

DAQ Overview

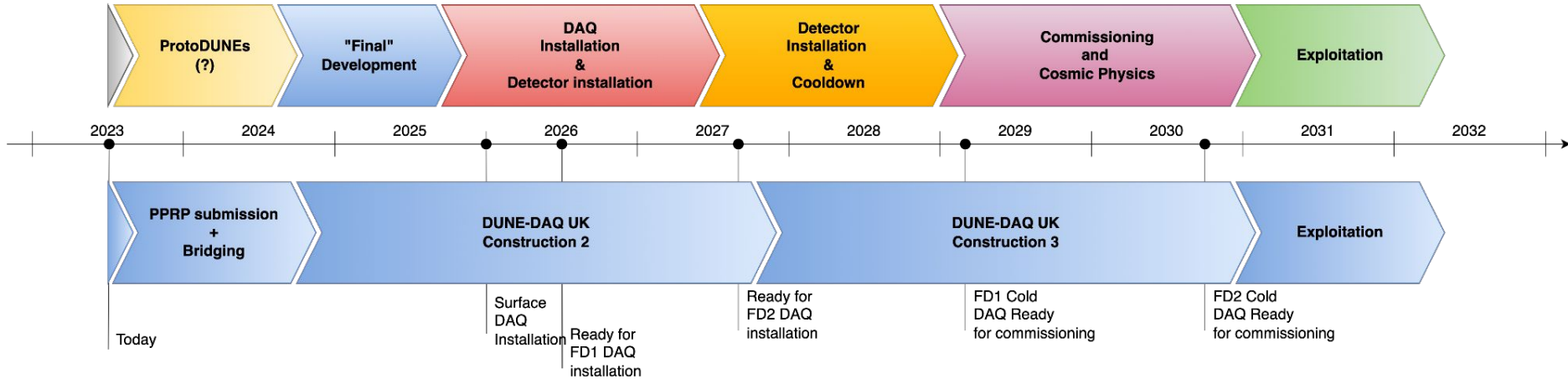
A. Thea, J. Brooke



DAQ Project

- DAQ will become a project alongside PIP-II, Target, APAs, Physics
 - PI : Jim Brooke / Deputy PI : Alessandro Thea
 - PM : Andra (+ additional PO effort)
 - Project coordination structure to be decided
- Project will run until cosmic commissioning period with FD1+FD2 (~2031)
 - Anticipate 2 grant phases, with mid-grant review
- This change does not significantly affect the planning

Timeline



- Where are we now?
 - Development based around ProtoDUNEs
 - Approaching production/procurement phases, and final development
 - Re-planning the project and preparing for PPRP proposal

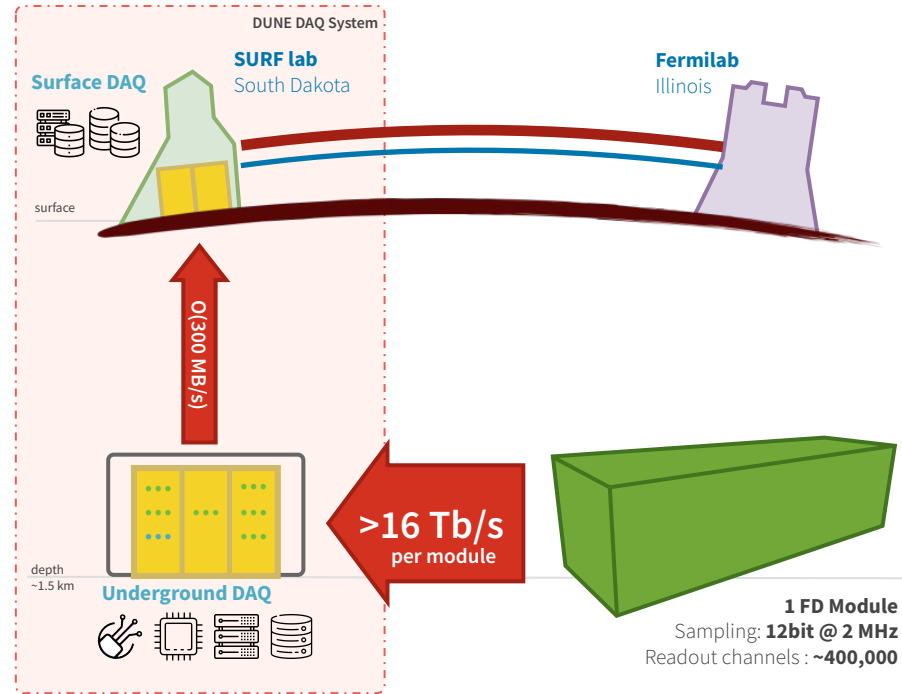
The DUNE Trigger and DAQ system

DUNE DAQ System Goals

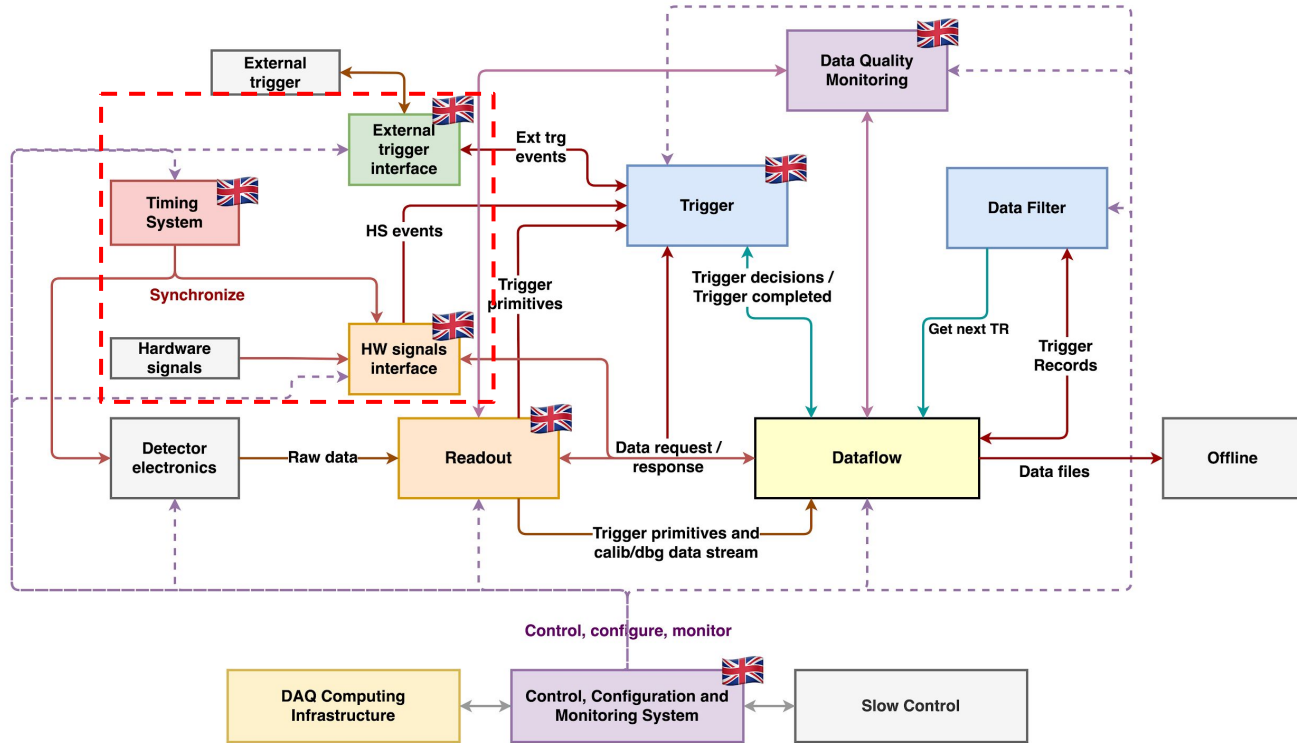
- Distribute clock and unique timestamping to all detector components
- Collect large amount of data from detector
- Selects only interesting interactions
- Buffers the full data stream for ~100s for supernova physics
- Deliver selected interactions to permanent storage
- Serve both Far and Near detector

Unique key challenges

- High data rate, high uptime
 - ▶ Use of commodity networking, computers, and storage
 - ▶ High-performance and resilient custom and off-the-shelf software for the remaining DAQ functions
- Remote experimental site
- Deep underground in an active mine



DUNE FD DAQ



Recent Highlights

Summary

Timing

- Integration with TDE
- Approaching pre-production phase

Readout

- Transition to SW-based Ethernet readout
- Preparation for network procurement

CCM

- Increasing numbers of contributors
- Run Control moving to final design
- Deployment via Kubernetes
- Configuration model

Trigger

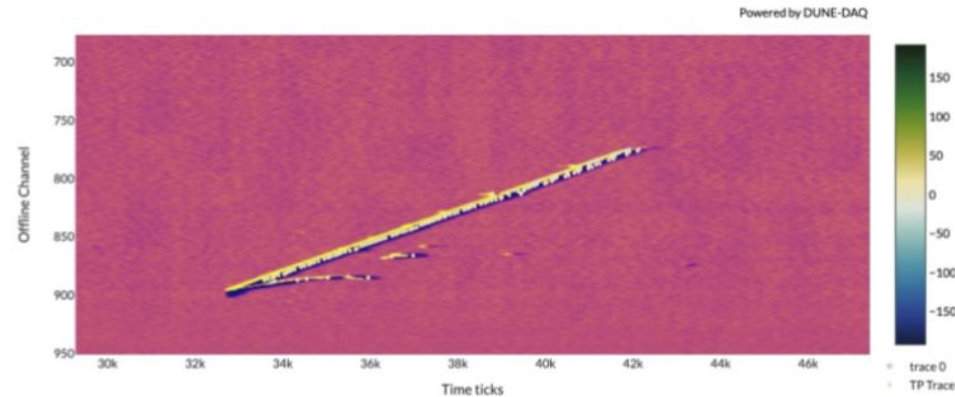
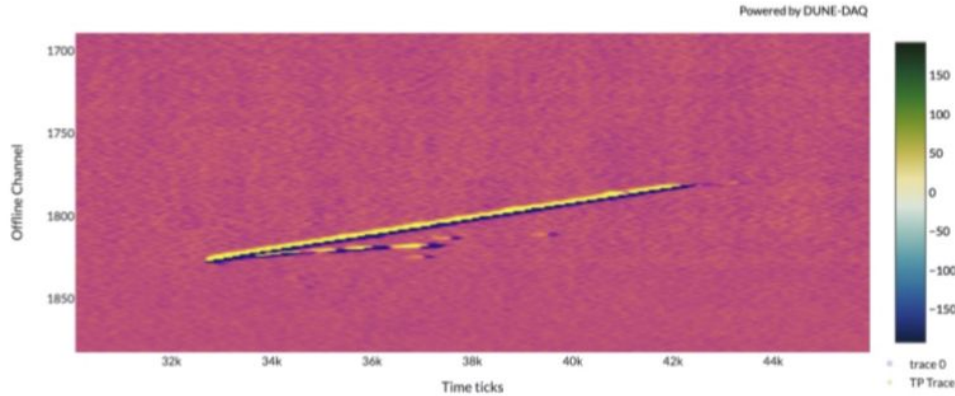
- Re-establish development team
- Re-establish SW-based TPG
- Latency measurements

DQM

- Development paused

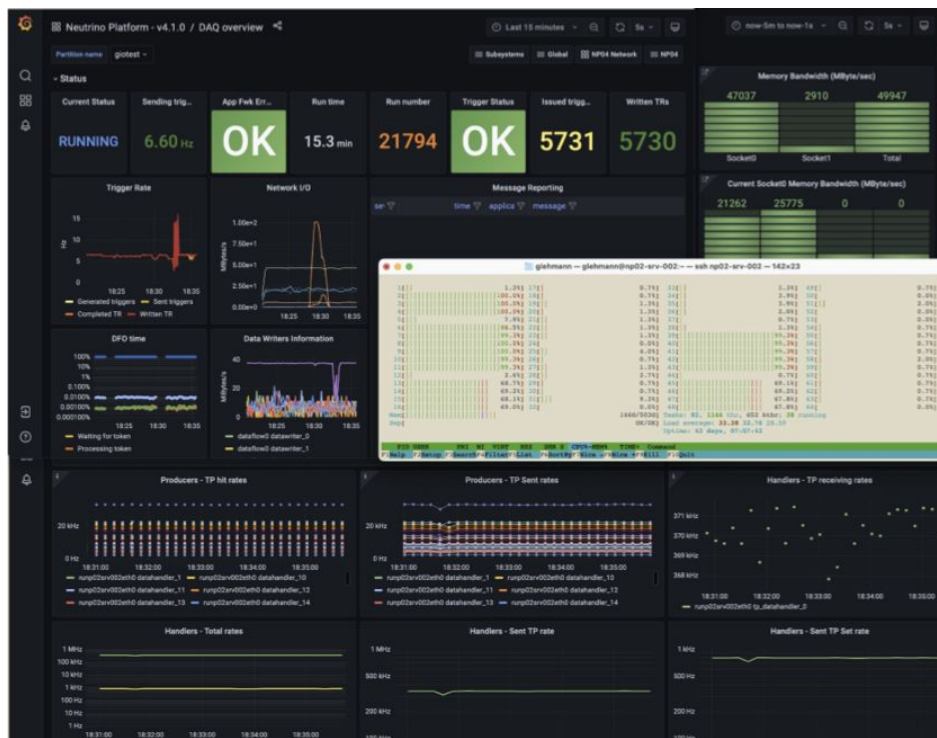
Activities at EHN1

- Three VD coldbox tests (Feb-May)
 - Re-establish SW TPG and Trigger chain
 - Trigger rate and latency measurements
 - Induction plane view of Michel event →
- Integration tests - mostly ongoing
 - WIB / Readout (Ethernet)
 - DAPHNE / Readout (FELIX)
 - DAPHNE / Timing
 - TDE / Timing



Transition to Ethernet Readout

- Tests performed using WIBs and Eth readout servers
 - HermesTx firmware configured by DAQ
 - Data sent via switch to NIC
- Tested both APA and CRP readout configurations
- Successfully tested SW Trigger primitive generation
- Some optimisation achieved
- Still to do :
 - Monitoring and error reporting
 - In-depth performance testing
 - SNB recording demo
 - Network tests at scale



Consortium Planning Exercise

- **Targeting four dune-daq releases per year**
 - *dune-daq-4.0.0* : released
 - *dune-daq-4.1.0* : in preparation now
- **Release planning exercise**
 - Mapping SW deliverables in detail onto forthcoming releases
 - Currently looking ahead to end '24
 - Aim to implement final designs for key components
 - Timing, readout, run control, configuration, operational monitoring
- **Planning process is evolving**
 - Find ways to build it into the standard release cycle procedure

Reviews

- **Mid-Grant Review / Jan OsC (UK)**
 - Midway through UK re-planning exercise
 - Highlight some of the issues (readout technology change) and steps to tackle them
- **Final Design Review (International)**
 - Major effort in DAQ consortium to document the system design
 - https://edms.cern.ch/ui/file/2812882/1/DUNE_DAQ_System_Design_v1.1.pdf (180 pages)
 - Positive outcome
 - No surprises in feedback - known issues highlighted
- **June OsC (UK)**
 - Presented update on UK planning, overview of testing status
- **FNAL Director's Review (US)**
 - Review designs, plans, status ahead of CD2/3 review
 - Positive feedback. Recommendations re: spares, personnel risks, trigger algorithm development

Project Planning

Planning Process

- **Re-planning project started in late '22**
 - Change in readout technology (Ethernet + SW TPG)
 - Original plan pre-dated current consortium organisation and system design
 - Delays/slippage (foreseen) in several areas
- **Planning process**
 - High-level requirements : for physics *and installation*
 - Define the scope & deliverables
 - Product breakdown schedule - what are we delivering
 - Work breakdown structure - what work do we need to do
 - Detailed resource loaded plan
 - Milestones
 - Resources/costs

Schedule Drivers

- DAQ schedule is driven by DUNE requirements at two key milestones :
- **Start of detector installation** - mid '26
 - HW : Timing system, readout network, limited capacity readout/CCM/DQM servers
 - SW : Readout, CCM, DQM
- **Start of commissioning with cold detectors** - late '28
 - Full capacity readout/CCM/DQM servers
 - SW : Trigger (inc TPG), CCM, “uptime” updates

Product Breakdown Schedule

Timing

1	Hardware	
1.1	Timing hardware	
1.1.1	GPS Interface Board (GIB)	Custom electronics
1.1.2	Master Interface Board (MIB)	Custom electronics
1.1.3	Fibre Interface Board (FIB)	Custom electronics
1.1.4	Hardware Signals Interface (HSI)	Custom electronics
1.1.5	uTCA crate	COTS
1.1.6	Timing optical network	COTS
1.1.7	GPS receiver	COTS
1.1.8	Timing ETI server	COTS
1.2	Readout hardware	
1.2.1	Readout switches	COTS
1.2.2	Readout optical modules	COTS
1.2.3	Readout fibres	COTS
1.2.4	Readout patch panels	COTS
1.2.5	Readout cables	COTS
1.2.6	Stage 1 readout servers	COTS
1.2.7	Stage 2 readout servers	COTS
1.3	CCM/DQM hardware	
1.3.1	Stage 1 CCM/DQM servers	COTS
1.3.2	Stage 2 CCM/DQM servers	COTS

CCM Readout

2	Firmware	
2.1	Timing firmware	
2.1.1	Timing master firmware	
2.1.2	Timing endpoint firmware	
2.1.3	Timing HSI firmware	
2.1.4	Timing GPS interface firmware	
2.1.5	Timing boards interface firmware	
2.2	Readout transmit firmware	
2.2.1	UDP Tx block firmware	
2.2.2	Readout TxMux block firmware	

CCM

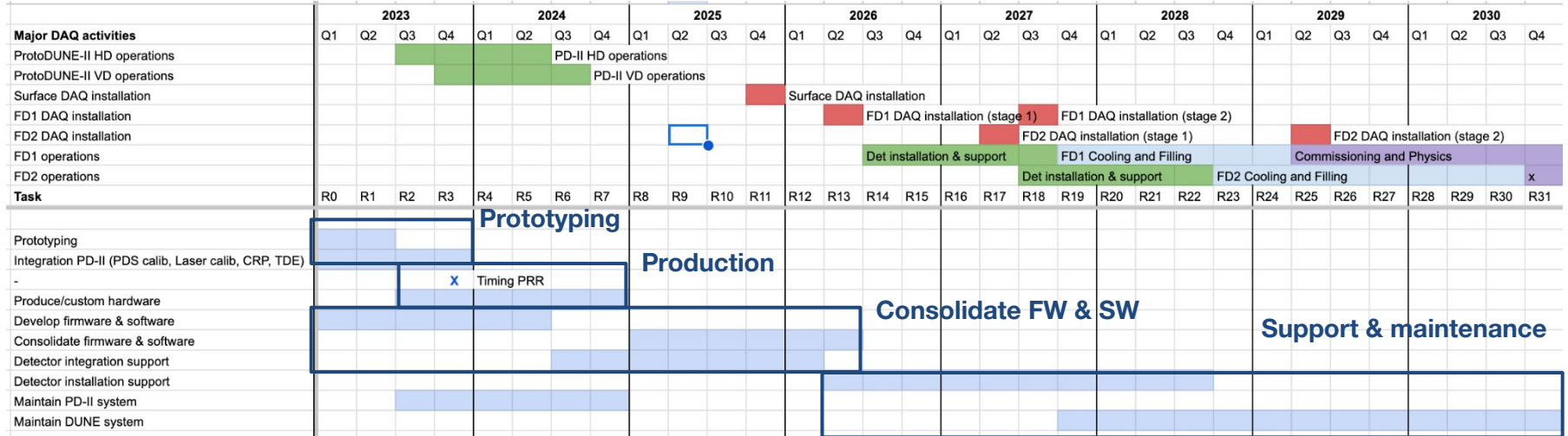
3	Software	
3.1	Timing software	
3.1.1	Timing system library	
3.1.2	Timing system DUNE-DAQ modules	
3.2	Readout software	
3.2.1	NIC data reception functions	
3.2.2	NIC data reception tools	
3.2.3	TPG framework	
3.2.4	TPG tools	
3.3	Run control software	
3.3.1	Run control appfwk interface	
3.3.2	Access control logic	
3.3.3	Resource control logic	
3.3.4	Process management	
3.3.5	Run control	
3.3.6	Run number	
3.3.7	Run registry	
3.3.8	Run conditions	
3.3.9	Supervisor	
3.4	Configuration software	
3.4.1	Configuration model	
3.4.2	Configuration data access library	
3.4.3	Configuration appfwk interface	
3.4.4	Configuration versioning tools	
3.4.5	Run configuration	
3.4.6	Resource control configuration	
3.4.7	Access control configuration	
3.4	Monitoring software	
3.4.1	Monitoring message software	
3.4.2	Monitoring error report system	
3.4.3	Operational monitoring	
3.4.4	Monitoring user interface	

Trigger

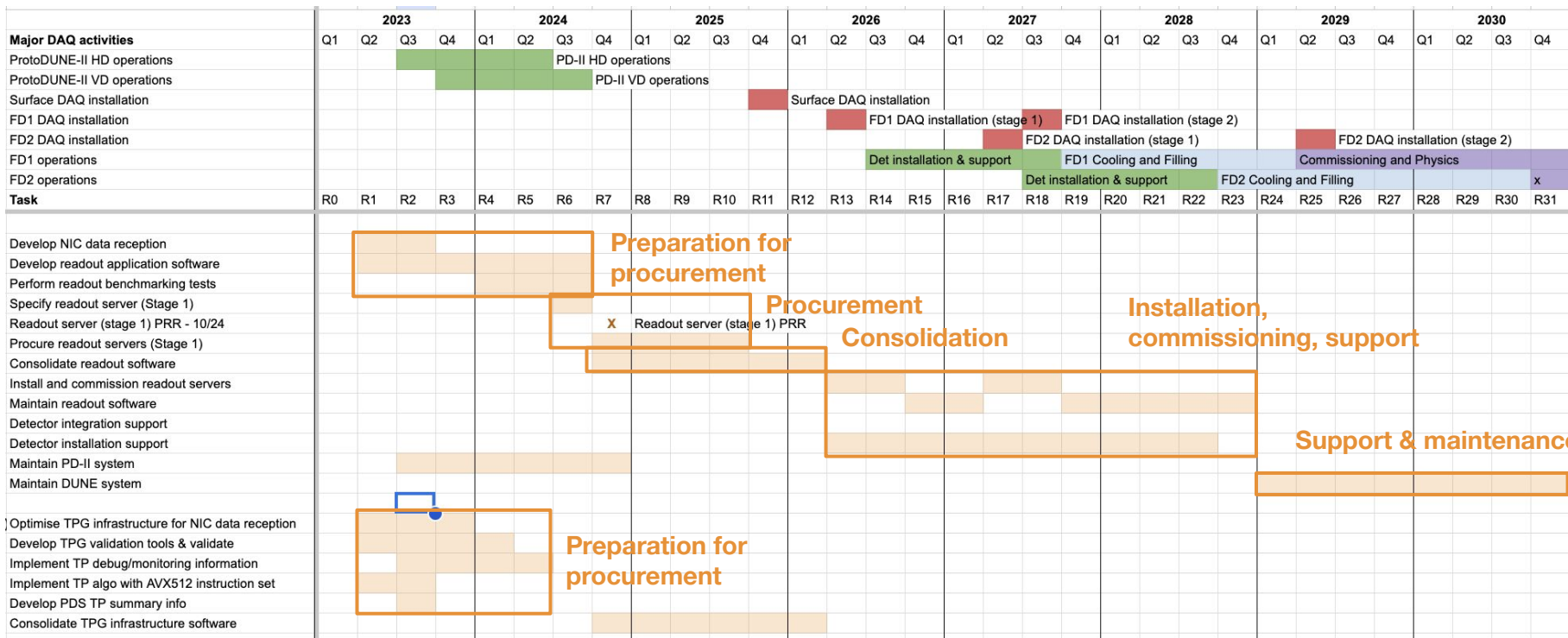
DQM

3.7	Trigger software	
3.7.1	Trigger infrastructure	
3.7.2	Module level trigger	
3.7.3	External trigger interface	
3.7.4	Trigger primitive algorithms	
3.7.5	Trigger object algorithms	
3.7.6	Trigger-simulation interface	
3.7.7	Trigger menu	
3.8	DQM software	
3.8.1	DQM front end	
3.8.2	DQM aggregator	
3.8.3	DQM back end	

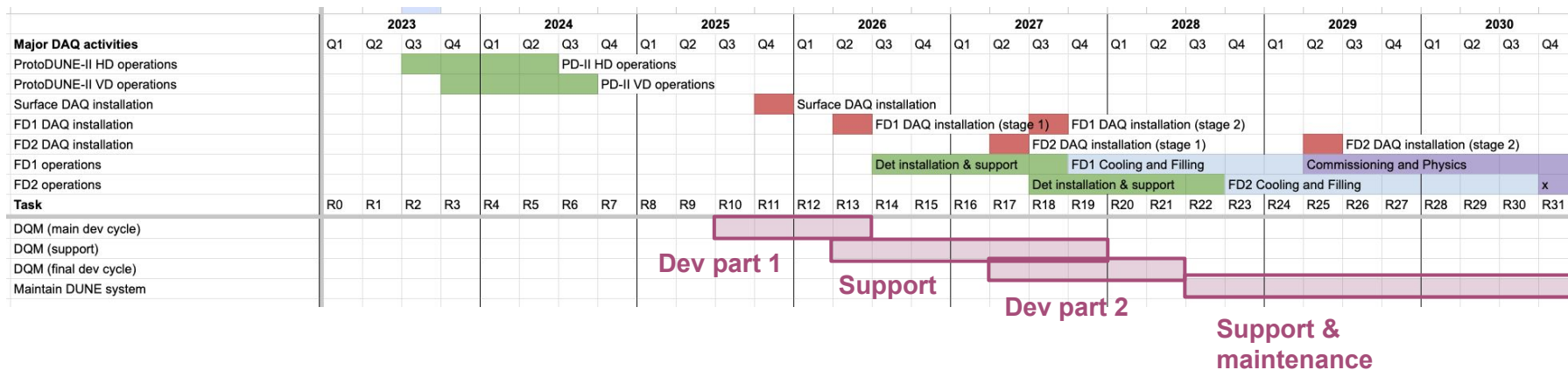
Timing



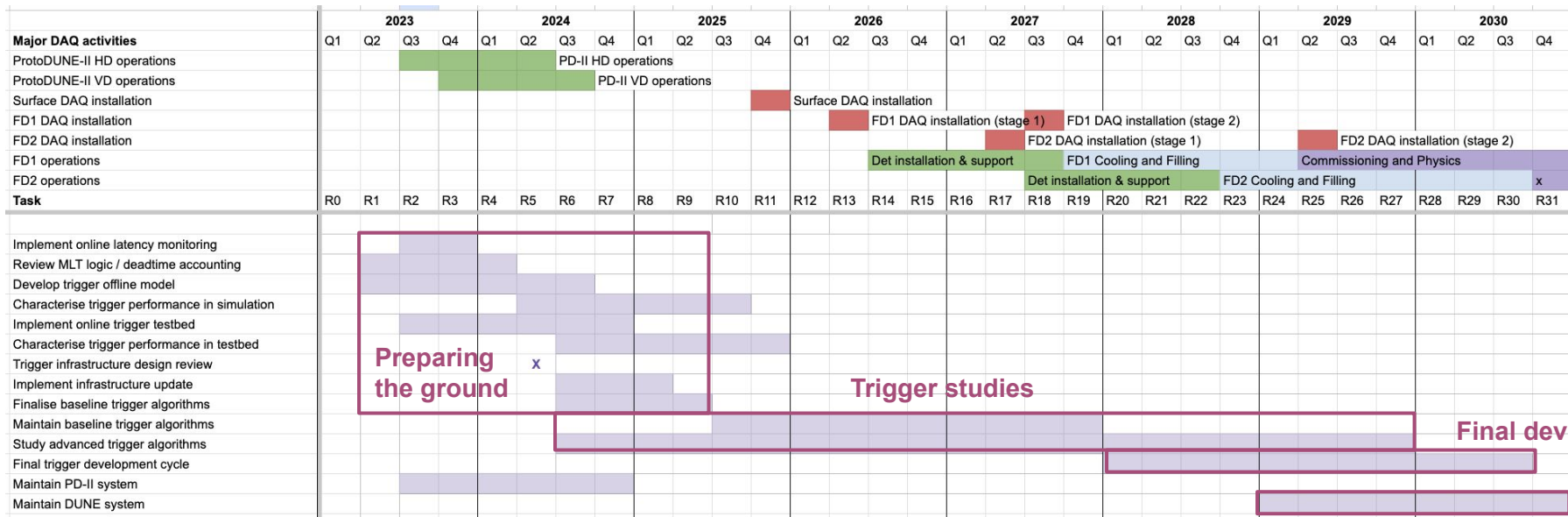
Readout SW



DQM



Trigger



Preparing the ground

Trigger studies

Final dev

Support & maintenance

Equipment

COTS servers

Custom production

COTS network items

Item	Unit cost	Prototyping		Stage 1		Stage 2	
		N	Total (kGBP)	N	Total (kGBP)	N	Total (kGBP)
CCM/DQM servers							
Worker node	4.96		0 0.0	10	49.56	44	218.06
Readout servers							
Readout node	19.75		1 25.0	11	217.26	75	1481.29
ETI server							
General purpose node	1.79		0 0.0	0	0.00	4	7.17
Timing system							
Timing system prototypes	15.4		2 30.8	0	0.00	0	0.00
Timing system production	287.8		0 0.0	1	287.83	0	0.00
Readout network							
Switch (40G/100G)	28.13		0 0.0	17	478.14	0	0.00
Switch (10G/100G)	26.64		0 0.0	38	1012.37	0	0.00
QSFP+	0.11		0 0.0	368	41.07	0	0.00
SFP+	0.03		0 0.0	3007	81.19	0	0.00
100G DAC	0.06		0 0.0	384	23.50	0	0.00
Fibres & Ancillary	177.92		0 0.0	1	177.92	0	0.00
Total			55.76		2368.83		1706.52
Grand total							4131.11

Next Steps

Outstanding Planning

- **Resource requirements for '27-'30**
 - Some taper in effort clearly expected
 - But difficult to draw a clear line between “construction” and “commissioning”
- **Key performance parameters**
 - ie. definition of successful delivery
 - Discussion started within consortium
- **Detailed resource loaded schedule**
 - Preparation underway
- **Milestones**
 - Tracking milestones will follow from detailed schedule
- **Project coordination structure**
 - Work streams & coordinators

Realising the Plan

- **Problem :**
 - Plan relies on substantial expertise in software engineering
 - Reliability & scalability requirements come into focus
 - Need to increase the UK DAQ capability for software engineering
- **Possible solutions :**
 - Hire more staff
 - Efforts to do so underway
 - Use University “Research Software Engineering” groups
 - Discussions with several institutes underway, some look promising
 - Training
 - Will start an activity within UK DAQ project to deliver this

Funding

- Asked to submit an **outline proposal** for feedback from OsC ahead of full proposal
 - Covering the full scope, ie. completion in ~2030
 - Deadline Sept '23
- Followed by **full proposal** for review by PPRP
 - Deadline late Nov/early Dec for PPRP meeting in early '24
 - Assume grants starting Oct '24, funding in two tranches
 - Concern raised about time for feedback between outline and full proposals
- Work on proposal documents about to start
 - Will be requesting input from PIs and activity coordinators

Summary

- **New project** - but planning remains largely unchanged
- Key areas of the project (Timing, Readout) **approaching the production/procurement phase**
- **Project re-planning is now well advanced**
 - Finalising the detailed schedule, plans for commissioning, and project coordination
- Identified **software engineering capability** within UK as an issue
 - Solution will include new hires, potential use of RSE groups, and training
- **Proposal preparation will start shortly**

Backup

