LAST RESULTS OF ANTARES

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ABSTRACT.
The ANTARES project is dedicated for neutrino astronomy, indirect search for dark matter and neutrino oscillations studies. Results from the 3-years $R\&D$ program and from the first prototype line are presented ,along with the expected performances of the 0.1 km^2 detector.

1. Introduction

The ANTARES collaboration was created in 1996. It groups now more than 17 laboratories through 5 countries and different institutes : Particles physics, astronomy and sea institutes.
The aim of ANTARES is to dectect and to study neutrinos :

- Galactic or extra galactic sources could emit neutrinos which can travel through very important distances without perturbation to the earth.
- if we suppose existence of neutralino as lightest supersymmetric particle, some models predict that neutralinos, due to gravitational effects, could be trapped by massive structure as sun, earth, black holes. When neutralino density in structure core is sufficient, there's annihilation of neutralino into different channels. Some of these channels includes neutrino which ANTARES could detect.
- it is possible with the ANTARES detector to see a modification of the energy spectrum due to the neutrino oscillations

2. Detection principle

The Earth acts as a shield for all particles except neutrinos, so the detection of up-going muons is a signature of muon neutrino interactions.

At high energies, angle between neutrino and muon is less than 0.25^o and important part of the neutrino energy is given to the muon. The muon, inside sea water, can be detected by its Cerenkov light emission with a three dimensional array of photomultipliers. It is possible to reconstruct the muon trajectory and hence the neutrino trajectory.

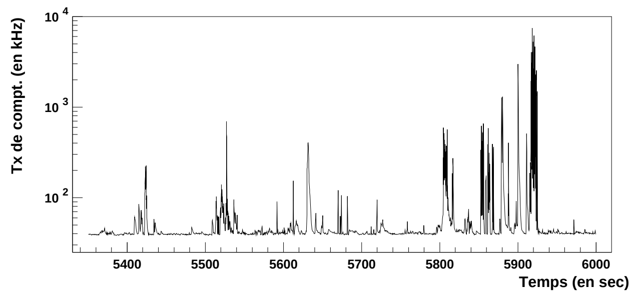

Fig. 1. Counting rate on a $10^{''}$ PMT as a function of time.

3. ANTARES site

The ANTARES collaboration has selected a site at 40 km from Toulon (centered around $42^o49^{'}N6^o10^{'}E$) at 2400 below sea level. A 300×300 m^2 area has been explored with a submarine in 1998.
This location allows a 3.5 π coverage of the sky and the survey of the galactic center.

4. Results from R&D period

Different parameters had to be well known to use such a submarine detector, so ANTARES immersed more than 30 autonomous lines (with their own electronics, PMTs, power supply). In fact there are three kind of tests so called test1, test2 and test3 :

- the optical background in Mediteranean sea has been measured with test1 lines; This background is composed of one hand, decay of potassium 40 with a rate of 60 kHz with a $10^{''}$ photomultiplier tube and on the other hand, light bursts created by organisms (bioluminecence) which give peak counting rates in the photomultiplier up to several MHz (fig. 1). However, dead time of this background induced on the electronics is less than 5%.
- Test 2 gave data on biofouling and sedimentation. Light transmission has been studied from 90^o from the vertical to 50^o and at 90^o, the loss of light transmission is less than 1.5% after 8 months with a saturation (figure 2).
- A important parameter is the water transparency and tests 3 were designed for this task. The absorption length for blue light (470 nm) is 47.9 ± 0.3 meters and an effective attenuation length is 45.5 ± 1.9 meters. The effective scatering length has been measured greater than 300 meters.

5. Prototype results

From November 1999 to June 2000, the collaboration immersed the first instrumented line connected to the shore via an electro–optical cable; This line was situated at 37

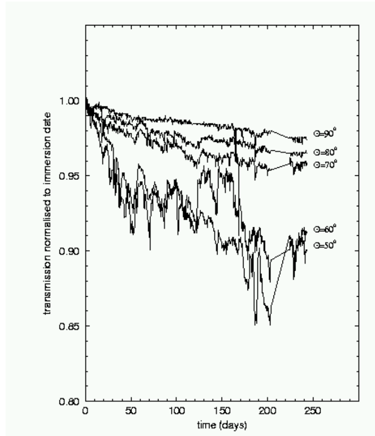

Fig. 2. Light transmission as a function of time

km from Marseille at 1000 m depth. The string is composed of 16 storeys separated by 15 m with two optical modules on each storey. There were 7 photomultipliers looking horizontally on 7 contiguous storeys. The line was also equipped with tiltmeters, compass and acoustic positionning system (figure 3).
Data obtained showed a very stable straight string, inclined 2.5^o from the vertical, with stable twist and tilt of 2^o and 0.2^o respectively.
The acousting positionning system,based on a triangulation between rangemeters placed on the string and transponders distributed around the string, gave a precision of 1 cm between rangemeters or transponders and less than 3 cm between rangemeters and transponders. It was also possible to reconstruct atmospheric muons from PMT data using hyperbolic fit of the PMT position as a function of the time of arrival (fig 4). More than 50000 events with 7 PMTs hit were recorded and more than 1350 events were reconstructed per day. Figure 5 shows the histogram of zenith angle from data and simulation. Difference between histograms is due to the fact that simulation parameters (absorption length,...) are these of ANTARES site and not demonstrator site.

6. $0.1km^2$ project

A schematic view of future ANTARES $0.1km^2$ detector is shown in figure 6. The detector is composed of 10 lines instrumented on 350 m. Lines are connected to shore via a junction box and a electro–optical cable and distance between lines is around 60 m. Each line is composed of 30 storeys,starting at 100 m above sea bed, separated by 12 m. A storey is formed of 3 optical modules with 45^o down–looking PMT and the local electronic control module.
There are also, along lines, positionning devices (rangemeters, tiltemeters,...) and light sources to calibrate PMTs.

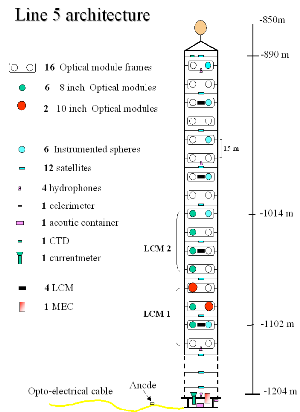

Fig. 3. schematic view of the prototype string.

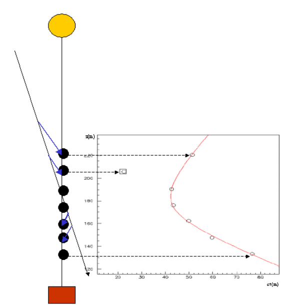

Fig. 4. Hyperbolic fit to reconstruct atmospheric muons.

Expected performances had been simulated with specially developed software packages. Studies shows that above 10 TeV, angular resolution is dominated by reconstruction (whereas below, resolution is dominated by physical angle between neutrino and muon) e. g. less than 0.4^o. The energy estimation is obtained from muon range measurement. Above 10 TeV, the energy is estimated within a factor 3.

7. Conclusion

From 1996 to 2000 ANTARES collaboration has performed a $R\&D$ phase to determine water properties of ANTARES site, test of submarine technologies and demonstrator line. Now ANTARES has started the $0.1km^2$ construction. The first line of the detector will be immersed in 2002 and the last one in 2004. This is the first step to the $1km^3$

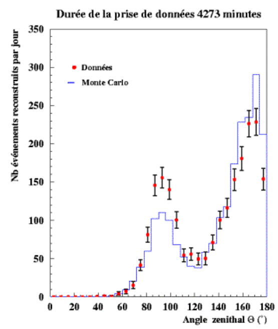

Fig. 5. Zenith angle of reconstruced events and simulation.

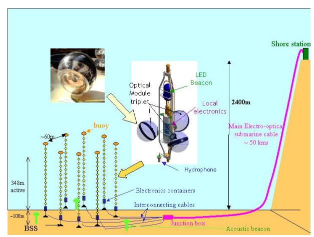

Fig. 6. Schematic view of future ANTARES $0.1 km^2$ detector.

detector in Mediterranean sea.

References

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