Tidal Disruption Events - The Radio Awakens

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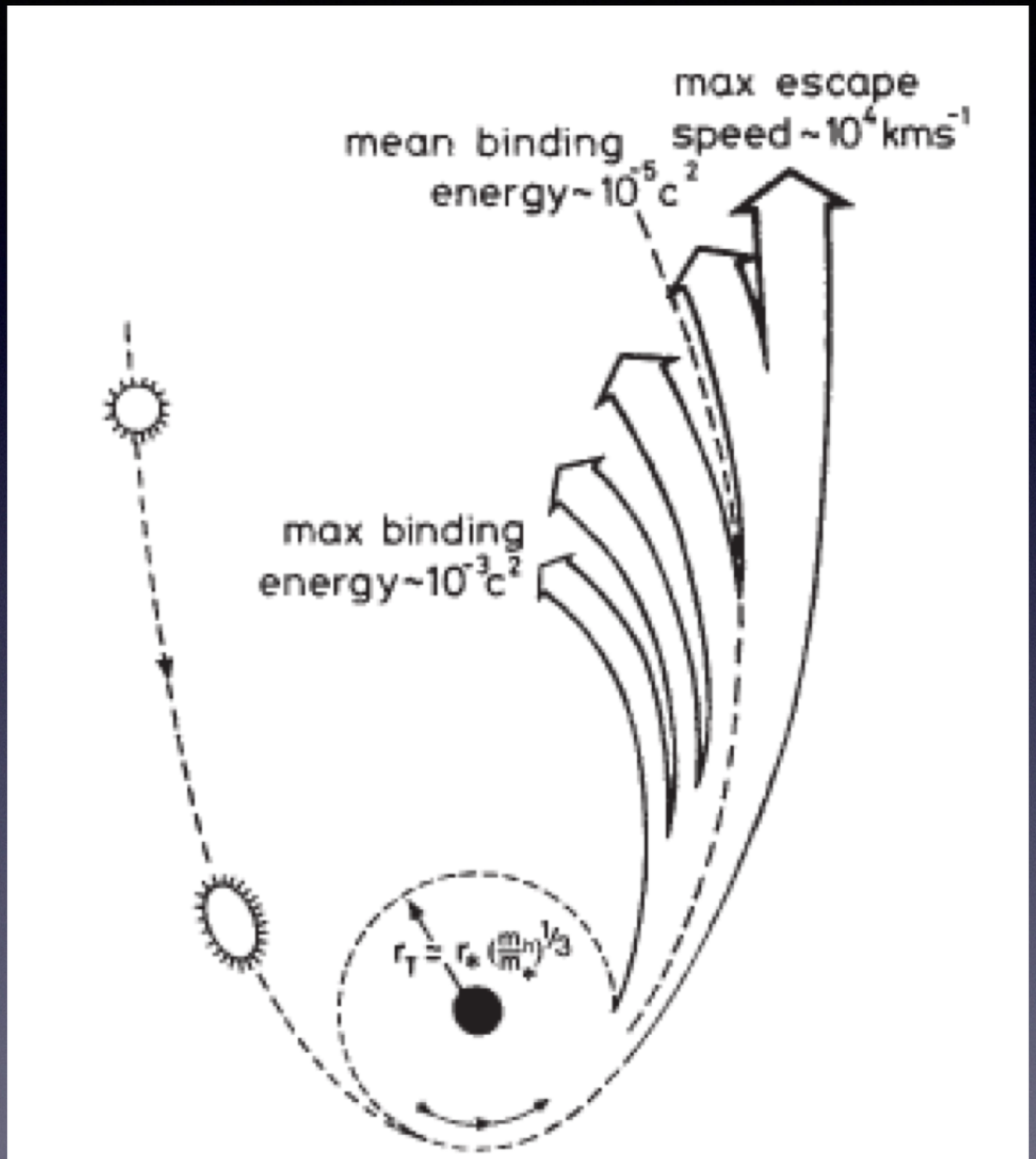
Binational Science Foundation

ISRAEL SCIENCE FOUNDATION

SIR ZELMAN COWEN
UNIVERSITIES FUND

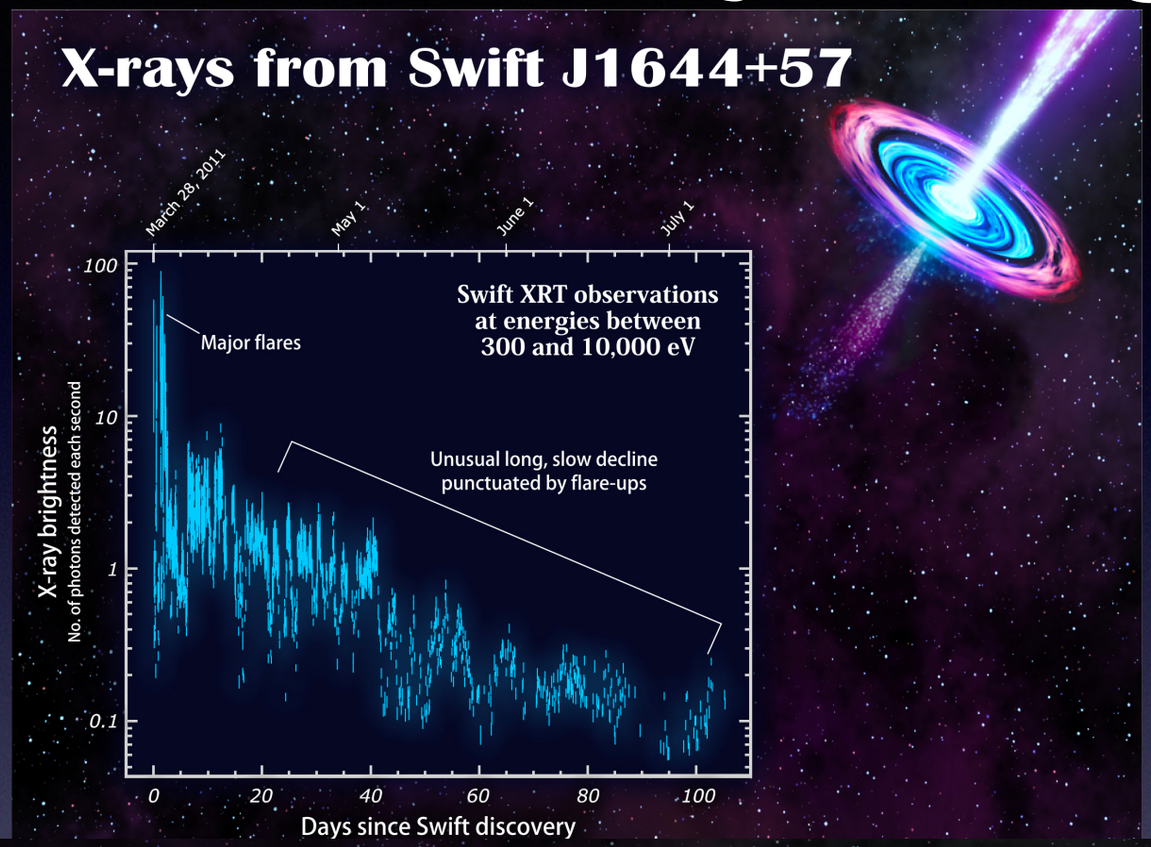
A Prediction



Rees (1988)

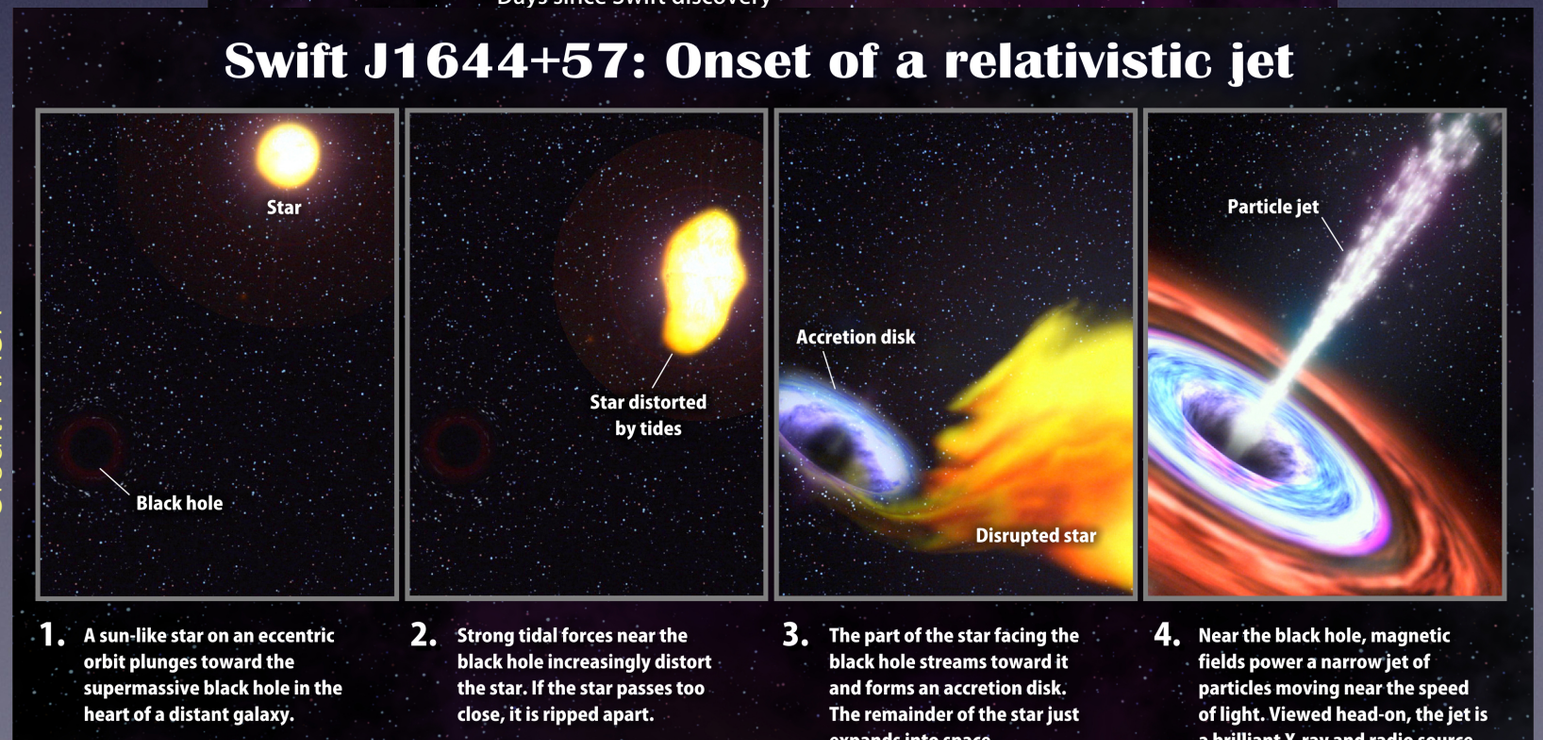
An outflow interacting with the BH environment may lead to radio emission.

The radio story begins…



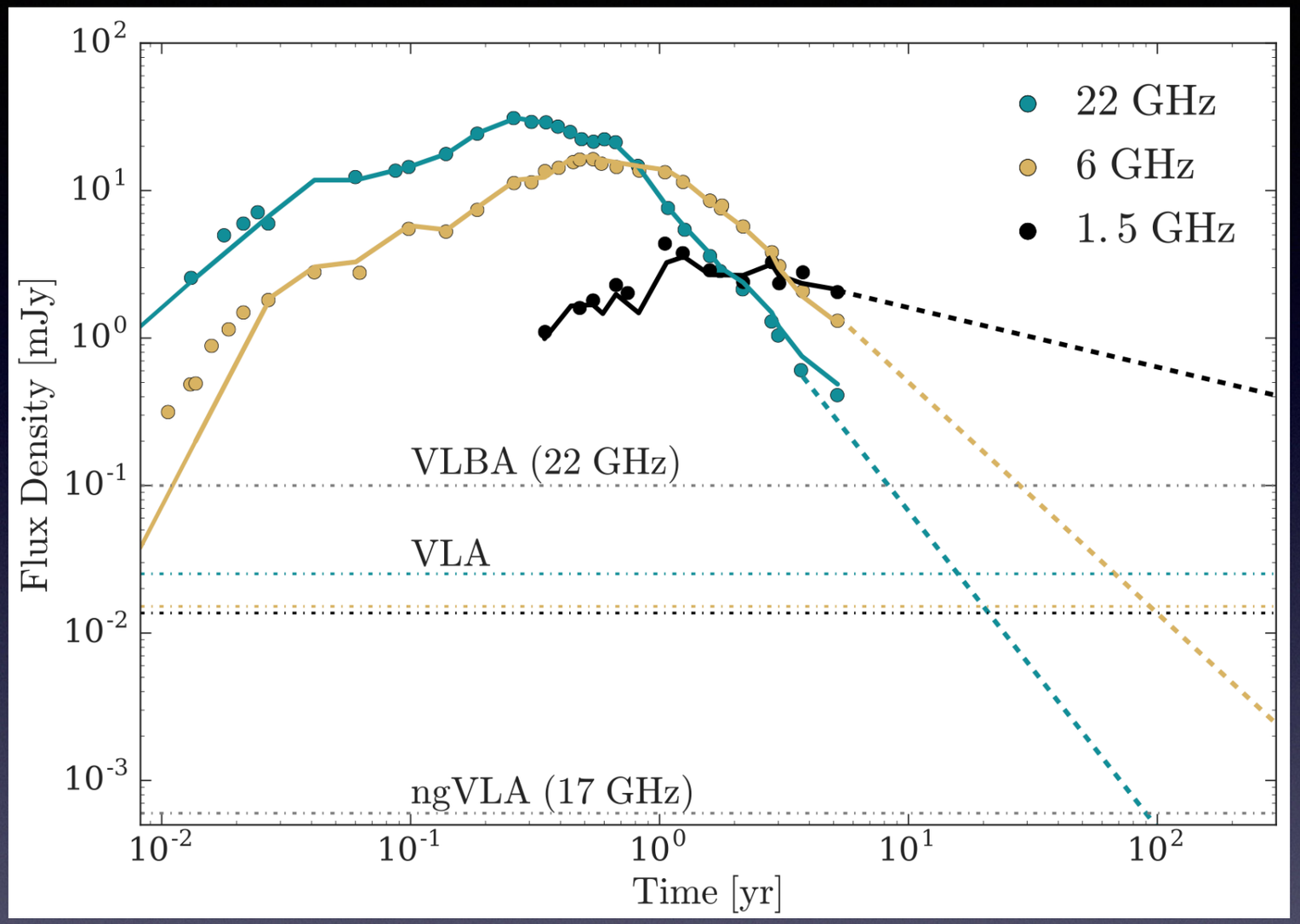
Credit: NASA

Bloom et al. 2011
Burrows et al. 2011
Levan et al. 2011
Zauderer et al. 2011
Berger et al. 2012
and more…



Credit: NASA

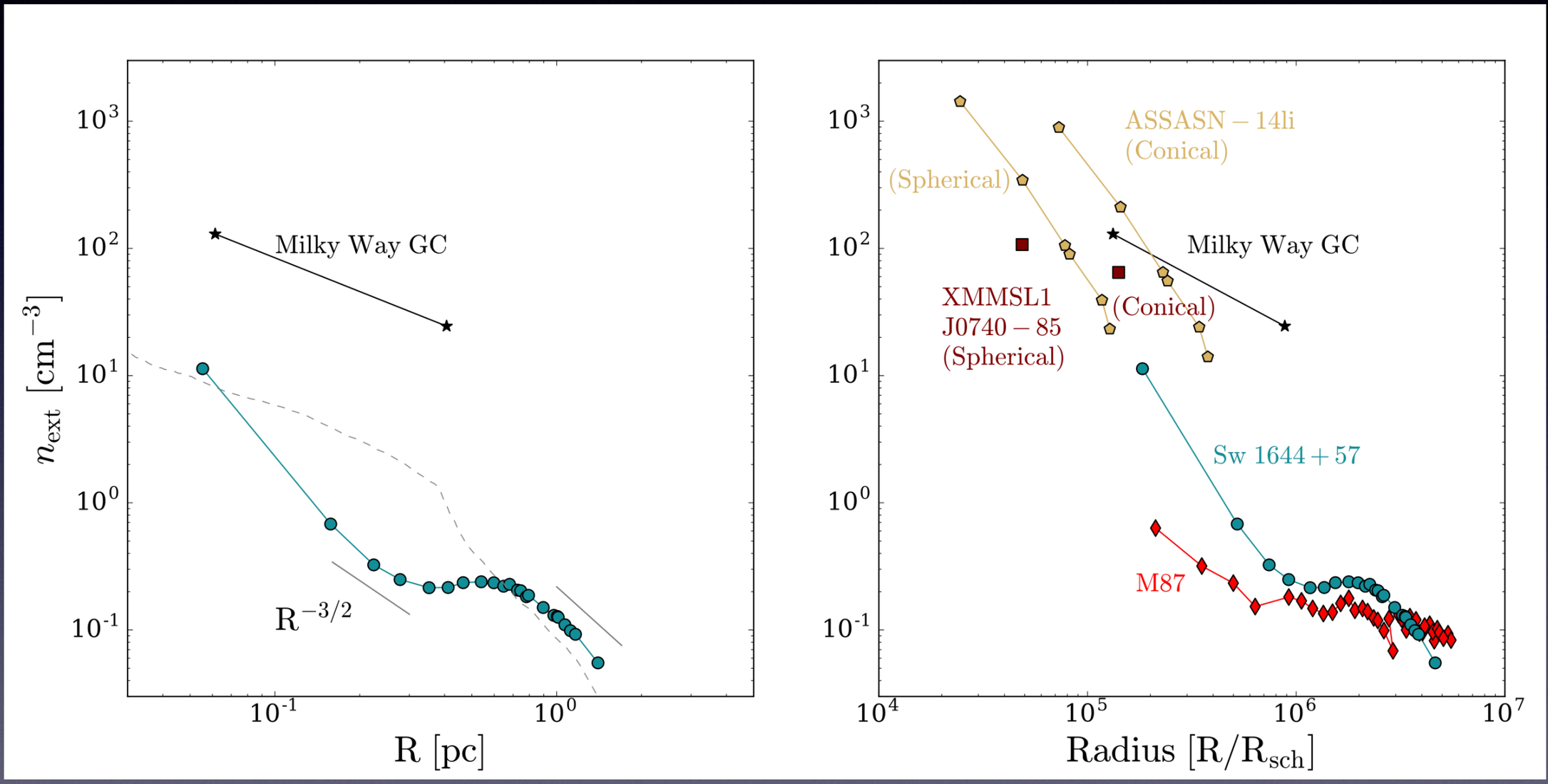
What Can We Learn?



Eftekhari et al. 2018

- Calorimetry
- Evolution of cooling processes
- Structured Jets
- Energy fraction in magnetic field
- Density variation in the close vicinity of the SMBH

CNM Density Profiles



Eftekhari et al. 2018

Do TDEs Always Produce Radio Emission?

Where are the rest of the radio TDEs?

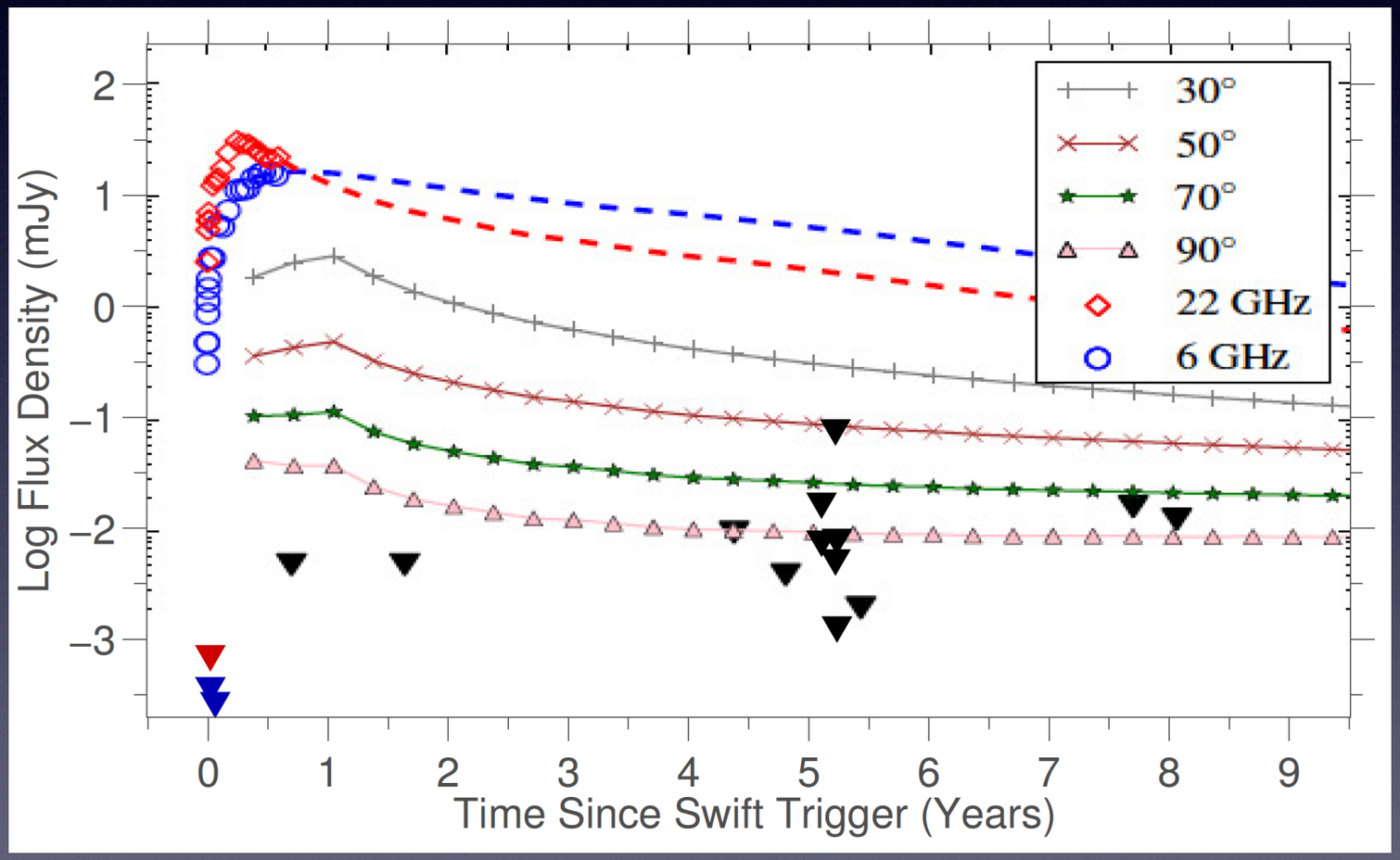


Figure adapted from Van-Velzen et al. (2013) + Arcavi et al. (2014) +additional limits

Where are the rest of the radio TDEs?

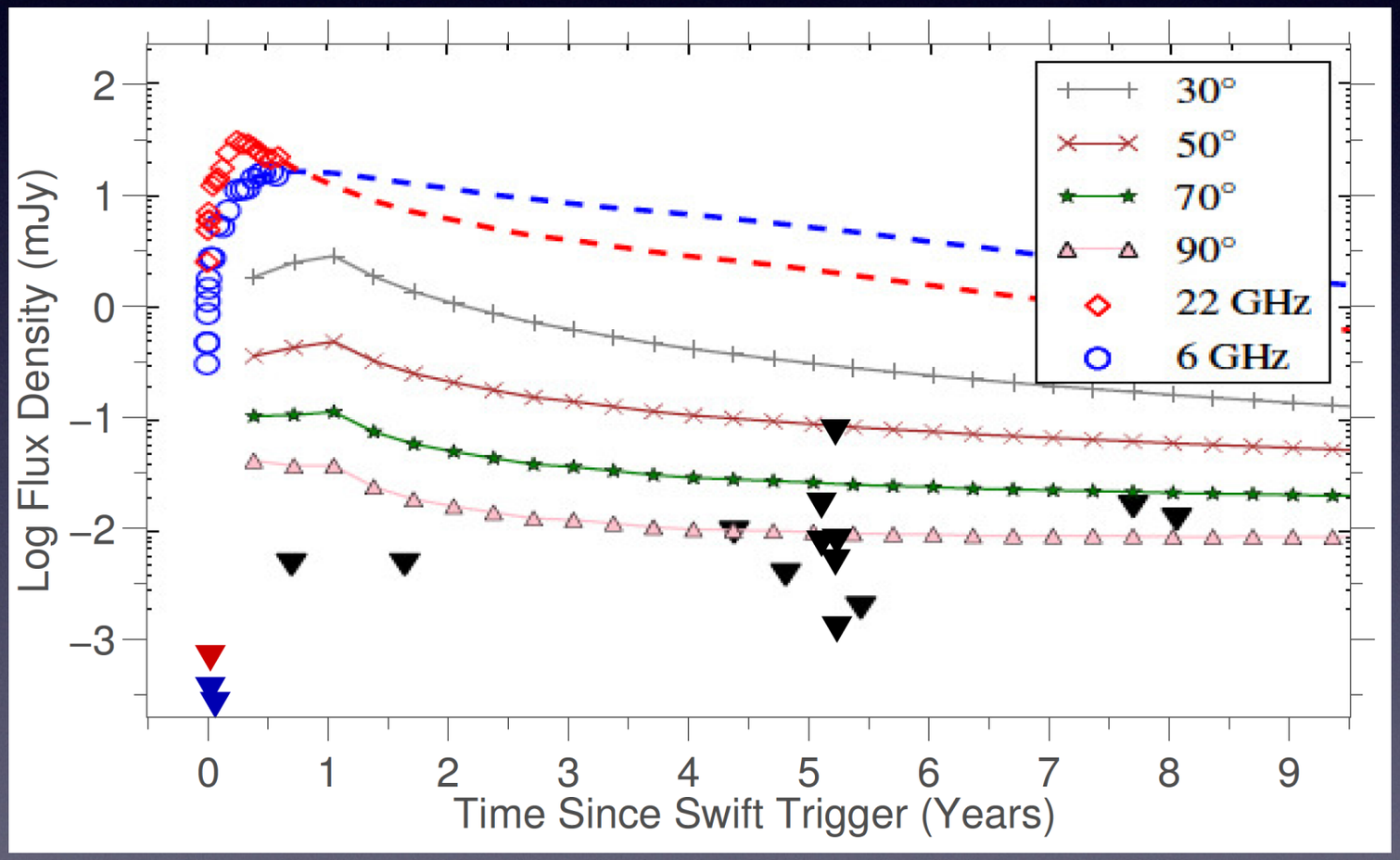
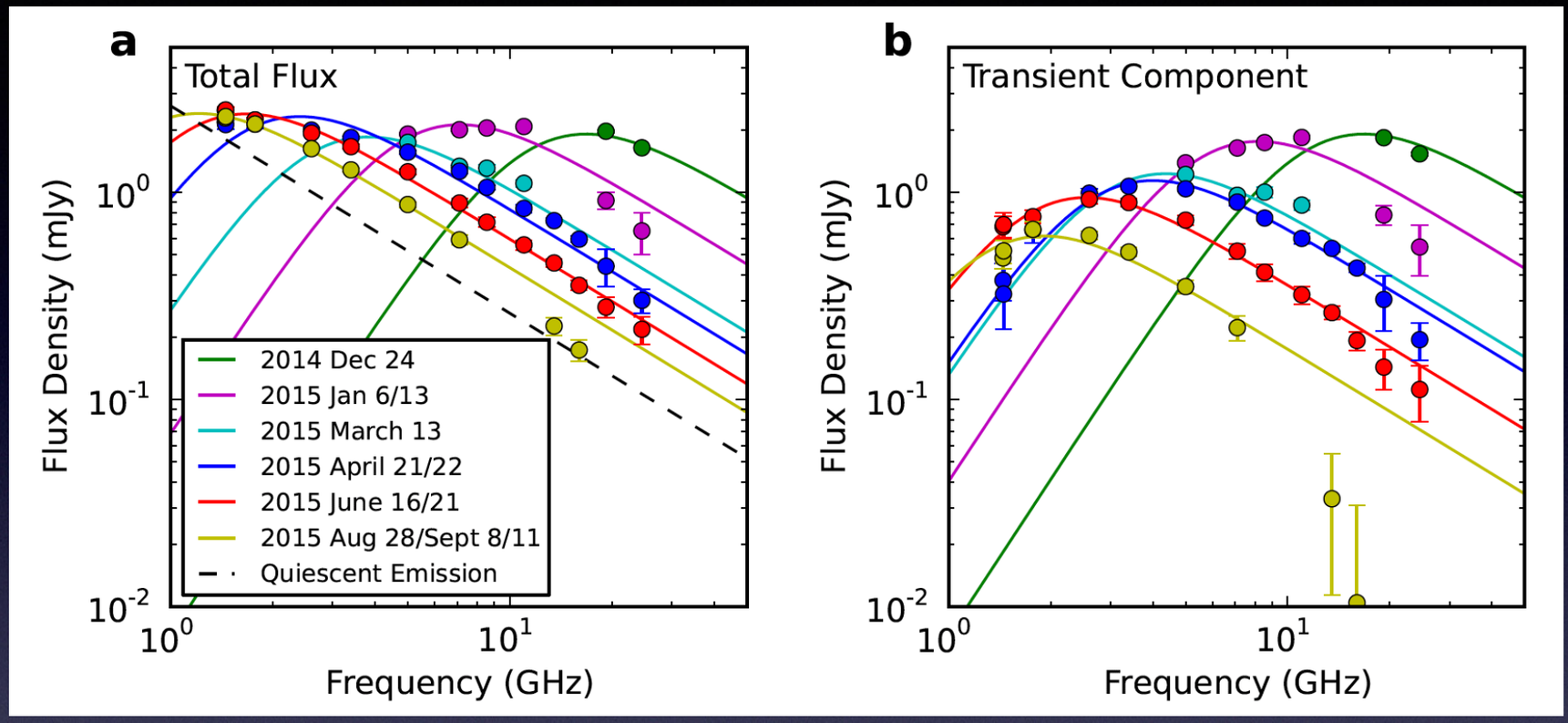


Figure adapted from Van-Velzen et al. (2013) + Arcavi et al. (2014) +additional limits

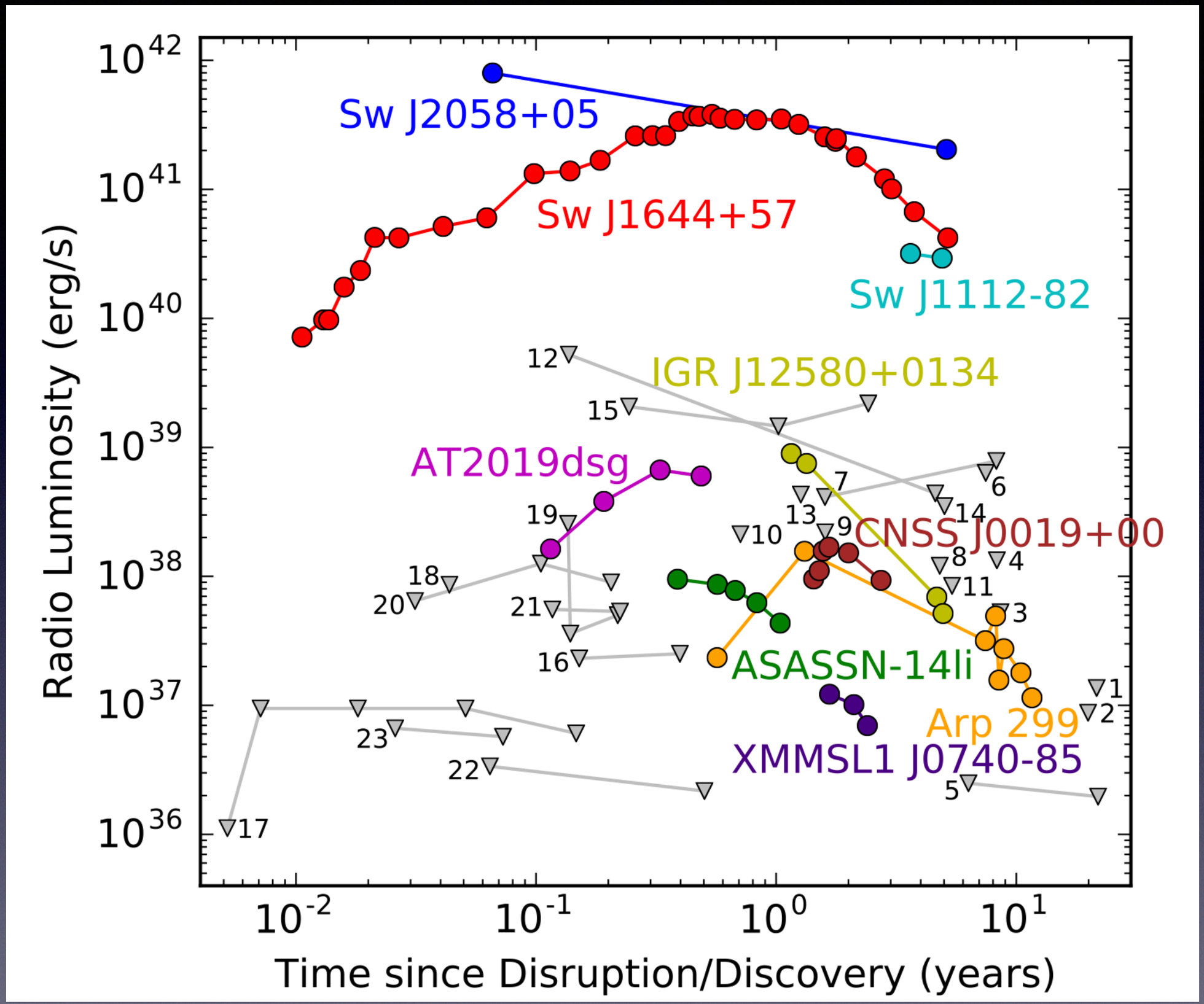
A dichotomy?

The Next Development: ASAS-SN14li



Alexander et al. (2015; see also van-Velzen 2015)

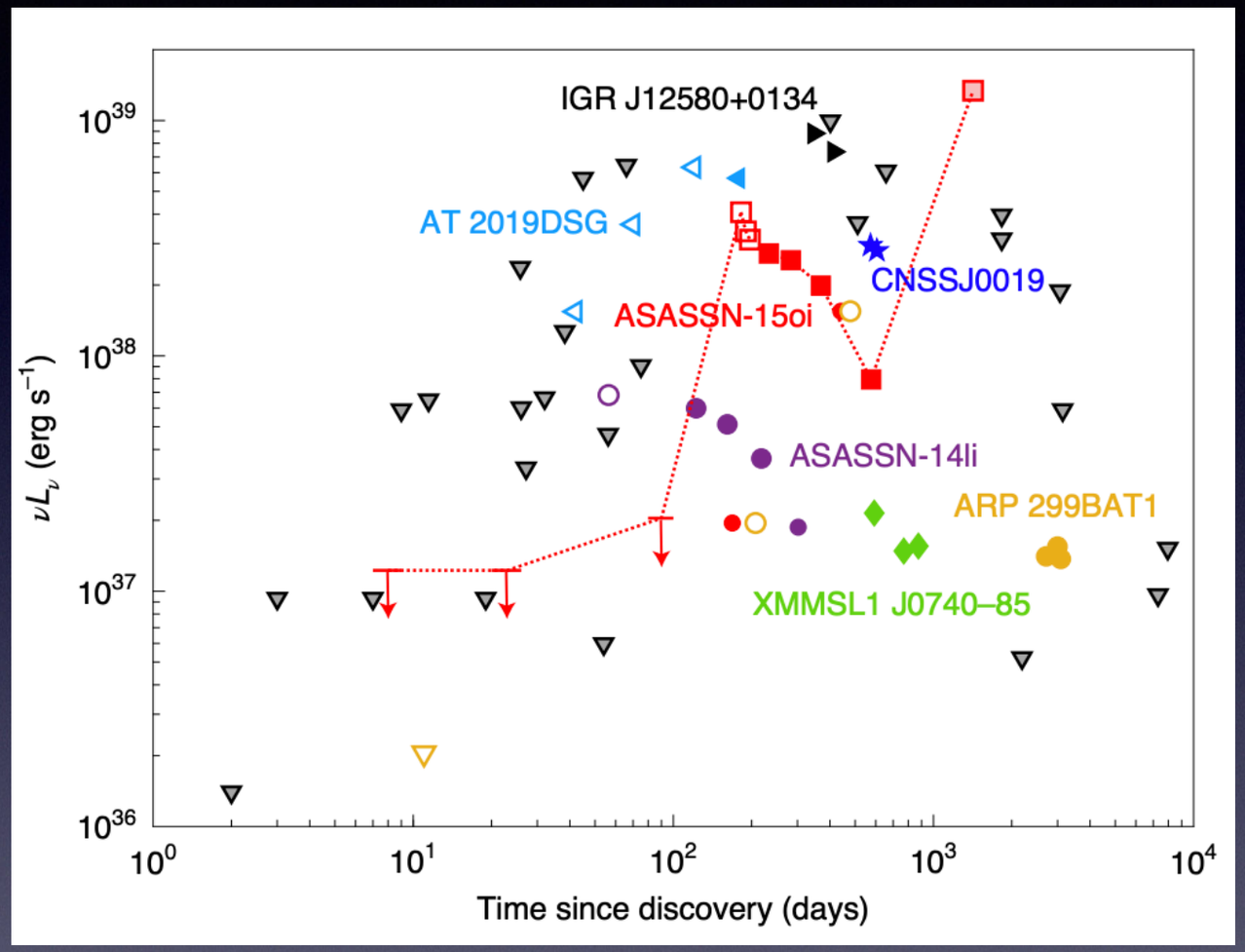
- Radio luminosity is two orders of magnitude below the luminosity of SwiftJ1644
- Peak below 1 .4 GHz in less than a year.
- Non-relativistic: velocities of ~ 12,000 km/s:
  Outflow from accretion disk (Alexander et al.)?
  Interaction of unbound debris (Krolik et al. 2016)?
  A narrow jet (van-Velzen et al.)?



Alexander, van-Velzen, Horesh, Zauderer (2020)

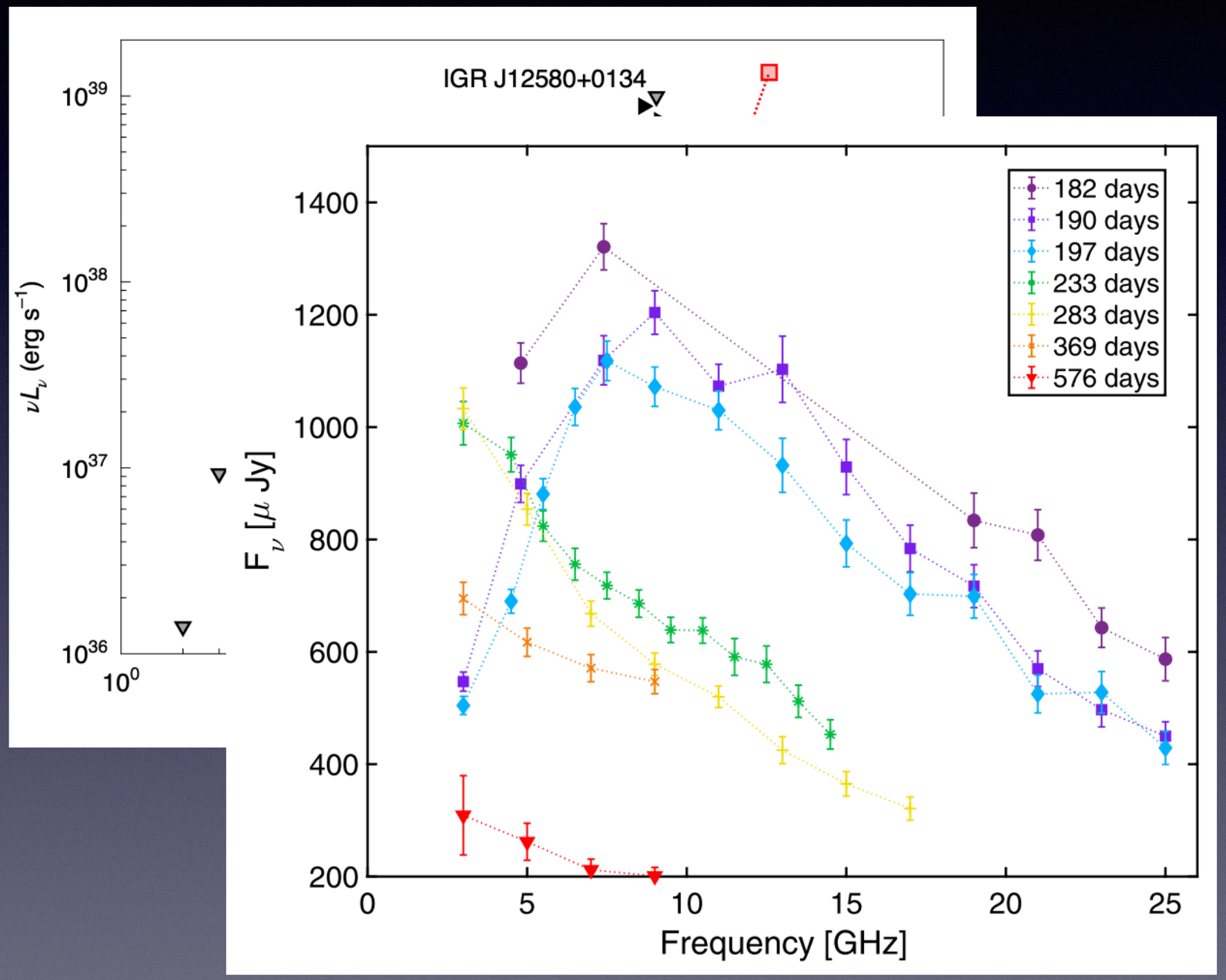
A New Phenomenon

Delayed Radio Flares



Horesh et al.
(2021a, Nature Astronomy)

Delayed Radio Flares



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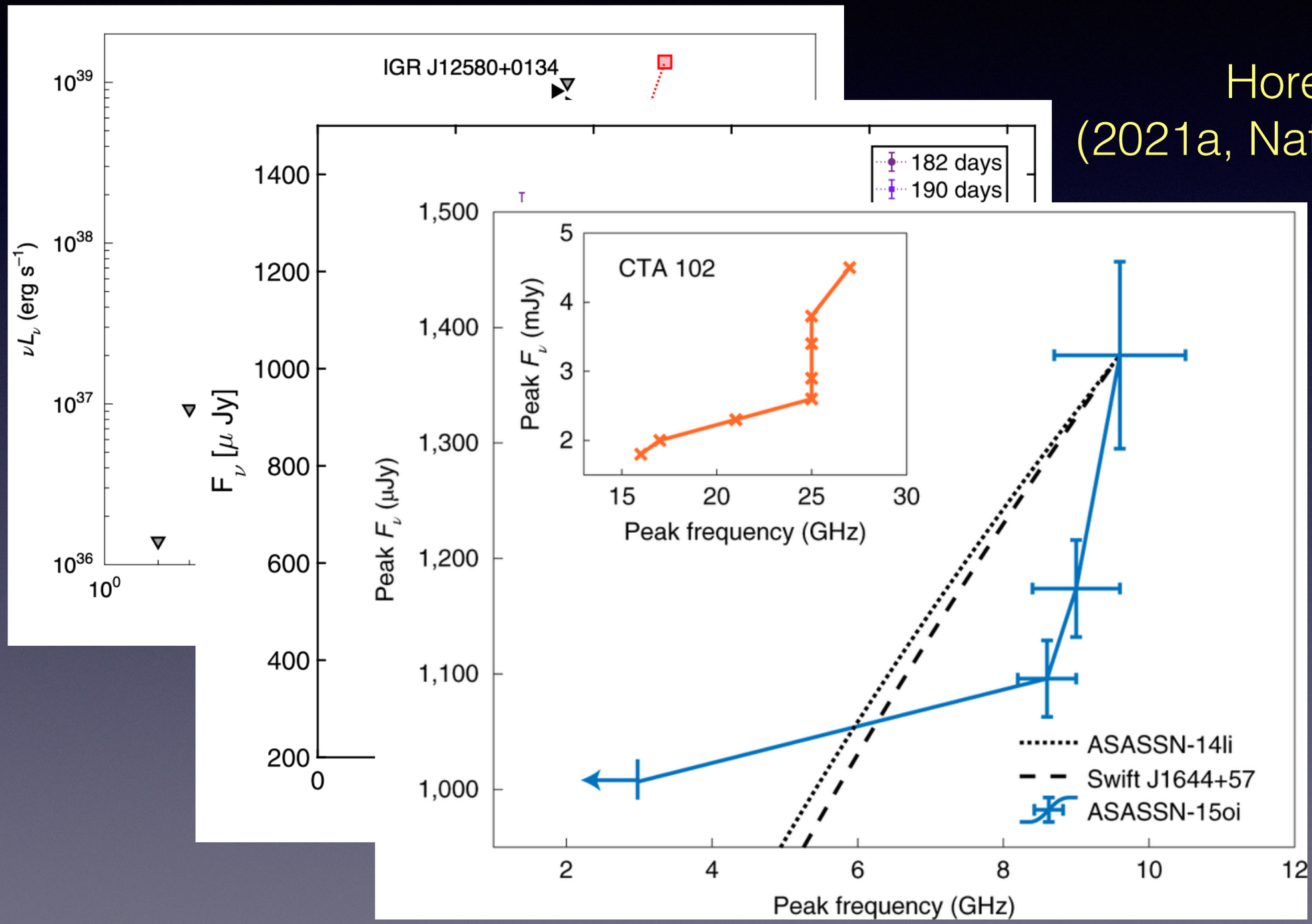

Delayed Radio Flares

Horesh et al.
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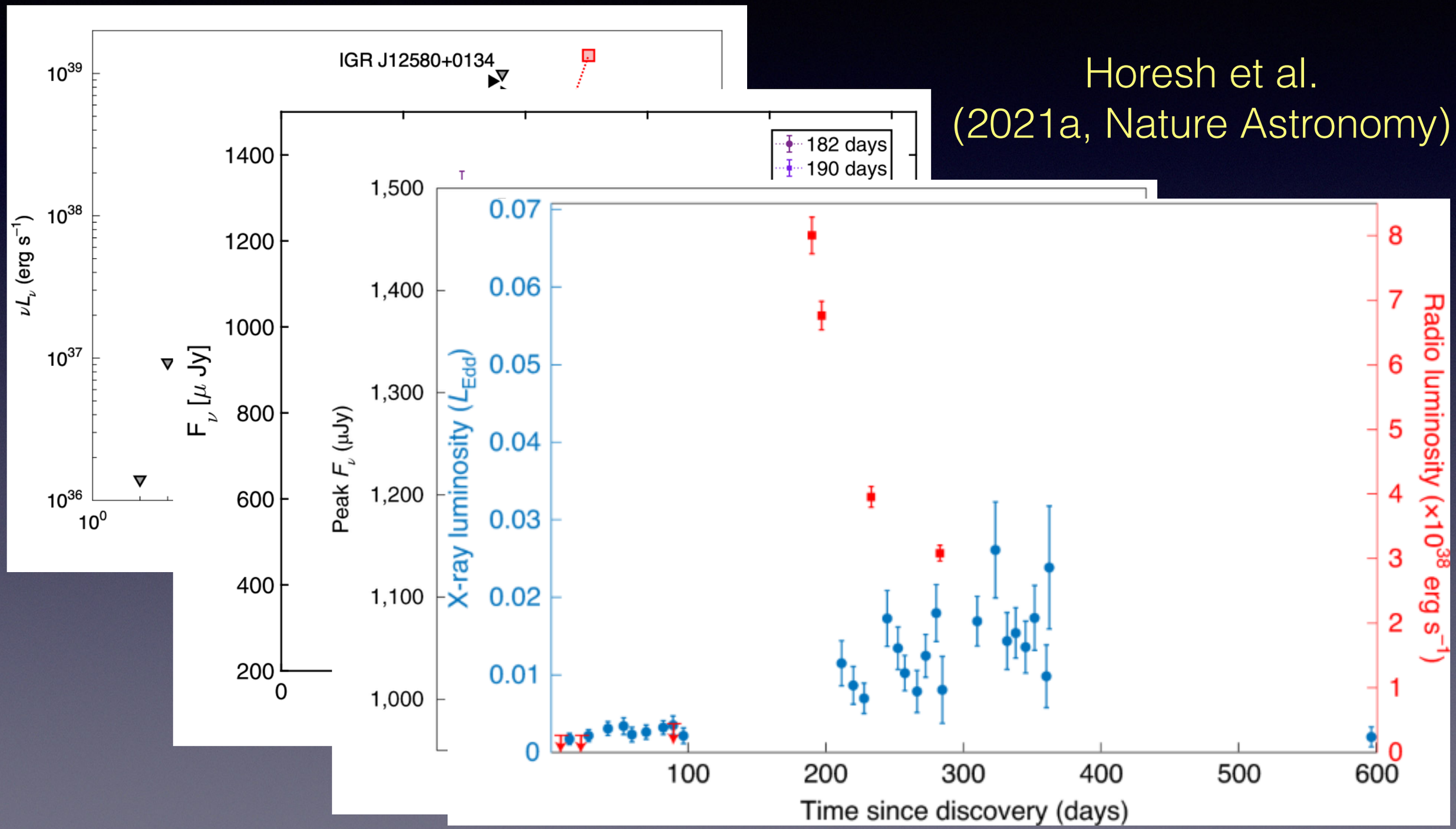
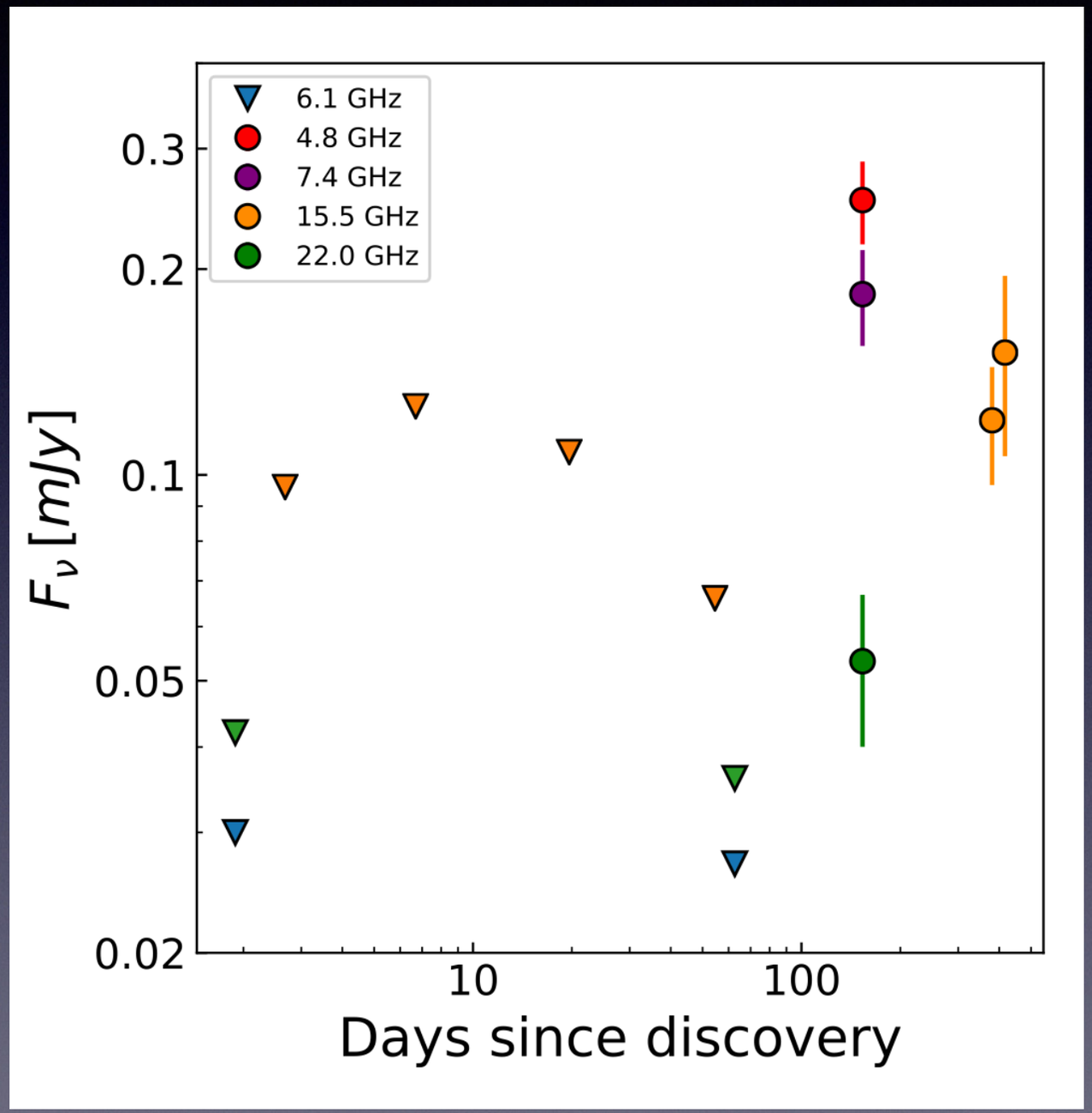
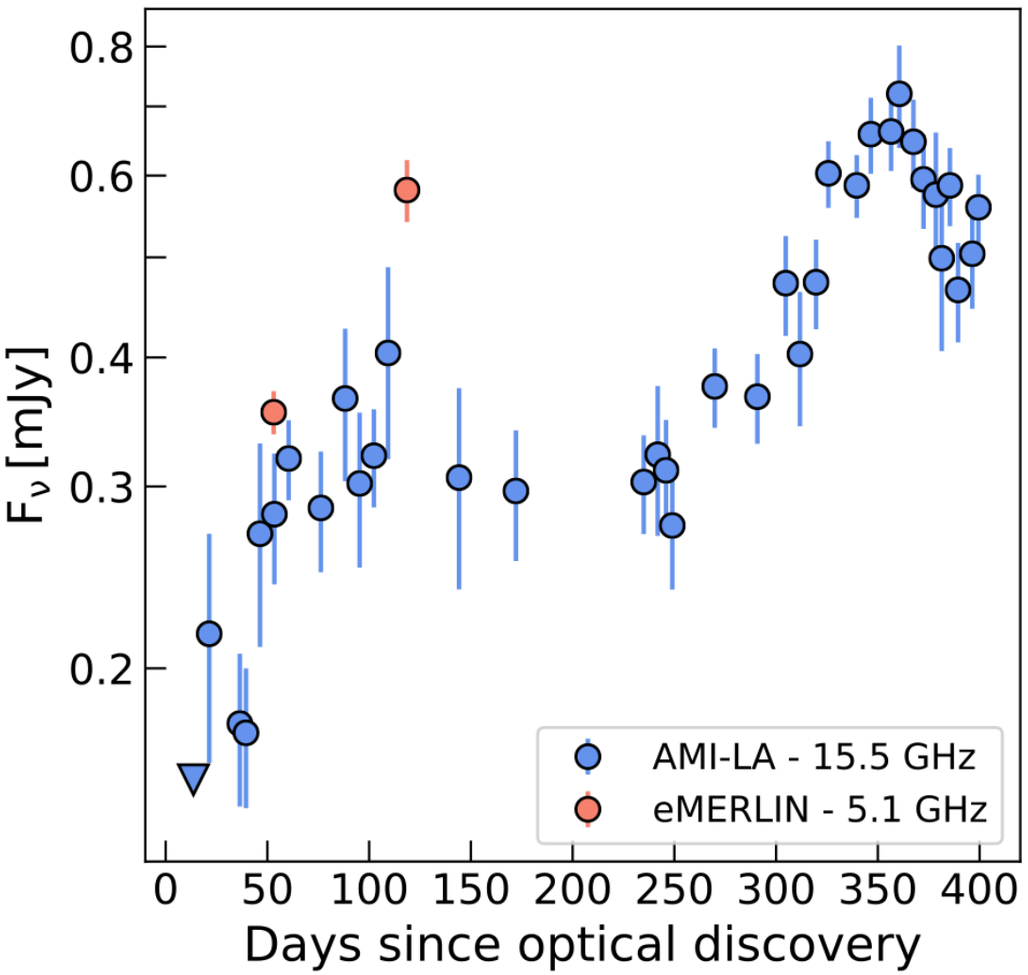


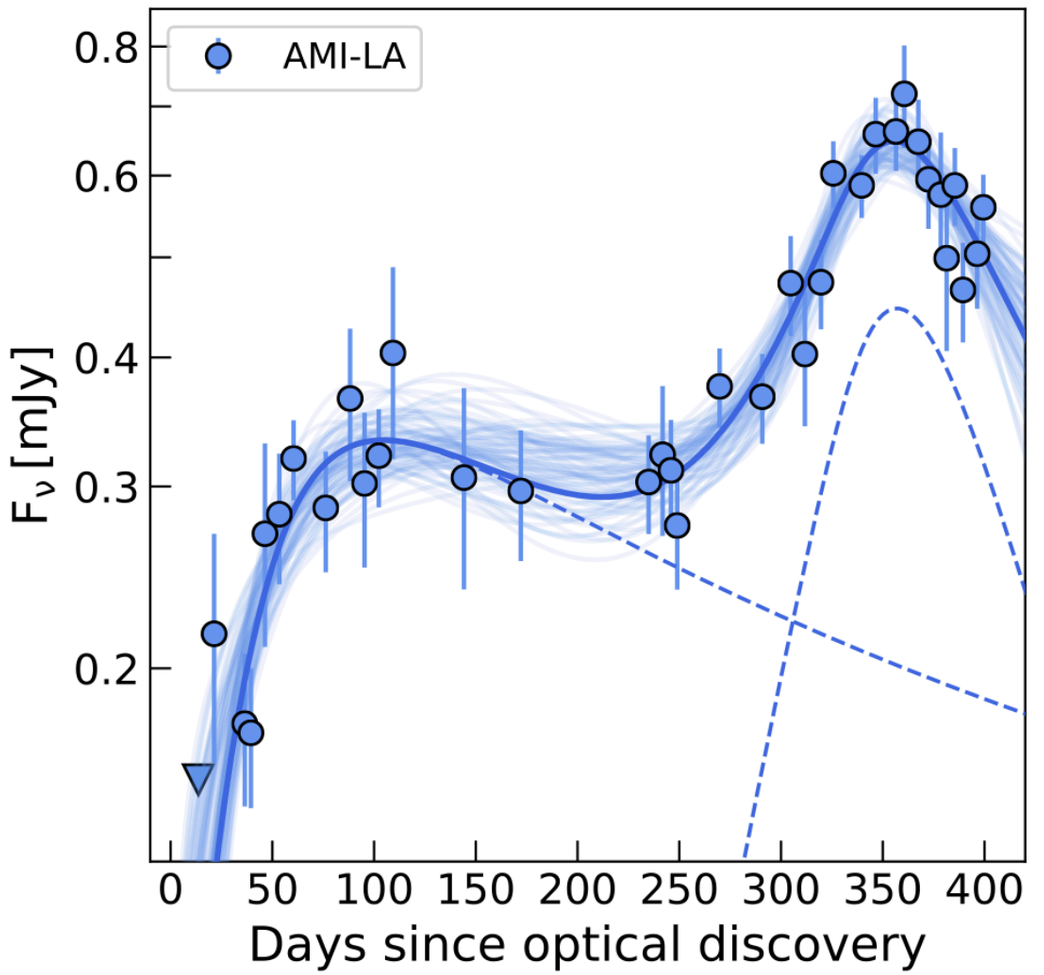
More Examples



iPTF16fnl
Horesh et al. (2021b)

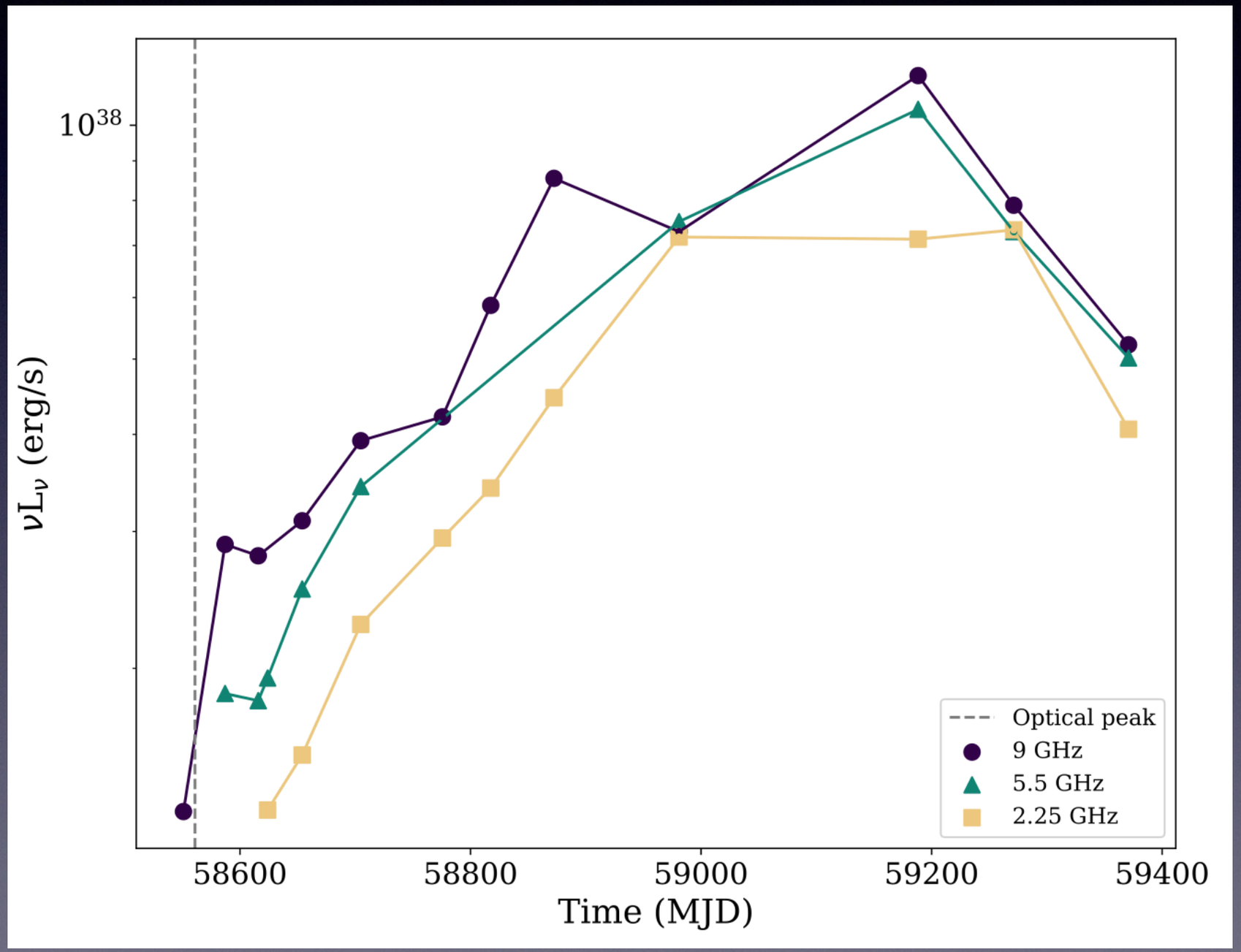
A More Complicated Picture





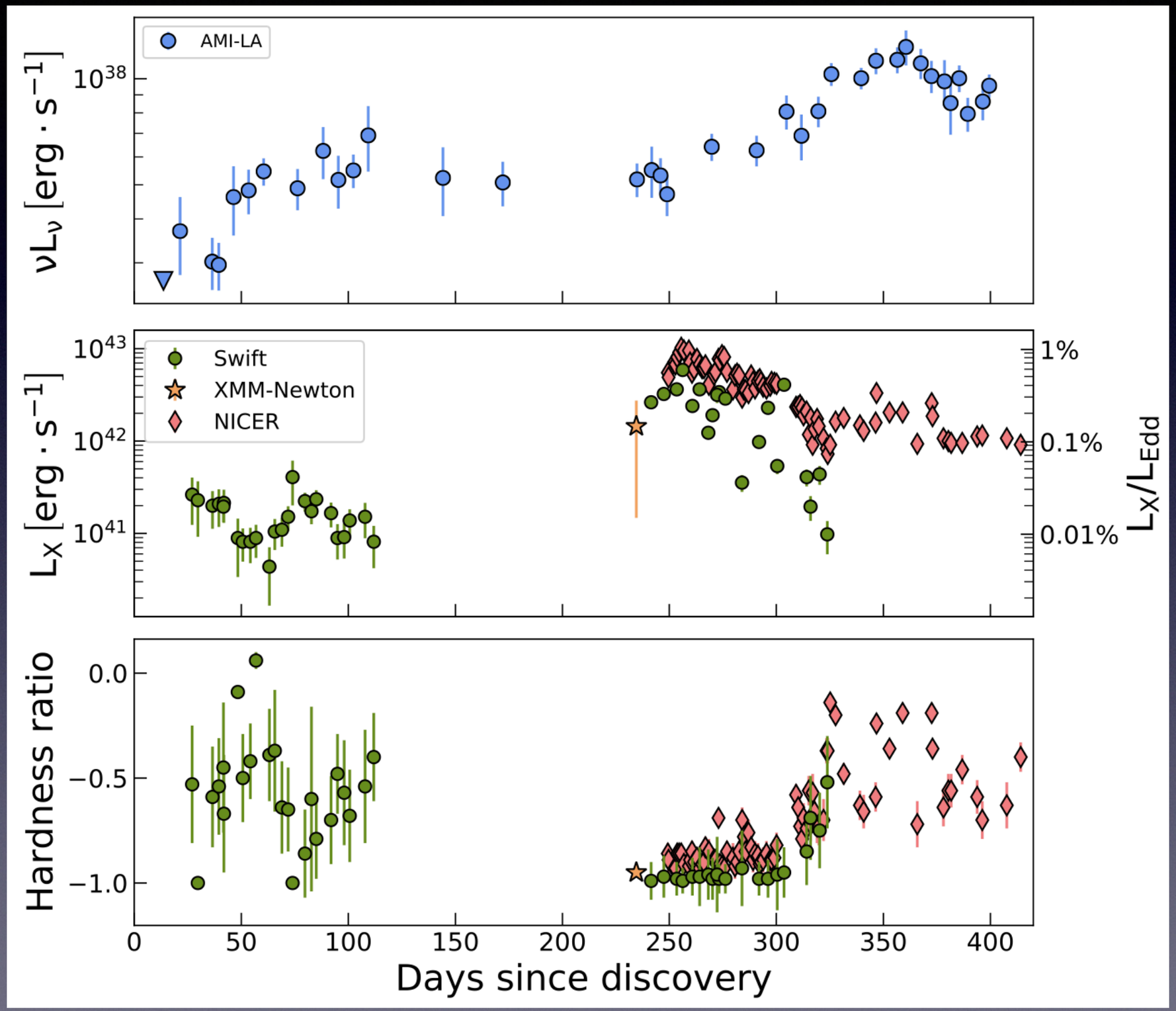
AT2019azh
Sfaradi, Horesh et al. (2022)

The Importance of High Cadence Observations



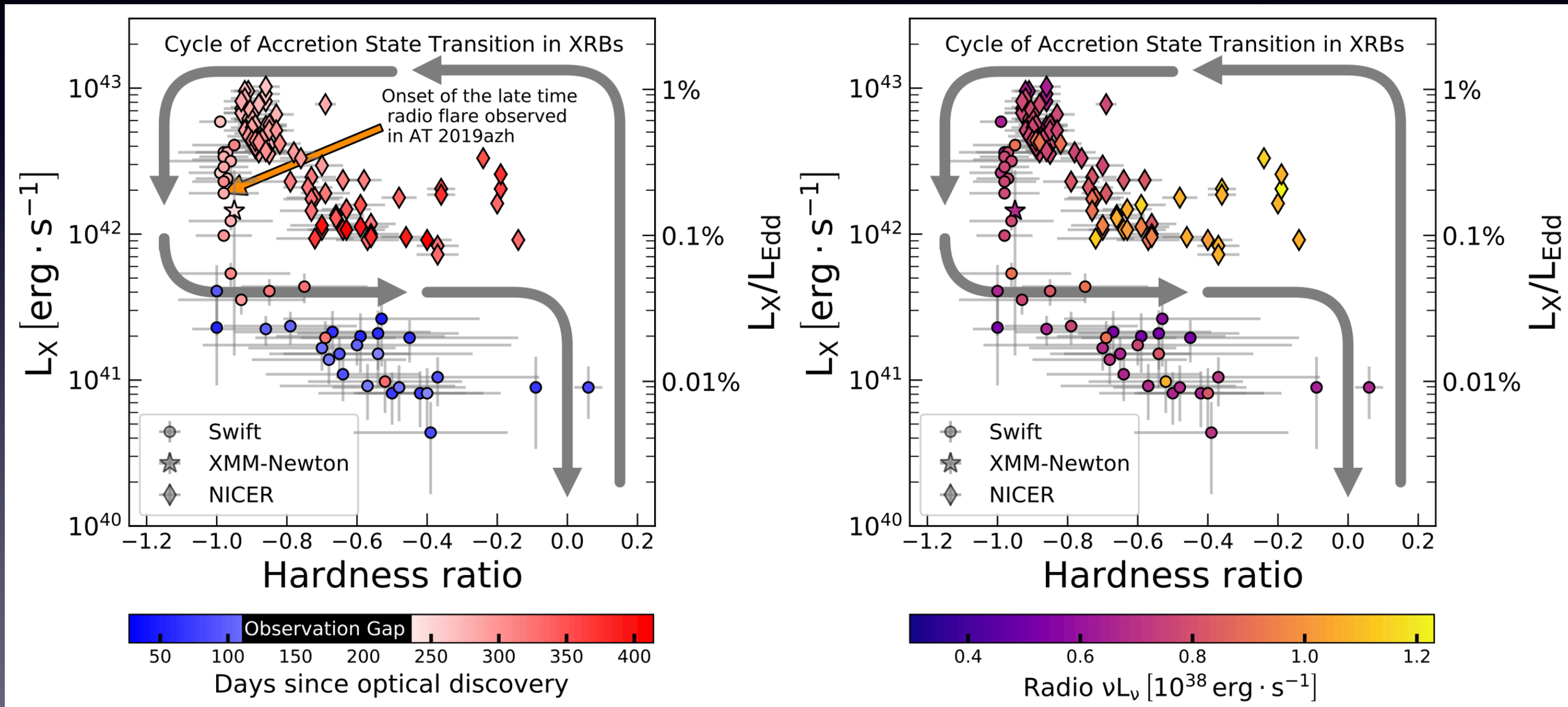
AT2019azh (Goodwin et al. 2022)

And Now Also With X-rays



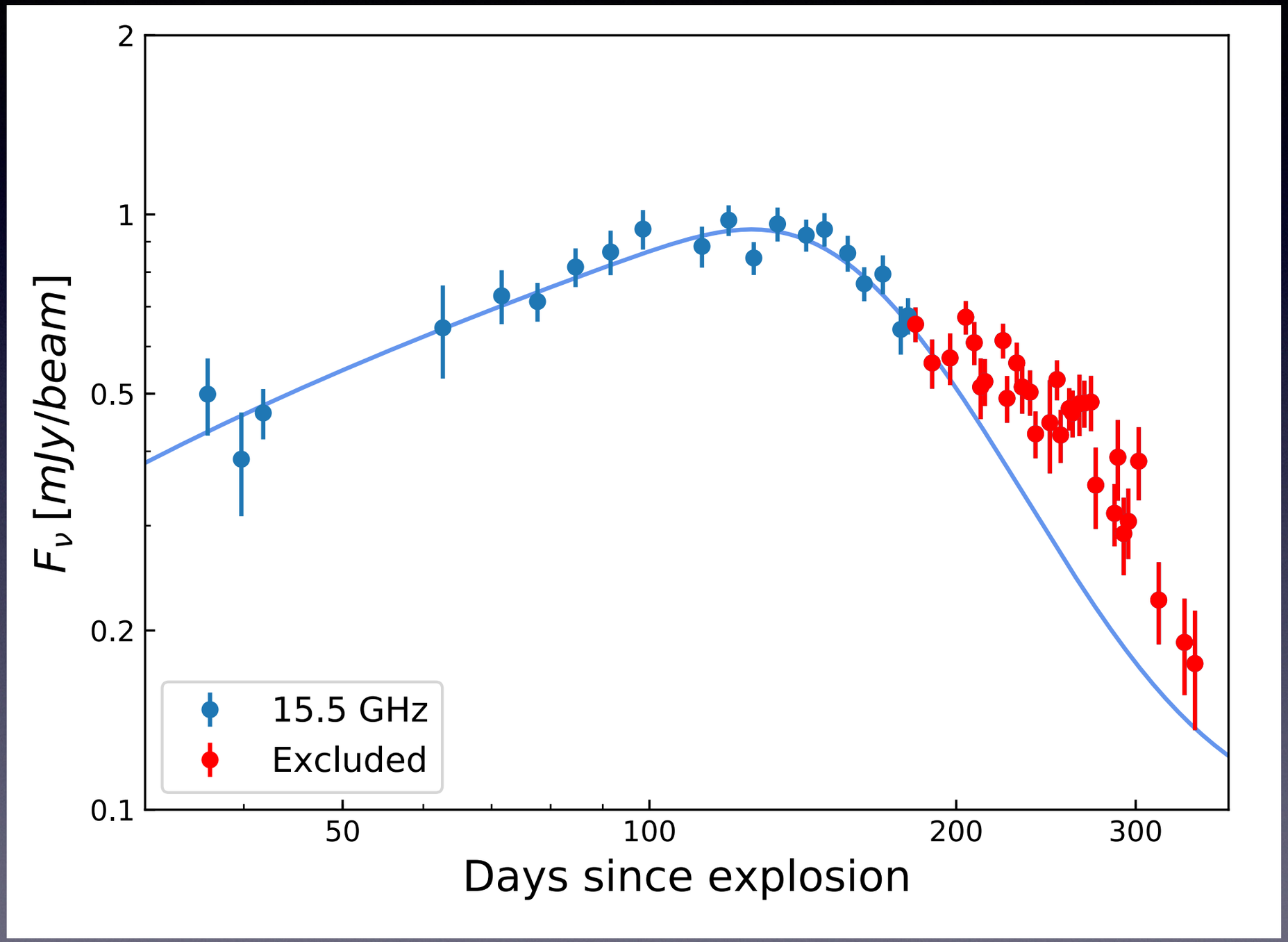
AT2019azh (Sfaradi, Horesh et al. 2022; X-ray from Hinkle et al. 2021)

An Accretion State Transition?

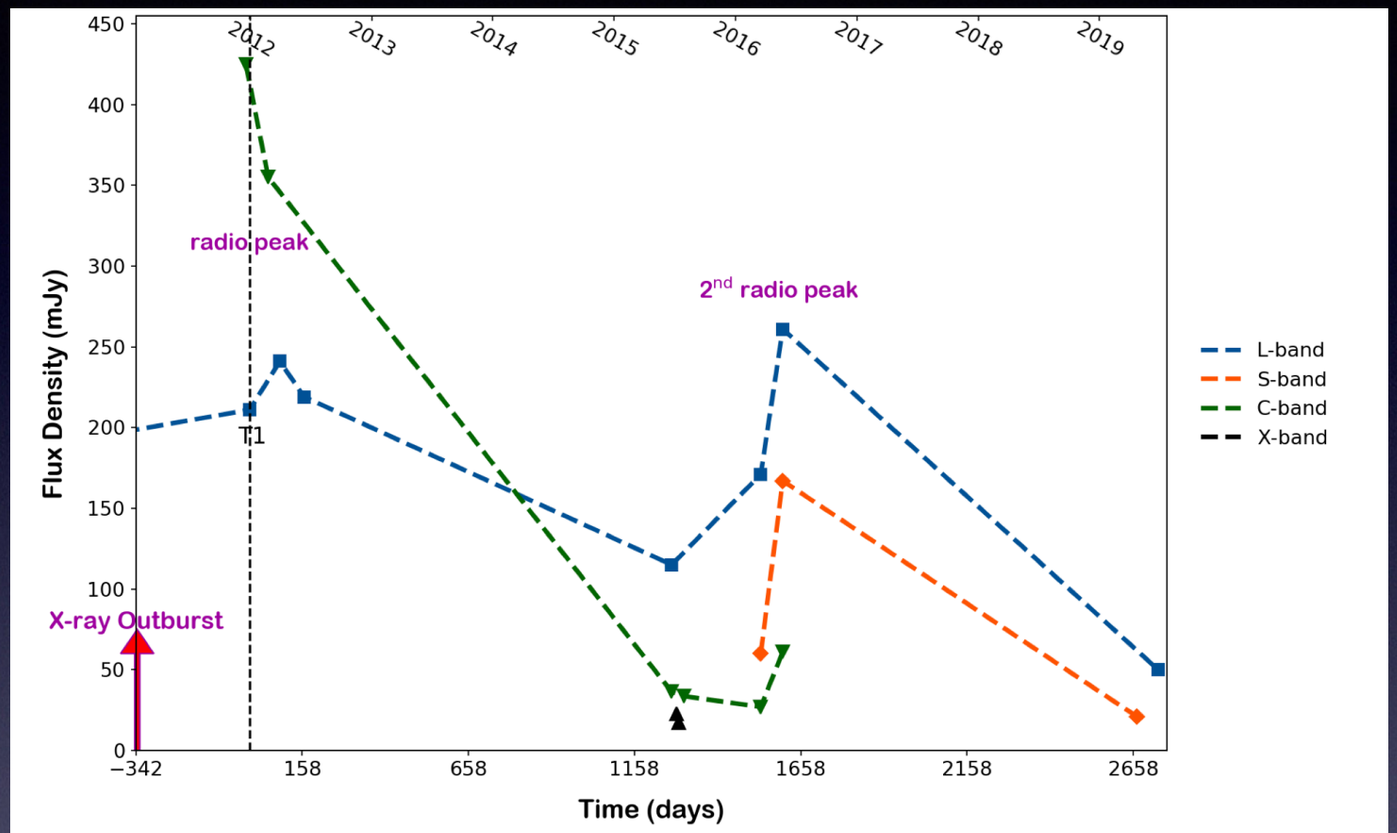


AT2019azh (Sfaradi, Horesh et al. 2022; X-ray from Hinkle et al. 2021)

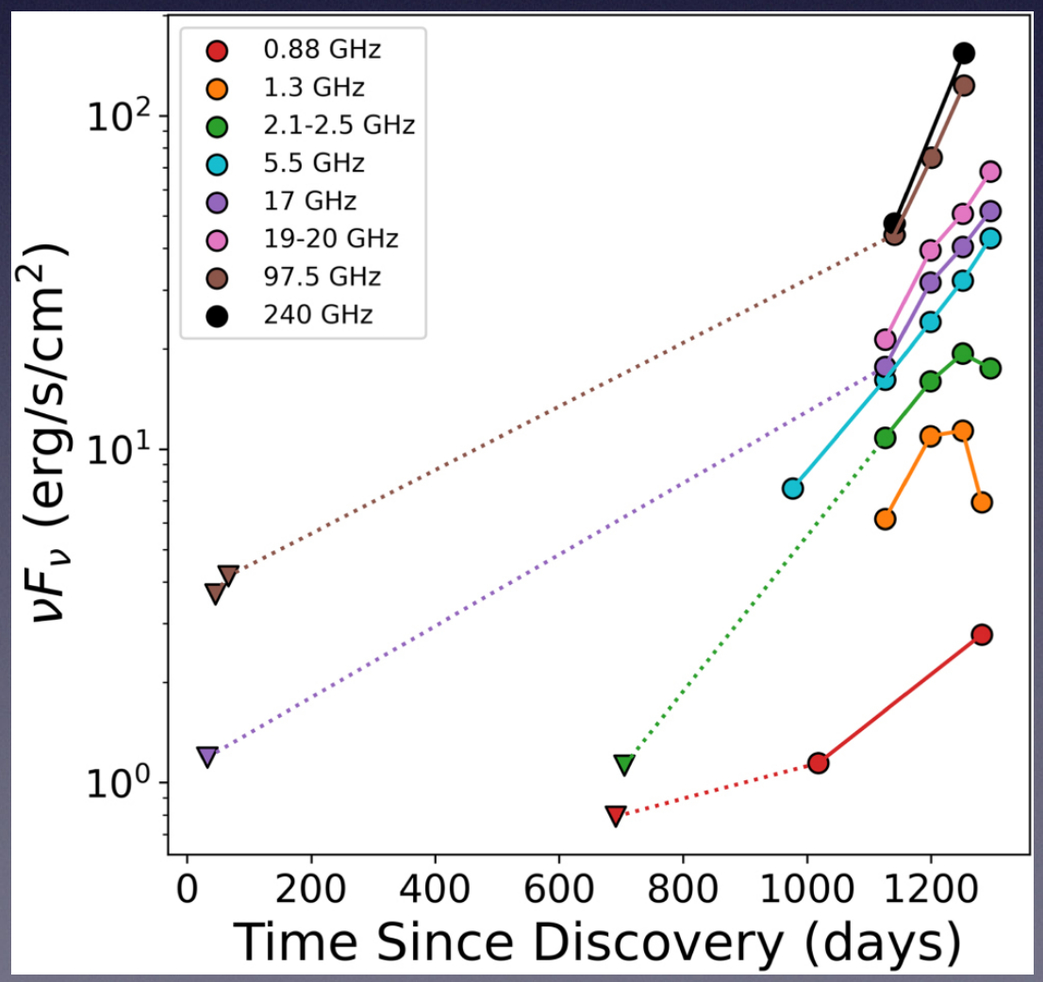
Short Term Variability



Confirmation by other teams

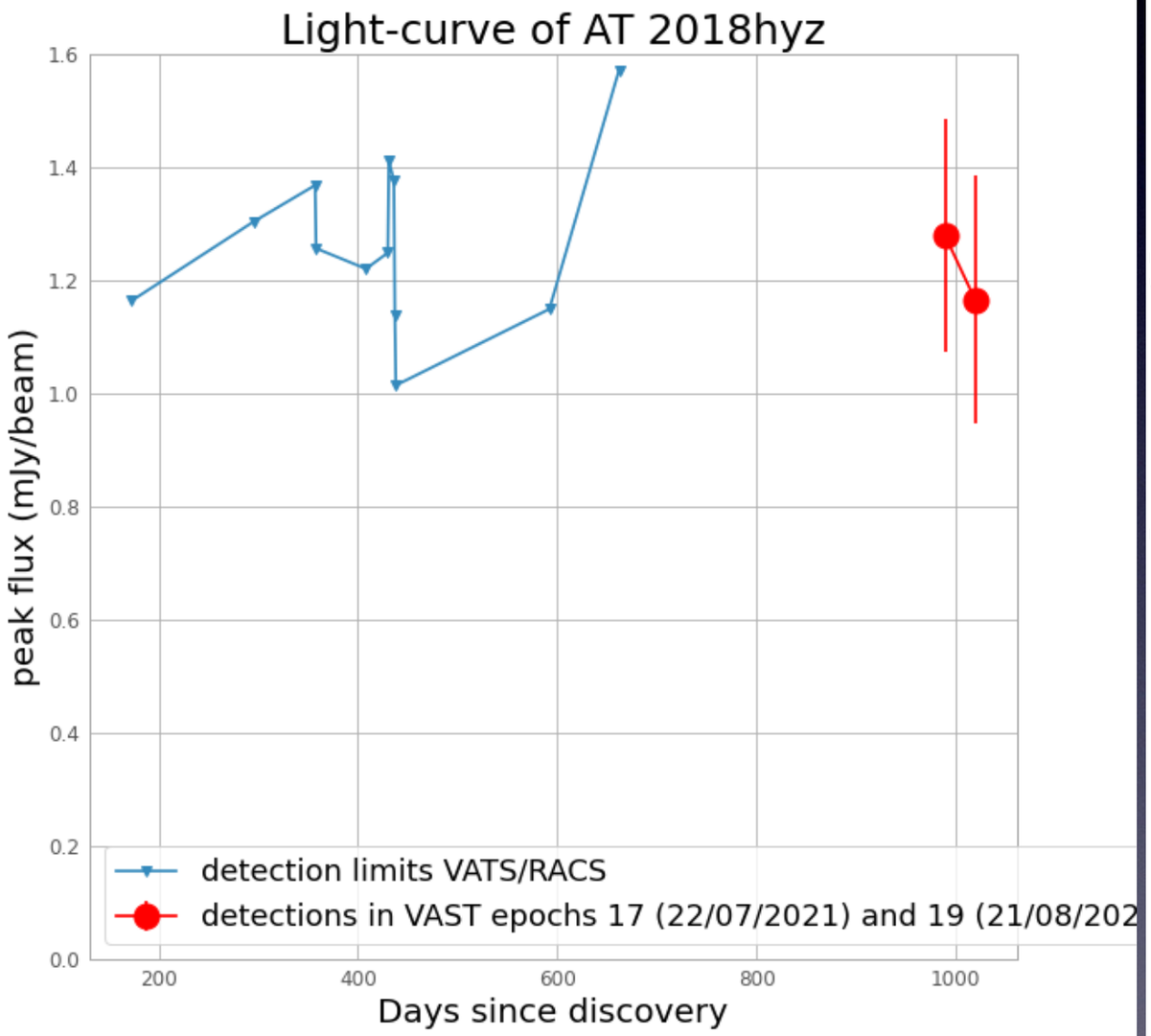


IGRJ1258 -
Perlmann et al. (2021)

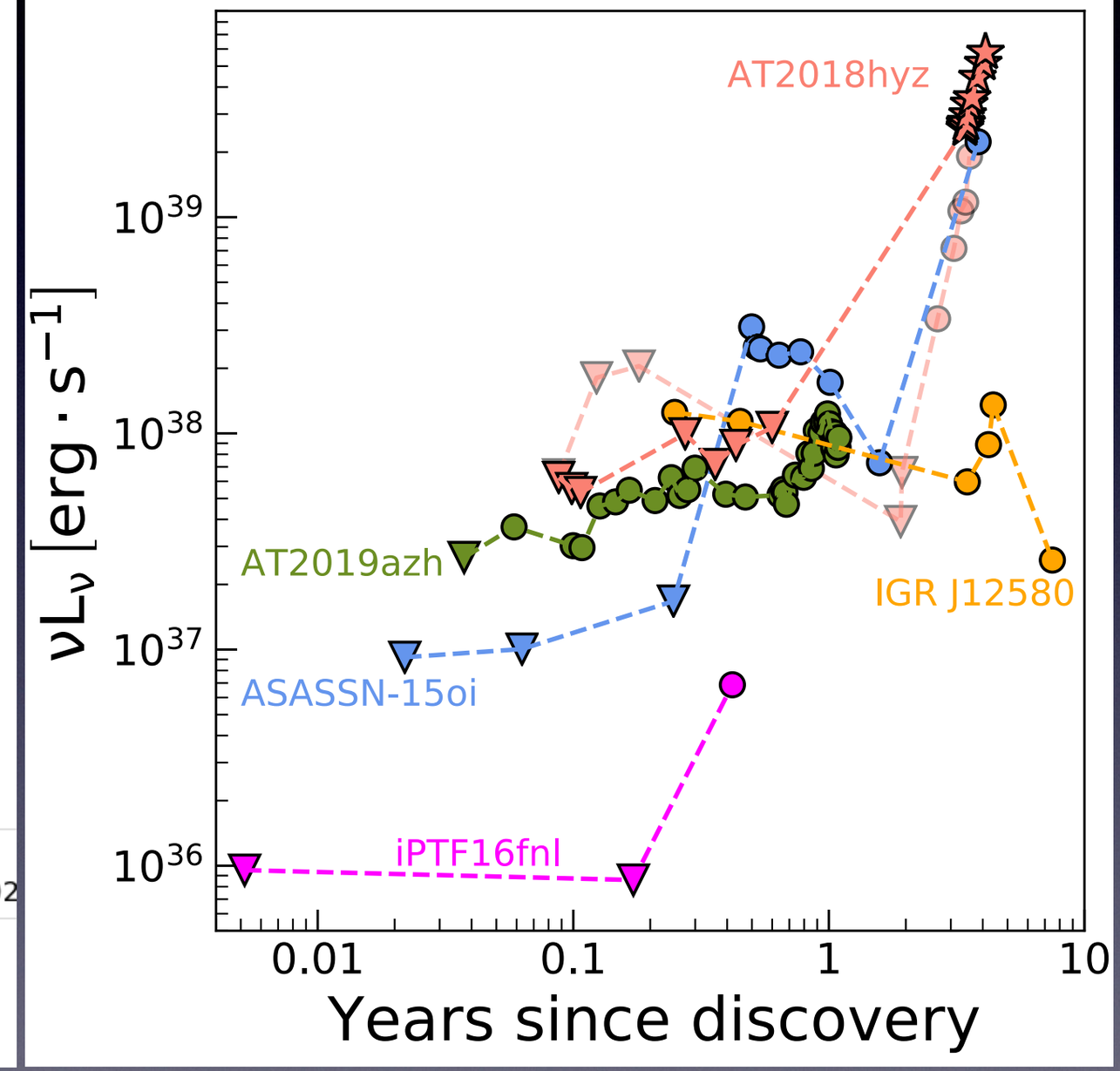


AT2018hyz
Cendes et al. (2022)

AT2018hyz

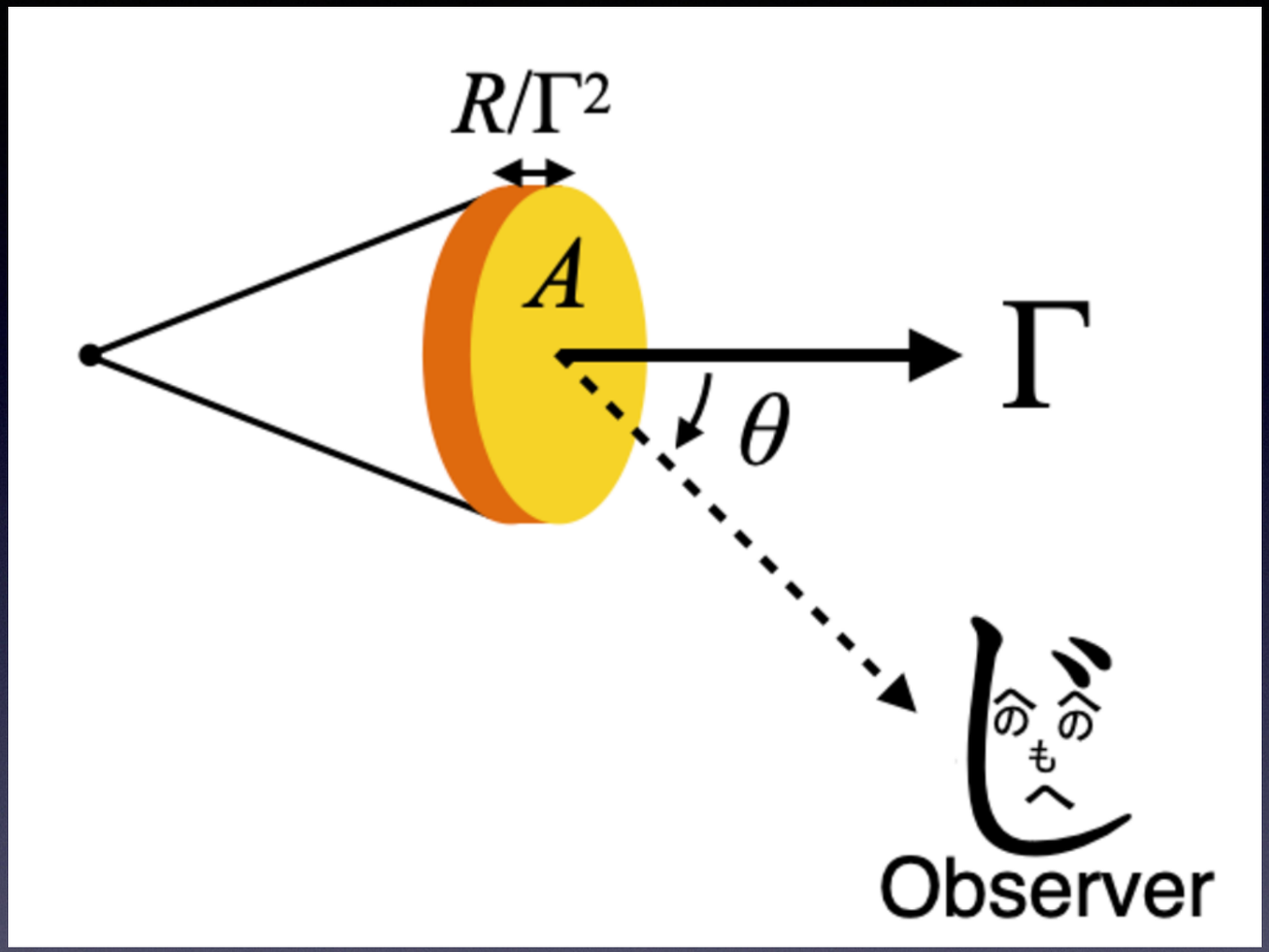


Detection in VAST,
A Radio Survey on the ASKAP Telescope
Horesh et al. (2022)



Followup Observations By the AMI Telescope (in prep)

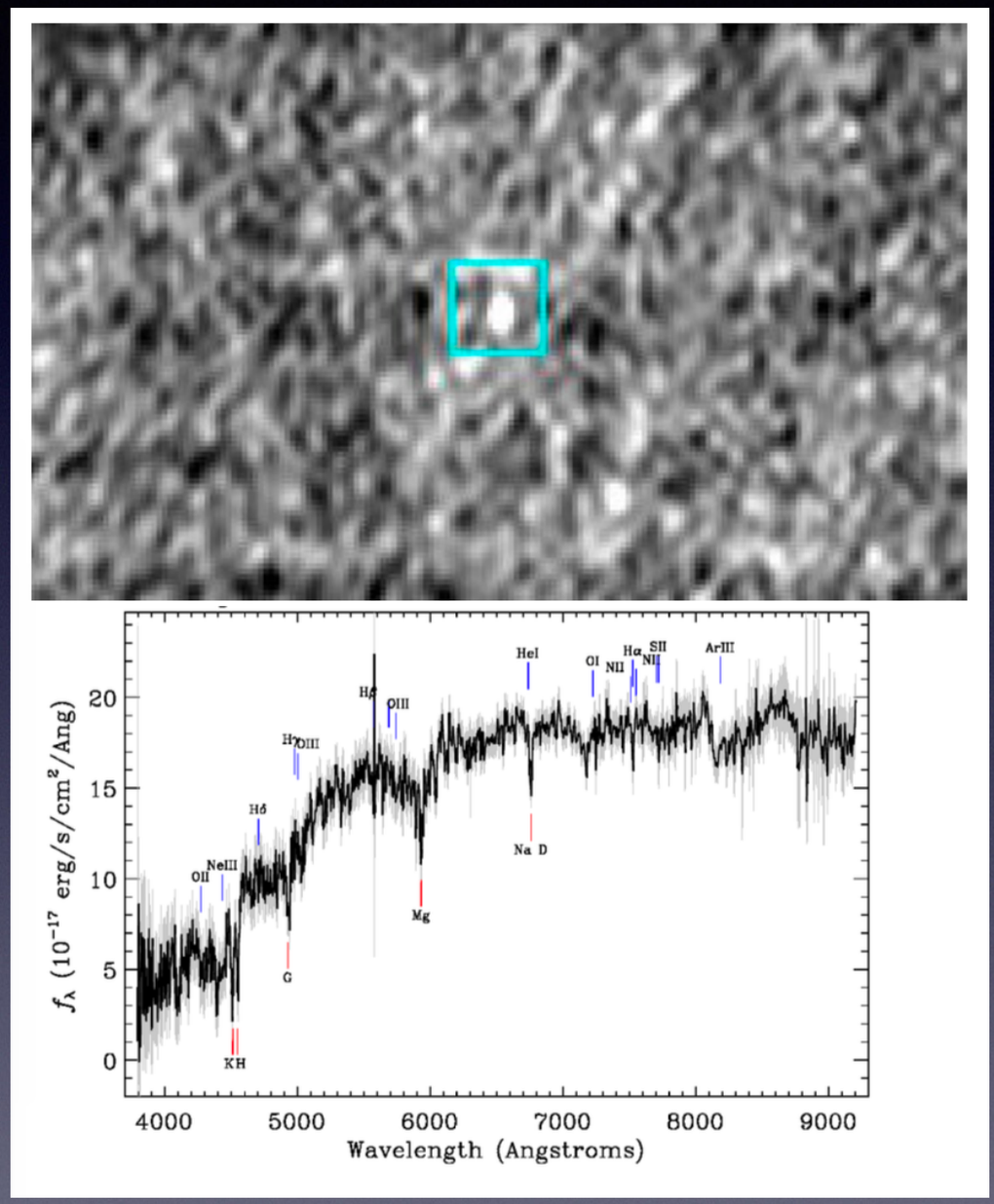
An Off Axis Jet?



Matsumoto & Piran (2022)

- May Work for AT2018hyz
- Does **NOT** work for ASASSN15oi, AT2019azh

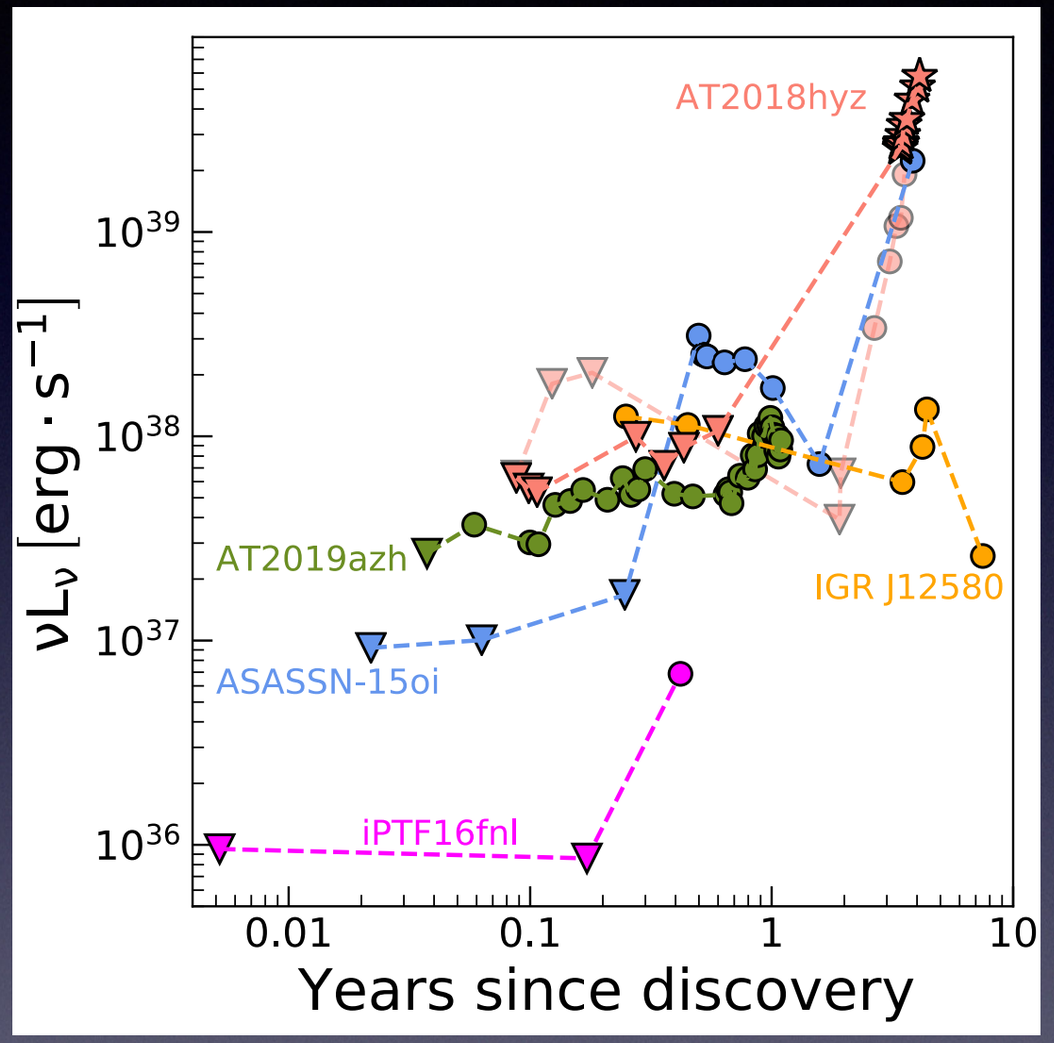
A Side Note



Compact weak radio sources - TDE relics?

Summary

- We uncovered a new phenomenon of delayed radio flares from TDEs
- Time scales - Some on a very specific time scale of ~ 200-300 days.
- Time Scales - Another prominent timescale is years after disruption.
- Multiple flares can occur.
- Some delayed radio flares may follow a delayed X-ray flare
- This phenomenon may be related to transition in accretion states (similar to XRBs).
- Some flares may be explained by an off-axis jet
- Some flares do require delayed outflow launching
- A live laboratory to study accretion physics and outflow (jet or otherwise) ejection



TO BE

CONTINUED...