PROCEEDINGS OF SCIENCE

ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany
37th International Cosmic Ray Conference
12–23 July 2021

Atmospheric neutrinos with the first detection units of KM3NeT/ARCA

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The KM3NeT Collaboration is constructing two deep-sea Cherenkov detectors in the Mediterranean Sea, aiming at neutrino oscillation measurements with the ORCA array, while the ARCA array aims at neutrino astronomy in the TeV range. In April 2021, 5 additional detection units have been deployed. The KM3NeT-ARCA instrumented volume is currently similar to the one of the ANTARES neutrino telescope. In this contribution, an analysis of the data obtained with the detector before April 2021 is presented as well as the very first data from the new KM3NeT-ARCA configuration. The performance is demonstrated using atmospheric muons and the first atmospheric neutrinos are shown.

37th International Cosmic Ray Conference (ICRC 2021)
July 12th – 23rd, 2021
Online – Berlin, Germany

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1. Executive summary

When completed, ARCA will be used for the search of astrophysical neutrino sources and for the detection of the diffuse astrophysical neutrino flux. For detectors focusing on neutrino astronomy, the background comes mainly from the contribution of the atmospheric muons and neutrinos; therefore, the goal is to suppress the contribution of the atmospheric events. Currently ARCA is at the construction phase therefore, the instrumented volume is too small for studies in terms of neutrino astronomy. The goal of this contribution is to demonstrate that with the first ARCA configurations, it is possible to reject the atmospheric muon background and detect atmospheric neutrino candidates. This task is quite challenging for ARCA as its geometrical configuration is optimized for high energy neutrinos. The very first data from the new KM3NeT/ARCA configuration, with 6 operational Detection Units (DUs), are also presented.

In this analysis, we focused on studying and applying requirements to reject poorly reconstructed events. Detailed comparisons between data and MC were performed in order to assess the detector performance. Then, an event selection based on quantities indicating the quality of the track fit was studied and applied in order to reject the poorly reconstructed events and to isolate atmospheric neutrino candidate events for the first data-taking periods with one and two operational DUs respectively (ARCA1&ARCA2).

The current ARCA configuration (ARCA6) operates with stable data taking from the middle of May 2021. For this contribution and with the goal to demonstrate the performance of the configuration, data have been reconstructed with an effective livetime of ~19 days. For all the reconstructed upgoing neutrino MC events in the low energy range ($E<10$ TeV) ARCA6 is expected to have an effective area comparable to the current ORCA configuration (6 operational DUs) and the ANTARES telescope. For the high energy range ($E > 100$TeV), for which ARCA is optimized, ARCA6 is expected to perform significantly better than ANTARES.

The aim of the contribution is to show that with a few % of the full ARCA detector, it is possible to detect atmospheric neutrinos and to achieve a powerful reduction of the atmospheric muon contribution. Furthermore, a good data/MC agreement verifies the KM3NeT technology, the detector understanding and detector calibration demonstrating the capability of the future KM3NeT detectors.