Reconstruction of muon LDF using ADC channel of UMD

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Annual HIRSAP Meeting
11 November 2022

Reconstruction of MLDF

CORSIKA simulated showers → Average MLDF + Muon time distribution

Toy simulations
CORSIKA showers library of fixed energy
EPOS-LHC and FLUKA.

Primaries : Fe, Pr
Zenith angles 30°, 45°
Energy range logE [17.5,19] in steps of 0.25

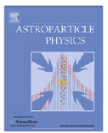
Binary data simulation

Astroparticle Physics 29 (2008) 461–470

Contents lists available at ScienceDirect

Astroparticle Physics

journal homepage: www.elsevier.com/locate/astropart



Underground muon counters as a tool for composition analyses

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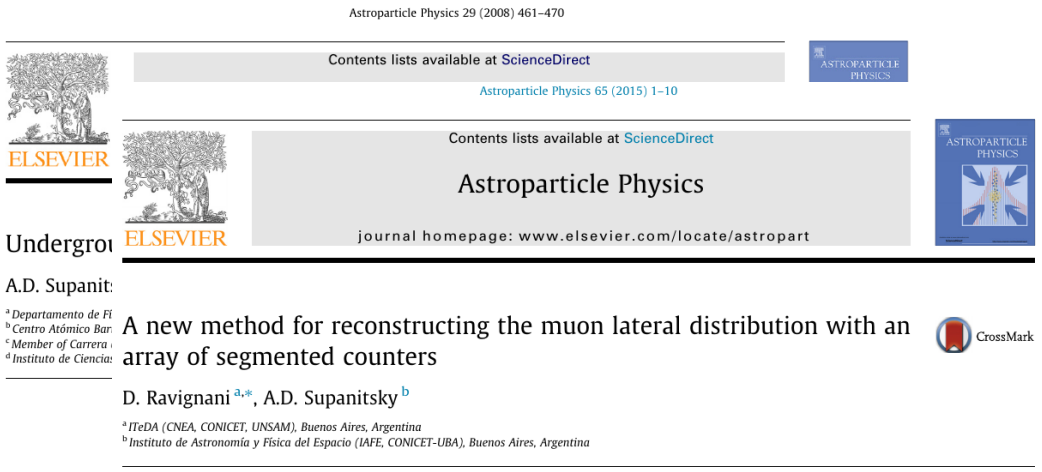
- Underground muon counter simulated (with pile up correction)

Binary data simulation



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Undergrou

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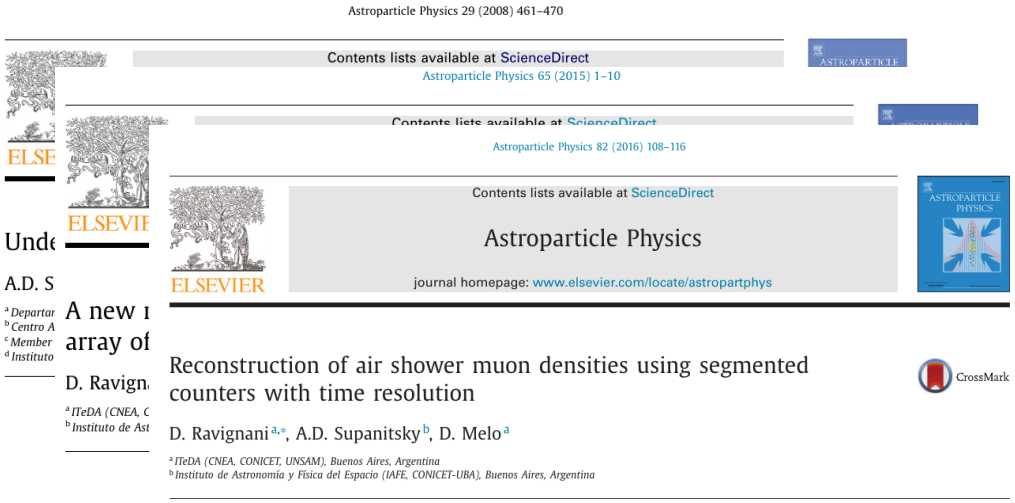
A new method for reconstructing the muon lateral distribution with an array of segmented counters

D. Ravignani [a,*], A.D. Supanitsky [b]

[a] ITeDA (CNEA, CONICET, UNSAM), Buenos Aires, Argentina
[b] Instituto de Astronomía y Física del Espacio (IAFE, CONICET-UBA), Buenos Aires, Argentina

Binary data simulation



Astroparticle Physics 29 (2008) 461–470

Contents lists available at ScienceDirect

Astroparticle Physics 65 (2015) 1–10

Astroparticle Physics 82 (2016) 108–116

Contents lists available at ScienceDirect

Astroparticle Physics

journal homepage: www.elsevier.com/locate/astropartphys

Reconstruction of air shower muon densities using segmented counters with time resolution

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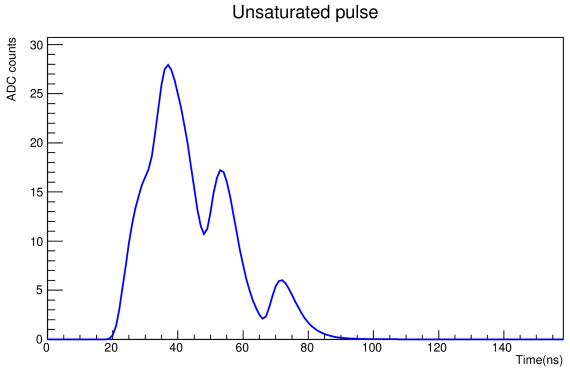
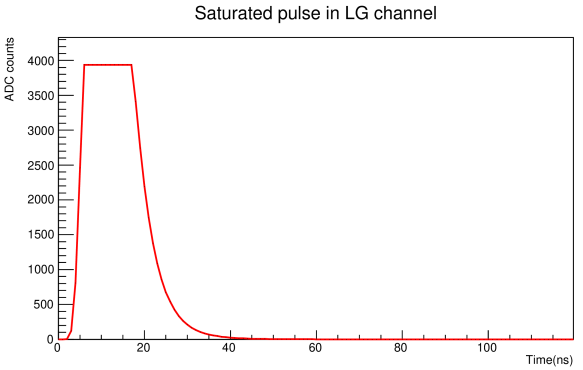
Current reconstruction method → profile likelihood method with the detector timing in the counter mode.

ADC data Simulation

- ADC signals

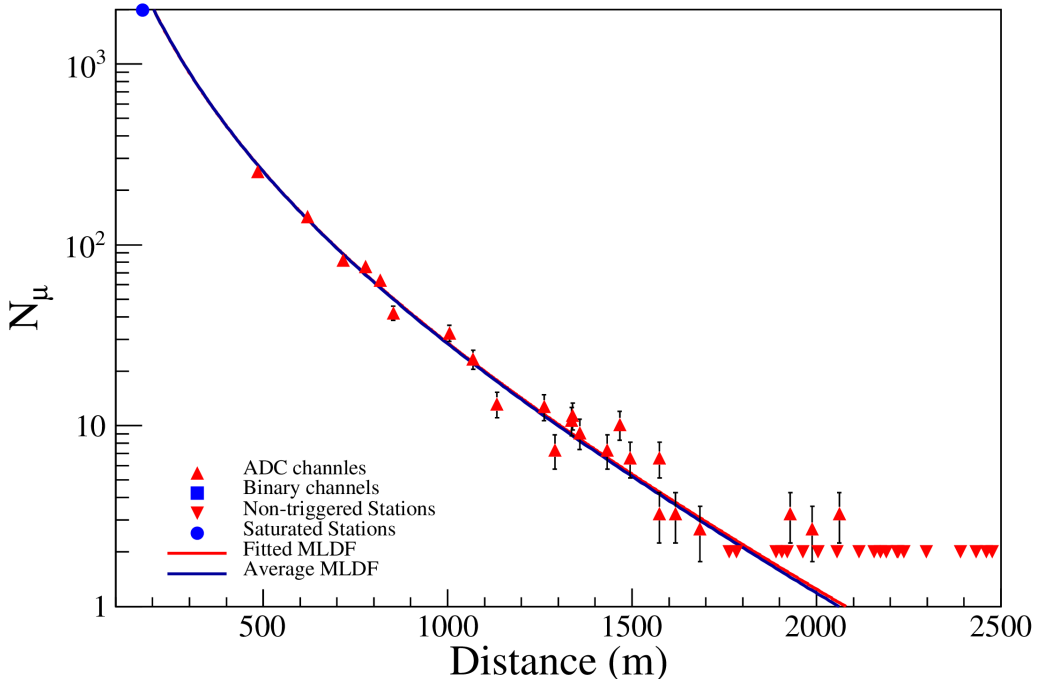
$$f(t;\mu,\sigma) = \frac{Q_J}{\sum_{i=1}^{N} \frac{e^{-\frac{(\ln(t_i - t_0)-\mu)^2}{2\sigma^2}}}{t_i - t_0}\Delta t} \cdot \frac{e^{-\frac{(\ln(t_i - t_0)-\mu)^2}{2\sigma^2}}\Delta t}{t_i - t_0}$$





Multiple signals arriving at different times added to get a single pulse.

Sample Event



Sample Event at $\log_{10}E = 19$ for Fe primaries at 30° zenith angle

Reconstruction of MLDF

- For each sampled event, the distance of the detector to the shower axis and arrival time of each muon are obtained.
- The average LDF → expected number of muons (μ) → actual number of muons
- The LDF is fitted to the detector data simulation by either minimizing the χ2 or by maximizing a likelihood function.

Reconstruction of MLDF

- For each event μ(r) was adjusted using a second Kascade Grande like muon LDF.

$$\mu = \mu_0 \frac{g(r)}{g(r_0)}$$

$$g(r) = \left(\frac{r}{r_1}\right)^{-\alpha} \left(1 + \frac{r}{r_1}\right)^{-\beta} \left(1 + \left(\frac{r}{10 r_1}\right)^2\right)^{-\gamma}$$

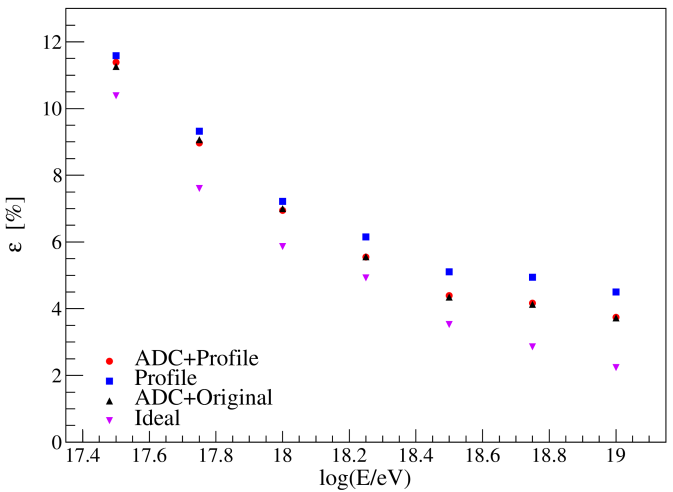
α = 0.75
r_0 = 450 m
r_1 = 320 m.

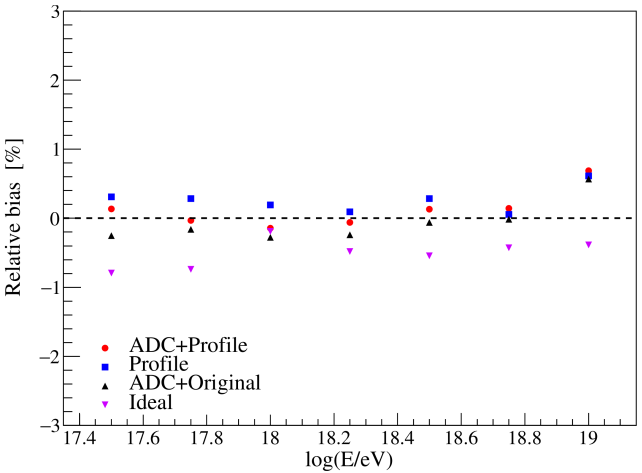
μ_0 and β are adjusted by minimizing the function

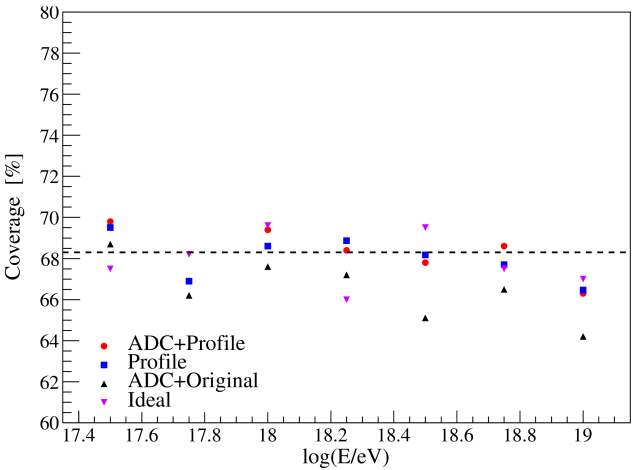
$$-2 \ln(L_{fit}(\mu_0, \beta)) = -2 \sum_i \ln L_i(\mu(r_i, \mu_0, \beta))$$

Recap

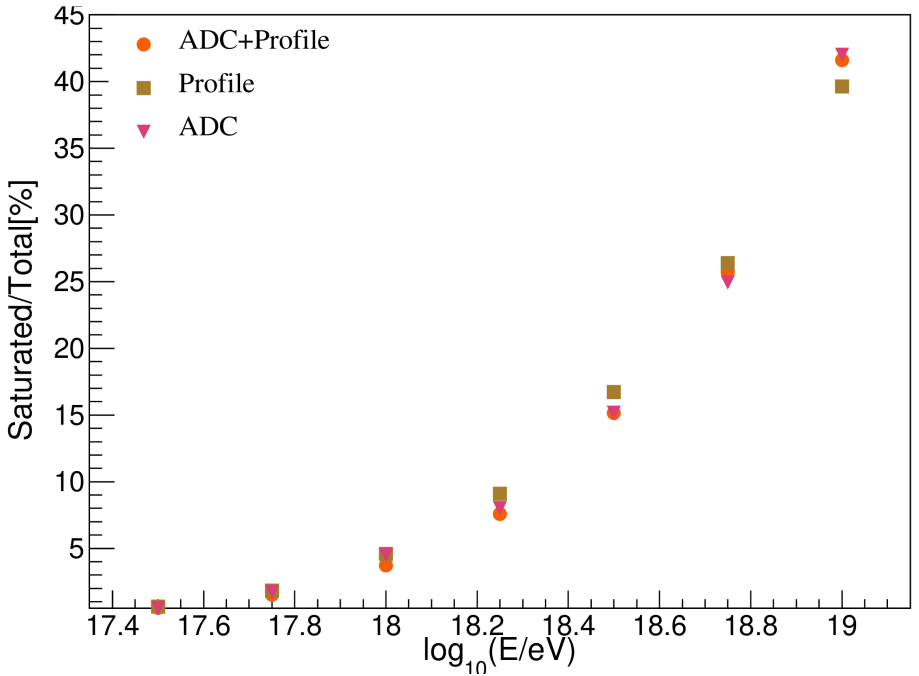
- Reconstruction methods used:
  - Combination of ADC & Profile
  - Combination of ADC & Original
  - Profile likelihood method
  - Ideal counter reconstruction method



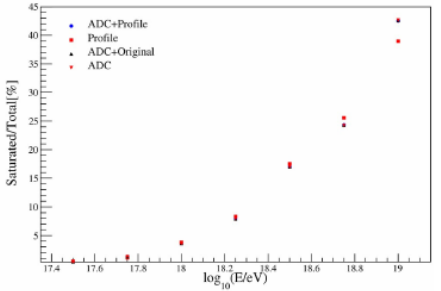




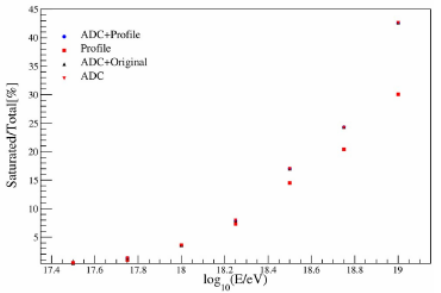
Reconstruction parameters



Saturated fraction



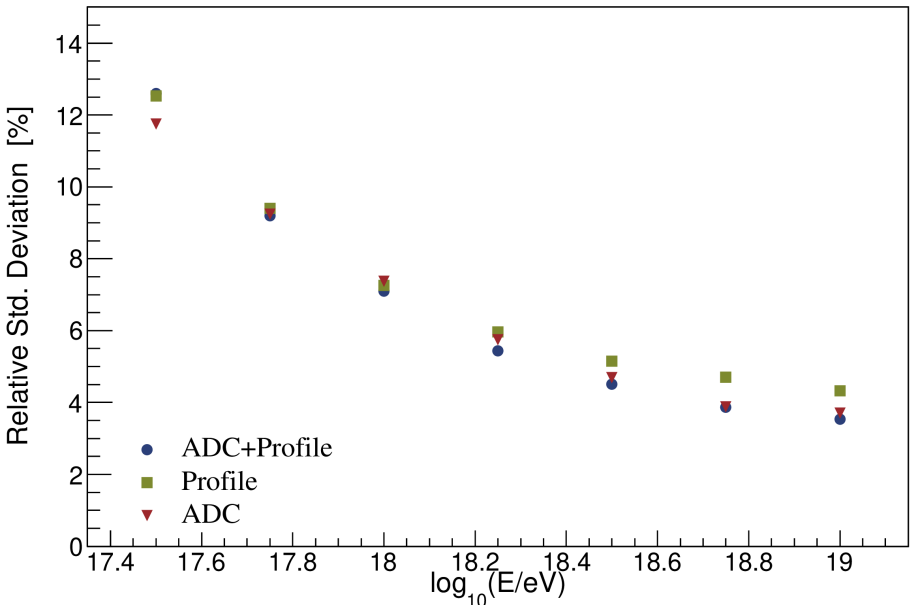
40 ns



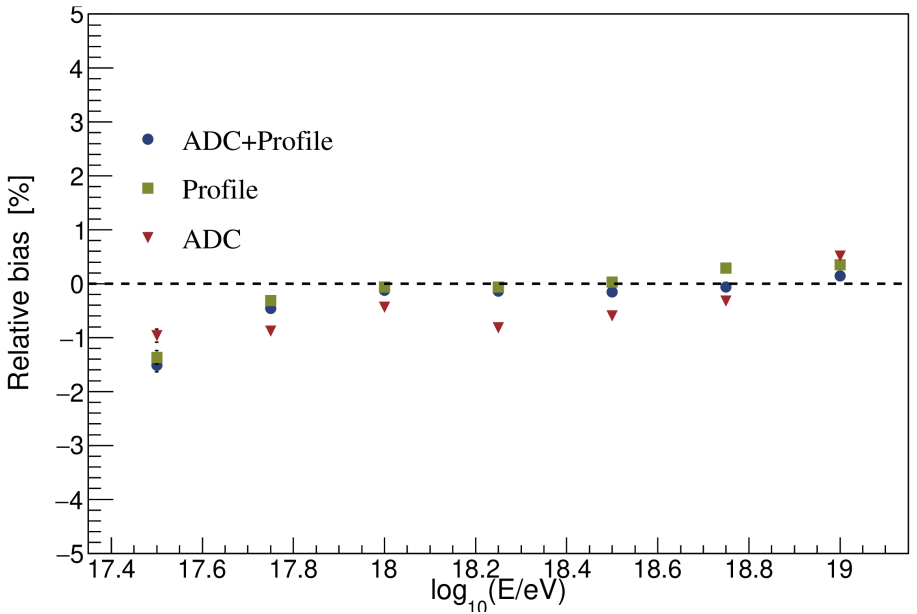
25 ns

When the bin width increases to 40, the counter saturates faster. ADC is independent of time bin used.

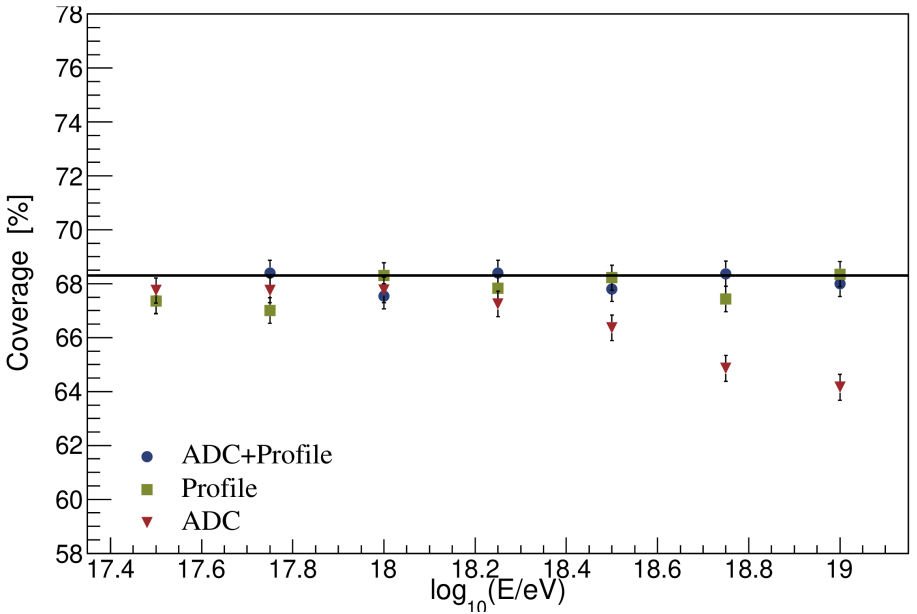
Reconstruction parameters



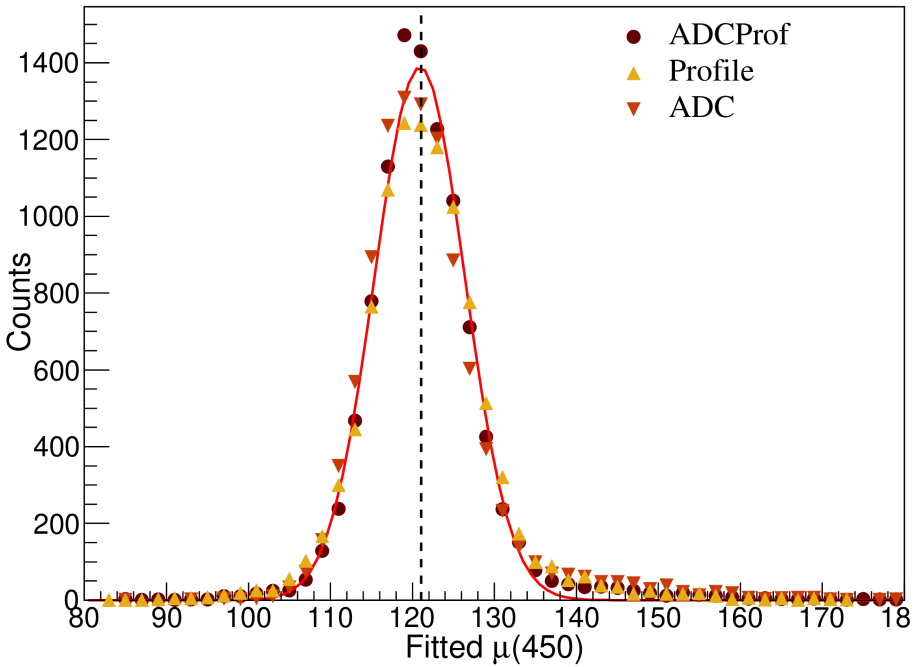
Relative standard deviation



Bias



Coverage



Distribution of reconstructed N_μ at 450 m for Fe primaries at $\log_{10}E = 18.5$

Summary

- The binary mode implemented in AMIGA is very efficient.
- Including the ADC channel,
  - The small bias and the low standard deviation achieved allows for a good estimation of μ(450).
  - does not improve the saturated fraction of stations.
  - ADC is not affected by pile-up effect or corner clipping effect and is independent of time bin used. So the method increases the precision of the UMD.