



PennState
Eberly College of Science

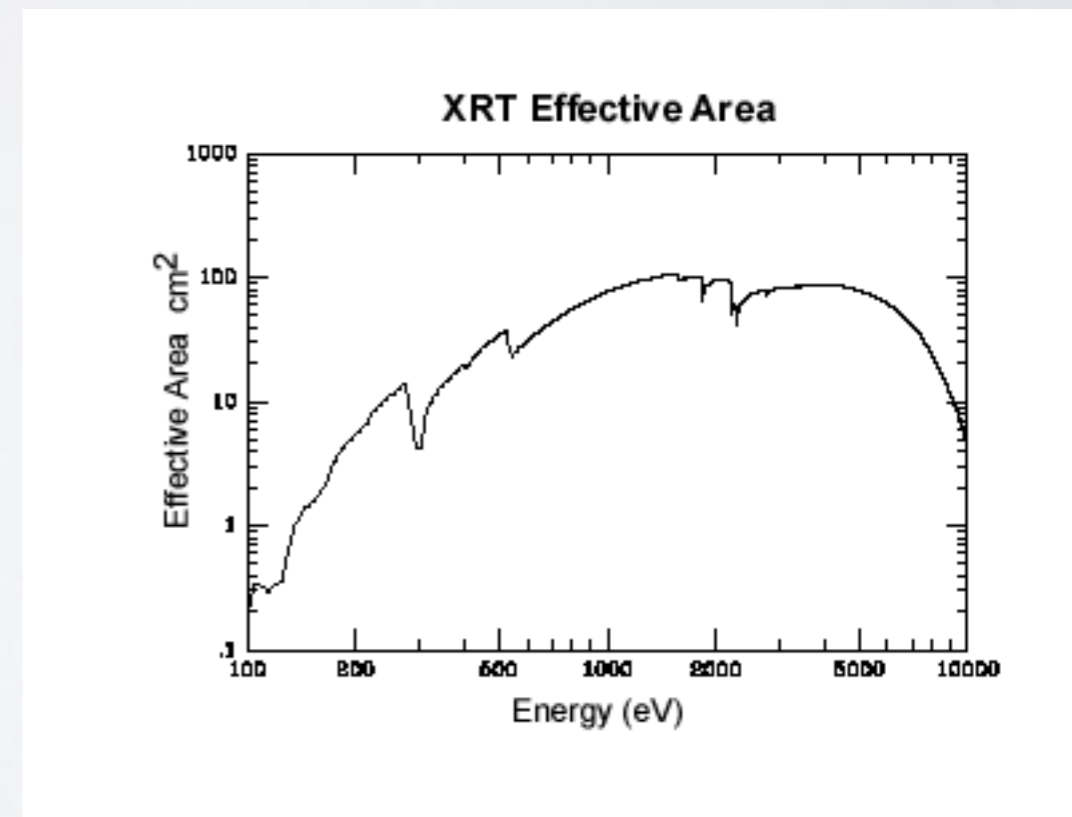
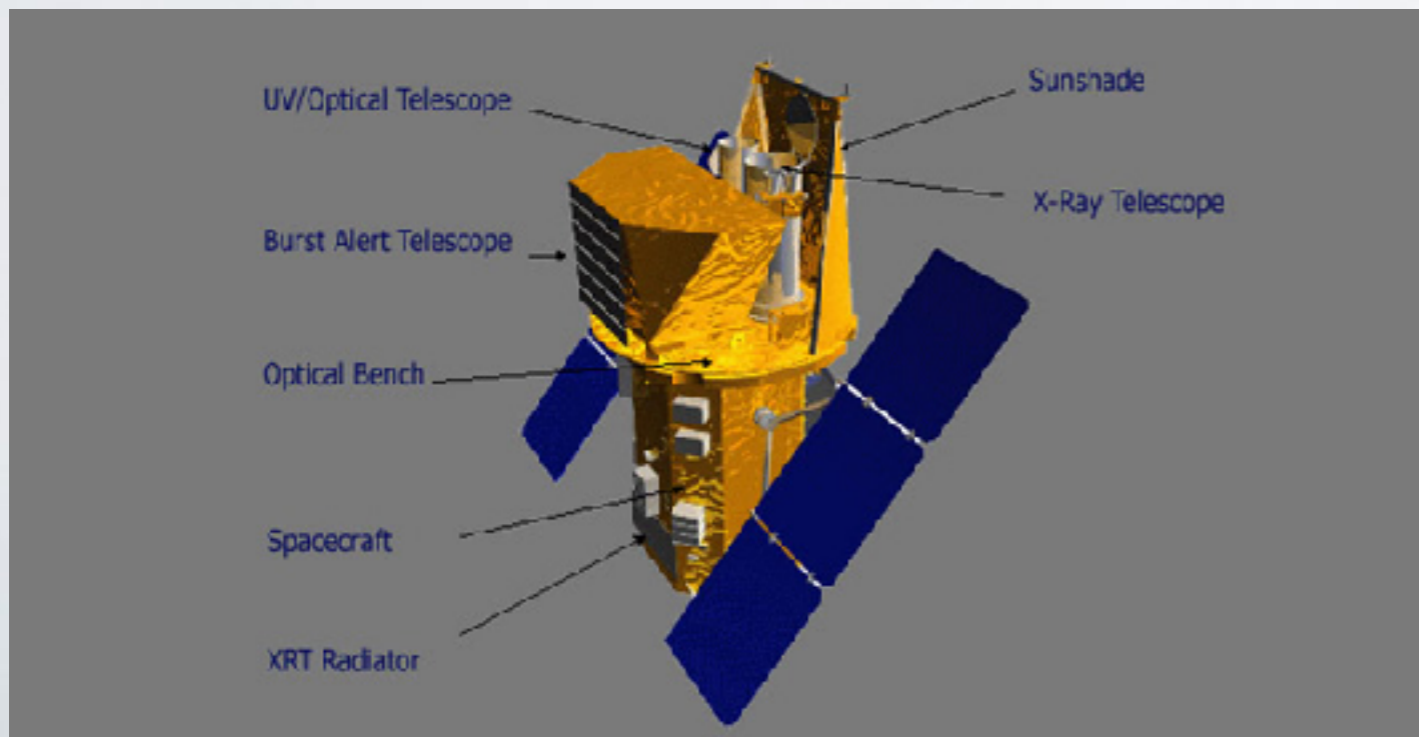
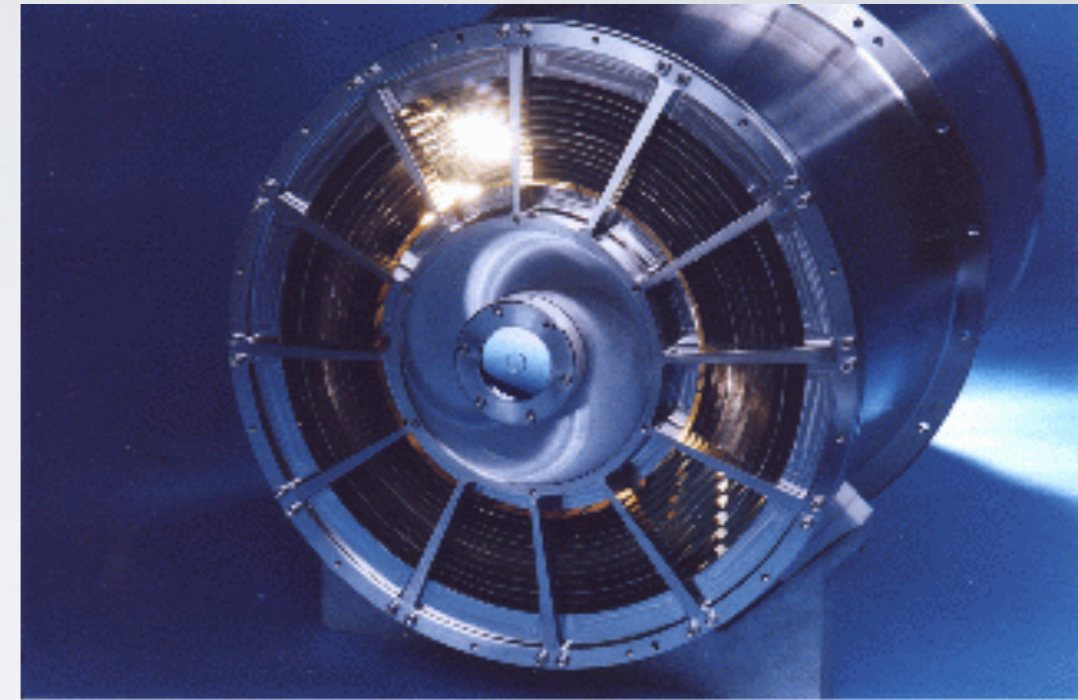


SWIFT OPERATIONS AND CALIBRATION (XRT + COORDINATED)

JAMIE A. KENNEA (Penn State),

DESCRIPTION OF XRT

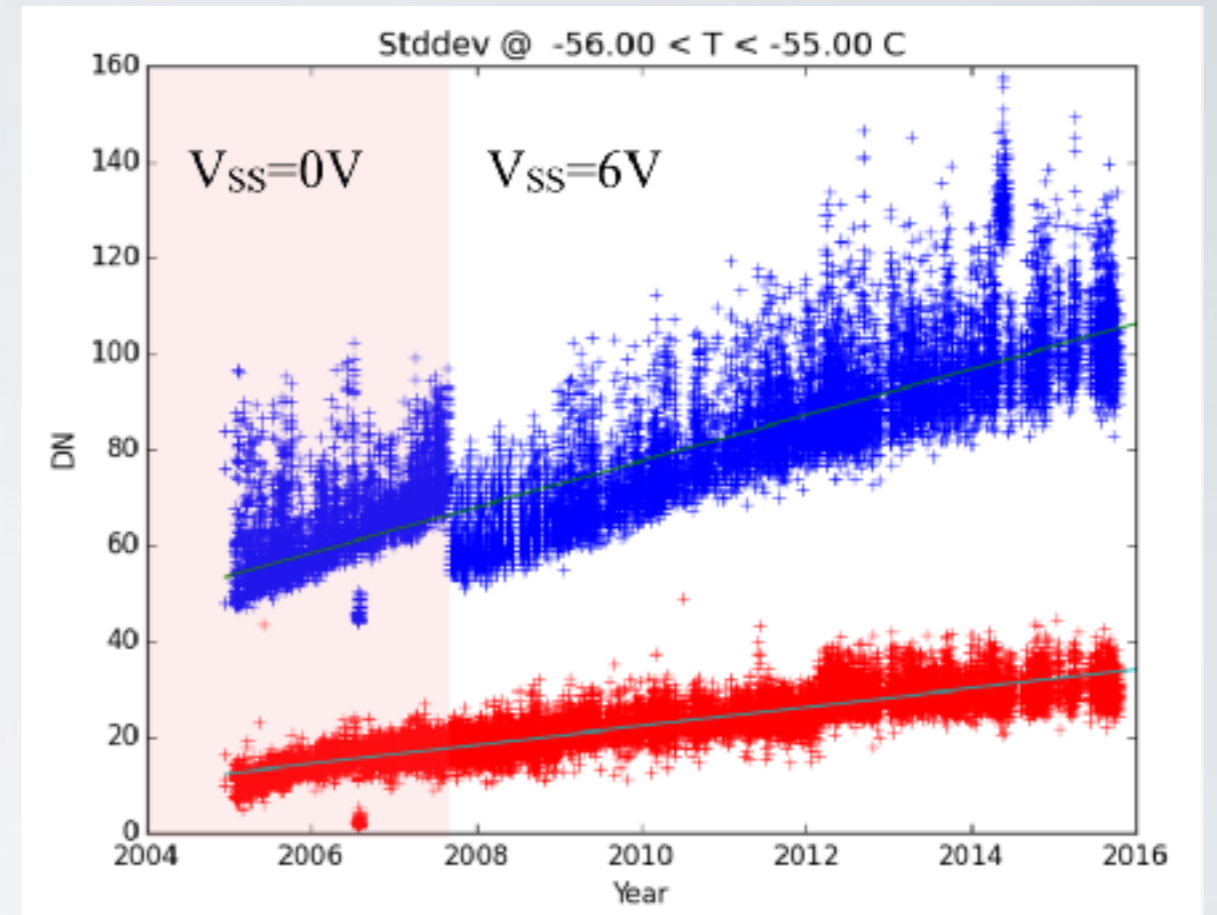
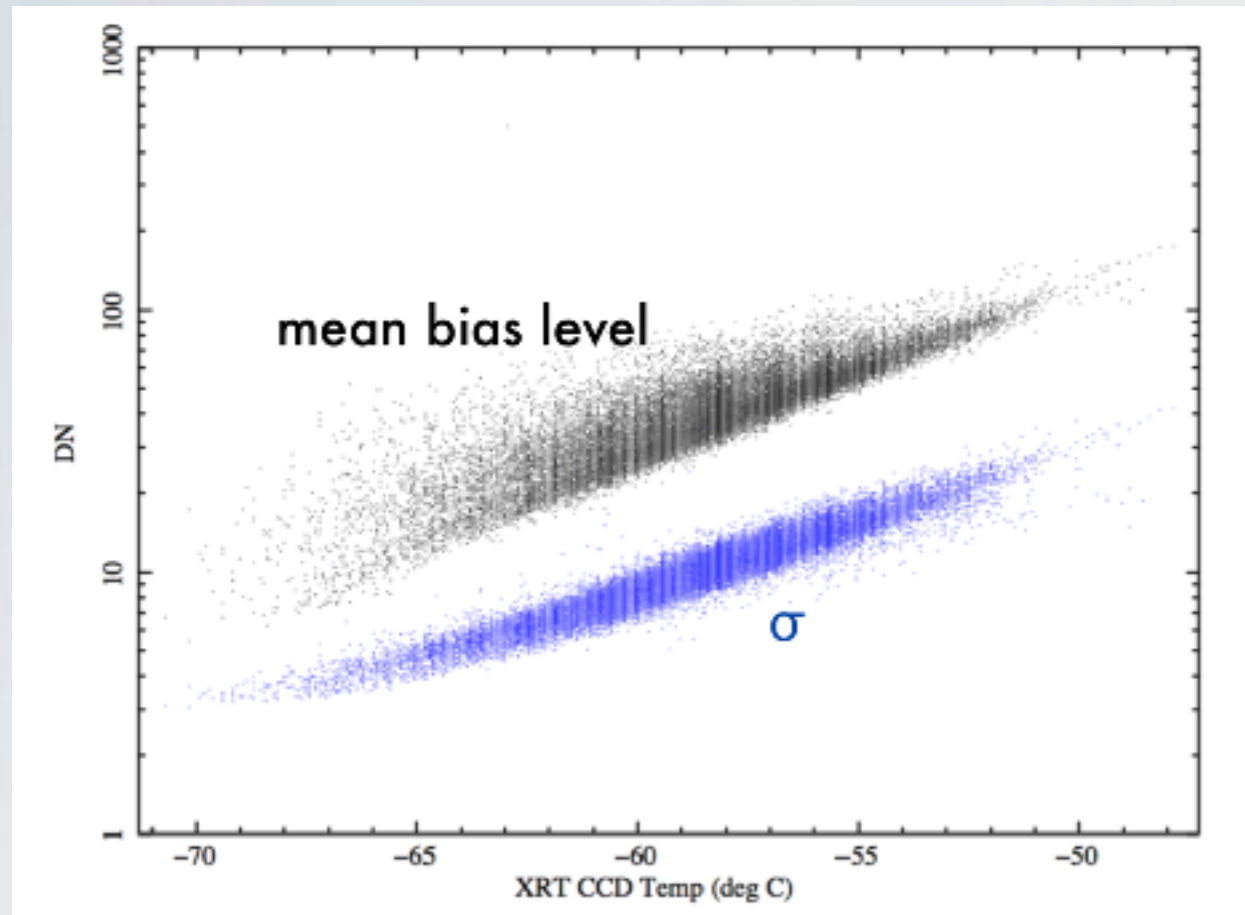
- Wolter Type I mirrors (JET-X spares)
- Single e2v CCD22 detector (same as XMM EPIC-MOS) 600x600.
- Energy range 0.2-10 keV
- Area = 110cm² @ 1.5 keV
- PSF 18 arc-sec HPD @ 1.5 keV



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 3×3 events which are telemetered in PC mode (CPMEAN).
- Above -50C , bias level rises too quickly to compensate, so data become very noisy.
- Gain is also temperature dependent, as well as traps.

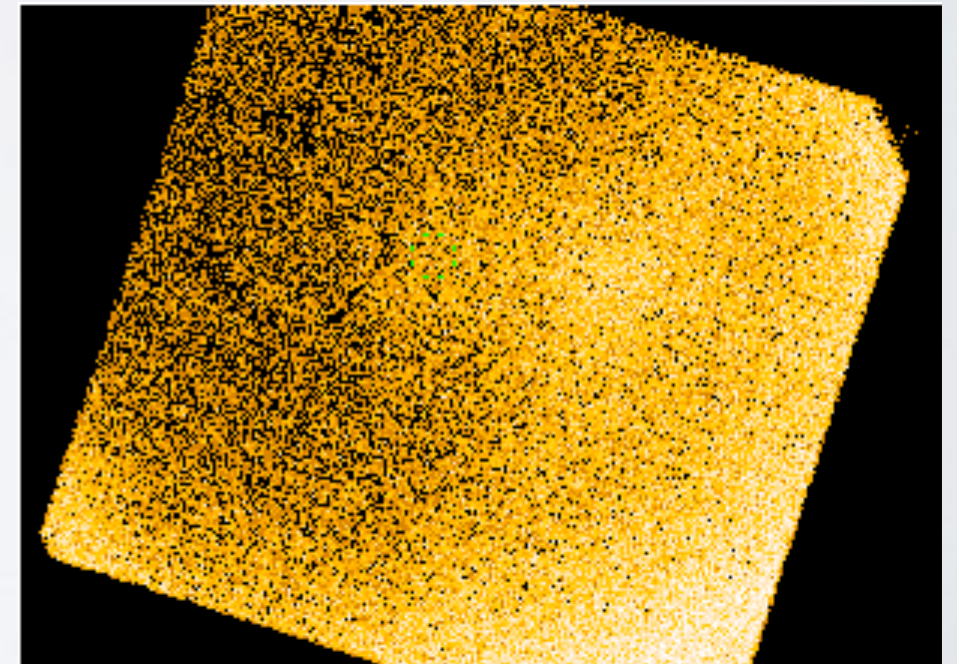
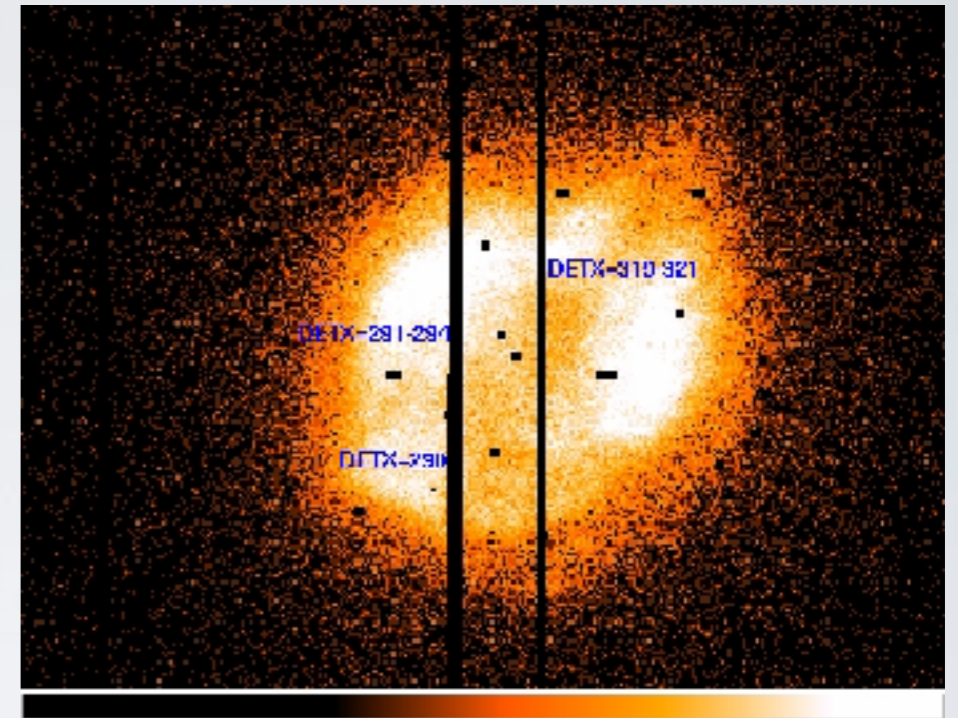
BIAS AND NOISE LEVEL



- 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

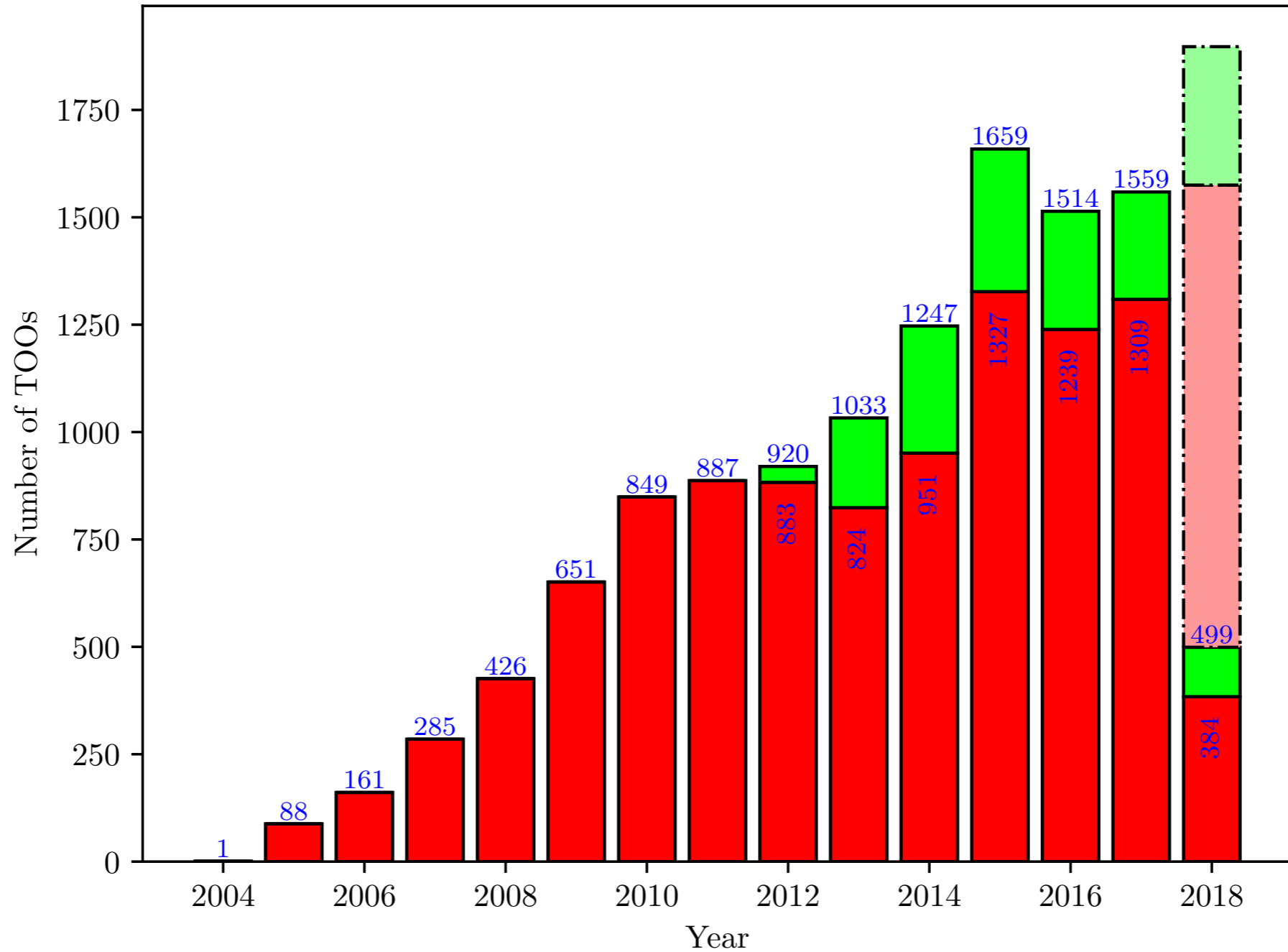
- Micrometeorite hit damage - hot columns
- Hot pixels
 - Masked out onboard (central 200x200) and rest filtered out on ground.
 - Temperature dependent!
- Earth limb contamination.
- Pile-up
 - PC mode 2.5s readout time - pile-up significant $> 1\text{c/s}$
 - WT mode 17ms readout time - pile-up an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



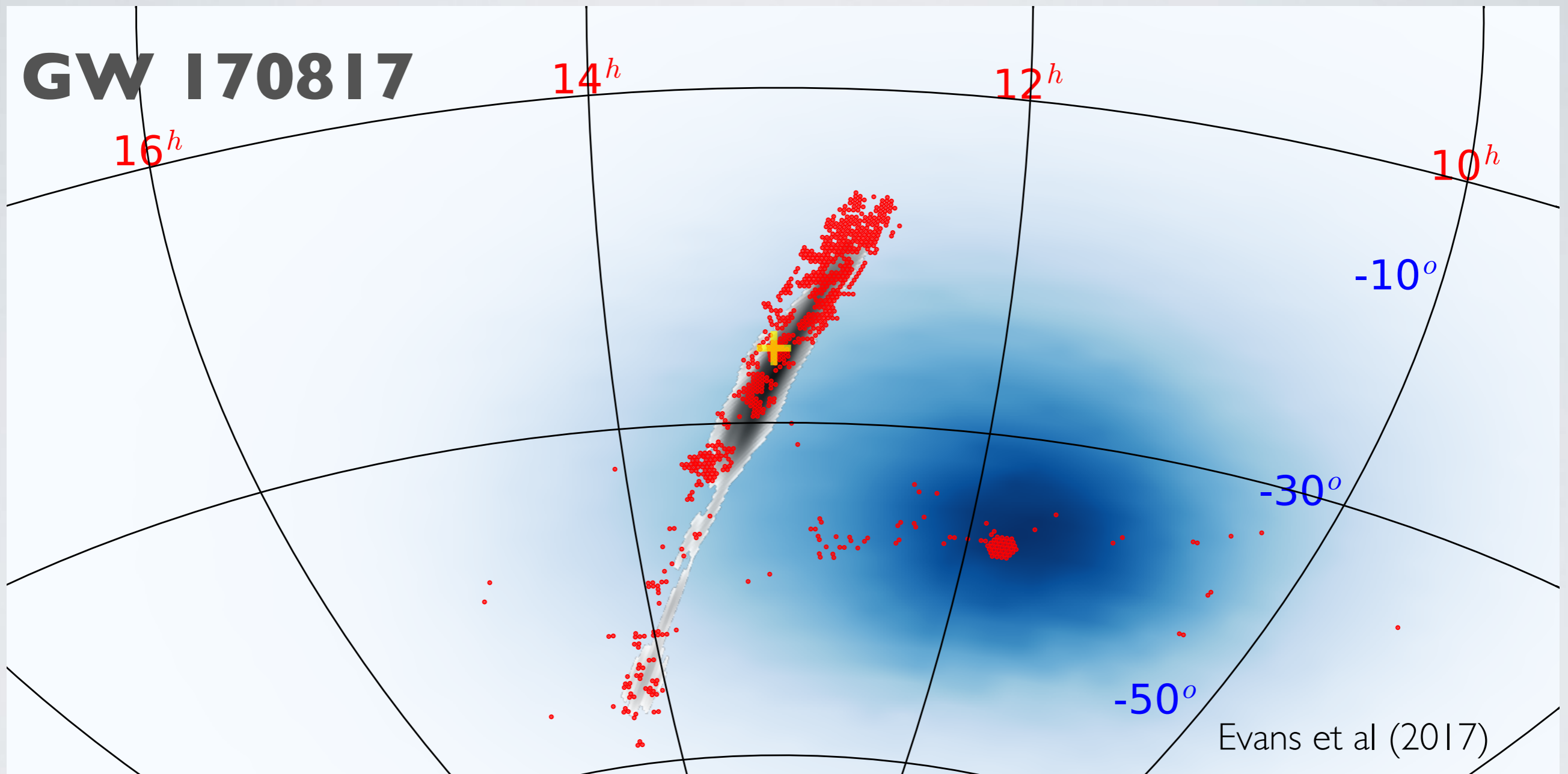
SWIFT OPERATIONS STATS

- In the past 28 days (as of Friday April 6th):
 - Swift has received 123 Target of Opportunity requests (4.4 per day)
 - 66 different TOO requesters in that time (so diverse community)
 - TOOs were for 95 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.

SWIFT DOES A LOT OF TOOS



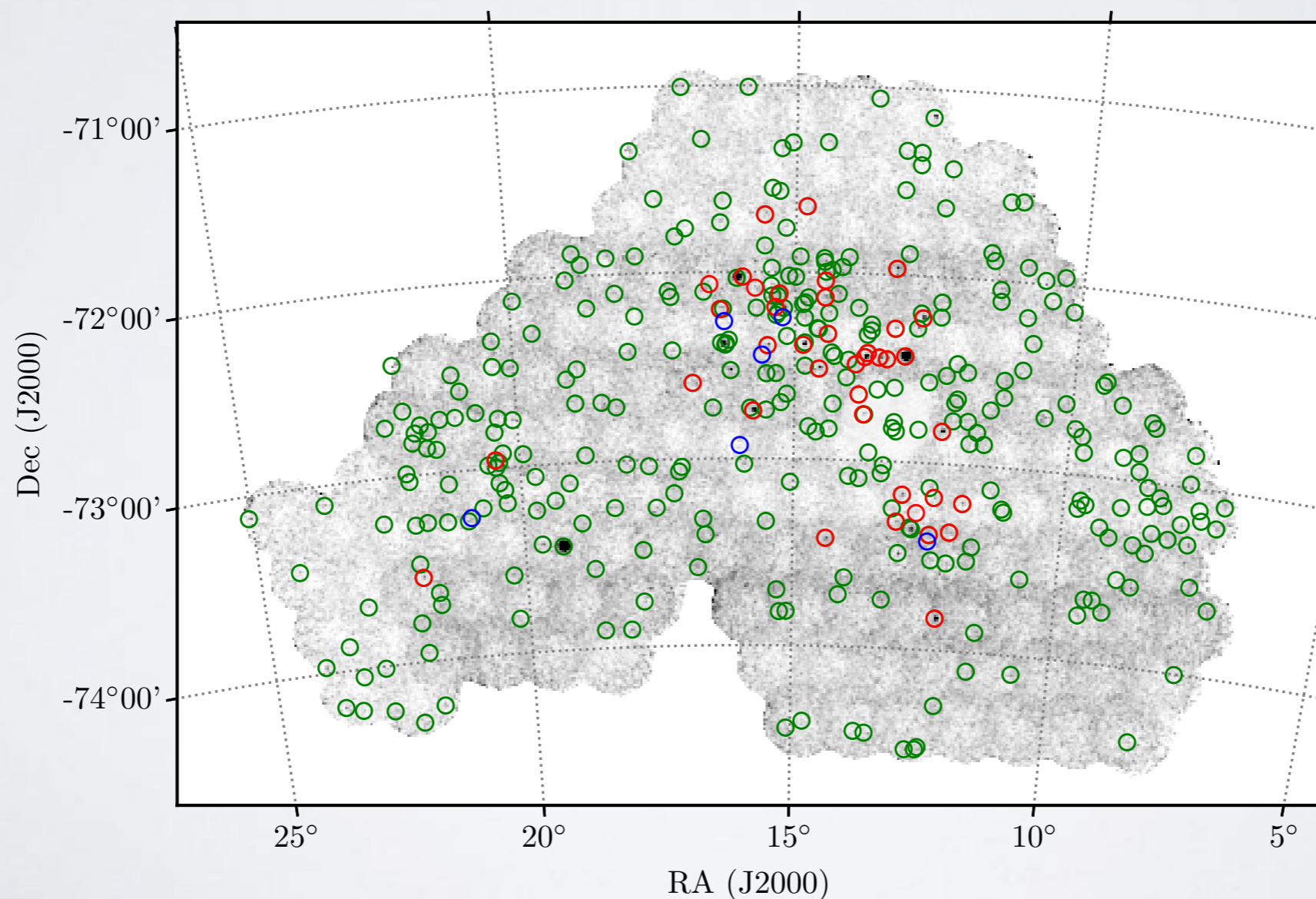
NEW OBSERVING MODE: MASS TILING



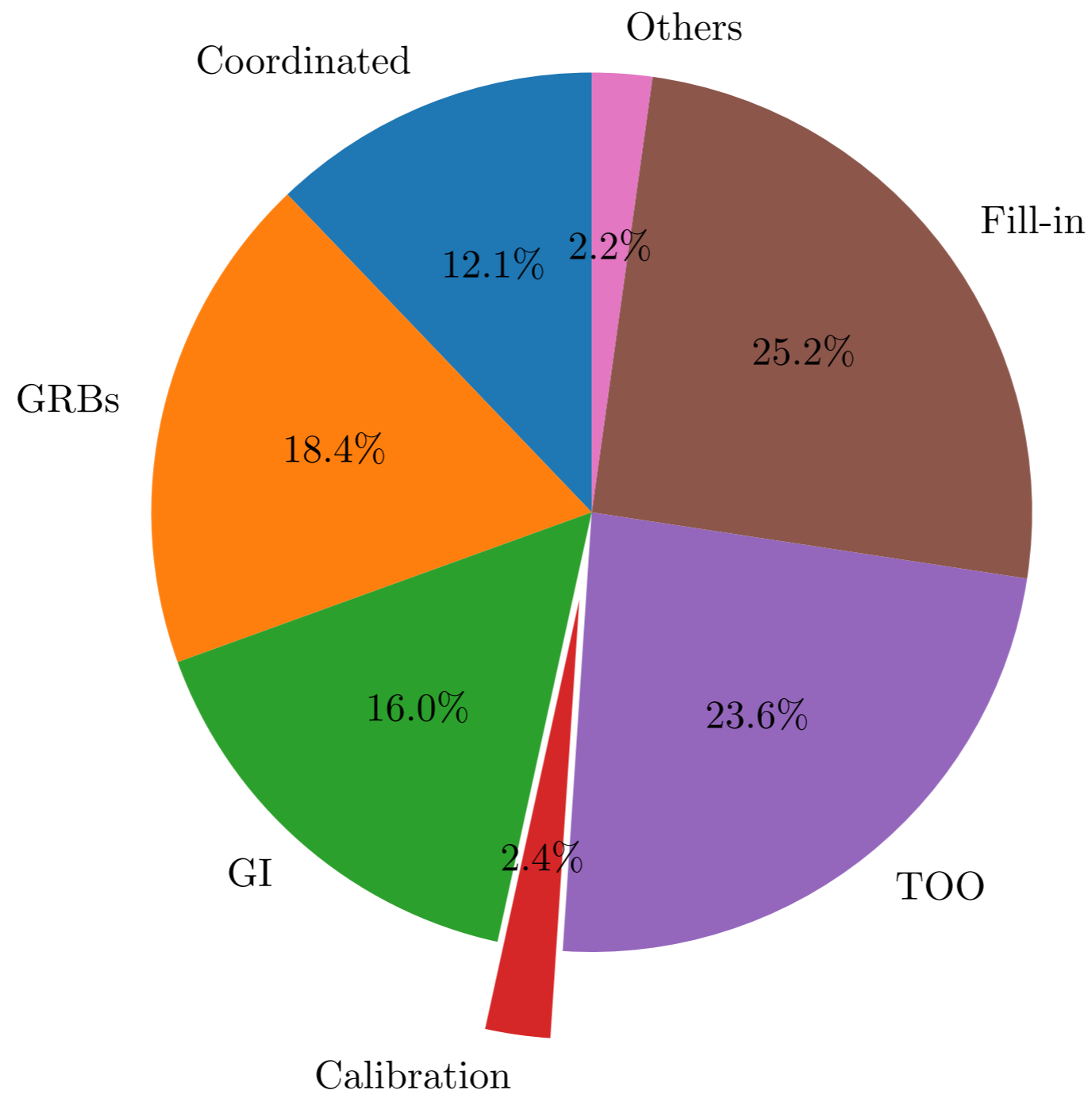
- GW170817:
 - 744 fields observed by Swift.
 - 92% of distance-weighted GW localization covered.

TILED SURVEYS

- S-CUBED (SMC Survey - Kennea+ 2018, ApJ *Submitted*)
- Galactic Bulge Survey (Heinke + Maccarone - Swift Cycle 13)
- LMC Survey (Zezas et al, starting 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 $\pm 69^\circ$ 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:
 - 5 pointings of Crab, 10ks each
 - 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 only.
 - Crab this year was flaring as the calibration campaign was underway!
- Other XRT cal targets:
 - NI 32D in PC mode - done in 2013, again in 2018.
 - 3C273 - WT, 20ks coordinated with large campaign. Will do again this year in July.

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
 - TOO's asking for more time
- Swift data provides vital $<3\text{keV}$ energy response to compliment NuSTAR data, but getting a good fit to both spectra can be troublesome.
 - See Kristin's talk on this issue.

CALDB STATUS

- Swift calibration is fairly stable over the past few years
- Last update to Swift XRT CALDB May 2017
 - Updates to PC and WT gain calibration
- 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 2017.
- See Andy Beardmore's talk tomorrow about on-going Swift calibration efforts.