γ/h discrimination with muon identification at Argo-Ybj

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ROMA TRE

- The Argo experiment

- Cosmic ray background rejection by means of muon identification
  - Simulation
  - Estimate of the background rejection effectiveness
  - Estimate of the sensitivity to the Crab nebula with muon identification

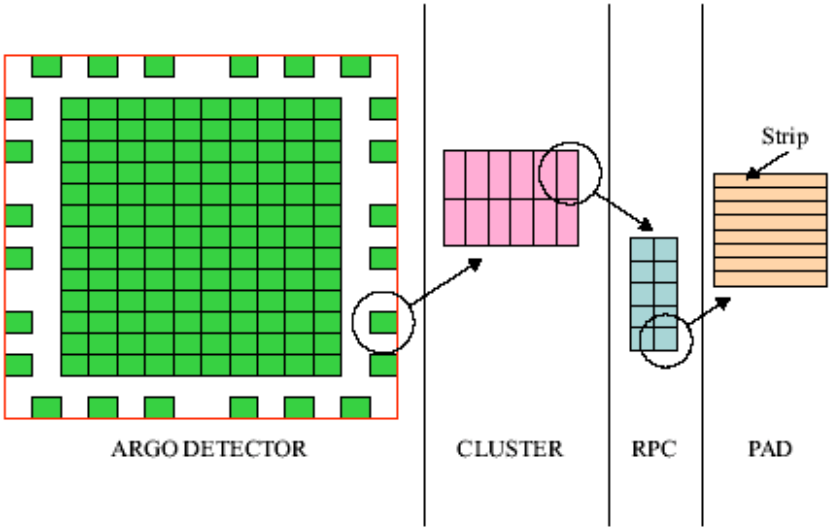
The Argo experiment

- Yangbaijing, Tibet
  - 4300 m a.s.l.
- Surface ~ 10^4 m^2
- RPC (Resistive Plate Chamber)
- Full Coverage

$E_{threshold}$ ~ 100 GeV

Continuous and systematic monitoring of the sky by means of a large field of view.

What does Argo measure?



Time and position of the first particle which hit one pad

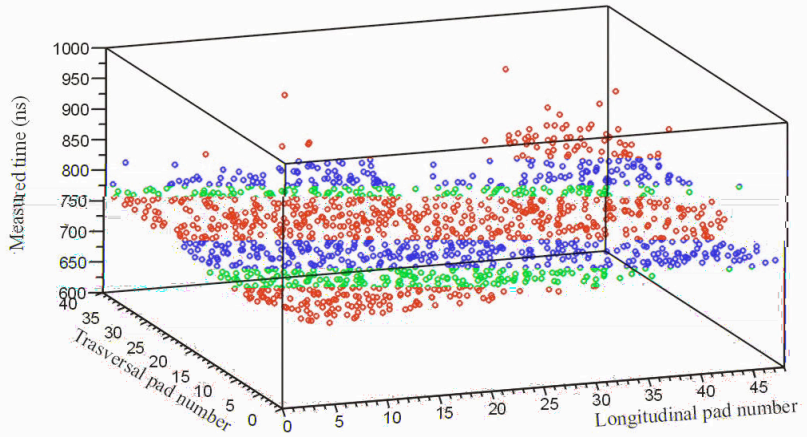
Number of hit pads

- Space-time distribution → primary DIRECTION
- Multiplicity → ENERGY distribution

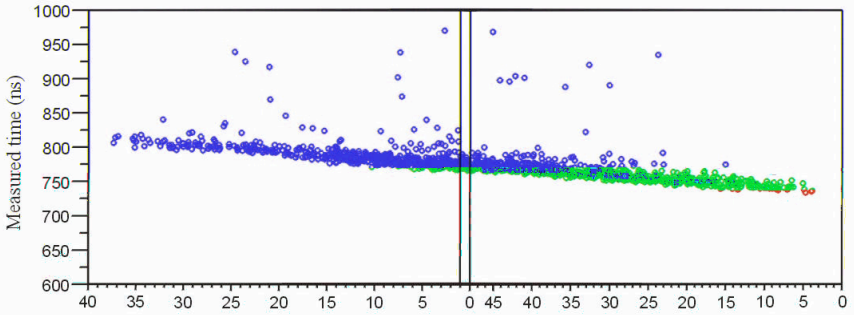
Status of the experiment

The detector is under construction:

- 30 clusters will be in data taking within June 2004
- 70 clusters will be in data taking within December 2004
- The whole apparatus will be in data taking at the end of 2005



Picture of an event on 16 clusters



The same event from such a point of view to appear as a plane

□-ray observation

□-ray observation from earth-based experiments suffers from the huge background constituted by charged primary hadrons

- good angular resolution

  For a detector surface of 1000 m^2:

  N(E>1TeV) ~ 6700 □/yr Crab nebula

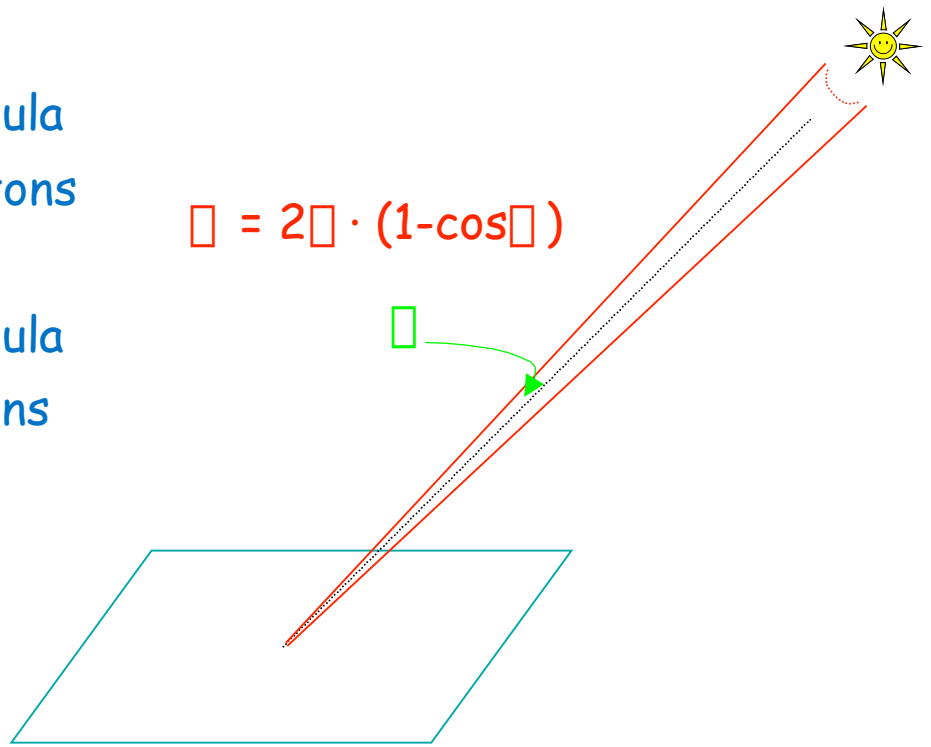
  N(E>1TeV) ~ $1.6 \cdot 10^9$ p/sr yr protons

  Solid angle aperture □ = 1°

  N(E>1TeV) ~ 5000 □/yr Crab nebula

  N(E>1TeV) ~ $1.5 \cdot 10^6$ p/yr protons

$$S = N\,□/(N)_p^{1/2} \sim 4$$



Background rejection

Background can be further reduced by exploiting the differences between the two kinds of air-shower…

- Topology (software algorithms)
- Particle type (hardware technique: **muon identification**)

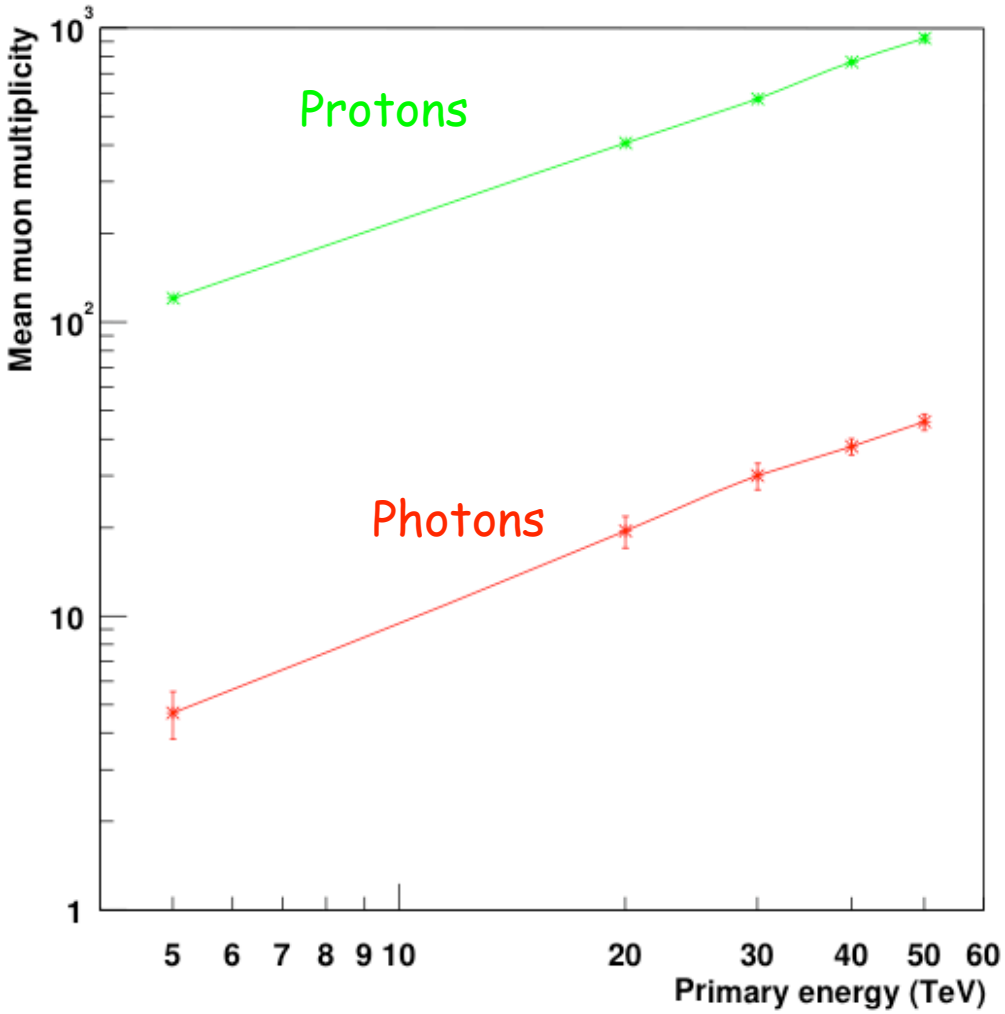
Sensitivity increases by a factor Q

$$S = \frac{N_{\gamma} \cdot \varepsilon_{\gamma}}{\sqrt{N_B \cdot (1 - \varepsilon_B)}} \quad \rightarrow \quad Q = \frac{\varepsilon_{\gamma}}{\sqrt{(1 - \varepsilon_B)}}$$

ε_{γ} electromagnetic air-shower fraction identified as such

ε_B hadronic air-shower fraction identified as such

Discrimination by means of muon identification (tens of TeV)



The mean number of muons for vertical air-showers as a function of the primary energy

Electromagnetic showers are poor in muons

- Pair production □⁺□⁻ □ ~10 □b
- Photo-production □ ~100 □b

Main purposes

This work is a study of the background rejection by means of muon identification with the Argo experiment

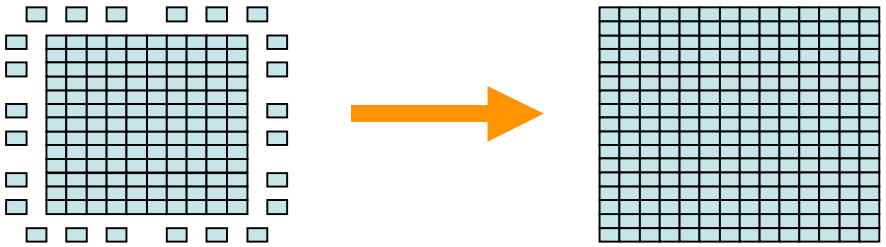
- At what energy the background rejection by using muon identification technique becomes effective?
- How much is it effective ?
- What is the ratio between signal and background fluctuation?

- The Crab nebula is the reference source
  - simulation of the Crab and background emission spectra
- At present Argo cannot detect muons: an ideal muon detector has been considered
  - simulation of the detector response
- Estimate of the background rejection efficiency
- Estimate of the sensitivity to the Crab

Simulation of the air-showers and the detector response

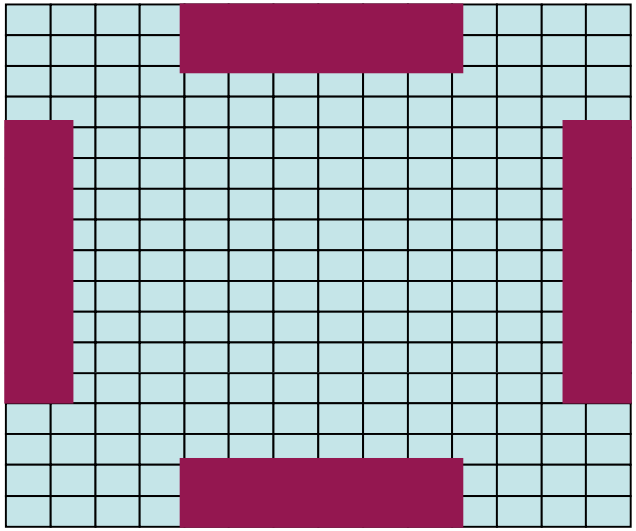
- CORSIKA
- Air-showers generated by photons(Crab)
  $\Phi(E) = 3.2 \cdot 10^{-7}\ E^{-2.49}\ m^{-2}\ s^{-1} TeV^{-1}$
- Air-showers generated by protons
  $\Phi(E) = 8.98 \cdot 10^{-2}\ E^{-2.74}\ m^{-2}\ s^{-1}\ sr^{-1}\ TeV^{-1}$

Sample	Events	Energy (TeV)	Index
Photons	406820	1-50	-1
Photons	72150	50-100	-1
Protons	530718	1-50	-1
Protons	94130	50-100	-1



- ARGO-G (GEANT3)
- Trigger multiplicity 20
- Layer of lead
- Noise 400Hz/Pad

Enlargement of the detector active surface



Ideal muon tracker

A_{tot} = 1500 m^2 A_{tot} = 2500 m^2

E_{μ} > 1 GeV

ε_{det} 100%

Event reconstruction and analisys

Argo reconstruction software: Medea++ (C^{++} code)

Noise filter

Air-shower core reconstruction

Arrival air-shower direction reconstruction

Event selection

$\theta_{70} = 0.29^{o}$

$\theta < 40^{o}$

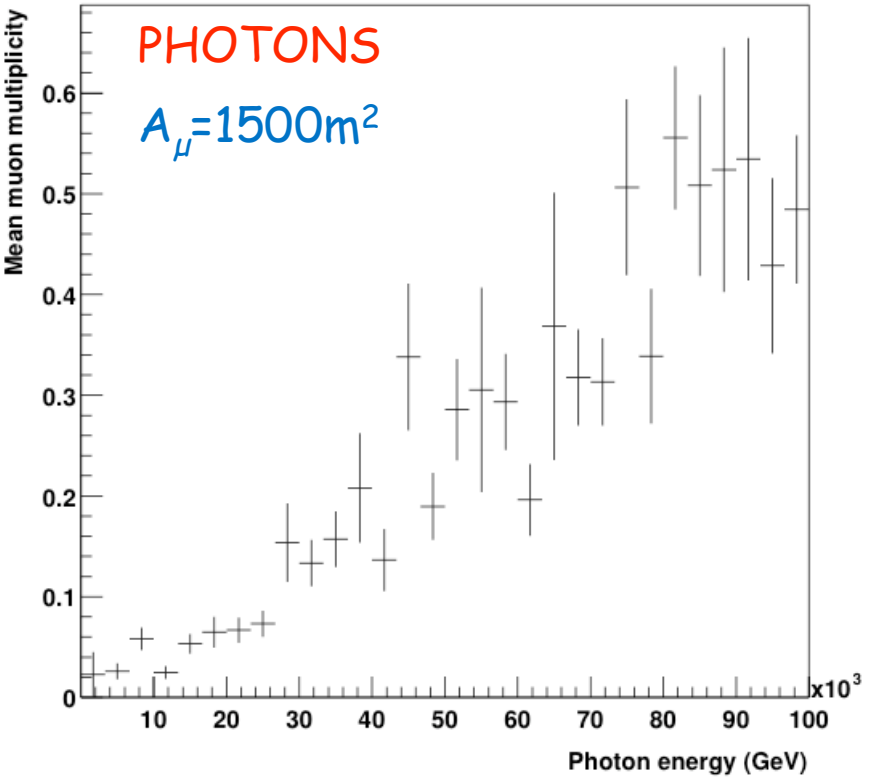
$A_f = 107X95\ m^2$

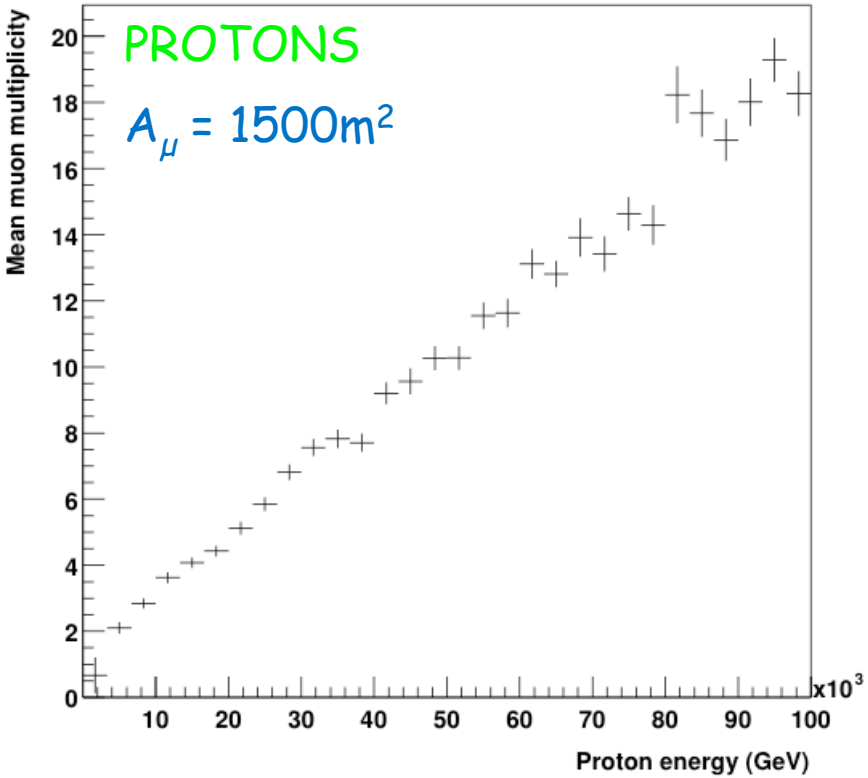
Multiplicity is the observable

Bin of integrated multiplicity

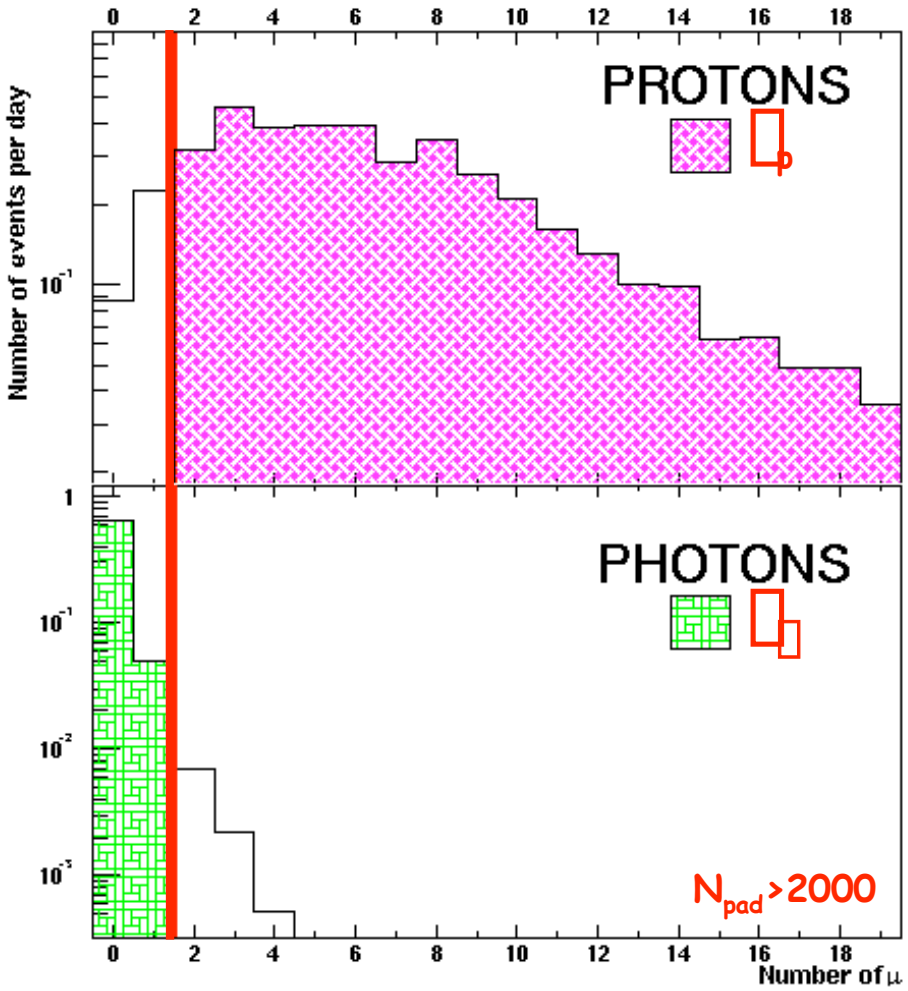
Mean muon multiplicity (A_μ = 1500m^2)

N_{pad} > 1000





Calculation of the rejection factor Q

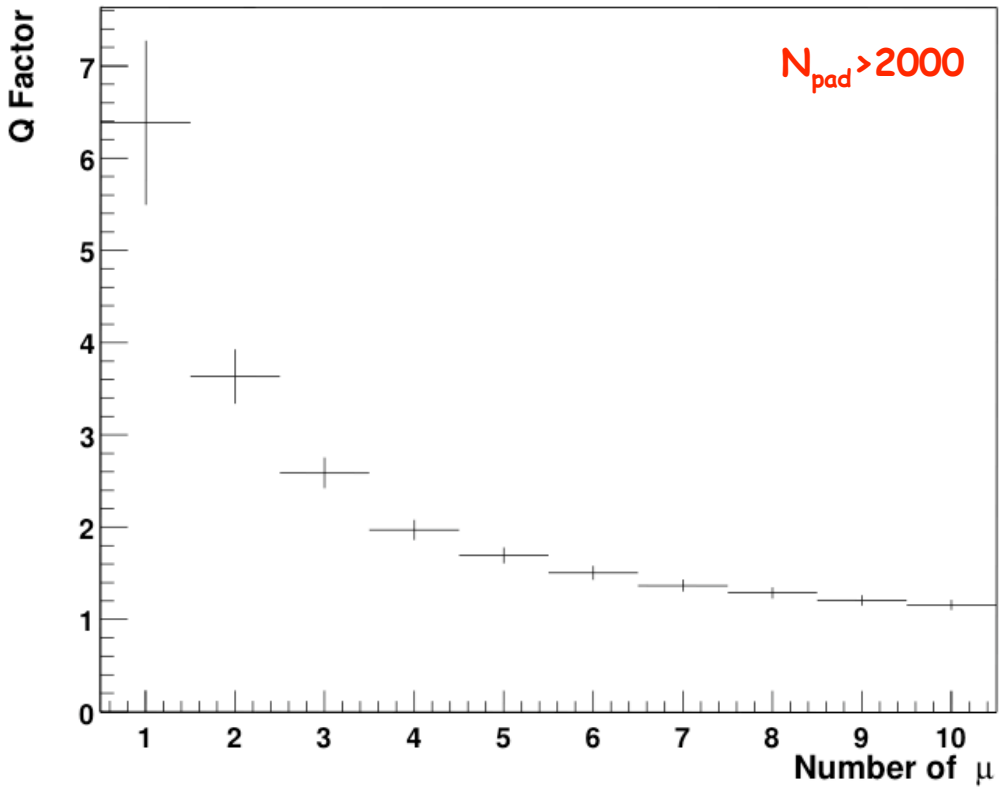


- Distribution of the number of muons contained in air-showers generated by protons and photons
- Choice of the number of muons with wich the two types of showers are discriminated : in the figure N_{μ} = 2
- Calculation of the identificiation efficiency ε_p

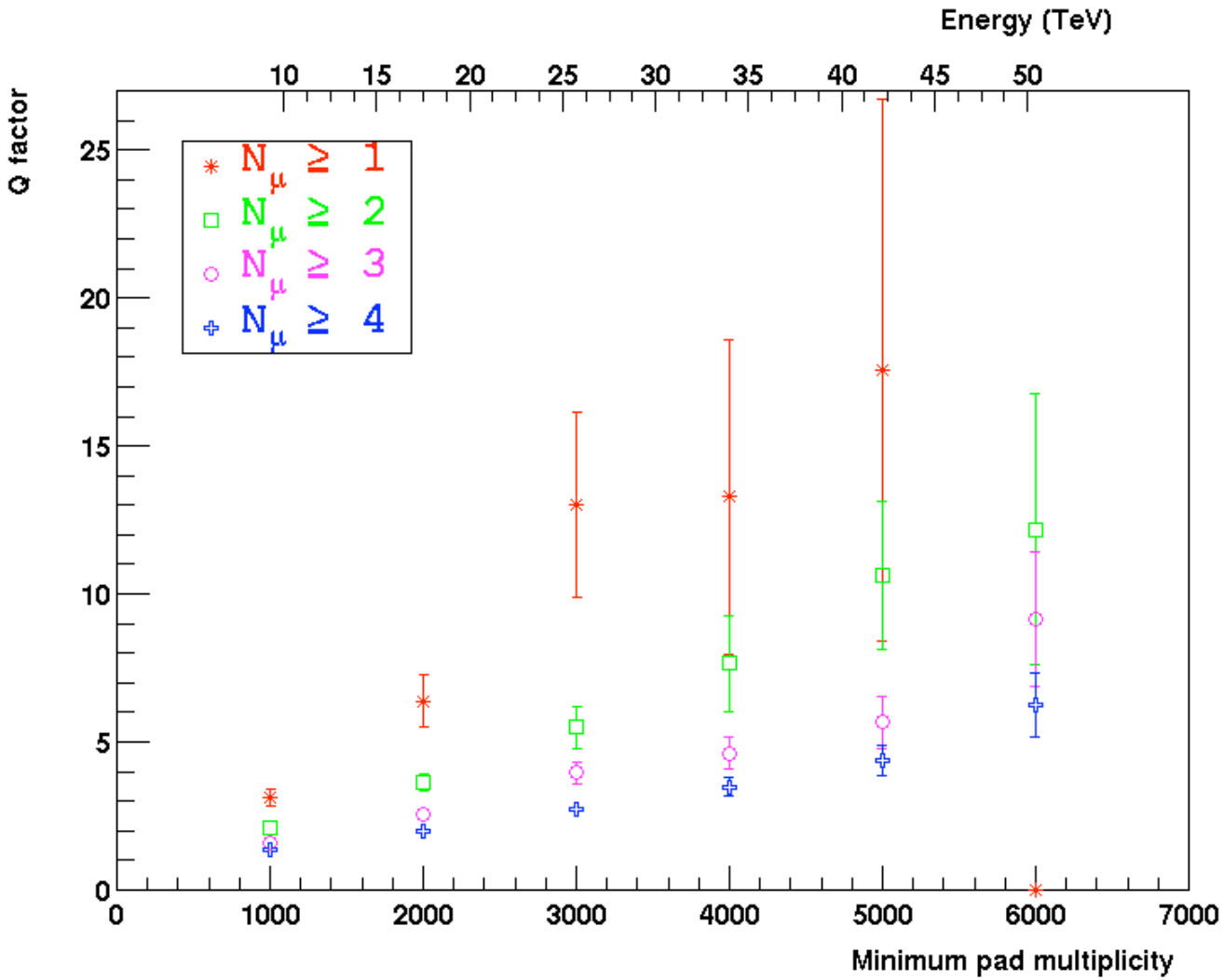
$$Q = \frac{\varepsilon_\gamma}{\sqrt{(1-\varepsilon_B)}}$$

Q versus muon number

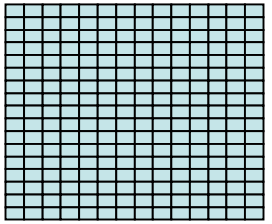
The same procedure can be applied for several values of the cut on the number of muons…

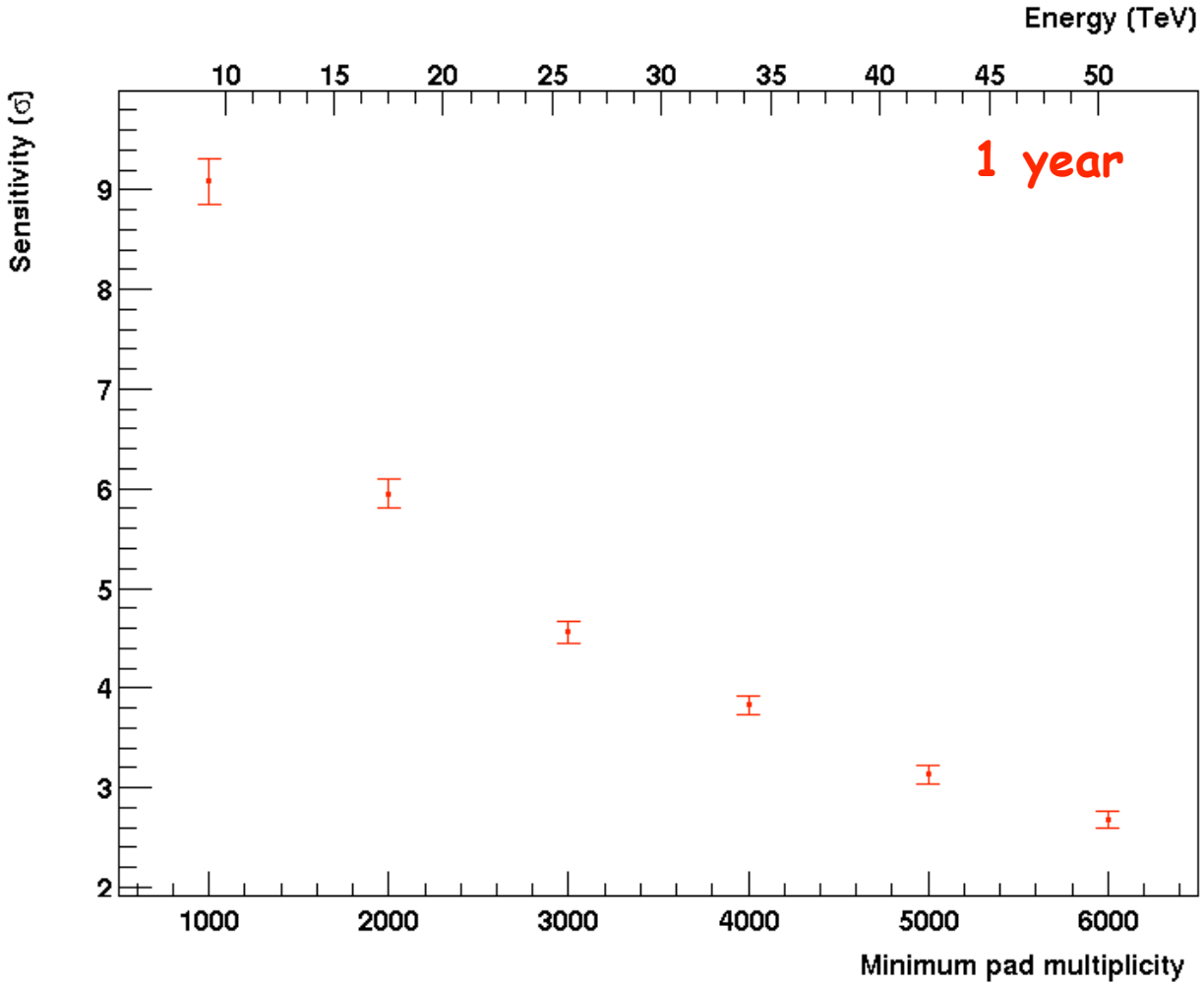


Q versus energy (1500 m^2)

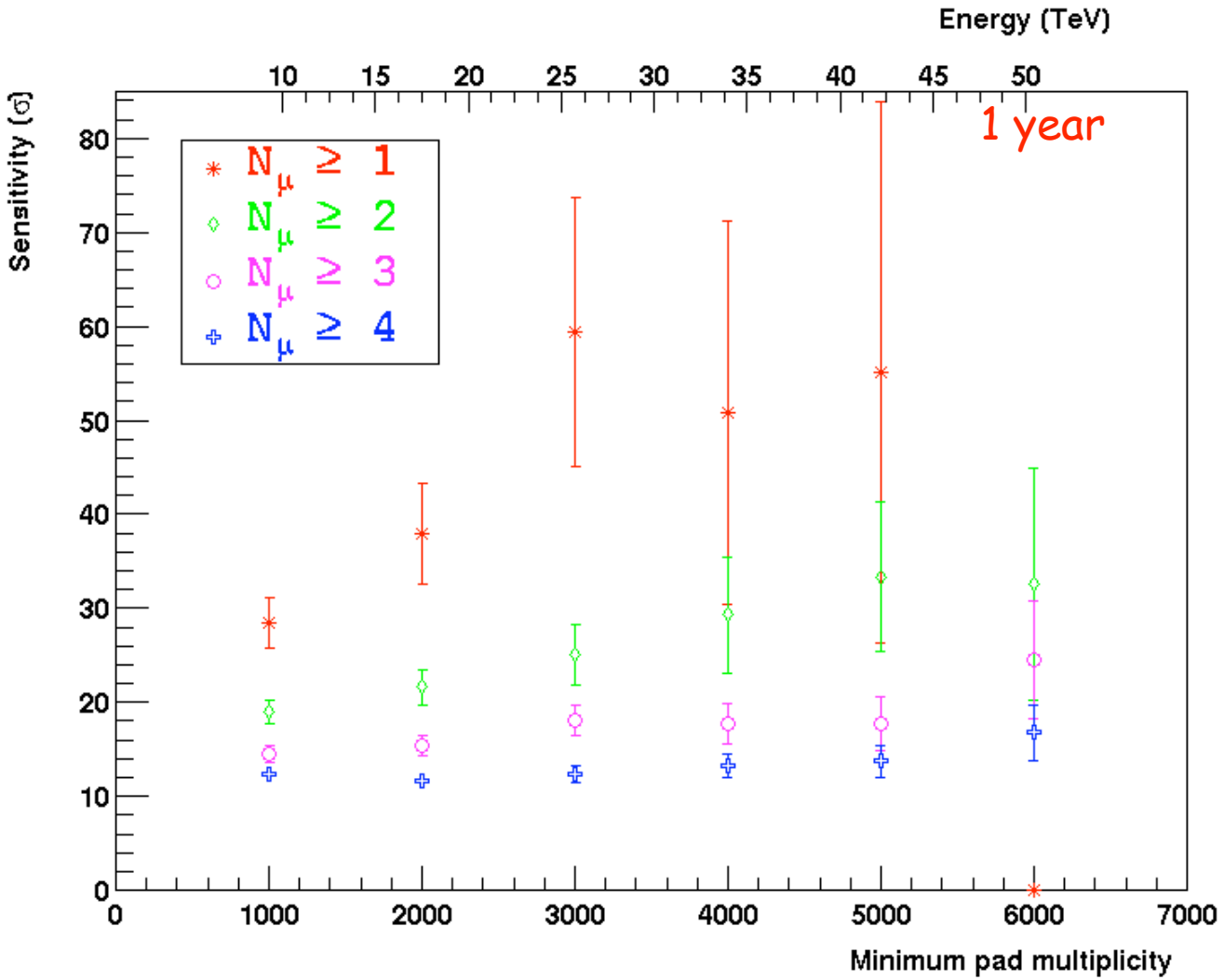


Sensitivity to the Crab nebula (no muon identification)

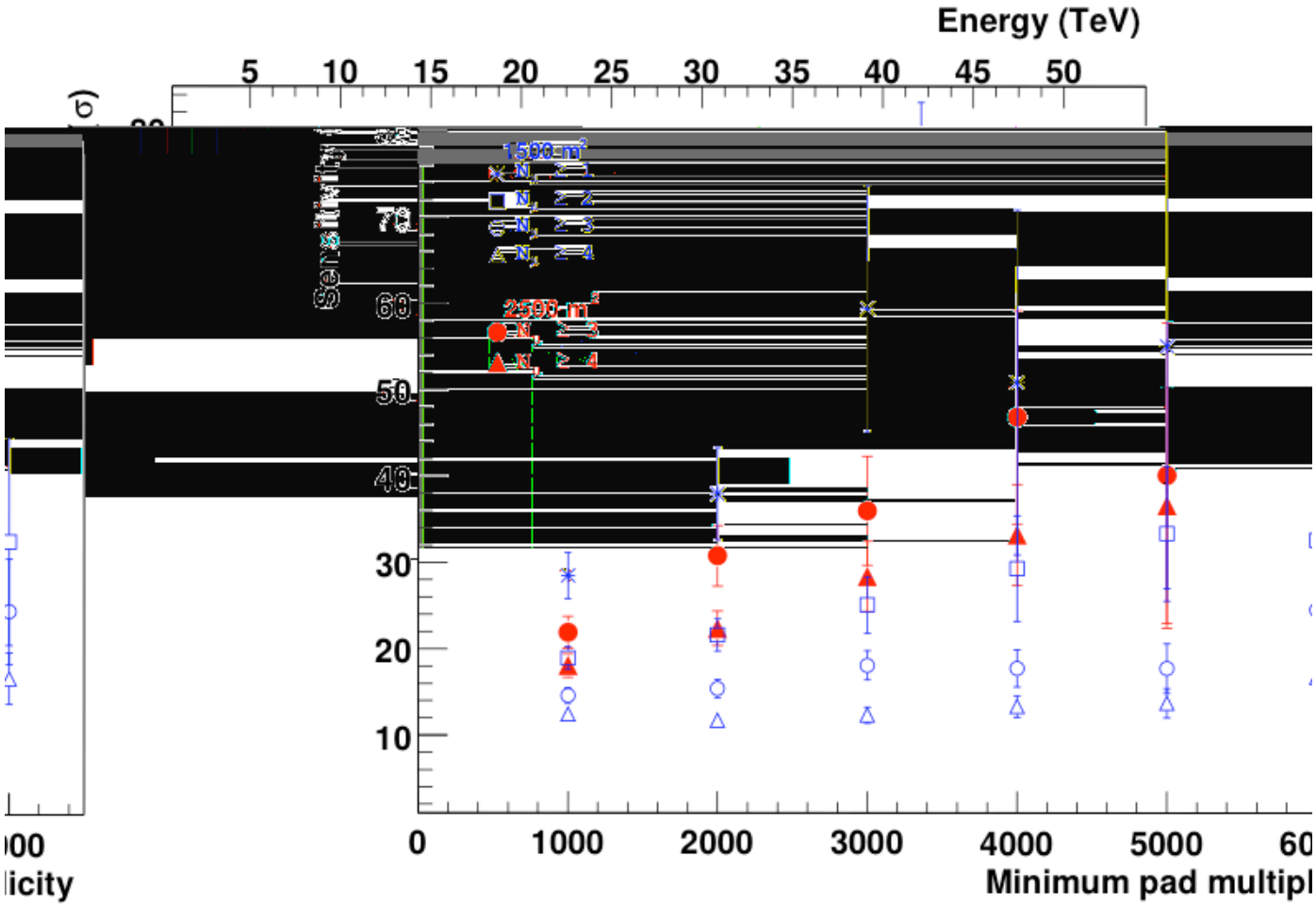




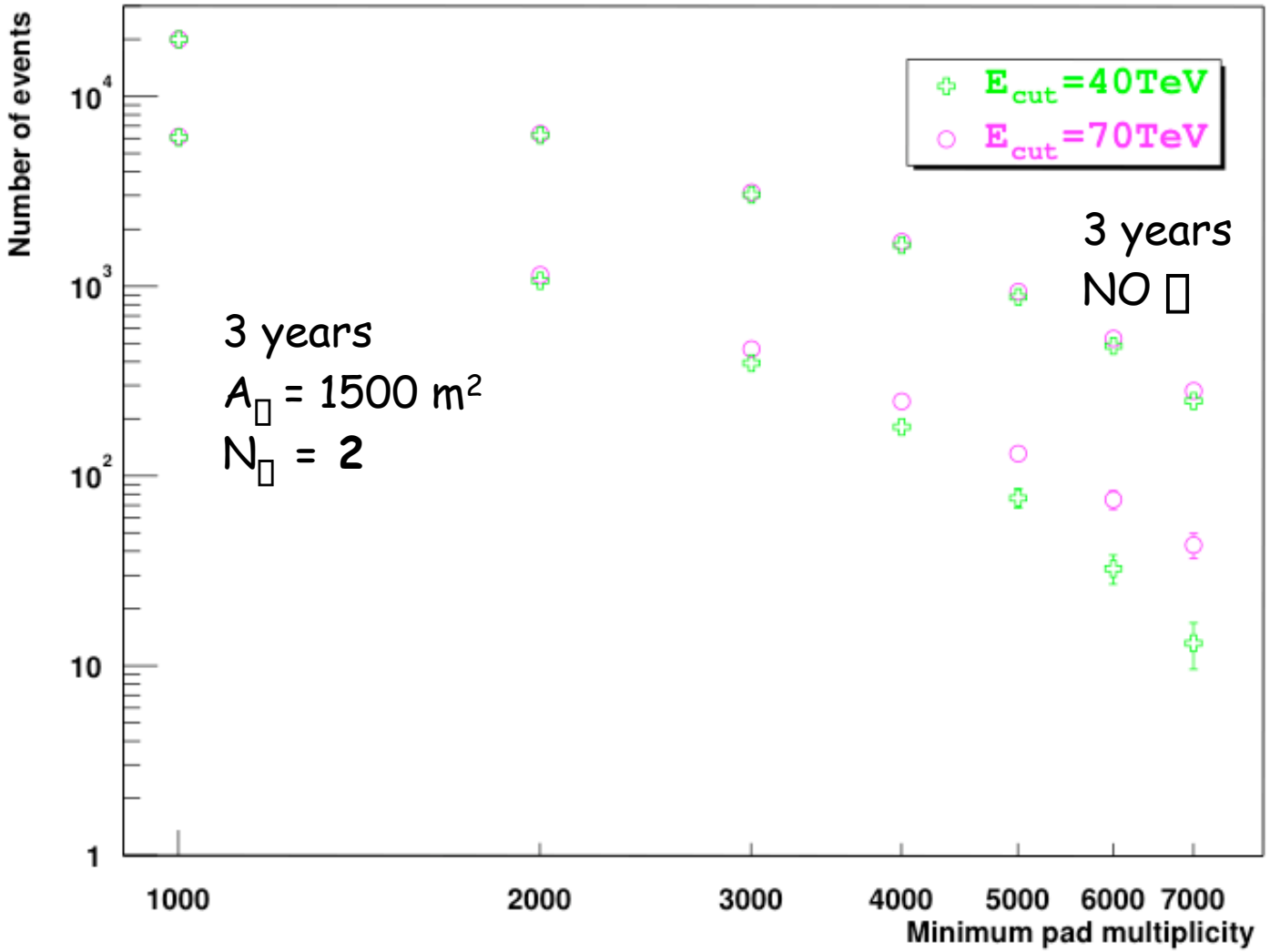
Sensitivity to the Crab nebula (with muon identification 1500 m^2)



Sensitivity to the Crab nebula
(with muon identification 1500 m^2 & 2500 m^2)



Study of the Crab spectrum at high energy



Conclusions

- A simulation study based on the different muon content which characterises electromagnetic and hadronic showers has been made with the view to identify the background for γ-ray observation with Argo.

- The background rejection factor Q has been estimated: good values for Q are at about 10 TeV.

- The sensitivity to the Crab by using the muon identification technique has been estimated: in 1 year of data taking, using a muon detector area of 2500 m^2, the sensitivity is 20σ at about 10 TeV and ~30-40σ at 40 TeV, with a discriminating muon value equal to 4 muons.