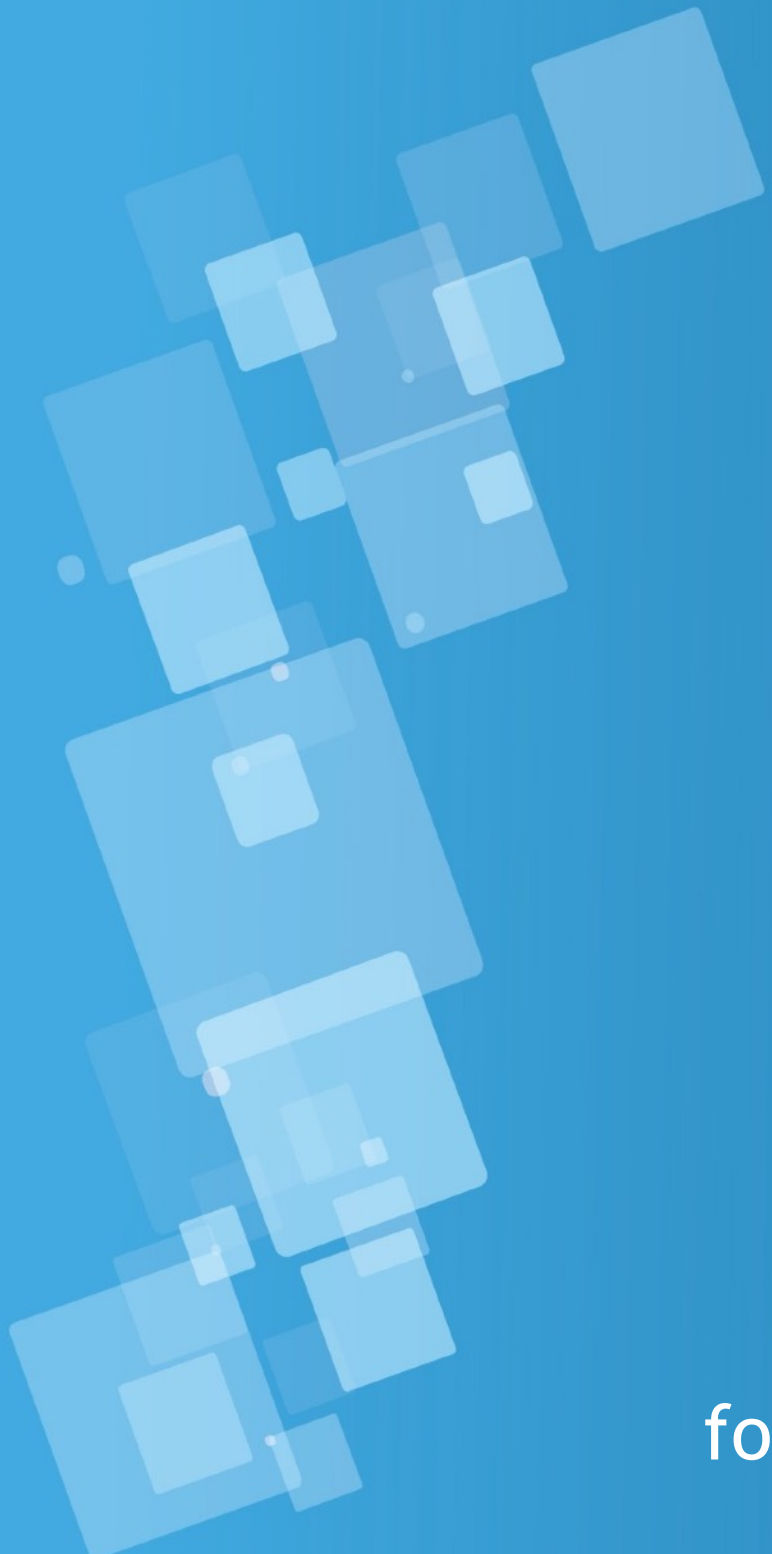

DEEP UNDERGROUND
NEUTRINO EXPERIMENT

DUNE computing and software

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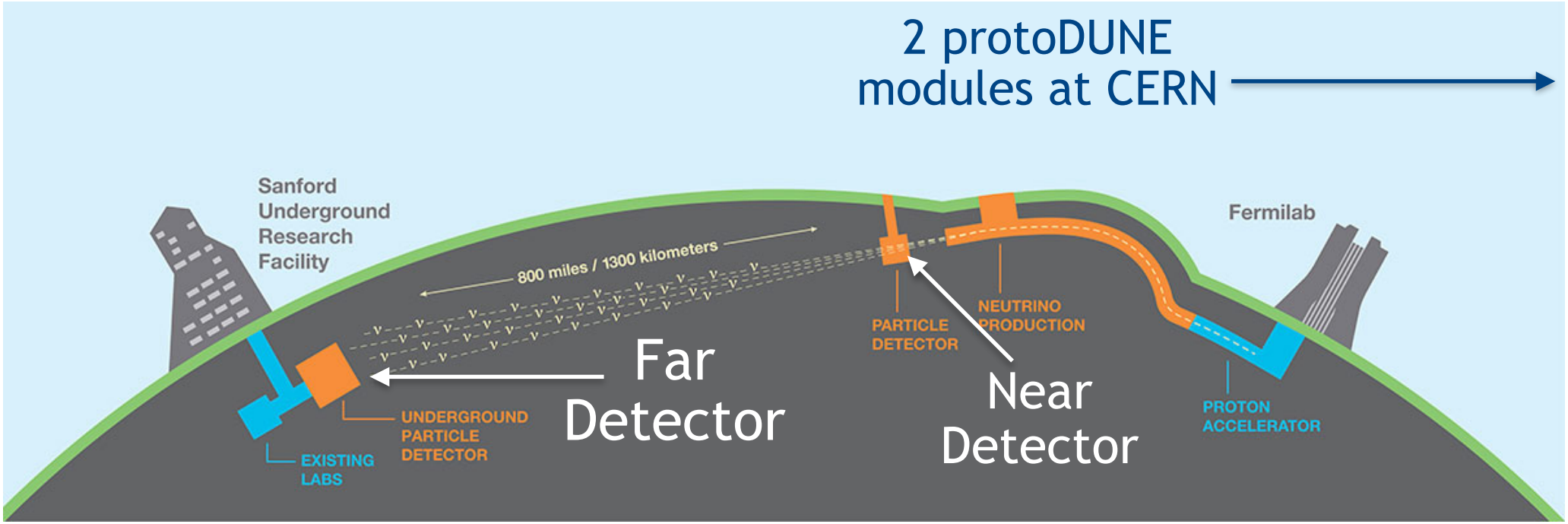
for the DUNE Computing Consortium

Overview

- What is DUNE
- Physics goals and implications
- Computing requirements
- Computing software
- Physics software
- UK involvement highlighted in red

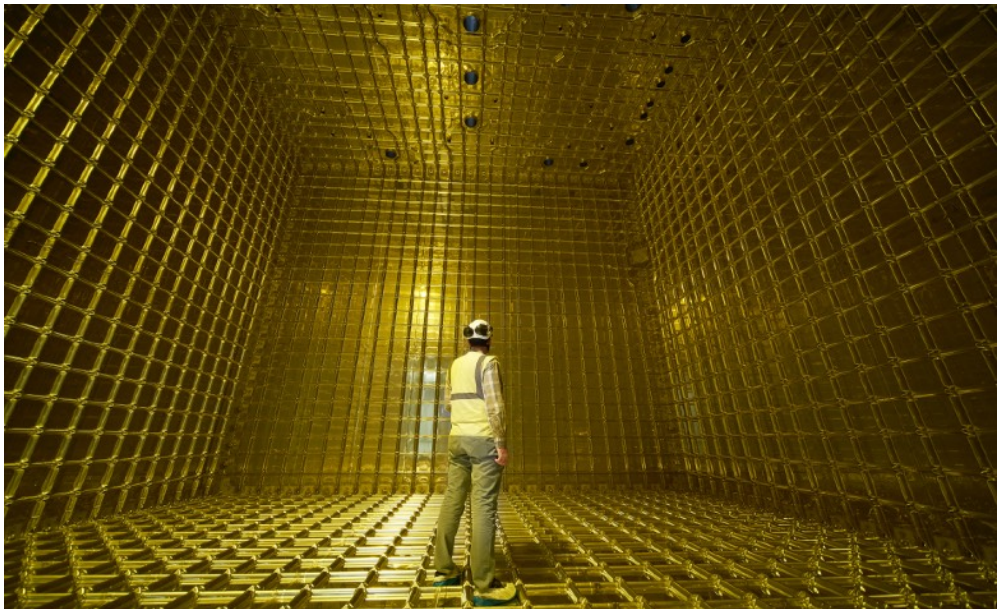
DUNE recap

- *"Make neutrinos at FNAL then detect some of them in South Dakota (and maybe supernovae and proton decays)"*
- Really 4 detectors: 2 protoDUNEs (now); Near and Far Detectors (mid 2020s onwards)



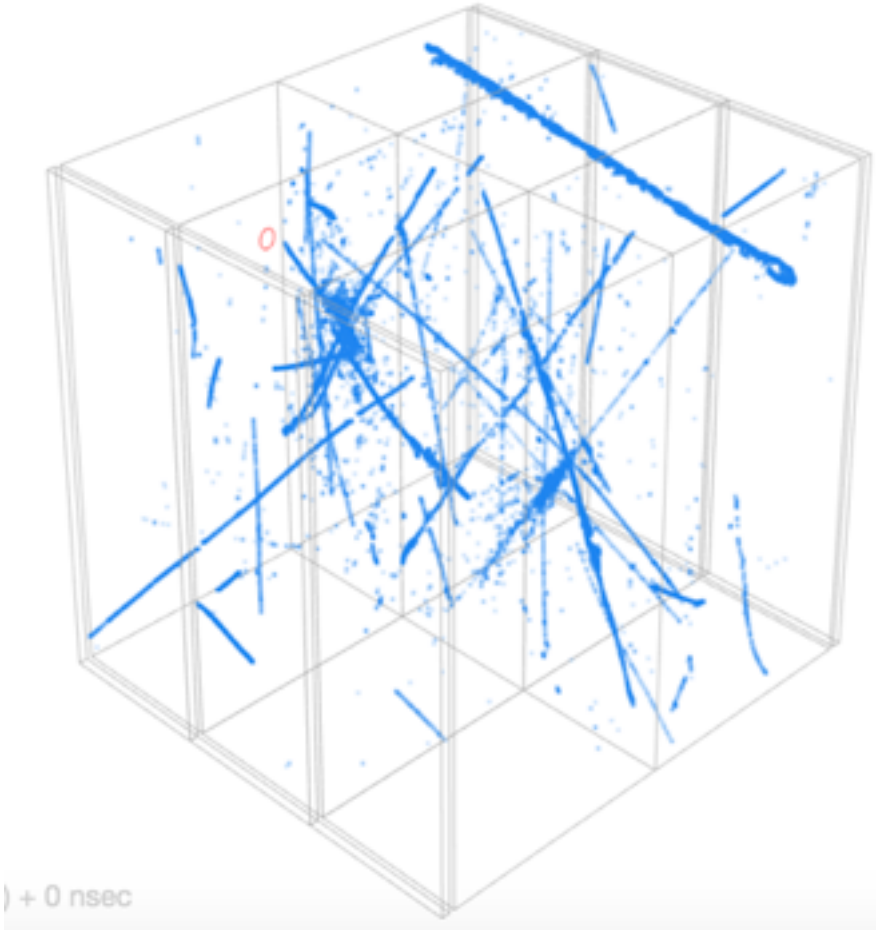
protoDUNEs, Far Detector and Near Detectors

- The eventual Far Detector will comprise four modules, each ~17000 tons of liquid argon
  - 1st: single phase, horizontal time projection chambers
  - Other technologies considered for 2 - 4
  - Expect ~30 PB/year in total from Far Detectors
- Two protoDUNE modules at CERN are being used to test full size components
  - pD I was single + dual phase
  - pD II will be horz + vert drift
- But much smaller than an FD module: only 800 tons of LAr



protoDUNE events

- The TPCs are continually sensitive, with triggering deciding what snapshots to record
- Quite like photographing a diffusion cloud chamber!
- The picture shows a protoDUNE SP beam event causing a cascade but lots of cosmic background tracks
- More like 3D images than hits in multiple sub detectors



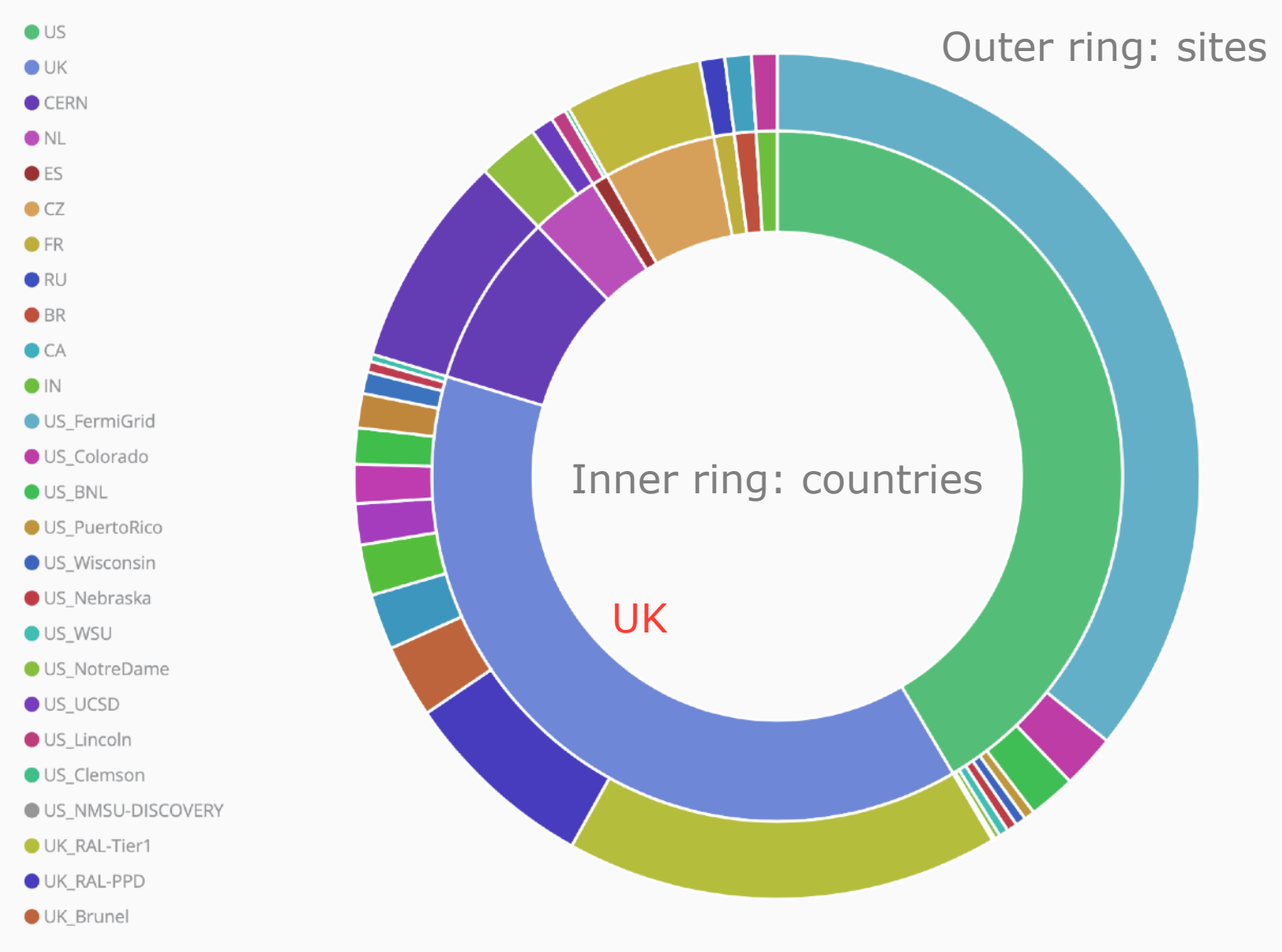
Physics goals

- Use the long baseline to observe neutrino mixing
  - Muon neutrinos at FNAL and ND
  - Electron (and tau) neutrinos can be observed at FD
    - Observe neutrino CP violation, determine neutrino mass hierarchy, and measure PMNS matrix elements
- Large neutrino detection volumes will also be sensitive to supernova neutrinos
  - If a supernova happens close enough, but then these very large (100 TB) events need to be processed quickly
- Large liquid argon volume is also sensitive to proton decay
  - If such a thing were to happen frequently enough …

Computing requirements

- Processing, simulation, and analysis all map reasonably well onto existing and planned WLCG grid resources
  - High Throughput capacity with good access to local bulk storage
  - As provided by GridPP+IRIS in the UK
  - **This is what we really need from partners like the UK**
- DUNE is also using HPC resources, including NERSC
  - We're not requesting HPC resources outside the US but could make use of them
- We're still focussed on conventional x86_64 CPUs but may be requesting GPUs too in the future

Non-HPC computing for DUNE, last 90 days



Computing software

- DUNE draws heavily on the FNAL heritage and FNAL neutrino experiments in particular
- Replacing SAM with RUCIO replica management and a data management system being developed (UK involved)
- Using FNAL's HEPCloud to manage provisioning at HPC sites and on commercial cloud resources
- Continuing to use GlideInWMS/HTCondor for lower level workload management
- Developing a DUNE metadata catalogue (MetaCat)
- Developing a DUNE workflow system to orchestrate data movements for productions and the workload system (UK led)

Physics software

- Grown out of LArSoft heritage of processing data from liquid argon time projection chambers
  - Pandora is used as a module within LArSoft for reconstruction
- UK involvement includes:
  - Pandora pattern recognition for DUNE
  - Pandora deep learning
  - Algorithms for the ND and different FD technologies
- (There's also significant UK involvement in the DUNE DAQ)

Summary

- DUNE has a series of milestones before the start of data taking with beam in the middle of the decade
  - Thanks to protoDUNEs at CERN we have real data to work with as we develop the computing and software systems
- UK is well represented in
  - Providing computing capacity from GridPP+IRIS
  - Developing the computing systems
  - Developing physics software (and DAQ)
  - Management of many of the areas within DUNE