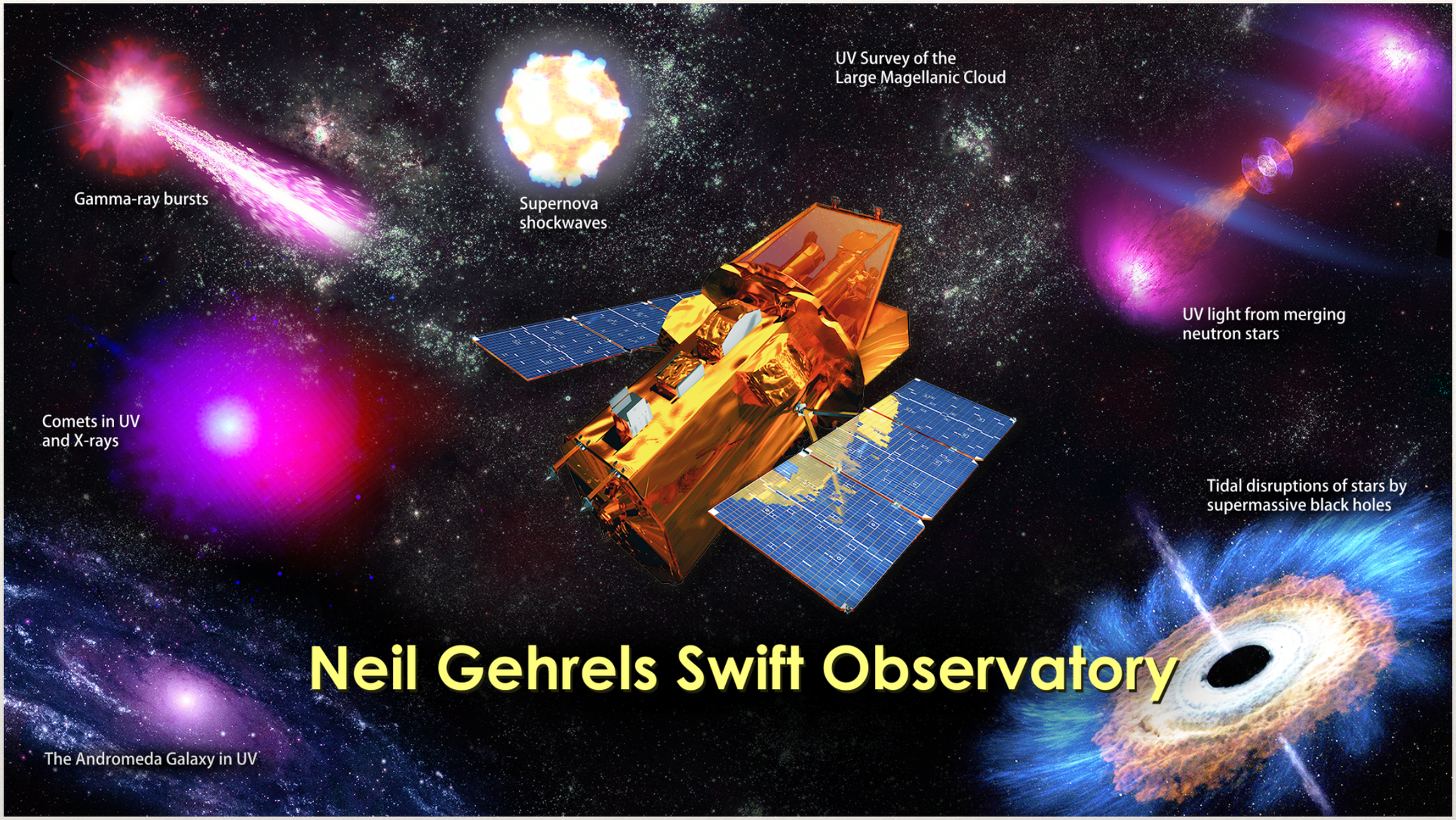
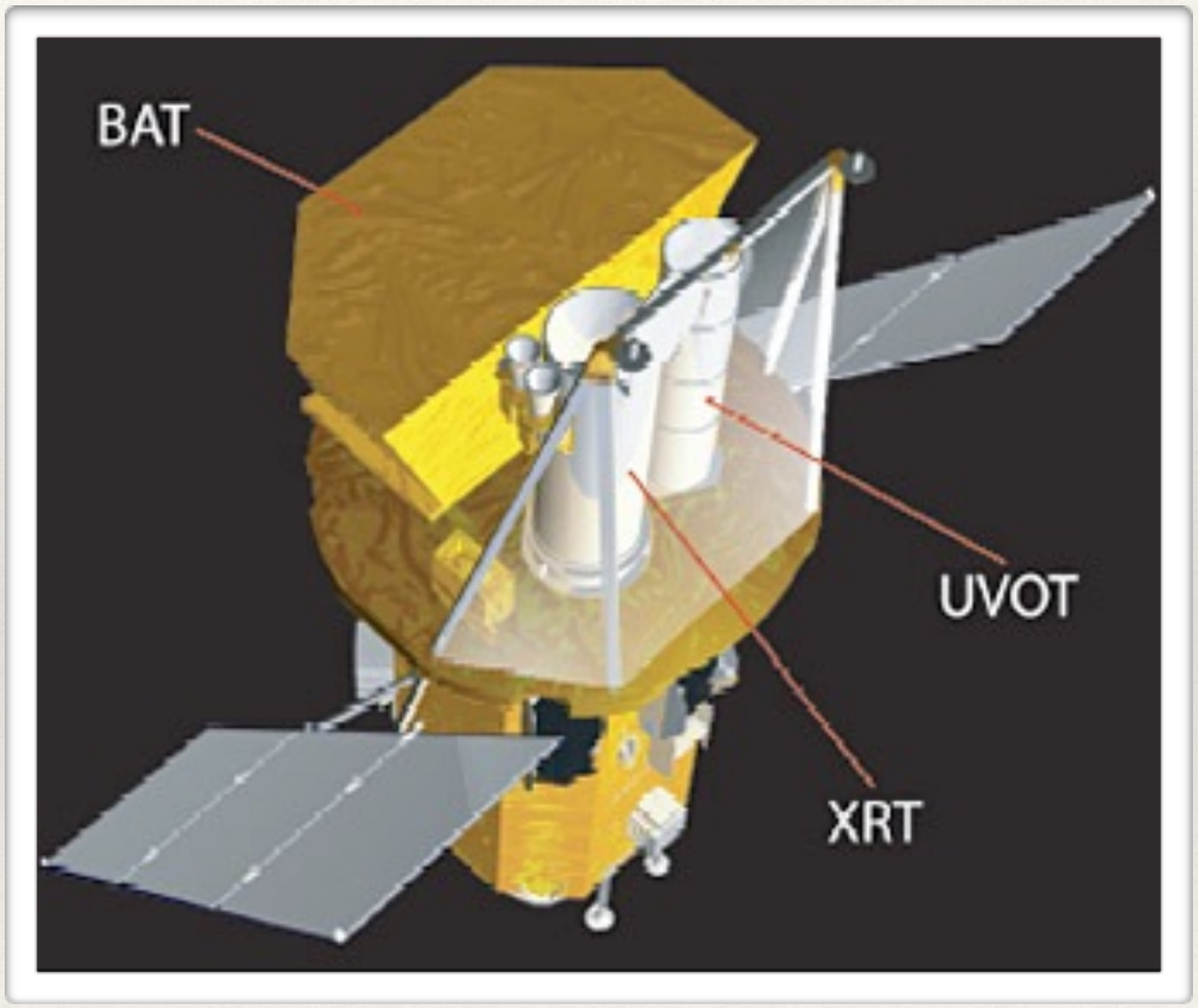


Neil Gehrels Swift Observatory Update

Brad Cenko
NASA GSFC
October 20, 2020

Instrument Suite

- Burst Alert Telescope (BAT): 15-350 keV, 1.4 sr field-of-view, ~ 3′ localization
- X-Ray Telescope (XRT): 0.2-10.0 keV, 24′ x 24′ field-of-view, 3″ localization
- UV/Optical Telescopes (UVOT): 170-650 nm, 17′ x 17′ field-of-view, 0.5″ localization



Evolving Observing Time

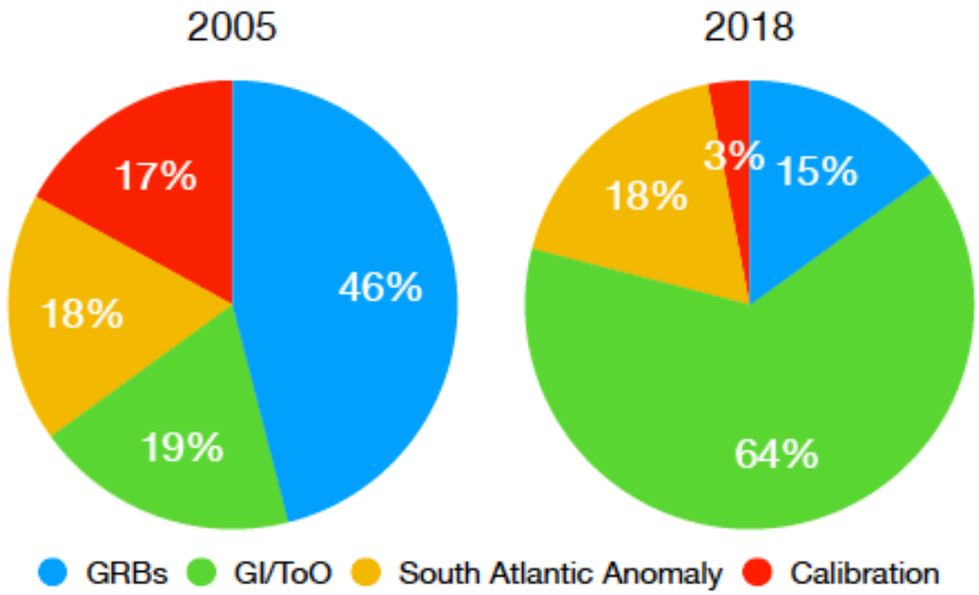


Figure 1: *Swift* observing allocations have changed since launch, based on scientific opportunities and community feedback. Most GRBs are now followed for a day or two, while GI observations and ToOs have greatly increased.

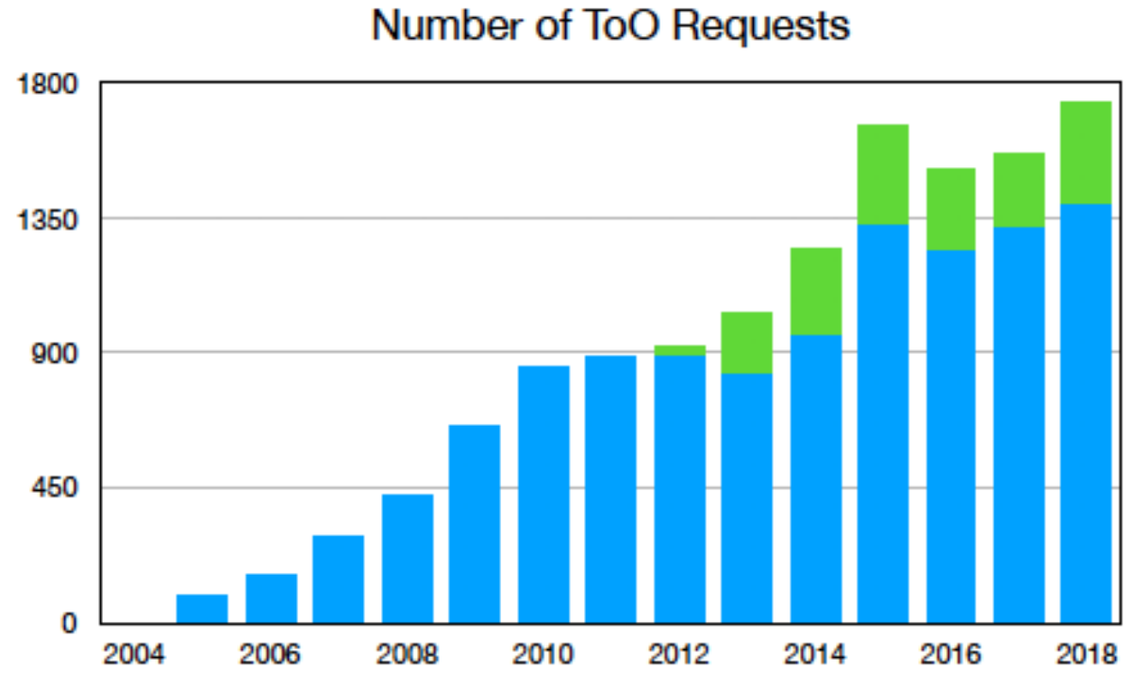


Figure 2: Very high levels of ToO requests reflect tremendous community interest. Coordinated *NuSTAR* observations are shown in green.

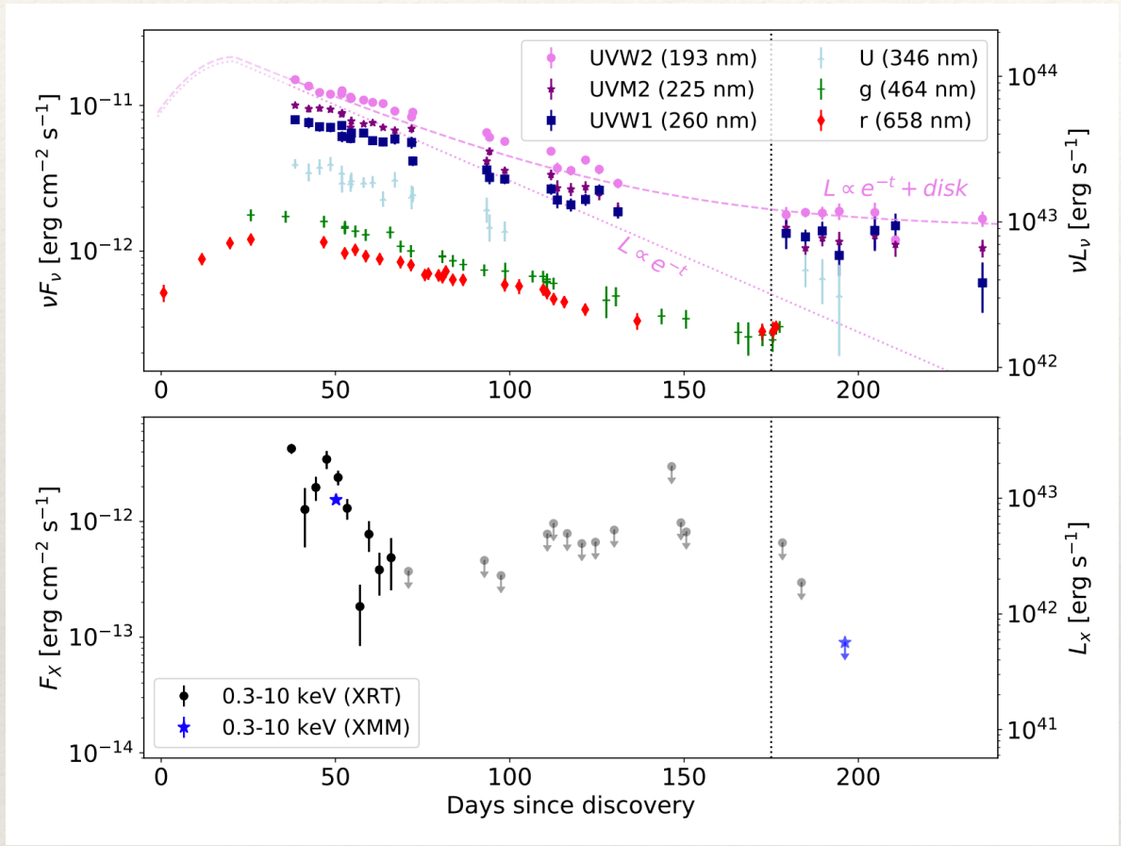
2019 Senior Review Priorities

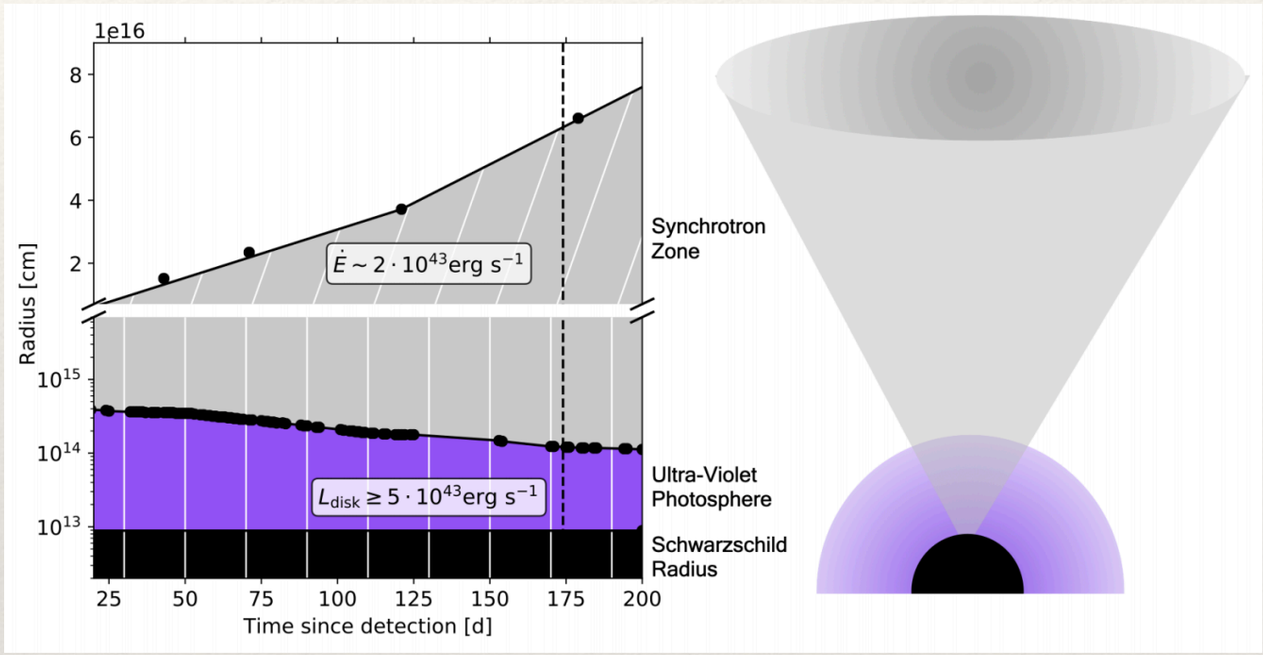
Scientific Prioritized Mission Objectives: Case for Five More Years

Swift provides discovery observations across many areas of astrophysics, from distant galaxies to comets. It is the only current mission designed specifically for GRBs, and is the primary partner for *NuSTAR* and *Fermi*. Our prioritized **scientific** mission objectives for the next five years are:

- *The Dawn of Multi-Messenger Astronomy:* Working synergistically with new/upgraded gravitational wave (GW) and neutrino detectors, *Swift* will help solve such long-standing questions as how relativistic jets are formed, where heavy (r-process) elements are synthesized, and how high-energy particles are accelerated.
- *LSST and the Time-Domain Revolution:* Both as a discovery engine and with rapid X-ray/UV follow-up of transients found in wide-field surveys (*e.g.*, ZTF, LSST), *Swift* will help uncover the progenitors of stellar explosions, determine how black holes grow and influence their host galaxies, and constrain the physics responsible for the large luminosities of active supermassive black holes.

A New Source of High-Energy Neutrinos?





Stein+ 2020

A tidal disruption event (TDE) with an engine-powered jet found spatially and temporally coincident with a high-energy neutrino

A Magnetar Origin for (some) FRBs

A Forest of Bursts from SGR 1935+2154

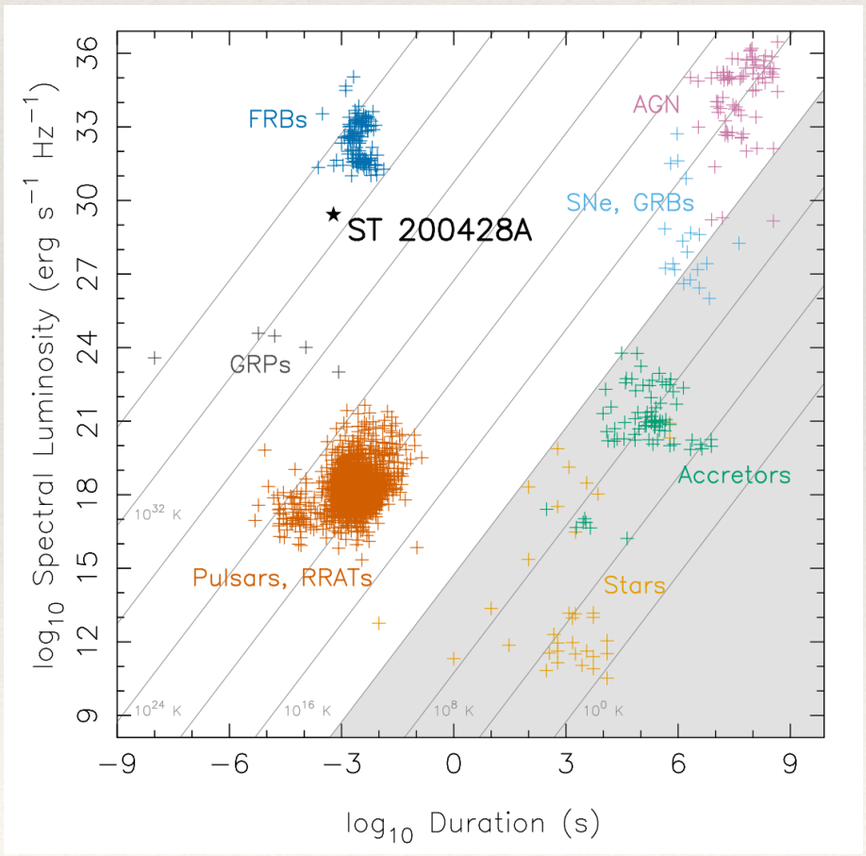
ATel #13675; ***David M Palmer (LANL) on behalf of the Swift/BAT Team***
*on **28 Apr 2020; 03:24 UT***
Credential Certification: David M. Palmer (palmer@lanl.gov)

Subjects: Soft Gamma-ray Repeater, Magnetar

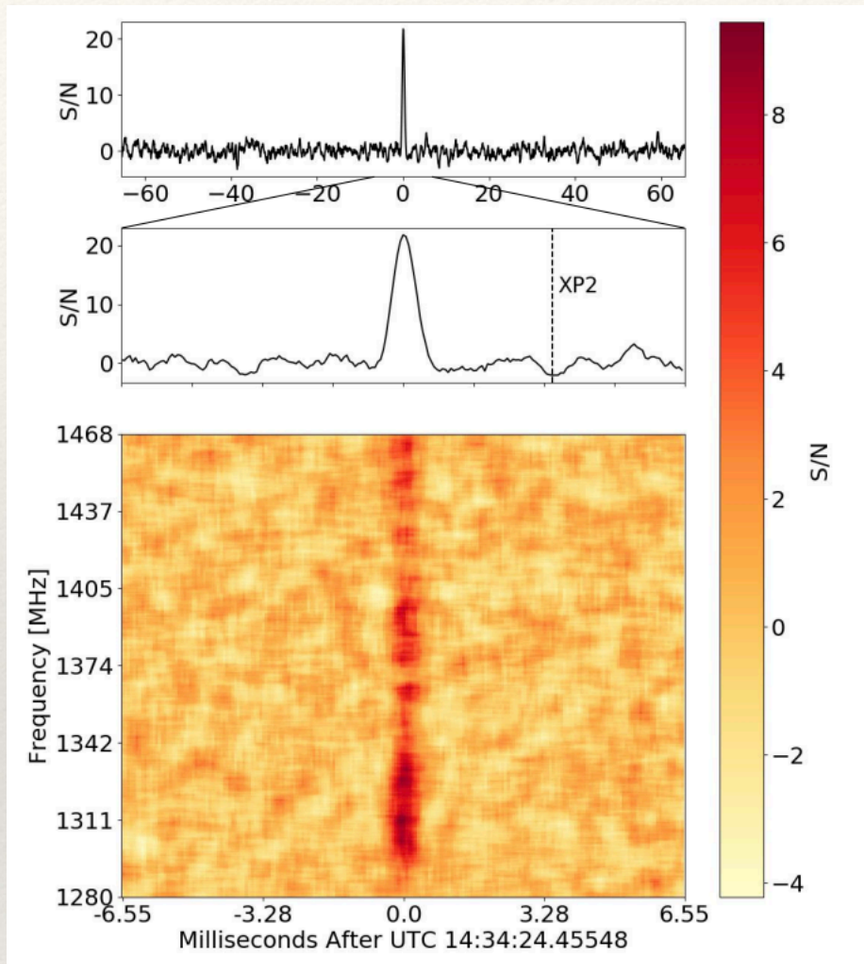
Referred to by ATel #: 13679, 13681, 13682, 13685, 13689, 13713, 13720, 13721, 13723, 13748, 13769, 13773, 13777, 13778, 13783, 13786, 13799, 13816

Tweet

At 18:26:20 of 2020-04-27 UT, the Swift Burst Alert Telescope (BAT) triggered and located a burst from the Soft Gamma Repeater SGR 1935+2154 (Trigger #968211). (GCN #27657; Barthelmy et al.) This burst, and many subsequent bursts described below, continuing to at least T+7 hours (the time of this writing) were also seen by Fermi/GBM (GCN #27659; Fletcher et al.)

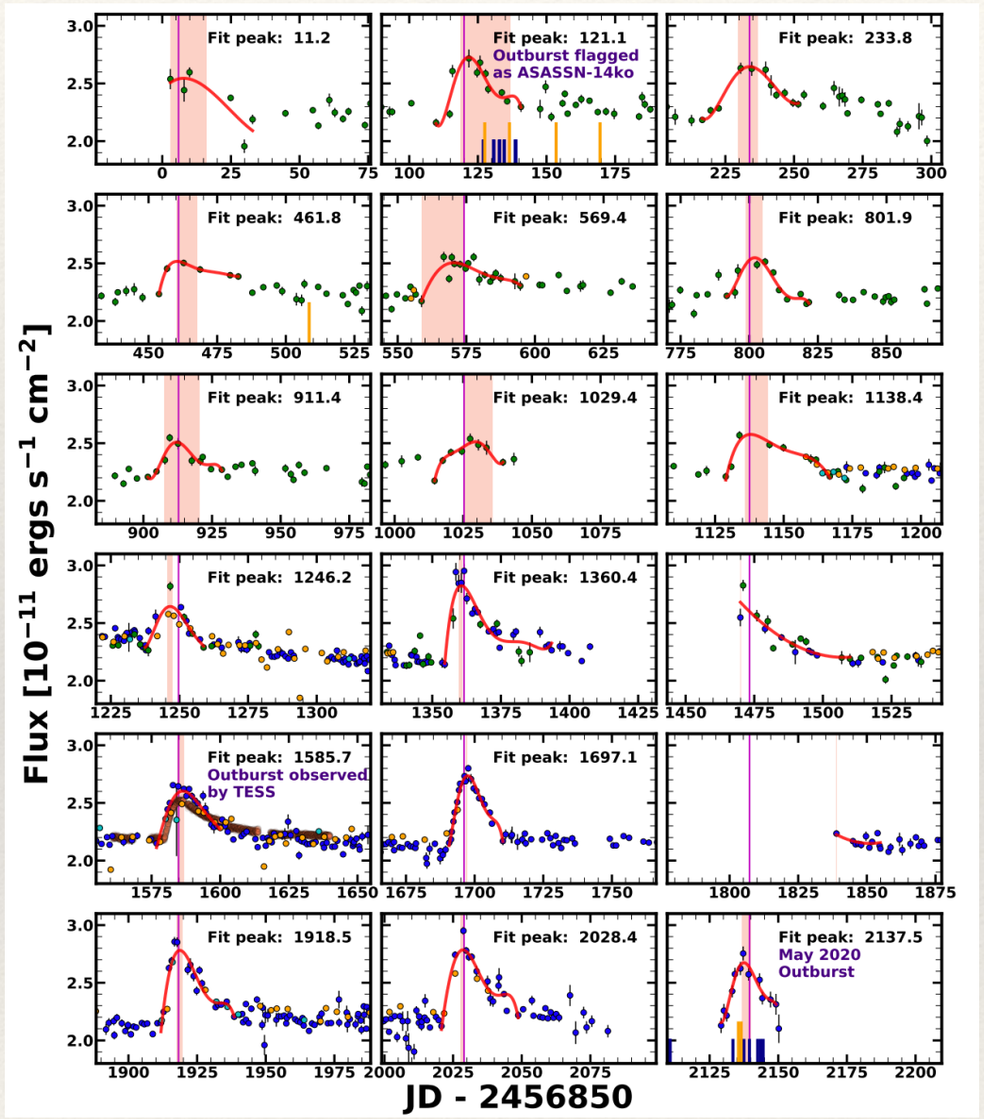


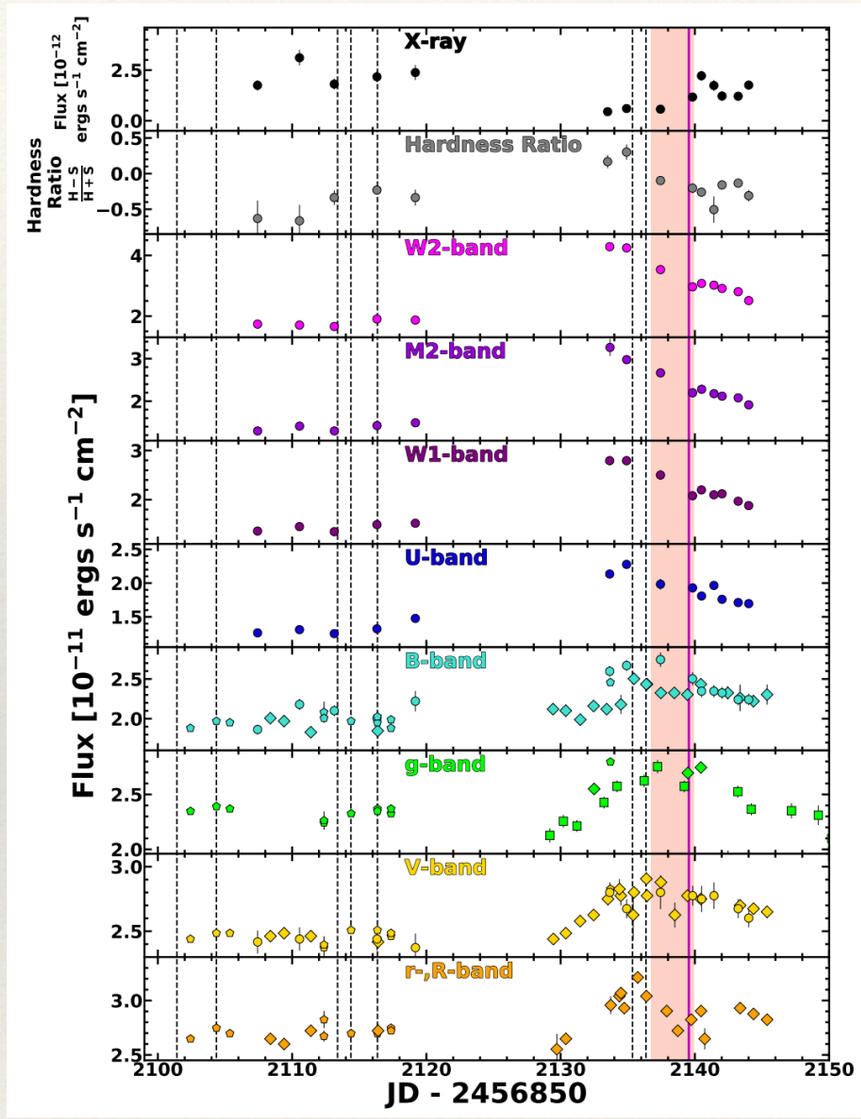
Bochenek+ 2020



A fast radio burst-like pulse coincident with gamma-ray giant flares from the Galactic magnetar SGR1935+2154

Periodic Nuclear Activity I: Partial TDE





Payne+ 2020

Period = 114 d, Pdot = -0.0017 (!), UV emission peaks before optical.
Interpreted as partial tidal disruption event (observations continuing).

Periodic Nuclear Activity II: Binary SMBH

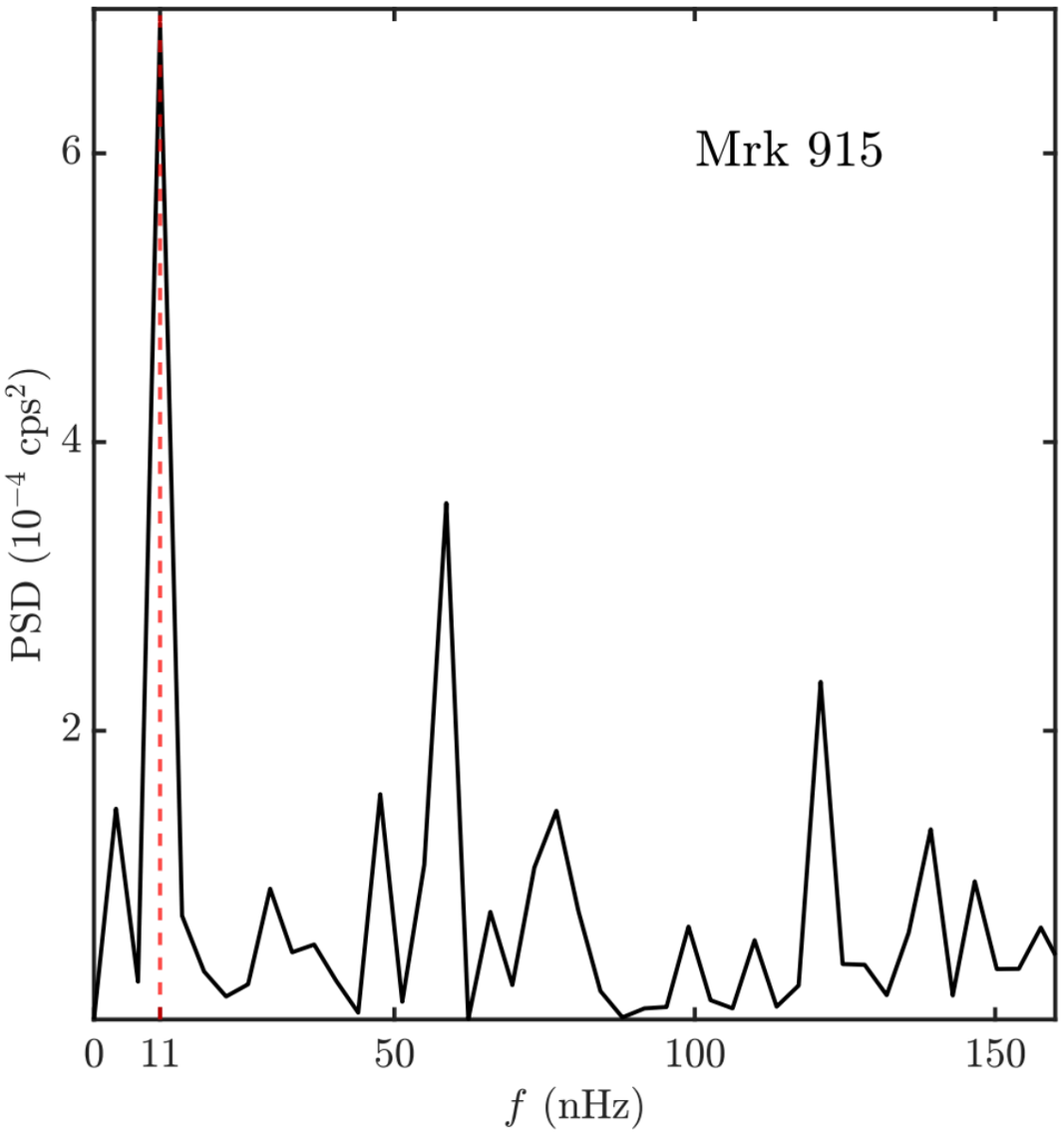


Figure 6. Power spectral density of Mrk 915. The red vertical dashed line represents the peak at $f_0 = 11 \pm 2$ nHz (or $P_0 = 35^{+7}_{-5}$ months).

Serafinelli+ 2020

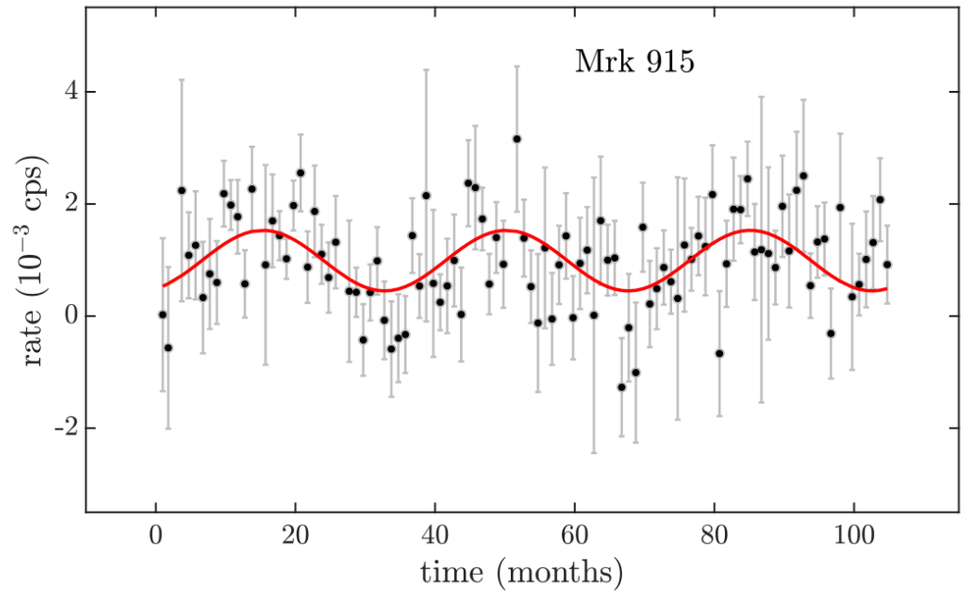
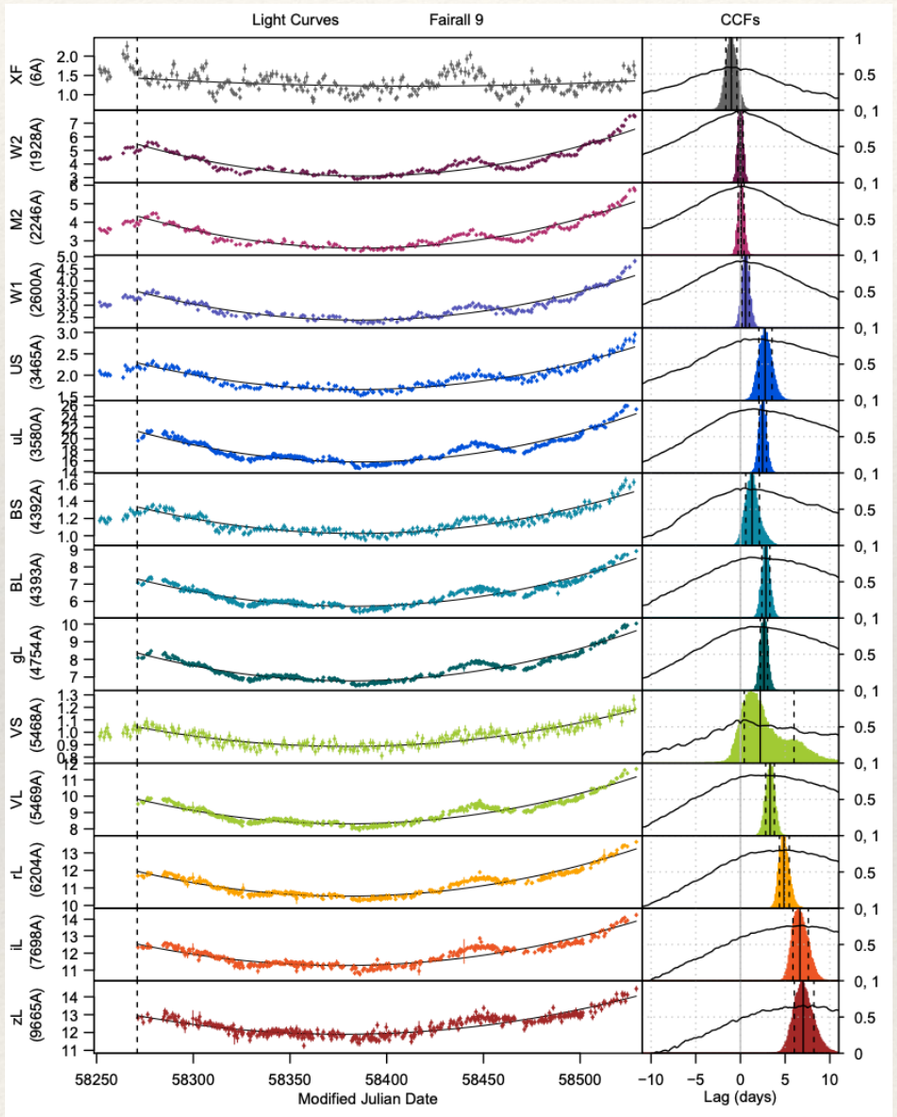


Figure 7. Hard X-ray light curve of Mrk 915. The red line represents the best-fit sinusoidal curve.

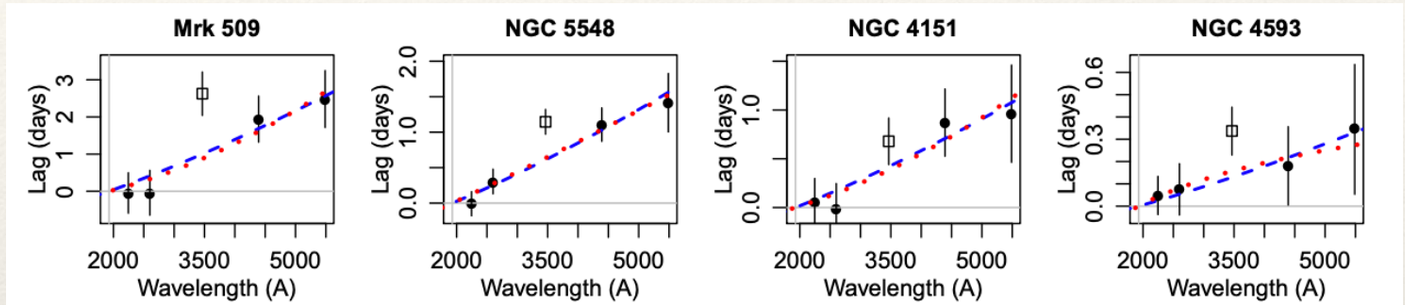
BAT Survey: 30x more sensitive than any previous all-sky hard X-ray survey. Evidence for periodicity in Mrk 915 consistent with binary supermassive black hole.

Intensive Reverberation Mapping



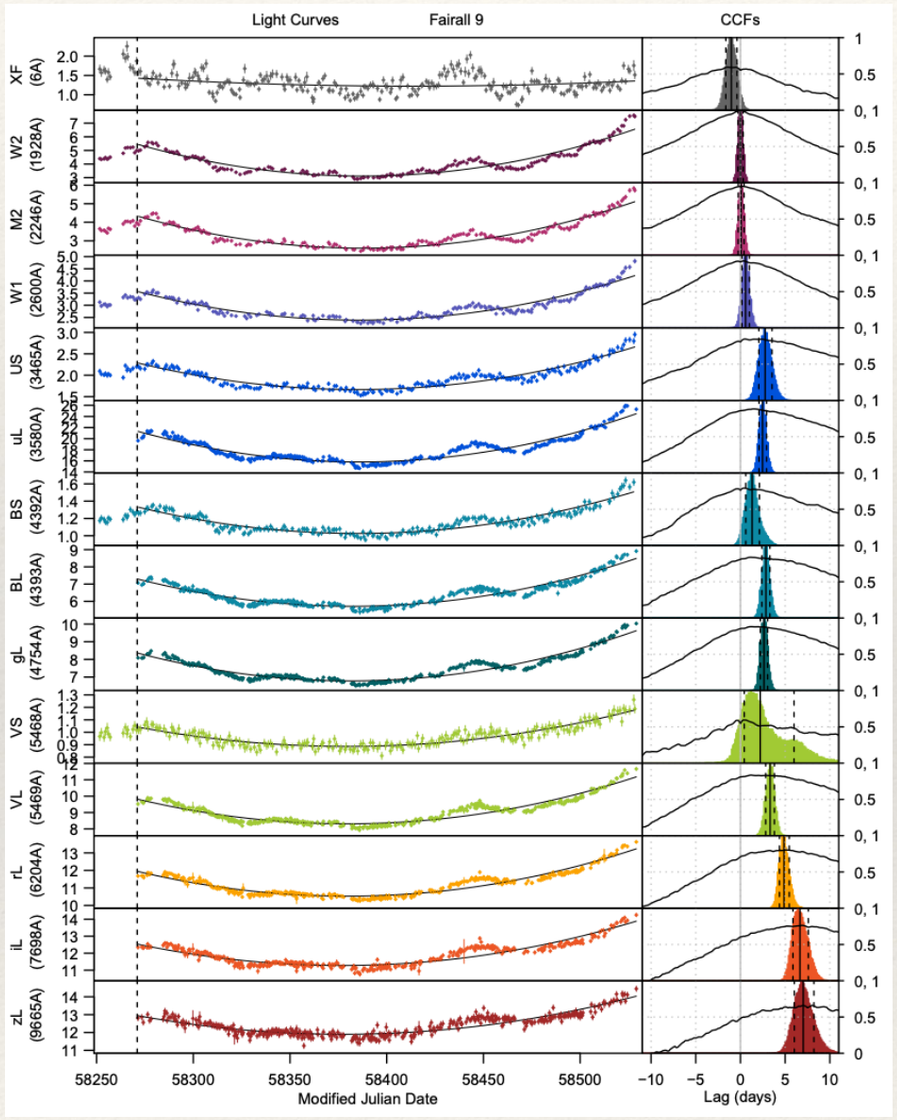
Hernandez+ 2020

Edelson+ 2020



Reverberation mapping probes structure of accretion disk, with UV uniquely sampling inner regions. With exception of U-band, shape is well fit by slim disk models, but size is ~ 3x larger than theory suggests.

Intensive Reverberation Mapping



Hernandez+ 2020

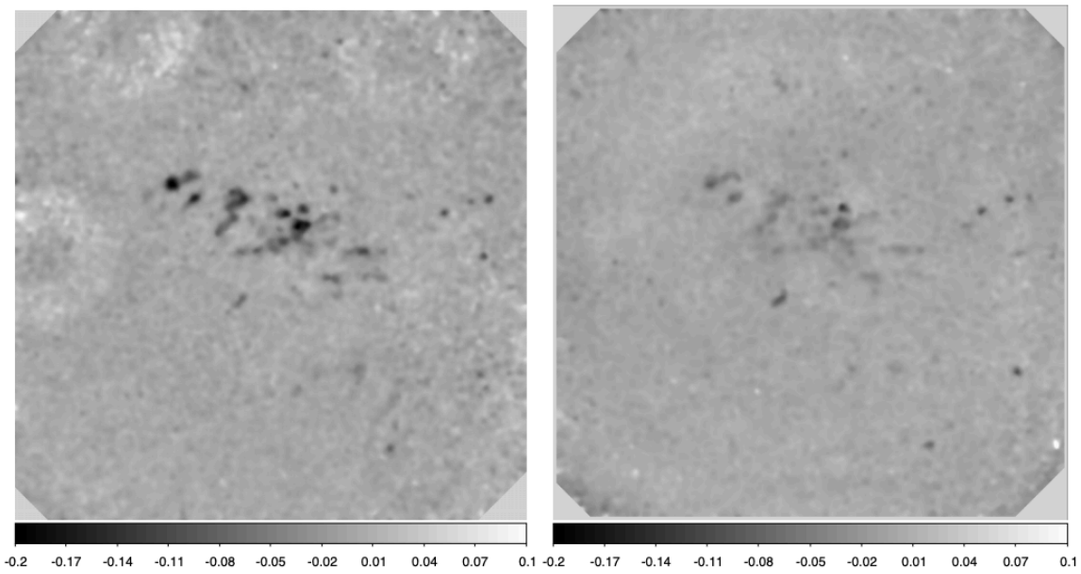


Figure A1. Heat maps combining data from all UV filters (left) and U filter data (right), both smoothed with a 5″ kernel. These are the final maps used to define the detector masks for the UV and optical bands. The greyscale ranges of the panels are matched, showing that the effect of the low sensitivity regions is greater in the UV than in the optical. The primary low sensitivity (dark) regions in the two maps line up, but the most extreme regions in one map are not the darkest regions in the other.

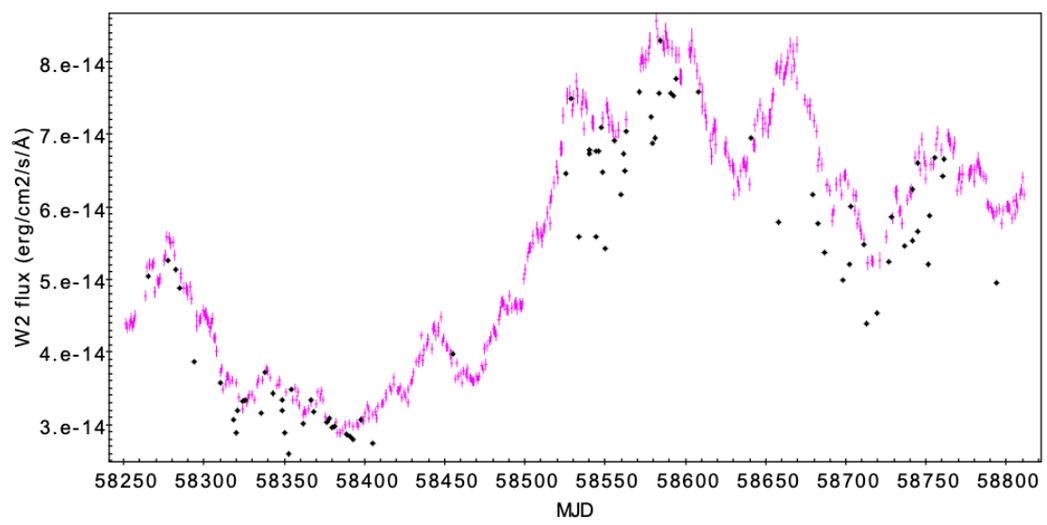


Figure A2. Fairall 9 light curve in W2. The filled, coloured points with error bars are the final sample of W2 measurements while the smaller black points are ones that pass all other screening but are flagged by the mask of low sensitivity regions.

UV Exoplanet Transits

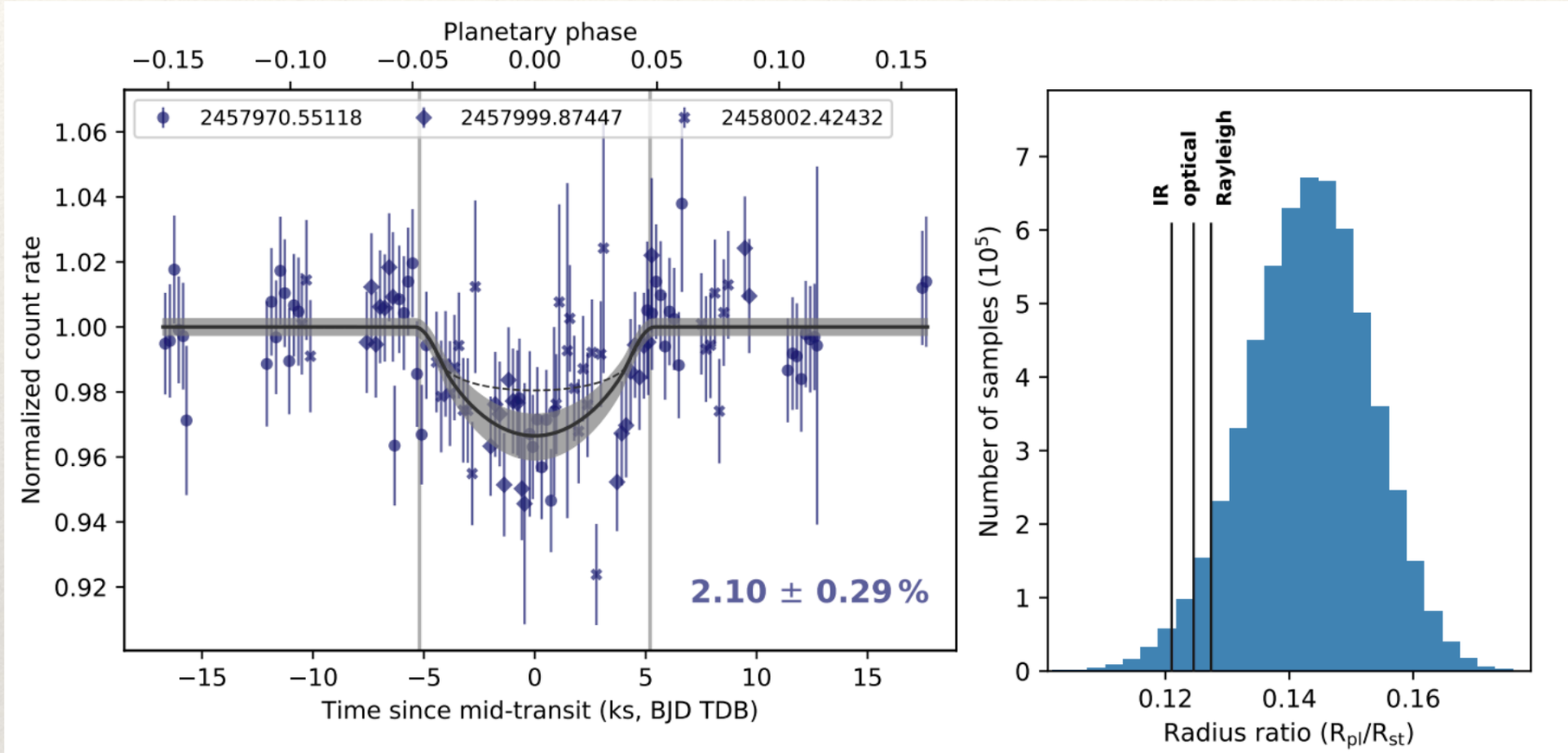


Fig. 2. *Left:* Phased light curves of WASP-121 during three transits observed with *Swift* UVOT labeled by their mid-transit times in BJD. The data are rebinned to 200 s intervals and corrected for the modeled systematic offsets. The uncorrected data are shown in Fig. A.1. The transit model with 1σ uncertainty interval of the out-of-transit flux level and transit depth is shown. The optical transit depth is depicted by the dashed line (B-filter, Delrez et al. 2016). The observed transit depth is given at the bottom with 1σ error. *Right:* Posterior of the radius ratio. Optical and IR values are indicated (Delrez et al. 2016; Evans et al. 2016) together with the expected NUV transit depth according to Rayleigh scattering.

Salz+ 2019

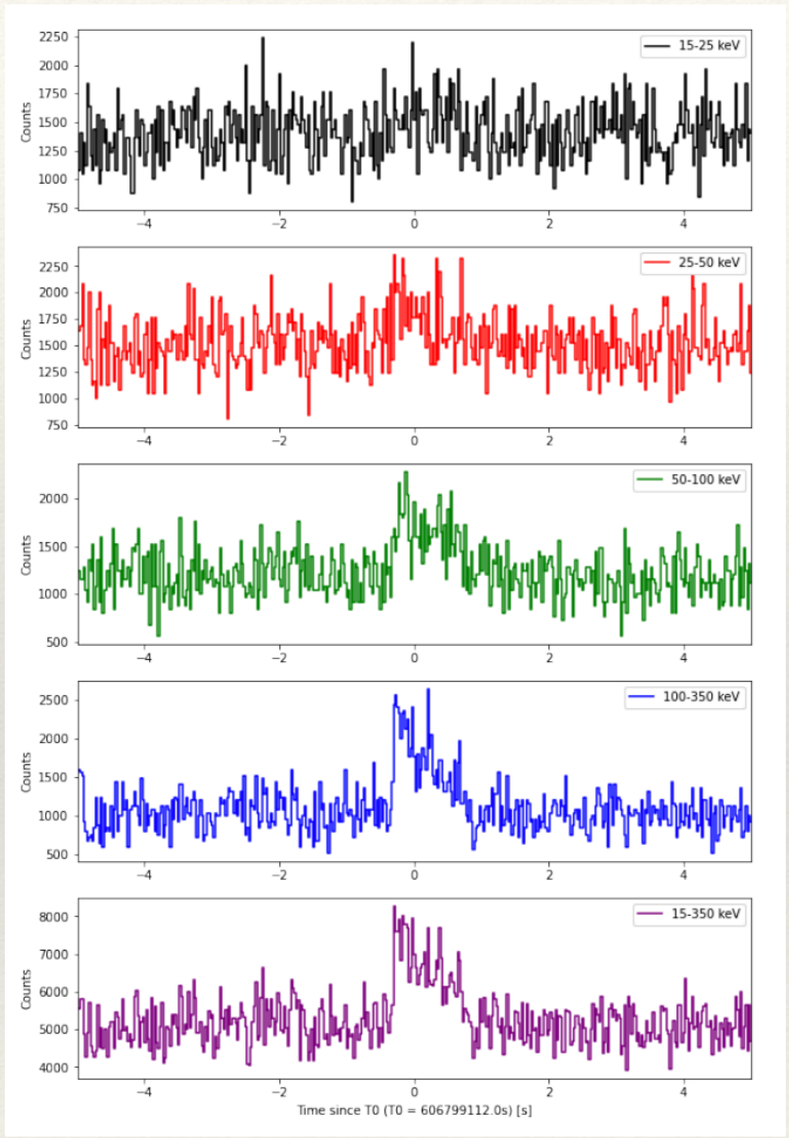
Improvements to relative UV photometry enables exoplanet transit measurements.
UV uniquely probes atmospheric chemistry models.

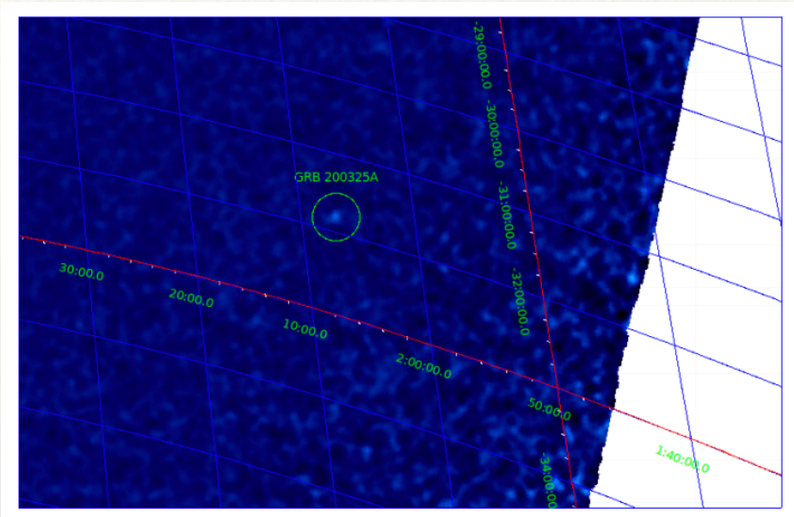
Time-Domain Best Practices

Table 1. Timeline of events for S200114f

T0 = 02:08:18	S200114f reaches Earth.
T0+∼02:50	cWB pipeline identifies S200114f in the LVC data stream.
T0 + 02:55	*Swift* MOC receives alert, and triggers GUANO.
T0 + 03:30	Trigger passes vetting, and is placed in GUANO queue for uplink.
T0 + 04:00	GUANO determines there is a serendipitous ground-station commanding pass within T0+25 minutes, and hence no need for a TDRSS contact. [a]
T0 + 24:00	GUANO passes command to commanding computers for uplink via the Malindi ground station.
T0 + 26:30	BRBD command uplinked to spacecraft.
T0 + 26:31	BRBD command executes onboard BAT computer, data successfully moved from ring buffer to the Solid State Recorder, and marked for high-priority downlink.
T0 + 01:50:00	Event data arrives on the ground for analysis.

Tohuvavohu+ 2020

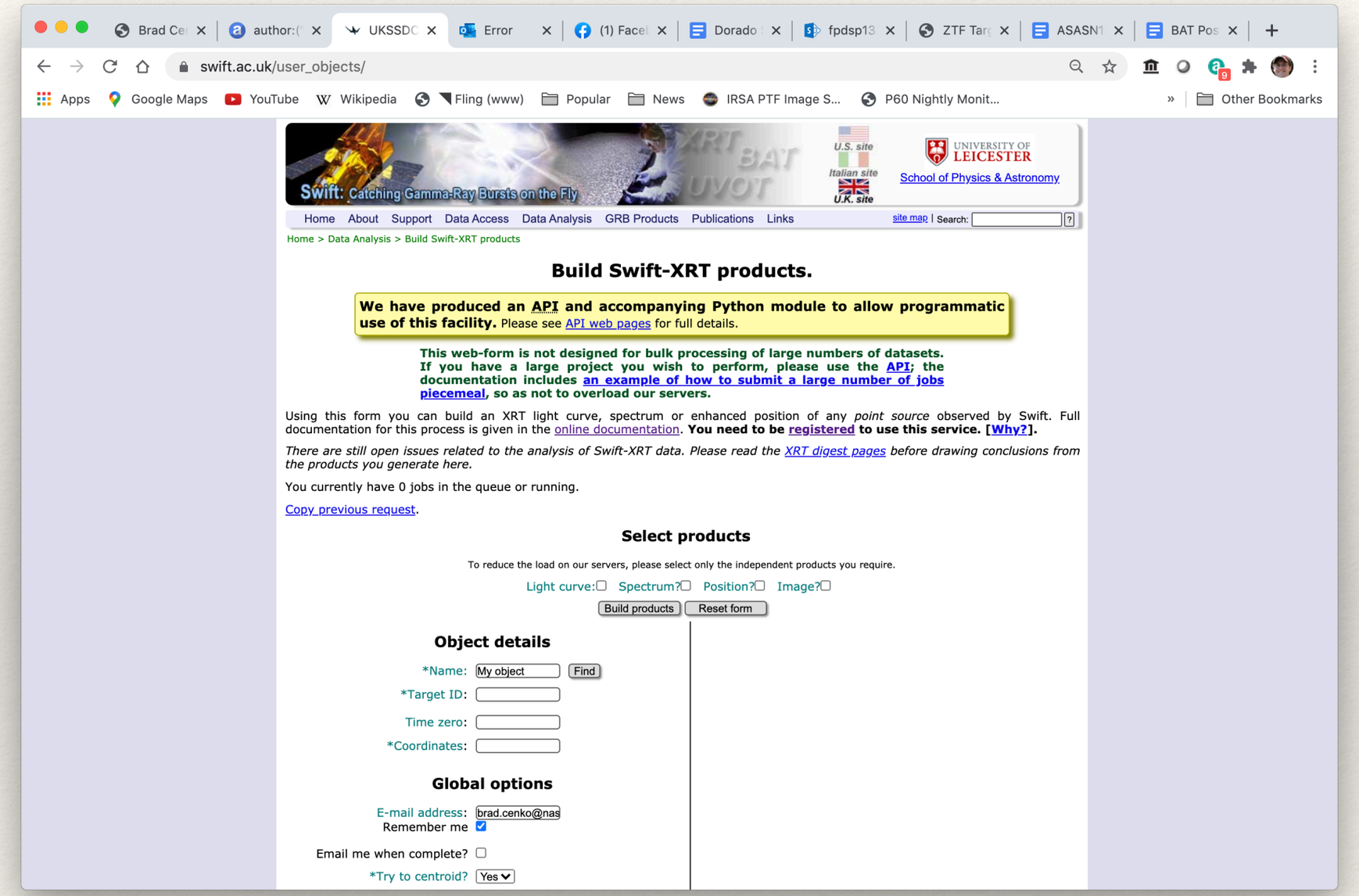




Gamma-ray Urgent Archiver for Novel Opportunities (GUANO): triggered requests for BAT event mode data

Software improvements can significantly increase scientific utility of existing missions, particularly in context of mission ecosystem.

Time-Domain Best Practices



Tools that produce **automated, publication quality** data products are invaluable.
They allow non-experts to use your data, significantly expanding user base.

Time-Domain Best Practices

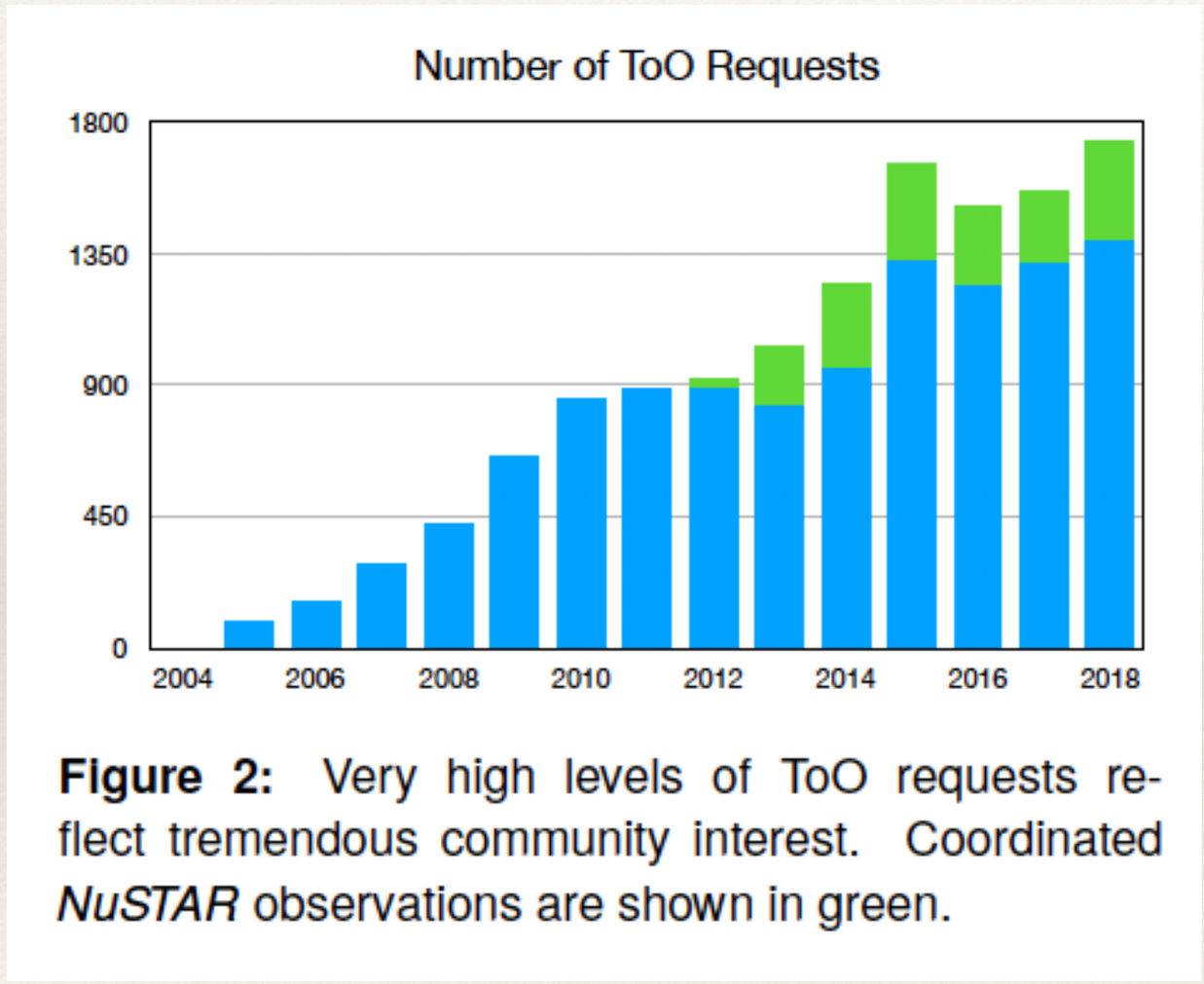
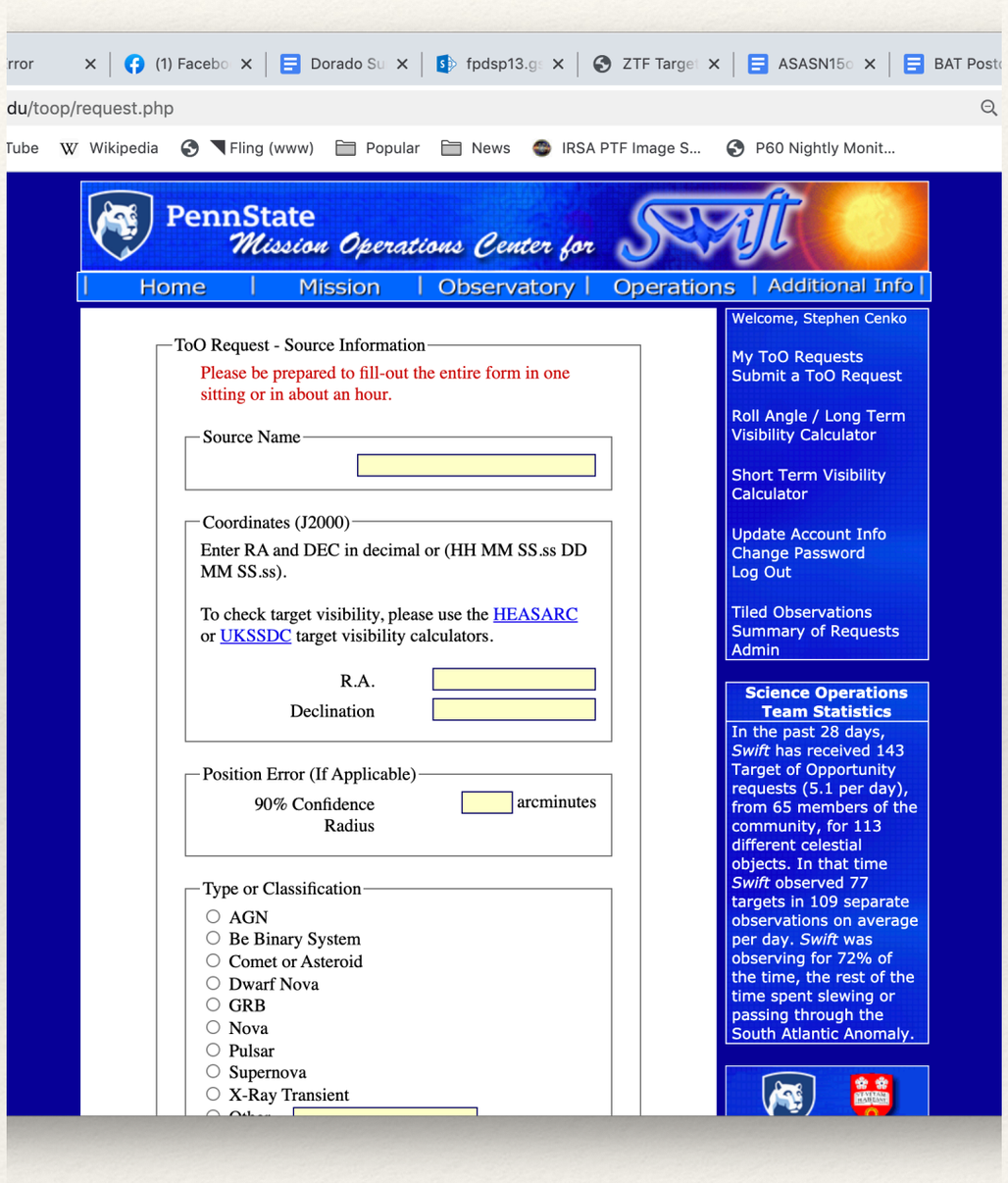


Figure 2: Very high levels of ToO requests reflect tremendous community interest. Coordinated *NuSTAR* observations are shown in green.



Current Target-of-Opportunity (DDT) proposals submitted manually via webform.
Can accommodate current rate (5x per day), but not anticipated growth.

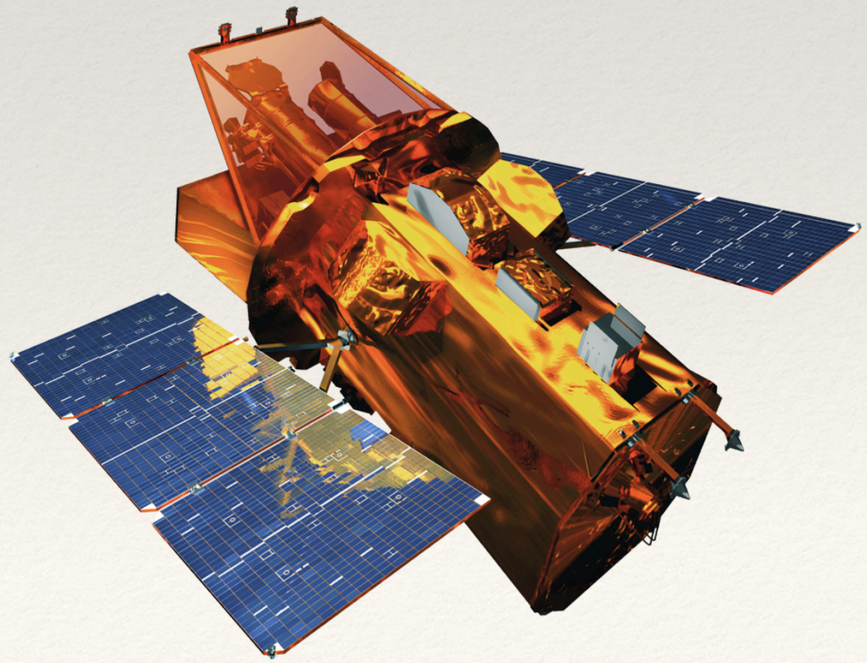
Time-Domain Best Practices

"Filter" (e.g., supernova within 2 days of explosion within 100 Mpc)

↓

API (Application Programming Interface) for automated submission and scheduling of pre-approved programs

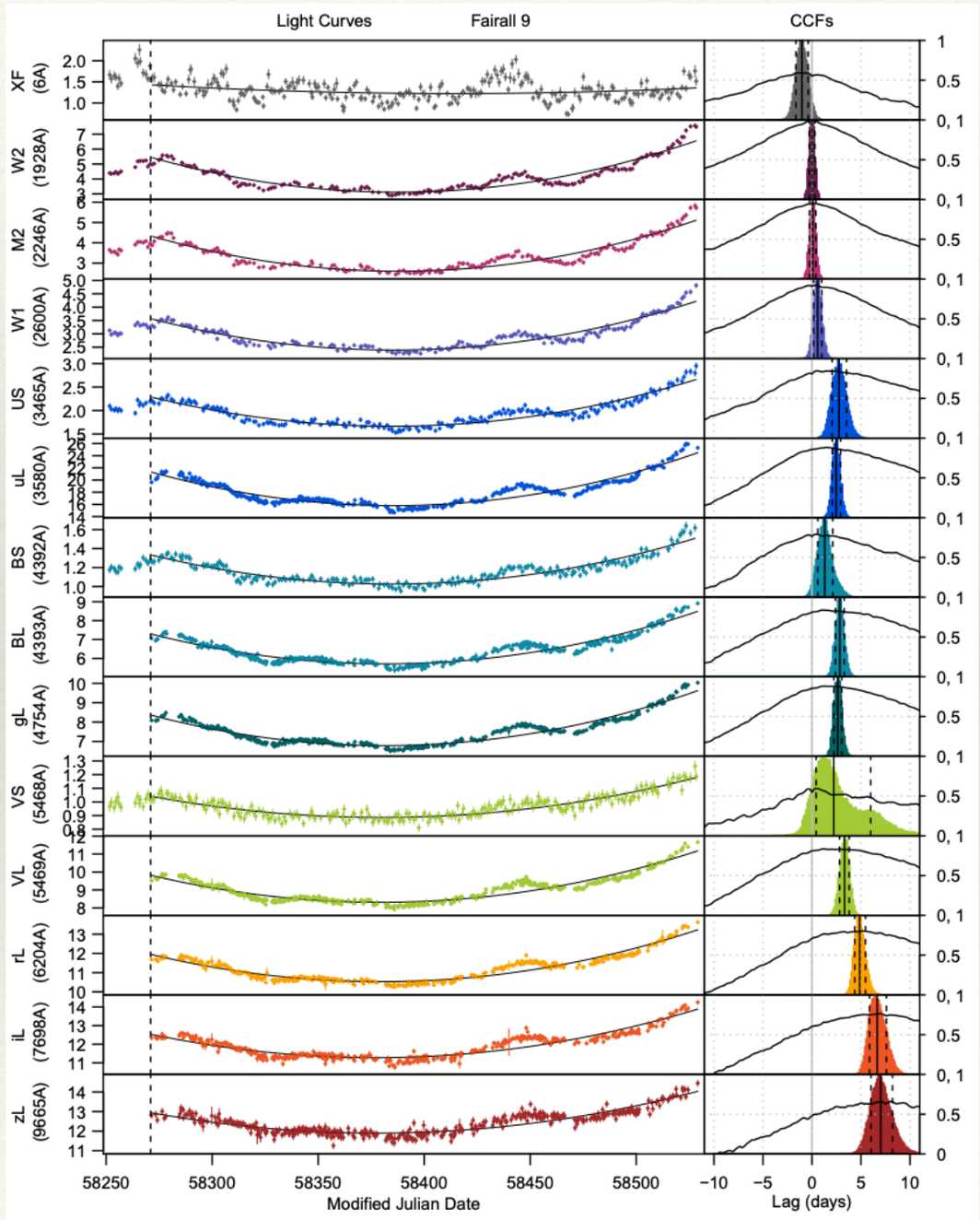
↓



Attempting to use current generation of surveys (e.g., ZTF, ASAS-SN) to build infrastructure for upcoming wide-field facilities (Rubin, Roman, SKA, …)

Time-Domain Best Practices

- Guest Investigator programs critical to get scientific input from community and maintain pool of engaged users
- Large programs (key projects) have been particularly impactful for *Swift* in recent years
- Awaiting results from first dual anonymous review in December



Hernandez+ 2020

Conclusions

- 16 years since launch, *Swift* remains a vibrant observatory conducting a diverse range of research cutting-edge research programs across the transient and multi-messenger domains
- Rapid slewing, UV + X-ray follow-up is expected to only grow in importance over next decade
- Automation and community engagement critical for success in these areas