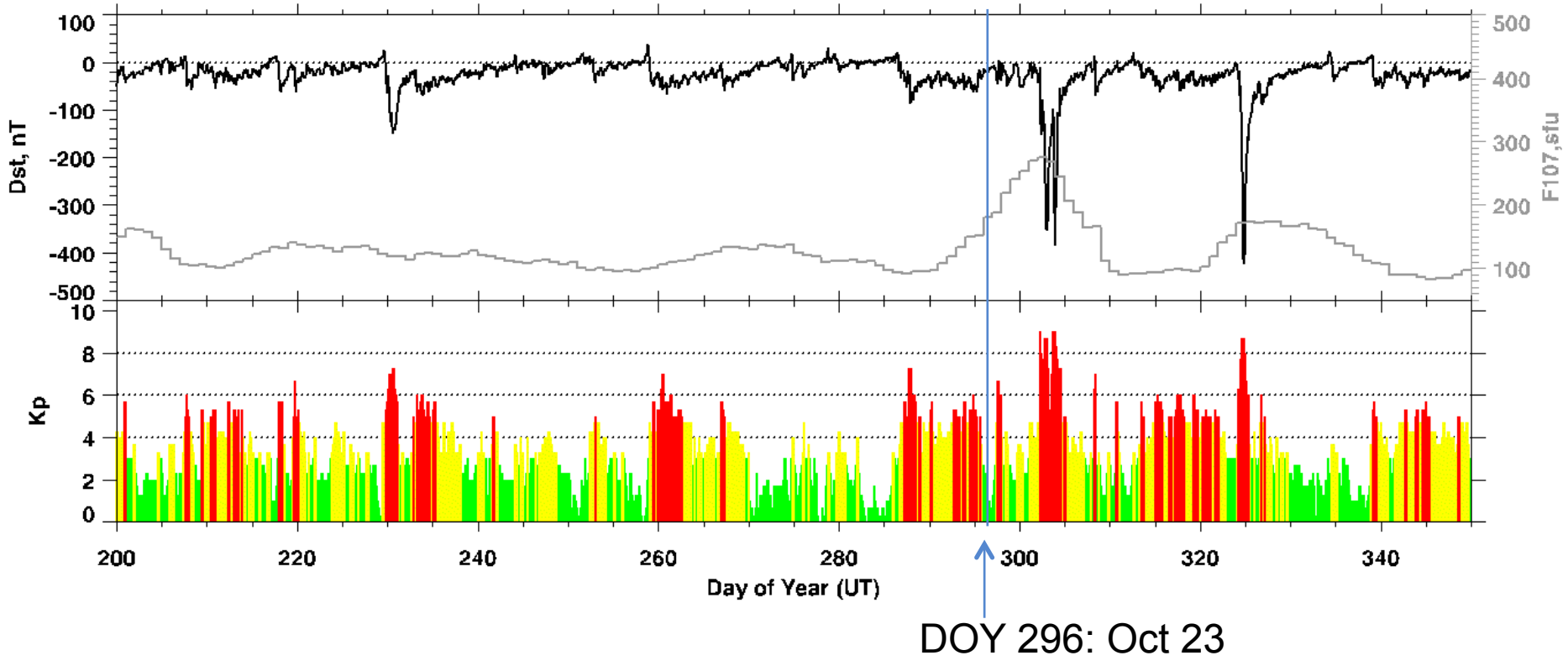
Examples of Space Environment Effects on Satellites

2003 Halloween Storm Impacts on Spacecraft (1)

- **Oct 23:**
  - ***Genesis*** **satellite at L1 entered safe mode, normal operations resumed on Nov. 3.**
  - ***Midori-2*****(*****ADEOS-2*****) Earth-observing satellite power system failed, safe mode, telemetry lost (23:55), spacecraft lost**
- **Oct 24:**
  - ***Stardust*****comet mission went into safe mode due to read errors; recovered.**
  - ***Chandra X-ray Observatory*** **astronomy satellite observations halted due to high radiation levels (09:34EDT), restarted Oct. 25**
  - ***GOES-9, 10 and 12*** **had high bit error rates (9 and 10), magnetic torquers disabled due to geomagnetic activity**
- **Oct 25:**
  - ***RHESSI*** **solar satellite had spontaneous CPU reset (10:42)**
- **Oct 26:**
  - ***SMART-1*****had auto shutdown of engine due to increased radiation level in lunar transfer orbit (19:23)**
- **Oct 27:**
  - ***NOAA-17*****AMSU-A1 lost scanner**
  - **GOES-8 X-ray sensor turned itself off and could not be recovered**
- **Oct 28-30:**
  - **Astronauts on *Intl. Space Station* went into service module for radiation protection**
  - **Instrument on *Integral* satellite went into safe mode because of increased radiation**
  - ***Chandra*** **observations halted again autonomously, resumed Nov 1**

Major indices during 2003 Dst, Kp, F10.7



2003 Halloween Storm Impacts on Spacecraft (2)

- **Oct 28:**
  - ***DMSP F16*** **SSIES sensor lost data twice, on Oct. 28 and Nov. 3; recovered. microwave sounder lost oscillator; switched to redundant system**
  - ***SIRTF*****, in orbit drifting behind Earth, turned off science experiments and went to Earth pointing due to high proton fluxes, 4 days of operations lost**
  - ***Microwave Anisotropy Probe*** **spacecraft star tracker reset and backup tracker autonomously turned on, prime tracker recovered**
- **Oct 29:**
  - ***Kodama*****data relay satellite in GEO; safe mode, signals noisy, recovery unknown**
  - ***RHESSI*****satellite had 2 more spontaneous resets of CPU (28, 17:40; 29, 03:32).**
  - ***CHIPS*** **satellite computer went offline on Oct. 29 and contact lost with the spacecraft for 18 hr. When contacted the S/C was tumbling; recovered successfully. Offline for a total of 27 hrs.**
  - ***X-ray Timing Explorer*** **science satellite Proportional Counter Assembly (PCA) experienced high voltages and the All Sky Monitor autonomously shut off, both instruments recovered Oct 30 but PCA again shut down. PCA recovery delayed into November.**

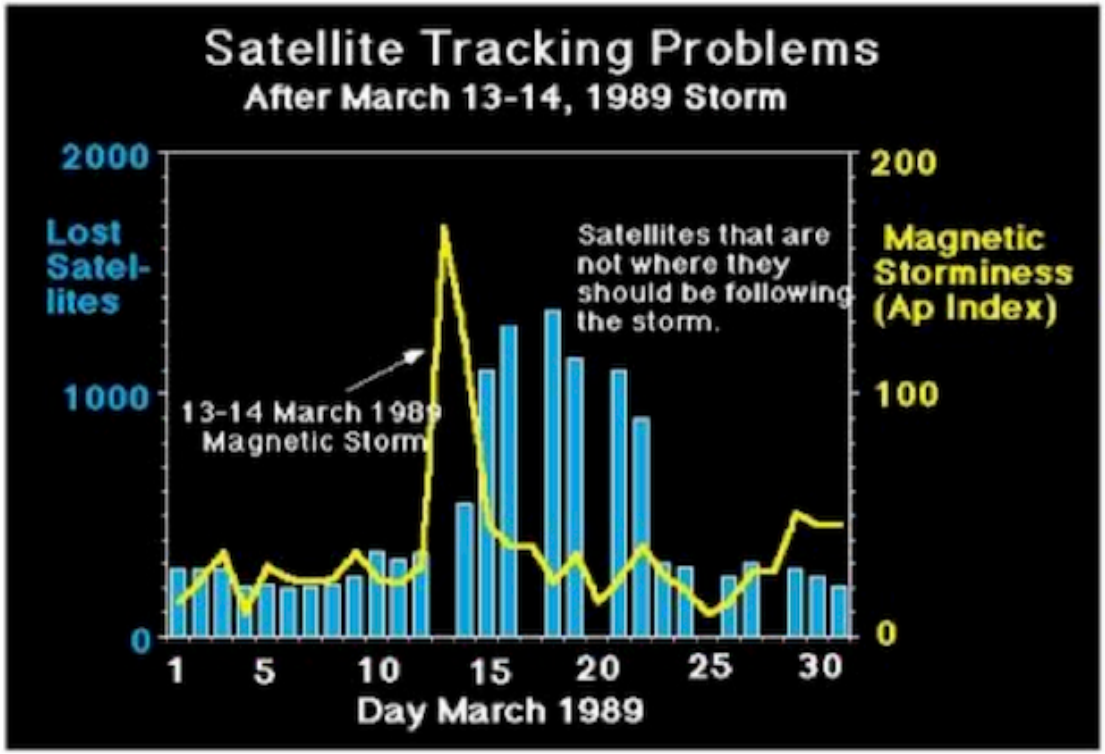
Allen and Wilkerson, 2010
http://www.ngdc.noaa.gov/stp/satellite/anomaly/2010_sctc/docs/1-1_JAllen.pdf

2003 Halloween Storm Impacts on Spacecraft (3)

- **Oct 28-31:**
  - **CDS instrument on *SOHO*spacecraft at L1 commanded into safe mode for 3 days**
  - ***Mars Odyssey* spacecraft entered safe mode, MARIE instrument had a temperature red alarm leading it to be powered off (Oct. 28). S/C memory error during downloading on 29 Oct corrected with a cold reboot on Oct. 31**
  - **Both *Mars Explorer Rover* spacecraft entered "sun idle" mode due to excessive start tracker events**
- **Oct 29:**
  - **NASA's Earth Sciences Mission Office directed all instruments on 5 spacecraft be turned off or safed due to Level 5 storm prediction. Satellites affected include *AQUA, Landsat, TERRA, TOMS, and TRMM***
- **Oct 30:**
  - ***ACE & Wind* solar wind satellites lost plasma observations**
  - **Electron sensors of *GOES*satellite in geosynchronous orbit saturated**
- **Nov 2:**
  - ***Chandra* observations halted again autonomously due to radiation. Resumption of observations delayed for days**
- **Nov. 6:**
  - ***Polar* TIDE instrument reset itself and high voltage supplies were disabled; recovered within 24 hr.**
  - ***Mars Odyssey* spacecraft commanded out of Safe mode; operations nominal.**

adapted from Allen and Wilkerson, 2010
http://www.ngdc.noaa.gov/stp/satellite/anomaly/2010_sctc/docs/1-1_JAllen.pdf

Space Weather Impacts on Satellite Positioning/Tracking

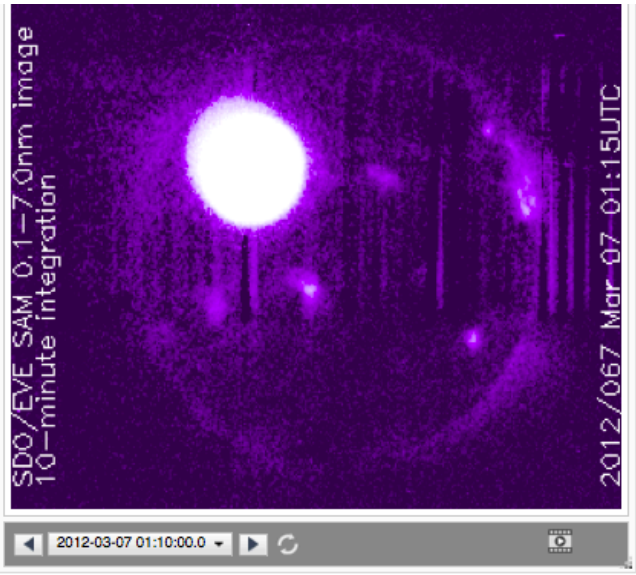


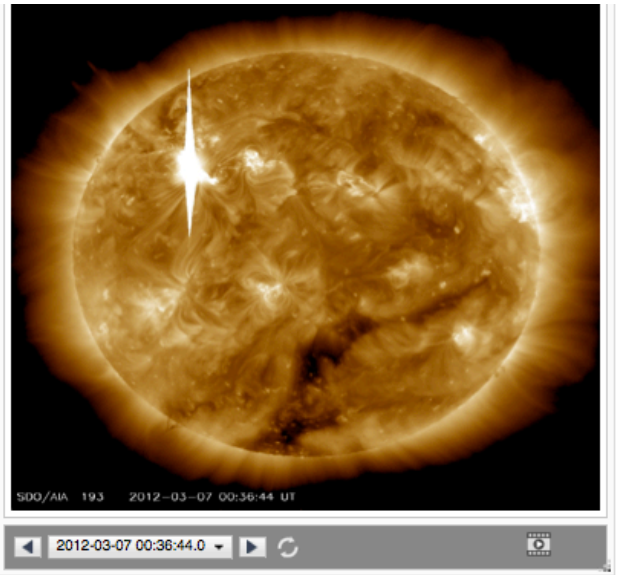
After a large geomagnetic storm in March, 1989, the North American Aerospace Defense Command (NORAD) had to re-identify hundreds of objects due to loss of tracking and compute their new orbits. During the same March 1989 storm event, for example, the NASA's Solar Maximum Mission (SMM) spacecraft had dropped its altitude as if it hit a “brick wall" due to the increased atmospheric drag.

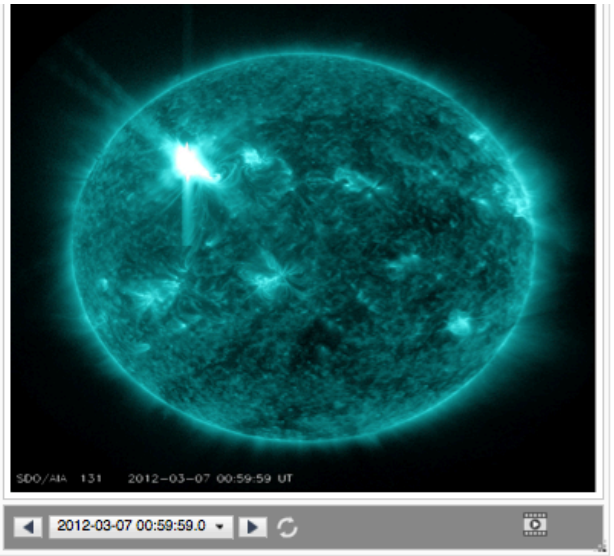
http://www.swpc.noaa.gov/impacts/satellite-drag

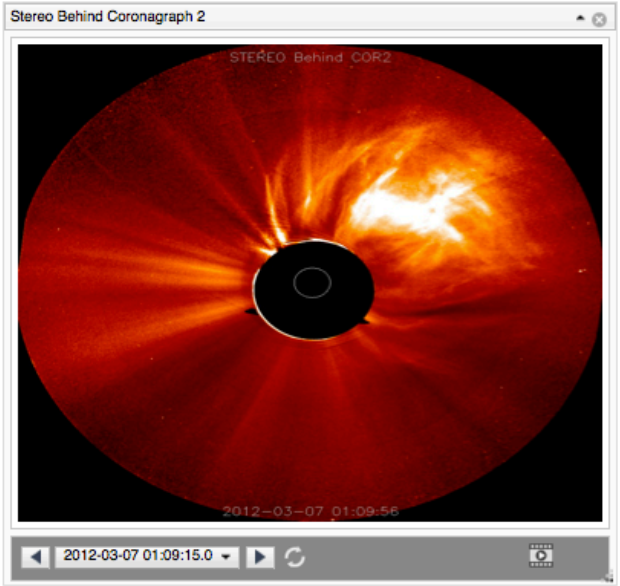
Operator response to SWx impacts for the March 2012 events spacecraft specific/instrument specific

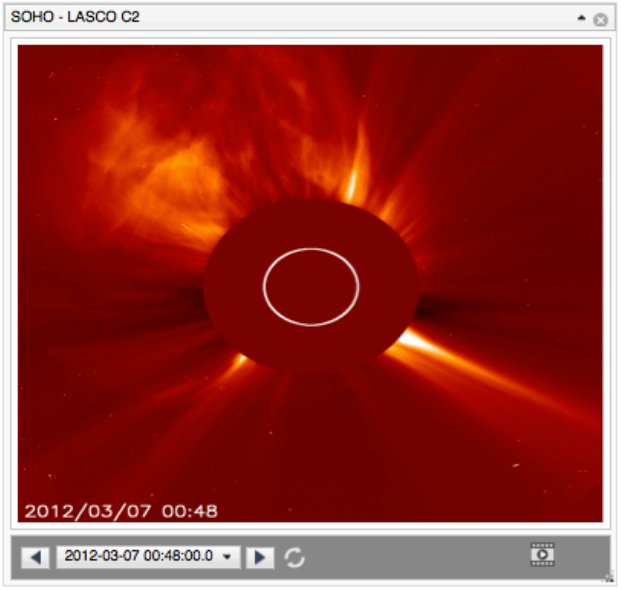
March 7 flares/CMEs

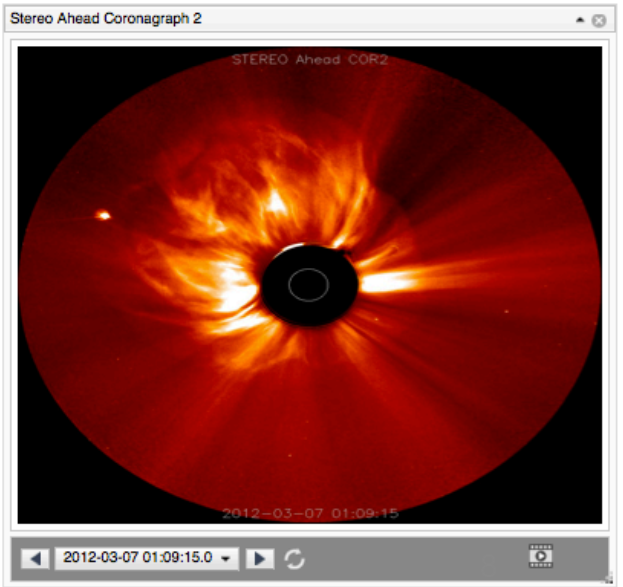


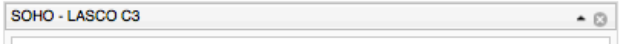


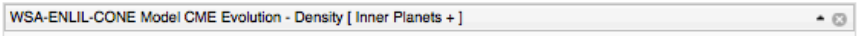




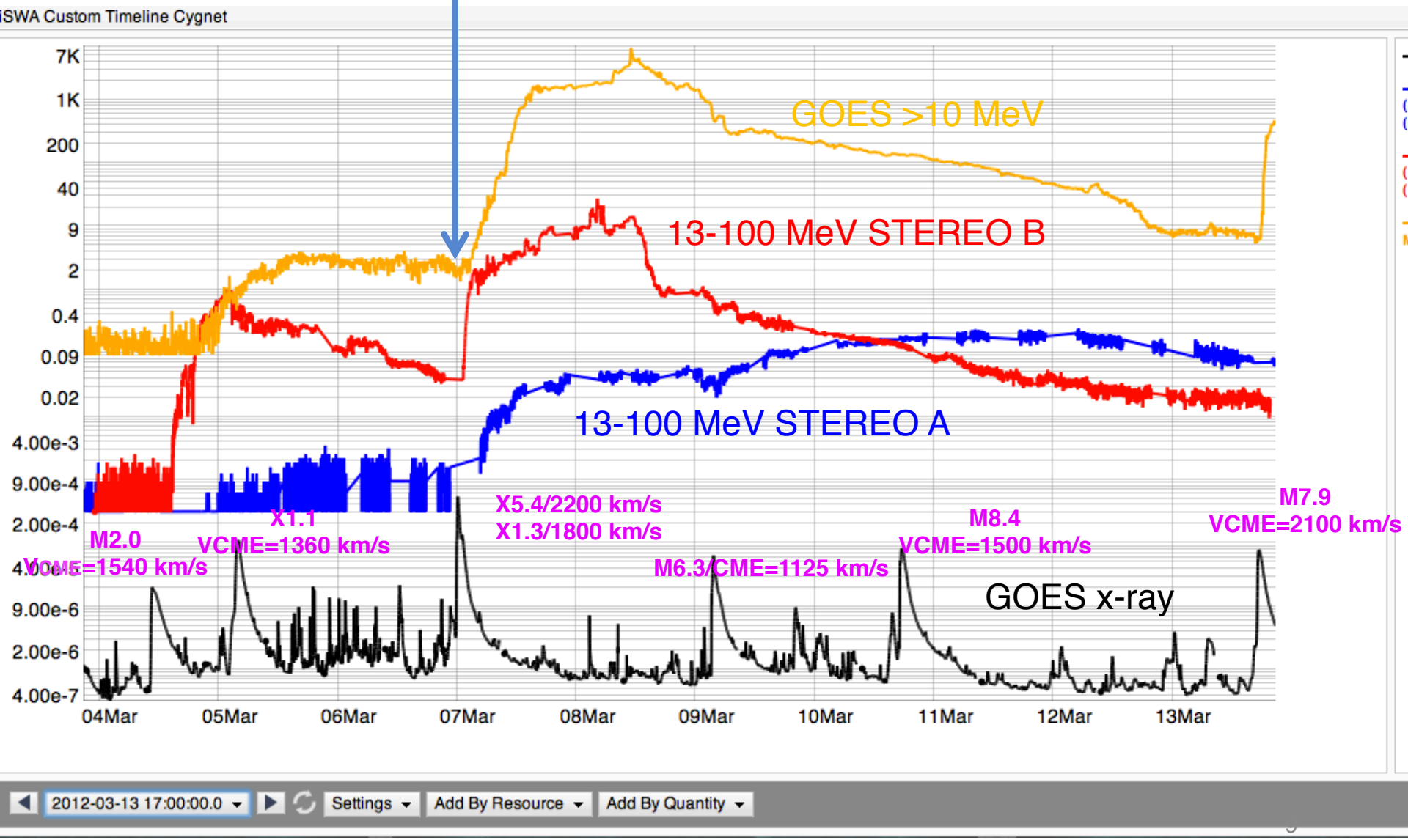








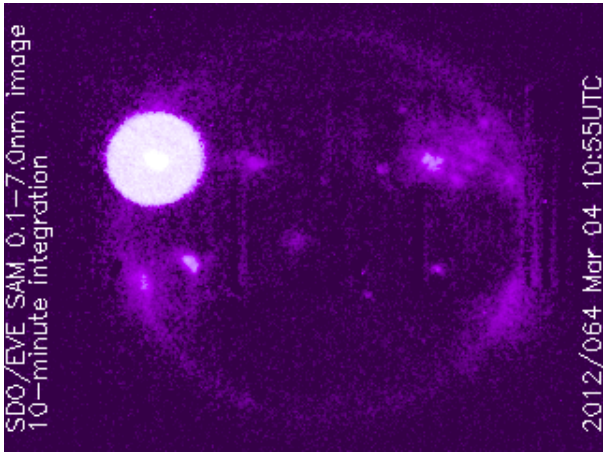
SEP: proton radiation (flare and CME)



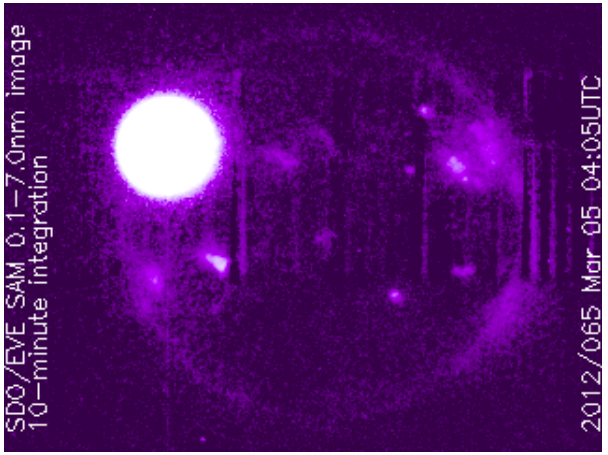
Major events from the long-lasting AR1429 during March 4 – 28, 2012

Flares of the Major Earth-Facing Events viewed by SDO EVE (x-ray)

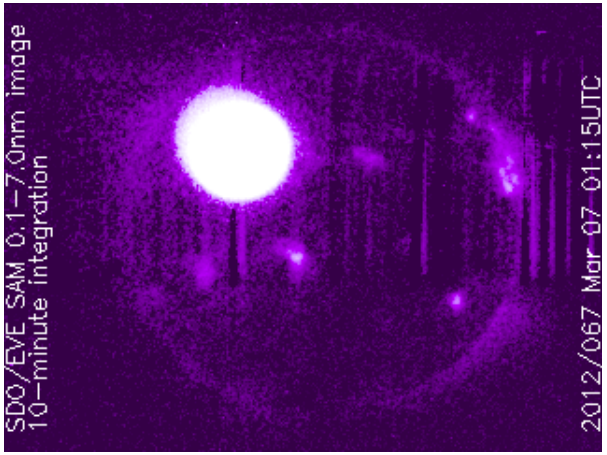
M2.0, 2012-03-04



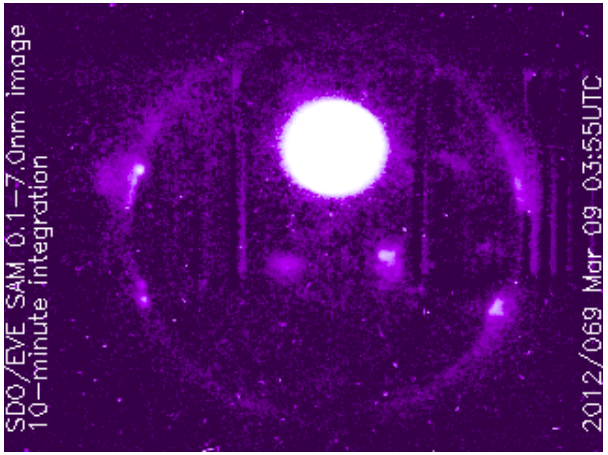
X1.1, 2012-03-05



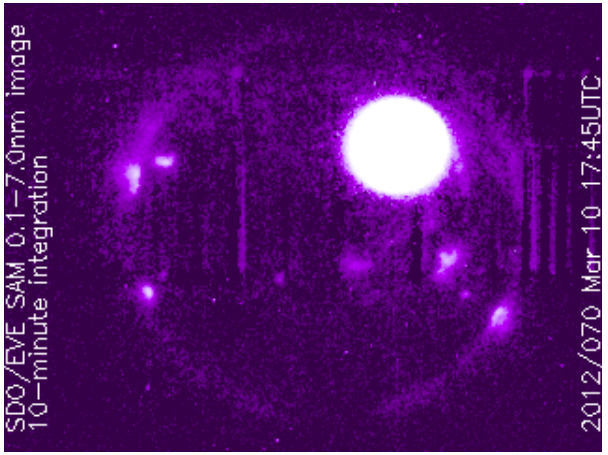
X5.4/X1.3 2012-03-07



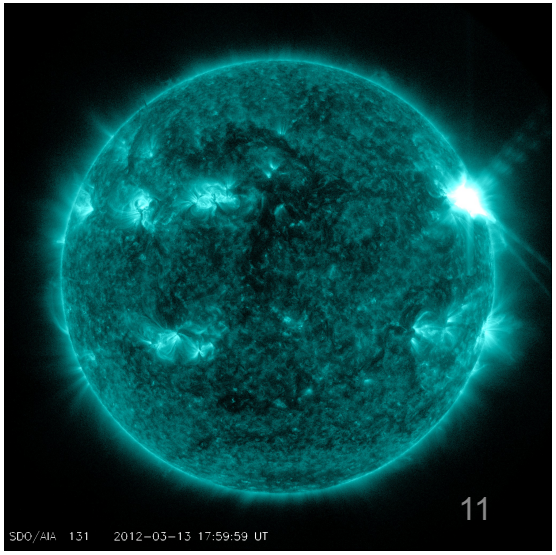
M6.3, 2012-03-09



M8.4, 2012-03-10

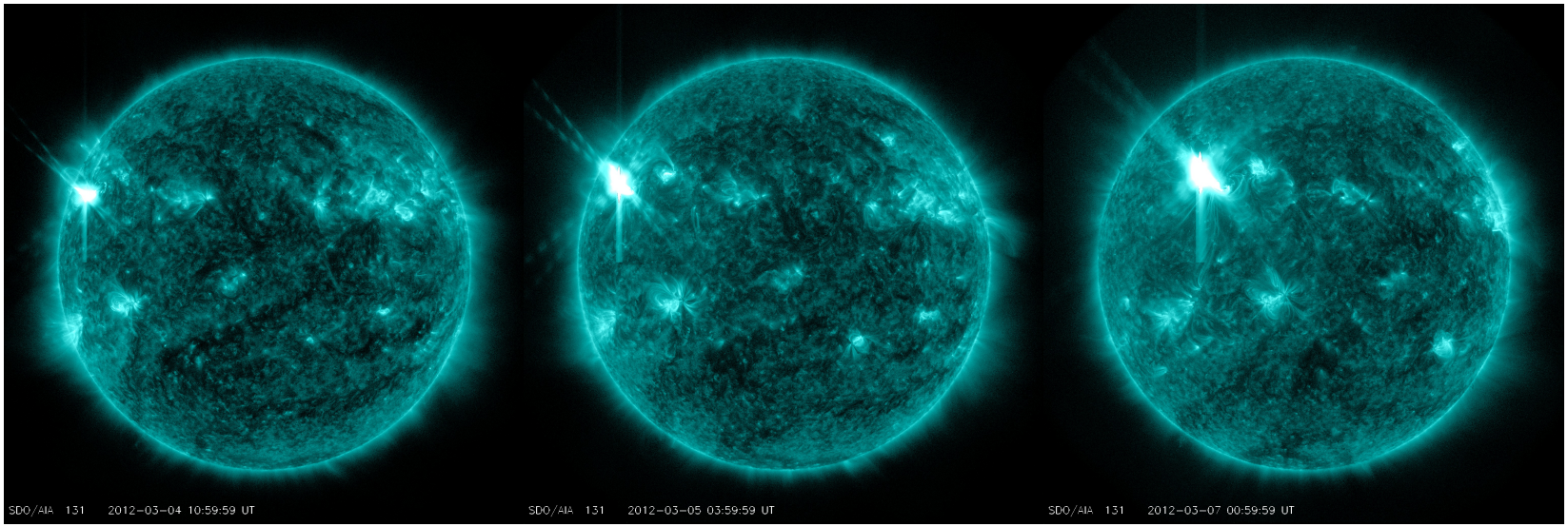


M7.9, 2012-03-13

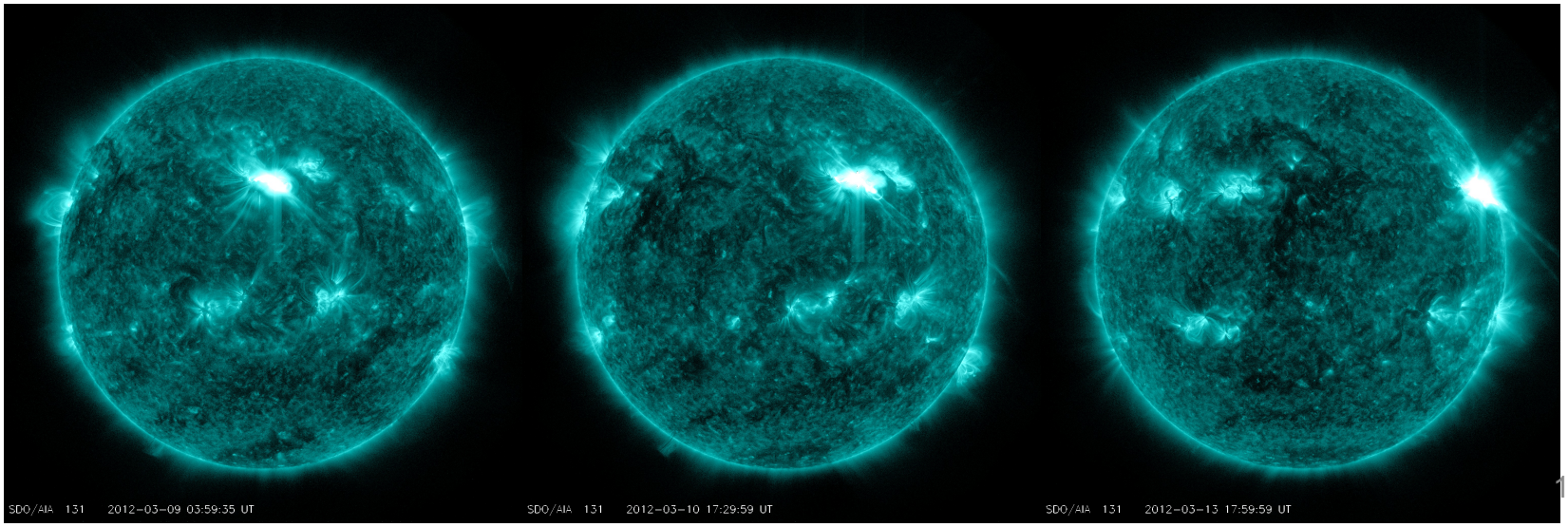


Flares of the Major Earth-Facing Events viewed by SDO AIA 131

M2.0, 2012-03-04 X1.1, 2012-03-05 X5.4/X1.3 2012-03-07

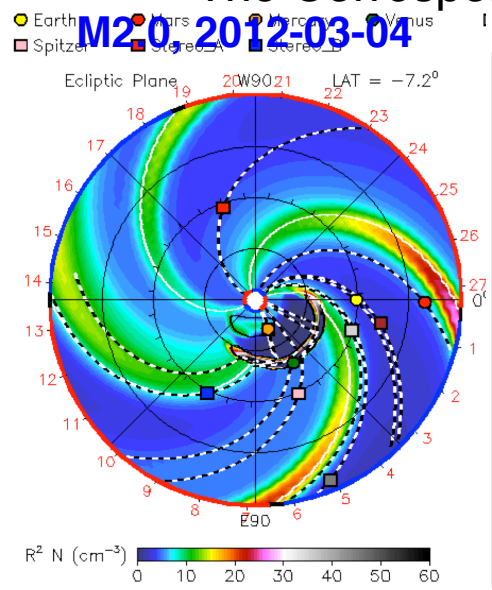


M6.3, 2012-03-09 M8.4, 2012-03-10 M7.9, 2012-03-13

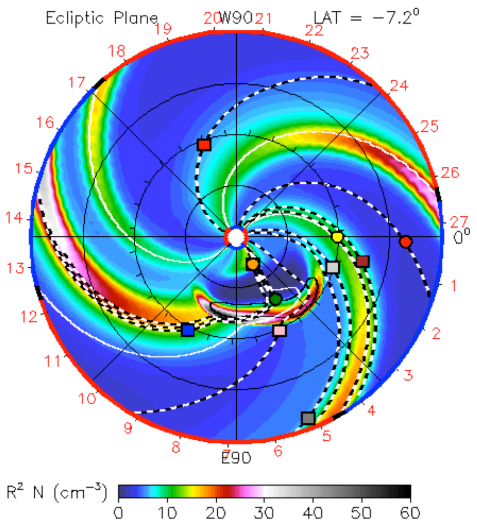


The Corresponding CMEs Associated with the Flares

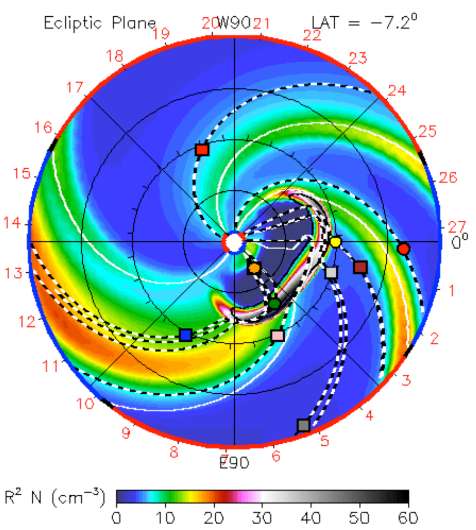
M2.0, 2012-03-04



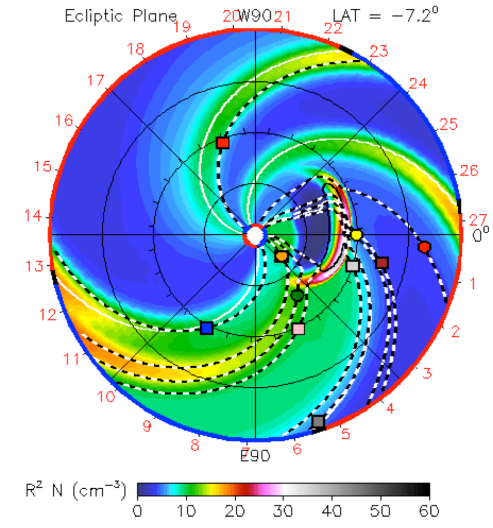
X1.1, 2012-03-05



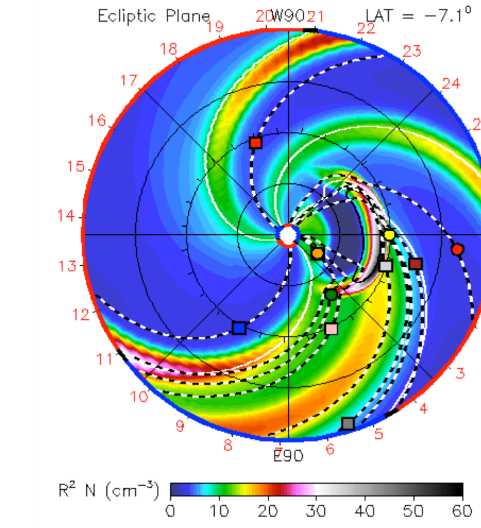
X5.4/X1.3 2012-03-07



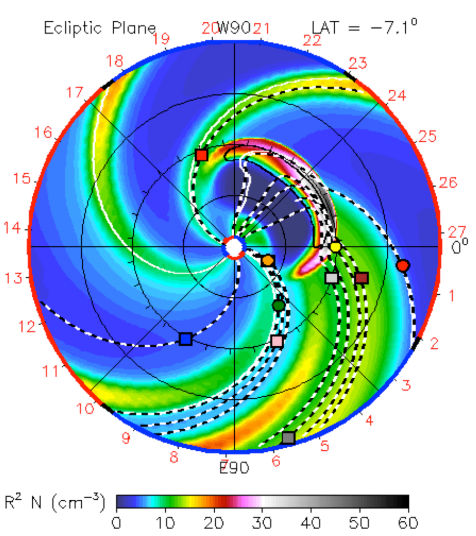
M6.3, 2012-03-09



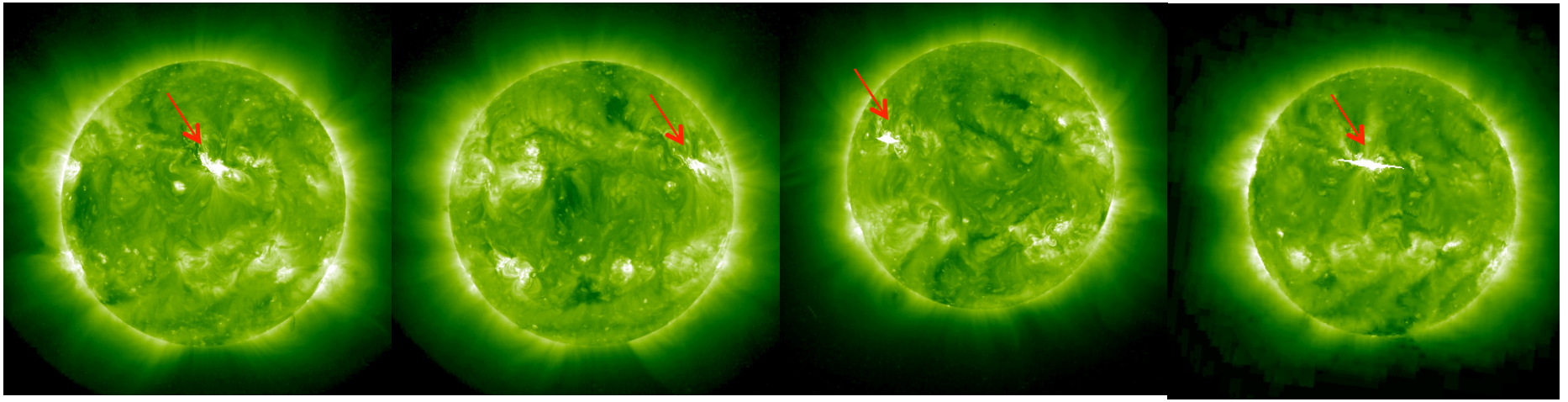
M8.4, 2012-03-10

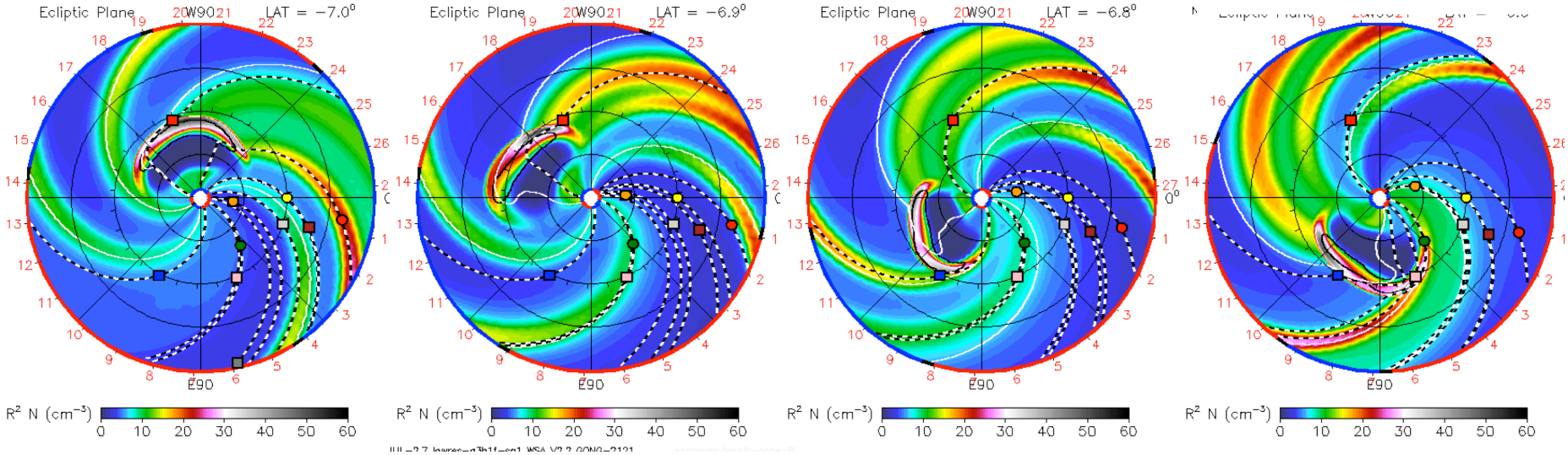


M7.9, 2012-03-13



STA: 2012-03-18 STA: 2012-03-21 STB: 2012-03-24 STB: 2012-03-26





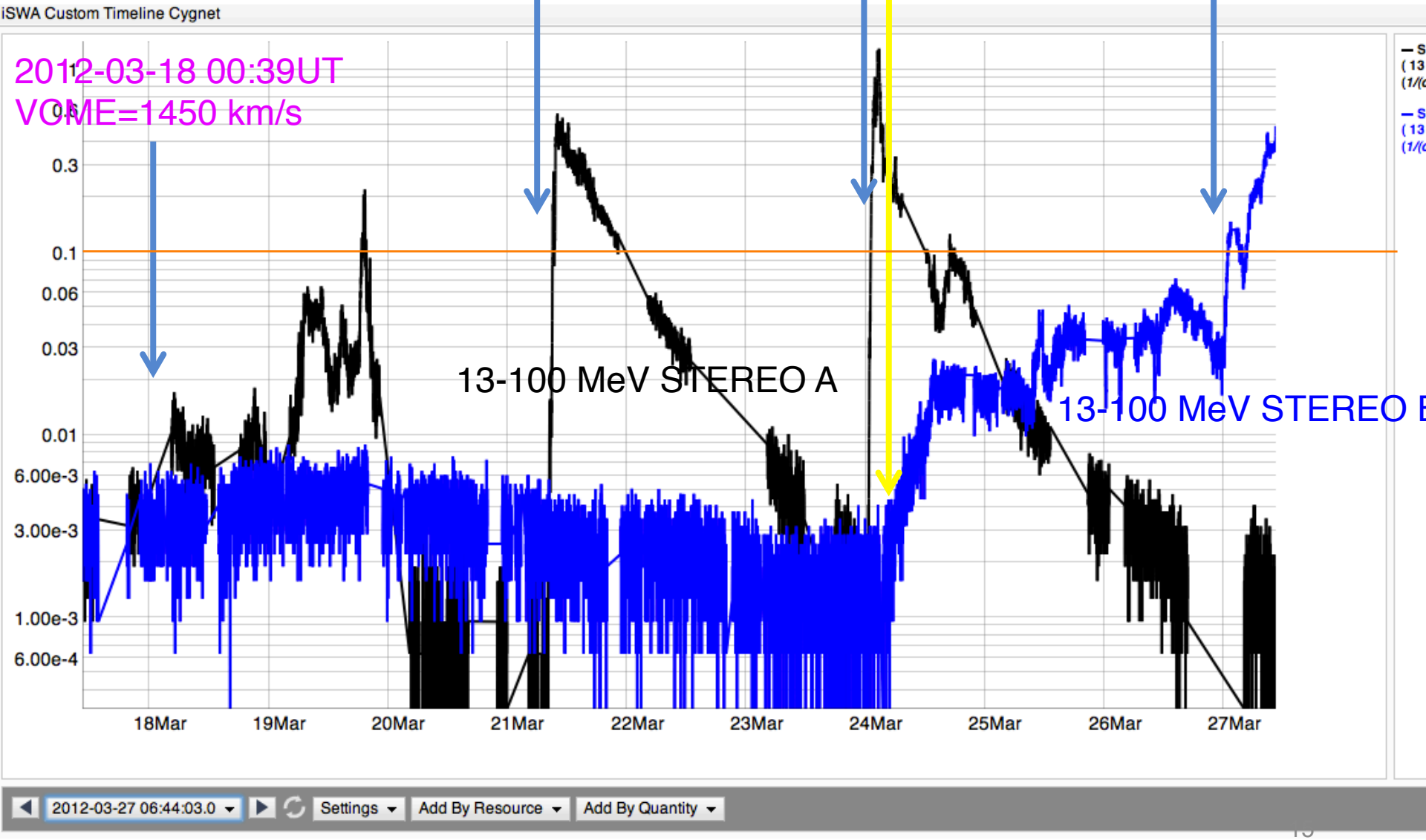
Backsided events in STEREO EUVI 195A (top) and CME model simulations (bottom)

2012-03-21 07:39 UT
VCME=1550 km/s

2012-03-24 00:39UT
VCME=1600 km/s

2012-03-26 23:12UT
VCME=1500 km/s

Enhanced proton radiation at STEREO A and B from the backsided events.



Supplementary Material

- View our video, Incredible Active Region 1429: One for the record books, to learn more about the activities from this region from March 4 – March 28, 2012. http://youtu.be/dxl5drPY8xQ
- Summary Video of the March 7, 2012 event

  http://youtu.be/HeoKf6NfEJI

  Full text of event summary

  http://goo.gl/dTnfd

Supplementary Material

- Youtube video from Henry Garrett at JPL - http://www.youtube.com/watch?v=NarzGDuYYX4

  2 hour and 40 minutes long