Highest Energy Neutrino Showers in EUSO

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EUSO experiment, while monitoring the downward Earth atmosphere layers, may observe among common Ultra High Energy Cosmic Rays, UHECR, also High Energy Neutrino-Induced Showers either blazing upward to the detectors at high (\(\sim\) PeVs) energies or at much higher GZK, \(\sim E_\nu \geq 10^{19}\) eV energies, showering horizontally in air or vertically downward. A small fraction of these upward, horizontal and vertical Shower maybe originated by direct astrophysical UHE neutrino interacting on terrestrial air layers itself; however the dominant UHE neutrino signal are Upward and Horizontal Tau Air-Showers, UPTAUS and HORTAUs (or Earth skimming \(\nu\)), born within widest Earth Crust Crown (Sea or Rock) Areas, by UHE \(\nu_\tau + \text{Nuclei} \rightarrow \tau\) interactions, respectively at PeVs and GZK energies: their rate and signatures are shown in a neutrino fluence map for EUSO thresholds versus other UHE air interacting neutrino signals and backgrounds. The effective target Masses originating HORTAUs seen by EUSO may exceed (on sea) a wide and huge ring volume \(\simeq 5130\) km\(^3\). The consequent HORTAUS event rate (even at 10\% EUSO duty cycle lifetime) may deeply test the expected Z-Burst models by at least a hundred of yearly events. Even rarest but inescapable GZK neutrinos (secondary of photopion production of observed cosmic UHECR) might be discovered in a few (or a tens) horizontal shower events; in this view an extension of EUSO detectability up to \(\sim E_\nu \geq 10^{19}\) eV threshold is to be preferred. A wider collecting EUSO telescope (3m diameter) might be considered.

Introduction: EUSO and GZK \(\nu\)

The very possible discover of an UHECR astronomy, the solution of the GZK paradox, the very urgent rise of an UHE neutrino astronomy are among the main goals of EUSO project. This advanced experiment in a very near future will encompass AGASA-HIRES and AUGER and observe for highest cosmic ray showers on Earth Atmosphere recording their tracks from International Space Station by Telescope facing dawnward the Earth. Most of the scientific community is puzzled by the many mysteries of UHECRs: their origination because of their apparent isotropy, is probably extragalactic. However the UHECR events are not clustered to any nearby AGN, QSRs or Known GRBs within the narrow (10-30 Mpc radius) volume defined by the cosmic 2.75 \(K\) proton drag viscosity (the so called GZK cut-off \[24, 39\]). The recent doublets and triplets clustering found by AGASA seem to favor compact object (as AGN) over more exotic topological relic models, mostly fine tuned in mass (GUT, Planck one) and time decay rate to fit all the observed spectra. However the missing AGN within a GZK volume is wondering. A possible remarkable correlation recently shows that most of the UHECR event cluster point toward BL Lac sources \[23\]. This correlation favors a cosmic origination for UHECRs, well above the near GZK volume. In this frame a relic neutrino mass \(0.1\) \(\text{eV}\) or \(m_\nu \simeq 0.1 \div 5\) eV) may solve the GZK paradox \[8, 9, 38, 37, 15, 20\] overcoming the proton opacity being ZeV UHE neutrinos transparent (even from cosmic edges to cosmic photon Black Body drag) while interacting in resonance with relic neutrinos masses in dark halos (Z-burst or Z-WW showering models). These light neutrino masses do not solve the galactic or cosmic dark matter problem but it is well consistent with old and recent solar neutrino oscillation evidences \[22, 24, 2\] and most
recent claims by KamLAND [27] of anti-neutrino disappearance (all in agreement within a Large Mixing Angle neutrino model and $\Delta m_{\nu}^2 \sim 7 \cdot 10^{-5}$eV$^2$) as well as these light masses are in agreement with atmospheric neutrino mass splitting ($\Delta m_{\nu} \simeq 0.07$eV) and in fine tune with more recent neutrino double beta decay experiment mass claim $m_{\nu} \simeq 0.4$ eV [28]. In this Z-WW Showering for light neutrino mass models large fluxes of UHE $\nu$ are necessary, higher than usual gray-body spectra of target relic neutrino or better clustering are needed [15, 34]; indeed a heaviest neutrino mass $m_{\nu} \simeq 1.2 - 2.2$ eV while still being compatible with known bounds, might better gravitationally cluster leading to denser dark local-galactic halos and lower neutrino fluxes [15, 34]. It should remarked that in this frame the main processes leading to UHECR above GZK are mainly the WW-ZZ and the t-channel interactions [9, 15]. These expected UHE neutrino fluxes might and must be experienced in complementary and independent tests.

1. UHE $\nu$ Astronomy by the $\tau$ Showering

While longest $\mu$ tracks in km$^3$ underground detector have been, in last three decades, the main searched UHE neutrino signal, Tau Air-showers by UHE neutrinos generated in Mountain Chains or within Earth skin crust at Pevs up to GZK ($> 10^{19}$ eV) energies have been recently proved to be a new powerful amplifier in Neutrino Astronomy [14, 10, 15, 33, 19]. This new Neutrino $\tau$ detector will be (at least) complementary to present and future, lower energy, $\nu$ underground km$^3$ telescope projects (from AMANDA, Baikal, ANTARES, NESTOR, NEMO, IceCube). In particular Horizontal Tau Air shower may be naturally originated by UHE $\nu_\tau$ at GZK energies crossing the thin Earth Crust at the Horizon showering far and high in the atmosphere [10, 12, 18, 19]. UHE $\nu_\tau$ are abundantly produced by flavour oscillation and mixing from muon (or electron) neutrinos, because of the large galactic and cosmic distances respect to the neutrino oscillation ones (for already known neutrino mass splitting). Therefore EUSO may observe many of the above behaviours and it may constrains among models and fluxes and it may also answer open standing questions. I will briefly enlist, in this first preliminary presentation, the main different signatures and rates of UHECR versus UHE $\nu$ shower observable by EUSO at 10% duty cycle time within a 3 year record period, offering a first estimate of their signals. Part of the results on UHECR are probably well known, even here it is re-estimated. Part of the results, regarding the UPTAUs and HORTAUs, are new and they rule the UHE $\nu$ Astronomy in EUSO.
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Figure 3. A very schematic Upward Tau Air-Shower (UPTAUs) and its open fan-like jets due to geo-magnetic bending at high quota (\(\sim 20 - 30\) km). The gamma Shower may be pointing to an orbital detector \([10], [12], [13]\). Its vertical Shower tail may be spread by geo-magnetic field into a thin eight-shape beam observable by EUSO as a small blazing oval (few dot-pixels) aligned orthogonal to the local magnetic field.

2. Upward UHE \(\nu\) Showering in Air

Let us first consider the last kind of Upward \(\tau\) signals due to their interaction in Air or in Earth Crust. The Earth opacity will filter mainly \(10^{14} - 10^{15}\) eV upward events \([31], [29], [1], [7], [10]\); therefore only the direct \(\nu\) shower in air or the UPTAUs around PeVs will be able to flash toward EUSO in a narrow beam (\(2.5 \cdot 10^{-5}\) solid angle) jet blazing apparently at \(10^{19} - 10^{20}\) eV energy. The shower will be opened in a fan like shape and it will emerge from the Earth atmosphere spread as a triplet or multi-dot signal aligned orthogonal to local terrestrial magnetic field. This signature will be easily revealed. However the observed air mass by EUSO is not \(10\%\) (because duty cycle) of the inspected air volume \(\sim 150 km^3\), but because of the narrow blazing shower cone it corresponds to only 3.72 \(\cdot 10^{-3}\) \(km^3\). The target volume increases for upward neutrino Tau interacting vertically in Earth Crust in last matter layer (either rock or water), making upward relativistic \(\simeq\) PeV \(\tau\) whose decay in air born finally an UPTAUs; in this case the effective target mass is (for water or rock) respectively \(5.5 \cdot 10^{-2} km^3\) or \(1.5 \cdot 10^{-1} km^3\). These volume are not extreme. The consequent foreseen thresholds are summarized for 3 EUSO years of data recording in Figure 4. The UPTAUs signal is nearly 15 times larger than the Air-Induced \(\nu\) Shower. A more detailed analysis may show an additional factor three (due to the neutrino flavours) in favor of Air-Induced Showers, but the more transparent role of PeV multi-generating upward \(\nu\) while crossing the Earth, makes the result summarized in figure. The much wider acceptance of BATSE respect EUSO and the consequent better threshold (in BATSE) is due to the wider angle view of the gamma detector, the absence of any suppression factor as in EUSO duty cycle, as well as the \(10\) (for BATSE) over \(3\) (for EUSO) years assumed of record lifetime. Any minimal neutrino fluence \(\Phi_{\nu}\) of PeVs neutrino

\[
\Phi_{\nu} \geq 10^2 eV cm^{-2} s^{-1}
\]

might be detectable by EUSO.

3. Downward and Horizontal UHECRs

Let us now briefly reconsider the nature of common Ultra High Cosmic Rays (UHECR) showers.
Their rate will offer a useful test for any additional UHE neutrino signals. Let us assume for sake of simplicity a characteristic opening angle of EUSO telescope of 30° and a nominal satellite height of 400 km, leading to an approximate atmosphere area under inspection of EUSO \( \sim 1.5 \cdot 10^5 km^2 \). Let us discuss the UHECR shower: It has been estimated (and it is easy to verify) a \( \sim 2 \cdot 10^3 \) event/year rate above \( 3 \cdot 10^{19} \) eV. Among these "GZK" UHECR (either proton, nuclei or \( \gamma \)) nearly 7.45\% \( \approx 150 \) event/year will shower in Air Horizontally with no Cherenkov hit on the ground. The critical angle \( 6^o \) corresponding to 7.45\% of all the events, is derived from first interacting quota (here assumed for Horizontal Hadronic Shower near 44 km following \[10\], \[12\], \[13\]): Indeed the corresponding horizontal edge critical angle \( \theta_h = 6.7^o \) below the horizons \((\pi/2)\) is found (for an interacting height \( h \) near 44 km): \( \theta_h = \arccos \left( \frac{\frac{R_o}{2}}{\frac{R_o}{2} + h} \right) \approx 1^o \sqrt{\frac{h}{10 km}} \). These Horizontal High Altitude Showers (HIAS) \[12\], \[13\], will be able to define a new peculiar showering, mostly very long (hundred kms) and bent and forked (by few or several degrees) by local geo-magnetic fields. The total UHECR above \( 3 \cdot 10^{19} \) eV will be \( \sim 6000 \) UHECR and \( \sim 450 \) Horizontal Shower within 3 years; these latter horizontal signals are relevant because they may mimic Horizontal induced \( \nu \) Air-Shower, but mainly at high quota \((\geq 30 \sim 40km)\) and downward. On the contrary UHE neutrino tau showering, HORTAUs, to be discussed later, are also at high quota \((\geq 23km)\), but upward-horizontal. Their outcoming angle will be \((\geq 3^o \sim 2^o)\) upward. Therefore a good angular \((\leq 0.2 \sim 0.1^o)\) resolution to distinguish between the two signal will be a key discriminator. While Horizontal UHECR are an important piece of evidence in the UHECR calibration and its GZK study, at the same time they are a severe back-ground noise competitive with Horizontal-Vertical GZK Neutrino Showers originated in Air, to be discussed below. However Horizontal-downward UHECR are not confused with upward Horizontal HORTAUs by UHE neutrinos to be summarized in last section. Note that Air-Induced Horizontal UHE neutrino as well as all down-ward Air-Induced UHE \( \nu \) will shower mainly at lower altitudes \((\leq 10km)\); however they are respectively only a small \((\leq 2\%, \leq 8\%)\) fraction than HORTAUs showers to be discussed in the following. An additional factor 3 due to their three flavour over \( \tau \) unique one may lead to respectively \((\leq 6\%, \leq 24\%)\) of all HORTAUs events: a contribute ratio that may be in principle an useful test to study the balanced neutrino flavour mixing.

4. Air Induced UHE \( \nu \) Shower

UHE \( \nu \) may hit an air nuclei and shower vertically or horizontally or more rarely nearly upward: its trace maybe observable by EUSO preferentially in inclined or horizontal case. Indeed Vertical Down-ward \((\theta \leq 60^o)\) neutrino induced Air Shower occur mainly at lowest quota and they will only partially shower their UHE \( \nu \) energy because of the small slant depth \((\leq 10^3 gcm^{-2})\) in most vertical down-ward UHE \( \nu \) shower. The observed EUSO air mass \((1500km^3)\), corresponding to a \( \sim 150 \) km\(^3\) for 10\% EUSO record

![Diagram](image-url)
time) is only ideally the UHE neutrino calorimeter. Indeed inclined ($\sim \theta \geq 60^\circ$) and horizontal Air-Shower ($\sim \theta \geq 83^\circ$) (induced by GZK UHE neutrino) may reach their maximum output and their event maybe observed; therefore only a small fraction ($\sim 30\%$ corresponding to $\sim 50 \text{ km}^3$ mass-water volume for EUSO observation) of vertical downward UHE neutrino may be seen by EUSO. This signal may be somehow hidden or masked by the more common down-ward UHECR showers. The key reading signature will be the shower height origination: ($\geq 40 \text{ km}$) for most downward-horizontal UHECR, ($\leq 10 \text{ km}$) for most inclined-horizontal Air UHE $\nu$ Induced Shower. A corresponding smaller fraction ($\sim 7.45\%$) of totally Horizontal UHE neutrino Air shower, orphan of their final Cherenkov flash, in competition with the horizontal UHECR, may be also clearly observed: their observable mass is only $V_{\text{Air-}\nu-\text{Hor}} \sim 11.1 \text{ km}^3$ for EUSO observation duty-cycle. These masses reflect into a characteristic threshold behaviour shown by bounds in Figure 7.

4.1. UHE $\nu_\tau - \tau$ Double Bang Shower

A more rare, but spectacular, double $\nu_\tau-\tau$ bang in Air (comparable in principle to the PeVs expected "double bang" in water [22]) may be exciting, but difficult to be observed; the EUSO effective calorimeter mass for such Horizontal event is only 10% of the UHE $\nu$ Horizontal ones ($\sim 1.1 \text{ km}^3$); therefore its event rate is nearly excluded needing a too high neutrino fluxes see Fig.6; indeed it should be also noted that the EUSO energy threshold ($\geq 3 \cdot 10^{18}\text{eV}$) imply such a very large $\tau$ Lorents boost distance; such large $\tau$ track exceed (by more than a factor three) the EUSO disk Area diameter ($\sim 450\text{km}$); therefore the expected Double Bang Air-Horizontal-Induced $\nu$ Shower thresholds are suppressed by a corresponding factor as shown in Figure 6. More abundant single event Air-Induced $\nu$ Shower (Vertical or Horizontal) thresholds are facing different Air volumes and quite different visibility as shown and summarized in Fig7. It must be taken into account an additional factor three (because of three light neutrino states) in the Air-Induced $\nu$ Shower arrival flux respect to incoming $\nu_\tau$ (and $\bar{\nu}_\tau$), making the Air target not totally a negligible calorimeter.

4.2. UHE $\nu_\tau - \tau$ Air Single Bang Shower

There are also a sub-category of $\nu_\tau - \tau$ "double bang" due to a first horizontal UHE $\nu_\tau$ charged current interaction in air nuclei (the first bang) that is lost from the EUSO view: their UHE secondary $\tau$ fly and decay leading to a Second Air-Induced Horizontal Shower, within the EUSO disk area. These horizontal "Double-Single $\tau$ Air Bang" Showers (or if you like popular terminology, these Air-Earth Skimming neutrinos or just Air-HORTAUs event) are produced within a very wide Terrestrial Crown Air Area whose radius is exceeding $\sim 600 – 800 \text{ km}$ surrounding the EUSO Area of view. However it is easy to show that they will just double the Air-Induced $\nu$ Horizontal Shower rate due to one unique flavour. Therefore the total Air-Induced Horizontal Shower (for all 3 flavours and the additional $\tau$ decay in flight) are summarized and considered in Fig.7. The relevant UHE neutrino signal, as discussed below, are due to the Horizontal Tau Air-Showers originated within the (much denser)Earth Crust: the called HORTAUs (or Earth Skimming $\nu_\tau$).

5. UHE $\nu_\tau - \tau$ from Earth Skin: HORTAUs

As already mention the UHE $\nu$ astronomy maybe greatly amplified by $\nu_\tau$ appearance via flavour mixing and oscillations. The consequent scattering of $\nu_\tau$ on the Mountains or into the Earth Crust may lead to Horizontal Tau Air-Showers :HORTAUs (or so called Earth Skimming Showers [12, 13, 10, 14]). Indeed UHE $\nu_\tau$ may skip below the Earth and escape as $\tau$ and finally decay in flight, within air atmosphere, as well as inside the Area of view of EUSO, as shown in Figure 8. Any UHE-GZK Tau Air Shower induced event is approximately born within a wide ring (whose radiuses extend between $R \geq 300$ and $R \leq 800 \text{ km}$ from the EUSO Area center). Because of the wide area and deep $\tau$ penetration [10, 12, 13] the amount of interacting matter where UHE $\nu$ may lead to $\tau$ is huge ($\geq 2 \cdot 10^5 \text{ km}^3$) however only a tiny fraction of these HORTAUs will beam and Shower within the EUSO
The Fluence threshold for EUSO has been estimated for a three year experiment lifetime. Competitive experiments are also shown as well as the Z-Shower expected spectra in most probable light neutrino mass values ($m_\nu = 0.04, 0.4$ eV). \cite{10, 12, 26, 15, 18}.

Area within EUSO. After carefully estimate (using also results in \cite{10, 10}, \cite{17, 18}) I probed a lower bound (in sea matter) for these effective Volumes respectively at ($1.1 \cdot 10^{19}$ eV) and at ($3 \cdot 10^{19}$ eV) energy:

$$V_{eff} \geq A_{EUSO} \cdot \frac{1}{2} \cdot \sin \delta \theta_{h_1} \cdot l_\tau \cdot \delta \theta_{h_1}$$ (1)

The above geometrical quantities $\delta \theta_{h_1}, l_\tau$, are the Earth Skimming or HORTAU angle and tau interaction length defined in reference \cite{10} while $A_{EUSO}$ is the EUSO Area. Assuming a characteristic EUSO radius of 225 km and at above energies one obtains a lower bound:

$$V_{eff} \simeq 5.13 \cdot 10^7 km^3$$

$$V_{eff} \simeq 6.25 \cdot 10^9 km^3$$

These are the bounds applied in red curves in figures. A more exact and detailed derivation offer a larger Volume:

$$V_{eff} \simeq A_{EUSO} \cdot (\sin \delta \theta_{h_1})^2 \cdot l_\tau$$ (2)

These volumes are twice the above considered bounds but are not discussed here. Therefore at GZK energies (1.1 $\cdot 10^{19}$ eV) the horizontal $\tau$ by HORTAUs are more than 50 times more abundant than any corresponding Horizontal Air Induced at energy 10$^{19}$ eV neutrino air-induced at the same energy. It should be remind that all these bound for EUSO in figure are already suppressed by a factor 0.1 due to minimal EUSO duty cycle.

However the Air-Shower induced neutrino may reflect all three light neutrino flavours, while HORTAUs are made only by $\nu_\tau, \bar{\nu}_\tau$ flavour. Nevertheless the dominant role of HORTAUs overcome (by a factor $\geq 15$) all other Horizontal EUSO neutrino event: their expected event rate are, at $\Phi_\nu \geq 3 \cdot 10^{3}$ eV cm$^{-2}$s$^{-1}$ neutrino fluence (as in Z-Shower model in Figure 9 – 10), a few hundred event a year and they may already be comparable or even may exceed the expected Horizontal CR rate. Dash curves for both HORTAUs and Horizontal Cosmic Rays are drawn assuming an EUSO threshold at 10$^{19}$eV. Because the bounded $\tau$ flight distance (due to the contained

**Figure 6.** EUSO threshold for Double bang $\tau$ Neutrino over other $\gamma, \nu$ and Cosmic Rays (C.R.) Fluence and bounds in different energy windows. The Fluence threshold for EUSO has been estimated for a three year experiment lifetime. Competitive experiment are also shown as well as the Z-Shower expected spectra in most probable light neutrino mass values ($m_\nu = 0.04, 0.4$ eV).\cite{10, 12, 26, 15, 18}.

**Figure 7.** EUSO thresholds for Horizontal and Vertical Downward Neutrino Air induced shower over other $\gamma, \nu$ and Cosmic Rays (C.R.) Fluence and bounds. The Fluence threshold for EUSO has been estimated for a three year experiment lifetime. Competitive experiments are also shown as well as the Z-Shower expected spectra in light neutrino mass values ($m_\nu = 0.04, 0.4$ eV).\cite{10, 12, 26, 15, 18}.
Figure 8. A schematic Horizontal High Altitude Shower or similar Horizontal Tau Air-Shower (HORTAUs) and its open fan-like jets due to geo-magnetic bending seen from a high quota by EUSO satellite. The image background is moon eclipse shadow observed by Mir on Earth. The forked Shower is multi-finger containing a inner $\gamma$ core and external fork spirals due to $e^+e^-$ pairs (first opening) and $\mu^+\mu^-$ pairs [10], [12], [13].

Figure 9. EUSO thresholds for Horizontal Tau Air-Shower HORTAUs (or Earth Skimming Showers) over few $\gamma$, $\nu$ and Cosmic Rays (C.R.) Fluence and bounds. Dash curves for HORTAUs are drawn assuming an EUSO threshold at $10^{19}$eV. Because the bounded $\tau$ flight distance (due to the contained terrestrial atmosphere height) the main signal is better observable at $1.1 \cdot 10^{19}$eV than higher energies. The Fluence threshold for EUSO has been estimated for a three year experiment lifetime. Z-Shower or Z-Burst expected spectra in light neutrino mass values ($m_\nu = 0.04, 0.4$ eV) are shown. [10], [12], [26], [15], [18].
terrestrial atmosphere height) the main signal is better observable at $1.1 \cdot 10^{19}$eV than higher energies as emphasized in Fig.9 – 10 at different threshold curves.

6. Conclusions

Highest Energy Neutrino signals may be well observable by next generation satellite as EUSO; the main source of such neutrino traces are UPTAUs (Upward Tau blazing the telescope born in Earth Crust) and mainly HORTAUs (Horizontal Tau Air-Showers originated by an Earth-Skimming UHE $\nu_\tau$). These showers will be opened in a characteristic thin fan-jet ovals like the 8-shape horizontal cosmic ray observed on Earth. The UPTAUs will arise mainly at PeV energies (because the Earth neutrino opacity at higher energies and because the shorter $\tau$ boosted length, at lower energies) [10]; UPTAUs will be detected as a thin stretched multi-pixel event by EUSO, whose orientation is polarized orthogonal to local geo-magnetic field. The EUSO sensibility (effective volume ($V_{eff} \sim 0.1 km^3$) for 3 years of detection) will be deeper an order of magnitude below present AMANDA-Baikal bounds. Horizontal Tau Air-Showers at GZK energies will be better searched and revealed. They are originated along huge Volumes around the EUSO Area. Their horizontal skimming secondary decay occur far away $\geq 500$ km, at high altitude ($\geq 20-40$ km) and it will give clear signals distinguished from downward horizontal UHECR. HORTAUs are grown by UHE neutrino interactions inside huge volumes ($V_{eff} \geq 5130 - 6250km^3$) respectively for incoming neutrino energy $E_{\nu} \simeq 10^{19}$ eV and $3 \cdot 10^{19}$ eV. To obtain these results we applied the procedure described in recent articles [16], [17], [18]. As summarized in last Figures the expected UHE fluence

$$\Phi_{\nu} \simeq 10^3 eV cm^{-2} s^{-1}$$

needed in most Z-Shower models (as well as in most topological relic scenario) to solve GZK puzzles, will lead to nearly a hundred of horizontal events a year comparable to UHECR ones. Even in the most conservative scenario where a mini-

Figure 10. EUSO thresholds for Horizontal Tau Air-Shower shower, HORTAUs (or Earth Skimming Showers) over all other $\gamma$, $\nu$ and Cosmic Rays (C.R.) Fluence and bounds. The Fluence threshold for EUSO has been estimated for a three year experiment lifetime. Competitive experiment are also shown as well as the Z-Shower expected spectra in light neutrino mass values ($m_\nu = 0.04, 0.4$ eV). As above dash curves for both HORTAUs and Horizontal Cosmic Rays are drawn assuming an EUSO threshold at $10^{19}$eV. [10], [12], [25], [15], [18].
nal GZK-ν fluence must take place (at least at
Φν ≃ 10eV cm−2 s−1
just comparable to well observed Cosmic Ray flu-
ence), a few or a ten of such UHE astrophysical
neutrino must be observed (respectively at 1019
eV and 3·1019 eV energy windows) during three
year of EUSO data recording. To improve their
visibility EUSO must, in our opinion one may:
a) Improve the fast pattern recognition of Hori-
zontal Shower Tracks with their few distant dots
with forking signature.
b) Enlarge the Telescope Radius to embrace also
lower 1019 eV energy thresholds where UHE neu-
trino signals are enhanced.
c) Consider a detection at angular Δθ and
at height Δh level within an accuracy Δθ ≤ 0.2°,
Δh ≤ 2 km.
Even all the above results have been derived care-
fully following [16],[17],[18] in a minimal realistic
framework they may be used within 10% nomi-
nal value due to the present uncertain in EUSO
detection capabilities.

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