Tau (and Muon) Airshower from Earth (and Space)

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10 Arguments =5+5 for a 10 minutes talk : a summary

- *1. A declaration: Neutrinos exist, even if they are invisible*
- *2. We study them by rare interactions, tracks or showers*
- *3. They are three, better six, well mixed by their mass flight*
- *4 The Atmospheric Neutrino by Cosmic Rays, are useless*
- *5 The astrophysical origine must glorify a new Astronomy*

next 5+5 Neutrinos Laws

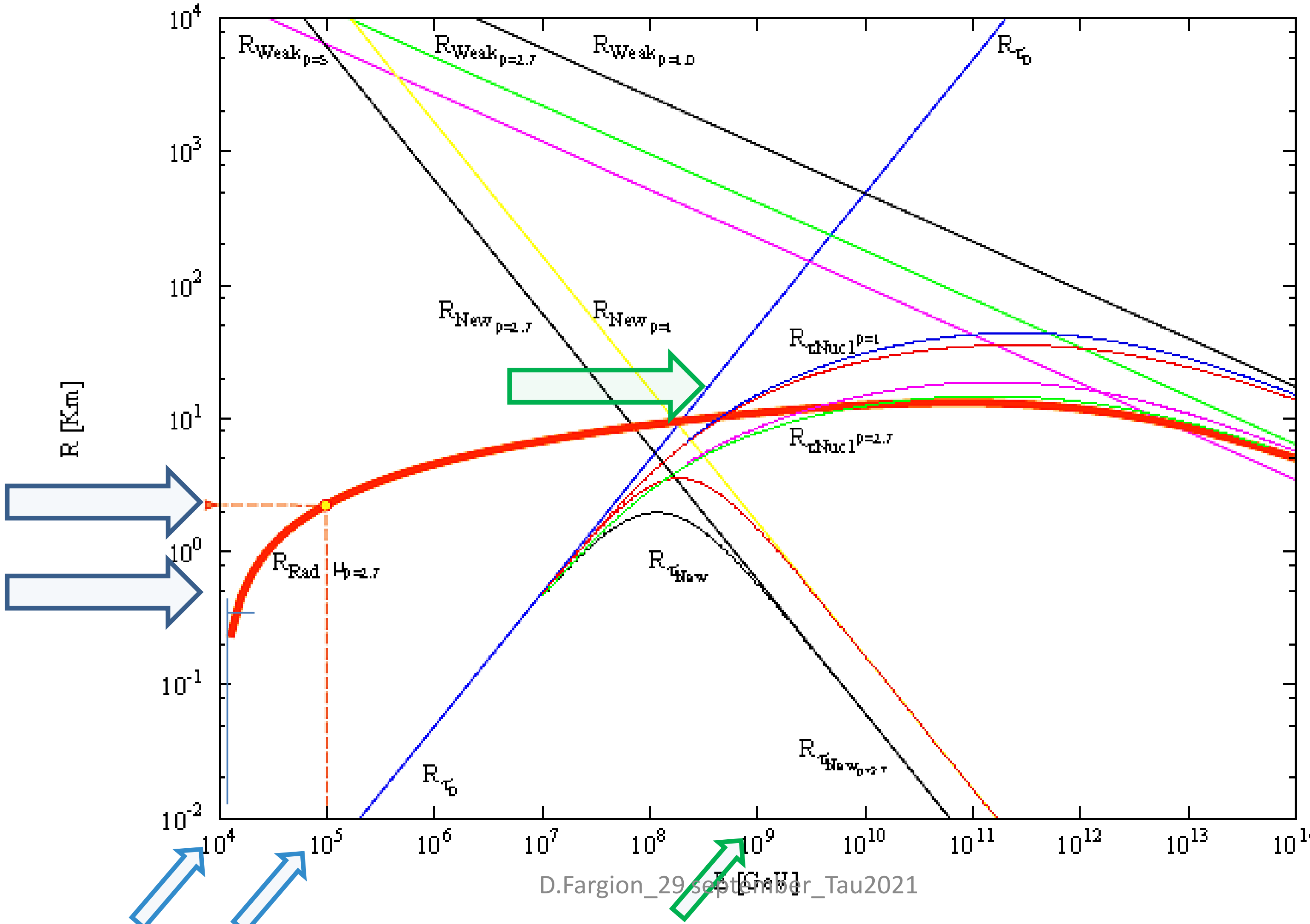
- *6 Do not create atmospheric tau neutrinos: mix them!*
- *7 Do not focus on all: just taus and muons airshowers*
- *8 Refer to time arrow: Tau 97-99 , Muon by Moon 2017-21*
- *9 Do not claim astronomy yet: Charm may be better*
- *10 Twin shadows by Muons from Moon: split the CP*

Electron, Muon and Tau neutrino signature

- *The neutrino detection requires an associated lepton birth signal.*
- ***Because of the weak interaction and because of the abundant cosmic ray noises, last century huge Kamiokande , SK, ICECUBE underground detector were preferred for the discover of a lepton traces, mostly electrons MeVs <-> but much better highest energy muons → more directional and above tensTevs, non atmospheric***

Lepton track depth in rock: Muon and Tau

Both Detectable from 10 TeV up EeVs energy



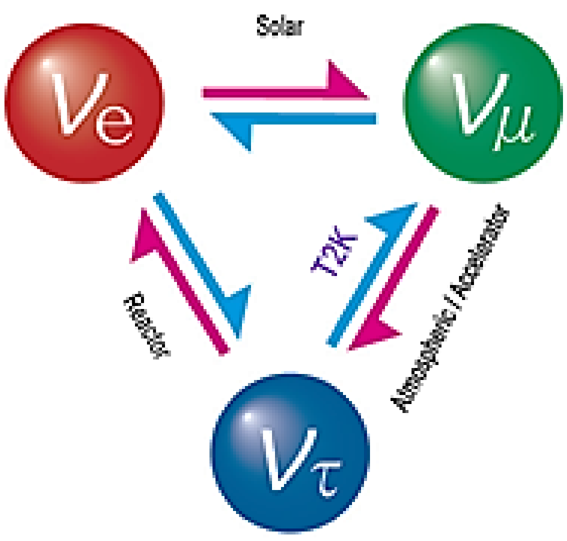
SIX NEUTRINO ASTRONOMY
Ruled by neutrino mass :
Majorana? Dirac?

Pauli: Neutrino is 1

Perl: Neutrino are not 2 but 3

Dirac add: Neutrino are not 3 but 6

Pontecorvo: Yes and they dance and mix



Neutrino oscillation between three generations

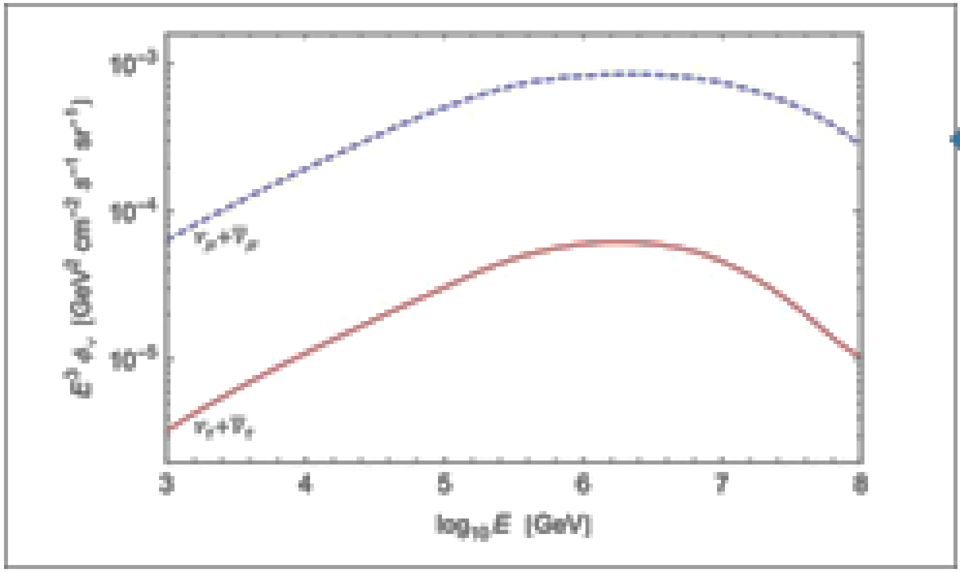
2018_D.Fargion

PeVs up EeVs Tau Airshowers from Earth Edges

- ***Tau neutrino at highest energy, its tau track, and its escape on air and decay in flight makes huge secondary ones,***
- ***an amplified signal, in number and in area.***
- ***Therefore PeV-EeV tau neutrinos escaping from mountains or Earth are easier to be discovered***

Why tau it is better

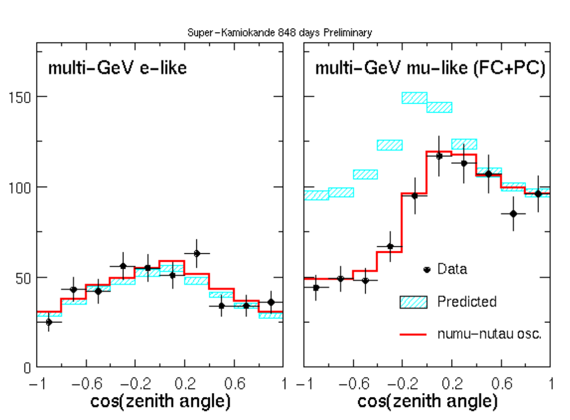
- Tau cannot be produced in atmosphere TeV energies.
- Tau cannot oscillate at TeV energy along the Earth
- Tau event cannot even be (much) born in atmospheric charm neutrinos



MUON

TAU

Kamiokande 1997 muon →tau
ICRC 1999 : TAU airshower
Salt Lake, USA June



HE.6.1.10

Horizontal Tau air showers from mountains in deep valley: Traces of UHECR neutrino tau

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The Astrophysical Journal, 570:909–925, 2002 May 10

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DISCOVERING ULTRA-HIGH-ENERGY NEUTRINOS THROUGH HORIZONTAL AND UPWARD τ AIR SHOWERS: EVIDENCE IN TERRESTRIAL GAMMA FLASHES?

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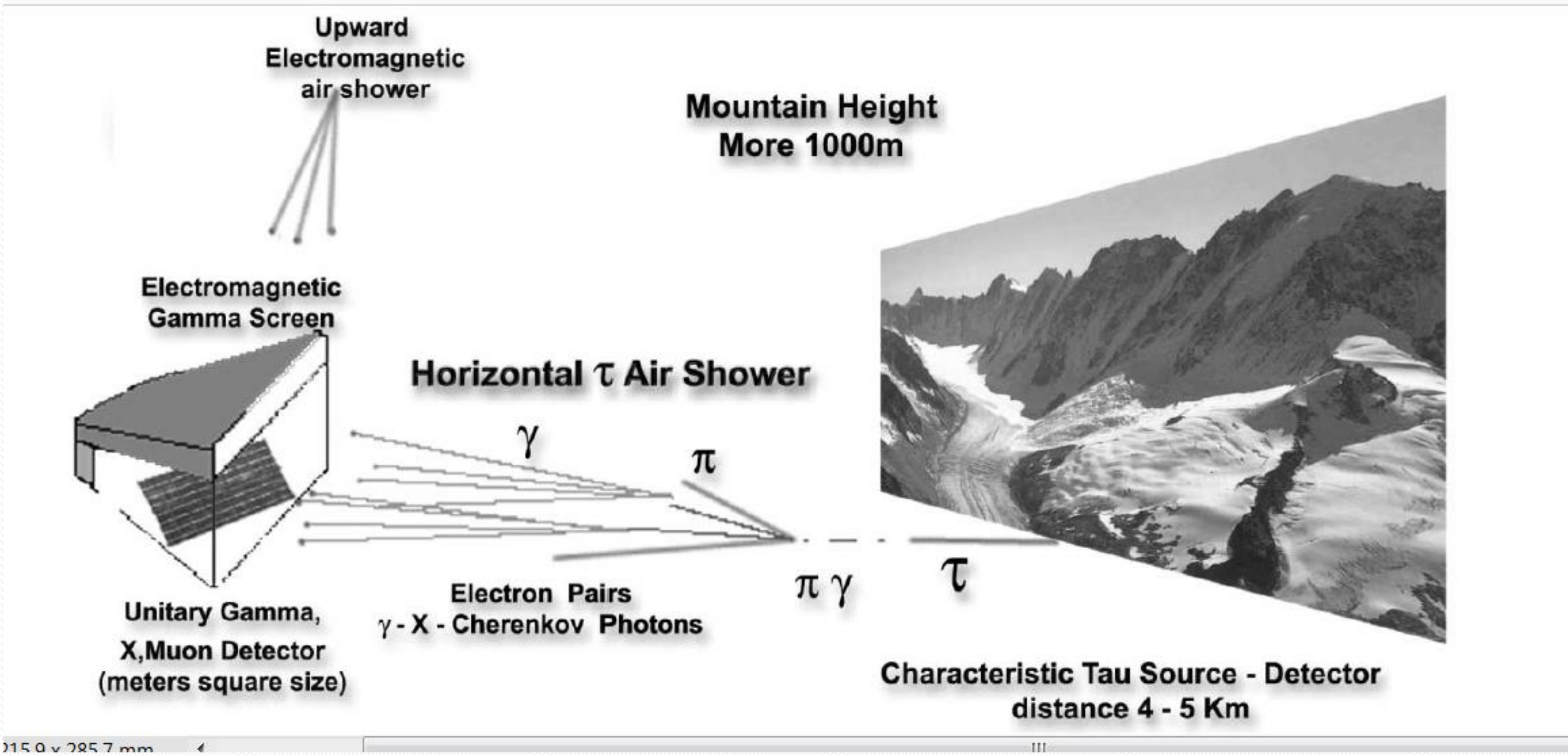
Tau Airshower in Deep Valley as in the GIANT experiment

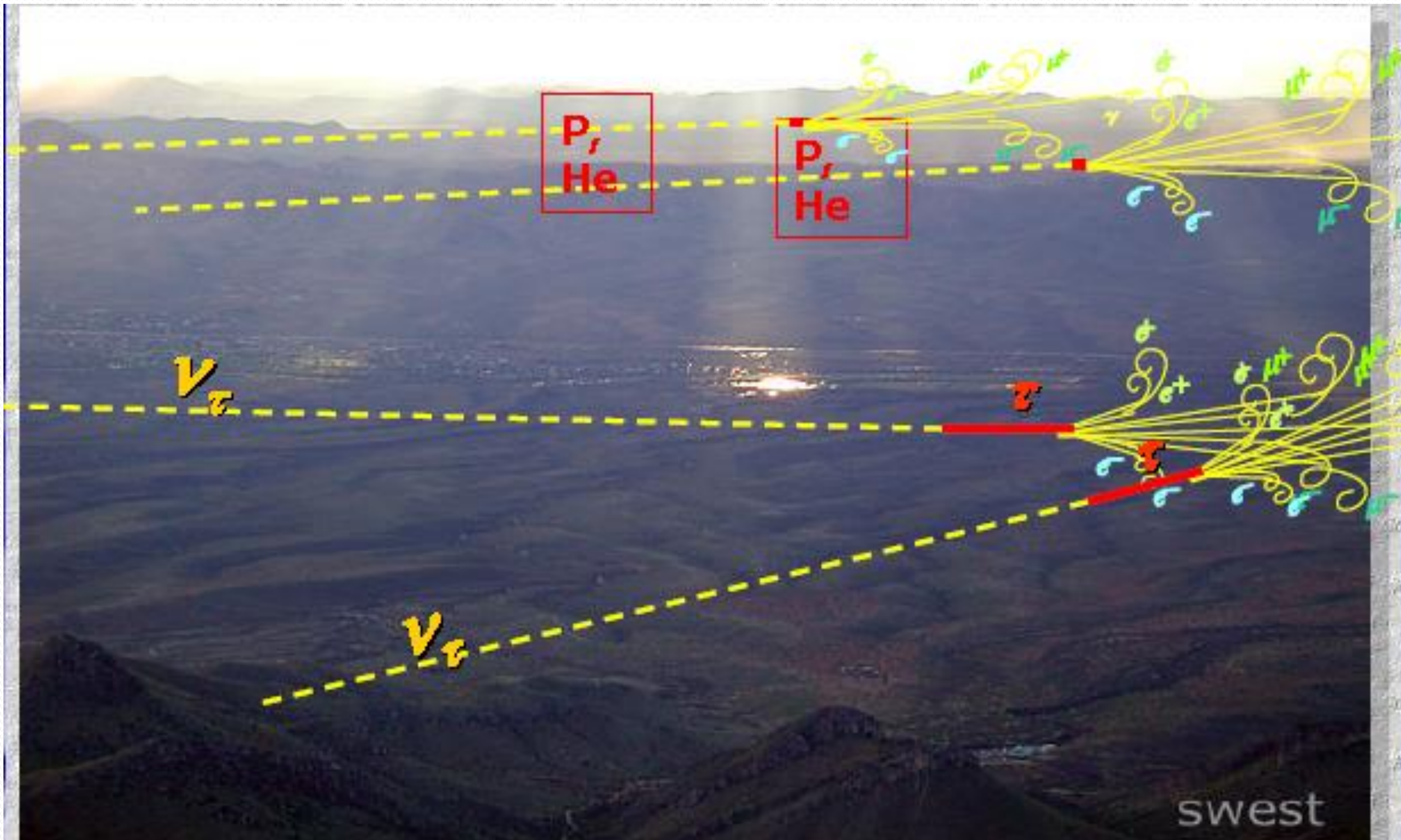


Tau airshower : a basic particle test DF, Apj 2002

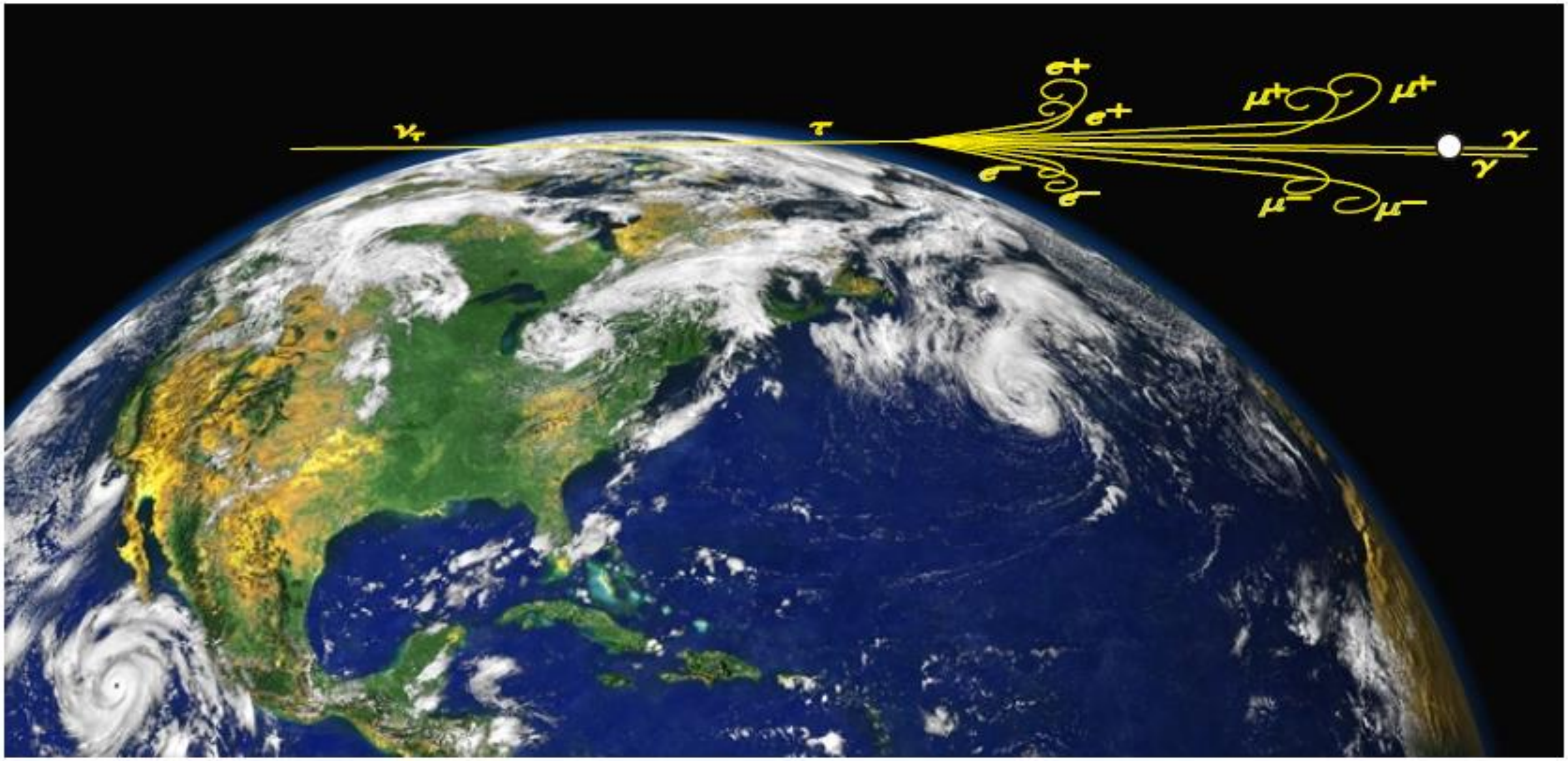
Decay	Secondaries	Probability	Air-shower
$\tau \to \mu^- \bar{\nu}_\mu \nu_\tau$	μ^-	$\sim 17.4\%$	Unobservable
$\tau \to e^- \bar{\nu}_e \nu_\tau$	e^-	$\sim 17.8\%$	1 Electromagnetic
$\tau \to \pi^- \nu_\tau$	π^-	$\sim 11.8\%$	1 Hadronic
$\tau \to \pi^- \pi^0 \nu_\tau$	π^-, $\pi^0 \to 2\gamma$	$\sim 25.8\%$	1 Hadronic, 2 Electromagnetic
$\tau \to \pi^- 2\pi^0 \nu_\tau$	π^-, $2\pi^0 \to 4\gamma$	$\sim 10.79\%$	1 Hadronic, 4 Electromagnetic
$\tau \to \pi^- 3\pi^0 \nu_\tau$	π^-, $3\pi^0 \to 6\gamma$	$\sim 1.23\%$	1 Hadronic, 6 Electromagnetic
$\tau \to \pi^- \pi^- \pi^+ \nu_\tau$	$2\pi^-$, π^+	$\sim 10\%$	3 Hadronic
$\tau \to \pi^- \pi^+ \pi^- \pi^0$	$2\pi^-$, π^+, $\pi^0 \to 2\gamma$	$\sim 5.18\%$	3 Hadronic, 2 Electromagnetic

AUGER best view at horizons:
at 30-40 km altitude: at 5-15 km:

UPWARD Tau Airshowers

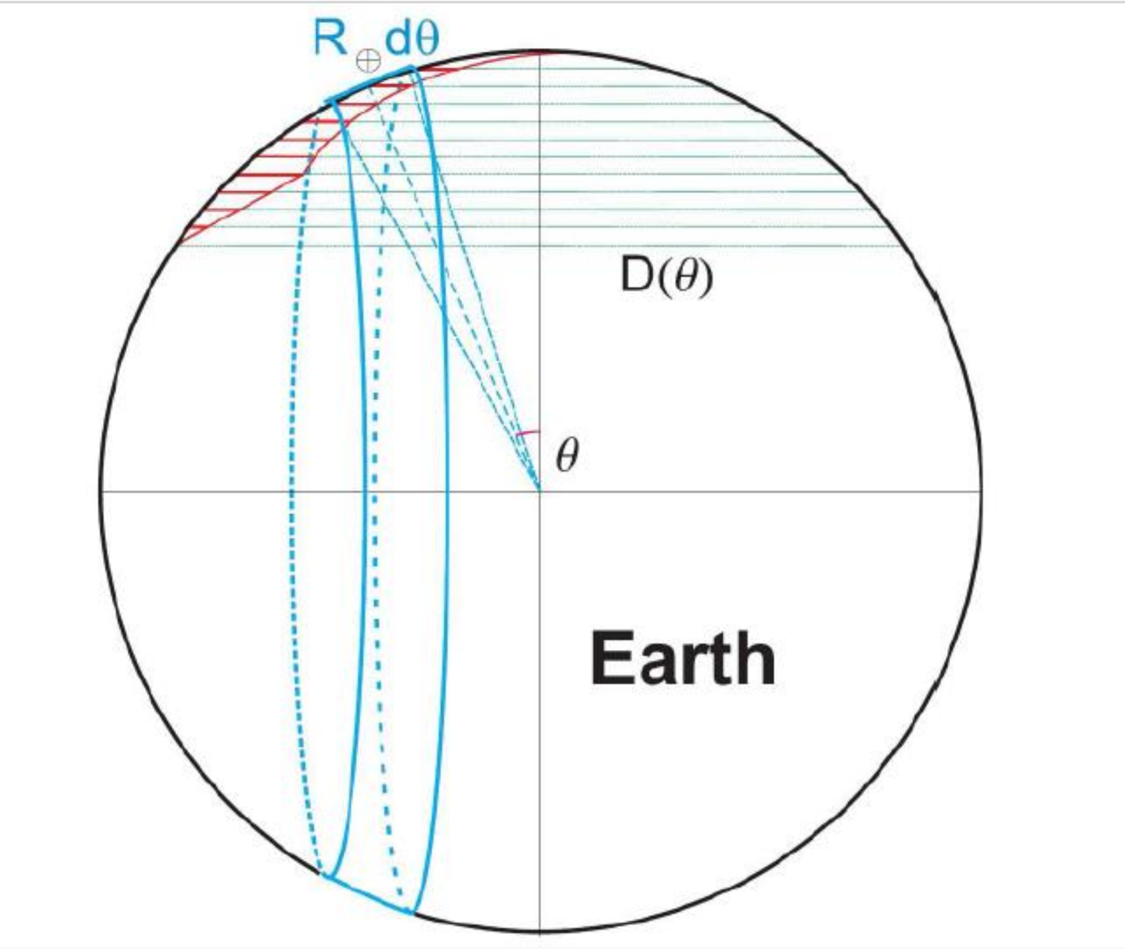


Tau Airshower at EeVs energy in Space by Poemma satellites



Tau Airshower from altitudes: ASHRA and MAGIC and CTA from the Top Mountains.

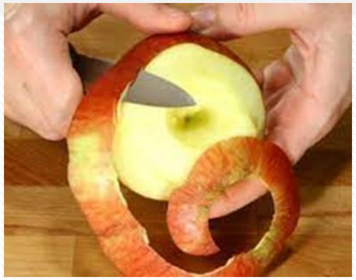
The Earth skin for skimming and airshowering tau : estimate



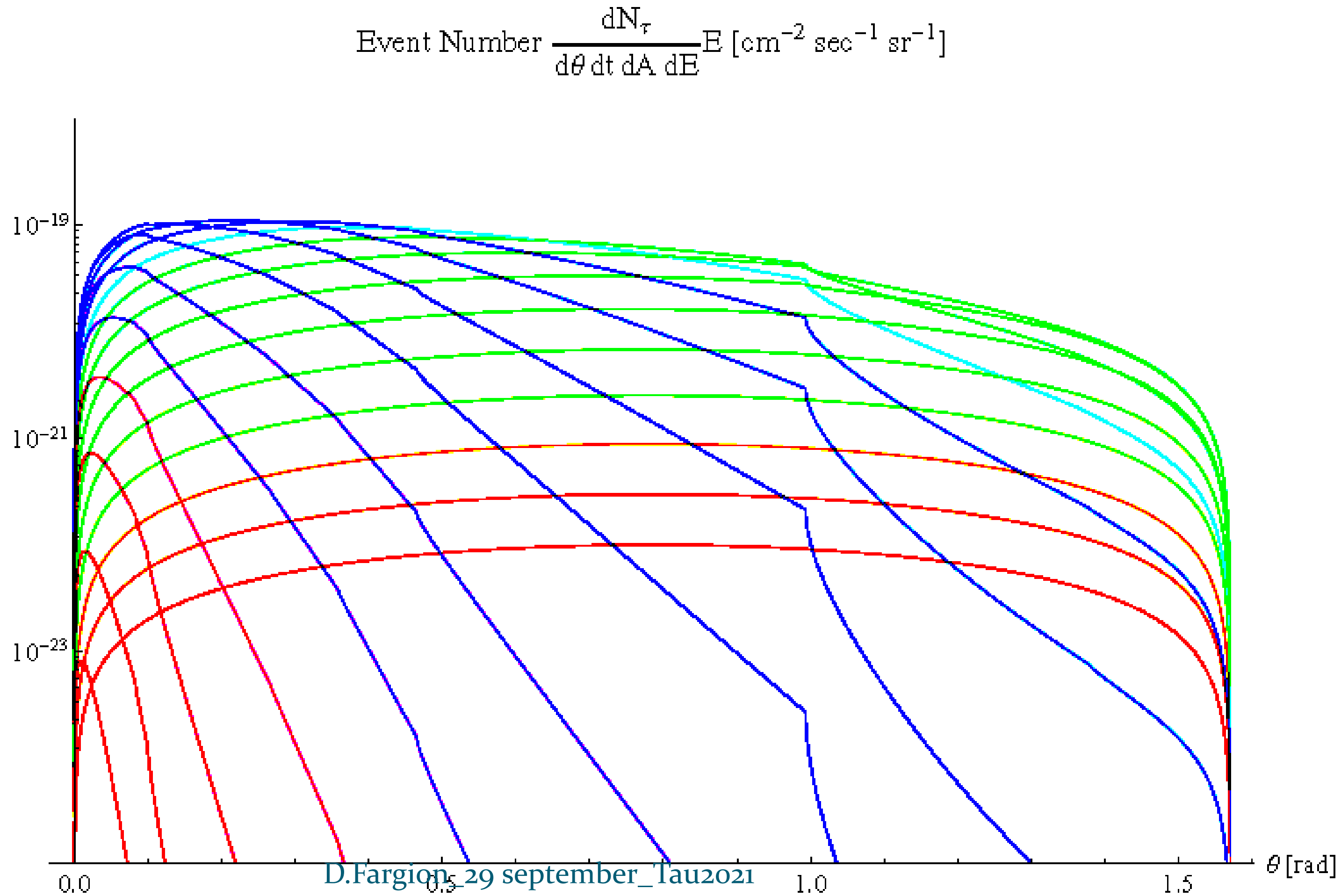
Effective volume for tau air-showering on Earth: ***DF Apj2004***

$$\frac{V_{tot}(E_\tau)}{A} = \left(1 - e^{-L_0/c\tau\gamma}\right) \cdot \left[\frac{L_{\tau(\beta)}(E_\tau)}{1 - \frac{L_{\tau(\beta)}(E_\tau)}{L_{\nu CC}(\eta E_\tau)}}\right] \cdot$$

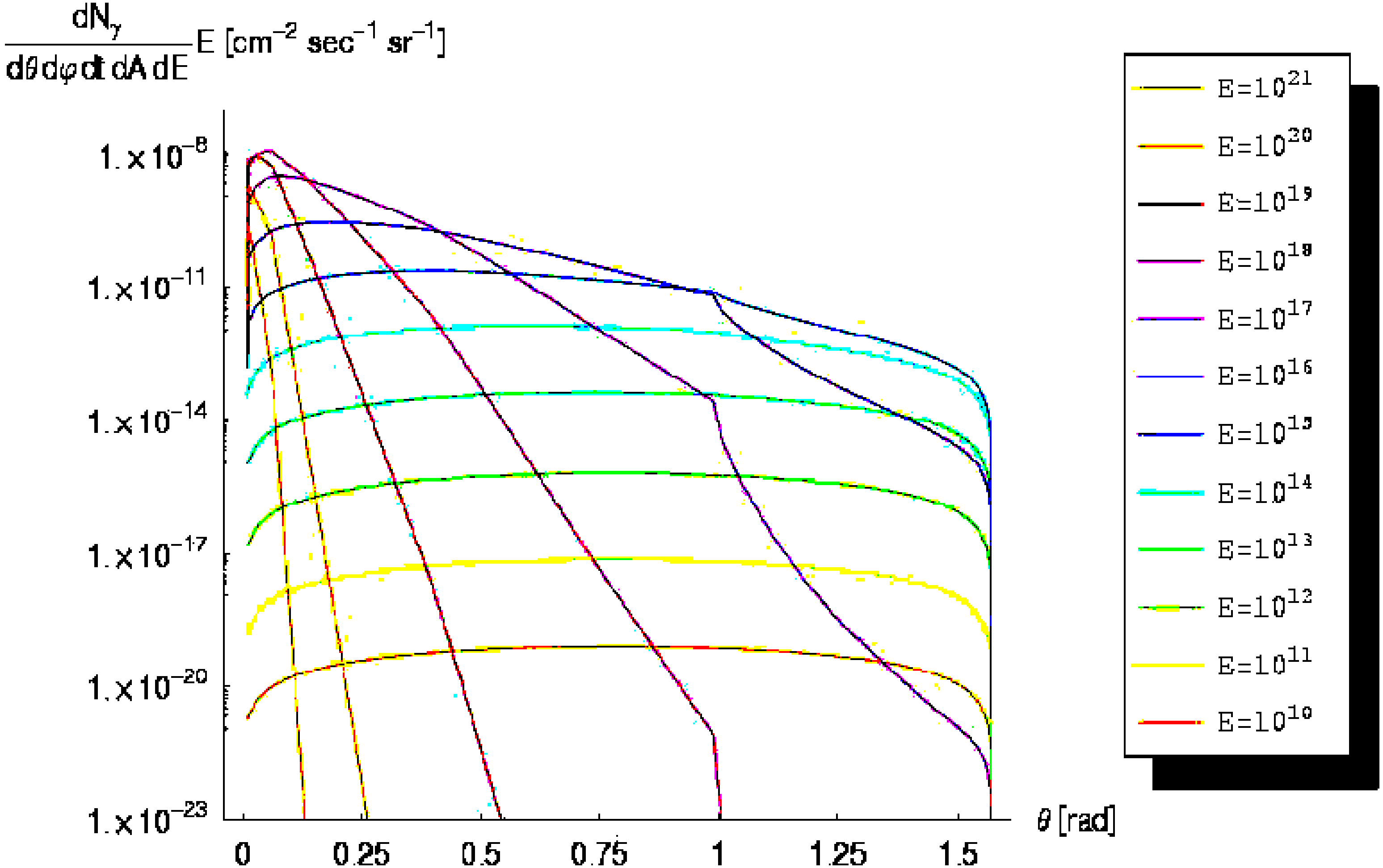
$$\cdot \int_0^{\pi/2} e^{-\frac{(D(\theta))}{L_{\nu CC}(\eta E_\tau)}} - e^{-\frac{x}{L_{\tau(\beta)}(E_\tau)}} \cos(\theta)\sin(\theta)\ d\theta$$



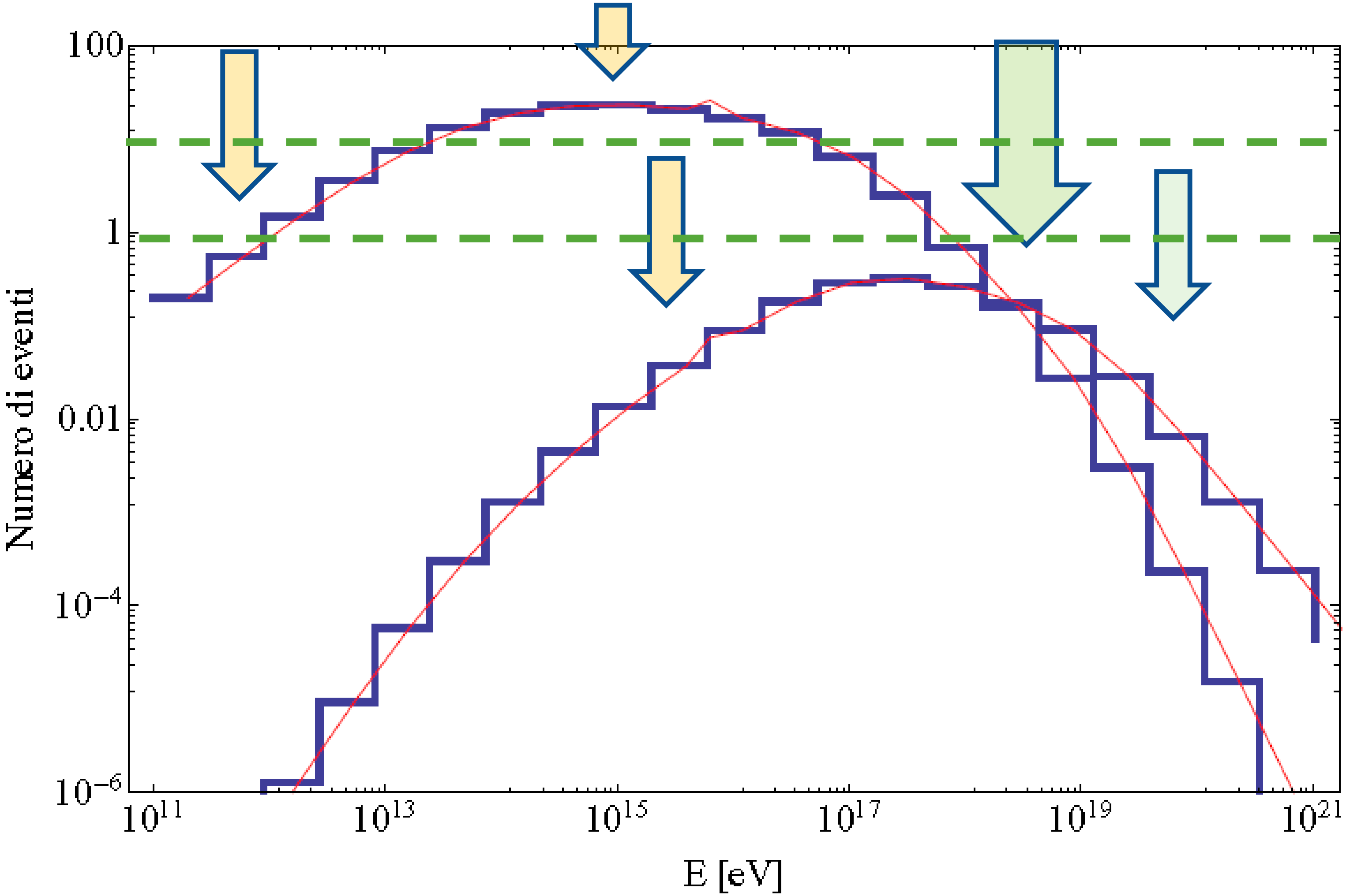
Differential tau event rate for energy and skimming angle 10 GeV eV up to 0.1 ZeV



Gamma and electron pairs by tau airshower



SD versus Fluorescence year rate in AUGER with ICECUBE flat flux: FLUORESCENCE rule above EeV in AUGER

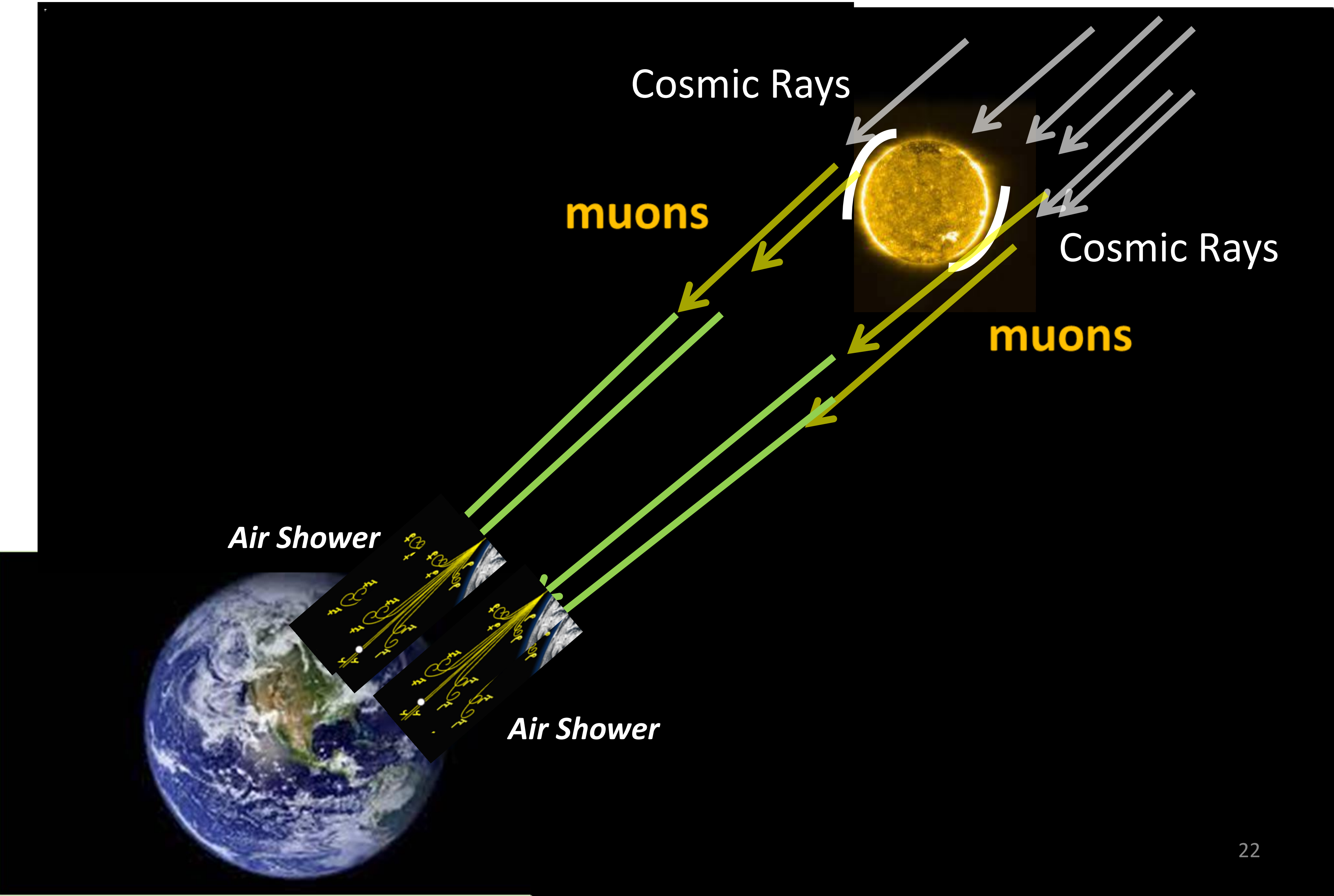


Taus on the clauds: A winning tool: three event at few /ten PeV a year if monitoring clouds in AUGER sky

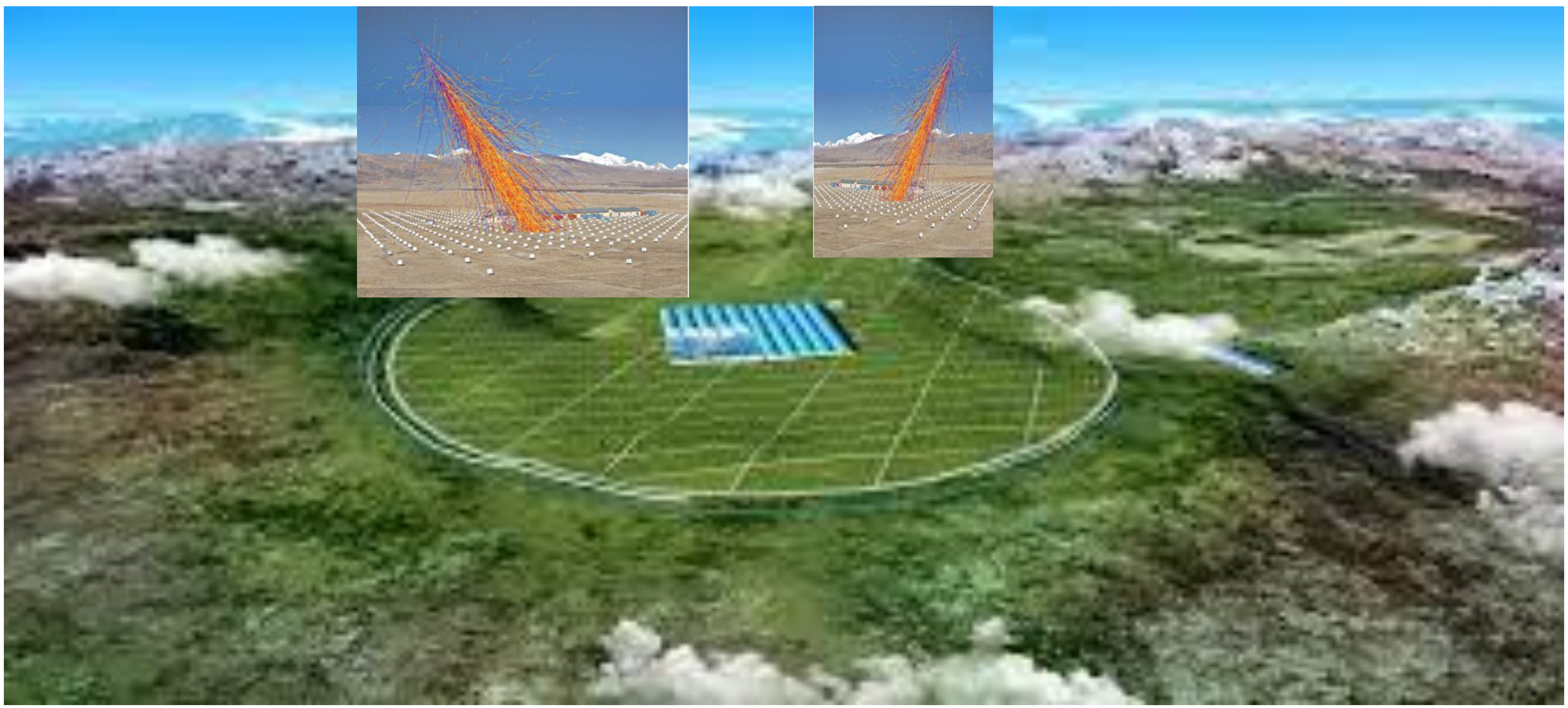
Figure 4: Upward Tau Air showering on the Auger clouds

Muon from space decaying as electrons are airshowering on Earth: the solar corona muon rings it is the most probable event

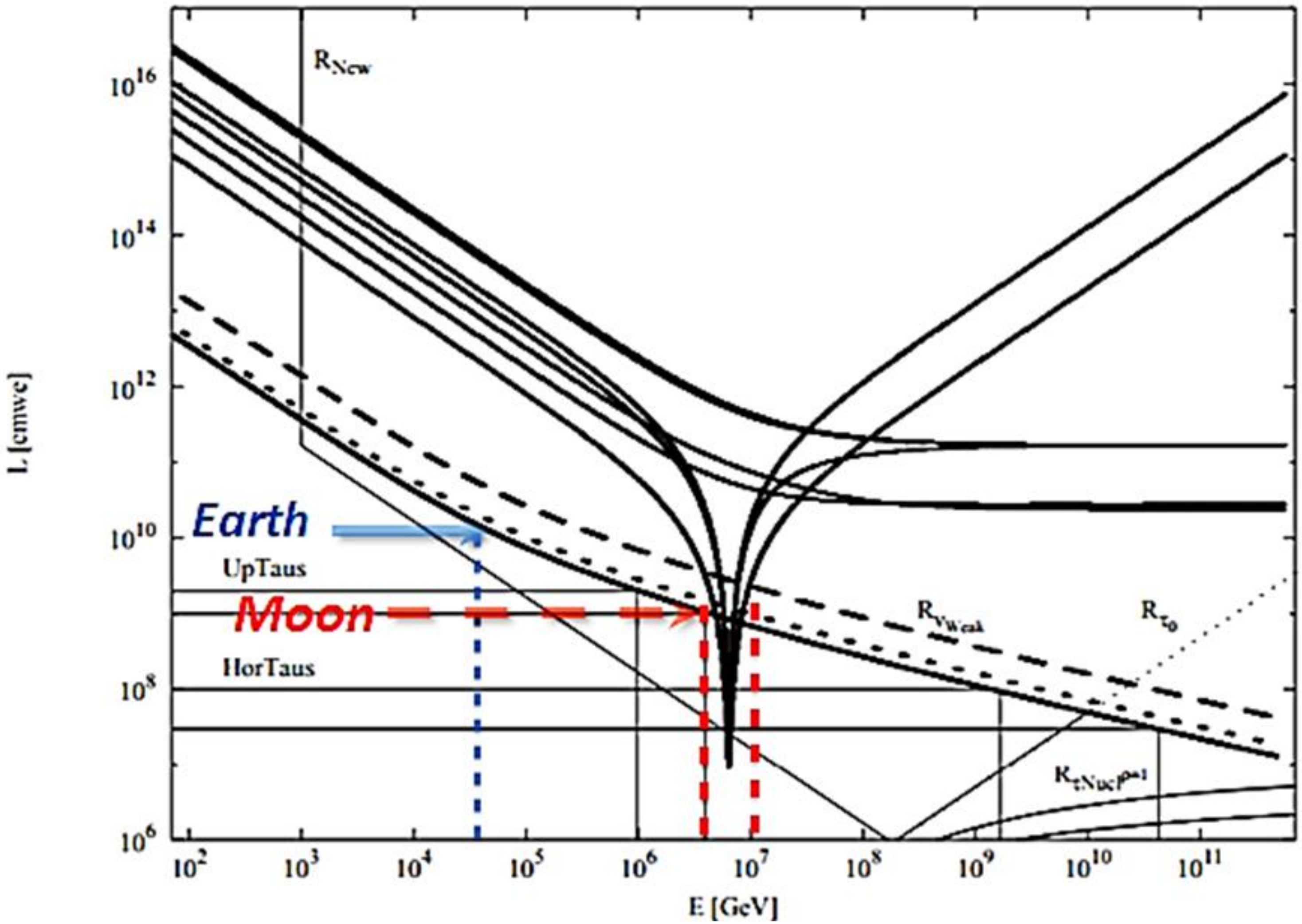
Muons from the Sun Corona: CR skimming



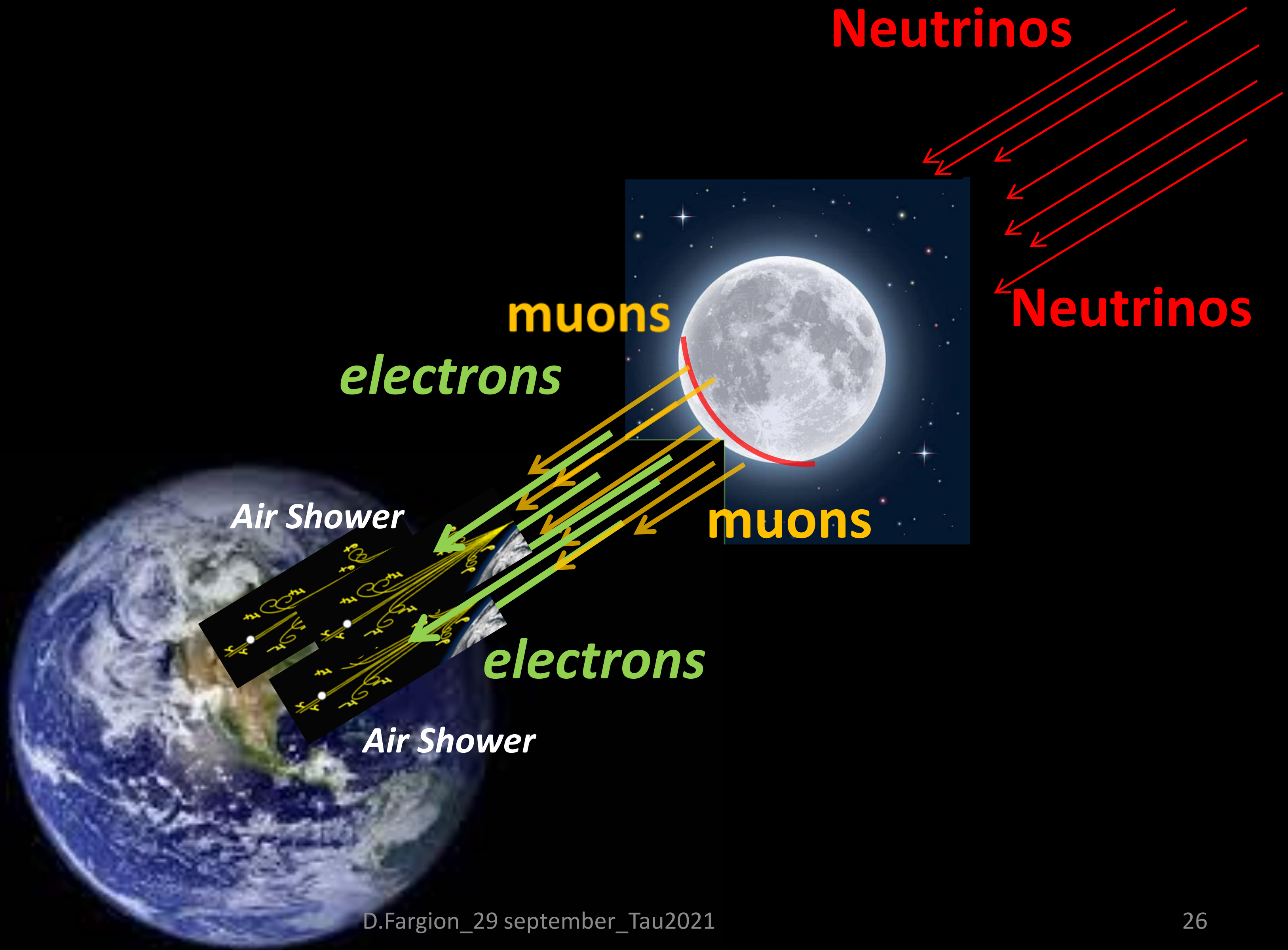
A detectable beta airshower as gamma one at square km Lhaaso array detector



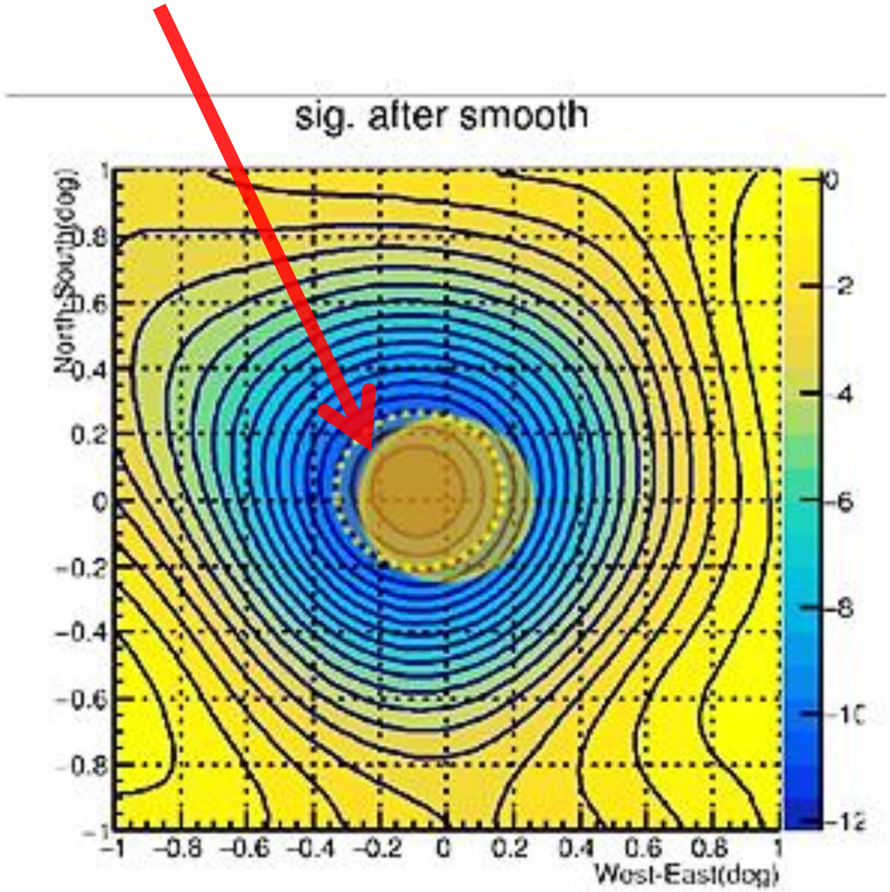
Sun is opaque to TeVs neutrinos. Moon is not



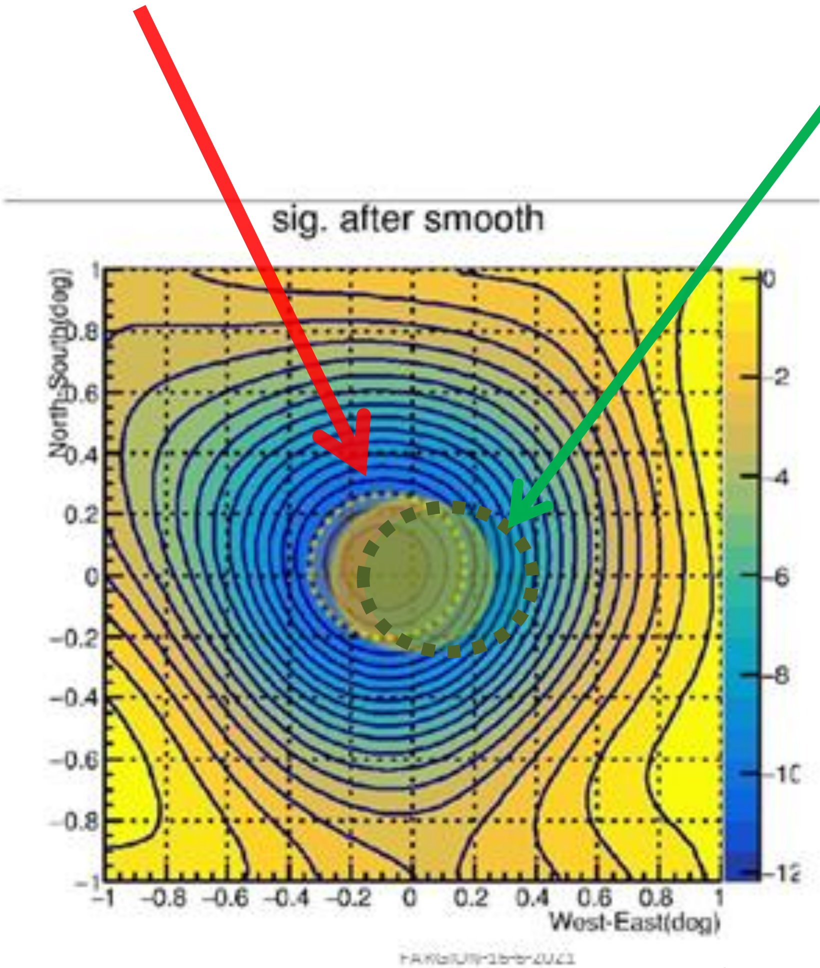
Tens TeVs muon-electron Airshowering are too long life to take place on Earth, but are fine tuned to arrive decaying from the Moon: 6-66 TeV energy

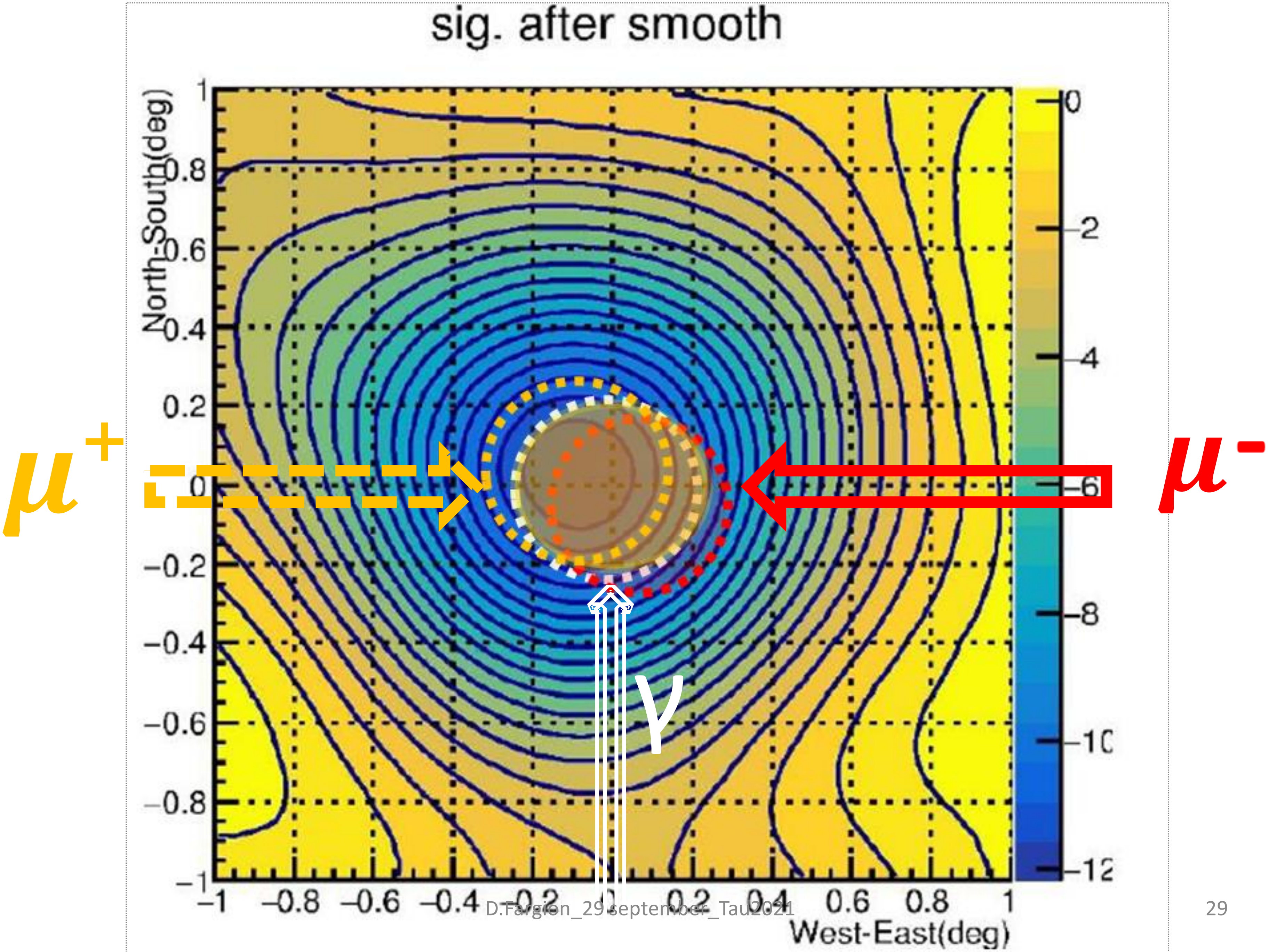

Neutrinos
Neutrinos
muons
electrons
muons
Air Shower
electrons
Air Shower

Two Neutrino Muon Shadows ?
Positive and null?



NO:Three Shadows : positive, null, negative by antineutrinos and neutrinos (positive muon) (negative muon)





sig. after smooth
North-South(deg)
West-East(deg)
μ+
μ-
γ

29 September 2021

- ***Conclusions***
- ***Tau : a test for real astronomy***
- ***Muons by Moon : a tuned spectrometer of CP cosmic neutrino symmetry***

Thank you for the attention

see Neutrino Signals 2021 –DF et all PosICRC2021_1208_0039

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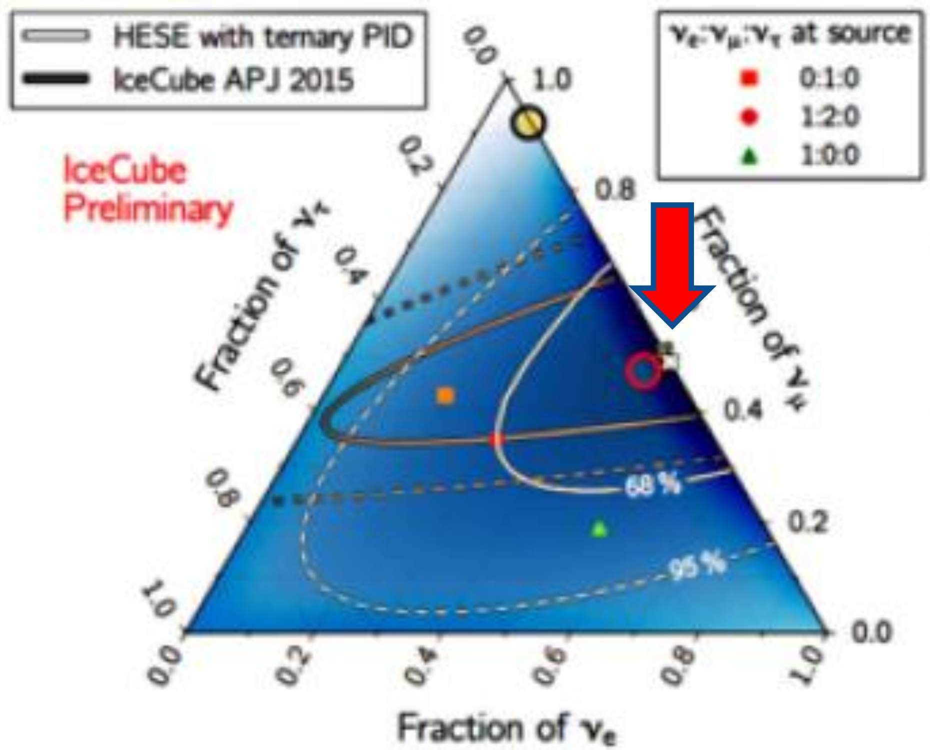
Munich 27 February 2017, Albrecht Karle,

- 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%).

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

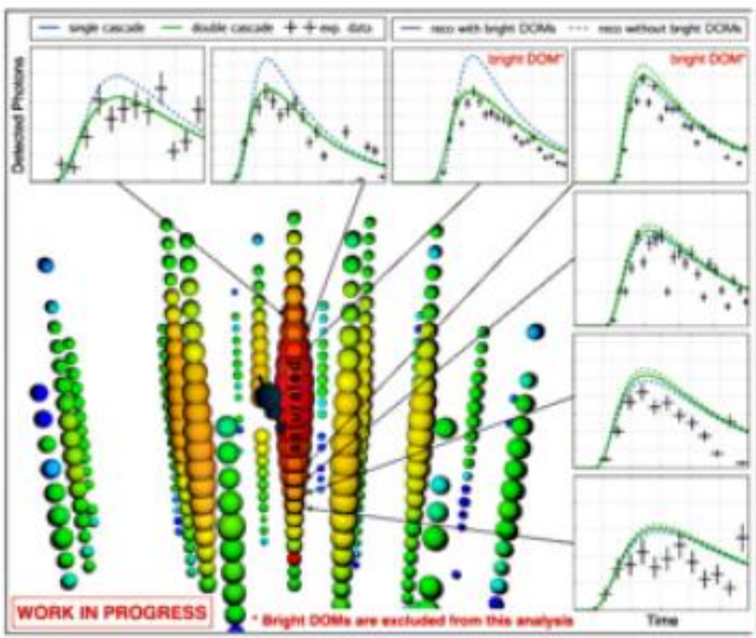
$f_{\nu_\mu} = 0.49^{+0.12}_{-0.13}$

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

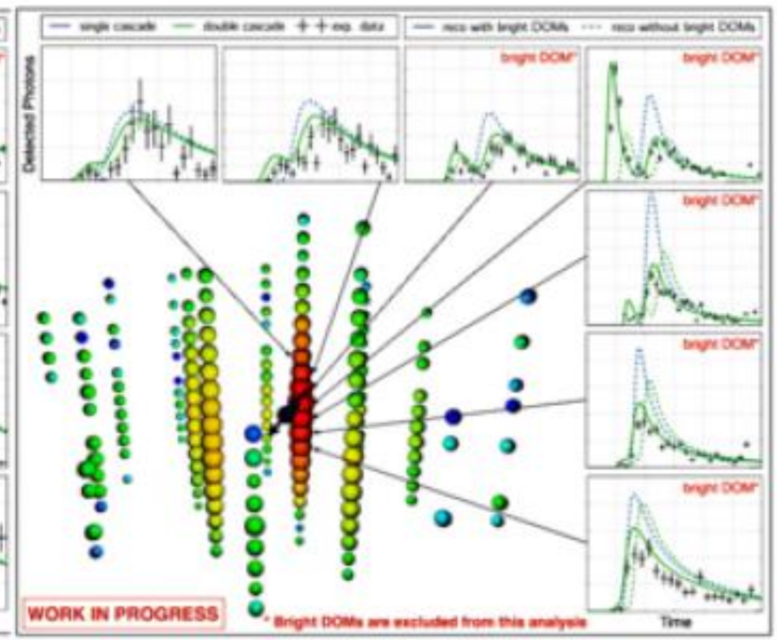
Usner et al. (IceCube Coll.), ICRC 2017

*Using HESE 3 year fit with E^-2.3 spectrum.

Two (unprobable) Tau double bangs within 36 UHE events above 100 TeV: Too few!



Double cascade Event #1



Double cascade Event #2

re 10: Among the most recent presentations (see [6, 27]) in the Neutrino 2018 Conference, t
date tau events have been displayed, but not declared in their identity: a first (probably the olde

The consequent muon rate by tau airshower ones