TDE rates and evolution

From Infrared to UV

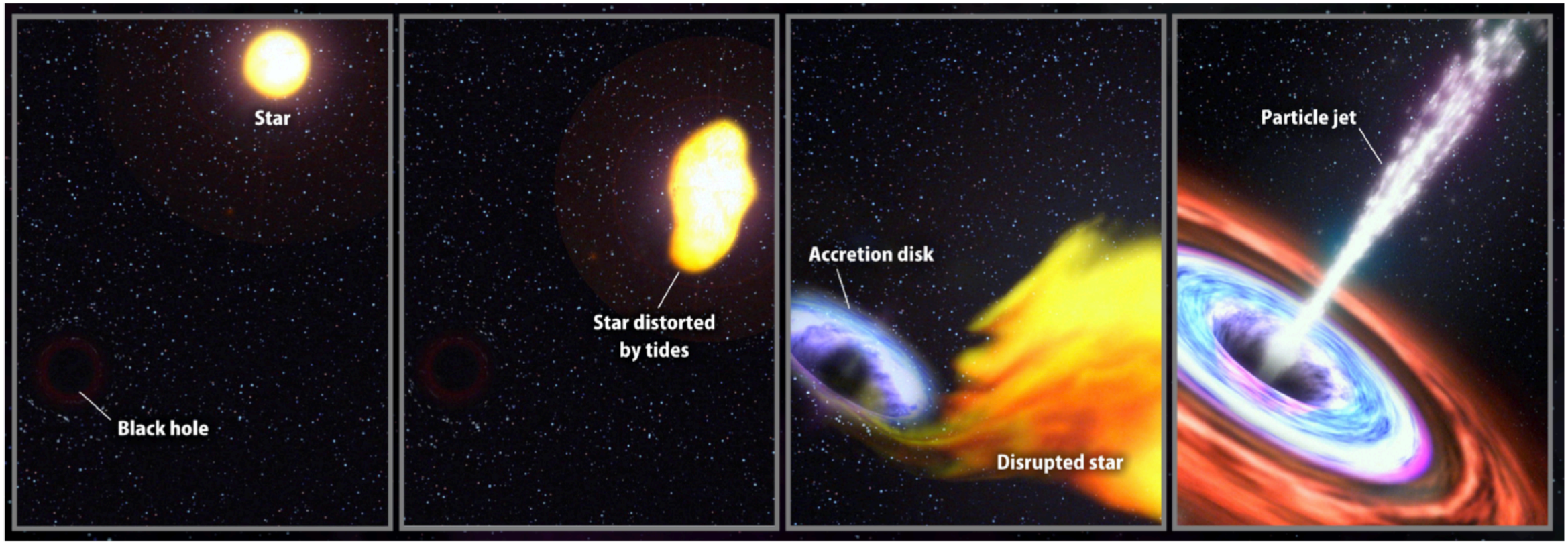
1. Introduction to Tidal Disruption Events
2. A comprehensive sample of infrared TDE candidates
3. TDEs with ULTRASAT

Jannis Necker

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

Tidal Disruption Events

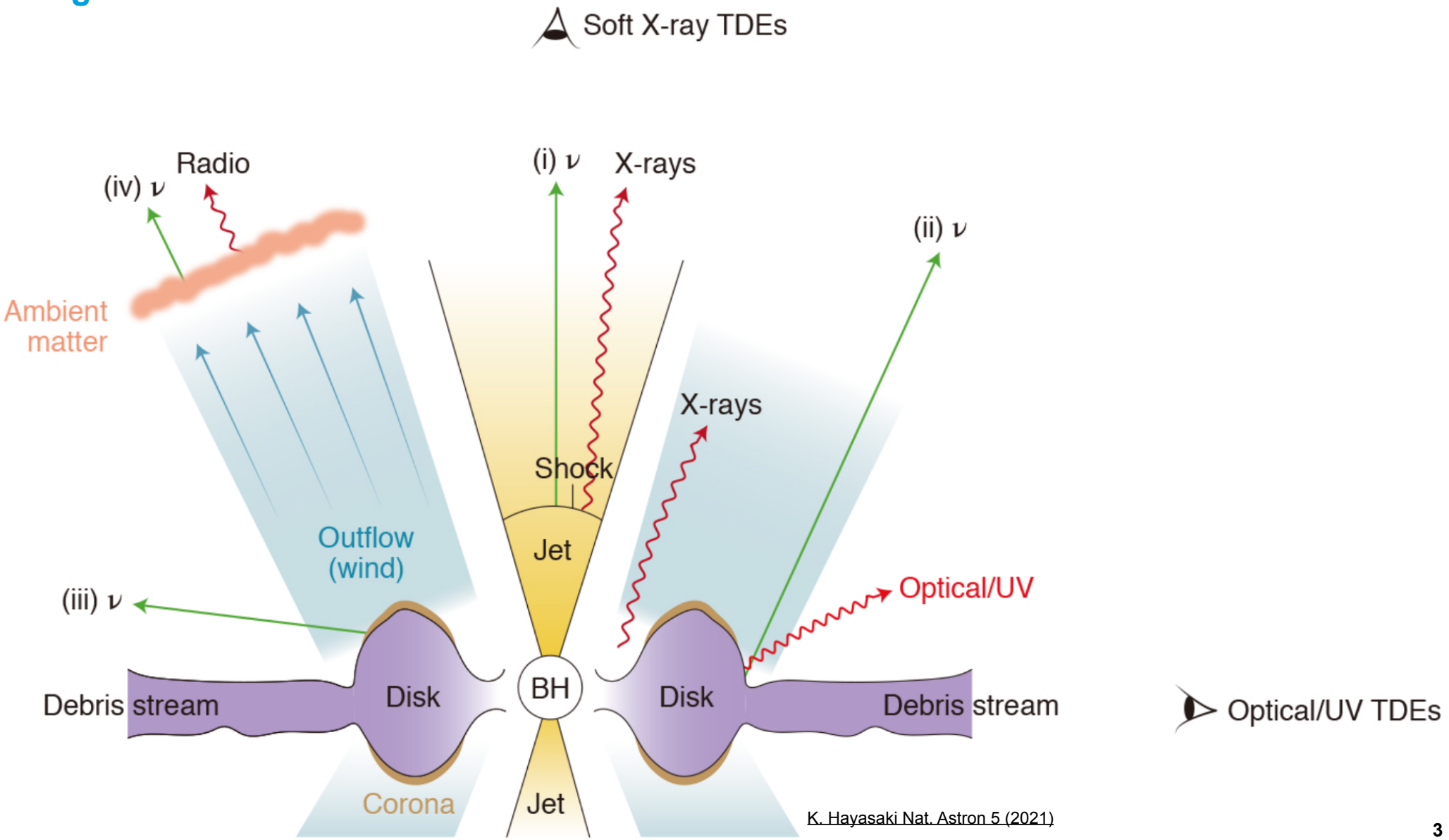


Credit: NASA

1 2 3 4

Tidal Disruption Events

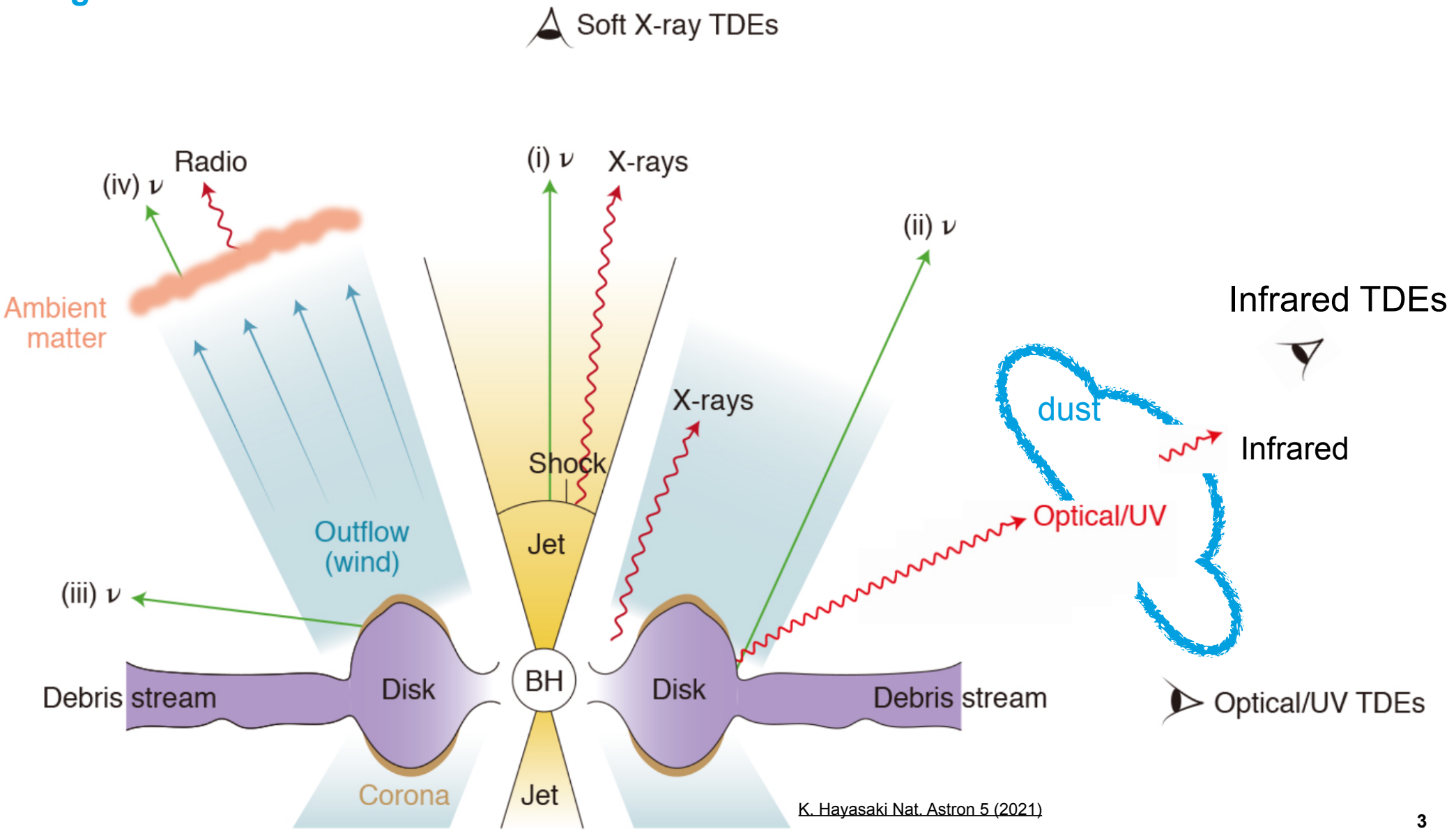
Electromagnetic signatures



K. Hayasaki Nat. Astron 5 (2021)

Tidal Disruption Events

Electromagnetic signatures



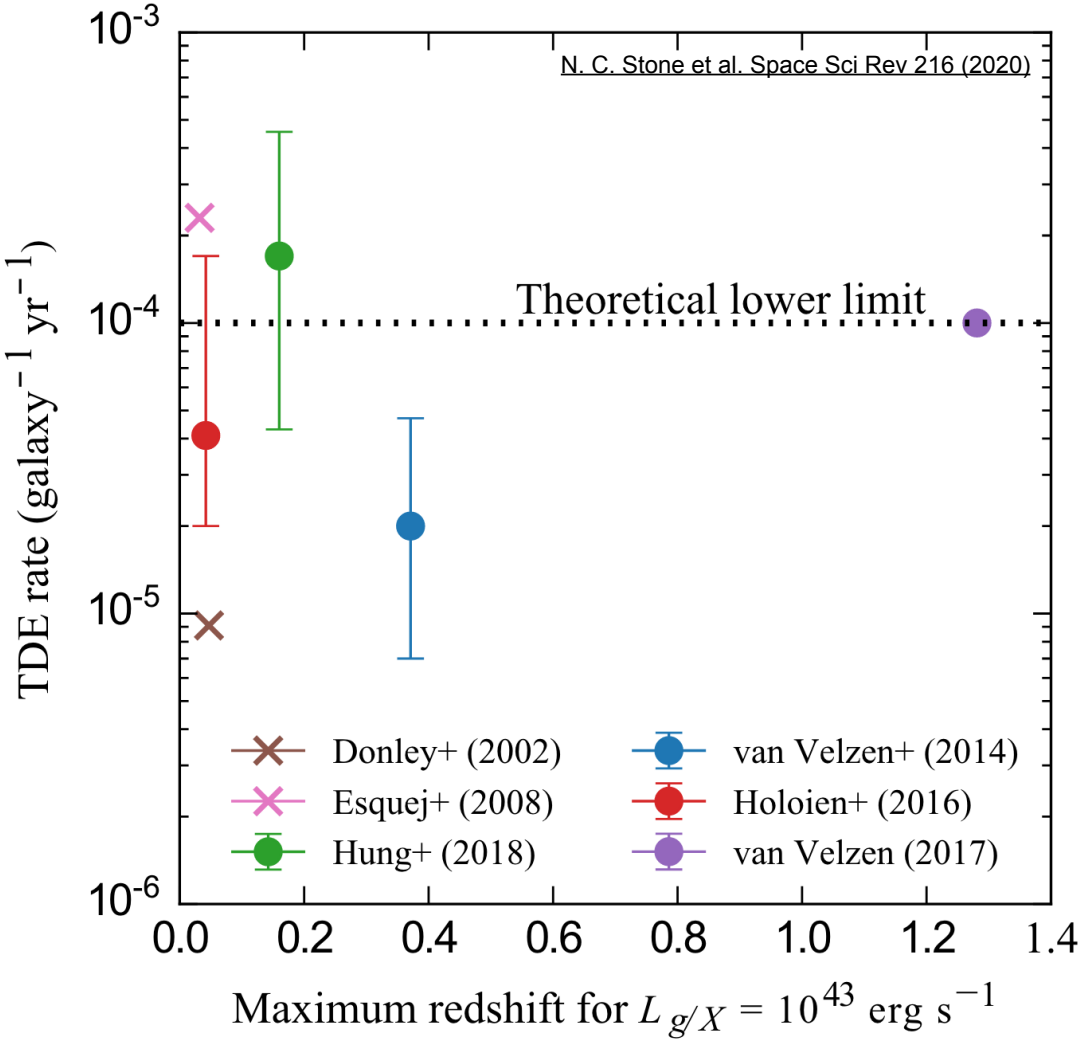
K. Hayasaki Nat. Astron 5 (2021)

Tidal Disruption Events

Event demographics

- Expectation from stellar dynamics in galactic cores: $\sim 10^{-4}\,\mathrm{galaxy}^{-1}\mathrm{year}^{-1}$
- Most observations at $\sim 10^{-5}\,\mathrm{galaxy}^{-1}\mathrm{year}^{-1}$
- Enhancement on post-starburst galaxies [1]
- Suppression in starburst galaxies potentially due to dust [1]

Obscured population part missing from rate studies

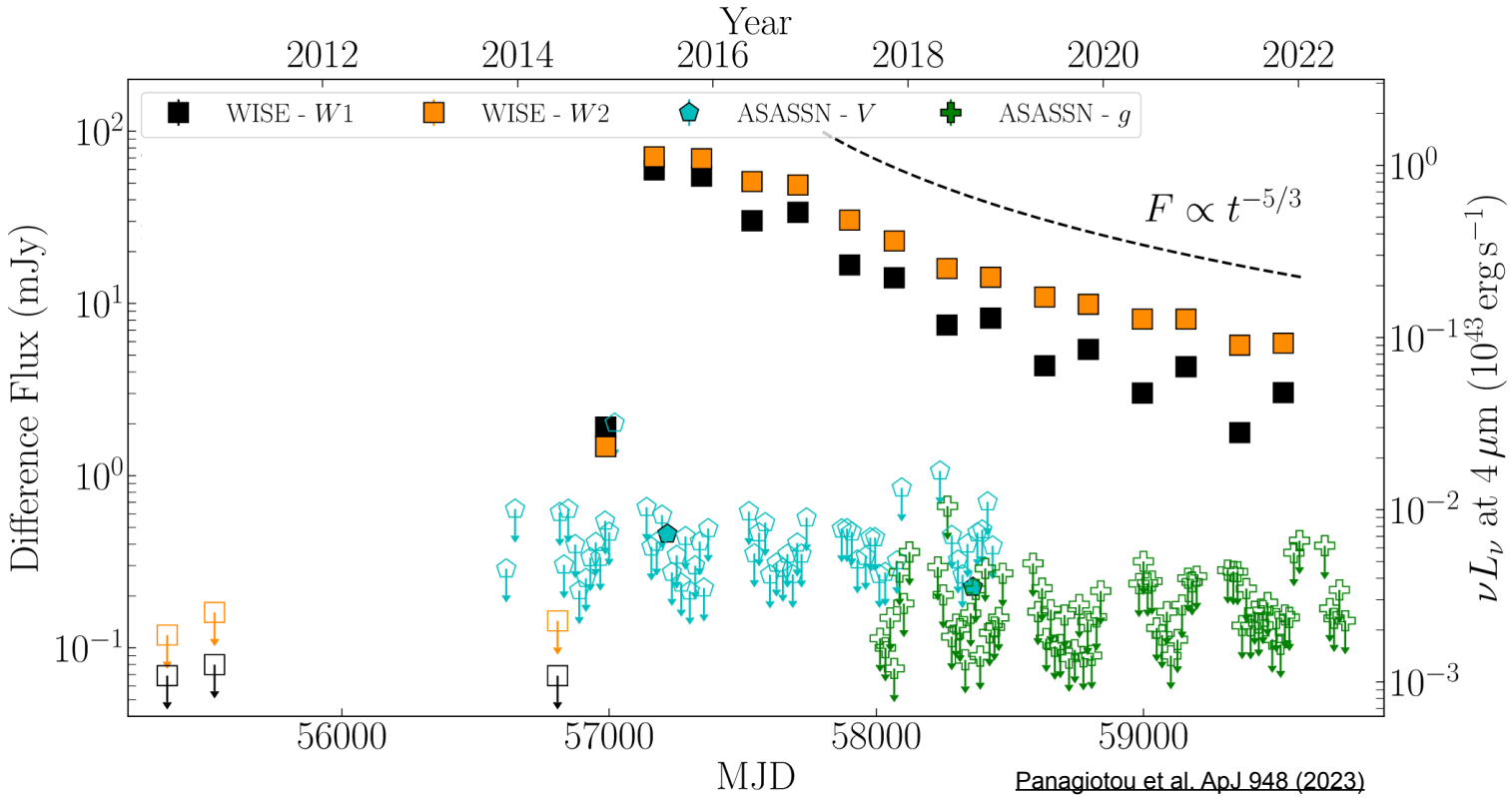


[1] Y. Yao et al ApJL 955 (2023)

Flaires:
A comprehensive catalog of infrared flares

- Part of TDE population may be missing but possibility of **IR detection demonstrated**
- IR flare **samples exist but** either **limited** in sky area [2] or volume [3]

[2] Jiang et al. ApJS 252 (2021) [3] Masterson et al. ApJ 961 (2024)

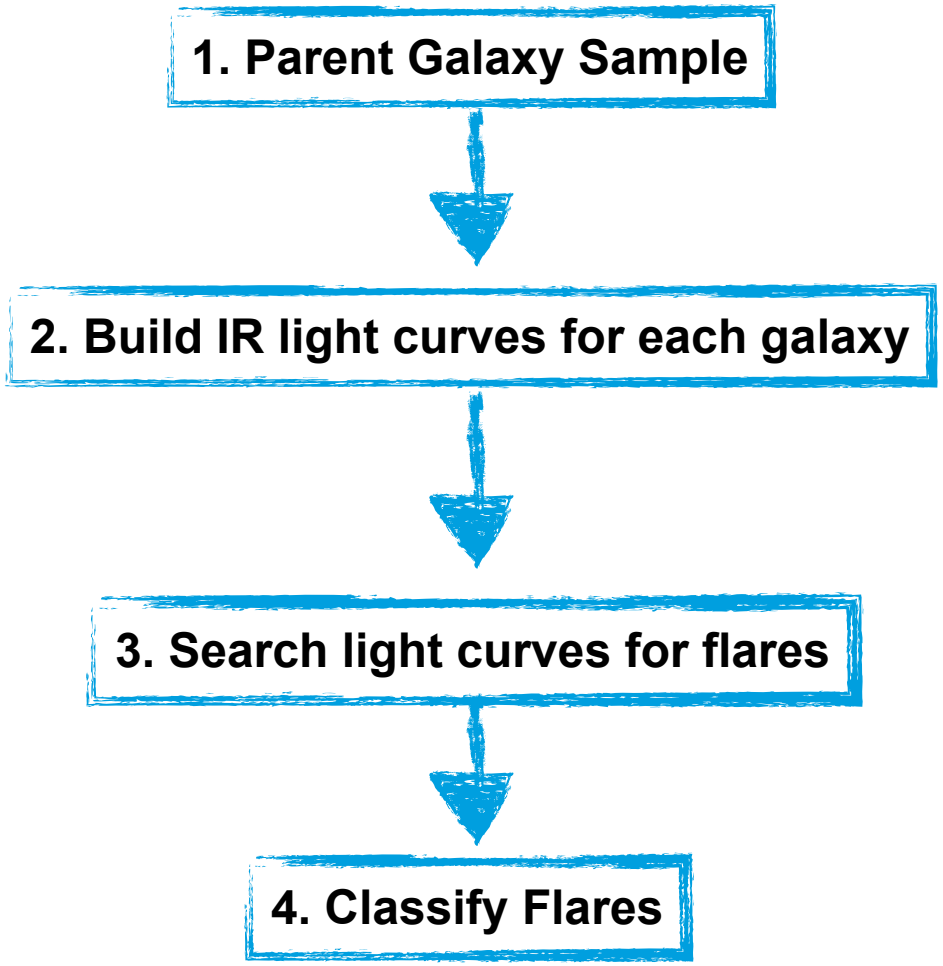


Panagiotou et al. ApJ 948 (2023)

Build **comprehensive catalog of infrared flares**
(Originally for high-energy neutrino correlation studies)

Flaires

A Comprehensive Catalog of Infrared Flares



- List of **~40 million galaxies** assembled and crossmatched from three literature sources

- **Efficient download** of WISE data for $\mathcal{O}(10^6)$ objects
- **Combination of single exposures** for each visit for more robust data

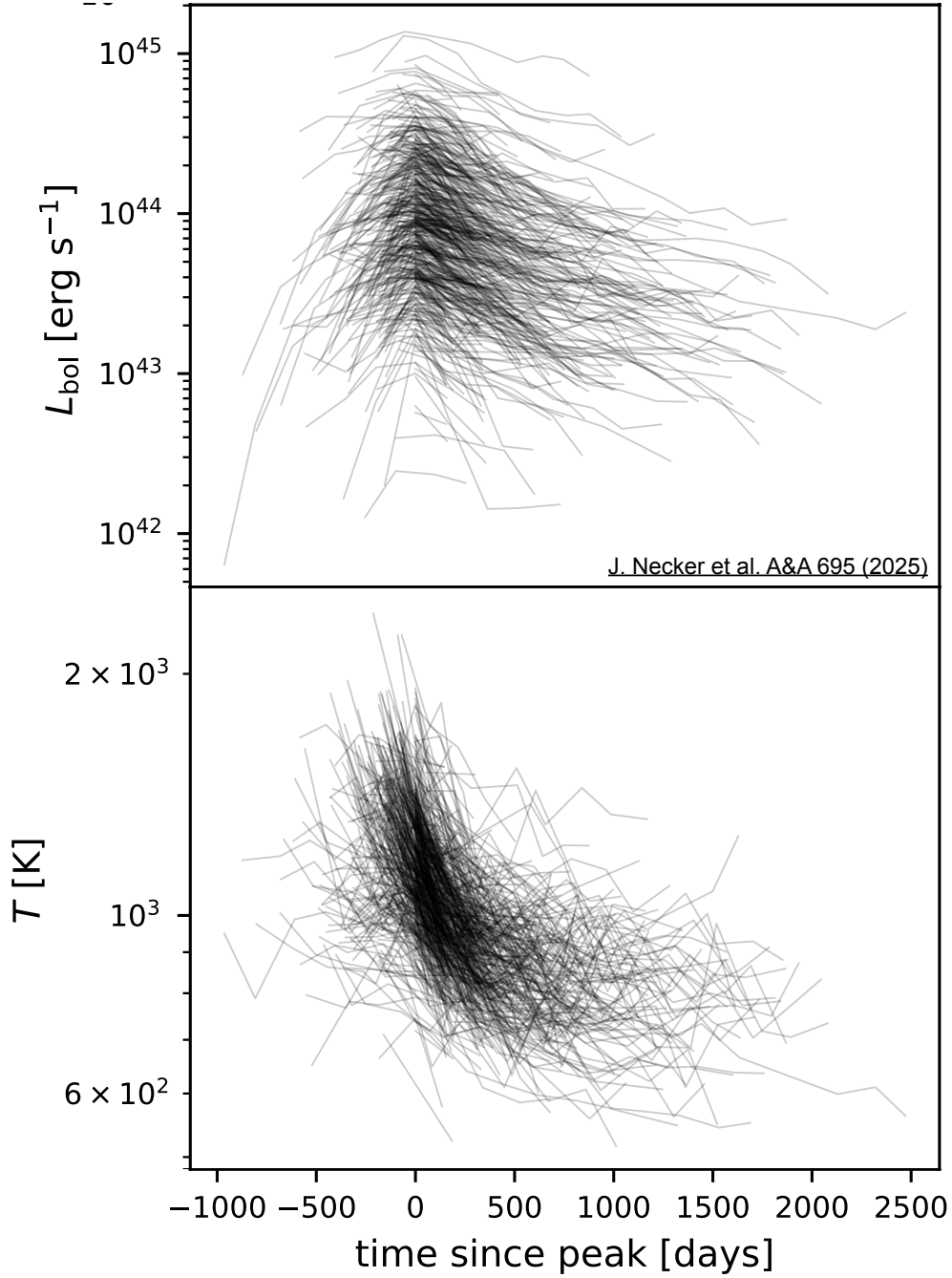
- **Identification of excesses** based on χ^2_{red} and Bayesian Blocks algorithm
- Selection of well-sampled **dust-echo-like flares**

- Inference of **dust radius and temperature**

Flaires

A Comprehensive Catalog of Infrared Flares

- Sample of ~800 dust echo candidates
- Consistent with TDEs:
  - ✓Emitted energy between $10^{51} - 10^{52}\,\mathrm{erg}$
  - ✓Temperature evolution: cooling from $\sim 1800\,\mathrm{K}$
  - ✓Location in galaxy center connected to the supermassive black hole
- Rate of $\sim 10^{-5}\,\mathrm{galaxy}^{-1}\mathrm{year}^{-1}$
  - consistent with other studies
  - Similar to optical and X-ray rates



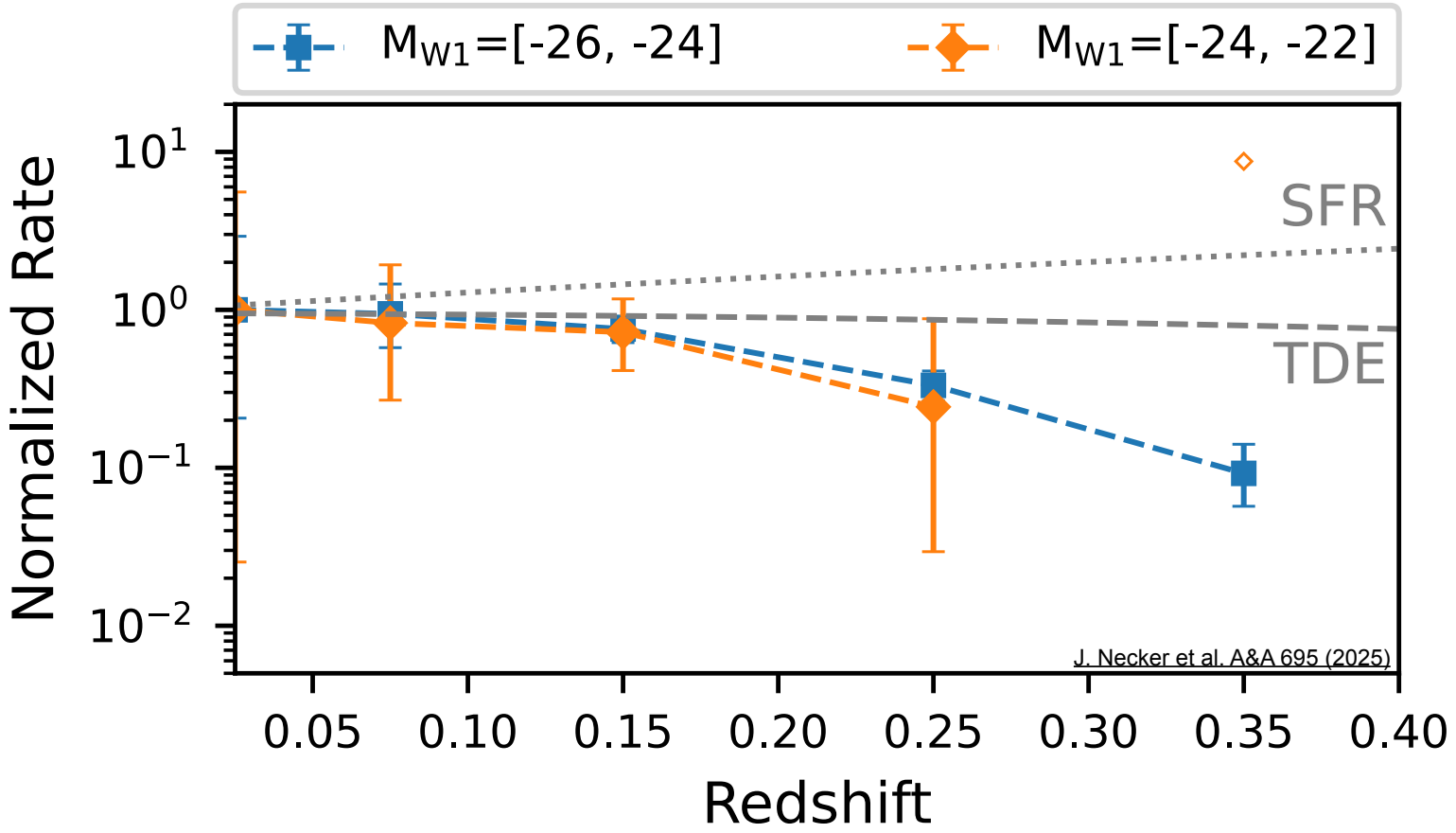
Flaires

Rate Evolution

- **Consistent with theoretical expectation** within uncertainties (statistical only)

Open questions:

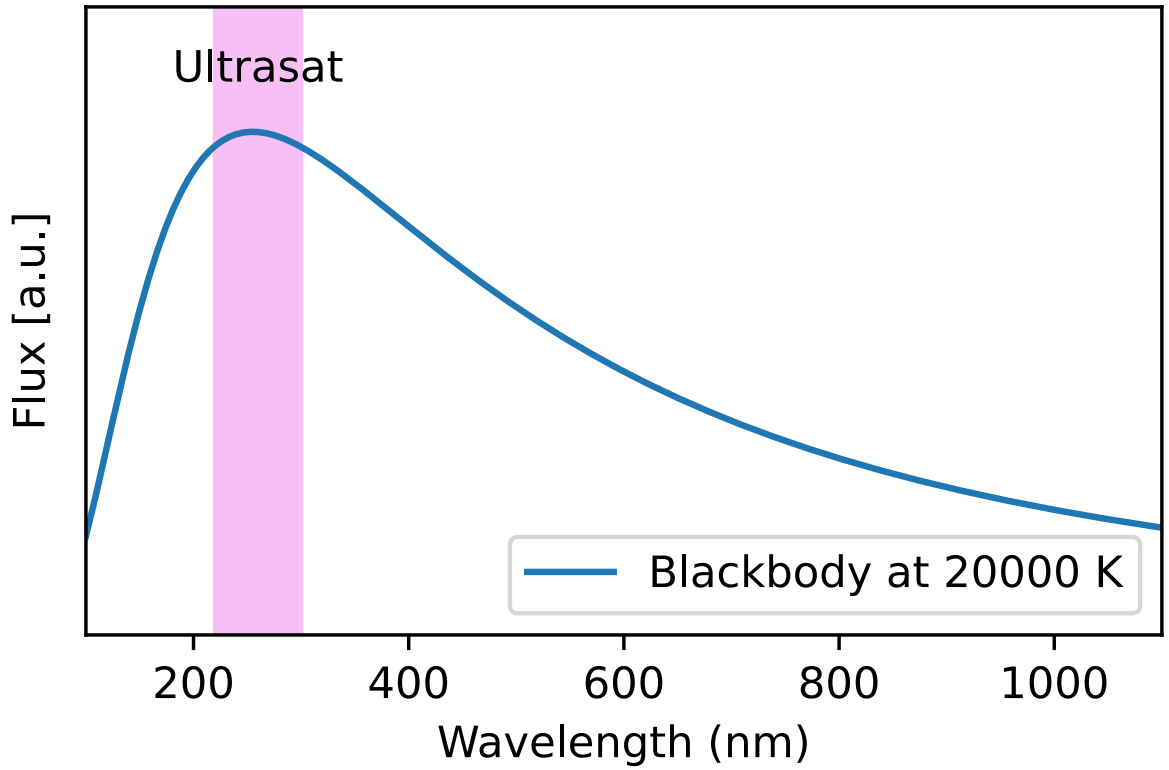
- Similar redshift evolution in other wavelengths?
- Redshift dependent dust amount?



Towards thousands of TDEs

Identifying TDEs with ULTRASAT

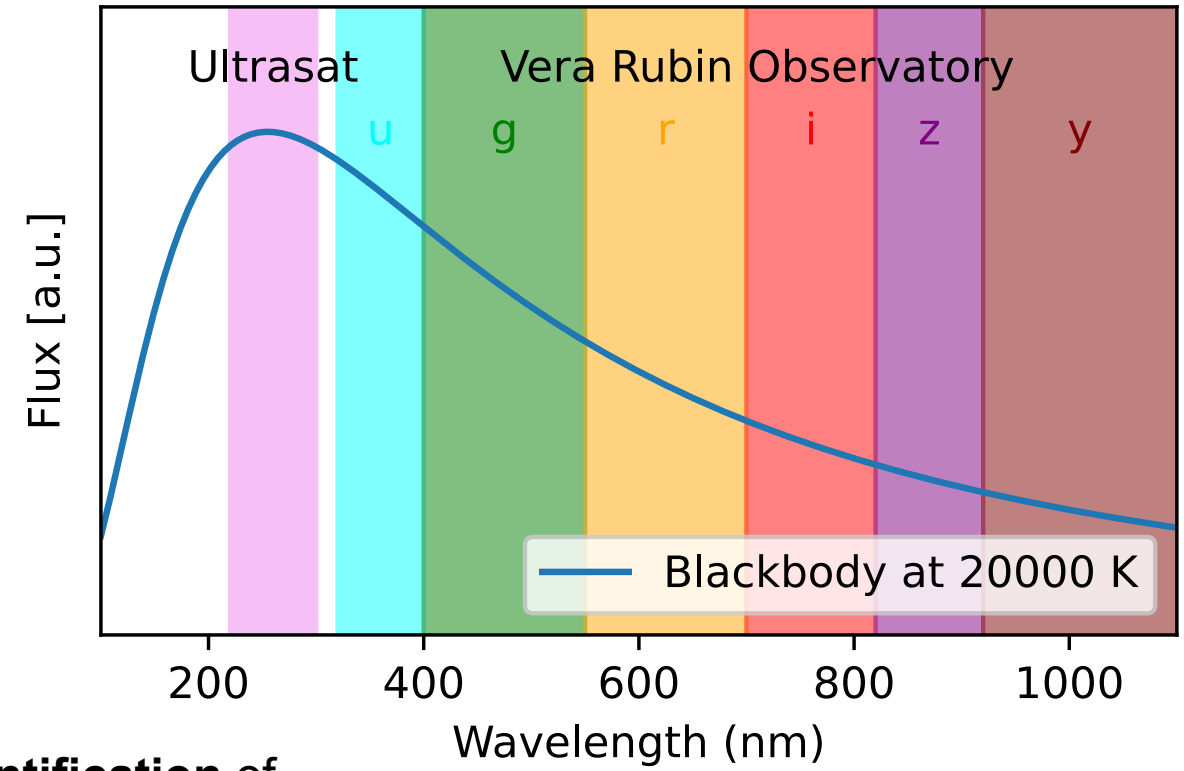
- Low-cadence survey: **1500 to 14000 TDE detections** per year
- **Challenging spectroscopic classification**: only possible for tens of sources



Towards thousands of TDEs

Identifying TDEs with ULTRASAT

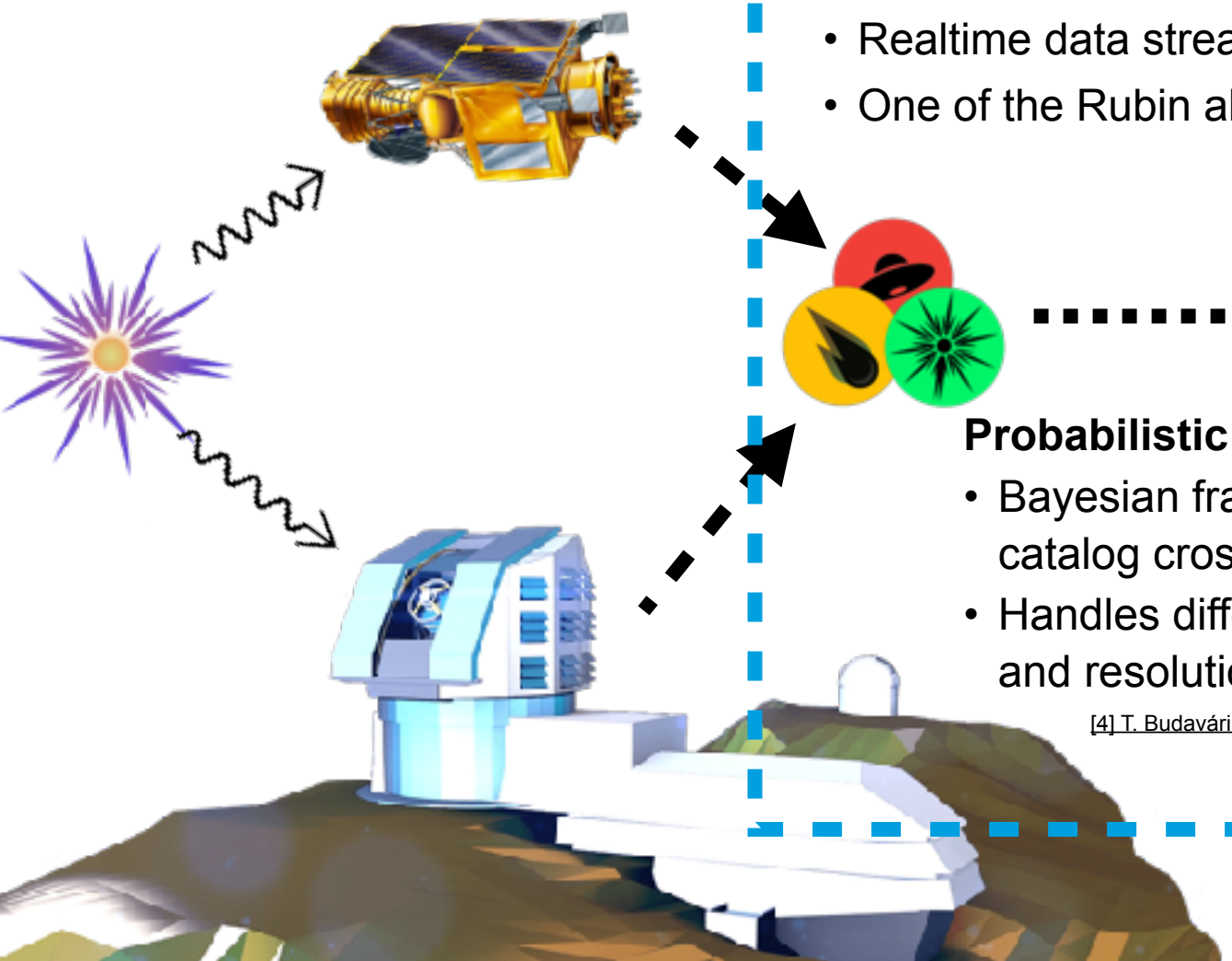
- Low-cadence survey: **1500 to 14000 TDE detections** per year
- **Challenging spectroscopic classification**: only possible for tens of sources
- Similar for the Vera Rubin Observatory
- **Combination of observations:**
  - multicolour observations from Rubin
  - good **constraint of blackbody temperature by ULTRASAT**



Photometric identification of TDEs with combined dataset

Towards thousands of TDEs

Combining Rubin and ULTRASAT detections



AMPEL

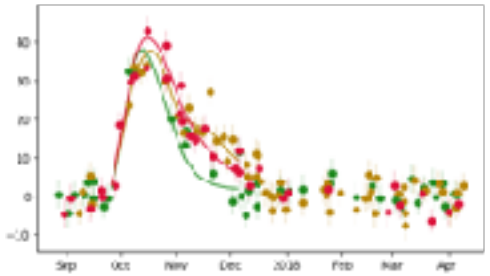
- Realtime data streaming framework
- One of the Rubin alert brokers

Probabilistic cross-identification [4]

- Bayesian framework developed for catalog crossmatch
- Handles different survey depths and resolutions

[4] T. Budavári and A. S. Szalay ApJ 679 (2008)

O/UV Lightcurve for photometric analysis



- Continuous prediction based on augmented photometry

TDE rates and evolution

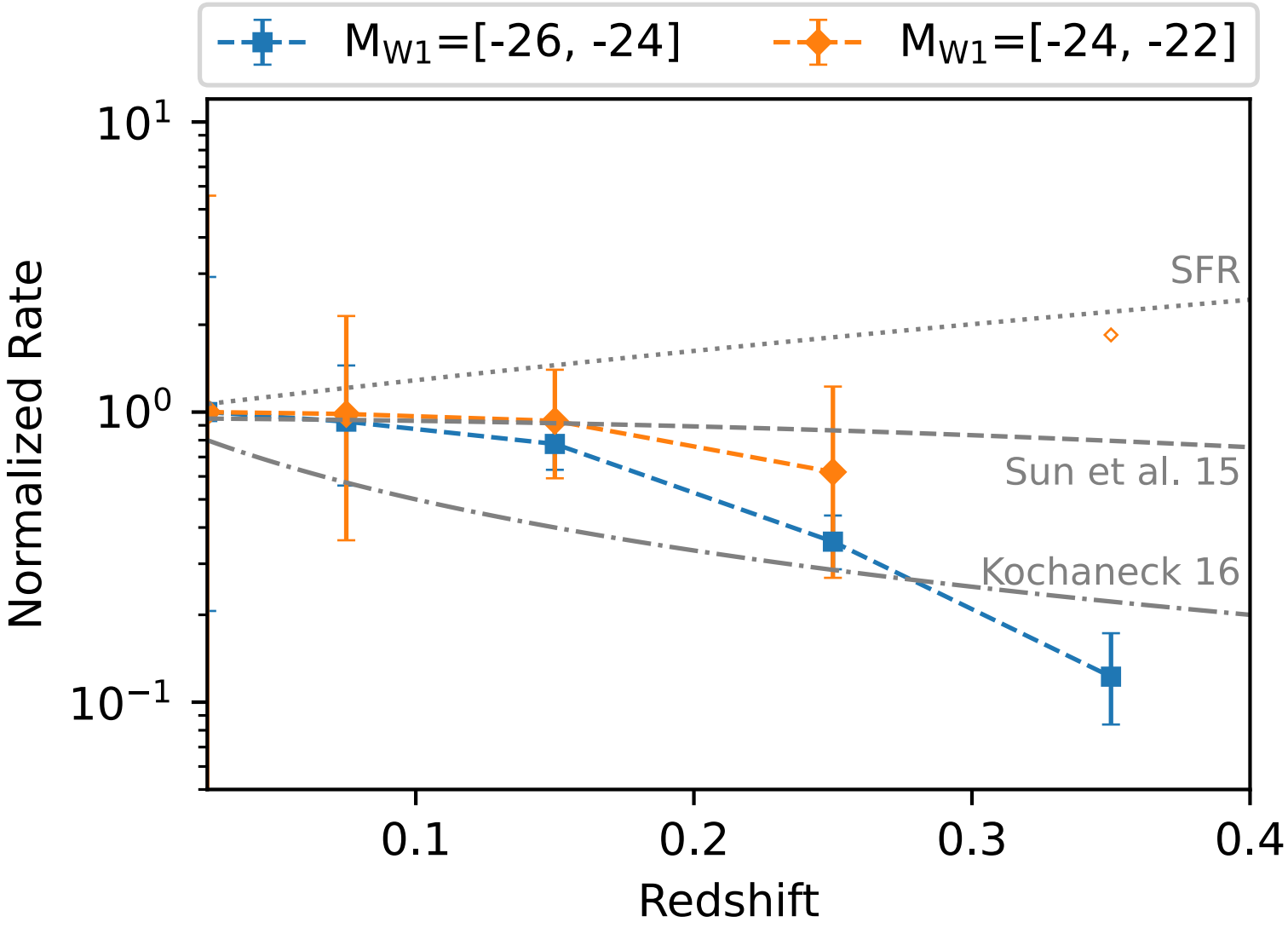
From infrared to UV

1. TDEs detected across different channels
2. Unlocking full population only through multiwavelength observations
3. Analysis of redshift evolution possible in the IR with hundreds of sources
4. Hopefully increase to thousands by combining Rubin and ULTRASAT detections

Backup

Flaires

Rate Evolution models



Flaires

Impact of different rate evolution models