Strobe-X and Tidal Disruption Events

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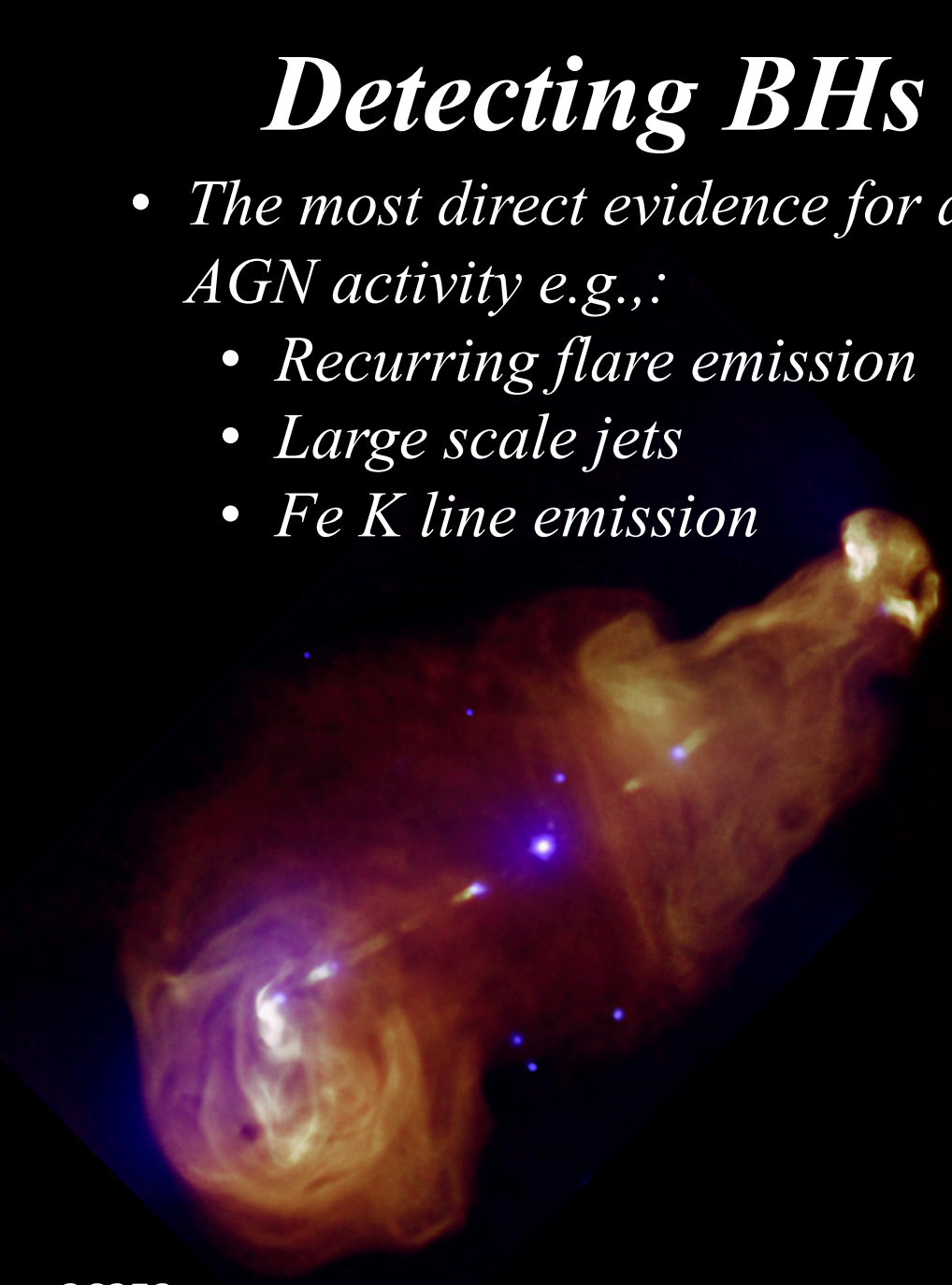
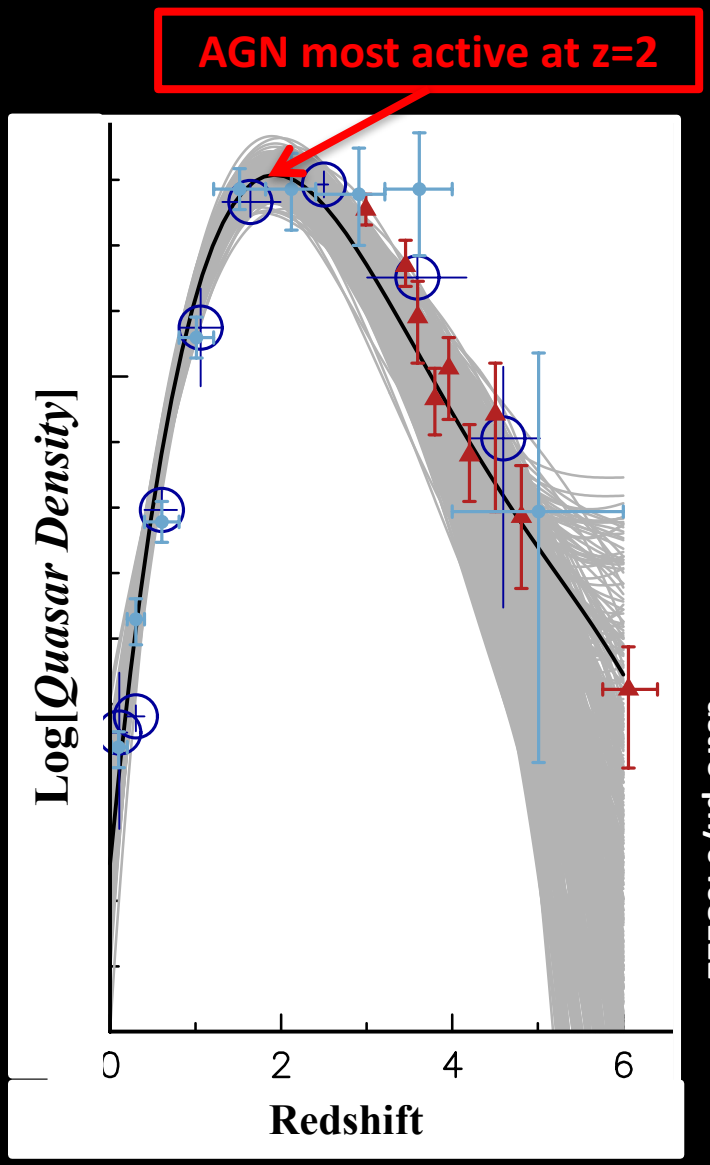
Detecting BHs in Galaxies

- *The most direct evidence for a BH is the detection of AGN activity e.g.,:*
  - *Recurring flare emission*
  - *Large scale jets*
  - *Fe K line emission*



3C353 http://chandra.harvard.edu/photo/2013/archives/



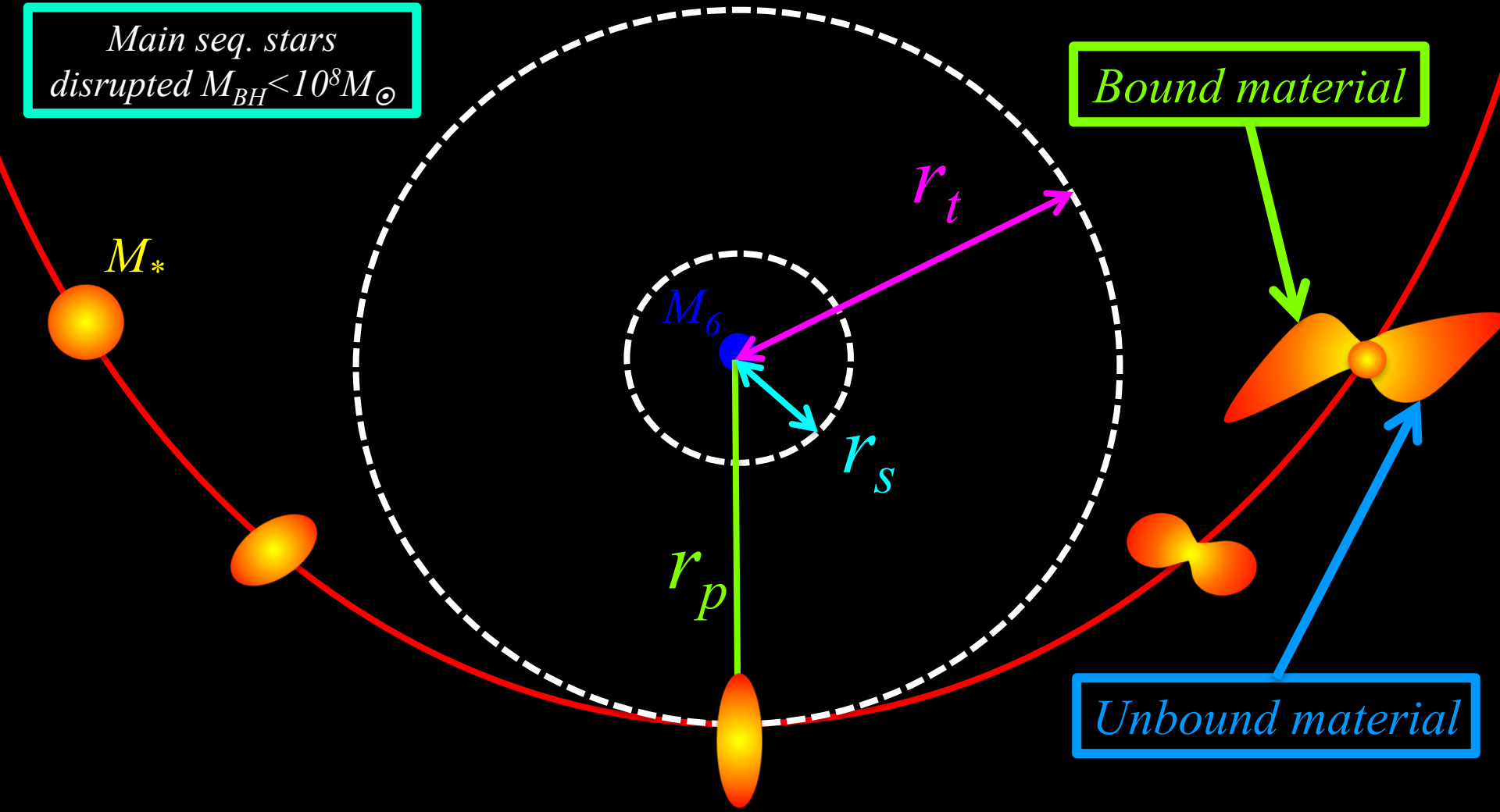
Tidal disruption events (TDEs)

$$r_t = 7 \times 10^{12} \left(\frac{r_*}{r_\odot}\right) \left(\frac{M_*}{M_\odot}\right)^{-1/3} M_6^{1/3} \text{ cm}$$

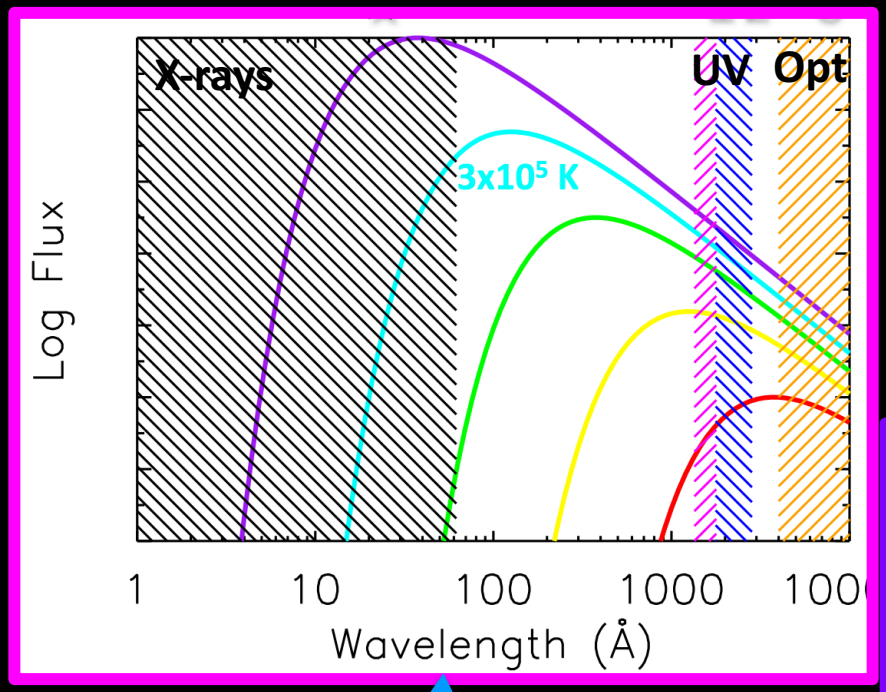
(Tidal radius)

Disruption occurs at $r_p \leq r_t$

Main seq. stars disrupted $M_{BH} < 10^8 M_\odot$

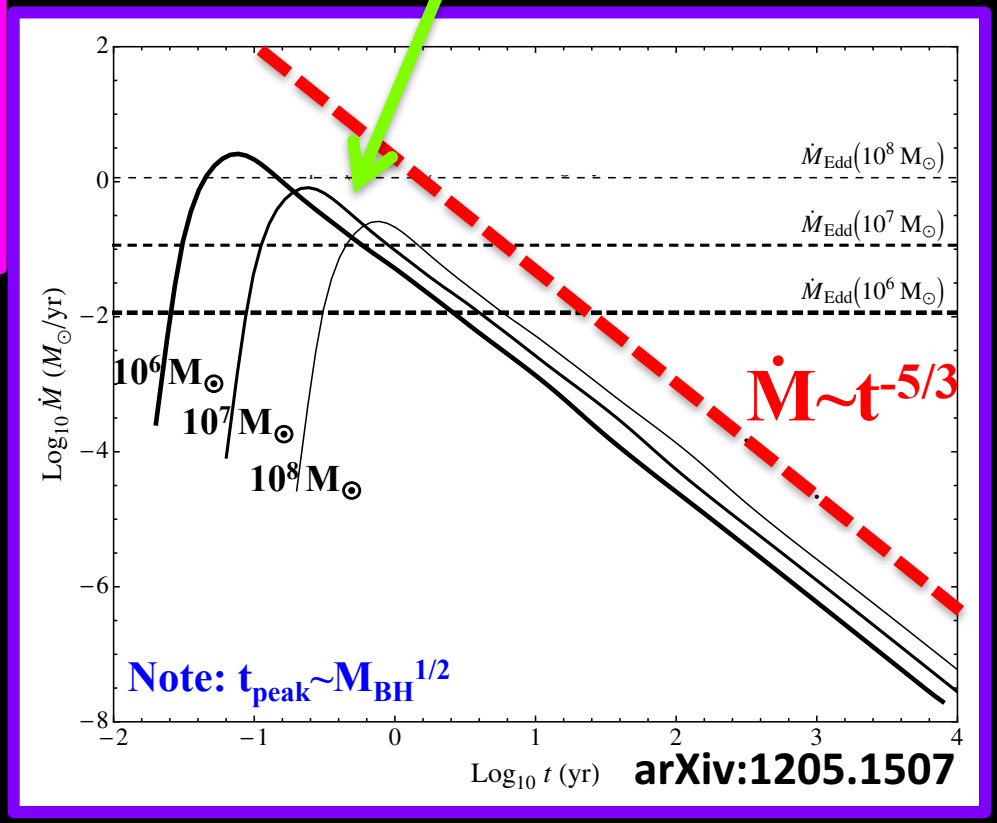


Luminous accretion powered flare



e.g., Ulmer (1999)

For M_{BH} <10^7 $M_\odot$, accretion will be Super-Eddington

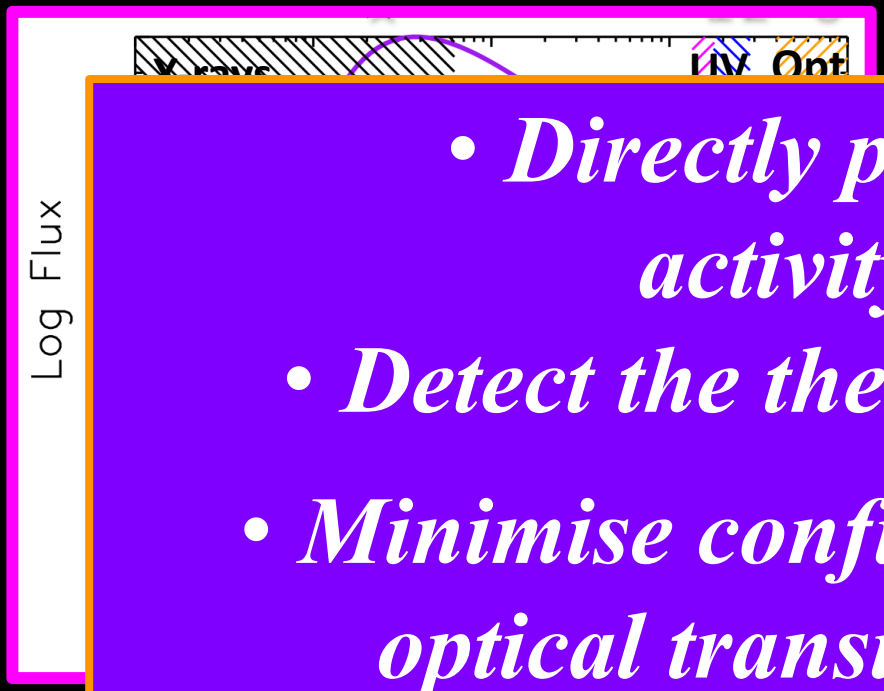


Inner accretion disk reaches temperature ≥ 10^5 K, leading to a luminous thermal flare peaking at UV or soft X-ray wavelengths

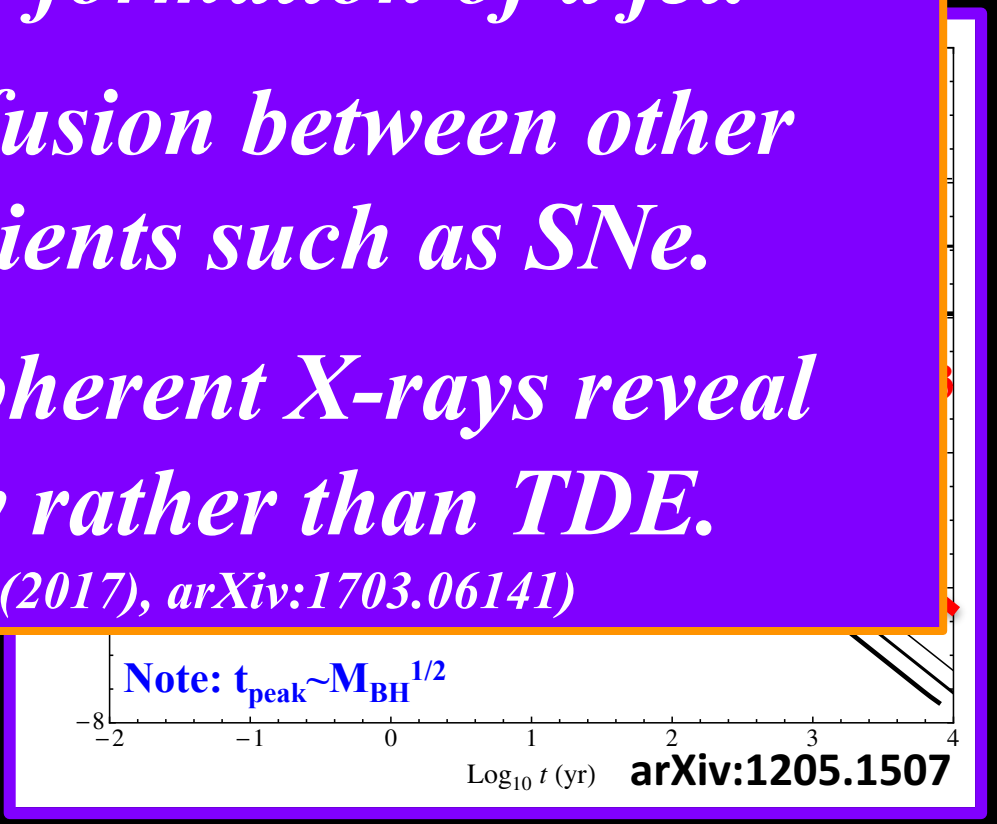
Why look at X-rays from TDEs?

- *Directly probe accretion activity/structure.*
- *Detect the the formation of a jet.*
- *Minimise confusion between other optical transients such as SNe.*
- *Recurring/incoherent X-rays reveal AGN activity rather than TDE.*

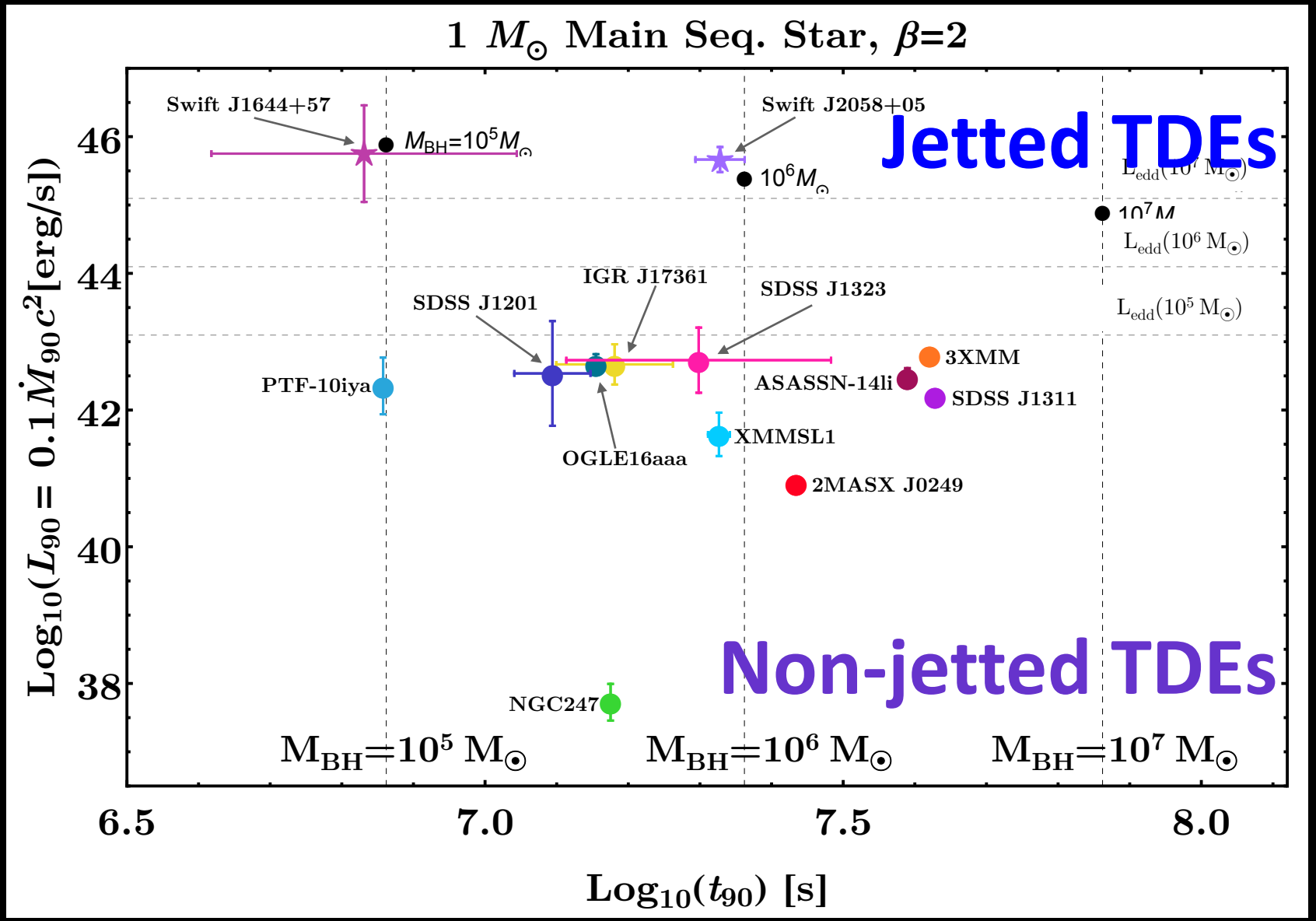
(see Auchettl et al. (2017), arXiv:1703.06141)



peaking at UV or soft X-ray wavelengths

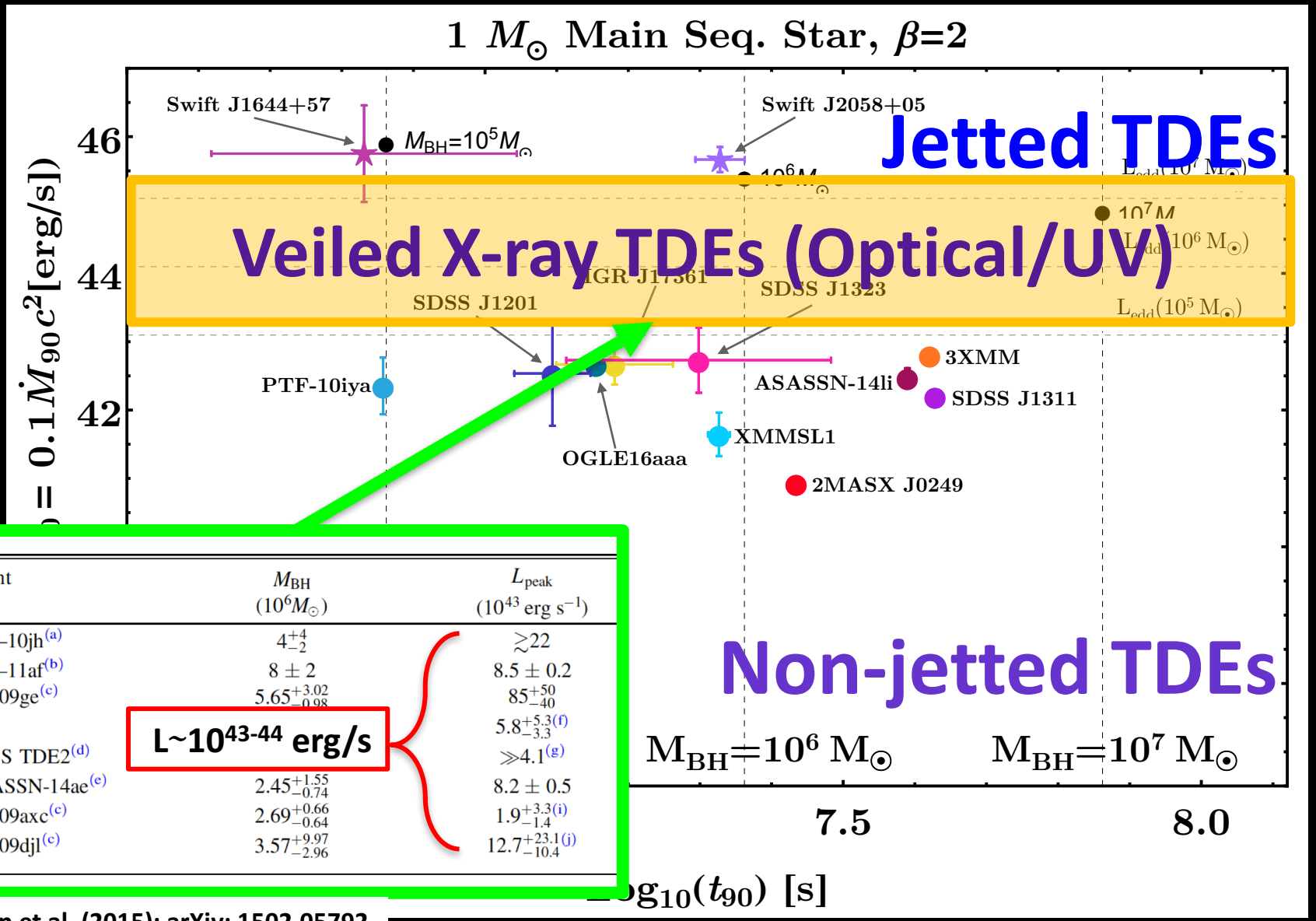


X-ray TDE demographic



Auchettl et al. (2017), arXiv:1611.02291

X-ray TDE demographic



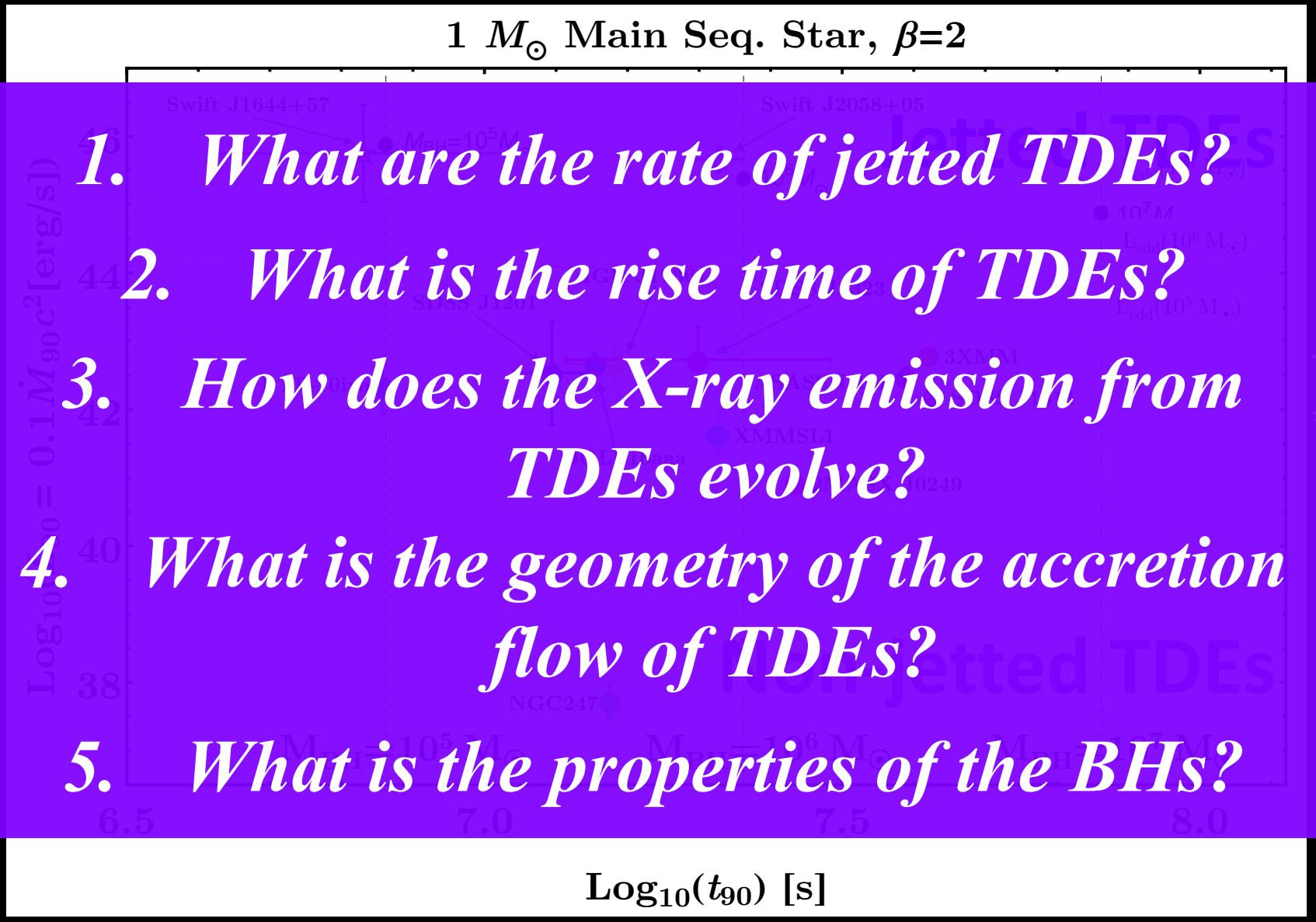
Event	M_{BH} ($10^6 M_\odot$)	L_{peak} (10^{43} erg s^{-1})
PS1–10jh[a]	4^{+4}_{-2}	$\gtrsim 22$
PS1–11af[b]	8 ± 2	8.5 ± 0.2
PTF09ge[c]	$5.65^{+3.02}_{-0.98}$	85^{+50}_{-40}
SDSS TDE2[d]		$5.8^{+5.3}_{-3.3}$[f]
		$\gg 4.1$[g]
ASASSN-14ae[e]	$2.45^{+1.55}_{-0.74}$	8.2 ± 0.5
PTF09axc[c]	$2.69^{+0.66}_{-0.64}$	$1.9^{+3.3}_{-1.4}$[i]
PTF09djl[c]	$3.57^{+9.97}_{-2.96}$	$12.7^{+23.1}_{-10.4}$[j]

L~$10^{43\text{-}44}$ erg/s

Piran et al. (2015): arXiv: 1502.05792

Auchettl et al. (2017), arXiv:1611.02291

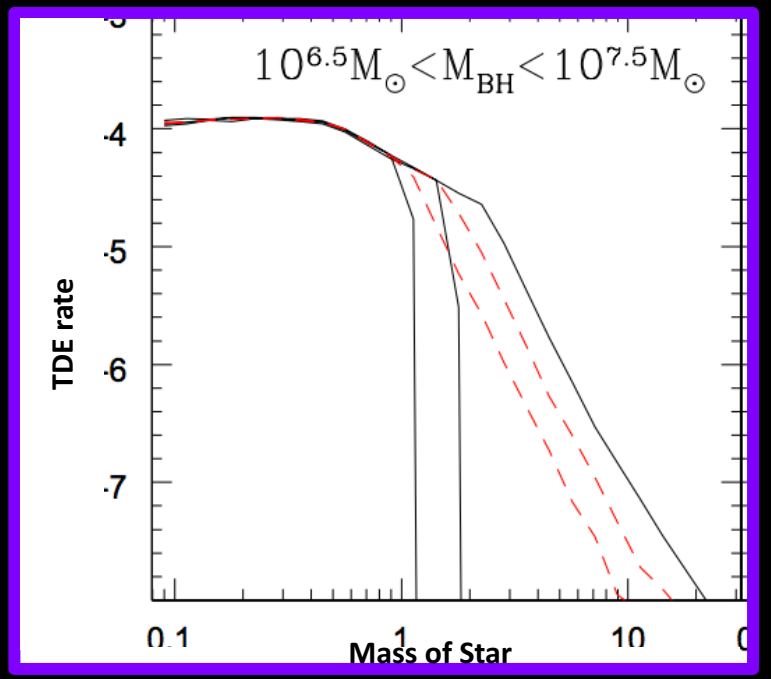
A few questions for Stobe-X



1. *What are the rate of jetted TDEs?*
2. *What is the rise time of TDEs?*
3. *How does the X-ray emission from TDEs evolve?*
4. *What is the geometry of the accretion flow of TDEs?*
5. *What is the properties of the BHs?*

What are the rate of TDEs?

- *Swift BAT detected 3 jetted TDEs:*
  - *Swift J1644+57, Swift J2058+05 and Swift J1112-82.*
- *But rates of jetted TDEs unknown and difficult to calculate due to no hard X-ray surveying instrument*
- *MAXI (arXiv:1605.01724) estimated that between 0.0007-34% of TDEs have a jet.*
- *The WFM is ideal for characterising the rates of jetted TDEs in an unbiased way.*



arXiv: 1601.06787

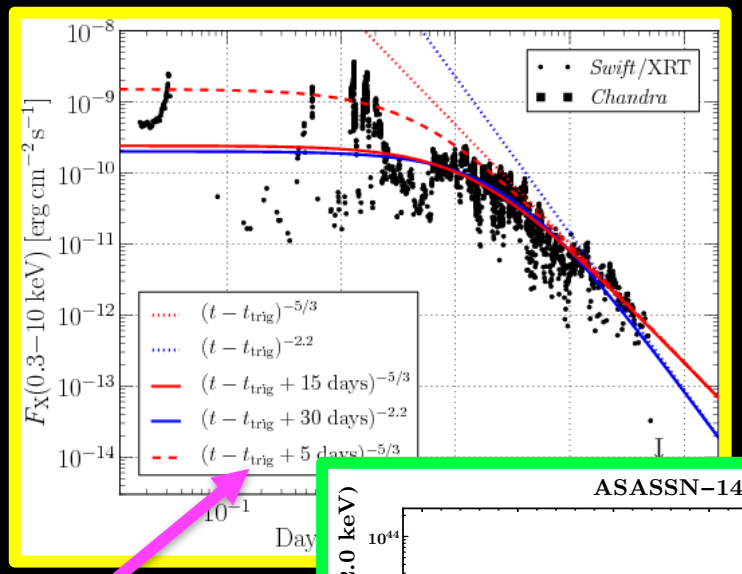
Theoretically
~10^{-4} pr yr assuming a sun-like star.

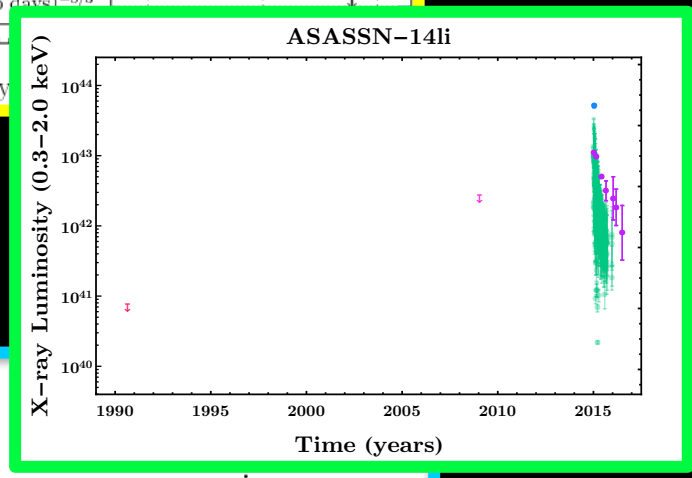
e.g., astro-ph/0305493, arXiv:1410.7772

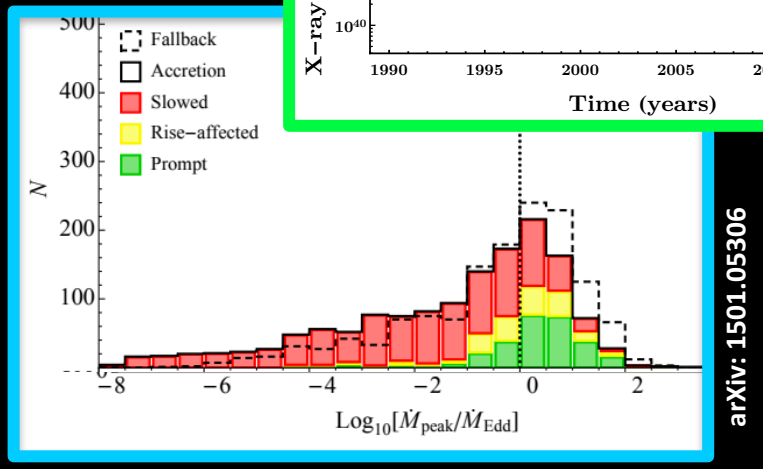
Observationally:
Optical and X-ray inferred TDE rate:
(1-17)x10^{-5} yr^{-1} $galaxy^{-1}$
e.g., arXiv:0712.4149, arXiv:1507.01598

What is the rise time of TDEs?

- *One of the major uncertainties in TDE studies is how quickly does the accretion start and whether optical and X-ray emission occurs simultaneously.*
  - *A14li: optical upperlimit 10 days before detection (1507.01598), but X-ray upperlimit many years before (1611.02291).*
- *Depending on choice of t_{peak} will change the decay rate.*
  - *see e.g., Swift J1644+57*
- *Prompt and slow-rise TDEs*
- *WFM's coverage will be able to help us constrain t_{peak}*

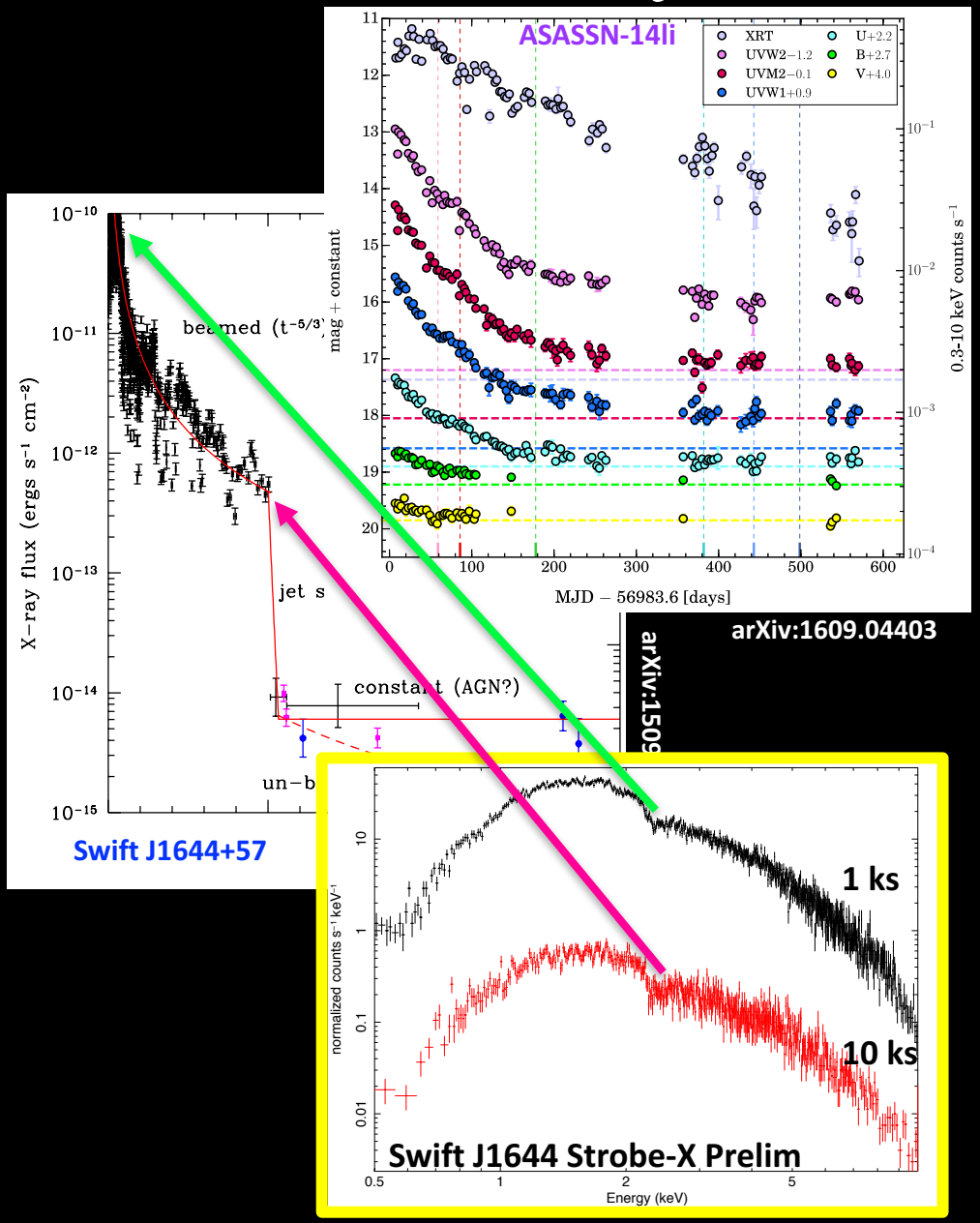






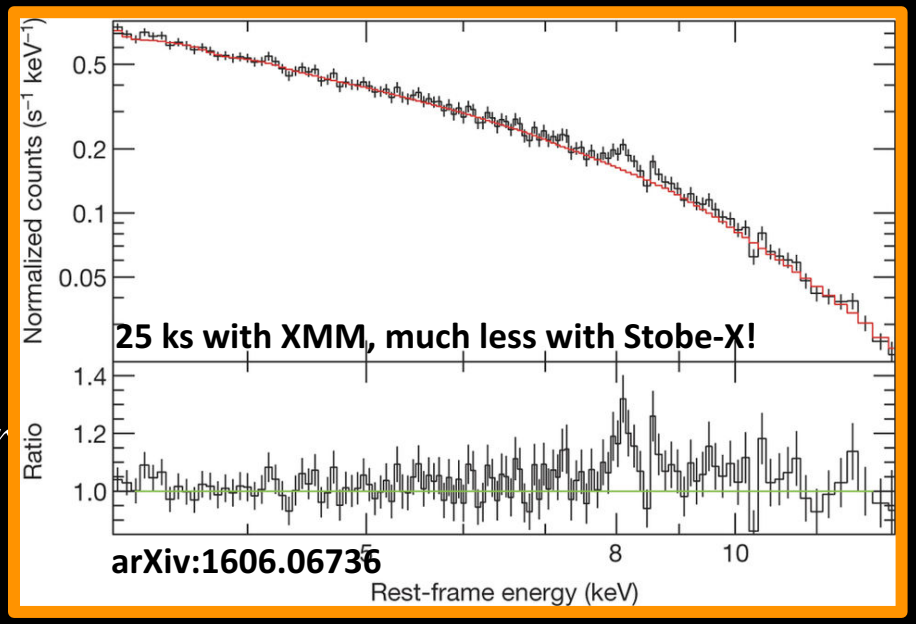
How do TDEs evolve in X-rays?

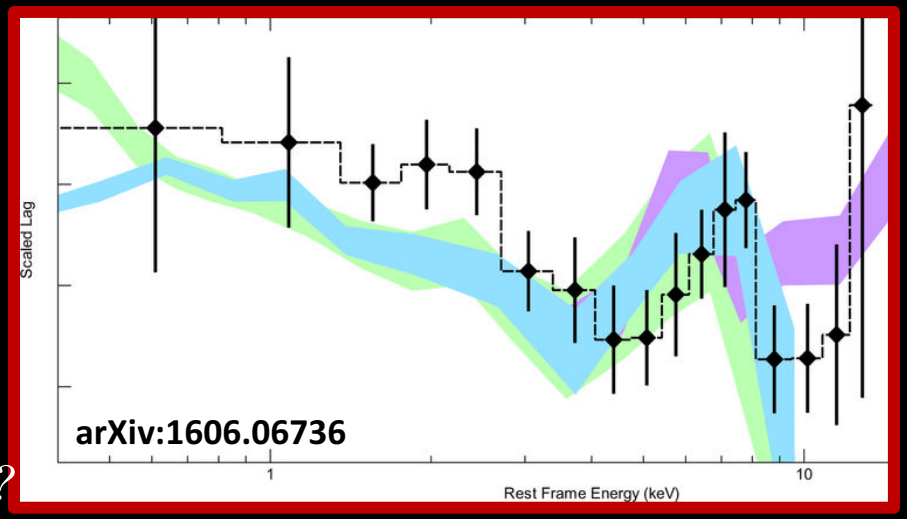
- *Currently, only a handful of TDEs have well defined X-ray coverage*
  - *e.g., ASASSN-14li, Swift J1644+57*
- *WFM will be able to detect nearby and bright transients which is IDEAL for multi-wavelength follow-up.*
  - *SKA, Athena, optical surveys*
- *XRCA and LAD will allow us to perform 0.2-30 keV spectroscopy.*



What is the geometry of the accretion?

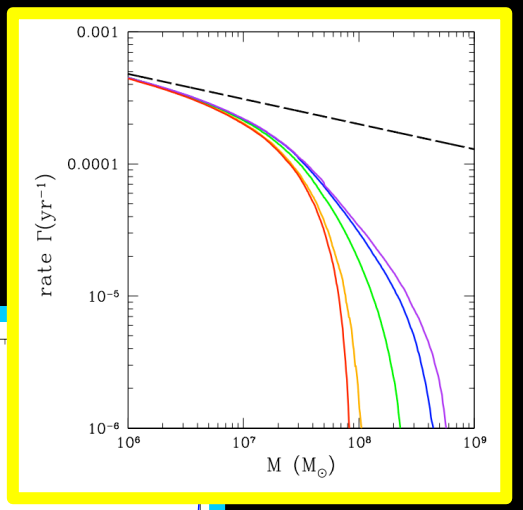
- *Impressive effective area of Strobe-X is the ideal instrument for reverberation studies in TDEs.*
- *Reverberation of redshifted iron Kα photons reflected off the inner accretion flow seen in only one TDE*
  - *Swift J1644: Kara et al. (2016)*
- *Similar to that seen in AGN, but Fe gravitationally redshifted and Doppler blueshifted to 8 keV, indicating fast flows.*
  - *Is this just a special example?*
  - *What about on smaller timescales?*

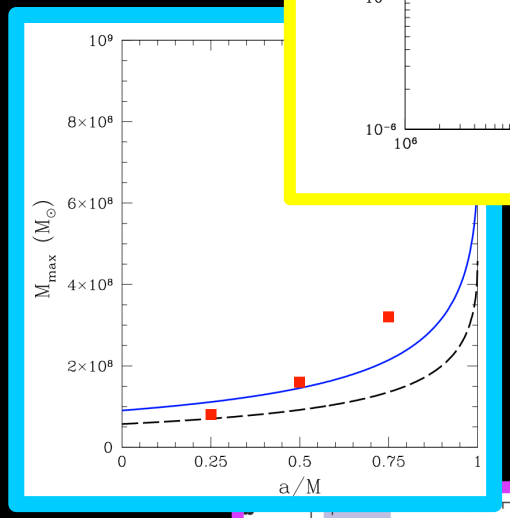


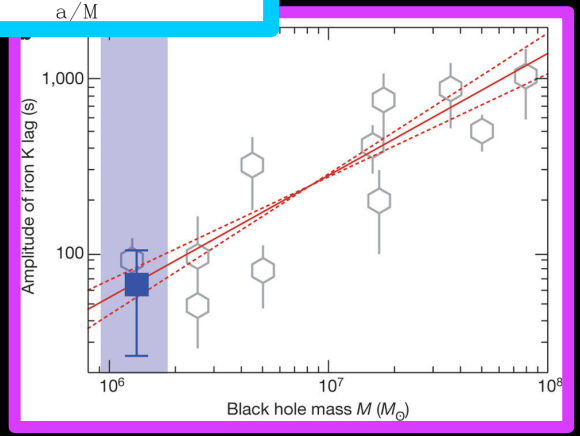


What are the properties of BH?

- *Constraining the mass and spin of the BH that produced a TDE is highly sort after.*
  - *Most TDEs detected have BH masses ~$10^{5\text{-}7}M_{sun}$.*
  - *Spin does not seem to be important for intermediate mass BHs.*
  - *But do we get TDEs for >$10^{8}M_{sun}$ with high spin (ASASSN-15lh: 1507.03010, 1609.02927).*
  - *Can we constrain the rates?*
- *Strobe-X can help constrain these properties through:*
  - *detecting the brightest events*
  - *reverberation mapping and other methods applied to AGN,*
  - *Well defined light curves.*







Other questions to think about

- *Are jetted TDEs only seen in higher redshift Galaxies (z~0.8) as currently suggested by observations?*
- *What percentage of emission is converted into thermal and non-thermal emission in TDEs?*
- *If we can constrain the BH mass and spin of a TDE, can we constrain observationally the mass of the star assuming Hills mass limit?*
- *How absorbed (N_H) are TDEs? Do we see no evidence of variability in column density as suggested by Auchettl et al. (2017).*
- *What is the maximum absorption (N_H) of a TDE before we can see it? What does this tell us when compared to AGN?*
- *Do we see any correlation with the emission detected in X-rays with other wavelengths e.g., 1709.02882, 1703.07024*
- *What is the X-ray luminosity function of TDEs in both soft and hard X-ray energy bands?*
- *Is there any evidence of AGN emission in E+A galaxies?*
- *What are the constraints on prior AGN emission of TDE candidates presented from optical or other surveys?*
- *How can we distinguish TDEs from AGN properties?*
- *Do we see quasi periodic oscillations from TDEs like that seen from AGN?*
- *What is the correlation between timing and spectroscopy of both the thermal and non-thermal emission in these sources?*
- *Do optical/UV TDEs show any X-ray emission at all during their evolution?*