**Feedback on the Single Phase Far Detector TDR** 16-Sept-19

The following contains LBNC feedback on the July 26 draft (online version dated August 8) of the Single Phase Far Detector TDR. Overall, the document has matured significantly and is in very good shape. While some comments are included below, much of the review of the current draft did not yield actionable comments. We appreciate the efforts of the collaboration to develop the TDR and respond to our comments on previous drafts.

**Chapter 1. Executive Summary**

This chapter is in very good shape. The word “architecture” is misspelled on page 1-17.

P1-8: I am having difficulty reconciling all of the numbers; 3.5m drift length at 1.6mm/us is not 2.4msec, more like 2.2msec

P1-10: 48% attenuation; exp(-2.4/3) is 45% attenuation making the observed signal 55% of the un-attenuated one?

P1-11: “We use this 39Ar contamination to form a requirement that all other
detector components must introduce radioactive contamination at a rate negligible to that of the 39Ar” – how negligible is negligible

P1-11: Discussion on required spatial resolution. For a 5mm wire spacing, with a distributed charge you obtain a position resolution of 5/sqrt(12) which is 1.4mm. the drift inverse velocity of 1.6us/mm so that would argue that you actually don't need better than 2.3us on t0. Please verify my arithmetic?

P1-11: leading to a requirement of at least 0.5 photoelectrons per MeV detected for events in
all parts of the detector.  -> a forward reference here would greatly help the reader.

P1-21: This is a very coarse set of milestones; I think there is a more detailed set later in the TDR and it would be helpful to forward reference this (Figure 3.24?)

**Chapter 2. Anode Plane Assemblies**

P2-39: “The X, U and V layers of wires are connected to the CE (housed in boxes mounted on the APA) either directly or through DC-blocking capacitor” – this is open to misinterpretation and it would be better to spell out which layer is connected directly and which are connected through blocking capacitors.

2-54: Figure 2-24 Given suggests that the diverter may make things worse, it would be desirable to know what performance measure will be used to decide whether to include it or not.

2-56: “We are presently evaluating more accessible locations for the connection of the bias HV cables from the cryostat feedthroughs to the APAs, to minimize connection problems with the SHV connectors. In addition, during installation, we will include as part of the standard checkout procedure either a direct confirmation of the bias connection between a wire plane and its bias input on the feedthrough flange, or an indirect measurement of the connection by recording the charging current in the bias line when increasing the bias voltage to its nominal value.” -> it would be helpful to indicate how (i.e. performance metric) these design changes from the SP-1 design will be qualified.

P2-67: “A production site design review of the Daresbury facility is planned for October 2019,
and a production site readiness review is anticipated for June 2020, followed by the start of APA production for DUNE detector module #1 in August 2020.” Can a statement be made concerning the minimum understanding of the final design that will be necessary for a successful review?

P2-69: As presented the wire is from a single vendor. Is there no plan to qualify a second vendor?

P2-73: What is the consequence if the electrical tensioning measuring system fails to meet requirements?

P2-75: “The APA frames are bolted to mounts on the transport frames that incorporate shock
attenuating coil springs designed to reduce possible accelerations on the APA frames to less than 4g.” -> We also considered g load during shipping and handling when we shipped calorimeter modules to Europe. The g-force recorders were invariably tripped. Why is 4g sufficient? Is there a shipping standard?

P2-84: “Also planned is the construction of a pre-production APA for an integration test with CE and PD system at CERN in Spring 2020, which will fully test all interface aspects. This test will inform the final design review of the APA system in May 2020.” I would have thought that there would be critical milestones and therefore on the high level watch list?

P2-86: “In addition, through our prototyping efforts we will seek out at least one solid backup vendor for material supply and machining in both the USA and UK.” -> given the UK schedule doesn’t this mean that the identification of a backup vendor should be happening already now?

P2-108: “The actual effectiveness of lowering the E field between the GP and the FC will be tested in ProtoDUNE-SP running with CPA voltage of 120 kV instead of 180 kV.” The question here is when will this test be carried out?

**Chapter 3. High Voltage**

This chapter is in good shape. Comments below are mostly typos.

3-94 - first line - SP-FD-2 is not listed in teh table.

3-94 - first sentence of 3.1.3.1 a -> an

3-98 - second paragraph of Structural Considerations - “theCPAs”

3-98 - third paragraph, last sentence - garbled sentence structure, not sure if 49 is modifying 3 mm gaps, or why there is a hyphen

3-108 - last paragraph before 3.4.2, first sentence, extra comma. next sentence “before adapted”

3-110 just above Fig. 3.12 - still uncomfortable with the “If this feature remains in the SP module” - with no details about the process for how it would be removed, or a statement that the detector is fine even if they stay.

3-118 - broken fig reference, mid page.

3-119 - i still think you need to be more clear on jargon/terminology - the blips in the first paragraph are the same as the excessive current draw in bullet 2 of the second paragraph, correct?  why aren’t they then discussed as being clearly the same thing? why is the phrase “current streamers” only introduced in the final paragraph of this page - are these the same thing or different.   from the text, it’s not clear whether you have 1, 2, 3, or 4 questions about the performance, when i think in reality, you only have 1 (or maybe 2).

all that said, 99% uptime is impressive after optimization.

P3-119: “Understanding the origin of the “current streamers” is one of the goals of the long term operation of ProtoDUNE-SP in 2019 exposed to cosmic rays.” -> It is now August 2019 and we heard nothing in the July LBNC meeting - what if the source is not understood.

3-129 - last sentence before 3.8.3.2 - repeated “of”

Section 3.9 - repeated info in first two paragraphs, and the third paragraph again introduces tags as if they are new, when they were introduced in the first two paragraphs.

3-134 - all sounds good - will tablets be provided for each location? or will users be on their cell phones?

**Chapter 4. TPC Electronics**

Overall, this TDR chapter (TPC Electronics) has been much improved. A few comments below.

\* Page 4-147:

2nd paragraph: “The goal is to keep the total noise level as low as possible”.

This statement, as well as the sentences before and after this statement are all rather vague for TDR. S/N of 10, 5, 15 have been mentioned, and it is not clear what are the actual specifications (to achieve the main physics goals) and what is just more desirable (nice if achieved, not critical if not achieved). Table 4.1 is more clear.

\* 4-155

4.2. System Design

The first few sentences: all about low noise…. Kind of repeating what was described in page 4-147. These sentences are really not so useful here.

This section could simply start from “In this Section we describe the overall system design of the TPC electronics….”.

\*4-161:

“With the exception of COLDDATA PLL, serializer, and output driver,….. the digital sections of COLDdata and ColdADC were ….”.

Does this mean the “PLL, serializer and output driver” are potentially more sensitive to hot carrier effects?

\*4-163:

ColdADC designed to operate with an external 64MHz clock ….. and in the DUNE SP module this external clock will operate at 62.5MHz….

While (on page 4-177) "the CRYO operates synchronously with a 56MHz clock, does not require a fast command…”.

Why the clock frequency are designed so differently? It would be useful to explain the reason instead of just stating what they are (this is TDR, not just a collection of where things are at this point of development).

\*4-171:

LArASIC using SPI …and “only possible to read LArASIC configuration registers while writing new configuration data”….

Any particular reason these will not be changed? Worth explaining.

The fast command timing discussion section: haven’t had enough time to understand this section…. The CRYO doesn’t require fast command… would be helpful to explain the difference a bit more and the rational of the different design choices.

\*4-173:

COLDDATA: Will this section be updated with information from the prototype COLDATA ASIC?

\*4-181

“…. this will inform the need for further design of a system to collect any argon bubbles and channel them through the APA frame”.

The control of bubbles (generation as well as handling) is still not fully established. The text here is a fair description of where things are, but for TDR, it is desirable to have something more clear and convincing, as it is also related to the choice of ASIC and components. It is good that there is a test setup being prepare at BNL to study this.

\*4-190

4.2.7: Timing Distribution and Synchronization

This section has more description on how things work for the three-ASIC architecture, but much less on the CRYO-based solution. The two are quite different. It would be good to have more description for the CRYO-based architecture.

\*4-211

4.3.3 Reliability Studies

The reliability study and to establish the reliability required for the whole CE system is perhaps the most challenging task moving forward. The text has a reasonable description of the current understanding of this issue. While it’s good to see that a working group has been formed, this is a very challenging issue.

**Chapter 5. Photon Detection System**

P5-247: “No exposure to Sunlight. All other unfiltered sources: < 30 minutes integrated across
all exposures” Is this, for example, for the lifetime of the experiment? If not then what time period?

P5-248:
SP-PDS-6 – this seems to be a large contribution to the trigger rate for a system which only contributes to one of the three physics areas?

SP-PDS-8 – What has to fit through with 1mm minimum clearance - looks much too small. How can the minimum clearance be smaller than the maximum allowed deflection?

SP-PDS-9 – is this consistent with the other requirements (see above)
SP-PDS-12 – This seems to be a very tight requirement; what features of the design insure this (it wasn’t obvious to me)

P5-253: “detected by SiPMs or ARE lost”

P5-258: “Simulations suggest that this modification will lead to a significant increase of the collection efficiency” – These simulation results should be included in the TDR, especially since I presume they are used in the detector design optimization.

P5-259: “Half of the SiPM active detection area collects photons from the light guide, a quarter of the area on either side of the guide is free to collect the fraction of photons reflected off
the cell walls and windows.” ->  I presume the simulations above are what informs this statement?

P5-259: “The total WINDOW area for each”

P5-262: “The internal surface on the lateral sides of the cell are lined with the Vikuiti™ adhesive-backed dielectric mirror foil” -> it would help if this foil were indicated on the figure; the distance between the WLS and the SiPM should be shown also.

P5-264: “the promising FBK option in A way that”

**Chapter 6. Calibration Hardware**

No feedback on current draft.

**Chapter 7. Data Acquisition**

This chapter has shown significant improvement in recent versions.

**Chapter 8. Cryogenic Instrumentation and Slow Controls**

8-465  I’m confused by the definition of “goal” in the first paragraph, as I don’t recall seeing it phrased this way. The goal is an improved version enabling more detailed studies that would lead to improved design in subsequent detectors? I don’t understand how something defined this way makes sense, particularly as a “specification,” as presumably achieving the goal helps the existing detector in which you have achieved that goal do better physics, as opposed to do design studies…

8-470 - last sentence of opening paragraph - “constraint” is a typo

Sections 8.2.1.4 and 8.2.1.4.1

I’m not sure I’m convinced by any of this. In Fig. 8.15, I see several lines that sort of go through data points, with the one that maybe most convincingly goes through data points on the left proving least correct on the right.  Can you actually use this information to make a solid prediction (of purity, I suppose) that is then borne out in the data?  I realize this is still under study, but what makes you think that this is actually possible? I’m still not sure.  Similarly in 8.2.1.4.1, you talk about the power of the pumps off calibration but then acknowledge that it may not be valid. If you don’t have the pumps off calibration, is anything doable?

8-486 - last paragraph - I’m confused by the language here. On the surface, where the cosmic ray rate is high so you can measure the lifetime from data, there’s a large fluctuation in the lifetime, so it’s actually not possible to well measure the lifetime online? I think the point of this paragraph is to say that even in ProtoDUNE, where you can use data to measure the lifetime, the purity monitors were still more useful for realtime monitoring, once operating parameters were tuned to achieve adequate resolution, and that this will only be more true in DUNE.

Section 8.3.3/8.3.6- i still worry about managing all these instruments, values, etc. There’s no real discussion of how WinCC OA did in ProtoDUNE except “it worked, but it took effort, and it will take more effort in DUNE”.  That may be the best you can do, but do you feel comfortable with that? It doesn’t seem like there is a real alternative at this point…

8-518 - step 1 of 8.4.5.2 - not sure if this is a typo, but “top bottom plates” is a confusing construction

8-519, first full paragraph - how do you connect the sensors to the cables?

8-520 - gas analyzers - are you going to record the analog output as well - analog can be more reliable in many cases - i agree that digital as primary makes sense, but might be good to have the analog record as well.

8-523 - first paragraph, midway through - the deflection of the T-gradient being <5 cm seems like a specification/requirement that should be captured in teh top level table earlier in the chapter.

8-526 - first sentence of 8.4.6.8 - did you intend to write that they required no QA?

**Chapter 9. Detector Installation**

9-530 - last paragraph first sentence, typo “order of fifty of man years”

9-531 - shipping delays paragraph, typo - “form the consortia”. typo “detail shipping manual”

9-531 - components paragraph, typo - “generated the define”, “ownership if each part”, “executes”

i’m going to stop pointing out the typos here (there are more in subsequent paragraphs) - but 5 typos in 2 paragraphs is too many, this whole  section needs a copy editor.

9-548 - last full paragraph - “gaseous argon (gaseous argon (GAr))“

9-553 - have you thought about Rn plateout on wires during installation? The radon level underground can be pretty high - not sure if this would be a problem for DUNE though.

9-553 - second paragraph - typo “all materials must be brought thought”

9-558 - good to see clearly defined division of responsibilities between installation and consortia, in addition to interface documents.

9-558 - first paragraph of 9.2.5, last sentence - do you mean LN2 will not accumulate?

Fig. 9.21- consider putting on its side and filling a full page

9-585 - last paragraph - mention of a 14 m scissor lift. Earlier, we heard that 12 m was the largest battery operated lift that has been found (cleanroom compatible) - this is a different lift?

9-604 - is there any slack in manpower needed up to the 144 person cap? do you have any contingency on the labor, as problems come up?