

ProtoDUNE-DP Light Data

Clara Cuesta on behalf of the CIEMAT team

October, 31st 2019

Photon Detection System (PDS)

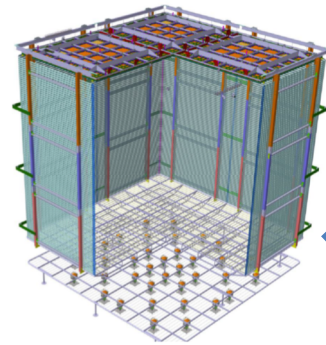
36 8" cryogenic photomultipliers (PMTs)
[JINST 13 \(2018\) T10006](#)

Wavelength-shifter:
PEN / TPB coating on PMT

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

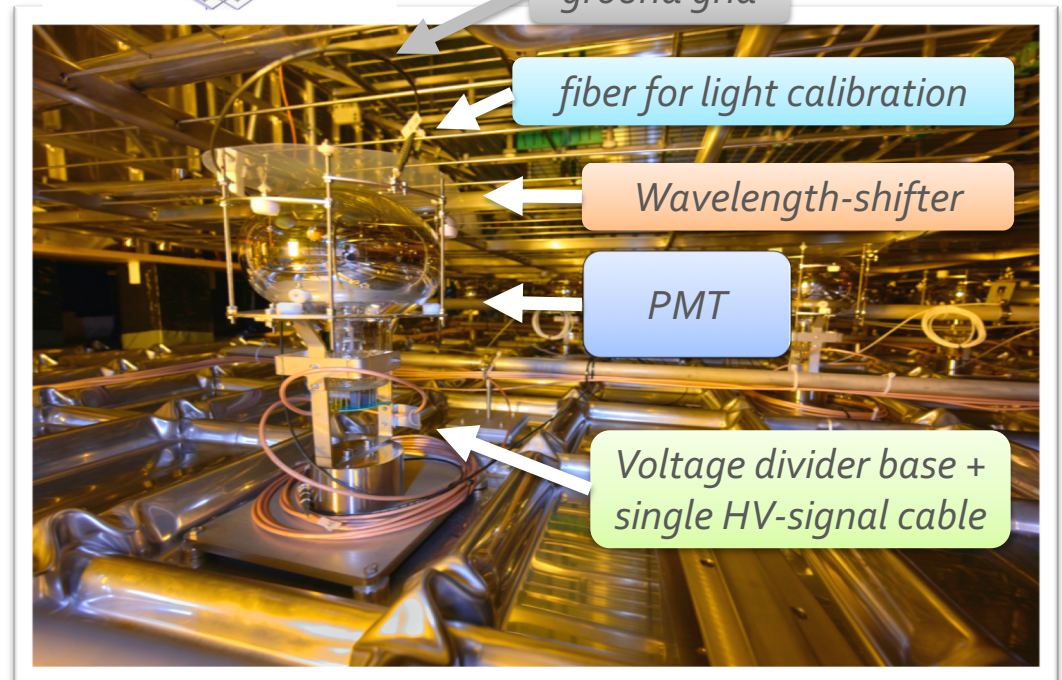
Light calibration system:
LED (external) & fiber based
[JINST 14 \(2019\) T04001](#)

DAQ system (external)



ProtoDUNE-DP

PDS placed below the ground grid



ground grid

fiber for light calibration

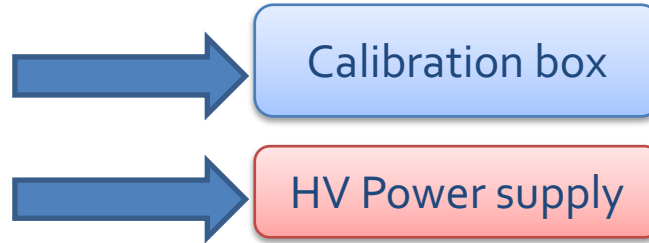
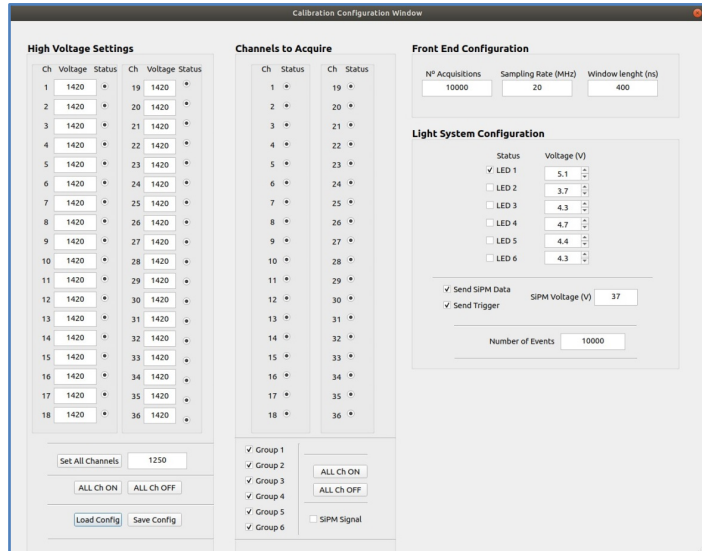
Wavelength-shifter

PMT

Voltage divider base + single HV-signal cable

Light DAQ

CIEMAT acquisition control software



The MIDAS interface shows a 'Run Status' section with a green 'Run 239' indicator, start time 'Tue Jan 29 14:42:25 2019', and running time '0h05m38s'. Below it is an 'Equipment' table:

| Equipment + | Status | Events | Events[/s] | Data[MB/s] |
|-------------|-------------|--------|------------|------------|
| FEV1740 | Initialized | 0 | 0.0 | 0.000 |

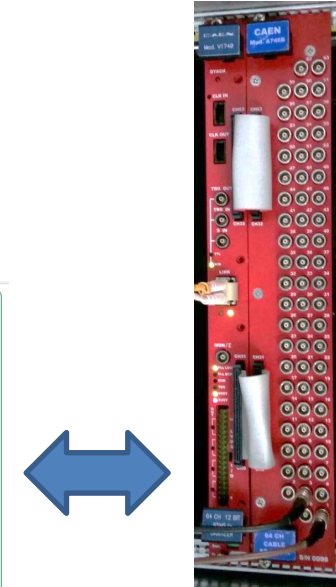
Below the equipment table is a 'Logging Channels' table:

| Channel | Events | MB written | Compr. | Disk Level |
|------------------|--------|------------|--------|------------|
| #0: run00239.mid | 1 | 0.029 | 100.0% | 21.1% |

At the bottom is a 'Clients' table:

| Client | Client | Client |
|-------------------------------|-------------------------|--------------------------|
| Logger [janenc-desktop] | mhttpd [janenc-desktop] | mserver [janenc-desktop] |
| feoV1740 [neutrinos18.ifa.es] | | |

MIDAS

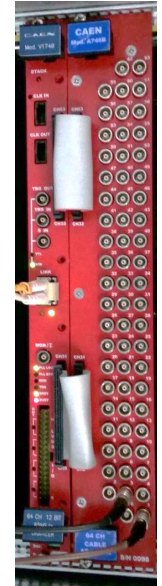
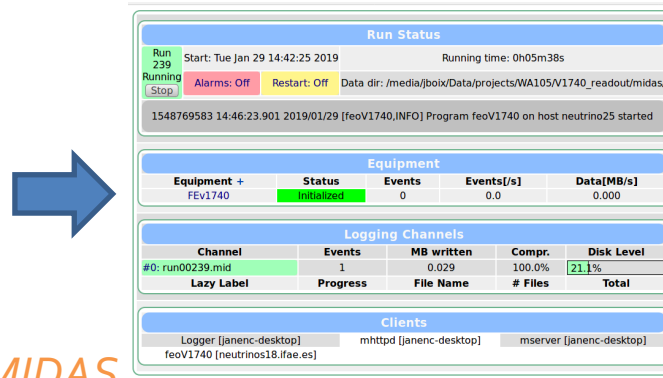
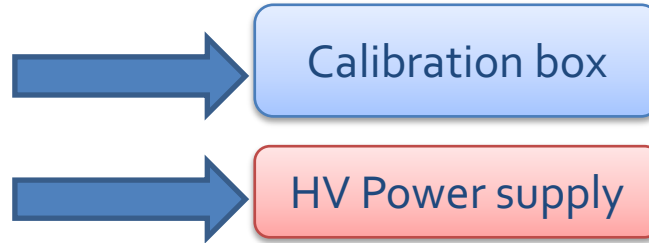
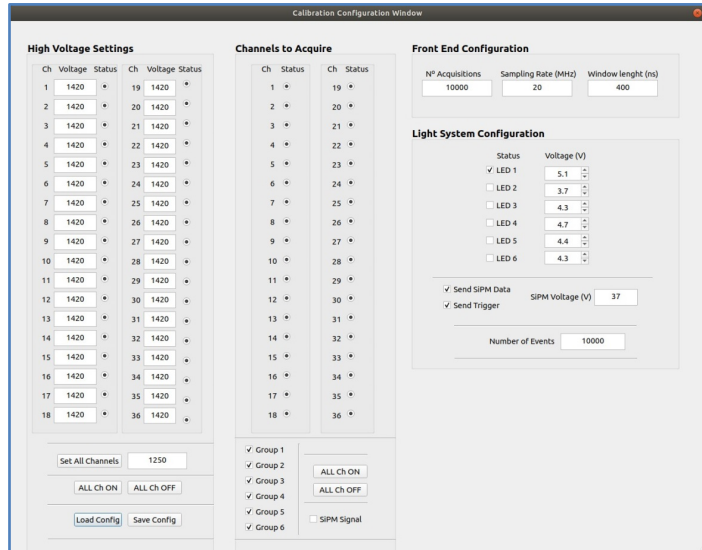


ADC CAEN v1740

- Based on **ADC CAEN V1740** and controlled by a PC running **MIDAS** software and a **custom software** developed at CIEMAT to integrate the control of the power supplies, the calibration light source and the ADC (through MIDAS).
- The light readout front-end is connected to the **White Rabbit network** for synchronism with the global DAQ by means of a PCI WR End-node (SPEC card) plugged into the LRO DAQ PC

Light DAQ

CIEMAT acquisition control software



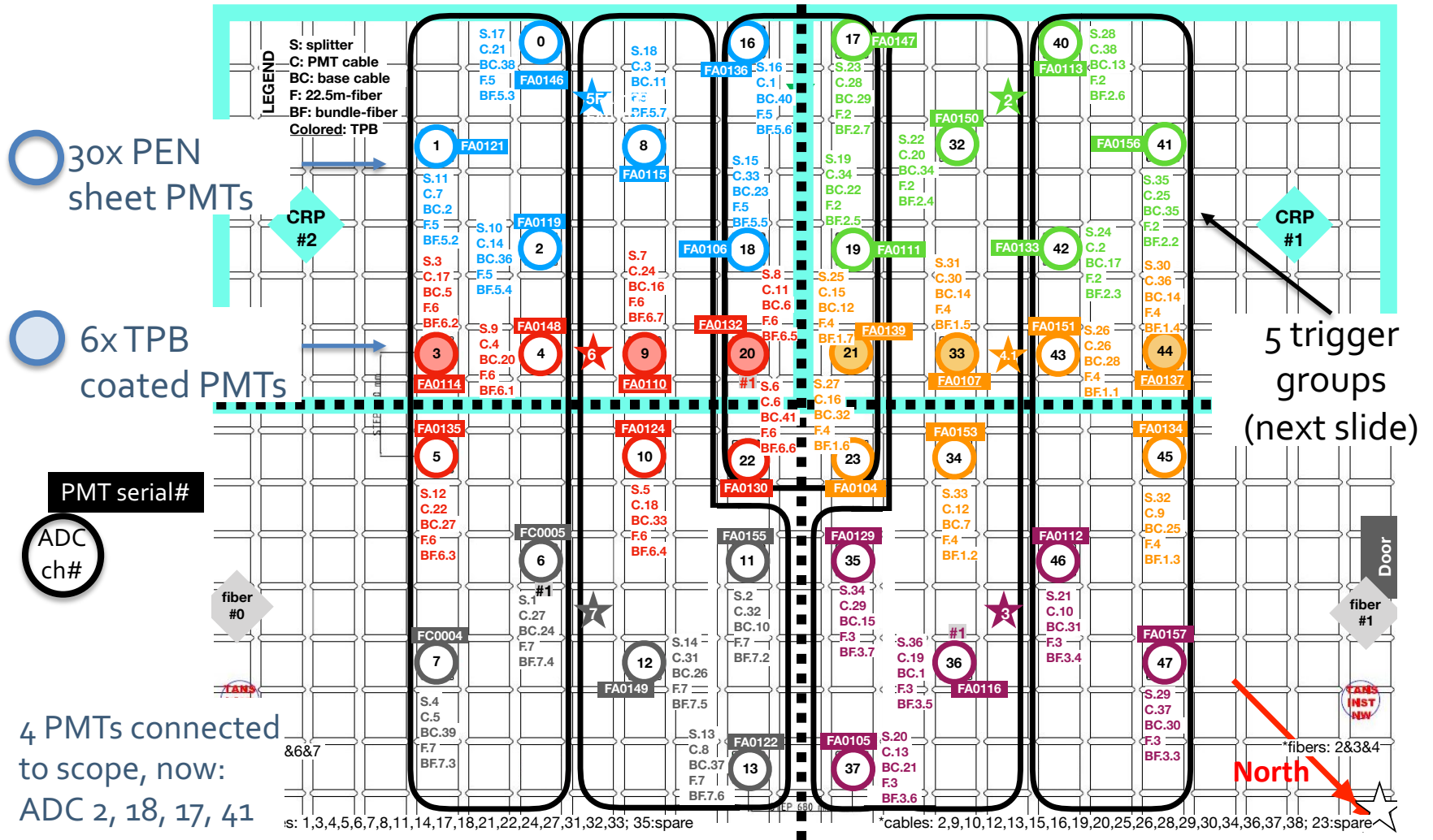
MIDAS

ADC CAEN v1740

CAEN V1740 main specifications:

- **64 channels** with **12 bits** and **2Vpp** dynamic range.
- Configurable sampling period between **16 ns** and 2048 ns.
- Capable of producing a **trigger** signal based on the coincidence of a programmable number of PMT signals over a given threshold level (all parameters on-line programmable).
- Connected to the computer by a **80 MB/s optical link** (CAEN CONET2).

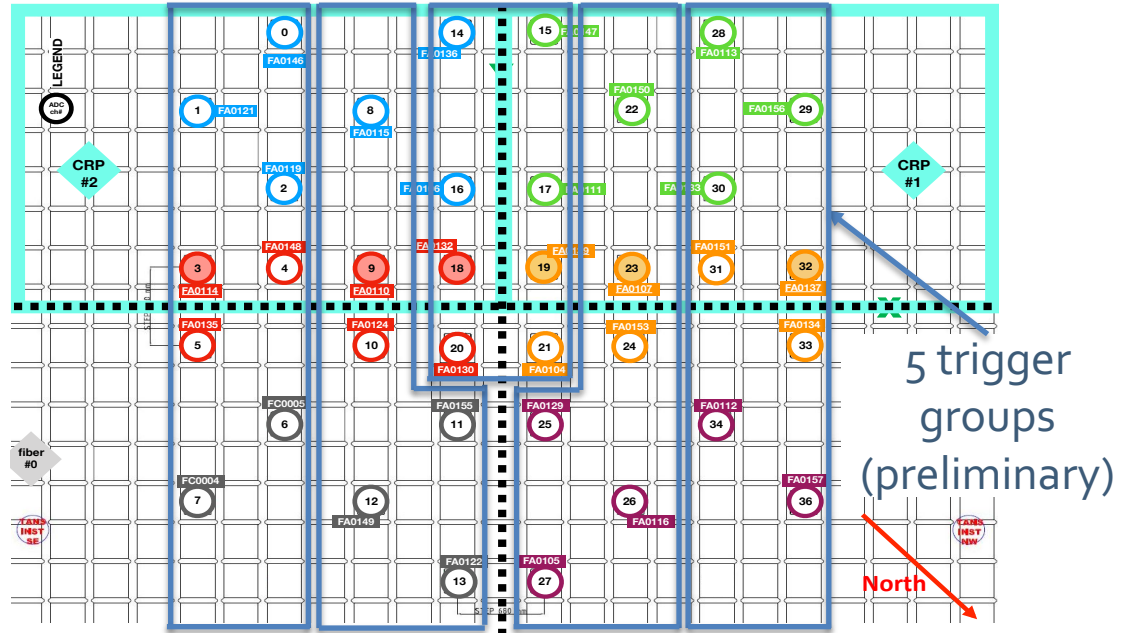
PDS Layout



PDS trigger

PDS trigger possibilities:

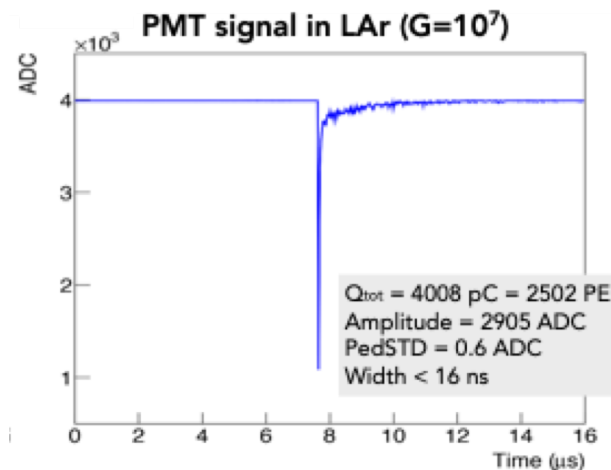
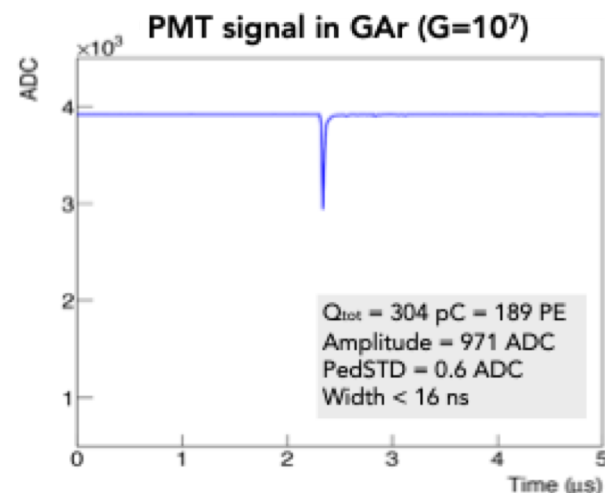
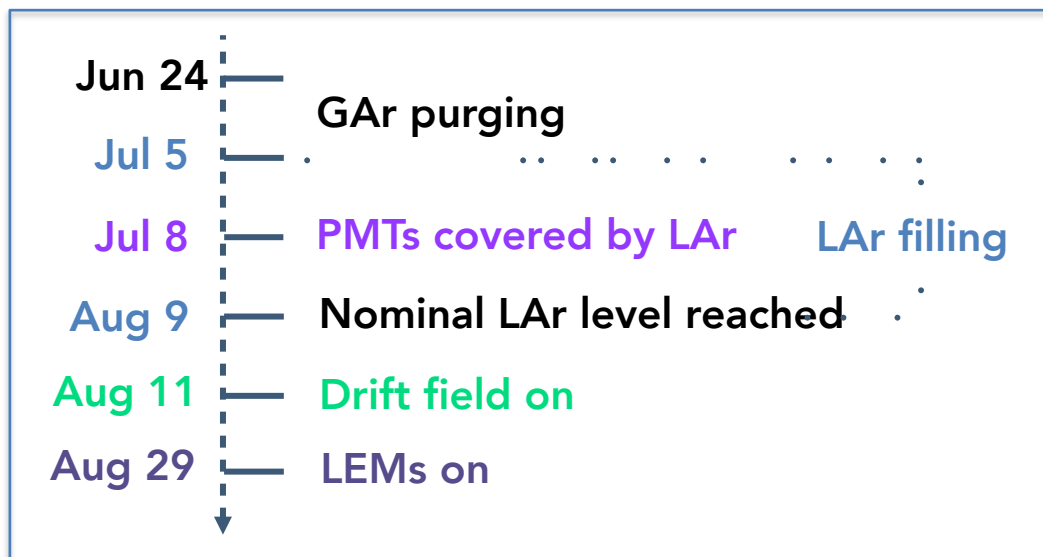
- ✓ Light calibration system
- ✓ Random trigger
- ✓ PMT self-trigger:
 - ✓ Possible to select PMTs in trigger within a group & number of groups in trigger
 - Working on trigger configuration to select tracks
 - **Global DAQ trigger & timing:** synchronized with charge signals (timestamp included in the light data)
 - ✓ Random trigger
 - ✓ Cosmic trigger system
 - PMT trigger
 - Charge trigger



Data taken

A lot of interesting light data already taken:

- GAr (runs @ RT)
- LAr w/o fields (S1)
- LAr w/ fields (S1 + S2)
- Runs w/ PMT & random triggers
- Runs triggering w/ external panels
- PMT calibration runs



Data location

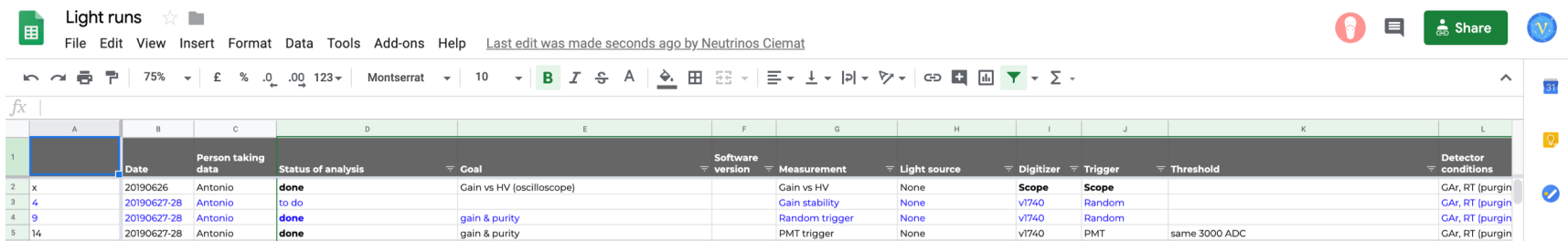
- Data are taken in the Light DAQ computer as a midas file (mid), then converted to root, and sent to the long-term eos location every day.



- All data is long-term saved in:
[/eos/experiment/neutplatform/protodune/rawdata/np02/PMT](#)
- Raw data as taken from Midas are saved in:
[/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/midas](#)
- ROOT data converted after using midas2root are saved in
[/eos/experiment/neutplatform/protodune/rawdata/np02/PMT/ROOT](#)
- Data are also copied to CASTOR:
 - A script runs every night to create the json files needed to send the data to CASTOR.
 - They are uploaded in batches using the dropbox folder in EOS.

Run information

- Data taken are described in the elog <https://pddpelog.web.cern.ch/elisa/display>
- Google spreadsheet “Light runs” summarizing run information: <https://docs.google.com/spreadsheets/d/1xnHmHhAyuBEnDiwCGrf7u8CXxpMyOMKAB1AnoZpLlaA/edit#gid=1315921346>



The screenshot shows a Google spreadsheet titled "Light runs" with the following data:

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|----|-------------|--------------------|--------------------|---------------------------|------------------|----------------|--------------|-----------|---------|---------------|---------------------|
| 1 | | Date | Person taking data | Status of analysis | Goal | Software version | Measurement | Light source | Digitizer | Trigger | Threshold | Detector conditions |
| 2 | x | 20190626 | Antonio | done | Gain vs HV (oscilloscope) | | Gain vs HV | None | Scope | Scope | | GA, RT (purgin) |
| 3 | 4 | 20190627-28 | Antonio | to do | | | Gain stability | None | v1740 | Random | | GA, RT (purgin) |
| 4 | 9 | 20190627-28 | Antonio | done | gain & purity | | Random trigger | None | v1740 | Random | | GA, RT (purgin) |
| 5 | 14 | 20190627-28 | Antonio | done | gain & purity | | PMT trigger | None | v1740 | PMT | same 3000 ADC | GA, RT (purgin) |

Run number, date, run goal, trigger, field conditions, Elog#...

- Contact me (clara.cuesta@ciemat.es) in case of questions.

Data analysis organization

- Using our own code to extract information (charge, amplitude, scintillation profile, baseline, peak time...)



- Aiming to include light data in LArSoft matched with the charge data.
 - ProtoDUNE-DP PDS geometry in LArSoft.
-
- Ana Gallego-Ros , José Soto-Otón, María Artero (MSc), Diana Navas, and Clara Cuesta from CIEMAT are working on the light data analysis.



- Contact us (clara.cuesta@ciemat.es) if you are willing to join!

On-going analysis topics

- **Gain**

- ✓ G vs HV, gain stability, top fibers
- ✓ PEN/TPB light reduction factor

- **Noise and system limitations**

- ✓ Electronics (pick-up) noise
- ✓ System limitations
 - Dark rate - Single photo-electron characterization

- **S1 study**

- ✓ Purity (τ_{slow} evolution)
- ✓ Cosmic muons from external panels
 - S1 (shape and rate) vs detector conditions

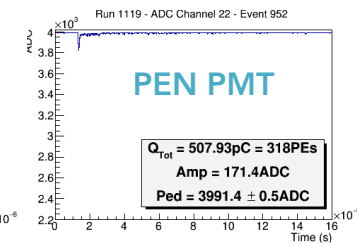
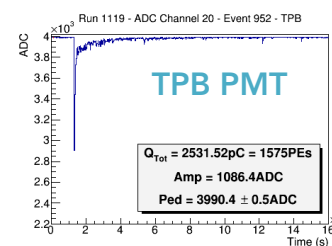
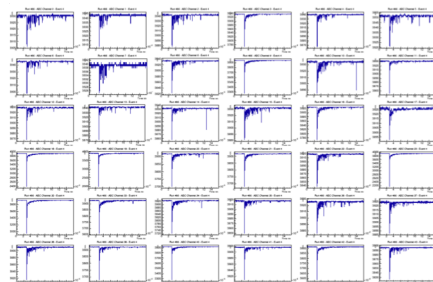
- **S2 study**

- S2 characterization (shape and rate) vs detector conditions

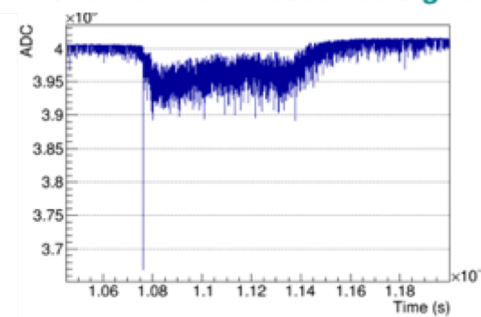


First results

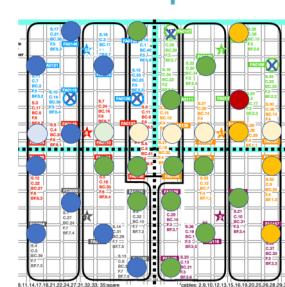
- All 36 PMTs operational
- Low noise < 1 ADC
- PMTs are stable
- Expected purity evolution
- PEN PMT 12% TPB PMT amplitude
- Light track observed with panels
- Electroluminescence light seen by all PMTs (>6 m away from PMTs)



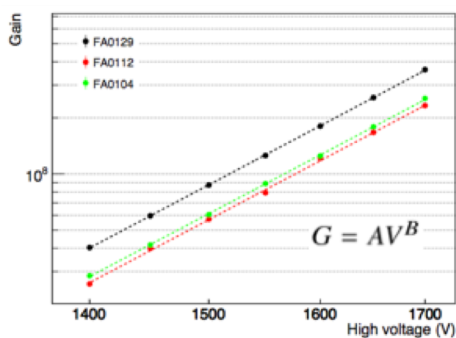
First electroluminescence signals



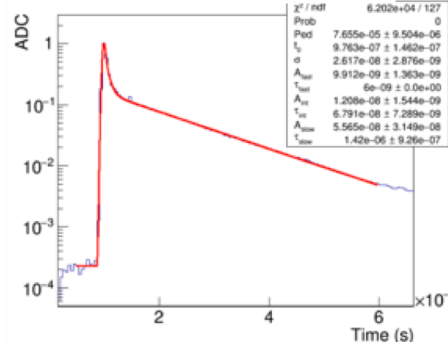
PEs with panels



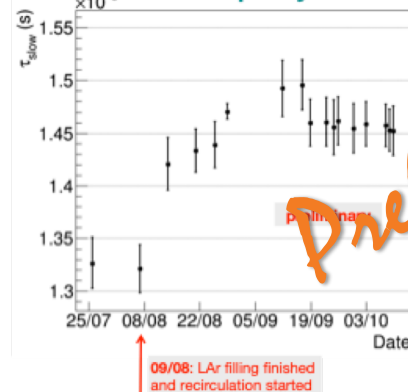
Light calibration system



Scintillation light profile



LAr purity



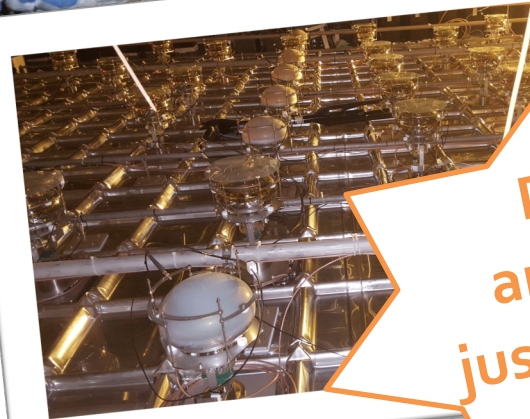
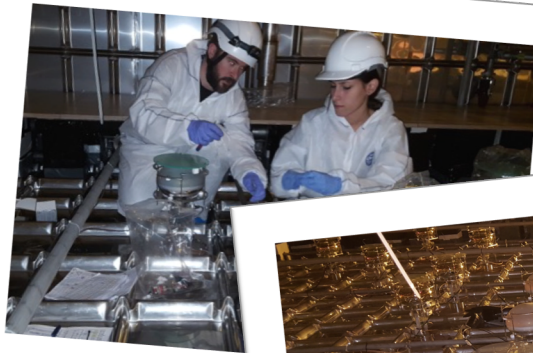
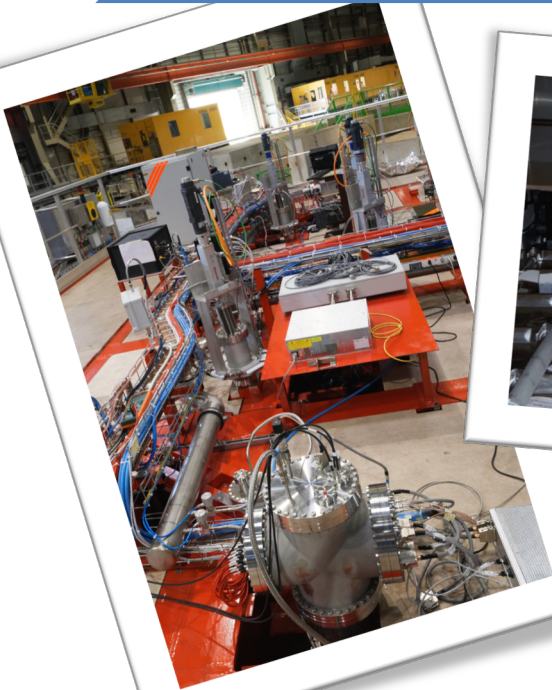
Preliminary

Summary

PDS
installation
Completed

Data taking in
GAr and LAr
w/o field
June-July 2019

Data taking in
LAr w field
August 2019



Data
analysis
just started