Searching for Tidal Disruption Events with VAST

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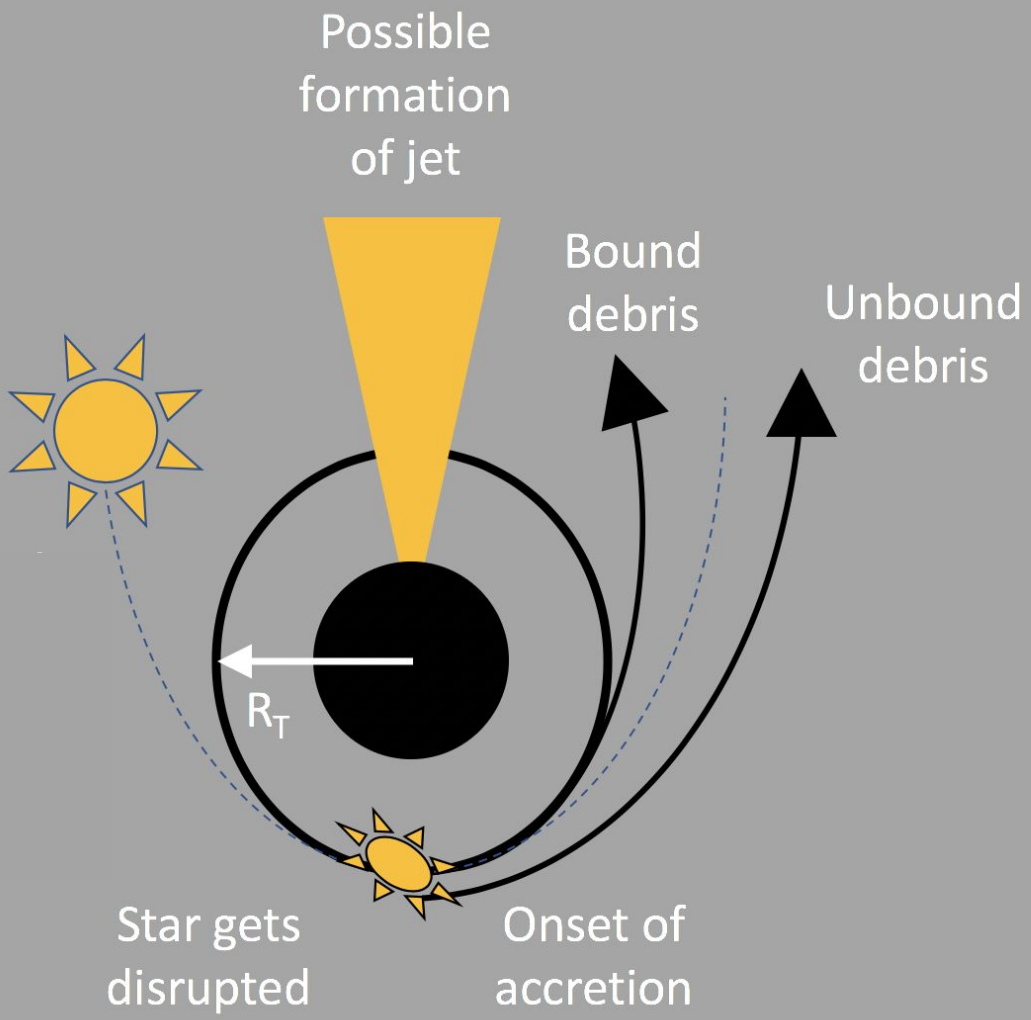
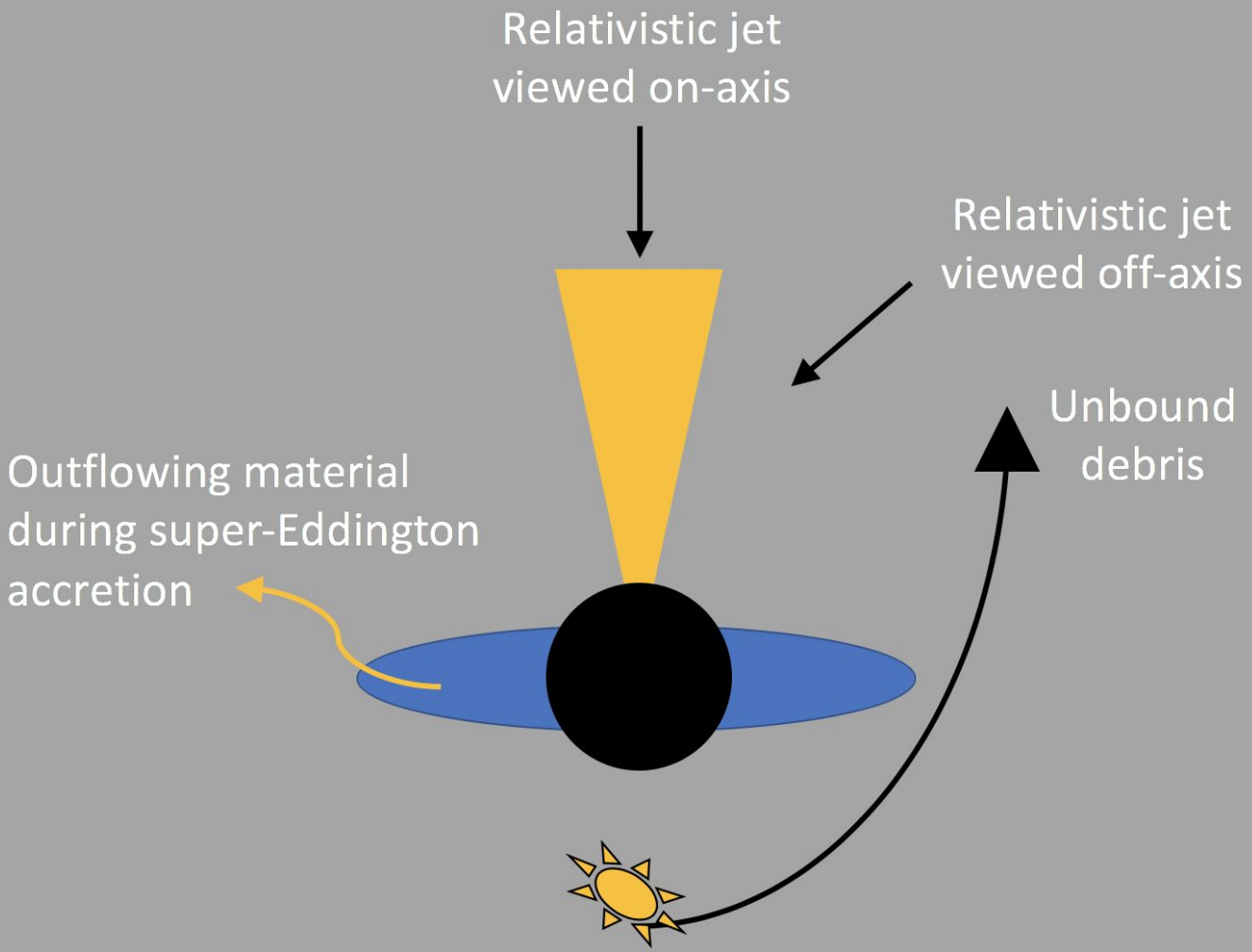
Image: Sophia Dagnello, NRAO/AUI/NSF

Tidal Disruption Event

When the tidal forces between a supermassive black hole and a star exceed the star's self gravity


Possible formation of jet
Bound debris
Unbound debris
R_T
Star gets disrupted
Onset of accretion


Relativistic jet
viewed on-axis
Relativistic jet
viewed off-axis
Unbound
debris
Outflowing material
during super-Eddington
accretion

Radio TDE Population

- Handful of TDEs with radio observations
- Only a few *discovered* in radio regime

Radio-discovered population

- Unbiased rate estimate of radio-bright TDEs
- Unique perspective on host galaxies

Variables and Slow Transients (VAST)

Upcoming ASKAP survey

- Observe ~10 000 square degrees of sky every day for ~2 years

Pilot version already complete

- 5,131 square degrees
- Central frequency of 888 MHz
- Typical image rms of 0.24 mJy/beam−1.
- 21 epochs over ~2 years

Image: CSIRO

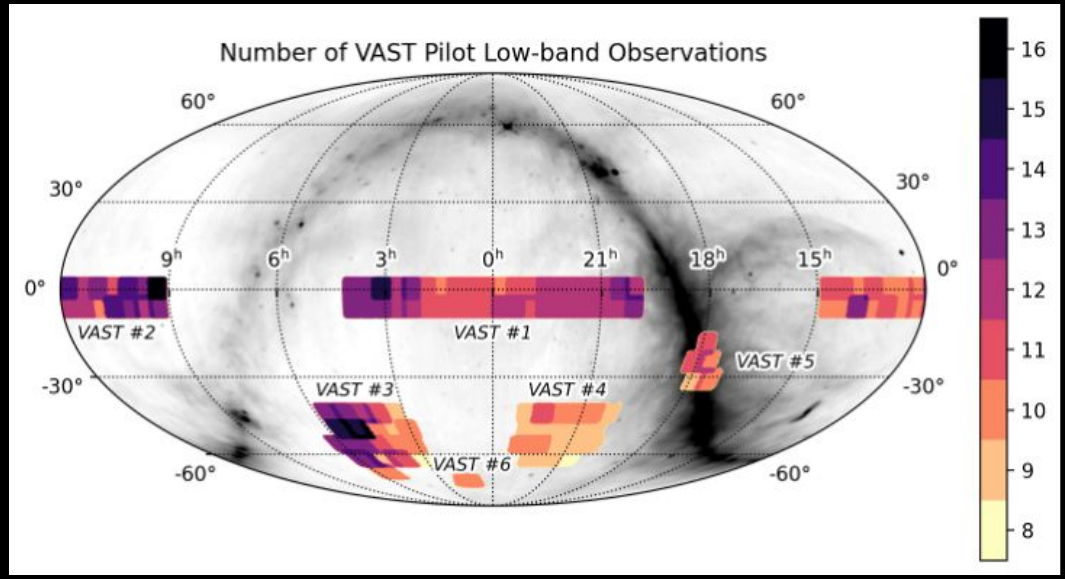
What would a TDE look like in the VAST Pilot?

TDE Simulation

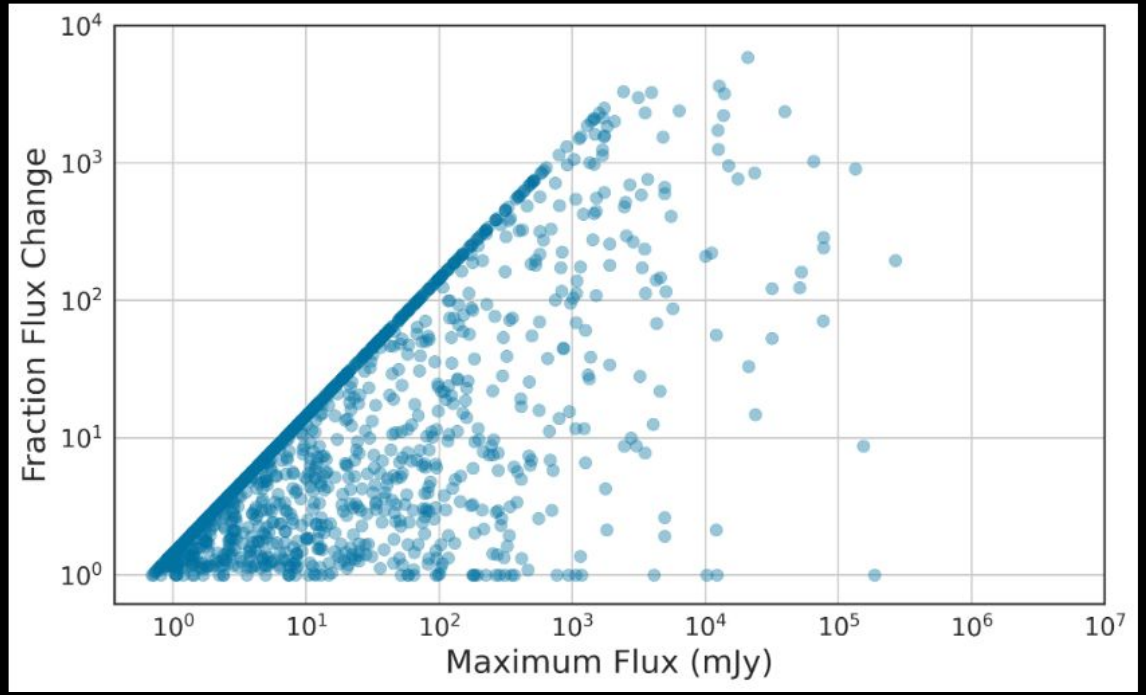
Simulate TDEs over range of

- Distance
- Explosion time
- Explosion energies
- Surrounding densities
- Location in sky
- Jetted or not

Project onto the VAST Pilot cadence and sensitivity.

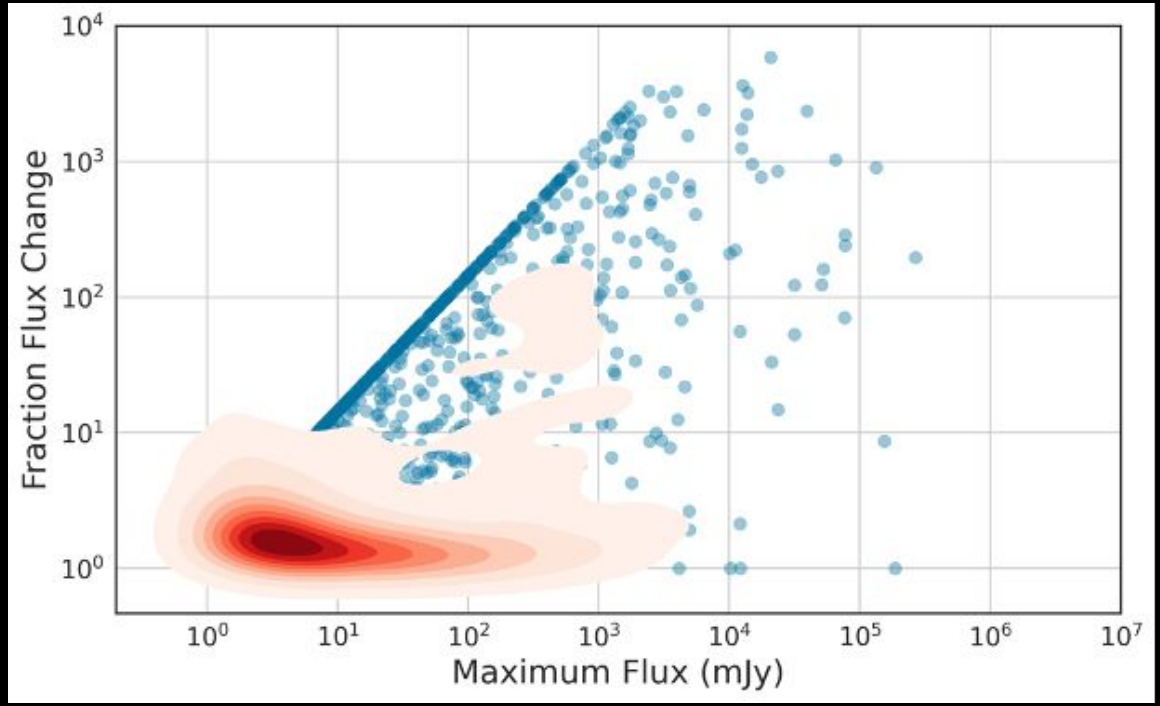


TDE Simulation



Modeled TDEs

TDE Simulation Comparison with AGN



Modeled TDEs

Known AGN

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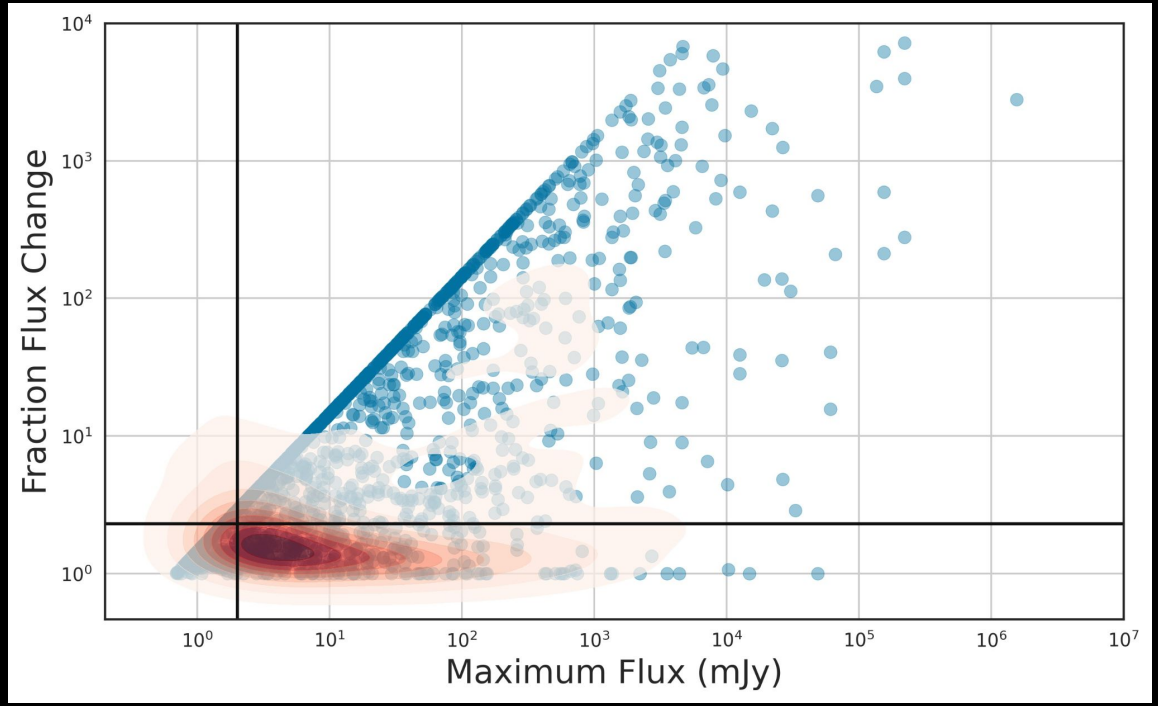


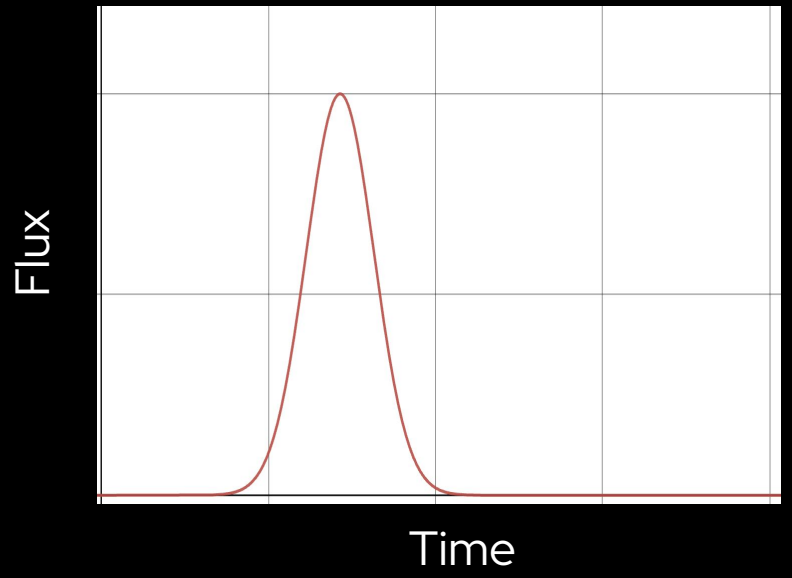
Modeled TDEs

Known AGN

Differentiating Lightcurves

Possible light curve morphologies

- **Flare from a quiescent galaxy**
- Repeated variability
- Dominant flare with underlying radio emission



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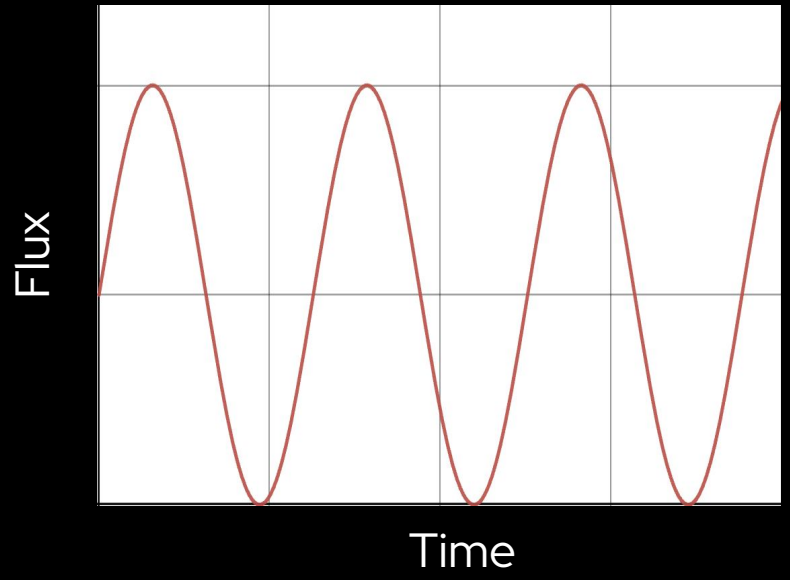

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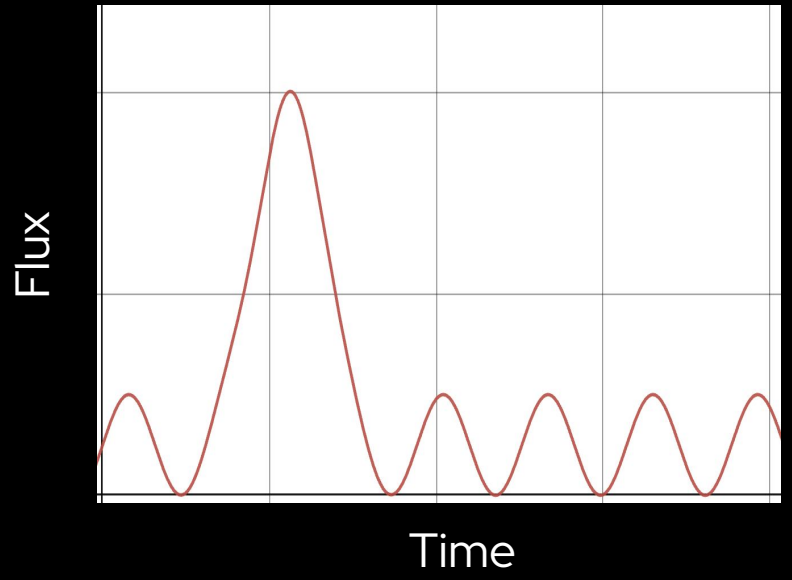

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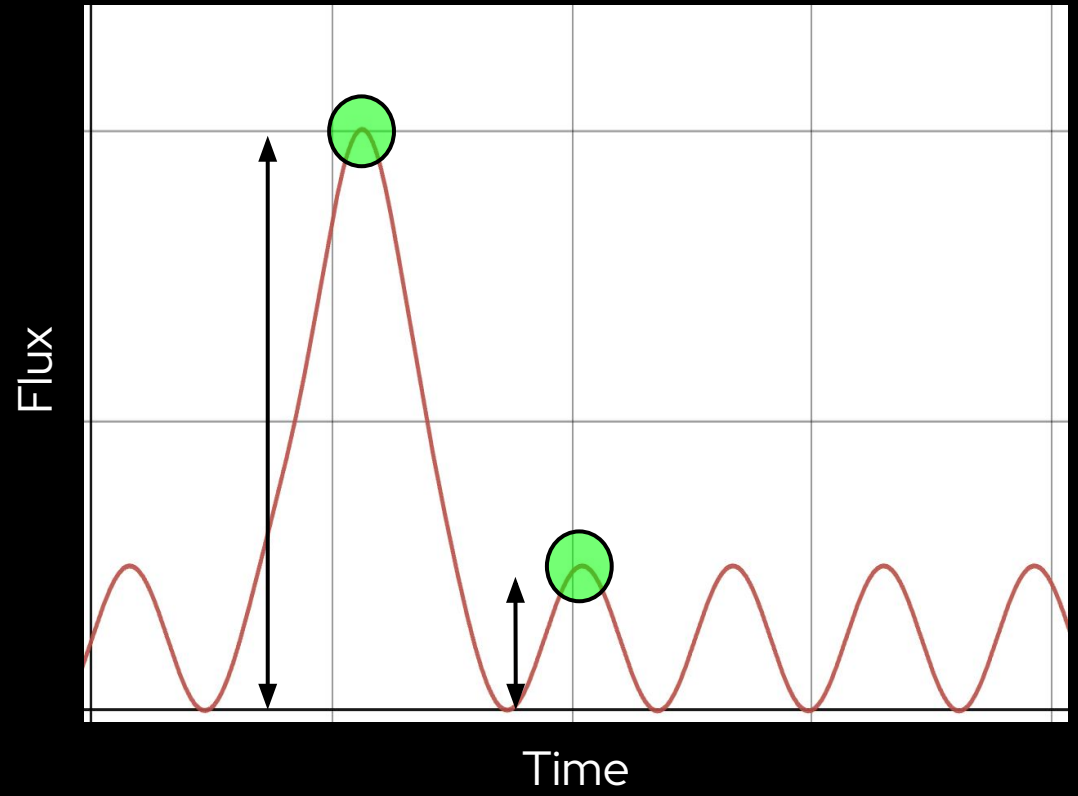
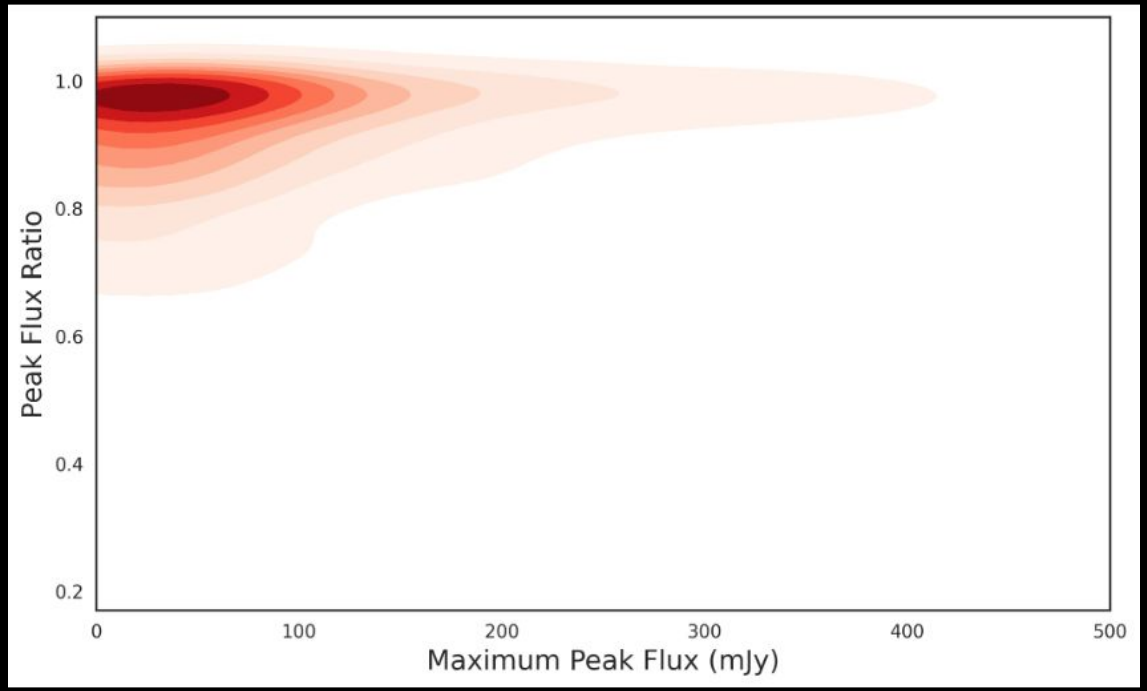


Peak Flux Ratio:

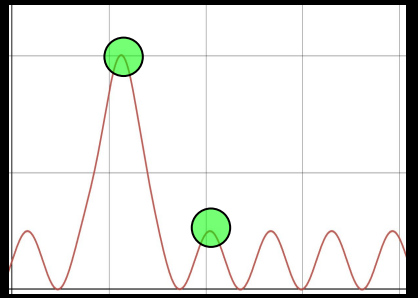
$$\frac{\textbf{Highest peak}}{\textbf{Second highest peak}}$$

Differentiating Lightcurves



VAST TDE Candidates

Known AGN



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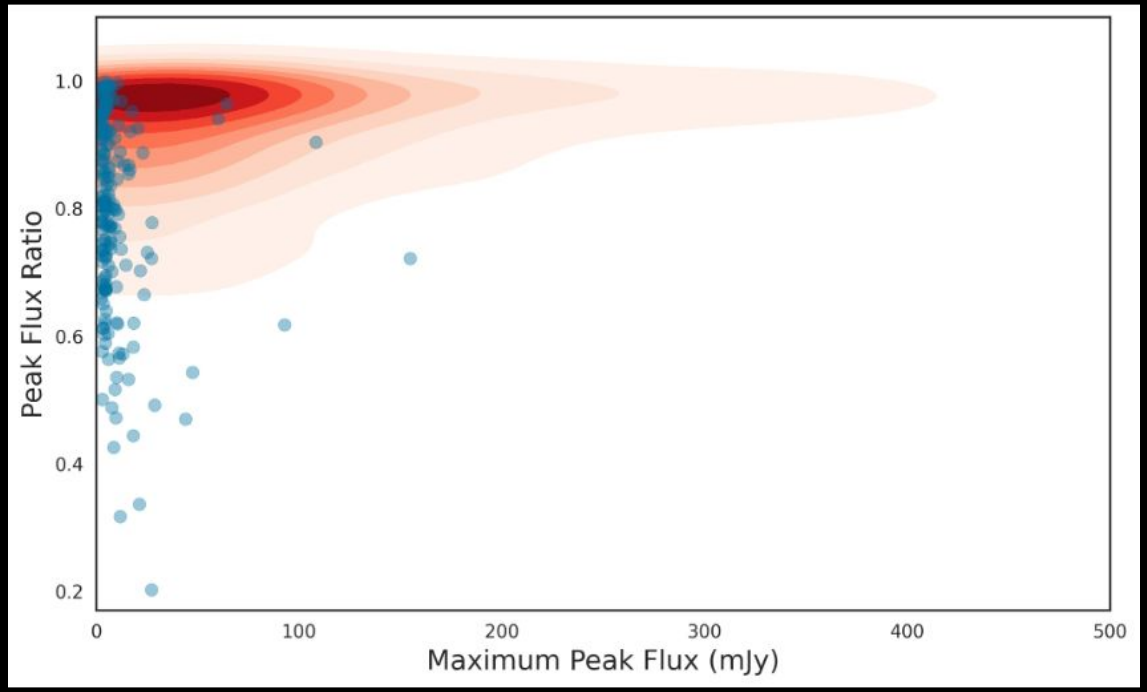

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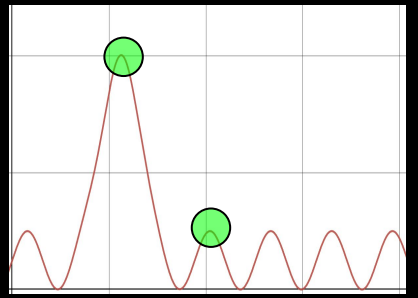

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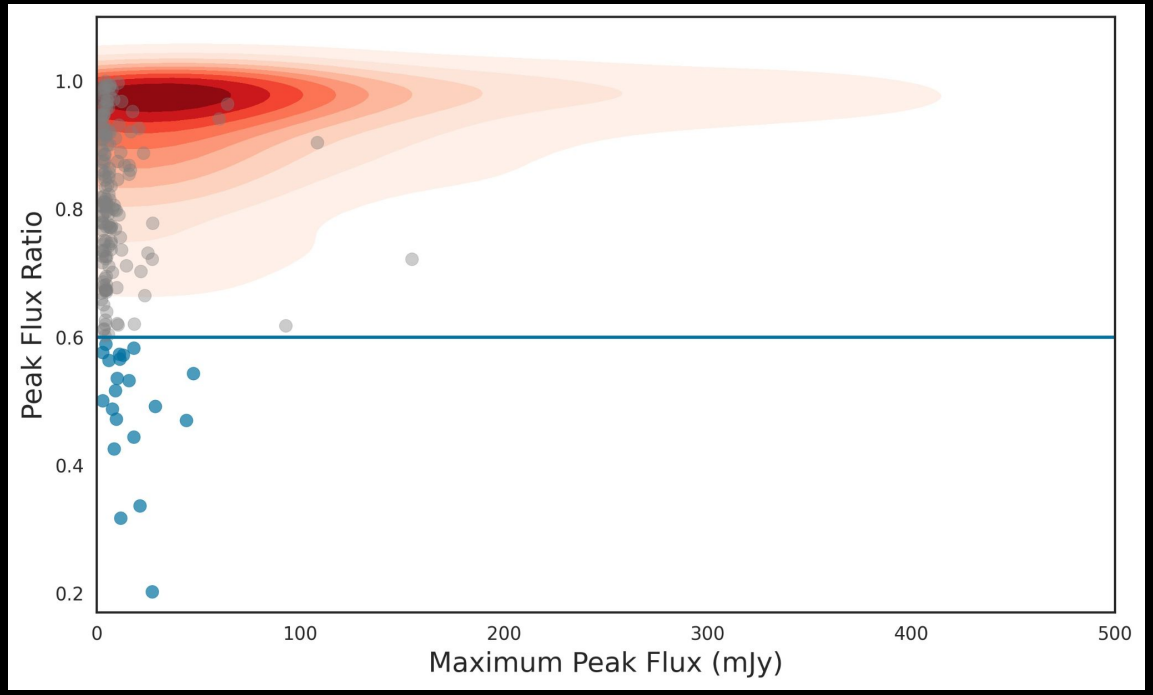

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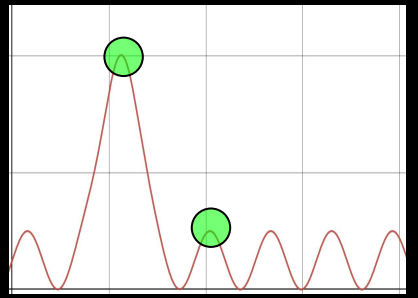


Candidate Selection

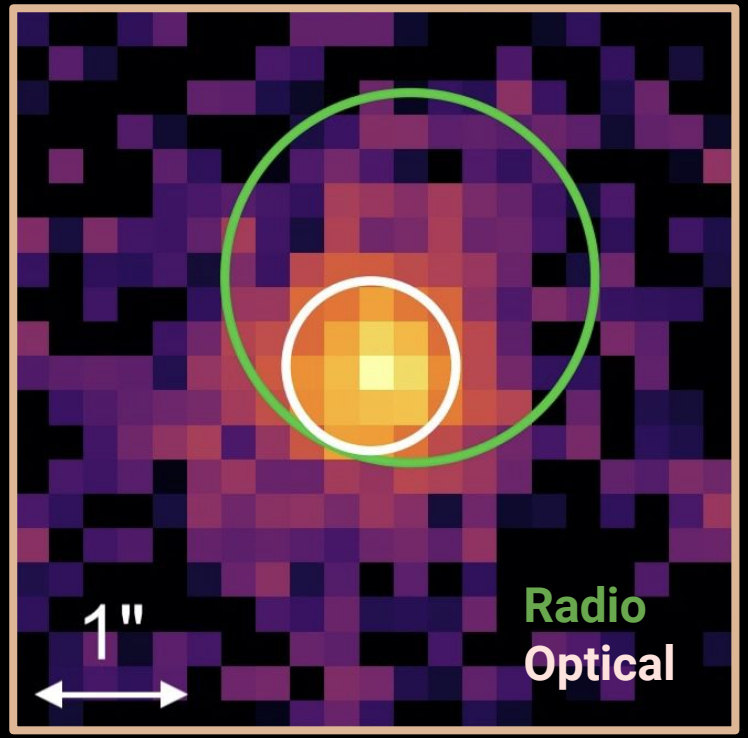
Selection Criteria

- Radio Variability
  - Varies by a factor of 2
  - T-statistic above the 95% confidence interval
- Lightcurve morphology
  - 1 significant flare

Selection Criteria

Coincident with Galaxy Nucleus

- Cross check with SDSS, Pan-STARRS, DES, Skymapper
- Require VAST position within 2 combined sigma of optical centroid



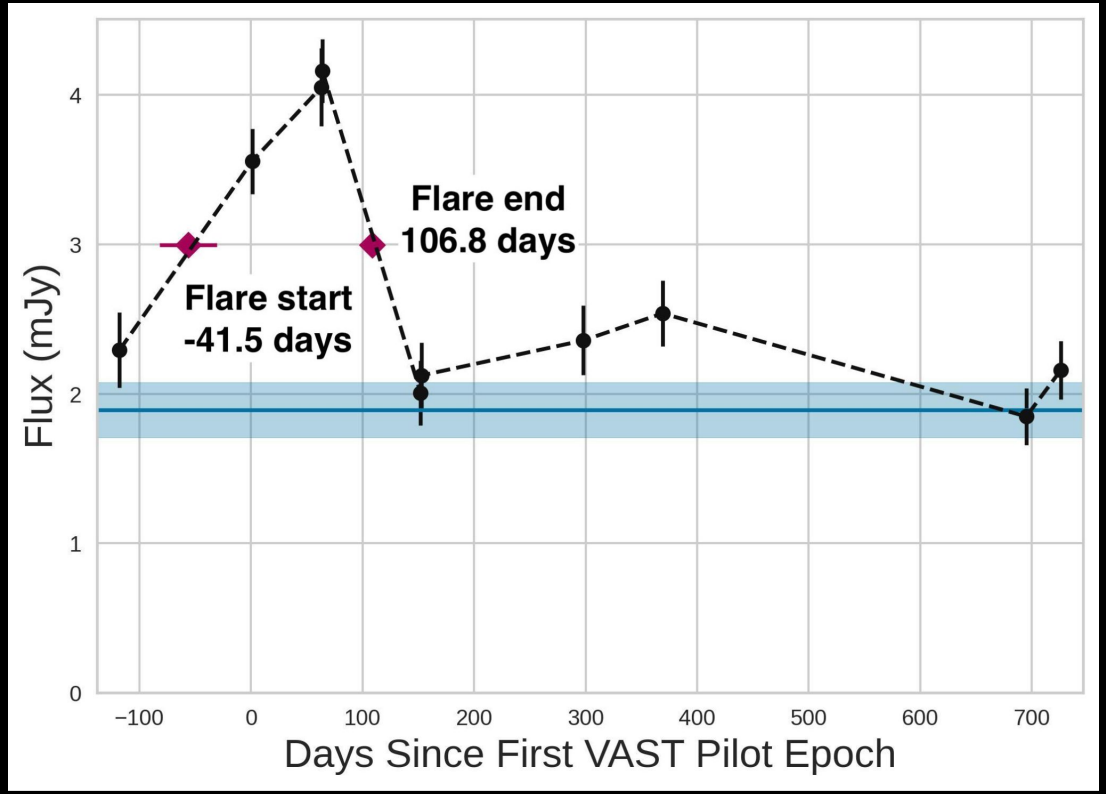
Properties of Candidates

Radio Light Curves

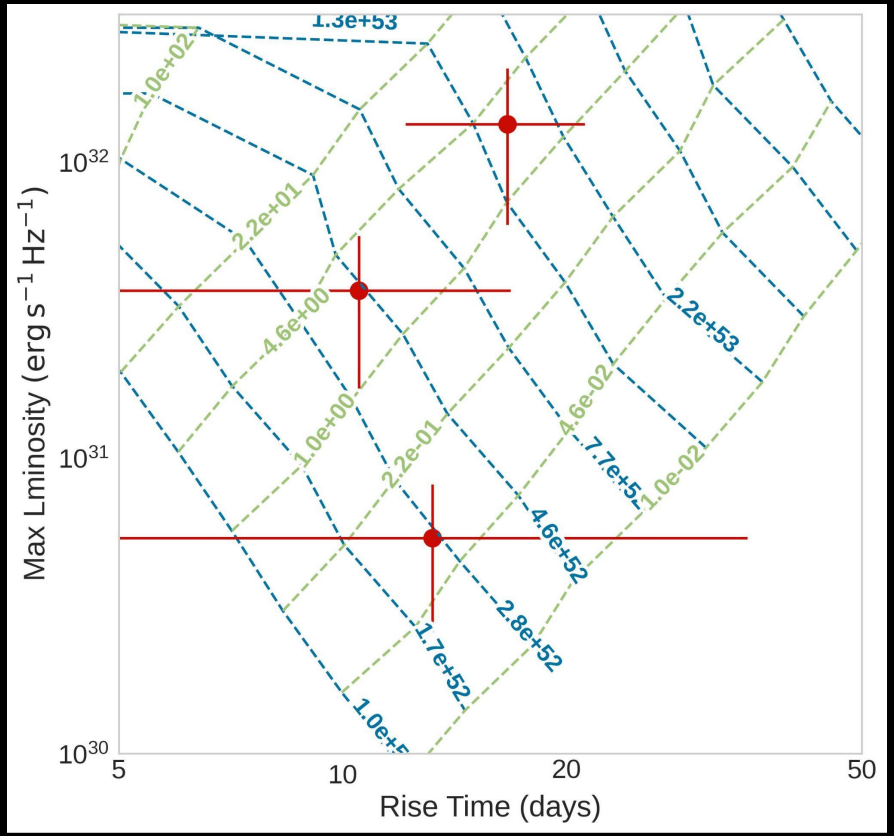
- Want to compare candidates to model TDEs
  - First fit for any underlying quiescent flux
  - Extract estimates for peak flux and time-to-peak
  - Compare to models of various energies and densities

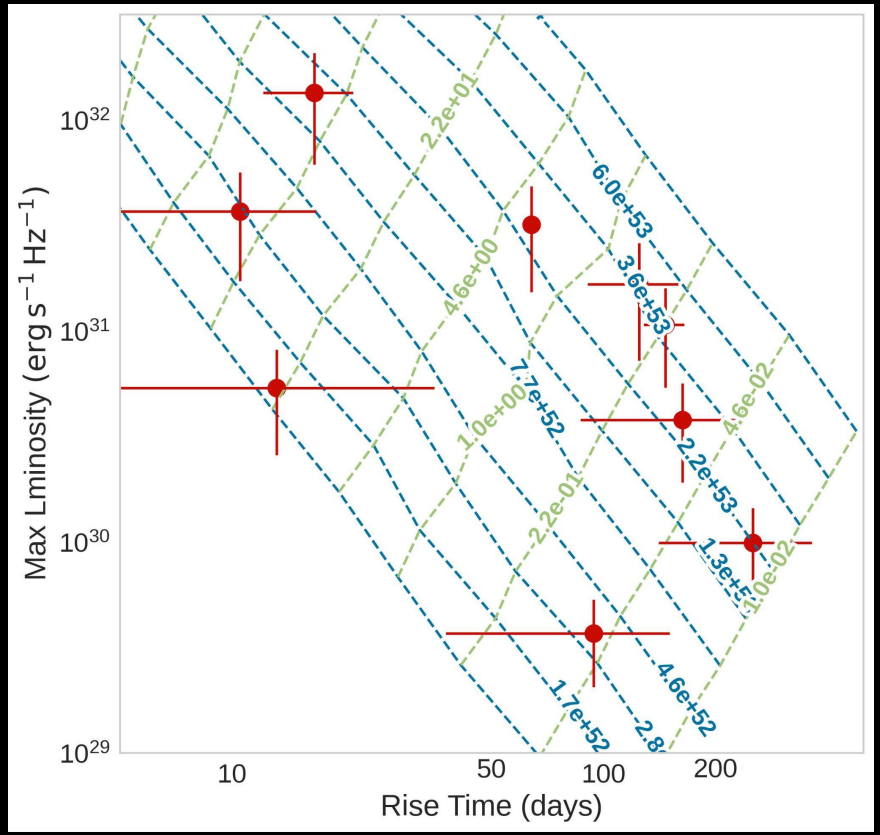
Radio Light Curves

Calculate rise time and peak luminosity of sources in sample



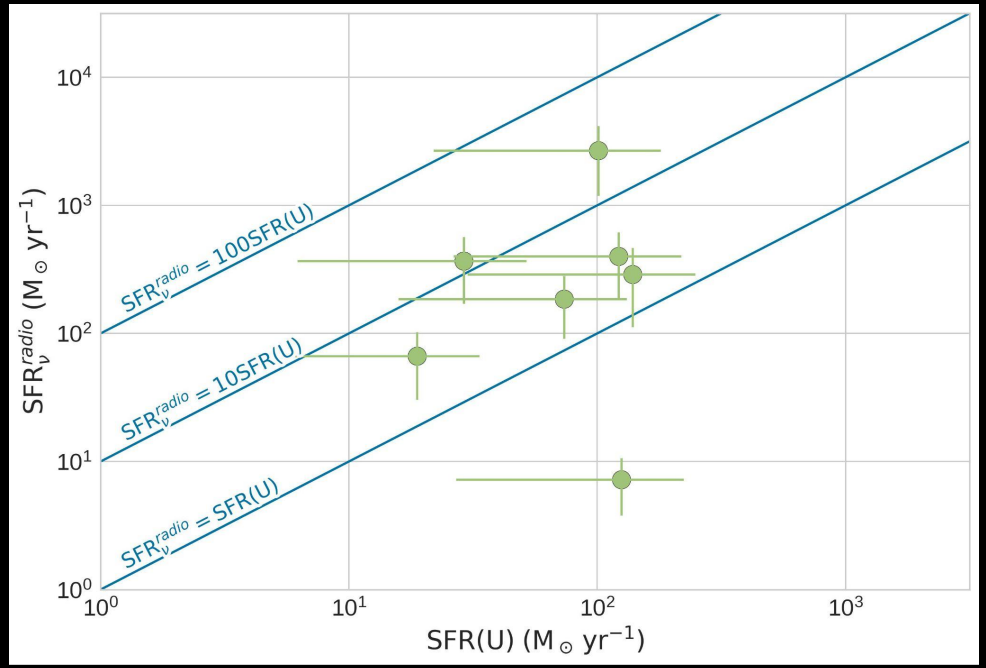
Radio Light Curves





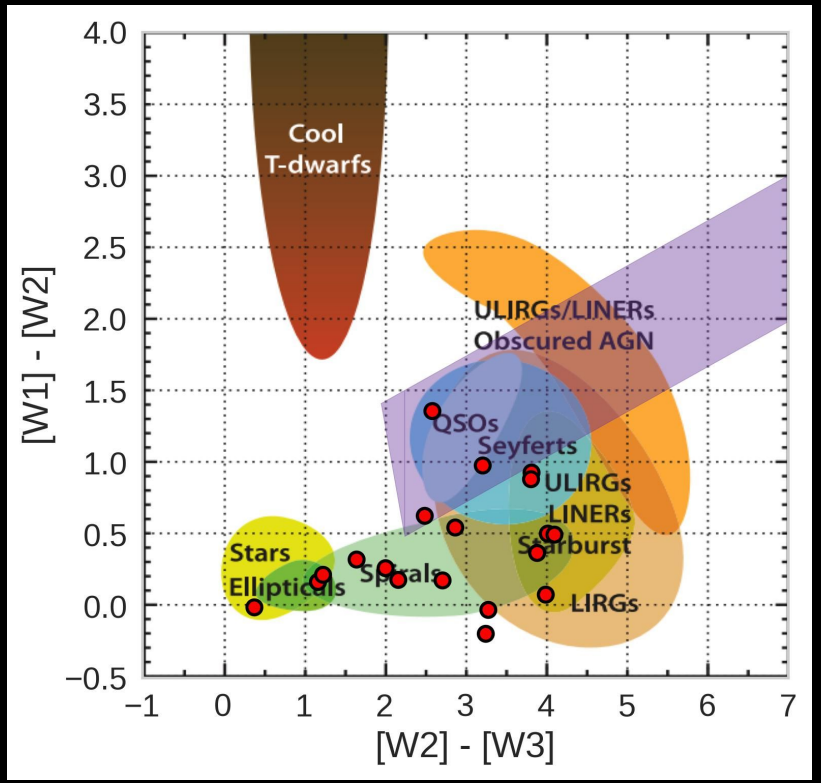
Host Galaxy - Star Formation

Can calculate star formation of host galaxies using optical magnitudes and quiescent radio flux



Host Galaxy

Infrared colours from WISE help to classify host galaxy



Volumetric Rates

- Using our final sample size can compare to percentages we expect to detect from simulation to recover physical rates
- If every source in our sample is a TDE: ~4 $Gpc^{-3}\,yr^{-1}$
  - Theoretical estimate for off-axis jetted TDEs: 10 $Gpc^{-3}\,yr^{-1}$
  - Observed estimate: 1 $Gpc^{-3}\,yr^{-1}$

Summary

- The VAST Pilot from ASKAP provides a new opportunity for a radio-identified population of TDEs
- We generated a simulated population of TDEs to know what to look for and how many to expect
- We chose selection criteria based on identifying as many TDEs as possible while minimizing contaminants from AGN