

# *Astrophysical or Atmospheric prompt neutrinos in Icecube?*

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*talk 291, 25 February 2021*

<https://pos.sissa.it/331/007/>

**2019**

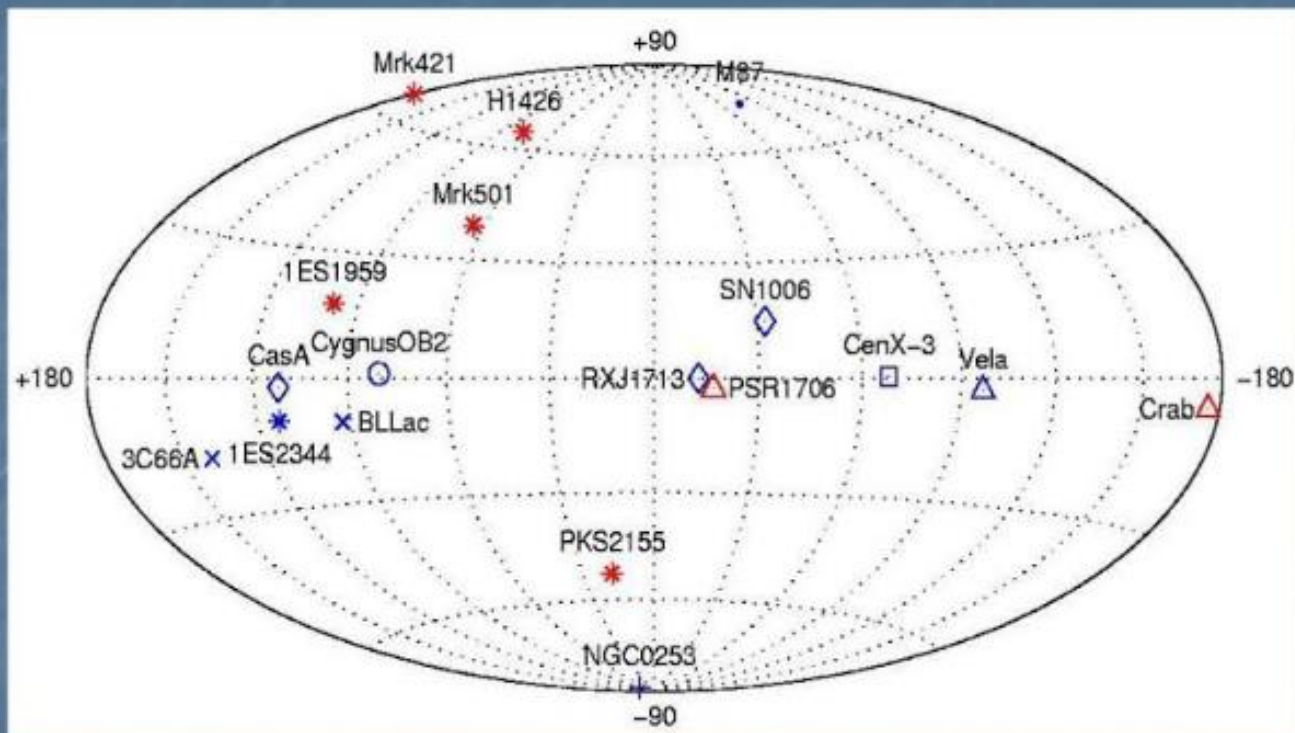
*A charming ICECUBE discover?*

# Open questions to Icecube

- *After a decade of Highest Energy Neutrino records at several tens TeV in Icecube we had observed among hundreds of events,*
- *(except an unique delayed neutrino-gamma 2017 flare):*
- 
- *NO any sharp correlated brightest gamma-neutrino source event.*
- *No brightest GRBs or SGRs .*
- *NO significant multi-plet clustering among HESE.*
- *NO Icecube any galactic plane signature.*
- *No significant tau double bangs.*
- *YES an Icecube comparable electro-muon nu flavor presence.*
- *All these almost missing imprint for any astrophysics are pointing to the main discover of the atmospheric charm neutrino signature able to rule and overcome and hide the underline astrophysical one.*

*The Earliest, the brightest gamma sources:  
All absent in ICECUBE*

Tev Gamma-ray Sky Status c.2003



18 Sources reported in refereed literature;  
10 are Extragalactic, 8 are Galactic

# All GRBs in cosmic map, none are correlated in space-time with Icecube

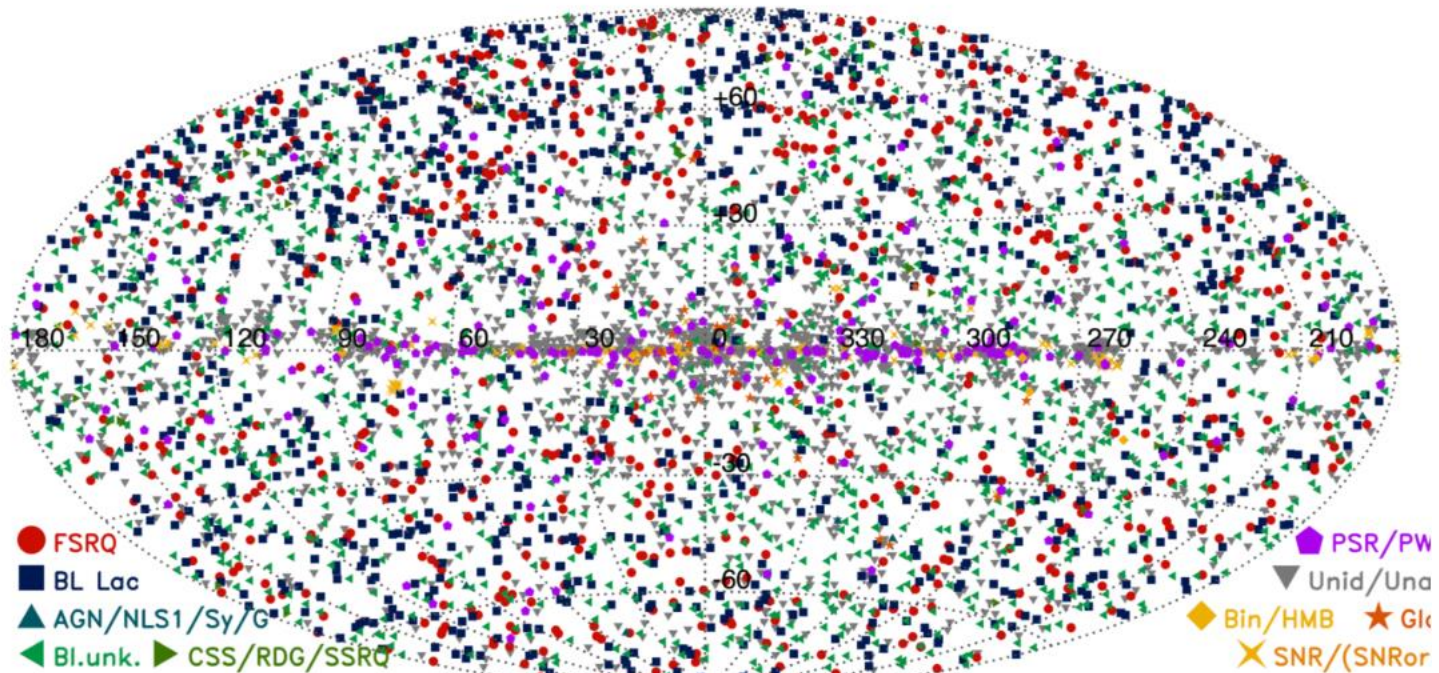
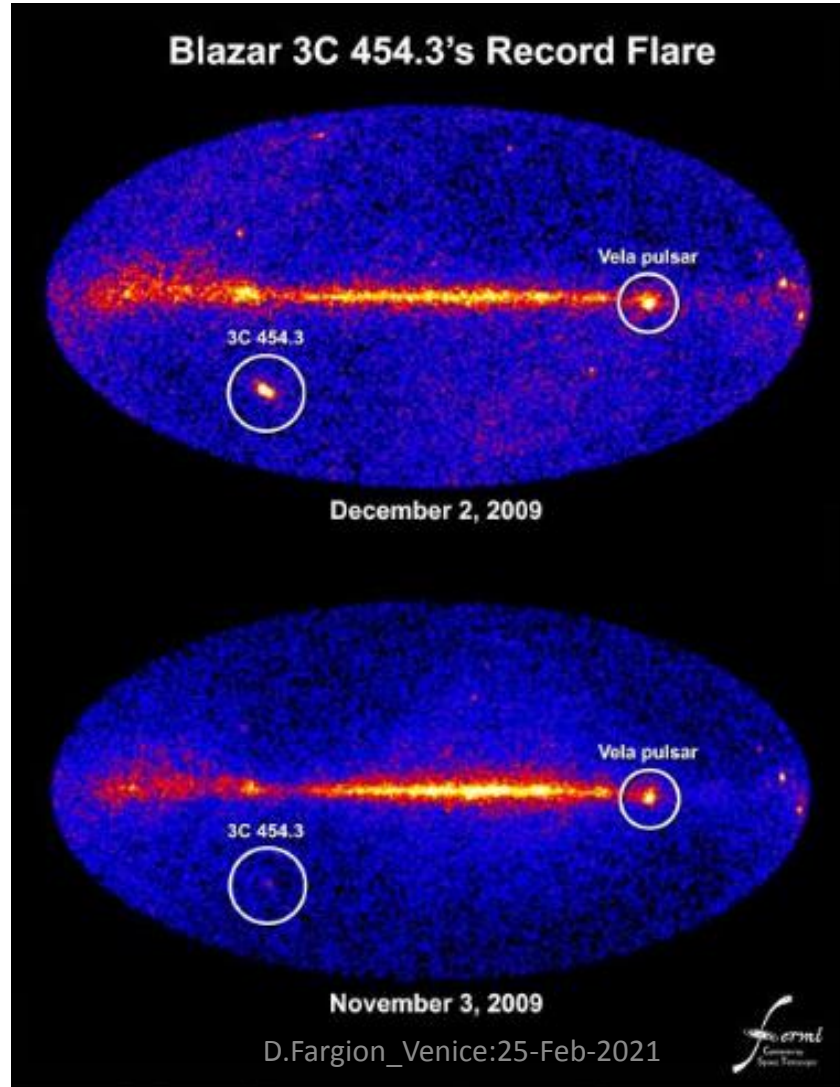


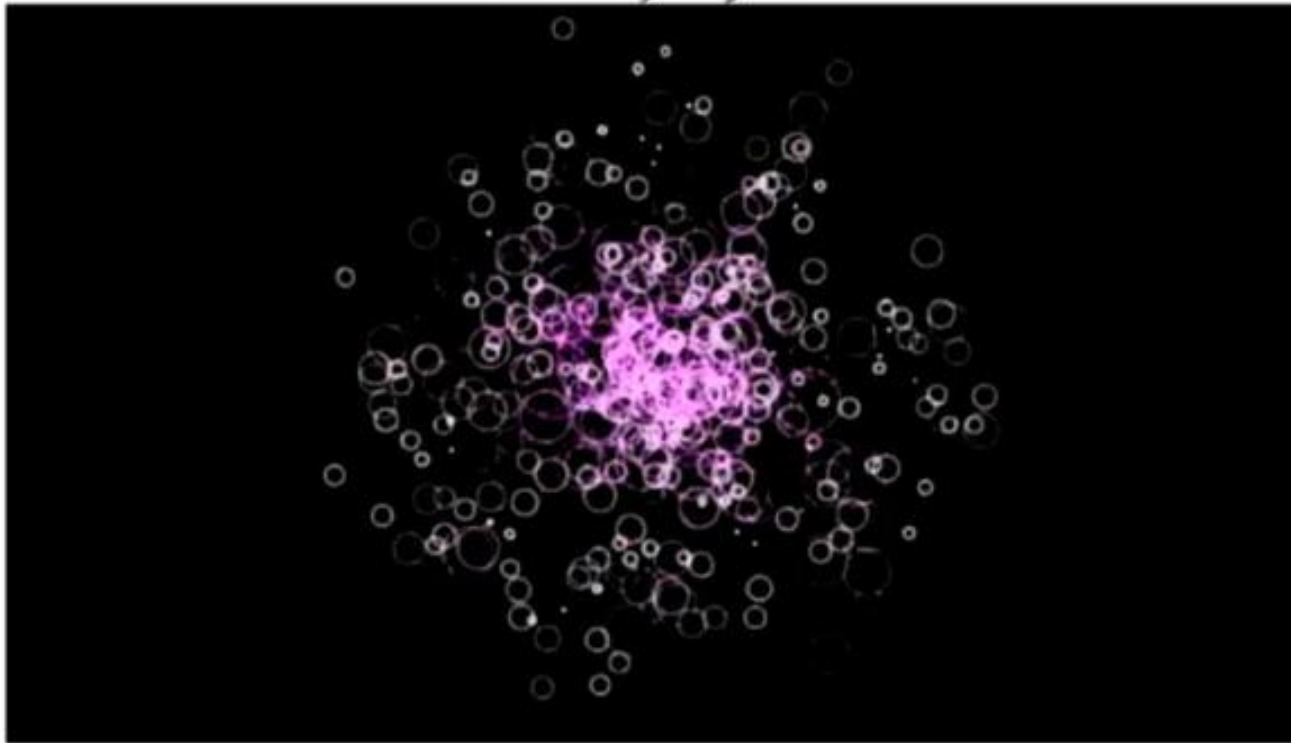
Figure 4: Left panel: Gamma-ray sky above 600 MeV in Galactic coordinates  $(l, b)$ . Both the diffuse Galactic emission and point sources are visible. Intensity indicates the (logarithmic) brightness of the flux, red corresponds to low-energy gamma rays around 1 GeV, and blue to gamma rays up to 300 GeV. Right panel: sources detected by *Fermi*-LAT above 100 MeV in 8 years.

*Rarest brightest event are **no correlated**  
to any Icecube tracks: 3 C 454.3*



*Two days of tens GeV brightest flare  
by 3C279 :it is **absent in 2015 Icecube***

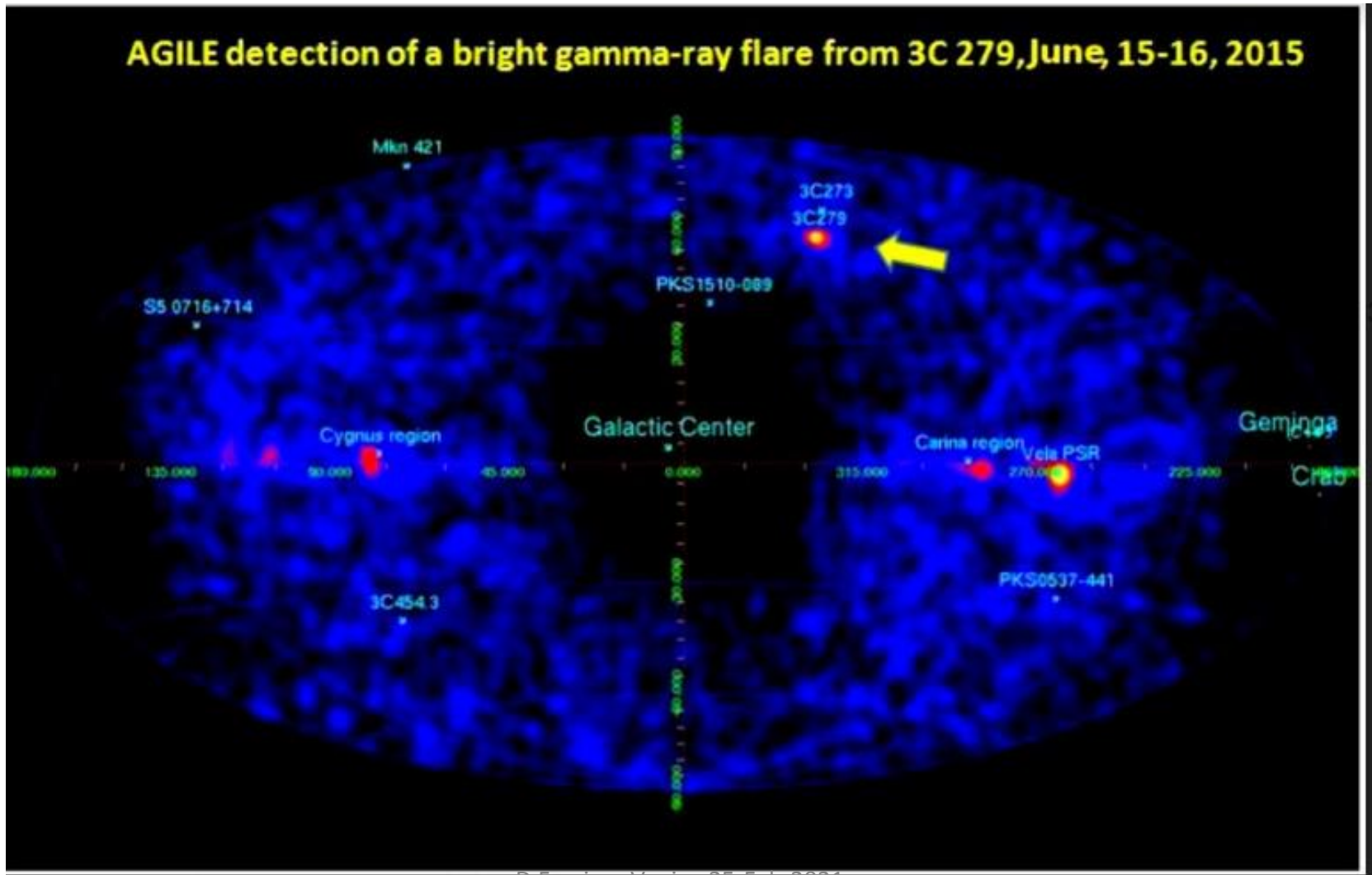
2015 July 22



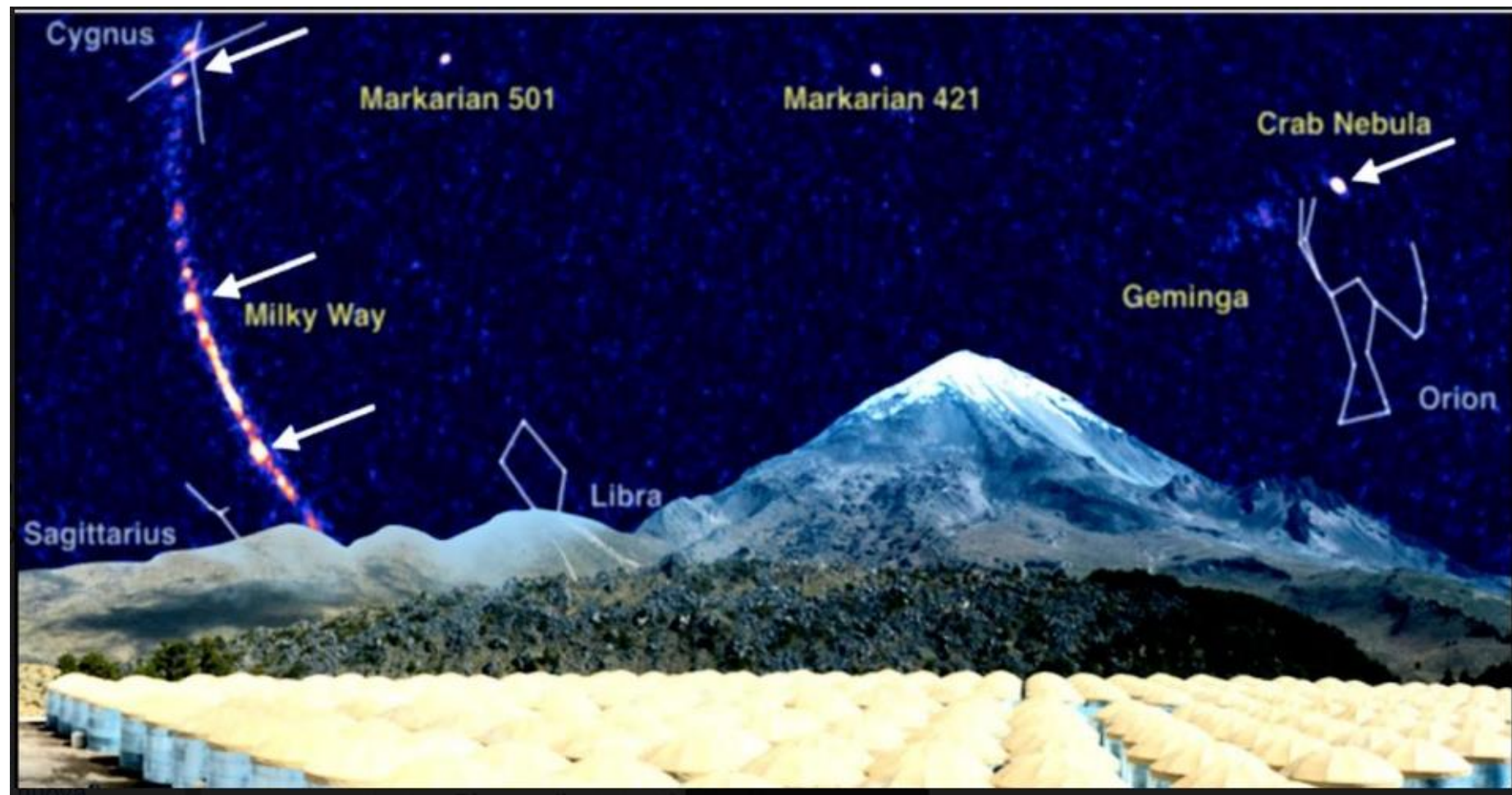
**Gamma-ray Rain from 3C 279**  
**Video Credit: [NASA](#), [DOE](#), [International  
Fermi LAT Collaboration](#)**

D.Fargion\_Venice:25-Feb-2021

*The same 3C 279 flare in AGILE 15-16 June  
as bright as Vela , **absent in Icecube***

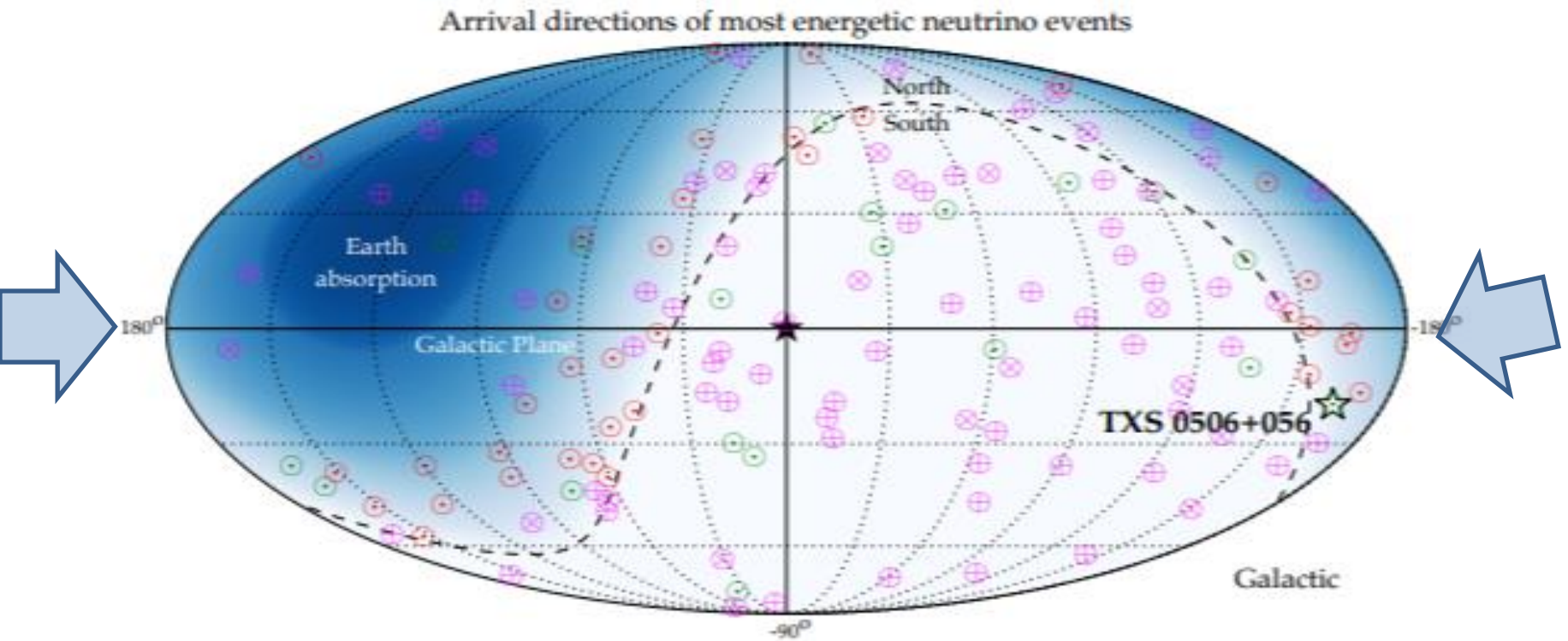


*The very sharp Hawc galactic plane signature  
at tens TeV energy: it is **absent in ICECUBE***





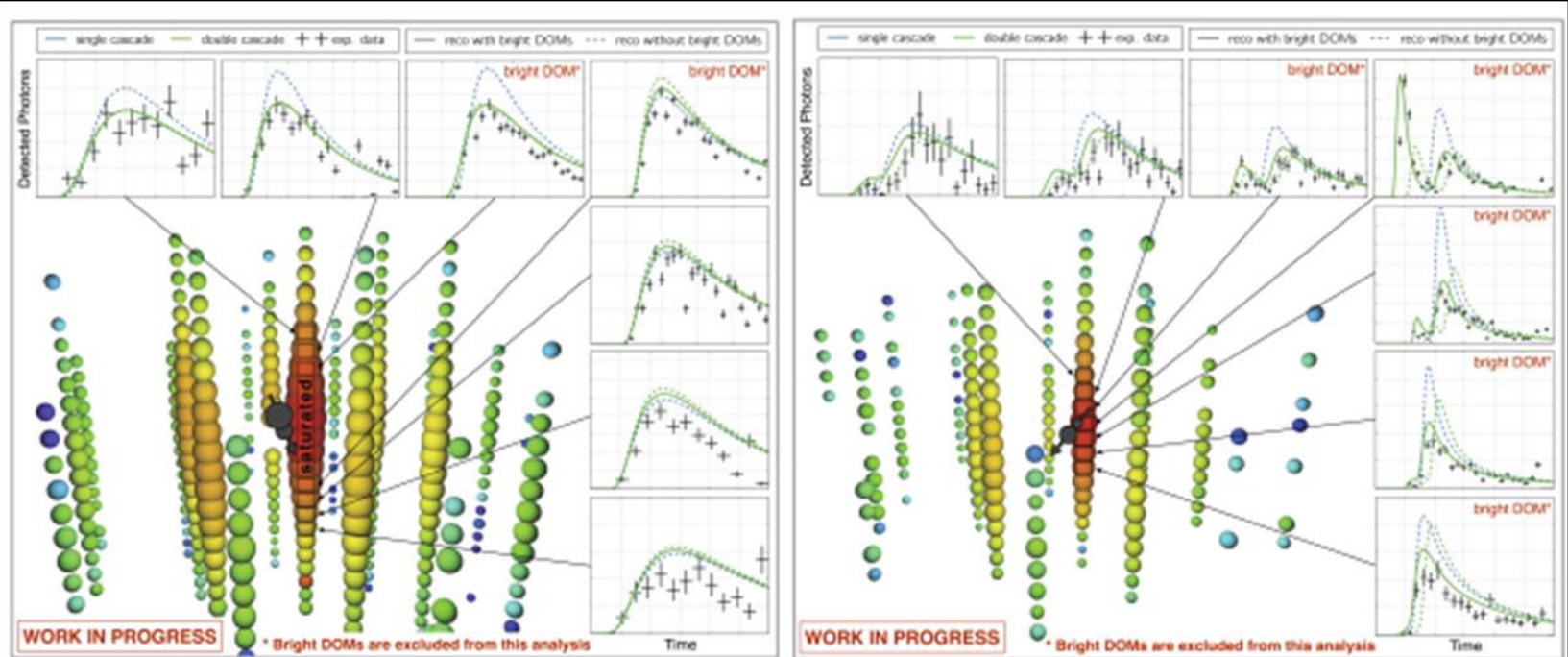
# The *absence of GALACTIC PLANE* in the neutrino HESE and the through going muons



Arrival directions of neutrino events from IceCube. Shown are upgoing track events, high-energy starting events (HESE) (tracks  $\otimes$  and cascades  $\oplus$ ) [6, 7, 10], and additional events published as public alerts ( $\odot$ ) [23, 24]. The blue-shaded region indicates where absorption of 100-TeV neutrinos becomes important. The dashed line indicates the equator of the Galactic Plane. We also indicate the location of the blazar TXS 0506+056 ( $\star$ ).

# Rare puzzling 2 tau (?) discovered among 36 SHOWERS !!

## The brightest NON CONSISTENT, the weakest, TOO NOISY



**Figure 5** Double cascade events: Event#1 (2012, left), Event#2 (2014, right). The reconstructed double cascade positions are indicated as grey circles, the direction indicated with a grey arrow. The size of the circles illustrates the relative deposited energy of the two cascades.

### Event#1:

- Shows no clear preference between a single cascade and a double cascade hypothesis
- Best-fit values:  $L = 16$  m,  $E_1 = 1.2$  PeV,  $E_2 = 0.6$  PeV,  $(E_1 - E_2)/(E_1 + E_2) = 0.29$

### Event#2:

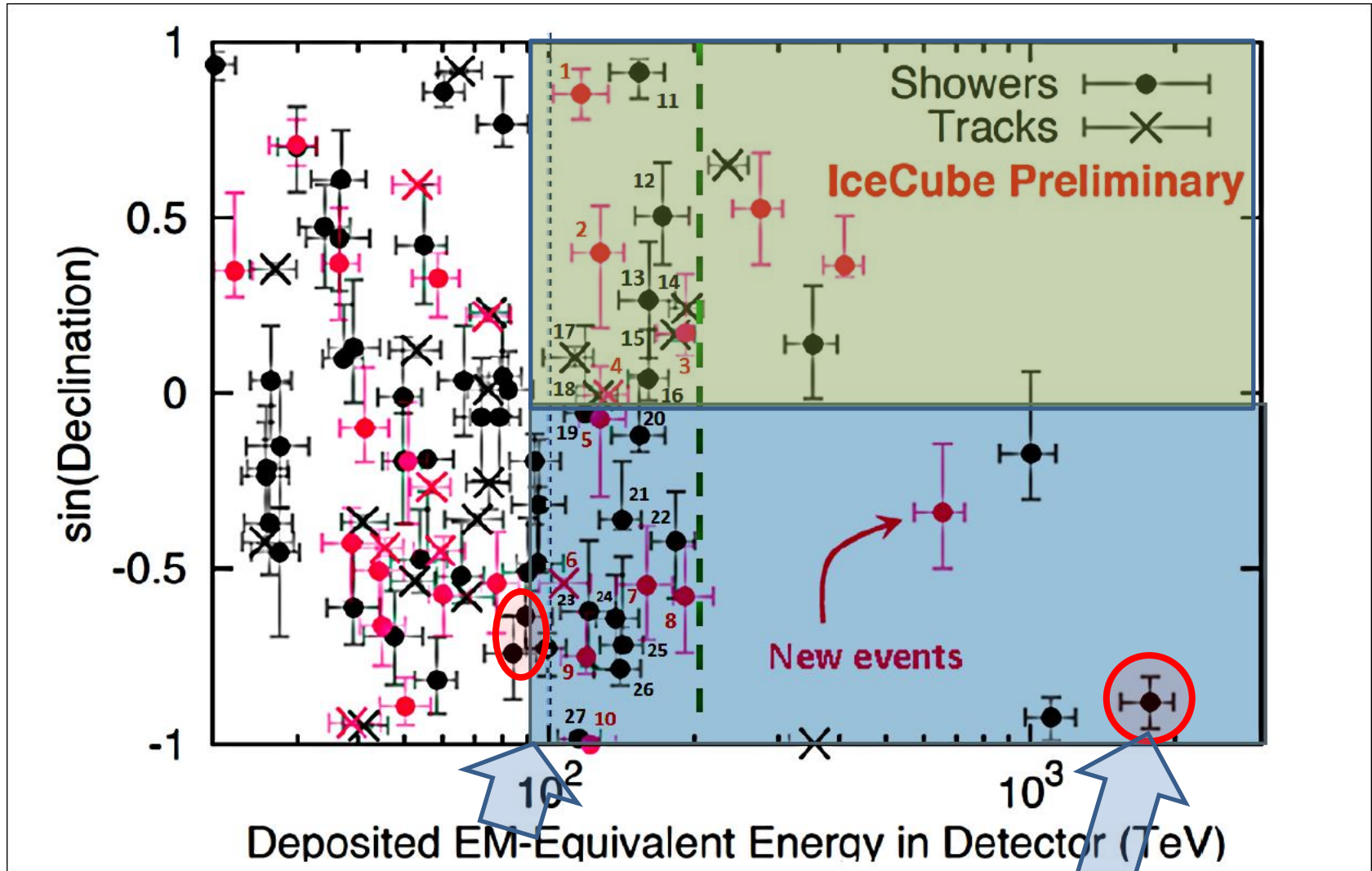
- The observed light arrival time pattern clearly favors the double cascade hypothesis
- Best-fit values:  $L = 17$  m,  $E_1 = 9$  TeV,  $E_2 = 80$  TeV,  $(E_1 - E_2)/(E_1 + E_2) = -0.80$

BIG BIRD 2 PeV from 2012 ?  
OPPOSITE SIGNALS AND SHORT

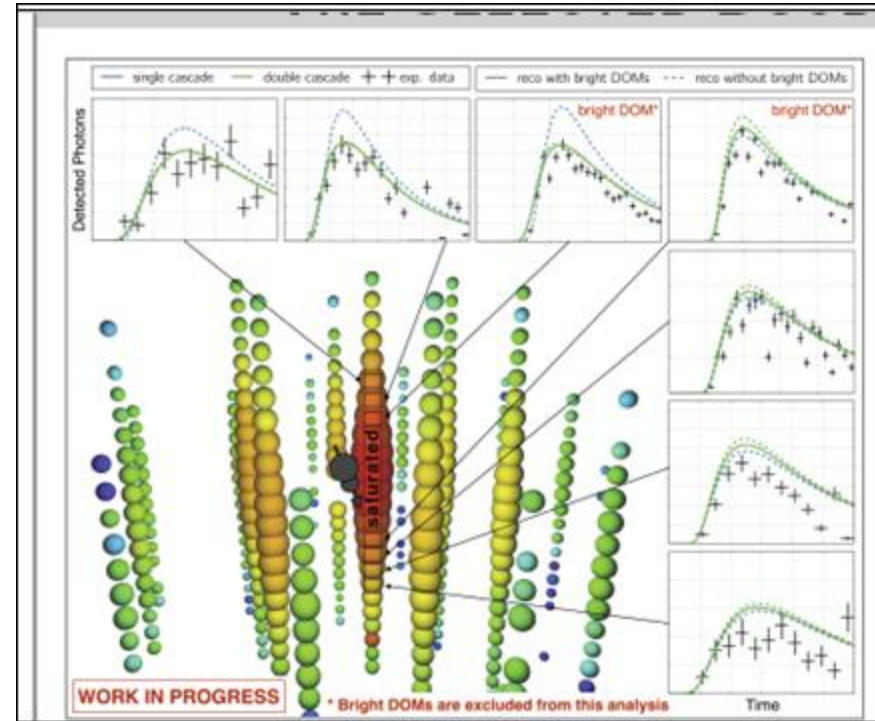
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The best candidate is the most noise one  
And opposite long respect its energy

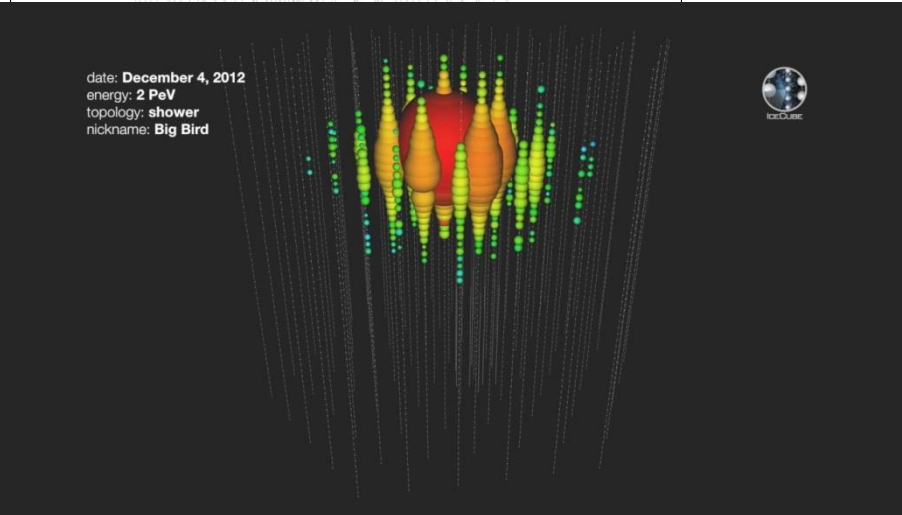
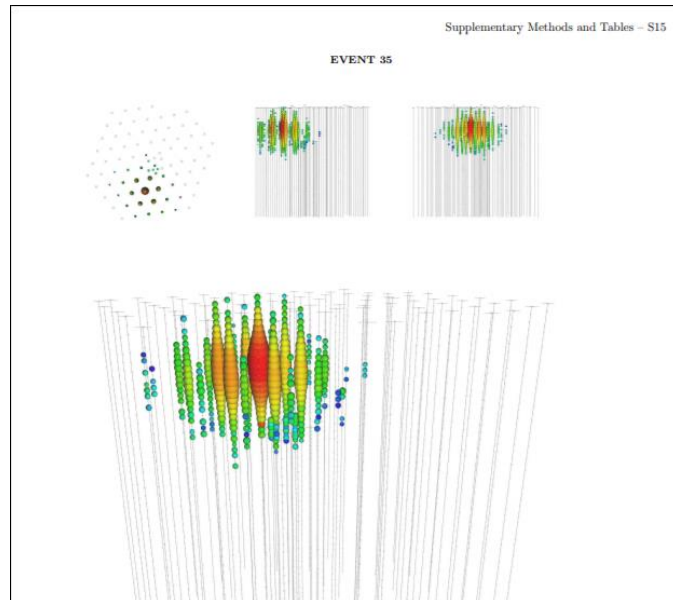
**Only Two Taus found above hundred TeV energies?**  
**There were 36 cascades-> versus only 2 tau! Too few!!**



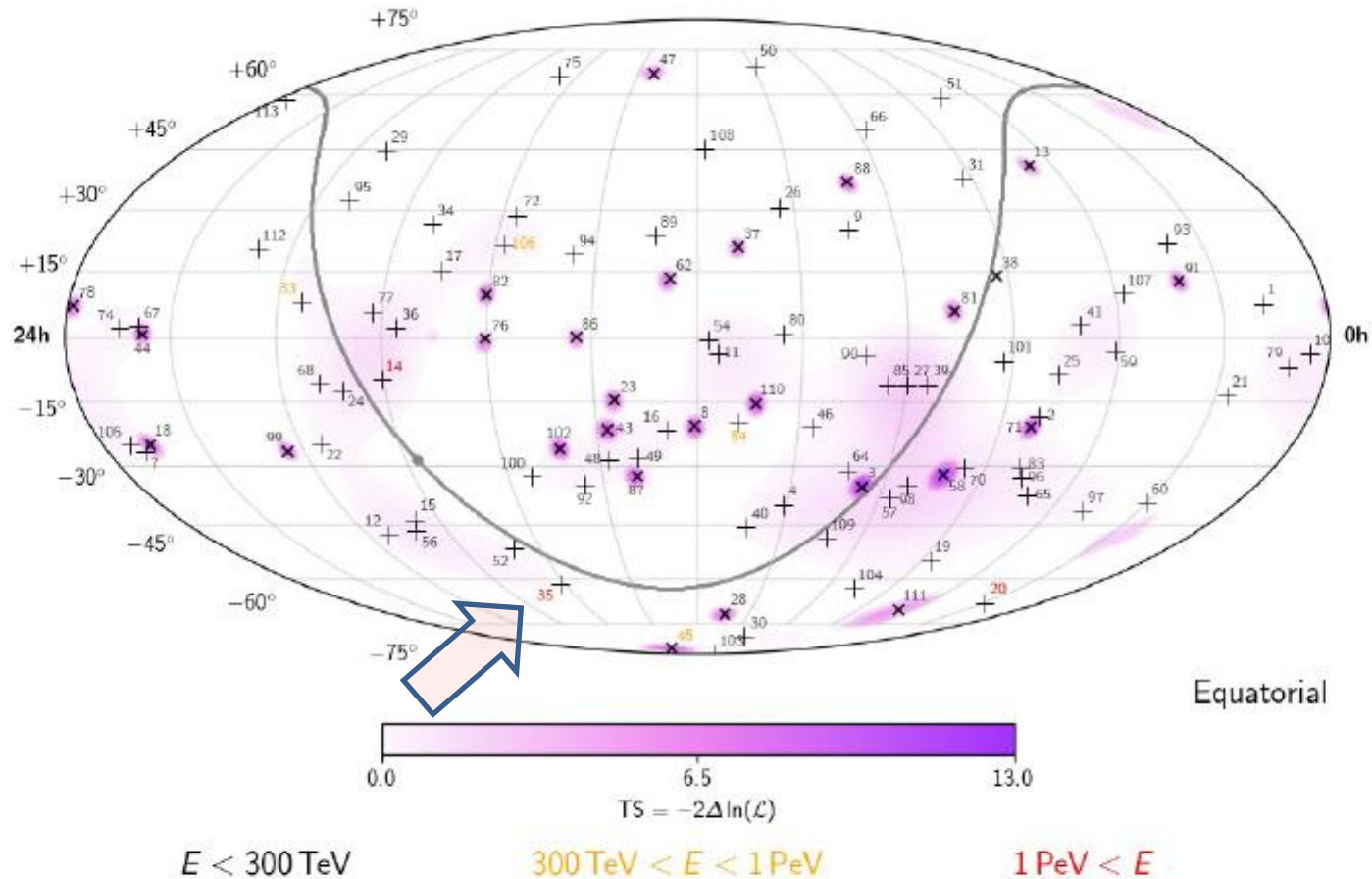
# The 2 tau events: The Historic Evento *n.35* : **Big Bird 2 PeV**..Since 2012---8 years long to claim a tau?



So far there have only been three neutrinos powerful enough to receive the full Sesame Street treatment, with **Big Bird** joining Bert, 2011, and Ernie, 2012.



# *Big-Bird: 2 PeV tau candidate pointing no-where: no correlation with known sources, no galactic plane*



ArXiv:2011.03545

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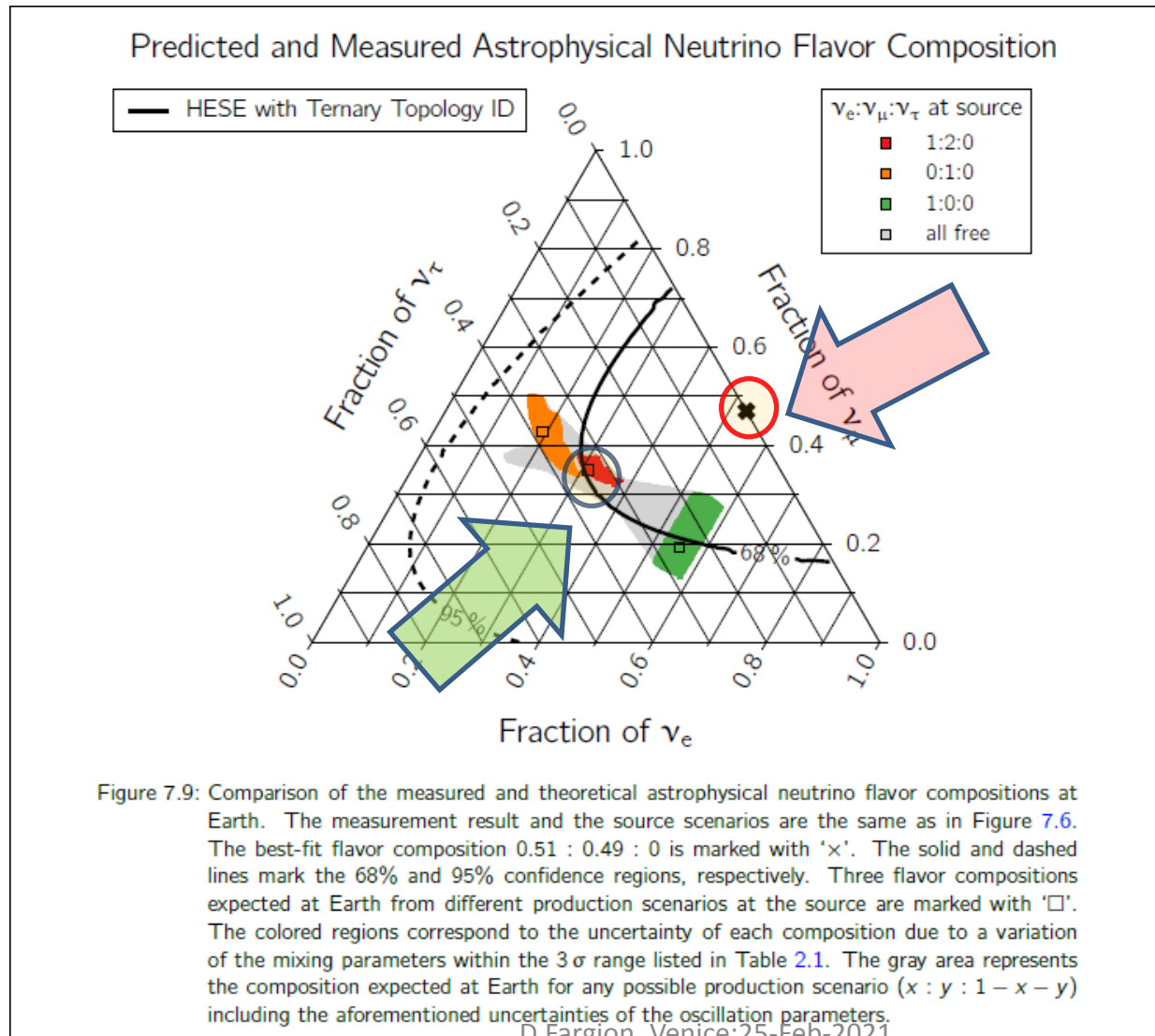
# *The Flavor puzzle in ICECUBE*

- Any cosmic Neutrino should be democratic in 3 flavors because cosmic mixing: **1:1:1 = >**
- **ASTROPHYSICS WAIT FOR : 3 cascade and 1 Tracks**
- **BUT** First 6 years Icecube are **CORRESPONDING** to:  
**1.6 cascade+1 track = 1:1:0....** (as prompt neutrinos)

**THEREFORE Astrophysic ARE not (much) observed:**

- just 1 electron and 1 muon, almost no tau signals!
- **AS FOR CHARMED ATMOSPHERIC ONES**



# The flavor link: Not at 1:1:1, but as observed at 1:1:0 on 2015 and 2017



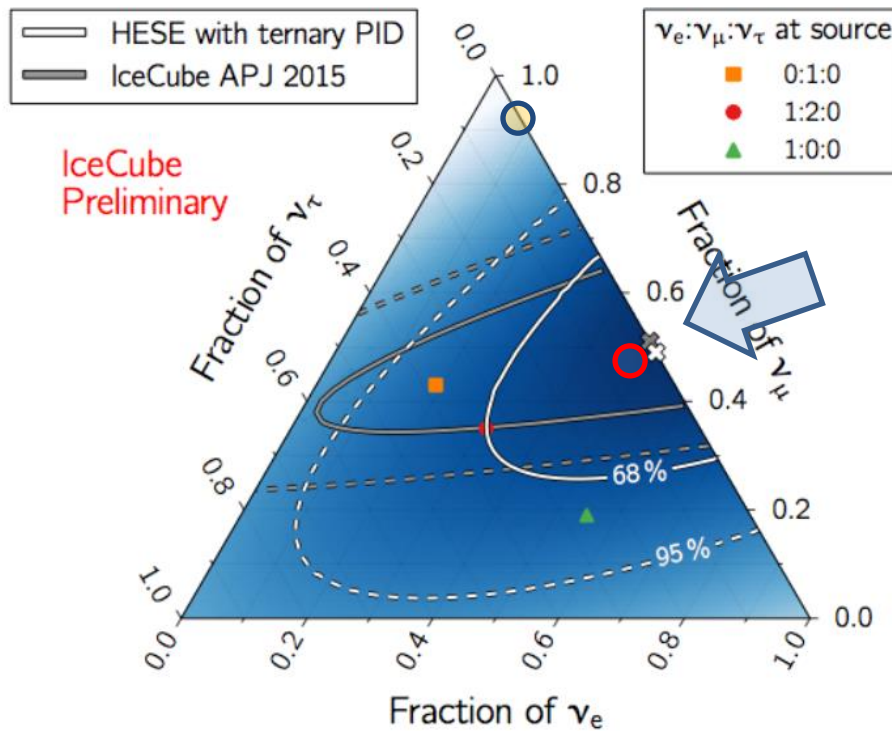



Munich 27 February 2017, Albrecht Karle,

**2015**  
**2017**

-  Prompt neutrino (with tau negligible term)
-  Conventional Atmospheric neutrinos

## Tau neutrino search - Flavor ratio




- Tau neutrinos seen: **0** 
- Expected: **~2.83 events\***
- Compatible with statistical fluctuation (9%).

$$f_{\nu_e} = 0.51^{+0.12}_{-0.13}$$

$$f_{\nu_\mu} = 0.49^{+0.12}_{-0.13}$$

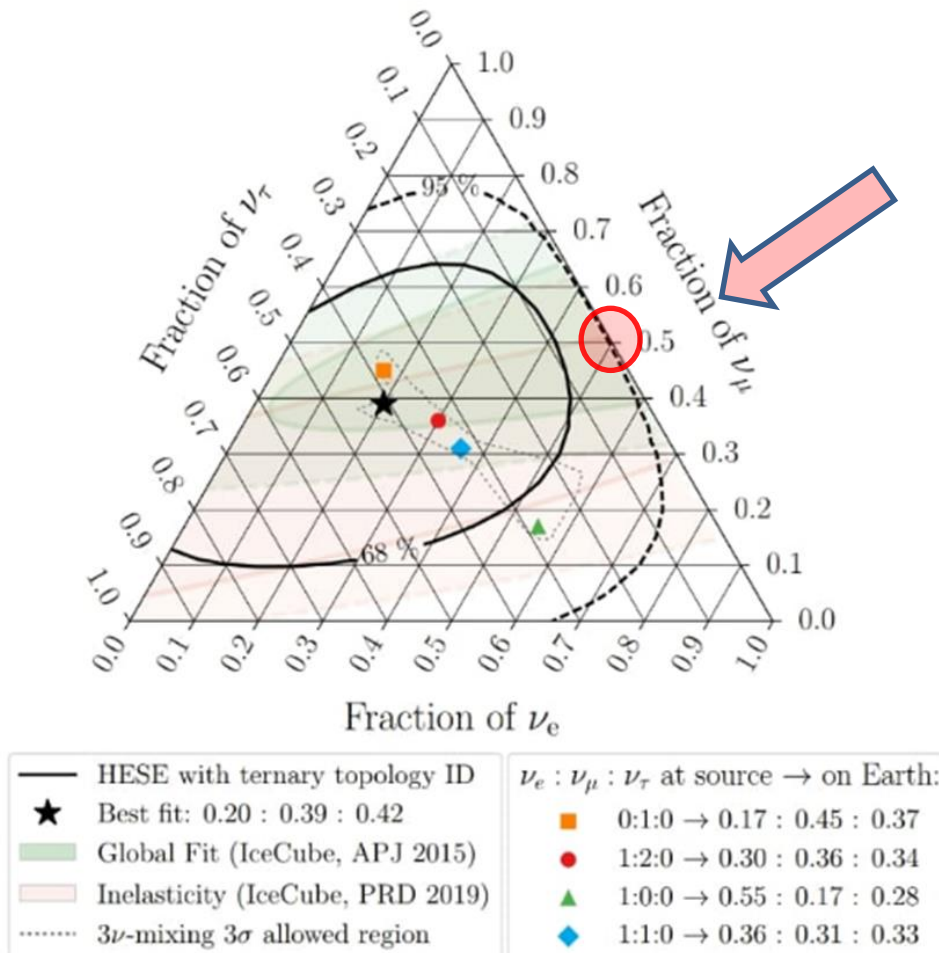
$$f_{\nu_\tau} = 0.00^{+0.16}_{-0.00}$$

\*Using HESE 3 year fit with  $E^{-2.3}$  spectrum. 



**Last slide in Halzen presentation**

**On February Venice and, On January in GSS 2021, Pointing To the 1,1,0 Flavor as Atmospheric Charmed one**



# Conclusions

*Even if Astrophysical neutrino would be our desired result, the possible discover of a charm dominant atmospheric signal deserve by itself our greatest Congratulations to Icecube team.*



**Volume 331 - Frontier Research in Astrophysics – III (FRAPWS2018)**  
**Opening Remarks**

## **A charming IceCube discover?**

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Full text: [pdf](#)

Pre-published on: November 14, 2019

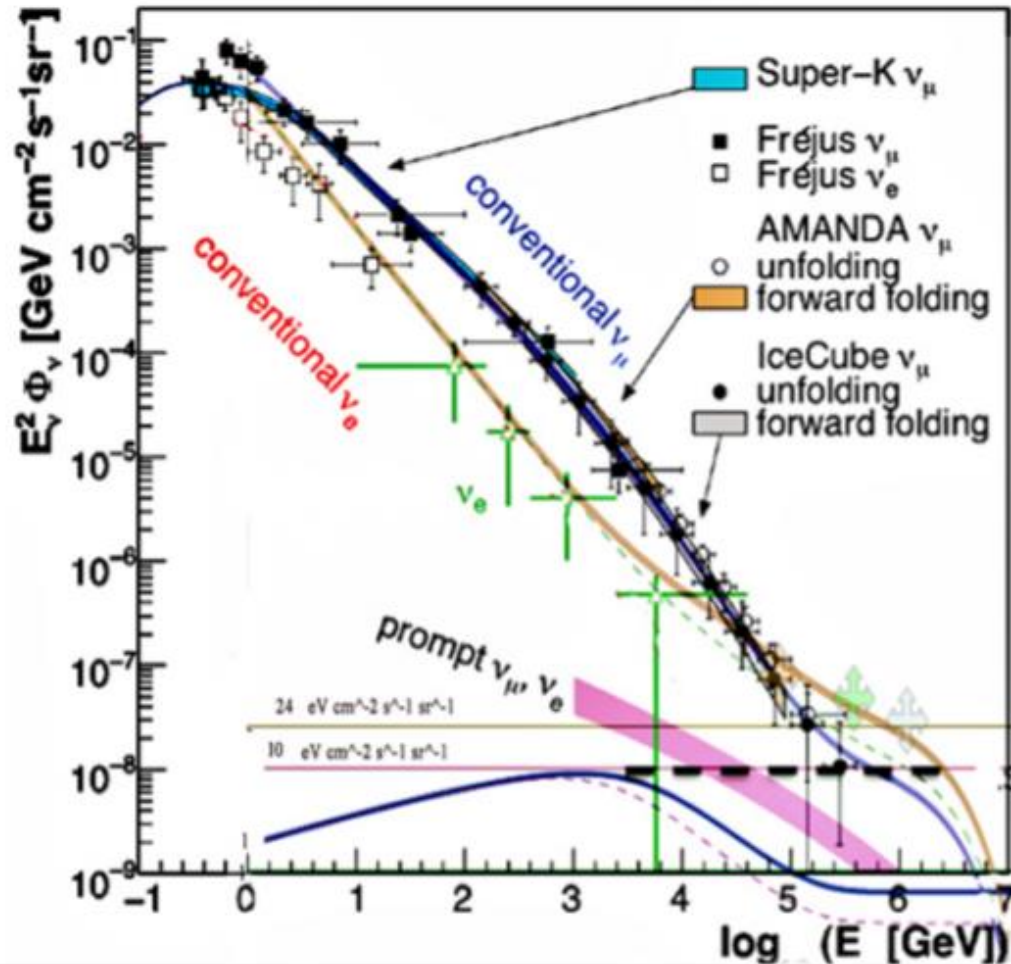
Published on: November 20, 2019

***Thank you***

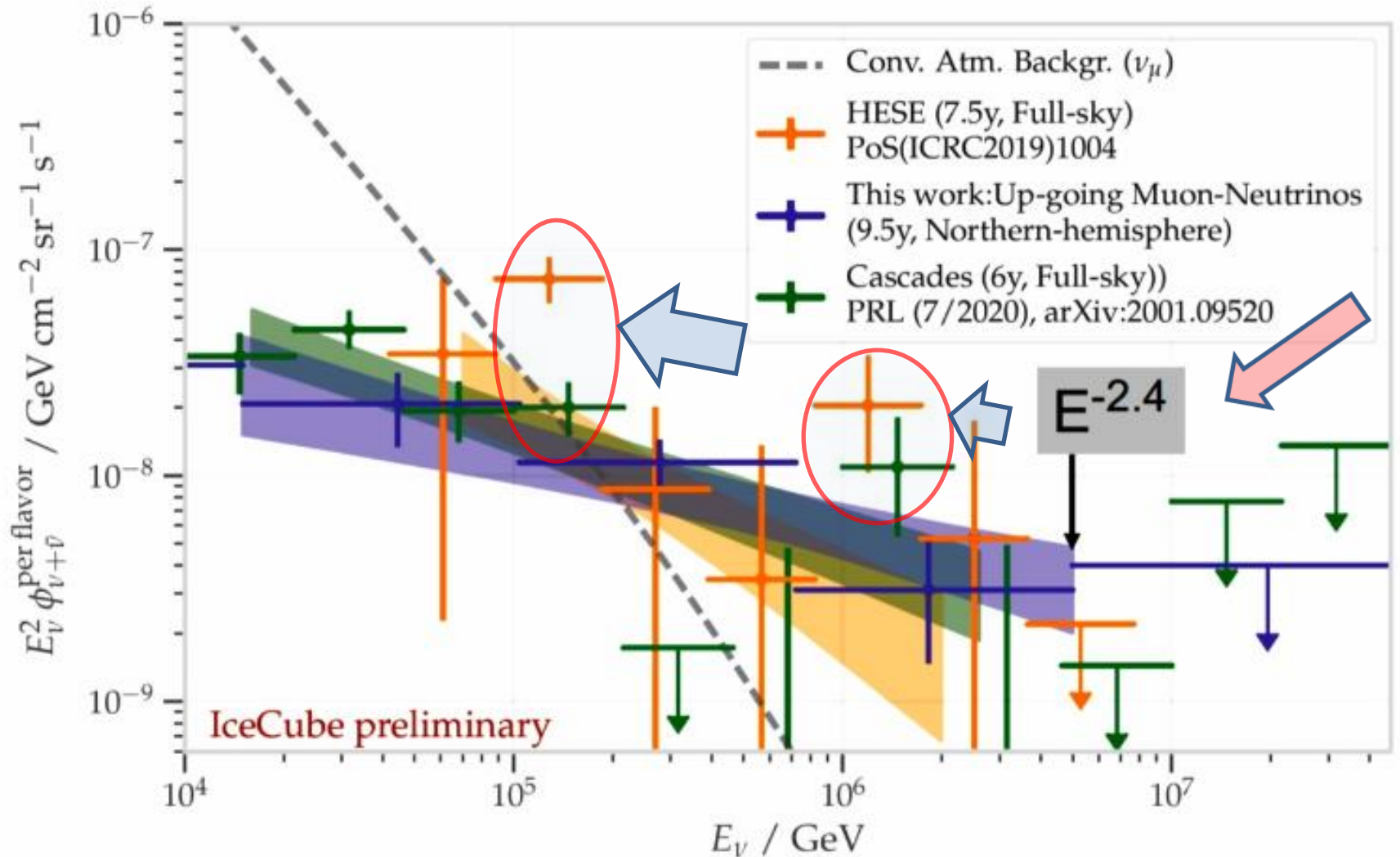
***ADDITIONAL SLIDES:***

<https://doi.org/10.1016/j.nima.2014.03.006>

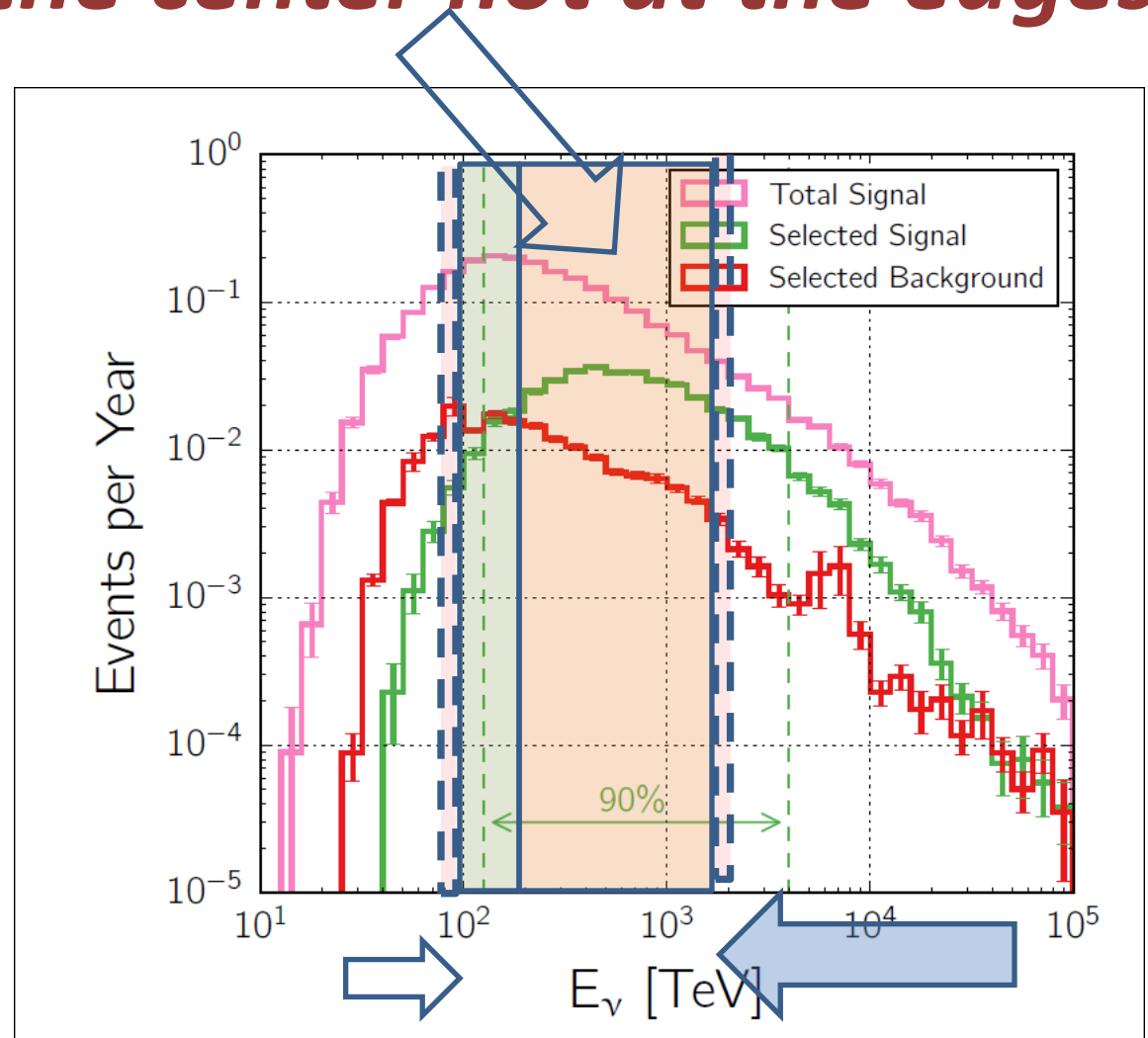
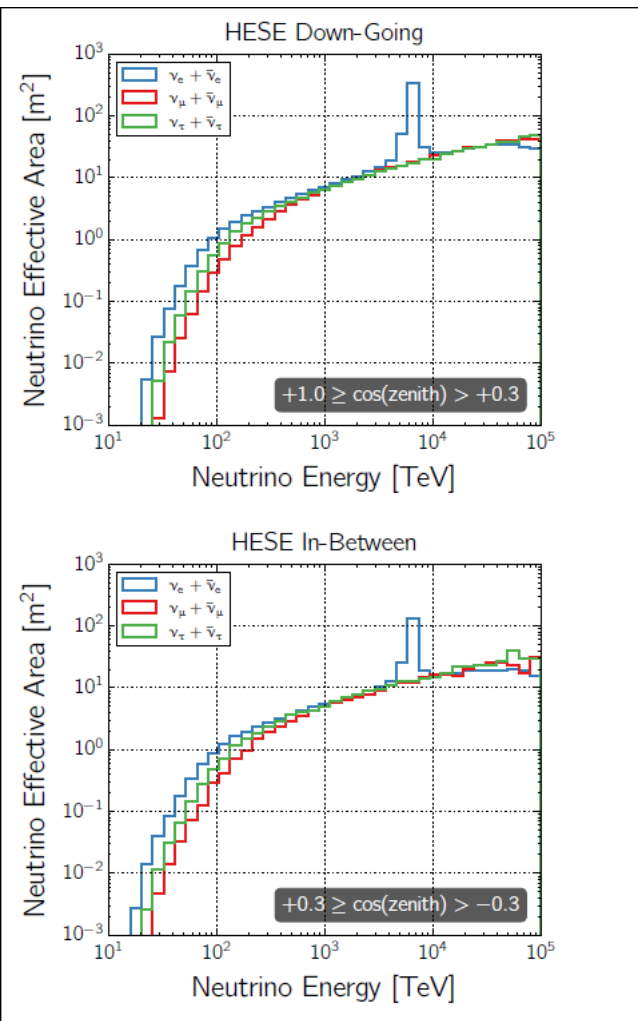
The cascades must overcome 3 times the tracks:  
not just the observed 1.6 times the tracks



# Telescopes\_Halzen.pdf

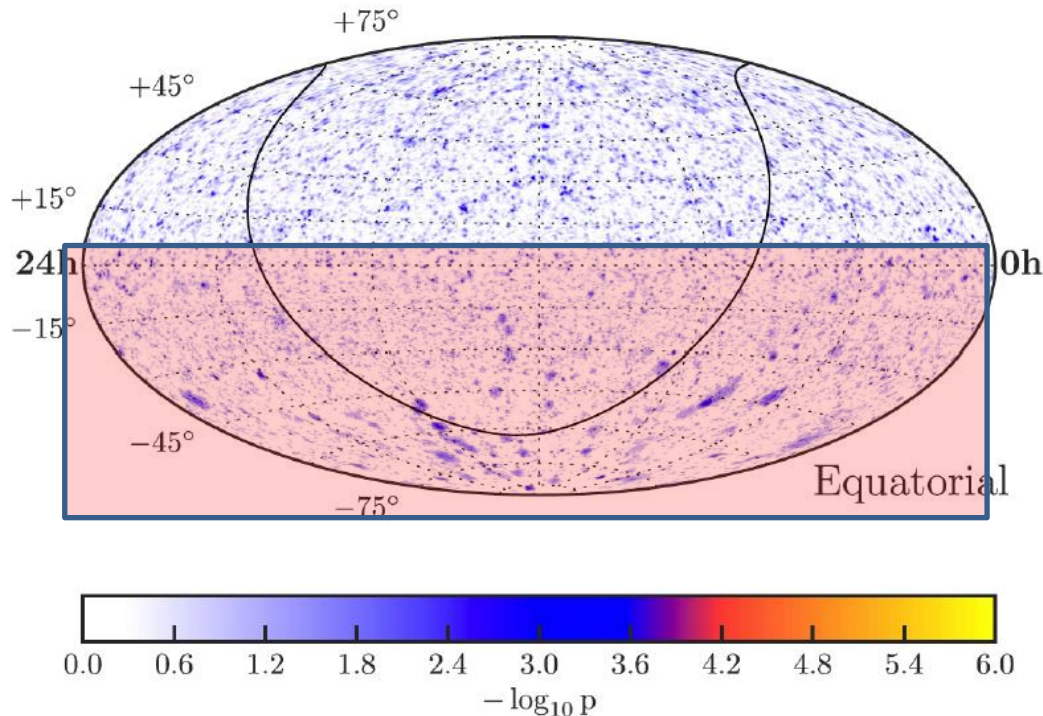


# *tau efficient detection: at best in the center not at the edges*



# *The smeared homogeneous Icecube sky with no clustering HESE*

## IceCube - Point Sources – 7 years



No significant PS reported

No correlation with list of 74 sources in both hemispheres. Galactic & Extragalactic

Most recent data periods:

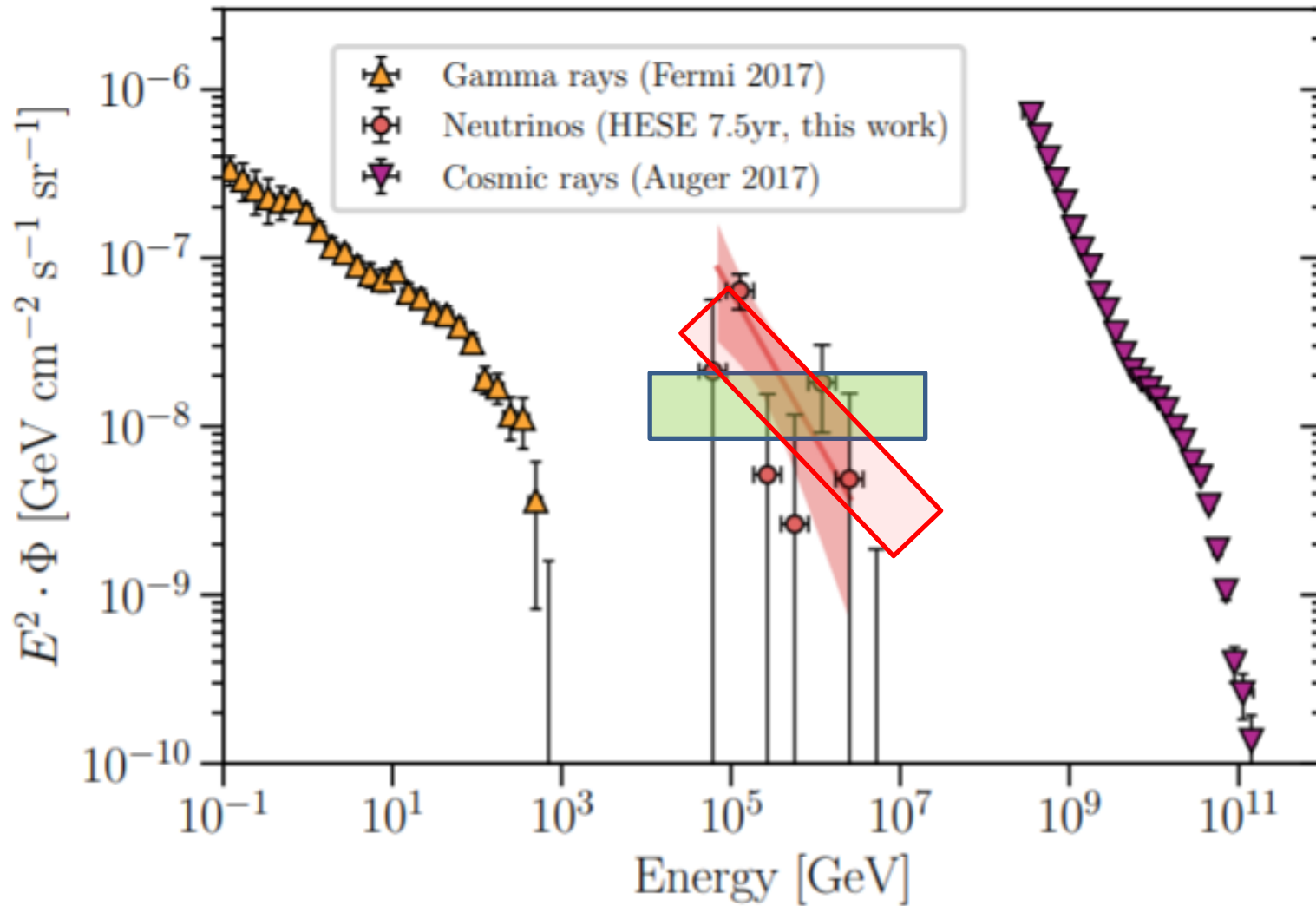
~80k northern hemisphere evt/yr (atm  $\nu$ )

~35k southern hemisphere evt/yr (atm  $\mu$ )

~200 starting tracks. Southern sky

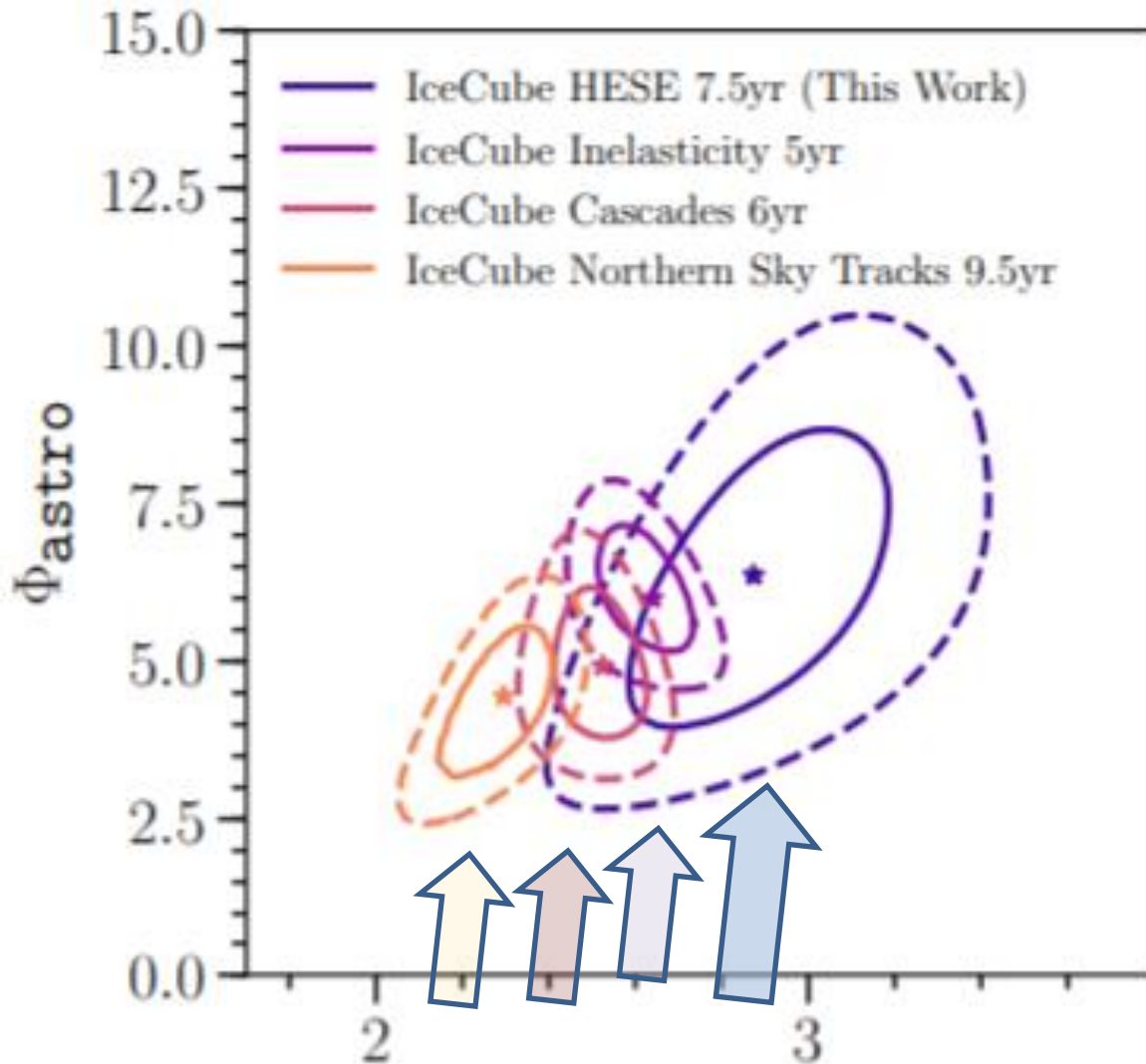
ApJ 835 (2017) 151

**A spectra index = -2 (astrophysics) or a better, -3 (Charm-CR) ?**





# The evolved index spectra from -2 to -3



*....Maybe TeVs photon opacity by cosmic IR allows the rise of cosmic TeVs-PeVs neutrinos?*

- *NO much relevant :*
- *Because the **tens TeV gamma**, their IR-decay will shine at tens GeVs transparent to cosmic IR ...Therefore the Galactic plane should be the dominant final signal as in Fermi sky*
- *( **but not yet observed in Icecube** )*

# IR opacity at TeVs gamma sky

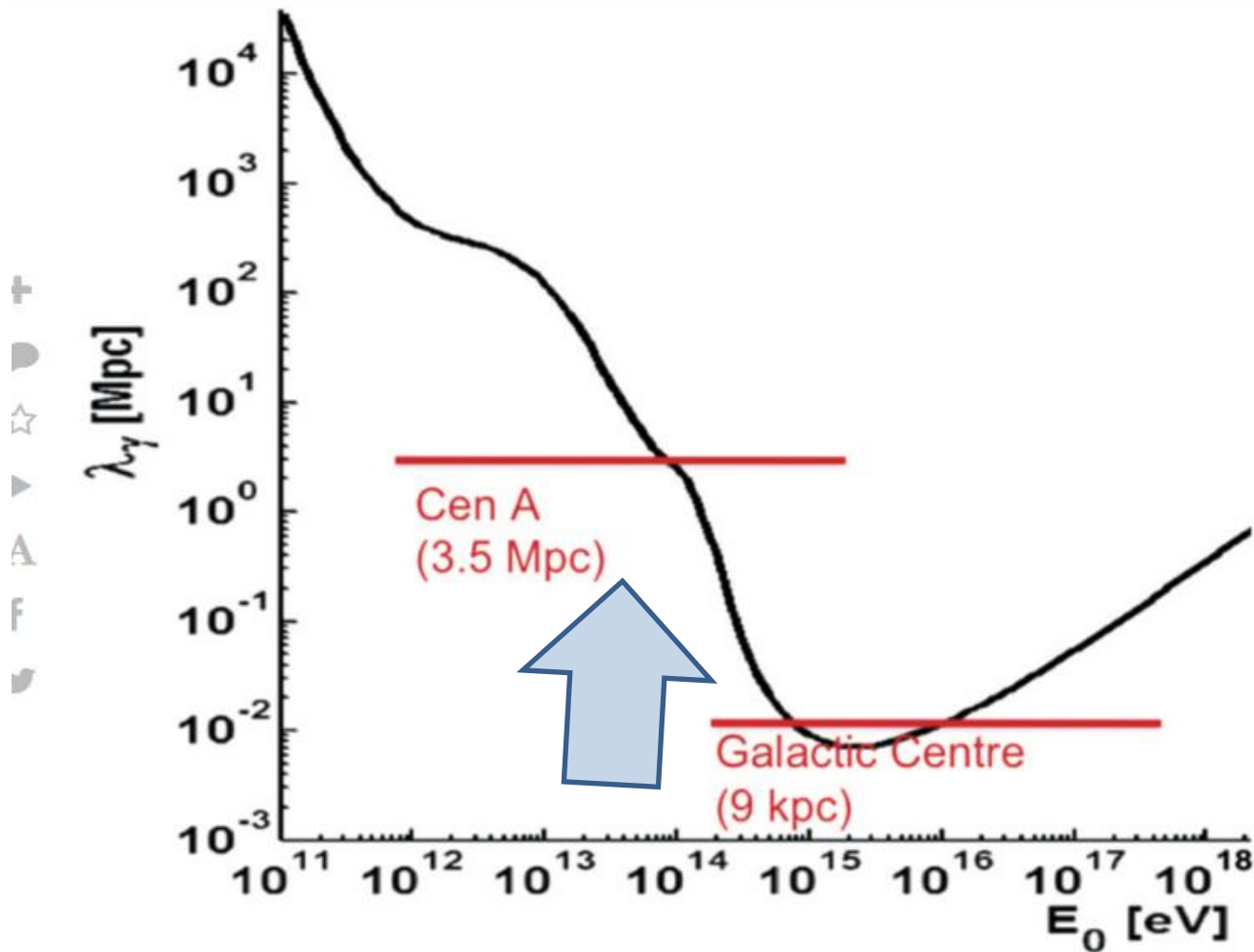
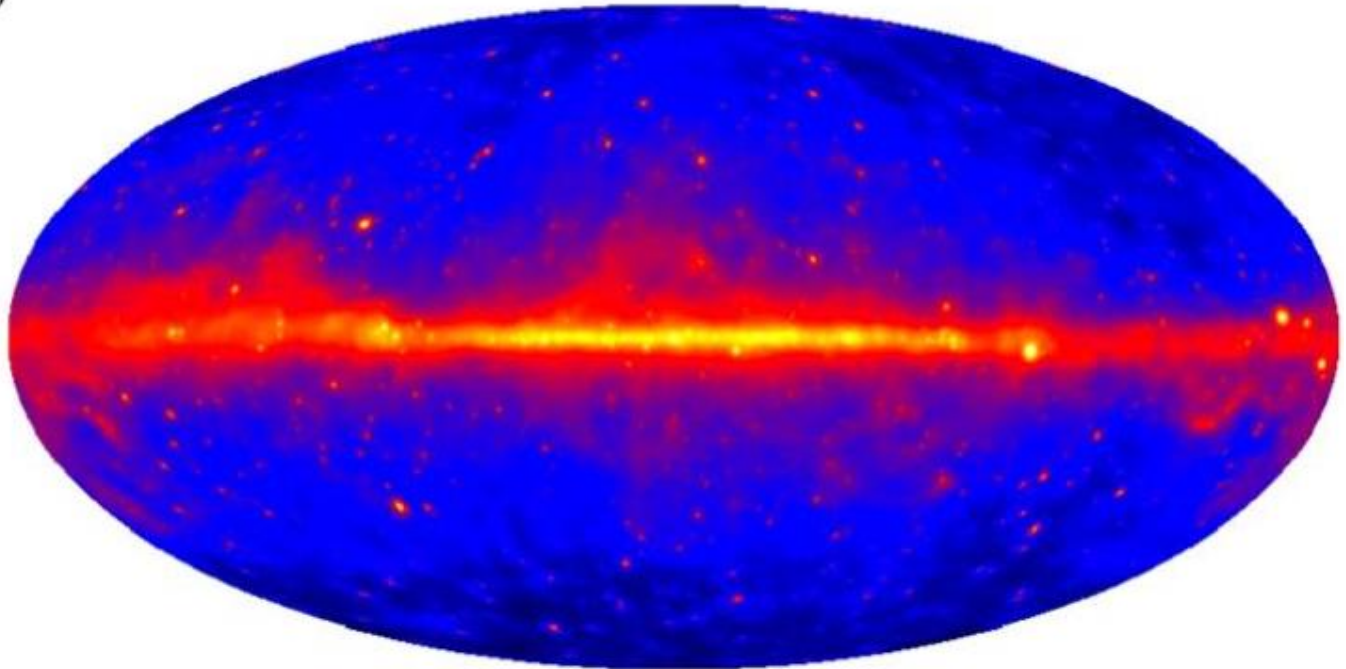


Figure 2: Mean free path of gamma rays of energies between 100 GeV and 1 EeV, at  $z = 0$  (deangelis2013). See text for details.

# *Fermi map : galactic plane. No traces of TeVs secondaries by IR opacity*

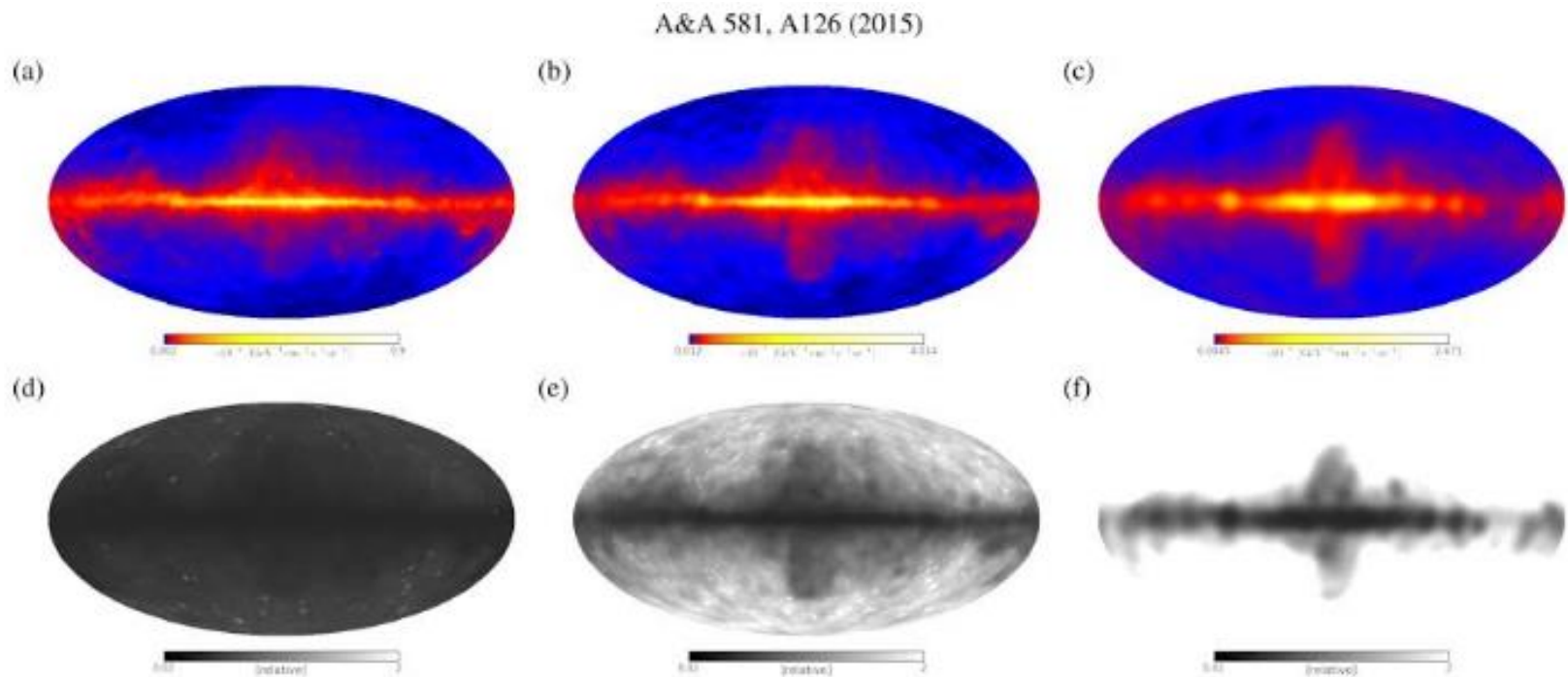
ipg M. Selig et al.: The denoised, decon  
Apri con Pixlr Editor

(a)



(c) = data/(a) - 1

***Indeed the TeVs gamma, their decay,  
should shower into GeV sky:  
still much ruled by Galactic plane***



**Fig. 2.** Diffuse  $\gamma$ -ray flux and its relative reconstruction uncertainty on a logarithmic scale at different energies in a Mollweide projection. Panels a)–c) show the reconstructed diffuse photon flux at roughly 2 GeV, 10 GeV, and  $\sim 100$  GeV. The photon flux is given in units of  $\text{GeV}^{-1} \text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1}$ . Note that the color scale varies. Panels d)–f) show the relative uncertainty on these reconstructions. Maps for all energy bands are available at the CDS.

# Charm may fit data

- ***Possible fit with charm atmospheric noise***

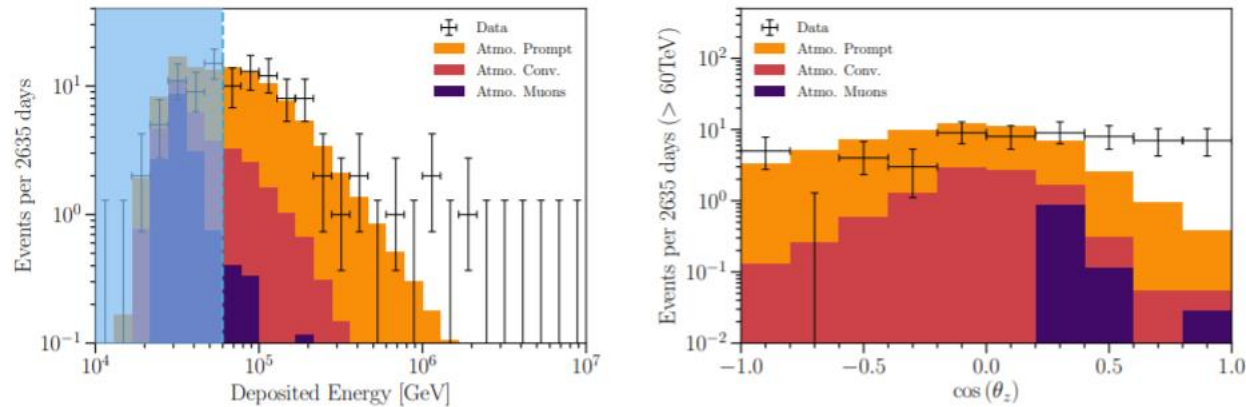


FIG. VI.12. *Atmospheric-background-only fit to the data.* In these figures we present the best fit in the absence of an astrophysical component. The left panel shows the deposited energy distribution and the right panel the angular distribution. As can be seen in the right panel, the angular distribution is in tension with the expectation in several bins. This amounts to a greater than  $5\sigma$  difference with respect to the best-fit astrophysical model. The colors are the same as in Fig. VI.1.

***Recent Nature March 2021:  
The detection of a partial Glashow  
cascades is not any definitive probe to neutrino Astrophysics;  
also charmed signals may lead to PeVs antineutrino electrons  
with -3 index and a natural suppression:  
An astrophysical spectra will need a spectra -2 requiring a  
sudden unnatural cut-off***

