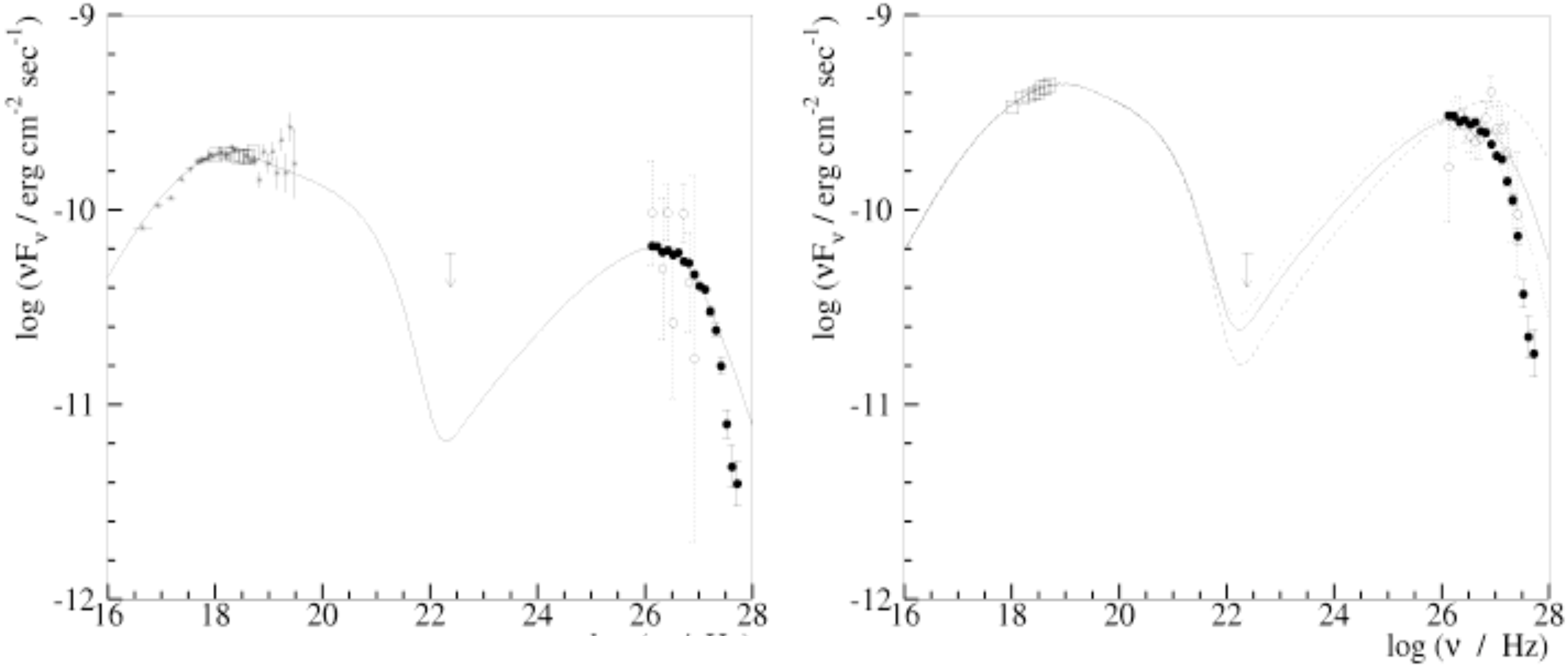
What are the physical changes that drive the observed
blazar variability?

This is a difficult question because many variability patterns have been seen.

The simplest: in SSC an increase in the injected electrons Should increase the synchrotron component linearly (because its flux scales with the the electron number) and the SSC component quadratically because its flux scales with The electron number and the synchrotron flux.

This quadratic variation is rare, but it has been seen:




Quadradic SSC variability in Mkn 501

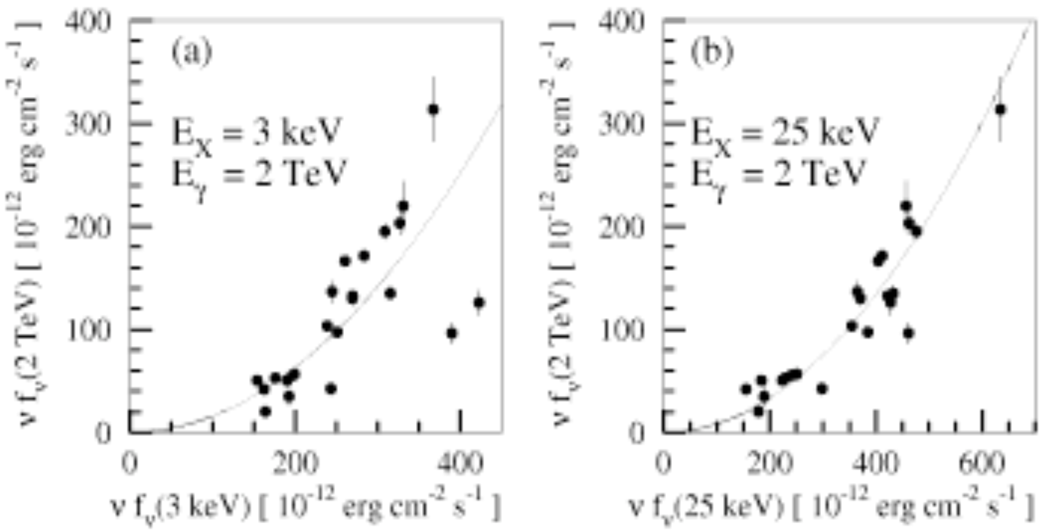
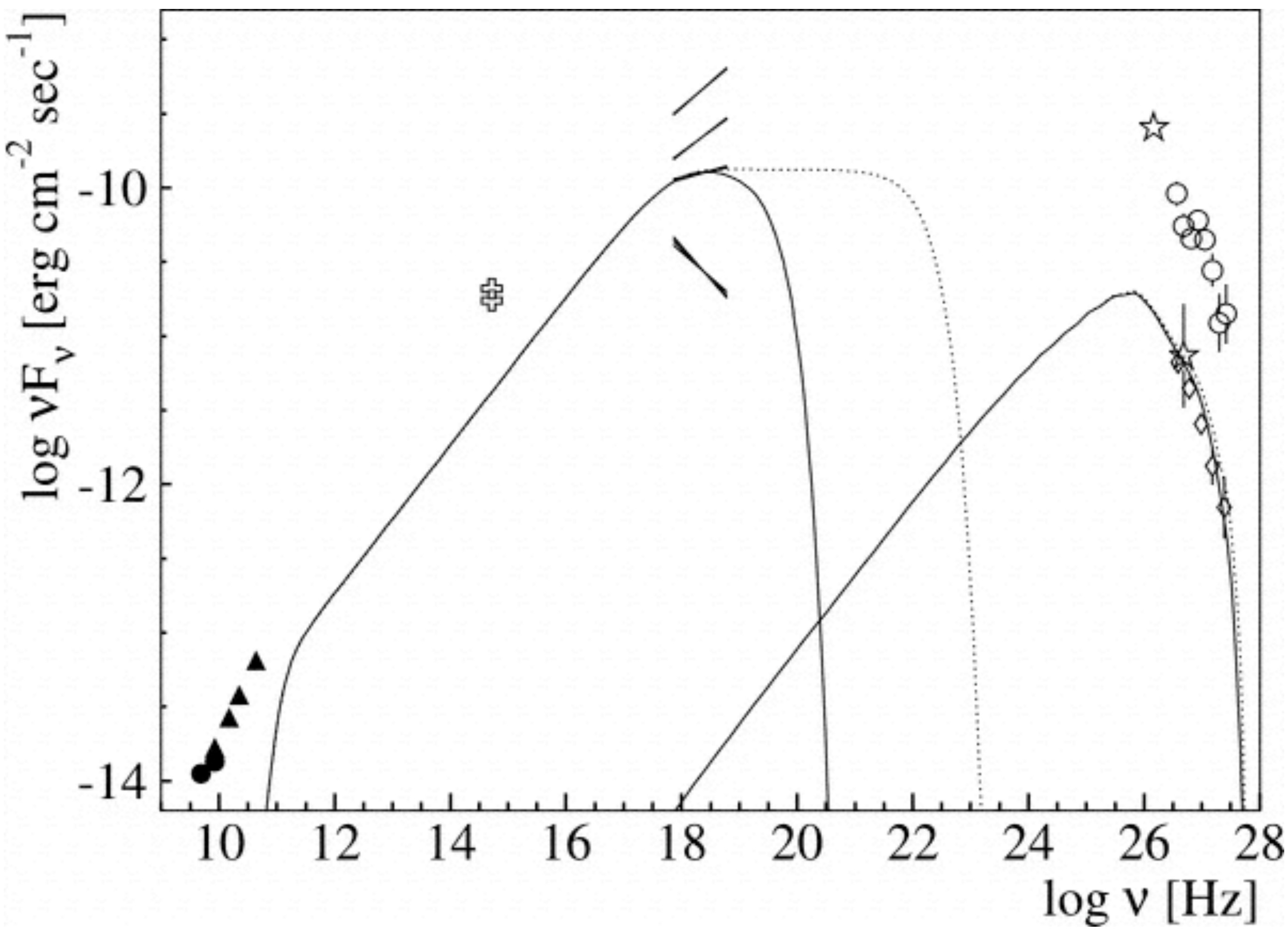
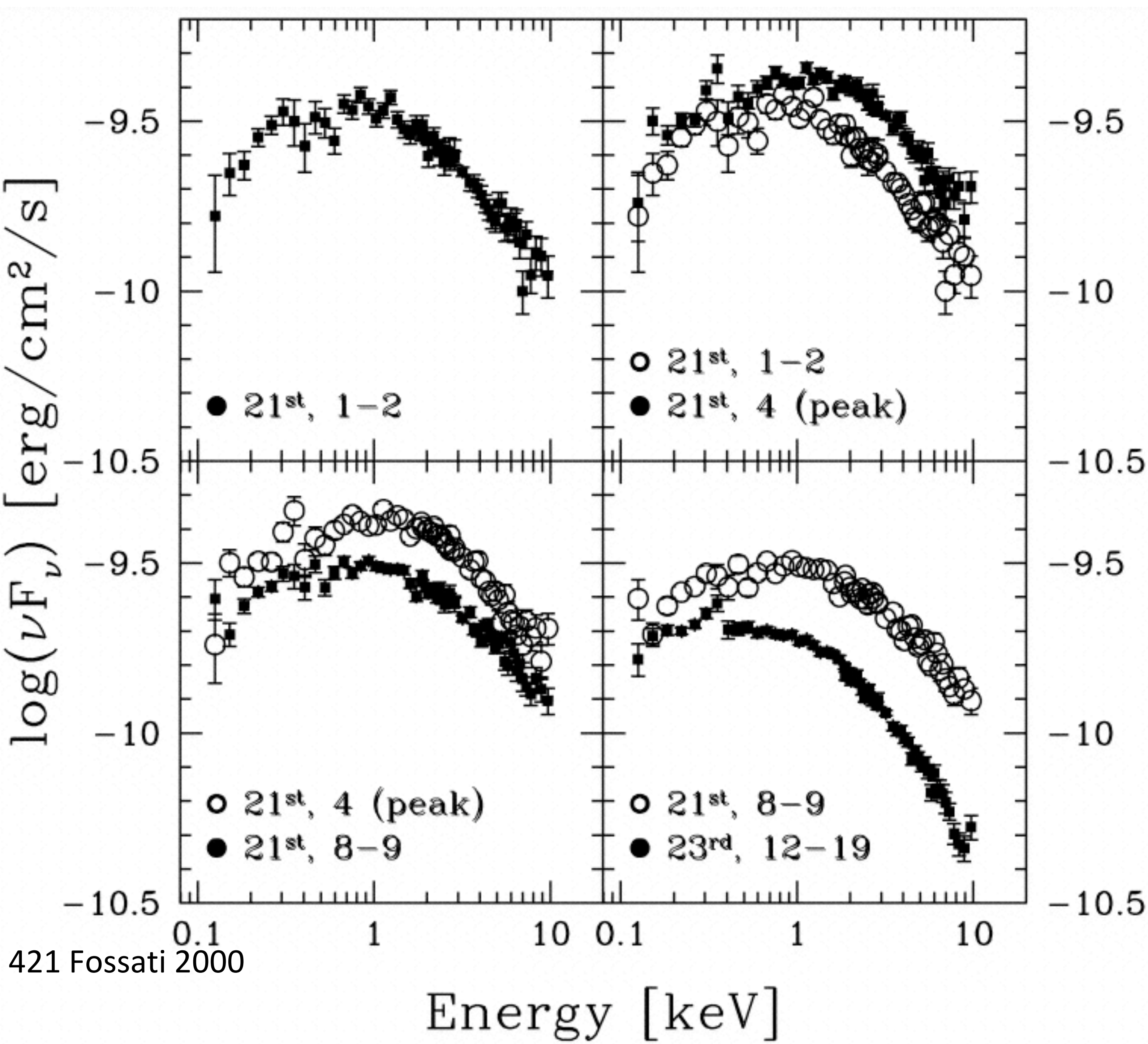



**Fig. 6a and b.** Correlation of the RXTE energy fluxes at $E_X = 3$ keV

But nature is much richer than that. A few cases follow.




1ES 1959+650 Krawczynski et al. 2004




MKN 421 Fossati 2000

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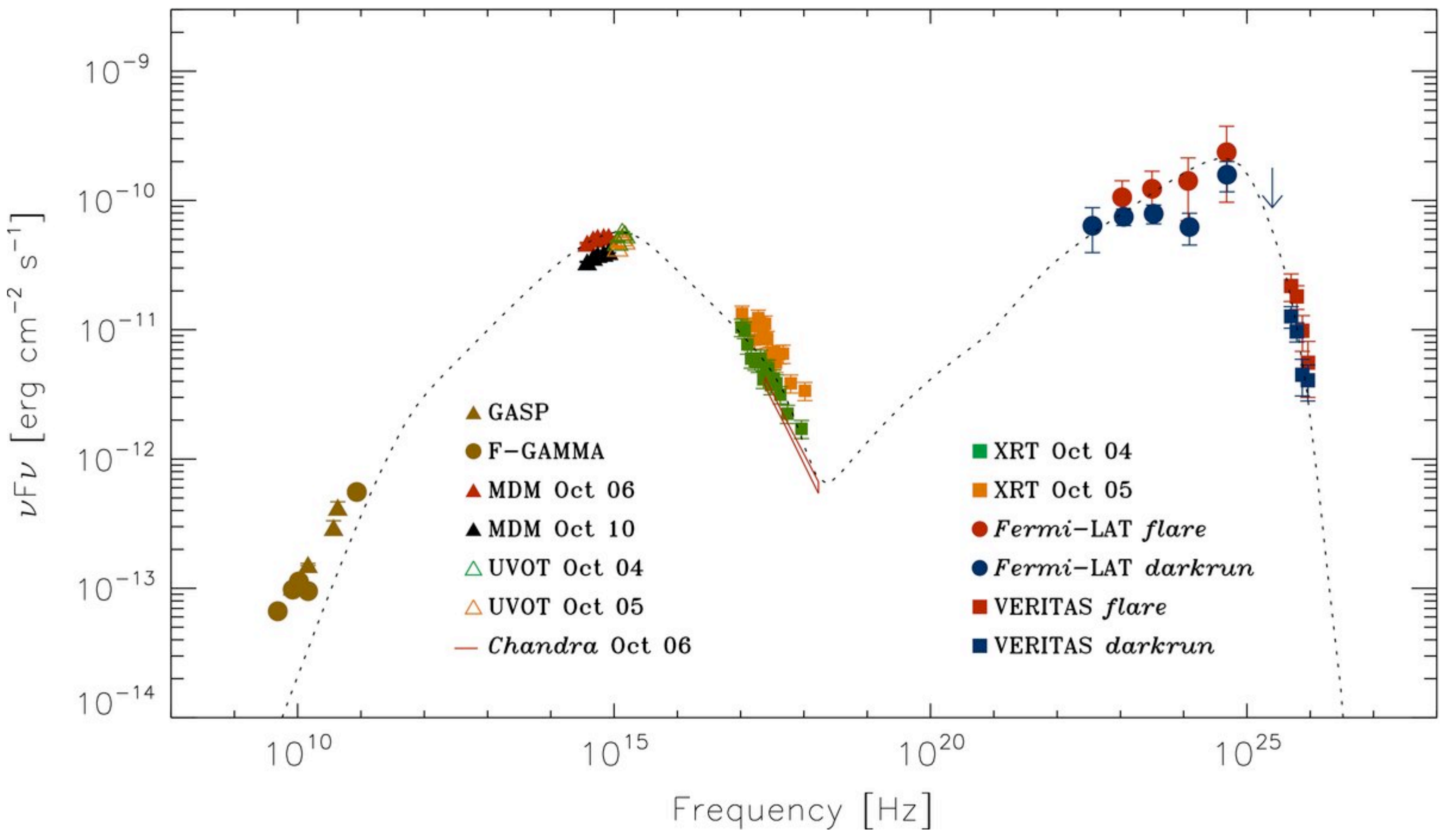


Abdo et al. 2011

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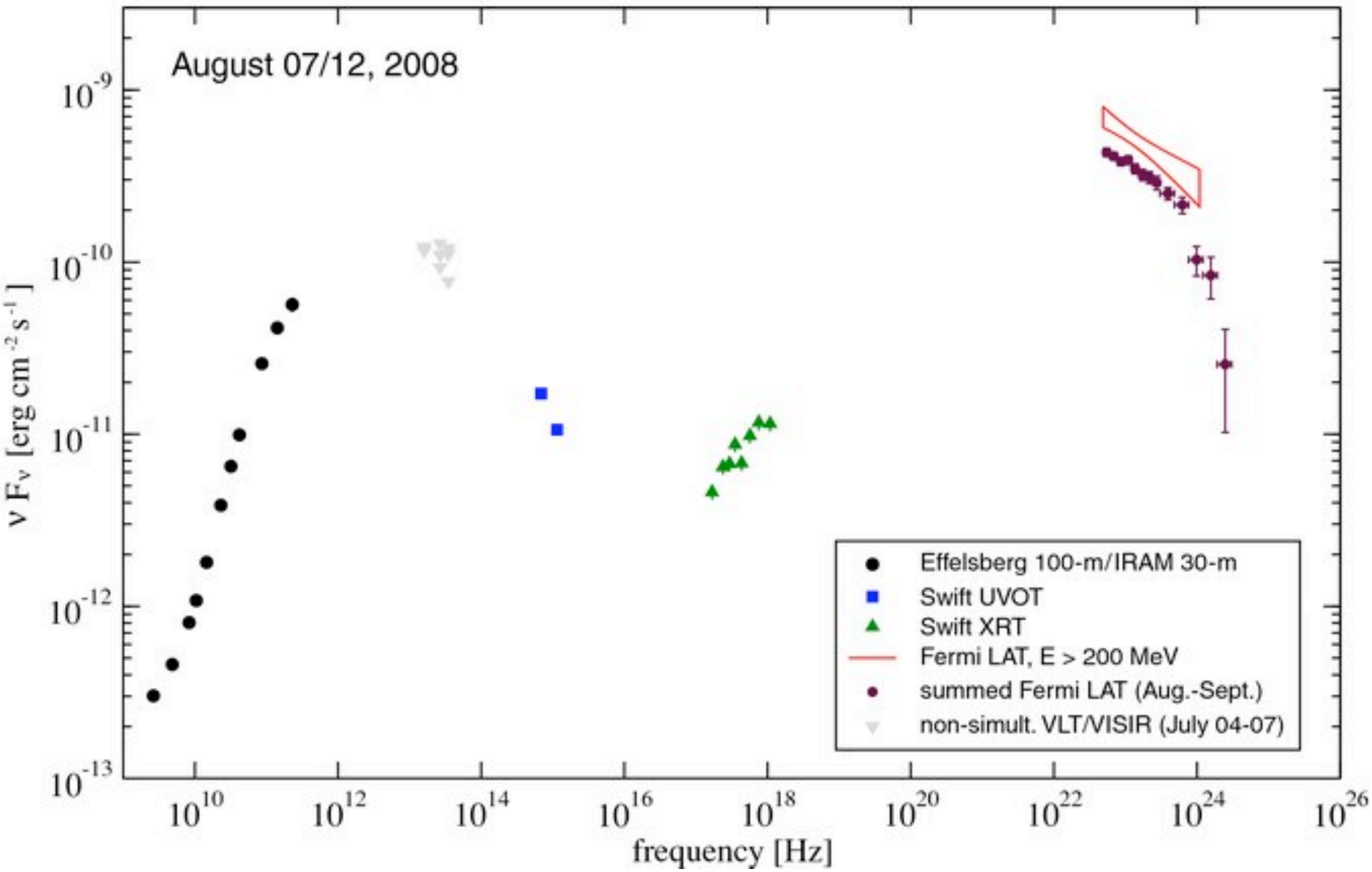


Abdo et al. 2009

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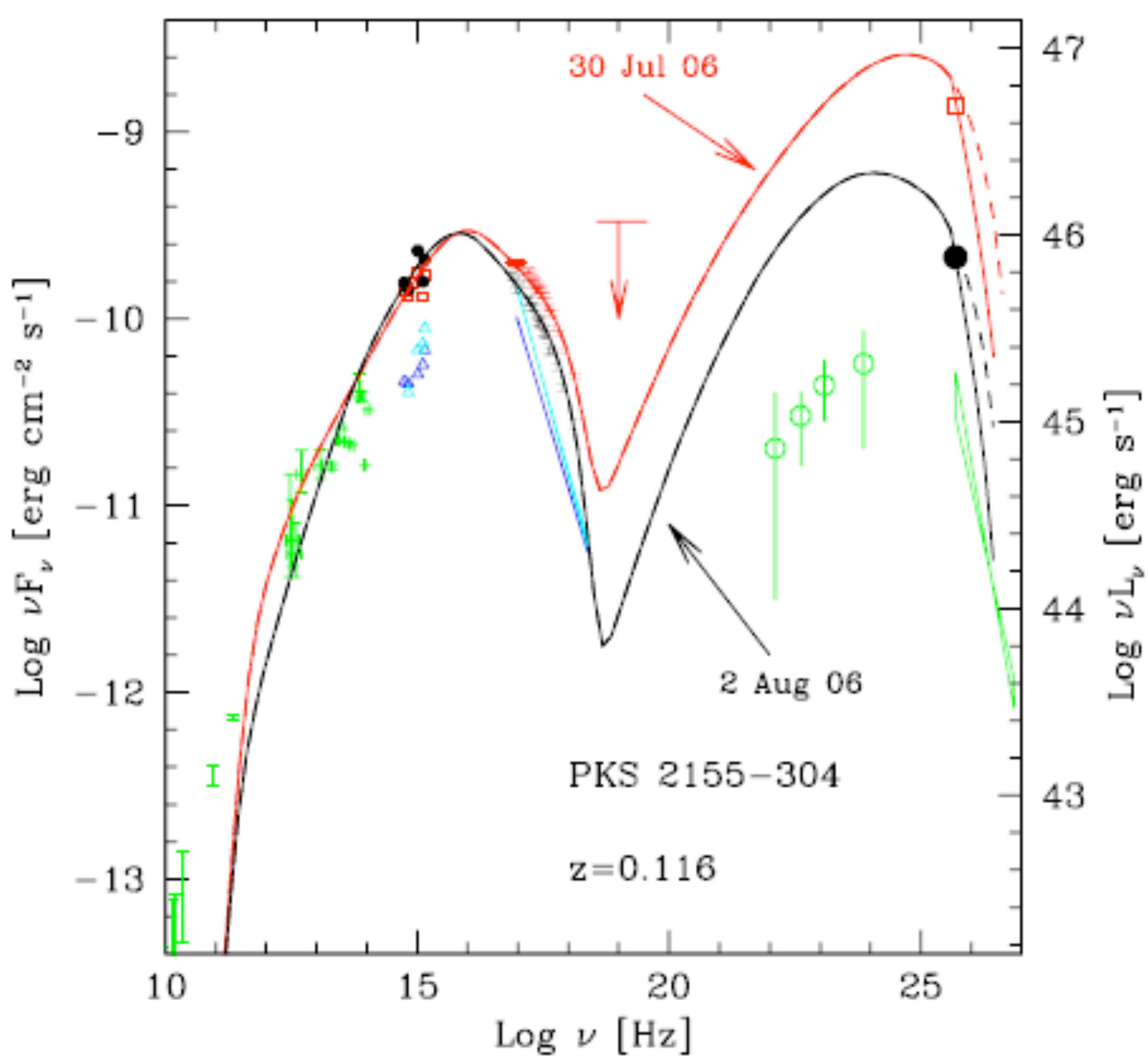
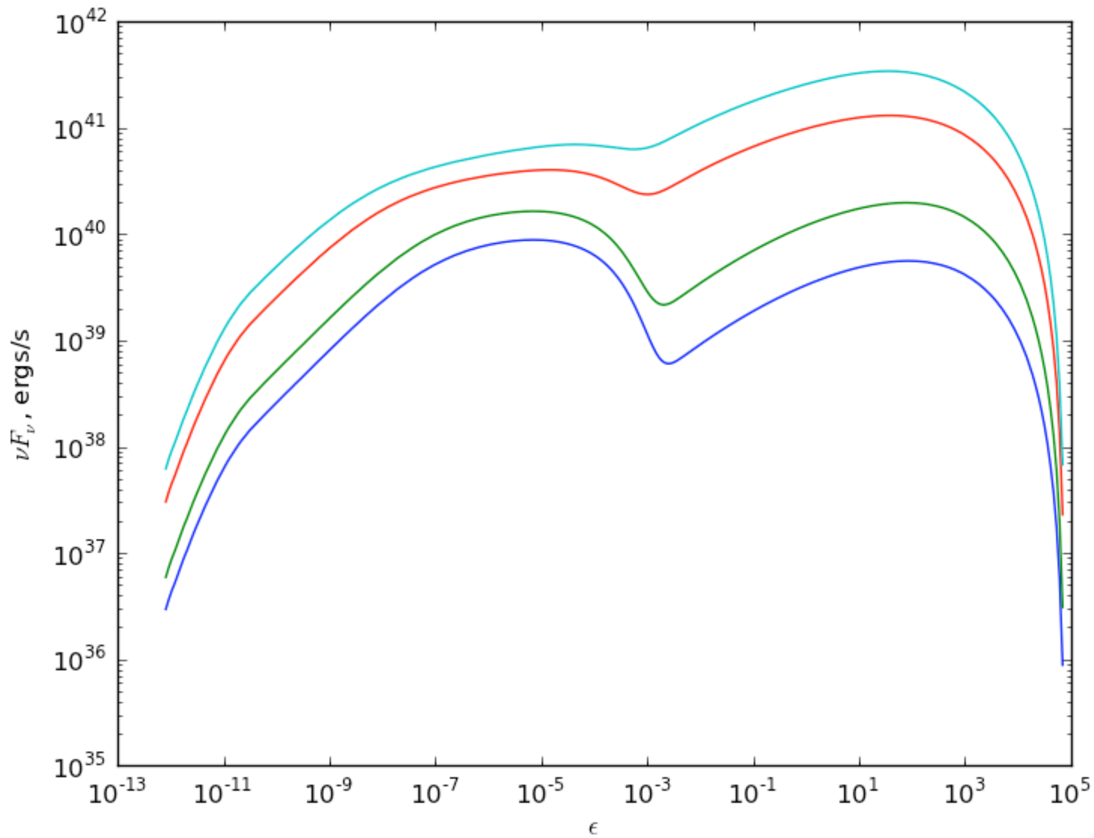



Foschini et al. 2007

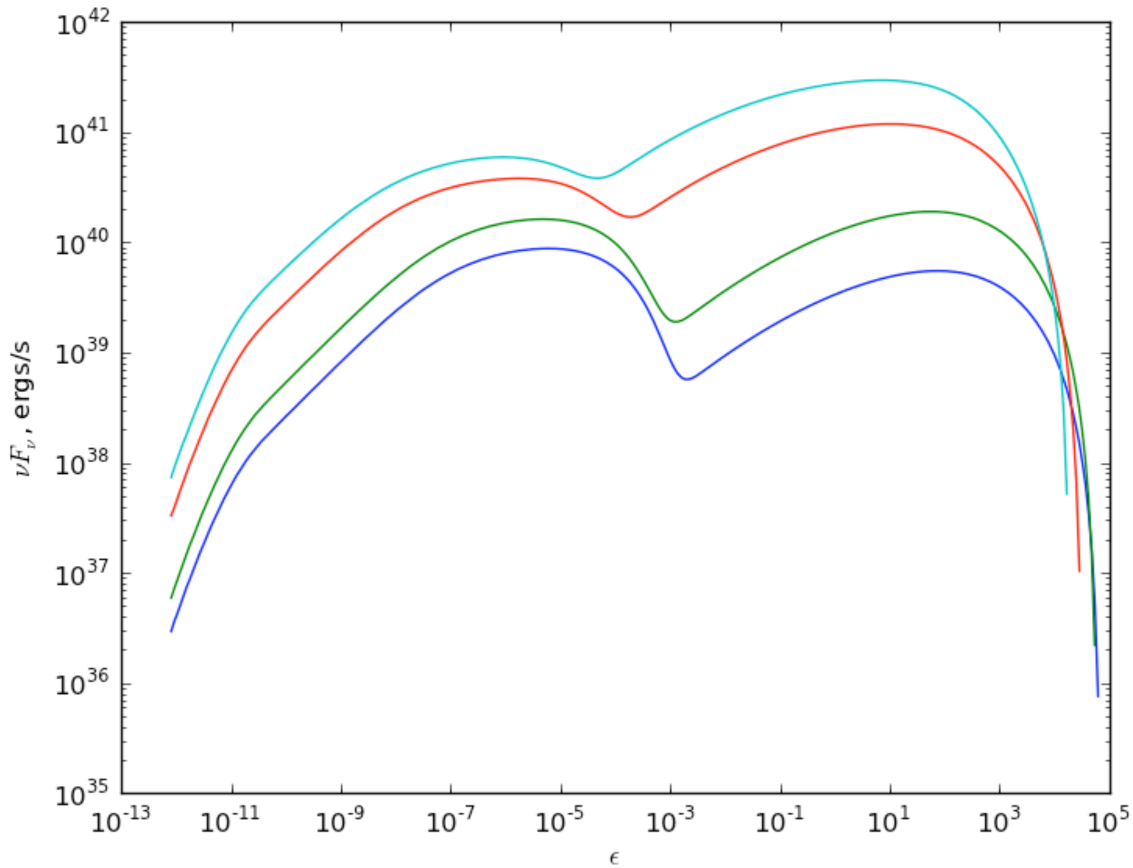
- How can we understand what are the causes of variability?
- We need a model that captures the basic components of reality in these systems, yet, it is general and does not depend on specifics:
- *Two zones – acceleration and radiation (see previous notes)*
- *Electrons in acceleration zone accelerate and escape into the radiation zone with separate characteristic times.*
- *Electrons in radiation zone cool by radiation and are not accelerated.*
- *No emission from acceleration zone (see previous notes that justify this approximation)*
- *Important: Photons from the radiation zone cool acceleration zone.*
- *This means that out two kinetic equations are coupled.*
- *We consider steady-state electron and radiation distributions*

# Case 1: Increase the injected power in the acceleration zone. Artificially Fix Maximum Electron Energy



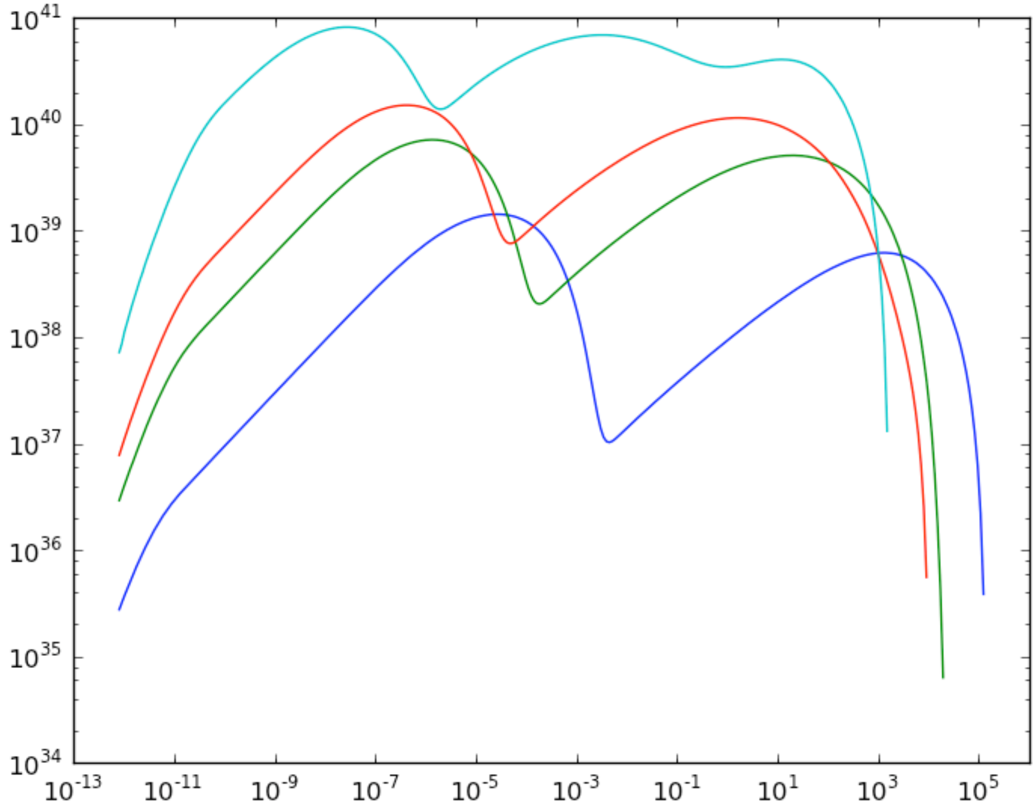

The SSC luminosity increases, which should decrease $\gamma_{max}$ in the acceleration zone. We artificially keep it constant. Notice how the Maximum energy of each component stays the same, but the cooling Break frequency (identified in the synchrotron spectrum by an arrow) decreases. This behavior does not seem to be commonly observed.

# Case 2: Allow Feedback Cooling



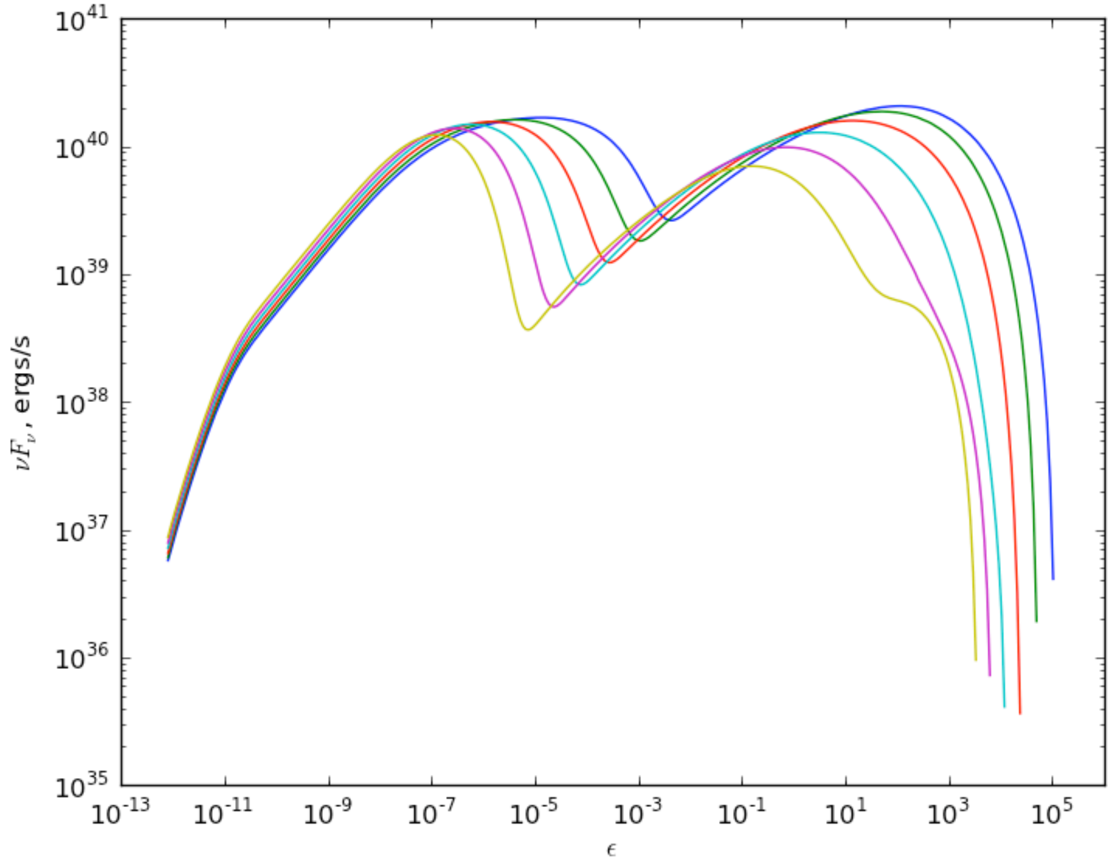

Notice high-energy component varies more strongly than low-energy as before, but maximum energy and other spectrum features shift redwards due to feedback. Neither this is commonly observed.

# Case 3: Vary Electron Injection & B Field in Equipartition




This is definitively not seen

# Case 4: Increase Acceleration and escape rate from the acceleration zone.




Maximum energy increases low frequency of both component does not change much, spectrum features move bluewards, Compton dominance increases slightly. This is very similar to commonly observed variations. So, in many cases we do see variability compatible with faster acceleration.

This is a promising venue for isolating the causes of the observed variability. Currently we can only compare steady-states, but the same approach can be used in time dependent simulations that can give us light curves to compare to observations.