WWW ACCESS TO THE ERNE SOLAR ENERGETIC PARTICLE DATABASE

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ABSTRACT/RESUME

ERNE is a particle instrument onboard the SOHO spacecraft[2]. A database containing a number of ERNE data products and a tool to access the data have been created. The tool offers an interactive search and display service accessible through internet. The currently available data consist of 1-minute proton and helium intensities at energies between 1.3 and 140 MeV/n from May 8, 1996 till June 30, 2001. Supplementary web-based services include archived proton and helium data ordered by Carrington rotations and a catalogue of high-energy solar particle events. In addition, continuously updated near-real time data are provided as plots of 2-hour average intensities. These services are freely available at http://www.srl.utu.fi.

1. INTRODUCTION

ERNE is one of the three particle instruments onboard the SOHO spacecraft [1]. Onboard SOHO, particle measurements are carried out from the solar wind energies up to relativistic proton energies. ERNE was designed to cover the upper range of energetic particles. With its two sensors ERNE is capable of measuring differential energy spectra of protons and helium in the range 1.3 – 140 MeV/n, providing integral fluxes at higher energies, and identifying and recording intensities of ions from carbon to iron from a few MeV/n up to hundreds of MeV/n. Both sensors rely on the ΔE-E-technique in particle identification and energy measurement. The low-energy sensor, LED, is a simple silicon telescope with seven independent front apertures. The high-energy sensor, HED, exploits both silicon detectors and scintillators to extend the operational energy range up to hundreds of MeV/n, and also possesses a precise directional sensitivity within its full view cone of 120^{o} [2].

Recently, the instrument completed its seventh year of successful operation in orbit (Lagrange L1 point). A database, freely accessible through the World Wide Web, containing a selection of ERNE data products, has been created. This paper describes the database and the tool to access, inspect, and download available data. Some supplementary web-based services are also introduced. The data application domains are briefly outlined and future developments of the activity are presented. Provision of this freely accessible web-based energetic particle data source is a service development activity fully funded by the University of Turku. These services are available at the web site http://www.srl.utu.fi/erne_data.

2. AVAILABLE BASIC DATA

The basic data consist of 1-minute proton and helium intensities derived onboard from pulse height measurements, and tabulated in energy and particle species by the onboard software of the instrument. The current data set covers the time period from May 8, 1996 till June 30, 2001. The earlier data from December 1995 till beginning of May 1996 are not included, because during this time period the initial verification and several updates of the onboard analysis software were carried out, and the data are considered less reliable. At the beginning of July 2001, a change to a new onboard data format was performed. The data with the new format are not presently available, but will be included in the database in near future. The data coverage of ERNE in the time period from May 1996 till June 2001, excluding the period of June-October 1998, when SOHO data were not available, is 93 %. The data gaps leading to this data coverage are primarily caused by uploads of updated onboard software and verification of their performance requiring brakes in nominal observations.

Differential intensities of protons and ^{4}He ions are measured in the energy range from 1.3 MeV/n to 140 MeV/n. In the onboard tabulation, this range is divided in energy channels. The maximum number of logarithmically spaced energy channels was 24 until April 19, 2000. Subsequently, the number of energy channels was raised to 68 by an onboard software update. This allows for incrementing successive energy channels in steps of a few percent only, which is considered sufficiently minute for users to construct energy intervals for their specific needs within the available energy range.

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[1] Part of the Väisälä Institute for Space Physics and Astronomy

[2] SOHO is a project of international collaboration between the European Space Agency and NASA.

3. ERNE DataFinder

The tool to access, retrieve, inspect, and download the data has been named as the ERNE DataFinder. The user interface is realised as a Java applet. The Java layer is responsible for initial search parameter compilations and final data presentation. An underlying IDL program suite handles the data retrieval and time-energy integration. The IDL-Java communication is based on the XML-technology.

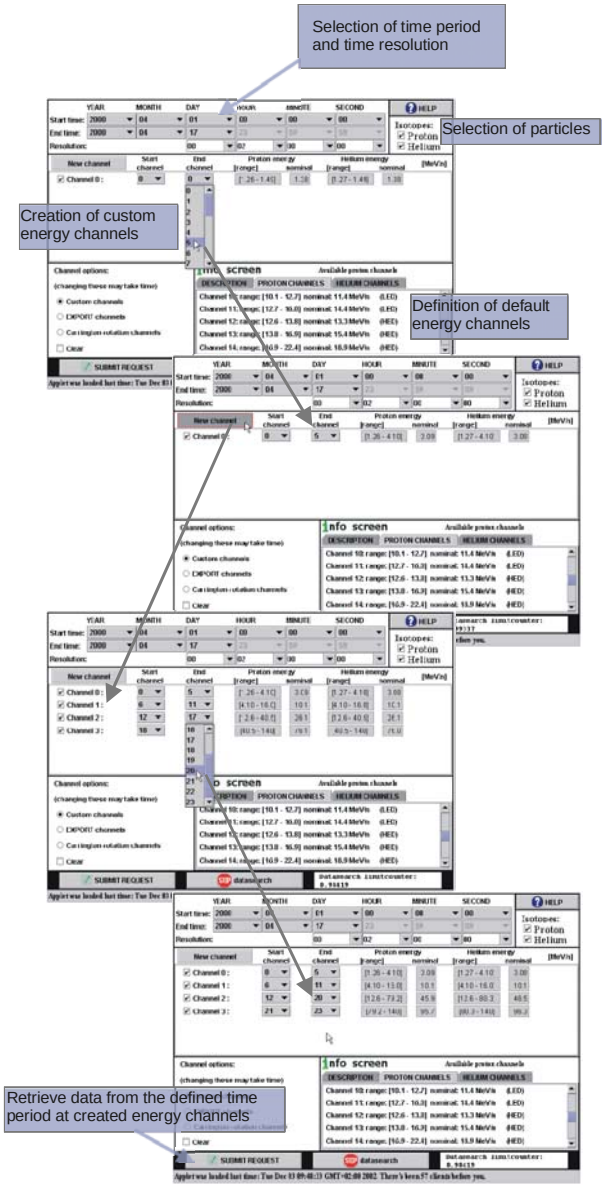

Fig. 1. ERNE DataFinder user interface.

Through the ERNE DataFinder, the user can construct data sets for specific purposes by retrieving data from a desired time period with a user-defined time resolution and energy binning within the boundary conditions determined by the basic data. When integrating over time, the intensity calculation is based on the true measurement time, thus eliminating effects of possible data gaps. When combining the basic energy channels to obtain the user-defined channels, the mean energies of created channels and the intensities in the appropriate energy intervals are calculated as weighted averages over the individual basic channels. The weighting factors are the respective GΔE-values, where G is the geometric factor and ΔE the width of each basic channel. Fig. 1 shows the user interface and the flow in constructing a user-defined set of energy channels within a desired time period and with a desired time resolution.

For visualisation of the generated data, the particle intensities at each energy channel can be plotted as a function of time (Fig. 2). The basic plot can be further manipulated to show only protons or helium at certain energy channels, presenting data with or without error bars, selecting the style of presentation, zooming in and out, etc. The resulting plot can be sent to a printer or stored as a GIF-file. For further analysis at user's own facilities, the data can be downloaded as an ASCII text file.

4. SUPPLEMENTARY WEB-BASED SERVICES

In addition to the intensities of protons and helium at freely selectable energy channels and time periods, there are a number of other data products available through internet, which have a pre-defined format in time span, time resolution, or energy.

Archived 2-hour averages of proton and helium intensities ordered by Carrington rotations are accessible in five energy channels between 1.8 and 51 MeV/n. Presently, the data coverage is from rotation #1906 (1996-02-13) to rotation #1975 (2001-04-09). These data can be retrieved as GIF-plots or as ASCII text files.

A solar energetic particle event catalogue is available. The compiled event list is based on high-energy proton measurements, requiring enhanced intensities above 12 MeV. 30-minute averages of protons in four energy channels between 12 and 100 MeV are presented as GIF-plots. Links to corresponding lower-energy ERNE/LED data are also provided. Basic information of the events, such as the start time, maximum intensity, rise time to the maximum, and duration of the event, is given (Fig. 3). This catalogue can be used as a source of quick-look data for solar events, and the data retrieved subsequently for detailed analysis through the ERNE DataFinder.

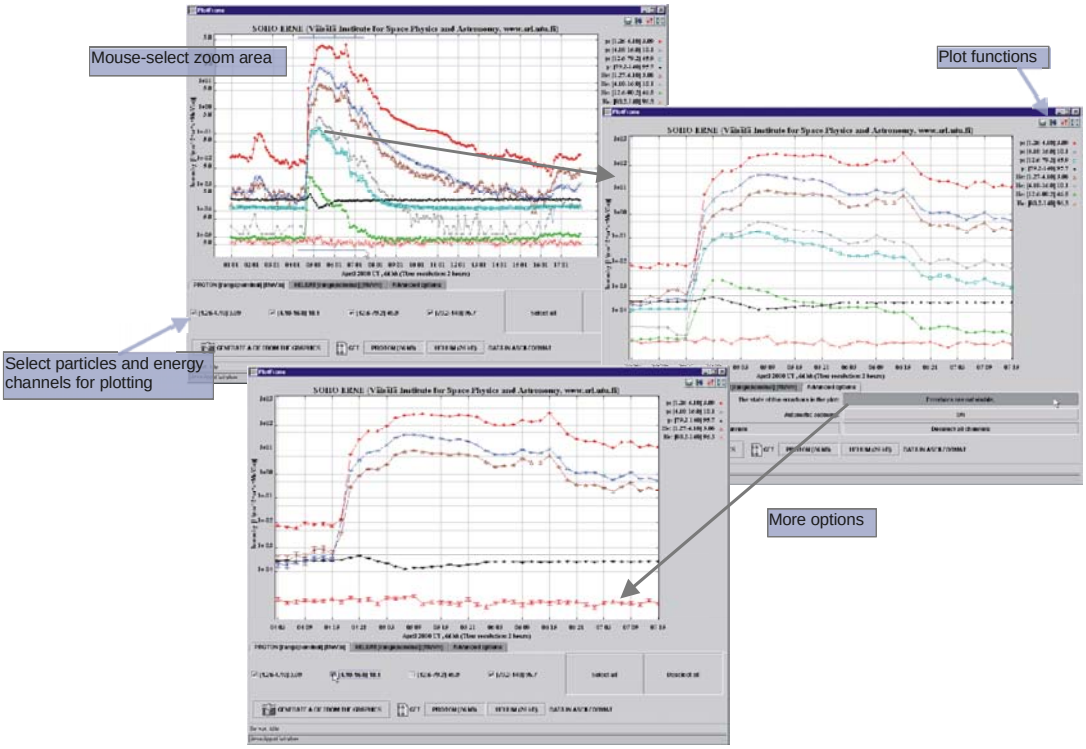

Fig. 2. Visualization of the selected data.

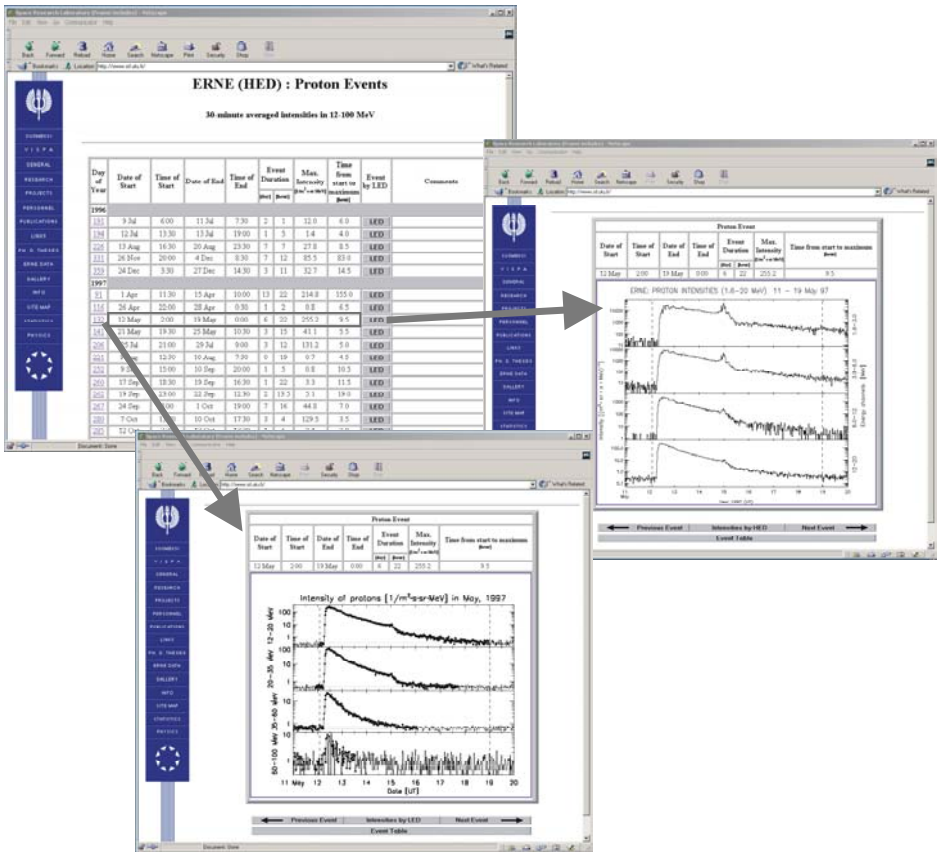

Fig. 3. An example plot from the solar energetic particle event catalogue.

Continuously updated plots of near real-time proton and helium intensities and helium-to-proton ratio are maintained. These data are regularly received from the SOHO Experiment Operations Facility at the Goddard Space Flight Center, and presented as two-hour averages in six energy channels between 1.8 and 100 MeV/n. Although these data are not complete, because they are only received during direct contacts to the SOHO spacecraft, they still provide a useful aid in determining conditions in interplanetary space, and potentially in predicting geomagnetic disturbances caused by approaching magnetic clouds.

5. DATA APPLICATIONS

The ERNE energetic particle data available through the online services as described in this paper are applicable in all domains, where detailed and precise knowledge of proton and helium intensities in the energy range 1-140 MeV/n are required. Currently, the most extensive use of the data is solar-terrestrial research, e.g., various aspects of impulsive and gradual solar particle events have been investigated. A direct space weather application is the search for energetic particle signatures of geoeffective coronal mass ejections, which could provide a method for predicting the occurrence of intense geomagnetic storms with a lead-time of several hours to a few days.

For technological purposes, the data can be applied, e.g., in post-analysis of spacecraft or instrument anomalies. From the data provided, fluencies of high-energy protons and helium can be calculated and the absorbed total dose under various shielding derived. Similarly, the sensitivities of technologies applied in space systems to single event upsets can be analysed by correlating the observed anomalies with provided particle intensities.

Finally, the near-real time proton and helium fluxes can be used as a source of an early warning of approaching potentially geoeffective interplanetary disturbances. E.g., by a careful analysis, the increase of the energetic particle intensity related to a strong interplanetary shock can be seen in the data well before the corresponding shock is observed in the solar wind data, giving some more time to react for potential exceptional geospace conditions. The data can also be used as alerts of potentially hazardous conditions for humans in space, giving online information of the development of fluxes of high-energy particles produced both at the Sun and in interplanetary shocks while the disturbances propagate through space towards the Earth.

6. SUMMARY AND FUTURE DEVELOPMENTS

An interactive tool to access ERNE proton and helium data through internet has been developed. The freely available data currently covers a five-year time period from 1996 till 2001 in the energy range 1.3-140 MeV/n with the time resolution of 1 minute. The tool enables the user to easily construct data sets covering a defined time period with a desired time resolution and energy binning. For visualisation of the generated data, the intensities can be plotted as a function of time and saved as a GIF-file. The generated data can also be downloaded as a text file for detailed analysis at the user's own facilities. Additional data products include archived data ordered by Carrington rotations, a catalogue of solar particle events, and near-real time particle intensities at several energies between 1.8 and 100 MeV/n. All these services are freely available at http://www.srl.utu.fi/erne_data.

Future developments of the web-based services include updates to provide access through the ERNE DataFinder to all of the data from May 1996 till present, and to maintain the data availablity with a minimum of delay from measurements. Access to anisotropy data of solar energetic particles will be included. A future goal is to provide more detailed near-real time data than currently available. Fluence calculations of energetic particles will also be supported allowing calculations of total absorbed dose and analysis of single event upsets.

7. REFERENCES

1. Torsti, J et al., Energetic Particle Experiment ERNE, *Solar Physics*, Vol. 162, 505-531, 1995.

2. Valtonen, E. et al., Energetic and Relativistic Nuclei and Electron Experiment of the SOHO Mission, *Nuclear Instruments and Methods in Physics Research*, Vol. A391, 249-268, 1997.