Groupe Observatoire Pierre Auger
Analyse des données

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biennale, 20-09-2011

Auger Scientific Production and our contribution

Journal papers in 2010/2011

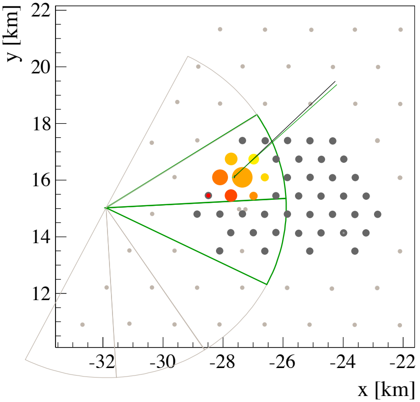
- 13 published papers (2 coordinated by LPNHE researchers: VCV correlation update, downgoing neutrinos)
- 6 submitted (1 by LPNHE: geomagnetic field)
- 3 internal review
- 4 editing phase (1 by LPNHE: infill spectrum)

38 ICRC proceedings (2 by LPNHE: geomagnetic field, infill array)

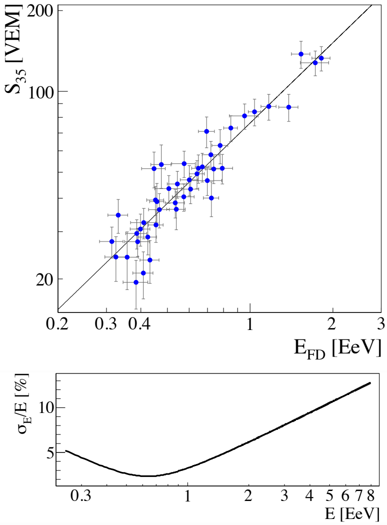
9 presentations at international conferences by LPNHE researchers.

Reconstruction and Spectrum

Infill Array



- **Auger extension for low energy events** (0.1 to 1 EeV)
- 750m spacing between detectors, sonstruction began in 2008
- 61 stations deployed
- data analysis based on methods developed for the regular array



Energy calibration

- event selection to assure an unbiased energy calibration
- strong quality cuts and fiducial field of view cuts
- 44 events with $3 \times 10^{17}\,\mathrm{eV} < E_{\mathrm{FD}} < 2 \times 10^{18}\,\mathrm{eV}$

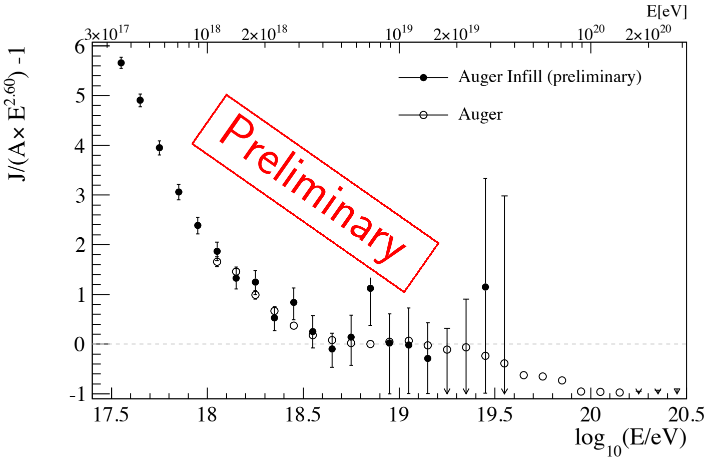
$$E_{\mathrm{SD}} = (12.7 \pm 2.5) \times 10^{15}\,\mathrm{eV} \cdot S_{35}^{(1.01 \pm 0.05)}$$

Energy uncertainties

- systematic (fit): 6% at 0.3 EeV, 13% at 8 EeV
- statistical (S_{35}): 16% at 0.3 EeV, 14% at 8 EeV
- FD energy systematic: 22%

(R. Pesce, poster 1160)

Infill Spectrum



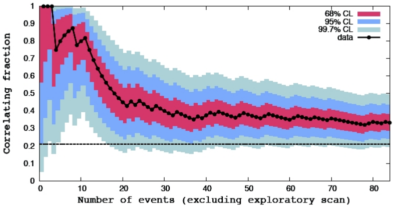
- extends the energy range down to 3×10^{17} eV (No resolution correction!)
- very good agreement with the combined spectrum (F.Salamida, talk 0893)
- slope for $E < 3 \times 10^{18}$ eV: $-3.33 \pm 0.03(\text{stat}) \pm 0.1(\text{sys})$

Anisotropy measurements

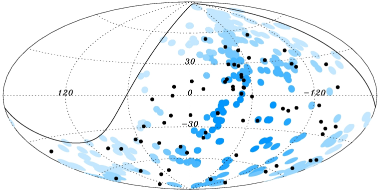
Point sources - 50 EeV and above

At highest energies: Correlation of event directions with AGN. Update of the result from 2007.

Auger

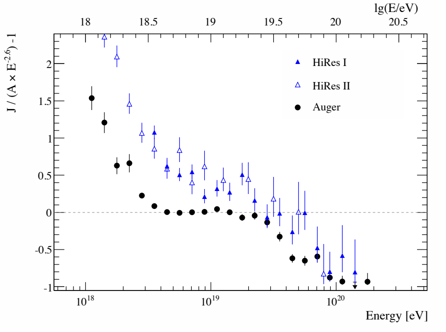


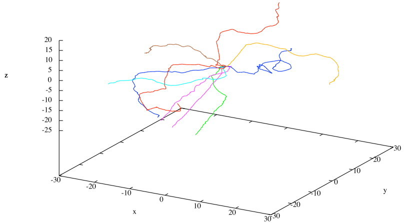
$P = 0.006$, $f = 33 \pm 5\%$



28 out of 84 correlate

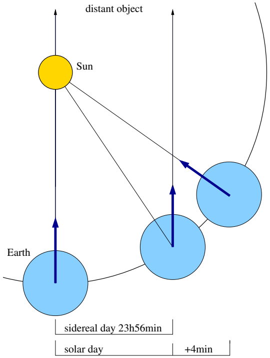
Why do we search for large scale anisortopies? One question that might be answered: Where is the transition from galactic to extragalactic CRs?





- **Transition at the ankle?**
- Gyroradius of a proton at 3EeV for 3muG galactic magnetic field: 1kpc.
- Anisotropy at transition should be measurable.
- At low energies: Do we see the galactic center?

Large scale anisotropy - harmonic analysis



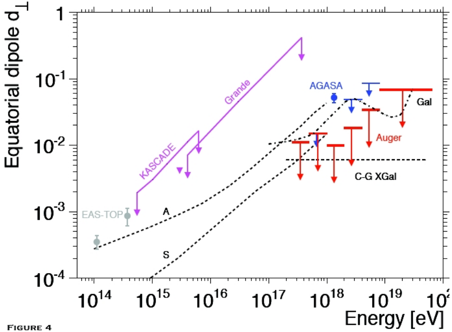
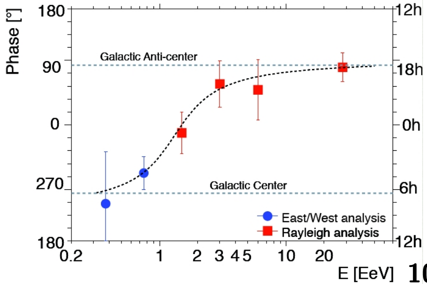


FIGURE 4



Large scale anisotropy - multipole method

- Direct **extension of the harmonic analysis** to the sphere. Find dipole, quadrupole...
- It is necessary to modify the standard multipole expansion to account for the incomplete and non-uniform coverage.

$$Z_l^m(\theta,\phi) = \sum_{l'=m}^{l} C_{l'l}^m \omega(\theta) Y_l^m(\theta,\phi)$$

- Important systematic: **the geomagnetic effect**.

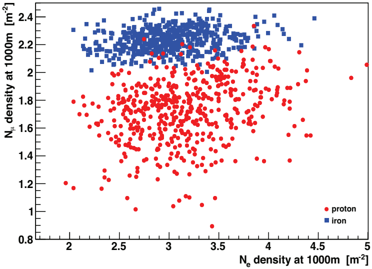
$$\tilde{E} = \frac{E}{\left(1 + G'(\theta)\left[\sin^2(\mathbf{u}(\theta,\varphi),\mathbf{b}) - \left\langle \sin^2(\mathbf{u}(\theta,\varphi),\mathbf{b}) \right\rangle_{\varphi}\right]\right)^b}$$

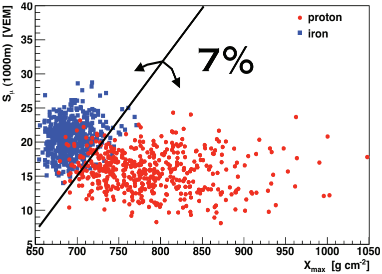
Composition and air shower characteristics

Composition from EAS characteristics

EAS can be characterized by only 3 parameters: E_0, X_{max} and N_μ

X_{max} and N_μ are sensitive to the primary particle



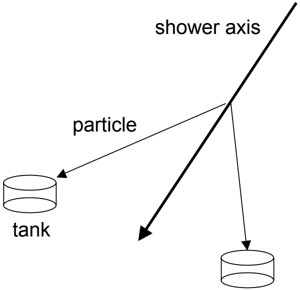


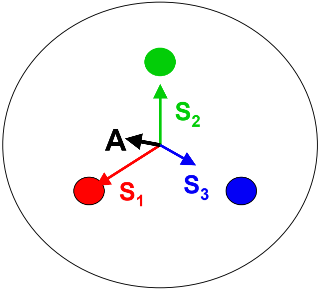
Strategy: determine X_{max} and N_μ

N_μ is inferred from S_μ

- **Total signal S_{tot} is directly measured in the tank**
  · Found a method to get S_μ from $S_{tot} - S_{em}(E_0, X_{max})$
- **Measure X_{max} and E_0** on an event by event basis
  · Crucial: Measure longitudinal development with a 100% duty cycle = **EASIER**
  Radio and Microwave detection of air showers

Muon signal in the tanks





asymmetry vector **A** = ($\mathbf{S}_1$+$\mathbf{S}_2$+$\mathbf{S}_3$) / ($|S_1|+|S_2|+|S_3|$)

- amplitude roughly proportional to θ of *particle* (if not too big)
- direction related to ϕ of *particle* (in average over orientations)

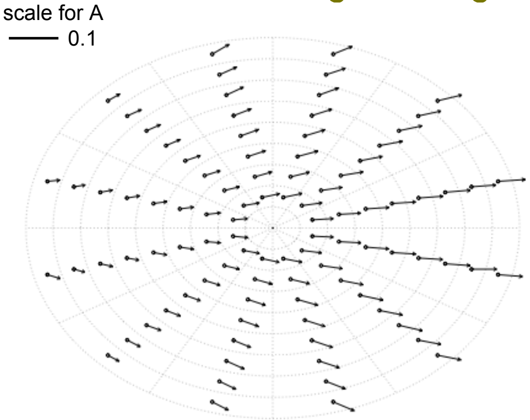
→ *the* ***divergence*** *of particles from the shower axis may be seen*

A may be computed on the full signal or on one slot of the FADC trace

Muon signal in the tanks

asymmetry on real data (36 < θ < 42 deg)

integrated signal



average asymmetry (shower direction) + *modulation* due to the ***divergence*** of particles from shower axis

Note: in the linear approximation, the average asymmetry gives a *self-calibration* of asymmetry vs angle