Observations of Swift J1644+57 and Implications for short-duration Transients

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ASTRONOMICAL INSTITUTE
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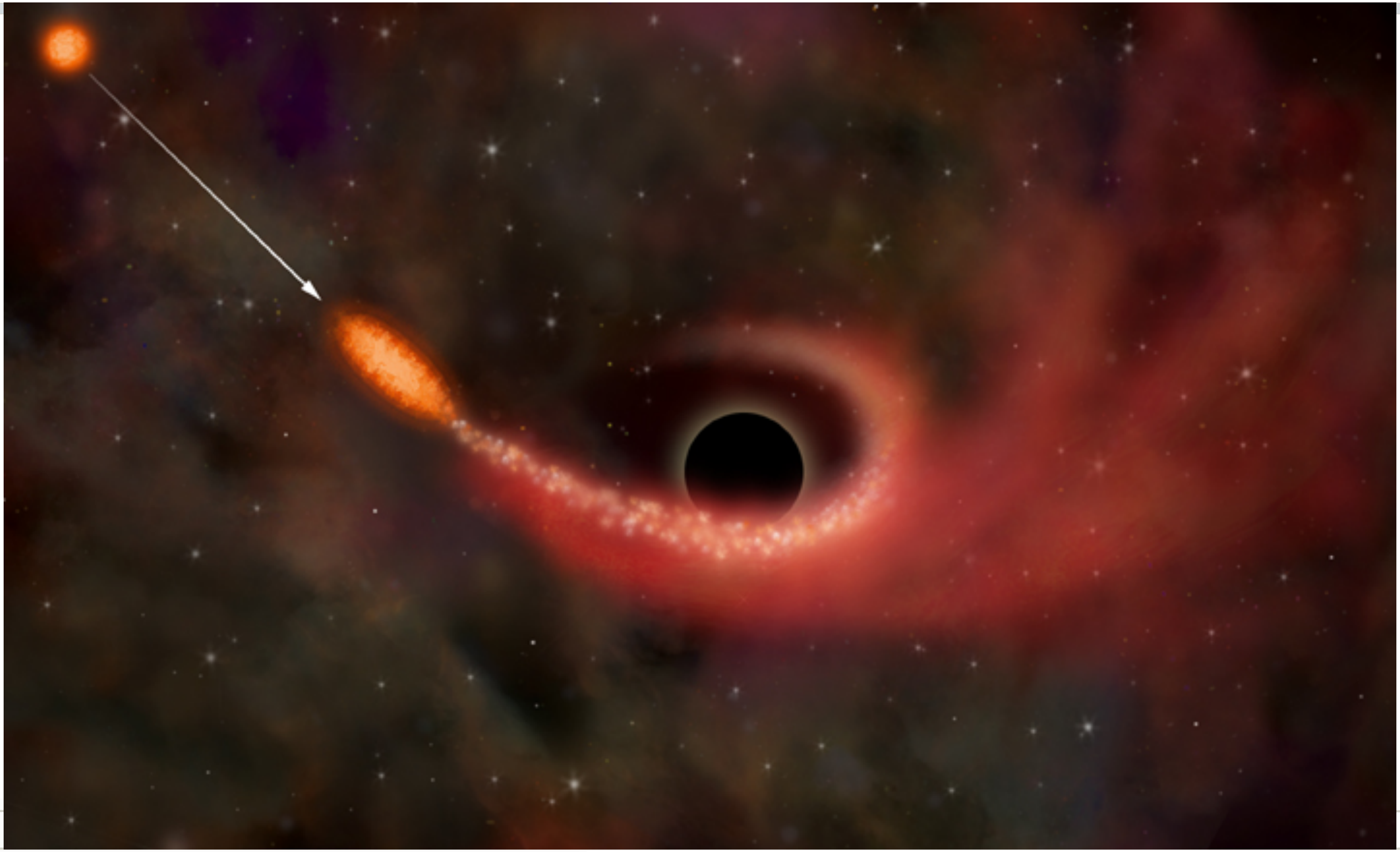
What are TDEs?



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Swift J1644+57

- Swift J1644+57 was first detected in March 2011 in gamma ray wavelengths
- Located near the center of a compact galaxy at z = 0.35
- Bright radio fluctuations observed on scale of months in GHz (Zauderer et al, 2011), believed to be from relativistic outflows pointed towards Earth
- Observations up to 600 days after the event indicate the jet has since turned off

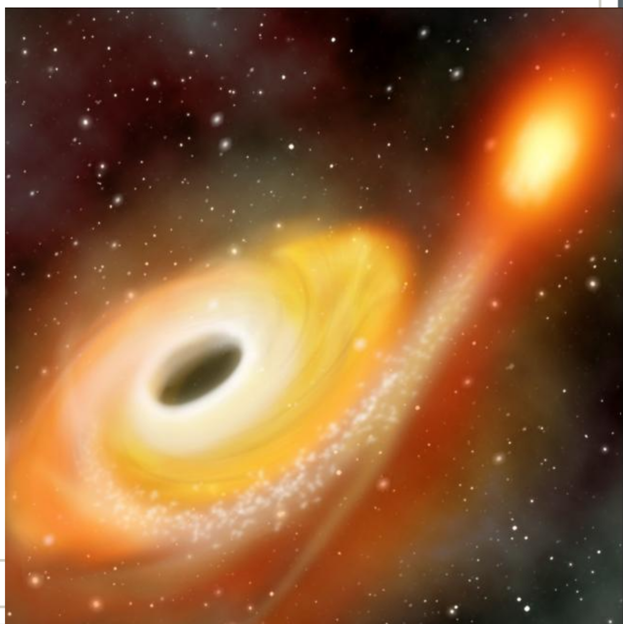


Image credit: LSST

At Low Frequencies

- Can place additional constraints on physical parameters of shock waves, magnetic fields, etc
- Rough estimates @150 MHz (based on Berger et al, 2012) predict a TDE peak >10 years after initial event, ~0.2 mJy brightness lasting several years
- If relativistic wind is highly magnetized, its interaction with the circumnuclear material could create brief (700 sec) pulses with a flux <100 Jy at low frequencies (Usov, 2000)

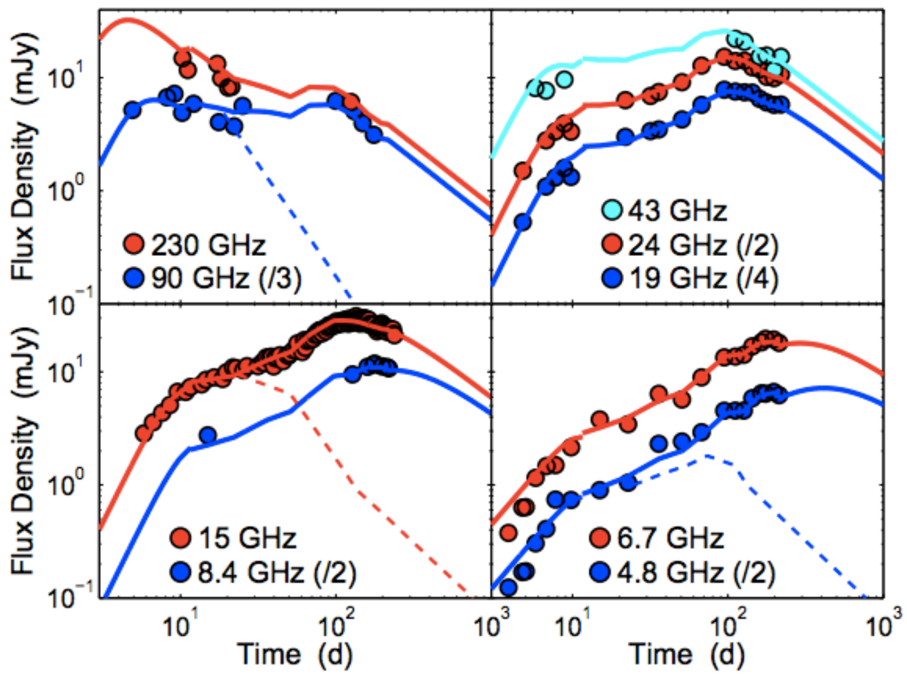
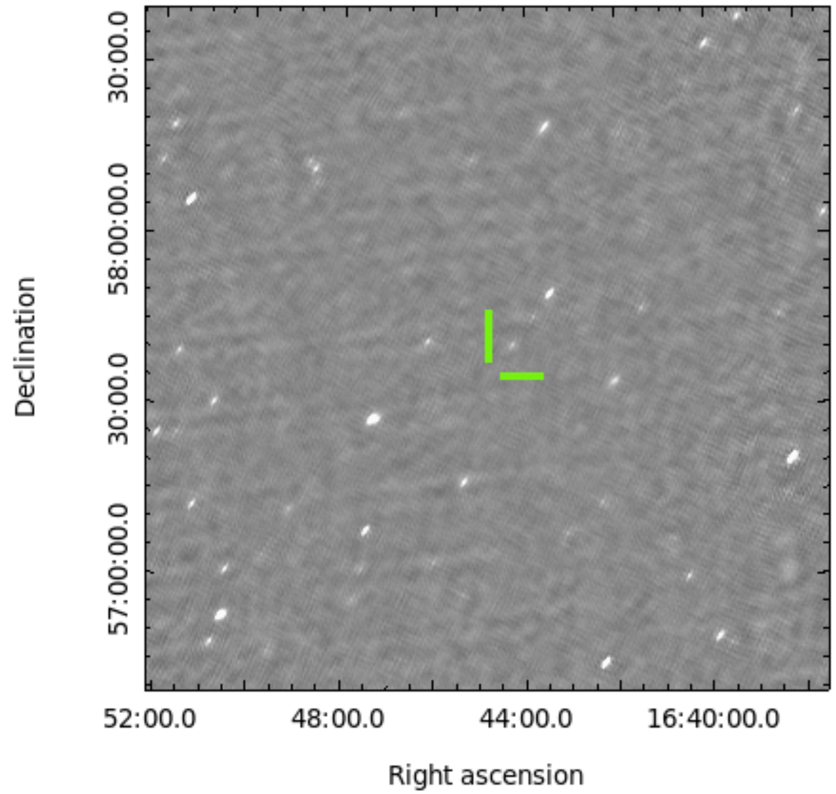


Image credit: Berger et al. 2012

LOFAR Observations

- An “extra target” during RSM observations from Feb- July 2013 @ 149 MHz
- All together, 4 hours of data used, stacked to make one image
- Peak flux density at TDE position is 24.7±8.9 mJy, using forced fit of a point source in PySE



What about RFI Flagging Effects?

- If we had a short duration transient from the TDE, could this be flagged out by automated flagging processes?
- Transient source looks like a quick burst of radiation, similar to what a computer algorithm classifies/flags as RFI
- This means a transient signal may be flagged out by the software at the observatory before the observer looks at the data

Overview- The AOFlagger

- Default automatic flagging method used by LOFAR
- Works with amplitude information of one polarization of a single sub-band
- It relies on thresholding, where cutoffs depend on their surrounding signal levels

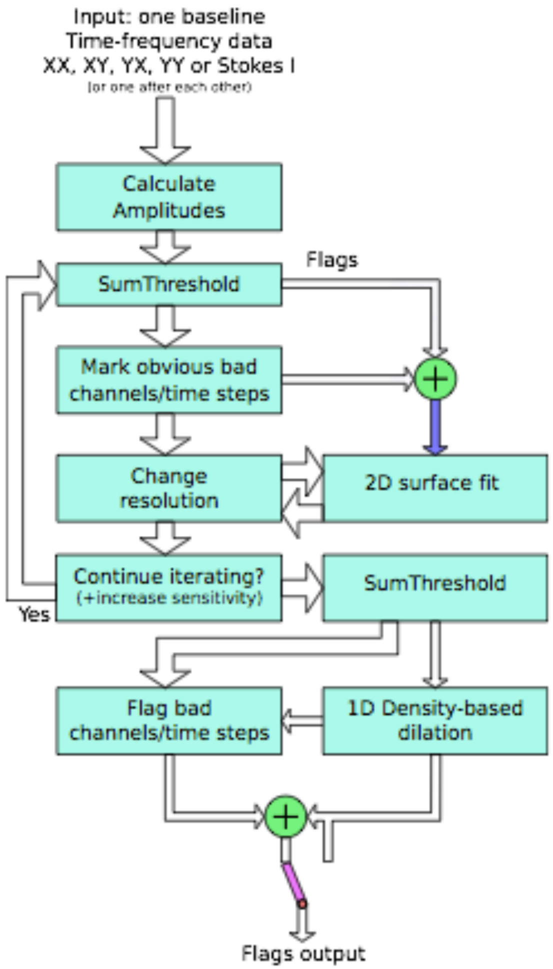
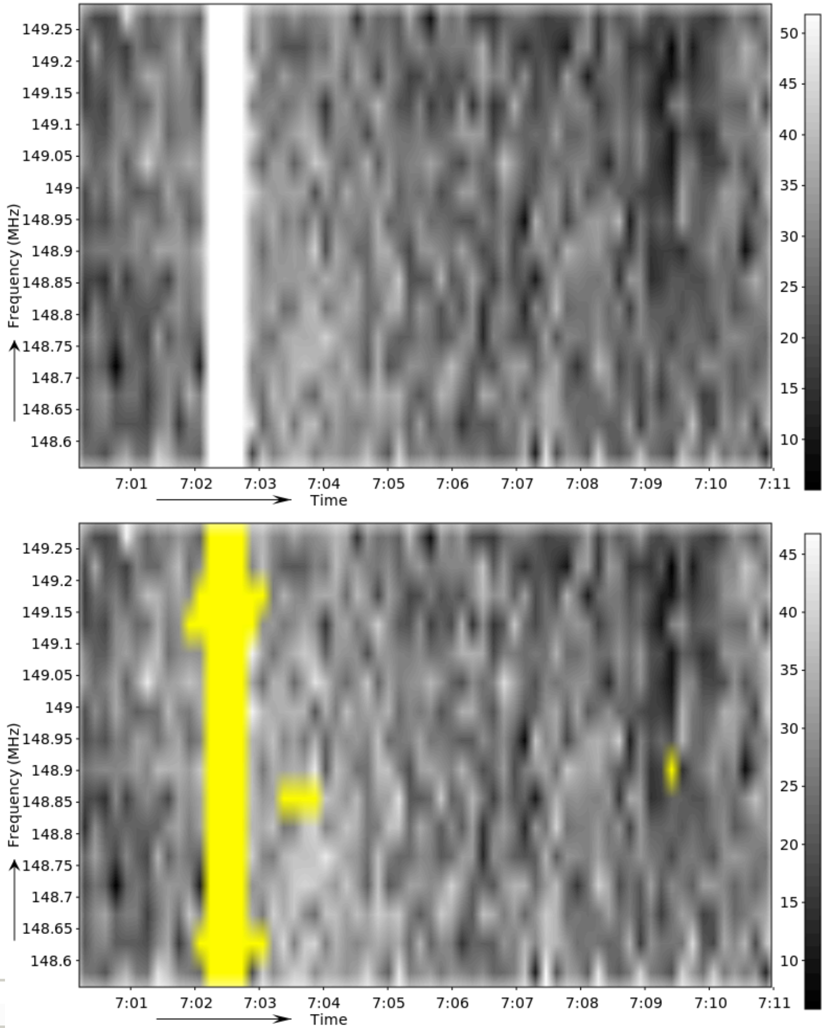


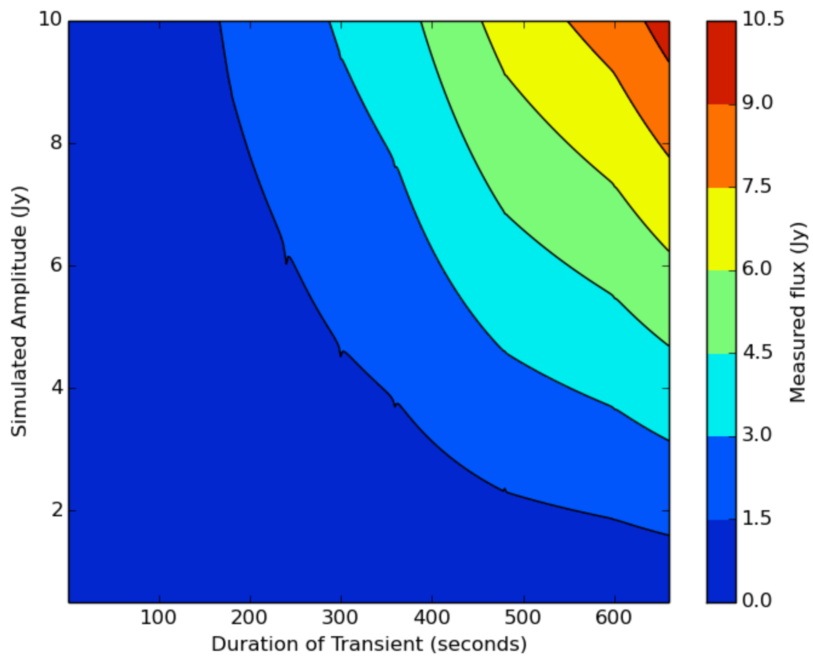
Image credit: Offringa et al.

RFI Flagging Example



Simulations

- In order to test what a transient signal would look like in the data, we injected transient signals with a "top hat" shape of given amplitude, duration into the data
- Data was then processed as usual
- Flux was measured at location of the transient in the image



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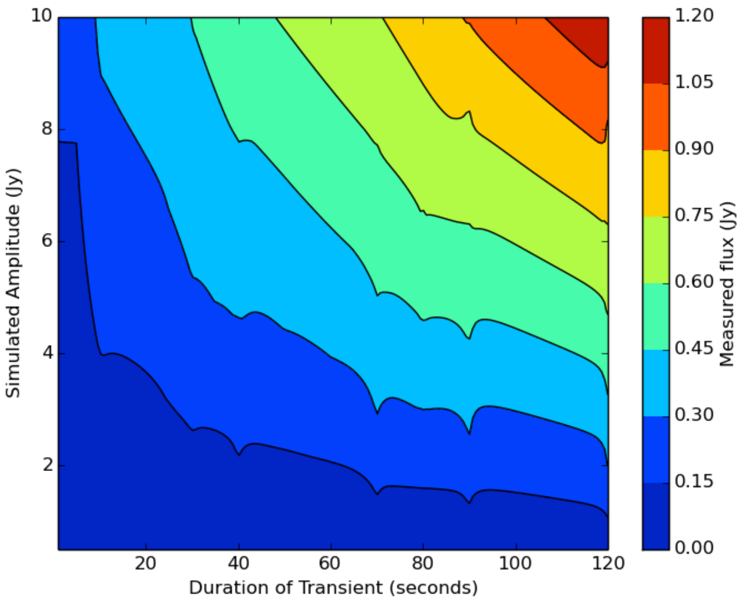
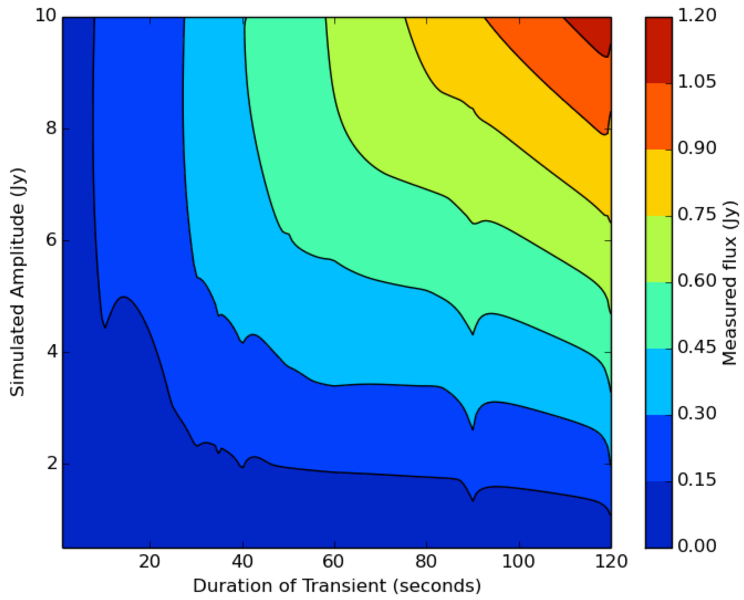


Unflagged Data



Flagged Data

Simulation Results

- When running the flagger, what happens depends on the duration (Δ t) of the transient:

$\Delta t < 10$ sec	10 sec $< \Delta t <$ 120 sec	$\Delta t < 120$ sec
FLAGGED	Partially **FLAGGED**	Unaffected

➢ *Right now, the briefest transients are likely flagged out when using AOFlagger*

Estimating Transient Rates

- Data was run through the Transients Pipeline (TraP), with no detections throughout the field
- Assuming a Poisson distribution of sources in the sky, with area Ω_{tot}= 11.35 deg^2, we can use the relationship

$$P(0) = e^{-\rho\Omega_{tot}} = 0.05$$

- From this, we get a snapshot rate (ρ) of $\rho < 2.2 \times 10^{-2} \, deg^{-2}$

Estimating Transient Rates

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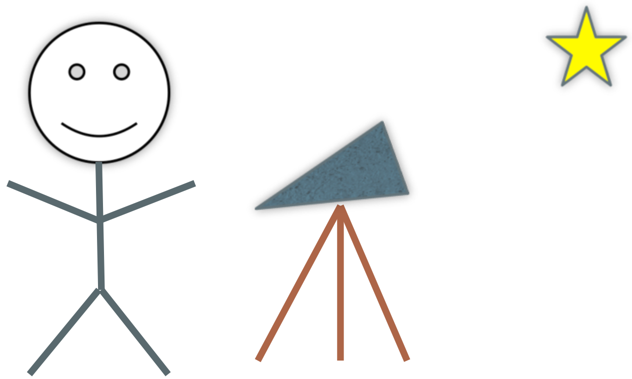

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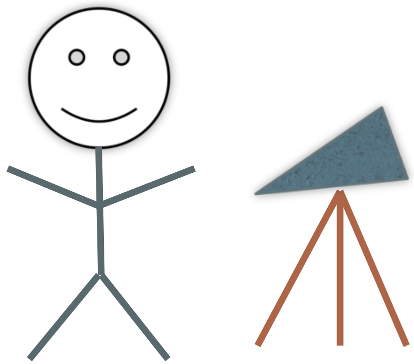

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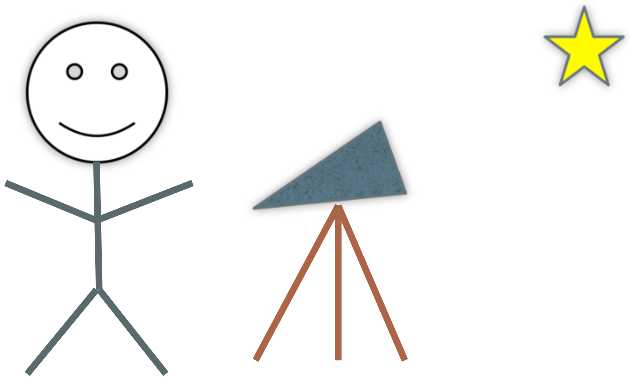

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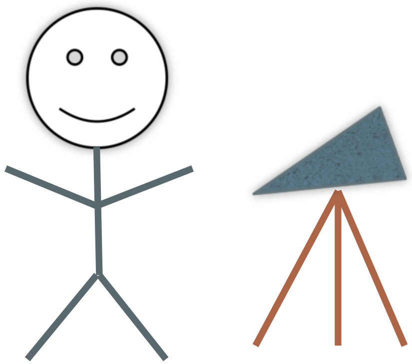
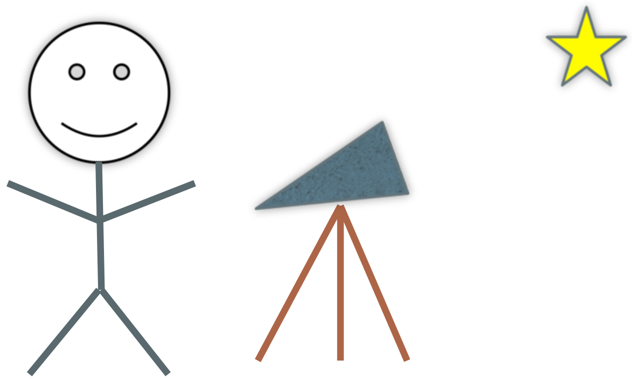


Estimating Transient Rates

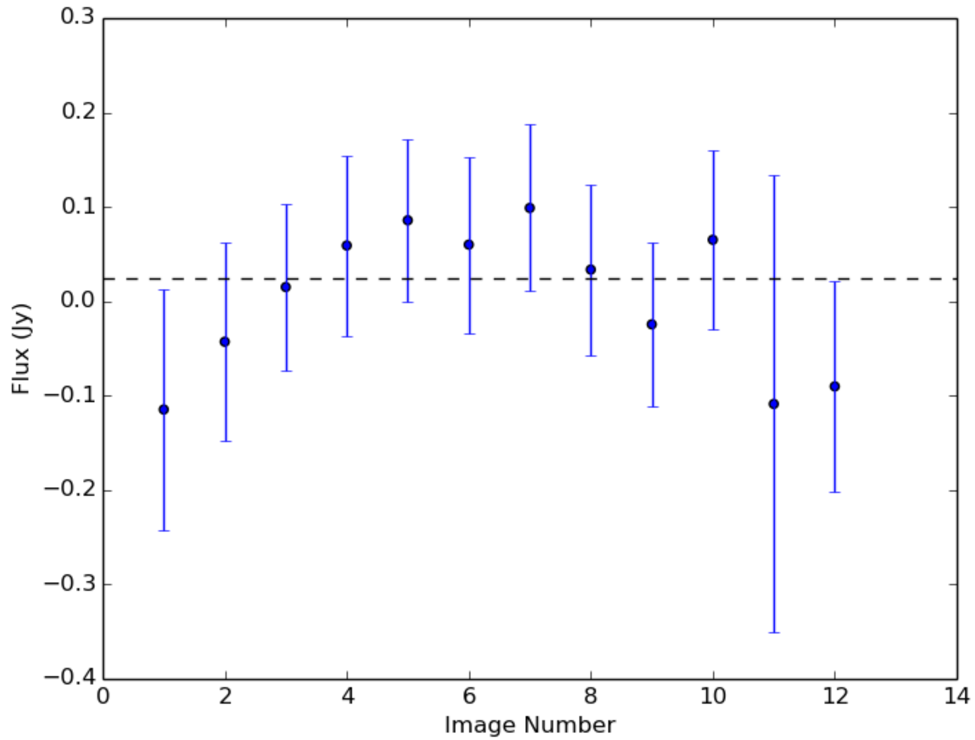
- Another question: how often do you see a transient from one spot in the sky?
- If a flash with duration t_{signal} occurs during an observation t_{obs}, with an original strength F_0…



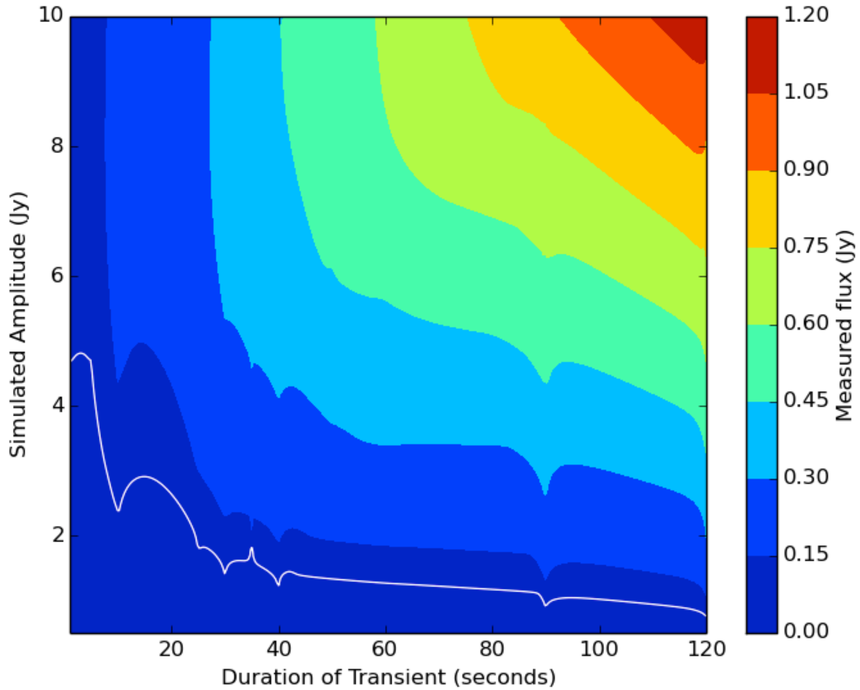
$$F_{signal} = \frac{t_{signal}}{t_{obs}} F_o$$

Transient Fluxes

- Measure fluxes in each image using forced fit in PySe at Swift J1644+57 location, use this to calculate weighted average (-0.015± 0.034 Jy)



Transient Cutoff



- Weighted average of fluxes from individual images calculated to be -0.015± 0.034 Jy

- No transients above white cutoff line were observed

Conclusions

- For Swift J1644+57, we found a peak flux density of 24.7 ± 8.9 mJy. We also did not observe any short duration transients from this source.
- Transients of Δt < 2min duration will be affected by RFI flagging… and for Δt < 10 sec they'll be flagged out altogether
- For the briefest transients, it may be necessary to image unflagged data to see if there are transients
- Another option would be to use the RFI flagger as a "transient finder"- check for instances where RFI is brief in time but broad in frequency

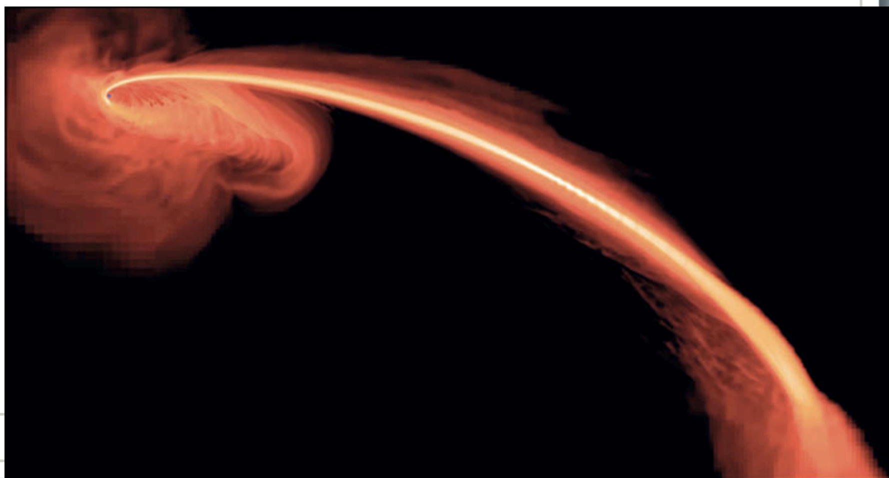


Image credit: NASA