Tidal disruption events in the SRG/eROSITA all-sky X-ray survey

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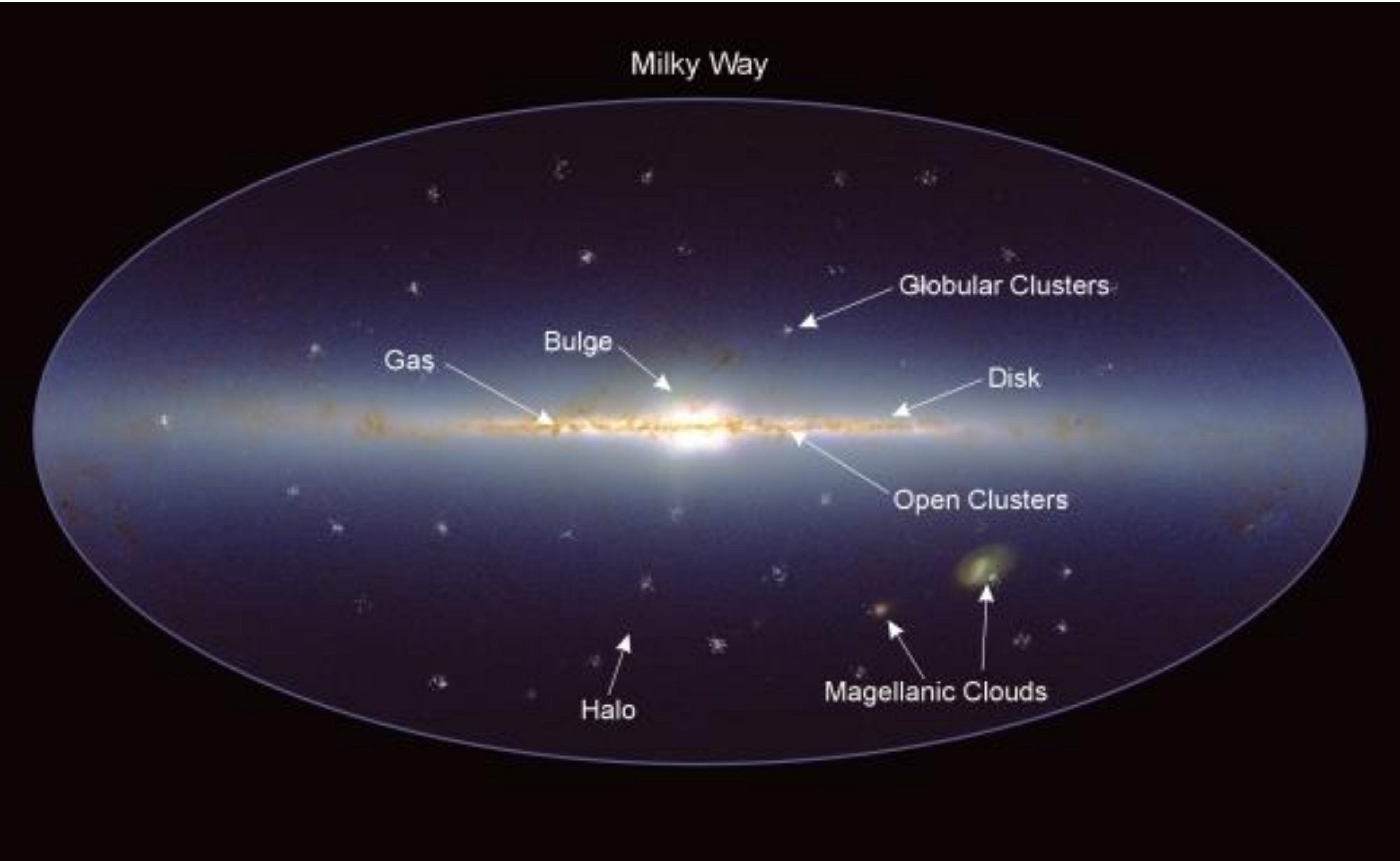
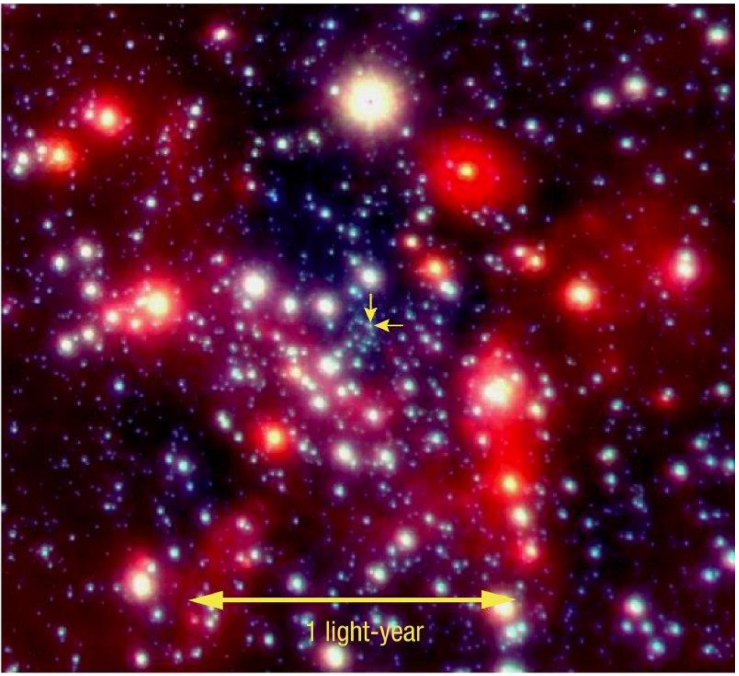
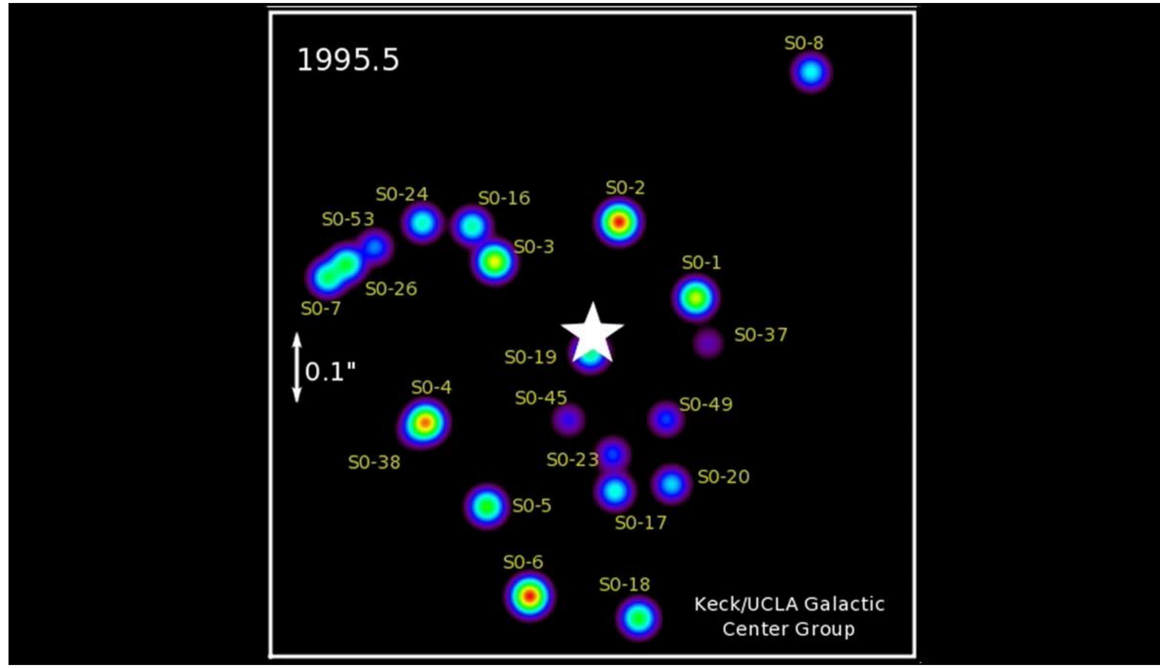
The Galaxy (Milky Way)





The Centre of the Milky Way
(VLT YEPUN + NACO)
ESO PR Photo 23a/02 (9 October 2002)

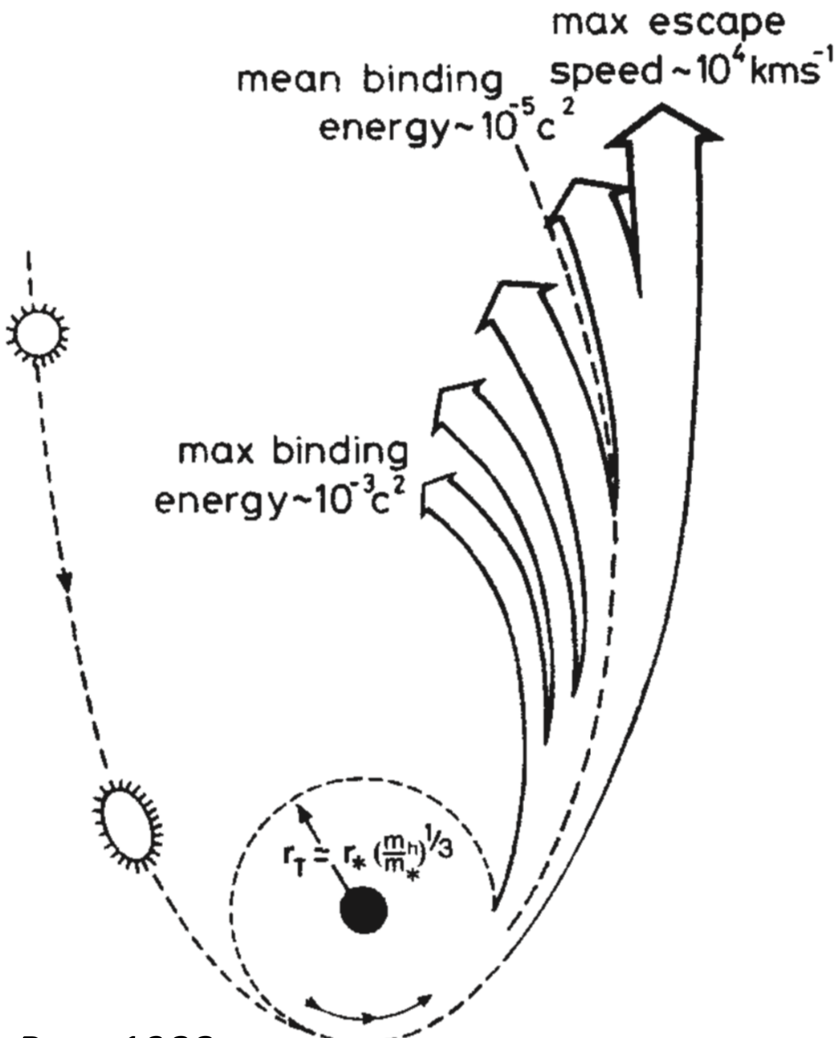


Stars in Kepler orbits around a Black Hole of 4 million solar masses

- There is ample evidence that such central supermassive (millions to billions of solar masses) black holes (**SMBHs**) and nuclear stellar clusters are present in most galaxies.

- These black holes are dormant most of the time (like the one in the center of our Galaxy).

- However, a quiescent central black hole may become very bright for a short time (months to years) if some star happens to come sufficiently close to it.

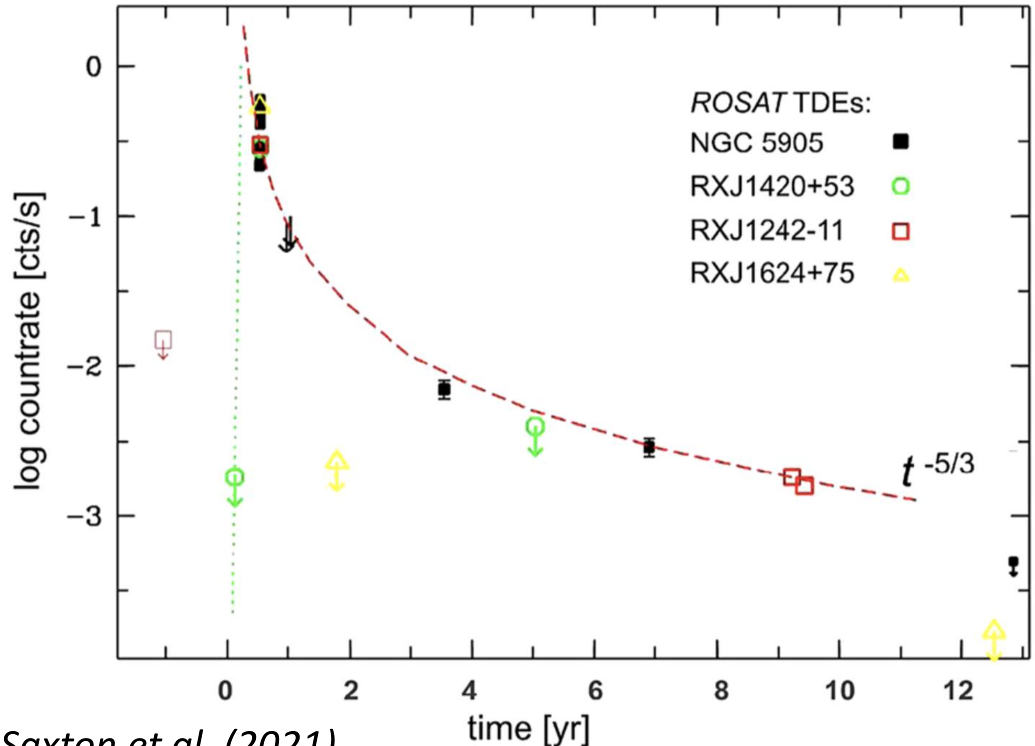


Rees 1988

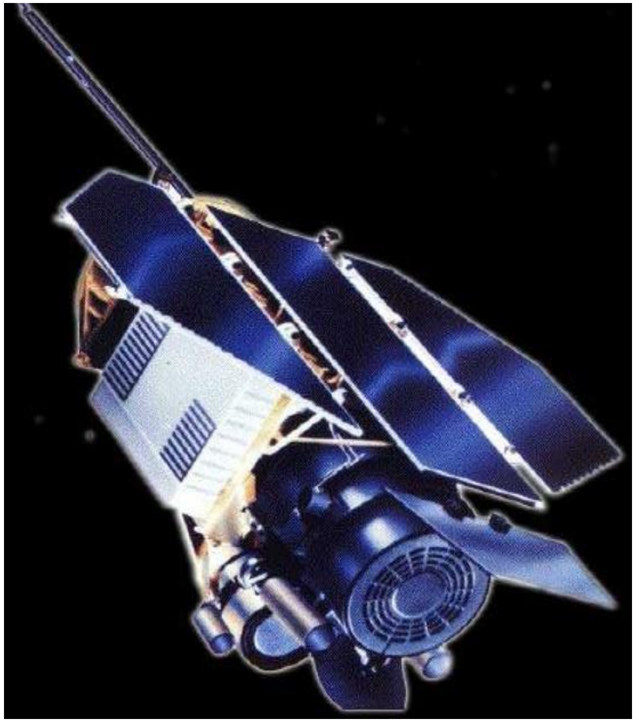
- If a star passes within the **tidal radius** of the SMBH, it will be ripped apart by the tidal forces of the latter.
- Half of the star's debris flies away, while the other half forms an accretion disk around the SMBH.
- Within the disk, the matter spirals in toward the SMBH and the gravitational energy is converted to radiation.
- All this holds true only for SMBHs lighter than 100 million solar masses. In the opposite case, the star will be entirely swallowed by the black hole, without a flare.

Collection: NASA Chandra Space Telescope Collection; Name: Animation of Star Ripped Apart by Giant Black Hole

Tidal disruption events (TDEs)



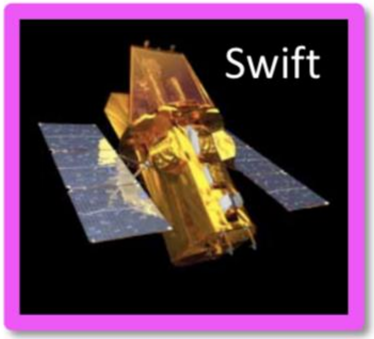
Saxton et al. (2021)

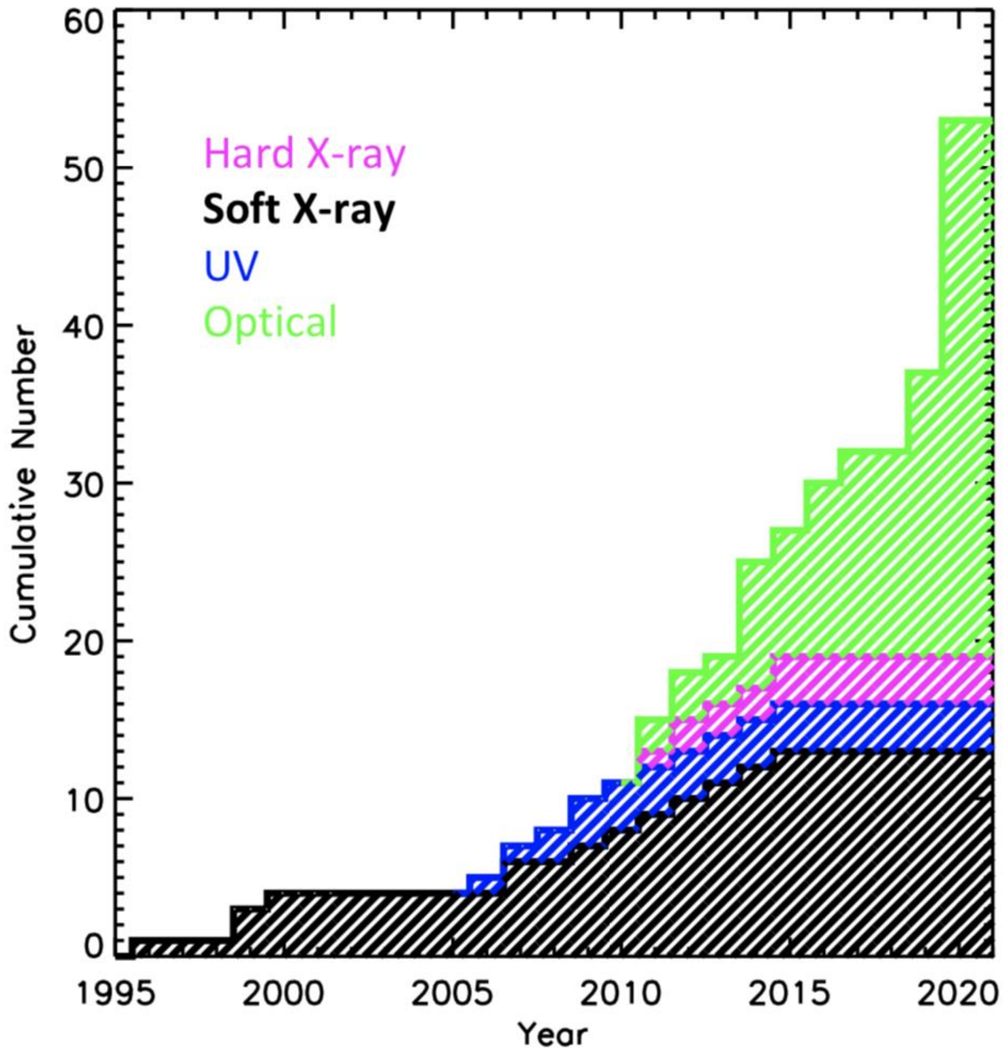


X-ray signatures:
- Fast rise, gradual decay
- Soft spectrum

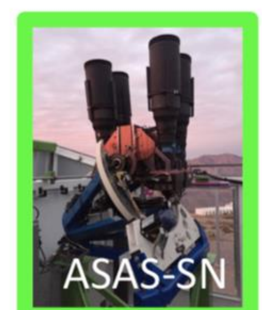
The first few TDEs were discovered by the ROSAT orbital observatory in the 1990s. In total, ~20 TDEs have been found by all X-ray observatories until recently.

Multi-λ Searches

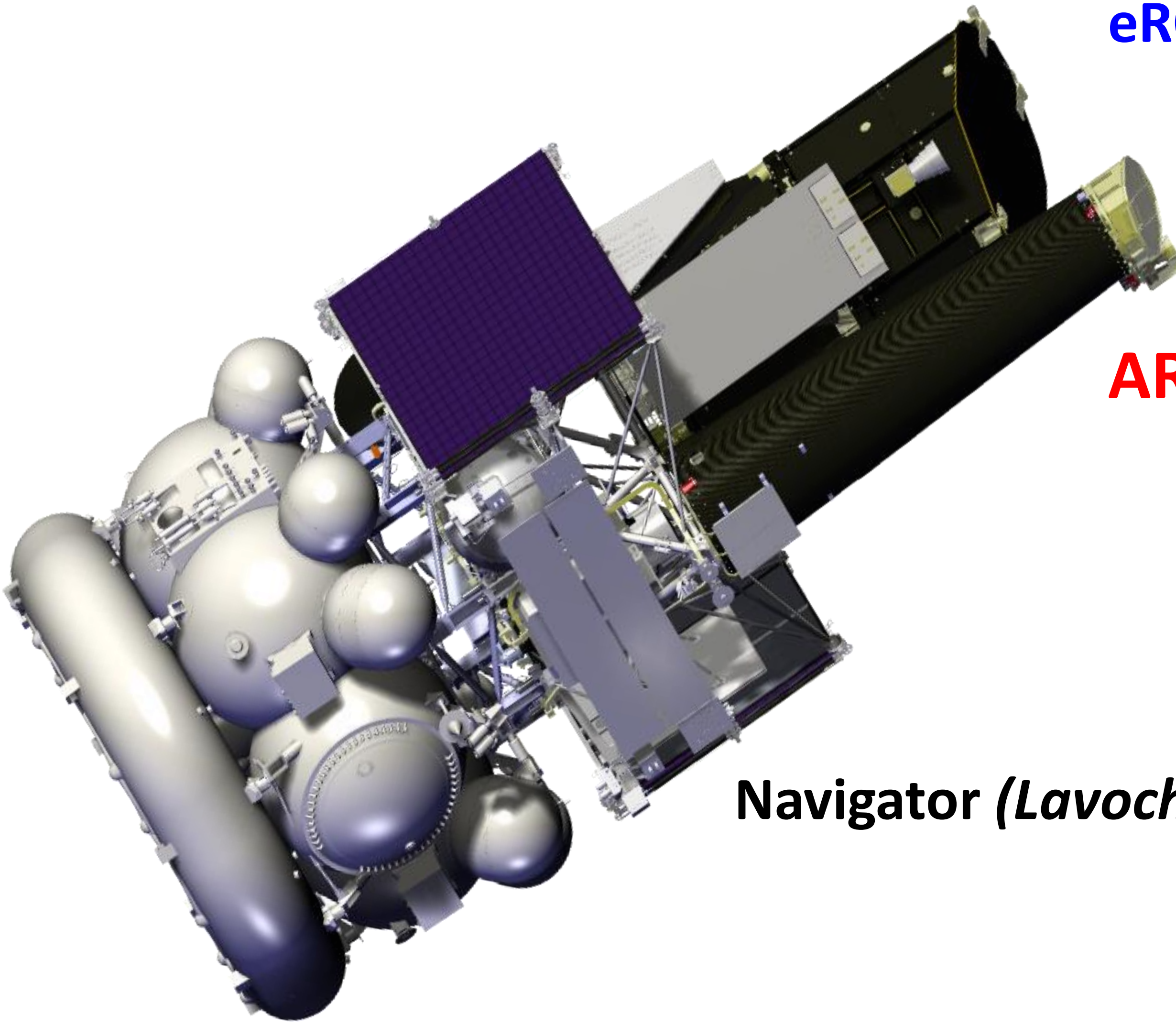




Credit: S. Gezari



The SRG Orbital X-ray Observatory

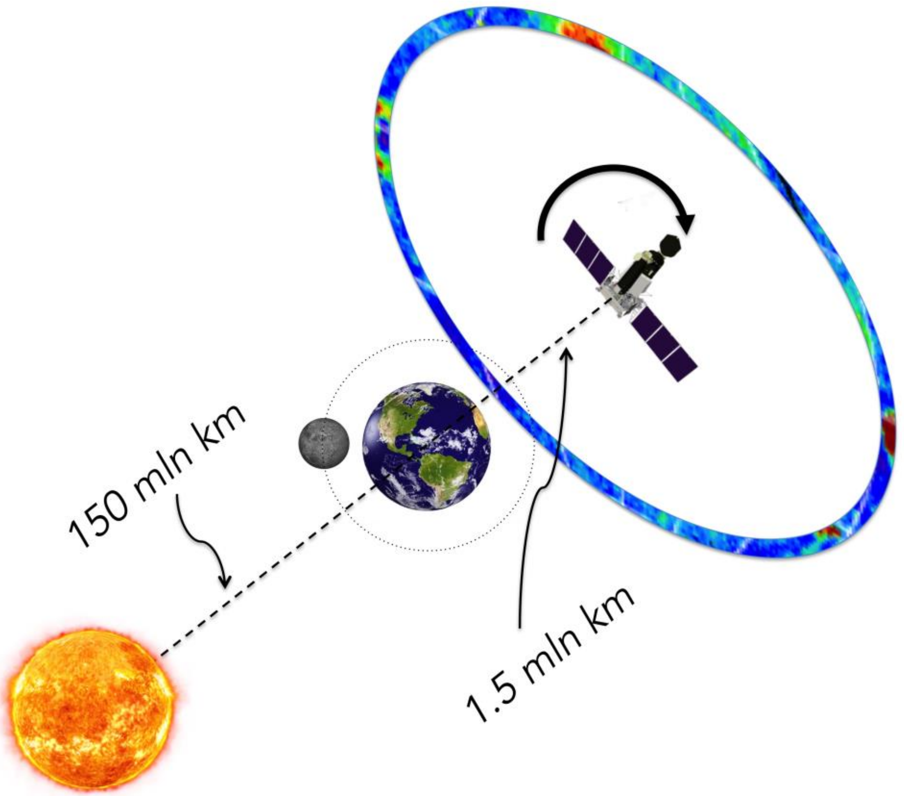


eROSITA *(MPE, Germany)*

ART-XC *(IKI, Russia)*

Navigator *(Lavochkin Association, Russia)*

- Launched 13 July 2019 toward the L2 point of the Sun-Earth system.
- All-sky X-ray survey started on 12 Dec. 2019.
- Due to rotation of the satellite (with a period of 4 hours) around its axis pointing at the Sun, the entire sky is scanned every 6 months.
- In total, 8 surveys are planned until Dec. 2023.
- The data are divided equally between the German and Russian scientific consortia, each being responsible for a half of the sky.



The first results of the search for TDEs in the SRG/eROSITA survey

- We produced and compared the catalogs of X-ray sources (nearly a million!) detected by eROSITA during the 1st and 2nd surveys in the Russian half of the sky ($0 < l < 180^o$).

- Selected those sources that were absent in the 1st survey but became bright in the 2nd (at least 10 times as bright as the upper limit in the 1st).

- Cross-correlated the SRG/eROSITA source catalog with optical, infrared etc. astronomical catalogs to remove stars and other variable X-ray objects. Compiled a list of TDE candidates.

- Carried out optical spectroscopic observations of these candidates.

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First tidal disruption events discovered by *SRG*/eROSITA: X-ray/optical properties and X-ray luminosity function at $z < 0.6$

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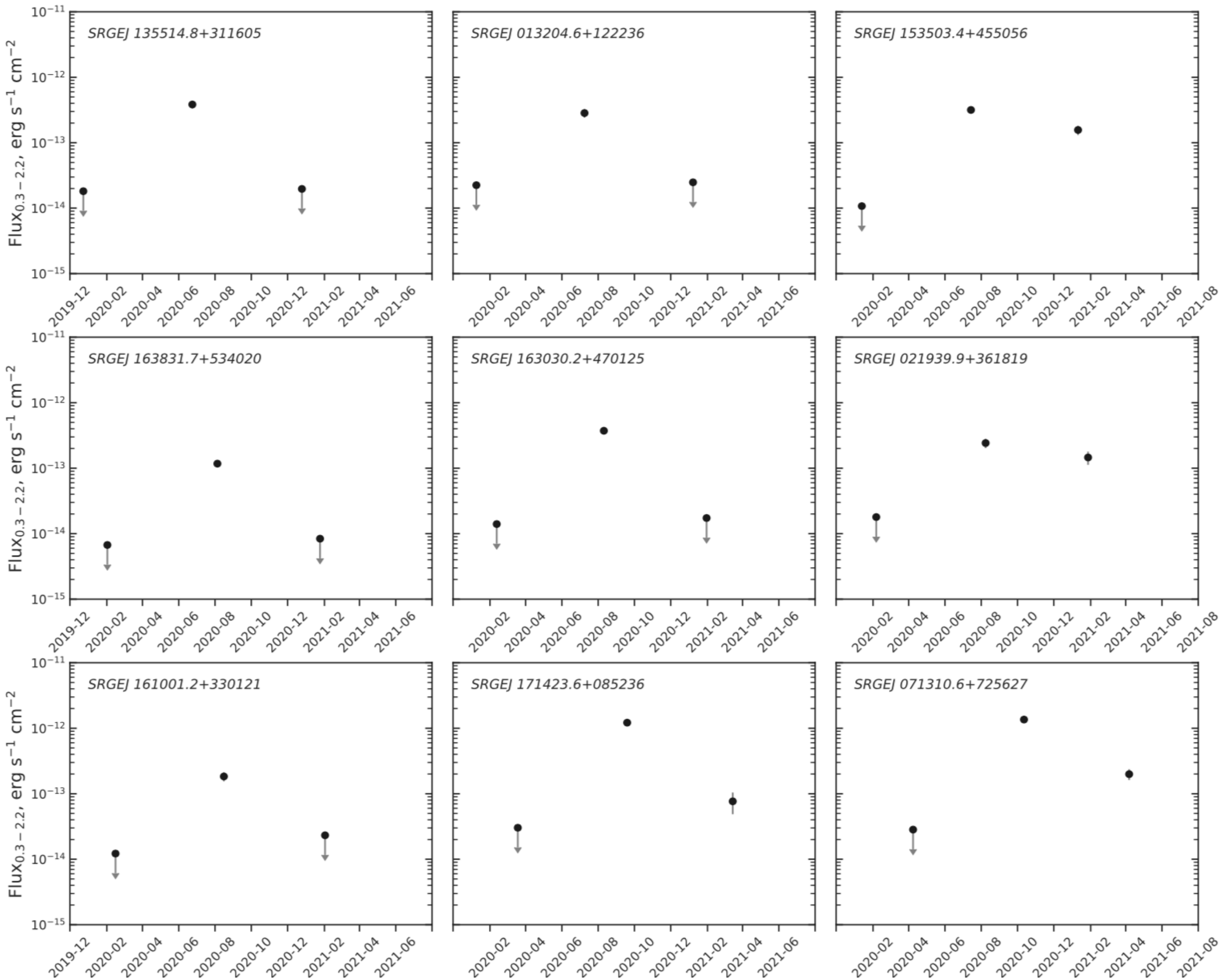
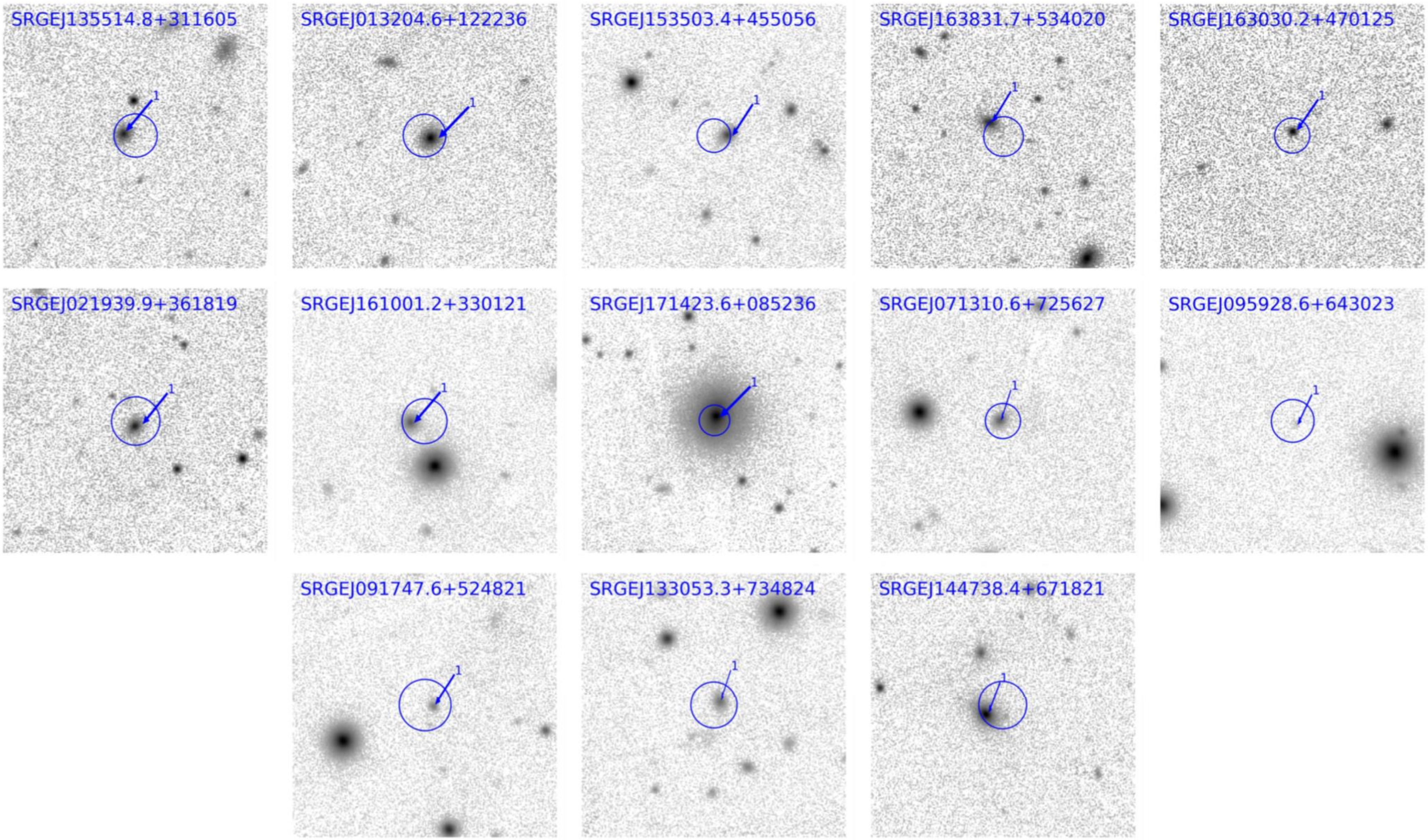
13 brightest, optically confirmed TDEs detected in the 2nd survey

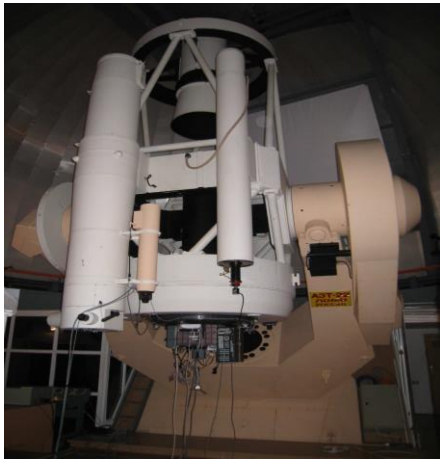
X-ray light curves (SRG/eROSITA)



Optical observations



In each case, there is a single extended optical object (galaxy) within the X-ray localization region (of ~5 arcsecond radius).



1.5-meter Russian-Turkish Telescope (Antalya, Turkey)

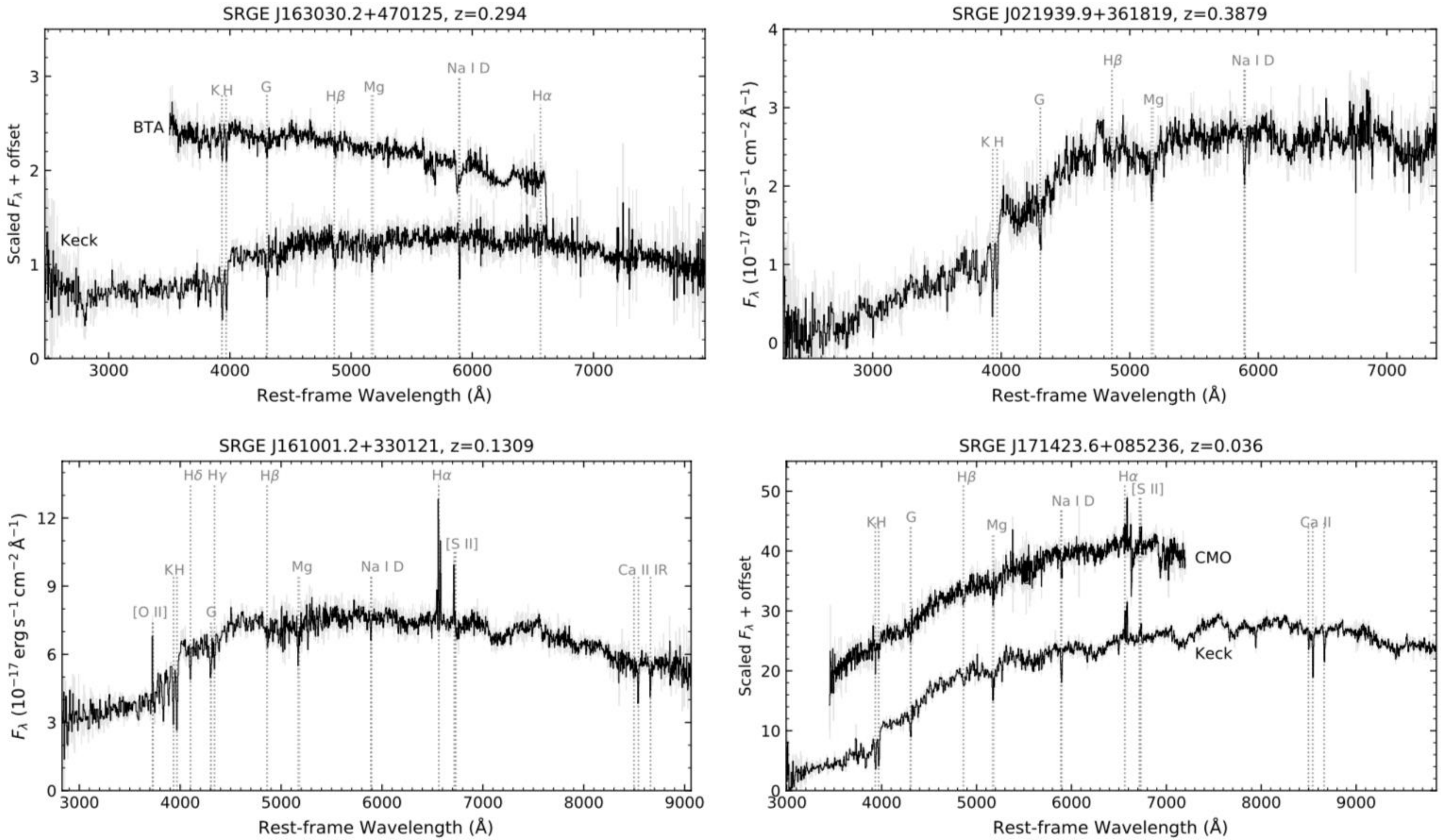
1.6-meter AZT-33IK (Sayan Mountains, Russia)

2.5-meter telescope of the Moscow State University (Caucases, Russia)

6-meter БТА (Caucauses, Russia)

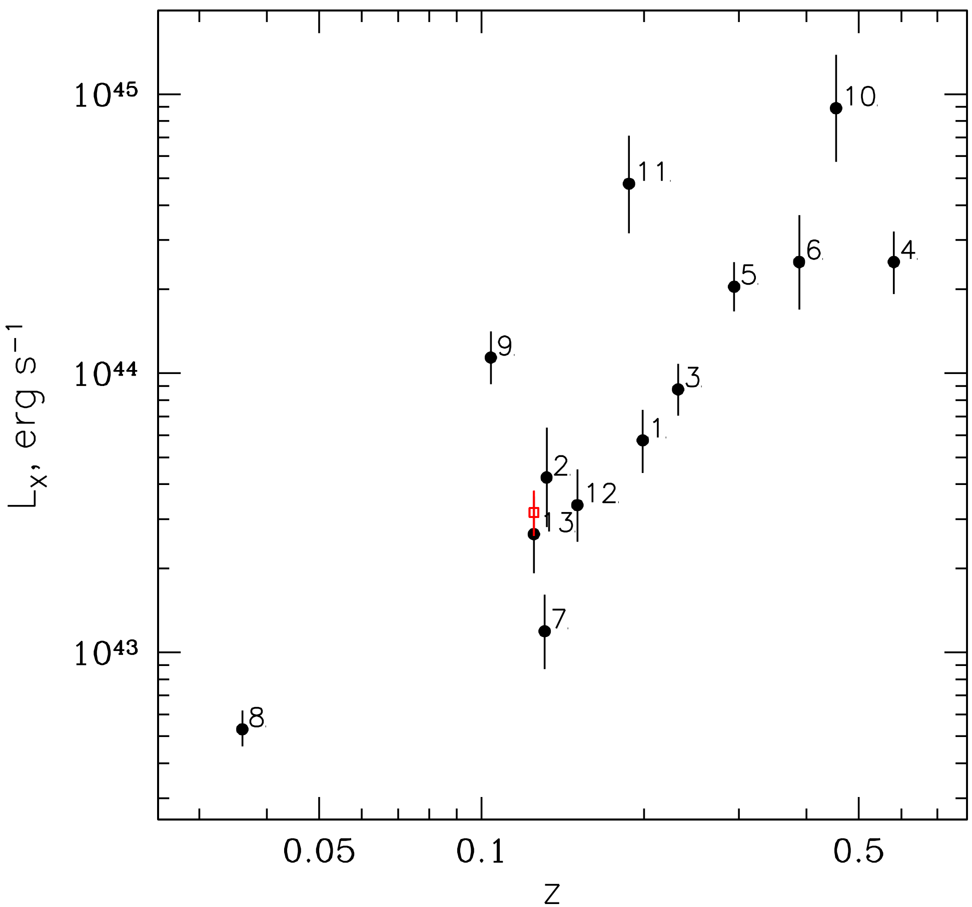
10-meter Keck-1 (Hawaii, USA)

Zwicky Transient Facility 1.2-meter Oschin Schmidt (California, USA)



X-ray detected TDEs usually show optical spectra typical of normal galaxies.
This is a distinguishing feature of TDEs.

Properties of the first SRG/eROSITA TDE sample



X-ray luminosity vs. redshift diagram

- SRG can detect TDEs out to redshifts of z~0.6, i.e when the Universe was 6 billion years younger than now.
- The X-ray luminosities of TDEs can reach 10^{38} watt. This corresponds to 3 x 10^{11} bolometric luminosities of the Sun and is more than the total luminosity of our Galaxy.

How often do TDEs occur in galactic nuclei?

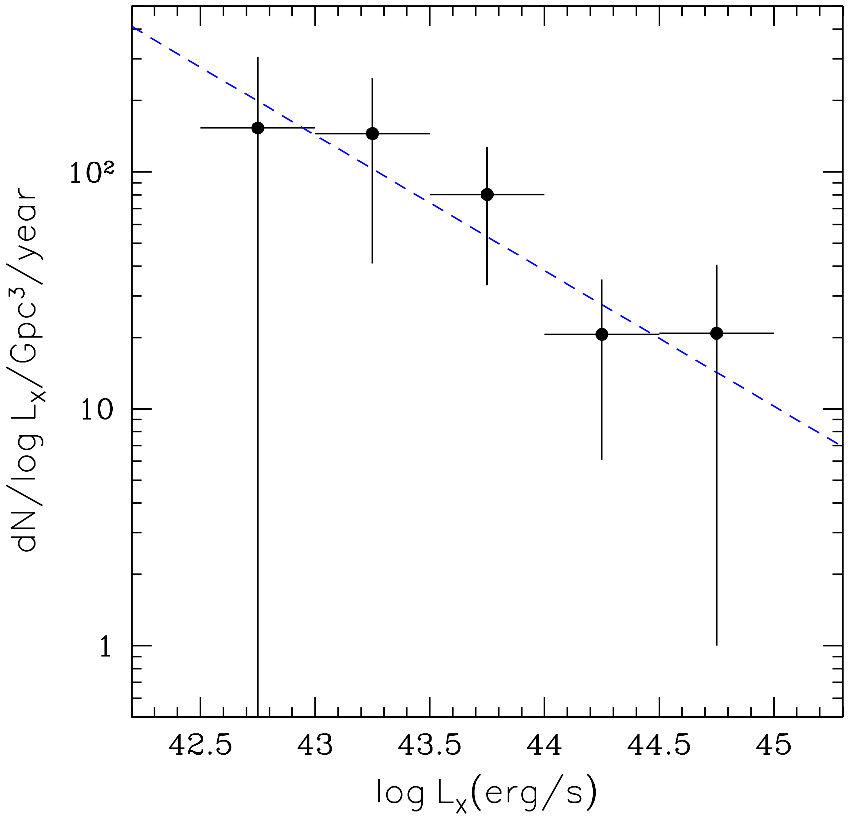
- Based on the SRG/eROSITA data:

R = (1.1±0.5) 10^{-5} TDE/galaxy/year

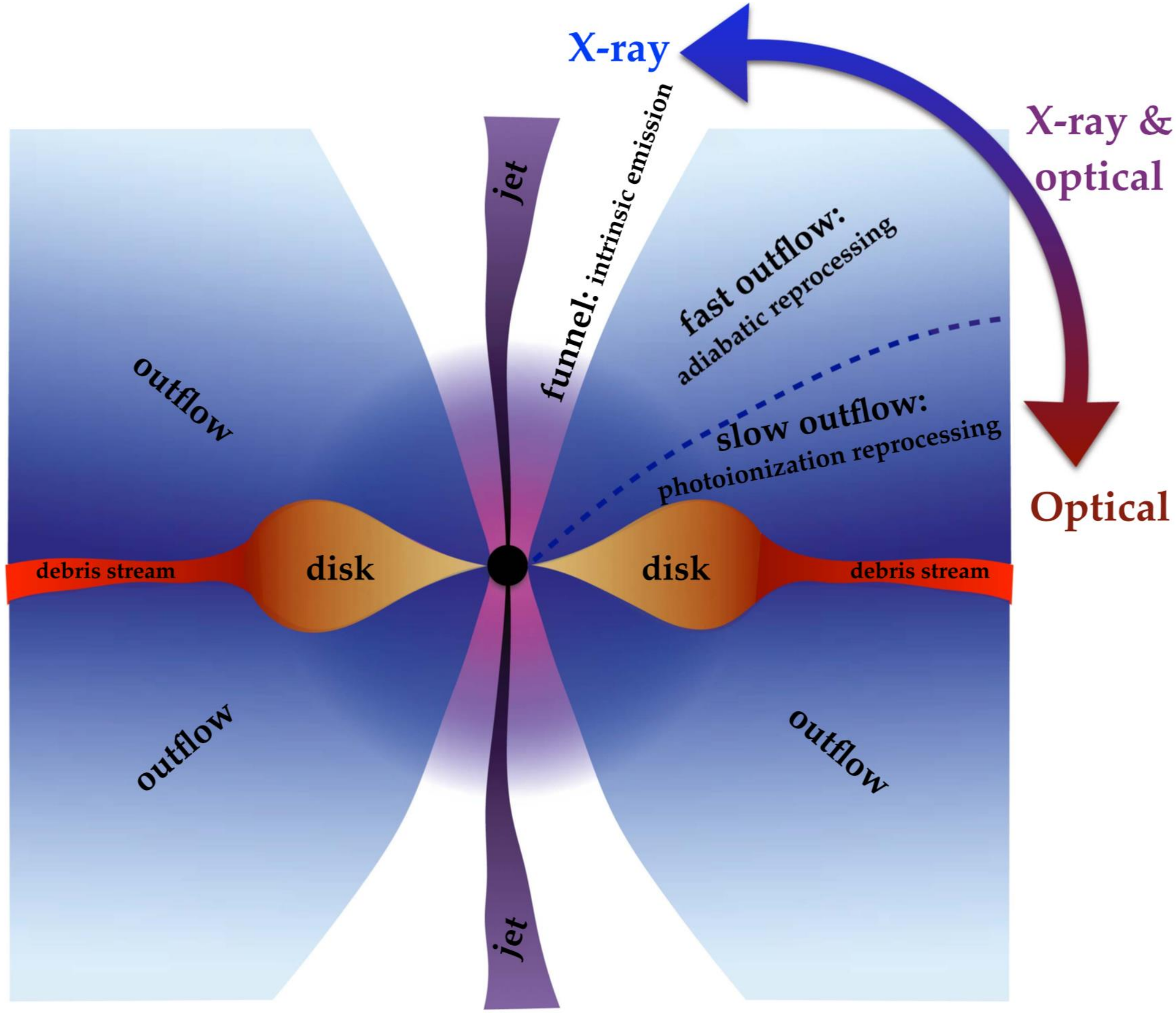
- For comparison, the rate of optically selected TDEs is an order of magnitude higher:

R ~ 10^{-4} TDE/galaxy/year

(van Velzen et al. 2020)



Is viewing angle the key factor?



Dai et al. 2018

Outlook

- We are now finding about 1 new TDE per week in the Russian half of the SRG/eROSITA sky. Already more than 50 TDEs detected.

- The most distant one is at z~1 (~6 billion years after the Big Bang).

- By the end of the SRG 4-year survey, ~700 TDEs can be found over the whole sky.

Using this unique data base, we can greatly improve our understanding of (i) the TDE phenomenon, (ii) physics of accretion onto black holes, and (iii) population properties of the central supermassive black holes in galaxies.