The Antares project aims to build a deep-sea Cherenkov Telescope for High Energy Neutrino Astronomy located in the Mediterranean Sea. The experiment, currently in the construction phase, has recently achieved an important milestone: the operation of a prototype line and of a line with monitoring instruments. These deployments allowed a thorough understanding of environmental parameters.
1 High Energy Neutrinos and AstroParticle Physics

The advantage of using neutrinos as new messengers lies on their weak interaction cross-section: unlike protons or gammas, they provide a cosmological-range, unaltered information from the very heart of their sources. The drawback is that their detection requires a huge detection volume. In all those aspects, neutrinos are comparable to gravitational waves (GW). This comparison applies also to the sources of high energy neutrinos themselves.

Such sources, either galactic or extra-galactic, are compact objects, involving relativistic movements of masses and particles, all necessary ingredients to have an efficient gravitational wave emission (see section 2.3). Most of those sources have already been extensively observed in $\gamma$: supernovae and their remnants, pulsars, microquasars and AGNs, gamma-ray bursters. The main question is to know whether or not those photons are produced by electrons $via$ inverse compton/synchrotron emission or by protons/nuclei $via$ production of neutral and charged pions, which decay to produce photons and neutrinos.

2 The Antares Neutrino Telescope

Antares can be seen as a fixed target experiment: a cosmic neutrino interacts in the Earth and produces a muon that propagates in sea water. The Cherenkov light emitted by the muon is detected by an array of photomultipliers arranged in strings, able to reconstruct the energy and direction of the incident muon/neutrino.

The main physical backgrounds are twofold. Atmospheric muons, produced in the upper atmosphere by the interaction of cosmic rays, can be discarded because of their downward direction. Atmospheric neutrinos on the other hand are more delicate to identify: produced on the other side of the Earth, they have exactly the same signature as the cosmic signal Antares awaits for. They also represent a powerful calibration tool.

2.1 The Antares Collaboration and the detector

The goal of the European collaboration Antares [1] is thus to build an underwater telescope dedicated to high energy neutrinos. Around 20 particle physics laboratories, astrophysics and oceanography institutes are taking part in the project. The selected site is in the Mediterranean Sea, 40 km from Toulon (Southern France), at a depth of 2500m.

The detector consists in twelve lines, each one being composed of 25 storeys. On each storey, 3 photomultipliers are looking downward, to be sensitive to upward-going muons only. The layout of the detector is described in Figure [1].
2.2 Physics Performance

The performances of ANTARES as a Neutrino Telescope are mainly estimated studying the effective area, as defined below (which convolved with a neutrino flux determines the event rate) and background rejection capabilities, mostly based on the angular resolution and energy reconstruction.

The effective area is defined as the ratio of detected neutrinos per unit of time over the incident neutrino flux. For angles around the vertical, as can be seen in Figure 2, it reaches its maximum for an energy $E_{\text{max}} \simeq 10^5$ eV, and then decreases because of the shadowing of the Earth.

The angular resolution is constant and equal to 0.2° (48 arcsec) for energies higher than 10 TeV as shown in Figure 2; below this energy, the resolution is dominated by kinematics. Above 10 TeV ANTARES will really be able to pinpoint a source in the sky, with the same resolution as the actual satellites dedicated to one of the most promising sources for high energy neutrinos, namely Gamma-Ray Bursters.

Due to its location, ANTARES will cover a 3.5$\pi$ sr fraction of the sky. AMANDA, the largest currently operational experiment, and soon ICECUBE, located at the South Pole, will only cover 2$\pi$ sr, but with the same exposition during the day. Furthermore, ANTARES will be able to observe the Galactic Centre, where INTEGRAL has recently observed a great deal of new point-like gamma sources. The two detectors will nevertheless be complementary with an instantaneous overlap of 0.5$\pi$ sr.
Figure 2: Effective area vs neutrino energy for various zenith angles (left) and expected angular resolution both for muons and neutrinos (right).

2.3 A step forward in Multi-Messenger Astronomy

With the forthcoming operation of Hess or GLAST for $\gamma$, AUGER for UHE cosmos rays, Virgo for GW and ANTARES for high energy $\nu$, the years to come will bring a harvest of new information related to the most energetic and powerful phenomena in the universe.

Good candidates for such a multi-messenger approach are microquasars, the galactic equivalents of quasars. More than 10 of these objects have been observed in our galaxy in all electromagnetic domains, and some models show that ANTARES could detect up to tens of events per year from some of them \[2\]. Furthermore, if the ultra-relativistic plasma “blob” ejected by microquasars is compact enough, efficient GW emission could take place \[3\], thus making the coincident neutrino emission easier to detect by ANTARES.

3 Deployments and Prototype Lines

Before launching the mass production of the lines, two prototypes of the final lines were built and deployed. Figure \[8\] illustrates the structure of the prototypes, together with the dates of previous deployments.

The deployments, connections and recovery of the lines were successful, and most of the components worked properly. One major problem showed up, though. Because of a broken optical fibre in the cable of the Prototype Sector Line (PSL), the clock signal only reached the bottom of the String Control Module, thus preventing any coincidence measurements between storeys. The accuracy in time calibration thus only reached $\sim 1$ms.

In about 100 days of running time, a large amount of data has nonetheless been recorded, and background light counting rates were extracted.
Background Light & Flow-induced Bioluminescence

The counting rates as recorded by the PMTs shows large and short-lived peaks, due to bioluminescent organisms (plankton), over a continuous baseline coming both from $\beta$-decay of $^{40}$K and bacteria, as previously observed [4]. Both the fraction of bursts and the continuous level are subject to great variations (see Figure 4, left plot, for an example).

Correlations with sea currents for the mean counting rates showed behaviours which could be the signature of flow-induced bioluminescence in the turbulences/boundary layers around the detector itself (see [5] and references therein). Figure 4 (right plot) shows the mean intensity (in kHz) as a function of sea current velocity.

4 Milestones for Antares and km3Net

The past years have seen the installation/operation of some of the key components in Antares. Next year, the PSL will be redeployed with a new electro-mechanical cable, together with an improved instrumentation line, and the mass production for all the lines will be launched. The Antares neutrino telescope is now scheduled to be operational by 2007, but physics studies will begin before its completion.

Antares must be seen as the first stage toward a km$^3$-scale telescope, for which European institutes involved in current neutrino astronomy projects (Antares, Nemo and Nestor) are already collaborating. This net-
work, km3NeT [6], will give birth to a telescope with which neutrinos will be as common a messenger as gamma-rays are now.

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