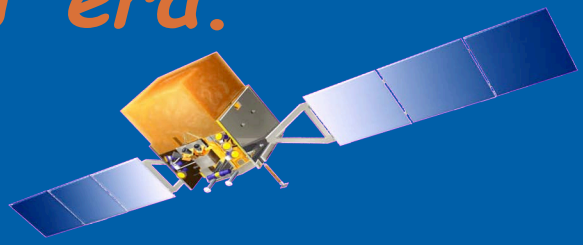
Blazars in the GLAST era.



Markos Georganopoulos[1,2]

Collaborators:

Eric Perlman[3]

Demosthenes Kazanas[2]

Julie McEnery[2]

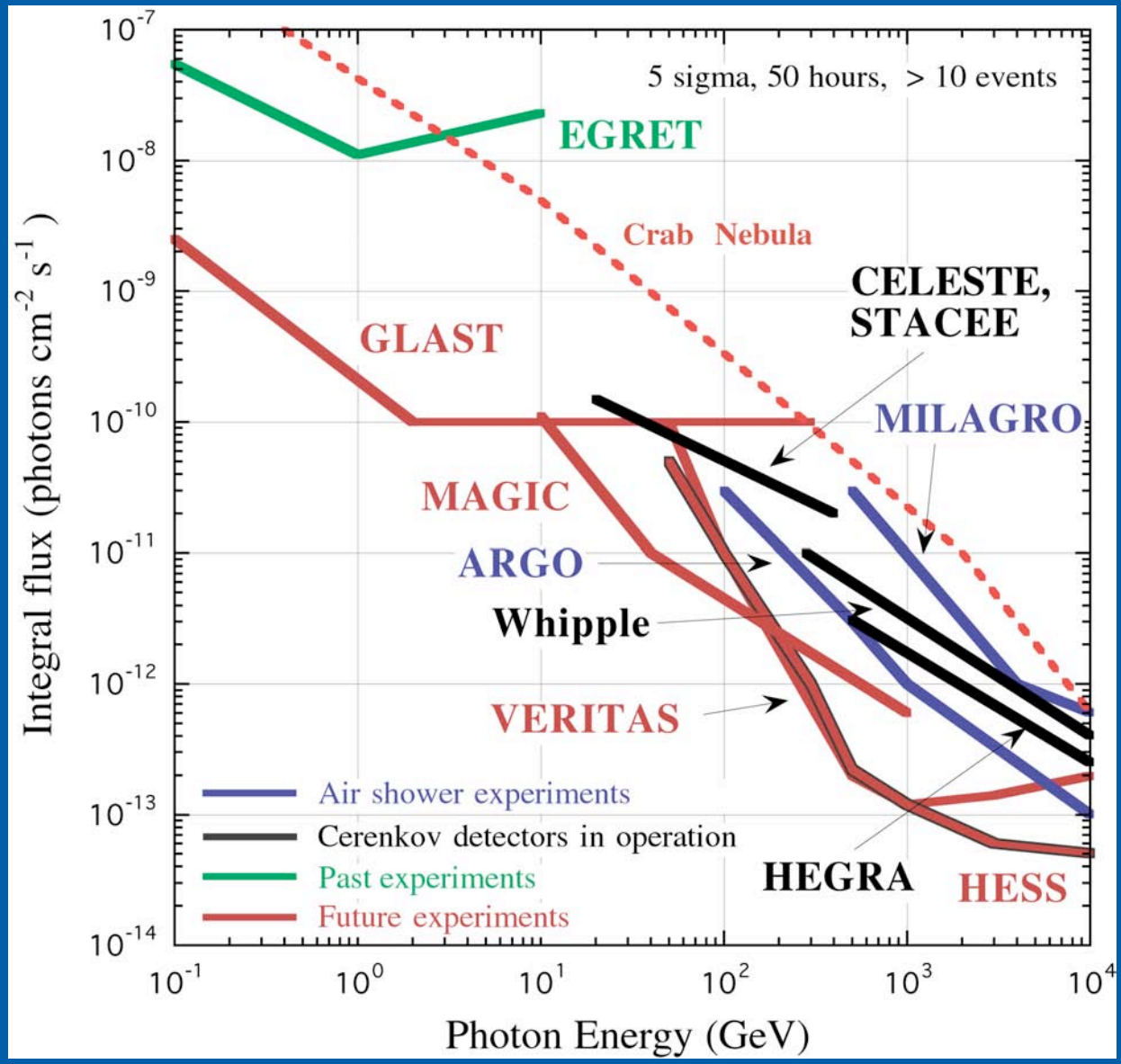
Philip Graff[2]

[1] University of Maryland, Baltimore County

[2] NASA Goddard Space Flight Center

[3]Florida Institute of Technology

GSFC, Jan 17 2007


5 sigma, 50 hours, > 10 events
EGRET
Crab Nebula
CELESTE,
STACEE
GLAST
MILAGRO
MAGIC
ARGO
Whipple
VERITAS
HEGRA
HESS
Air shower experiments
Cerenkov detectors in operation
Past experiments
Future experiments
Integral flux (photons cm^{-2} s^{-1})
Photon Energy (GeV)
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}

A six-pack of holy grails for jets (of somewhat decreasing holiness)

A six-pack of jet holy grails (of somewhat decreasing holiness)

- How are jets formed?

- How powerful and fast are they?

- How do jets interact with their environments?

- What is their matter/magnetic field content?

- Which component carries most of the power?

- How/why do they radiate?

A six-pack of jet holy grails (of somewhat decreasing holiness)

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- How powerful and fast are they?

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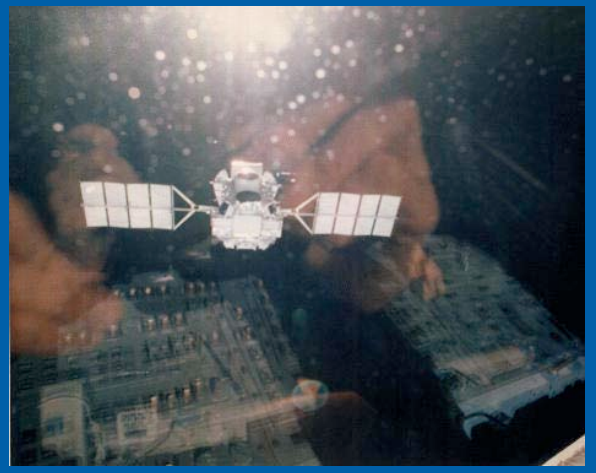
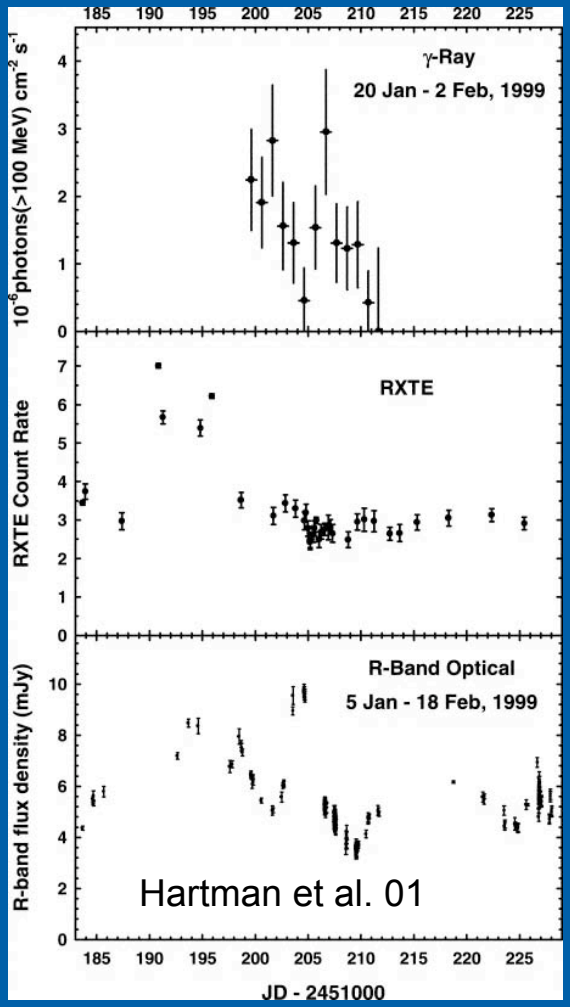
We are down here!

The EGRET legacy

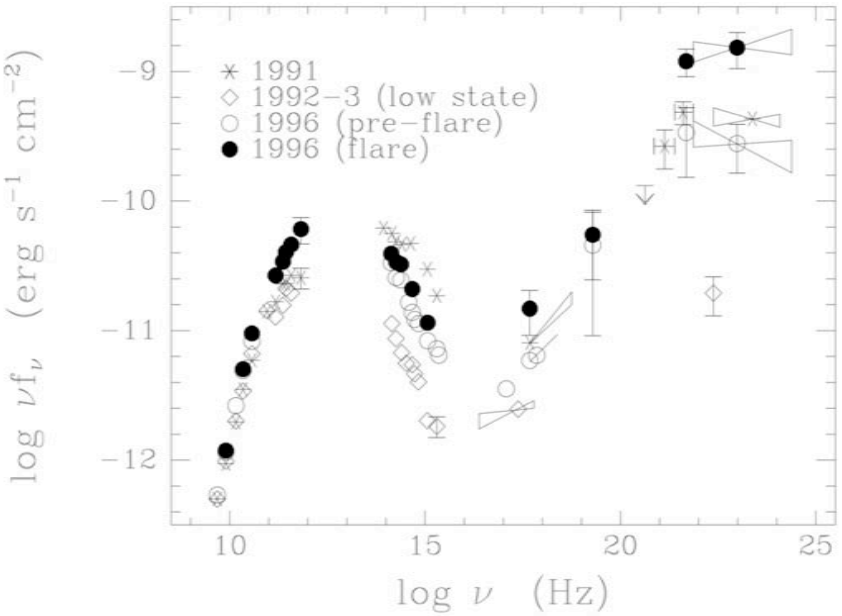
Not many people were anticipating that EGRET would detect 66 blazars.





Hartman et al. 01

3C 279, everyone's favorite blazar.



Wehrle et al. 98

What is the nature of the GeV emission?

From variability and γ-ray transparency arguments:

(ii) The flow is relativistic (Γ>5−10)

(i) The emission comes from a small area ($R \sim 10^{16}$ cm)

(iii) The emission must come from ~1pc away from the central engine

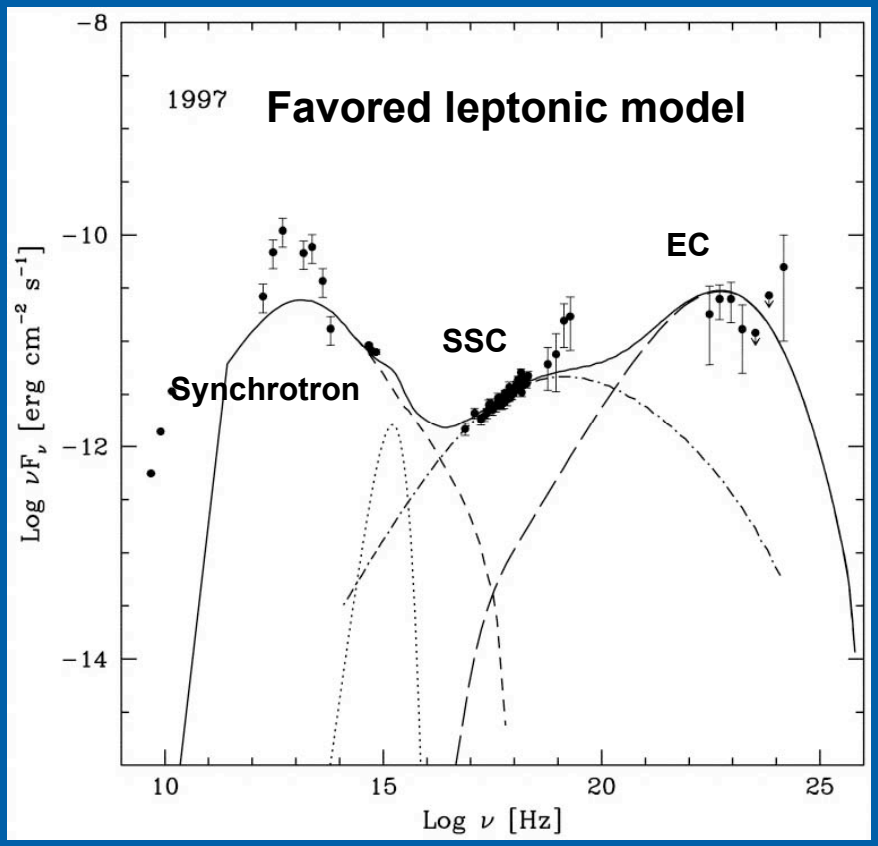
Two kinds of models:

Leptonic: electron acceleration and radiation, detailed modeling of observations

Hadronic: several flavors, based on relativistic protons transferring their energy to radiating leptons through interactions,

or radiating themselves.

In general, less developed, more difficult to simulate broadband SED and variability.

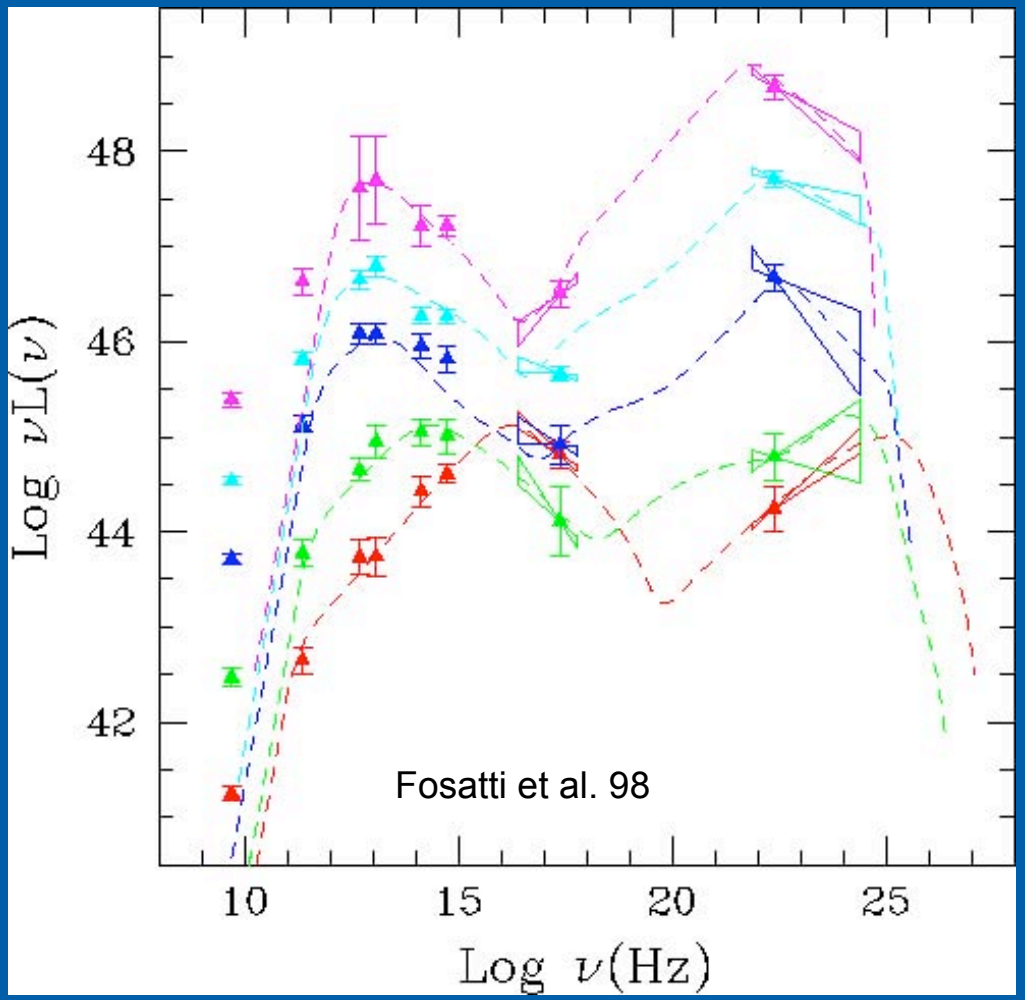


The blazar sequence: an early attempt for an "H-R" diagram for blazars.

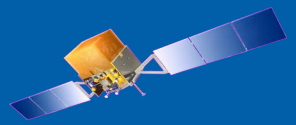
As the observed power of a source increases,

(i) the peak of both emission components shifts to lower energies

(ii) The dominance of the high energy component increases



What will GLAST bring?



> Sensitivity up by 10-30 times
> Continuous monitoring of the sky, wide field of view

(i) Track flares of bright blazars on hour timescales

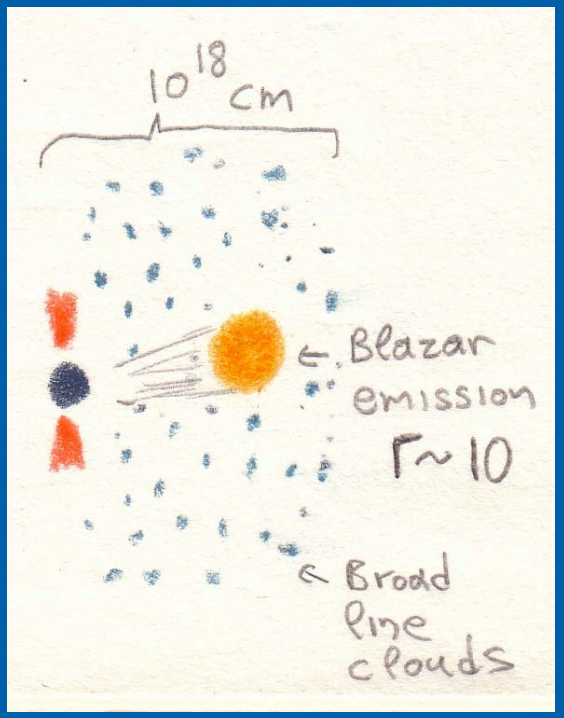
(ii) GLAST on line at the same time withTeV arrays, and X-ray telescopes. Flares at one band can triger observation at the others

(iii) EGRET found the divas,
GLAST will see many average Joe blazars

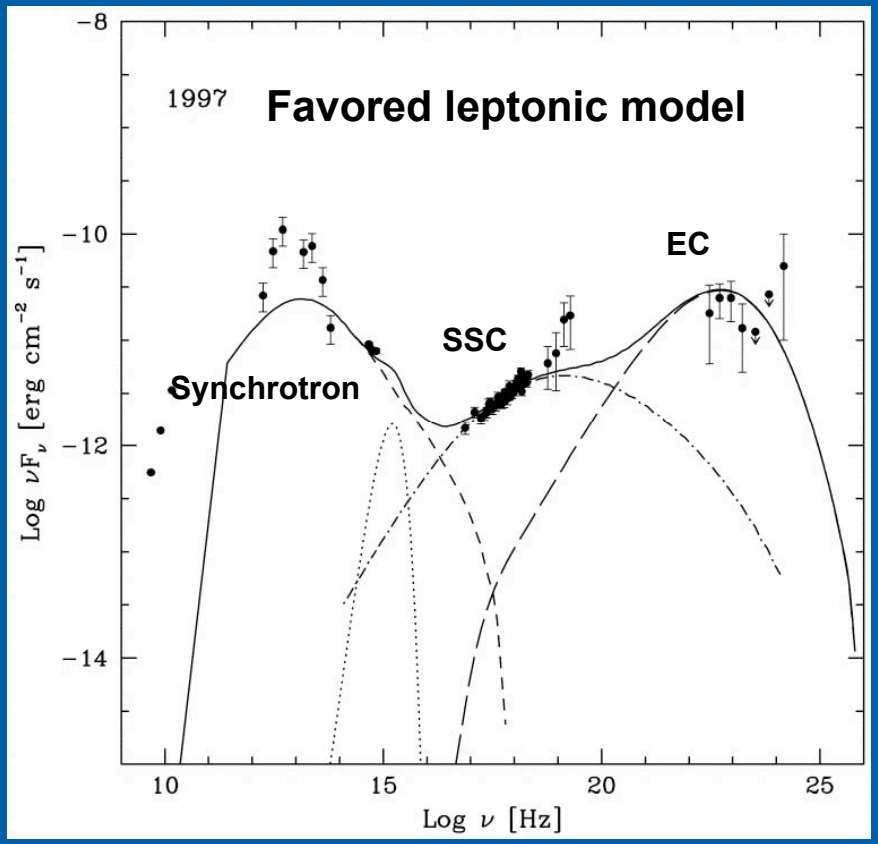
(iv) GLAST will detect many "closet blazars" and radiogalaxies with a range of jet misalignments

All in all: many more blazars and misaligned sources, detailed multiwavelength variability light curves of the brighter ones.

Leptonic models: SSC or EC of the BLR



$$U_{com} = \Gamma^2 U_{BLR}$$

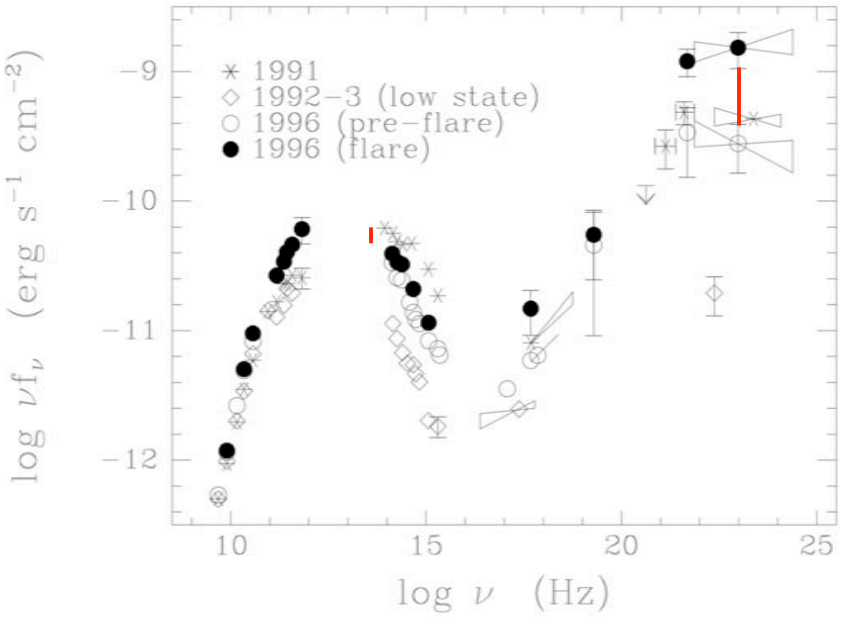


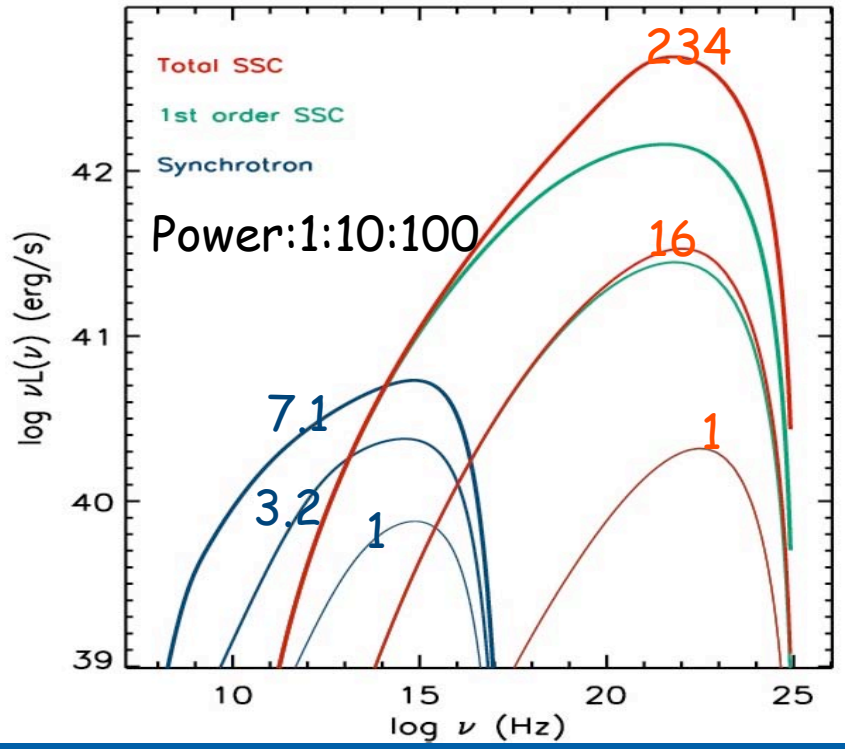
Motivation for the EC model

>Superquadratic variations in 3C 279.

>Analytical argument that SSC can only produce quadratic variations.

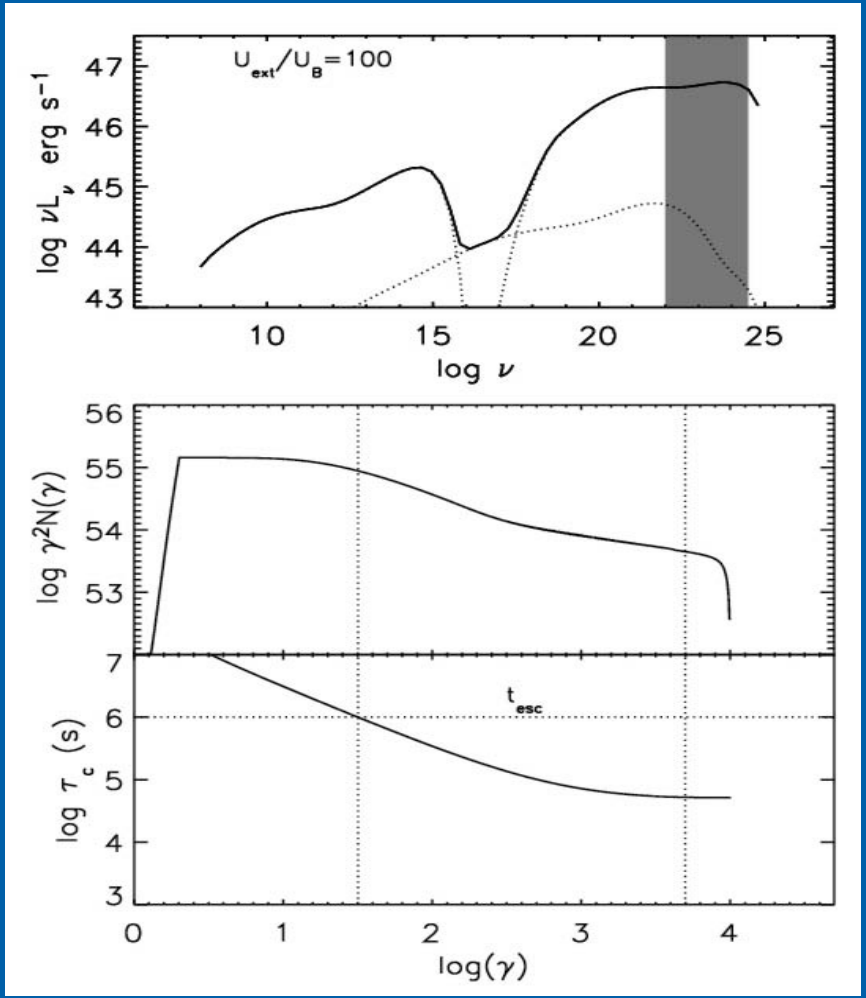
>Not true, increasing source power increases the importance of the SSC channel and produces superquadratic variations.





Georganopoulos et al. in prep.

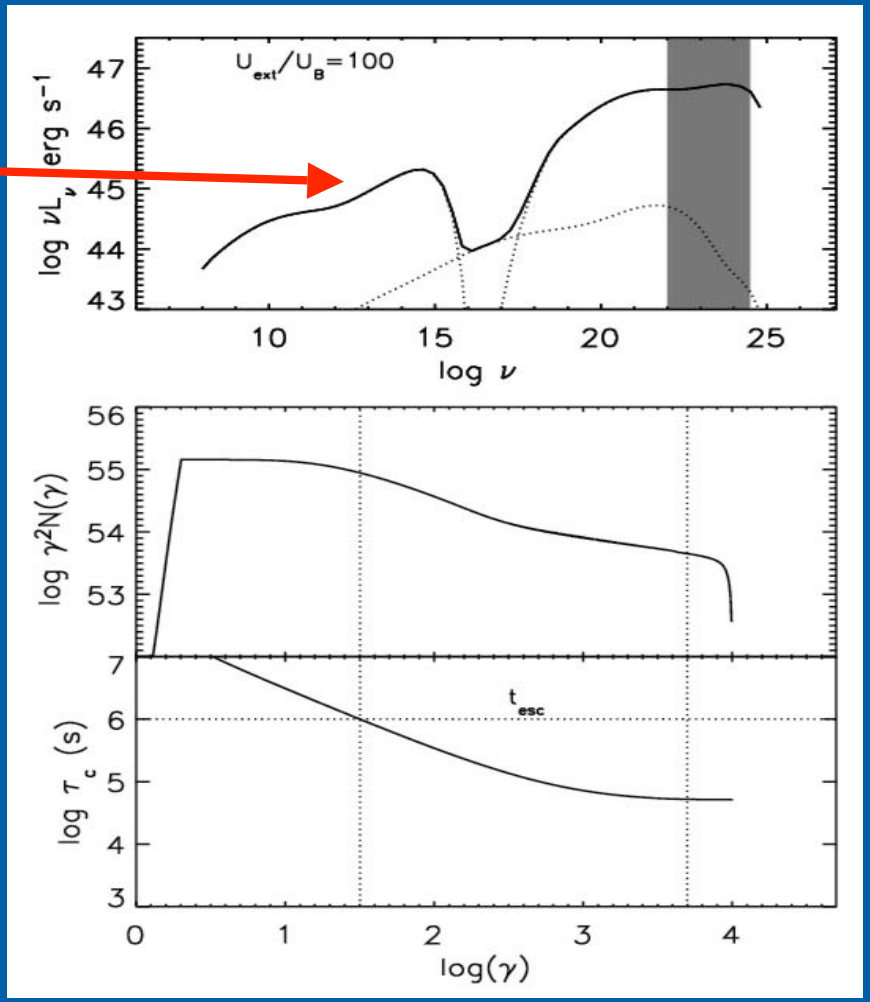
How EC dominated blazars should look? GLAST can tell the difference



How EC dominated blazars should look? GLAST can tell the difference

Unavoidable marks:

1. The hump in the synchrotron component



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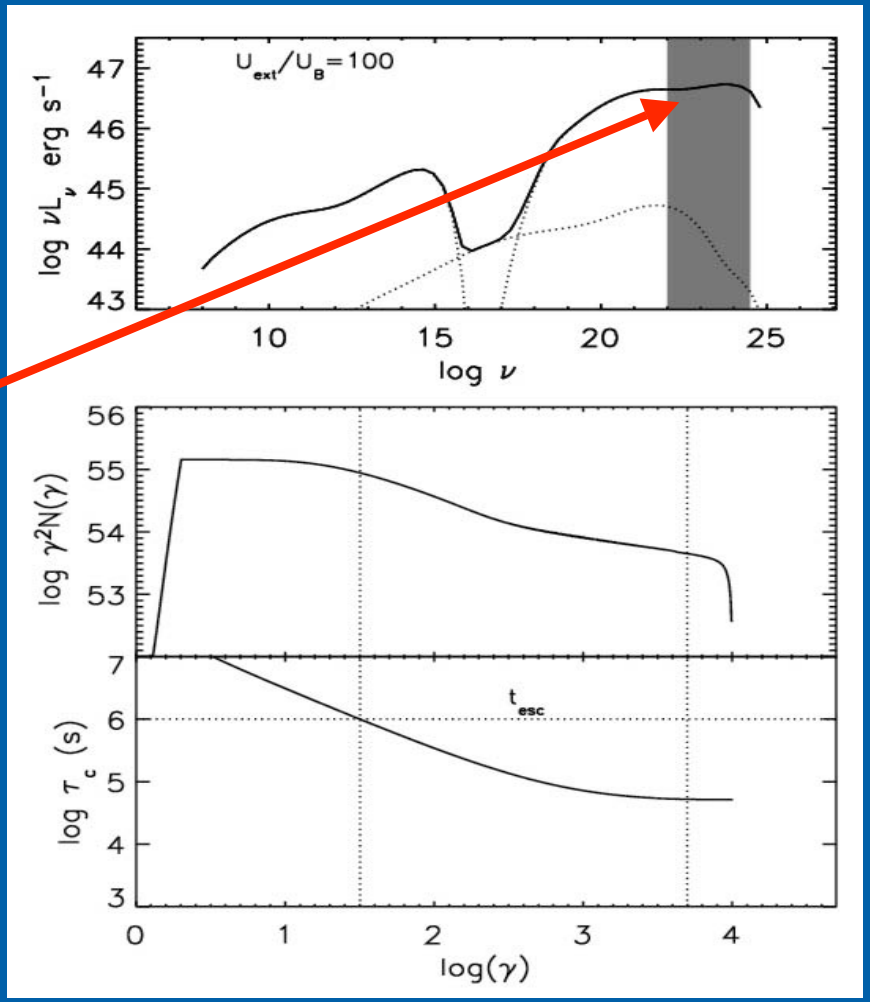

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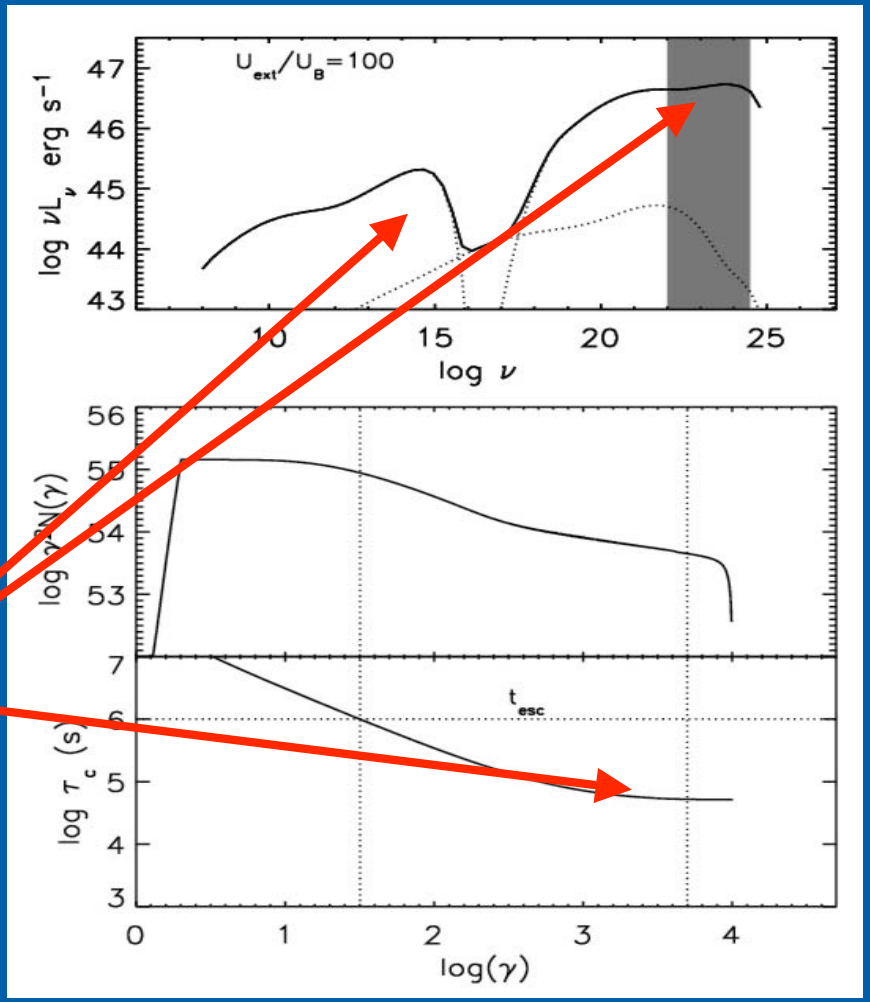
Unavoidable marks:

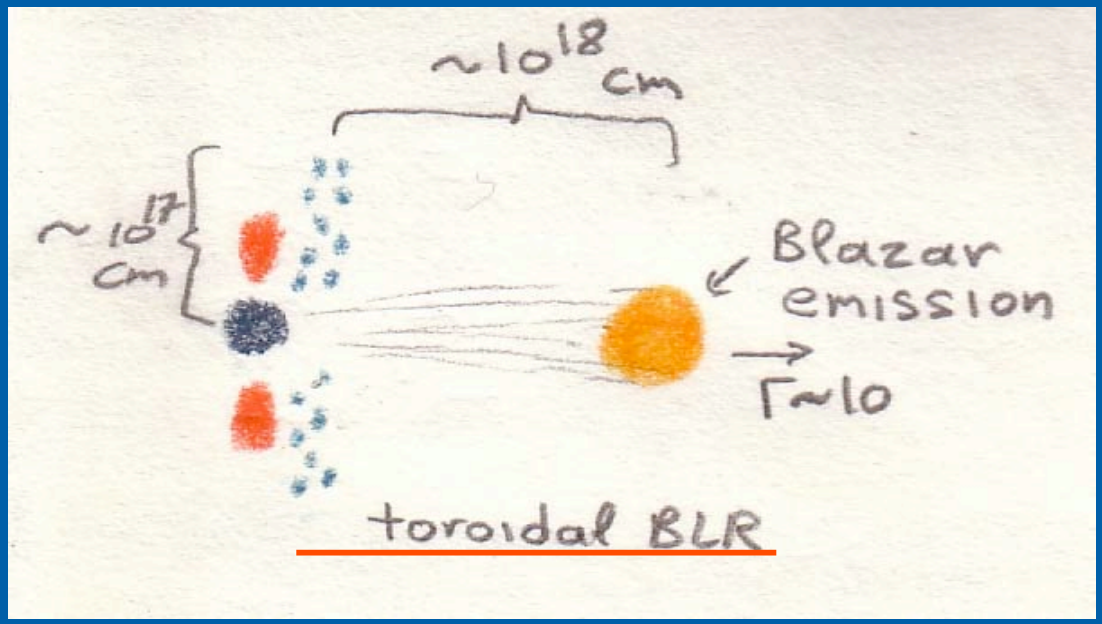
1. The hump in the synchrotron component
2. The flat/rising SED of the GeV component (rarely seen by EGRET, typical GeV spectrum is steep)
3. Achromatic variability at the synchrotron hump and the GLAST regime.



How can it not be EC off the BLR? Pita-type BLR: smaller and flat!

BLR size from reverberation mapping:
$R=1.5\ 10^{17}\ L_{46}^{1/2}$ cm
for a source like 3C 279.

Several independent arguments for a flat BLR



The BLR energy density, as measured in the blazar's comoving frame drops:

$U \propto 1/\Gamma^2$ instead of Γ^2

This reduces the EC power by up to $\Gamma^4 \sim 10^4$

Are we modeling variability right? NO

- *Our only hope for probing the unresolved emission region is through high energy variability studies.*

- *GLAST will provide unprecedented light curves.*

But can we model them right?

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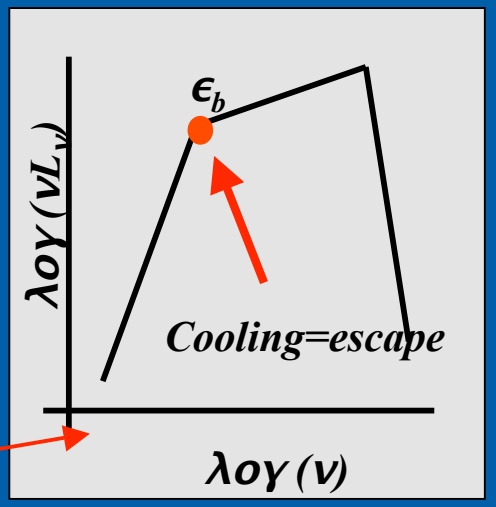

› ***IT'S A FEATURE, NOT A BUG:***

One zone models cannot treat variability at energies produced by electrons with radiative cooling time faster than the light crossing time.

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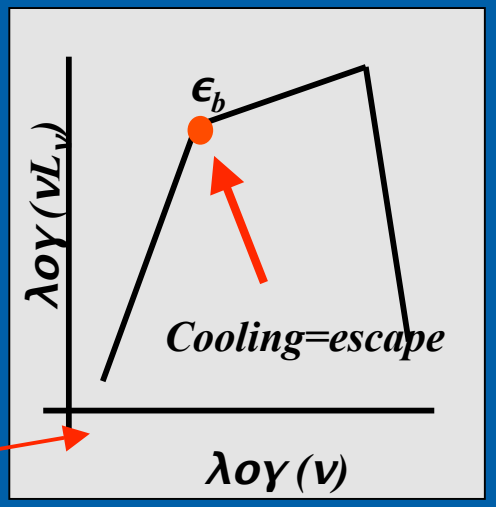

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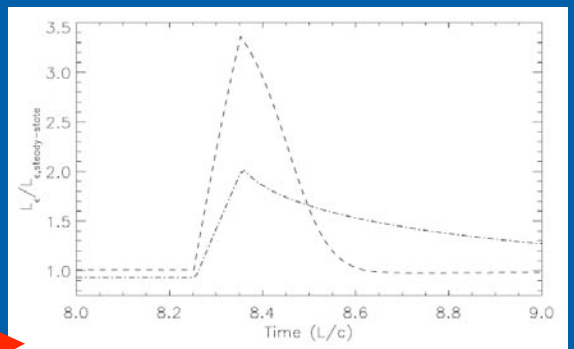
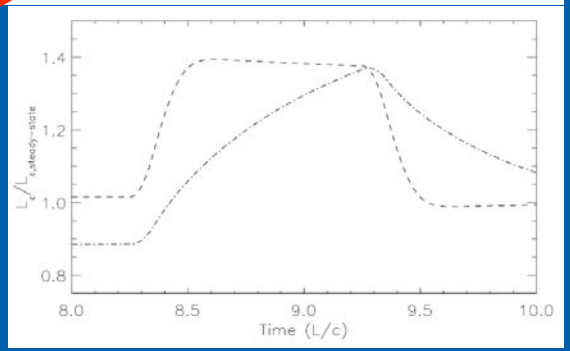


IT'S THE LAW:

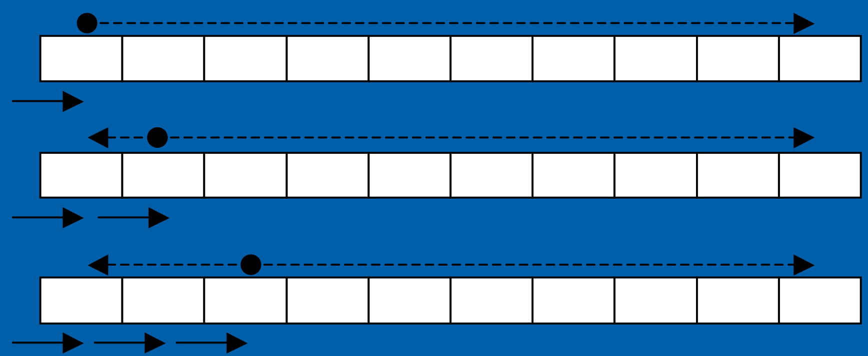
The fastest variability time is the light crossing time. And, it is frequency independent.



Variability, what needs to be done.

> *Inhomogeneous models.*

> *Simplest case: a pipe with non- local SSC losses.*



$$\frac{\partial n(\gamma,t)}{\partial t}+\frac{\partial}{\partial\gamma}\left[\dot{\gamma}n(\gamma,t)\right]+\frac{n(\gamma,t)}{t_{esc}}=q(\gamma,t)$$

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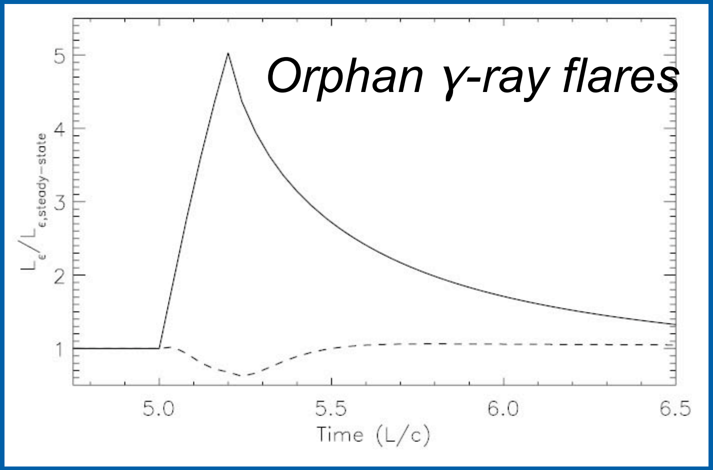
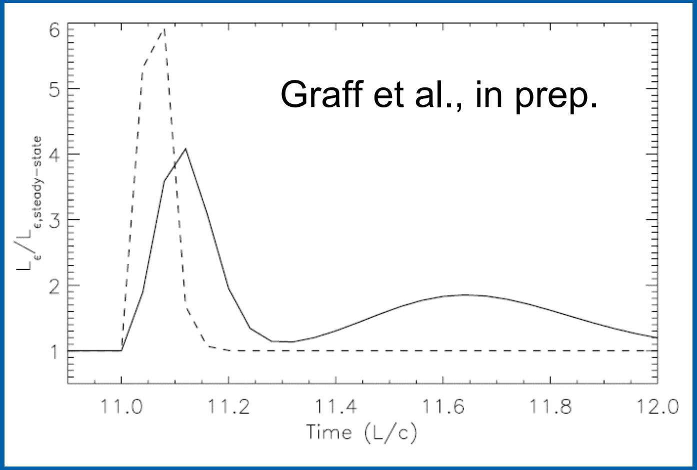


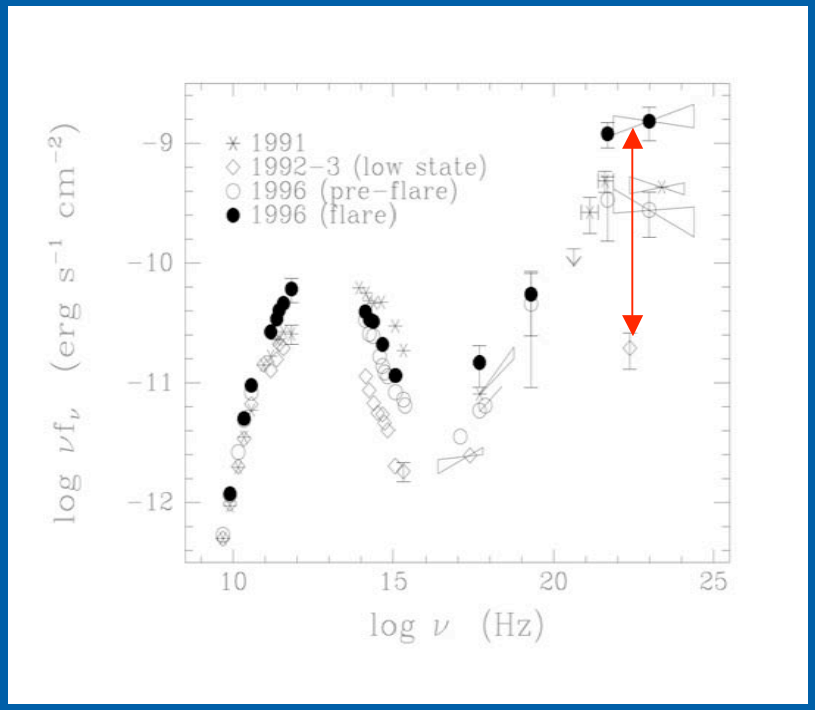


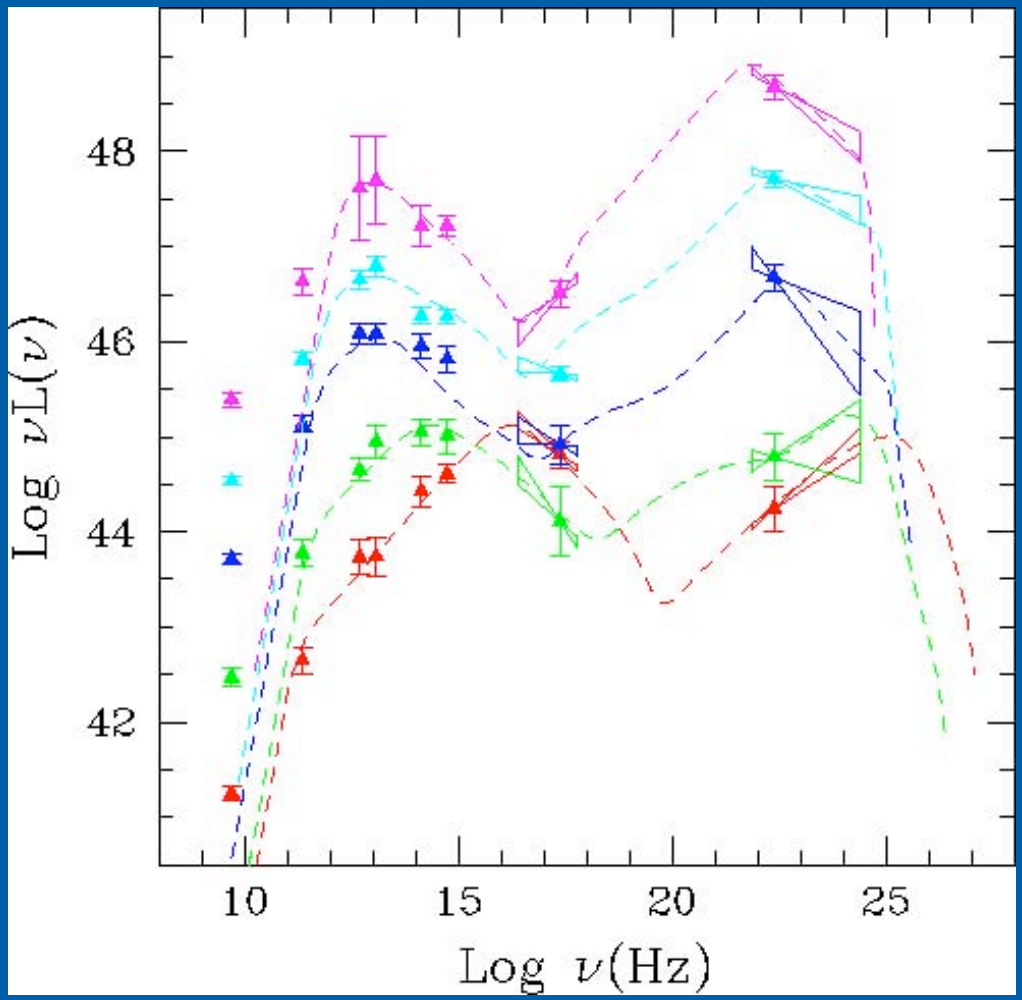
$$U(x,t,\varepsilon)=\int_{l_{\min}}^{l_{\max}} L\left(l,t=|x-l|/c,\varepsilon\right)/4\pi c(x-l)^2\,dl$$

The blazar sequence: an early attempt for an "H-R" diagram for blazars.

Problems

(i) GeV variability

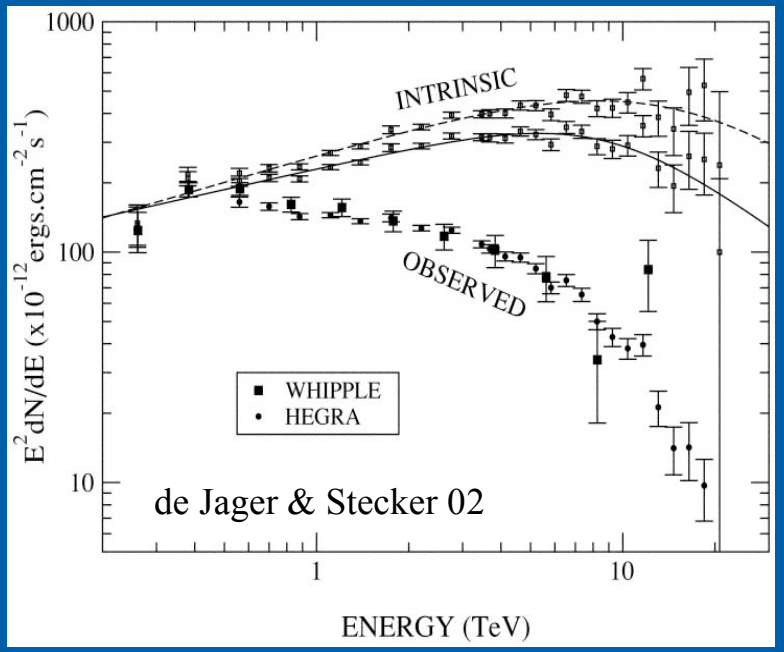


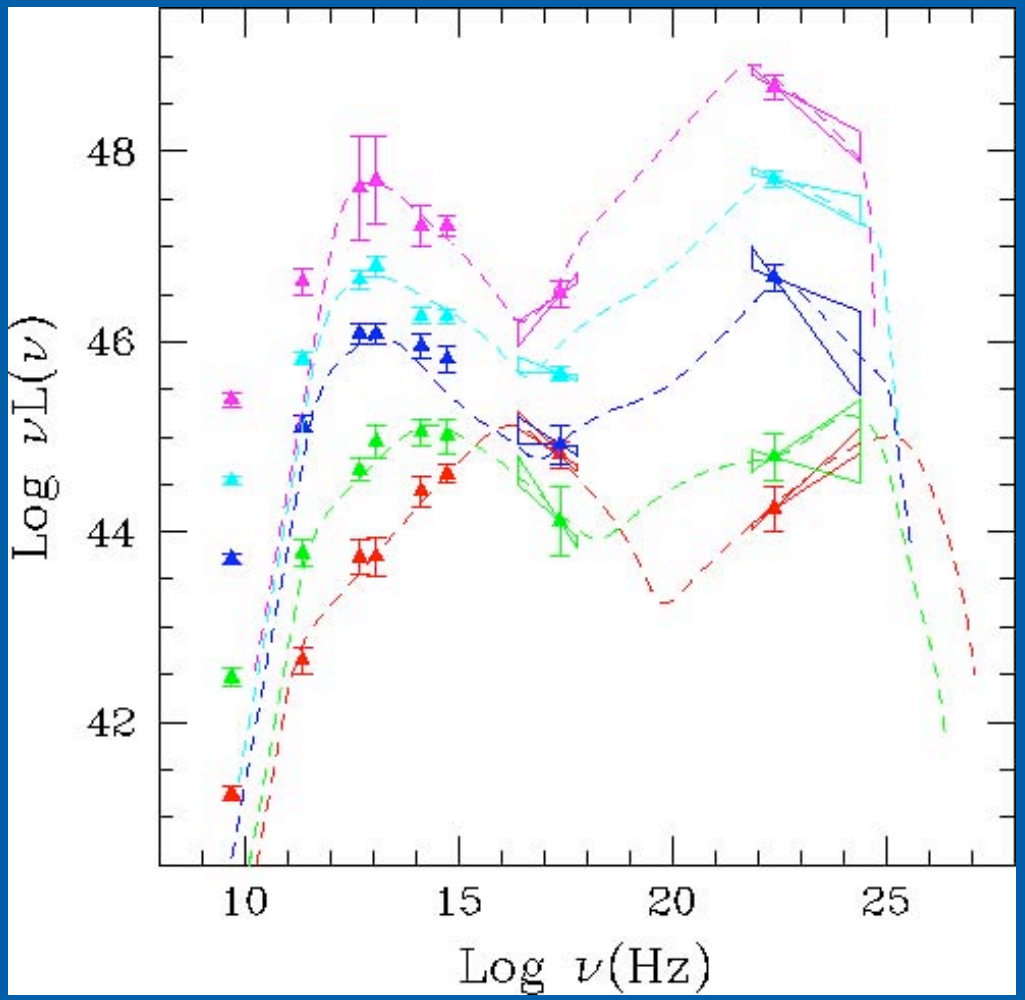


The blazar sequence: an early attempt for an "H-R" diagram for blazars.

Problems

(ii) TeV absorption from the NIRB underestimates TeV flux



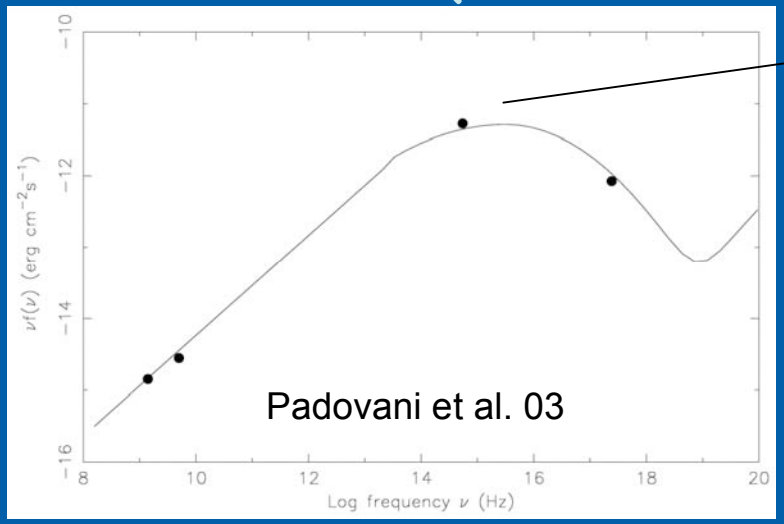


The blazar sequence: an early attempt for an "H-R" diagram for blazars.

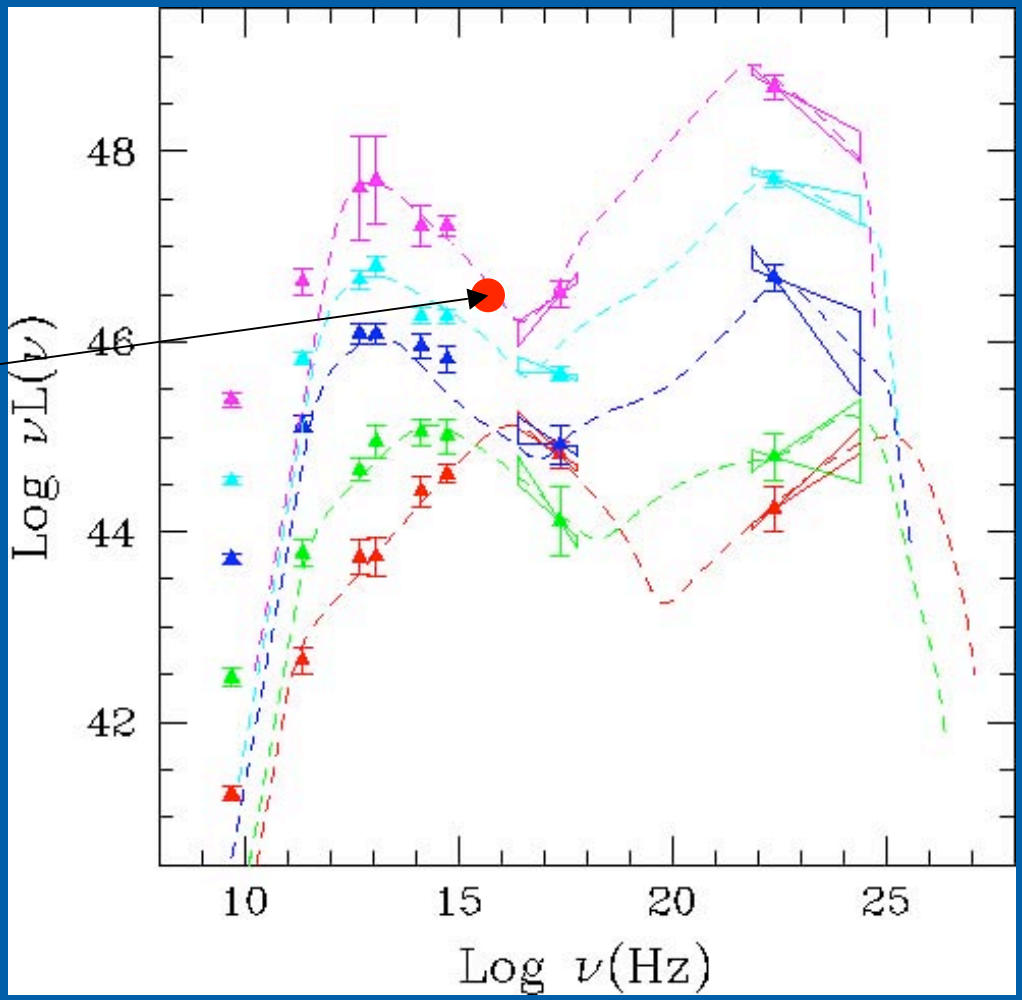
Problems

(iii) Renegade sources

High peak frequency FSRQ: HFSRQs



Padovani et al. 03

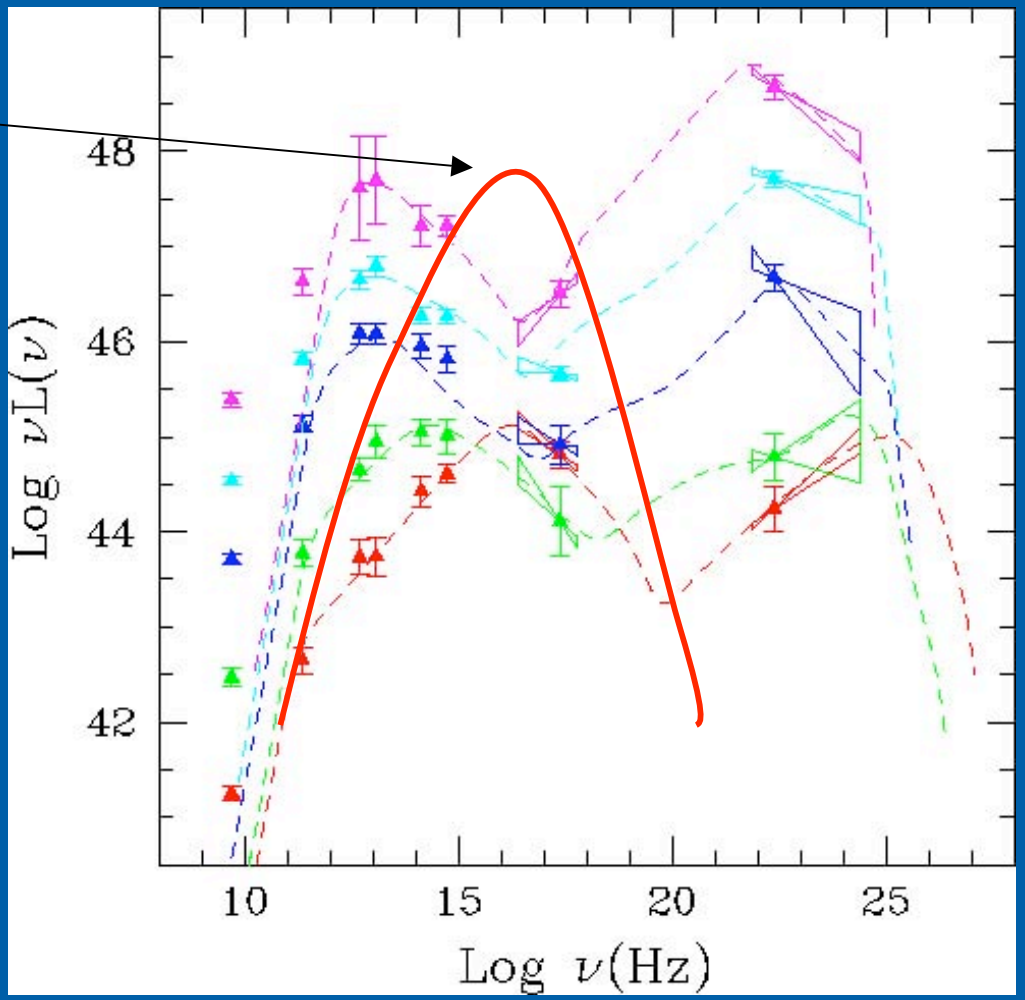


The blazar sequence: an early attempt for an "H-R" diagram for blazars.

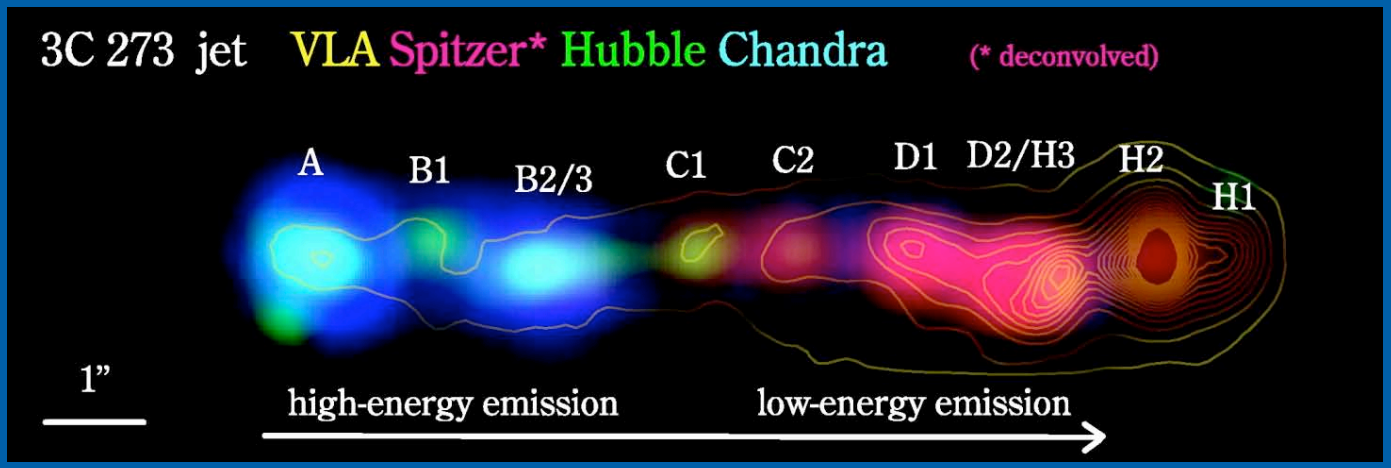
But still, nothing like that.
So, it must be partially true.

GLAST will provide critical information for the high energy bump of many blazars

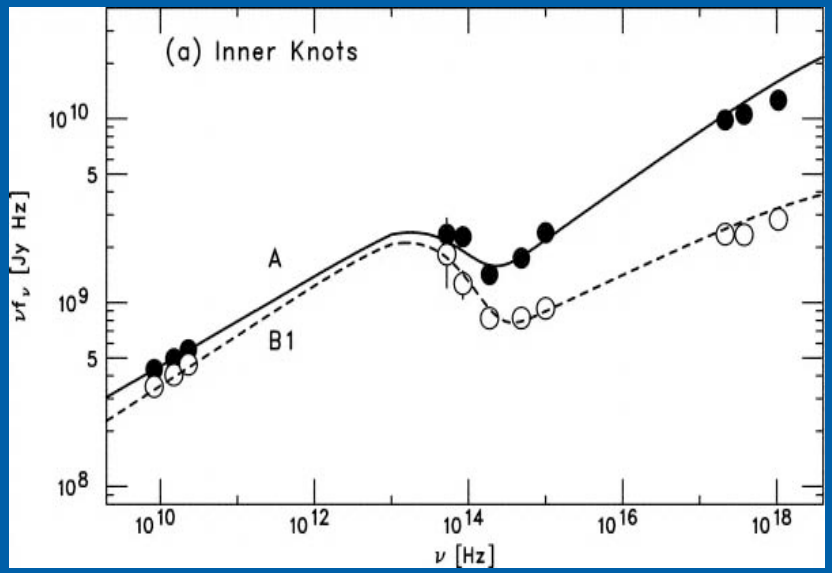
It will help us built a <u>new blazar sequence</u>
and, hopefully, understand what it means.

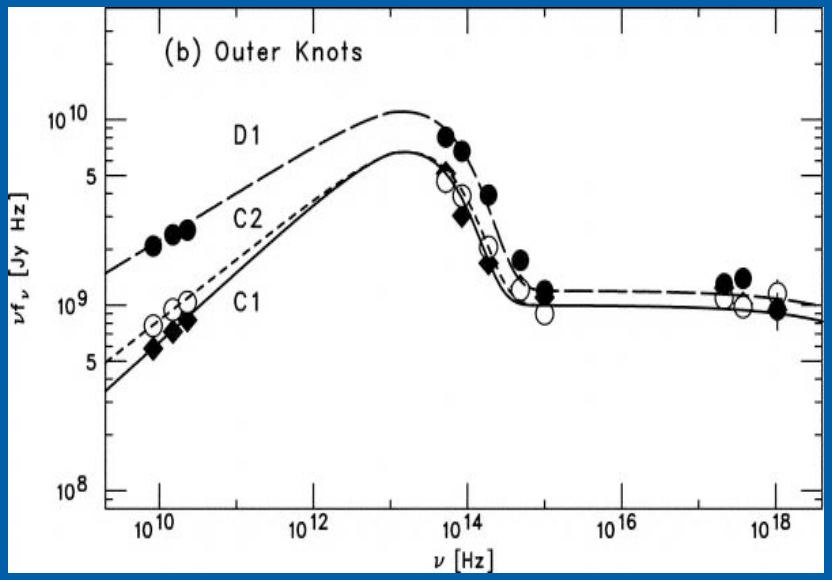


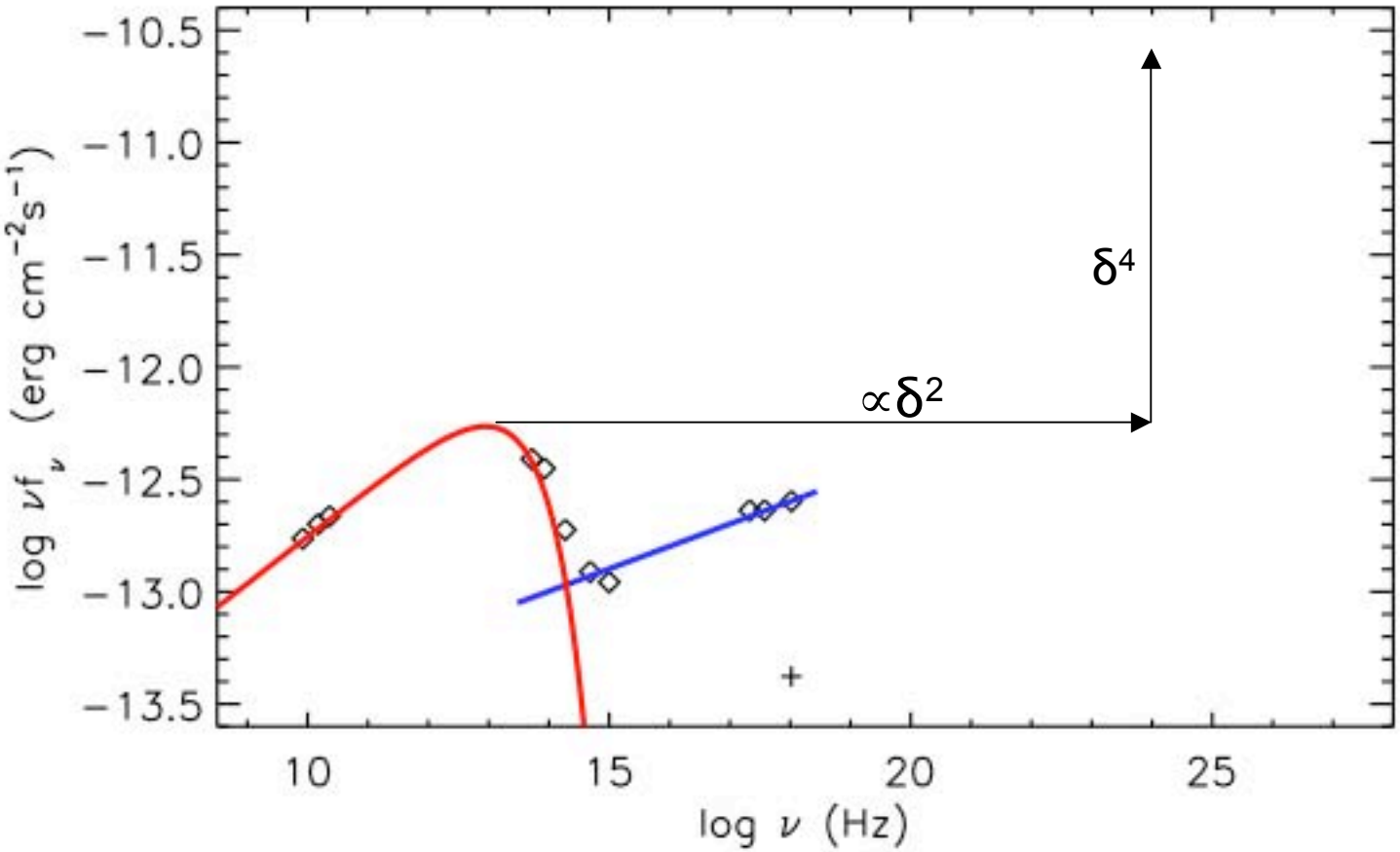
A diversion:
GLAST as a large scale jet speedometer

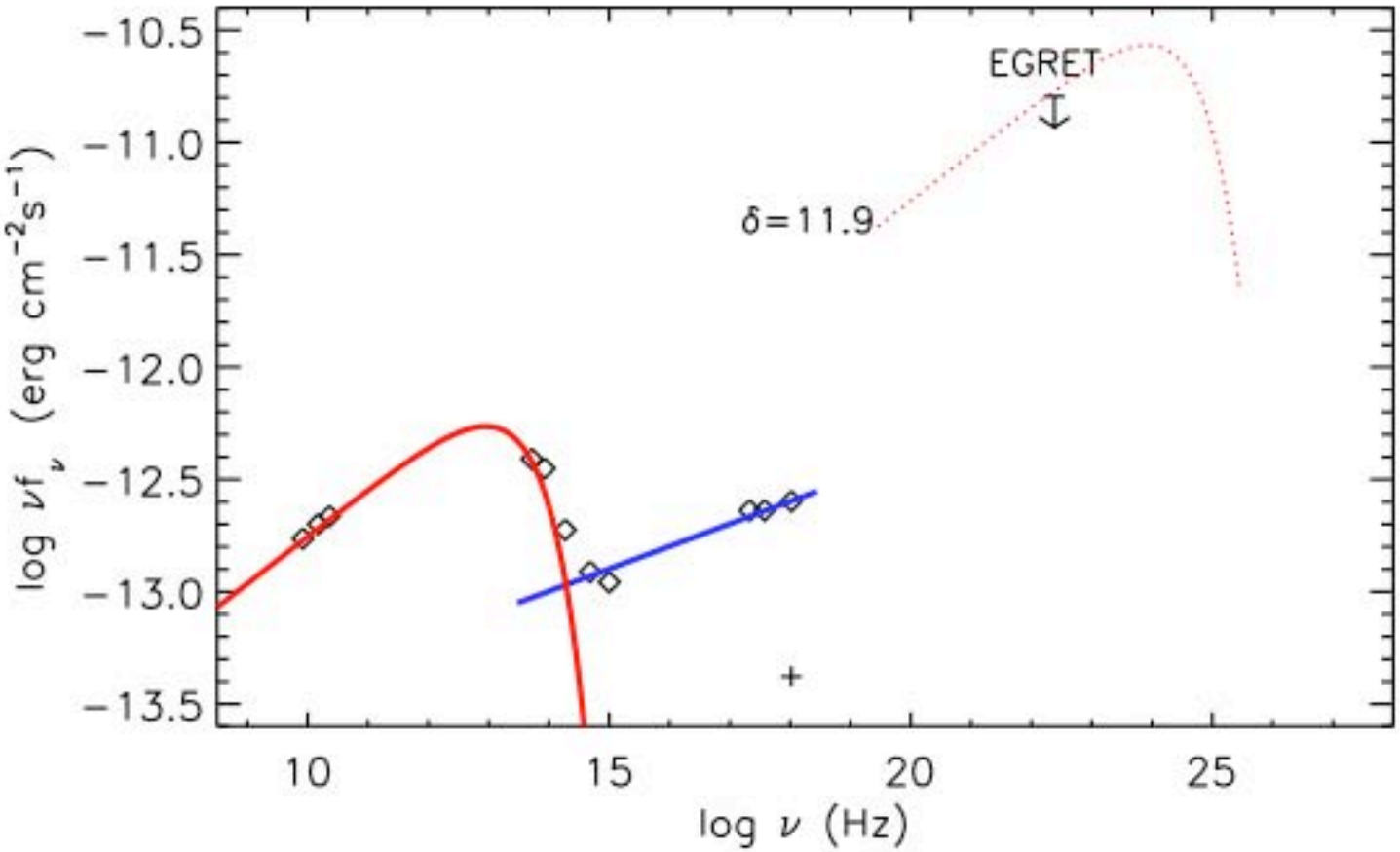


Uchiyama et al. 06

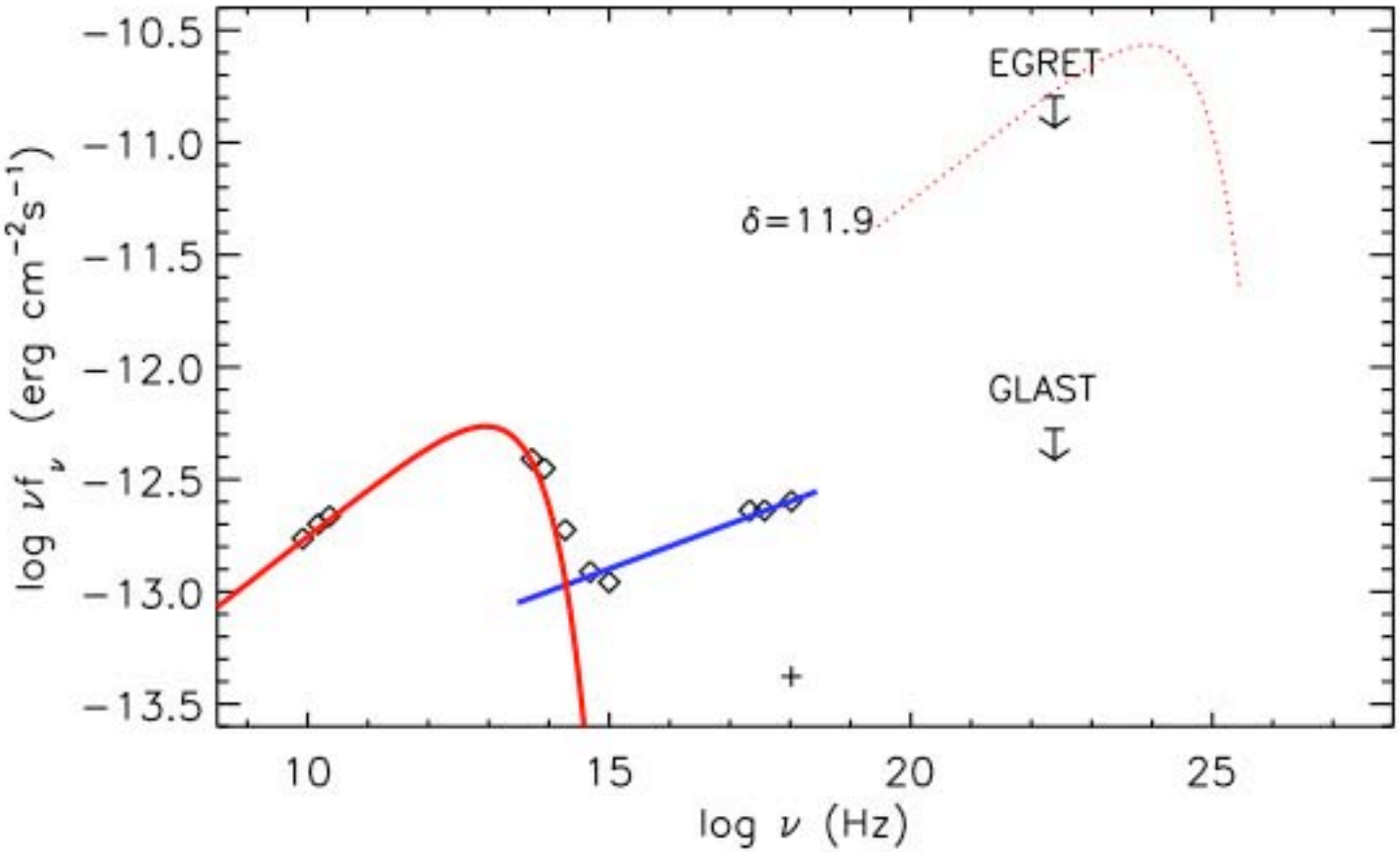




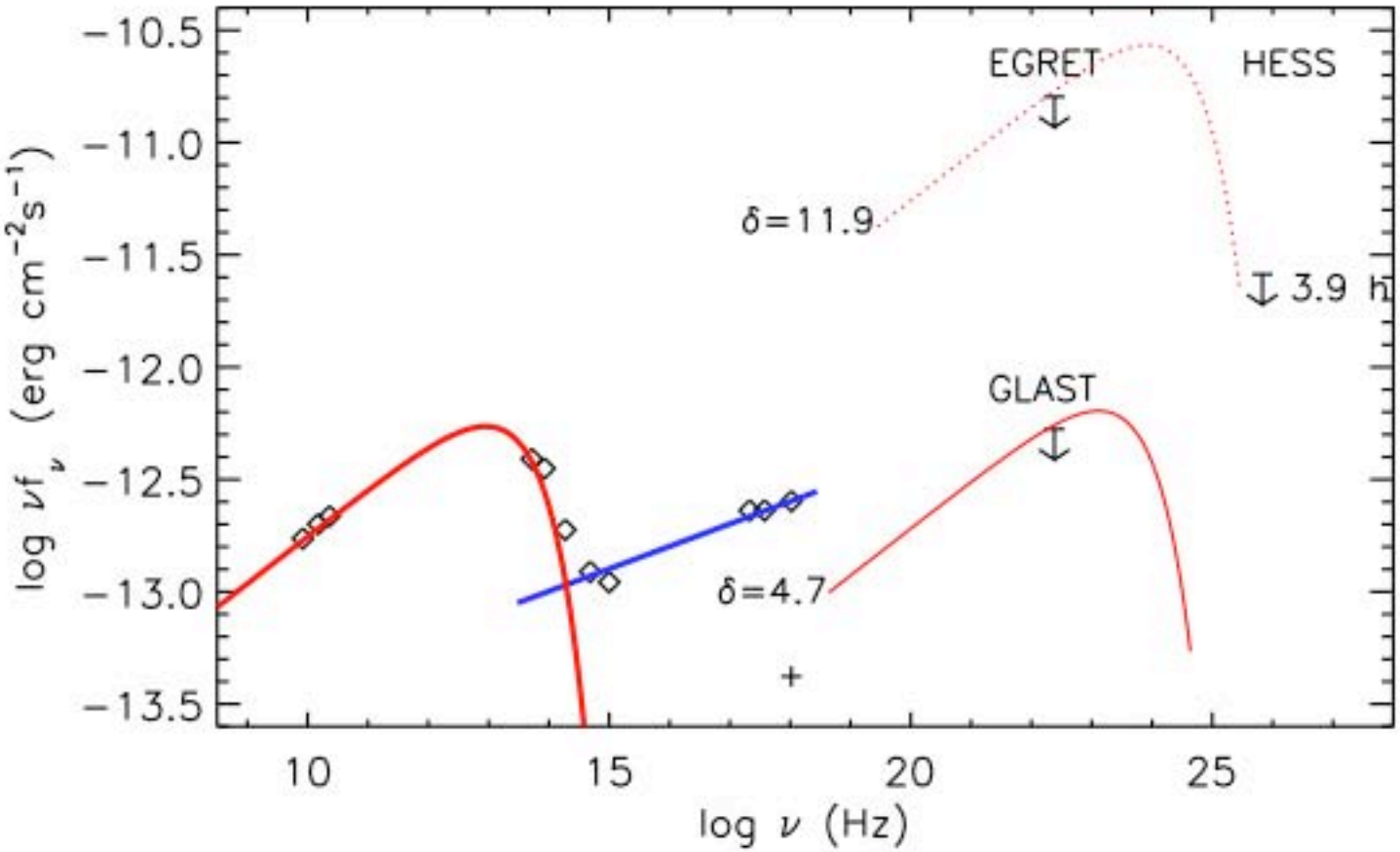

−10.5
−11.0
−11.5
−12.0
−12.5
−13.0
−13.5
log νf_ν (erg cm^−2 s^−1)
10
15
20
25
log ν (Hz)
δ^4
∝δ^2



Cool: Existing good old EGRET limits already require $\delta<11.9$


EGRET
δ=11.9
GLAST
log νf_ν (erg cm^-2 s^-1)
log ν (Hz)
−10.5
−11.0
−11.5
−12.0
−12.5
−13.0
−13.5
10
15
20
25

Georganopoulos et al. 06



If the blazar collaborates with an appropriately low state, GLAST can push the jet Doppler factor down to $\delta<4.7$