DUNE computing

Andrew McNab
University of Manchester
GridPP, LHCb, and now DUNE

Overview

- This talk focuses on DUNE computing, rather than software

- DUNE recap: protoDUNE, Near and Far Detectors
- Timescales
- Current computing status
- Technologies
- Getting involved

UK invests £65m in Deep Underground Neutrino Experiment in US

There were a lot of happy neutrino physicists around the UK and the US on Wednesday, as the long-standing partnership between the two countries in particle physics was bolstered by a new agreement
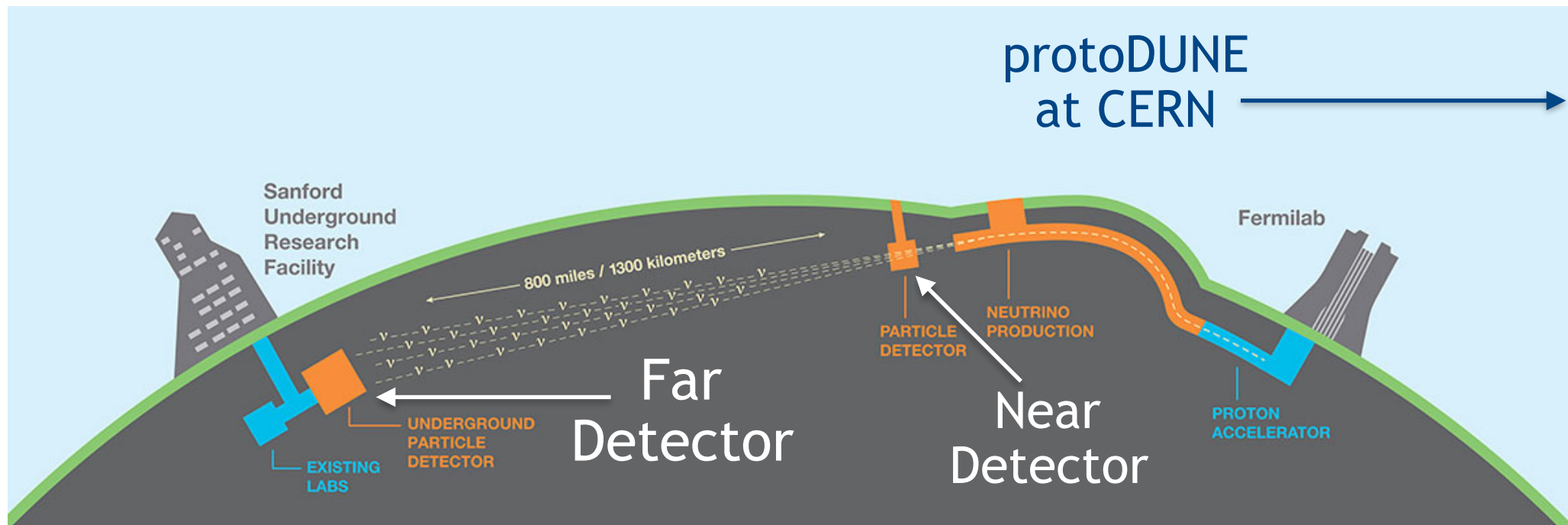
▲ Jo Johnson (UK Minister of State for Universities, Science, Research and Innovation) and Judith G. Garber (U.S. Acting Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs) signed the U.S.-UK Science and Technology Agreement on Sept. 20 in Washington, D.C. Photograph: STFC/FCO

DUNE computing   -   Andrew.McNab@cern.ch   -   GridPP42, Coseners, April 2019

DUNE recap

- *"Make neutrinos at FNAL then detect some of them in South Dakota (and maybe supernovae and proton decays)"*
- Really 3 detectors: protoDUNE; Near and Far Detectors

protoDUNE at CERN →

Sanford Underground Research Facility

← 800 miles / 1300 kilometers →

Far Detector

UNDERGROUND PARTICLE DETECTOR

EXISTING LABS

PARTICLE DETECTOR

NEUTRINO PRODUCTION

Near Detector

Fermilab

PROTON ACCELERATOR

protoDUNE and Far Detector

- The eventual Far Detector will comprise four modules, each ~17000 tons of liquid argon

  - Time Projection chambers, either Single (SP) or Dual Phase (DP), plus photon detection for ~triggering

- protoDUNE SP and DP at CERN are being used to test full size components using CERN neutrino beam

- But much smaller than an FD module: only 800 tons of LAr

  - SP is still the largest monolithic LAr TPC

5
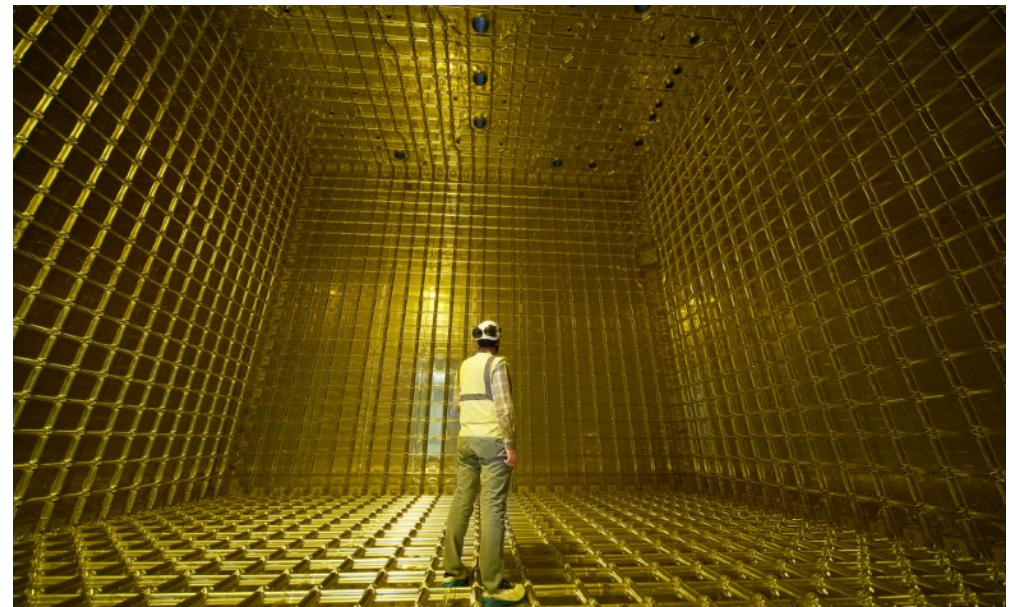
Timescales

CERN	protoDUNE-SP data taking with beam (and then cosmics)	Autumn 2018
CERN	protoDUNE-DP installed and start cosmics	Summer 2019
CERN	protoDUNE-II-SP and DP installed. Cosmics, and then beam	2021/22
S.Dakota	DUNE FD #1 installed. Cosmics	2025
S.Dakota	DUNE FD #2 installed. Cosmics	2026
S.Dakota	DUNE FD #1 and #2 data taking with FNAL beam	2026

protoDUNE events

- The TPC is continually sensitive, with triggering deciding what snapshots to record

- Quite like photographing a diffusion cloud chamber!

- The picture shows a protoDUNE event, with a beam neutrino causing a cascade but lots of cosmic background tracks

- More like 3D images than hits in multiple sub detectors

) + 0 nsec
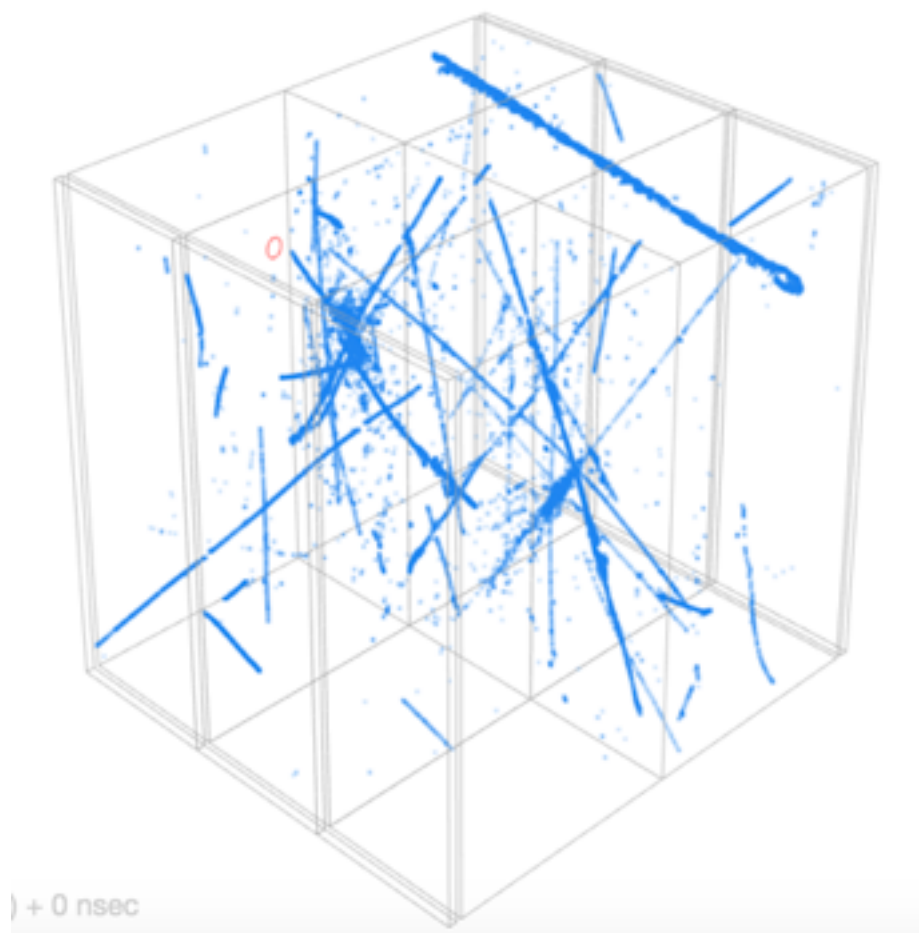
Event sizes

- protoDUNE raw events are each about 180 MB, at 10-25Hz
    - Compare ~2 MB for ATLAS/CMS p-p
    - And ~8 MB for ALICE Pb-Pb
    - During data taking had to reduce time window to cope
- The eventual Far Detector is 100x bigger than protoDUNE
    - We do just read out where the event has happened
    - But we also need to be able to record supernovae, with long time windows and event sizes up to TB
- So we are similar to the astronomy projects that need some access to slots significantly larger than 4GB/processor

Processing the data

- protoDUNE SP took about 2PB of raw data in 6 weeks of data taking with beam, leading to 1PB reconstructed data

- Aiming for 30PB/year raw data from eventual Far Detector
  - Near Detector data rate is likely to be larger

- FNAL will act as a "Tier-0" source of raw data, with data from FD handled internally and then exported from FNAL
  - But need a distributed approach after that to provide sufficient resources to process and analyse the data

- Experience of the LHC experiments and WLCG tells us that this is already manageable
  - Not trivial though of course

Current computing status

Computing resources

- Storage

  - dCache/pnfs at FNAL, EOS/Castor at CERN, Echo at RAL

  - Recruited several UK Tier2 sites last year (DPM, dCache)

  - More storage being on-boarded: CC-IN2P3, PIC/CIEMAT

- Jobs

  - Grid submission via Glidein WMS

    - So HTCondor-CE, ARC, CREAM are all ok

    - Onboarding process much faster than when we started (eg NIKHEF and CIEMAT last month)

  - Able to use capacity provisioned by FNAL's HEPCloud

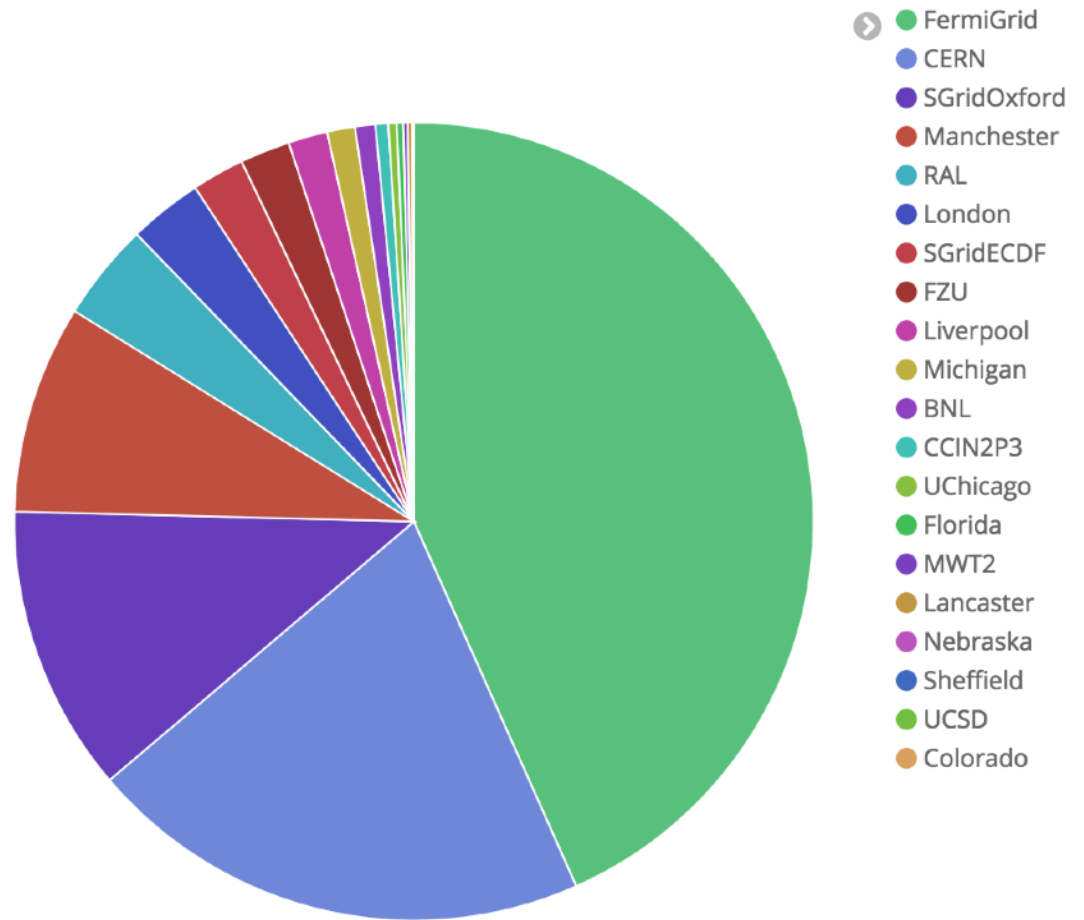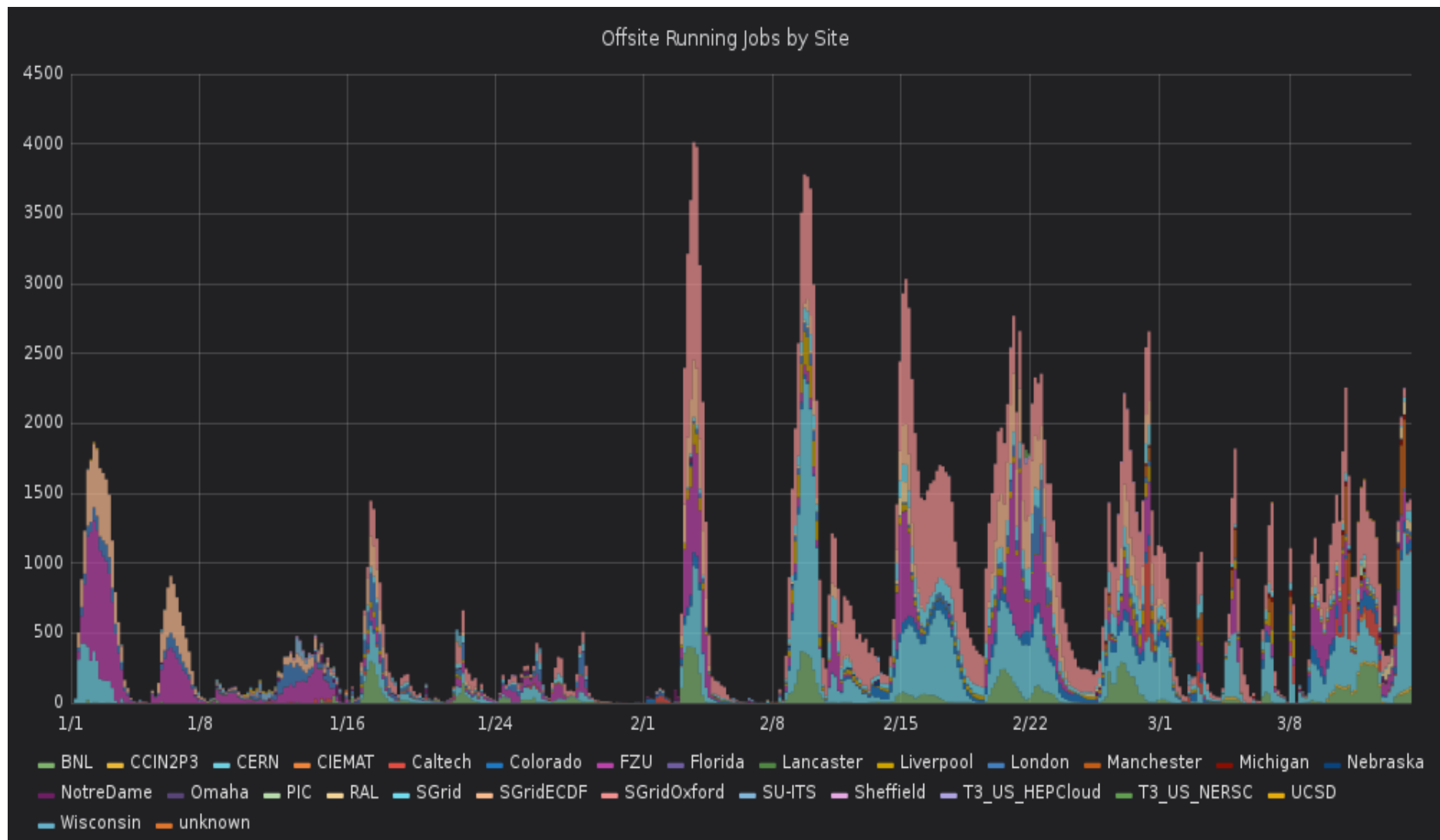 - Already a small amount of HPC resources being used

DUNE and WLCG

- DUNE wants to act like a "normal" WLCG VO from the point of view of sites

  - Easier for everyone; leverages existing infrastructure

- DUNE has been invited by the WLCG MB to "observe" at MB meetings, GDB, TFs etc

  - First step towards the wider "SCI" evolution of WLCG

- We're taking practical steps

  - Created a DUNE GGUS Support Unit so can communicate routine problems to sites via normal tickets

  - Updated VO ID card for people who pick up VOMS info

  - Usage already logged via APEL, visible in EGI portal

12

protoDUNE worldwide data processing

- Location of grid jobs November 1-24, during protoDUNE data taking.

- A total of ~250,000 reconstruction and simulation jobs were run.

- Up to 17,000 jobs at once
  - ~10 hrs/job (up to 24hrs)

- 60% were external to the dedicated resources at FNAL

- **So protoDUNE already used WLCG sites and implicitly WLCG infrastructure**

- FermiGrid
- CERN
- SGridOxford
- Manchester
- RAL
- London
- SGridECDF
- FZU
- Liverpool
- Michigan
- BNL
- CCIN2P3
- UChicago
- Florida
- MWT2
- Lancaster
- Nebraska
- Sheffield
- UCSD
- Colorado

2019 jobs to end of 2019Q1, excluding FNAL

Offsite Running Jobs by Site

DUNE computing - Andrew.McNab@cern.ch - GridPP42, Coseners, April 2019

Technologies

- Inherited long-standing FNAL platforms (SAM, GlideinWMS, FIFE)

  - Mostly just using FNAL (and CERN) batch though

- Already decided to base data management around RUCIO

- Need somewhere to put the file-description metadata that's currently in SAM

  - Edinburgh has offered to enable RUCIO to use an external metadata database (amongst other DUNE-flavoured RUCIO work)

- Need a workload management system that is aware of RUCIO's knowledge of replica locations

  - Starting to evaluate DIRAC, with DIRAC/RUCIO interface in mind - but other solutions are in the mix

- Need a more automated production management system built on top of the WMS

Getting involved as a site

- DUNE is a GridPP supported VO so you should be able to add us just like any other VO

  - And it counts as part of the other VOs 10% of course

  - For people with IRIS hardware: DUNE is also a prominent IRIS VO ☺

- The dune-computing-sites@fnal.gov mailing list on listserv.fnal.gov is open to non-DUNE members

  - Intended for people who want to participate in the rollout and help with onboarding sites

- Half hour meetings at 3pm UK time on Mondays on Zoom

  - Zoom details, agenda etc announced on the list

Summary

- DUNE has a series of milestones before the start of data taking with beam in 2026

  - Thanks to protoDUNE SP and DP we have real data to work with as we develop the computing model and systems

- Process of moving to a distributed, grid model is already well underway

  - Many Tier-1/Tier-2 sites already recruited and more welcome

  - Want to look like a "normal" WLCG VO

- Decisions/evaluations of data and workload management systems ongoing

Backup slides

ProtoDUNE @CERN (from Heidi Schellman)

Two walls of the cryostat are covered with 3 planes of wires spaced 0.5 cm apart. Total of **15,360** wires

The electrons take ~ 3msec to drift across and you need to detect and time them for the full time

Each wire is read out by 12-bit ADC's every 0.5 microsecond for 3-5 msec. Total of around **6,000** samples/wire/readout.

Around **230 MB/readout** → **80-100 MB compressed**

ProtoDUNE was read out at **10-25 Hz for a 6 week test run**

2.5 GB/sec --> **< 1 GB/sec after compression**

One issue – this is a **1%** prototype of the real 4-module beast

The big one won't read out as often….

One channel