

No Tau? No Astronomy!

Daniele Fargion*

Physics Department & INFN Rome1, Rome University 1, P.le A. Moro 2, 00185, Rome, Italy

MIFP, Via Appia Nuova 31, 00040 Marino (Rome), Italy

E-mail: daniele.fargion@roma1.infn.it

Pietro Oliva

Niccolò Cusano University, Via Don Carlo Gnocchi 3, 00166 Rome, Italy

MIFP, Via Appia Nuova 31, 00040 Marino (Rome), Italy

Department of Sciences, University Roma Tre, Via Vasca Navale 84, 00146 Rome, Italy

E-mail: pietro.oliva@unicusano.it

Since 2013 IceCube cascade showers sudden overabundance have shown a fast flavor change above 30-60 TeV up to PeV energy. This flavor change from dominant muon tracks at TeVs to shower events at higher energies, has been indebted to a new injection of a neutrino astronomy. However the recent published 54 neutrino HESE, high energy starting events, as well as the 38 external muon tracks made by trough going muon formed around the IceCube, none of them are pointing to any expected X-gamma or radio sources: no one in connection to GRB, no toward active BL Lac, neither to AGN source in Fermi catalog. No clear correlation with nearby mass distribution (Local Group), nor to galactic plane. Moreover there have not been any record (among a dozen of 200 TeV energetic events) of the expected double bang due to the tau neutrino birth and decay. An amazing and surprising unfair distribution in flavor (suppressing tau) versus an expected democratic one. Finally there is not a complete consistence of the internal HESE event spectra and the external crossing muon track ones. Moreover the apparent sudden astrophysical neutrino flux rise at 60 TeV might be probably also suddenly cut at a few PeV in order to hide the (unobserved, yet) Glashow resonance peak at 6.3 PeV. A more mundane prompt charmed atmospheric neutrino component may explain most of the IceCube puzzles. If in this near future, 2017-2018, ICECUBE does not discover any tau neutrino signals somewhere (by double bang) there are a list of consequences to face. These missing correlations and in particular the tau signature absence force us to claim. as in a famous Martini spot: No Tau? No Astronomy.

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1. Introduction

Since 2013 [1] the sudden change of Ultra High Energy (UHE) neutrino flavor (IceCube high-energy starting events, HESE) was discussed by us in the framework of the long-awaited birth of a UHE ν astronomy [3, 4, 5, 6]. Indeed, up to TeV energy the UHE ν are following the expected spectra of atmospheric ν secondaries for which it is found a flux ratio of ν_μ ($\bar{\nu}_\mu$) over ν_e ($\bar{\nu}_e$) of $\phi_{\nu_\mu} : \phi_{\nu_e} \approx 20 : 1$. Suddenly, at few tens TeVs, the flavor revolution kicks in: four times more shower or cascade events, started by ν_e , or by ν_τ or by Neutral Current (NC) events, (respect to muon tracks) appeared in IceCube: $\phi_{\nu_\mu}^{\text{tracks}} : (\phi_{\nu_e} + \phi_{\nu_\tau} + \phi_{\text{NC}}) = 1 : 4$ [7].

Since 2015, IceCube observed an integral number of 54 HESE events where τ signals. among highest ten above 200 TeV energy, are totally absent. Unfortunately, no neutrino astronomy arose since then, though only very recently a high-energy ν s flux at TeV energy made by cascades, claimed to be weakly anisotropic were published [9]. We shall neglect it in present paper. Indeed, above 200 TeV neutrino energy the so-called double chain of events producing first a shower, $\nu_\tau + N$, and then a consequent τ with its decay forward (ten meter or more) in a second shower (double bang mechanism) [10], it was in principle observable but experimentally still undetected nor in 2013 nor in 2015 [12], neither it was in more recent analysis [13]. In fact, at least a 10 of such events above 200 TeV were not revealing any τ . Now, the ν_μ and ν_e , as known, are extremely polluted by atmospheric noises, while ν_τ (and $\bar{\nu}_\tau$) are the unique beyond-doubt probe of an extraterrestrial signal. Why tau has not been detected? [2] There are, truthfully, several arguments to keep in mind before any claim of ν astronomy arising from the 54 HESE events:

1) There are no clear Galactic plane signatures. Most gamma Fermi MeV-GeV and even TeV telescope astronomy do show both rare extragalactic but also a clear galactic plane signal. At

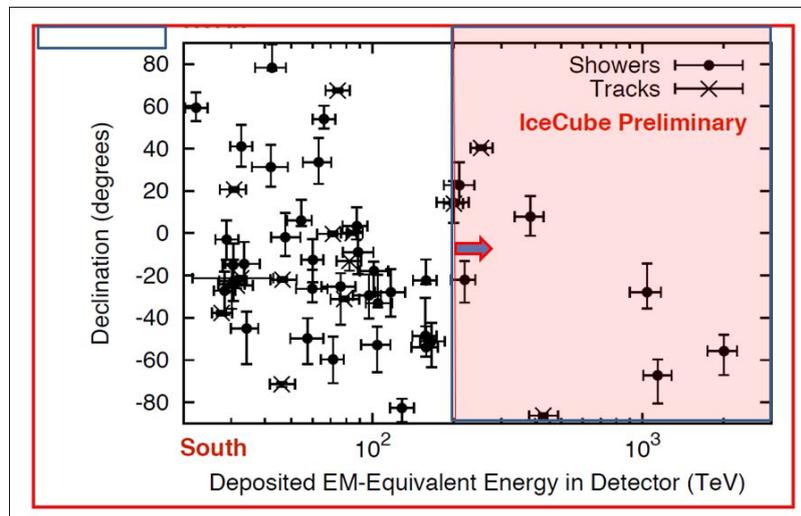


Figure 1: About ten neutrino events above 200 TeV energy have been considered in the IceCube for the tau discover. Their absence is puzzling. In near future, by double record times, by enlarged ICECUBE area and volume, by enhanced filtering at lower energy threshold, the tau twin bangs, the events will double or multiply as they might be detected even at 100 TeVs energy.

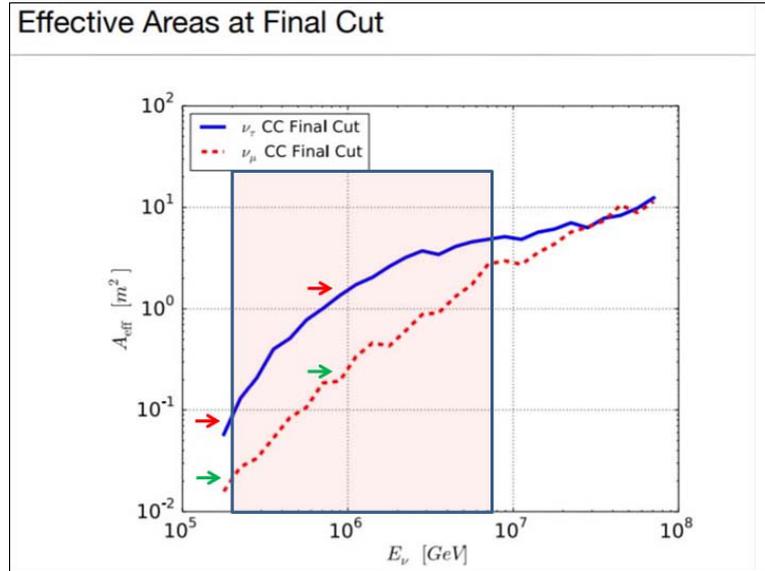


Figure 2: Different effective area for the charged current among muon and tau neutrino. Note the remarkable difference and remind the presence of three HESE muon tracks above 200 TeV while the more probable tau signal is still totally absent.

energy below TeVs (tens GeV or below) the whole Universe is still transparent to energy gamma sky: there is not any cosmic dominant signal over the galactic one. One of course may mention a PeV IceCube shower event pointing somehow to our Galactic Center direction but there are not too many additional clear galactic signals within the last 54 events. Let us mention also as an additional analogy, the Gamma Ray Bursts: (GRB) are cosmic and isotropic but their twin Soft Gamma Repeaters (SGR) are mostly galactic and they present in a non negligible number.

2) There are no GRB- ν correlated events. These GRBS events are the most (apparent) gamma brightest flashes and they were expected to be in correlated shining activity with highest neutrino energy (if these GRBS sources are of hadronic nature). A possible solution we suggested occurs in a different scenario for GRB sources made mostly by binary BH-NS collapse forming a jet not by hadrons jets but just by electron pairs jets, see [8].

3) There are no at all any AGN- ν expected connections. There are several persistent AGN flaring TeV sources with no correlation with these 54 IceCube events.

4) There is a puzzling disagreement in power spectra among HESE events ($\sim E^{-2.6}$, similar to cosmic ray spectra) and the through-going ones ($\sim E^{-2.1}$), why?

5) There is a probable through-going event leaving 4 PeV energy released by a probable 8 PeV primary ν_μ ; surprisingly, there is not yet any $\bar{\nu}_e + e \rightarrow W^-$ leading to Glashow resonant event expected in HESE list at 6.3 PeV [17]. This contradictions may become larger and larger because of the Glashow resonant absence event respect other additional PeVs signals.

6) No self-narrow clustering occurred within the UHE ν_μ events. They are quite collimated signals, (contrary to cascade ones). There are indeed some weak correlation [5], that might point to a few galactic sources, but at least a more narrow clustering would favor a real true Astronomy.

7) The 3 years of IceCube record (2013-2015) are going to be doubled soon (ICRC 2017, end of

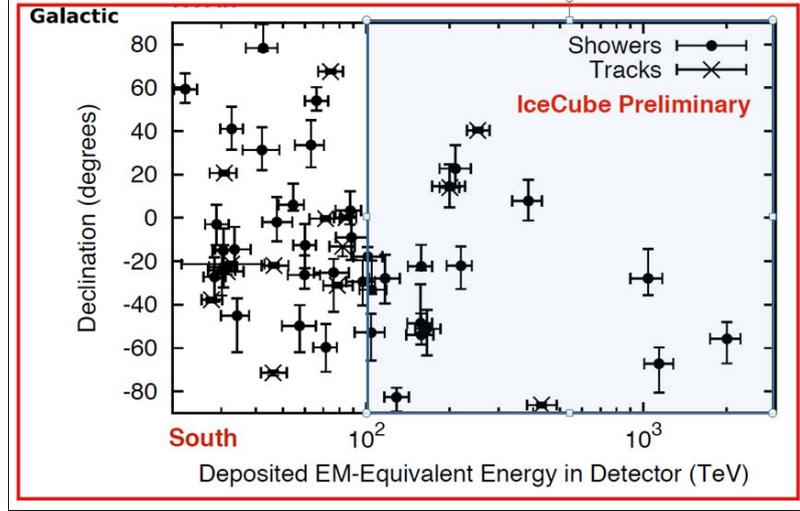


Figure 3: The case of a future ability to verify the tau twin bangs also at 100 TeVs energy would be essential. For three years record there are nearly 18 events. In case of twice a record (at 2017-2018) the total number may be doubled up to 35 events.

2017?); additional volumes and improved techniques may double or tripled the event candidate to a tau appearance. If the ν_τ ($\bar{\nu}_\tau$) will still be absent there will be just a main escape door: HESE events are mostly atmospheric prompt (charmed) events that are mostly made by ν_e , $\bar{\nu}_e$, ν_μ , $\bar{\nu}_\mu$ in equal rate, with a negligible tau component [11]. Their spectra then must be by definition a photocopy of Cosmic Rays one ($\sim E^{-2.6}$), as indeed they partially they show. The prompt neutrino asymmetric flavor spectra ($\phi_{\nu_\mu} : \phi_{\nu_e} : \phi_{\nu_\tau} = 1 : 1 : \frac{1}{20}$), disfavoring the tau flavor, as it has been observed by ICECUBE, it may oppose to the expected astrophysical democracy,(because complete mixing), of $\phi_{\nu_\mu} : \phi_{\nu_e} : \phi_{\nu_\tau} = 1 : 1 : 1$.

In this very first summary as we underlined in the title, paraphrasing a famous Italian Martini spot, we are forced to claim once again “No Tau? No Astronomy!”.

2. Near future tau detections

The present and the future τ search may be soon improved by three factors: The time larger sample; the enlarged IceCube area and volume; the lowering of the energy threshold from 200 TeV to 100 TeV. Indeed a new method for astrophysical tau neutrino search in the waveforms is being implemented by IceCube leading to a lower detection energy threshold to about (100 TeV). The first time increase data imply that if for 914 days (three years) there have been recorded nearly ten events above 200 TeV, (see Fig. 1), in 6 years data that are being going to be possibly doubled.

2.1 The simplest, the best: how many tau double bang?

Let us try to imagine the fate of an hadronic astrophysical neutrino: If it has been originated by any common pion π^\pm or K^\pm decay, first into μ^\pm and later on by muon decay, we would expect as a first approximation an astrophysical neutrino with no neutrino tau flavor $\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} = 0 : 1 : 2$. Or for a normalized to unity flux: $\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} = 0 : \frac{1}{3} : \frac{2}{3}$.

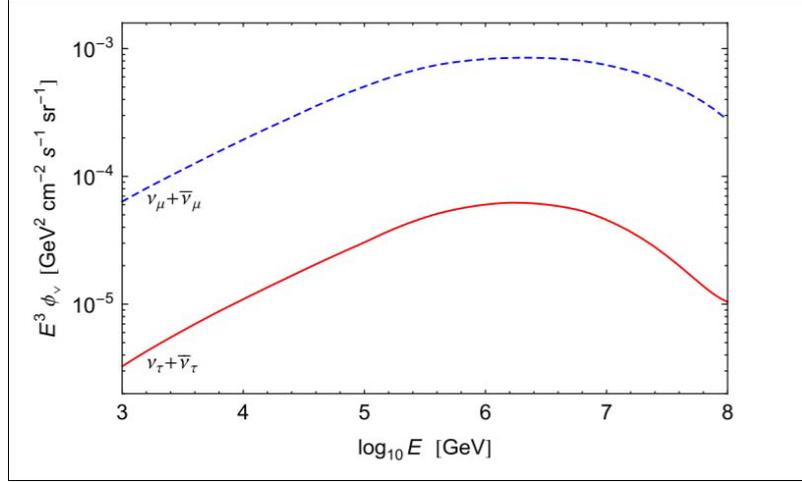


Figure 4: In the simplest prompt neutrino spectra we must foresee the same rate for μ and ν_μ as well as ν_e and their antiparticles, see [11]. Anyway at lower rate nevertheless there must be also a tenth of tau signals.

However the well known neutrino oscillation and mixing and final de-coherence will lead to an almost complete democratic rate $\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} = 1 : 1 : 1$ or in normalized rate:

$$\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} = \frac{1}{3} : \frac{1}{3} : \frac{1}{3}$$

The result is nearly the same for prompt (astrophysical) neutrino sources whose later on flight oscillations and mixing will normalize in a democratic final rate. The consequence is the follow: if IceCube neutrinos are all astrophysical (as the highest ones at 200 TeV and above should be), than the expectance of their presence or absence is given by simple binomial distribution: in particular assuming an astrophysical neutrino where there is an equal probability to observe an electron, a tau or a muon or their Neutral Current at equal $\frac{1}{4}$ rate,

$$\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} : \Phi_{\nu_{NC}} = \frac{1}{4} : \frac{1}{4} : \frac{1}{4} : \frac{1}{4}$$

therefore the probability $P_{\text{No-}\tau}$ not to observe any tau neutrino within N trials is simply

$$P_{\text{No-}\tau} = \left(\frac{3}{4}\right)^N. \quad (2.1)$$

The consequent absence in the 914 days IceCube old data (see Fig. 1) of any tau signal among 9 or 10 events is respectively only:

$$P_{\text{No-}\tau}(9) = \left(\frac{3}{4}\right)^9 = 7.5\%, \quad P_{\text{No-}\tau}(10) = \left(\frac{3}{4}\right)^{10} = 5.6\%. \quad (2.2)$$

These probabilities are already telling us that the tau absence is in tension with the astrophysical interpretation. If the same estimate will be doublet by twice the event number (see Fig. 3) because a lower energy threshold at 100 TeV, or by a ten times larger IceCube 2 volume, we should wait for:

$$P_{\text{No-}\tau} = \left(\frac{3}{4}\right)^{18} = 0.56\%. \quad (2.3)$$

This (a very near future hypothetical) case will exclude an astrophysical nature of IceCube events. On the same statistical view the larger acceptance for tau neutrino in IceCube respect muon neutrino (see Fig. 2) imply a contradictory statistical situation where among 10 events three are by muons (at least a factor 3.5 suppressed by their cross section respect the tau one), none are tau. Indeed in this frame, assuming as obvious the equal NC (neutral current) contribute by all the three astrophysical neutrinos but keeping the muon suppression by a factor at least 3, we expect the following flux ratio of events: $\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} : \Phi_{\nu_{NC}} = 1 : \frac{1}{3} : 1 : 1$ that will reflect in a normalized

$$\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} : \Phi_{\nu_{NC}} = \frac{3}{10} : \frac{1}{10} : \frac{3}{10} : \frac{3}{10}$$

$$P_{\text{No-}\tau} = \left(\frac{7}{10}\right)^9 = 4\%.$$

$$P_{\text{No-}\tau} = \left(\frac{7}{10}\right)^{10} = 2.82\%. \quad (2.4)$$

In this prospective the ten times tau absent event imply already a significant tension with present glorified astrophysical interpretation. These results will be greatly amplified by a doubled candidate number as twice the observed ones:

$$P_{\text{No-}\tau} = \left(\frac{7}{10}\right)^{18} = 0.16\%. \quad (2.5)$$

No tau appearance within 18 near future records may imply at 99.84% level the inconsistency of the ICECUBE astrophysical neutrino origin.

2.2 The charmed neutrino flux and their tau suppression

Finally the alternative interpretation of charmed neutrino signals made (see Fig. 4) by ν_e , ν_μ and by their antiparticles and by their common neutral current will imply a final observed flux:

$$\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} : \Phi_{\nu_{NC}} = 1 : 1 : \frac{1}{10} : \frac{21}{30} \quad (2.6)$$

that last tiny term $\frac{1}{10}$ it is due to the additional ν_τ rate, while the $\frac{21}{30}$ it is due to the electron, muon and small tau neutral current events. In that case, as one may easily see, the absence of tau event it is a much more probable outcome; the normalized fluxes will be:

$$\Phi_{\nu_e} : \Phi_{\nu_\mu} : \Phi_{\nu_\tau} : \Phi_{\nu_{NC}} = \frac{30}{84} : \frac{30}{84} : \frac{3}{84} : \frac{21}{84} \quad (2.7)$$

The consequent probability to not observe a tau in charmed frame it is

$$P_{\text{No-}\tau} = \left(\frac{81}{84}\right)^{10} = 69.5\% \quad (2.8)$$

that it is well compatible with the present IceCube tau absence. In a near future, doubling the data, this probability may becomes

$$P_{\text{No-}\tau} = \left(\frac{81}{84}\right)^{18} = 51.96\%, \quad P_{\text{No-}\tau} = \left(\frac{81}{84}\right)^{20} = 48.3\%. \quad (2.9)$$

Therefore the eventual not discover or just a single tau discover within next future 20 candidate events (above 200 TeV) may be (in equal probability) well allowed in the prompt atmospheric interpretation, while it will be still a rare case, quite well in tension with any astrophysical interpretation:

$$P_{\text{No-}\tau} = \left(\frac{3}{4}\right)^{20} = 0.317\%, \quad P_{\tau=1} = \left(\frac{3}{4}\right)^{19} \cdot \frac{1}{4} \cdot 20 = 2.11\% \quad (2.10)$$

The ideal case where the energy threshold is reduced to 100 TeV and the data record is doubled is leading to nearly 35 candidates. Therefore in this future optimal rate the probability to not observe a tau will be extremely severe

$$P_{\text{No-}\tau} = \left(\frac{3}{4}\right)^{35} = 0.0042\%. \quad (2.11)$$

3. Conclusion

The absence of tau signal in old three years record of IceCube data is allowed within a $P_{\text{No-}\tau} = 5.6 - 7.5\%$ narrow windows of possibility assuming an astrophysical interpretation, while it is a quite probable outcome in a prompt charmed neutrino scenario $P_{\text{No-}\tau} = 69.5\%$. The very near double future 18 – 20 candidate events above 200 TeV in IceCube for the last 6-7 years record, the eventual persistent absence of the tau it will lead to $P_{\text{No-}\tau} = 99.7\%$ or at $P_{\text{No-}\tau} = 98\%$ probability, assuming that IceCube events are of astrophysical nature. To accept the astrophysical neutrino nature we will expect two or even more tau events within the next future 20 candidates. For instance the probability to have at least two tau in astrophysical vision within 20 events is:

$$P_{N_{\tau}=2} = \left(\frac{3}{4}\right)^{18} \cdot \left(\frac{1}{4}\right)^2 \cdot 10 \cdot 19 = 6.7\%. \quad (3.1)$$

Thus, in a near future either we should observe several tau double bang, otherwise the neutrino astronomy is at stake, more or less severe. Only and mainly the tau air-shower road-map [14] it might open in a guaranteed way our eyes to a neutrino sky, as in present and future experiments [15], [16], [18].

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