PennState
Eberly College of Science

SWIFT OPERATIONS AND CALIBRATION (XRT + COORDINATED)

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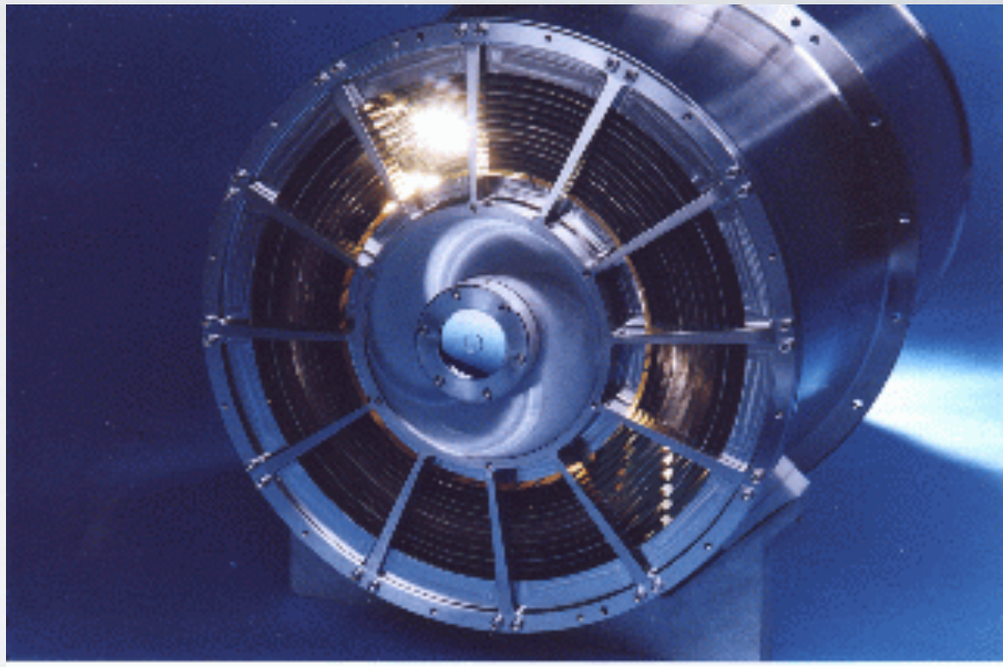
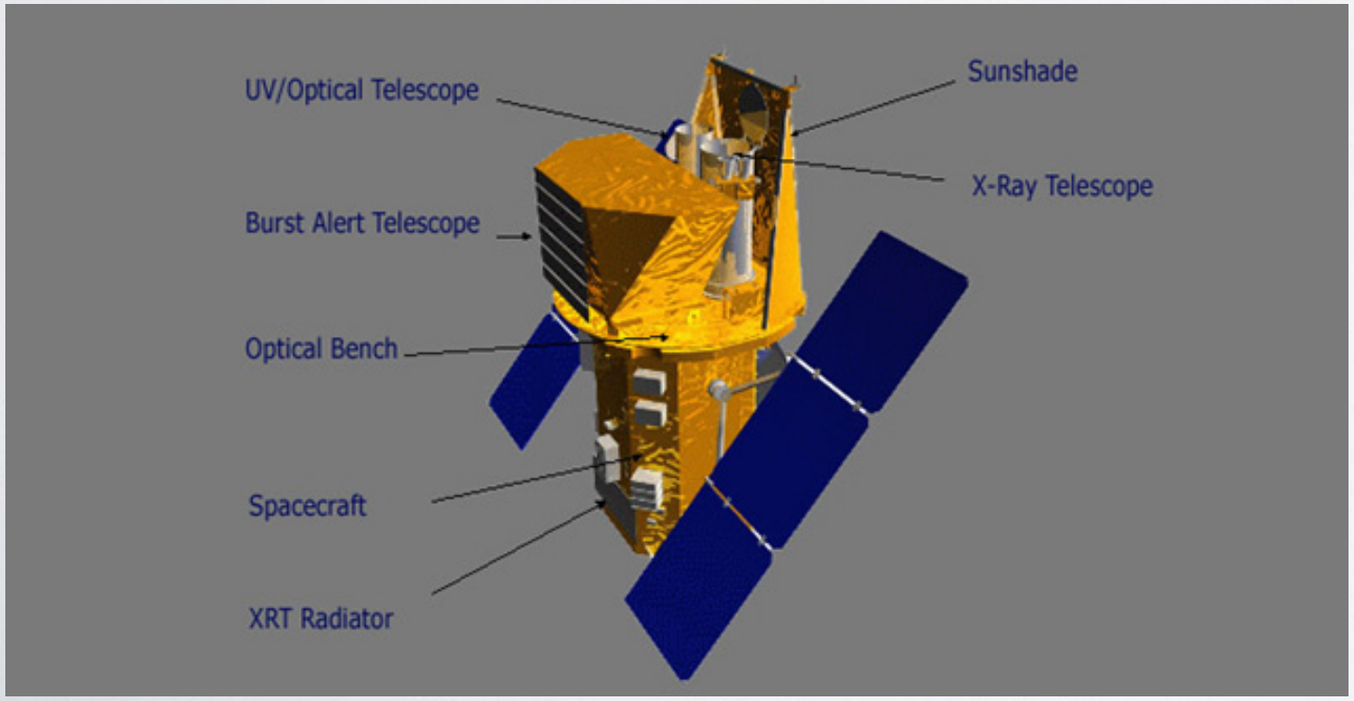
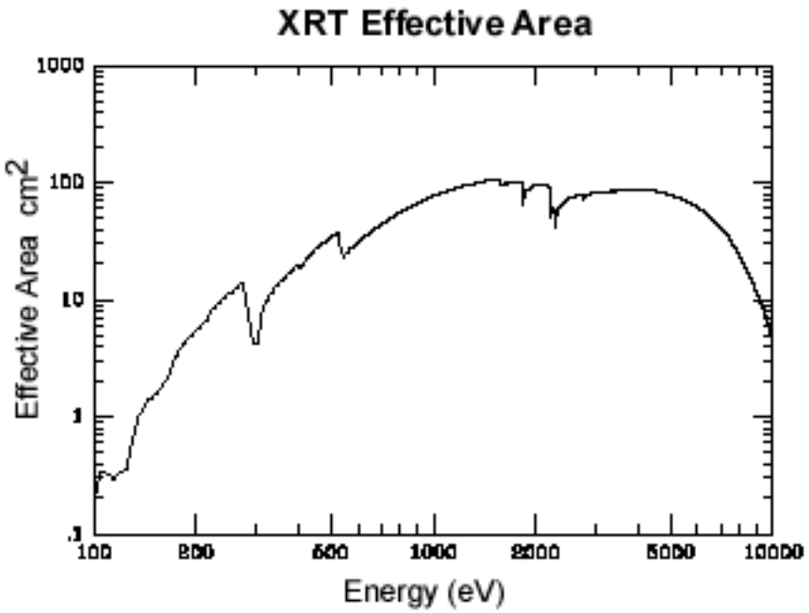
DESCRIPTION OF XRT

- Wolter Type I mirrors (JET-X spares)
- Single e2v CCD22 detector (same as XMM EPIC-MOS) 600x600.
- Energy range 0.2-10 keV
- Area = 110cm2 @ 1.5 keV
- PSF 18 arc-sec HPD @ 1.5 keV



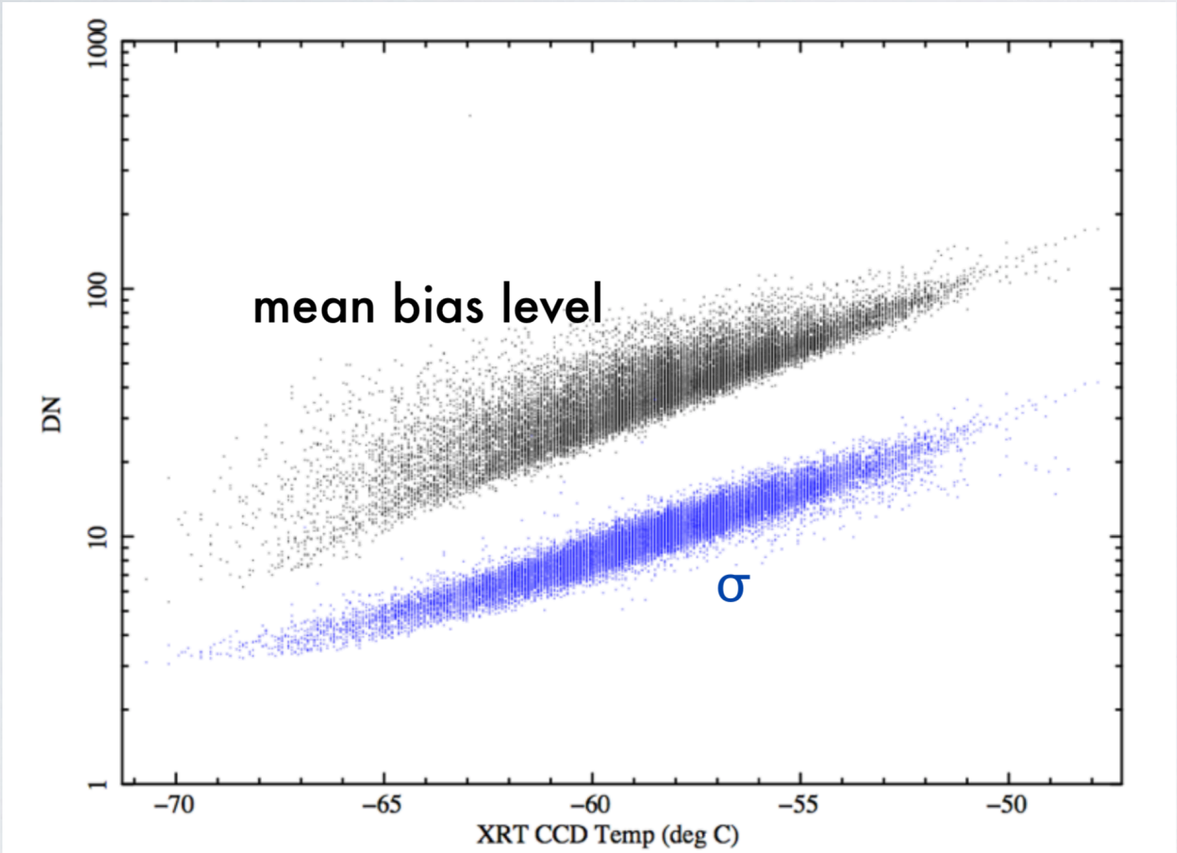


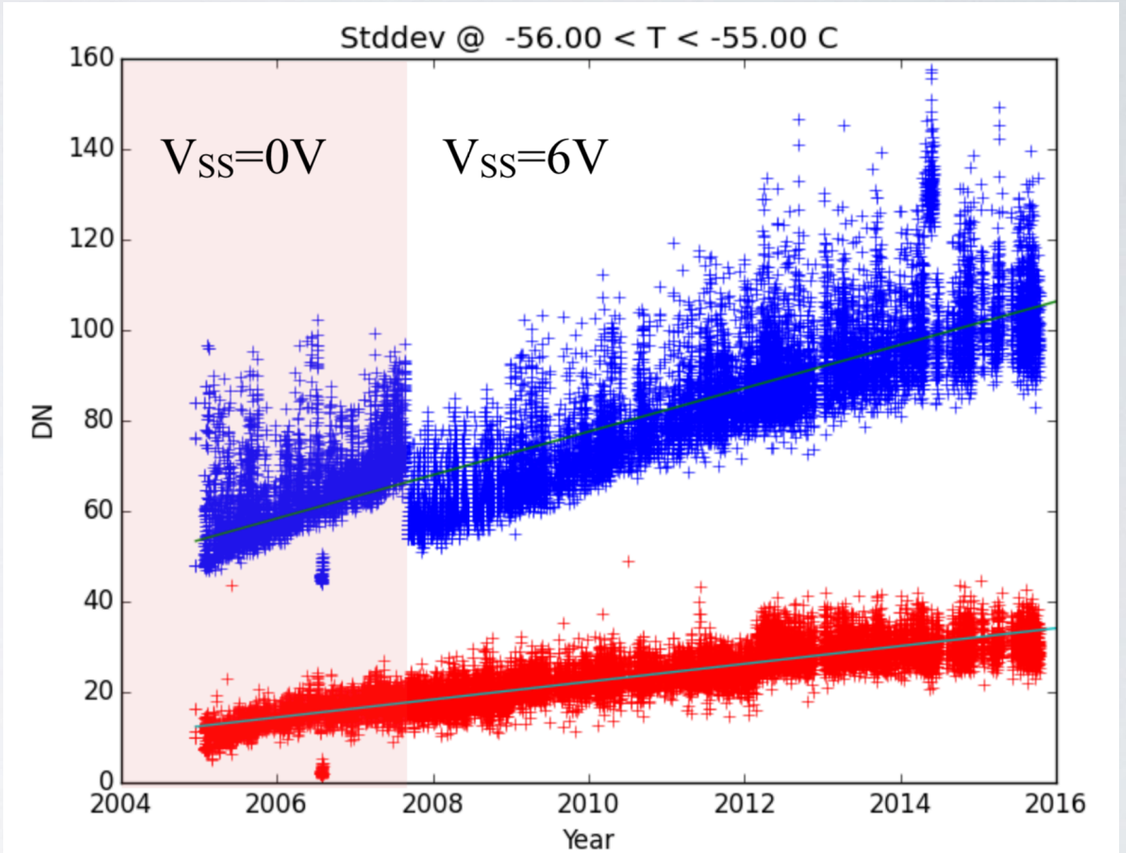


XRT CAL ISSUES - TEMPERATURE

- TEC cooler broke very early, so XRT is cooled passively.
- Operating temperature supposed to be -100C, instead varies between -80C and -40C
- Bias level temperature dependent. Temperature varies on orbital timescales, but bias maps only taken during slews.
  - Attempt to compensate for this by taking on-the-fly bias estimate from corner pixels of 3x3 events which are telemetered in PC mode (CPMEAN).
- Above -50C, bias level rises too quickly to compensate, so data become very noisey.
- Gain is also temperature dependent, as well as traps.

BIAS AND NOISE LEVEL

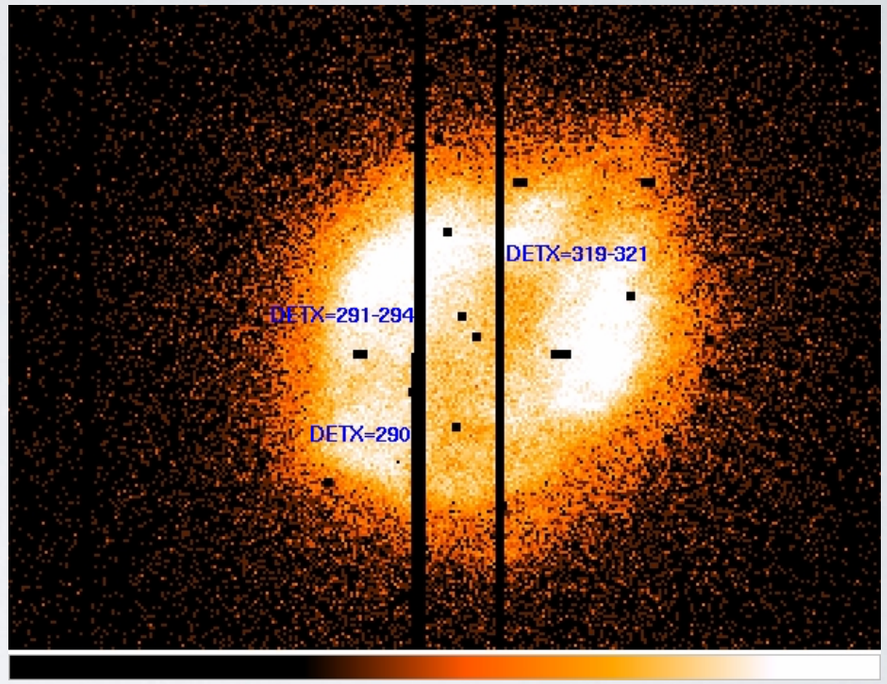


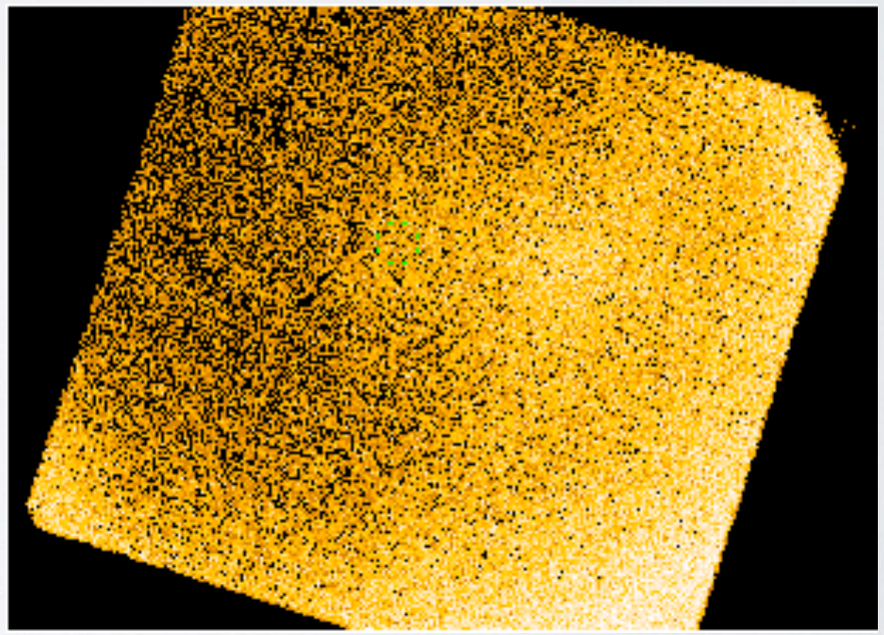


- XRT bias level both temperature dependent and evolve over time.
- Bias subtracted on-board, but only once per orbit
- Occasionally have to update parameters for bias map.

OTHER XRT CAL ISSUES

- Micrometeorite hit damage - hot columns
- Hot pixels
  - Masked out onboard (central 200x200) and rest filtered out on ground.
  - Temperature dependent!
- Earth limb contamination.
- Pile-up
  - PC mode 2.5s readout time - pile-up significant > 1c/s
  - WT mode 17ms readout time - pile-up an issue > 100c/s
- Optical loading - due to light leaking through the filter for bright stars.

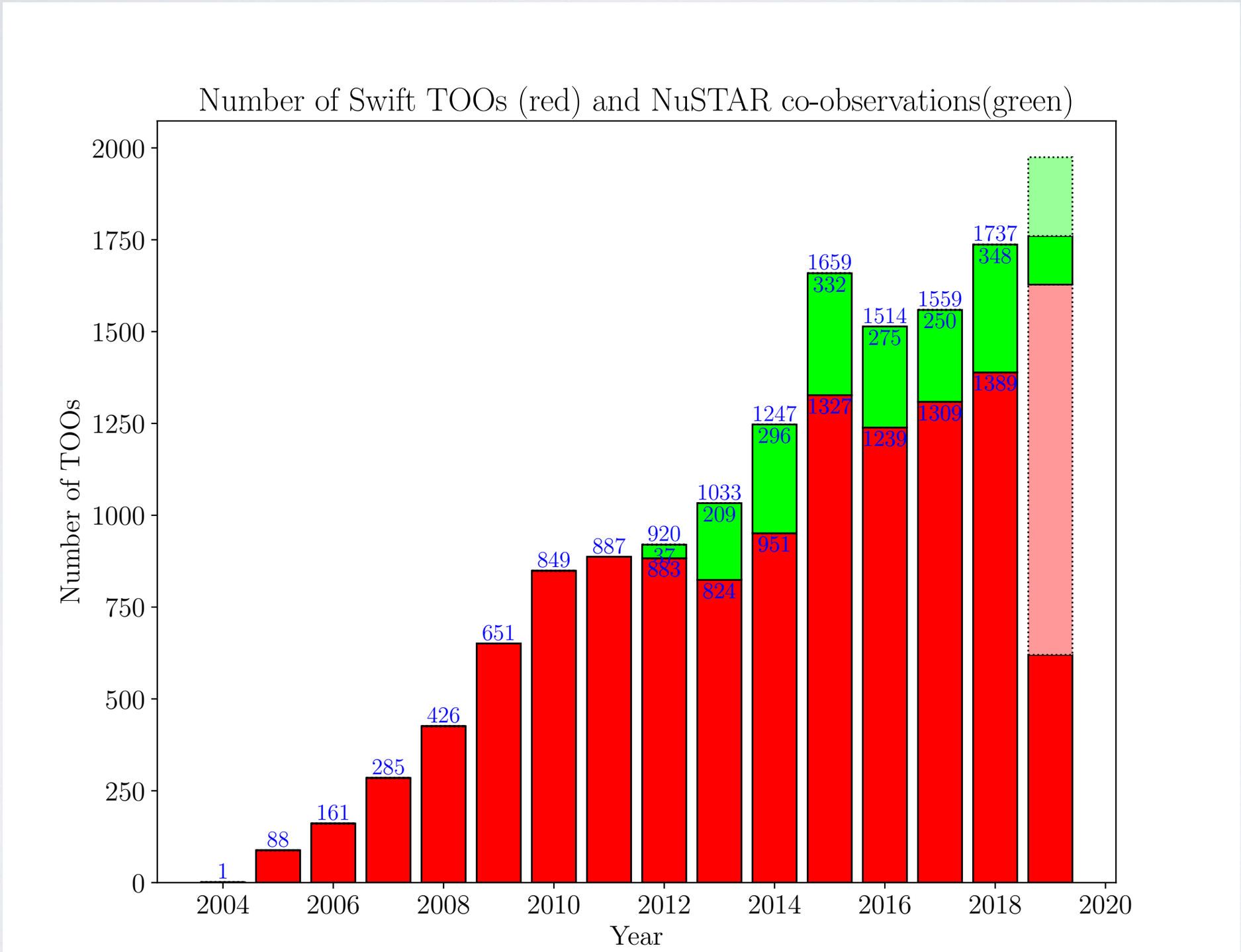




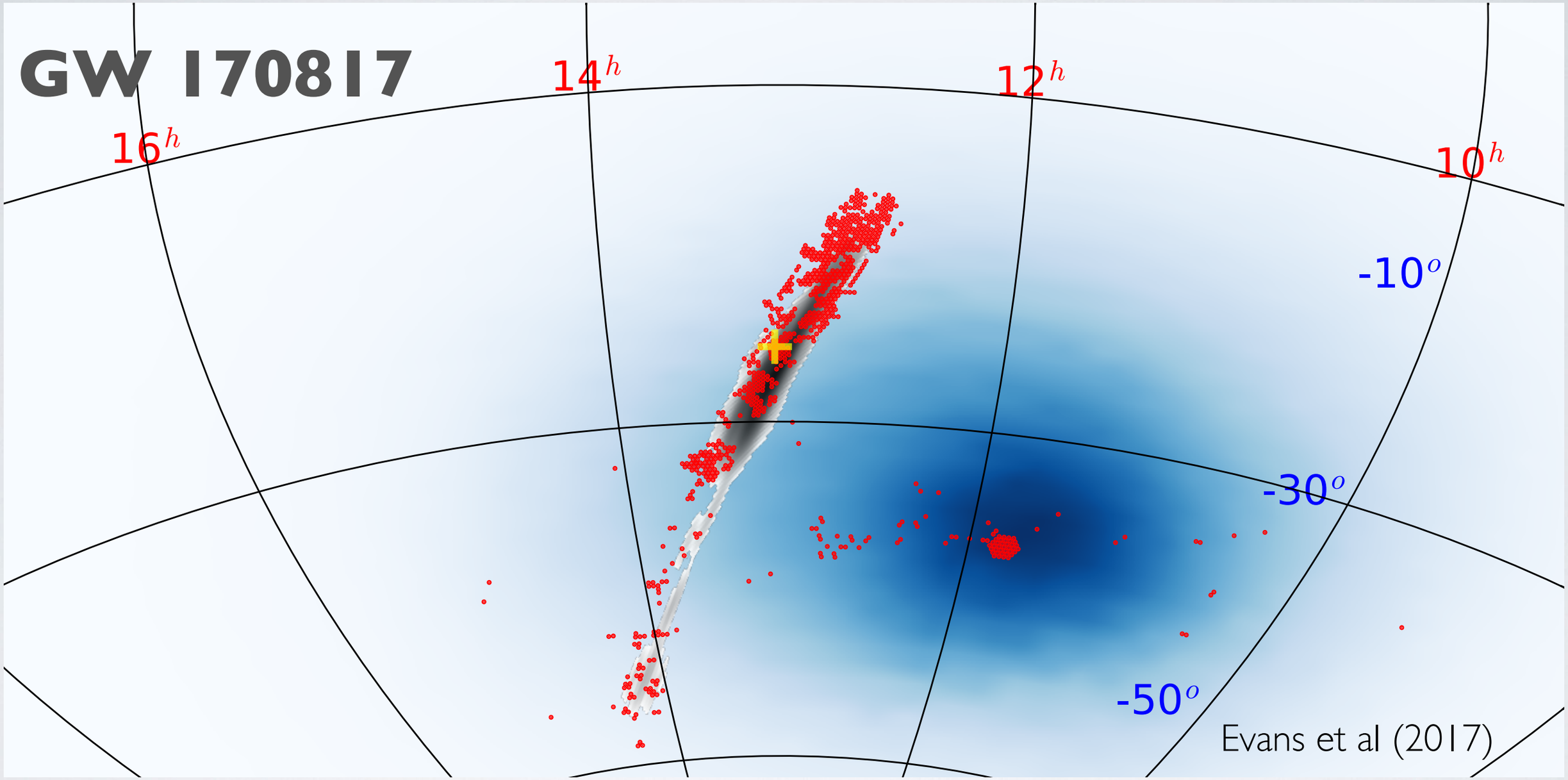
SWIFT OPERATIONS STATS

- In the past 28 days (as of today):
  - Swift has received 137 Target of Opportunity requests (4.9 per day)
  - 64 different TOO requesters in that time (so diverse community)
  - TOOs were for 120 different celestial objects
- On average Swift observes 60-70 unique targets per day.
  - Mean exposure per snapshot is 515s, max for scheduling is 1800s (30min), min usually 300s (although smaller with tiling).
- Swift's observing efficiency is 74%. Rest of the time spent slewing and passing through SAA.
- LIGO O3 means that we spend a lot of time tiling LIGO regions with short (80s) exposures, taking hundreds over first 48 hours after trigger.

SWIFT DOES A LOT OF TOOS



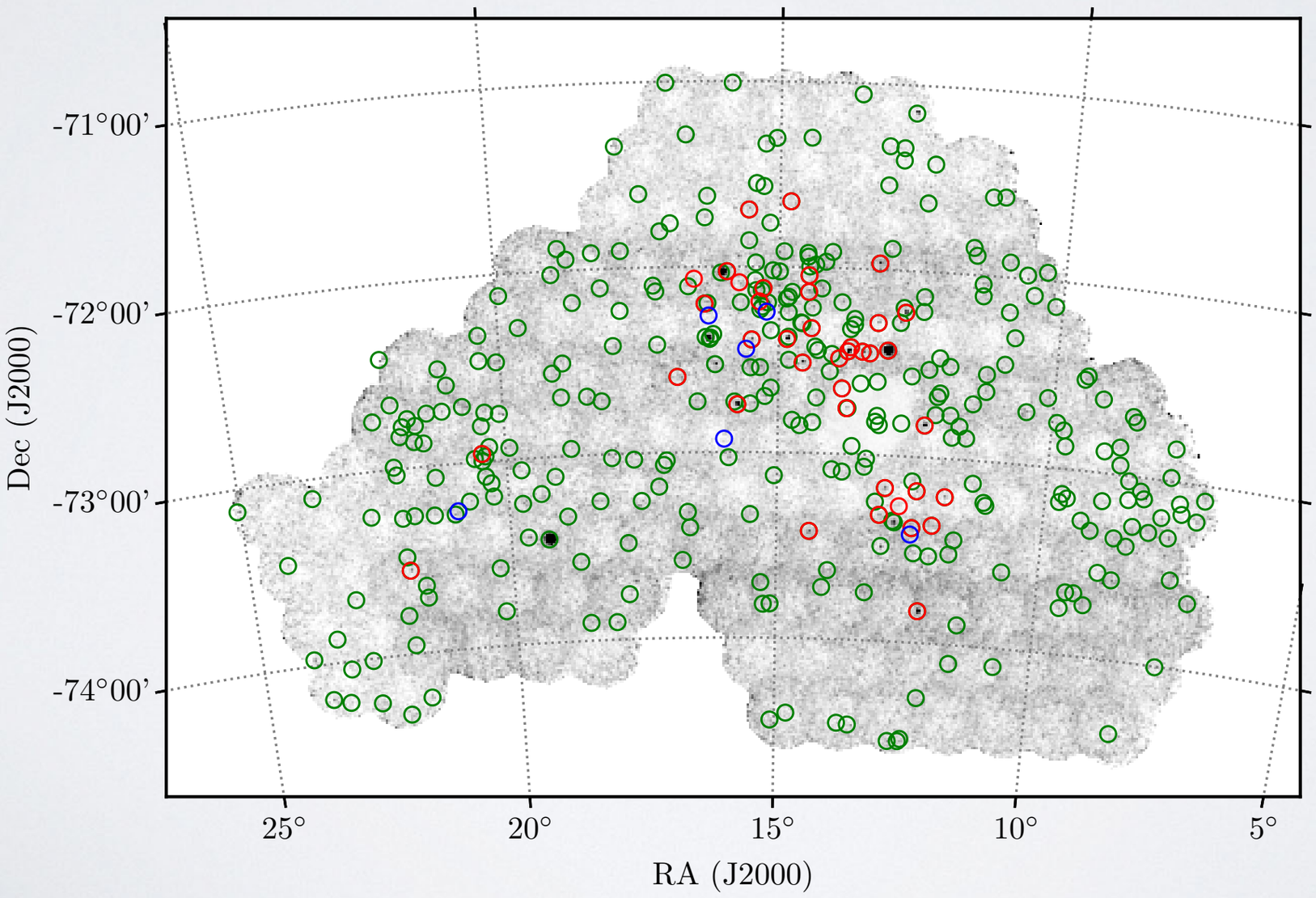
NEW OBSERVING MODE: MASS TILING



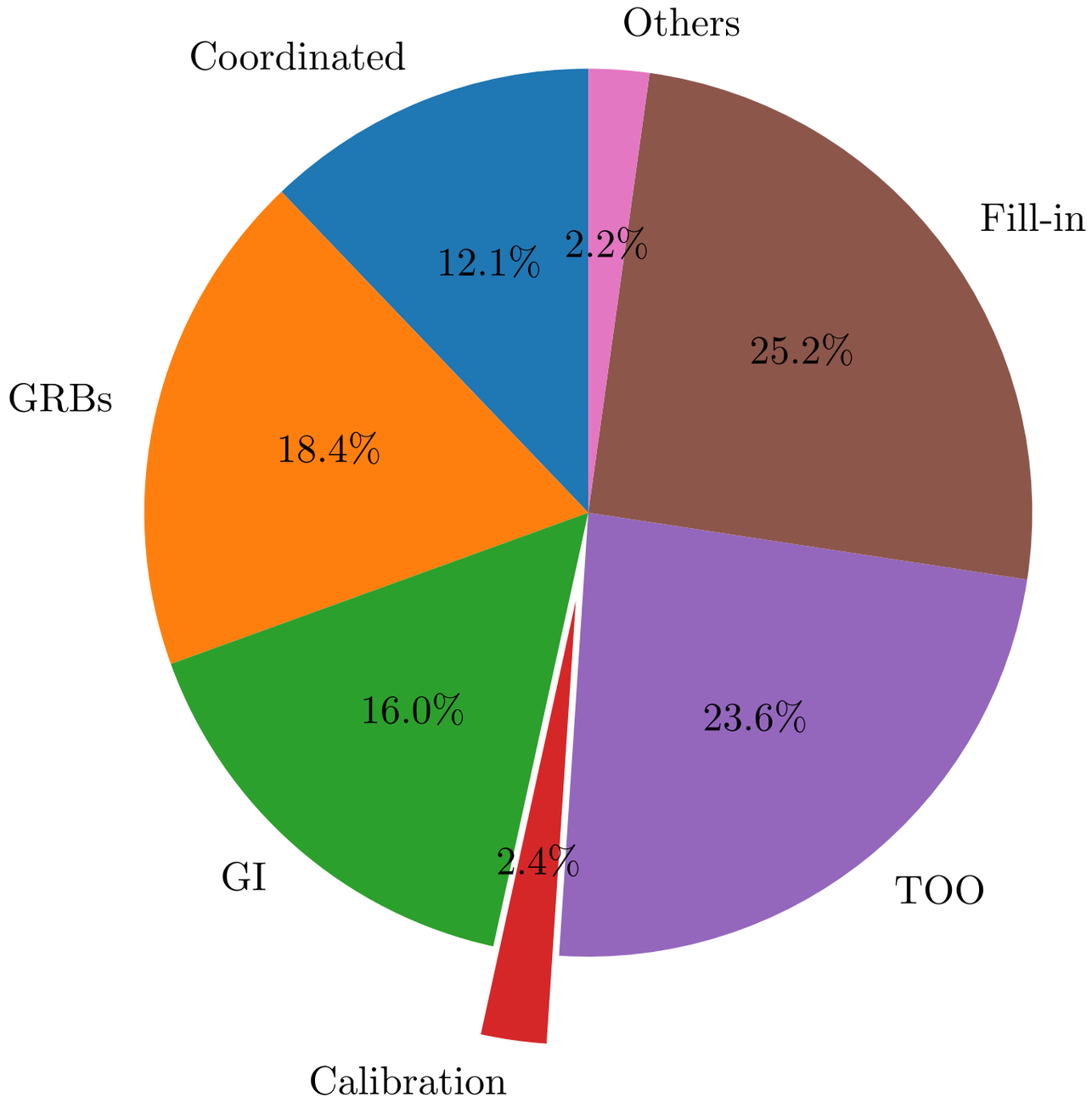
- GW170817:
  - 744 fields observed by Swift.
  - 92% of distance-weighted GW localization covered.

TILED SURVEYS

- S-CUBED (SMC Survey - Kennea+ 2018, ApJ, 868, 47)
- Galactic Bulge Survey (Heinke + Maccarone - Swift GI Cycle 13+15)
- LMC Survey (Zezas et al, performed in Swift Cycle 14)



SWIFT OBSERVATION BREAKDOWN



SWIFT XRT CALIBRATION

- Swift XRT calibration goals as follows:
  - Calibrate Windowed Timing (WT) mode with standard sources
  - Calibrate Photon Counting (PC) mode with standard sources
  - Join in cross calibration with other observatories (typically picking PC or WT based on source brightness).
- Due to the way Swift performs plans (daily) we almost never drive when cross-cal are scheduled:
  - Moon and Sun constraints are similar or smaller than other observatories.
  - Only weird constraint is our "pole" constraint for targets near our orbit pole. Only really affects stuff near +/-69deg dec, e.g. E0102, N132D.

REGULAR CALIBRATION TARGETS

- Swift has a program of Calibration observations which are repeated yearly, on the following targets:
  - E0102: 20ks in WT + PC, every 6 months - 80ks total
  - RX J1856.3-3734: 20ks in WT+PC, every 6 months, 80ks total
  - SNR G21.5: 30ks in PC, once per year.
  - Tycho: 20ks in PC over 15 pointings covering the CCD once a year, 300ks total
    - Used to map CCD traps in PC mode
  - Cas A: 10ks in WT over 6 pointings covering the WT window once a year, 60ks total.
    - Used to map CCD traps in WT mode
- Total regular calibration time = **0.6 Ms/year**, or about **2.4%** of total observing time

COORDINATED CALIBRATION

- BAT calibration (yearly):
  - 5 pointings of Crab, 10ks each, each pointing offset at different locations across the BAT FOV.
  - 50ks / per year
  - This year we joined in the big campaign on the Crab for the final (on-axis) pointing
    - For XRT Crab isn't very useful - piled up, extended. Good for timing calibration, but that's well calibrated already.
- 3C273 - WT, 20ks coordinated with large campaign. Will do again this year in July.
- Other XRT cal targets:
  - N132D in WT mode - done in 2013, again in 2019. Now done yearly.

NUSTAR COORDINATION

- Swift observes all NuSTAR targets for 2ks.
  - Exceptions: XMM and Chandra coordinated observations where XRT data are deemed unnecessary
- Some targets observed longer
  - BAT detected AGNs and some other surveys 7ks
  - Swift time given out through NuSTAR GI panel
  - TOOs asking for more time
- Swift data provides vital <3keV energy response to compliment NuSTAR data, but getting a good fit to both spectra can be troublesome.
  - Kristen's talk earlier

CALDB STATUS

- Swift calibration is fairly stable over the past few years
- Last update to Swift XRT CALDB April 2019
  - Updates to PC and WT gain calibration file format (just placeholders for now) - waiting on new HEASOFT release to support new gain files.
- Last RMF update in July 2014
- Detector bias and noise level slowly increases with time, so occasional updates on-board to bias levels made. Last update in May 2018.
- See Andy Beardmore's talk earlier today about on-going Swift calibration efforts.