# Pierre Auger

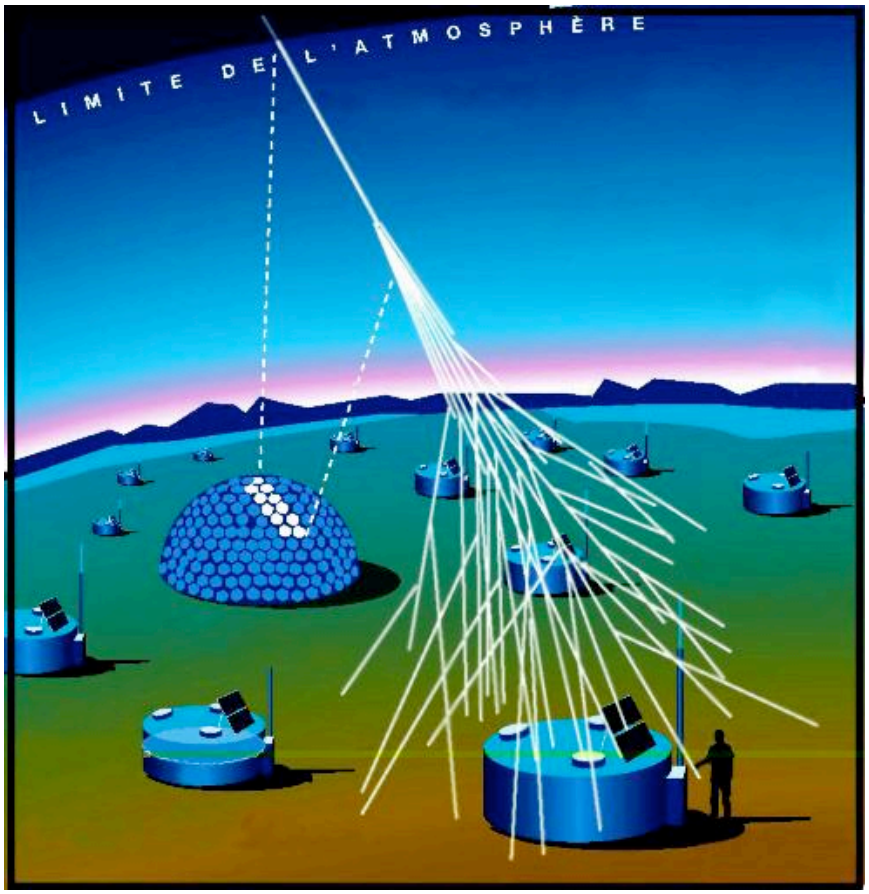
- 2 Giant Ground Arrays (30 x AGASA) with Fluorescent detectors (HYBRID detector)
- independent techniques allow control of systematics

Challenge: to reach

$> 10^4 - 10^5$ km$^2$ sr yr

Present experiments

$\sim 10^3$ km$^2$ sr yr

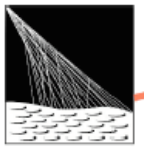



**PIERRE AUGER** Observatory (South)

3,000 km$^2$ array + 4 Fluorescence Telescopes

Aperture 6,600 km$^2$ sr - reach > $10^4$ in 2 years

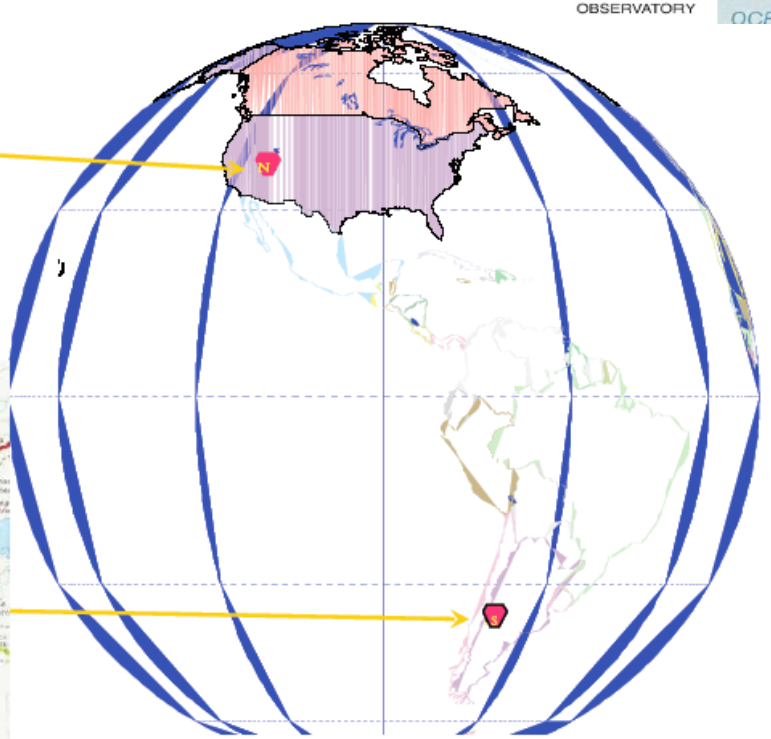
# The observatory

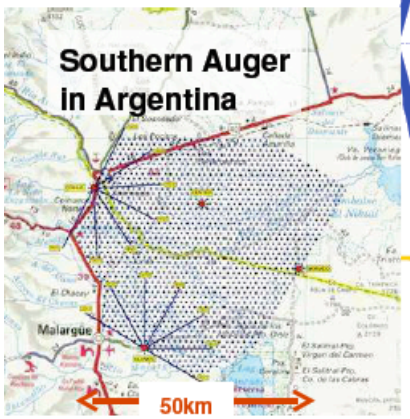



PIERRE AUGER OBSERVATORY

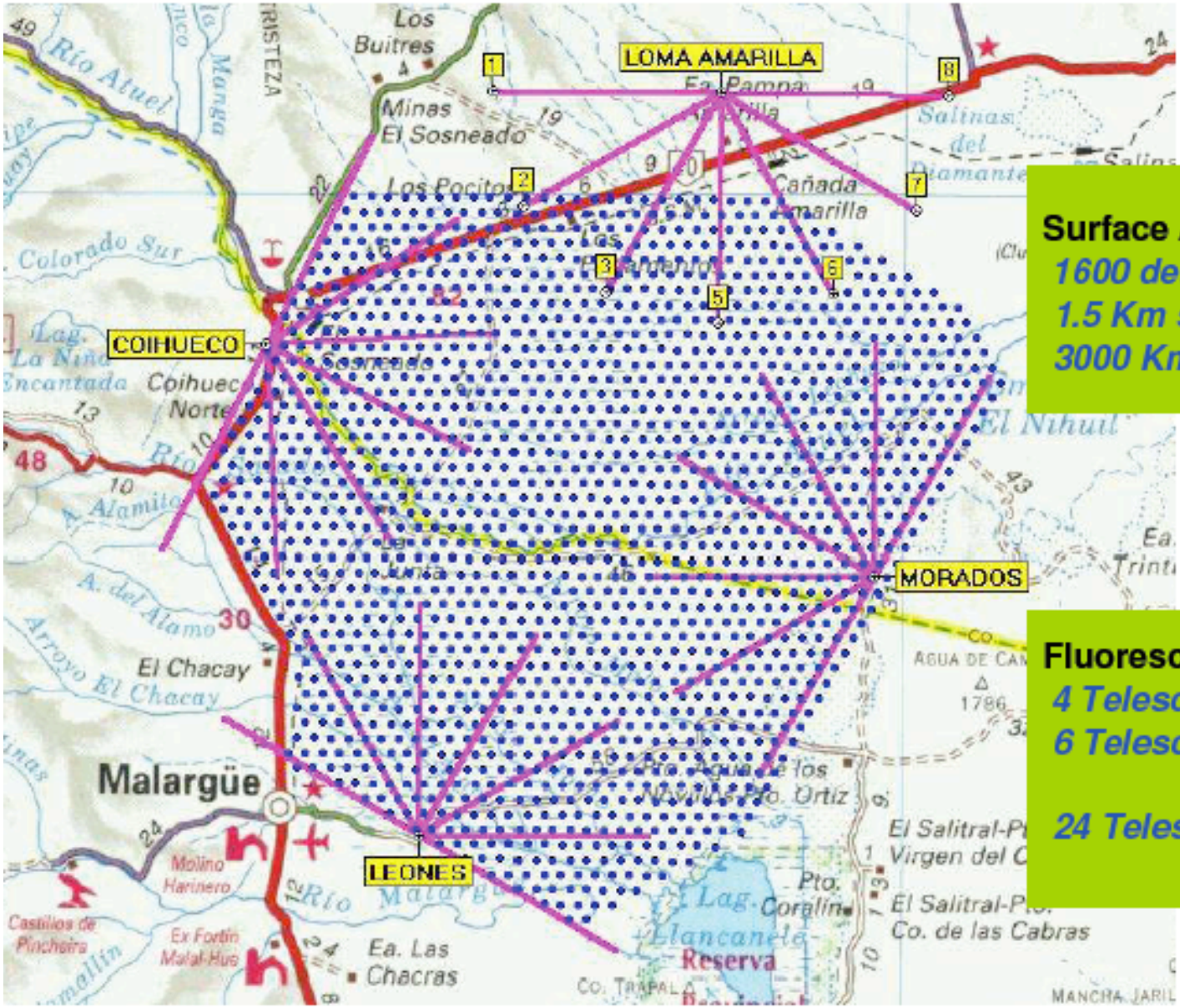
*Pierre Auger Observatory*

**Northern Auger in Colorado**





# The plan




**Surface Array**

*1600 detector stations*

*1.5 Km spacing*

*3000 Km²*

**Fluorescence Detectors**

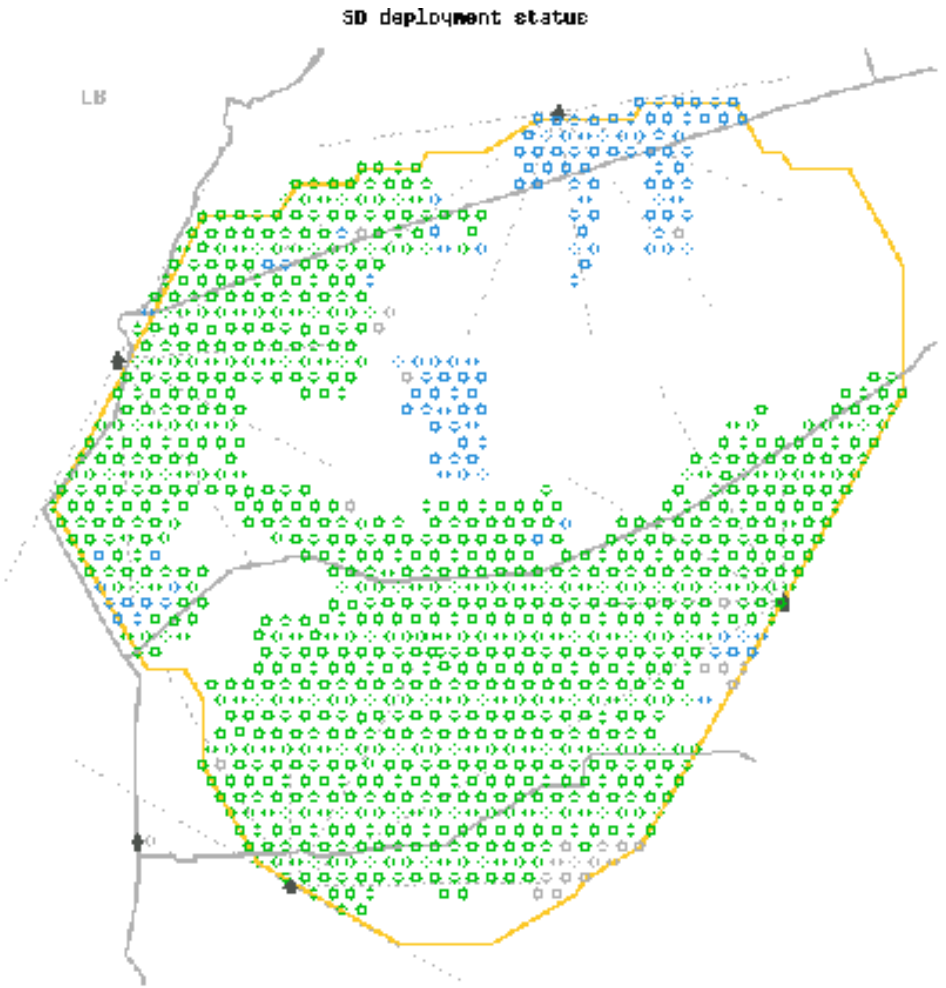
*4 Telescope enclosures*

*6 Telescopes per enclosure*

*24 Telescopes total*

**AGASA spectrum >> 100 events/yr above $10^{20}$ eV**

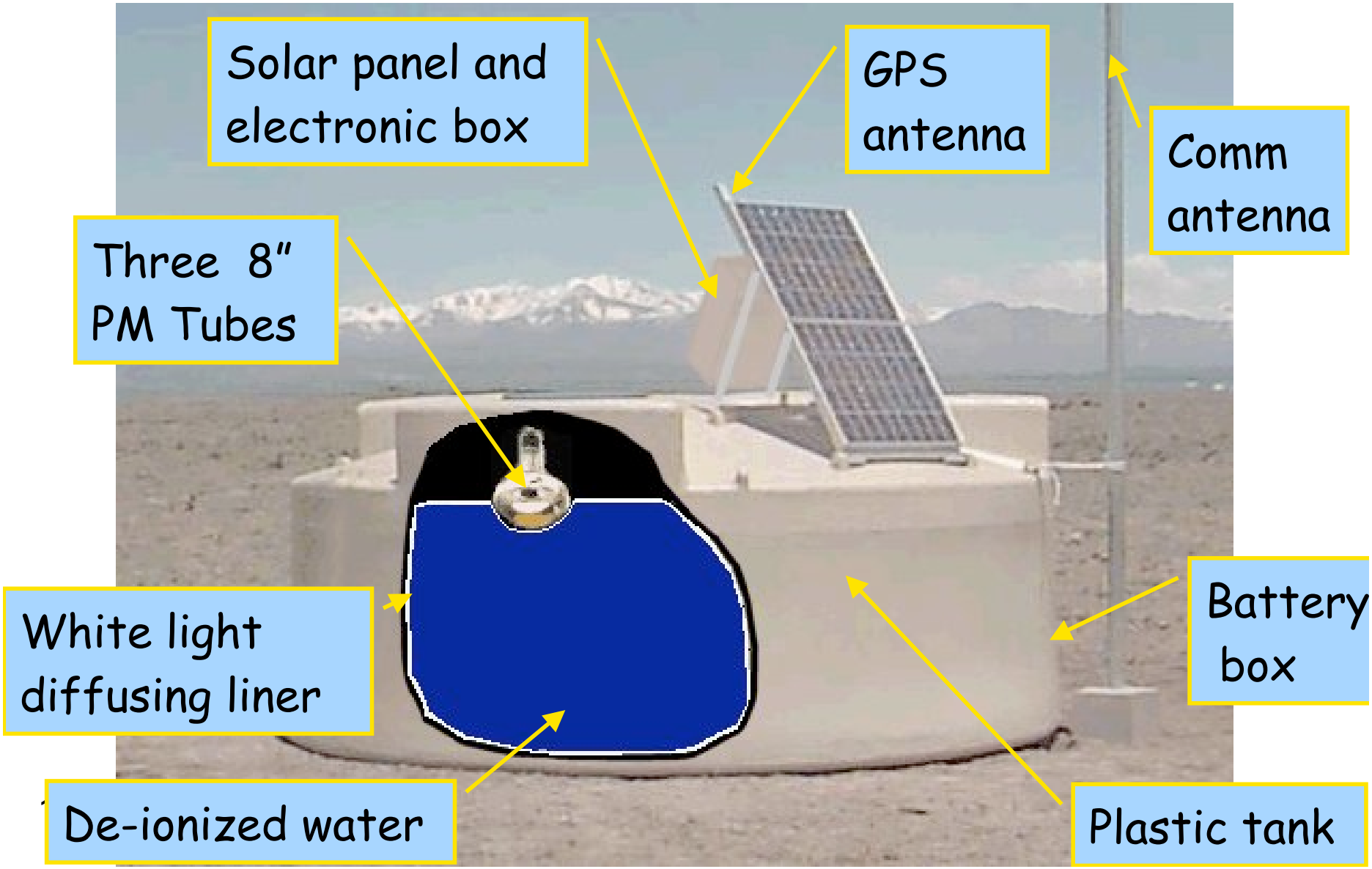
# Status



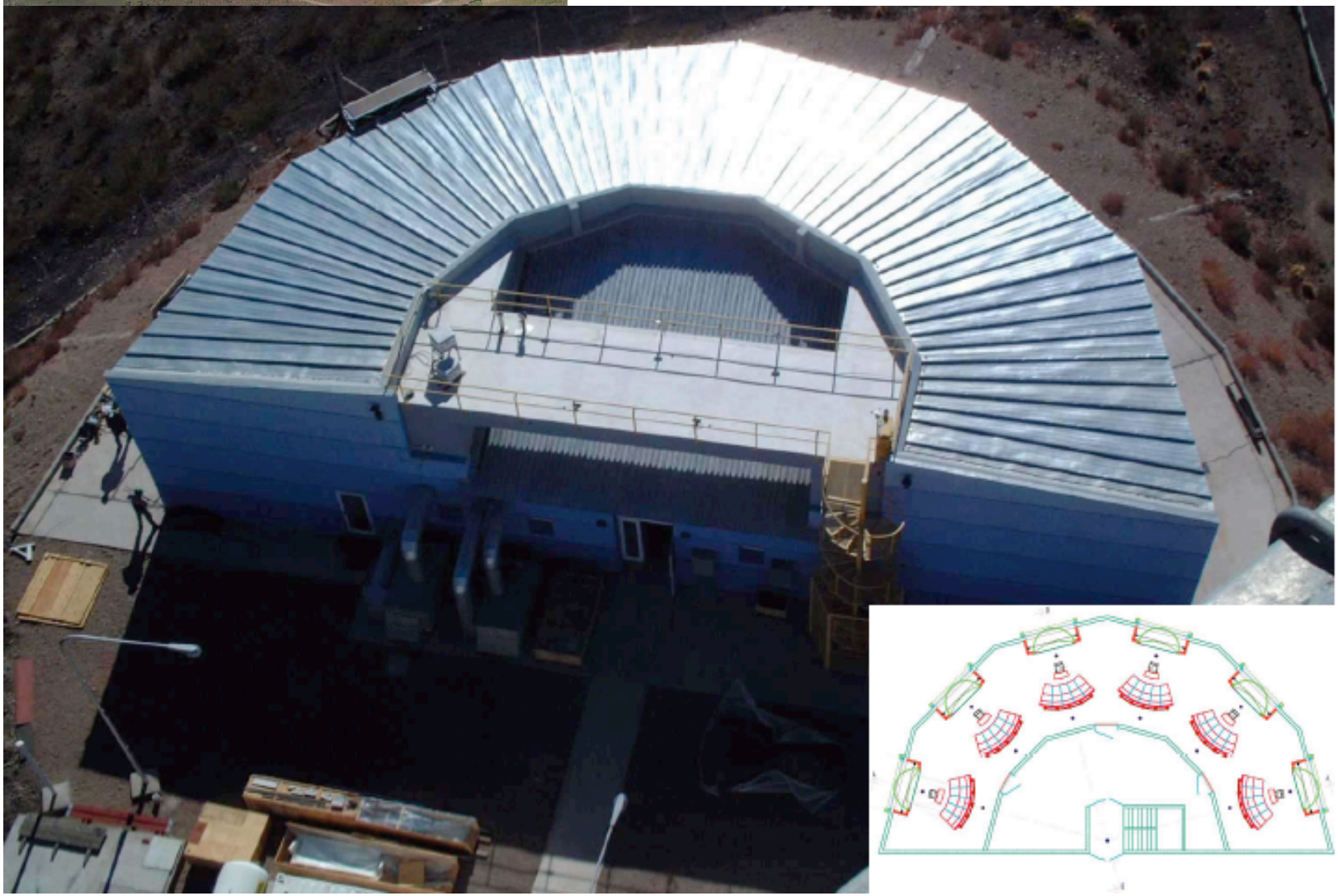

**15 February 2006**

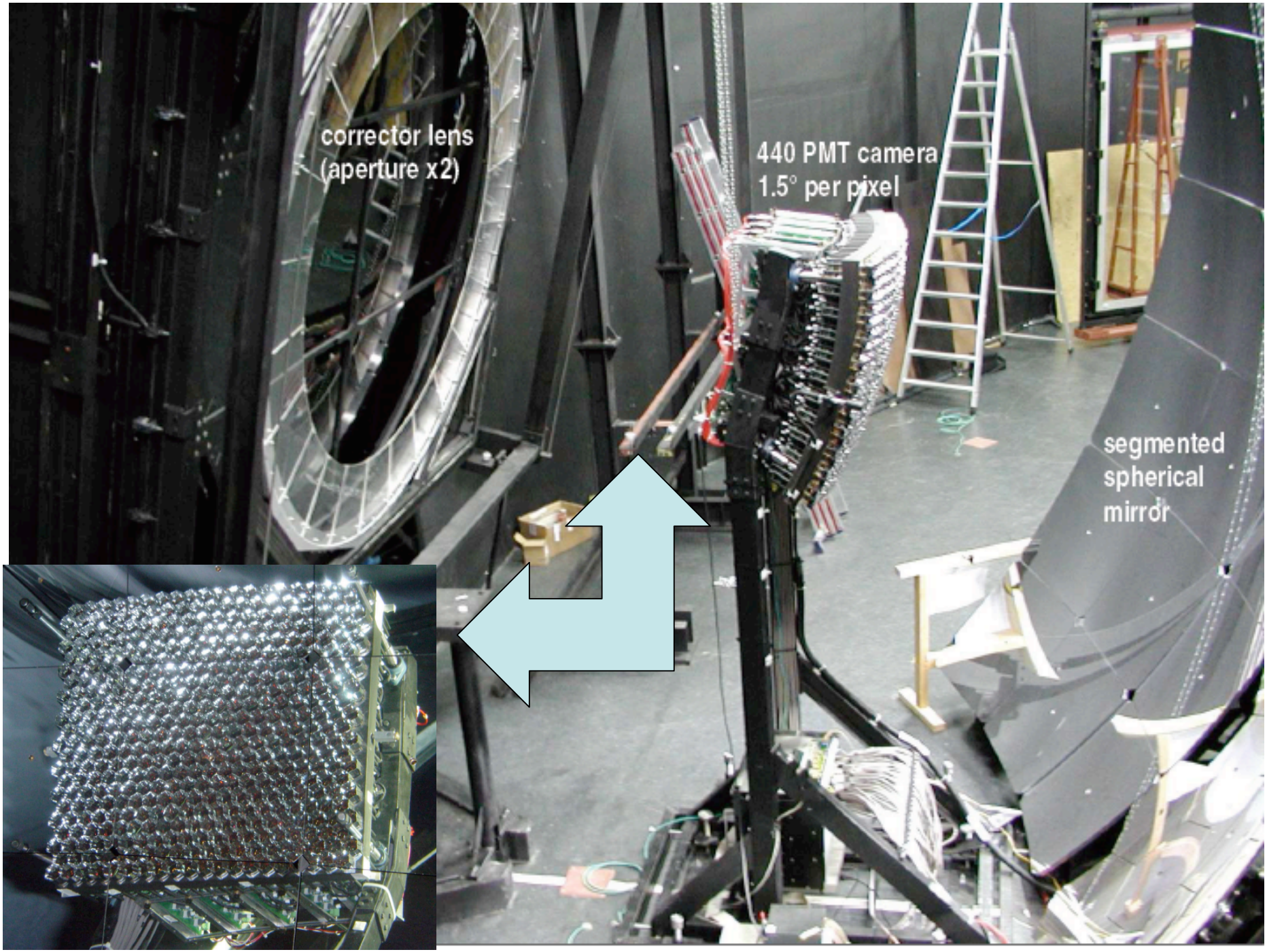
There are 1115 tanks deployed, 1043 with water and 919 with electronics

# Surface Detectors

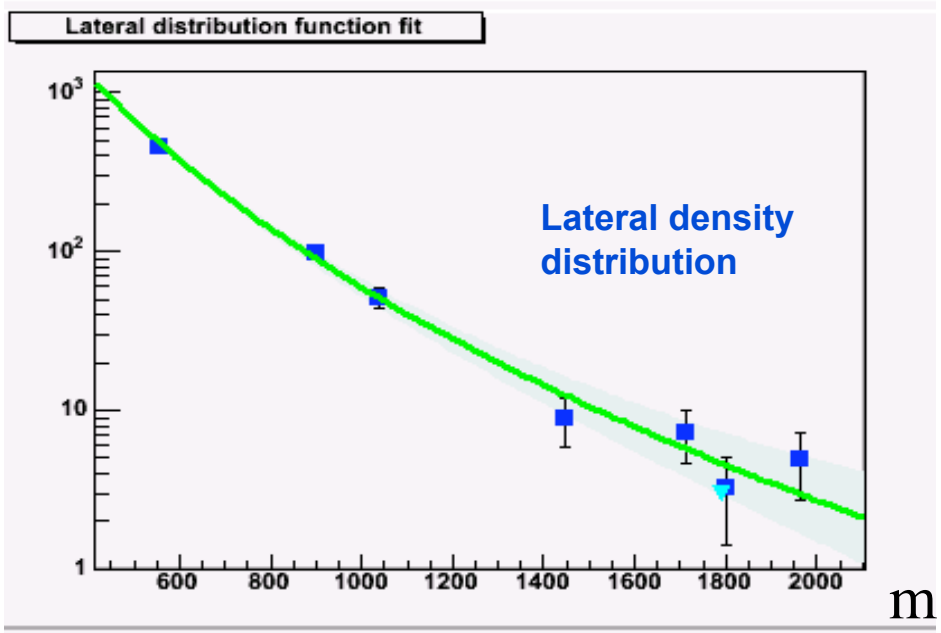


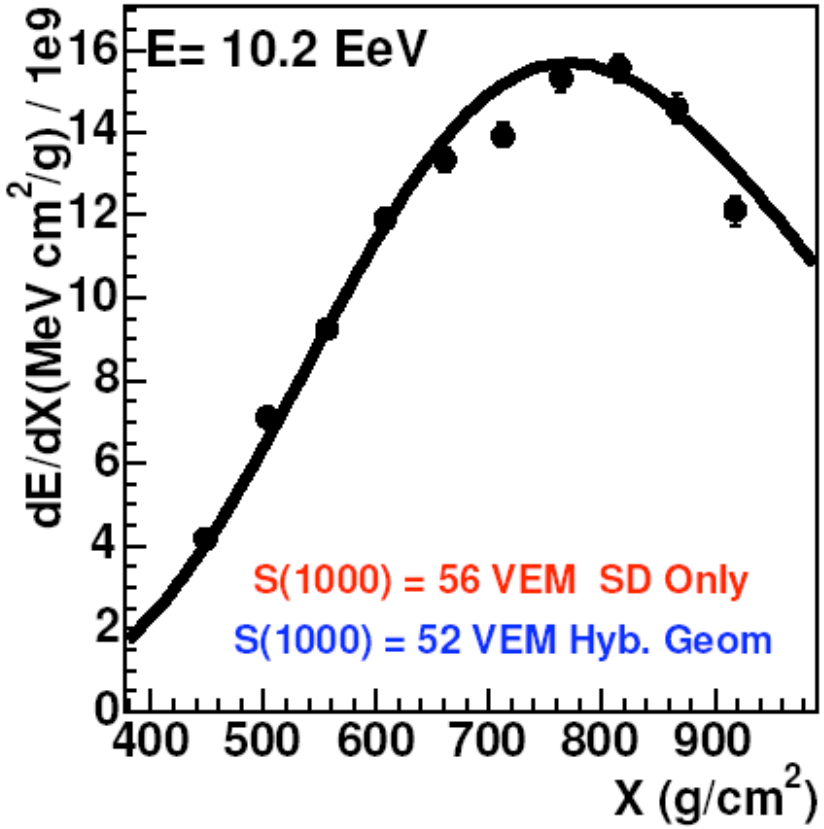
# Fluorescent detectors

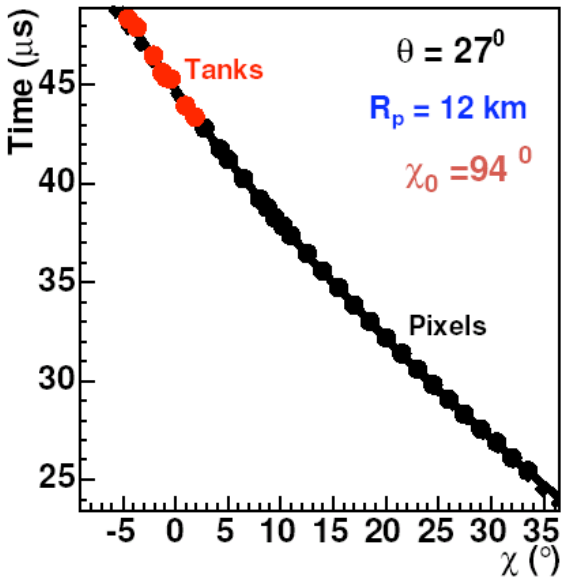


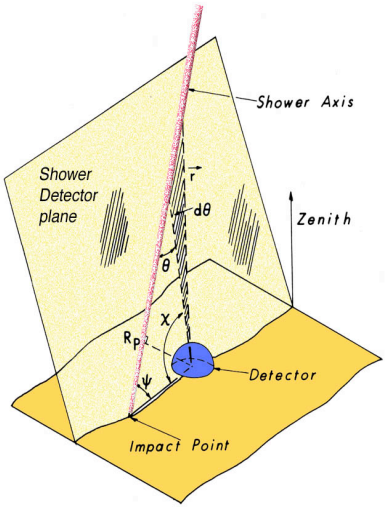

corrector lens
(aperture x2)
440 PMT camera
1.5° per pixel
segmented
spherical
mirror

# Zenith angle ~ 30º, Energy ~ 10 EeV FD (hybrid events) have both traverse and longitudinal shower information



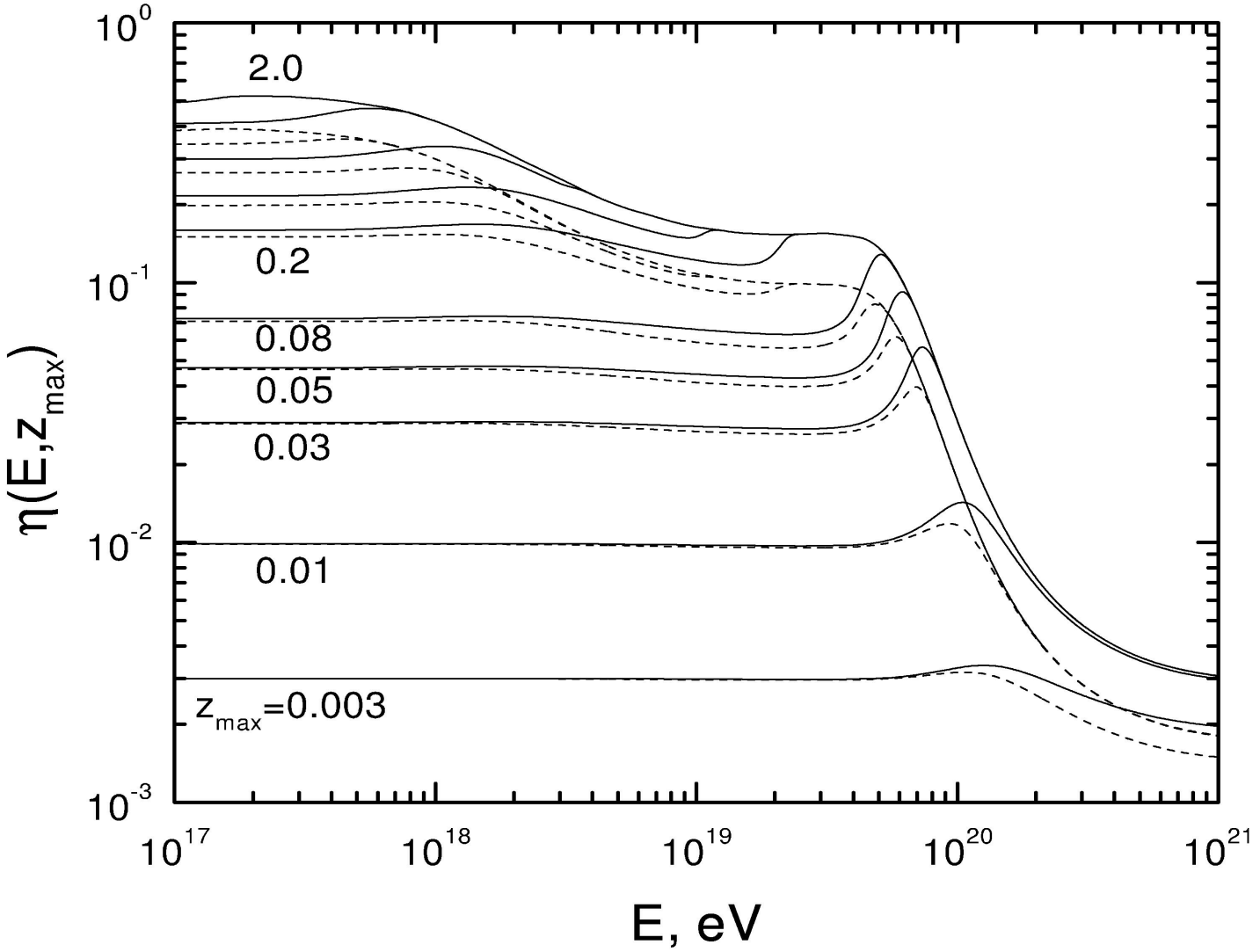



# Energy Losses of protons

Berezinsky et al. 03

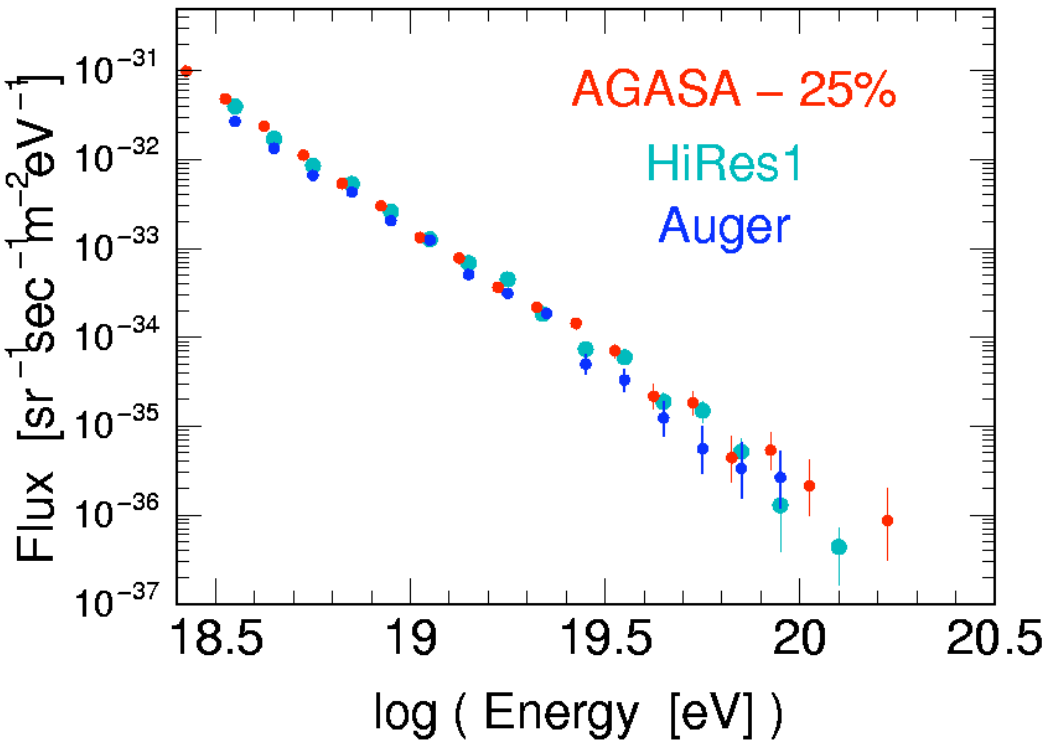



modification factor: $J_{obs}(E,z) = \eta(E,z) \times J_{injec}(E)$

# Energy spectrum in Auger

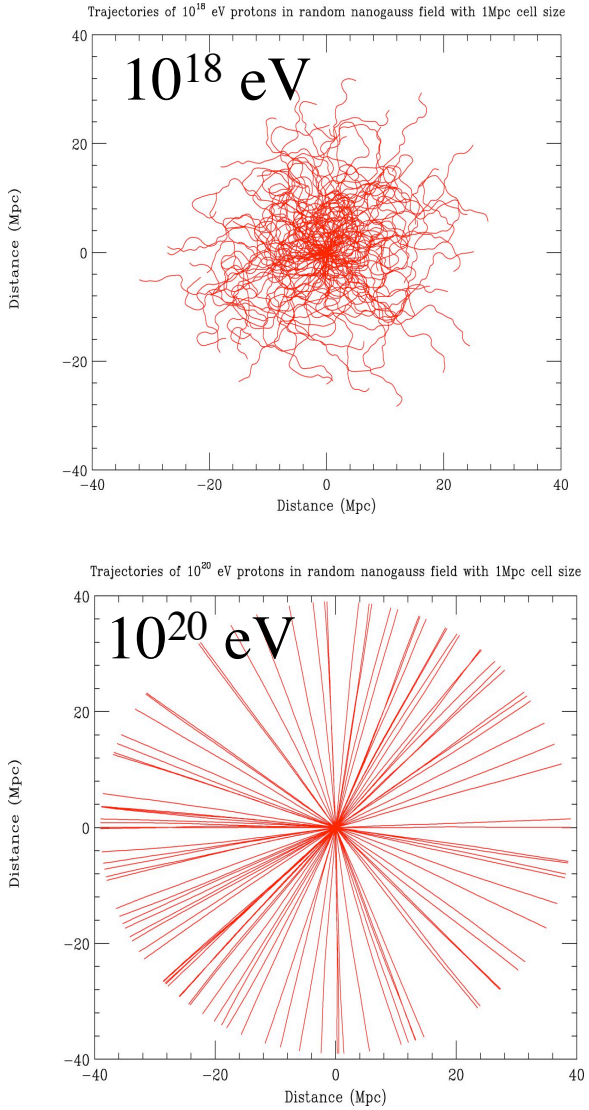
- SD data → ground parameter S(1000) = SD signal at 1000m
- Determine the S(1000)→ Energy & Zenith Angle conversion
  - Zenith Angle dependence: SD and Hybrid data
  - Fluorescence Detector energy scale Normalization via Hybrids (error < 25%)
- + SD exposure

→ measured spectrum.



# Anisotropies

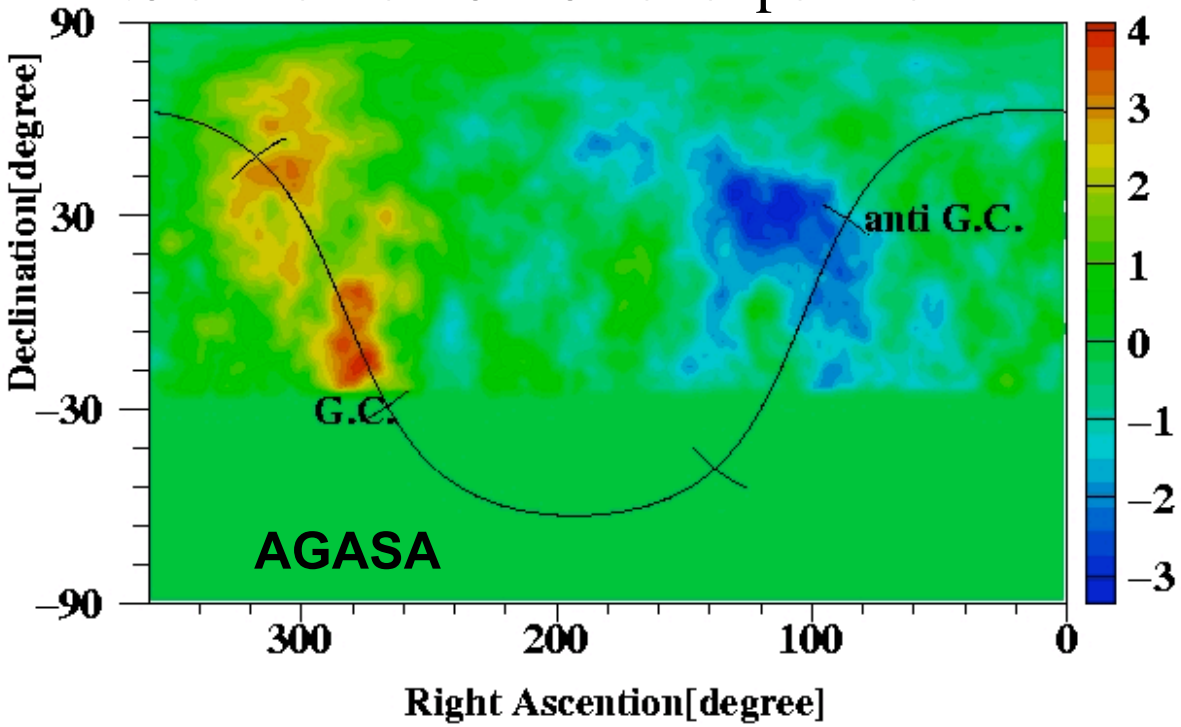
**Astronomy with p is possible at Energies above ~ $10^{19}$ - $10^{20}$ eV**



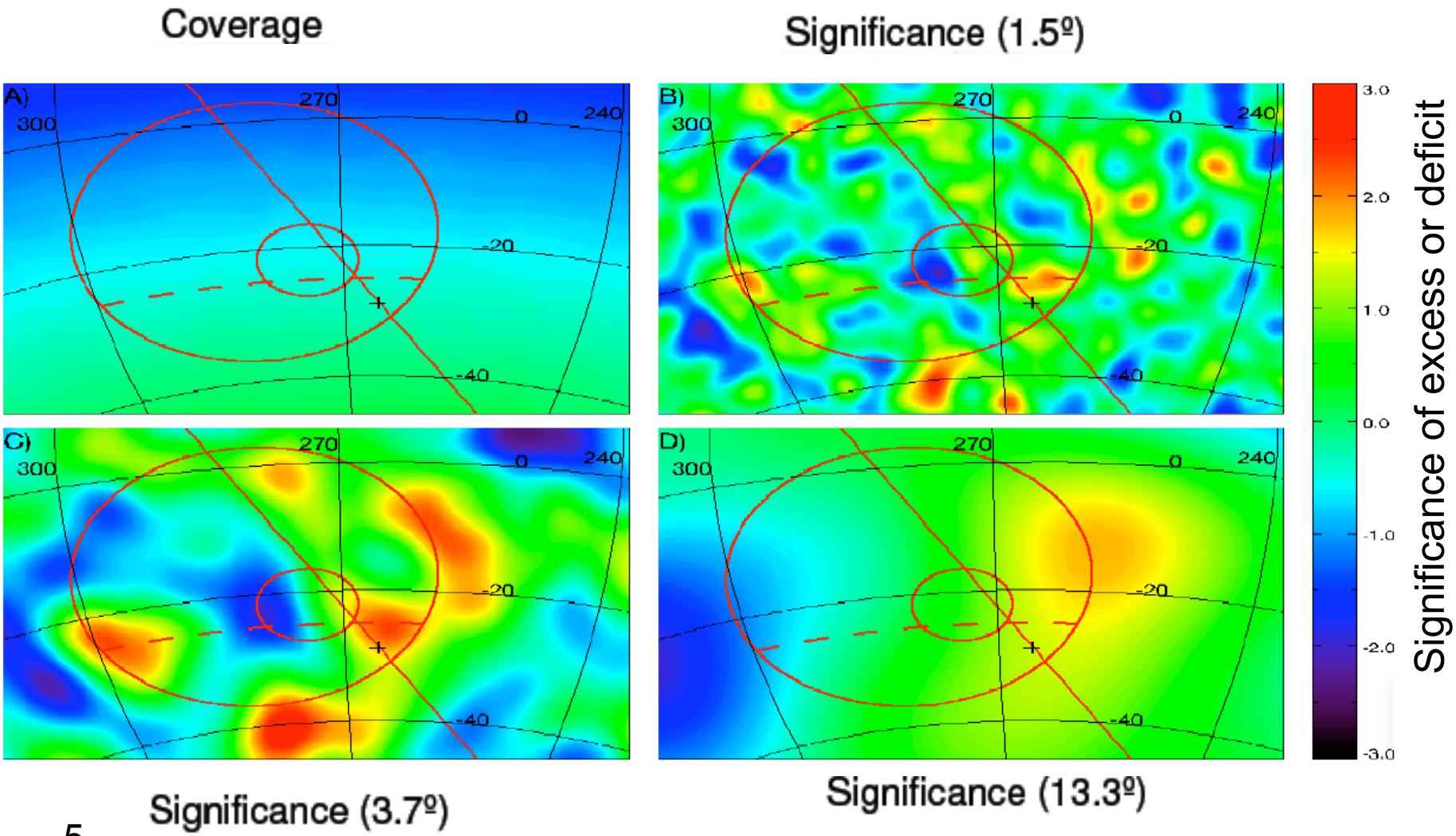

- AGASA: excess 4.5σ 20 deg window near the GC with E=1-2.5EeV.

http://arxiv.org/pdf/astro-ph/9906056

- SUGAR 2.9σ excess with 5.5 degree window near the GC with E=0.8-3.2EeV.
- No evidence from other experiments



# Auger sees nothing (ICRC2005)!



# Suggested readings

P. Sokolsky Introduction to Ultrahigh Energy Cosmic Ray Physics
Addison-Wesley 1989

Stanev High Energy Cosmic rays Springer 2004

T.K. Gaisser Cosmic Rays and Particle Physics
Cambridge University Press, 1990.

M. Lemoine & G. Sigl, Physics and Astrophysics of Ultra-High-Energy Cosmic Rays

http://pdg.lbl.gov/2005/reviews/cosmicrayrpp.pdf