Diffuse astrophysical neutrino flux searches with KM3NeT/ARCA

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An all-flavour search for diffuse astrophysical neutrino fluxes, using data obtained with the first KM3NeT/ARCA configurations, is presented. The KM3NeT research infrastructure includes two neutrino telescopes under construction with one of them, KM3NeT/ARCA, focusing on the detection of high energy neutrinos (>TeV) from astrophysical sources. The KM3NeT/ARCA detection units are deployed offshore Capo Passero, Italy at a depth of 3500 m, delivering data as the construction of the detector is ongoing. The two search cases considered here are an all-sky diffuse flux and a flux coming from the Galactic Ridge, namely $|b| < 2^\circ$ and $|l| < 30^\circ$, in Galactic coordinates. The event selection is based on machine learning techniques and a bayesian method for the statistical analysis is employed.

KM3NeT Detectors

KM3NeT [1] is a research infrastructure housing two Cherenkov detectors in the Mediterranean Sea:

KM3NeT/ARCA [offshore Capo Passero, Italy @3500m depth]: optimized for the detection of high-energy (TeV-PeV) astrophysical neutrinos
KM3NeT/ORCA [offshore Toulon, France @2500m depth]: optimized for atm. neutrino oscillation studies

Same technology, different spacing
- 31 x 3” PMTs hosted in a pressure resistant glass sphere, the **Digital Optical Module (DOM)**
- 18 DOMs anchored at the seafloor with buoyancy at the top form a **Detection Unit (DU)**
- 115 DUs evenly spaced form a **Building Block (BB)**

For KM3NeT/ARCA the distance between DUs is 90 m; DOMs are spaced by 36m. When complete, ARCA will consist of 2 BBs.

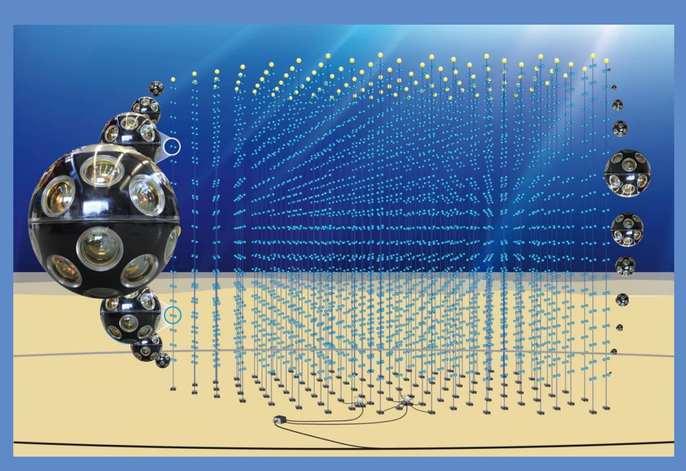
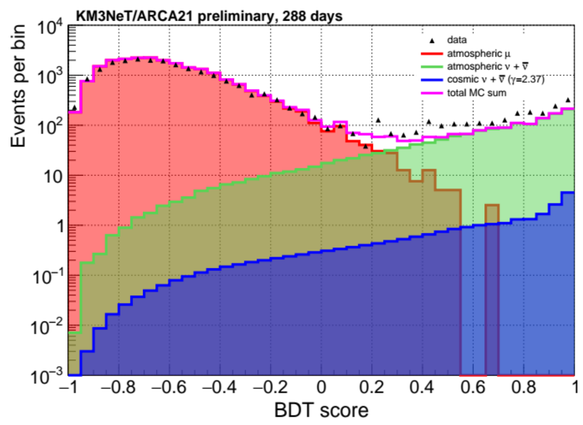


Photo of a DOM and artist’s impression of a Building Block

Event Selection and BDT

Data are collected during the detector construction. Data taking periods are named according to the number of active DUs. Here data are presented from the early stages of KM3NeT/ARCA, ARCA6-8-19-21 configurations.

Events reconstructed as up-going tracks are selected (based on the type of the search) using trigger level information and variables indicating the quality of the track reconstruction. A Boosted Decision Tree (BDT) classifier using ROOT TMVA [2] was applied. Cut optimization is based on the minimization of the MRF [3].

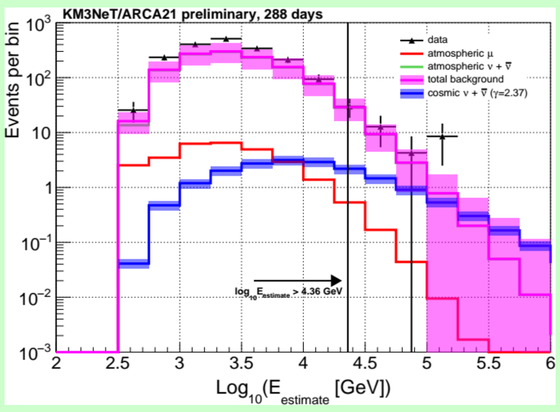


Main background comes from atmospheric muons misreconstructed as upgoing.

Approximately 288 days of exposure with ARCA21

	Before BDT	After BDT
Atmospheric μ	~ 27000	~ 29
Atmospheric ν	~ 1200	~ 960
Cosmic ν	~ 21	~ 16

All-sky search



The measurement of a diffuse flux of cosmic neutrinos can provide an insight in resolving the particle acceleration mechanisms at place at distant astrophysical sources.

Signal events come from upgoing neutrinos of astrophysical origin of all 3 flavours and both interaction channels (CC and NC) reconstructed as tracks. Atmospheric upgoing neutrinos (Honda [4] & Enberg [5] along with a correction for the presence of the cosmic ray knee) and atmospheric muons represent the physics background.

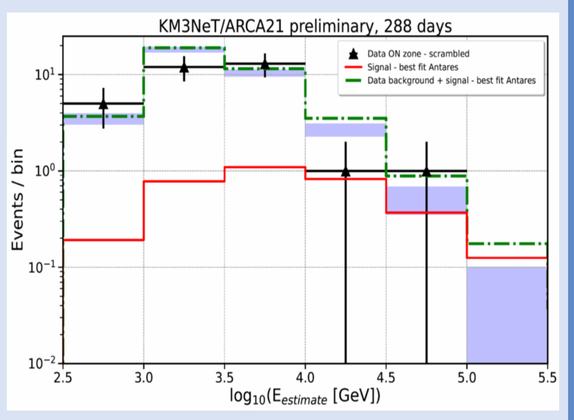
The flux is parameterized with an unbroken power-law and as a baseline, IceCube’s reported values [6] $\varphi_0 = 1.44 \times 10^{-18}$ $GeV^{-1}cm^{-2}s^{-1}sr^{-1}$ (@100TeV) and $\gamma = 2.37$ are used.

Galactic Ridge search

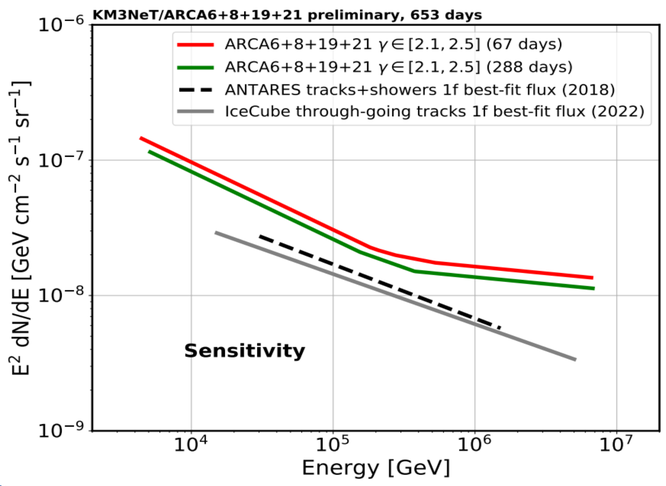
The measurement of a possible excess of events coming from the Galactic Ridge (ON zone) is attempted.

An ON-OFF zone technique, adopted also in previous ANTARES analyses [7] is employed. The search takes place around an extended region with Galactic coordinates $|l| < 30^\circ$ and $|b| < 2^\circ$.

Background is derived directly from data, using regions where no contribution from the signal is expected. Each event is moved in time in order to avoid Fermi Bubbles and the Galactic Ridge region. This methodology has the advantage of re-using the same events multiple times, reducing the overall final statistical error.

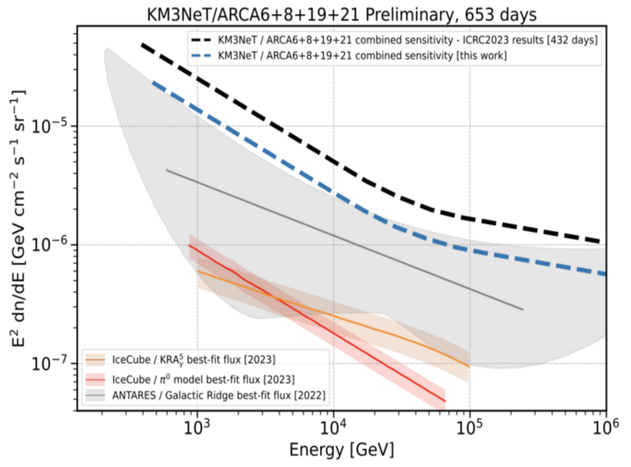


Statistical Analysis



A maximum likelihood method [7] based on the Bayesian interpretation of probability is used for the statistical analysis of the samples. The likelihood functions of the four configurations -ARCA6, ARCA8, ARCA19 and ARCA21- are combined to produce the detector sensitivity to an astrophysical neutrino flux at 90% C.I. as a function of the energy. The convolution for a selection of spectral indices is plotted.

As the KM3NeT/ARCA detector is growing and more data are collected, we are quickly approaching the ANTARES and IceCube fitted fluxes.



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After the recent Sea Operation, ARCA will be operating with a total number of 33 DUs!

Vasileios Tsourapis acknowledges the support of the Hellenic Foundation for Research and Innovation (HFRI) under the 3rd Call for HFRI PhD Fellowships (Fellowship Number: 5403).