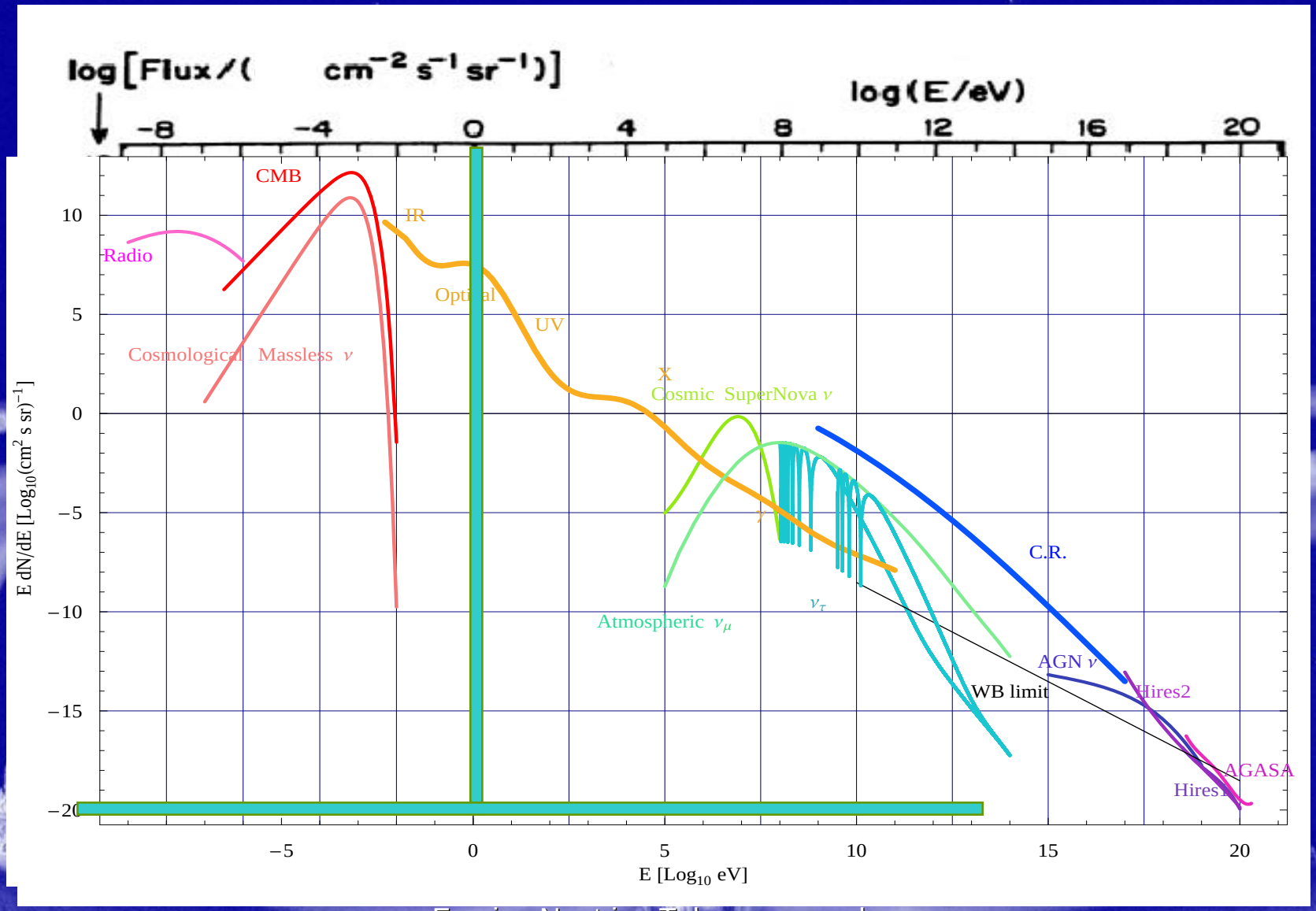
Neutrino Telescopes and Tau Neutrino

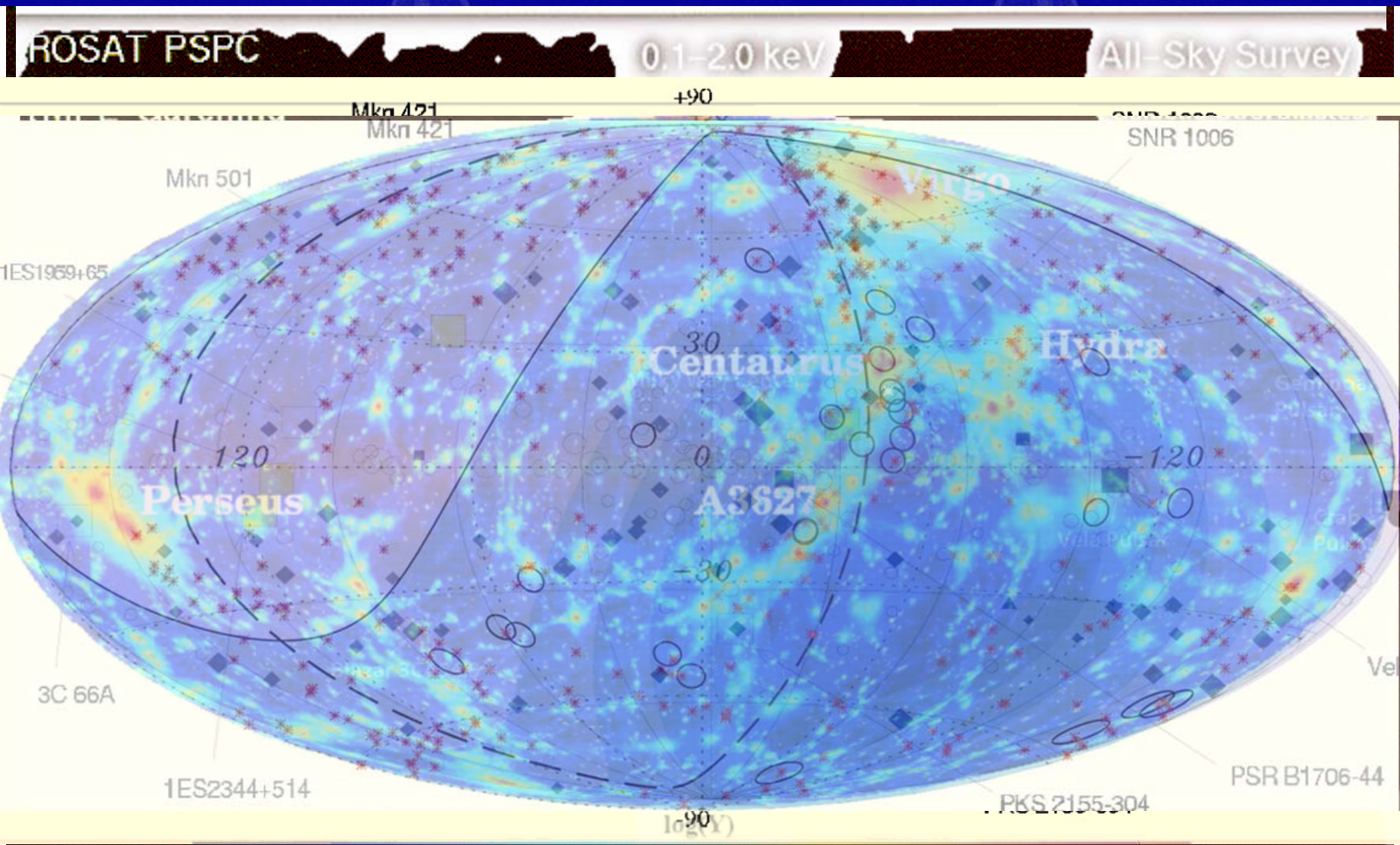
Flux Number of Wider Astronomy



Galileo and the New Ten Astronomy

- Galileo Optics Astronomy ruled 4 Century
- Maxwell extensions ruled last Century
- UHECR p-He new Astronomy born in 2007
- (9) New Astronomy at the edge
- 1) Neutron Astronomy: GeV-PeVs-EeVs-GZK.
- 2) Anti-Neutron GZK by Anti-Galaxies (?)
- 3) Gravitational Waves (?) Astronomy
- 4) UHE SUSY Astronomy: Neutralino-??
- 5-6-7-8-9-10 Neutrino Astronomies

UHECR astronomy and UHE Neutrino Astronomy Connection
Remember : not one but 6 different Neutrino Astronomy at edge.



Different Cross-sections-DIFFERENT THRESHOLDS..and OPACITIES

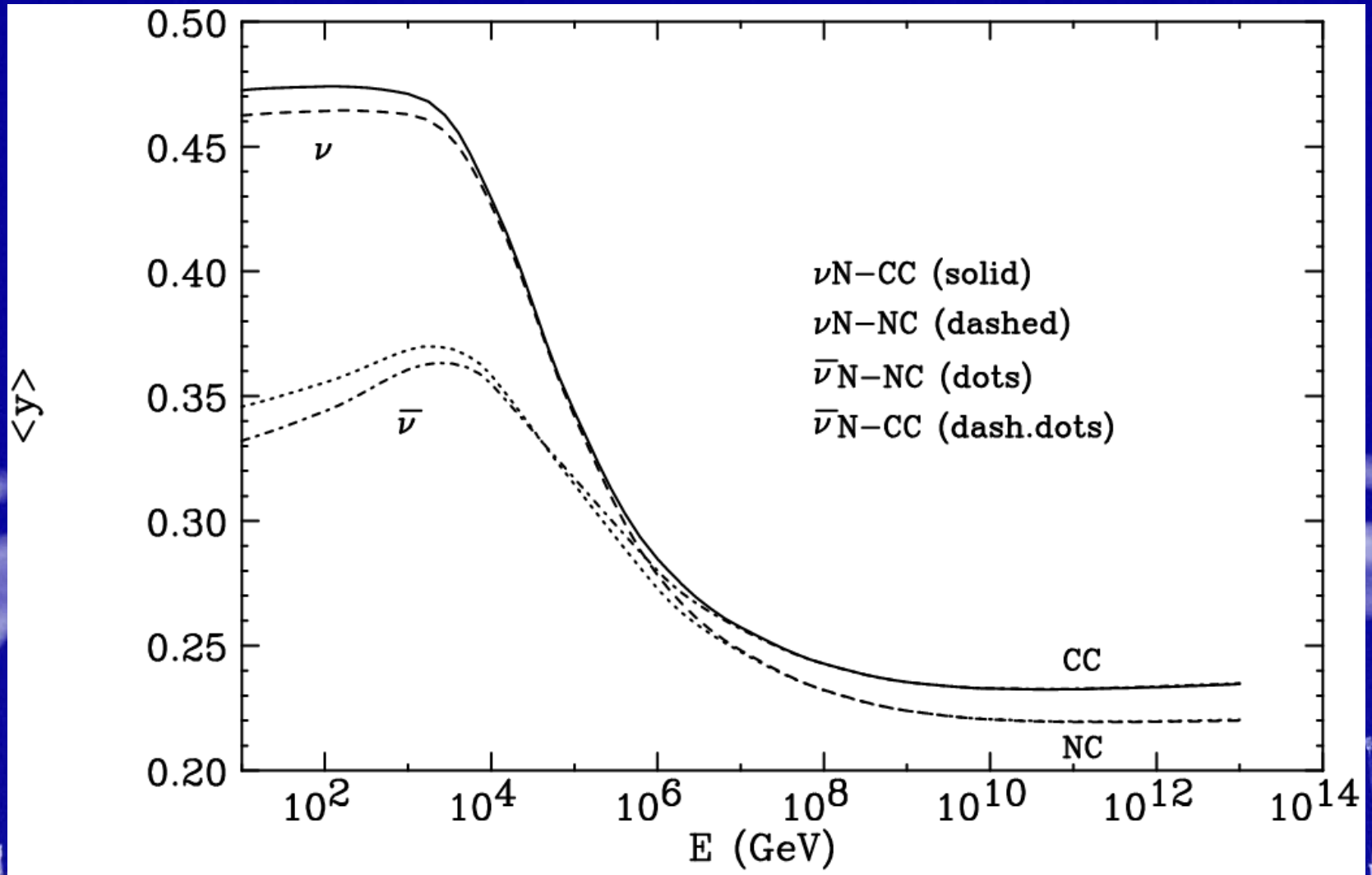
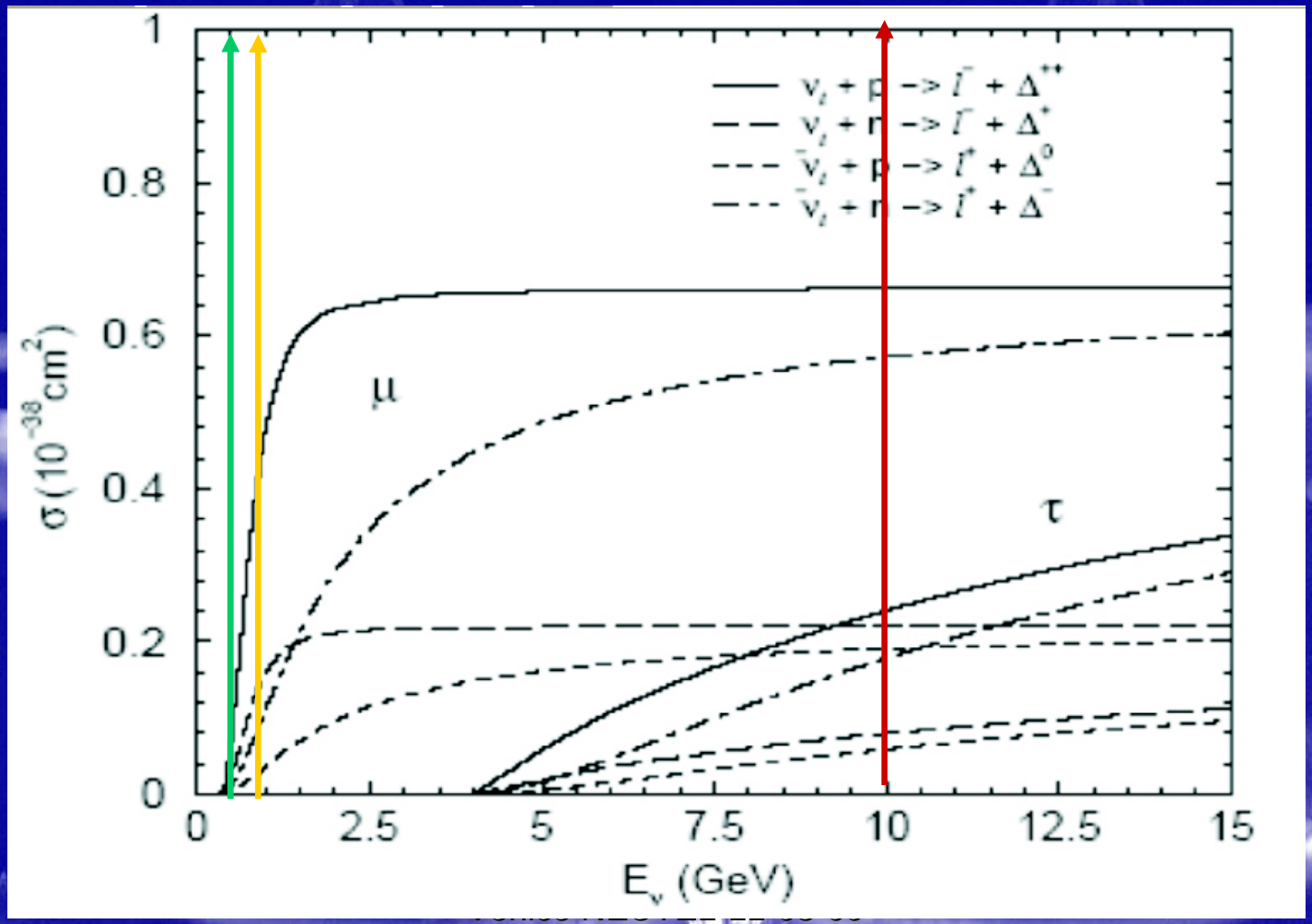
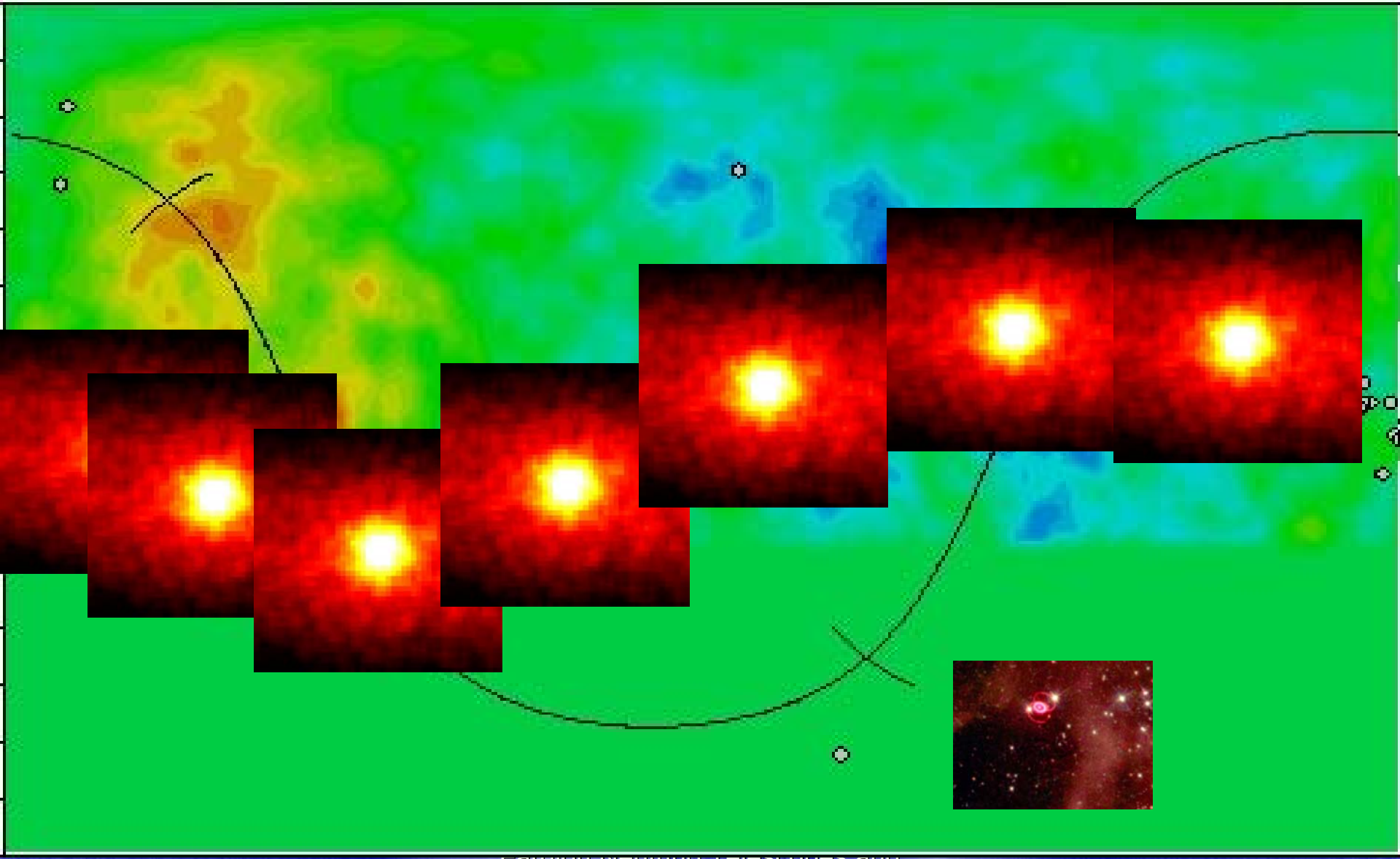


Fig. 2

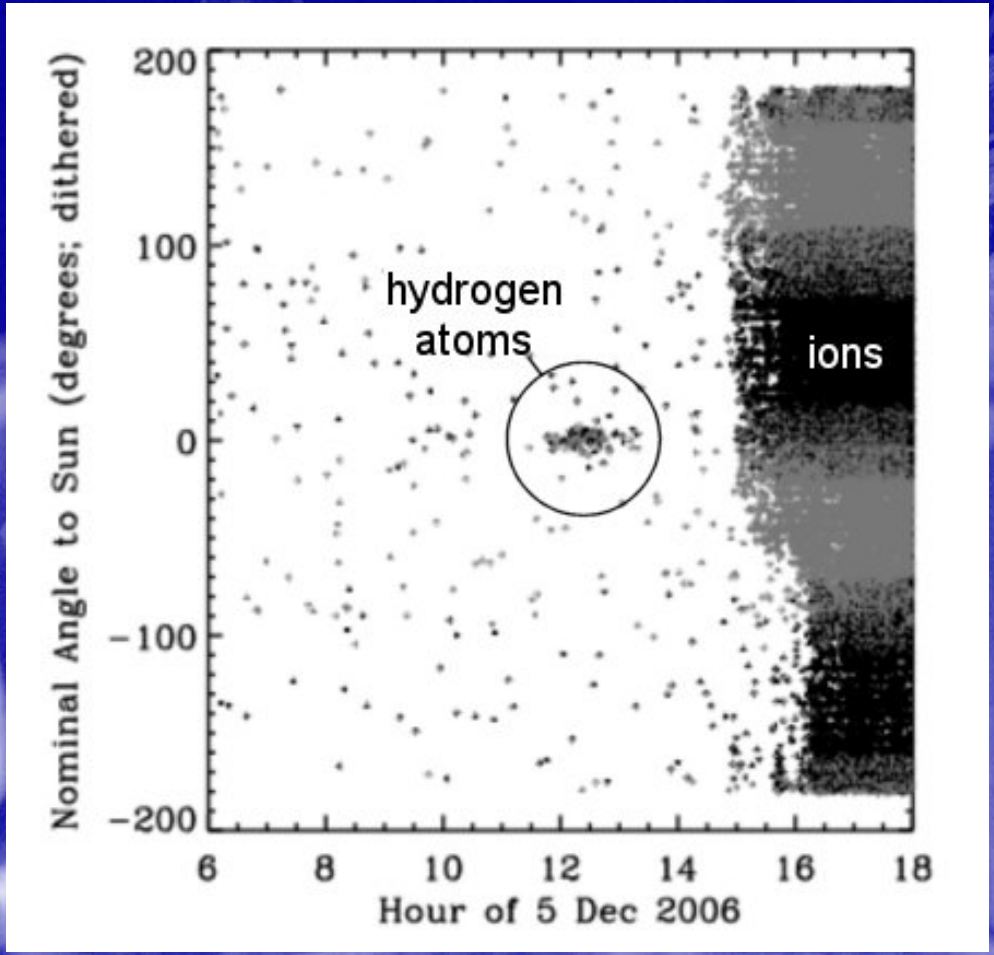
The lepton thresholds



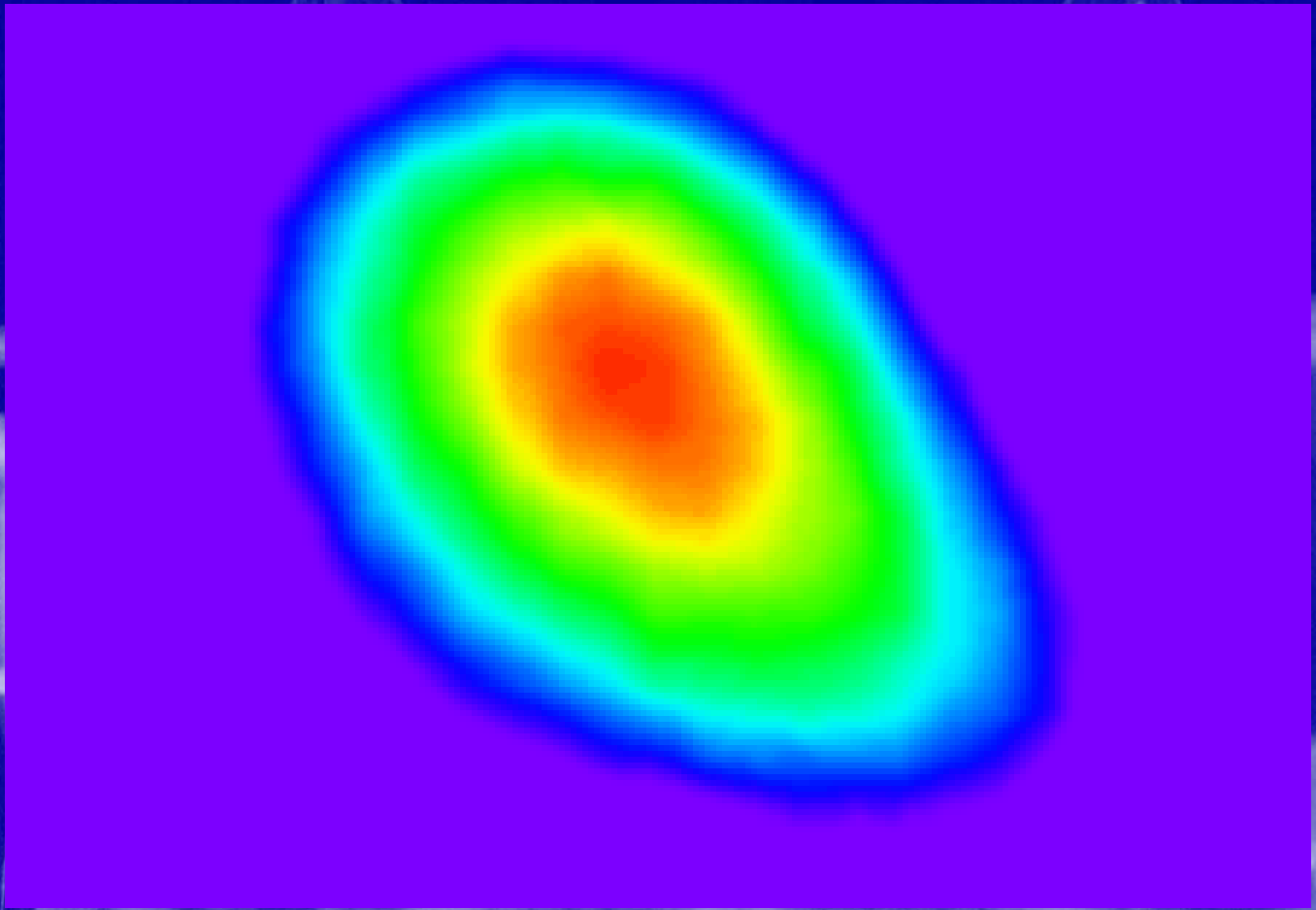
EeV AGASA MAP 1999: A UHE NEUTRON ASTRONOMY? Denied by AUGER. Electron Neutrino ASTRONOMY inside huge Atmospheric Nu Noise: Sun +SN 1987A



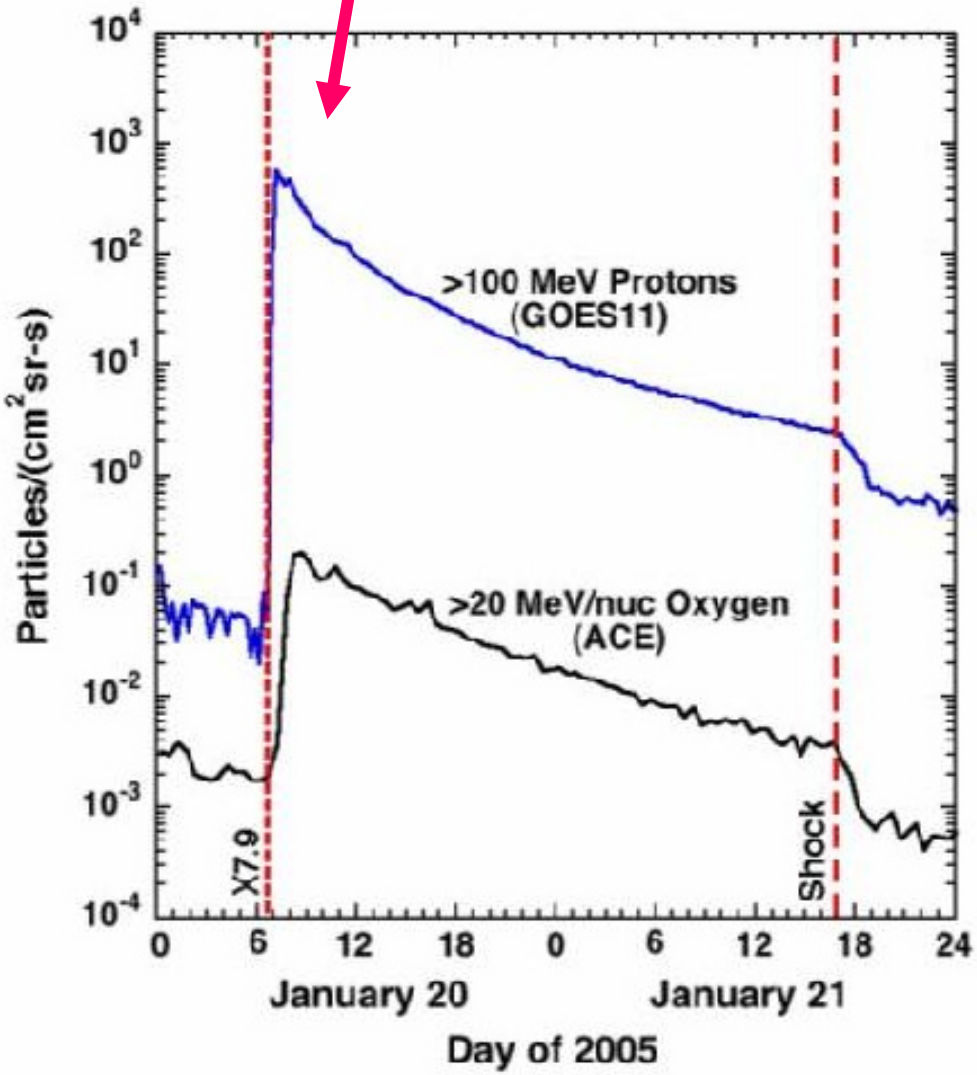
Solar Flare atoms astronomy ?

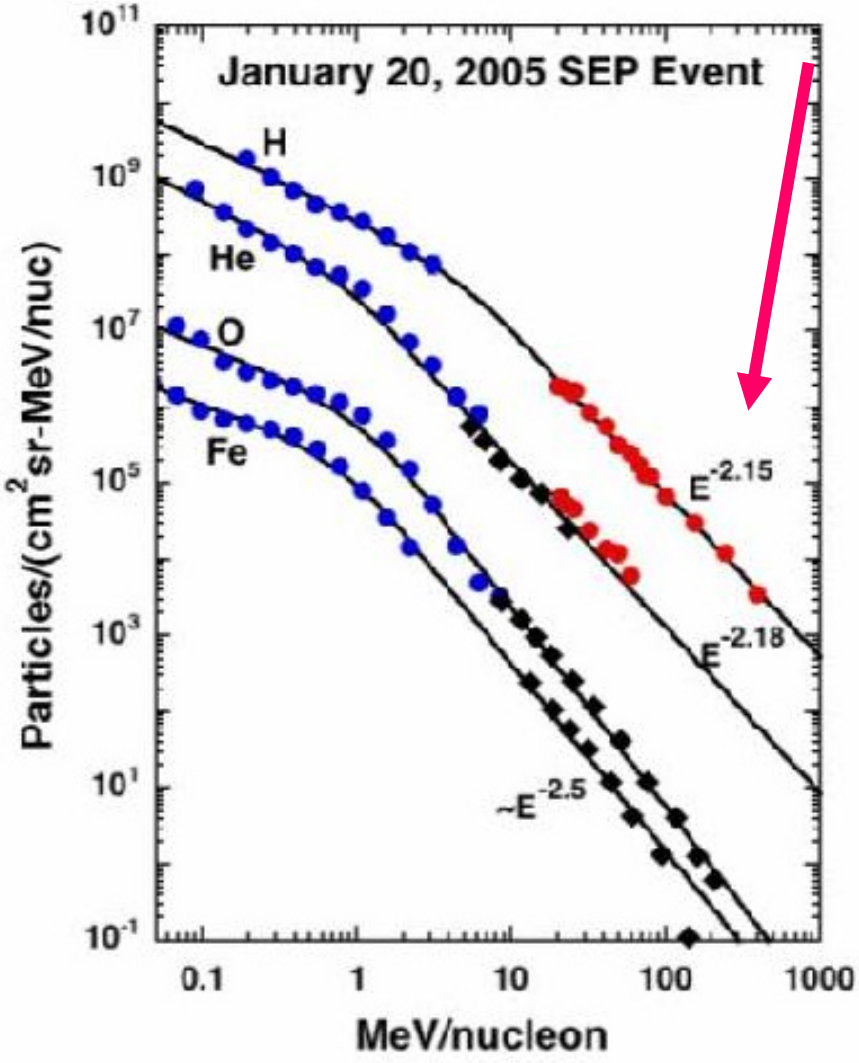


Neutron Astronomy: Solar Flare by OSSE 1991

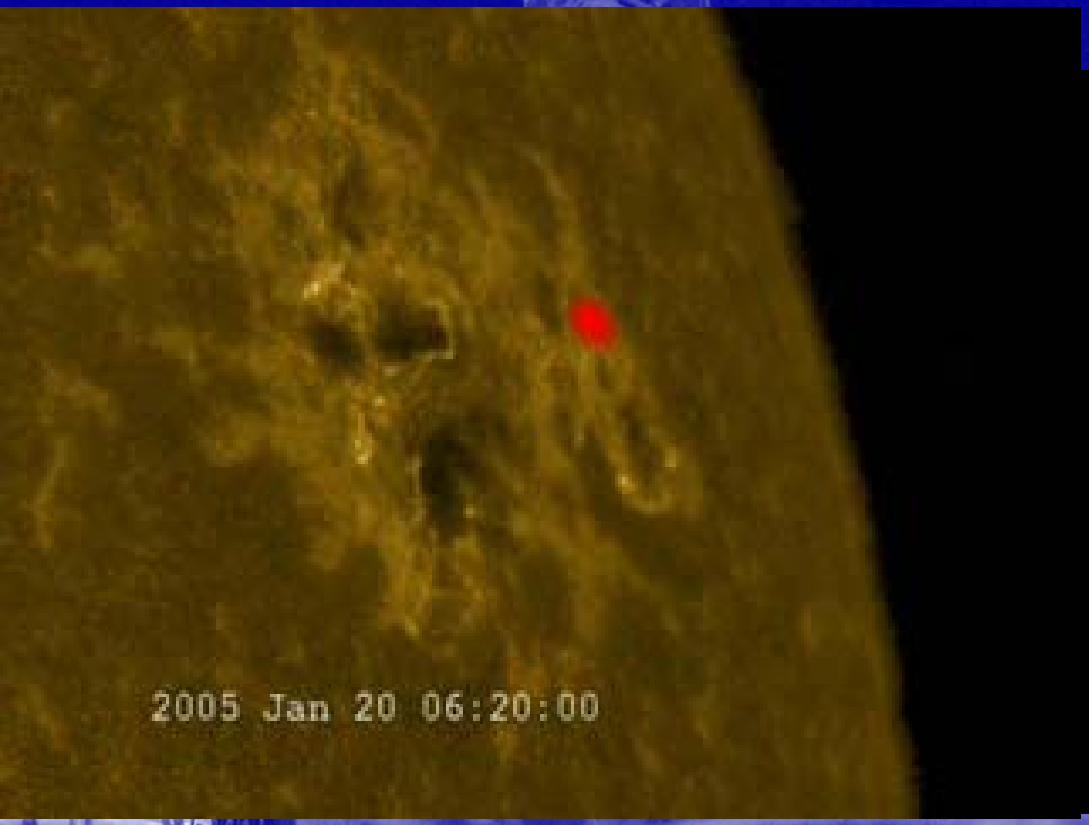


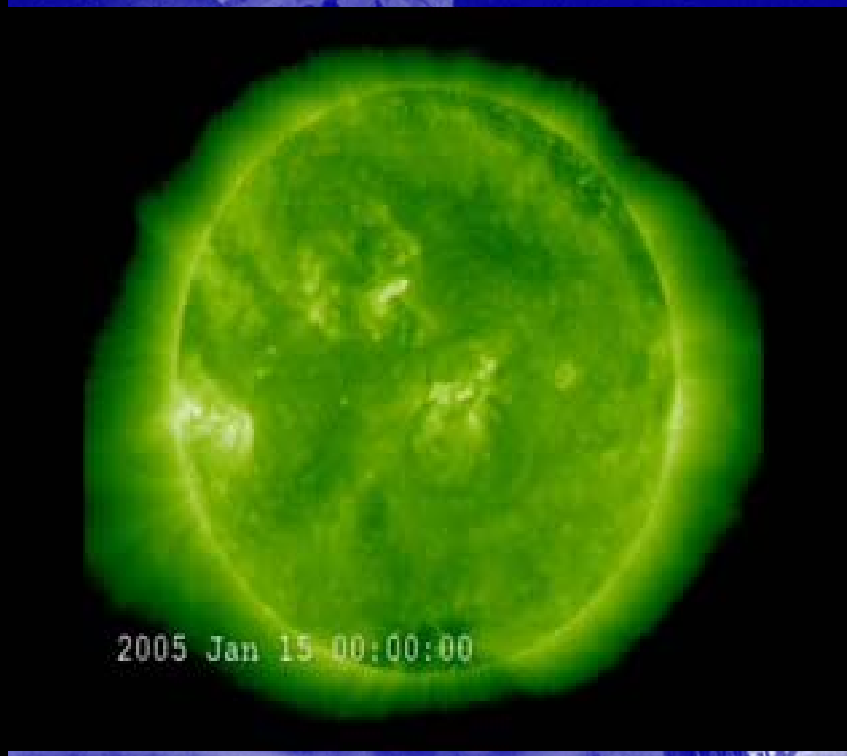
Space Weather Aspects of the January 20, 2005 Solar Energetic Particle Event



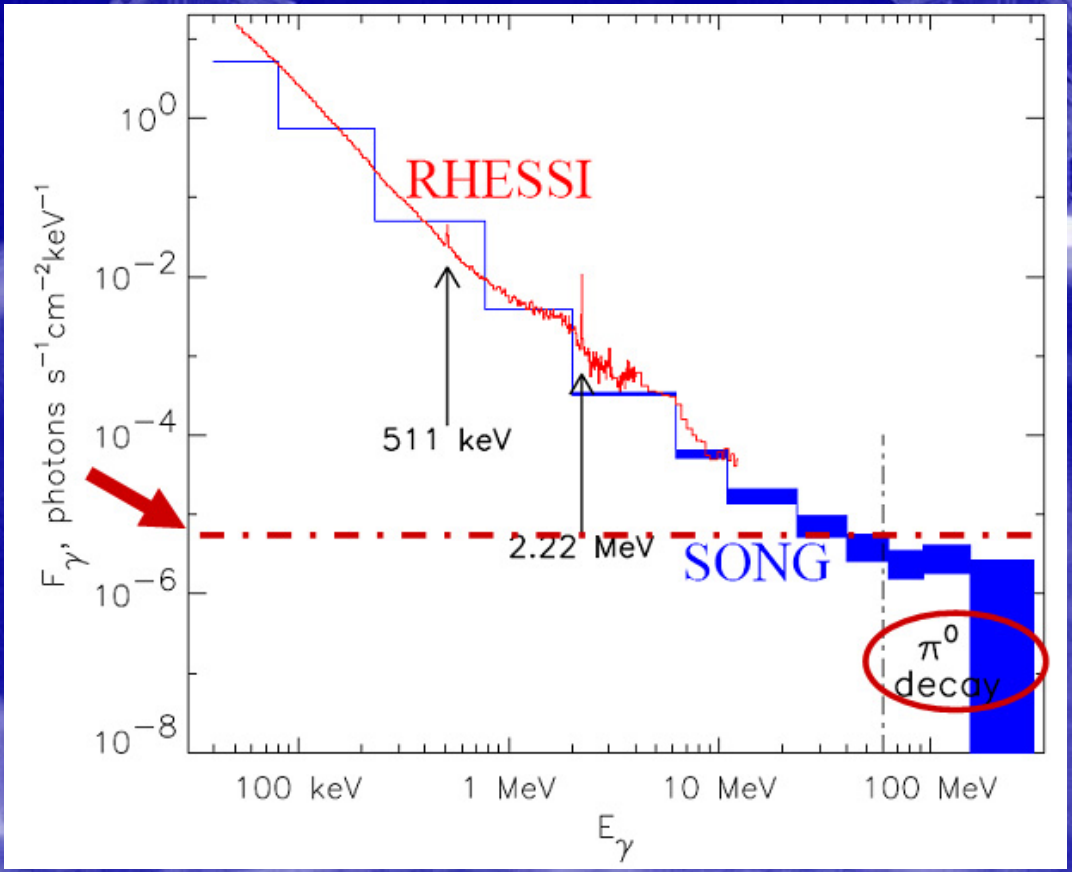


The inner blowup of last January 2005 solar flare

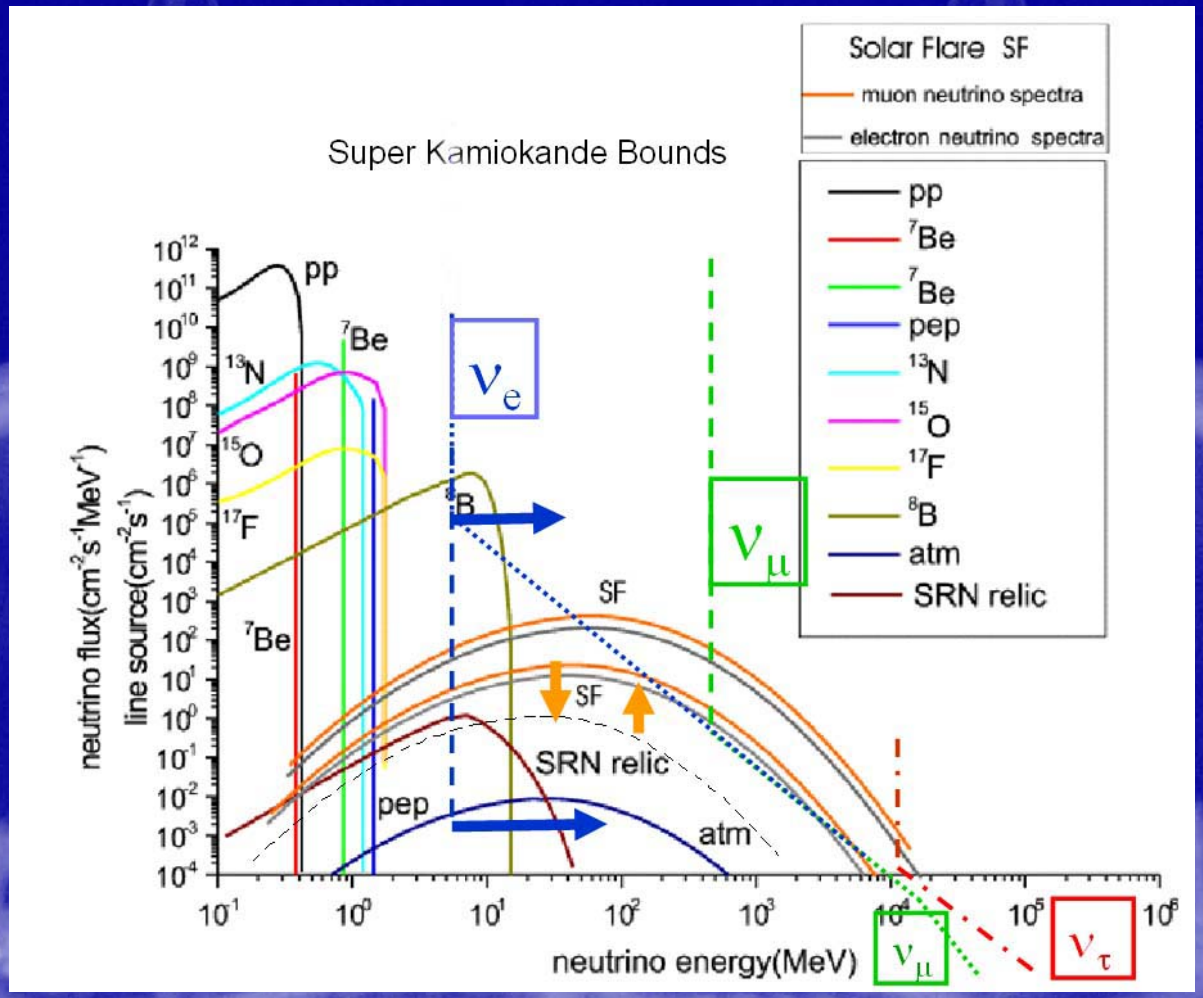




Lower Bound by Observed gamma-pion bump

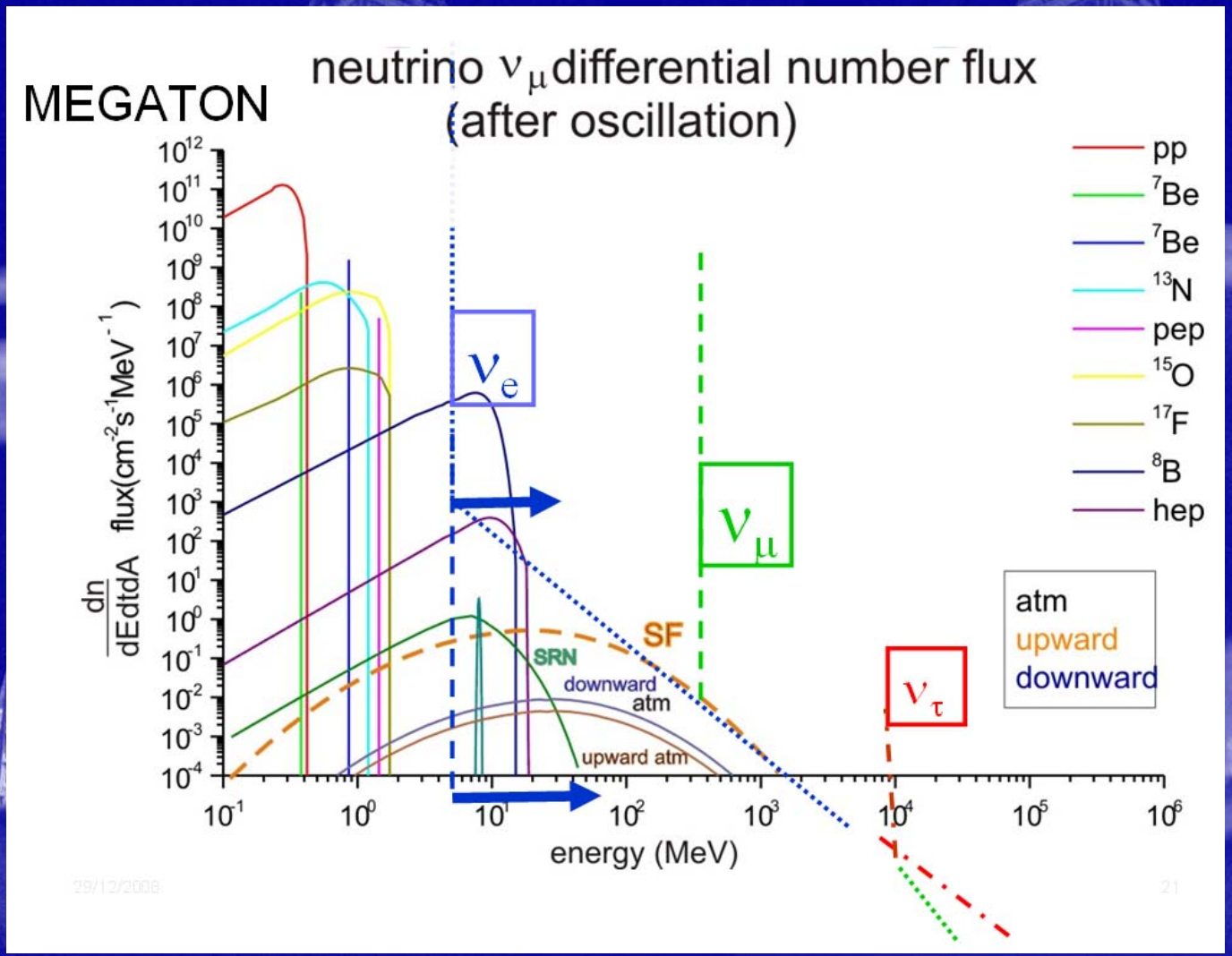


Solar Flare are nearby engine of Low energy Neutrinos: all the Flavor now

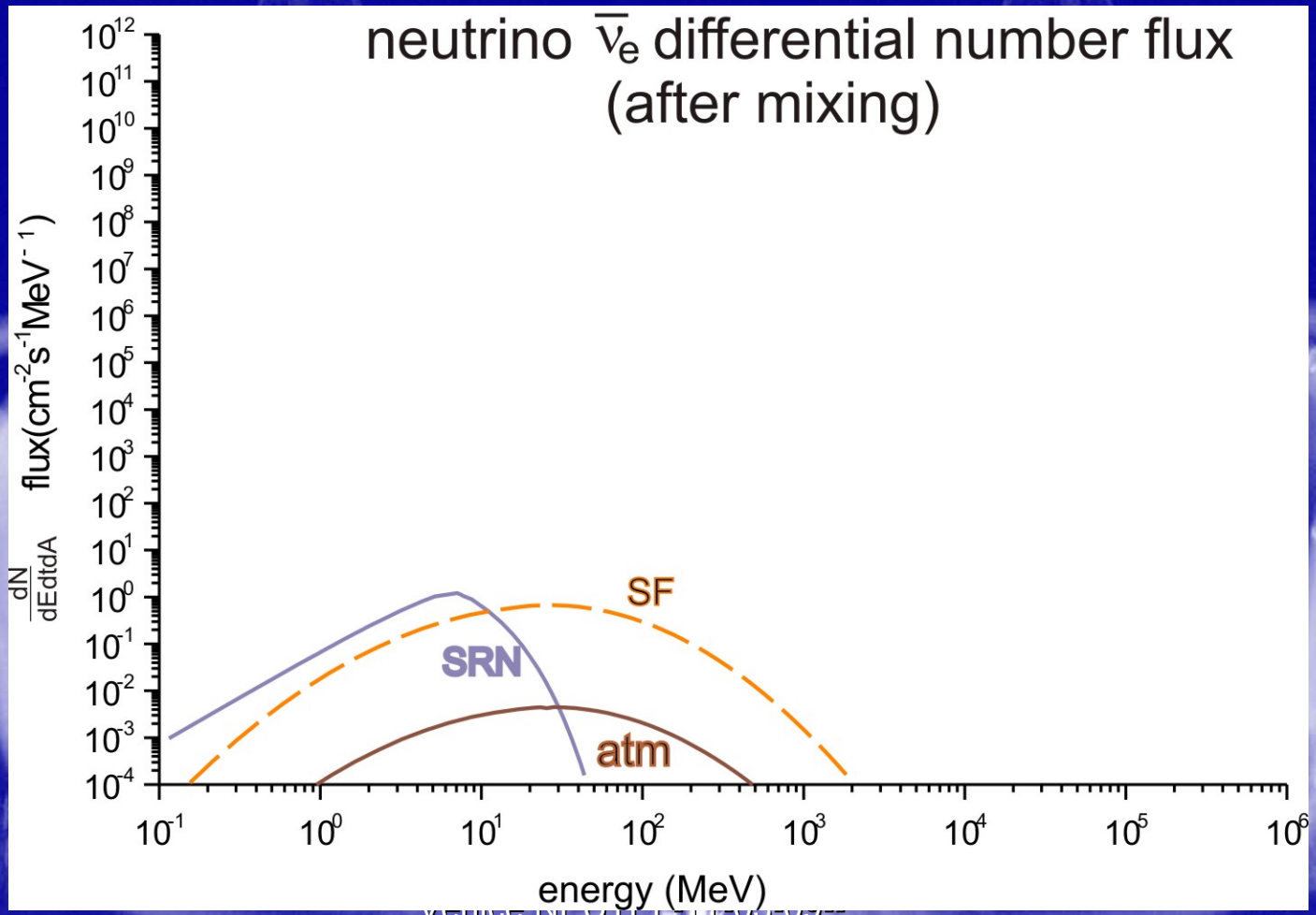


Megaton Must see their signal

ICDC in ICE Cube- 5 Megaton- may see Flare, but marginally the Tau see also0803.3044, maybe the Muons- IMPORTANT POSSIBILITY FOR GRBs correlations



Anti-neutrinos are the best



Neutrino CROSS SECTIONS
Need for Large Volumes and Amplifiers

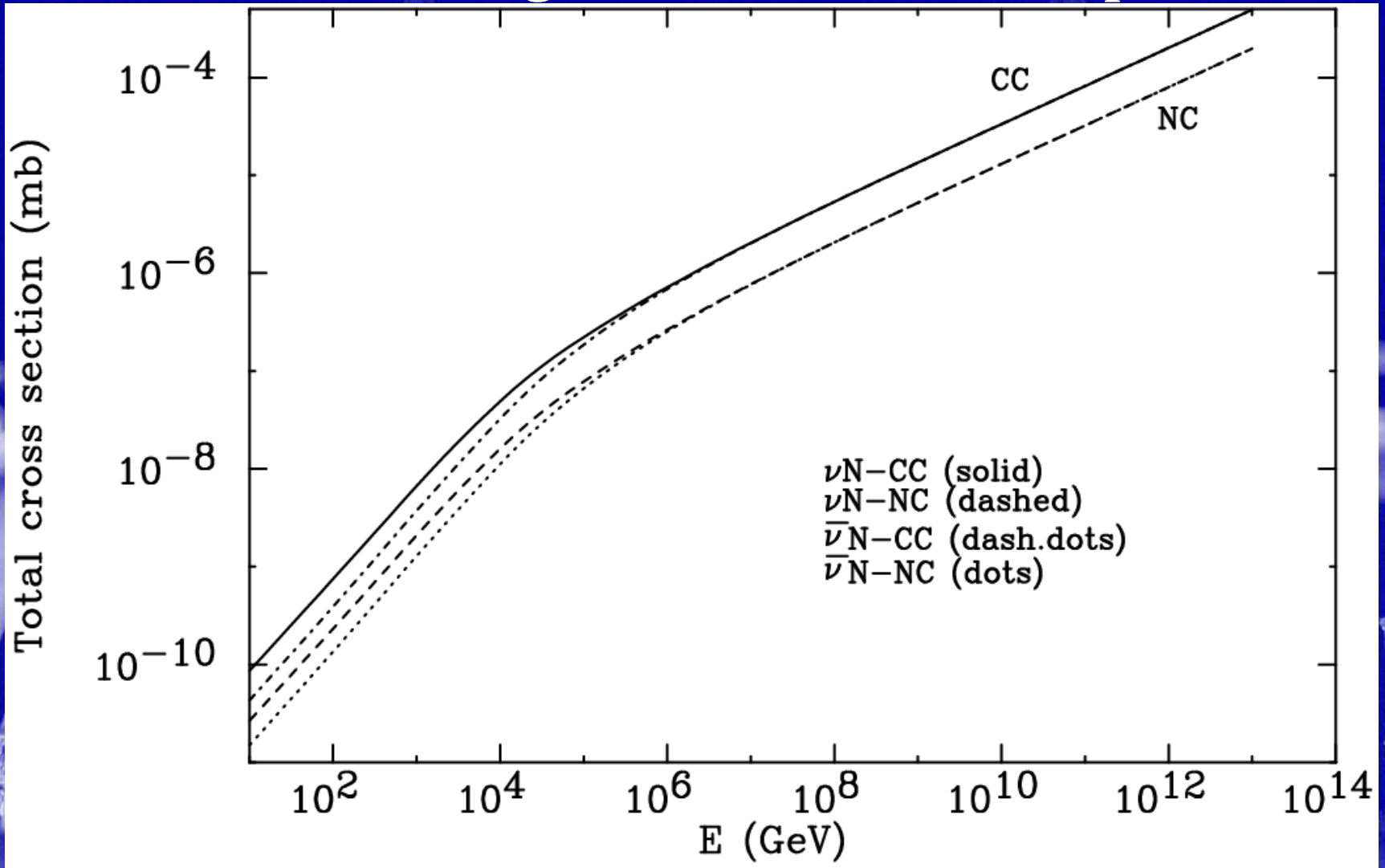
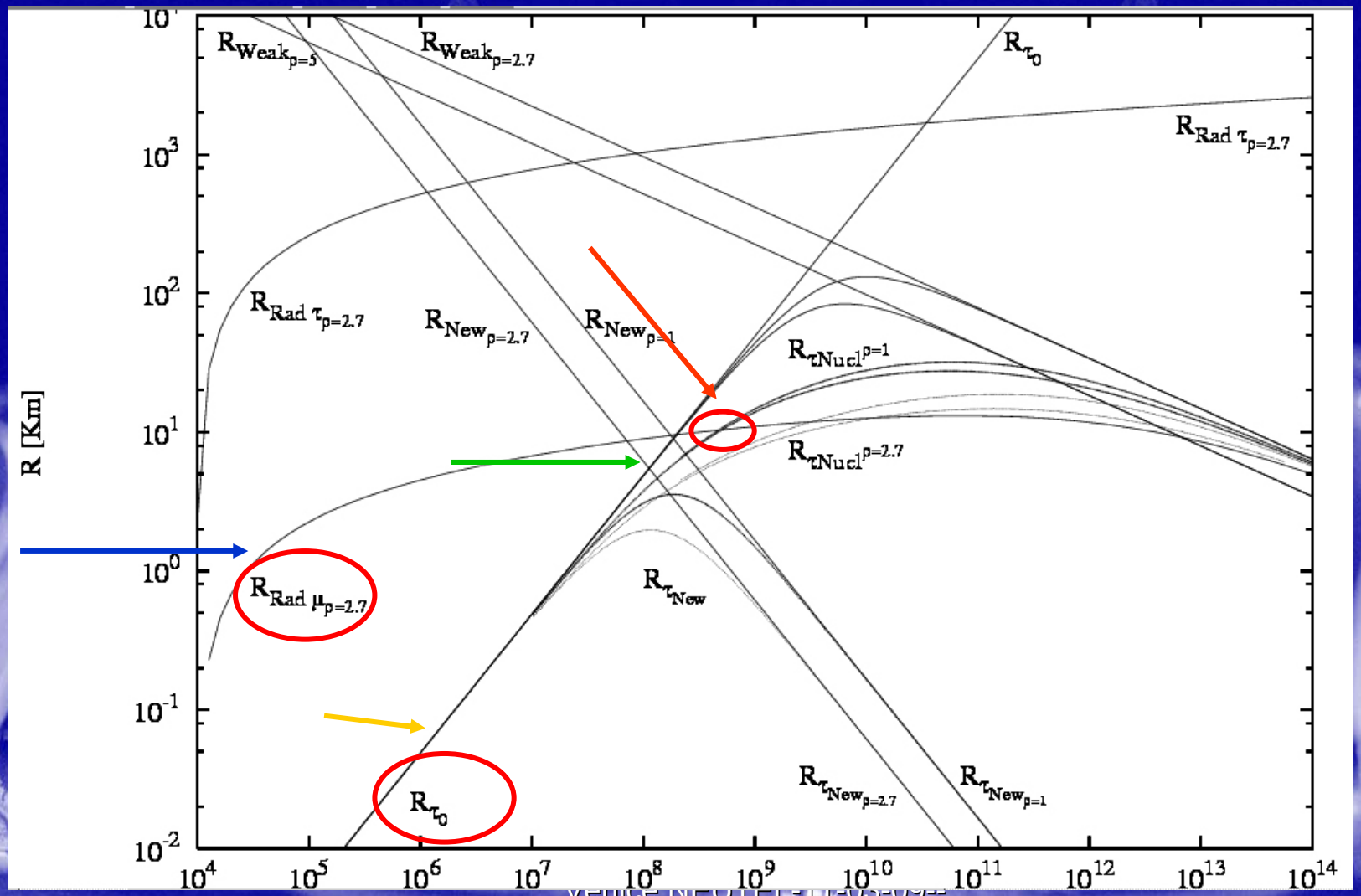


Fig. 1

Unstable tau versus muons at highest energy

*A **NEUTRINO AMPLIFIER** D.Fargion et al. 1999-*

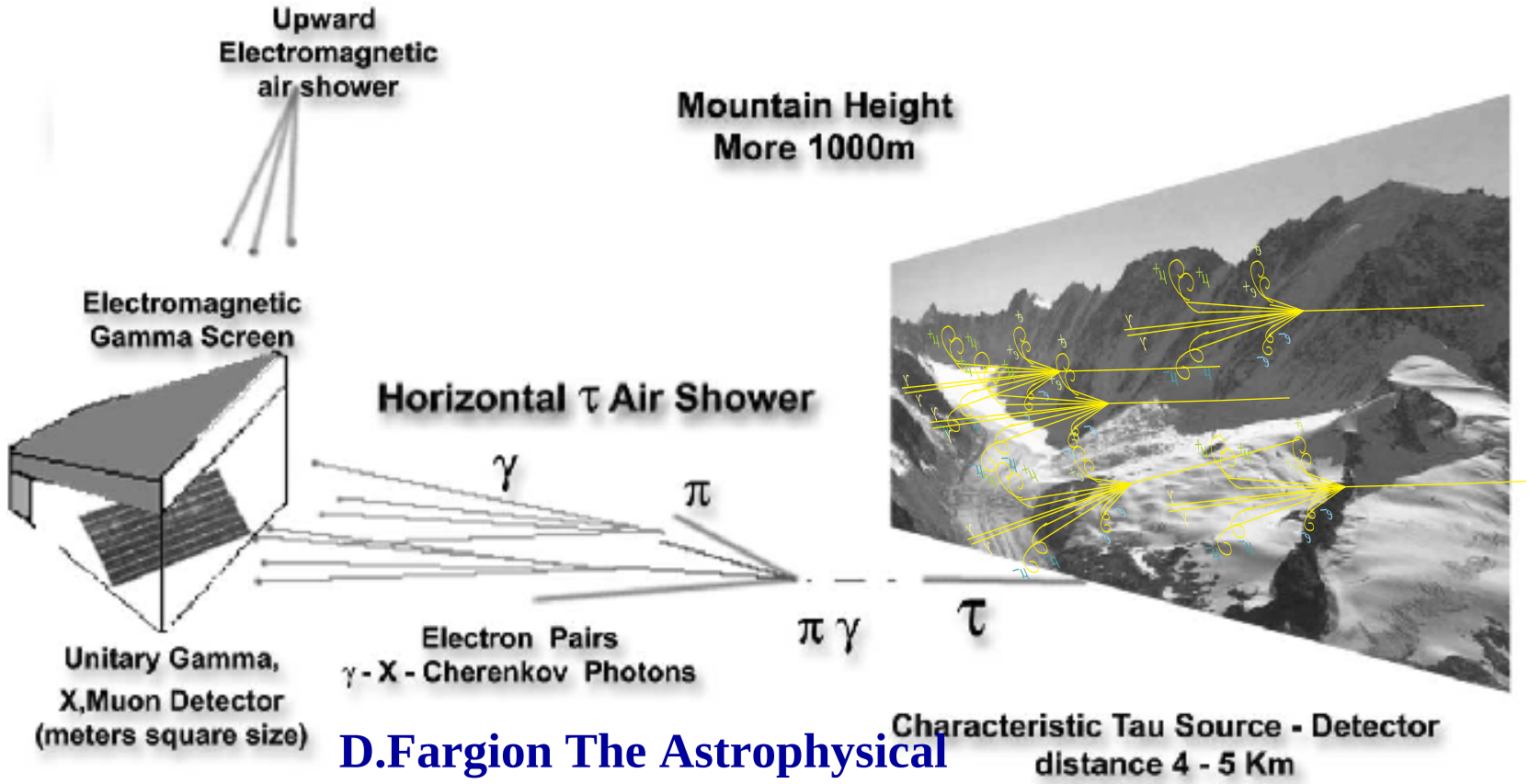
DF.ApJ 2002 and DF et al. ApJ 2004, DF et al NIM 07, Nucl Phys B 09



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

ICRC-1999

D. Fargion [1], A. Aiello [2], R. Conversano



D.Fargion The Astrophysical Journal,570,p.909. 2002

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

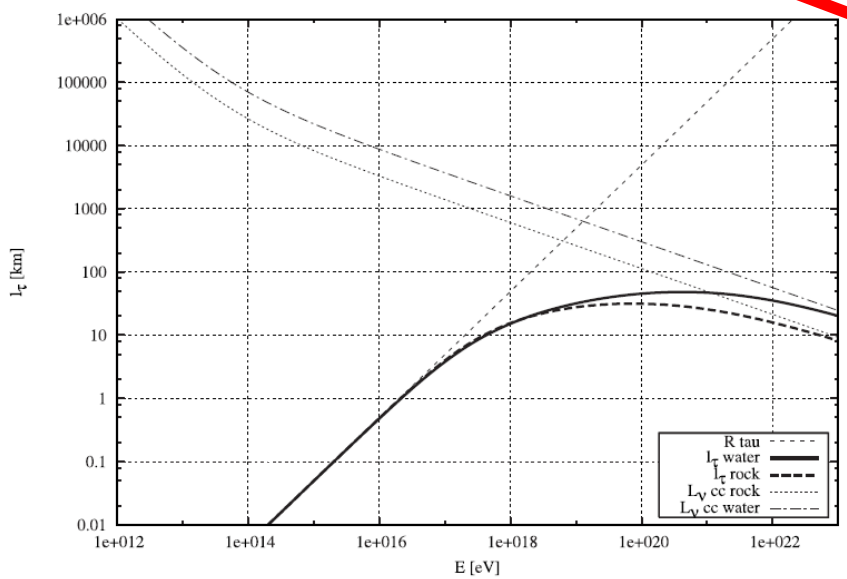
Why Horizontal – Upward Tau Showering is so much linked to neutrino mass and mixing ?

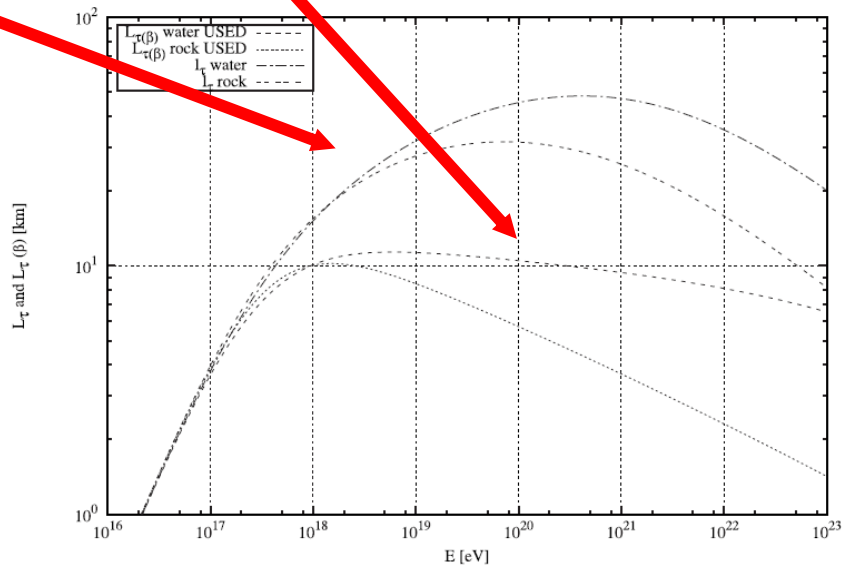
Because mixing, even for minimal masses guarantee the flavour transformation from Muon Neutrinos to the Tau Neutrinos.

Galactic and cosmic distances are huge respect oscillation lenghts.

$$L_{\nu_\mu - \nu_\tau} = \boxed{8.3\,\mathrm{pc}} \left(\frac{E_\nu}{10^{19} eV}\right) \left(\frac{\Delta m^2_{ij}}{(10^{-2} eV)^2}\right)^{-1}$$

Long exausted- Shortest Hardest





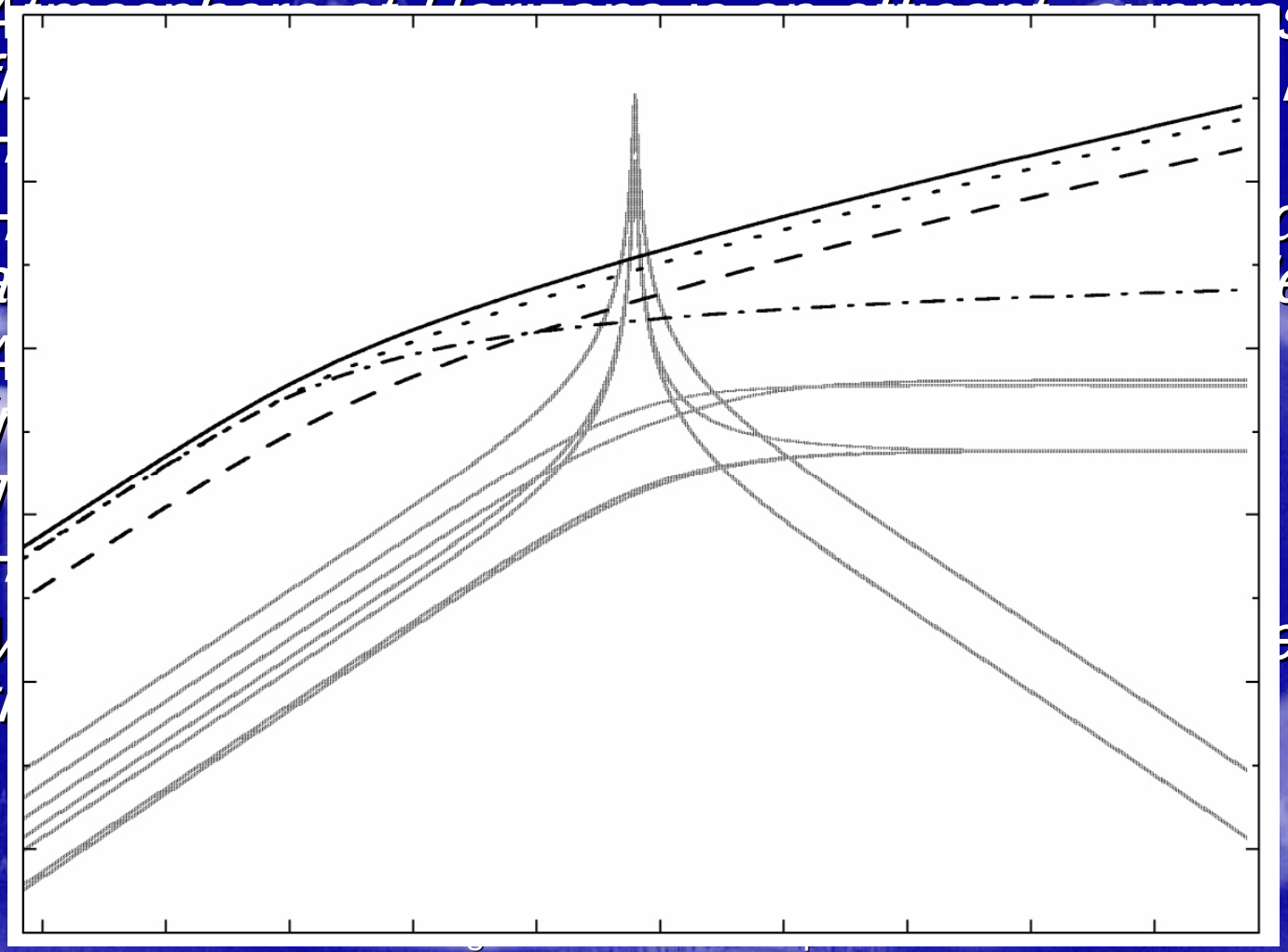
Tau Air-Showers: Astronomy versus Elementary Particle Tau

TABLE 1
TAU AIR SHOWER CHANNELS

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

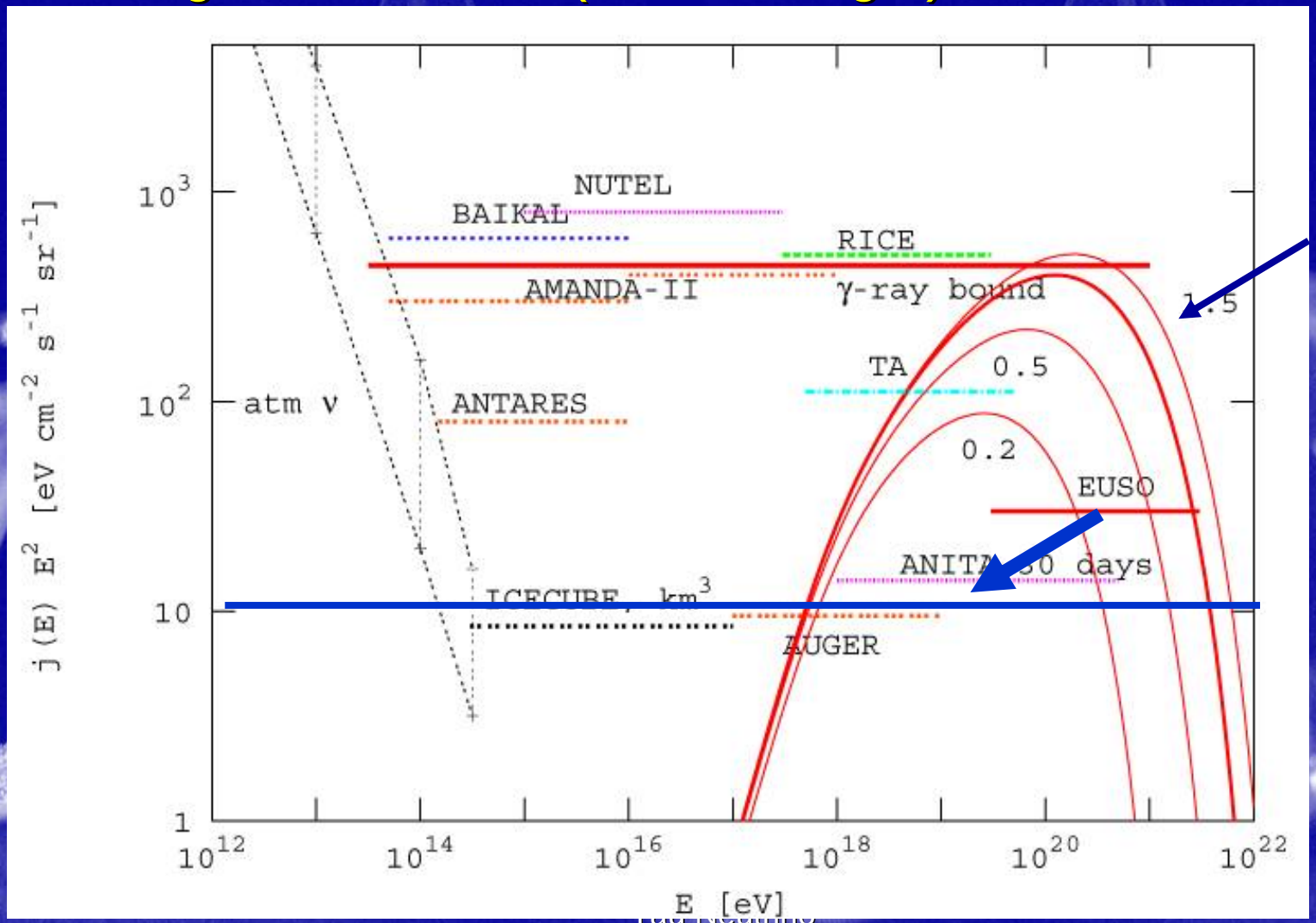
Cosmic Ray Flashes above the Earth edges

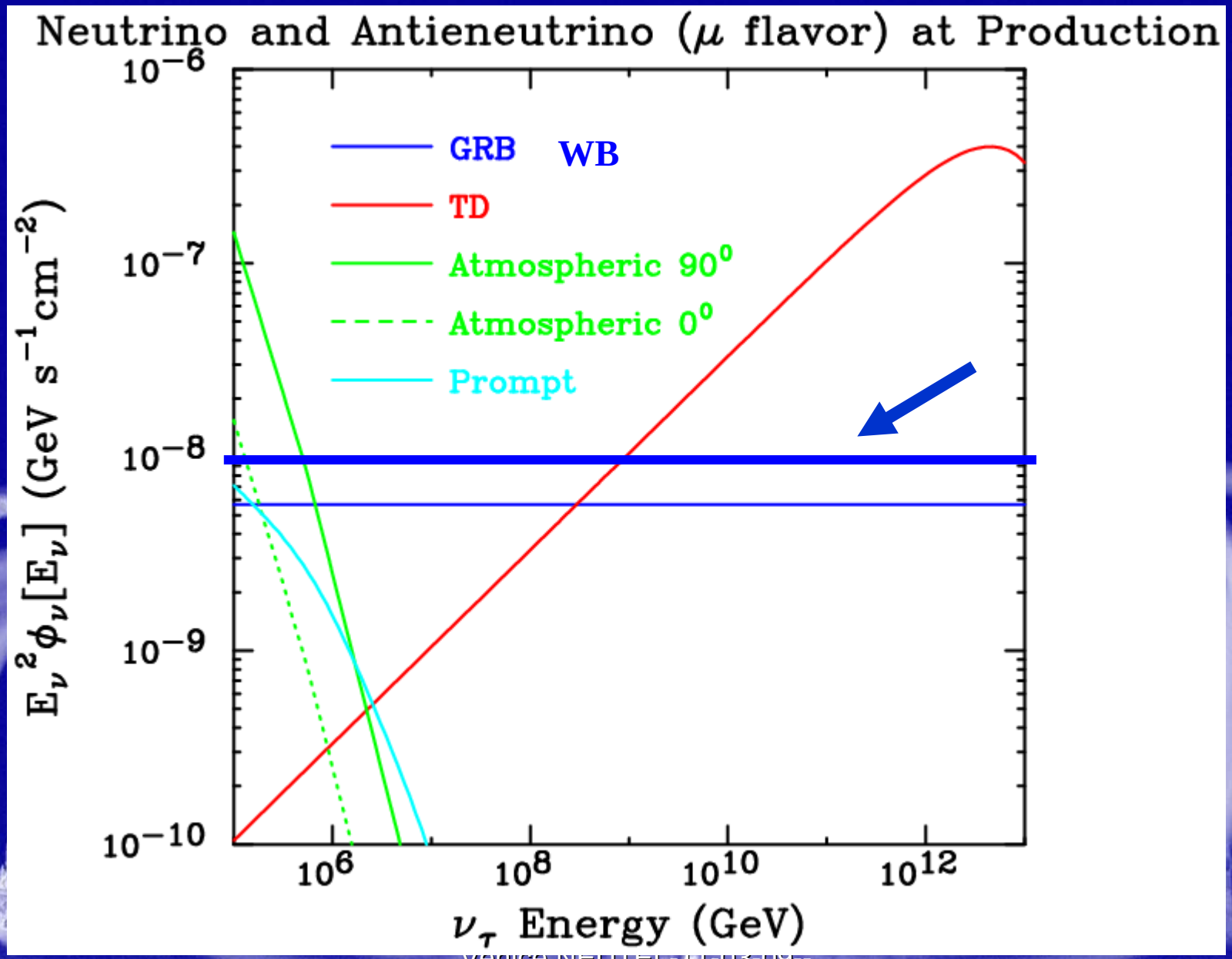
- *A ssing*
  f for
  H
- *H ding in*
  a e .
- *A*
  i
- *T*
  H
- *M ense*
  t



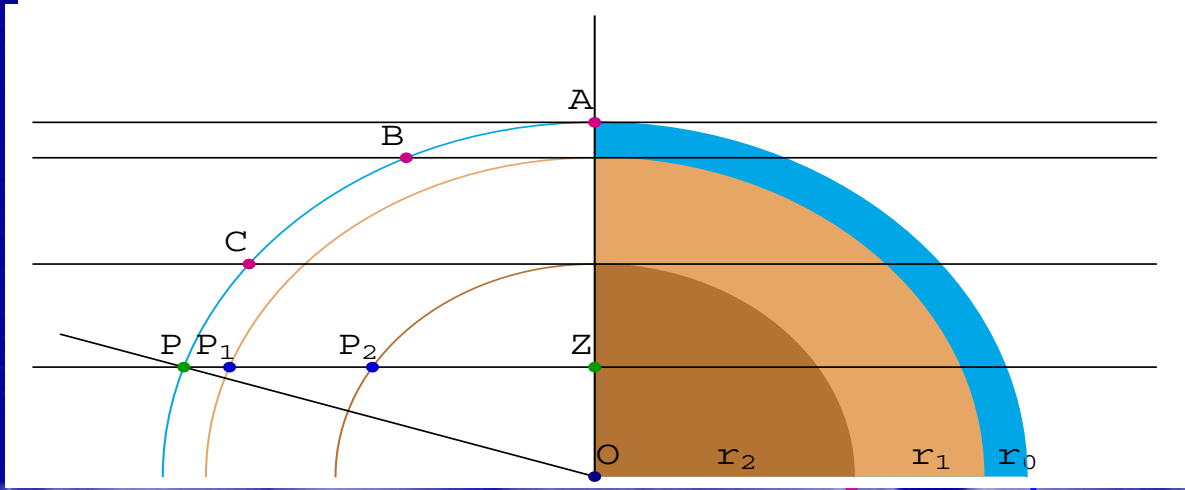
Expected GZK neutrino flux

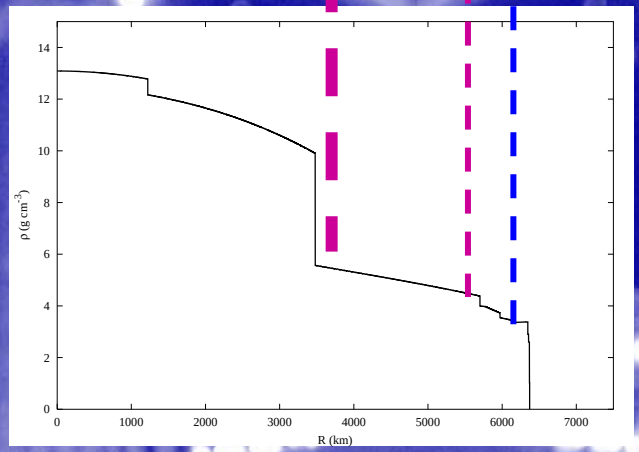
following most authors (Semikoz,Sigl..)



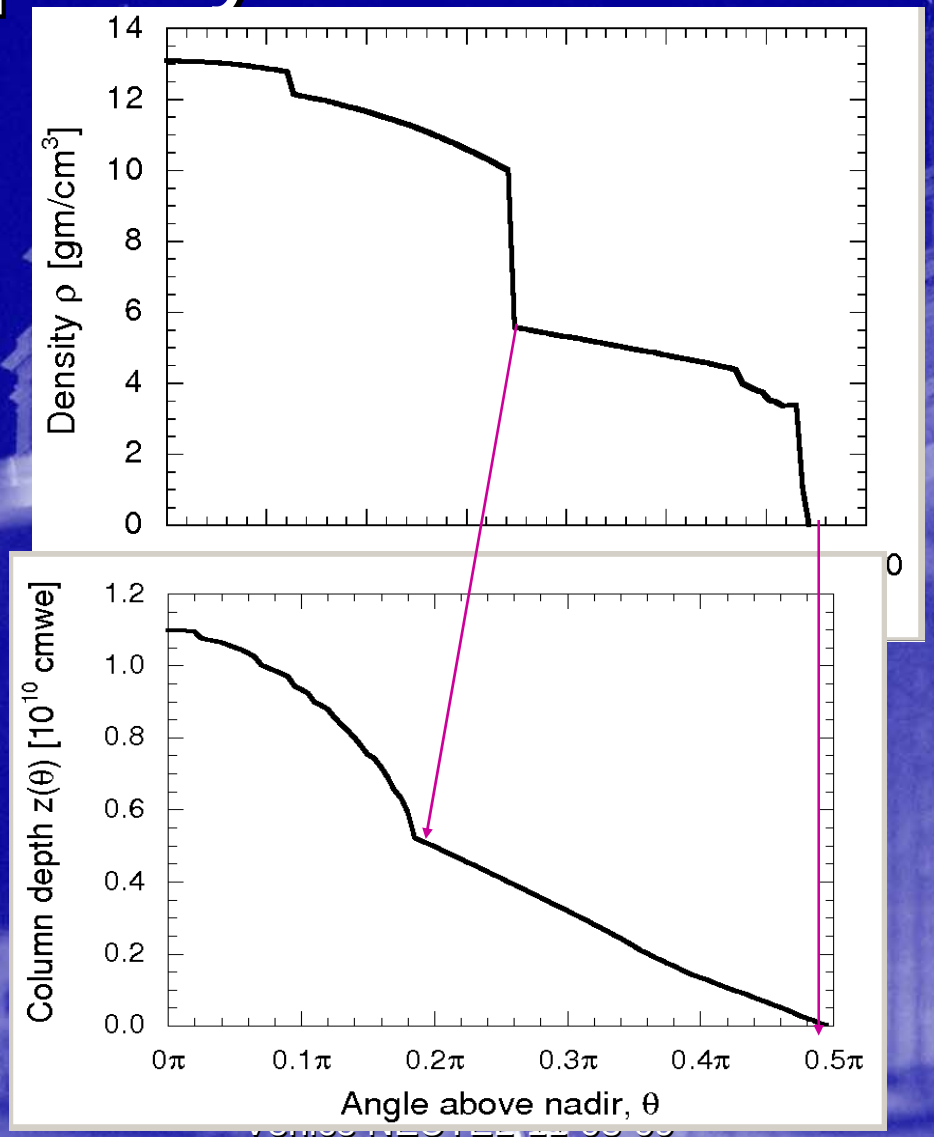

Neutrino and Antieneutrino (μ flavor) at Production
GRB
WB
TD
Atmospheric 90°
Atmospheric 0°
Prompt
$E_\nu^2 \phi_\nu[E_\nu]$ (GeV s^{-1}cm^{-2})
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^6
10^8
10^{10}
10^{12}
ν_τ Energy (GeV)

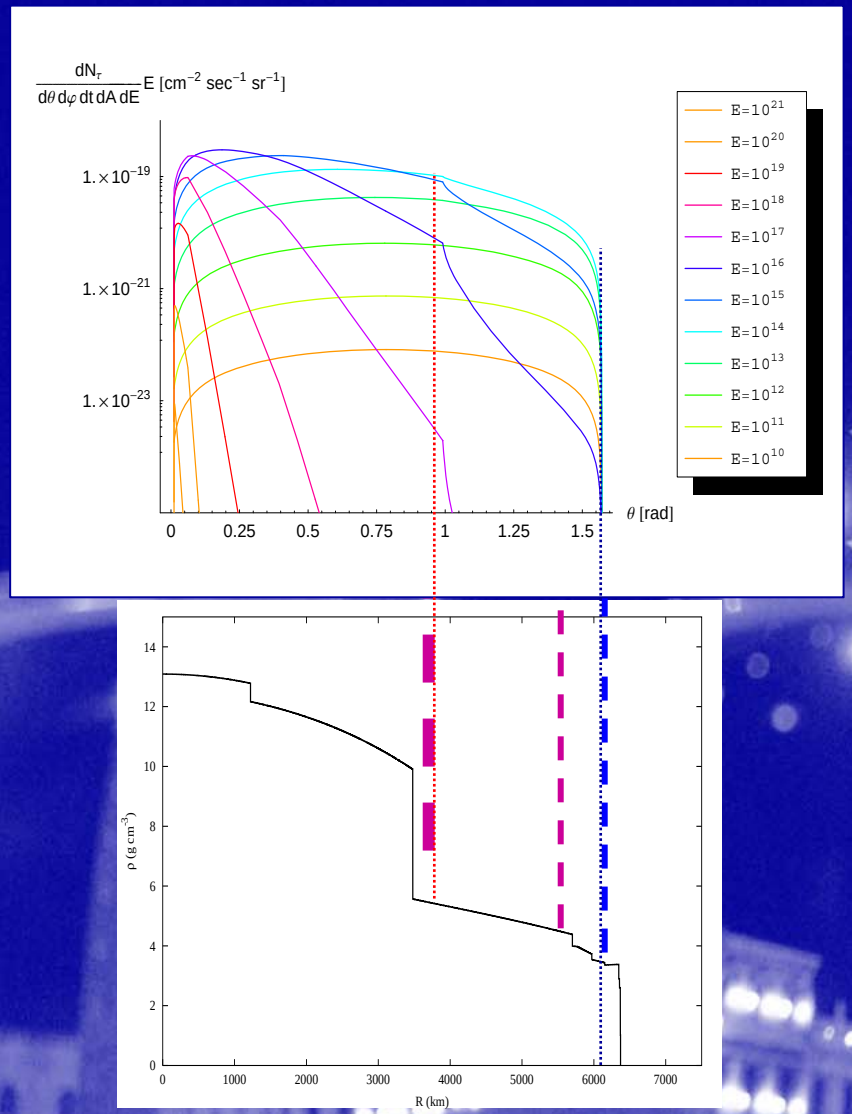
Earth Opacity by Inner Density Structures

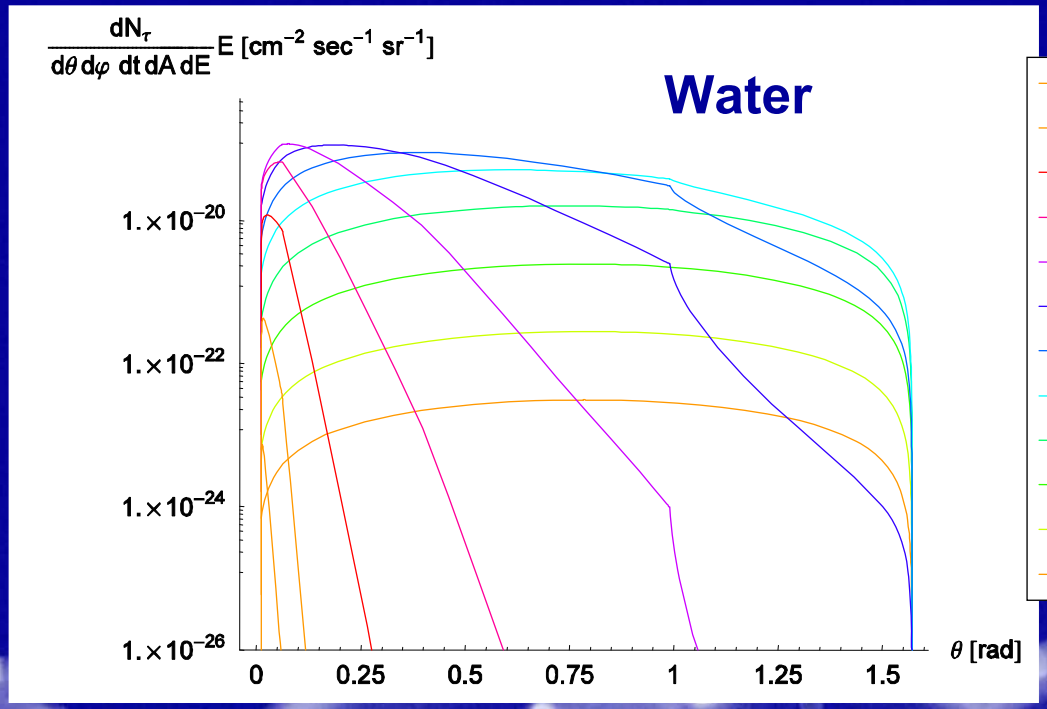


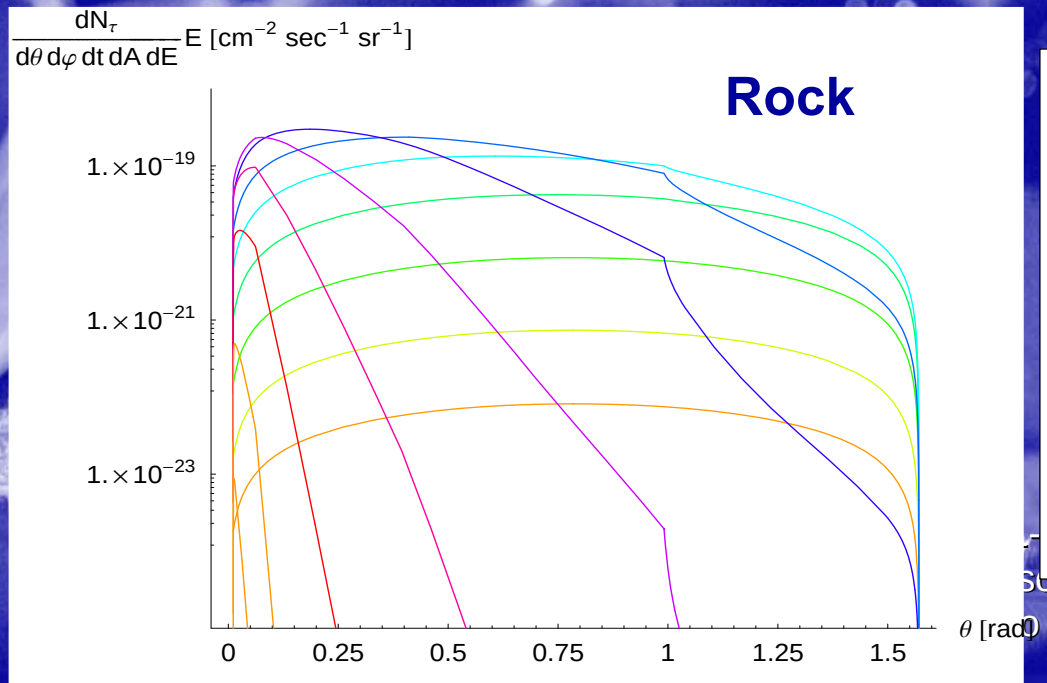


Earth Opacity




$\frac{dN_\tau}{d\theta\, d\varphi\, dt\, dA\, dE}$ E [cm^{-2} sec^{-1} sr^{-1}]
1.×10^{-19}
1.×10^{-21}
1.×10^{-23}
0
0.25
0.5
0.75
1
1.25
1.5
θ [rad]
E=10^{21}
E=10^{20}
E=10^{19}
E=10^{18}
E=10^{17}
E=10^{16}
E=10^{15}
E=10^{14}
E=10^{13}
E=10^{12}
E=10^{11}
E=10^{10}
ρ (g cm^{-3})
R (km)

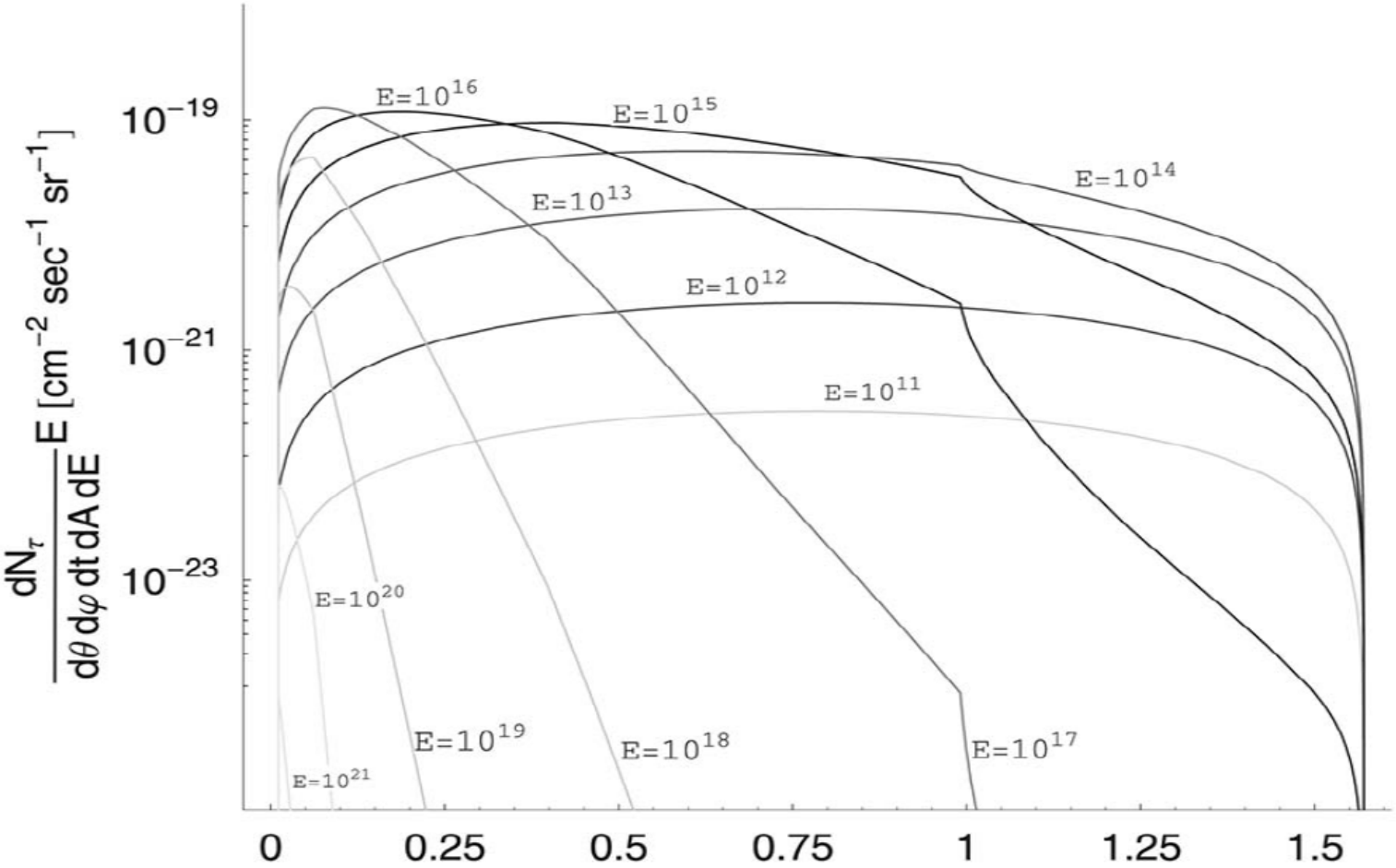




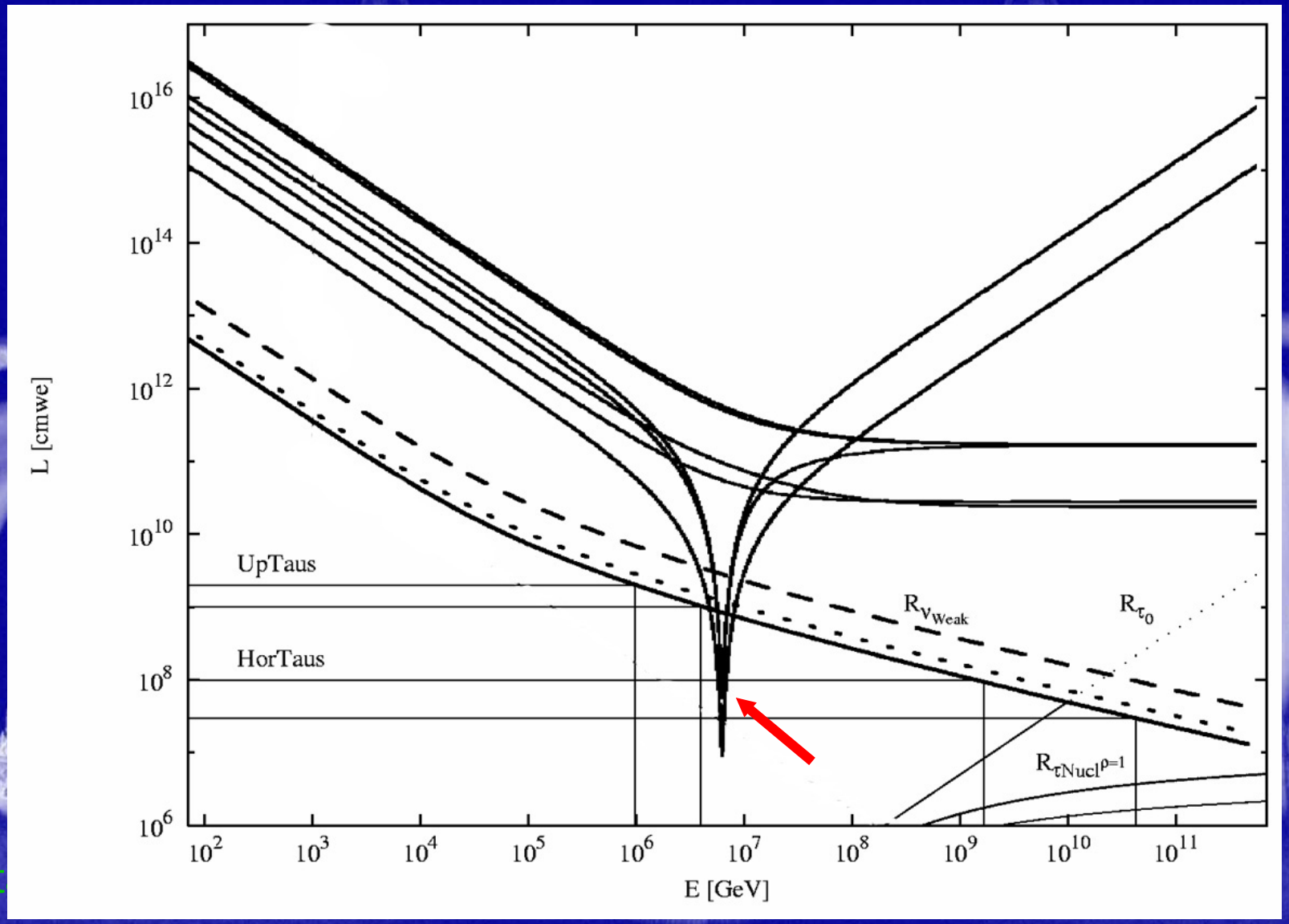
astro-ph/0501033
astro-ph/0409460
Nucleare Phys B
D.Fargion, M.Grossi,
M.De Santis,
P.G. de Sanctis Lucentin

xpected Tau
vents at
different angles.
ZK input
utrino flux

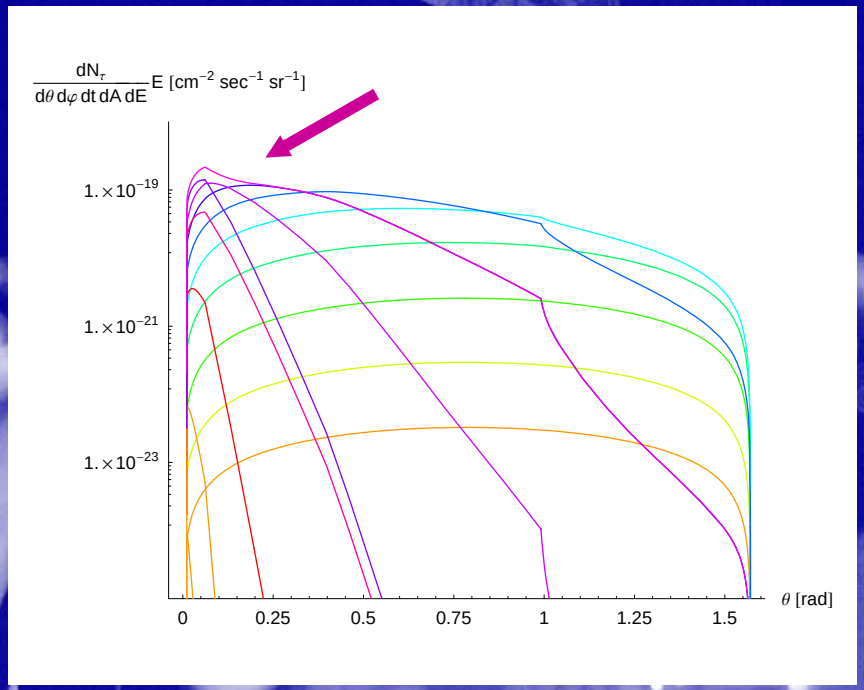
The Inner Earth and the ν_τ

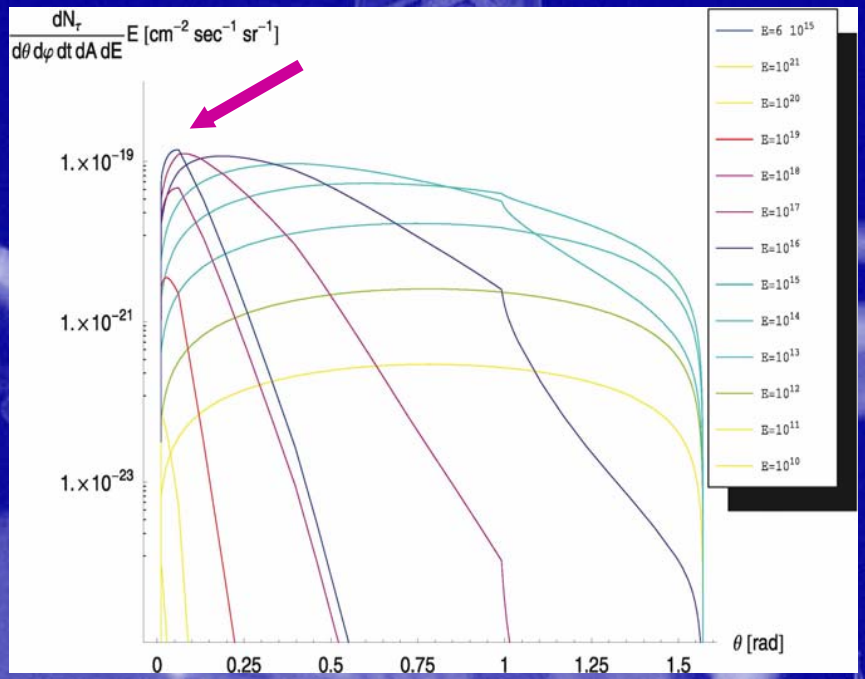


Tau Air-Showers is born *also* by Electron Anti-neutrino- hitting electron in air or rock by Glashow W-resonance whose decay may produce Tau air-showers

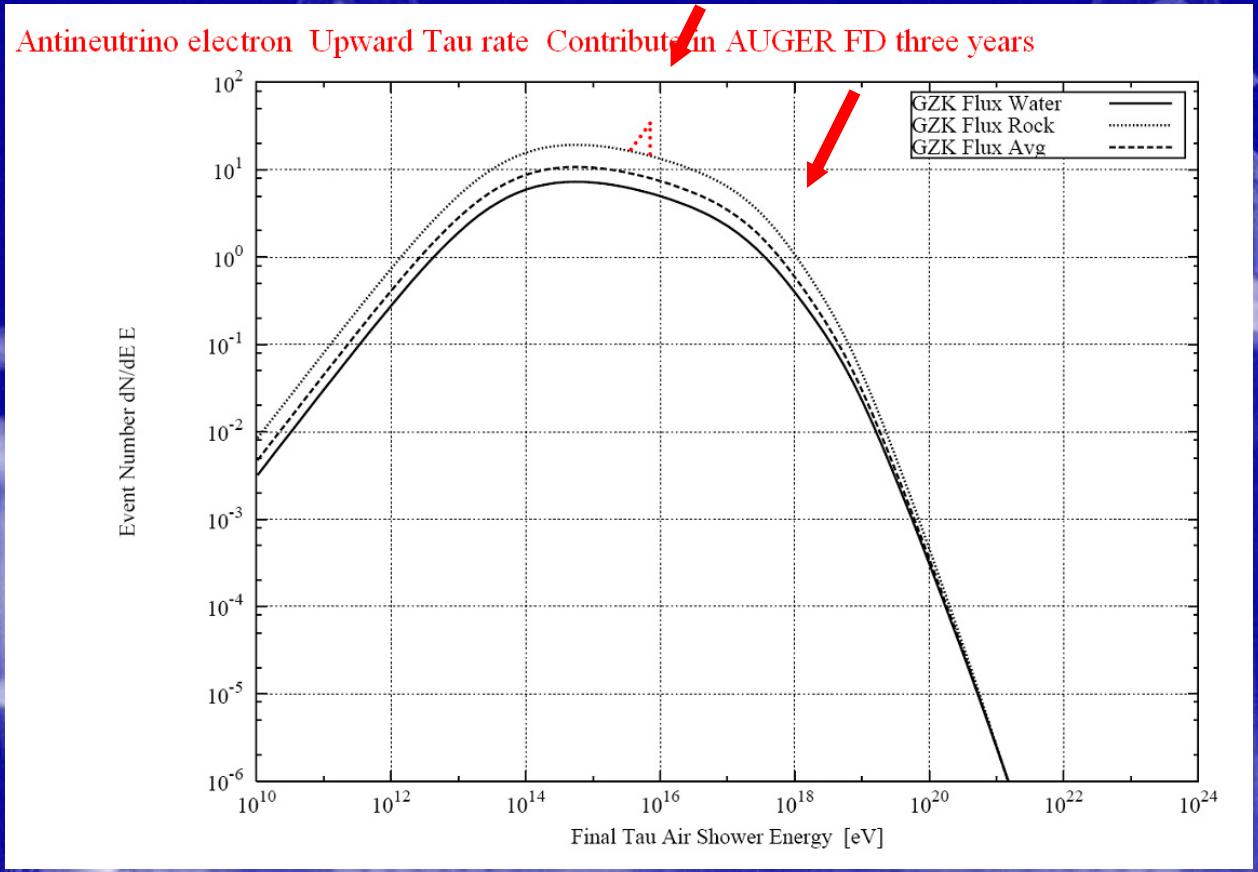


ν_τ Taus and Anti-ν_e into Taus: Testing CPT in our Universe

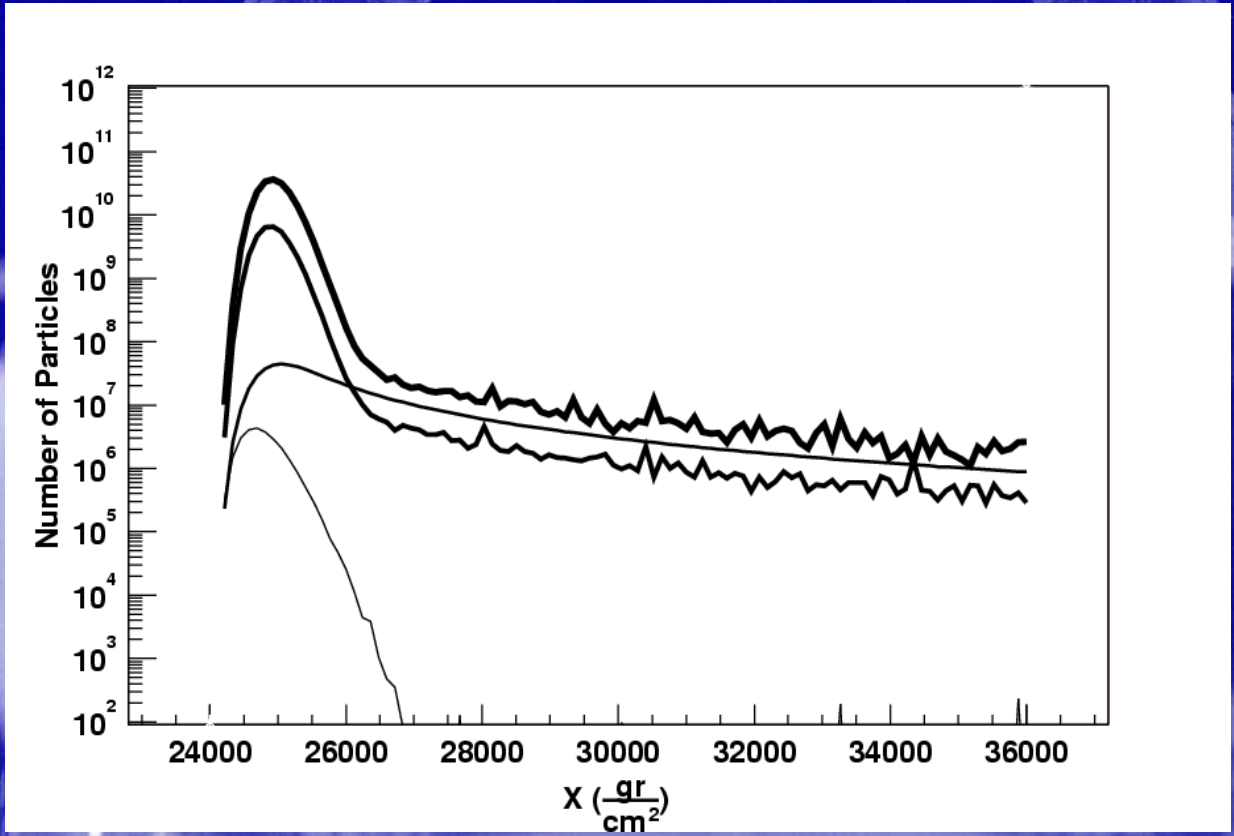




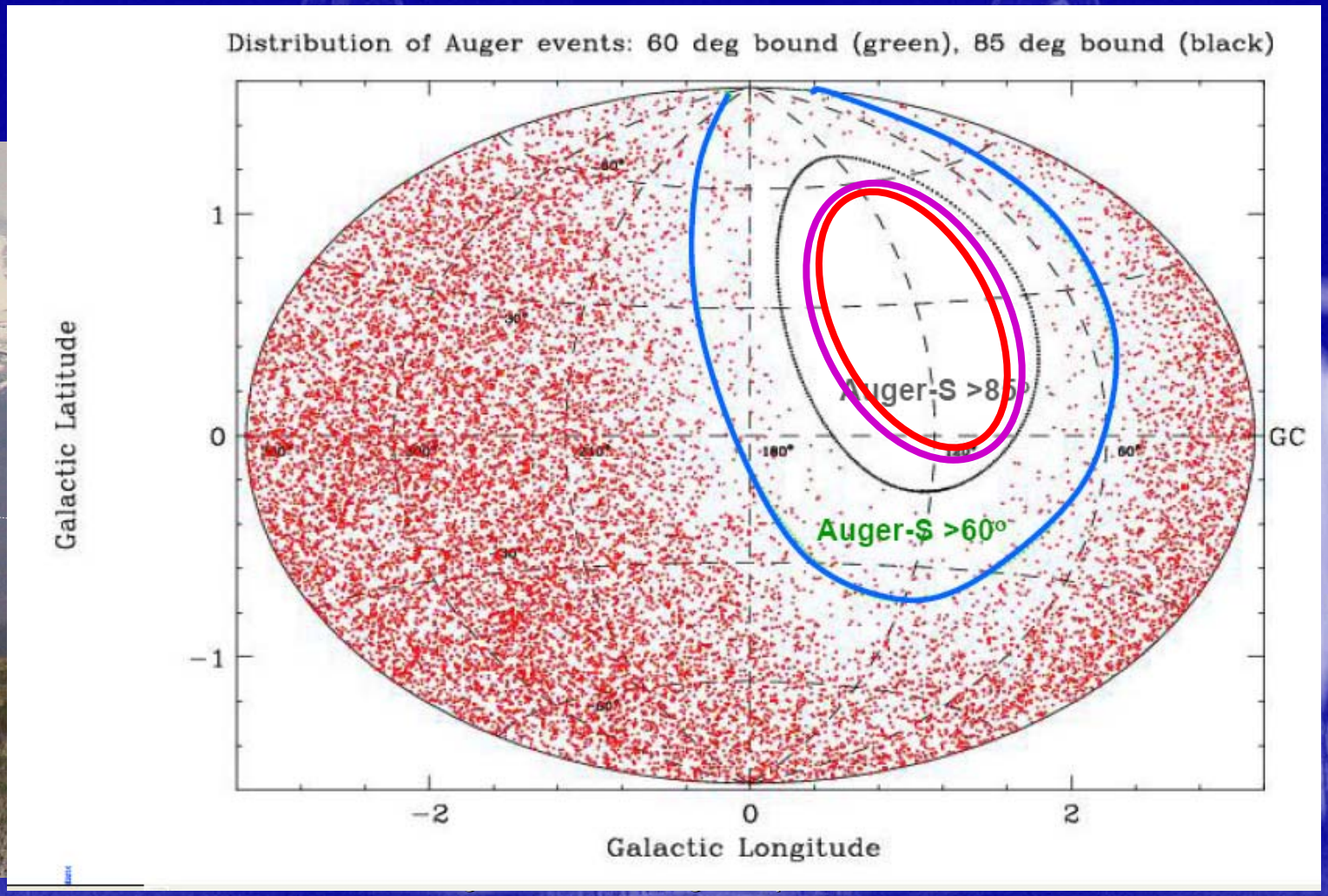
Total rate in Auger for Tau Airshower Fargion-2004-2006



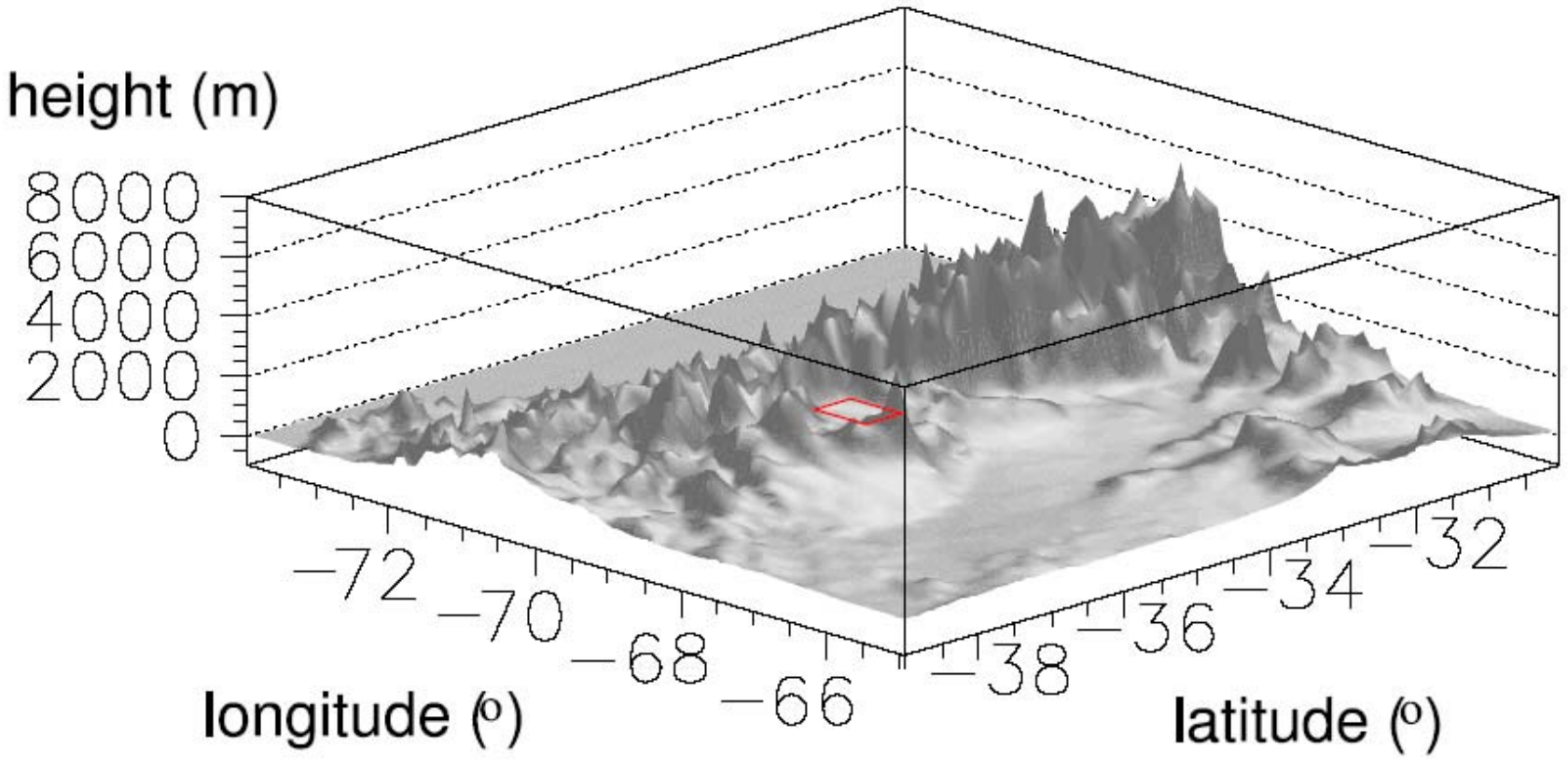
Electromagnetic versus Muon bundle: No e.m. below 75-80° Only UHE Neutrinos and Upward Tau (10-50 more) at horizons



The Ande Mountains as a target for detecting UHE neutrino tau by Horizontal Air-Showers at AUGER: ANDE SHADOWs (ring mask at horizons) on GZK Cosmic Rays from West and Young Horizontal Tau Air-Showers at EeVs



The Ande Shadows on AUGER



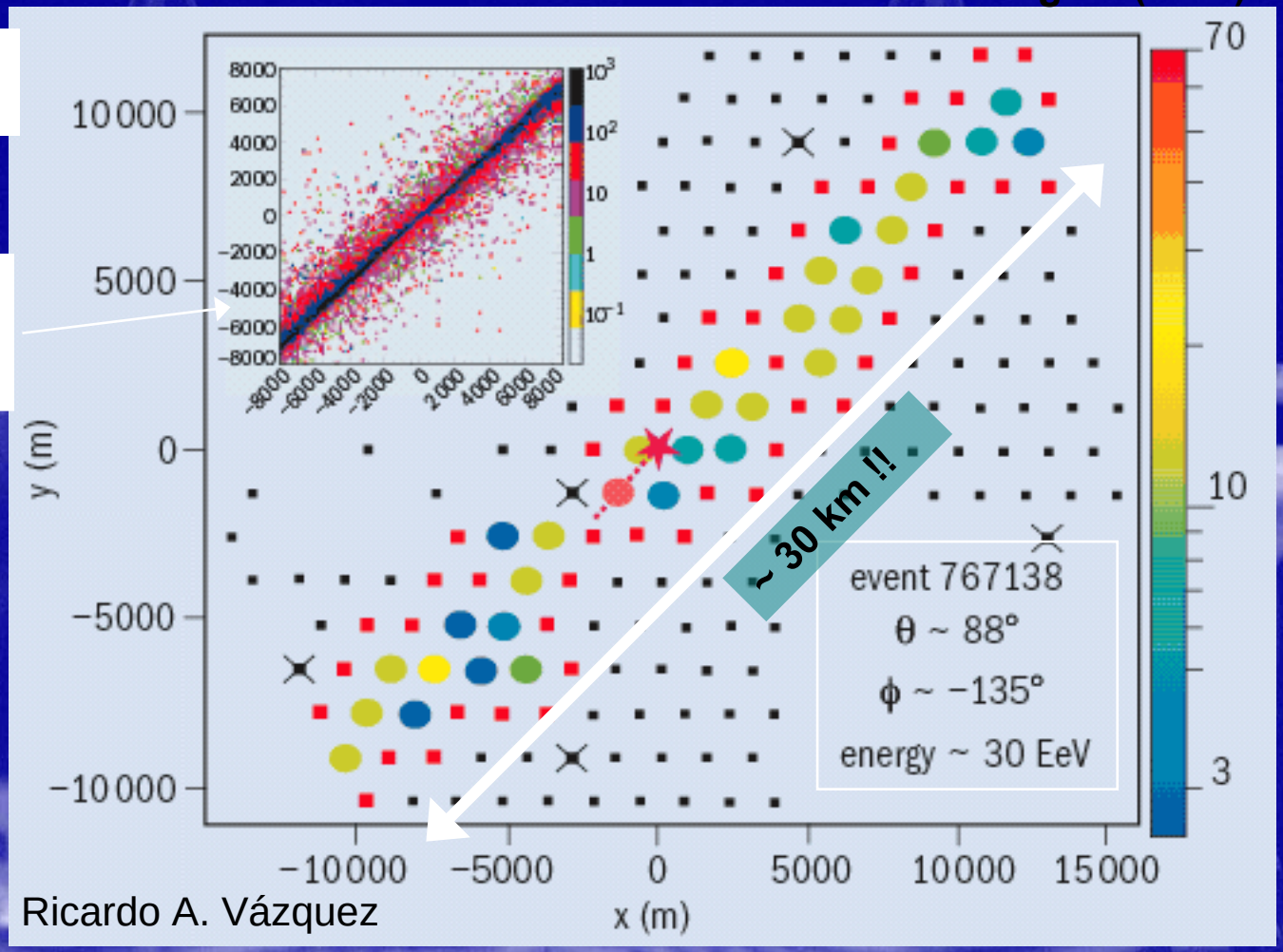
Pastor et. All 2005

Inclined Auger example

$\theta=88^0$

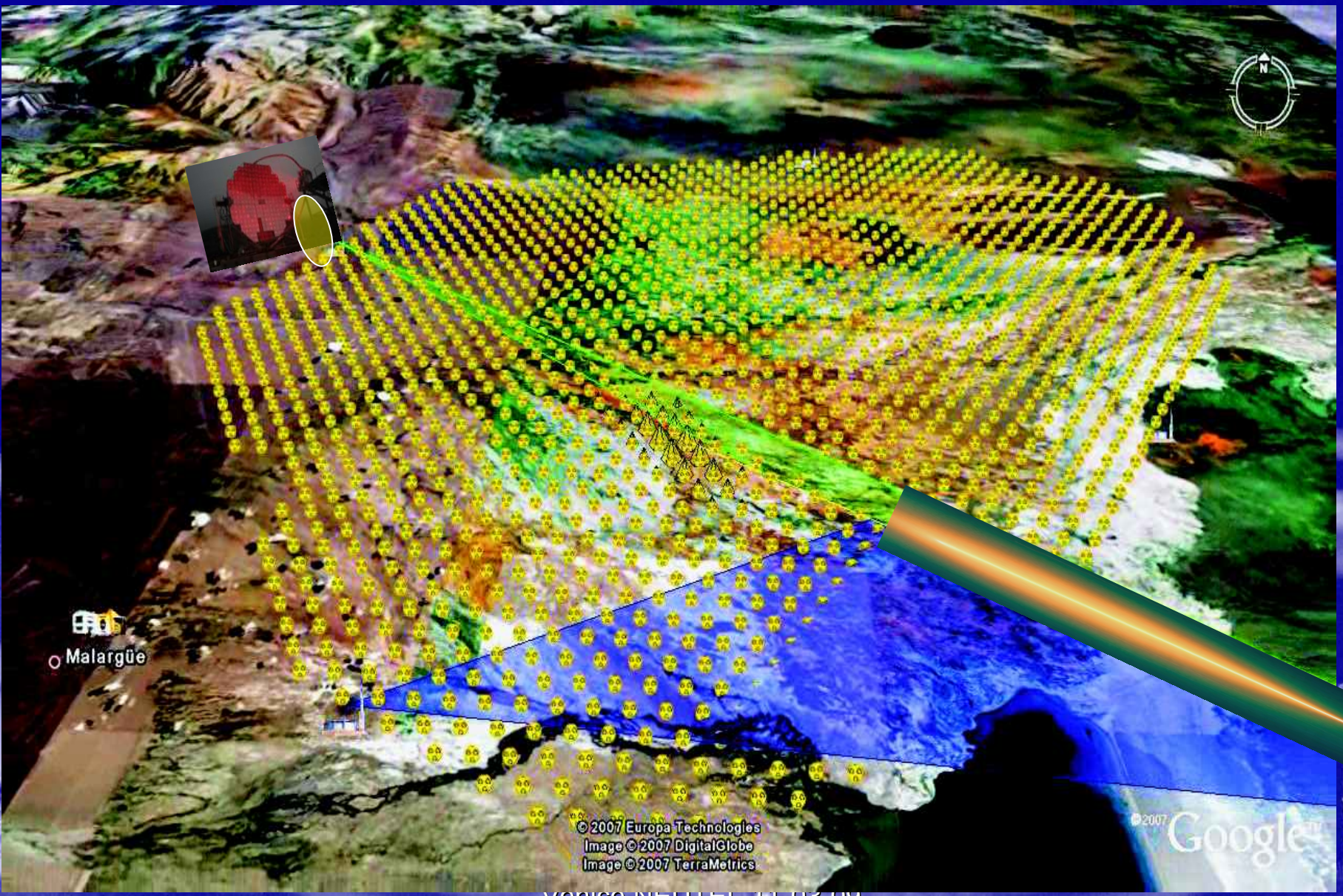
CERN Courier
July 25 2006

MC simulation of an event with the same angle

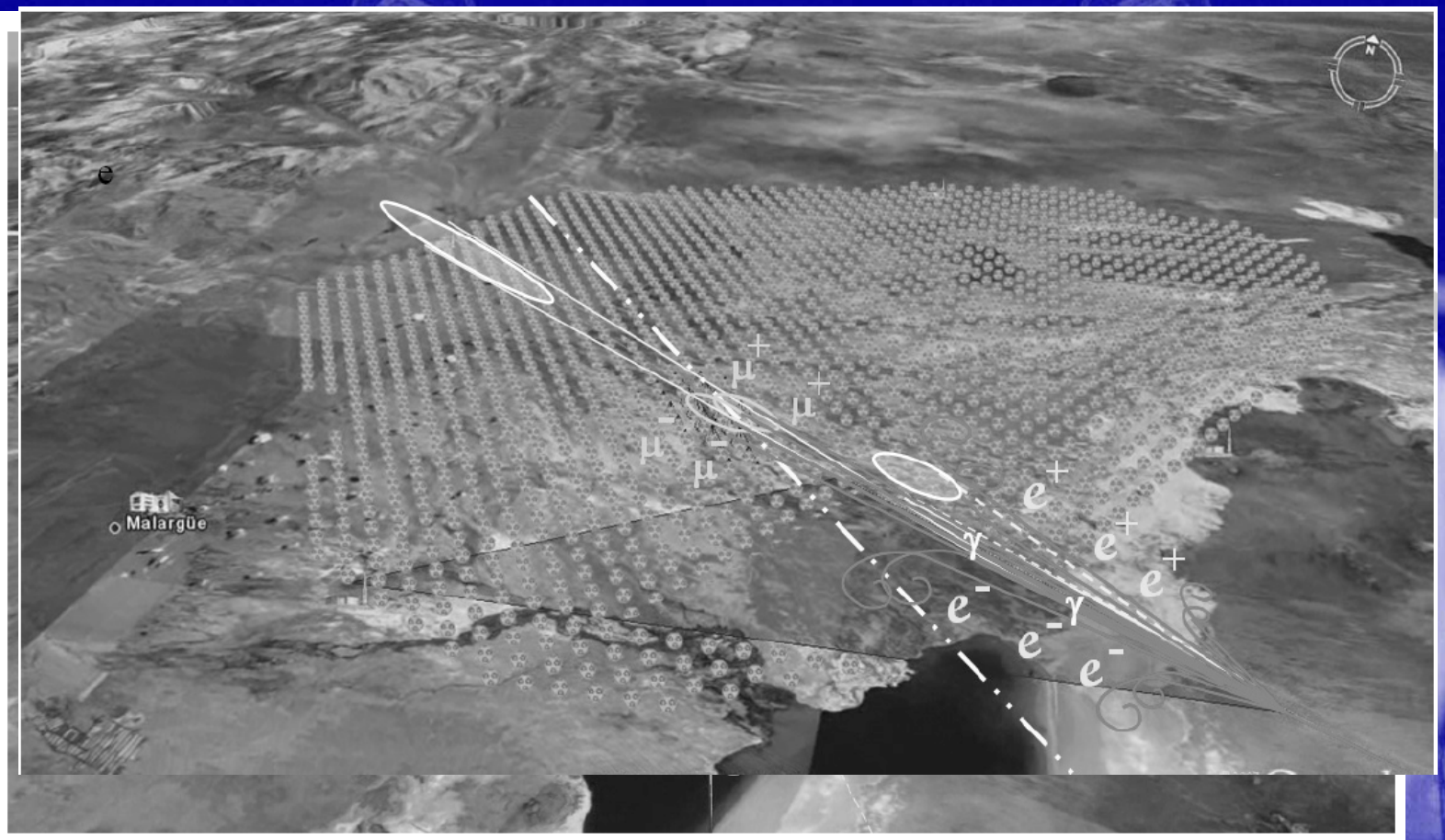


Ricardo A. Vázquez

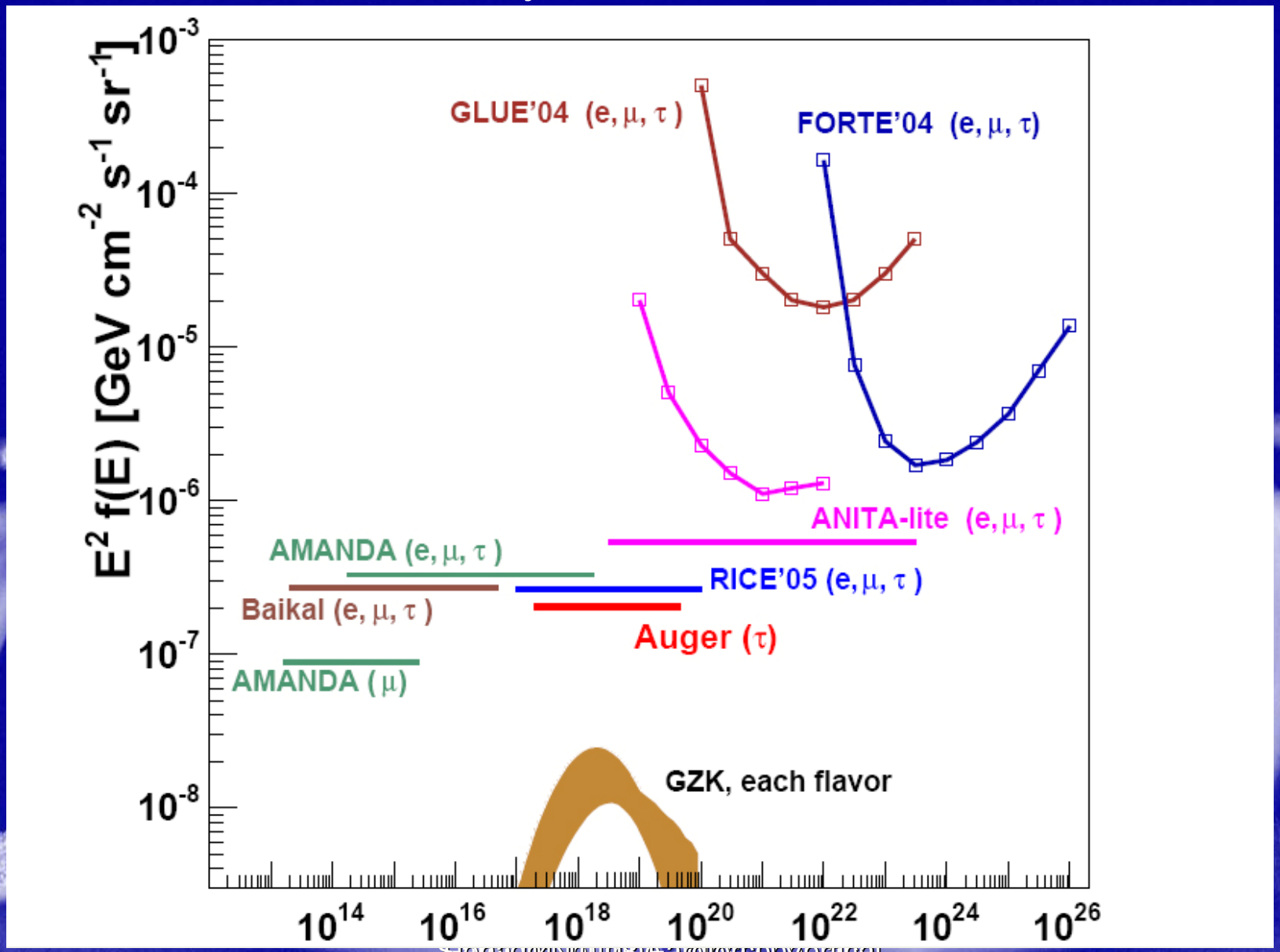
2-lobed footprint on the ground due to muon deflection by the geomagnetic field


Malargüe
© 2007 Europa Technologies
Image © 2007 DigitalGlobe
Image © 2007 TerraMetrics
©2007 Google

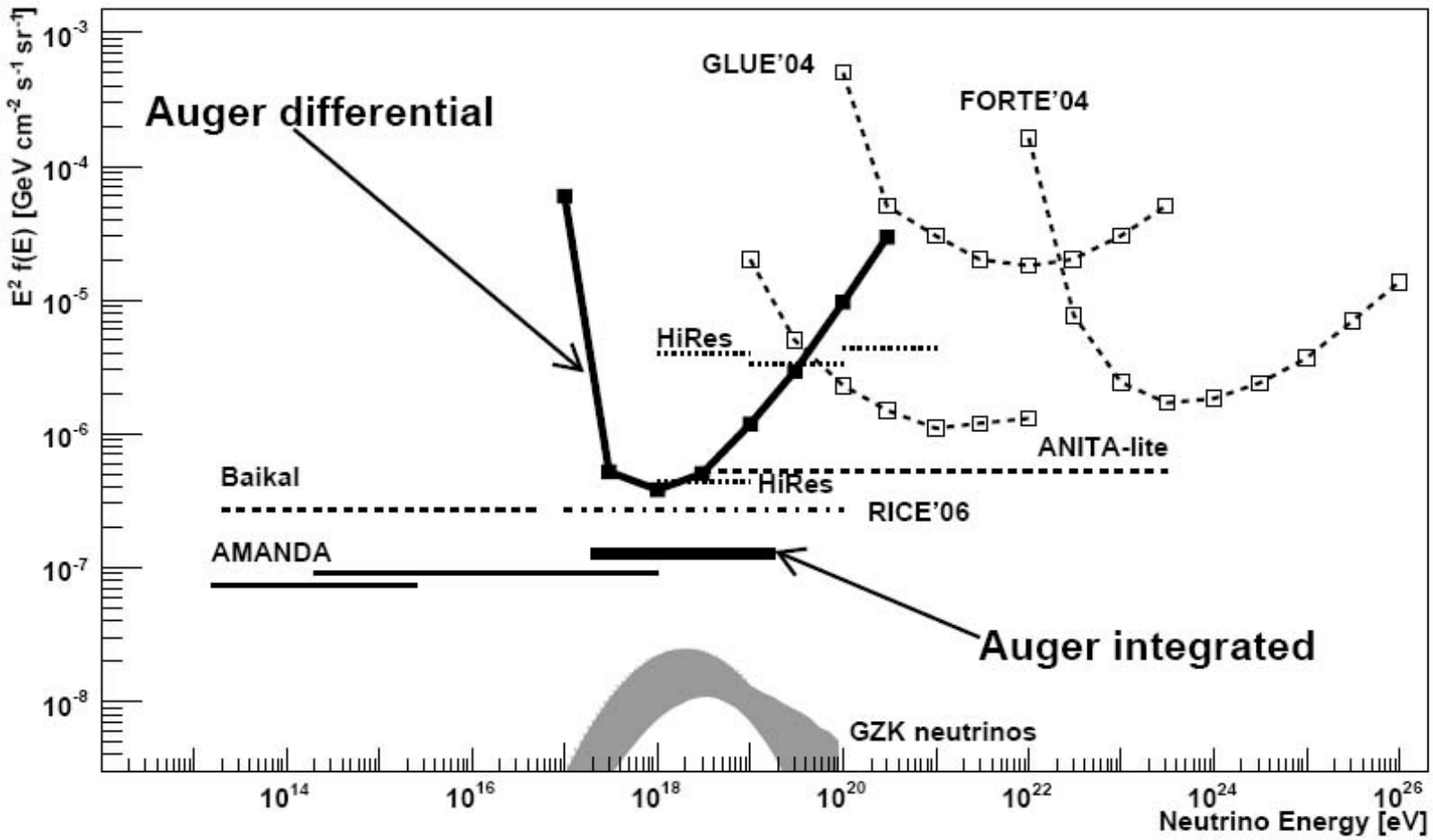
The Radiography of the shower



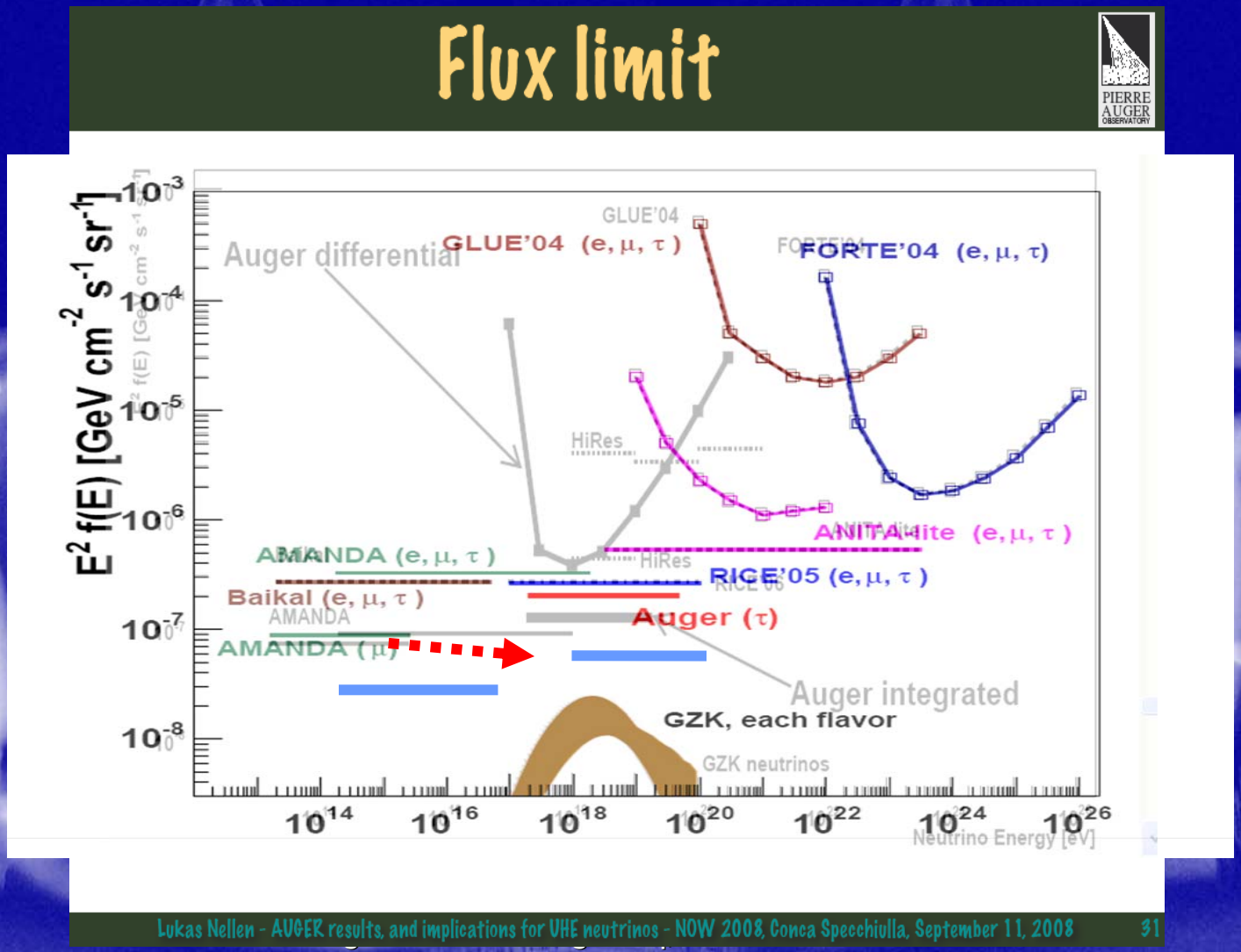
First Answers in UHE neutrinos in AUGER: 10-20 years
TAU inclined Air showers mostly from the Ande



Second Auger: 2007 predictions



Last Tau updated NOW 08- Versus DF - RICAP 07



Counting Tau on clouds (Also in Hess-Magic and Veritas) by AUGER via Cherenkov reflections

Figure 4: Upward Tau Air showering on the Auger clouds

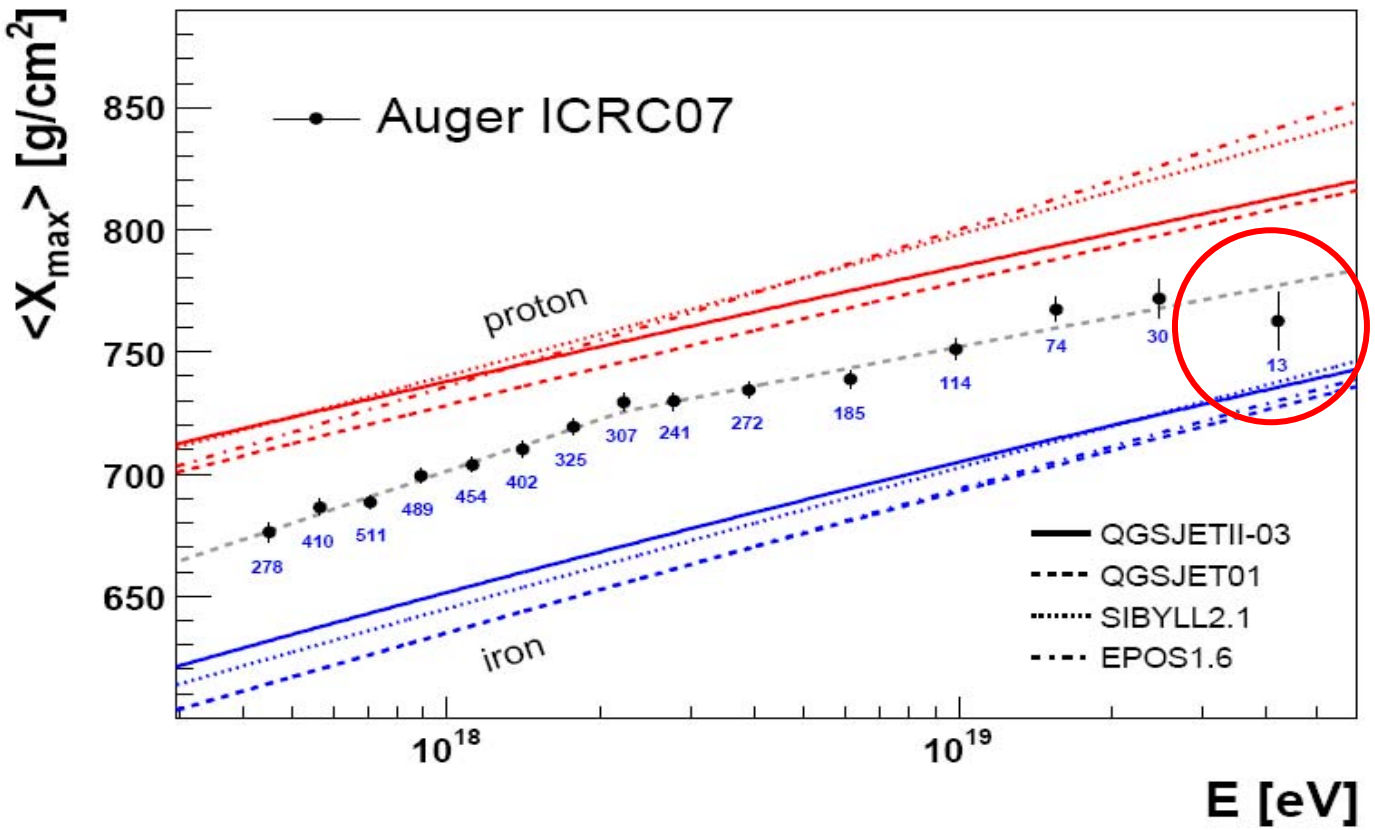
UHECR versus Neutrino Astronomies

- Attention: Not just one UHECR : **nuclei or nucleon**

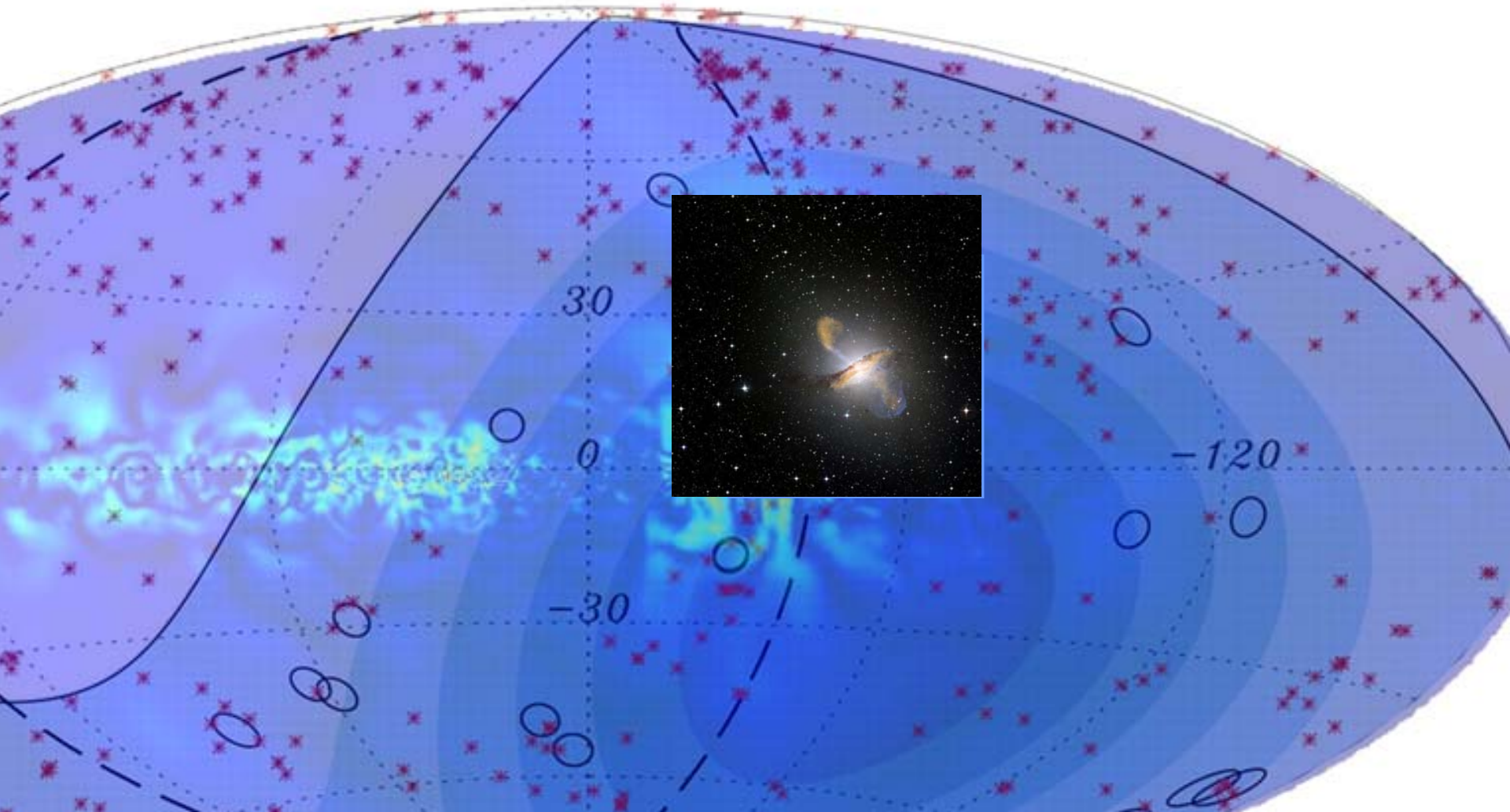
AUGER Michael Unger , Pierre Auger July

Composition puzzle

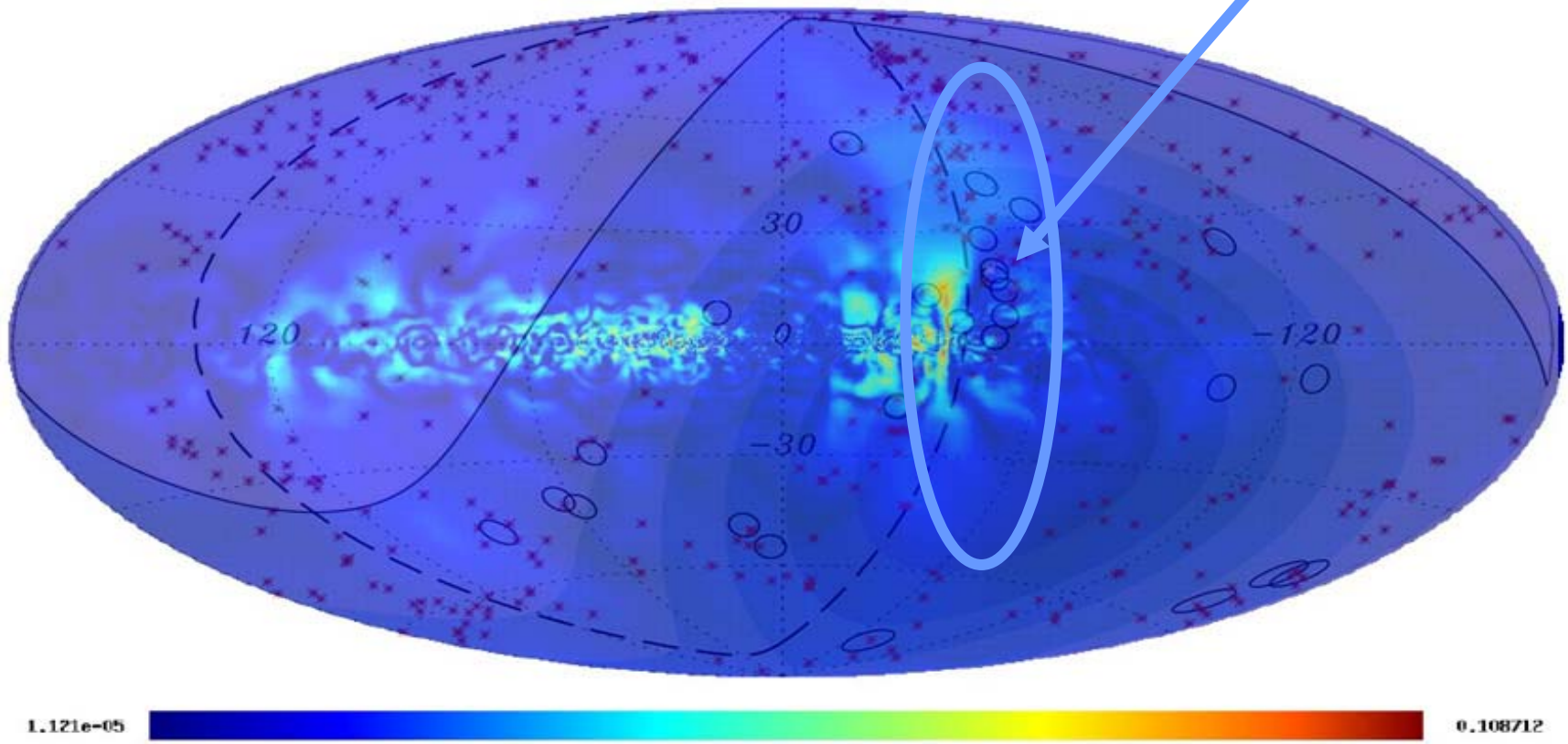
30TH INTERNATIONAL COSMIC RAY CONFERENCE



Why an apparent UHECR-Super Galactic Correlation? Polarized-Radio show the link between Cen A (3.8 Mpc)- $B_{Galactic:}$



Map-Polarization2

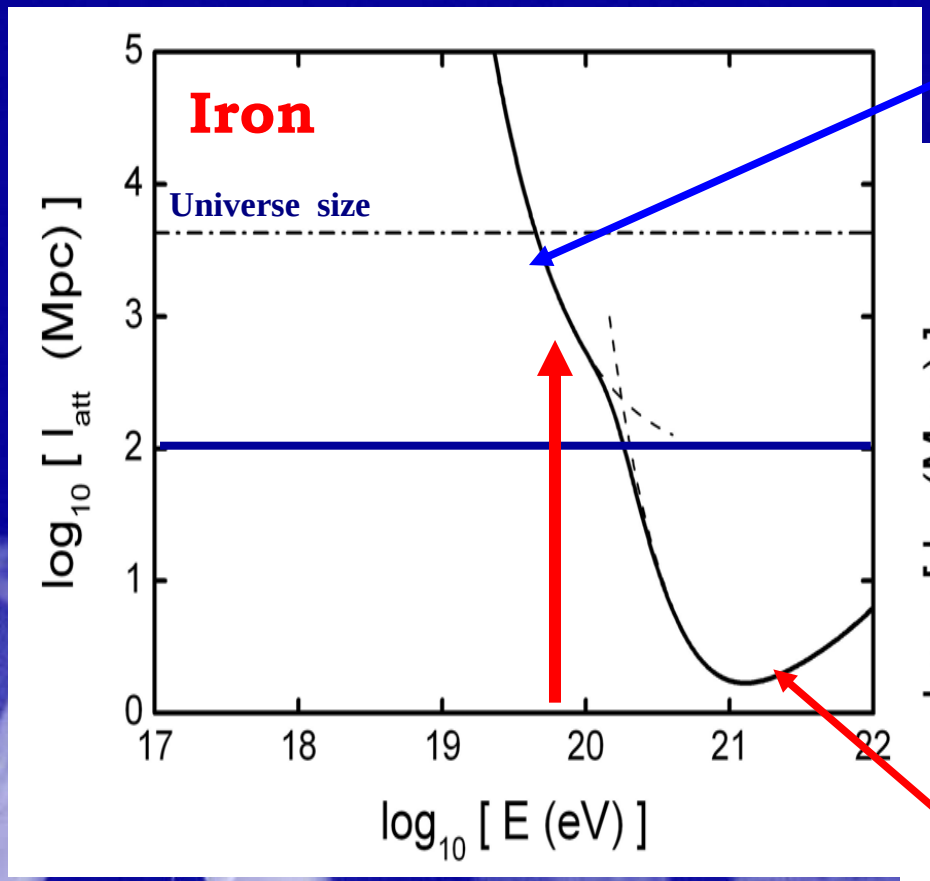


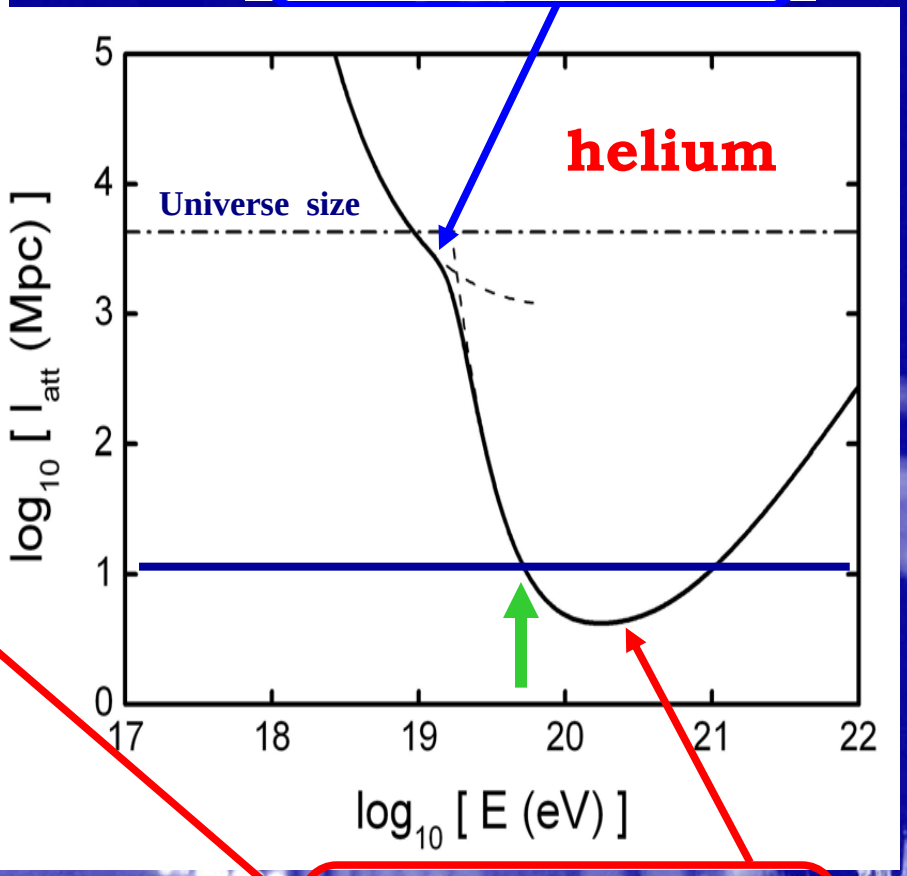
UHE Nuclei energy losses

Pair production

$$A\ \gamma \rightarrow A\ e^+ e^-$$

$$\beta^A_{pair}(E_A) = \frac{Z^2}{A}\beta^N_{pair}(AE_N)$$





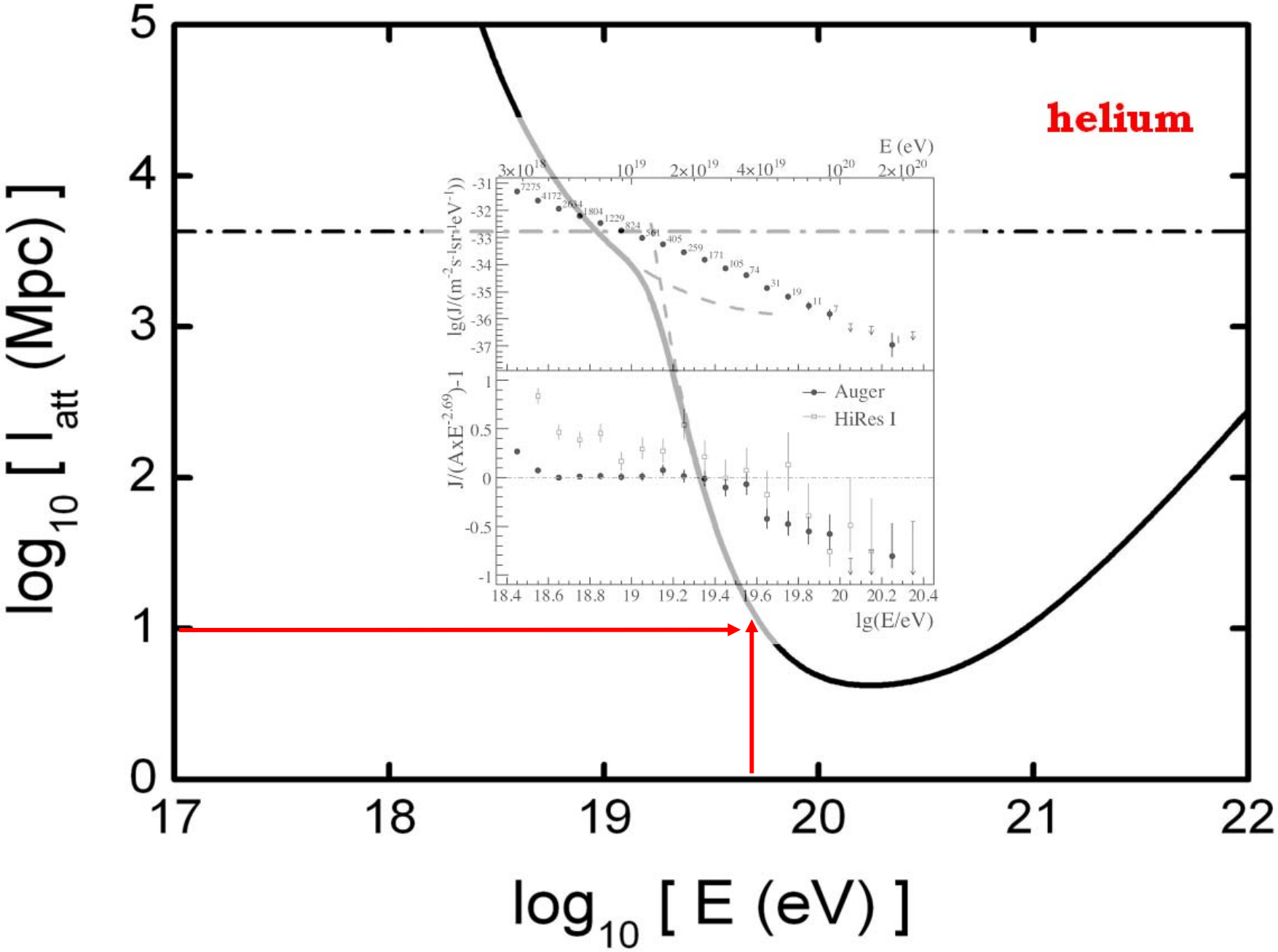
Pair production has no particular effect on the flux

Depletion of the flux

- Iron
- Helium

Photodisintegration

$$A\ \gamma \rightarrow (A-1)\ N$$
$$\rightarrow (A-2)\ 2N$$


helium
log10 [Iatt (Mpc)]
log10 [E (eV)]
E (eV)
lg(J/(m-2s-1sr-1eV-1))
J/(AxE-2.69)-1
lg(E/eV)
Auger
HiRes I

Deflections inside our Galaxy and along Galactic Plane toward Cen A

ing He^4 (see Fig.1) by spiral galactic magnetic fields along the plane is $\delta_{rm} \geq$:

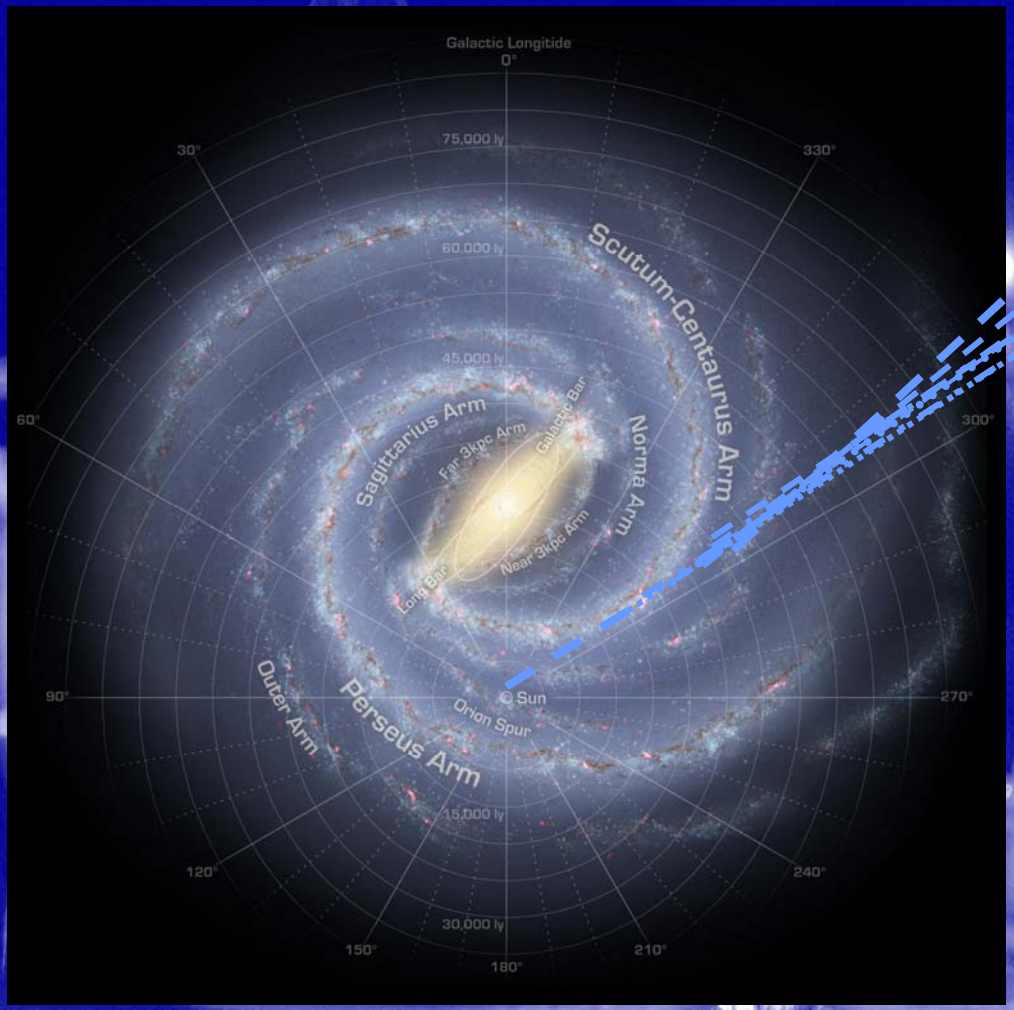
$$11.3^\circ \cdot \frac{Z}{Z_{He^4}} \cdot \left(\frac{6 \cdot 10^{19} eV}{E_{CR}}\right)\left(\frac{B}{3 \cdot \mu G}\right)\sqrt{\frac{L}{20kpc}}\sqrt{\frac{l_c}{kpc}} \quad (1)$$

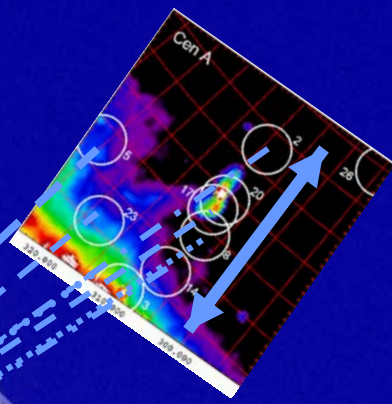
This *Lightest Nuclei for Highest Cosmic Rays* model implies and foresees among the other, additional clustering of UHECR events around the nearest AGN Cen-A (the lightest UHECR the more correlated to the source, the heavier and with larger charges, the most bent and spread ones). The model explains the absence or a poor signal from Virgo (too far for the fragile nuclei

So lightest nuclei may trace nearer Universe not show Virgo and fit AUGER GZK imprint

see astro-ph/0902.3290

CEN-A UHECRs



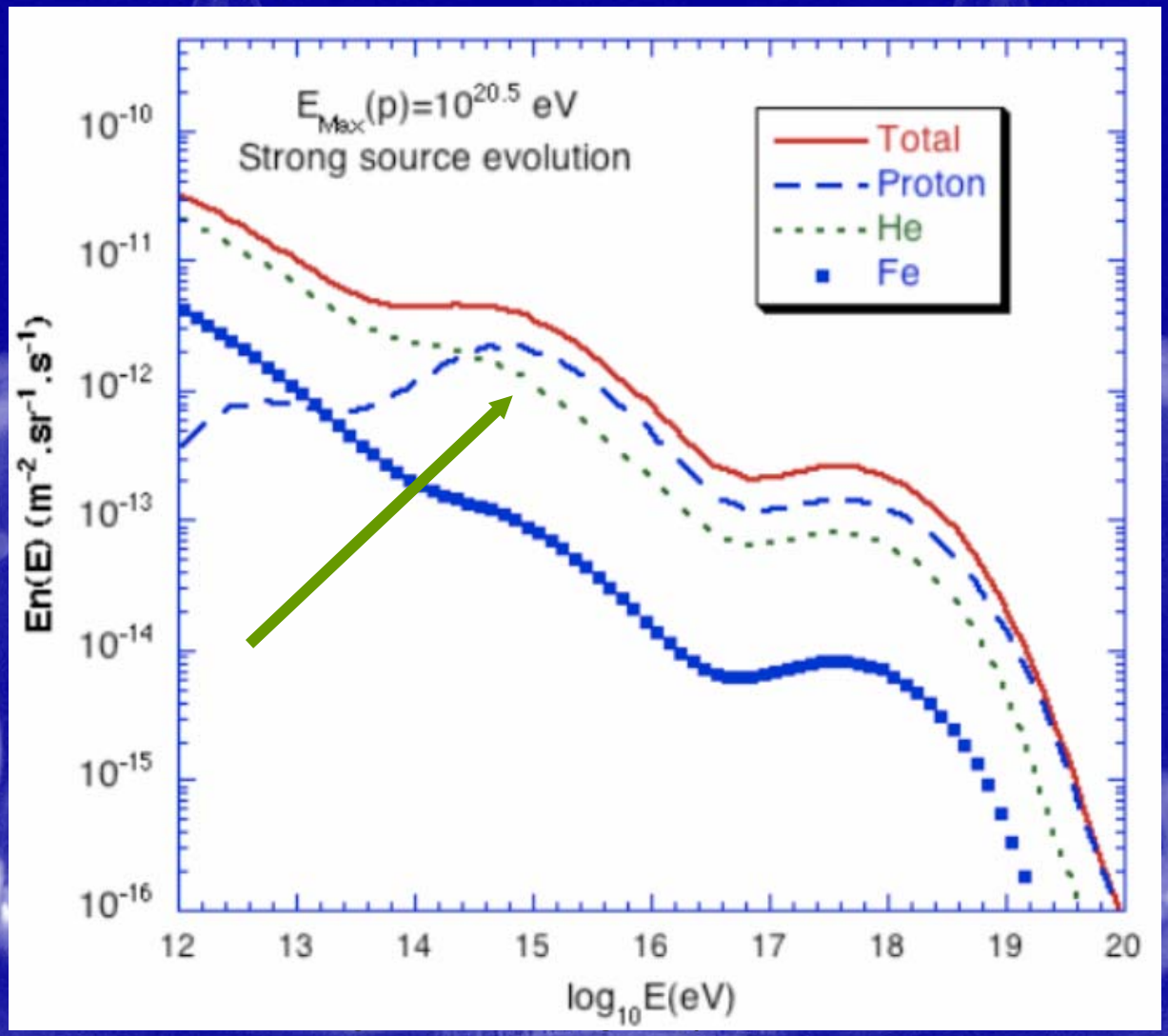


Simulation of Tau Neutrino Flux Down-Vertical
for Horizontal Tau Neutrino

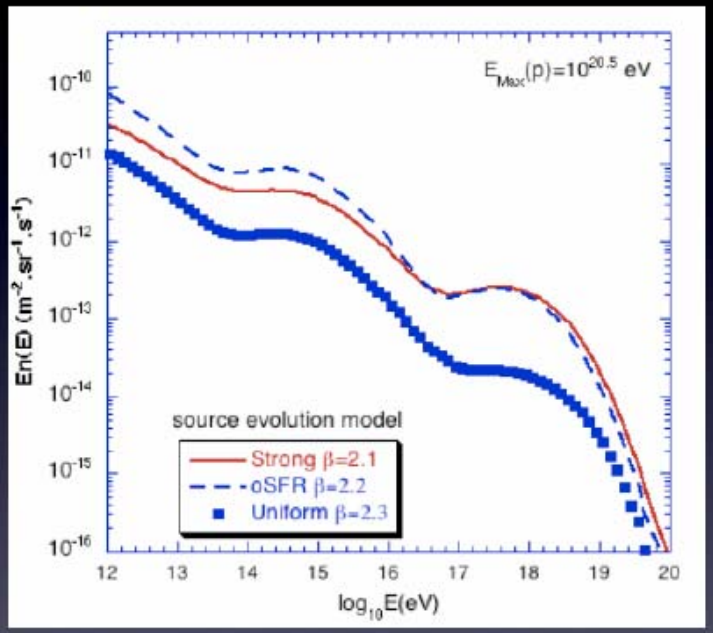
Conclusions: UHECR by He-like and UHE Tau at horizons

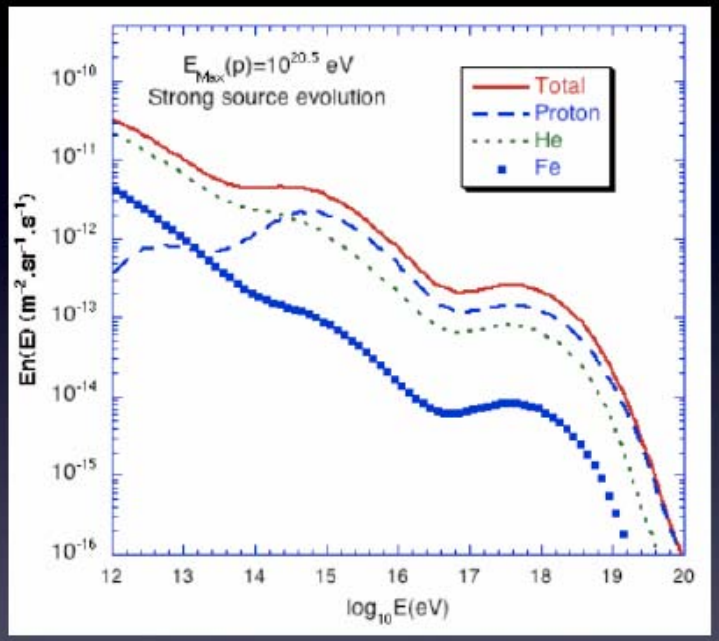
- The Lightest Nuclei UHECR may explain the AUGER anisotropy signal bent by vertical galactic field: No Virgo maybe due to early GZK for He and apparent Super Galactic correlation by unfortunate chance
- Future-present Auger UHECR must cluster around Cen A spread along B_gal. Axis. Mostly in NORTH side. The Ande Shadows in AUGER hides taus
- Neutrino apperance also the edge IN AMIGA AND HEAT lower edges

First new predictions for He



More at PeVs spread energy





three peaks like in the pure proton case but the third one is shifted to lower energies
Shape of the neutrino flux from nuclei different as the proton case

MAGIC , while pointing a GRB , SGR or BL Lac Below The Horizons (~ 1% of the GRB-SGRs events) on rock behave (near EeV ν_τ energy) as a 75 km^3 NEUTRINO TELESCOPE

astro-ph/0511597
D. Fargion
Progh.Part.Nucl.Phys.57 (2006) 384-393.

Horizons distance d= 167 km √(h/2.2 km) Cerenkov Shower opening angle ~ 0.3°

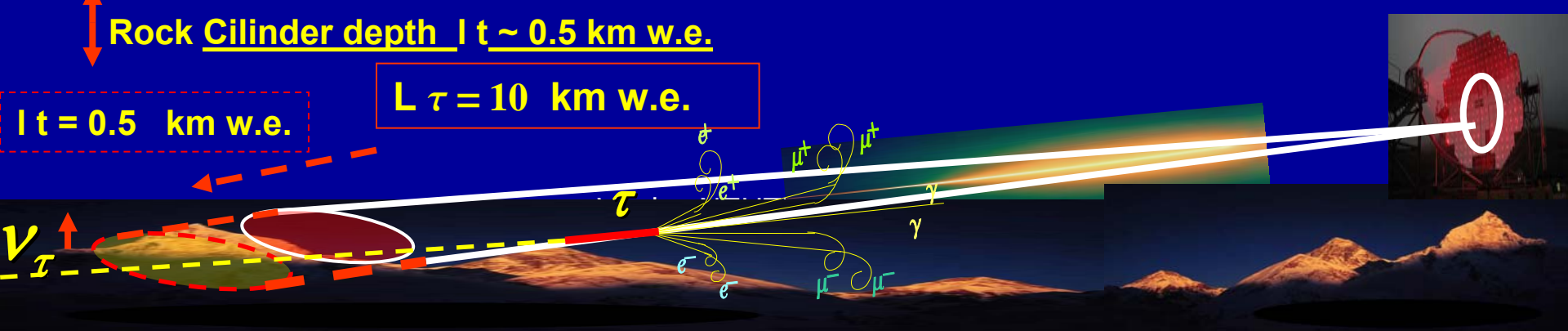
Inclined Conic Rock Base Area A ~ 3*50 =150 km^2

Inclined Rock Cilinder depth L τ ~ 10 km

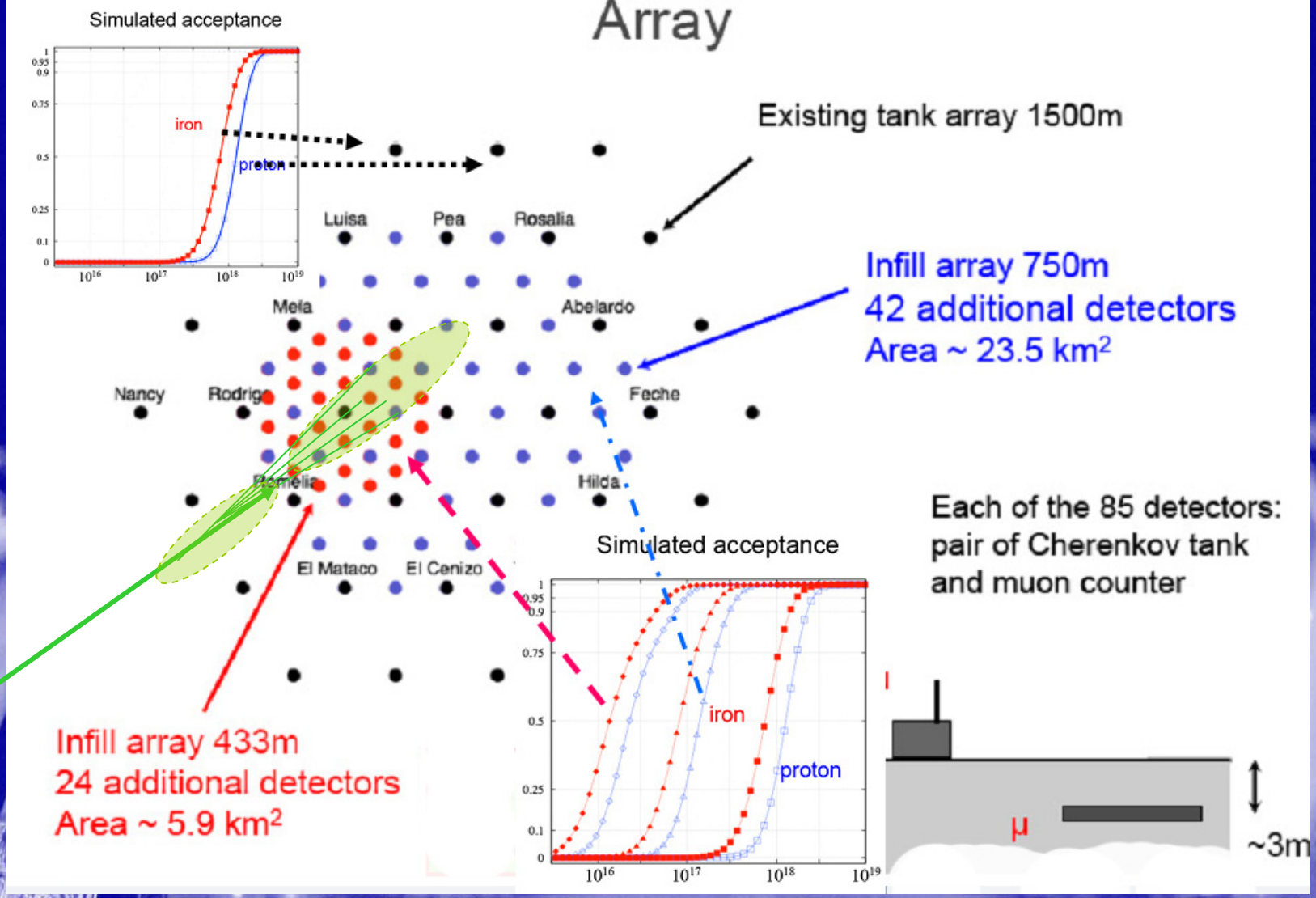
Rock Cilinder depth l t ~ 0.5 km w.e.

l t = 0.5 km w.e.

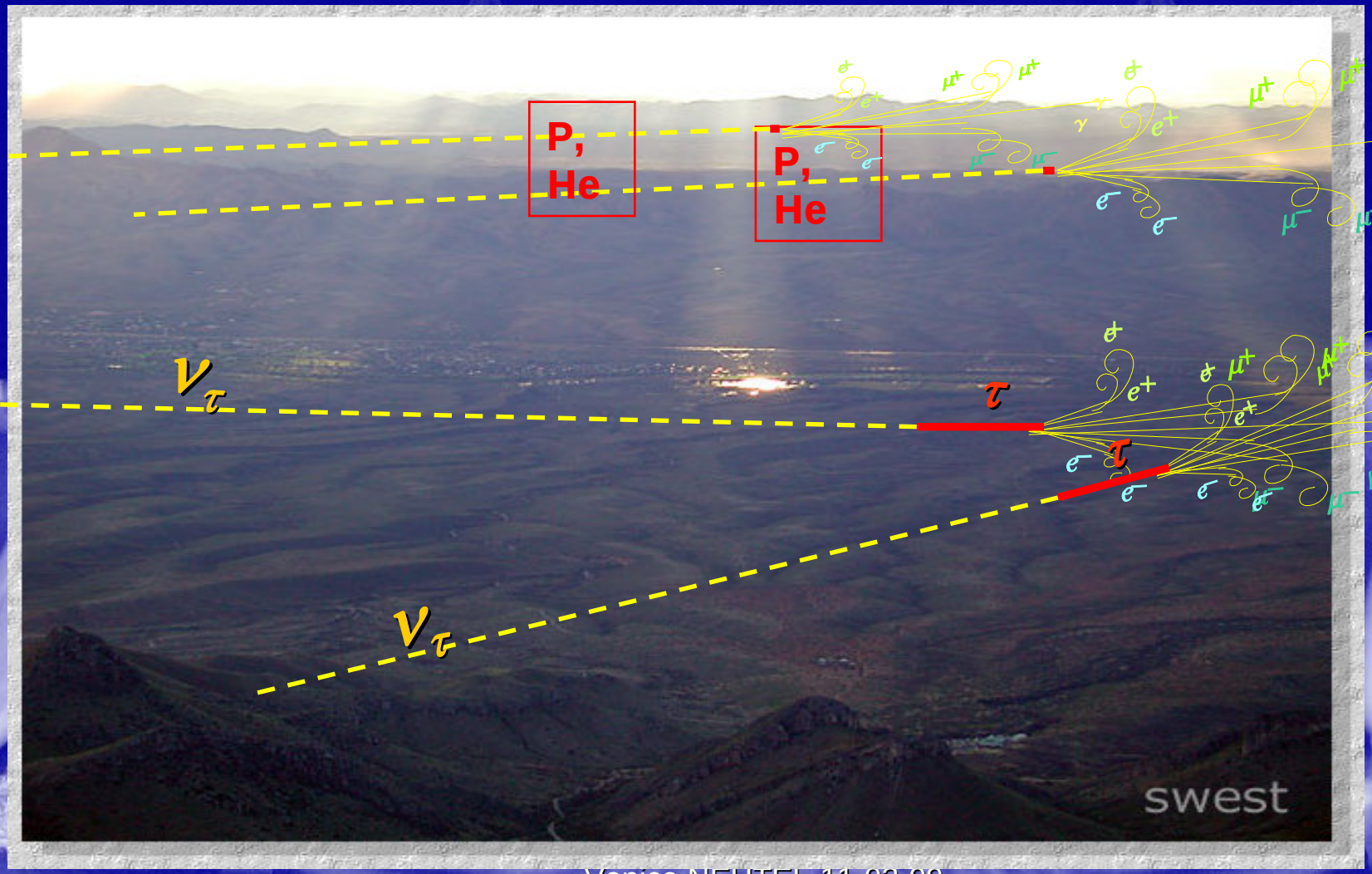
L τ = 10 km w.e.

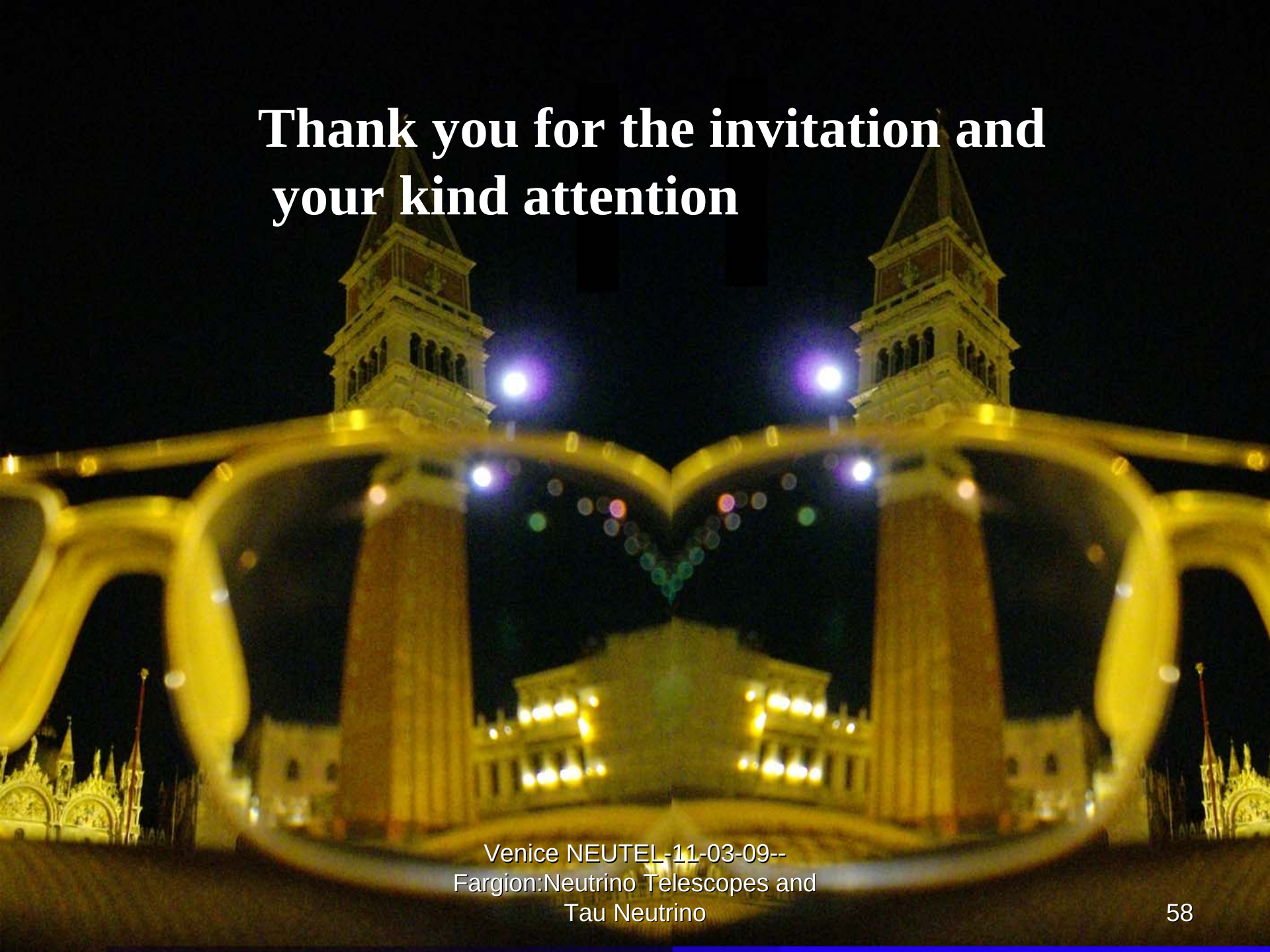


AMIGA: Auger Muons and Infill for the Ground Array



In Conclusion, while Nuclei shine up Horizontally,
up-ward Tau air-Shower rise by a Neutrino Sky under our own Sky : the Earth ....Within a few 2-3 years in AUGER-AMIGA-HEAT

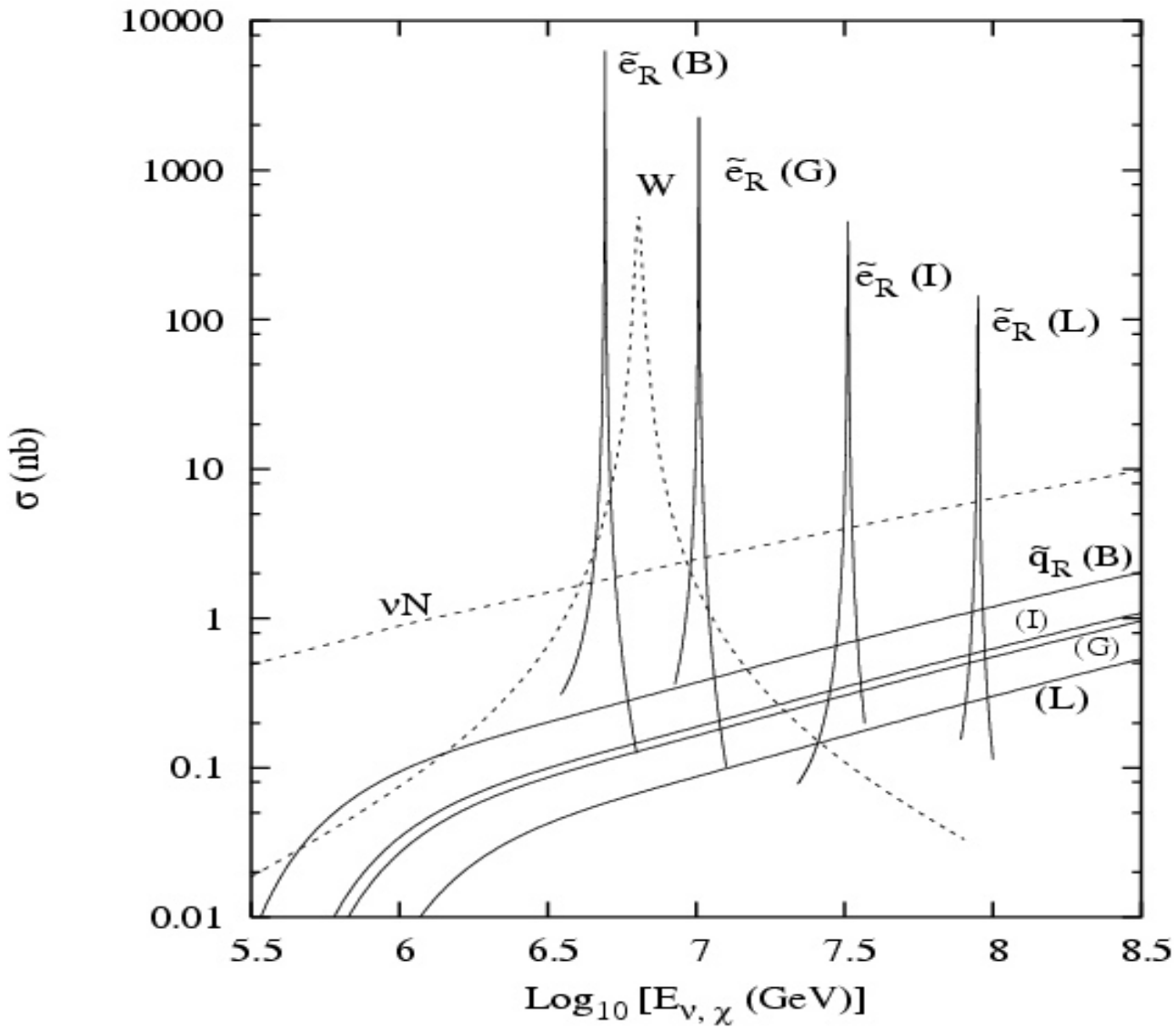




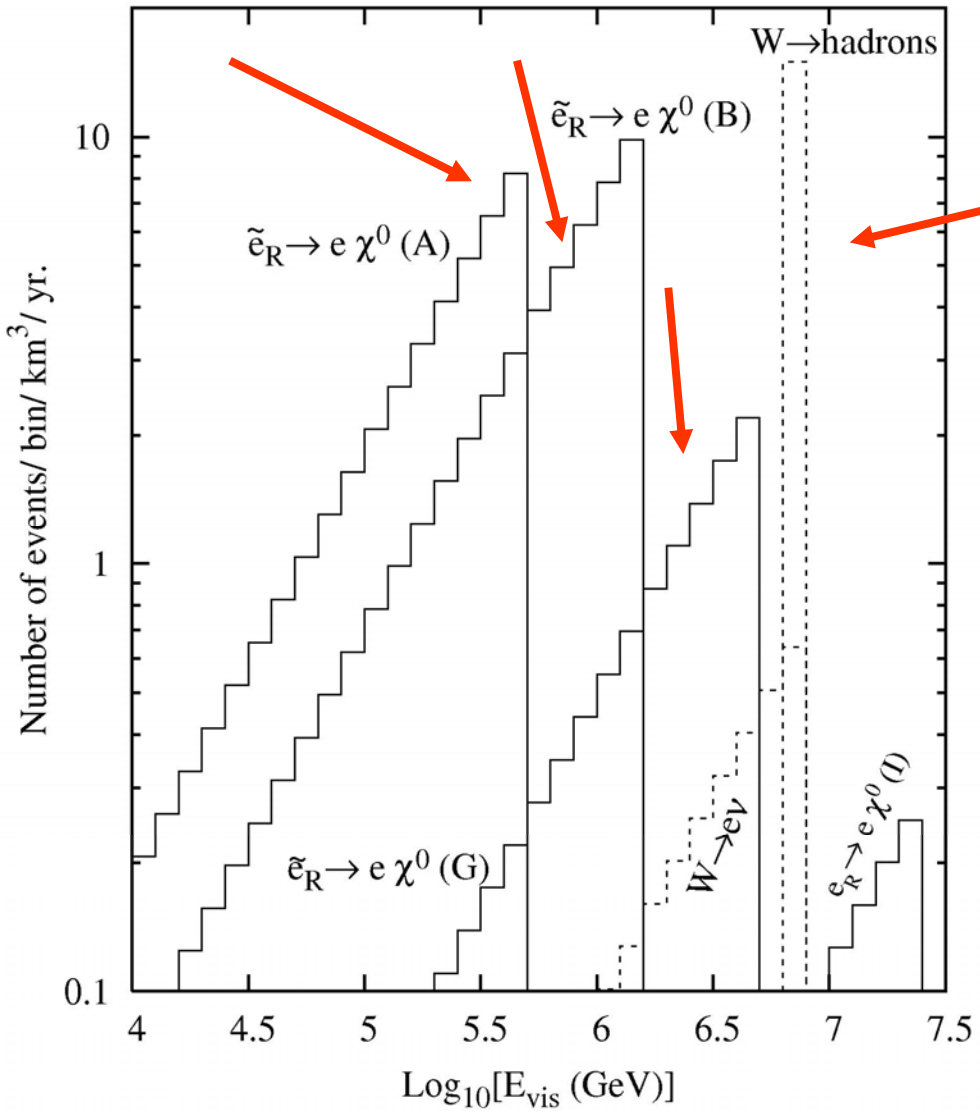
Thank you for the invitation and your kind attention

SUSY Underground with showers

- by
- ion)
- ^3

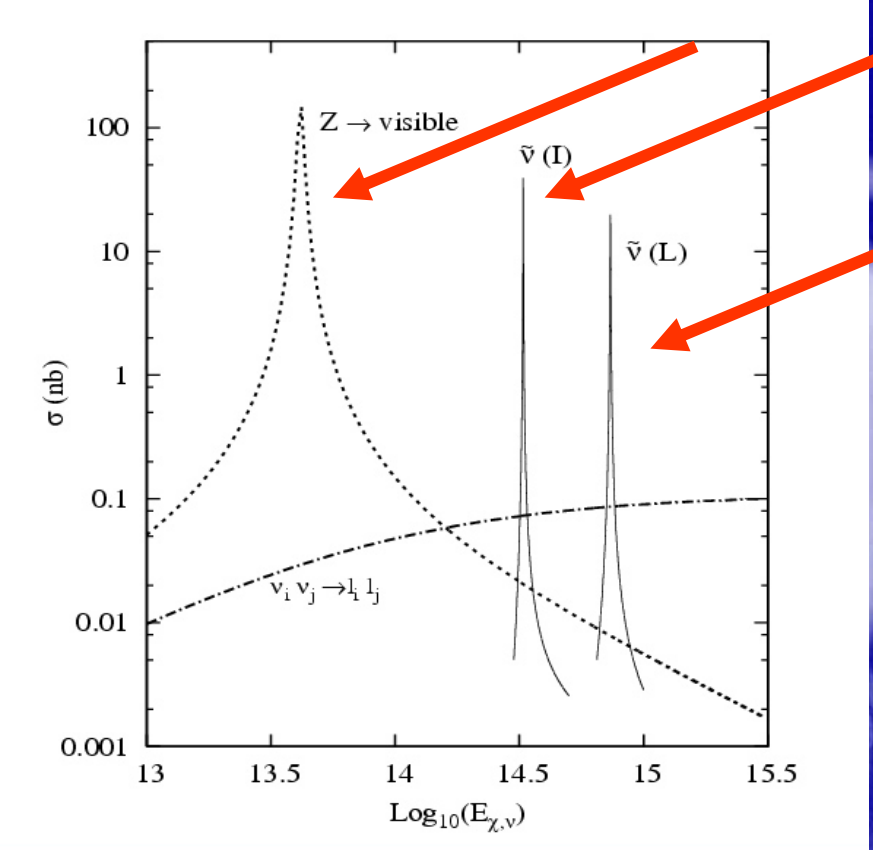


Real Energy released per SUSY Showers: Imprint of Selectrons (and Squark) mass



UHE neutralino scattering onto relic light neutrino leading to Sneutrino - Burst

The UHE Neutralino-neutrino Showers
In a Sneutrino-Burst as neutrino-anti-neutrino
In Z-Burst model.
A remind for Z
Burst model, able
To solve UHECR
Puzzle by light relic
0.4-0.1 eV
neutrino
Mass.



Venice N
Fargion:Ne

D. Fargion, B. Mele and A. Salis, Astrophys. J. **517** 725 (1999)

25 APRIL 2008 : a huge Flare

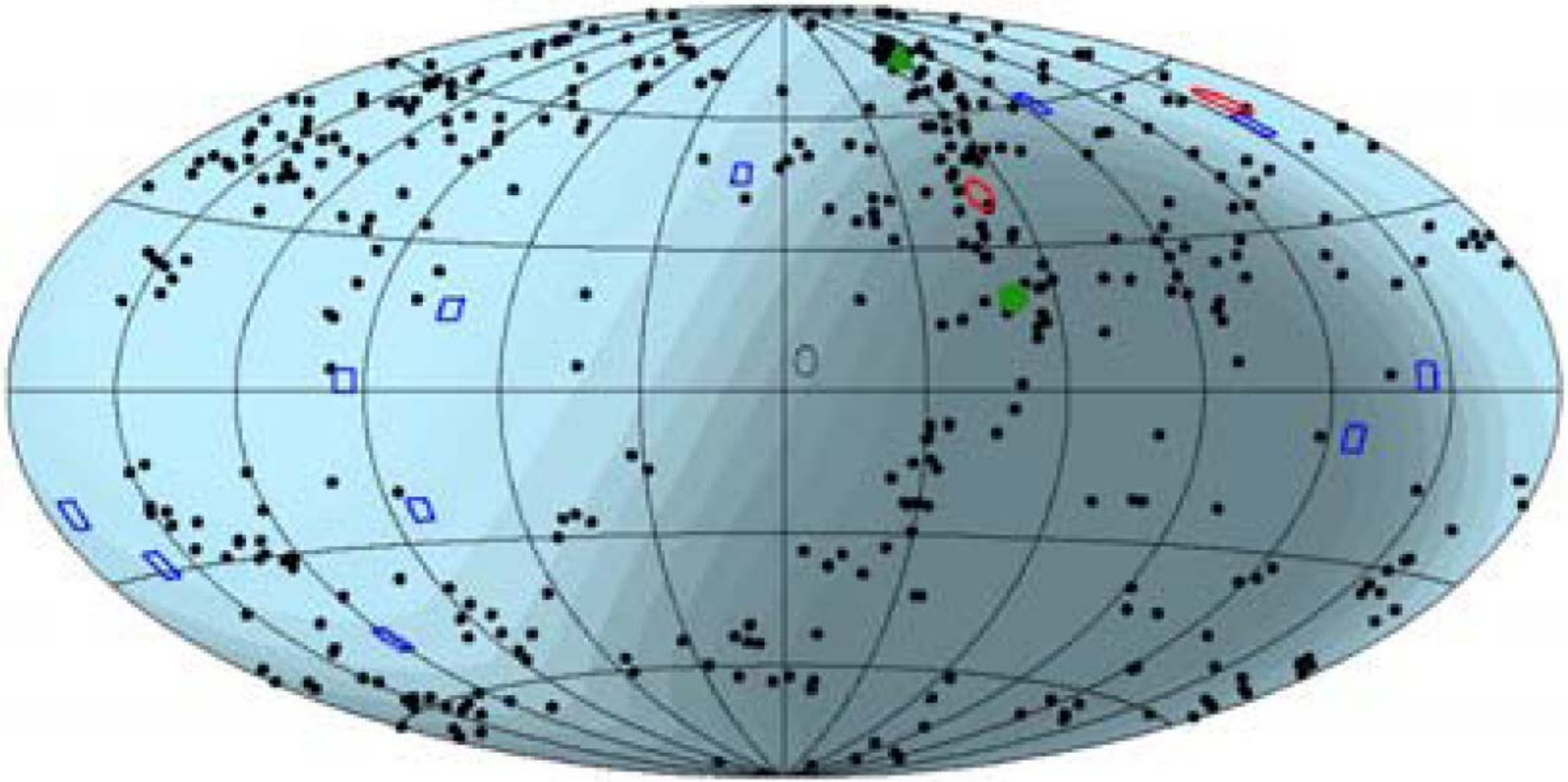
- Wow! Satellite Catches Bright Solar Flare From a Another Star
- Satellite Catches Bright Solar Flare From a Another Star

- NASA's Swift satellite picked up one of the brightest solar flares ever seen — not from our own sun,
- but a star 16 light-years away. This flare packed the power of thousands of solar flares combined,
- and a flare of this magnitude from our own sun would have stripped Earth's atmosphere and sterilized
- the planet. Astronomers say the flare would have been visible to the naked eye on April 25, 2008
- if the star had been easily observable in the night sky at the time. As it was, the flare's brightness
- caused Swifts' Ultraviolet/Optical Telescope to shut down for safety reasons.
- But Swift was able to study the flare for over 8 hours with its X-ray capabilities.

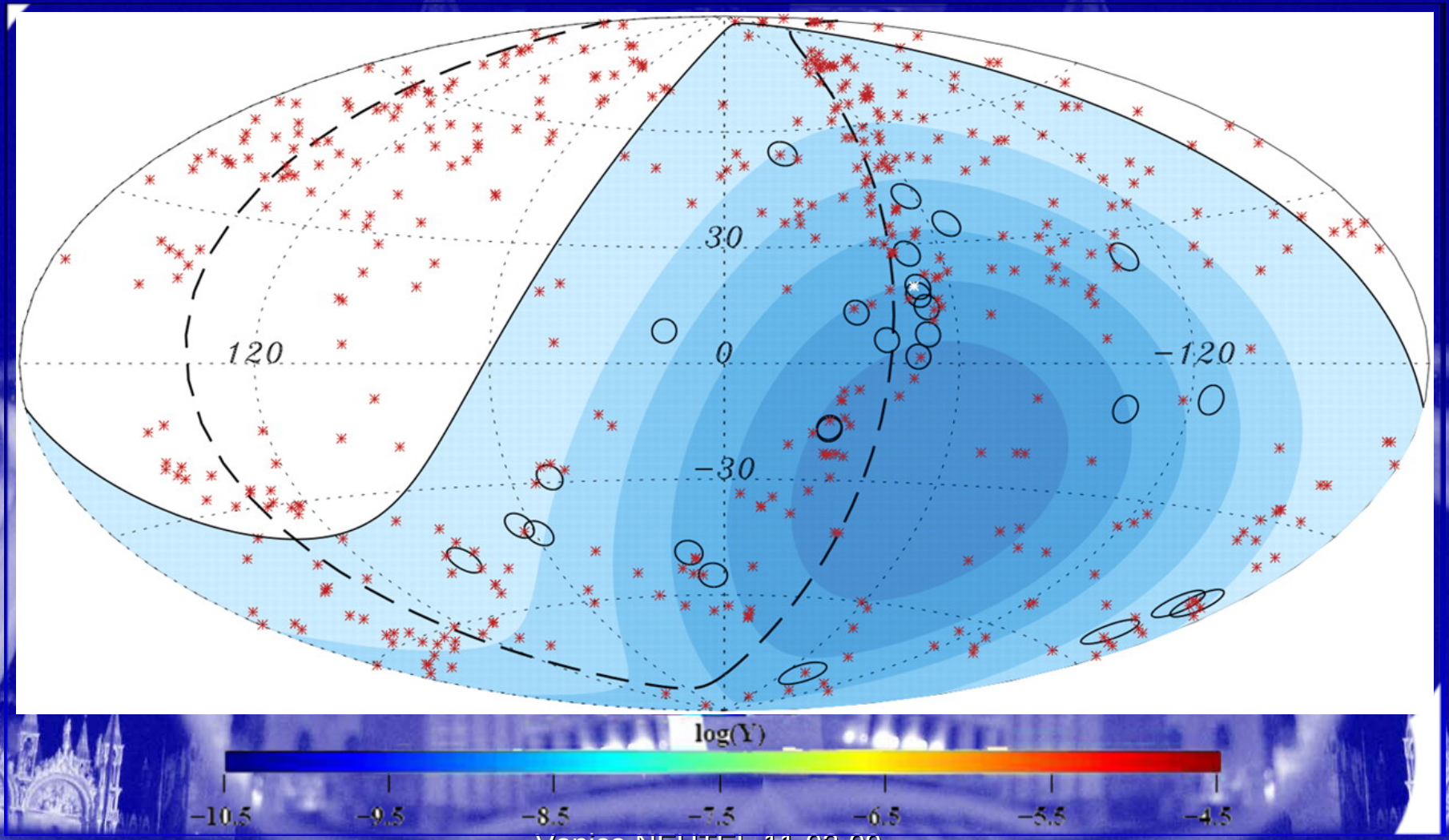
- The Swift satellite normally searches for gamma ray bursts,
- and is surrounded with detectors that look for bursts of light.
- The spacecraft then "swiftly" and autonomously re-points itself to the location of the burst.
- However, this was no gamma ray burst, just a solar flare. But what a solar flare!

- The star, EV Lacertae, is a basic red dwarf, the most common type of star in the universe.
- It shines with only one percent of the Sun's light, and contains only a third of the Sun's mass.
- It's one of our closest stellar neighbors, but normally is not visible with the naked eye,
- as it holds a magnitude of -10.

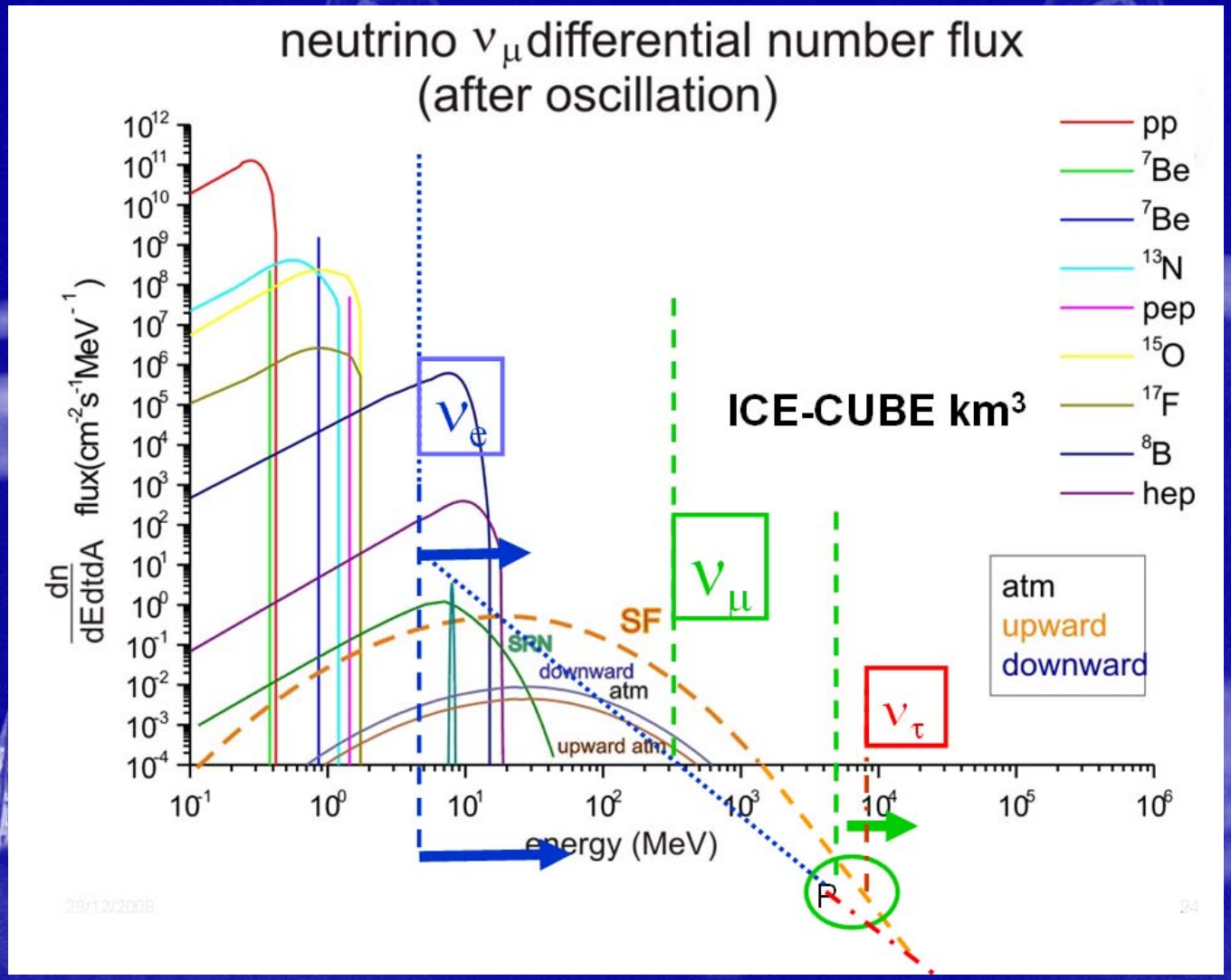
Radio versus UHECR



UHECR versus IR: A clear Nearby Universe Signal?

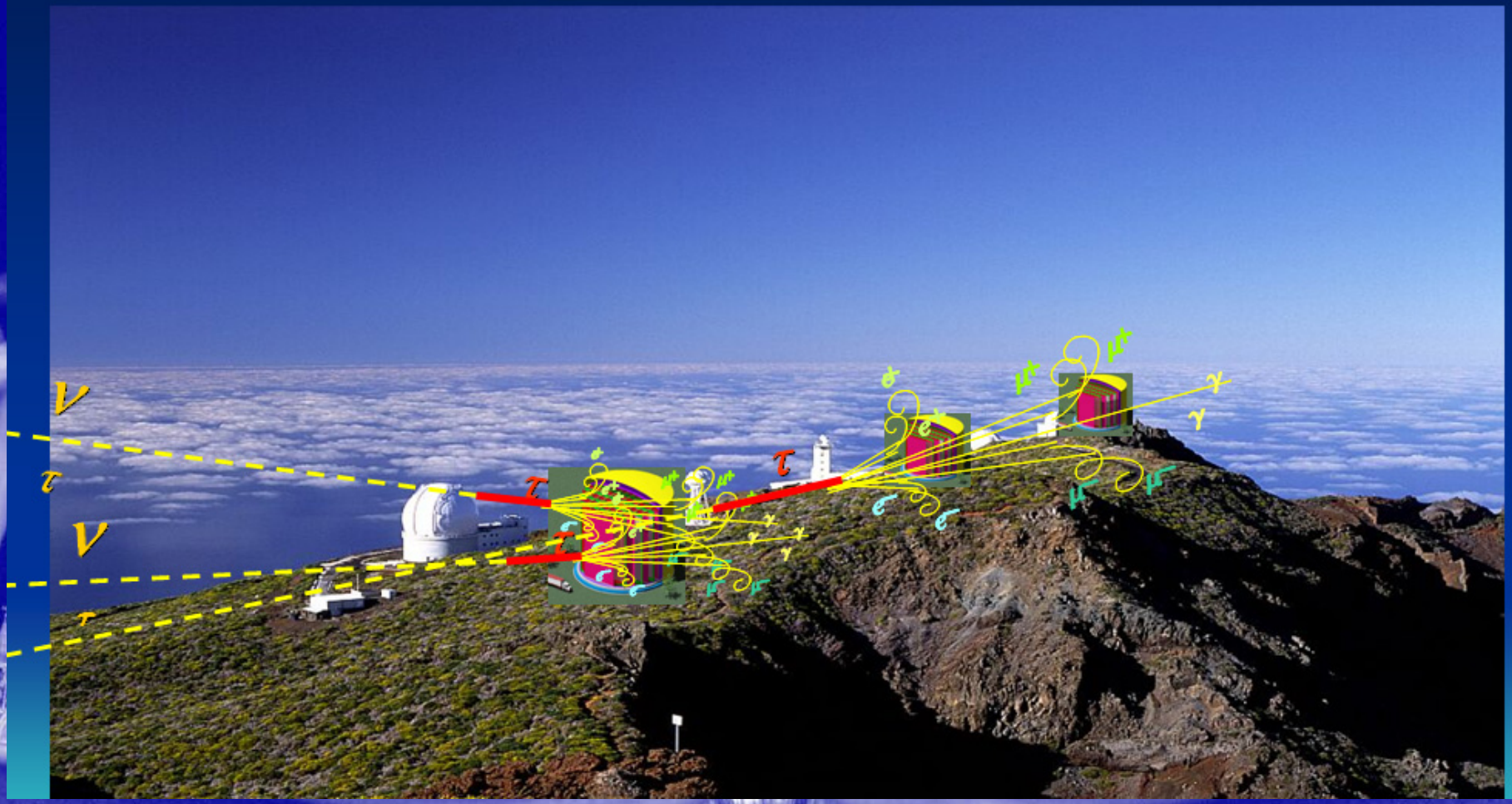


Icecube might but marginally

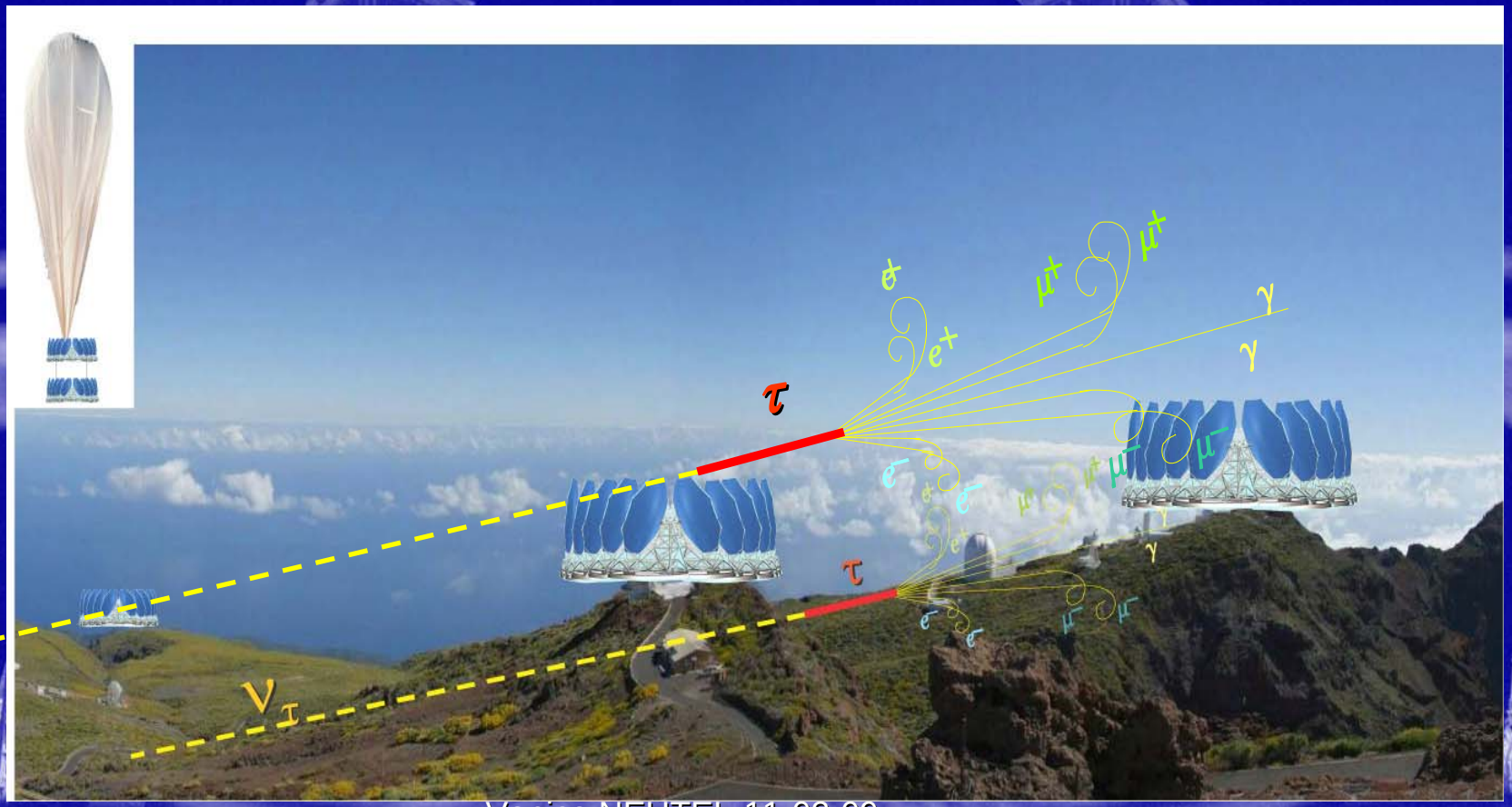


Skimming meteorites and asteroids

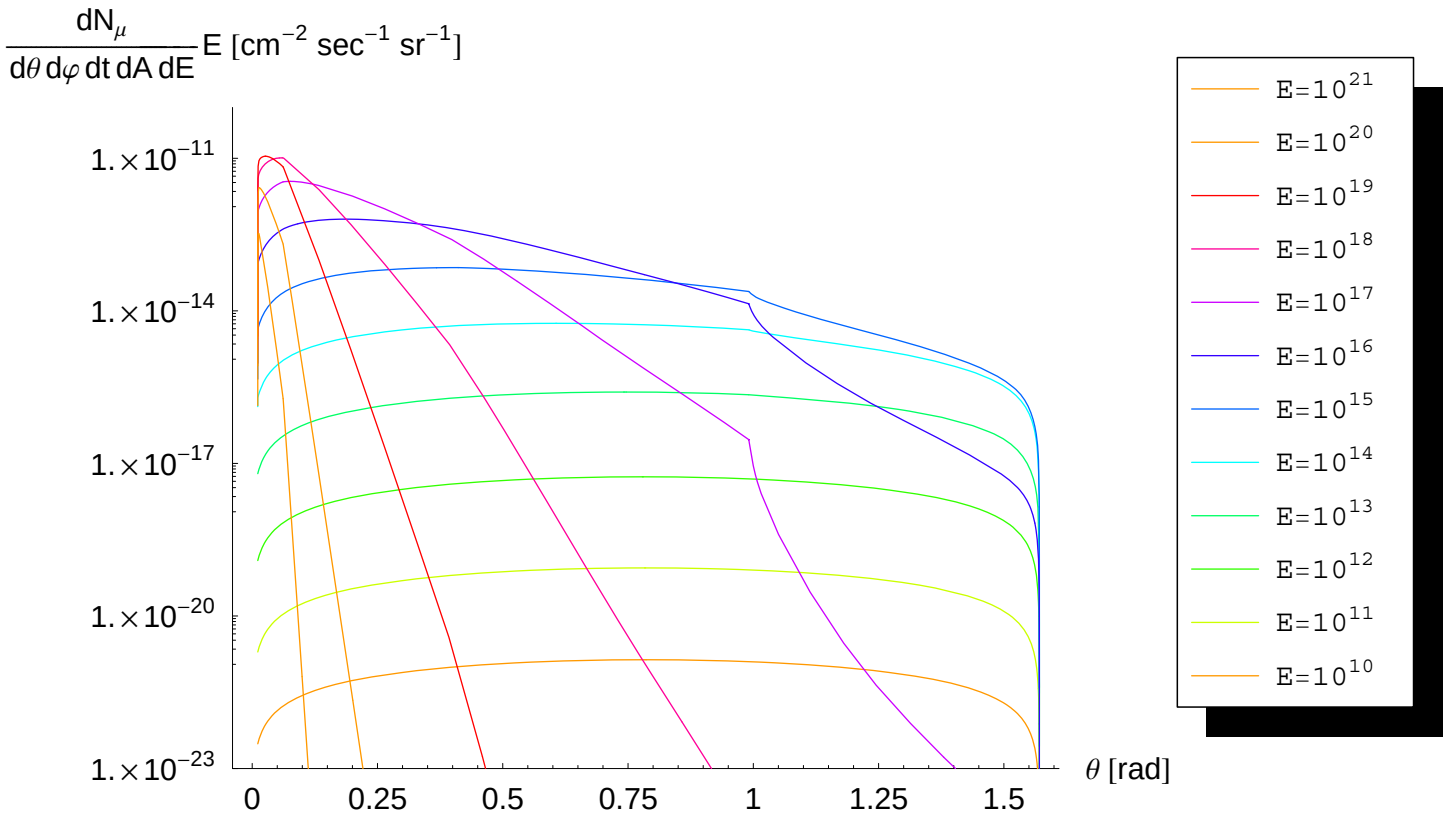
*We also propose today: NEVOD,ICARUS,**FLARE** or UNO in crown arrays on peak mountains tracing Upward Horizontal AirShowers*



Air Showers on the Crown array telescope



Muon Bundles by GZK ad Tau airShowers: more than atmospheric ones



Gamma from GZK neutrino and Tau