General Comments

- The monolithic detector design concept presented does have merit and includes interesting features that should be considered further.
- This proposal places one of the most delicate and time consuming aspect of the project, wire installation, in series with the other two time consuming, on-critical-path operations: cavern excavation and cryostat construction. This will definitely increase the duration of the project.
- The material that was presented is very conceptual, and therefore lacks sufficient engineering detail to lend itself to a careful evaluation and proper trade study *at this time.* For example, the process of how one would handle up to 20 m lengths of wire reliably, how to provide proper floor support, single sided APA planes with adequate structural frame members, etc. None of these engineering issues are impossible to solve given adequate resources and time. That said, it would be a monumental task to pursue all of the engineering design and prototyping tasks that are necessary and still come close to building a detector in the 2021 timeframe. It is not possible to meet these challenges at the current level of funding in the US alone.
- The principle issue that has no engineering solution is the overall notion of assembling a monolithic style detector in a confined space (cryostat) a mile underground, in a remote area. To build a reliable detector of these proportions will require skilled labor for assembly. While some students may participate, the bulk of the effort will have to be executed by professional technicians and engineers whom may be difficult and costly to mobilize for a sustained period of time. The other major drawback to the monolithic detector design is that it forces fabrication to occur in series after the cryostat is completely assembled and checked out. This will certainly add to the overall time required to go from project start to detector turn on.

Photon Detection

- The proposal to use TPB coated PMTs looking through a cathode plane to reach the middle of the TPC 7m away will have very non-uniform light detection threshold for the supernova neutrino measurement. However the other technologies acrylic bars, TPB radiators on WLS fibers or coated plate style detectors have not yet shown if they will achieve sufficient light collection capability to provide a reliable T0 trigger for low energy events. The collaboration will need to decide how viable are the alternatives and how much effort we want to invest in this. Developing a PMT based alternate in the event that the other technologies cannot achieve the goal is a reasonable effort. The film coated PMT option could be a lower-cost lower-risk design but it will be less capable. This is an interesting debate for the collaboration. Conservative baseline vs lower threshold. In any event a joint working group with the goal of modeling and measuring the performance of all alternates would be the preferred path forward.
- One factor that will need addressed if PMTs are to be used is the survivability of the tubes at 15m Ar depth and also any risk if there are shock waves from HV discharge. Information may be available on this which could show there are no issues but we have seen no studies.
- The WLS coated PMTs must be installed before the wires, and will not be accessible once the wires are in. There could be a long installation period when the WLS coatings are exposed to light and humidity. If the WLS material is sensitive to these environmental conditions and

requires restriction, it would complicate the installation process: e.g dim light vs delicate wire handling, ESD in dry air vs sensitive electronics.

- Question to ourselves: If we swap the APA/CPA order, do we need photon detectors in the center APA wall? The PDs are to give us timing information for fiducial volume determination. The central TPC region does not need timing for fiducial cut.

Ullage

- The goal should be to reduce the ullage to the minimum possible limited by safe cryogenic operation. We should ask if 2% is achievable when the design of the cryostat has reached the level to allow analysis of failure modes. Depending on the implementation of the TPC ceiling attachment scheme, a larger clearance between the TPC and ceiling may be preferred.

APA/CPA Plane Ordering

- The APA/CPA arrangement is good for minimizing stored energy in the TPC. Although with the CPA moved inside the TPC, the stored energy is still close to 100J for a 5kton detector. Further HV discharge mitigation measures are still required.
- If the cathode plane has low mass then no fiducial volume cut around the cathode plane should be necessary, which could lead to a better use of the available LAr. It is expected that this will be a better configuration. This is preferred in the CERN single phase prototype TPC since full track containment is a key requirement.
- Cost issues will need to be revisited when it is clearer who will be doing what, but we would support adopting this as a basis for further designs. However this implies that we would want the CERN single-phase test to also have this configuration. At present it is unlikely that we will have enough funding to construct six APAs. Understanding how a joint detector effort can come together is important. If the CERN single-phase proposal is to be submitted in June then this is time critical.

- A perforated metal sheet has poor optical transparency. If the light detectors are only located behind the outer wire frames, the lower cathode transparency combined with Rayleigh scatter will make the light detection threshold for the central drift region much higher than the outer ones. Wire meshes with good optical transparency are too sparse that the drift field is distorted where the solid structure members are. We'll need to study if this is tolerable, or need some additional field correction on the cathodes.

Detector Ground interface

- LBNE had adopted a conservative 0.5m minimum boundary between the cathode plane and the cryostat. Revisiting this requirement and seeing if a better design of the space between the TPC and the cryostat which makes better use of the LAr would be good. Studies to understand the fields in this region and strategies to reduce the gap will be beneficial.

Field Cage

- The metal extrusion panels look to be a good compromise to make a modular field cage design though the details need to be developed. It does not have the high electric field issue associated with the PCB based construction, and is more resilient against discharges.
- The design LBNE persuaded based on standard circuit board technology could be lower cost and lighter, but it is in a development phase. The 35t test may give greater confidence in this technology, but the HV mitigation and possible failure modes need careful consideration.
- The field cage modules constructed from metal profiles with larger radius of curvature will reduce the electric field. But the closely placed ground plane will increase the field on the field cage electrodes. Modeling the fields is needed. Adding a ground plane 20cm from the field cage will more than double the stored energy in the field cage compared to the LBNE configuration.
- Issues related to HV discharge, resistor protection, and stored energy need to be considered as in all field cage designs. The surge suppressors used at microboone could provide sufficient protection for the resistors. Understanding the panel coupling and the behavior during HV discharge is important. Working through the issues in a joint fashion would be a good approach.
- It is not clear that the radioactive contaminants in the FR4 pose a real threat to the TPC performance. The 511keV gamma from ^{40}K does not travel into the fiducial volume. And the light is well below our PD threshold. However we do not have a detailed simulation of the impact of light from the particle decay in the field cage.

Monolithic wire plane wall

- At 14 meters the wire frames are roughly the height of a 4 story building. They would have to be several times thicker than the current LBNE APAs in order to stand on its own - even with stabilization at the top. With enough intermediate guy wires or braces between the top and bottom the central wire frame could probably be made stable at current APA thickness but these supports will have impact on the active TPC volume. Making it several times thicker than the current APA would of course consume active volume. Perhaps that internal volume could be a place for photon detectors - eliminating the need for transparent CPAs. This would start to be similar to a very thick version of the present APAs.
- There is no easy way to include diagonal braces to the inner cathodes and the wire frame of the TPC to prevent side to side sways, except in the two end caps. This could be a problem if we have to design for any minor seismic activities.
- With massive wire frames, the load distribution of the TPC on the thin membrane floor, and the dynamic movement during cool down and warm up is much more complex than hanging from ceiling.
- If the structural elements are all open instead of tubular (as suggested on page 6 of the slides) the structural problems would be more severe. Open structures have a tiny fraction of the

torsional rigidity of closed tubular structures. The tubular structures could, however, have quite a few ventilation holes and still retain a reasonable portion of their torsional stiffness.

TPC Installation

- The LBNE APA's X and Grid planes could be assembled from pre-fabricated wire modules if collaboration participation is needed. However, overall, the wire winding on the APAs is probably more efficient.
- Handling 12 to 20 meter lengths of wire modules safely and reliably with floor to ceiling heights of greater than 12m is far more challenging than in a 4m tall cryostat. The installation of the angled wire planes are difficult to parallelize and will take a long time. It is not clear if any repair can be done if some mishaps occur during this long installation period when many people are working very close to the wires.
- Even though the construction techniques can be prototyped and tested, the actual wire frame assembly can only be tested after it is completed inside the cryostat. This is in direct contrast to the LBNE design, in which the APAs are fully assembled and can be fully tested (including cold tested) before TPC installation.
- Time tension adjustment on the wire frame probably requires access to all four edges of the wire frame. This requires scaffold over the entire top of the TPC (13m high, 30-60m long) or a cherry picker moving back and forth in front the wire planes: a risky operation.
- The installation of the intermediate wire support pegs could be a very time consuming process. Over the ~12m height of the TPC, there will be multiple rows of such supports at different height and on each level, the pegs need to be inserted every 3-4mm over the entire 30-60m length of the TPC. At 1kg tension, a 20m long wire will sag more than the wire pitch, which means the wires need to be nudged manually to its position.
- It is not clear if the intermediate wire support structure actually captures the wires or merely guide the wires to their position. If not captured, a broken 20m long wire on the outer most plane may cause some serious damage.
- If the TPC is to be made with no access to the back side then the fabrication order and procedure needs to be carefully thought out. Once wires are in place there will be no access to the PMT tubes or ground planes or anything else located on the walls. If this is planned for it may be okay - but better access is always a plus.

Electronics

- Electronics will have much higher input capacitance from both the long wires, and the cables/feedthrough capacitance. The signal to noise ratio of this configuration is probably a factor 2 to 3 lower than the LBNE design.