



Understanding unusual flux drops in the 2012 outburst of 4U 1630-472



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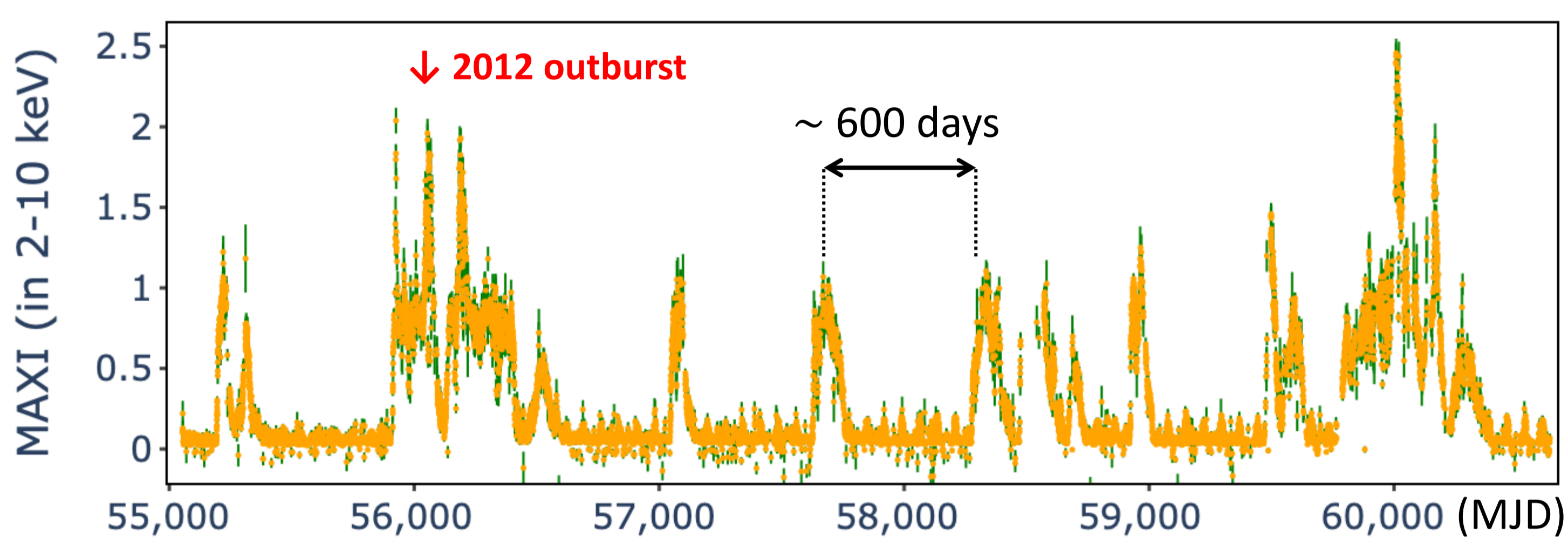
Abstract

The black hole X-ray binary 4U 1630-472 shows outbursts repeatedly with an interval of 600 days. We studied the 2012 outburst, which was one of the biggest outbursts of the source. We found unusual X-ray flux drops by ~50% with a duration of ~1 day at its brightest phase, which is much shorter than the timescale of accretion but longer than the dynamical timescale in the inner region of the accretion disk. To understand the cause of the drops, we compared the MAXI and Swift spectra obtained during and outside the drops. We found that, during the drops, the source decreased its flux without significantly changing the spectral shape below 10 keV. We consider a possible interpretation for the observed spectral variation: fully ionized, Compton-thick gas passed through our line of sight and reduced the apparent X-ray flux.

Introduction

4U 1630-472

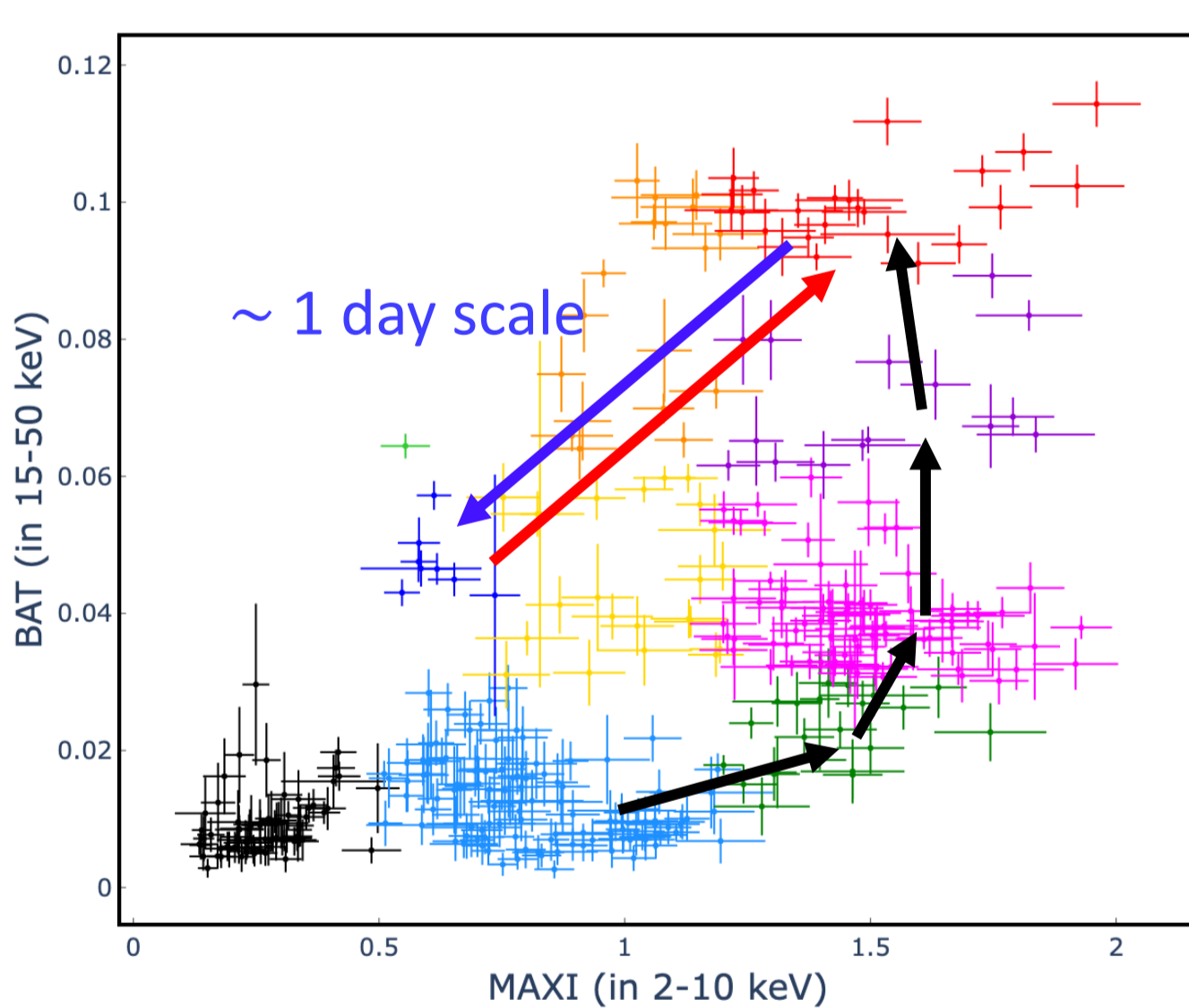
- A Galactic transient black hole X-ray binary
- $D = 10$ kpc (e.g., [1])
- $i = 70$ deg (e.g., [1])
- Shows outbursts repeatedly with an interval of ~600 days.
- Among them, giant outbursts, which are brighter and longer, are observed once per ~several outbursts



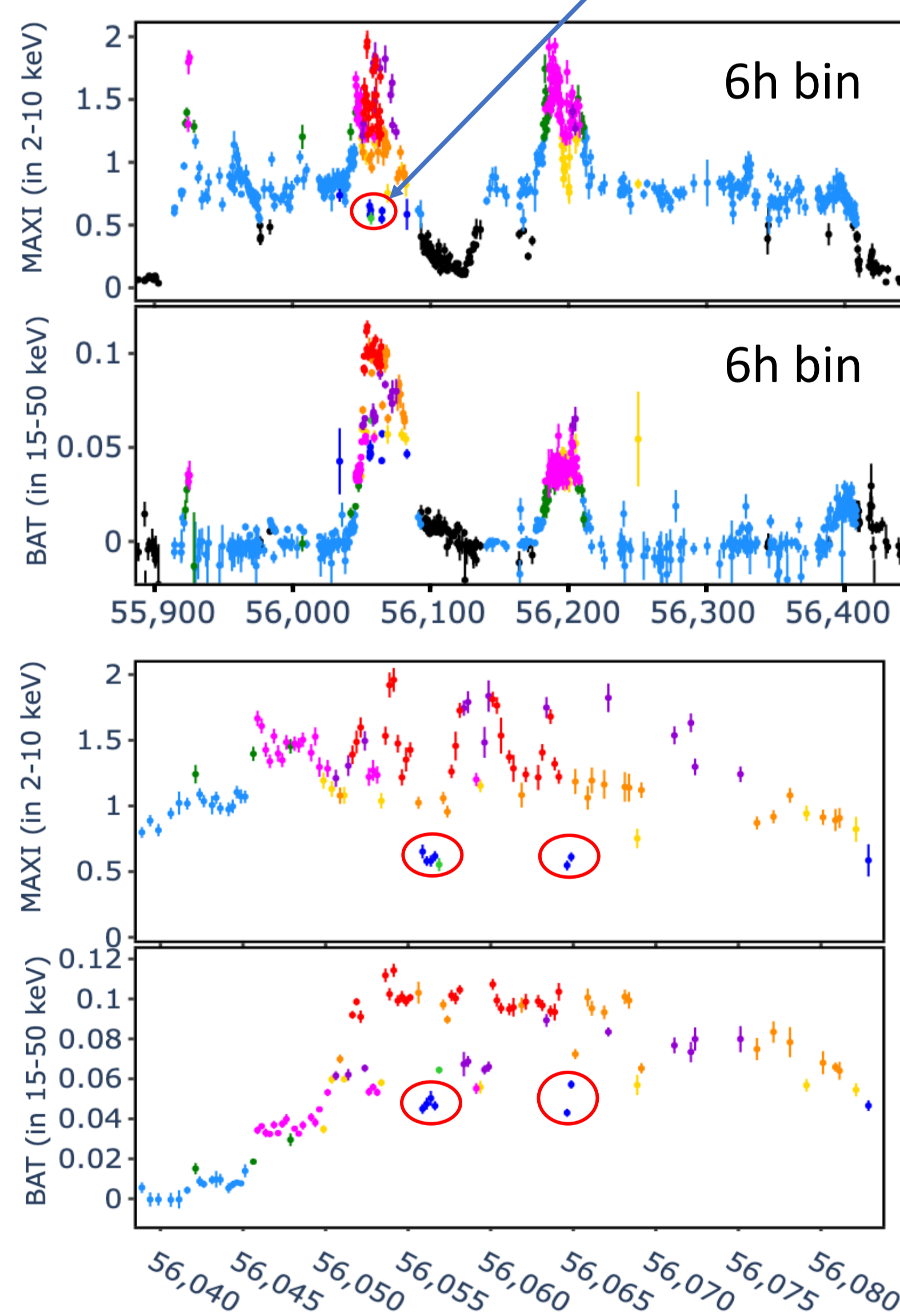
The 2012 outburst

We found **unusual drops of X-ray flux** on MJD 56056, 56064.

Note: the color codes were defined based on the count rates from the MAXI/GSC and Swift/BAT.

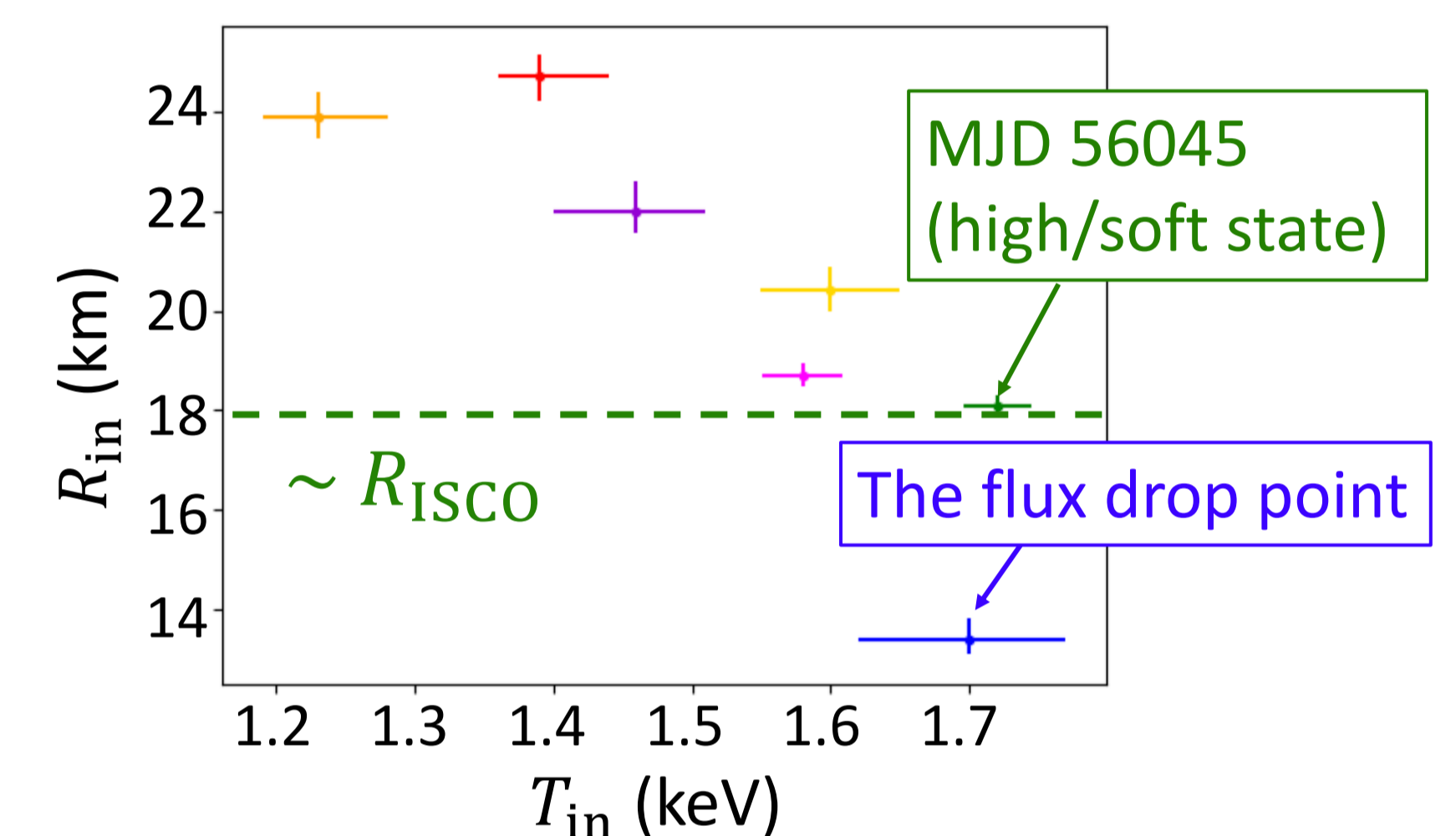
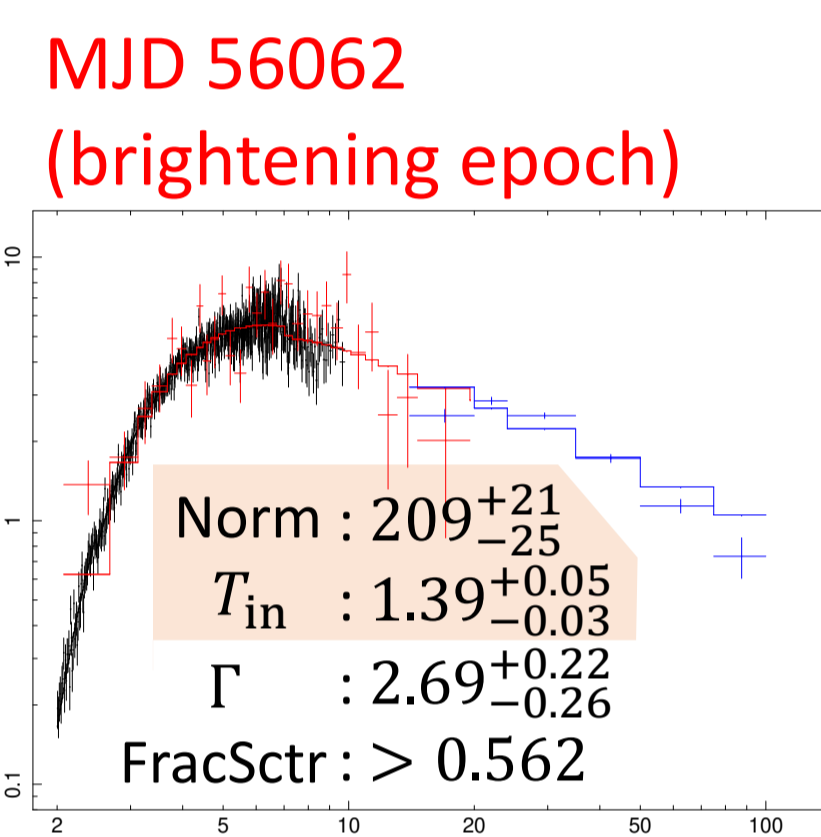
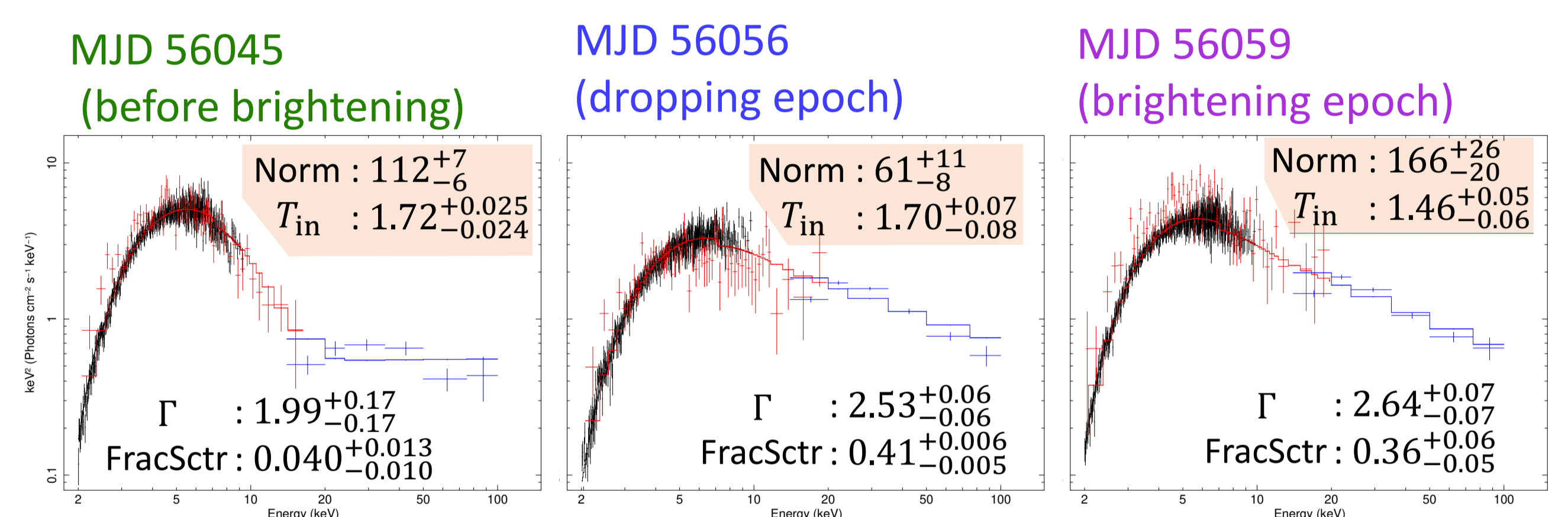


Enlarged view around the flux drop



Results

We found that the source decreased its flux without changing the spectral shape compared to the other very high state.



$$\text{Norm} = \left(\frac{R_{\text{in}}}{D_{10}} \right)^2 \cdot \cos i$$

We estimated the inner disk radius R_{in} from the norm. of the diskbb model

Assuming R_{in} on MJD 56045 is the inner most stable circular orbit (ISCO) radius (R_{ISCO}), R_{in} during the flux drop is below R_{ISCO} (!?)
Maybe the norm. (which reflects the disk luminosity) during the drop is underestimated?

Discussion

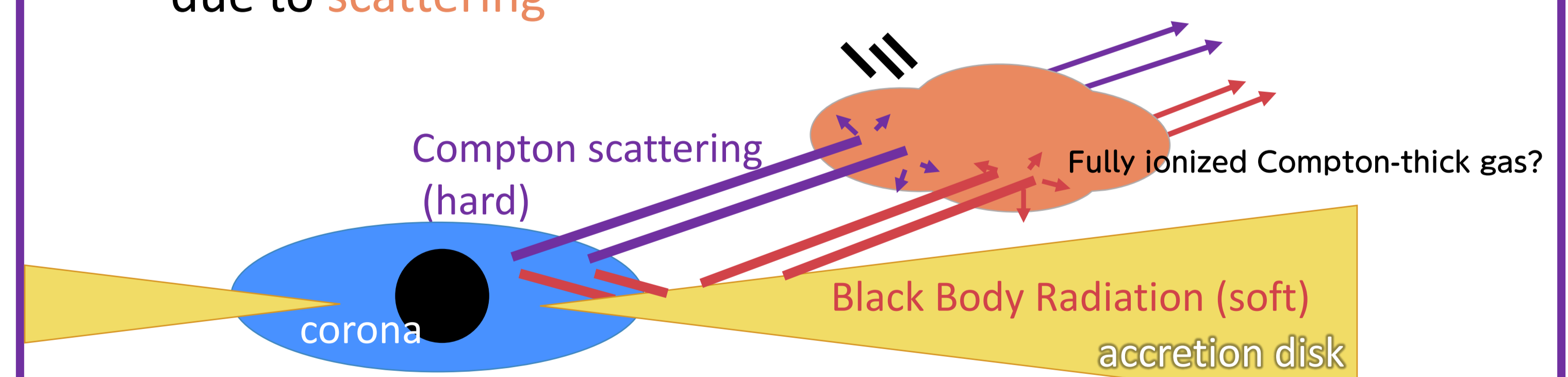
We found that

- The flux drop occurred in both soft and hard X-rays together
- The value of R_{in} (or norm.) was smaller during the drop

Possible interpretation:

Fully ionized, Compton-thick gas passed through our line of sight

- Both soft and hard X-rays would appear reduced due to scattering



Summary

- We found unusual flux drops with a duration of ~1 day in the 2012 outburst.
- From the spectral analysis, we found
 - The spectral shape during the drops was the same as that in the other very high state.
 - But the value of R_{in} (or the disk luminosity) was significantly smaller.
- We interpreted the drop that fully ionized, Compton-thick gas passed through our line of sight and reduced the apparent flux by scattering.

Reference

[1] Takafumi Hori et al. (2018) ApJ, 869, 183

Used Data and Modelling

Data MAXI/GSC, Swift/BAT and XRT
: MJD 56045, 56056, 56059, 56062

Swift/BAT and XRT (MAXI data are unavailable)
: MJD 56048, 56050, 56065

Model

Tbabs × simpl × diskbb

Interstellar absorption Compton Disk blackbody

Note: we first fit the data allowing N_{H} to vary and obtained an averaged value of $N_{\text{H}} = 11.4$. Then we fixed N_{H} at this value and got the final best-fit results.

