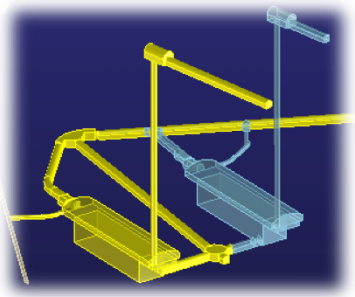
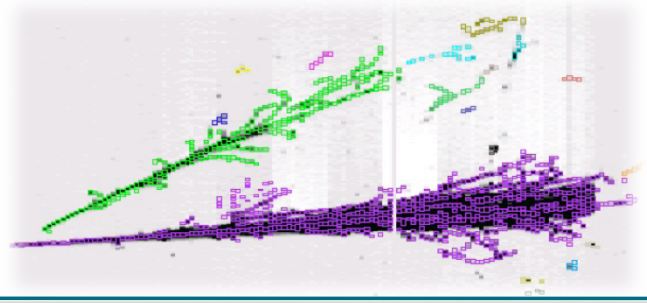
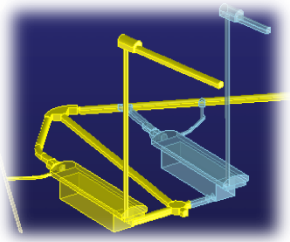




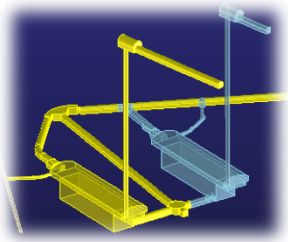
Data Acquisition

WBS 1.5.4



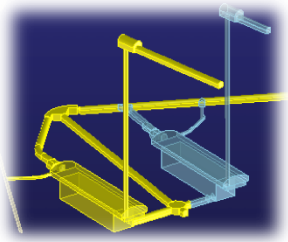
Outline

- Scope & Requirements
- Overview
- ES&H and QA
- Organization/Contributors
- Risks, Mitigations & Prototypes
- Cost estimate, schedule and milestones
- Alternatives
- Work remaining for CD-1
- Summary



DAQ System Scope

- Configuration, control of detector operations
- Generation & distribution of timing signals
- Collection of data from TPC, Photon & Veto systems
- Event building, filtering, fast processing
- Slow controls, including experiment conditions monitoring
- Operator interface (Run Control)

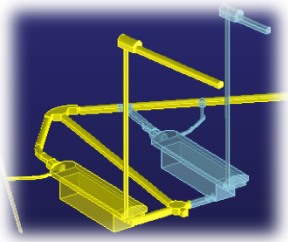


Requirements – I

- Signals to and from detector elements
  - Provide configuration/control signals to TPC et al.
  - Collect raw data via xface w/ front-end electronics
    - 2 MHz sampling rate at the front-ends.
    - 1.6 ms maximum drift time.
- Timing
  - Distribute synchronized clock signals
  - Incorporate LBNE beam spill signal information

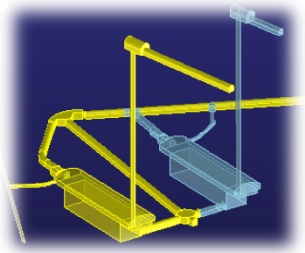
Requirements – II

- Event building, filtering and storage
  - Unpack, assemble data into single event records
    - Note free-running data flow from front-ends
    - Note 1.6ms maximum drift & approx. readout block times
    - DAQ must handle events spanning multiple readout blocks.
  - Event record format must be amenable to analysis
  - DAQ must compute & apply event selection criteria
- Pulsing/testing of front-end electronics
  - Initiate, collect, record detector checkout data
  - DAQ must be operational during electronics installation & commissioning



Requirements – III

- Run Control and Data Monitoring
  - Allow experimenters to operate detector
  - Monitor data collection integrity & data quality
- Slow Controls
  - Interface w/ hardware operating in support of detector systems (power supplies, etc.).
  - Monitor detector, subsystems, environmental conditions
  - Interface w/ Cryogenics control systems to provide information/interlock signals for detector operations



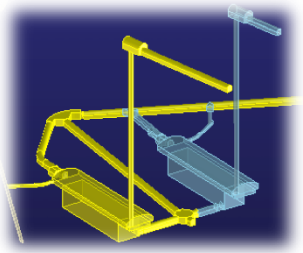
DAQ System Overview

Rates/data sizes of dominating processes

- All numbers are per APA
- Zero-suppression assumed, unless noted otherwise
- "Instantaneous data rates" are for 1.6ms timeframe
- "Avg data rates" factors in rate for 'rare' processes

1 APA (out of 168)
= 2.5m x 7m
x (2 x 2.47m drift)
= 119 tons LAr
= 3840 wires
x 3088 sample (@2 Msps)

Process	Rate (kHz/APA)	Samples (per APA)	Inst. Data Rate (Mbps)	Avg. Data Rate (Mbps)
Generic 1.6 ms interval (not zero-suppressed)	0.63	1.2×10^7	92,000	92,000
Cosmic ray muons	0.0006	5×10^4	400	0.4
10 GeV EM shower (*Avg. at 0.6 Hz CR μ rate)	—	1×10^6	9,000	9*
Radioactivity: U/Th (γ's) ^{39}Ar/^{85}Kr (β's)	~ 1 42	40 24	0.48 12	0.48 12
Electronics noise (not common mode)	2	15	0.4	0.4



DAQ System Overview

Key Features

Costs
- $2.8M DI, 36% Contingency

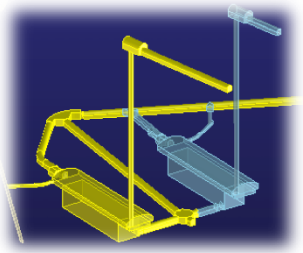
Design
- Draws from existing/designed NOvA, MicroBooNE, D-Zero, etc., systems
- Exploits commodity commercial components
- 48 Gbps throughput capacity for 1.5 Gbps average rate (whole detector).

Acquisition
- In-house construction + commodity computing/networking components

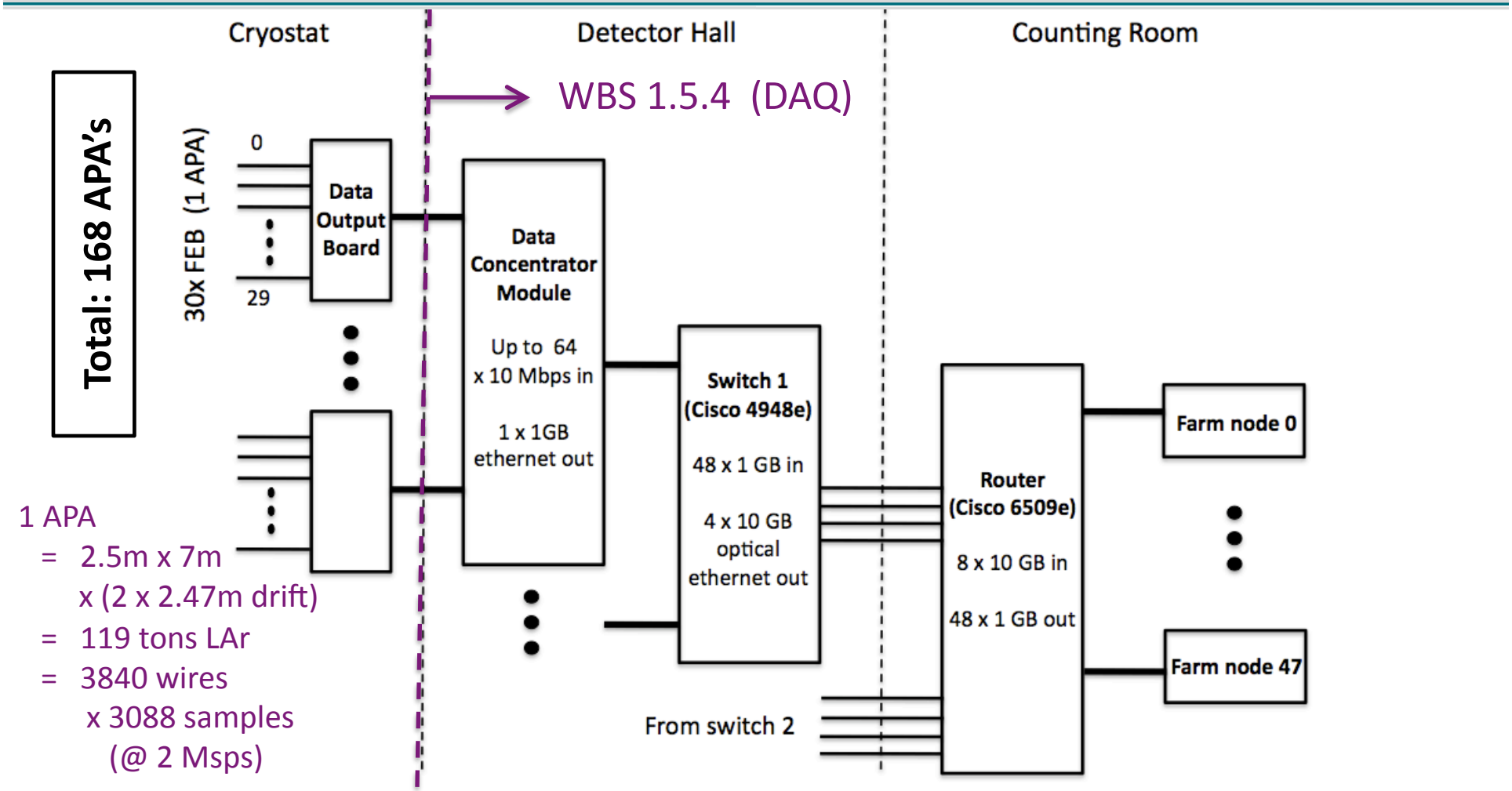
Risks
- Rates, Sparsification, DUSEL network bandwidth

Prototypes
- NOvA components

Critical Milestones
- None



DAQ System Overview



DAQ System Overview – Data Concentrator Module

- Based on NOvA Design
  - Up to 64 inputs
  - Collects serial data
  - Combines and packetizes data for transmission to Data Farm nodes via ethernet network.
- More detail in breakout.

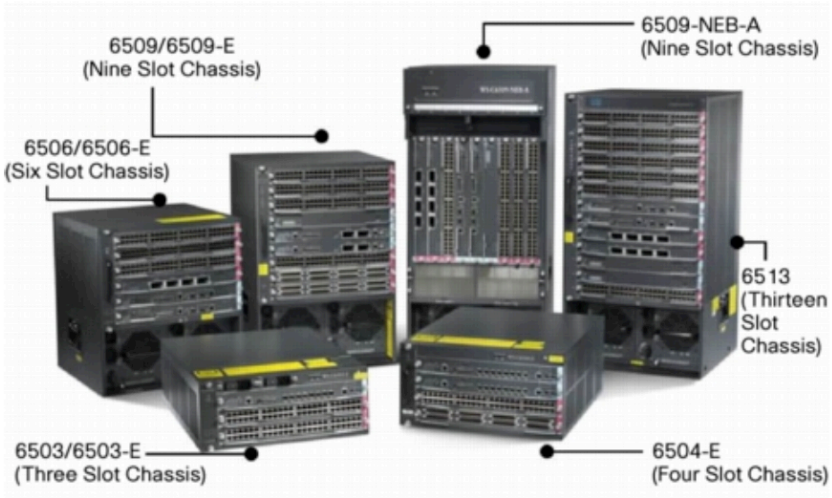
DAQ System Overview – Timing System

- Based on NOvA Design
  - Central Facility: GPS receiver & Master timing unit
  - Distributed Components: Slave timing unit
    - Distributes synchronized clock signal to front-ends
- More details in breakout session.

Ethernet Switch Array

- Need to route data from DCM's to Data Farm in Counting Room
- More detail in breakout.

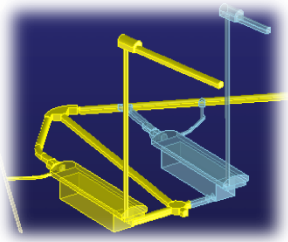
Cisco 4948E Ethernet Switch
48 x 1GB in / 4 x 10GB optical out



Cisco 6500 Router Chassis Series

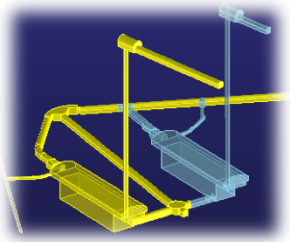
Data Farm & Online Computing

- Specifications:
  - 48 compute nodes
  - 100 TB staging disk system
- More Details in Breakout Session.



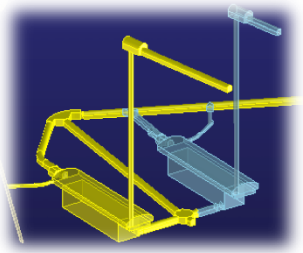
Power Requirements / Racks

- In the Detector Hall:
  - ~15 kW power required
  - Relatively small number, *O*(10's), of racks needed
    - Location is important (timing system)
  - Integrated with shielding/grounding plan
- More Details in Breakout Session.



ES&H and QA

- ES&H
  - Hazards:
    - Construction site hazards during Installation/commissioning in detector hall.
    - Fire hazards for electronic equipment.
  - ES&H plan:
    - Involve ES&H professionals in all phases
- Quality Assurance
  - Comment:
    - extensive use of commercial components
  - QA plan:
    - QA responsibility lies with suppliers/manufacturers.



Contributors

Argonne – xface w/ Veto System
- Jon Paley

BNL – xface w/ Front End
- Veljko Radeka
- Gianluigi De Geronimo
- Craig Thorn
- Bo Yu

Columbia U. – DAQ Architecture
- Leslie Camilleri
- Cheng-Yi Chi
- Mike Shaevitz
- Bill Sippach
- Bill Willis

FNAL – DAQ Architecture
- Mark Bowden
- Marvin Johnson

Indiana U. – Project Management
- Jon Urheim

Oxford U. – DAQ Architecture
- Giles Barr

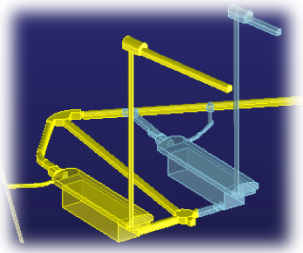
SMU – Optical drivers
- Tiankuan Liu
- Jingbo Ye
- Ping Gui

Yale U. – Online/Offline Software
- Eric Church

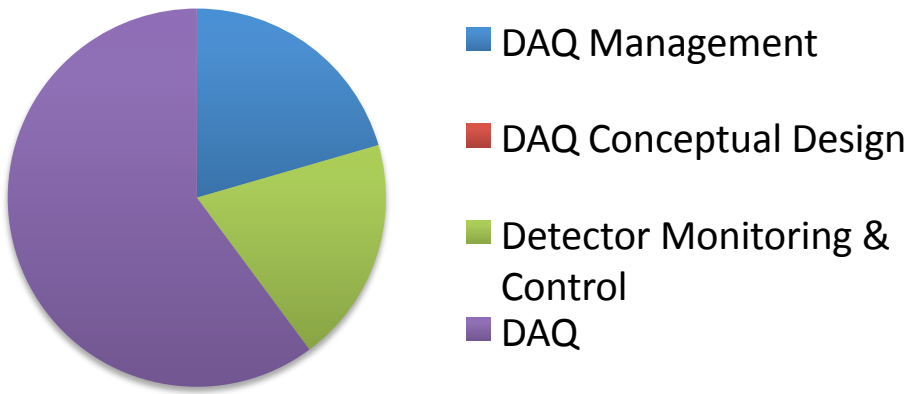
Note: Organizational structure currently under development

Risks, Mitigations & Prototyping

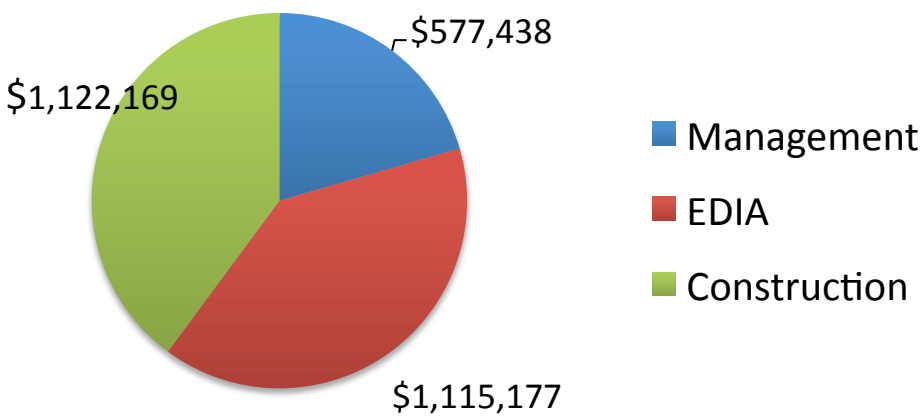
- Rates due to radioactivity, cosmics higher than expected.
  - Mitigation: Design for comfortable bandwidth margin.
- Sparsification at front-end not as effective as expected.
  - Mitigation: Put more processing capacity into DCM's.
  - Prototyping: The ~800-ton instrumented membrane cryostat prototype will be extremely helpful.
- DUSEL LAN/WAN not reliable.
  - Mitigation: augment local data storage capacity.

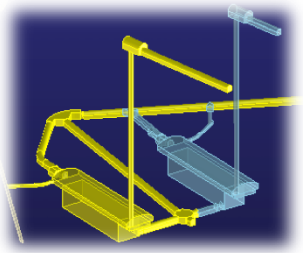


Cost Breakdown



Cost break down:
See Breakout for details.

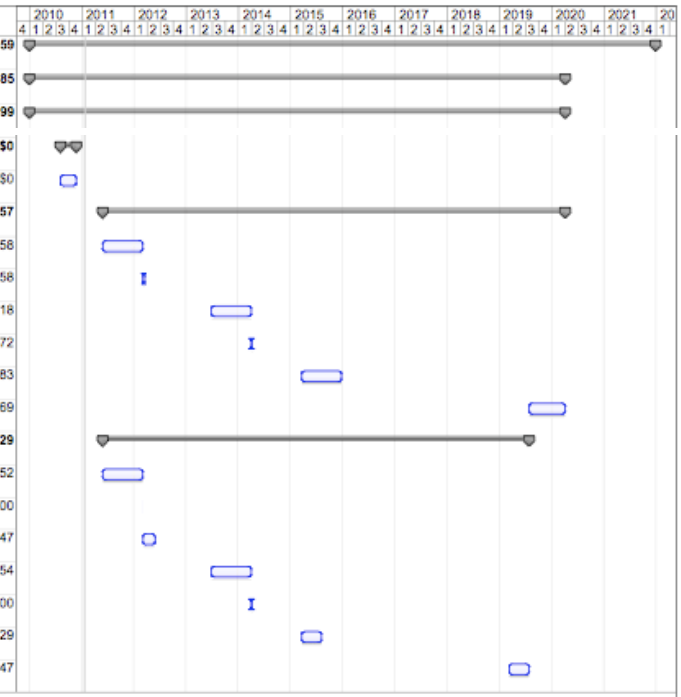




Schedule

2010 2020

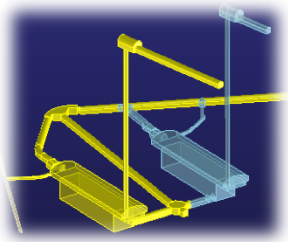
ID	WBS	Task Name	Start	Finish	Duration	Base Labor	Base M&S	TEC	TPC
1	**1.05**	**Liquid Argon Detector (800L Membrane x 1 Detector)**	**Thu 10/1/09**	**Wed 9/29/21**	**3130 d**	**$18,046,052**	**$133,212,552**	**$174,462,191**	**$237,681,359**
182	**1.05.04**	**Data Acquisition**	**Thu 10/1/09**	**Mon 1/6/20**	**2678 d**	**$811,520**	**$882,620**	**$2,814,785**	**$4,300,885**
183	**1.05.04.01**	**DAQ Management**	**Thu 10/1/09**	**Mon 1/6/20**	**2678 d**	**$256,320**	**$4,620**	**$577,438**	**$806,299**
195	**1.05.04.02**	**DAQ Conceptual Design**	**Mon 5/10/10**	**Fri 8/27/10**	**80 d**	**$0**	**$0**	**$0**	**$0**
196	1.05.04.02.01	DAQ conceptual design	Mon 5/10/10	Fri 8/27/10	80 d	$0	$0	$0	$0
197	**1.05.04.03**	**Detector Monitoring & Control**	**Tue 3/1/11**	**Mon 1/6/20**	**2310 d**	**$121,600**	**$242,000**	**$544,043**	**$1,074,357**
198	1.05.04.03.01	Detector Monitoring Preliminary Design	Tue 3/1/11	Mon 12/5/11	200 d	$16,000	$32,000	$72,323	$142,358
199	1.05.04.03.02	Detector Monitoring preliminary design review	Tue 12/6/11	Mon 12/19/11	10 d	$4,000	$0	$8,929	$17,858
200	1.05.04.03.03	Detector Monitoring final design	Fri 3/29/13	Thu 1/2/14	200 d	$16,000	$2,000	$38,003	$73,718
201	1.05.04.03.04	Detector Monitoring final design review	Fri 1/3/14	Mon 1/6/14	2 d	$800	$0	$1,786	$3,572
202	1.05.04.03.05	Detector Monitoring construction	Mon 12/22/14	Fri 9/25/15	200 d	$48,800	$200,000	$333,492	$666,983
203	1.05.04.03.06	Detector Monitoring checkout	Tue 4/30/19	Mon 1/6/20	180 d	$36,000	$8,000	$89,511	$169,869
204	**1.05.04.04**	**DAQ**	**Tue 3/1/11**	**Mon 4/29/19**	**2130 d**	**$433,600**	**$636,000**	**$1,693,304**	**$2,420,229**
205	1.05.04.04.01	DAQ preliminary design	Tue 3/1/11	Mon 12/5/11	200 d	$120,000	$2,400	$270,607	$377,752
206	1.05.04.04.02	DAQ preliminary design review	Tue 12/6/11	Wed 12/7/11	2 d	$2,400	$0	$5,357	$7,500
207	1.05.04.04.03	DAQ Prototype	Thu 12/8/11	Wed 2/29/12	60 d	$24,000	$102,400	$170,718	$306,547
208	1.05.04.04.04	DAQ final design	Fri 3/29/13	Thu 1/2/14	200 d	$160,000	$2,400	$359,895	$502,754
209	1.05.04.04.05	DAQ final design review	Fri 1/3/14	Mon 1/6/14	2 d	$2,400	$0	$5,357	$7,500
210	1.05.04.04.06	DAQ construction	Mon 12/22/14	Fri 5/8/15	100 d	$104,800	$486,800	$788,678	$1,095,729
211	1.05.04.04.07	DAQ checkout	Tue 12/11/18	Mon 4/29/19	100 d	$20,000	$42,000	$92,692	$122,447



Project: LAr Schedule 1a
Date: Wed 10/20/10

Task | Progress | Summary | External Tasks | Split
Split | Milestone | Project Summary | External MileTask

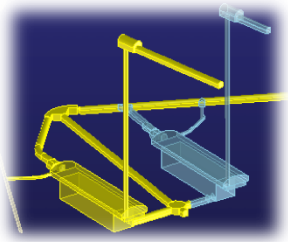
Page 1



Alternatives

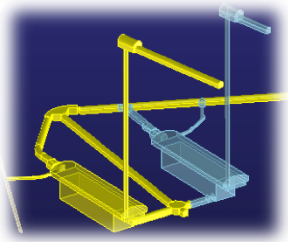
- Put more processing at interface w/ cold electronics. Could carry out additional sparsification/data compression if needed.

- Build separate event records from each APA.
  - Would make network/switch middle stage much simpler
  - Would make offline analysis simpler for events contained within 1 APA
  - Would make offline analysis more complex for events spanning multiple APA's.



Work Remaining for CD-1

- Refine estimates of rates and data size.
- Tune DAQ architecture to expected data flow.
  - Get more reliable component counts.
- Provide more technical detail for the following systems:
  - Timing system
  - Run Control
  - Slow Controls
  - Interfaces with Veto, Photon & Cryogenics systems
- Refine to cost & schedule estimates.



Summary

- The DAQ system design depends on detector/front-end electronics configurations. The design is in early phases relative to systems upstream.
- Evaluation of physics/background rates & data sizes shows modest throughput requirement, despite high channel count/sampling rate.
- A system exploiting commercial ethernet switch arrays is viable.
- And, the main custom components (Data Concentrator Modules, Timing system) can be based on NOvA modules now being constructed/commissioned.
- The LAr20 DAQ reference design is conservative, and could be built using components available today.