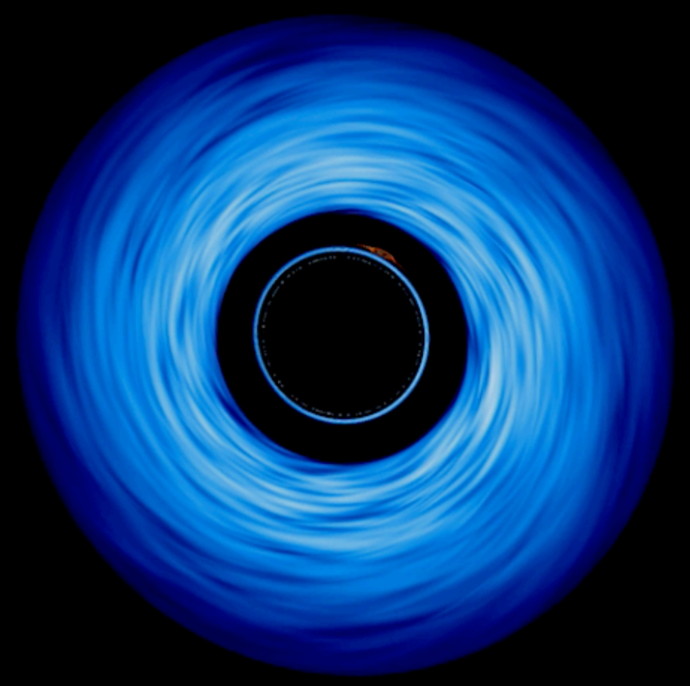
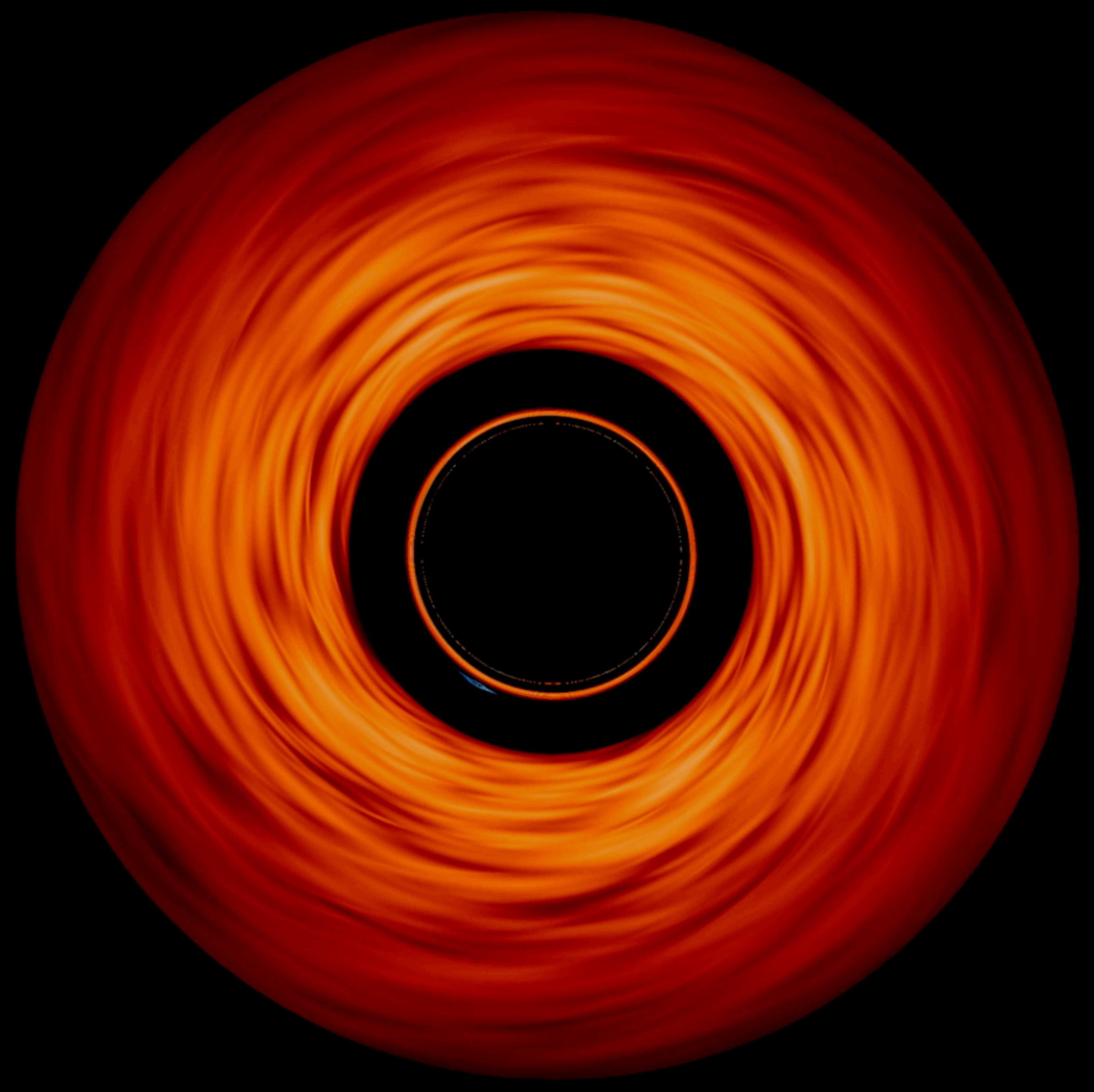
Precursors to LISA SMBHB Mergers





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NASA Goddard

TDAMM Workshop
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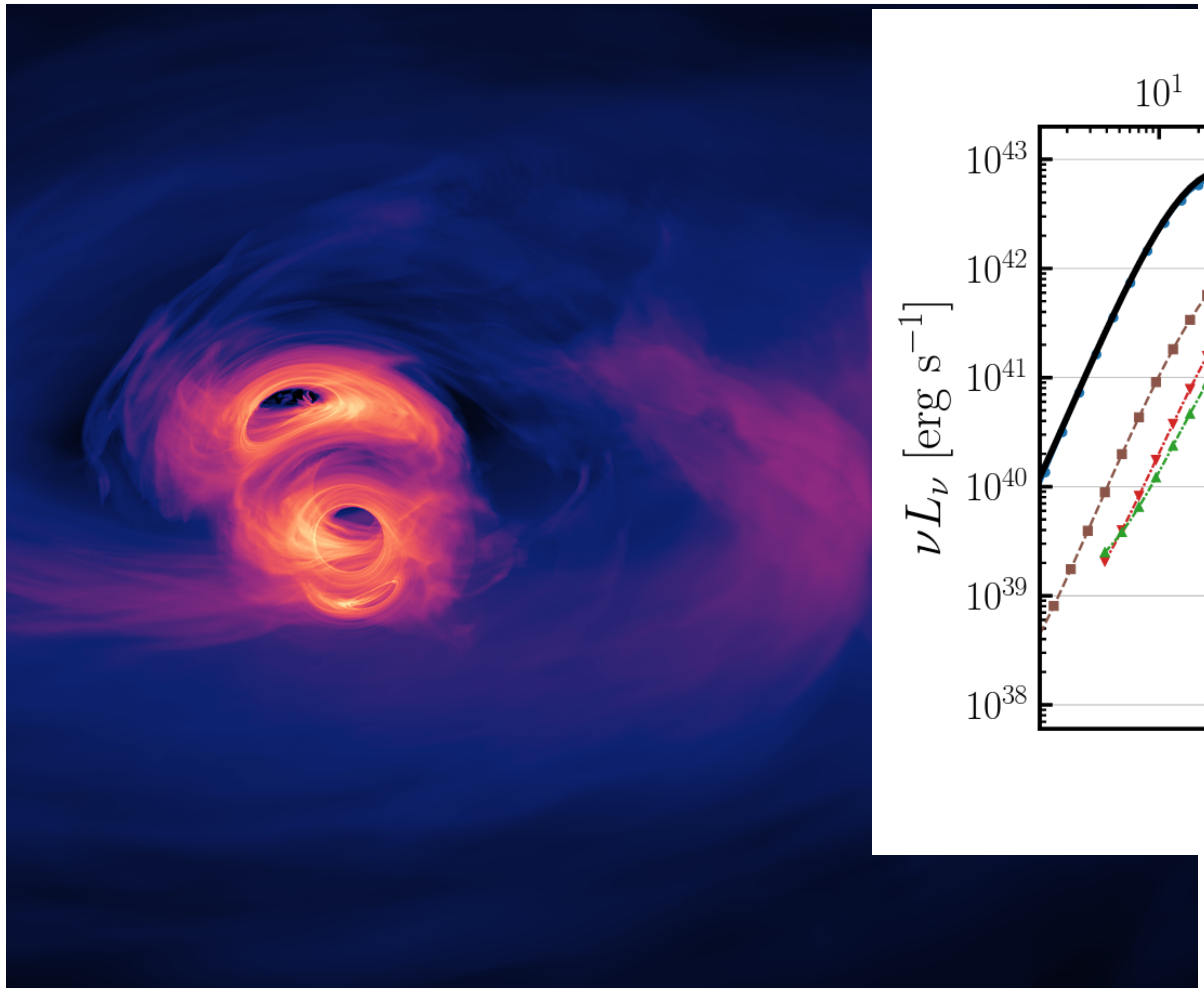
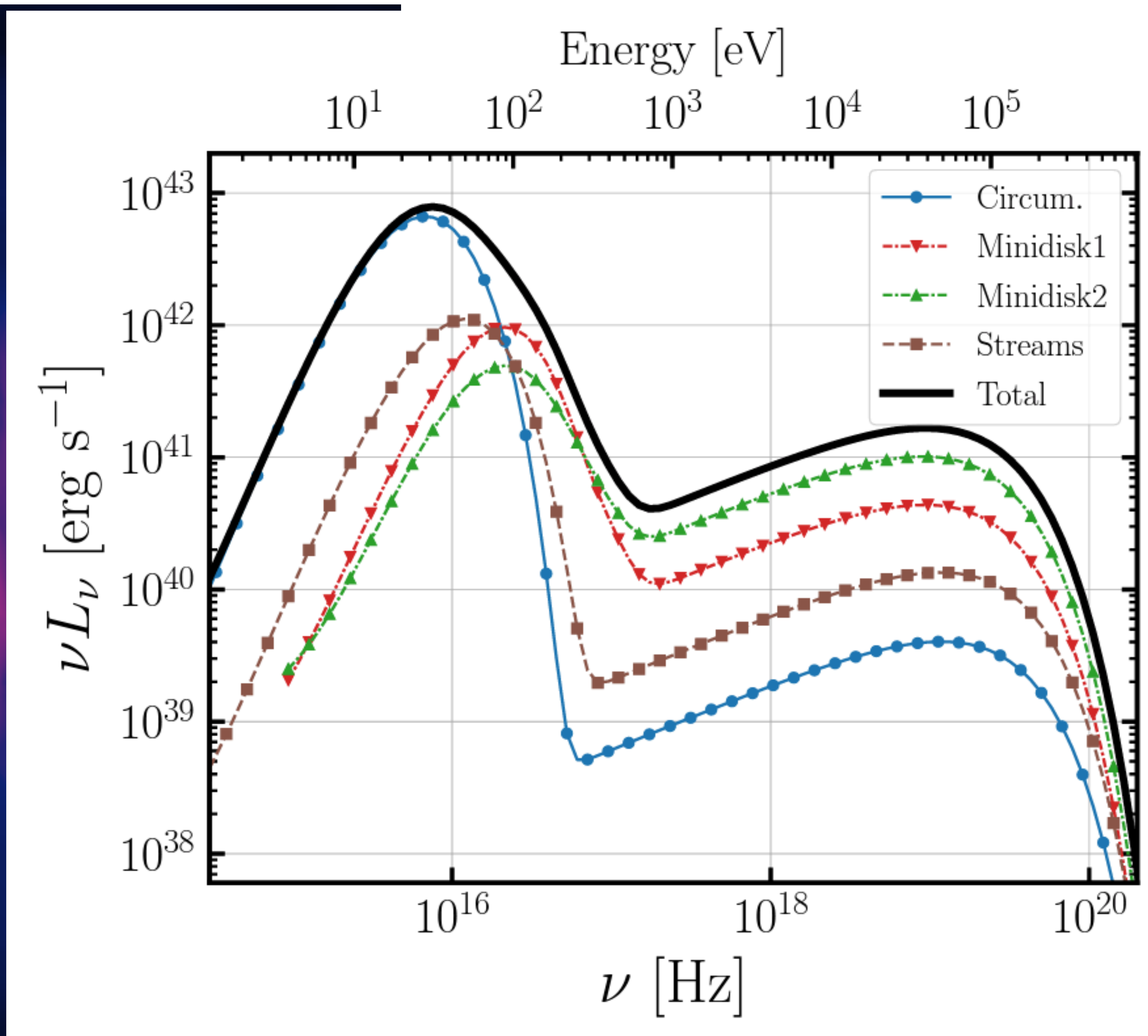
Electromagnetic Counterparts to LISA SMBHBs

- $M_{tot}=10^6\ M_{sun}$
- $q=0.1$
- $z=1$
- $L_x(in) \sim L_{Edd} \times f_x(a)$
- $f_x(a) \sim 0.1+1/a$
- $L_x(out) \sim L_x(in) \times R_{isco}/a$
- $L_{var} \sim L_x(in)\ a^{-1/2}$
- $F_{XRT} \sim 3\times10^{-15} \times (1\ hr/ttm)$

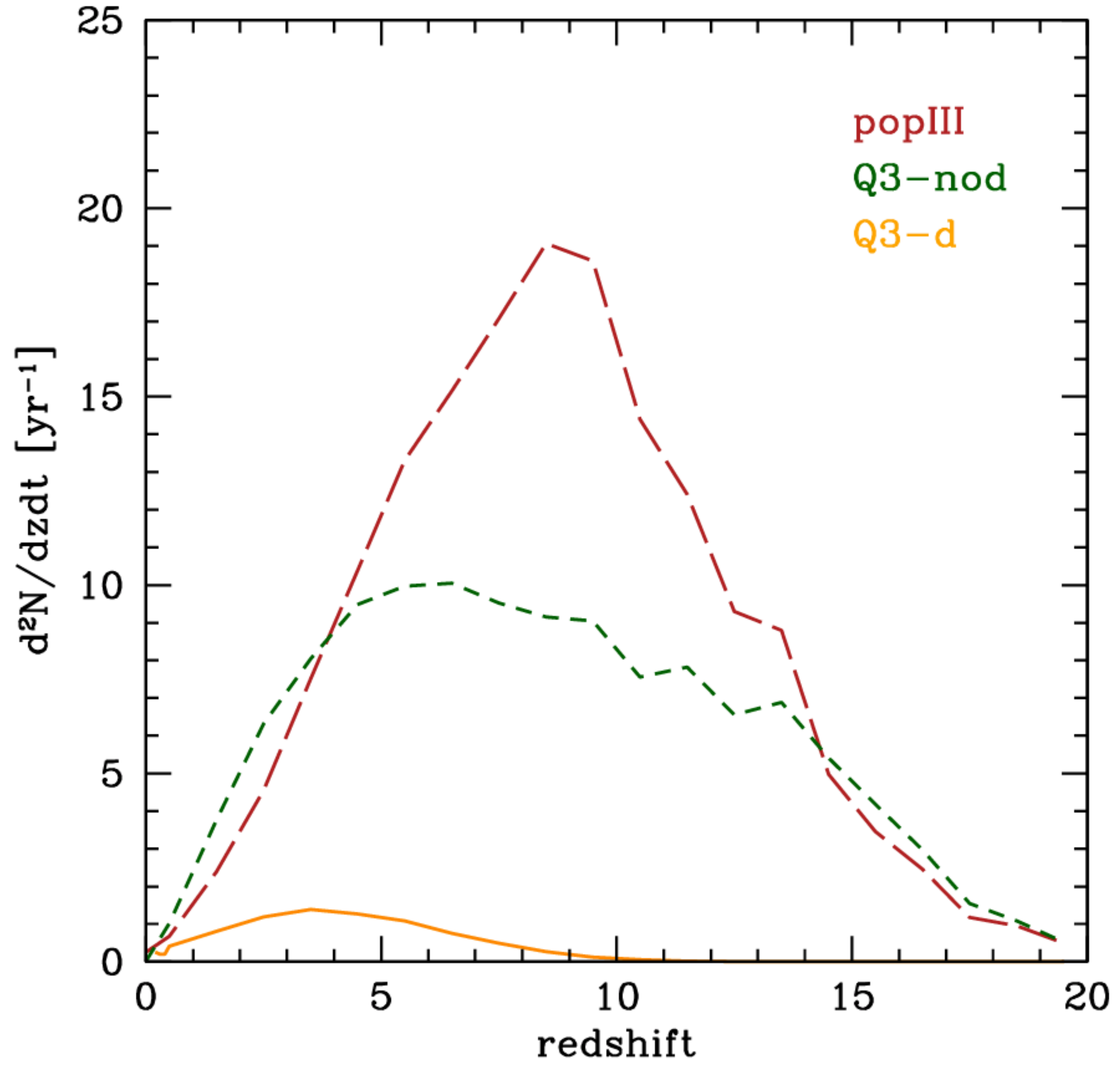


Noble+ 2018

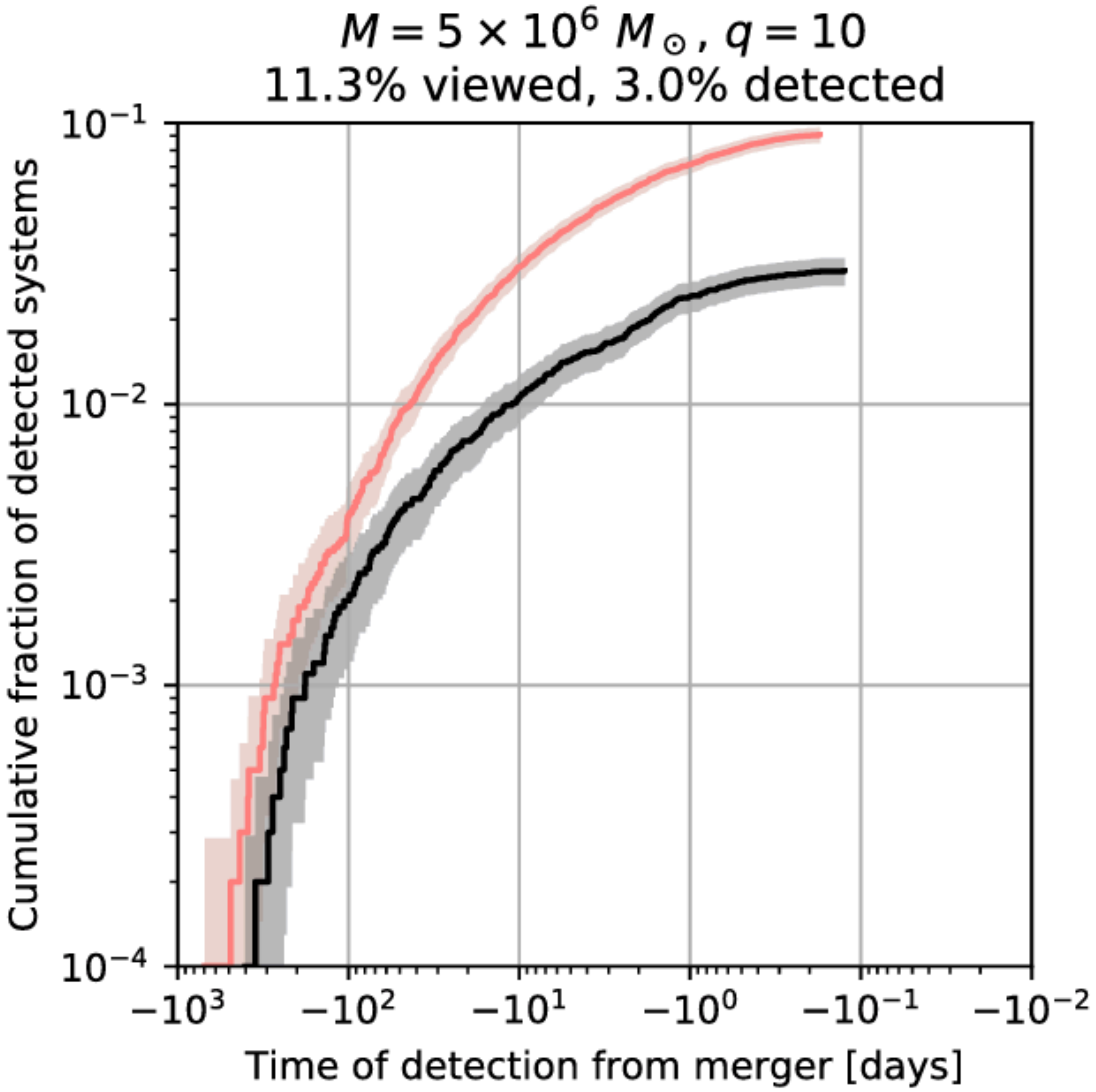


Gutierrez+ 2022

Merger rates; detection rates



Klein+ 2016



Dal Canton+ 2019

Precursors to LISA sources are far more numerous

- From Klein et al. (2016), we estimate merger rate of ~0.01 $\mathrm{Gpc^{-3}\,yr^{-1}}$

- Assume a fraction f_{gas} of the SMBHB sources are surrounded by circumbinary accretion disks

- These systems will be accreting at a rate f_{Edd} of the Eddington limit and modulated with amplitude ~10-30% and period $P \sim P_{orb}$

- This means that ~500,000 systems within z<1 will have T_{orb}~1 month, or <u>20 within 100 Mpc</u>

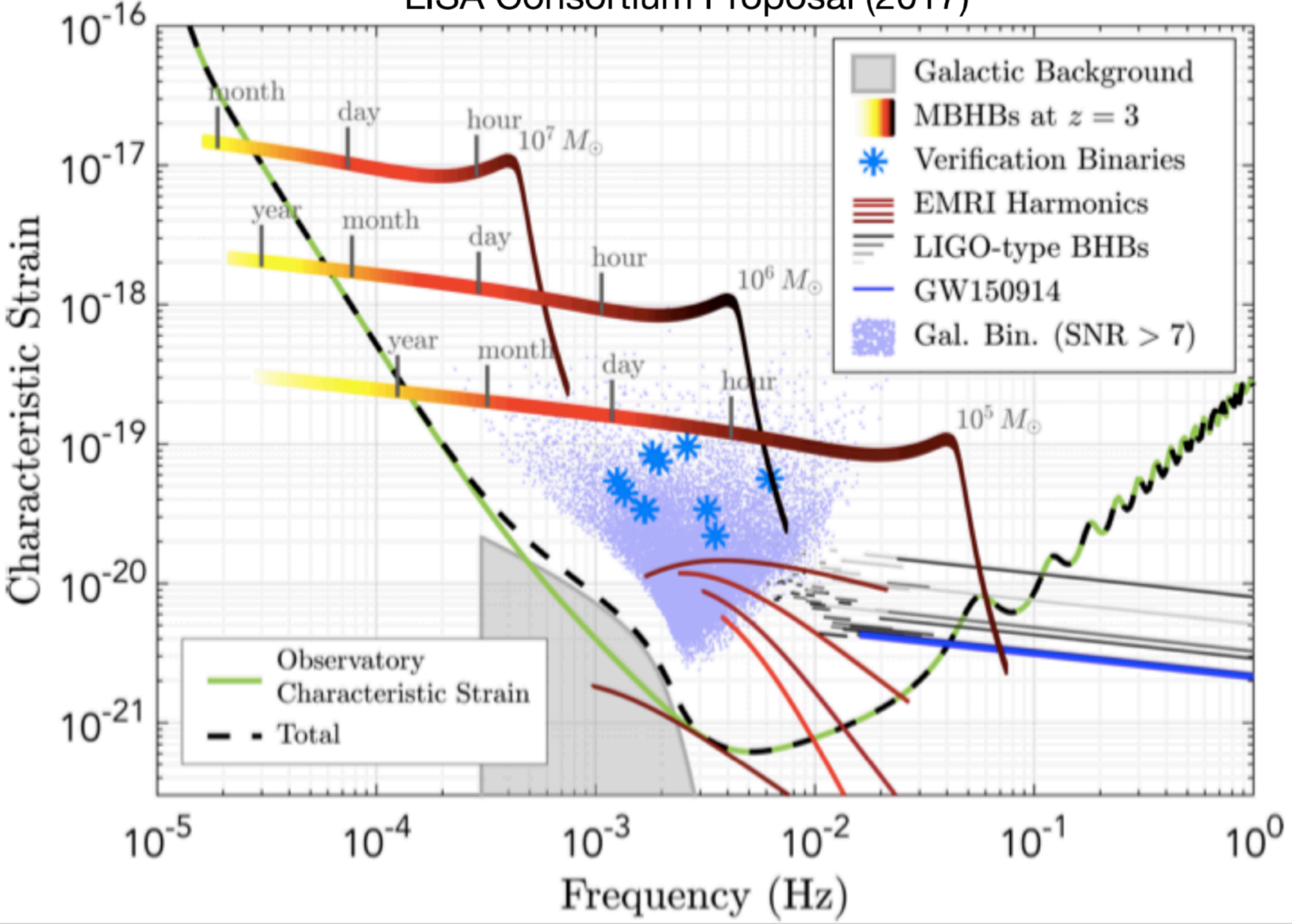
Time to merger:

$$t_{\rm merge} = \frac{5}{256}\frac{c^5}{G^3}\frac{a^4}{m_1 m_2 (m_1+m_2)}$$

so for $m_1 = 10^6 M_\odot$, $q = 0.1$, the system has a separation of $a \approx 70\, r_g$ and an orbital period $T_{\rm orb} = \frac{2\pi}{\sqrt{G(m_1+m_2)}} a^{3/2} \approx 5$ hr a year before merger.
In terms of $T_{\rm orb}$, the time to merger scales like $t_{\rm merge} \propto T_{\rm orb}^{8/3}$, so if we set $T_{\rm orb} = 1$ month, we get $t_{\rm merge} = 5 \times 10^5$ yr.

Precursors to LISA sources are far more numerous

LISA Consortium Proposal (2017)



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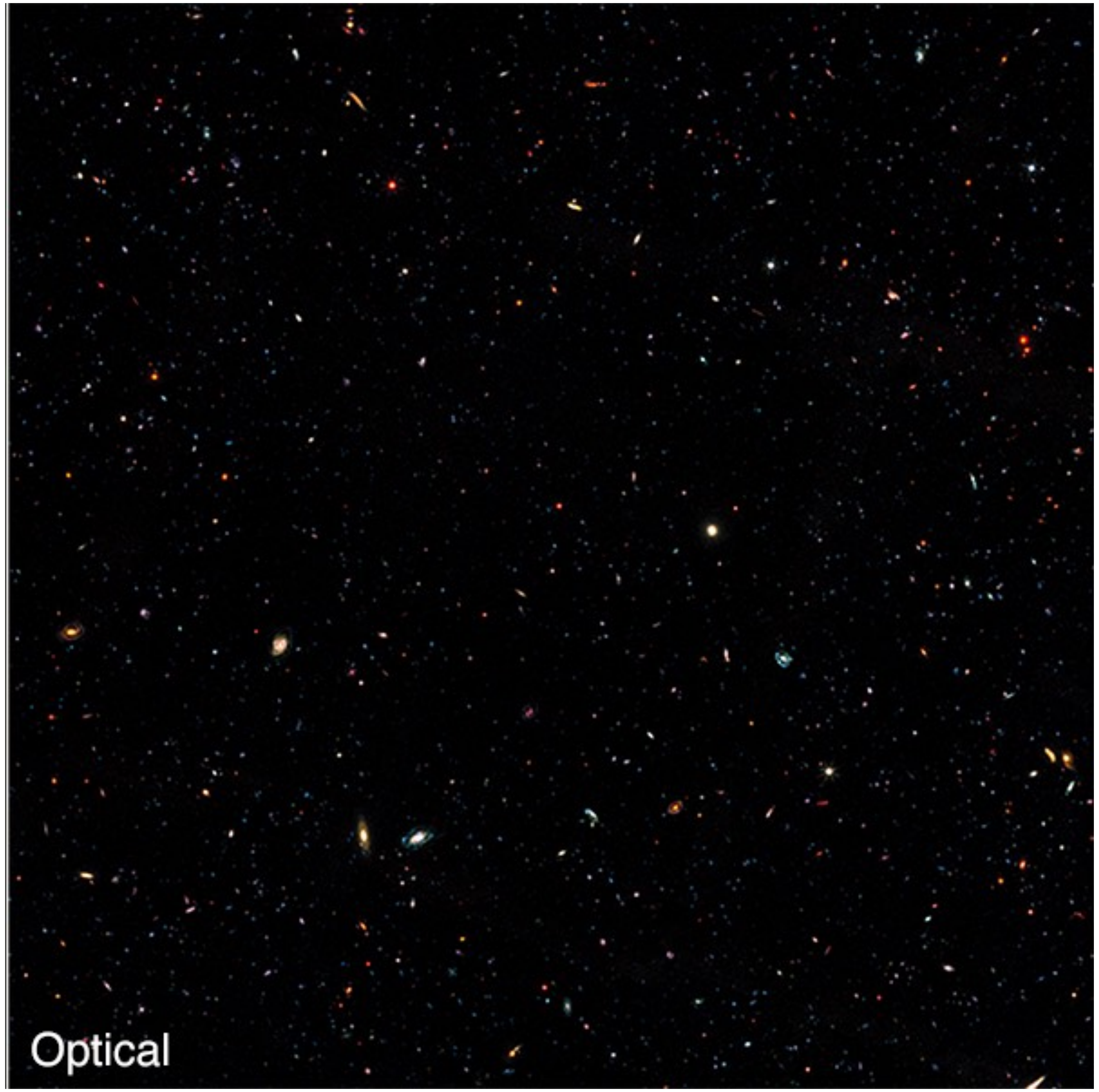
Observational strategies: optical

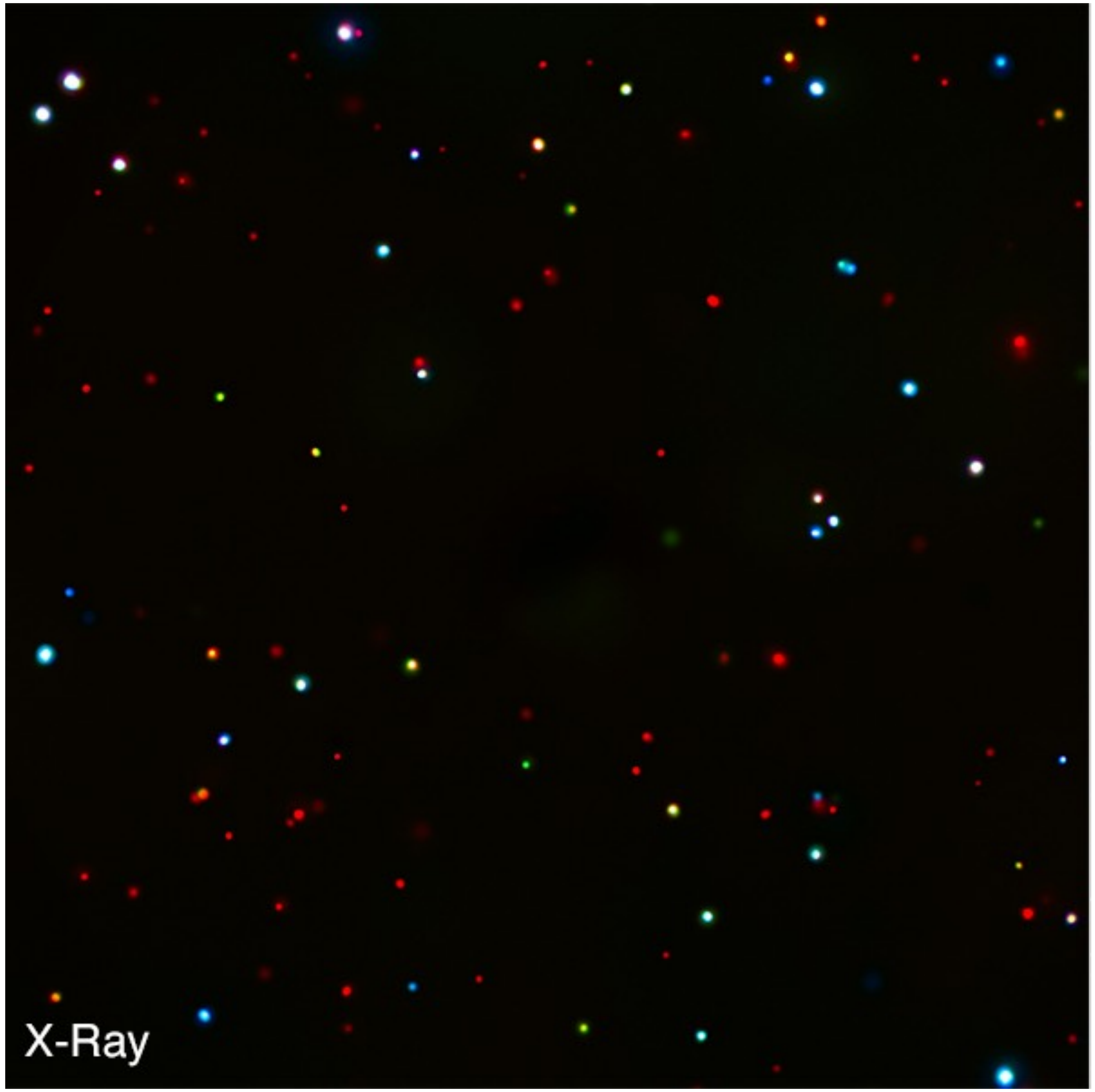
- LSST fov 9.6 deg^2
- $m < 23$ mag in 15sec!
- $N > 10^4\ deg^{-2}$



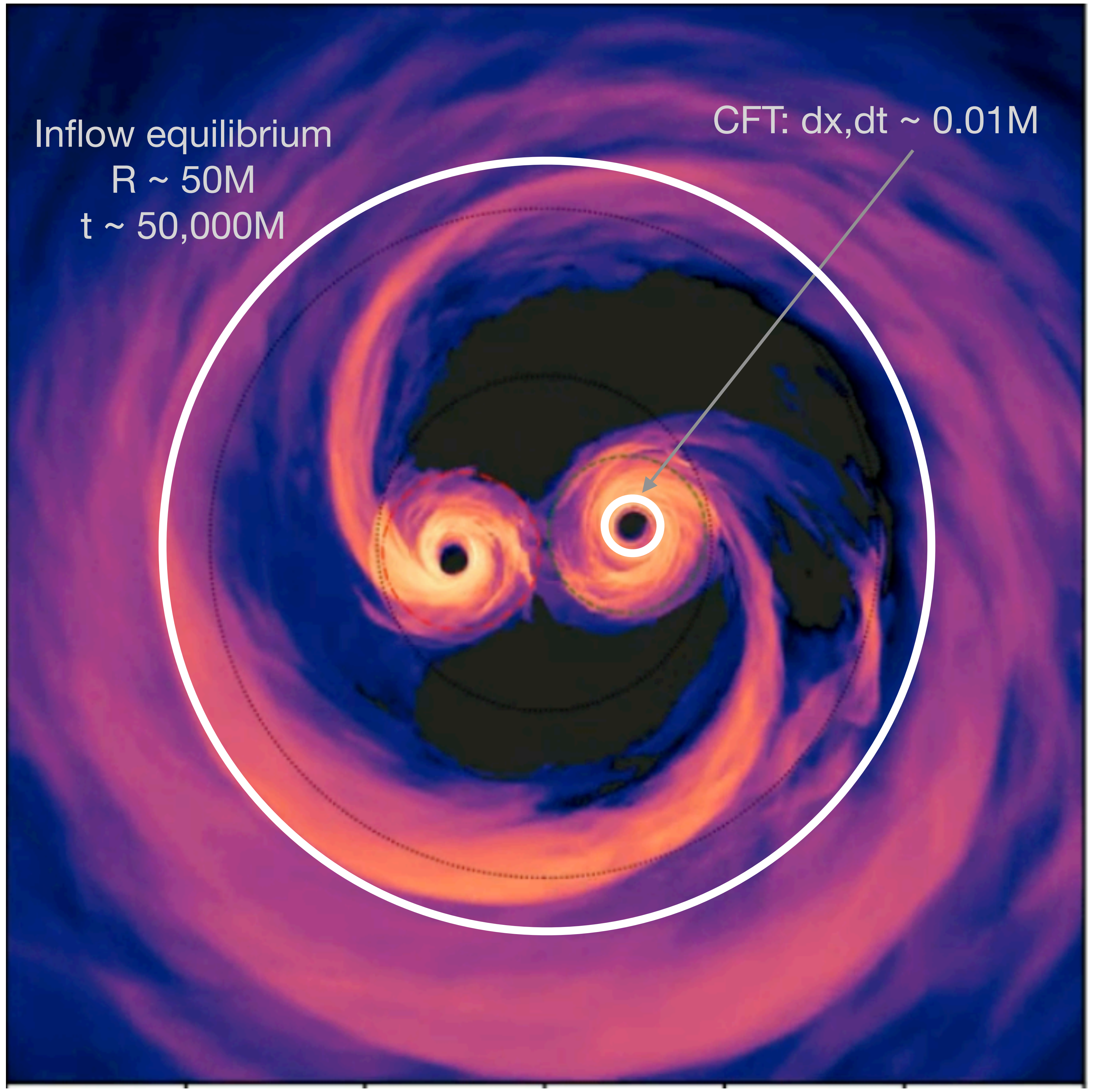
Observational strategies: X-ray (deep vs wide)

- TAP XRT fov 1.0 deg^2
- F ~ $1x10^{-16}$ erg/s/cm^2 in 1 d
- N ~ 10^4 deg^{-2} (cf Chandra deep field)
- N_{pre} ~ 10 (T_{orb} < 1 mo, z<1)
- dFx ~ $5x10^{-16}$ erg/s/cm^2

- TAP XRT tiling 100 deg^2
- F ~ $1x10^{-14}$ erg/s/cm^2 in 1 d
- N ~ 10 deg^{-2} (cf ROSAT XS)
- N_{pre} ~ 1 (T_{orb} < 1 mo, z<0.14)
- dFx ~ $5x10^{-14}$ erg/s/cm^2



Theoretical strategies/challenges: dynamic range



Gutierrez+ 2022

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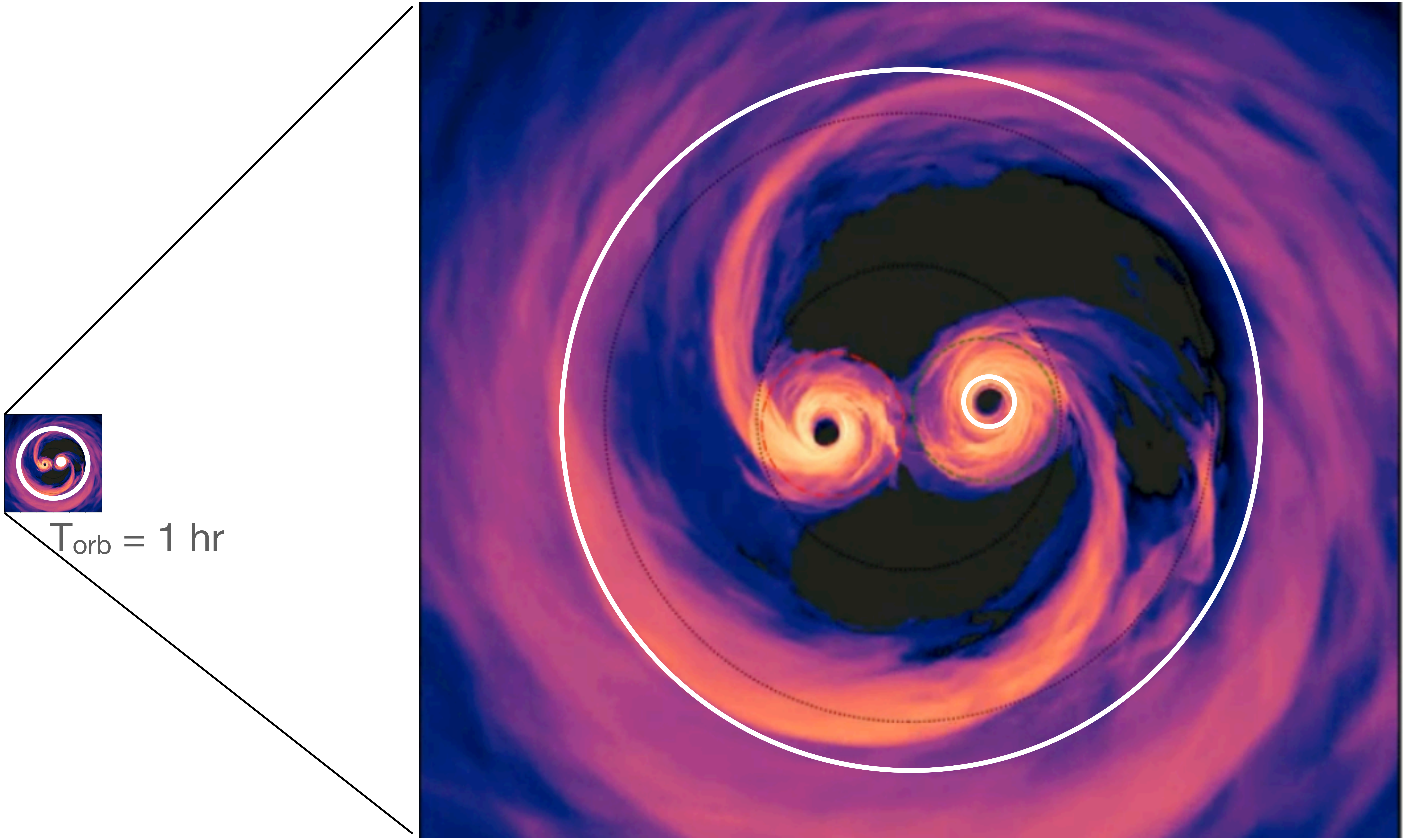

Questions/eye candy