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Study of muons from high energy cosmic ray air showers measured with the Tibet hybrid experiment (YAC-II + Tibet-III + MD)

J.Huang[a,*] **for the Tibet ASγ collaboration**

[a] *Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China*

E-mail: huangjing@ihep.ac.cn

The interpretation of the EAS data relies on the employment of hadronic interaction models, which are subject to theoretical and experimental uncertainties that may hamper composition studies of cosmic rays. To check the reliability of such models at the energies relevant for EAS studies, the study of the number of muons becomes extremely useful, since they are sensitive to the hadronic interactions that occur in the early phases of the EAS development. In the paper, we check the number of muons in hadronic interaction models with the hybrid experiment (YAC-II + Tibet-III + MD). For an air-shower event, the Tibet air-shower array (Tibet-III) provides the arrival direction and the air-shower size which are interrelated to primary energy, the Yangbajing Air shower Core detector (YAC-II) array measures the high energy electromagnetic particles in the very forward region so as to obtain the characteristic parameters of air-shower cores, at the same time, the underground MDs record the number of high energy muons above 1 GeV. Since we can select proton events with high accuracy by YAC-II almost independent on the hadronic interaction models, the accompanying number of muons induced by proton events can be fed out. With the unique advantages of YAC-II array, our results show that the description of muon numbers in different hadronic interaction models can be well checked to avoid the ambiguity of the primary cosmic-ray mass composition around the knee energy region by the Tibet hybrid experiment (YAC-II + Tibet-III + MD).

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Full Authors List: the Tibet ASγ Collaboration

M. Amenomori[1], Y. W. Bao[2], X. J. Bi[3], D. Chen[4], T. L. Chen[5], W. Y. Chen[3], Xu Chen[4], Y. Chen[2], Cirennima[5], S. W. Cui[6], Danzengluobu[5], L. K. Ding[3], J. H. Fang[3,7], K. Fang[3], C. F. Feng[8], Zhaoyang Feng[3], Z. Y. Feng[9], Qi Gao[5], Q. B. Gou[3], Y. Q. Guo[3], Y. Y. Guo[3], Y. Hayashi[10], H. H. He[3], Z. T. He[6], K. Hibino[11], N. Hotta[12], Haibing Hu[5], H. B. Hu[3], K. Y. Hu[3,7], J. Huang[3], H. Y. Jia[9], L. Jiang[3], P. Jiang[4], H. B. Jin[4], K. Kasahara[13], Y. Katayose[14], C. Kato[10], S. Kato[15], I. Kawahara[14], T. Kawashima[15], K. Kawata[15], M. Kozai[16], Labaciren[5], G. M. Le[17], A. F. Li[3,9,18], H. J. Li[5], W. J. Li[3,10], Y. Li[4], Y. H. Lin[3,7], B. Liu[19], C. Liu[3], J. S. Liu[3], L. Y. Liu[4], M. Y. Liu[5], W. Liu[3], H. Lu[3], T. Makishima[14], Y. Masuda[10], S. Matsuhashi[14], M. Matsumoto[10], X. R. Meng[5], Y. Meng[3,7], A. Mizuno[15], K. Munakata[10], Y. Nakamura[15], H. Nanjo[1], C. C. Ning[5], M. Nishizawa[20], R. Noguchi[14], M. Ohnishi[15], S. Okukawa[14], S. Ozawa[21], X. Qian[4], X. L. Qian[22], X. B. Qu[23], T. Saito[24], M. Sakata[25], T. Sako[15], T. K. Sako[15], T. Sasaki[11], J. Shao[3,9], T. Shibasaki[26], M. Shibata[14], A. Shiomi[26], H. Sugimoto[27], W. Takano[11], M. Takita[15], Y. H. Tan[3], N. Tateyama[11], S. Torii[28], H. Tsuchiya[29], S. Udo[11], R. Usui[14], H. Wang[3], S. F. Wang[5], Y. P. Wang[5], Wangdui[5], H. R. Wu[3], Q. Wu[5], J. L. Xu[4], L. Xue[8], Z. Yang[3], Y. Q. Yao[4], J. Yin[4], Y. Yokoe[15], Y. L. Yu[3,7], A. F. Yuan[5], L. M. Zhai[4], H. M. Zhang[3], J. L. Zhang[3], X. Zhang[2], X. Y. Zhang[8], Y. Zhang[3], Yi Zhang[30], Ying Zhang[3], S. P. Zhao[3], Zhaxisangzhu[5], X. X. Zhou[9] and Y. H. Zou[3,7]

[1]Department of Physics, Hirosaki University, Hirosaki 036-8561, Japan.
[2]School of Astronomy and Space Science, Nanjing University, Nanjing 210093, China.
[3]Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China.
[4]National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China.
[5]Department of Mathematics and Physics, Tibet University, Lhasa 850000, China.
[6]Department of Physics, Hebei Normal University, Shijiazhuang 050016, China.
[7]University of Chinese Academy of Sciences, Beijing 100049, China.
[8]Institute of Frontier and Interdisciplinary Science and Key Laboratory of Particle Physics and Particle Irradiation (MOE), Shandong University, Qingdao 266237, China.
[9]Institute of Modern Physics, SouthWest Jiaotong University, Chengdu 610031, China.
[10]Department of Physics, Shinshu University, Matsumoto 390-8621, Japan.
[11]Faculty of Engineering, Kanagawa University, Yokohama 221-8686, Japan.
[12]Faculty of Education, Utsunomiya University, Utsunomiya 321-8505, Japan.
[13]Faculty of Systems Engineering, Shibaura Institute of Technology, Omiya 330-8570, Japan.
[14]Faculty of Engineering, Yokohama National University, Yokohama 240-8501, Japan.
[15]Institute for Cosmic Ray Research, University of Tokyo, Kashiwa 277-8582, Japan.
[16]Polar Environment Data Science Center, Joint Support-Center for Data Science Research, Research Organization of Information and Systems, Tachikawa 190-0014, Japan.
[17]National Center for Space Weather, China Meteorological Administration, Beijing 100081, China.
[18]School of Information Science and Engineering, Shandong Agriculture University, Taian 271018, China.
[19]Department of Astronomy, School of Physical Sciences, University of Science and Technology of China, Hefei 230026, China.
[20]National Institute of Informatics, Tokyo 101-8430, Japan.
[21]National Institute of Information and Communications Technology, Tokyo 184-8795, Japan.
[22]Department of Mechanical and Electrical Engineering, Shangdong Management University, Jinan 250357, China.
[23]College of Science, China University of Petroleum, Qingdao 266555, China.
[24]Tokyo Metropolitan College of Industrial Technology, Tokyo 116-8523, Japan.
[25]Department of Physics, Konan University, Kobe 658-8501, Japan.
[26]College of Industrial Technology, Nihon University, Narashino 275-8575, Japan.
[27]Shonan Institute of Technology, Fujisawa 251-8511, Japan.
[28]Research Institute for Science and Engineering, Waseda University, Tokyo 162-0044, Japan.
[29]Japan Atomic Energy Agency, Tokai-mura 319-1195, Japan.
[30]Key Laboratory of Dark Matter and Space Astronomy, Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210034, China.

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