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Searches for point-like sources of cosmic neutrinos with 13 years of ANTARES data

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The main goal of the ANTARES neutrino telescope is the identification of neutrinos from astrophysical sources. Thanks to its location in the Northern hemisphere, ANTARES can rely on an advantageous view of the Southern Sky, in particular for neutrino energies below 100 TeV. This feature, combined with a very good angular resolution for high-quality selected events, makes the telescope an excellent tool to test for the presence of point-like sources, especially of Galactic origin. In ANTARES, track-like events (mainly resulting from ν_μ charged current – CC – interactions) are reconstructed with a median angular resolution of 0.4° while for shower-like events (mainly coming from ν_e CC and all-flavour neutral current – NC – interactions) a median angular resolution of 3° is achieved. The ANTARES Collaboration published the result of the search for cosmic point-like neutrino sources using track-like and shower-like events collected during nine years of data taking [Phys. Rev. D 96 (2017) 082001]. In this contribution, the update to this analysis using a total of 13 years of data recorded between early 2007 and early 2020 (3845 days of livetime) is presented. Moreover, the results of the dedicated searches for neutrino candidates from the tidal disruption events AT2019dsg and AT2019fdr, recently indicated as the most likely counterparts of two high-energy IceCube neutrinos, IC191001A and IC200530A, are reported.

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1. Executive summary

ANTARES is a high-energy neutrino telescope made of a three-dimensional array of 885 photomultiplier tubes (PMTs), deployed at 2500 m below the surface of the Mediterranean Sea, 40 km off-shore from Toulon, France. Being located in the Northern hemisphere and immersed in sea water, ANTARES can count on a clear visibility of the Southern Sky, and thus of the Galactic Centre, and on a very good angular resolution. This makes it an excellent tool in the search for point-like sources, especially of Galactic origin, and a valid instrument to follow-up the recent evidence of neutrino emission from the blazar TXS 0506+056 and possibly from tidal disruption events (TDEs) AT2019dsg and AT2019fdr, reported by the IceCube Collaboration.

In these proceedings, the results of several searches for point-like sources using ANTARES data are presented. This analysis updates the 9-year ANTARES point-like source search [Phys. Rev. D 96, 082001 (2017)], and the subsequent 11-year analysis [PoS ICRC2019 (2020) 920], employing a total of 13 years of data. Moreover, recently improved calibrations have been used to reconstruct all the ANTARES events. The data set includes 10162 tracks and 225 showers recorded in ANTARES between January 29, 2007 and February 29, 2020 (3845 day livetime).

The search for spatial clustering of events above the known background expectation relies on an unbinned maximum likelihood approach, in which the signal and background PDFs are given by the product of a directional and an energy term. Two searches for astrophysical neutrino sources are performed using the whole described data set: a scan over the whole ANTARES visible sky, and a survey of 121 astrophysical candidates. Moreover, the results of dedicated searches for cosmic neutrinos associated with AT2019dsg and AT2019fdr are reported. In this case, only the events detected by ANTARES from the day of the discovery of each TDE (2019 April 9 and 2019 April 27, respectively), until the day of the last available fully-calibrated ANTARES data, 2020 February 29, have been used, corresponding to a livetime of 315 and 298 days, respectively.

In the full-sky search, the ANTARES visible sky is scanned to look for the most significant excess of signal events, without making any assumption about the source position. The most significant cluster of this search, i.e. the cluster with lowest pre-trial p-value, is found at a right ascension of $\alpha = 39.6^\circ$ and a declination of $\delta = 11.1^\circ$ with a pre-trial p-value of 6.8×10^{-6} (4.3σ), corresponding to a post-trial significance of 48%. The second most significant location is found at equatorial coordinates ($\alpha = 343.8^\circ$, $\delta = 23.5^\circ$) and corresponds to the full-sky hotspot found in the 11-year ANTARES point-like source search.

In the candidate-list search, a pre-selected list of potential neutrino sources is investigated to look for an excess of neutrino events. The most signal-like cluster is found at the location of the radio-bright blazar J0242+1101, with a pre-trial p-value of 6.7×10^{-5} (3.8σ), and 2.4σ post-trial significance. The source is located at 1° angular distance from the full-sky hotspot. J0242+1101 is followed in significance by TXS 0506+056 (2.8σ pre-trial), HESSJ0632+057 (2.1σ pre-trial) and the Galactic Centre (2.0σ pre-trial). Limits at 90% C.L. on the one-flavour neutrino flux normalization are reported for each investigated source.

No significant cluster is found at the location of AT2019dsg and AT2019fdr. In both cases, only one event has been detected within 5° from the TDE. Upper limits on the one-flavour neutrino flux and fluence normalisation are reported.