DUNE computing

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for the DUNE Computing Consortium
Overview

- This talk focuses on DUNE computing, rather than software
- DUNE recap: protoDUNE, Near and Far Detectors
- Timescales
- Scale of the problem
- Current computing status
- Technologies
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 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 timing

- protoDUNE SP and DP at CERN are being used to test full size components
  - But much smaller than an FD module: only 800 tons of LAr
    - SP is still the largest monolithic LAr TPC
## Timescales

<table>
<thead>
<tr>
<th>Location</th>
<th>Event Description</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERN</td>
<td>protoDUNE-SP data taking with beam (and then cosmics)</td>
<td>Autumn 2018</td>
</tr>
<tr>
<td>CERN</td>
<td>protoDUNE-DP installed and start cosmics</td>
<td>Summer 2019</td>
</tr>
<tr>
<td>CERN</td>
<td>protoDUNE-II-SP and DP installed. Cosmos, and then beam</td>
<td>2021/22</td>
</tr>
<tr>
<td>S.Dakota</td>
<td>DUNE FD #1 installed. Cosmos</td>
<td>2025</td>
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<tr>
<td>S.Dakota</td>
<td>DUNE FD #2 installed. Cosmos</td>
<td>2026</td>
</tr>
<tr>
<td>S.Dakota</td>
<td>DUNE FD #1 and #2 data taking with FNAL beam</td>
<td>2026</td>
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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
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** 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 week)
  • Able to use capacity provisioned by HEPCloud
  • Already a small amount of HPC resources being used
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
2019 jobs to date, excluding FNAL

Offsite Running Jobs by Site

- BNL
- CCIN2P3
- CERN
- CIEMAT
- Caltech
- Colorado
- FZU
- Florida
- Lancaster
- Liverpool
- London
- Manchester
- Michigan
- Nebraska
- NotreDame
- Omaha
- PIC
- RAL
- SGrid
- SGridECDF
- SGridOxford
- SU-ITS
- Sheffield
- T3 US HEPCloud
- T3 US NERSC
- UCSD
- Wisconsin
- unknown

DUNE computing - Andrew.McNab@cern.ch - H/O/W, JLab, March 2019
Technologies in use

- Transitioning from “everything at FNAL/CERN” to a grid model
- Inherited long-standing FNAL general platforms (eg SAM and GlideinWMS pool) and FNAL neutrino platforms (eg FIFE)
  - SAM has file metadata and replica locations
  - Most jobs are submitted to Glidein pool and sent out to sites
    - Lots of direct batch submission at FNAL/CERN still by users
- Starting to use RUCIO to place data at sites
  - Developing SAM/RUCIO interface
Technologies going forward

- Already decided to base data management around RUCIO
- Need somewhere to put the file-description metadata that’s currently in SAM
  - RUCIO may be able to handle this in future, but leaning towards a standalone database
- 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
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
- Decided to use RUCIO for data management
- Evaluation of workload management and higher level production management options has started
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....