2x2 Overall Schedule and Cost

Ting Miao – Fermilab

August 2, 2021

2x2 Project Documentation

ArgonCube

- Project documentations are posted to the agenda indico
  - WBS, milestones, risk table, interfaces, M&S costs
  - DUNE docDB is used to achieve technical notes
- WBS schedule is resource loaded
- M&S cost tables for cryogenics, installation and electronics
- Milestones and risks are also tabulated
- Interface issues between subsystems are being documented
- To go through the documentation briefly now
  - Management session reserved for detail discussion

Interface Documetnation – DUNE docDB 23046

ArgonCube

2x2 subsystem	Subsystem lead/contact
Installation and integration	**Min Jeong Kim** (FNAL)
FNAL Cryogenics design	**Mike Zuckerbrot** (FNAL)
Electronics integration	**Linda Bagby** (FNAL)
Light readout electronics	Nikolay Anfimov/Sasha Selyunin (Dubna)
Charge readout electronics	Armin Karcher (LBNL)
Drift HV - power supply, cable, filter box	Saba Parsa (Bern)
Drift HV - feedthrough	Knut Skarpaas (SLAC)
TPC module structure	Davide Porzio (Bern)
Cryostat, cryogenics and cryo feedthrough	Igor Kreslo / Roger Haenni (Bern)

- Major interface issues are captured
- Responsibilities are specified and documented

Interface Topics and Responsibilities

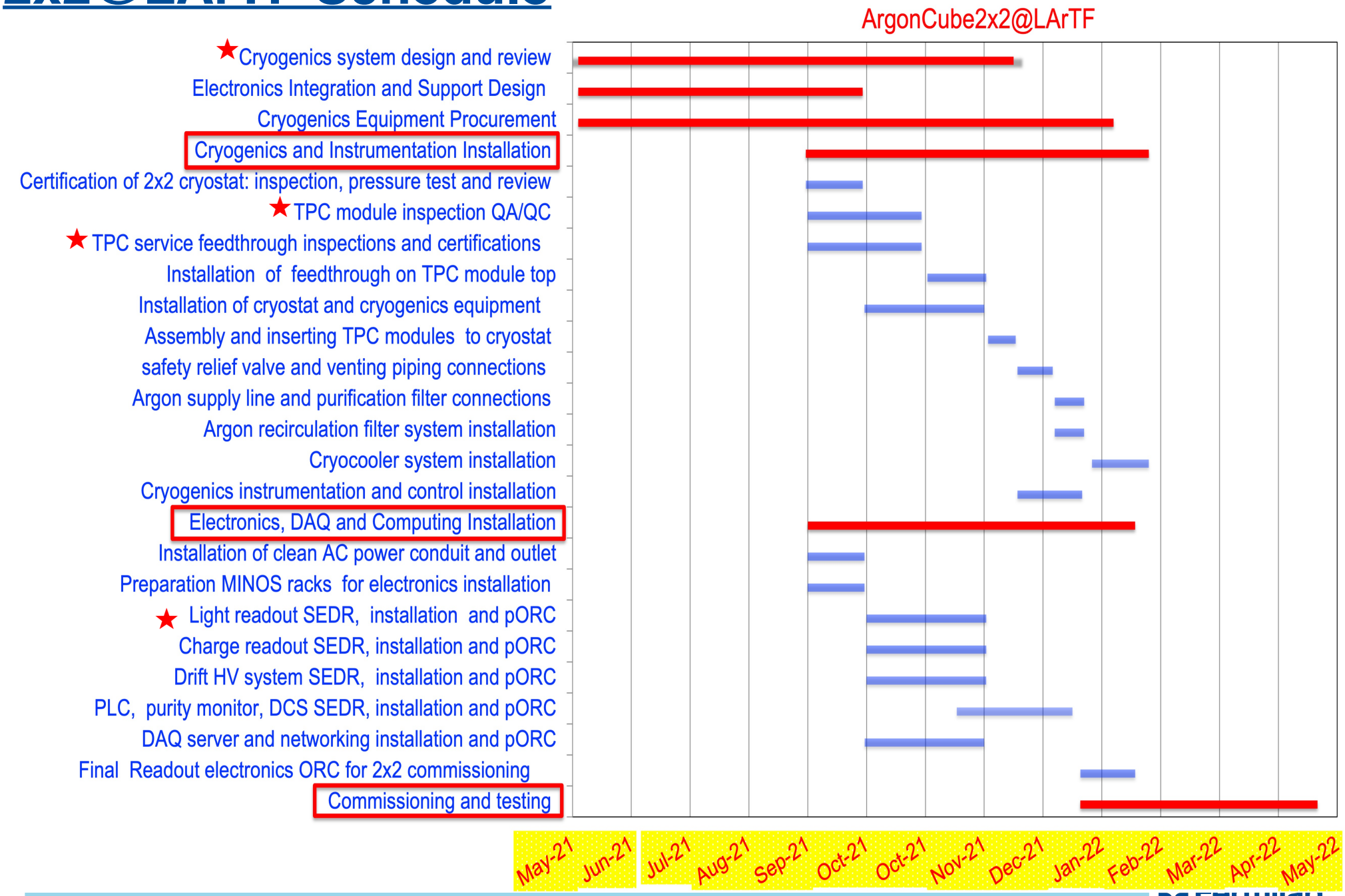
Interface Issues	Subsystem Responsibly	DUNE docDB
Cryogenic equipment specification and procurement	**Bern** provides initial P&ID and list of equipment, their connection on main cryostat top and on TPC modules	
	FNAL Cryogenics group completes the P&ID and equipment list, and specify additional procurement	
LAr filter vessel design	**Bern** provides CAD file of filter vessel from singleCube test and list of equipment and connections implemented	
	FNAL Cryogenics group modifies the vessel diameter and specify procurement plan	
Cryo equipment AC and networking requirements	**FNAL Cryogenics group** provides AC power and networking requirements for cryogenics equipment	23112, 23093, 23090, 23096, 23098, 23106
	Electronics group provides AC outlets and network switch	
Cryo control rack layout and networking	**FNAL Cryogenic control** to provide specification of PLC rack, its power budget and network connection	21459, 21958
	Electronics group provides AC outlets, emergency backup power and network switch	
Cryo equipment layout and support requirement	**FNAL Cryogenics group** provides dimension of cryogenics equipment and piping connection scheme	
	Installation group provides layout design and installation support	
Piping routing and length	**FNAL Cryogenics group** provides piping scheme of cryogenics, venting and ODH mitigation	
	Installation group provide layout design and installation support	
Cryostat and cryogenics equipment access support	**FNAL Cryo group** provides cryostat and cryogenics operation and access requirement	
	Installation group designs and builds access platform, support stand and transfer cart	

2x2@LArTF Schedule

ArgonCube

- Schedule-driven tasks
  - Cryogenics engineering and safety reviews (May 2021–Feb 2022)
    - P&ID, VIE, piping note, ODH analysis, process control
    - Cryogenics equipment specifications and procurements
    - Safety reviews – CSS panels for LArTF and for MINOS
  - TPC QA/QC and service feedthrough qualifications (Sept 2021–Oct 2021)
    - Consortium subsystem groups to be onsite for TPC QA/QC
    - Potential impact from travel limits
  - Readout electronics ORC (ongoing, to complete before Dec 2021)
- Resource demand is high especially for Oct 2021—Feb 2022

2x2@LArTF Schedule



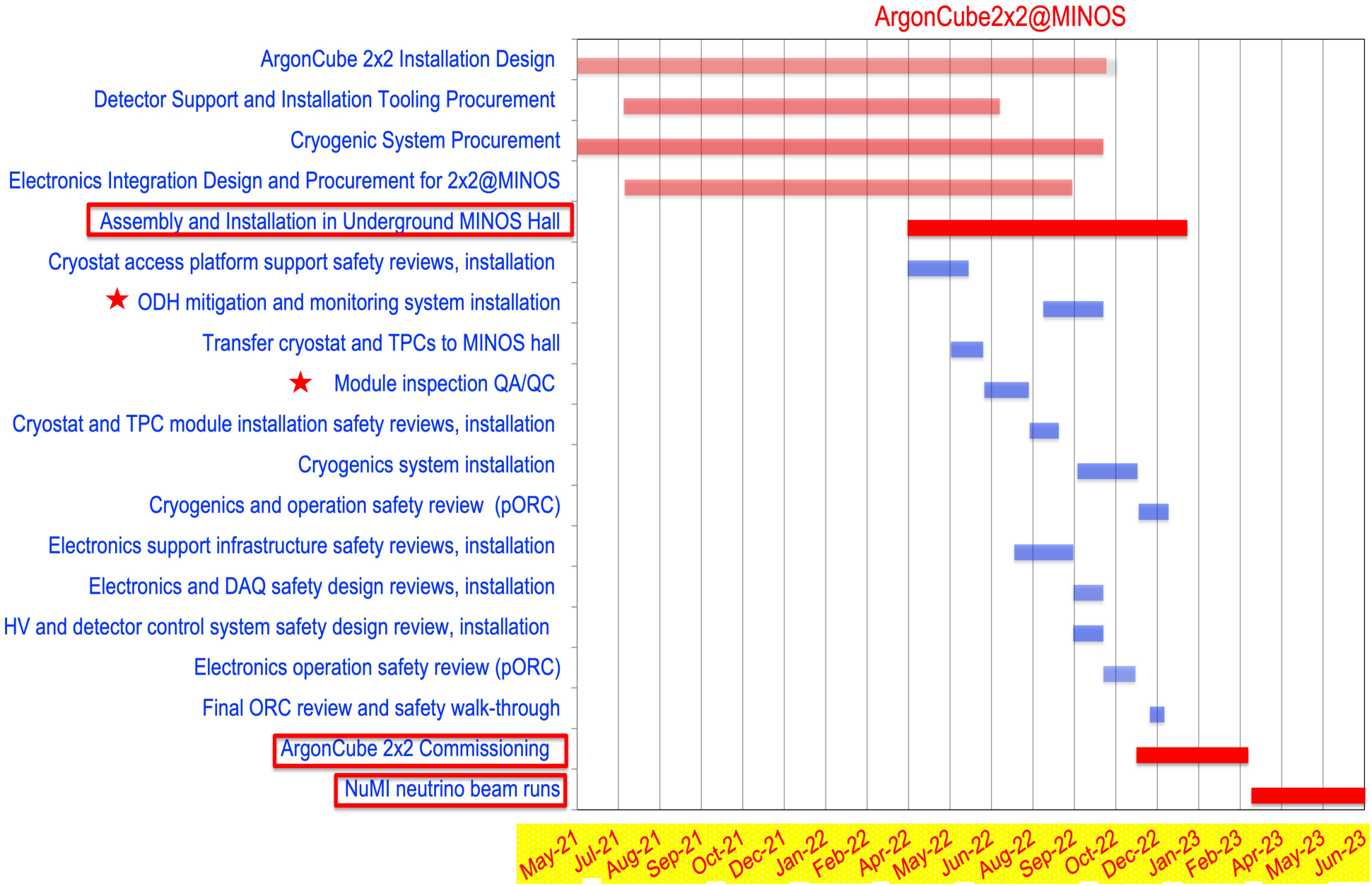
2x2@LArTF Tasks with Detail Dates

Tasks for 2x2@LArTF	*Start*	*Finish*
Cryogenics system design and review for 2x2@LArTF	5/7/2021	12/15/2021
Electronics Integration and support Design for 2x2@LArTF	5/7/2021	10/29/2021
Cryogenics equipment procurement	5/7/2021	2/4/2022
Cryogenics and Instrumentation Installation	8/31/2021	2/22/2022
Certification of 2x2 cryostat: inspection, pressure test and review	8/31/2021	9/29/2021
TPC module inspection QA/QC	9/1/2021	10/29/2021
TPC service feedthrough inspections and certifications	9/1/2021	10/29/2021
Installation of feedthrough on TPC module top	11/1/2021	12/1/2021
Installation of cryostat and cryogenics equipment	9/30/2021	11/30/2021
Assembly and inserting TPC modules to cryostat	12/2/2021	12/16/2021
safety relief valve and venting piping connections	12/17/2021	1/4/2022
Argon supply line and purification filter connections	1/5/2022	1/20/2022
Argon recirculation filter system installation	1/5/2022	1/20/2022
Cryocooler system installation	1/24/2022	2/22/2022
Cryogenics instrumentation and control installation	12/17/2021	1/19/2022
Electronics, DAQ and Computing Installation	9/1/2021	2/15/2022
Installation of clean AC power conduit and outlet	9/1/2021	9/30/2021
Preparation MINOS racks for electronics installation	9/1/2021	9/30/2021
Light readout SEDR, installation and pORC	10/1/2021	12/1/2021
Charge readout SEDR, installation and pORC	10/1/2021	12/1/2021
Drift HV system SEDR, installation and pORC	10/1/2021	12/1/2021
PLC, purity monitor, DCS SEDR, installation and pORC	11/16/2021	1/14/2022
DAQ server and networking installation and pORC	9/30/2021	11/30/2021
Final ORC of readout electronics and DAQ for 2x2@LArTF	1/18/2022	2/15/2022
Commissioning and testing	1/18/2022	4/20/2022
HV, PLC and detector control commissioning	1/18/2022	2/15/2022
DAQ commissioning	2/16/2022	3/17/2022
LAr filling and purifying	2/23/2022	4/20/2022
Commissioning runs to reach stable HV setting	4/6/2022	4/20/2022
Cosmic Ray and BNB Runs	4/21/2022	5/19/2022

2x2@MINOS Schedule

- While testing 2x2 in LArTF, support infrastructures for MINOS hall will be designed and installed as parallel efforts
  - Cryostat access platform
  - Low noise transformer and AC distribution for LAr TPC electronics
- ODH mitigation is one key task for 2x2 in MINOS
  - ODH mitigation to involve FESS – updating exhaust fan and extra duct work
- The start of 2x2@MINOS installation is driven by delivery and QA/QC for the final TPC modules
  - Last two modules are scheduled to produced before summer 2022

2x2@MINOS Installation Schedule



2x2@MINOS Tasks and Dates

ArgonCube

WBS Tasks	Start Date	Finish Date
Preliminary Installation Design	**10/25/18**	**7/8/21**
ArgonCube 2x2 Installation Design	**5/7/21**	**10/17/22**
Cryogenics design and review for 2x2@LArTF	5/7/21	12/15/21
Cryogenic design and review for 2x2@MINOS	5/20/22	10/17/22
Transportation and installation tooling	5/10/21	6/6/22
Detector support and access platform in MINOS hall	9/13/21	4/7/22
Detector Support and Installation Tooling Procurement	7/8/21	7/6/22
Cryogenic System Procurement	5/7/21	10/14/22
Electronics Integration Design and Procurement for 2x2@MINOS	7/9/21	9/14/22
ArgonCube 2x2@LArTF Installation and Test	9/1/21	5/19/22
Assembly and Installation in Underground MINOS Hall	7/9/21	1/3/23
Re-installation of Minerva modules for ArgonCube test	7/9/21	11/2/21
Cryostat access platform support safety reviews, installation	4/8/22	6/6/22
ODH mitigation and monitoring system installation	8/17/22	10/14/22
Decommissioning of 2x2@LArTF and transfer cryostat and TPCs to MINOS hall	5/20/22	6/20/22
Module inspection QA/QC	6/21/22	8/3/22
Cryostat and TPC module installation safety reviews, installation	8/4/22	9/1/22
Cryogenics system installation	9/19/22	11/16/22
Cryogenics and operation safety review (pORC)	11/17/22	12/16/22
Electronics support infrastructure safety reviews, installation	7/20/22	9/15/22
Electronics and DAQ safety design reviews, installation	9/15/22	10/14/22
HV and detector control system safety design review, installation	9/15/22	10/14/22
Electronics operation safety review (pORC)	10/14/22	11/14/22
Final ORC review and safety walk-through	11/28/22	12/12/22
ArgonCube 2x2 Commissioning	11/15/22	3/3/23
NuMI neutrino beam runs	3/6/23	6/30/23

2x2 Milestones and Critical Tasks

- Three sets of milestones to track 2x2 progress
  - TPC module and electronics delivery
  - 2x2@LArTF installation
  - 2x2@MINOS installation
- Similarly, a list of critical tasks are compiled in the risk table
  - Impact on schedule is the most concern from those risks
  - Extra resources and extended durations are added to those tasks
  - Cost and technical risks are likely to be reduced with LArTF test

2x2 Milestones

	#	Milestone Tasks	Completion
TPC and Electronics Delivery	1	2x2 cryostat arrives Fermilab from BERN	July 30, 2021
	2	First TPC module and major cryogenics equipment received by FNA	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
2x2@LArTF	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
2x2@MINOS	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	December 16, 2022
	15	Electronics and DAQ are ready for 2x2 commissioning	November 14, 2022
	16	2x2 is ready to start commissioning	January 3, 2023
	17	2x2 is ready for physics data running	March 3, 2023

Risk Table

Ranking	Critical Tasks	Risk Impact	Task Completion Dates
1	Cryostat vessel certification	Schedule	9/29/21
2	Cryocooler system specification and delivery	Schedule & Cost	1/21/22
3	Cryogenics P&ID and equipment specification	Schedule	9/29/21
4	Cryocooler system installation	Schedule	2/22/22
5	Final ORC of readout electronics and DAQ for 2x2@LArTF	Schedule	2/15/22
6	TPC module inspection QA/QC	Schedule & Cost	10/29/21, 8/3/22
7	Additional cryogenic equipment procurement for MINOS	Cost, Schedule & Technical	10/14/22
8	ODH mitigation and monitoring system installation for 2x2@MINOS	Cost & Schedule	10/14/22
9	Cryogenics and operation safety review for 2x2@MINOS	Schedule	12/16/22
10	Cryostat access platform support installation	Cost & Schedule	6/6/22
11	Low-noise transformer and AC distribution in MINOS	Cost	11/2/21
12	Networking upgrade in MINOS hall	Cost	9/14/22
13	Timing and trigger interfaces with ACNET system	Schedule	9/14/22

Labor and Cost

- Labor and cost estimates are based on past experiences of LAr TPC experiments and underground installations
  - 2x2 has a very experienced engineering team
- Engineering labors are from neutrino division and PPD
  - Engineers from the two divisions have good record of working together
- M&S estimates are from vendor quotes or past procurements
  - Major cryogenics equipment procurement are almost completed
  - Key electrical infrastructure equipment are none-cost: uBooNE spare AC transformer, DC power supply from MINOS etc.

Technical Labor and M&S Cost

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

All Divisions	M&S	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)
Support for FY2022	$450 K	277	200	117	147	225	153	155	162

Summary

- 2x2 schedule was put together using past experiences of LAr TPC experiments and underground installations
- High level milestones are defined
- Interfaces issues of 2x2 subsystems are being documented
- Time-critical tasks of TPC delivery, cryostat certification, and equipment procurement are identified and being monitored
- 2x2@LArTF is a critical step to work out technical and schedule issues before underground installation

Overall Schedule 2x2 Test at Fermilab

WBS Tasks	Start Date	Finish Date
Preliminary Installation Design	10/25/18	7/8/21
ArgonCube 2x2 Installation Design	05/07/21	10/17/22
Detector Support and Installation Tooling Procurement	7/8/21	7/6/22
Cryogenic System Procurement	5/7/21	10/14/22
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	9/14/22
ArgonCube 2x2@LArTF Installation and Test	9/1/21	5/19/22
Assembly and Installation in Underground MINOS Hall	4/8/22	1/3/23
ArgonCube 2x2 Commissioning	11/15/22	3/3/23
2x2 NuMI Runs	3/6/23	12/29/23

Backup Slides

Interface Issues and Responsibilities (Cont.)

Interface Issues	Subsystem Responsibly	DUNE docDB
Rack layout and installation	**Electronics group** provides list of racks, size of racks, access and space clearance requirement	22971, 22639
	Installation groups provides layout 3d model and installation support	
Cable routing and cable tray	**Electronics group** provides cable routing scheme from TPC to electronics on the cryostat top and in the electronics readout racks	
	Installation group provides layout 3d model, cable length calculation and installation support	
Cable tray support installation	**Electronics group** provides list of cable trays and their locations	
	Installation group provides layout 3d model and cable tray support design	
Layout and AC support for on-detector TPC electronics	**Dubna/LBNL/Bern groups** provide equipment list, AC/DC power budget and networking requirement for light/charge/drift HV electronics located on top of cryostat flange	21540, 20615, 20681, 18300
	Electronics and installation groups provide AC distribution, electrical safety protection, network switch and layout 3d model	
Rack building for electronics and DAQ	**Dubna/LBNL/Bern groups** provide single line electrical diagram of light/charge/drift HV readout and control electronics placed inside electronics racks	22809, 21809, 20490, 20943, 20681
	Electronics group provides clean AC outlets, racks, rack protection, network switch, cabling support and guidance for operation readiness clearance (ORC) review	
Cryostat feedthrough and safety review	**Bern/SLAC/DUBNA/LBNL** groups provide list of feedthrough, design file and their pressure test of module structure, drift high voltage, light and charge readout systems	21579
	Cryogenics group provides 3d layout, guideline for feedthrough pressure test, guidance for operation readiness clearance (ORC) review	
Cryostat and TPC module installation	**Bern/LBNL groups** provide CAD file, equipment list on cryostat and TPC modules	
	Installation group provides integration 3d model, lifting fixture and installation engineering and safety review	
TPC module assembly and QA/QC	**Bern provides** TPC module QA/QC procedure and instruction from module-0 experience.	
	Installation group to provide mechanical support	

2x2@LArTF WBS and Resource

Tasks for 2x2@LArTF	Start	Finish	FTE Labor/M&S
Cryogenics system design and review for 2x2@LArTF	5/7/2021	12/15/2021	CryoE:120d + ME:40d + ME.Design:30d:+ME.Proc:20d
Cryogenics P&ID, equipment specification and layout	5/7/2021	9/29/2021	CryoE:10d+ME.Design:5d
Cryogenics equipment layout and support design	5/7/2021	9/29/2021	ME:5d+ME.Design:3d
Cryocooler & condenser process system design and engineering notes	7/20/2021	9/15/2021	CryoE:10d
Water chiller process system design and engineering note	8/17/2021	10/14/2021	CryoE:10d
Argon filter vessel engineering note and safety review	9/16/2021	10/15/2021	CryoE:10d
Argon piping and engineering notes: supply, filling and venting	8/31/2021	10/28/2021	CryoE:30d+Me:5d+ME.Design:5d
ODH analysis and mitigation design	10/29/2021	11/30/2021	CryoE:10d
Cryogenics control design	9/16/2021	11/15/2021	ME:Process:20d
Cryogenics operation engineering note - failure mode and effect, what-if an	11/15/2021	11/30/2021	CryoE:5d
Cryostat vessel FEA, engineering notes and certification test design	7/6/2021	9/29/2021	ME-FEA:20d+CryoE:15d
Cryogenics and control design review	12/1/2021	12/15/2021	CryoE:5d+ME.Design.5d + ME:5d
Cryocooler system connection and installation design	10/15/2021	12/14/2021	CryoE:10d+ME.Design.5d + ME:5d
Cryogenics piping layout and connection design	10/29/2021	11/30/2021	CryoE:5d+ME.Design.5d
Electronics Integration and Support Design	5/7/2021	9/29/2021	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 for 2x2@LA	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 for 2x2@L	8/3/2021	9/29/2021	Physicist:10d +CompSP:5d +EE:10d
Documentation and review of electronics installation plan for 2x2@LArTF	9/30/2021	10/29/2021	Physicist:5d +CompSP:5d +EE:5d
Cryogenics Equipment Procurement	5/7/2021	2/4/2022	CryoE:45d
Cryostat cooling equipment procurement	5/7/2021	2/4/2022	$280 K
Cryostat valves and filter vessels procurement	7/2/2021	12/27/2021	$30 K
Additional equipment procurement for main cryostat and filter vessels	6/7/21	10/28/21	$20 K
Cryogenics and Instrumentation Installation	8/31/2021	2/22/2022	CryoE:60d+ME:40d + ME.Process:10d + EE:12d+MT:120d+ ET:20d
Certification of 2x2 cryostat: inspection, pressure test and review	8/31/2021	9/29/2021	CryoE:10d+ MT:10d+ME_FEA:10d
TPC module inspection QA/QC	9/1/2021	10/29/2021	physicist:20d +ME:5d+EE:5d+MT:10d
TPC service feedthrough inspections and certifications	9/1/2021	10/29/2021	physicist:20d +CryoE:5d+ME:5d+MT:10d
Installation of feedthrough on TPC module top	11/1/2021	12/1/2021	CryoE:5d+ME:5d+MT:20d
Installation of cryostat and cryogenics equipment	9/30/2021	11/30/2021	CryoE:10d+ME:5d+MT:20d
Assembly and inserting TPC modules to cryostat	12/2/2021	12/16/2021	ME:5d+MT:5d
safety relief valve and venting piping connections	12/17/2021	1/4/2022	CryoE:5d+MT:10d
Argon supply line and purification filter connections	1/5/2022	1/20/2022	CryoE:5d+MT:10d
Argon recirculation filter system installation	1/5/2022	1/20/2022	CryoE:5d+MT:10d
Cryocooler system installation	1/24/2022	2/22/2022	CryoE:10d+ME:5d+EE:2d+MT:20d
Cryogenics instrumentation and control installation	12/17/2021	1/19/2022	CryoE:5d+ME.Proce:10d+ EE:5d+ET:20d
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
HV, PLC and detector control commissioning	1/18/2022	2/15/2022	EE:10d+ME.proces:5d
DAQ commissioning	2/16/2022	3/17/2022	Physicist:40d+ComSP:20d
LAr filling and purifying	2/23/2022	4/20/2022	CryoE:30d+ME.proces:10d+EE:5d
Commissioning runs to reach stable HV setting	4/6/2022	4/20/2022	EE:5d+ME.Process:5d
Cosmic Ray and BNB Runs	4/21/2022	5/19/2022	CryoE:5d+EE:5d+ME.proce:5d+ComSP:5d

Resource assignment for each task

2x2@LArTF Key Design Tasks

Tasks for 2x2@LArTF	*Start*	*Finish*
Cryogenics system design and review for 2x2@LArTF	5/7/2021	12/15/2021
Cryogenics P&ID, equipment specification and layout	*5/7/2021*	*9/29/2021*
Cryogenics equipment layout and support design	*5/7/2021*	*9/29/2021*
Cryocooler & condenser process system design and engineering notes	*7/20/2021*	*9/15/2021*
Water chiller process system design and engineering note	*8/17/2021*	*10/14/2021*
Argon filter vessel engineering note and safety review	*9/16/2021*	*10/15/2021*
Argon piping and engineering notes: supply, filling and venting	*8/31/2021*	*10/28/2021*
ODH analysis and mitigation design	*10/29/2021*	*11/30/2021*
Cryogenics control design	*9/16/2021*	*11/15/2021*
Cryogenics operation engineering note - failure mode and effect, what-if analys	*11/15/2021*	*11/30/2021*
Cryostat vessel FEA, engineering notes and certification test design	*7/6/2021*	*9/29/2021*
Cryogenics and control design review	*12/1/2021*	*12/15/2021*
Cryocooler system connection and installation design	*10/15/2021*	*12/14/2021*
Cryogenics piping layout and connection design	*10/29/2021*	*11/30/2021*
Electronics Integration and support Design for 2x2@LArTF	5/7/2021	10/29/2021
AC distribution and isolated TPC grounding scheme	*5/7/2021*	*8/31/2021*
Rack layout and AC power budget	*6/7/2021*	*8/31/2021*
DAQ, computing and networking for 2x2@LArTF	*8/3/2021*	*9/29/2021*
Integration design for drift HV, detector and cryogenics control for 2x2@LArTF	*8/3/2021*	*9/29/2021*
Support design for TPC on-detector electronics and DAQ readout for 2x2@LArTF	*8/3/2021*	*9/29/2021*
Documentation and review of electronics installation plan for 2x2@LArTF	*9/30/2021*	*10/29/2021*
Cryogenics equipment procurement	5/7/2021	2/4/2022
Cryostat cooling equipment procurement	*5/7/2021*	*2/4/2022*
Cryostat valves and filter vessels procurement	*7/2/2021*	*12/27/2021*
Additional equipment procurement for main cryostat and filter vessels	*6/7/21*	*10/28/21*
Cryogenics and Instrumentation Installation	8/31/2021	2/22/2022
Electronics, DAQ and Computing Installation	9/1/2021	2/15/2022
Commissioning and testing	1/18/2022	4/20/2022
Cosmic Ray and BNB Runs	4/21/2022	5/19/2022

2x2@MINOS WBS and Resource

Task for 2x2@MINOS	Start	Finish	FTE Labor/M&S
Cryostat and TPC Installation Design	5/10/2021	6/6/2022	ME:95d + ME.Design:70d:+ME.FEA:10d+CryoE:5d
Design and review of cryostat transfer cart	5/10/2021	7/7/2021	ME:10d+ ME.Design.10d
Design and review of module installation	7/7/2021	9/1/2021	ME:10d+ ME.Design.10d+ME.FEA:10d
Cryostat vessel support and access platform design and review	9/13/2021	2/8/2022	ME:25d+ME.Design:25d
Cryostat cooling and LAr supply equipment layout and support	2/9/2022	4/7/2022	ME:20d + ME.Design:10d + CryoE:5d
Tooling design for installation in MINOS hall	2/9/2022	4/7/2022	ME:20d+ME.Design:10d
Engineering and safety review of installation for 2x2@MINOS	4/8/2022	6/6/2022	ME:10d+ME.Design:5d
Cryogenics Installation Design	5/20/2022	########	CryoE:110d + ME:40d + ME.Design:40d:+ME.Proc:25d
Cryogenics P&ID, equipment specification and piping engineering notes	5/20/2022	7/19/2022	CryoE:20d+ME.Design:10d
Cryogenics venting engineering note and layout design	5/20/2022	8/16/2022	CryoE:30d+ME.Design:5d
ODH mitigation, monitoring and installation design	5/20/2022	8/16/2022	CryoE:30d+ME.Design:10d
Cryogenics equipment support design	5/20/2022	8/16/2022	ME:30d+ME.Design:15d
Final cryogenics control design	8/17/2022	10/14/2022	ME.Process:10d +CryoE:10d
Cryogenics operation engineering note - failure mode and effect, what-if analyse	8/17/2022	9/15/2022	CryoE:10d
Cryogenics and control design review	9/16/2022	10/17/2022	CryoE:10d+ME.10d + Me.Process:5d
Electronics Integration and support Design	7/9/2021	8/26/2022	EE:40d + ME.Proc:40d + ET:10d +ComSP:95d
Low-noise transformer and AC distribution	7/9/2021	11/2/2021	EE:10d+ET:10d
Isolated TPC grounding scheme and monitoring	5/20/2022	7/19/2022	EE:10d +ET:10d
Timing and trigger interfaces with ACNET system	5/20/2022	9/14/2022	Physicist:20d+CompSP:15d
HV, detector and cryogenic control system	5/20/2022	9/14/2022	Physicist:10d+EE:20d+CompSP:20d +ME.Process:40d
DAQ and networking	5/20/2022	9/14/2022	physicist:20d+CompSP:40d
Control room support in Wilson hall ROC-west	5/20/2022	9/14/2022	CompSP:20d
Cryogenic equipment procurement	7/19/2022	########	CryoE:10d+ME:5d
Additional cryogenic equipment procurement for MINOS	8/17/2022	10/14/2022	$50 K
Cryogenics equipment support structure procurement	7/19/2022	9/14/2022	$20 K
Assembly and Installation in Underground MINOS Hall	7/9/2021	1/3/2023	CryoE:55d+ME:55d + ME:Des:10d+ ME.Proc:15d + EE:70d+MT:194d+ ET:70d+CompSP:65d
Re-installation of Minerva modules for ArgonCube test	7/9/2021	11/2/2021	ME:10d+ MT:64d +EE:10d +ET:25d+ComSP:20d
Cryostat access platform support installation	4/8/2022	6/6/2022	ME:10d+ ME.Design:10d+ MT:20d
ODH mitigation and monitoring system installation	8/17/2022	10/14/2022	ME.Process:10d+ ME:10d +MT:20d
Decommissioning of 2x2@LArTF and transfer cryostat and TPCs to MINOS hall	5/20/2022	6/20/2022	CryoE:5d+ME:5d+EE:5d +ET:10d+MT:20d
TPC module inspection QA/QC	6/21/2022	8/3/2022	ME:5d+ MT:10d
Cryostat and TPC module assembly and installation	8/4/2022	9/1/2022	CryoE:5d+ME:10d+ MT:30d
Cryogenics system installation	9/19/2022	11/16/2022	CryoE:20d+ MT:40d+ME:10d
Cryogenics and operation safety review (pORC)	11/17/2022	12/16/2022	CryoE:10d + EE:5d
Electronics support infrastructure installation	7/20/2022	9/15/2022	EE:20d + ET:20d +ComSP:20d
Electronics and DAQ installation and safety review	9/15/2022	10/14/2022	EE:10d + ET:10d +ComSP:10d
HV and detector control system installation and safety review	9/15/2022	10/14/2022	EE:5d+ET:5d+ME.Process:5d +CompSP:5d
Electronics operation safety review (pORC)	10/14/2022	11/14/2022	EE:5d+CompSP:5d
Final ORC review and safety walk-through	12/16/2022	1/3/2023	CryoE:5d+ME:5d +EE:5d+ComSP:5d
ArgonCube 2x2 Commissioning	11/15/2022	3/3/2023	CryoE:30d+ ME.Proc:25d + EE:25d+ComSP:90d
HV & detector control commissioning	11/15/2022	12/14/2022	ME.Process:5d+EE:5d +ComSP:10d
DAQ commissioning	11/15/2022	1/13/2023	EE:10d+CompSP:40d
LAr filling and purifying	1/4/2023	3/3/2023	CryoE:20d+ME.Process:10d
First runs to reach stable HV setting	2/16/2023	3/3/2023	CryoE:10d+EE:10d+ME.Process:10d+ CompSP:40d
2x2 NuMI Runs	3/6/2023	12/29/2023	CryoE:35d+ME.Proc:20d +EE:20d+ComSP:70d
NuMI neutrino beam runs	3/6/2023	6/30/2023	CryoE:20d+EE:20d+ME.Process:20d+ CompSP:40d
DAQ runs and 2nd round NuMI neutrino runs	7/3/2023	12/29/2023	CryoE:15d+ME.Process:15d+ CompSP:30d

M&S Cost for Cryogenics and Installation

ArgonCube

Equipment / Service	Brand / Vendor	Procurement Status	Cost Estimate [$]	Contingencye [$]	Contingency [%]	Contingency code	FY21	FY22	FY23	WBS
1.8KW Cryocoolers	CryoMech AL600	PO approved. Jane Graves is the buyer	$205K	$.0K	0%	M1	$51K	$154K		1.4.1.2
Condenser	CryoMech or Ability Engineering	Talking to CryoMech	$50K	$10.0K	20%	M3	$50K			1.4.1.4
Chiller	Haskris	Procurement in process	$38K	$.0K	0%	M1	$38K			1.4.1.6
Relief valve	Alternative to AG9300 (Bern fund)	Vendor search by Mike Z								1.4.2.2
LAr filter vessels	Based on Bern vessel (Bern fiund)	Need design modification								1.4.2.4
Cryostat qualification (contract for cryostat inspection)	local boiler inspection company		$10K	$3.0K	30%	M4	$10K			1.6a.1
Cryogenic equipment on main cryostat vessel	Bern deliverable	To define additional items for 2x2@FNAL	$20K	$6.0K	30%	M4	$20K			1.6a.2.3
Cyogenic equipment on LAr filters	Bern deliverable	To define additional items for 2x2@FNAL	$10K	$3.0K	30%	M4	$10K			1.6a.2.3
Roughing/Turbo pump for cryostat vaccum insulation	Pfeiffer vacuume	PO submitted	$30K	$.0K	0%	M1	$30K			1.4.2/6
Heater/vaporizer	Recycled from PC4		$2K	$.4K	20%	M3	$1K	$1K		1.4.1
Venting connection line (MINOS cavern; LArTF)			$20K	$4.0K	20%	M3	$10K	$10K		1.6a.2.6
Supply connection line (LArTF)			$5K	$1.0K	20%	M3	$5K			1.6a.2.5
Purity monitor feedthrough and its readout electronics	New matching flange on 2x2		$5K	$1.0K	20%	M3	$5K			1.6a.2.8
Gas analyzers	Recycle from uBooNE and PAB	uBooNE/PAB	$5K	$1.0K	20%	M3	$1K	$5K		1.6a.2.8
Module lifting fixture		Design	$5K	$2.0K	40%	M5	$5K			1.3.4
Cryostat transfer cart	In-house Design	Grainger for caster and Ryerson for channel	$5K	$.0K	0%	M1	$5K			1.3.3
LAr filter transfer cart			$5K	$1.5K	30%	M4	$5K			1.3.5
Cryo equipment support			$5K	$1.5K	30%	M4	$5K			1.3.5
Implementation of ODH measures; exhaust fan replacement		conceptual design --> detailing early 2022	$120K	$48.0K	40%	M5		$120K		1.6.3
LAr supply for 2x2 in MINOS			$40K	$12.0K	30%	M4		$20K	$20K	1.7.6&1.8.3
Cryostat access platform and cryostat support, support for cryogenic equipment, racks and cable trays etc.		conceptual design --> detailing early 2022	$80K	$32.0K	40%	M5		$80K		1.3.1

M&S Cost for Electroncis Support

ArgonCube

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 electrician work for clean AC and grounding impendence monitor	$20K	$4.0K	20%	M3	$20K			1.6a.3.1
LArTF electrician work for cryogenics AC power	$10K	$2.0K	20%	M3	$10K			1.6a.3.1
LArTF network equipment and installation for 2x2@LArTF	$10K	$2.0K	20%	M3	$10K			1.5a.3
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	$20K	$2.0K	10%	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	$35K	$7.0K	20%	M3		$35K		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