

# Dual Phase Photon Detection System Consortium Meeting

Inés Gil-Botella

DPPD Consortium Meeting

3 March 2020



**Ciemat**  
Centro de Investigaciones  
Energéticas, Medioambientales  
y Tecnológicas



# Topics for today

- Next LBNC meeting in March, 4-6
- SPE background measurements in ProtoDUNE-DP (Ana)

# LBNC meeting, March 4-6

- They expect a session including a general DP update and DP analysis + breakout session
- In particular, they asked:
  - **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.

# LBNC meeting, March 4-6

- A general talk about ProtoDUNE-DP will be given by Dominique on Tuesday
  - 6 slides from the Photon Detection System with latest analyses
- A breakout session is scheduled for Wednesday
- A 23 page-document with the answers to the LBNC list of questions has been prepared

# DPPD contribution to the LBNC

- See next slides for Dominique's talk
- **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 ( $\sim 0.3$  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.

D. Duchesneau  
LAPP, Annecy

- Cryogenic operation
- CRP performance
- CRP stability tests
- Photon detection system
- Run plan and next steps

04/03/2020

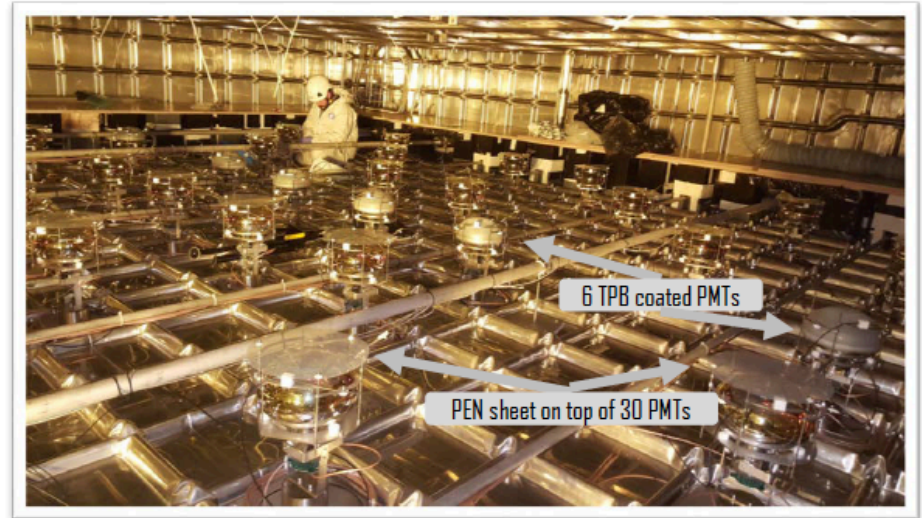
D. Duchesneau / ProtoDUNE-DP Status

LBNC  
Fermilab, March 4<sup>th</sup>, 2020

# Photon detection system

## - New data and analysis

- Data taken with Cosmic Ray Tagger (CRT) with and w/o drift and extraction
- Cathode HV scan from 0 to 50 kV => variation of S1 as a function of field
- Calibration runs with LED-fiber system and with alternative system for systematic comparison
- Light runs with PMT trigger taken weekly to monitor slow scintillation constant for stability studies



04/03/2020

D. Duchesneau / ProtoDUNE-DP Status

25

# Photon detection system:

## Summary of data collected (updated from December)

- Data taken almost every day since June 2019
  - PMTs are switch ON-OFF several times per day to allow cameras to survey the liquid surface and purity monitor measurements
- All data is long-term saved in eos:
  - Raw data as taken from MIDAS
  - ROOT data converted
- Midas data is also copied to CASTOR
- > 1300 runs taken
- This represents:
  - >200 hours of data (84 M events)
  - 33 TB of MIDAS data, 8.4 TB of ROOT files
- ~ Weekly calibrations
- Several long overnight PMT runs:
  - 11 runs of 8-24 h with and without fields

| <i>Trigger</i>                                       | # of runs | # of events | time (h) |            |
|--|-----------|-------------|----------|------------|
| CRT Panels   | 30        | 152k        | 120      | stat x40   |
| Random trigger                                       | 101       | 12M         | 11       |            |
| Calibration runs                                     | 666       | 14M         | 7        |            |
| PMT trigger runs                                     | 556       | 57M         | 81       |            |
| <b>Random trigger in coincidence with charge DAQ</b> | 10        | 144k        | 4        | <b>NEW</b> |
| <b>Total</b>   | 1363      | 84M         | 223      |            |

| <i>LEMs voltage</i> | # of runs | # of events | time (h) |         |
|---------------------|-----------|-------------|----------|---------|
| 0kV                 | 368       | 34M         | 77       |         |
| 1.5kV               | 40        | 1M          | 0.3      |         |
| 1.6kV – 3.0kV       | 98        | 5M          | 24       |         |
| 3.1kV – 3.5kV       | 193       | 5.6M        | 70       |         |
| 3.6kV               | 8         | 360k        | 0.4      |         |
| Tests               | 659       | 37M         | 51       |         |
| <b>Total</b>        | 1363      | 84M         | 223      | stat x2 |



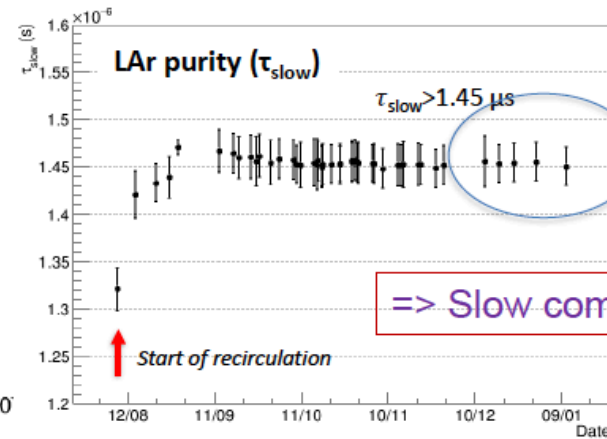
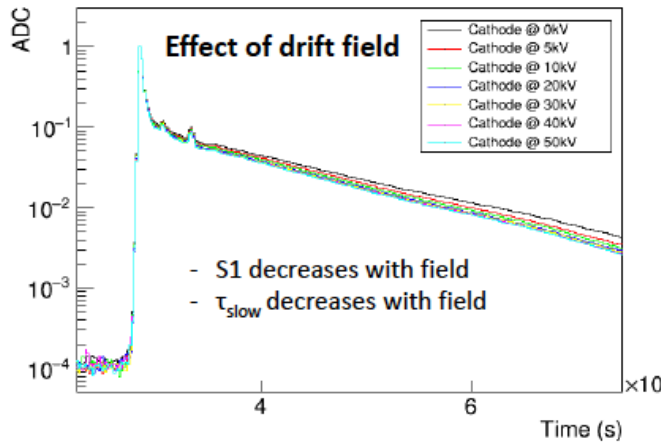
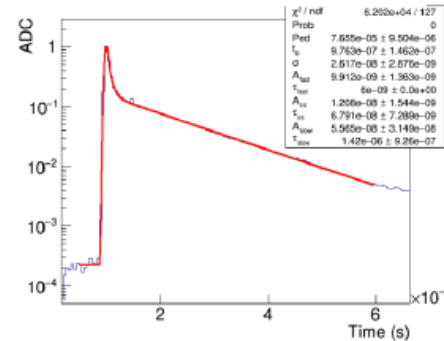
# Photon detection system:

## Data analysis: purity monitoring

ongoing

- Cosmic muons produce scintillation light on LAR
- Scintillation profile can be obtained averaging waveforms
- No drift field is applied (full recombination of electrons)
- Fit: convolution of 1 gaussian with 3 exponentials
- $\tau_{\text{slow}}$  component is an indicator of LAR purity

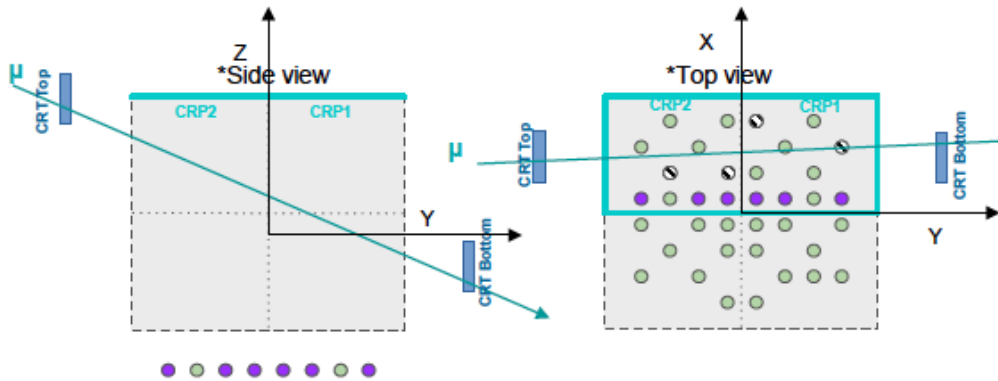
Scintillation light profile



New measurements since last LBNC

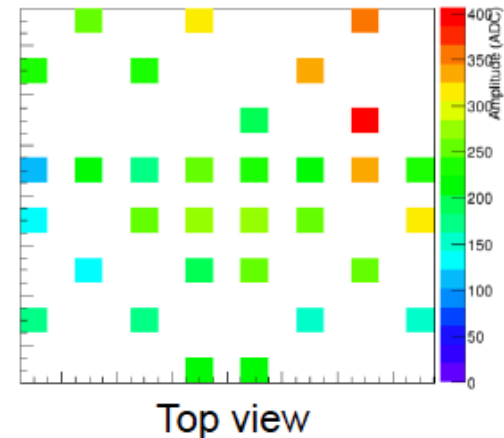
=> Slow component stable

# Photon detection system: Data with Cosmic Ray Tagger trigger



- TPB/PEN PMT gains are tuned to equalize their response
- The pattern  $CRT_{TOP} - CRT_{BOTTOM}$  is clearly visible, increasing the amount of light as the muons get closer to the PMTs

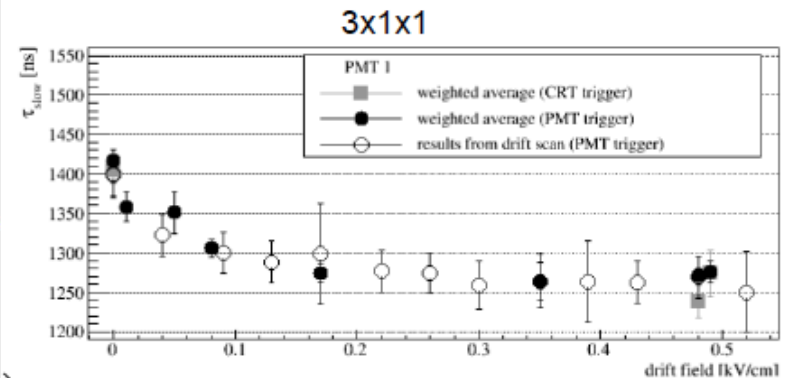
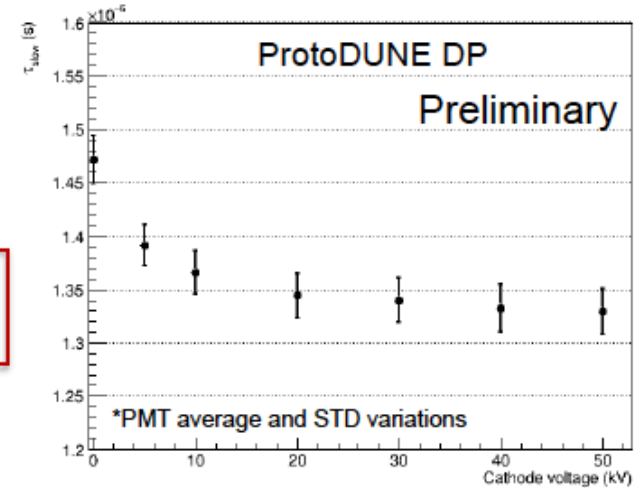
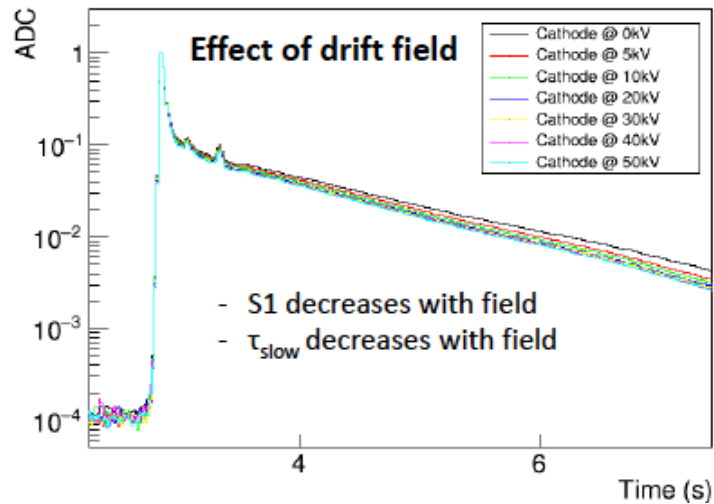
Average S1 amplitude (ADC)



# Photon detection system:

## Cathode voltage scan (New)

- A dedicated scan on the cathode voltage was done to study the dependence of the scintillation light with the drift field.
- Scintillation profile is obtained by averaging waveforms, and the tau slow parameter is obtained by fitting the convolution of 1 gaussian with 3 exponential (see previous slide).
- $\tau_{\text{slow}}$  component shows a dependence with the drift field (top right), as it was observed in the 3x1x1 data (bottom right).

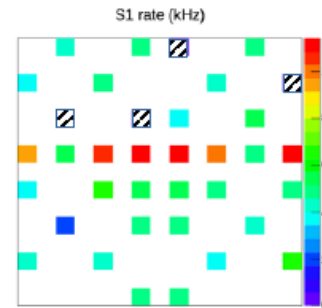


# Photon detection system:

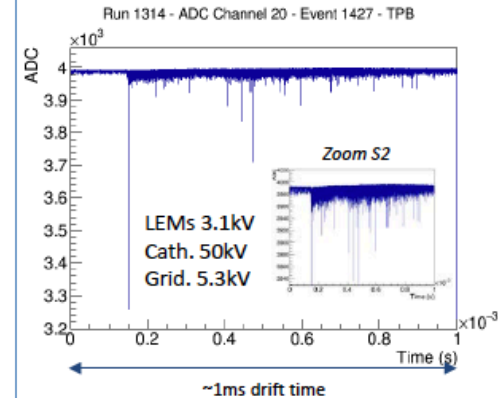
## Analysis ongoing

- Data taking continues and analyses are ongoing: S1 and S2 studies
- Several key requirements are being validated (S/N, timing, linearity,...)

- **S1 rate (muon rate) preliminary:**
  - Random trigger, PMTs at G 1e7, no fields
  - TPB PMTs: ~ 9 kHz
  - PEN PMTs: ~ 4 kHz



## S2 signal electroluminescence signals



## Next goals:

- Operate the system in stable conditions with long runs
- More data with new external muon panels
- Acquire more data in coincidence with charge readout (development of a combined analysis)
- Data with 6 m drift (S1 and S2 signal correlation, electron lifetime measurement, cosmic muon identification...)

# Xe doping + reflective foils

- We should organize some work in the next weeks to understand the impact of these possibilities in ProtoDUNE-DP phase II (including other possible ideas for next phase)
  - Follow Xe doping activities in ProtoDUNE-SP (measurements ongoing)
  - Develop more detailed studies (beyond Rayleigh scattering) with impact in our detector requirements

# Next meetings

- Next LBNC meeting at Fermilab: 4-6 March 2020
- March 17, DPPD meeting
- March 31, DPPD meeting