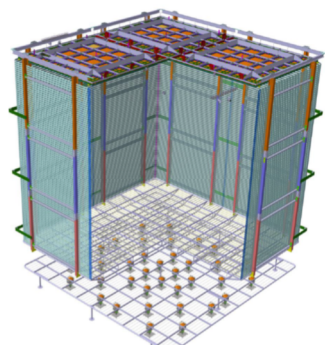


# ProtoDUNE Dual Phase Light Calibration System installed at NP02

Clara Cuesta

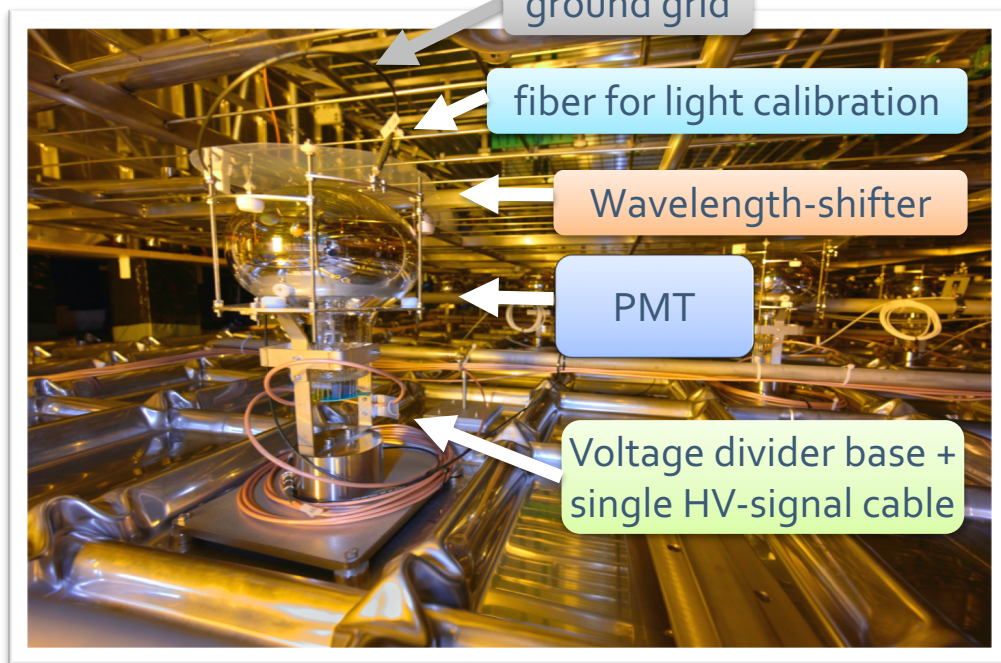
May, 23<sup>rd</sup> 2022

# ProtoDUNE-DP Photon Detection System



ProtoDUNE-DP

PDS placed below the ground grid



**36 8" cryogenic PMTs**

[JINST 13 \(2018\) T10006](#)

[JINST 15 \(2020\) P09023](#)

**Wavelength-shifter:**

PEN / TPB coating on PMT

**Voltage divider base + single HV-signal cable + splitter (external)**

**Light calibration system: LED (external) & fiber based**

[JINST 14 \(2019\) T04001](#), [DocDB #24478](#)

**DAQ system (external)**

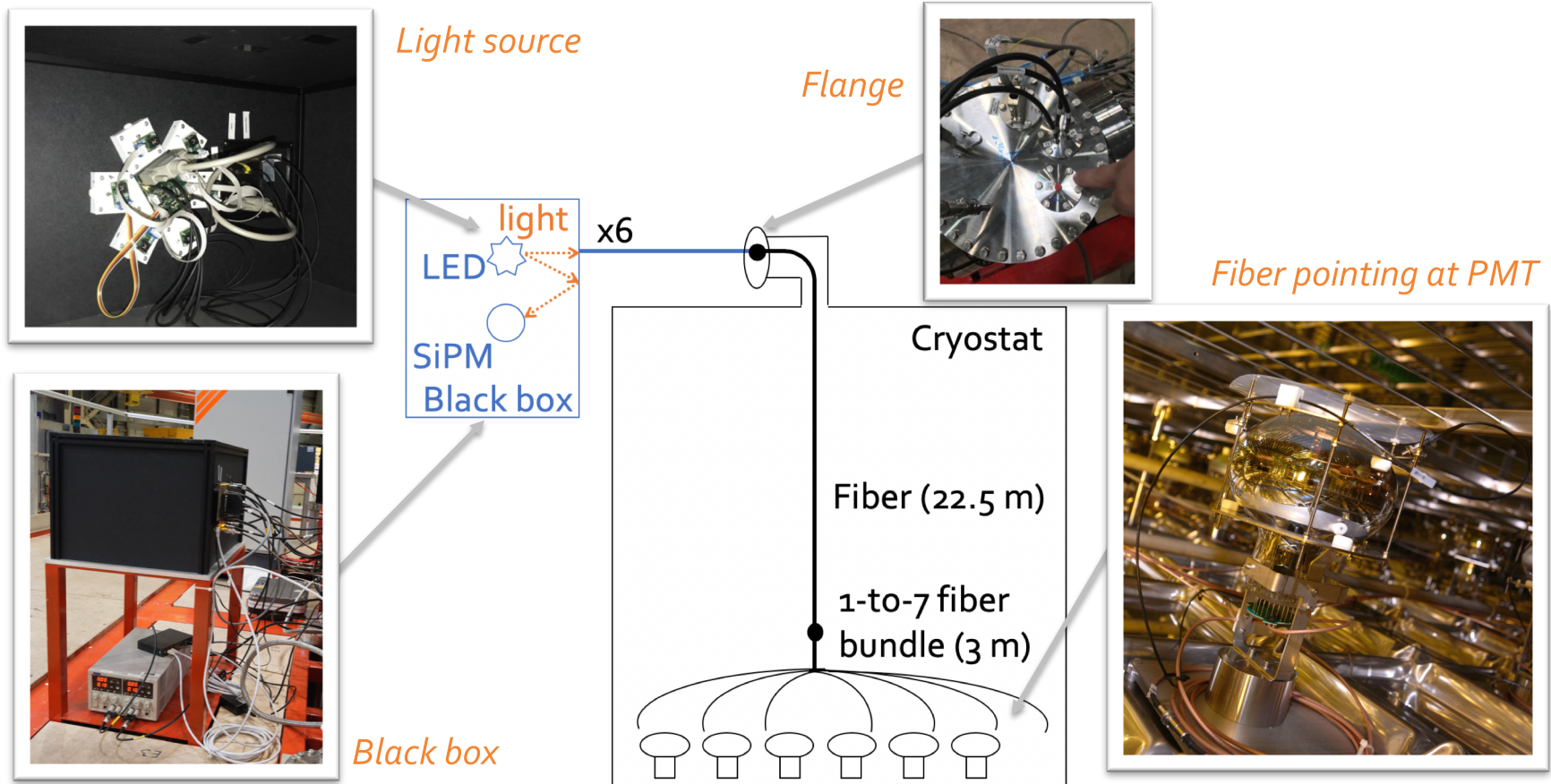
[IEEE Trans Nucl. Sci. 68 \(2021\) 2334](#)

## Successful performance

- Scintillation light detection in the 6-m drift-length ProtoDUNE Dual Phase liquid argon TPC, [arXiv:2203.16134](#)
- [A. Gallego-Ros \(CIEMAT\) PhD Thesis](#)

# ProtoDUNE-DP Light Calibration System

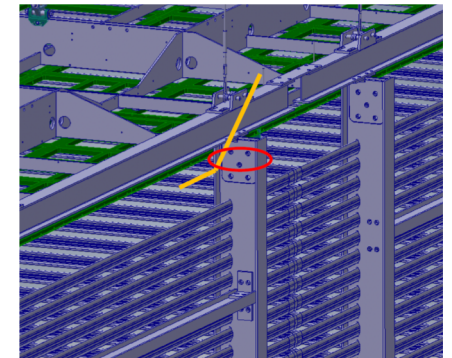
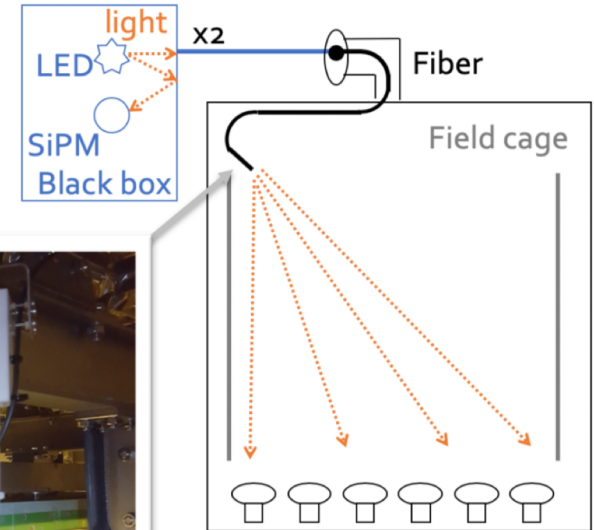
- **Baseline LCS:** LED-Fiber based with one fiber pointing at each PMT



# ProtoDUNE-DP Light Calibration System

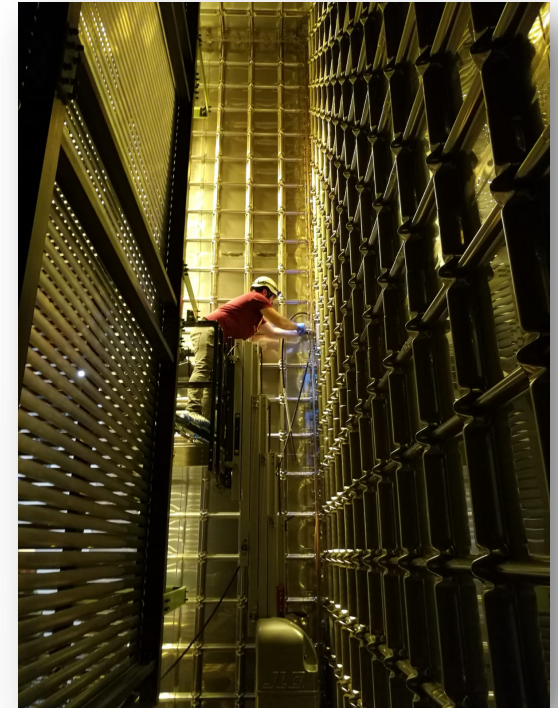
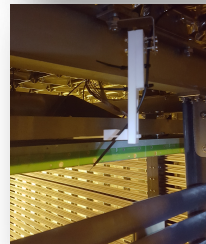
- Alternative LCS:

- 2 fibers placed on top of the field cage to calibrate several PMTs with a single fiber
- More convenient as number of fibers and cost are reduced



# ProtoDUNE-DP LCS installed at NP02

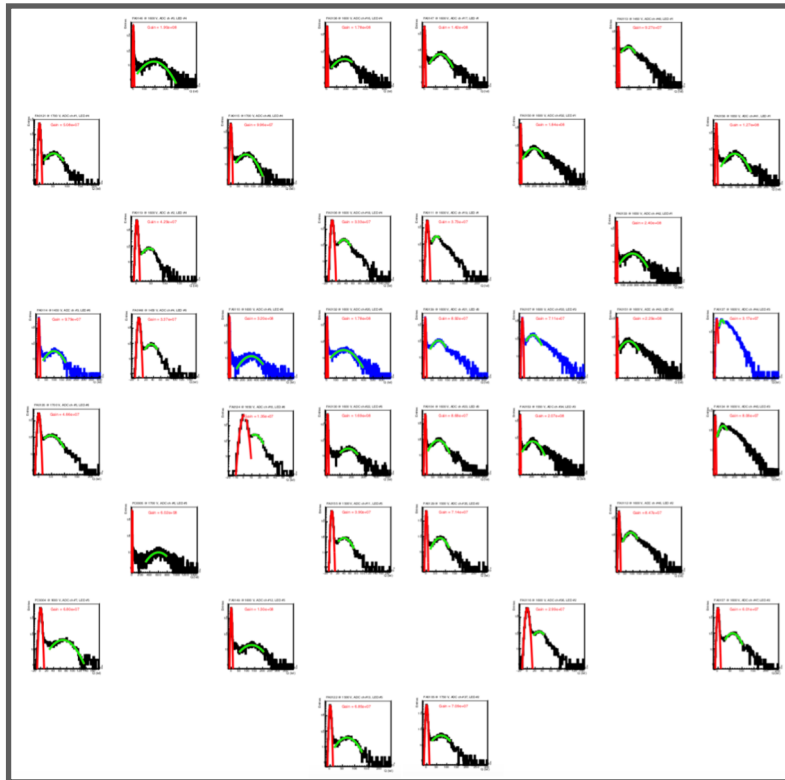
- Black box with **light source** (6 Kaputschinsky LED drivers) and reference sensor
- Out of the cryostat: 6 fibers to cryostat  
*Thorlabs,  $\varphi$  1000-mm, M59Lo1*
- 2 **CF40**, each with 3 optical FT *Allectra*
- Inside the cryostat (6x):
  - **22.5-m fiber**  
*Thorlabs  $\varphi$  800-mm, FT800UMT, SS jacket*
  - Matting sleeve - *vacuum compatible*
  - **3-m 1-to-7 bundle** → 1 fiber per PMT  
*Thorlabs  $\varphi$  200-mm, FT200UMT, SS jacket common end, black jacket at split ends*All fibers with SMA connectors
- Inside the cryostat (2x)
  - **5-m fiber**  
*Thorlabs  $\varphi$  800-mm, FT800UMT, black jacket SMA connector + bare end*



It's ready to reuse or adapt it for ProtoDUNE-VD!

# ProtoDUNE-DP calibration performance

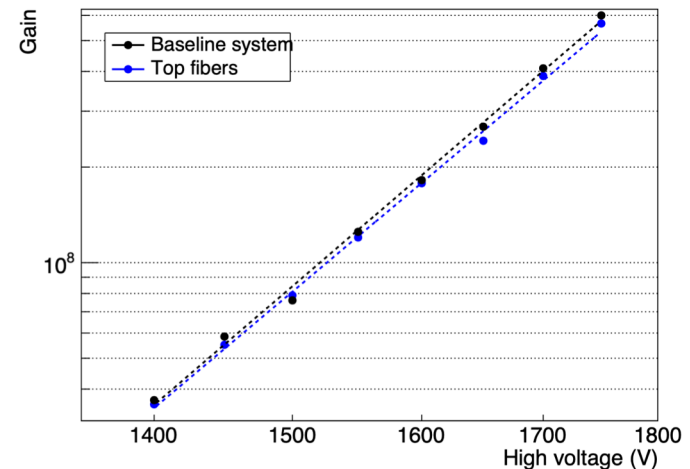
## Alternative LCS validation



Example of calibration with top fibers

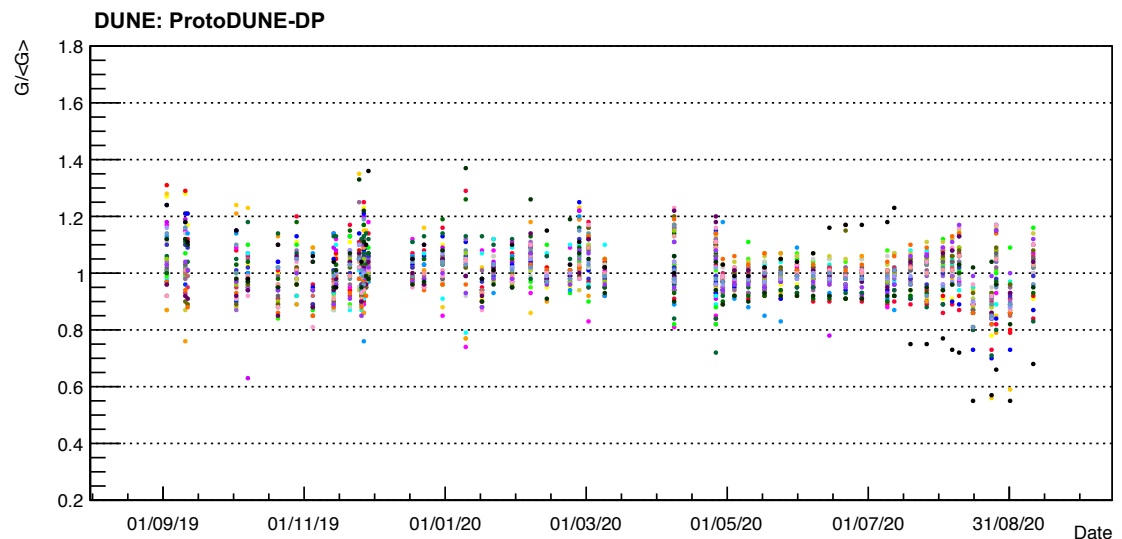
- Goal: PMT calibration using alternative LCS + comparison with baseline system
- Result: We calibrated all the PMTs with one fiber

Example: FA0136,  
 $\Delta G@1500V = 6\%$



# ProtoDUNE-DP calibration performance

- **Goal:** to calibrate the PMT response by determining the PMT gain. It is important to guarantee equalized PMT response and to measure the light collected in PE units.
- The **LCS illuminates the PMT** photocathode at the **SPE level** in order to determine the PMT gain. The calibration light rate is kept to  $\sim$ kHz to avoid PMT fatigue
- The gain **calibration method** is based on measuring the SPE charge at a given voltage.
- **PMTs were biased** at the HV required to achieve the target gain according to the calibration.
- Calibrations were carried out weekly and a **gain correction** based on the closest calibration is applied in the analysis.
- PMTs were switched on and off every day.
- PMT gains are quite **stable**, average value of the gain STD at 1500 V for 36 PMTs is 9%.



# References

- Design, validation and performance of the light calibration system of ProtoDUNE Dual Phase, DocDB [#24478](#)
- [A. Gallego-Ros \(CIEMAT\) PhD Thesis](#)
- A light calibration system for the ProtoDUNE-DP detector, [JINST 14 \(2019\) T04001](#)
- ProtoDUNE-DP Light Acquisition and Calibration Software, [IEEE Trans Nucl. Scie. 68 \(2021\) 2334](#)