



Calibration status of Swift BAT Hard X-ray instrument

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Agenda

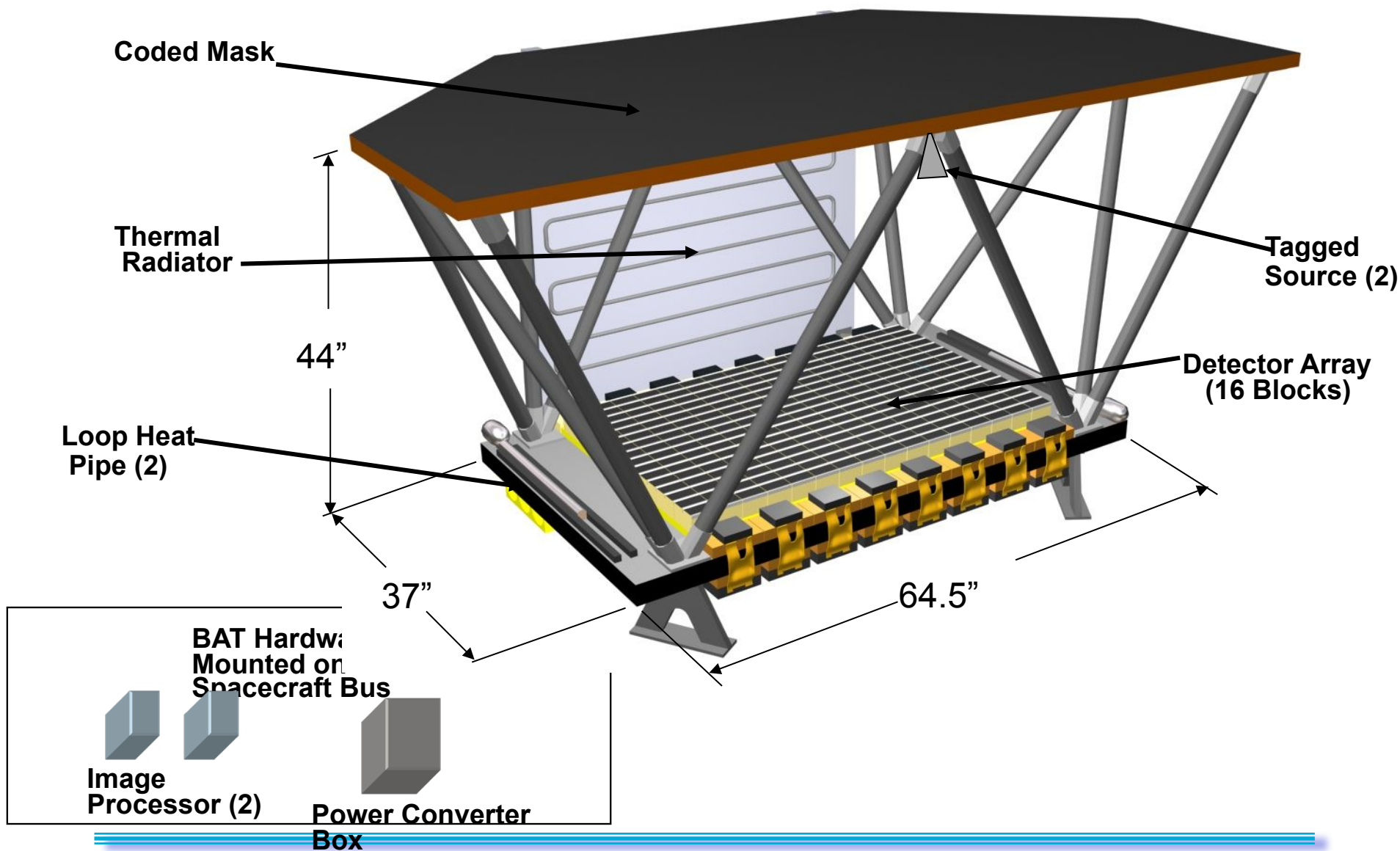


- BAT refresher
- Calibration philosophy
- Post-launch results
- Current status

- Summary: BAT performance similar to post-launch, small detector gain shifts



Swift BAT





Swift BAT



- **Launched** November 2004
- **Energy Range** 15 - 150 keV (nom)
- **Field of View** 2 Sr, partially coded
- **Spatial Resolution** 21' FWHM, centroid to 3' position information
- **Spectral Resolution** 3 keV FWHM, average
- **Sensitivity** 0.2 photons/cm²/sec
- **Timing Accuracy (end-2-end)** 250 usec (knowledge;
- **Timing Resolution** 100 usec



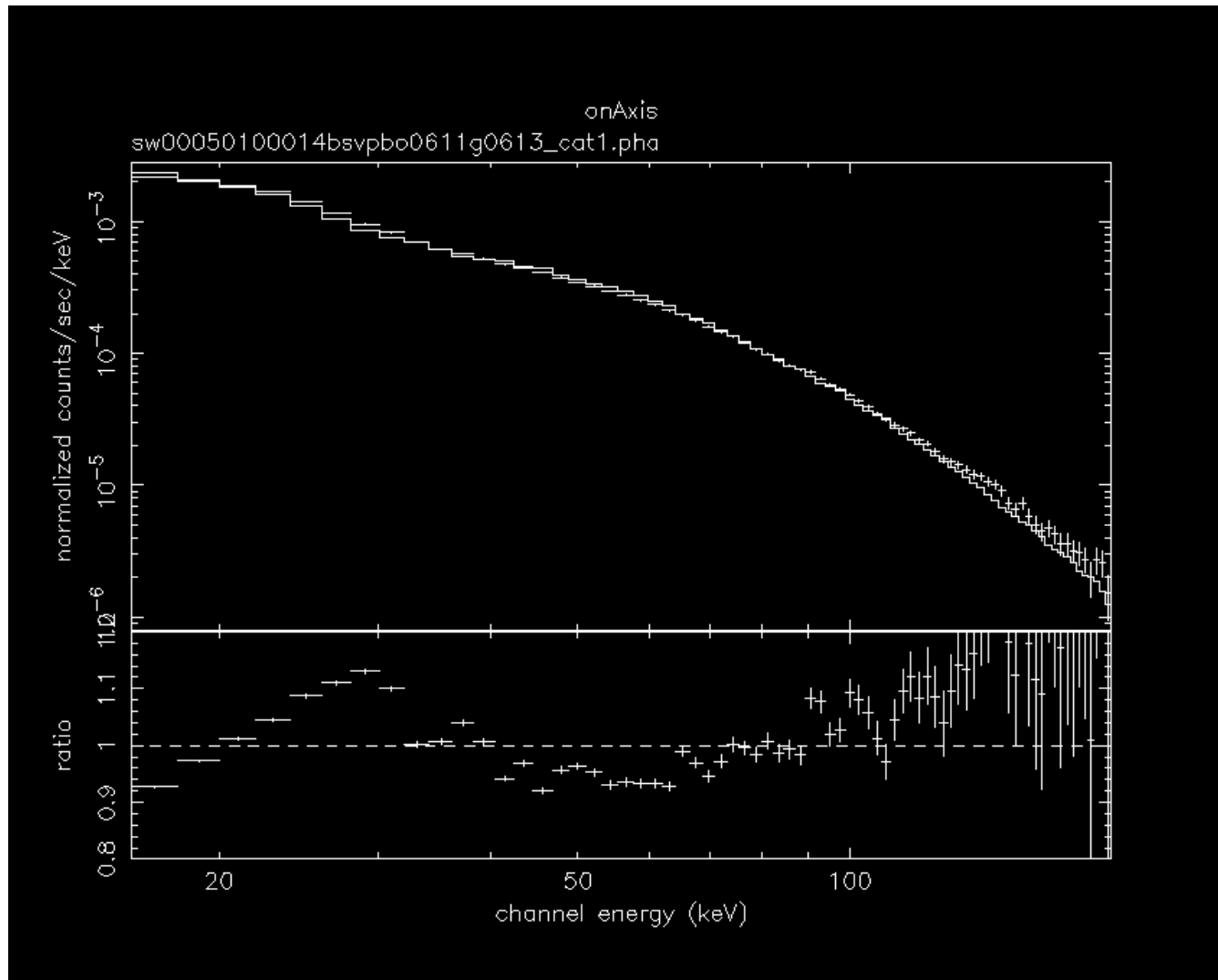
Calibration Approach



- Extensive pre-launch calibration activities
 - ❑ Set of radioactive line sources, primarily to determine gain and detector redistribution
- Post-launch calibration with Crab Pulsar+Nebula
 - ❑ In 15-150 keV band, the Crab is the most constant source
 - ❑ Refinement based on observations
- Continuing Mission
 - ❑ Monitoring of calibration performance



Crab First Light Spectrum





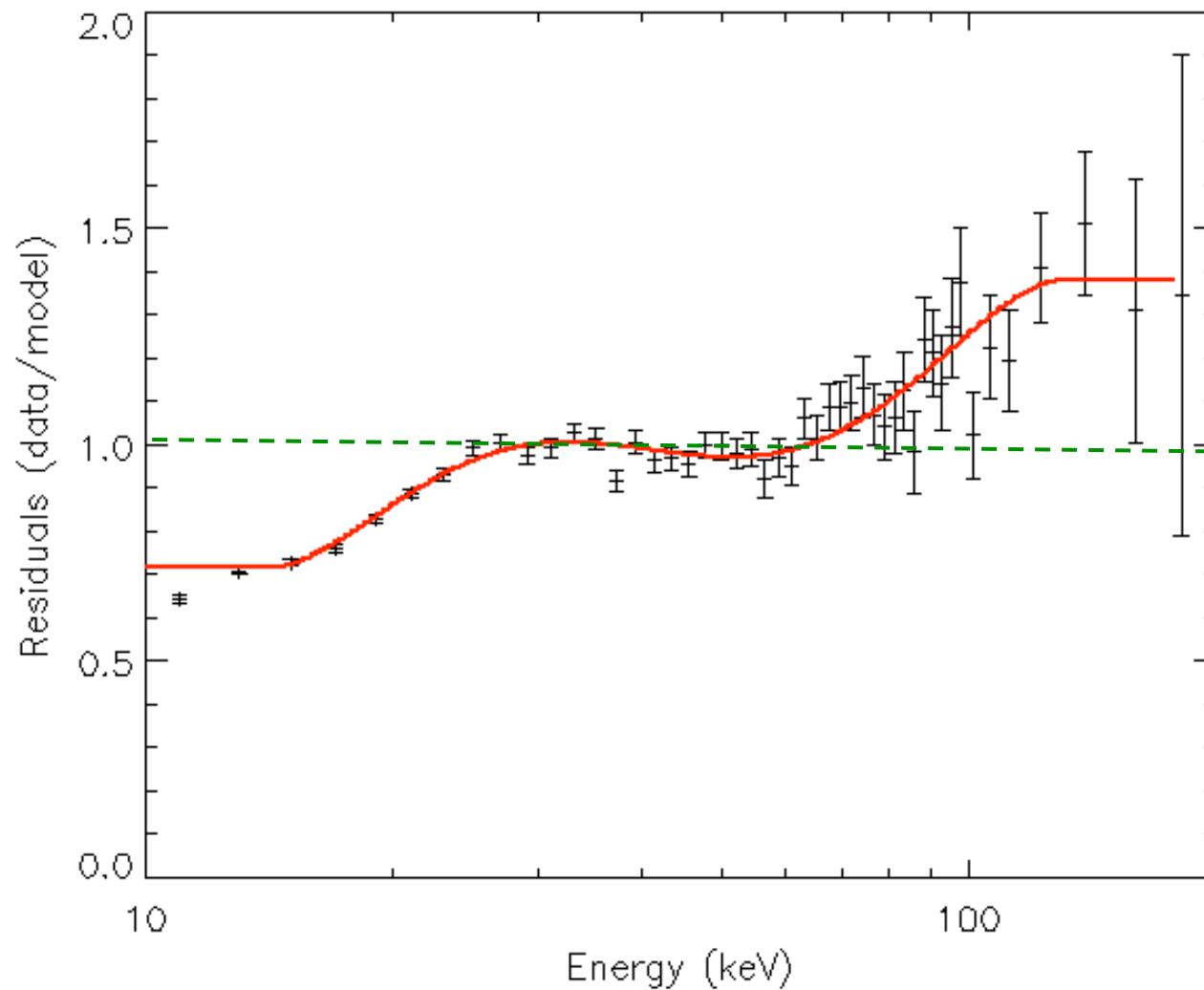
Post Launch Calibration Philosophy



- Use 30-100 keV band as “good” calibration range
 - ❑ This fixes Crab shape and normalization
 - Power law photon index 2.15
 - Normalization 10.17 at 1 keV
- Adjust <30 keV and >100 keV to match canonical spectrum
 - ❑ Since launch in 2004, we have not altered the 30-100 keV response parameters
 - ❑ Low energy error interpreted as unmodeled passive material in BAT FOV (confirmed by off-axis behavior)
 - ❑ High energy error later confirmed to be high energy response modeling error (downscatter from <1 MeV) as well as mis-modeled detector physics MuTau parameters
- Standard analysis inserts systematic errors into spectrum files
- Long Term: Monitor calibration behavior

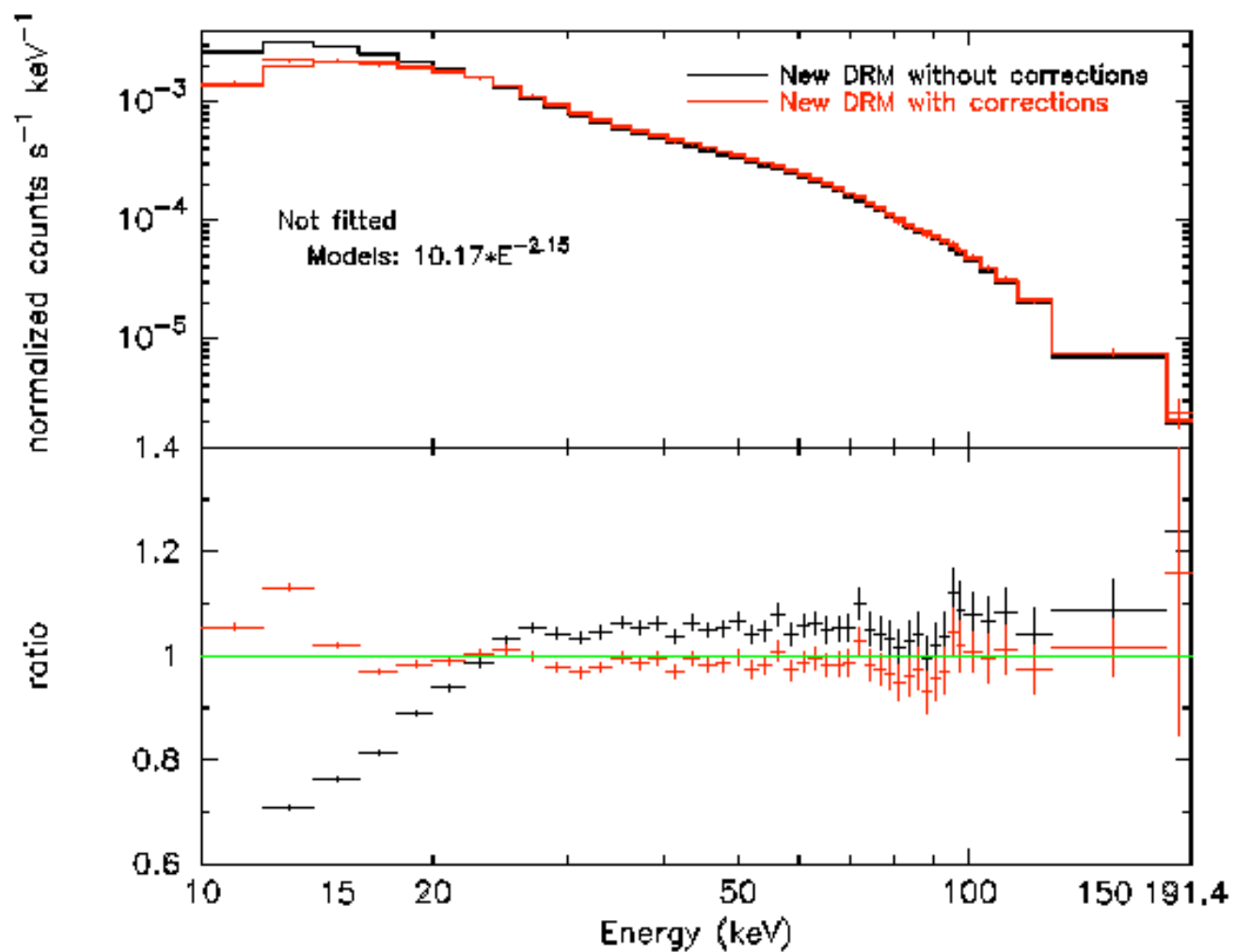


Post Launch BAT Residuals





Before/After Correction

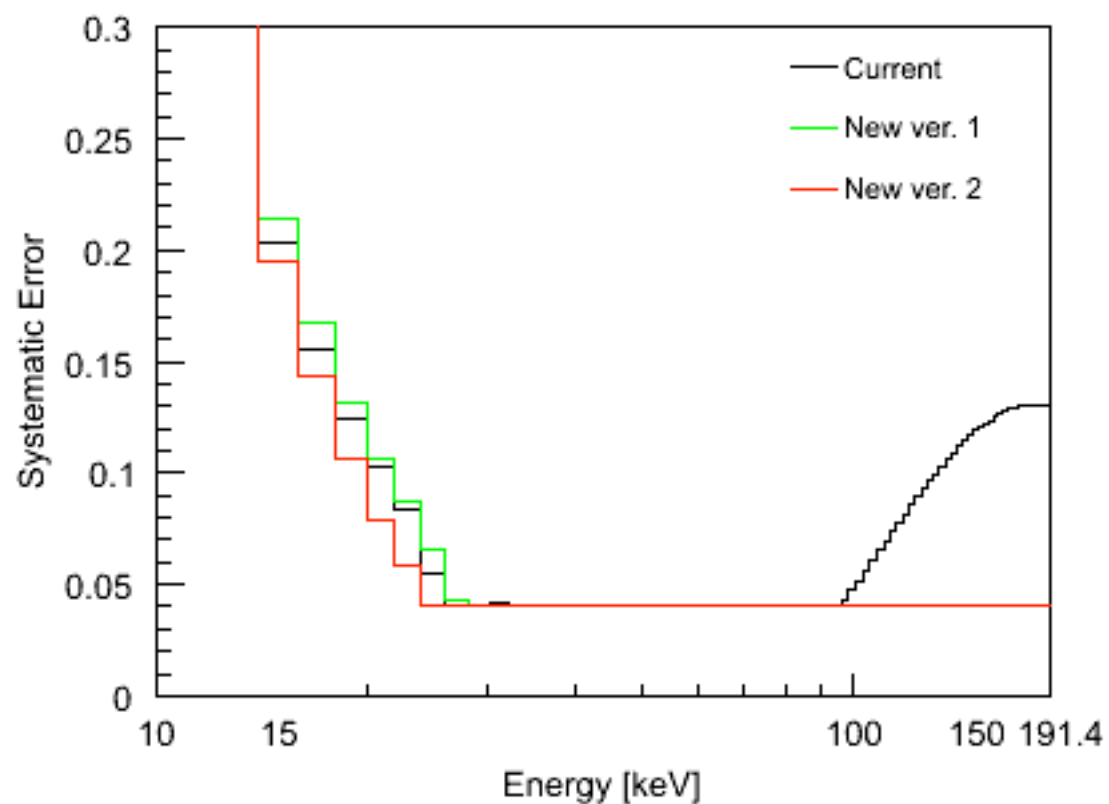




Systematic Error Vector



- Applied to every spectrum with batupdatephakw





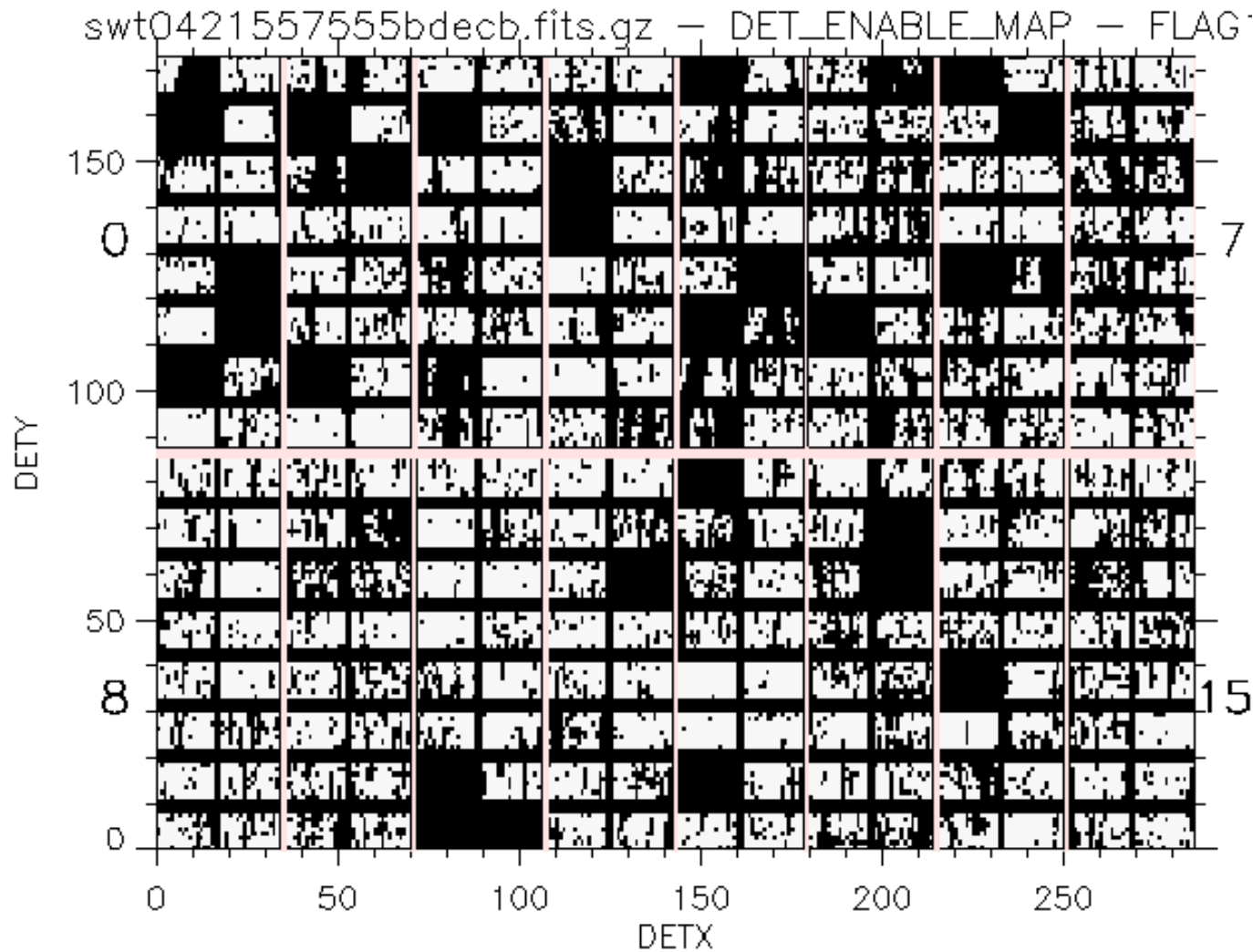
Long Term Monitoring



- Routine re-enabling of detectors (S. Barthelmy)
 - ❑ Typical number of enabled detectors: 22k of 32k
- Routine yearly calibration observations
 - ❑ Monitor flux and spectral shape performance of instrument at all off-axis angles
- On- and off-axis positions of Crab Nebula+Pulsar
 - ❑ On-axis
 - ❑ $\pm 30^\circ$ in Y
 - ❑ $\pm 45^\circ$ in X
- Work by CM, Amy Lien & Taka Sakamoto

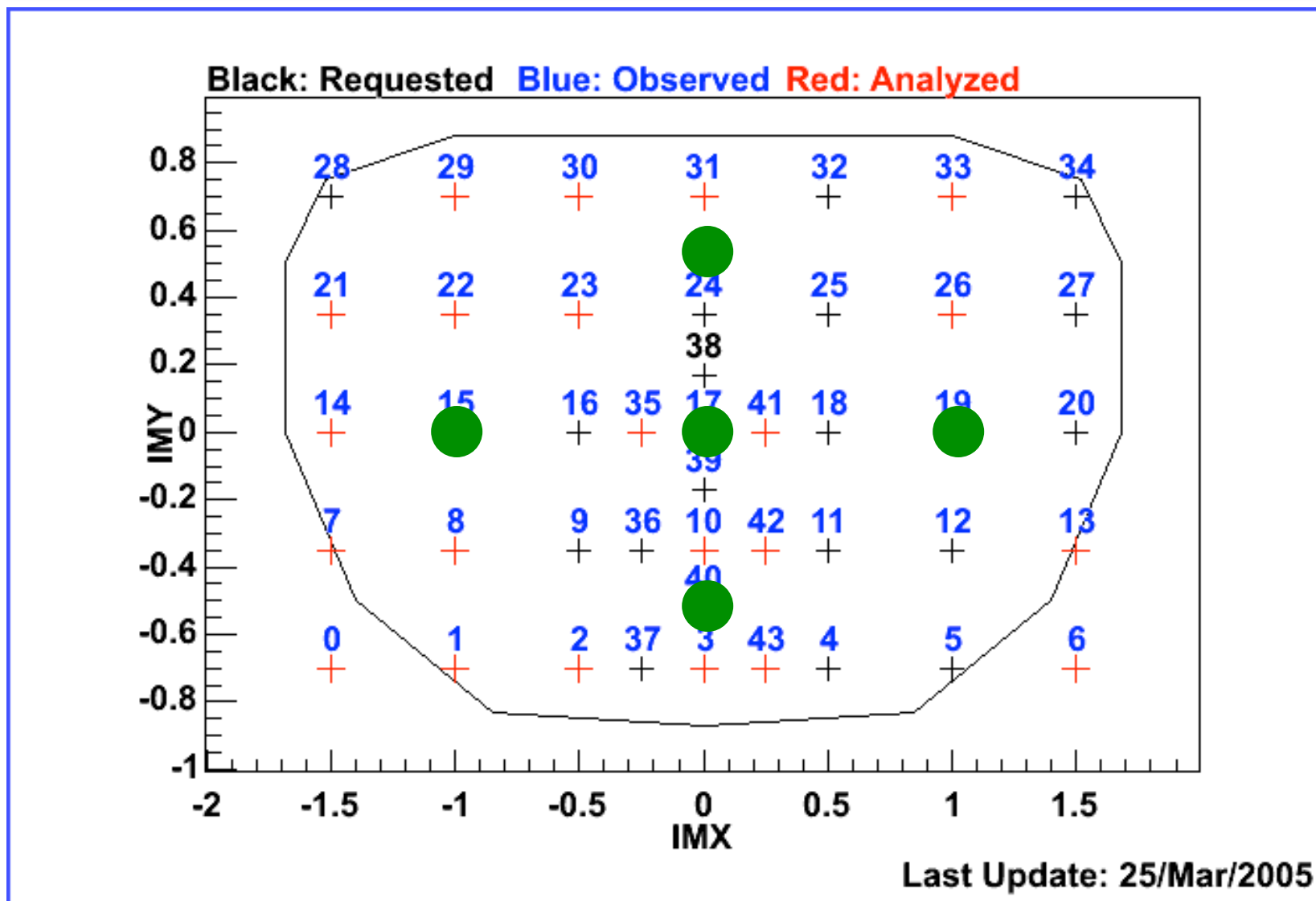


Enabled Detectors



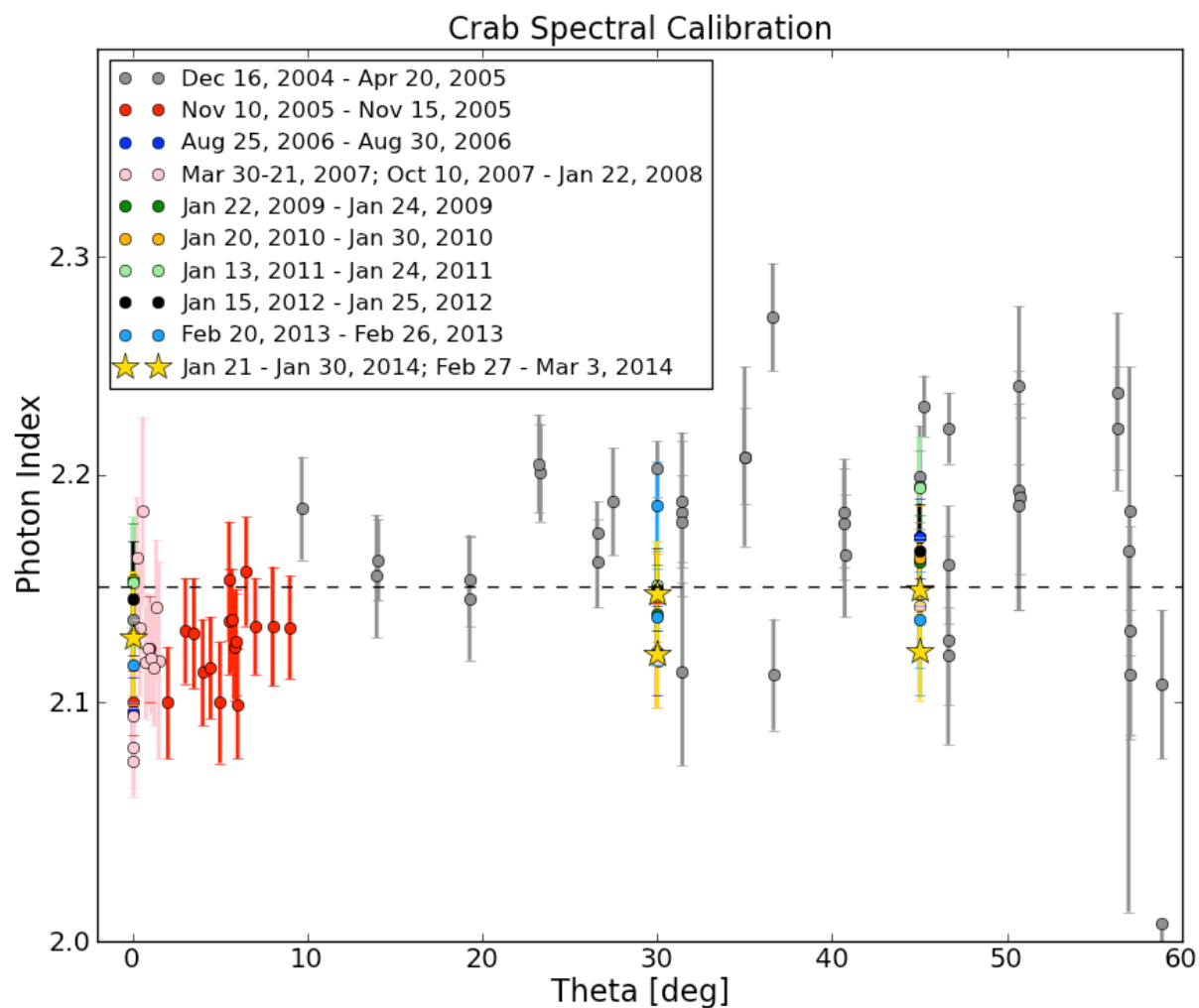


Calibration Locations



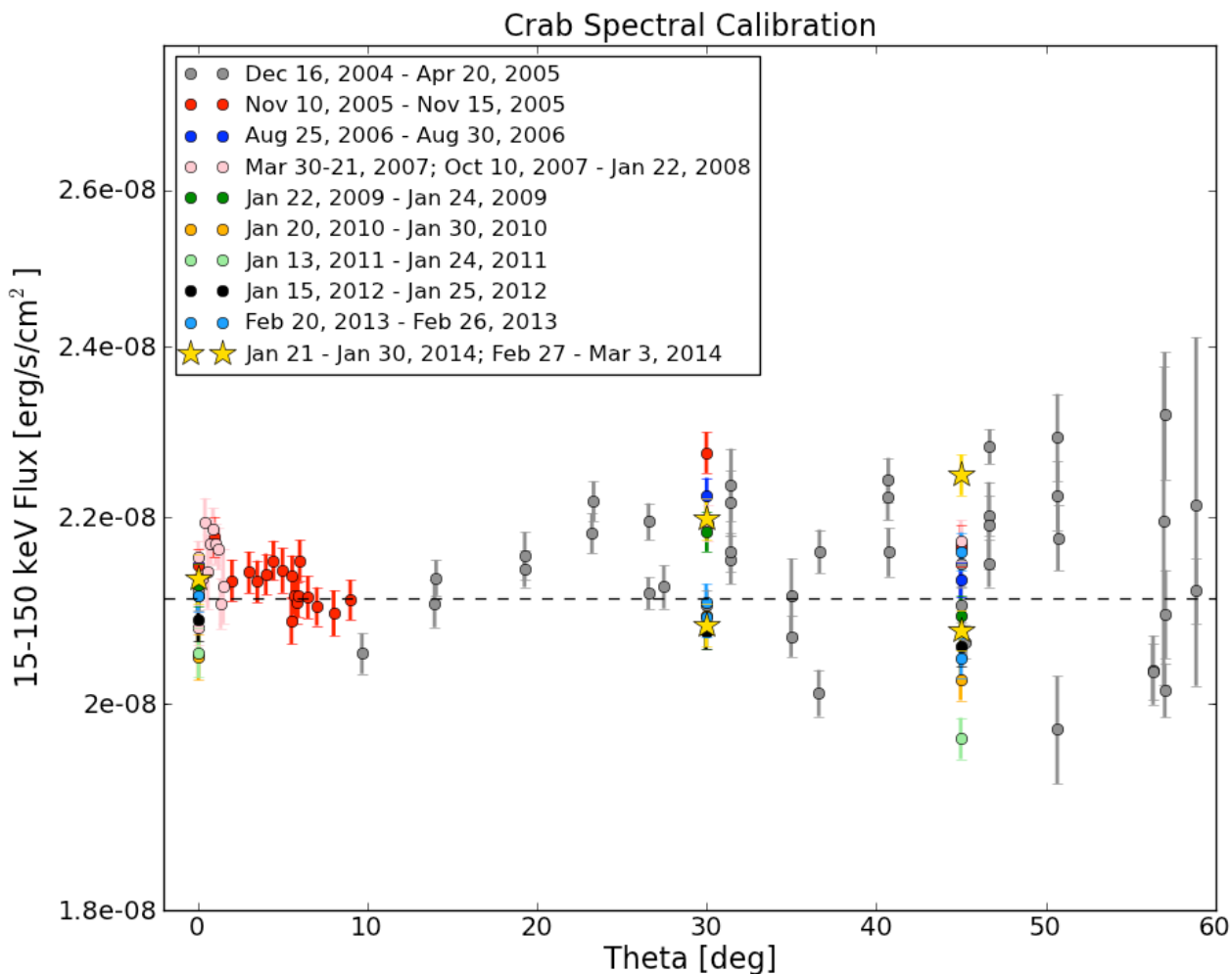


Monitoring Results: Shape



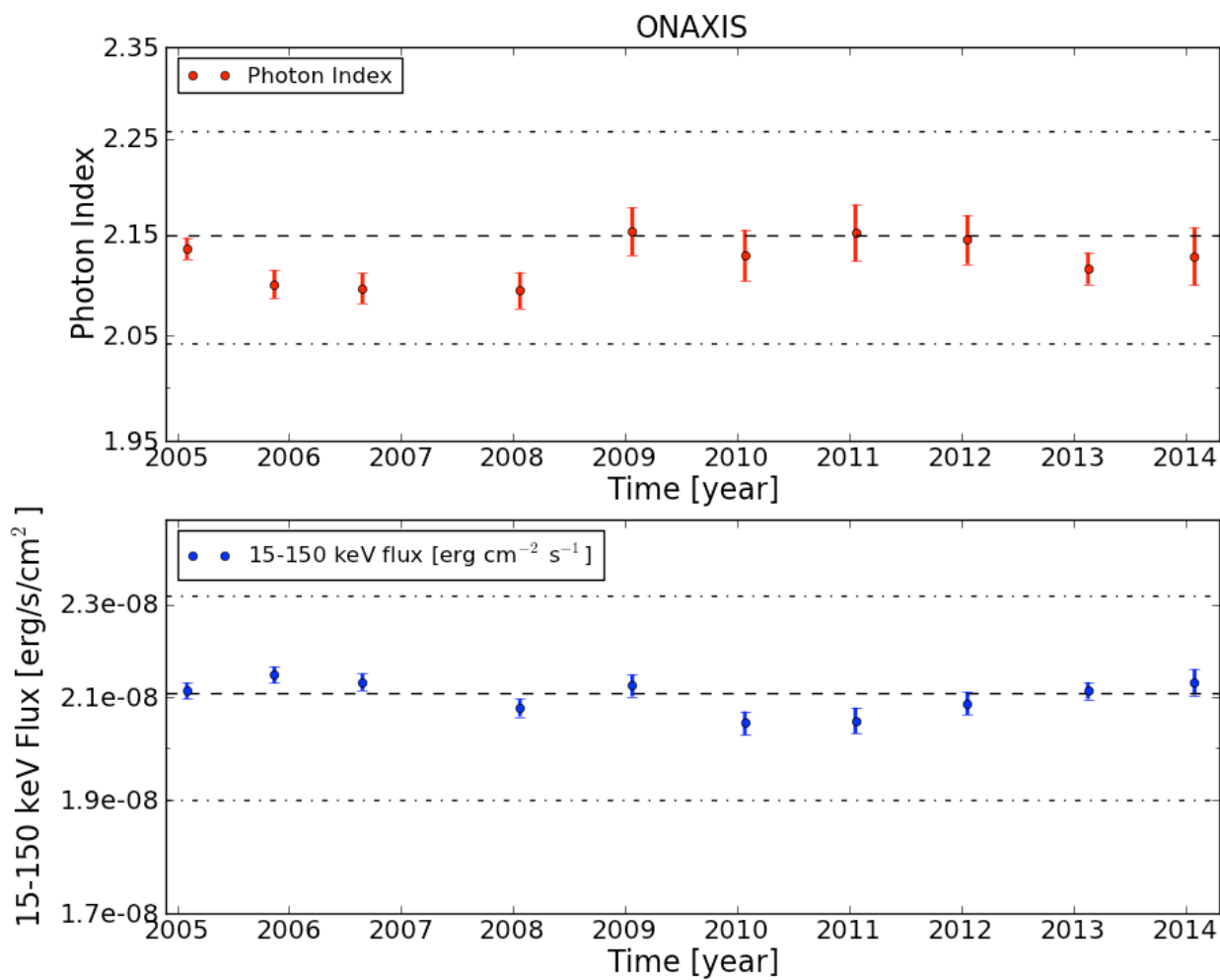


Monitoring Results: Flux



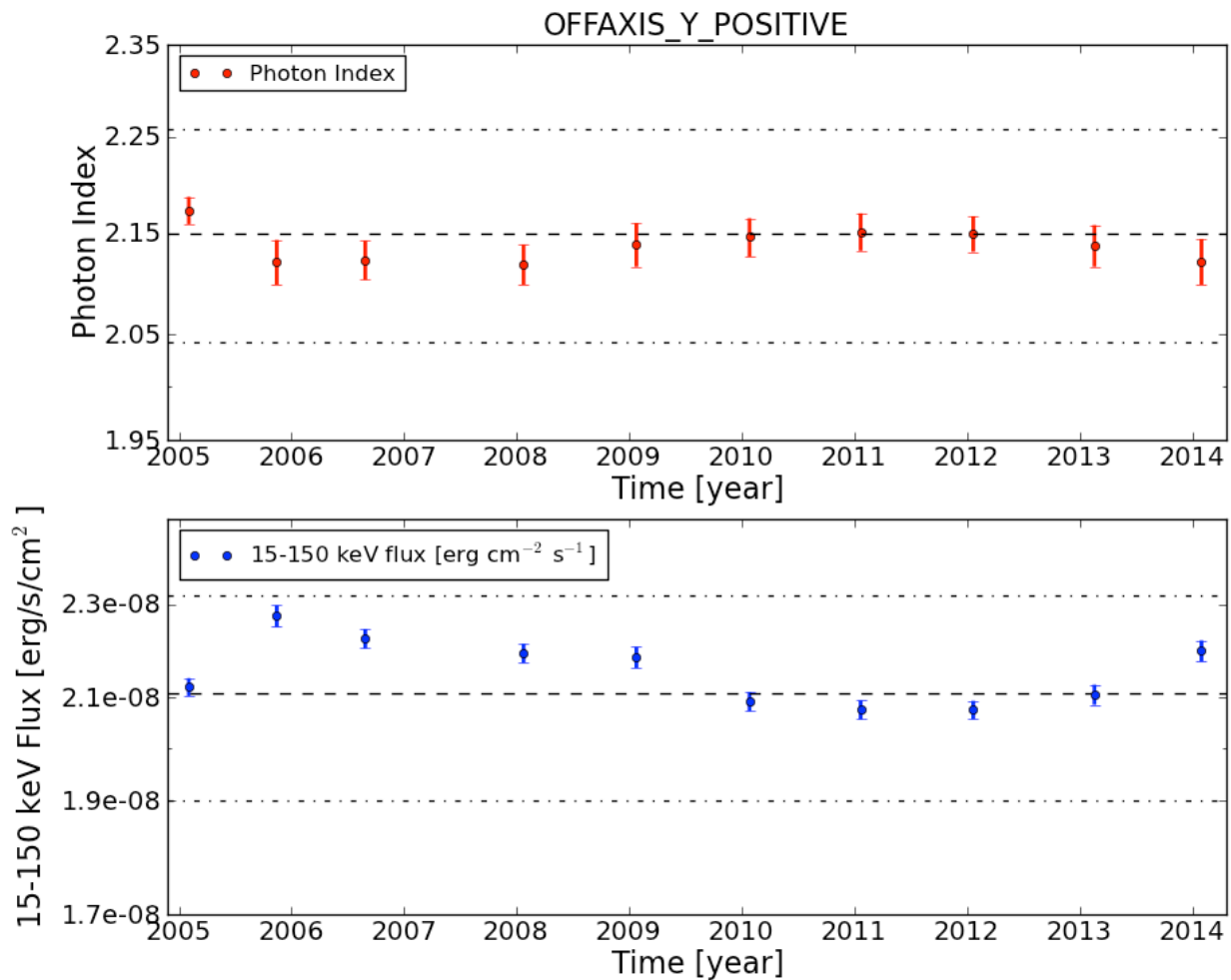


On-Axis Performance



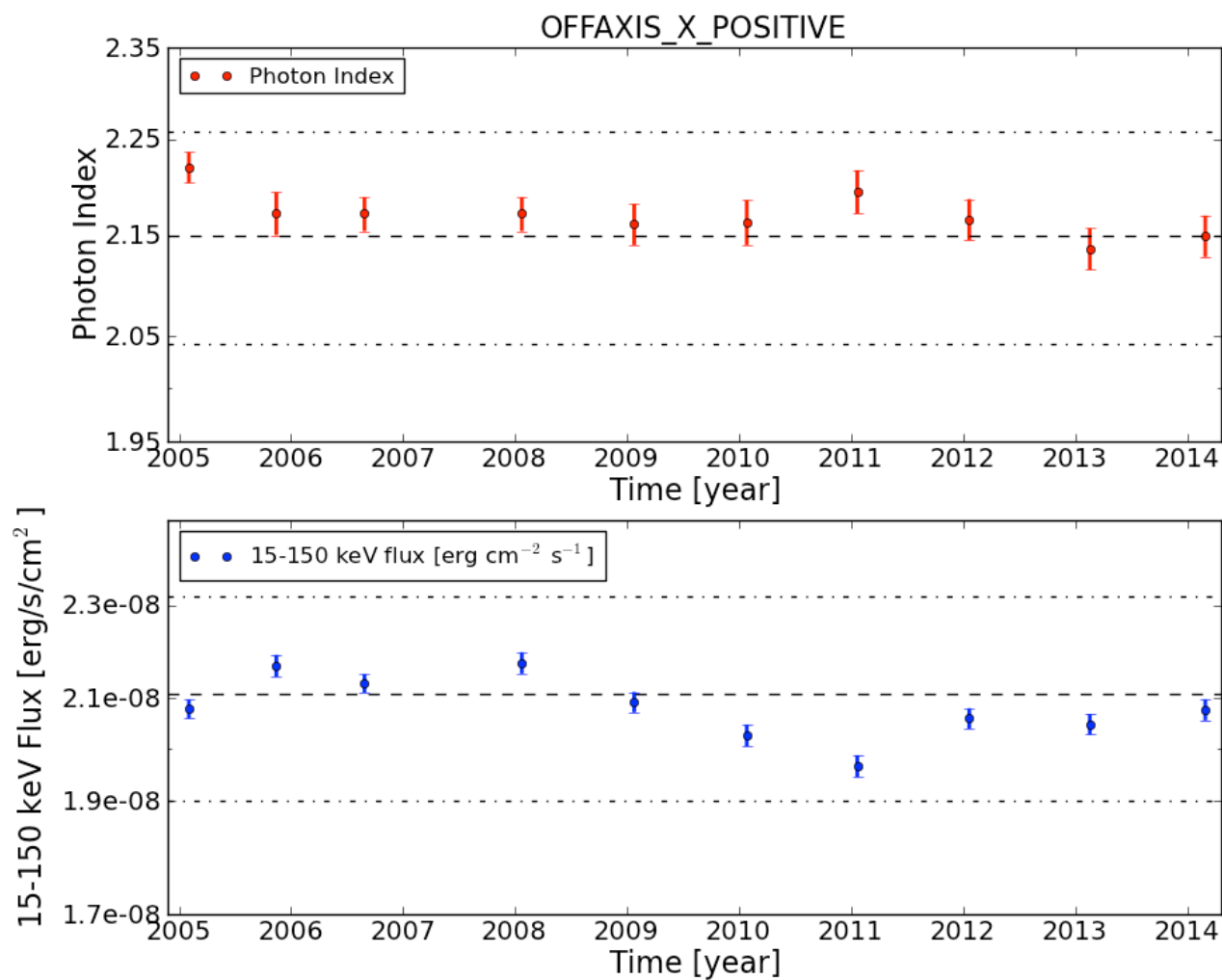


Off-Axis (+Y)



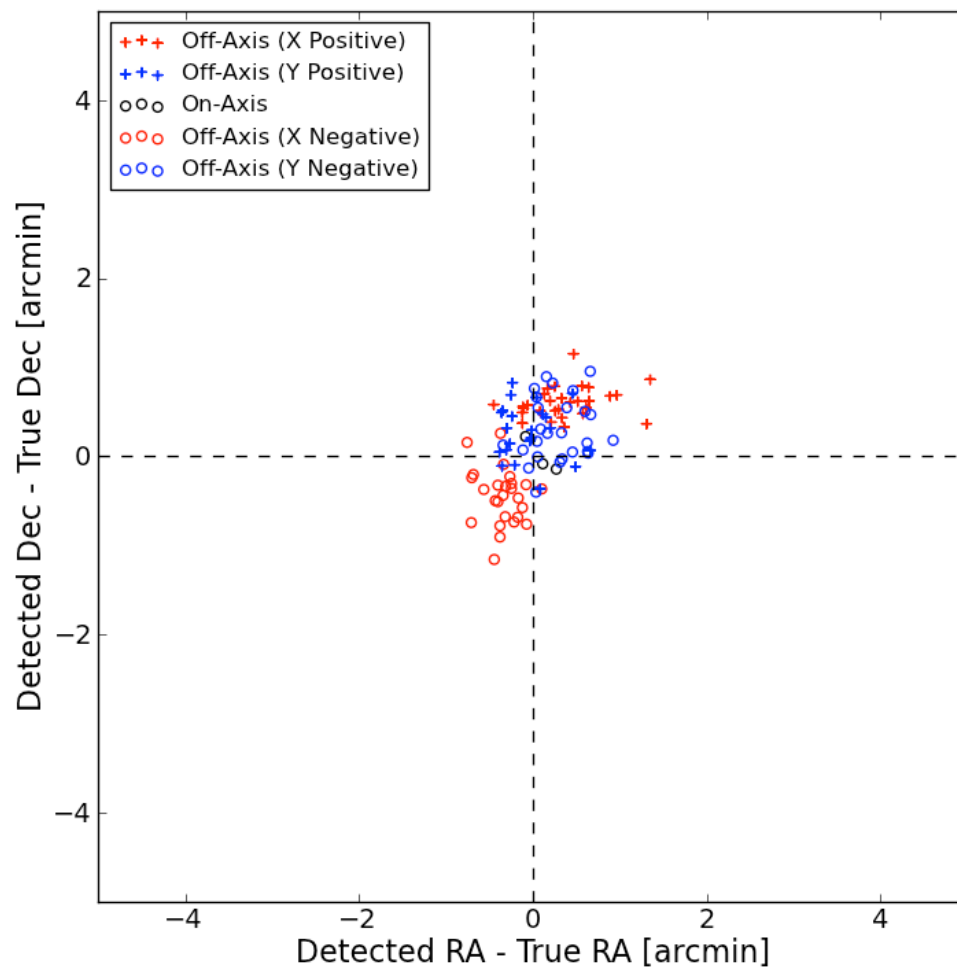


Off-Axis (+X)



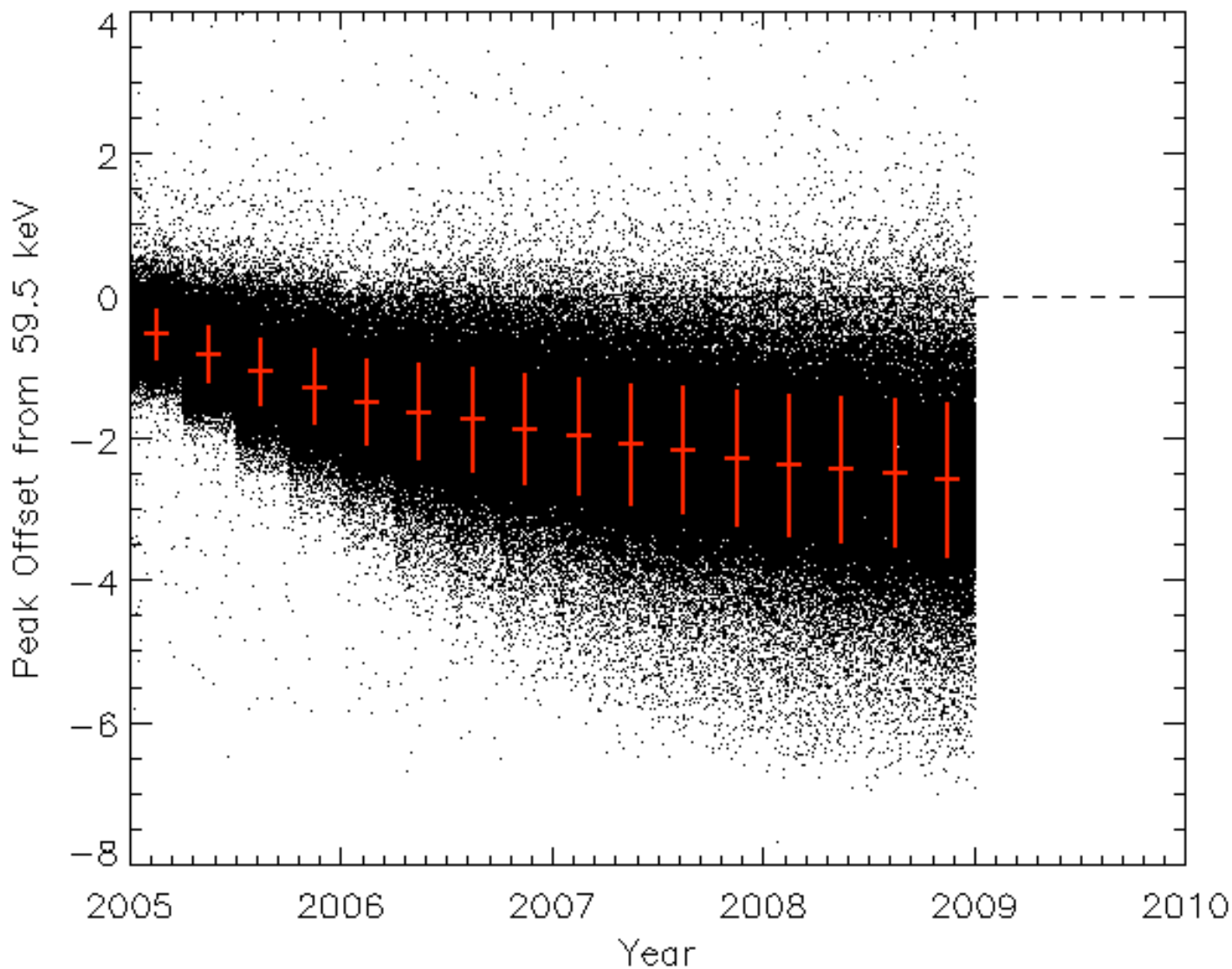


Centroiding Performance





Post Launch Gain Drift





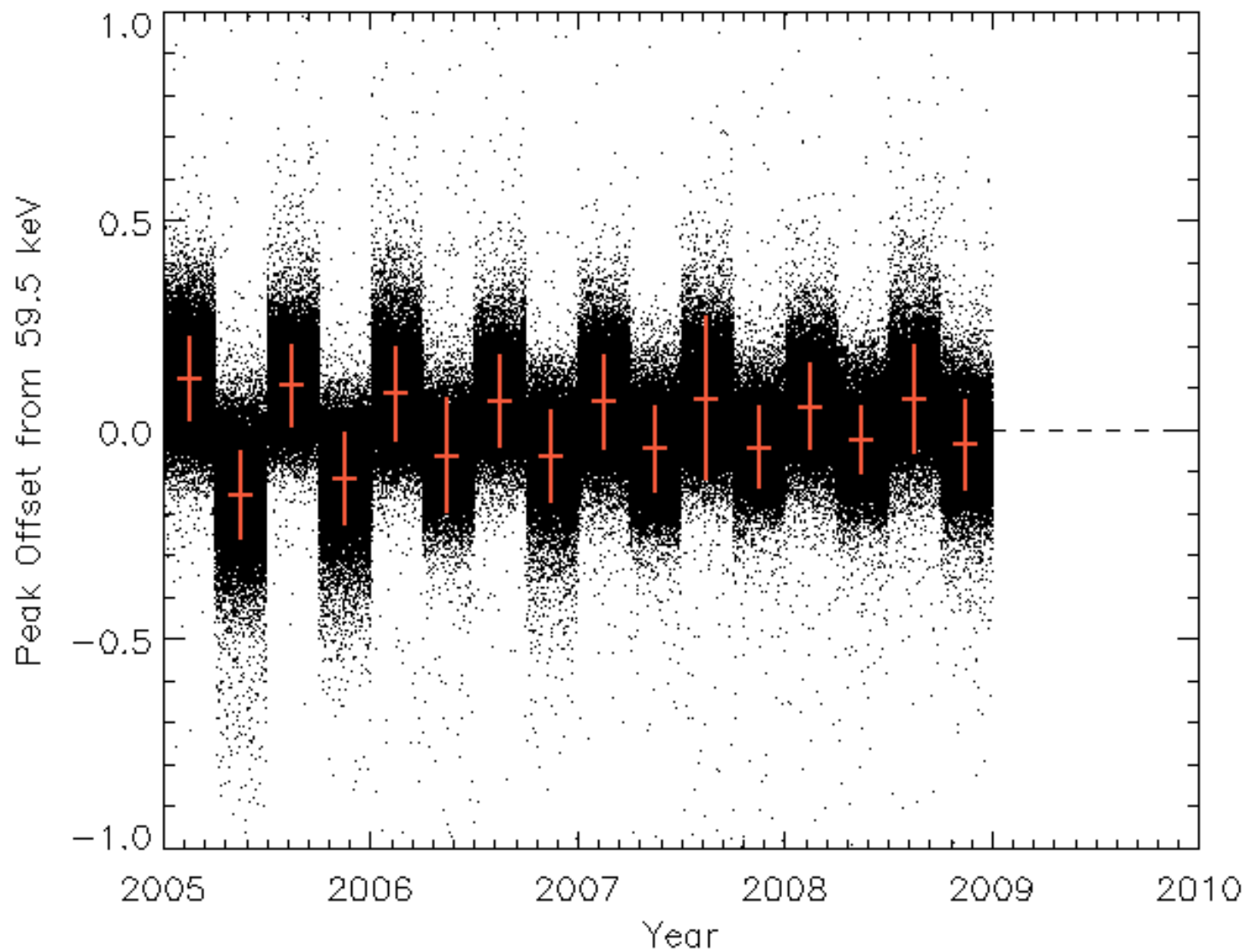
Post Launch Gain Drift



- Array-average gain drift: ~4%
- Individual detector gain scatter: ~2%
- No change in electronics gain or offset
- INTEGRAL/ISGRI reports similar drifts
- We believe this is a gradual detector damage which reduces ability to collect all deposited charge



Gain Drift Corrected





Summary



- BAT 30-100 keV flux normalization and shape, based on pre-launch calibration, have not been “fudged” since launch
 - ❑ Post-launch calibration files & software still valid
- Low-energy error modeled as extra passive material
- Continuing performance
 - ❑ Detectors routinely re-enabled
 - ❑ Detector flux & shape performance constant to within known intrinsic Crab variability levels
 - ❑ Detector gain slowly varying (correction files to be announced)