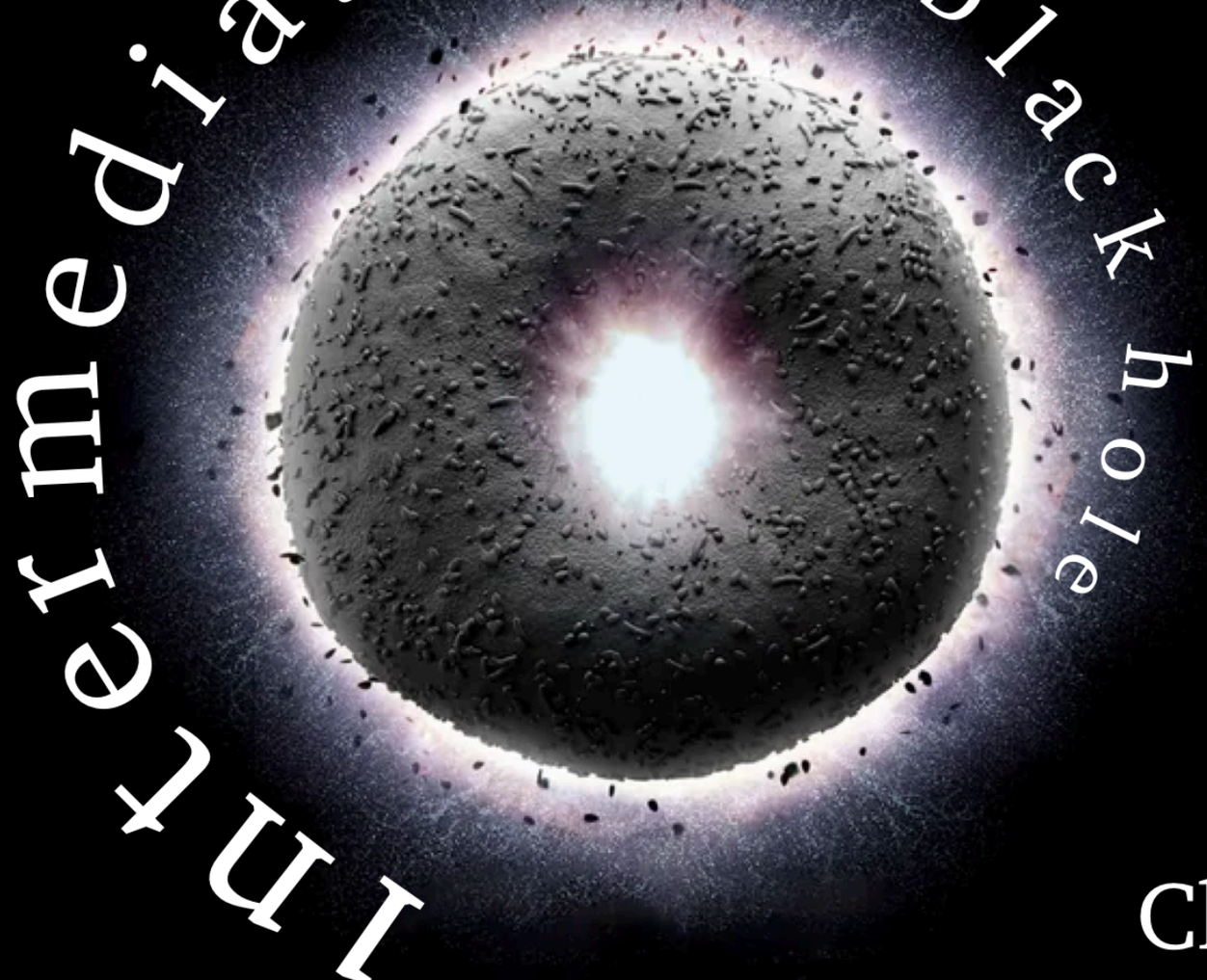
A fast rising tidal disruption event from an intermediate mass black hole



Charlotte Angus

DARK Cosmology Centre

@astro_angus

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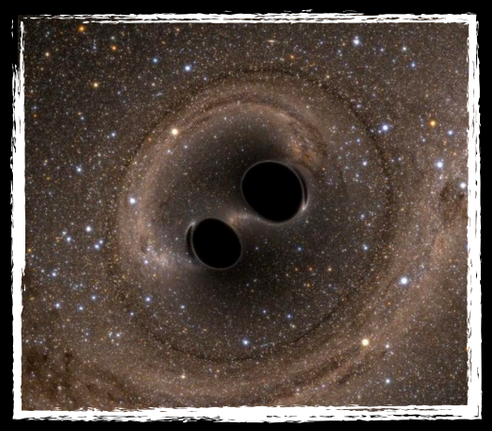
Black hole masses



Stellar Mass Black Holes (~1- 100 $M_\odot$)

Intermediate Mass Black Holes

Supermassive Black Holes (>1,000,000 $M_\odot$)

Black Hole (BH) Mass

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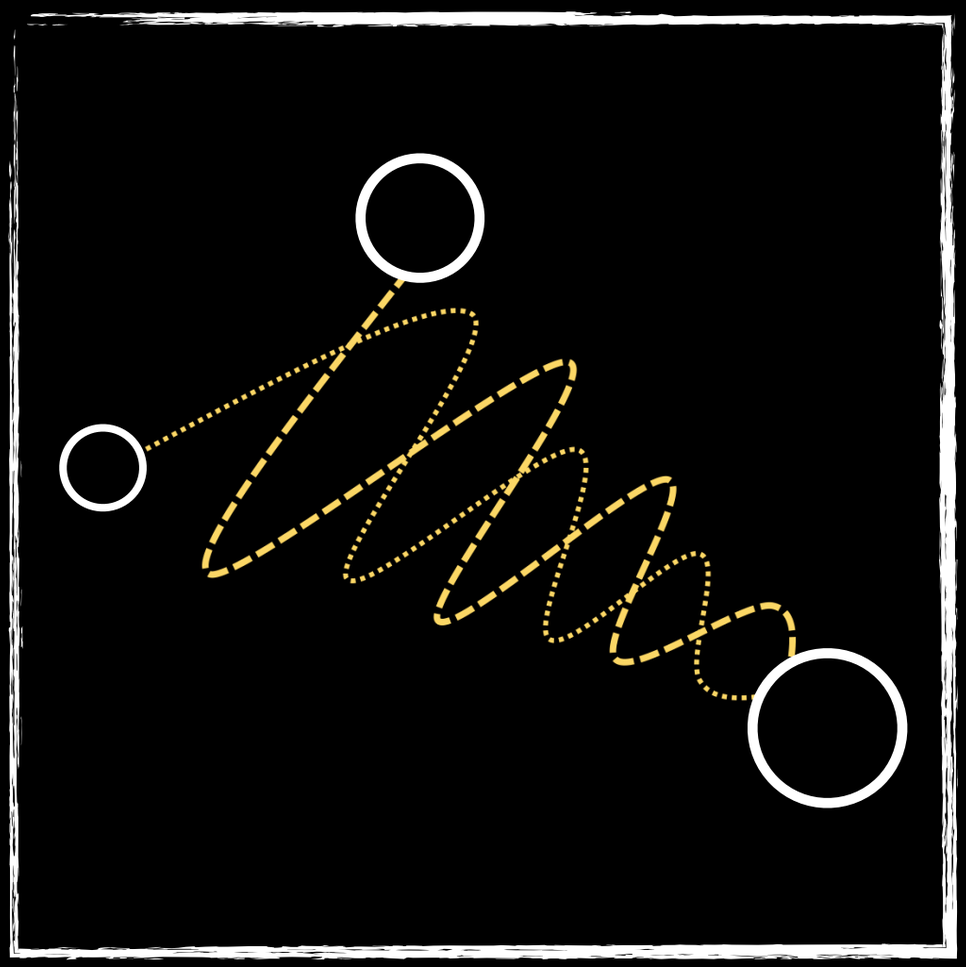
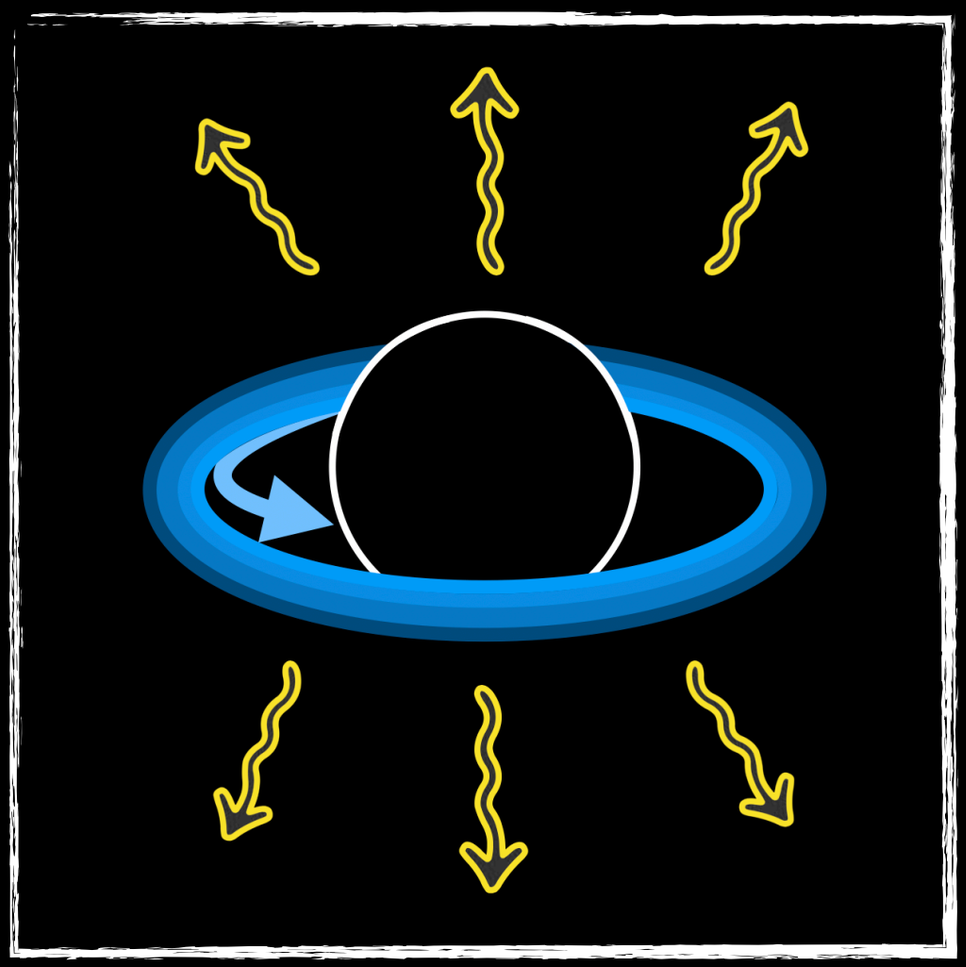
Why IMBHs are important



Source of
gravitational waves
in LISA era



Understanding accretion
and **BH growth**

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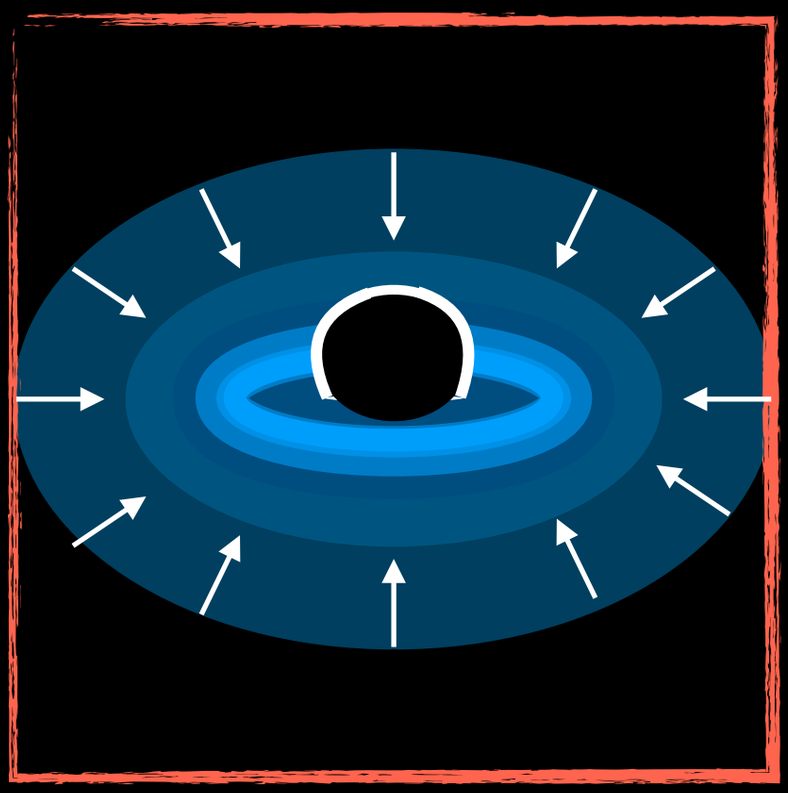
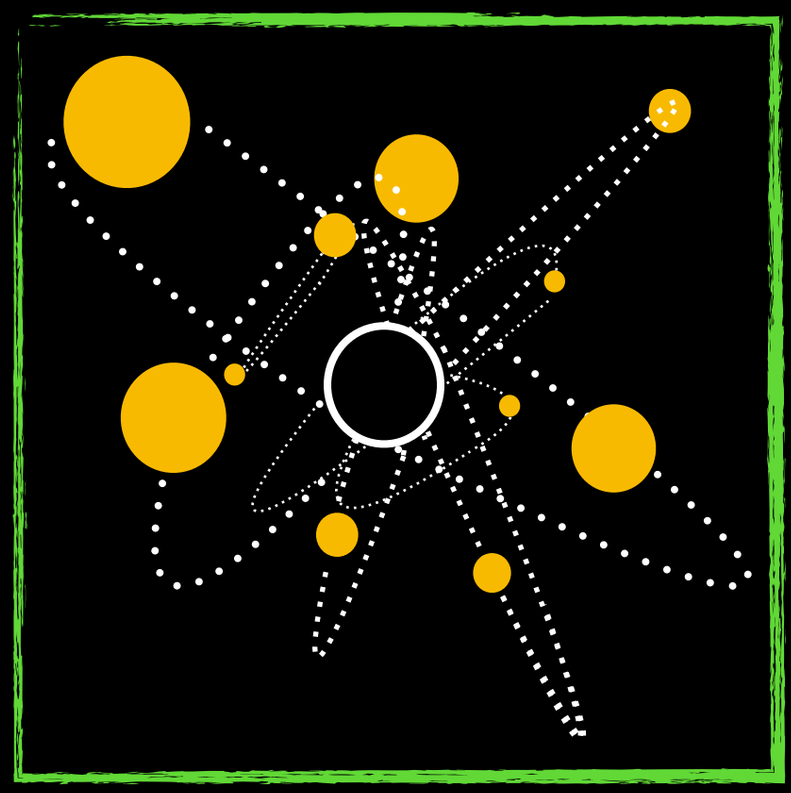
IMBH as seeds

Direct Gas Collapse



Population III Stars

Gravitational runaway mergers



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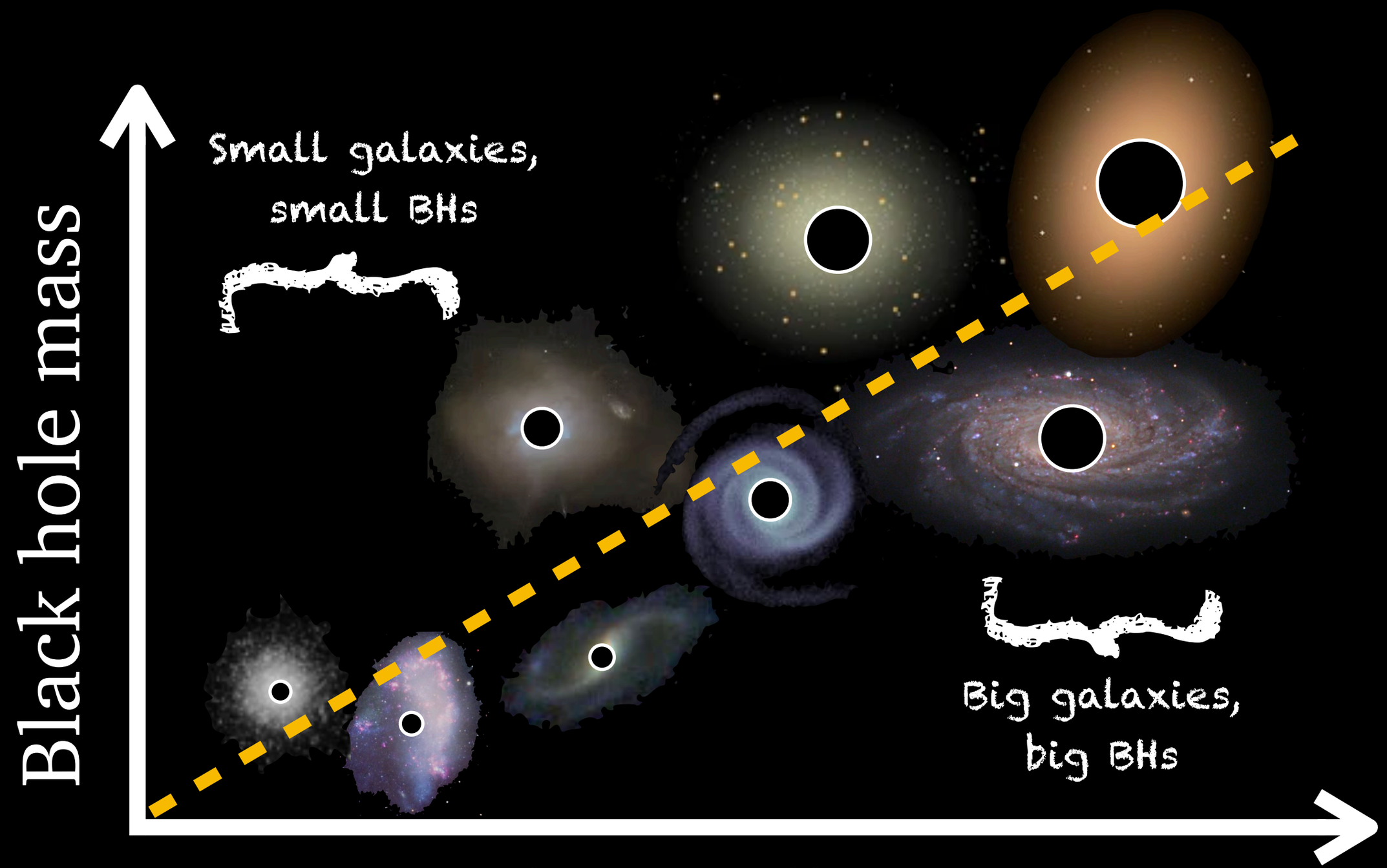
Where do we find IMBHs?



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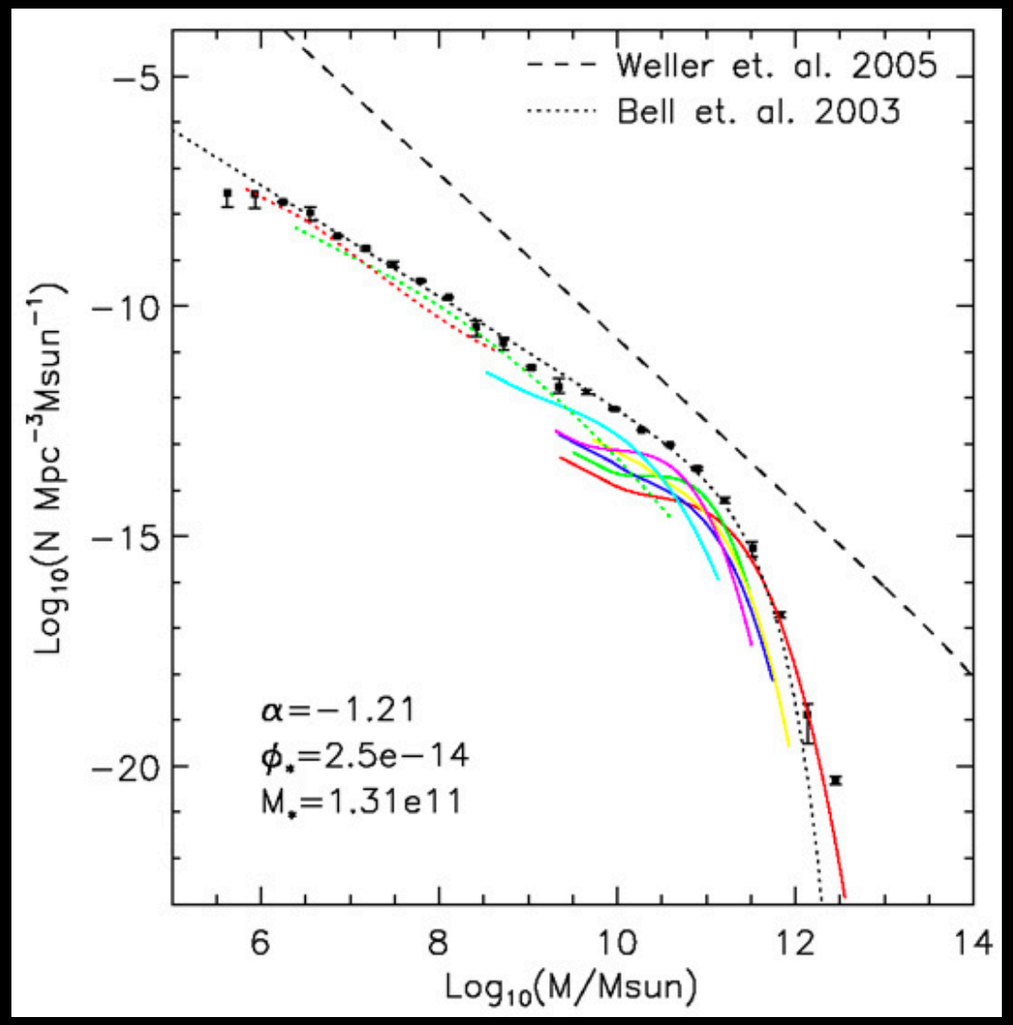
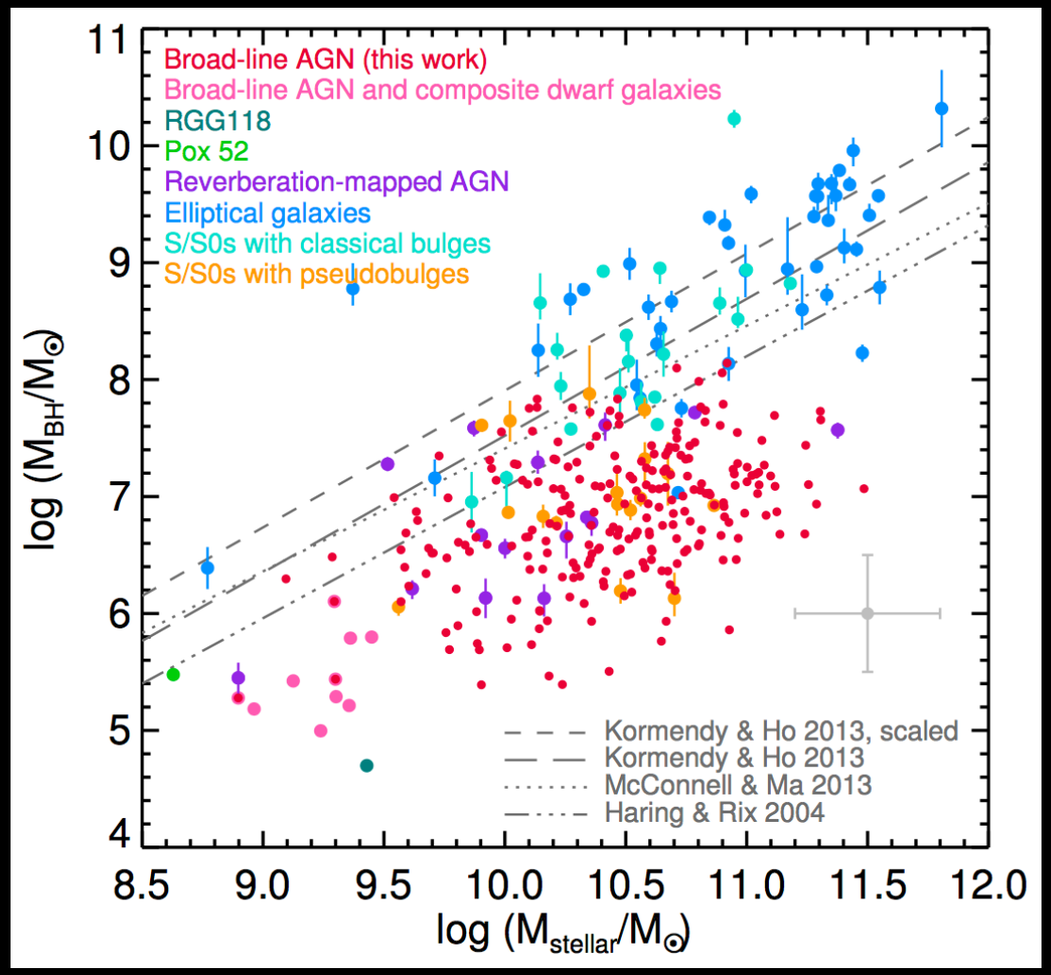
IMBHs in dwarf galaxies

There are lots of dwarf galaxies…





…but we haven't detected black holes in many of them

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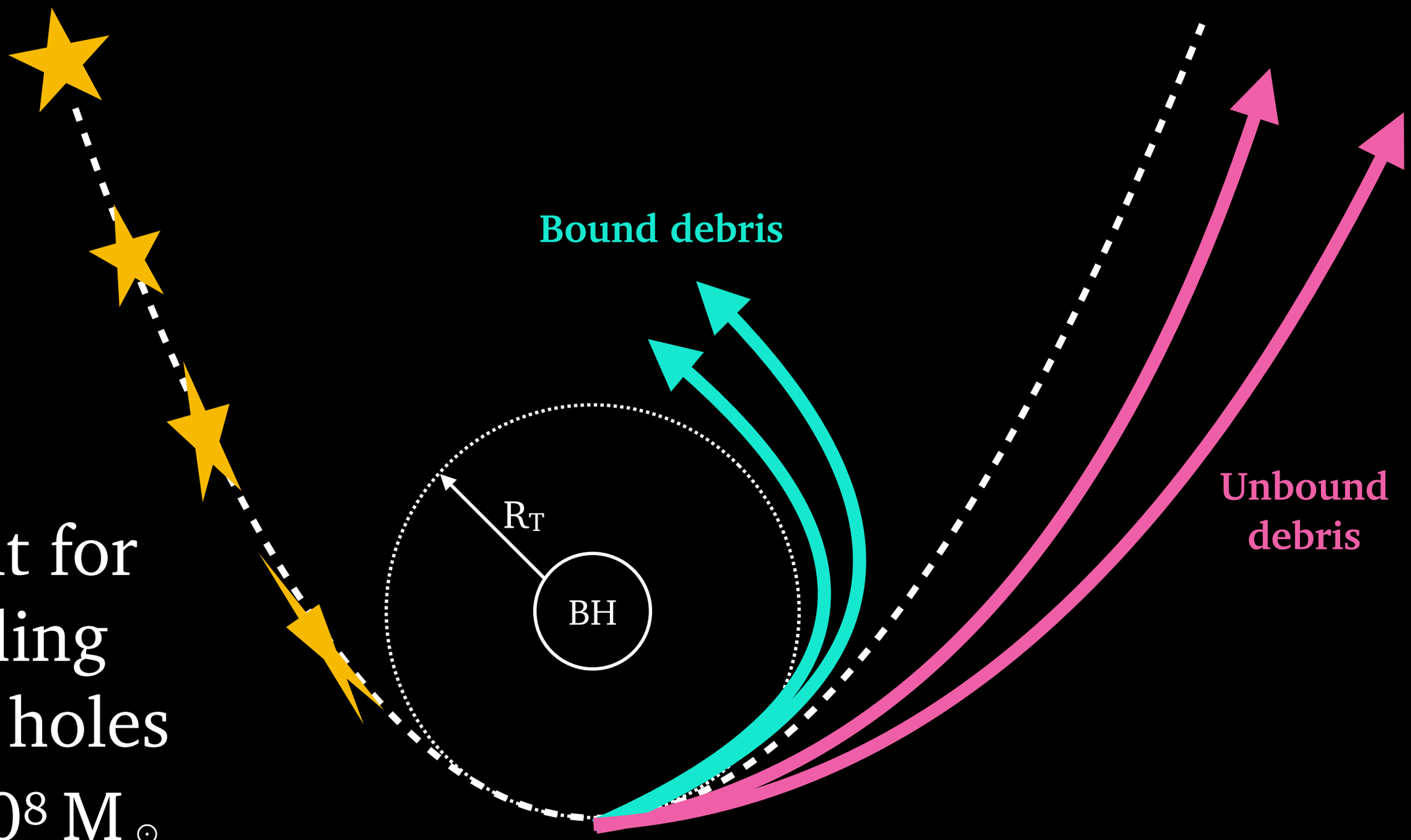
Tidal disruption events



Great for finding black holes $< \sim 10^8\,M_\odot$

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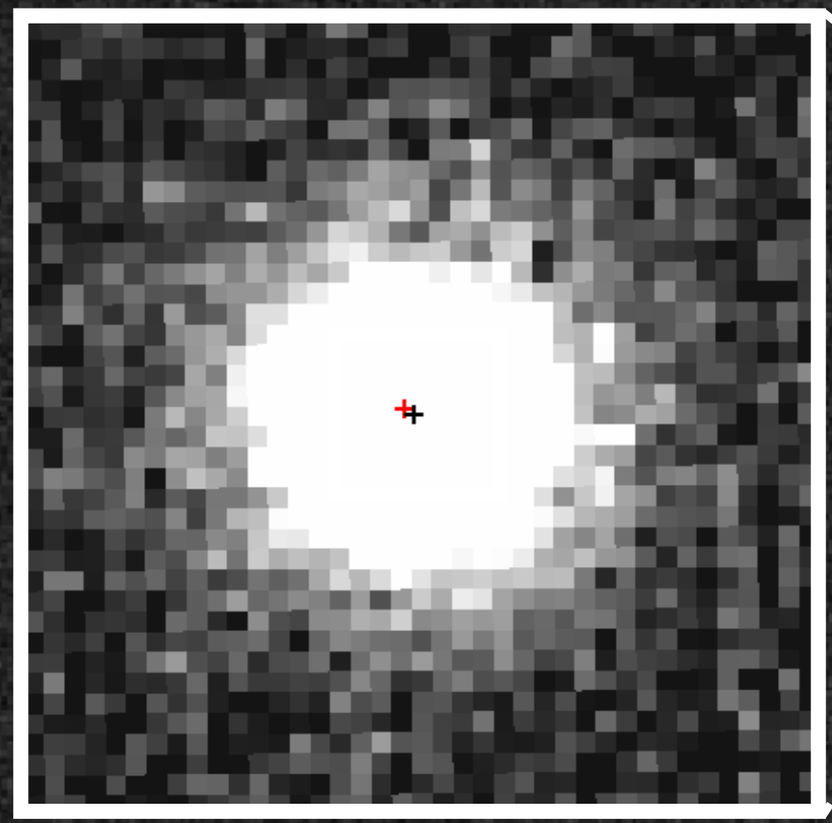
AT 2020neh



z=0.062

E

N

10"

PS1 r

AT 2020neh

z=0.062

HST UV

+416d

500 pc

E

N

10"

PS1 r

AT 2020neh

z=0.062

HST UV

+416d

500 pc

#everythingonabagel

E

N

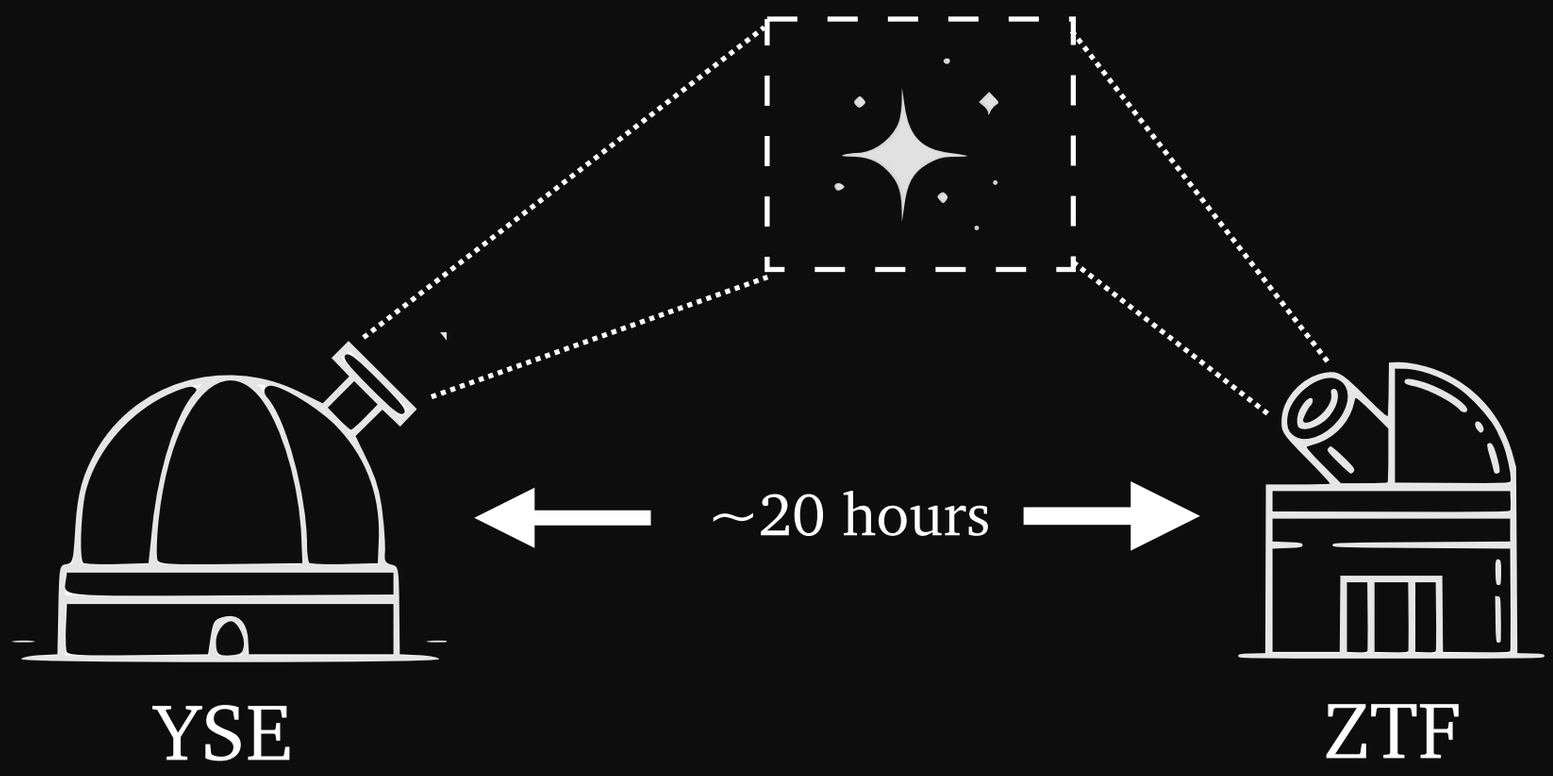
10"

PS1 r

Young Supernova Experiment (YSE)

Optical survey using the Pan-STARRS telescopes

- g,r,i,z band
- 3-day cadence
- 21.5 mag (g,r,i)
  20.5 mag (z)



Unique strategy: “foreshadowing” other survey fields by ~20hrs

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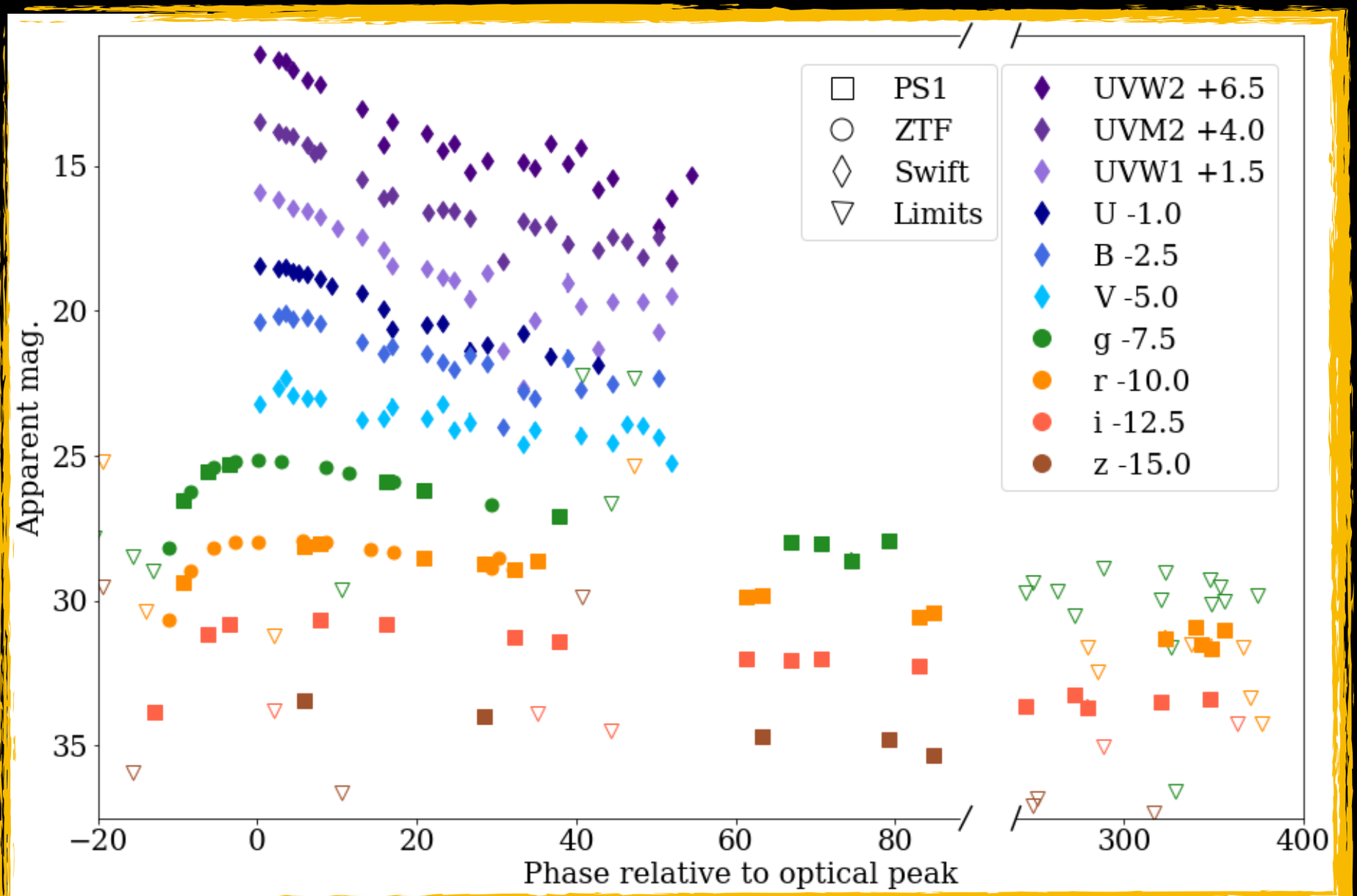
AT2020neh



- Nuclear transient at z=0.062
- Really early detection within YSE (i-band)

Good pre-explosion photometry from YSE —> **good rise constraints**

Angus et al. 2022

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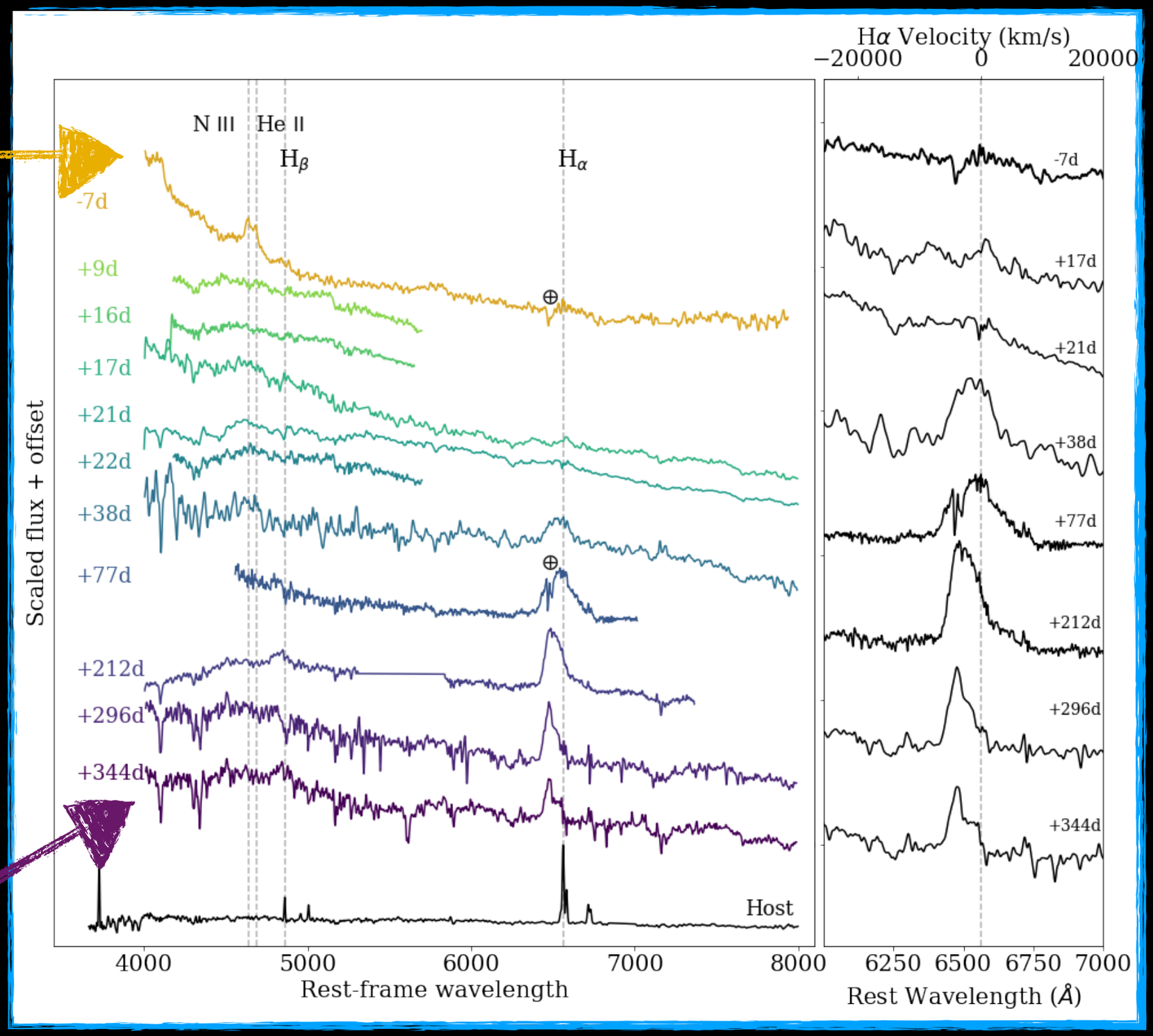
Spectral evolution

Bowen fluorescence features

Featureless

Broad balmer lines with increasing blueshift

No nebular phase features (not a supernova)



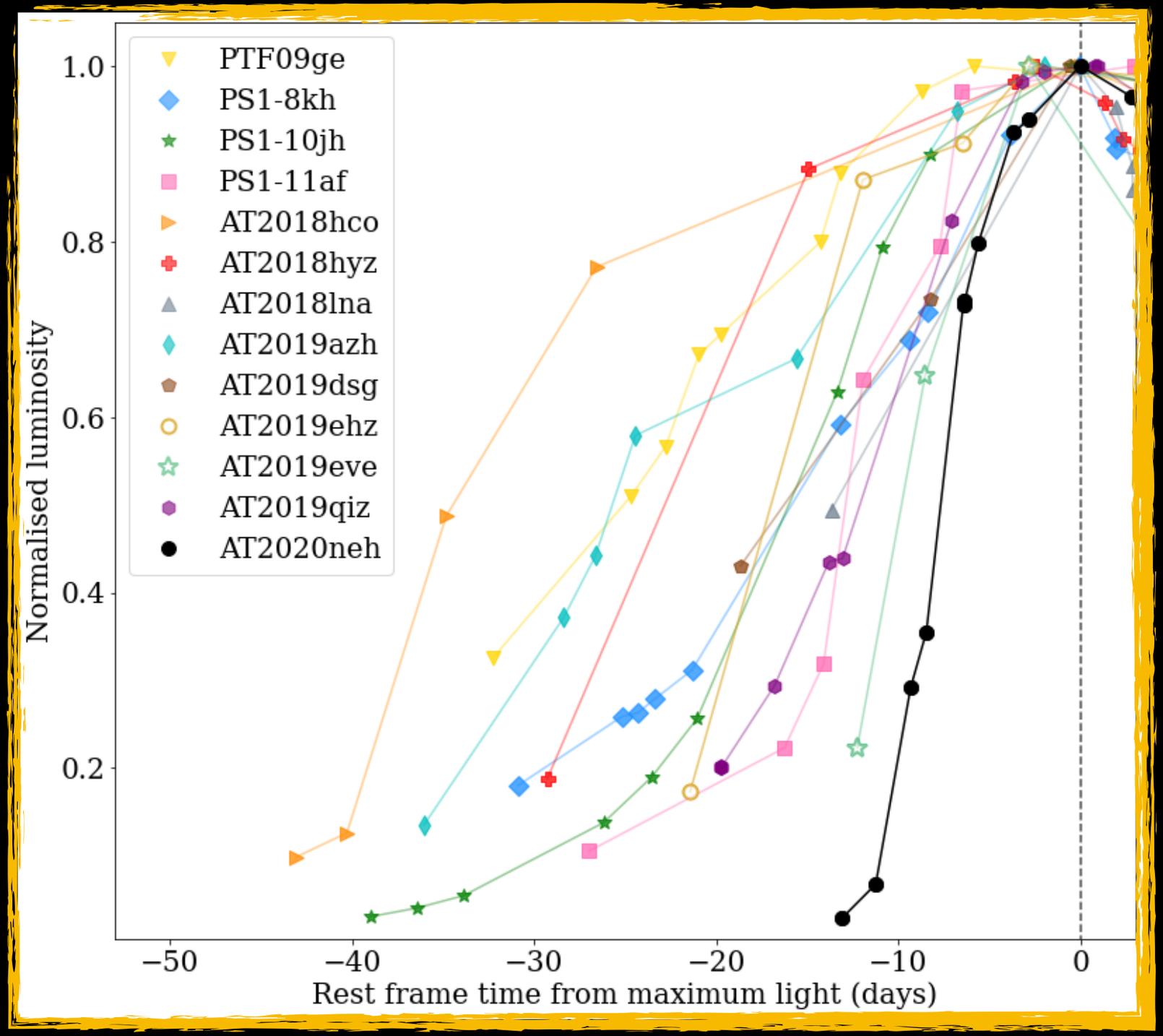
Angus et al. 2022

Fast rising

It's a TDE…but it's really ***FAST***

<u>Total rise time = 13 days!</u>

Factor of ~3 faster than other known TDEs



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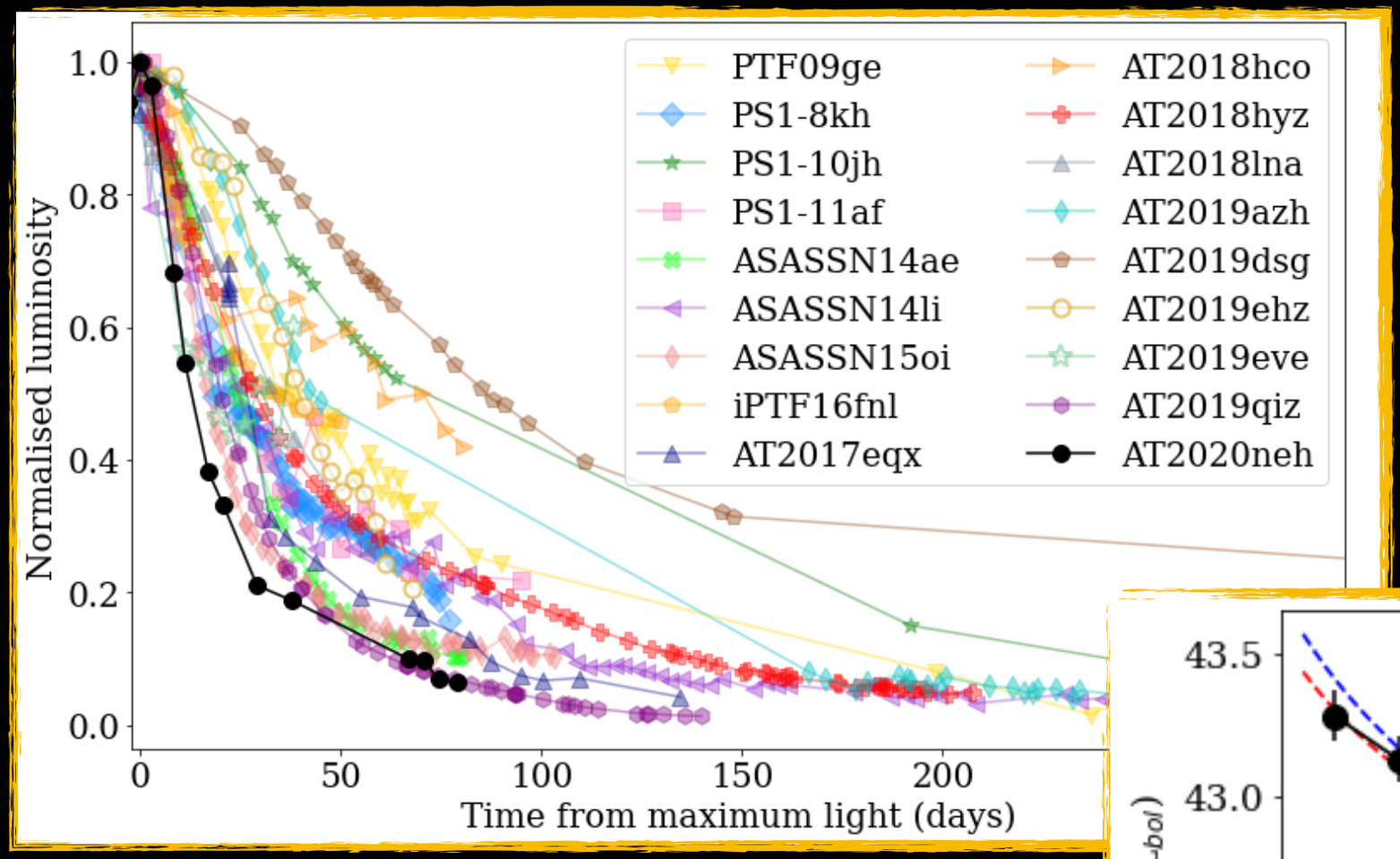
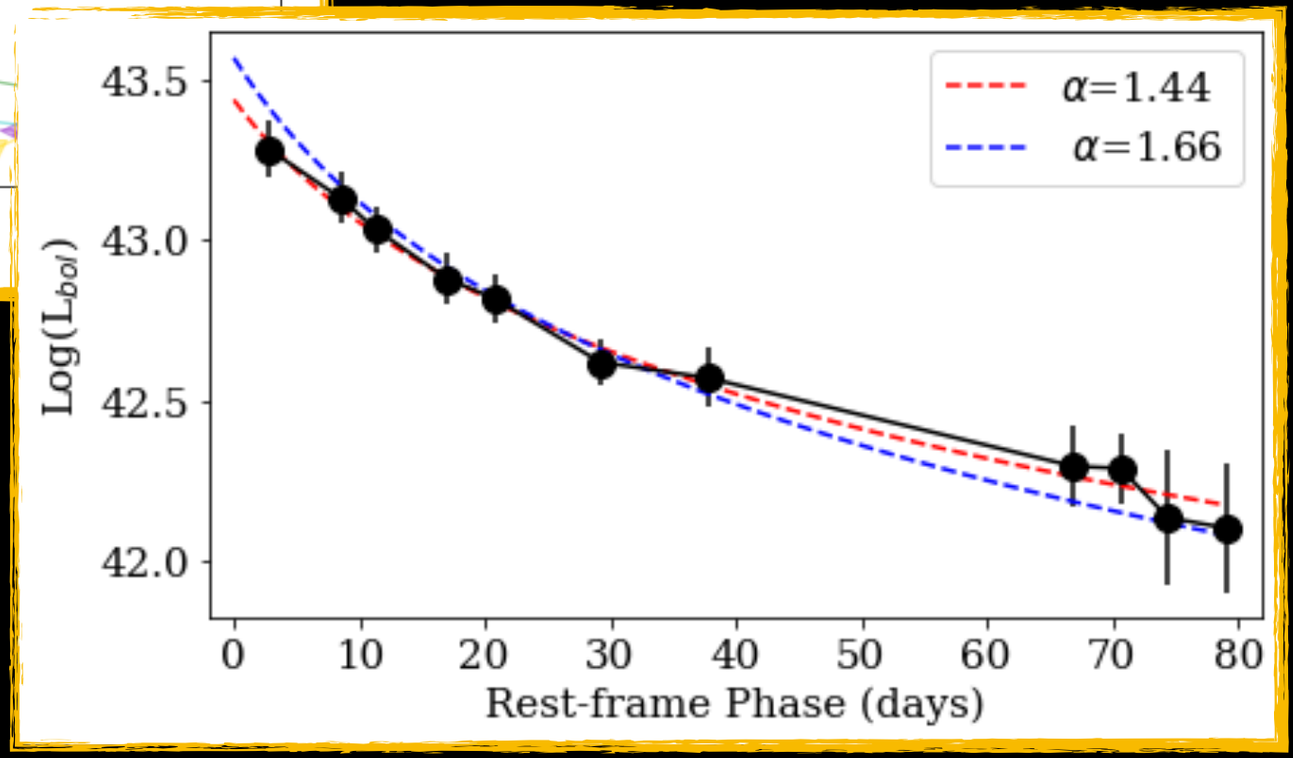
‘Normal’ decline



$$L \propto \dot{M} \propto t^{-\alpha}$$

$$\alpha \sim \frac{5}{3}$$



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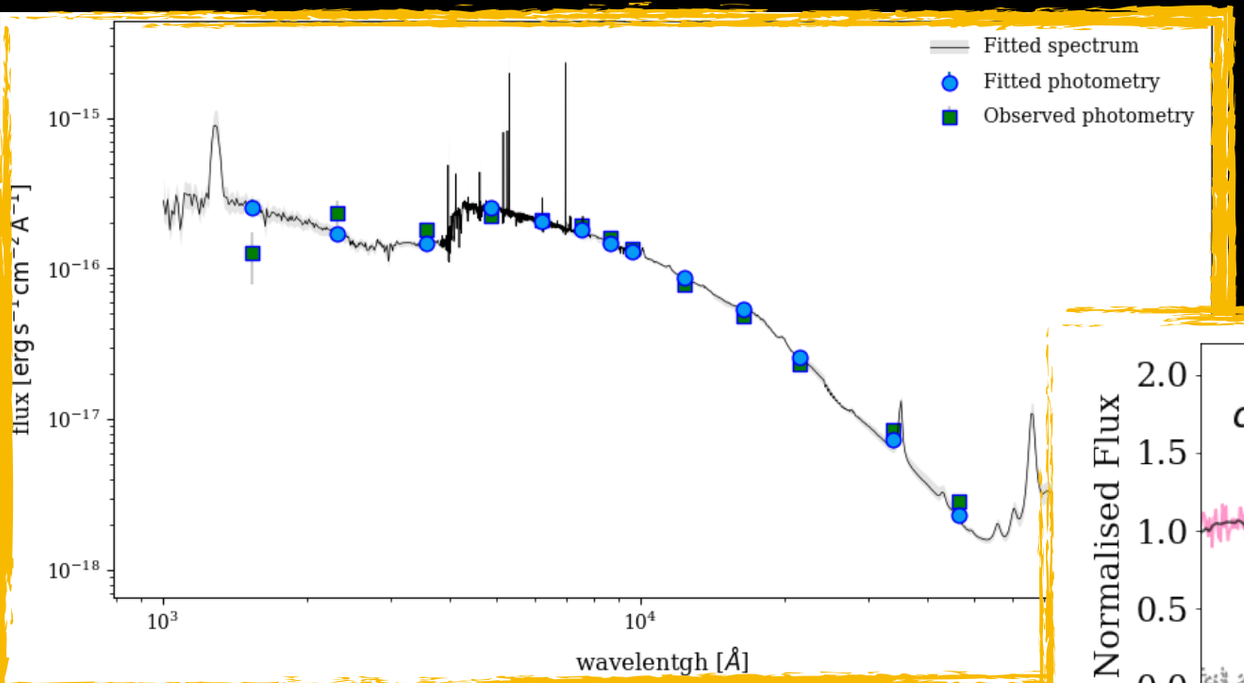
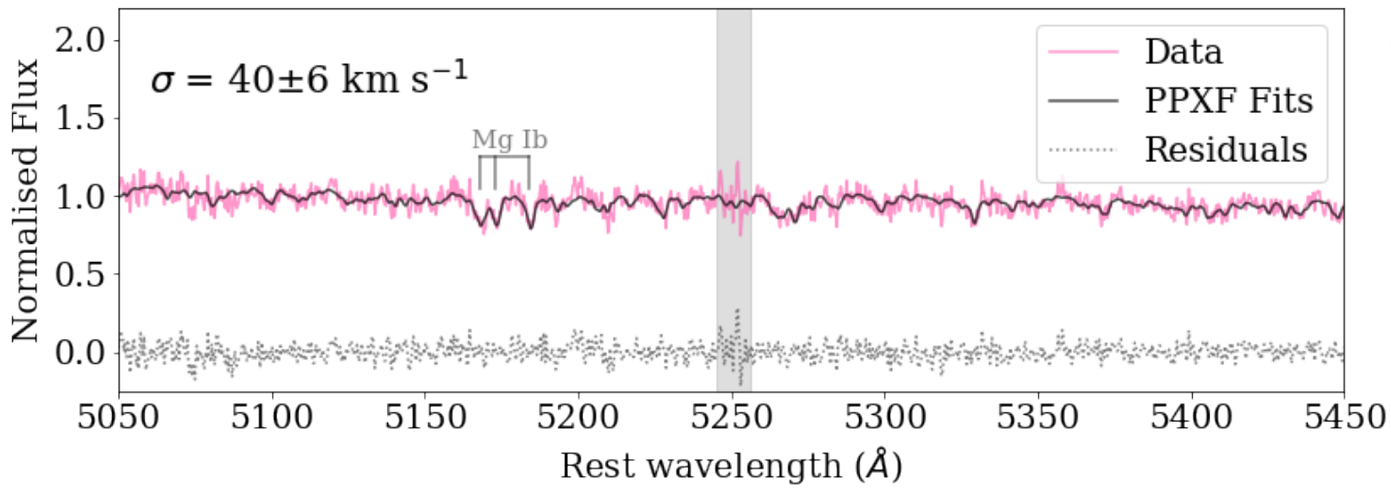
BH mass estimates





Angus et al. 2022

$\log M_* \sim 9.5\ M_\odot$

Using Reines M_* - M_{BH} scaling relation

—> $\log M_{BH} \sim 5.87$

Using the M_{BH} - σ relation

—> $\log M_{BH} \sim 5.0$

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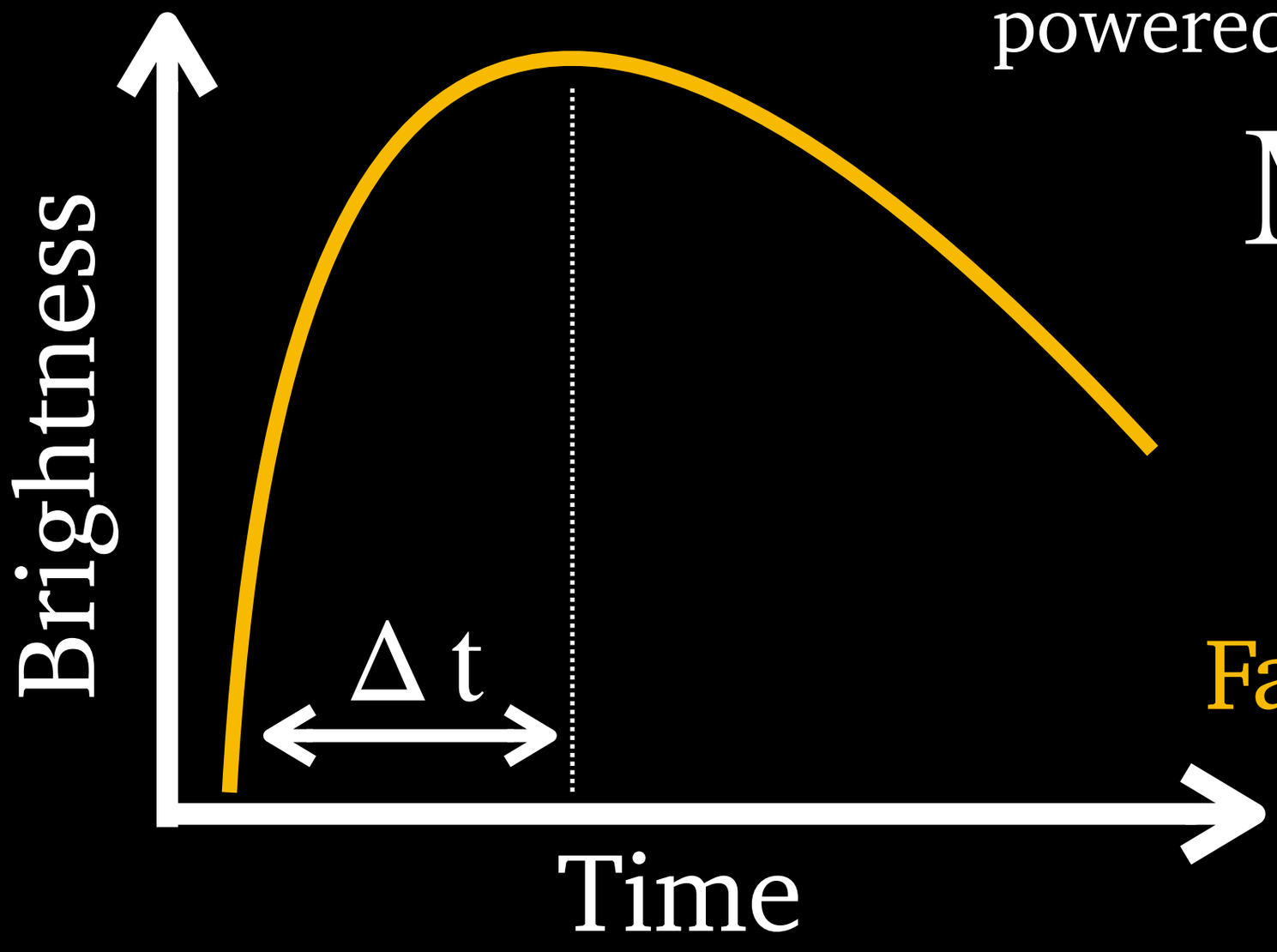
TDEs as M_{BH} probes

Theoretically, for light curves powered by fallback accretion *

$$M_{BH} \propto \Delta t$$



Fast rise ≈ low M_{BH}

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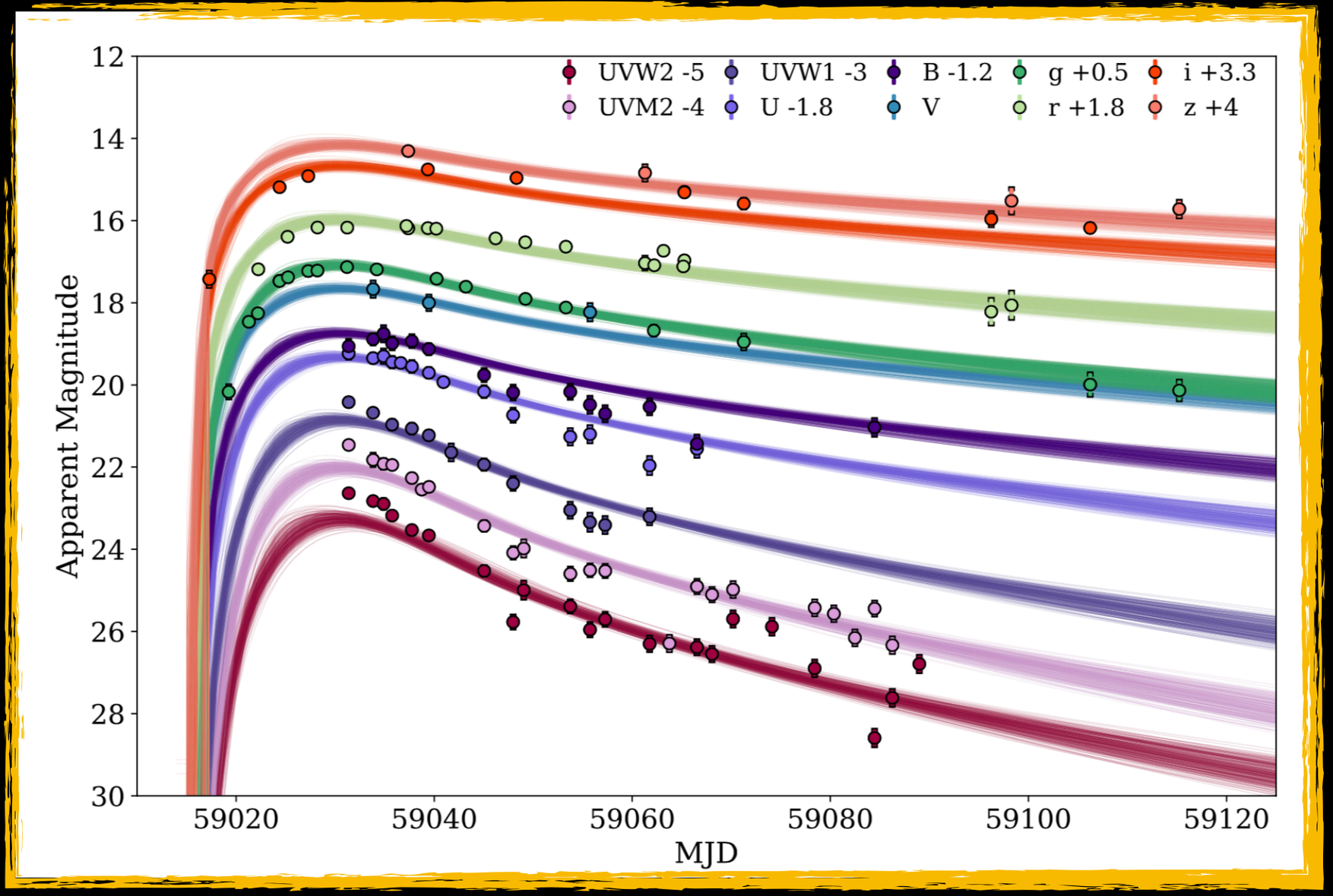
TDEs as M_{BH} probes

Modelling light curve using MOSFiT

M_{BH} from the TDE fallback time

—> $\log M_{BH}$ ~ 4.7 - 5.7



Angus et al. 2022

Intermediate Mass Black Hole (IMBH)

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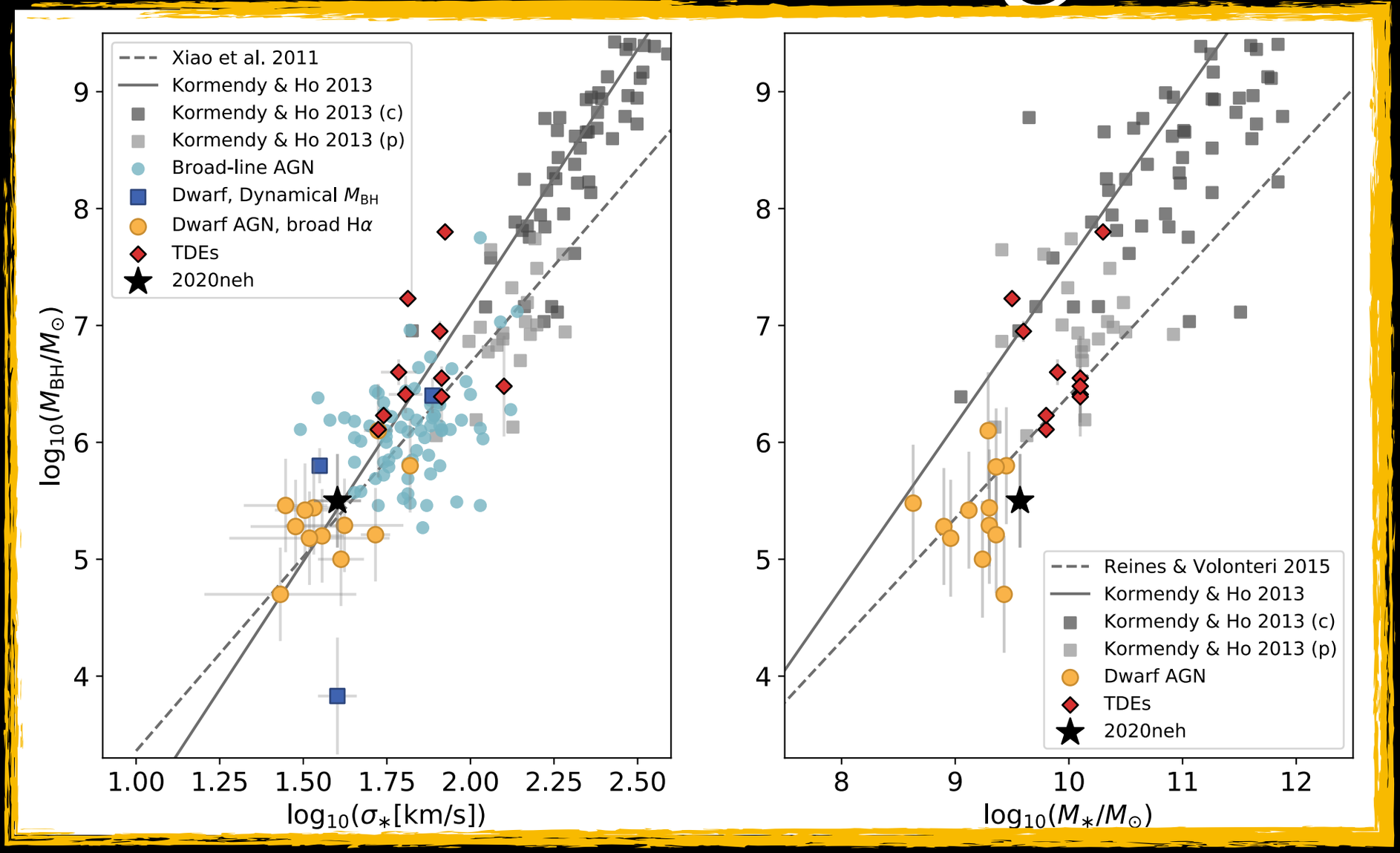
IMBHs in dwarf galaxies



AT 2020neh-like events give us a new way to explore quiescent BHs in dwarf galaxies

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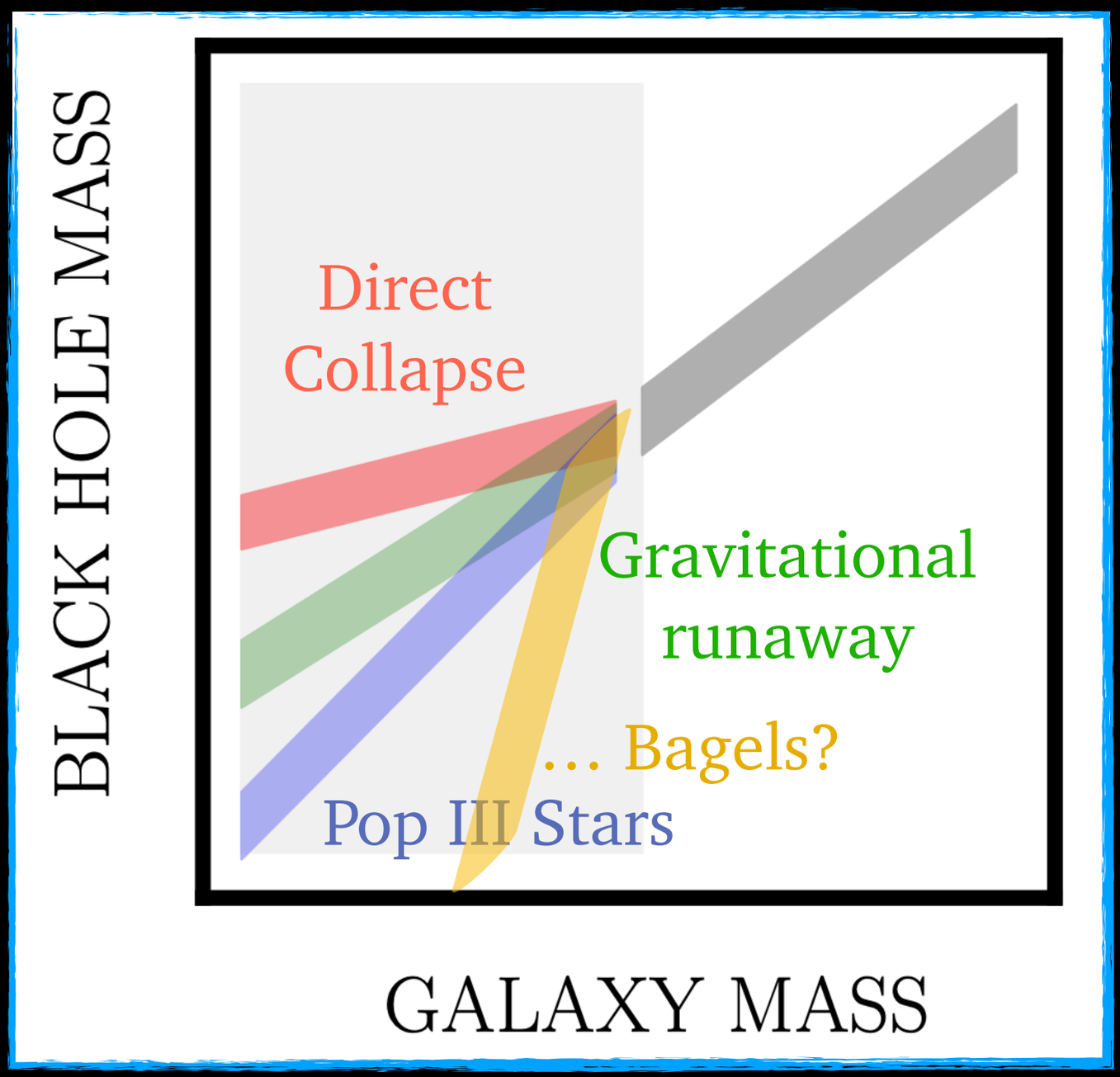
IMBHs in dwarf galaxies



Different IMBH formation mechanisms will influence the low mass end of scaling relations

AT2020neh-like TDEs provide a new way to explore this space

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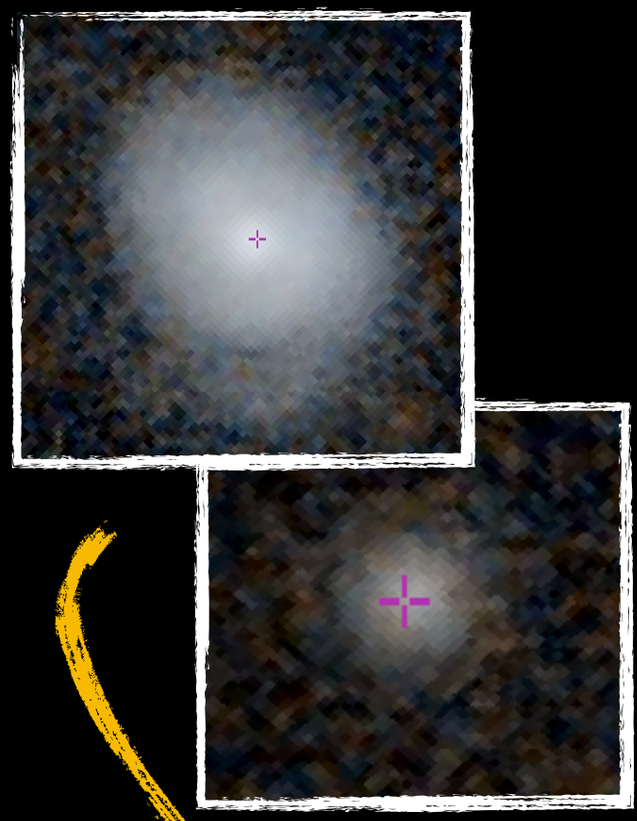
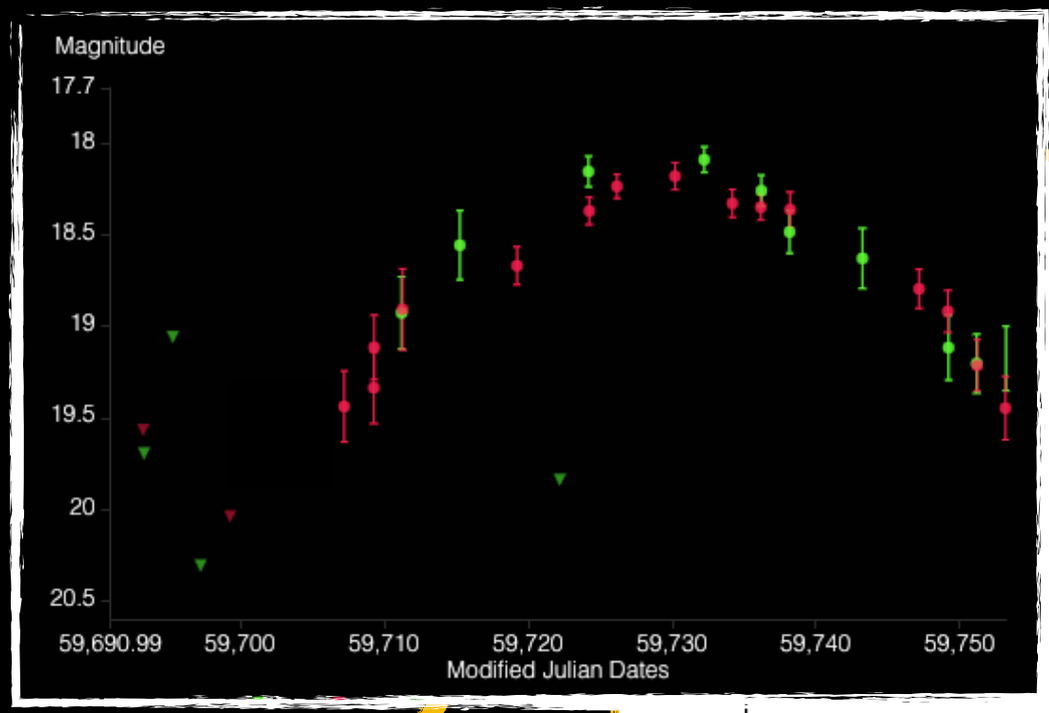
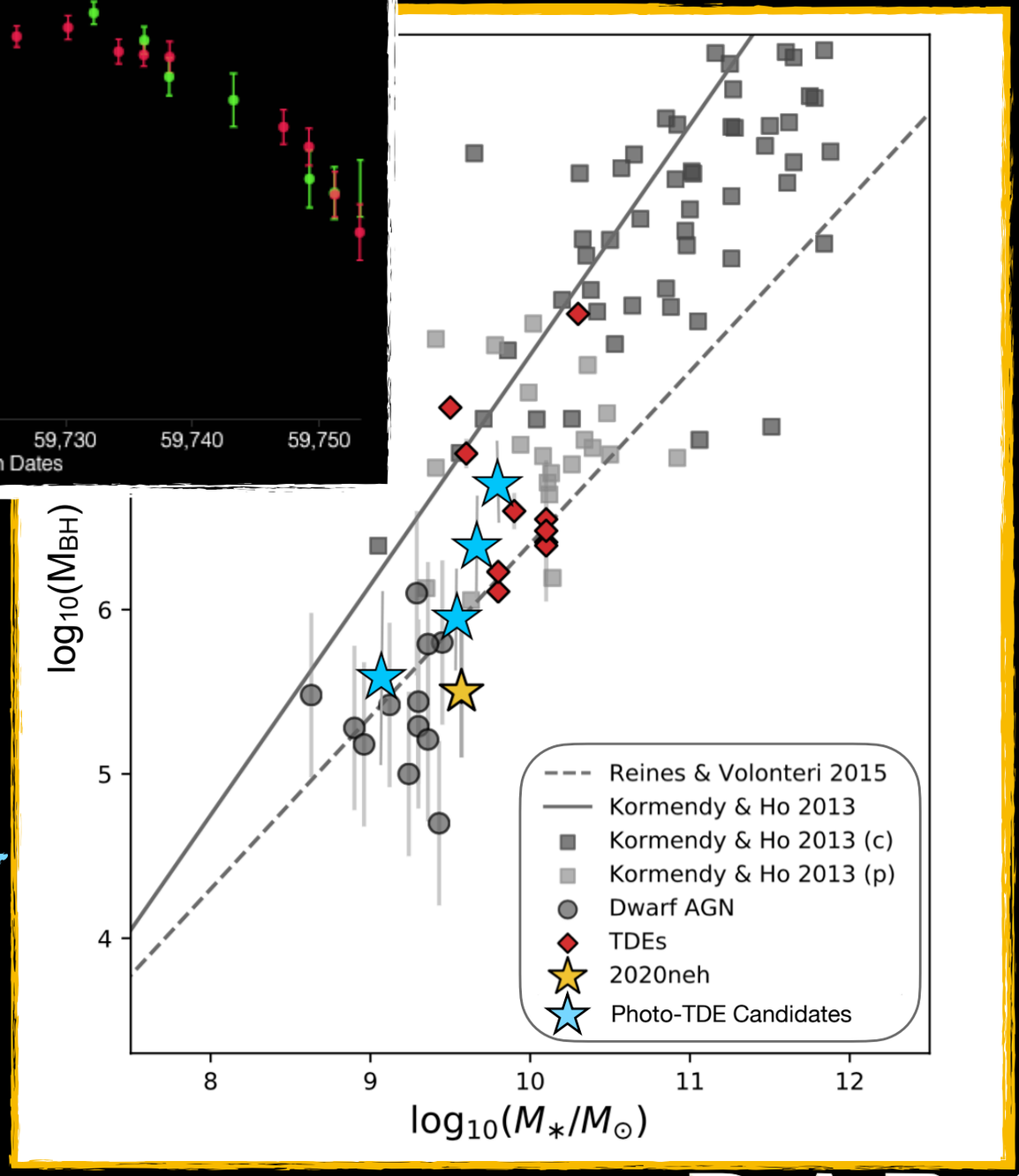
Future IMBH-TDE studies





Photometric fast TDE candidates



Angus & Pursiainen *in prep.*

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TL;DL

(Too long; didn't listen!)

- Identifying IMBHs is vital for our understanding of black hole growth and evolution

- Combined survey data flows (e.g. YSE + ZTF) are an excellent way to identifying young or quickly evolving transients

- Combined AT 2020neh was a fast rising TDE produced by an IMBH in a dwarf galaxy

- Future AT 2020neh-like events may provide a route to probing the IMBH population and their formation mechanisms AT2020neh

#everythingonabagel

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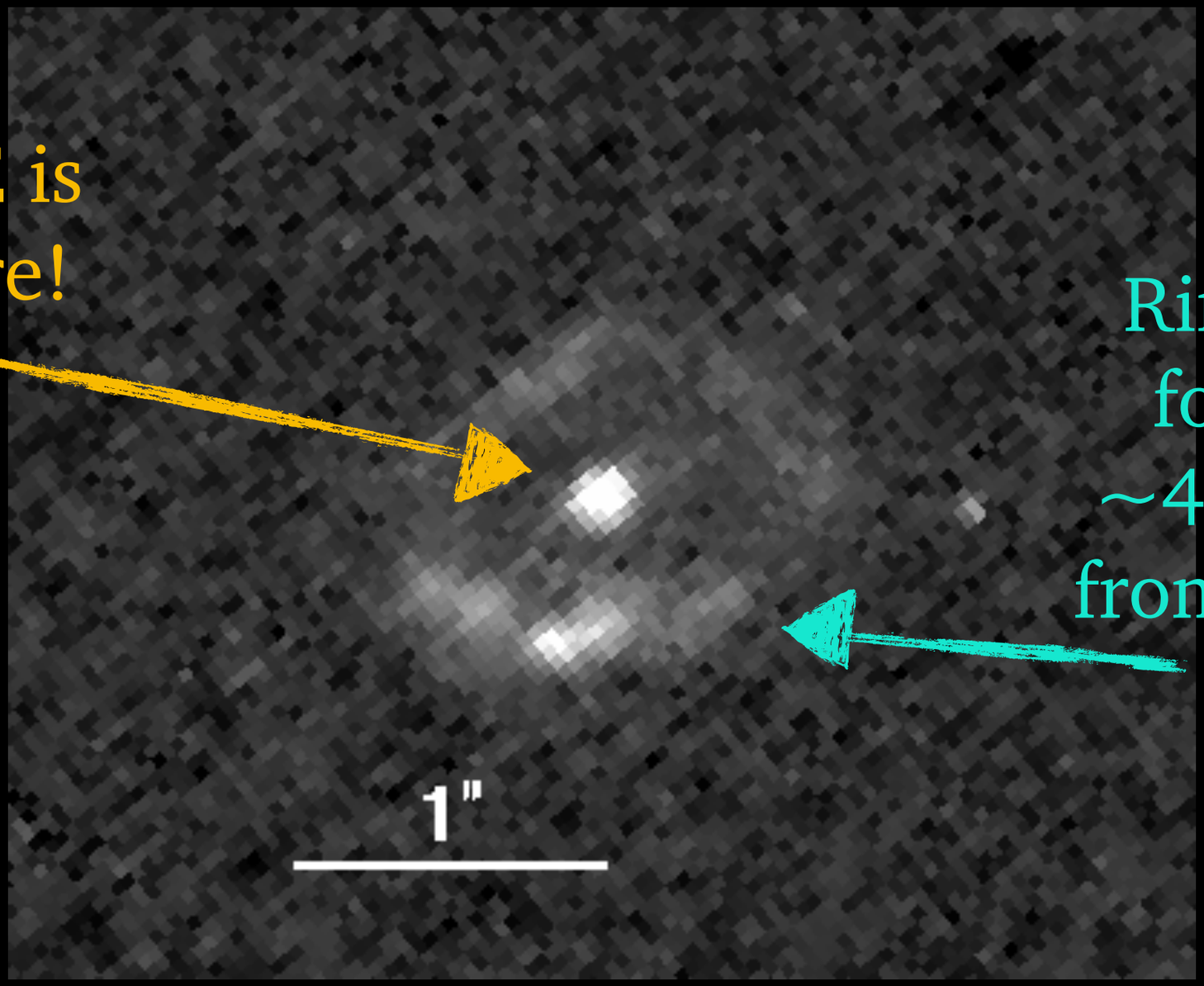
When you put EVERYTHING on a bagel

Late time (>400d) UV imaging with HST

The TDE is still there!



Ring of star formation ~450-900 pc from the black hole

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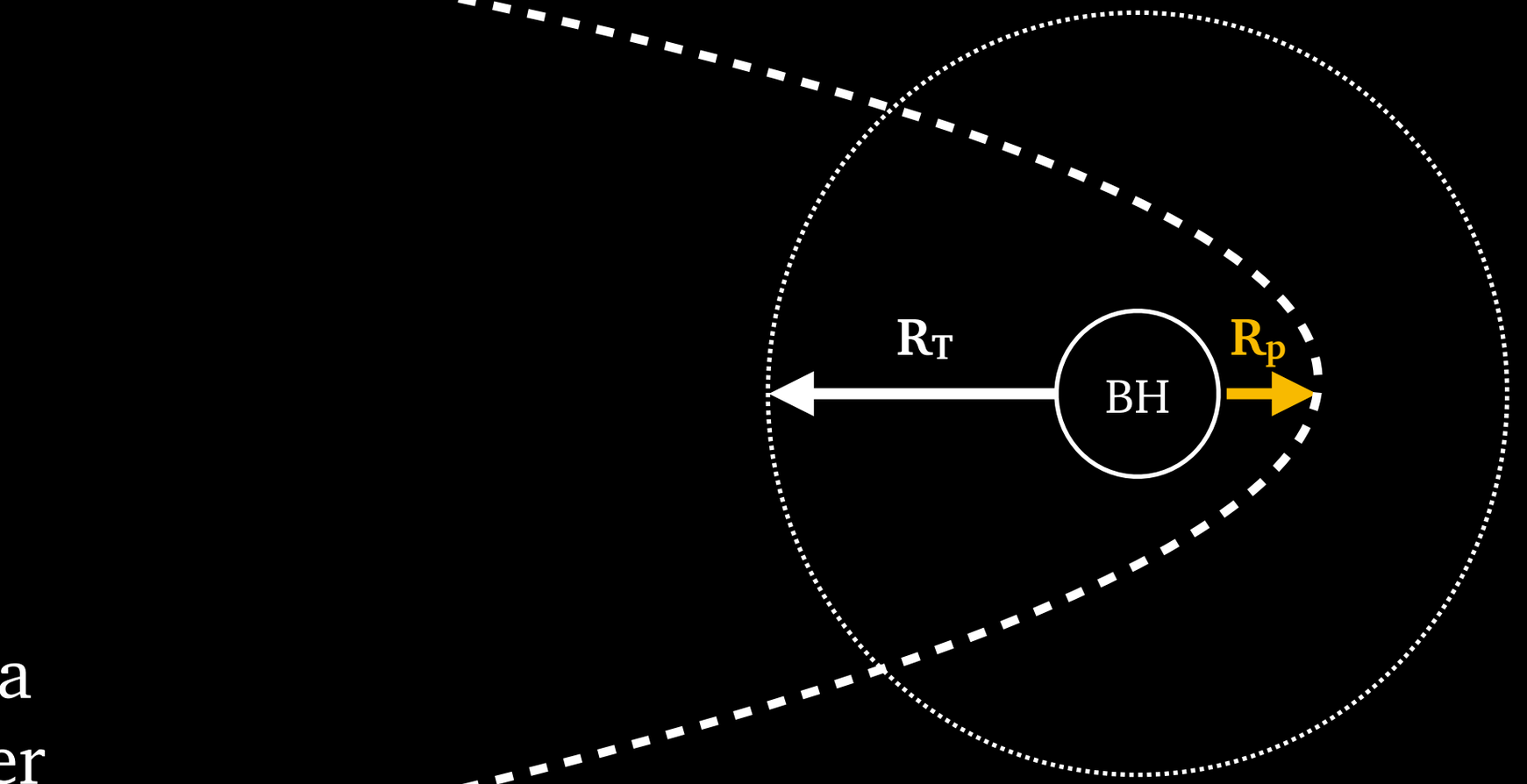
AT2020neh-like events are rare

The TDE impact parameter

$$\beta = \frac{R_T}{R_p}$$

AT2020neh requires a high impact parameter for the bound material to circularise



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