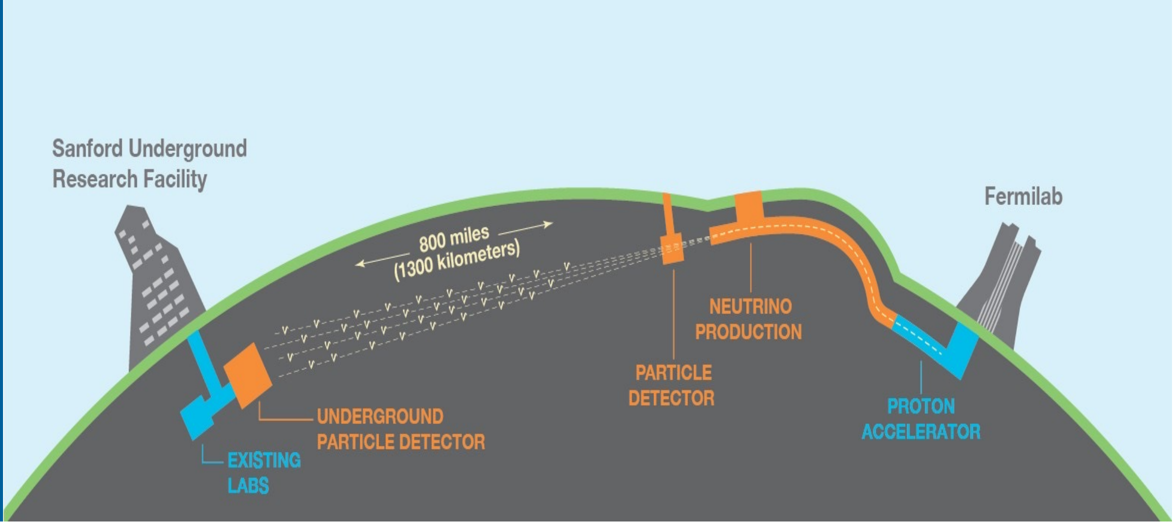
DUNE VD FAR DETECTOR PDS CALIBRATION AND MONITORING



ZELIMIR DJURCIC, FLAVIO CAVANNA

DUNE FD-2 (VD) Photon Detector Workshop, July 27-28.

Calibration and Monitoring Requirements of PDS system

- **Three (main) Monitoring and Calibrating Items:**

1) Monitoring the stability of response of the **Liquid Ar + Xe mixture** in the TPC Active Volume (and re-calibrating it periodically)
   -Verify concentration and monitor uniformity of Xe distribution within the LAr TPC volume.

2) Calibrate and monitor stability of response of photon detector **SiPMs, readout electronics and wls** components over time
   -Calibrate and monitor gain ($g_i\left[\frac{\mathrm{PE}}{ADC}\right]$) and calibration factors ($k_i\left[\frac{\mathrm{Ph_{Det}}}{ADC}\right]$) stability, monitor stability of ARAPUCA wavelength shifter, characterize time resolution.

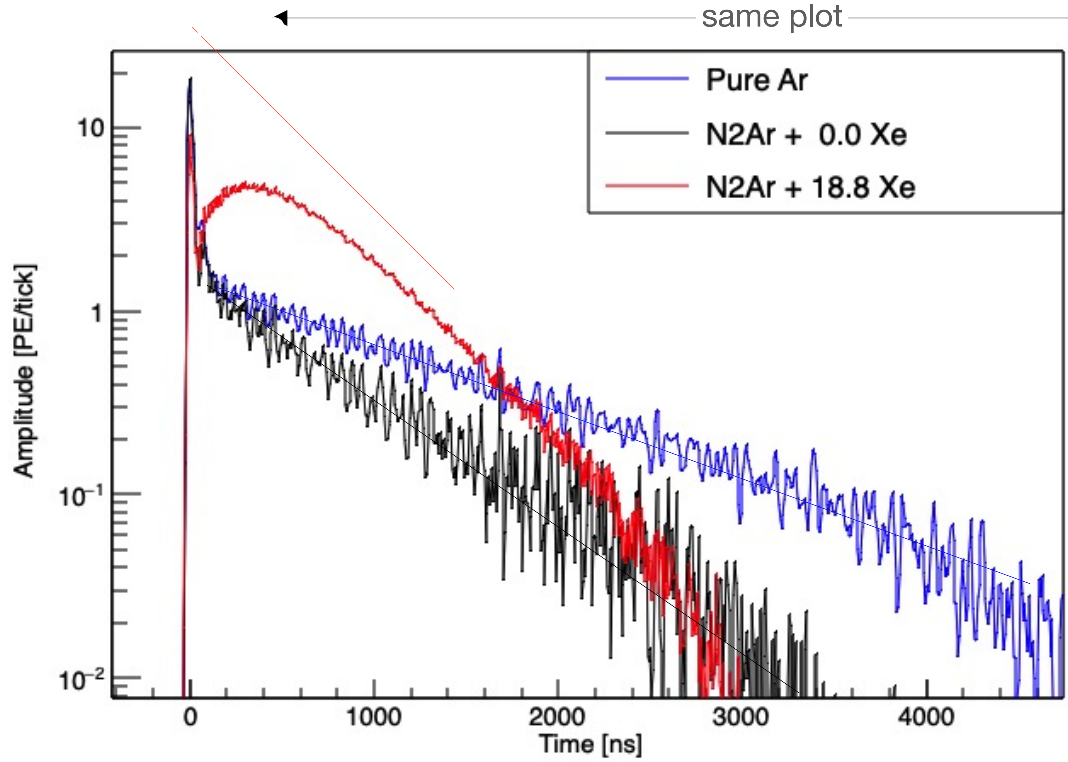
3) Calibrate absolute energy scale
   -Monitoring the stability of the ***xARAPUCA Photon Detector*** response by performing an absolute Light calibration $\mathrm{LY}(x,y,z)\left[\frac{\mathrm{Ph_{Det}}}{\mathrm{MeV}}\right]$.

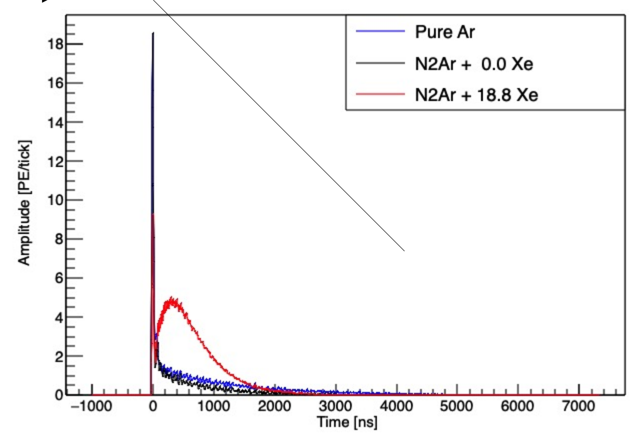
- Each component (1, 2 and 3) may show variations (or develop decline) over time.

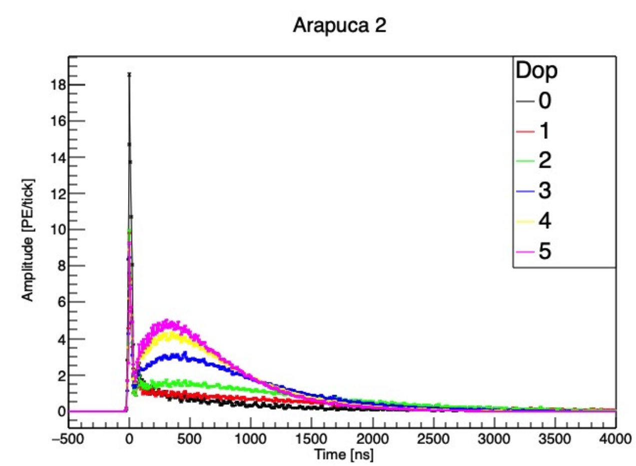
1) Monitor Xe content in LAr

Liquid Ar + Xe mixture response: acquire individual signal waveform $L(t)$ - average waveform $\langle L(t) \rangle$ demonstrated to be very useful handle to monitor LAr purity (wrt N2 contamination) and very sensitive to Xe concentration in Ar + Xe mixtures.

same plot





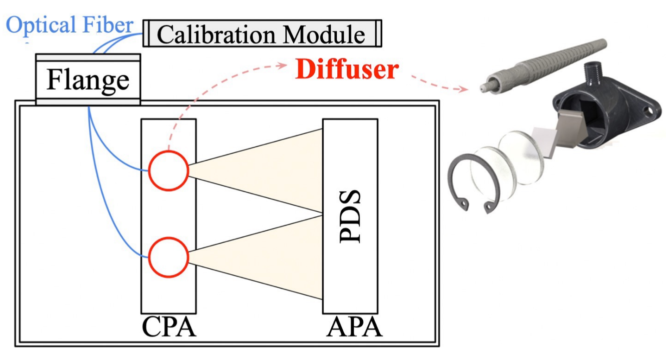


Liquid Ar + Xe mixture response from ProtoDUNE-SP

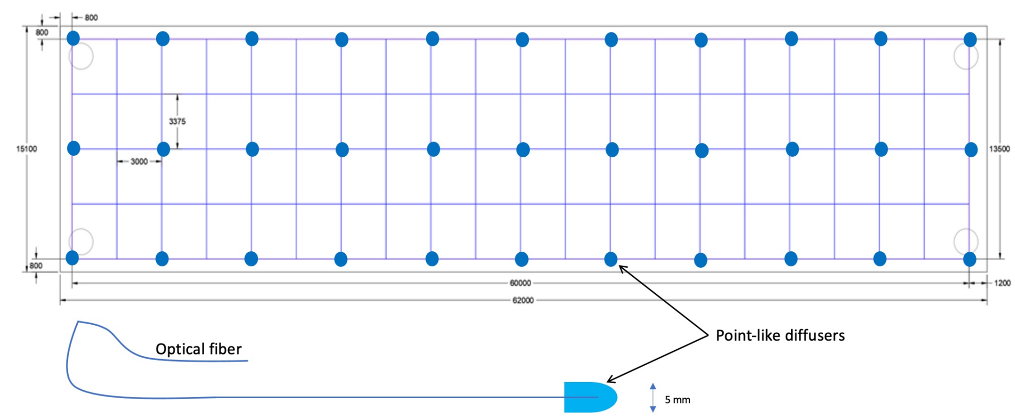
2) Calibrate and monitor stability SiPMs, r/o electronics, wls, dt

- Achieved with pulsed UV-light system: demonstrated in ProtoDUNE-SP for DUNE FD-1
  - -Calibrate and monitor PD response over time
  - -System consists of warm (electronics calibration modules 275/360 nm light)) and cold components (optical fibers and diffusers).
- FD1-HD concepts was demonstrated over >100 day period in ProtoDUNE-SP
  - -Used to fully characterize the PD gain, crosstalk, time resolution, PDS stability vs time
  - -The UV-light calibration and monitoring system for FD2-VD is “sketched” in CDR.

ProtoDUNE-SP/FD-1-HD



FD-2-VD



- Diffuser glass, fiber routing, optical feedthrough, light source circuitry, calibration electronics have been designed and tested for FD1-HD.
- Primary differences wrt FD1-HD are the number/location of diffusers, length of fiber.
  - -For FD2-HD diffuser distribution to be optimized for cathode and cryostat wall PDs.

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2) Calibrate and monitor stability SiPMs, r/o electronics, wls, dt (cont.)

- **References on FD1-HD UV-light Calibration/Monitoring System**:

  -ProtoDUNE-SP Performance Paper: JINST 15 (2020) 12, P12004.

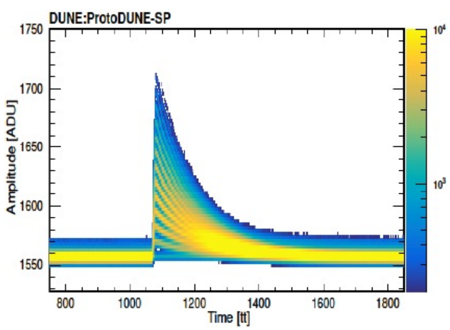
  -DUNE FDTDR Volume IV: The DUNE FD-SP technology, arXiv: 2002.03010.

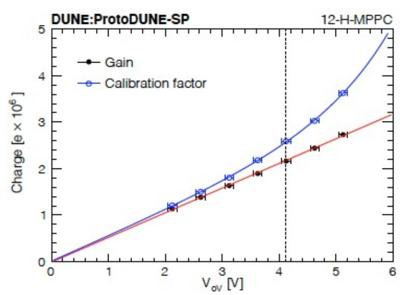
  -Recent Reviews:

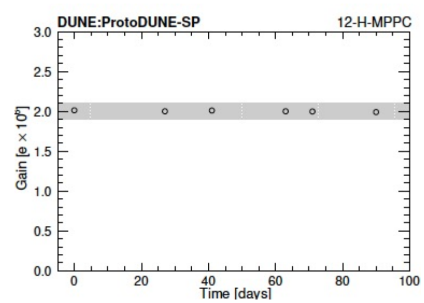
  - ➢ DUNE-SP PDS Conceptual Design Review (30% Design Review)-November 12-13, 2018, https://indico.fnal.gov/event/18460/
  - ➢ DUNE Far Detector Scope Reviews - June 17-20, 2018, https://indico.fnal.gov/event/20996/

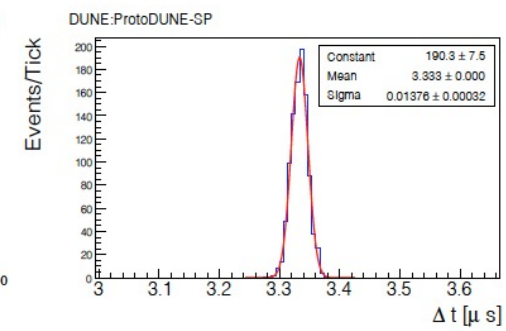
  -Recent Talks: DUNE-doc-22246-v1 (as an example).

➢ Some of the UV-light calibration/monitoring results published JINST 15 (2020) 12, P12004:









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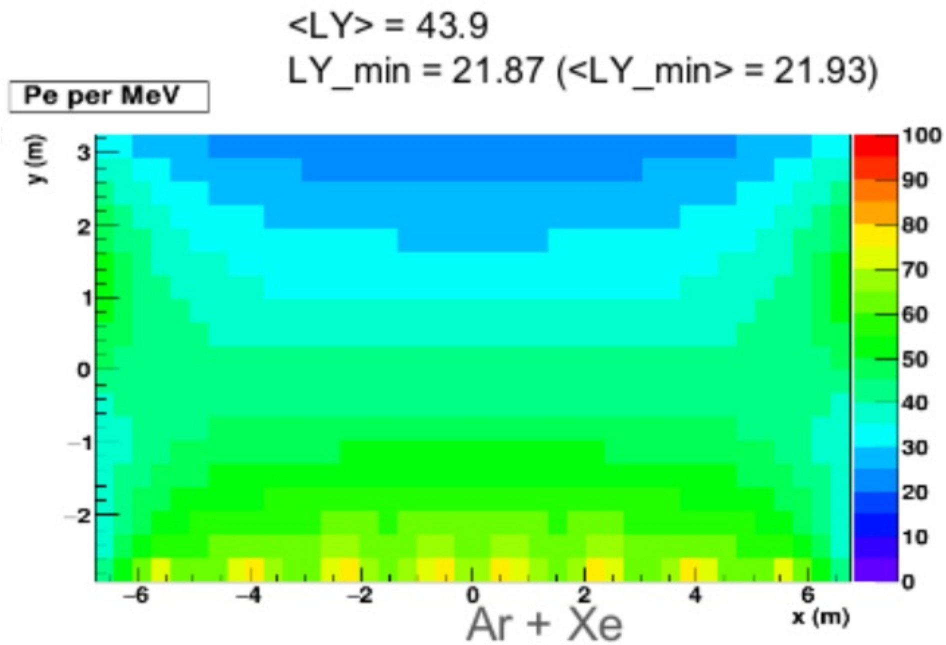
3) Calibrate absolute energy scale



position-dependent total light-yield mapping
the response of the detector across its volume
as obtained from simulations

- Need measure/monitor absolute detection efficiency and absolute energy scale
  -Ideally derive the calibration map as a dependence of **measured** light yield on particle energy as function of detector location:

i.e. absolute Light calibration $\mathrm{LY}(x, y, z)\left[\frac{\mathrm{Ph_{Det}}}{\mathrm{MeV}}\right]$

3) Calibrate absolute energy scale (cont.)

- What are the potential approaches to achieve this goal?

➢ Options are being explored by running experiments (neutrino LArTPCs and DM LArTPCs)

-short **cosmic** tracks (mostly works for surface LArTPC detector) inside LAr

→define volume voxels - from TPC reconstruction and with flash matching

-**radioactive sources** deployed at fixed (x, y, z) positions

-**injection of short-lived radioactive gas** diffused in the LAr volume (e.g. Rn-source, with decay(s) in LAr Volume voxels)

-**pulsed neutron generator** inducing 6 MeV n-capture event in LAr Volume voxels

-**Ionization Laser**?

- Need explore options (simulate, test, validate, …).

BACKUP SLIDES

LAr Readout Technologies

- **Module #1**
  - -3.6 m **horizontal drift**
  - -vertical anode wire planes
  - -vertical resistive cathode
  - -photon detectors

- **Module #2**
  - -6.5 m **vertical drift**
  - -horizontal PCB anode readout (CRP)
  - -horizontal grid cathode
  - -photon detectors