Understanding tidal disruption events with THESEUS

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Tidal disruption events (TDEs)

Detecting TDEs allows us to find massive black holes normally too faint to detect

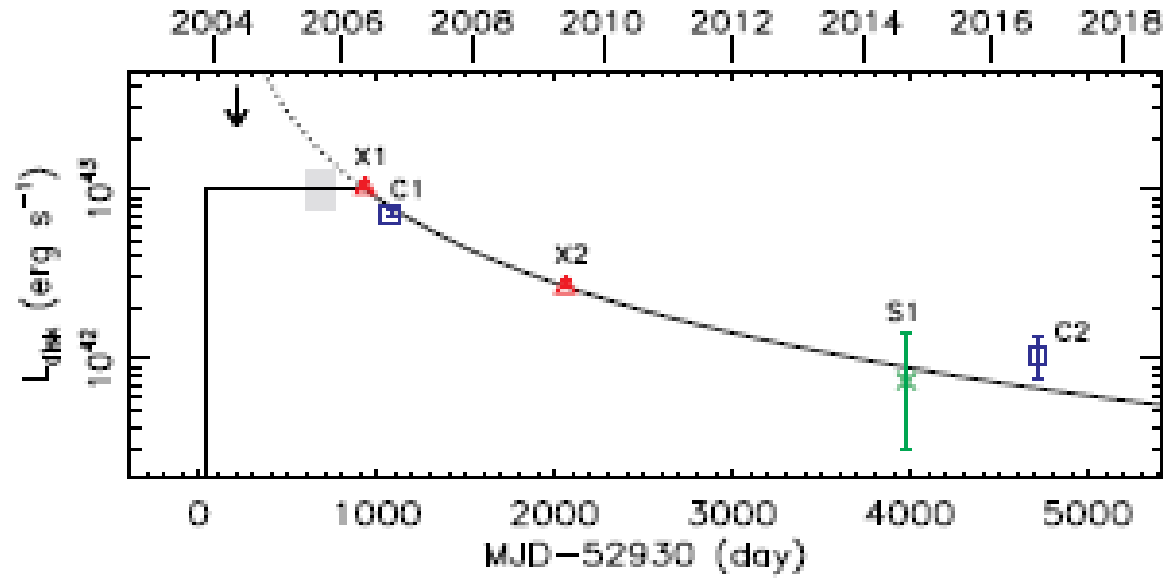
Tidal radius inside black hole (BH) event horizon for $M > 10^8 M_\odot$

Observe TDE from lower mass BHs + accretion (super-)Eddington

Could help understand the growth of supermassive black holes (SMBH)

$1.7 \pm^{2.85}_{1.27} \times 10^{-4}$ TDE per galaxy per yr (Hung et al., 2018)

Typical X-ray emission from TDEs

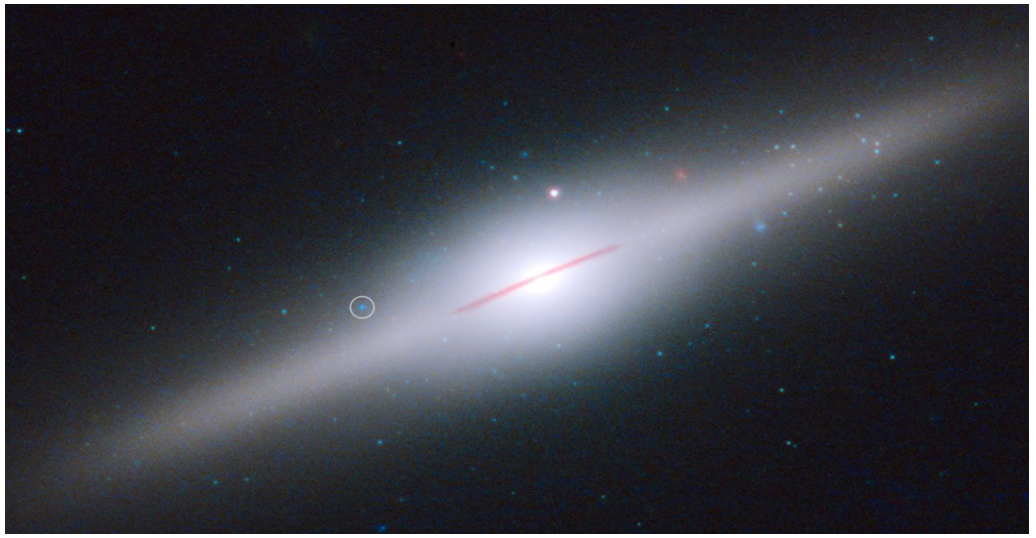


Lin et al. Nature Astronomy (2018)

D_L=247 Mpc

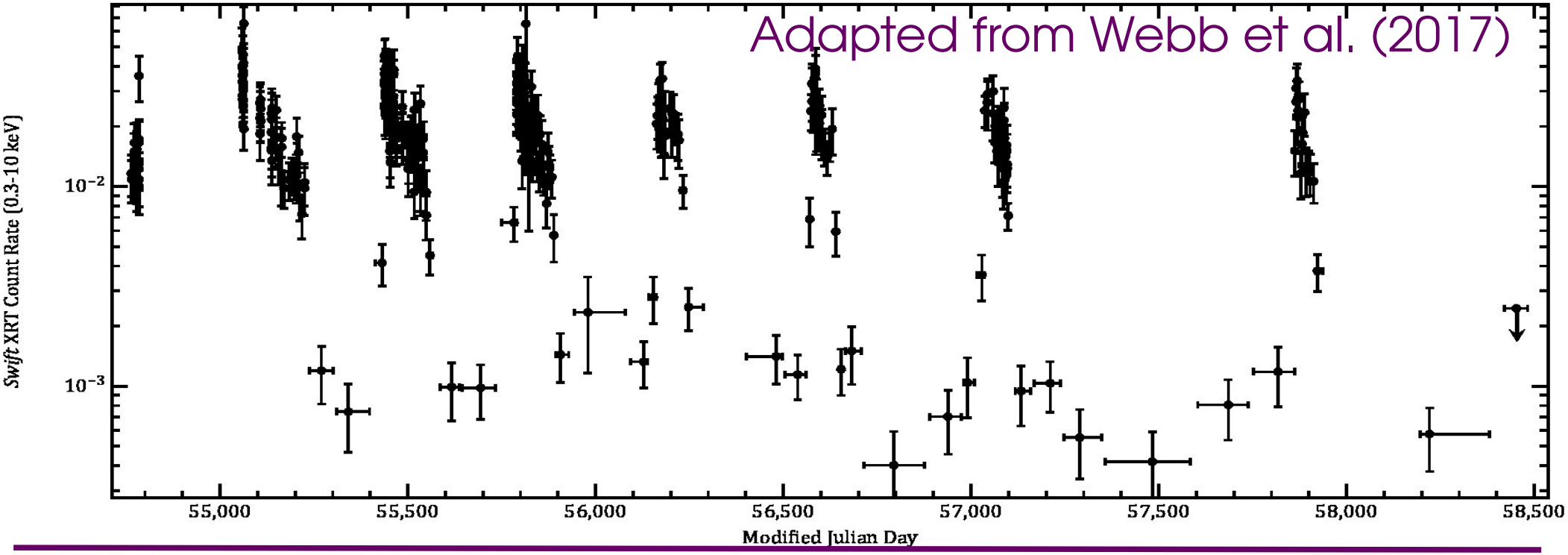
$5.3 \times 10^4 M_\odot$ < mass < $1.2 \times 10^5 M_\odot$

Failed tidal disruption events



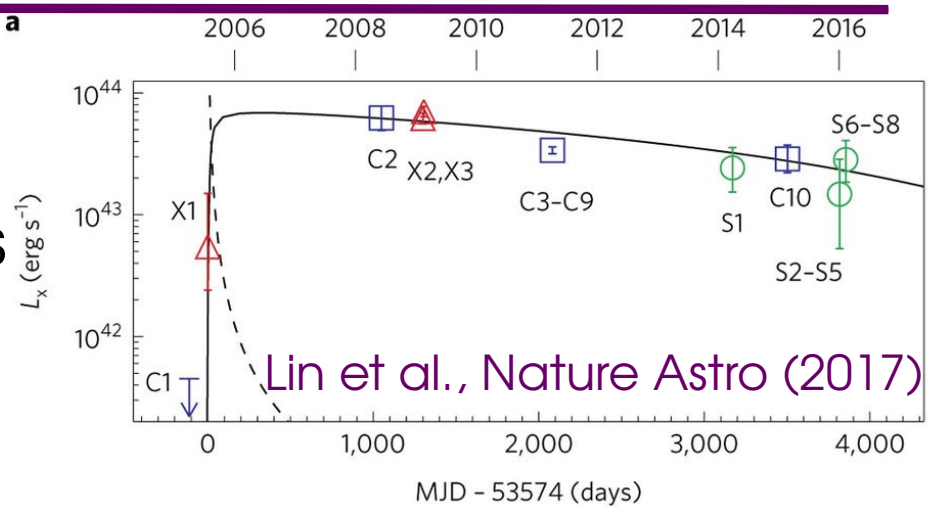
- HLX-1 associated with ESO 243-49 at 95 Mpc (Farrell, Webb et al. 2009, Nature ; Wiersema, Farrell, Webb et al. 2010)
- $L_{x(max)} = 1.2 \times 10^{42}$ erg s^{-1} (Godet, Barret, Webb et al. 2009)
- 9200 < M < 92000 M⊙ (Webb et al. 2012, Science)

Adapted from Webb et al. (2017)



Open questions concerning tidal disruption events

Why is outburst duration so variable?
- maybe linked to accreted star mass
- or inefficient circularisation of debris stream, so high fallback



Why do some TDEs have hard spectra instead of thermal spectra?
- possibly due to jets (e.g. Auchettl et al. 2017)
- or e.g. shocks in accretion flows (Hryniewicz & Walter 2016)

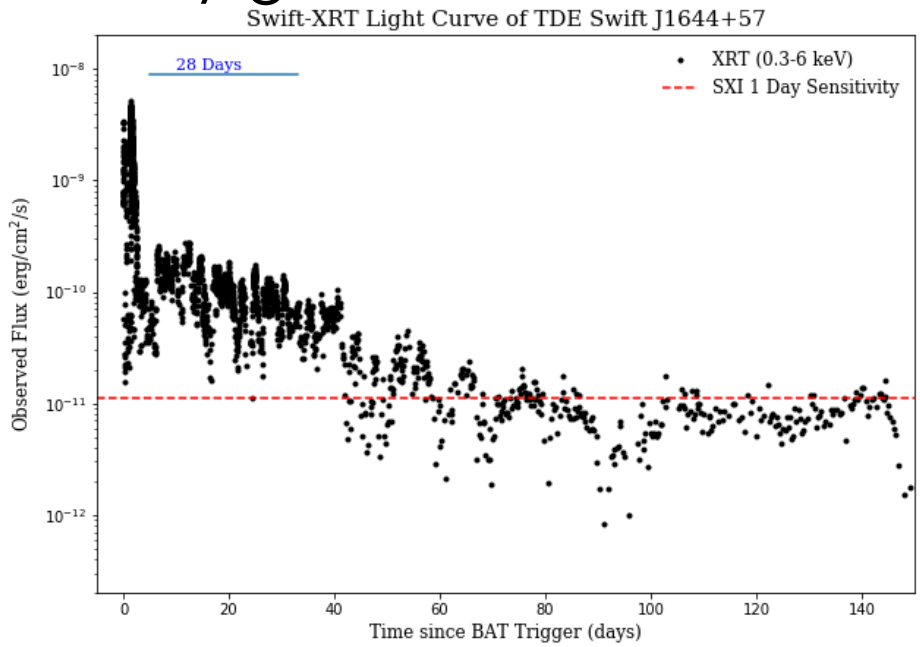
Why are some TDEs detected at some wavelengths and not others?
- possibly from reprocessing of X-ray emission from the disk
- or from shocks between the debris streams as they collide
- or a combination of both
- or due to viewing angle, obscuration by dust, or something else

How can THESEUS help

Large field of view allows us to observe many galaxies at a time, increasing number of detections

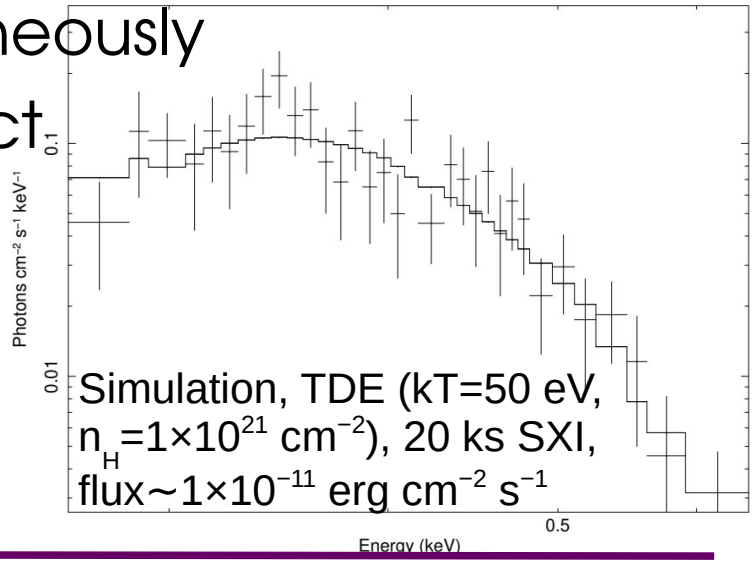
Repeated observations of same field allows high cadence lightcurves, that can be modelled

XGIS will detect and follow hard TDEs, allowing us to determine their nature



IRT + SXI will probe two wavebands simultaneously to investigate the nature of TDEs, and detect local dust through IR "echos", lasting years

Modelling X-ray spectra can give clues to the black hole mass, the accretion regime, the TDE environment



Synergies with other observatories

Follow-up observations with other observatories will allow, for example :

Athena : Fe line detection (modelling gives BH mass & spin), metallicity of the environment using light from the TDE, detect outflows, study reverberation to probe structure of accretion flow

LISA : Follow binary SMBH discovered in Theseus TDEs

ELT : Determine distances, quasi-simultaneous optical observations

LSST : Follow-up LSST TDEs, to determine X-ray nature

….add your favorite observatory here !

TDEs discovered with THESEUS

Supposing 0.02 galaxies Mpc $^{-3}$,Theseus will detect approximately :

- 30 short soft TDEs/yr < 480 Mpc (but detection possible < 1.3 Gpc)
- 40 long (⅓ soft TDEs) soft TDEs/yr < 480 Mpc
- 10 hard TDEs/yr < 290 Mpc (given large FOV of XGIS)
- 4 TDEs/yr containing intermediate mass black holes < 290 Mpc

- THESEUS may double the sample of TDEs detected by eROSITA
- Follow-up long duration TDEs detected with eROSITA
- THESEUS will provide detailed lightcurves for TDE candidates, not possible with other X-ray missions
- Searching for TDEs in real time, will allow good follow-up rapidly
- THESEUS will provide X-ray spectra for a constraint on SMBH mass
- Some failed TDEs may also be discovered