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

KM3NeT

arca&orca

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KM3NeT

The KM3NeT project actually consists of two three-dimensional Cherenkov neutrino detectors built with the same technology but with different dimensions:

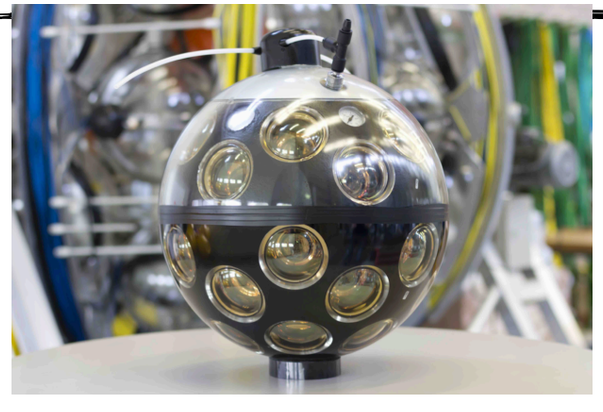
- ARCA detector: installed at a sea bottom depth of about 3500 m near Capo Passero (IT)
- ORCA detector: installed at a sea bottom depth of about 2500 m near Toulon (FR).

The detector consists of the so-called Digital Optical Modules (DOMs)

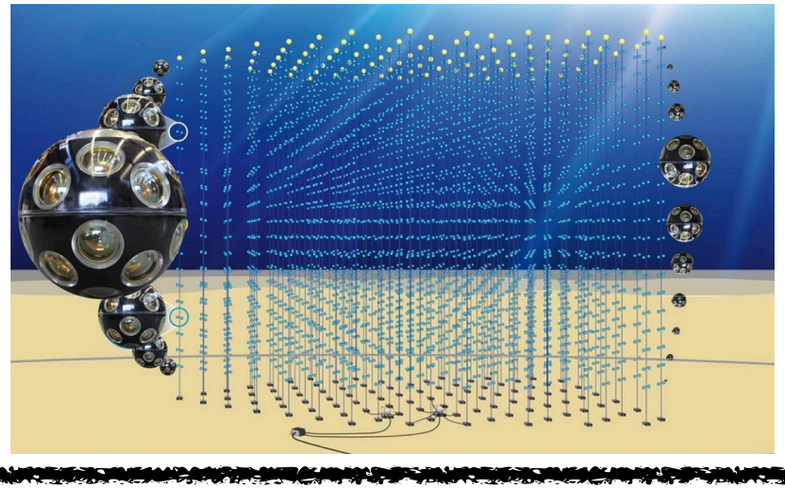
- *Contains 31 photomultiplier (PMT)*
- *A vertical sequence of DOMs forms a so-called Detection Unit (DU)*

The ARCA detector is a km^3-sized detector:

Vertical distance between DOMs is 36 meters, horizontal spacing between the DUs is almost 90 meters.



Digital optical module (DOM)



115 DUs compose 1 building block

[1] Letter of Intent for KM3NeT 2.0

<u>The main goal of ARCA:</u>

- *Astrophysical neutrino flux.*
- *Identify possible sources of high-energy neutrinos.*

The ARCA detector is optimised to have a maximum detection efficiency in the neutrino energy 1 TeV - 10 PeV

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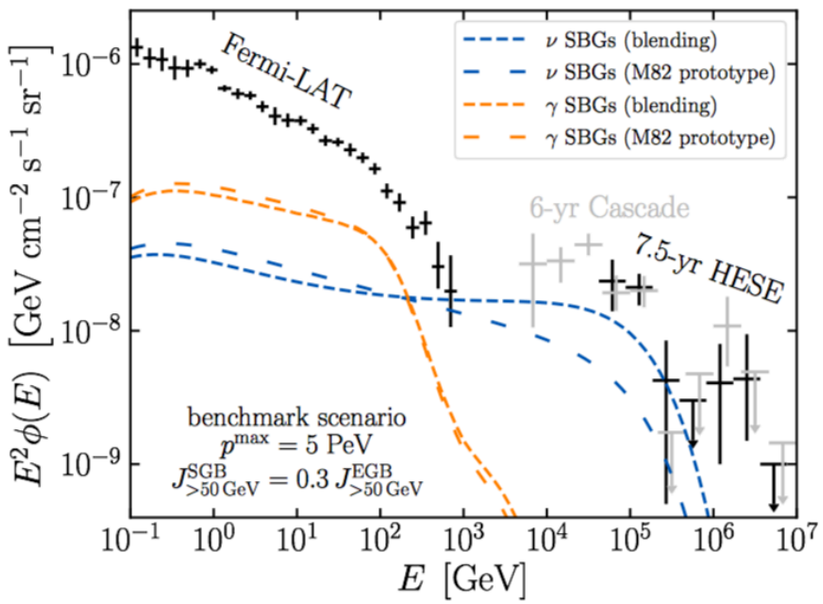
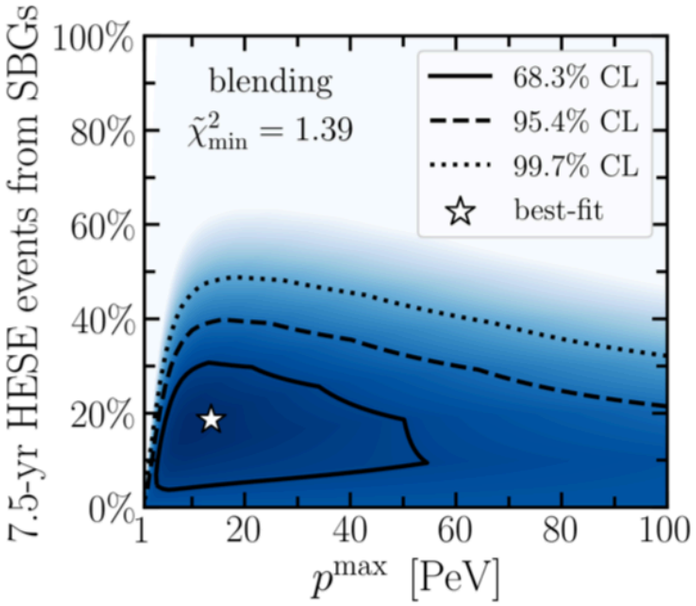
STARBURST GALAXIES

- *Starburst galaxies (SBGs) are a class of galaxies with a high star formation rate.*
- *SBGs are known as "reservoirs" of high-energy cosmic-rays.*
- *SBGs can be considered as garanteed "factories" of high energy neutrinos.*

Any chance to observe the SBG diffuse signal with ARCA telescope?





SED considered:

$$\Phi_{\nu_\mu} = 2.74 \cdot 10^{-12} \left(\frac{E}{100GeV}\right)^{-2} \cdot e^{\frac{-E}{0.5PeV}}$$

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

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

DATA ANALYSIS

Objective: *Determine the possibility for KM3NeT/ARCA to detect the SBGs diffuse neutrino flux*

Calculation of sensitivity:

$$\Phi_{90} = \Phi_s \cdot \frac{n_{90}}{n_s}$$ upper limit following the Neyman method [3]

→ 100 GeV - 10 PeV divided in 11 bins

Signal: *neutrino SBGs* $\nu_\mu - \bar{\nu}_\mu$ CC

Background: *atmospheric muon and neutrino* $\nu_\mu - \bar{\nu}_\mu$ CC

Selection chain in order to reject the background:

→ pre-selection for up-going events ($\theta_{rec} < 100°$)

→ Multivariate analysis with machine learning: boost decision tree (**BDT**) was used.

bin-per-bin selection

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

Several assumptions:

→ Only track events.

→ 5 years of data taking.

→ 2 building block considered.

KM3NeT preliminary

Interval energy	Atmospheric muon	Atmospheric neutrino	Signal
10^2 GeV	175002.2	10917.0	24.47
$10^{2.5}$ GeV	303931.4	29031.8	53.0
10^3 GeV	877022.0	26660.6	141.2
$10^{3.5}$ GeV	5347572.6	12061.6	169.9
10^4 GeV	29622046.0	3176.6	142.8
$10^{4.5}$ GeV	30205346.3	519.4	90.0
10^5 GeV	4762621.1	58.1	37.5
$10^{5.5}$ GeV	203797.1	8.7	10.1
10^6 GeV	35751.7	0.3	1.5
$10^{6.5}$ GeV	16214.8	0.0184	0.13
$10^{6.5}$ GeV	7942.9	0.00064	0.02

EVENTS BEFORE CUTS

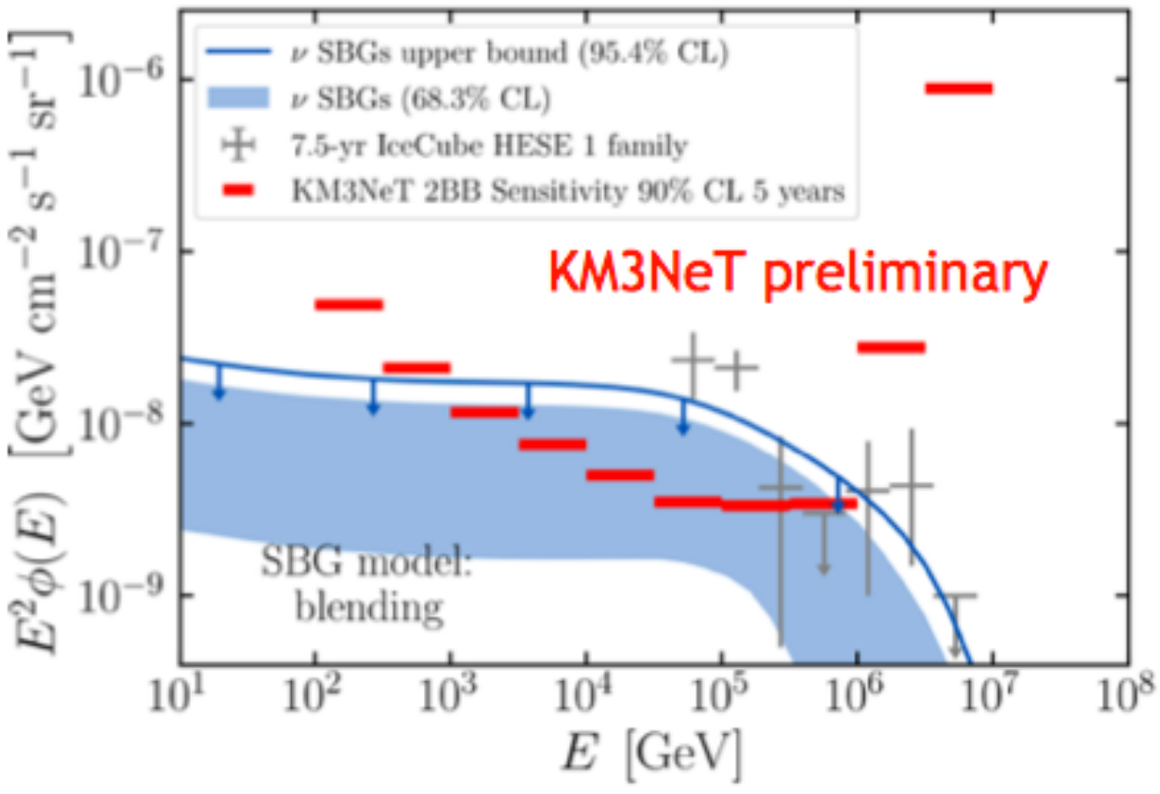
KM3NeT preliminary

Interval energy	Atmospheric muon	Atmospheric neutrino	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	33.3	38.6	35.6
10^5 GeV	0.0	20.3	13.2
$10^{5.5}$ GeV	0.0	1.08	5.2
10^6 GeV	0.0	0.03	0.35
$10^{6.5}$ GeV	0.0	0.0085	0.012
$10^{6.5}$ GeV	0.0	0.0	0.0

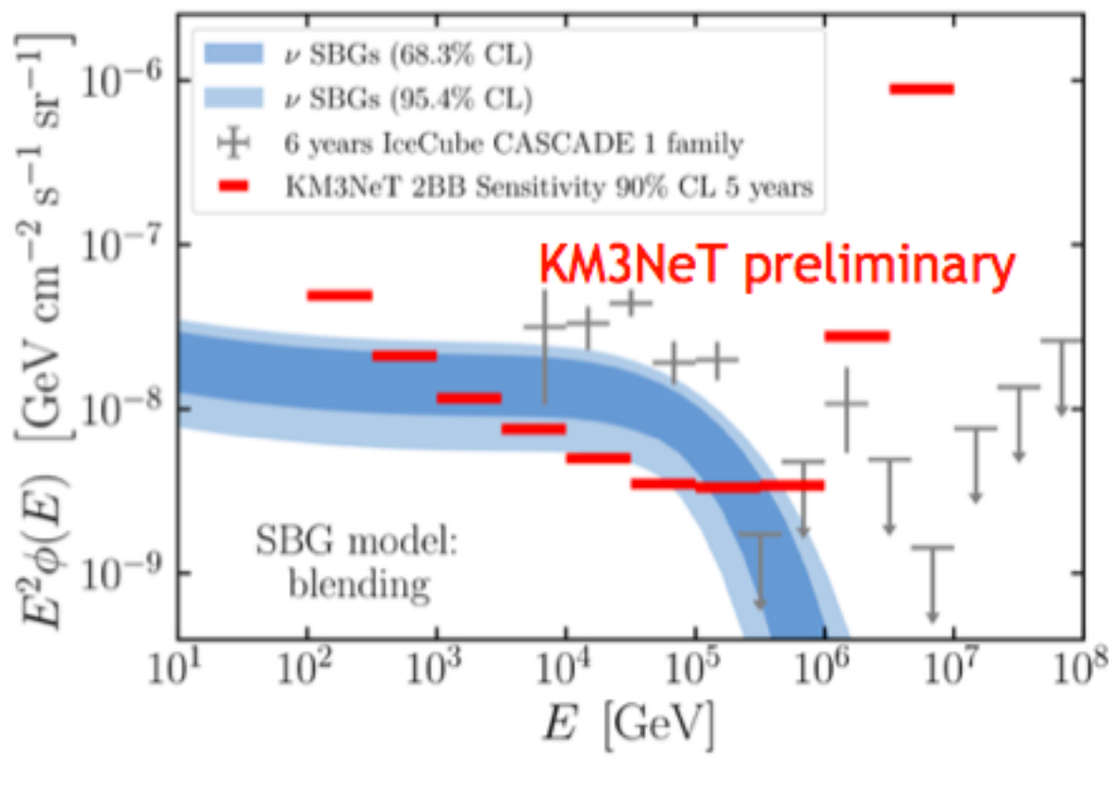
EVENTS AFTER CUTS

KM3NeT/ARCA SENSITIVITY FOR SBGS SIGNAL

Sensitivity at 90% CL for 2BB of ARCA and 5 years of data taking in comparison with the SBG model obtained from EGB and HESE



Sensitivity at 90% CL for 2BB of ARCA and 5 years of data taking in comparison with the SBG model obtained from EGB and CASCADE



5 years of KM3NeT/ARCA will be crucial to constrain the spectral features of “reservoir” sources

CONCLUSIONS

- *The calculation of the differential sensitivity for SBGs diffuse neutrino flux with KM3NeT/ARCA was performed.*
- *We expected that the SBGs signal can be constrained by 2 BB KM3NeT/ARCA in 5 year of data taking.*
- The minimum sensitivity resides in a energy 100 TeV, where the SBGs spectral energy distribution is expected to peak.
- This contribution demonstrate that the SBGs can be important component for the astrophysical neutrino flux measured up to now.