UHECR Observation with All-sky Survey High Resolution Air-shower telescope

(Ashra)

Ashra Collaboration

Makoto Sasaki

(ICRR, University of Tokyo)

EHE CR & ν Air Shower Detection

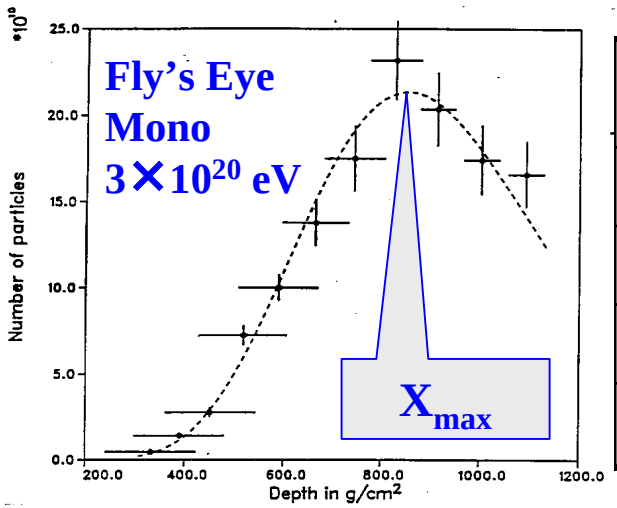
Atmosphere is a good Calorimeter.

Rad. Length	36.7g/cm^2 => 28 X_0
Int. Length	90 g/cm^2 => 11 λ_I
Critical Energy	81MeV
Moliere Radius	91m(STP)

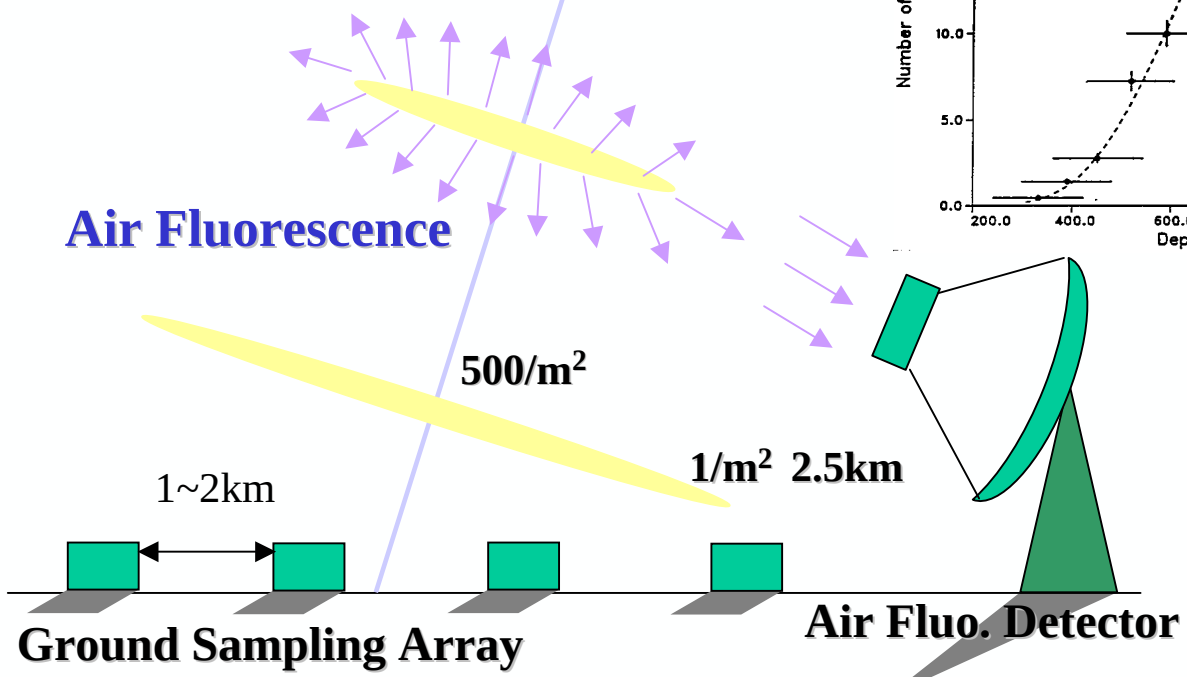
And it scintillates!
~5 UV γ/electron/m

p, Fe, γ , ν interaction

- Air Fluorescence Detector
  - Total Absorption Calorimetry
  - Long. Development => PID
  - Fly's Eye, HiRes, TA



Primary @ 10^{18}eV	<X_{max}> (g/cm^2)
Fe	700
p	800
γ	1000
ν	Any



- Ground Sampling Array
  - 2D-sampling e & γ
  - Energy: MC+ ρ (600m)
  - Little power of PID
  - AGASA, AUGER, etc

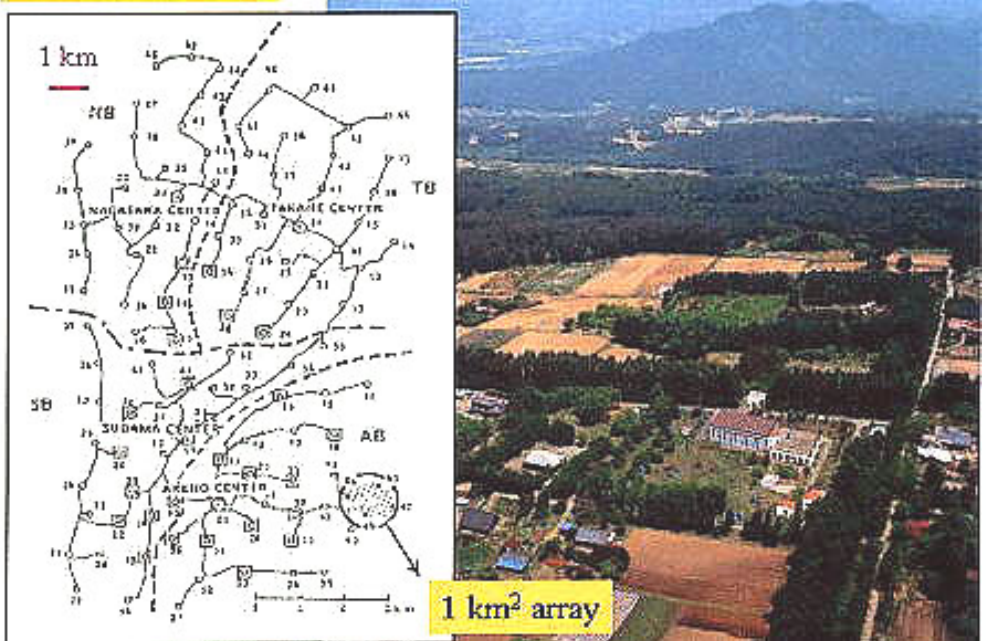
地上サンプル検出器

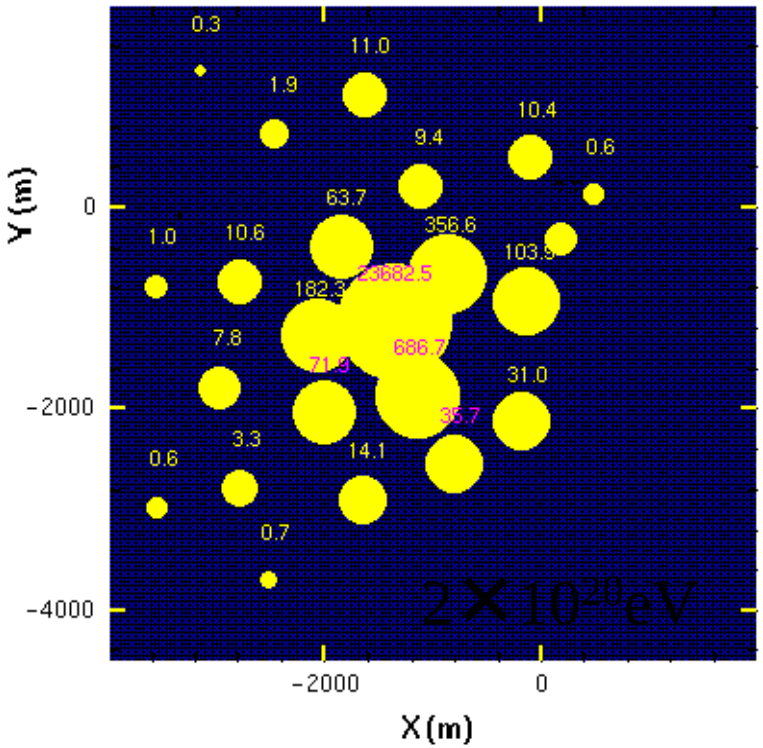
Akeno Giant Air Shower Array (AGASA)

Muon counter housing (x 8). Other types (x 19)

Scintillation counter (x 111)

100 km^2 array

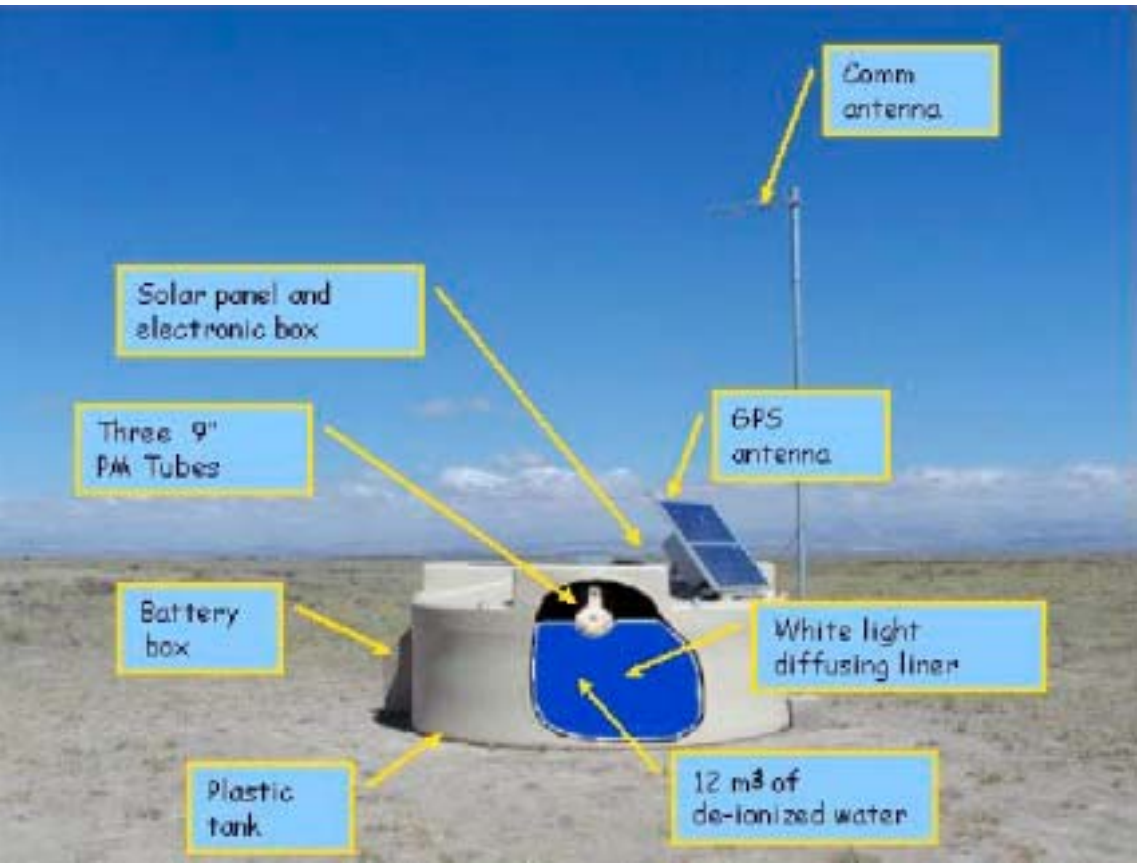




角度精度　2〜3°

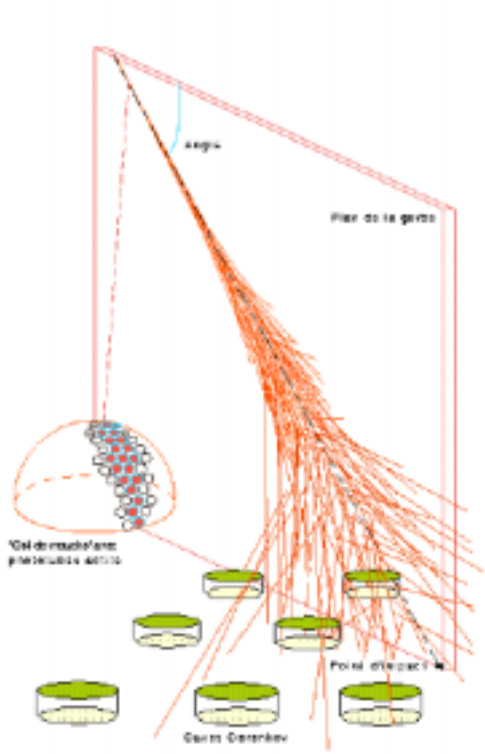
再構成におけるMC依存

Auger **検出器**


Comm antenna
Solar panel and electronic box
Three 9" PMT Tubes
GPS antenna
Battery box
White light diffusing liner
Plastic tank
12 m³ of de-ionized water

Auger 計画

ハイブリッド

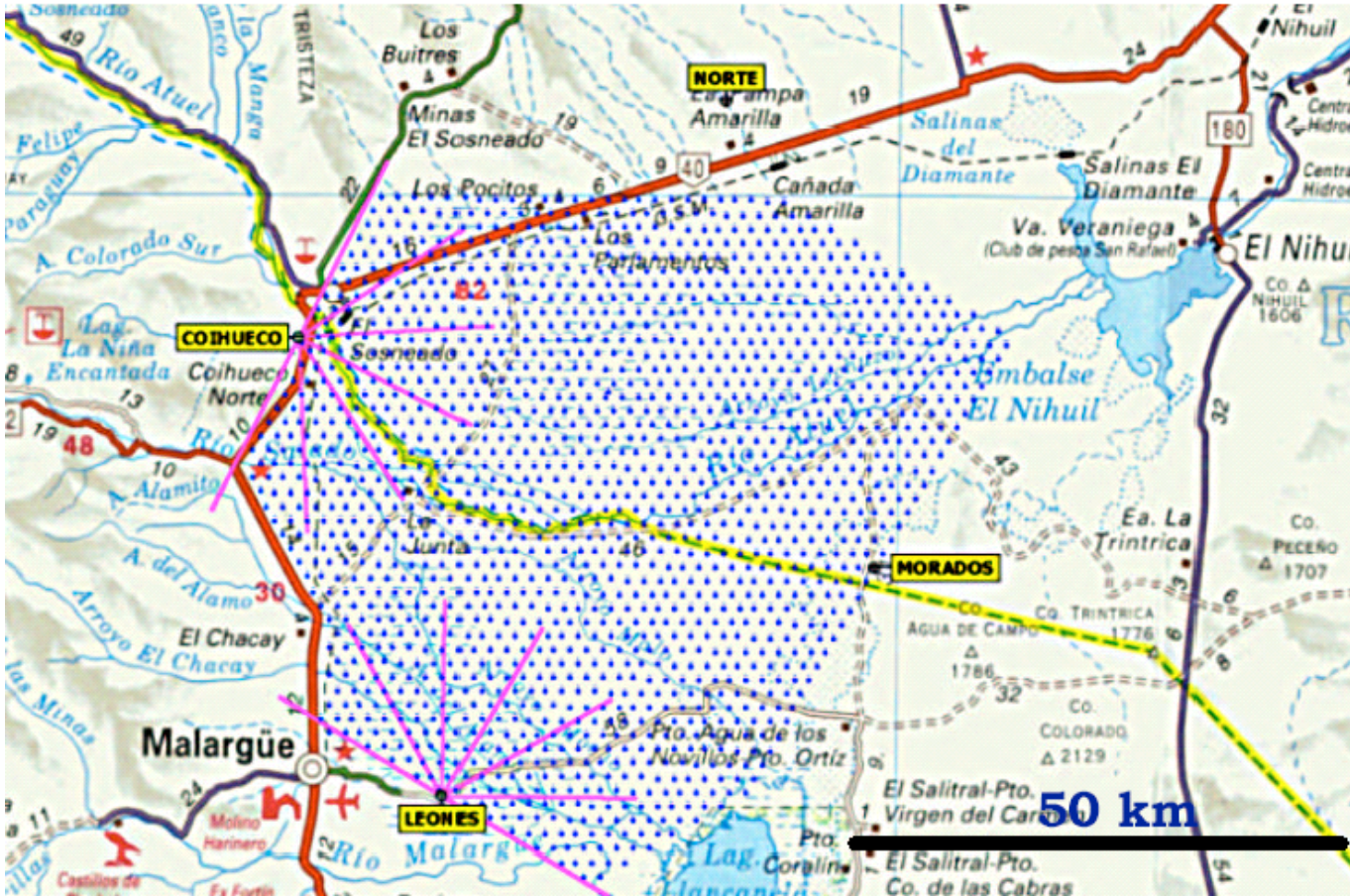


面積 AGASA ×30、　2005年からフル稼働

3000 km^2

1600 surface detectors, 1.5 km spacing, triangular grid

4 FD buildings at the periphery, with 6 telescopes each



Extragalactic CR Origin

1. Magnetic deflection:
2. Model Simulation

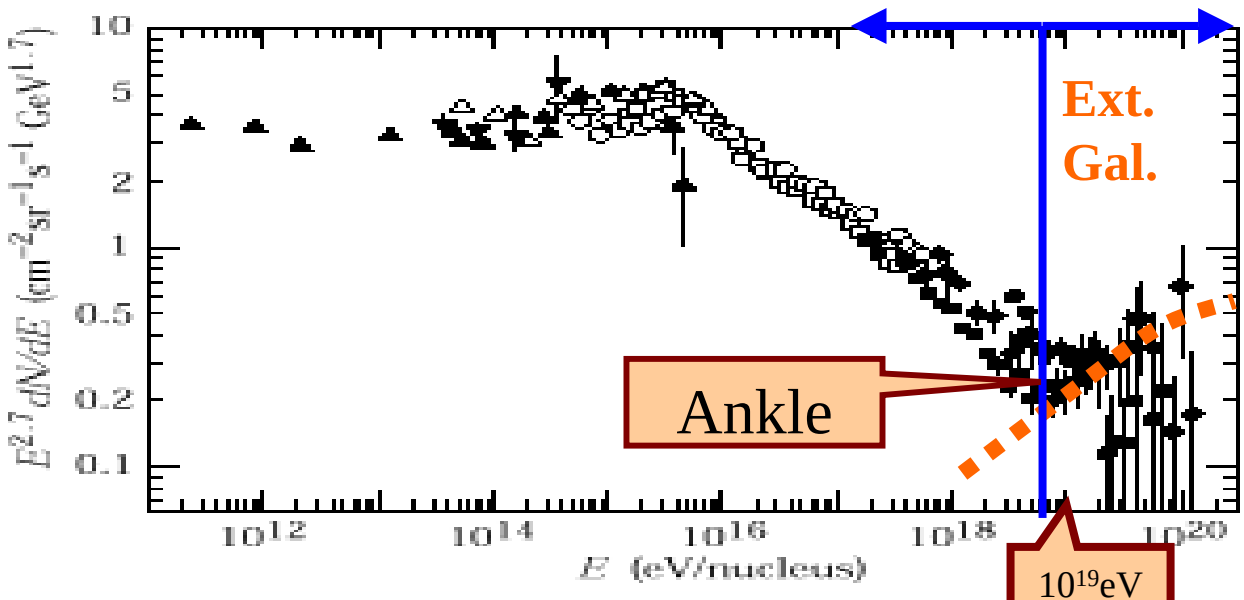
$$\theta \approx \frac{L_{kpc}\, ZB_{\mu G}}{E_{18}} = \frac{L_{Mpc}\, ZB_{nG}}{E_{18}}$$

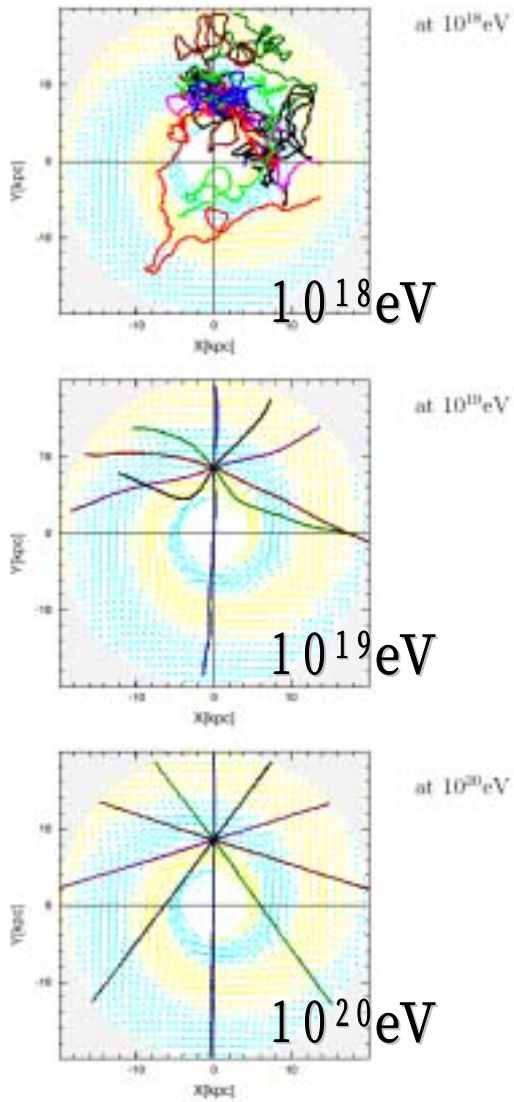
$$R_{kpc} \approx \frac{E_{18}}{ZB_{\mu G}}$$

=> EHECR (>10^{19}eV) can point origins.

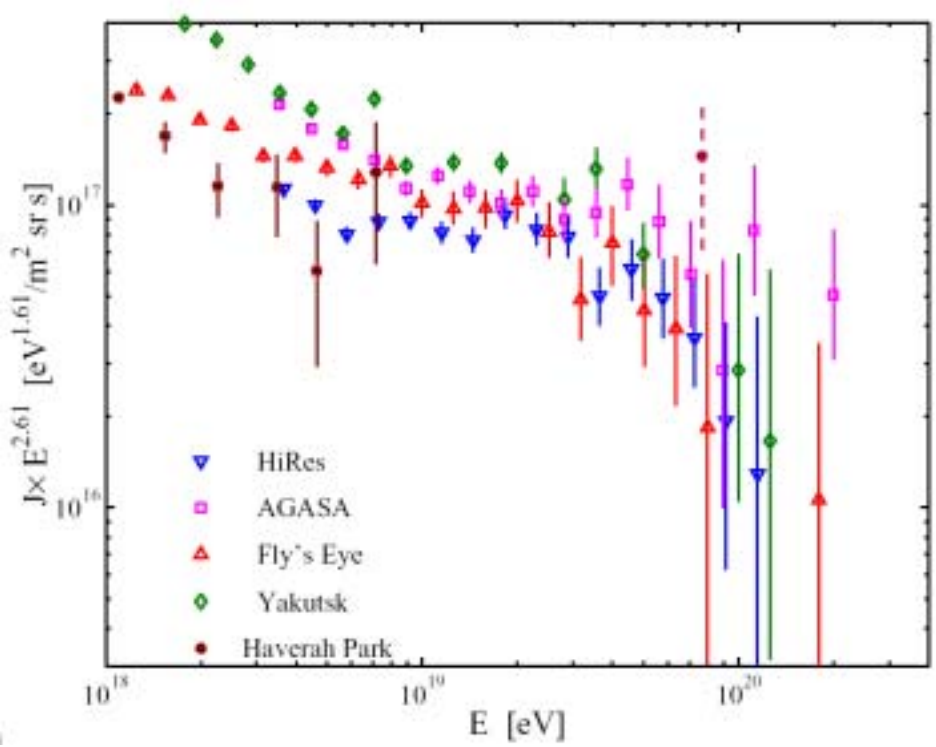
3. Measured Spectrum Structure

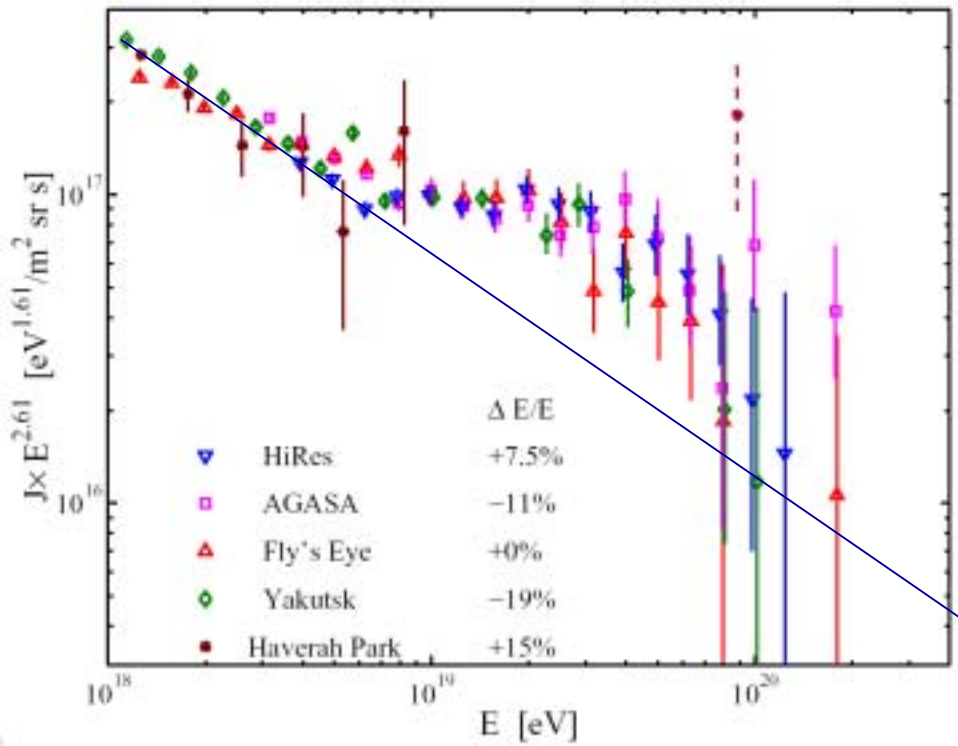
=> Extragalactic origin of EHECR





実験間の系統誤差



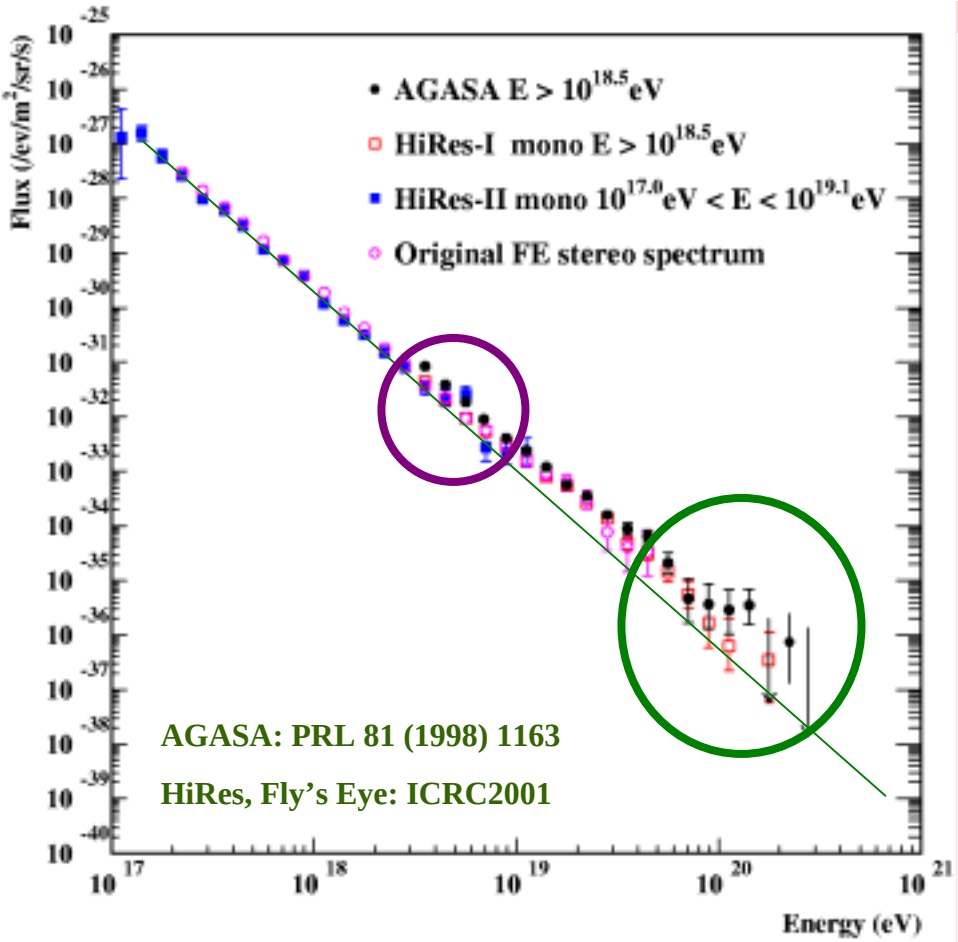


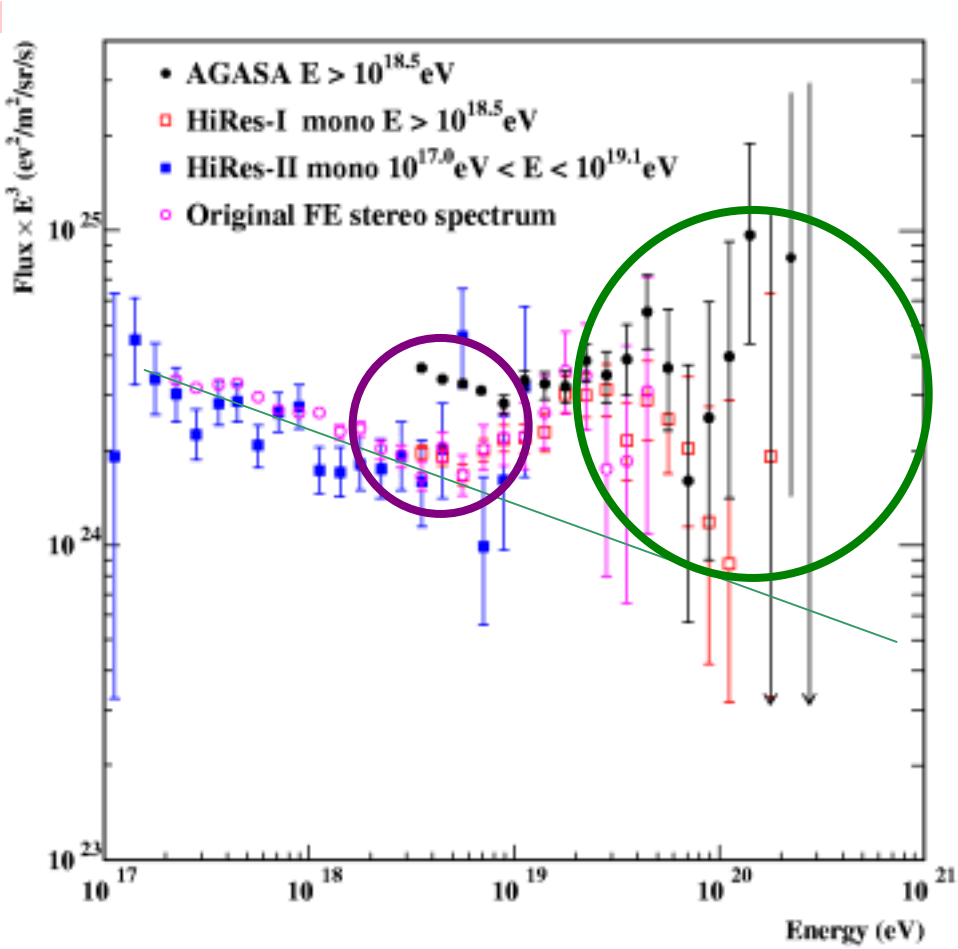
Bahcall & Waxman, hep-ph/0206217

=> ~ 20% 系統誤差の確認

=> 銀河外成分の存在の確認

•EHECRの現状





1) **大域的一致=>銀河外起源**

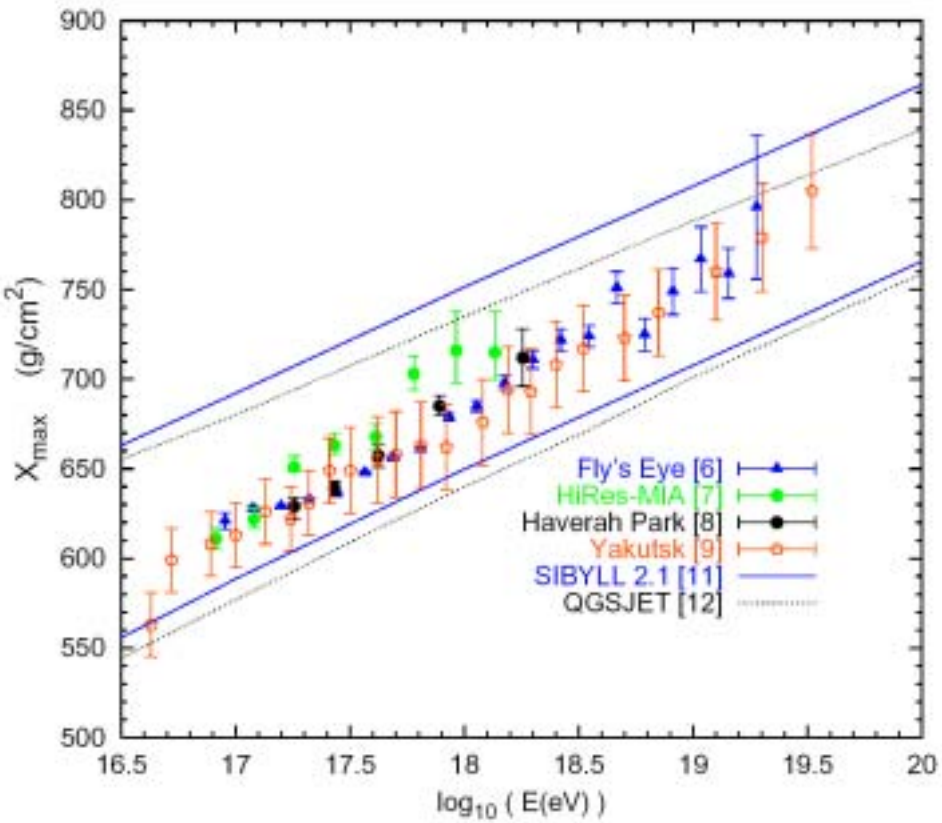
2) **E>$10^{19.5}$ eV =>脆弱な統計**

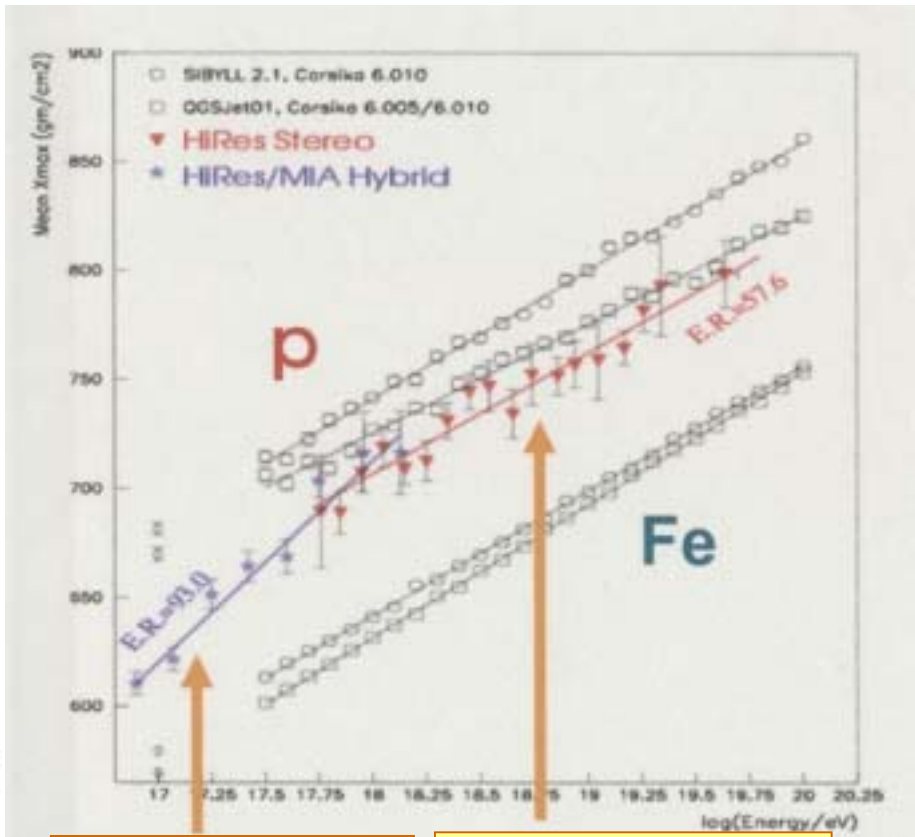
3) **E<10^{19} eV =>系統的研究の必要性**

- **TA基底方針(1997~)**
  - **広いエネルギー領域**
  - **大気蛍光検出器**
    => 3次元カロリメタ
    => 全観測量較正
  - **巨大アレイ**

普遍的妥当性

銀河外成分は陽子？





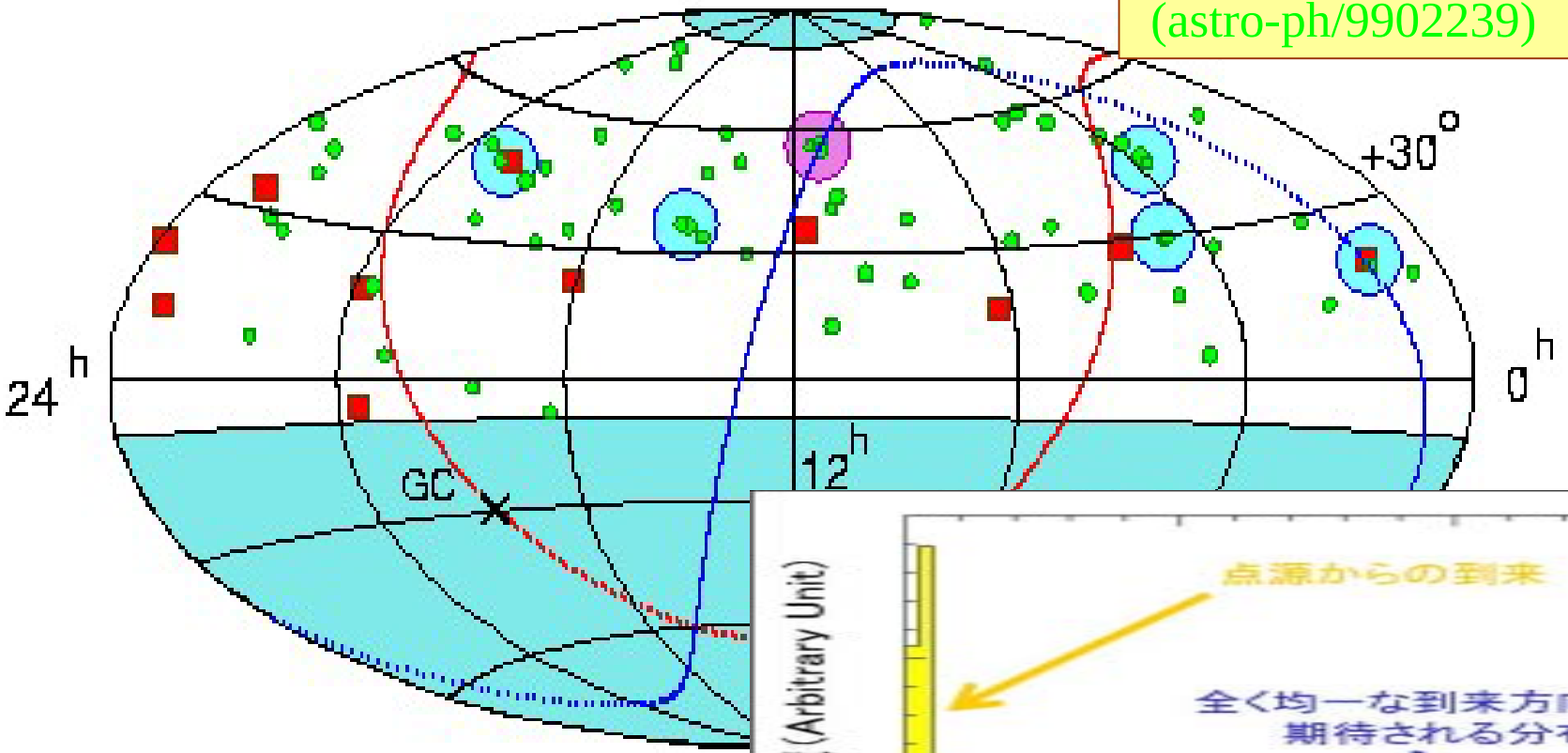
HiRes-MIA

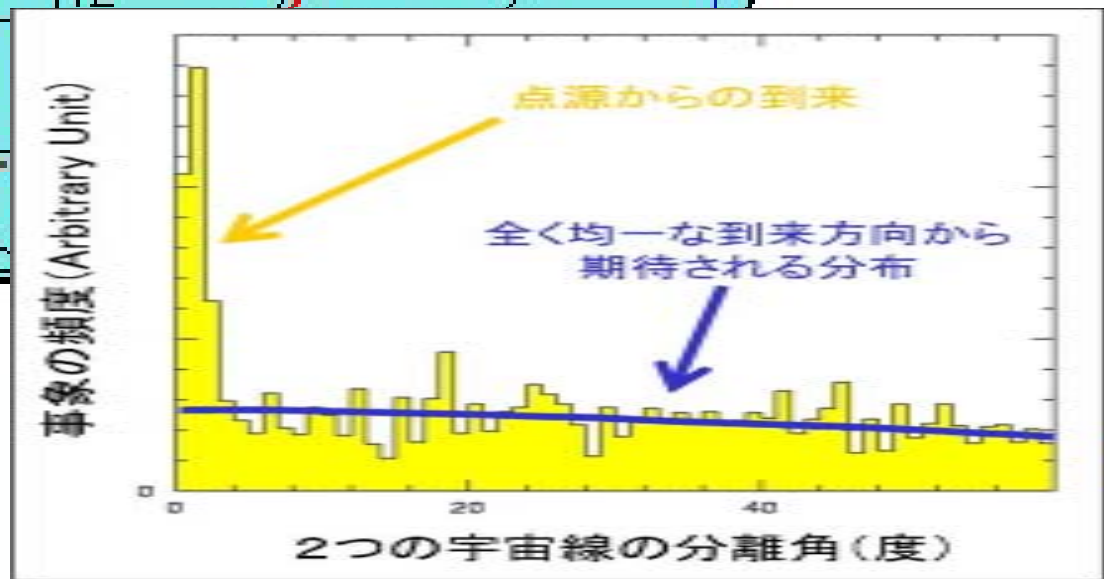
HiRes Stereo

AGASAクラスター

$10^{19.6}$eV以上でクラスター
(59事例から)
- doublet: 5個
- triplet: 1個
- => 5σ有意性

(astro-ph/9902239)





γ-loud BL Lacとの相関 (2)

銀河磁場の影響
電荷、対称･反対称

Galactic magnetic field: spiral model

$$B_z = 0; \qquad B_\theta = B\cos(p); \qquad B_r = B\sin(p)$$

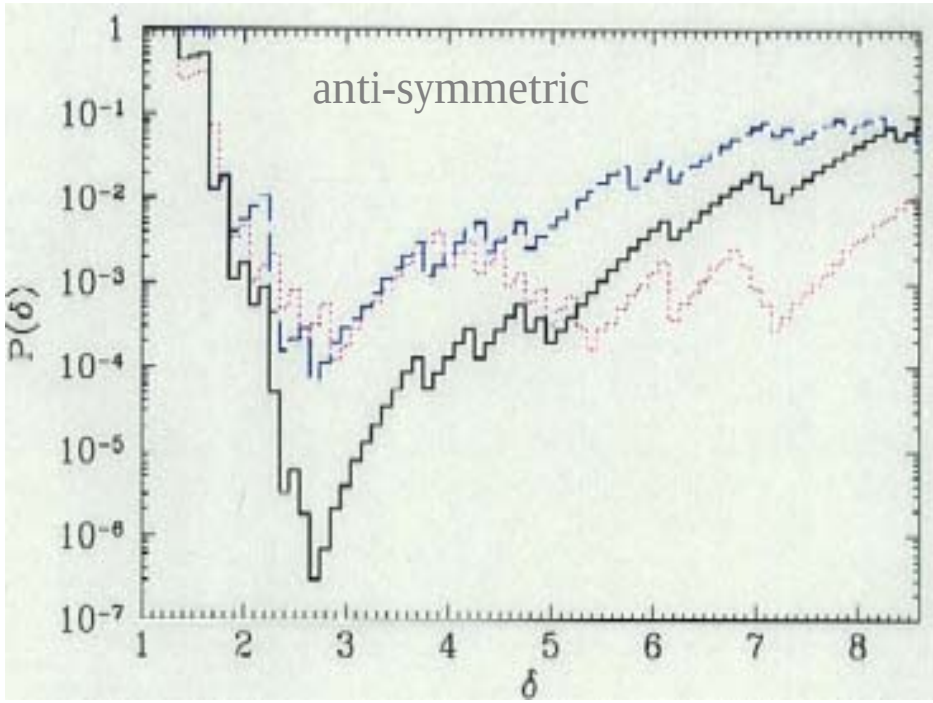
$$B = \frac{b}{r}\cos\left[\theta - \beta\ln\left(\frac{r}{R}\right) + \phi\right]\exp\left(-\frac{|z|}{h}\right)$$

Here $R = 8.5$ kpc - distance to the Galactic center.

Constants b, β, ϕ and h are expressed through 4 parameters:

$B_0 = 1.4\mu$G	—	local value
$p = -8°$	—	pitch angle
$d = -0.5$ kpc	—	distance to field reversal
$h = 1.5$ kpc	—	extent in halo

ＢＧから起こる確率 P(δ) vs 相関角 δ



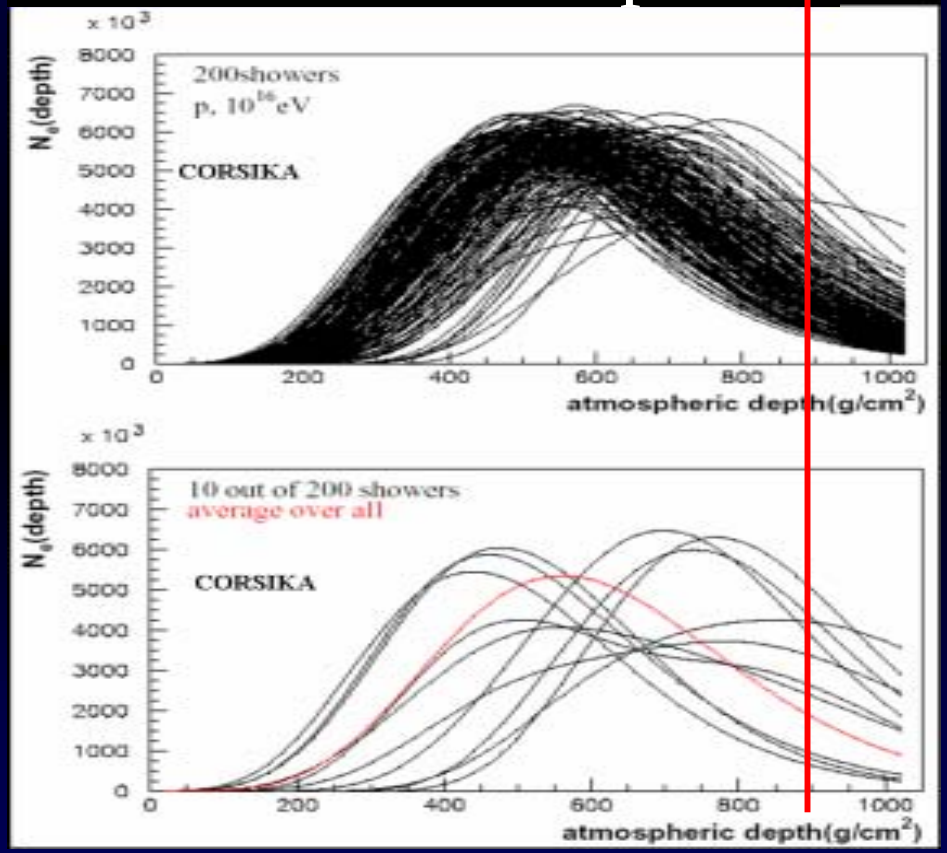
Black: $Q = 0, +$

Blue: $Q = +$

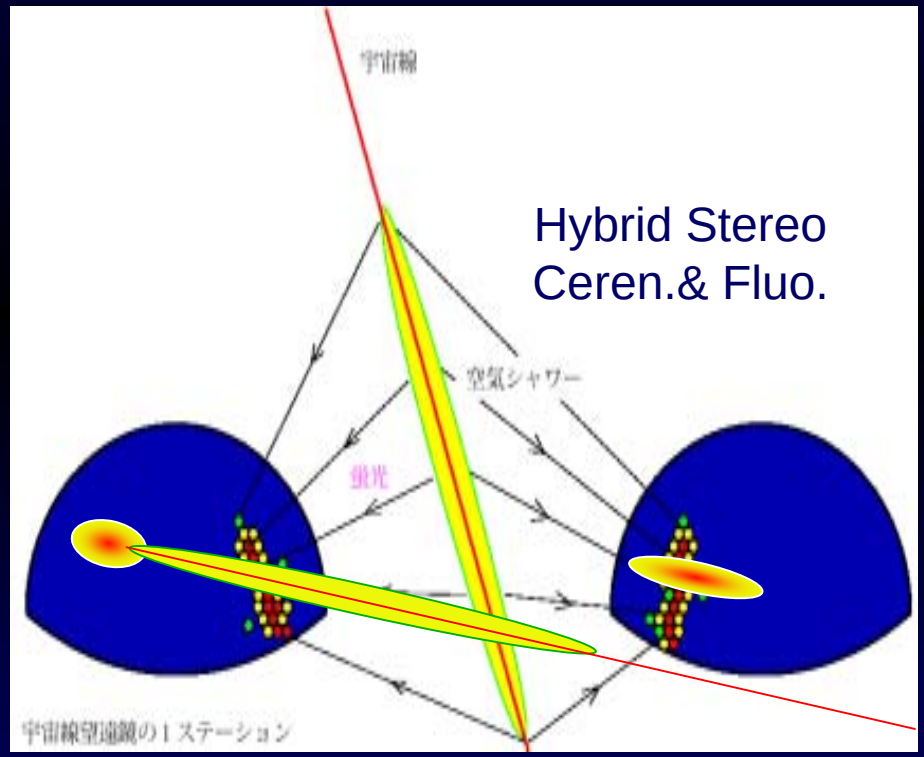
Red: $Q = 0$

Advantages of Air-light Technique

1. Shower Development



2. Stereo Observation



Unbiased and Redundancy Measurement

=> Precise Prim. Energy and Direction