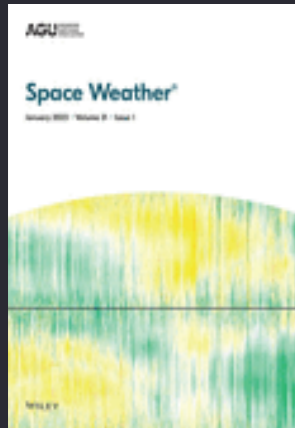




Details

Space Weather
Volume 21, Issue 1

Jan 2023

ARTICLE

The First Ground-Level Enhancement of Solar Cycle 25 as Seen by the High-Energy Particle Detector (HEPD-01) on Board the CSES-01 Satellite

[View article page](#)Matteo Martucci, Monica Laurenza, Simone Benella, Francesco Berrilli, Dario Moro, Luca C... [See all authors](#)

CITE



Check for updates

© 2022. The Authors.

<https://doi.org/10.1029/2022SW003191>Space Weather^{*}

RESEARCH ARTICLE

10.1029/2022SW003191

Key Points:

- High-Energy Particle Detector (HEPD-01) measurements of solar protons (50–250 MeV) emitted during the first ground-level enhancement of solar cycle 25
- Spectral analysis conducted on an energy-extended, time-integrated proton spectrum using also ACE, ERNE, and EPHIN data
- Time-of-arrival analysis in good agreement with the literature and highlights the central role of HEPD-01 at energies around hundreds of MeV

Correspondence to:

M. Martucci,
matteo.martucci@roma2.infn.it

Citation:

Martucci, M., Laurenza, M., Benella, S., Berrilli, F., Del Moro, D., Giovannelli, L., et al. (2023). The first ground-level enhancement of solar cycle 25 as seen by the High-Energy Particle Detector (HEPD-01) on board the CSES-01 satellite. *Space Weather*, 21, e2022SW003191. <https://doi.org/10.1029/2022SW003191>

Received 13 JUN 2022

Accepted 6 OCT 2022

Author Contributions:

Data curation: Simona Bartocci
Funding acquisition: Roberto Battiston, Donatella Campana, Piergiorgio Picozza, Marco Ricci, Roberta Sparvoli
Investigation: Matteo Martucci, Monica Laurenza, Simone Benella, Francesco Berrilli, Dario Del Moro, Luca Giovannelli, Alexandra Parmentier, Mirko Piersanti
Project Administration: Cristian De Santis, Piergiorgio Picozza, Roberta Sparvoli
Resources: Andrea Contini, Matteo Mergé, Giuseppe Osteria, Francesco Perfetto, Sergio Bruno Ricciarini
Software: Simona Bartocci, William J. Burger, Luca Carfagna, Andrea Contini,



The First Ground-Level Enhancement of Solar Cycle 25 as Seen by the High-Energy Particle Detector (HEPD-01) on Board the CSES-01 Satellite

Matteo Martucci^{1,2}, Monica Laurenza³, Simone Benella³, Francesco Berrilli², Dario Del Moro², Luca Giovannelli², Alexandra Parmentier^{1,2}, Mirko Piersanti⁴, Gabor Albrecht^{5,6}, Simona Bartocci¹, Roberto Battiston^{5,6}, William J. Burger^{6,7}, Donatella Campana⁸, Luca Carfagna^{1,2}, Giuseppe Consolini¹, Livio Conti^{1,9}, Andrea Contini^{10,11}, Cinzia De Donato¹, Cristian De Santis¹, Francesco Maria Follega^{5,6}, Roberto Iuppa^{5,6}, Alessandro Lega^{5,6}, Nadir Marcelli^{1,2}, Giuseppe Masciantonio¹, Matteo Mergé^{1,2}, Marco Mese^{12,13}, Alberto Oliva¹¹, Giuseppe Osteria⁸, Francesco Palma^{1,2}, Beatrice Panico⁸, Francesco Perfetto⁸, Piergiorgio Picozza^{1,2}, Michele Pozzato¹¹, Ester Ricci^{5,6}, Marco Ricci¹⁴, Sergio Bruno Ricciarini¹⁵, Zouheikha Sahnoun¹¹, Valentina Scotti^{12,13}, Alessandro Sotgiu^{1,2}, Roberta Sparvoli^{1,2}, Vincenzo Vitale¹, Simona Zoffoli¹⁶, and Paolo Zucconi^{5,6}

¹INFN, Sezione di Roma "Tor Vergata", Rome, Italy, ²Department of Physics, University of Rome "Tor Vergata", Rome, Italy, ³INAF-IAPS, Rome, Italy, ⁴Department of Physical and Chemical Sciences, University of L'Aquila, L'Aquila, Italy, ⁵University of Trento, Trento, Italy, ⁶INFN-TIFPA, Trento, Italy, ⁷Centro Fermi, Rome, Italy, ⁸INFN-Sezione di Napoli, V. Caiafa, Naples, Italy, ⁹Uninettuno University, Rome, Italy, ¹⁰University of Bologna, Bologna, Italy, ¹¹INFN-Sezione di Bologna, Bologna, Italy, ¹²Now at ASI Space Science Data Center (SSEC), Rome, Italy, ¹³University of Naples "Federico II", Naples, Italy, ¹⁴INFN-LNF, Rome, Italy, ¹⁵IFAC-CNR, Florence, Italy, ¹⁶Italian Space Agency, Rome, Italy

Abstract In this work we present the High-Energy Particle Detector (HEPD-01) observations of proton fluxes from space during the 28 October 2021 solar energetic particle event, which produced a ground-level enhancement on Earth. The event was associated with the major, long-duration X1-class flare and the concomitant coronal mass ejection (CME) that erupted from the Active Region 12887. This is the first direct measurement from space of solar particles emitted during the current solar cycle, recorded by a single instrument in the energy range from ~50 MeV/n up to ~250 MeV/n. We have performed a Weibull-modeled spectral analysis of the energy spectrum in the wide energy range 300 keV–250 MeV, obtained from combination of HEPD-01 proton measurements with the ones from ACE/ULEIS, SOHO/EPHIN, and SOHO/ERNE. The good agreement between data and model, also corroborated by a comparison with other spectral shapes commonly used in these studies, suggests that particles could have possibly been accelerated out from the ambient corona through the contribution of stochastic acceleration at the CME-driven shock, even if the presence of seed populations influencing spectral shape could not be excluded. Finally, a Solar Proton Release time of 16:01 UTC ± 13 min and a magnetic path-length of $L = 1.32 \pm 0.24$ AU have been obtained, in agreement with previous results for this event. We remark that new and precise data on protons in the tens/hundreds MeV energy range—like the one provided by HEPD-01—could shed more light on particle acceleration as well as provide a reliable parametrization of solar energetic particle spectra for Space Weather purposes.

Plain Language Summary In this work we present the observation from space of protons emitted by the Sun during the 28 October 2021 solar event. This event was particularly strong and it was even registered at Earth by instruments called Neutron Monitors. Such highly energetic phenomena are rather rare and they can give a lot of information on particle acceleration and propagation from Sun to Earth. By using data from various spacecrafts, like High-Energy Particle Detector, we were able to address some characteristics of this event, like its duration, the most probable mechanism that accelerate particles, the path traveled by such particles, as well as to constrain the time in which they are accelerated.