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Alliance for Astroparticle Physics



BERGISCHE UNIVERSITÄT WUPPERTAL

Experimental Status and Recent Results of the Pierre Auger Observatory

Tobias Winchen for the Pierre Auger Collaboration

DPG Frühjahrstagung 2015, Wuppertal



PIERRE AUGER OBSERVATORY

Cosmic Ray Energy Spectrum



Tobias Winchen for the Pierre Auger Collaboration

Extensive Air Showers



The Pierre Auger Observatory





Surface Detector 1660 Water Cherenkov stations 1.5 km spacing 3000 km² covered area

Fluorescence Detector 27 telescopes at 4 sites with 180° view

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Main Detector Components

Fluorescence detector

- Energy resolution^{*} < 6%</p>
- Angular resolution^{*} < 0.5°</p>
- 13% duty cycle: clear and moonless nights



Surface detector

- Energy resolution^{*} < 15%</p>
- Angular resolution^{*} <1°</p>
 - ~ 100 % duty cycle



* Showers with energy above 10 EeV and zenith angle below 60°

The End of the Cosmic Ray Energy Spectrum



The End of the Cosmic Ray Energy Spectrum



More on Energy Spectrum: T13.5

Composition



High Elevation Telescopes (HEAT)





X_{max}

Auger Muon and Infill for the Ground Array (AMIGA)



Infill

49 additional SD Stations in 750 m grid
Completed in Sept. 2011
→ Lower energy threshold

Muon Detectors

84 additional underground muon counters Under construction

→ Distinguish electromagnetic and muonic component

Auger Scintillator Upgrade



Composition information from Ratio of muon number / electron number

Can be measured with layered detector



$$\begin{pmatrix} S_{\rm top} \\ S_{\rm bot} \end{pmatrix} = \begin{pmatrix} a_{{\rm top},\gamma} & a_{{\rm top},\mu} \\ a_{{\rm bot},\gamma} & a_{{\rm top},\mu} \end{pmatrix} \begin{pmatrix} S_{\gamma} \\ S_{\mu} \end{pmatrix}$$

Auger Engineering Radio Array (AERA)





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Joint Analysis of Large Scale Anisotropy with the Telescope Array Collaboration

Aab et al., Astrophys.J. 794 (2014) 2, 172, arXiv: 1409.3128

Telescope Array

- Located in Utah
- Largest cosmic ray experiment on the northern hemisphere
- 38 Fluorescence telescopes
- 507 Surface detector stations
- Area 700 km²



Joint analysis of data above 10 EeV

Auger Data (Southern Hemisphere)

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First Full Sky Multipole Decomposition of UHECR Data



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Signatures of Deflection in Magnetic Fields

Stochastic deflection in turbulent magnetic fields

Spectrometer effect in coherent magnetic fields



Search for Patterns in the Arrival Directions

Aab et al., Submitted to EPJ C, arXiv:1410.0515





No evidence for structure in directions found

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More on Anisotropy T92.4, T92.6

Search for Point Sources of EeV Photons

The Astrophysical Journal, ApJ, 789, 160 (2014) arXiv:1406.2912

- Photons expected from acceleration processes
- Propagation distance limited by pair production to ~ Mpc
- Photon induced shower develop deeper in the atmosphere
- Combine 2 FD + 3 SD observables in multivariate analysis



Directional Limit on the EeV Photon Flux



No point sources found Photon flux every direction below 0.25 eV cm⁻² s⁻¹

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International Collaboration



- More than 480 scientists from more than 90 institutions in 19 countries
- German contributions from Aachen, Bonn, Hamburg, Karlsruhe, Siegen and Wuppertal
 - 28 contributions to this conference

Summary

 \rightarrow ...

- The Pierre Auger Observatory is the largest experiment to study cosmic rays with E > 10¹⁸ eV
- Low energy enhancements connect to other experiments and study possible transition from galactic to extragalactic UHECR
- Upgrade to measure composition at highest energies
- Selection of recent results
 - → Upper limit on multipole moments
 - No evidence for patterns expected from magnetic fields
 - \rightarrow Directional upper limit on photon flux

Constrain astrophysical models on UHECR origin and propagation

Additional topics on this conference: Particle physics at EeV energies, detector development, Cosmo Geophysics, ... T25.1, T25.2, T25.8, T26.1, T26.2, T26.6, T50.8, T51.8 Status and Recent Results of the Pierre Auger Observatory

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