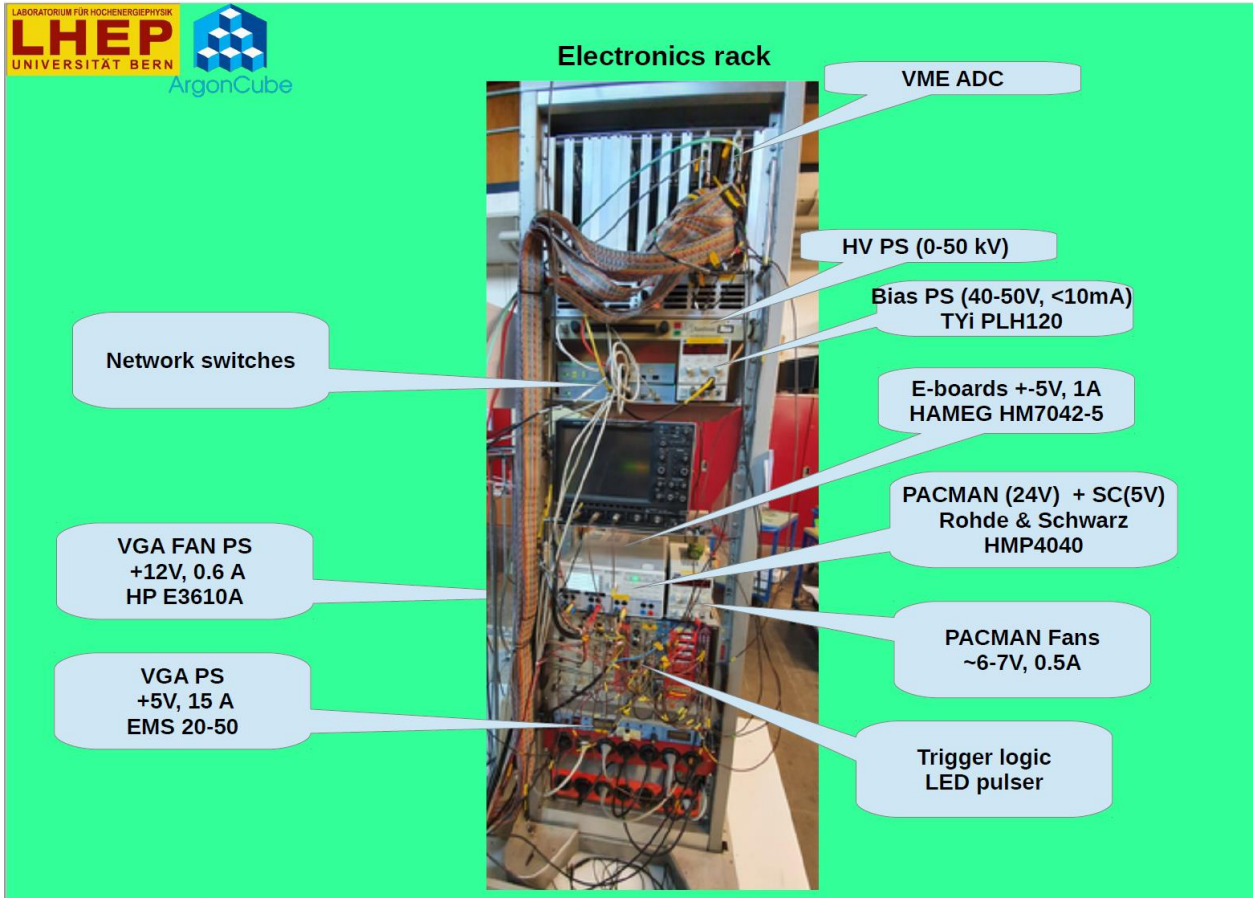
Electronics and Readout Integrations
Answers to Question #7

Linda Bagby

Cost & Schedule Review for ND-LAr 2x2 Demonstrator

August 2 – 4, 2021

Power Supply List



	U0	U3	U5	U7	U4	U1
Nominal Voltage	+5 Volts	+3.3 Volts	-12 Volts	-5 Volts	+5 Volts	+12 Volts
Adjustable Range	2V to 7V	2V to 7V	7V to 16V	2V to 7V	2V to 7V	7V to 16V
Maximum Output	115A or 550W	115A or 550W	11.5A or 150W	115A or 550W	30A or 150W	46A or 550W

- From 6.10.2021
- L: VME Crate + PS
- HV Drift
- SiMP Bias (?)
- L: E-Boards
- C: PacMan + SC
- C: PacMan Fans
- L: VGA Fans
- L: VGA PS

Answer to Question #7

- 7. What will the Wiener power supplies be used for, and if it's to power the 2x2 electronics, does this mean that the DC power supplies used at Bern are not going to be used at Fermilab?

- The MINOS Wiener power supplies are used to power the VME64X crates used for the Light readout system (ADC). Light requires 2 crates + supplies. We will also prepare a spare crate/power supply assembly.
- MINOS Wieners can also be used for VGA Power Supply and Fans, E-boards.
- We will be using the BERN HV Drift power supply.

Answer to Question #7

- 7. Could you remind us where in the WBS this effort (testing and possibly refurbishing the power supplies) is reflected?

- 1.6a.3.2: Preparation MINOS racks for electronics installation (VME crates
  - EE:5 days, ET: 20 days
- 1.6a.3.3: Recabling Wiener DC Power Supply for Light Readout
  - EE: 10 days, ET: 20 days

Refurbishing Electronics racks and VME crates for 2x2	$15K	$3.0K	20%	M3	$15K			1.6a.3.2
Recabling Weiner DC Power Supply for light readout	$5K	$2.0K	40%	M5	$5K			1.6a.3.3

1.6a.3.2	*Preparation MINOS racks for electronics installation*	1.5a.1	20	9/1/21	9/30/21	EE:5d+ET:20d	$15 K
1.6a.3.3	*Light readout SEDR, installation and pORC*	1.6a.3.1	40	10/1/21	12/1/21	EE:10d+ET:20d	$10 K

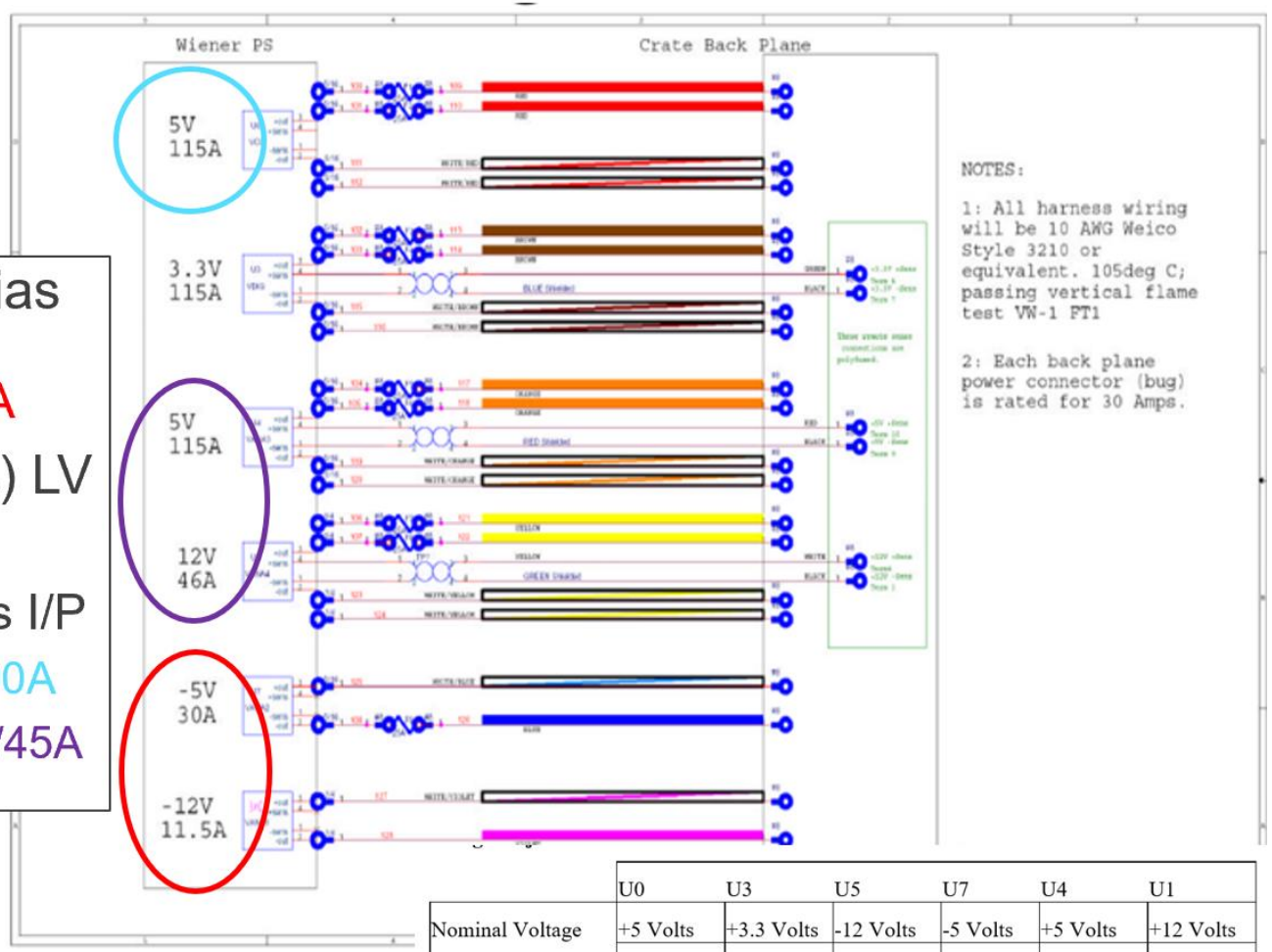
Back Ups

Scope of Work: Infrastructure DC Image

ArgonCube

MINOS Minder

- LV ASIC Bias (LMH6624)
  - +/-5V, 4A
- PGA (VGA) LV PS
  - 2 options I/P
    - +5V/90A
    - +/-5V/45A



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Maximum Output	115A or 550W	115A or 550W	11.5A or 150W	115A or 550W	30A or 150W	46A or 550W

Outline

- Introduction to subsystem and deliverables
- Scope of work
- Resource plan and schedule
- Installation and commissioning plans and labor
- List of risks
- Summary

Electronics Integration Deliverables

- The Fermilab ND Electrical Group provides the following services
  - Cryogenics Equipment, AC Distribution, and Networking
    - AC Power Distribution and networking
    - Purity Monitor Electronics
    - Network Switches
  - Cryogenics Controls Rack layout and Networking
    - AC Power Distribution, emergency back up power, networking
  - Rack Layout and installation
    - List of rack specifications and accessibility requirements

Electronics Integration Deliverables

- The Fermilab ND Electrical Group provides the following services
  - Cable Routing and Cable trays
    - Cable routing scheme from TPC to all electronics racks
  - Cable Tray support installation
    - List of cable trays and locations
  - Layout and AC support for on-detector TPC electronics
    - AC Power Distribution
    - Electrical safety protection
    - Networking
  - Rack building for Electronics and DAQ
    - ‘low-noise’ AC Power Distribution
    - Rack protection
    - Networking
    - Cabling
    - DC Power Distribution

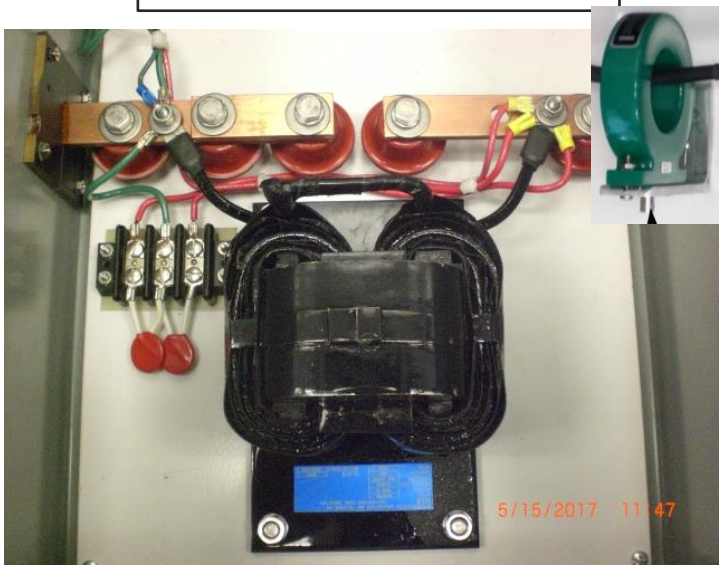
Scope of Work: AC Power Distribution

- Design, fabrication, installation
  - LArTF installation
    - 3 systems; Building, 'low-noise', and Generator back-up
  - MINOS installation
    - 4 systems; Building, Quiet, 'low-noise', and Generator back-up
- Documentation
  - LArTF: DUNE DocDB # 22642
  - MINOS: DUNE DocDB# 20762
- Safety reviews
  - The Building, Quiet, and Generator back-up installations are completed by contract electricians and follow NEC code.
  - The 'low-noise' system, as a custom design, undergoes an ORC for approved by the AHJ at Fermilab. A NEC code 'equivalency' document is provided to the review committee.
- Interface to other systems
  - Power requirements are provided by the Installation, Cryogenics, Dubna, LBNL, and Bern groups.

Scope of Work: 'low-noise' Images

DS Transformer

SI + CT Enclosure



Impedance Monitor (GIZMO)

Scope of Work: Networking/Slow Controls

- Design, fabrication, installation
  - Networking requirements are the basis of the design
    - Slow Controls
  - All equipment is selected and installed by the Fermi Networking group.
- Documentation
  - LArTF:
  - MINOS: DUNE DocDB #22971
- Safety reviews
  - Networking equipment is all commercial.
  - Rack level ORCs verify power distribution and cabling safety.
- Interface to other systems
  - Fermi Networking, Cryogenics, Dubna, LBNL, and Bern groups.

Scope of Work
MINOS: Networking/Slow Controls

- Platform/cryostat
  - One network switch with 10 Gb fiber uplink
  - 22 1Gb copper ports
- Catwalk
  - 3 options
    - One managed network switch per rack
    - One unmanaged network switch per rack
      - Need an uplink location -> switch with fiber ports
  - ~ 24 1Gb copper ports
- Cryo rack
  - Operation during power outage
  - No space for a switch in the rack
  - No rack protection
  - 1 1Gb copper for computer
- Server/Minerva racks
  - One network switch with 10 Gb fiber uplink
  - 12 1 Gb copper ports
  - 4 10 Gb copper ports

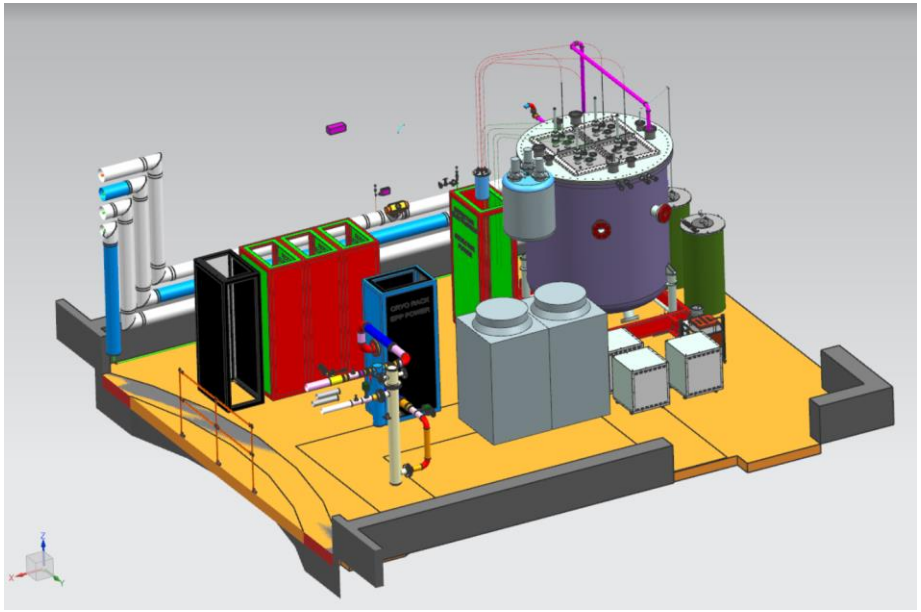
Scope of Work: Rack Layout

- Design, fabrication, installation
  - Quantity and Rack layout locations have been identified based on power service and electronics proximity requirements.
- Documentation
  - LArTF/MINOS: DUNE DocDB# 22971
- Safety reviews
  - Rack locations comply with egress and access requirements.
- Interface to other systems
  - Installation, Cryogenics, Networking, Dubna, LBNL, Bern groups

Scope of Work: Rack Layout Images

ArgonCube

LArTF



4 Cabtron

2 Server

MINOS

8 Cabtron

2 Server

Scope of Work: Cable Trays and Routing

- Design, fabrication, installation
  - TPC to Top Plate electronics and detector electronics racks.
- Documentation
  - LArTF:
  - MINOS:
- Safety reviews
  - ORC for overall installation
- Interface to other systems
  - Installation, Cryogenics, Networking, Dubna, LBNL, Bern groups

Scope of Work: Rack Builds

- Design, fabrication, installation
  - Rack builds are planned to follow NEC and equipment cooling requirements.
  - Infrastructure is provided for each rack
    - Rack Protection
    - Smoke/temperature sensors
    - AC Switch Box
    - Power Distribution Unit (PDU)
- Documentation
  - Rack Build Tool: DUNE DocDB# 20490
- Safety reviews
  - Safety Engineering Design Reviews are conducted on all custom designs or modified commercial equipment.
  - pORC reviews are conducted on all assembled rack builds.
- Interface to other systems
  - Cryogenics, Dubna, LBNL, and BERN groups

Scope of Work: Infrastructure AC Images

- System Sensor 1412B ionizing smoke sensor
  - Very old
  - Need to replace

- RPS
  - Includes a plethora of features
  - We'll use 1: smoke detection
  - Networkable

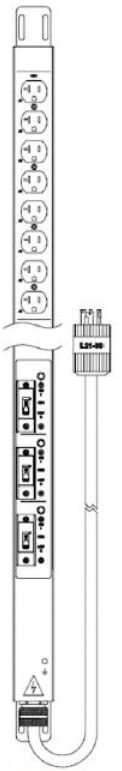
- AC Relay Unit (Switch Box)
  - Provides
    - 1 120VAC/20A
    - 1 208VAC/20A SP
      - Hubble 2326

Scope of Work: Infrastructure AC Images

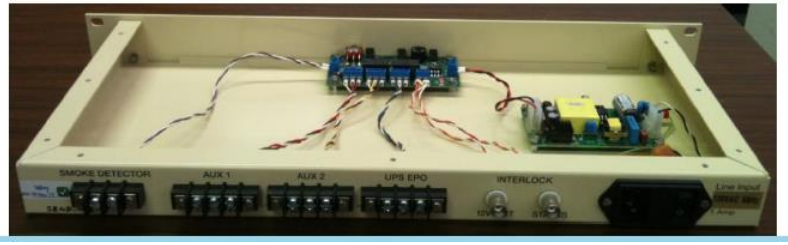
Sensor System 2W-B or 2WT-B
Photoelectric
smoke/temp (135°F) sensor

120V/20A (16A cont.)

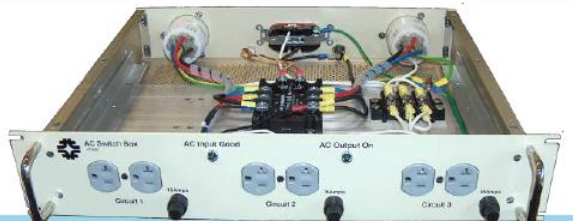
120V/30A (24A cont.)



Rack Protection Chassis



208V/3ϕ/30A (24A cont. / ϕ)



Resource Plan and Schedule

- High level design schedule and milestones

Task Name	Start	End
Preliminary Installation Design	10/25/18	7/8/21
ArgonCube 2x2 Installation Design	05/07/21	8/25/22
Detector Support and Installation Tooling Procurement	8/3/21	7/6/22
Cryogenic System Procurement	5/7/21	8/24/22
Electronics Support Design and Procurement for 2x2@LArTF	5/7/21	10/29/21
Electronics Integration Design and Procurement for 2x2@MINOS	7/9/21	8/24/22
ArgonCube 2x2@LArTF Installation and Test	8/4/21	4/29/22
Assembly and Installation in Underground MINOS Hall	7/9/21	12/12/22
ArgonCube 2x2 Commissioning	10/25/22	2/10/23
2x2 NuMI Runs	2/13/23	11/30/23

Resource Plan and Schedule

- High level design schedule and milestones

#	Milestone Tasks	Completion
1	2x2 cryostat arrived FNAL from BERN	July 30, 2021
2	First TPC module and major cryogenics equipment arrived FNAL	August 31, 2021
3	Last TPC module received for LArTF test (2nd TPC)	October 29, 2021
4	All drift HV component received for 2x2@LArTF	November 1, 2021
5	All light readout electronics received for 2x2@LArTF	November 1, 2021
6	All charge readout electronics received for 2x2@LArTF	November 1, 2021
7	Completion of preliminary installation design	July 8, 2021
8	Completion of 2x2@LArTF cryogenics design	December 15, 2021
★ 9	Electronics and DAQ are ready for 2x2@LArTF test	February 15, 2022
10	Cryogenics system is ready for 2x2@LArTF test	February 22, 2022
11	Completion of LArTF test and 2x2 is ready to move to MINOS hall	May 19, 2022
12	Final TPC modules received for MINOS test (3rd and 4th TPCs)	July 6, 2022
13	Completion of 2x2@MINOS cryogenics design	October 17, 2022
14	Cryogenics system is ready for 2x2 commissioning	January 3, 2023
★ 15	Electronics and DAQ are ready for 2x2 commissioning	December 13, 2022
16	2x2 is ready to start commissioning	January 18, 2023
17	2x2 is ready for physics data running	March 17, 2023

Electronics Integration Schedule

Electronics Integration Tasks for 2x2@LArTF

Electronics Integration Labor

- Installation & commissioning duration estimates for 2x2@LArTF

Electronics Integration Tasks for 2x2@LArTF	Start	Finish	FTE Labor
Electronics Integration and support Design	**5/7/2021**	**10/29/2021**	EE:60d + ME.Proc:10d + ComSP:45d
AC distribution and isolated TPC grounding scheme	5/7/2021	8/31/2021	EE:20d
Rack layout and AC power budget	6/7/2021	8/31/2021	EE:15d+ComSP:15d
DAQ, computing and networking for 2x2@LArTF	8/3/2021	9/29/2021	CompSP:10d+Physicist:10d
Integration design for drift HV, detector and cryogenics control	8/3/2021	9/29/2021	Physicist:10d +ME.Process:10d +CompSp:10d+EE:10d
Support design for TPC on-detector electronics and DAQ readout	8/3/2021	9/29/2021	Physicist:10d +CompSP:5d +EE:10d
Documentation and review of electronics installation plan	9/30/2021	10/29/2021	Physicist:5d +CompSP:5d +EE:5d
Electronics, DAQ and Computing Installation	**9/1/2021**	**2/15/2022**	EE: 36d + ET:60d+ME.Proc:12d + CompSP:7d
Installation of clean AC power conduit and outlet	9/1/2021	9/30/2021	EE:5d
Preparation MINOS racks for electronics installation	9/1/2021	9/30/2021	EE:5d+ET:20d
Light readout SEDR, installation and pORC	10/1/2021	12/1/2021	EE:10d+ET:20d
Charge readout SEDR, installation and pORC	10/1/2021	12/1/2021	EE:5d+ET:10d
Drift HV system SEDR, installation and pORC	10/1/2021	12/1/2021	EE:5d+ET:10d
PLC, purity monitor, DCS SEDR, installation and pORC	11/16/2021	1/14/2022	EE:2d+ME.proce:5d+ET:5d
DAQ server and networking installation and pORC	9/30/2021	11/30/2021	EE:2d+ComSP:5d+ET:5d
Final ORC of readout electronics and DAQ for 2x2@LArTF	1/18/2022	2/15/2022	CryoE:2d+ME:2d+ EE:2d+ME.proce:2d+ComSP:2d
Commissioning and testing	**1/18/2022**	**4/20/2022**	CryoE:30d+EE:20d+ME.proce:20d +ComSP:20d

Labor estimate for each tasks

Similar table for 2x2@MINOS

Resource Plan and Schedule

- Big purchasing items and their costs with procurement schedule

Equipment / Description	Base Cost Estimate [$]	Contingency [$]	Contingency [%]	Contingency Code	FY2021 Cost	FY2022 Cost	FY2023 Cost	WBS
MINOS AC for MINERvA racks (208V 3-phase)	$10K	$4.0K	40%	M5	$10K			1.6.1
LArTF electrical work for clean AC and grounding impendence monitor	$20K	$4.0K	20%	M3	$20K			1.6a.3.1
LArTF electrical work for cryogenics AC power	$10K	$2.0K	20%	M3	$10K			1.6a.3.1
LArTF network equipment and installation for 2x2@LArTF	$20K	$4.0K	20%	M3	$10K			1.6a.3.7
Old DAQ servers re-installation for 2x2@LArTF	$5K	$1.5K	30%	M4	$5K			1.6a.3.7
Refurbishing Electronics racks and VME crates for 2x2	$15K	$3.0K	20%	M3	$15K			1.6a.3.2
Recabling Weiner DC Power Supply for light readout	$5K	$2.0K	40%	M5	$5K			1.6a.3.3
Cryo control PLC rack rebuilt for 2x2	$5K	$1.0K	20%	M3	$5K			1.5a.4
License fee for Ignition SCADA	$20K	$4.0K	20%	M3	$20K			1.5a.4
LAr pump VFD and its control with PLC	$5K	$1.5K	30%	M4		$5K		1.6a.3.6
Purity monitor readout electronics	$12K	$2.4K	20%	M3		$10K		1.6a.3.6
Timing and trigger equipment - WR switch, decoders	$10K	$2.0K	20%	M3		$10K		1.6a.3.7
MINOS hall network updating for 2x2@MINOS	$15K	$3.0K	20%	M3		$15K		1.5.5
MINOS ODH monitoring and alarming with PLC	$20K	$6.0K	30%	M4		$20K		1.6.3
DAQ servers for 2x2@MINOS	$25K	$7.5K	30%	M4		$10K	$15K	1.5.5
Control room setup	$15K	$4.5K	30%	M4			$15K	1.5.6
MINOS low-noise AC transformer and grounding impendence monitor	$10K	$3.0K	30%	M4		$10K		1.5.1
MINOS grounding impendence monitor	$5K	$1.0K	20%	M3		$5K		1.5.2
Total	**$227K**	**$56.4K**			**$100K**	**$85K**	**$30K**	

List of Risks

- Risk mitigation method
  - 5 (Schedule): Final readout electronics ORC
    - Prior to installation of custom designs, collect design documentation and samples as soon as possible to conduct Safety Engineering Design Review
  - 11 (Cost): 'low-noise' XFMR and AC Distribution in MINOS
    - Use spare transformer and refurbish rack protection systems
    - Submit SOW as soon as possible

Ranking	Critical Tasks	Risk Impact	Task Completion Dates	WBS Element #
1	Cryostat vessel certification	Schedule	9/29/2021	1.2.5a.7 & 1.6a.2.0
2	Cryocooler delivery	Schedule & Cost	1/21/2022	1.4.1.2
3	Cryogenics P&ID and equipment specification	Schedule	9/29/21	1.2.5a.1
4	Cryocooler system and support installation	Schedule	2/22/2022	1.6a.2.8
5	Final Readout electroncis ORC for 2x2 commissioning	Schedule	2/15/2022	1.6a.3.8
6	TPC module delivery and QA/QC for 2x2@LArTF and 2x2@MINOS	Schedule & Cost	10/29/21, 7/6/22	1.6a.2.1/1.6.5
7	Additional cryogenic equipment and cryocooler procurement for MINOS	Cost, Schedule & Technical	10/14/2022	1.4.4& 1.2.5.1 & 1.6.7
8	ODH mitigation and monitoring system installation for 2x2@MINOS	Cost & Schedule	10/14/2022	1.2.5.3 & 1.6.3
9	Cryogenics and operation safety review for 2x2@MINOS	Schedule	12/16/2022	1.6.8
10	Cryostat access platform design and installation in MINOS	Cost & Schedule	4/7/2022	1.2.3.1 & 1.3.1
11	Low-noise transformer and AC distribution in MINOS	Cost	11/2/21	1.5.1
12	Networking upgrade in MINOS hall	Cost	9/14/2022	1.5.5 &1.5.3
13	Timing and trigger interfaces with ACNET system	Schedule	9/14/22	1.5.3

Summary

- Overall status
  - AC Distribution
    - ‘low-noise’ AC Distribution Description of Work and Requisition for LArTF have been submitted.
    - Rack locations are defined at both locations
  - Rack builds and Infrastructure are becoming clearer
- Outlook
  - Once support personnel are freed up from other duties, can begin effort in earnest
- Concerns
  - Long lead times on electrician work
  - Support personnel (Engineering and Technicians)
  - // effort on both locations

Resource Plan and Schedule

ArgonCube

- FTEs for design, installation and commissioning

All Divisions	Cryo Engineer (FTE days)	Mech Engineer (FTE days)	Mech Designer (FTE days)	Process Control Engineer (FTE days)	Mech Technician (FTE days)	Electrical Engineer (FTE days)	Electrical Technician (FTE days)	Computing Specialist (FTE days)
Technical support for FY2019-20	105	105	50	10	0	50	0	0
Technical support for FY2021	190	125	70	10	104	125	25	95
Technical support for FY2022-2023	367	205	117	189	225	213	155	327

Installation and Commissioning Plans and Labor

- Decommissioning of 2x2@LArTF and installation labor for 2x2@MINOS

Task (2x2@MINOS Specific)	***Start***	***Finish***	***FTE Labor/M&S***
Assembly and Installation in Underground MINOS Hall	7/12/2021	11/1/2022	
Re-installation of Minerva modules for ArgonCube test	7/12/2021	11/3/2021	ME:10d+ MT:64d +EE:10d +ET:25d+ComSP:20d
Cryostat access platform support safety reviews, installation	4/8/2022	6/6/2022	ME:10d+ ME.Design:10d+ MT:20d
ODH mitigation and monitoring system installation	7/6/2022	10/28/2022	ME.Process:10d+ ME:10d +MT:20d
Decommissioning of 2x2@LArTF and transfer cryostat and TPCs to MINOS hall	5/9/2022	6/7/2022	CryoE:5d+ME:5d+EE:5d +ET:10d+MT:20d
Cryostat and TPC module installation safety reviews, installation	6/8/2022	7/7/2022	CryoE:5d+ME:10d+ MT:30d
Cryogenic system installation	9/2/2022	11/1/2022	CryoE:20d+ MT:40d+ME:10d
Electronics support infrastructure safety reviews, installation	7/7/2022	9/1/2022	EE:20d + ET:20d +ComSP:20d
Electronics and DAQ safety design reviews, installation	9/1/2022	9/30/2022	EE:10d + ET:10d +ComSP:10d
HV and detector control system safety design review, installation	9/1/2022	9/30/2022	EE:5d+ET:5d+ME.Process:5d +CompSP:5d
Electronics operation safety review (pORC)	9/30/2022	10/31/2022	EE:5d+CompSP:5d
ArgonCube 2x2 Commissioning	11/1/2022	2/17/2023	
HV & detector control commissioning	11/1/2022	12/1/2022	ME.Process:5d+EE:5d +ComSP:10d
DAQ commissioning	11/1/2022	12/30/2022	EE:10d+CompSP:40d
Cryogenic control and operation safety review (pORC)	11/2/2022	12/2/2022	CryoE:10d + EE:5d
Final ORC review and safety walk-through	12/5/2022	12/19/2022	CryoE:5d+ME:5d +EE:5d+ComSP:5d
LAr filling and purifying	12/20/2022	2/17/2023	CryoE:20d+ME.Process:10d