

Indirect search for dark matter in the Galactic Centre combining ANTARES and IceCube

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For the ¹ANTARES and ²IceCube Collaborations [*presenter]



Dark matter particles accumulating in astrophysical environments can be indirectly searched through their annihilation into neutrinos.

ANTARES and IceCube have conducted independent searches for WIMPs in the Galactic Centre [1,2], obtaining comparable limits in the mass range 50 GeV/c² – 1 TeV/c².

We have performed a combined likelihood analysis of the two data samples [3], upon agreement for data exchange between the two collaborations, looking at four annihilation channels

($\tau^+ \tau^-$, bb^- , $\mu^+ \mu^-$, $W^+ W^-$) and two halo profiles (Navarro-Frenk-White [4], Burkert [5]).

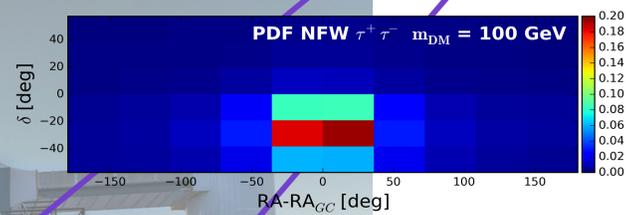
No dark matter signal was found unblinding the joint ANTARES and IceCube data set; combined limits improve up to a factor 2 with respect with the stand-alone ones.

This work has also permitted to unify the analysis techniques towards a common benchmark, relevant with the advent of the next generation of detectors IceCube Gen-2 and KM3NeT.

IceCube [2]

Inner strings vetoed by outer detector:

- DeepCore + 7 surrounding strings, only optical modules with depth 2140-2420 m
- Signal and background events described by sky position relative to the Galactic Centre

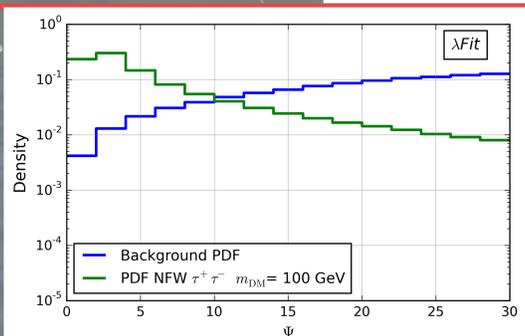
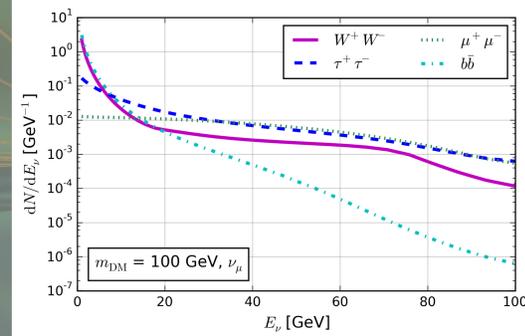
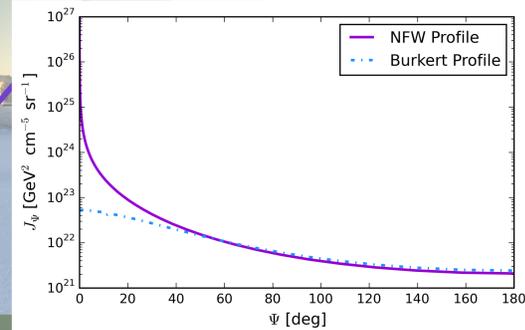


Method: combined binned likelihood

$$\mathcal{L}(\mu) = \prod_{i=\min}^{\max} \text{Poisson}(n_{\text{obs}}(i); n_{\text{obs}}^{\text{tot}} f(i; \mu)) \quad (1) \quad \mathcal{L}_{\text{comb}}(\mu) = \prod_{k=A,I} \mathcal{L}_k(\mu_k) \quad (2) \quad \mu = \frac{N_{\text{sig}}}{N_{\text{tot}}} = \frac{N_{\text{sig}}^A + N_{\text{sig}}^I}{N_{\text{tot}}^A + N_{\text{tot}}^I} = \frac{N_{\text{sig}}(s_A + s_I)}{N_{\text{tot}}(b_A + b_I)} \quad (3)$$

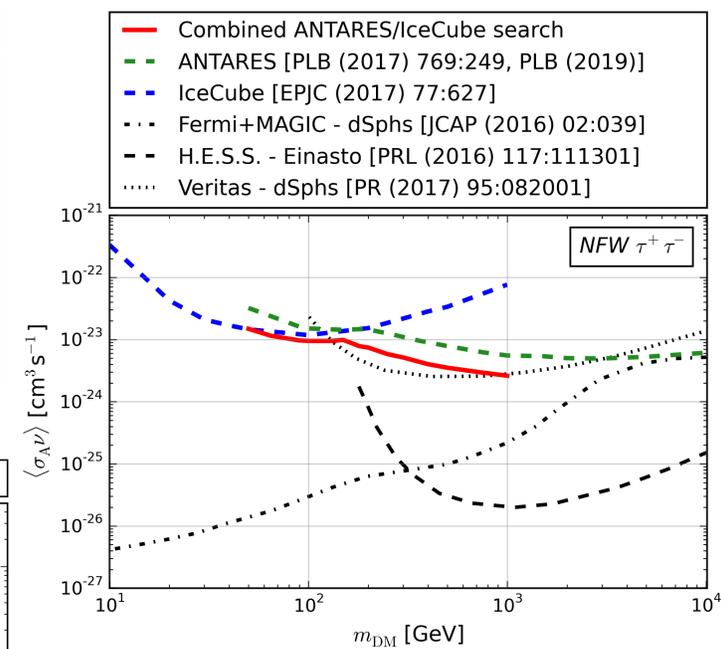
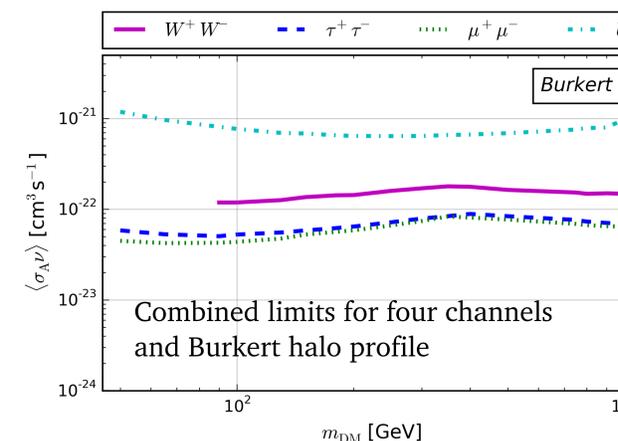
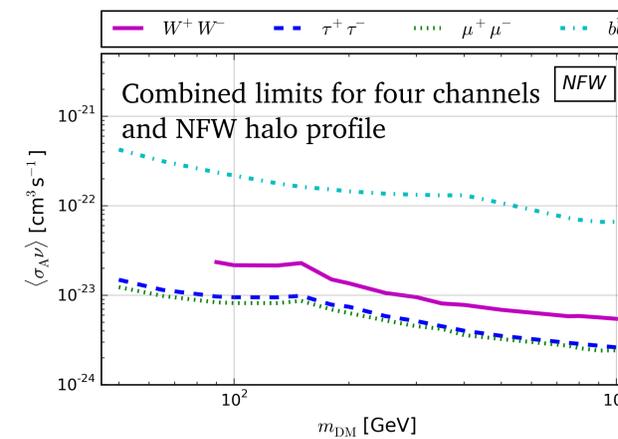
The single experiment likelihood (1) is defined from the Poissonian probabilities of measuring n_{obs} events in bin (i) expecting $f(i, \mu)$, obtained from the two experiments PDFs shown on the left. The combined likelihood (2) is maximised with respect to a unique variable: the combined signal to background ratio μ (3). The index A, I represents ANTARES and IceCube.

Common to both analyses



Results

No significant excess of signal neutrinos is found in the direction of the Galactic Centre. Limits on the thermally-averaged cross section for dark matter pair-annihilation are up to a factor 2 better than stand-alone ones



In red: combined limits for WIMP WIMP $\rightarrow \tau^+ \tau^-$ with NFW profile in context with other results: IceCube and ANTARES stand-alone limits are in blue and green respectively. On the left panels, combined limits for all annihilation channels and two different halo profiles.

ANTARES [2]

Full detector, atmospheric muons regularly vetoed by the Earth:

- Data recorded between 2007 and 2015 over 2101.6 days of lifetime
- Signal and background events described by angle with the Galactic Centre

References:

- [1] A. Albert et al. (ANTARES), Phys. Lett. B 769, 249-337 (2017), [Erratum: Phys. Lett. B (2019)]
- [2] M. G. Aartsen et al. (IceCube), Eur. Phys. J. C 77, 627 (2017)
- [3] Combined search for neutrinos from dark matter self-annihilation in the Galactic Centre with ANTARES and IceCube [arXiv:2003.06614]
- [4] J. F. Navarro, C. S. Frenk, and S. D. M. White, Astrophys. J. 462, 563 (1996)
- [5] A. Burkert, Astrophys. J. 447, L25 (1995)
- [6] M. Cirelli et al., JCAP 1103, 051 (2011)