Study of the high-energy diffuse neutrino flux with the ANTARES telescope

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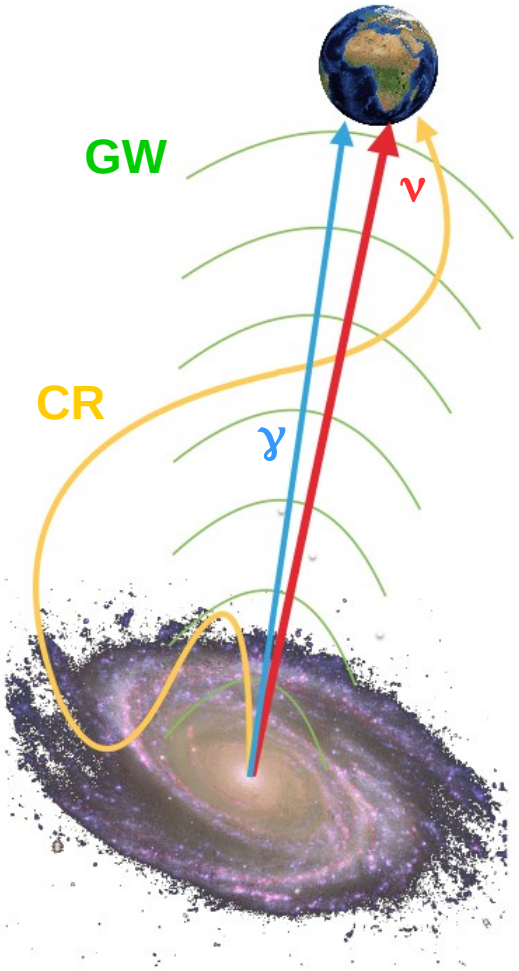
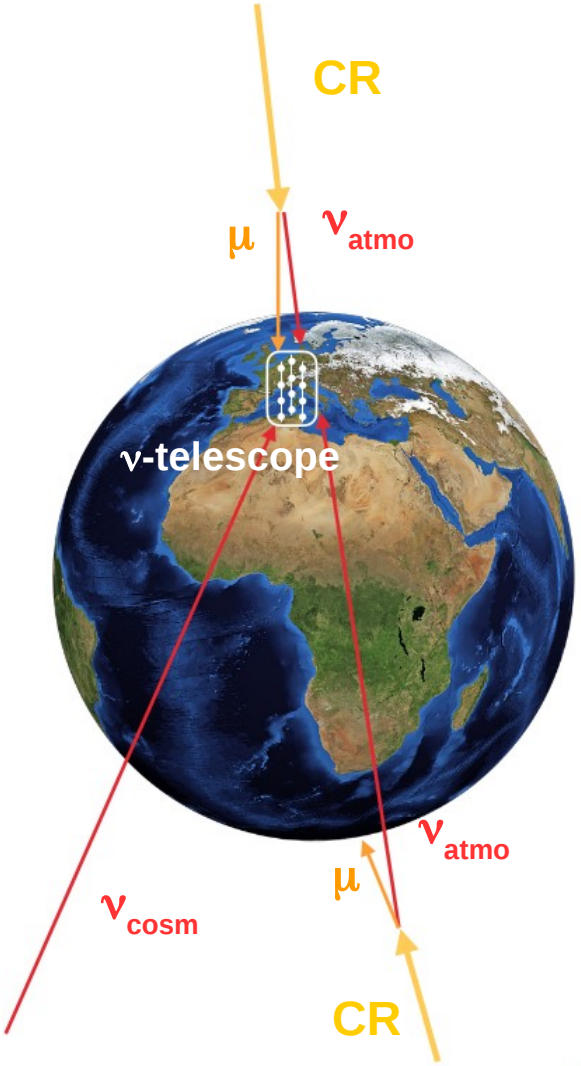
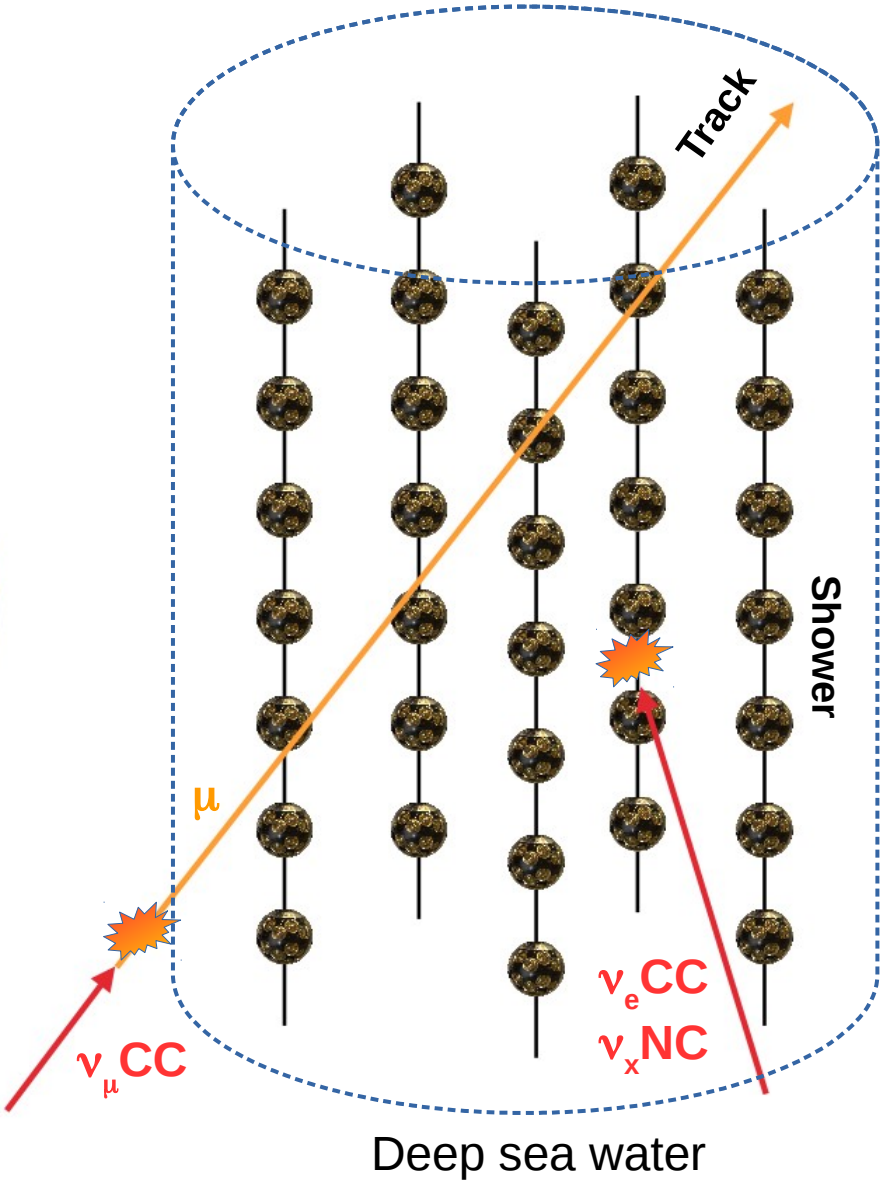
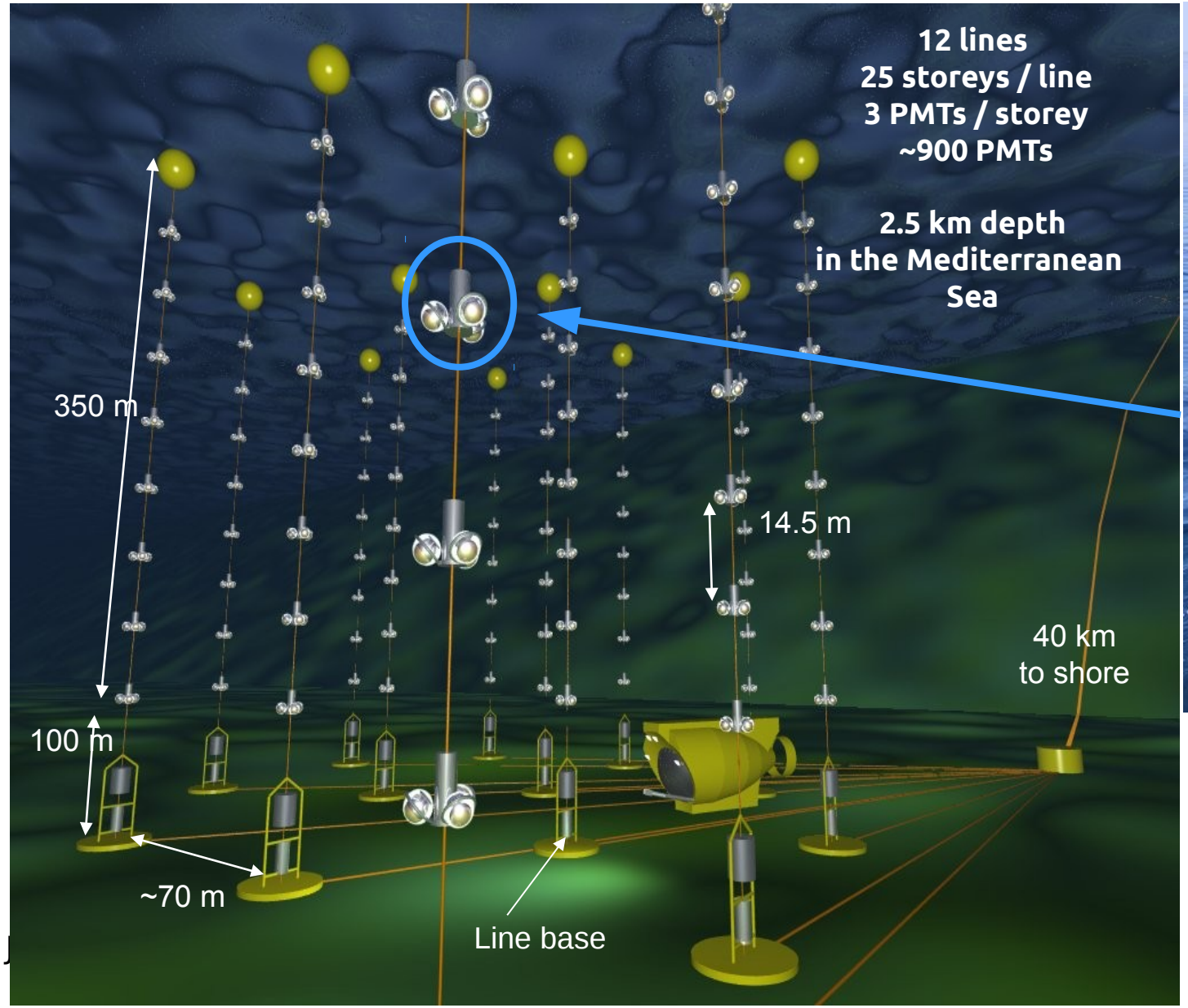
Neutrino astronomy in a nutshell







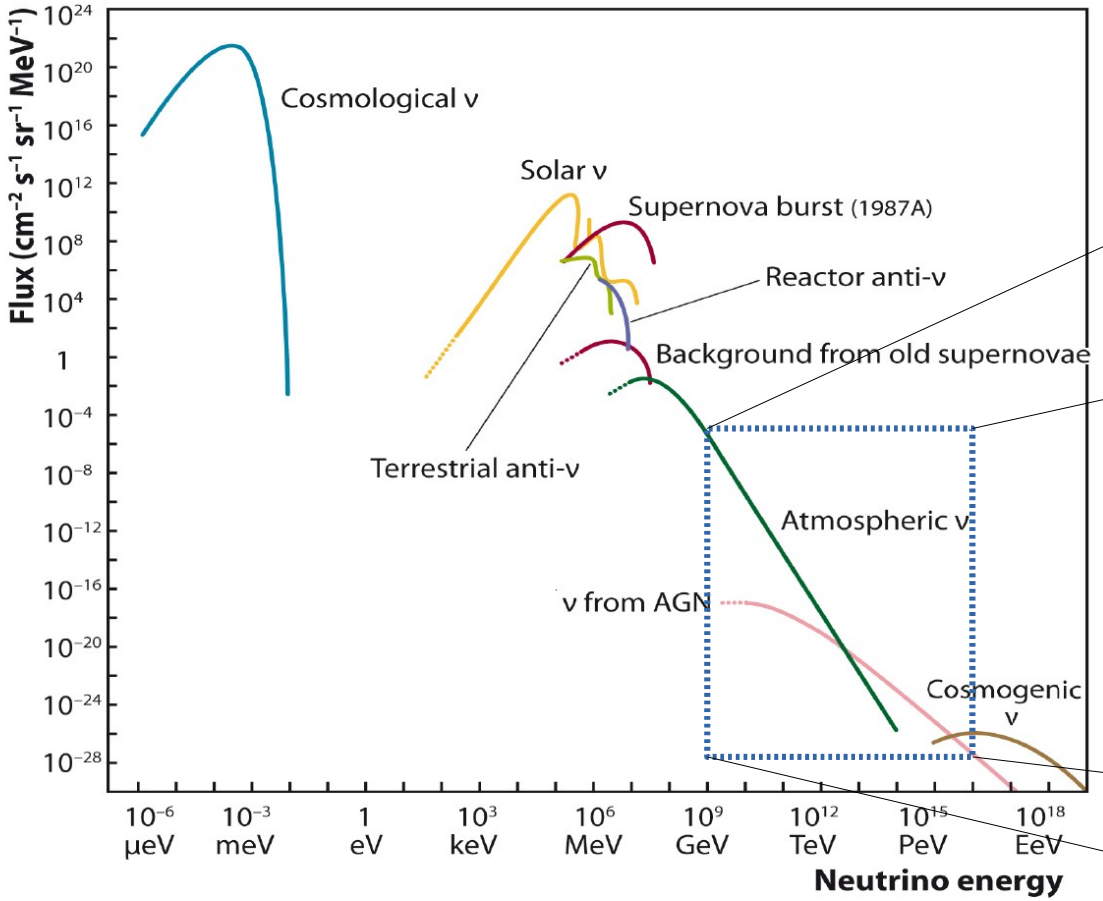
The ANTARES neutrino telescope

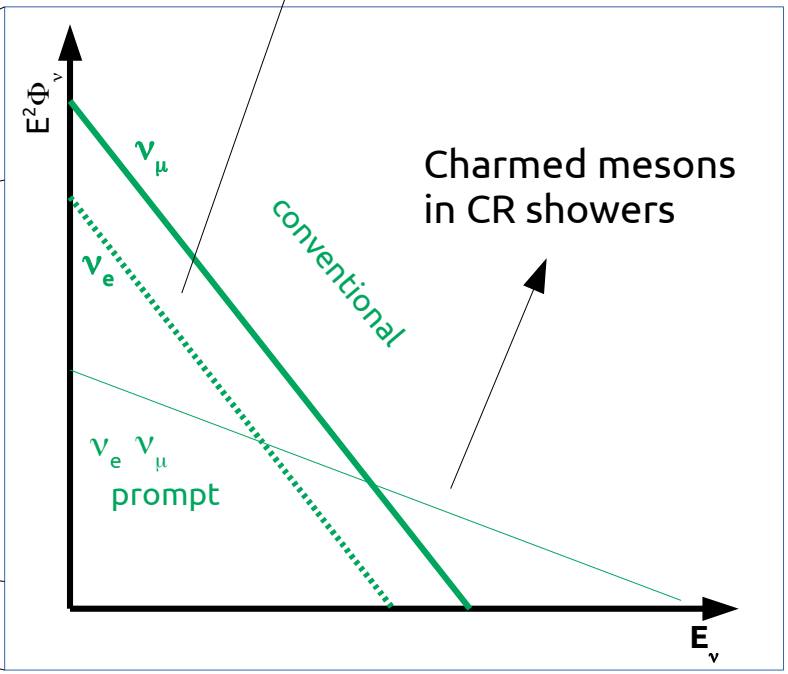


Taking data since 2007

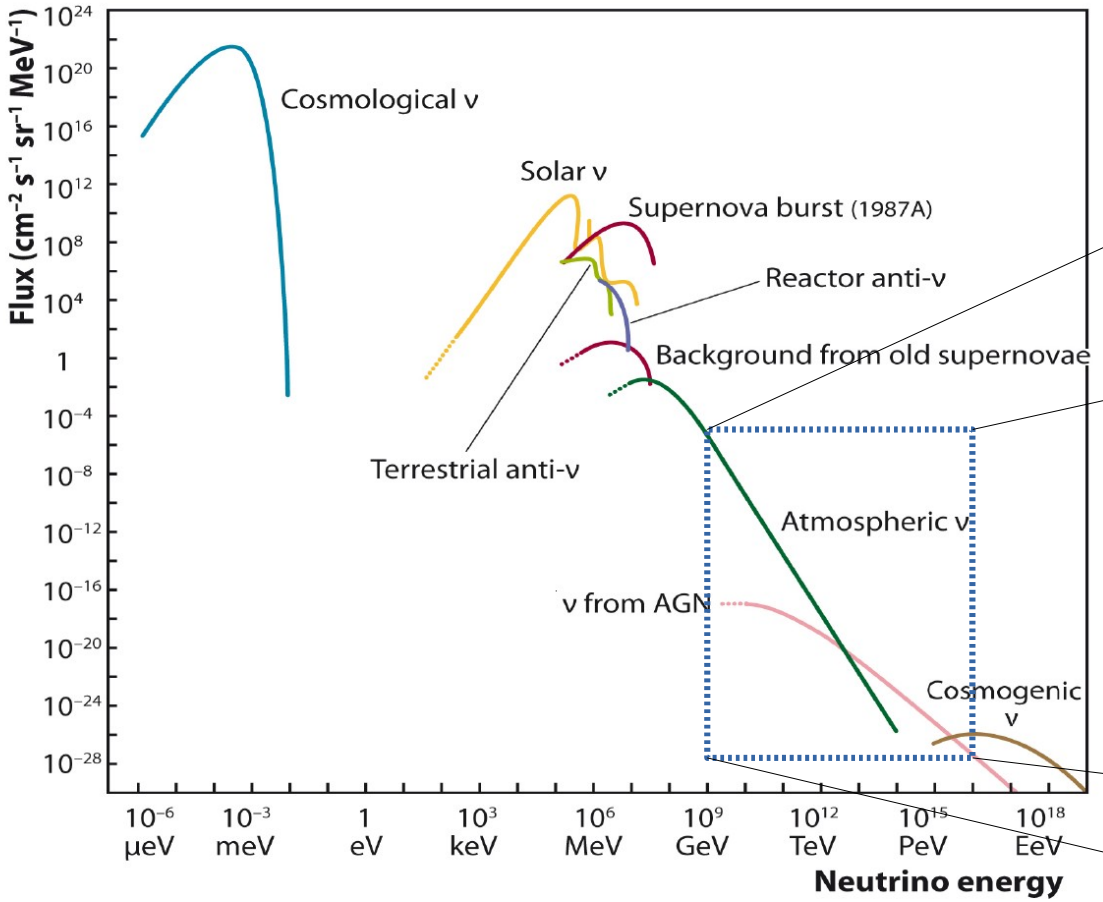
Diffuse neutrino fluxes

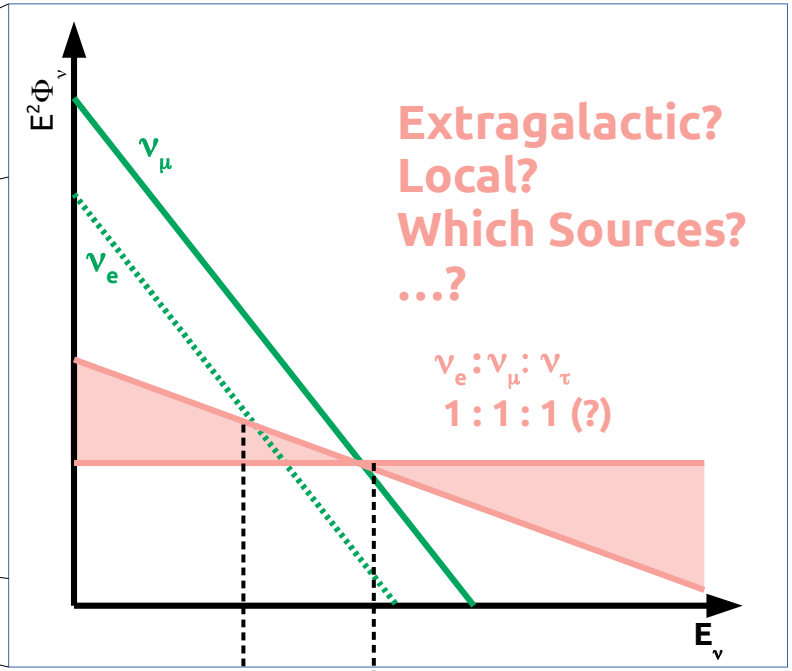
Conventional: Honda et al.
PRD **75** (2007) 043006
Prompt: Enberg et al.
PRD **78** (2008) 043005





Diffuse neutrino fluxes

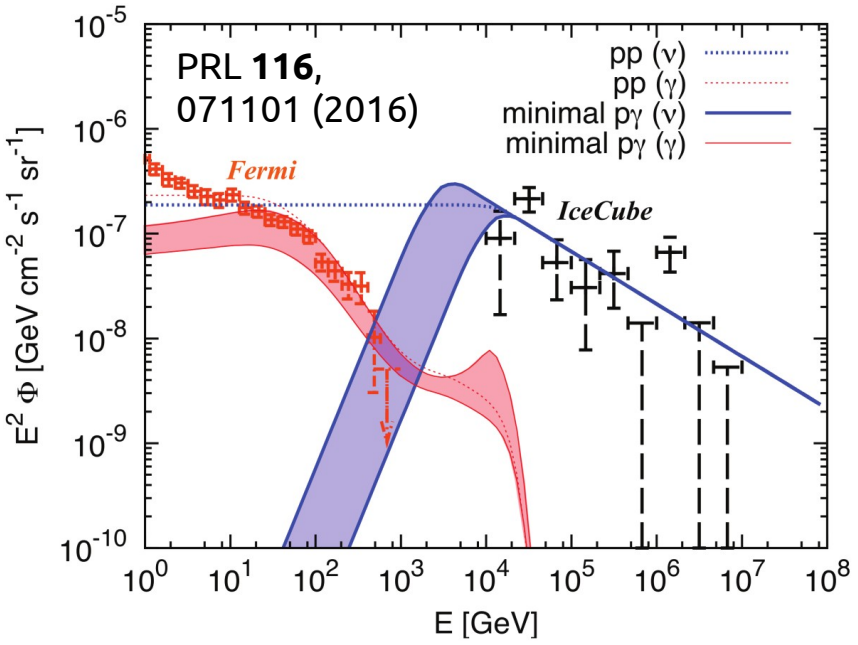


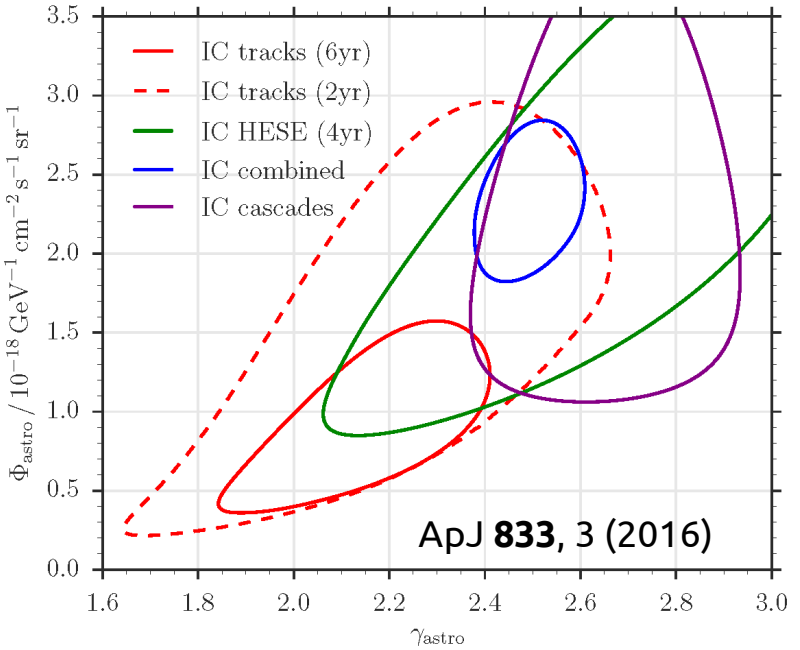


Atmos-to-Cosmic transition
30-200 TeV

High-energy diffuse neutrino fluxes

- IceCube detection → highly significant, isotropic, in flavour equipartition
- Power-law spectral behaviour
  - Too soft?
  - hard in the track channel/Northern Sky
  - soft in the shower channel/all-sky





All-flavour searches for a diffuse flux of cosmic neutrinos

Track-like events (ν_μCC + taus-to-tracks)

→ large volume + good background rejection
→ limited energy resolution + high threshold (>100 TeV)

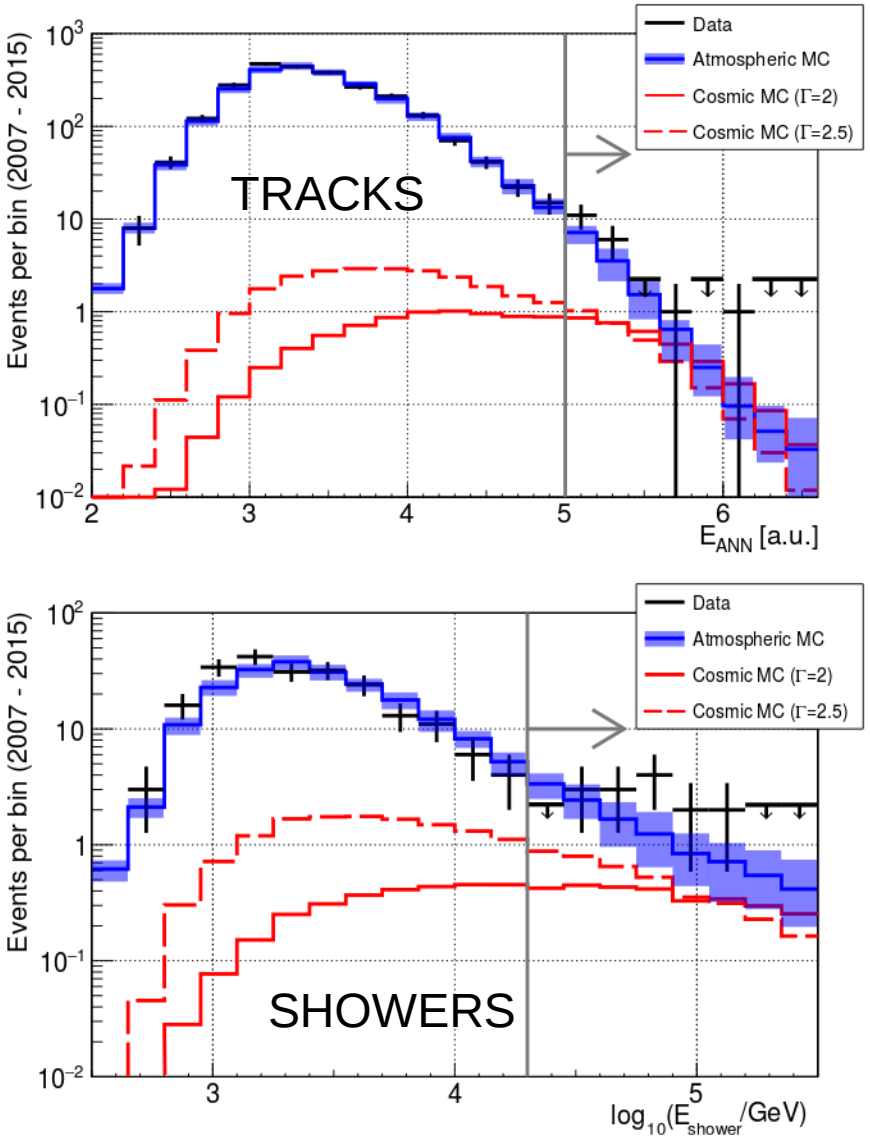
Shower-like events (ν_xNC + ν_eCC + taus-to-showers)

→ good energy reconstruction and lower background (>10 TeV)
→ only in a limited fiducial volume

ANTARES can be complementary to IceCube – even if less sensitive

The ANTARES 2007 – 2015 results

ApJ Lett **853**, L7 (2018)



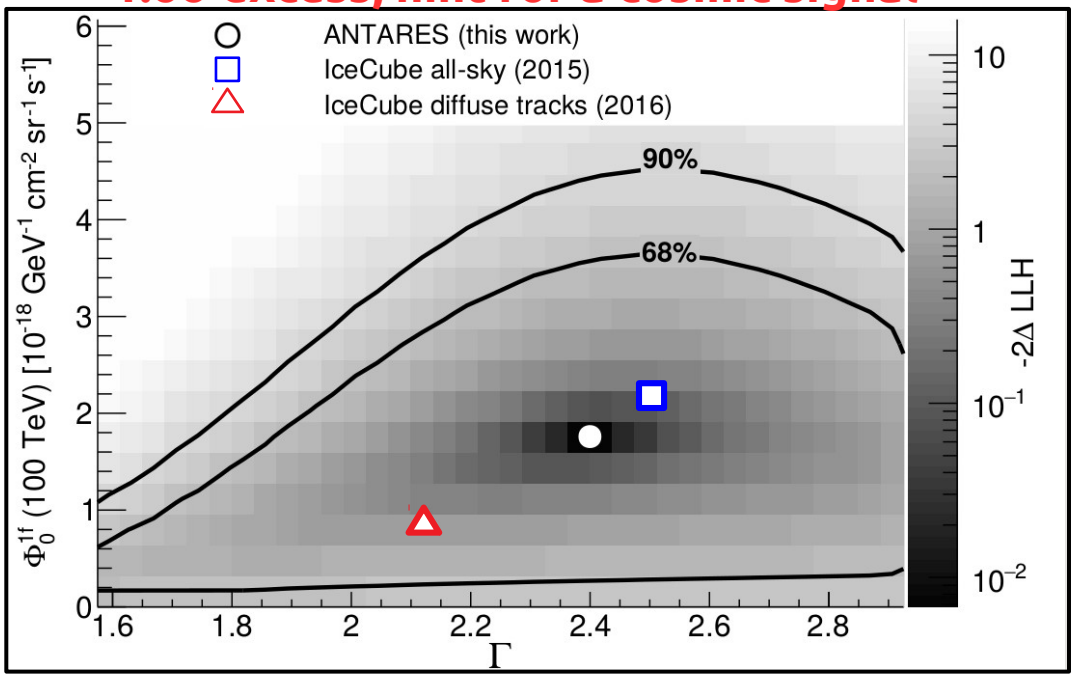
33 events (**19 tracks + 14 showers**) in **data**

24 ± 7 (stat.+syst.) events from **background MC**

Atmospheric flux 25% higher than models

Likelihood fitting of the excess

1.6σ excess, hint for a cosmic signal



$\Phi^{1f}(100\ \text{TeV}) = (1.7 \pm 1.0)\ 10^{-18}\ (\text{GeV cm}^2\ \text{s sr})^{-1}$

$\Gamma = 2.4^{+0.5}_{-0.4}$

New results (2016-2018, 880d livetime)

Preliminary

Jan 2016 – Jun 2018 to be *added to the previous sample*

Tracks, optmised selection

1.5 signal events are expected for an $E^{-2.5}$ signal spectrum with **6.4** background events

8 events in data

Showers, optimised selection

2.0 additional signal events with **5.7** expected in the background hypothesis

9 events in data

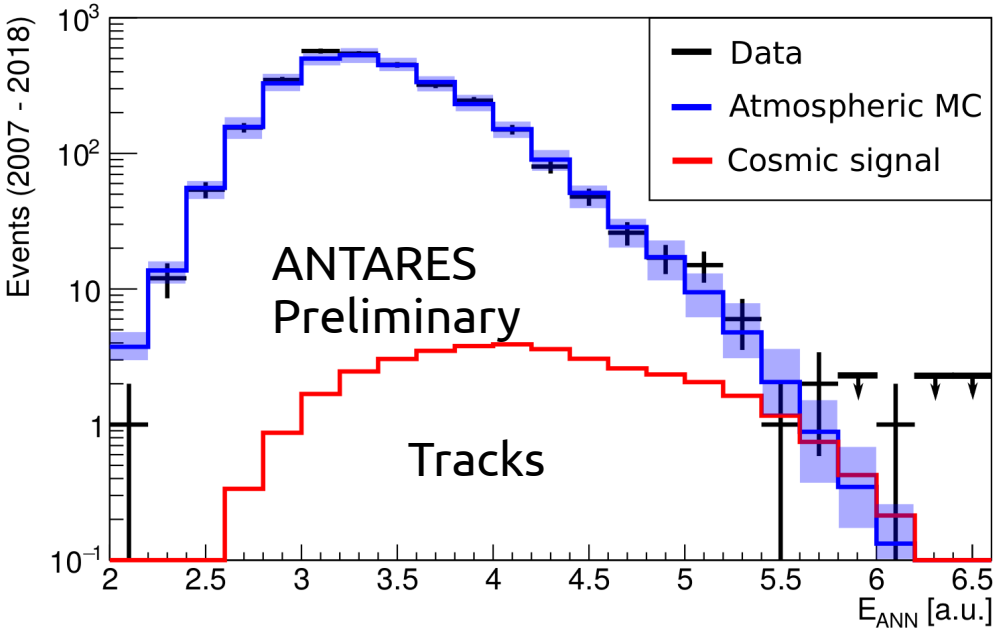
New results (2007-2018, 3380d livetime)

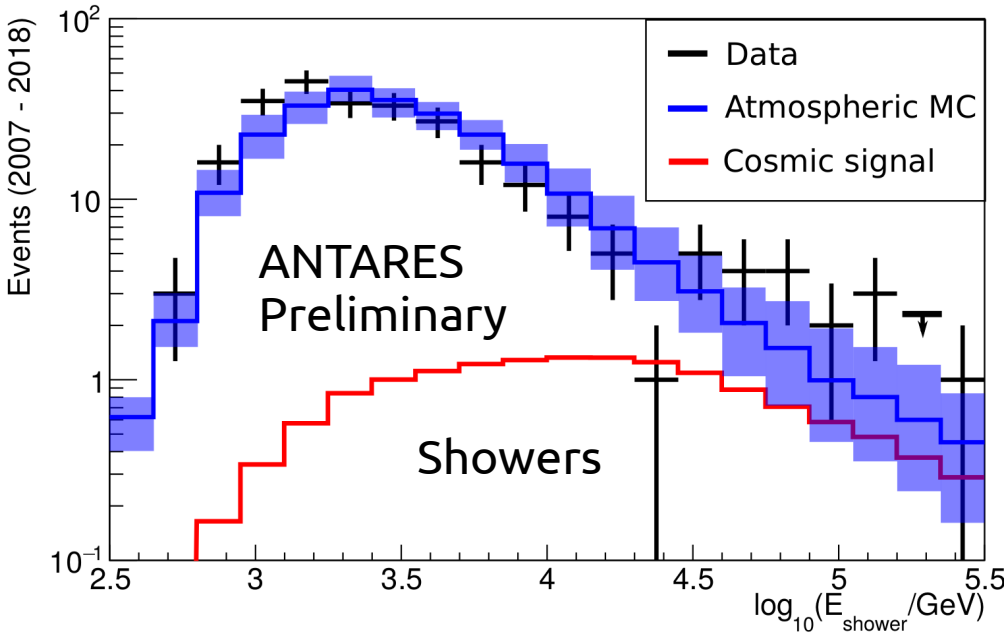
Preliminary

Jan 2016 – Jun 2018 added to the previous sample

Overall → data: 50 events (**27** tracks + **23** showers)
Overall → bkg MC: 36.1 ± 8.7 (stat.+syst.) of which **19.9** tracks and **16.2** showers

Null-cosmic rejected at 90% c.l. using counting statistics (*Conrad et al.* method, with syst.)
Atmospheric background scaled up by ~25%



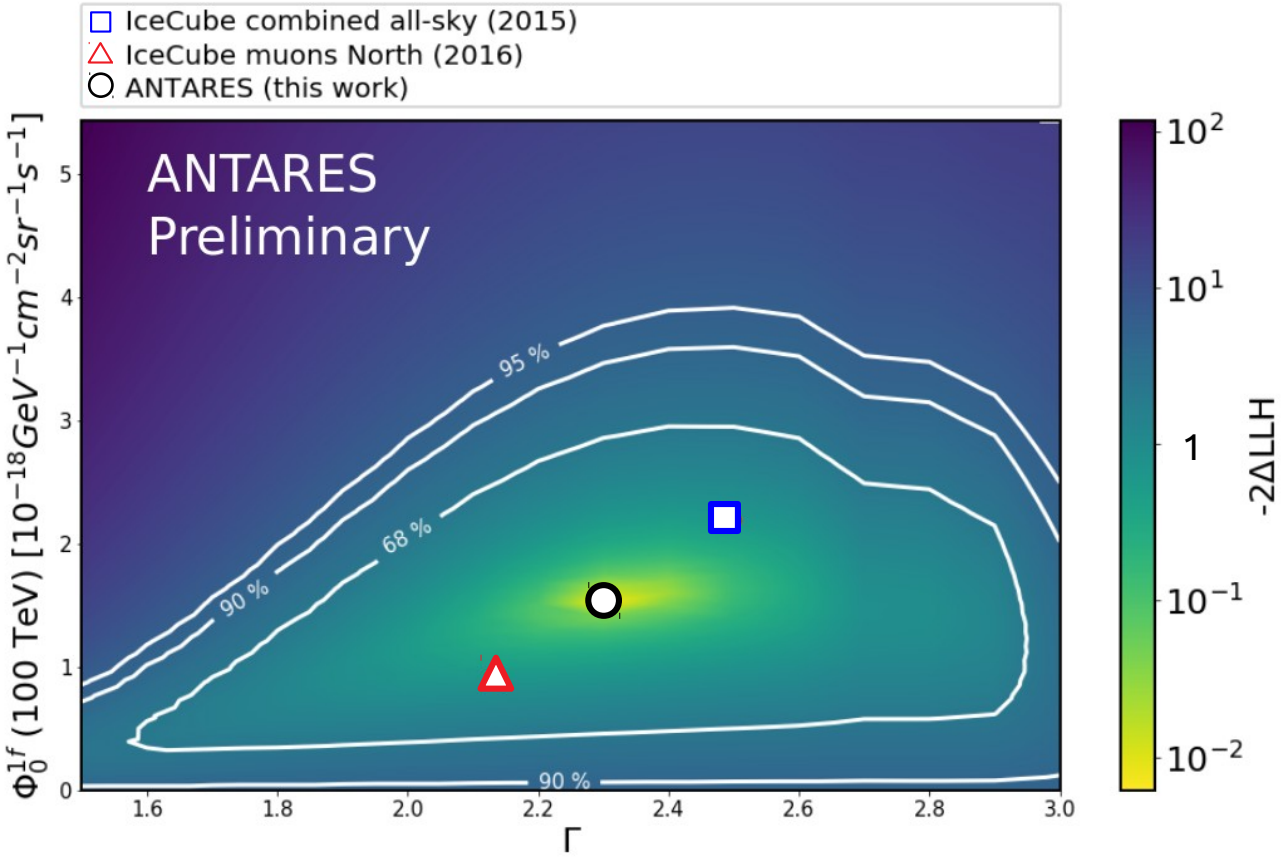


New results (2007-2018)

Preliminary

***Likelihood fitting* of the high-energy sample**

Atmospheric (Honda + Enberg together) fitted simultaneously with the cosmic flux normalisation and spectral index of the ***track and shower samples together***



$\Phi^{1f}(100\ \text{TeV}) = (1.5 \pm 1.0)$
$10^{-18}\ (\text{GeV cm}^2\ \text{s sr})^{-1}$
$\Gamma = 2.3 \pm 0.4$

Atmospheric flux
1.25 x (Honda + Enberg)

From the fit
1.8σ excess
0-cosmic excluded c.l. >90%

New results (2007-2018)

Preliminary

Individual fitting of the separate samples

Tracks $\Phi^{1f}(100\ \text{TeV}) = (0.8^{+0.5}_{-0.4})\ 10^{-18}\ (\text{GeV cm}^2\ \text{s sr})^{-1}$
$\Gamma = 2.0^{+0.8}_{-0.4}$
Atmospheric flux: **1.3 x (Honda+Enberg)**

Showers $\Phi^{1f}(100\ \text{TeV}) = (2.1 \pm 0.8)\ 10^{-18}\ (\text{GeV cm}^2\ \text{s sr})^{-1}$
$\Gamma = 2.4 \pm 0.4$
Atmospheric flux: **1 x (Honda+Enberg)**

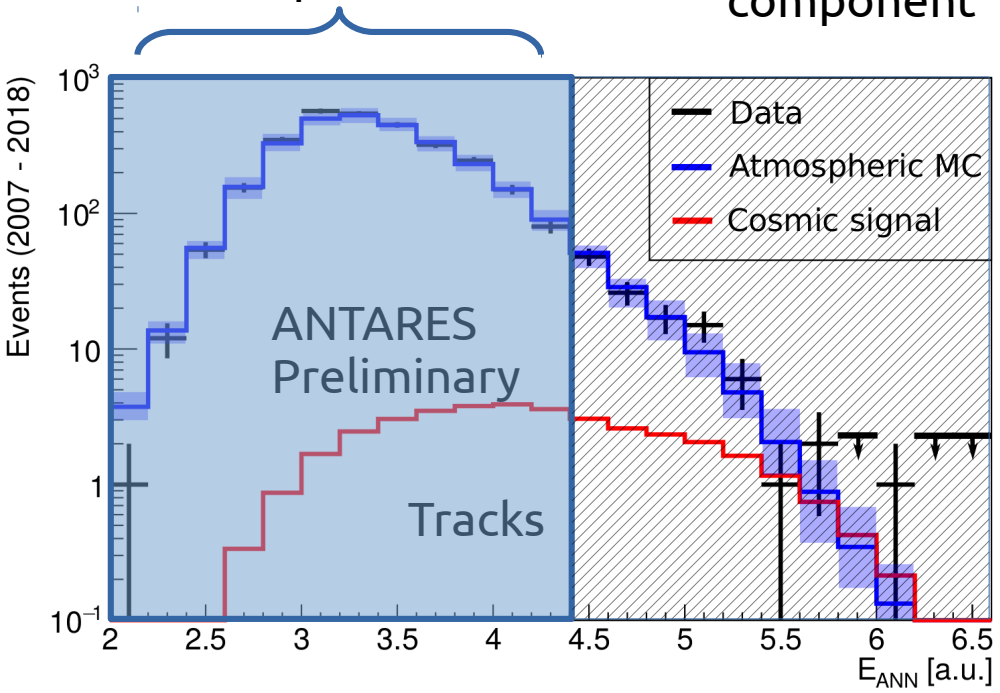
Not really significant but still interesting

New results (2007-2018)

Preliminary

Atmospheric neutrinos

Low-energy sample → Dominated by the conventional component → Constrain its contribution by fitting the distribution



$\Phi_{conv} = 1.3 \pm 0.1 \times \Phi_{Honda}$

$\Delta\Gamma = -0.1 \pm 0.1$

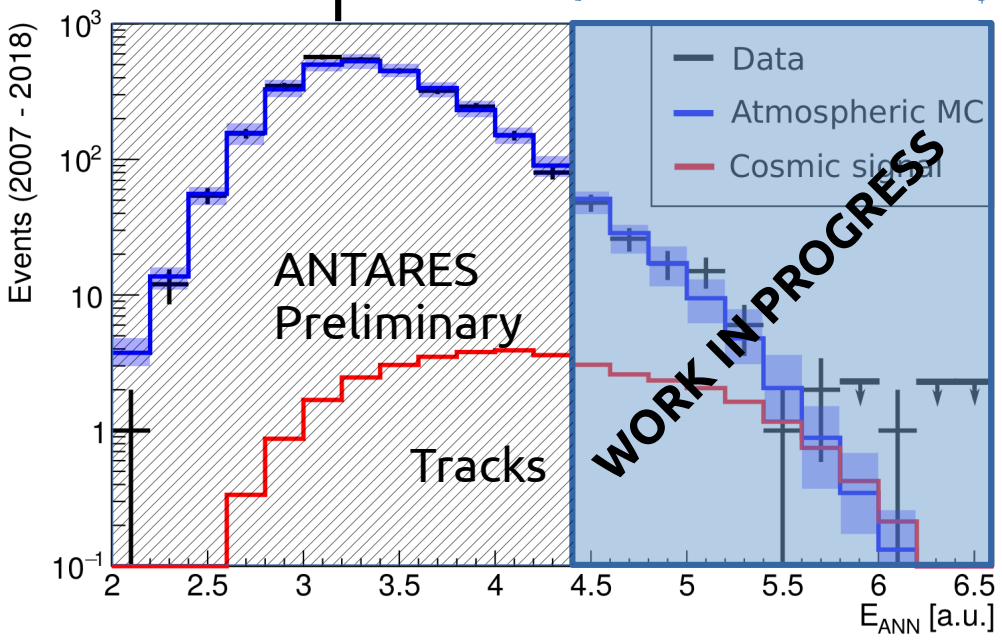
New results (2007-2018)

Preliminary

Atmospheric & cosmic neutrinos

$\Phi_{conv} = 1.3 \times \Phi_{Honda}$

$\Delta\Gamma = -0.1$



Fix conventional to the low-energy fit

Assess the prompt/cosmic contribution in the results

+ more on atmospherics from a new shower sample selection in development

Outlook

- 2007-2018 data sample: **50** events in data with **36.1 ± 8.7** from MC backgrounds
- **1.8σ** excess over the (Honda + Enberg) flux
- Likelihood fit of the excess
- Null-cosmic excluded at 90% c.l.

- Re-optimisation in the shower channel ongoing with **improved background rejection**
- **New MC** to solve data/MC issues in the energy estimation
- **Better handle on atmospheric component** also in the shower channel