

Dual Phase Photon Detection System Consortium Meeting

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DPPD Consortium Meeting

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Topics for today

- Feedback from LBNC meeting in March, 4-6
- Study of the relative timing accuracy among PMTs in ProtoDUNE-DP (Jose)
- Light signal rates per channel in ProtoDUNE-DP (Ana)

LBNC meeting, March 4-6

- LBNC Practice Talks (main agenda still not public):
 - <https://indico.fnal.gov/event/23479/>
- A general talk about ProtoDUNE-DP was given by Dominique on Tuesday
 - 6 slides from the Photon Detection System with latest analyses
- A breakout session happened on Wednesday
 - The 23 page-document with the answers to the LBNC list of questions was discussed

DPPD contribution to the LBNC

- **Photon Detection System**

(12) We would like to see a summary of the analysis results and plans. And to hear about considerations for adding Xe.

- **Since last LBNC meeting in February**, we have continued with the Photon Detection System (PDS) data taking to monitor the performance and stability of the system. The external Cosmic Ray Taggers (CRT) were used to provide the trigger to the PDS. Long overnight runs were acquired to accumulate enough statistics as CRT rate is low (~ 0.3 Hz). Data were acquired with and without drift field. Studies on the scintillation light dependence with the cathode voltage with different trigger conditions and SPE measurements are ongoing. PDS keeps operating in stable conditions as observed in the analysis of the calibrations, and tau-slow component monitoring.
- **For the coming weeks**, we plan to continue taking regular PMT calibrations and acquire more long runs of data with CRT trigger, hopefully, in coincidence with the charge readout.
- Regarding the **addition of Xe in ProtoDUNE-DP**, we look forward to seeing the results of the Xe doping tests at ProtoDUNE-SP, especially in terms of the production light yield, stability and volume uniformity, including the impact on the scintillation time profile. Simulation studies of Xe doping in DUNE DP Far Detector are included in the Dual-Phase TDR Volume. This is an interesting option to be considered as an alternative to the baseline design with half coverage reflector/WLS panels.

LBNC closeout

- Next slides are just some excerpts from the LBNC closeout regarding ProtoDUNE-DP and the Photon Detection System
- Next Technical Board Meeting, Thursday, March 19
 - We will be informed about the next meetings

- The committee congratulates DP on significant progress in the protoDUNE run since the December LBNC meeting.
- At an interim video meeting on Feb 6 and in follow-up Q&A, DP provided the committee with detailed descriptions and discussion of the issues and progress to date. This was very much appreciated.
- We think a similar meeting in about 2 months would again be very useful.

Cryo/Liquid Conditions

- Since November, repeated regeneration of a filter in the recirculation system is no longer necessary, leading to much more stable cryo conditions and allowing DP to make significantly more progress.
- Since then, the liquid purity has improved steadily. The long purity monitors indicate ~ 9 ms e-drift lifetime has been achieved.
- **Surface instabilities (both bubbles and ripples) continue to be concerns that impact stable CRP operation. Further studies are planned at protoDUNE and in an upgraded/new cold box.**
- **The committee considers it important to continue these studies and to foresee the surface behavior in the full scale module.**
- An operational procedure, applying overpressure for \sim hours once per week, generally suppresses bubble formation for several days, allowing periods for studying CRP sparking and gain.
- Intervention surgery on the HV extender is planned to extend the drift field to full depth. The baseline plan requires removing $\sim 25\%$ of the liquid to allow the surgery, followed by refilling. The entire process is likely to take 2-3 months. An alternative approach that would perform the surgery in liquid is under consideration.

CRP Sparking

- The typical LEM spark rate is $\sim 3/\text{CRP}/\text{hr}$, with Grid sparks at $\sim 0.3/\text{CRP}/\text{hr}$. While the electronics is protected from LEM sparks, the 6kV Grid sparks permanently damage the readout ASIC. Sparks can be in bursts, with correlation between sparking involving multiple LEMs and the Grid – the mechanism is not yet understood.
- Studies include changes in the quenching resistors, introduction of capacitive coupling, and mapping HV settings – an extensive program.
- During these studies the electronics is disconnected for protection and is only connected for very limited periods for CRP performance studies - only several days in total so far.
- An increasing number of LEMs (currently 26 of the 72) are kept at reduced voltages to avoid repeated sparking, so excluded from performance studies.

CRP Performance

- The CRP gain fell by a factor ~ 2 in early operations, then plateaued. This behavior is consistent with prior bench tests and attributed to charge up effects.
- However the plateau value is about a factor two less than expectation based on bench tests (correcting for operating pressure). Voltage scans are planned to understand contributions to the gain to further study this.
- Noise characteristics indicate a microphonic/vibration between LEM surface and anode. While this should be understood and mitigated in the design, it this is not an issue for present studies.
- The short in the HV extender limits the depth of the uniform drift field to about 1m. The non-uniform field beyond this leads to clearly observed curvature in the tracks.

PDS

- Initial studies to date include fast/slow scintillation components and correlation with drift field and LAr purity, S1 and S2 signal correlation, TBM vs PEN WLS
- Ready now to take runs together with the charge readout, followed by combined data-taking with full drift depth after the HV surgery.
- **DP should continue to carefully manage the “budget” in grid spark damage to first complete CRP gain studies and then take this combined data.**

- **The committee considers that understanding the sparking issues and CRP gain are the highest priorities for the run.**
- Once these studies are complete, the HV surgery (which carries some risk) will allow important measurements, including developing tracking/analysis to full depth, mapping space charge effects on the field, and correlating the PDS with charge data.
- **We consider it very important that, if needed, the running period be extended to complete this full program.**

LEM/CRP R&D towards ProtoDUNE-II

- Design improvements and prototyping to address CRP deformation and sparking are underway.
- Initial plans were presented to develop new CRPs for a second protoDUNE run, including prototypes for improved LEMs and CRP mechanical structure, testing of a new CRP design (small prototype), and production of two full CRPs for protoDUNE.
- A new cold-box is needed to support the program of studies and extensive and long term testing of the new design.
- **The committee considers the new/upgraded cold box and associated cryo systems to be essential to this plan.**
- **The plan should include stress testing of a prototype and long term testing of the new CRP design.**
- **Specifications for the amplitude of surface irregularities that can be tolerated by the new CRP design should be developed.**

Recommendations

- If necessary, the present run should be extended to complete the program outlined.
- At completion of the run, DUNE should hold a technical workshop and review assessing what has been learned and R&D plans that can lead to a successful demonstration of final design in protoDUNE II.
- The R&D will require additional resources, including a new cold box and associated systems to support studies of the liquid surface, and demonstration of robustness of the new CRP design.

- We're happy to see progress on the DP analysis, but we note that this is less mature than the SP analysis and has a factor of two less in manpower
 - We suggest that additional support is obtained from software experts to strengthen the DP analysis team
- We encourage the SP and DP groups to continue moving towards using common tools for simulation and analysis techniques as much as possible

- **ProtoDUNE DP** is being operated systematically to learn as much as possible about the Dual Phase technology. To understand the path forward for this technology, a detailed R&D plan needs to be articulated clearly, then reviewed, and evaluated formally, by the DUNE collaboration at a high level.
- The **ProtoDUNE DP analysis** shows advances in the basic analysis of the data taken over the course of the past months. The LBNC believes that it sees opportunities for the DP analysis team to further derive support, expertise and advice from the SP team.

Next meetings

- March 31, DPPD meeting
- April 14, DPPD meeting
- In-person DUNE collaboration meeting in South Dakota
CANCELLED
 - Possible remote meetings in place of full collaboration meeting
 - Zoom regular DUNE meetings continue as usual