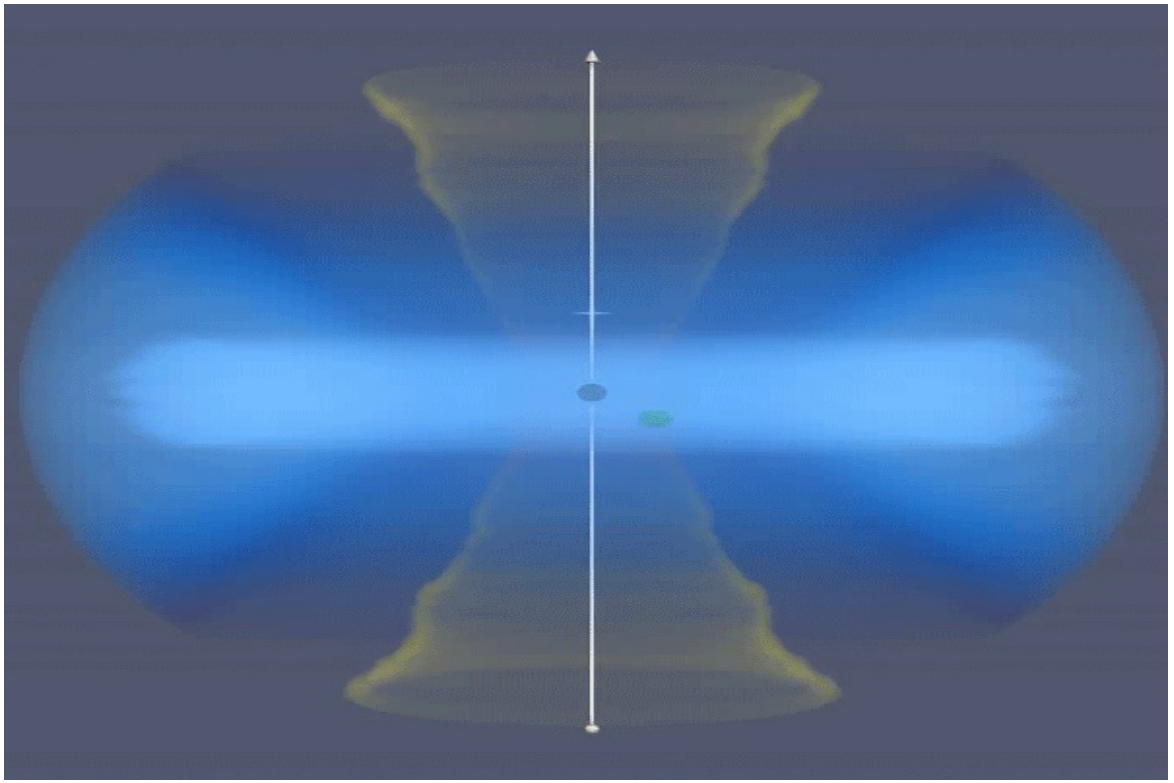
A supermassive black hole's persistent “hiccups” in a far-off galaxy

By DJ & Co.

(Pasham, Tombesi, Sukova & Others)



May 7, 2024

Highlights

Detected by ASAS-SN (the All Sky Automated Survey for SuperNovae), a network of 20 robotic telescopes situated in various locations across the Northern and Southern Hemispheres.

The telescopes automatically survey the entire sky once a day for signs of supernovae and other transient phenomena.

ASASSN-20qc: astrophysical flare from the nucleus of a galaxy at a redshift of 0.056 (luminosity distance of 260 Mpcs).
Discovered on December 20, 2020

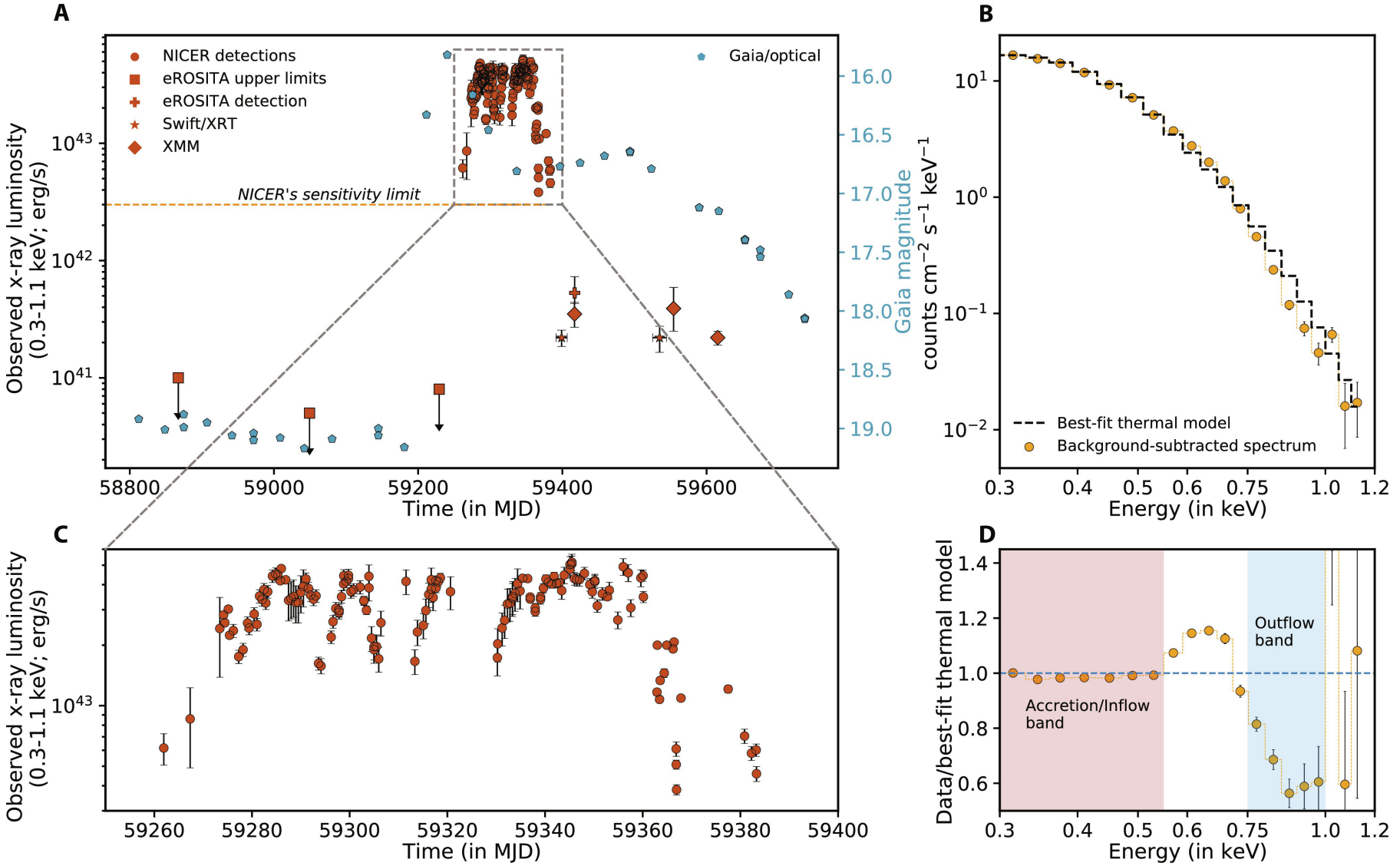
Conventional picture of black hole accretion disks, which scientists had assumed are relatively uniform disks of gas that rotate around a central black hole.

A new picture: accretion disks may be more varied in their contents, possibly containing other black holes and even entire stars.

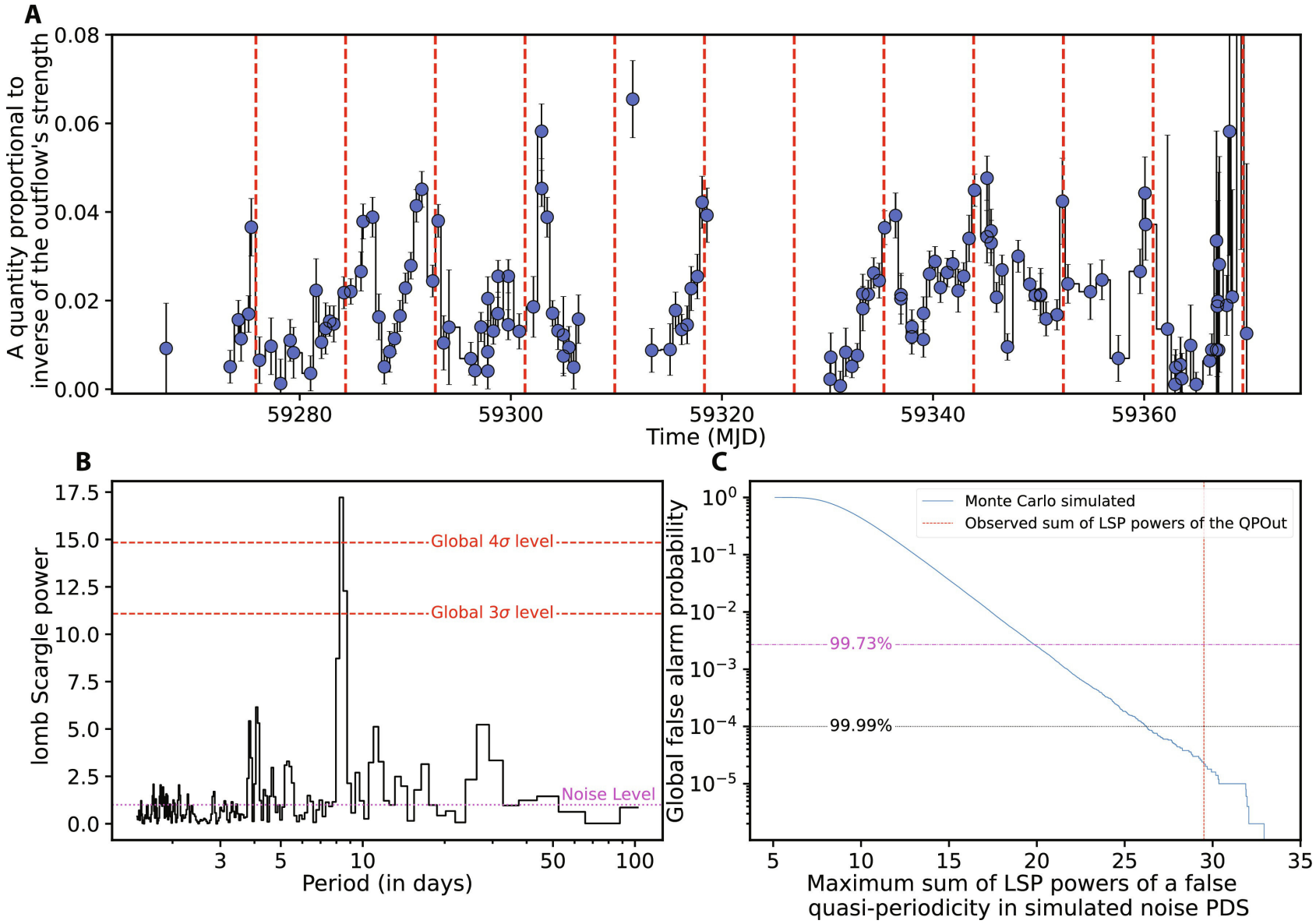
Precursors of gravitational wave events

Quasi-periodic variability in x-ray absorption interpreted as quasi-periodic outflows (QPOuts)

Long-term evolution and a sample x-ray spectrum highlighting the outflow
(A) observed x-ray & optical evolution.
(B) Combined x-ray spectrum using all NICER data (yellow) & the best-fit emission model (black histogram).
(C) Zoom-in of the outburst near the x-ray peak.
(D) Ratio of the average energy spectrum using all NICER data in ODR and the best-fit thermal model.



Summary of ASASSN-20qc's timing analysis.
(A) A lower ODR value implies a stronger outflow and vice versa. The dashed vertical red lines are uniformly separated by 8.5 days.
(B) Lomb-Scargle periodogram (LSP) of the ODR. The strongest signal is near 8.5 days.
(C) Global false alarm probability. This curve was generated using extensive Monte Carlo simulations The global statistical significance of the 8.5-day quasi-periodicity is >4.2σ.



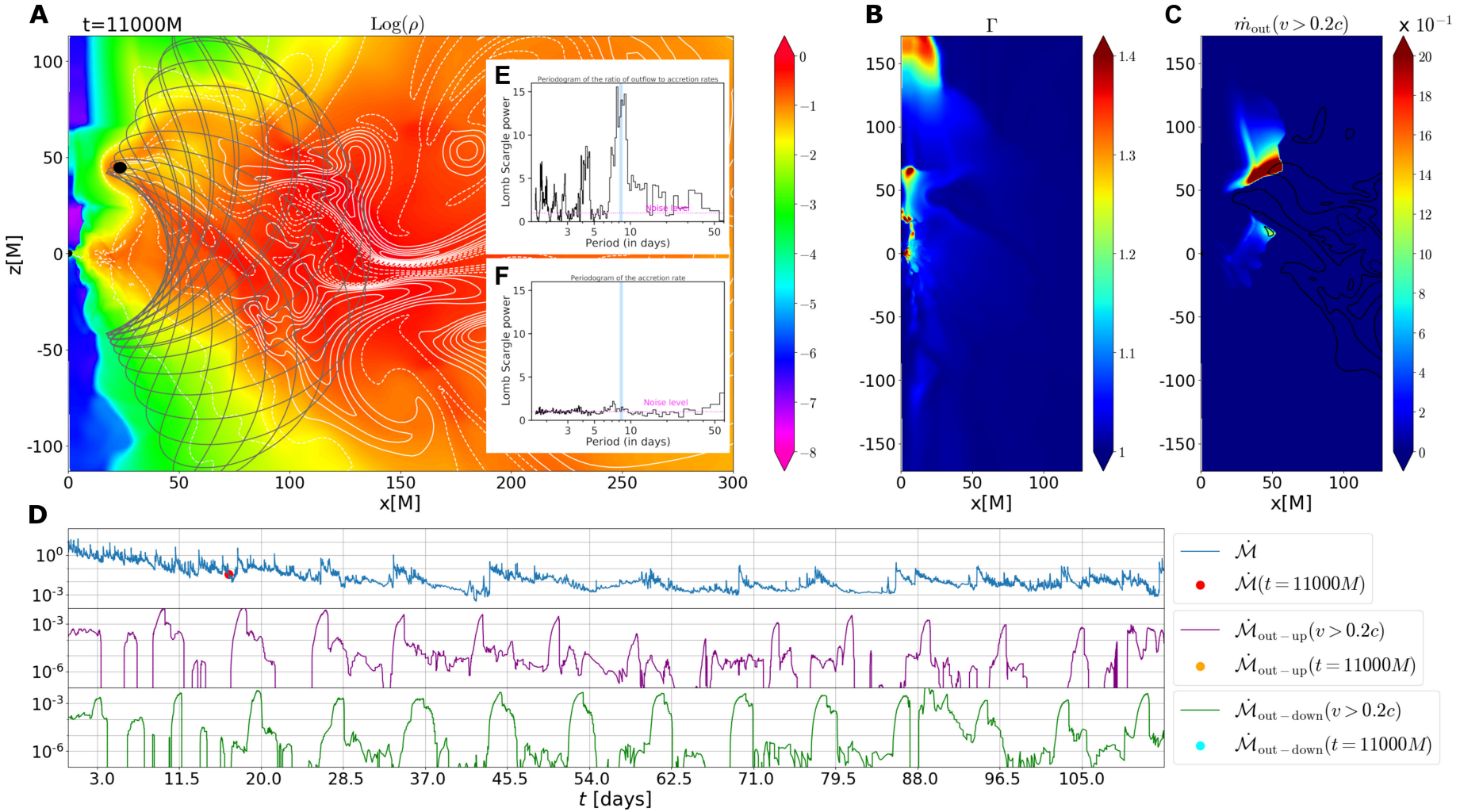
2D GRMHD simulation (HARM code): SMBH mass was set to $10^{7.4} M_{\odot}$ and the perturbing companion is in an elliptical orbit (eccentricity, e = 0.5) with an observed orbital period of 8.5 days and has an influence radius of three gravitational radii

(A) Logarithm of mass density expressed in arbitrary units. White contours indicate the magnetic field configuration. The position and size of the perturber are shown by the black circle, while the gray line displays its trajectory in the 2D slice.

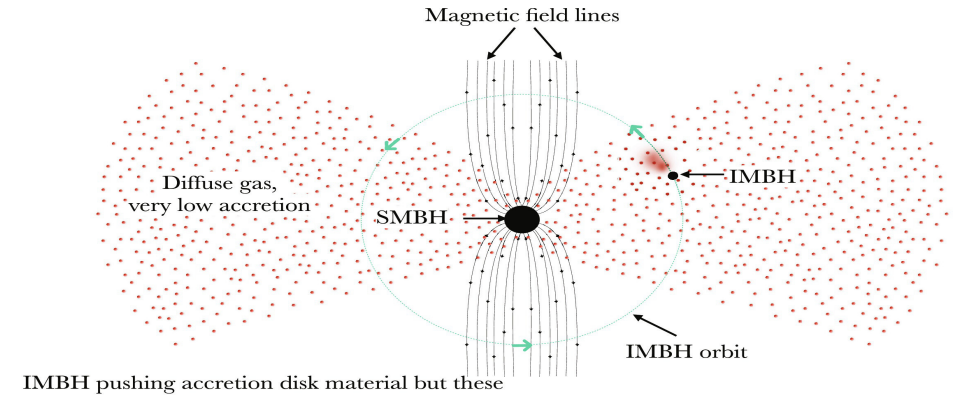
(B) Spatial distribution of the Lorentz factor of the gas bulk motion.

(C) Spatial distribution of the mass outflow rate with v > 0.2c.

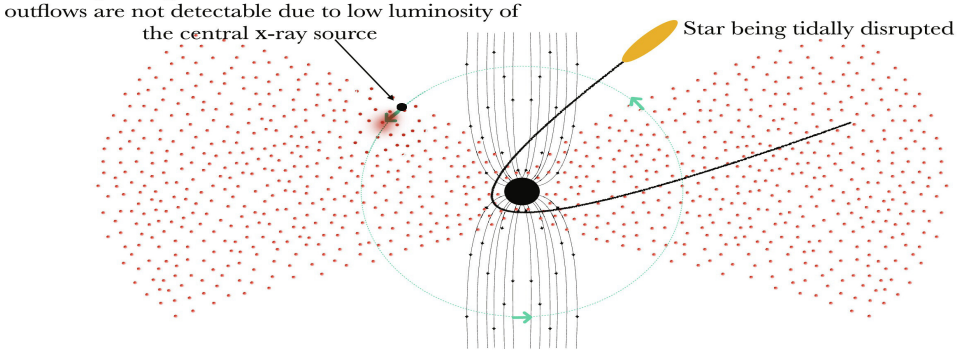
(D) Temporal profiles of the inflow rate (blue), the outflow rate through the upper funnel (purple), and the outflow rate through the lower funnel (green). Vertical lines are uniformly separated by 8.5 days.



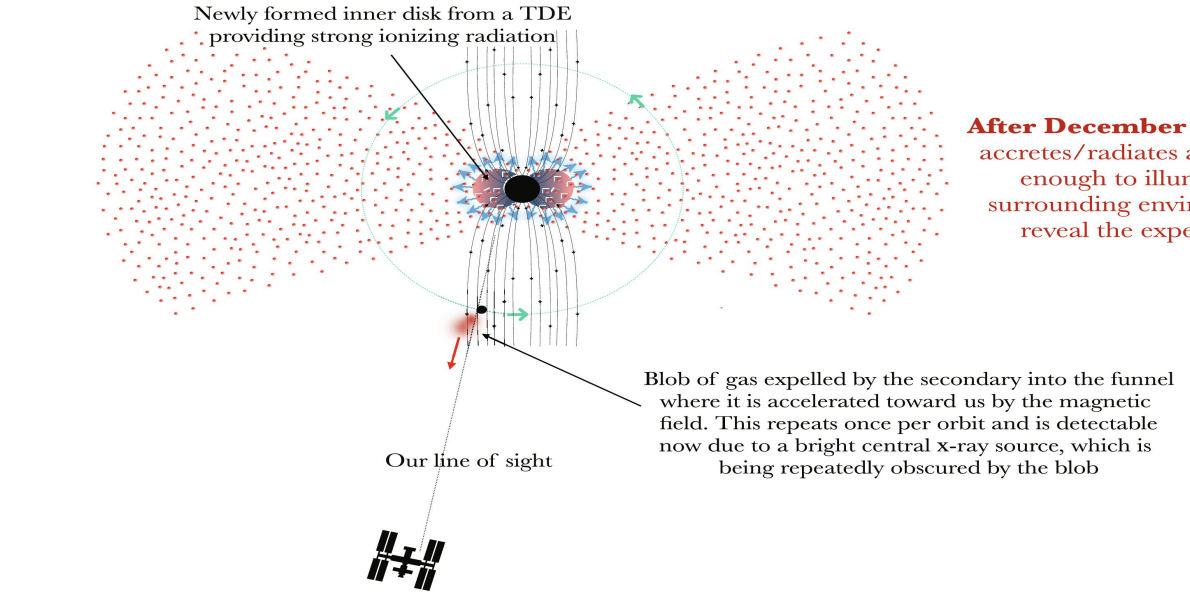
Schematic of a potential model : A gravitationally bound (preexisting) IMBH located at roughly 100 Rg from the central SMBH can explain the repeated outflows seen here. Secondary plunges through the preexisting (non-TDE) accretion flow, modulating the outflow on the orbital period.



Pre-2020 outburst: SMBH+IMBH binary. SMBH accreting at $<2\times10^{-5}$ Eddington



In December 2020: a major accretion episode occurs, likely from the tidal disruption of a star



After December 2020: SMBH accretes/radiates at a level high enough to illuminate the surrounding environment and reveal the expelled blobs

Thank you.