LAr scintillation-light measurements from ProtoDUNE Dual Phase first-year data

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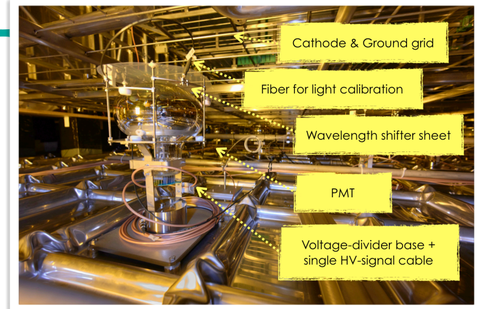
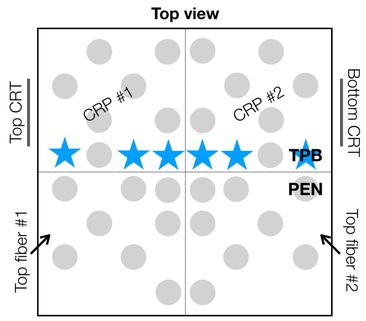
1. THE PHOTON DETECTION SYSTEM (PDS)

Crucial system to provide event timing, trigger for non-beam events and calorimetric measurements

- **ProtoDUNE-DP is a 300-ton dual-phase LAr TPC** operated with cosmic rays at the CERN Neutrino Platform [1]
- **The PDS is formed of 36 8" cryogenic photomultipliers** (PMTs): Hamamatsu R5912-MOD20, fully characterized [2]
- **Wavelength shifter [3]: PEN** sheet (x30) / **TPB** coating (x6)
- Different trigger modes:
  - **PMT self trigger** (Hz-kHz)
  - **Random trigger** (configurable rate)
  - **External trigger**: LCS (1 kHz), in coincidence with charge readout (10 Hz), Cosmic-ray tagger (CRT) panels (0.3 Hz)



PMT data (June 2019 to May 2020):
>1500 runs
>400 hours
>93 M events



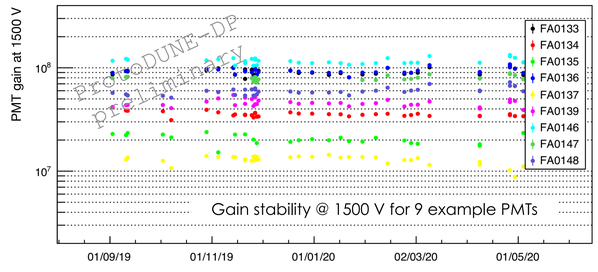
2. LIGHT CALIBRATION SYSTEM (LCS) PERFORMANCE

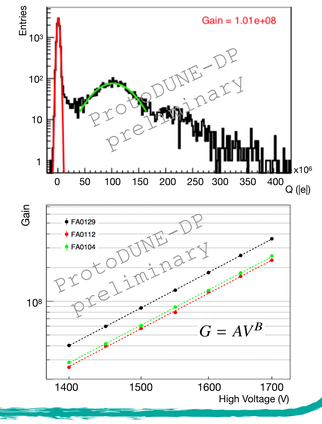
Average of the mean gain variations (per PMT) in 9 months: $\langle \Delta G_{1500\ V} \rangle_{36PMTs}$ = **(8 ± 2)%**

- LED & fiber based system to monitor the PMT gains during the detector operation
- **Baseline configuration:** one fiber pointing at each PMT photocathode [4]
- **Alternative LCS:**
  - Two fibers at the cryostat top
  - More convenient for DUNE
  - $\langle \Delta G_{1500\ V} \rangle_{36PMTs}$ wrt baseline LCS = -9 ± 7%

Method for PMT gain determination

1) PMT HV scan (1400-1750 V) illuminating at the single-photoelectron (SPE) level
2) SPE integration
3) SPE spectrum fit (two gaussians)
4) Gain vs HV curve for each PMT

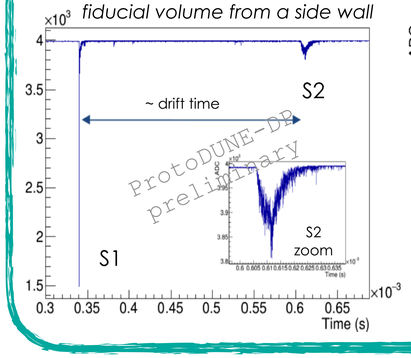




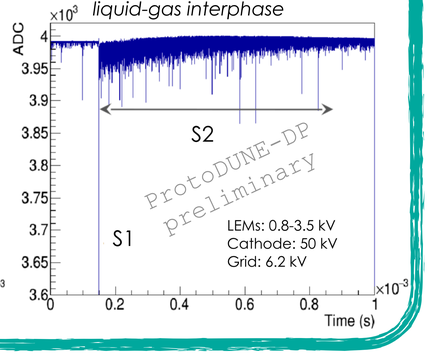
3. SCINTILLATION LIGHT SIGNALS

- Data with **drift, extraction and amplification** fields [1]
- Scintillation light at 128 nm from excimer decay:
  - **S1 signal**: prompt scintillation light
  - **S2 signal from the electroluminescence** of the electrons extracted in the gas argon (>6 m away from the PMTs) **observed in all PMTs!**

Example 1: *Track entering the fiducial volume from a side wall*



Example 2: *Track crossing the liquid-gas interphase*



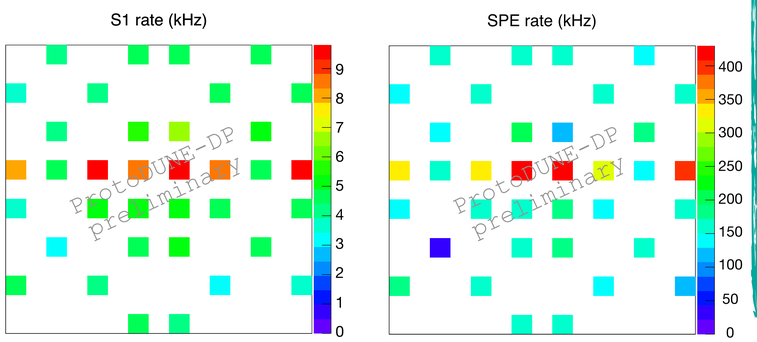
4. MUON-DETECTION & BACKGROUND STUDIES

S1 signal rate

- Pulses in the waveforms with amplitude > 3 PE
- **PEN PMTs: 4.5 ± 0.7 kHz**
- **TPB PMTs: 9.0 ± 0.6 kHz**

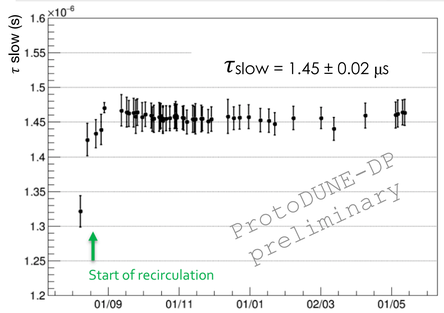
SPE rate @ G=10^7

- SPE characterization: amplitude = 7 ± 3 ADC
- **PEN PMTs: 150 ± 30 kHz**
- **TPB PMTs: 370 ± 50 kHz**



5. LIGHT PROPAGATION IN LIQUID ARGON

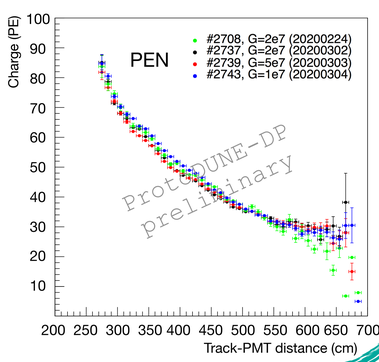
Slow component lifetime



- **Scintillation profile fitted** to a convolution of one gaussian with three exponentials
- The τ_{slow} component is an **indicator of the LAr purity**

Rayleigh-Scattering (R. S.) length study

- **CRT-trigger runs:** PMT and CRT informations are matched according to their timestamps
- The **correlation** between track-PMT distance and PMT collected signal will allow an estimation of the R.S. value
- **Simulations** for different R. S. lengths are ongoing



REFERENCES **[1]** arXiv:1807.10340 **[2]** JINST 13 (2018) T10006 **[3]** Neutrino2020 poster by J. Soto **[4]** JINST 14 (2019) T04001

DEEP UNDERGROUND NEUTRINO EXPERIMENT