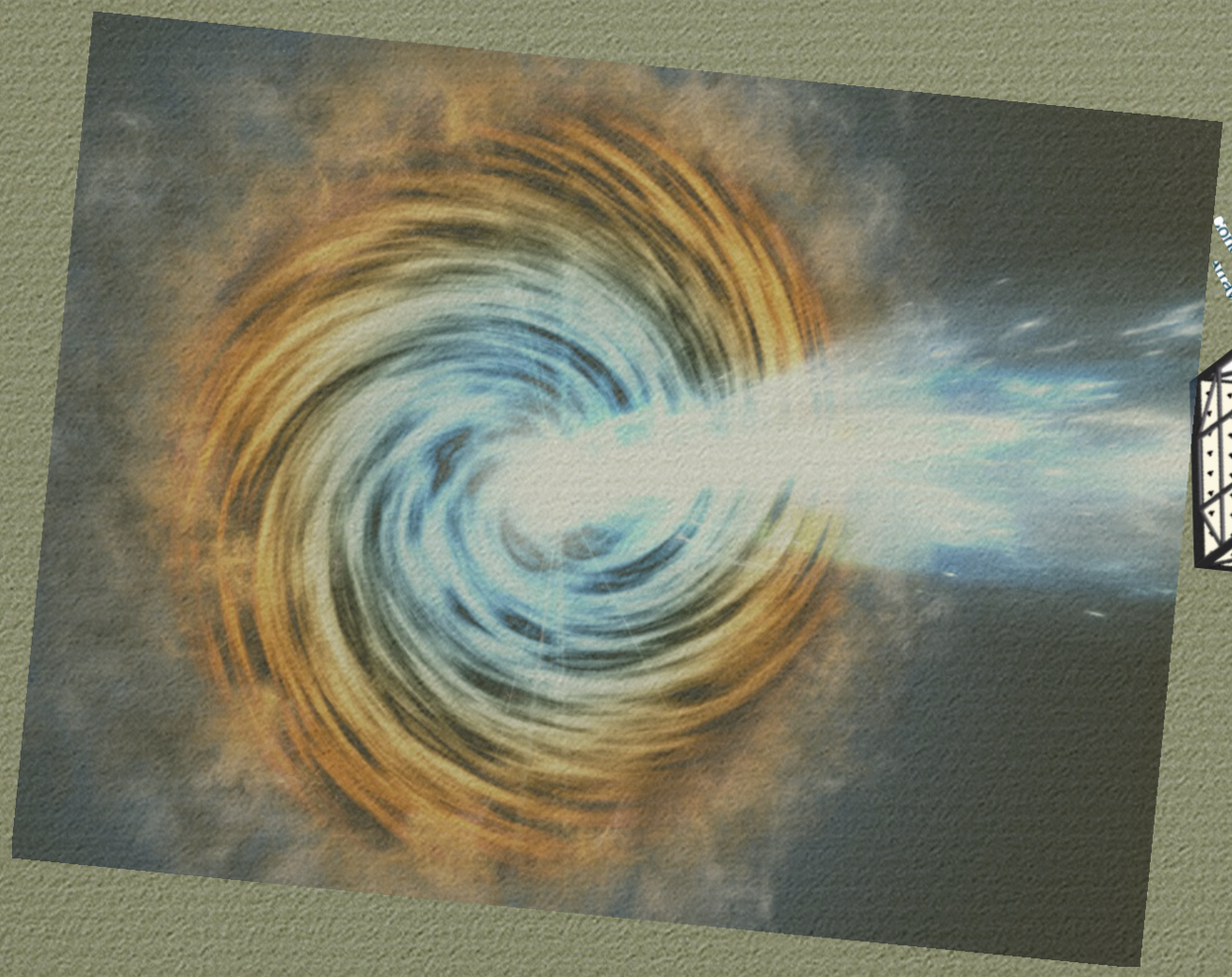
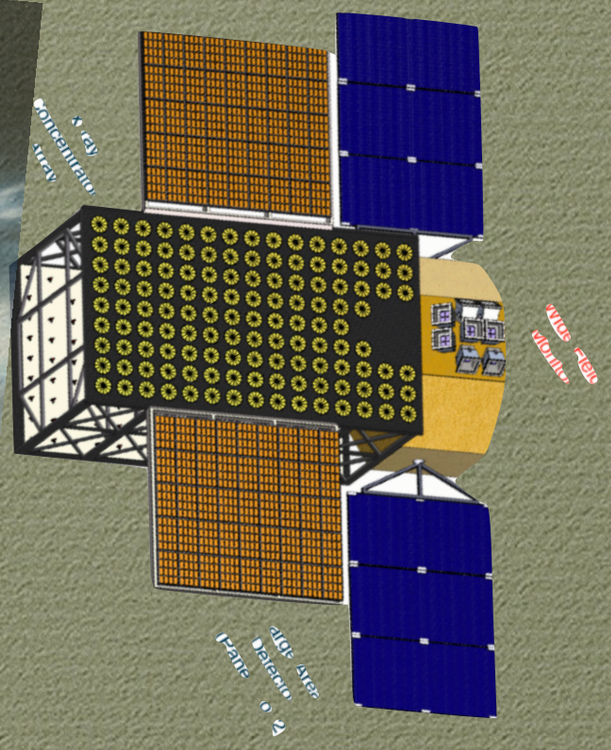
STROBE-X for Blazars





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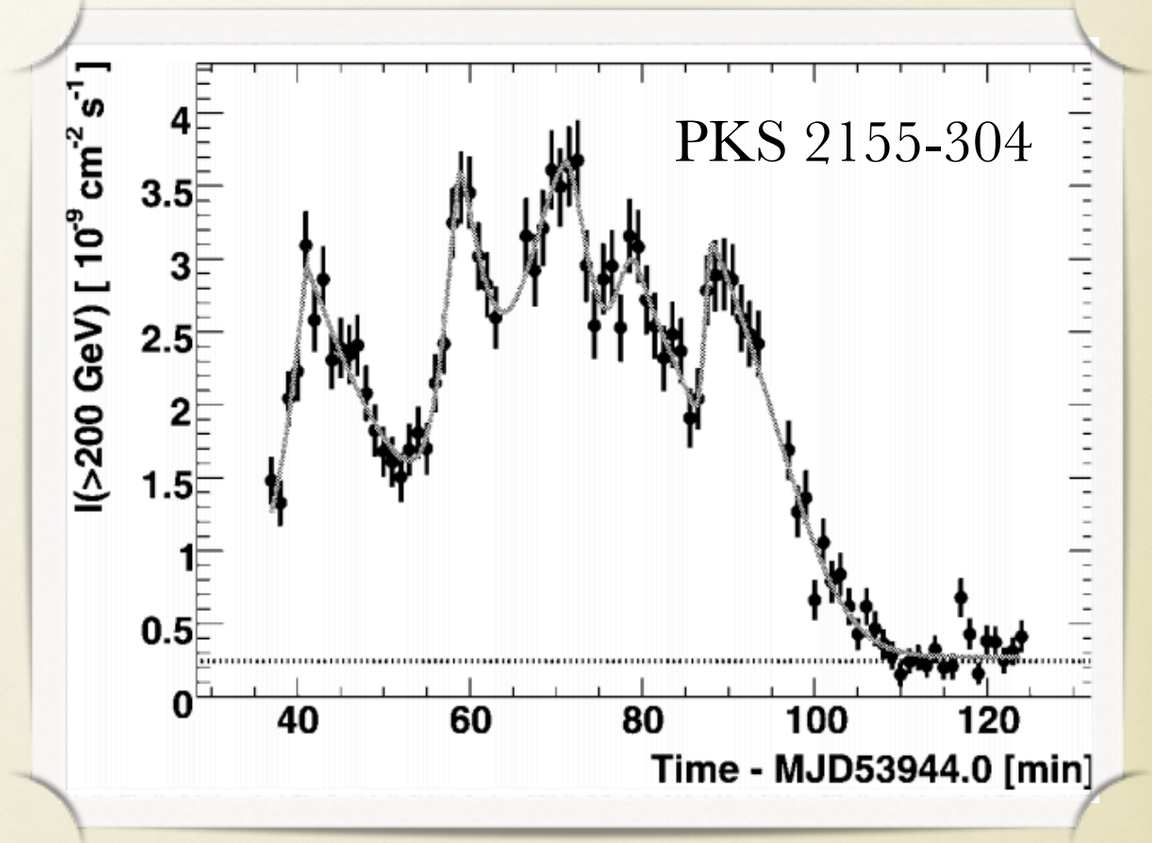
Rapid Blazar Flares

- Blazars are known to exhibit extremely fast flares
- Timescale of variability indicates
  - the size of the emission region
  - the location of the emission region (assuming a conical jet)
  - underlying radiative processes (leptonic vs. hadronic, others?)

Rapid Blazar Flares

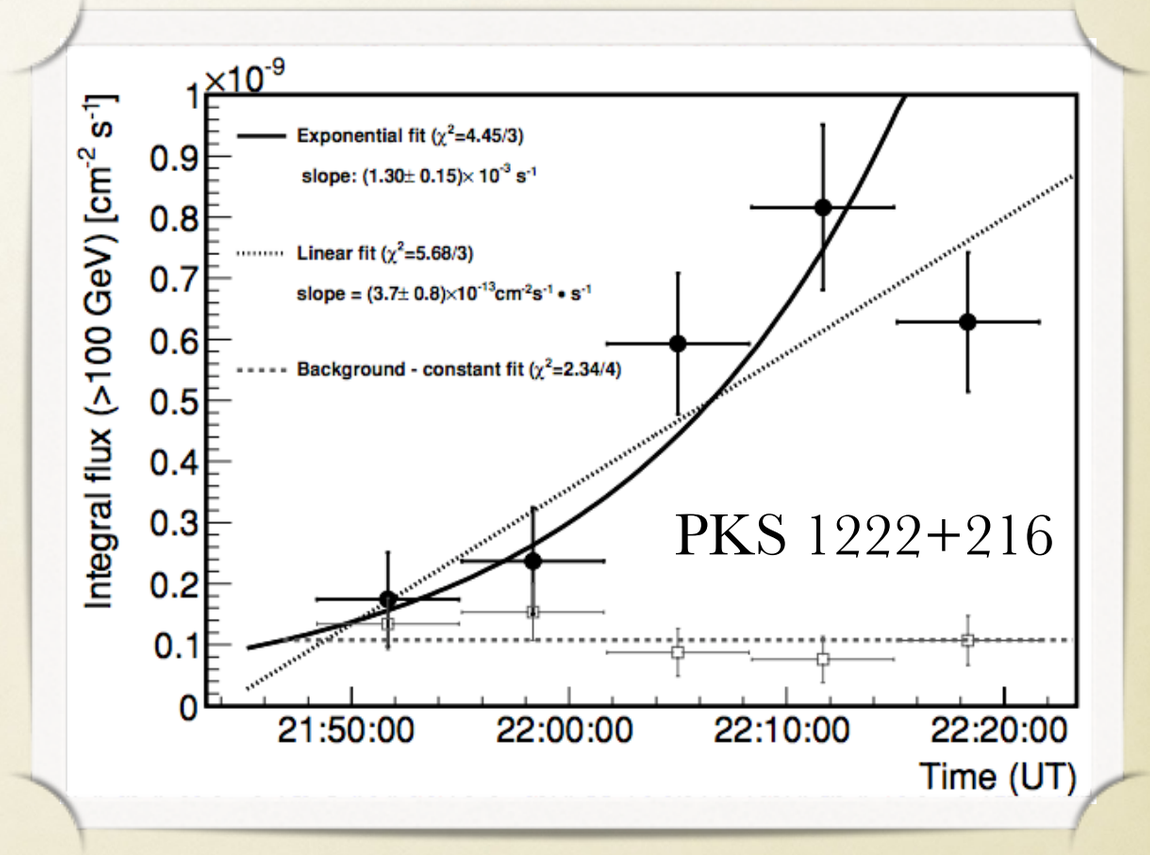
- Blazars are known to exhibit extremely fast flares
- TeV flares



(Ahronian+, 2007, ApJ, 664, 71)

Rapid Blazar Flares

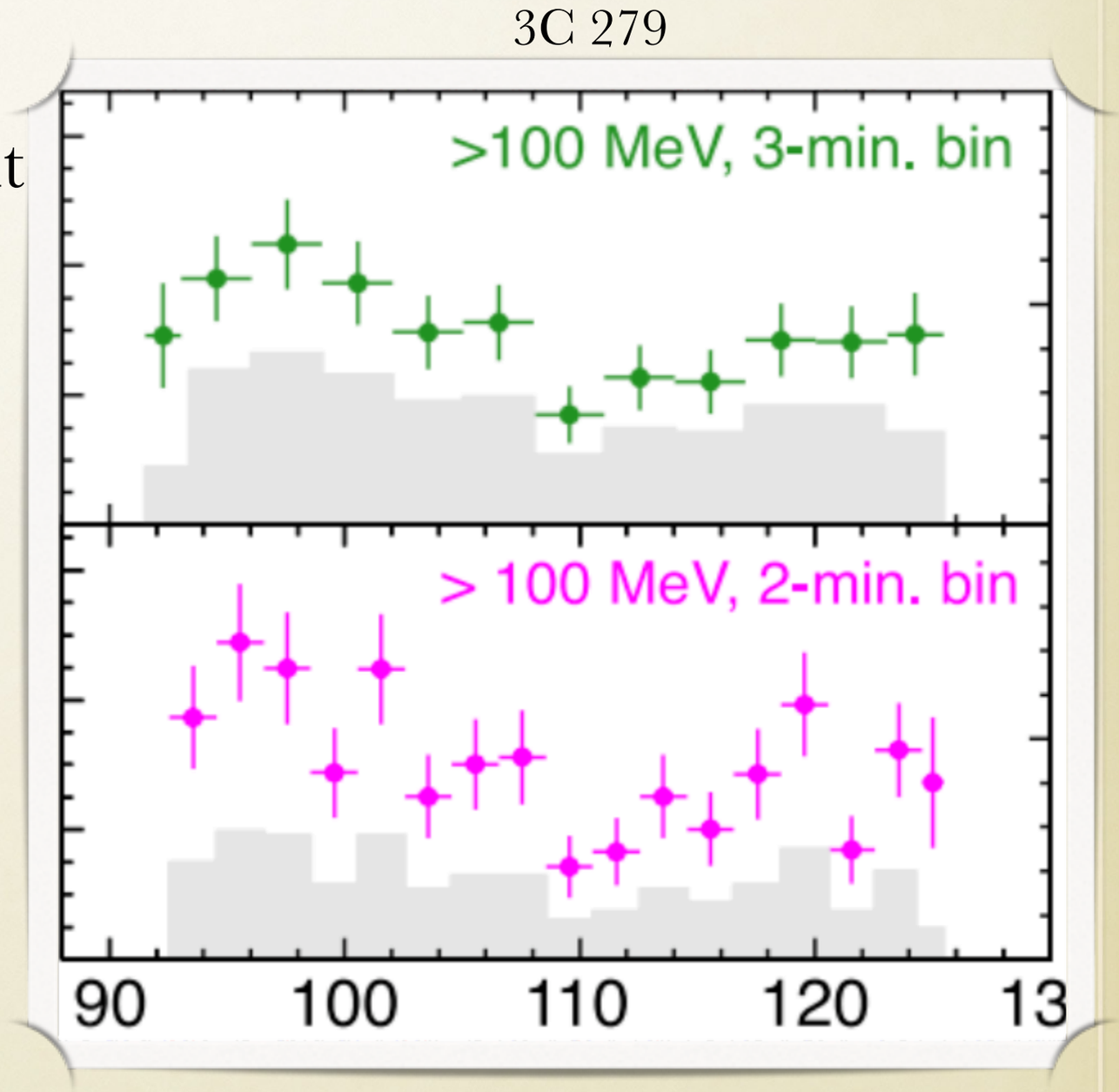
- Blazars are known to exhibit extremely fast flares
- TeV flares
- Both flat spectrum radio quasars (FSRQs) & BL Lac objects show extremely rapid variability (~few minutes)



(Aleksic+, 2011, ApJ, 730, 8)

Rapid Blazar Flares

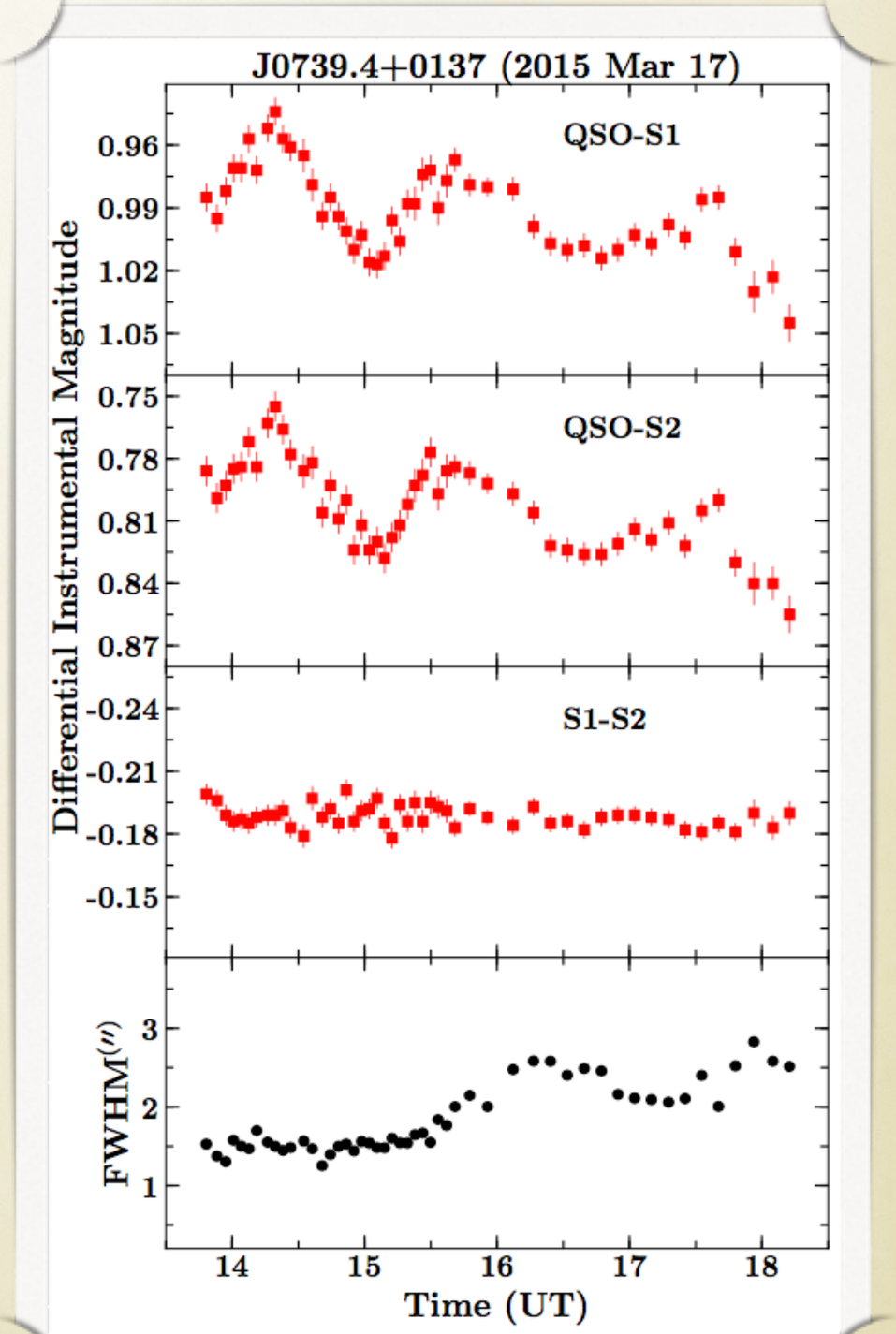
- Blazars are known to exhibit extremely fast flares
- Gamma-ray flares
- Minute scale flux variations detected primarily from FSRQs



(Ackermann+, 2016, ApJ, 824, 20)

Rapid Blazar Flares

- Blazars are known to exhibit extremely fast flares
- Optical flares
- Both FSRQs & BL Lacs



(Paliya+, 2017, ApJ, 844, 32)

What about the X-rays

A SEARCH FOR FAST X-RAY VARIABILITY FROM ACTIVE GALACTIC NUCLEI USING *SWIFT*

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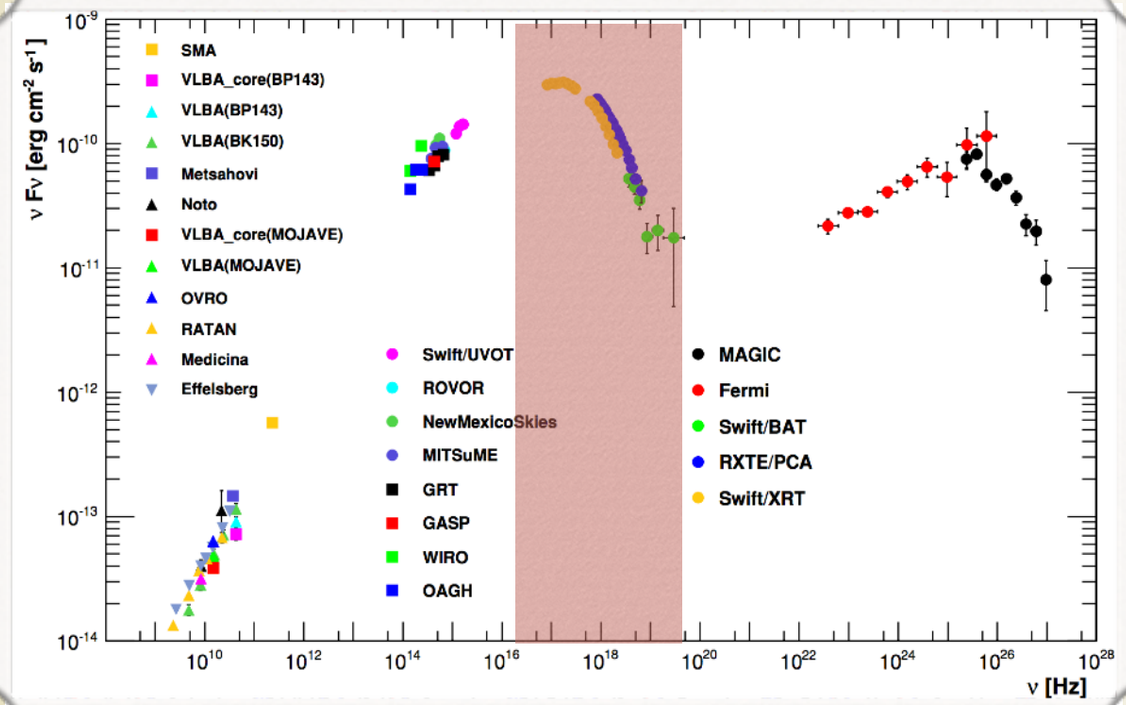
ABSTRACT

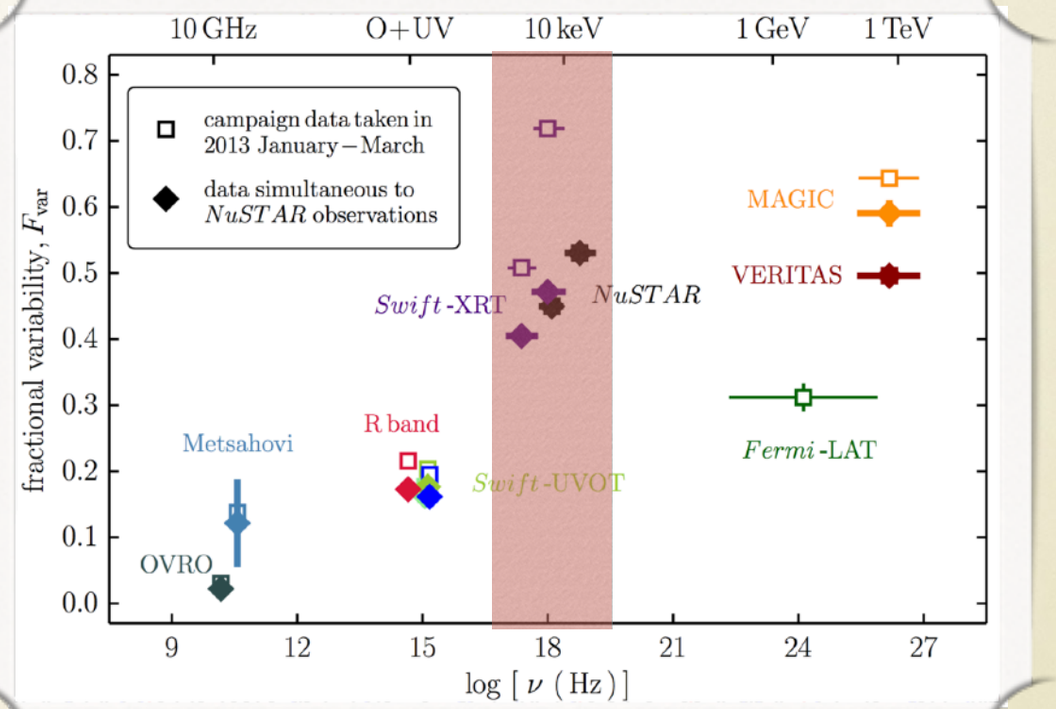
Blazars are a class of active galactic nuclei (AGNs) known for their very rapid variabilty in the high energy regions of the electromagnetic spectrum. Despite this known fast variability, X-ray observations have generally not revealed variability in blazars with rate doubling or halving timescales less than approximately 15 minutes. Since its launch, the *Swift* X-ray Telescope has obtained 0.2–10 keV X-ray data on 143 AGNs, including blazars, through intense target of opportunity observations that can be analyzed in a multiwavelength context and used to model jet parameters, particularly during flare states. We have analyzed this broad *Swift* data set in a search for short timescale variability in blazars that could limit the size of the emission region in the blazar jet. While we do find several low-significance possible flares with potential indications of rapid variability, we find no strong evidence for rapid (<15 minutes) doubling or halving times in flares in the soft X-ray energy band for the AGNs analyzed.

Earlier attempts did not lead to success

X-ray Emission in Blazars



(Abdo+, 2011, ApJ, 736, 131)

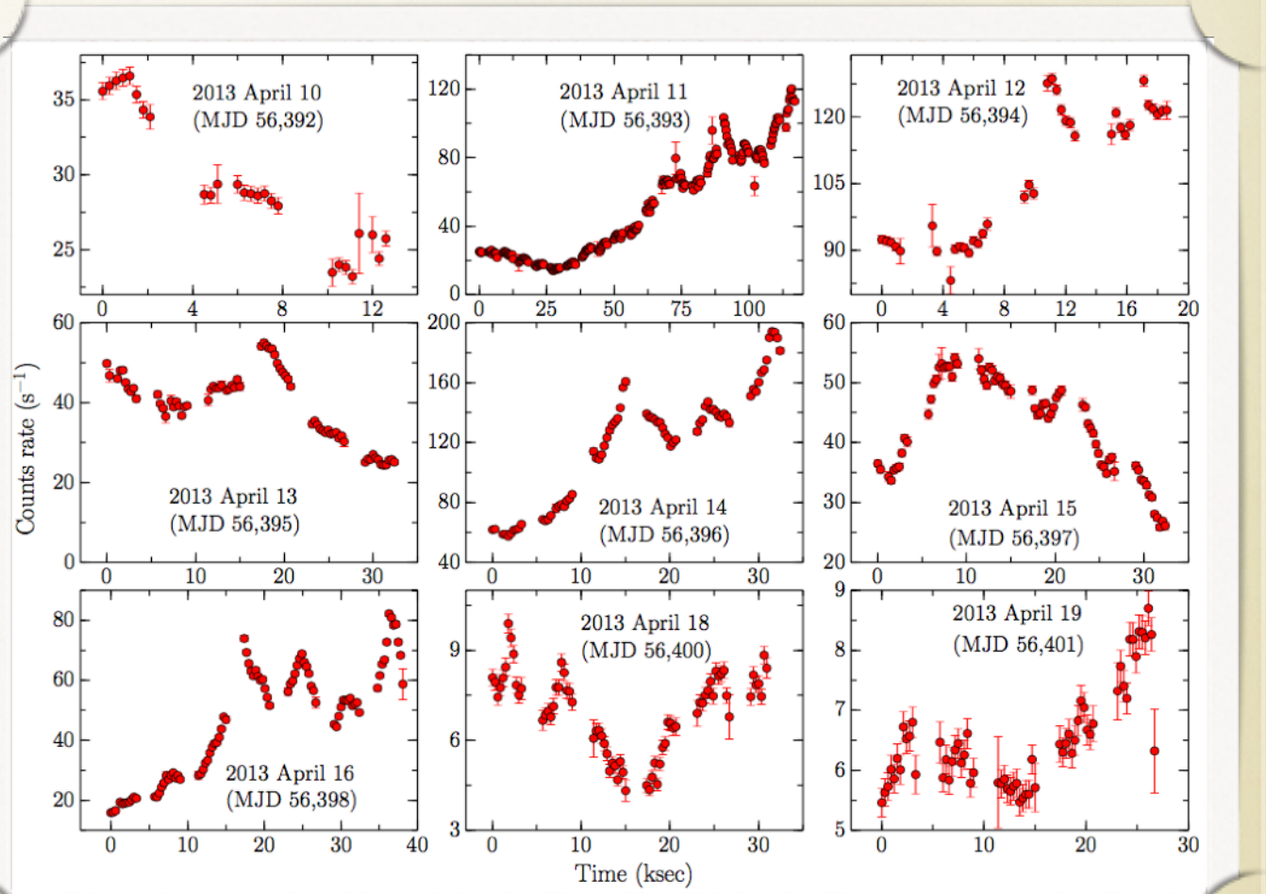


(Balokovic+, 2016, ApJ, 819, 156)

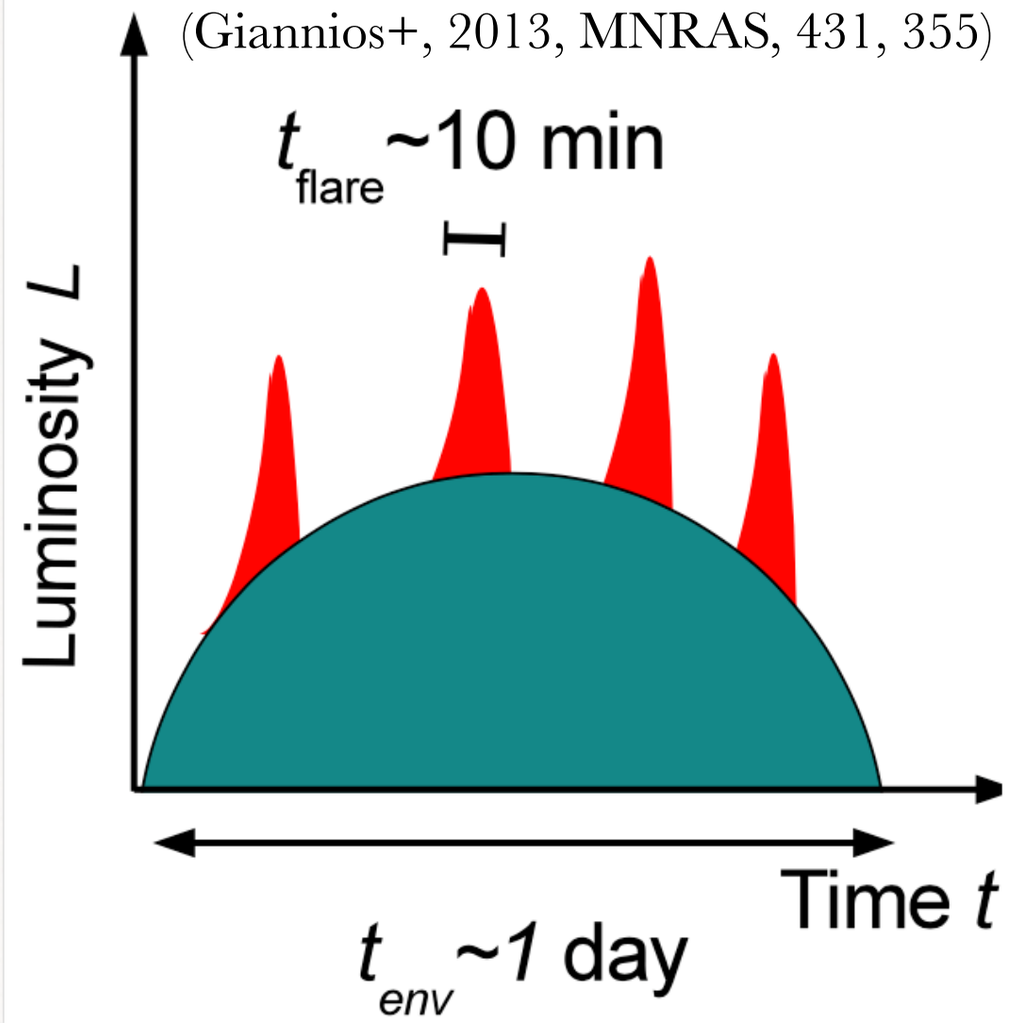
- The X-ray & TeV emissions in BL Lac objects originate from the highest energy electrons
- This implies that **BL Lacs** are the most variable in the X-ray and TeV bands ($t_{cool} \propto \gamma^{-1}$) and should be **primary target for STROBE-X**

Hard X-ray: NuSTAR

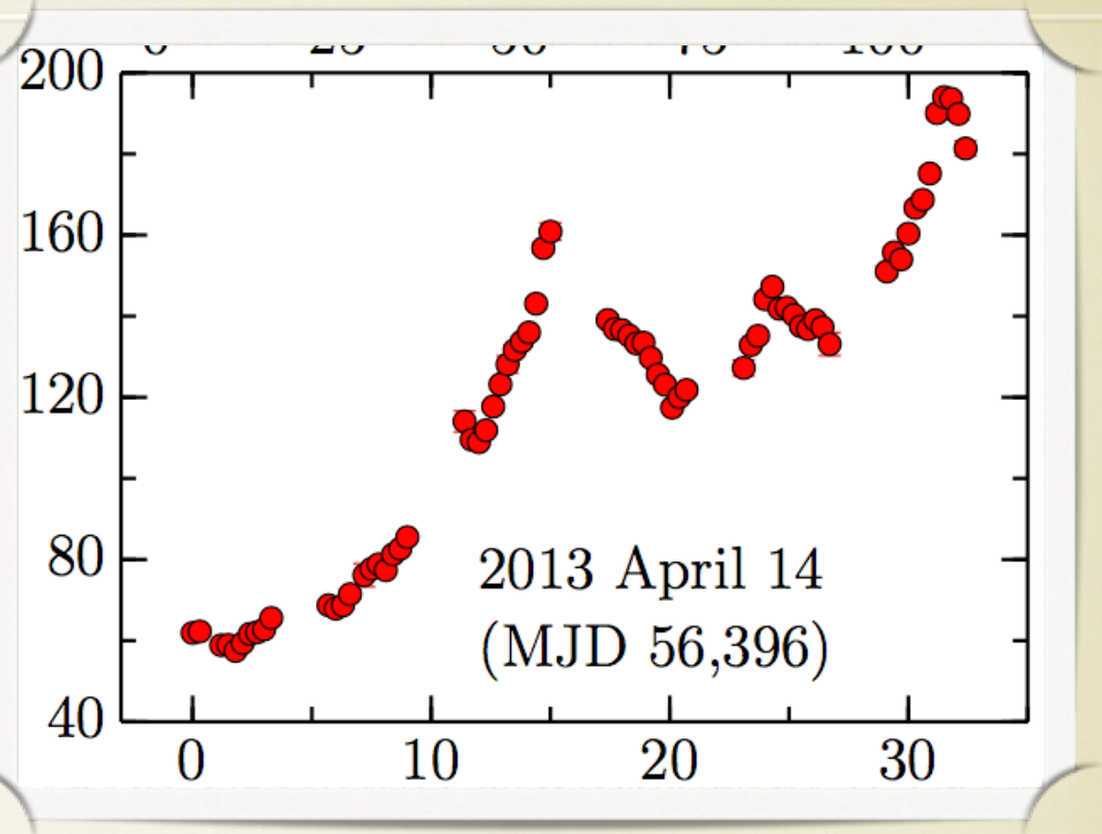
- *NuSTAR* observations of Mrk 421 during a giant X-ray outburst in April 2013
- The shortest flux doubling time ~15 minutes
- This is ~light crossing timescale of the black hole event horizon for Mrk 421

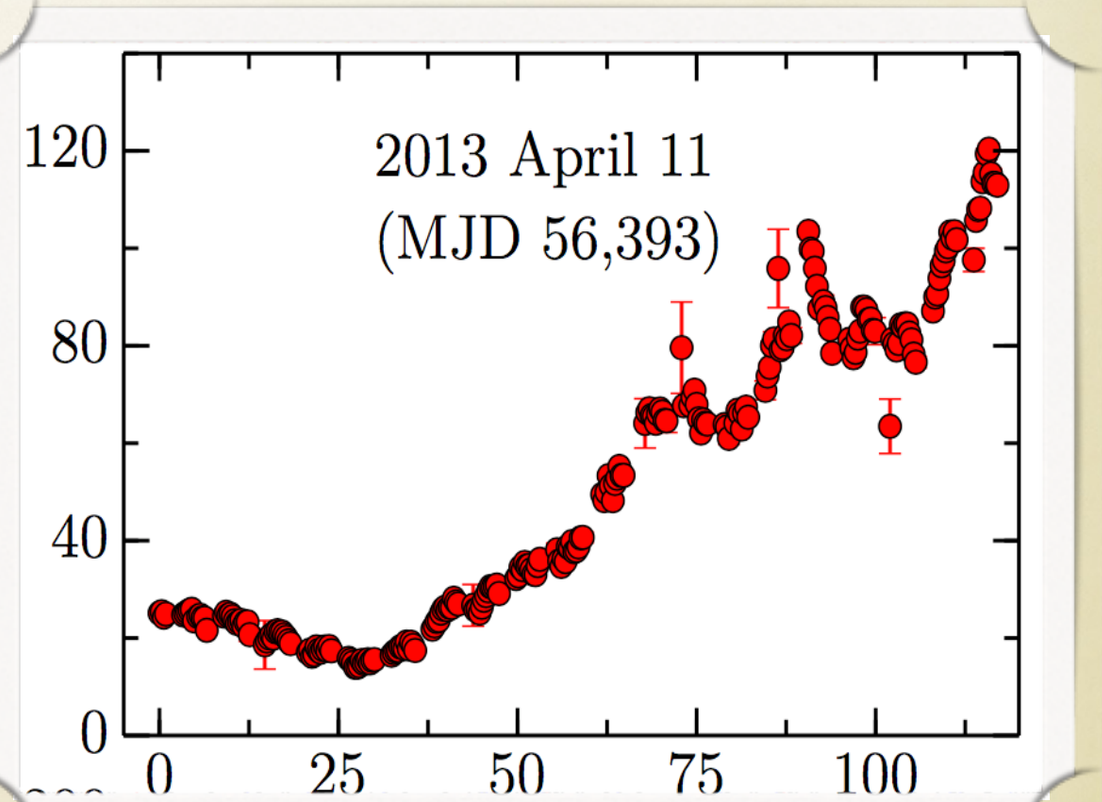


(Paliya+, 2015, ApJ, 811, 143)



- Evidence of the magnetic reconnection events?
- **We are limited by the observations!!**
- **STROBE-X can provide the breakthrough**



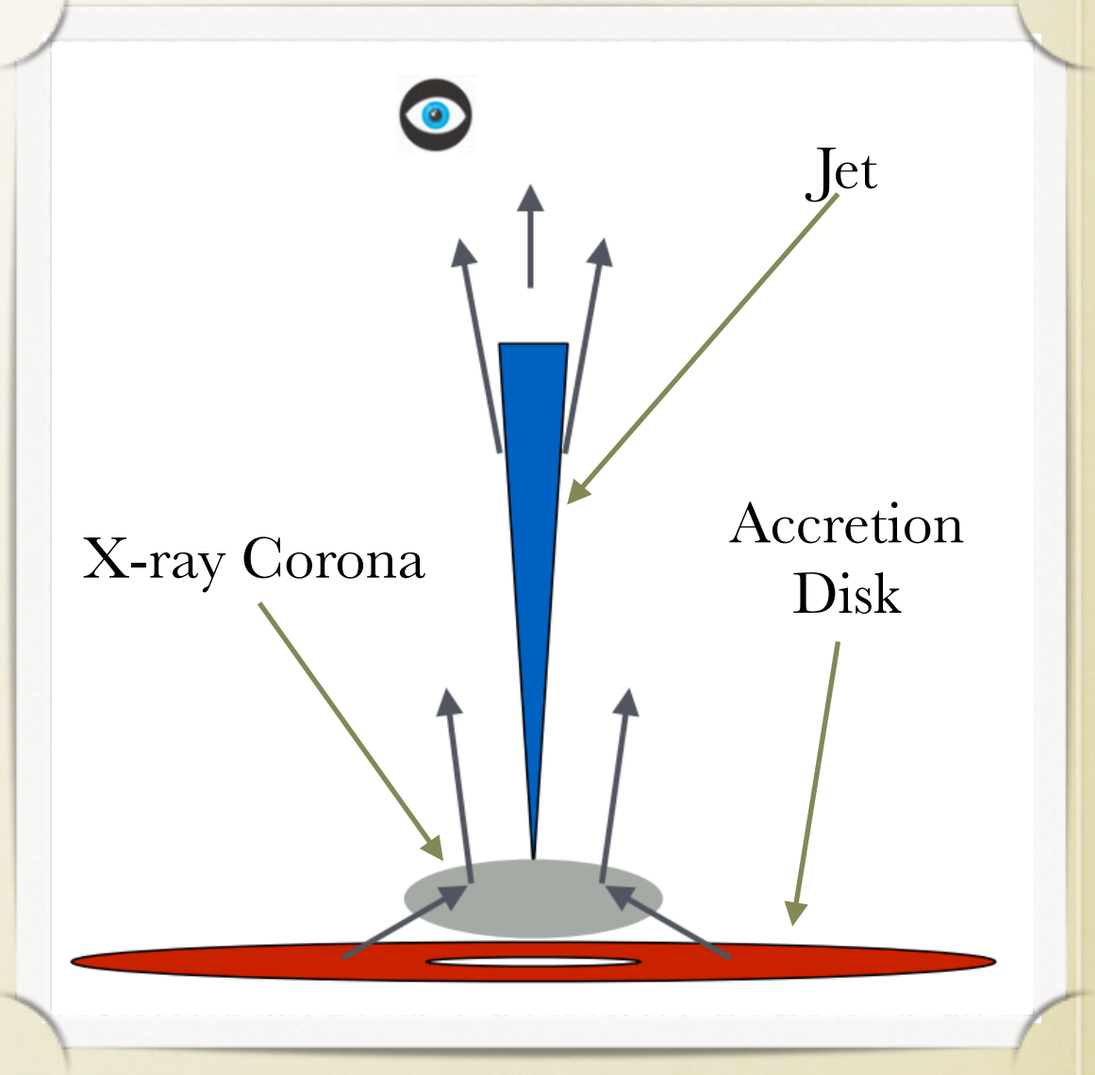


The Strategy

- Select the a few bright BL Lacs (Mrk twins, PKS 2155-304, 1ES 1959+650 etc.)
- Keep an eye on them using the all sky monitoring capabilities of the 'Wide-Field Monitor (WFM)'
- WFM can also be used to alert TeV telescopes in real time of extremely strong flares
- Observe as long as possible with X-ray Concentrator Array (XRCA) and the Large Area Detector (LAD)
- Fine time binned (<5 min) light curve will discriminate the origin of the X-ray emission, e.g., between the reconnection events and shock-in-jet scenario

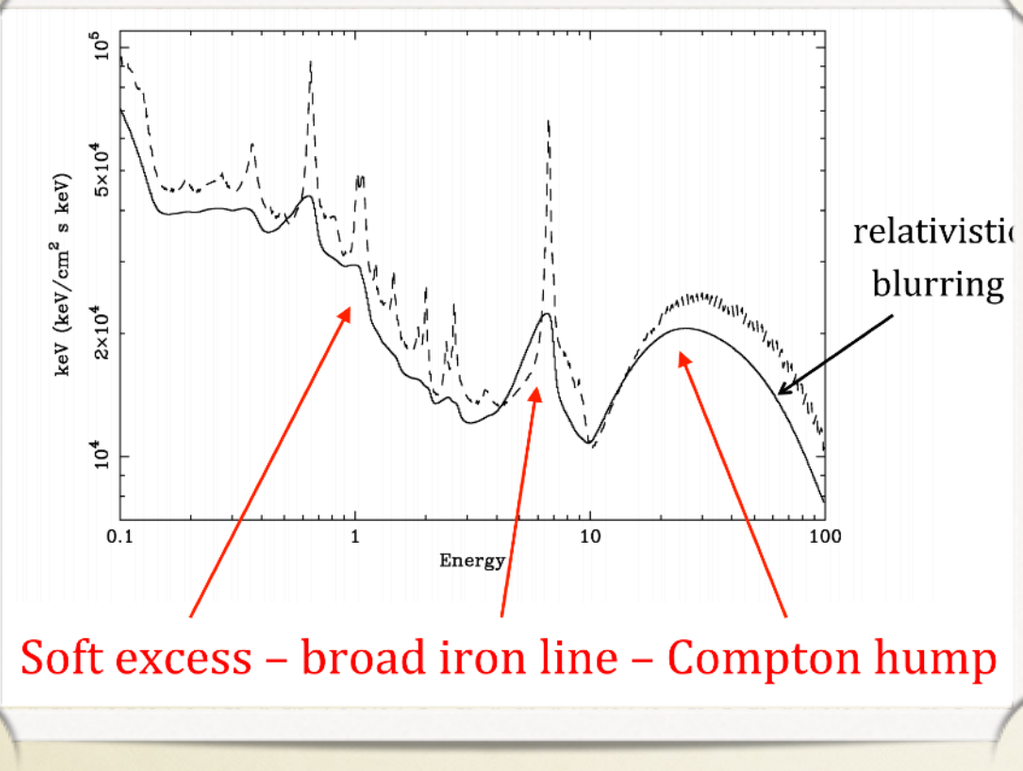
The jet-disk Connection

- Gamma-ray emitting narrow line Seyfert 1 galaxies are a strong case to study the disk-corona-jet connection
- X-ray coronal emission mostly dominate at soft X-rays (≲2 keV) and the jet emission takes over beyond that
- X-ray reverberation mapping of γ-NLSy1 sources



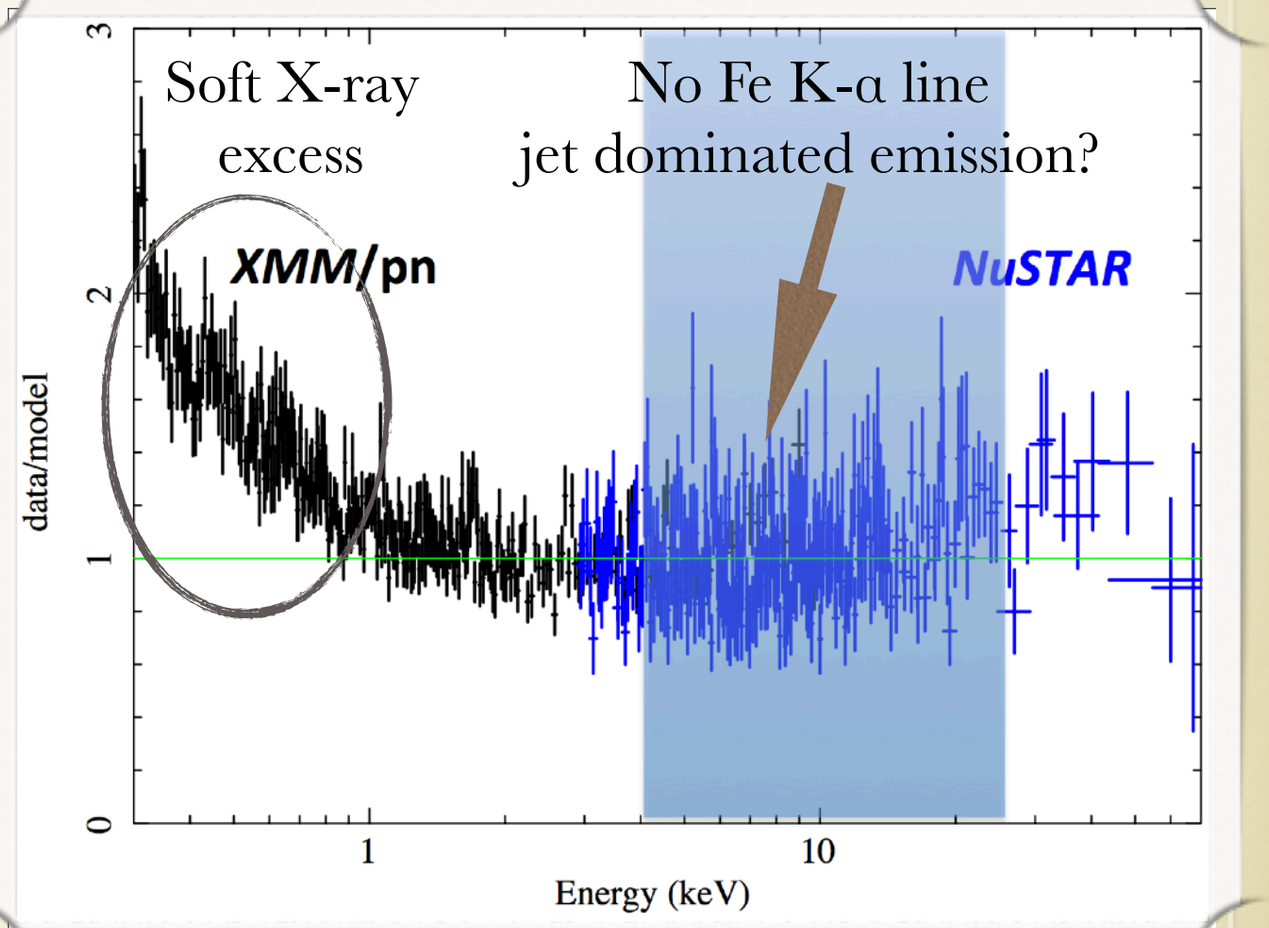
(P.C.: J. Larsson)

RQ-NLSy1 galaxy



(A. C. Fabian, 2016, AN, 337, 375)

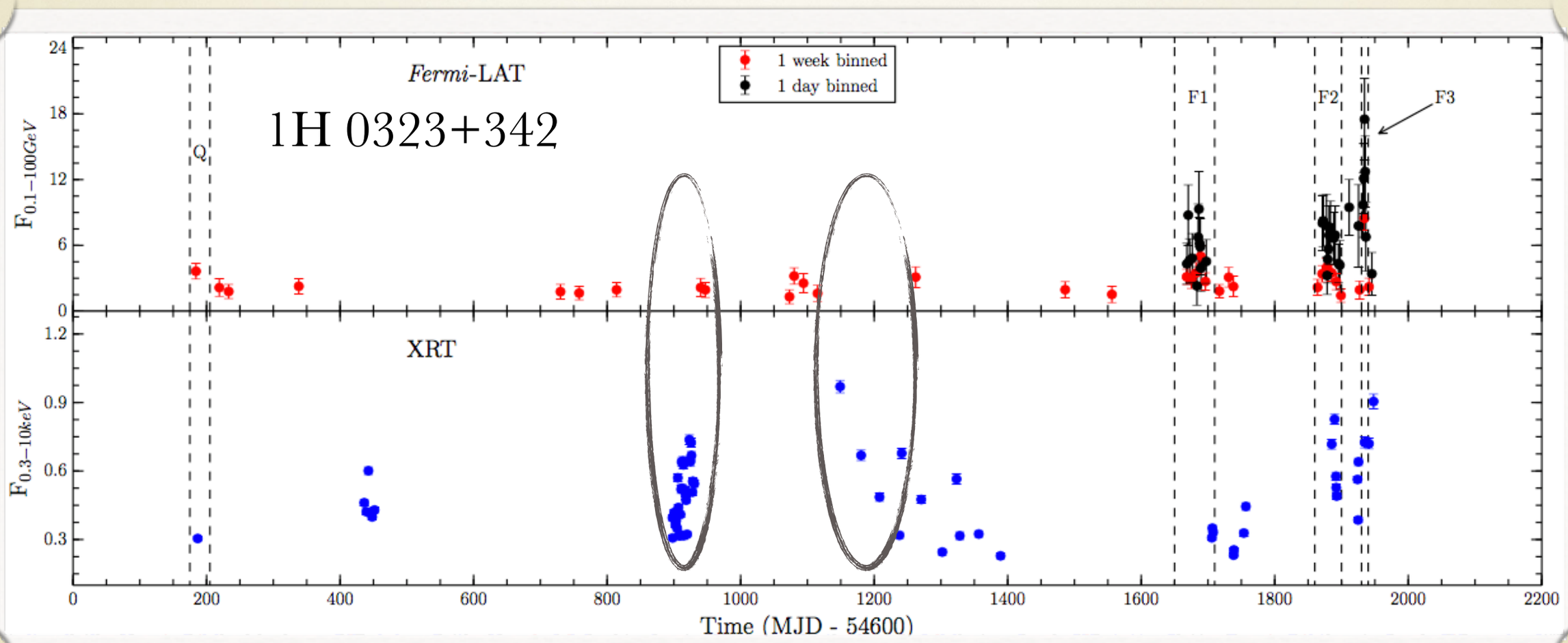
γ-NLSy1 galaxy



(L. Brenneman, in XMM Universe, 2017)

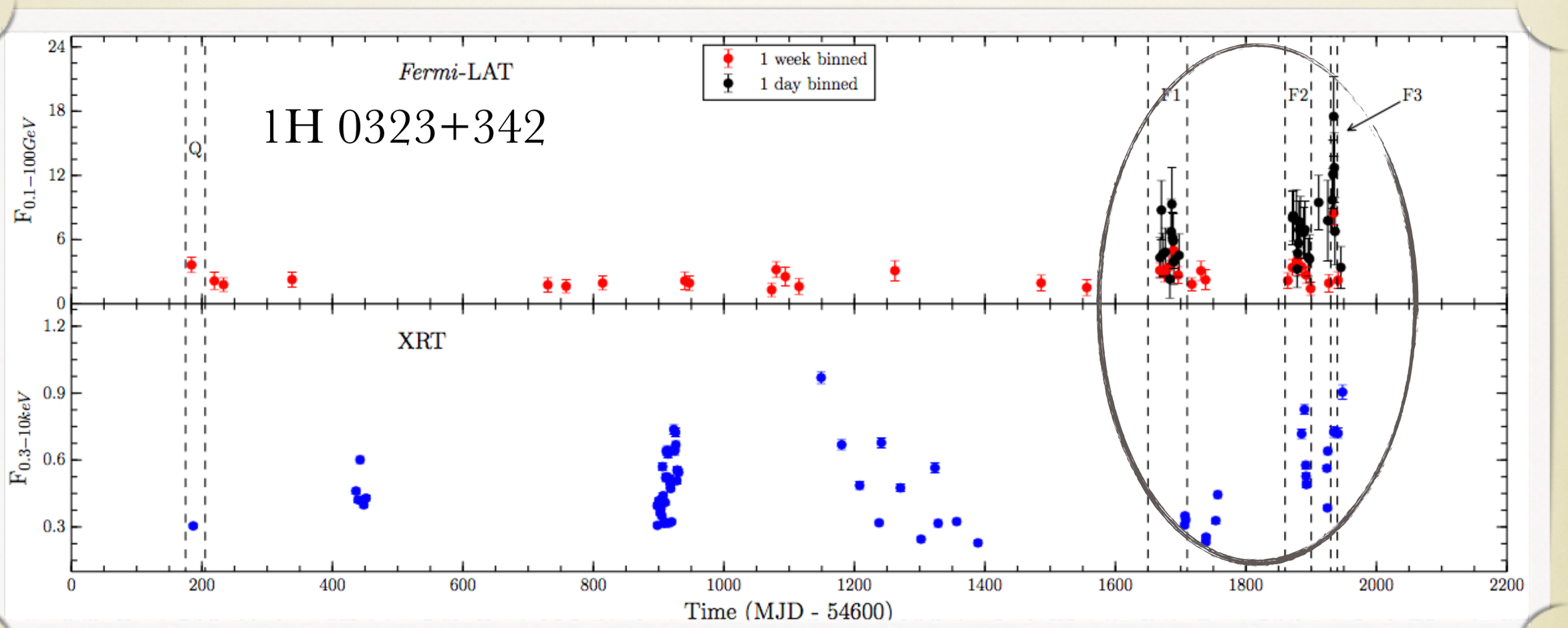
- γ-NLSy1 galaxies are possibly a missing link between RQ sources and jetted systems
- Simultaneous XRCA and LDA observations will be crucial

The jet-disk Connection



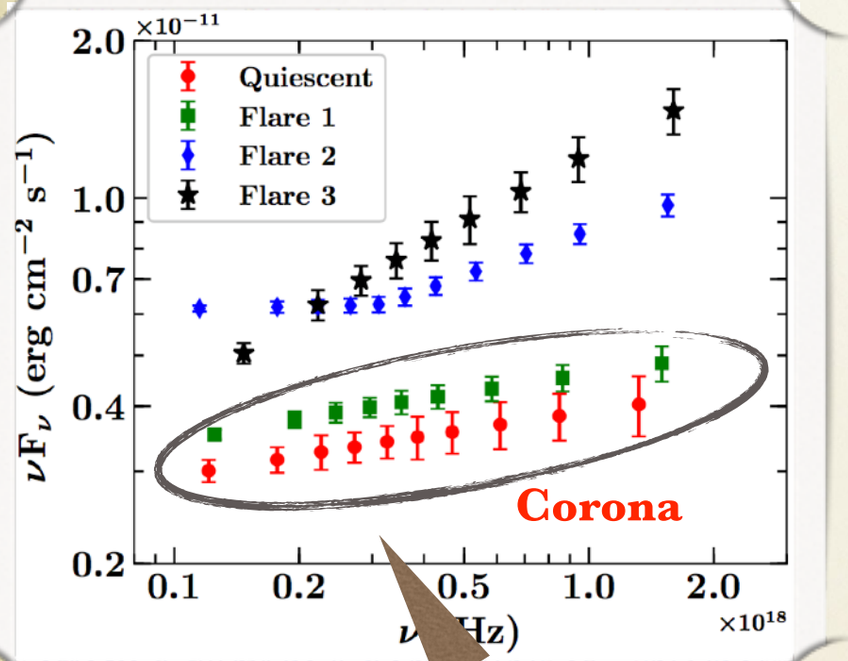
- Observations of the orphan X-ray flares with no γ-ray counterparts: X-ray corona flares?

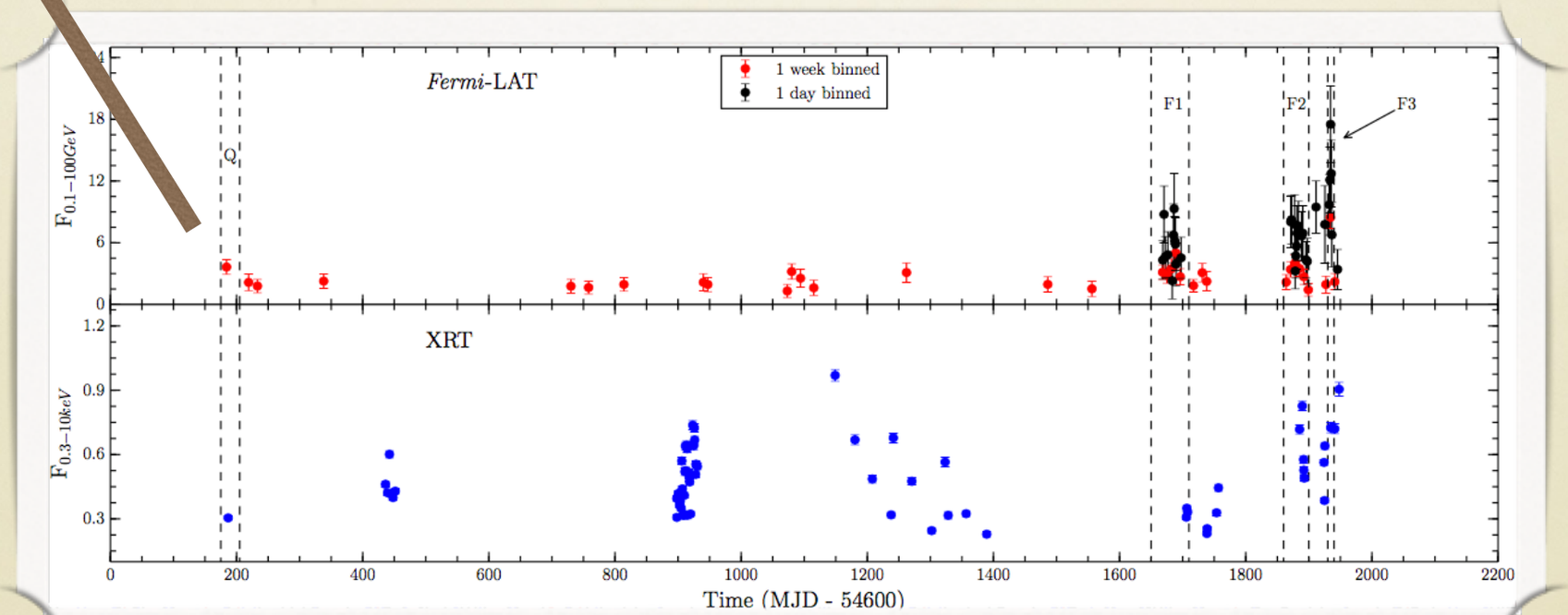
The jet-disk Connection



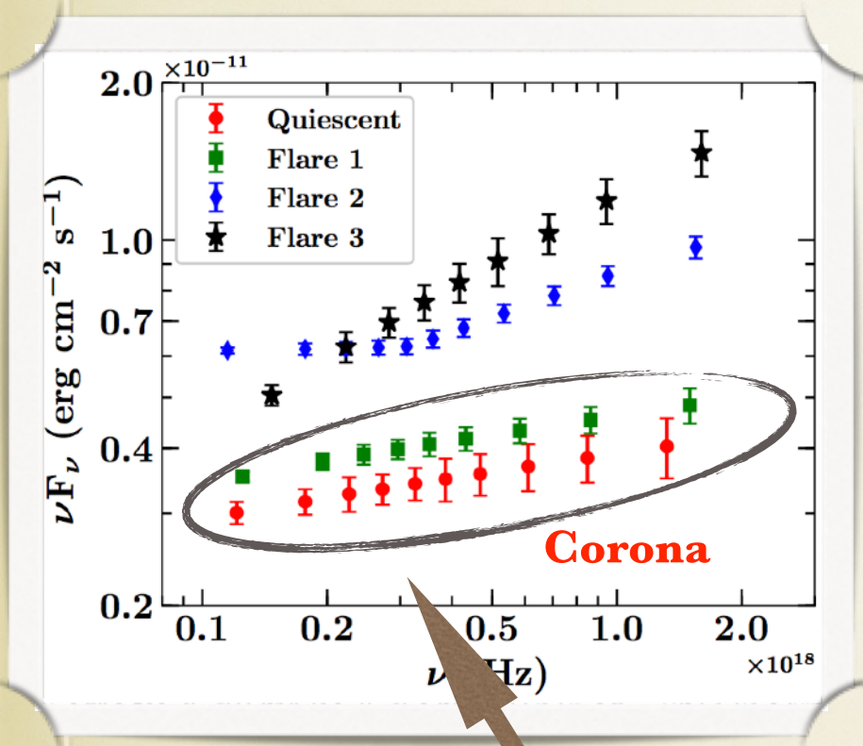
- Observations of the orphan X-ray flares with no γ-ray counterparts: X-ray corona flares?
- Later, GeV flares with the elevated X-ray emission were also detected: evidence of the jet dominated emission?

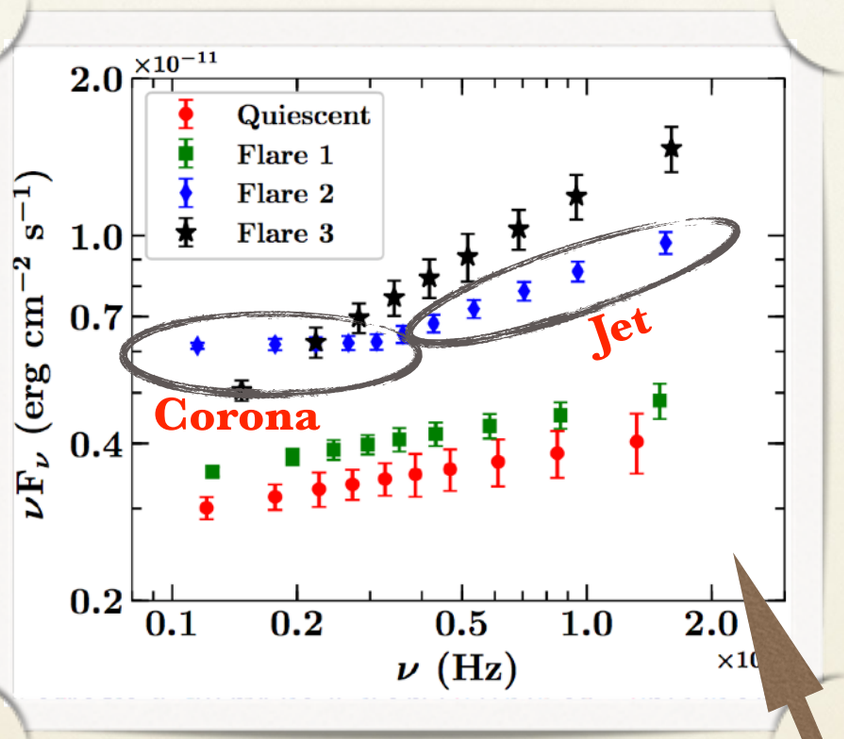
The jet-disk Connection

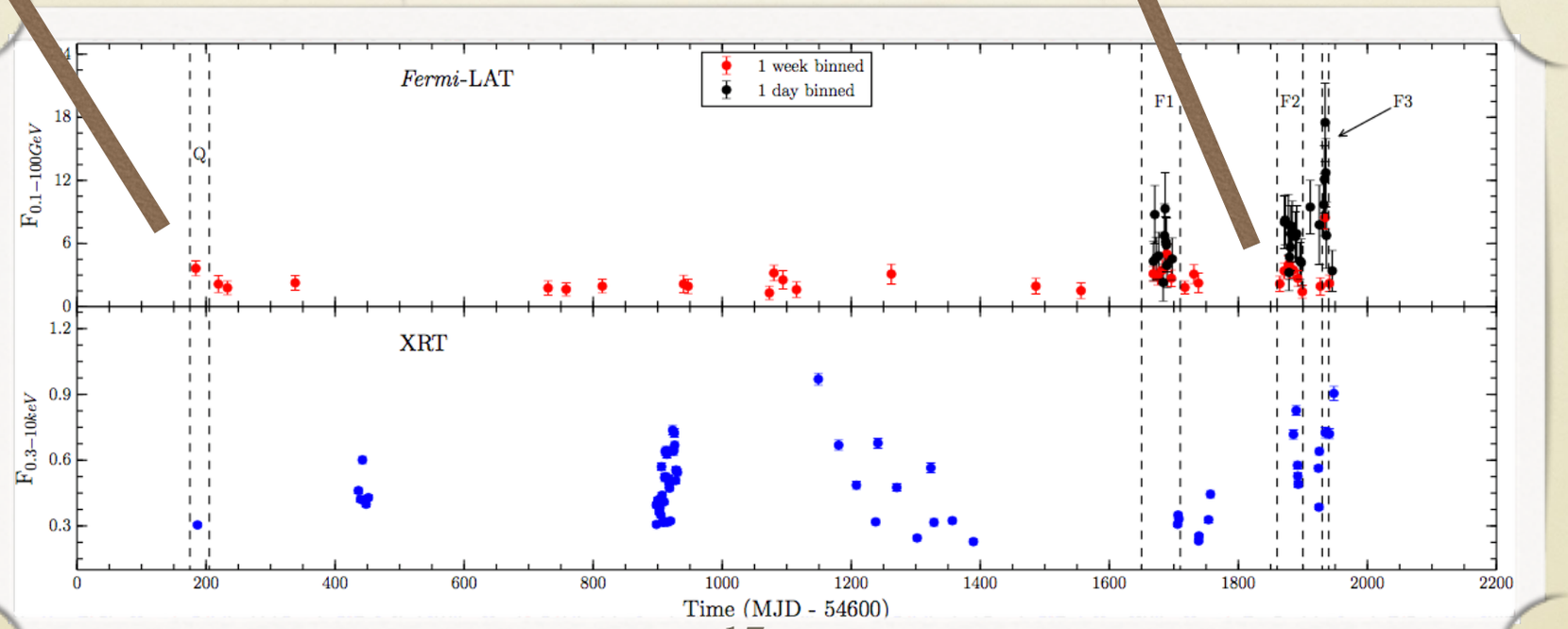




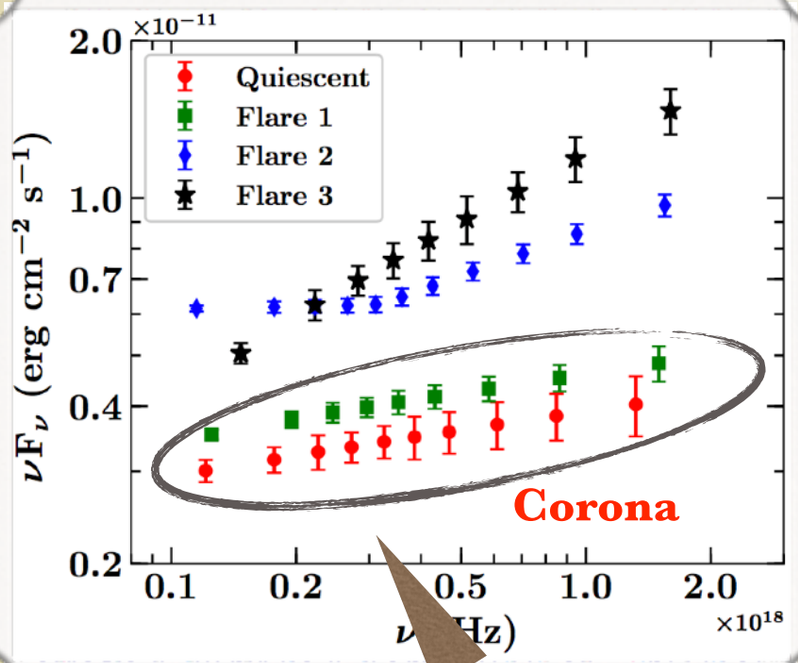
The jet-disk Connection

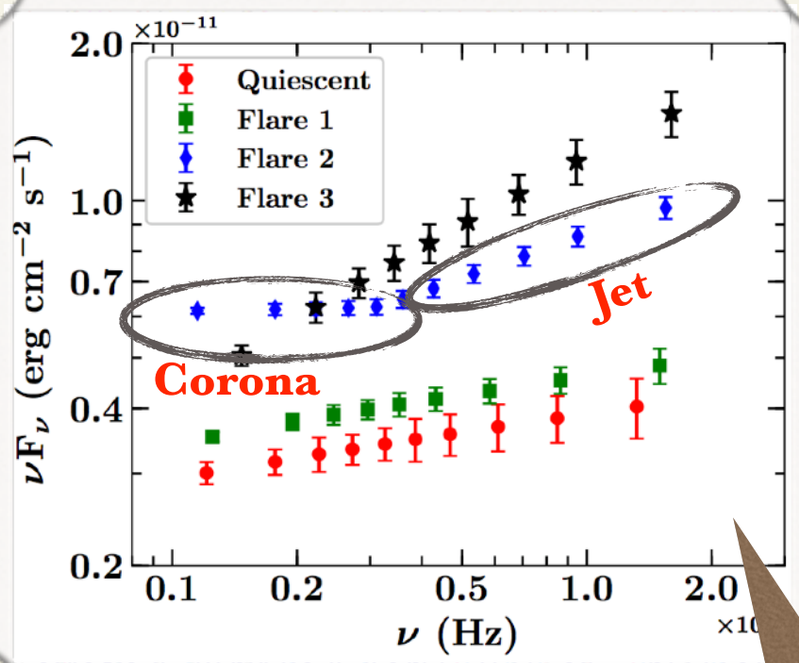


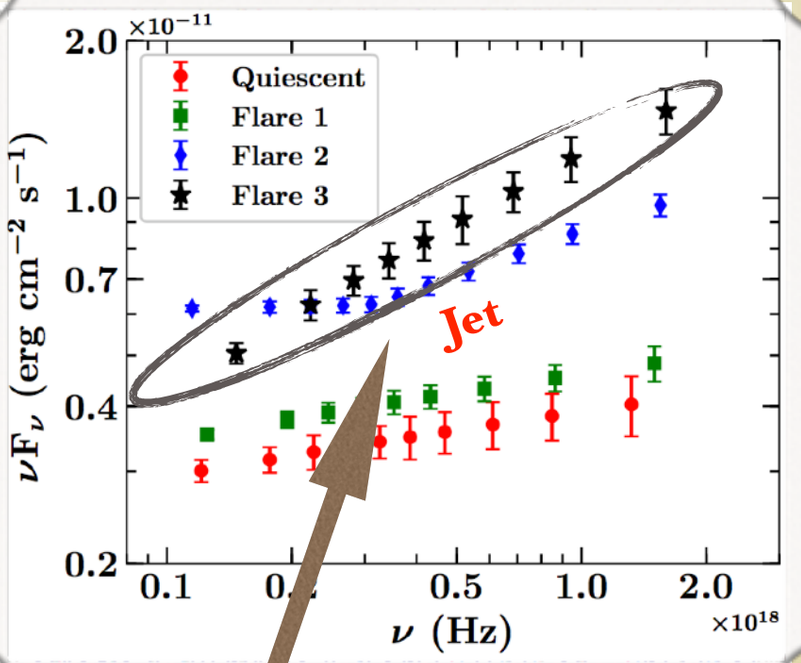


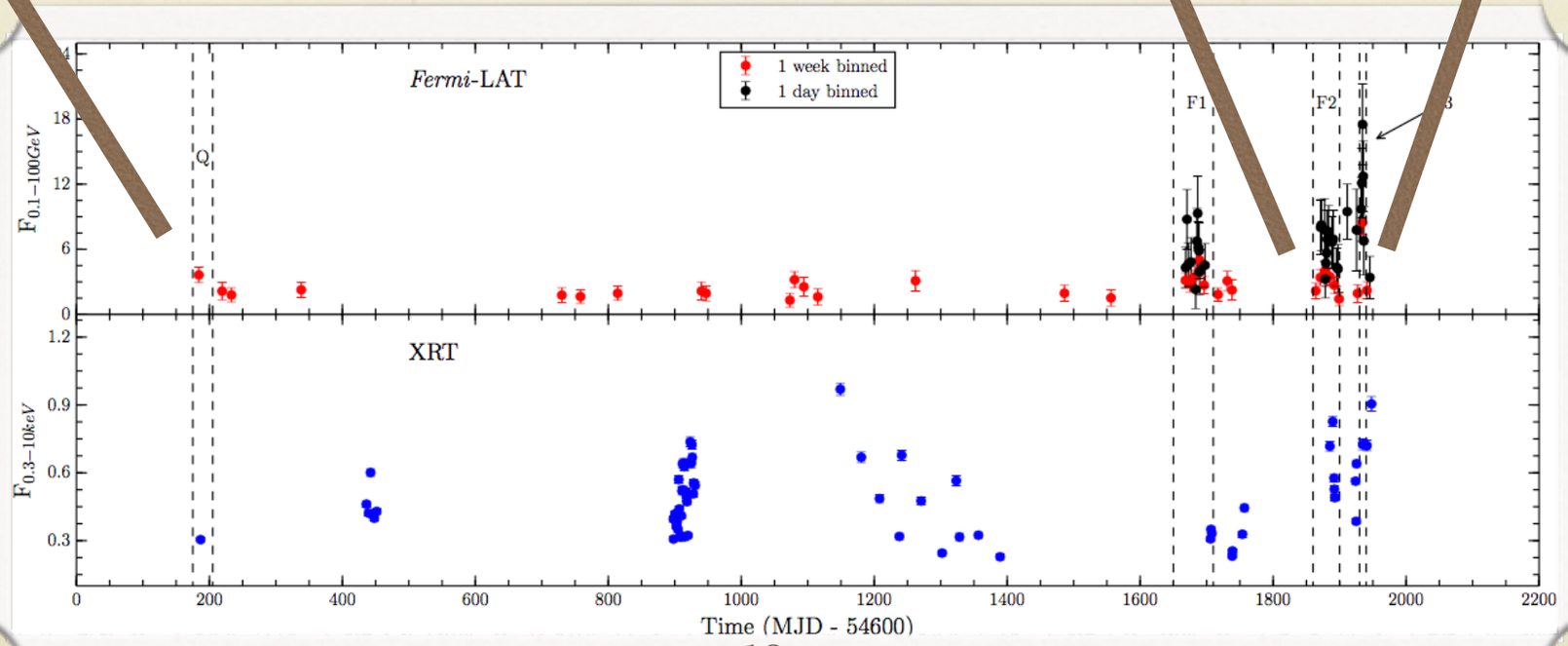


The jet-disk Connection





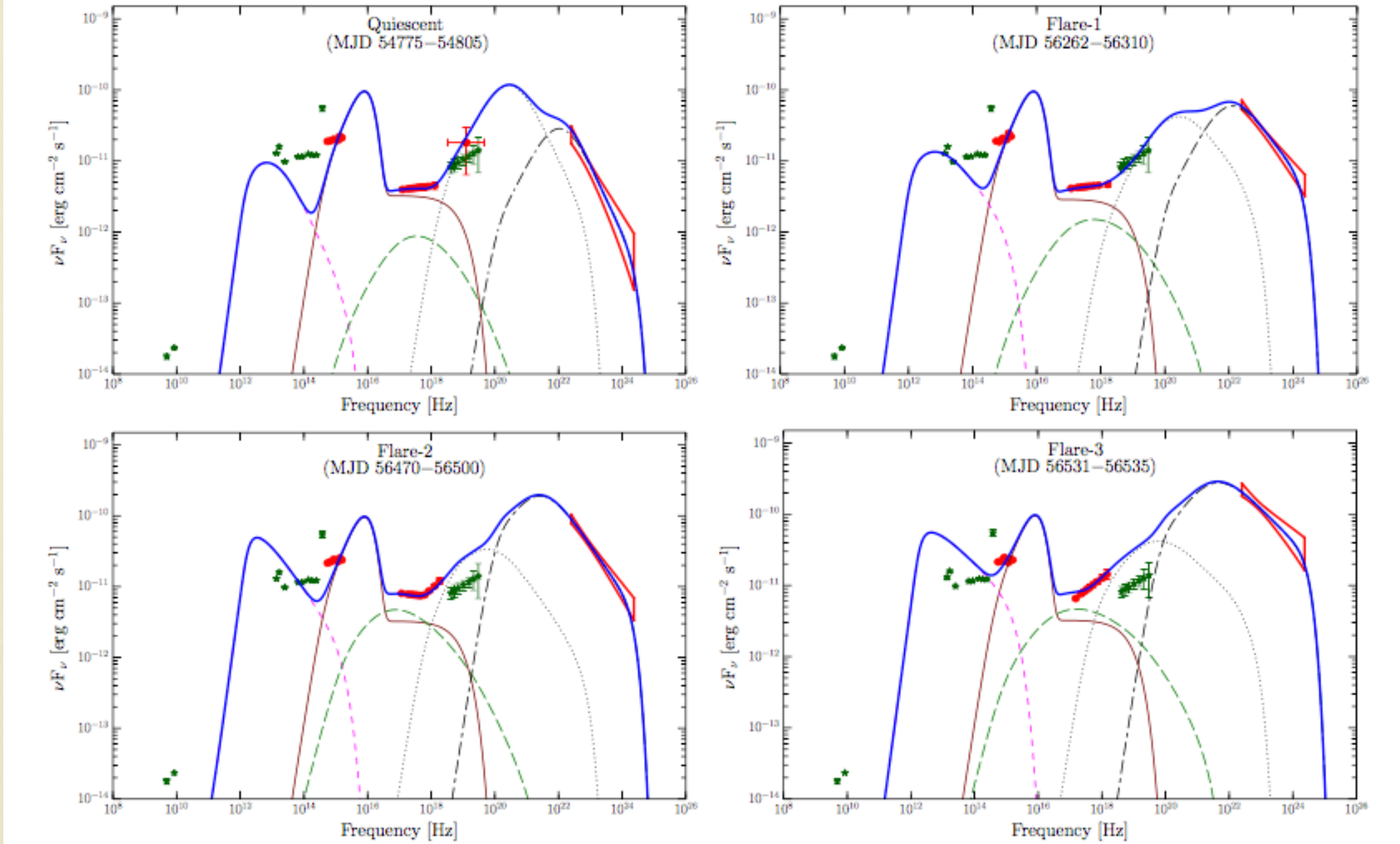




Summary

- STROBE-X has the power to resolve the flaring X-ray emission from blazars (particularly BL Lacs) down to minute (or even smaller) timescales
- This will allow us to understand the mechanisms of the X-ray production throwing more light on the jet environment
- γ-NLSy1 galaxies are the primary target to study the disk-corona-jet connection in an unprecedented detail, both in their low and elevated activity states

!!Thank You!!



Broadband SED behavior of 1H 0323+342