Studies on mass sensitive parameters and monitoring of the operation of the surface detector with data of the Pierre Auger Observtory

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UNACH

XXXI Reunión Anual de la División de Partículas y Campos de la SMF
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CINVESTAV-ZACATENCO
Mexico City

Outlook

- Mass composition and New Physics
- The Pierre Auger Observatory
  - Mass composition with Risetime $t_{1/2}$
    - A new parameter based on $t_{1/2}$: R_{chis}
    - Status of the study
  - Monitoring SD with direct light on PMTs in time
    - Direct light
    - Characteristic line

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Mass Composition and new Physics

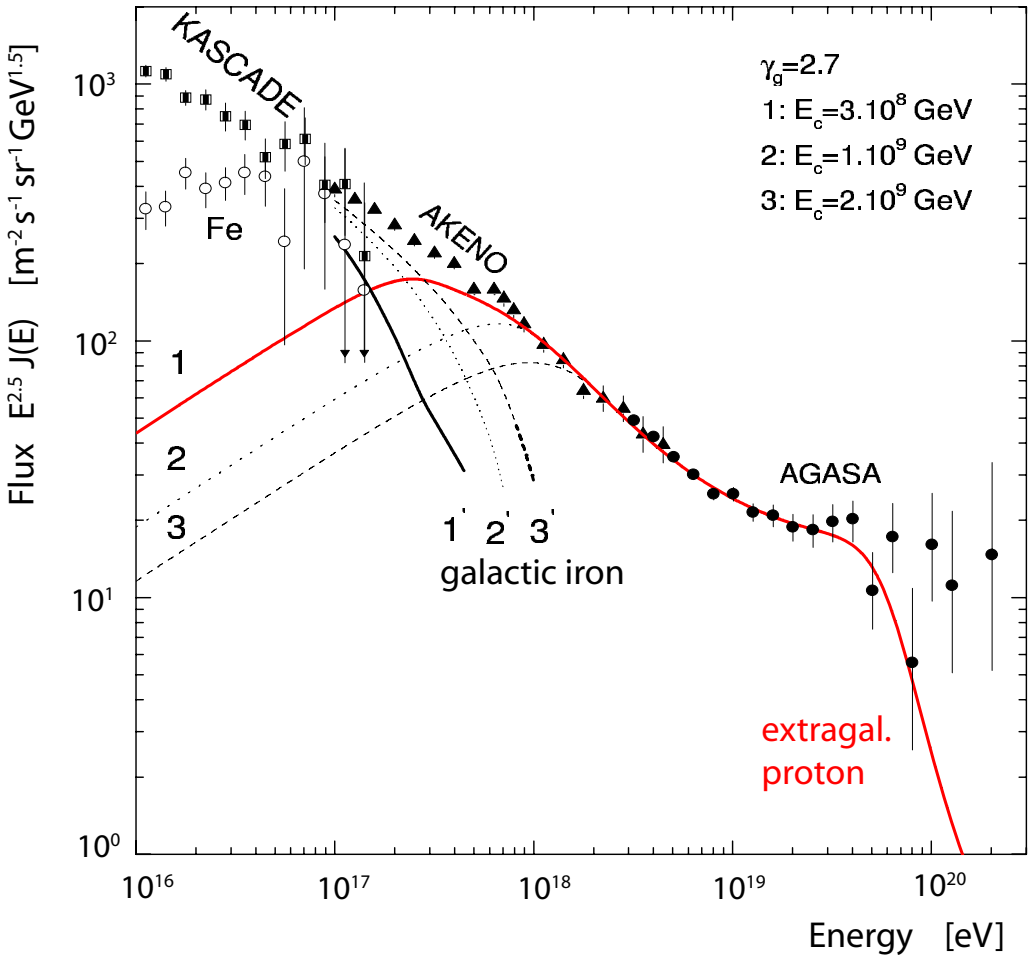
- Needed to understand: CR Origin, acceleration and propagation mechanisms
- Feedback with elementary particles interactions at high energies

- Theory:

  Mixture or light

- Experiment:

  Mixture or heavy



Dip model. V. Berezinsky 30th ICRC (2007), arXiv:0710.2750

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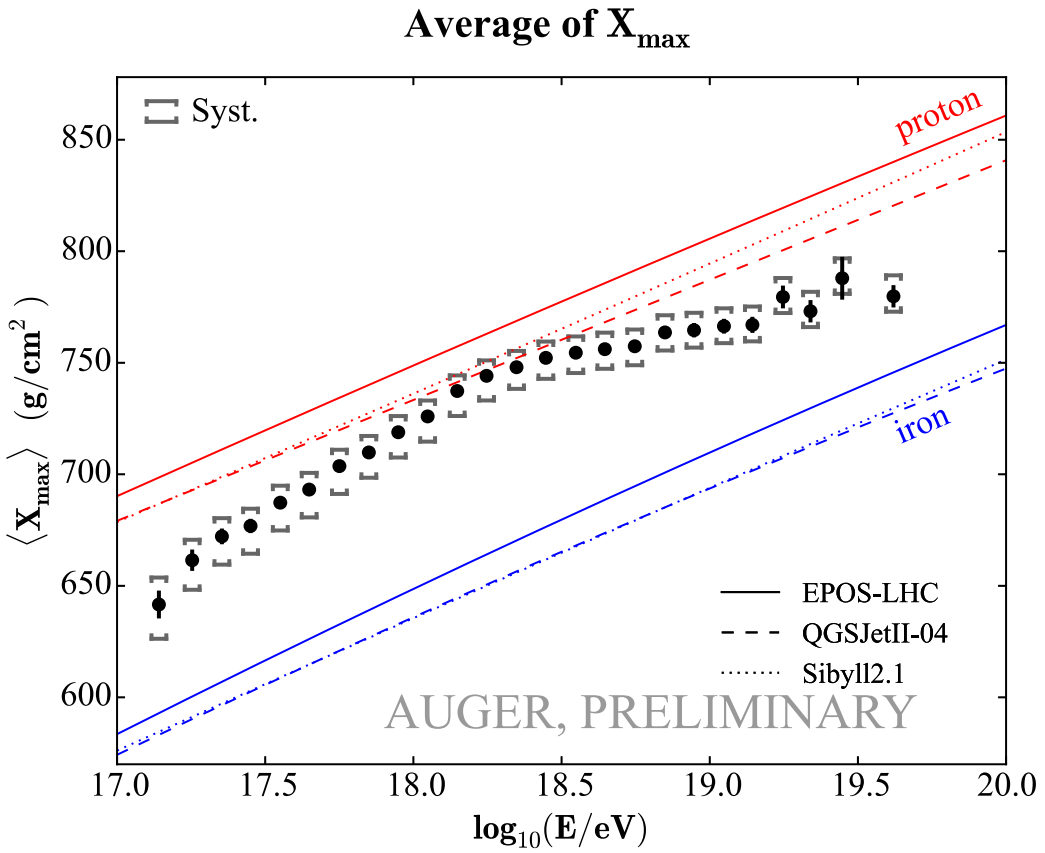

ICRC
The Astroparticle Physics Conference
34th International Cosmic Ray Conference
July 30 - August 6, 2015
The Hague, The Netherlands

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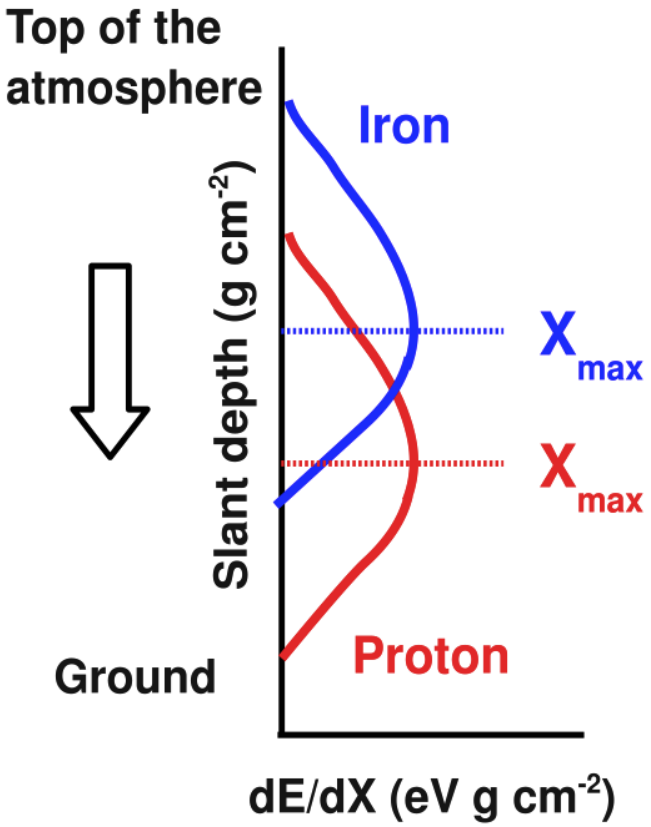
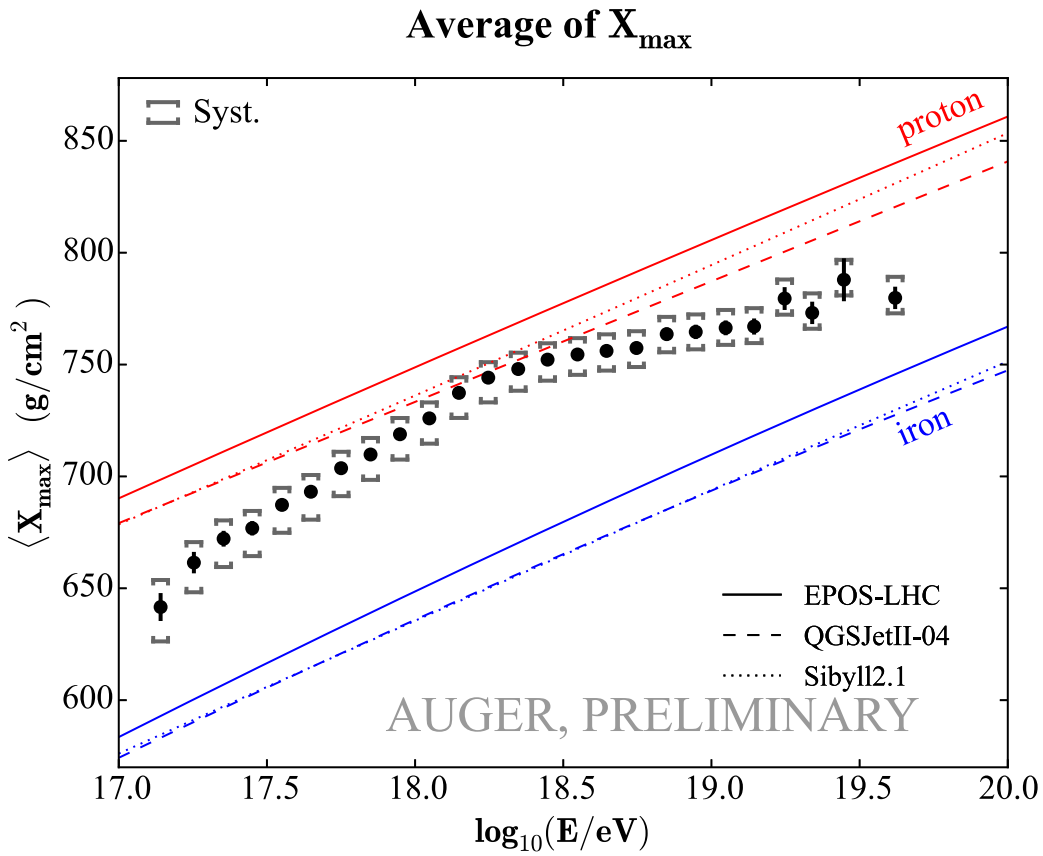
Mass Composition of UHECR





Mixed mass composition
compared with hadronic interaction models

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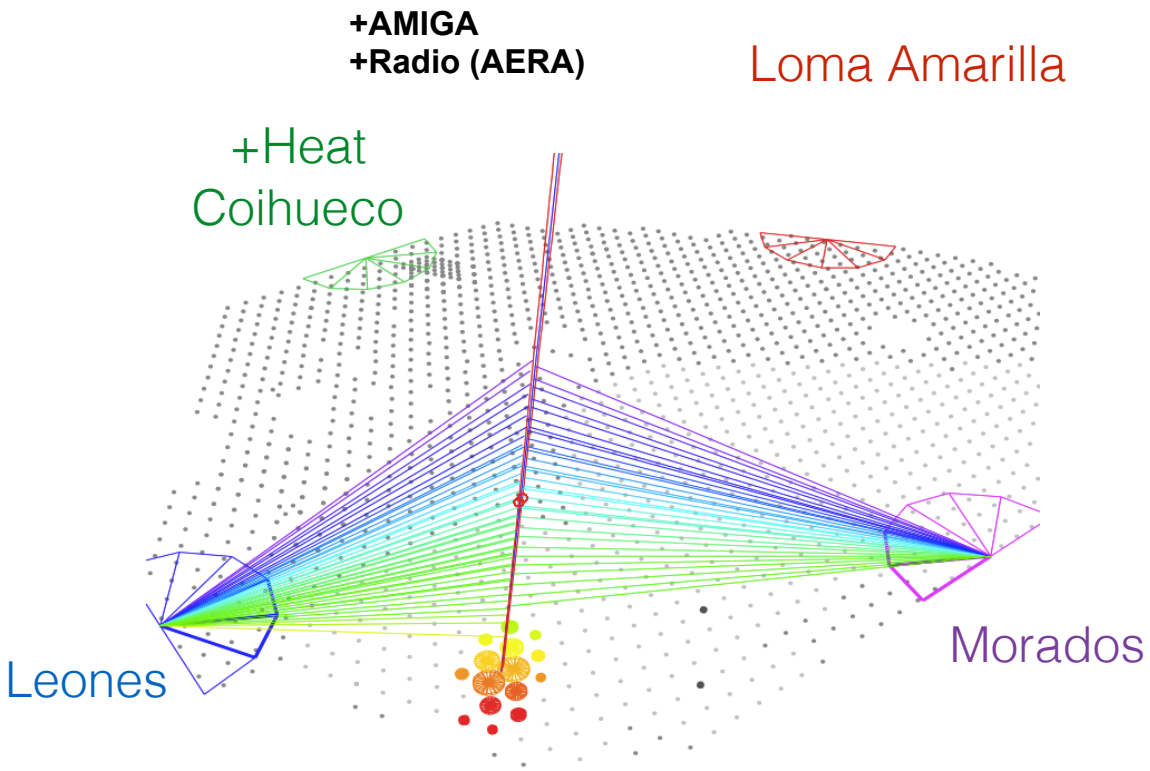
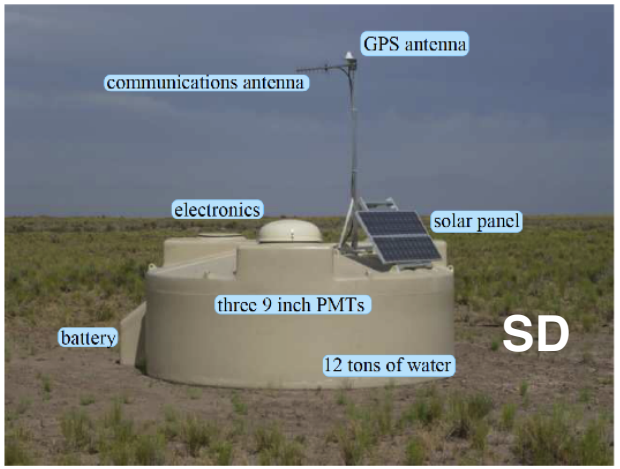
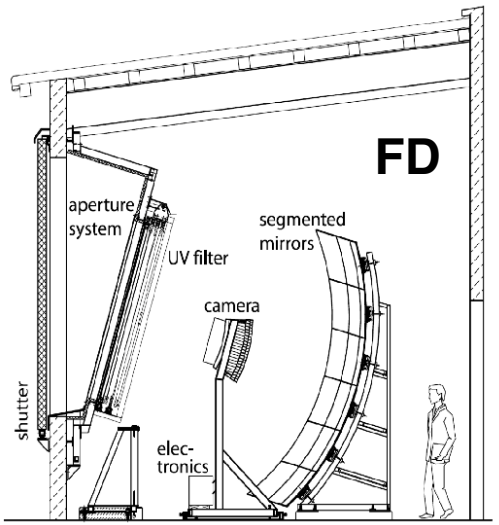
The Pierre Auger Observatory



Area of 3000 km^2





24 fluorescence telescopes in 4 sites (FD)
1660 surface detector (SD) stations

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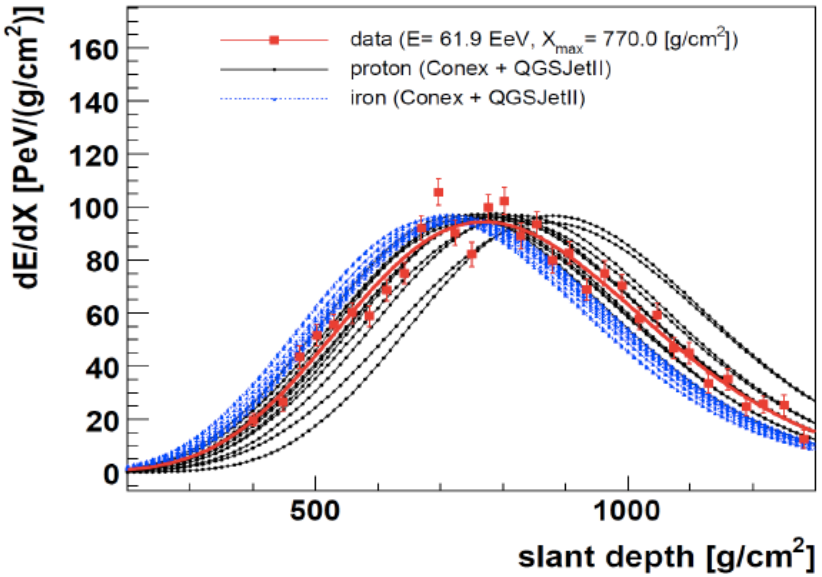
Mass composition sensitive parameters in Auger

- Radius of curvature (Rc)
- Muon fraction (average values based on simulations or event by event)
- Muon/electron ratio
- Muon production depth
- X_{max}
- Risetime, $t_{1/2}$ (Asymmetry parameter, Deltas, fluctuations)
- Multivariable analysis (mean based)



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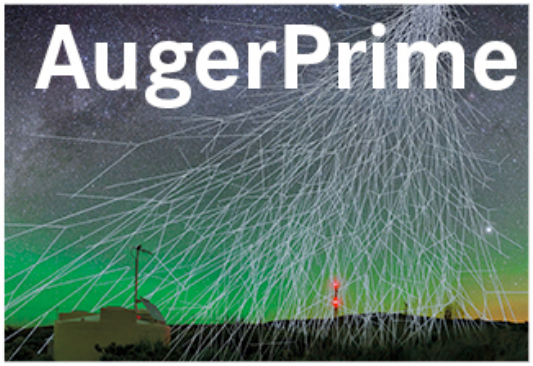
PIERRE AUGER OBSERVATORY



Primary cosmic **R**ay **I**dentification with **M**uons and **E**lectrons

- Goals:
  - Mass Composition
  - Improve sensitivity to proton contribution
  - EAS and hadronic interactions at high energies
- Upgrades:
  - Surface Scintillator Detector (SSD)
  - Substitution of current electronics
  - AMIGA
  - Extension of duty cycle of FD

The SSD can distinguish between
the electromagnetic and muonic component

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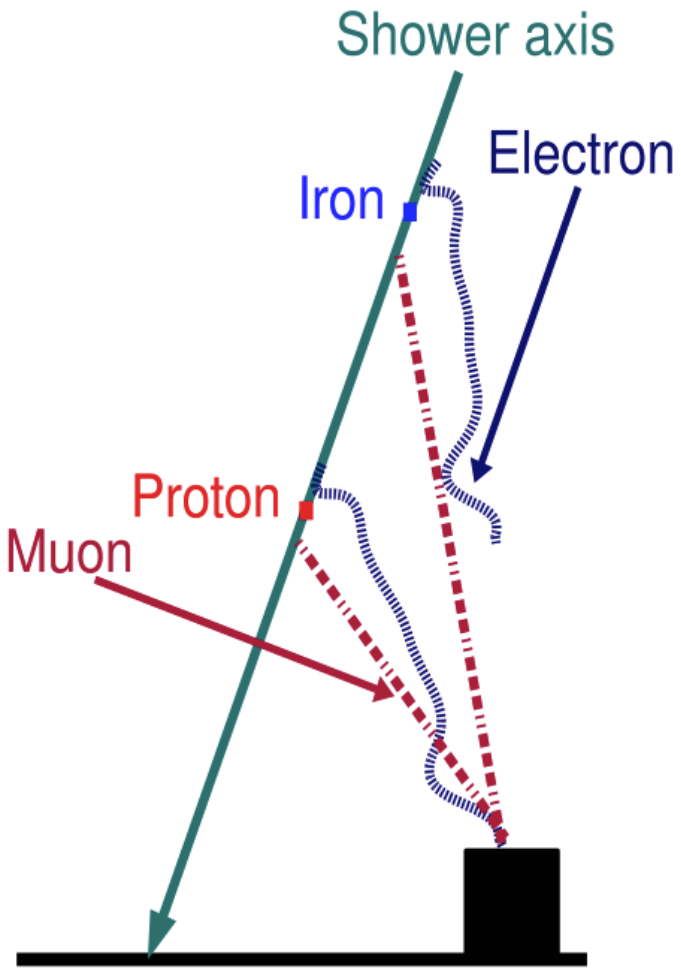
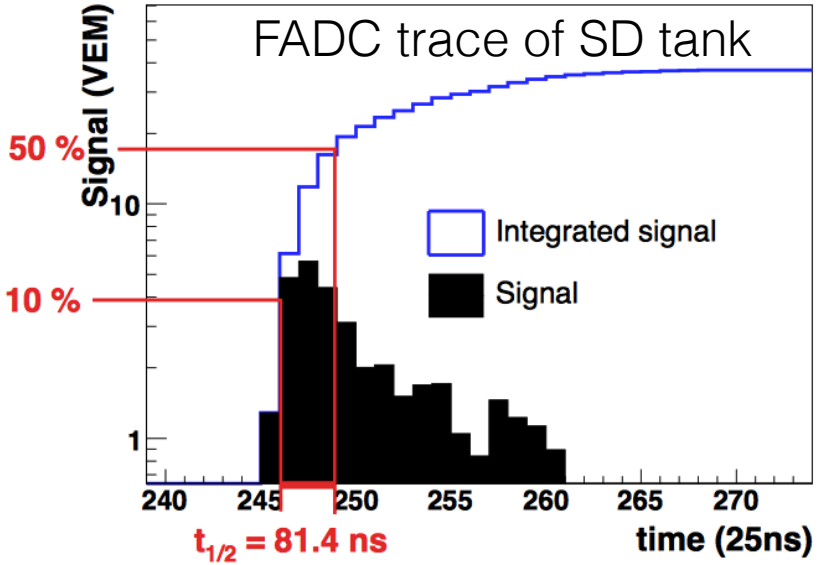
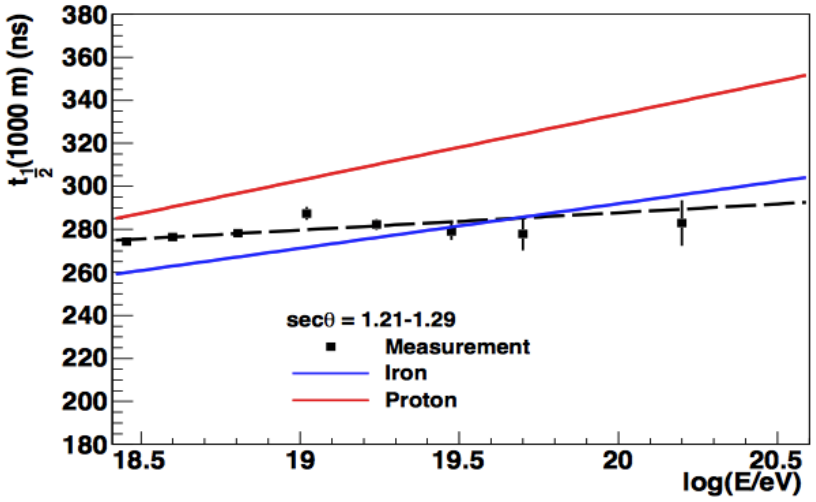
The SD mass composition sensitive parameter $t_{1/2}$



Particles arriving at ground





t1/2 as mass sensitive parameter

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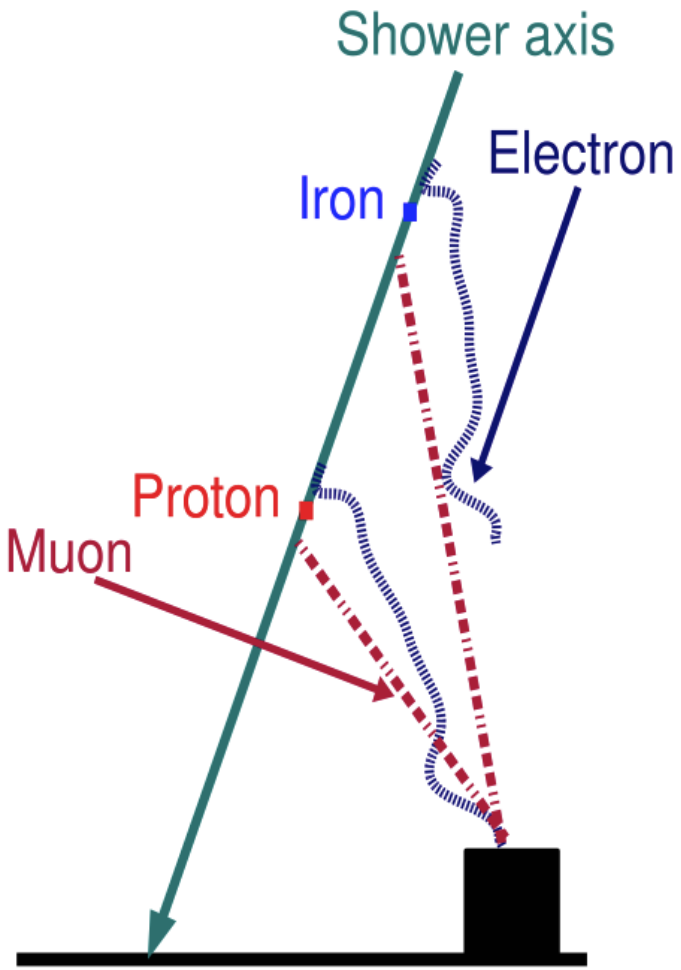
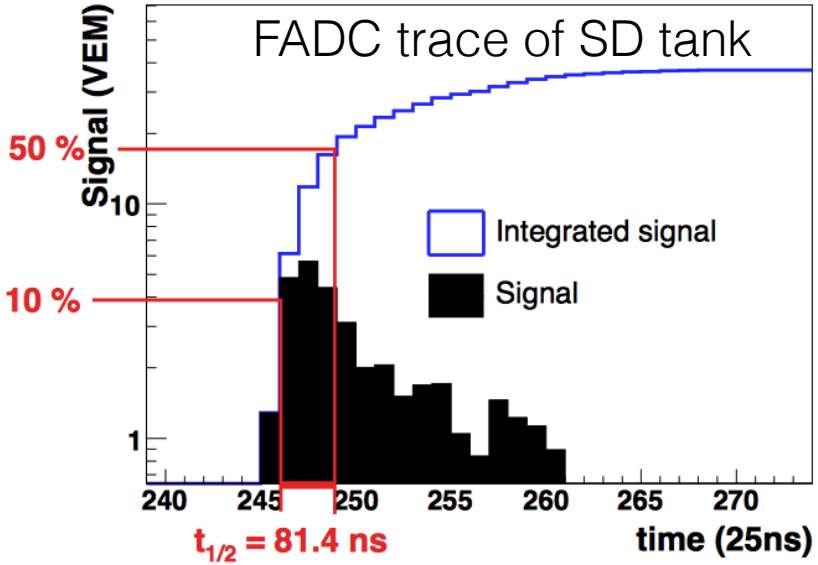
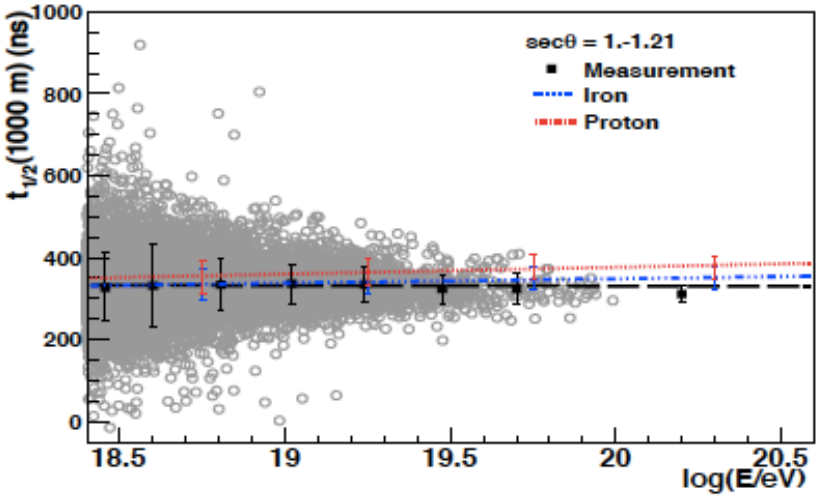
The SD mass composition sensitive parameter $t_{1/2}$



Particles arriving at ground





t1/2 as mass sensitive parameter

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Study of risetime as a function of energy, zenith angle and distance to the shower core

Hernán Castellanos Valdés

Goal:

- To optimize the characteristic distance to the shower core to consider the risetime for each event in order to decrease fluctuations

Future:

- To explore the new risetime as a mass composition sensitive parameter and compare it with results obtained for risetime at 1000 m
- To explore other relations as X_{max} vs $\triangle$Core

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Study of rise time as a function of energy, zenith angle and distance to the shower core

Hernán Castellanos Valdés

Method:

We analyzed events with angles around 30° - 39°, 40° - 49° and 50° - 60°, for a fixed energy. We consider retime as a function of the distance to the shower core. Fits of the following forms are considered:

$$f(x) = 40 + ax + bx^2$$

$$f(x) = 10 + (a^2 + bx^2)^{1/2} - a$$

$$f(x) = 40 + ax$$

The distance where the fits intersect is the characteristic distance of the event to be considered

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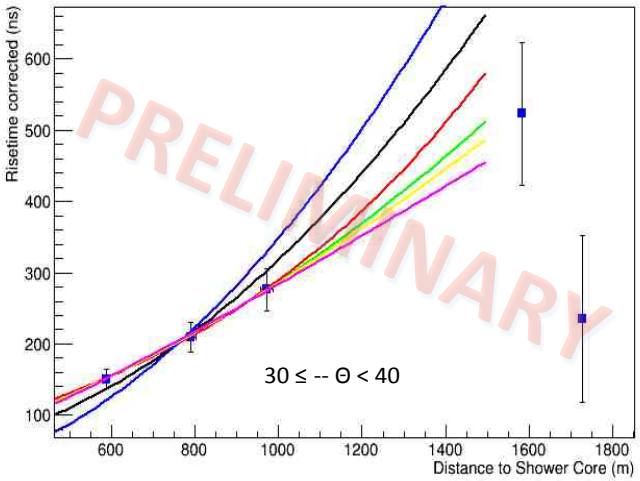
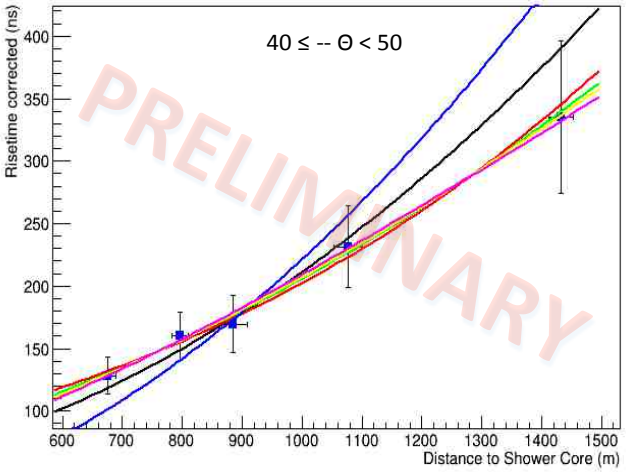
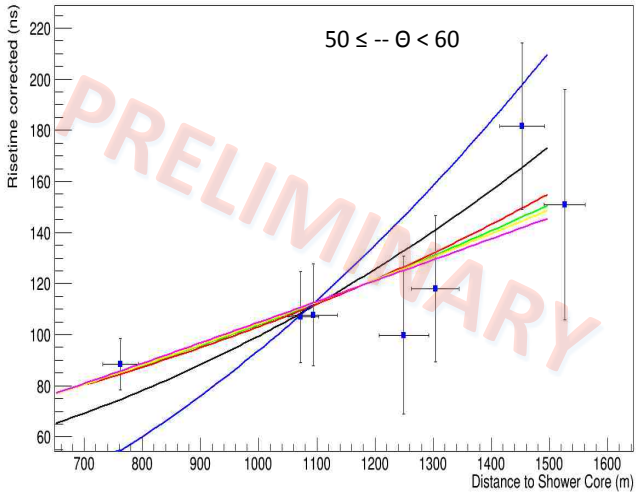
Some examples



Zenith angle:36.56°
Energy: 2.19x10^{19} eV
Intersection at:765 m



Zenith angle:44.77°
Energy: 1.37x10^{19} eV
Intersection at:910 m



Zenith angle:57.57°
Energy: 1.62x10^{19} eV
Intersection at:1095 m

There is a different intersection distance of the fitted functions of risetime, for events with different zenith angles. That distance might be used for performing more accurated studies on mass composition.

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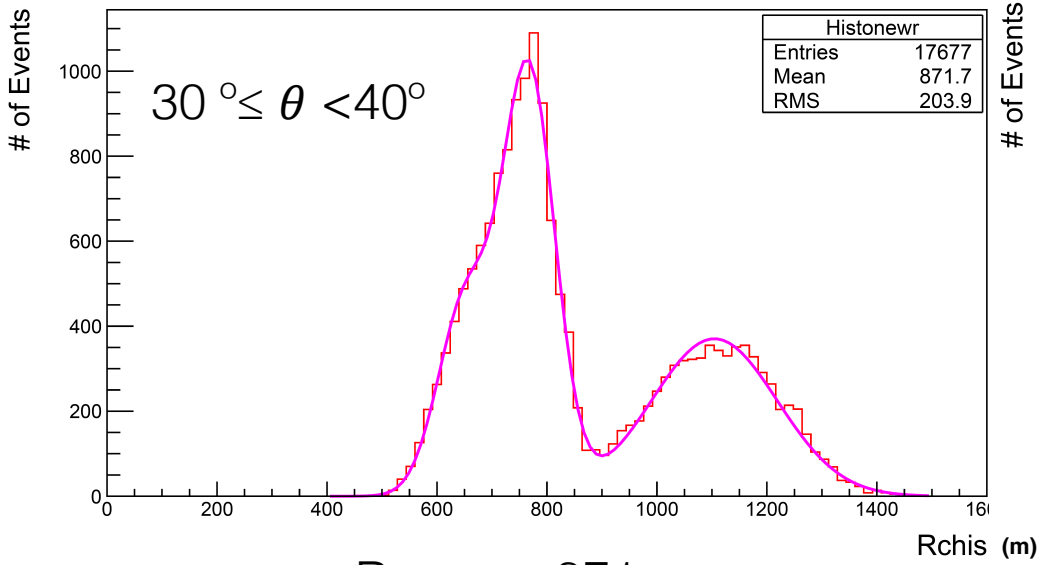
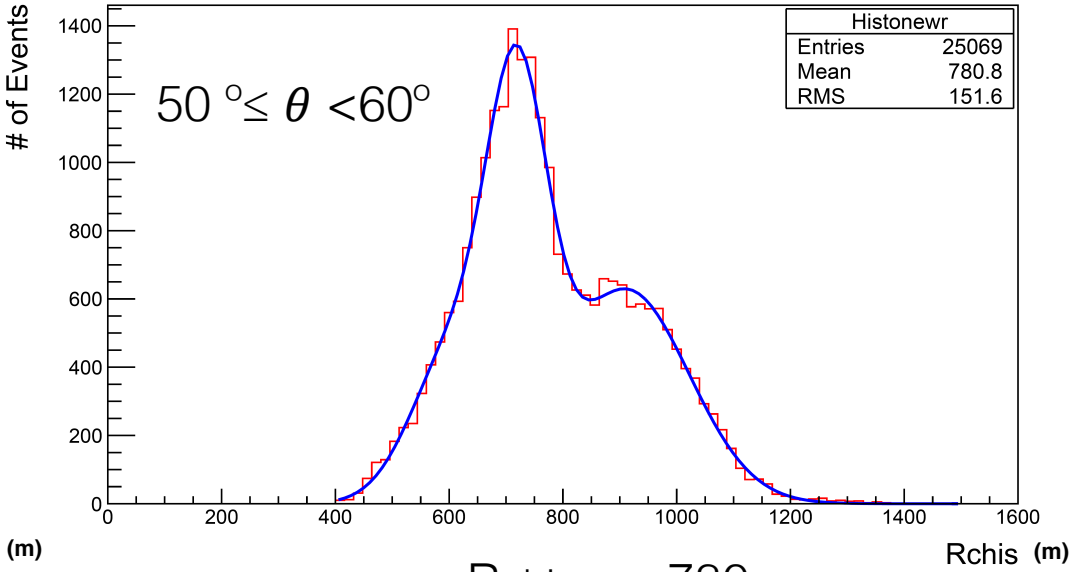
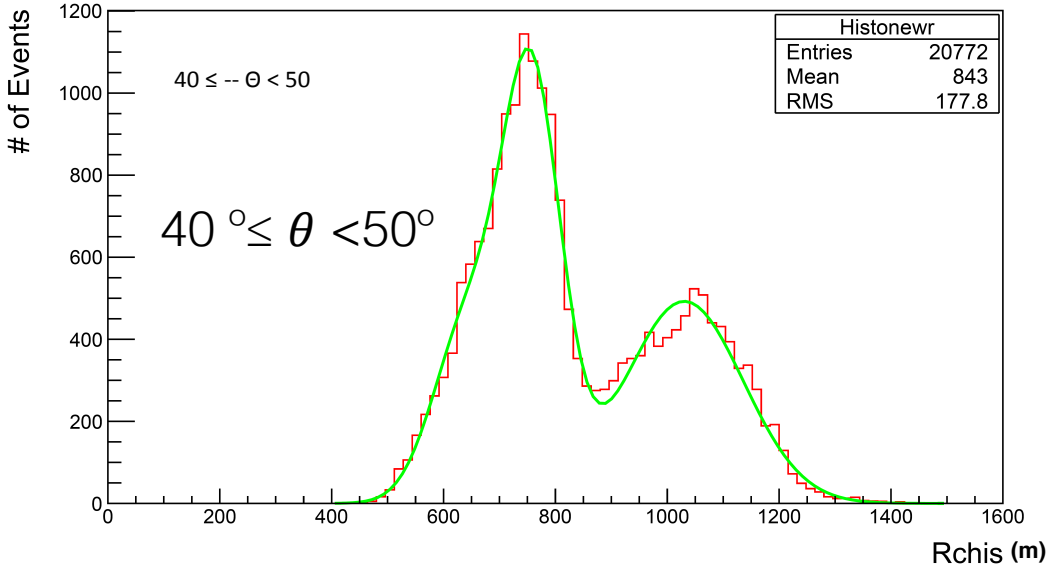
Mean behaviour for events 2004-2015



< Rchis >= 871 m



< Rchis >= 780 m



< Rchis >= 843 m

Events having good fits with the explored functions

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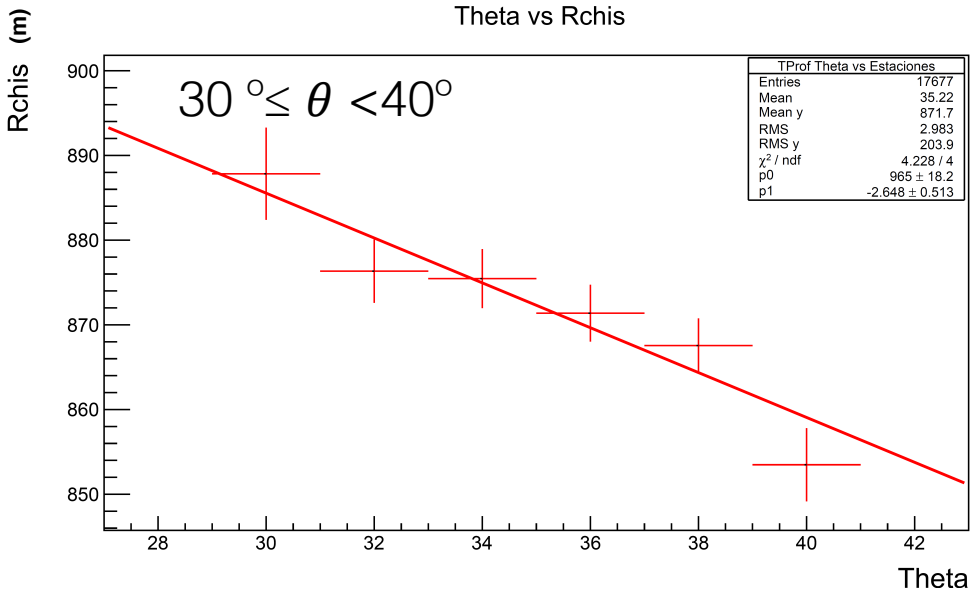
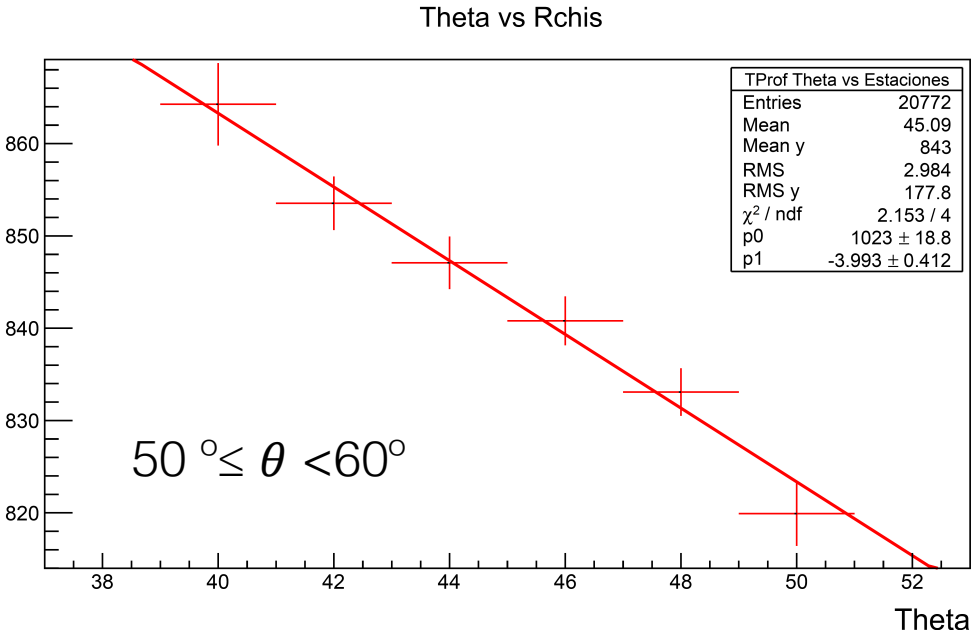
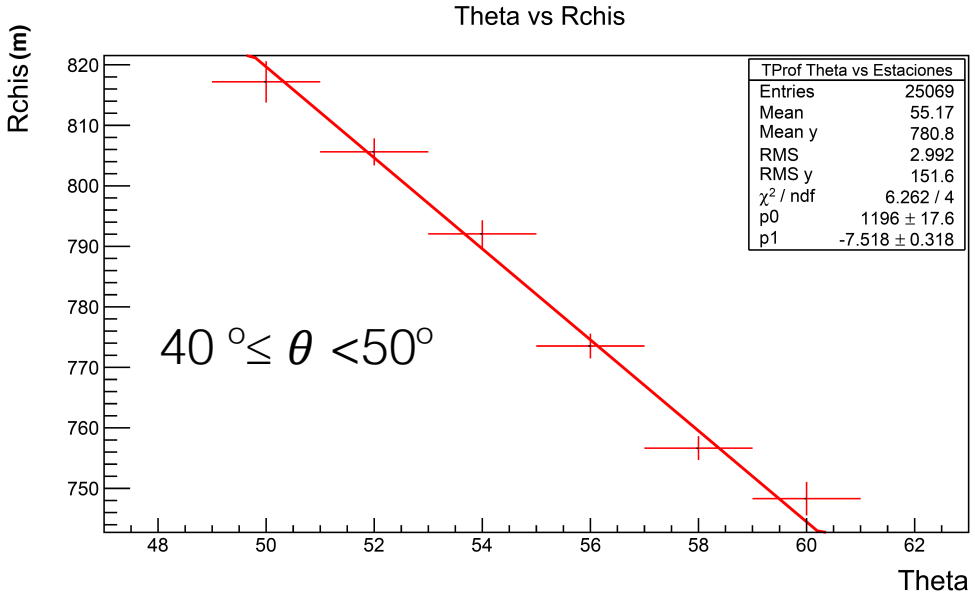
Mean behaviour for events 2004-2015







Range of Θ	Fit's slope
30°-40°	-2.648
40°-50°	-3.993
50°-60°	-7.518

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Next short term steps

- To use the linear fit to obtain R_{chis} for one event, given θ
- Once having R_{chis}, to obtain the value of $t_{1/2}$ for such distance, i.e. $t_{1/2}(R_{chis})$
- To compare $t_{1/2}(R_{chis})$ with $t_{1/2}(1000)$ to check if the spread of $t_{1/2}(R_{chis})$ is smaller than for $t_{1/2}(1000)$. If it is true, then $t_{1/2}(R_{chis})$ can be used for performing mass composition sensitive studies with simulations.
- A dependence with the energy will be also explored

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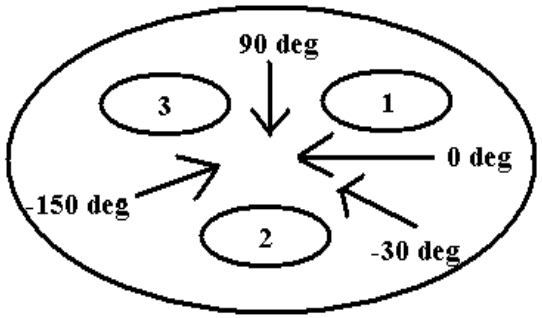
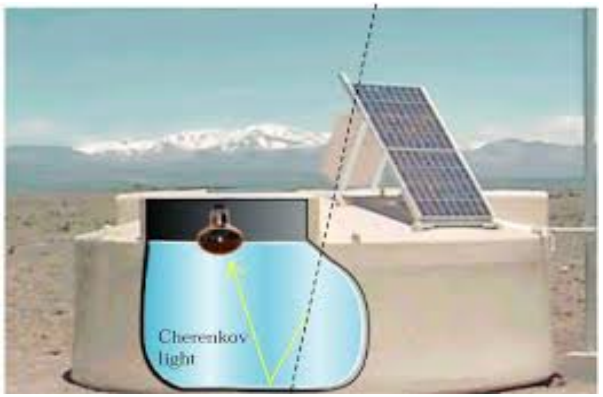
Direct light in the SD and their change in time

Pedro Valencia Esquipula

Goal:

- To observe the effects of direct light in the tanks of the SD, and their evolution in time.
- The change in time could provide information on the physical state of each tank.
- Such information can be also used for studying possible systematic effects in the measurements made by the SD
- To quantify effects of the PMT's aging





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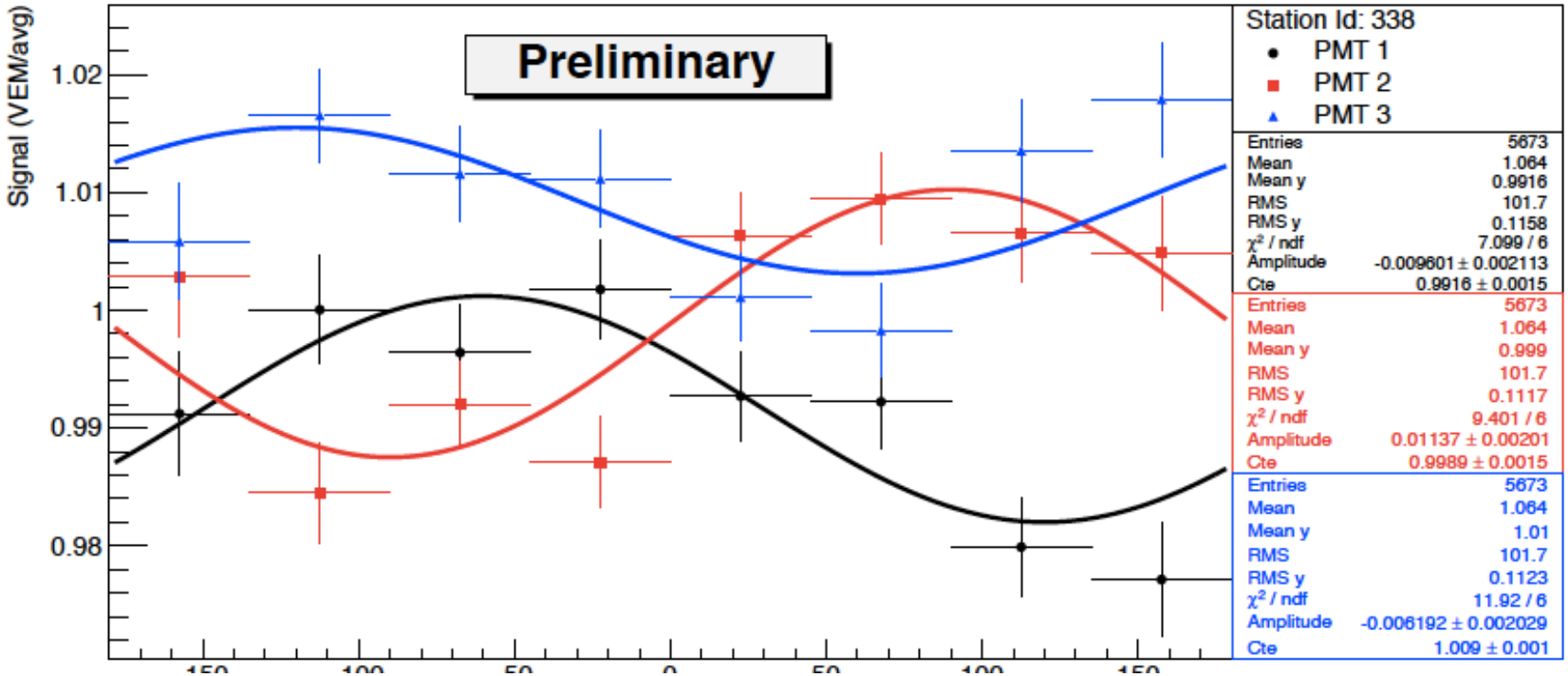
Direct light in the SD and their change in time

$$A\sin(\frac{\pi(x-k)}{180})+b$$



For zenith angles $0\,^{o} \leq \theta < 60^{o}$
Tank ID: 338

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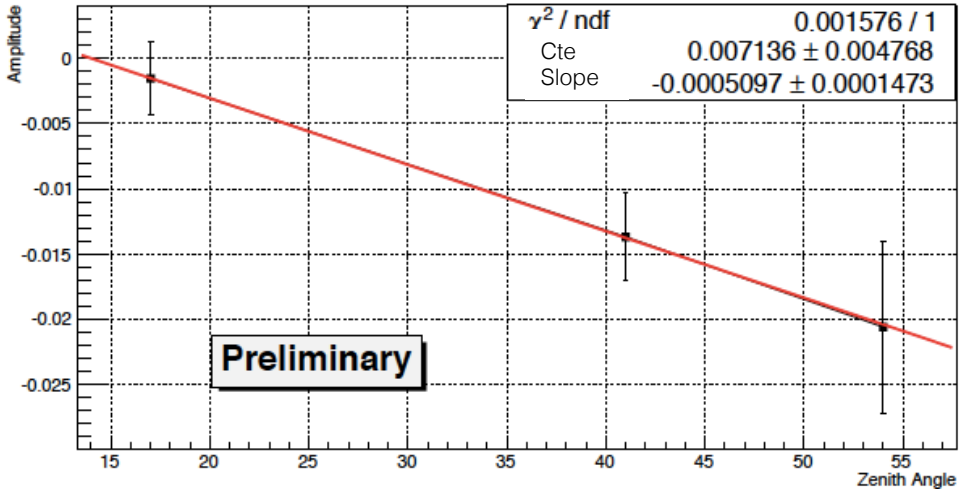
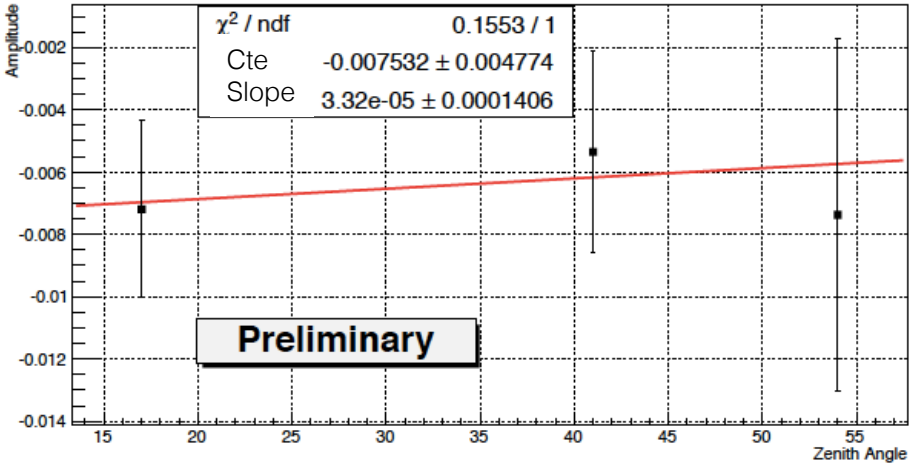
Amplitud (A) as a function of zenith angle

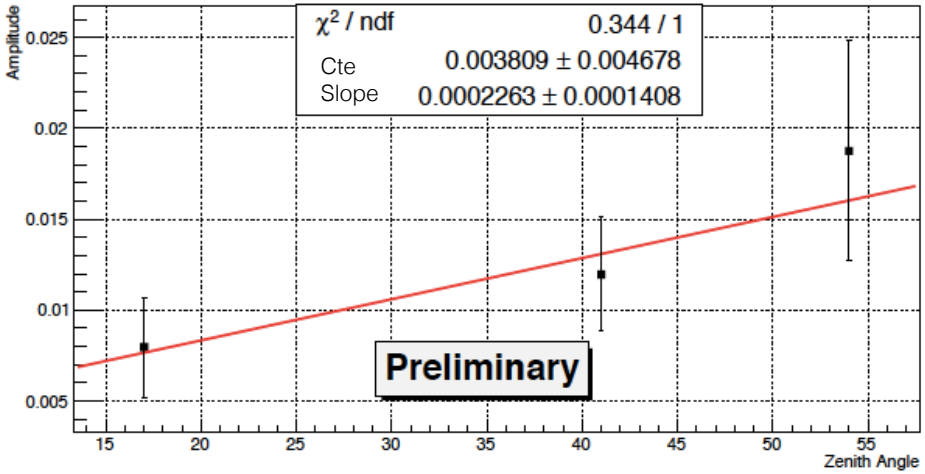
We consider three ranges of zenith angle with the same solid angle: 0°-34°, 34°-48°, 48°-60°



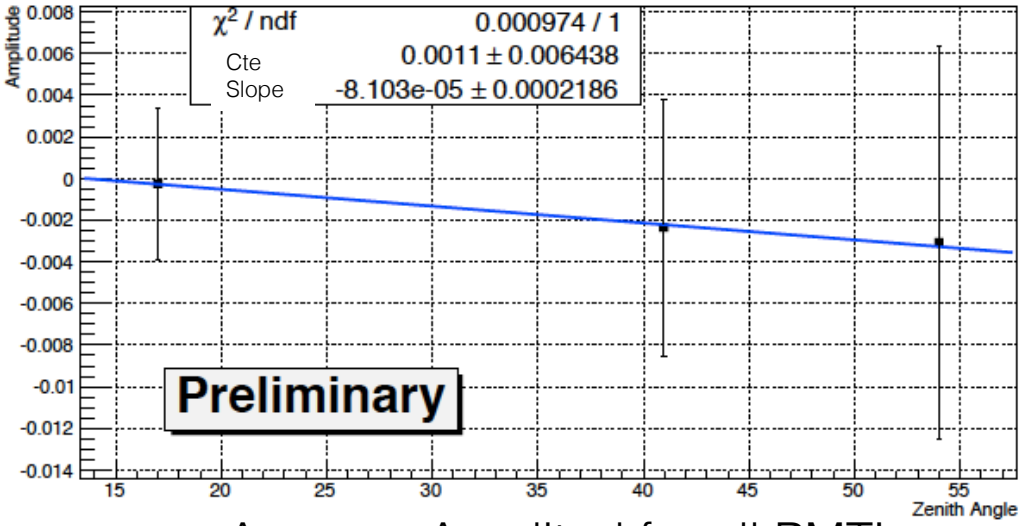
PMT 1



PMT 3



PMT 2



Average Amplitud for all PMT's

Characteristic line

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Short term future

- The same kind of study will be performed for 9 time intervals between 2004 and 2013, a characteristic line will be obtained for every interval.

- The possible change in the slopes of characteristic lines will be used to estimate the aging of the PMTs

- The signal will be explored in order to find some change in time related to the PMT's aging

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Thank you!

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24-26 May 2017
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