The Advanced CCD Imaging Spectrometer (ACIS) is CXO’s premier science instrument, most often used in CXO’s screening operations for the 28 instrument campaigns. ACIS CXD detectors were observed to be much worse than expected.

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The grazing incidence optics used to focus the short wavelength x-rays are also efficient at focusing the soft protons from the space environment onto the observatory focal plane which degrades the energy resolution and charge transfer efficiency of the Advanced CCD Imaging Spectrometer front-illuminated CCD’s.

Damage to the ACIS 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 P7 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 ACES/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 ~10-200 keV proton environment primarily responsible for damage to ACIS’s front-illuminated CCD’s.

Overview

- The most often requested science instrument onboard CXO (ACIS) cannot be operated in high flux, soft proton environment within the magnetosphere and solar particle events due to a CO damage mechanism from ~100-200 keV protons.
- The ACE EPAM instrument provides the only data source available for directly measuring the soft protons in interplanetary space that damage ACIS’s.
- No other users of ACE EPAM RTSW data have been identified to date, it appears that CXO 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 (DSCOVR) spacecraft becomes the primary NOAA solar weather data source from Sun-Earth 1L Lagrange point, and DSCOVR does not have instrumentation onboard 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 CXO since it allows continuous monitoring 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 ACIS radiation damage is a fluence issue, with long exposure periods to soft proton flux required for significant damage to CCD’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 times up to once per hour can be used by CXO to monitor soft proton environment.

The Future of ACIS 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 Observatories (DSCOVR) in late 2014
- DSCOVR will become the primary NOAA-solar weather plasma data source
- ACE RTSW coverage will be discontinued
- DSCOVR carries a MAG/SWEPAM type cold solar wind and magnetic field instrument
- No replacement for non-thermal EPAM, Au energetic particle instruments on DSCOVR

DSCOVR is planned as an interim solution for an ACE replacement with release of an RFP for a full replacement after DSCOVR is launched.

- Full ACE replacement satellite could have a more complete set of cold plasma, energetic particle instruments including an EPAM replacement which will be a gap 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 24°
- ~65 hr mission period

- 5-year primary science mission
- Currently in 2nd 5-year extension
- Planning for 3rd to 2019 and 4th to 2023

The table above indicates Solar Cycle 24 events where ACIS 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 ACIS 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 P7 channel from the NOAA RTSW data stream. In addition, there is one period of low solar activity due to high Earth’s magnetic field strength and command to the 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 soft protons that would not have triggered the autonomous protection systems, leaving the ACIS instrument vulnerable to additional radiation degradation.

The above graphs represent two examples of periods with lost ACIS science observations (gray boxes) and the corresponding temporal variations in the radiation environment measured over a range of energies by GOES and ACIS instruments. Radiation interferences during the current solar cyclestemmed from a number of sources including autonomous HRC events, a single event upset that put the spacecraft in safe mode, and the manual events based on the ACE P7 flux. The autonomous HRC events (~500 events) are caused by radiation from high energy solar particle events and sometimes the solar flare but not always, from the high flux of soft protons. The ACE P7 instrument is the only source of real time 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.

ACIS

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