ISTITUTO DI ASTROFISICA SPAZIALE E FISICA COSMICA DI PALERMO

Insights from the Swift satellite on Black Hole X-ray Binaries

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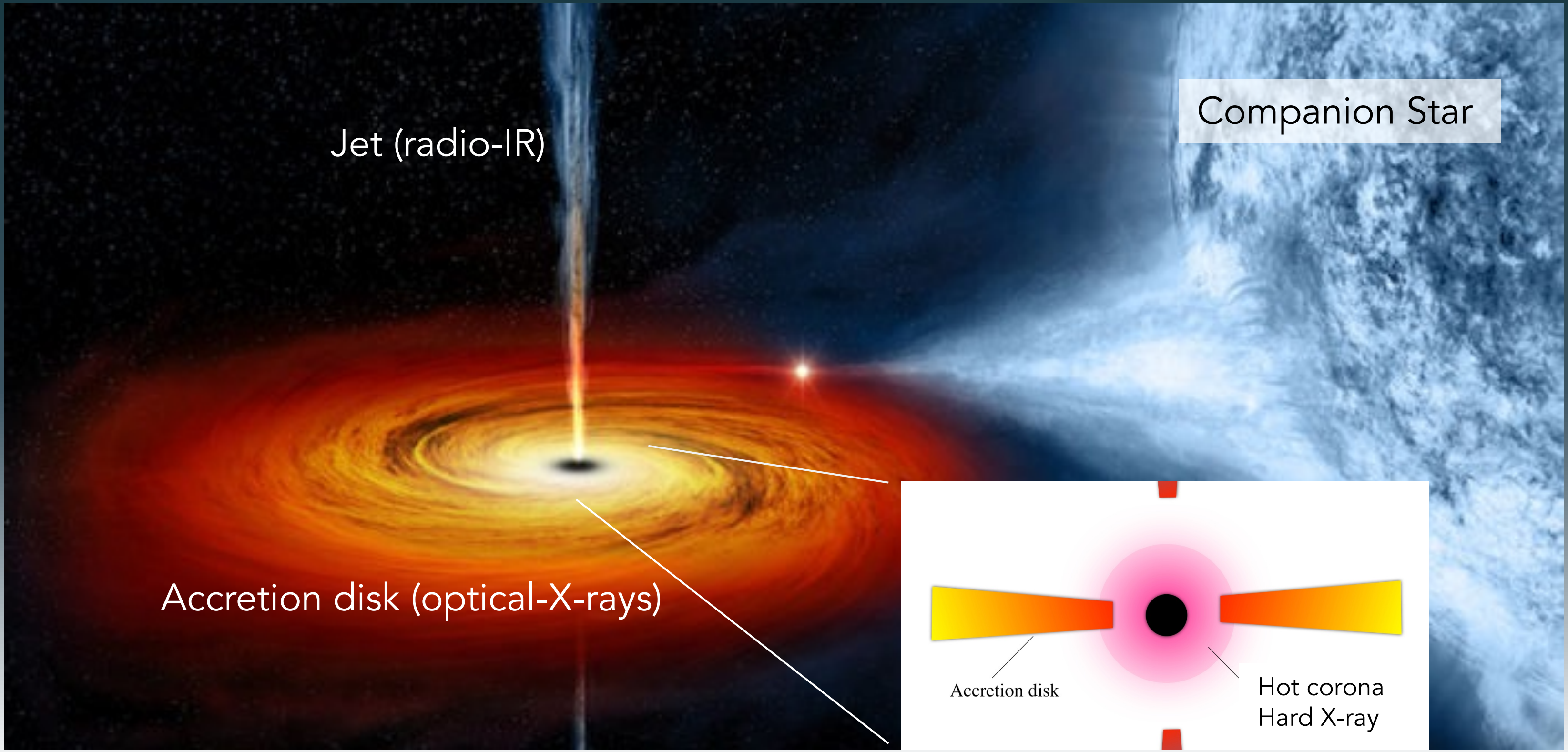
Celebrating 20 years of Swift Discoveries

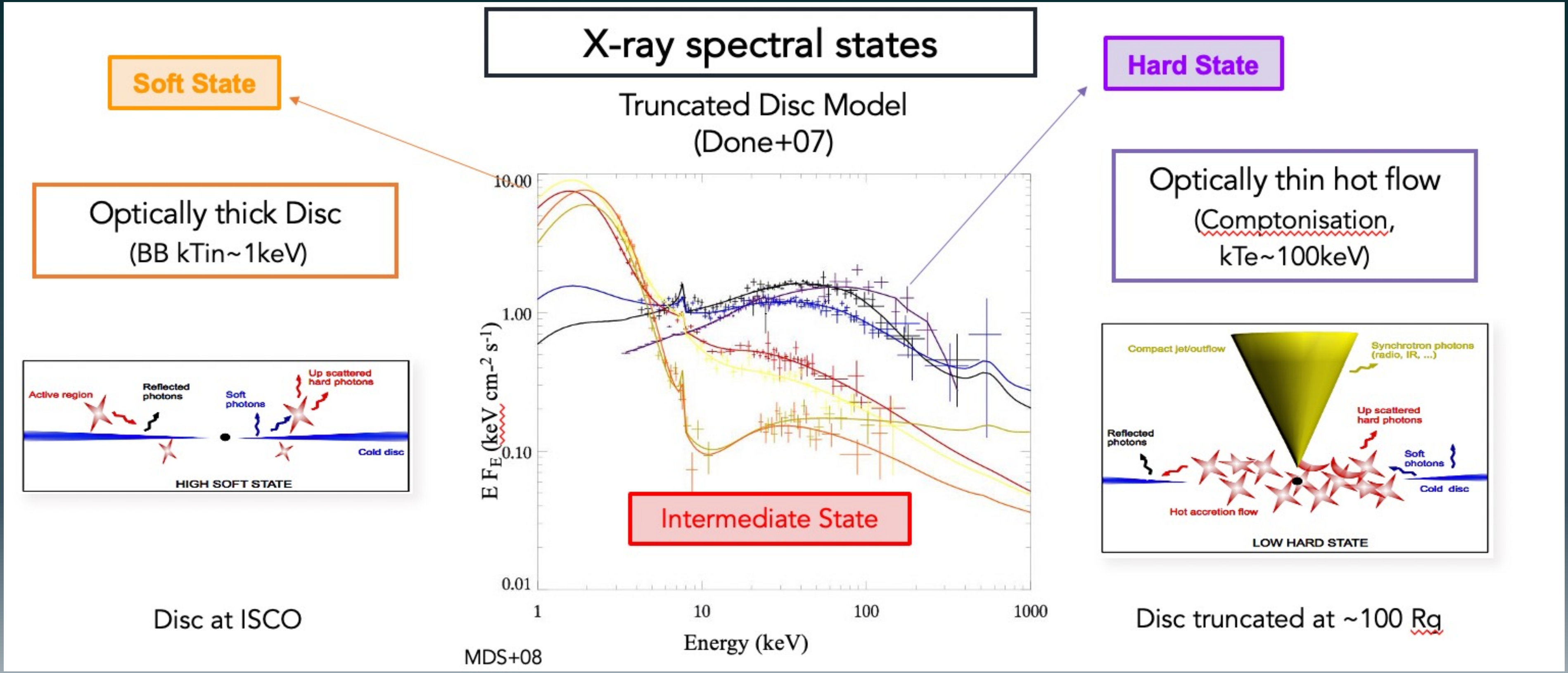
Black-hole X-ray binary

* Binary stars composed of BH accreting matter from a companion star.
* Accretion (disk and corona) – Ejection (jets and winds)

✓78 BH Transients in the Galaxy (thousands predicted)
✓11 persistently accreting

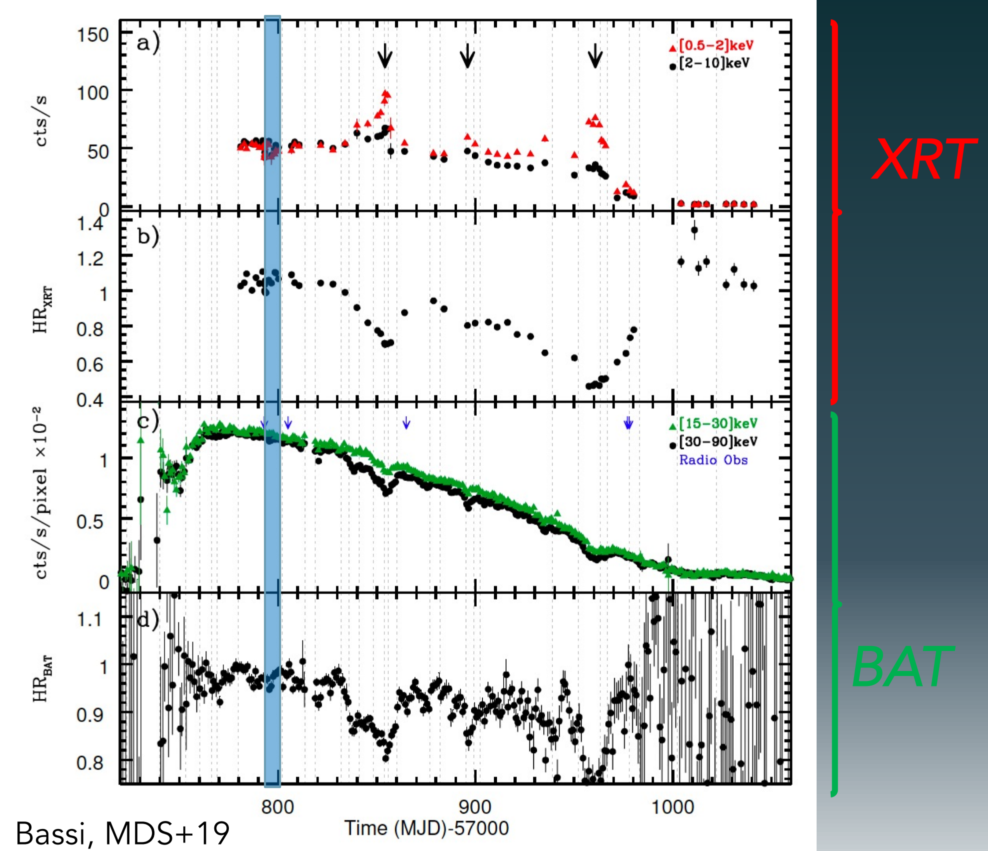
(Tetarenko+16; Corral-Santana+16 and updates)





These different states are explained in
terms of changes in the geometry of the accretion.

GRS 1716-249: the 2016-17 outburst, after 26 years



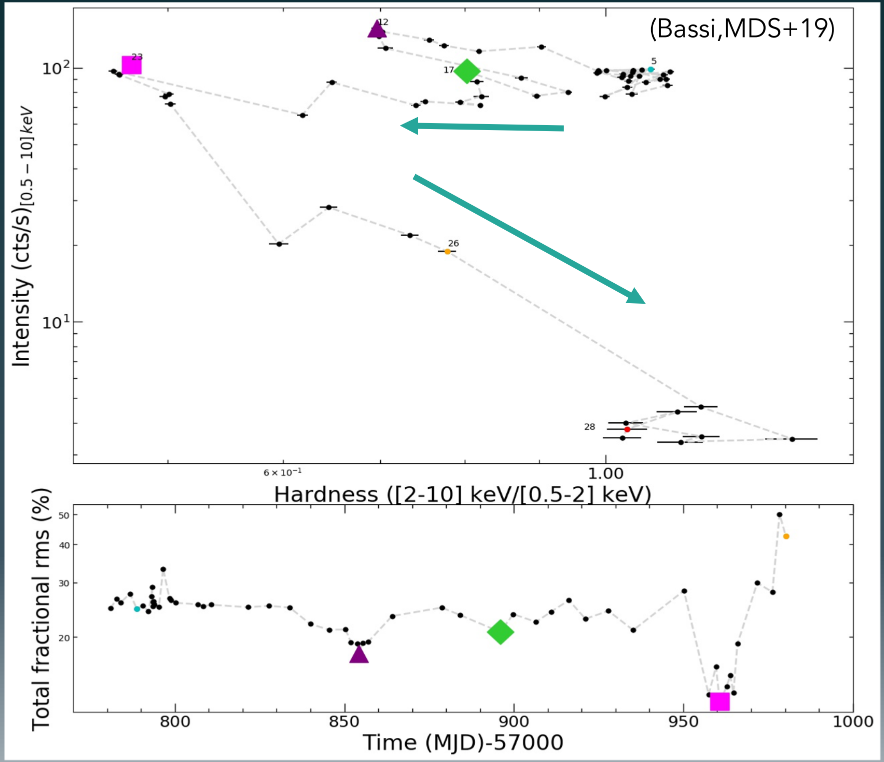
Bassi, MDS+19

X-ray/Radio monitoring of the long outburst (Bassi+19)

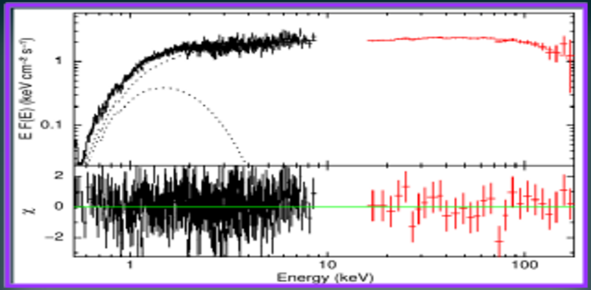
MW campaign (from radio to γ-rays) during the hard state on 2017 February (Bassi+20) to study the nature of the MeV tail (>200 keV).
Is it due by jets?

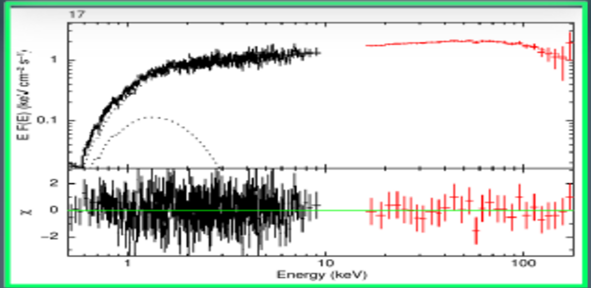
- ATCA
- REM
- Neil Gehrels Swift Observatory
- INTEGRAL

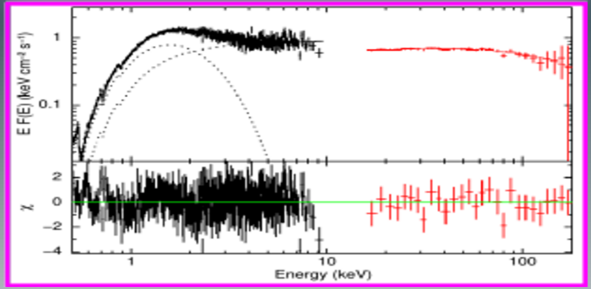
The outburst evolution study of GRS 1716-249



XRT spectral and timing study:
a failed transition outburst

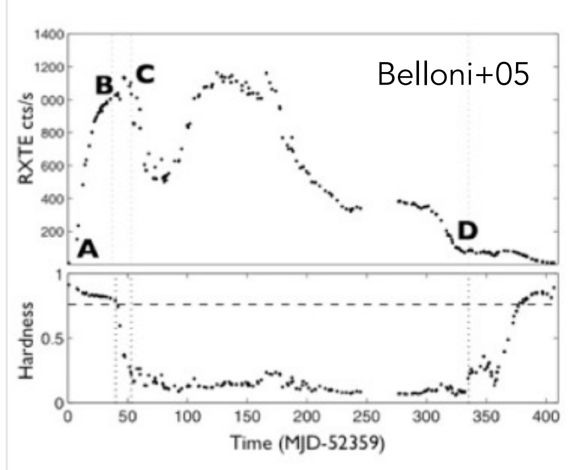


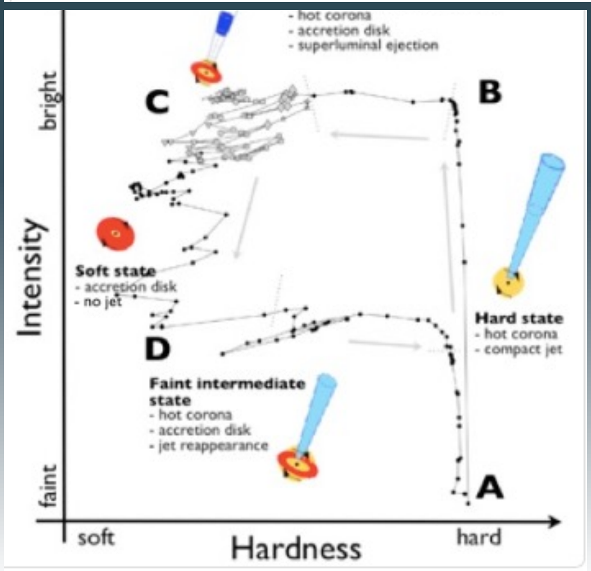


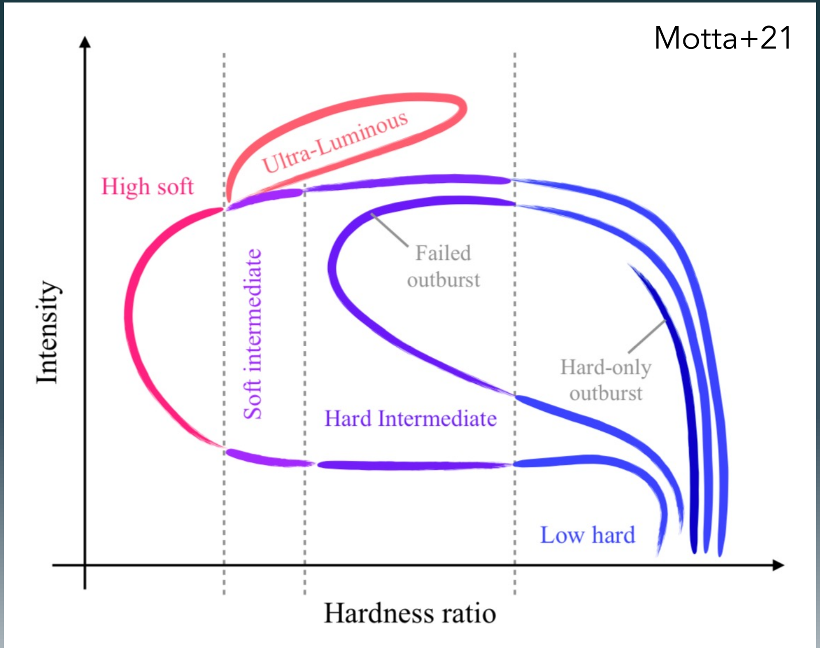


XRT-BAT spectral evolution
from HS-to-HIMS-to-LHS

When in outburst, several BH transients evolve in a Hardness Intensity Diagram following a specific pattern through the spectral states, a diagram called q-diagram.

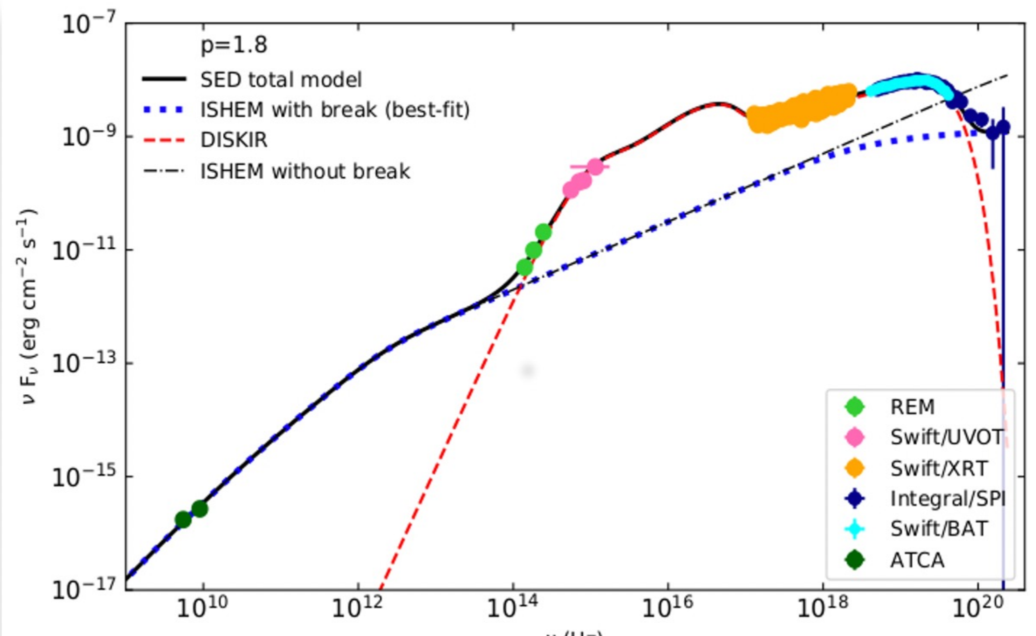






- 40% of BHB have shown a "failed transition"
- peak luminosities lower than 0.1 L_{edd} (Tetarenko+16)

The MW campaign on GRS 1716-249 for the jets physics study and the origin of the soft γ-ray tail (jets?)



Bassi, Malzac, MDS+20

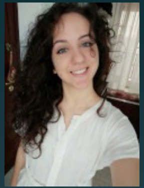
The SED was fitted with different components:

- Accretion flow emission: disc+thermal Comptonization
- Jet emission: Internal shock emission model (ISHEM, Malzac+14)

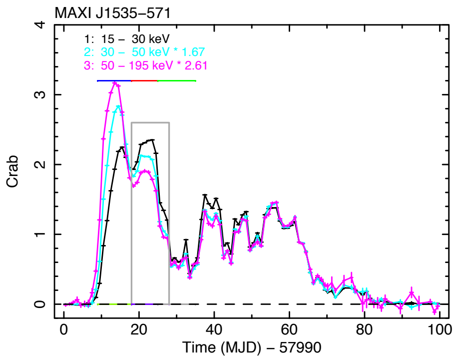
It is not possible to reproduce the soft γ-ray emission with reasonable parameters (e.g. Jet inclination $\vartheta<6°$, electron energy distribution index p<2)

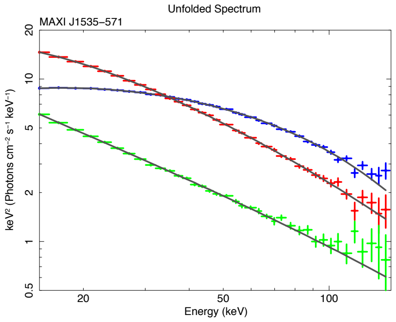
Accretion flow and jet evolution of the BH transient MAXI J1535-571

(Miceli et al. in prep.)

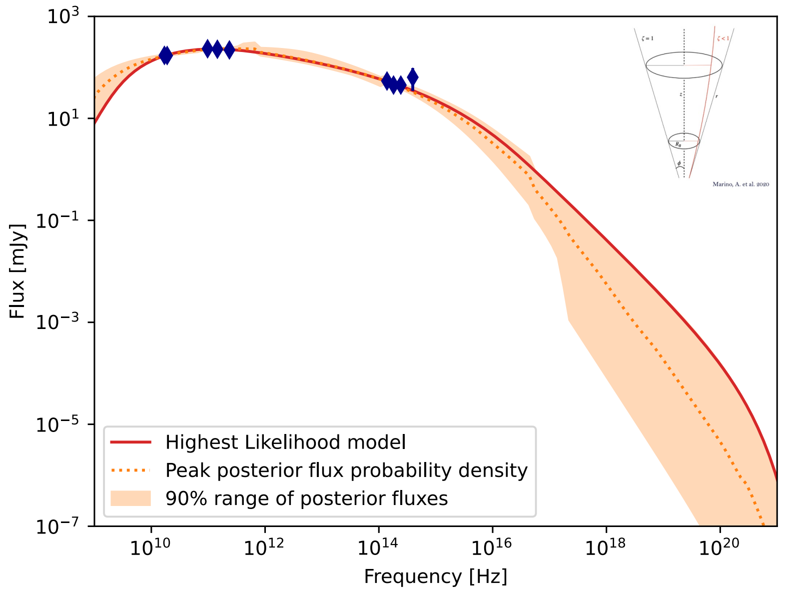


- Outburst in 2017
- Hard X-ray spectral evolution with BAT



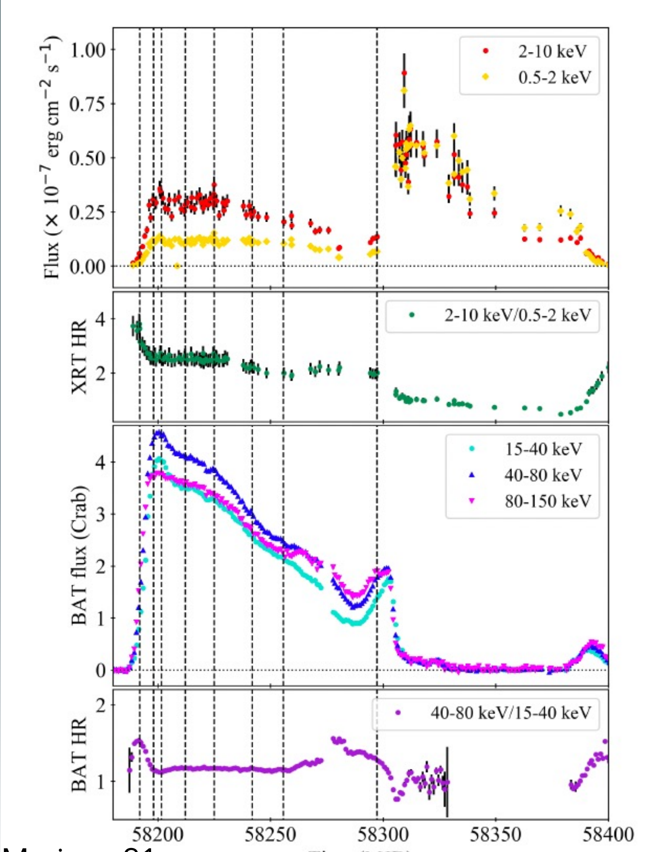


6 MW observations to study the jet evolution



SEDs modelled by ISHEM: a parabolic geometry of the jet is required

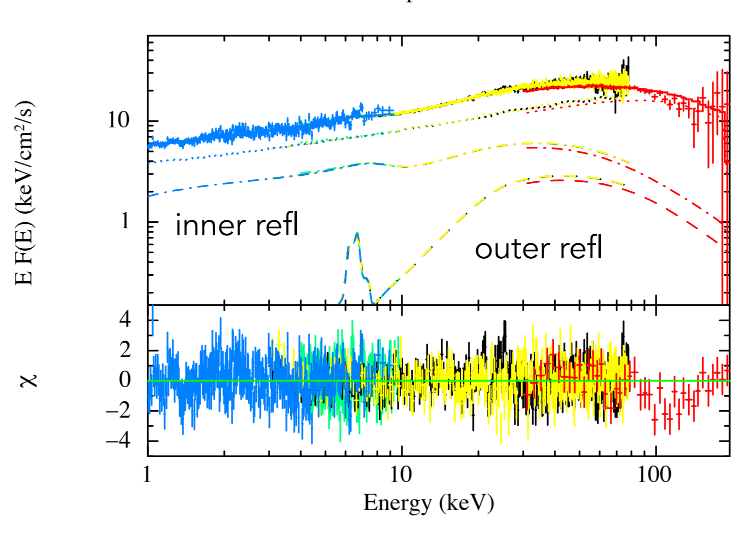
The Bright BH transient MAXI J1820+070: modelling with JED-SAD (a unified accretion-ejection paradigm, Ferreira+06, Petrucci+13)



Marino+21

8 broadband spectra of quasi-simultaneous XRT+NuSTAR+NICER+ BAT

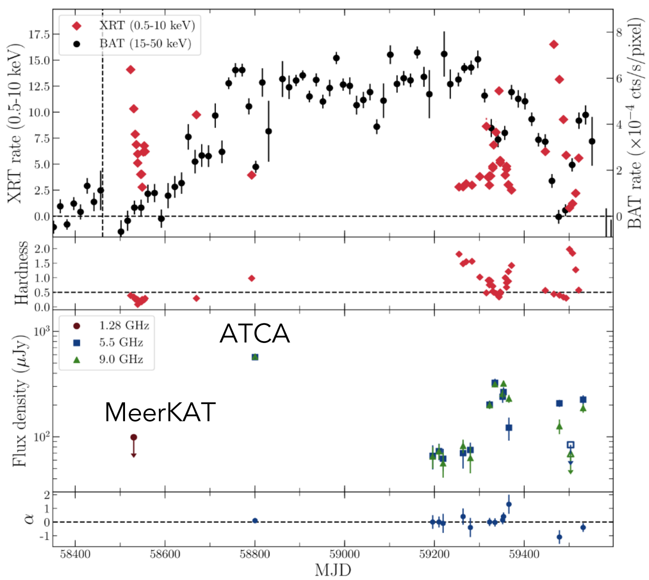
Marino+21



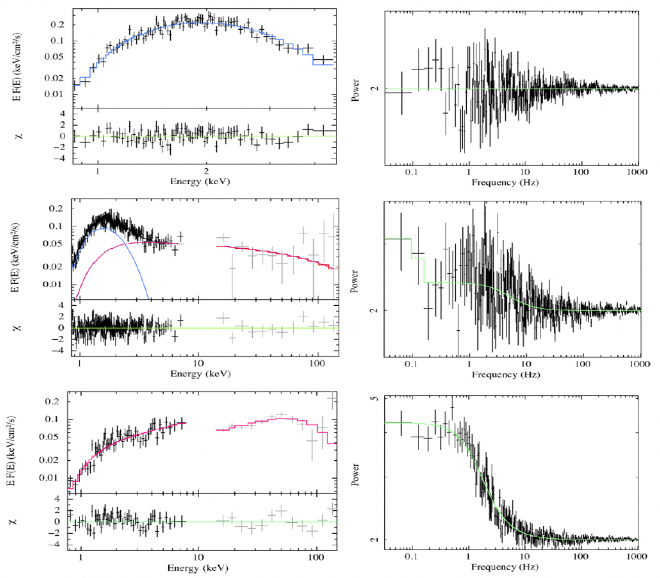
- Two reflection components required
- the disk is truncated in the HS and it approaches the BH during the transition to the intermediate state.

Long term monitoring of the puzzling source MAXI J1810-222

Russell, MDS+22



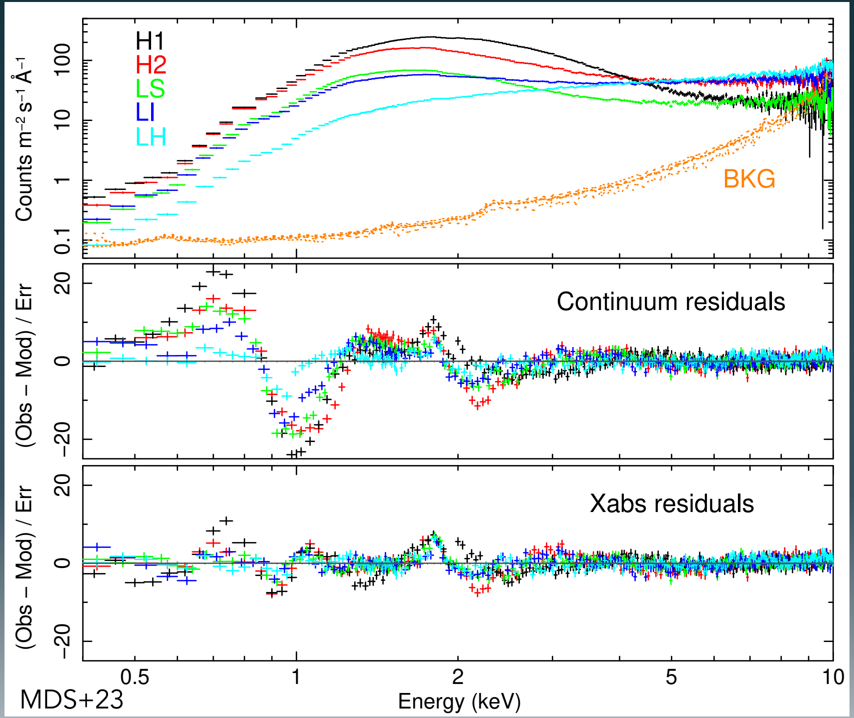
Russell, MDS+22

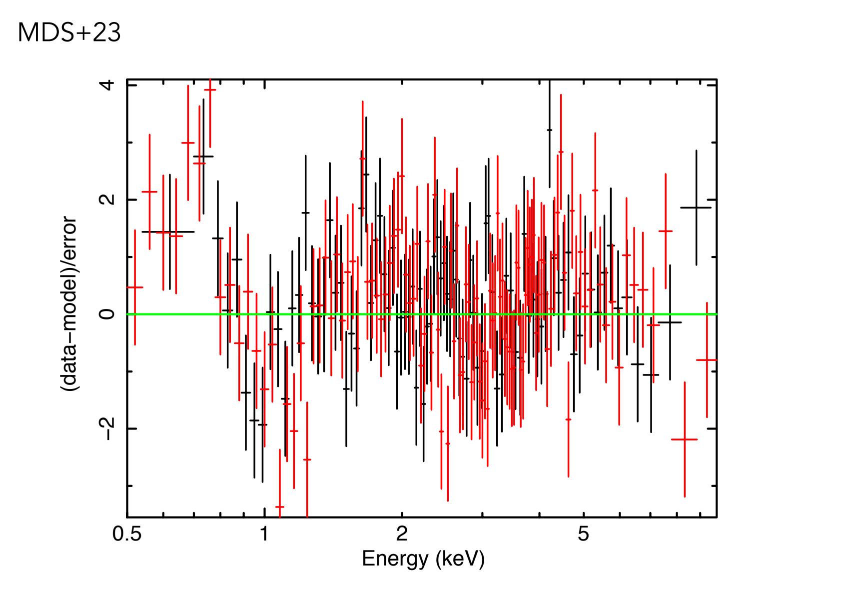


- -Discovered in 2018 (November) it was classified as soft X-ray transient
- -Soft X-ray emission and radio upper limit
- -Hard X-ray detection (Swift/BAT) with the BAT-IMAGER SW (Segreto+10)
- -Radio follow-up in 2019 November: refined position

Swift and ATCA long monitoring: BH transient at high distance (>8 kpc) with a peculiar outburst evolution

The NICER spectra show a strong P-Cygni-like spectral feature around 1 keV → Winds

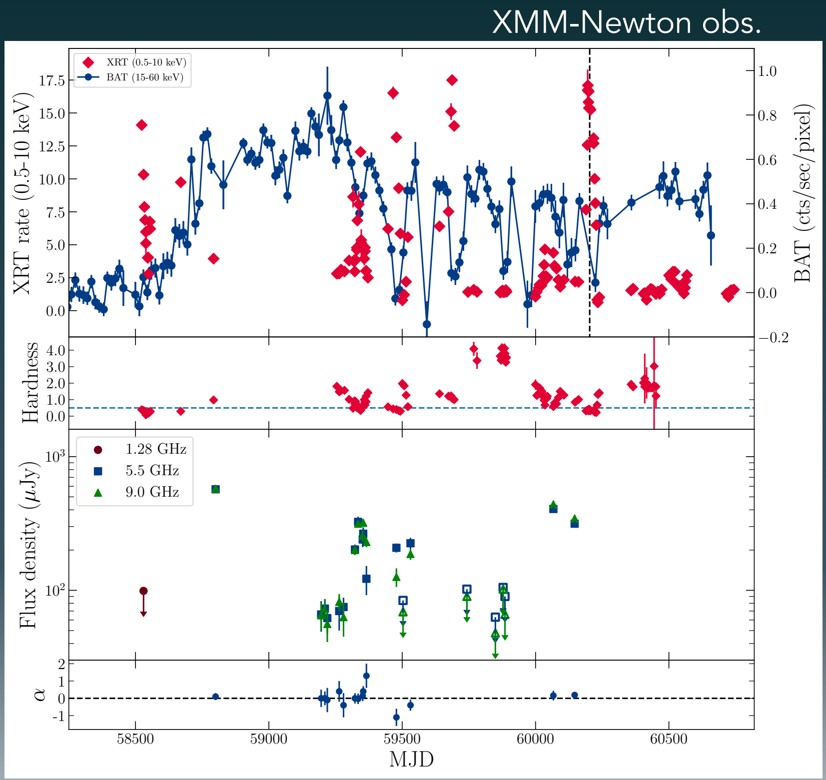


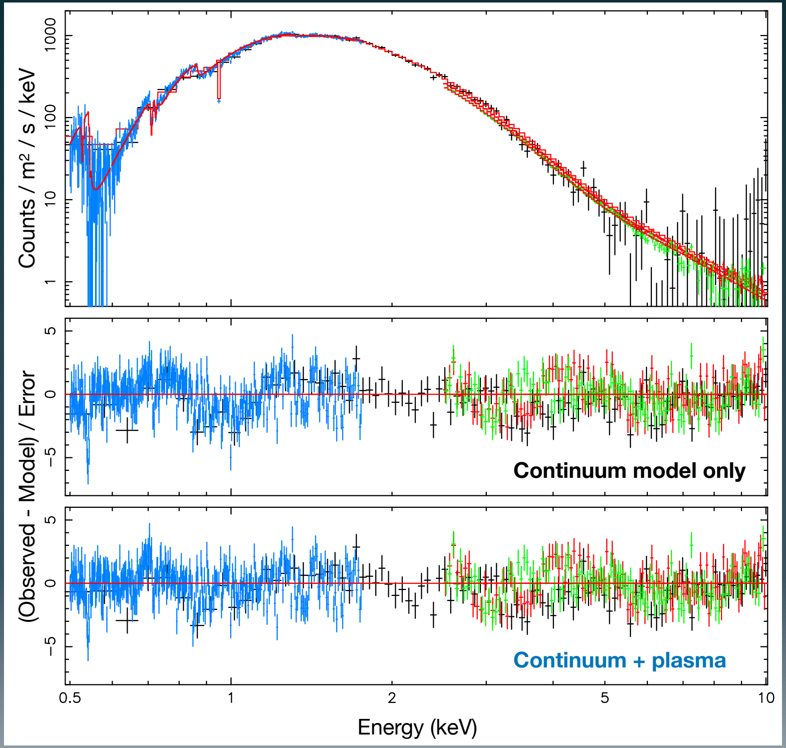


Feature confirmed by XRT (no instrumental)

Photoionization model: outflows with mildly relativistic velocities (v~0.15 c in high states)

XMM-Newton observation (high res. spect.) accepted in AO22 (PI: MDS): XRT trigger



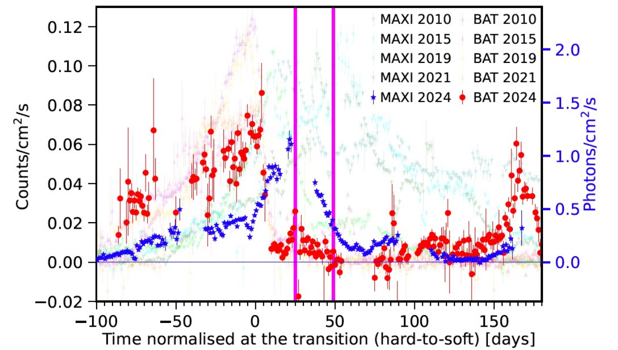


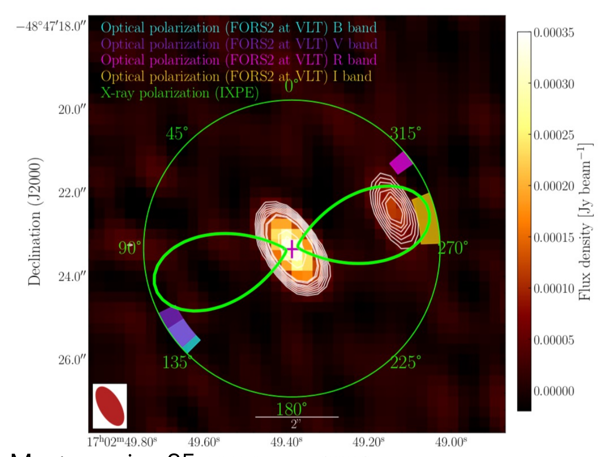
Quasi-persistent behaviour:
still active after more than 6 years

RGS confirms a broad (~0.1 keV) absorption feature at 1.0 keV and a v_{LOS} ~0.1 c

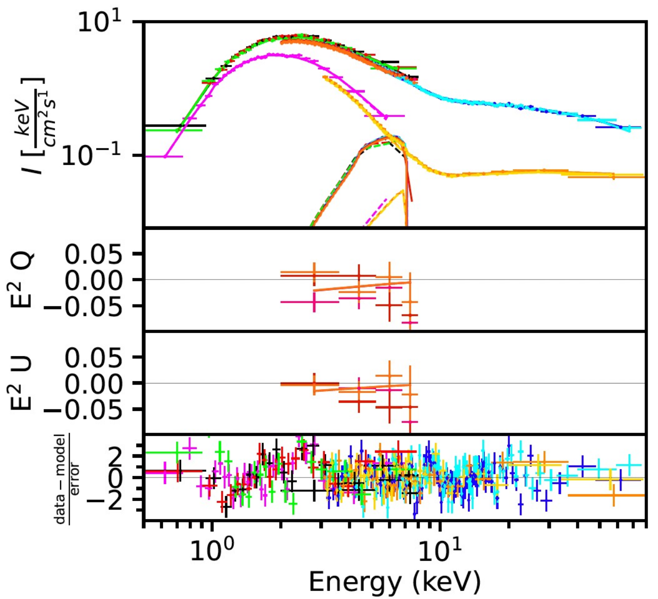
(Pinto, MDS et al. in prep.)

IXPE (and MW) observations of GX 339-4 by the Italian BH team





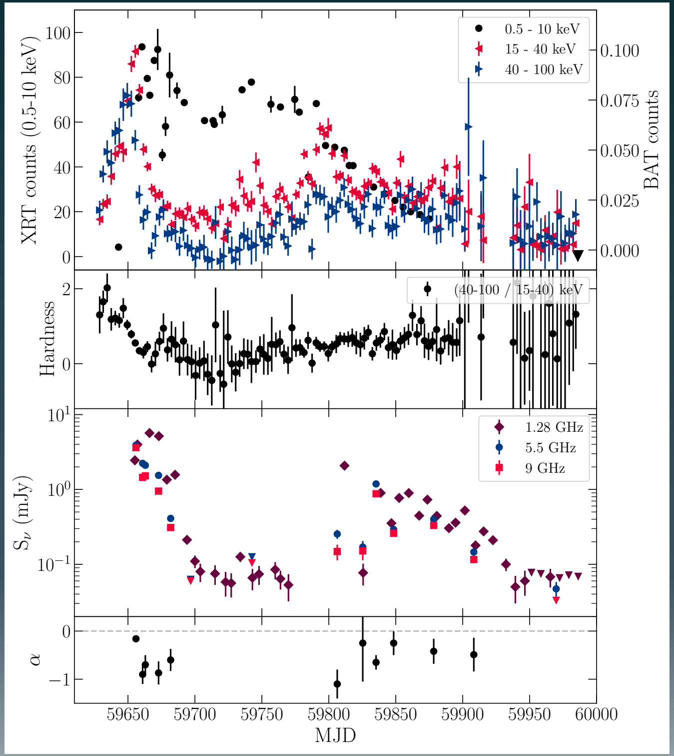
Mastroserio+25

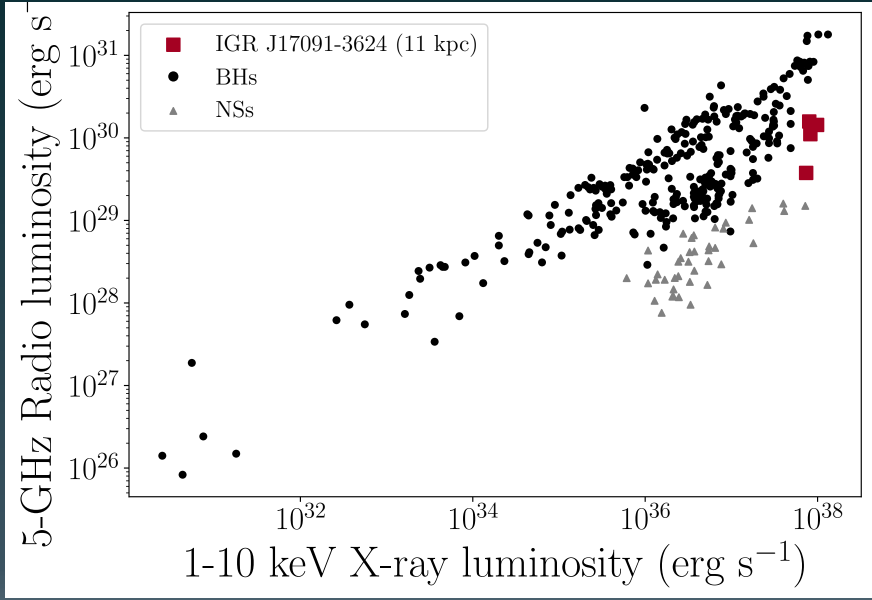


Swift/XRT provided the spectral coverage below 2 keV

Polarization measurements (radio, optical and X) suggest that the corona is horizontally extended on the plane of the accretion disc (Mastroserio et al., ApJ, 2025)

IGR J17091-3624: the radio/X-ray monitoring of the 2022 outburst (Russell et al in prep.)



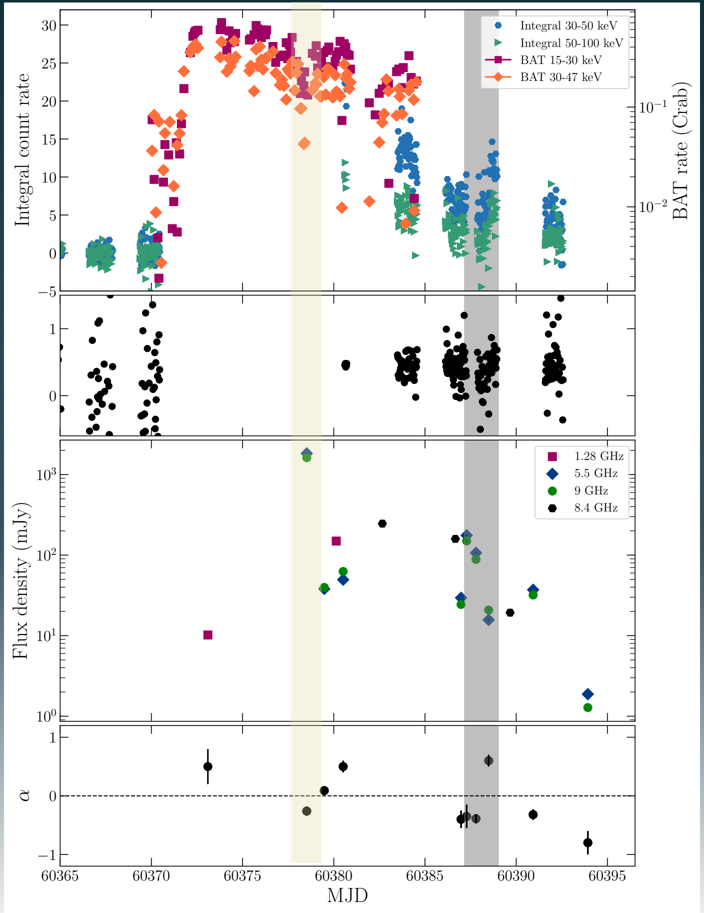


Two different distances have been proposed:

- 11-17 kpc (Rodriguez+11)
- > 20 kpc (Rao+12)

Our radio/X-ray correlation suggests that the distance should be well within 11-17 kpc (or even closer)

Swift J151857.0-572147: two intriguing radio/X-ray observations during the 2024 outburst



- Progressive increasing in the hard X-ray flux (grey rect.) corresponded to a very fast (about 2 days) switch-on of the compact jet (MDS+ in prep.)

- A giant radio-flare (~ 2 Jy, yellow rect.) during a fast hard X-ray decreasing (Russell+ in prep)

Conclusions

The *Neil Gehrels Swift Observatory* is the best suited mission for the study of the outburst evolution of transient X-ray binaries (either with BH or with NS):

1) It is the only mission with a very rapid response in pointing to sources
2) It allows long term monitoring
3) XRT provides good statistics of spectra and timing study
4) It has provided the observing flexibility necessary for coordinating simultaneous MW observations
5) BAT is currently the only telescope working in hard X-ray which can monitor uniformly the transient X-ray binaries
6) XRT ensures the soft X-ray coverage in crowded field during the IXPE DDTs (e.g. MAXI J1744-294 planned on April 6th)

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THANKS SWIFT TEAM!

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THANKS FOR YOUR ATTENTION