Project MOMO: Multimessenger astrophysics of the blazar and candidate binary SMBH OJ 287

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Intro: The blazar OJ 287 is one of the best candidates todate for hosting a compact binary supermassive black hole (SMBH; Valtonen+ 2021).

Bright optical flares in its lightcurve are explained as impacts of a secondary SMBH on the accretion disk of the massive primary SMBH (1.8 10^{10} M_{sun}).

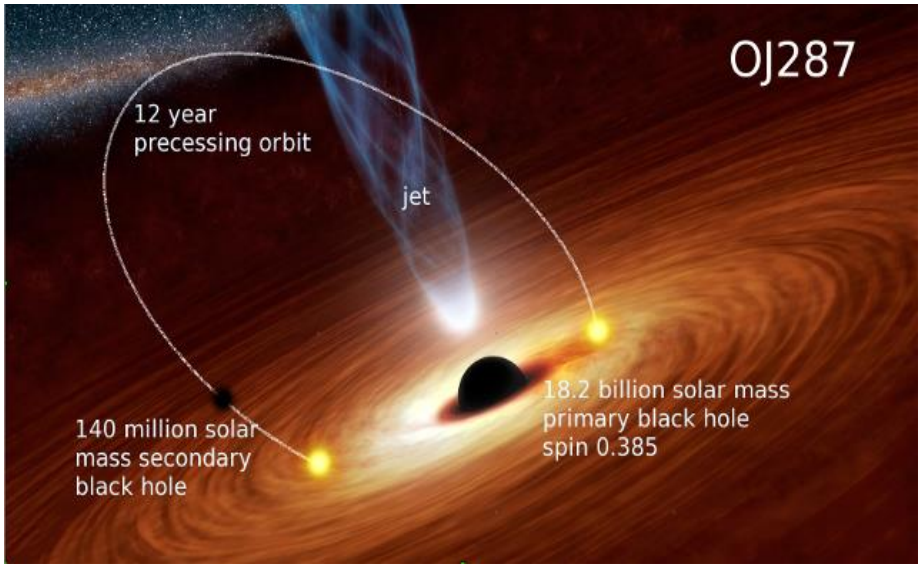
Our project MOMO (*Multiwavelength Observations & Modelling of OJ 287*) **is the densest and longest multi-year, MWL monitoring of OJ 287 ever**, since 12/2015. It includes:

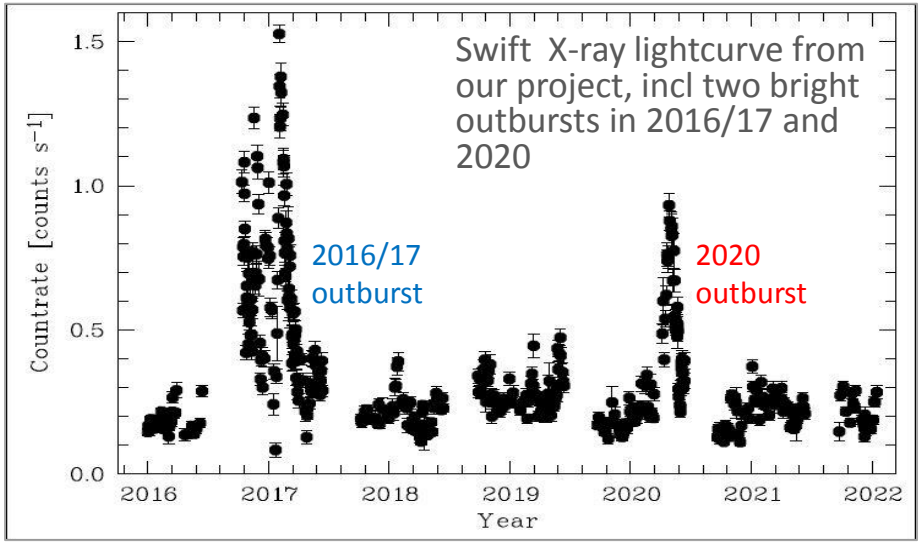
* radio: 1-40 GHz @ Effelsberg
* 3 opt, 3 UV bands: Swift
* X-rays: Swift
* γ-rays: Fermi, public
* + deep follow-ups:optical, XMM, NuSTAR,...

→ timing, spectra, SEDs, ... at all activity states of OJ 287

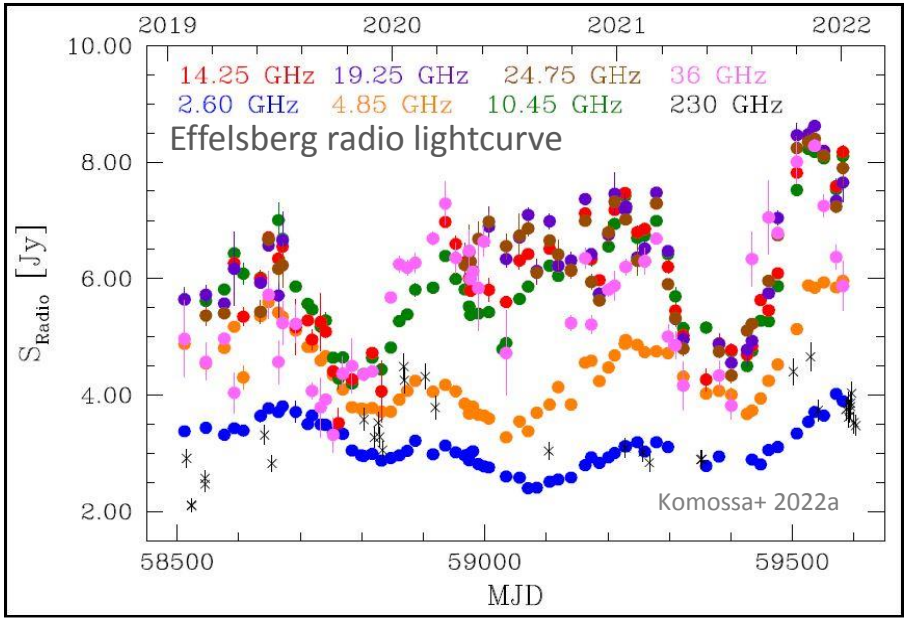
→ **blazar (disk-jet) physics and tests of binary model**

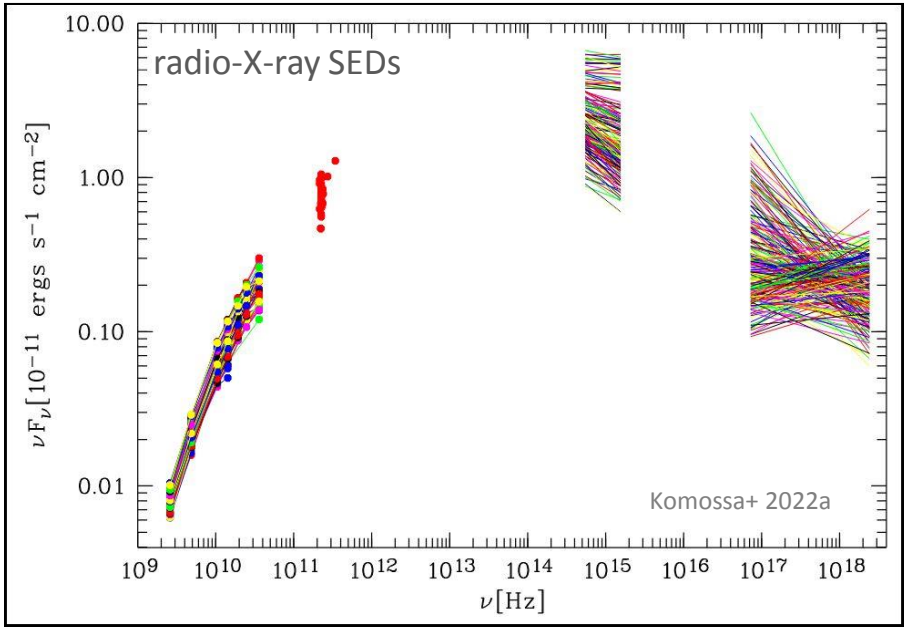
→ *Astronomers' telegrams* alerts on outbursts, deep fades, ... within days

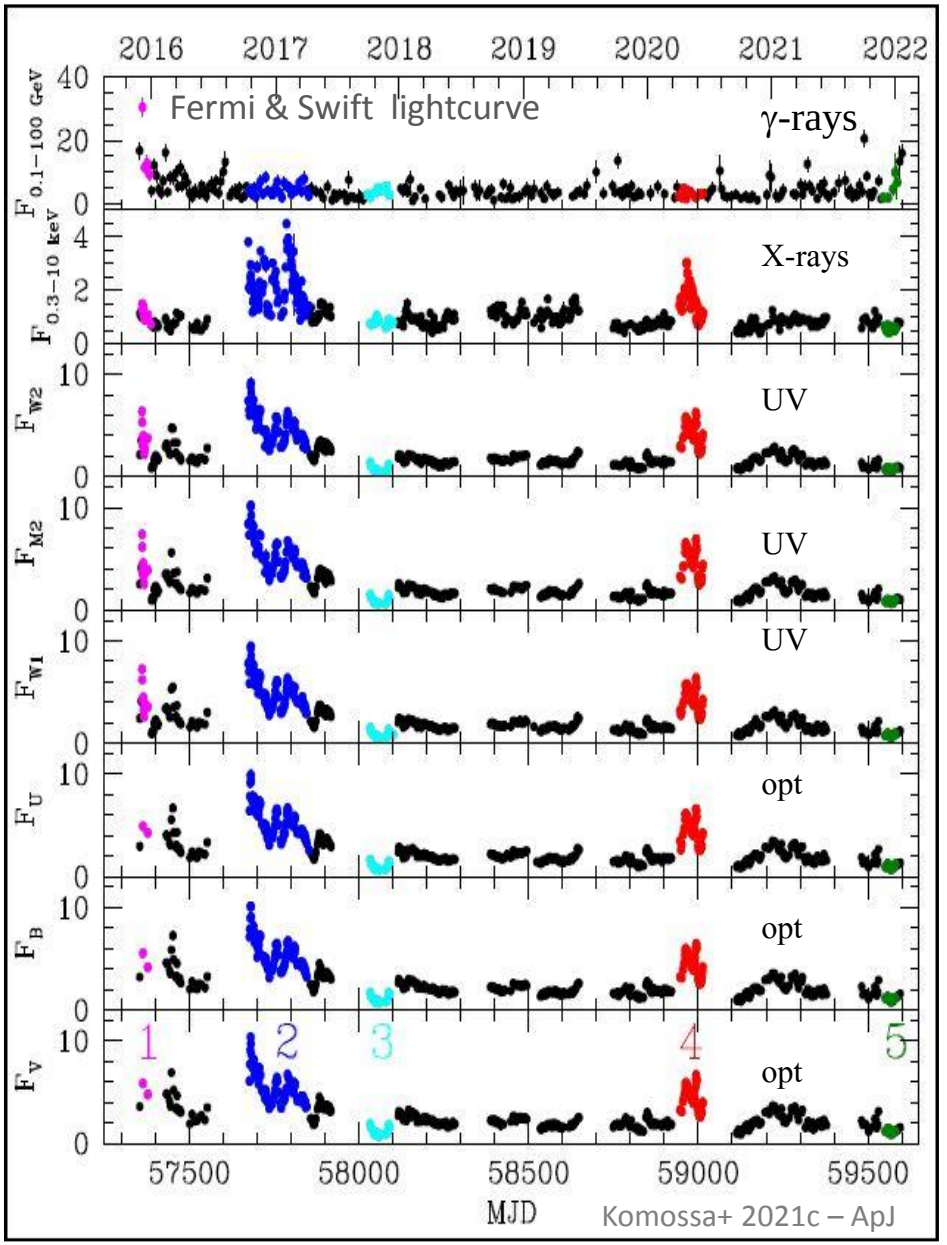




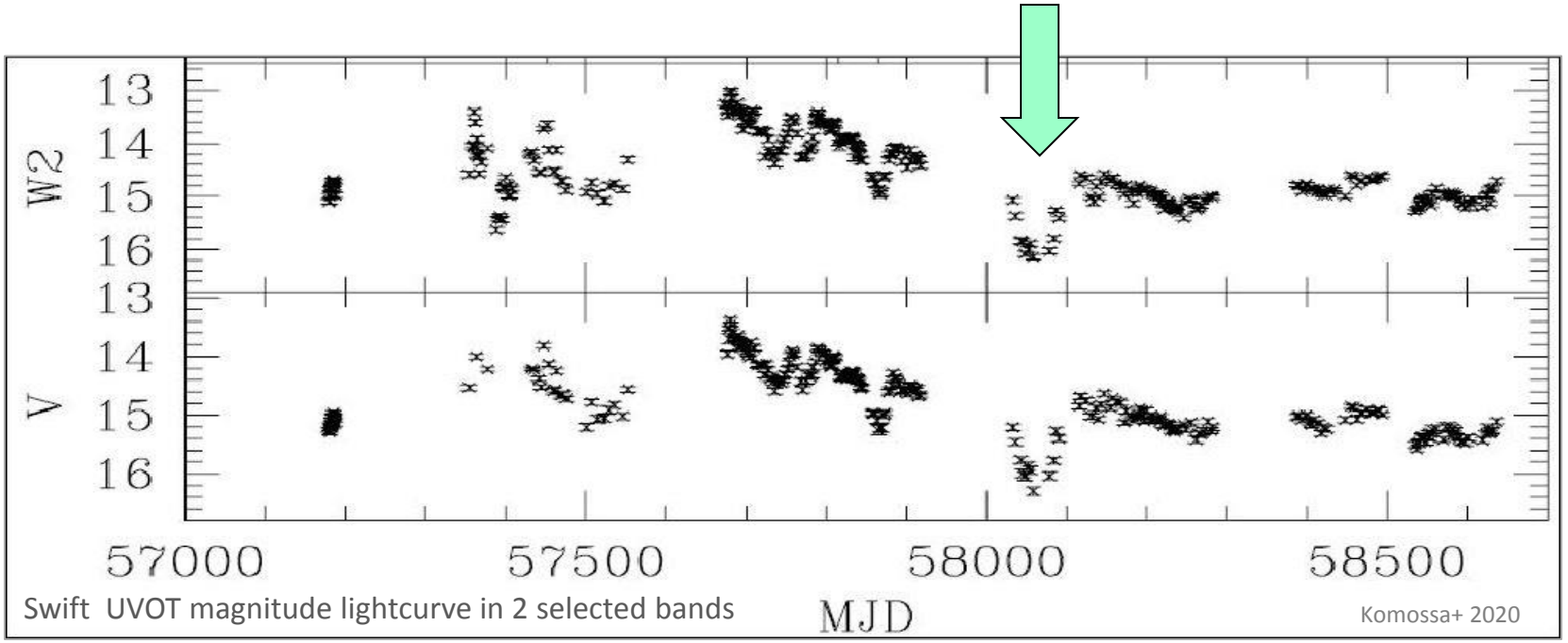
Komossa+ 17, 20, 21a,b,c, 22a, b-inprep; *ATel #8411, 9629, 9632, 10043, 12086, 13658, 13702, 13785, 14052, 15145*


2019
2020
2021
2022
14.25 GHz
19.25 GHz
24.75 GHz
36 GHz
2.60 GHz
4.85 GHz
10.45 GHz
230 GHz
Effelsberg radio lightcurve
Komossa+ 2022a
S_{Radio} [Jy]
MJD


radio-X-ray SEDs
Komossa+ 2022a
$\nu F_\nu [10^{-11}$ ergs s^{-1} $cm^{-2}]$
ν[Hz]

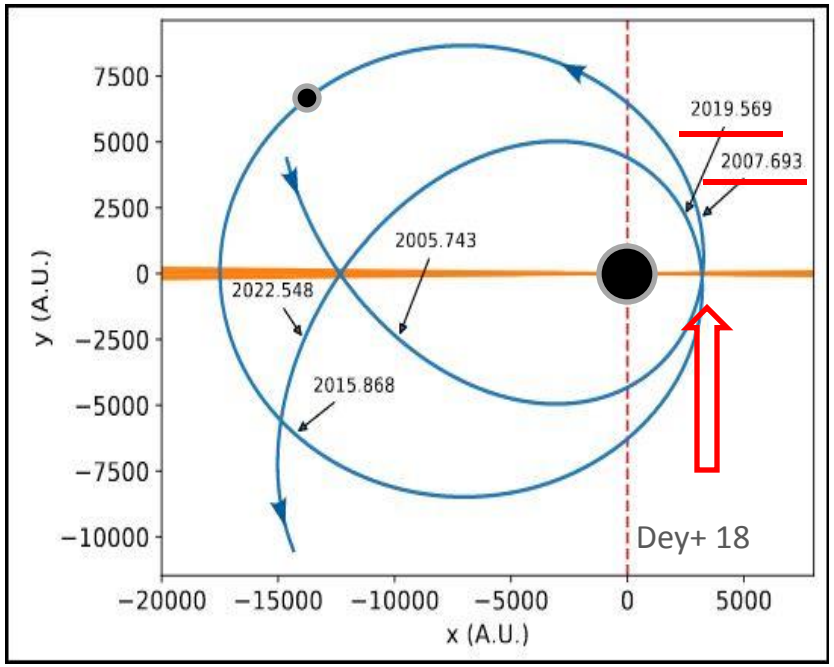

Fermi & Swift lightcurve
γ-rays
X-rays
UV
UV
UV
opt
opt
opt
1
2
3
4
5
MJD
Komossa+ 2021c – ApJ

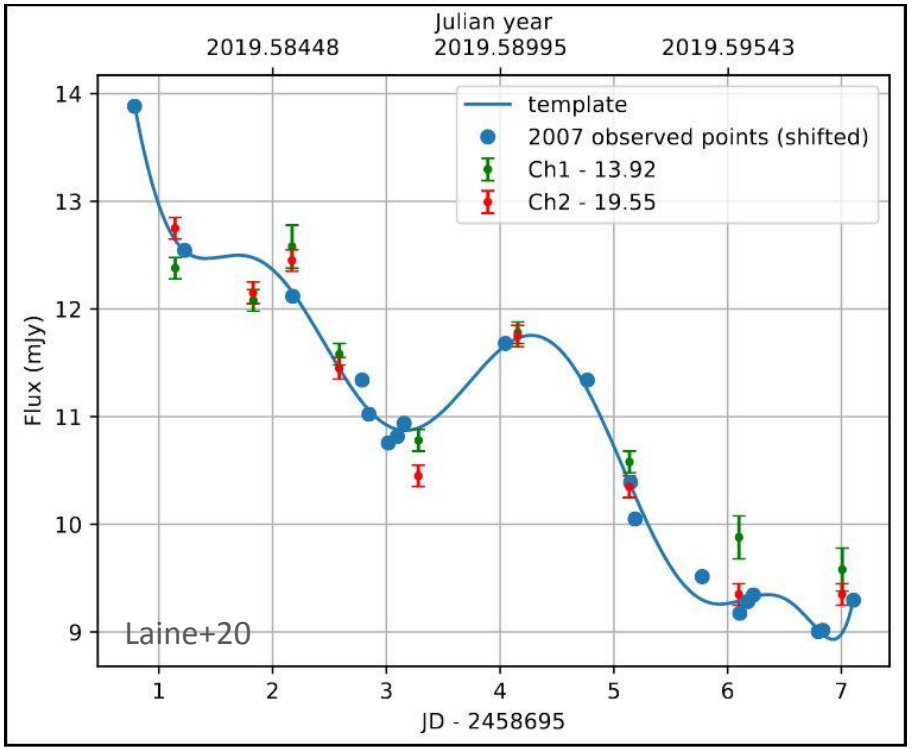
Recent outstanding events: 2017 deep fade



* Peculiar, symmetric UV-optical deep fade discovered in 2017, lasting for two months
* Passing of 2ndary SMBH near jet of primary, so temporary jet deflection [Takalo+ 1994] ?
  → geometry does not match (from predictions of Valtonen 2021): secondary is behind disk
* Occultation event from passing of dusty cloud ? → no evidence for extinction (strong UV reddening not observed)
* → temporary jet dispersion or deflection at core or in an off-center bright quasi-stationary jet feature [Komossa et al. 2020, 2021c--ApJ]

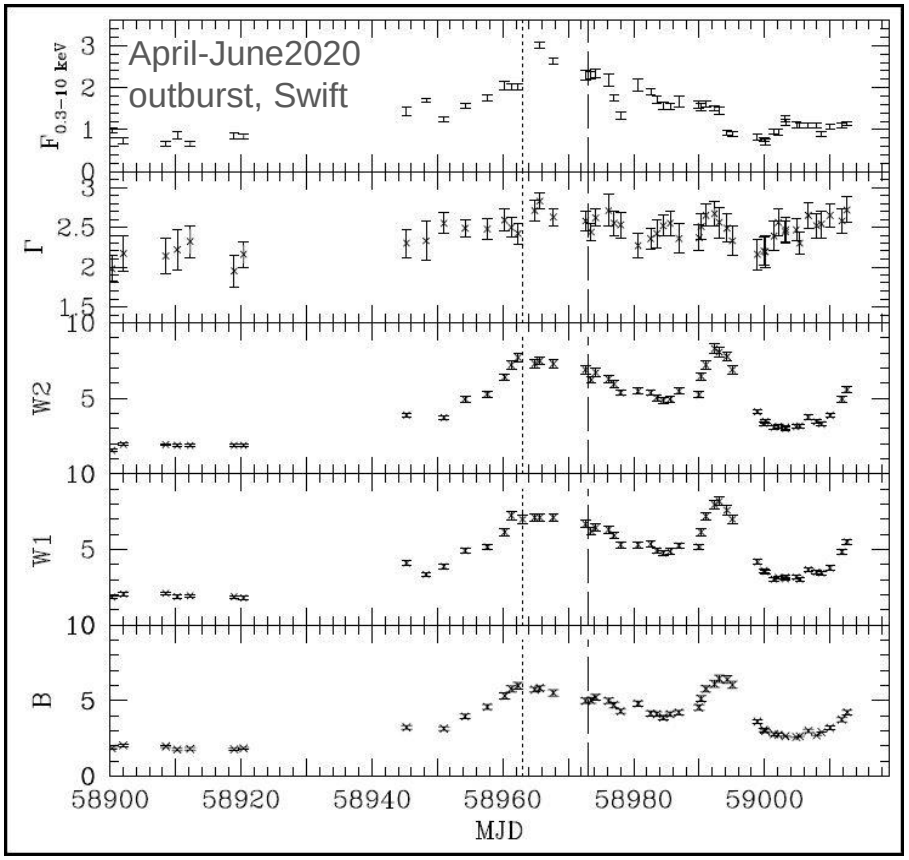
Recent outstanding events: 2019 thermal impact flare with *Spitzer*

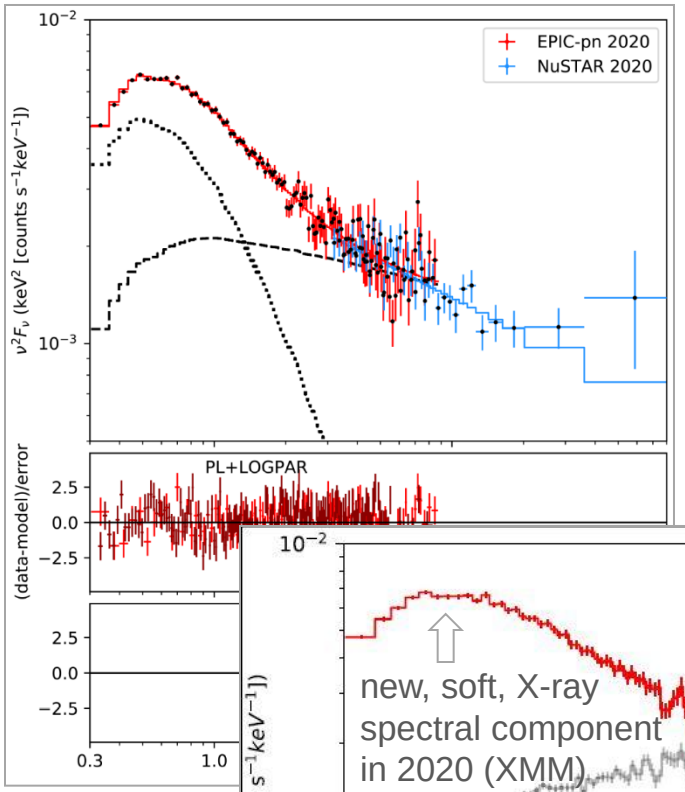


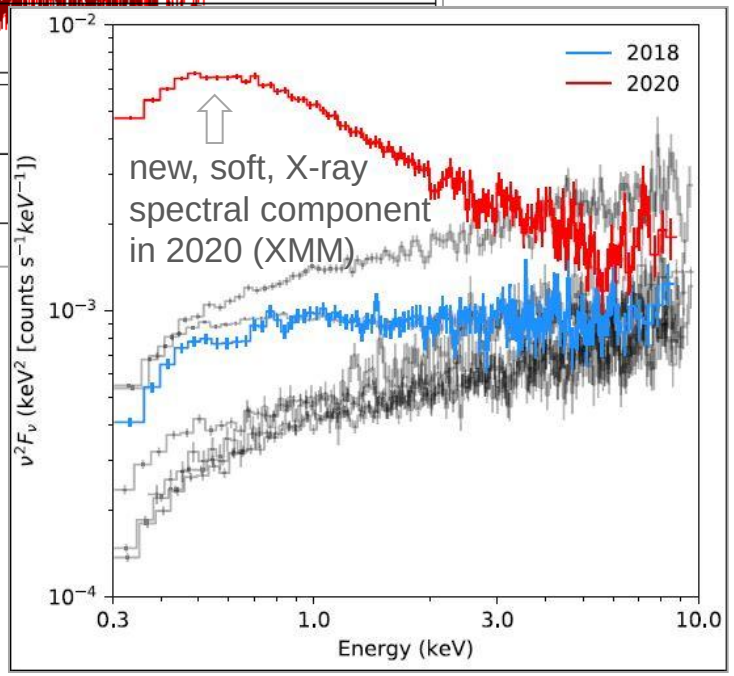


* Prediction: 2007 and 2019 impacts at similar disk location → reliable timing
* Unobservable in opt. from ground + from space with Swift, but *Spitzer* could observe (IR)
* *Spitzer* observed flare within ~3 hrs of predicted impact flare in July 2019, confirming binary model [Laine et al. 2020]
* We detect coincident γ flare +- 1d [MOMO]. Indicates new mechanism of gamma-ray production. Similar gamma-flare during previous 2015 impact flare. [Komossa et al. 2022]

Recent outstanding events: 2020 outburst with *Swift, XMM, NuSTAR, EB*







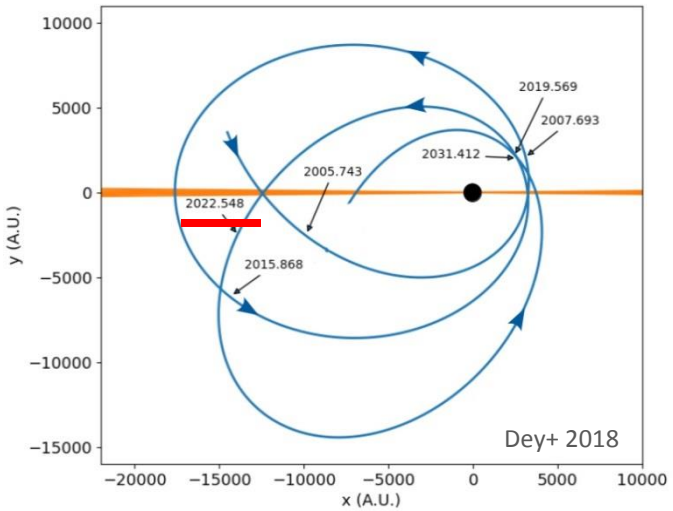
* Discovery of outburst & new , extreme component in X-rays
* Multi-λ obs: synchrotron flare (variability too rapid for primary disk, small opt-UV lags <=1 d, broad-band SED, radio flaring, ...) → launch of new jet component
* Timing consistent with predicted binary-model **after-flare**; Δt (acc-jet) ~ few months

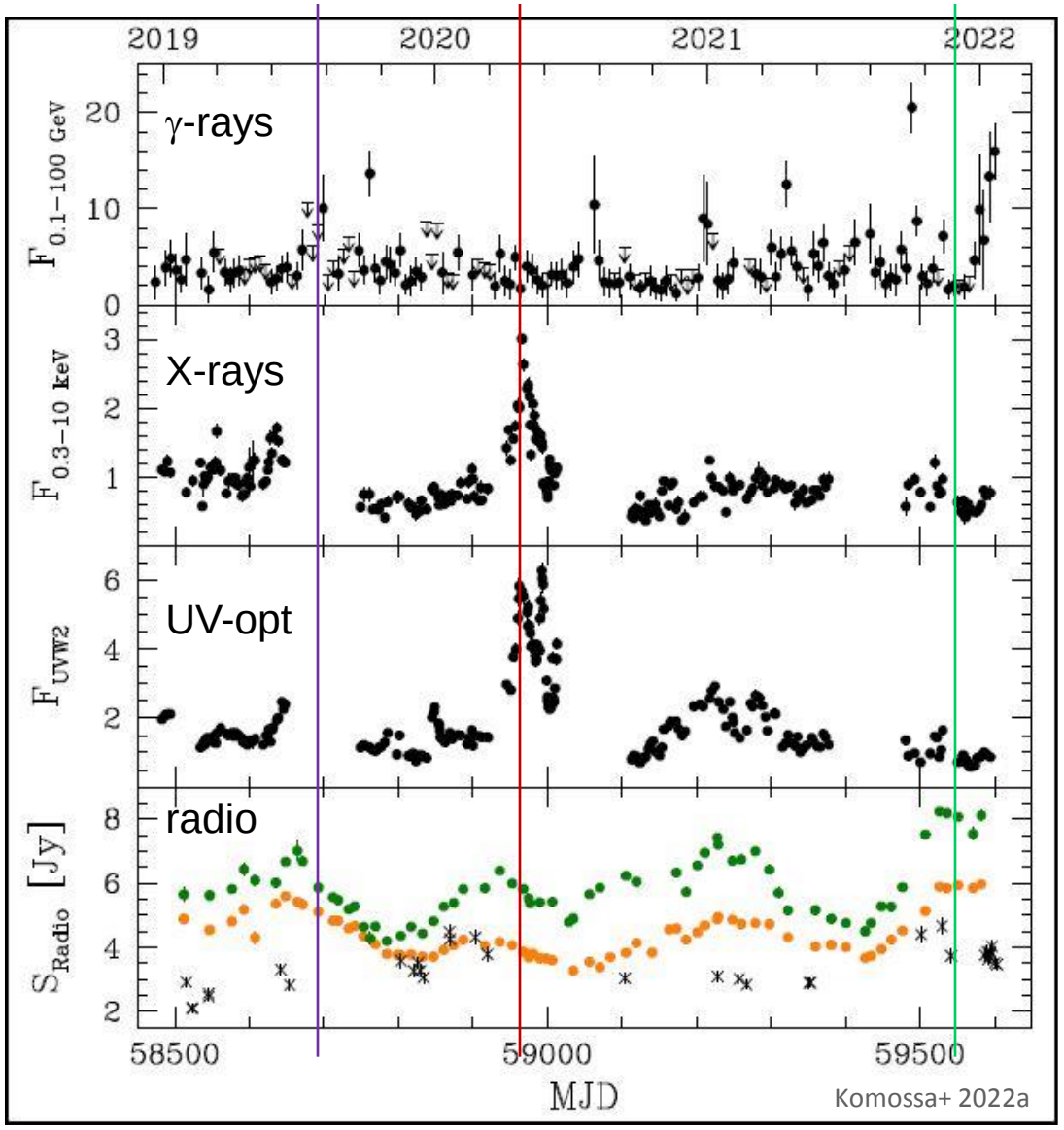
Komossa, Grupe, Parker + 20

summary of recent outstanding events and binary predictions

* 2017 outburst
* 2017 deep fade
* 2019 Spitzer IR flare: → impact flare
* 2020 outburst → binary after flare ?
* 2021 impact → sharp radio/gamma-ray flare: likely unrelated primary jet activity
* predicted 2022 flare – tbd (not observable in optical from ground/ space since „sun constrained“)

MOMO continues. Long-term goal is to cover 1-2 binary orbital periods.





Komossa+ 2017, 2020, 2021a,b,c,d, 2022a, b-inprep