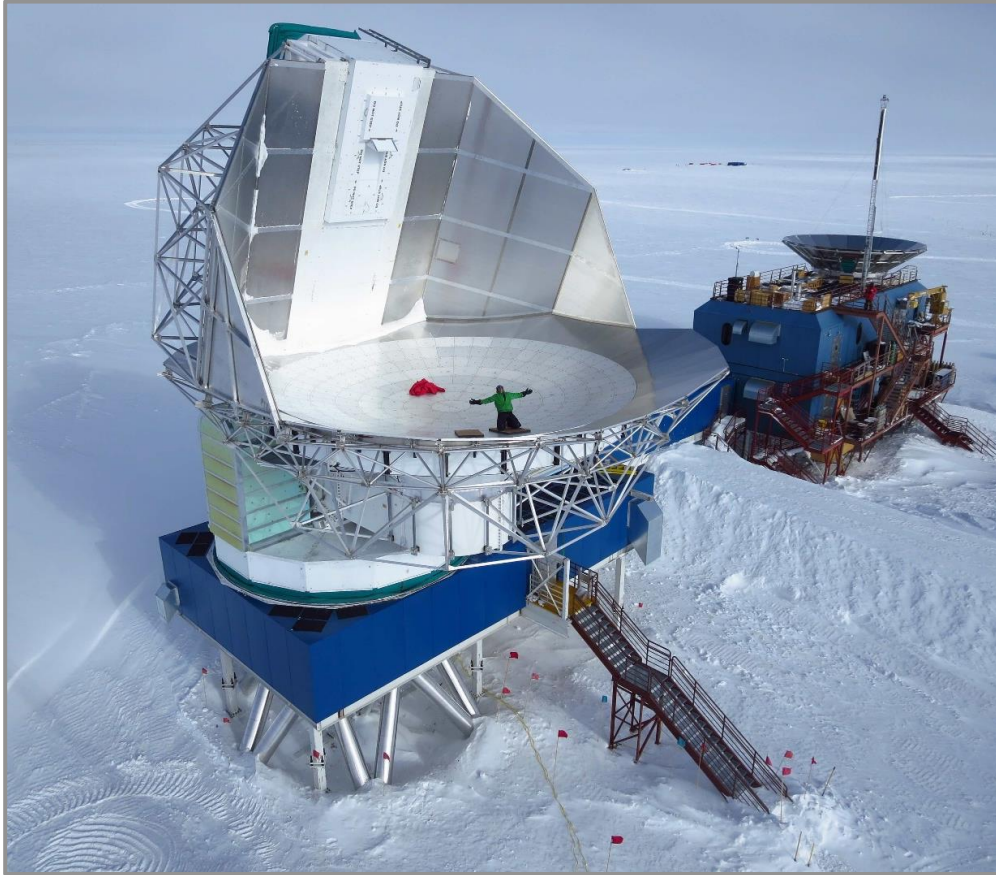


World's leading dark energy telescope...3 (of 6) years released



- 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



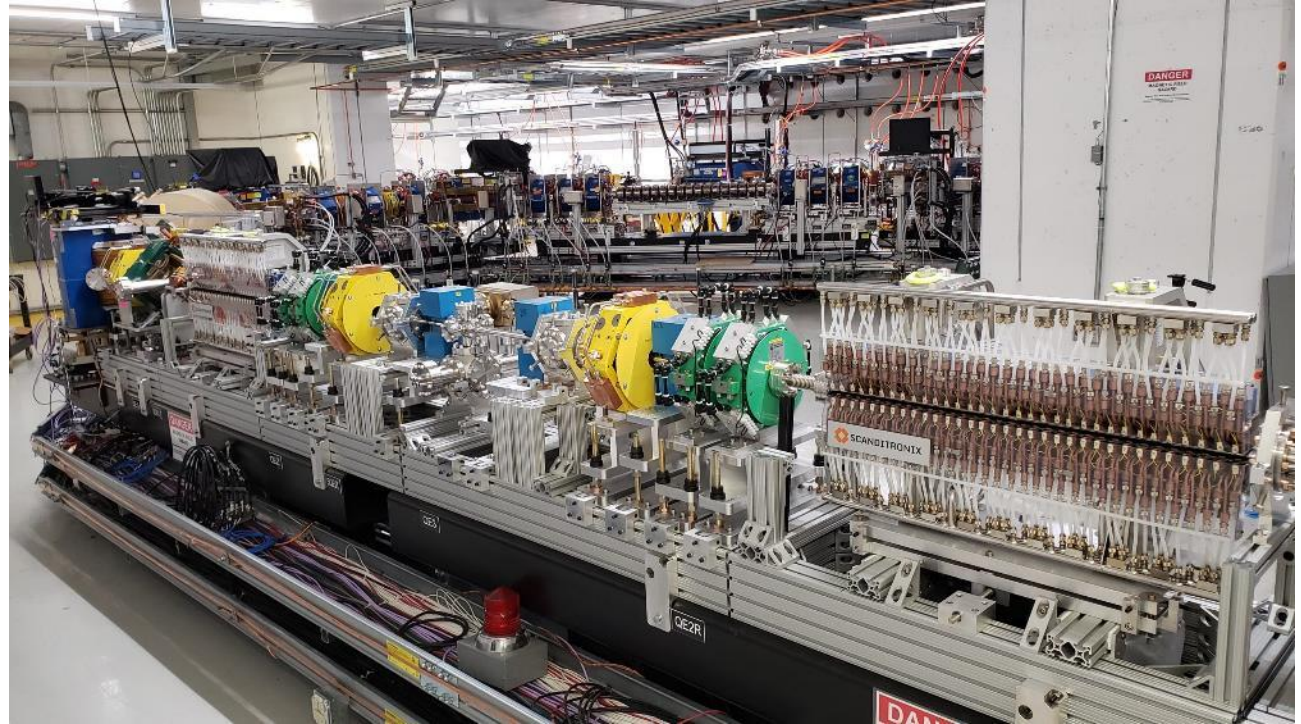
SPT-3G camera (16,000 detectors), and operating at South Pole

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

Portable Industrial Accelerator

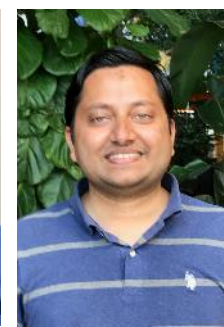
- Fermilab researchers are making substantial steps towards compact superconducting accelerators for applications like wastewater treatment, medical isotope production



Charles Thangaraj

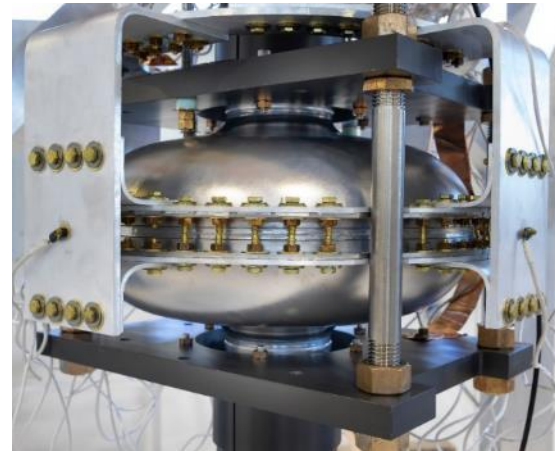
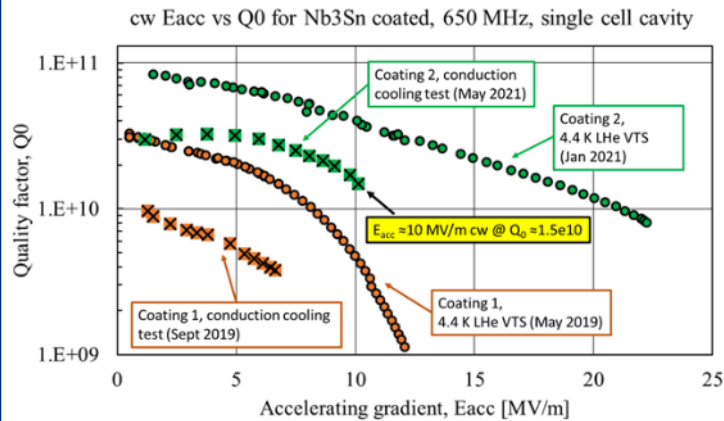


Sam Posen

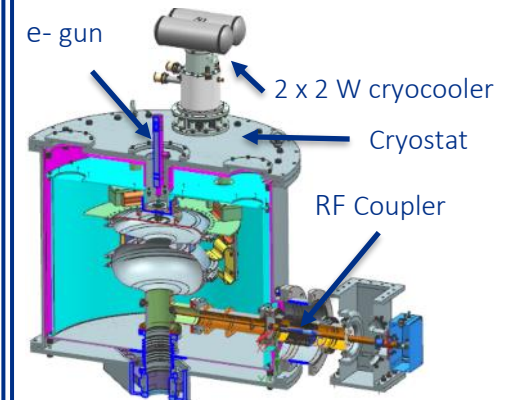


Ram Dhuley

Current result: Nb₃Sn cavity + cryocooler + conduction cooling



Next step: compact accelerator prototype



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 R. Bloomberg “The most extraordinary event of the year” - [Michael Bloomberg](#)

May 7, 2021, 4:00 AM CDT

VELOCITA HEFFERNAN IDEAS 05.10.2021 07:00 AM

WIRED

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.



Mark Hamill
@HamillHimself

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

The New York Times @nytimes - Apr 7

Breaking News: Evidence is mounting that a tiny subatomic particle is being influenced by forms of matter and energy that are not yet known to science but which may nevertheless affect the nature and evolution of the universe. [nyti.ms/3uzX0cb](#)

Biden Tax Plan Aims to Curtail Use of Havens

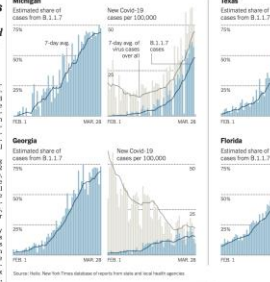
Loophole Has Enriched Global Corporations

By JIM TAKERSLEY and KLAN KAPPELBERG

WASHINGTON — Large companies like Apple and Microsoft in Spain have long employed complicated maneuvers to reduce or eliminate their tax bills by shifting income on paper between related accounts and shell entities, while driving down corporate tax receipts for the federal government.

Contagious Variant Is Fueling Surge in Infections Across the U.S.

Genetic studies suggest new strain of the coronavirus may be spreading faster than B.1.1.7 variant, Page A1



ISIS and African Militants Join in a Marriage of Convenience

By CHRISTINA GOLDSTEIN and ERIC SCHEIDT

CONGOLENESE — The Islamic State's self-declared caliphate in northeastern Iraq, Afghanistan and elsewhere has been fighting for years in the Horn of Africa, where analysts say it has forged alliances with local militia groups in Syria and Iraq, and with the Islamic State's self-declared caliphate in northeastern Iraq, Afghanistan and elsewhere.

New York to Provide \$2.1 Billion For Undocumented Immigrants

By ANNE CORRIAN and LES FERRE-ANDRE

NEW YORK CITY — A year ago, a bid to exclude undocumented immigrants with a felony killing conviction from the city's public housing program was rejected by the city's Board of Social Services.

United States Senate WASHINGTON, DC 20510

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

A Particle's Tiny Wobble Could Upend the Known Laws of Physics

By ALL WATKINS



A view of the Fermilab National Accelerator Laboratory in Illinois is used to study subatomic particles.

The results, the first from an experiment called Muon g-2, agreed with earlier experiments from Brookhaven National Laboratory in 2001 that were viewed with skepticism.

Advertisers Fleeing Pandemic Strain the West's Rescue Teams

By ALL WATKINS
DENVER — Rescue teams and food banks are the women who get food and aid for the homeless, and they are struggling to keep their doors open as the pandemic strains their budgets.

The results, the first from an experiment called Muon g-2, agreed with earlier experiments from Brookhaven National Laboratory in 2001 that were viewed with skepticism.



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-2 Performance Baseline – Dec 2020: TPC \$978M (+\$310M IKC), Early CD-4 Dec 2028
 - ▶ 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***



Main Injector

Transfer Line

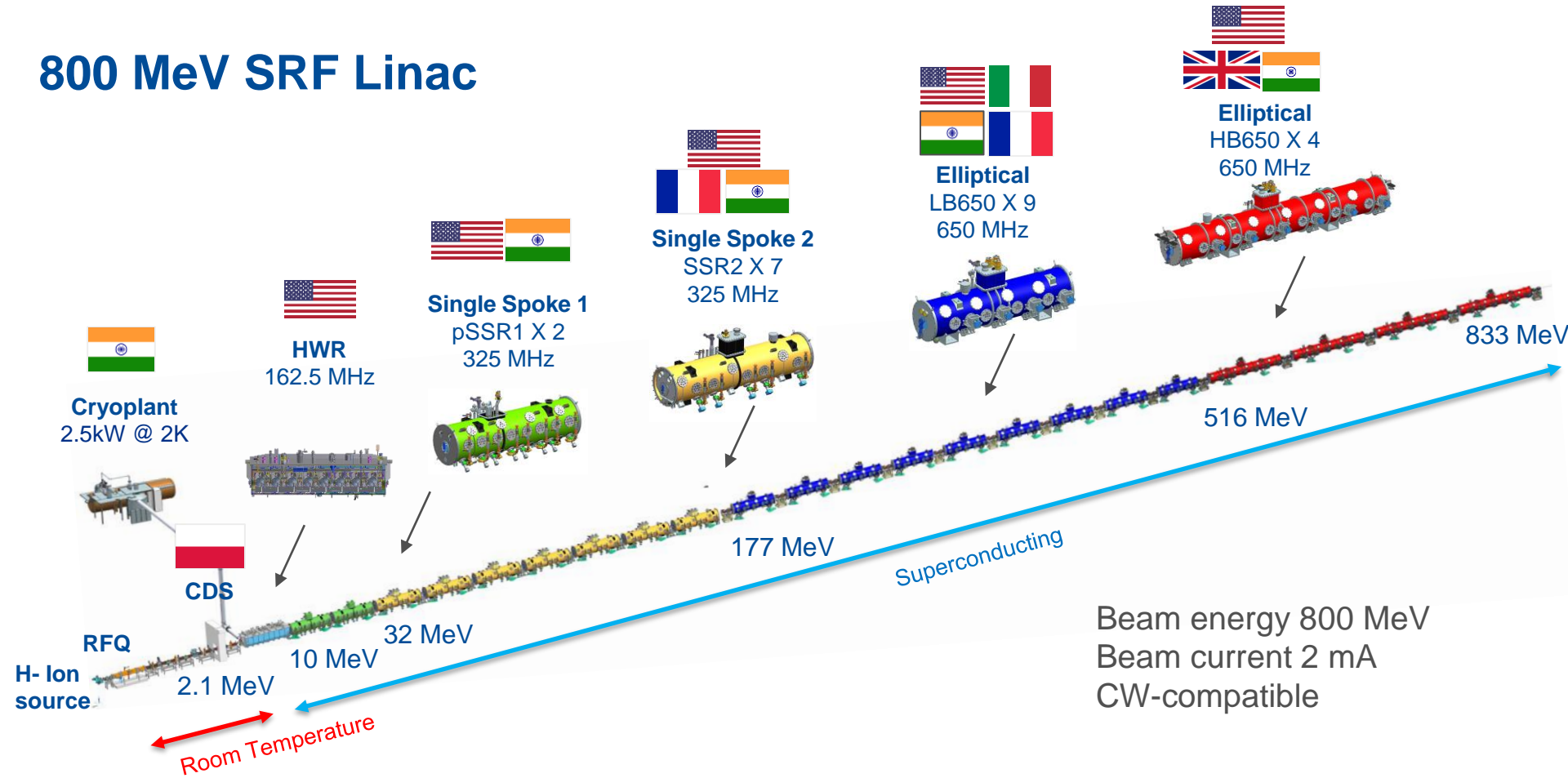
PIP-II

SRF Linac

Booster



800 MeV SRF Linac

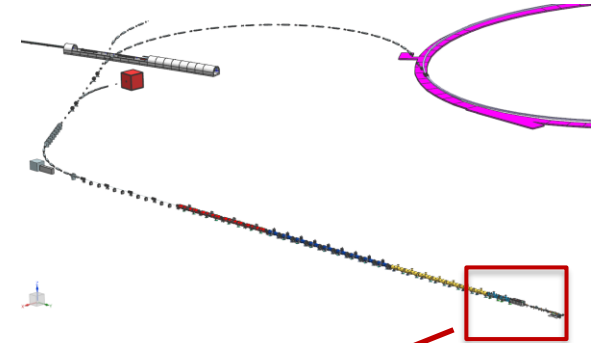


PIP-II is the world's highest energy and highest power CW proton linac, and the first U.S. accelerator project to be built with major international contributions

PIP-II Injector Test (PIP2IT) – Testbed for PIP-II Technologies



PIP2IT is a near-complete Front End of PIP-II with first two cryomodules



Ion source and LEBT
30 keV

RFQ

MEBT
2.1 MeV

HWR

10 MeV

SSR1

HEBT
22 MeV

Dump



Argonne
NATIONAL LABORATORY



BERKELEY LAB
Bringing Science Solutions to the World

Fermilab

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



<https://app.truelook.com/?u=fc1599677013#tl> live
<https://app.truelook.com/?m=16002500832205565503647>



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 Meringa
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



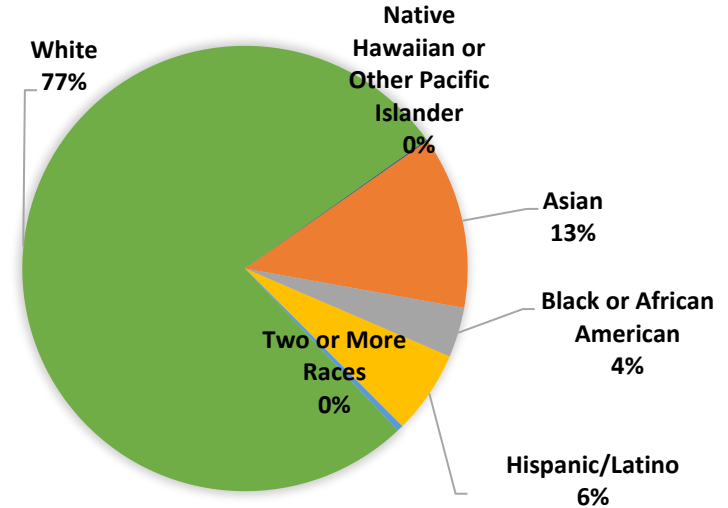
Liz Sexton-Kennedy
Chief Information
Officer

Chief of EDI Sandra Charles creating New Workforce Pipelines

- PIP-II ASPIRE Fellowship
(**A**ccelerator **S**cience **P**rogram to **I**ncrease **R**epresentation in **E**ngineering)
- 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



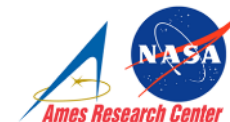
Targets

- Black/AA representation to 15%
- Hispanic/Latino to 18%



A DOE National Quantum Information Science Research Center

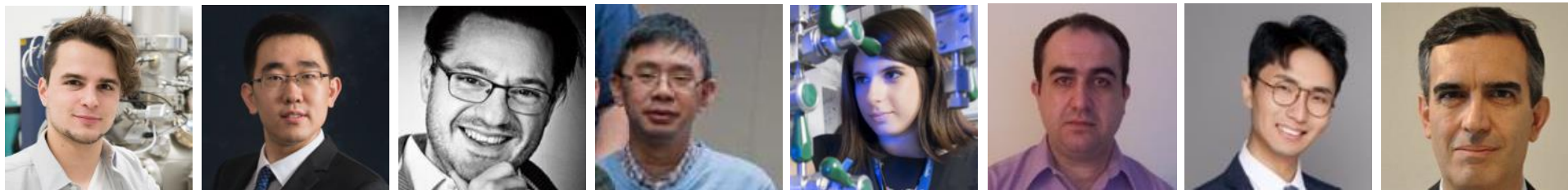
20 Institutions
>250 Collaborators



Unitary Fund

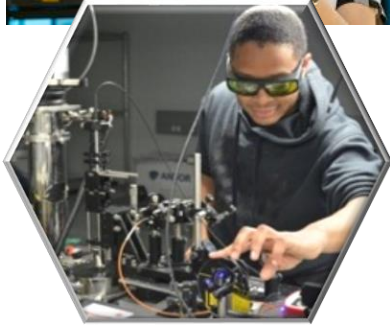


Building a diverse quantum workforce: 22 new SQMS hires at Fermilab



*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

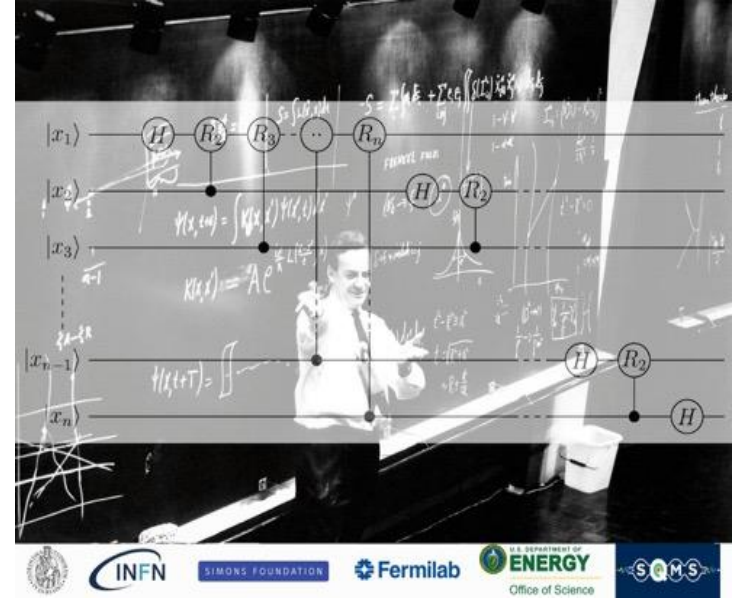
<https://internships.fnal.gov/sqms-quantum-undergraduate-internship/>



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



**Report of the DOE
Quantum Internet
Blueprint Workshop**

**From Long-distance Entanglement to
Building a Nationwide Quantum Internet**

February 5-6, 2020

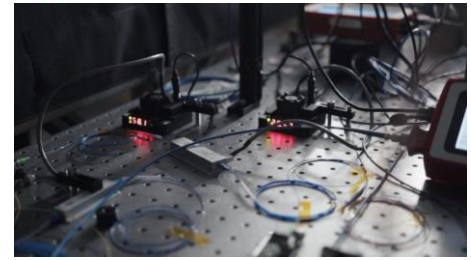


Tektronix Photon Spot
TeraXion UNIVERSITY OF CALGARY
oz Optics
HighFinesse Laser and Electronic Systems
AdvR Quantum Opus



Caltech JPL Jet Propulsion Laboratory California Institute of Technology
AT&T HARVARD
NORTHWESTERN UNIVERSITY
Fermilab

- 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



**Alan Thomas
Varghese**
IT Associate



**Jonathan Daniel
Eisch**
Applications Physicist



Benjamin Hawks
Artificial Intelligence
Associate



Balu Kattera
Application Developer
& Systems Analyst



Carlos Salazar
Communications
Associate



Tammy Walton
Associate Scientist



Juan Favela
Network Analyst



Travis Hountondji
Systems Administrator



**Jovan Pavle
Mitrevski**
Applications
Physicist



Divya Sirikonda
Detector Electronics
Engineer

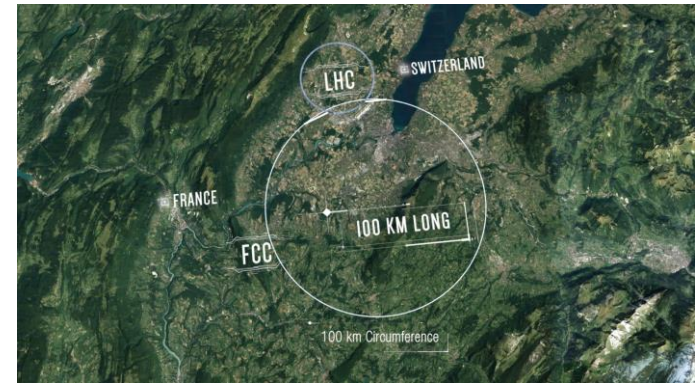
New Theory Division

- 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

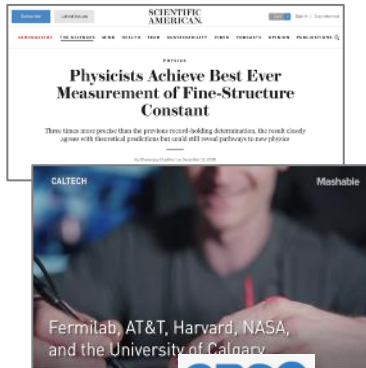
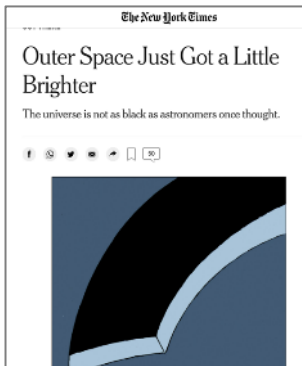


Future Colliders Group formed

- 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



Social Media

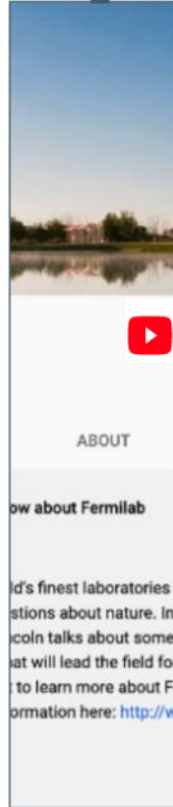


4.3 Million Views

Inspiring the next-generation STEM workforce

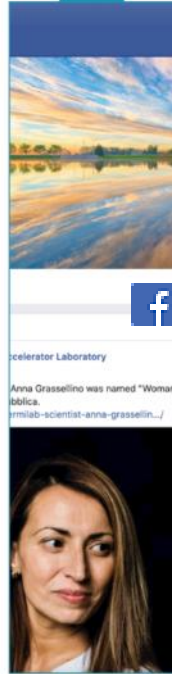
545K*

1



103K*

2



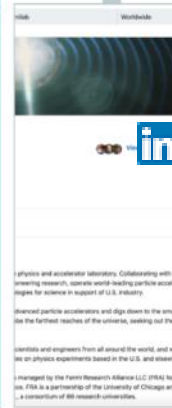
83K*

3



33K

4



30K **

5



*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



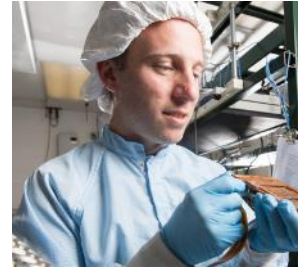
Joe Lykken
 2021 Secretary's Honor Award



Aria Soha
 Servant Leadership Award, Society of Hispanic Professional Engineers



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



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



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



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.



2020-2021 UEC group photo



Thanks to UEC for organizing this meeting
and to DOE and NSF for their support

