Re-thinking Calibration from a Mission Perspective

Cross-Calibration as if it really mattered

D. Jerius

Smithsonian Astrophysical Observatory

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Outline

Calibration as the CALDB

The focus is on the **Observer**

- The final (only?) product is the CALDB
- Accompanying documentation is oriented towards usage, not provenance.
- Input data products or analyses are not published
- Inter-operability with other missions is not a primary goal

Ooops!

What happens after

- ... a mission ends
- ... a mission downsizes
- ... calibration scientists move on to other projects
- ... instrument teams deliver and move on

Does Calibration End? *Yes!* *No!* *Maybe?*

Case in Point: Mirror Contamination

The *Chandra* Optics team wanted to evaluate how contamination might affect *XMM-Newton*'s mirrors; the *XMM-Newton* scientists with the requisite knowledge and the requested data were no longer available.

Calibration Transcendent

Focused on the **Observer** and **other Calibration Scientists**

In addition to the Observer focused objectives:

- Standardization of pre-CALDB products
- Publishing of pre-CALDB products, analyses, techniques
- Public availability of ground calibration data

A comprehensive public archive
of a mission's calibration history.

Calibration and Operations Continuity

It is important to have ***continuity*** between pre-flight calibration teams and on-orbit operations and calibration teams.

Pre-flight teams include instrument teams as well as telescope teams.

What does this mean?

- On-orbit Ops/Data Center works with pre-flight calibration teams to integrate pre-flight calibration data into data archive *in a useable fashion*.
- Pre-flight Teams must be involved in on-orbit calibration planning in order to provide them with an inclusive view of the end-to-end calibration.
- Pre-flight Teams must provide *all* data products and procedures (and analysis pipelines) to Ops/On-orbit Calibration Team.

Example: *Chandra* Optics Calibration

Things that didn't work out as well as they might have.

1. Optics Calibration Team *not* part of Data Center (existed before Chandra X-ray Center)
2. Tasked *solely* with ground calibration
3. Official archive of ground-calibration data done with little input from calibration team
   - No way to correct data in archive
   - Measurement meta-data not part of archive
   - Archive never used by Calibration Team
   - Everyone had their own databases w/ personal "fixes" – very difficult to synchronize
4. Spectral analysis pipelines – fragile and only operable by one person

Some things were unavoidable, but quite a few weren't

Example: *Chandra* Optics Calibration

Things that did go right.

1. Same personnel on pre-flight and on-orbit Calibration Teams
2. No catastrophic disk failures
3. Our memory isn't as bad as it might be.

In many ways we were very lucky

Outline

Overview

Getting Ground Calibration correct is **difficult**

- Calibration time is very limited
- Things ~~can~~ ***will*** go wrong.
- Calibration plans are success oriented
- Calibration Teams are focused on immediate calibration activities, not post-deployment activities

Calibration Teams need assistance to ensure that their work fits into the overall data and analysis retention scheme.

Data

Science is only as good as the Calibration.
Calibration is only as good as the Ground Calibration.
Ground Calibration is only as good as the Data.

- Systematic errors are hard to disentangle

  In spite of having absolutely calibrated detectors (which refuse to agree) *Chandra* Optic calibration errors are dominated by systematic errors
- Use more than one (type) of detector. Use three, just to be sure.
- You can't quantify Systematic Errors without Duplicate Measurements
- Systematic Errors must be propagated, but we don't have a good framework in which to do so.

Analysis

Ground Calibration Analysis pipelines are
as important
as On-orbit Analysis Pipelines

- Pipelines must be verified and tested and maintained to avoid bit-rot.
- Pipelines need to be modified to accomodate new data or data formats or techniques.
- Ground calibration data may be reanalyzed at any point in the mission.
- Pipelines may be run by scientists not involved with original calibration effort.

Outline

What is a *Legacy Program*?

"Traditional" legacy programs provide archives of data for future use.

For calibration this might be

... A list of standard sources

... A standard astrophysical model for each source

... Observational data and a CALDB

Does this cover it all? *No.*

In order to be able to replicate past results, we also need:

- Versioned analysis software
- Versioned data
- Versioned supporting databases (e.g. atomic data)

Beyond the Traditional

Calibration is more than a CALDB

- Cross-calibration requires exposure of more than what is distilled in the CALDB to other calibration groups.
- Cross-calibration must be made part of the “Prime Directive” of new missions
- Additional resources must be allocated to accomodate the enhanced needs for cross-calibration.
- Calibration Teams are the best advocates for enhancing the stature of cross-calibration activites during development and scoping of new missions.

The data will out-live us all

Our true legacy is providing future scientists with the means to use the data in ways we'd never dream of