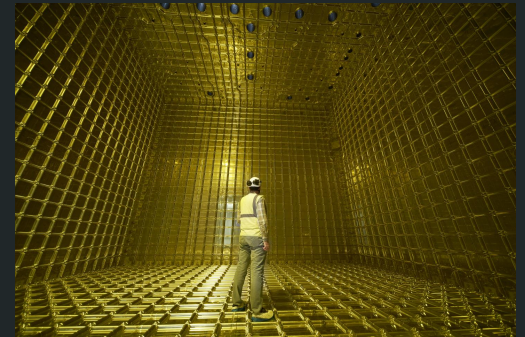




DUNE @ Oliver Lodge

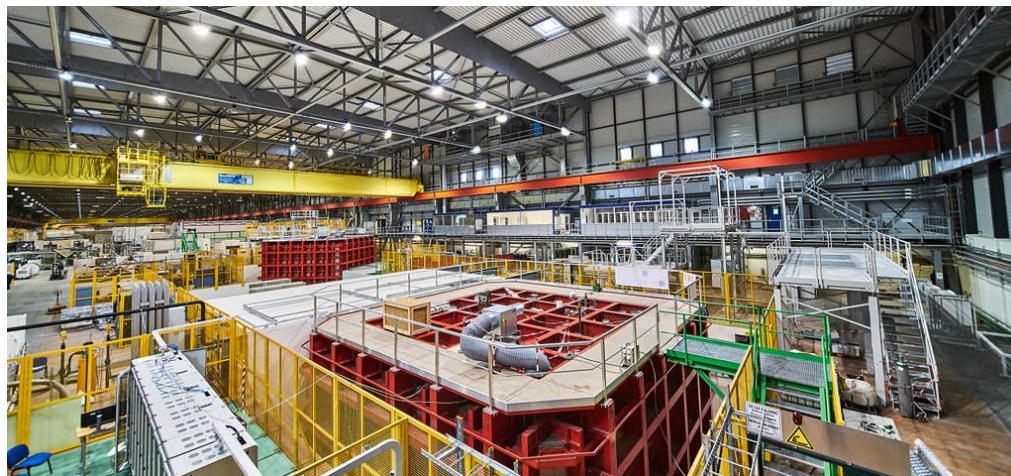
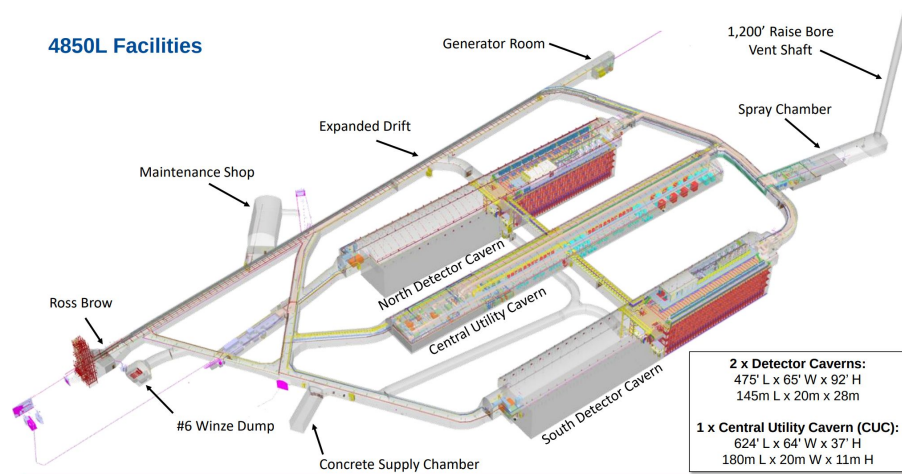
Marco Roda, Christos Touramanis, et al.

20 May 2022
(Christmas) HEP meeting



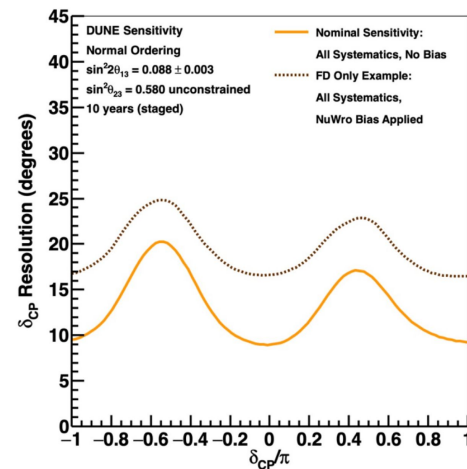
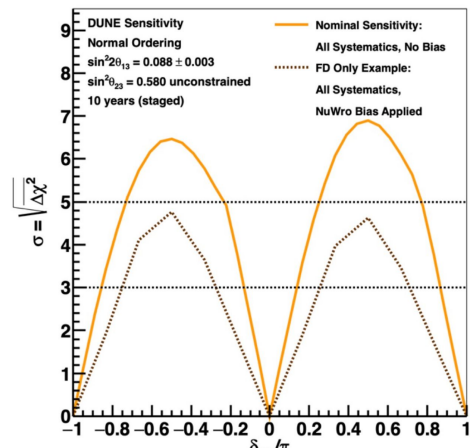
Overview

- Intense (anti-)neutrino beam
 - From Fermilab to SURF - about 1300 Km
 - Multiple physics goals
 - CP violation in the lepton sector
 - Precision tests of the 3-neutrino paradigm
 - Proton decay, neutrinos from supernovae
 - BSM
- 4 caverns housing 10 Kt LAr TPCs
 - 3D imaging - bubble chamber quality
 - energy measurements capability
 - two types of modules
 - horizontal drift
 - vertical drift (No Liverpool involvement)
 - integrated photon readout
- The collaboration
 - 1,500 collaborators
 - about 200 institutes from 32 countries
 - UKRI 65 M project:
 - APAs, DAQ, PIP-II cryomodules, proton target
- ProtoDUNE
 - Test beam facility at CERN
 - Took beam data in 2018
 - ProtoDUNE-II being installed for data taking in 2022-23



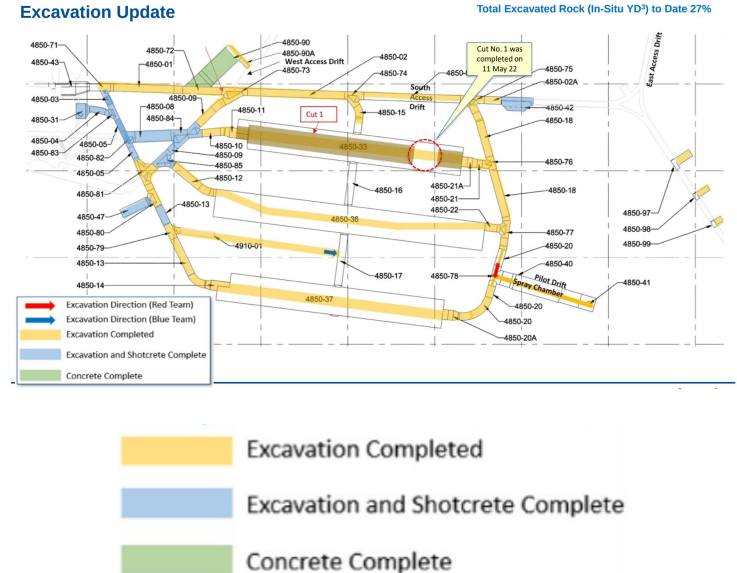
Physics program

- Standard Oscillation framework
 - Enough to be able to resolve mass hierarchy and measure CP violation
 - Possibly with 5 sigma significance depending on the value
- BSM
 - proton decay in the $p \rightarrow K^+$
 - neutrino anomalies
- Supernova neutrinos
- ProtoDUNE
 - 4 papers in preparation from 2018 test beam - Argon cross sections
 - Pion absorption and charge exchange
 - Neutron
 - Kaon
 - O(10) analyses ongoing
 - Plus performance and detector papers



Latest news from the ongoing Collaboration Meeting @ FNAL

- DUNE baseline (phase I):
 - 2 FD modules, 3-system ND, 1.2MW
 - FD1: Single Phase, Horizontal Drift
 - we make the APAs for it
 - FD2: Single Phase, Vertical Drift
 - no UK involvement in the hardware
 - ND: LAr TPC,
 - muon spectrometer, SAND (on-axis detector and beam monitor)
 - DOE review (CD1-RR) in July
 - Physics start in 2028
 - atmospheric and supernova neutrinos, proton decay
 - Near Detector completion: 2031
 - First beam 2031: start of long baseline physics
- Phase II additions
 - FD modules 3,4; Gas Argon TPC in ND; 2.4MW
- Excavation at Far Site progressing well
- APA production for FD1 started at Daresbury



People

APA

- Christos Touramanis: APA consortium leader
- Dave Payne: quality control & surveys
- Krish Majumdar: APA consortium hardware database development
- Peter Cooke (replacing P. Sutcliffe): APA frames production; APA Shipping Frames engineer
- George Stavrakis: ASF design
- Mechanical Workshop: manufacturer of APA wiring heads, other bespoke items
- Dave Sim, Tony Watling, Matt Brown: APA production team

DAQ

- Marco Roda: Core SW, CCM monitoring
- Carlos Chavez: unit-tests, CCM control
- Adam Abed Abud (student): Dataflow

APA

Anode Plane Assembly

Major achievements in 2021

- Final Design Review: September 2021
- Production Readiness Review: February 2022

- 1st APA made at Daresbury and tested at CERN (Oct-Dec 2021)
- 3 more APAs for ProtoDUNE-II: 2 at CERN, 1 in construction at Daresbury
- Currently preparing APAs for ProtoDUNE II at CERN (Matt Brown)

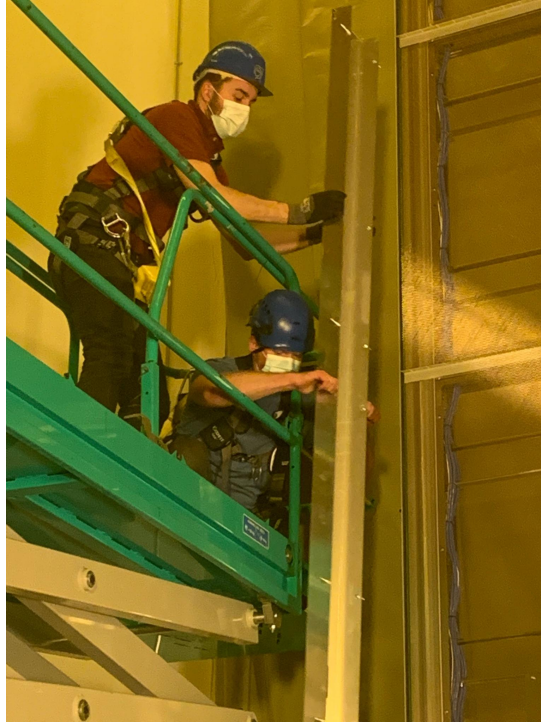
- First FD APA: starting at Daresbury
 - 150 APAs to be made in total
- Production to continue until end 2026

- APA Shipping Frame:
 - 2 prototypes made by DSM, delivered to CERN
 - 1 prototype made at CERN, now at PK Marine (Liverpool) loaded with ProtoDUNE APAs, to be transported to Fermilab, then SURF to go underground as part of a full transportation cycle test

APA Factory at Daresbury (photo from PRR)



APA 1 tests at CERN (Oct.-Dec. 2021)



APA Shipping Frame



CERN



PK Marine (Liverpool)



APA frame QC with laser trackers (David Payne)



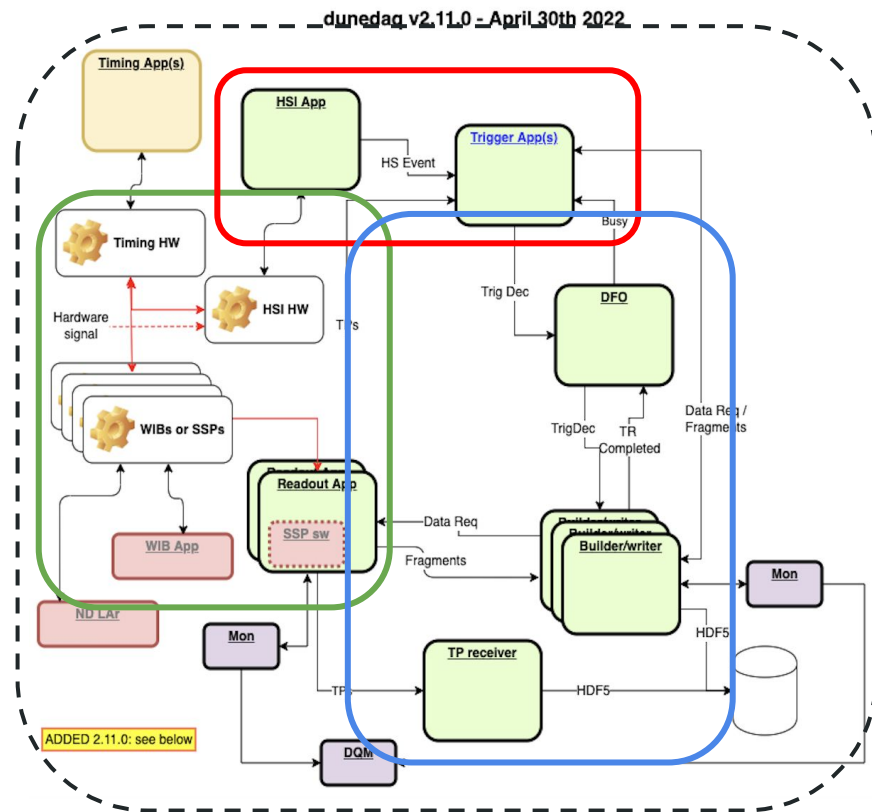
David's shoulder

picture taken at DSM (the frame manufacturer) in South Shields

DAQ

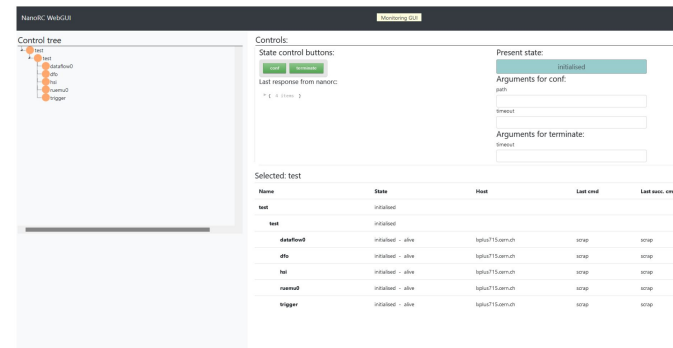
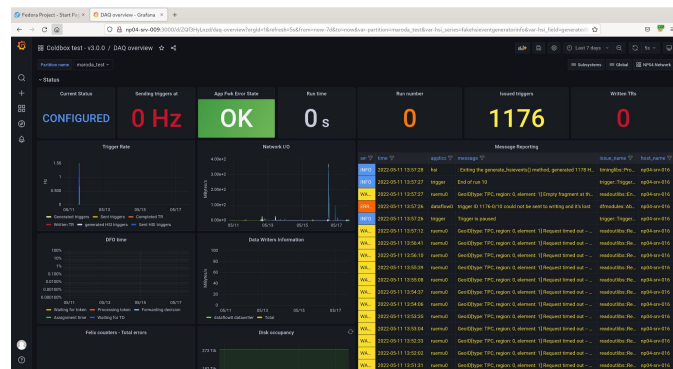
The DUNE DAQ

- Distributed system with 4 main components
 - **Upstream DAQ**
 - based on FELIX technology
 - combination of firmware and dedicated servers
 - Stores data streams from the hardware waiting for requests
 - It generate Trigger primitives to be send to
 - **Trigger and data selection**
 - Mostly software based
 - Analyses TP and generate Trigger Decision
 - **DataFlow**
 - Move data between the applications
 - Constructs Trigger Records (events) and writing on disk
 - CCM - Configuration, Control and Monitoring
 - Pervasive system - part of the core software design
 - Dedicated apps for data quality monitoring at many levels
- Very low dead time required
 - Due to supernova neutrinos searches
- Some numbers
 - each FD module expected to produce about 1.5 TB/s
 - O(1K) applications at the far detector site
 - plus a number of services and databases
- Same infrastructure to be used for ND and FDs
 - And for ProtoDUNE II



Liverpool contributions

- Present from the very beginning of the DAQ construction (Spring 2020)
 - Design and implementation of the core framework
 - Development of the event building applications and many other initial components (Marco)
 - Integration test infrastructure (Carlos)
 - ...but UK interest has now shifted
 - Dataflow (or core SW) moved mostly to the US
 - UK involvement is in CCM (Liverpool and others) and Trigger
- Run control at DUNE DAQ (Carlos)
 - Python based run control configuration and maintenance work
 - Software developments to handle multiple partitions and related configuration changes
- Monitoring (Marco)
 - Based on a number of databases (kafka, influxDB) to store the data and then plotted using grafana dashboards
 - C++ code specific for every module are used to generate the data inside the applications
 - Eventually we will add a supervisor system that will be able to automatically operate some automatic recovery actions

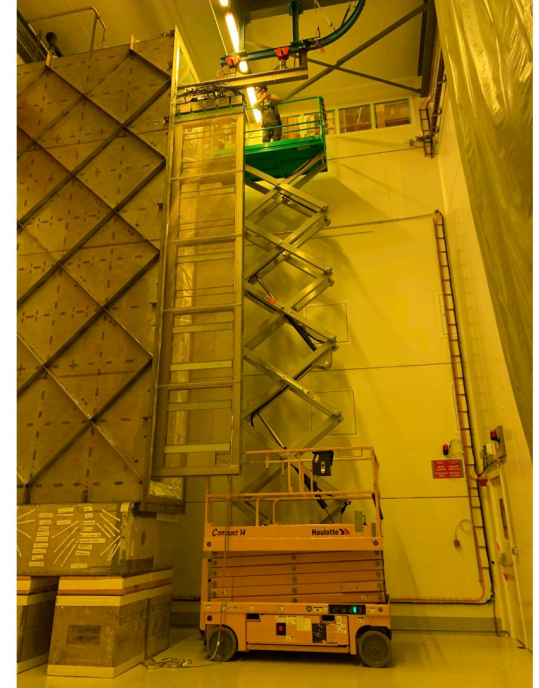


Liverpool contributions (cont)

- Kubernetes based DUNE DAQ
 - almost zero deadtime and long time run has some impact on the technology
 - Containers will help us to decouple our system from the nuisances of OS evolution, etc
 - Allow respawning applications
 - Working on implementing K8s cluster to run DAQ applications processes (Carlos)
 - Integration with nanoRC and configuration development between k8s and nanoRC (Carlos)
 - Moving all the services required for monitoring infrastructure into K8s pods and services (Marco)
- Configurations
 - Configurations are generated using dedicated applications
 - We recently changed the way we send data between applications
 - All the configuration generation had to be updated according to the new system (Carlos)

Current DAQ activities

- You have seen the development work
 - The system is currently exercised with cold box tests
- Coldbox tests at CERN at the beginning of the year
- In total four new APAs to be tested
 - One APA already tested
 - Job completed by the summer
- Of course beam data in late autumn



Summary

- Despite COVID, things are progressing well
 - Many Liverpool contributions in key roles
- APA production started at Daresbury
- DAQ in development, successfully tested for Coldbox tests
- We are about to start publishing physics papers from data
- Many other activities are ongoing but Liverpool is not involved

