Expectations for the high-energy neutrino detection from Starburst galaxies with KM3NeT/ARCA

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Abstract

Star-forming (SFG) and Starburst Galaxies (SBG) are extra galactic sources which could massively produce high-energy neutrinos. In principle, they could play a rather important role for explaining at least a sizeable part of IceCube's observations. Using a recent theoretical model which implemented a blending of spectral indexes, we present the KM3NeT/ARCA expectations for such a diffuse flux. In particular, we provide the 5-year differential sensitivity for the two building blocks of ARCA. We make use only of the track-like events in the range of 100 GeV - 10 PeV differentiate in 11 bins of energy. Remarkably, we show how the upcoming neutrino telescope could observe the diffuse SFG and SBG within 5 years of data taking. We found the minimum of the sensitivity at around 100 TeV, which is also the energy where the SBG contribution is expected to peak. This would not only constrain the multi-component fit of the observed astrophysical neutrino flux at that energy (100 TeV), but would also provide us a direct link between that star-forming activity in reservoirs environments and the hadronic emissions

[1] Ambrosone et al. MNRAS, V. 503, May 2021, p. 4032-4049

[2] J. Neyman, Phil. Trans. Roy. Soc. A, 236, p. 333, 1937

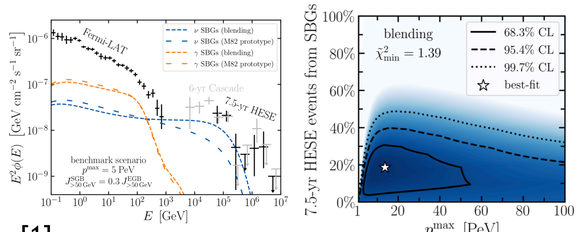
Introduction

- Starburst Galaxies could well explain up to 40% of IceCube's extra-terrestrial observations.

- A new phenomenological scenario considering a blending of spectral indexes is likely to capture the spectral propriety of their ***real*** flux.

- This model privilege a high-energy proton cut-off of the order of 1-20 PeV.

- The computed spectral energy distribution peaking at hundreds of TeVs, seems to be compatible with a significative observation by KM3NeT/ARCA in a few years of data taking.



[1]

Simulated signal and background

Background considered:

- Atmospheric muons (MC version ARCA115: **v5.2**)
- Atmospheric neutrinos ($\nu_\mu - \bar{\nu}_\mu$) CC (MC ARCA115 version: **v5.1**)

Signal considered:

Cosmic neutrinos ($\nu_\mu - \bar{\nu}_\mu$) CC from SBGs (MC ARCA115 version: **v5.1**). SED used:

$$\Phi_\nu(E) = 2.74 \cdot 10^{-12} \cdot \left(\frac{E}{100\ \text{GeV}}\right)^{-2} \cdot E^{-E/0.5PeV}$$

$GeV^{-1}cm^{-2}s^{-1}$

KM3NeT/ARCA differential sensitivity for the SBGs diffuse flux

Objective

To explore the capability of KM3NeT/ARCA detector to observe the diffuse neutrino flux produced by SBGs.

Method

Calculation of differential sensitivity defined as:

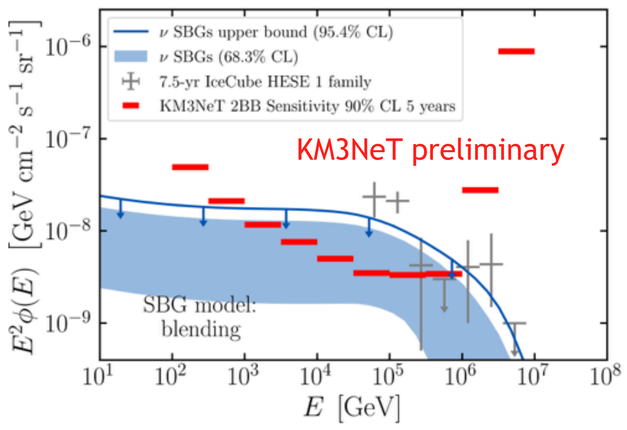
$$\Phi_{90} = \Phi_s \cdot \frac{n_{90}}{n_s}$$ at 90% C.L. median upper limit obtained with Neyman method [2]

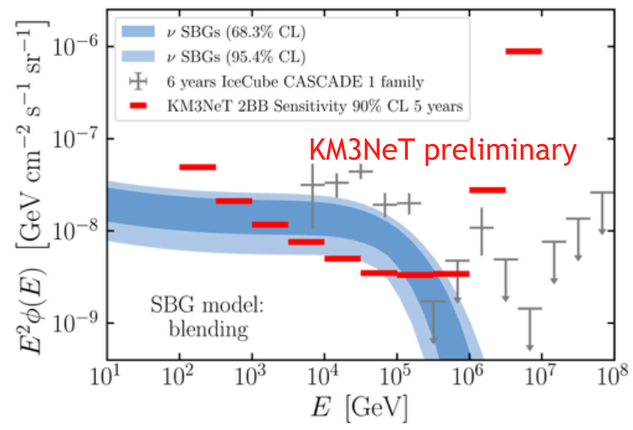
Selection chain applied in order to reject the background

1) *Pre-selection for upgoing events ($\theta_{rec} < 100°$).*
2) *Multivariate analysis with machine learning: a boost decision tree was used.*

1)100 GeV - 10 PeV divided in 11 bins.
2)Two building blocks configuration.
3)5 years of data acquisition.
4)Only track-like events used.
5)Homogeneus diffuse signal considered.

The differential sensitivity KM3NeT/ARCA (2 building blocks) for the diffuse SBGs neutrino signal is calculated in the energy range of 100 GeV - 10 PeV considering an observative time of five years.





Expected signal from two different scenarios compared with the computed sensitivity: on the left scenario HESE and Fermi-LAT EGB are taken into account, otherwise on the right CASCADE and Fermi-LAT EGB.

Reconstructed events

We report the number of events obtained for background and signal before and after the selection chain applied.

Events before cuts

Interval	Atmospheric muon	Atmospheric neutrinos	Signal
$10^2 GeV$	175002.2	10917.05	24.47
$10^{2.5} GeV$	303931.4	29031.81	53.06
$10^3 GeV$	877022.0	26660.69	141.20
$10^{3.5} GeV$	5347572.6	12061.63	169.91
$10^4 GeV$	29622046.	3176.89	142.87
$10^{4.5} GeV$	30205346.3	519.46	90.05
$10^5 GeV$	4762621.1	58.12	37.50
$10^{5.5} GeV$	203797.1	8.76 KM3NeT preliminary	10.14
$10^6 GeV$	35751.7	0.30	1.5
$10^{6.5} GeV$	16214.8	0.0184	0.13
$10^7 GeV$	7942.9	0.00064	0.020

Events after cuts

Interval	Atmospheric muon	Atmospheric neutrinos	Signal
$10^2 GeV$	3.36	4683.0	15.4
$10^{2.5} GeV$	37.1	12150.8	34.3
$10^3 GeV$	41.5	11397.2	75.8
$10^{3.5} GeV$	74.2	3137.2	91.7
$10^4 GeV$	48.8	411.7	67.7
$10^{4.5} GeV$	33.36	38.6	35.6
$10^5 GeV$	0	20.3	13.2
$10^{5.5} GeV$	0	1.08 KM3NeT-preliminary	5.27
$10^6 GeV$	0	0.030	0.35
$10^{6.5} GeV$	0	0.0085	0.012
$10^7 GeV$	0	0	0

Conclusions

In this contribution we study the possibility to observe the SFGs and SBGs diffuse neutrino signal.Furthermore we provide the calculation of the differential sensitivity in the energy range 100 GeV - 10 PeV. We can summarise our results obtained: in 5 year of KM3NeT/ARCA observations the aspected diffuse signal from SBGs can be constrained. This would imply a important step forward for the multicomponent description of the astrophysical neutrino flux measured up to now.