

Referências Bibliográficas

- [1] V.F. Hess, Uber Beobachtungen der durchdringenden Strahlung bei sieben Freiballonfahrten, *Physik. Zeitschr.* 13, 1084-1091 (1912). 1, 2
- [2] C. D. Anderson, The positive electron, *Phys. Rev.*, 43, 491-494 (1933). 1, 2
- [3] C. D. Anderson, The apparent existence of easily detectable positives, *Science*, 76, 238-239 (1932). 1, 2
- [4] C. M. G. Lattes, H. Muirhead, G. P. S. Occhialini, and C. F. Powell, Processes Involving Charged Mesons, *Nature*, 159, 694-697 (1947). 1, 2
- [5] J. Abraham et al., Properties and performance of the prototype instrument for the Pierre Auger Observatory, *Nucl. Instr. and Meth. A*, 523 50-95 (2004). 1, 2, 3
- [6] J. Abraham et al., Correlation of the highest energy cosmic rays with nearby extragalactic objects. *Science*, 318, 938-943 (2007). 1, 2.8, 2.3
- [7] J. D. Hague for the Pierre Auger Collaboration, Proc. of the 31th ICRC, Łódź, Poland (2009). 1, 2.8, 2.3
- [8] P. Abreu et al., Update on the correlation of the highest energy cosmic rays with nearby extragalactic matter. *Astropart. Phys.* 34, 314-326 (2010). 1, 2.8, 2.3
- [9] J. Abraham et al., Measurement of the Depth of Maximum of Extensive Air Showers above 10^{18} eV, *Phys. Rev. Lett.* 104, 091101 (2010). 1, 5, 5.1, 5.2
- [10] M. S. Longair. High Energy Astrophysics. Cambridge University Press. Volume 2. Second Edition (1994). 2, 2.2.1
- [11] P. Auger, P. Ehrenfest, R. Maze, J. Daudin, and R. A. Fréon. Extensive Cosmic-Ray Showers. *Review of Modern Physics*, 11, 288-291 (1939). 2
- [12] J. Linsley, Evidence for a Primary Cosmic-Ray Particle with Energy 10^{20} eV, *Phys. Rev. Lett.* 10, 146-148 (1963). 2

- [13] H. Ohoka et al., Further development of data acquisition system of the Akeno Giant Air Shower Array, *Nucl. Instr. and Meth. A*, 385, 268 (1997). 2
- [14] D. J. Bird et al., Evidence for correlated changes in the spectrum and composition of cosmic rays at extremely high energies. *Phys. Rev. Lett.* 71, 3401-3404 (1993). 2, 2.1
- [15] T. Abu-Zayyad et al., Measurement of the Cosmic-Ray Energy Spectrum and Composition from 10^{17} to $10^{18.3}$ eV using a Hybrid Technique. *The Astrophysical Journal*, 557, 686 (2001). 2, 3.1
- [16] C. Amsler et al. [Particle Data Group], *Phys. Lett. B* 667, 1 (2008). 2.1
- [17] J. Cronin, Cosmic rays: the most energetic particle in the universe, *Review of Modern Physics*, 71, 2 (1999). 2.1, 2.6
- [18] T. Antoni et al. KASCADE measurements of energy spectra for elemental groups of cosmic rays: Results and open problems, *Astropart. Phys.* 24, 1 (2005). 2.1
- [19] D. Allard, E. Parizot, and A. V. Olinto. On the transition from Galactic to extragalactic cosmic-rays: spectral and composition features from two opposite scenarios, *Astropart. Phys.* 27, 61-75 (2007). 2.1
- [20] Berezhinsky, V., Gazizov, A., Grigoreva, S. On astrophysical solution to ultrahigh energy cosmic rays. *Phys. Rev. D*, 74, 043005 (2006). 2.1
- [21] M. Nagano et al. Energy spectrum of primary cosmic rays above $10^{17.0}$ eV determined from extensive air shower experiments at Akeno. *J. Phys. G: Nucl. Part. Phys.* 18(2), 423-442 (1992). 2.1
- [22] W. D. Apel et al. Kneelike Structure in the Spectrum of the Heavy Component of Cosmic Rays Observed with KASCADE-Grande, *Phys. Rev. Lett.* 107, 171104 (2011). 2.1
- [23] K. Greisen, End to the Cosmic-Ray Spectrum?, *Phys. Rev. Lett.* 16, 748 (1966). 2.1.1
- [24] G. T. Zatsepin and V. A. Kuz'min, Upper Limit of the Spectrum of Cosmic Rays, *JETP Lett.* 4, 78 (1966). 2.1.1
- [25] D. Harari, S. Mollerach, E. Roulet, On the ultrahigh energy cosmic ray horizon. *J. Cosm. Astropart. Phys.* 11, 012 (2006). 2.1.1

- [26] The Pierre Auger Project Design Report, Auger Collaboration, November 1996. 2.1.1, 2.2
- [27] A. Letessier-Selvon, Theoretical and Experimental Topics on Ultra High Energy Cosmic Rays, XXVIII International Meeting on Fundamental Physics, Sanlucar de Barameda, Cadiz Spain, 14-18 February 2000. 2.1.1
- [28] J. Abraham et al. Observation of the Suppression of the Flux of Cosmic Rays above 4×10^{19} eV, *Phys. Rev. Lett.* 101, 061101 (2008). 2.1.1, 2.3, 3.2.3, 3.13
- [29] E. Fermi. On the Origin of the Cosmic Radiation. *Phys. Rev.* 75, 1169-1174 (1949). 2.2.1
- [30] T. Gaisser. Cosmic Rays and Particle Physics. Cambridge University Press (1990). 2.2.1, 2.2.1, 2.4, 2.2.1, 2.5
- [31] M. Nagano and A. A. Watson. Observations and implications of the ultrahigh-energy cosmic rays. *Review of Modern Physics*, 72(3), 689-732 (2000). 2.2.2, 2.2.2
- [32] A. M. Hillas. The Origin of Ultrahigh-Energy Cosmic Rays. *Ann. Rev. Astron. Astrophys.* 22, 425-444 (1984). 2.2.2
- [33] V. Berezhinsky, M. Kachelriess and A. Vilenkin, *Phys. Rev. Lett.* 79, 4302 (1997) [arXiv:astro-ph/9708217]. 2.2.2
- [34] P. Bhattacharjee and G. Sigl, *Phys. Rev. D* 51, 4079 (1995) 2.2.2
- [35] J. Abraham et al. Upper limit on the cosmic-ray photon fraction at EeV energies from the Pierre Auger Observatory, *Astropart. Phys.* 31, 399-406 (2009). 2.7, 2.2.2
- [36] J. Abraham et al. An upper limit to the photon fraction in cosmic rays above 10^{19} eV from the Pierre Auger Observatory, *Astropart. Phys.* 27, 155-168, (2007). 2.2.2
- [37] W. Heitler, The Quantum Theory of Radiation, third edition, Oxford University Press, London (1954).. 2.4.1, 2.4.4
- [38] J. Matheus, A Heitler model of extensive air showers, *Astropart. Phys.* 22, 387-397, (2004). 2.4.1, 2.4.2, 2.4.4, 2.10, 2.4.4
- [39] J. Abraham et al, The fluorescence detector of the Pierre Auger Observatory, *Nucl. Instr. and Meth. A*, 620, 277-251 (2010). 3.2, 3.1.1, 3.4, 3.1.1, 3.1.2, 3.5

- [40] R.M. Baltrusaitis et al., The Fly's Eye detector: Present and future, *Nucl. Instr. and Meth. A*, 240, 410 (1985). 3.1
- [41] Patrick Younk, Brian Fick, On SDP Reconstruction Accuracy. Internal Note of the Pierre Auger Collaboration, GAP-2006-086. 3.1.1
- [42] M. Straub, Mass composition studies with the low energy extension HEAT at the Pierre Auger Observatory. Internal Note of the Pierre Auger Collaboration, GAP-2012-016. 3.1.1, 3.15
- [43] T. K. Gaisser and A. M. Hillas, Proc. of the 15th ICRC, 8, 353, Plovdiv, Bulgaria (1977). 3.1.2, 5.1
- [44] X. Bertou et al., Calibration of the surface array of the Pierre Auger Observatory, *Nucl. Instr. and Meth. A*, 568, 839 (2006). 3.2
- [45] I. Allekotte et al., The Surface Detector System of the Pierre Auger Observatory, *Nucl. Instr. and Meth. A*, 586, 409 (2008).3.2
- [46] R. Vasquez, Event Reconstruction in Pierre Auger Observatory. Trasgo Meeting (2008). 3.6
- [47] J. Abraham et al., Trigger and aperture of the surface detector array of the Pierre Auger Observatory, *Nucl. Instr. and Meth. A*, 613, 29-39 (2010). 3.2, 3.7, 1, 3.8, 3.9, 3.2.2
- [48] K. Caballero, Composition studies of Ultra High Energy Cosmic Rays using Data of the Pierre Auger Observatory. Internal Note of the Pierre Auger Collaboration, GAP-2010-037. 3.10, 3.11, 3.2.3
- [49] C. Bonifazi, A. Letessier-Selvon and E. M. Santos, A model for the time uncertainty measurements in the Auger surface detector array, *Astropart. Phys.* 28, 523 (2008). 3.2.3, 4.3.1, 4.4, 5.2.3
- [50] D. Veberic and M. Roth, SD Reconstruction, Offline Reference Manual. Internal Note of the Pierre Auger Collaboration, GAP-2005-035. 3.2.3
- [51] P. Billoir, Reconstruction of first year EA events from the Surface Detector. Internal Note of the Pierre Auger Collaboration, GAP-2002-040. 3.2.3, 3.2.3
- [52] T. Schmidt, Measurement of the Flux of Ultra High Energy Cosmic Rays using very inclined Extensive Air Showers measured at the Pierre Auger Observatory. Internal Note of the Pierre Auger Collaboration, GAP-1010-046. 3.2.3

- [53] CDAS software group, Event reconstruction, release v4r8. 3.12, 3.2.3, 3.2.3, 3.2.3, 4.3
- [54] P. Bauleo, A. Castellina, R. Knapik, Auger Surface Detector Signal Accuracy from Production Tanks. Internal Note of the Pierre Auger Collaboration, GAP2004-047. 3.2.3, 4.1, 4.3, 4.3
- [55] D. Barnhill for the Pierre Auger Collaboration, Proc. 29th Int. Cosmic Ray Conf., Pune, India (2005). 3.2.3
- [56] Talianna Schmidt, Ioana C. Maris, Markus Roth, Fine Tuning of the LDF parameterisation and the Influence on S1000. Internal Note of the Pierre Auger Collaboration, GAP2007-106. 3.2.3, 4.2
- [57] M. Roth for the Pierre Auger Collaboration, Proc. 28th Int. Cosmic Ray Conf., Tsukuba, Japan (2003). 3.2.3
- [58] K. Kamata and J. Nishimura, *Prog. Theoret. Phys. Suppl.* 6, 93 (1958). 3.2.3
- [59] K. Greisen, *Progress in Cosmic Ray Physics*, volume 3, North-Holland, Amsterdam (1956). 3.2.3
- [60] P. Billoir, P. da Silva, Towards a Parametrization of the Lateral Distribution Function and its Asymmetries in the Surface Detector. Internal Note of the Pierre Auger Collaboration, GAP-2002-073. 3.2.3
- [61] M. Roth for the Pierre Auger Collaboration, Proc. 30th Int. Cosmic Ray Conf. Merida, Mexico (2007). 3.2.3, 3.2.3
- [62] N. Accialini, A. Almela, D. Alonso, F. Barabás, P. Buchholz, U. Fröhlich, Y. Kolotaev, M. Niechciol, M. Pontz, A. Cancio, R. Caruso, F. Contreras, G. De Innocenti, G. De La Vega, L. Del Peral, A. Etchegoyen, P. Fitzelew, A. Fuster, F. Gallo, R. Gamarra, B. AMIGA Status Report. Internal Note of the Pierre Auger Collaboration, GAP-2011-120. 3.3
- [63] M. Díaz Castro, R. Shellard, C. Bonifazi, E. M. Santos, Accessing shower to shower fluctuations with the LDF slope parameter. Internal Note of the Pierre Auger Collaboration, GAP-2012-031. 4
- [64] C. Fracchiolla, C. Bonifazi, A. Letessier-Selvon, O. Blanch, Angular resolution with the Super-Hexagon. Internal Note of the Pierre Auger Collaboration, GAP-2008-095. 4.3.2, 5.2.3

- [65] T. Bergmann et al., One-dimensional hybrid approach to extensive air shower simulation. *Astropart. Phys.* 26, 420 (2007). 5, 5.2
- [66] N. N. Kalmykov and S. S. Ostapchenko, *Phys. At. Nucl.* 56, 346 (1993). 5, 5.2
- [67] S. S. Ostapchenko, *Nucl. Phys. B, Proc. Suppl.* 151, 143 (2006). 5, 5.2
- [68] T. Pierog and K. Werner, *Phys. Rev. Lett.* 101, 171101 (2008). 5, 5.2
- [69] E. J. Ahn et al., *Phys. Rev. D* 80, 094003 (2009). 5, 5.2
- [70] <http://root.cern.ch/drupal/> 5.2.1
- [71] K. Nakamura et al. [Particle Data Group], *J. Phys. G* 37, 075021 (2010). 5.2.1, 5.2.3
- [72] D. Allard, M. Ave, N. Busca, A. Chou, C. Newman-Holmes, P. Priviteru, G. Rodriguez, A. Watson, T. Yamamoto, E. Zas. A guide-line to the Auger-Surface-Detector Analysis. Internal Note of the Pierre Auger Collaboration GAP-2006-024. A.2

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Apêndice

A.1

Estações Silenciosas

Uma estação define-se como silenciosa quando ela está ativa ao acontecer o evento (em funcionamento), porém, não atinge o valor mínimo para chegar ao nível básico de disparo T1.

A.2

Estações Saturadas

Chuveiros muito energéticos depositam uma quantidade grande de energia nos detectores perto do ponto de impacto. Assim, às energias mais alevadas, a eletrônica e as PMTs dos detectores podem ficar saturados, levando a que o sinal coletado pela estação seja menor que o sinal real.

A saturação acontece para sinais maiores à aproximadamente 800 VEM. As estações saturadas podem levar como efeito colateral uma determinação errado do parâmetro S1000, e consequentemente da energia. No entanto, os sinais reais destas estações podem ser recuperados em alguns casos [72].