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A New Method for Finding SEP Event Onset Times and Evaluating Their Uncertainty: Poisson-CUSUM-Bootstrap Hybrid Method

Solar energetic particles (SEPs) are highly energetic charged particles that have their origin of acceleration in strong space-weather driving phenomena that the Sun produces, e.g., solar flares and coronal mass ejections. These particles pose a radiation hazard to both technological equipment and living organisms in space, which is why the nature of these events is an important subject of study in the modern age where space technology is being applied more and more every day.

The onset time of an SEP event at varying energies is a key piece of information in relating the in-situ particle measurements to the remote-sensing observations of solar eruptions. Accurate knowledge of the onset time is an indispensable requirement for identifying the acceleration mechanisms and the source of the energetic particles. What traditional methods lack, however, is the assessment of the uncertainty related to the onset time.

Our method employs a unique combination of a statistical quality control scheme, Poisson-CUSUM, coupled with statistical bootstrapping. By choosing random samples from the background intensity preceding an SEP event and varying the integration time of the data, the method is able to produce a set of distributions of possible onset times. From this set of distributions we extract the most probable onset time and uncertainty intervals relating to this set of distributions.

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