DUNE DAQ Conceptual Design Review

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Review Welcome

- Many thanks to the reviewers for helping us with this process

- Progress so far (15 months since consortium startup):
  - ProtoDUNE-SP DAQ was commissioned and operated successfully
  - DAQ conceptual design established and documented
    - You will detect some ‘design by committee’; much more work needed in coming year
  - First pass completed on resources and organisation
  - An active and growing group of institutes working together
- What we hope to get out of this
  - Confirmation of direction of travel, before the technical design phase
  - Assessment whether boundaries, interfaces, scope are understood and appropriate
    - Allowing other groups to carry on with their design process in parallel with us
  - Judgement on whether resources and schedule are feasible

DUNE Science and Far Detector

- Precision measurement of oscillation parameters (δ_{CP}, mass hierarchy, θ_{23})
  - Maximum instrumented mass, flat trigger efficiency, beam trigger gate
- Measurement of nu flux from supernovae; proton decay
  - Maximum uptime; no deadtime; self-trigger with low threshold; connection to SNEWS
- Secondary / additional science goals (atmospheric nu, WIMPs, solar nu, etc)
  - Maximum flexibility in triggering and data selection (as an ongoing requirement)

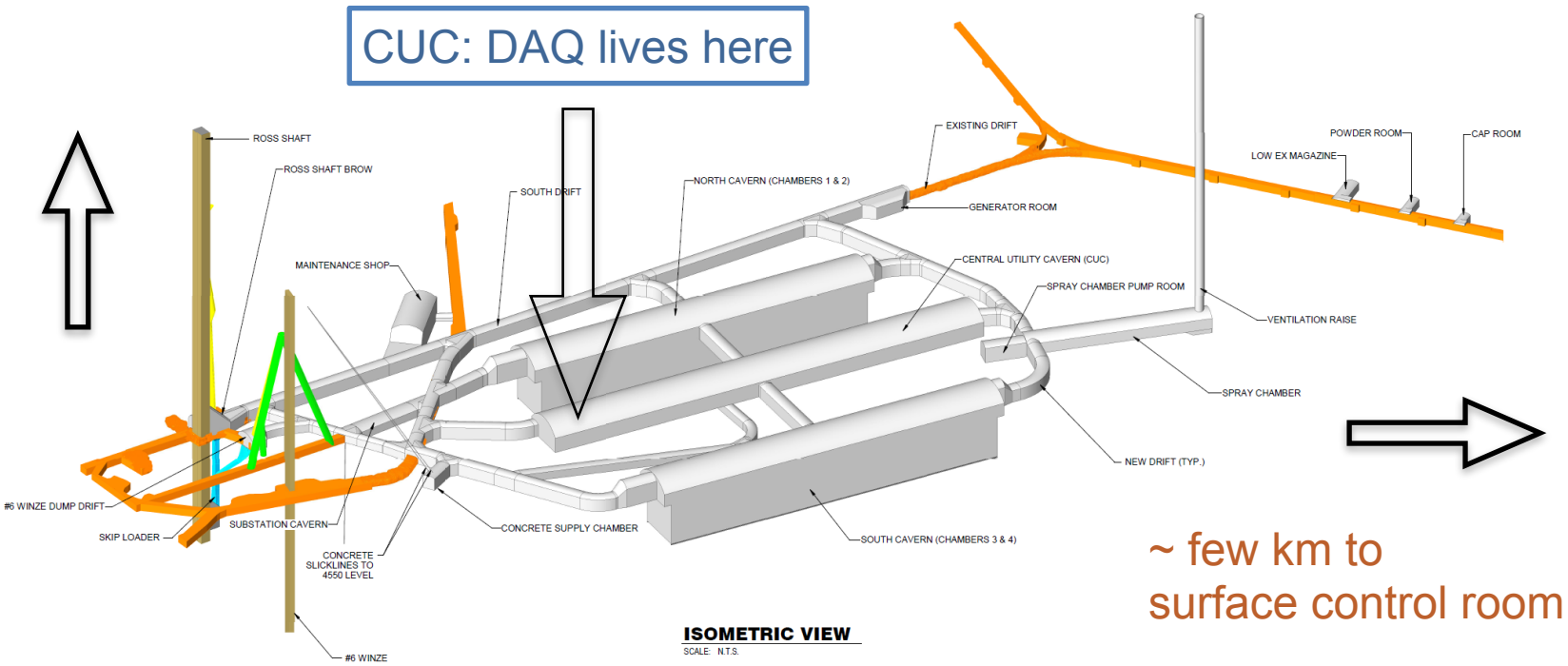
- Detector will be four 10kT modules, staged over a few years
  - DAQ must support physics running in parallel with construction, commissioning, tests
- Detector technology is LAr TPC, plus sensitive photon detector system
  - Basic readout block is few ms drift time = O(10GB) of data for whole module
- Detector is deep underground (1.5km) for background reduction
  - Many components of DAQ will be difficult and time-consuming to access
- Detector is designed to sustain >95% uptime
  - Extreme reliability, redundancy, maintainability requirements (c.f. LHC ~30% uptime)

How to Speak DUNE

- A translation to CERN / LHC jargon

- DAQ = “readout, trigger and online computing”
- Data selection = “first level trigger and event filter”
- Consortium = “subdetector project”
- Front end = “detector interface to readout and trigger, local buffer”
- Back end = “event builder, filter, global disk buffer, run control”
- DAQ kit = “full readout chain and timing source on a single PC"
- CUC (central utility cavern) = “underground counting room”
- ITF (integration and test facility) = “surface assembly area”
- TDR: For DUNE, a one-volume object, less detail than for LHC

Physical Layout



~ few km to surface control room

- DAQ split between 4850ft level and surface; minimise data traffic to surface
- Strong constraints on cooling (450kW), space (~50 racks) for all four modules
  - Also strong schedule constraints on CUC installation and commissioning

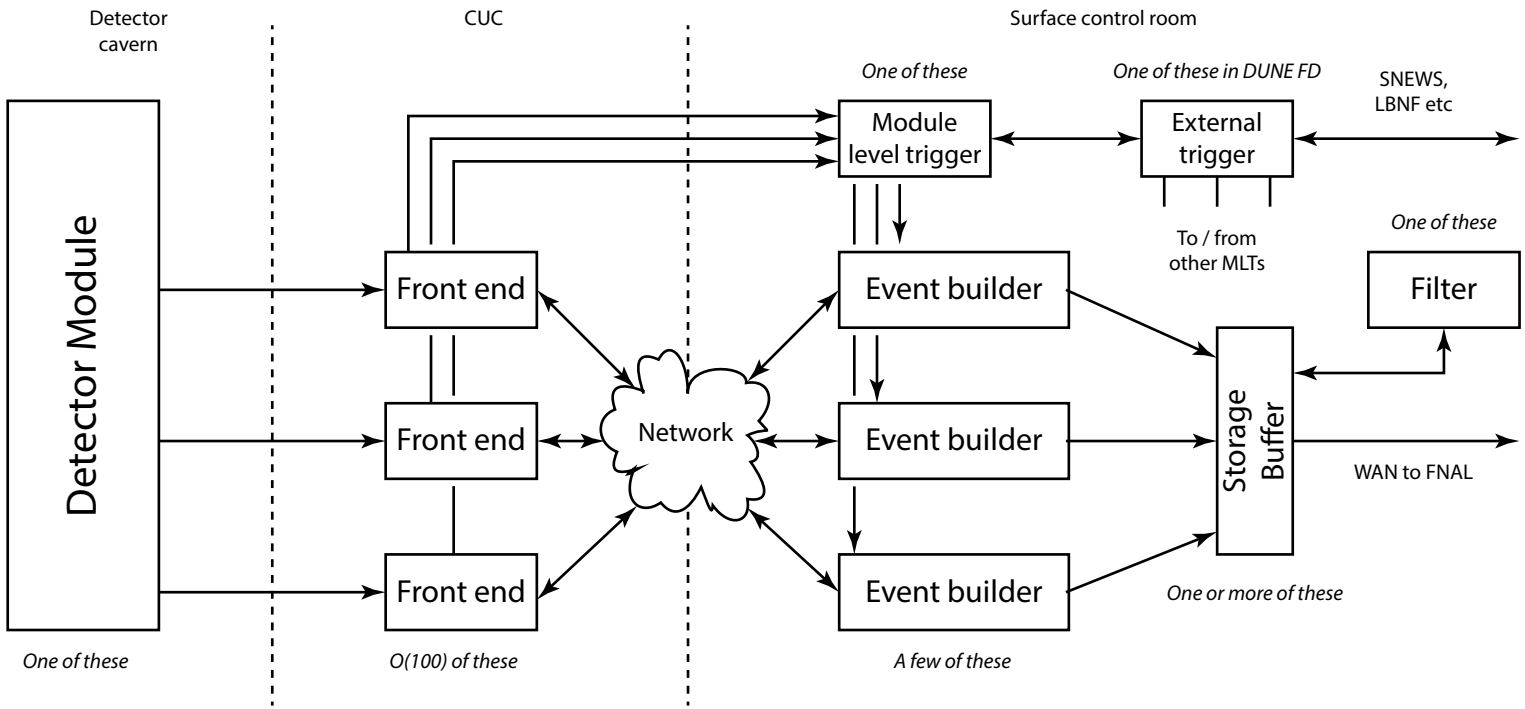
DAQ Scope and Functionality

- DAQ scope
  - Begins at fibres from the detector (no galvanic link to cryostats)
  - Ends at WAN network interface (fibres to FNAL via ESnet)
  - DAQ provides common computing and network services for other systems
  - All slow control and safety functions are outside DAQ
- Basic DAQ functionality
  - Provide basic timing and synchronisation for subdetectors
  - Receive, synchronise, compress, buffer streaming data from subdetectors
  - Extract trigger primitives, summarising local activity in detector
  - Make local, module, and cross-module trigger decisions
  - Build ‘events’ from selected space-time volumes, buffer, and relay to permanent storage
  - Carry out local data reduction and filtering steps as required

Design and Philosophy

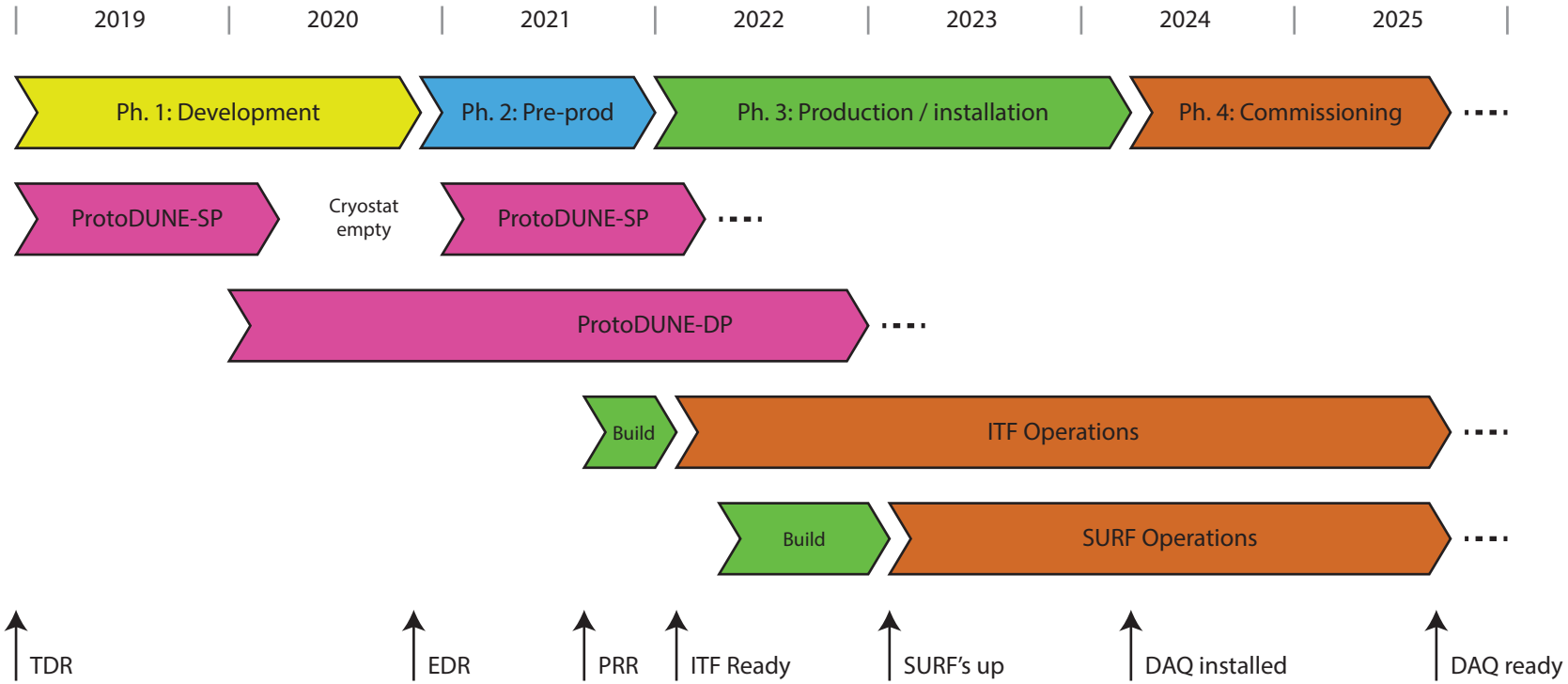
- What's different and interesting about DUNE DAQ? (= 'key challenges')
  - System has be partitioned and flexible ('permanent commissioning')
  - Special requirements from SNB (storage of full data for tens of seconds)
  - Difficult-to-access location: emphasis on reliability and remote operations
  - Relatively short time scale to design, build and commission system
- Design principles
  - A single scalable system design for all detector modules
  - Ability to recording and store full detector data with zero deadtime (for studies and SNB)
  - Design very conservatively for first module
    - Use infrastructure for all four modules at from the start; keep data selection 'as dumb as possible' in the first year
  - Preserve possibility to add DAQ capacity as required (first LAr TPC at this scale)
  - Design for extreme robustness, reliability and redundancy
- Design priorities
  - Robustness → Scalability → Ease of deployment and commissioning → Ease of design and construction → Operation costs → Capital costs

Conceptual Design



- Not shown: timing system, control paths (see later talks)

Outline Schedule



- ProtoDUNE DAQ until now managed as a distinct project
  - Now in the process of establishing a single common DUNE FD DAQ project
  - ProtoDUNE operations and upgrade (SP and DP) will continue to be a key activity

DAQ Consortium

- 32 institutes in Europe, Japan, Latin America, US
  - Healthy level of participation: >50 active individuals, and growing steadily
  - Much focus on ProtoDUNEs until now
- Divided into working groups for the conceptual design era
  - Architecture / hardware & interfaces / computing / data selection / infrastructure and facilities
  - Plus simulations group, as our contact point to physics requirements
- Process of identifying responsibilities / resources is ongoing
  - Key subsystems of DAQ are covered by large labs / groups of institutes
  - In some cases, funding is being sought to support a greater participation
  - >80% of required capital funds identified; but we severely lack effort
    - Influx of experts from ProtoDUNE from 2019 will begin to address this
    - Have already taken steps to simplify our design; main concern now is online software effort

Schedule for Today

- Requirements
- Interfaces
- ProtoDUNE – lessons learnt
- Readout
  - Inter-process communication; control and monitoring
  - Front end; back end; timing
- Data selection
- Project planning
  - Schedule, resources and risks
  - Development plan; installation and logistics
- Summary

- Please stop us during talks and ask questions (noting tight schedule)