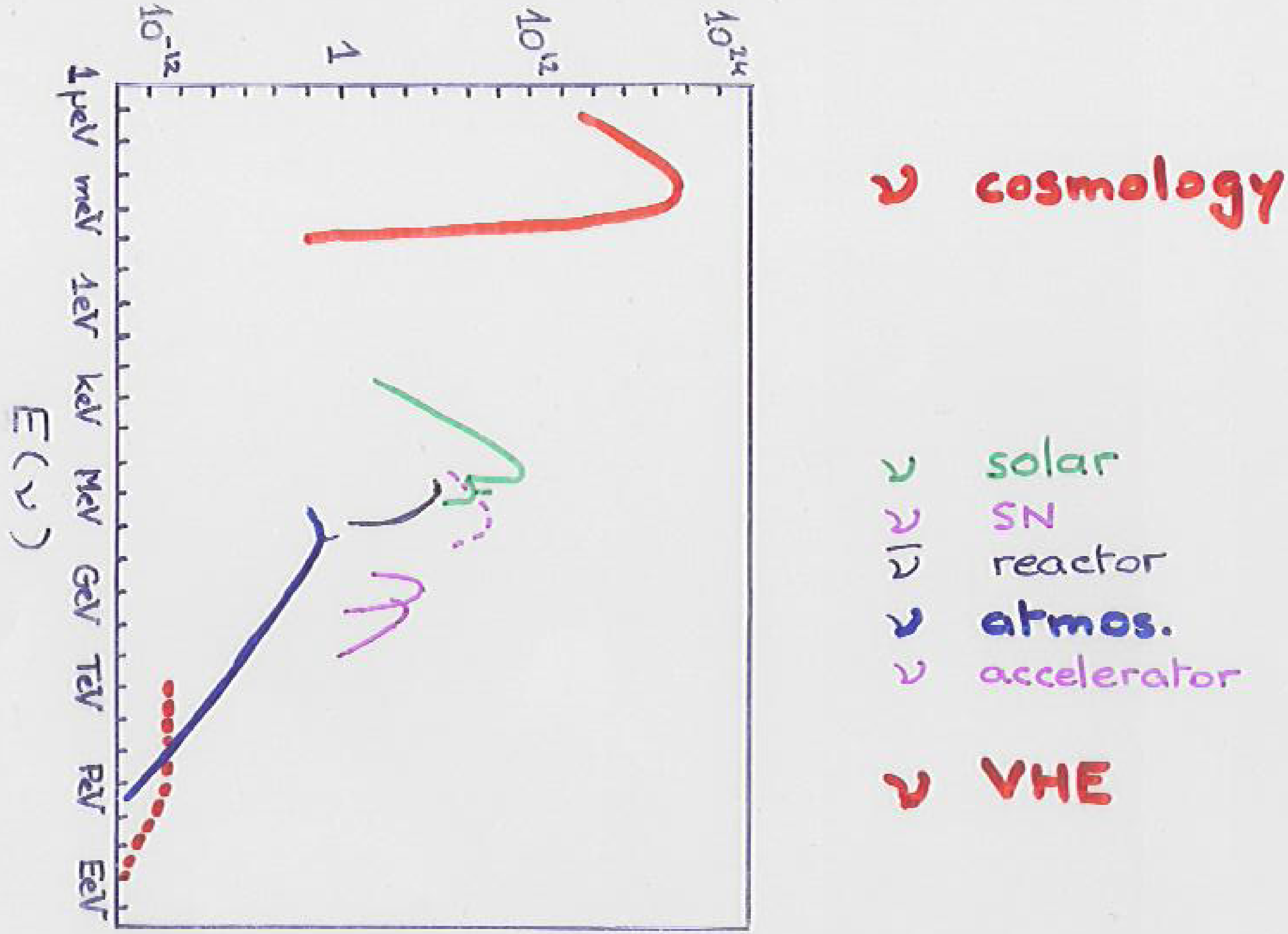
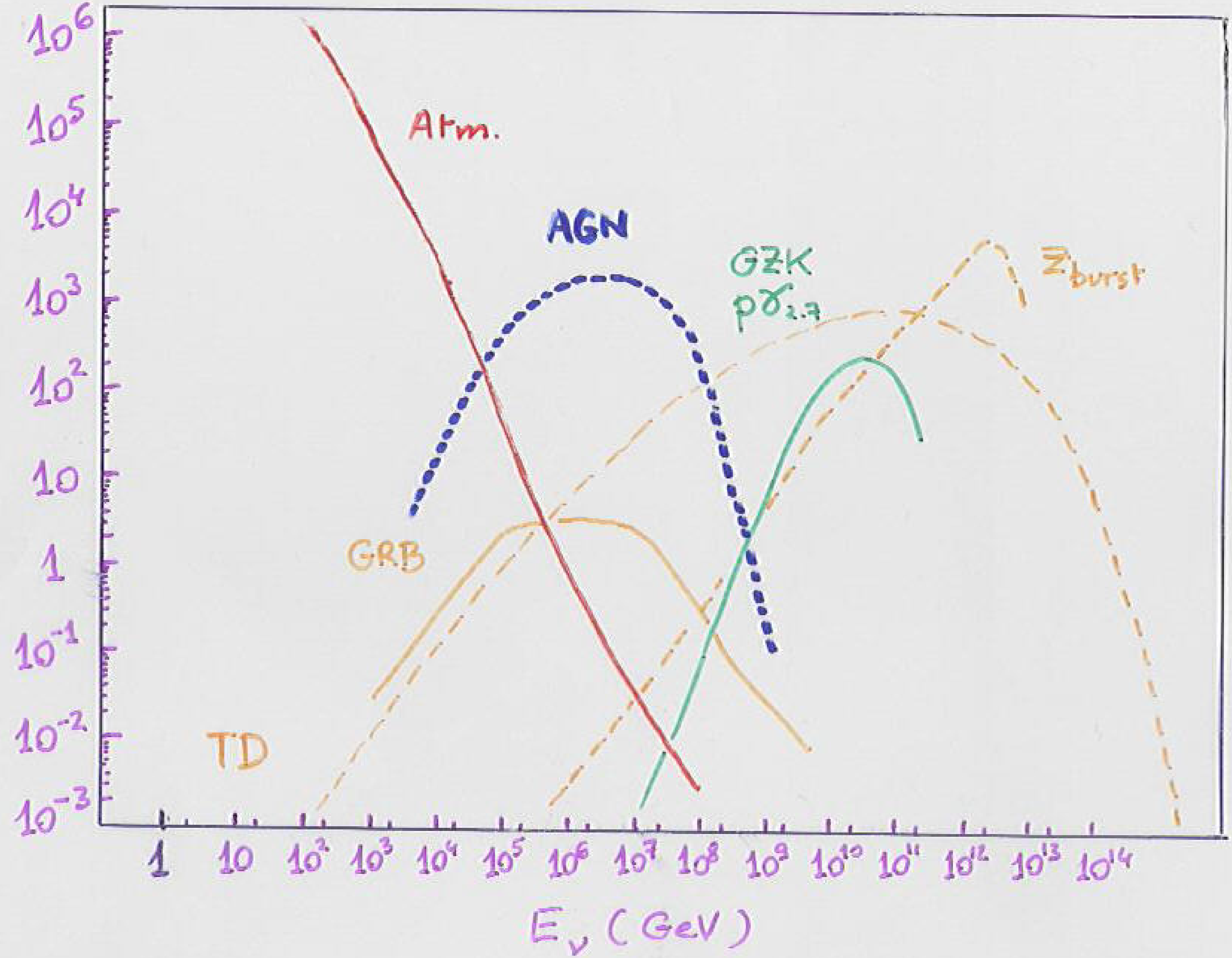
NATURAL NEUTRINO SOURCES


10^-12
1
10^12
10^24
1µeV
meV
1eV
keV
MeV
GeV
TeV
PeV
EeV
E(ν)
ν cosmology
ν solar
ν SN
ν̄ reactor
ν atmos.
ν accelerator
ν VHE



Atm.
AGN
GZK
pγ2.7
Z burst
GRB
TD
E²Φ(E) eV/cm² s sr
E_ν (GeV)
10^6
10^5
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
1
10
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
10^10
10^11
10^12
10^13
10^14

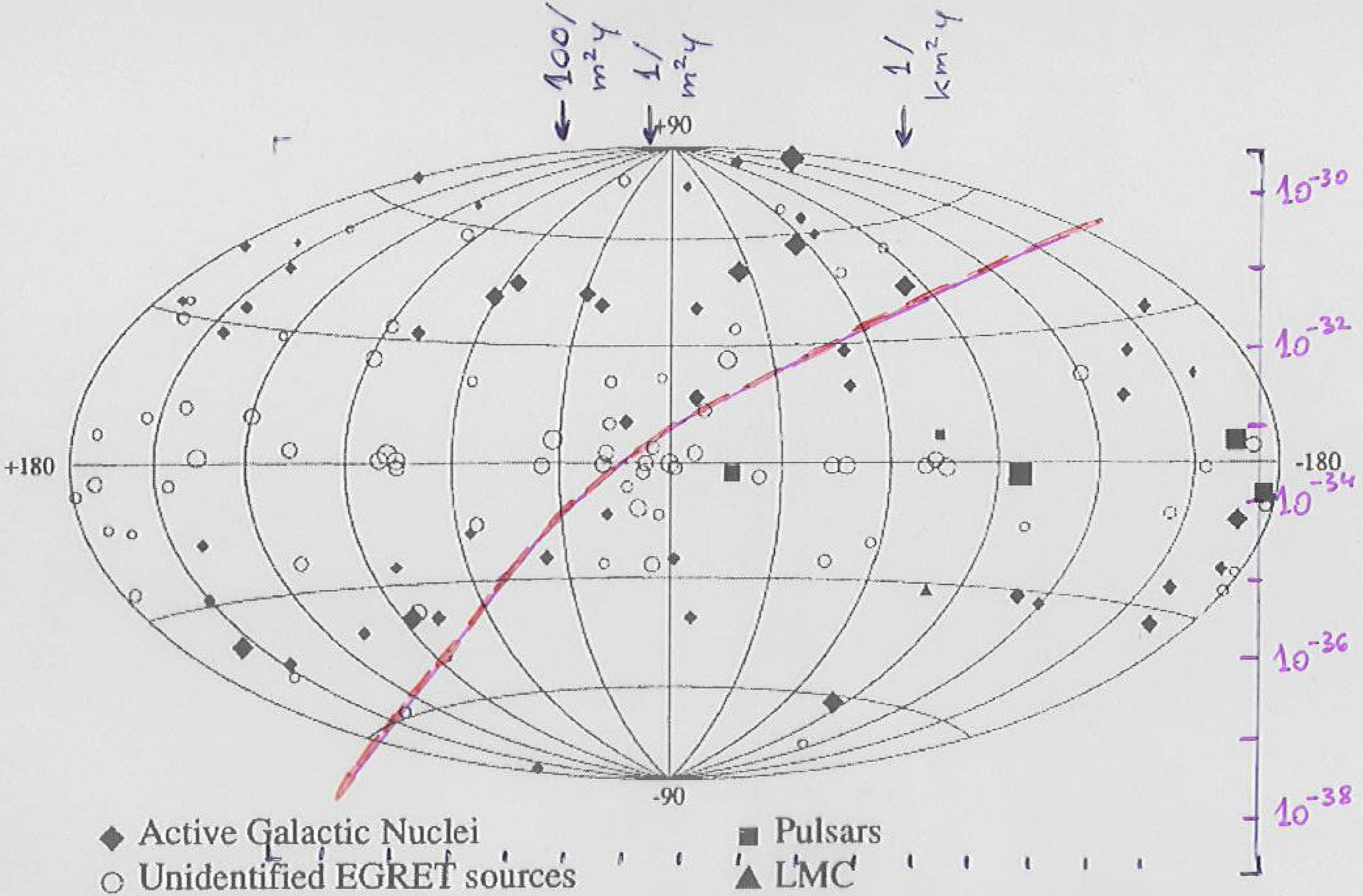
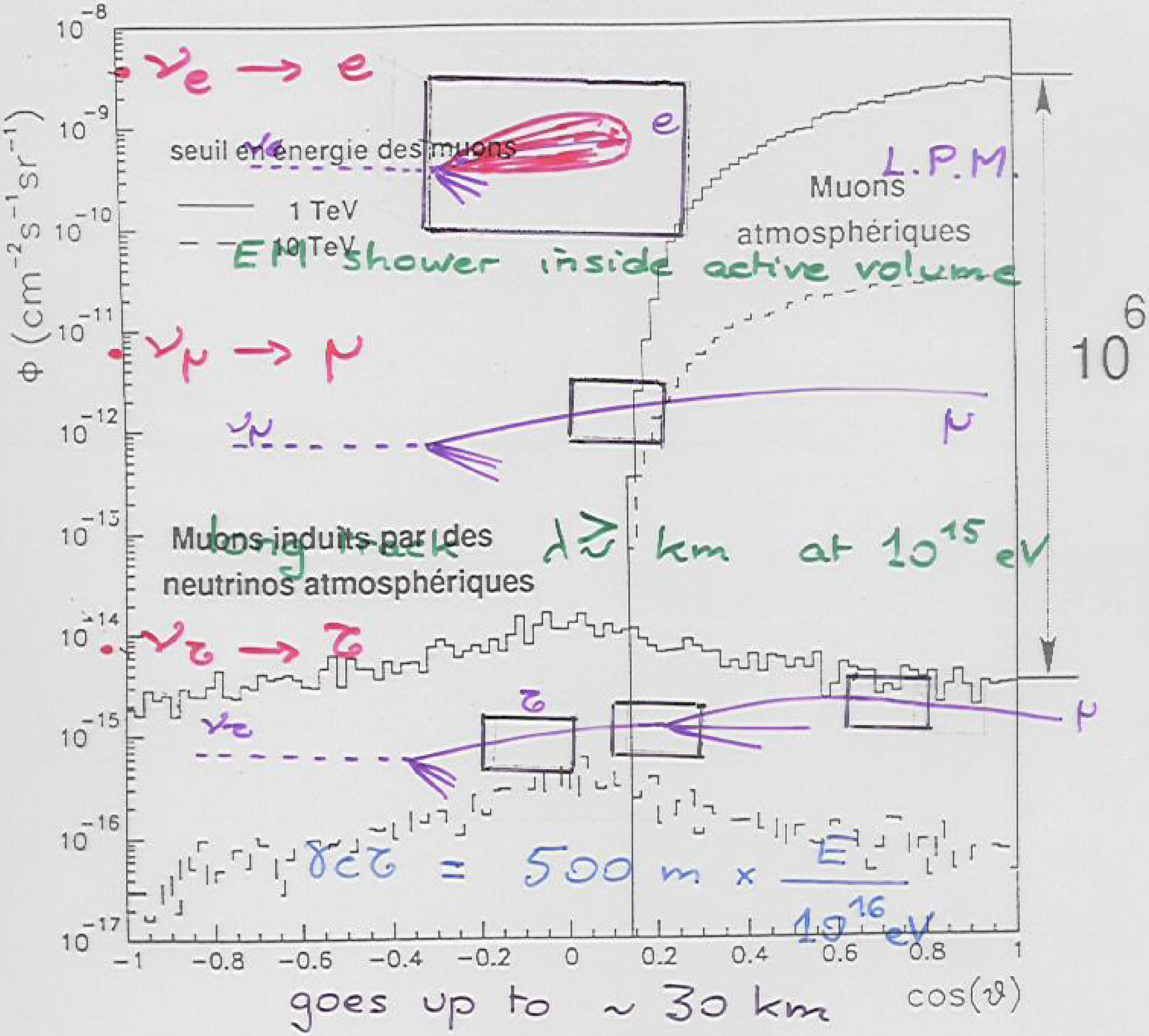


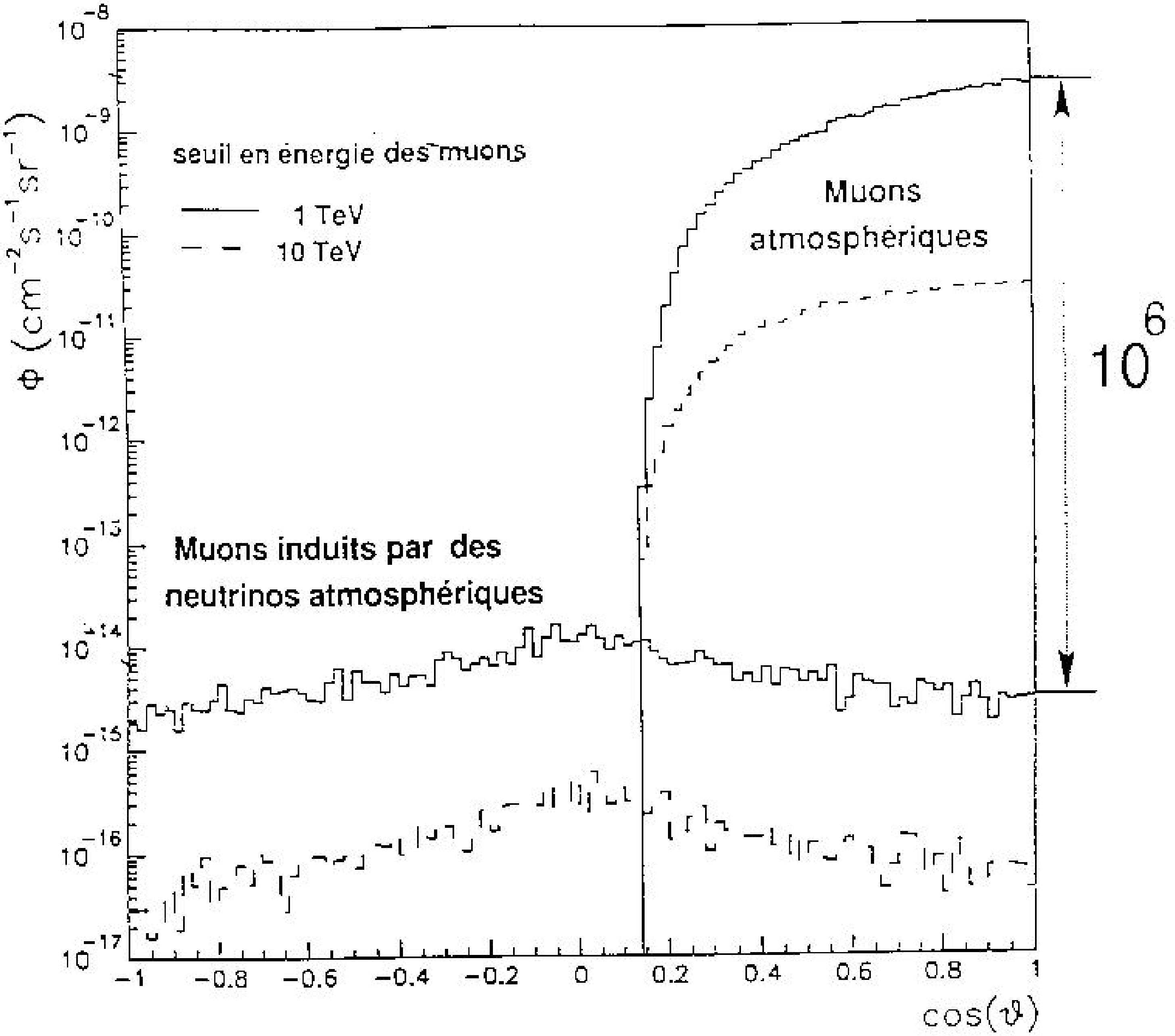
FIG. 5.—Second EGRET source catalog, shown in Galactic coordinates. The size of the symbol represents the highest intensity seen for this source by EGRET at energies above 100 MeV.

DETECTION



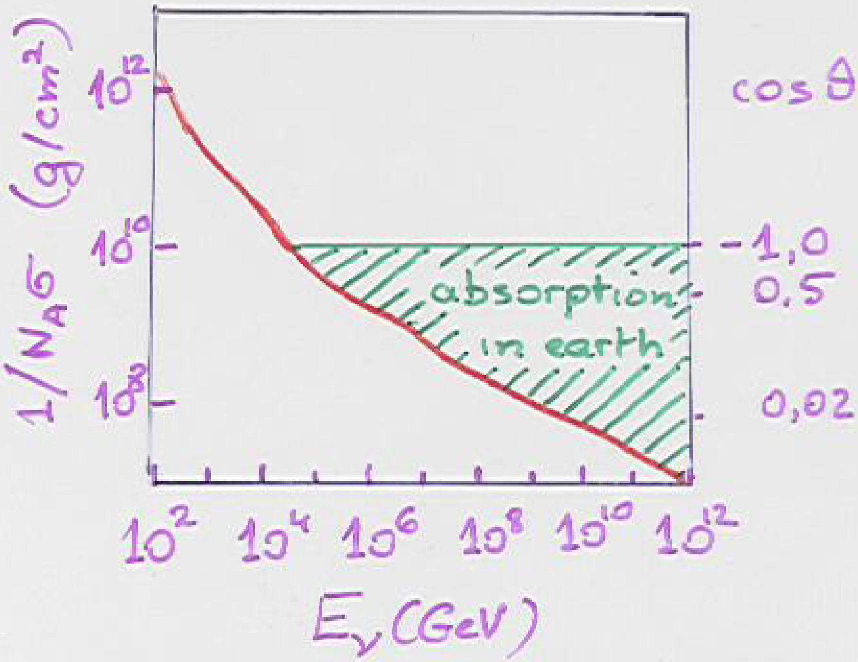
Importance of oscillations
with maximum mixing

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

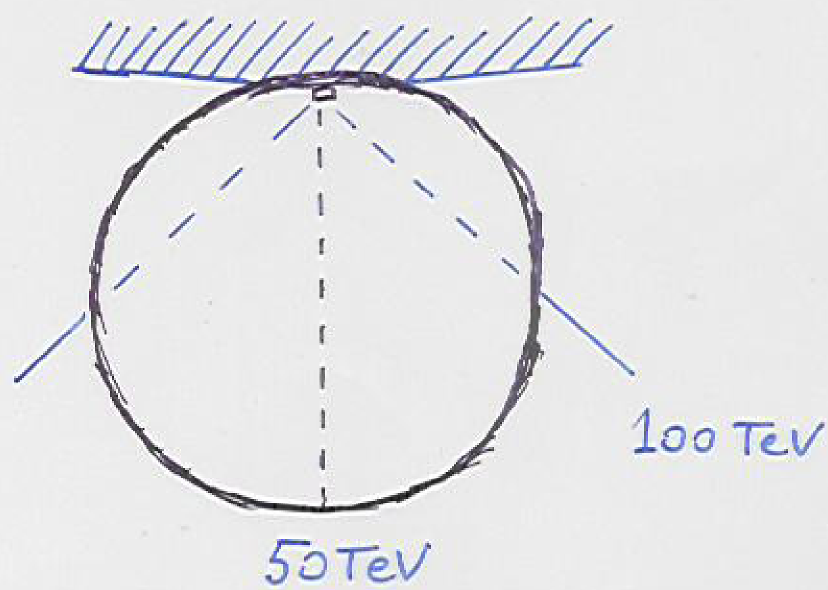


seuil en énergie des muons
1 TeV
10 TeV
Muons atmosphériques
Muons induits par des neutrinos atmosphériques
10^6
$\Phi\ (cm^{-2}s^{-1}sr^{-1})$
$\cos(\vartheta)$
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-16}
10^{-17}
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

EARTH OPACITY

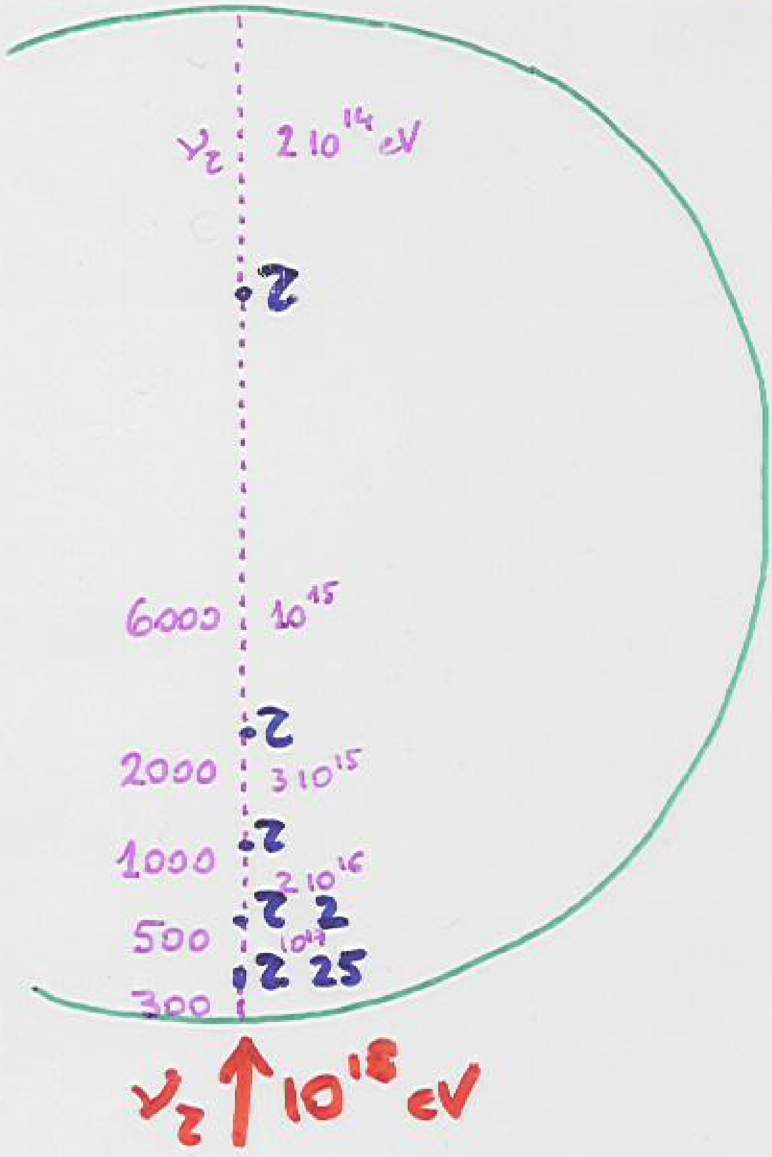


Mean free path

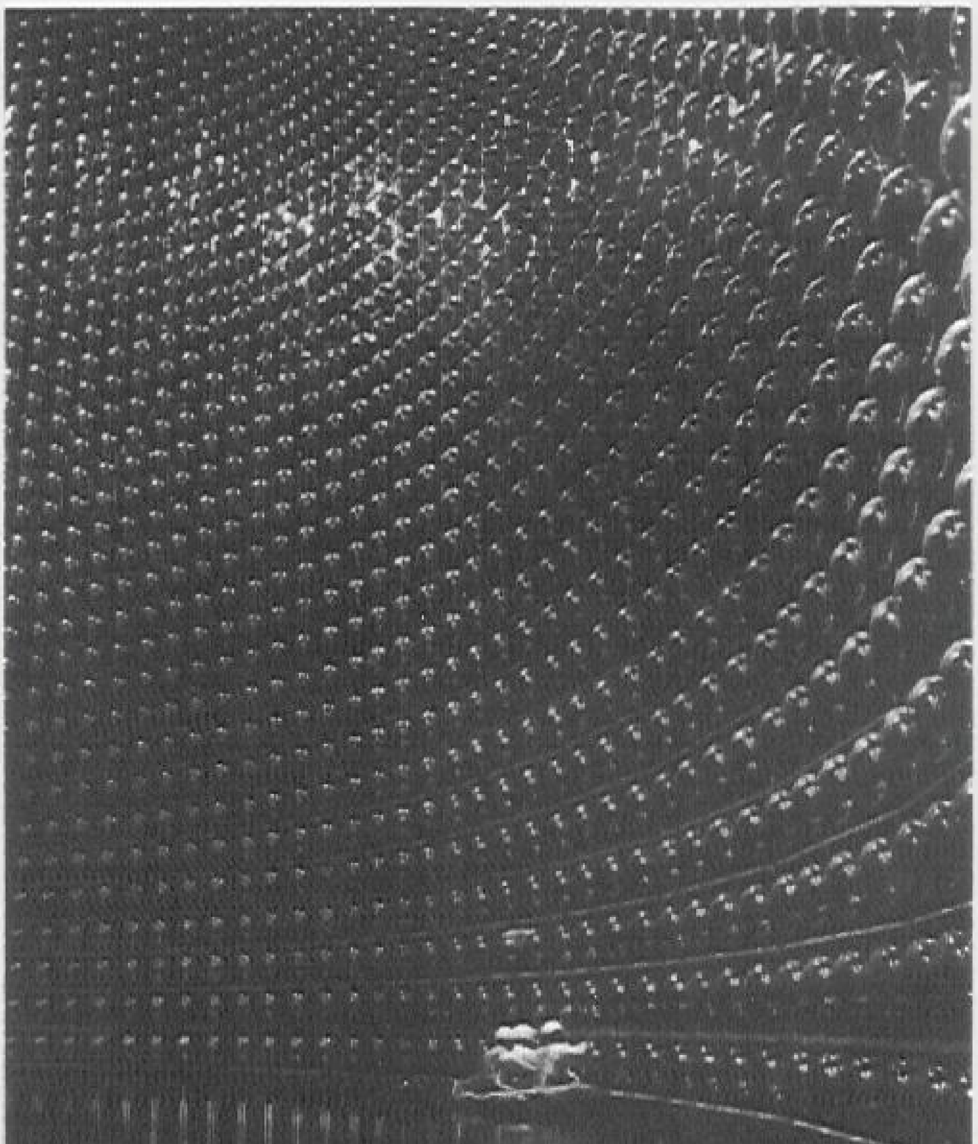


ν_τ MULTIBANGS

transparency
but
E degradation



ν_τ 10^{18} end up in $\sim 2.10^{14}$ eV
10^{19}
⋮

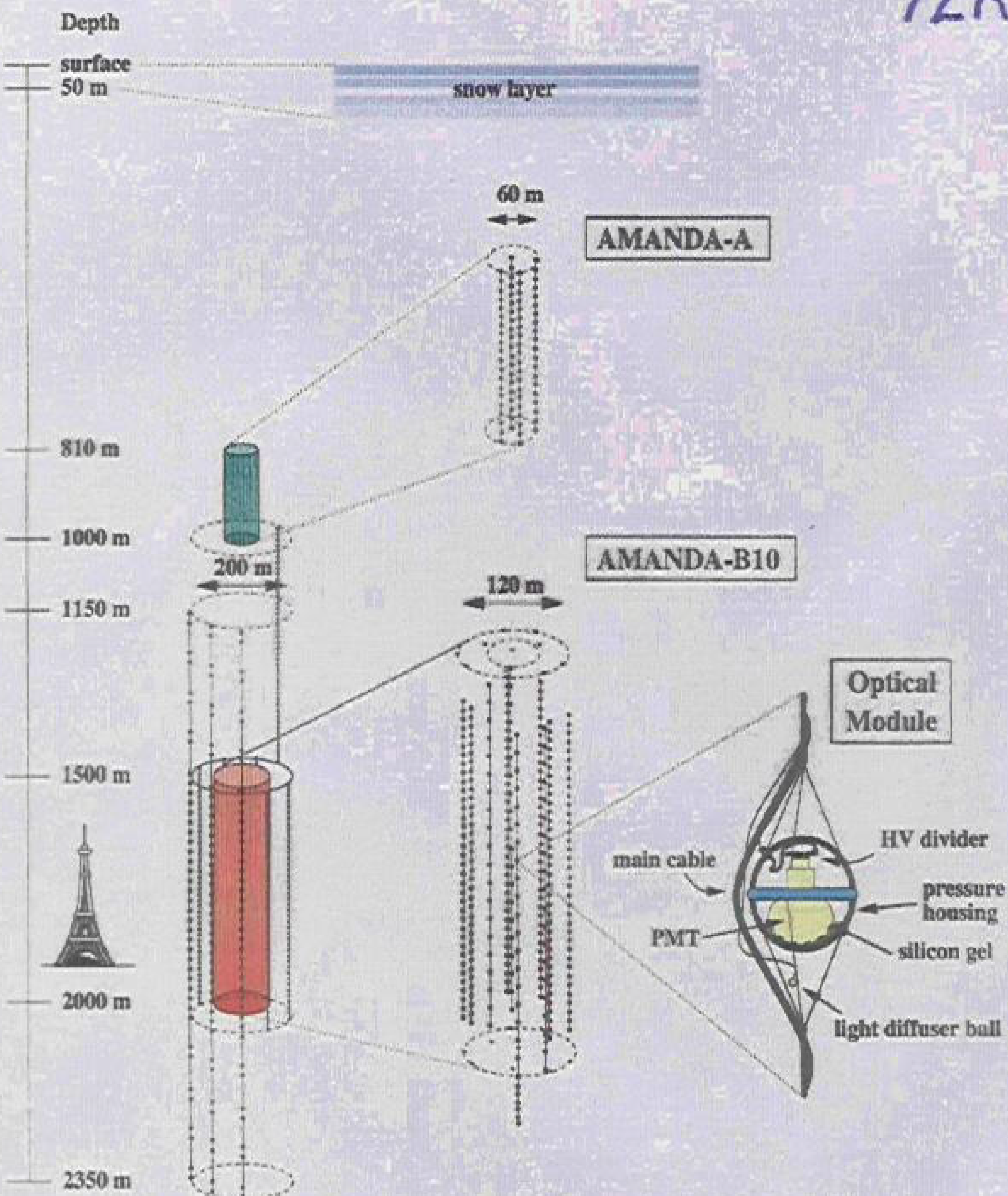


ANTARES Detector Design

- 13 flexible strings of photosensors Strings are anchored at the sea-bed and held taut by their own buoyancy
- Each string is 450m high with the first 100m un-instrumented
- 30 storeys per string, 12m between storeys
- 3 PMTs per storey
- 60m between strings

- Power into the array and data readout is via a 40km electro-optical cable
- Each string is connected to the electro-optical cable via a Junction Box

Y2K



AMANDA as of 2000
Eiffel Tower as comparison
(true scaling)

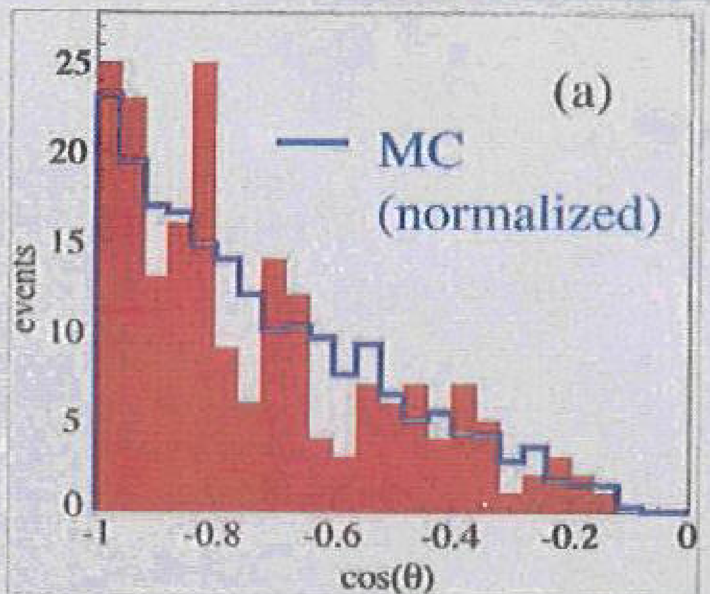
zoomed in on
AMANDA-A (top)
AMANDA-B10 (bottom)

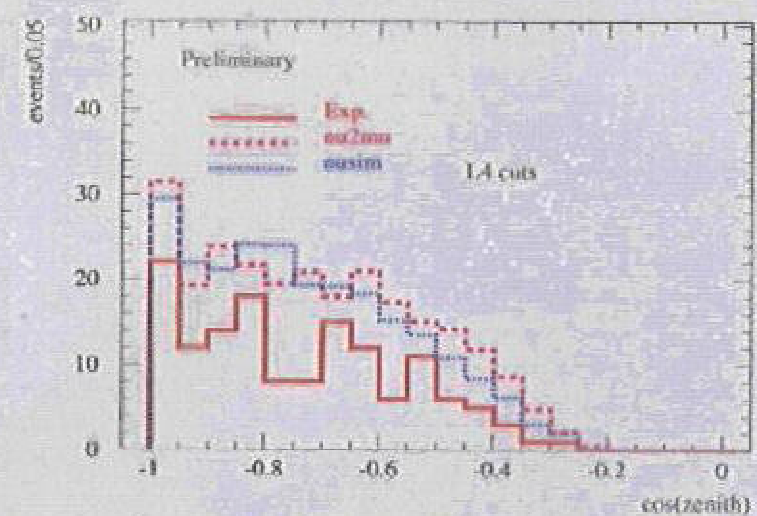
zoomed in on one
optical module (OM)

AMANDA

Angular Distributions

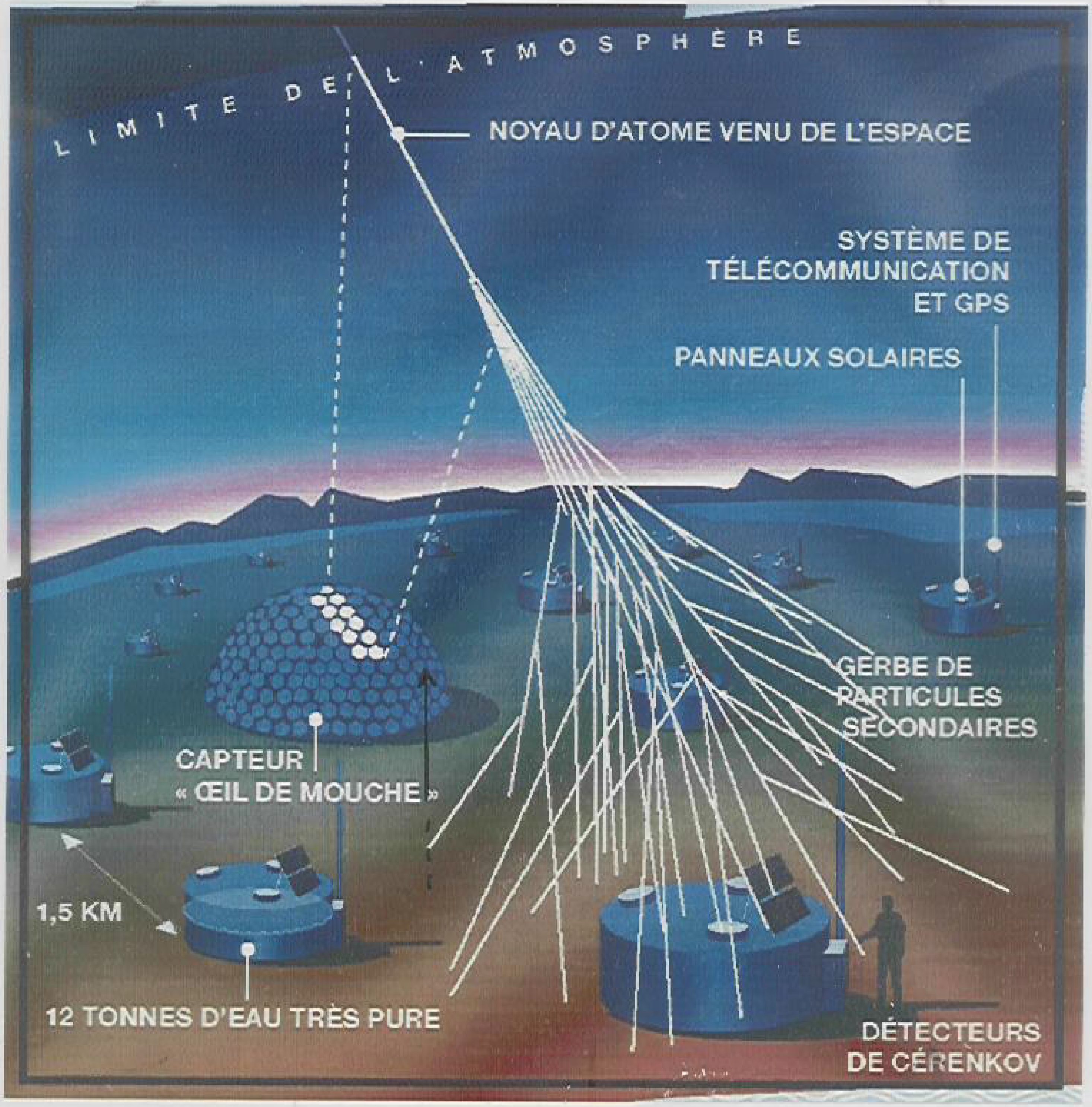
Two distinct analysis techniques, but not independent





6/14/00

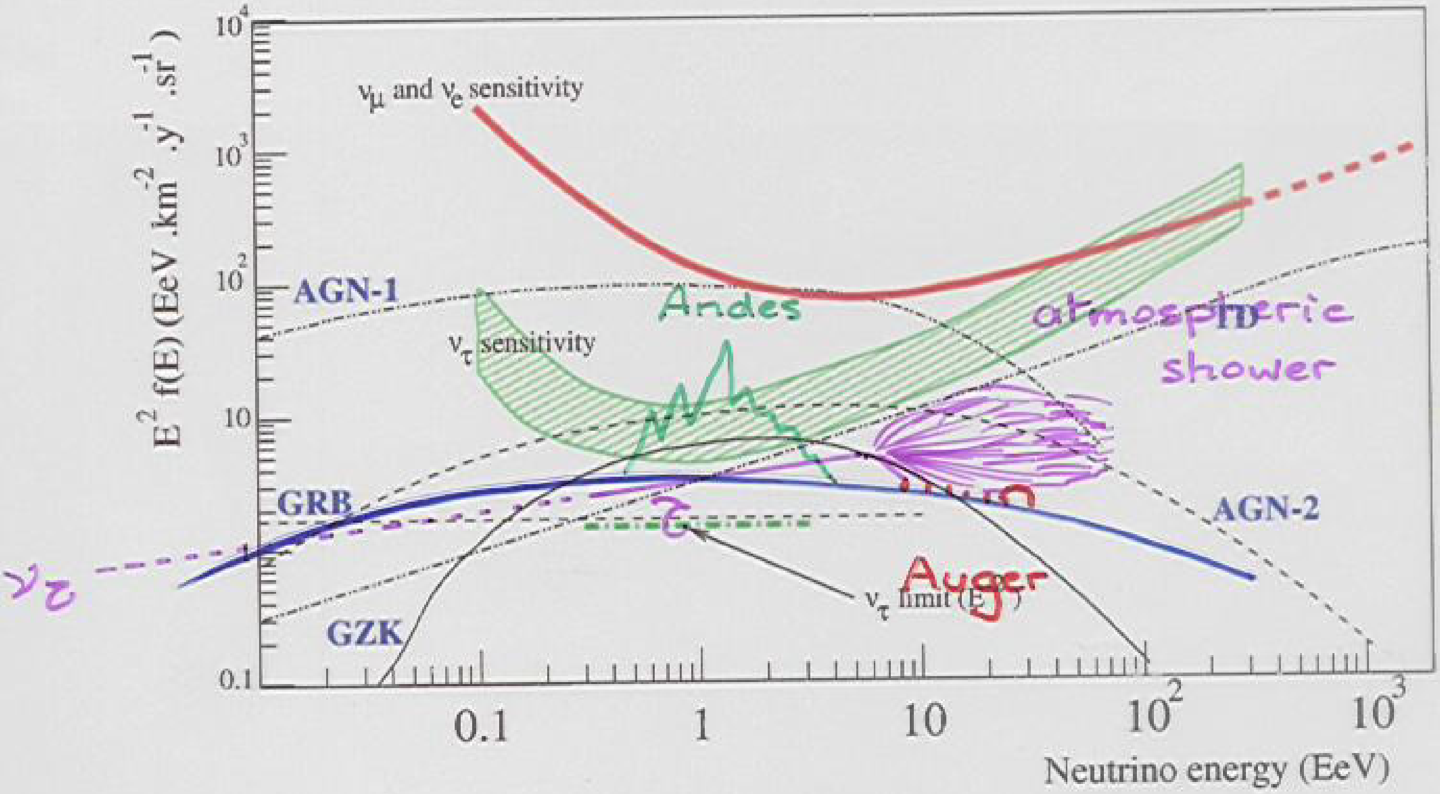
Steven W. Barwick



LIMITE DE L'ATMOSPHÈRE
NOYAU D'ATOME VENU DE L'ESPACE
SYSTÈME DE TÉLÉCOMMUNICATION ET GPS
PANNEAUX SOLAIRES
GERBE DE PARTICULES SECONDAIRES
CAPTEUR « ŒIL DE MOUCHE »
1,5 KM
12 TONNES D'EAU TRÈS PURE
DÉTECTEURS DE CÉRENKOV

Neutrinos

A summary of Auger expected performances



Hatched area represents two extreem DIS energy loss models.

Flux divided by two (full mixing hypothesys $\nu_e : \nu_\mu : \nu_\tau = 1:1:1$).

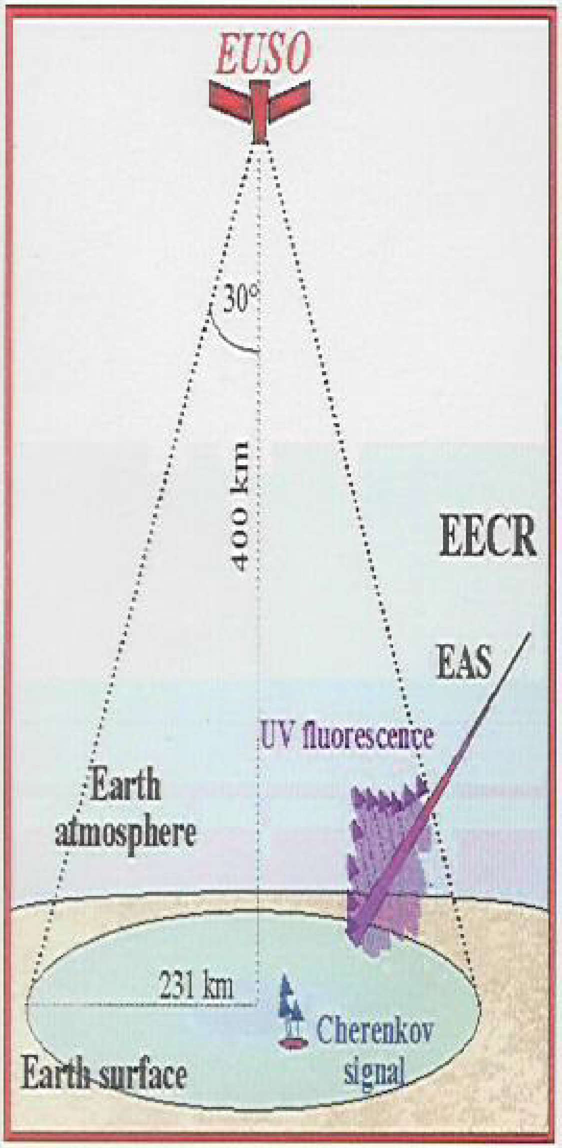
Dotted line speculative. Dahsed line probable. Solid line certain.

Limit is 90% C.L after 5 years.

Expected number of events after 5 years.

E-loss	AGN-1	TD	GRB	GZK	AGN-2
BS+PP	135.0	11.5	2.5	8.5	14.5
BS+PP+DIS-high	50.0	4.0	1.0	3.0	5.5

EUSO principle of operation

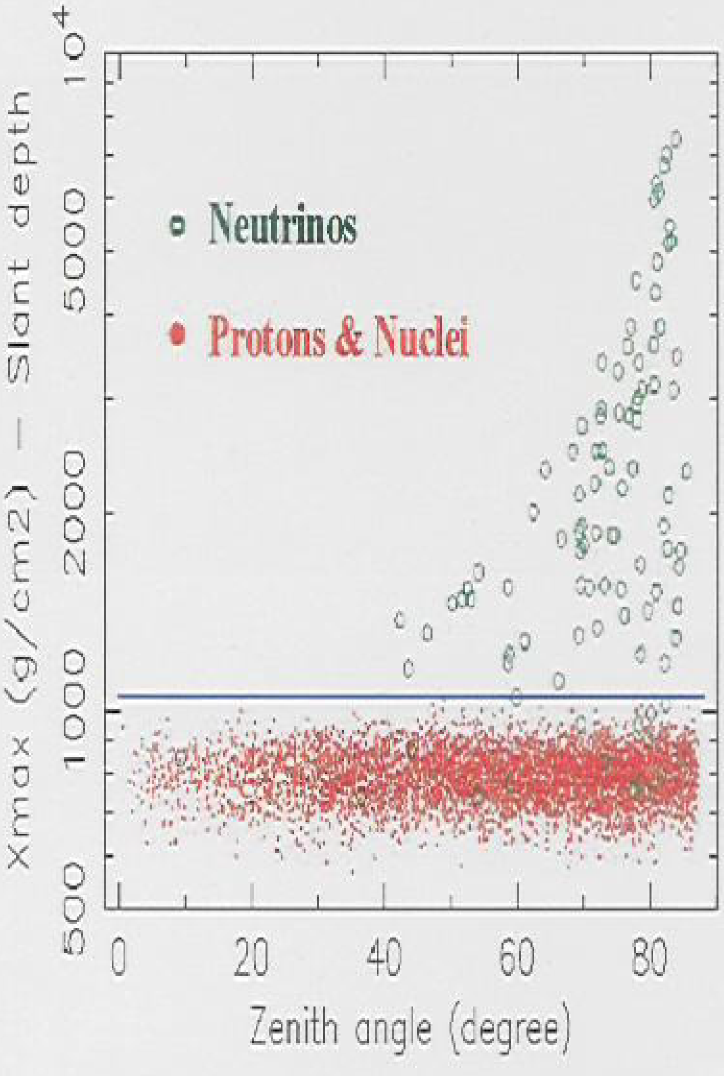


Viewed at some instant from a distance, an EAS appears as a relatively small disc-shaped luminous object. When it is viewed continuously, the object moves on a straight path with the speed of light. As it does so, the disc luminosity changes from so faint to be undetectable, up to a maximum followed by a gradual fading.

The general goal of the *EUSO* space mission is to acquire the dynamic image of events that occur when an individual energetic particle strikes the Earth atmosphere producing UV fluorescence light as the end-result of the complex relativistic cascade process.

The UV fluorescence produced by cosmic rays (protons, nuclei, gamma rays, neutrinos, ...) can be disentangled from the general background and measured; other phenomena as Gamma Ray Bursts (GRB), meteors, lightning, atmospheric flashes, distribution of minor components in the atmosphere, can also be observed and studied.

Neutrinos, protons, nuclei



Shower depth distribution from Monte Carlo simulations: neutrino events can be distinguished from proton and nuclei.

RADIODETECTION

EM showers emit coherent Č radiation

negative net charge propagating

Coherence when $\lambda >$ cascade diameter

radio wave

signal rises as E^2

Prototype RICE at South Pole

above 10^{17} eV

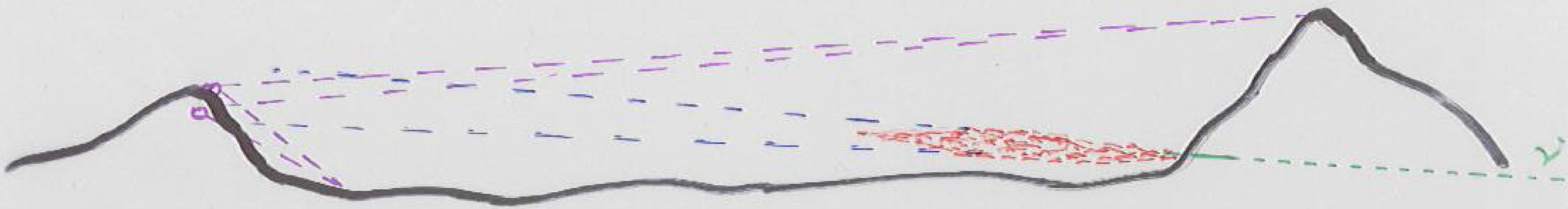
- The moon as a target

existing radiotelescopes

$$E^2 \frac{dN}{dE} \lesssim 10^4 \text{ eV/cm}^2 \text{ s sr}$$

at 10^{20} eV

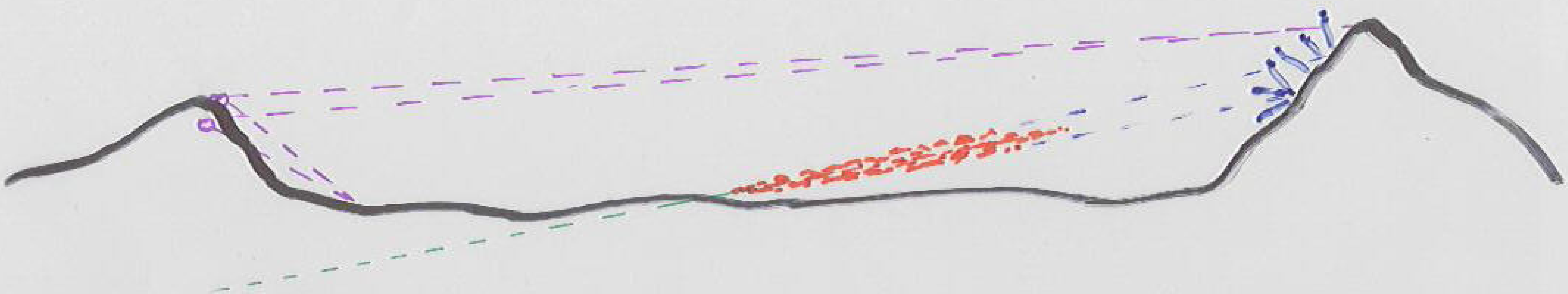
CERENKOV



Threshold $10\ \gamma_e$ at $5\ 10^{15}$ eV with 20 cm ø telescope

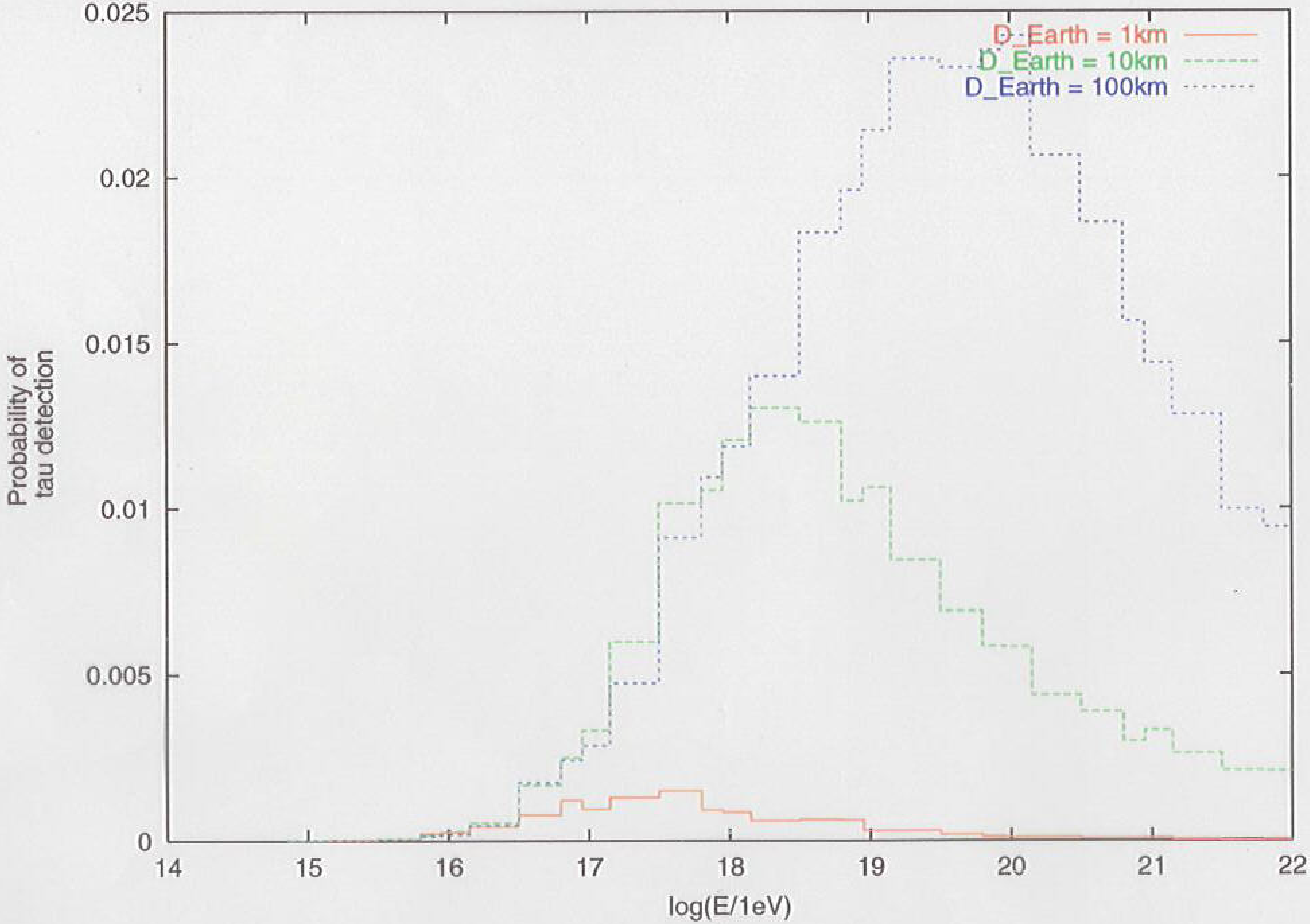
40 km

FLUO + CERENKOV

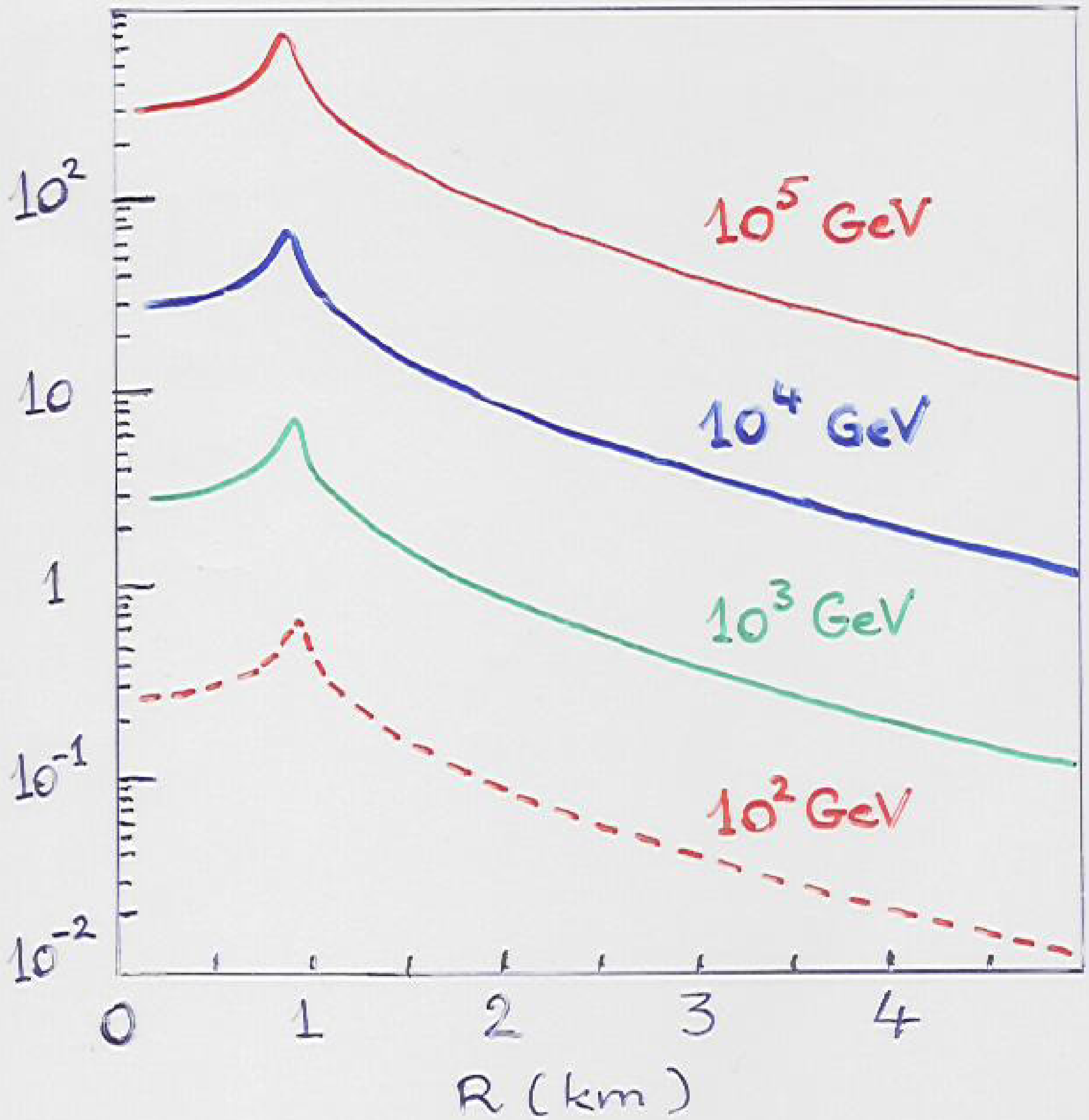


Threshold $N_\gamma \times 1.10^{-10}$ $10\gamma e$ at $2\,10^{17}$ eV   1m ∅ telescope

40 km

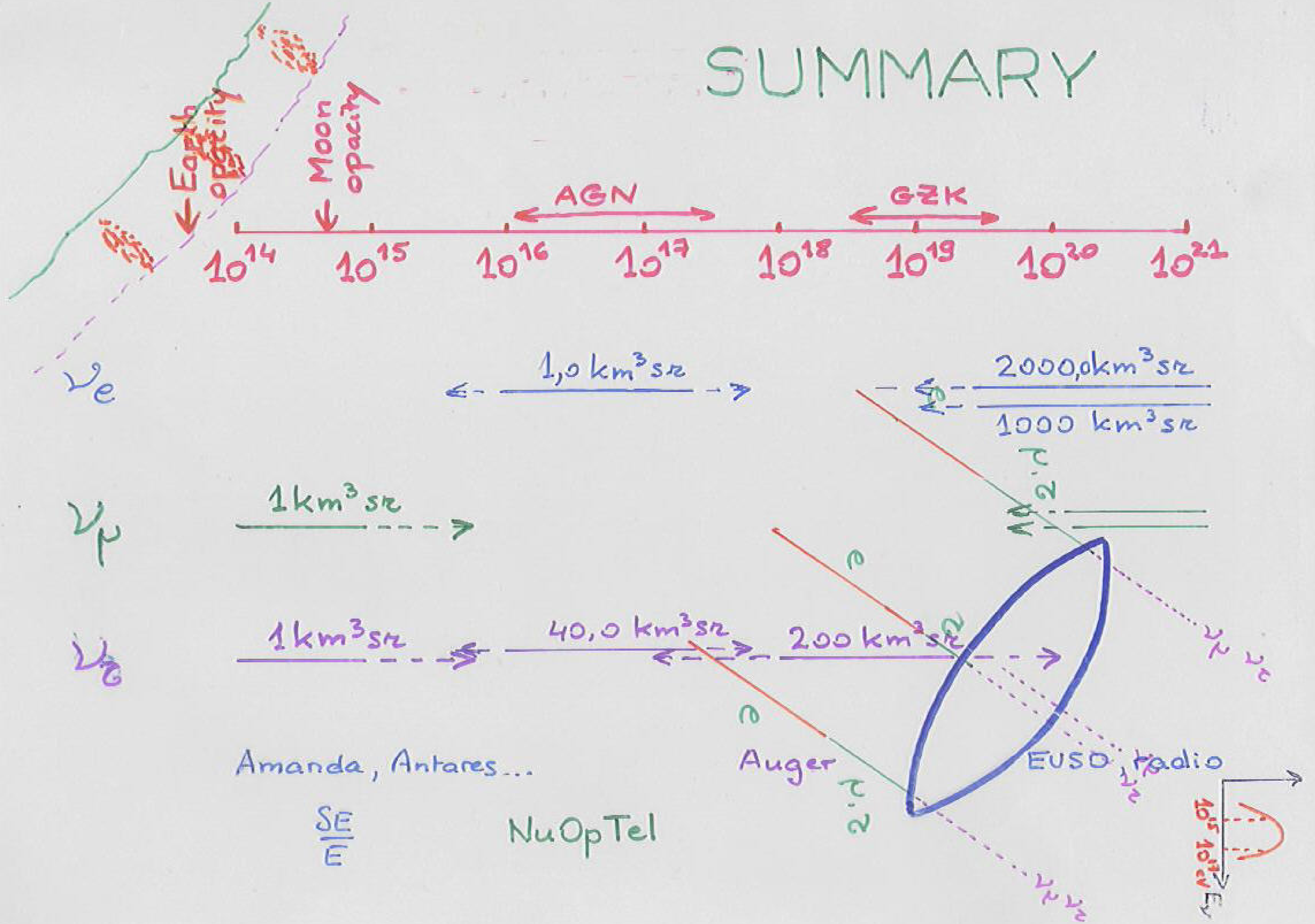


D_Earth = 1km
D_Earth = 10km
D_Earth = 100km
Probability of tau detection
log(E/1eV)
0.025
0.02
0.015
0.01
0.005
0
14
15
16
17
18
19
20
21
22



10^2
10
1
10^{-1}
10^{-2}
N_γ / m^2
10^5 GeV
10^4 GeV
10^3 GeV
10^2 GeV
0
1
2
3
4
R (km)

SUMMARY



Earth opacity
Moon opacity
AGN
GZK
10^14 10^15 10^16 10^17 10^18 10^19 10^20 10^21
ν_e
1,0 km³sr
2000,0 km³sr
1000 km³sr
ν_μ
1 km³sr
ν_τ
1 km³sr
40,0 km³sr
200 km³sr
Amanda, Antares...
Auger
EUSO, radio
δE/E
NuOpTel