Measurement of Liquid Argon Scintillation Light Properties by means of an Alpha Source inside the CERN 10-PMT Facility

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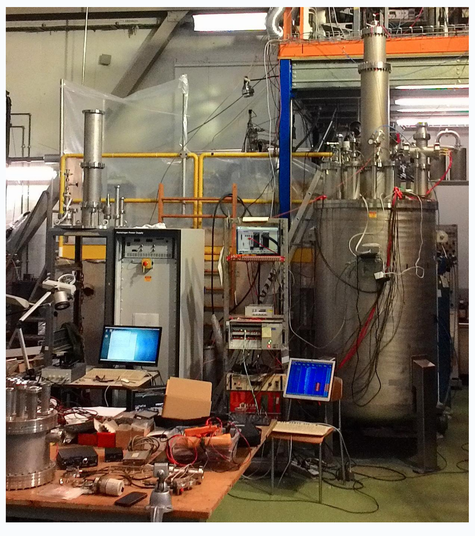
A particle detection system which exploits the scintillation light produced by ionizing particle in liquid argon (LAr) has been assembled at CERN. The system is based on a dewar (1 m diameter, 1.5 m height) housing 10 large-area photomultipliers (PMT). The system has been instrumented with an alpha source mounted on an extendible support which permits to vary vertically the distance between the source and the PMT window plane and to vary horizontally the source position below the PMT plane. Arrays of SiPM integrated in the source support are used for the data acquisition trigger and to define the t_0 of the light generation. PMT and SiPM signals have been taken at different distances and positions. Data are used for the measurement of some properties of the LAr scintillation light, such as the propagation of VUV photons.

1 - INTRODUCTION

The detection of light produced by the scintillation of the liquid argon (LAr) plays a crucial role for triggering and for the determination of the absolute time of the events (t_0) in experiments exploiting the Liquid Argon Time Projection Chambers (LAr-TPCs) technique for neutrinos physics and rare events researches.



A LAr test facility has been set up at CERN [1] to perform at small scale studies on performances of DAQ and trigger electronics to be installed in larger volume LAr-TPCs, such as ICARUS at FNAL (see M. Diwan *The ICARUS T600 detector as far detector within SBN program* at this conference).

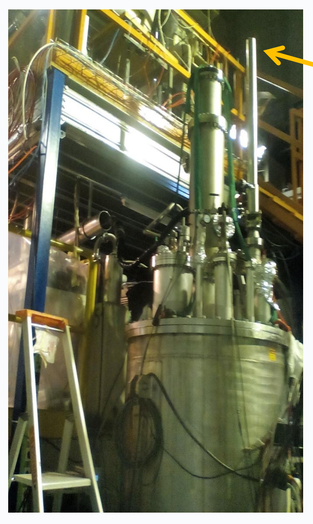
Ionizing events were already measured by exposing the system to cosmic rays. The facility has been recently instrumented with an alpha source mounted on a extendible support which permits to vary the source position inside the active volume.

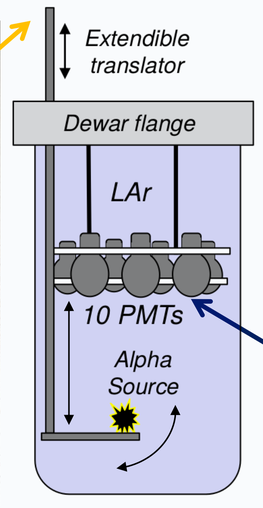
The system was instrumented at CERN in the framework of INFN and CERN Neutrino Platform activities.

[1] M. Babicz et al., *A particle detector that exploits Liquid Argon scintillation light* NIM A https://doi.org/10.1016/j.nima.2019.162421

2 – THE CERN 10-PMT FACILITY

The CERN 10-PMT facility consists of 10 Hamamatsu R5912-MOD PMTs with an 8 in hemispherical photocathode, where 6 PMTs are coated with TPB wavelength shifter for the detection of the 128 nm VUV LAr scintillation light, and 4 PMTs are left without TPB for the detection of visible photons only. The setup is installed in a double-wall, vacuum-insulated 1500 litres LAr cryostat. The cryostat is approximately 2 m high and has 112 cm external diameter, 96 cm internal diameter.

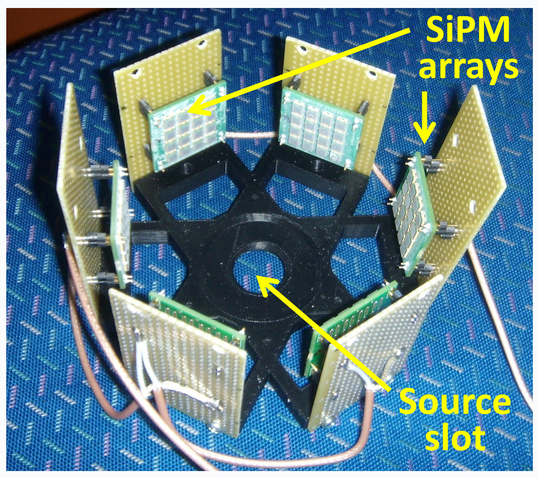


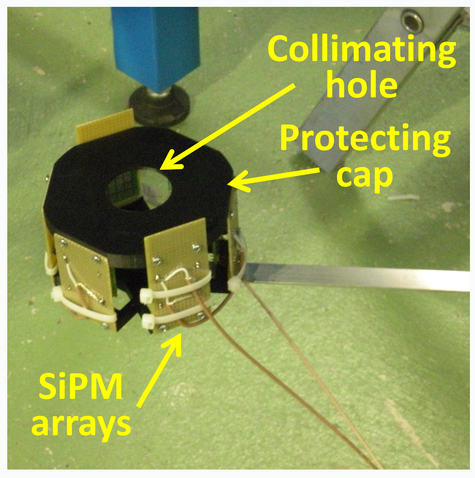


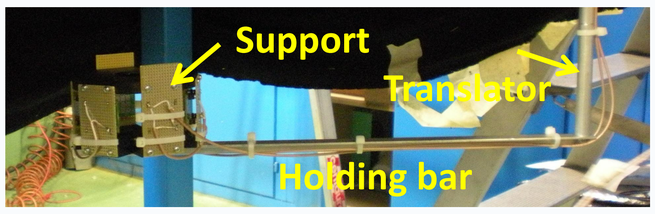
The set-up has been instrumented with a mechanical cryogenic extendible translator, mounted on the dewar top flange, which permit the internal translation and rotation of a support hosting an alpha source and a SiPM-based detection system.

3 – ALPHA SOURCE

The alpha source is a ^{241}Am with 39 kBq activity. A dedicated support with hexagonal shape (110 mm width, 60 mm high) has been realized to host the source, collimate the emerging light and hold up 6 arrays of SiPM (16 units each) used for the data acquisition trigger and for the definition of the t_0 of the light generation. A protecting (110 mm diameter) cap with a 40 mm hole is used to shade the SiPM arrays from the light produced by cosmic rays in the detector active volume.







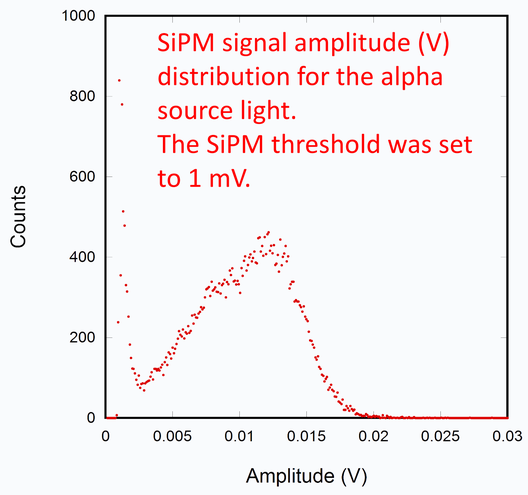
The translation system permits to vary the source distance from the PMT plane in a 0-90 cm range. The rotation, is in a 0-90° degree range allowing the positioning below different PMTs.

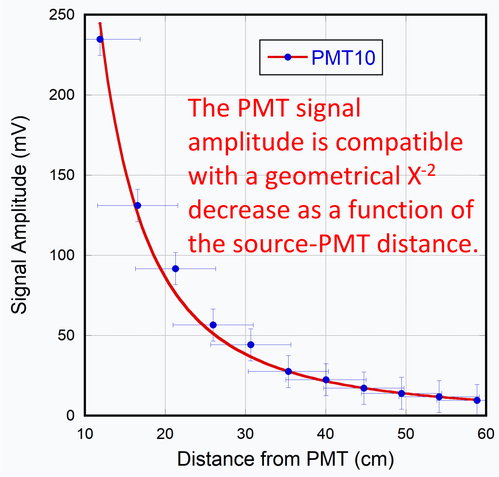
4 - TRIGGER AND DAQ

6 SiPM arrays with 16 Hamamatsu S12572-050P each are used to generate the DAQ trigger signal. In each array the devices are configured in 4p4s (4 parallel arrays of 4 units in series) mode. Each array is coated with TPB to make the devices sensitive to VUV light. The 16-SiPM arrays are coupled in parallel in two groups of 3 arrays, in order to have two separate trigger lines. Being the SiPM arrays combined with the source holding, they also provide the t_0 signal for timing studies.

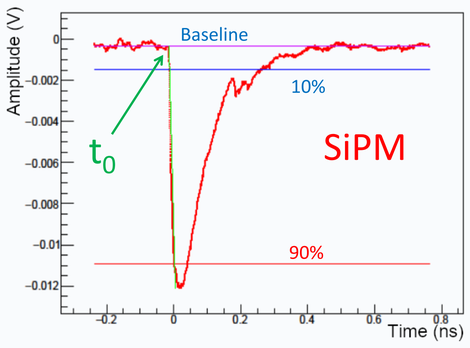
The DAQ is carried out by means of a digital oscilloscope (Tektronix MSO64 25 GS/s) used to acquire for each run a SiPM array and 3 PMT signals.

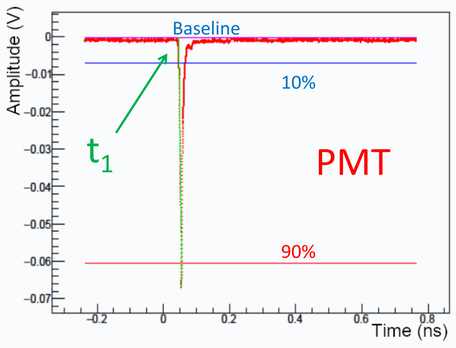
In each set of acquisition runs, the horizontal position of the source was set below the axis of one of the 3 PMTs and this position was kept during the source vertical translation.





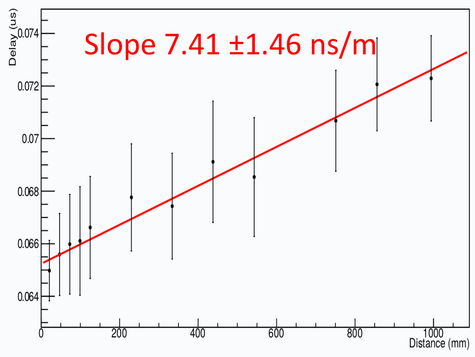
5 – PRELIMINARY RESULTS





The determination of the delay (t_1-t_0) between the SiPM response and the PMT activation is performed by determining for each event the intersection point between the baseline and the extrapolated line fitting the 10% and 90% of the signal amplitude.

The slope of the straight line fitting the delays for different position gives an estimation of the velocity of VUV photons in liquid argon. The obtained preliminary results are compatible with other published measurement [2]



[2] M. Babicz et al., *Experimental study of the propagation of scintillation light in Liquid Argon* Nuclear Inst. and Meth. A 936 (2019) 178

6 – POSSIBLE STUDIES

Additional studies that can be carried out with this detection system, concern:

- ✓ The capability of the PMT system to localize the alpha source position using both the time and amplitude information;
- ✓ The comparison between simulated and real events to adjust the parameters of simulation programs;
- ✓ Studies on the light attenuation in LAr;
- ✓ Studies on PMT detection efficiency;
- ✓ Studies of the trigger efficiency as a function of threshold/multiplicity on different PMT signals;
- ✓ Studies on PMT timing/gain calibration;
- ✓ …

All these studies are useful in view of the implementation of large LAr detector systems.

CONCLUSION

A 10-PMT particle detection system which exploits the scintillation light produced by ionizing particle in liquid argon has been assembled at CERN. The system, originally designed to operate with cosmic rays, has been upgraded with a mechanical translation system which permits to vary the position of an alpha source in the detector active volume. Arrays of SiPM integrated in the source support are used for the data acquisition trigger and to define the t_0 of the light generation.

This system permits the measurement of some properties of the LAr scintillation light, such as the propagation of VUV photons, and permits comparison between simulated and real events.

This facility allows studies on the trigger efficiency in view of implementation in large LAr detectors.