A New Way to Predict Solar Energetic Particle Environments

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- Several models have been developed that predict the peak fluxes and fluences of high energy solar particles in interplanetary space. These models are used to specify environments for spacecraft design.
- All of the fluence models use the same basic procedure, which requires several choices to be made concerning such things as the data set, the definition of a particle event, the solar cycle variation of event frequency and the mathematical function used to fit the observed distribution of event sizes.
- The choices made in the JPL 1991 fluence model are re-examined in response to criticisms made in the literature. We show that the choices made in the JPL model are valid.
- We will also present a new basic procedure for predicting the fluence and peak flux environments which bypasses some of the more controversial of these choices.

The JPL 1991 is one of a class of fluence models which follow the lead set by King (1974). The basic method of developing a fluence model contains several steps;

1- Choose a data set

2- Identify solar energetic events and calculate the fluence during each event

3-Determine the mathematical form of the probability distribution of event fluences.

4- Choose a class of missions of interest (for example a mission in interplanetary space at I AU for 3 years). Using the function determined in step 3, generate the total fluence for a large random sample of such missions.

5- Using this large sample, calculate the distribution of mission integrated fluences.

Choosing a data set

Require: Long time series of commensurate data set.

The data set for energies >10 MeV used for the JPL model form such a set.

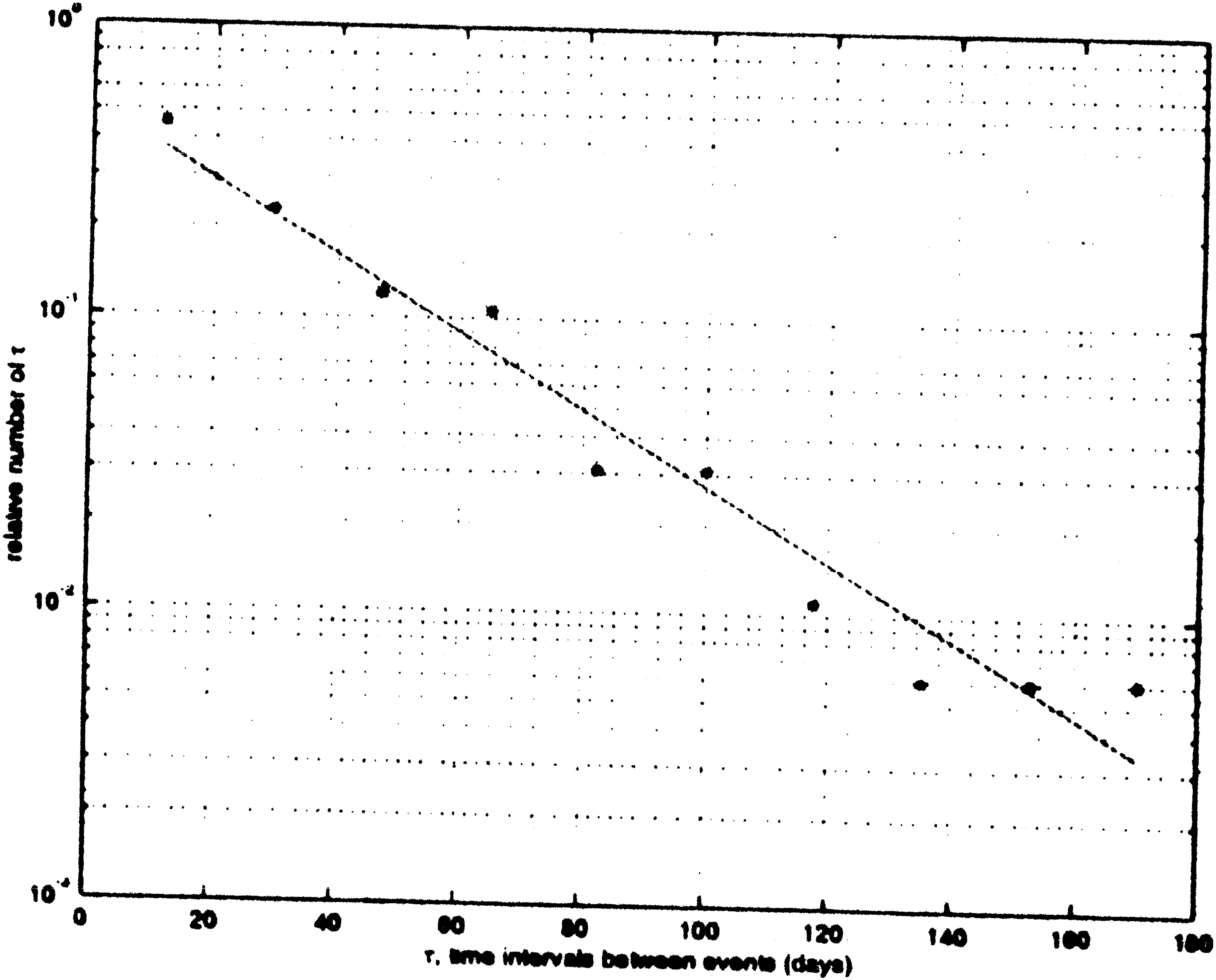
Data sets combining spacecraft within magnetosphere or in low Earth orbit with interplanetary data are not commensurate.

Identify solar energetic events and calculate the fluence during each event

Requirement : the events need to be independent for sampling techniques to be valid---i.e. events must be randomly distributed in time.

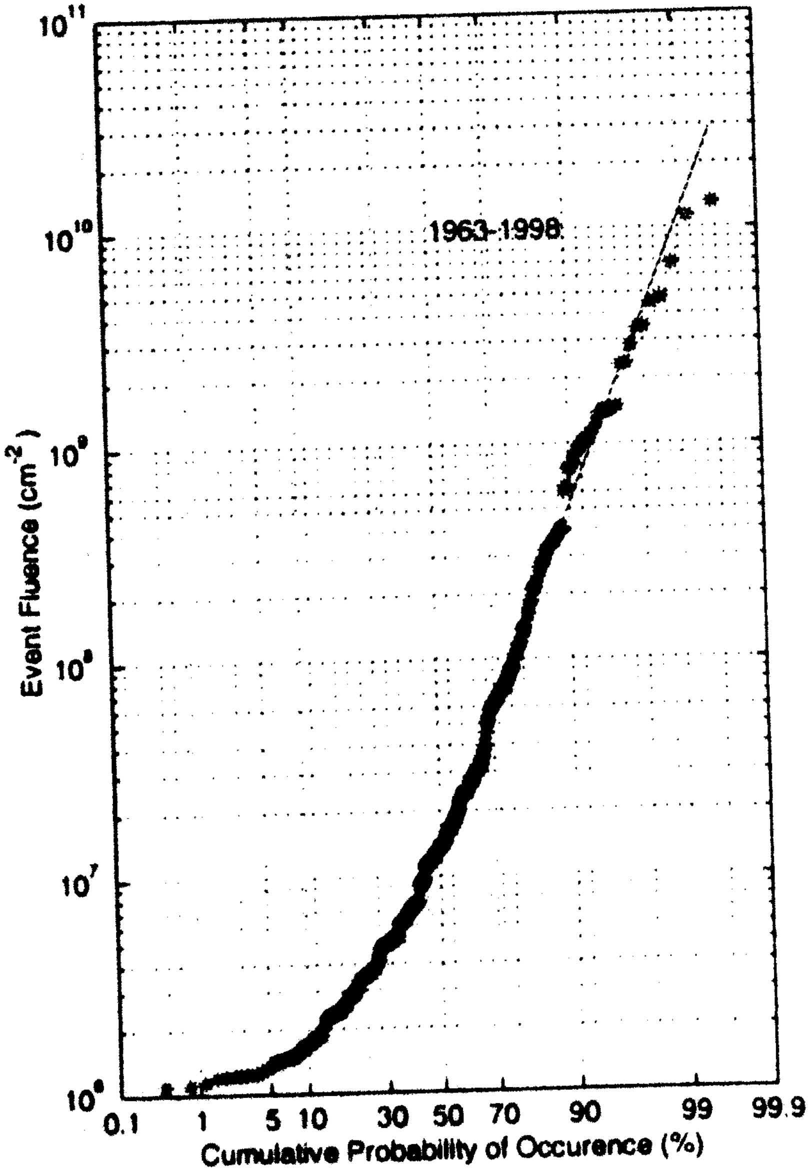
Problem: Individual major CMEs occur in series, i. e. are not randomly distributed

Solution: Define events so that a series of related CMEs constitutes a single event . Test for independence (see next viewgraph).

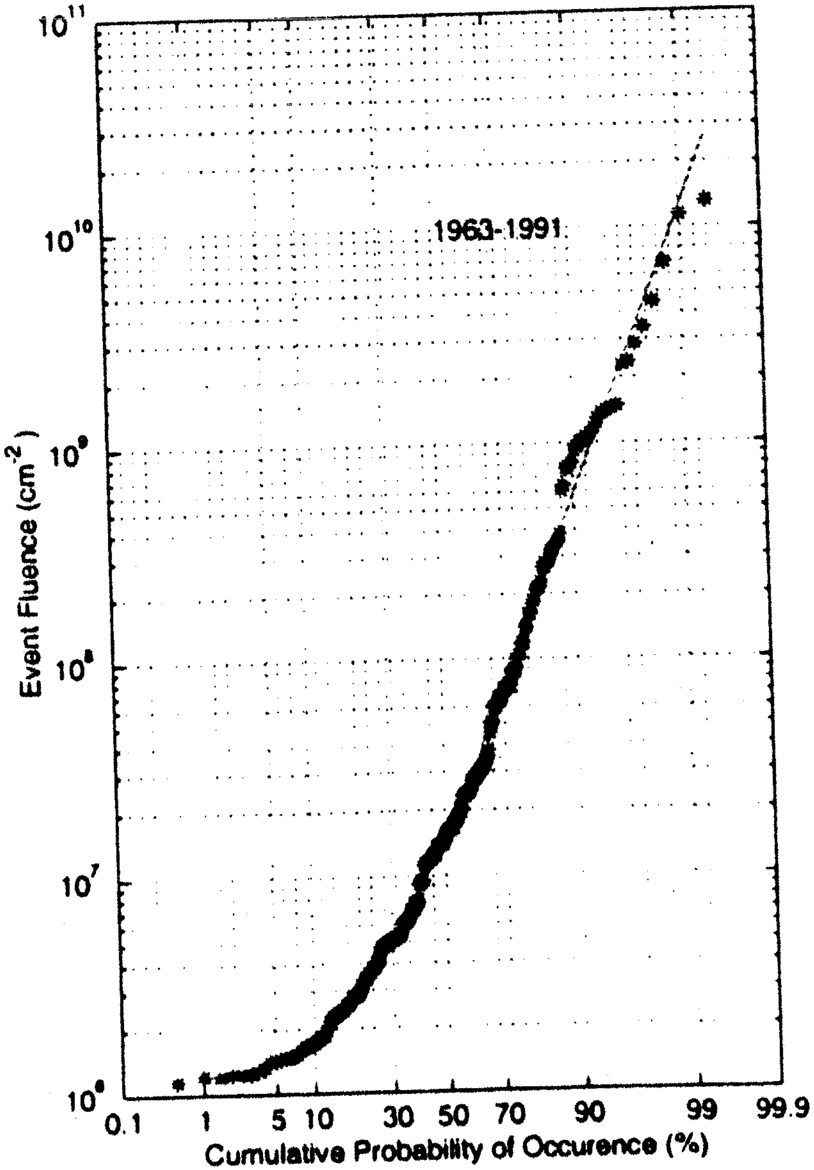


10^0
10^-1
10^-2
10^-3
relative number of τ
0
20
40
60
80
100
120
140
160
180
τ, time intervals between events (days)

Viewgraph showing independence of the events—i. e. the time between events is distributed randomly.



1963-1998
Event Fluence (cm^{-2})
Cumulative Probability of Occurence (%)



1963-1991
Event Fluence (cm^{-2})
Cumulative Probability of Occurence (%)

Determine the mathematical form of the probability distribution of event fluences.

Show that the distribution does not change in time. Viewgraph

Choose mathematical function to represent distribution

Requirement : That the important events are included properly.

Choices tested exponential, power law, Type 1 and Type 2

Choose mission trajectory and generate the total fluence for a large random sample of such missions. Straightforward computer simulation.

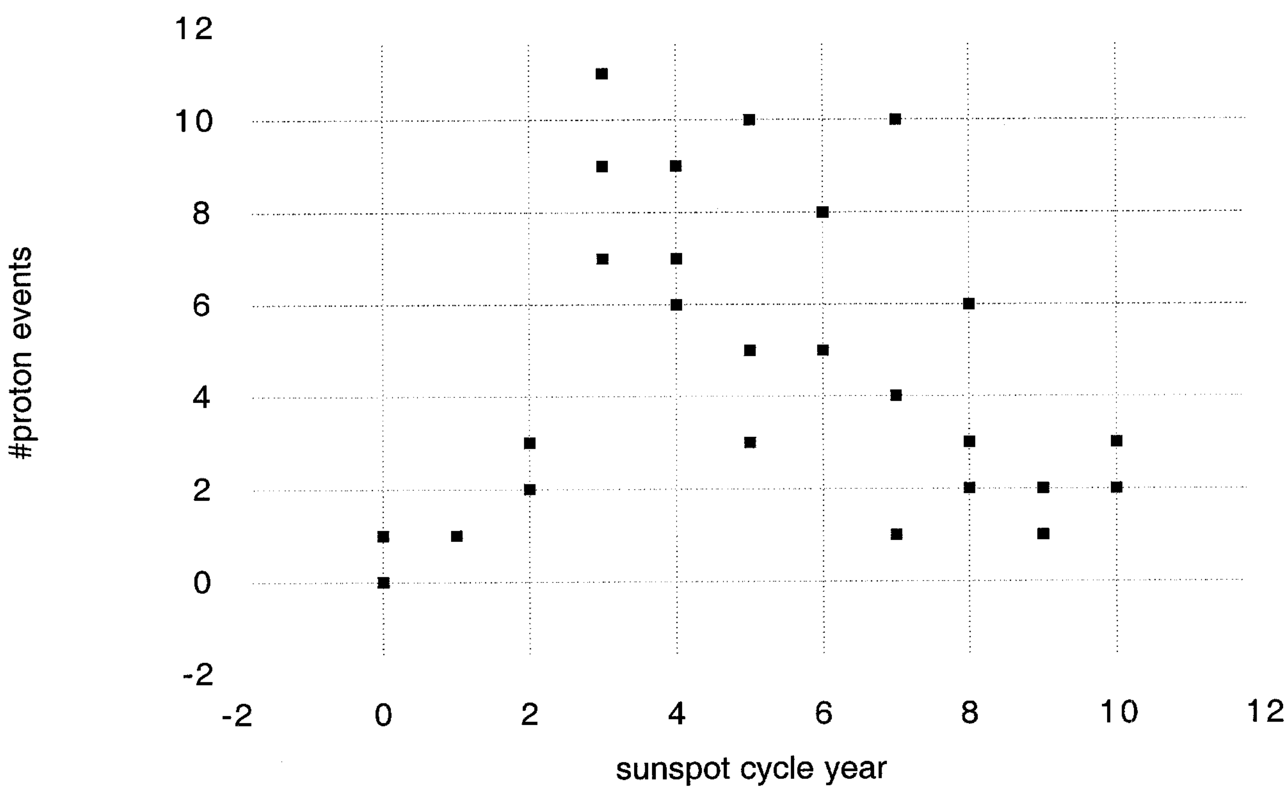
Using this large sample, calculate the distribution of mission integrated fluences and express result as the confidence level that the total mission will not exceed a given value.

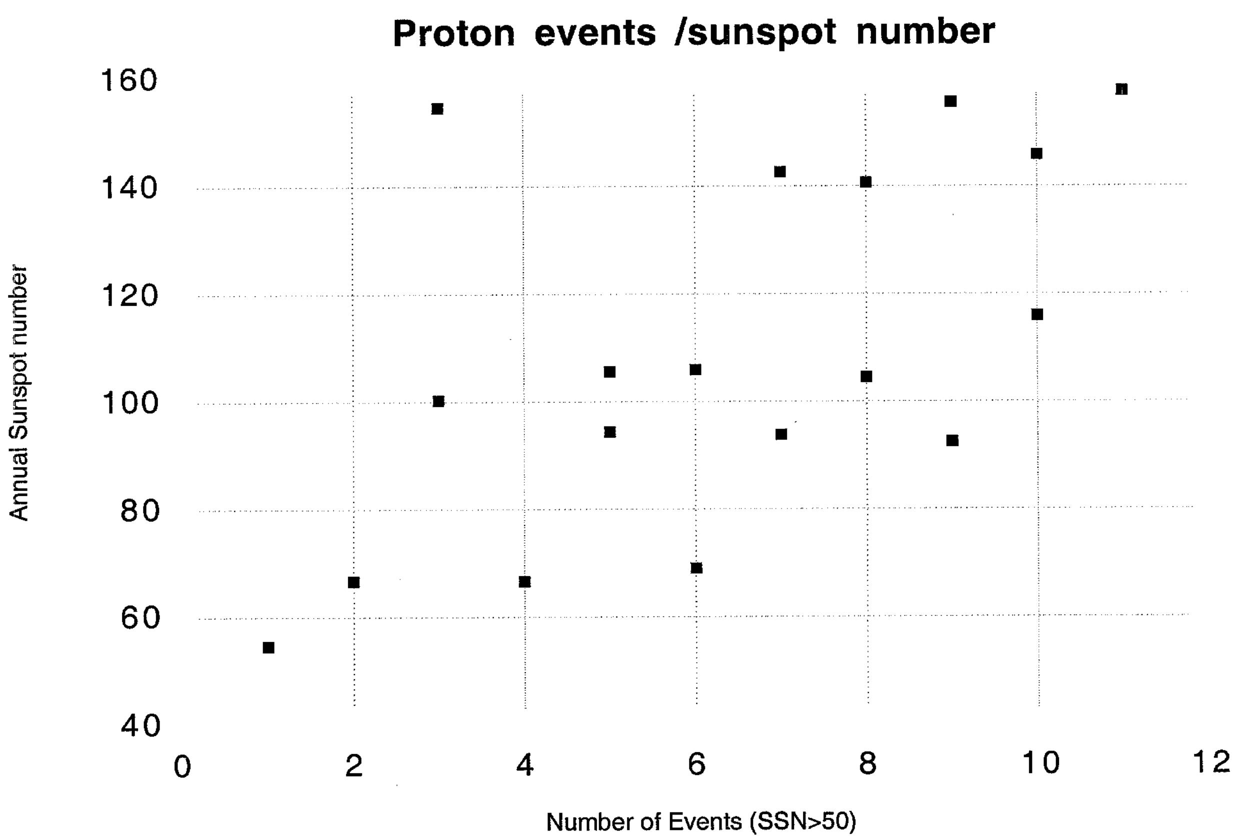
This is straightforward but opens the door for a new method.

New method for fluences and fluxes.

What we really need is an estimate that, if we launch the spacecraft on a given mission on a given day, we can be assured that the mission integrated fluences and peak fluxes will not exceed a selected level.

Since the data set has been shown to be stable now we can directly calculate the fluences and peak fluxes that would have been experienced by a spacecraft if it had been launched on any day during the past three solar cycles for which we have data.


#proton events
sunspot cycle year
12
10
8
6
4
2
0
-2
-2
0
2
4
6
8
10
12


Proton events /sunspot number
160
140
120
100
80
60
40
0
2
4
6
8
10
12
Annual Sunspot number
Number of Events (SSN>50)