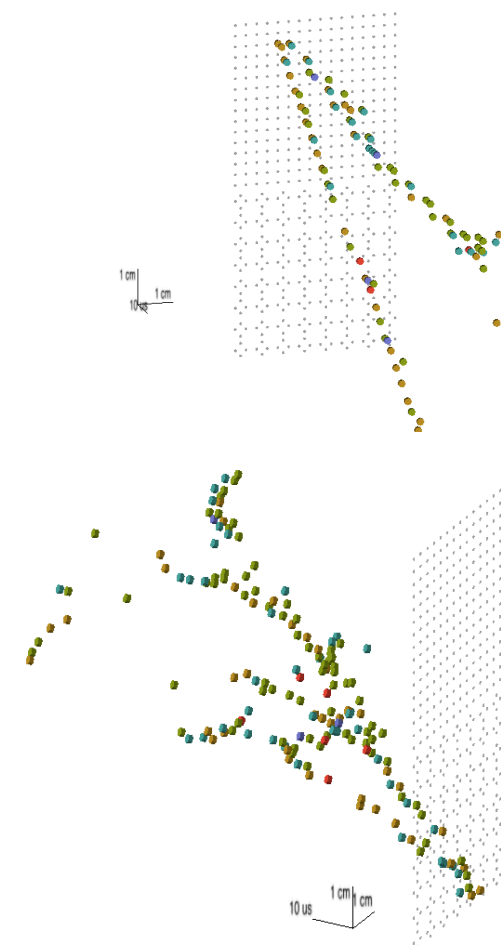
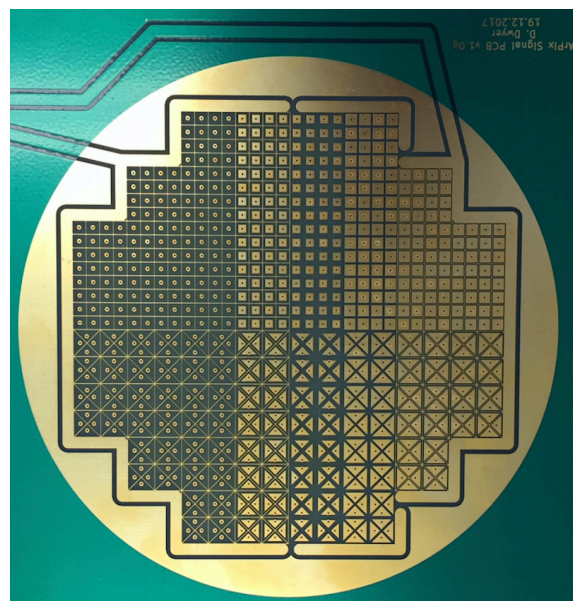
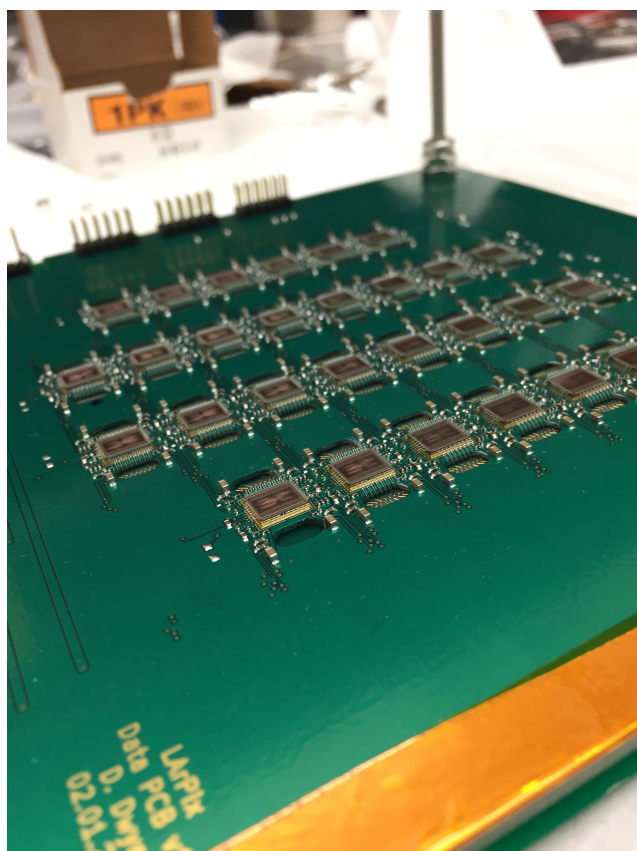




Status of the LArPix Readout System for the ArgonCube 2x2 Demonstrator

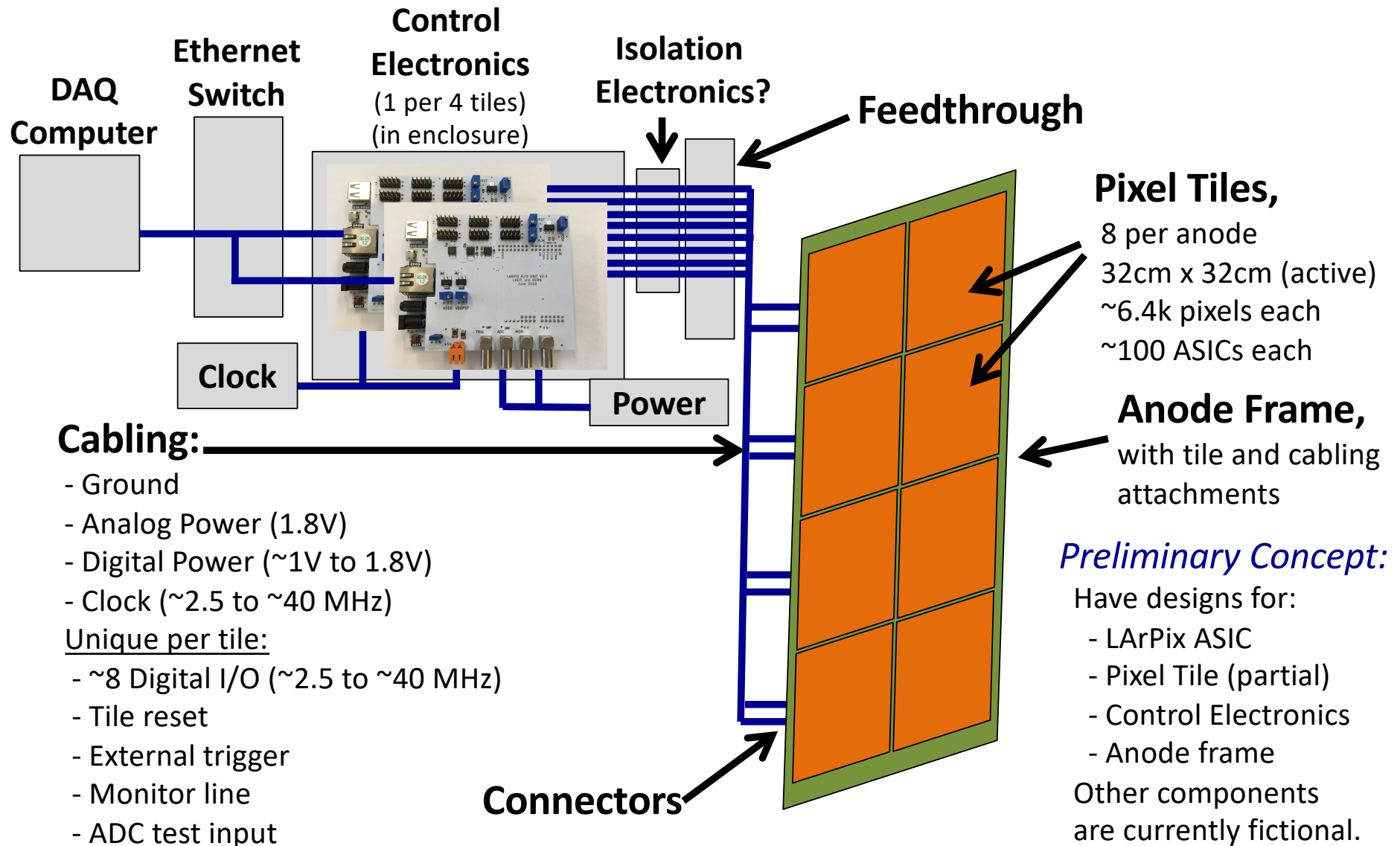
Dan Dwyer

May 25, 2019



System Concept

Rough concept for the ArgonCube 2x2 pixel readout system



Pixel Tile Anode

Current CAD model for ArgonCube 2x2 Pixel Anode (K. Skarpass)

Inner face (pixels)

Outer face (ASICs)

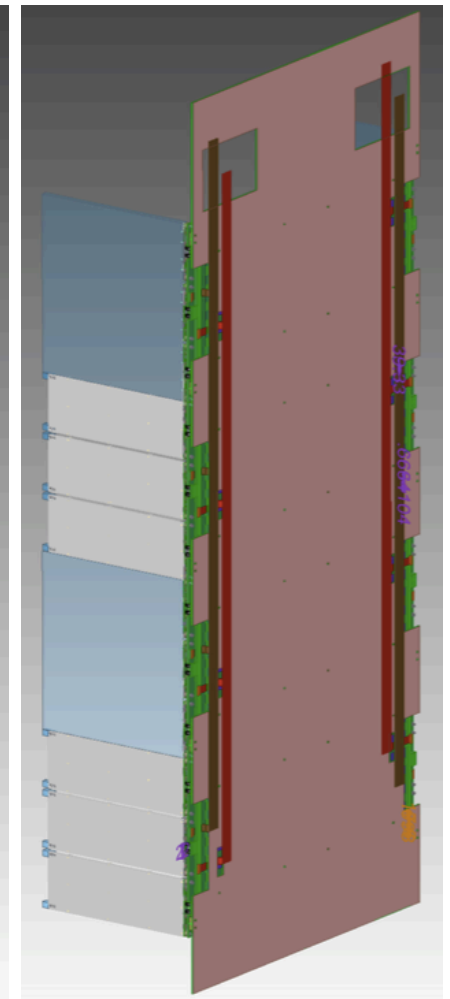
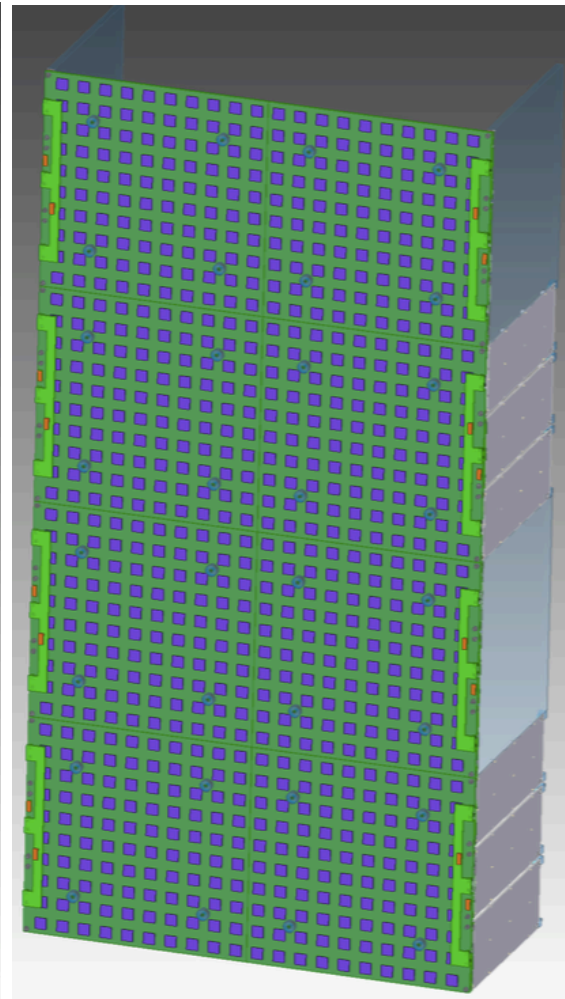
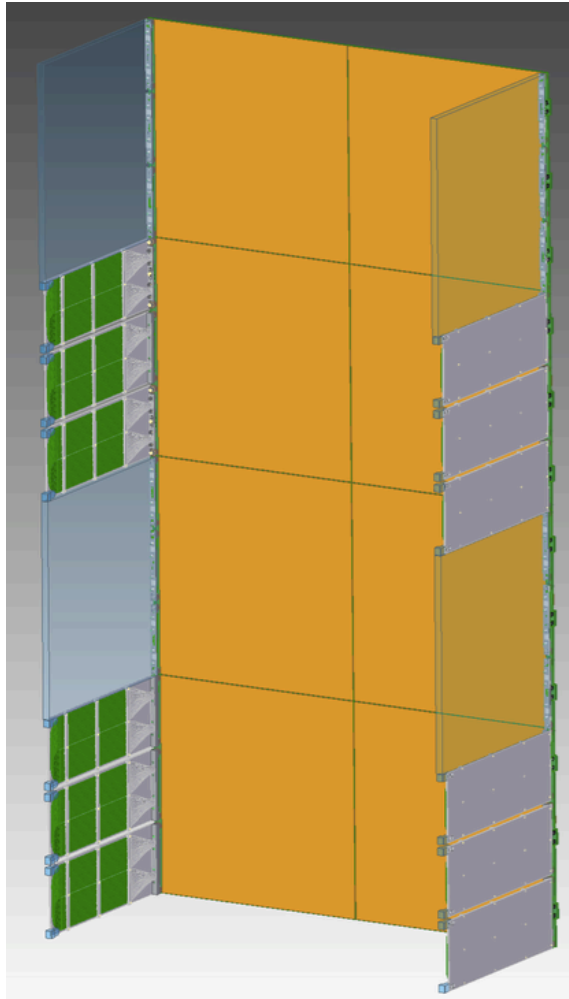
Frame (G10)

8 tiles / anode

Per tile:

- 6.4k pixels
- 100 ASICs
- 1 connector
- 4 mount points

Light collectors
mounted along
anode edges



DAQ Electronics

Design:

Custom mezzanine
on Arty 7 FPGA board

Cable to pixel tile(s)

Current: 50-pin ribbon cable

2x2 plan: kapton flex? (inside cryostat), ? (outside cryostat)

Power: GND, VDDA, VDDD

I/O: CLK_2X, RESET, EXT_TRIG, MOSI/MISO (2x2: ~8 pairs, 4 active)

Analog: ADC_TEST_IN, MONITOR_OUT



DAQ Computer
(via ethernet hub)



Chip config.

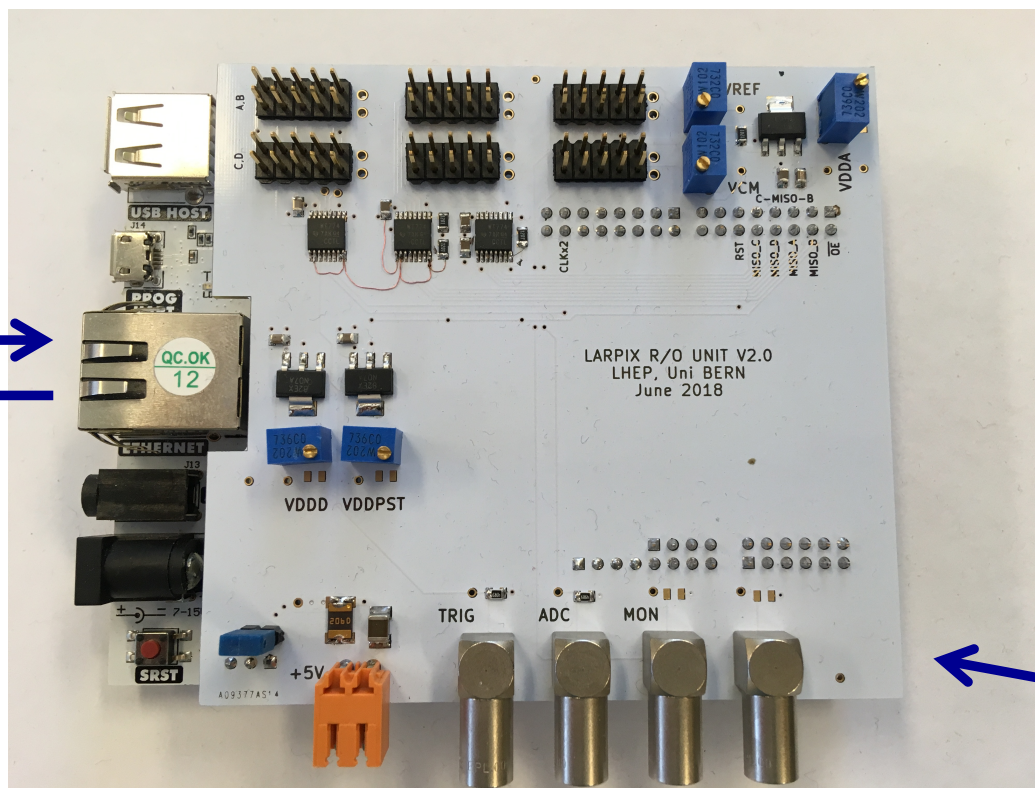
Pixel data

Format: ZeroMQ

High-performance
asynchronous messaging

Protocol:

TCP/IP over RJ-45



Data capacity:

100 kHz pixel hits
per MOSI/MISO pair
(at 10 MHz CLK_2X)

Expected operation:

~64 kHz pixel rate/tile
(on surface)
~6 kHz pixel rate/tile
(underground)

System Clock:

Arty 7 accepts
external clock

System Power: +5V

Extras: External Trig., ADC Test, Monitor



Recent Progress



Progress on scalable design:

- Adapted control software
- Packaged 158 LArPix-v1 ASICs (155 successful) in QFP-100pin format
- Developed new pixel tile using single PCB format for ease of assembly
- Loaded 20 packaged ASICs on 5 pixel tiles, all tested at RT and in LN
- No observed changes in performance using packaged vs. unpackaged ASICs.
- Yield: 18/20 at RT, no further loss at LN temperature (caveat: low stats).
- Boards survived repeated exposure high thermal gradients (~ 100 K / ~ 10 cm)
→ *Suggests v2 system design approach is valid.*

LArPix-v2 ASIC:

- Demonstrated 180nm CMOS SRAM block functions in liquid nitrogen.
- v2 ASIC design in final stages of validation. Proceeding to production soon.

Pixel Readout Group:

- Building the team to deliver the pixel readout system for the 2x2 Demonstrator

See talk by P. Madigan at DUNE Collaboration Meeting (22 May, 2019)



LArPix-v2 Schedule



Tight schedule between v2 ASIC production and 2x2 installation

Start of production set by v2 ASIC submission.

→ Has slipped from March, but is now converging on a realistic date (early June).

Component testing:

- 1) Detailed characterization of the unpackaged LArPix-v2 ASIC (Aug-Sep)
- 2) Detailed characterization of the packaged LArPix-v2 ASIC (Aug-Sep)
- 3) LArPix-v2 ASIC qualification (Sep-Jan)

Targets: Sep ~100-200 ASICs; Oct ~2000 ASICs; Dec ~8000 ASICs

- 4) Unloaded Pixel tile PCB qualification (Sep-Dec)

Brief assessment of each PCB before component/ASIC loading.

Targets: Sep ~5-10 small prototype tiles; Oct ~20 tiles; Dec ~100 tiles

Pixel tile testing:

- 1) Prototypes tile testing (Sep-Oct)

Test a small number (5 to 10) small-scale (~16cm x ~16cm, ~25 ASICs) prototype tiles using the v2 ASIC.

Key questions:

- Is tile design adequate?

- 2) Initial full-scale tile testing (Nov-Dec)

Test a moderate number (~20) of production scale (~32 x ~32, ~100 ASICs) pixel tiles.

Send to Bern and install in first 2x2 module.

- 3) Remaining full-scale tile testing (Dec-Mar)

Test ~80 production scale pixel tiles to instrument the 3 other 2x2 modules, plus 1 spare module, plus ~10% spares.

Send to FNAL and install in the remaining 2x2 modules.



Emerging Roles



Establishing clear institutional roles in pixel system for the 2x2 detector

UPenn:	System design review and revision, PCB design, evaluation
Caltech:	Packaged ASIC and pixel tile assessment at room temperature
UCSB:	Detailed ASIC characterization at room temp (room, cryo?)
CSU:	Detailed pixel tile characterization, tuning, and calibration (room, cryo)
UTA:	Large-scale cryogenic tile testing and integration before 2x2 installation
SLAC:	TPC mechanical structure design, interfaces with pixel tile
Rutgers:	DAQ hardware/software interfaces and development

Also:

Expect most groups will engage with pixel TPC simulation and analysis studies

At DUNE Collaboration meeting: *P. Madigan*

Tutorial on operation of v1 LArPix system, and shared 4-chip test systems to partners.



Pixel Readout Group



Email list: dune-larpix@fnal.gov

To subscribe, send an email to listserv@listserv.fnal.gov with the following body:

subscribe dune-larpix FirstName LastName

Slack Channel:

#larpix: <https://dunescience.slack.com/messages/CJHSX24UU>

Weekly Meeting: Thursdays, 1pm CT

Agendas:

Connection: <https://fnal.zoom.us/j/272084897>

Shared Directory:

Relevant documents, schematics, meeting notes:

<https://drive.google.com/open?id=1WSRoQhp7BPbIF5GF7YKJWjXvqGOUDO4M>

ArgonCube:

Send email to James Sinclair (james.sinclair@lheb.unibe.ch) to join ArgonCube email list.

Bi-weekly meetings: Thursdays, 11am CT



Schedule



ArgonCube

Fermilab Test Beam Project T-1563

Schedule and Resource Summary

From T. Miao

WBS Element	WBS Description	Lead Institutions	Start Date	Finish Date	FNAL Labor (type : working days)	M&S (\$)
1	ArgonCube 2x2 Installation in MINOS Hall		10/25/18	2/4/21		
1.1	Preliminary Installation Design		10/25/18	6/20/19		
1.1.1	Review of argonCube 2x2 detector installation concept	BERN	10/25/18	4/23/19	Eng.Phys:70d + CryoE:125d + ME:FEA:10d	
1.1.2	Detector installation and transportation layout	FNAL	4/24/19	6/21/19	Eng.Phys:10d + Mech.Design:30d+ME:10d	
1.1.3	Cryogenic equipment requirement and layout	FNAL/BERN	10/25/18	8/20/19	CryoE:180d+ME:FEA:20d+ME:45d+ Mech.Design:70d+Eng.Phys:50d	
1.1.4	Electronics support requirement and layout	FNAL/BERN/LBNL/UTA	1/25/19	11/20/19	EE:95d+CompSP:40d +CryoE:10d+Mech.Design:5d	
1.1.5	<i>Preliminary detector and cryogenic installation design review</i>	FNAL/BERN	8/21/19	9/19/19	CryoE5d+ME:5d+Mech.Design:5d + EE:5d + Eng.Phys:5d	
1.1.6	Preliminary electronics installation design review	FNAL/BERN/LBNL/UTA	11/21/19	12/6/19	EE:5d+Mech.Design:5d +CompSP:5d	
1.2	ArgonCube 2x2 Installation Design		9/20/19	3/25/20		
1.2.1	Cryostat and TPC module shipping container designs	BERN/FNAL	9/20/19	11/19/19	ME:5d+Mech.Design:5d+Eng.Phys:5d	
1.2.2	<i>Contract and ship ArgonCube 2x2 to FNAL from BERN</i>	BERN	11/20/19	3/18/20		
1.2.3	Detector support and access platform in MINOS hall		9/20/19	12/19/19	ME:30d+Mech.Design:30d+ CryoE:5d+Eng.Phys:10d	
1.2.4	Installation and transportation tooling		12/20/19	3/10/20	ME:25d+Mech.Design:50d + Eng.Phys:10d	
1.2.5	Cryogenic design and review		9/20/19	2/20/20	cryoE: 150d+ Mech.Design:65d +Eng.Phys:50d	
1.2.6	Review of installation tooling procurement plans	BERN/FNAL	3/11/20	3/25/20	Eng.Phys:5d	
1.3	Detector Support and Installation Tooling Procurement	FNAL	3/26/20	5/21/20	ME:5d+ Eng.Phys:5d	\$20 K
1.4	Cryogenic System and Support Procurement	FNAL	3/26/20	5/21/20	Eng.Phys:10d	\$300 K
1.5	Electronics Support Design and Procurement		12/9/19	4/3/20	EE:100d+CompSP:100d +ME:Process:40d	\$70 K
1.6	Assembly and Installation		3/26/20	8/19/20	ME:30d+CryoE:55d+EE:45d+MT:100d+ ET:40d+CompSP:20d+Eng.Phys:50d+ ME:Process:10d	\$110 K
1.7	ArgonCube 2x2 Commissioning		6/23/20	11/18/20	ME:Process:25d+CompSP:55d+CryoE:40d +ME:15d+EE:35d+Eng.Phys:60	\$20 K
1.8	Detector Operation and Maintenance Tests		11/19/20	2/4/21	ME:Process:5d+CompSP:30d+CryoE:20d+ ME:10d+EE:10d+MT:30d+Eng.Phys:20d	\$20 K

	Cryo Engineer + Eng. Physicist	Mech Engineer + Designer	Electrical Engineer	Mech Techs + Elec Techs	Computing Specialist
Technical support for WBS 1.1 to 1.2 Designs (2019+)	475d + 205d	255d+265d	105d		45d
Technical support for WBS 1.3 to 1.8 Installation & commissioning & test (2020)	185d + 175d	75d	190d	190d + 40d	205d