A tau scenario application to a search for upward-going showers with the Fluorescence Detector of the Pierre Auger Observatory

BERGISCHE
UNIVERSITÄT
WUPPERTAL

Ioana Alexandra Caracas[a] on behalf of the Pierre Auger Collaboration[b]

[a] *University of Wuppertal, Department of Physics, Gaußstraße 20, Wuppertal, Germany*
[b] *Observatorio Pierre Auger, Av. San Martín Norte 304, 5613 Malargüe, Argentina*
Full author list: http://www.auger.org/archive/authors_icrc_2021.html
E-mail: spokespersons@auger.org

GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

37th *International Cosmic Ray Conference (ICRC 2021)*
July 12th – 23rd, 2021
Online – Berlin, Germany

ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany
37th International
Cosmic Ray Conference
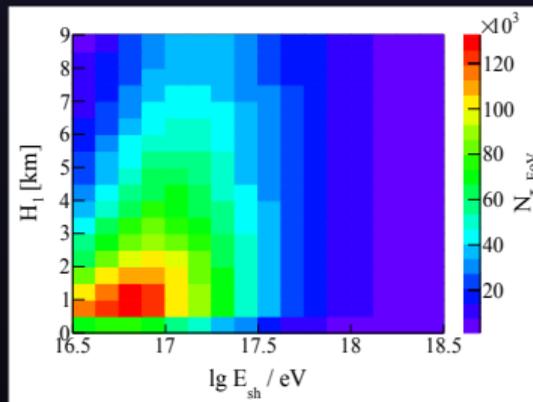12–23 July 2021

- ANITA: observation of two coherent radio pulses → can be interpreted as steeply up-going cosmic ray showers
  - shower energies ≈ few tenths of an EeV
  - zenith angles: $\theta \approx 117°$ resp. $\theta \approx 125°$
- Pierre Auger Observatory: generic search of such events in terms of up-going cosmic ray air showers using the Fluorescence Detector (FD) - presented in
  827. Search for upward-going showers with the Fluorescence Detector of the Pierre Auger Observatory - M. Mastrodicasa
- Here: Recast the generic FD search in terms τs inducing up-going air showers

- Simulation code adapted from NuTauSim
- Tau leptons ignoring the production mechanism
  - injected both below and above Earth proportional to the media density
  - energy losses inside Earth accounted for
  - primary energies: $\lg E_0 \,/\, \mathrm{eV} \in [16.5, 20]$
  - zenith angles: $\theta \in [110°, 180°]$ (match the general search)
- Tau candidates: taus decaying in the FD-FoV (cases 3 and 5)
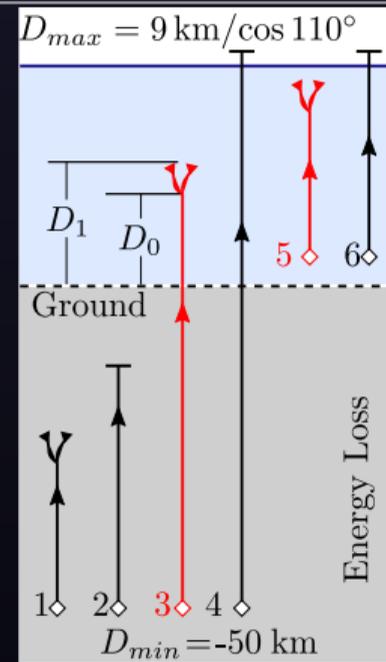
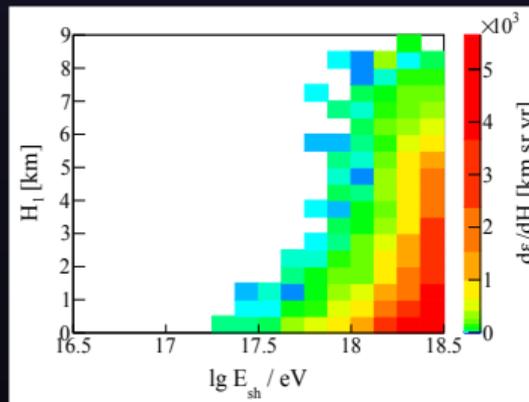- Tau decay particles used to get height of first interaction and calorimetric energy of the shower
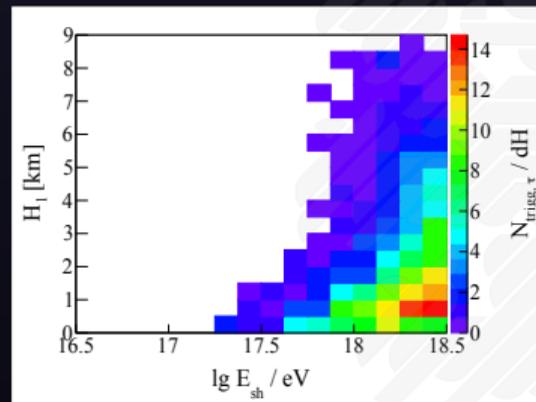
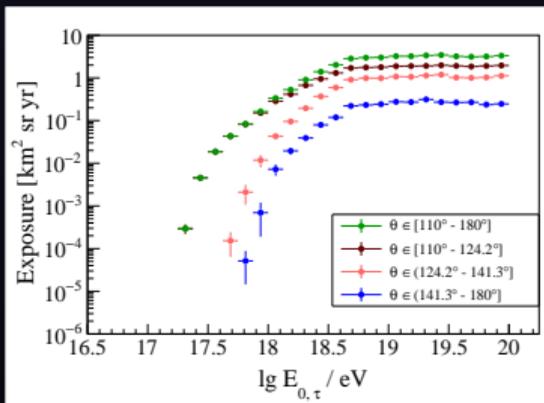**τ- decay induced showers in the FD-Fov** × **Exposure of the FD to upgoing showers** = **τ - decays registered by the FD**

$$N_{\mathrm{fov}}(E_{\mathrm{sh}}, H_1) \times \frac{\mathcal{E}(E_{\mathrm{sh}}, H_1)}{2\pi S_{gen} \Delta T} = N_{\mathrm{trig}}(E_{sh}, H_1) \rightarrow \begin{array}{c} \text{back-tracked to} \\ \text{primary energy} \end{array} \rightarrow N_{\mathrm{trig}}(E_0 | E_{sh}, H_1)$$

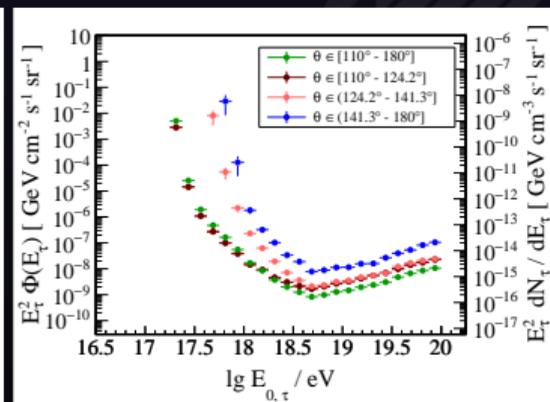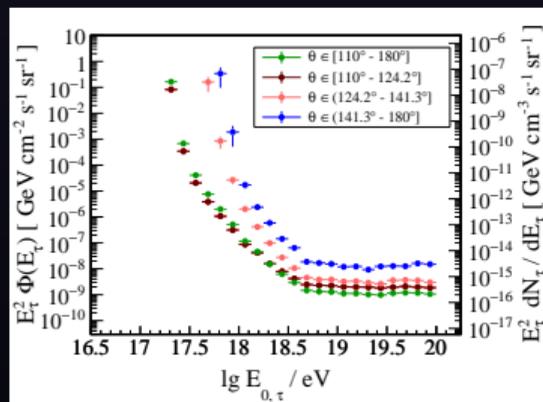**Exposure to τ-induced showers vs. τ primary energy**

- 14 years of FD data

Upper Flux Limits (FC, CI = 95%) for τ-induced showers vs. τ primary energy

- 1 event passing the analysis cuts (background consistent)

$$dN/dE_0 \propto E^{-1}$$

$$dN/dE_0 \propto E^{-2}$$

- The response of the FD of the Pierre Auger Observatory has been studied in terms of τ-induced air showers
- Simulations of up-going τ-induced air showers have been performed
  - τ-leptons decaying in the FD-FoV represent the main candidates for the current study
- Exposure and Upper flux limits to up-going tau-induced air showers are presented
  - Serves as an example for adaptation of general study presented in
    827. Search for upward-going showers with the Fluorescence Detector of the Pierre Auger Observatory - M. Mastrodicasa

Contact: spokespersons@auger.org

Poster and Proceedings:
https://indico.desy.de/event/27991/contributions/102156/

Discussion:
https://indico.desy.de/event/27991/sessions/10552/