Ultra-high energy neutrinos at the Pierre Auger Observatory

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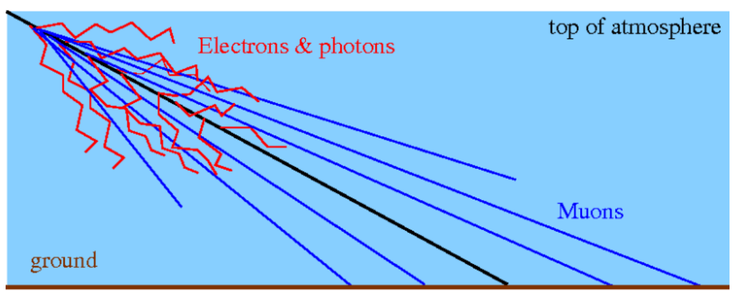
- Neutrinos with energies above 100 PeV are detectable with the Surface Detector array (SD) of the Pierre Auger Observatory.
- Neutrino identification is efficient for neutrinos of all flavors at large zenith angles, as well as for Earth-skimming tau neutrinos.
- No neutrino candidates were found up to 31 March 2017.

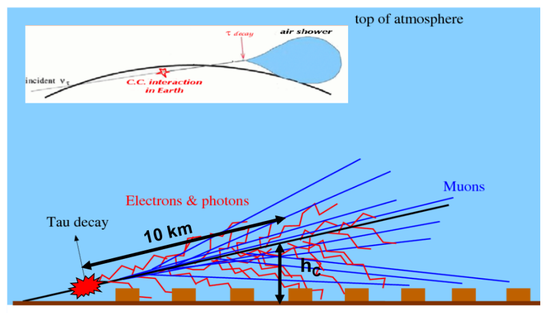
- Upper limits to:
  - Diffuse flux of UHE neutrinos
  - Flux from point-like steady sources.
  - Energy in EeV neutrinos by BH-BH and NS-NS mergers.

CONCEPT FOR ν IDENTIFICATION: νs can penetrate large amounts of matter and generate a shower close to the surface detector with a significant electromagnetic component → search for **inclined and young showers**

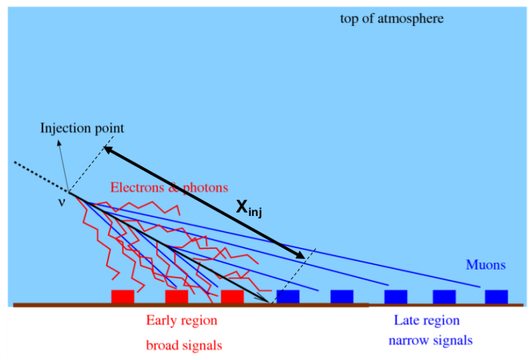
Inclined cosmic ray



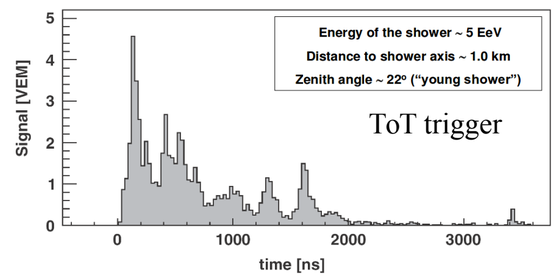
Earth-skimming ν_τ

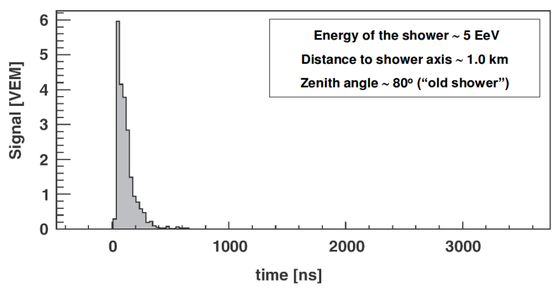


Down-going ν



Signal traces in water cherenkov stations

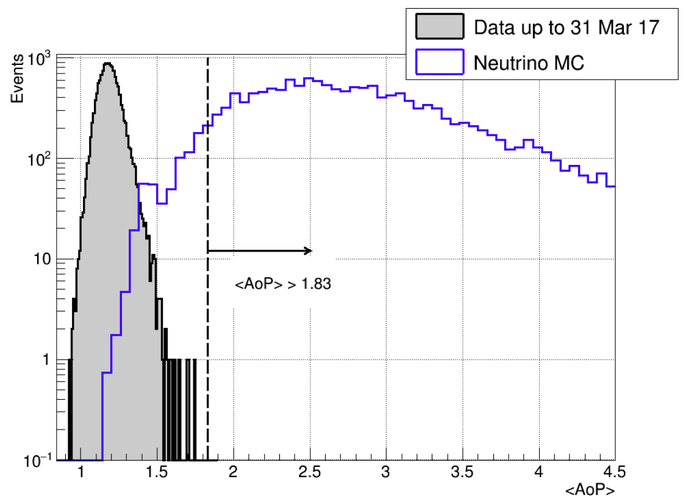




Selection criteria

Selection	Earth-skimming (ES)	Down-going high (DGH)	Down-going low (DGL)
Flavours & interactions	ν_τ CC	ν_e, ν_μ, ν_τ CC&NC	ν_e, ν_μ, ν_τ CC&NC
Angular range	θ >90º	θ∈(75º,90º)	θ ∈(60º,75º)
Inclined showers	L/W > 5	θ_{rec} > 75º L/W > 3	θ_{rec} ∈(58.5º, 76.5º)
	‹V›∈(0.29, 0.31) m ns^{-1}	‹V›< 0.313 m ns^{-1}	
	rms(V) < 0.08 m ns^{-1}	rms(V)/‹V›< 0.08	
Young showers	‹AoP› > 1.83	Fisher discriminant based on AoP of early stations	≥ 75% of stations close to shower core with ToT triggers
	AoP_{min} > 1.4 if N_{st} = 3		Fisher discriminant based on AoP of early stations close to shower core

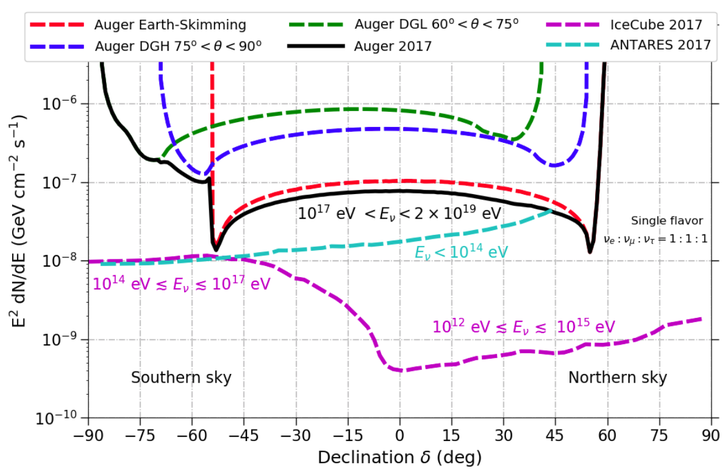
Data unblinding



Unblinding for Earth-skimming channel.

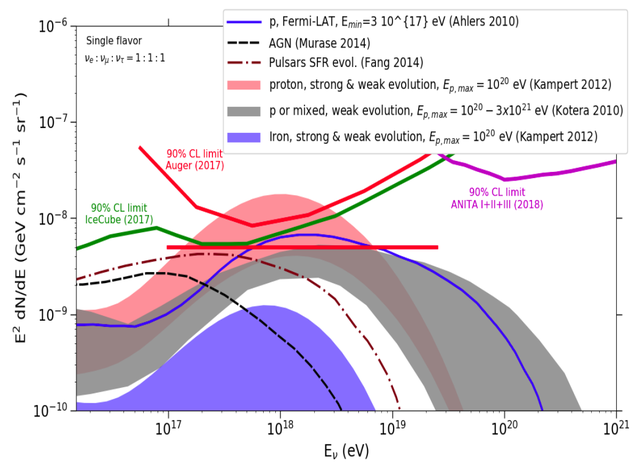
No candidates found in any channel (Earth-skimming & Downward-going) up to 31 March 2017.

Limit to point-like sorces of UHE ν



Upper limits at 90% CL for $k^{PS}\,E^{-2}$ as a function of source declination.

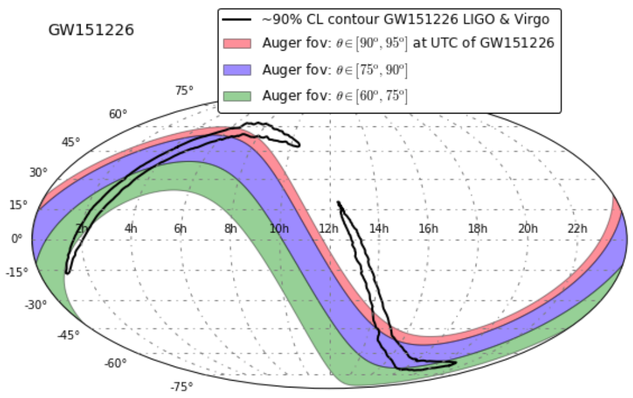
Limit to diffuse flux of UHE ν



Integral bound for a kE^{-2} neutrino spectrum:

$k < 5\ 10^{-9}$ GeV cm^{-2} s^{-1}

Strong constraints on cosmogenic ν models assuming pure protons at the sources.



Gravitational wave 151226

Instantaneous field of view (colour bands) at the moment of coalescence of GW151226 and 90% CL contour of the GW (black line).

No ν candidates found in ±500s around time of GW or 1 day after GW.

The most restrictive upper limit on the total energy emitted per flavor in UHE ν achieved at declination δ~ 55º ($E_{\nu,tot} < 0.44\ M_\odot\ c^2$).