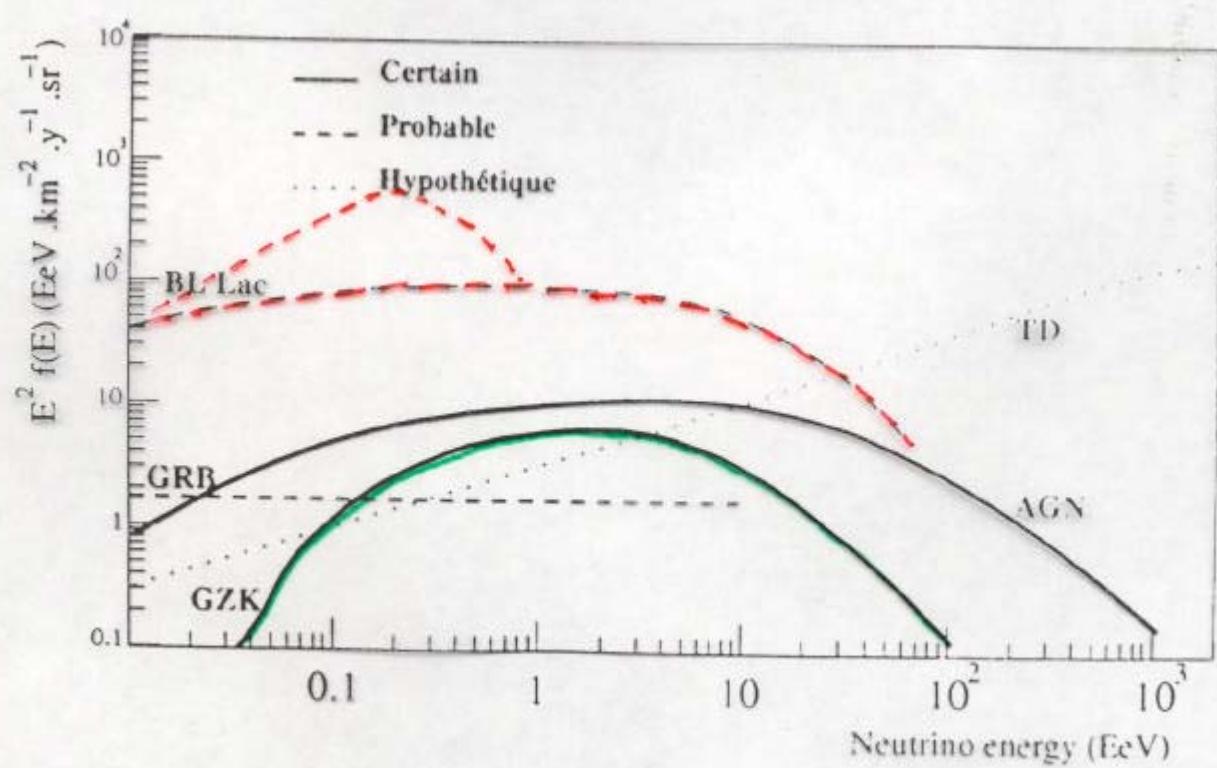
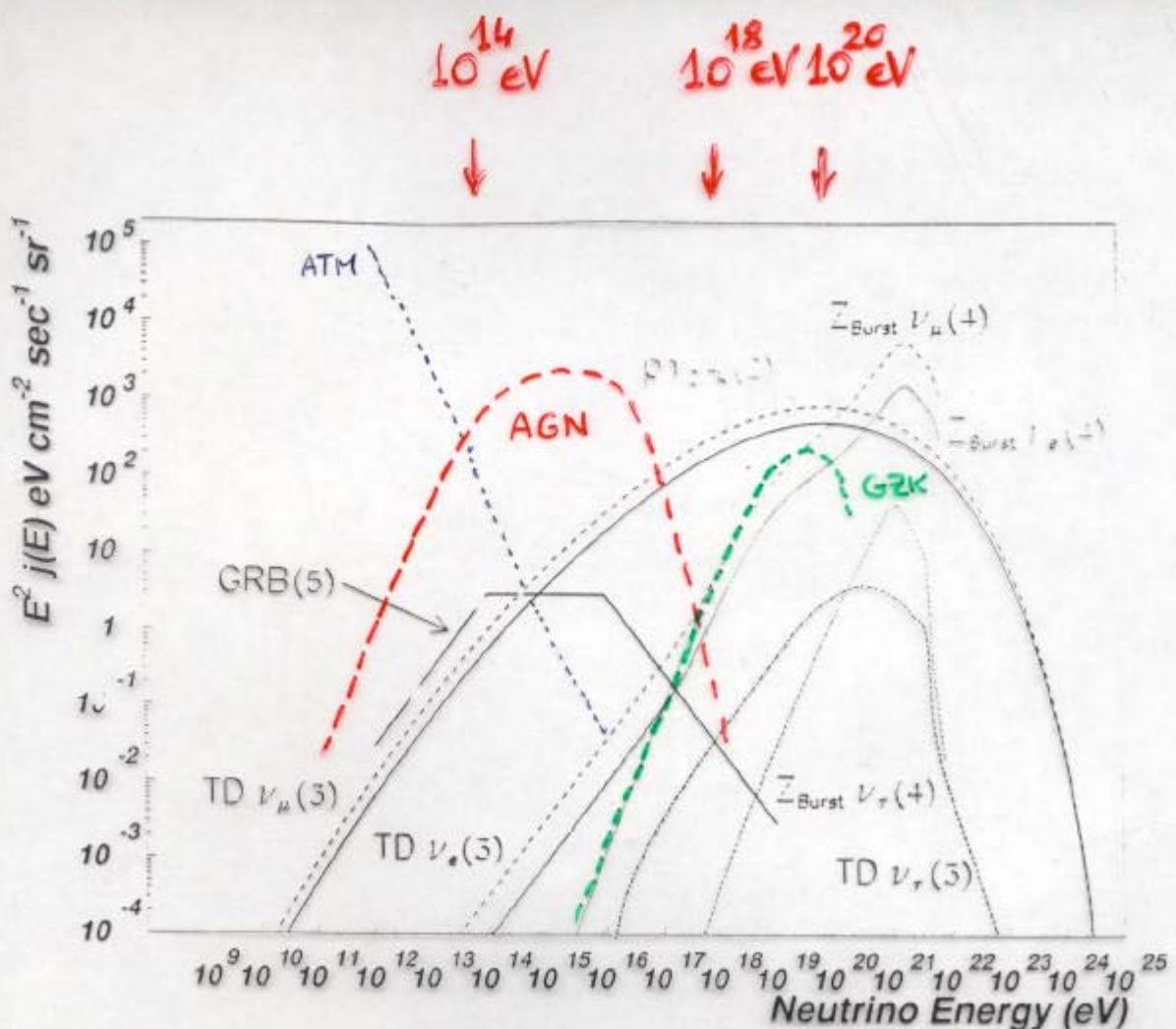


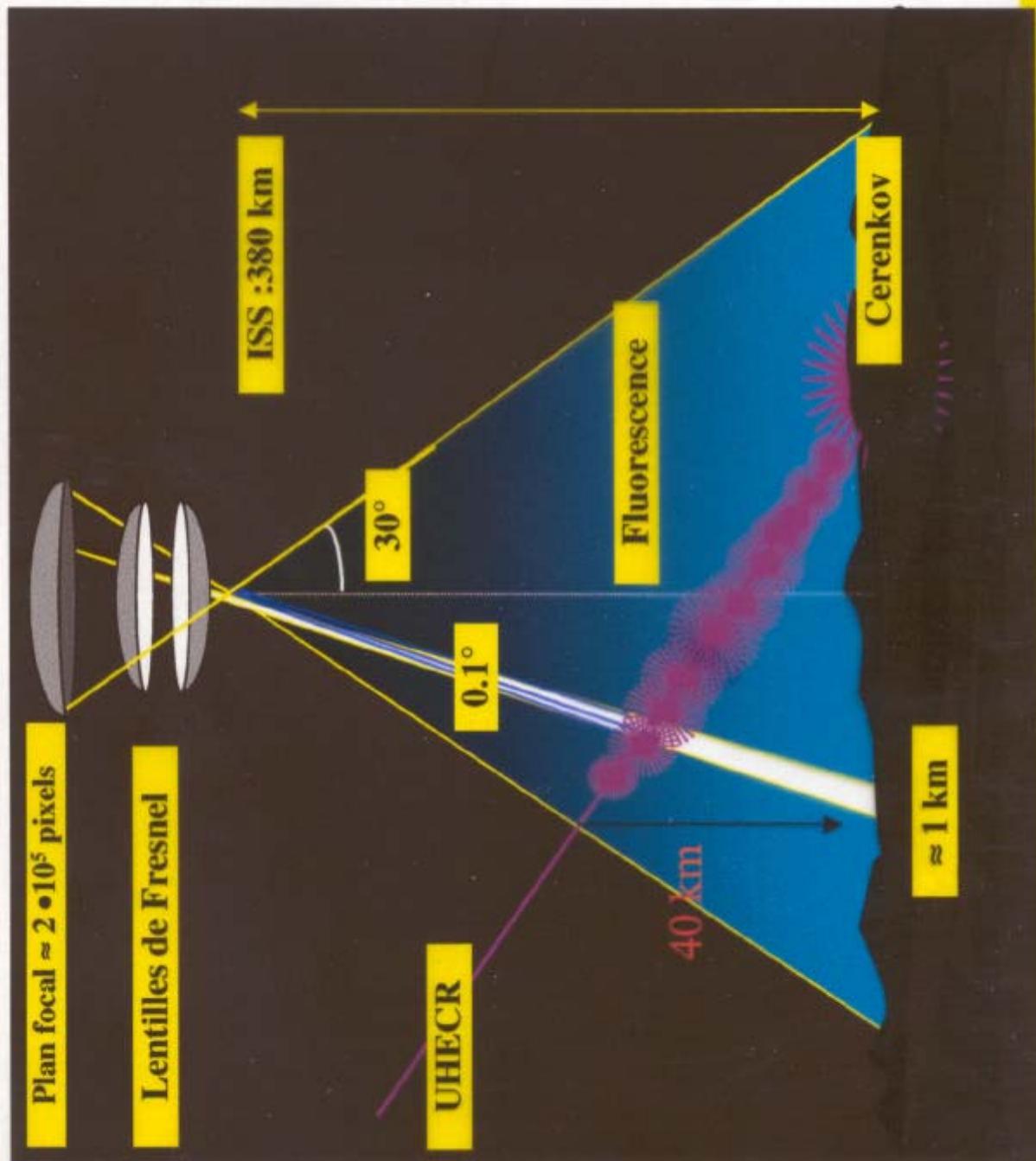
—

DETECTING H.E. NEUTRINOS
THROUGH
ATMOSPHERIC SHOWERS

—



La Physique d'EUSO (1)

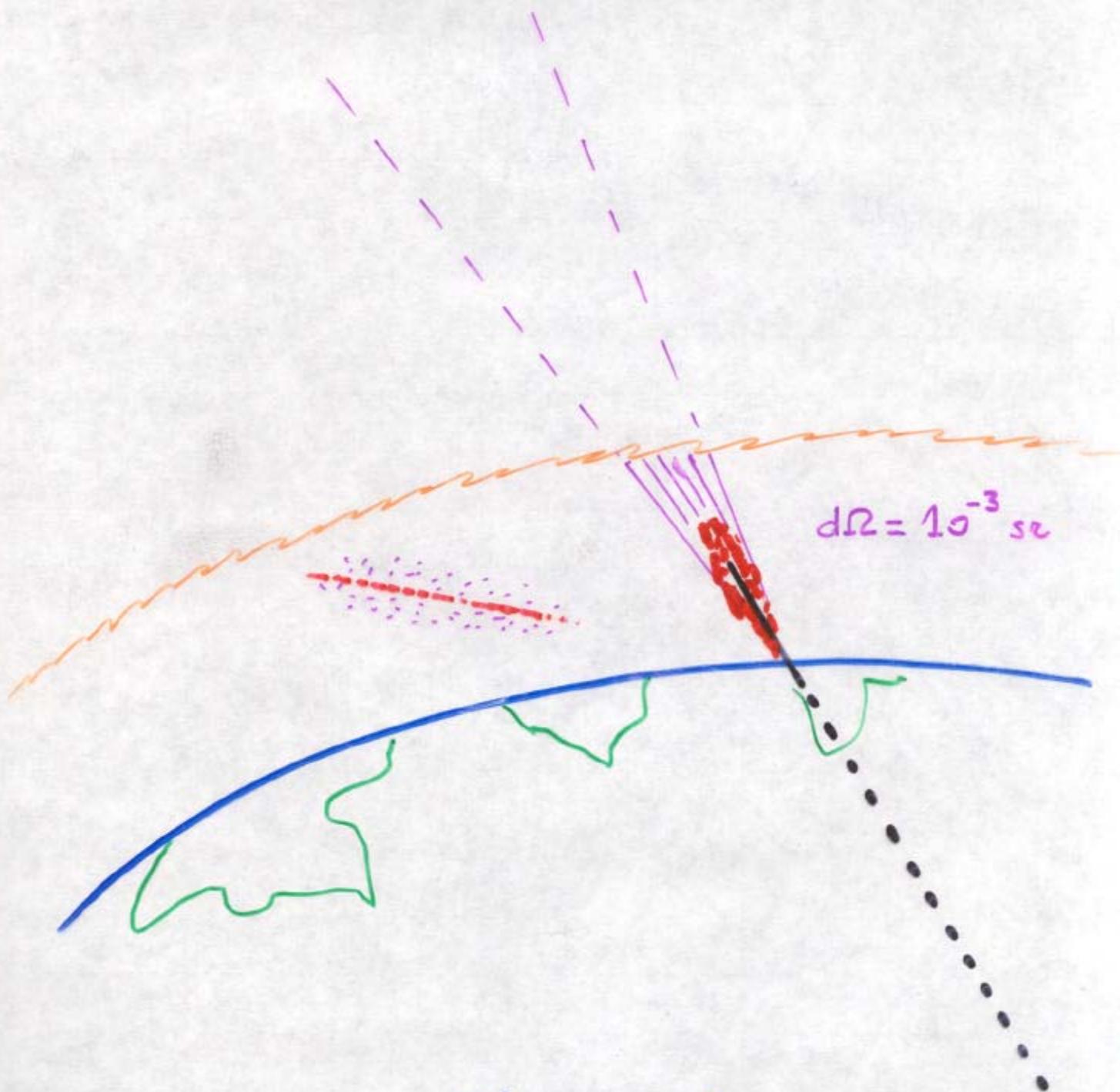


Thomas Patzak: L'expérience EUSO

Journée APC 29/01/02



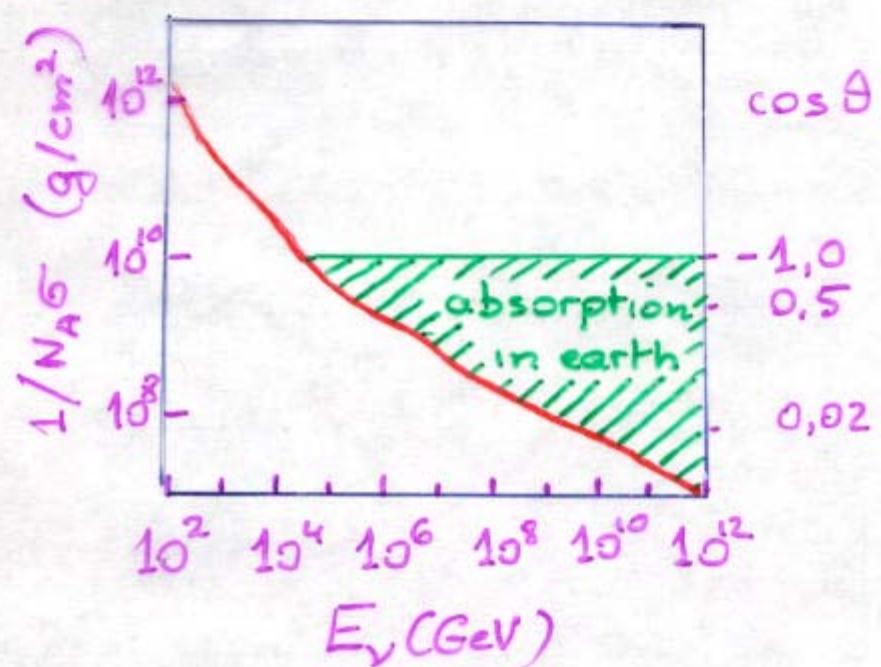
CERENKOV vs. FLUO



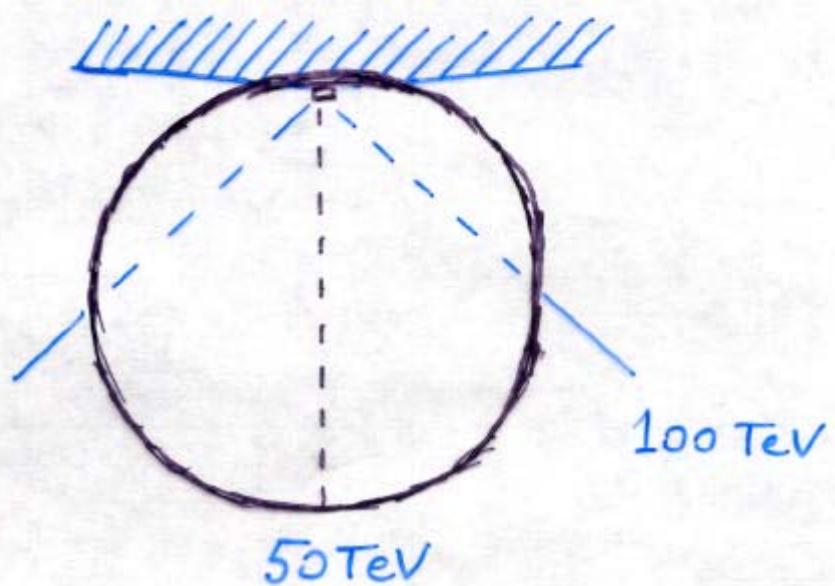
$\nu_e \rightarrow e$

$\nu_\tau \rightarrow \tau \rightarrow e, \pi^0$

EARTH OPACITY



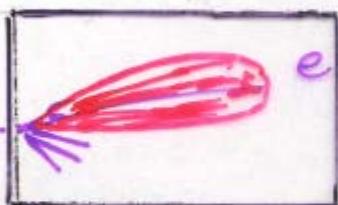
Mean free path



DETECTION

• $\nu_e \rightarrow e$

ν_e



L.P.M.

EM shower inside active volume

• $\nu_\mu \rightarrow \mu$

ν_μ

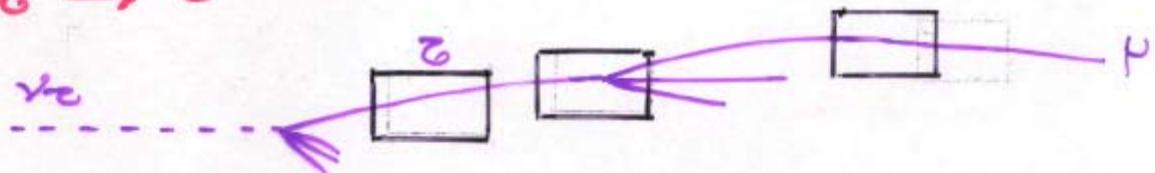


μ

long track $\lambda \gtrsim \text{km}$ at 10^{15} eV

• $\nu_\tau \rightarrow \tau$

ν_τ



μ

$$\gamma_{\text{CT}} = 500 \text{ m} \times \frac{E}{10^{16} \text{ eV}}$$

goes up to $\sim 30 \text{ km}$

Importance of oscillations
with maximum mixing

$$\nu_e : \nu_\mu : \nu_\tau = 1 : 1 : 1$$

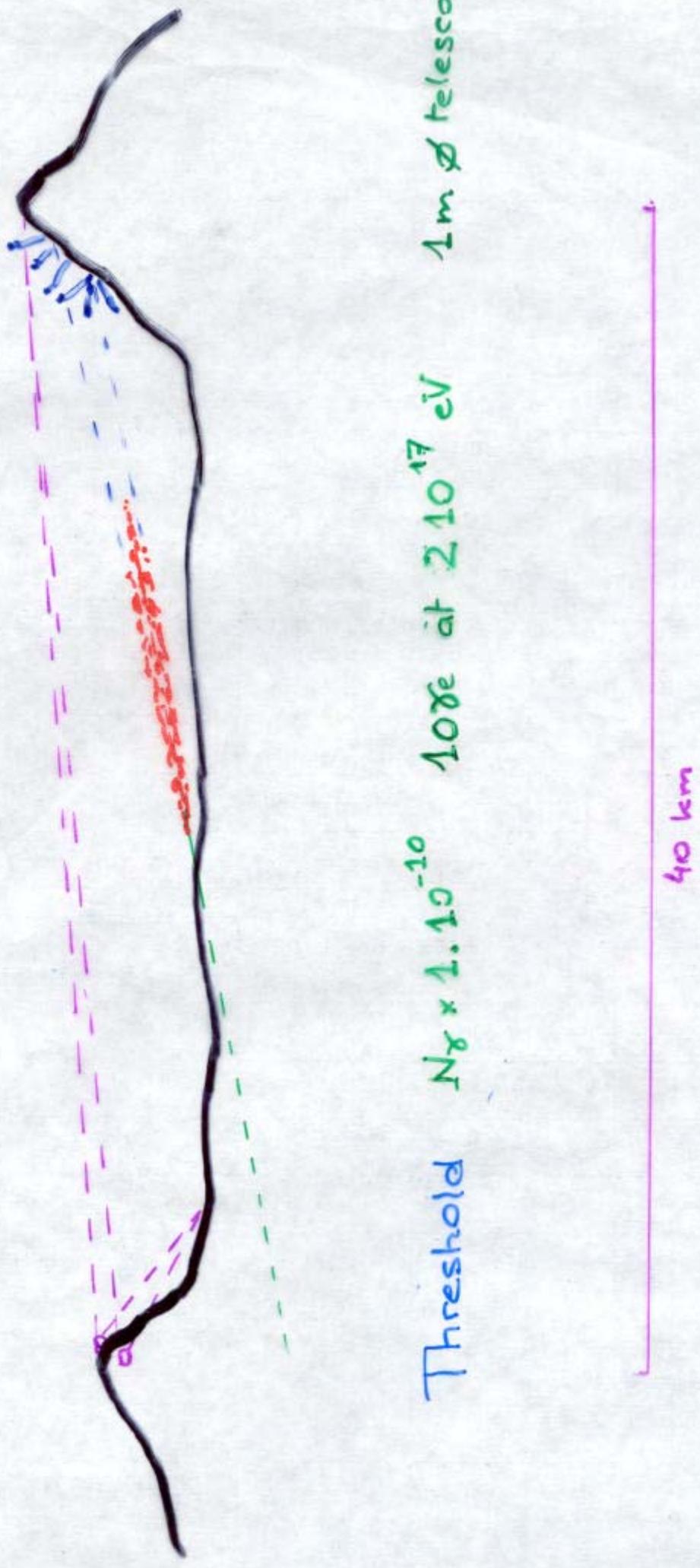
CERENKOV



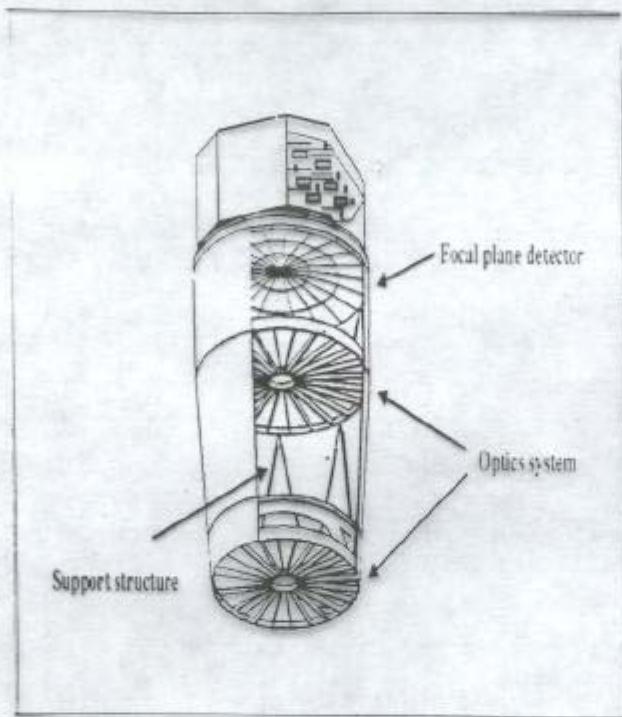
Threshold 10¹⁶ eV at 5×10^{15} eV with 20 cm ϕ telescope

40 km

FLUO + CERENKOV



EUSINO...



.Optics 1 m diameter

.Focal plane

200 photoel / ns

MAPMT's 10 ns

10% random occup
with 20 000 pixels

.2 telescopes in coincidence.
stereo

GAW (Gamma Air Watch): a novel imaging Cherenkov telescope

G. CUSUMANO, G. AGNETTA, B. BIONDO, O. CATALANO, S. GIARRUSSO,
G. GUGLIOTTA, L. LA FATA, M.C. MACCARONE, A. MANGANO, T. MINEO, F.
RUSSO, B. SACCO

IFCAI Consiglio Nazionale delle Ricerche, Palermo, Italy

ABSTRACT. GAW (Gamma Air Watch) is a new imaging Cherenkov telescope designed for observation of very high-energy gamma-ray sources. GAW will be equipped with a 3 meter diameter Fresnel lens as light collector and with an array of 300 multi-anode photomultipliers at the focal plane. The pixel size will be 4 arcmin wide for a total field of view of 10.5 degrees. With respect to the planned imaging Cherenkov telescopes (CANGAROO III, HESS, MAGIC, VERITAS) GAW follows a different approach for what concerns both the optical system and the detection working mode: the Cherenkov light collector is a single acrylic flat Fresnel lens (instead of mirrors) that allows to achieve wide field of view; the photomultipliers operate in single photoelectron counting mode (instead of charge integration). The single photoelectron counting mode allows to reach a low energy threshold of ~ 200 GeV, in spite of the relatively small dimension of the GAW optic system.

1. Introduction

At energies around 0.03 TeV the emission from galactic and extragalactic sources is too weak to be detected by instruments onboard satellites because of their poor effective area. Actually, since the flux of an astronomical source decreases as the energy increases, observations at higher energy need a huge effective area that is not feasible with space detectors. Only ground-based experiments achieve enough effective area to observe the very low intensity and the soft spectra emitted in this extreme energy band. Observations can be performed either by detecting the shower of secondary particles produced by the interaction of gamma-ray entering into the high atmosphere, or by detecting the Cherenkov light emitted by the relativistic charged component of the shower. The spread of the secondary particles and the intrinsic Cherenkov light cone aperture (1.3 degrees in air) allow a strong increase of the effective area being the detectors sensible to gamma rays whose trajectory is hundreds of metres far from them. Imaging Cherenkov telescopes, thanks to their large collection area ($\sim 10^5$ m²) and to their very high efficiency in rejecting the cosmic ray background, have turned out to be the most sensitive instruments for the observation of astrophysical sources above 250 GeV.

In this paper we present a novel imaging Cherenkov telescope, GAW (Gamma Air Watch) designed to observe gamma-ray sources above 200 GeV. The main components of the telescope (optics, focal surface detector and operative mode) are described in Sect.2; the performance is presented in Sect.3.

GZK NEUTRINOS

Range $10^{17} \rightarrow 10^{20}$ eV

Technique : fluo + ē flash

Telescope observing

80 km^2 , 1 sr
during $3 \cdot 10^6$ s

→ 10 events (ν_e)

Good angular resolution $< 10 \text{ mrad}$

Direction

Correlation (GRB?)

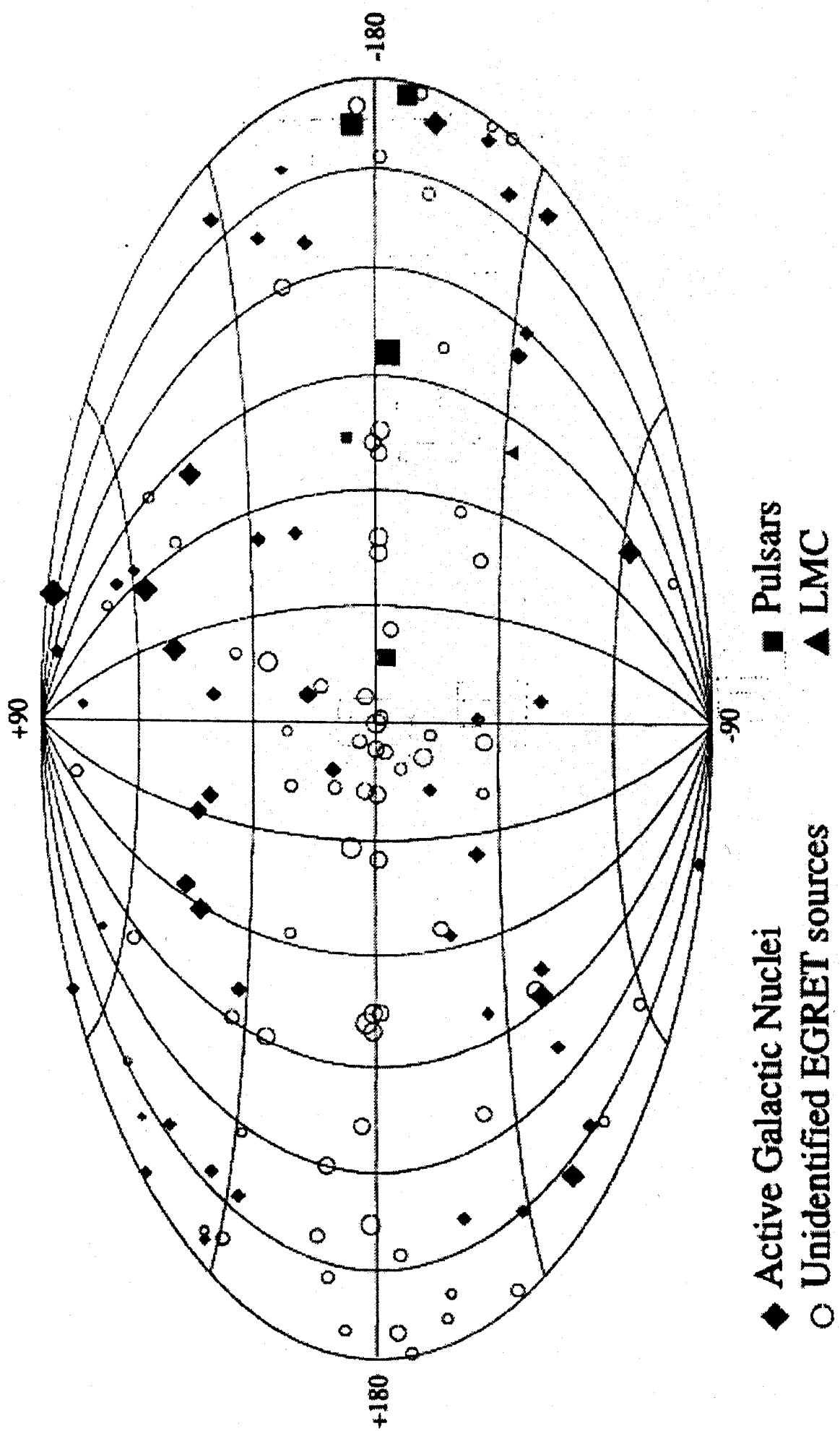
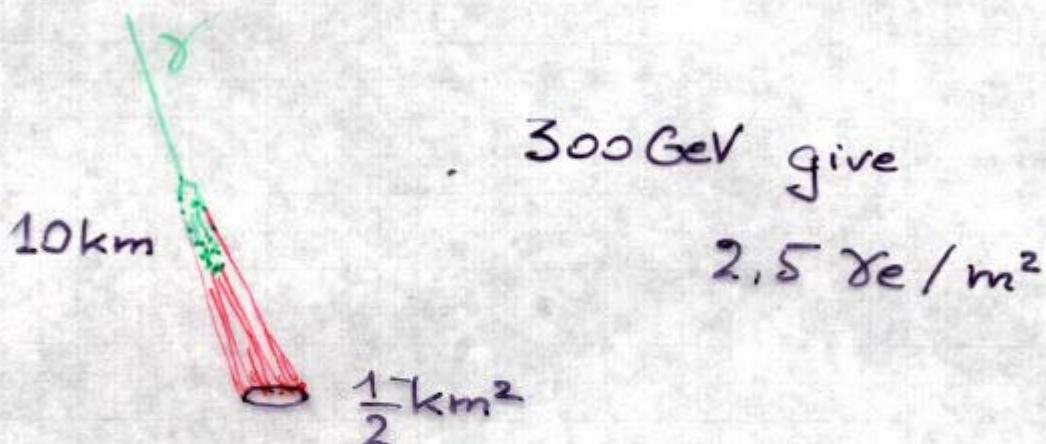


FIG. 5.—Second EGRET source catalog, shown in Galactic coordinates. The size of the symbol represents the highest intensity seen for this source by EGRET at energies above 100 MeV.

EUSINO THRESHOLD

Cerenkov light

experience of γ ray detectors



300 GeV give

2.5 Ze/m^2

aperture
valley

40 cm \varnothing

1 m \varnothing

20 km

$4 \cdot 10^{13} \text{ eV}$

$7 \cdot 10^{12} \text{ eV}$

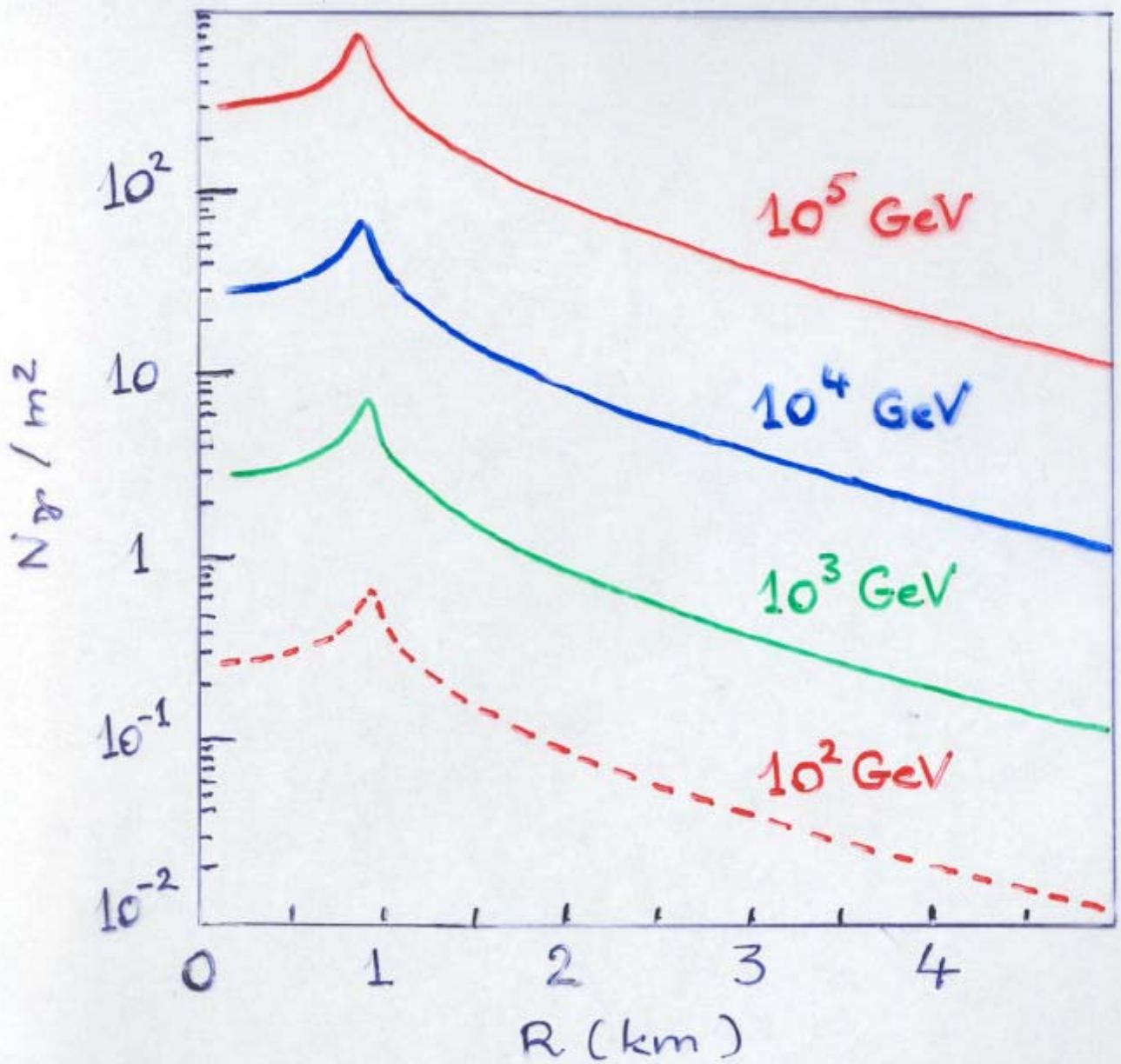
40 km

$1.6 \cdot 10^{14} \text{ eV}$

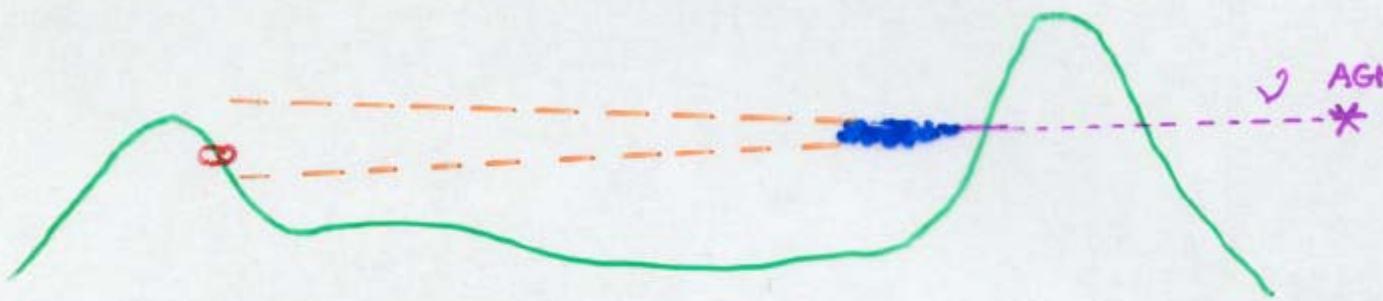
$3 \cdot 10^{13} \text{ eV}$

for 10 γ (in 1 pixel)

For AGN neutrinos $20 \text{ cm } \varnothing \Rightarrow 7 \cdot 10^{14} \text{ eV}$



PHYSICS BACKGROUND



$7 \cdot 10^{14}$ eV in Cerenkov light



$5 \cdot 10^{18}$ eV in primary cosmic track

$1 / \text{km}^2/\text{year}$

$\Rightarrow 10 \text{ events} / 3 \cdot 10^6 \text{ s} / \text{surface}$

but photons spread over $\sim 3 \mu\text{s}$

EUSINETTI...

Series of small telescopes

20 cm optics

314 cm^2 60 pe / 10 ns

\Rightarrow 600 pixels

10% random occupancy

Probability to have 10γ in 1 pixel

10^{-2} in 1s for a given pixel

2 telescopes in coincidence

"same" pixel seeing 10γ

1 in 10^3 years !

Effective surface $\sim 1 \text{ km}^2/\text{telescope}$

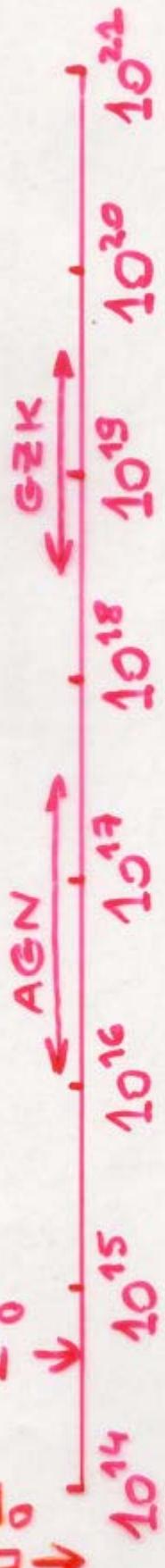
Counting rate

~ 1 event/pair of telesc. (Stecker)

~ 10 events/pair of telesc. (Protheroe)

SUMMARY

\rightarrow Earth opacity



ν_e

ν_μ

ν_τ

$$\frac{1,0 \text{ km}^3 \text{s}^{-2}}{\leftarrow \rightarrow} = \frac{2000,0 \text{ km}^3 \text{s}^{-2}}{\leftarrow \rightarrow} = \frac{1000 \text{ km}^3 \text{s}^{-2}}$$

$$\leftarrow \rightarrow$$

$$\frac{1 \text{ km}^3 \text{s}^{-2}}{\leftarrow \rightarrow}$$

$$\frac{40,0 \text{ km}^3 \text{s}^{-2}}{\leftarrow \rightarrow} = \frac{200 \text{ km}^3 \text{s}^{-2}}{\leftarrow \rightarrow} \rightarrow$$

Amanda, Antares ...

Auger

$\frac{SE}{E}$

NuOpTel

EUSO, radio