A giant radio flare from Cygnus X-3 with associated gamma-ray emission

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G. Dubus
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on behalf of the Fermi-LAT collaboration
+
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Gamma-ray binaries

- 5 gamma-ray binaries known, emit most of their power above 100 MeV
- Massive star + compact object

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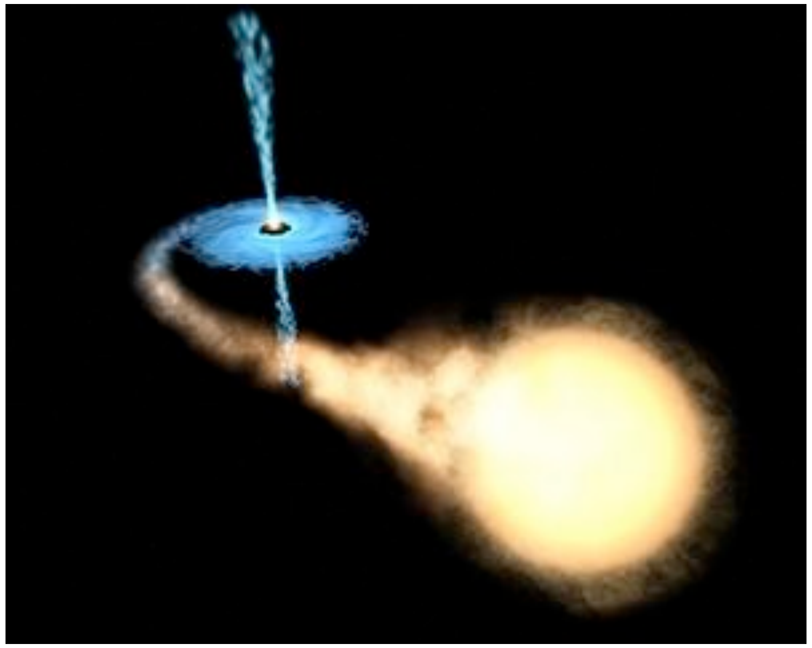
- Question: Where are the particles accelerated to VHE?
  - Shocked pulsar wind (PSR B1259-63)
  - Jet

Microquasars

- Produce relativistic jets
- Long time candidates for gamma-ray sources
- Cyg X-1 detected in VHE gamma-rays by MAGIC (Albert et al. 2007)
- No VHE gamma-ray emission from GRS 1915-105 (HESS Coll. 2009)
- Cyg X-3 detected by Fermi-LAT and Agile



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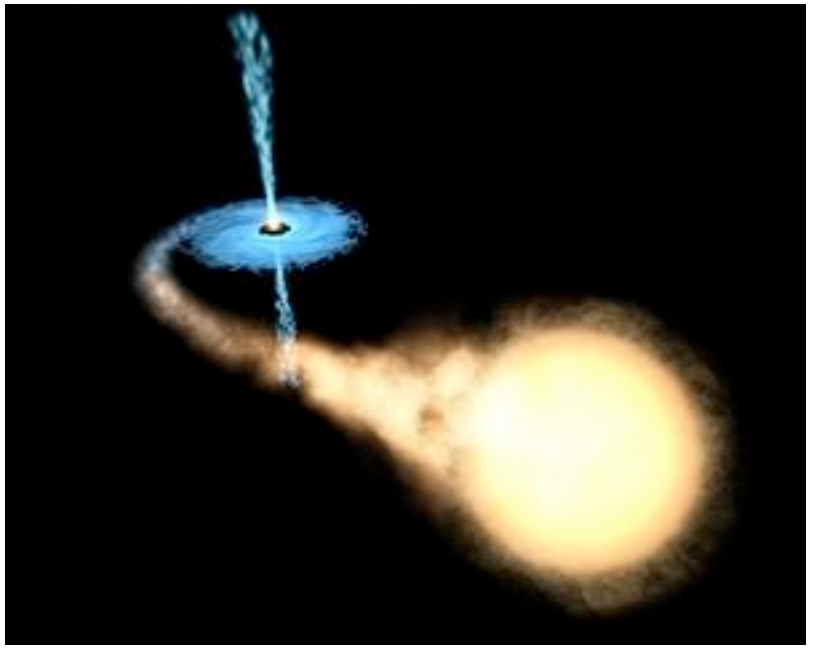
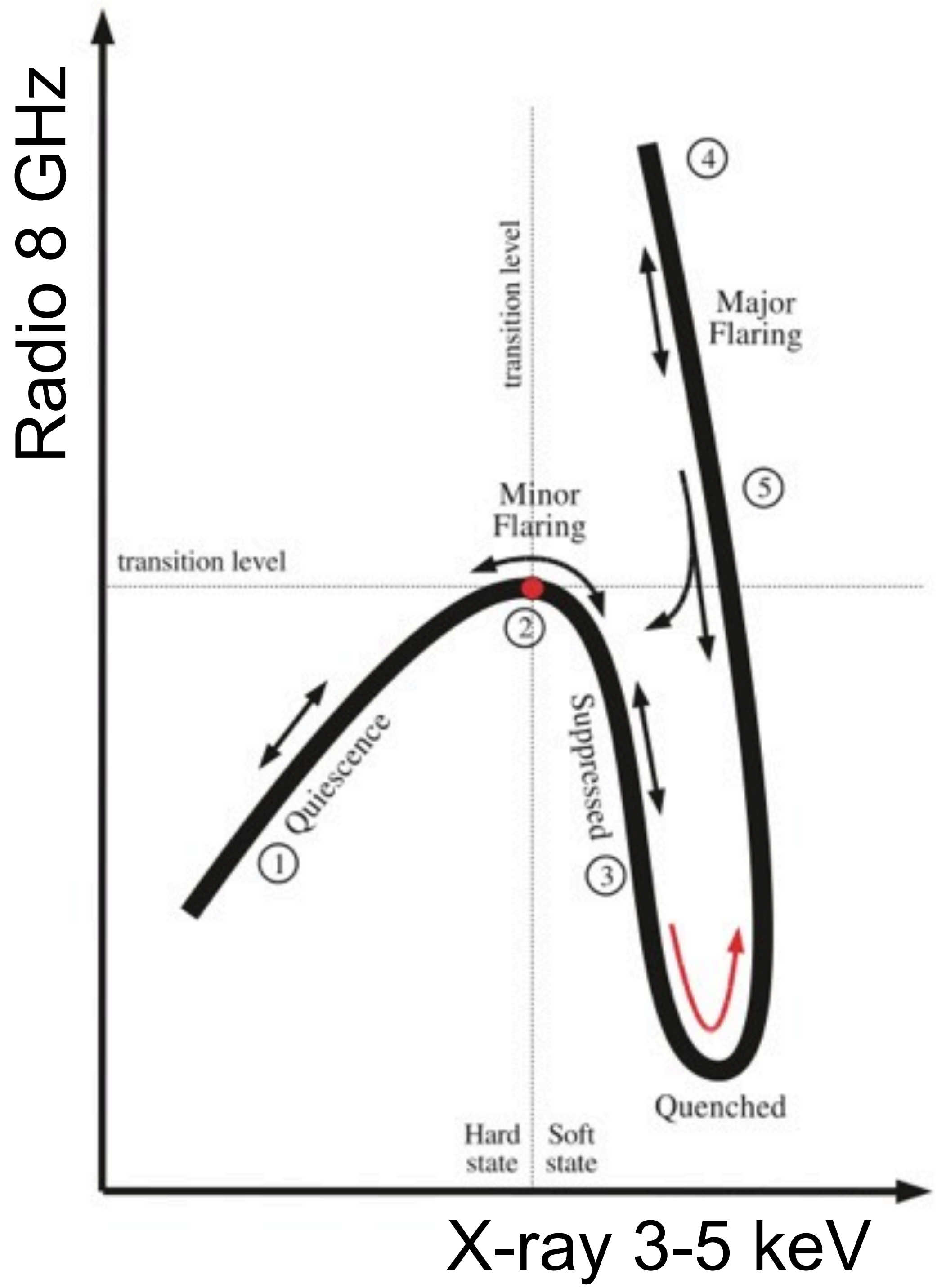
- Question: What makes Cyg X-3 special?



Cygnus X-3



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- One of the brightest binaries in radio
- High mass companion (WR star)
- Short orbital period 4.8 hr
- Gamma-rays orbitally modulated
- Gamma-rays produced during jet ejection, but when exactly and where?

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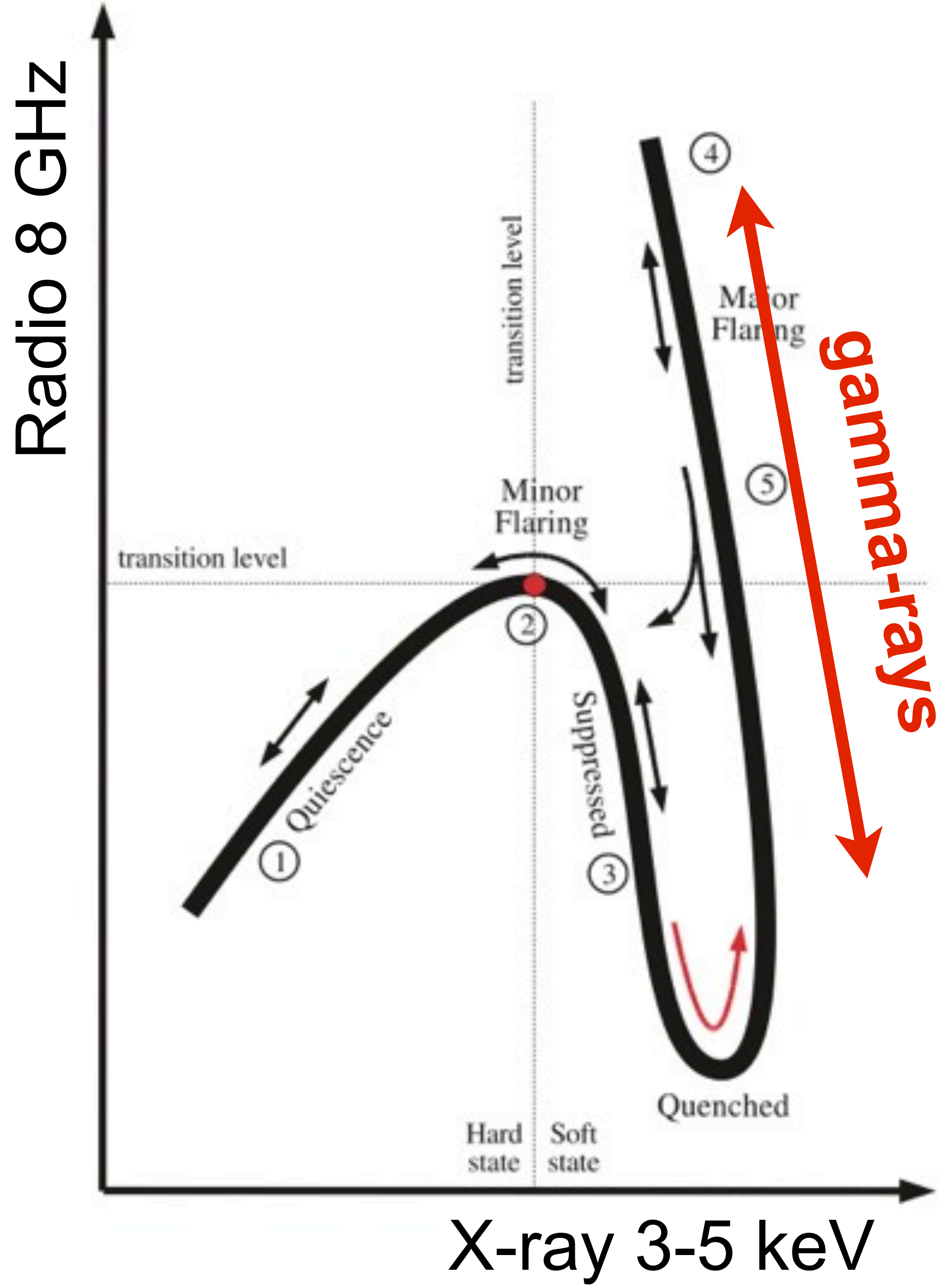

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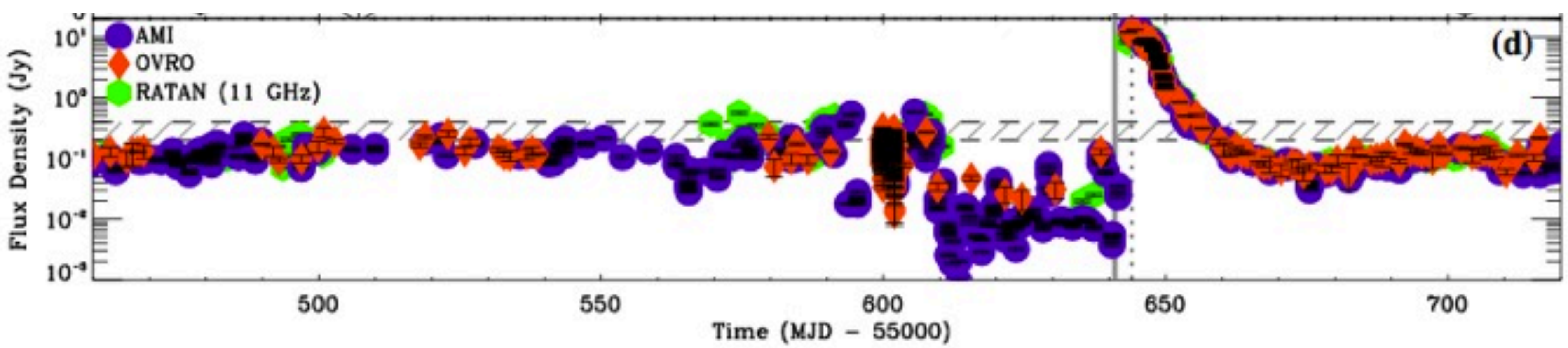
21 September, 2010 - 8 June 2011



radio
11 & 15 GHz

Multi-wavelength monitoring
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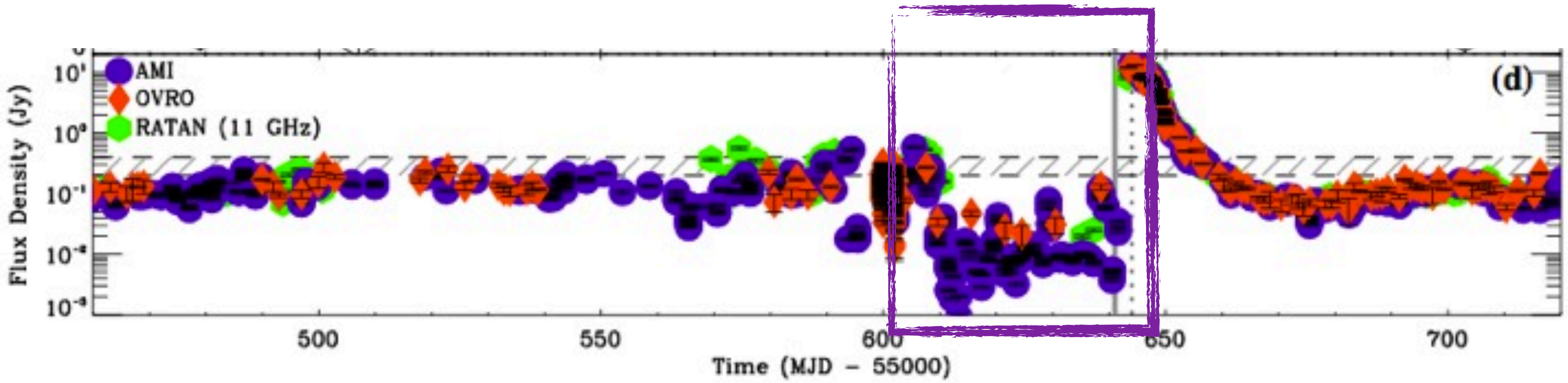
quenched
state



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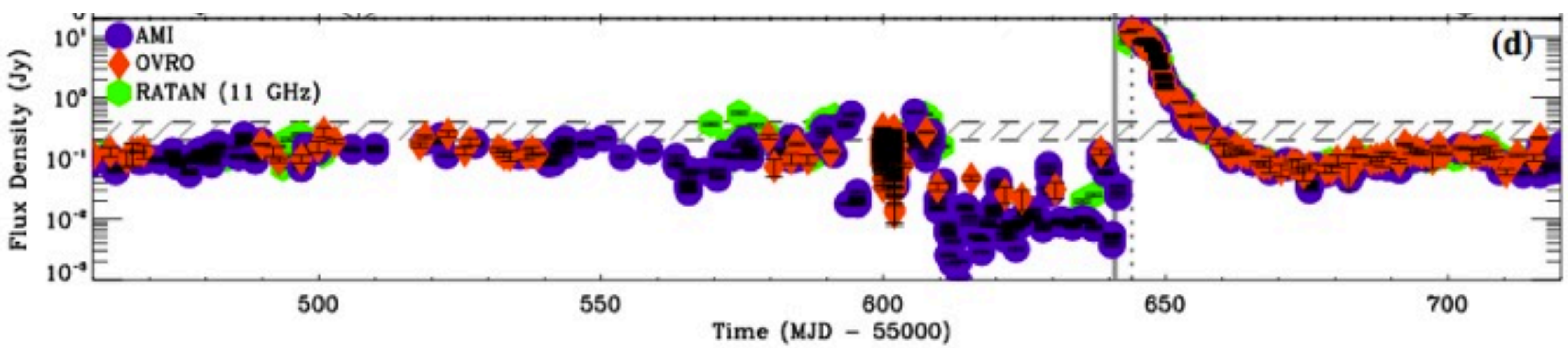
major
radio
flare



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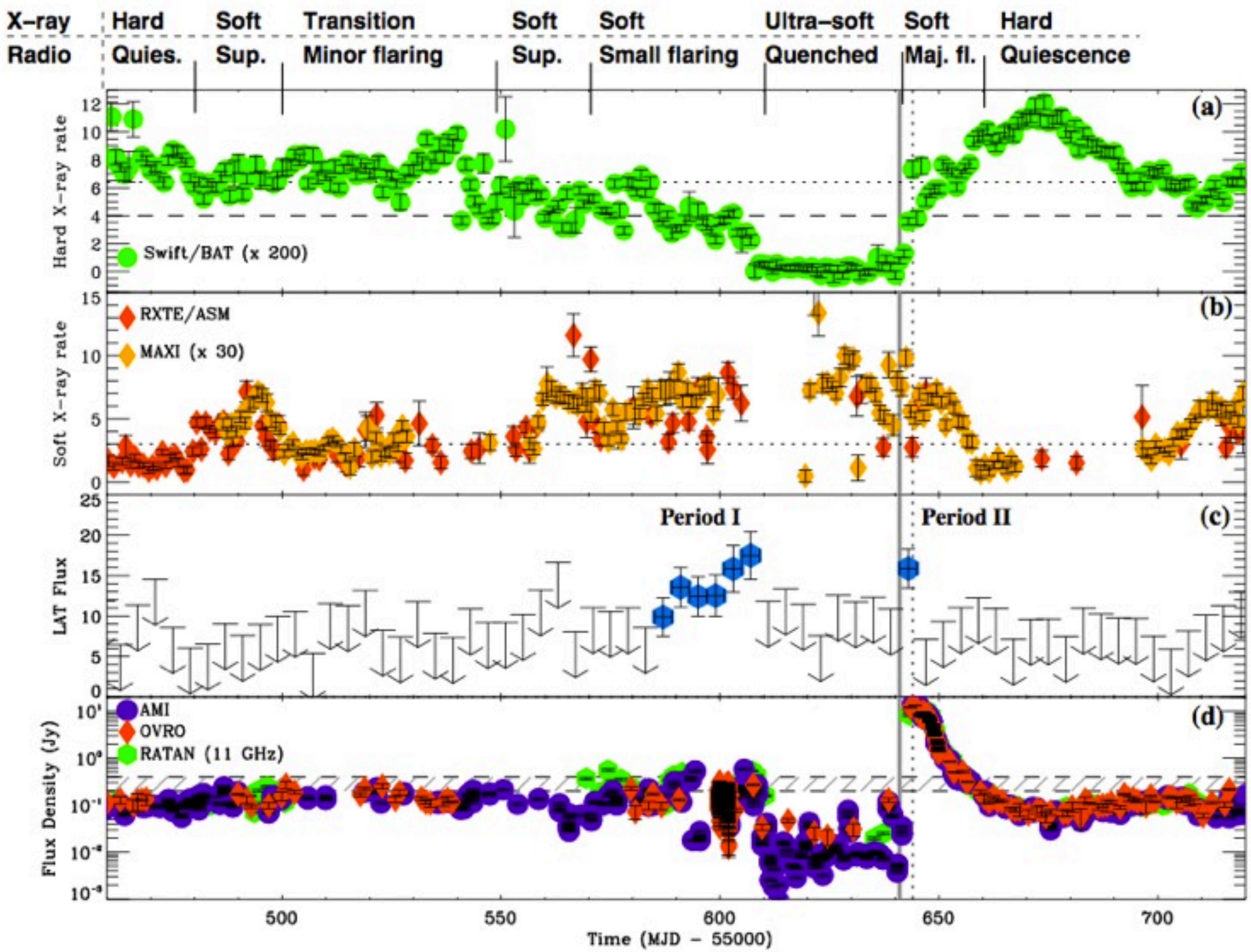

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15-50 keV

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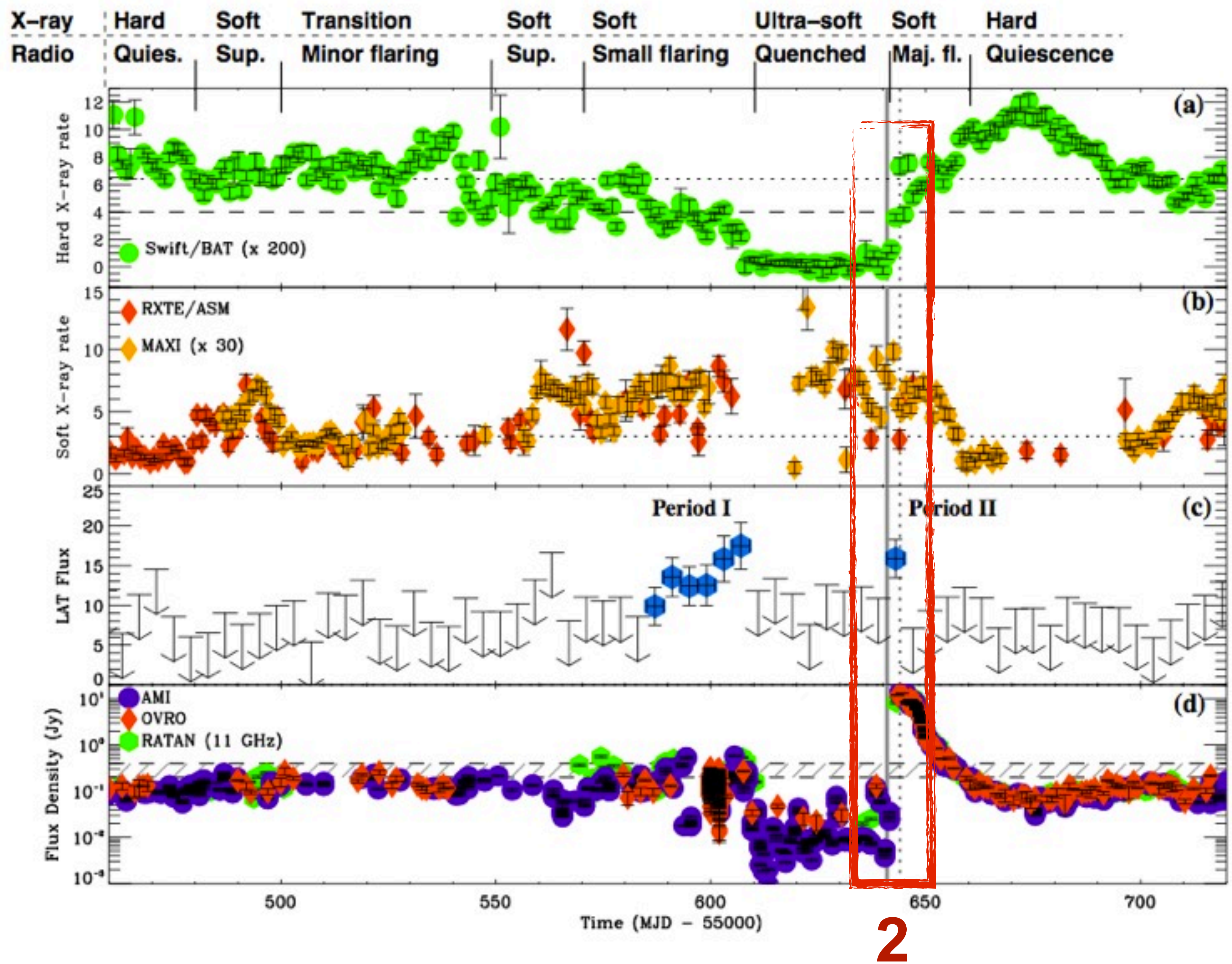

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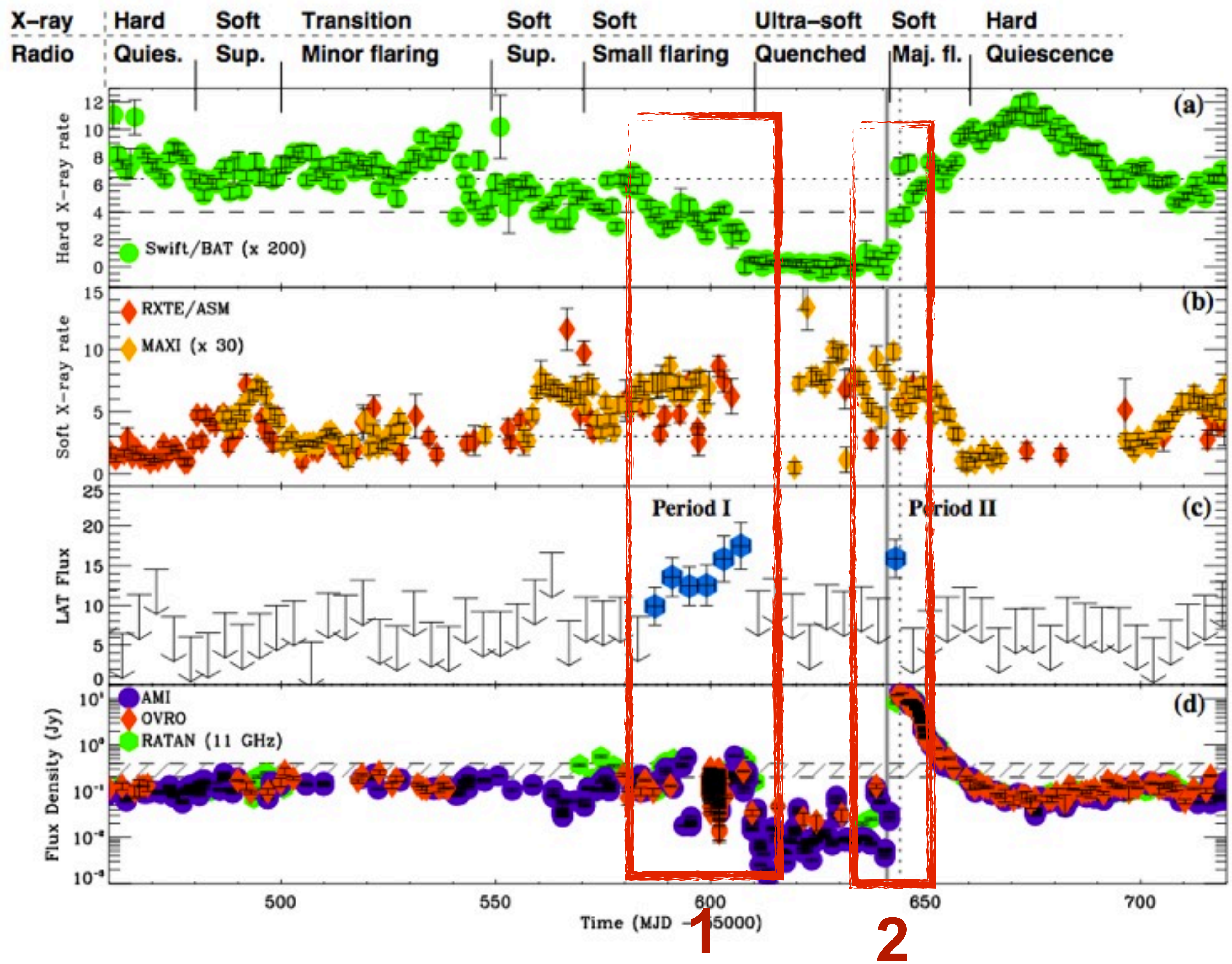

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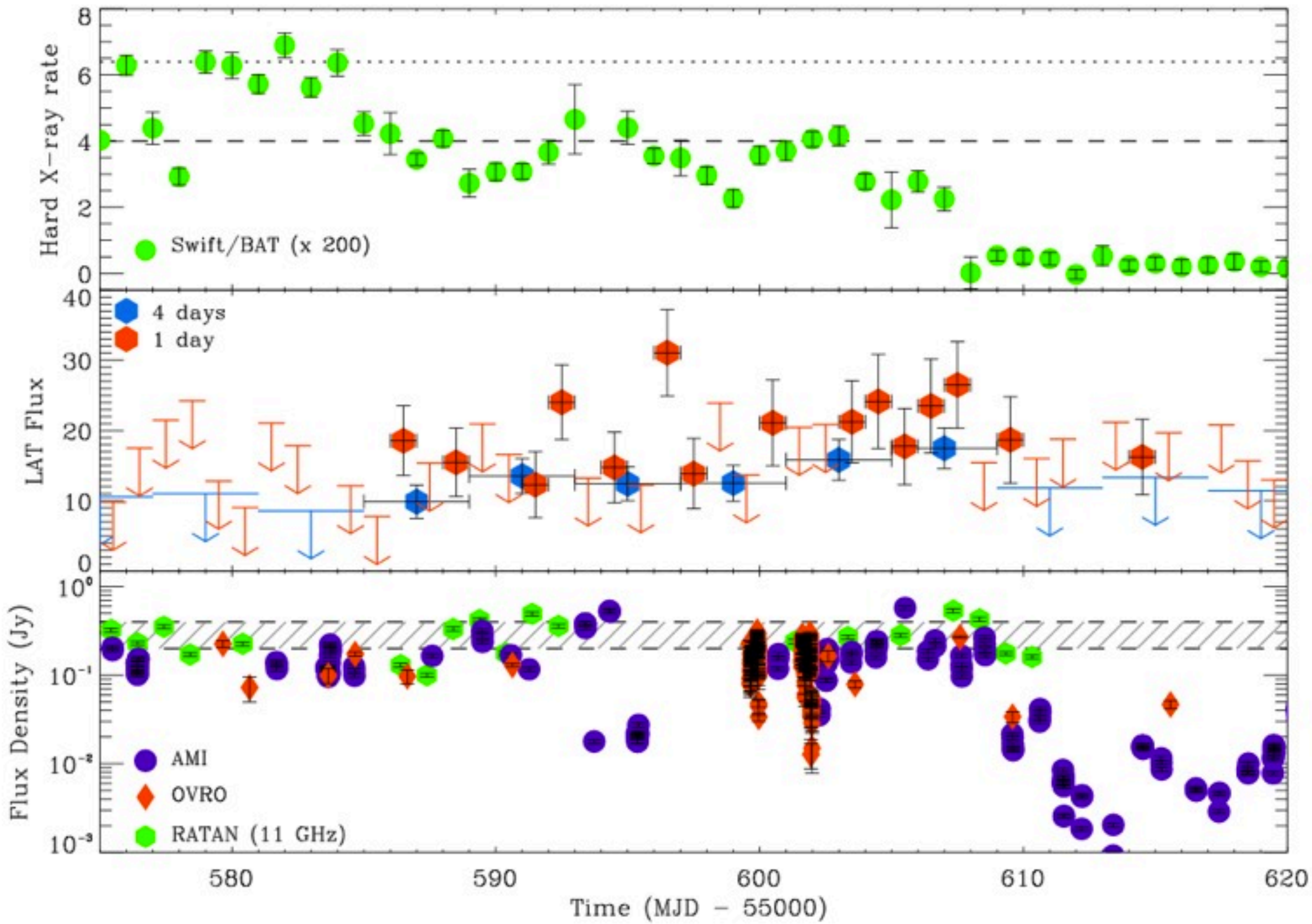

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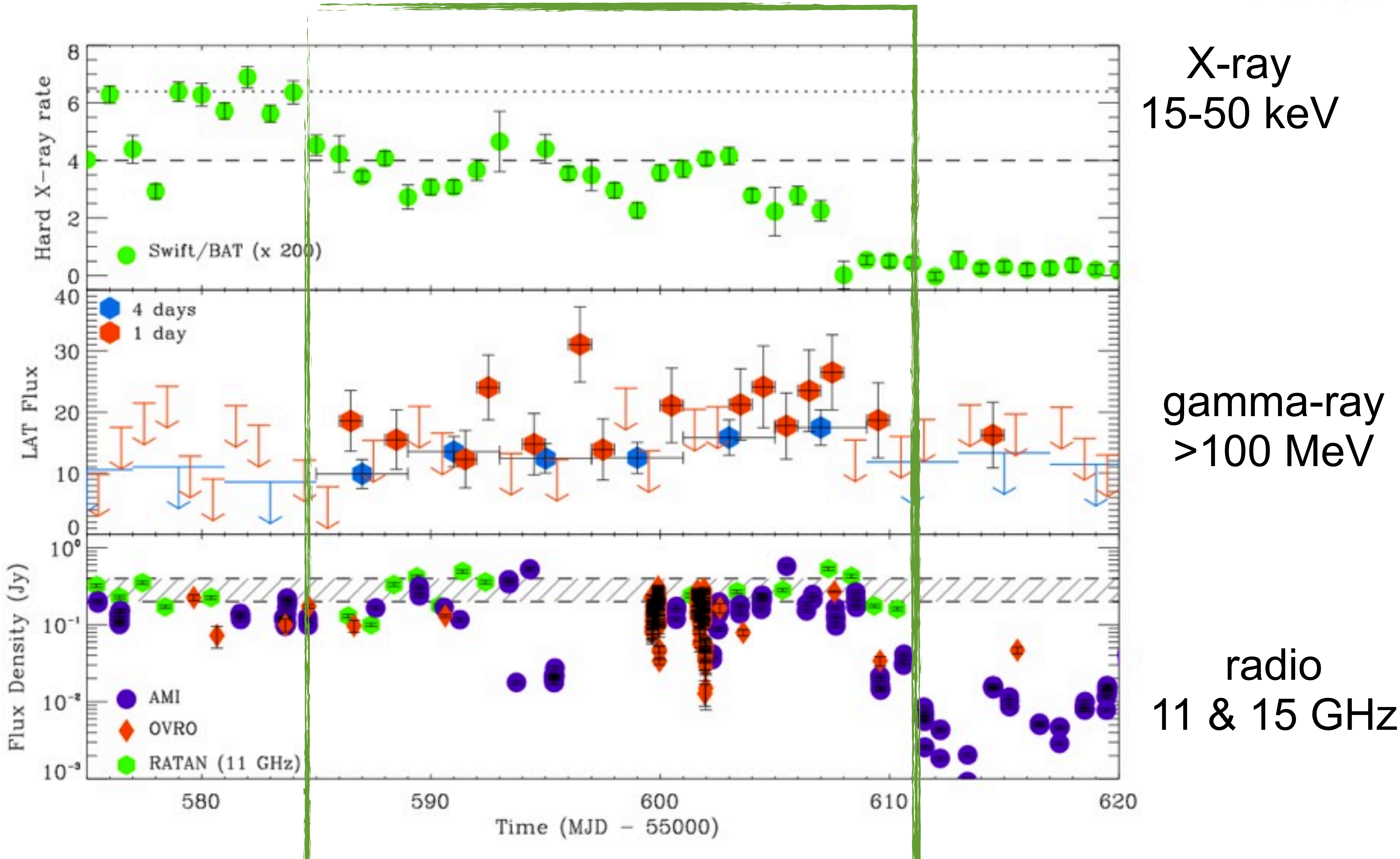

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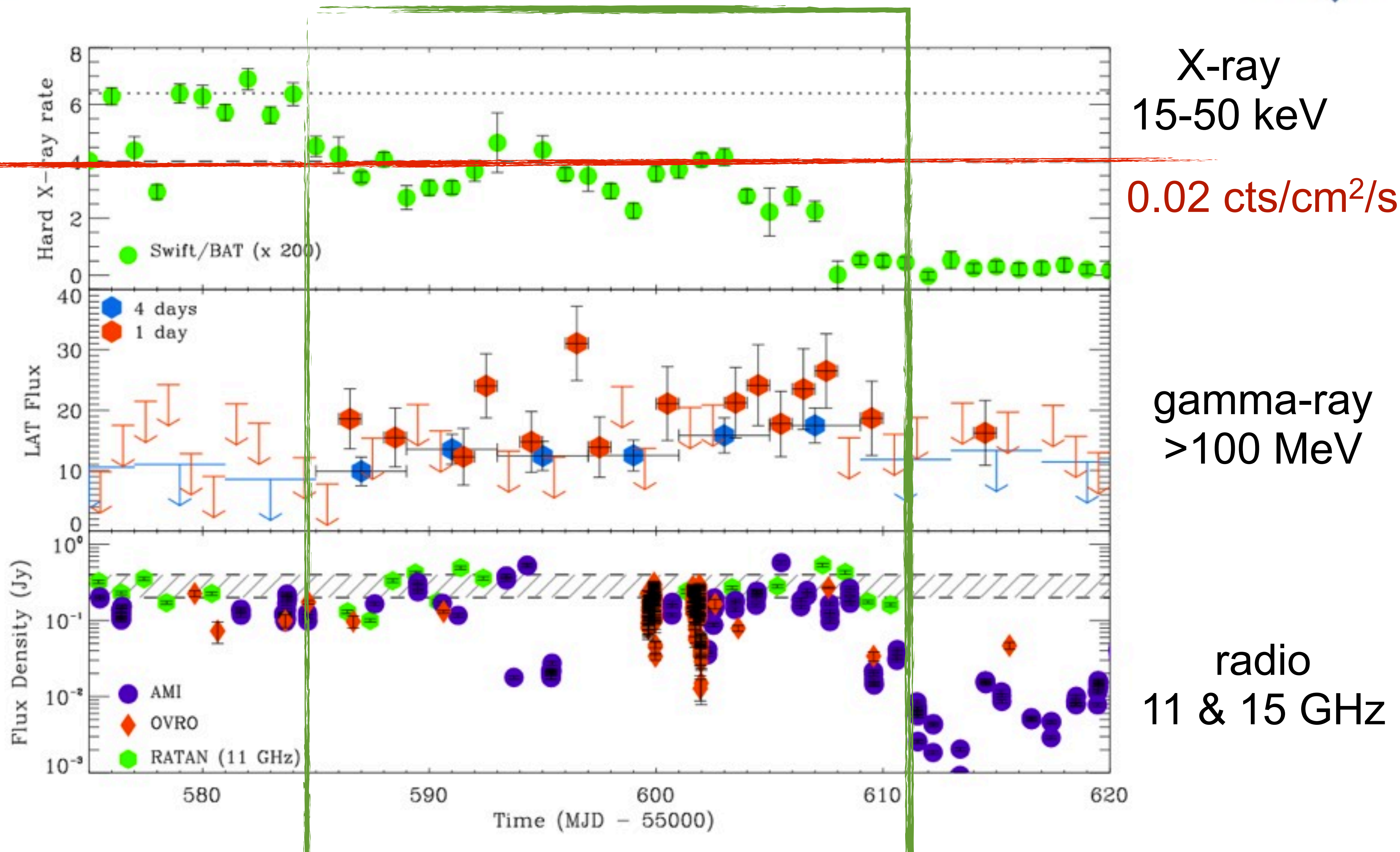

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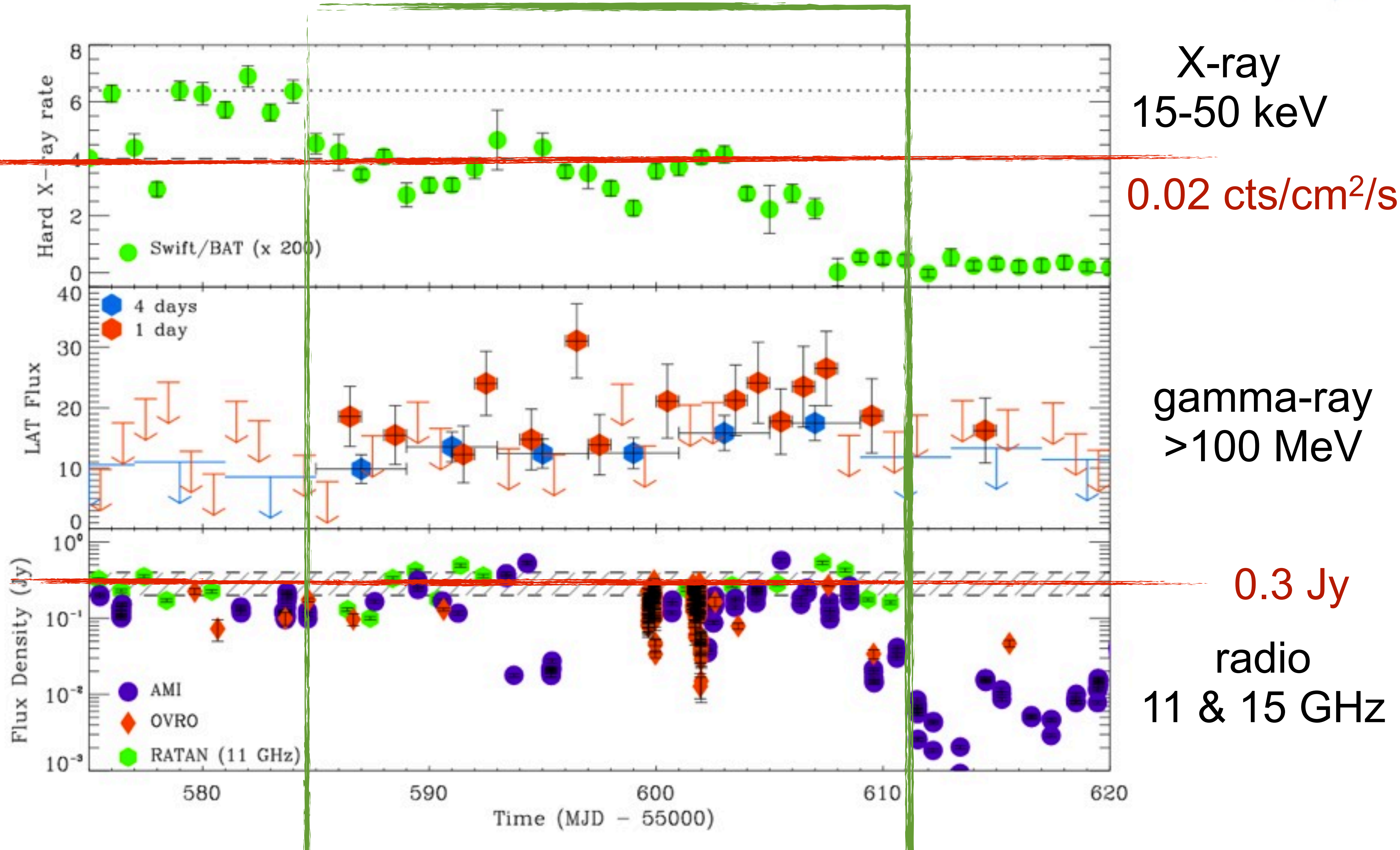

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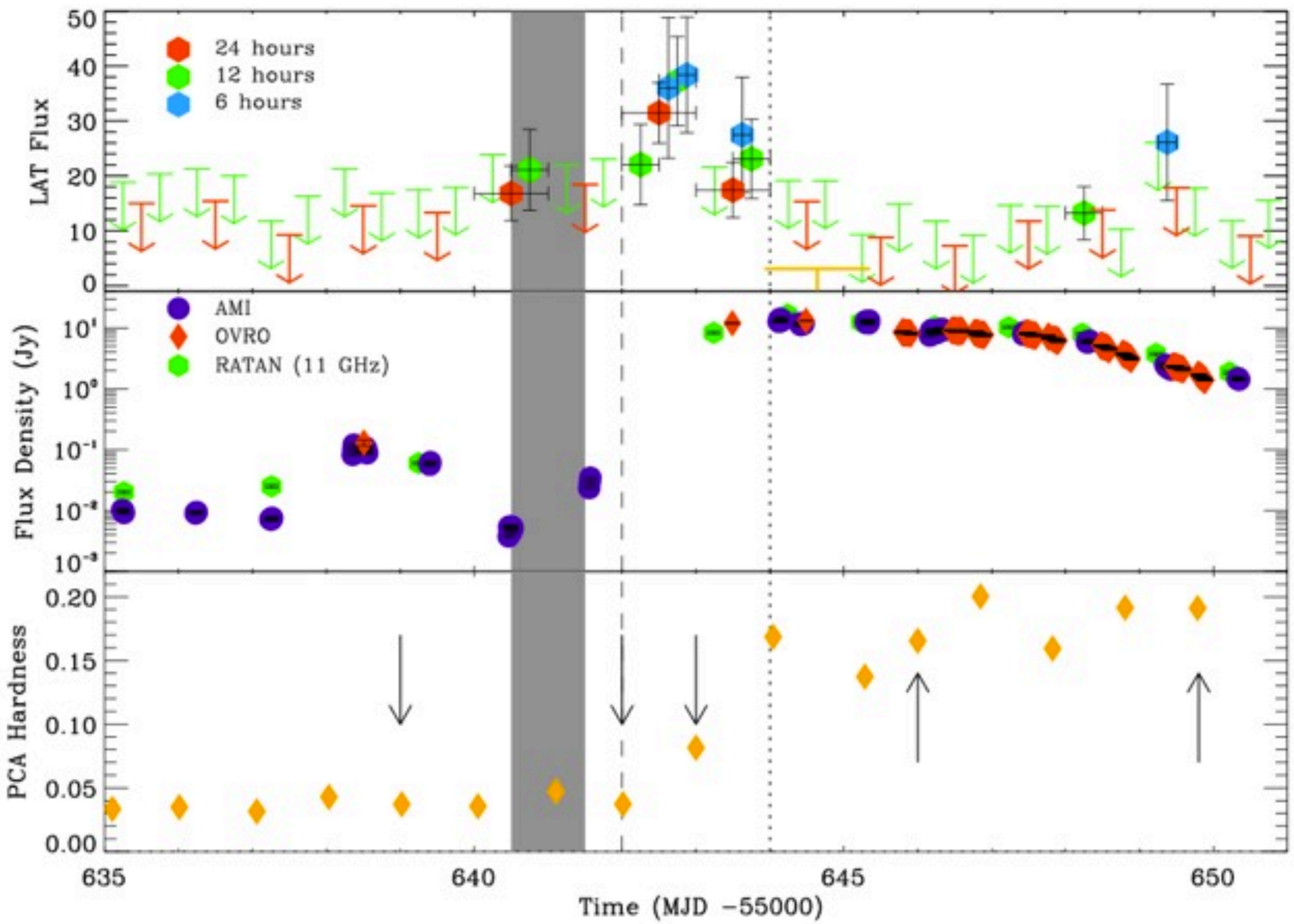

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X-ray
hardness
ratio & RXTE
spectra (arrows)

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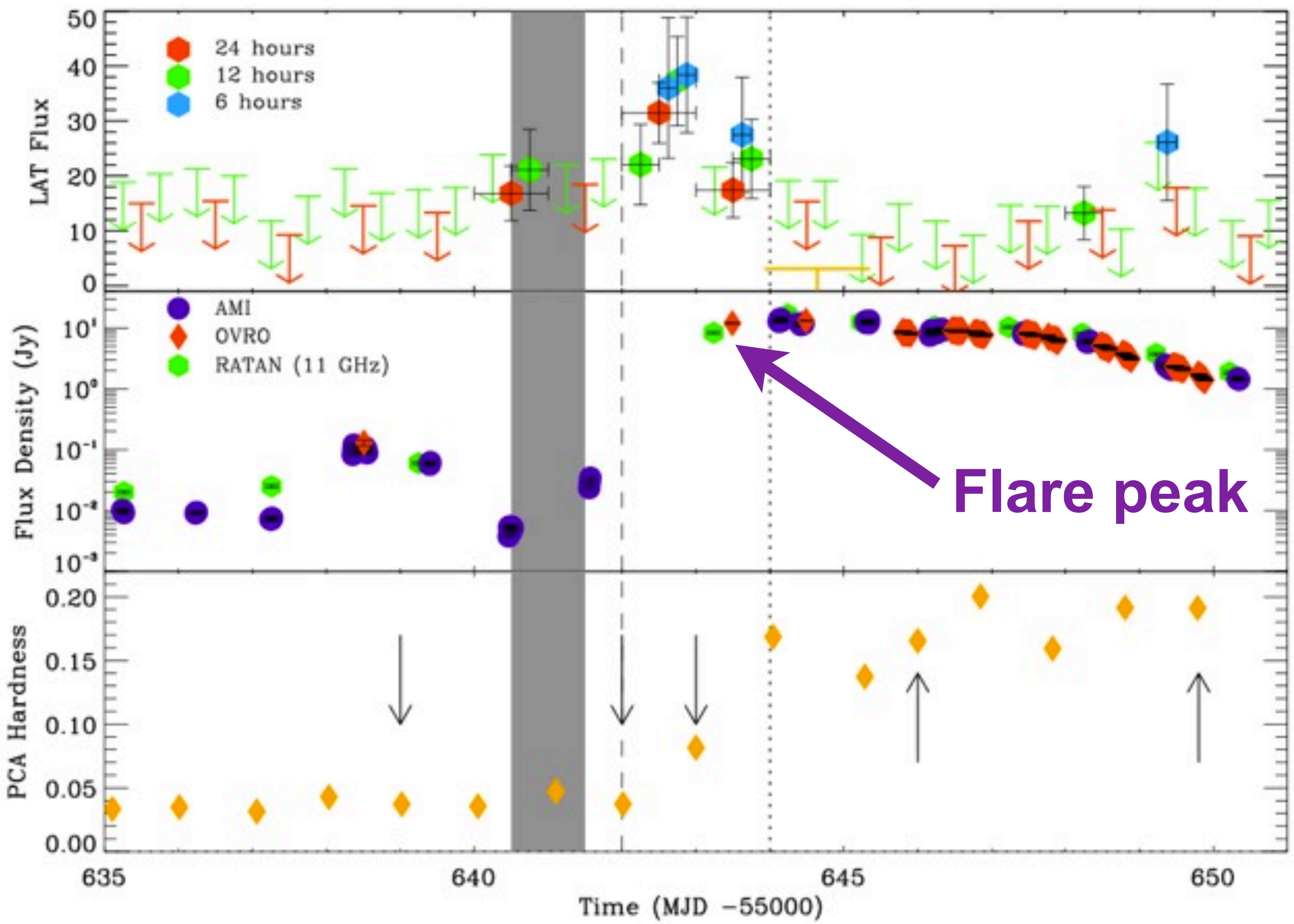

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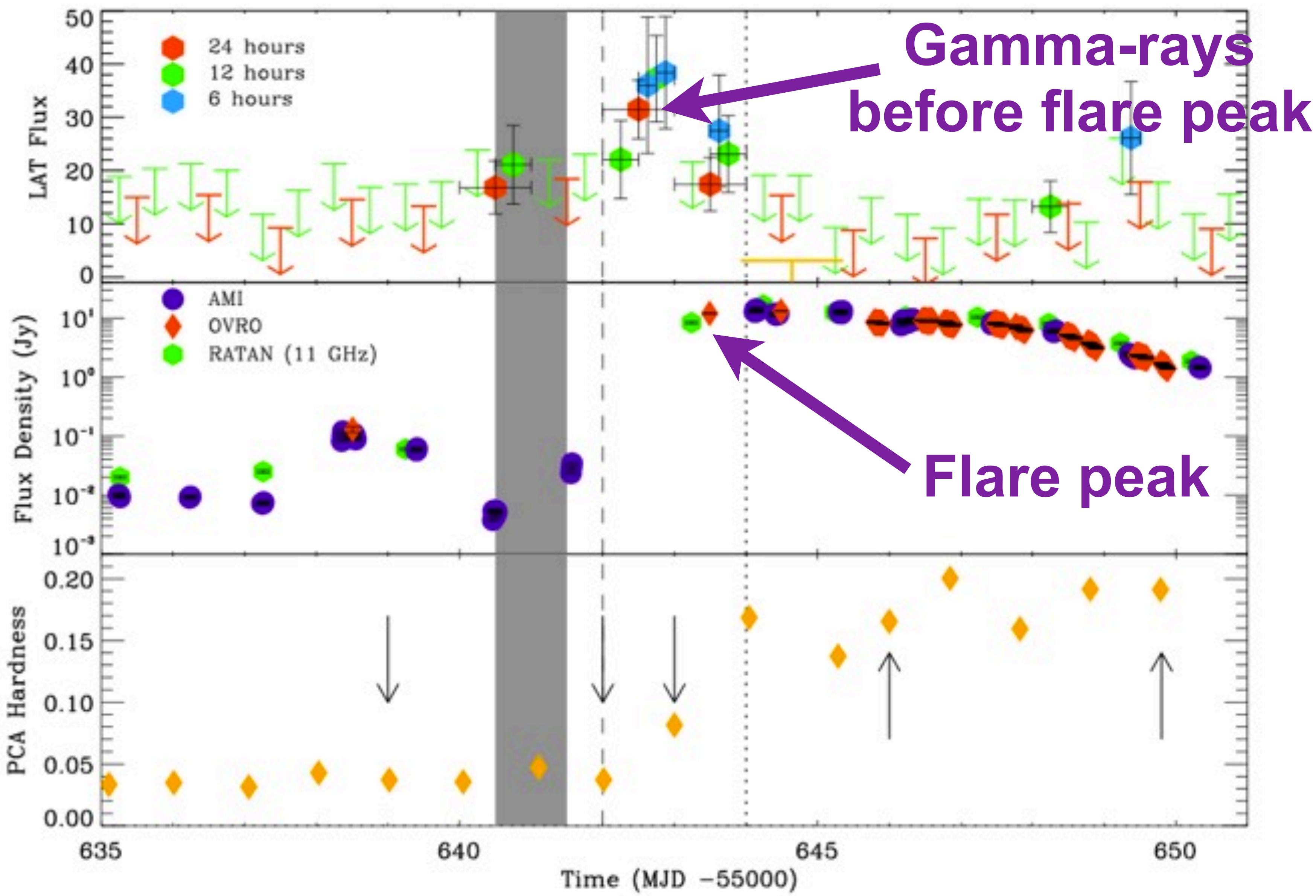

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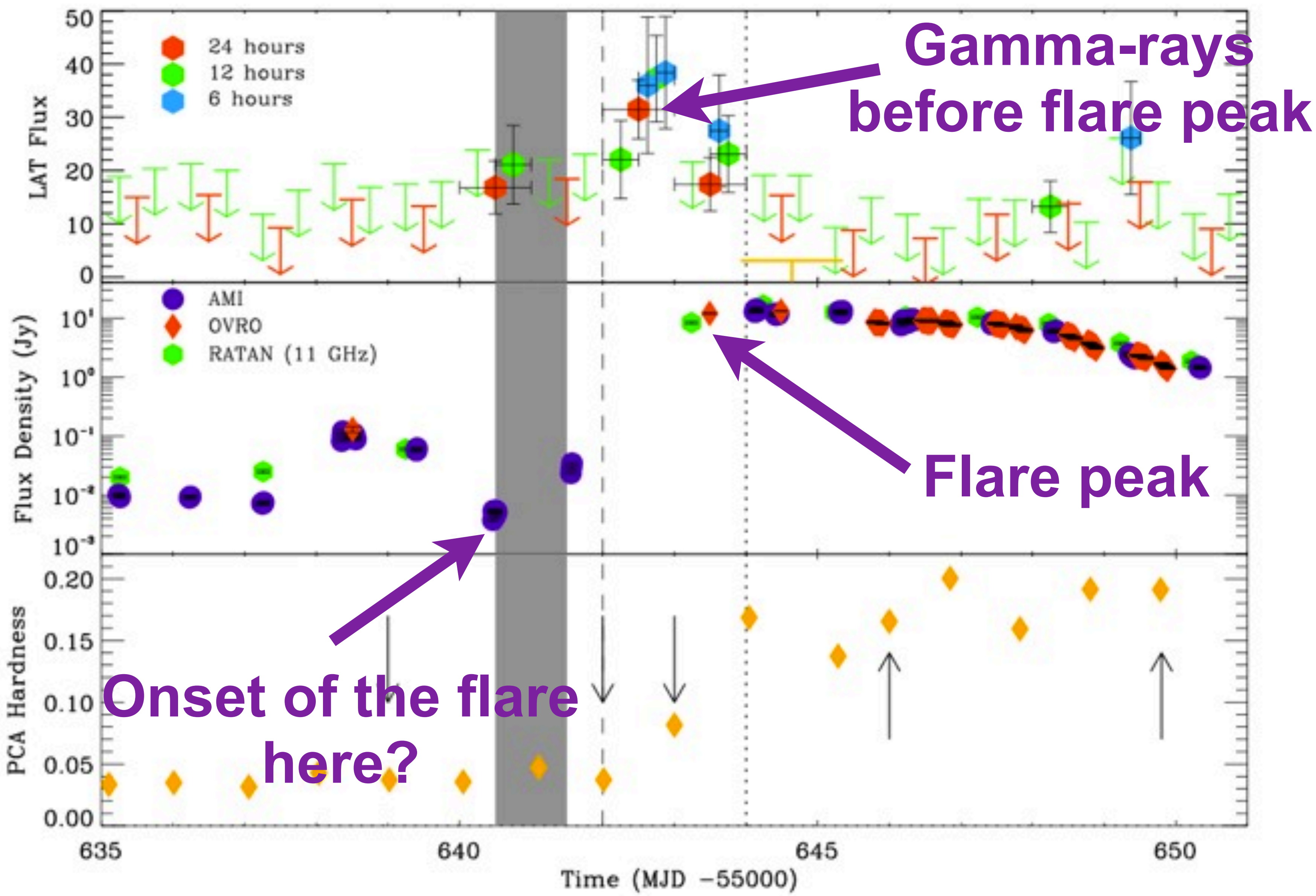

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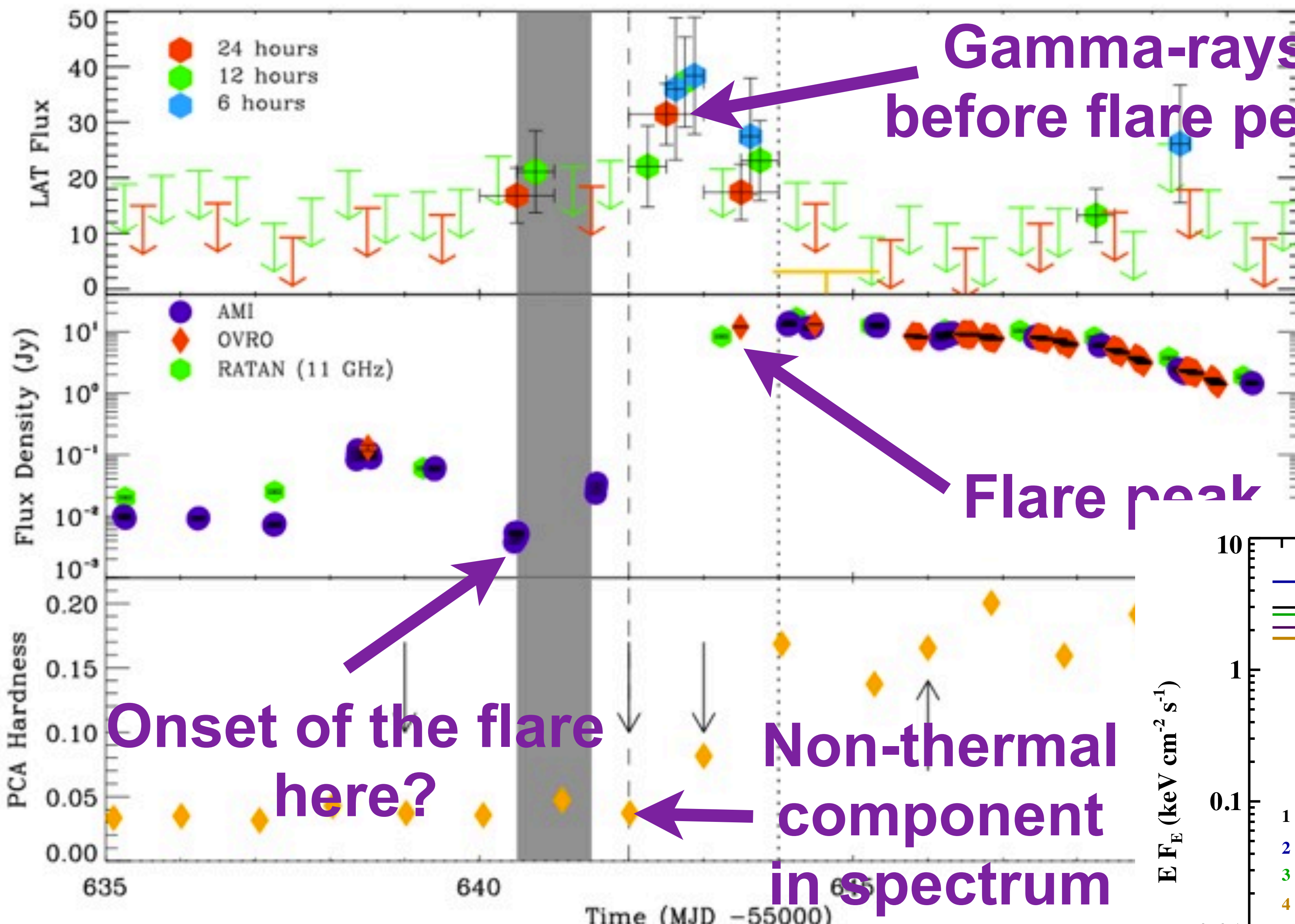


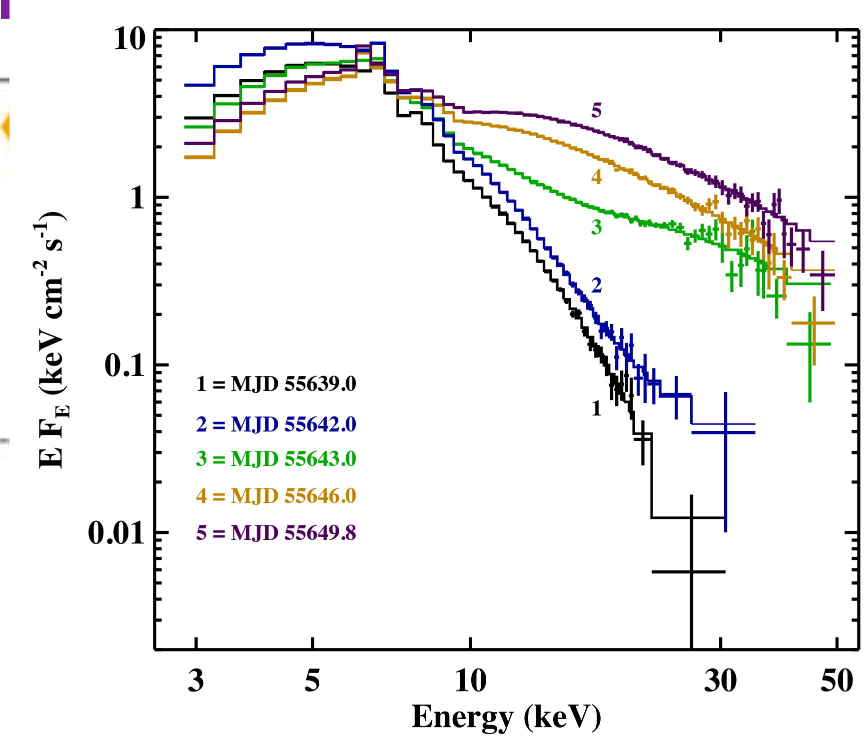
Gamma-rays before flare peak

Flare peak

Onset of the flare here?

Non-thermal component in spectrum

gamma-ray >100 MeV



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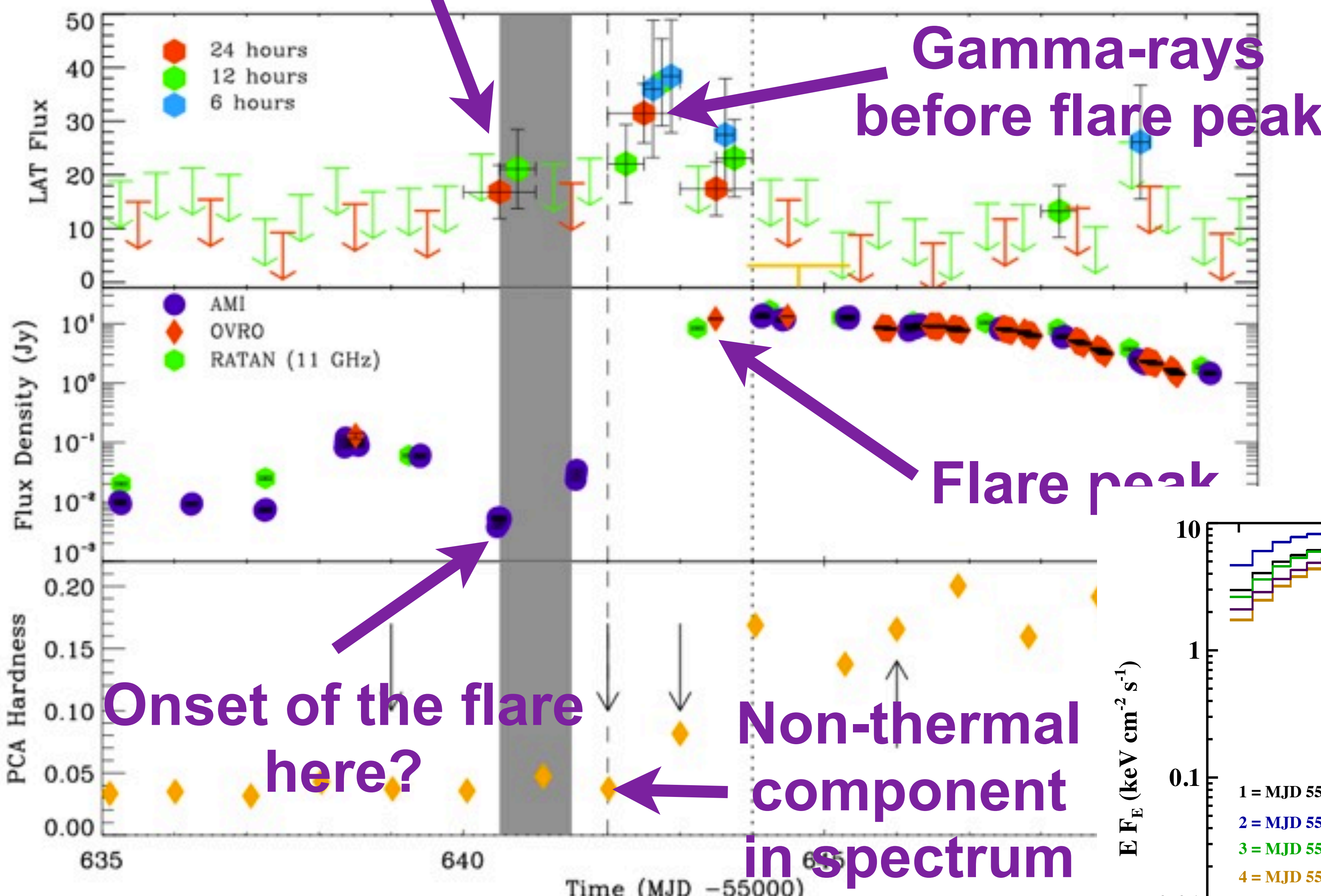

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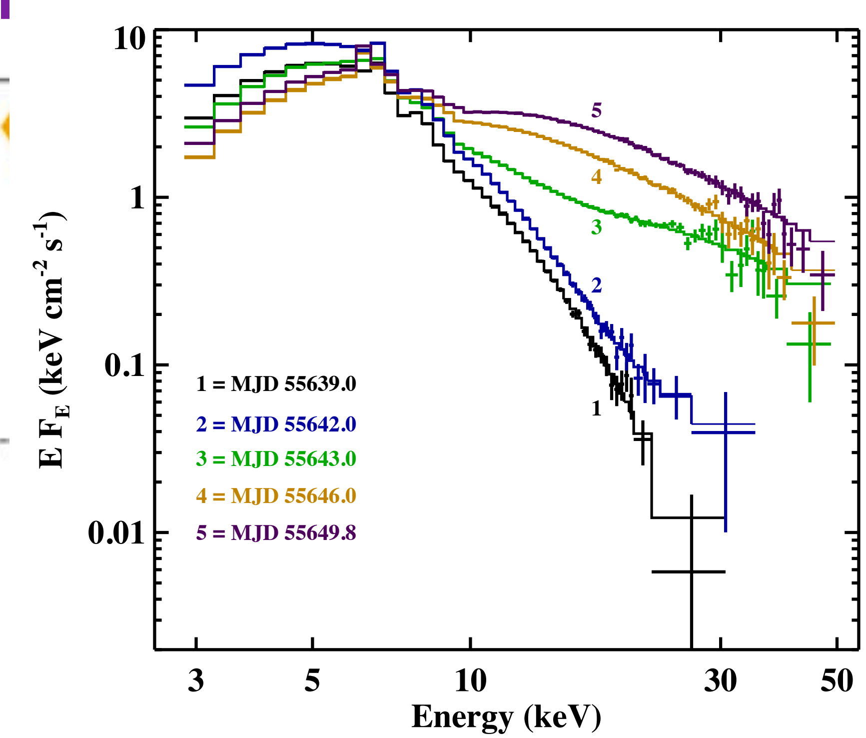

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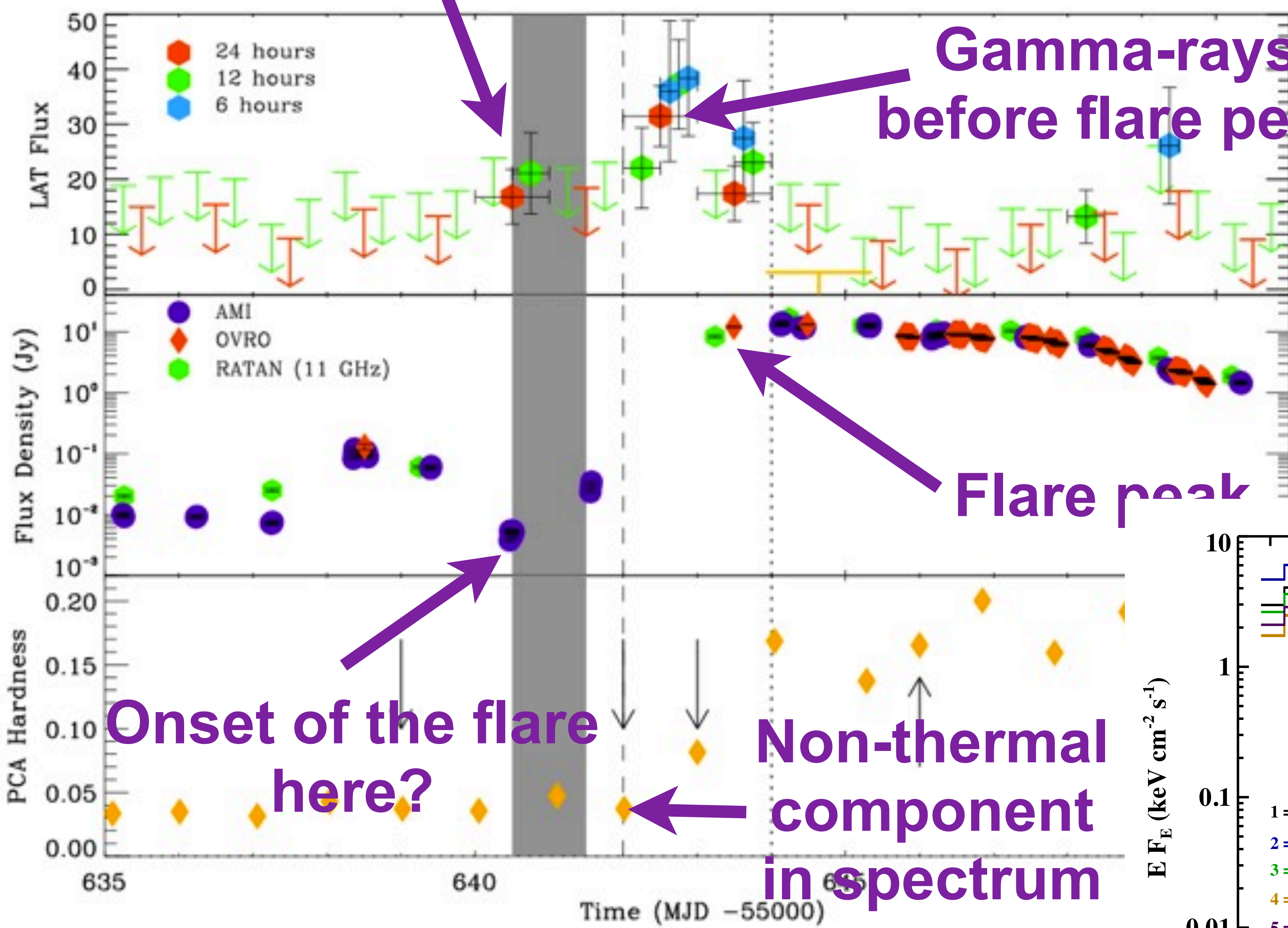

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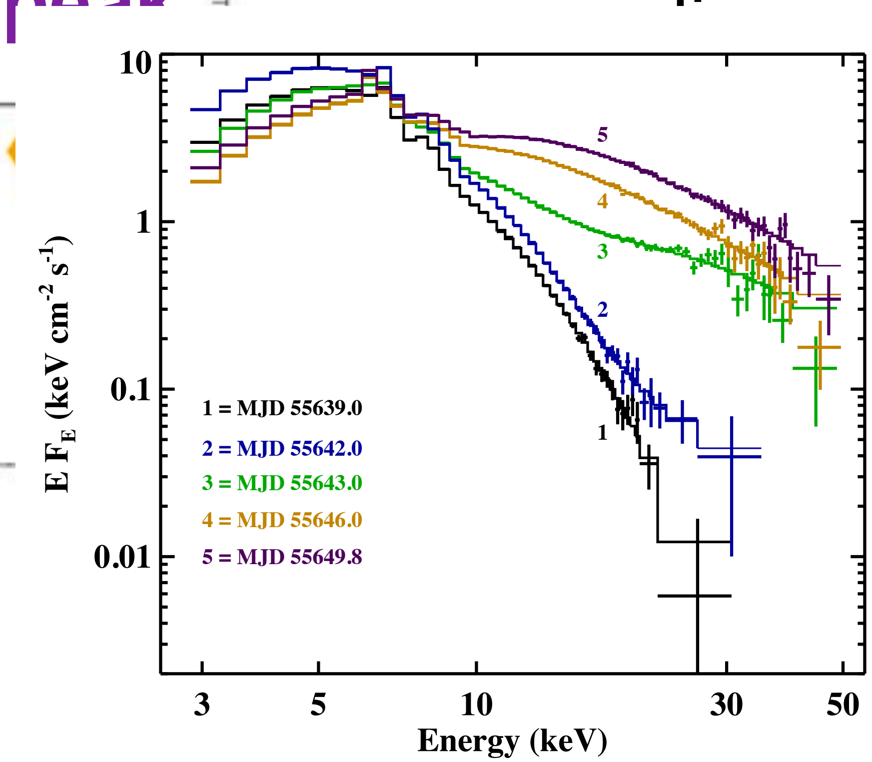
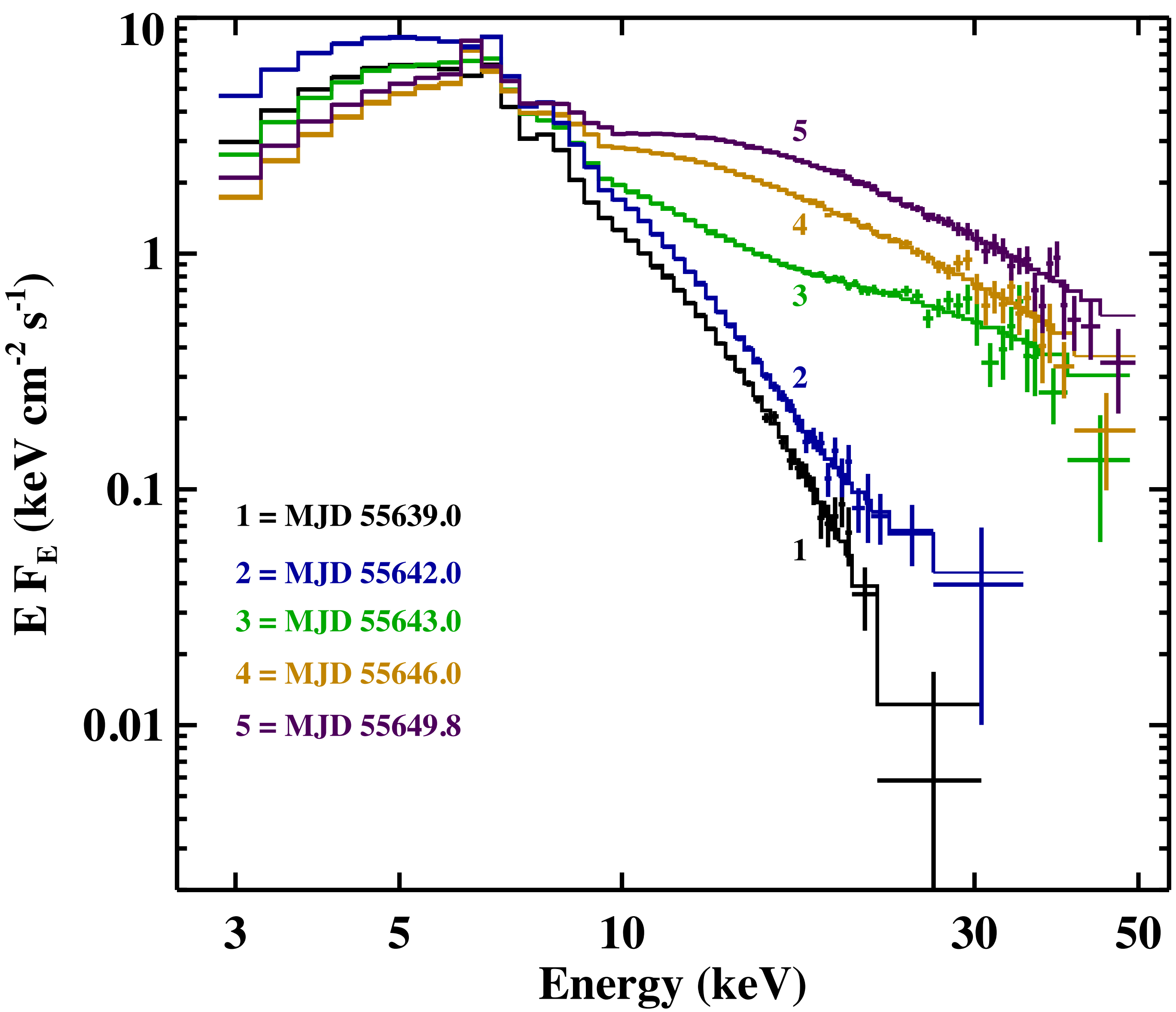


Simultaneous rise radio + non-thermal X-ray + gamma-ray

X-ray spectra (RXTE)



ISM absorption

Partial absorber

Iron line feature

Hybrid thermal/non-thermal Comptonization model (eqpair, Coppi 1992, 1999)

Extrapolation of spectrum 3 10-50 keV to GeV band, is several orders of magnitude lower than LAT flux.

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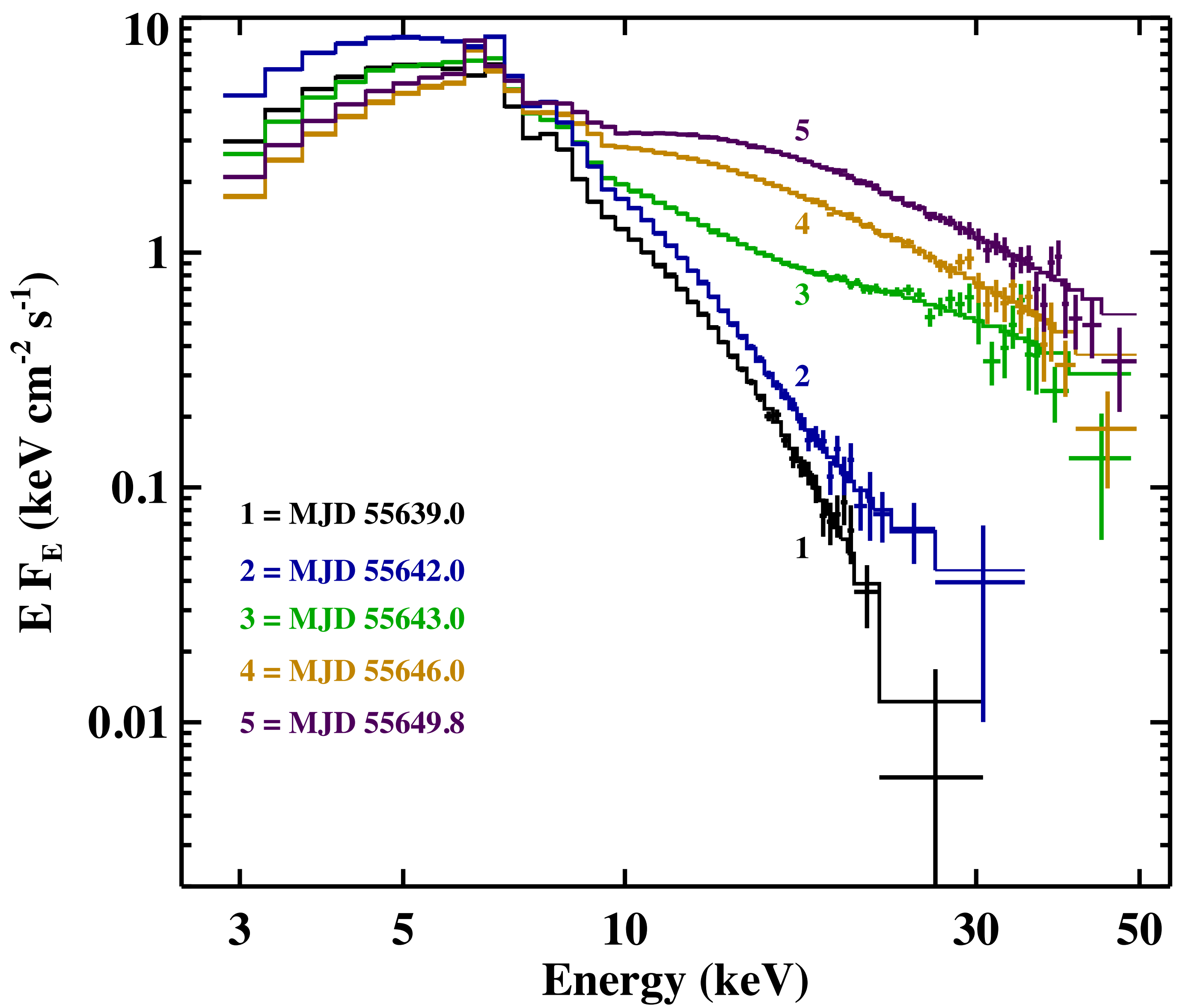

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hard X-rays and gamma-rays can NOT be parts of the same powerlaw component

Gamma-ray trigger criteria

- Soft X-ray state: 3-5 keV at RXTE/ASM above 3 cts/s
- Low level of hard X-ray emission: Swift/BAT below 0.02 cts/ cm^2/s
- Rapid radio emission from relativistic jet: 15 GHz above 0.2-0.4 Jy. Major flares are not necessary!

Possible scenario

- Shock forms at various distances along the jet (Lindfors et al. 2007; Miller-Jones et al. 2009)

- Transition **IN**/**OUT** of the ultrasoft X-ray state signal a **decrease**/**increase** in jet efficiency with non-thermal region moving **CLOSER**/ **FURTHER** from the compact object

- Gamma-ray emission is most efficient at “sweet-spot” bounded by strong pair production on thermal X-rays and declining seed photon density for inverse Compton scattering (Cerutti et al. 2011; Sitarek & Bednarek 2011)

- Detections prior to and after the quenched state when shock moves through this region