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Scientific Computing For Users

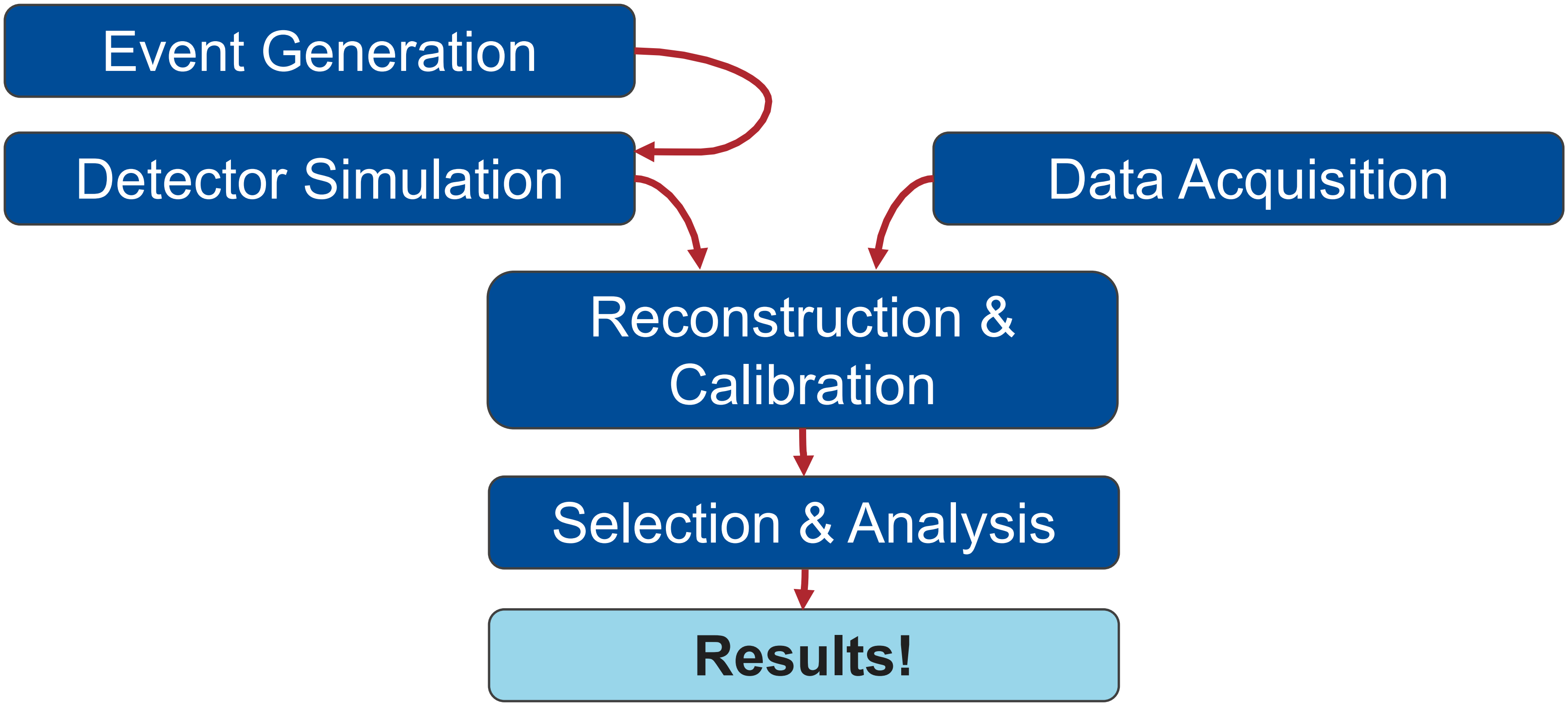
Wesley Ketchum

51st FNAL Users' Meeting

20 June 2018

What is Scientific Computing?

- The computing we use to perform our science!



What is Scientific Computing *Division* ?

- *Our goal: work with experiments to develop and support the computing solutions we need to get our physics results*
  - Online and offline
  - Software and hardware
  - Current and future experiments

- We are a mix of scientific, computing, and engineering professionals

- We are part of the diverse user community and members of experiments at the energy, intensity, and cosmic frontiers

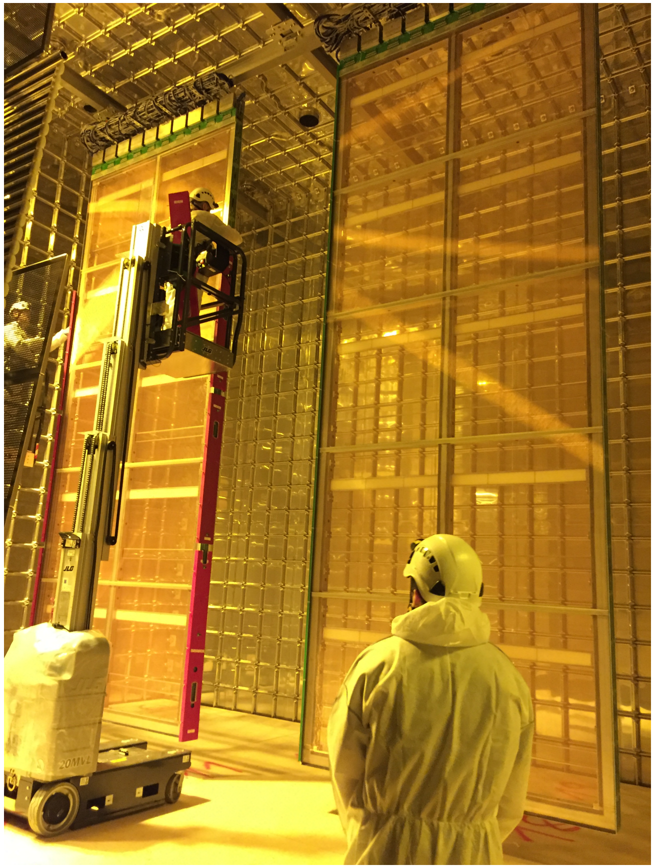
About me

- Associate Scientist in SCD
  - Real-time systems engineering department
- I’m a neutrino physicist
  - Focusing on SBN searches for non-standard oscillations
- I also work on DAQ systems
  - Focusing on development, commissioning, and operation of DAQs for LArTPCs

Data Acquisition

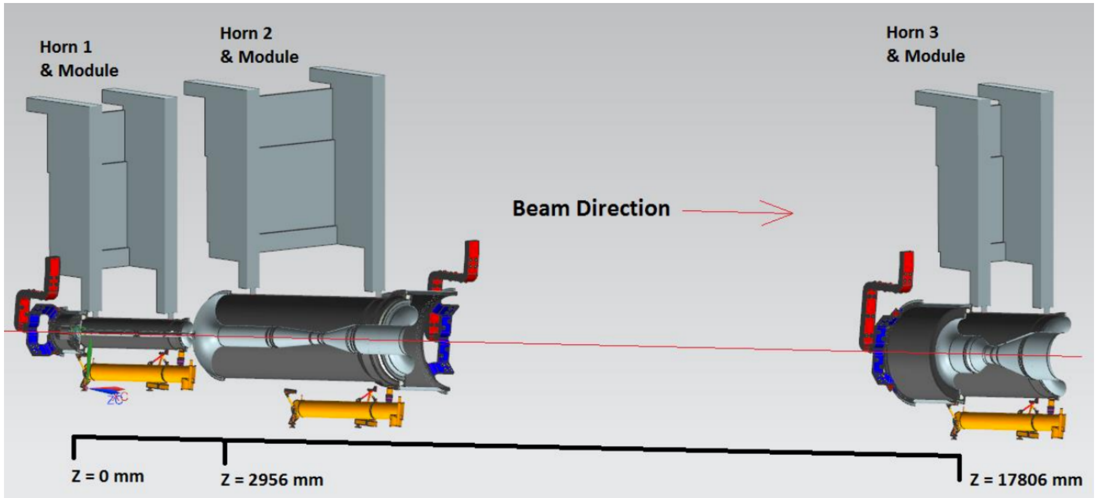
- Modern HEP experiments have a broad array of needs:
  – Interaction and readout rates
  – Online filtering/event-selection
  – Event data size
- Working with experiments to develop hardware and software for acquiring, collating, and storing, and monitoring data from detectors
  – *artdaq*: common DAQ framework, used in DarkSide, LArIAT, ProtoDUNE, SBN, Mu2e, and more!
  – *Off-the-shelf DAQ (otsdaq): provide simple interfaces to devices → supporting test-beam DAQ at FNAL!*

ProtoDUNE

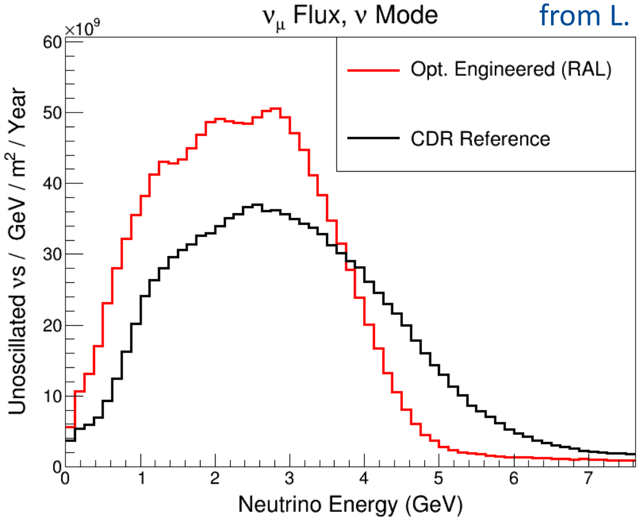


Simulation

- Work with experiments to develop, support, and improve simulation software (e.g. Synergia, Pythia, GENIE, GEANT4)
- Example: *How do we optimize beam design to maximize sensitivity to CP violation in DUNE?*
  - ➢ Design change: 3 focusing horns, longer target
  - ➢ Increases neutrino flux in energies important for oscillations!
    - ➢ *Equivalent to ~70% increase in mass for some physics goals*

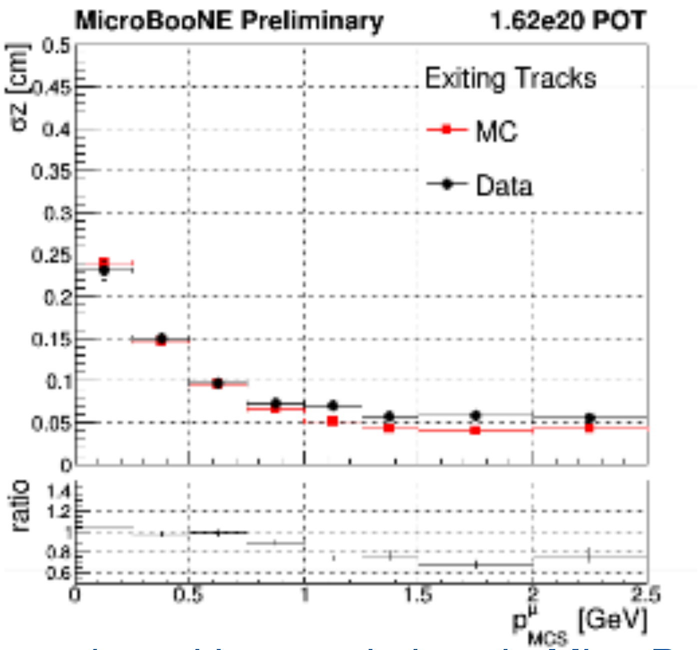


from L. Fields



Reconstruction and calibration

- Develop and support common toolkits for experiments, like…
  - *art* event-processing framework
  - *ConDB* database for calibrations and detector/beam conditions
  - *LArSoft* package for LArTPC simulation, reconstruction, and analysis
- Work with experiments to develop, improve, and optimize algorithms
  - Example: improved Kalman-filter-based track fitting in LArSoft and data-driven resolution measurements

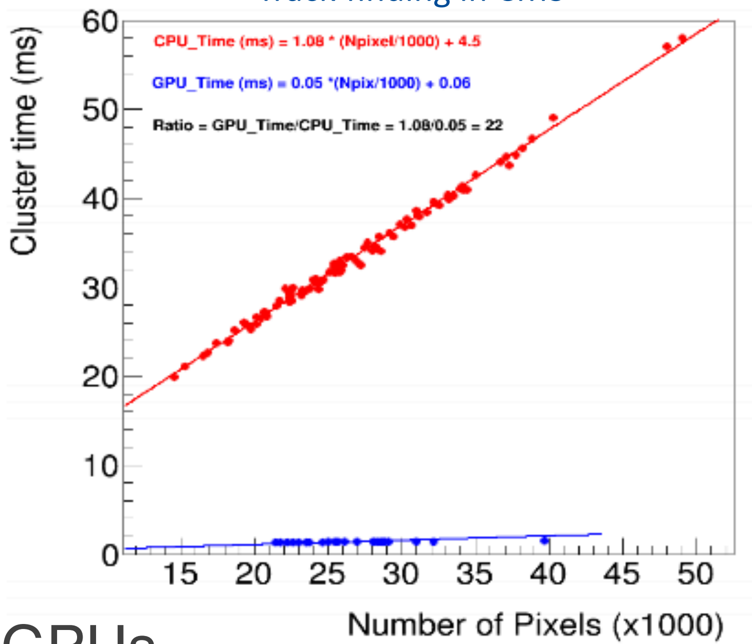


Probing track position resolutions in MicroBooNE

Adapting algorithms for new architectures

- Modern architectures provide more computing cores which allow more parallelization
- We are working with experiments to update and improve software to make better use of new architectures
  - e.g. multi-threaded *art*
- Example: *How will we improve particle tracking and pattern recognition in high-occupancy environments like HL-LHC?*
  - Current algorithms don't scale well to larger pileup
  - Working with CMS collaborators to develop new approaches → using GPUs

Track-finding in CMS

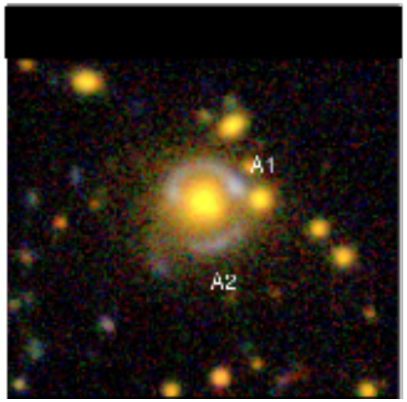


F. Pantaleo, CHEP2016

Machine Learning

- Convolutional neural networks becoming critical analysis techniques in HEP
- Working with experiments to develop tools, applications, and share knowledge
- Example: *How can we find more strong lenses in sky surveys?*
  - Currently rely on human supervision of algorithms
  - Collaborating with universities to build CNNs to detect and measure, lensed objects → dramatically increase our sample of lenses

Lensed galaxy



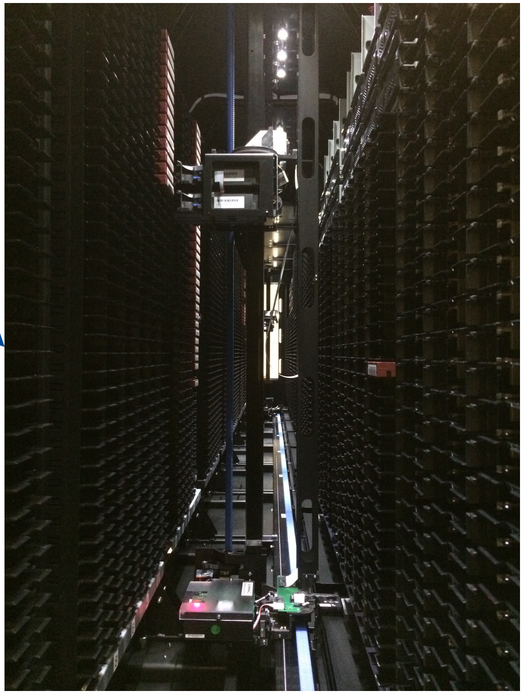
Lens type

	Galaxy	Quasar	SNe
Today (all)	1000	<50	2
DES	2,000	120	5
LSST	120,000	8,000	120

Nord+2016; Collett+2015; Gavazzi+2008; Oguri+Marshall, 2010

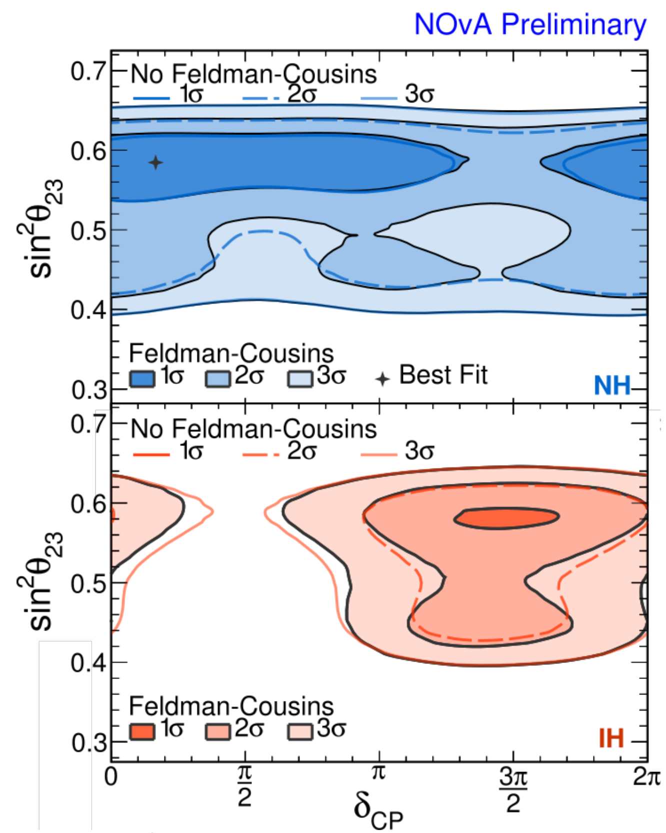
Computing Facilities

- We provide and maintain resources for experiments at Fermilab and the LHC
  - ~65 thousand total computing cores
  - ~50 PB of disk storage and ~150 PB of tape storage
- Work with users and experiments to support and maintain servers, networking, and other infrastructure



Using all that computing

- We develop and support common tools to enable **<u>big</u>** computing
  - Tools like *jobsub*, *File Transfer Service, SAM, IFDH, CVMFS*
- Work with institutions across the world to access more computing in the *Open Science Grid*
  - Last year ~100M opportunistic CPU hours!
- Example: *NOνA computing for anti-neutrino appearance/disappearance results*
  - ~14M CPU hours (2 million jobs!) over 11 months for simulation, reconstruction, and data selection
  - *<u>~20M CPU hours in ~2 days for final analysis using NERSC via HEPCloud</u>*

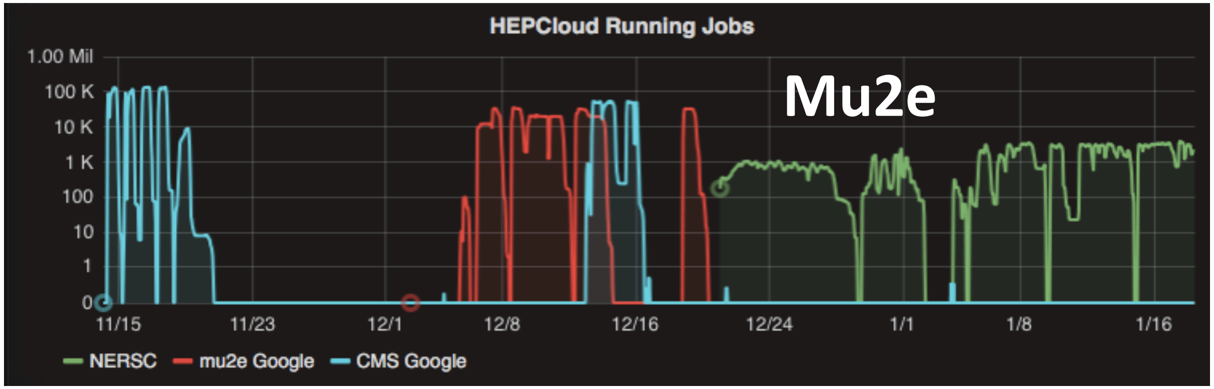


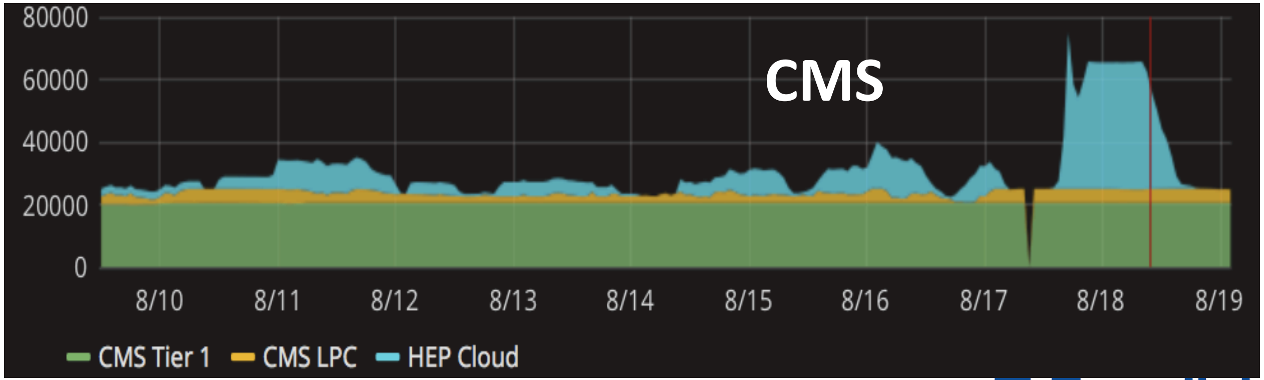
see D. Doyle's New Perspectives Talk!

HEPCloud

- We are working with the community to develop the tools to enable access to diverse set of computing resources
  - "Conventional", high-performance computing, commercial resources, etc. in a common interface and automated routing

Working with experiments to roll out production system this year!

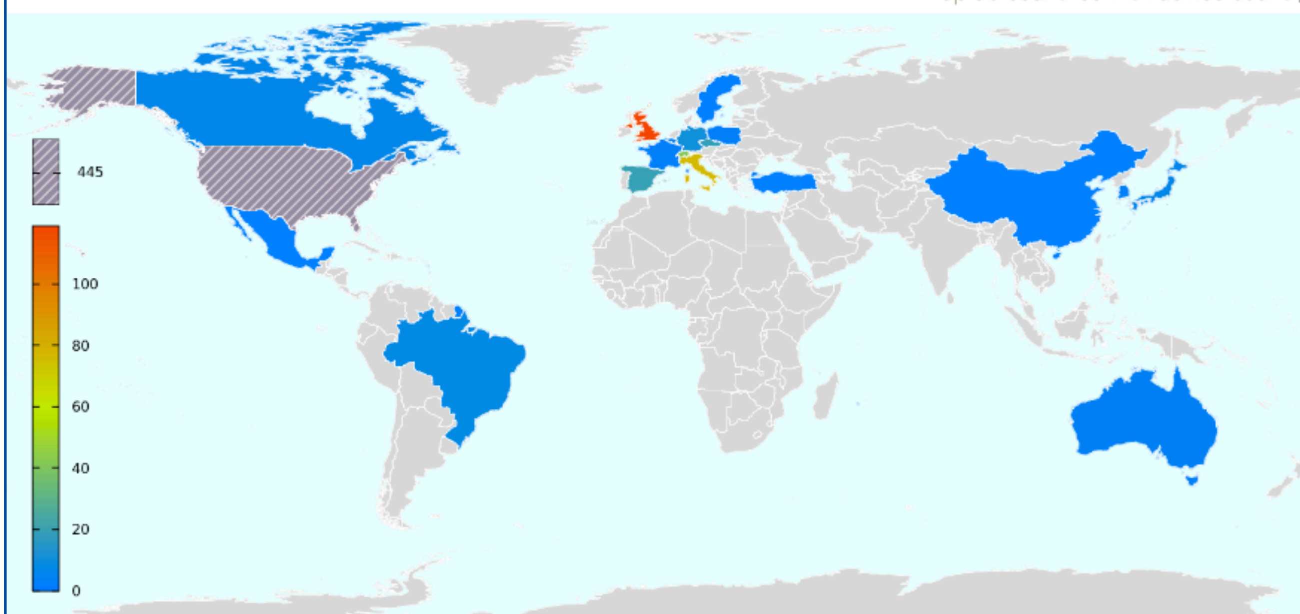




Improving services to users

- Working to improve our computing services to our global user community
- Example: *eduroam WiFi network*
  - Providing access for users at Fermilab and across the world

Top 30 countries with device count ▶



Number of guest devices by country of origin (unknown origin 0%)

Country	count
USA	445
United Kingdom	119
Italy	77
Switzerland	42
Spain	19
Czech Republic	18
Germany	10
Brazil	7
Japan	6
Canada	6
Belgium	4
Australia	3
South Korea	2
Poland	2
France	2
Turkey	1
Sweden	1
Mexico	1
Hong Kong	1
China	1

Summary

- Scientific computing division works with and as part of the experiments to maximize our science reach
  - Support operation of experiments and computing facilities
  - Develop both common and custom hardware and software solutions to meet the needs of our experiments

- As computing architectures evolve and needs of experiments grow in scale, we work with experiments to evolve our tools to be ready for those challenges

- Talk to members of SCD in your experiment to find out more!