1. There are a number of tasks with labor estimates that ended in the past. Can you point to a few of those tasks and explain how much labor was actually used for those tasks, and how that compares to what your initial labor estimate was for that task?

Mike Z's answer:

- 1.4.2.1 (relief): ~95-100% of estimated labor used
- 1.4.2.7 (vacuum cart): ~70-80% estimated labor used

2. There are a number of upcoming large tasks that have labor estimates: we'd like to see what your basis of estimate is for the labor required for these tasks: by now Fermilab has a long history of bringing up liquid argon detectors, so can you give us an example of how much labor the same task took for the ProtoDUNE or MicroBooNE version of that task, or maybe the 35-ton version of that task for something closer to the scale of this effort? We propose to drill down on task 1.4.2, for example: Procurement of cryostat valves and filter vessels: are those estimates based on past cryogenic procurements?

Mike Z: Yes, estimates are based on similar procurements made for uboone and SBND

We'd also like you to show us the basis of estimate for a large design task, and a large installation task, and if possible an example from a previous similar effort if there was one.

Mike Z on 1.2.5a.5, 1.2.5a.6 and 1.2.5a.7: Argon filter and piping design and engineering

- Argon filter/piping estimates for design are based on labor used for similar designs and specifications produced for uboone, SBND, PAB etc. I don't have specific labor figures for each spec as there's no difference in task codes, so the basis is from personal experience.

Min Jeong on 1.6a.2.4 -- Assembly and inserting TPC modules to cryostat

A lot of steps are involved for this task and still more technical details (from Bern on module details) may be necessary to plan the task properly. Considering the steps involved – described below - and complexity of task (particularly, the alignment of modules), 10 FTE days (5 for Mechanical Engineer; 5 for Mechanical Technician) seems to be reasonable at the moment. Unfortunately, there is no exact example or a prior experience in mounting multiple modules together.

Steps

- Clean/empty the space around the cryostat
- Bring the mobile crane
- Bring a forklift to steer the move of cryostat transfer cart
- Move the cryostat to the outside of building
- Suspend the module lifting fixture on the crane
- Attach the module mounting frame to the module lifting fixture
- Align modules on the floor
- Bring the module mounting frame on the top of modules; make bolted connections between modules and the mounting frame (while the assembly of the module lifting fixture and the module mounting frame suspended by the crane)
- Apply counterweight for weight balancing
- Lift assembly and insert to the cryostat
- Disconnect the module lifting fixture from the module mounting frame
- Make bolted connections between modules and the cryostat
- Move the cryostat inside the building

3. We would like to see a labor profile: On slide 14 Ting showed the labor estimates for some people for all of FY2022, but not year by year for all the years. Can you please show a labor profile broken down by quarter if possible for this effort? For example, we are also curious if you are expecting to get people working at 100% FTE for shorter periods, or if you are basing this schedule on assuming that people you get will only be working at 50% FTE.

We draw labor resources from engineers and technician groups of TSD department. Most of them work for multiple projects. We do not worry much about keeping them busy (they are!). We use people even if they are only available for a short period of time – electrician technicians for example.

For cryogenics and mechanical engineers, the schedule planned took into consideration the number of engineers available to 2x2 and to all projects in the neutrino division.

We work closely with the neutrino division's TSD for engineering resource planning – see resource required and assigned for remaining months of 2021 – last page. We are still working on filling the gap.

Mike Z is to focus on 2x2@LArTF for the next 6-8 months

4. We also note that the table on slide 14 does not include physicist labor. Could you also give an estimate (by quarter or by year) for how much physicist effort you are planning to have on these tasks, and if possible, how much of that physicist labor is Fermilab and how much is non-Fermilab physicist labor?

Physicist labor are mostly from consortium subsystems for their responsibilities of electronics readout and control for light readout, charge readout, and drift HV. There is still on-going discussion on how many will be available for LArTF test at Fermilab. Those are separately managed by the ND-LAr consortium.

2x2 electronics installation does not have many repeated (manual) installation tasks. Most of the heavy lifting and infrastructure installation (rack preparation etc.) are done by technicians.

2x2@MINOS DAQ integration is expected to be done by consortium subsystem students and postdocs. Role and responsibility of the DUNE-DAQ ND group is to be defined.

(Minerva re-installation is different story)

5. In the WBS document you call out "physicist" for some of the labor on some tasks: similar to the last question, can you specify where that physicist labor comes from? Is it 100% Consortium (including University) physicist labor, or is that labor considered separately?

Most of the physicist labors are expected to be from consortium. Subsystem managers determine how many people they send to FNAL to get their system installed and commissioned. Here is an estimate I gave to Michele:

- **Light readout installation and commissioning: 5 people from Dubna (input from Nikolay)**
- **Charge readout: 3 people from LArPix group, 1 people on Pacman**
- **Drift HV: 2 Bern people on Spellman PS, filter box and cabling; 1 people from SLAC on feed-through**
- **Module structure including service feedthrough installation and certification: 2 from Bern**
- **TPC module QA/QC: 3 people (CSU)**
- **3-5 people to work with Linda and Geoff on rack configuration, RPS, grounding monitoring, networking, DAQ server installation**
- **Additionally, we need lead/contact person for slow control and DAQ from each of the three subsystems of light, charge and drift HV.**

Again, those are separately managed by ND-LAr consortium leads.

6. Does the lifting fixture shown in Min's talk have to be rebuilt, or is it still in the design phase?

Min Jeong answer

It is at the conceptual design stage (Refer to slide 20 and 41 of MinJeong's talk). We are currently performing a FEA to determine if we need an extra pick point in the middle (where all four modules meet together) and to finalize our design parameters (size and thickness of box beam, etc.).

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

Linda answer: Separate slides posted

8. Minor issue: Task 1.1.4.2 has a projected start date that is 1 day after the projected finish date, but the "duration" listed is 10 working days. Please correct this.

Done.

9. We noticed that "ODH mitigation, monitoring and installation design" does not start until May 2022, but the predecessor to that task is already complete (it has a completion date in the past). Is there a reason you are waiting to start that task?

At this moment, we have only one cryogenics engineer spending significant time on 2x2 (70% of Mike Z's time).
We will need to finish LArTF before spending cryogenics engineer time on MINOS detail design.
We are still working with TSD to close the resource gap.

10. how close are the TPC electronics delivery to the critical path, and what is the schedule for delivering the electronics to Fermilab? (We discussed the delivery schedule of each module, but does the associated readout come with each module, for example?)

Readout electronics delivery schedules come separately from modules.

For 2x2@LArTF

- Electronics delivery schedule for 2x2@LArTF: 1.6a.3.10, 1.6a.3.11, 1.6a.3.12.
- There is about one month contingency time between pORC for subsystem electronics and starting final ORC (Christmas holiday)
- There is one month difference between DAQ commissioning completion date and LAr filling/purification completion date.
- Overall, there is about a 2-month contingency for electronics delivery on paper. In practice, 1 month contingency.

For 2x2@MINOS

- DAQ commissioning has a 1.5 months early start time than LAr filling
- Beam timing, trigger and integration with Minerva need this extra time

11. Can you say more about the cycle time associated with adding an additional module to the cryostat? For example, could you put one (or two) modules into the cryostat, fill it, test those modules, and then add another one (or two modules)? Or do you need to warm up, empty the vessel, and then add more modules? Is the answer different depending on if you're in LarTF or if you're in MINOS?

Min Jeong answer:

No cold extraction and insertion of modules are allowed at Fermilab due to the Fermilab safety regulations. There is no difference in locations.

Time required for warming up is the same at both locations: about 1-2 days. Refilling the cryostat at LArTF can be done within 1-2 days using pure liquid from MicroBooNE cryostat. It will take at least a week in MINOS cavern, but it could be shortened if we knew our plan in advance (we could save a couple days by starting to deliver portable dewars earlier).

(specifically: is the schedule you've presented only assuming that you are filling one time at LArTF and one time at MINOS?). Yes.

Resource Type	2x2 Labor Estimate in FTE Fraction						
	June	July	August	Sept	Oct	Nov	Dec
Cryo Eengineer(MikeZ,KathrineL,FrizS)	0.50	1.00	1.00	1.00	1.00	1.25	1.25
ME (MJK+Sai+Andy+JimK)	0.50	0.50	0.75	1.00	1.00	1.00	0.50
Engineer Manager (MJK+Barry+MikeZ)	0.25	0.50	0.50	0.50	0.50	0.50	0.50
Designer (PPD-Gary Smith)	0.25	0.25	0.50	0.50	0.25	0.25	0.25
FEA (PPD-Ang Lee)	0.50	0.50	0.25	0.25	0.00	0.00	0.00
EE Manager (Linda Bagby)	0.25	0.50	0.50	0.50	0.50	0.50	0.50
EE (Linda Bagby+Matt Micheli)	0.00	0.50	0.50	0.50	0.50	0.50	0.50
ME-Instrumentation (Nichole+Micheli)	0.10	0.10	0.50	0.50	0.50	0.50	0.50
Mech/Elec Techs	0.00	0.25	0.25	0.50	0.75	0.75	0.75
DAQ/Computing Proferssional	0.25	0.25	0.50	1.00	1.00	1.00	1.00
OPS Support	0.25	0.50	0.50	0.50	0.75	0.75	0.75

Figure 2 Labor requested from 2x2 project

	July				August					September	FY22 Begins	October	November	December
	7/06-7/09	7/12-7/16	7/19-7/23	7/26-7/31	8/02-8/06	8/09-8/13	8/16-8/20	8/23-8/27	8/30-9/03	9/07 - 9/30		10/01-10/31	11/01-11/30	12/01-12/31
DUNE 2x2 ND-LAr Prototype Resources														
Cryogenic Engineer - Mike Zuckerbrot	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70		0.70	0.70	0.70
Cryogenic Engineer - Kathrine Laureto	0.20	0.20	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Cryogenic Engineer - Fritz Schwartz	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10		0.10	0.10	0.10
Mechanical Engineer - Min Jeong Kim, Sai Kancharla	0.35	0.35	0.35	0.35	0.60	0.60	0.60	0.60	0.60	0.85		0.85	0.85	0.35
PPD Engineering Physicist Manager - Jim Kilmer	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15		0.15	0.15	0.15
Engineering Manager - Min Jeong Kim, Barry Norris	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50		0.5	0.5	0.5
PPD Designer Supervisor - Gary Smith	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.50	0.50	0.50		0.25	0.25	0.25
PPD Principal Engineer - Ang Lee	0.50	0.50	0.50	0.50	0.25	0.25	0.25	0.25	0.25	0.25		0.00	0.00	0.00
Senior Engineering Physicist - Linda Bagby	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50		0.50	0.50	0.50
Electrical Engineer - any	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50		0.50	0.50	0.50
Controls Engineer - any	0.10	0.10	0.10	0.10	0.50	0.50	0.50	0.50	0.50	0.50		0.50	0.50	0.50
Computing Services Specialist - Geoff Savage, Donatella Toretta	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.50	0.50	1.00		1.00	1.00	1.00
PPD Mechanical Technician - any	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.50		0.75	0.75	0.75
OPS Support (ELO) - Steve Hahn, Cindy Joe	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50		0.75	0.75	0.75
Mechanical Technician - any	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.05	0.00	0.00
Electrical Technician - any	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.50		0.75	0.75	0.75

Figure 1 Labor available to 2x2 project