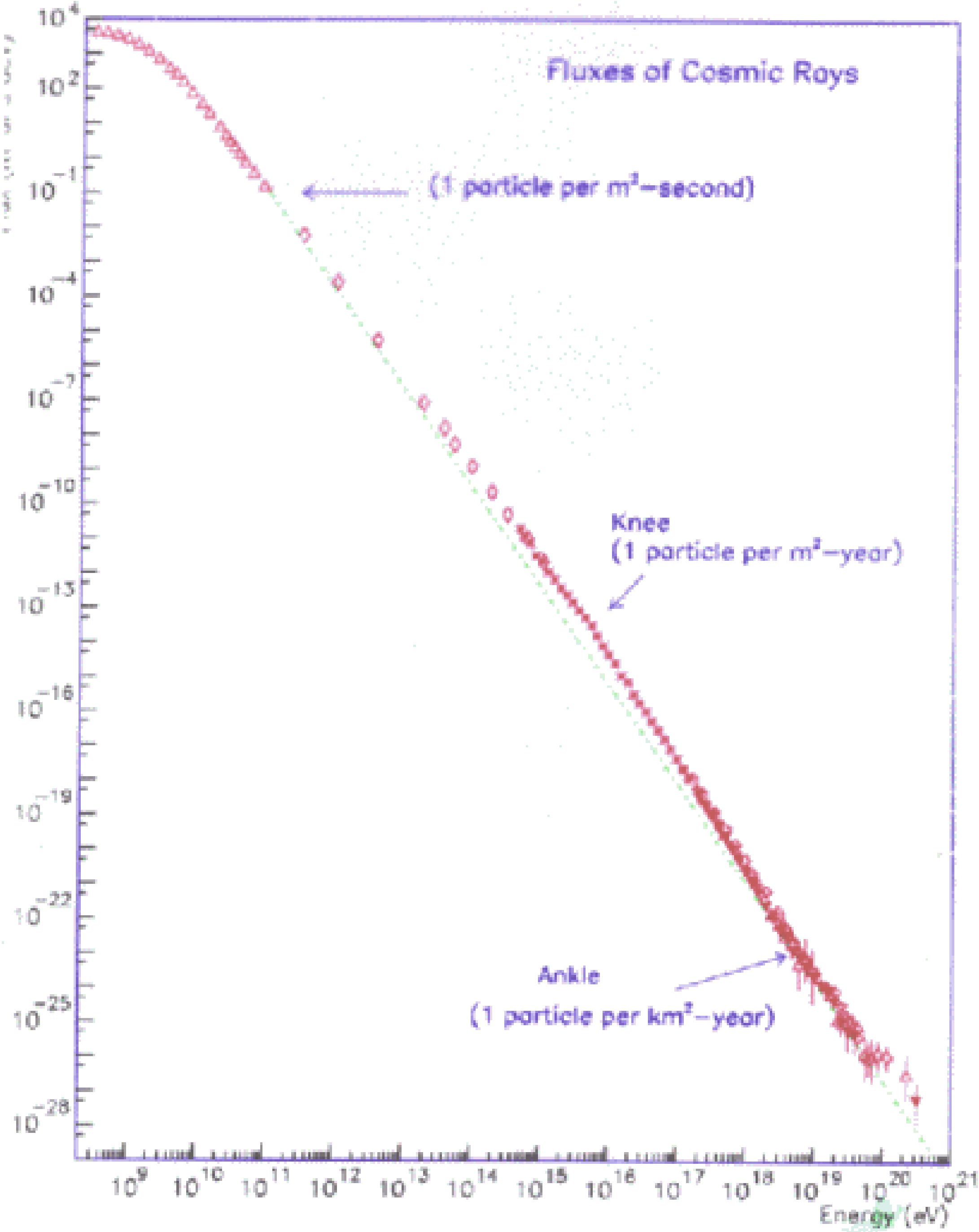
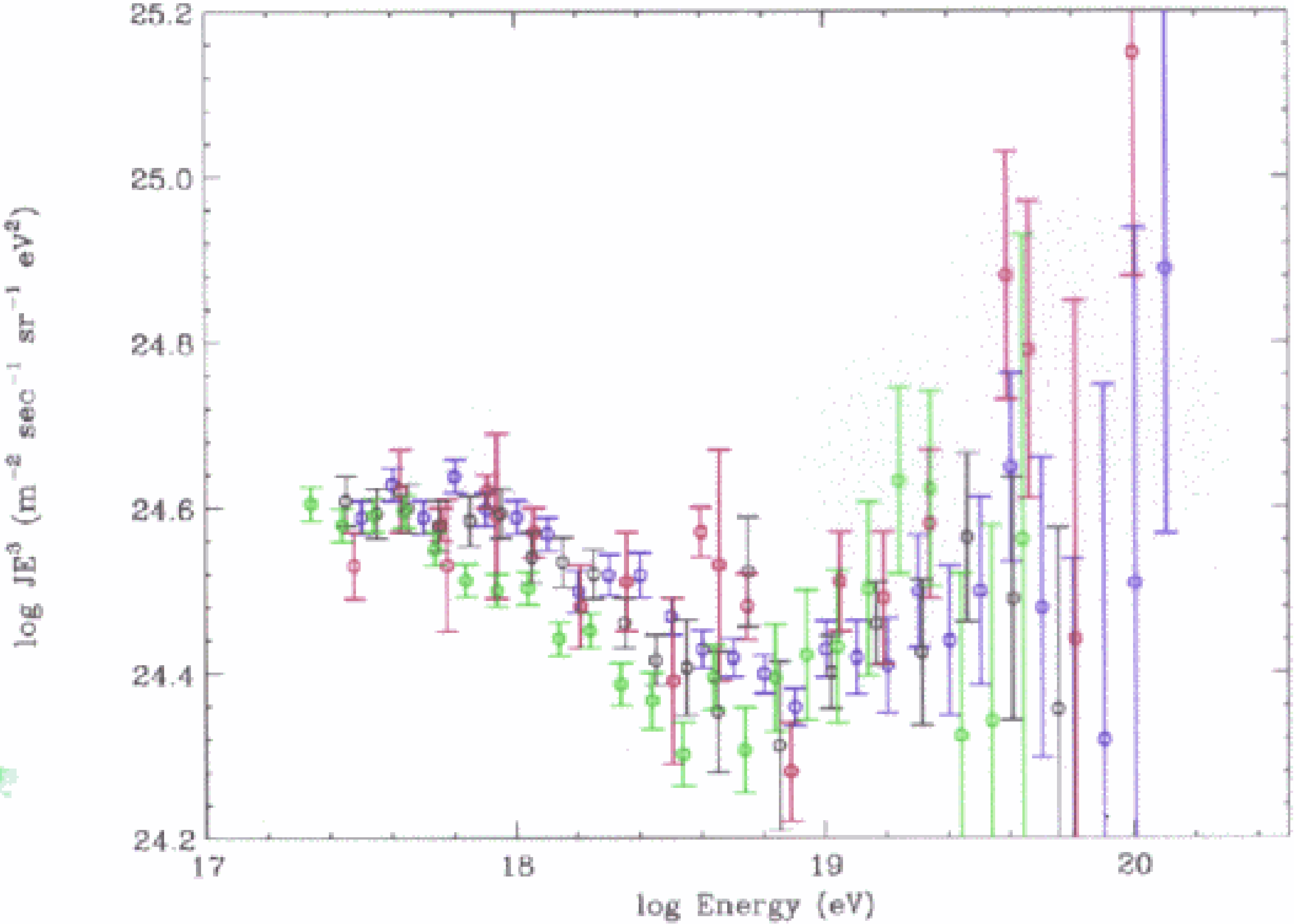
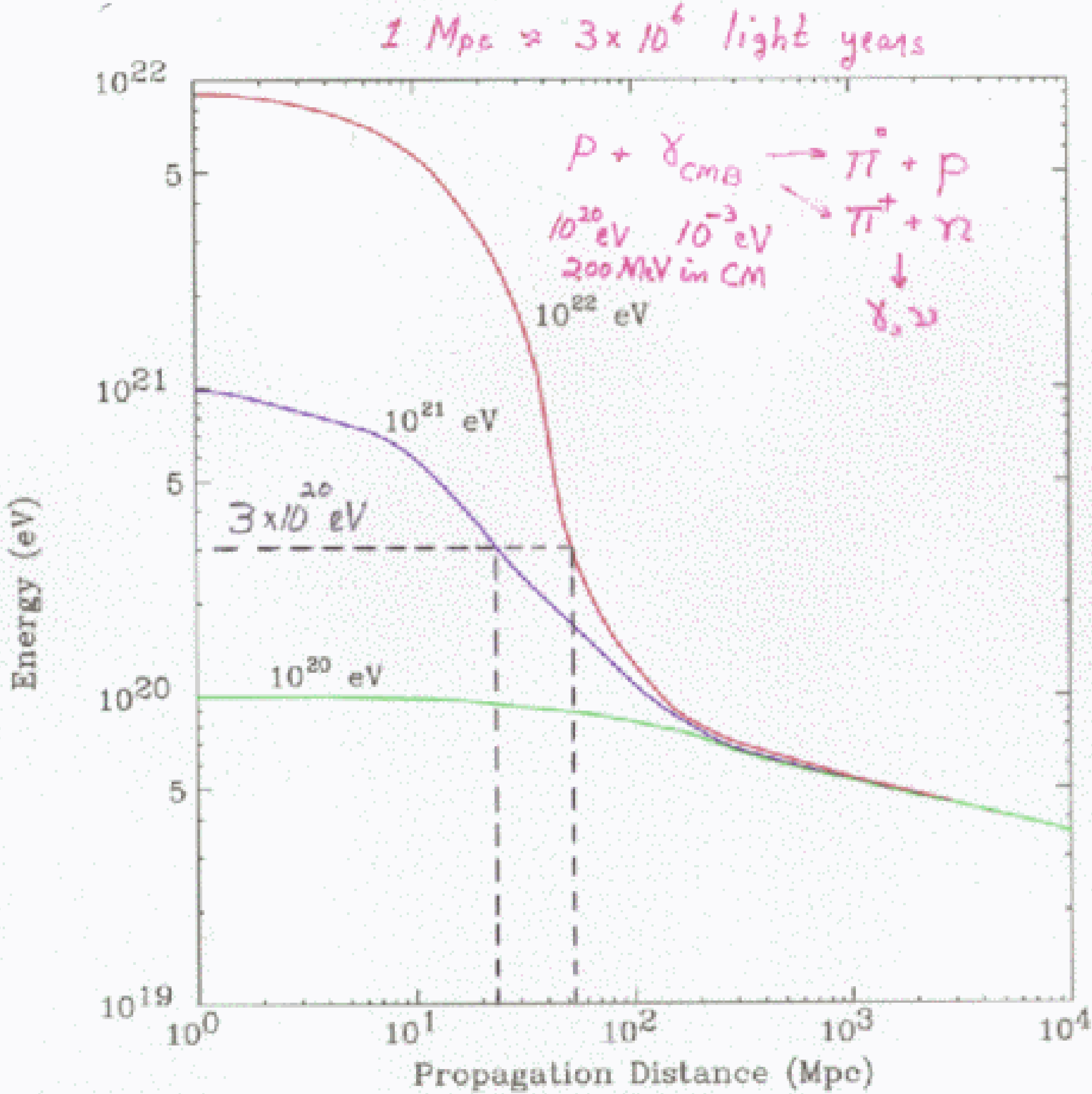

Fluxes of Cosmic Rays
(1 particle per m²−second)
Knee
(1 particle per m²−year)
Ankle
(1 particle per km²−year)
10^4
10^2
10^-1
10^-4
10^-7
10^-10
10^-13
10^-16
10^-19
10^-22
10^-25
10^-28
10^9 10^10 10^11 10^12 10^13 10^14 10^15 10^16 10^17 10^18 10^19 10^20 10^21
Energy (eV)

H 37

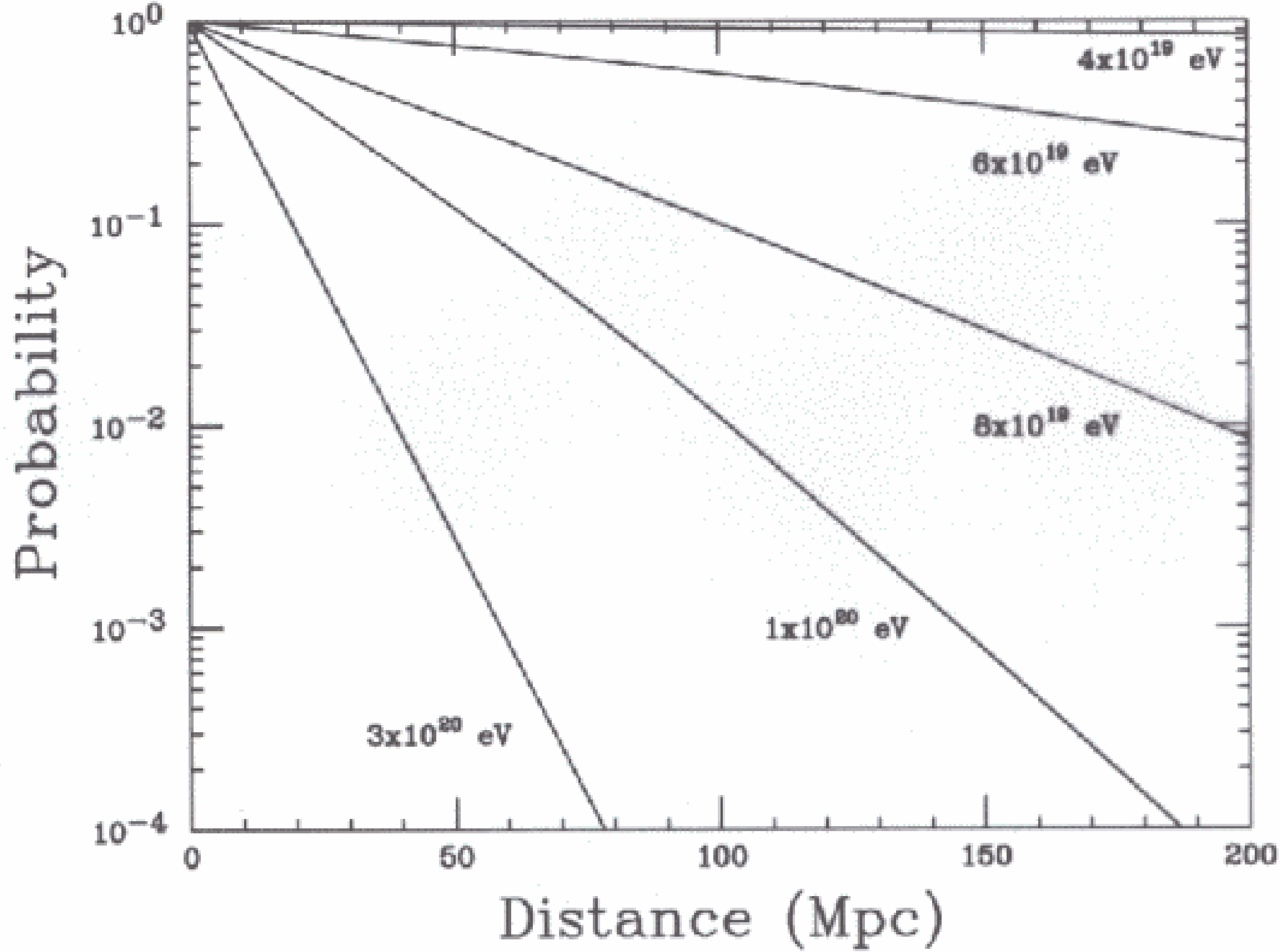
Note: $\times E^3$

AGASA (blue), Yakutsk (black), Haverah (red), Flys Eye (green)





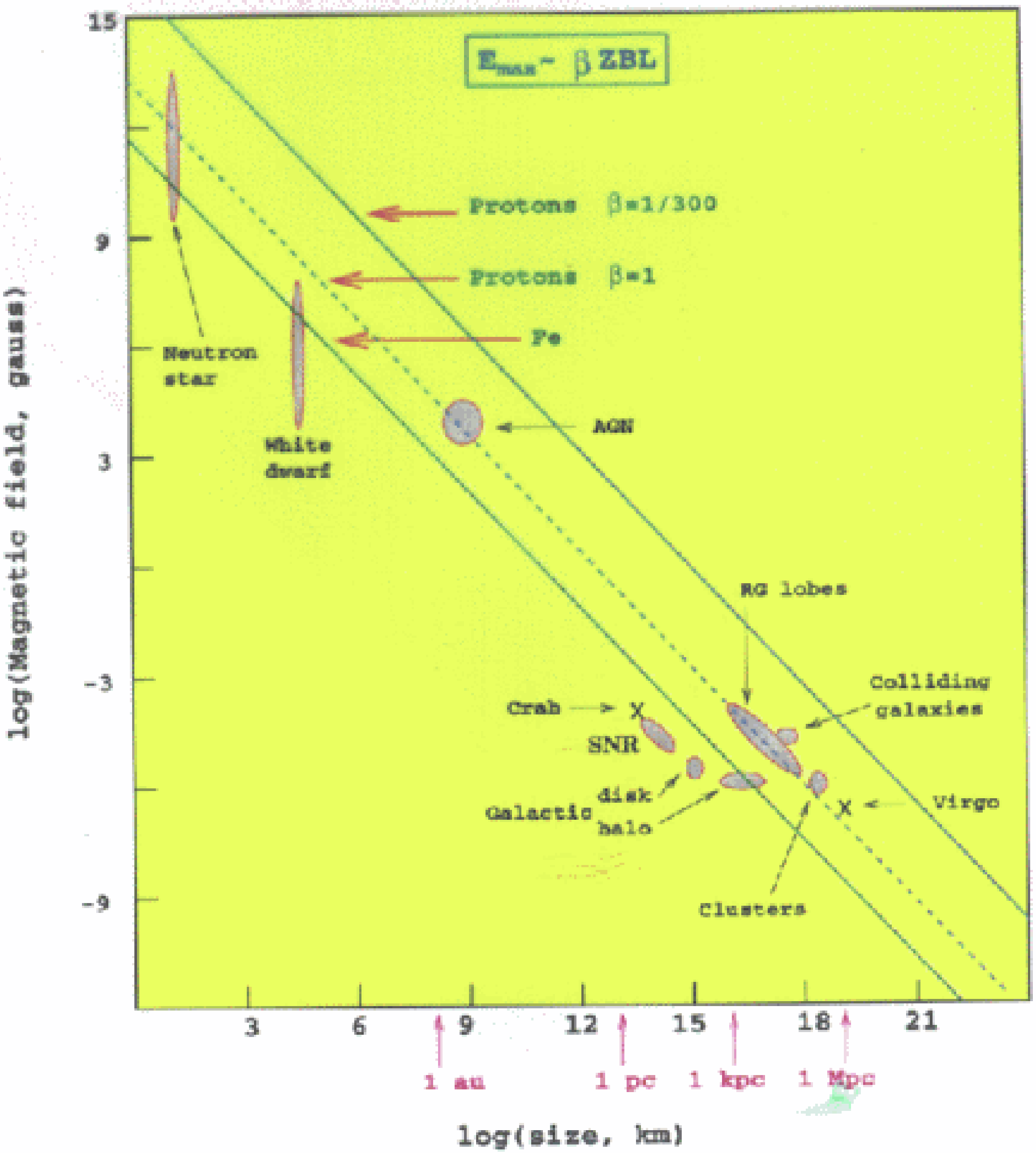
1 Mpc ≈ 3 x 10^6 light years
p + γ_CMB → π° + p
→ π⁺ + n
↓
γ, ν
10^20 eV 10^-3 eV
200 MeV in CM
10^22 eV
10^21 eV
3 x 10^20 eV
10^20 eV
Energy (eV)
Propagation Distance (Mpc)



4x10^19 eV
6x10^19 eV
8x10^19 eV
1x10^20 eV
3x10^20 eV
10^0
10^−1
10^−2
10^−3
10^−4
Probability
0
50
100
150
200
Distance (Mpc)

Reviews Astronomy and Astrophysics
1984 22 425 M Hillas

Hillas-plot (candidate sites for E=100 EeV)



10

In this report, we first show the updated energy spectrum above 3×10^{18}eV with events until May 2000. And then we show the cosmic-ray arrival direction distribution with the additional dataset of the Akeno 20 km^2 array (A20) before 1990. Important informations for the present analysis are listed below, and for details refer our publications [1, 2, 3, 4, 5, 6, 7, 8].

Exposure :	4.6×10^{16} m^2 s sr
Energy conversion formula :	$E = 2.03 \times 10^{17}\ S_0(600)$ eV
Attenuation of S(600) :	$S_\theta(600) = S_0(600) \exp\left[-\frac{920}{500}(\sec\theta - 1) - \frac{920}{594}(\sec\theta - 1)^2\right]$
Error in S(600) determination :	$\pm$ 30 % above 10^{19}eV
Error in arrival direction determination :	1.6° above 4×10^{19}eV

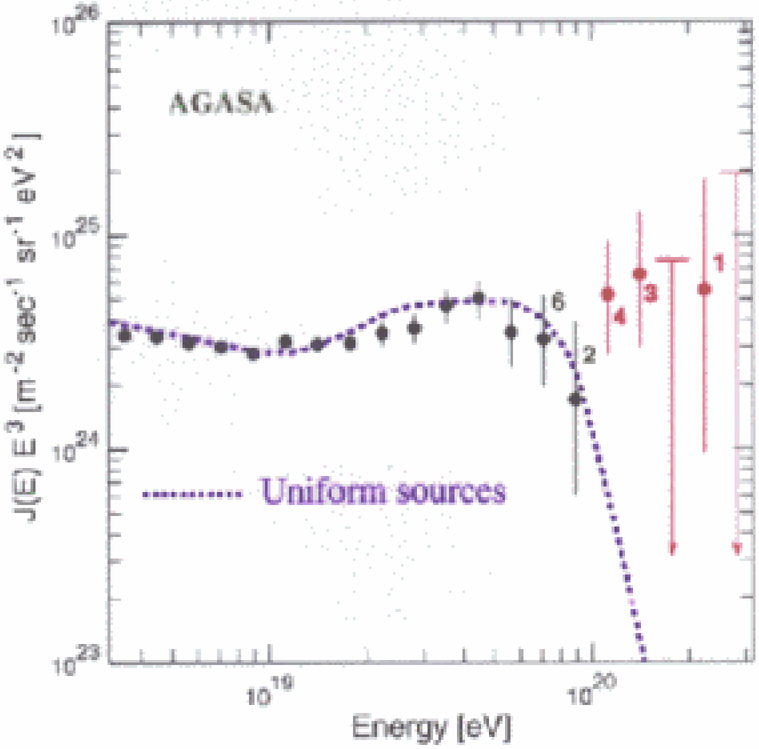
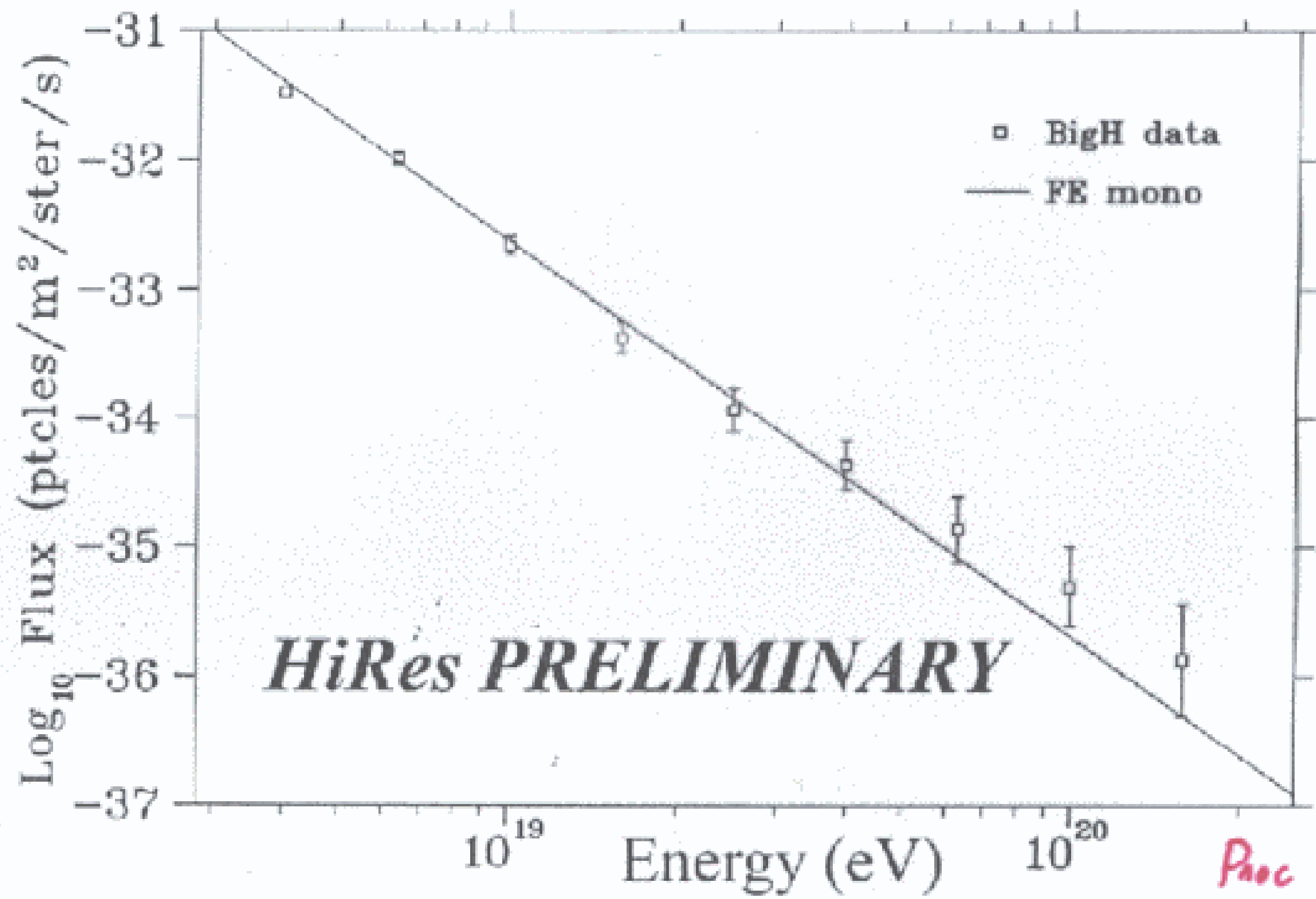


Figure 1: Energy spectrum observed with AGASA. The vertical axis is multiplied by E^3. Error bars represent the Poisson upper and lower limits at 68% and arrows are 90% C.L. upper limits. Numbers attached to points show the number of events in each energy bin. The dashed curve represents the spectrum expected for extragalactic sources distributed uniformly in the Universe, taking account of the energy determination error.

M Teshima astro-ph/0008102

Astrophys J 522, 255 (1999)



1999 ICRC (Salt Lake City) W. Springer Proc Vol P 264

Figure 1: The points and error bars represent the monocular energy spectrum as measur
by HiRes-I. The superimposed line represents the fit to the Fly's Eye monocular spectrum

Magnetic Fields (z = 1)

Galaxy ≈ 1 μgauss

Extragalactic ≲ 10^{-9} gauss (disordered)

Clusters 0.1 - 1 μgauss

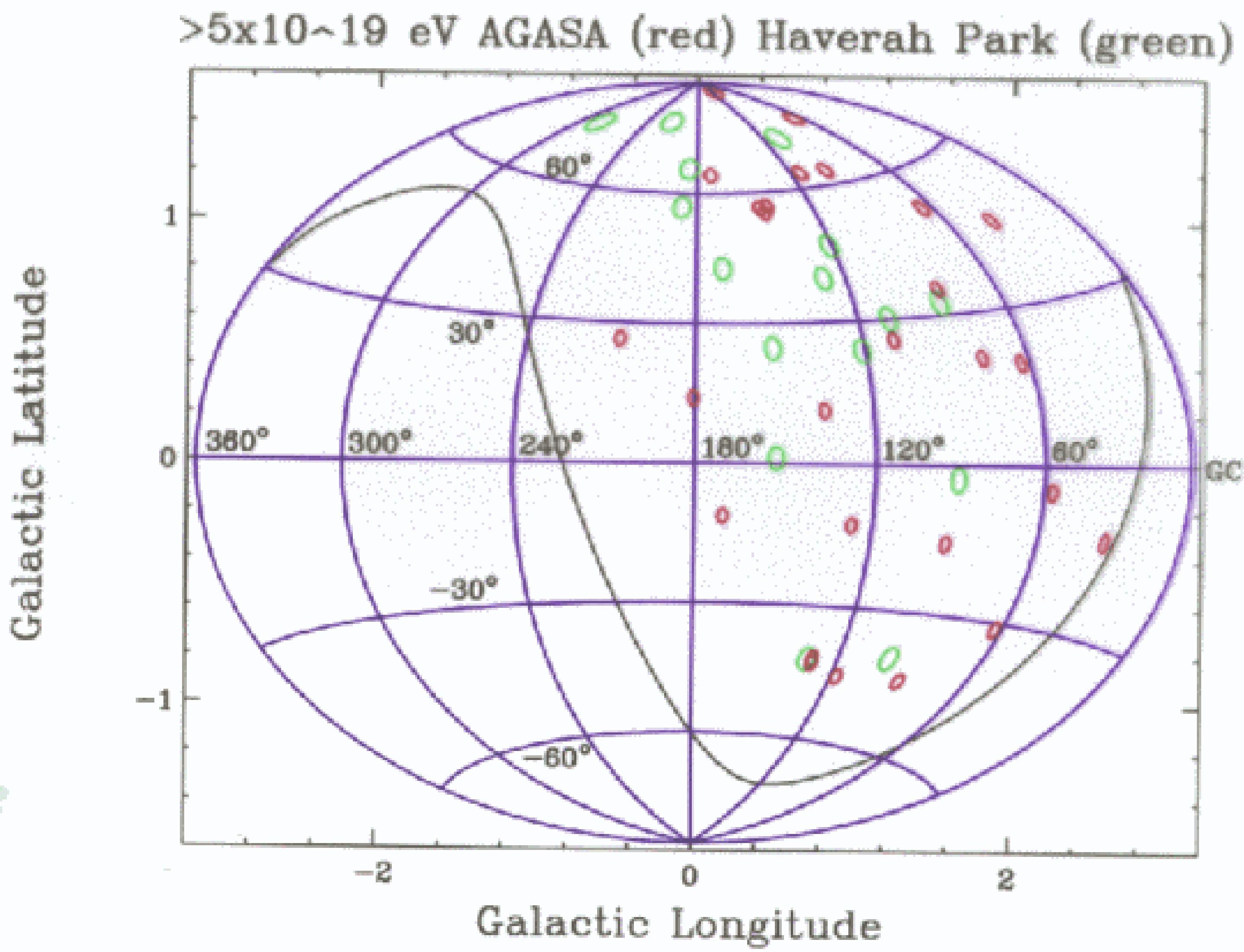
Radii of curvature (10^{20} eV)

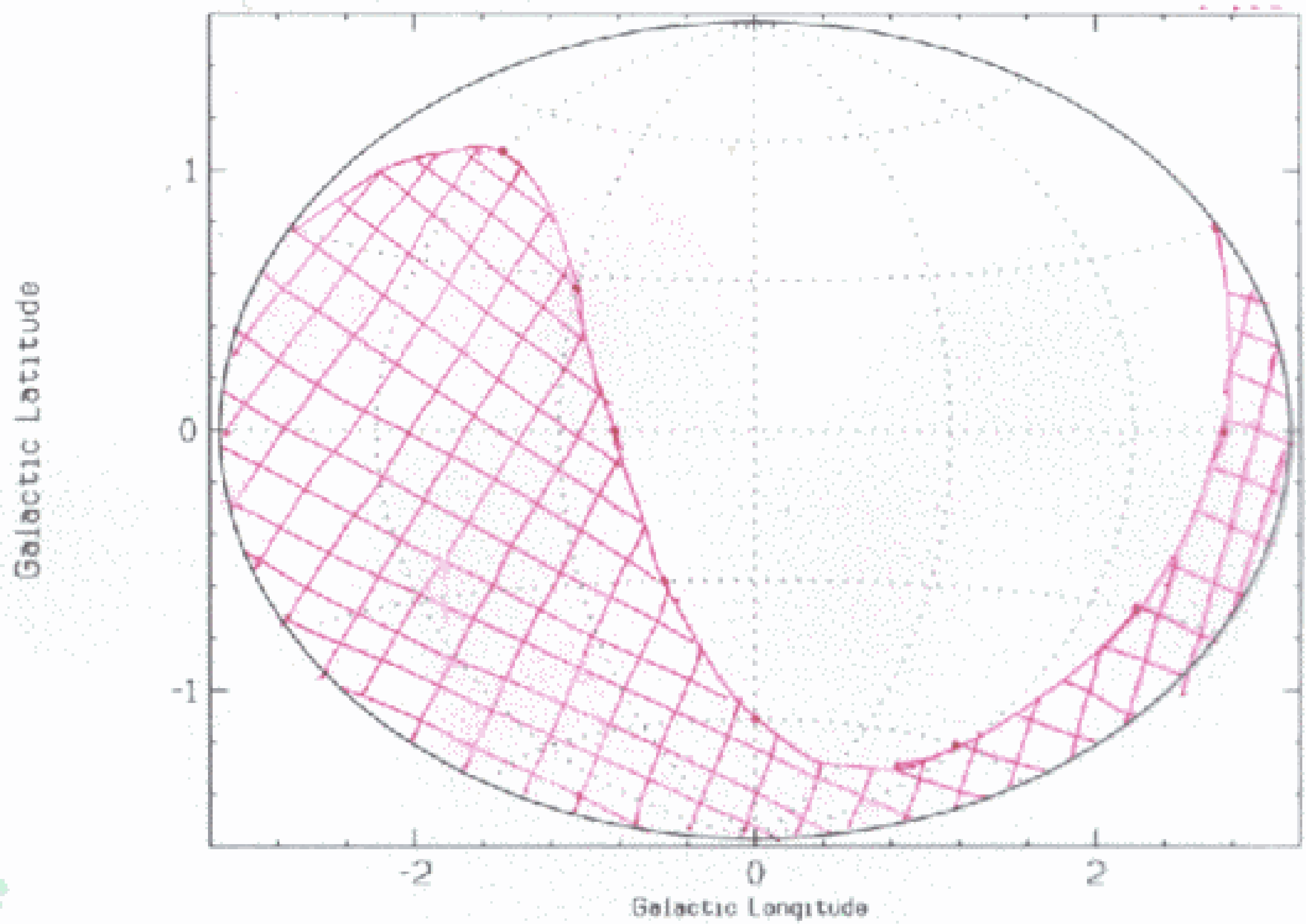
Galaxy 100 kpc

(Galaxy ≈ 25 kpc diameter
1 kpc thick)

Extragalactic ≫ 100 Mpc

Cosmic rays may "point" to source


>5x10~19 eV AGASA (red) Haverah Park (green)
Galactic Latitude
Galactic Longitude
1
0
−1
−2
0
2
60°
30°
−30°
−60°
360°
300°
240°
180°
120°
60°
GC


Galactic Latitude
1
0
-1
-2
0
2
Galactic Longitude

Conceptual Design by International Team

Fermilab (February - July 1995)

- Two 3000 km^2 arrays each with 1600 detectors on 1.5 km grid. Located at mid latitude in southern and northern hemispheres
- Fluorescence detectors located within the surface arrays to observe the same showers. A "hybrid" detector.
- Two independent measurements for 10% of the cosmic rays. This is particularly important for the energy measurement.
- Full efficiency for detection of cosmic rays with energy above 10^{19} eV.
- Surface detectors are water tanks 10 m^2 in area, 1.2 meters deep. They detect shower particles by Čerenkov light.
- Use "new" technologies.
- Power by solar panel ⇒ low power electronics.
- Communication by wireless.
- Time measurement by GPS.

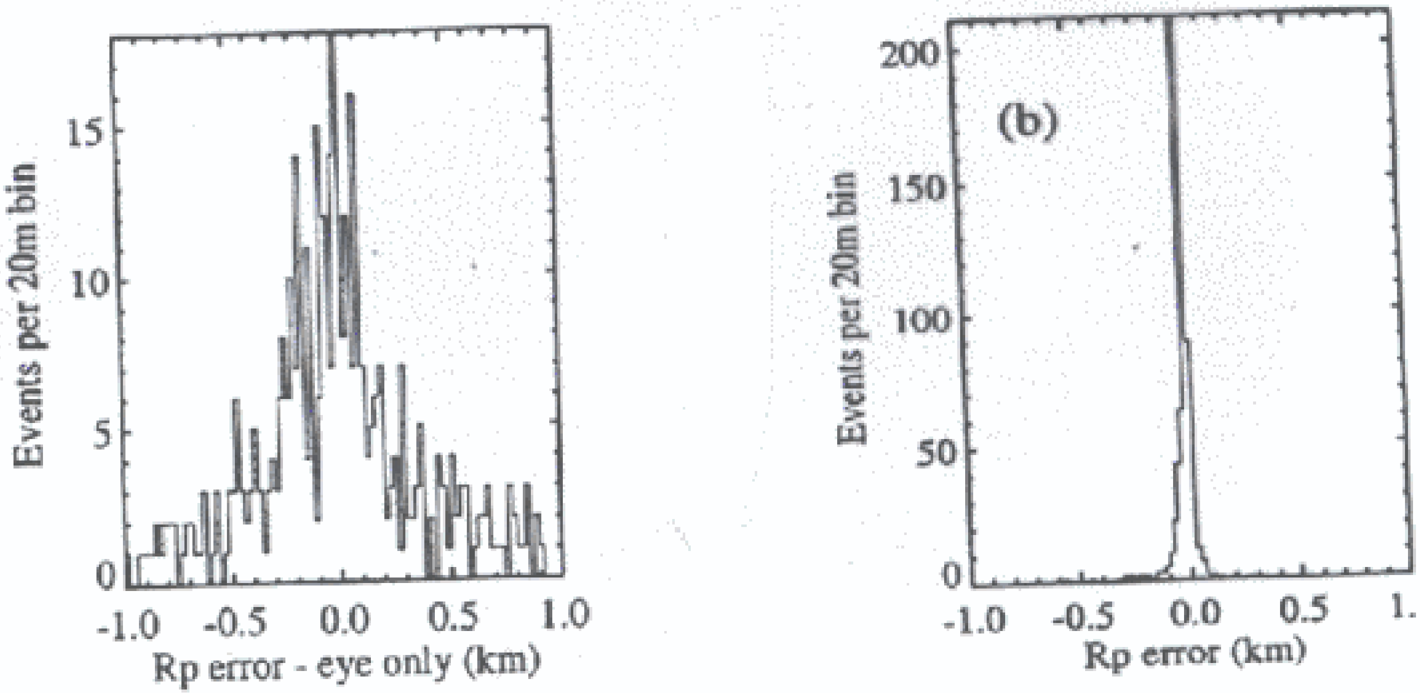
- Data distributed to worldwide collaboration by Internet

Properties of Surface Array of Cherenkov Tanks for Energy $\geq 10^{19}$ eV

- 100 % Duty cycle
- Aperture well defined and independent of energy
- Response translationally invariant
- Uniform coverage of right ascension daily
- Response independent of weather conditions
- Approximate muon/electromagnetic separation
- Quality of event increases with energy

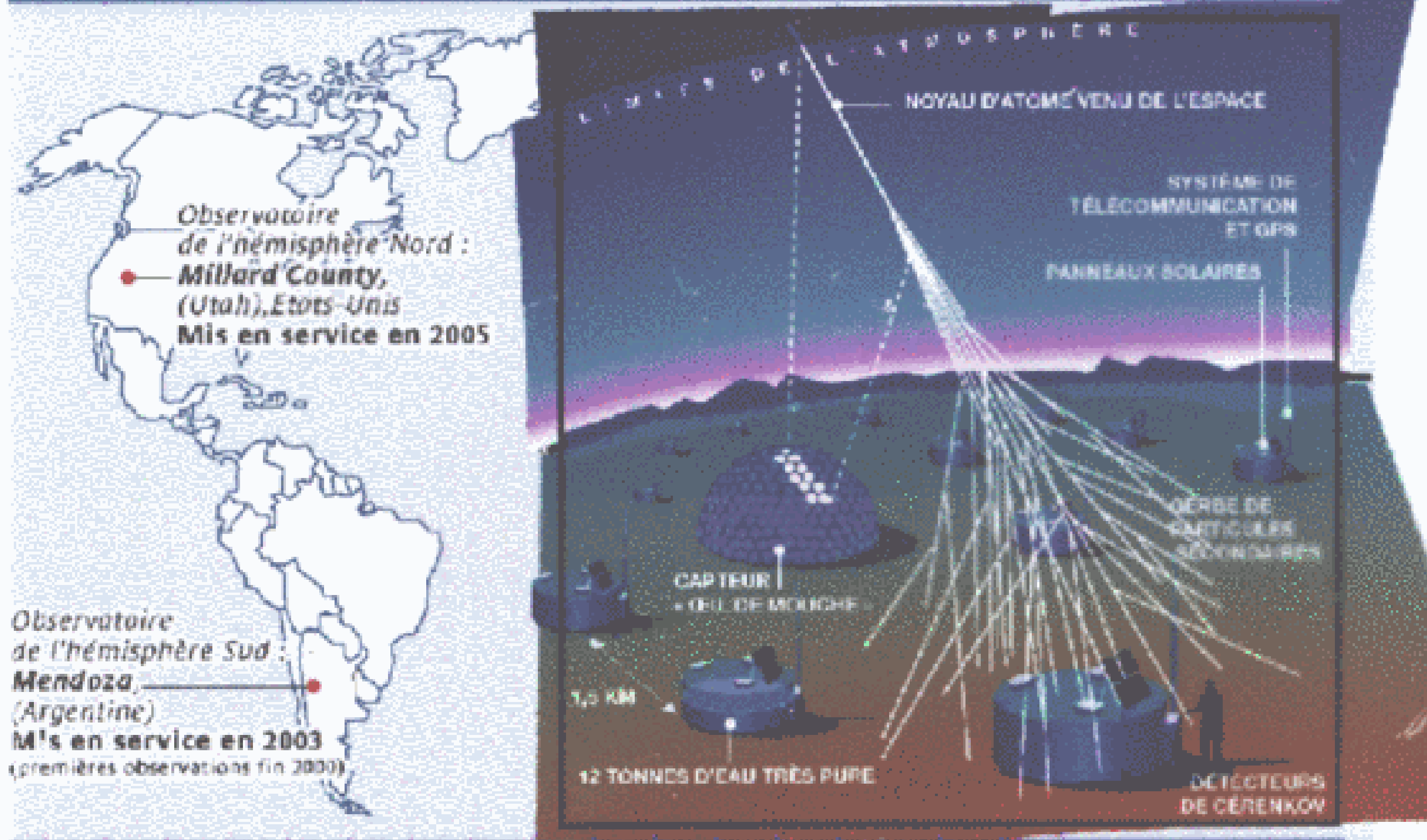
Addition of Fluorescence Detector [Hybrid Array] (for 10 % of Events)

- Every surface event registered by at least one fluorescence eye: 60 % surface events with more than two eyes
- Quality of event reconstruction for single eye as good as stereo eyes
- Accurate reconstruction of shower geometry without knowledge of tank amplitudes
- Redundant measurement of energy
- Superb information for events with energy $\geq 10^{20}$ eV



Events per 20m bin
15
10
5
0
-1.0
-0.5
0.0
0.5
1.0
Rp error - eye only (km)
(b)
Events per 20m bin
200
150
100
50
0
-1.0
-0.5
0.0
0.5
1.
Rp error (km)

De magnifiques gerbes de particules secondaires



Infographie : Le Monde

Une pluie continue de particules venues de l'espace percute chaque seconde l'atmosphère. L'énergie de certaines d'entre elles défie l'imagination. En trente-cinq ans, seules une dizaine ont été observées. Trop peu. C'est la raison pour laquelle dix-neuf pays ont décidé de construire deux observatoires géants de 3 000 km^2 constitués chacun de trois capteurs « œil de mouche » pour suivre leurs traces en altitude et de 1 600 autres à effet Cérenkov pour détecter leur impact au sol.

Le Monde May 29, 1999 1600 tanks

www.auger.org

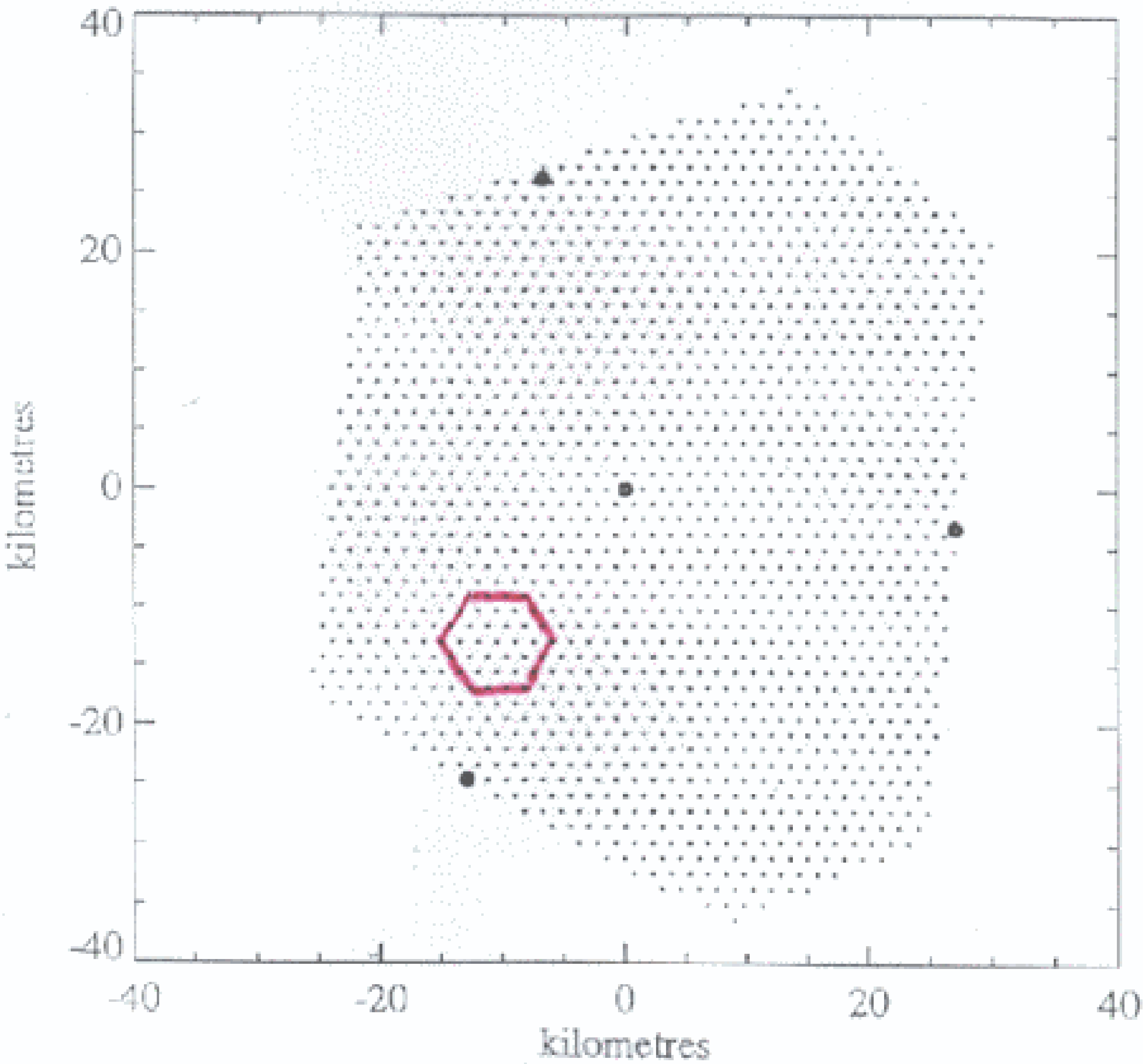
~200 GAP notes

details

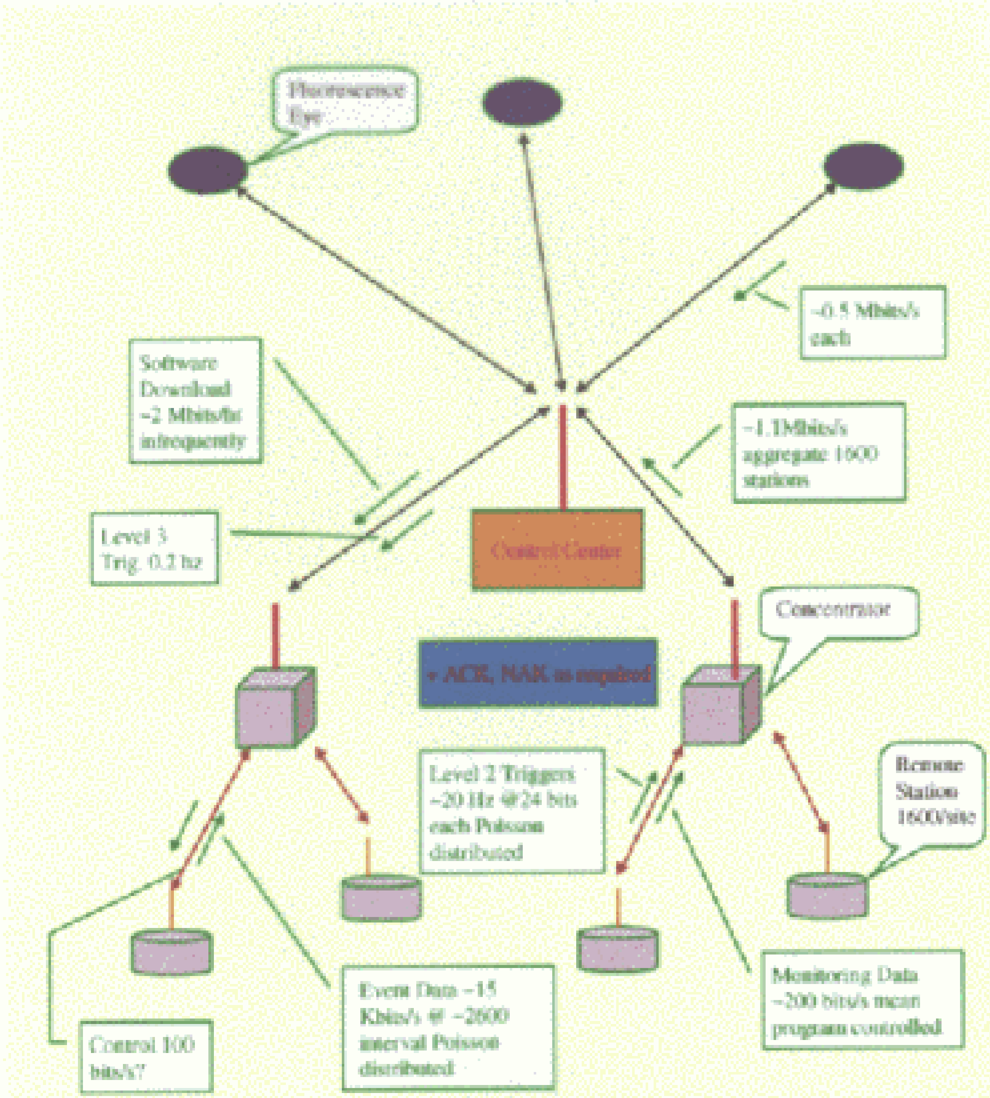
Rosanna Cester

Friday 9 AM

Engineering Array



Auger Communications System Functional Overview



2/18/98

100 events/year

$E \geq 10^{20}$ eV ($\theta_z < 60°$)

× 1.5 all θ_z

RMS Energy error 10%

Systematic 10-15%

RMS angle error 0.5°

Errors ~ × 2 smaller
for hybrid events

P. Billoir
GAP 2000-25

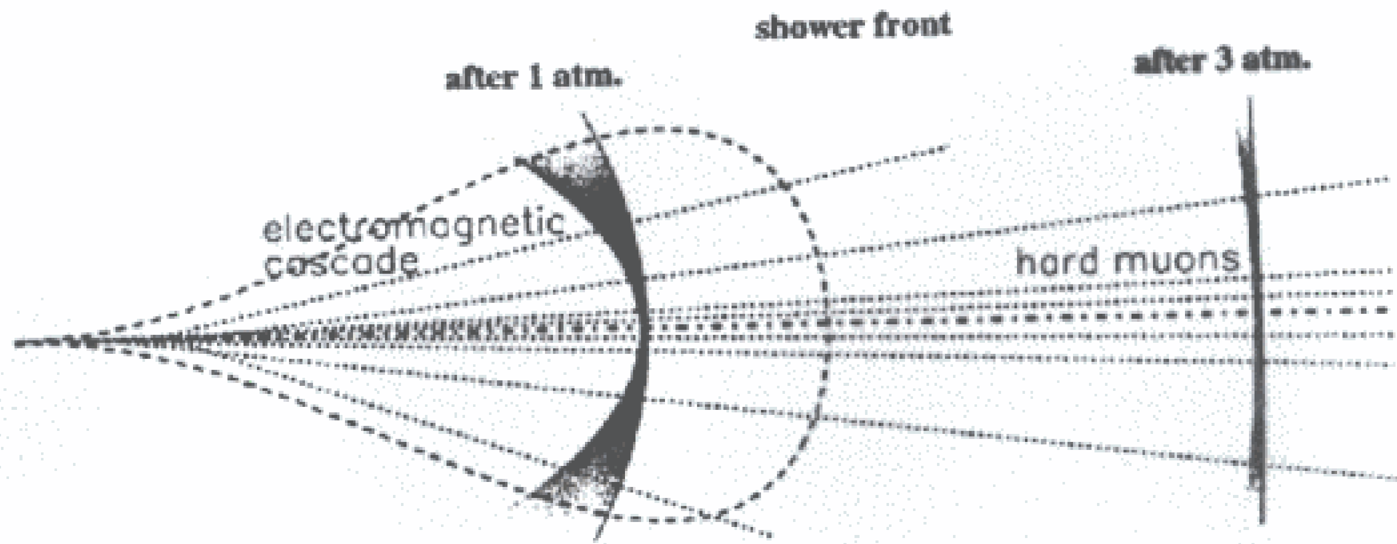


FIGURE 7. Horizontal shower development.

14 countries

Auger Tasks

Infrastructure	Argentina
Surface Detector: Tanks/mechanics	Argentina Brazil China Mexico USA
Surface Detector: **PMT/electronics**	France (Vietnam) Russia USA
Fluorescence Detector: **Mechanics/optics**	Brazil Czech Republic Germany Italy Mexico Poland
Fluorescence Detector: Electronics	Germany Italy
Fluorescence Detector: **Calibration**	Australia Slovenia USA
Communications	United Kingdom
Management	Fermilab USA

Deep showers $> 75^\circ$ θ_z

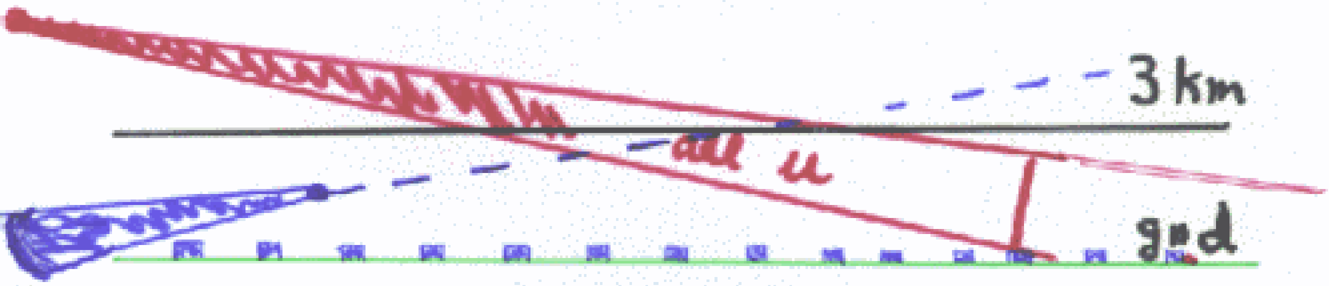
$\Delta\Omega \approx 1$ sr

Target volume $3000\,km^2 \times 3\,km$

Density of air $10^{-3}\,gm/cm^3$

Target mass $\approx 10^4\,km^3 \times 10^{-3}$

$= 10\,km^3 - sr$



Normal shower — all μ, plane shower front

Penetrating shower eg ν_e — μ + em, curved thick shower front (ie normal shower) between a distant horizontal shower and

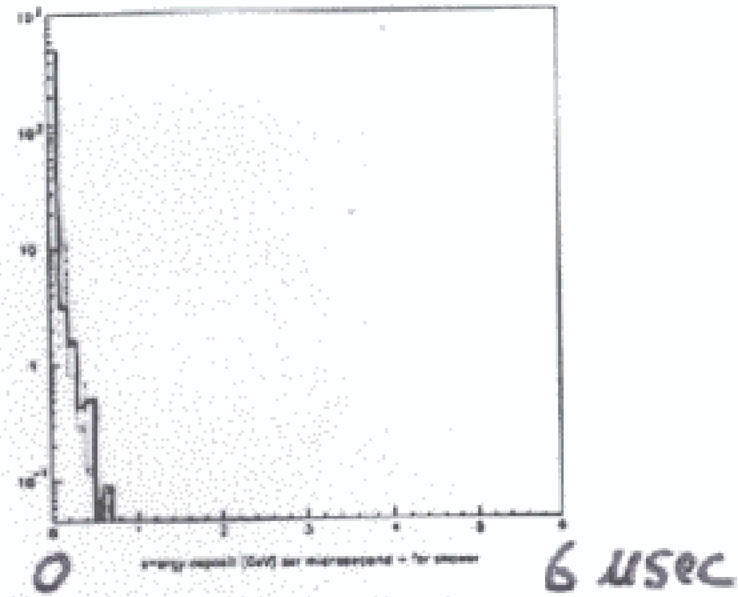


Figure 23: Arrival time of shower energy for distant showers initiated at zenith angle $\geq 80^{\circ}$. The curve from highest to lowest correspond to distance from the shower axis of 0.5, 1.0, 1.5, 2.0 km respectively.

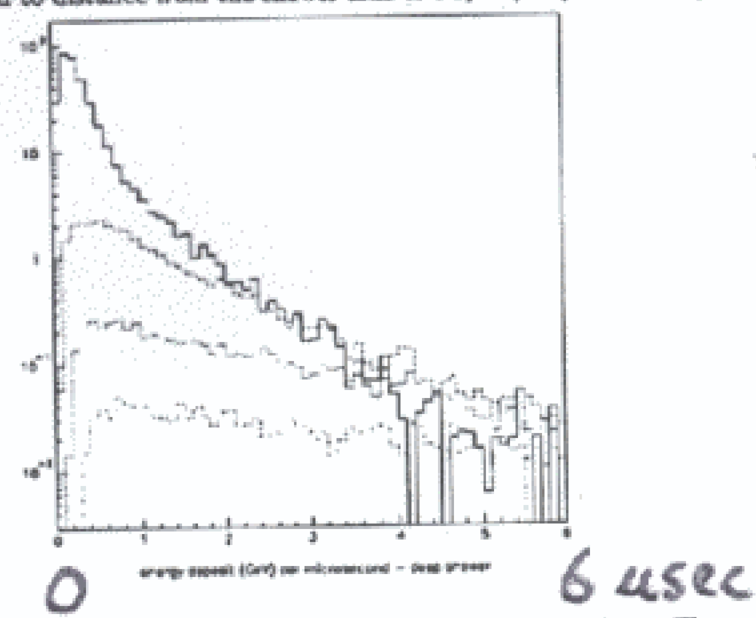
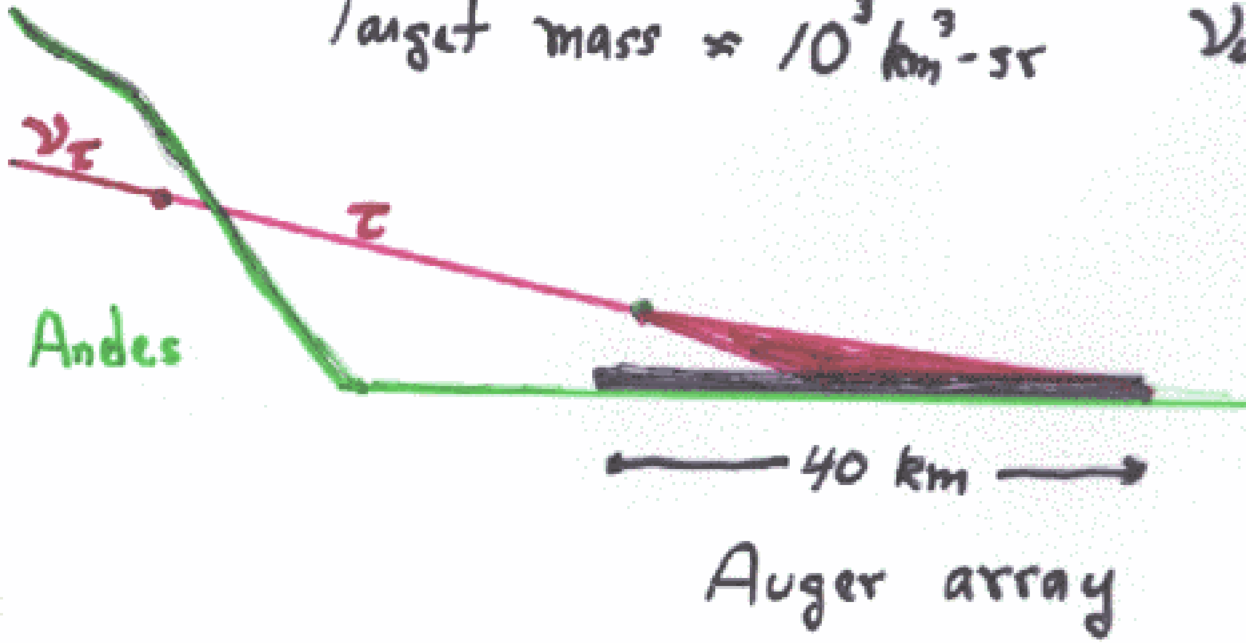


Figure 24: Same conditions as Figure 23 for a shower initiated deep in the atmosphere. The curves run highest to lowest correspond to distance of the triggered detector from the shower axis of 0.5, 1.0, 1. respectively.

τ mean decay length = 50 km at 10^{18} eV

Target mass ≈ 20 km^3-sr ν_e (water

Target mass ≈ 10^3 km^3-sr $\nu_\mu \to \nu_\tau$ equiv



astro-ph/0009444

A. Letessier Selvon

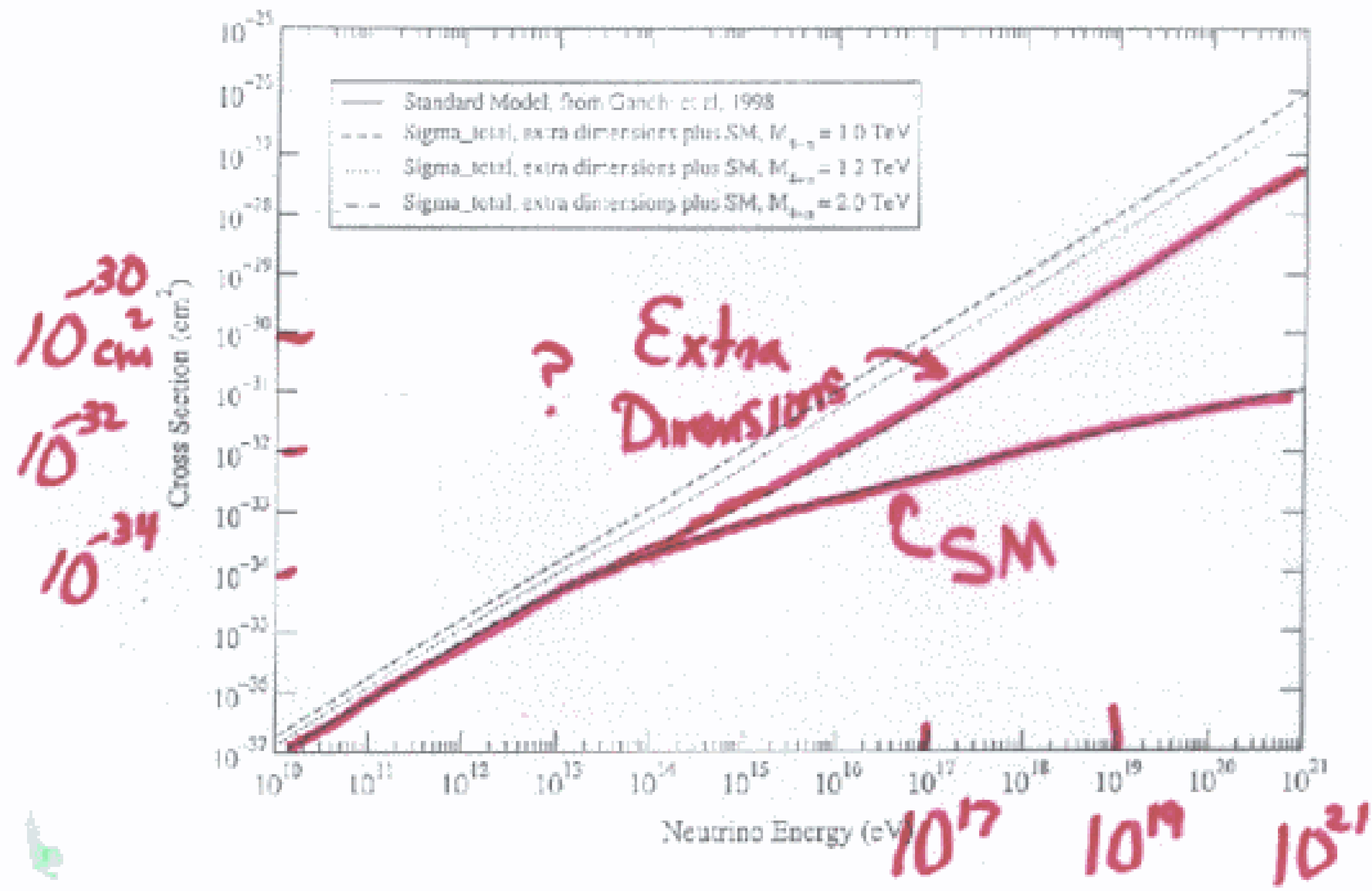
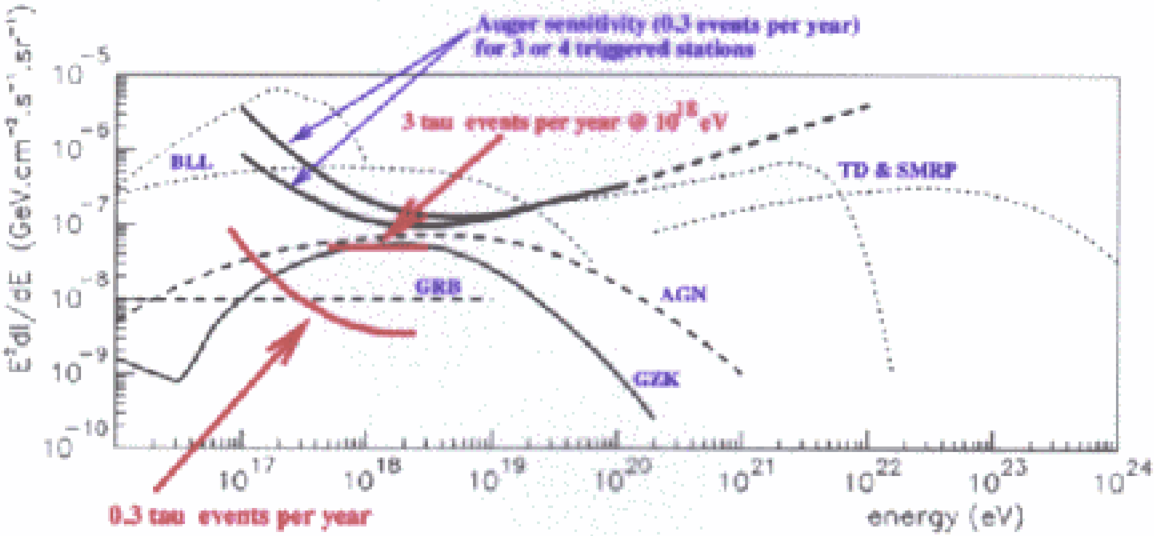


FIG. 2. Cross section for νN interaction, assuming neutrinos incident on nucleons at rest. The solid curve is for the Standard Model, charged current [32], as appropriate for electron neutrino detection (see text). Remaining curves give Standard Model plus the contribution from extra dimensions at various scales in the parameterization of Eq. (8): dashed line for $M_{4+n} = 1.0$ TeV, dotted line for $M_{4+n} = 1.2$ TeV, dot-dashed line for $M_{4+n} = 2.0$ TeV.



Auger sensitivity (0.3 events per year)
for 3 or 4 triggered stations
3 tau events per year @ 10^18 eV
BLL
TD & SMRP
GRB
AGN
GZK
0.3 tau events per year
E²dI/dE (GeV.cm⁻².s⁻¹.sr⁻¹)
energy (eV)