PIERRE AUGER OBSERVATORY

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HEAT - a low energy enhancement of the Pierre Auger Observatory

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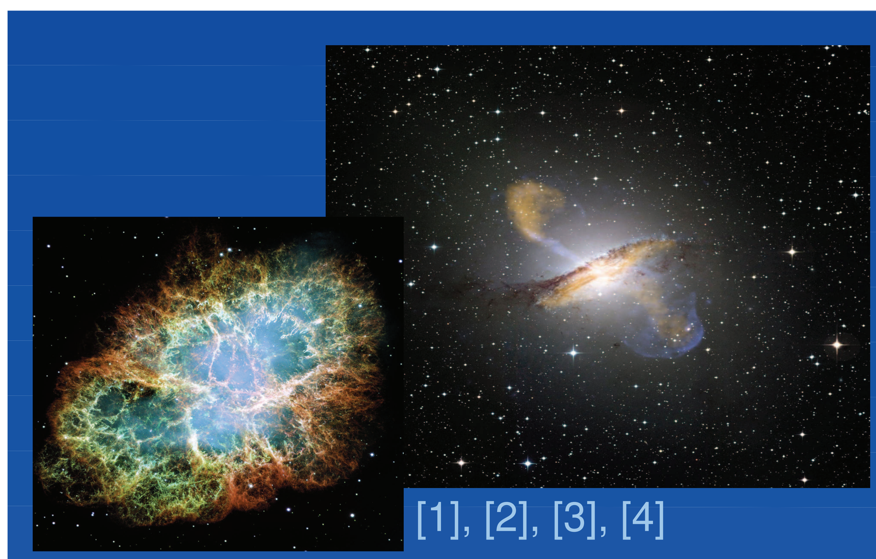


[1], [2], [3], [4]

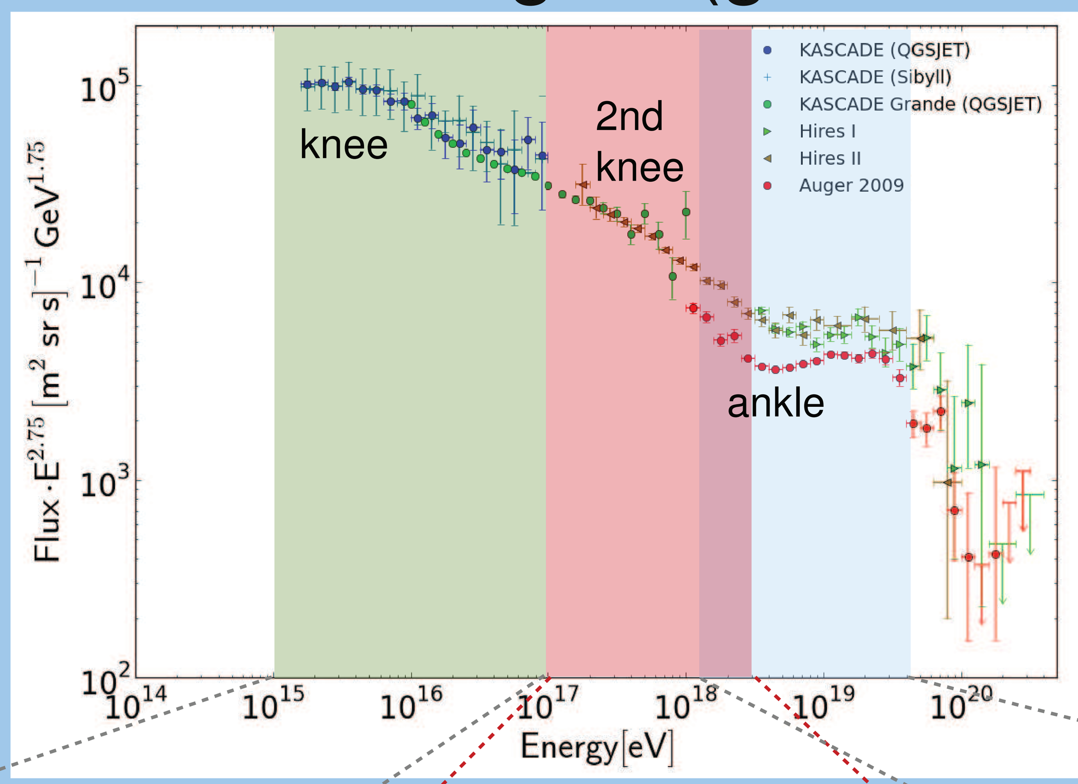
Exploring the nature of cosmic rays at the transition region (galactic/extragalactic)

Rich physics potential in energy range between 2nd knee and ankle

- Transition from galactic to extragalactic cosmic rays is expected to happen in this region
- Expect different type of cosmic ray sources and therefore also a change in composition
- Several independent measurements with different methods of composition determination desirable for this energy region

Methods to determine composition:

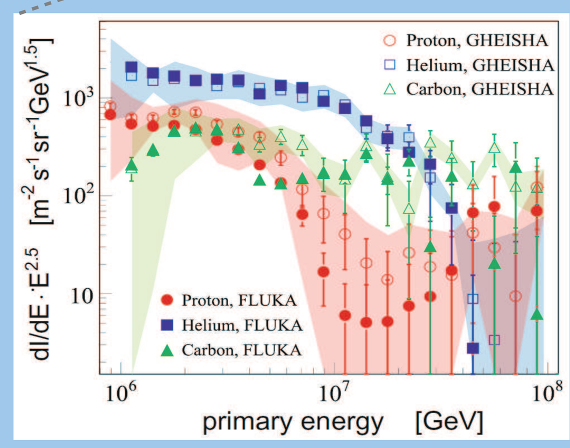
- Fluorescence detectors like Auger telescopes: X_{max} = atmospheric depth at which the longitudinal development of a shower reaches its maximum in terms of number of secondary particles
- Surface detector arrays with electron/muon separation like KASCADE: electron-muon number ratio



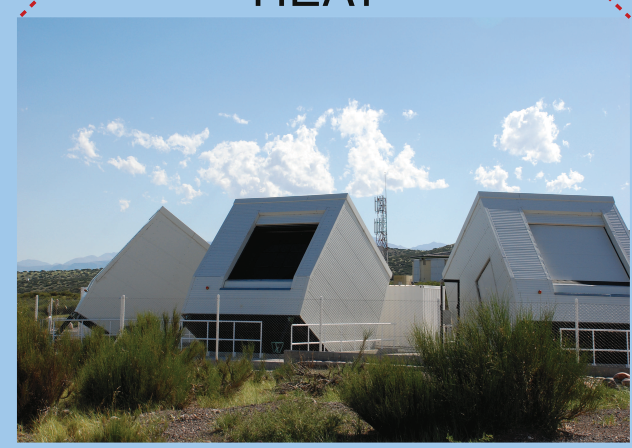
References of data in energy spectrum

KASCADE
T. Antoni et al., Astropart. Phys. 24 (2005) 1
KASCADE Grande
M. Bertaina, Proc. of 31th Int. Cosmic Ray Conf. 2009
Hires I, II
R.U. Abbasi et al., Phys. Rev. Lett. 100 (2008) 101101
Auger
F. Schüssler, Proc. of 31th Int. Cosmic Ray Conf. 2009

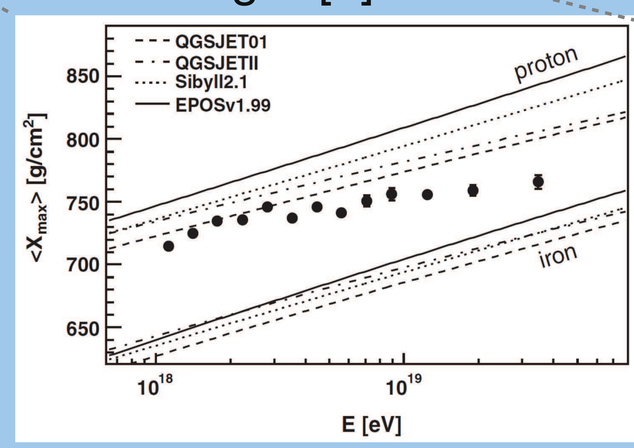
KASCADE [5]



HEAT



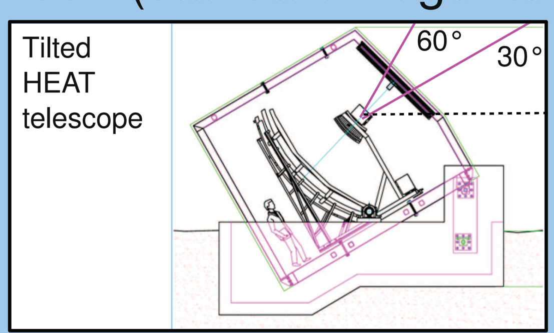
Auger [6]

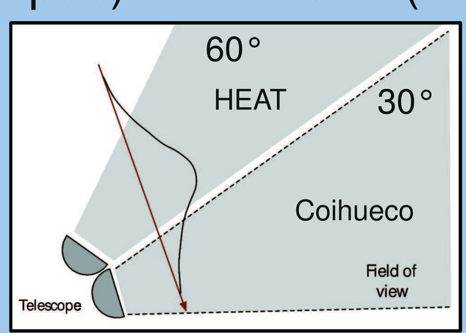


High Elevation Auger Telescopes

Auger low energy enhancement HEAT

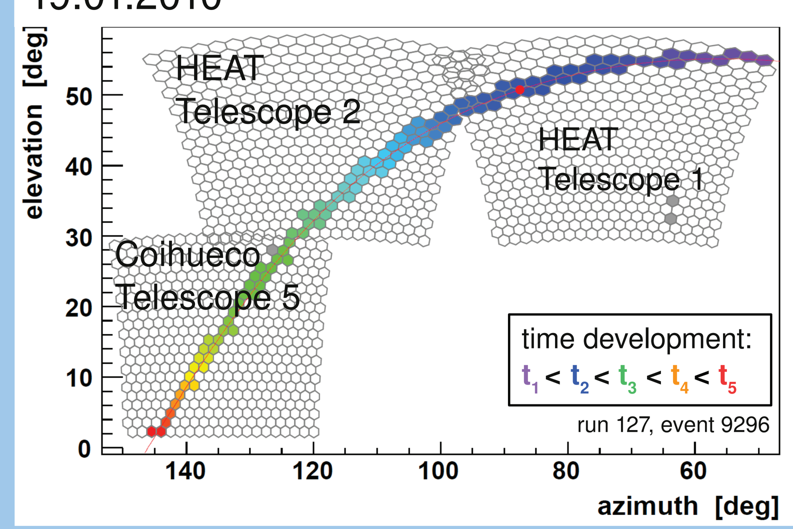
- Three additional tiltable fluorescence telescopes close to existing fluorescence telescopes (Coihueco)
- Lowering energy threshold of Auger by one order of magnitude down to 10^{17} eV by extending the field of view in elevation: 0°- 30° (standard Auger telescopes) + 30°- 60° (HEAT)



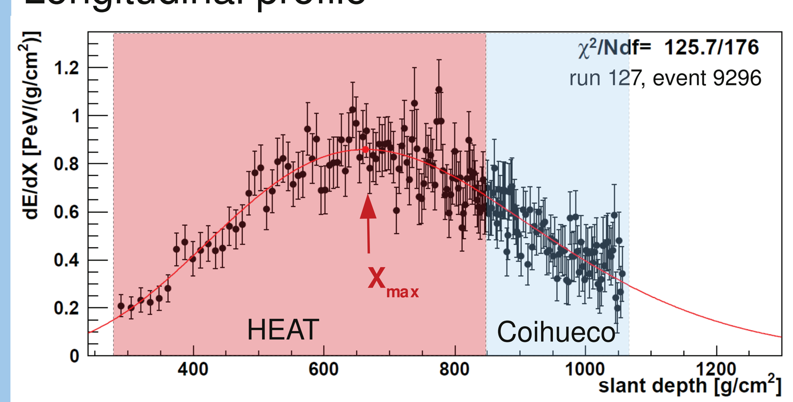


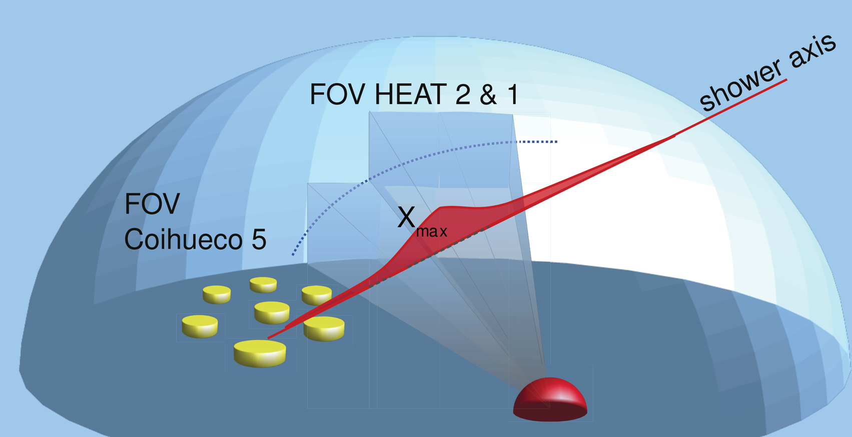
- Monitoring of camera position in optical aperture of telescope in tilted position to guarantee stability of camera position
- Upgraded electronics to handle increased trigger rates

Event seen in HEAT and Coihueco on 19.01.2010



Longitudinal profile



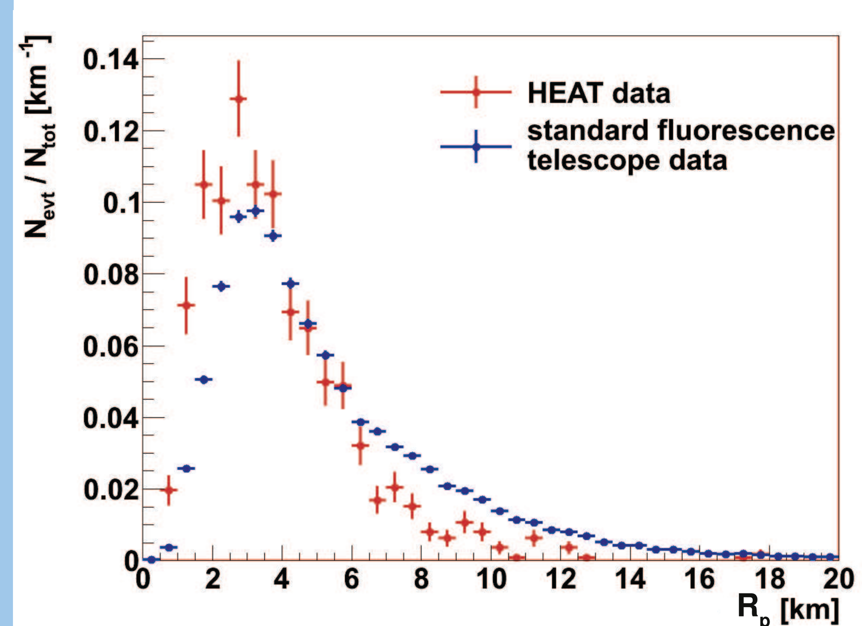


A shower is only used for physics analysis if the reconstructed shower maximum X_{max} is in the field of view of the fluorescence telescopes. Low energy showers emit less fluorescence light and therefore they can only be detected closer to the telescope.
→ This geometric bias is reduced by the additional field of view of HEAT at higher elevation.

HEAT data taking

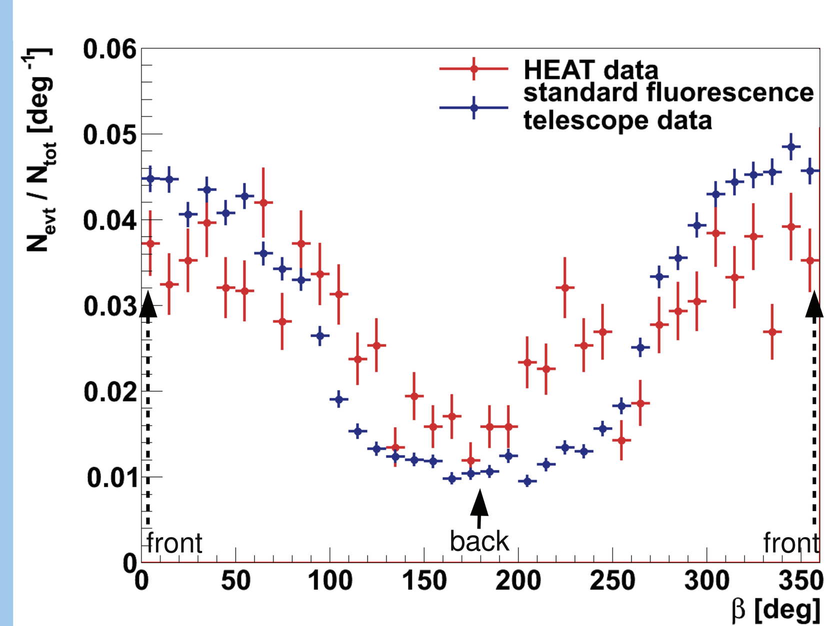
- Installation of HEAT finished in 2009
- Data taking since September 2009
- Duty cycle of HEAT: 15% (only in moonless nights)
  → same duty cycle as standard Auger telescopes
- HEAT trigger rate: ~1 trigger/min
  → 10 x higher than trigger rate of standard Auger telescopes, as assumed from steeply decreasing energy spectrum
- First physics results expected in 2011

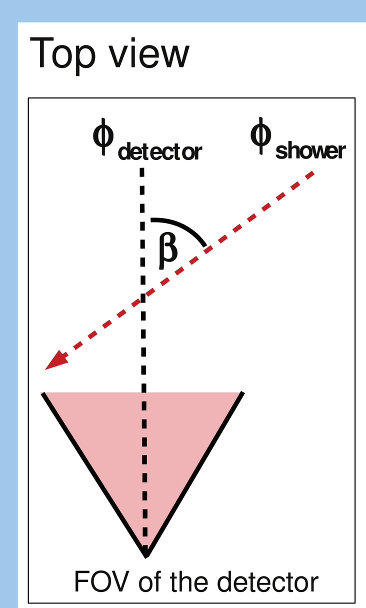
Observed minimum distance to shower axis



HEAT detects more showers closer to the detector and less at larger distance.

Observed angle $\beta = \phi_{shower} - \phi_{detector}$





HEAT is less dependent on whether a shower crosses its field of view from the front or back.

References

[1] NASA Hubble Space Telescopes Wide Field and Planetary Camera 2 (1999, 2000)
[2] X-ray: Chandra X-ray Observatory, NASA/CXC/CfA, R.Kraft et al.
[3] Submillimeter: MPIfR/ESO/Atacama Pathfinder Experiment (APEX) telescope, A.Weiss et al.
[4] Optical: Wide Field Imager on the Max-Planck/ESO 2.2 m telescope
[5] T. Antoni et al., Astropart. Phys. 24 (2005) 1
[6] The Pierre Auger Collaboration, Phys. Rev. Lett. 104 (2010) 091101

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