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Cosmic ray composition and energy spectrum from 1–30 PeV using the 40-string configuration of IceTop and IceCube

R. Abbasi[ab], Y. Abdou[w], M. Ackermann[ap], J. Adams[p], J.A. Aguilar[v], M. Ahlers[ab], D. Altmann[i], K. Andeen[ab,1], J. Auffenberg[ab], X. Bai[af,2], M. Baker[ab], S.W. Barwick[x], V. Baum[ac], R. Bay[g], K. Beattie[h], J.J. Beatty[r,s], S. Bechet[m], J.K. Becker[j], K.-H. Becker[ao], M. Bell[am], M.L. Benabderrahmane[ap], S. BenZvi[ab], J. Berdermann[ap], P. Berghaus[ap], D. Berley[q], E. Bernardini[ap], D. Bertrand[m], D.Z. Besson[z], D. Bindig[ao], M. Bissok[a], E. Blaufuss[q], J. Blumenthal[a], D.J. Boersma[a], C. Bohm[ai], D. Bose[n], S. Böser[k], O. Botner[an], L. Brayeur[n], A.M. Brown[p], R. Bruijn[y], J. Brunner[ap], S. Buitink[n], K.S. Caballero-Mora[am], M. Carson[w], J. Casey[e], M. Casier[n], D. Chirkin[ab], B. Christy[q], F. Clevermann[t], S. Cohen[y], D.F. Cowen[am,al], A.H. Cruz Silva[ap], M. Danninger[ai], J. Daughhetee[e], J.C. Davis[r], C. De Clercq[n], F. Descamps[w], P. Desiati[ab], G. de Vries-Uiterweerd[w], T. DeYoung[am], J.C. Díaz-Vélez[ab], J. Dreyer[j], J.P. Dumm[ab], M. Dunkman[am], R. Eagan[am], J. Eisch[ab], R.W. Ellsworth[q], O. Engdegård[an], S. Euler[a], P.A. Evenson[af], O. Fadiran[ab], A.R. Fazely[f], A. Fedynitch[j], J. Feintzeig[ab], T. Feusels[w], K. Filimonov[g], C. Finley[ai], T. Fischer-Wasels[ao], S. Flis[ai], A. Franckowiak[k], R. Franke[ap], K. Frantzen[t], T. Fuchs[t], T.K. Gaisser[af], J. Gallagher[aa], L. Gerhardt[h,g], L. Gladstone[ab], T. Glüsenkamp[ap], A. Goldschmidt[h], J.A. Goodman[q], D. Góra[ap], D. Grant[u], A. Groß[ae], S. Grullon[ab], M. Gurtner[ao], C. Ha[h,g], A. Haj Ismail[w], A. Hallgren[an], F. Halzen[ab], K. Hanson[m], D. Heereman[m], P. Heimann[a], D. Heinen[a], K. Helbing[ao], R. Hellauer[q], S. Hickford[p], G.C. Hill[b], K.D. Hoffman[q], R. Hoffmann[ao], A. Homeier[k], K. Hoshina[ab], W. Huelsnitz[q,3], P.O. Hulth[ai], K. Hultqvist[ai], S. Hussain[af], A. Ishihara[o], E. Jacobi[ap], J. Jacobsen[ab], G.S. Japaridze[d], O. Jlelati[w], H. Johansson[ai], A. Kappes[i], T. Karg[ao], A. Karle[ab], J. Kiryluk[aj], F. Kislat[ap], J. Kläs[ao], S.R. Klein[h,g], J.-H. Köhne[t], G. Kohnen[ad], H. Kolanoski[i], L. Köpke[ac], C. Kopper[ab], S. Kopper[ao], D.J. Koskinen[am], M. Kowalski[k], M. Krasberg[ab], G. Kroll[ac], J. Kunnen[n], N. Kurahashi[ab], T. Kuwabara[af], M. Labare[n], K. Laihem[a], H. Landsman[ab], M.J. Larson[am], R. Lauer[ap], M. Lesiak-Bzdak[aj], J. Lünemann[ac], J. Madsen[ah], R. Maruyama[ab], K. Mase[o], H.S. Matis[h], F. McNally[ab], K. Meagher[q], M. Merck[ab], P. Mészáros[al,am], T. Meures[m], S. Miarecki[h,g], E. Middell[ap], N. Milke[t], J. Miller[n], L. Mohrmann[ap], T. Montaruli[v,4], R. Morse[ab], S.M. Movit[al], R. Nahnhauer[ap], U. Naumann[ao], S.C. Nowicki[u], D.R. Nygren[h], A. Obertacke[ao], S. Odrowski[ae], A. Olivas[q], M. Olivo[j], A. O'Murchadha[ab], S. Panknin[k], L. Paul[a], J.A. Pepper[ak], C. Pérez de los Heros[an], D. Pieloth[t], N. Pirk[ap], J. Posselt[ao], P.B. Price[g], G.T. Przybylski[h], L. Rädel[a], K. Rawlins[c,*], P. Redl[q], E. Resconi[ae], W. Rhode[t], M. Ribordy[y], M. Richman[q], B. Riedel[ab], J.P. Rodrigues[ab], F. Rothmaier[ac], C. Rott[r], T. Ruhe[t], D. Rutledge[am], B. Ruzybayev[af], D. Ryckbosch[w], T. Salameh[am], H.-G. Sander[ac], M. Santander[ab], S. Sarkar[ag], S.M. Saba[j], K. Schatto[ac], M. Scheel[a], F. Scheriau[t], T. Schmidt[q], M. Schmitz[t], S. Schoenen[a], S. Schöneberg[j], L. Schönherr[a], A. Schönwald[ap], A. Schukraft[a], L. Schulte[k], O. Schulz[ae], D. Seckel[af], S.H. Seo[ai], Y. Sestayo[ae], S. Seunarine[l], M.W.E. Smith[am], M. Soiron[a], D. Soldin[ao], G.M. Spiczak[ah], C. Spiering[ap], M. Stamatikos[r,5], T. Stanev[af], A. Stasik[k], T. Stezelberger[h], R.G. Stokstad[h], A. Stößl[ap], E.A. Strahler[n], R. Ström[an], G.W. Sullivan[q], H. Taavola[an], I. Taboada[e], A. Tamburro[af], S. Ter-Antonyan[f], S. Tilav[af], P.A. Toale[ak], S. Toscano[ab], M. Usner[k], N. van Eijndhoven[n], D. van der Drift[g,h], A. Van Overloop[w], J. van Santen[ab], M. Vehring[a], M. Voge[k], C. Walck[ai], T. Waldenmaier[i], M. Wallraff[a], M. Walter[ap], R. Wasserman[am], Ch. Weaver[ab], C. Wendt[ab], S. Westerhoff[ab], N. Whitehorn[ab], K. Wiebe[ac], C.H. Wiebusch[a], D.R. Williams[ak], H. Wissing[q], M. Wolf[ai], T.R. Wood[u], K. Woschnagg[g], C. Xu[af], D.L. Xu[ak], X.W. Xu[f], J.P. Yanez[ap], G. Yodh[x], S. Yoshida[o], P. Zarzhitsky[ak], J. Ziemann[t], A. Zilles[a], M. Zoll[ai], The IceCube Collaboration

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[a] III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany
[b] School of Chemistry & Physics, University of Adelaide, Adelaide SA 5005, Australia
[c] Dept. of Physics and Astronomy, University of Alaska Anchorage, 3211 Providence Dr., Anchorage, AK 99508, USA
[d] CTSPS, Clark-Atlanta University, Atlanta, GA 30314, USA
[e] School of Physics and Center for Relativistic Astrophysics, Georgia Institute of Technology, Atlanta, GA 30332, USA
[f] Dept. of Physics, Southern University, Baton Rouge, LA 70813, USA
[g] Dept. of Physics, University of California, Berkeley, CA 94720, USA
[h] Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA
[i] Institut für Physik, Humboldt-Universität zu Berlin, D-12489 Berlin, Germany
[j] Fakultät für Physik & Astronomie, Ruhr-Universität Bochum, D-44780 Bochum, Germany
[k] Physikalisches Institut, Universität Bonn, Nussallee 12, D-53115 Bonn, Germany
[l] Dept. of Physics, University of the West Indies, Cave Hill Campus, Bridgetown BB11000, Barbados
[m] Université Libre de Bruxelles, Science Faculty CP230, B-1050 Brussels, Belgium
[n] Vrije Universiteit Brussel, Dienst ELEM, B-1050 Brussels, Belgium
[o] Dept. of Physics, Chiba University, Chiba 263-8522, Japan
[p] Dept. of Physics and Astronomy, University of Canterbury, Private Bag 4800, Christchurch, New Zealand
[q] Dept. of Physics, University of Maryland, College Park, MD 20742, USA
[r] Dept. of Physics and Center for Cosmology and Astro-Particle Physics, Ohio State University, Columbus, OH 43210, USA
[s] Dept. of Astronomy, Ohio State University, Columbus, OH 43210, USA
[t] Dept. of Physics, TU Dortmund University, D-44221 Dortmund, Germany
[u] Dept. of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2G7
[v] Département de physique nucléaire et corpusculaire, Université de Genève, CH-1211 Genève, Switzerland
[w] Dept. of Physics and Astronomy, University of Gent, B-9000 Gent, Belgium
[x] Dept. of Physics and Astronomy, University of California, Irvine, CA 92697, USA
[y] Laboratory for High Energy Physics, École Polytechnique Fédérale, CH-1015 Lausanne, Switzerland
[z] Dept. of Physics and Astronomy, University of Kansas, Lawrence, KS 66045, USA
[aa] Dept. of Astronomy, University of Wisconsin, Madison, WI 53706, USA
[ab] Dept. of Physics, University of Wisconsin, Madison, WI 53706, USA
[ac] Institute of Physics, University of Mainz, Staudinger Weg 7, D-55099 Mainz, Germany
[ad] Université de Mons, 7000 Mons, Belgium
[ae] T.U. Munich, D-85748 Garching, Germany
[af] Bartol Research Institute and Department of Physics and Astronomy, University of Delaware, Newark, DE 19716, USA
[ag] Dept. of Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, UK
[ah] Dept. of Physics, University of Wisconsin, River Falls, WI 54022, USA
[ai] Oskar Klein Centre and Dept. of Physics, Stockholm University, SE-10691 Stockholm, Sweden
[aj] Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794-3800, USA
[ak] Dept. of Physics and Astronomy, University of Alabama, Tuscaloosa, AL 35487, USA
[al] Dept. of Astronomy and Astrophysics, Pennsylvania State University, University Park, PA 16802, USA
[am] Dept. of Physics, Pennsylvania State University, University Park, PA 16802, USA
[an] Dept. of Physics and Astronomy, Uppsala University, Box 516, S-75120 Uppsala, Sweden
[ao] Dept. of Physics, University of Wuppertal, D-42119 Wuppertal, Germany
[ap] DESY, D-15735 Zeuthen, Germany

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ABSTRACT

The mass composition of high energy cosmic rays depends on their production, acceleration, and propagation. The study of cosmic ray composition can therefore reveal hints of the origin of these particles. At the South Pole, the IceCube Neutrino Observatory is capable of measuring two components of cosmic ray air showers in coincidence: the electromagnetic component at high altitude (2835 m) using the IceTop surface array, and the muonic component above ~1 TeV using the IceCube array. This unique detector arrangement provides an opportunity for precision measurements of the cosmic ray energy spectrum and composition in the region of the knee and beyond. We present the results of a neural network analysis technique to study the cosmic ray composition and the energy spectrum from 1 PeV to 30 PeV using data recorded using the 40-string/40-station configuration of the IceCube Neutrino Observatory.

1. Introduction

The flux of cosmic rays at Earth is known to follow a steep power-law spectrum over a large energy range. The index of this spectrum is approximately constant at energies lower than about 3 PeV, where the spectrum steepens in a feature known as the "knee". A further kink in the spectrum, known as the "ankle", occurs around 1 EeV where the spectrum becomes flatter again. The origins of these spectral changes are still uncertain. Currently, the most popular model predicts cosmic ray acceleration in shock fronts via the first order Fermi mechanism [1]. More specifically, at energies up to $\sim 10^{17}$ eV, the source of this acceleration mechanism is often attributed to supernova remnants; a cut-off energy which depends upon nuclear charge (Z) of the particle accelerated at the source could be responsible for a mass-dependent knee; the ankle is then attributed to cosmic rays from extragalactic sources such as gamma-ray bursts or active galactic nuclei [2–4].

* Corresponding author.
E-mail address: karen.andeen@cern.ch (K. Andeen).
[1] Karlsruher Institut für Technologie, Institut für Experimentelle Kernphysik, D-76131 Karlsruhe, Germany
[2] Physics Department, South Dakota School of Mines and Technology, Rapid City, SD 57701, USA.
[3] Los Alamos National Laboratory, Los Alamos, NM 87545, USA.
[4] Also Sezione INFN, Dipartimento di Fisica, I-70126 Bari, Italy.
[5] NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA.