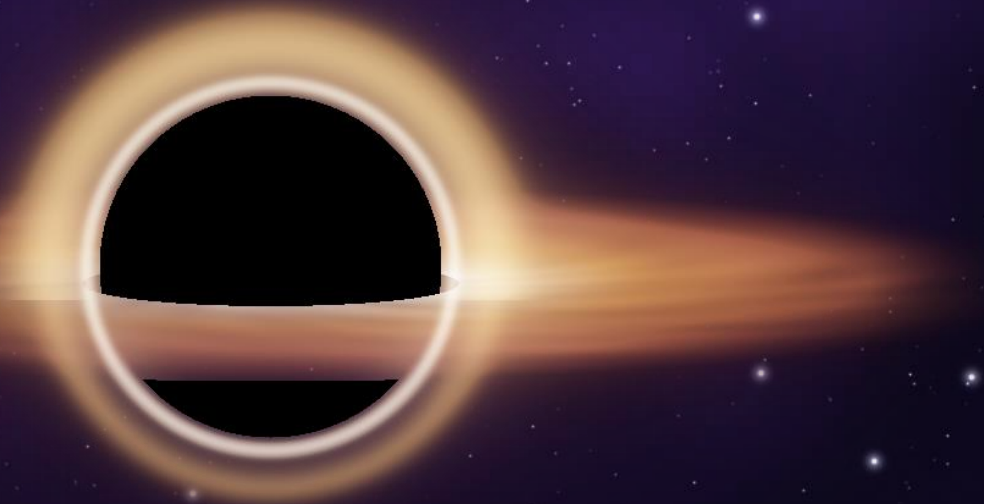


Feeding the Little Monster

An accreting intermediate-mass
black hole in a minor-merger
secondary galaxy

Marko Mićić
Dodge Postdoctoral Fellow
University of Oklahoma



The missing middle

Stellar

seen everywhere



The missing middle

Stellar

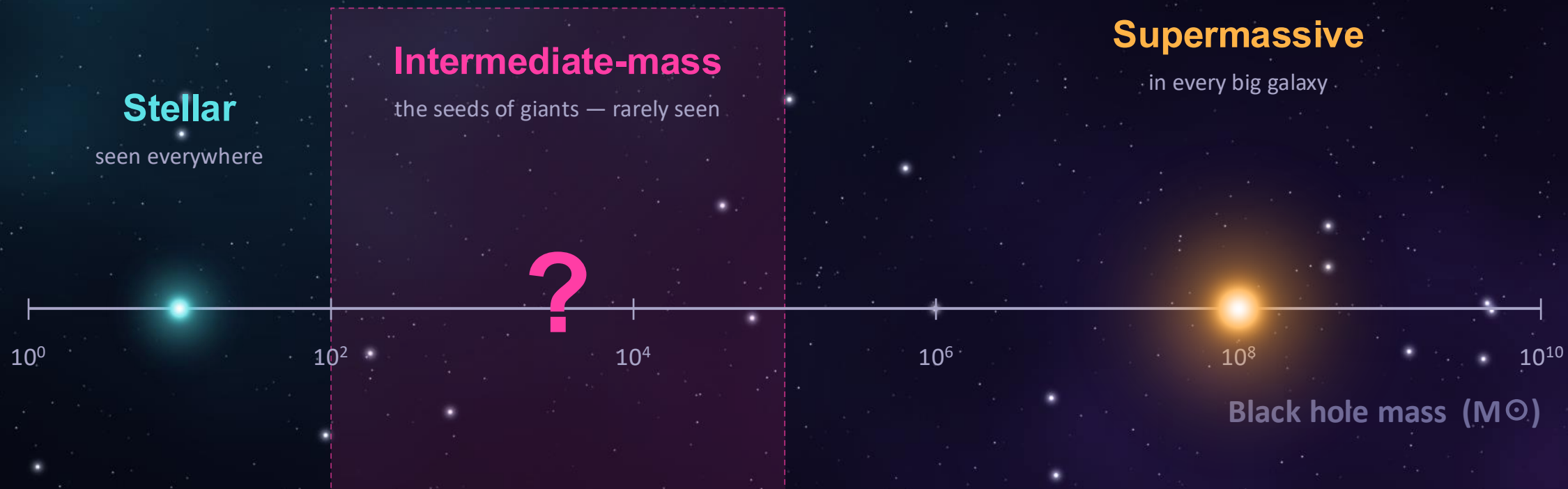
seen everywhere

Supermassive

in every big galaxy



The missing middle



Little monsters starve in the dark

They live in dwarf galaxies



Little monsters starve in the dark

They live in **dwarf galaxies**

Their gas is **clumpy and thin**

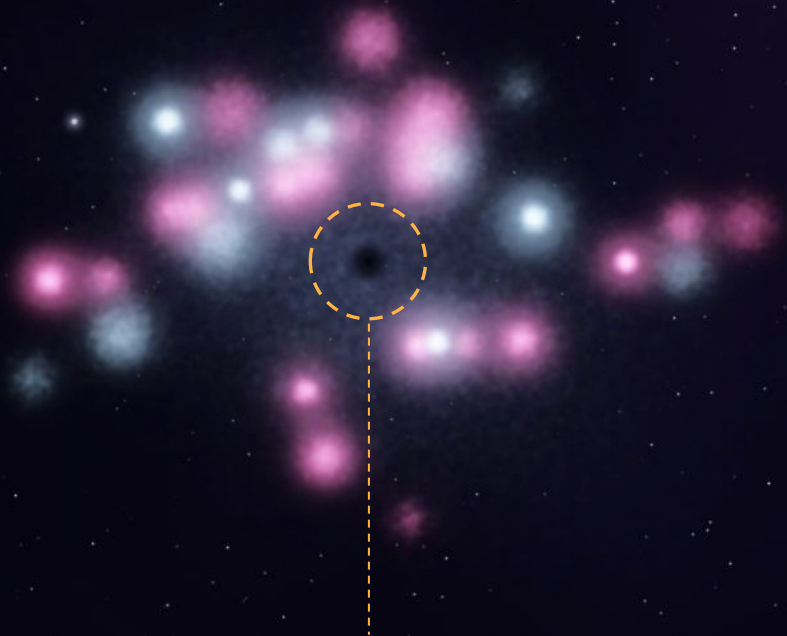


Little monsters starve in the dark

They live in **dwarf galaxies**

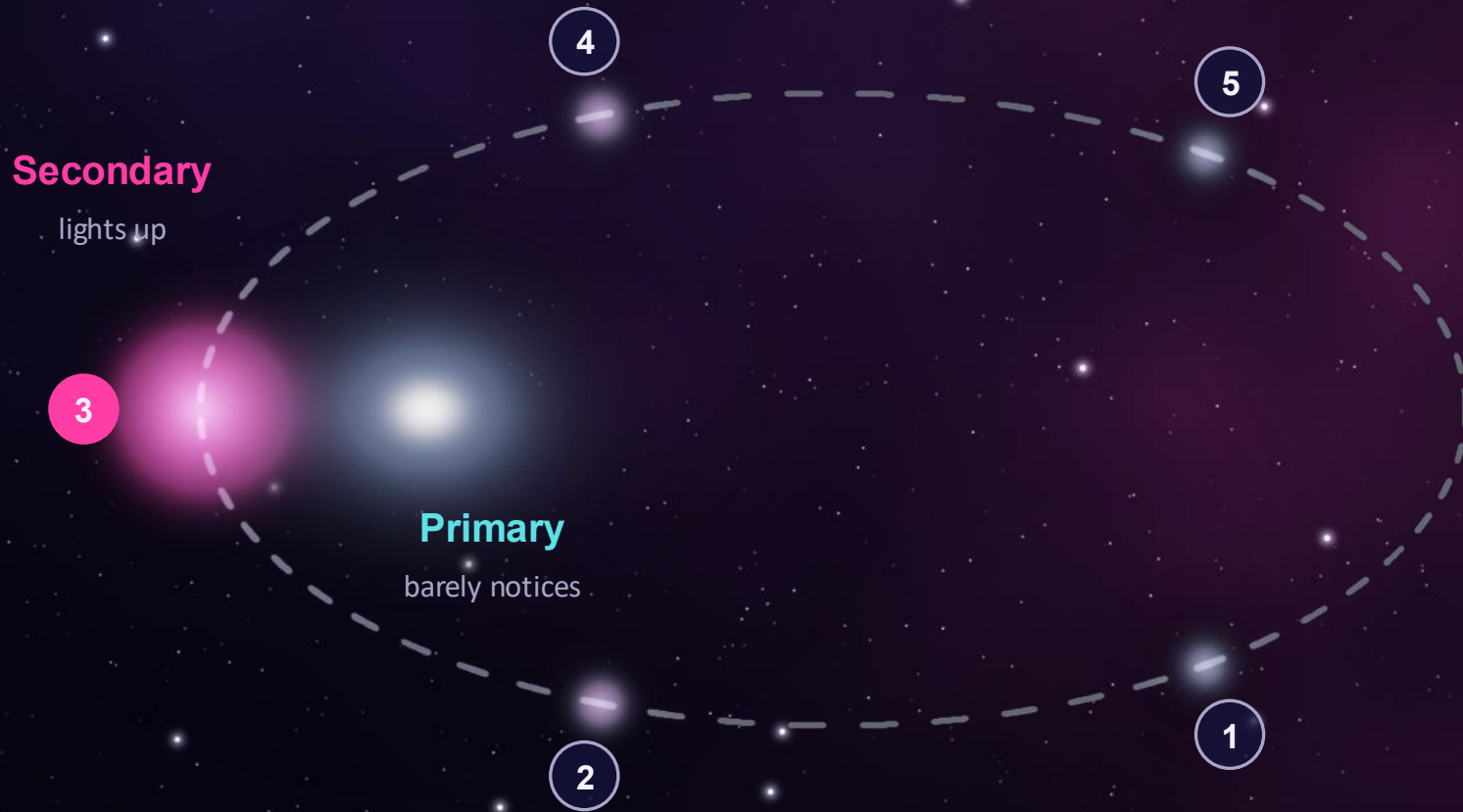
Their gas is **clumpy and thin**

They stay **dormant**

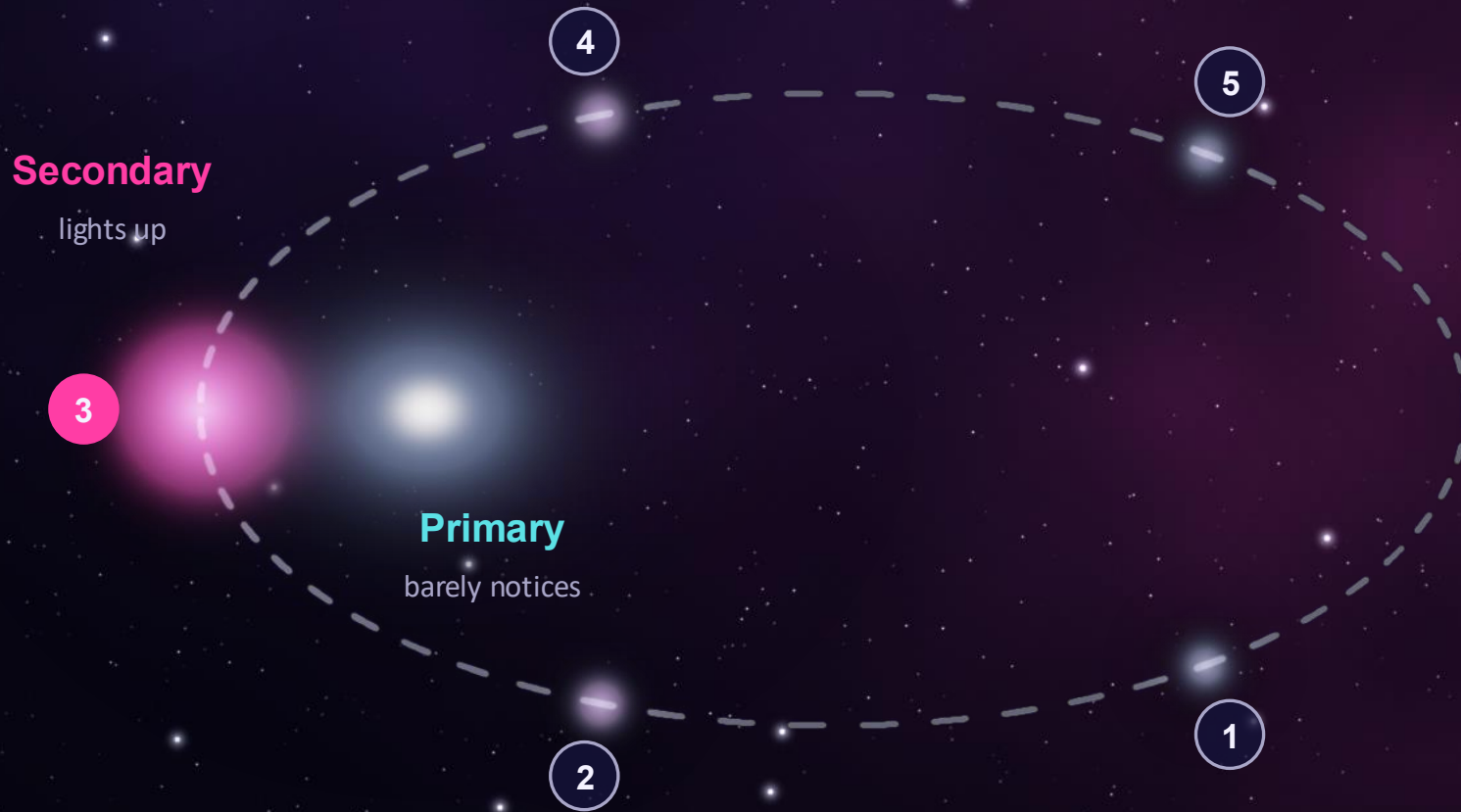


dormant black hole

Minor mergers wake them up



Minor mergers wake them up



10×

black-hole mass growth

Minor mergers wake them up

Observationally, this channel is almost
unexplored

10×

black-hole mass growth

lights up

3

Primary

barely notices

2

1

Minor mergers wake them up

Observationally, this channel is almost unexplored

The idea: build a sample of minor-merger pairs and look at them in X-rays

10×

black-hole mass growth

Primary

barely notices

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1

Minor mergers wake them up

Observationally, this channel is almost unexplored

The idea: build a sample of minor-merger pairs and look at them in X-rays

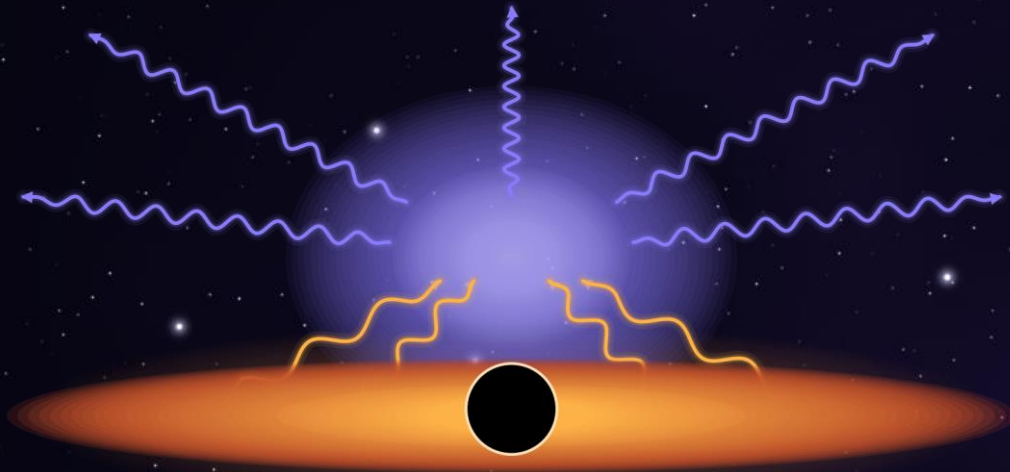
What does a highly accreting IMBH look like in X-rays?

10×

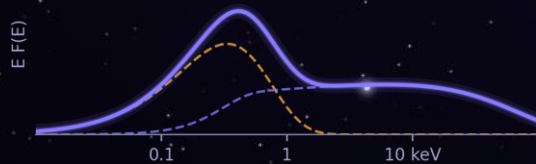
black-hole mass growth

Why the power law disappears

NORMAL ACCRETION



- 1 Disk emits seed photons
- 2 Hot corona inverse-Compton upscatters them

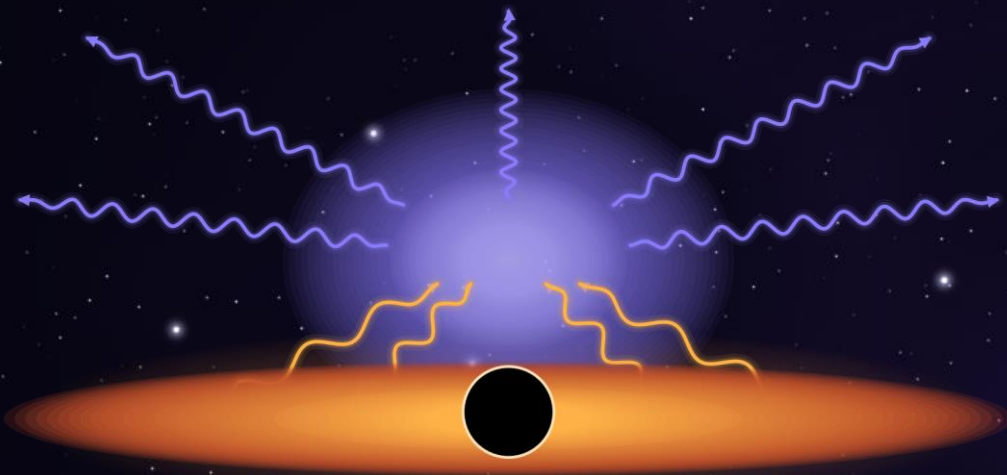


$$\frac{\Delta E}{E} \approx \frac{4 k T_e}{m_e c^2}$$

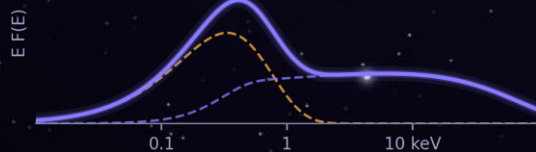
*energy gained per scattering builds
the power law*

Why the power law disappears

NORMAL ACCRETION



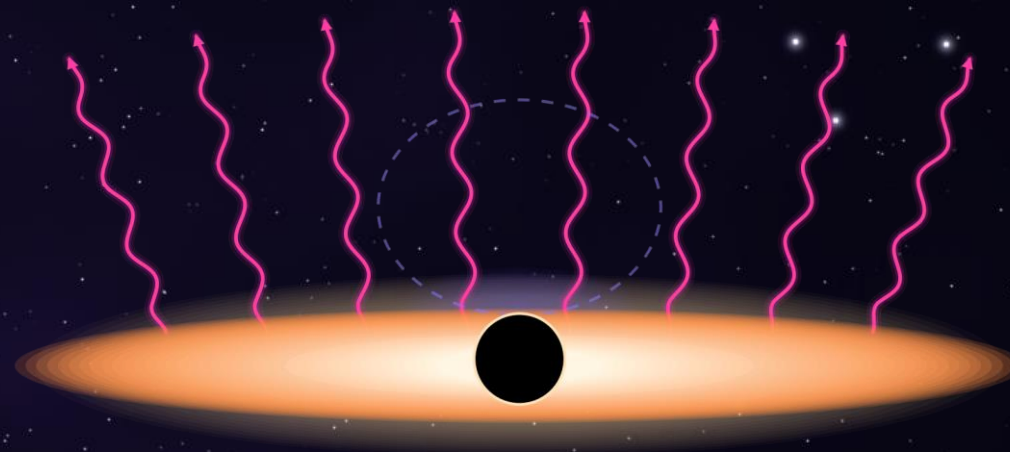
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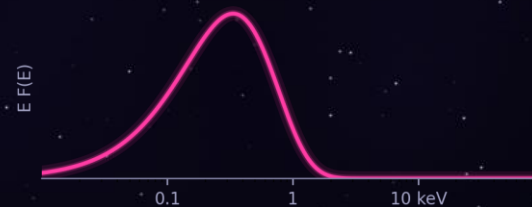
$$\frac{\Delta E}{E} \approx \frac{4 k T_e}{m_e c^2}$$

energy gained per scattering builds the power law

HIGH ACCRETION



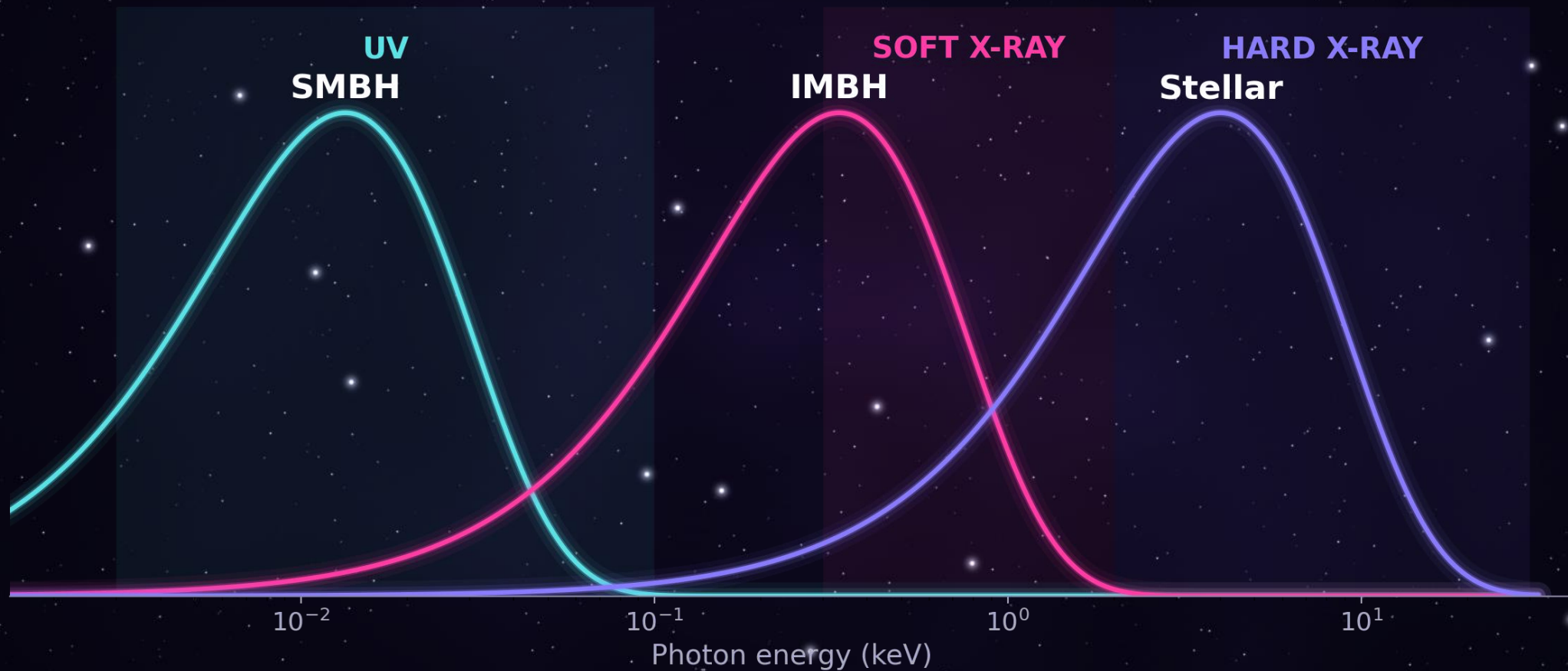
- 3 Flood of seed photons cools the corona
- 4 Corona collapses — only the disk remains



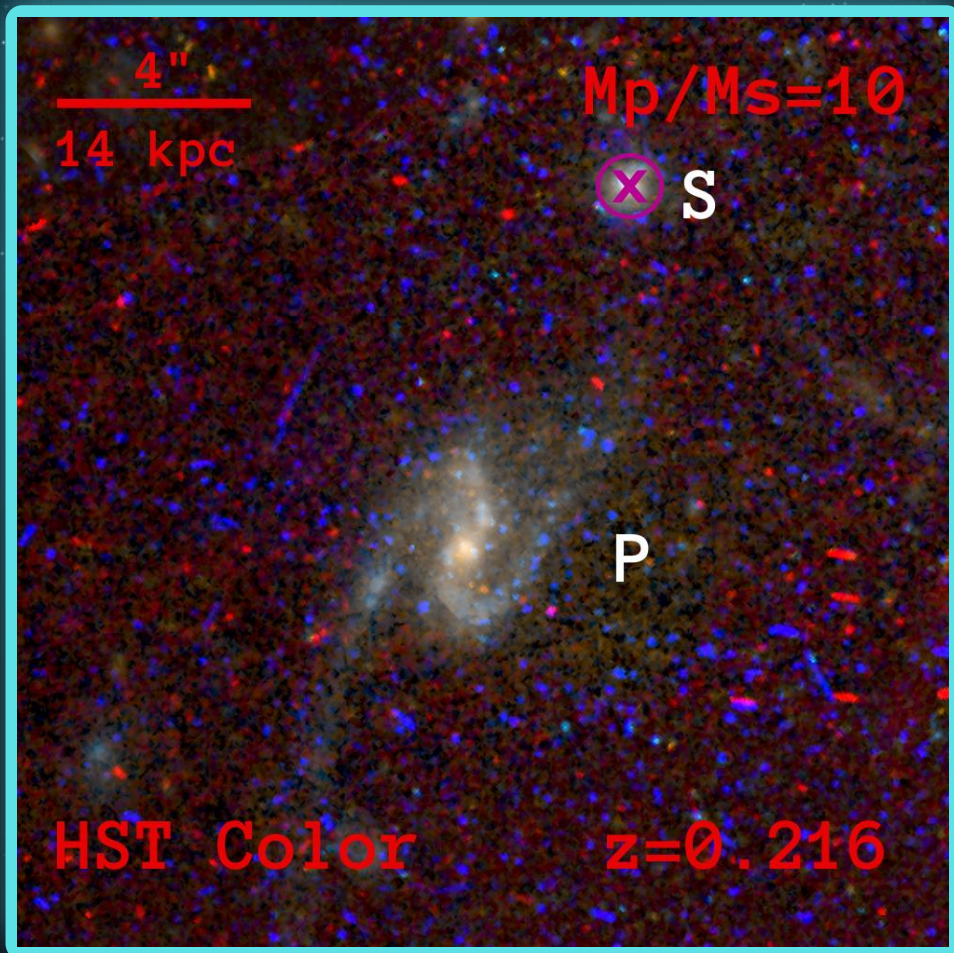
$$P_C \approx 4 \sigma_T c U_{\text{rad}} \frac{k T_e}{m_e c^2}$$

Compton cooling grows with seed-photon density

Hungry IMBHs should glow in soft X-rays



Meet the pair



$z = 0.216$

same redshift, $\Delta z = 0.0002$

10 : 1

stellar-mass ratio

~26 kpc

projected separation

$10^{8.24} M_\odot$

secondary stellar mass

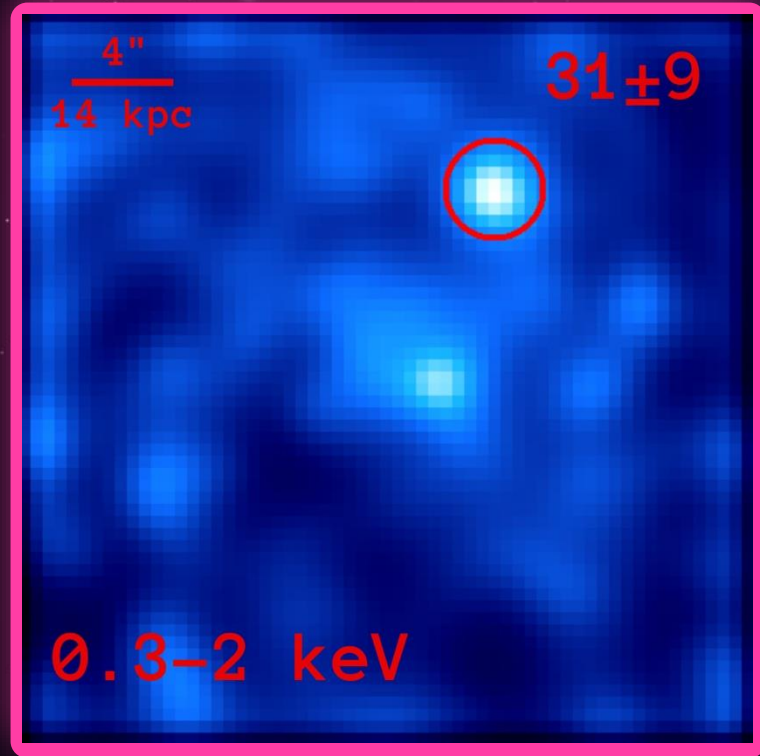
Chandra Deep Field South

> 100 Chandra ACIS-I observations

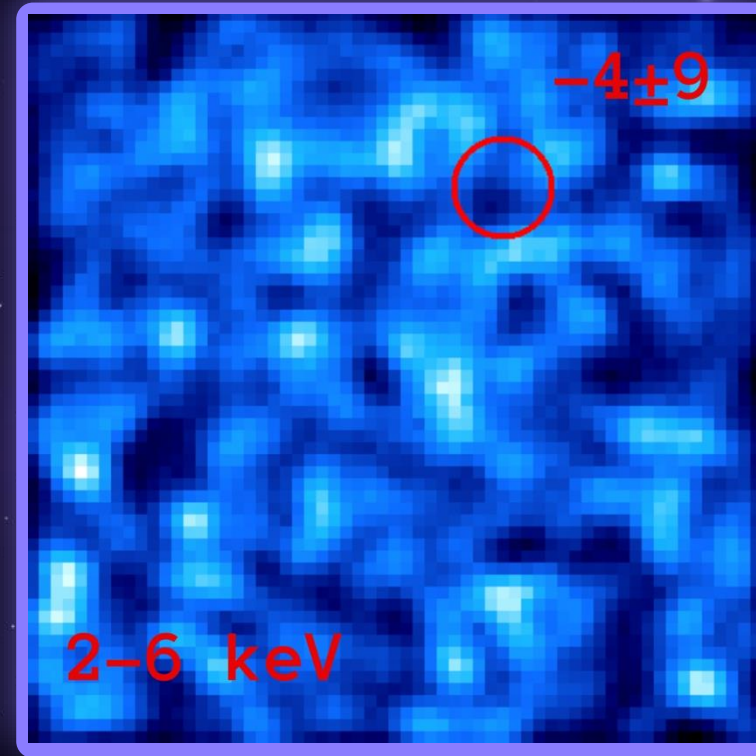
6.6 Ms total exposure (≈ 76 days)

1999 – 2016 observing baseline

All soft. Nothing hard.



31 ± 9



-4 ± 9

Too few photons for a spectral fit

split into three bands



BEHR

Bayesian, exact for Poisson
source + background counts

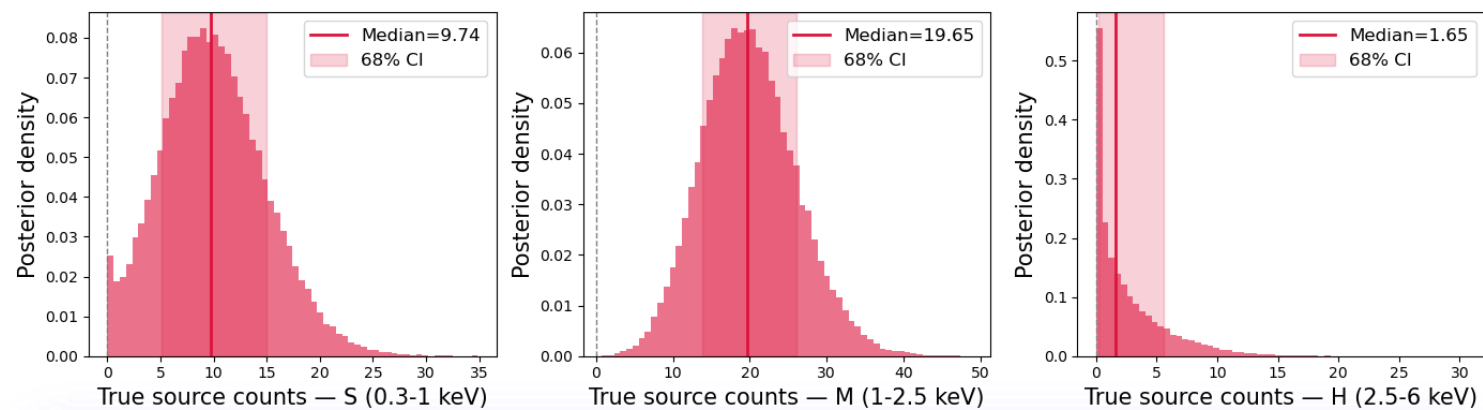
$$HR1 = \frac{M - S}{M + S} \quad HR2 = \frac{H - M}{H + M}$$

spectral shape

Net counts

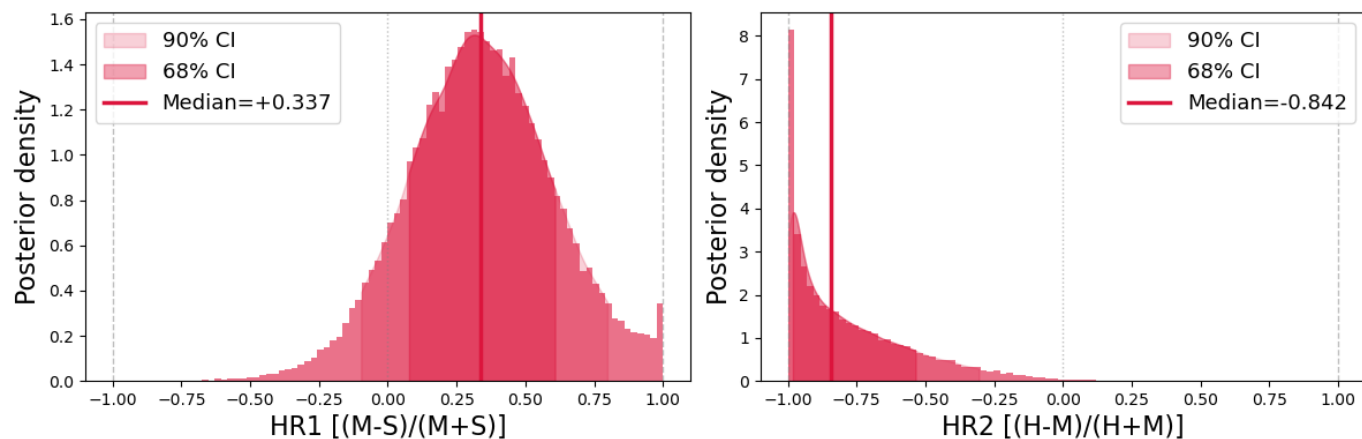
luminosity

Where the 31 photons fall



$$\text{HR1} = +0.34 \pm 0.27$$

$$\text{HR2} = -0.84 \pm 16$$



$$\text{Total} \approx 32 \pm 8$$

Simulate models, keep what matches BEHR

Models

1. Disk blackbody

`phabs × diskbb`

2. Absorbed disk blackbody

`phabs × intrinsic abs. × diskbb`

3. Power law

`phabs × powerlaw`

Simulate models, keep what matches BEHR

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At every grid point:

300 fake spectra

Sherpa fake_pha through the stacked Chandra
ARF / RMF

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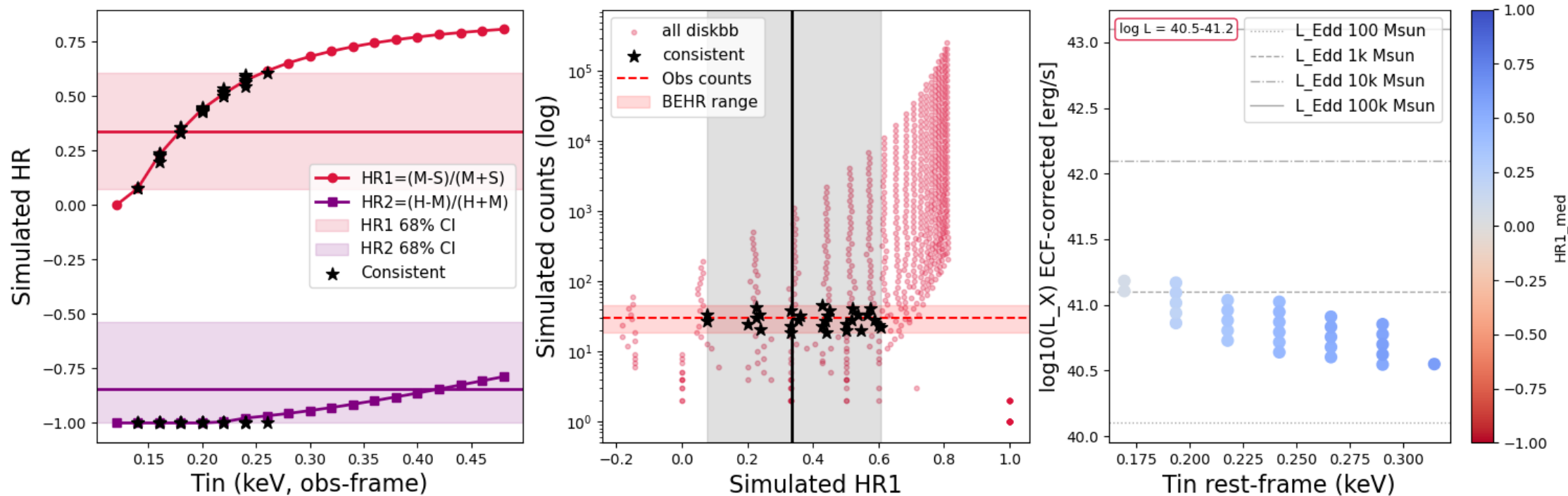
At every grid point:

300 fake spectra

Sherpa fake_pha through the stacked Chandra ARF / RMF

Keep a model only if HR1, HR2 and counts all fall inside the BEHR 68% intervals

Accretion disk fits



**$kT_{in} = 0.18-0.30$
keV**
rest-frame inner disk

$L = 10^{40.5-41.2}$
erg/s, 0.3-6 keV

$HR2 \approx -1$
corona quenched

$N_H < 10^{21}$
 cm^{-2} — no obscuration

Two observables, one black-hole mass

Thin-disk temperature

$$kT_{\text{in}} = 1.2 \left(\frac{M_{\bullet}}{10 M_{\odot}} \right)^{-1/4} \dot{m}^{1/4} \text{ keV}$$

Eddington scaling

$$\dot{m} = \frac{L_{\text{bol}}}{L_{\text{Edd}}} \approx \frac{L_X}{1.26 \times 10^{38} M_{\bullet}}$$

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Solve for M and $\dot{m}$

$$M_{\bullet} = \frac{1.44}{kT_{\text{in}}^2} \sqrt{\frac{10 L_X}{1.26 \times 10^{38}}} M_{\odot} \quad \dot{m} = \sqrt{\frac{kT_{\text{in}}^4 L_X}{10 \times 2.0736 \times 1.26 \times 10^{38}}}$$

THE LITTLE MONSTER

~2,000 $M_{\odot}$

range 800 – 5,000 $M_{\odot}$

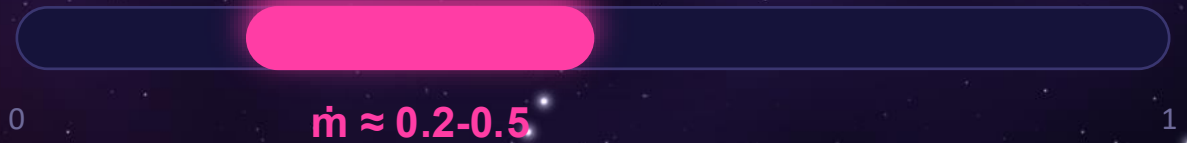


THE LITTLE MONSTER

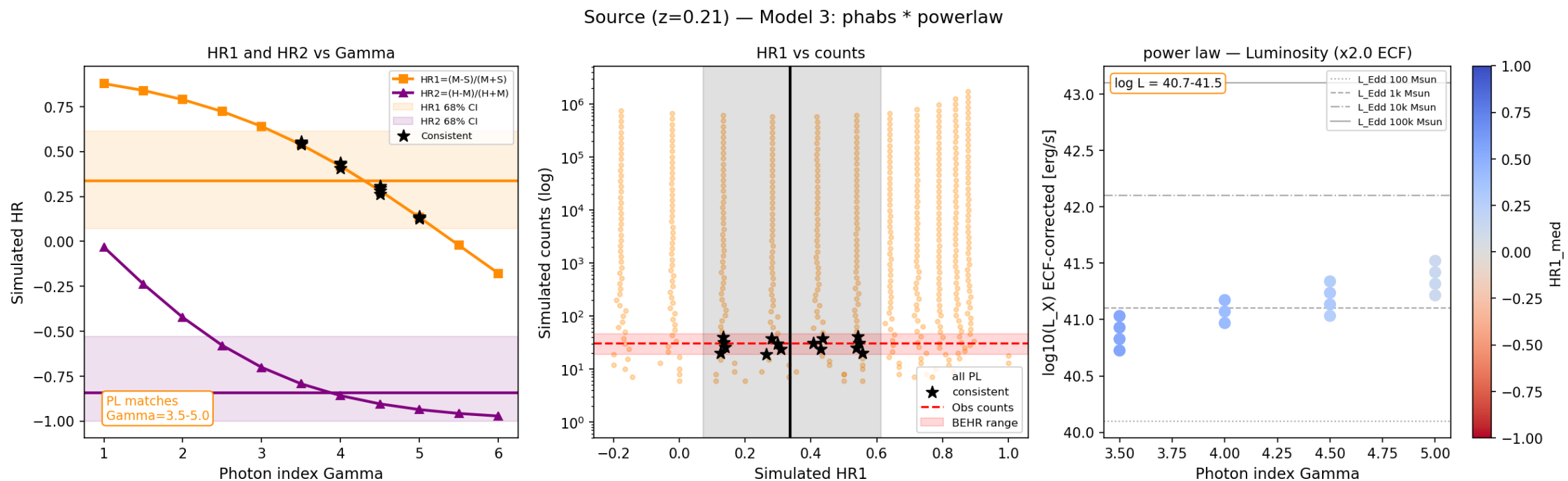
$\sim 2,000 M_{\odot}$

range 800 – 5,000 $M_{\odot}$

Accretion rate



A power law works only if absurdly steep



$$\Gamma = 3.5 - 5$$

required photon index

$$\Gamma \approx 2.5 - 3$$

even extreme NLS1s stop here

→ still an IMBH

disk model preferred

Could it be a stellar-mass impostor?

Temperature

inner disk / photosphere



Could it be a stellar-mass impostor?

Temperature

inner disk / photosphere



Luminosity

vs. the ULX population



The takeaways

Caught **feeding**

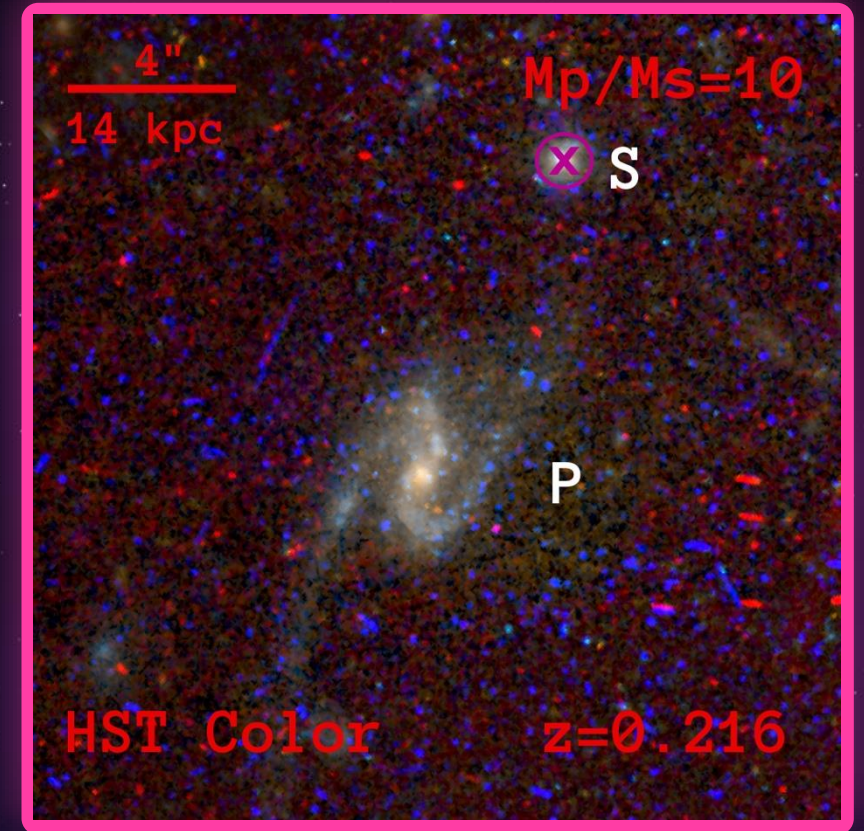
A thermal, high/soft-state IMBH in a dwarf galaxy

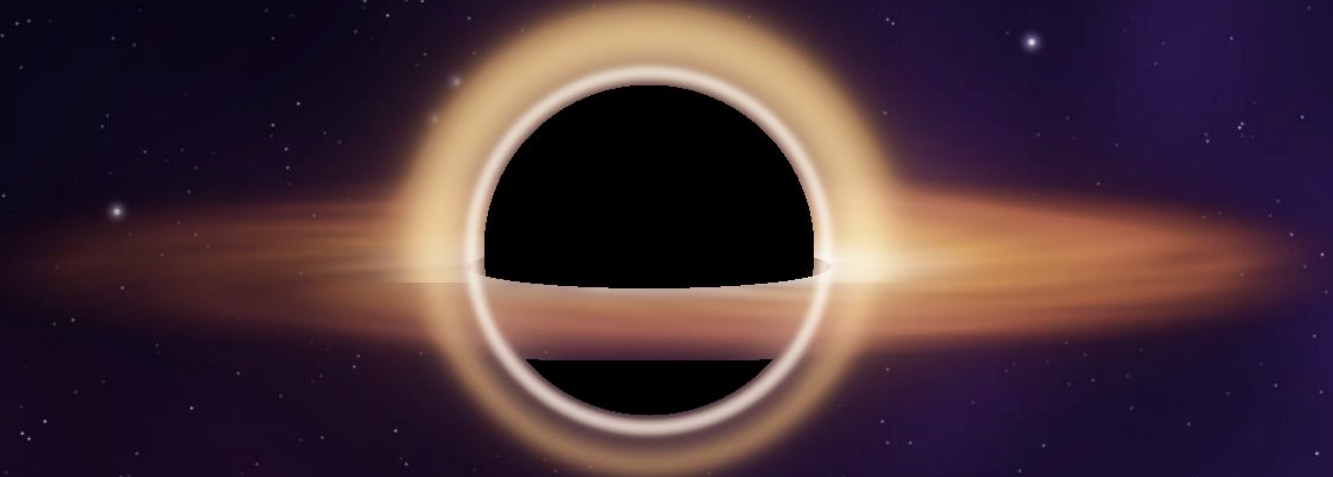
Merger-fed, as predicted

Observational support for growth spurts in secondary galaxies

A new place **to hunt**

Dwarf galaxies interacting with a bigger neighbor





Thank you

