GNN Monthly
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News from the Experiments

KM3NeT

Welcome KM3NeT/ARCA33 and KM3NeT/ORCA24!
(Report sent by Paschal Coyle)

25 October 2024 - The October sea campaigns at both the KM3NeT's ARCA and ORCA sites have led to major progress in expanding detector installations and improving calibration systems.

At the ARCA site, the so-called Phase-1 part of the seafloor network was completed with the addition of two 'standard' detection units (DUs). Construction of Phase-2 was started with the installation of two new junction boxes and connection of three new 'WWRS' DUs. These exploit a new data acquisition architecture based on the full white rabbit protocol. The operation also included deployment of a Calibration Base hosting an additional calibration laser, as well as important maintenance tasks, such as recovering and replacing acoustic beacons. Due to the onset of bad weather, we were obliged to return to shore before all the DUs onboard could be deployed. All optical modules of the deployed strings are fully operational. KM3NeT/ARCA now comprises 33 detection units.

At the ORCA site, a 60-hour calm weather window allowed the team to deploy the Calibration Base with its Instrumentation Unit, to install two additional DUs and recover one. The Calibration Base hosts a calibration laser and an acoustic beacon. The Instrumentation Unit host devices at three different depths which measure the sea currents and the speed of sound.


Components for ARCA on the deck of the Optimus Prime ship: in the foreground a junction box, behind it a couple of spools with the submarine interlink cables plus some DUs.


Preparing an ORCA DU for deployment

Node 1 of ORCA is now complete and fully functional, an important milestone in the construction of ORCA. The total number of functional detection units at ORCA has now reached 24.

IceCube

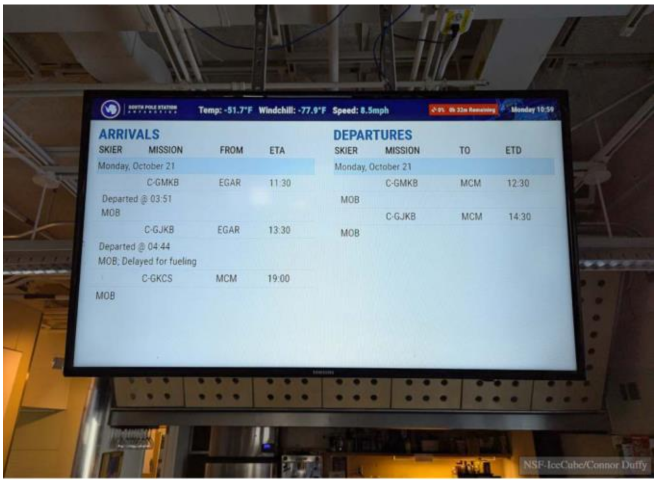
The first Twin Otters have landed at the South Pole two weeks ago, with a small box of freshies in one of the passenger cabins: avocados, lemons, limes, and this delectable mandarin:

The arrival of the Twin Otters offered the perfect staging for a winterover photo. As seen in the next picture, everyone gathered in front of one of the planes before it returned to McMurdo (photos Connor Duffy).

The IceCube present winterovers are preparing for the South Pole station opening with a spring cleaning of the station and the IceCube Laboratory. They have also been working with the operations team in the north on a set of full-detector calibration runs focused on the module dark noise characteristics. Cargo for the summer season is heading south and is mostly still in transit to Christchurch, New Zealand. The 150m-long surface cables for the IceCube Upgrade are already staged in McMurdo and are awaiting transport to the pole for installation this season.

420 optical modules have been shipped, all 292 DEggs from Chiba and first 128 mDOMs from Zeuthen. These modules are intended to be stored at the South Pole over the winter. The rest of the mDOMs is going to be shipped next season.

PS: meanwhile much more freshies reached the Pole, and the galley scroll is now filling with flight and passenger information, a sure sign that summer is truly about to begin (see the next two photos).



Baikal GVD

The collaboration is going to deploy 2 clusters with 9 strings (eight located within the cluster and one “outer string” filling the holes between clusters) and to lay two shore cables – provided the ice is good enough for a long season. Naturally, the plan also includes some repair operations of equipment deployed in previous years.

Another truck with OMs left Moscow last week. So, in early November 280 tested OMs will be in Baikalsk.

Meanwhile, assembly and testing of OMs in Dubna is continuing. At the start of the expedition about 700 OMs will hopefully be ready for deployment. The underwater DAQ electronics is already assembled and presently under long-term tests.

Last season, there was a lack in components for the acoustic positioning system due to economic sanctions. For the coming season this problem seems to be solved.

The "optical" cluster (equipped with optical fibers along the strings) is going to be extended by two additional strings. The fibers (also object of sanctions) will be bought in China.

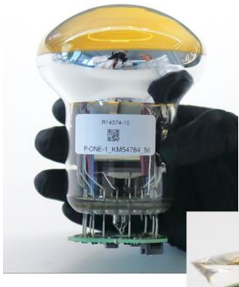
The Chinese participants are going to modify the electronics of their 12-OM string (deployed last season) and add a second string with 24 OMs.

P-ONE

After Mattias Dannninger's extensive report on the P-ONE acoustic receiver system in last GNN Monthly, we can enjoy another extensive status report, this time submitted by Lea Ginzkey (TUM): First phase of integration done for P-ONE-1

The production of the optical modules for P-ONE's first mooring line has been in full swing at TUM. A single line consists of 40 optical modules comprising two glass hemispheres connected via a titanium flange. Each sphere houses 16 PMTs. Since August, we have made gel pads that will optically couple the PMTs to the glass hemispheres. We've reached the second phase and will start to integrate the PMTs by coupling the gel pads to the glass.

In the first step of production, the gel pad is formed in a mold that incorporates the PMT, resulting in a gel pad that directly adheres to the PMT's cathode. In the second step, each unit is inserted into the hemisphere individually. The PMT is secured within a frame using a removable spring-mounted fixture. This modular design allows exchanging PMTs after integration. The picture series below shows those two production steps, how the gel pad sits on the PMT, and how a completed hemisphere looks from the outside.



We have introduced a shift system for the gel pad production process, with one team handling production in the morning and another removing cured pads in the afternoon, followed by quality inspections. This streamlined workflow ensures a continuous production cycle and has boosted efficiency, thanks to the dedication and quick learning of our rotating teams. As the teams come from different projects within the group, clear communication and feedback have been essential. Fortunately, the commitment and enthusiasm of everyone involved have made these efforts both enjoyable and successful.

The pictures below show the latest morning team working on the gel pad production in our clean tent.

With the completion of the gel pad production, we are going to integrate PMTs into the hemispheres (see last picture), test them in-house, and prepare for shipment to TRIUMF in Vancouver, where the modules will be assembled before deployment in the Pacific Ocean. We're eager for the next steps and lessons ahead!

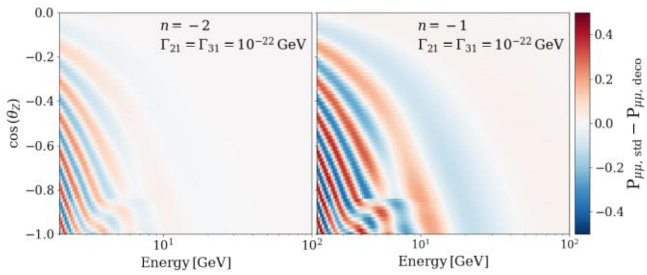
Publications

The KM3NeT Collaboration has submitted a paper *Search for quantum decoherence in neutrino oscillations with six detection units of KM3NeT/ORCA* to JCAP, posted at [2410.01388 (arxiv.org)](). The main author is Nadja Lessing from IFIC Valencia. The analysis uses the same data as the paper *Measurement of neutrino oscillation parameters with the first six detection units of KM3NeT/ORCA* (see last GNN Monthly and [2408.07015 (arxiv.org)]()).

Neutrinos as an open quantum system may interact with the environment which introduces stochastic perturbations to their quantum phase. This mechanism leads to a loss of coherence along the propagation of the neutrino – a phenomenon commonly referred to as decoherence – and ultimately, to a modification of the oscillation probabilities.

Fluctuations in space-time, as envisaged by various theories of quantum gravity, are a potential candidate for a decoherence-inducing environment. Consequently, the search for decoherence provides a rare opportunity to investigate quantum gravitational effects. The present analysis uses atmospheric neutrinos with energies of a few GeV to 100 GeV. Adopting an open quantum system framework, the strength of the decoherence is described by the two parameters Γ_{21} and Γ_{31}. Following previous studies (see details in the paper), a dependence of the type $\Gamma_{ij} \propto (E/E_0)^n$ on the neutrino energy is assumed and the cases $n = -2, -1$ explored.

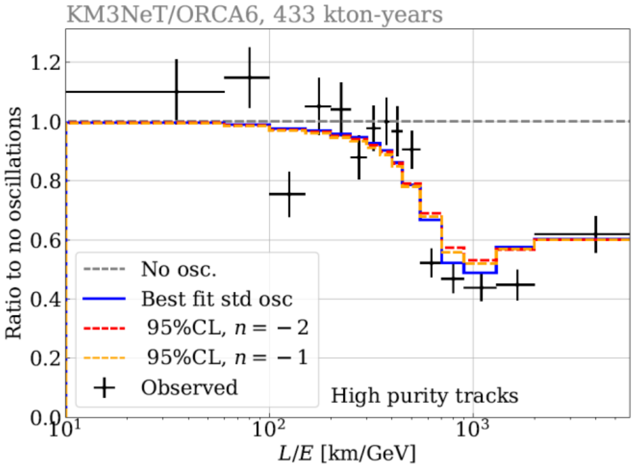
The next figure shows the difference between ν_μ survival probabilities assuming standard oscillations and assuming decoherence (case $\Gamma_{21} = \Gamma_{31}$) as a function of the neutrino energy and zenith angle.



Difference in the ν_μ survival probabilities between standard neutrino oscillations, P_{std}, and assuming decoherence, P_{deco}, (case $\Gamma_{21} = \Gamma_{31} = 10^{-22}$ GeV) as a function of the neutrino energy and zenith angle for n = −2 (left) and n = −1 (right).

The impact of decoherence is visible in the whole range of the zenith angle which means that neutrinos from all directions can contribute to the sensitivity of the detector. The standard oscillation parameters are based on the NuFit 5.0 result including Super-Kamiokande data, where the mixing angle has a value of θ_{23} = 49.2° for normal ordering. Since decoherence causes a damping of the oscillation amplitude, its effect can partially be replicated or compensated for by changing the value of the mixing angle. The sensitivity to decoherence is highest for maximal mixing (θ_{23} = 45°) because then the difference between the oscillation probability assuming standard oscillations, P_{std}, and assuming decoherence, P_{deco}, is largest, making it easier to distinguish between the two.

No significant deviation with respect to the standard oscillation hypothesis is observed. Therefore, 90% CL upper limits can be estimated, with $\Gamma_{21} < 4.6\cdot10^{-21}$ GeV and $\Gamma_{31} < 8.4\cdot10^{-21}$ GeV for n = −2 and $\Gamma_{21} < 1.9\cdot10^{-22}$ GeV and $\Gamma_{31} < 2.7\cdot10^{-22}$ GeV for n = −1, respectively. The next figure compares the measured oscillation pattern with the pattern expected for standard oscillations and for decoherence models, with the parameter values fixed at the upper limits obtained from this analysis.



Ratio of events with respect to the no oscillations hypothesis as a function of L/E for the standard oscillations best fit and the decoherence models n = −2, −1 with $\Gamma_{21} = \Gamma_{31}$ fixed at their respective 95%CL upper limit.

Impressum

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