Luminous extra-galactic (multi-messenger) transients

Peter Jonker, Paul O'Brien, Arne Rau
et al. (SWG2.6)

SRON
Netherlands Institute for Space Research

erc
European Research Council
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Department of Astrophysics
Radboud University Nijmegen

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SWG2.6:

- Gamma-ray bursts [V. D' Elia]
- Athena follow-up GW events [Rossi & Troja]
- Supernova shock breakout
- New sources? [G. Stratta]
- Tidal disruption events [this talk]

Serendipitous discovery by the WFI of X-ray transients → fast alerts

Why study tidal disruption events?

- SMBHs in quiescent galaxies; growth models
- Origin of ultra-high energy cosmic rays?

  Batista & Silk 2017
- Provide proof for existence of BH event horizon?

  van Velzen 2017; Lu, Kumar & Narayan 2017
- Measuring Lense-Thirring precession?

  Stone & Loeb 2012
- study Super-Eddington accretion, jet formation…

A tidal disruption event

WD-BH encounter

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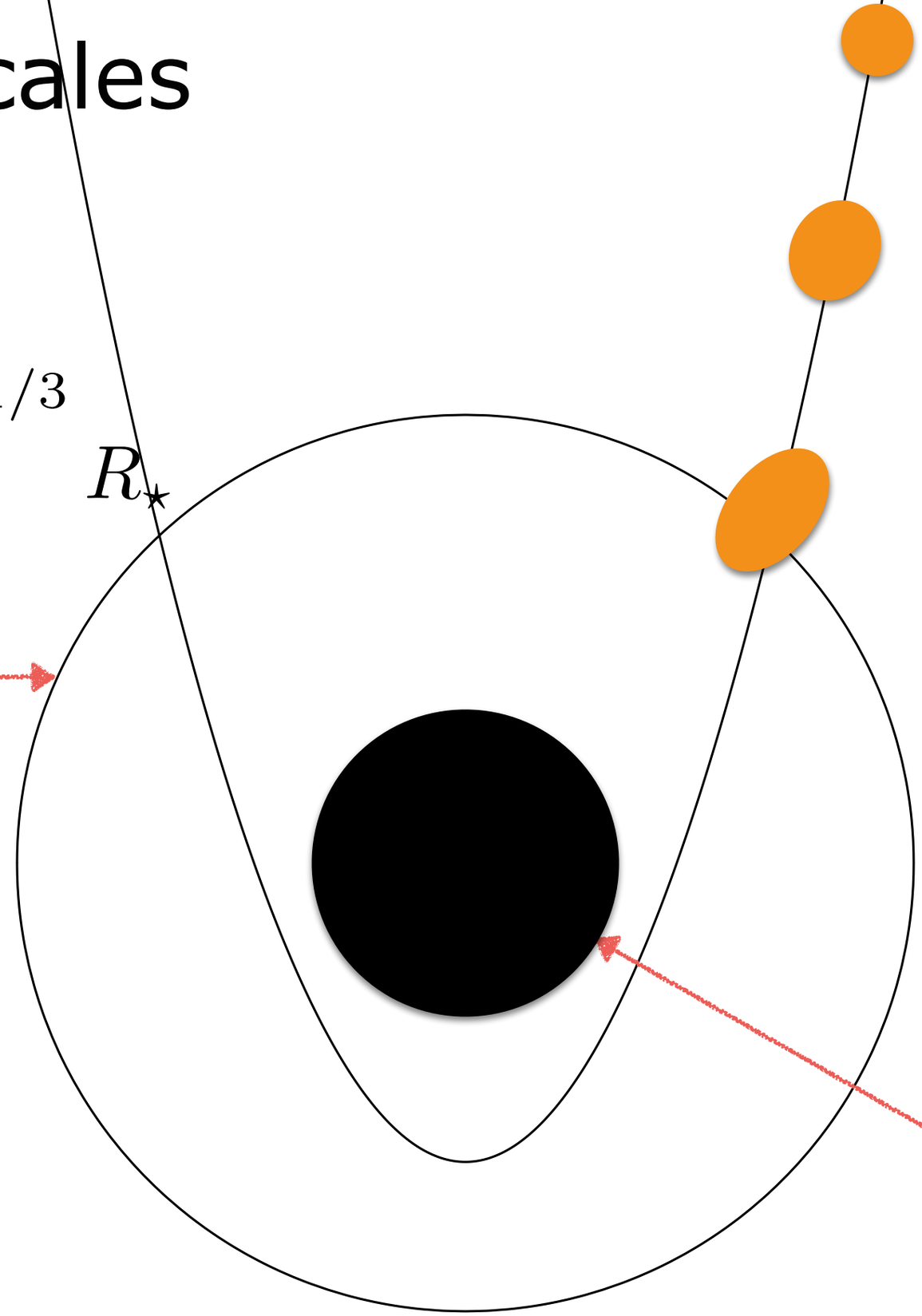
masses (sol.)	0.2 (WD) & 1000 (BH)
in. separation	50 (in 1.E9 cm)
hydrodynamics	SPH (4 030 000 particles)
EOS, gravity	Helmholtz, N
nucl. burning	red. QSE-network (Hix 98)
simul. time	5.4 min
color coded	column density
penet. factor	12

coding, simulation, visualisation: S. Rosswog

Rosswog et al. 2009

Important scales

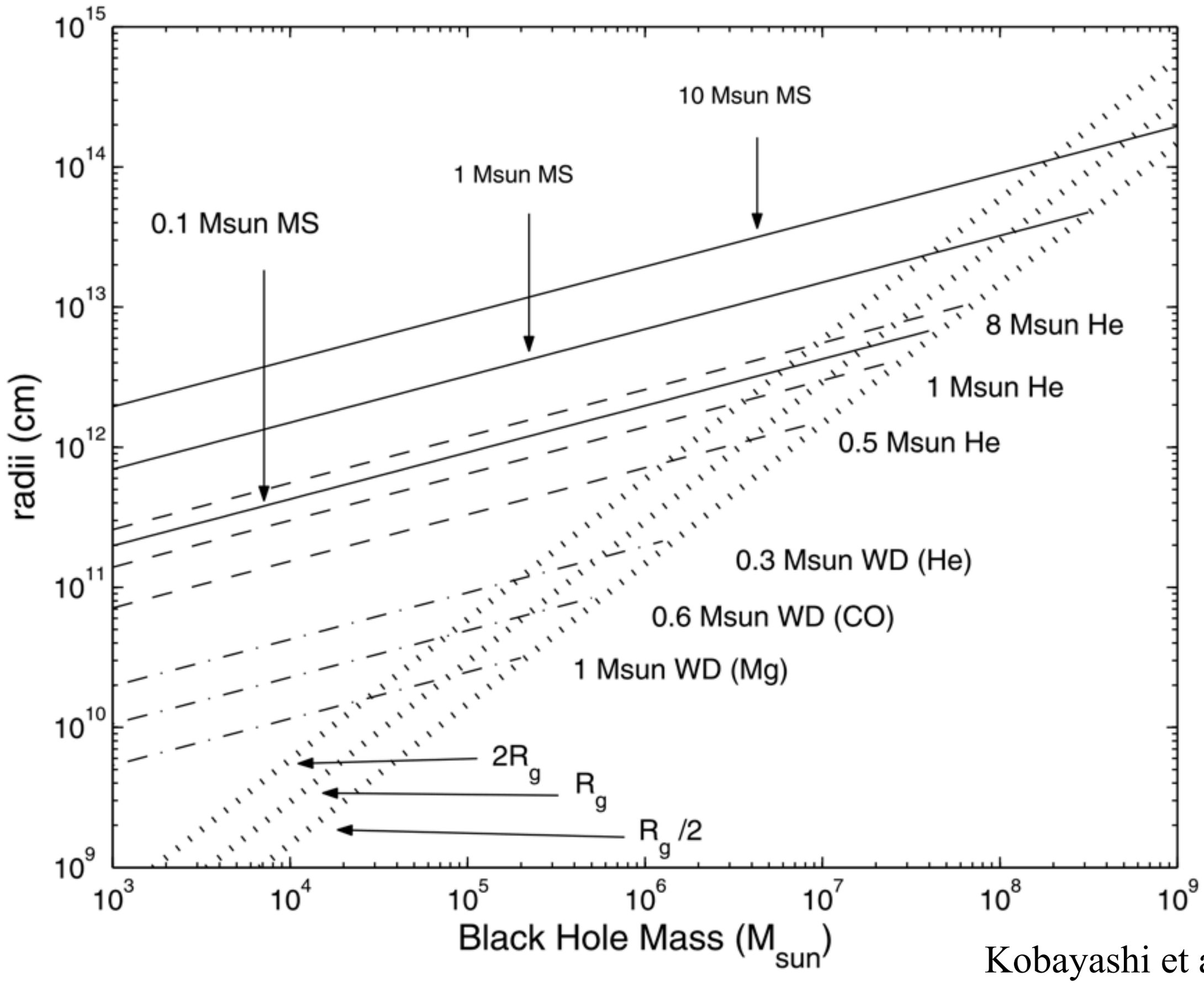
$$R_T = \left(\frac{M_{BH}}{M_\star}\right)^{1/3} R_\star$$



$$R_S = \frac{2GM_{BH}}{c^2}$$

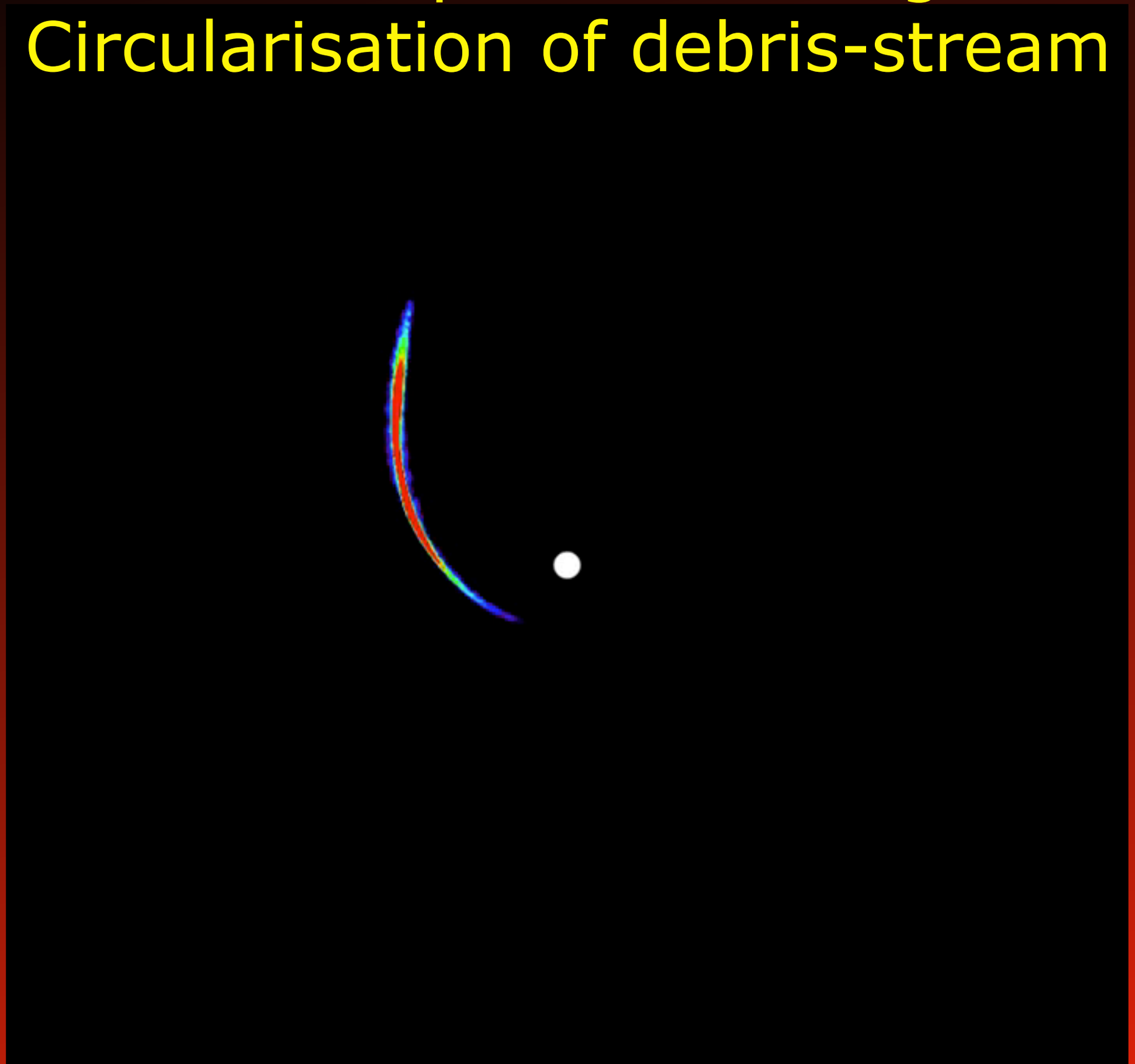
$$R_T \gtrsim R_S \; for \; M_{BH} \lesssim 10^8 M_\odot \left(\frac{R_\star}{R_\odot}\right)^{3/2} \left(\frac{M_\star}{M_\odot}\right)^{-1/2}$$

Tidal and horizon radius: R_*, M_*, a



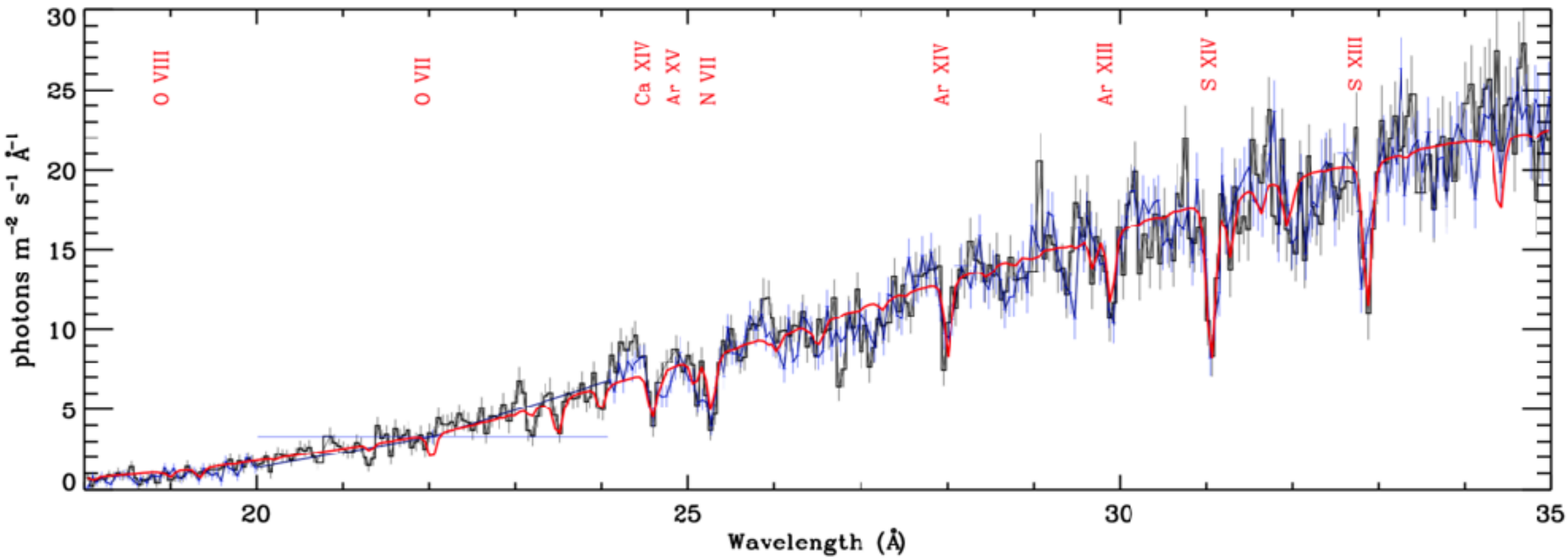
Kobayashi et al. 2004

From disruption to EM signal: Circularisation of debris-stream



Bonnerot et al. 2016 (and on youtube)

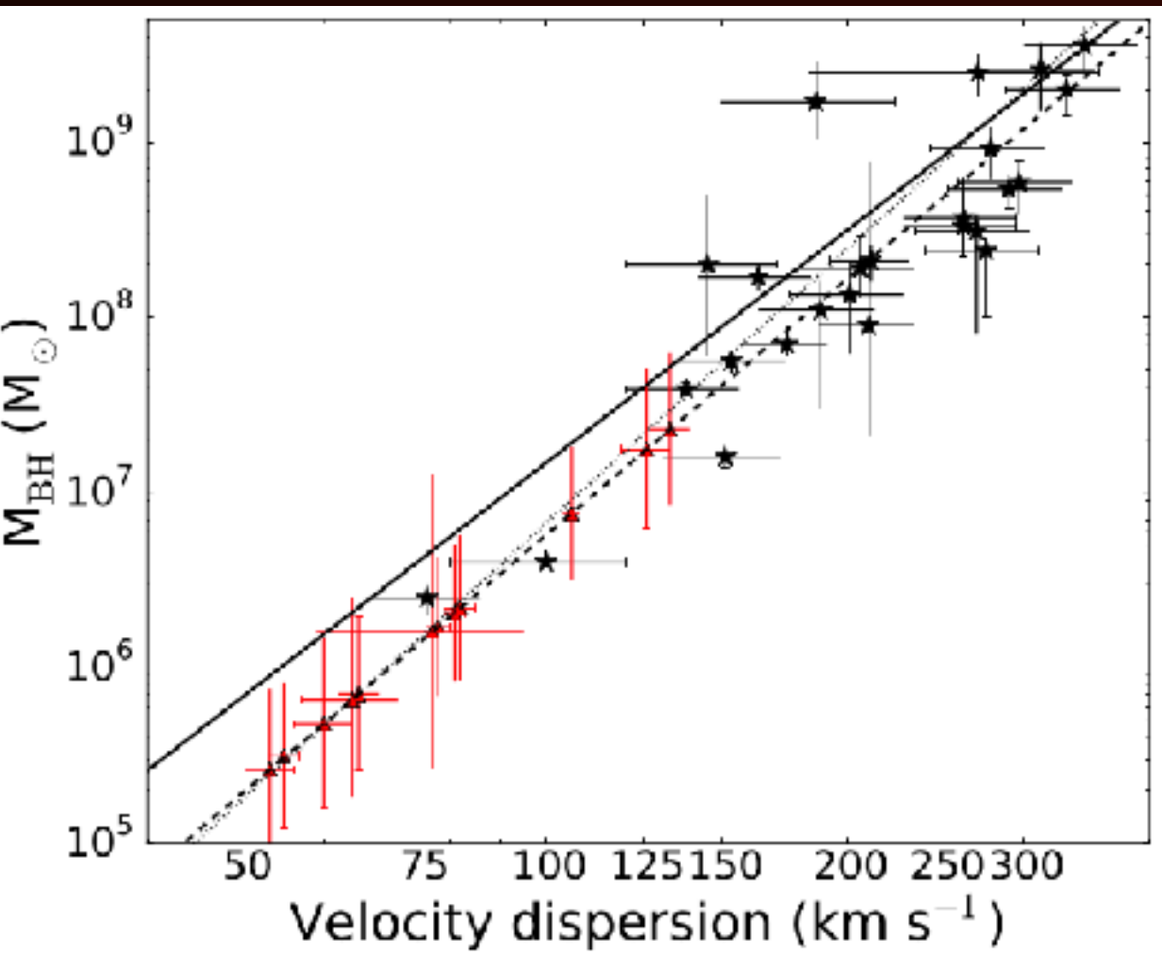
X-ray spectra: outflows or stream

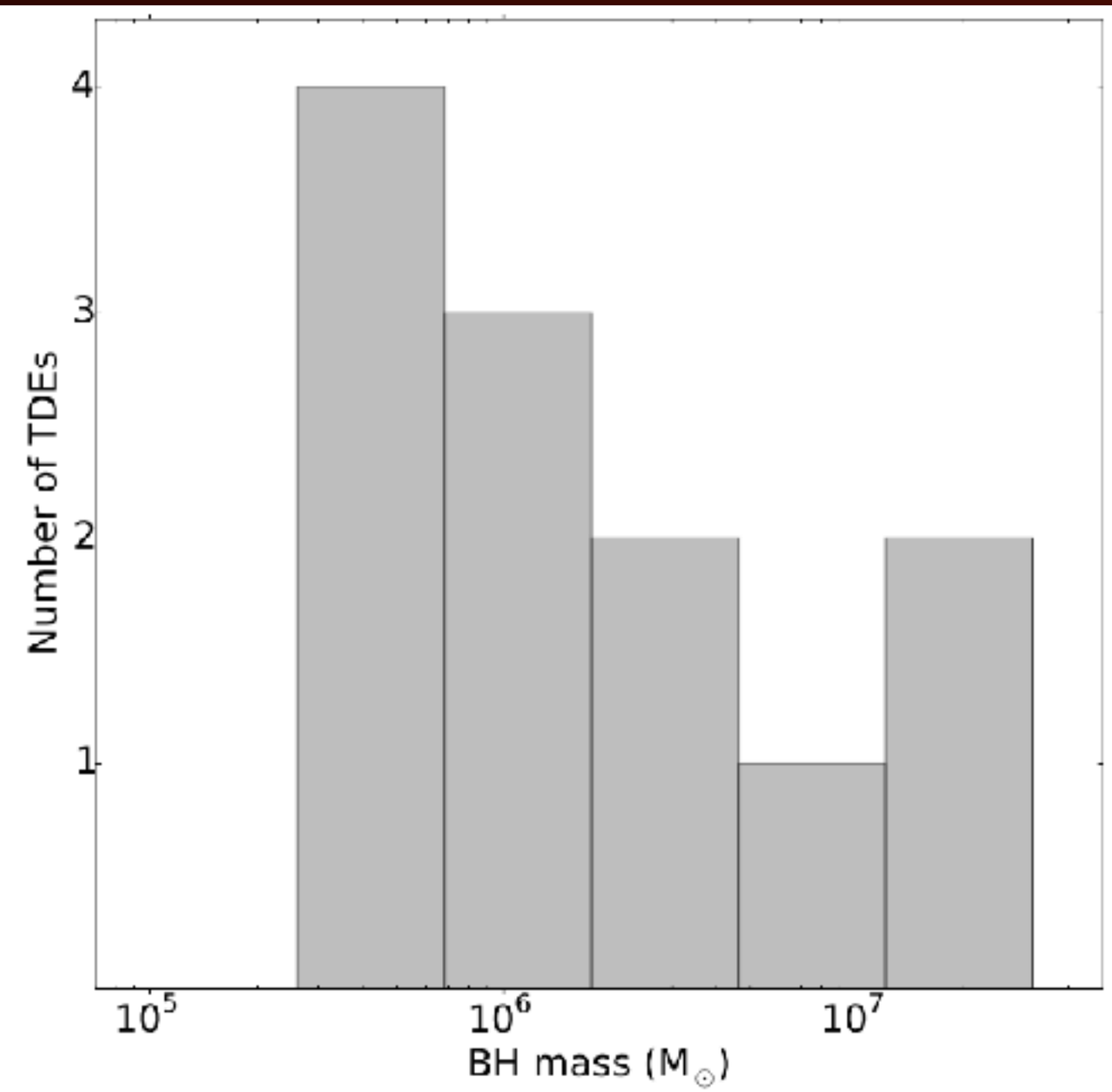


94 ksec XMM-Newton RGS

TDE ASASSN-14li: Miller et al. 2015

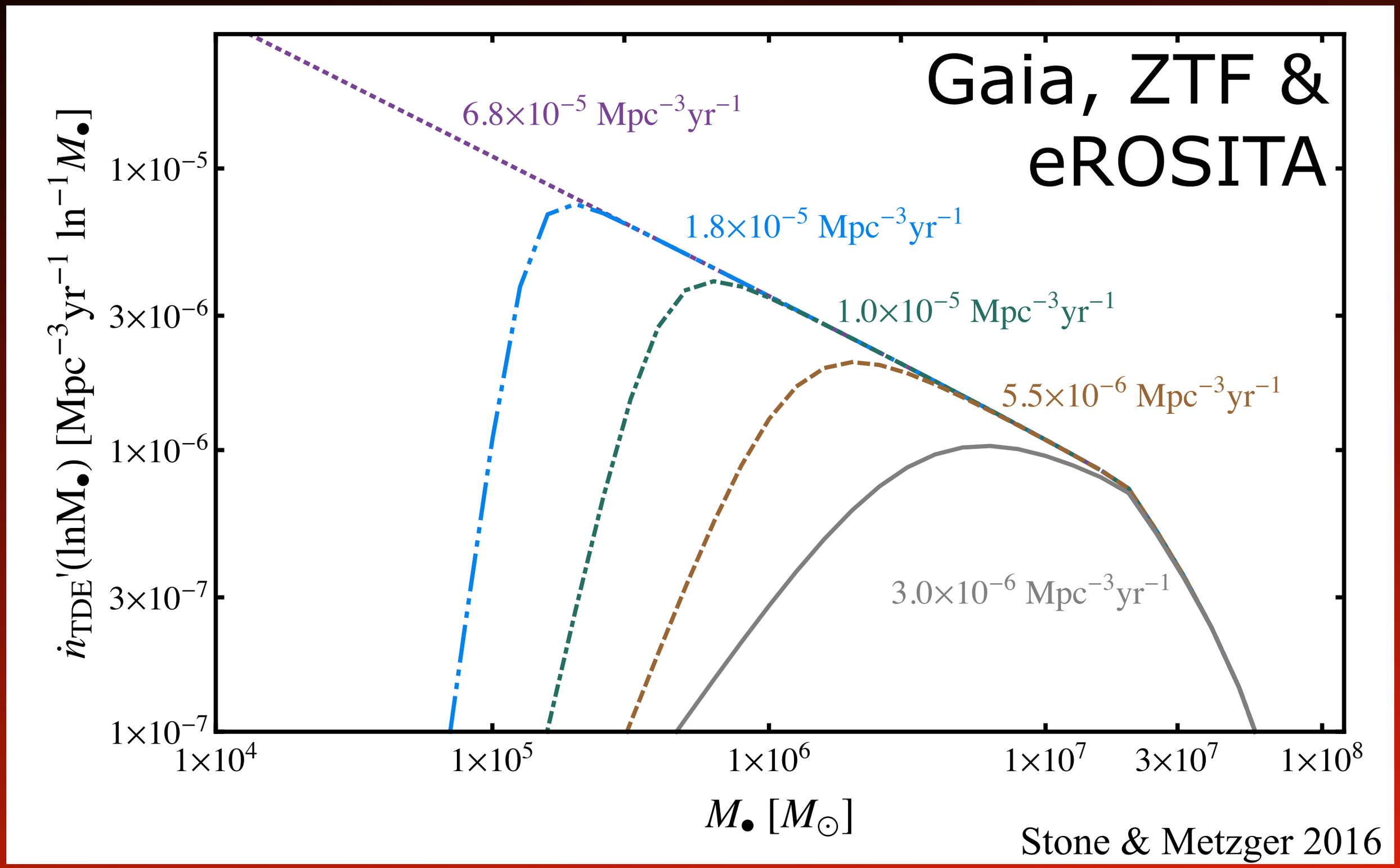
TDEs favour low-mass SMBHs





Wevers et al. 2017

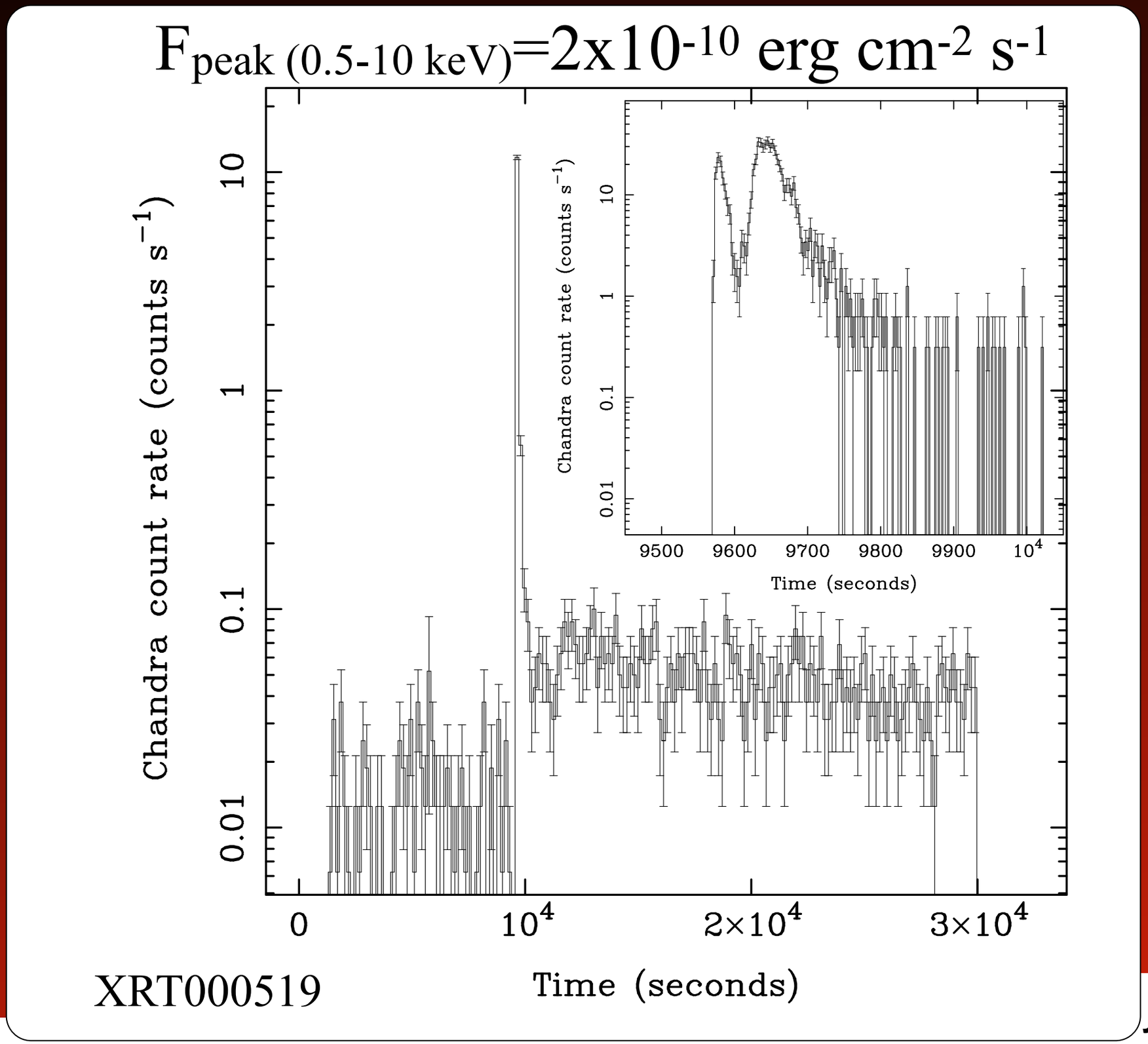
BH seed mass set tidal disruption rate



Blagorodnova et al. 2016; Gezari et al. 2018; Khabibullin, Sazonov, Sunyaev 2014

Fastest TDEs?

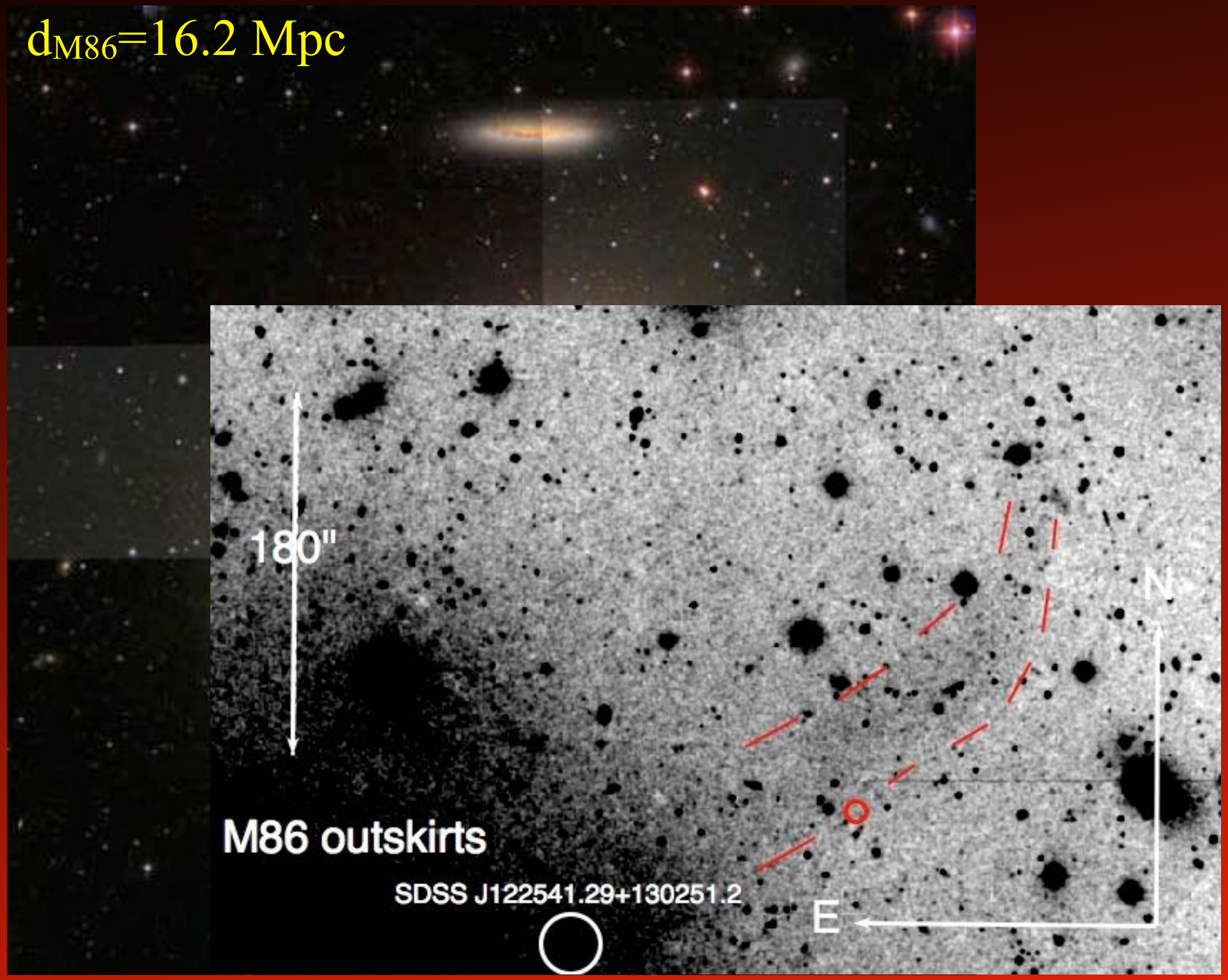
Detection of a fast X-ray transient



Jonker et al. 2013

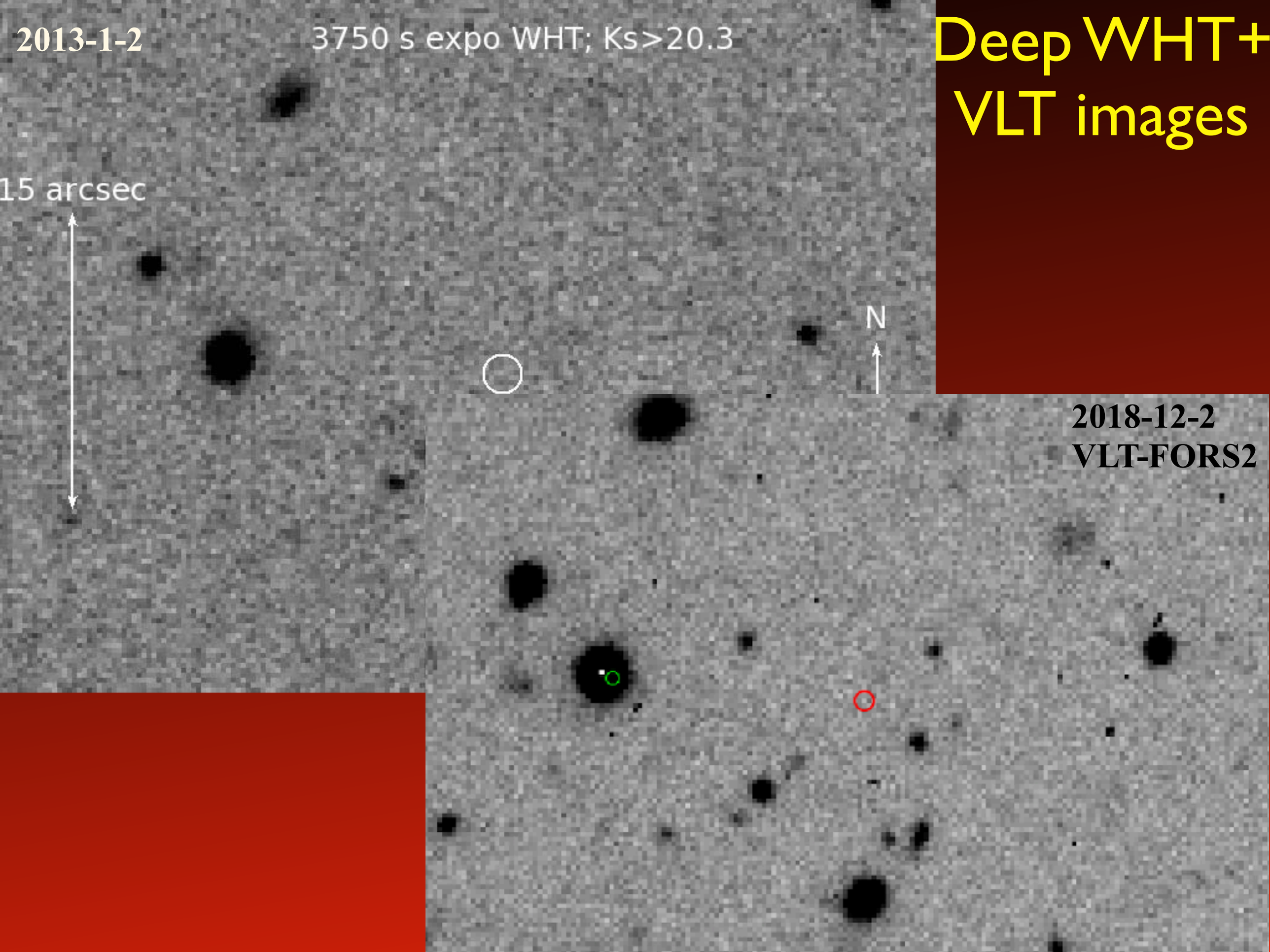
X-ray flashes related to NS-NS mergers?: Matsumoto & Kimura 2018

M86

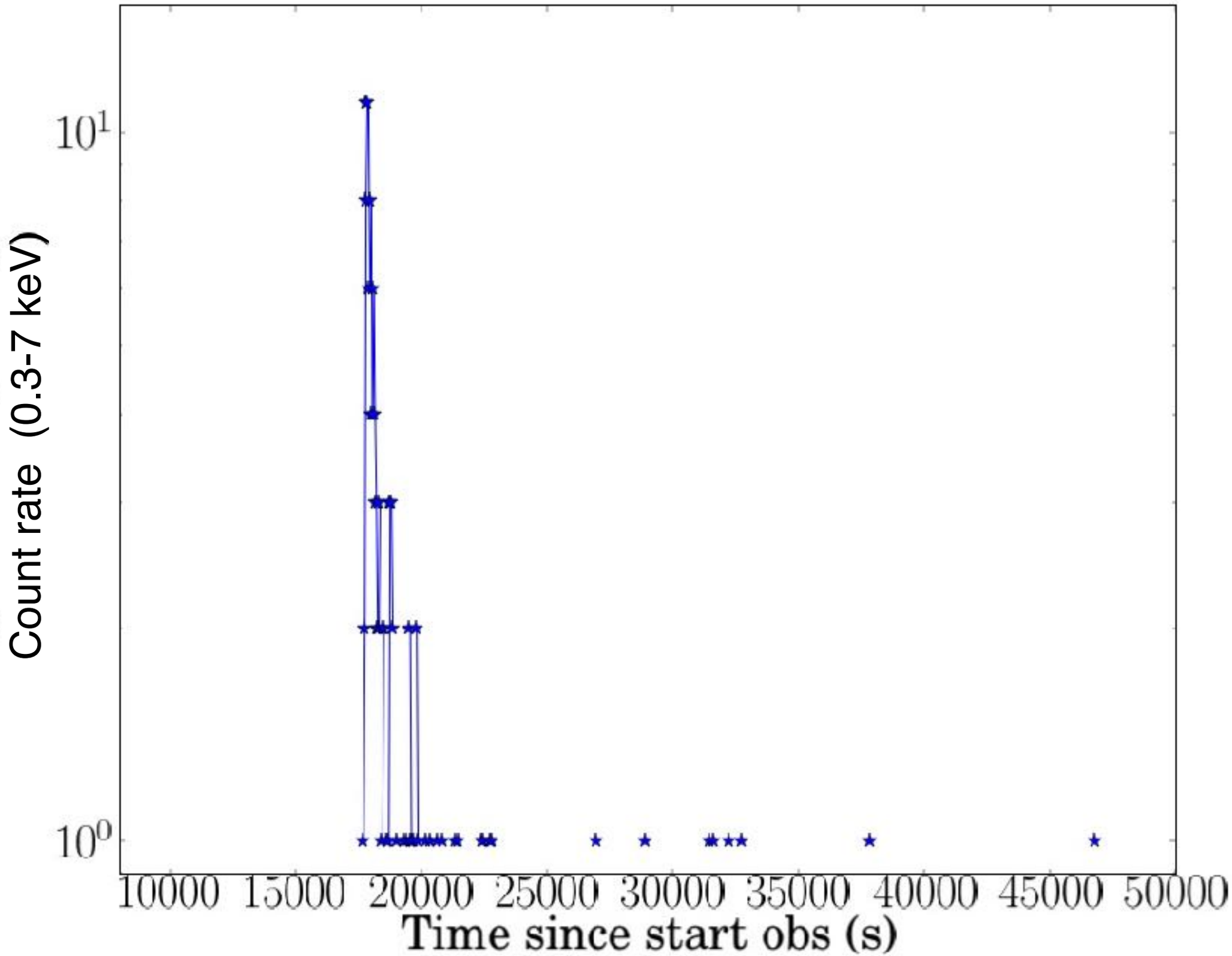


SDSS

Deep WHT+ VLT images

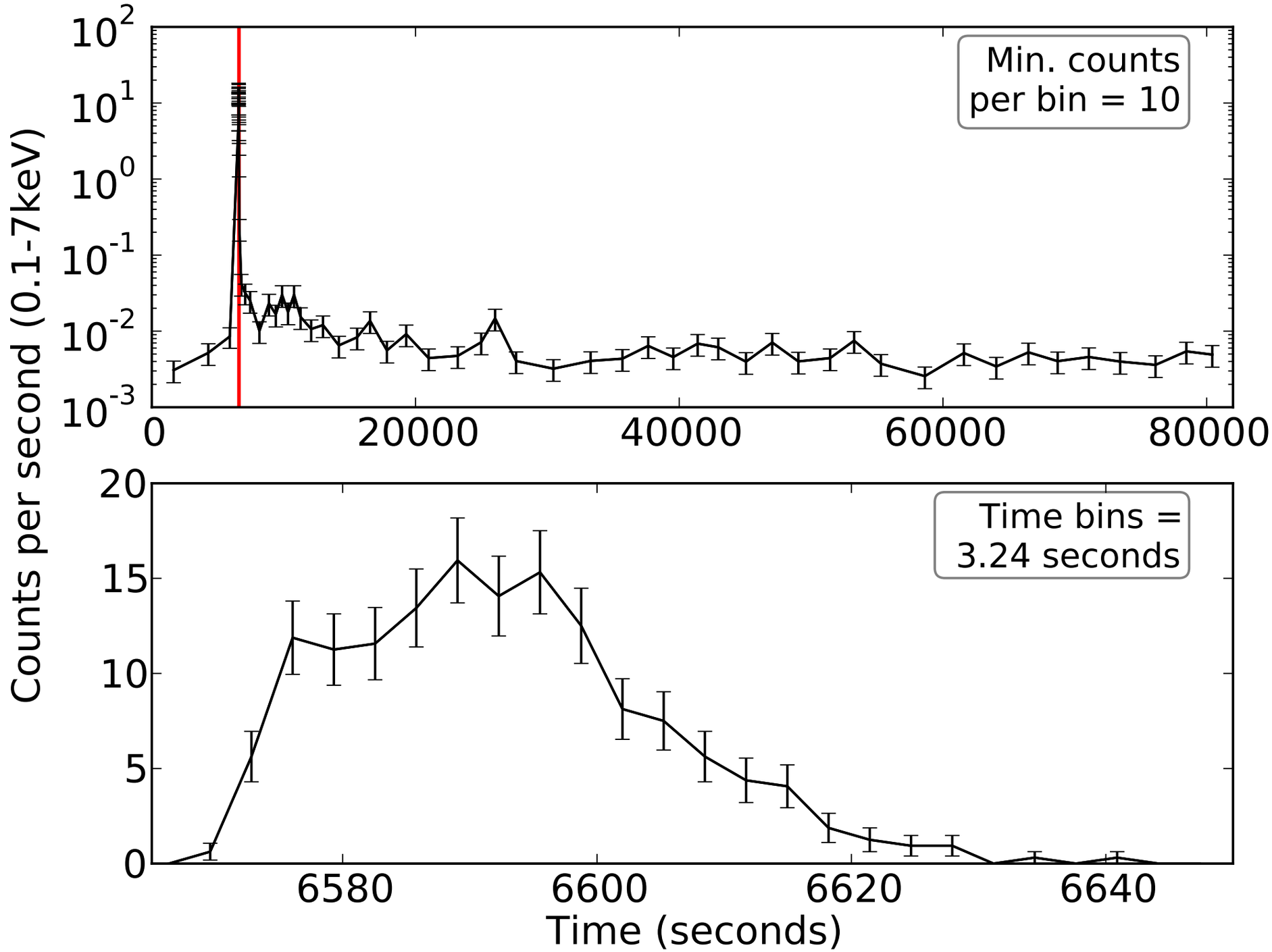


More fast X-ray transients:



Bauer et al. 2017

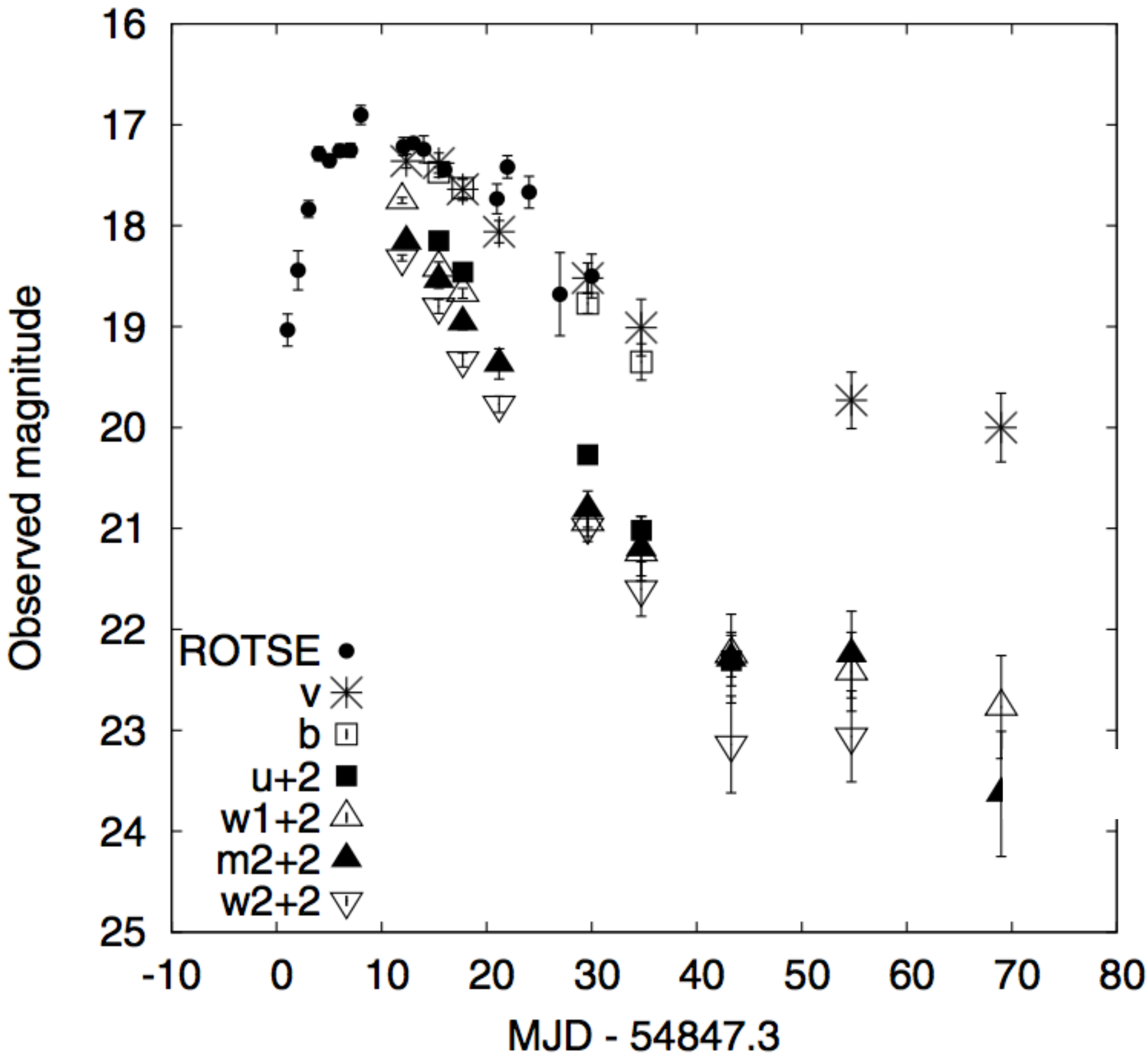
More fast X-ray transients:



Glennie, Jonker, et al. 2015

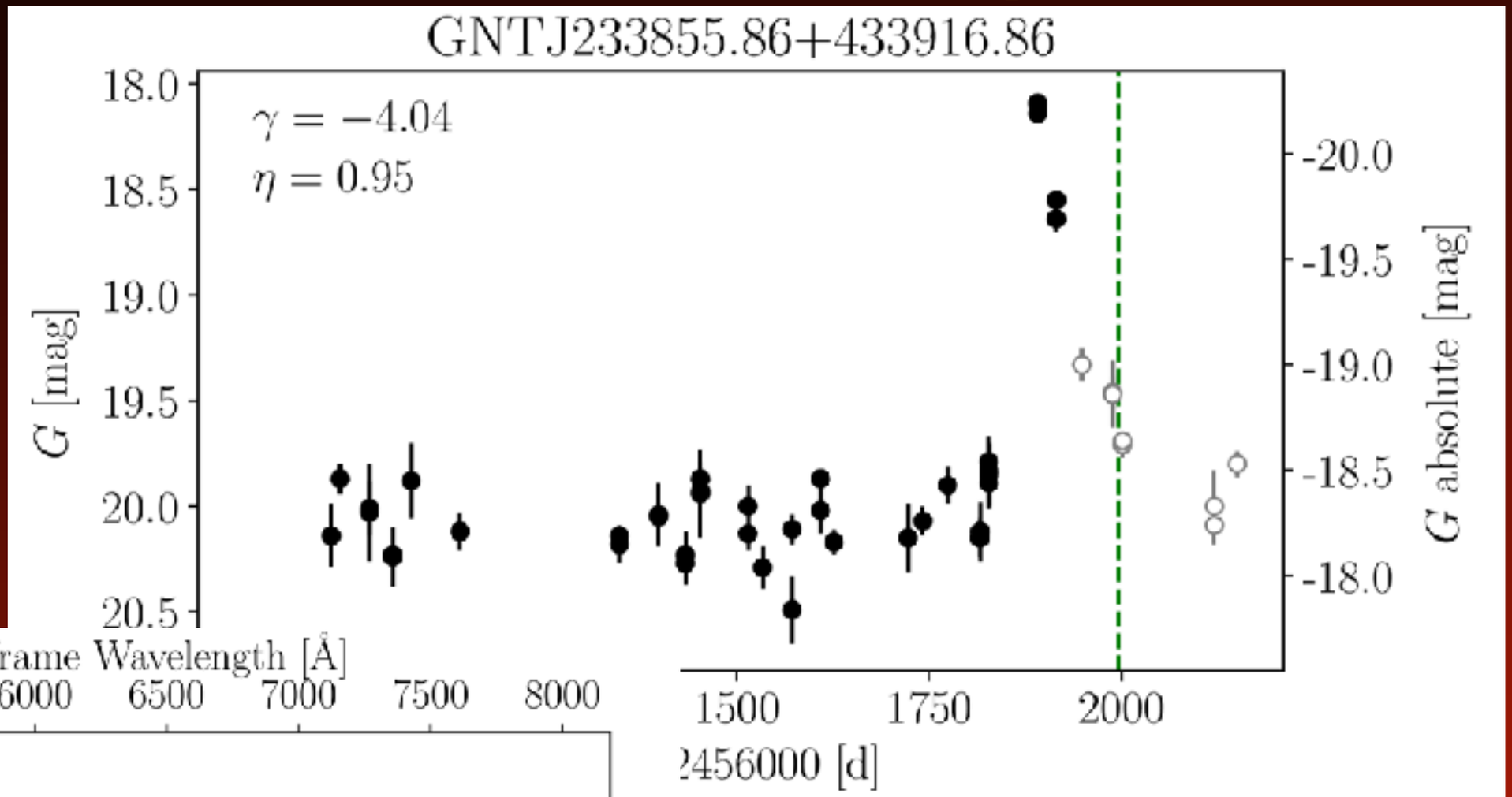
eROSITA ~1/d

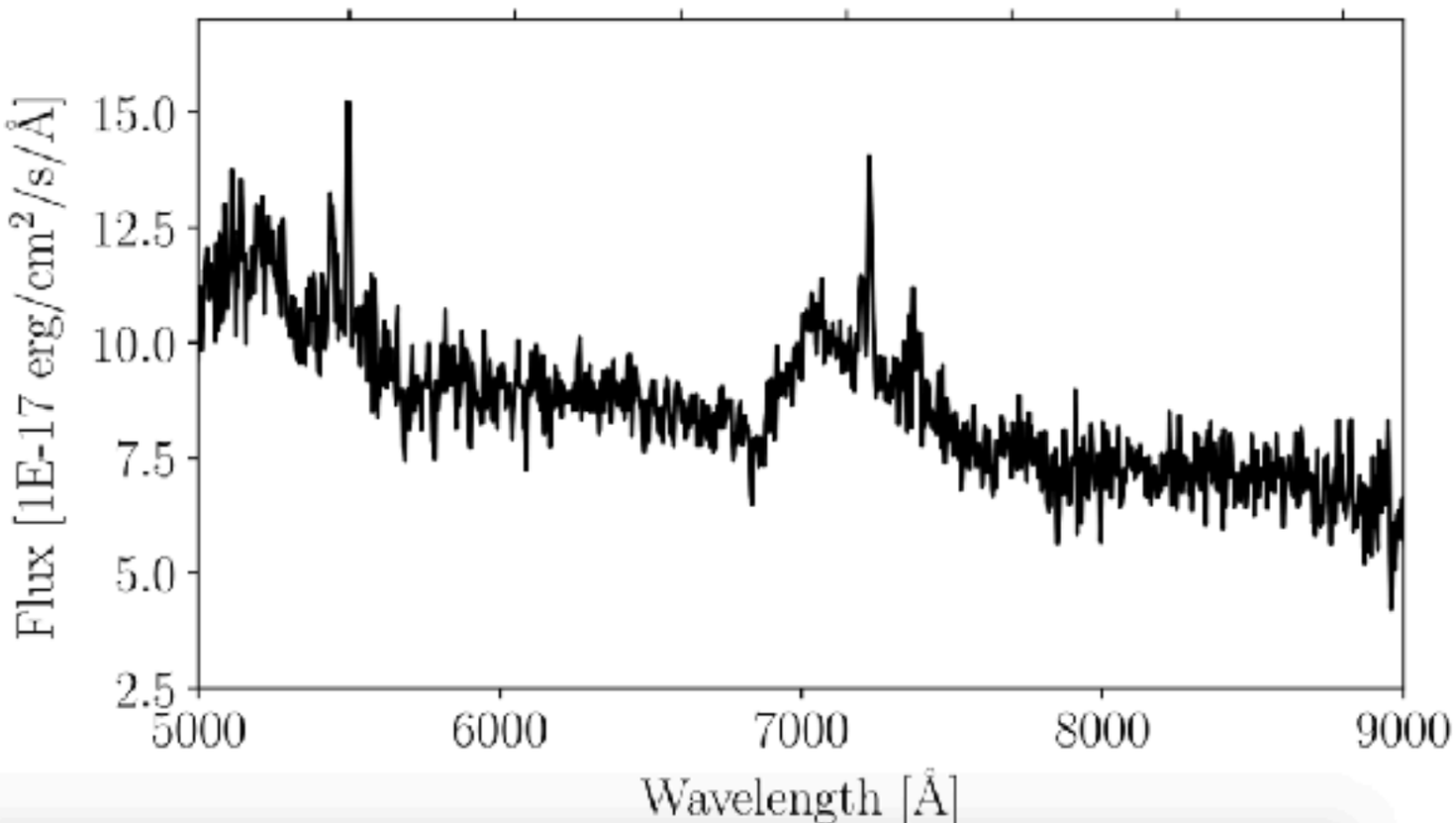
Extreme TDEs: Fast events (low-mass BHs?)



Vinkó et al. 2015

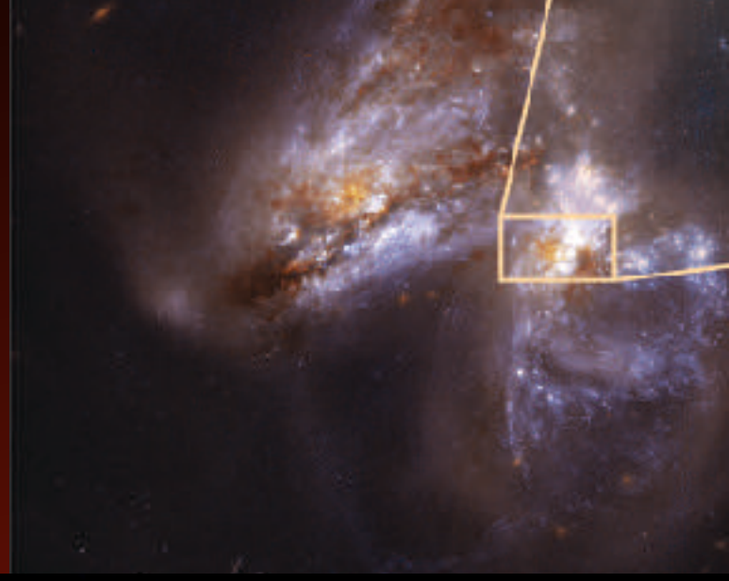
480 Gaia nuclears in 1 year

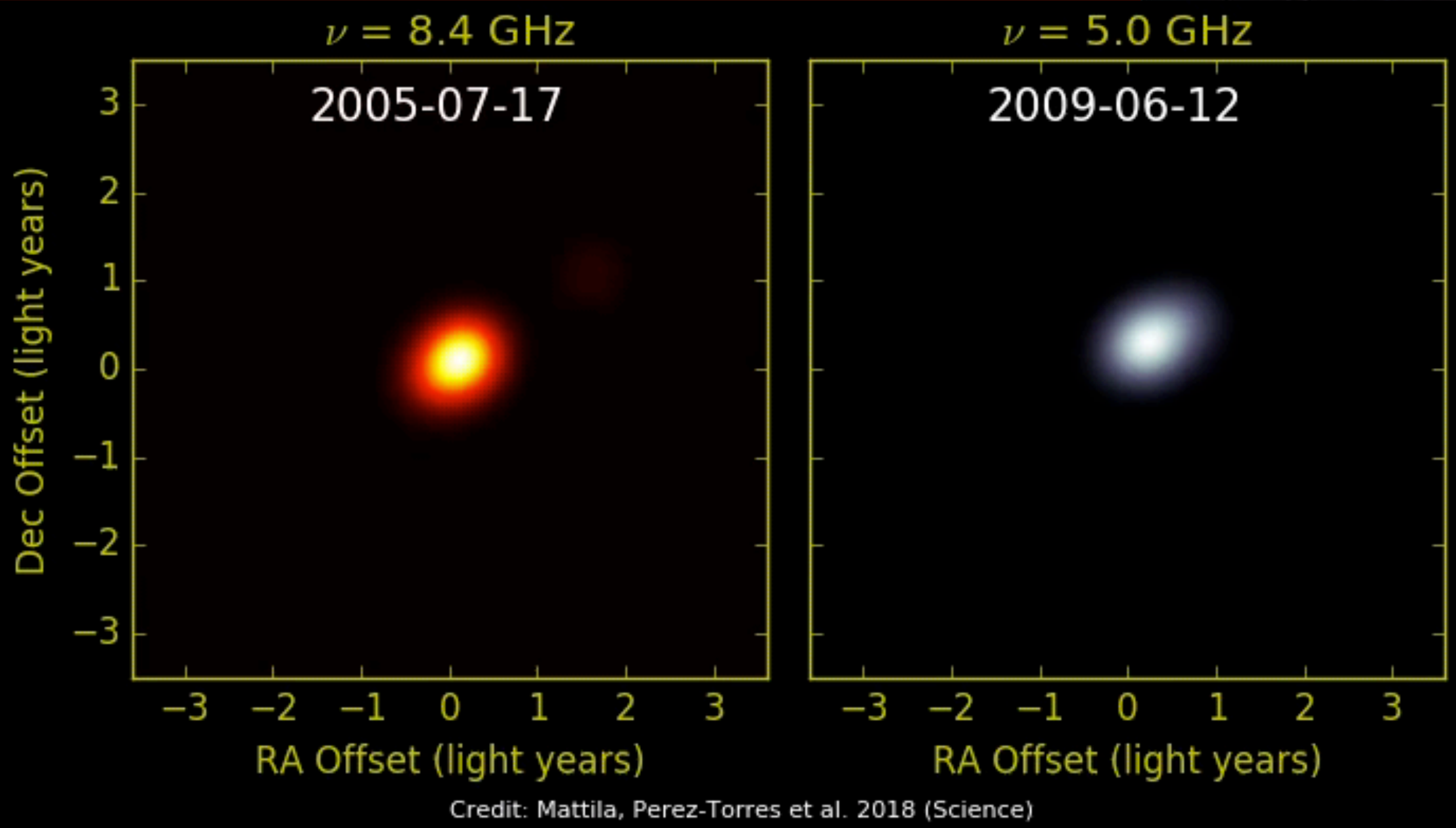




Kostrzewa-Rutkowska, Jonker, et al. 2015

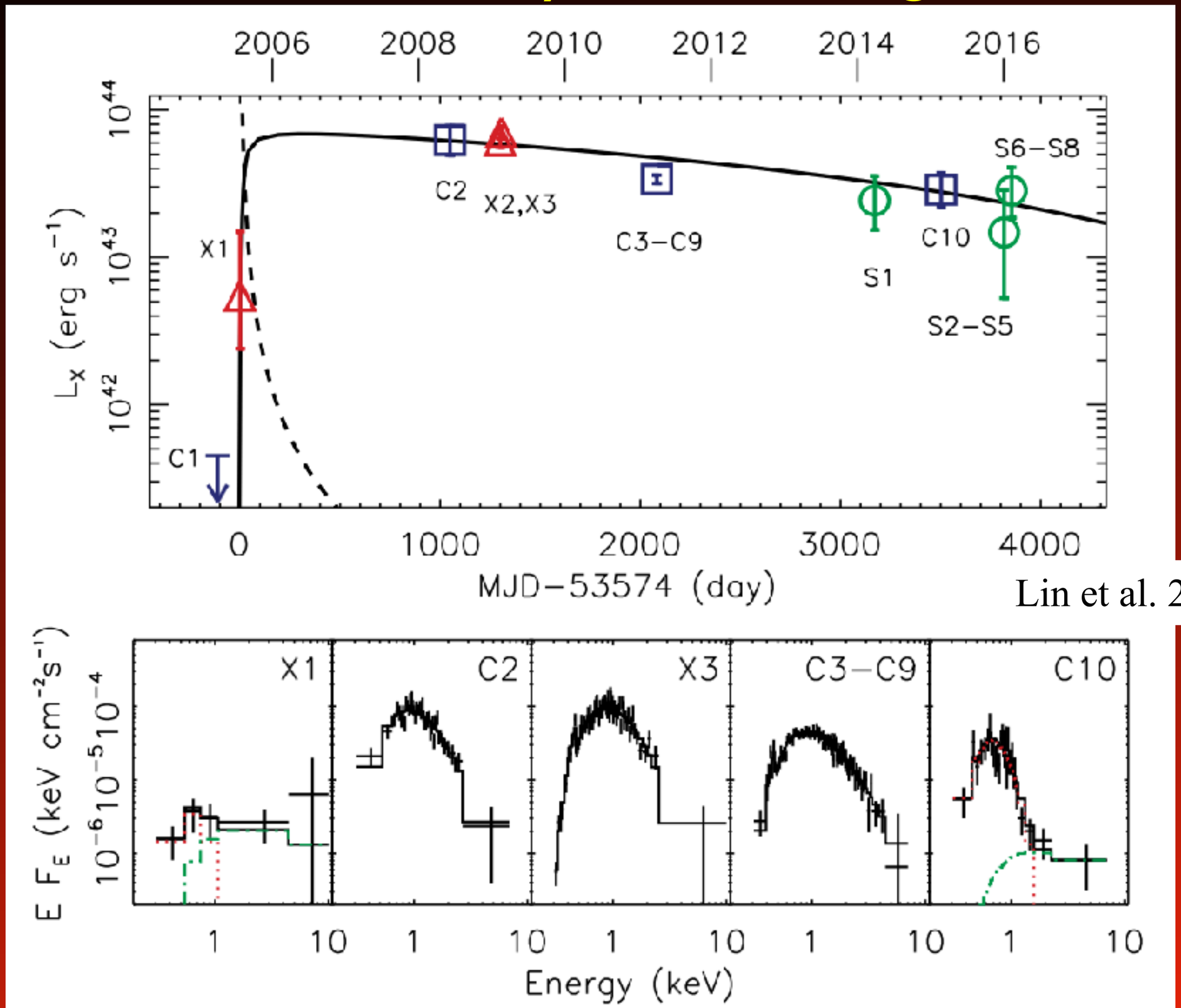
Extreme TDEs: in Arp 299





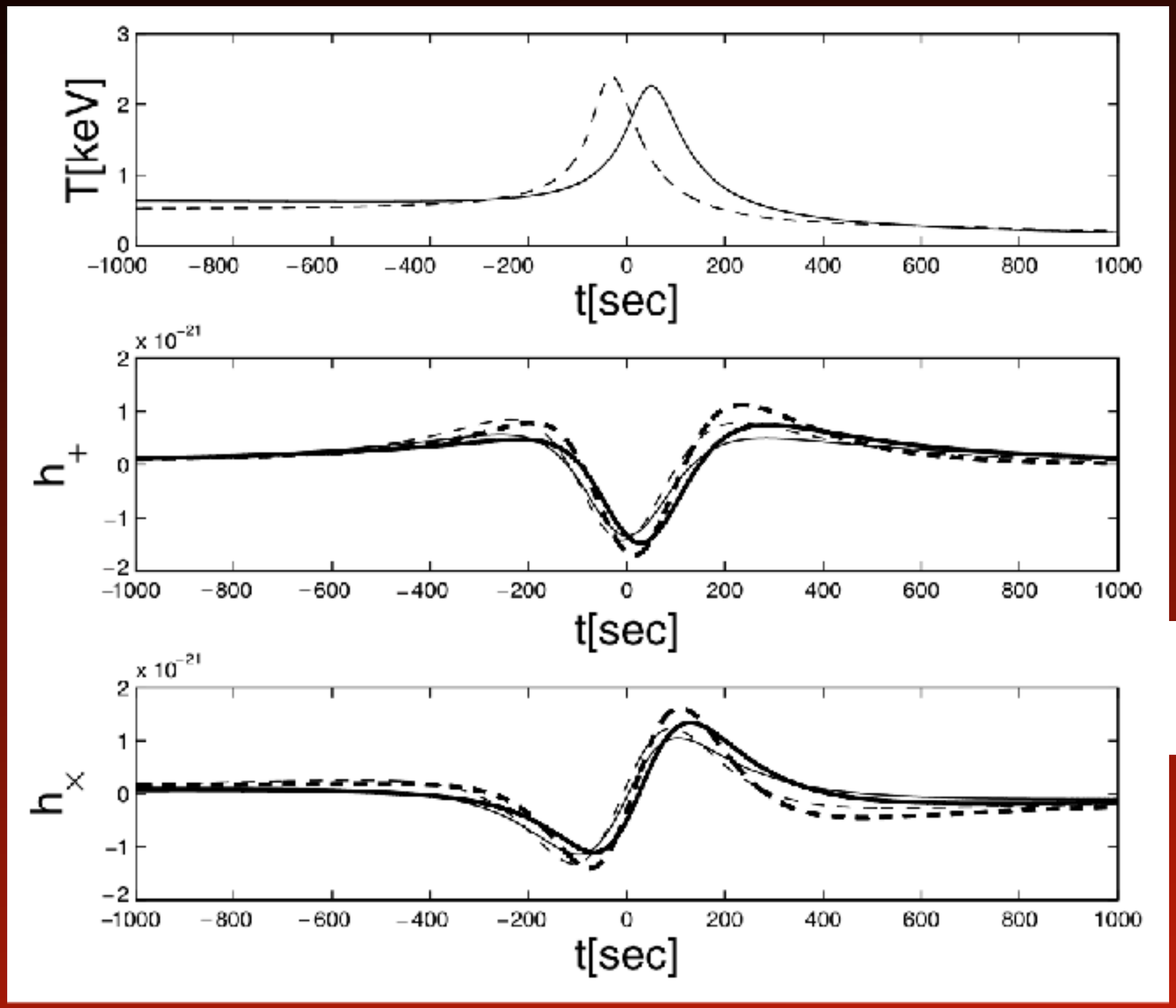
Mattila, Torres et al. 2018; Science

Extreme TDEs: X-ray; decade long event



Lin et al. 2017 Nat

EM (X-ray [?]) & GW transient upon disruption



Kobayashi et al. 2004
Guillochon et al. 2009

$$h \sim 2 \times 10^{-22} \beta \left(\frac{D}{10\,\mathrm{Mpc}} \right)^{-1} \left(\frac{R_*}{R_\odot} \right)^{-1} \left(\frac{M_*}{M_\odot} \right)^{4/3} \left(\frac{M_{BH}}{10^6 M_\odot} \right)^{2/3}$$

Conclusion:

- There exist a (large) number of fast X-ray transients
- Are they off-axis GRBs, TDEs or do we need another source type?
- Athena-WFI alerts on serendipitously discovered X-ray flares
- TDEs are a great new tool to study SMBHs and their formation