Scintillation light production, propagation and detection in the 4-ton dual-phase LAr-TPC demonstrator

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The DUNE experiment

Physics:
- Neutrino oscillation parameters, mass ordering and CP violation
- Sensitivity to non beam searches (proton decay, supernovae events, etc.)

DUNE FD: 4x10kton LArTPC modules
- Single and dual-phase technology
- 3D track reconstruction at high resolution
- Sensitivity to low energetic events

The 4-ton demonstrator

Goal: assess the feasibility of the DP technology at the ton scale towards DUNE

Technological milestones:
- Extraction of ionization charge over 3 m² area
- Amplification in pure Ar vapor by multiple 50x50 cm² LEMs
- Readout of the signal on collection planes with strips up to 3 m

Light detection system
- Five R2521-Mod PMTs (3 inch), different bases and TPB coating configurations
- Tₚ time used as a trigger

Scintillation light

Three exponential contributions are needed to fit the scintillation time profile (S1)

Two benchmark light signals:
- Scintillation light (S1)
- Electro-luminescence light (S2)

Evolution of Tₛ with the drift field

Dependence of the fast/slow ratio with the drift field (opposite behavior found in literature)

Monitoring of LAr purity through the Tₛ (almost constant during all the data-taking)

Electro-luminescence light

A dedicated algorithm developed to identify the S2 signal

A study on the comparison data-MC is ongoing to study unknown parameters related with the S2 light (e.g. electro-luminescence gain, Gₑ)

Prospects

- A paper is in preparation to summarize all these studies and results
- Pursue the analysis in ProtoDUNE-DP
- Light data taking already started

G in drift

Electronics

Cosmic Ray Taggers (CRT) panels

5 fold coincidence of S1 signal over threshold

Tracks reconstruction for each event (available also without drift field)

charge and light events have been matched offline

Rayleigh scattering

better agreement data-MC for λₑ ≈ 55 - 163 cm

MC simulation

- data driven event generation
- light maps for LAr and GAr
- different Rayleigh scattering length (20cm, 55cm, 163 cm)
- absorption length (λₑ = 30m)
- PMT response simulation
- agreement data-MC

Rayleigh scattering

Evolution of Τₛ

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