

# The past and future power of the **NOT** to study **tidal disruption events** and their **infrared echoes**

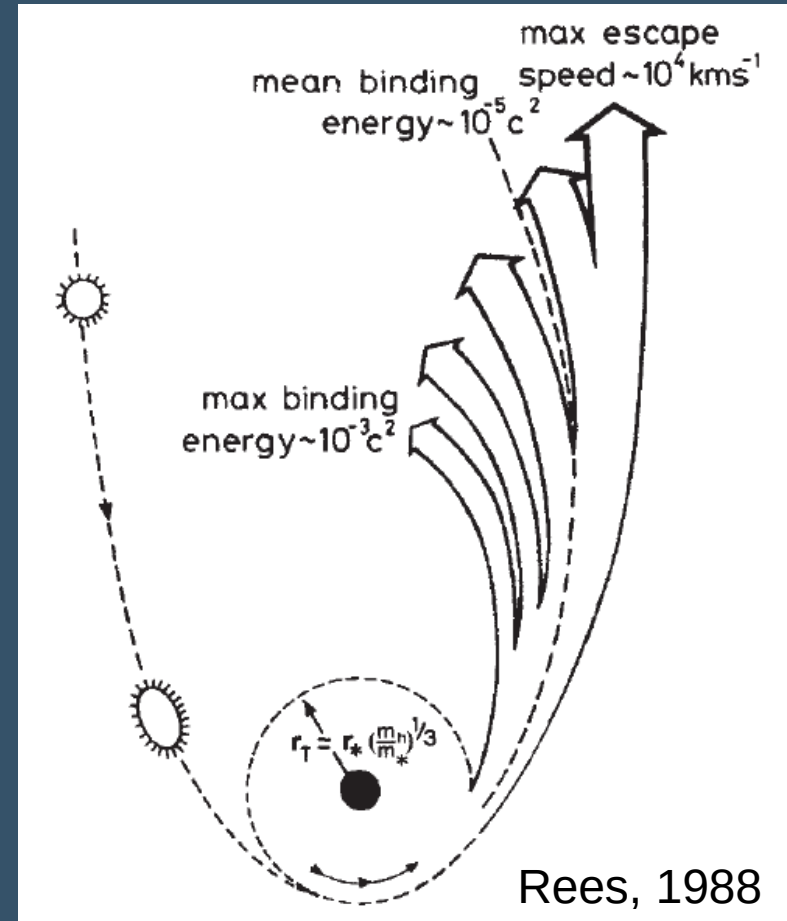
**Tom Reynolds,**  
Seppo Mattila, Erik Kool



# What are Tidal disruption events (TDEs)?

- Star passes into Roche radius of a SMBH, and is torn apart.
- Half remains bound, the rest escapes.
- Bound material is accreted, producing luminous flare.
- Expected energy release:  $10^{53}$  erg
- Rate  $\sim 10^{-4}$  / year in average galaxy.

See later talks:  
Charalampopoulos, Koljonen



# SED of “typical” TDE ASASSN-14li

## IR

- Time Delay
- 1500-2000 K
- IR echo from dust heated by the TDE

NB: SED shown is incomplete

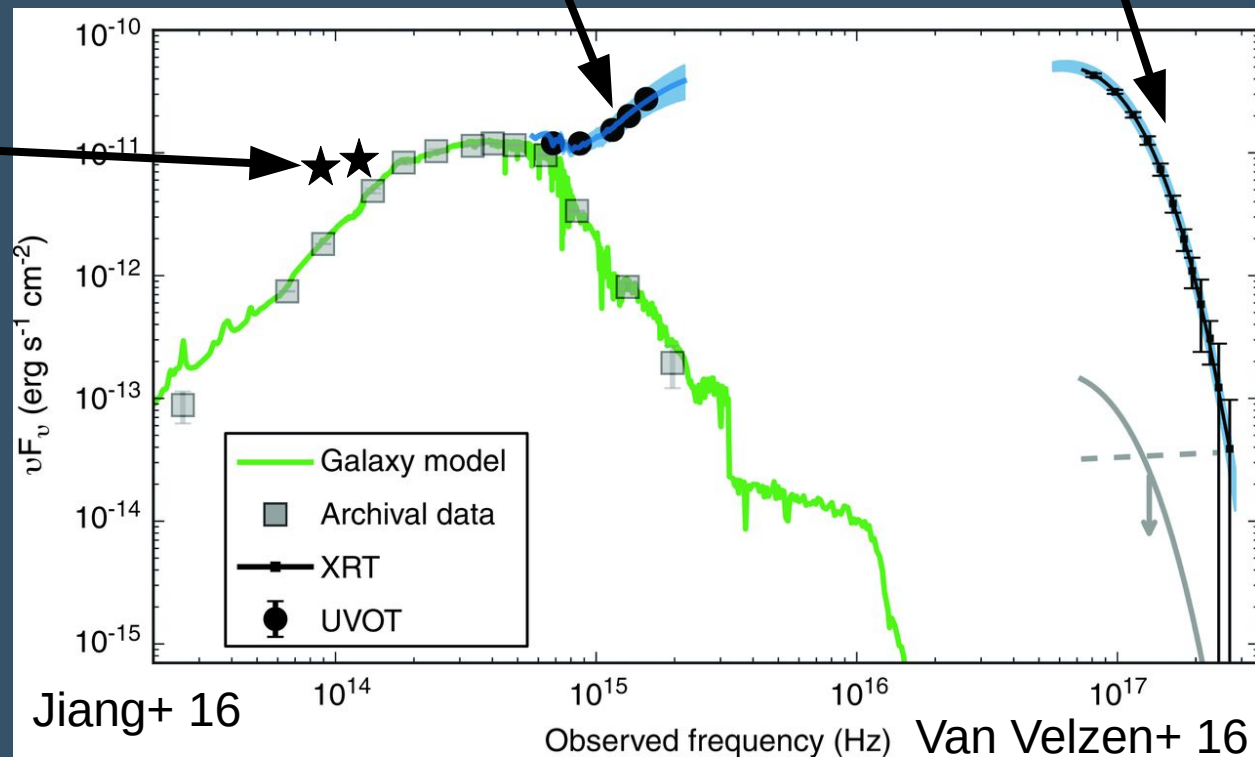
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Koljonen

## UV/Optical

- A few  $\times 10^4$  K
- 1000s of  $R_s$
- Origin uncertain

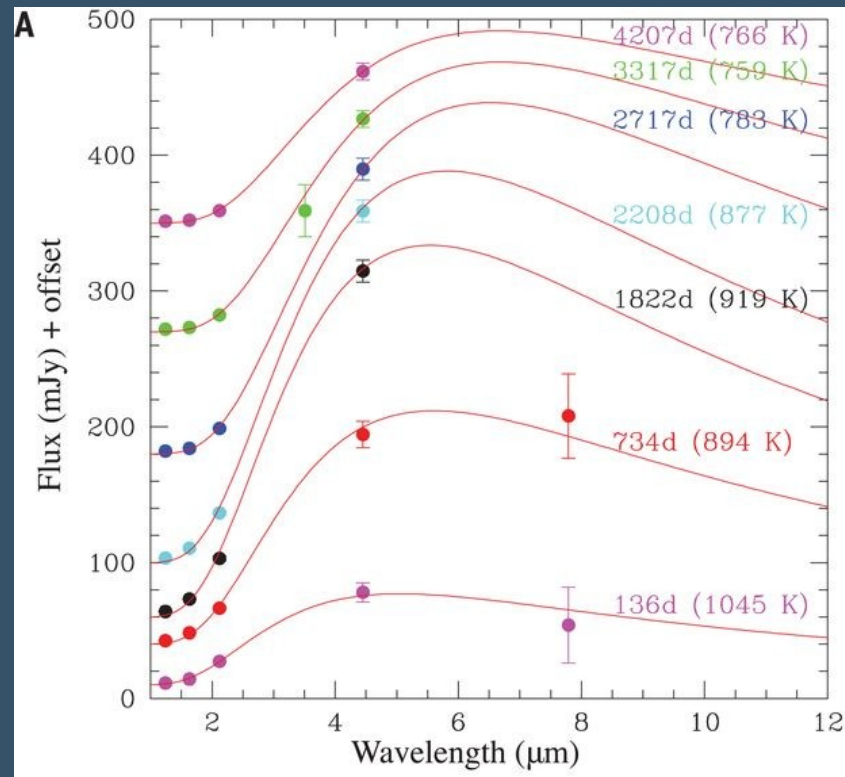
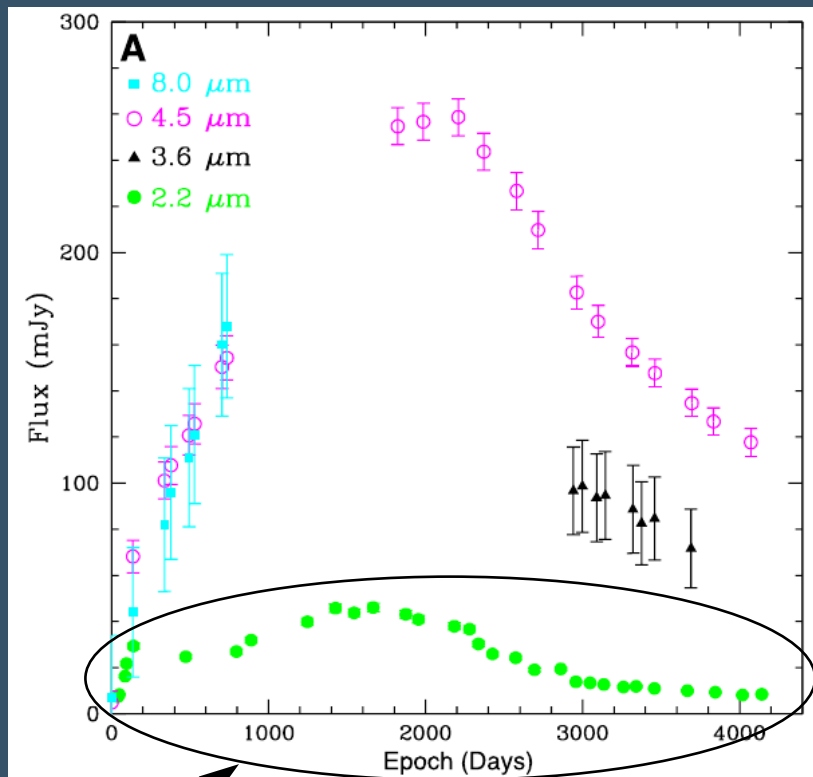
## Soft X-rays:

- Accretion disc
- Very hot
- $\sim 1 R_s$



# Arp 299-B AT1

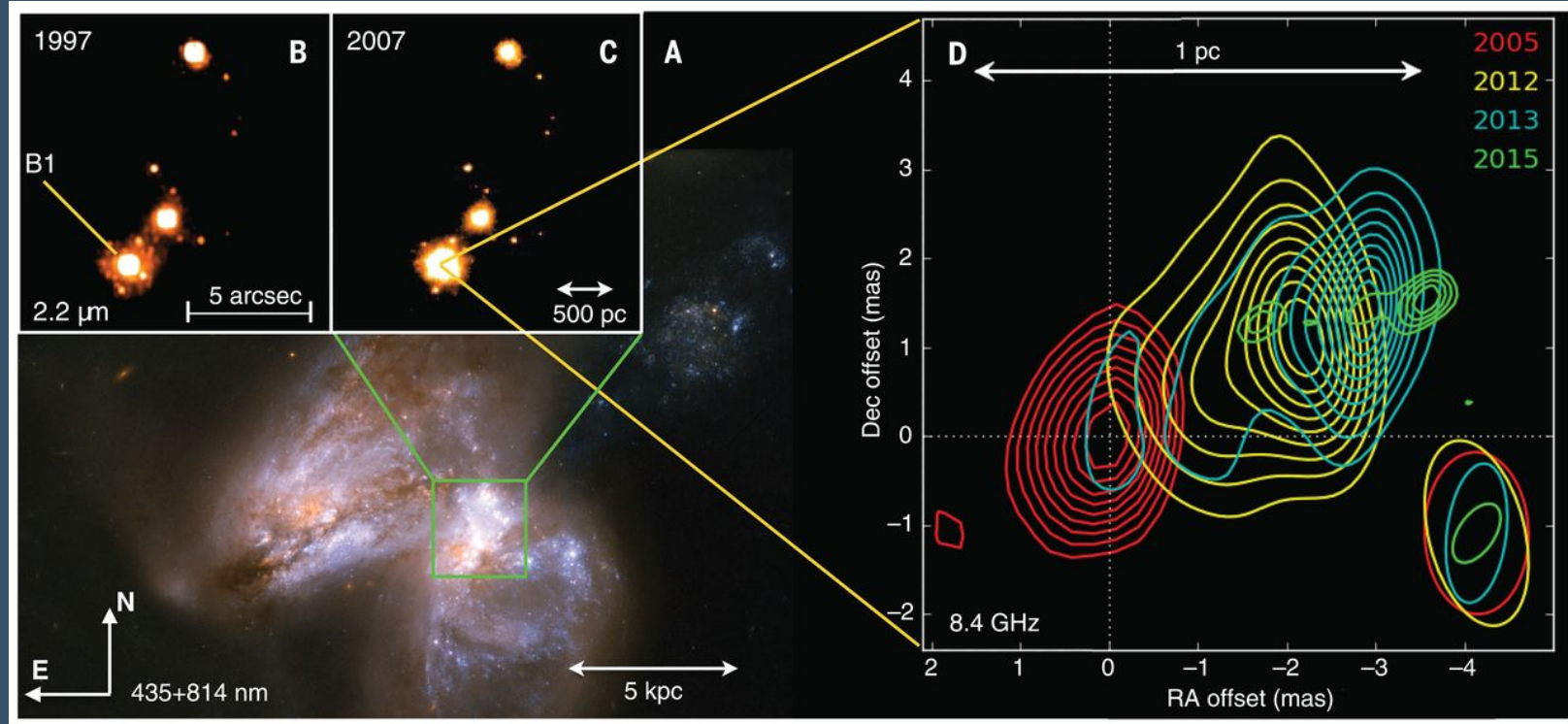
- Nuclear transient **discovered in NIR.**
- Not luminous in the optical or soft X-rays => heavily obscured.
- Total radiated energy:  $>10^{52}$  erg.



- NIR NOTCam imaging => temperature measurement

Mattila, Pérez-Torres+,  
Science, 2018

# Arp 299-B AT1



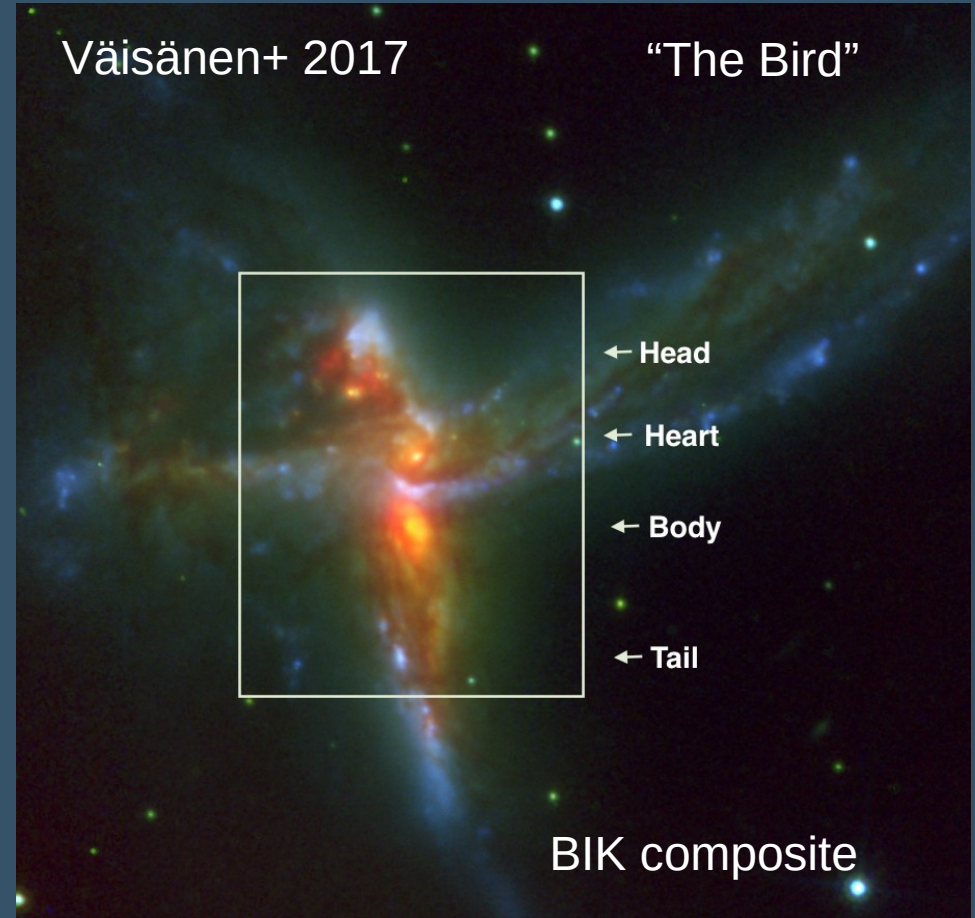
- Angle of **resolved radio jet** provides strong evidence for **TDE**.
- Host galaxy is a Luminous Infra-red Galaxy (LIRG)
- Model fitting of SED and X-rays reveal Type 2 AGN in nucleus.

Mattila, Pérez-Torres+,  
Science, 2018

# Luminous Infra-red Galaxies (LIRGs)

- Luminous in IR (8-1000  $\mu\text{m}$ ):  $L_{\text{IR}} > 10^{11} L_{\odot}$
- Warm dust: starburst, AGN or both.
- ~50% interacting/mergers:
  - **Enhanced tidal disruption event (TDE) rates** due to dual SMBHs (Li+ 2019) and enhanced stellar densities (Stone & Van Velzen 2016)
- High star formation rates  
=> can produce **a few core-collapse supernovae** per year!

For a review, see Perez-Torres+ 2021

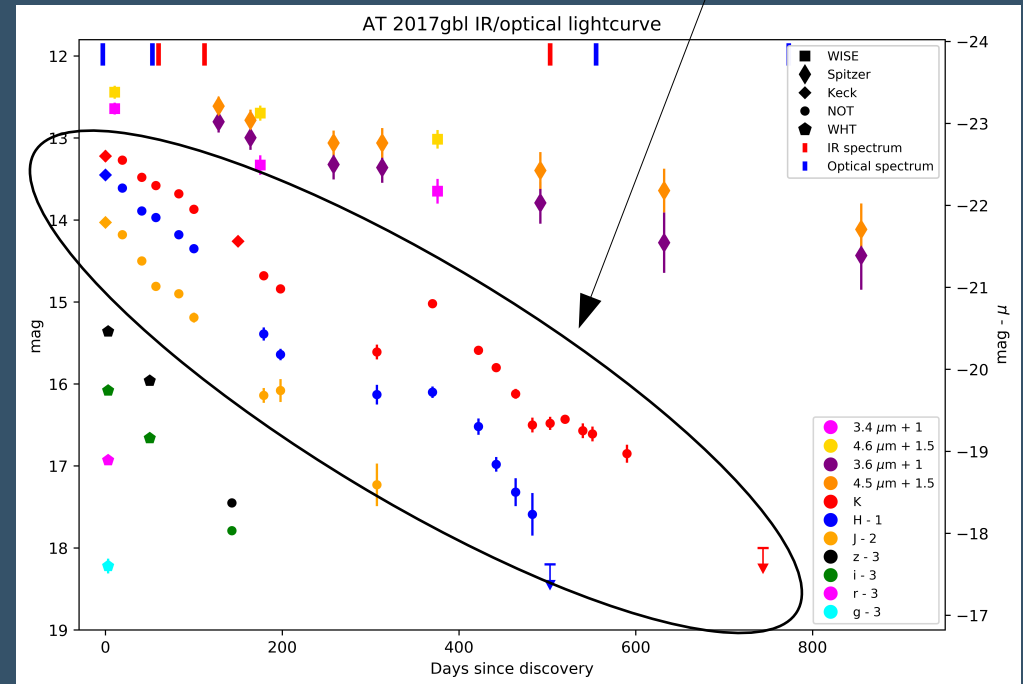
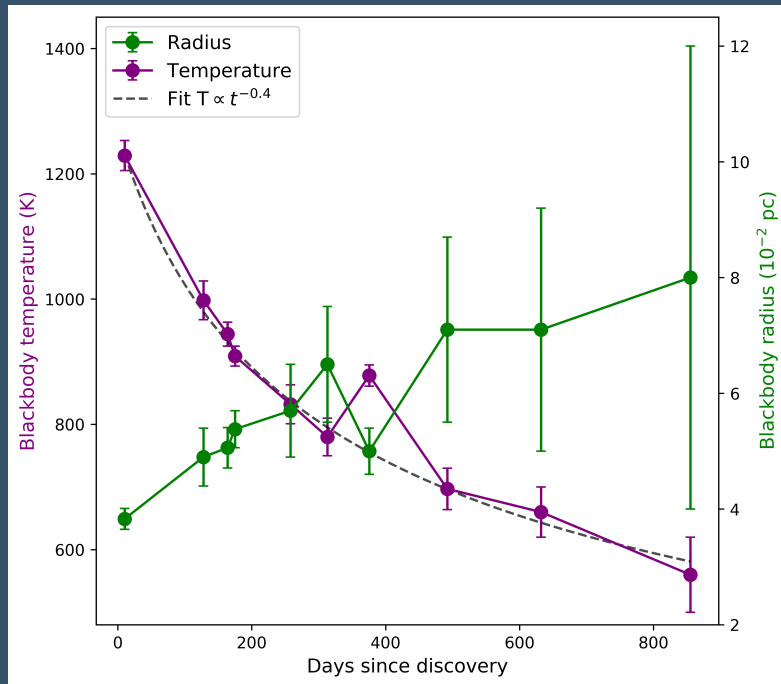


# AT 2017gbl in IRAS 23436+5257

Kool+ 2020

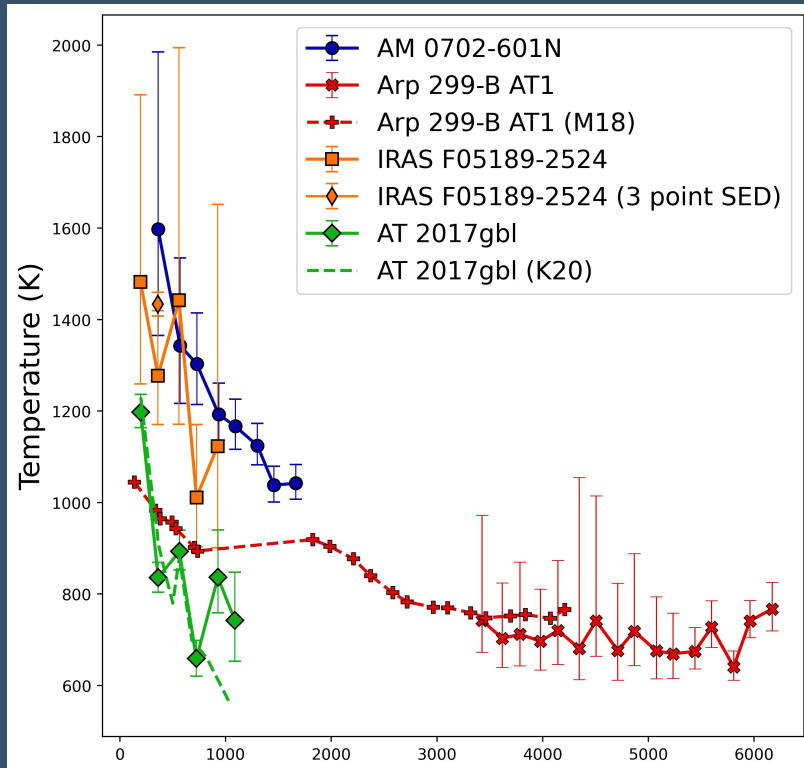
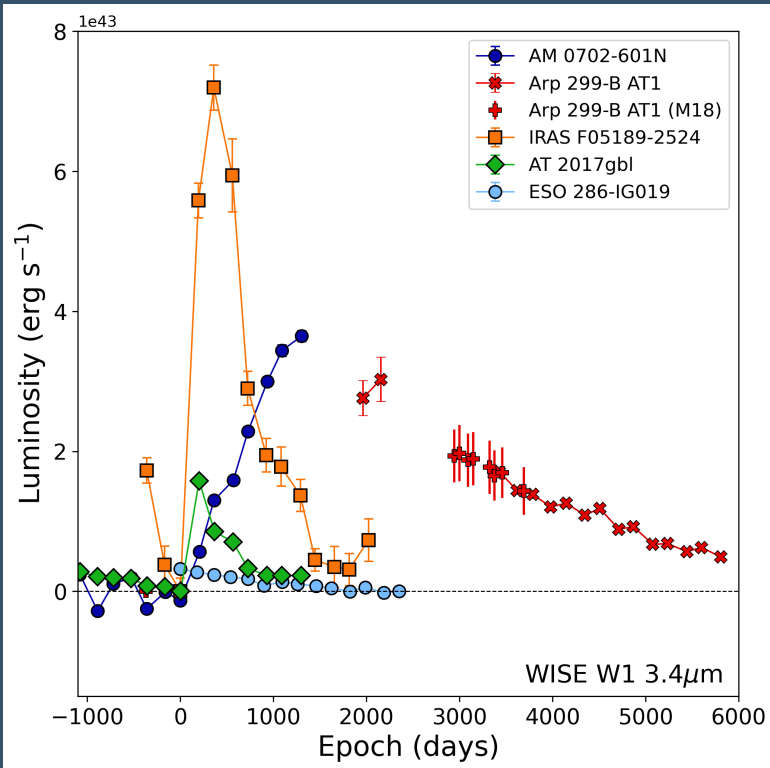
- Discovered in AO-assisted Keck search for obscured SNe in LIRGs
- Luminous in IR and radio, faint in the optical.
- Radio properties rule-out SN  
=> find **dust obscured TDE** most plausible scenario.
- **Rate of AT 2017gbl-like events  $10^{-1.4} - 10^{-2.8} \text{ LIRG}^{-1} \text{ yr}^{-1}$ .**

NOTCam crucial again



# More nuclear transient in LIRGs with WISE

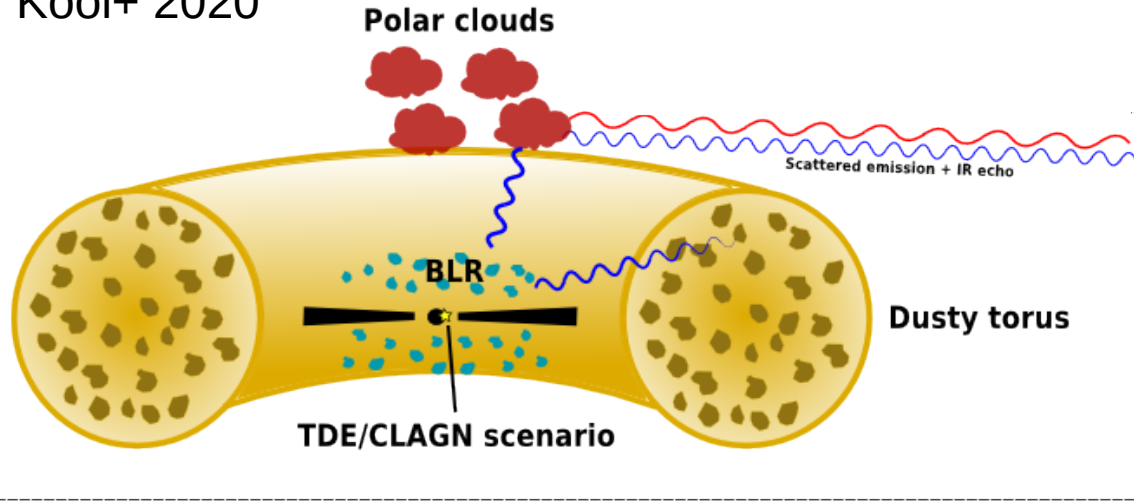
- Search with NEOWISE: three more transients, one similar to Arp 299-B AT1
- New rate:  $10^{-2.3}$ - $10^{-2.8}$  transients LIRG $^{-1}$  year $^{-1}$



Large uncertainties  
without NOTCam!

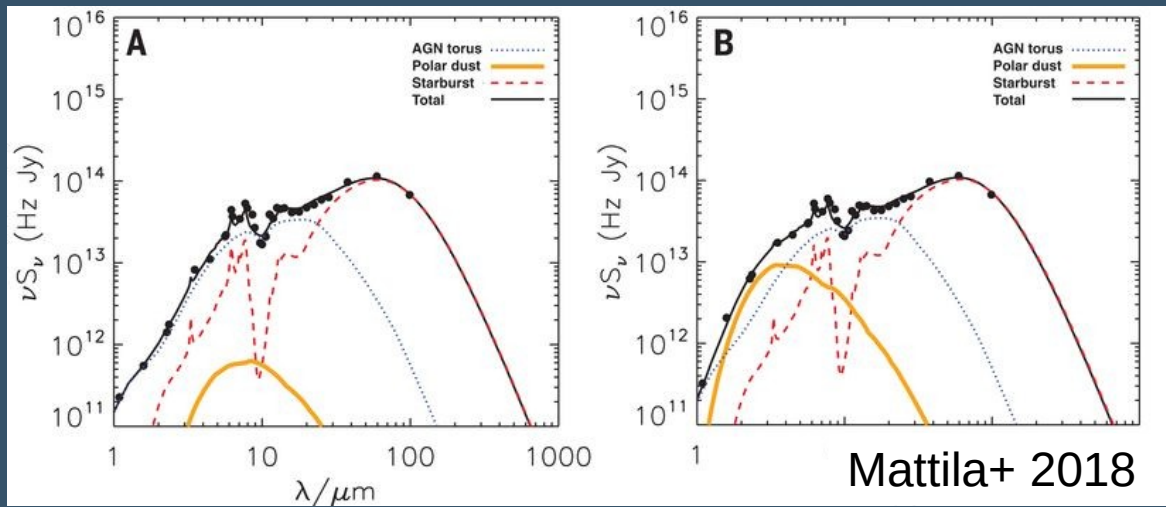


Kool+ 2020



- Our discoveries occur in active galaxies – unlike “typical” TDEs
- IR emission consistent with dust in the polar regions of the AGN torus

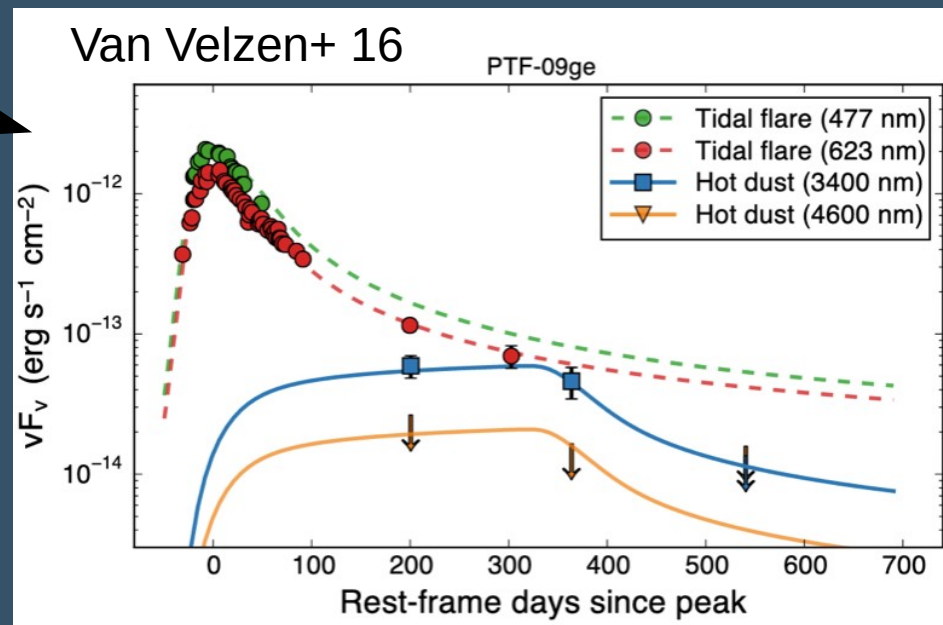
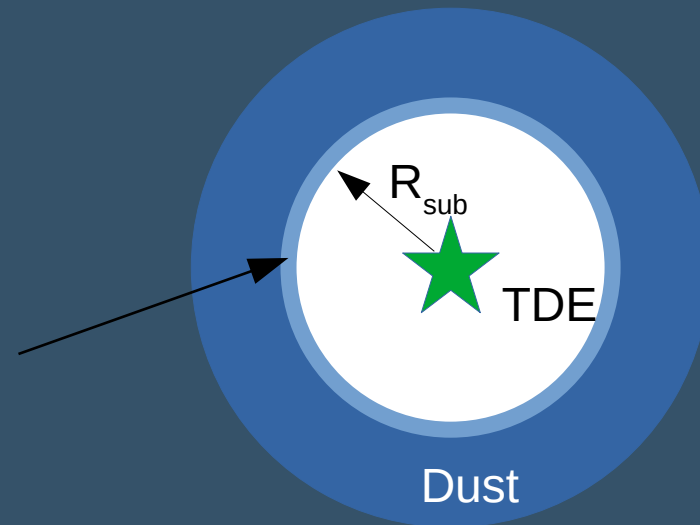
- Evidence for obscured AGN from SED fitting implies very large extinctions in line of sight.



SED fitting methods:  
Efstathiou+ 1995,2000,2009,2013,2021

# What about “typical” TDEs?

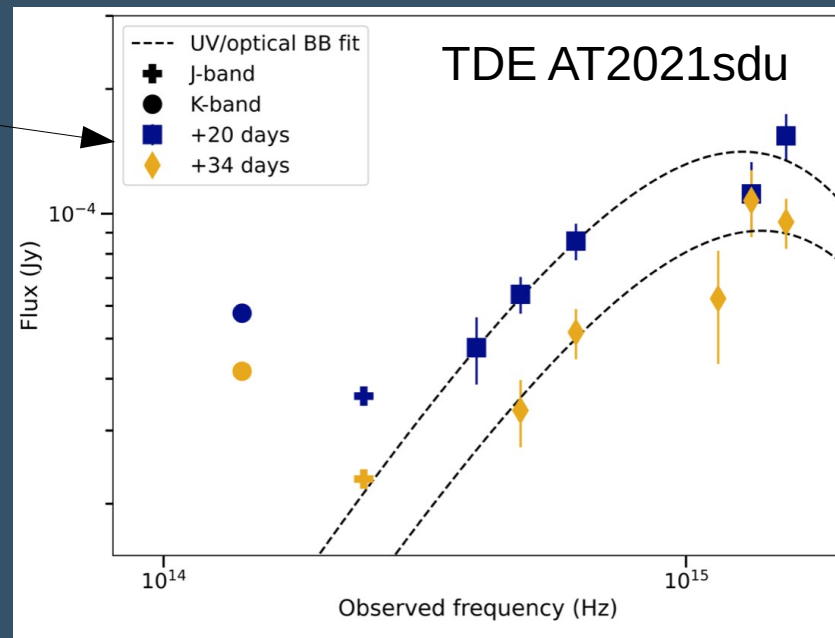
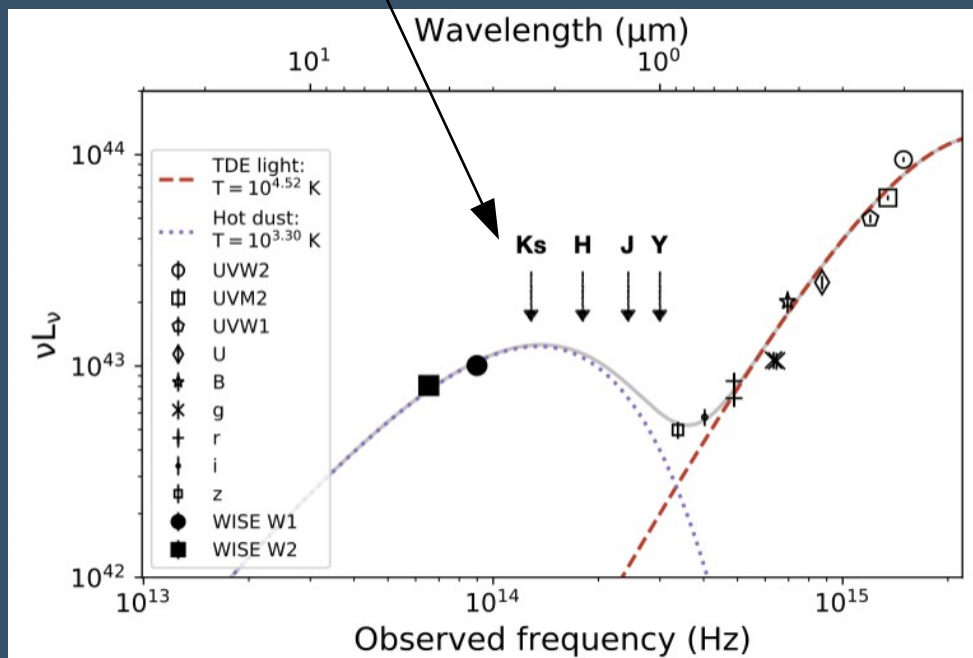
- IR echos are observed in optical TDEs.
- In quiescent galaxies, dust exists close to the SMBH
  - TDE destroys the dust out to sublimation radius  $R_{\text{sub}}$
  - At  $R_{\text{sub}}$ , dust has sublimation temperature  $T_{\text{sub}}$ .
- Modelling of the IR echo reveals:
  - Dust radius  $\sim 0.1\text{pc}$
  - Total energy  $\sim 10^{52}$  erg
  - “Covering factor”  $\sim 1\%$  (very low!)
- For accurate measurement of **intrinsic energy** of the TDE we need **higher cadence** and **better SED coverage**
- Can resolve the “**Missing Energy Problem**”



## 1. Title of proposal:

Near-infrared detection and study of tidal disruption events

- NOTCam > NEOWISE
- 6 months => 2-3 weeks
- SED sampling



- Program: Spring 2021 - present
- SoftToO vital for followup
- We are discovering evolution on a never before seen IR timescale for TDEs!

# Conclusions

- 1) Heavily obscured TDEs are hiding behind the dust in starforming galaxies and AGN.
- 2) To observe the IR echoes from TDEs, we need better cadence and SED coverage than provided by NEOWISE – NOTCam!
- 3) NTE will **dramatically** improve our strategy:
  - Simultaneous optical+IR => Complete sampling of the TDE SED
  - Always mounted => Freedom to observe at any cadence
  - NIR spectral coverage – almost completely unexplored for TDEs!

