Discovery of ATLAS17jrp as an optical, infrared, and X-ray bright TDE

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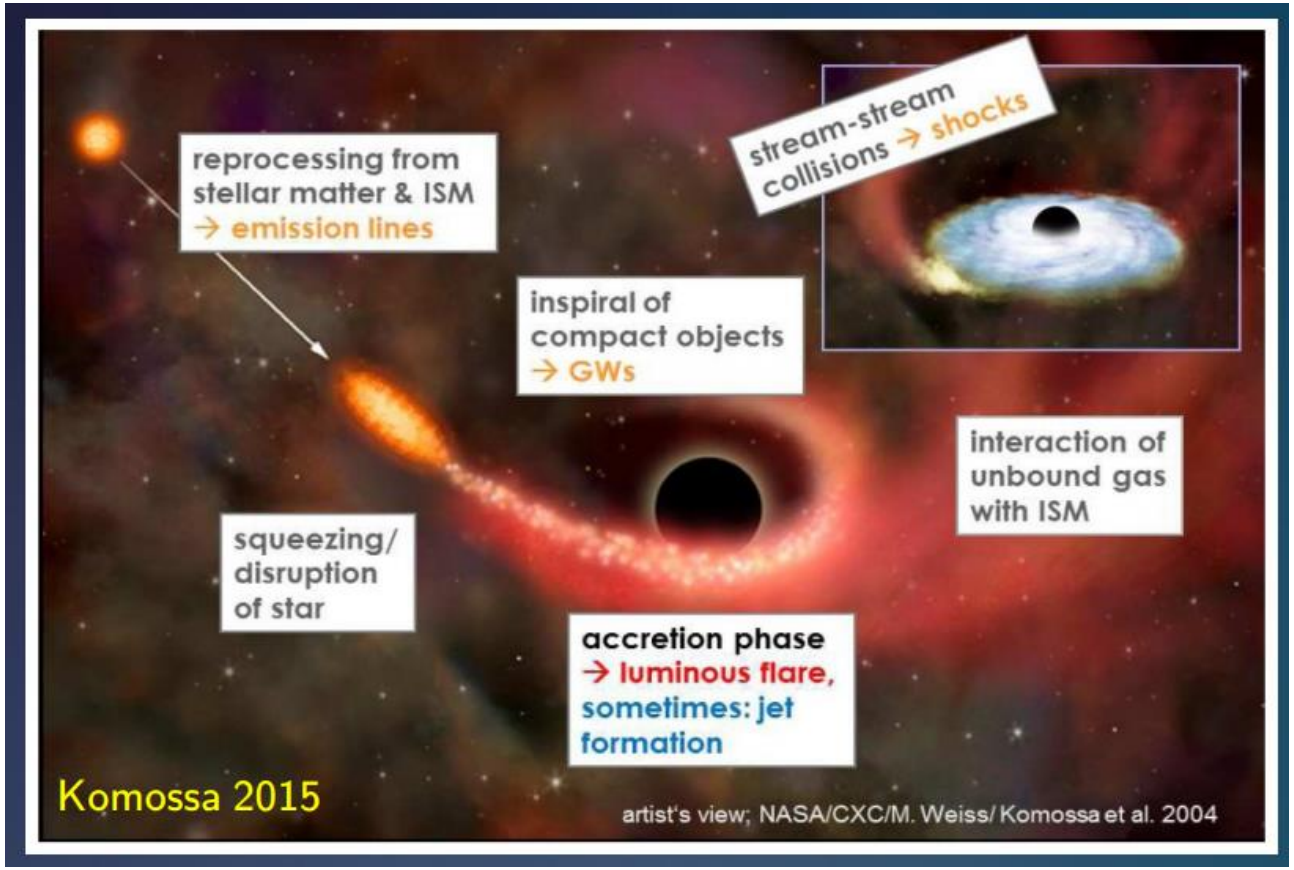
Theoretical prediction for TDEs at first



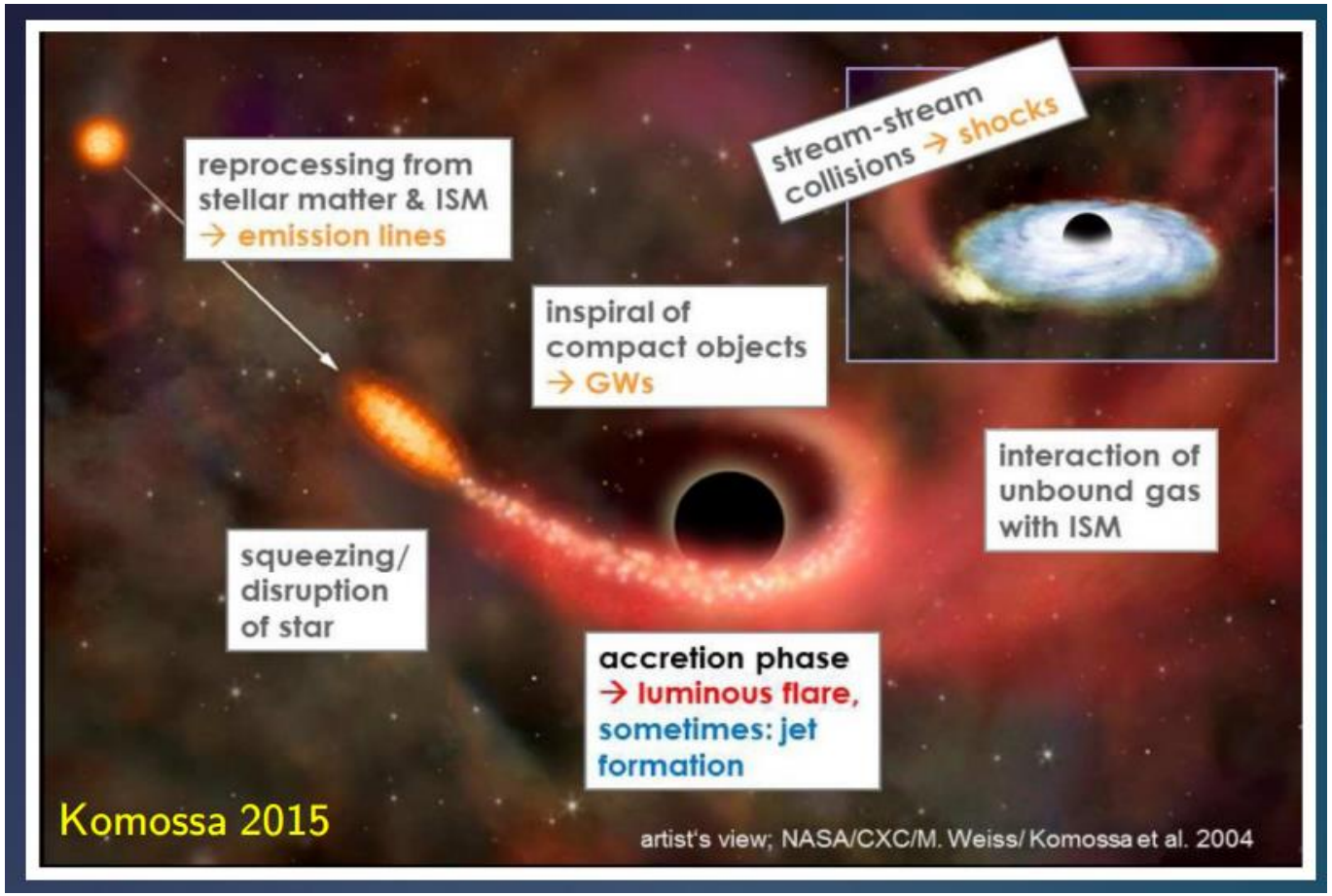
TDEs was first theoretically predicted in 1970s

(e.g., Hills 1975,Young+1978,Rees+1988, Evans & Kochanek 1989, Phinney+1989)

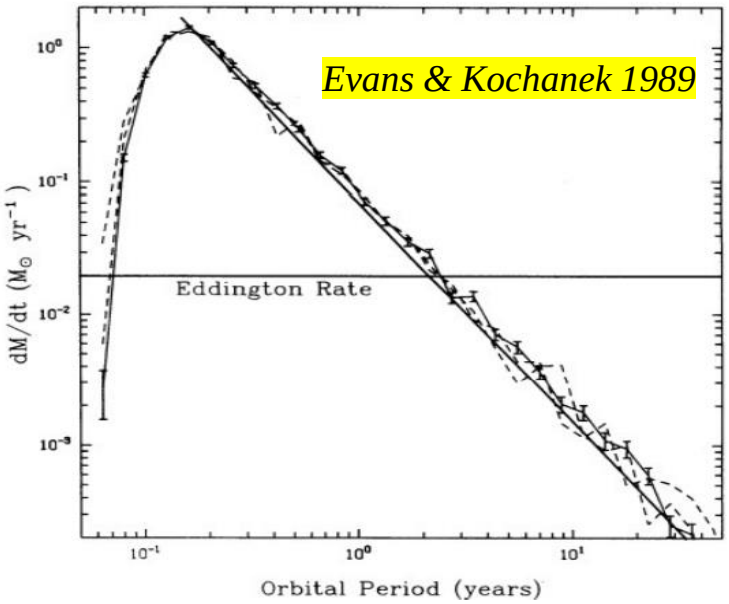
$$r_t = R_* \left(\frac{M_{BH}}{M_*}\right)^{\frac{1}{3}}$$

$$R_* < Rs$$

Theoretical prediction for TDEs at first

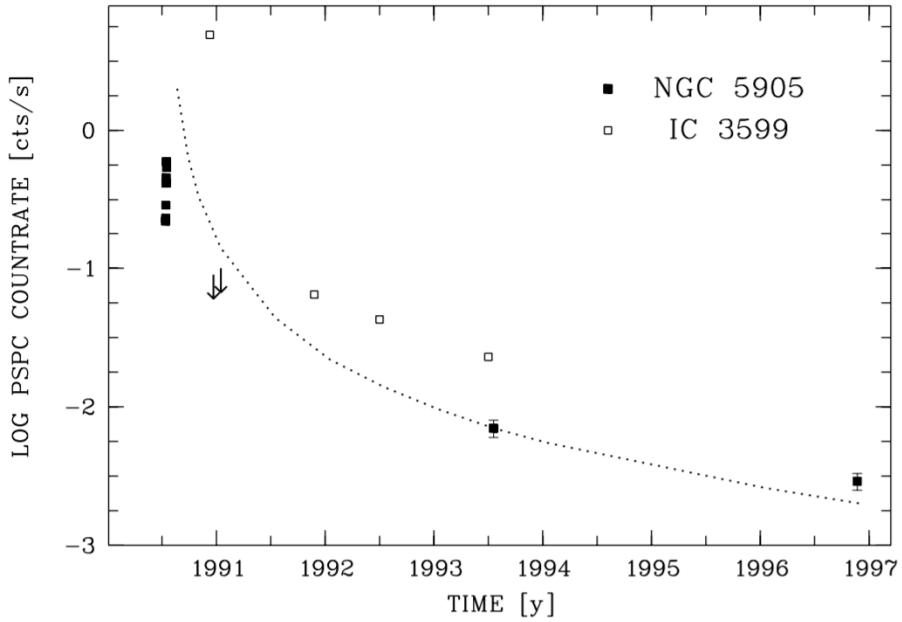


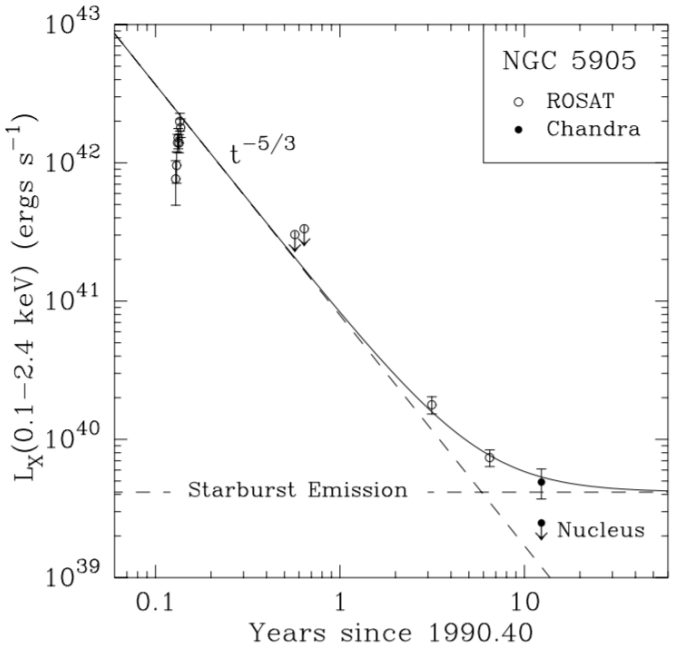
- $r_t > R_s$, (solar like, $M_{BH} < 1e8$)
- A flare peak at soft x-ray
- Super Eddington rate
- (-5/3) Power-law decay



First TDEs found in Soft X-ray

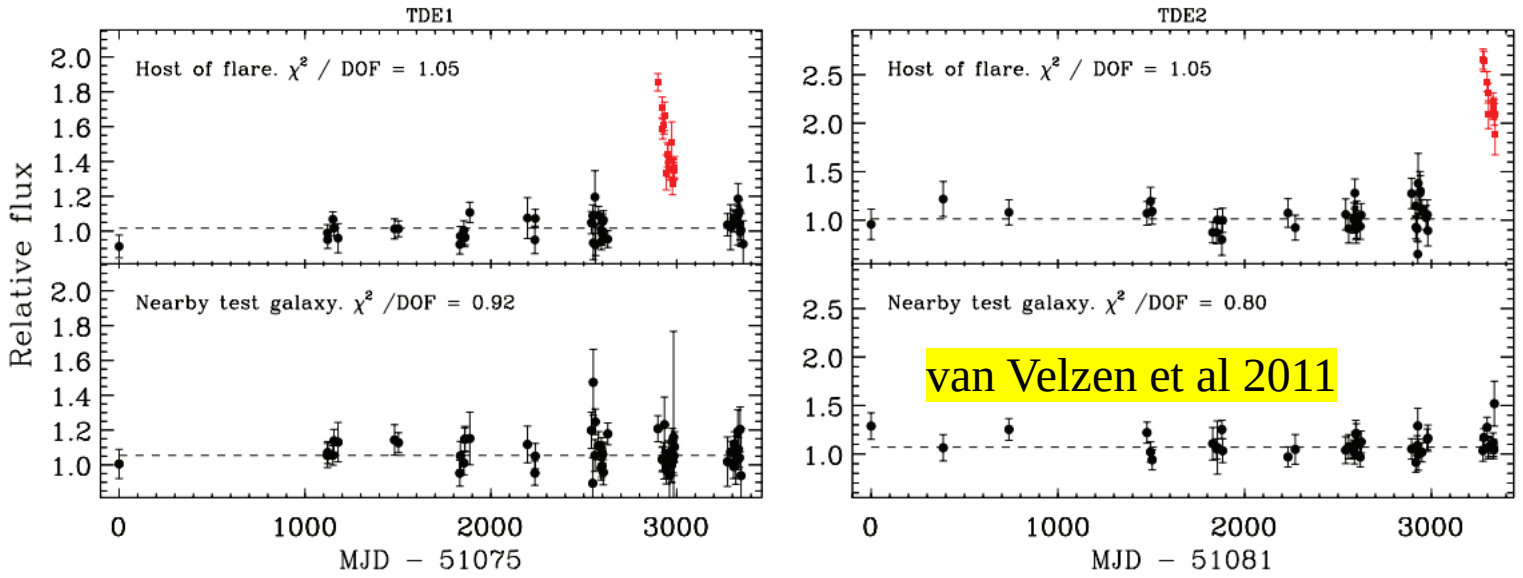
- ROSAT all sky surveys and its follow-up pointed observation (Donley et al 2002)
- Extremely soft ($\Gamma > 3$), luminous (L~$10^{41} - 10^{44}$ erg/s)
- A rate ~1e-5 /year/galaxy



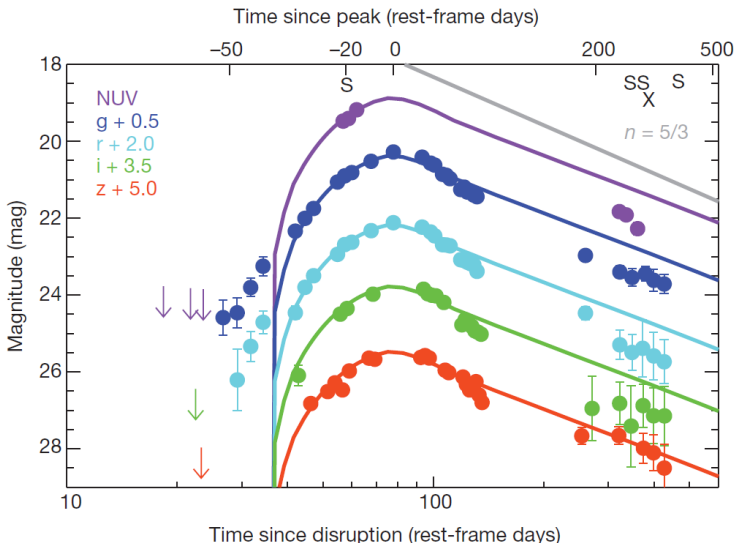


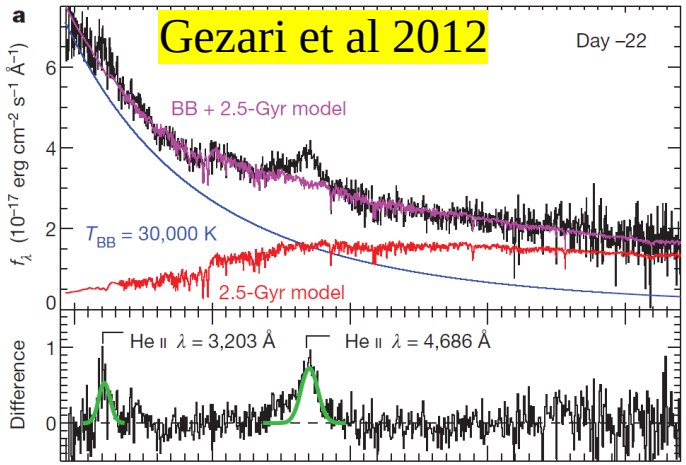
A decade afterwards---First Optical TDEs

First two optical TDE from SDSS Stripe 82 : TDE1 & TDE2

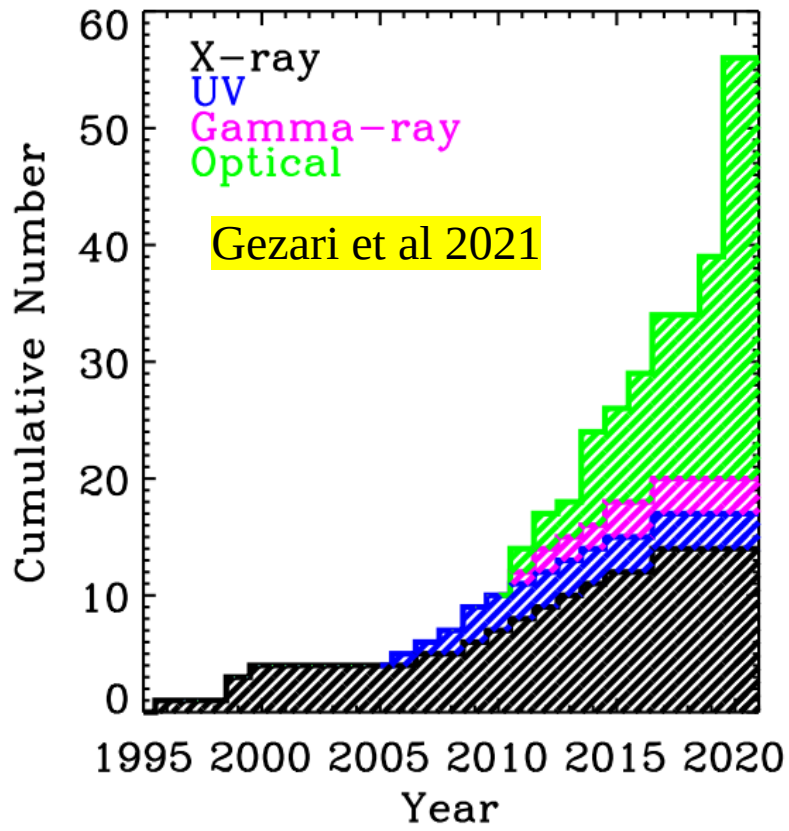


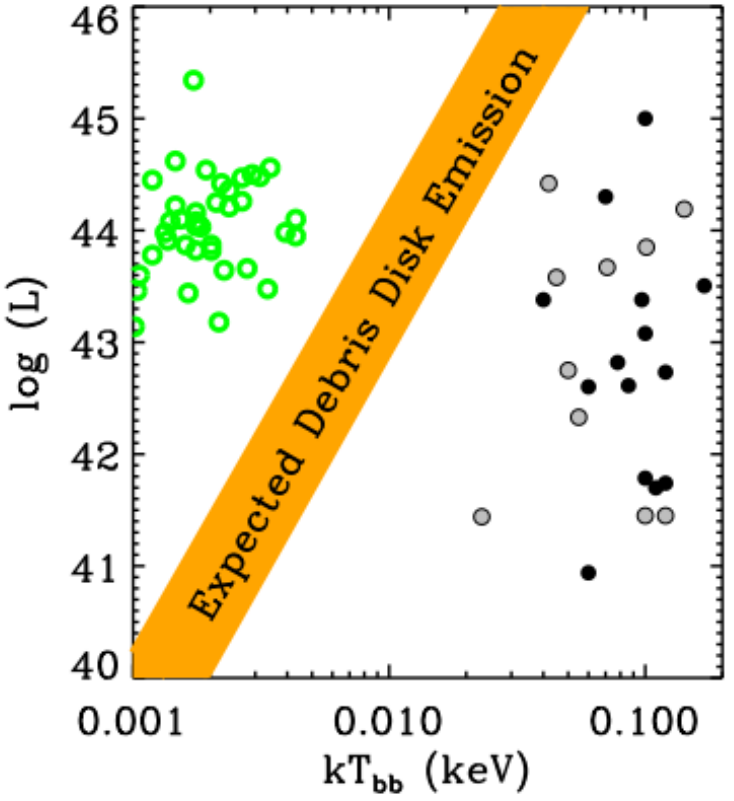
- A roughly constant temperature ~few 10^4 K
- A light curve well descried by the simulation
- Blue continuum well fitted by a black body
- Very broad HeII lines ~10000 km/s





Accumulating number and diversity





A dust-enshrouded TDE

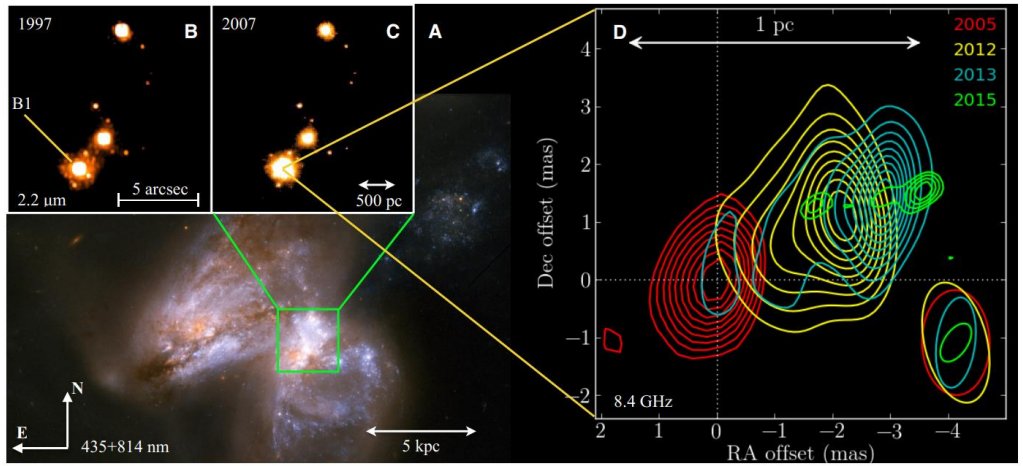
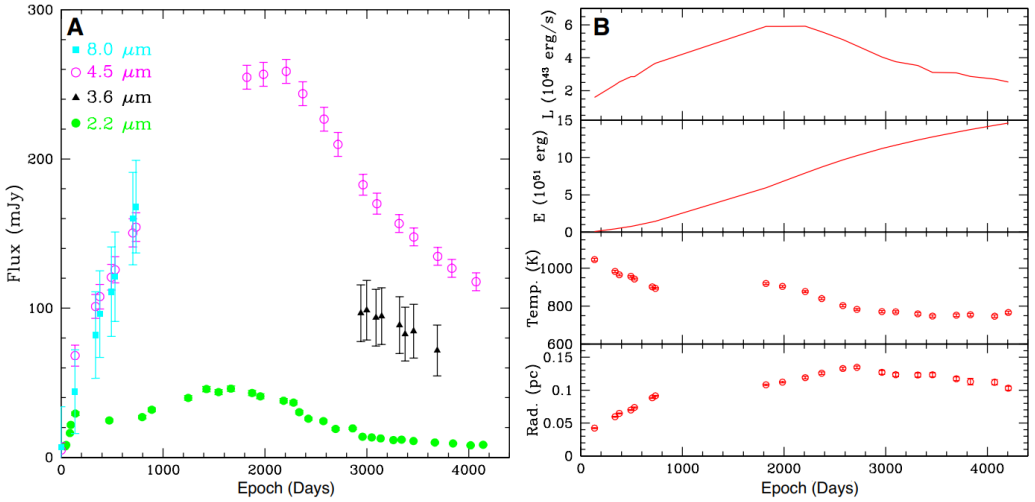
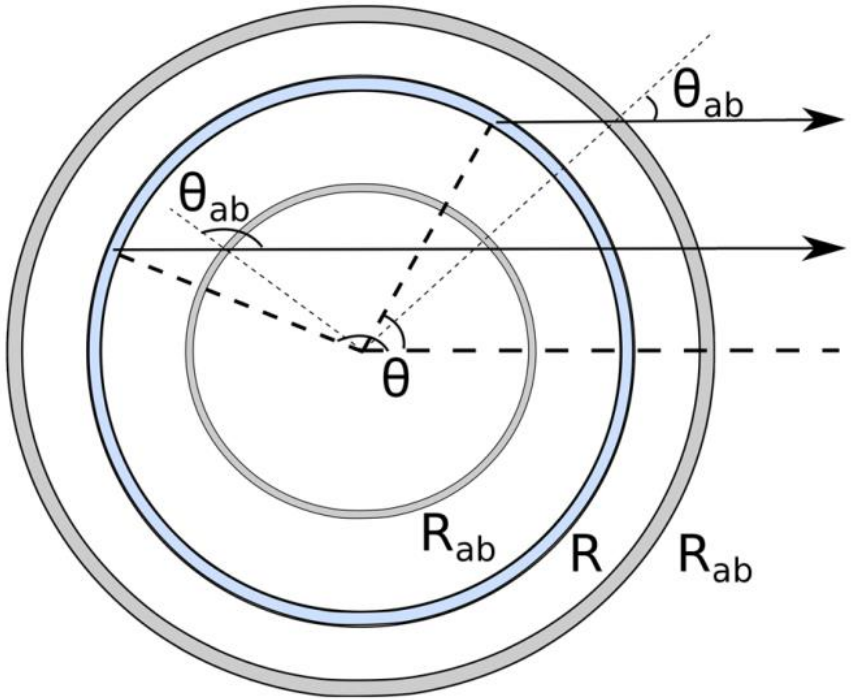


Figure 1. The transient Arp 299-B AT1 and its host galaxy Arp 299. (A) A color-composite

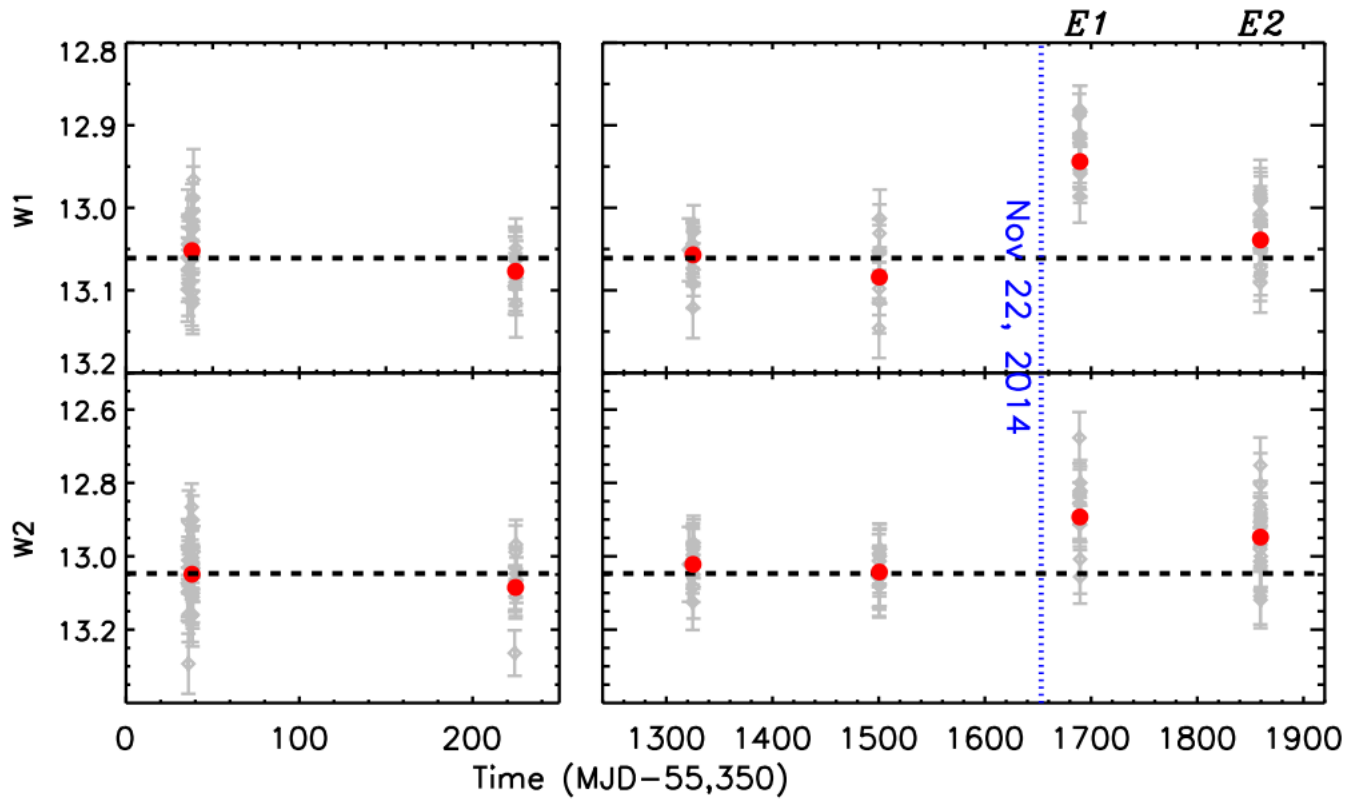


Dusty TDE can be missed by optical and X-ray survey but revealed by the infrared echoes (IR echoes)

IR echoes of TDEs



Lu&Kumar 2018

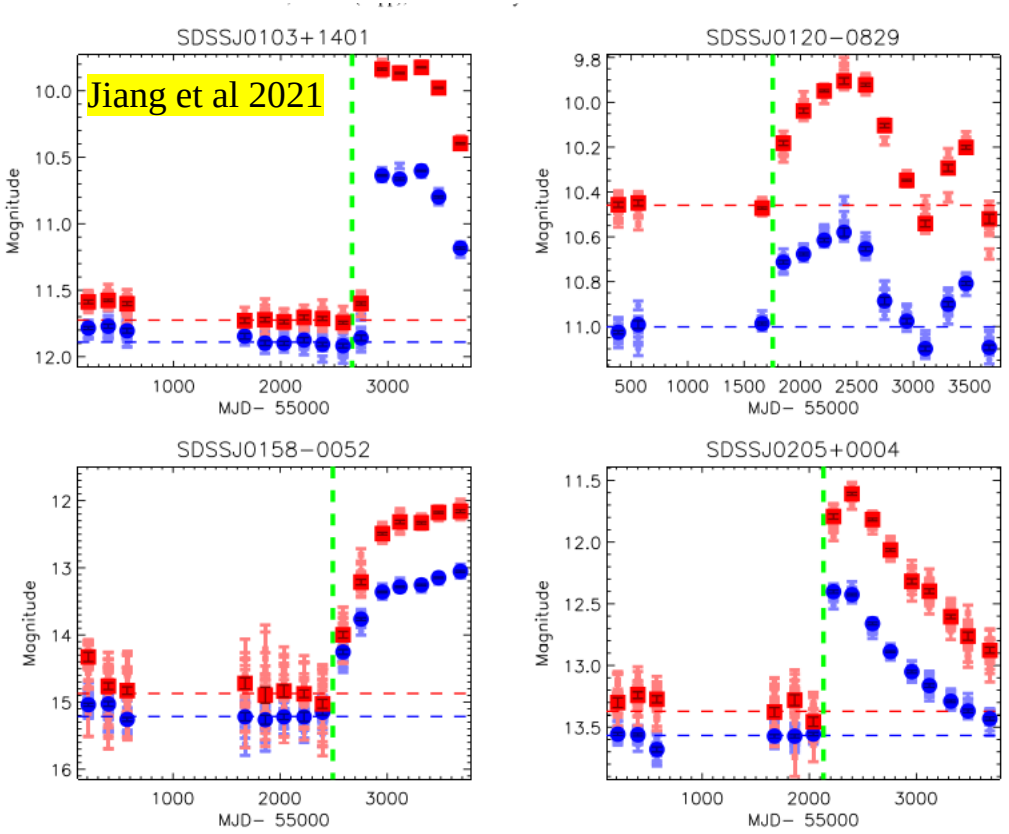


Jiang et al 2016

$$e^{-\tau_{UV}} \frac{L(t_r)}{4\pi R^2} \pi a^2 Q_{UV} = \langle Q_{abs} \rangle_P \, 4\pi a^2 \sigma T^4 - 4\pi a^2 \frac{da}{dt} \frac{\rho}{\mu} B$$

A low dust luminosity ~2.5e41 erg/s

MIRONGs



SDSS spec galaxies (z<0.35) — ~1.1 million

MIR variable (>0.5 mag) — 1038

MIR outburst — 137

median redshift ~0.1

When matching multi-band photometery , we discovered the ATLAS17jrp

contents

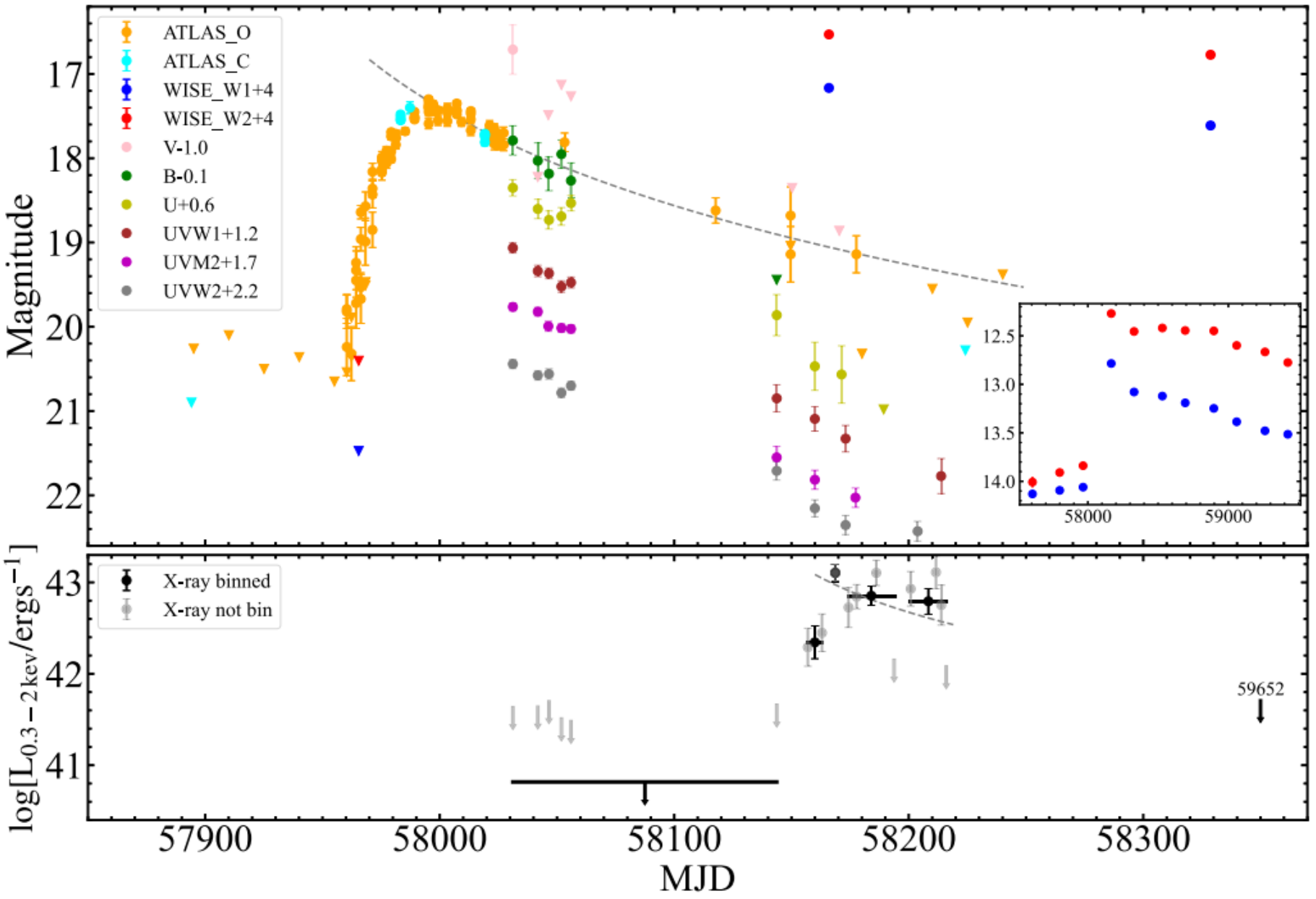
- Introduction to TDE and MIRONG
- ATLAS17jrp and its implication
- Conclusion

ATLAS17jrp

A monthly rise to a peak luminosity about 10^{44} erg/s and then decay follow -5/3 powlaw

Nearly constant 19000-20000K within weeks to months

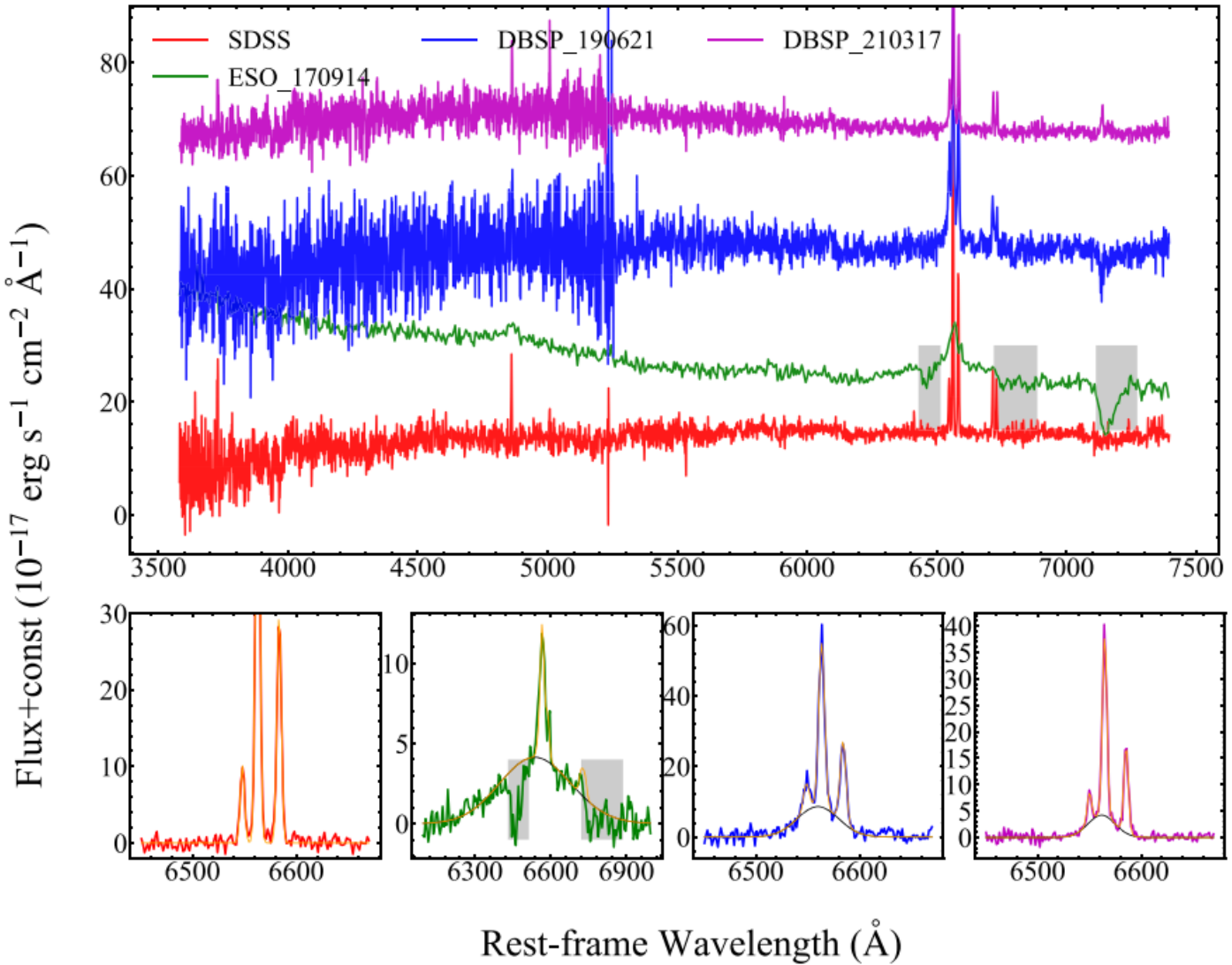
Delayed X-ray brightening at ~170 days delay after optical peak



Spectra Follow-up

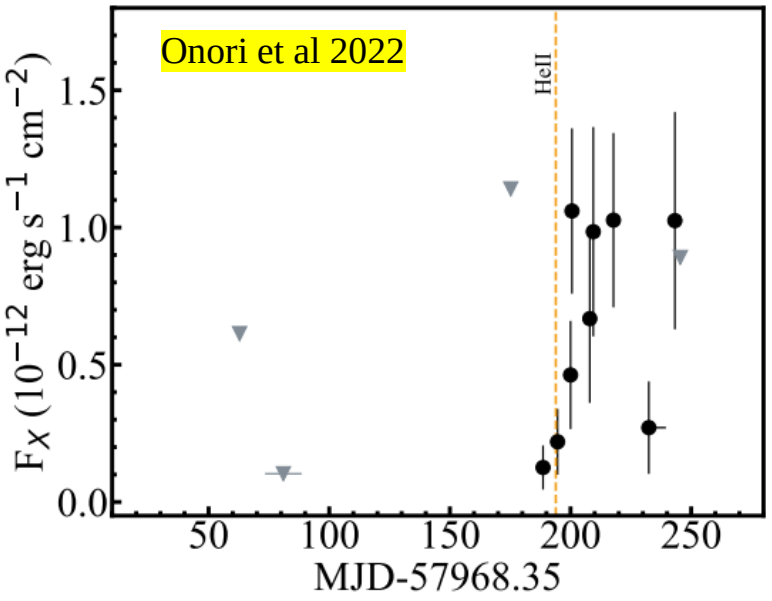
Broad Balmer lines
FWHM~15000 km/s ,which
narrowed to 1900 km/s at last

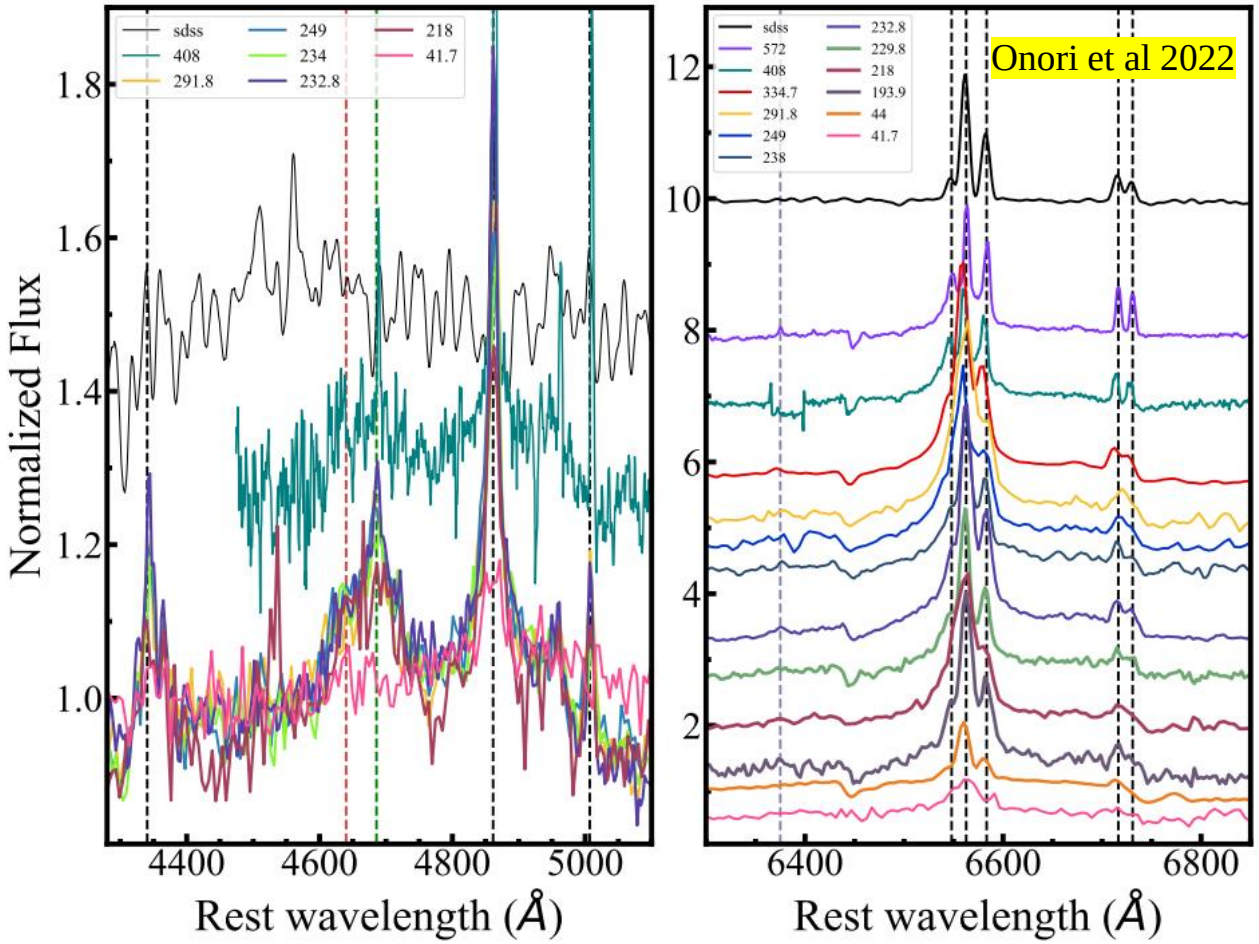
A robust TDE candidate



Spectra Follow-up

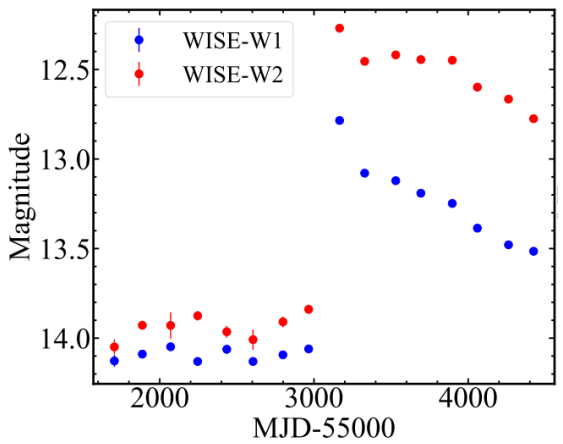
HeII and high ionization coronal lines emerged after X-ray brightening



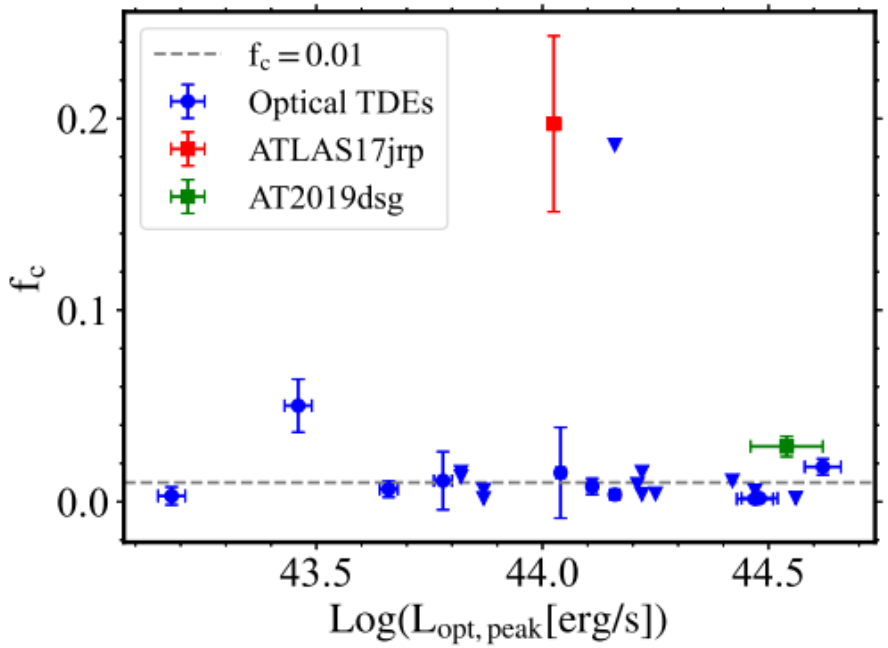


Luminous infrared---Implication for Dusty TDE

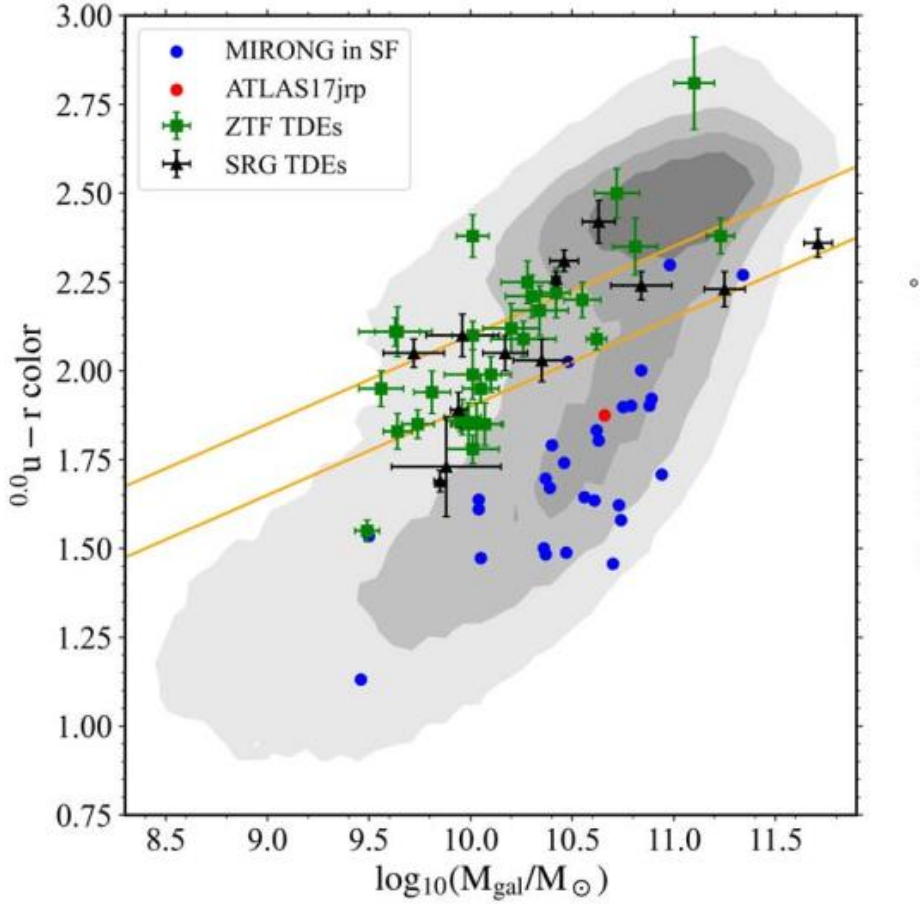
A luminous infrared with peak luminosity ~$10^{43.32}$ erg/s



A about one magnitude higher covering factor ~0.2



Dust obscuration may play an important role in the absence of TDE in SF galaxies

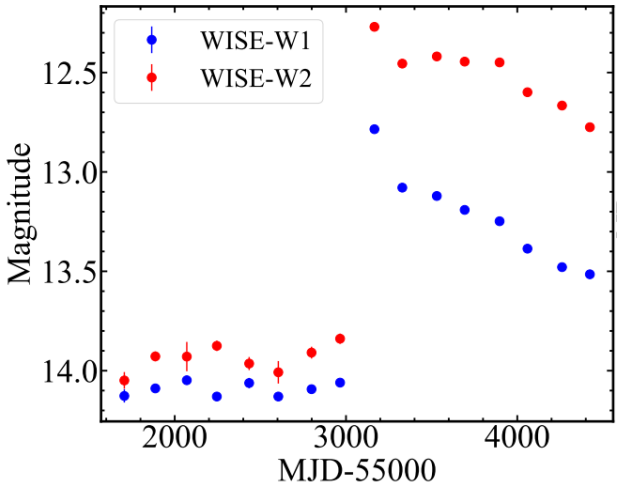


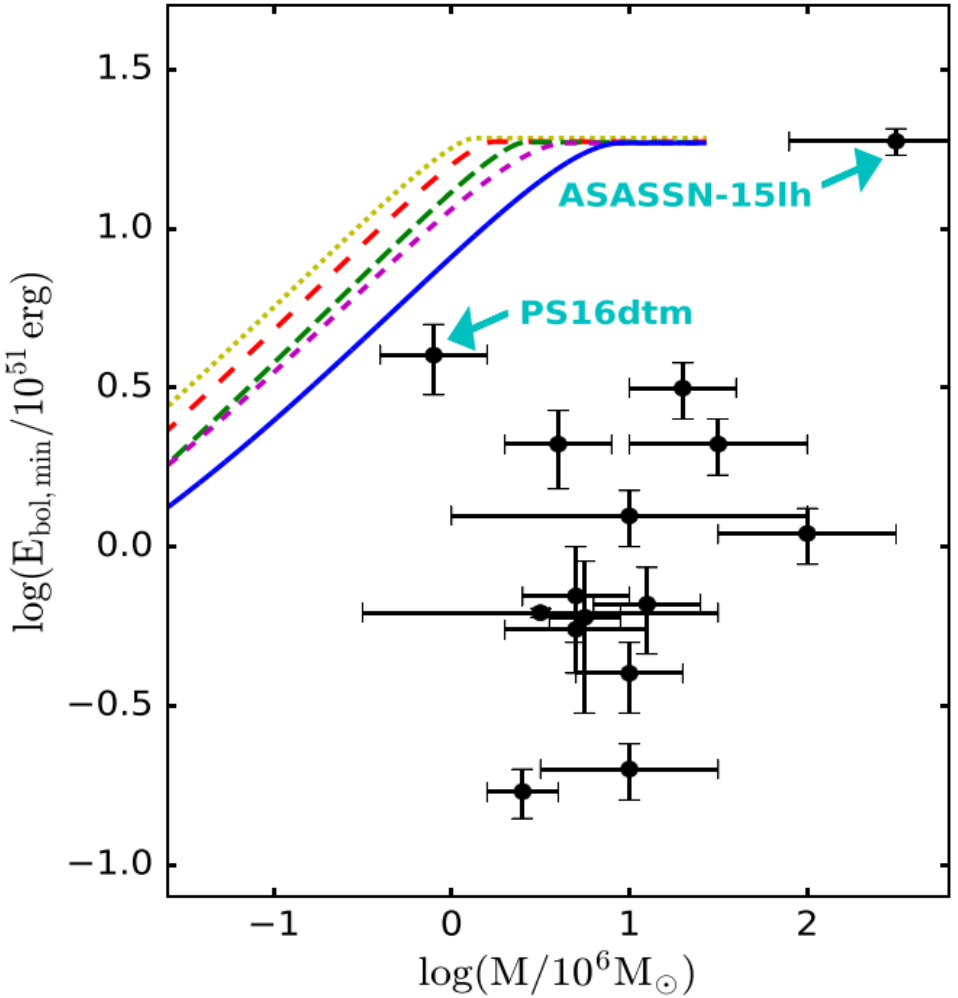
Luminous infrared---Implication for missing energy

For ATLAS17jrp :
Integrated IR energy : 10^{51} erg
Total energy was expected to reach: 10^{52} erg

Integrated Optical energy: ~10^{51} erg
Integrated X-ray energy :~10^{50} erg

Others with energy>1e52 erg:
Arp299-B, F01004 (ULIRG), PS16dtm (AGN)



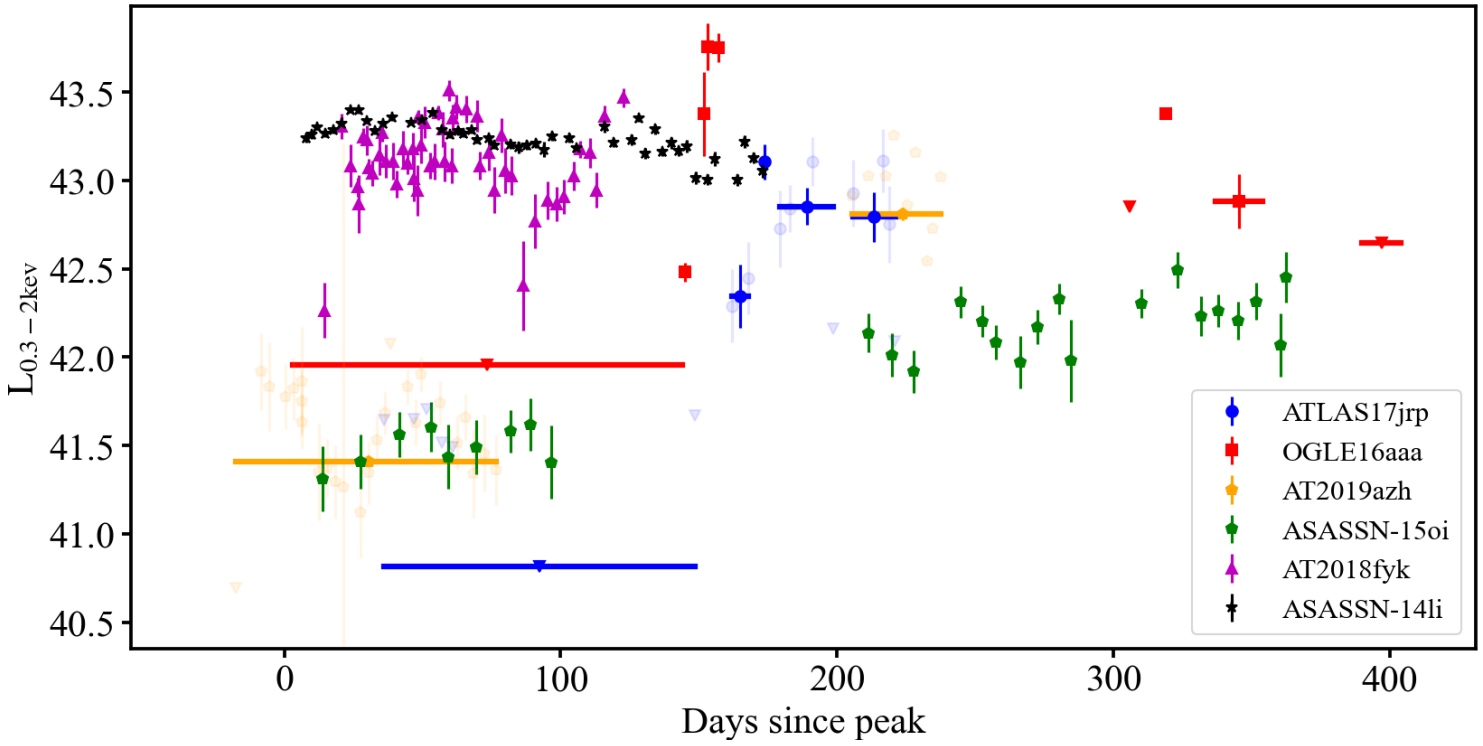


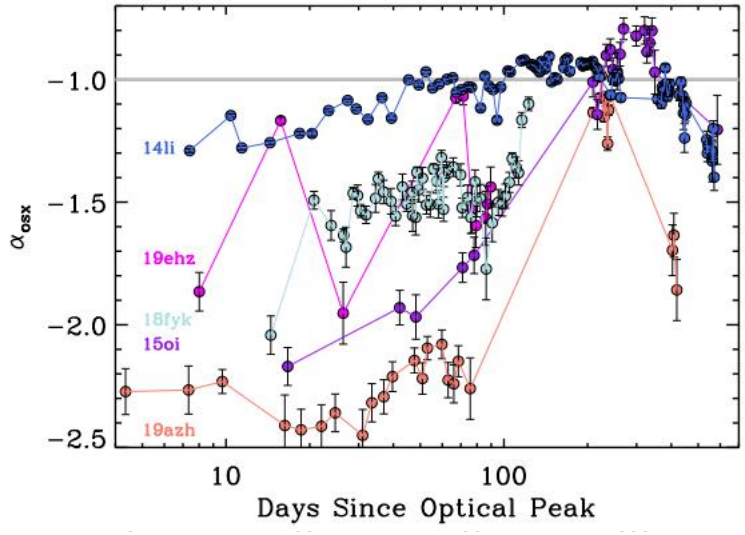
Delayed X-ray brightening----Implication for emission mechanism ?

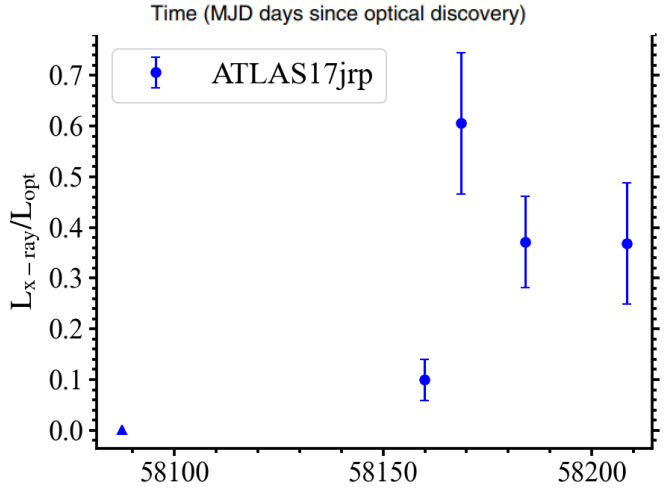
Two scenario for late time X-ray brightening:

delayed X-ray accretion after stream-stream collision

reprocessing model

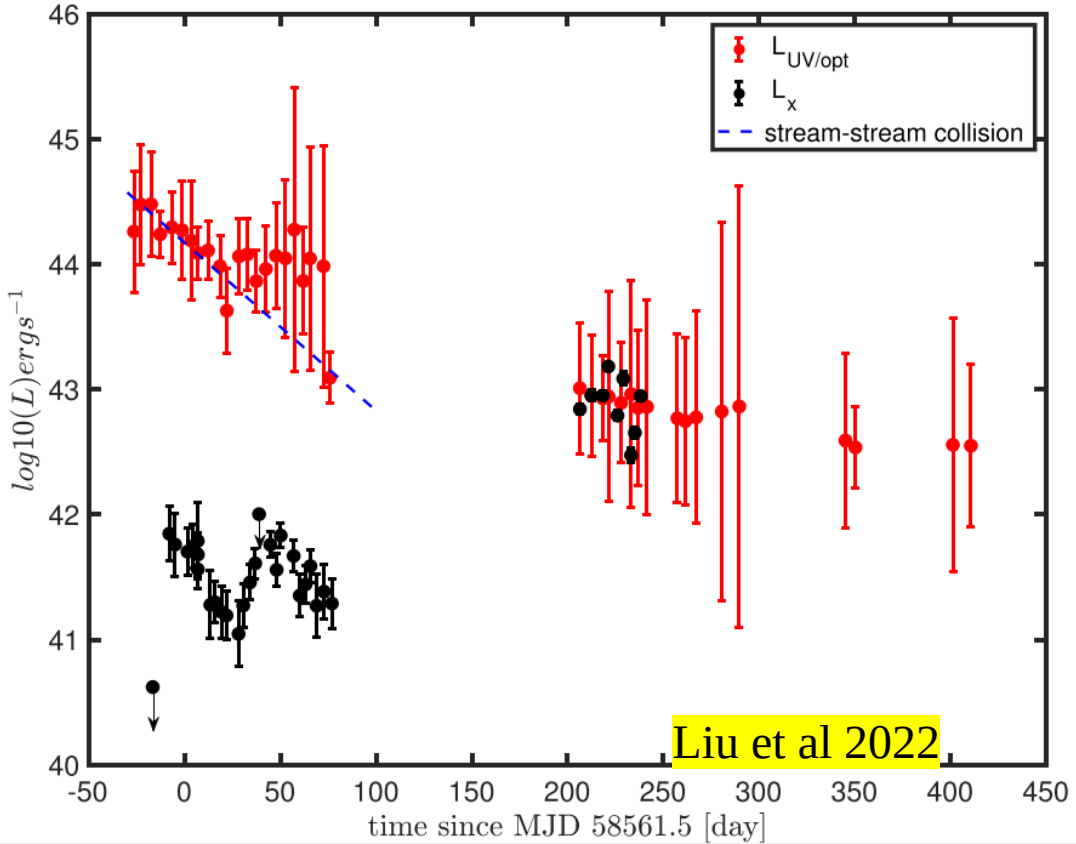


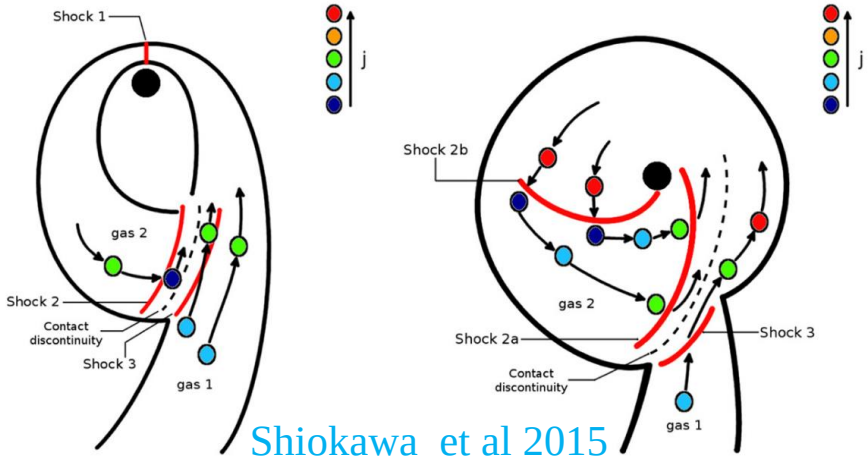




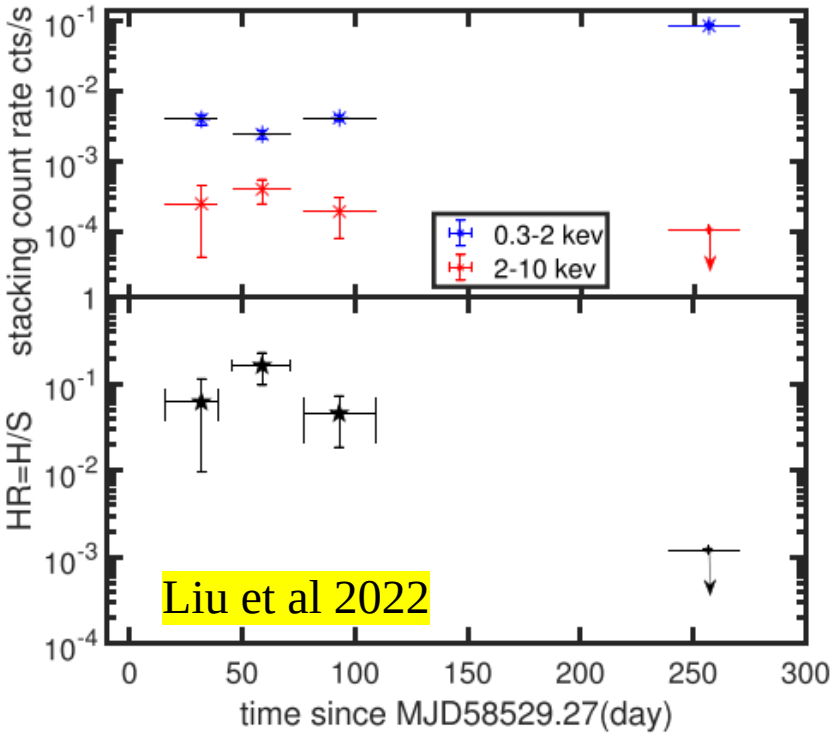
AT2019azh

Delayed accretion



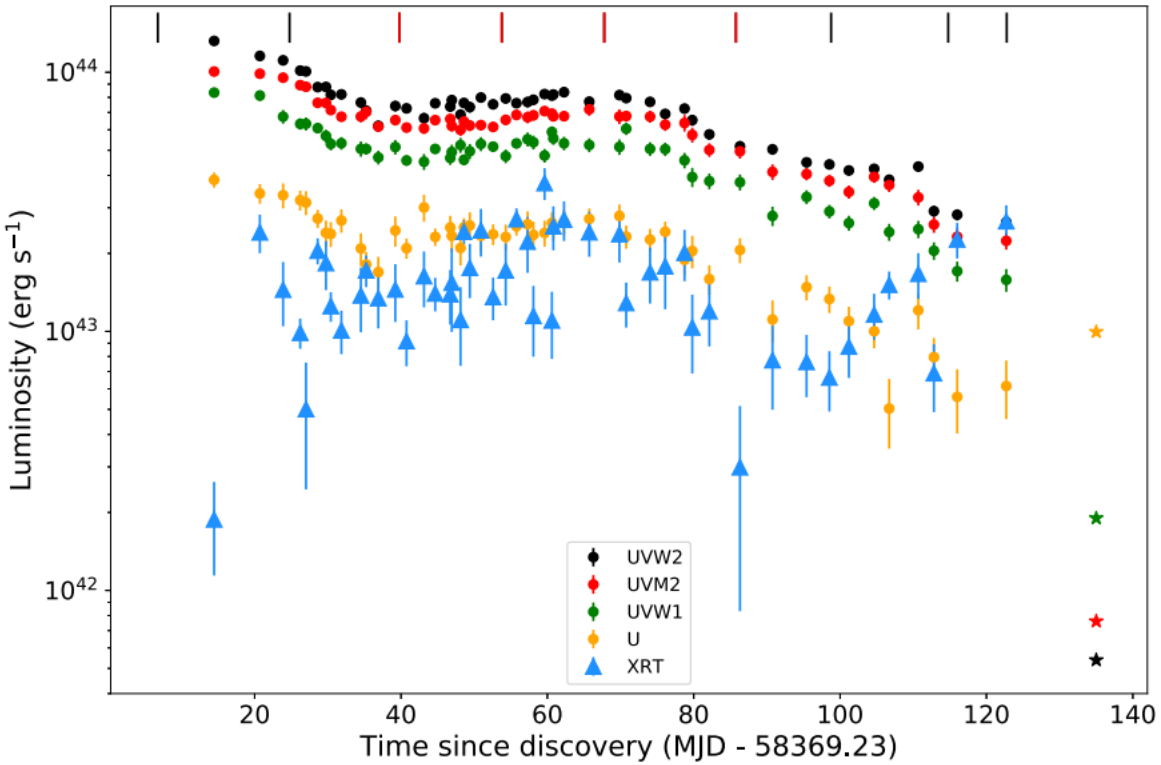


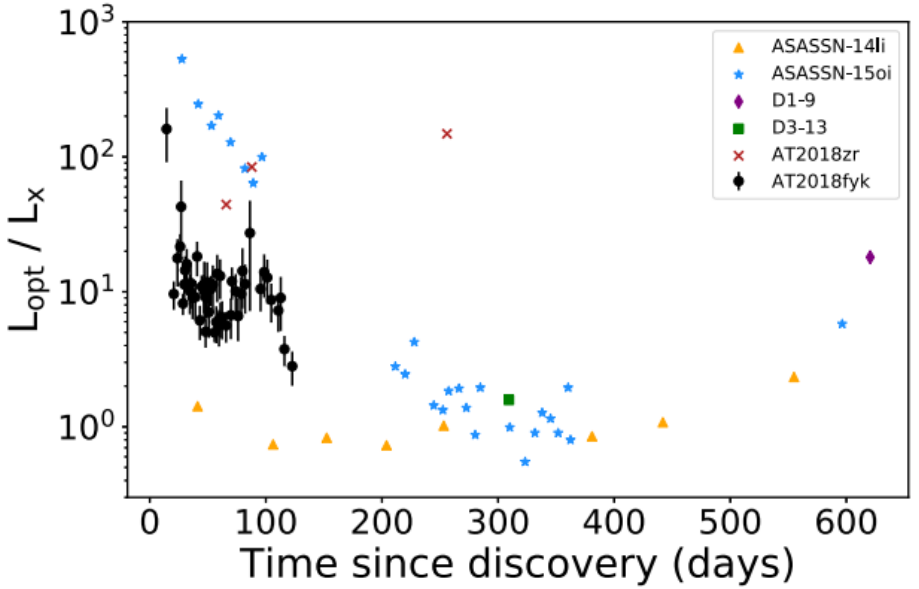
Shiokawa et al 2015

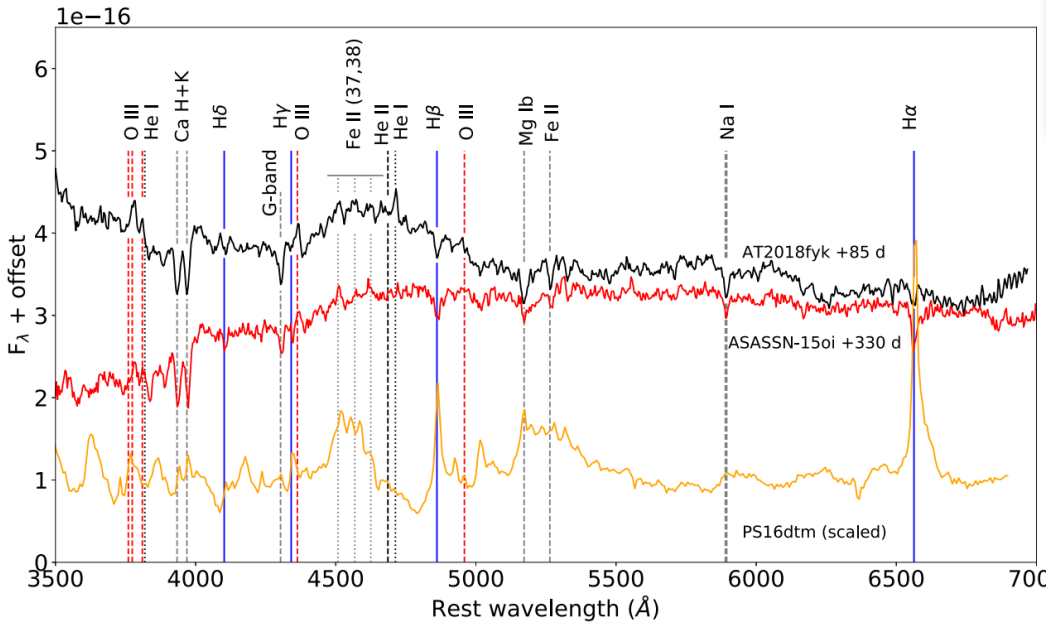


AT2018fyk

Rapid formation of disk and reprocessing

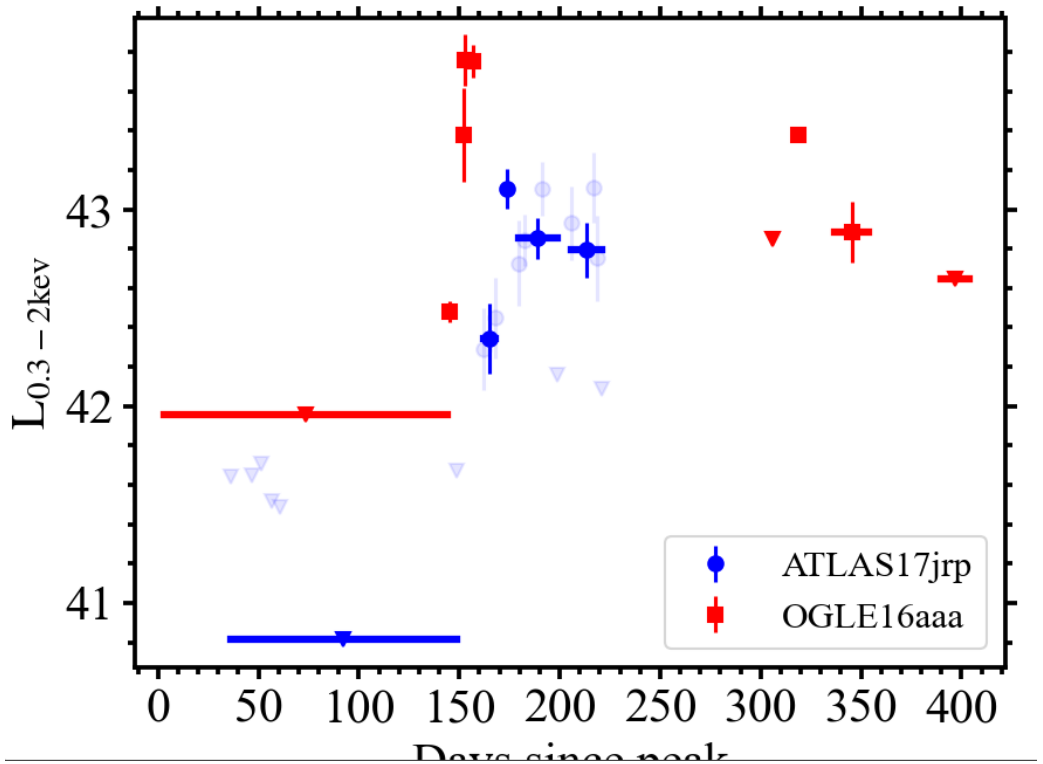


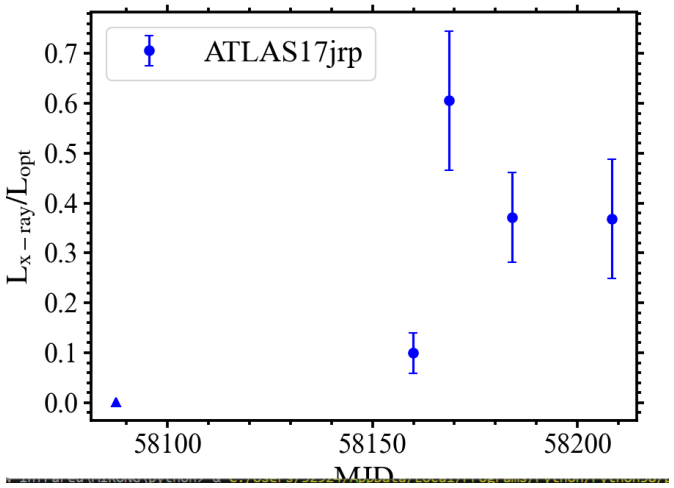


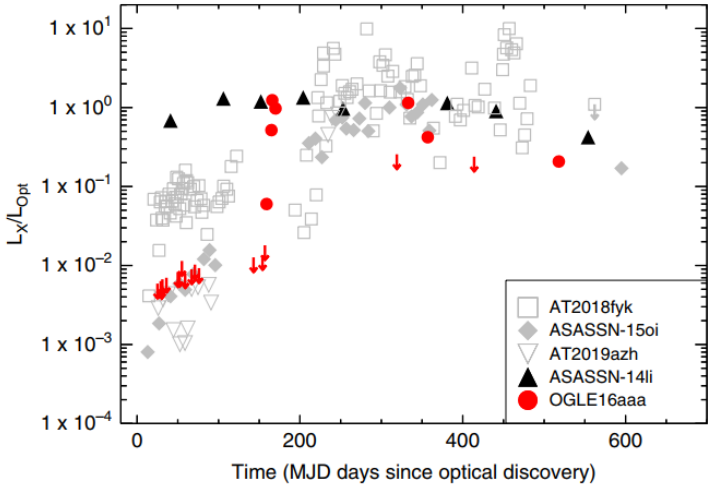


ATLAS17jrp similar to OGLE16aaa

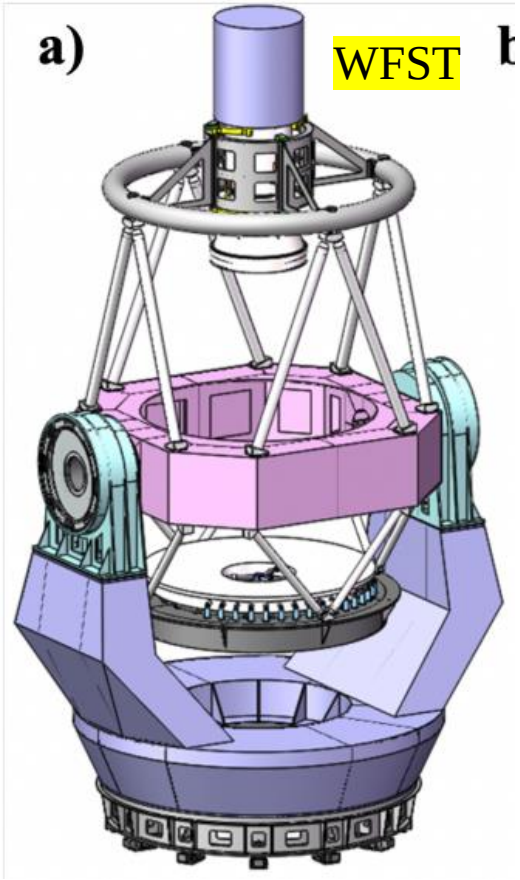
Delayed accretion or obscuration ?







Mutli-band joint for better understanding



Hundreds of TDE per year was expected for WFST (Lin et al 2022)

Conclusion

- ATLAS17jrp as a robust TDE candidates:
  - a monthly rise to a peak luminosity about 10^{44} erg/s
  - decline follow about -5/3 powlaw
  - nearly constant temperature~19000-20000 K
  - broad Balmer (15000km/s) and HeII lines
- Implications
  - dust obscuration may play an important role in the absence of TDE in SF galaxies
  - useful tool to test missing energy puzzle
  - Delayed X-ray brightening : delayed accretion or reprocessing ?

Thanks ! And any question ?