The Antares Detector

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Introduction

The Antares telescope [1] is a large area water Cherenkov detector meant to perform neutrino Astronomy in the deep Mediterranean sea. Among many other considerations, the detector has been designed to be efficient to the detection of neutrinos emitted by high energy sources such as active galactic nuclei, gamma ray bursts, micro-quasars or super- nova remnants. In order to maximize the sensitivity in this point source search, the estimation of the arrival direction of the neutrino has to be as accurate as possible. The second crucial point for the neutrino astronomy is the energy estimation. In order to discriminate between the point source signal and the background due to cosmic ray interaction with the atmosphere, the energy has also to be estimated accurately. This poster presents the performances of the Antares detector with respect to the scientific objectives mentioned.

Principle of detection

Detect the Cherenkov light emitted by the leptons issued from the interaction between up-going neutrinos and the matter surrounding the detector.Arrival direction and energy of the neutrino are extracted from the time and charge of the signal of each hit *OM*.

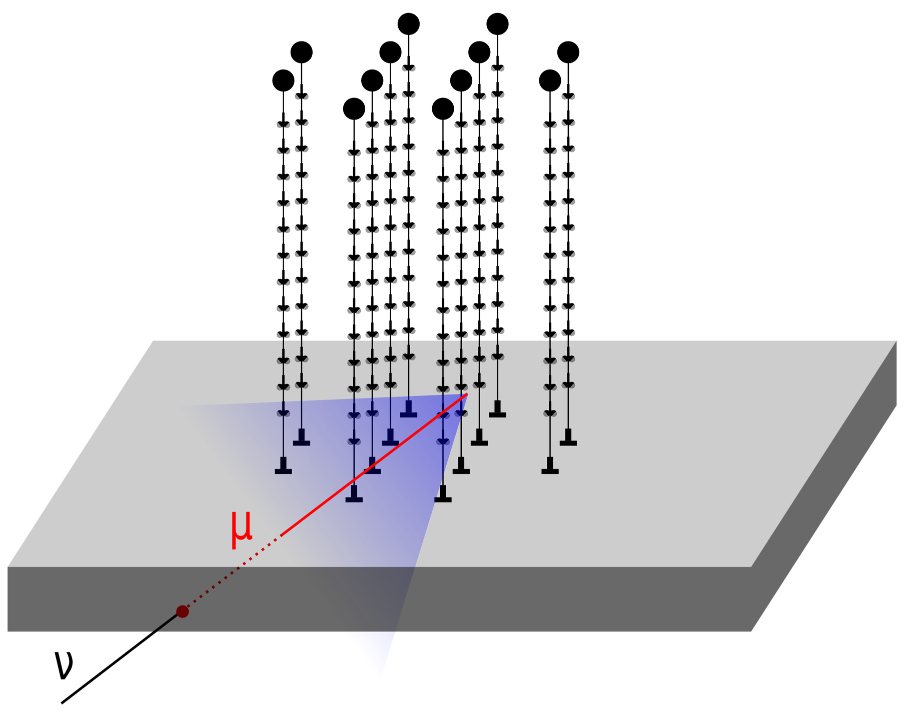

Figure 1: An up-going neutrino interacts in the earth, the secondary lepton emits cherenkov light.

Detector

Configuration

The Antares telescope is a tri-dimensional array of light detectors. 12 vertical lines are anchored on the ground. Each line is composed of 25 storeys, each storey consisting in 3 optical modules [2] (*OM*: photomultiplier tube glued in a glass sphere). The 3 *OMs* are looking down at 45° to the up-going cherenkov light.

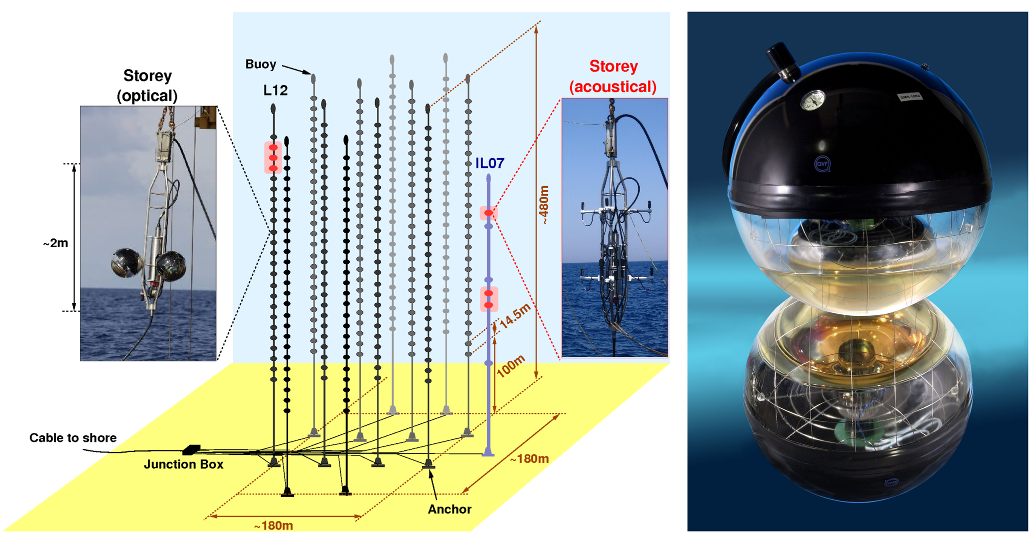

Figure 2: The tri-dimensional array of light detectors can be seen on the left. An optical module on the right.

Acquisition

OM signals are sent to the Local Control Module where their time and charge are digitized provided their amplitude exceeds a L0 threshold set at 0.3 pe [3]. All data are sent to shore for triggering and registration.

Triggers

- L1: local coincidence or charge above a high threshold (3 pe)
- physics trigger based on combination of L1s

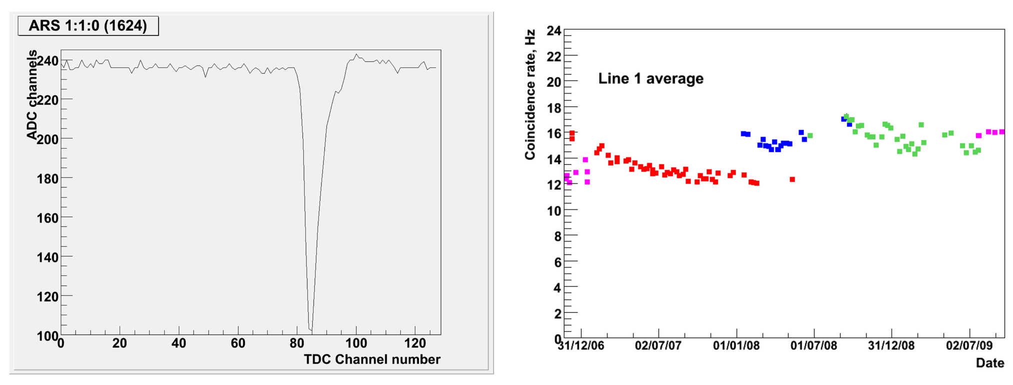

Figure 3: On the left, *OM* signal digitized in oscilloscope mode (640 MHz sampling). On the right, event rate for L1 trigger, color code corresponds to readjustment of the *PMT* gain.

Reconstruction

Data

signal arrival time and charge

Procedure

- calibration
- hit treatment
- triggers
- particle track minimization

Maximization

- likelihood maximization
- point and direction
- cylindrical symmetry
- except for bright points

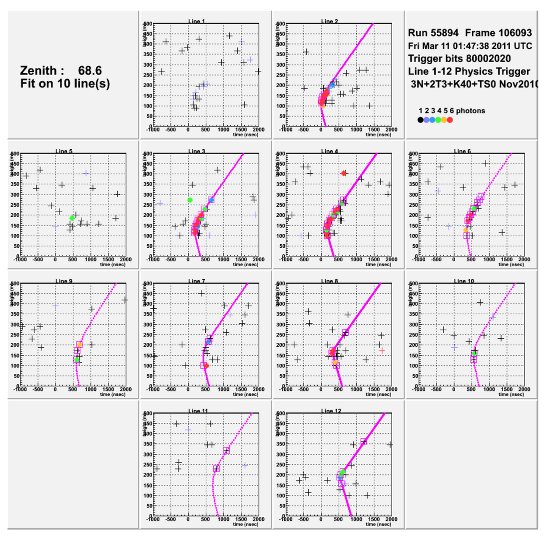

Figure 4: An up-going neutrino. For each graph, the depth of the detection unit is shown as a function of the time.

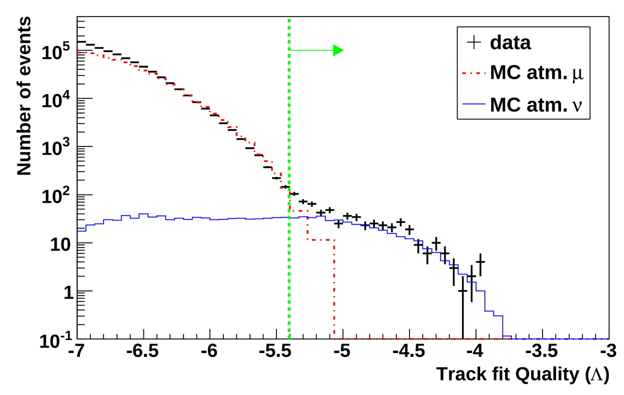

Figure 5: reconstruction quality for the data and the simulation. The quality improves for large number of events.

Acceptance

Assumption

flux: isotropic, slope of E^{-2} and integral of E^{-7}

Calculation

factor between observed number of events and normalized flux [4]

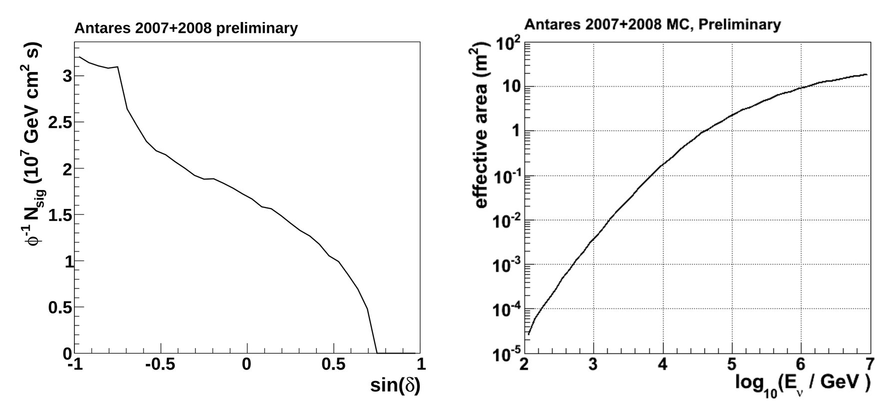

Figure 6: On the left, acceptance as a function of the declination. On the right, effective area as a function of the energy logarithm.

Angular resolution

Definition

angle that contains 68% of the reconstructed tracks when compared to the true arrival direction [4]

Systematics

- angle between the neutrino and the muon
- angle between the true and the reconstructed muon tracks

Estimation

Compare MC neutrinos with reconstructed tracks

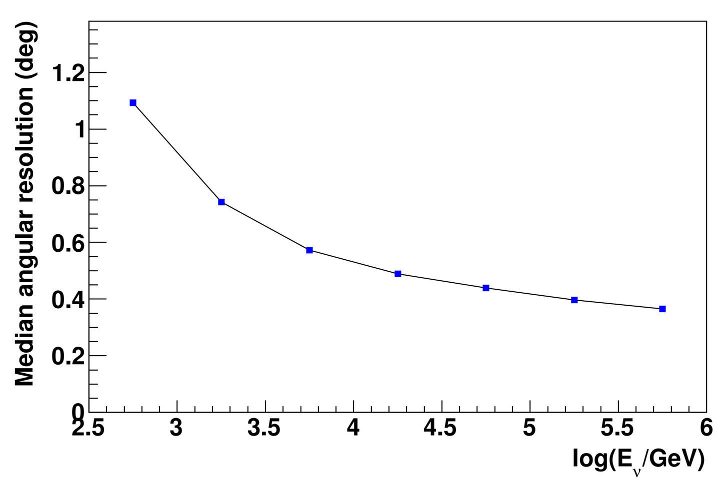

Figure 7: Angular resolution of the detector as a function of the neutrino energy.

Other detectors

An instrumentation line has been deployed for oceanographic measurements:

- intensity and direction of the flow (Acoustic)
- sound velocity (velocimeter)
- conductivity and temperature (CT)
- light attenuation (transmissiometers)
- mixing and ventilation of water masses (dissolved oxygen sensor)
- bio-luminescent organisms (cameras).

Conclusion

Since its completion in 2008, the Antares telescope is in acquisition detecting in average slightly less than 3 atmospheric neutrinos a day. All the requirements of the detector have been fulfilled and the failure rate is still below the expectations. The accuracy of the optical module positioning (20 cm), the time resolution (1 ns) and consequently the angular resolution are below the expected values. The successful operation of Antares represents an important step towards a future km3 high-energy neutrino observatory and marine sciences infrastructure.

References

[1] Antares Coll., NIM A 656 (2011) 11.
[2] Antares Coll., NIM A 484 (2002) 369.
[3] Antares Coll., NIM A 570 (2007) 107.
[4] Antares Coll., Astrop. Phys. 31, 4 (2009) 277