Hint for a TeV neutrino emission from the Galactic Ridge with ANTARES

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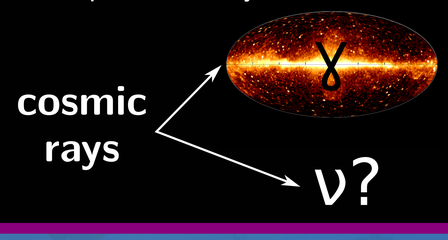
Motivations

➸ The Galactic Ridge (GR) region hosts intense high-energy sources.

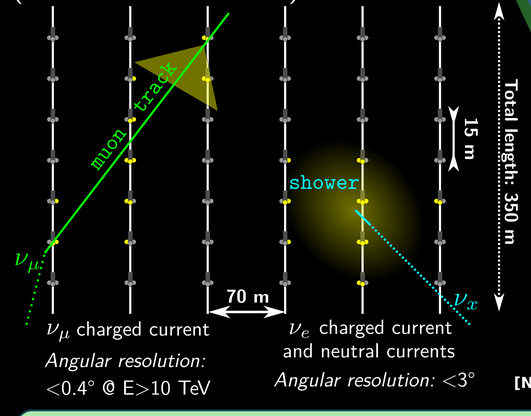
GR definition: $|l| < 30°$ & $|b| < 2°$

➸ The cosmic ray spectrum in the GR is unknown (may have a cutoff or not).
➸ Gamma-ray measurements from Fermi point to a hard spectrum $E^{-2.5}$.
➸ Neutrino emission from GR is also expected, but yet unconfirmed.



ANTARES telescope

➸ Telescope in the depths of the Mediterranean Sea.
➸ 12 lines equipped with PMTs.
➸ Operated from 2007 to 2022 (now decommissioned).



ν_μ charged current
Angular resolution: <0.4° @ E>10 TeV

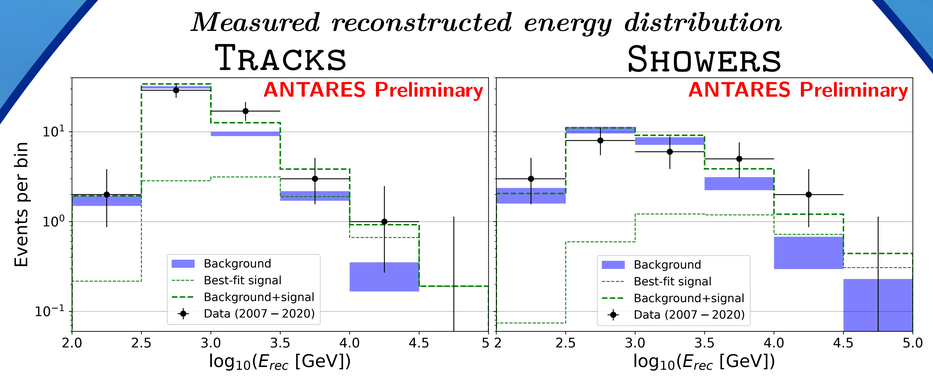
ν_e charged current and neutral currents
Angular resolution: <3°

[NIM.A 656 (2011), 11-38]

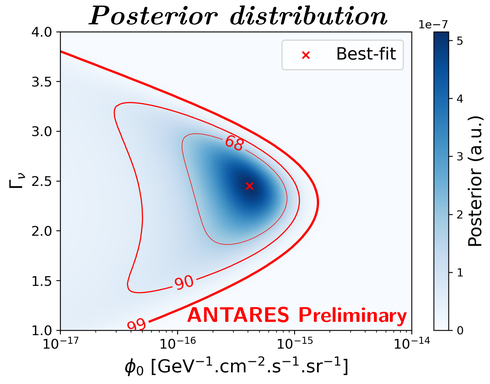
Sensitivity: *50 GeV to >100 TeV neutrinos of all flavours*

Results

Measured reconstructed energy distribution



Posterior distribution

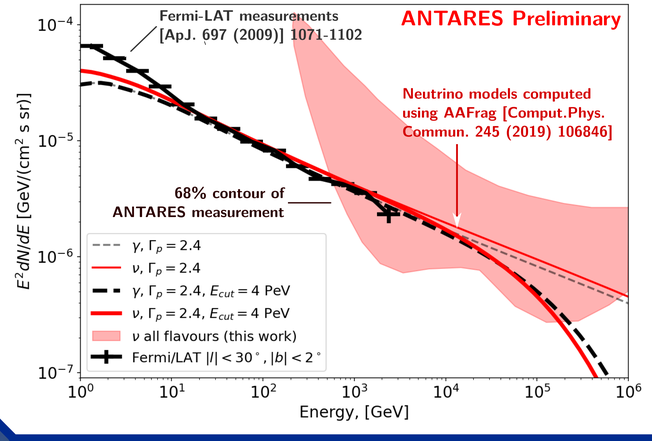


A 2σ excess from the Galactic Ridge region is obtained using ANTARES tracks+showers.

Best-fit spectrum:

$$\frac{dN_\nu}{dE_\nu} = 4.0^{+2.7}_{-2.0} \cdot 10^{-16} \left(\frac{E}{40\,\mathrm{TeV}}\right)^{-\left(2.45^{+0.22}_{-0.34}\right)} \mathrm{GeV}^{-1}\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}$$

$$\text{Flux at } 1\,\mathrm{GeV} = 7.6^{+5.0}_{-3.9} \cdot 10^{-16}\,\mathrm{GeV}^{-1}\mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}$$



Publication under preparation

Neutrino selection

TRACKS

☑ Events selected with quality cuts to suppress atmospheric muons. **[Phys.Lett.B 760 (2016), 143-148]**
☑ Reconstructed as upgoing.
☑ Direction within the region:
$|l| < 30°$ & $|b| < 2°$.
☑ Energy estimated using μ energy loss and correcting for detector evolution.

SHOWERS **[Phys.Lett.B 816 (2021) 136228]**

☑ Not selected as tracks.
☑ Classifiers to select good-quality showers and ν_e-like events.
☑ Direction within:
$|l| < 33°$ & $|b| < 5°$.

Analysis

❶ Dataset from 2007 to 2020.
❷ Background B_i estimated using off regions in the data.
❸ Signal $S_i^{(\Gamma)}$ for $E^{-\Gamma}$ spectrum from MC simulations **[JCAP 01 (2021), 064]** $\frac{dN_\nu}{dE_\nu} = \Phi_0 \left(\frac{E_\nu}{40\,\mathrm{TeV}}\right)^{-\Gamma}$
❹ Plot reconstructed energy E_{rec} spectra for tracks and for showers.
❺ Both are fitted with background+signal.

$$P(\Phi_0, \Gamma_\nu) = \int \prod_{i=1}^{N_{\mathrm{bins}}} \mathrm{Poisson}\left(\overbrace{N_i}^{\text{observed events}}, B_i + \Phi_0 S_i^{(\Gamma_\nu)}\right) \times \pi(\{B_i\}) \times \pi(\{S_i^{(\Gamma_\nu)}\}) \times \pi(\Phi_0, \Gamma_\nu) \times \prod_i \left(\mathrm{d}B_i \mathrm{d}S_i^{(\Gamma_\nu)}\right)$$

$P(\Phi_0, \Gamma_\nu)$: posterior probability

- $\pi(\{B_i\})$: statistical uncertainties from off regions
- $\pi(\{S_i^{(\Gamma_\nu)}\})$: 20% systematic uncertainty on MC
- $\pi(\Phi_0, \Gamma_\nu)$: flat prior on parameters
- $\prod_i \left(\mathrm{d}B_i \mathrm{d}S_i^{(\Gamma_\nu)}\right)$: marginalisation over nuisance parameters

- best-fit point
- containment contours
- sensitivities