Astrophysical or Atmospheric prompt neutrinos in Icecube?

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See: 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

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
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.
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 most energetic neutrino events

Earth absorption

Galactic Plane

TXS 0506+056

Arrival directions of neutrino events from IceCube. Shown are upgoing track events, high-energy starting events (HESE) (tracks ☒ and cascades ☐) [6, 7, 10], and additional events published as public alerts (☉) [23, 24]. The blue-shaded region indicates where absorption of 100-TeV neutrinos becomes important. The dashed line indicates the equator and also indicates the location of the blazar TXS 0506+056 (★).
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: $L = 16\, \text{m}$, $E_1 = 1.2\, \text{PeV}$, $E_2 = 0.6\, \text{PeV}$, $(E_1 - E_2)/(E_1 + E_2) = 0.29$

**Event#2:**
- The observed light arrival time pattern clearly favors the double cascade hypothesis
- Best-fit values: $L = 17\, \text{m}$, $E_1 = 9\, \text{TeV}$, $E_2 = 80\, \text{TeV}$, $(E_1 - E_2)/(E_1 + E_2) = -0.80$

BIG BIRD 2 PeV from 2012?
OPPOSITE SIGNALS AND SHORT

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!!
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
D.Fargion_Venice:25-Feb-2021
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

Figure 7.9: Comparison of the measured and theoretical astrophysical neutrino flavor compositions at Earth. The measurement result and the source scenarios are the same as in Figure 7.6. The best-fit flavor composition 0.51 : 0.49 : 0 is marked with ‘x’. The solid and dashed lines mark the 68% and 95% confidence regions, respectively. Three flavor compositions expected at Earth from different production scenarios at the source are marked with ‘□’. The colored regions correspond to the uncertainty of each composition due to a variation of the mixing parameters within the 3σ range listed in Table 2.1. The gray area represents the composition expected at Earth for any possible production scenario \( (x : y : 1 - x - y) \) including the aforementioned uncertainties of the oscillation parameters.
Prompt neutrino (with tau negligible term)
Last slide in Halzen presentation

On February Venice and, On Jenuary 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.
Thank you

ADDITIONAL SLIDES:
Flavor revolution? 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.
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 ν)
~35k southern hemispheric evt/yr (atm μ)
~200 starting tracks. Southern sky

**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 $z = 0$. See text for details.

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

(c) = data/(a) − 1
Indeed the TeVs gamma, their decay, should shower into GeV sky: still much ruled by Galactic plane
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 5σ 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 annatural cut-off