All-flavour cosmic diffuse neutrino search with ANTARES

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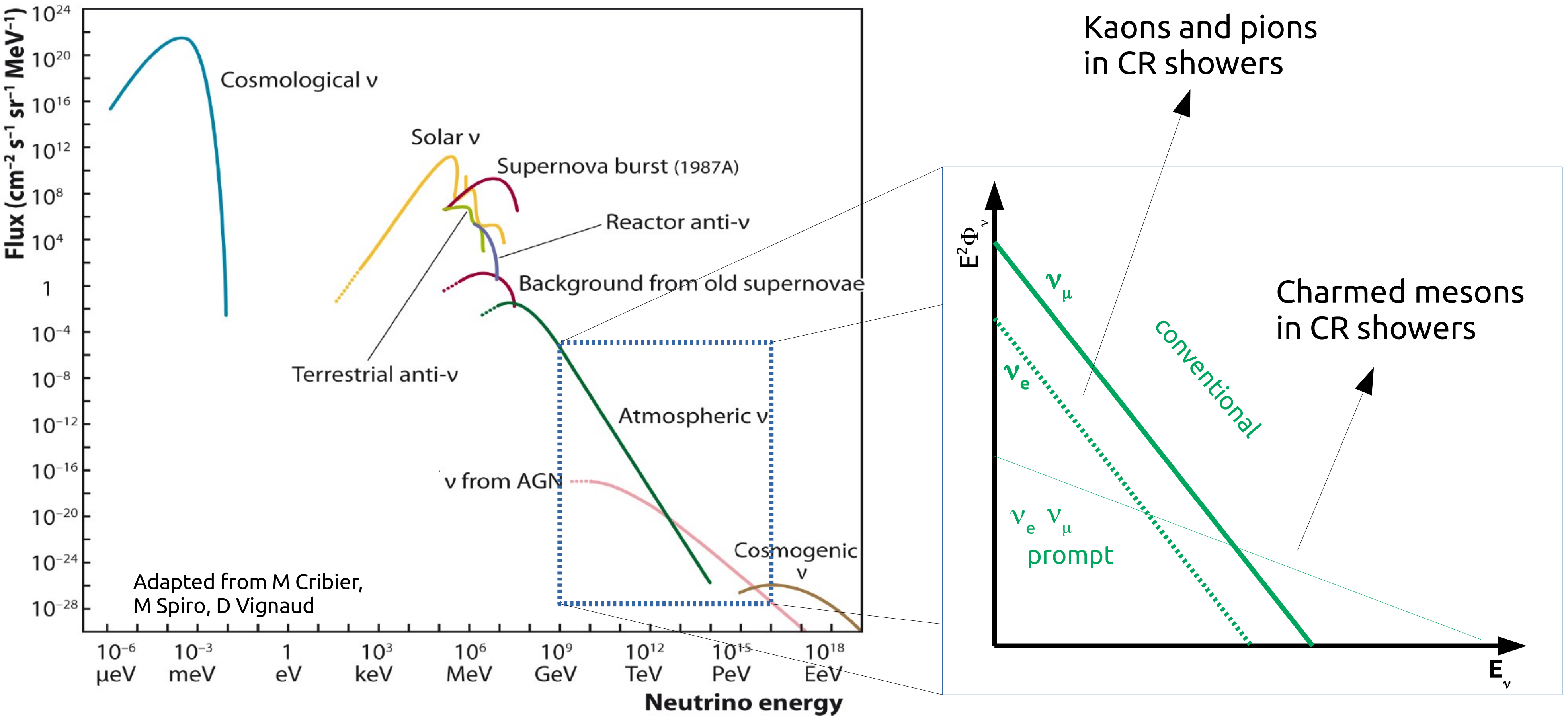
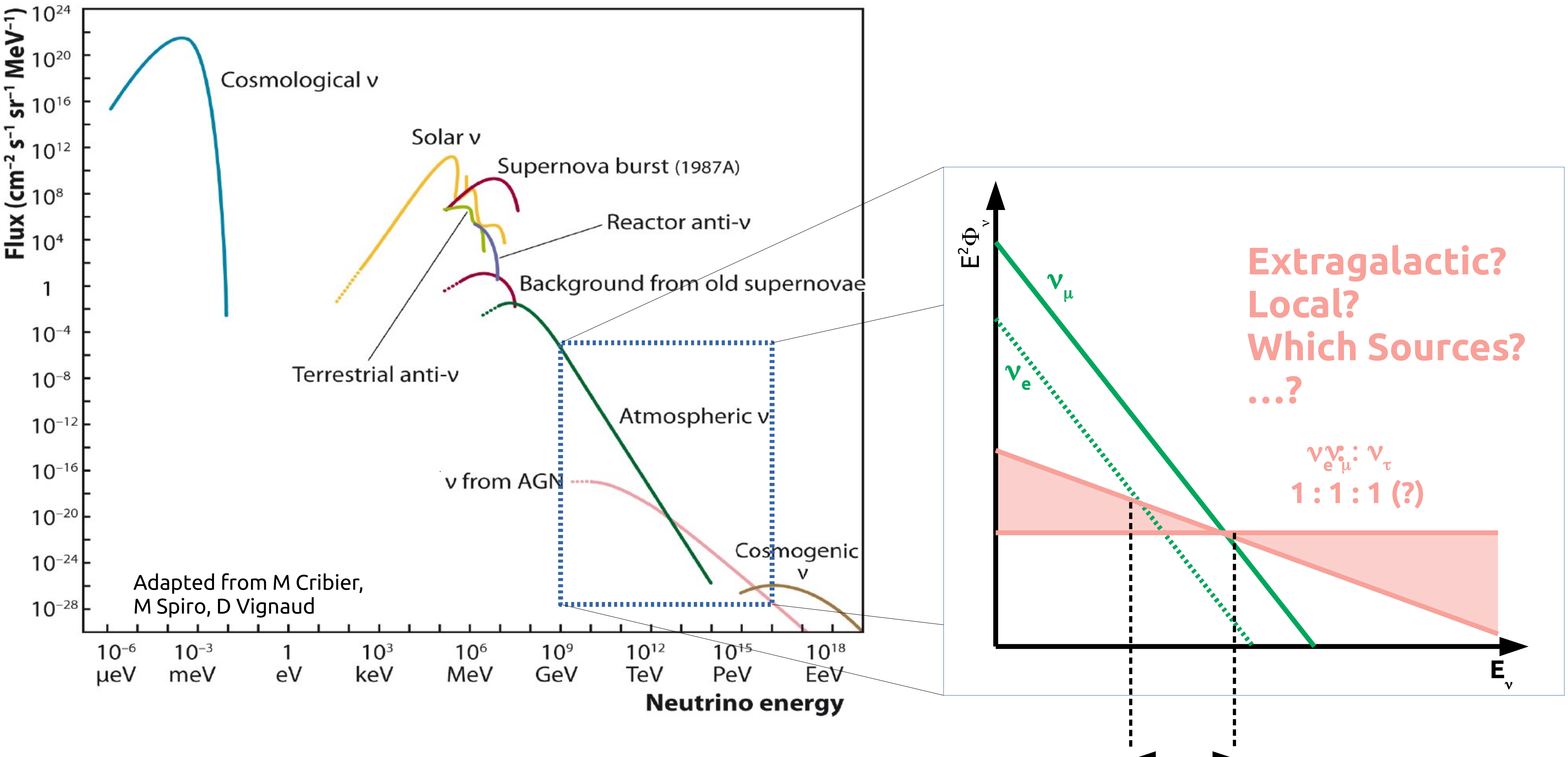
VLVnT2021

HE Diffuse neutrino fluxes



HE Diffuse neutrino fluxes



Atmos-to-Cosmic transition
30-200 TeV

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 is complementary to IceCube – even if less sensitive**

The ANTARES event samples

- **Tracks**
  - Sub-degree angular resolution
  - Rough energy estimation (0.3-0.5 decades)
  - Best rejection of atmospheric muon foregrounds (<%)

  ~1 ev/d for atmospheric fluxes

- **Showers**
  - 2-4 degree angular resolution
  - Optimal energy resolution (10-20%)
  - ~OK rejection of atmospheric muon foregrounds (~20-40%)

  <0.1 ev/d for atmospheric fluxes

The ANTARES new event samples

- **Tracks**
  - Sub-degree angular resolution
  - Rough energy estimation (0.3-0.5 decades)
  - Best rejection of atmospheric muon foregrounds (<%)

  ~1 ev/d for atmospheric fluxes

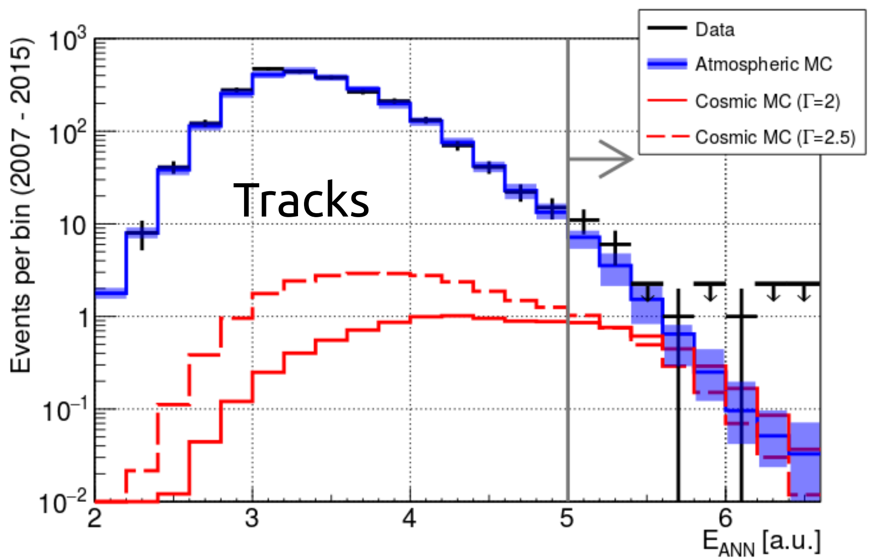
- **Showers**
  - 2-4 degree angular resolution
  - Optimal energy resolution (10-20%)
  - ~~~OK rejection of atmospheric muon foregrounds (~20-40%)~~

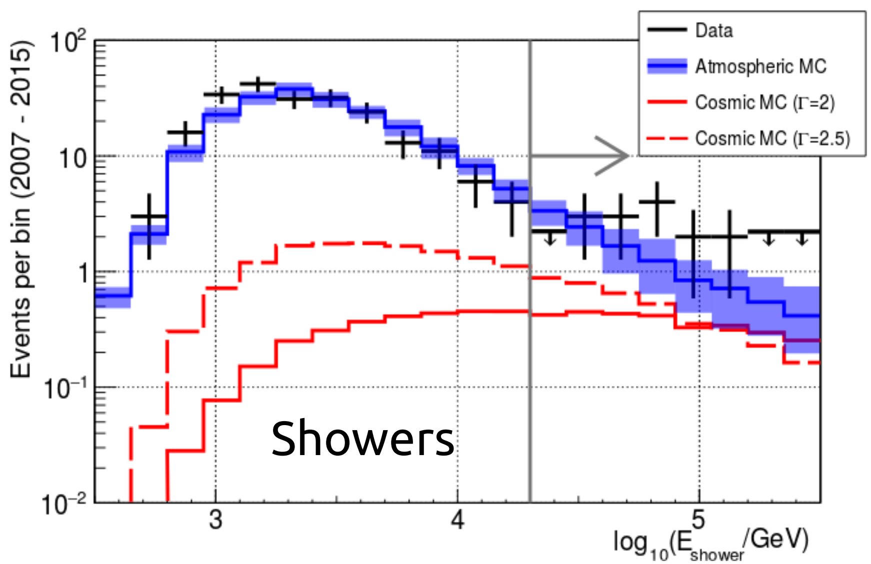
  Very good rejection of atmospheric muon foregrounds (<%)

  ~0.3 ev/d for atmospheric fluxes

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

The old, 2007-2015 results





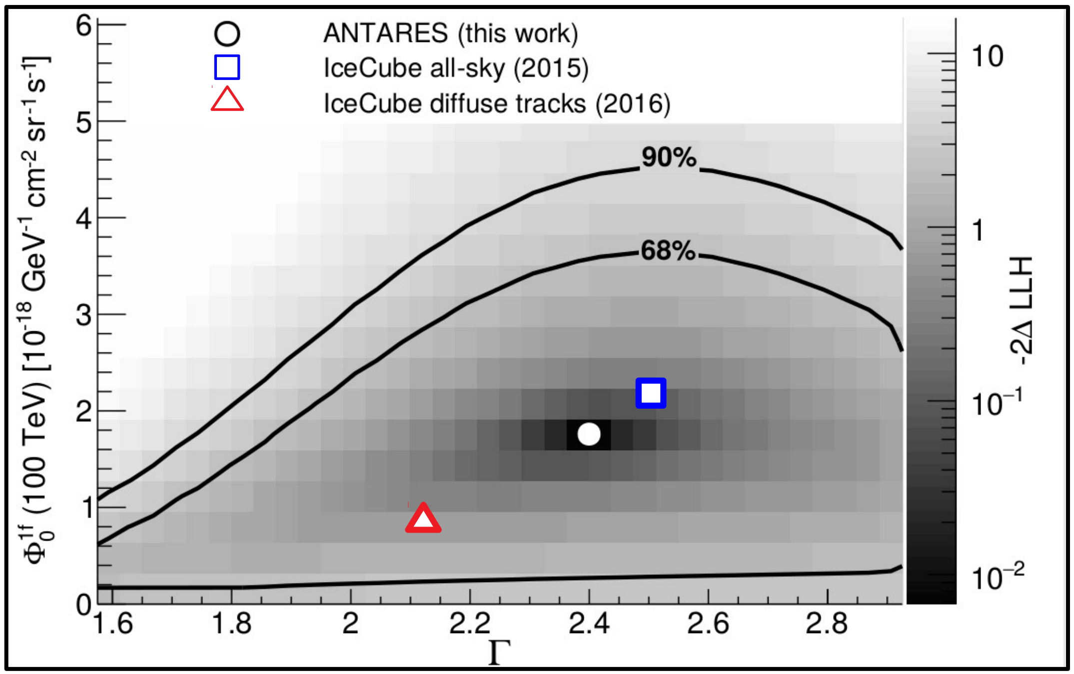
33 events (**19 tracks + 14 showers**) in **data**

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

Atmospheric flux 25% higher than models

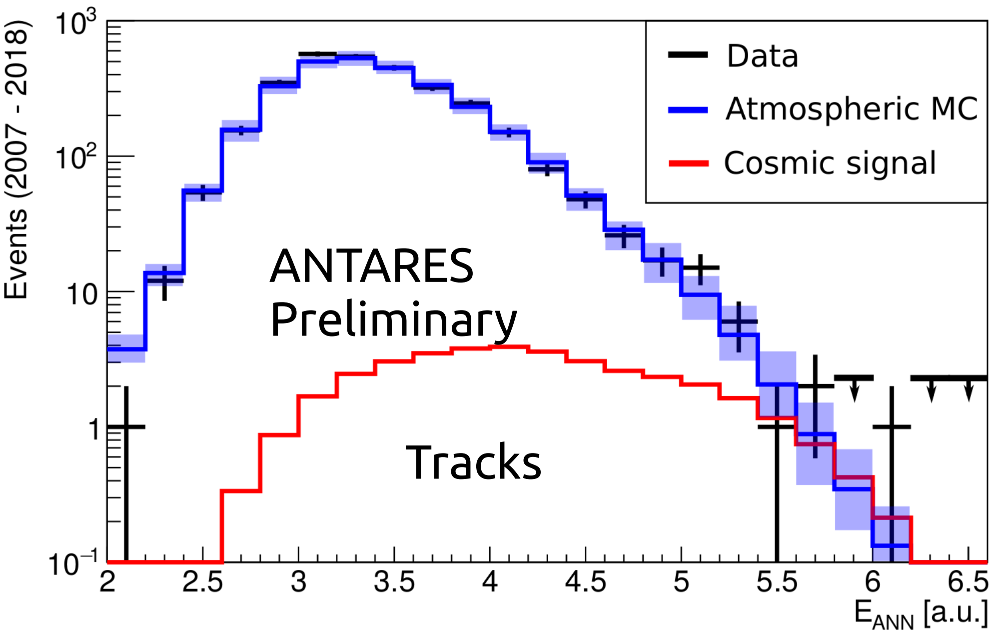
Likelihood fitting of the excess

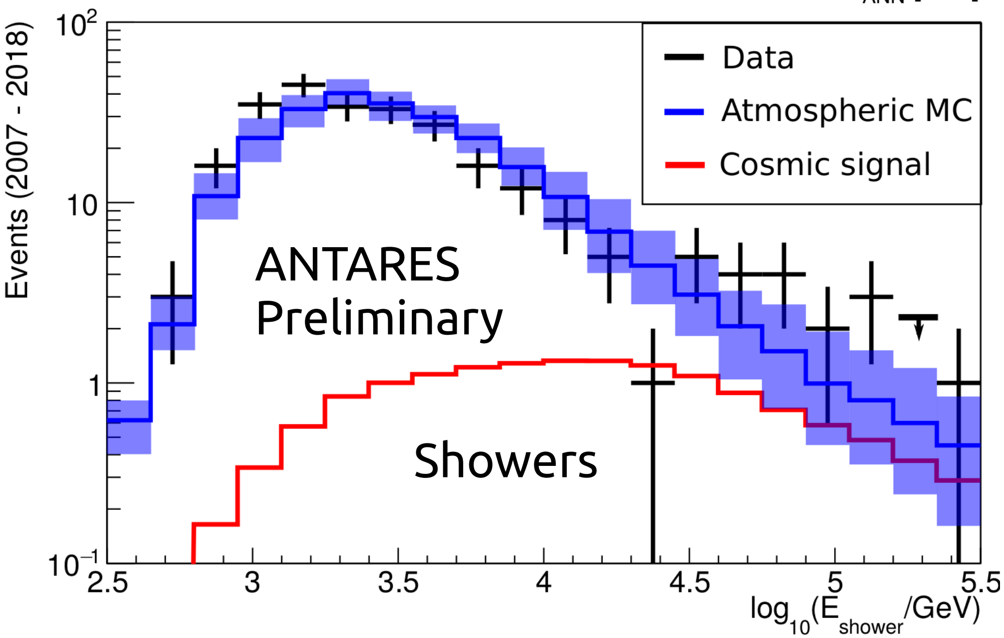
1.6σ excess, hint for a cosmic signal



PoS(ICRC2019)
891

The ICRC19 results, 2016-2018 added-up

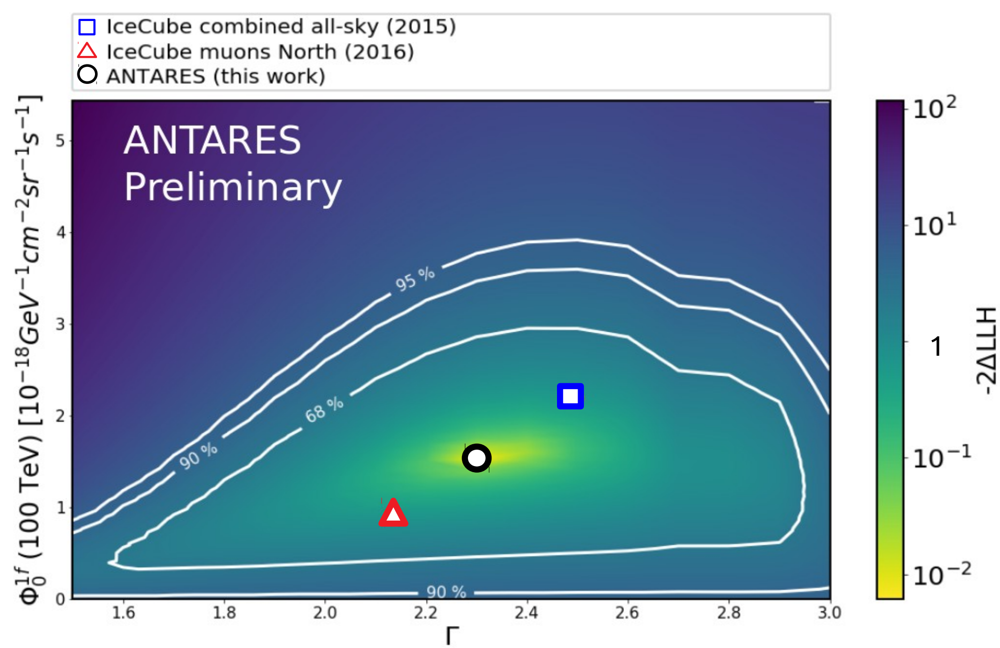




~same event selection

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

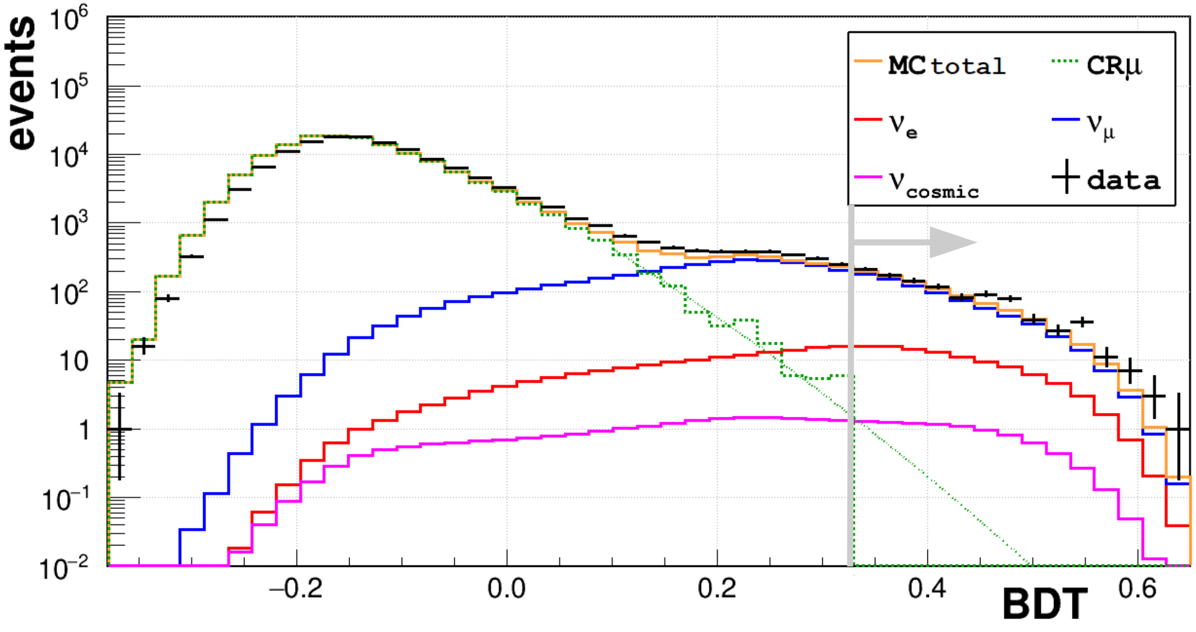
1.8σ excess
0-cosmic excluded c.l. >90%



PLB **816** (2021) 136228

The new shower selection

- Developed for measuring the spectrum of atmospheric neutrinos
- All-flavour showering events included



Multivariate analysis (BDT) to remove track-like events:

– keeps all-flavour “contained” events

– mainly rejects wrongly reconstructed atmospheric muons

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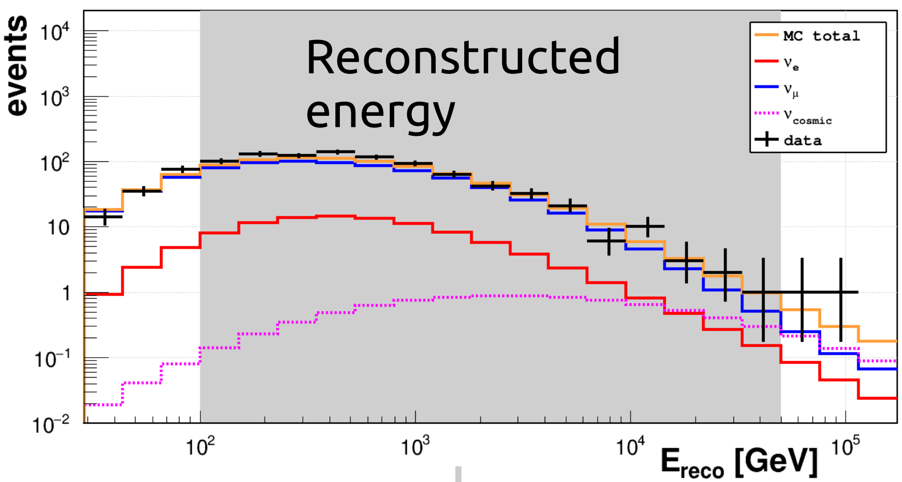
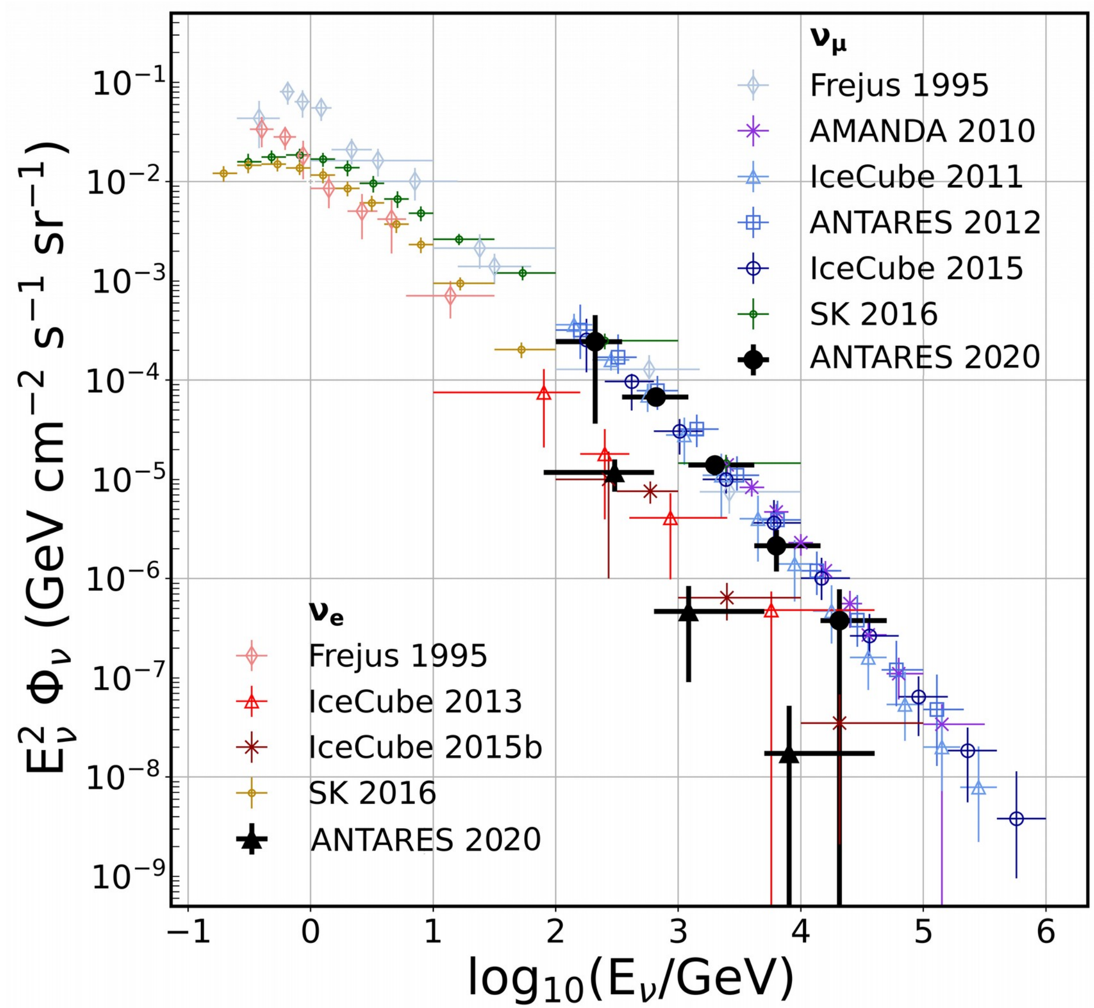
The new shower selection

- Unfolding applied on the reconstructed energy distribution to obtain "true" neutrino energy distribution



Unfolding + effective area + systematics evaluation



Applying it to the cosmic diffuse analysis

- The same event selection can be applied to a diffuse analysis

  Pros:

  - Strong reduction of the atmospheric muon background

    → remove the largest systematic uncertainties in the previous analysis

  - Large statistics (x5 with respect to the old selection) at lower energies

    → improve the precision of the likelihood estimation

  Cons:

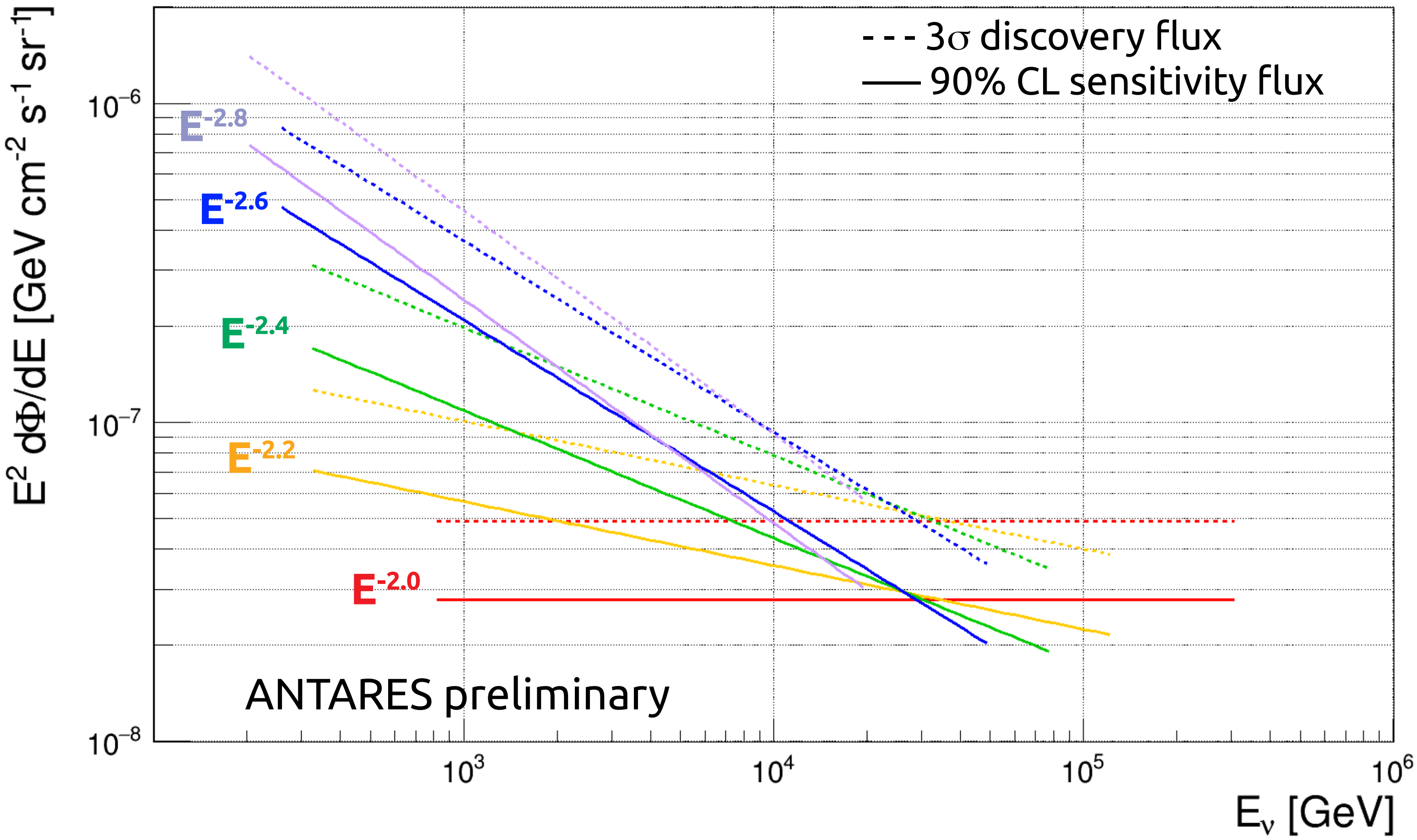
  - Slightly lower effective area above 50 TeV

Applying it to the cosmic diffuse analysis

- Also, in development, new analysis method
  - Move from a binned to an unbinned analysis
  - Use 2D (zenith-energy) or 3D (zenith-energy-background discriminator) PDF for tracks and cascades
  - First sensitivities produced for the shower sample

Sensitivities of new shower sample

Tested all-sky, power-law spectra from E^{-2} to $E^{-2.8}$
No systematics added yet



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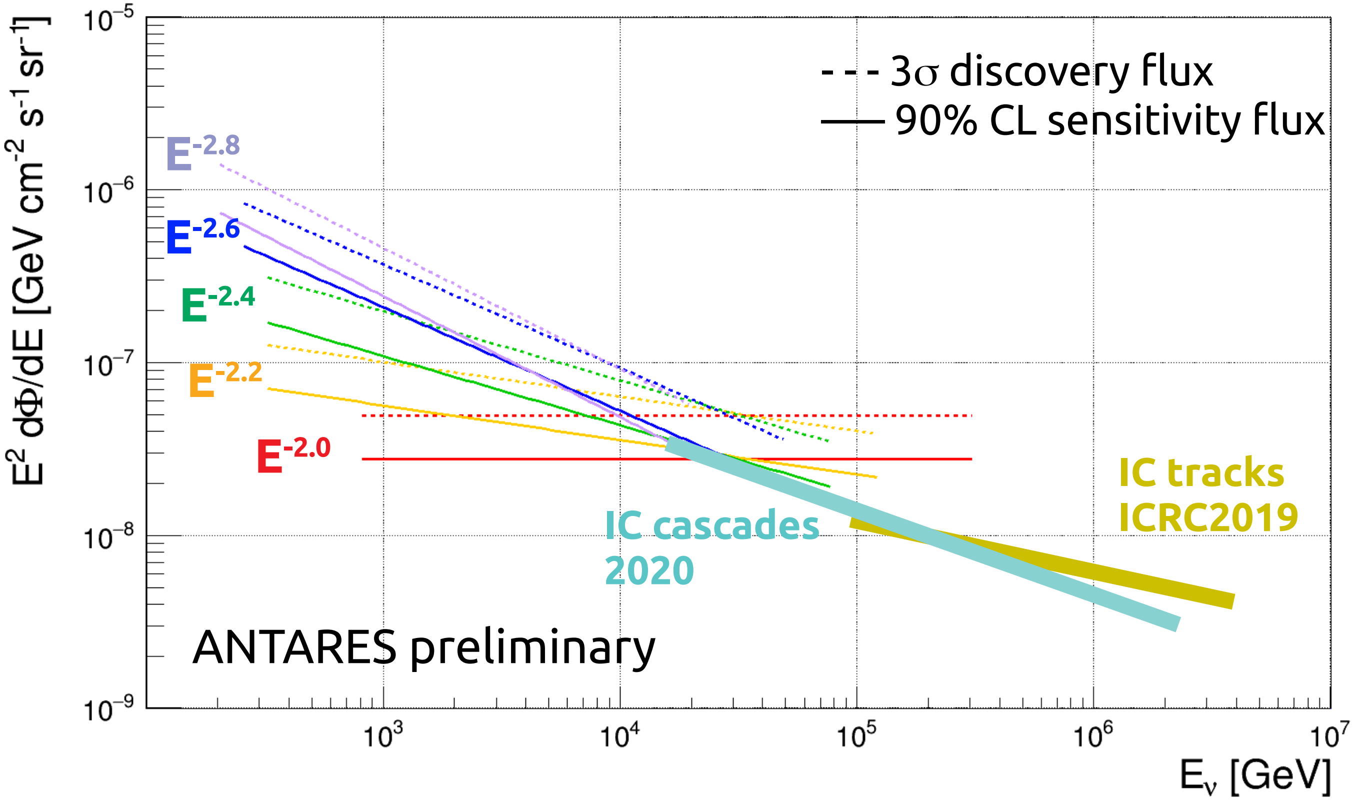

Note: Different definition of the validity energy range between ANTARES and IceCube

Outlook

- Mild excess of high-energy neutrinos observed in ANTARES
- Currently exploiting new ways to improve the results, as presented today
  - New event selection
  - Improved systematics
  - New analysis method
- Updated results expected for the summer