Tidal disruptions rate at hard X-rays

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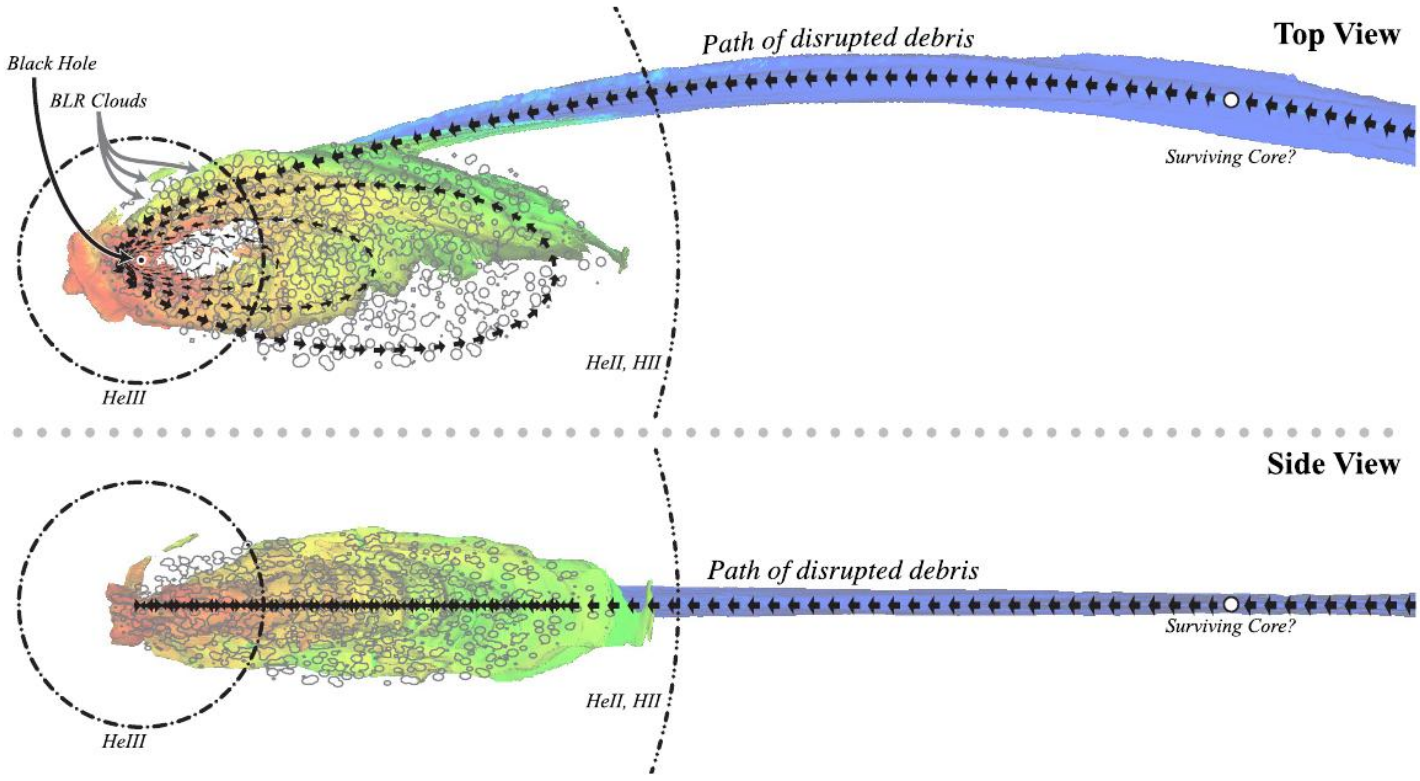
December 15th, 2015
28th Texas Symposium, Geneva

(based on Hryniewicz & Walter, arXiv:1505.06612)

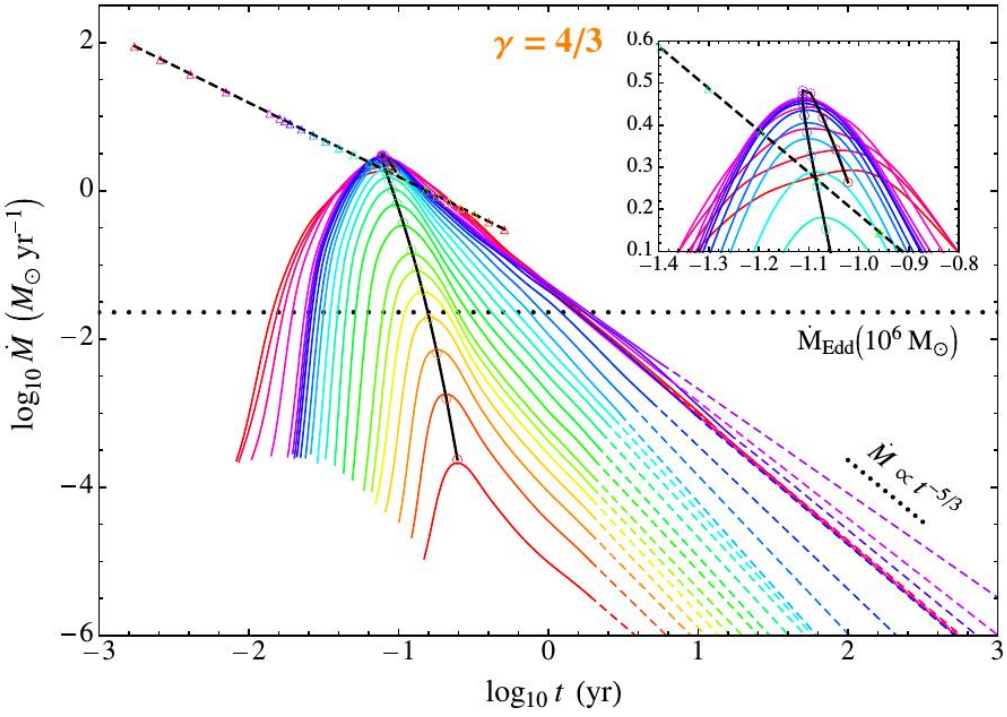
TDEs — simulations



Guillochon et al. (2014)

Star or substellar body disrupted by a compact object (black hole)

Simulations & theory



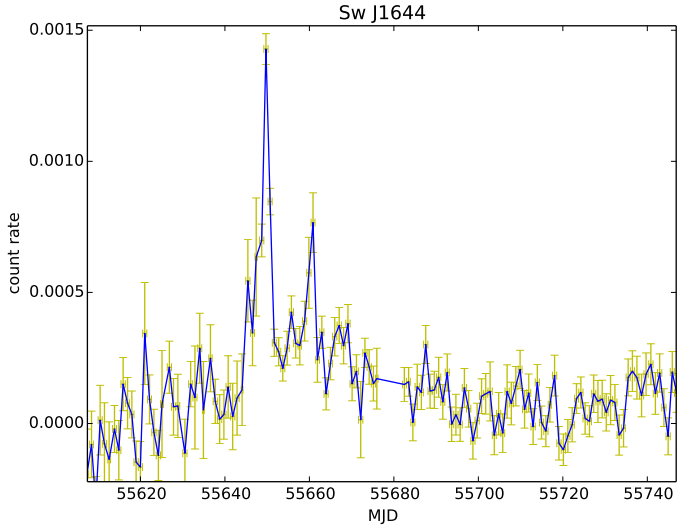
Guillochon & Ramirez-Ruiz (2013)

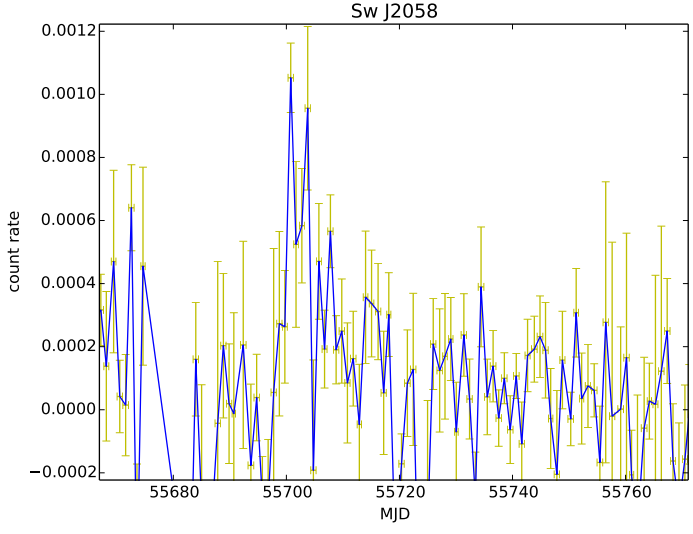
Accretion rate evolution depending on the impact factor.

Theoretical relation

$$\dot{M}(t) = \frac{2\pi}{3}(GM_h)^{2/3}\frac{dM}{dE}t^{-5/3}$$

Known TDEs





$>$ 46 known TDEs.

Among them:

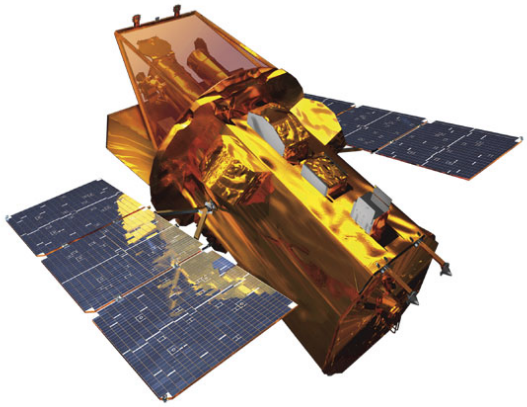
- 36 observed in IR/opt/UV,
- 24 at soft X-rays,
- 4 at hard X-rays,
- 2 radio emiters.

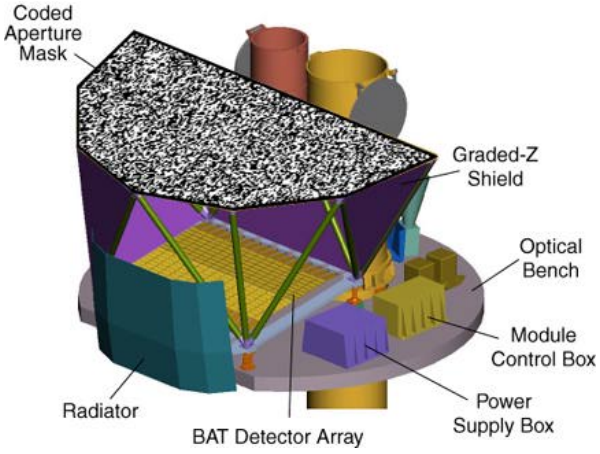
SMBH hosts (exception: WD + icy planet).
2 hard X-rays flares + radio flares are associated with jets in relativistic TDEs.
2 other are due to disruption of a planet

Swift Burst Alert Telescope

Swift

- 10 years of continuous operation
- observing whole sky





BAT

- 1.4 sr field of view (half coded)
- 14-195 keV spectral range
- Gaussian noise distribution

images: NASA

\+ Good dust penetration at hard X-rays!

Aim

Estimate TDE rate at hard X-rays.

Approach

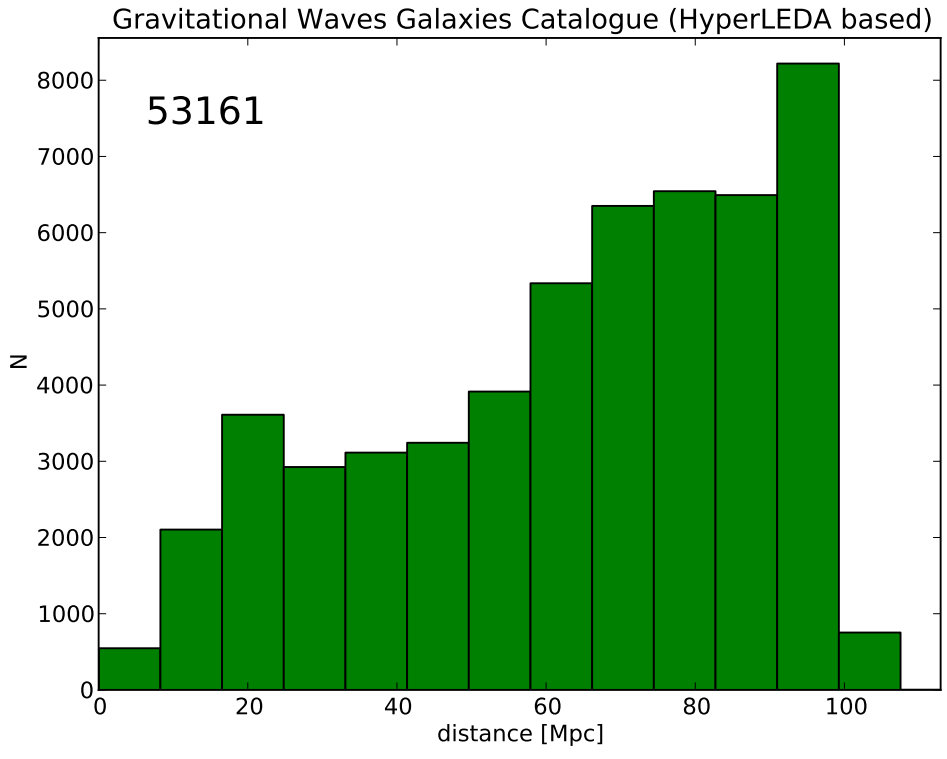
- search in nearby galaxies
- generating LC and images
- identification and removal of persistent sources
- flare detection (continuous positive flux excess in LCs)
- treshold on flare's significance and duration
- check for contaminations
- visual verification

Galaxies

Initial sample

Gravitational Wave Galaxy Catalogue catalogue (White et al. 2011)

- 53161 galaxies
- 150 globular clusters
- d $\leq$ 100 Mpc
- mostly optical identifications



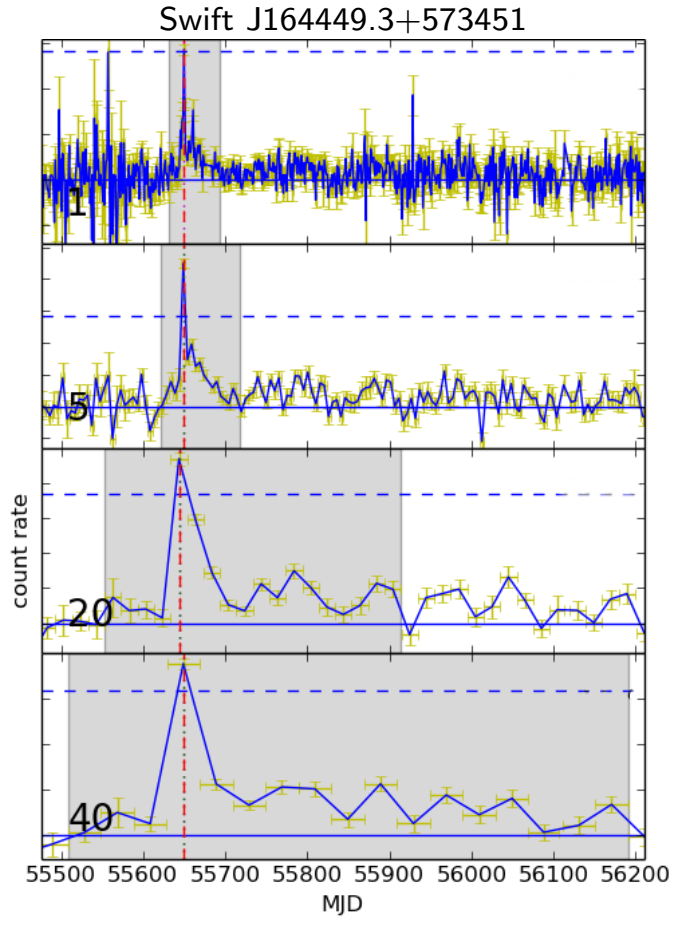
targets overlaping (due to BAT limited spatial resolution)

BAT LC

We chose 5 days time binning as good option for our purpose.

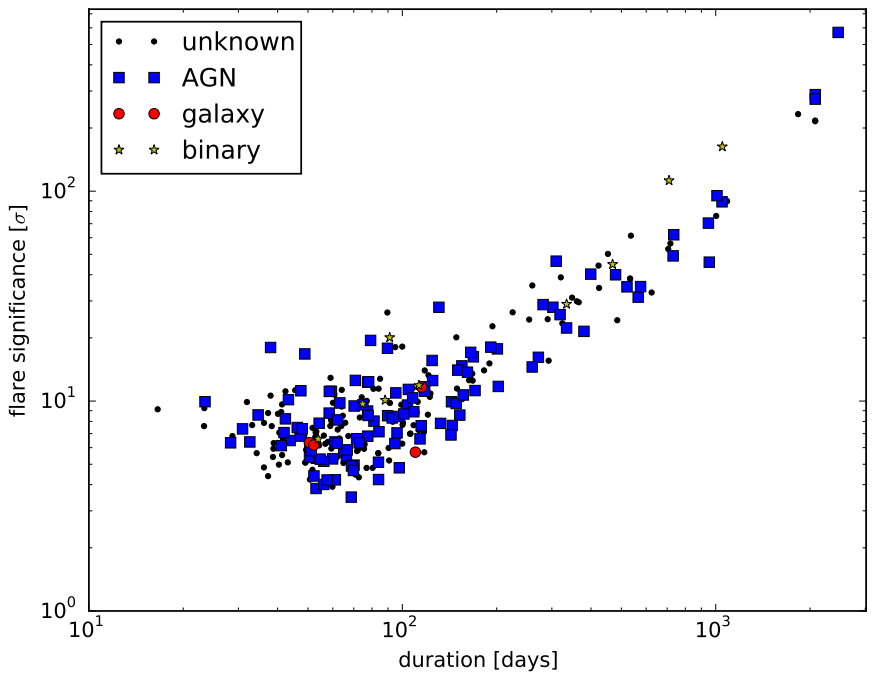
Steps

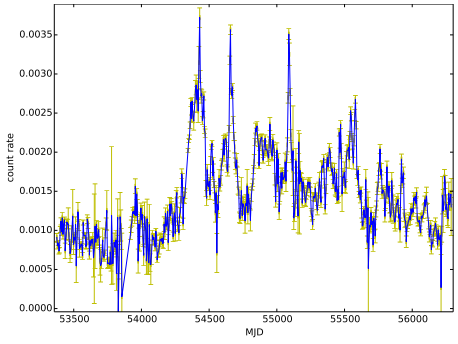
- LC on the position of every GWGC galaxy
- the most significant positive flux excess detection
- image for a flare period
- PSF fitting and significance estimation

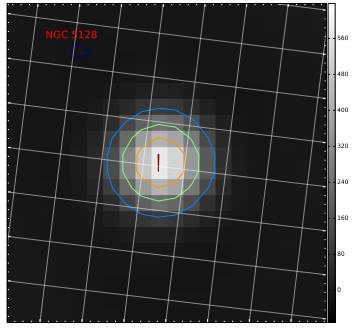


Persistent sources

Persistent sources were identified based on the level of the average flux outside detected flare period.
5 new candidates for unknown persistent sources.



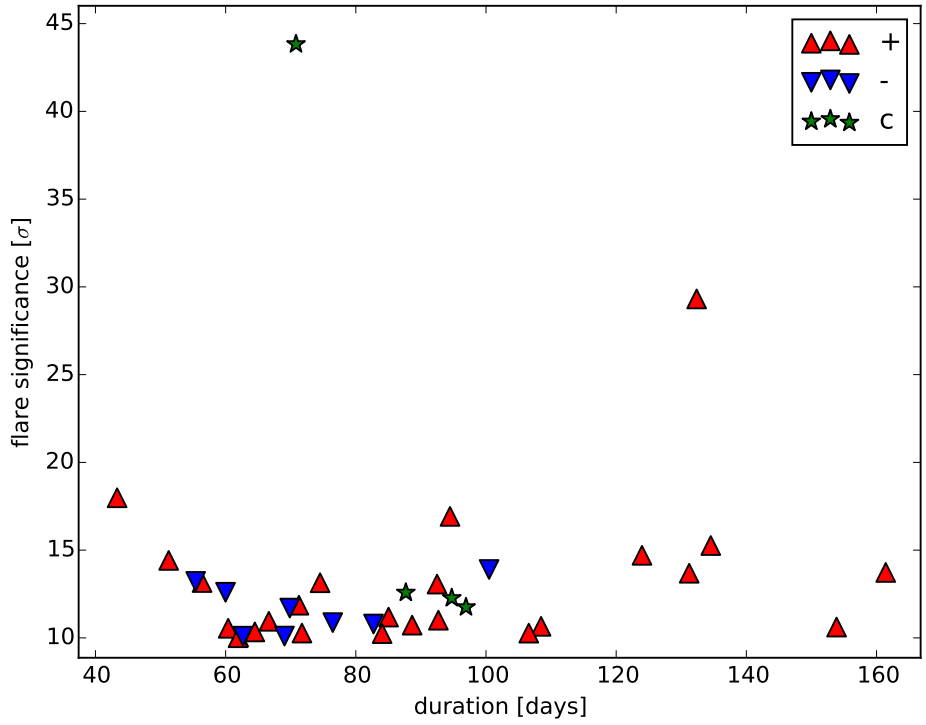




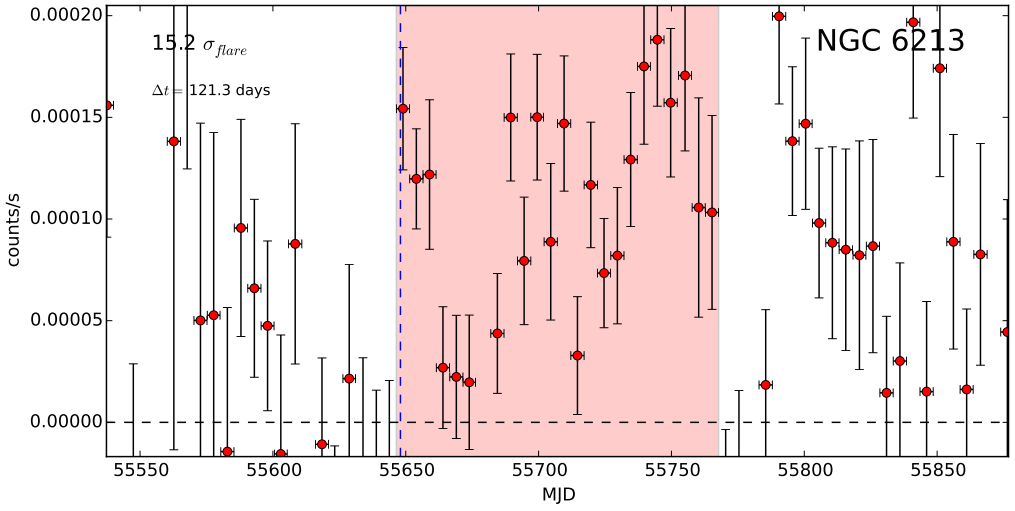
Flares in non-persistent sources

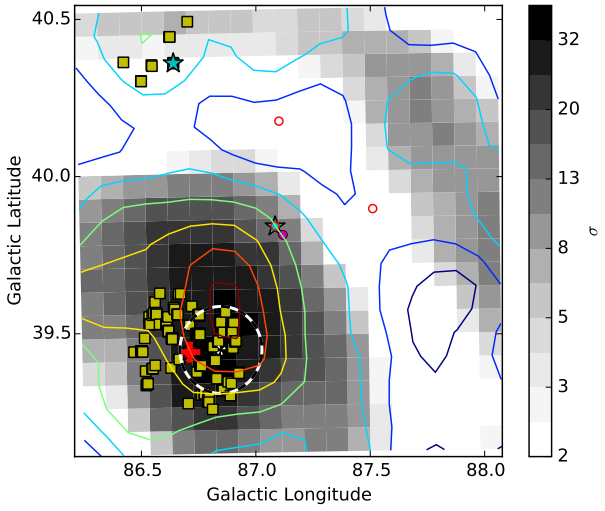
Interesting region

- high (integrated) significance ($> 10\sigma$)
- long flares (>40 days)
- 27 non-AGNs candidates



Verification





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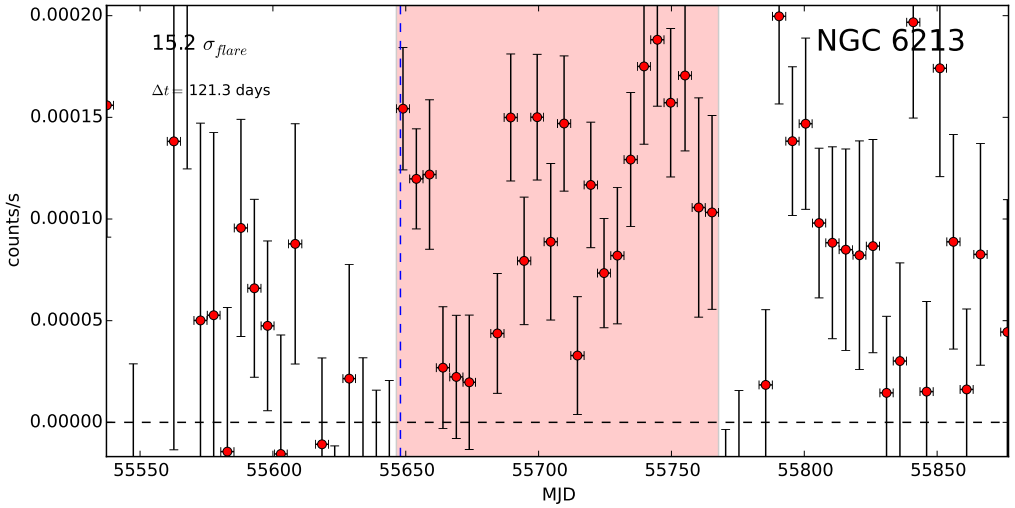
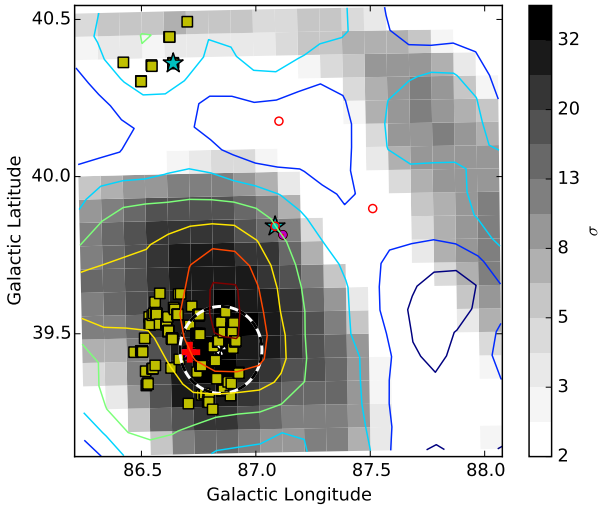
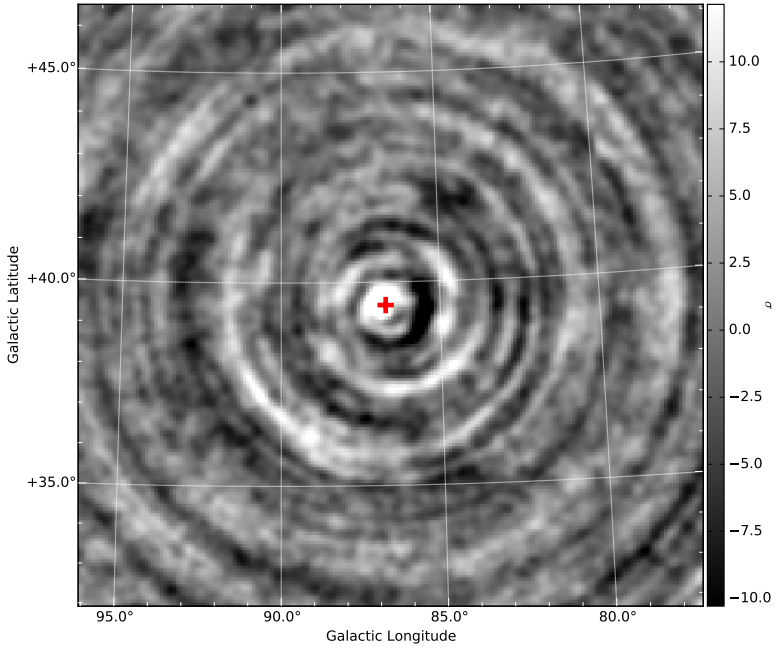


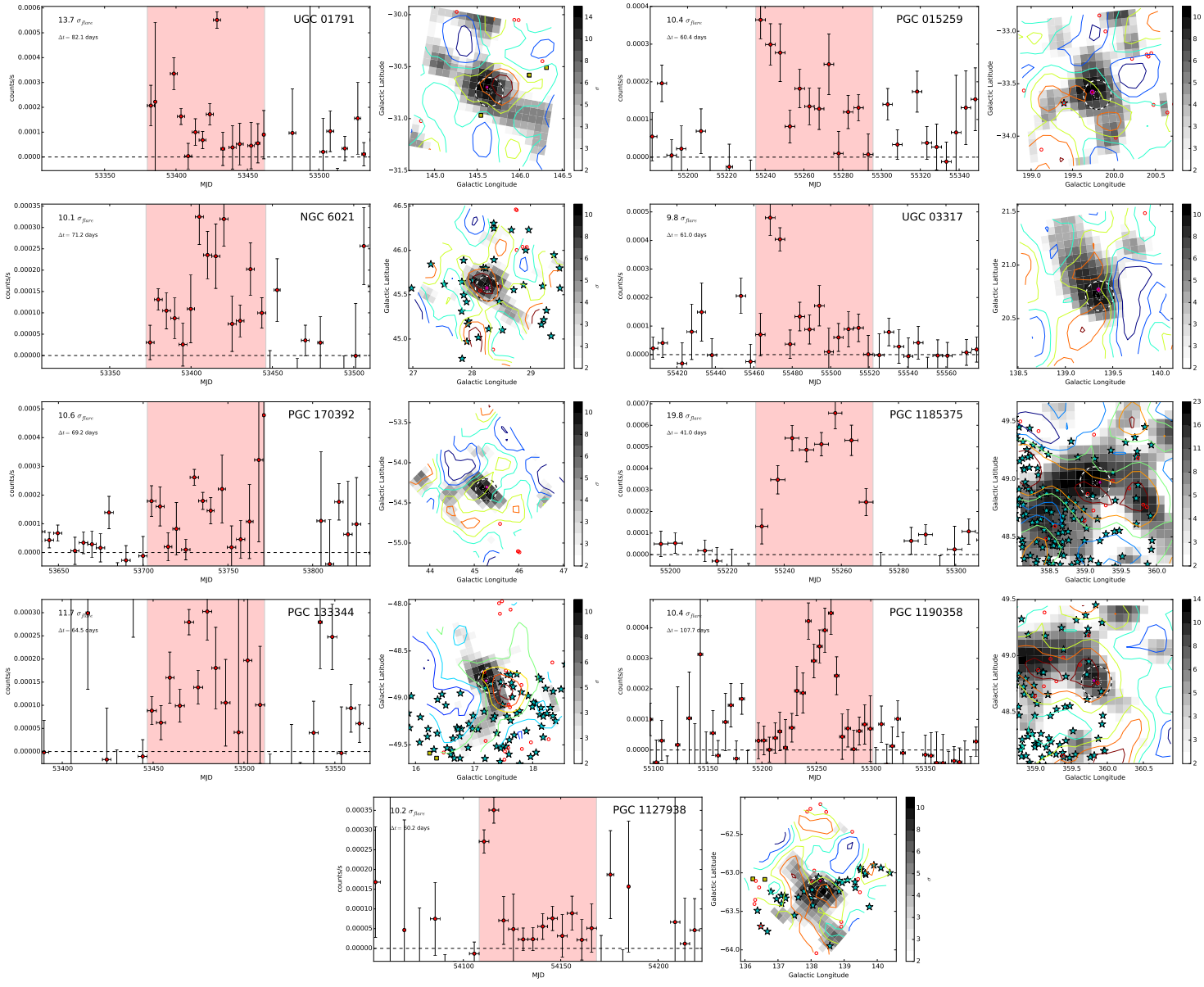


Checks

- contamination by known bright BAT sources
- PSF match
- visual inspection
- BAT artifacts

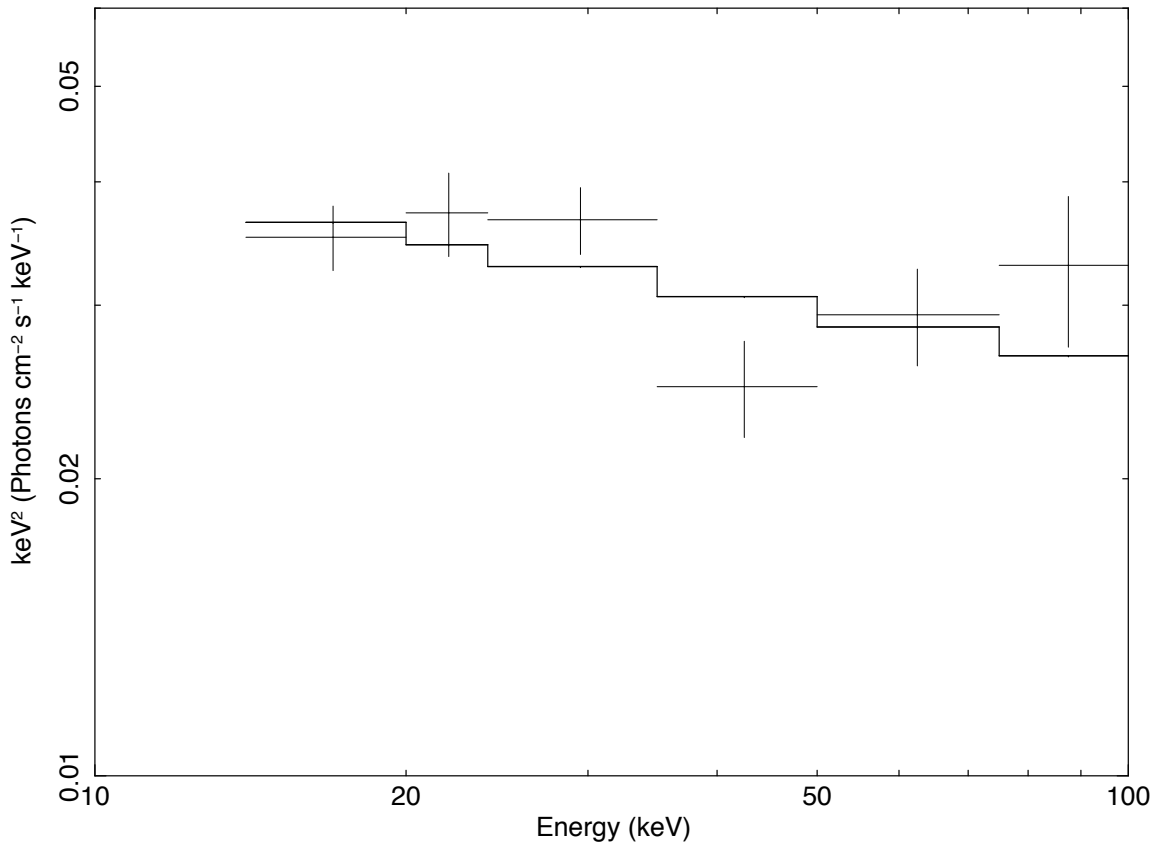


TDE candidates



TDE's average spectrum

The average spectrum in the BAT TDE sample is consistent with power-law AGN spectra. Inverse Compton processes and electrons acceleration in shocks in the accretion flow take place.



$\sim$ 4% of the total flux is emitted at hard X-rays? (in AGNs it was suggested by Risaliti & Elvis 2004).

TDE frequency

If we have ~ 9 true candidates from BAT alone:

$$\dot{N}_{TDF} \approx 2.1 \times 10^{-5}\ \mathrm{yr}^{-1}\mathrm{galaxy}^{-1}$$

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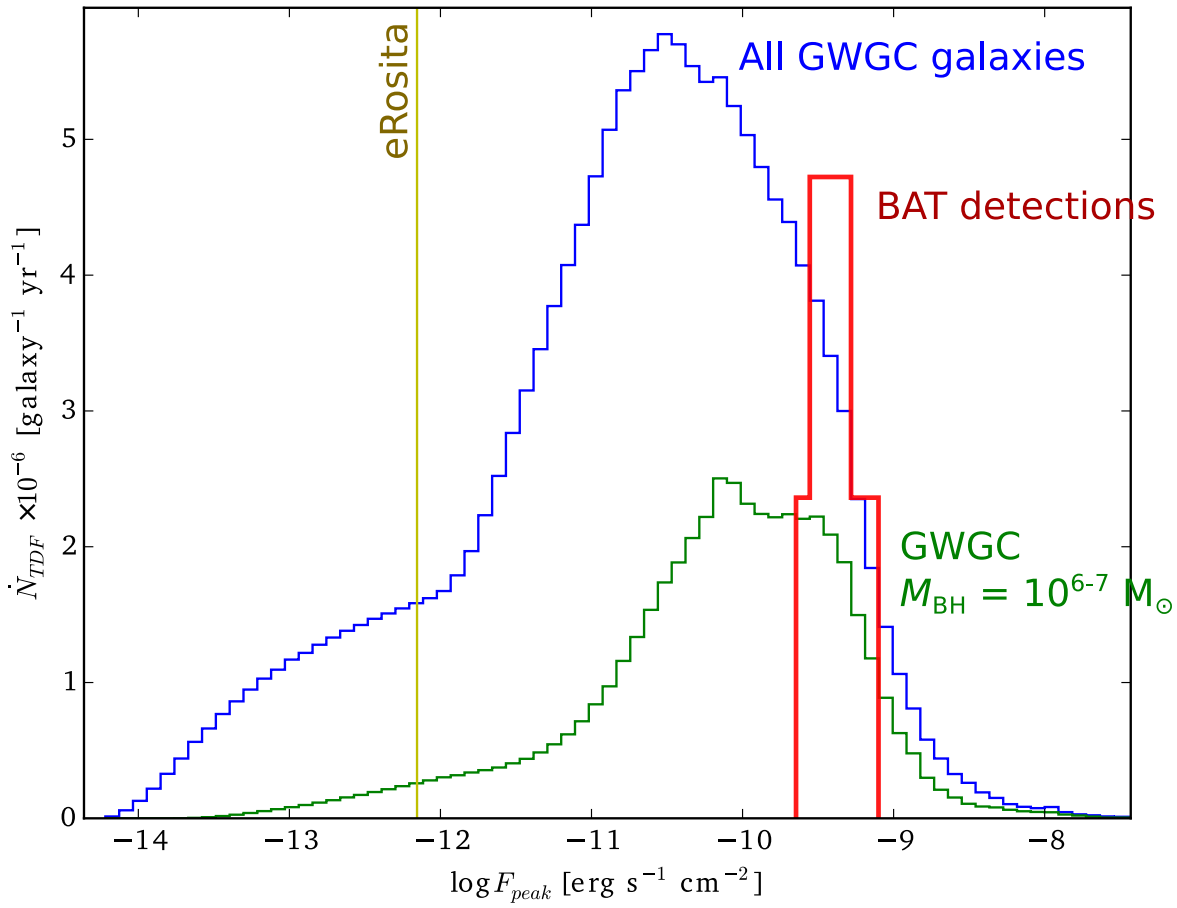
Previous estimations:

- SDSS galaxies (sensitive to high mass SMBHs; van Velzen et al. 2012)
  $< 3 \times 10^{-4}\ \mathrm{yr}^{-1}\mathrm{galaxy}^{-1}$
- N-body simulations (Sgr A* like SMBHs; Brockamp et al. 2011)
  $(5.5 \pm 2.7) \times 10^{-5}\ \mathrm{yr}^{-1}\mathrm{galaxy}^{-1}$
- RASS data (Donley et al. 2002)
  $9.1 \times 10^{-6}\ \mathrm{yr}^{-1}\mathrm{galaxy}^{-1}$ (large X-ray outbursts from inactive galaxies)
  $8.5 \times 10^{-4}\ \mathrm{yr}^{-1}\mathrm{galaxy}^{-1}$ (AGNs)

TDE detectability

Possibility of TDE detection at hard X-rays. Peak flux histogram for GWGC. Assuming stellar MF, estimating GWGC BH masses and geometrical probability of encounter.



Summary

- Already known TDEs were detected in our search, so procedure works.
- We propose 9 new non-relativistic TDE candidates.
- Emission from the TDEs is similar to the AGNs emission.
- Estimated TDE rate at hard X-rays is consistent with those in lower energy bands.
- Low sensitivity is compensated by detections of dusty objects?
- 2 new hard X-ray persistent sources were proposed (edge-on active galaxies).

Thank you