Astroparticle Physics in Chiapas

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UNACH

Meeting of the Cosmic Rays Division of the Mexican Physical Society
3-5 October 2018
Puebla, México

Outlook

- Mass composition and New Physics
- The Pierre Auger Observatory
  - Mass composition with Risetime $t_{1/2}$
    - A new parameter based on $t_{1/2}$: Rchis
    - Status of the study
  - Monitoring SD with direct light on PMTs in time
    - Direct light
    - Characteristic line
- HAWC Experiment
  - Analysis for looking for new gamma ray sources from the galactic plane
  - Estimation of the energy for Cosmic Rays
  - Escaramujo Project
    - Muon lifetime
    - Muon flux as a function of altitude with Escaramujo detector
  - LAGO Experiment
  - HPC at UNACH

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Mass Composition and new Physics

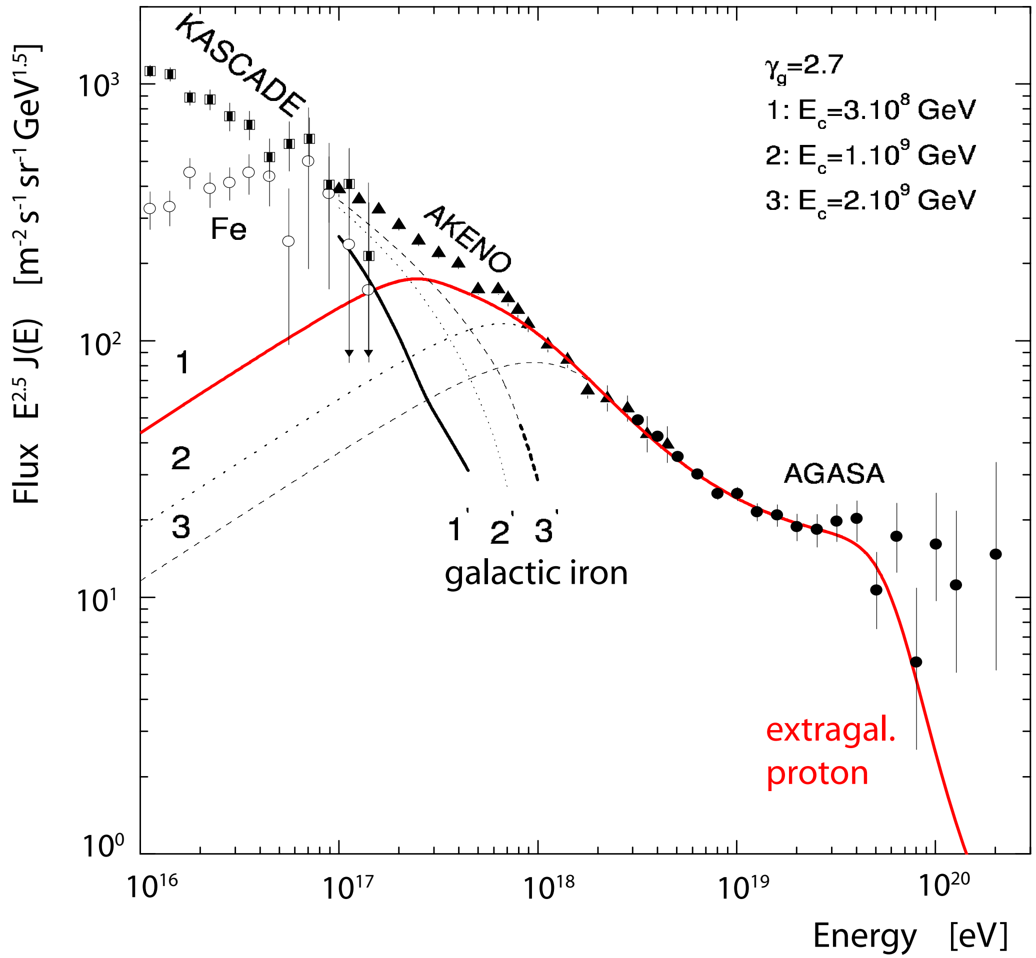
- Needed to understand: CR Origin, acceleration and propagation mechanisms
- Feedback with elementary particles interactions at high energies

- Theory:

  Mixture or light

- Experiment:

  Mixture or heavy



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

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Mass Composition and new Physics

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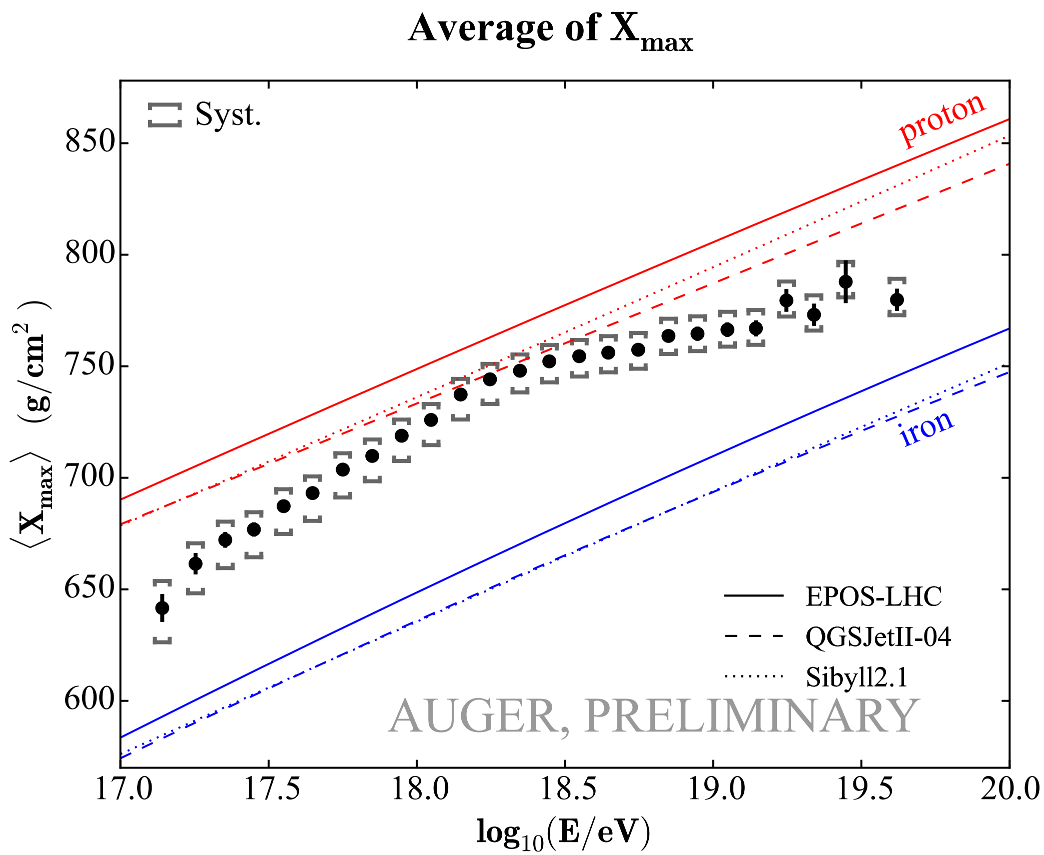
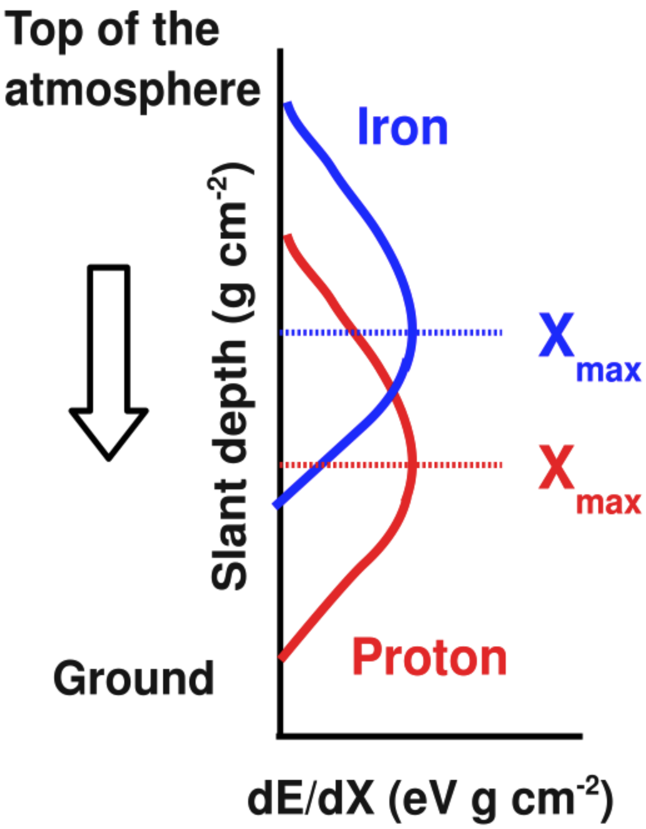
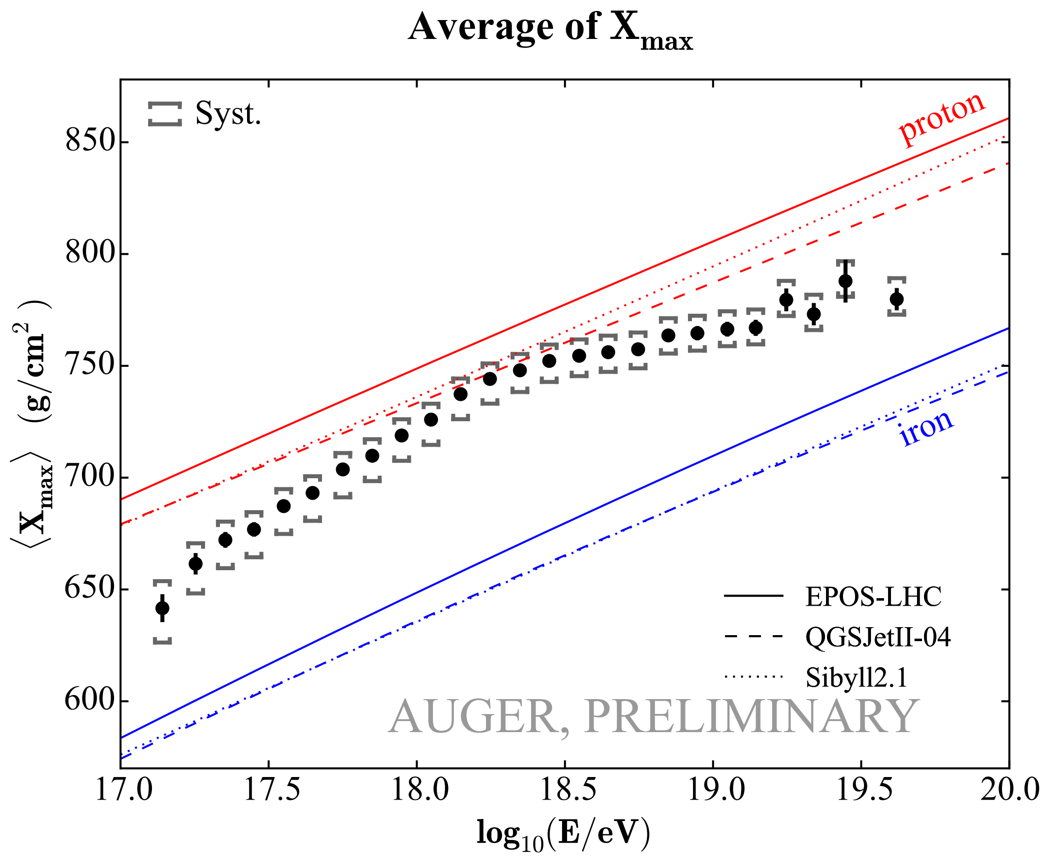


ICRC
The Astroparticle Physics Conference
34th International Cosmic Ray Conference
July 30 - August 6, 2015
The Hague, The Netherlands

Mass Composition of UHECR





Mixed mass composition
compared with hadronic interaction models

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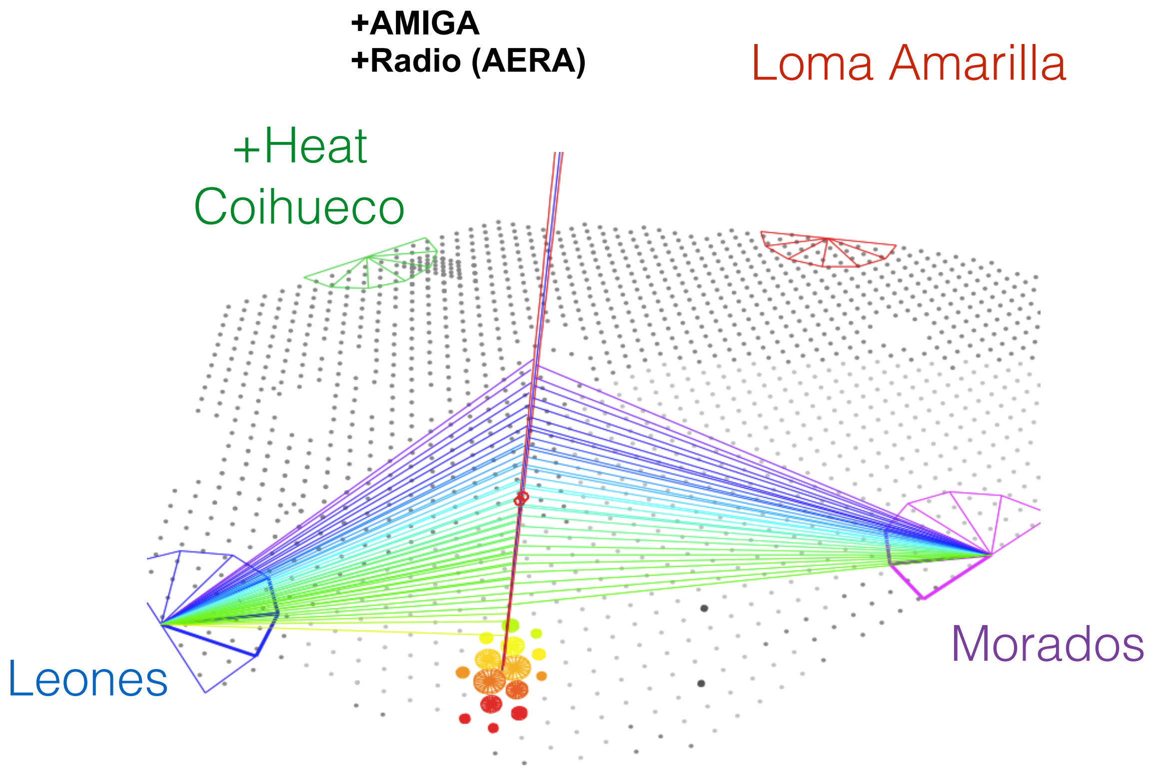
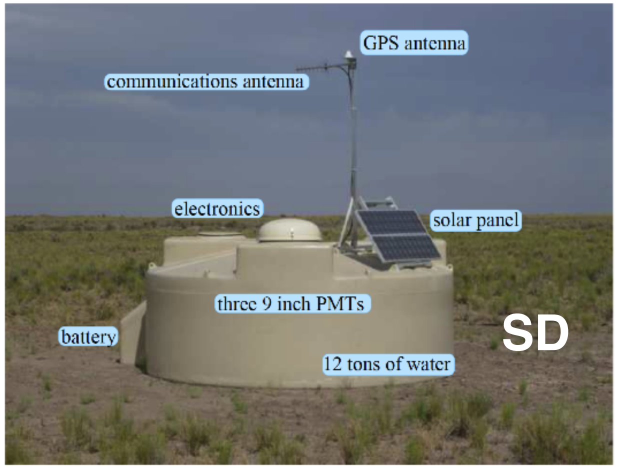
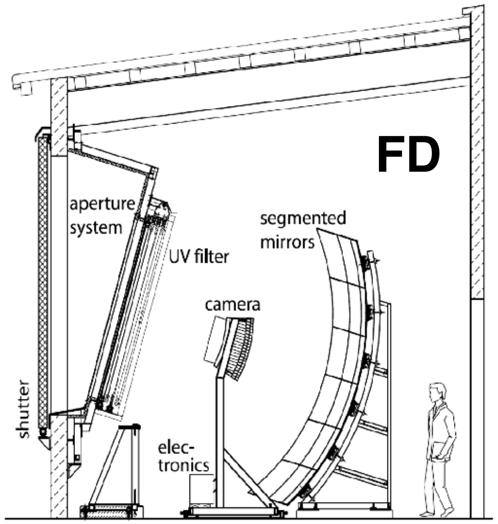
The Pierre Auger Observatory



Area of 3000 km²





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

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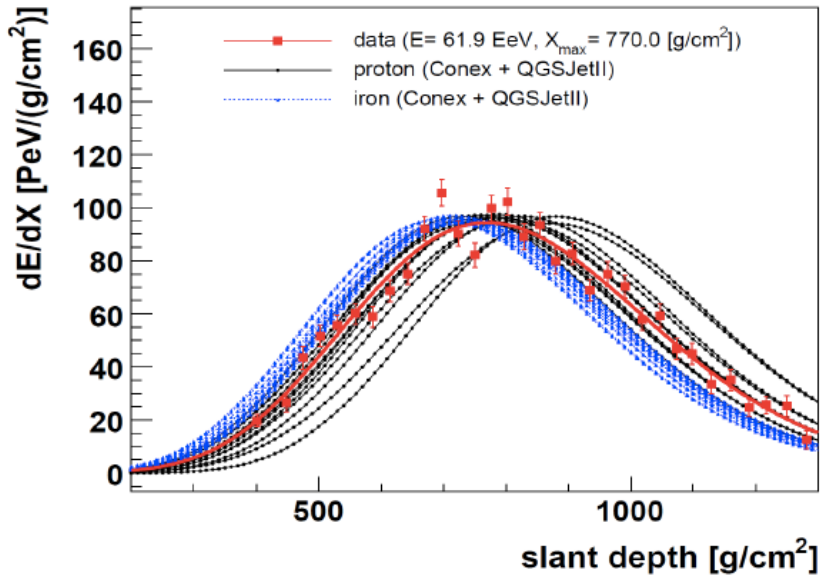
Mass composition sensitive parameters in Auger

- 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

AugerPrime

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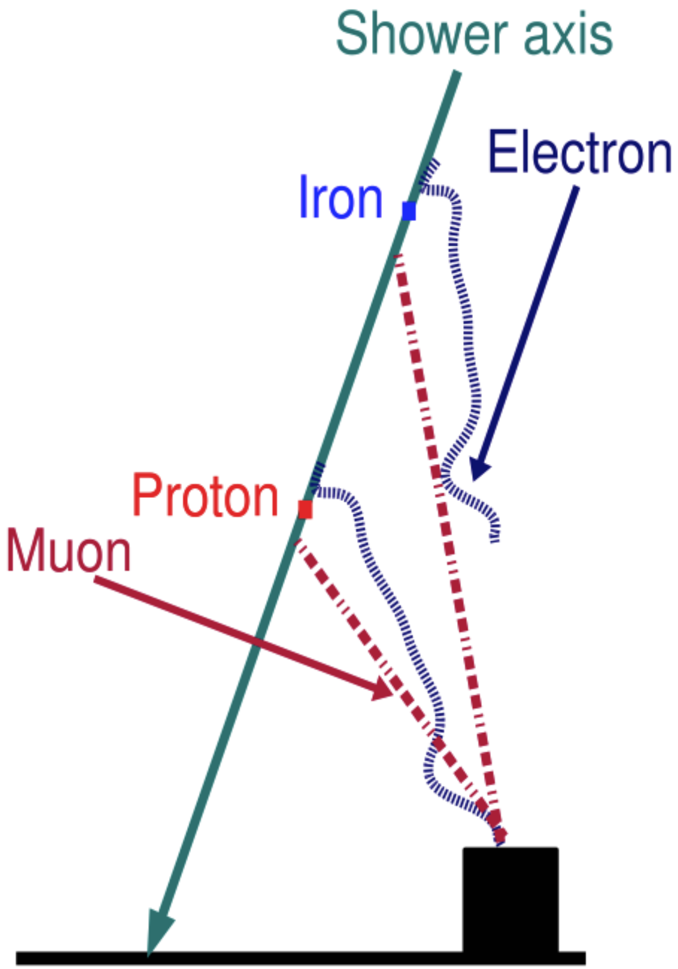
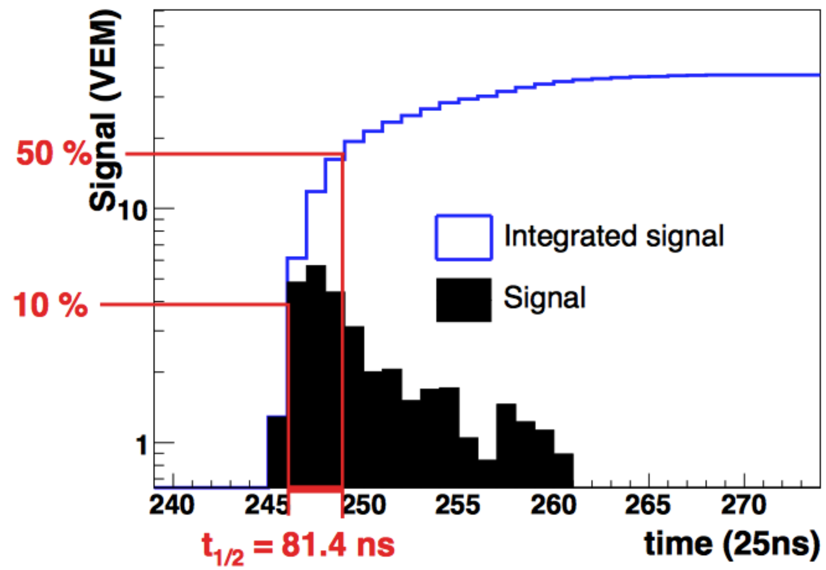
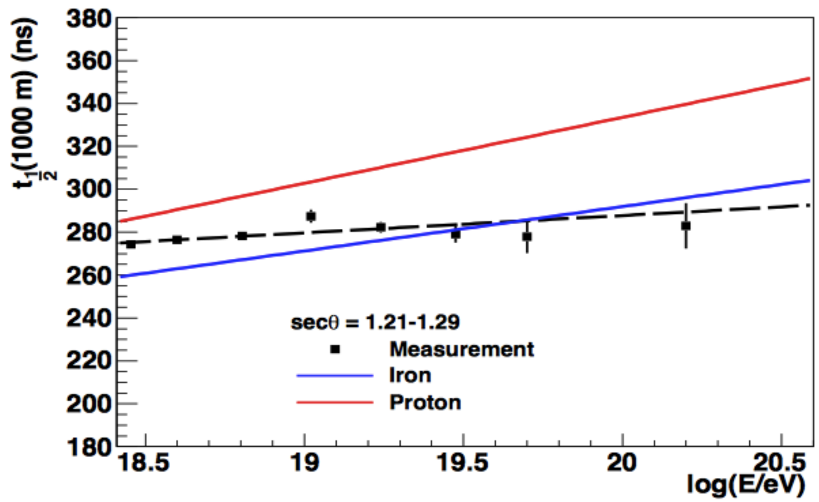
The SD mass composition sensitive parameter $t_{1/2}$



Particles arriving at ground

FADC trace of SD tank





t1/2 as mass sensitive parameter

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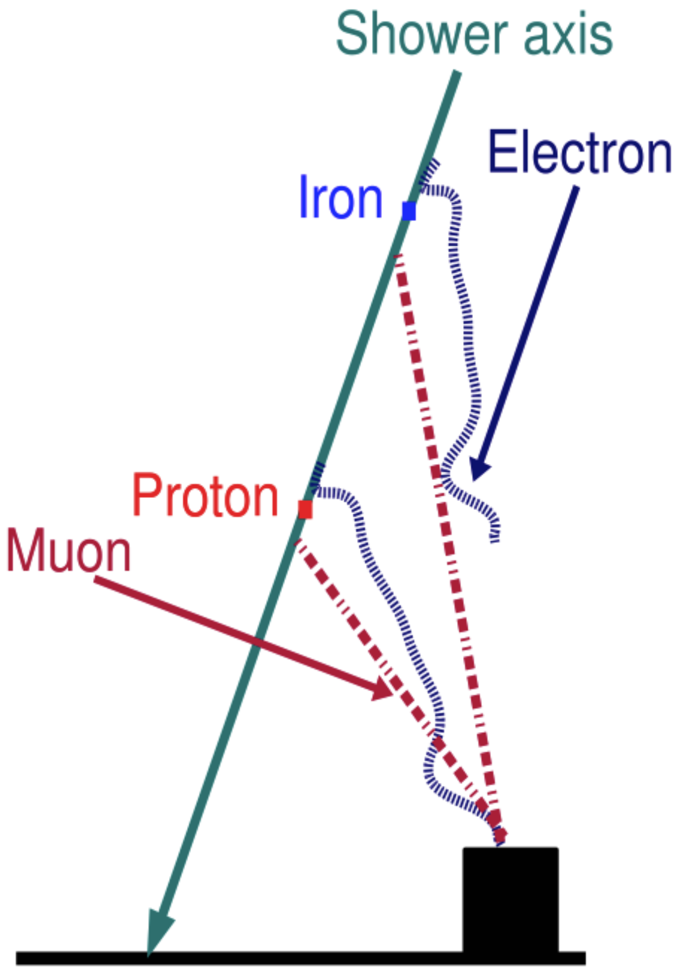
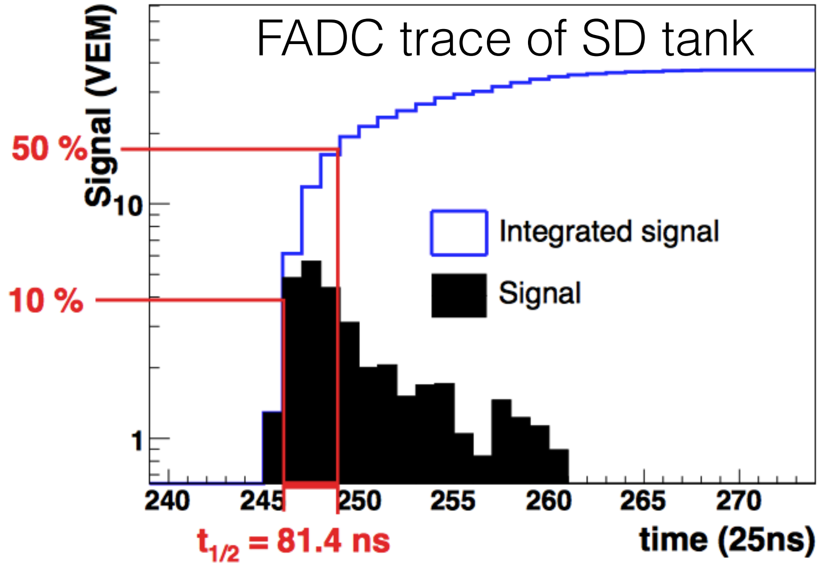
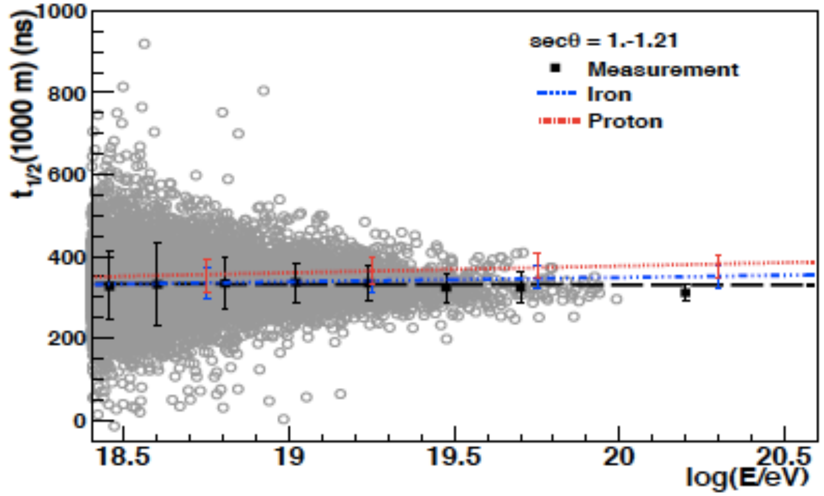
The SD mass composition sensitive parameter $t_{1/2}$



Particles arriving at ground





t1/2 as mass sensitive parameter

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

Hernán Castellanos Valdés

Goal:

- To optimize the characteristic distance (no 1000 m) to the shower core to consider the risetime for each event in order to decrease the spread

Future:

- To explore the new risetime as a mass composition sensitive parameter considering the dependence on the energy and to compare it with results obtained for risetime at 1000 m

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Study of rise time as a function of 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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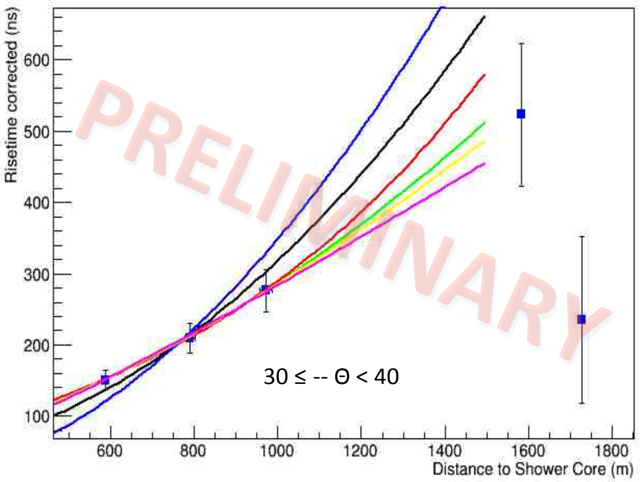
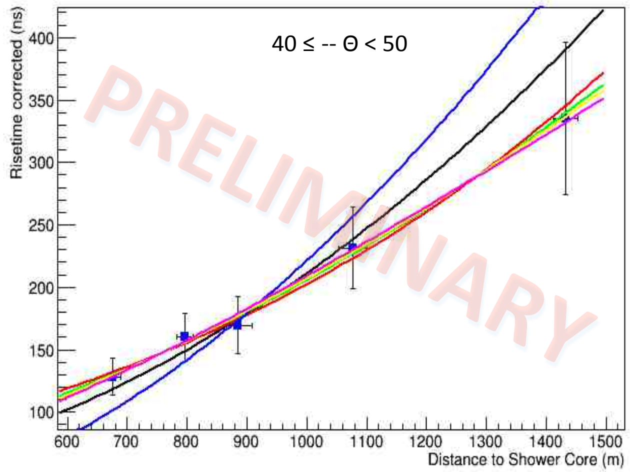
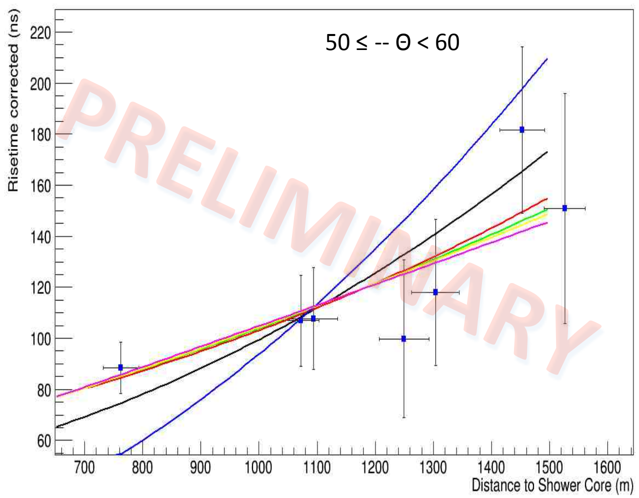
Some examples





Zenith angle:36.56°
Energy: 2.19×10^{19} eV
Intersection at:765 m

Zenith angle:44.77°
Energy: 1.37×10^{19} eV
Intersection at:910 m



Zenith angle:57.57°
Energy: 1.62×10^{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 accurate studies on mass composition.

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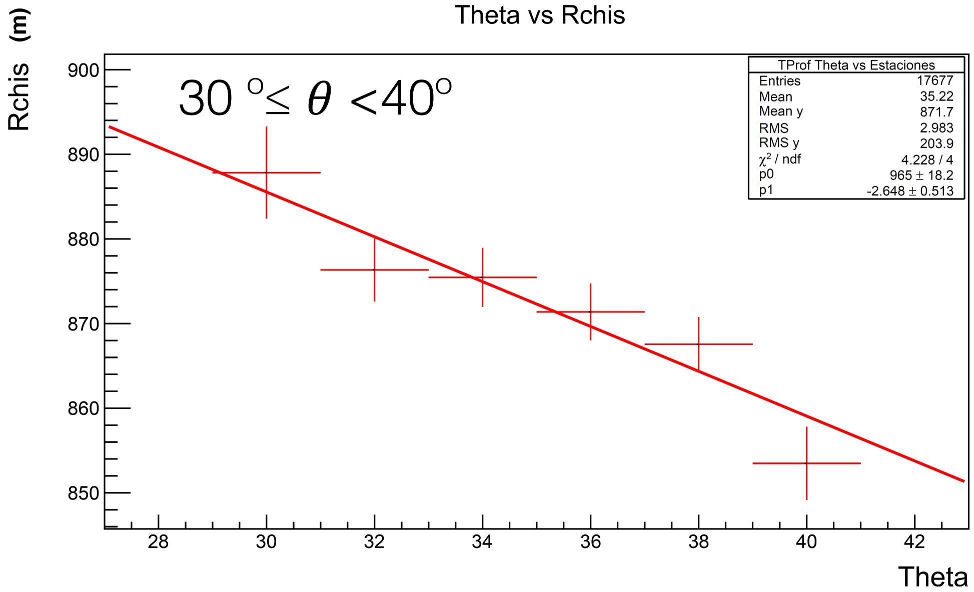
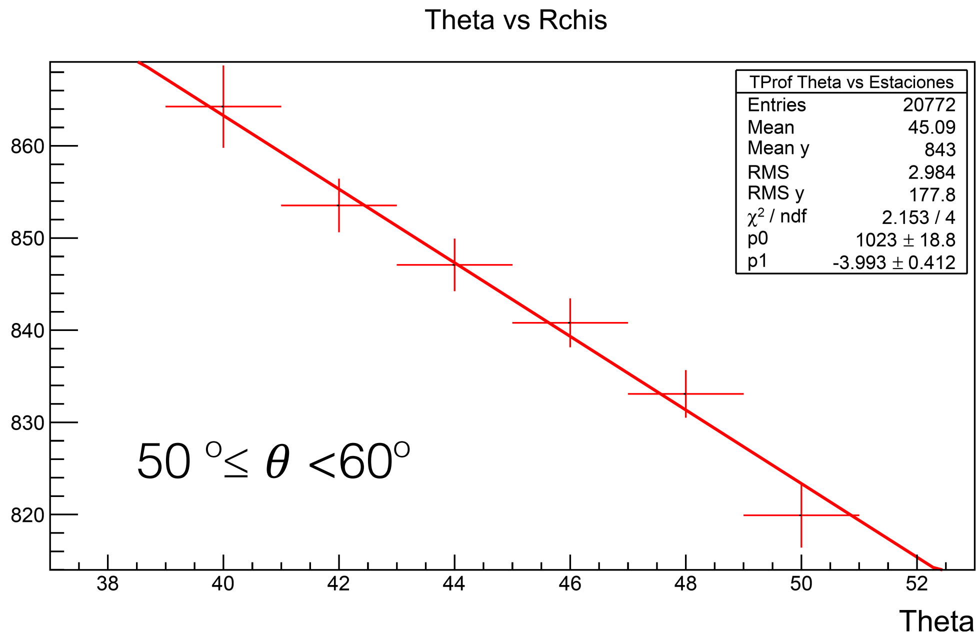
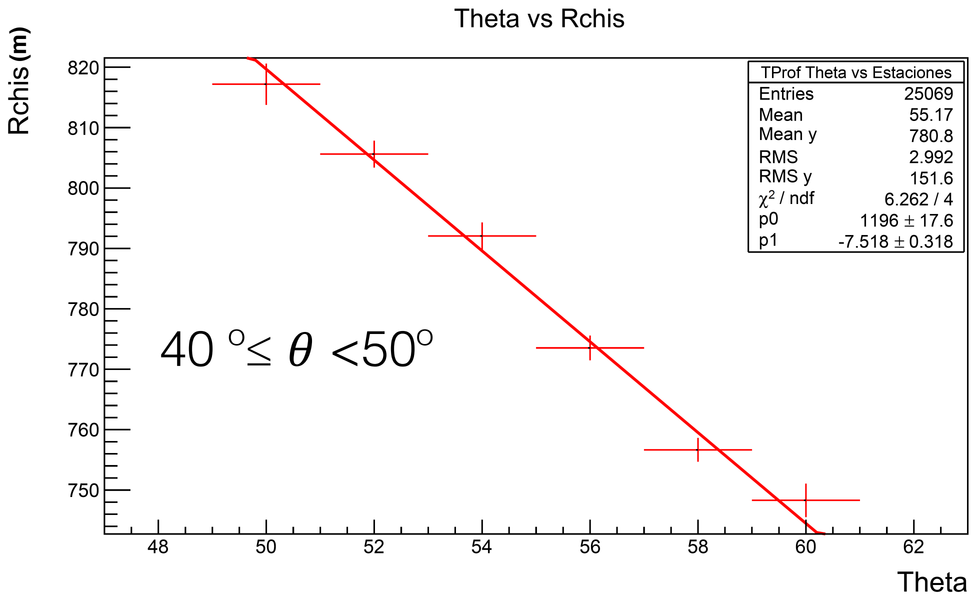
Mean behaviour for events 2004-2015







From the linear fit it is possible to obtain Rchis given a θ

To obtain $t_{1/2}(r)$ it is used the function:

$$t_{\frac{1}{2}}(r,\theta,E) = 40 + A(E)\cdot\alpha(\theta)\cdot r + B(E)\cdot\beta(\theta)\cdot r^2$$

Where r can be Rchis or 1000

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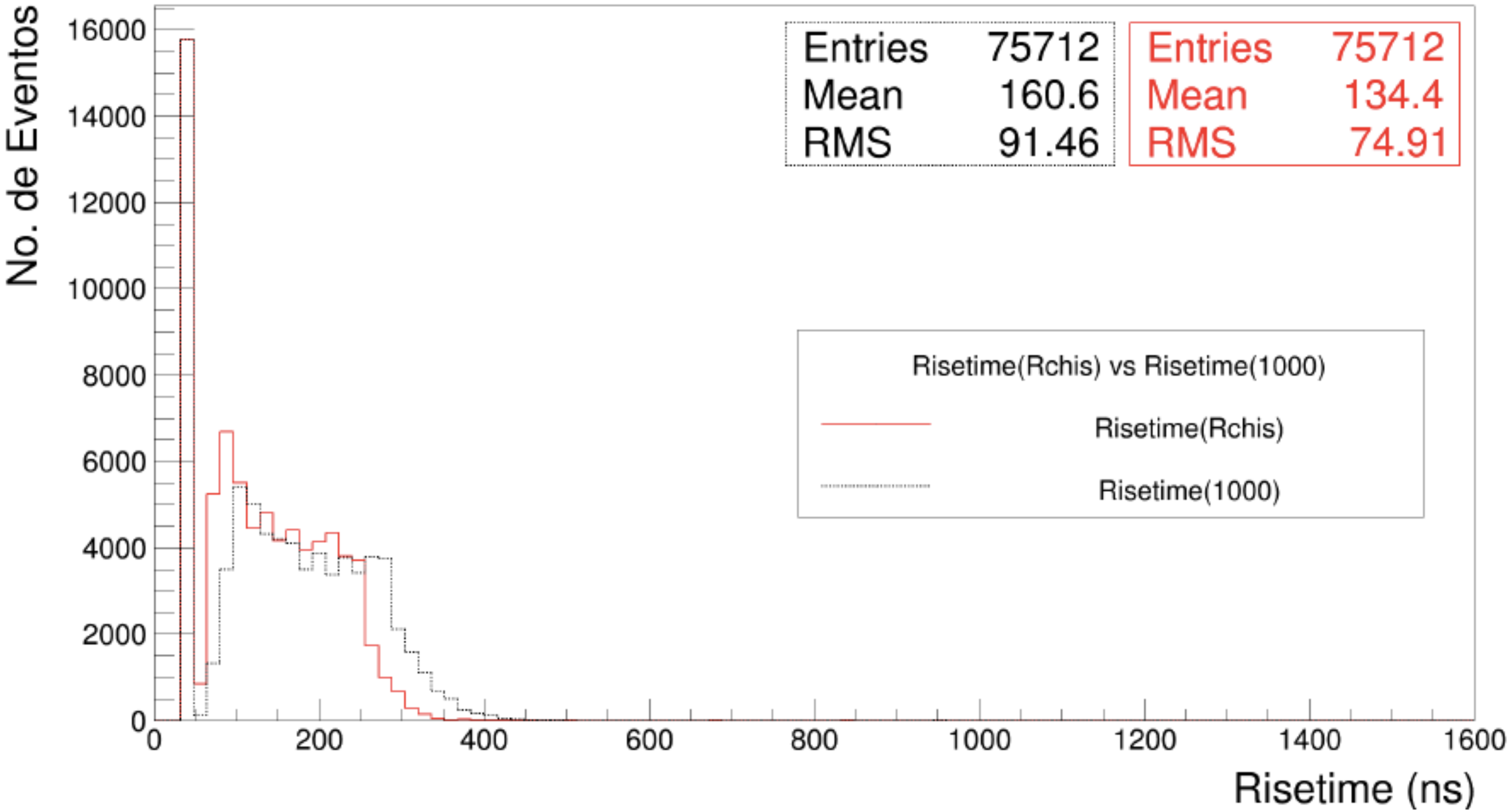
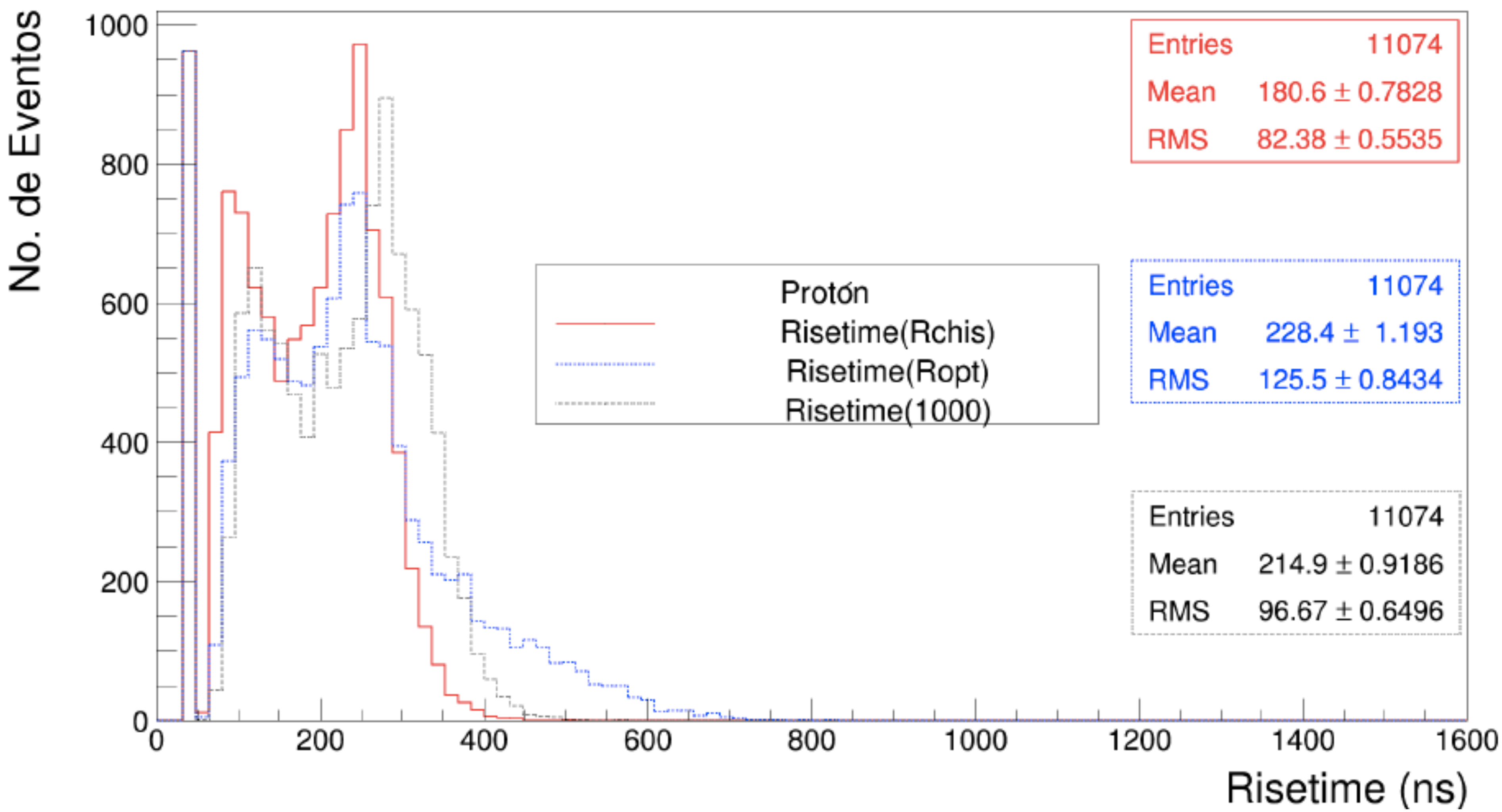
$t_{1/2}$(1000m) vs $t_{1/2}$(Rchis)
Using the fit of a function:



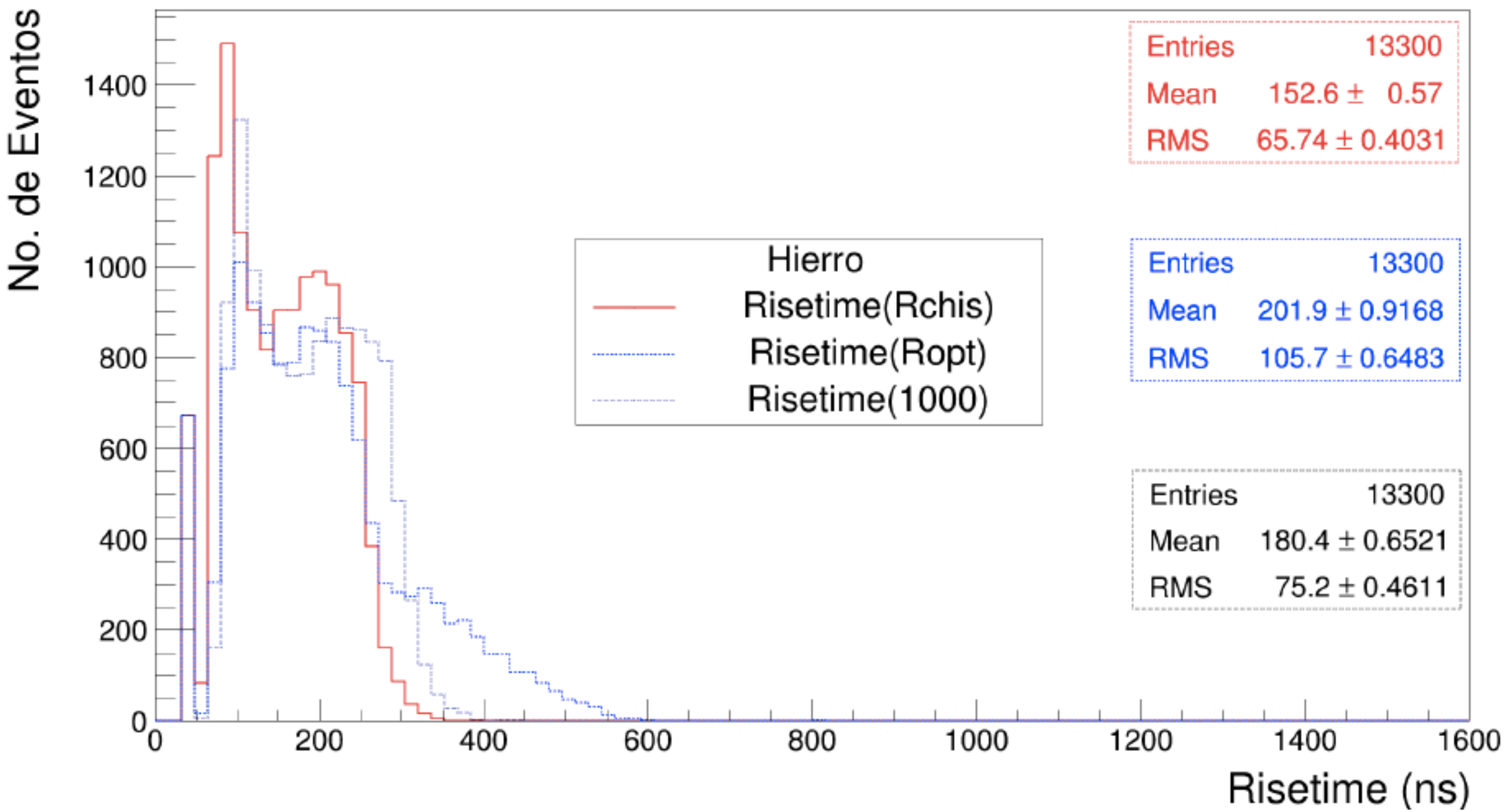
Spread at Rchis < Spread at 1000m

Comparison with simulations

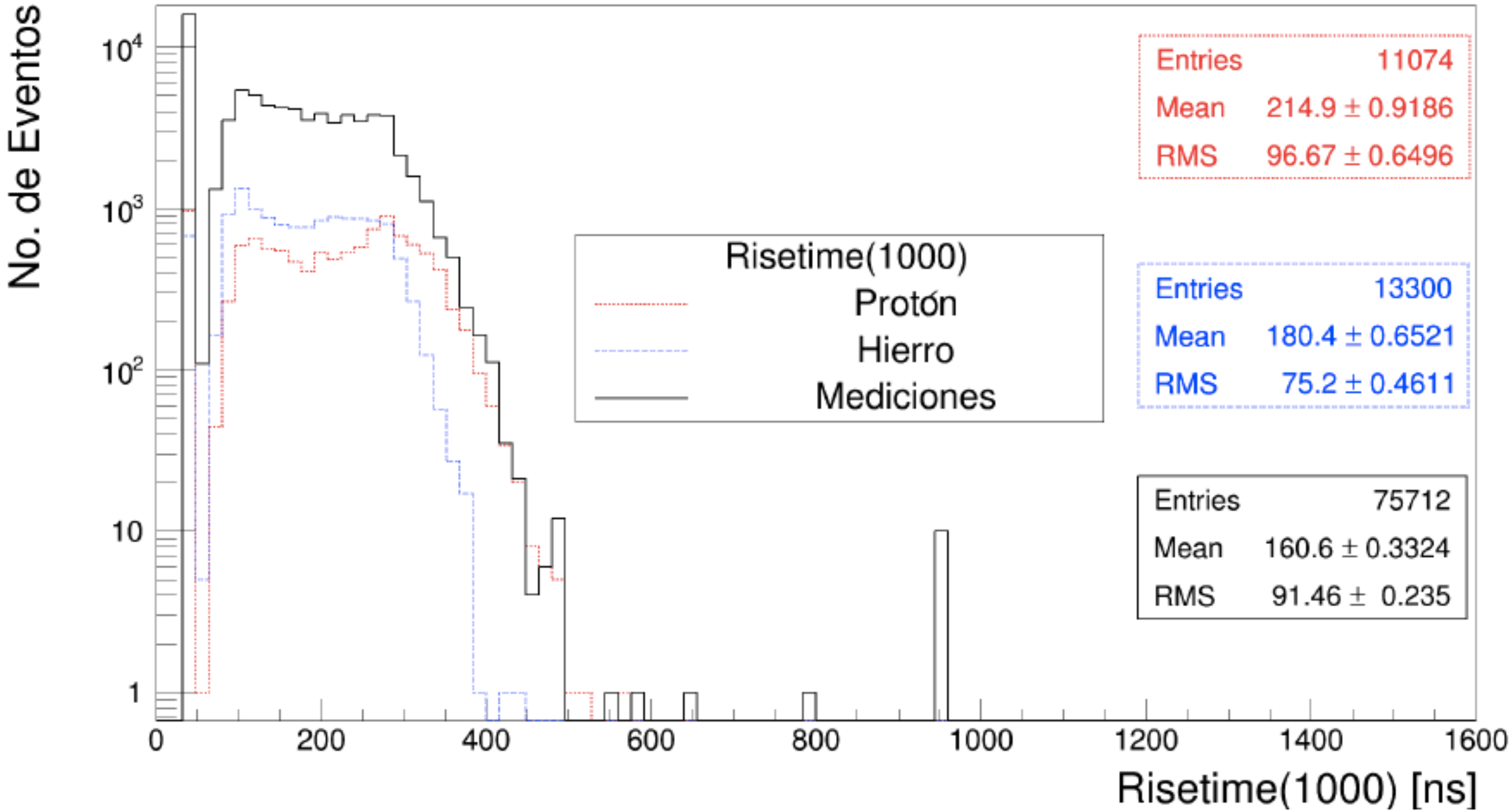
Offline Valentine, CORSIKA, QGSJET II-04



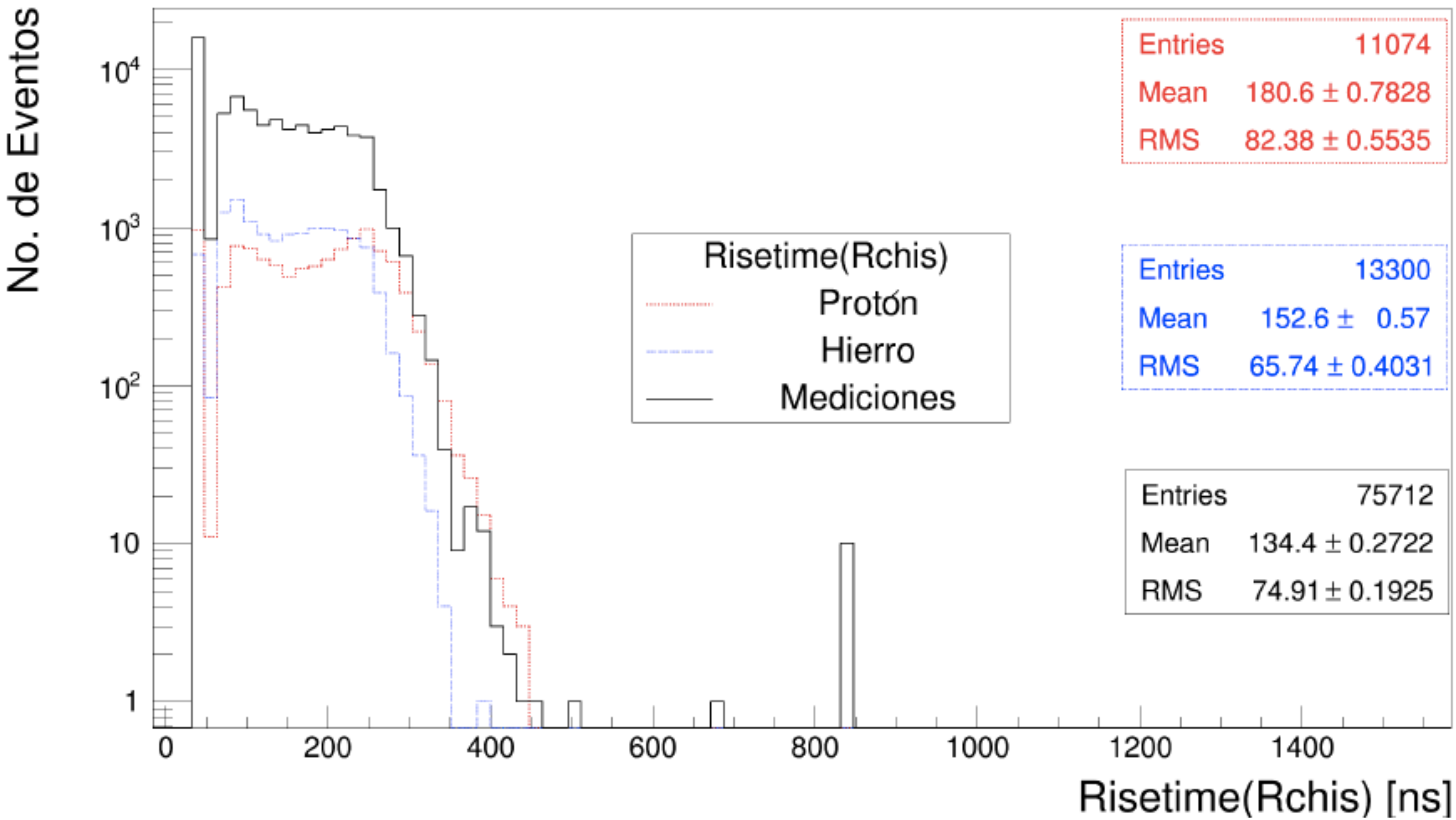
Comparison with simulations



Separation power for mass composition



Separation power for mass composition



Conclusions

- The spread of $t_{1/2}(R_{chis})$ is smaller than for $t_{1/2}(1000)$
- The separation power of $t_{1/2}(R_{chis})$ is similar to that of $t_{1/2}(1000)$
- The $t_{1/2}(R_{chis})$ variable can be used as mass composition parameter and possible to improve results obtained with $t_{1/2}(1000)$

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Next short term steps

- Systematic error's calculations are to be done
- A dependence with the energy will be also explored
- To explore other relations as X_{max} vs $\triangle$Core (talk by Maximiliano Limón)

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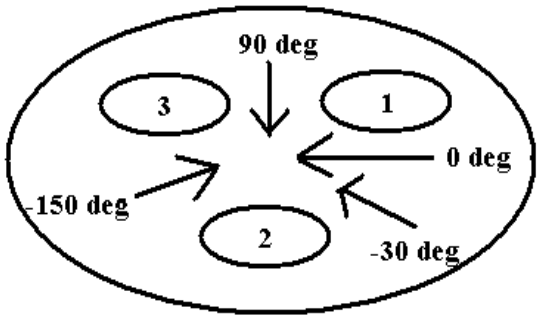
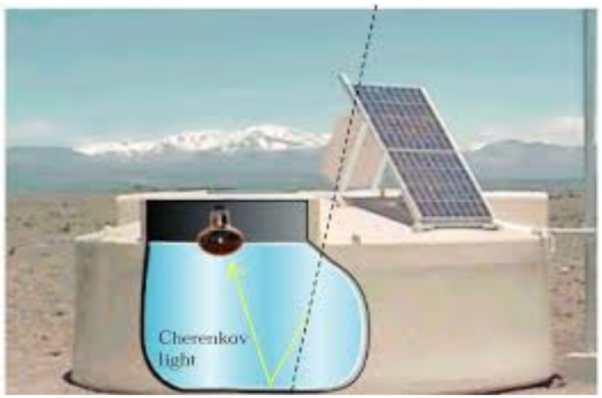
Direct light in the SD and their change in time

Pedro Valencia Esquipula

Goal:

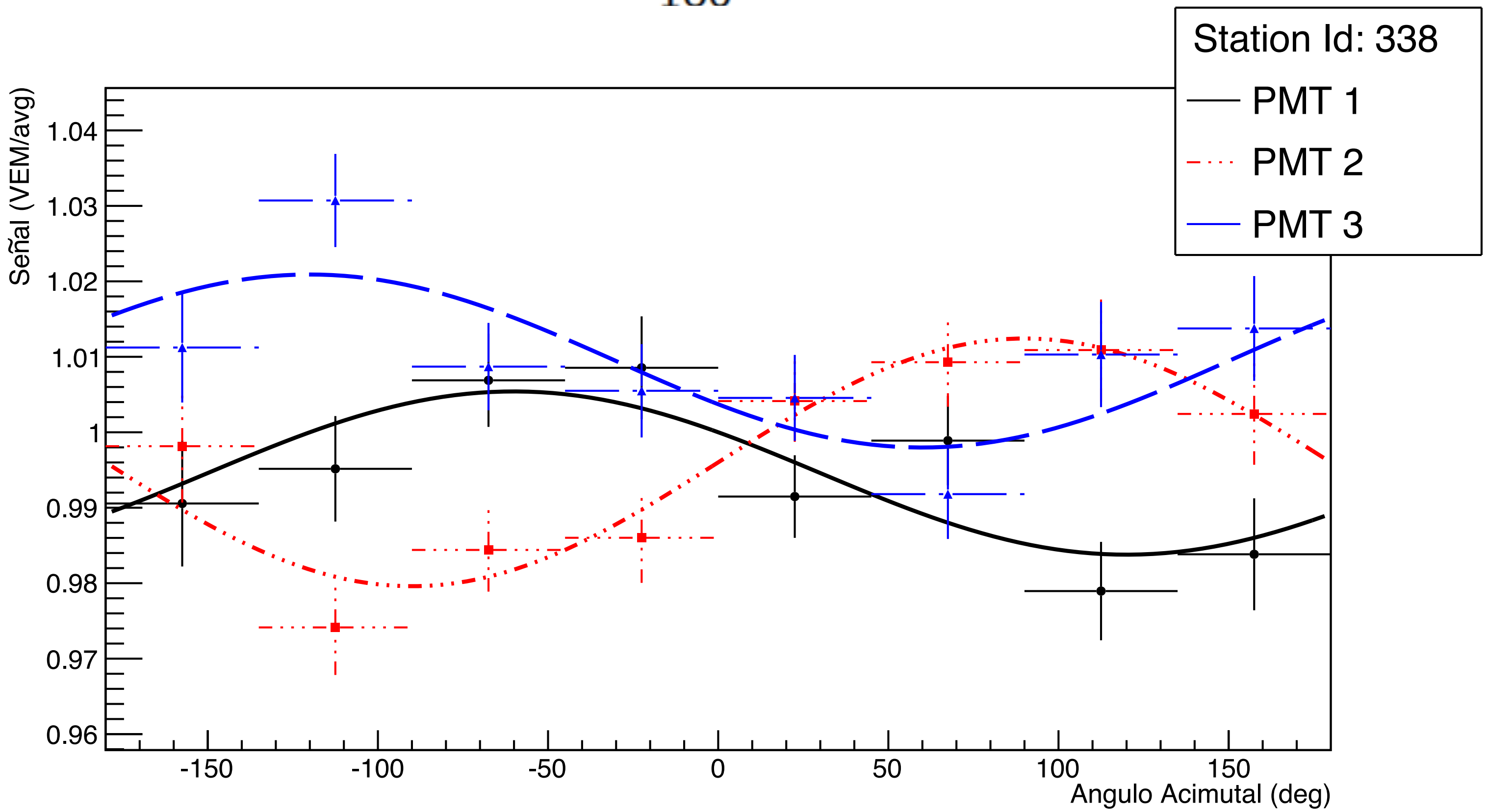
- To observe the effects of direct light in the tanks of the SD, and their evolution in time.
- The change in time could provide information on the physical state of each tank.
- Such information can be also used for studying possible systematic effects in the measurements made by the SD
- To quantify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





Direct light in the SD and their change in time

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



For zenith angles $0\,^{\circ} \leq \theta < 60^{\circ}$

Tank ID: 338

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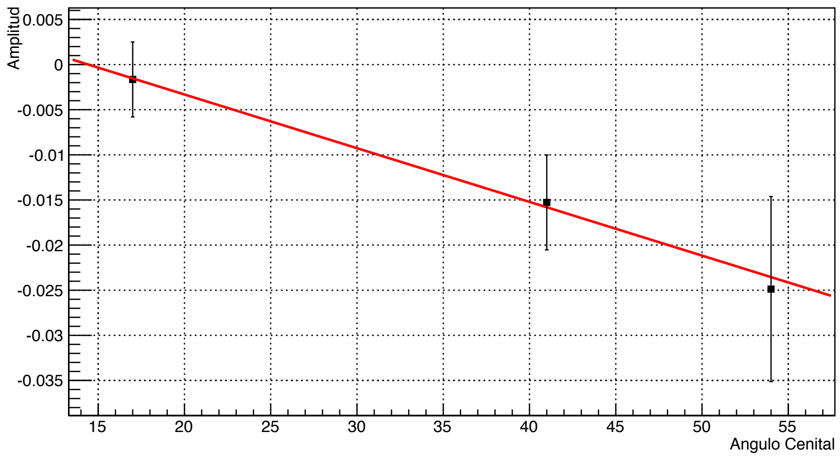
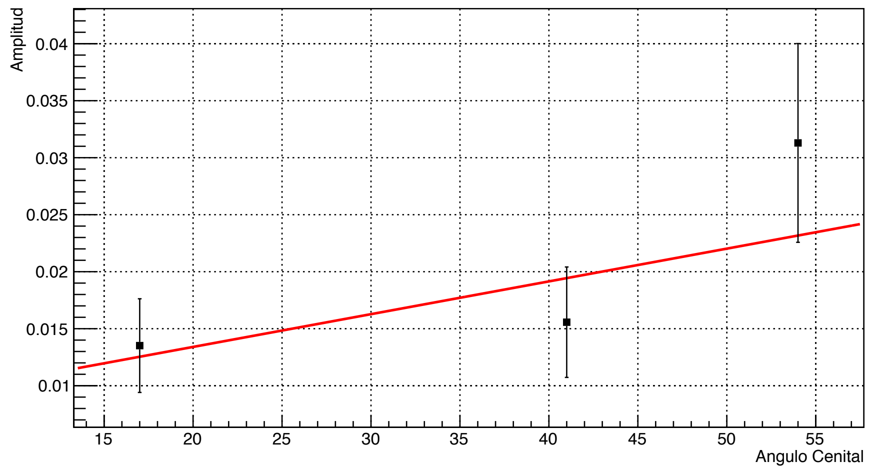
Amplitud (A) as a function of zenith angle

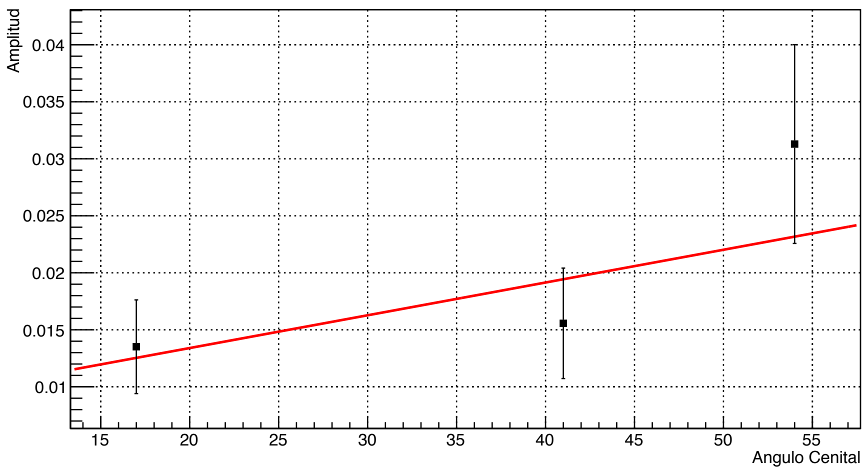
We consider three ranges of zenith angle with the same solid angle: 0^{o}-34^{o}, 34^{o}-48^{o}, 48^{o}-60^{o}



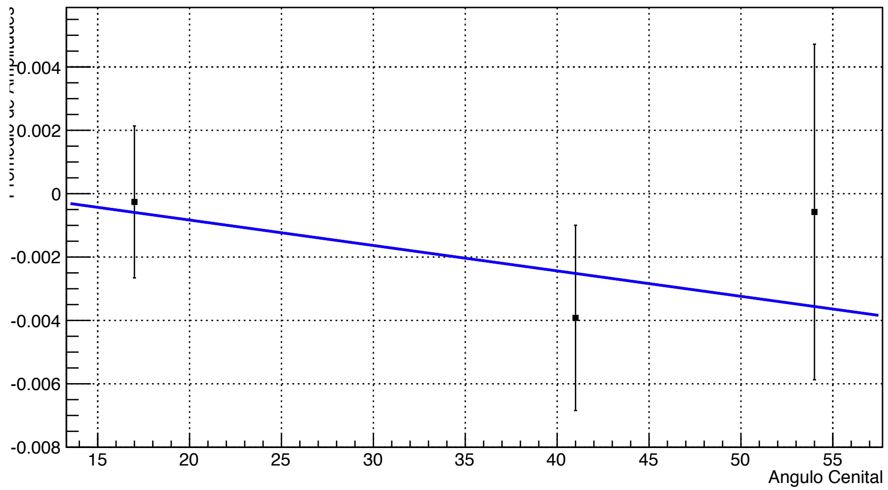
PMT 1



PMT 3



PMT 2



Average Amplitud for all PMT's

Characteristic line

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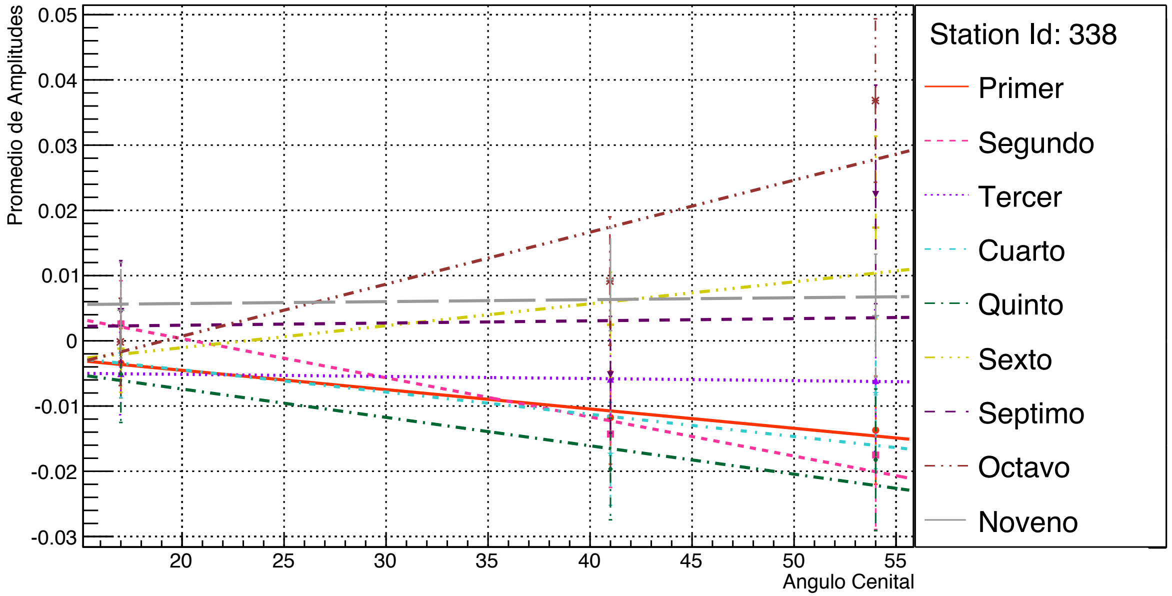
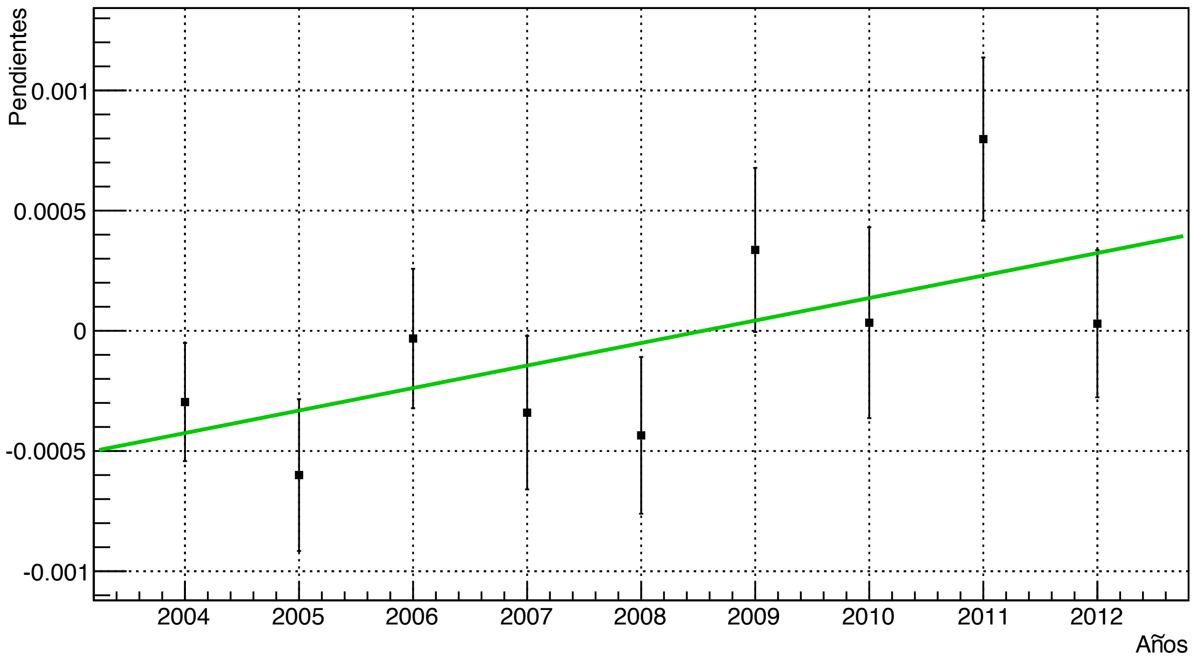
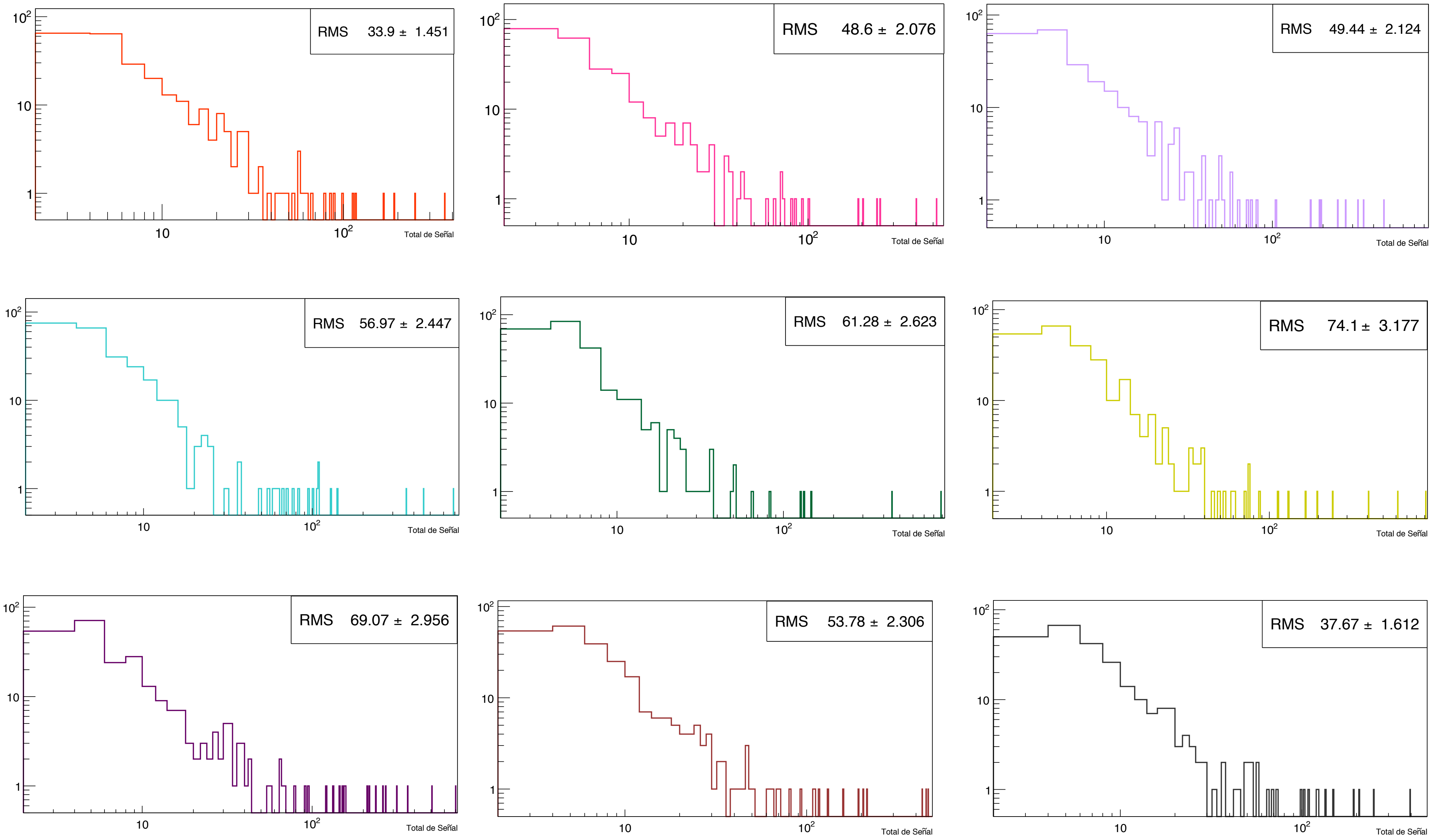
Characteristic lines for 9 years



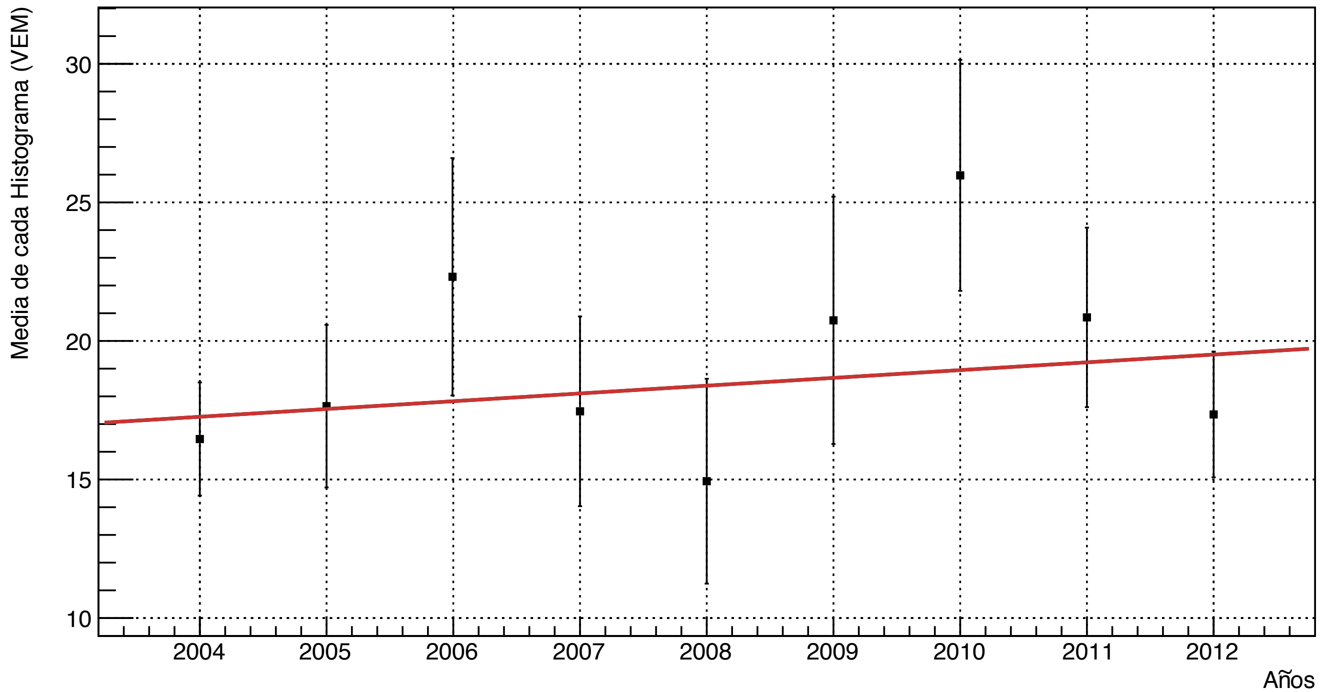
Slopes of characteristic lines in time



Signal per year of one tank

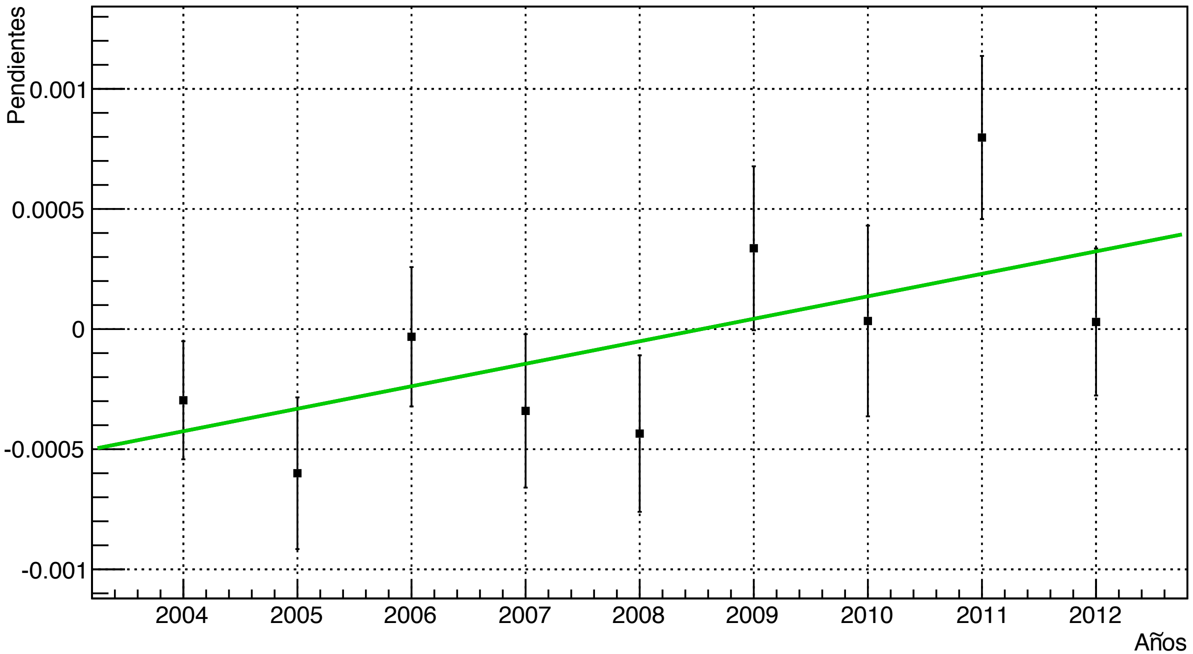


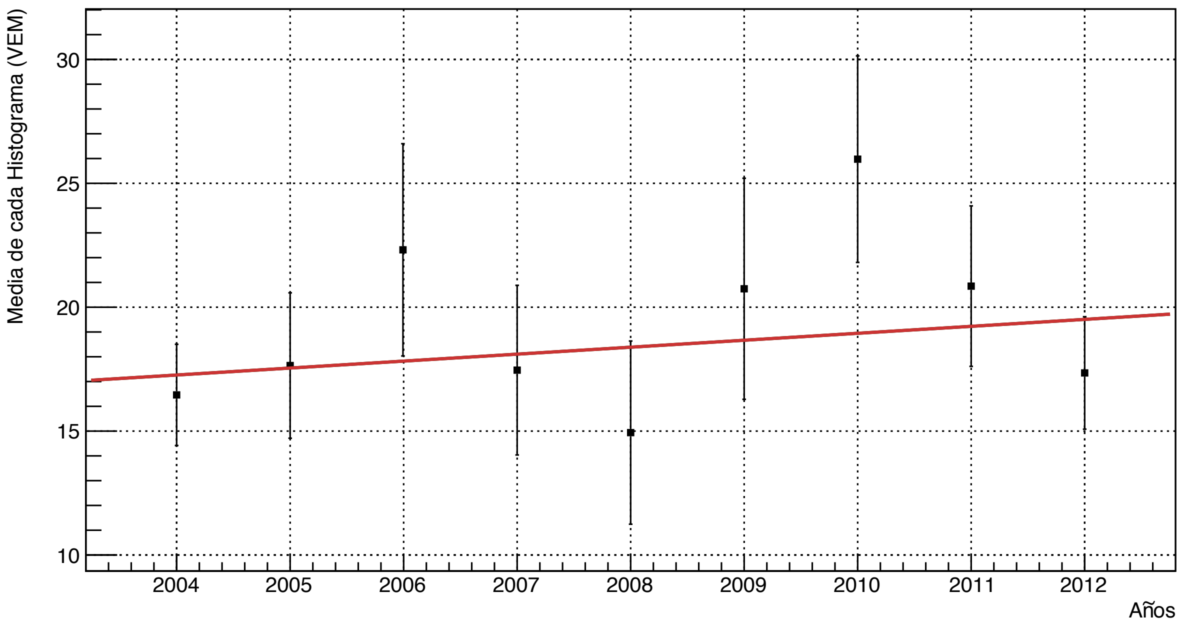
Mean value of signal for 9 years



For this tank there is also a non zero slope

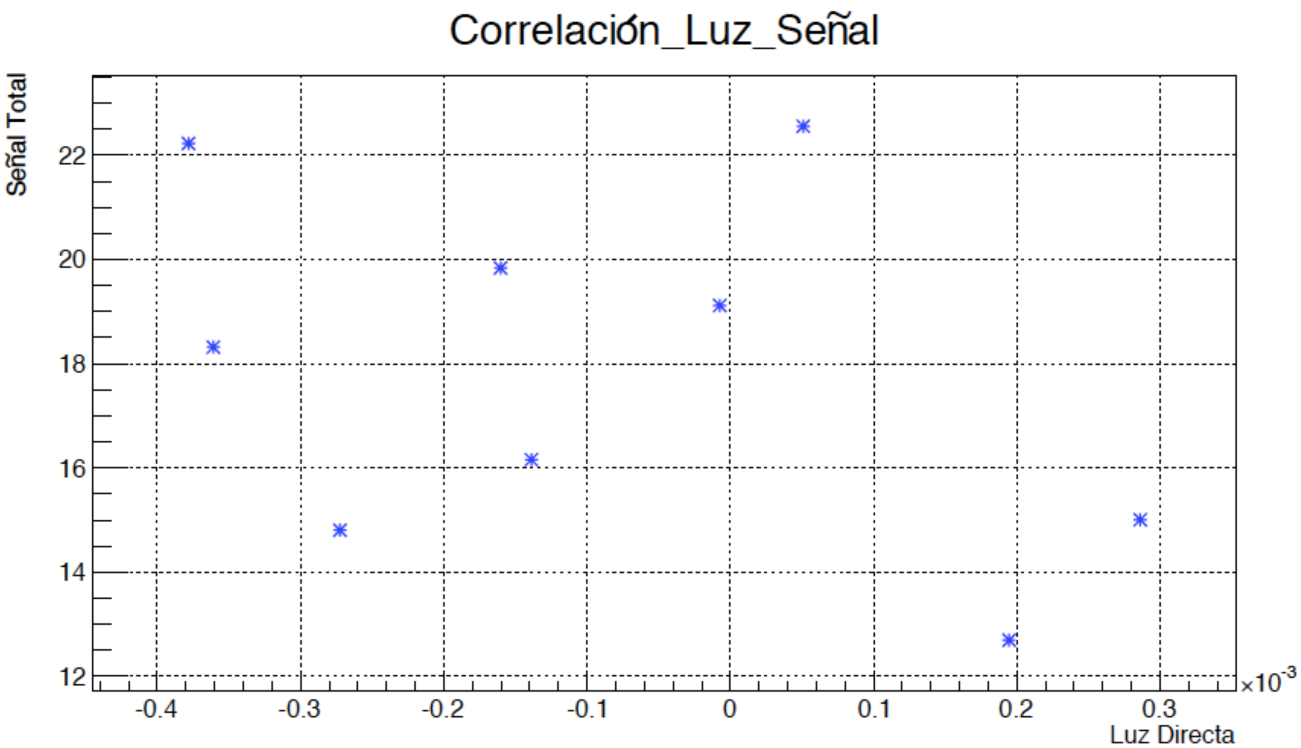
Time lines of Direct light vs Signal





- Both parameters show a change in time (effects of the PMT's aging in the total signal?)
- The correlation between both parameters is small (from -0.41 to 0.51 for all 9 stations)
- The change in time could provide information on the physical state of each tank
- There is a modulation observed, which could be related to other physical phenomena

Time lines of Direct light vs Signal



Correlation 0.51
for tank 338

- Both parameters show a change in time (effects of the PMT's aging in the total signal?)

  The correlation between both parameters is small (from -0.41 to 0.51 for all 9 stations)

  The change in time could provide information on the physical state of each tank

  There is a modulation observed, which could be related to other physical phenomena

Conclusions

- The evolution of the direct light at the SD stations, as a function of time, can be observed. It has been quantified for 9 stations
- A slightly change in the total signal as a function of time has been observed
- A modulation of the direct light as a function of time has been observed and must be studied
- Possible causes of the change in time of the direct light must be studied. Suggestions are the change in the quality of the water, ageing of the inner walls (tyvek), ageing of the PMT's, or variations in the temperature
- The change in time of the direct light has a minor impact in the temporal evolution of the total signal, since the correlation found is small. The impact on the total energy estimation is negligible due to the calibration procedure

Short term future

- The possible change in the slopes of characteristic lines could be used to estimate the aging of the PMTs or of other parts of the SD detector

- It is necessary to study the new modulation observed

- The same kind of study for PMTs in other conditions could be performed in order to study the ageing (ACORDE-ALICE-LHC)

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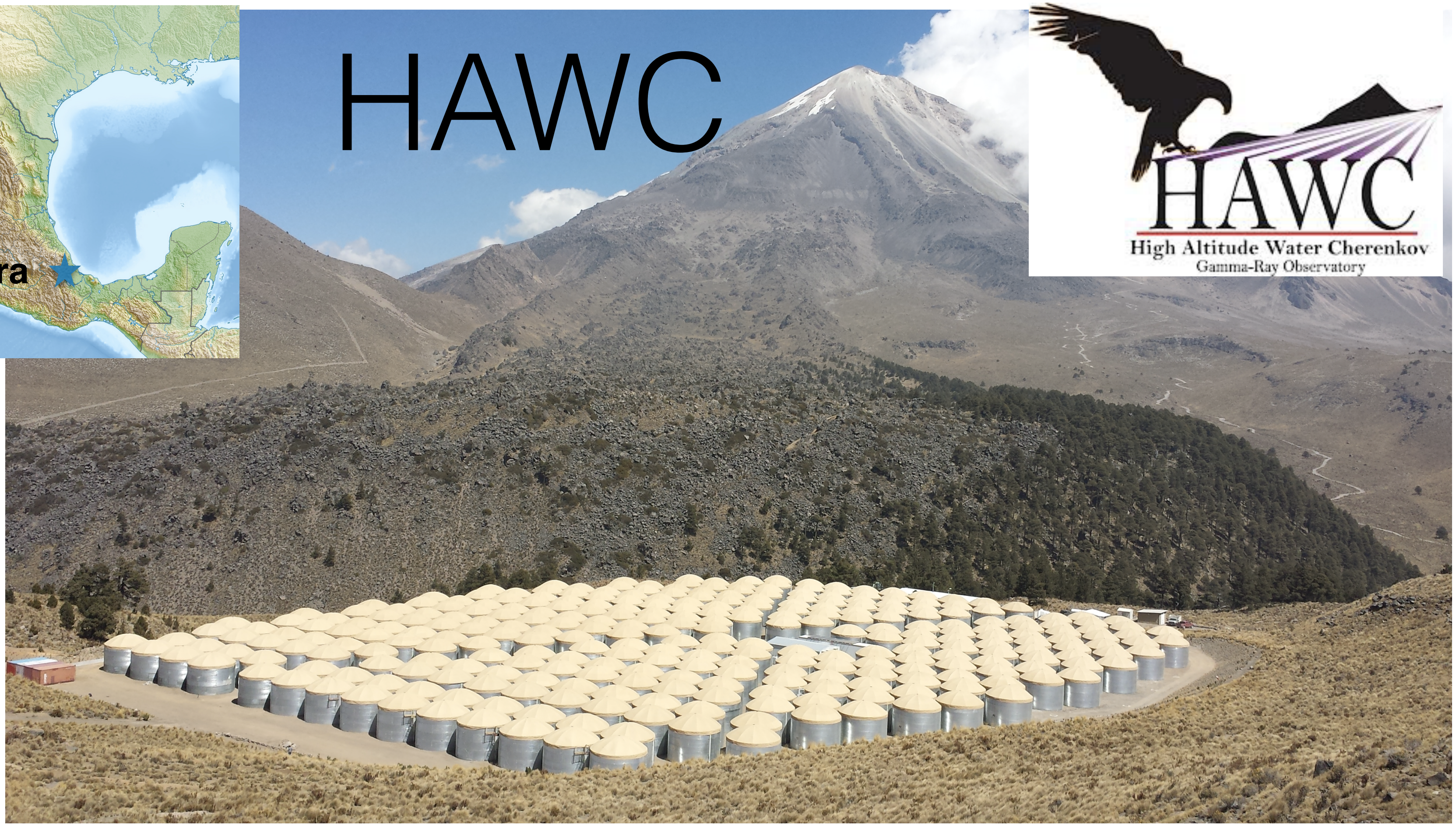
HAWC

HAWC
High Altitude Water Cherenkov
Gamma-Ray Observatory



300 WCD
4100 m
Latitude 19° N

USA, Mexico, Poland

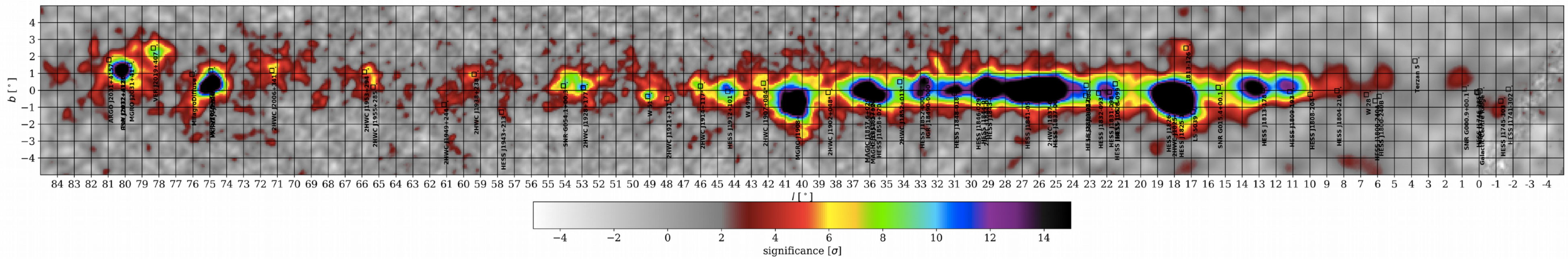
Angular resolution 0.1°-1.0°
Field of view 2sr (2/3 sky each day)
Effective Area 22500 m²
Sensitivity: ~Crab @ 5σ each day

Analysis for looking for new gamma ray sources from the galactic plane

José Iván Abadía Sarmiento, Cederik León de León Acuña and Karen S. Caballero Mora

Goal:

- To propose possible new sources of gamma rays at the galactic plane region, observed by HAWC
- To use the tools developed by HAWC to identify sources, based on likelihood analysis
- To compare results obtained by other instruments in order to confirm gamma ray sources



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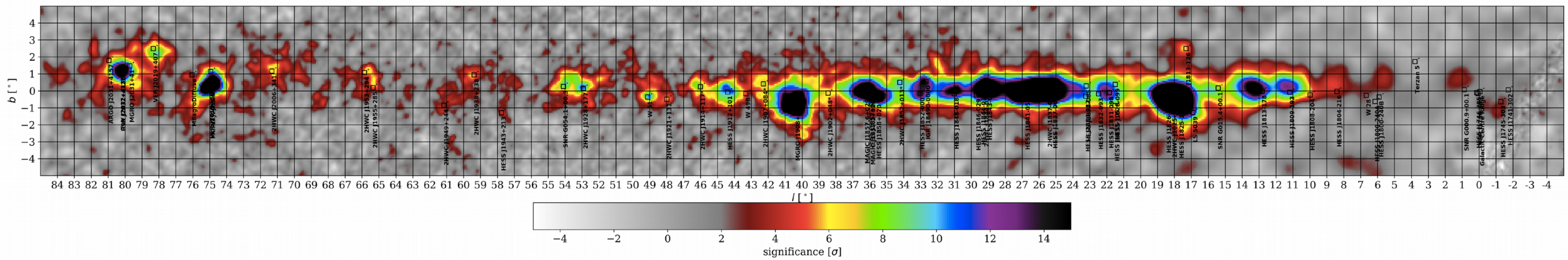
Analysis for looking for new gamma ray sources from the galactic plane

José Iván Abadía Sarmiento

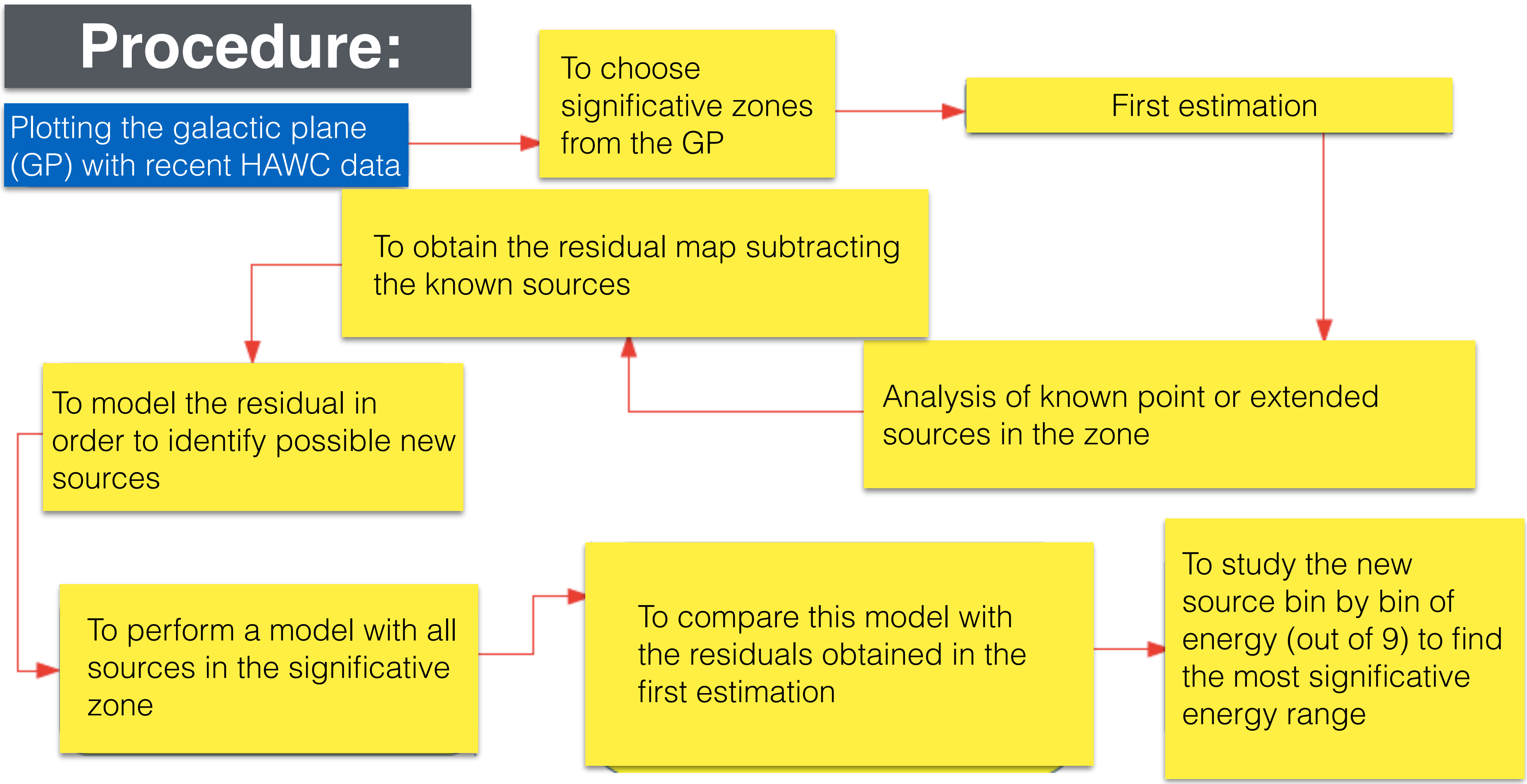
Method:

- A TS is defined and a maximum likelihood method is performed, all defined in 3ML software
- 3ML uses all available information on known sources in order to propose models to describe new candidates.
- The model is convoluted with the response of the instrument (HAWC) and it is compared with measurements. Then the maximum likelihood method is performed
- The method can be used also to disentangle sources and to discover possible new ones



Analysis for looking for new gamma ray sources from the galactic plane

José Iván Abadía Sarmiento

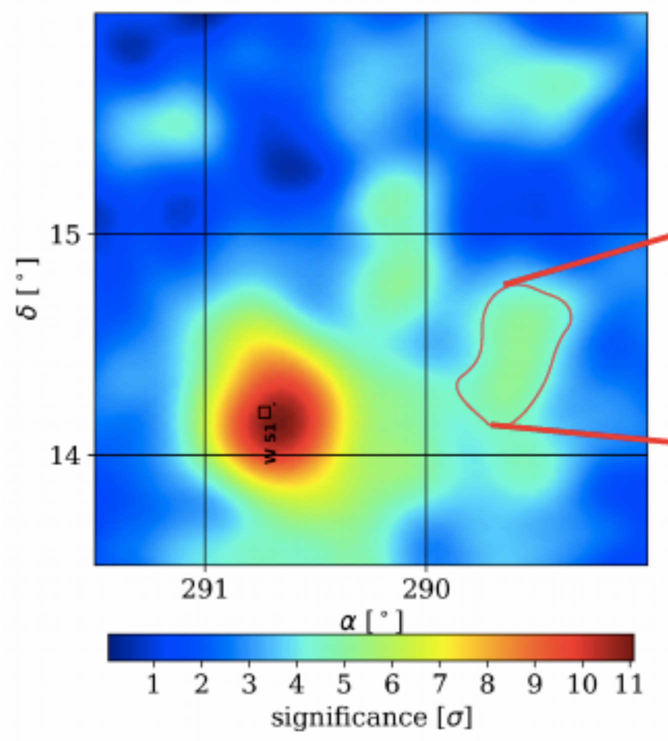


Analysis for looking for new gamma ray sources from the galactic plane

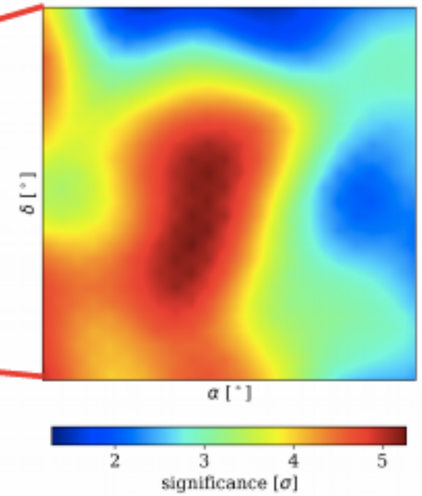
José Iván Abadía Sarmiento

Procedure:

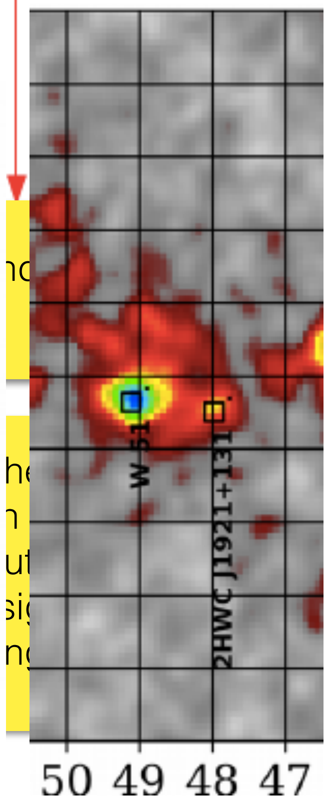
Plotting the galactic plane (GP) with recent HAWC data → To choose significative zones from the GP → First estimation



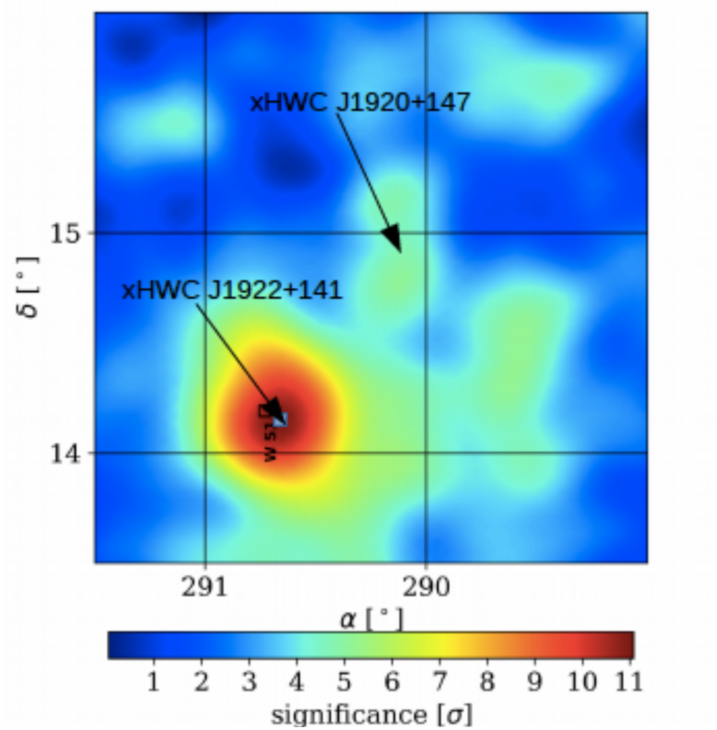
Source 2K



AR = 289.60
Dec = 14.36
SIGN. = 5.27



Analysis for looking for new gamma ray sources from the galactic plane



To choose significative zones from the GP

First estimation

the residual map subtracting
sources

Analysis of known point or extended sources in the zone

To compare this model with the residuals obtained in the first estimation

To study the new source bin by bin of energy (out of 9) to find the most significative energy range

xHWC J1922+141 PUNTUAL

RA = 290.65
Dec = 14.13
Flujo = 11.4 ± 1.2 x10^{-15} TeV^{-1} cm^{-2} s^{-1}
Indice = -2.7 ± 0.09

xHWC J1920+147 PUNTUAL

RA = 290.13
Dec = 14.75
Flujo = 4.8 ± 1.5 x10^{-15} TeV^{-1} cm^{-2} s^{-1}
Indice = -3.13 ± 0.19

MAP 20170929 COLAS RIVIERE/ Colaboración HAWC.

@gmail.com

Analysis for looking for new gamma ray sources from the galactic plane

José Iván Abadía Sarmiento

Procedure:

Plotting the galactic plane (GP) with recent HAWC data

To choose significative zones from the GP

To obtain the residual map subtracting the known sources

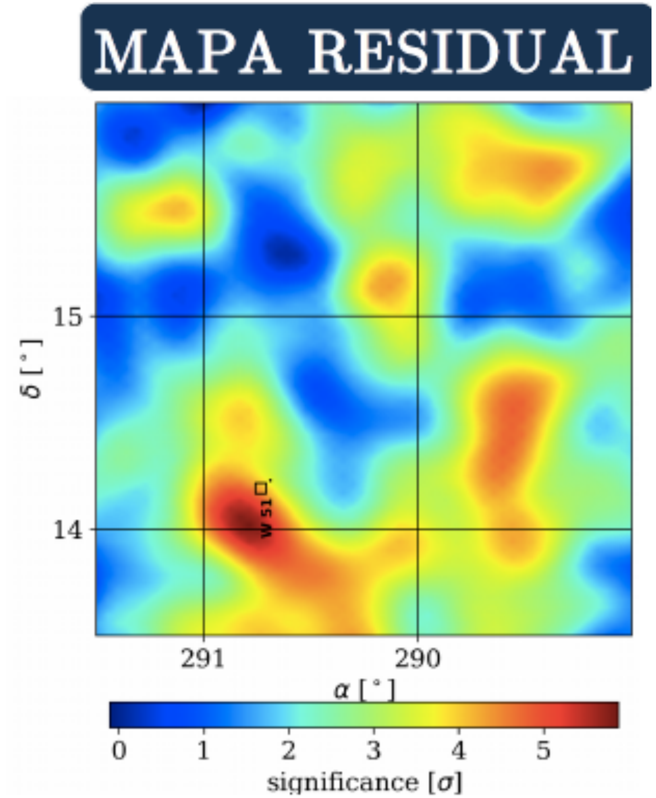
Analysis (sources i

To model the residual in order to identify possible new sources

To perform a model with all sources in the significative zone

To compare this model with the residuals obtained in th first estimation

energy range



Min: -0.11 (291.05, 16.02)
Max: 5.88 (290.79, 14.02)
Map value at origin: 2.23

Karen S. Caballero Mora UNACH karen.scm@gmail.com

Analysis for looking for new gamma ray sources from the galactic plane

José Iván Abadía Sarmiento

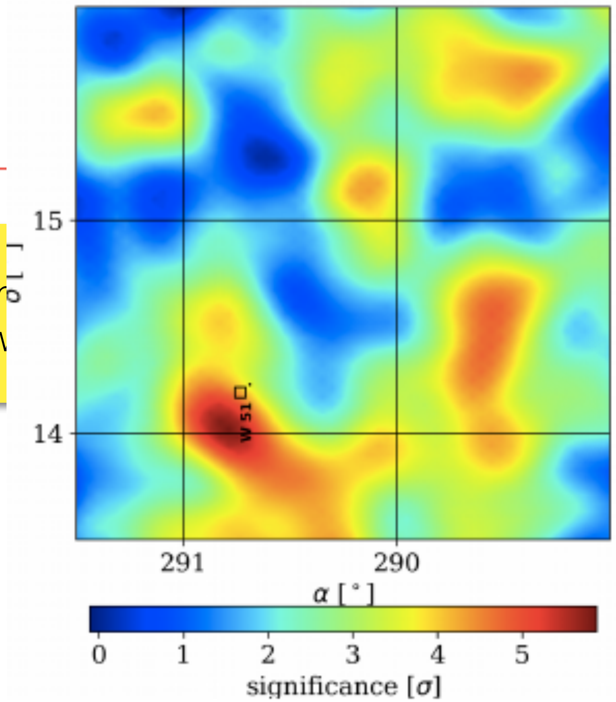
Procedure:

Plotting the galactic plane (GP) with recent HAWC data

To obtain
the know

To model the residual in order to identify possible new sources

To perform a model with all sources in the significative zone



Min: -0.11 (291.05, 16.02)
Max: 5.88 (290.79, 14.02)
Map value at origin: 2.23

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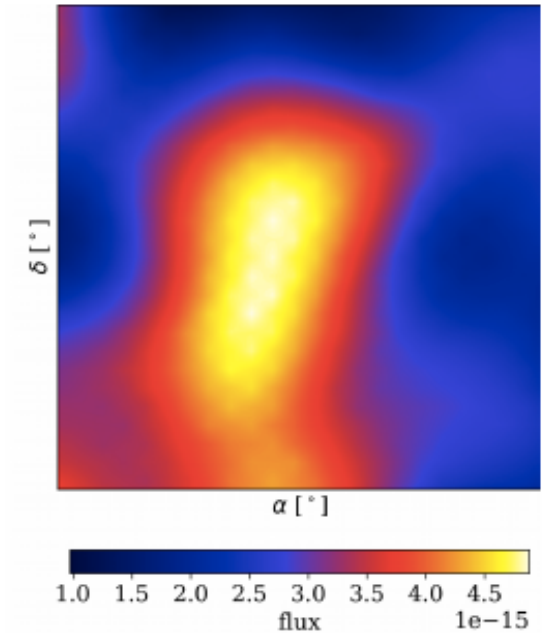


FLUJO RESIDUAL

Min: 9.73e-16 +/- 1.02e-15(289.73, 15.02)
Max: 4.88e-15 +/- 1.08e-15 (289.60, 14.36)
Map value at origin: 4.82e-15 +/- 1.07e-15

Analysis for looking for new gamma ray sources from the galactic plane

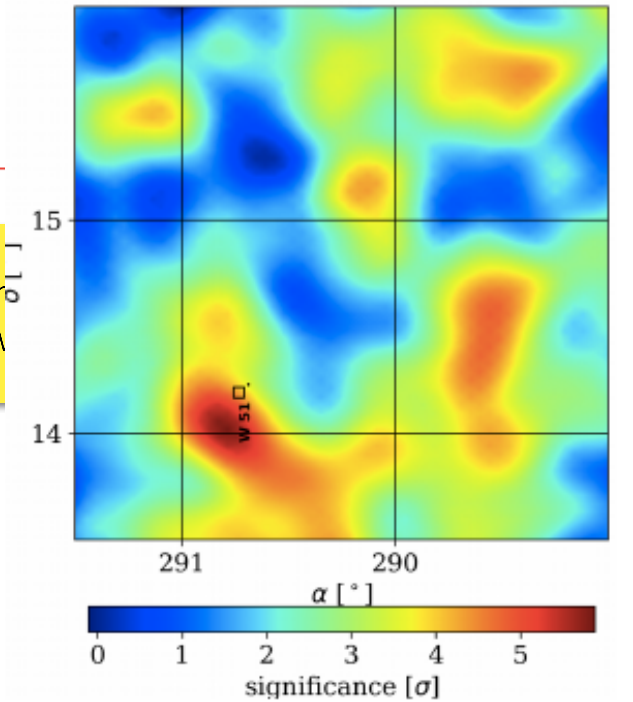
Procedure:

Plotting the galactic plane (GP) with recent HAWC data

To obtain the know

To model the residual in order to identify possible new sources

To perform a model with all sources in the significative zone



Min: -0.11 (291.05, 16.02)
Max: 5.88 (290.79, 14.02)
Map value at origin: 2.23

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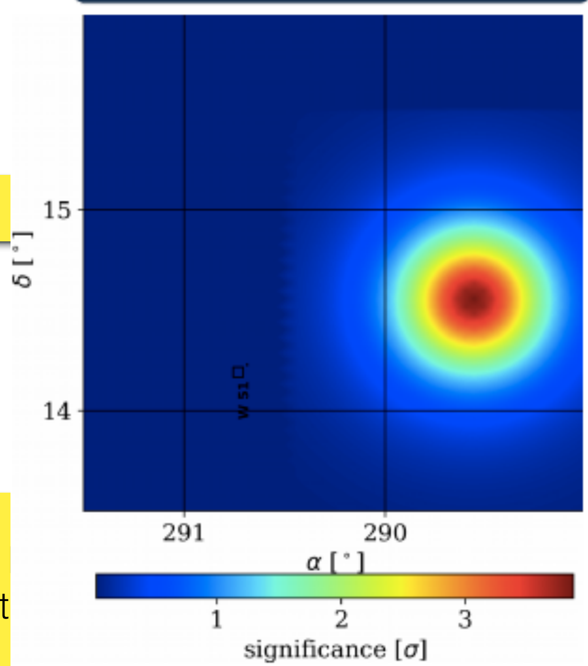
MODELO



POSIBLE NUEVA FUENTE. (FLUJO)
(4.6 -1.4 +1.3) x 10^-15

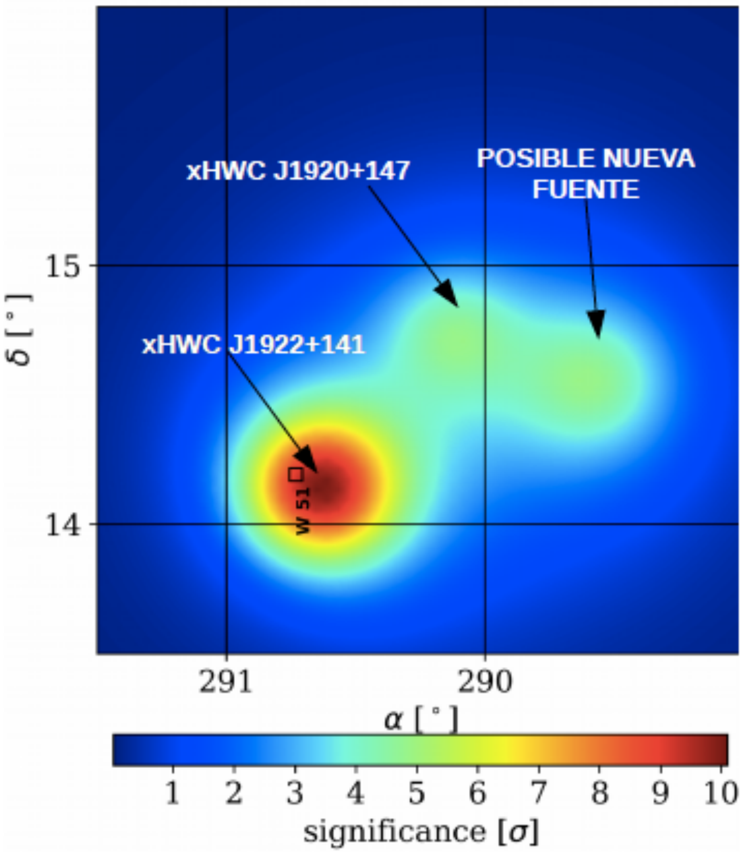
nd

POSIBLE NUEVA FUENTE.(ÍNDICE)
-3.13 -0.21 +0.20

TS: 23.2639
Signif.: 4.82326

Karen S. Caballero Mora UNACH karen.scm@gmail.com

Analysis for looking for new gamma ray from the galactic plane



PARÁMETROS DEL MEJOR FIT

xHWC J1922+141 (10.30 +/- 0.13) x 10^-15
xHWC J1922+141. -2.63 -0.10 +0.11

xHWC J1920+147. (2.4 -1.7 +1.5) x 10^-15
xHWC J1920+147. -2.5 -0.4 +0.5

POSIBLE FUENTE. (4.600 +/- 1.3) x 10^-15
POSIBLE FUENTE. -3.120 +/- 0.19

Test statistic: 144.744
Significance: 12.0309

irst estimation

he residual map subtracting sources

Analysis of known point or extended sources in the zone

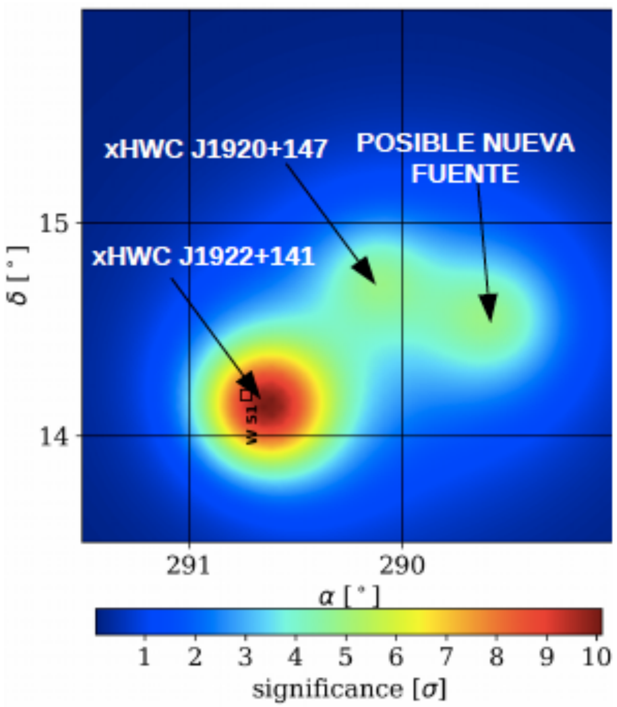
To perform a model with all sources in the significative zone

To compare this model with the residuals obtained in the first estimation

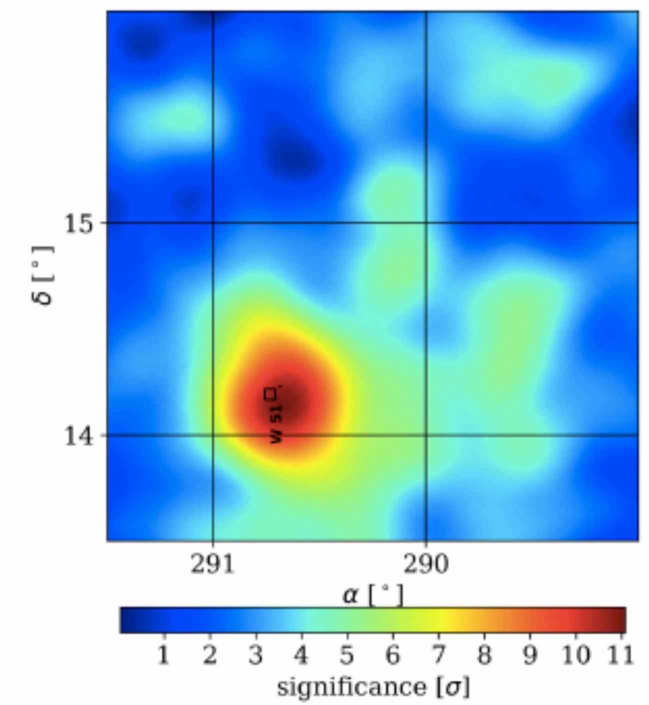
To study the new source bin by bin of energy (out of 9) to find the most significative energy range

Karen S. Caballero Mora UNACH karen.scm@gmail.com

Analysis for looking for new gamma ray fr... plane



Min: 0.01 (291.49, 16.02)
Max: 10.10 (290.65, 14.13)
Map value at origin: 4.51



Min: 0.04 (291.05, 16.02)
Max: 11.08 (290.65, 14.13)
Map value at origin: 4.85

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First estimation

wn point or extended
zone

sources

To perform a model with all sources in the significative zone

To compare this model with the residuals obtained in the first estimation

To study the new source bin by bin of energy (out of 9) to find the most significative energy range

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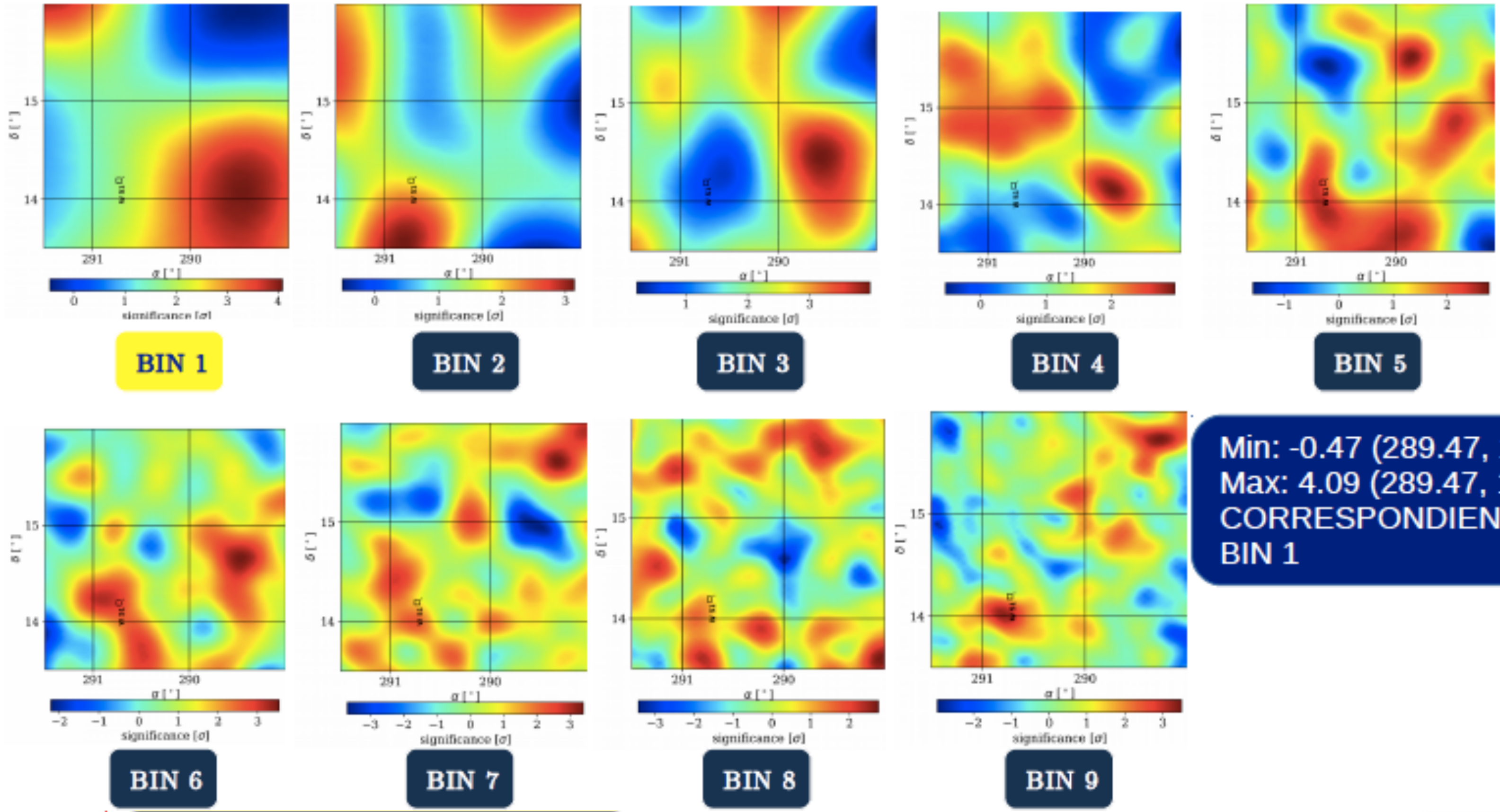
Analysis for looking for new gamma ray



Min: -0.47 (289.47, 15.95)
Max: 4.09 (289.47, 14.09)
CORRESPONDIENTE AL BIN 1

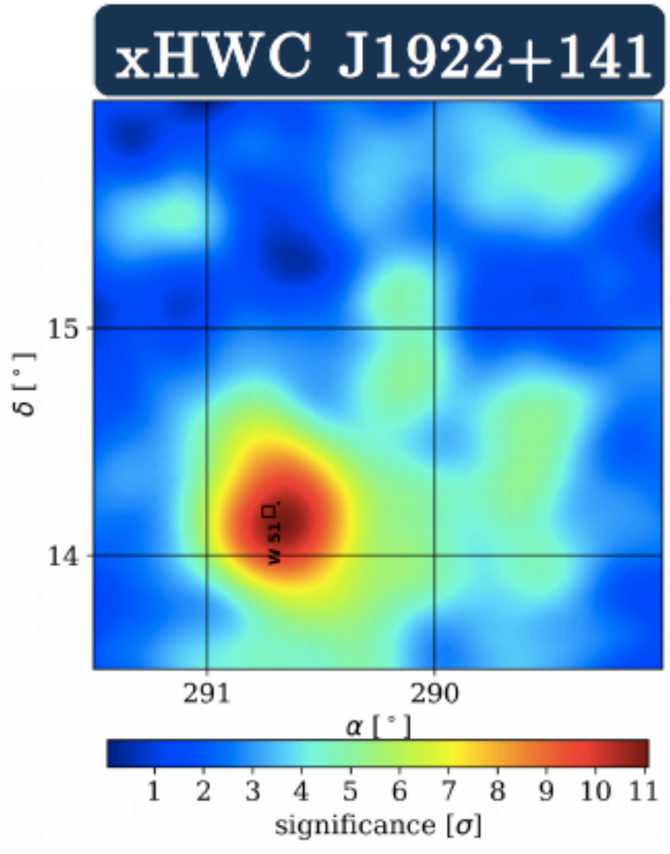
d

To perform a model with all sources in the significative zone

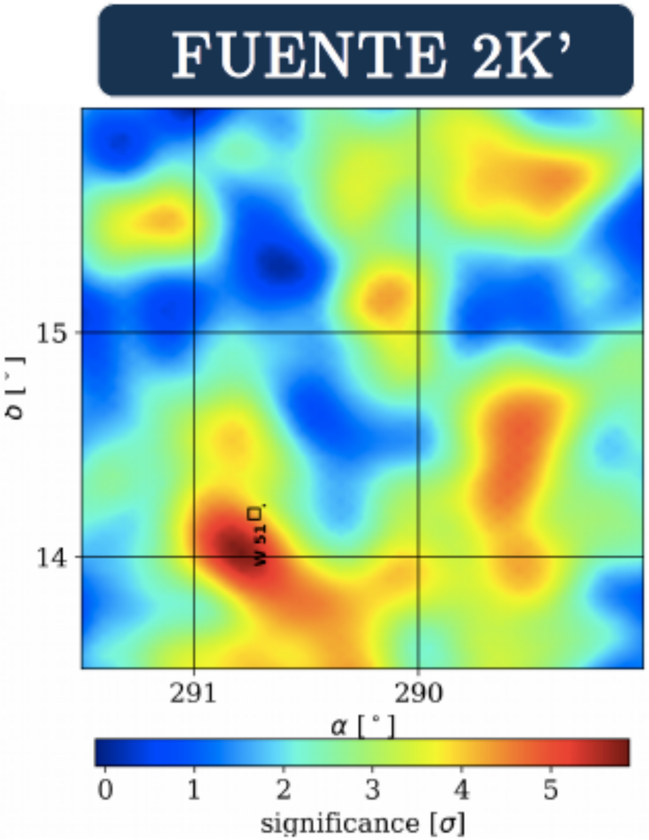
To compare this model with the residuals obtained in the first estimation

To study the new source bin by bin of energy (out of 9) to find the most significative energy range

Another possible new source appears after subtracting, disentangling from the known sources



Min: 0.04 (291.05, 16.02)
Max: 11.08 (290.65, 14.13)



Min: -0.11 (291.05, 16.02)
Max: 5.88 (290.79, 14.02)

2K' was overlapped with source xHWC J1922+141

Both sources are near to W51 observed by MILAGRO (290.73,14.19)

2K' and xHWC J1922+141 do not coincide exactly with W51

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Conclusions and future work

- A procedure based on 3ML methods has been developed
- Two possible new gamma ray sources from the galactic plane are proposed, namely 2K(289.56,14.55) and 2K' (291.05,16.02)

- The procedure is being improved by taking into account HAWC angular resolution and by using all energy bins when performing the model

- A characterization of the sources at an astrophysical level is to be done

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Estimation of the energy for Cosmic Rays with HAWC

Fidel Estrada Jiménez

Method:

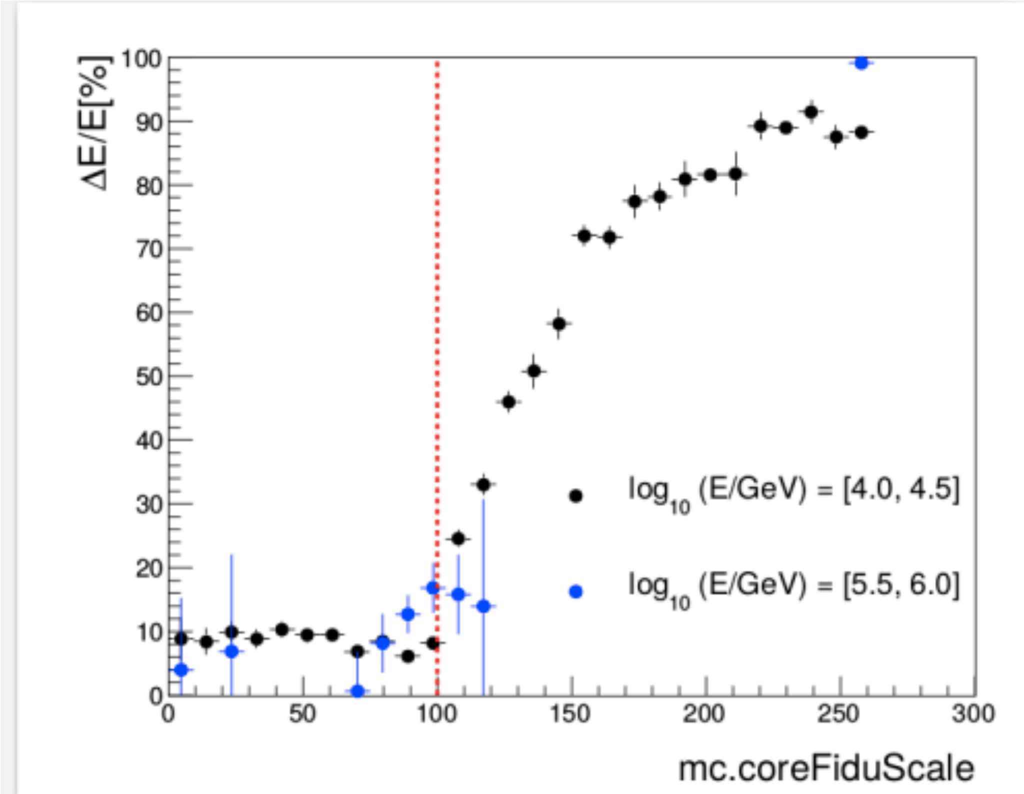
- The core of the shower must be estimated with accuracy in order to be able to correctly describe the lateral distribution of the shower on the surface
- Templates based on simulations of proton and iron primaries are performed
- The core position and energy from templates will be compared with the information from measurements
- The comparison is made through a maximum likelihood analysis
- The template corresponding to the maximum likelihood according to the measurements will give information on energy and core position

Estimation of the energy for Cosmic Rays with HAWC

Fidel Estrada Jiménez, JC Arteaga-Velázquez, KS Caballero Mora

Goal:

- To improve the estimation of the energy for Cosmic Rays in HAWC for vertical and inclined events



Motivation:

- The larger the distance from HAWC center, the worst the energy estimation
  - This becomes more important for inclined showers
- The energy estimation is optimized for gammas but not for Cosmic Rays

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Method:

- The core of the shower must be estimated with accuracy to correctly describe the energy of the primary cosmic ray

- Templates based on simulations of proton primaries are performed
  - Templates for calculation of shower energy in HAWC introduced by Zig and Vikas
  - Templates used in this method:
    - log10(Qeff) vs (x_sdc,y_sdc) instead of r_sdc
    - Produced in energy bines of 0.10 in log10(E/GeV), for the total range $1.95 < \log10(E/GeV) < 6.25$
    - One template per energy bin, a total of 42 templates.
    - Zenith angle in the range $0^\circ < \theta < 11.17^\circ$
    - The core of the produced shower is at the center of the template (z axis)
    - The early part of the shower is at +x_sdc
    - and the late part is at -x_sdc, this could be important for inclined events for possible asymmetries in the signal
    - To perform the test, a grid of size x = [-100, 150] m and y = [160, 340] m with cells of 10 m side is considered.
    - The analysis is done on the shower plane (x_sdc,y_sdc)

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Method:

- How to use the templates?
  - Considering a measured event, positions of the PMTs are transformed to shower disk coordinates.
  - A comparison is performed with a Chi2 test to find the template with the maximum Chi2 probability of agreement with the measured log10(Qeff)
  - The number of the template will give the corresponding energy and the core position will be also determined from the test.

- This method can be applied to inclined showers since the shape of the shower front on the array is taken into account

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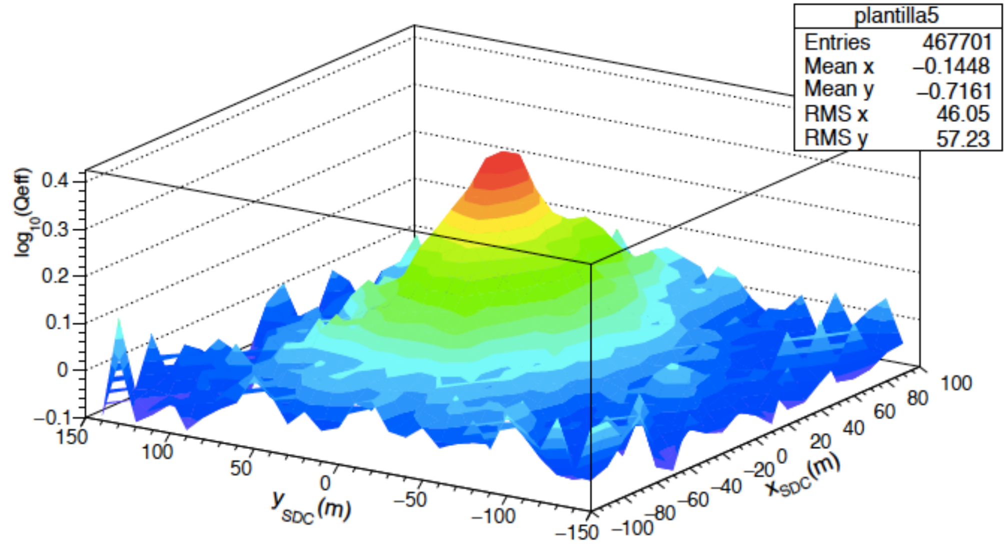
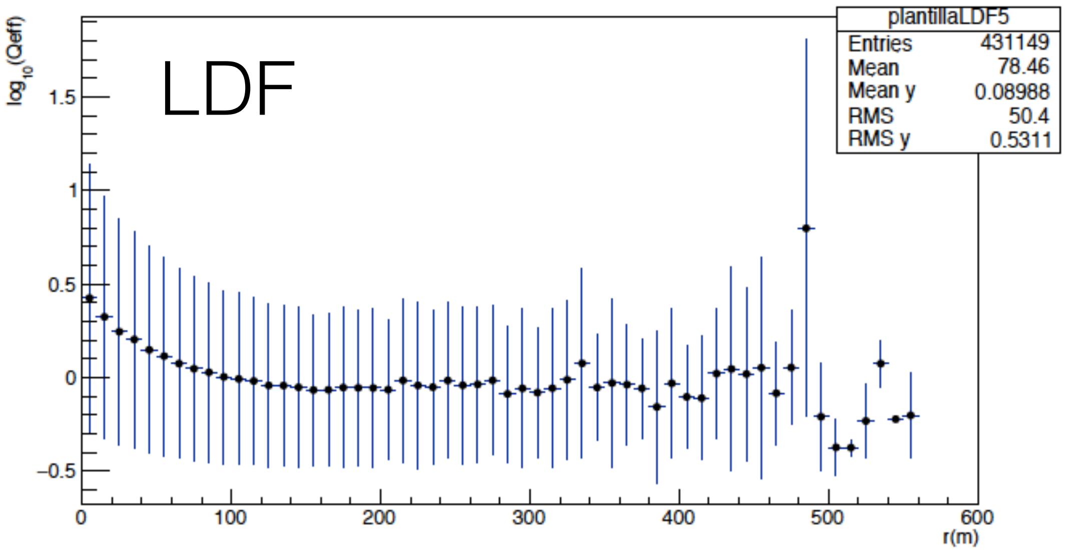
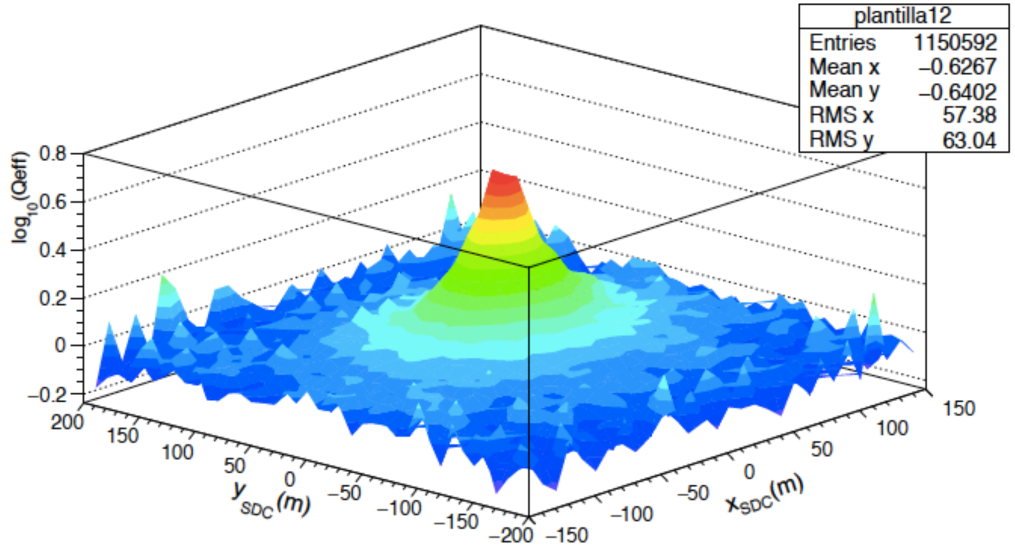
Examples

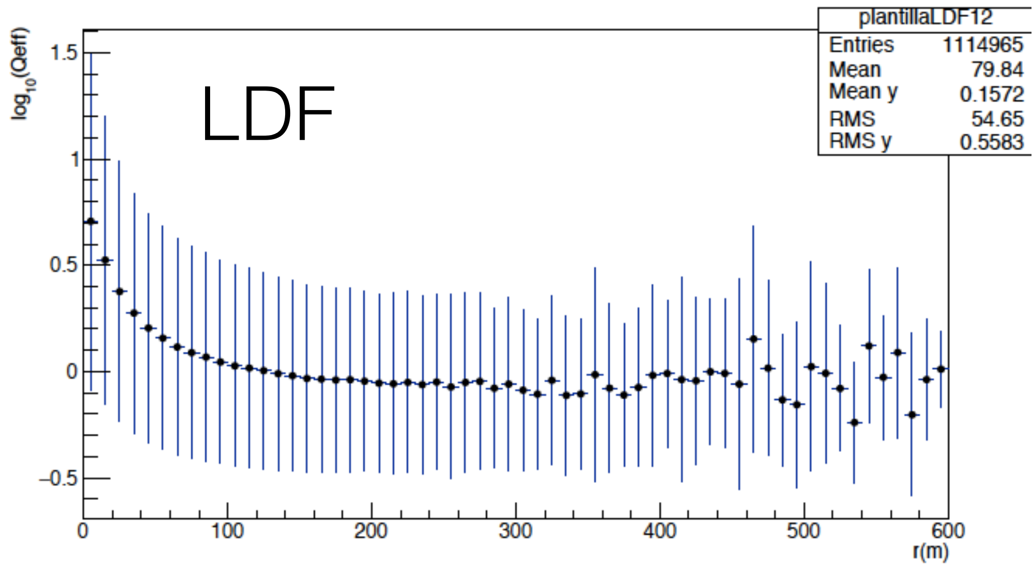
Template 5, Energy:
2.35 < log10(E/GeV) < 2.45





Template 12, Energy:
3.05 < log10(E/GeV) < 3.15

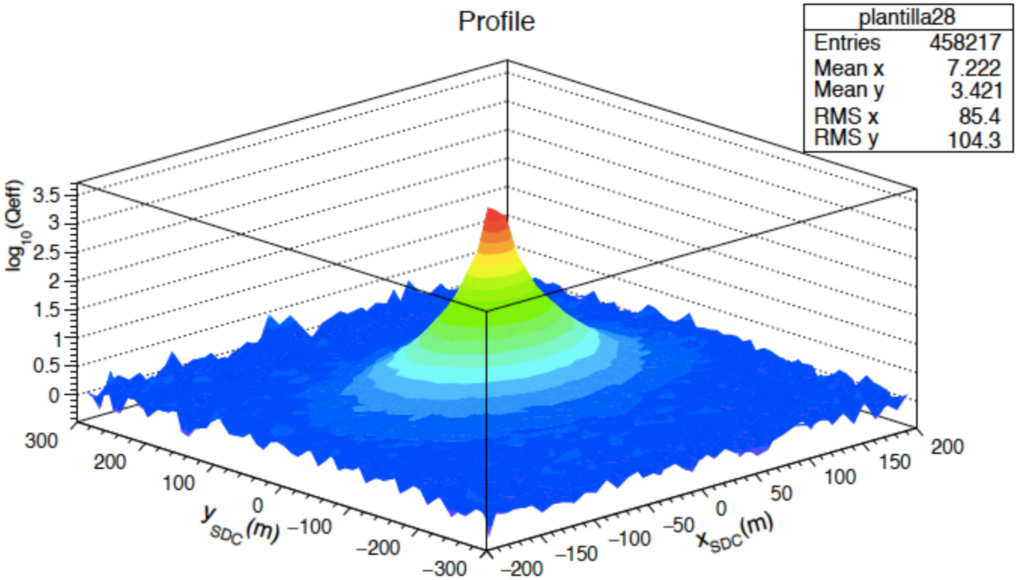


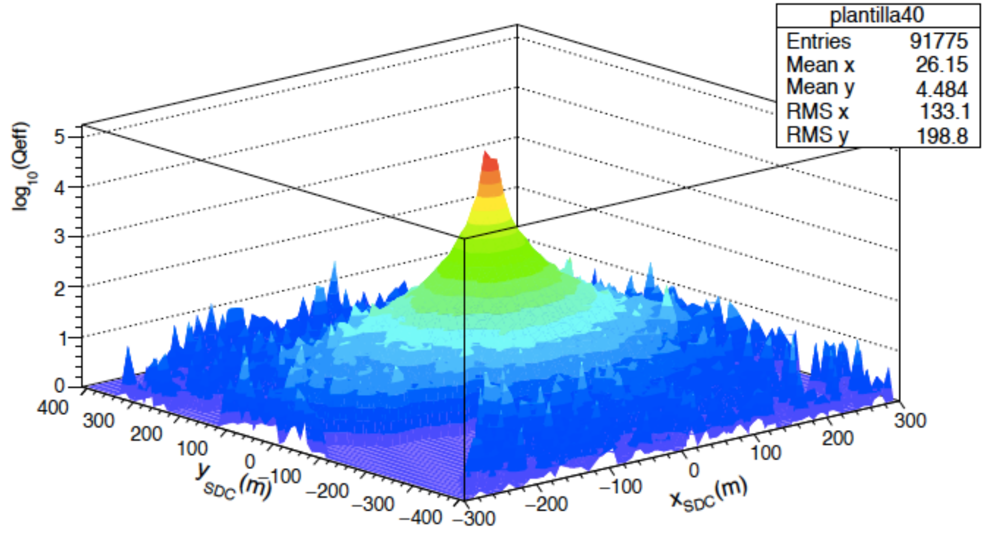


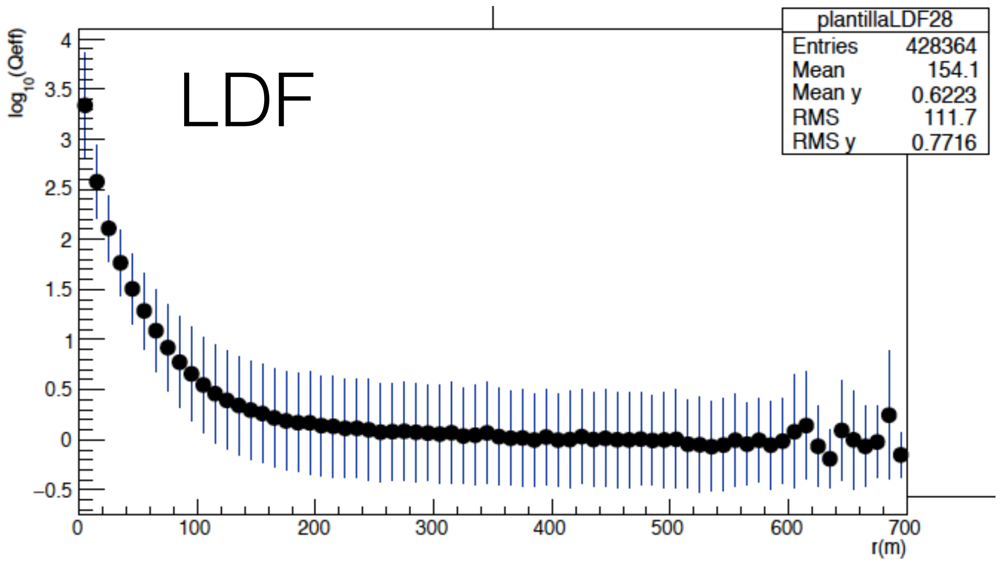
Examples

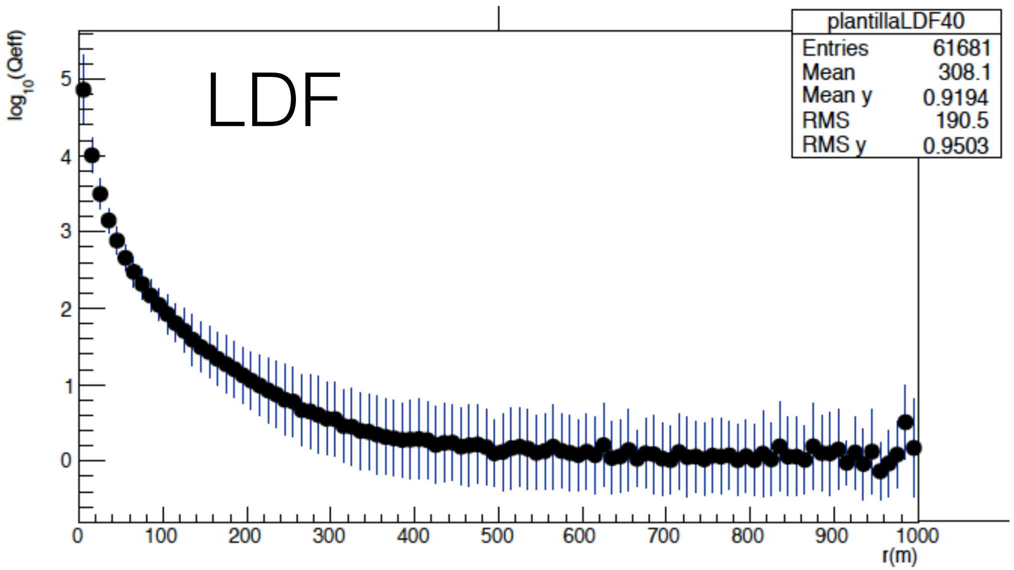
Template 28, Energy:
4.65 < log10(E/GeV) < 4.75

Template 40, Energy:
5.85 < log10(E/GeV) < 5.95



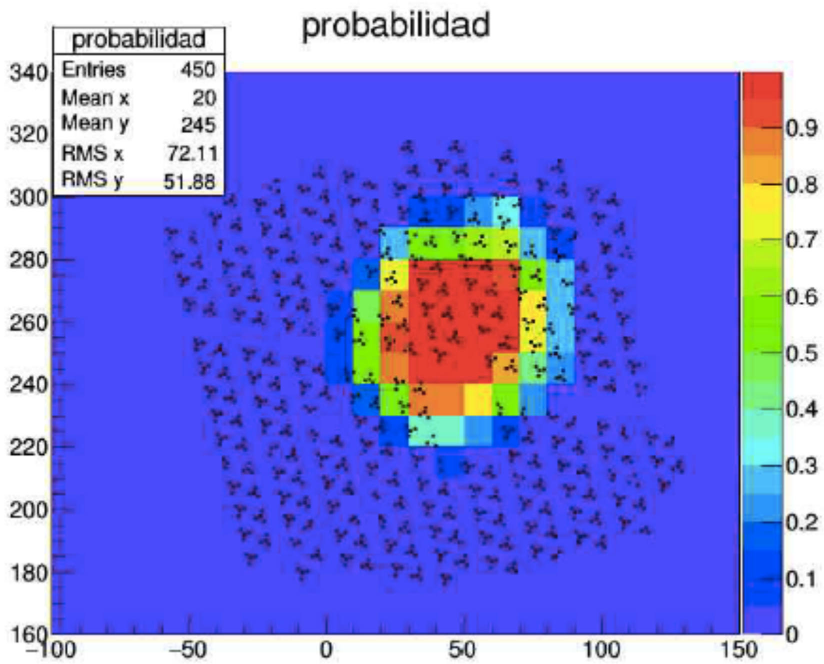






Estimation of the energy for Cosmic Rays with HAWC

The templates are calculated at the shower disk plane



Results of the fit for a MC proton event		
Rx **True**	Ry **True**	log10(ETrue/GeV)
59.27	247.01	2.951
Rx **Estimated**	Ry **Estimated**	Chi2
40	250	235.632
Chi2 Probability	No. **Template**	Corefiduscale
0.99984	14	29

Template 14 corresponds to
log10(ERec/GeV) = 3.3
True energy is log10(ETrue/GeV) = 2.951
—> ~12% Relative error

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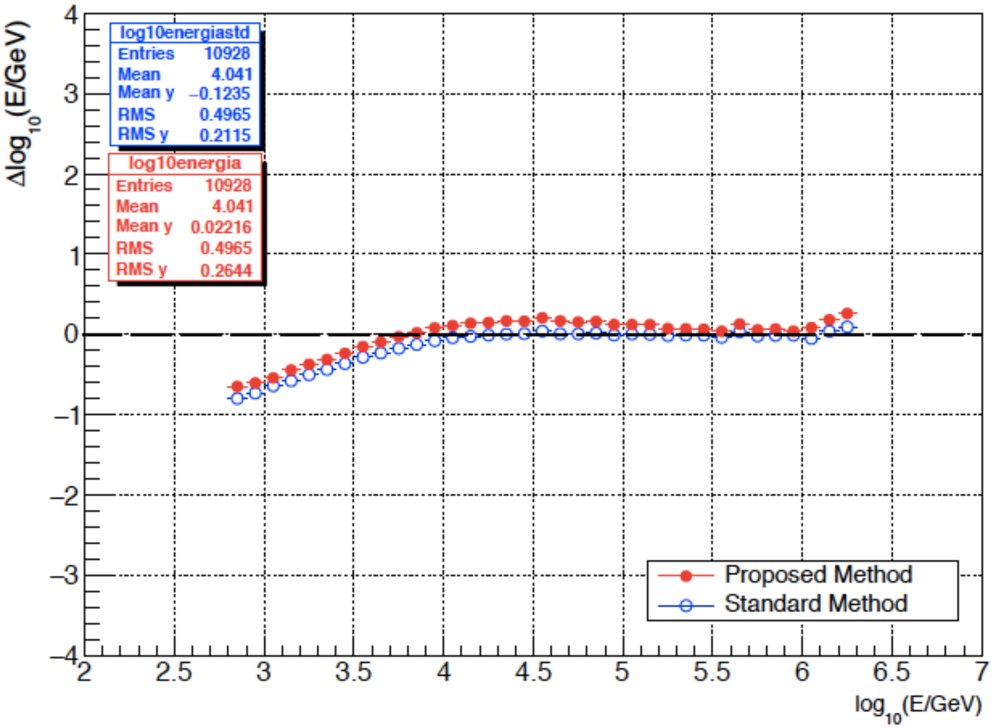
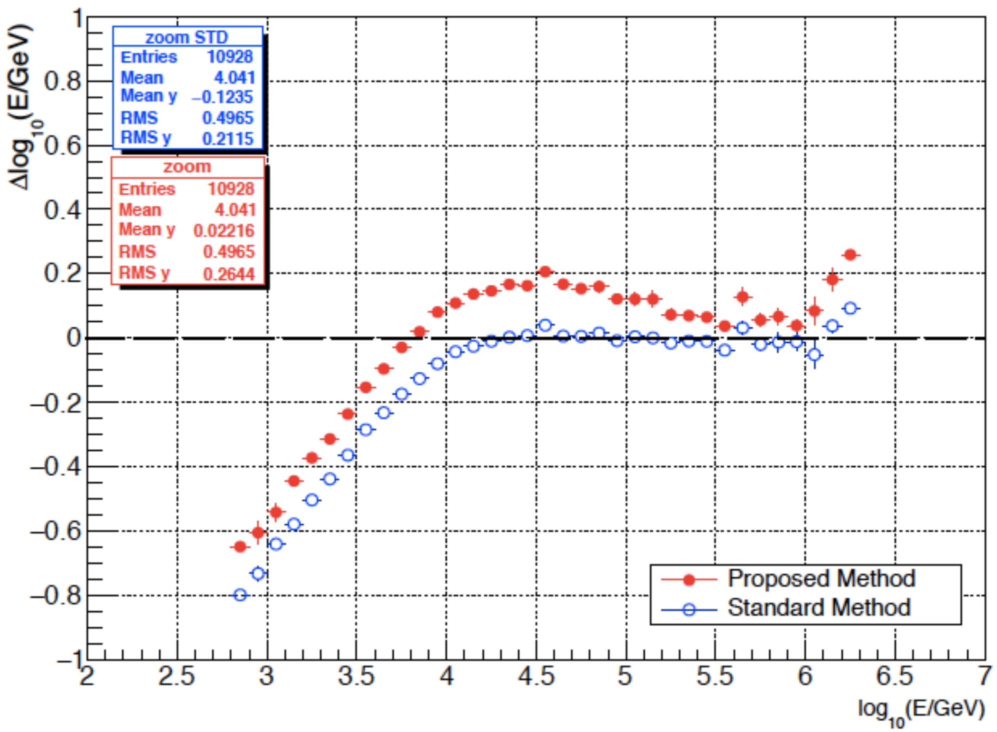
Results

- A first study with 0° < θ < 11.17° and 1.95 < log10(E/GeV) < 6.25 for simulated proton showers is presented

Comparison of the energy estimation using the standard method (blue) by Zig, with the proposed method (red)
The maximum difference is ~0.2 log10(E/GeV)



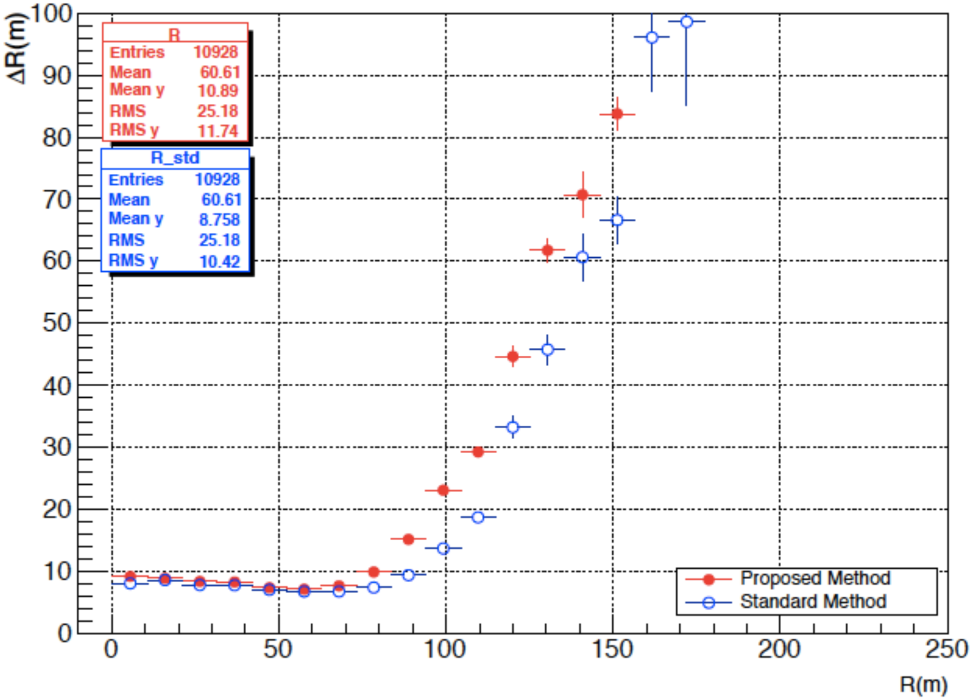


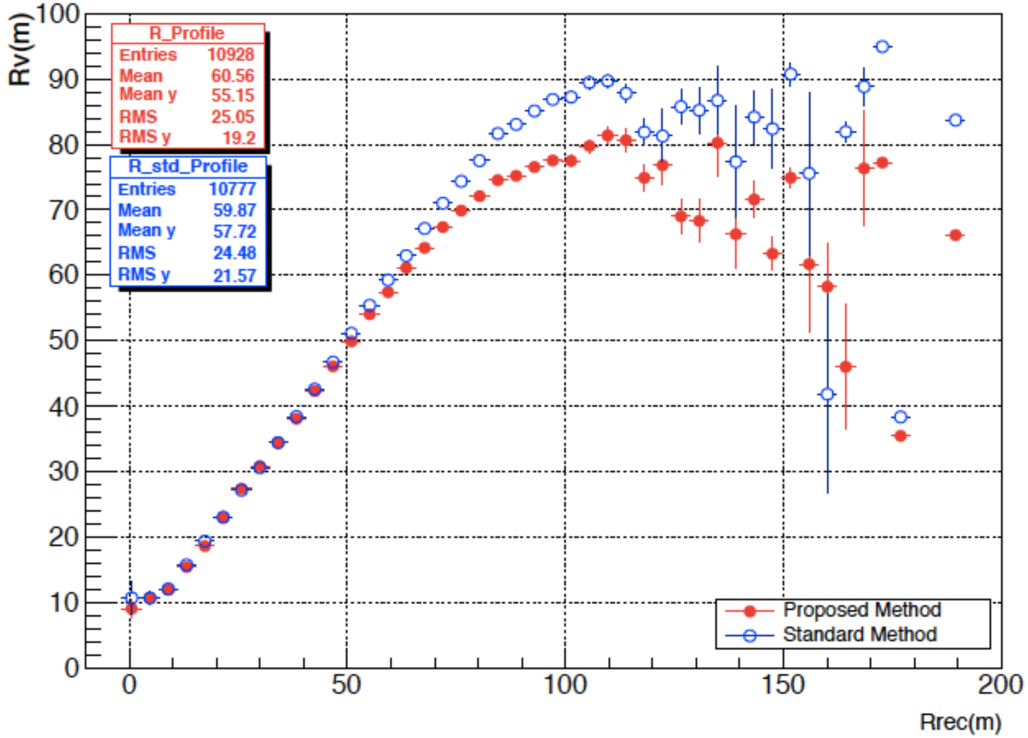
Test with simulations

Karen S. Caballero Mora UNACH karen.scm@gmail.com

Results

Comparison of the core estimation using the standard method (blue) with the proposed method
Good agreement from 0m to 90m





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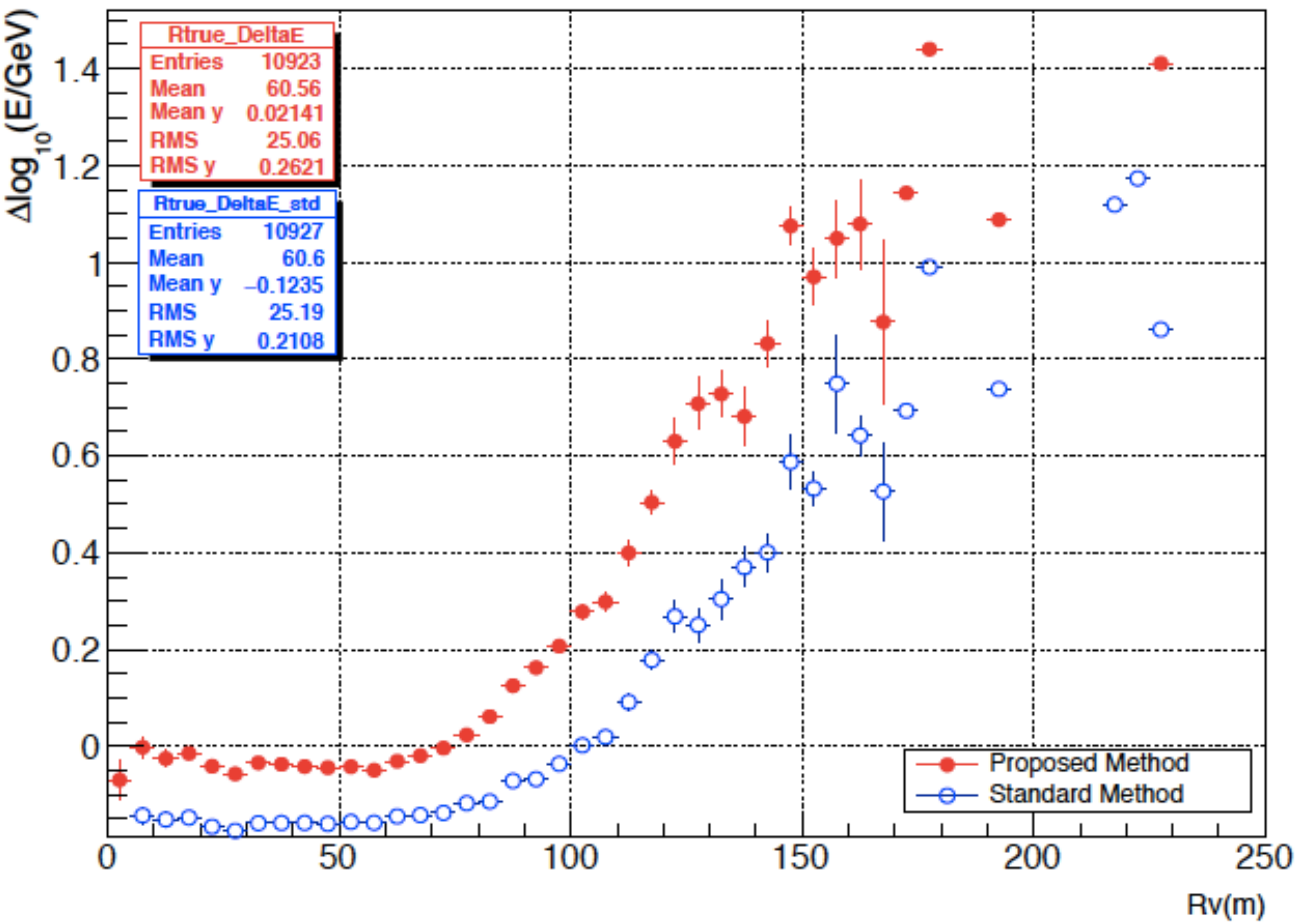
Results

As a function of the core position, the energy estimation obtained from the proposed method works fine from 0m to 90m, where the core position is estimated accurately



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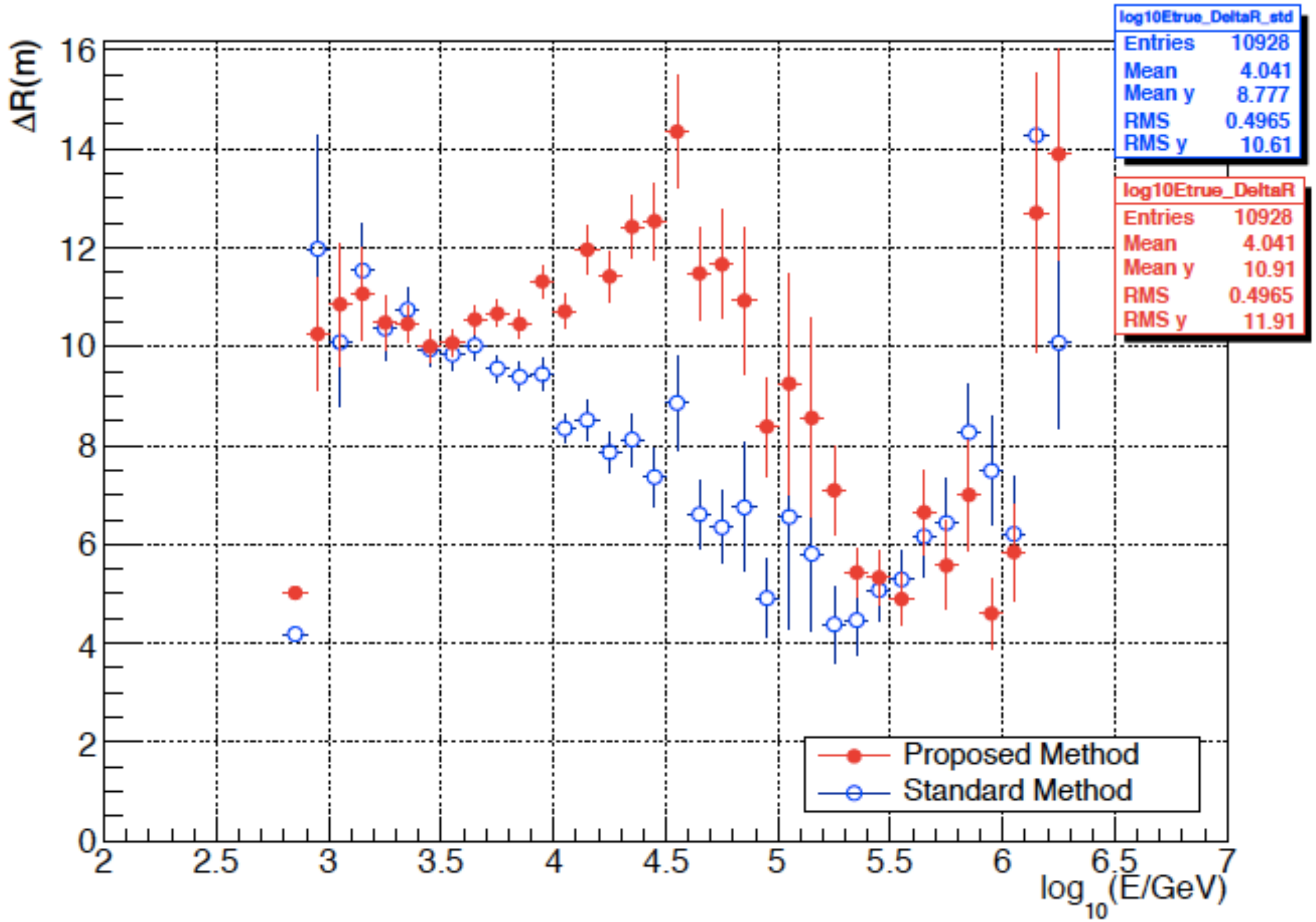
Results

As a function of the energy, the core estimation obtained from the proposed method is in good agreement with the standard estimation in the ranges:

2.9 GeV < log10(E/GeV) < 3.7 GeV and
4.8 GeV < log10(E/GeV) < 6.1 GeV



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Conclusions and future work

- A procedure based on simulations for estimating the energy of the vertical and inclined showers produced by cosmic rays measured by HAWC is being developed, the first very preliminary results have been presented
- Method motivated by the need to include possible asymmetries from inclined events
- It is being tested and can be improved (improvement with LL for instance)
- Systematic errors of events far from the center of HAWC are larger for this method than for the standard one
- On average the method reproduces in good agreement the core position for distances from 0m to 90m, and for low and high energies, but at intermediate energies there seems to be a bias with respect to the standard estimation which has to be investigated
- The method must be explored for more zenith angle ranges (inclined showers)
- The method will be tested using the core obtained with the standard estimation
- Templetes built with proton and iron are going to be tested

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Escaramujo Project

Luis Rodolfo Pérez Sánchez, Víctor Manuel López Luna y Tadeo Dariney Gómez Aguilar

The Escaramujo Project provided a series of hands-on laboratory courses on High Energy Physics and Astroparticle Instrumentation in Latinamerican Institutions. The Physicist Federico Izraelevitz traveled on a van, from Chicago to Buenos Aires.

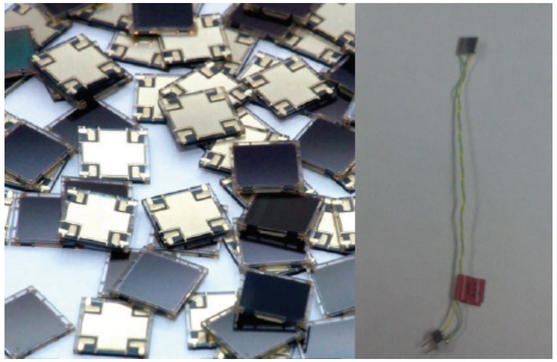
The courses took place at Institutions in México, Guatemala, Costa Rica, Colombia, Ecuador, Perú, Bolivia, Brasil, Paraguay and Argentina, at an advanced undergraduate or graduate level

All institutions remain linked as a community that can contribute to the larger worldwide efforts in cosmic ray science through data collection and analysis.

It initiated in Chiapas on August, 2015.
Finished in February, 2016 in Argentina

http://www.escaramujo.net

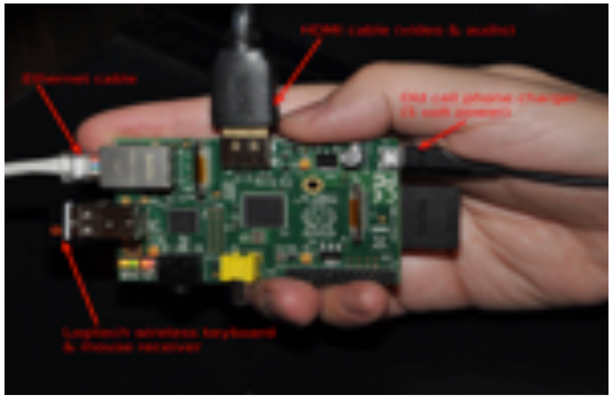
The detector



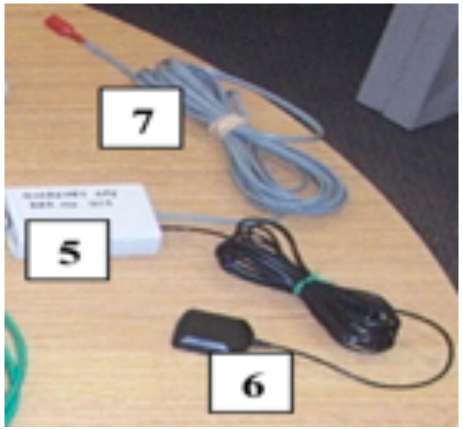
3-Plastic scintillators (EJ-200) and 3-SiPM MicroFC-60035-SMT, SensL

Monitor

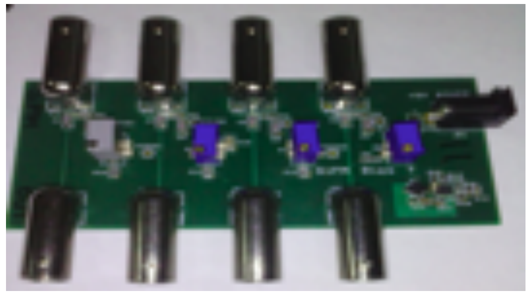
The readout is done with a time-to-digital converter board (QuarkNet)
Four input channels.



Data is collected with a Raspberry PI2, single board computer.



5. GPS module. 6. GPS antenna 7. Temperature sensor.

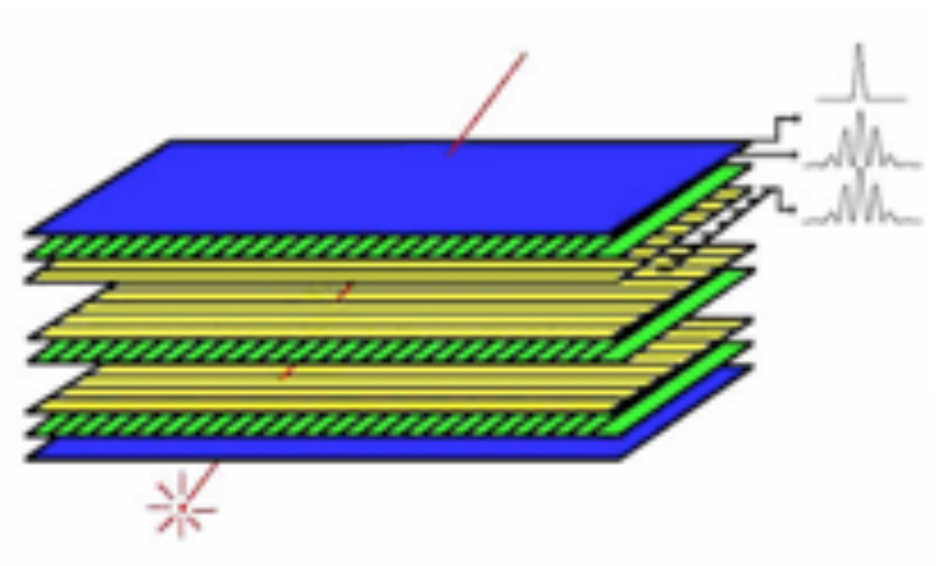


Preamplifier to set the bias voltage, 27 V to 36 V.

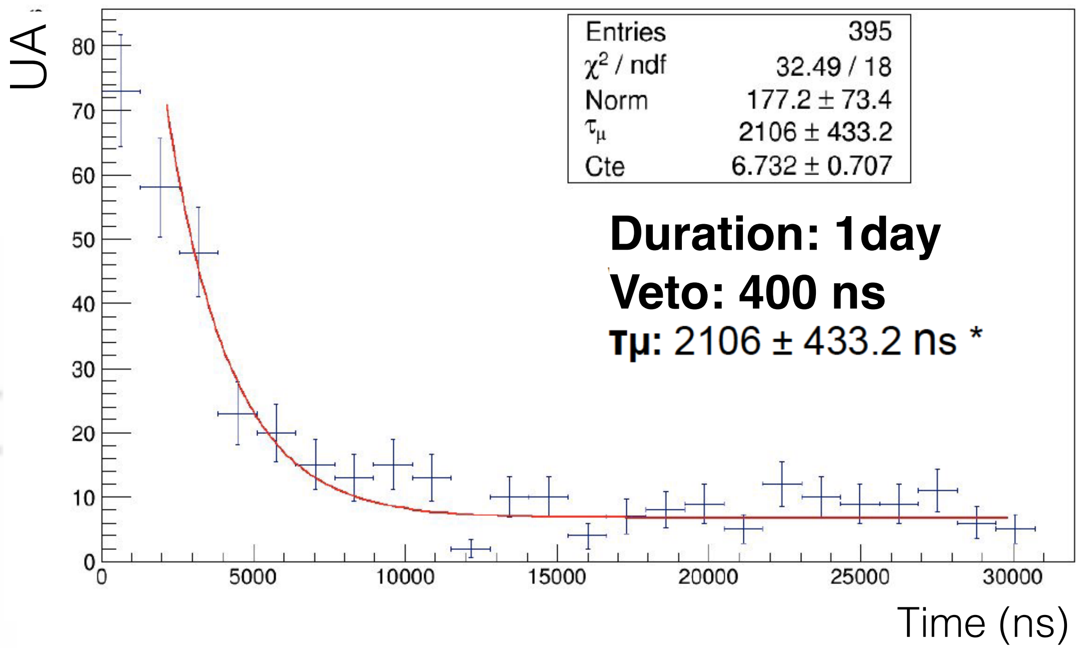
http://www.escaramujo.net

Some measurements

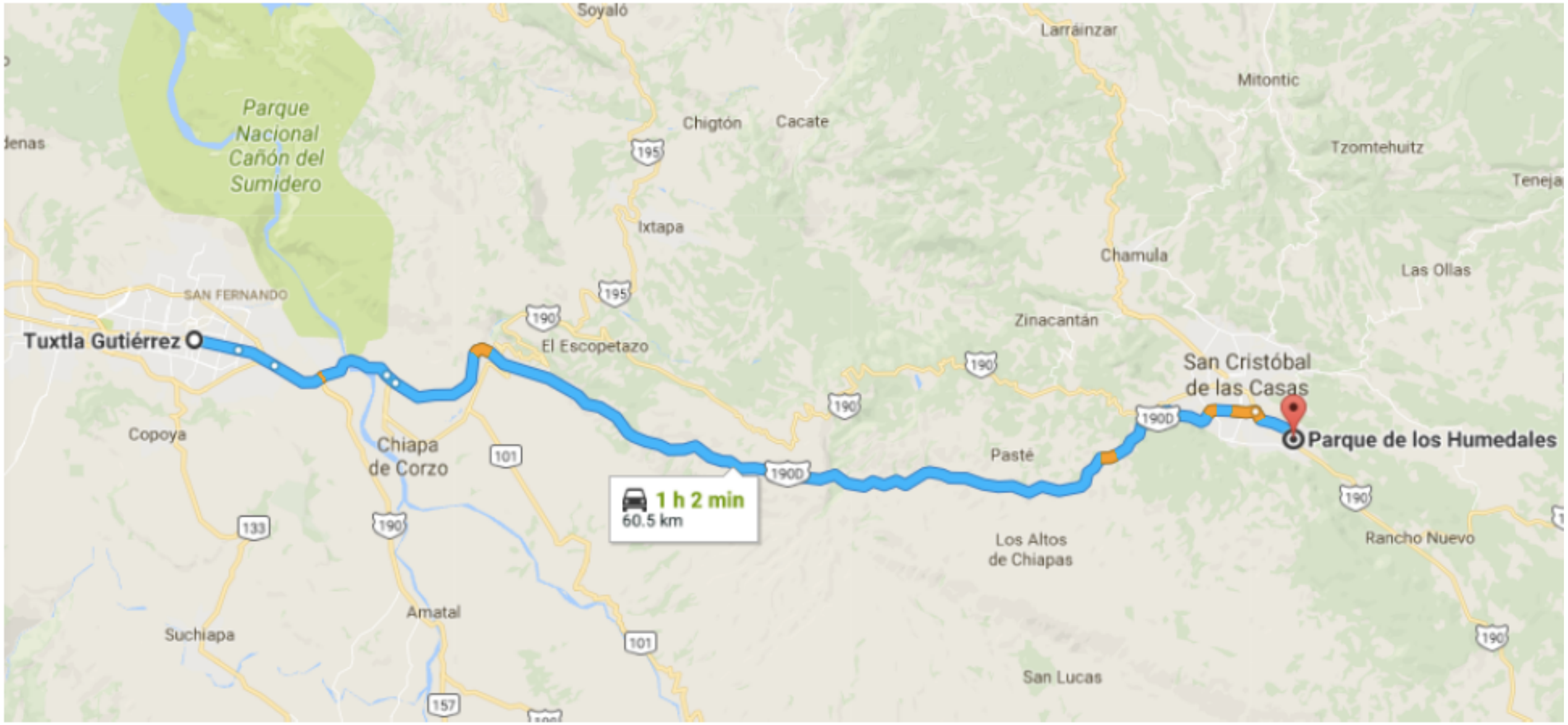
- 2-fold coincidences
- 3-fold coincidences
- Muon lifetime
- Muons' flux
- Laboratory lectures



Muon lifetime

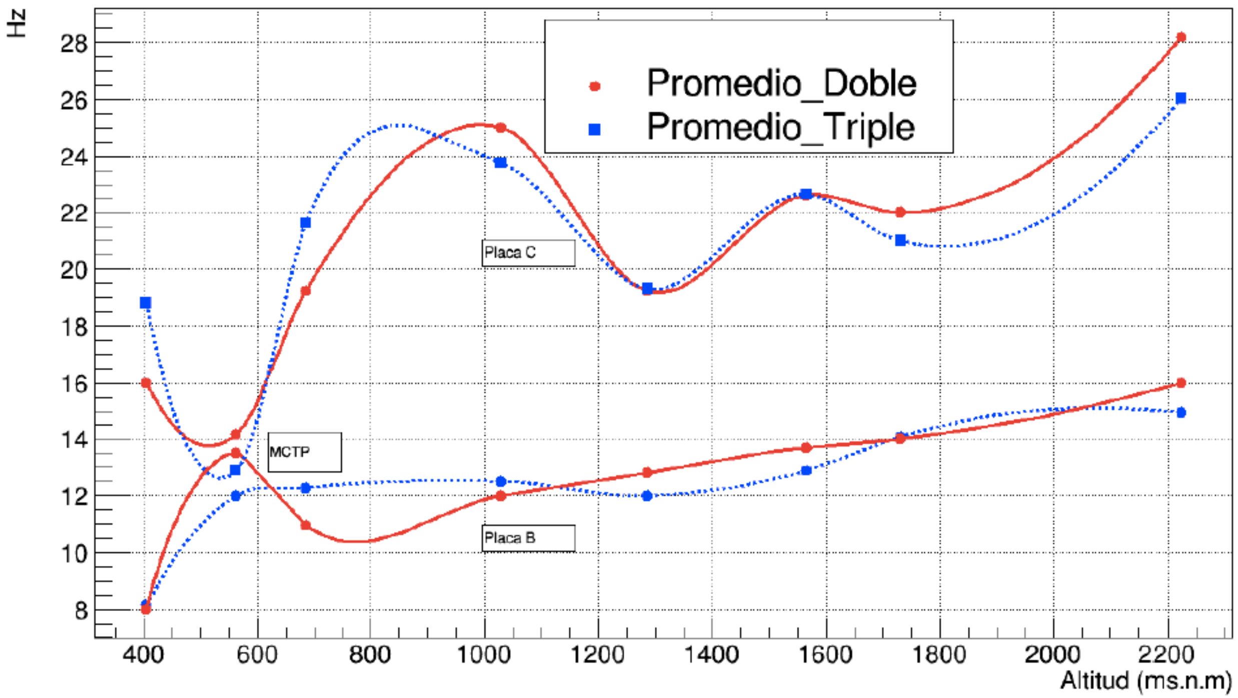


Muon's flux as function of the altitude

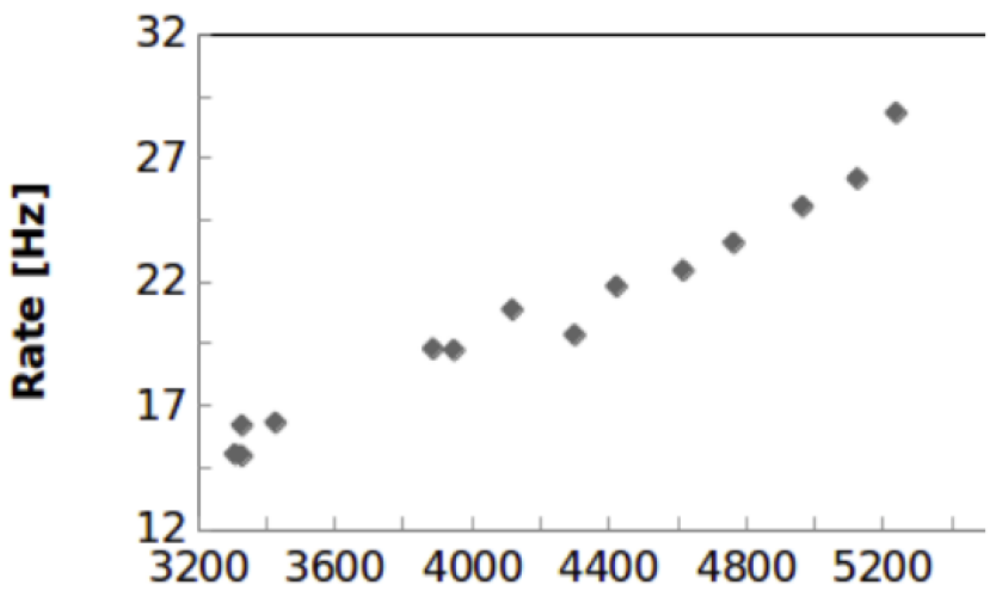


Road followed for performing the measurements
Measurement done during 5 minutes in each point

Muon’s flux as function of the altitude



Results measurements in each plate
Plate C presented problems



Results obtained with Escaramujo in Bolivia
The increase of the rate, according to plate B is in agreement, around 10 units for the whole measurement

Muon's flux as function of the altitude

$Altitud(m.s.n.m)$	$\Phi \quad triple(m^{-2}s^{-1})$	$\Phi \quad doble(m^{-2}s^{-1})$
404,943	129,93	128,26
562,626	207,73	216,35
685,484	196,71	175,13
1028,411	200,4	207,73
1285,916	201,06	204,88
1565,927	206,46	219,26
1731,779	225,66	229,6
2221,653	239,06	255,9

Obtained with Escaramujo in Chiapas

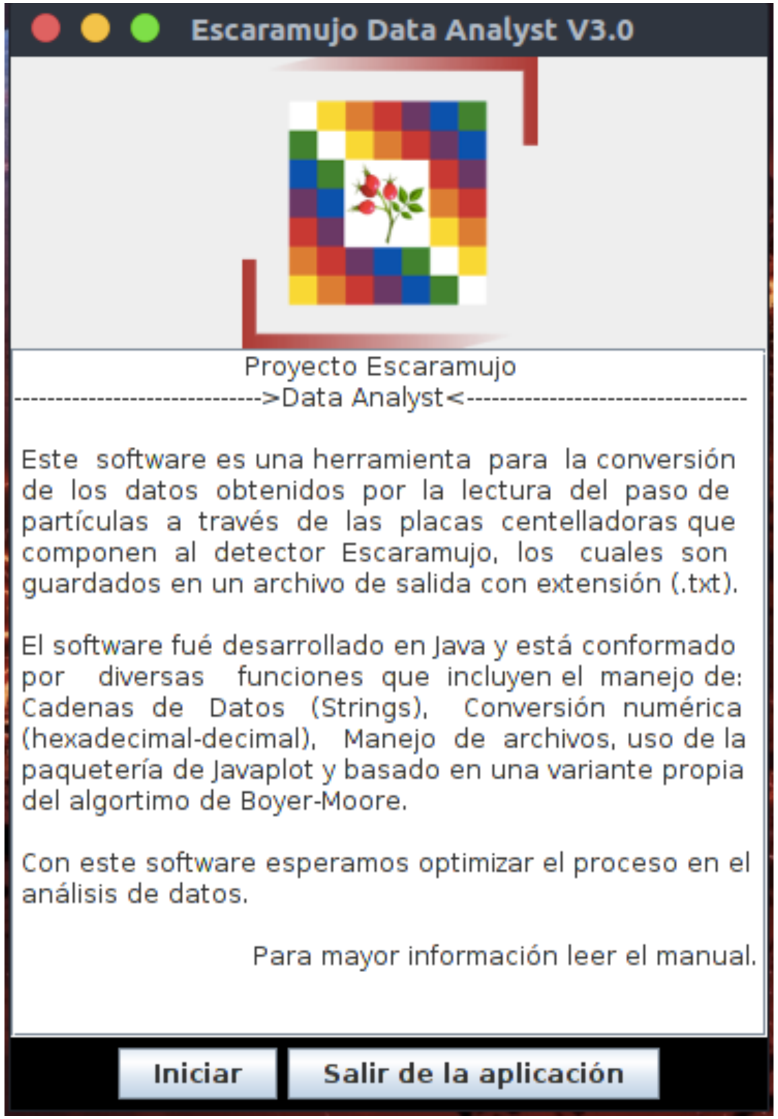
Similar results than:

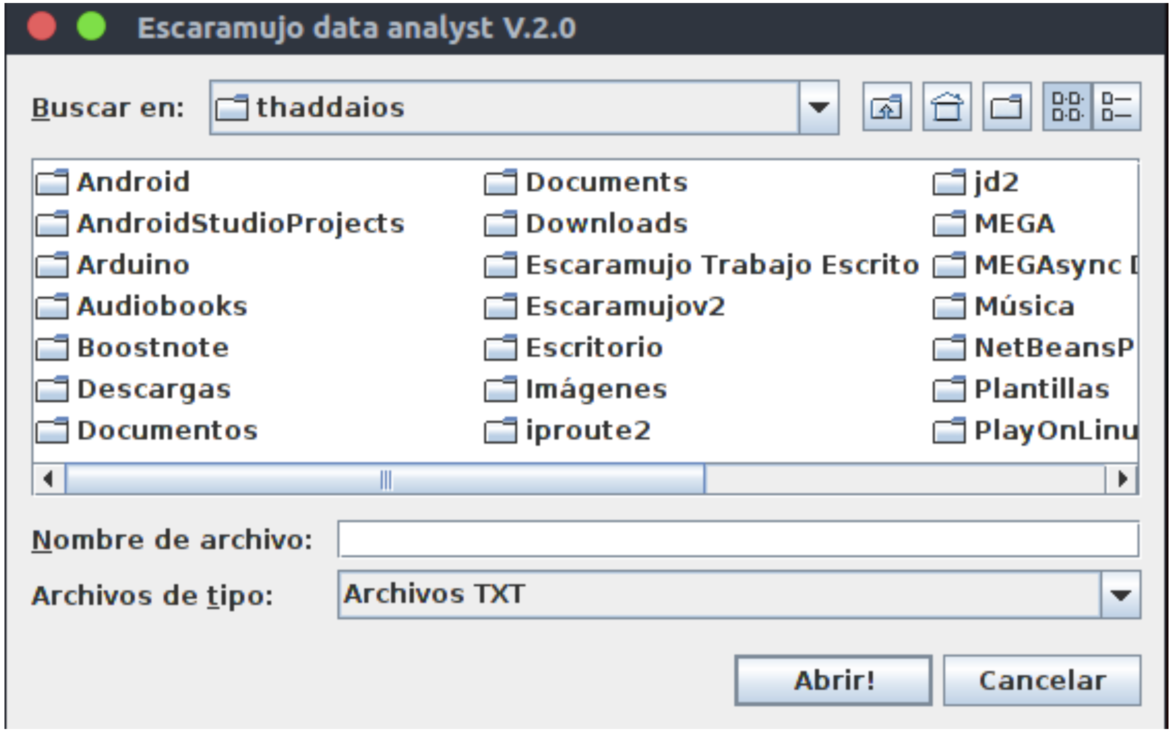
$Altitud(m.s.n.m)$	$\Phi(m^{-2}s^{-1})$
655 ± 5	$146,74 \pm 8,24$
588 ± 5	$145,30 \pm 8,14$
408 ± 5	$143,24 \pm 7,97$
70 ± 5	$128,05 \pm 7,19$
64 ± 5	$122,28 \pm 6,76$
7 ± 5	$119,07 \pm 6,69$

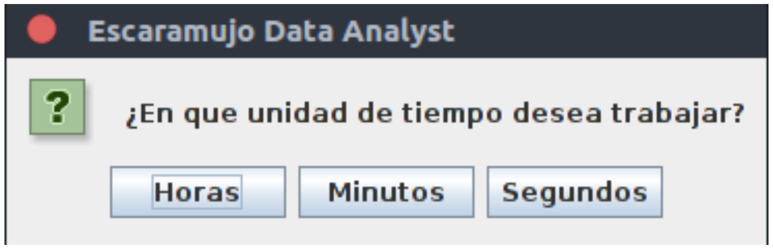
Obtained in Rumania with a similar detector

(B. Métrica et al. A mobile detector for measurements of the atmospheric muon flux in underground sites, 2009)

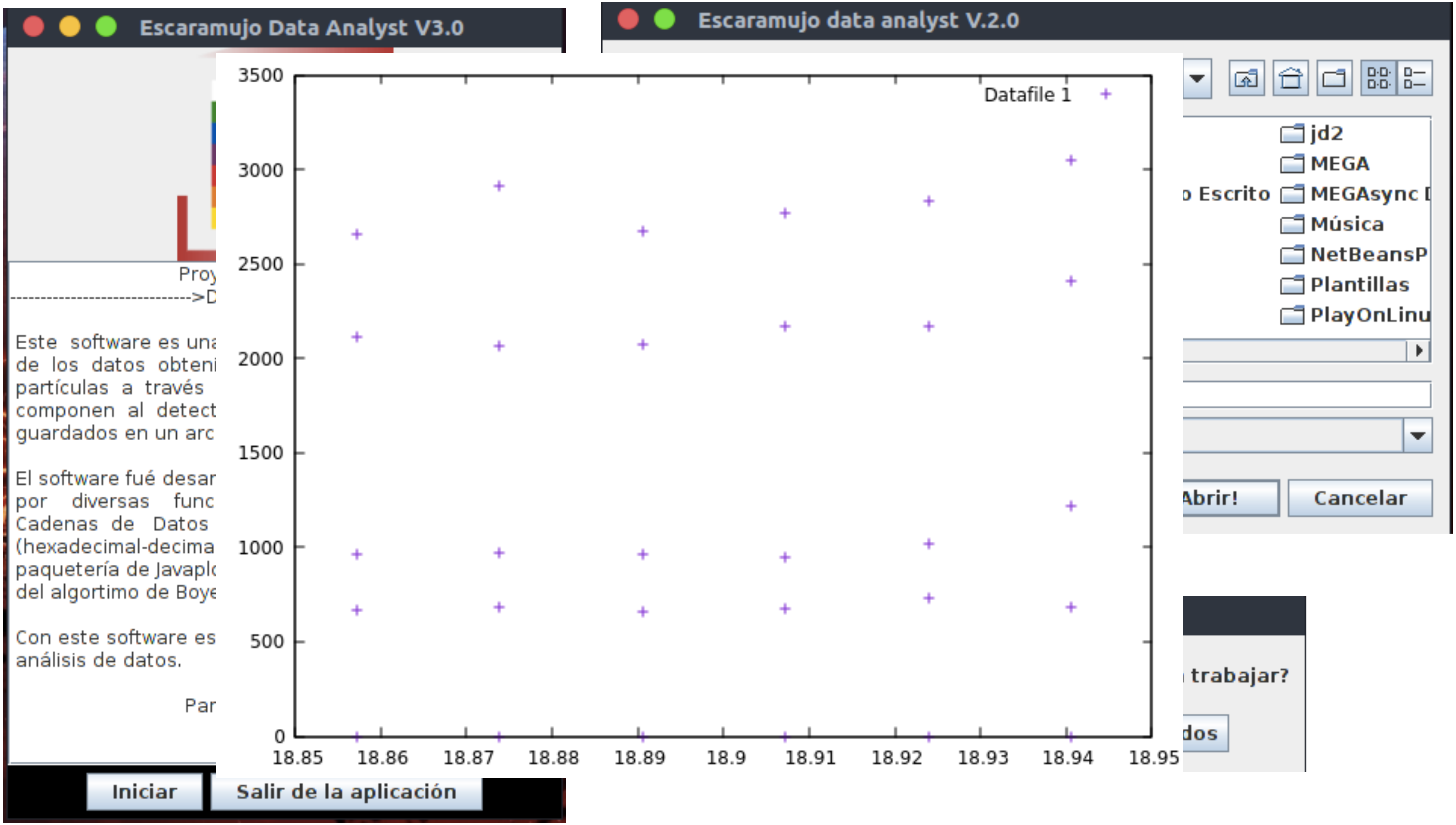
Software for data analysis







Software for data analysis



Conclusions and future work

- Measurements of the muon flux as a function of the altitude can be performed using Escaramujo.
- The optimum parameters of the instrument must be set and improved for the measurement next time
- The software for data analysis of Escaramujo is being performed and can be shared with the other Escaramujos

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LAGO experiment

Hugo de León Hidalgo for LAGO-Chiapas

Latin **A**merican **G**iant **O**bservatory

1.- Scientific objectives: to study high energy astroparticles, Meteorology and Space Climatology, and Atmospheric radiation and its applications

2.- Academic objectives: To train Latin American students in high energy physics and astroparticle physics, and to form an open and collaborative network of high energy physics researchers.

External layers

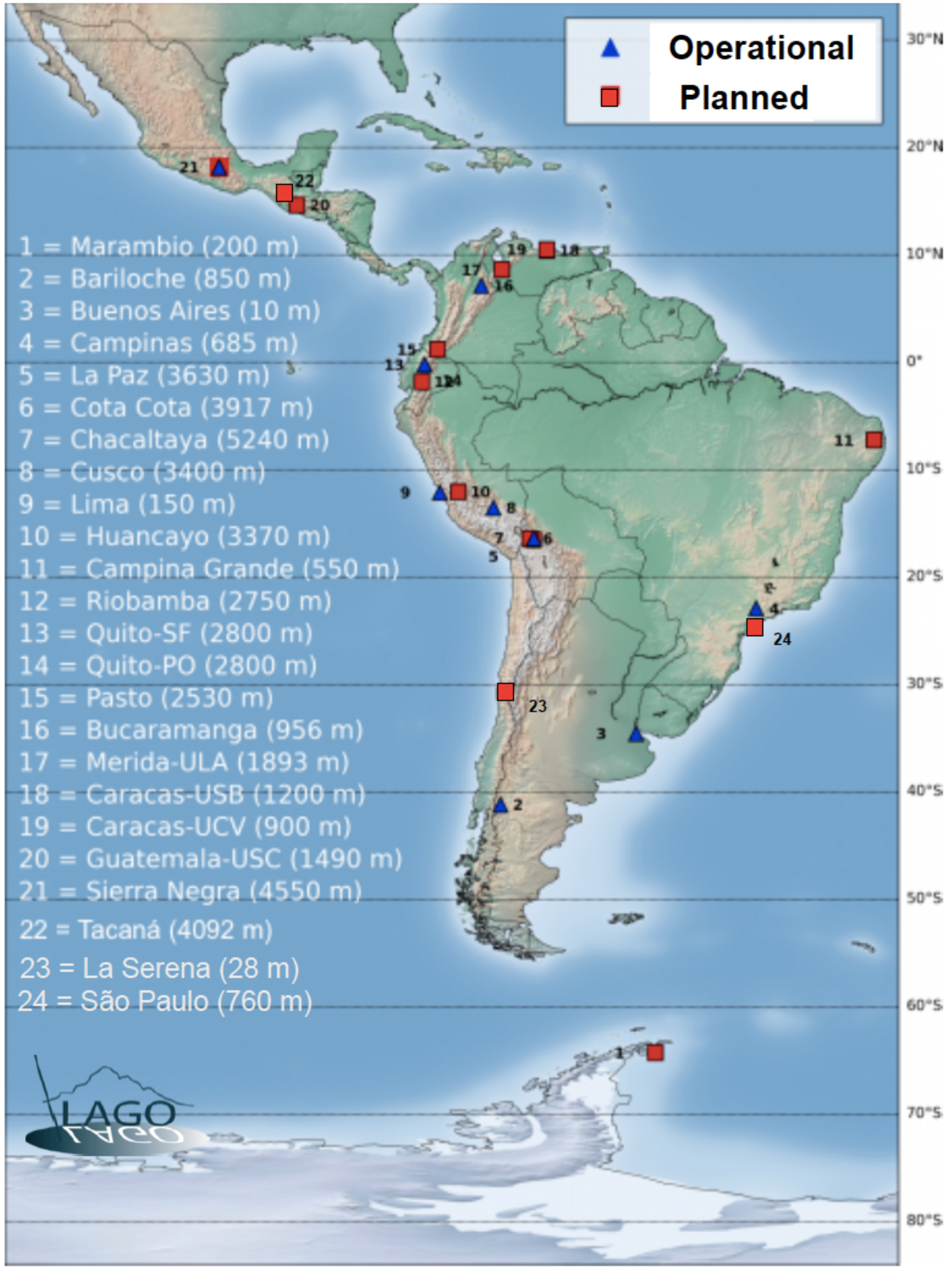
Tyvek inside

Tank already prepared

Base built

LAGO experiment

Hugo de León Hidalgo for LAGO-Chiapas



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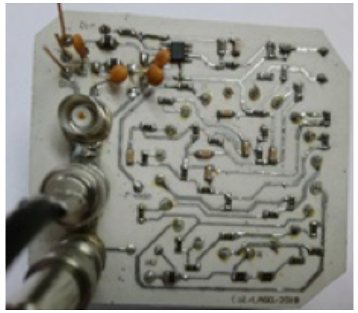
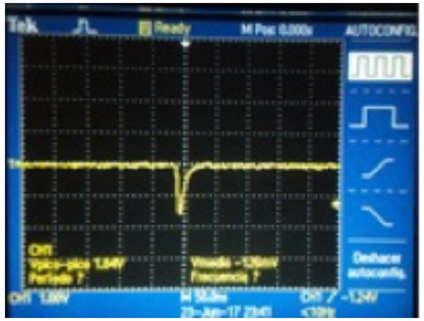
9" PMT



Card developed for PMT

CAEN setup for data acquisition



Atmospheric muon seen by the PMT

Conclusions and future work

- Estimation of SPE
- Studies for VEM estimation
- Light studies in the tank (see talk by Christian Ramírez)
- Calibration
- Full the WCD

- To deploy the tank at FCFM Campus
- To deploy one tank on Tacaná Vulcano

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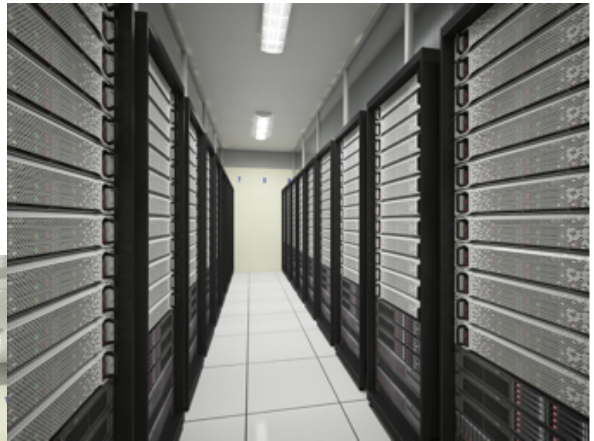
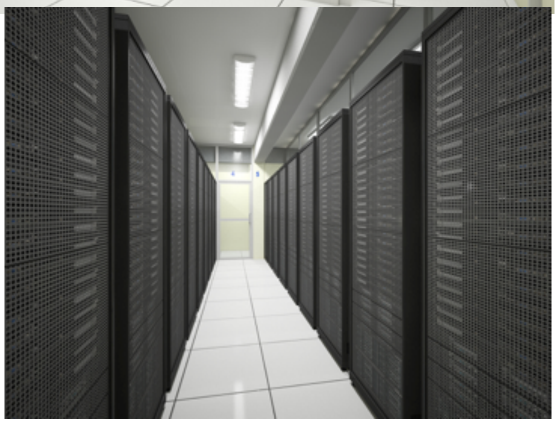
High Performance Computing at UNACH
LARCAD

Motivated by HAWC through a donation from CERN 2015

- 364 Servers
- 24 Switches
- 26 Racks
- **Academic IXP**







Thank you!

Karen S. Caballero Mora UNACH karen.scm@gmail.com

Backup slides

- **Simulations used:**

$HAWCROOT/sim/reco/aerie_svn_27754/systematics/best_mc/test_nobroadpulse_10pctlogchargesmearing_0.63qe_25kHzNoise_run5481_curvature1/proton/succeeded/

- **Cuts applied:**

rec.nHit>=75
rec.angleFitStatus==0
rec.CxPE40XnCh>=60
rec.coreFiduScale<130 ---> To ensure an efectiva area of 30 % larger than HAWC array
.
1.0*rec.nHit>=0.3*rec.nChAvail ------> To consider data produced when at least 30% of the available channels are activated

rec.nChAvail>0

- **Real data used**

$HAWCROOT/data/hawc/reconstructed/hawcprod/v2.02.02/config-33660/reco_xcdf/2016/06/run005481/

- **AERIE version 2.02.02**

CORSIKA Simulations used for SD analysis

Simulations
Napoli library (all details taken from Fausto's email announcing the library to the collaboration)
Access pointl http://natter.na.infn.it:18501/
Points of contactl Fausto Guarino guarino@na.infn.it, Roberta Colalillo colalillo@na.infn.it, Alexey Yushkov yushkov.alexey@gmail.com
Attachmentsl napoli_files.tar.gz, includes an example script using wget to retrieve the files from the Napoli server
Interaction modelsl EPOS LHC, EPOS 1.99, QGSJet II.03, QGSJet II.04, Sibyll 2.1
Primary particlesl p, He, O, Fe
Index of the energy spectruml -1

MC (CORSIKA) energy range: lgE=18.5-19.0 is covered by all models and primaries, for the other energy bins see the MC energy distributions in the attached pdf file (number of events with one FD eye at least)

All information regarding the CORSIKA production are included in the small.tgz files (CORSIKA input cards).

Zenith angles: 0-65 degrees, flat in cos^2(theta)

CORSIKA thinning: “optimal” 1e-6 (see an example input card in the attachment for more parameters)

Each CORSIKA shower was reconstructed 6 times with Offline v2r9p5 with the core randomly distributed over the SD (Relevant CORSIKA and Offline config files are attached).

If you are planning on simulating using the CORSIKA files, please note that the following cuts were used:
ECUTS   1.000E-01 1.000E-01 2.500E-04 2.500E-04

From the CORSIKA manual on ECUTS: The low energy cut-off (in GeV) of the particle kinetic energy may be chosen differently for hadrons (without π 0 ’s) (i = 1), muons (i = 2), electrons (i = 3), and photons (including π 0 ’s) (i = 4). Accordingly, you will need to change some of the cuts in the CachedShowerRegenerator.xml.in and/or CachedXShowerRegenerator.xml.in used in your application.

```
<!-- Particle energy cuts -->
  <EnergyCuts>
    <ElectronEnergyCut unit="MeV"> 0.25 </ElectronEnergyCut>
    <PhotonEnergyCut   unit="MeV"> 0.25  </PhotonEnergyCut>
  </EnergyCuts>
```

It's alright if your threshold values are under the ECUT values, but if your threshold are over, you will not properly simulate.

Further comments

The branch names in our trees are not so explicit, so we attach the an authentic reader Read_ADST_SD_Valentine.cc (containing even some Italian and Neapolitan words) that was used to convert ADST files, there you can easily find the meaning of each branch. The program has a long story so if some branches have strange names or some pieces of code look awkward simply respect it as archaeological artifacts :). There is a flag fXmaxFlag which is used to mark the eye with the longest track, if event is mono fXmaxFlag=1 always, if it is a multi-eye event the eye with the longest track will have fXmaxFlag=1 and other eyes fXmaxFlag=0. One can notice that there is a number of FD cuts saved as well (fFidCosCut, fFidDistCut, fFidFOVCutPRL10, fFidFOVCutICRC11, fFidFOVCutICRC13, fXmaxInFOVCut, fFitChi2SigmaCut, fTrackLengthCut, fPBrassCut), one can apply them separately for the event selection, or simply use flongXmaxCut==1 to get the events that pass all long Xmax paper quality and FOV cuts (this was tested on long Xmax paper data). We have a standalone code to combine Xmax and energies of the eyes for the stereo events, but it should pass a quick revision, let us know if you are interested in getting it [in principle even simply selecting the eye with the longest track fXmaxFlag==1 brings
https://web.ikp.kit.edu/augeroracle/doku.php?id=auger:data
http://natter.na.infn.it:18501/se04a1/ADST_v2r9p5/QGSJET-II.04/