A Space Weather Event on the Microwave Anisotropy Probe (MAP)

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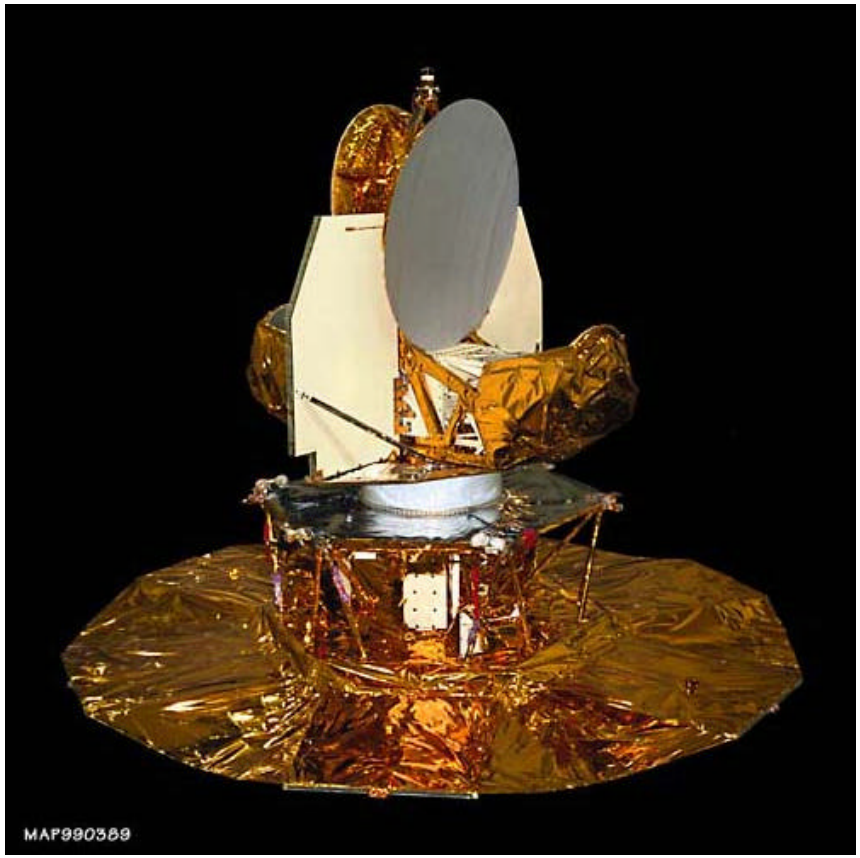
Outline

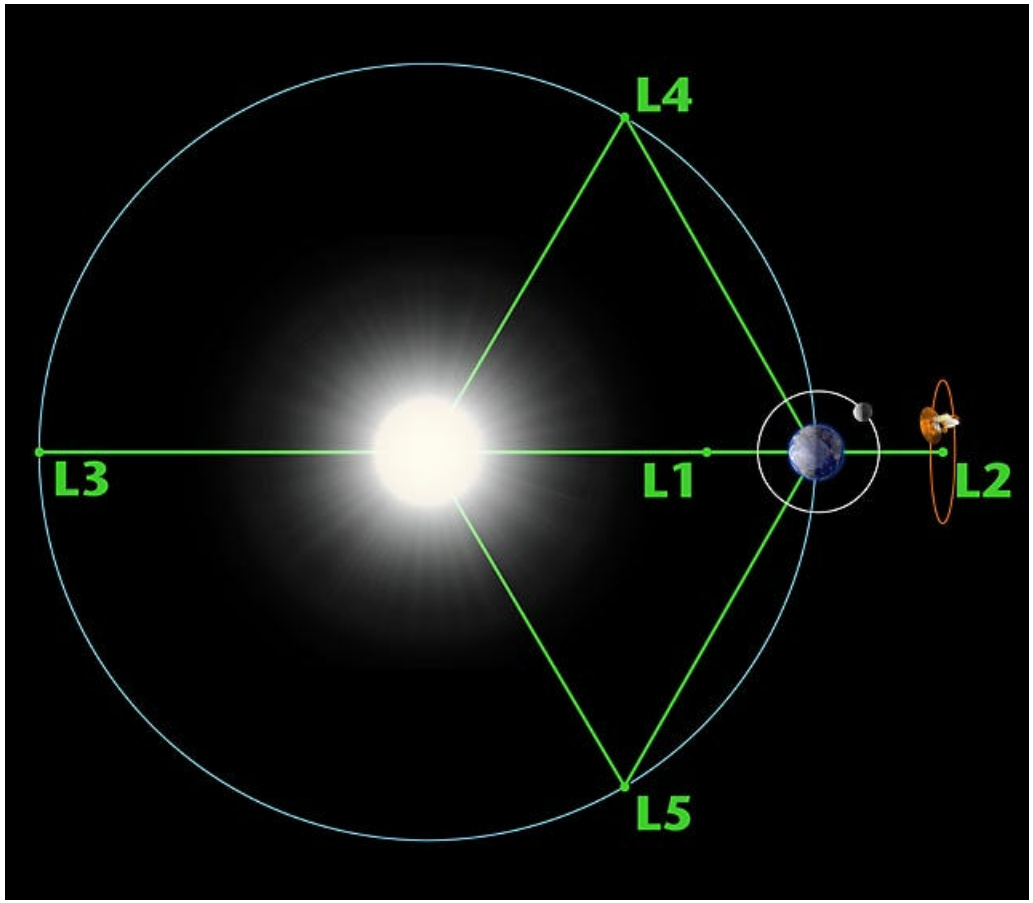
- **Introduction**
- **The MAP environment during the anomaly**
- **Anomaly Analysis**
- **Space weather monitoring and forecast**
- **Conclusion**

Introduction



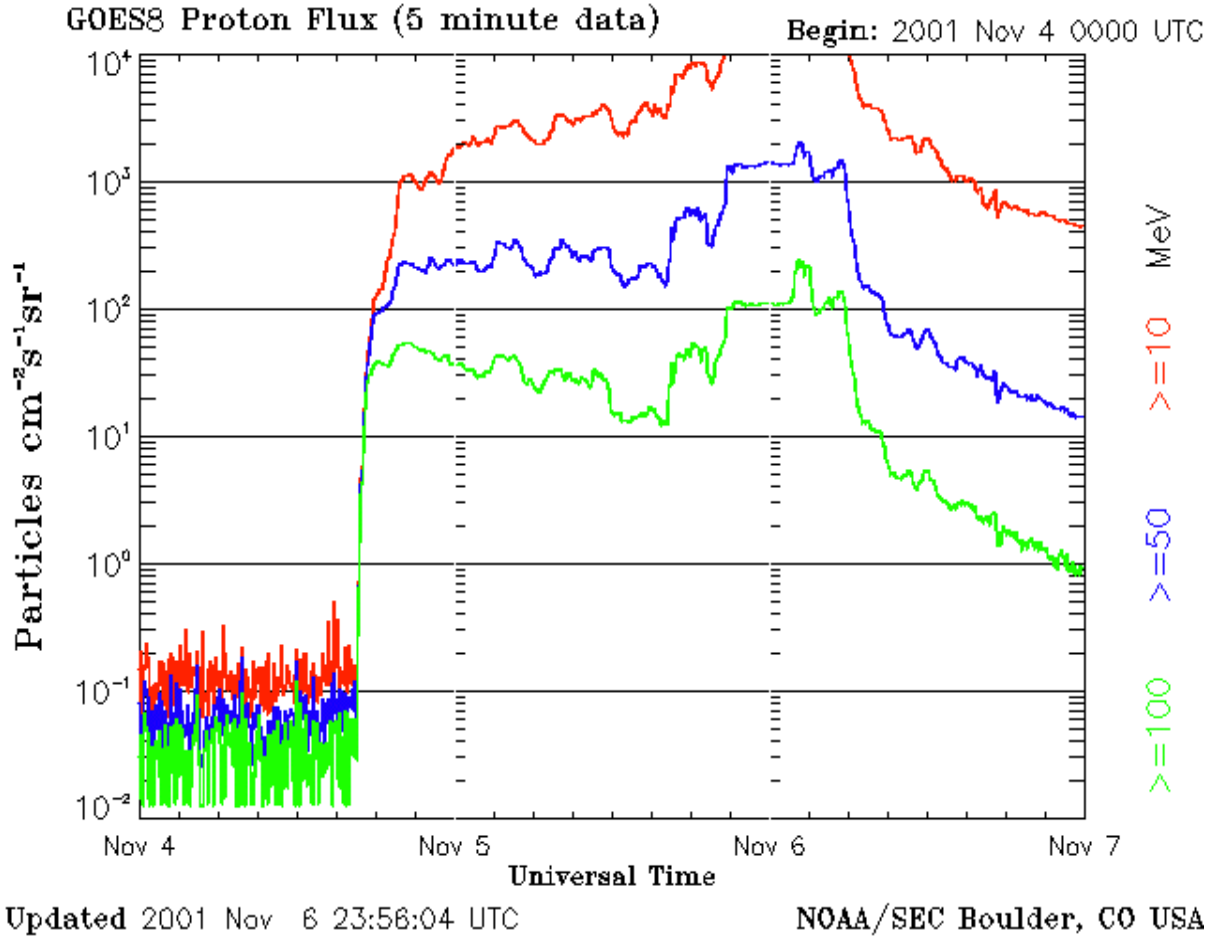
- **Launched June 30, 2001.**
  - **Had phasing orbits prior to insertion in final orbit.**
- **Reached its final position on L2 end of September, 2001.**
- **An event occurred causing a reset of spacecraft processor on November 5, 2001.**

MAP Radiation Environment



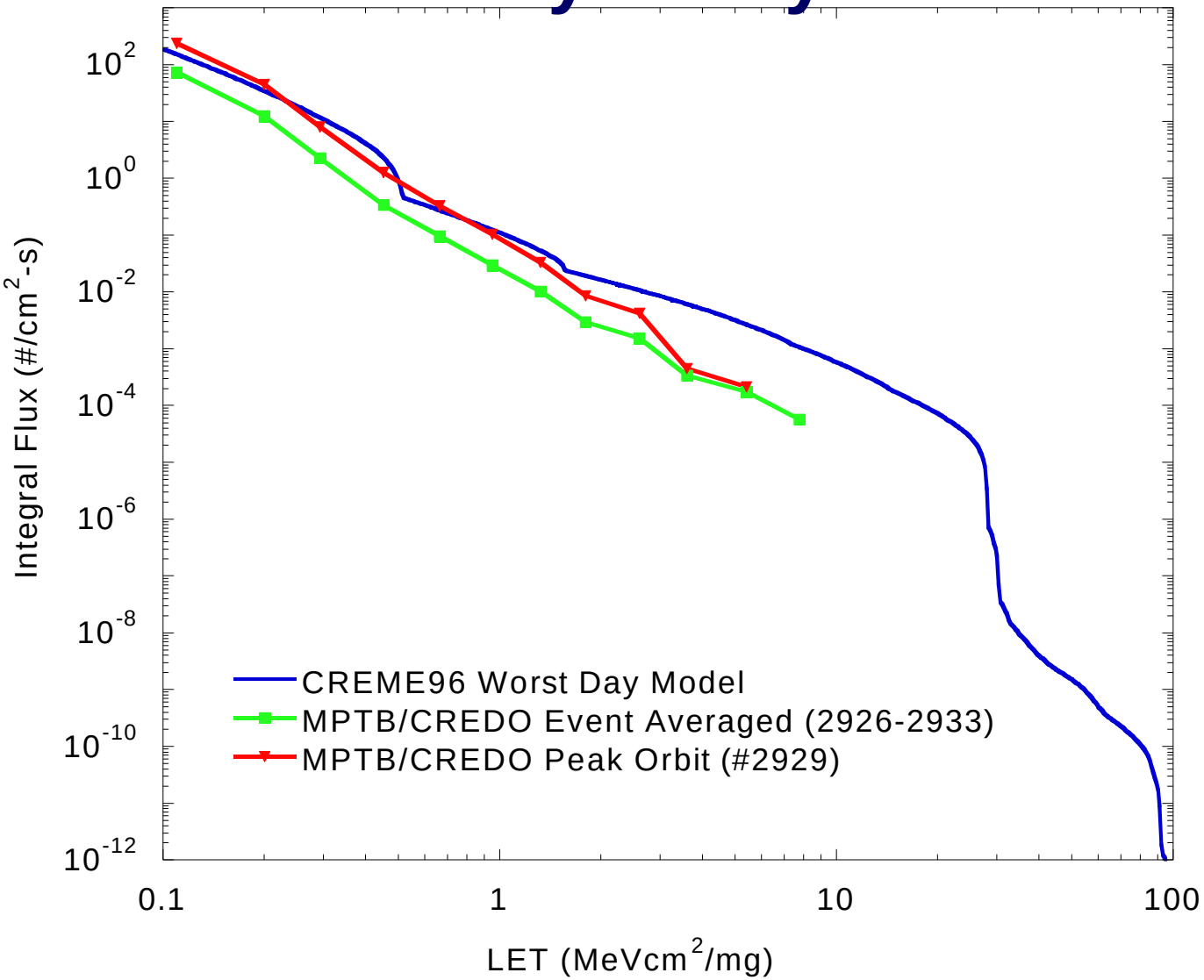
- **Potential anomaly inducing environment**
  - **GCR**
  - **Solar Particles**

Environmental activity during the anomaly-protons



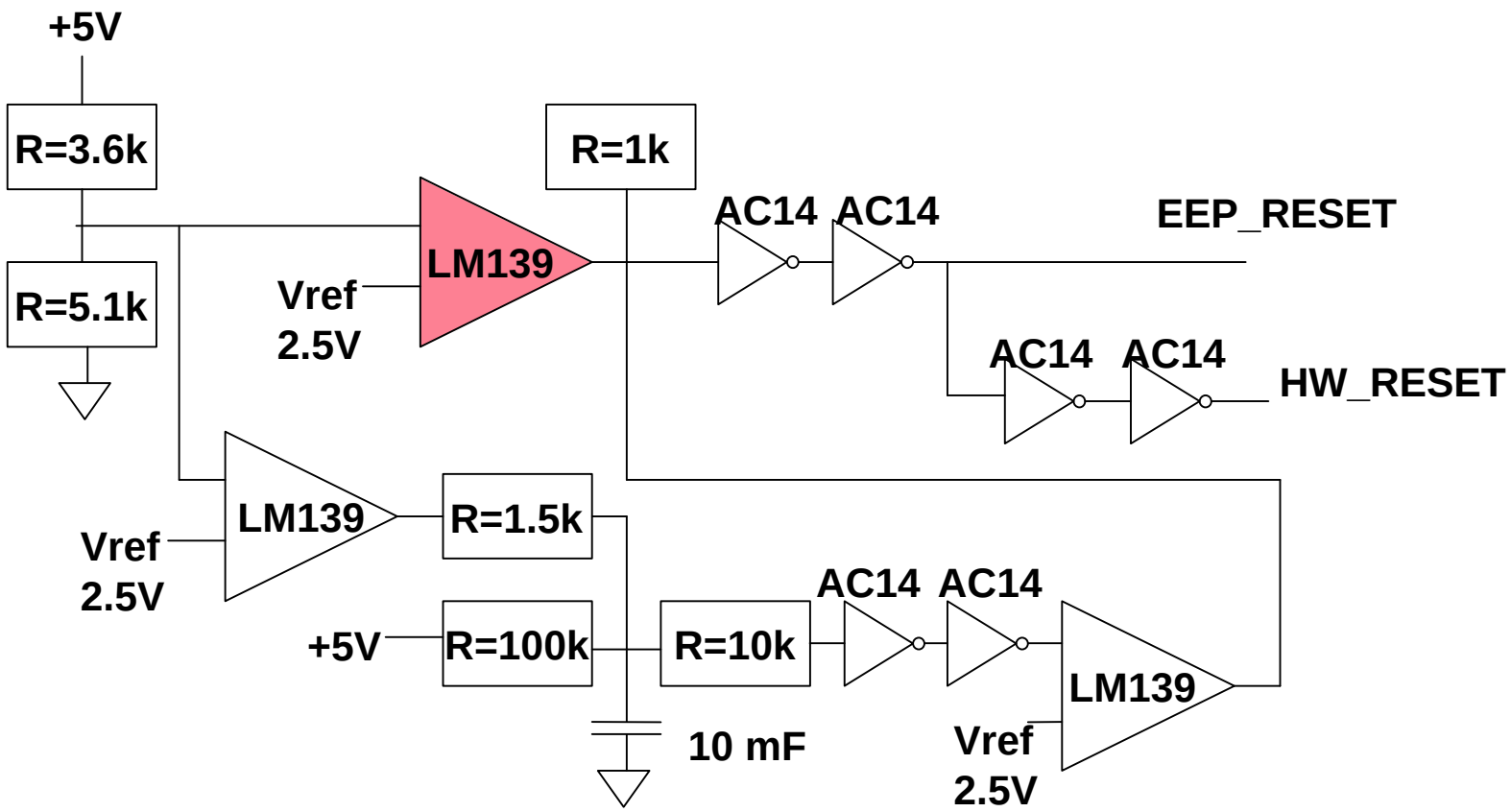
Data from NOAA/SEC/SWO, http:sec.noaa.gov

Environment activity during the anomaly-heavy ions

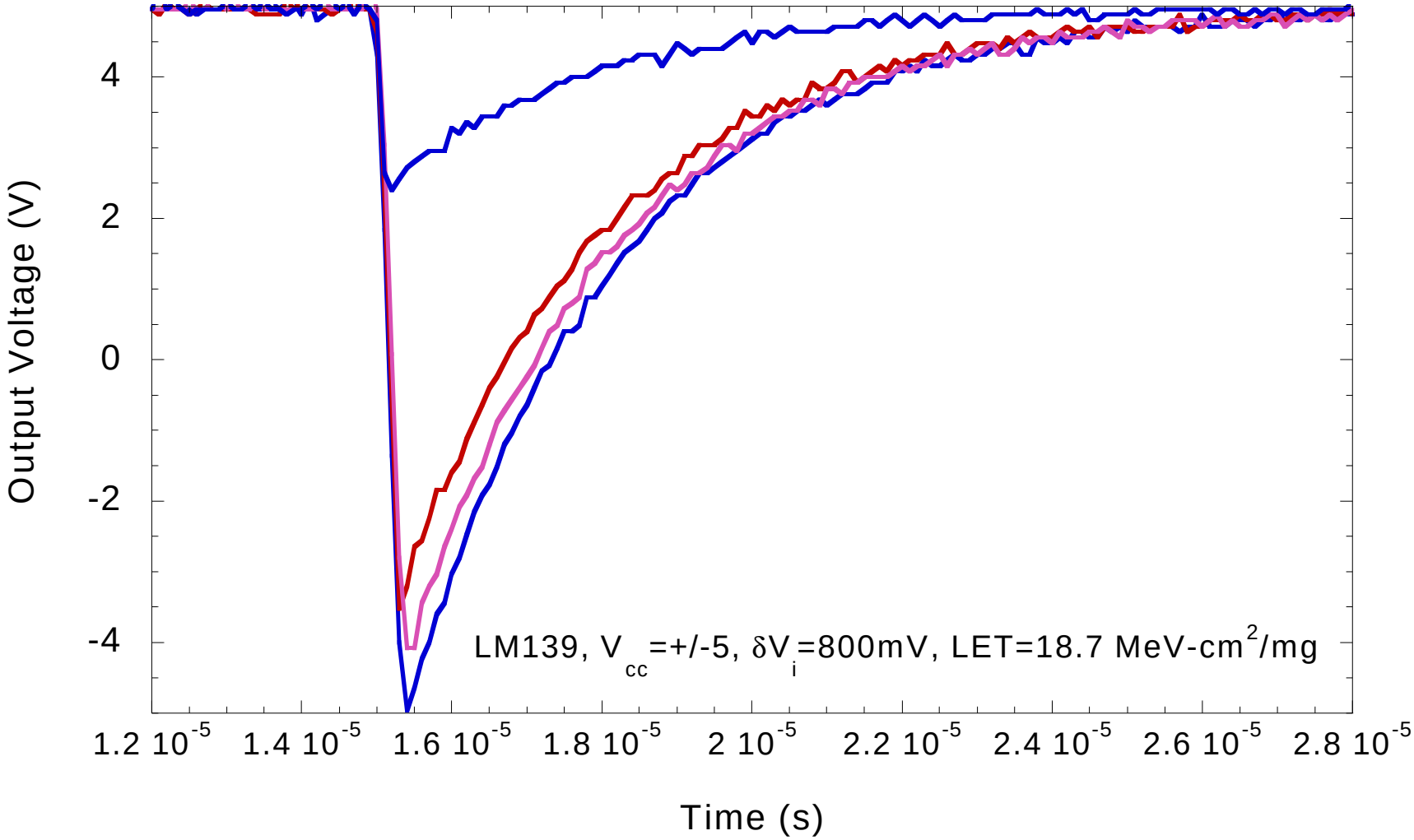


After C. Dyer & al., presented at NSREC 2002

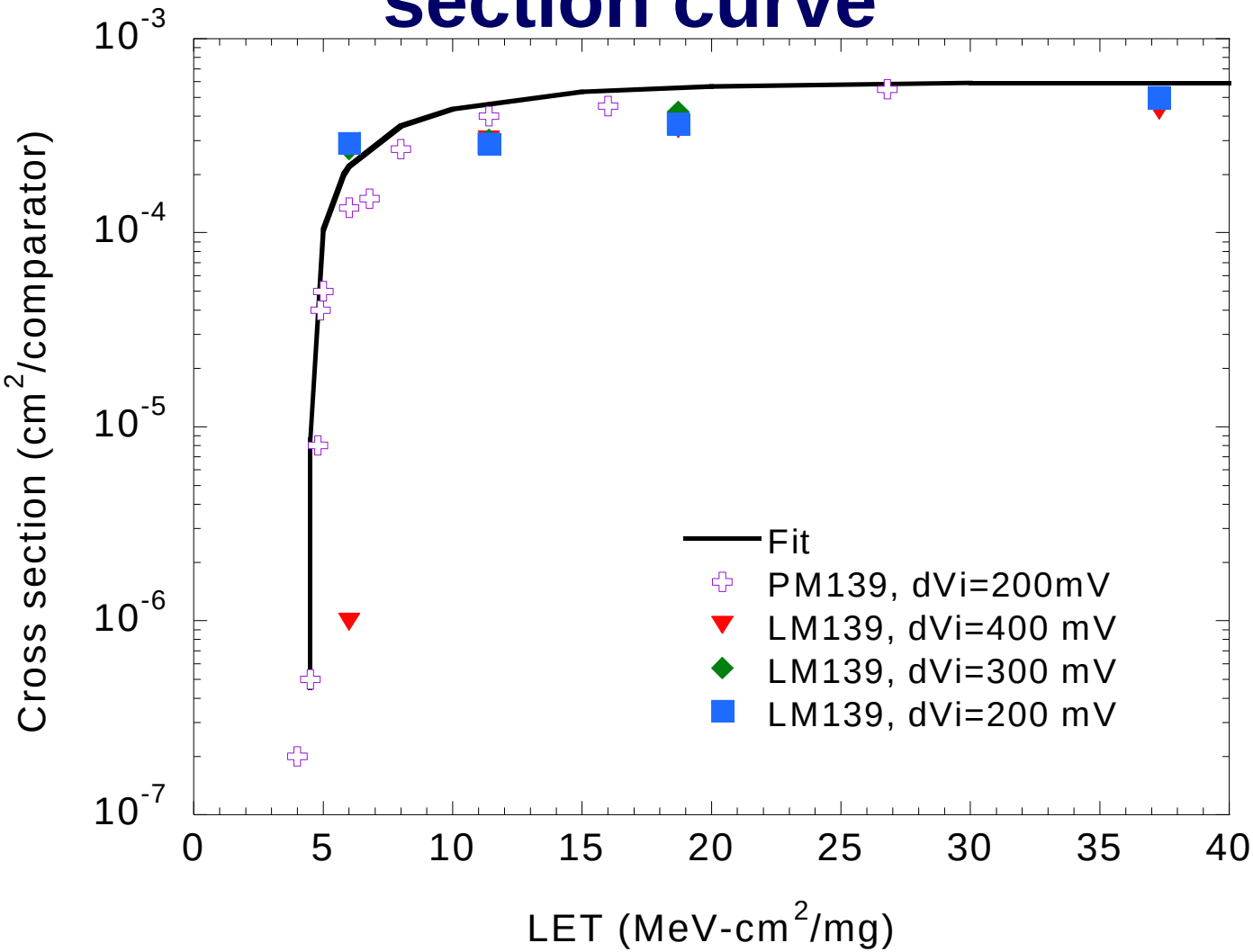
Anomaly analysis-
sensitivity of design



PM139/LM139 - typical Single Event Transient (SET) shape

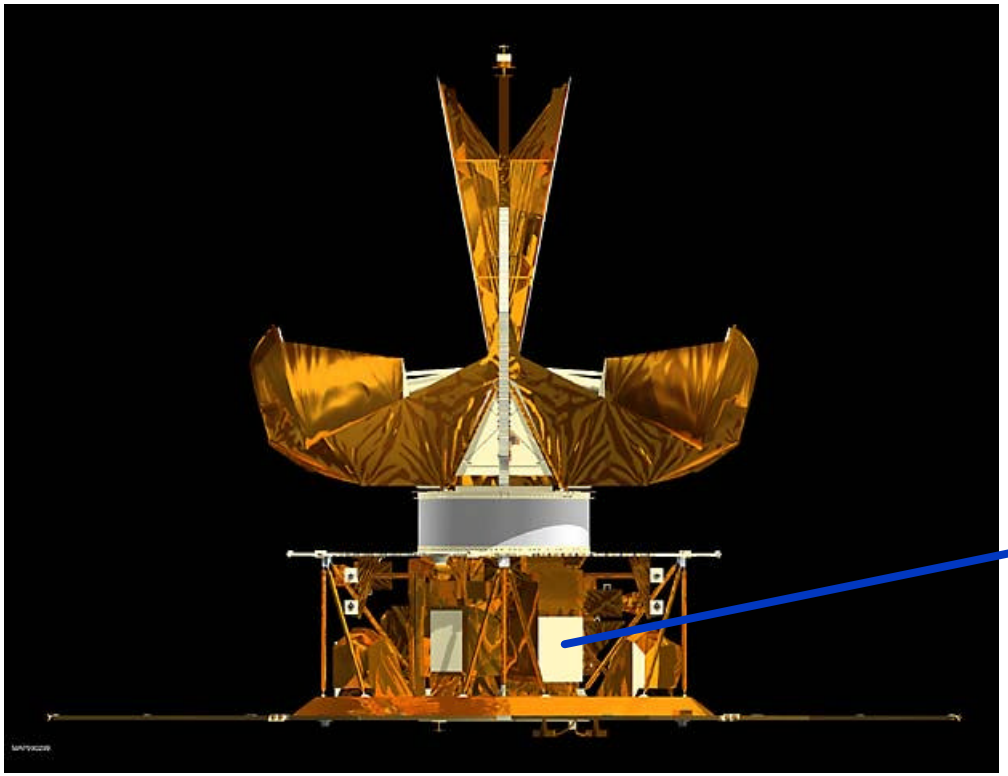


PM139/LM139 heavy ion SET cross section curve

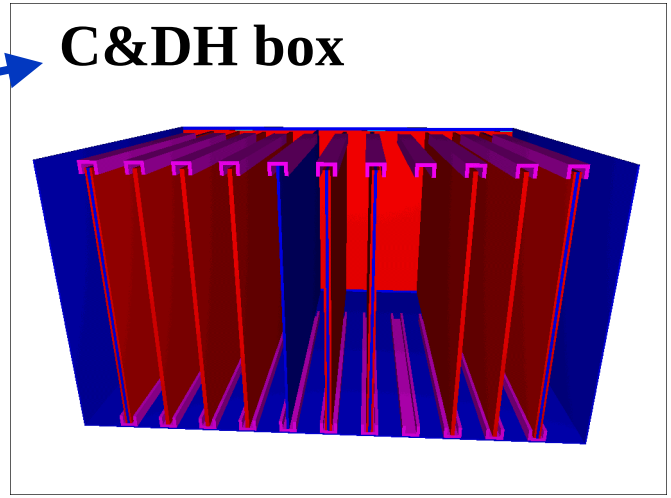


PM139 data after A. Johnston & al., IEEE Trans. On Nucl. Sci., vol. 47,nº6, Dec. 2000

Shielding Assumptions



Based on total dose analysis, shielding on the Control &Data Handling processor board is equivalent to 500 mils (12.7 mm) of aluminum shielding



SET Rates on L2

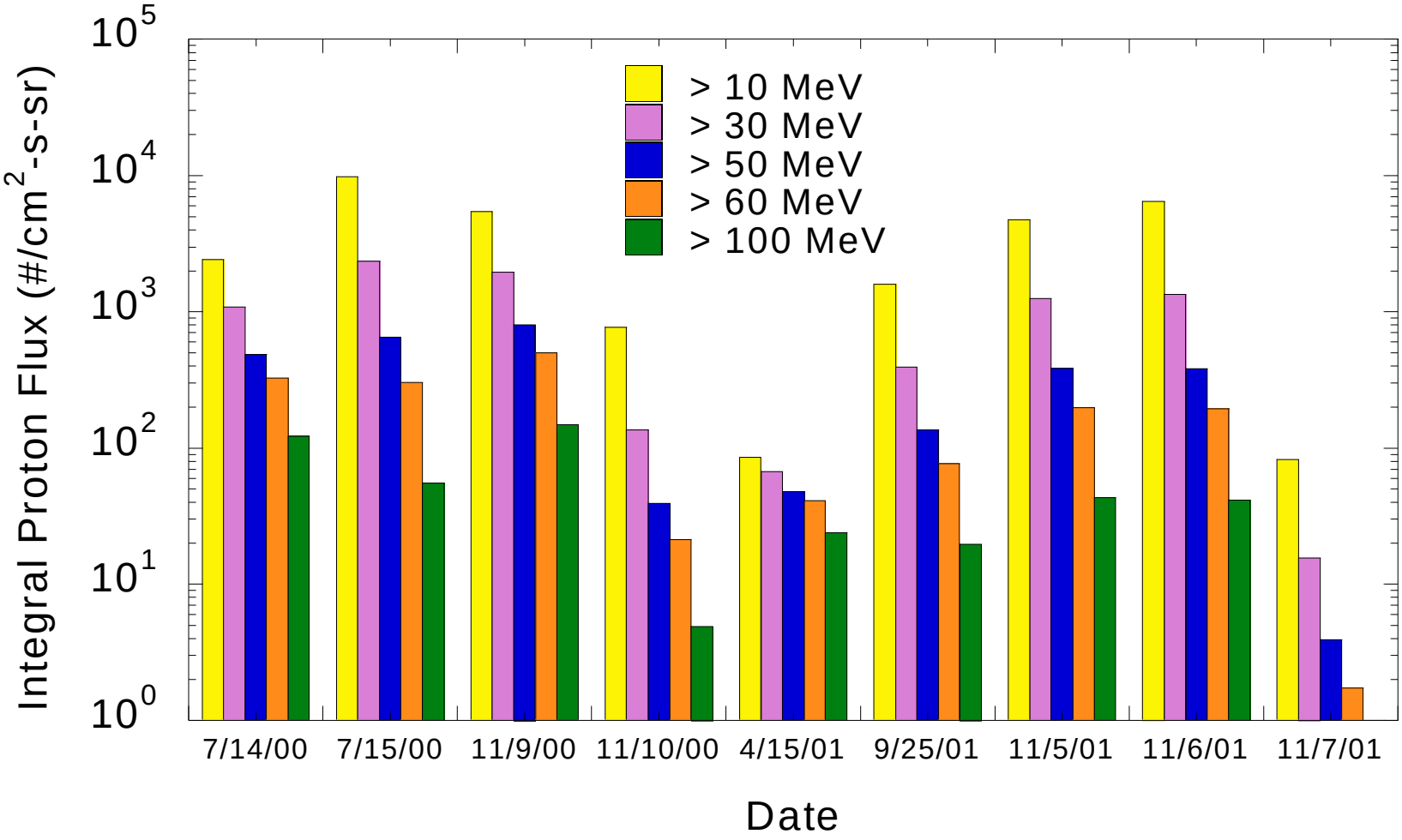
Sensitive volume thickness (mm)	GCR SET rate CREME96, solar maximum (event/comparator-day)	Solar Event CREME96, worst day (event/comparator-day)
10	1.8E-3	5.1E-1
15	1.7E-3	3.0E-1
20	1.6E-3	1.8E-1
30	1.5E-3	6.5E-2
40	1.3E-3	4.4E-2
60	9.9E-4	3.4E-2

No other anomaly has occurred since November 5, 2001.

Space Weather Monitoring and Forecasts

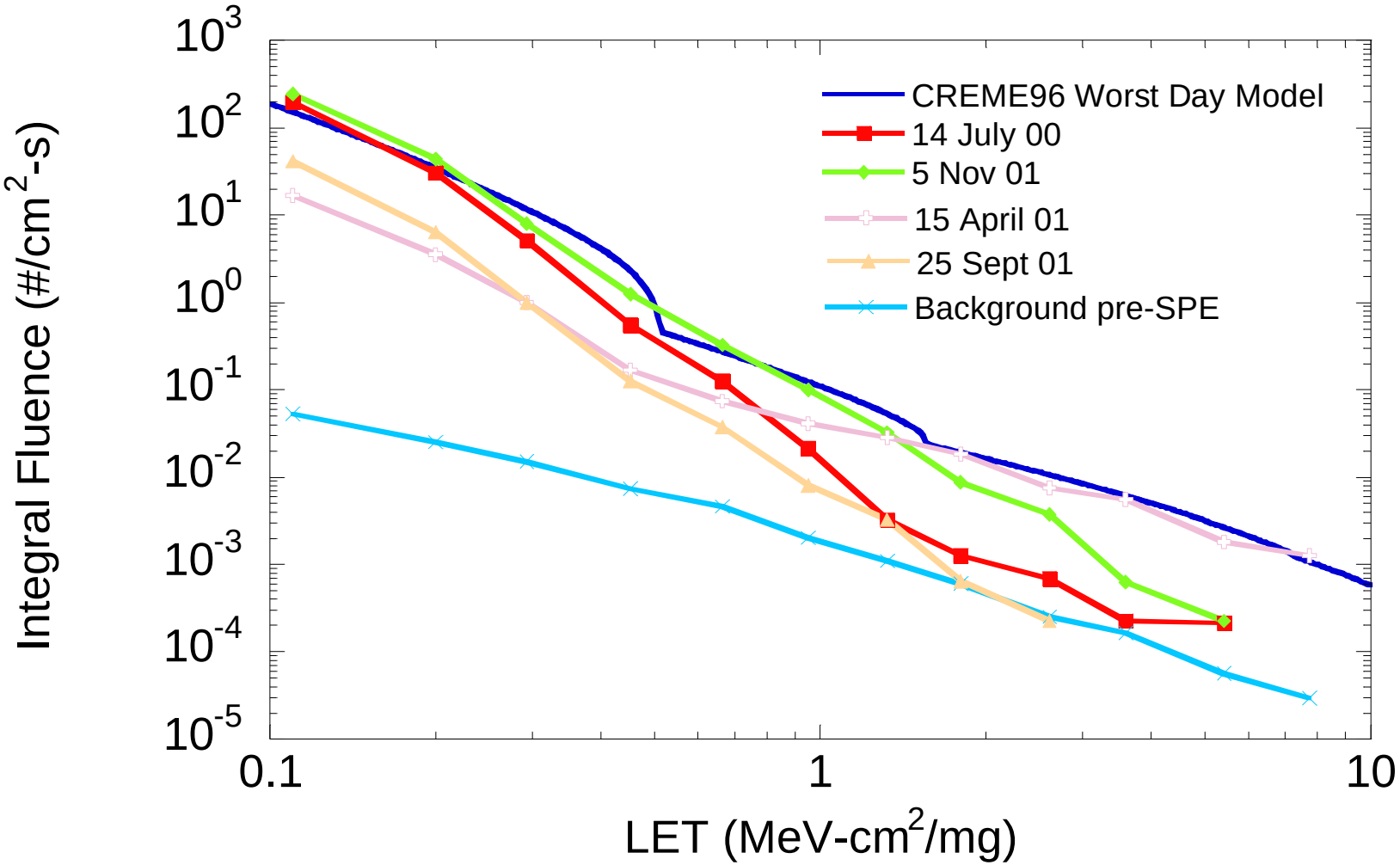
- **NOAA Space Environment Center (SEC) Space Weather Operations branch (SWO)**
  - **http://sec.noaa.gov/**
  - **issues warning and alerts on space weather**
- **Solar radiation storm criteria**
  - **>10 MeV solar protons fluxes**
    - **warning:** **flux > 10 p/s-sr-cm^2 expected**
    - **alert:** **flux > 10 p/s-sr-cm^2** **Minor**
      flux > 100 p/s-sr-cm^2 **Moderate**
      flux > 1000 p/s-sr-cm^2 **Strong**
      flux > 10,000 p/s-sr-cm^2 **Severe**
      flux > 100,000 p/s-sr-cm^2 **Extreme**
  - **>100 MeV solar protons fluxes**
    - **warning:** **flux > 1 p/s-sr-cm^2 expected**
    - **alert:** **flux > 1 p/s-sr-cm^2**

Solar Events Proton Fluxes



Data from NOAA, http://spidrdev.ngdc.noaa.gov

SPE Heavy Ion LET Spectra



After C. Dyer & al., presented at NSREC 2002

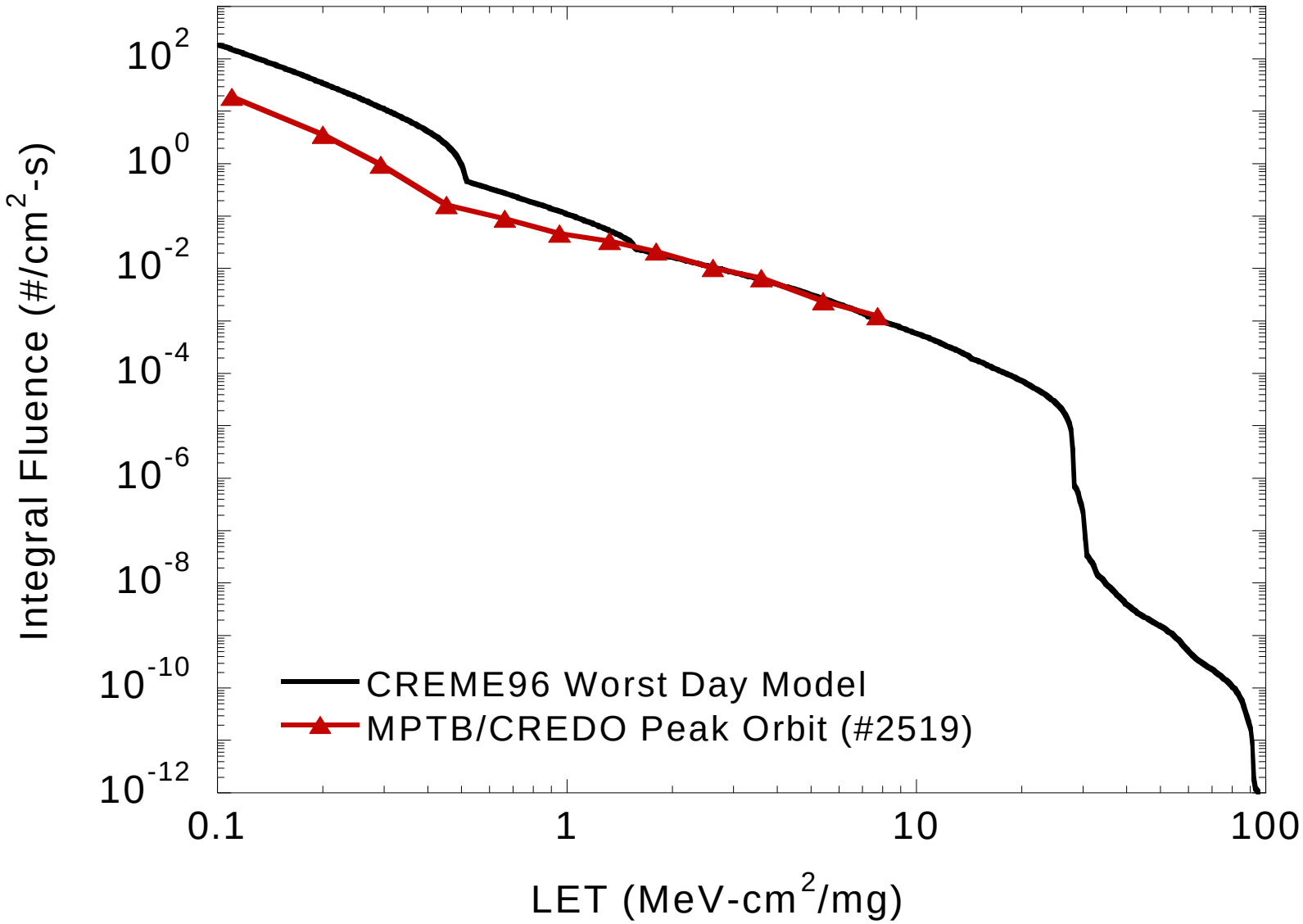
Conclusion

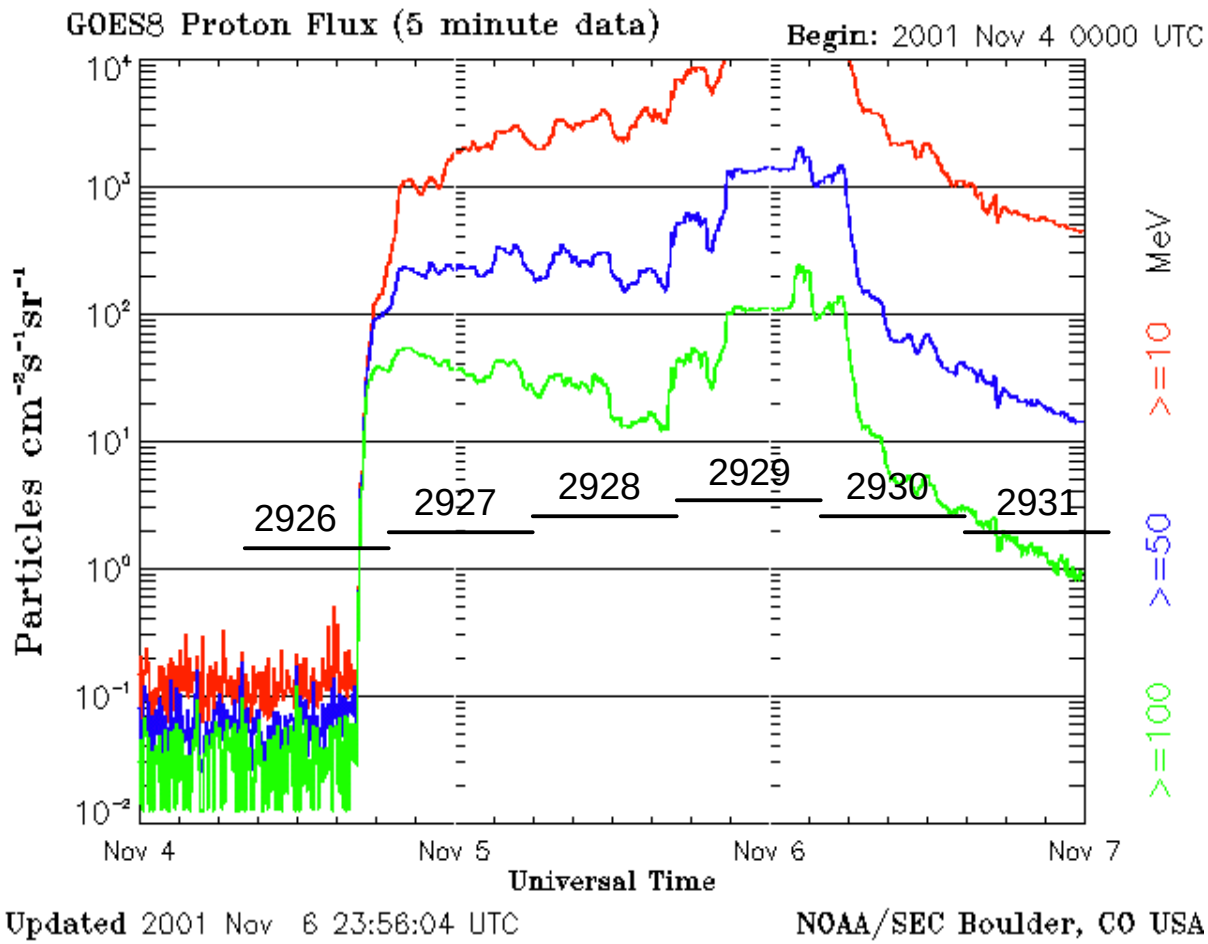
- **A solar heavy ion induced SET on a PM139 is the probable cause for the anomaly, but a GCR induced SET can not be discounted.**
- **The accuracy of SET rate prediction in linear devices still need to be improved.**
- **Measurements from the CREDO LET instrument on MPTB have been very useful for identifying the cause of the reset.**
- **This anomaly demonstrates the need for accurate space weather information including high energy solar heavy ions.**

Acknowledgment

The authors thank Clive Dyer and Art Campbell for providing the MPTB/CREDO3 data during the MAP anomaly analysis.

Backup slides


Integral Fluence (#/cm2-s)
10^2
10^0
10^-2
10^-4
10^-6
10^-8
10^-10
10^-12
0.1
1
10
100
LET (MeV-cm2/mg)
CREME96 Worst Day Model
MPTB/CREDO Peak Orbit (#2519)


GOES8 Proton Flux (5 minute data)
Begin: 2001 Nov 4 0000 UTC
Particles cm⁻²s⁻¹sr⁻¹
Universal Time
Nov 4
Nov 5
Nov 6
Nov 7
>=10 MeV
>=50
>=100
2926
2927
2928
2929
2930
2931
Updated 2001 Nov 6 23:56:04 UTC
NOAA/SEC Boulder, CO USA