Notes of ongoing Constellation-X Calibration Meetings

==========

First calibration meeting was held at the June 20, 2000 FST meeting

---

We require an on-board calibration source for the detectors

Calibration must be set out for all phases of the mission
- schedule resources
- cost estimates
- mass, power resources
- optical alignments
- mirror contamination
- will calibration take away from science time?

Various important items:
PSF
E, energy response
instrumental deltaE
optics/gratings together
calorimeter
HXT + detector

How much calibration should we do on the ground?

Does grating calibration need to wait until the mirrors are assembled?
Can we do some with some mirror shells?

Make room in the schedule for a full end-to-end calibration with the calorimeter and mirrors together.

Radiation belt monitor? ACE warnings.

NGST radiation at L2 - see report

Transfer phase: The trip to L2 will give us 3 months of check-out time, but the radiation environment will change with distance.

What about orbital attitude during transfer -
How much can we control the spacecraft during the transfer?

Lessons learned from the first satellite (radiation damage, etc.) can be applied to the 2nd, 3rd, and 4th satellites. Do we have time to make changes on a few months timescale?
What kinds of contingency plans will we have to fix or replace things pre-launch?
Modular instruments?

SXT
- There were conflicts in the effective curves around 1 keV, but the response in the decadal report now matches the nominal XRS response - nickel mesh, etc.

Baseline filters vs. new filters - keep ourselves open.

Establish and document a calibration baseline!
Gather the current status of the mirror areas, detector efficiency, background.

coolers:
http://irtek.arc.nasa.gov/CryoDev.html

==========

Second Calibration meeting was held on July 11, 2000
(Kim, Jay, R. Kelley, J. Leaman)

Problems are (1) a lack of money for ground calibration and (2) changes between launch and transfer to L2. Should we do the minimum ground calibration needed and then do the rest in-orbit?

1) Basic ground calibration with mirror segments or whole mirror on its side.
2) in-orbit

First we need to pursue the in-orbit part. **That's where the real calibration counts. What hardware do we have to purchase in the next year?

When the calorimeter gets to 2 eV resolution, we'll want funding for a good monochrometer and calibration hardware.
- monochrometer at GSFC or MSFC?
schedule -
-> in-orbit plan
-> ground hardware strategy (purchasing)
-> later end-to-end plan

in-flight calibration

- detectors
- radiation (long-term)
- background (long-term)
- environmental changes

CCDs and grating
How does the dispersion relation change? Mechanical stability in the grating mounting.

Rich Kelley points out an issue with noise isolation for the reaction wheels and gyros - fixed vs. extendible bench option. Is all the movable hardware located on the mirror end?

Need calibration error budget for each term. Instrument terms; Mission terms.

Revisit top-level calibration requirement of +/-0.2 eV for the calorimeter.
Is this good enough?

Locate calibration plans and procedures for XMM and Chandra and Astro-E.

What percentage accuracy do we need. Calibrate the calorimeter resolution to 10%?

Model ourselves on the AXAF approach?
We need to balance between the bottom-up and top-down approach.
We have cross calibration issues that AXAF didn't have.
Constellation-X cannot afford to fully calibrate all 12 instruments.

XRS - measure the transmission of the 5 blocking filters
- calibrate the filters separately before integration.

What must be calibrated for each satellite?
This will impact the design requirement. For example, have the calorimeter designed so that we can test it horizontally (for an end-to-end test with mirror shells).

Collect any "lessons learned" from prior missions.

Calibration targets:
- check-out phase and normal operations

How important are stray light issues for the HXT?

Flight hardware impacts? Start to define what hardware we need for our ground/on-orbit calibration. Strawman definition of the hardware.

==========

At the Hawaii HEAD meeting was held on November 8, 2000
(Jay, Kim, Nancy Brickhouse, Mark Bautz, Randall Smith)

Energy resolution needs to be 800-1,200 based on current science results from XMM and Chandra.

Contact FST members and see what they think we should be optimizing for. We need to solicit input from scientists on the calibration.

The Chandra wavelength scale is based on a couple of lines, but there is line blending.

Con-X resolution is 0.05 angstroms - how well do we need to calibrate?
Calibrate to 10%, 20%?

HEG FWHM is 0.01 angstrom. We need to calibrate to 2 milli-angstroms.

The relative calibration will be as challenging as the absolute calibration.
Will the relative stability remain linear at all wavelengths?

We need to know the calorimeter temperature to 1 milli-Kelvin.
We will have to track the temperature at all times.

What atomic physics do we need know before launch?
What are our error terms?
Do we know the line energies well enough? Maybe not for an electron impact source.

For the grating we need at least one calibration line per chip.
0.1-1.2 keV is the energy range to cover.

Should we have an automatic calibration source that "turns on" every few hours. How often?

HEG - Herman Marshall has found no wavelength deviations in the HEG calibration. The wavelength scale has not changed in orbit, but the Chandra requirements are less stringent than ours.

HEG and MEG currently differ by 5 milli-angstroms in their wavelength scales.

**Action item: Need an electron impact source spectrum. Find out what lines are present. They should be strong and unique enough that they can be distinguished from the celestial sources.

Chandra calibration:
- HEG was calibrated on the ground.
- The line-shape function (probability distribution) is being done in orbit.
- AXAF calibration budget was about 1 million.
- Absolute flux calibration for the AXAF XRCF not as good as it should have been.

Can we calibrate the first Constellation-X satellite on the ground and then do most of the calibration for the others on-orbit? Can we totally calibrate 2, 3, and 4 based on 1? What about 1 and 3? It depends on how different they are. What if we loose our best calibrated satellite?

Are celestial targets good enough for the wavelength scale?

We need **scientifically justifiable** calibration requirements!

- Decide these requirements based on discussions with scientists.

Constellation-X is planned to have zero-order imaging. The image is needed to get the pointing accuracy. Current requirement is to locate the zero-order image.

CCDs - after delivery at the observatory level, how much calibration time to they need? (about 1 month?) AXAF had three months scheduled and ended up with 11 days.

How well we know the effective area from 0.2-1.5 keV will affect the line ratios due to how the continuum will be drawn/measured.

**Action item: Develop a strawman mission; plan for the known science first.