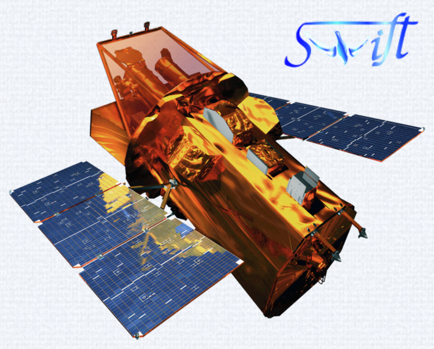


The Detector Status of the *Swift* Burst Alert Telescope

Amy Lien[1,2], Craig Markwardt[1], Scott Barthelmy[1], Brad Cenko[1], Hans Krimm[3], David Palmer[4], Takanori Sakamoto[5]

[1]NASA Goddard Space Flight Center, U.S.A, [2]CRESST/UMBC, U.S.A., [3]NSF, U.S.A., [4]Los Alamos National Laboratory, U.S.A., [5]Aoyama Gakuin University, Japan

Abstract

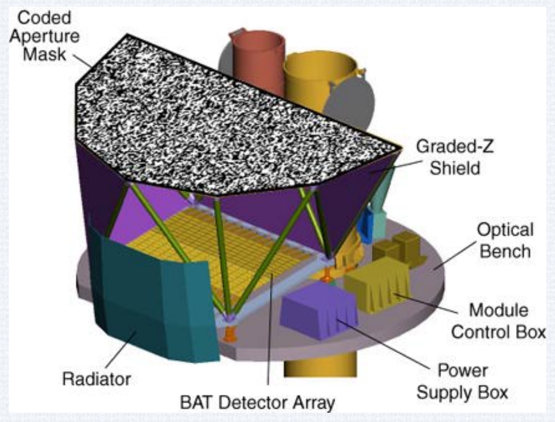
We present the detector status of the *Swift* Burst Alert Telescope (BAT). The yearly BAT calibration using the Crab nebula shows stable performance in both the position and spectral measurements. Throughout the years, BAT spends ~ 78% of the time performing observations. The number of enabled detectors decreases over time due to an increasing number of noisy detectors. In 2017, the number of enabled detectors is ~ 63% of the number in 2005. The updated detector gain calibration shows ~ 4% gain shift on average, which will have an impact mainly on observations with exposure times larger than ~ 500 ksec, and sources fainter than ~ 4 mCrab. The updated calibration is available on the HEASARC Swift BAT CALDB release (Oct. 2017), which includes the most recent gain shift information and the global bad time intervals.

Swift Burst Alert Telescope (BAT)

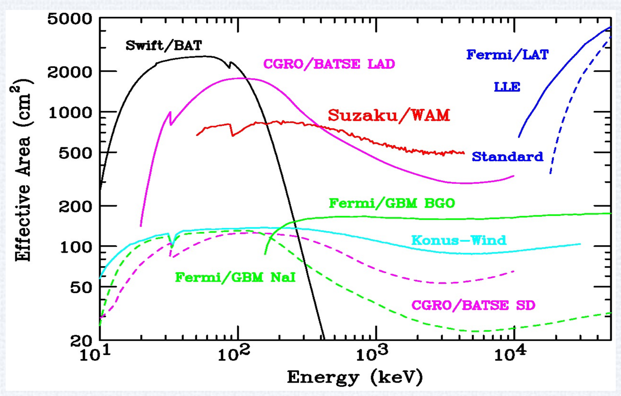
Gehrels. et al. (2004), Barthelmy et al. (2005)

Parameter	Value	Comment
Energy Range	14–195 keV	
Field of View	~ 85° × ~ 120°	0% partial coding
	2.29 sr	5% partial coding
	1.18 sr	50% partial coding
	0.34 sr	95% partial coding
Point Spread Function	19.5′	Mosaicked sky maps
	22′	in center of snapshot FOV
	14′	at corners of snapshot FOV
Detector Area	5243 cm^2	32,768 CdZnTe detectors, 4 mm × 4 mm × 2 mm
Aperture	50% open	Coded mask, random pattern
Coded Mask	~ 52,000 tiles	5 mm × 5 mm × 1 mm Pb
Pointing constraints	> 45°	Sun
	> 30°	Earth limb
	> 20°	Moon

Baumgartner et al. (2013)

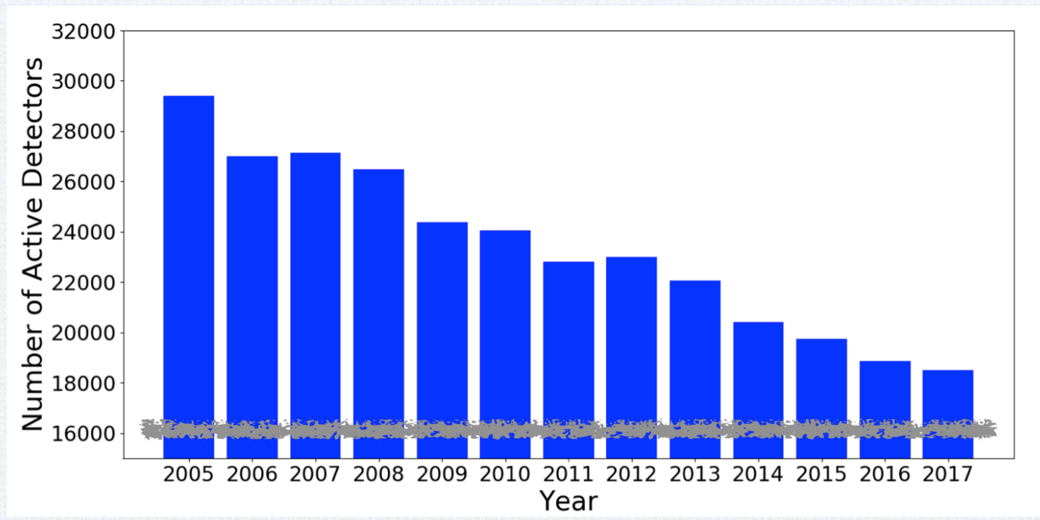


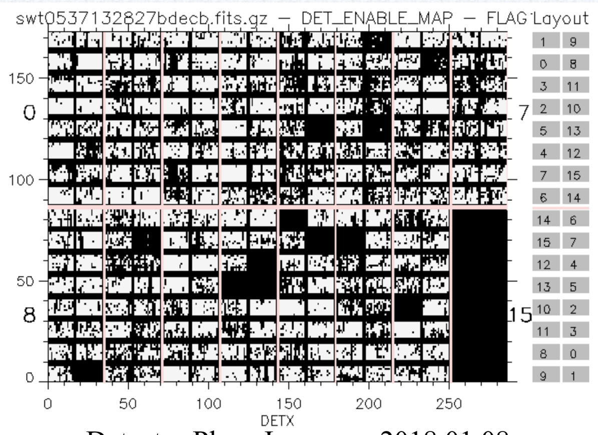
Barthelmy et al. (2000)



Yamaoka et al. (2016)

Number of enabled detectors

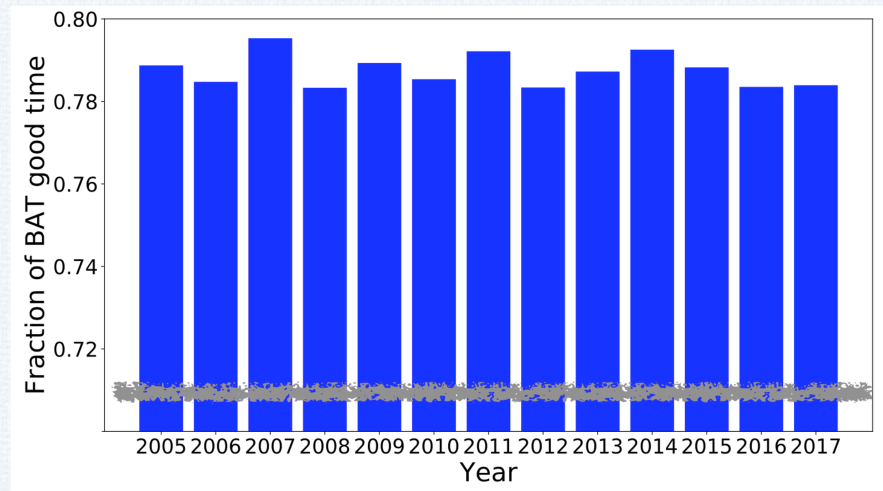




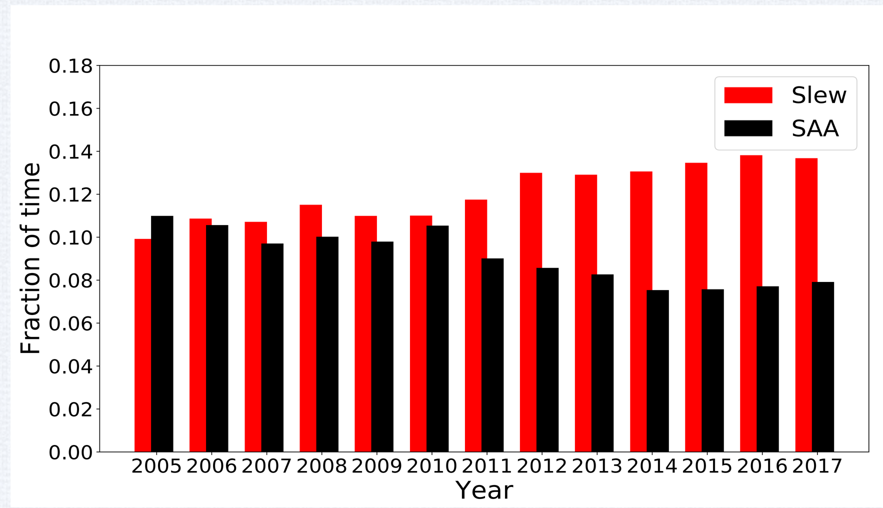
- Detector Plane Image on 2018.01.08

- Number of enabled detectors decreases over time due to the increase of noisy detectors.
- The number of enabled detectors in 2017 is ~ 63% of that in 2005.

BAT observation time



- BAT consistently spends ~ 78% of the time performing observations.
- Updated global bad time interval (i.e. intervals that might have potential calibration issues) is released on the HEASARC *Swift* BAT CALDB (Oct. 2017).

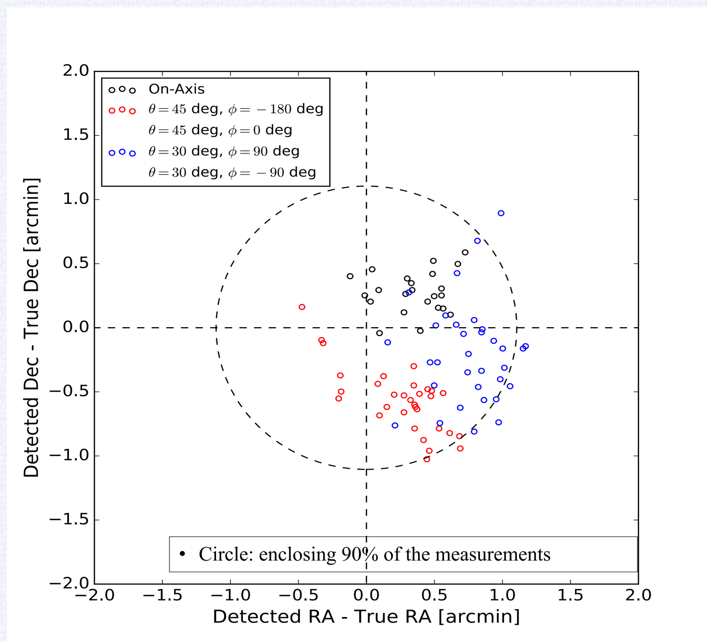


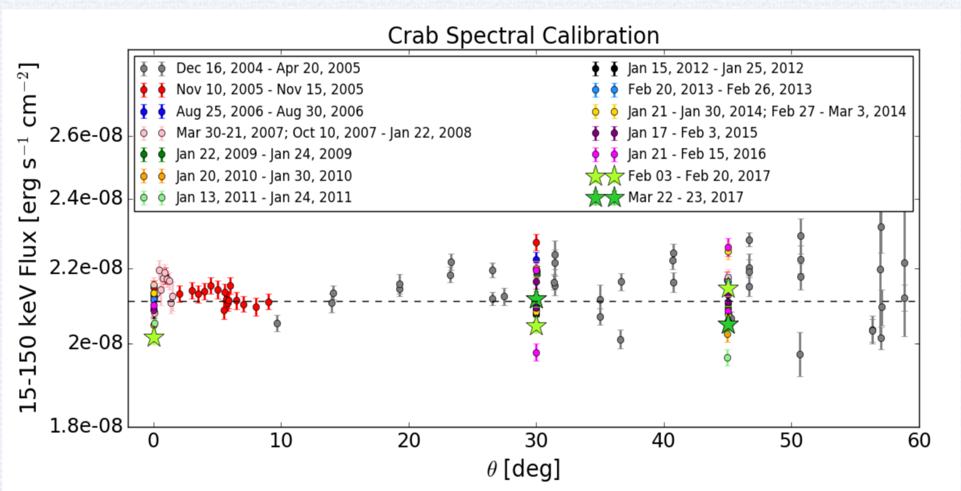
- Slew time increases over time due to the increase of ToO observations.
- SAA time decreases over the past ~ 10 years due to the increase of solar activity.

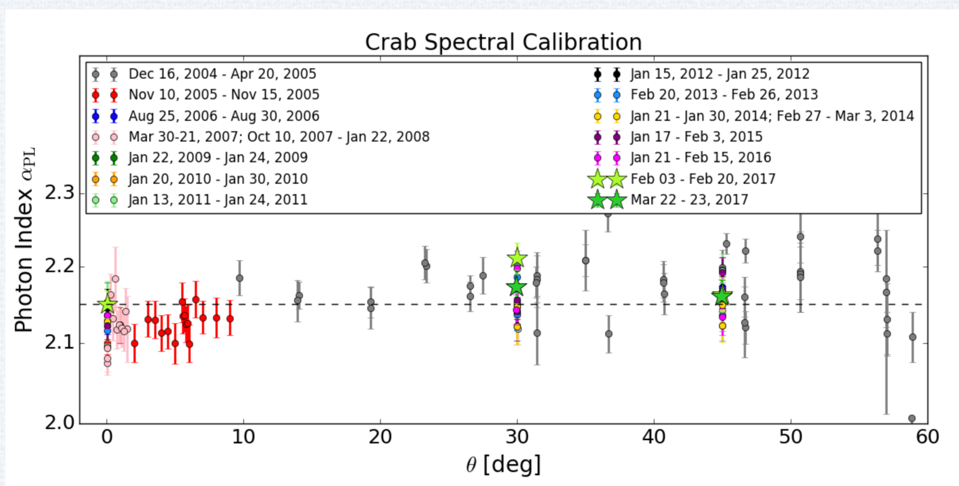
Annual Crab calibration

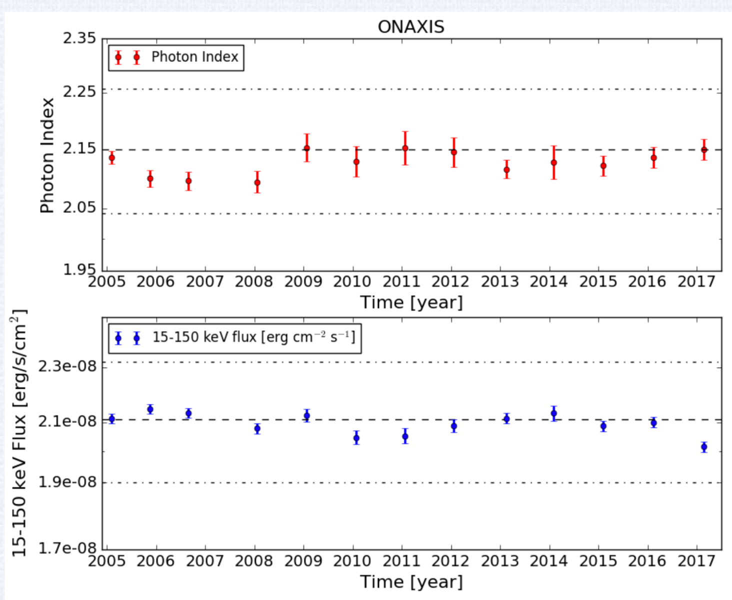
- The BAT team performs annual calibration based on observations of the Crab nebula from different observing angles.
- The Crab photon index and flux measured at different observing angles are consistent with the canonical Crab parameters* to within +/- 5% and +/- 10%, respectively.
- The position measurements are within ~ 1 arcmin from the true Crab position*.

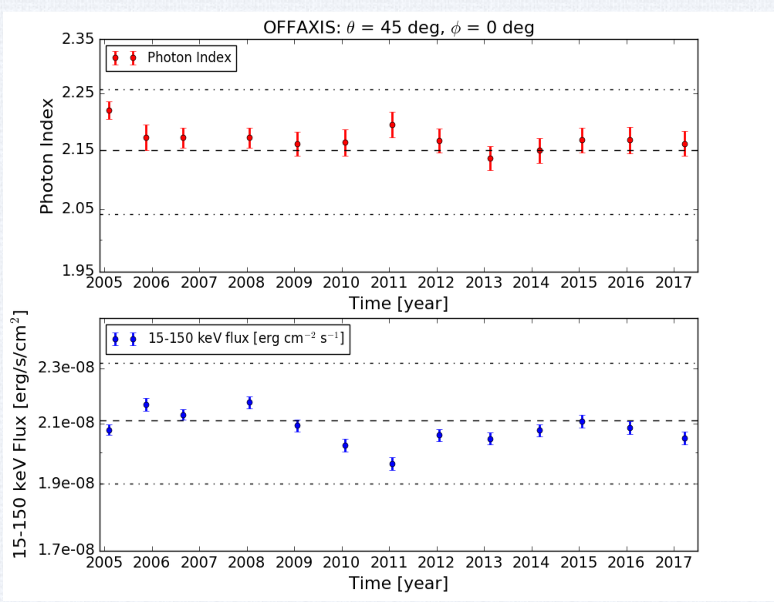
* Canonical Crab parameters: photon index = 2.15, flux = 2.11 × 10^{-8} erg/cm^2/s
* True Crab position: (ra, dec) = (83.6332, 22.0145) deg.





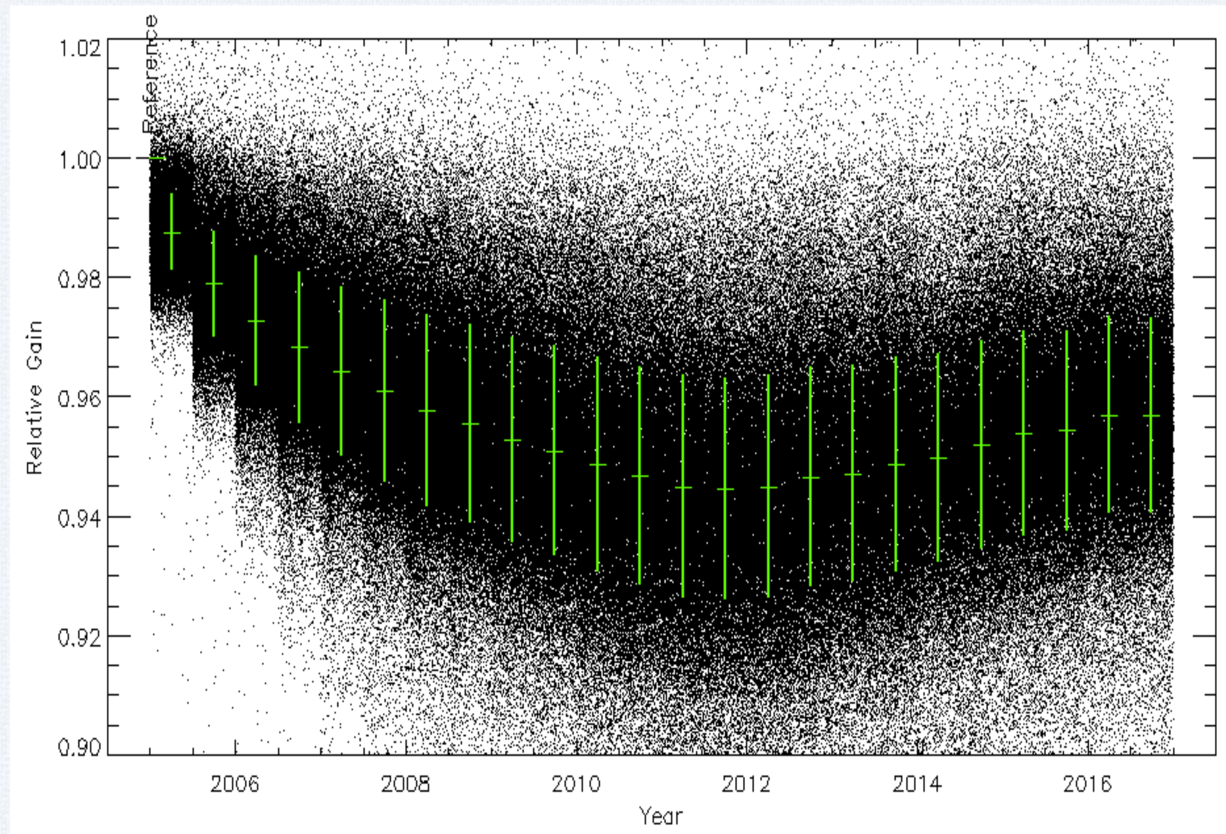






Detector Gain Calibration

- Detector gain shift: the BAT measurement of the ^{241}Am 59.5 keV line has been shifted by ~ 4% (~ 2 keV) since launch.
- Detector-to-detector gain variations should generate additional pattern noise.
- The error introduced by the gain shift is expected to be dominant over statistical noise for exposures greater than ~ 500 ksec.
- For survey data with the standard 8 energy bins, the gain shift can affect sources that are ~ 4.4 mCrab or fainter.
- New gain shift is released on the HEASARC *Swift* BAT CALDB (Oct. 2017).



Summary: Impact on the BAT data analysis

- On-axis and off-axis calibration from the Crab nebula shows stable results for localization and spectral analysis since launch.
- The gain calibration is updated through 2017. Results show that on average the gain shifts by ~ 4%. The major shift occurs during the first ~ 5 years of the mission, and the shift remains relatively stable in recent years. This gain shift does not have a significant impact on short duration observations, such as GRBs. But it does affect observations longer than ~ 500 ksec, or sources fainter than ~ 4 mCrab.
- The number of BAT enabled detectors decreases over time. Comparing to 2005, the number of enabled detectors has decreased by ~ 37%. For a photon counting instrument, the sensitivity $\propto \sqrt{N_{\rm det}}$, and thus the sensitivity is reduced by ~ 20%.
- The observation time has remained stable to date.
  - Increasing slew time is compensated by the decreasing of SAA time in recent years.
  - Global bad time is updated through 2017. Recently, there has not been much global bad time.