Systematic investigations of stellar tidal disruption flares

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A new tool to study black holes and galaxies

- Probe dormant supermassive black holes
- Study *inactive* galatic nuclei
- Intermediate-mass BHs
- Merging SMBHs; EM counterparts for LISA (Stone & Loeb 2011)

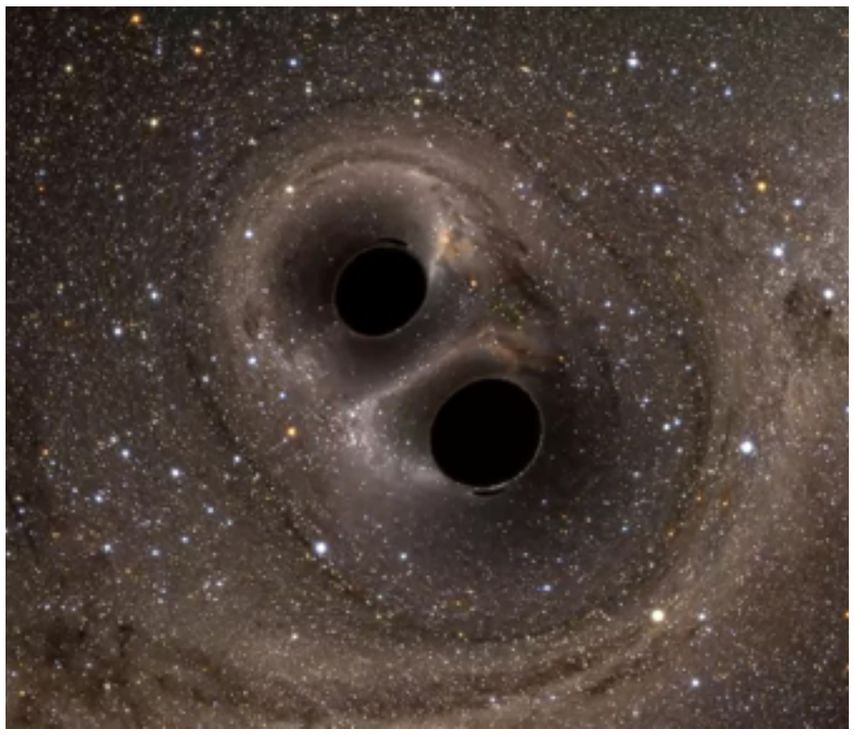

image credit: SXS

A new tool to study black holes and galaxies

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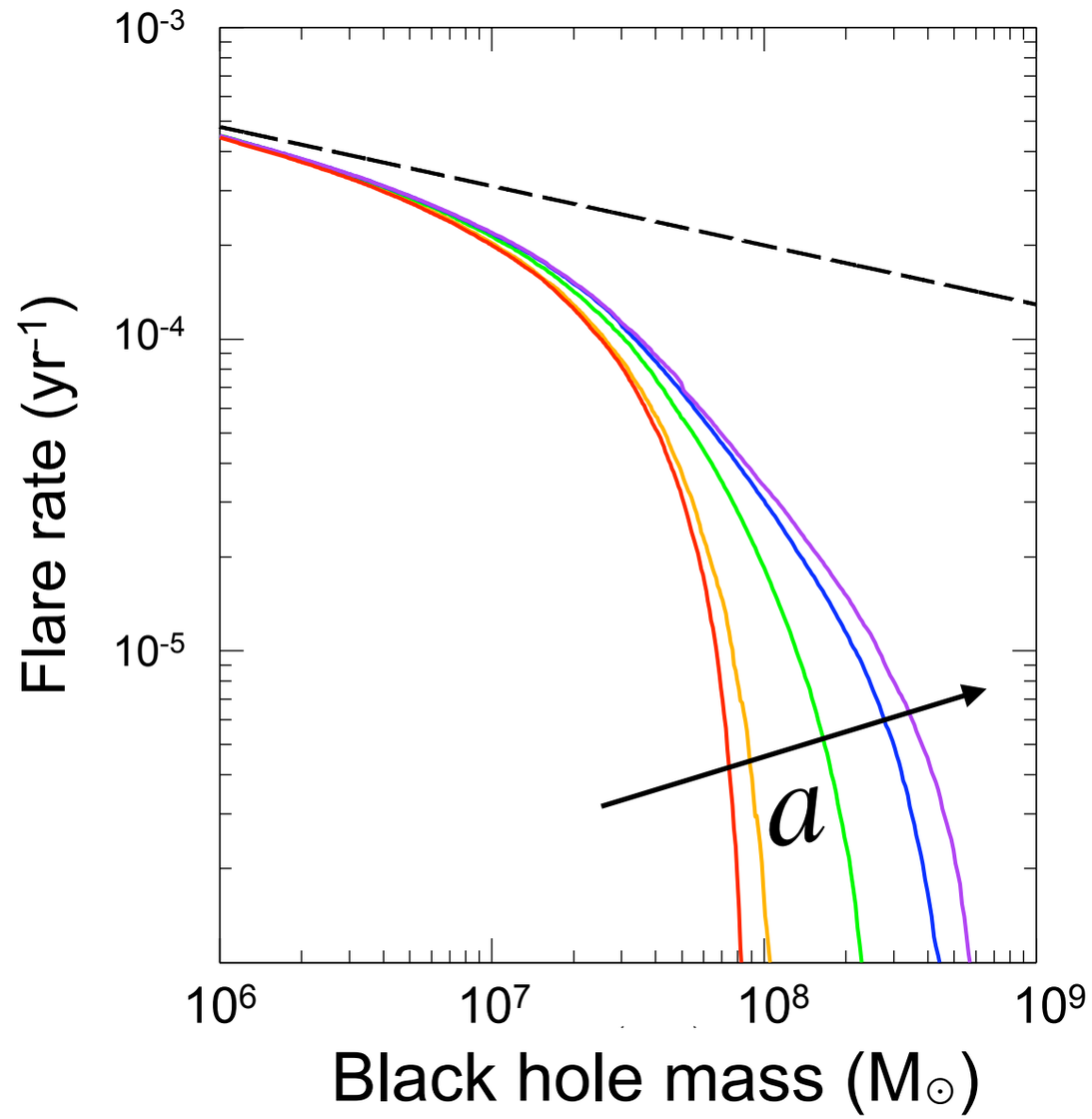
- Accretion physics
- Jet physics
- BH event horizon and spin



Kesden (2011)

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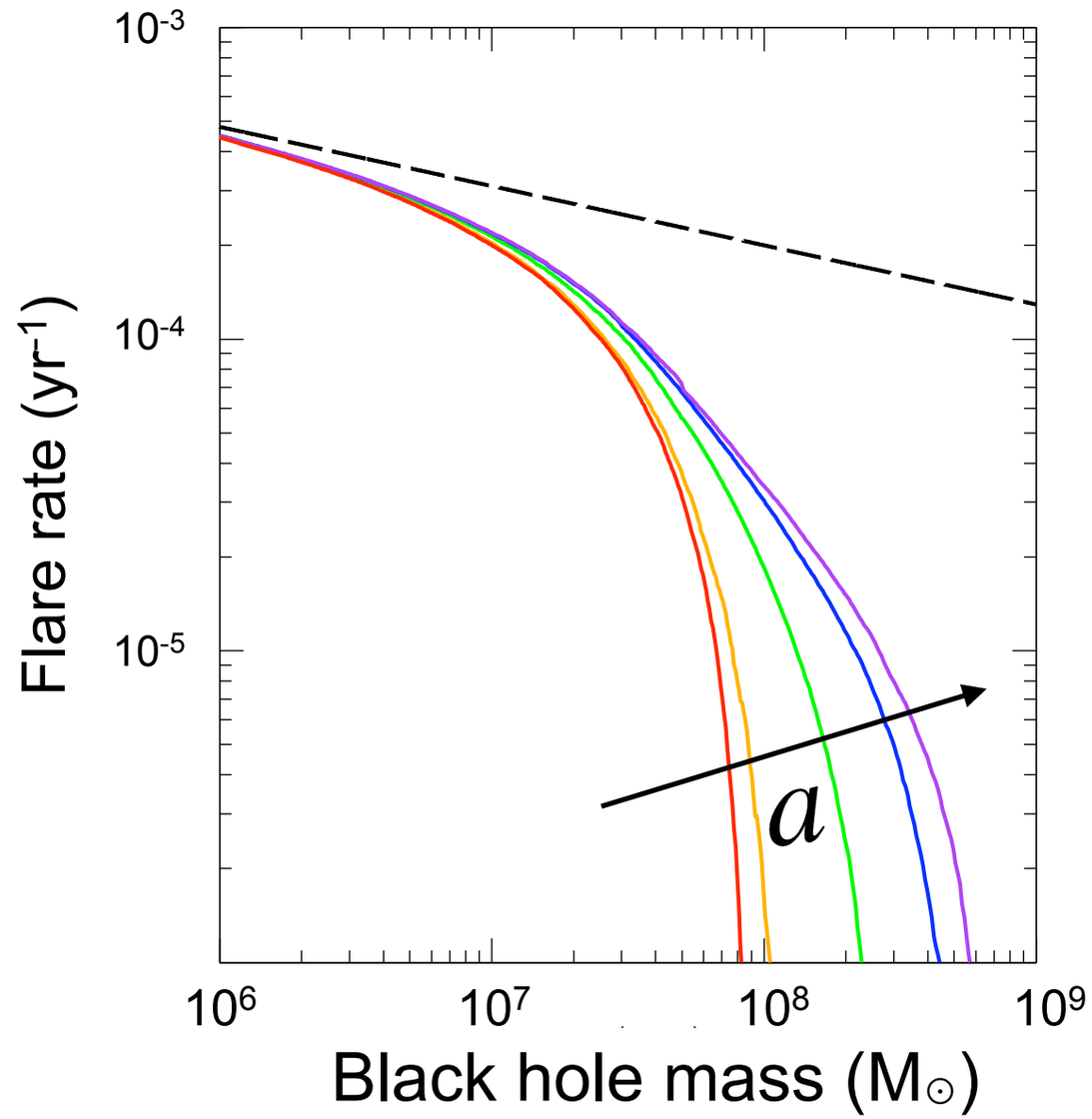
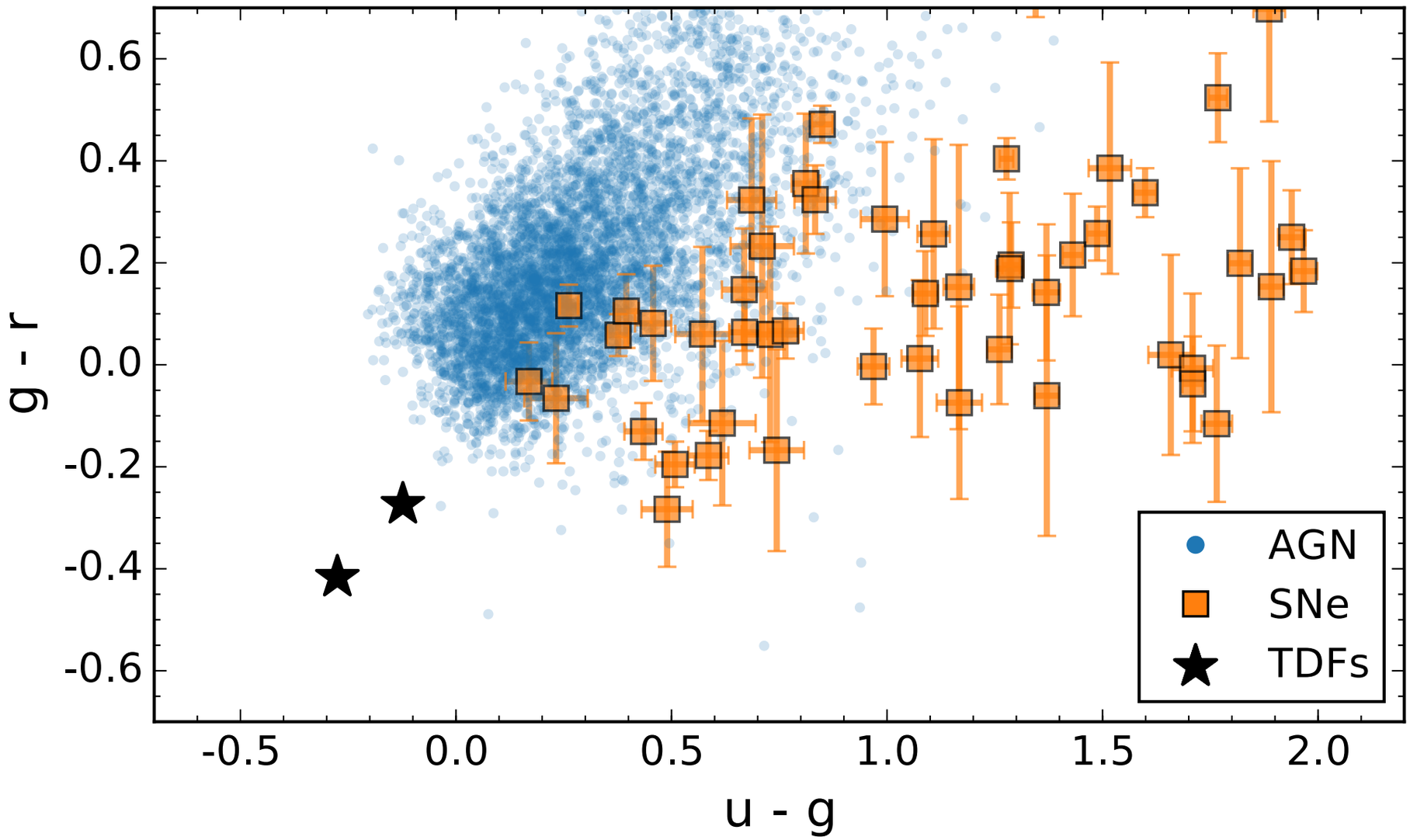
- Accretion physics
- Jet physics
- **BH event horizon**



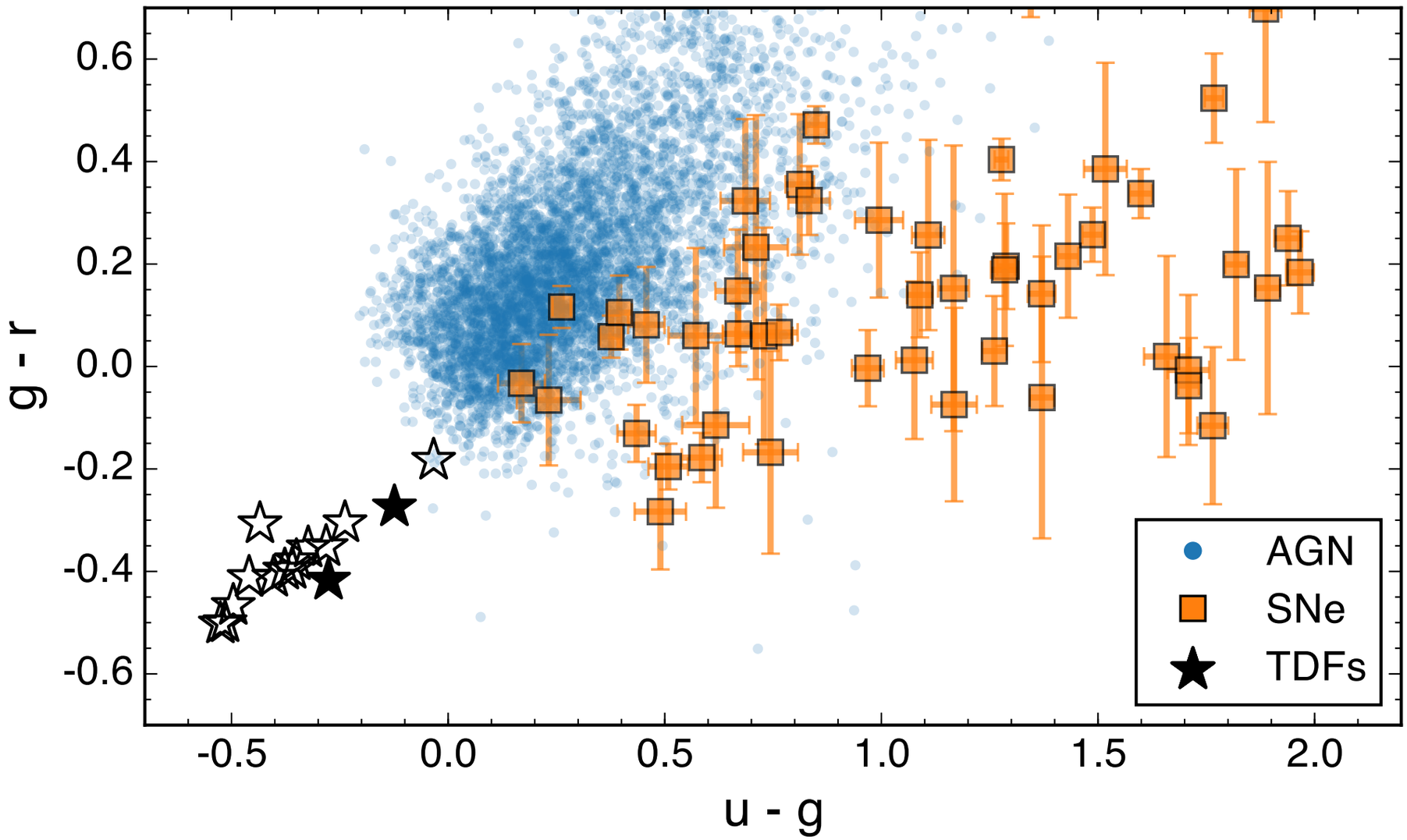
Kesden (2011)

TDF locus in optical surveys (2010)



adapted from van Velzen et al. (2011), using SDSS Stripe 82 data

TDF locus in optical surveys (July, 2017)



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TDF Impostors

- Accretion disk instabilities,
  new type of CLAGN

- A new kind of SNe,
  exclusive to galatic nuclei
  Saxton, Perets, & Baskin (2017)

- Collisions of stars on bound orbits (EMRIs)
  Metzger & Stone (2017)

- How do we test this?

Goal of this talk

Demonstrate rate suppression due to the black hole horizon

(Paper on the arXiv this evening)

Timeline of optical/UV TDFs

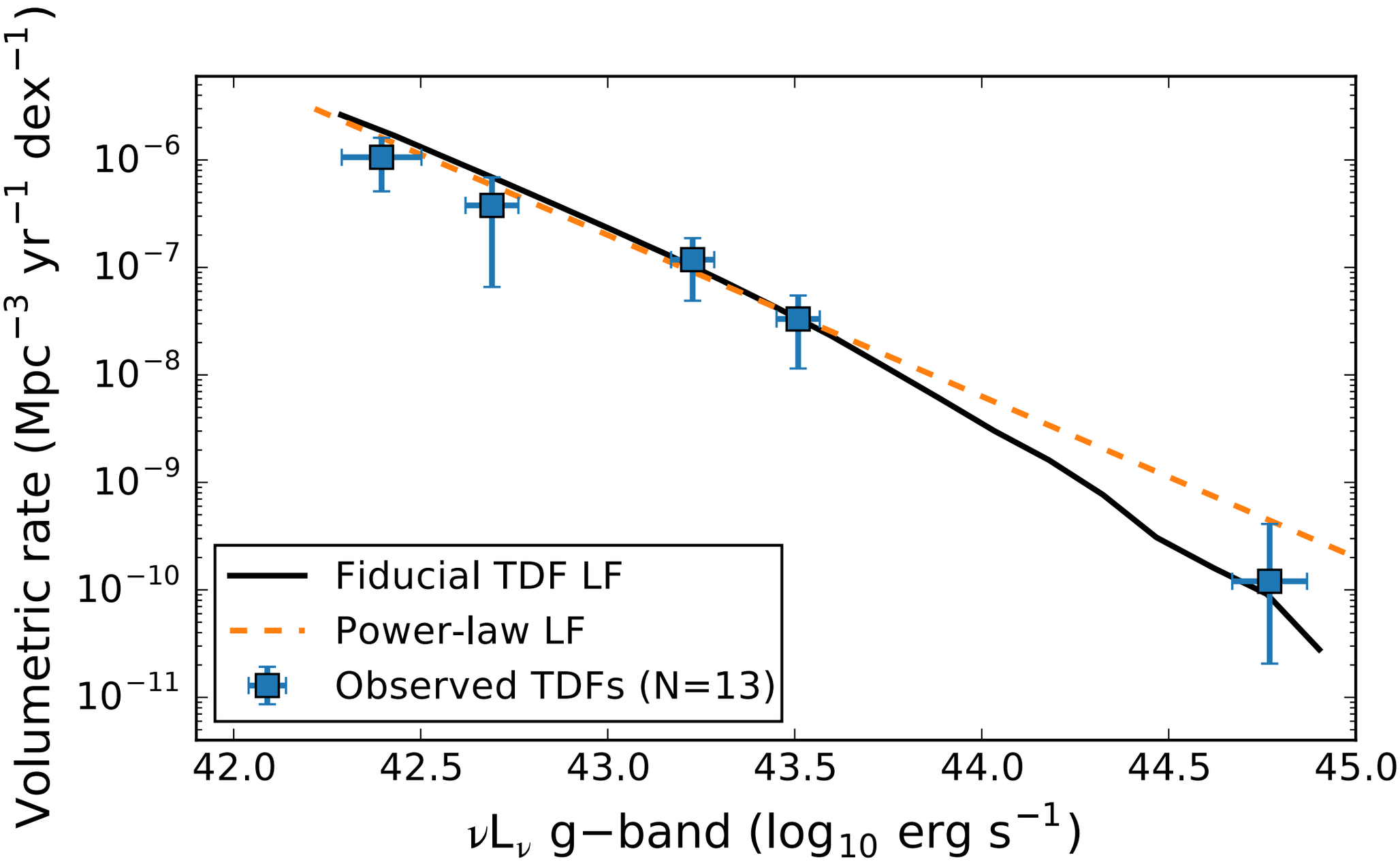
Normalization of the different surveys

Number of flares = Survey duration / Area x Efficiency x Volume x Rate

	Number of flares	Z_{max}	Survey duration x Area (yr deg^2)
GALEX	3	0.44	10
SDSS	2	0.14	200
ASAS-SN	4	0.02	80,000

The optical TDF luminosity function

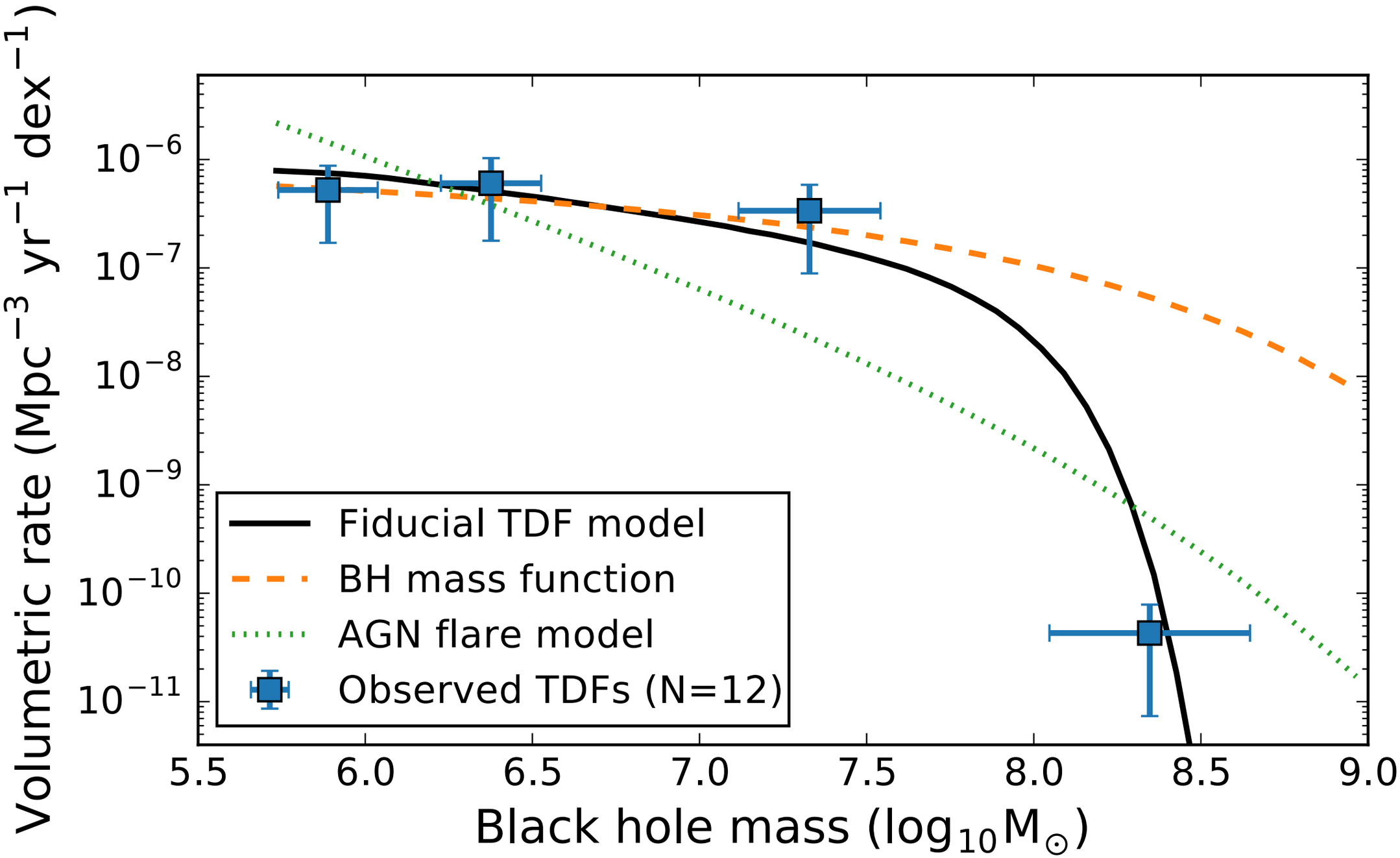
(using $1/V_{max}$ method)



van Velzen (2017)

The TDF host galaxy black hole mass function

(using $1/V_{max}$ method)

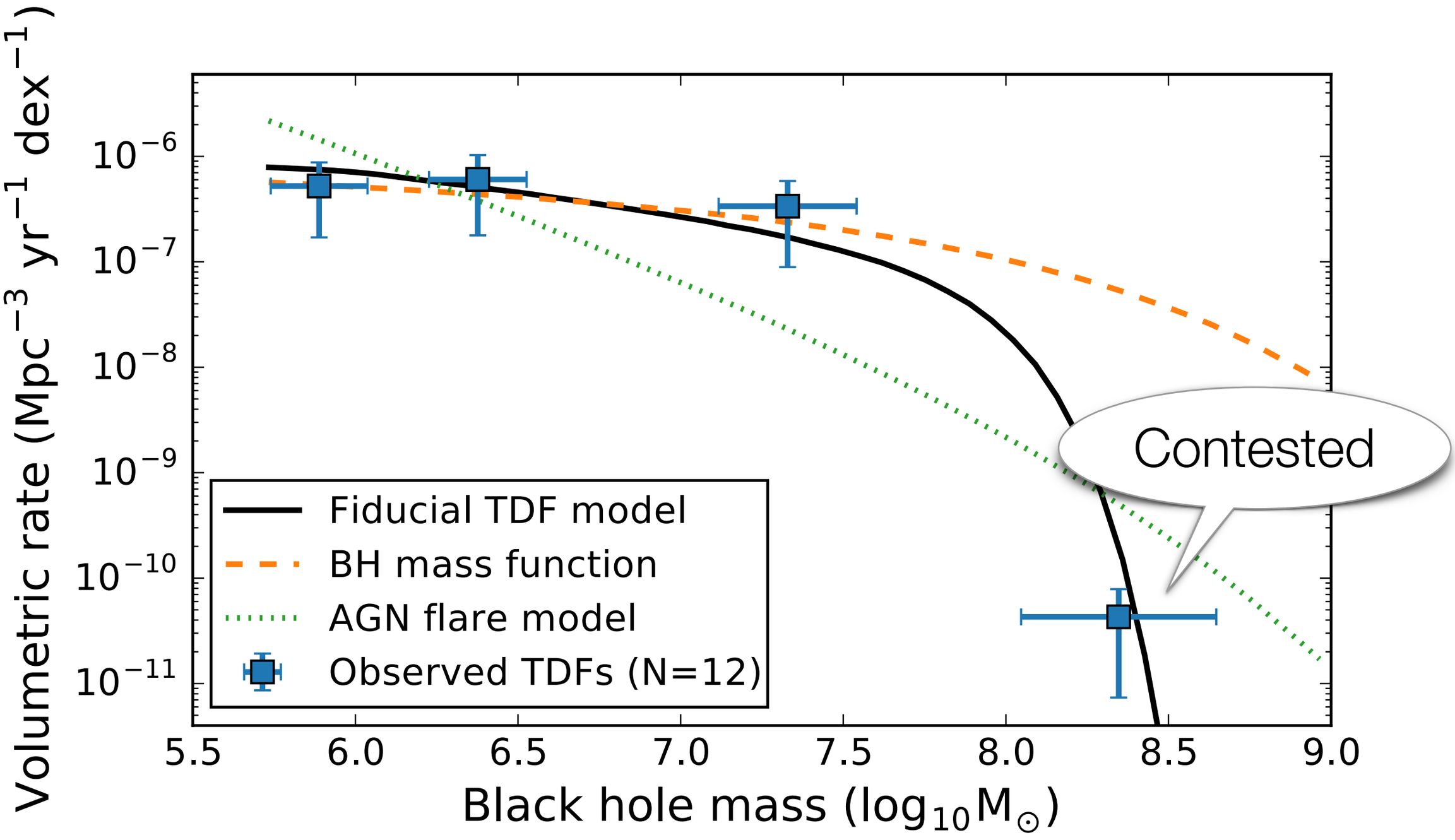


van Velzen (2017);
data from Wevers et al. (arXiv:170608965)

Take home message 1

- Steep turnover in black hole mass function
- Very challenging for *any* TDF impostor scenario

The TDF host galaxy black hole mass function



ASASSN-15lh

Superluminous SN
(Dong et al. 2016)

TDE from Kerr BH
(Leloudas et al. 2017)

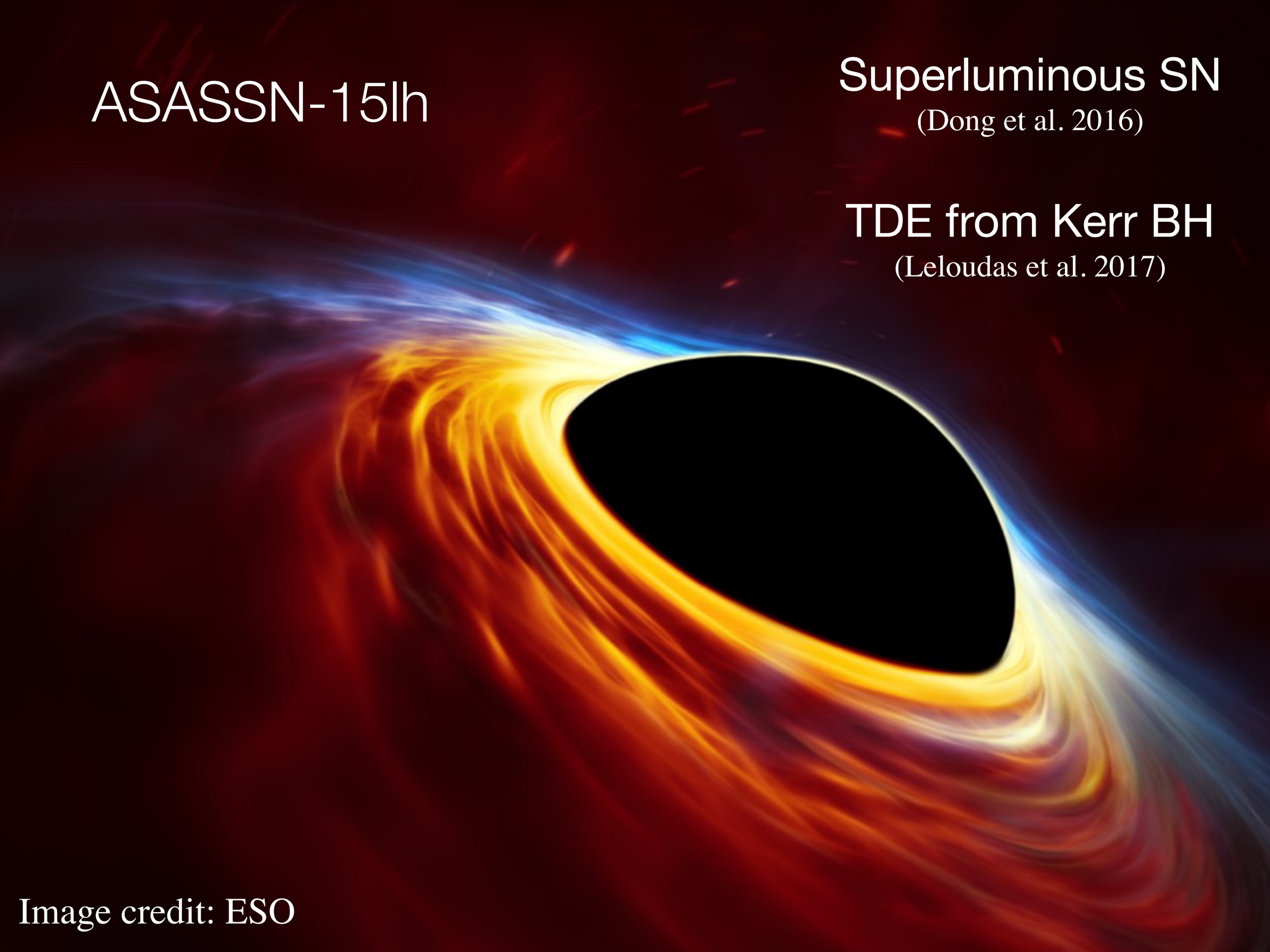
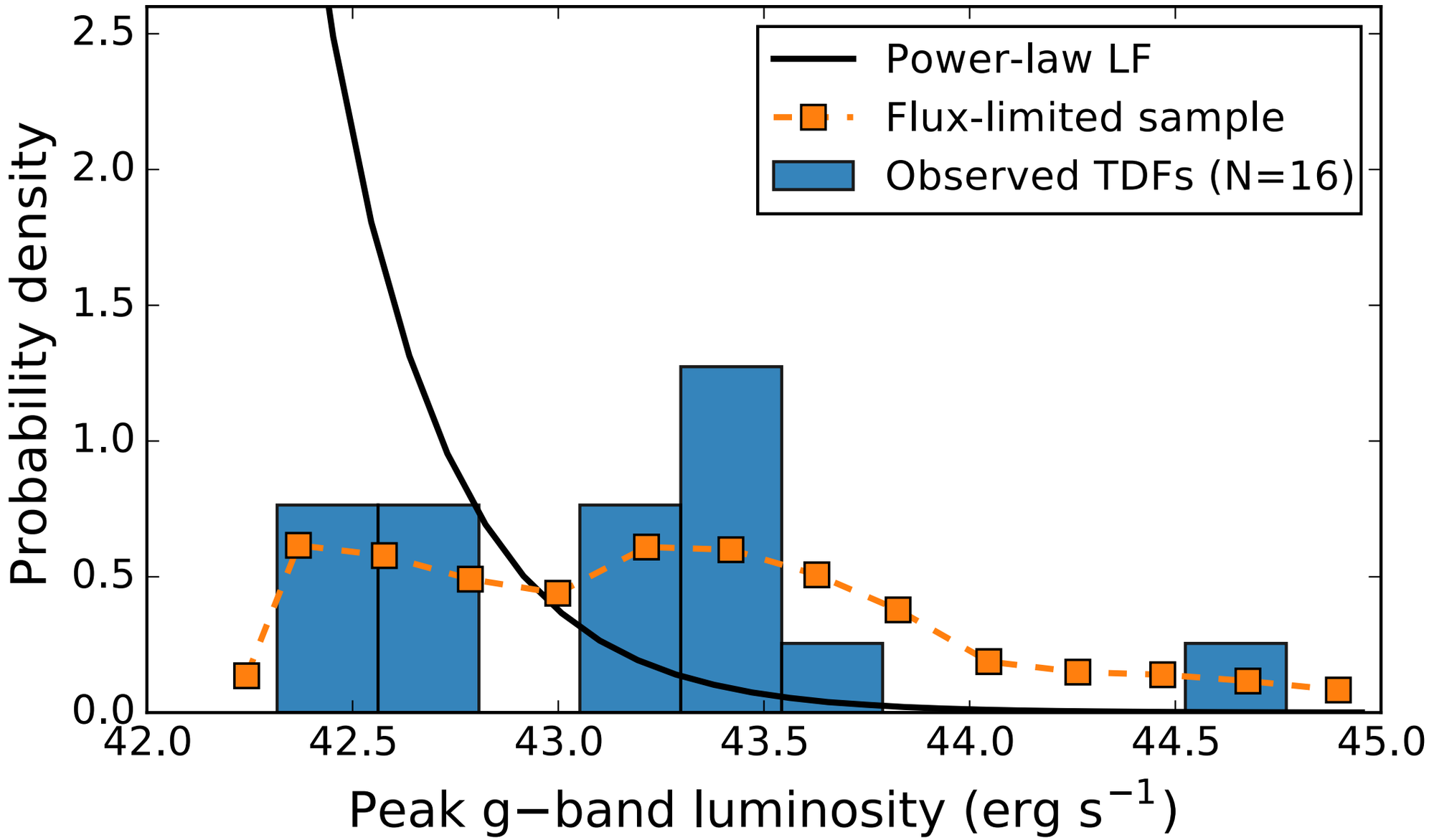
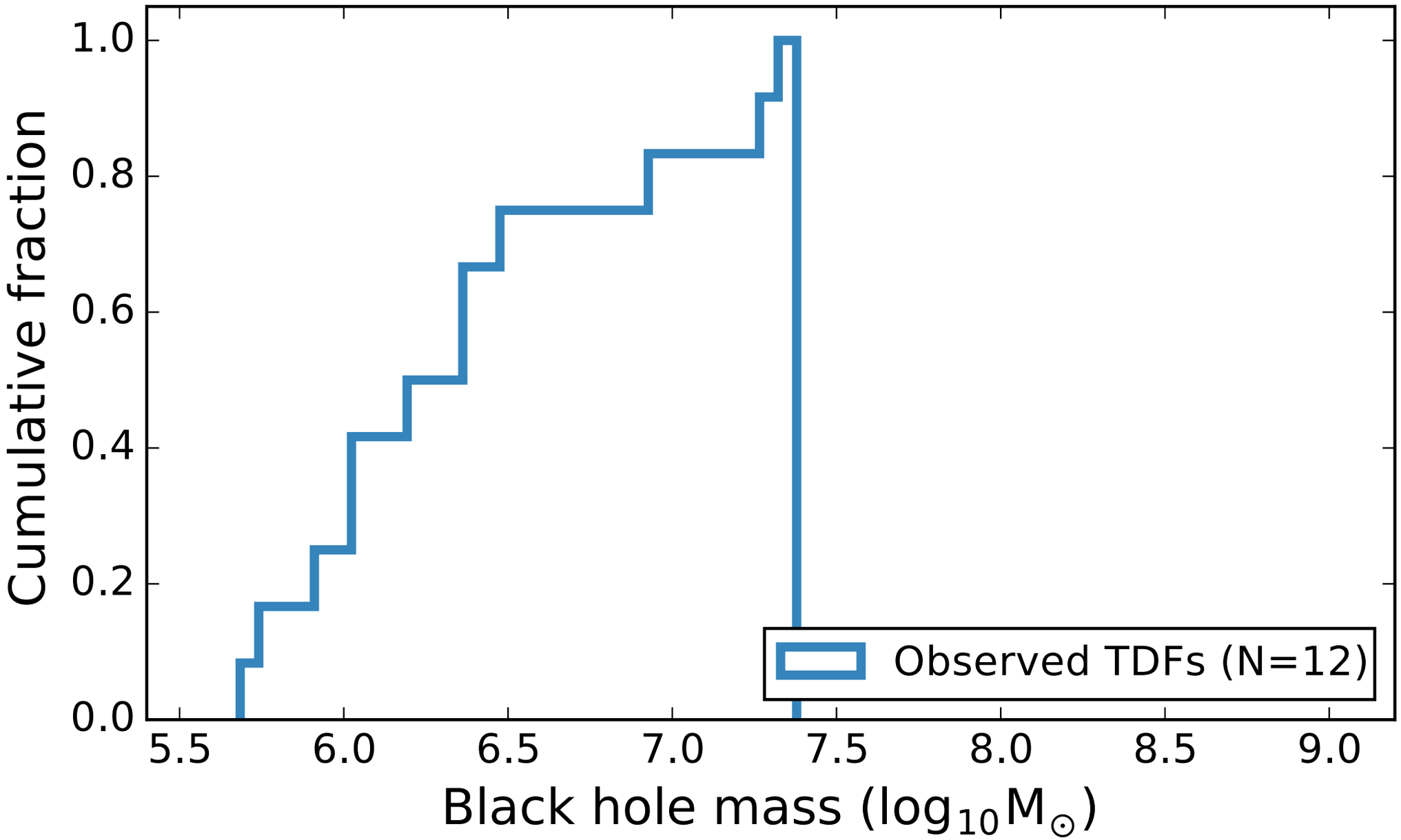


Image credit: ESO

Next step: forward modeling



Observed black hole mass distribution



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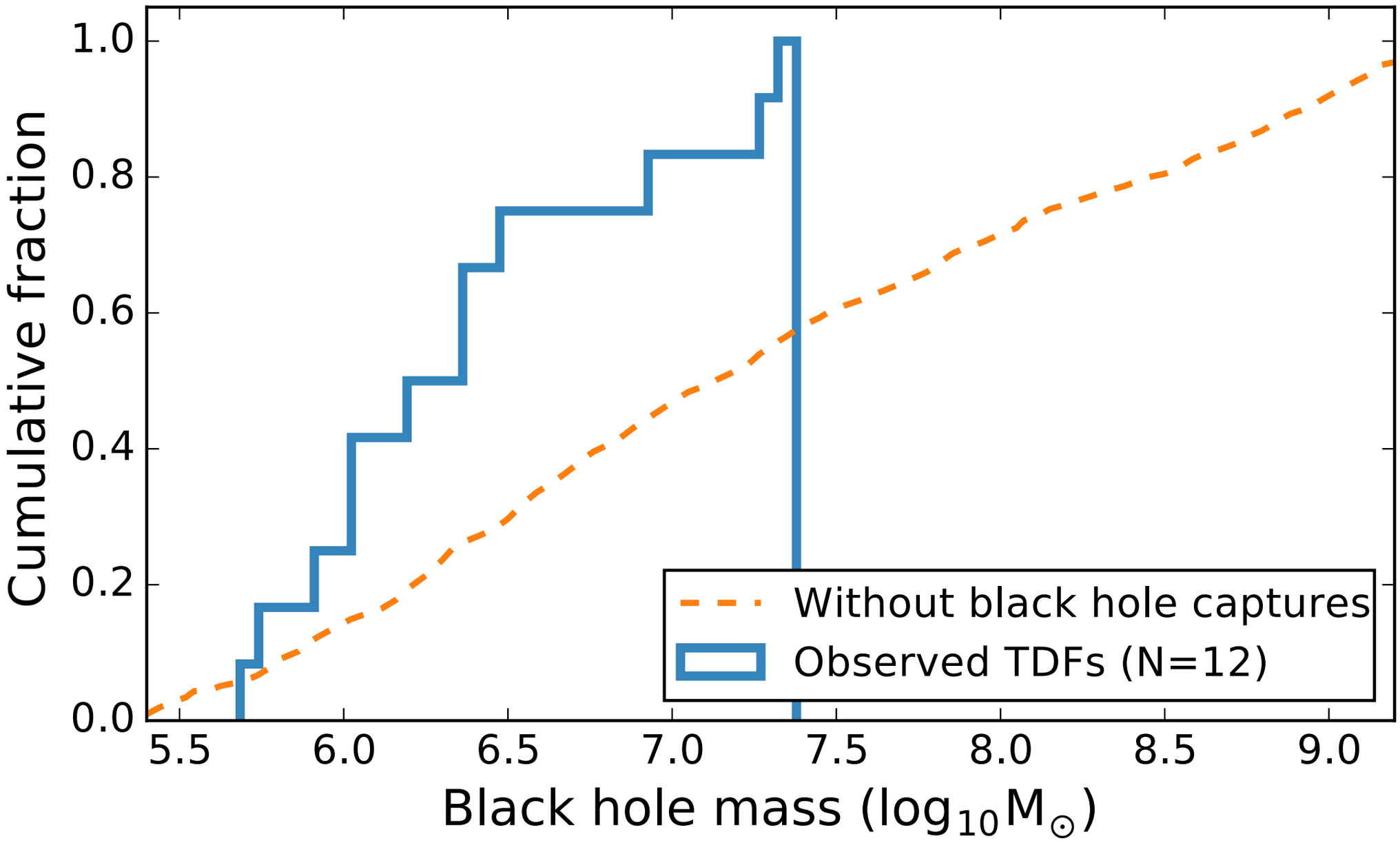

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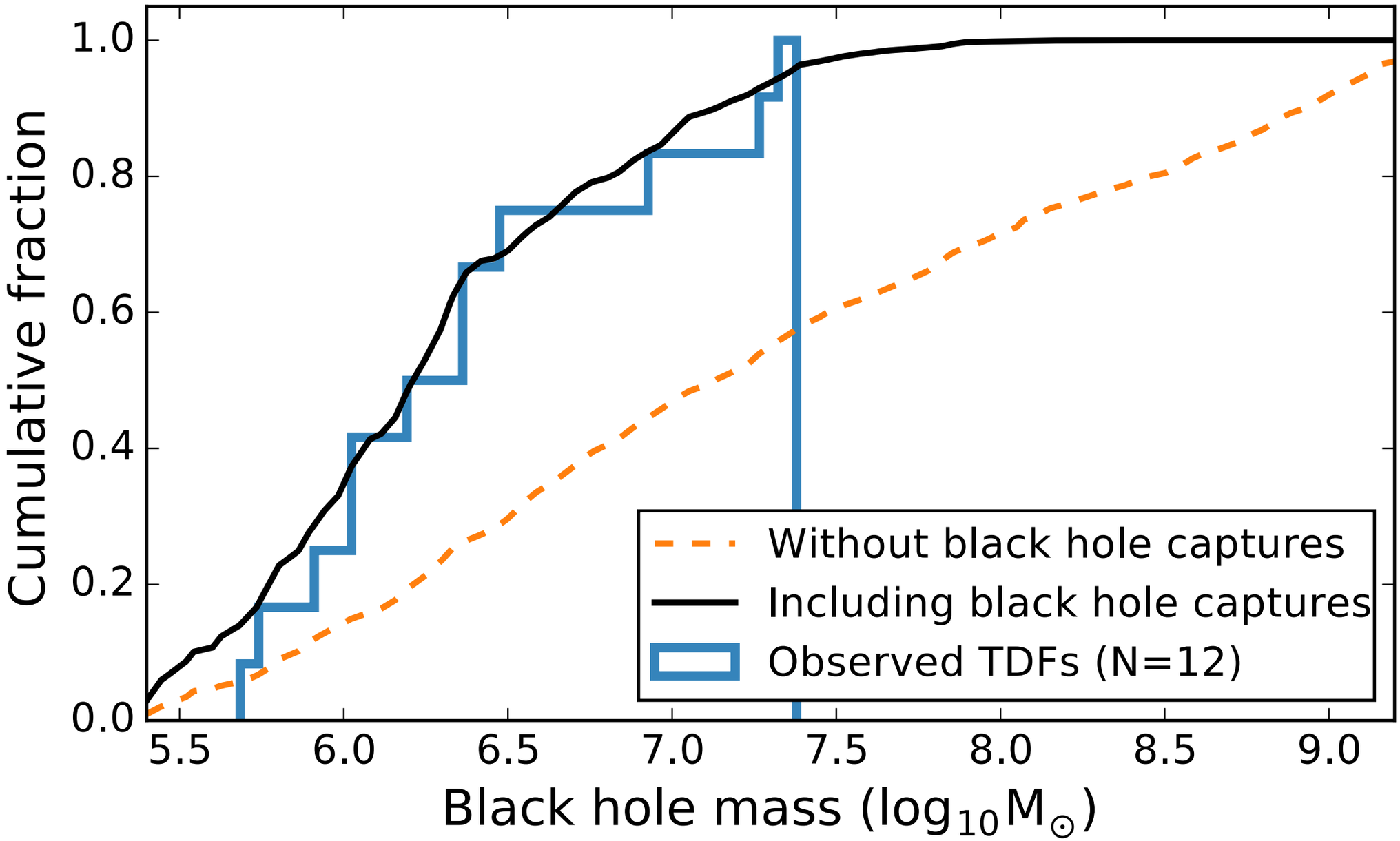
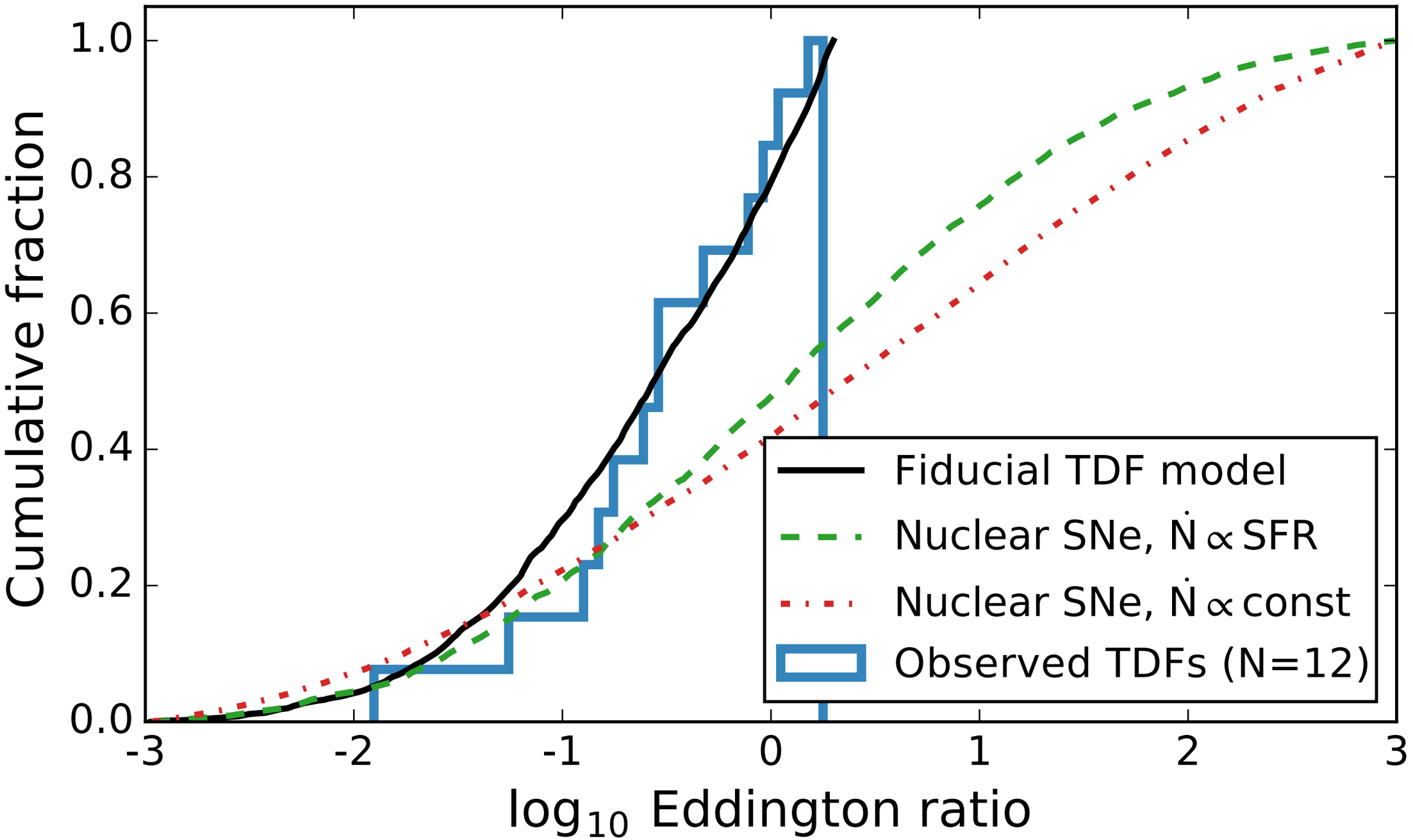


van Velzen et al. (in prep); Wevers et al. (arXiv:170608965)

Observed Eddington ratio distribution

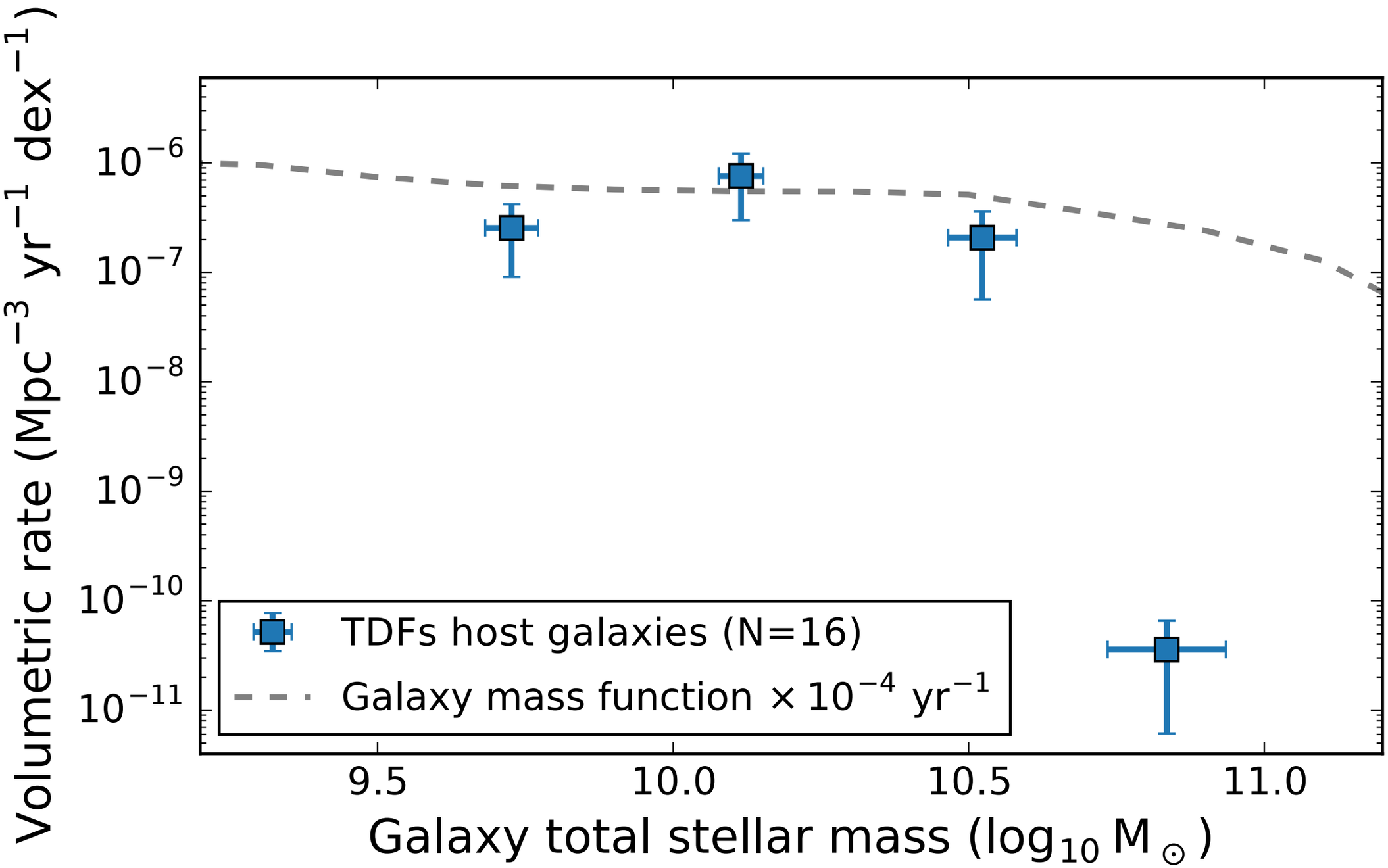


Take home message 2

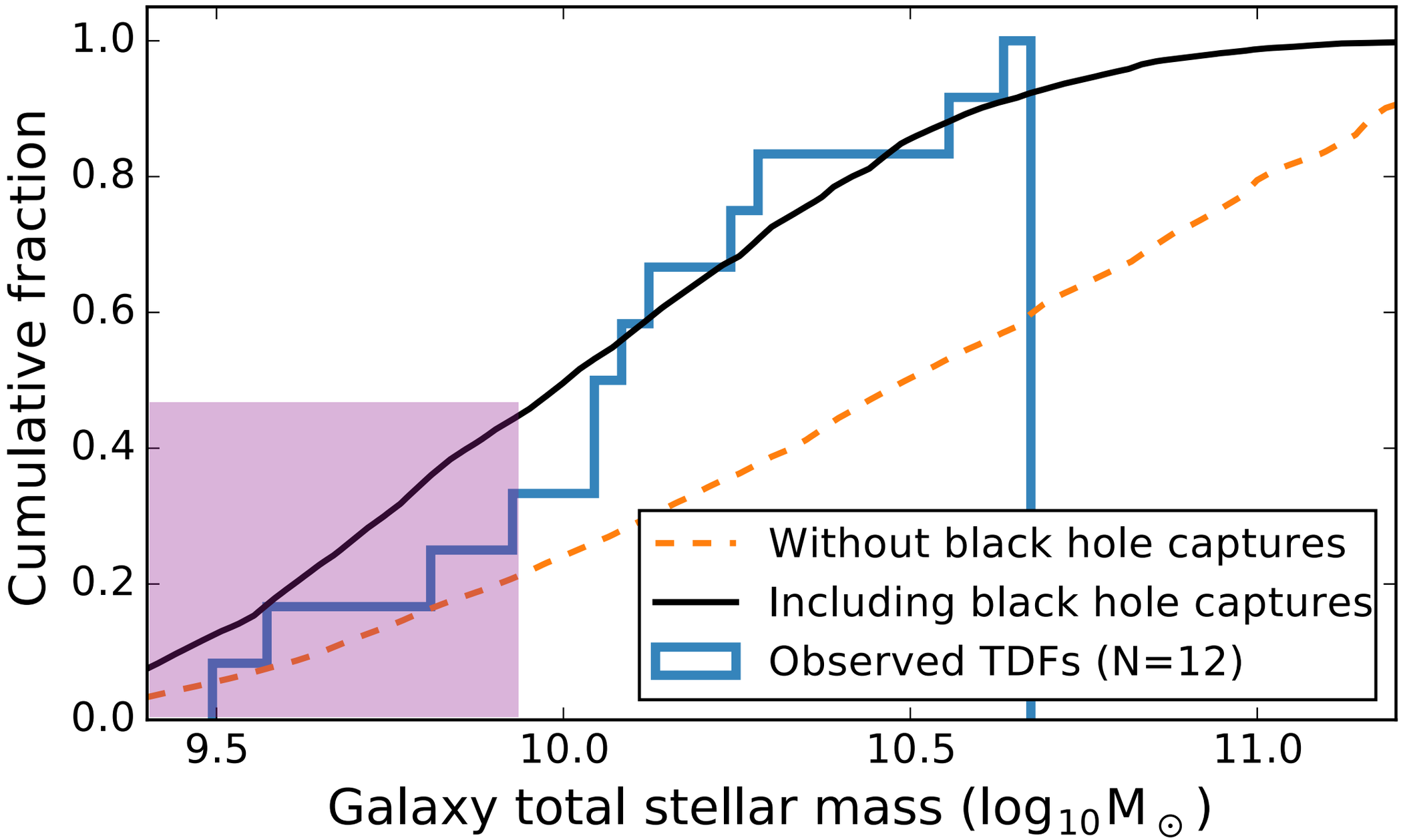
- Significant lack of flares from high-mass BHs
- Very challenging for *any* TDF impostor scenario

TDE science

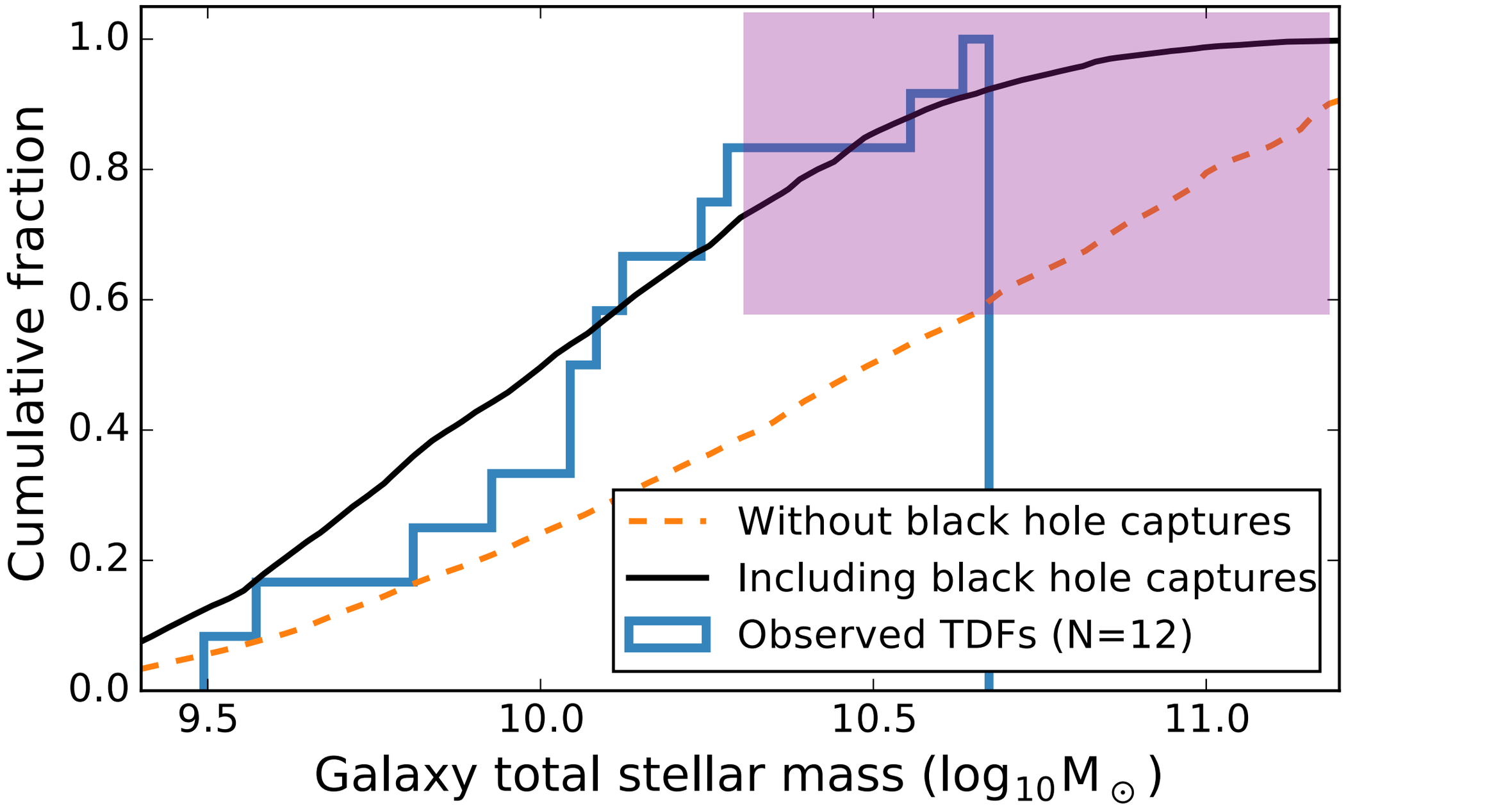
Rate as a function of galaxy mass: higher than previous measurements



Black hole occupation fraction: constant for $M_{BH} > 10^{5.5}\ M_{\odot}$



Black hole spin:
suggestive evidence for high spin (a~0.9)



Summary

- **Detected strong turnover in the TDF black hole mass function:**
  - Inconsistent with current TDF impostor scenarios.
  - High black hole spin (a~0.9) implied
- **TDF luminosity function is steep:**
  - Per-galaxy rate is high (10^{-4} yr^{-1})
- Rate constant at low mass:
  - No large circularization inefficiencies
  - Constant black hole occupation fraction