Primary interaction and composition of UHECR at the Pierre Auger Observatory using distributions of Risetime at 1000 m

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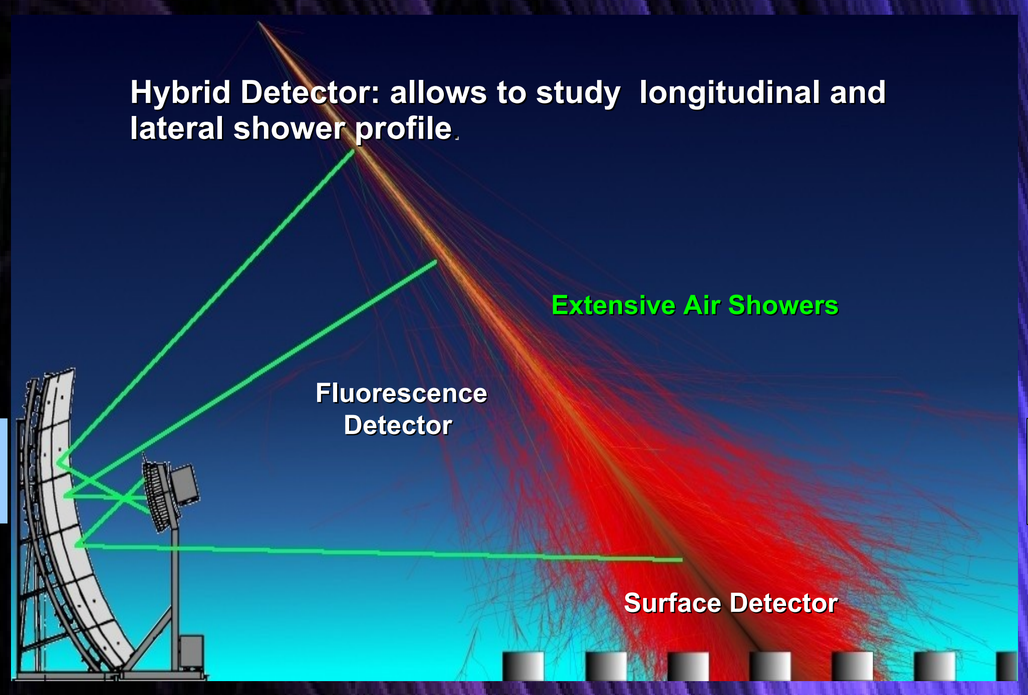
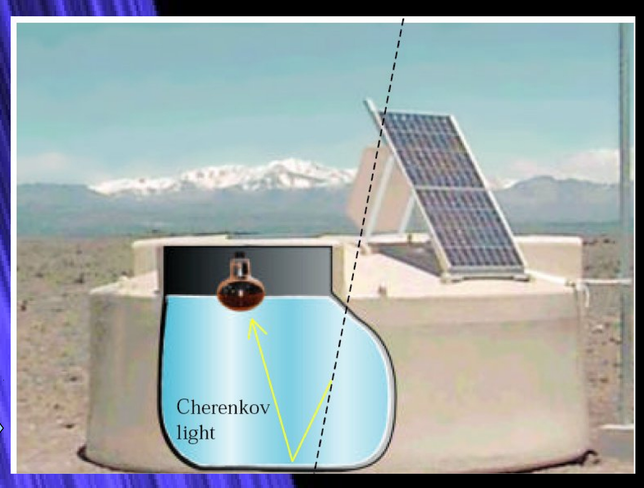
Abstract

Extensive air showers induced by cosmic rays of different species contain different number of electrons and muons at ground. Is is well known that heavy nuclei have larger muon component than lighter nuclei.
The time distribution of the shower front particles reaching the ground detectors is sensitive to the muon to electron ratio and hence to primary composition. Of particular interest is the time in which the signal in the detectors rises to half of the total integrated signal (Risetime). The Risetime at 1000 m from the shower axis, obtained on event by event basis, is a robust variable to build different observables carrying information about mass composition and cross section of the first interaction.

24 fluorescence telescopes placed in 4 buildings surrounding the surface array area.

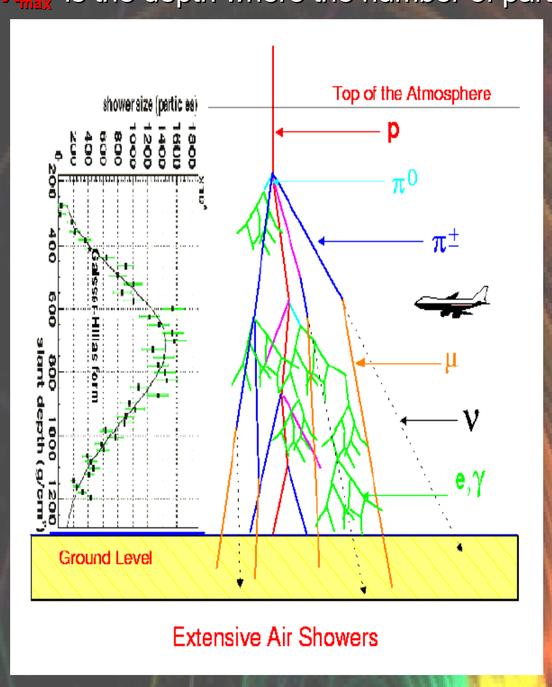


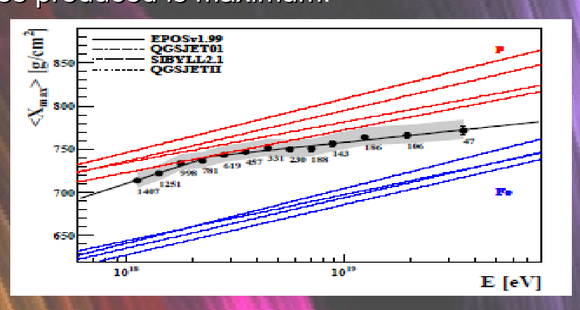


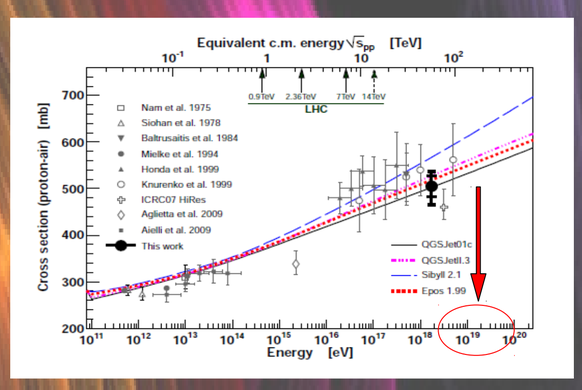
The Cherenkov light produced by the extensive shower particles traversing the detector is viewed by three photomultiplier tubes. There are 1660 stations in a triangle grid covering 3000 km^2.

Xmax: FD observable to infer mass composition and cross section

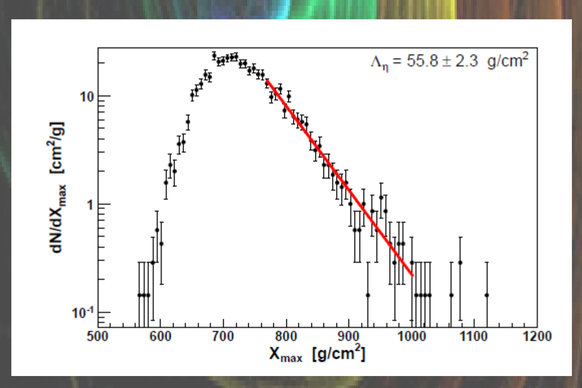
X_1 is the depth of the first interaction point.
X_{max} is the depth where the number of particles produced is maximum.







The Xmax distribution tail is related to the 1° interaction point distribution.



Energy Bin: Log (E/eV) from 18 to 18.5

$$\frac{dp}{dX_1} = \frac{1}{\lambda_{p-air}} e^{-X_1/\lambda_{p-air}}$$

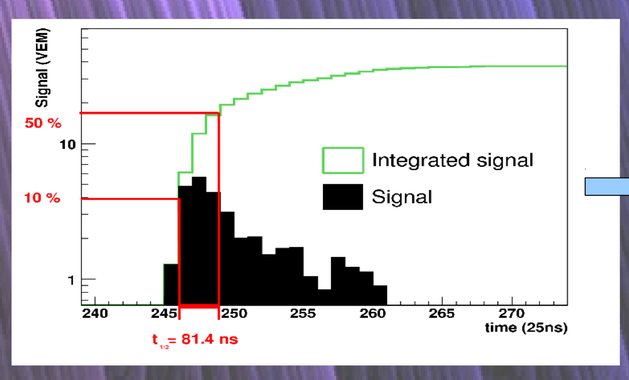
$$\sigma_{p-air} = \frac{\langle m_{air} \rangle}{\lambda_{p-air}}$$

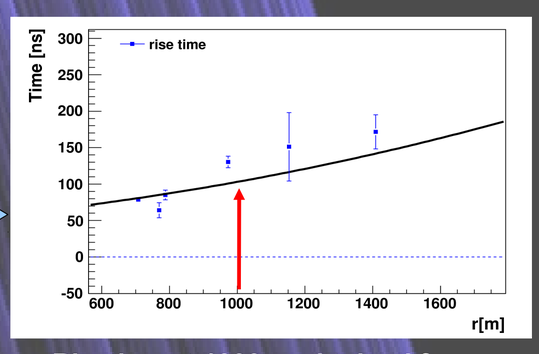
$$dN/dX_{max} \propto \exp(-X_{max}/\Lambda_\eta)$$

Risetime1000 : SD observable to infer mass composition and cross section ?

The Risetime: time for the signal to grow from 10% to 50 % of the total signal.

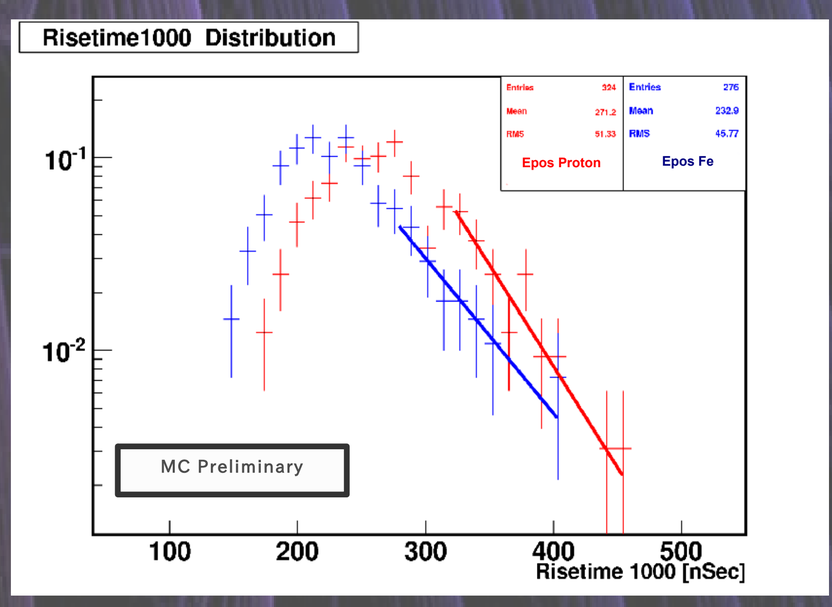
This observable is sensitive to mass composition.



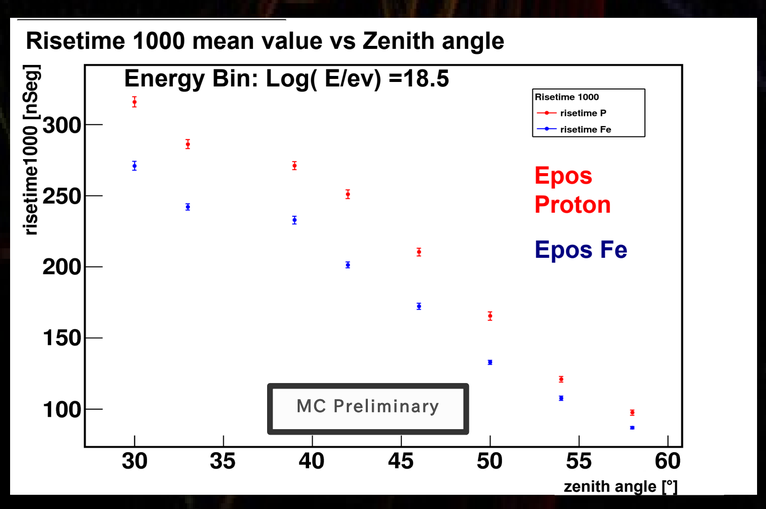


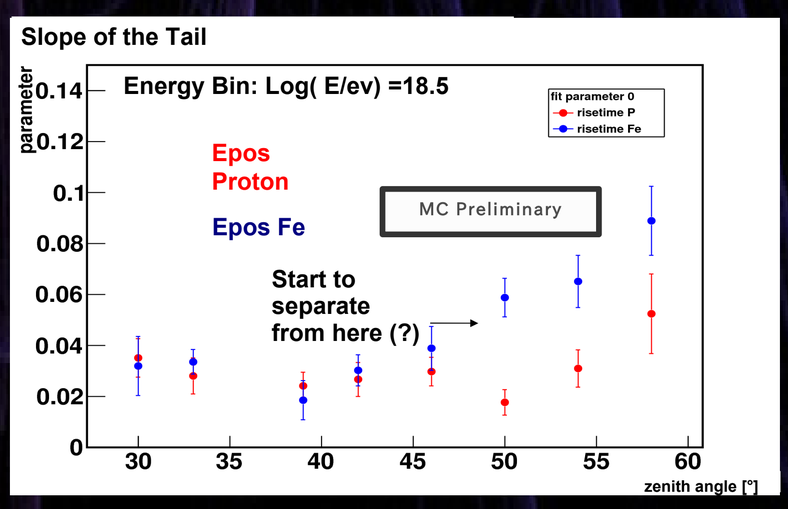
Risetime at 1000 m obtained from a fit event by event.

Idea: Fit the tail from the Risetime(1000) distribution and use this parameter to infer Composition and Cross Section



Risetime at 1000 m for events with energy of Log (E/eV)= 18.5 and Zenith Angle = 45º.





Summary

We study the distributions of Risetime at 1000 m at different energies. Optimization of the data selection for characterizing the tails and improving the quality of the individual Risetime fits are ongoing.

References

[1] Ralf Ulrich, Johannes Blumer, Ralph Engel, Fabian Schussler, Michael Unger. March 2009. New J.Phys.11:065018,2009.
[2] Karen Salomé Caballero Mora , PHD Thesis: Composition Studies of Ultra High Energy Cosmic Rays using Data of the Pierre Auger Observatory.
[3] H. Wahlberg (por la colaboracion Pierre Auger) 31th International Cosmic Ray Conferences (ICRC 2009), July 7-15, 2009, Łódź, Poland.
[4] Studies of Cosmic Ray Composition and Hadronic Interactionmodels. ICRC July 2011. China e-Print: arXiv:1107.4804 [astro-ph.HE]