Overview

- The most often requested science instrument onboard CXO (ACIS) cannot be operated in high flux, soft proton environment within the magnetospheric and solar particle events due to a CD damage mechanism from ~100-200 keV protons.
- The ACE EPAM monitor provides the only data source available for directly measuring the soft protons in interplanetary space that damage ACIS CD’s.
- No other users of ACE EPAM RTSW data have been identified to date, it appears that Chandra is the only program using the EPAM data.
- Current NOAA plans to discontinue ACE RTSW data starting late 2014 or early 2015 when the Deep Space Climate Observatory (DISCOVER) spacecraft becomes the primary NOAA space weather data source from Suo-Earth 11 Lagrange point, and DISCOVER does not have instrumentations to monitor the proton energy range required to protect the ACIS detector.
- The loss of this real-time data stream could cause a significant impact to the science lifetime and data quality for this Great Observatory.

Current CXO ACE EPAM Data Requirements

- Chandra requires real-time ACE EPAM data for monitoring and implementing manual interruptions of Chandra science operations if necessary. ACE Science Center Level 2 (verified) and Browse (unverified) science products are not updated often enough to be useful for operational support.
- Access to 5-minute average ACE EPAM RTSW data (status quo) is the preferred option for Chandra since it allows continued interruption of our radiation mitigation strategies to minimize the proton damage in the ACIS CCD detectors and the importance of real-time data sources that are used to protect the ACIS detector system from space weather events.
- However, data rates are negligible as ACE proton radiation damage is a fluence issue, with long exposure periods to soft proton flux required for significant damage to CD’s.
- Lower real-time data rates are acceptable as long as sufficient information is available to estimate soft proton fluence, ACE EPAM RTSW data rates at periods up to once per hour can be used by Chandra to monitor soft proton environment.

The Future of ACE Real-time Data

The ACE/EPAM RTSW records are the only real-time data currently available for detecting soft ~100-200 keV proton events in interplanetary space that impact the ACIS instrument.

NOAA plans to replace ACE with Deep Space Climate Observatory (DISCOVER) in late 2014
- DISCOVER will become the primary NOAA-space weather data source
- ACE RTSW coverage will be discontinued
- DISCOVER carries a MAG/SWEPEM type cold solar wind plasma and magnetic field instrument

No replacement for non-thermal EPAM, SA energetic particle instruments on DISCOVER

DISCOVER is planned as an interim solution for an ACE replacement with release of an RFP for a full replacement after DISCOVER at some cost.
- Full ACE replacement satellites could have a more complete set of cold plasma, energetic particle instruments including an EPAM replacement that will be in service for a few years for the real-time energetic particle data.
- None of this has been authorized by Congress so it is all uncertain at best
- The gap could be many years

Loss of ACE/EPAM soft proton data will impact CXO operations.
- Are there other spacecraft or space weather users that require the RTSW ACE EPAM data for operations that will be similarly impacted?
- The CXO Program would like to know...

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Introduction to the Chandra X-ray Observatory (CXO)

CXO launched 23 July 1999 onboard STS-93
- Current orbit: ~1.6 Re x 23.7 Re x 74", ~63.5 hour period Mission
- 5-yr primary science mission
- Currently in 2nd 3-yr extension
- Planning for 3rd to 2019 and 4th to 2023

The table above indicates Solar Cycle 24 events where ACS science data was lost due to radiation events. Autonomous “auto” events are triggered by a high flux of solar energetic particles that generate high count rates in either the anti-coincidence shield of the High Resolution Camera (HRC) or the EPAM E1300 channel. The on-board radiation monitoring system sends a signal to autonomously move the ACS instrument from the focal plane position to a protected location that cannot be accessed by the soft protons for these events. Manual events require operator intervention based on ground based monitoring of the ACE F3 channel from the NOAA RTSW data stream. In addition, there is one period of high solar activity that the CXO science team could benefit from the enhanced Command Telemetry Unit that put the spacecraft in safe mode. Of note is that four out of fourteen events that result in lost science observations are manual events due to only soft protons that would not have triggered the autonomous move to the radiation protection systems, leaving the ACS instrument vulnerable to additional radiation degradation.

The above graphs represent two examples of periods with lost ACS science observations (gray boxes) and the corresponding temporal variations in the radiation environment measured over a range of energies by GOES and ACE instruments. Radiation interceptions during the current solar cycle show a range of fluxes of significant and autonomous HIC events, a single event upset that put the spacecraft in safe mode, and the manual events based on the ACE F3 rates. The autonomous HIC at ~300-500 eV proton energy level from high energy solar particle events and sometimes even lower but not always, from the high flux of soft protons. The ACE F3 instrument is the only source of real data that can be used to guard against soft proton events that are not accompanied by high energy particles. All of the on-board autonomous systems are driven by high energy particle events.

The Advanced CCD Imaging Spectrometer (ACIS) is CXO’s premier science instrument, most often operated in observatory programs. Currently, the AXP, ATNF, and others are using ACIS to monitor the solar wind and interstellar medium.

Damage to the detector has been successfully mitigated through a combination of careful mission planning, autonomous on-board radiation protection, and manual intervention based upon real-time monitoring of the soft proton environment.

Manual intervention for soft proton events in interplanetary space is based on monitoring 115 – 15 keV proton fluence using data from the P4 channel of the Electron, Proton, and Alpha Monitor (EPAM) instrument on the Advanced Composition Explorer (ACE) spacecraft.

NOAA Space Weather Prediction Center (SWPC) currently provides ACE/EPAM as a component of the Real Time Solar Wind (RTSW) data stream. ACE/EPAM is the only data source for real-time measurements of the ~100-200 keV proton environment primarily responsible for damage to ACIS CD’s interplanetary space.

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