

Multifrequency variability properties of gamma-bright AGN

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acknowledgements:



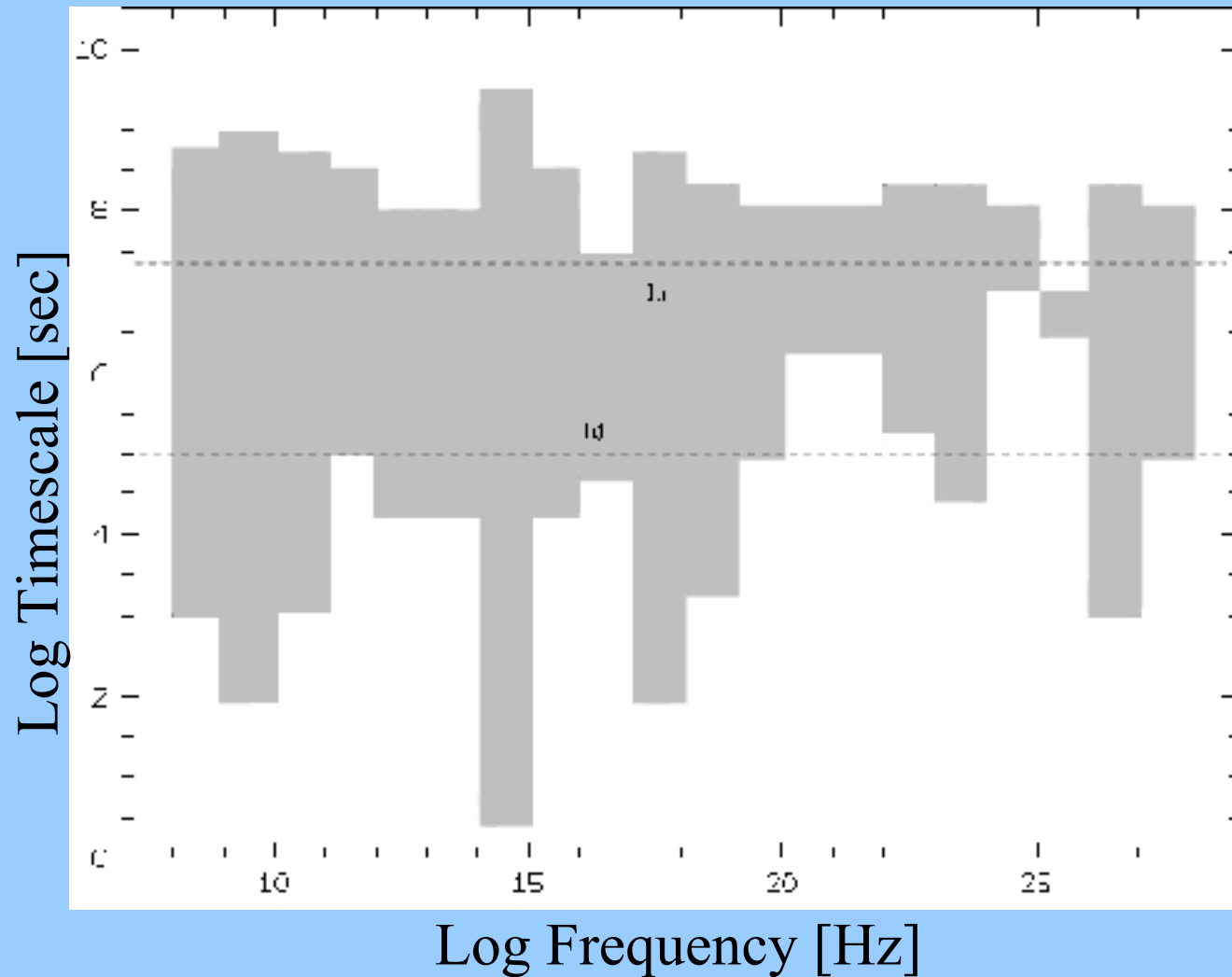
ENIGMA network
HESS collaboration



Parameter space of variability

AGN variability

Parameter space explored.
Variability found everywhere.

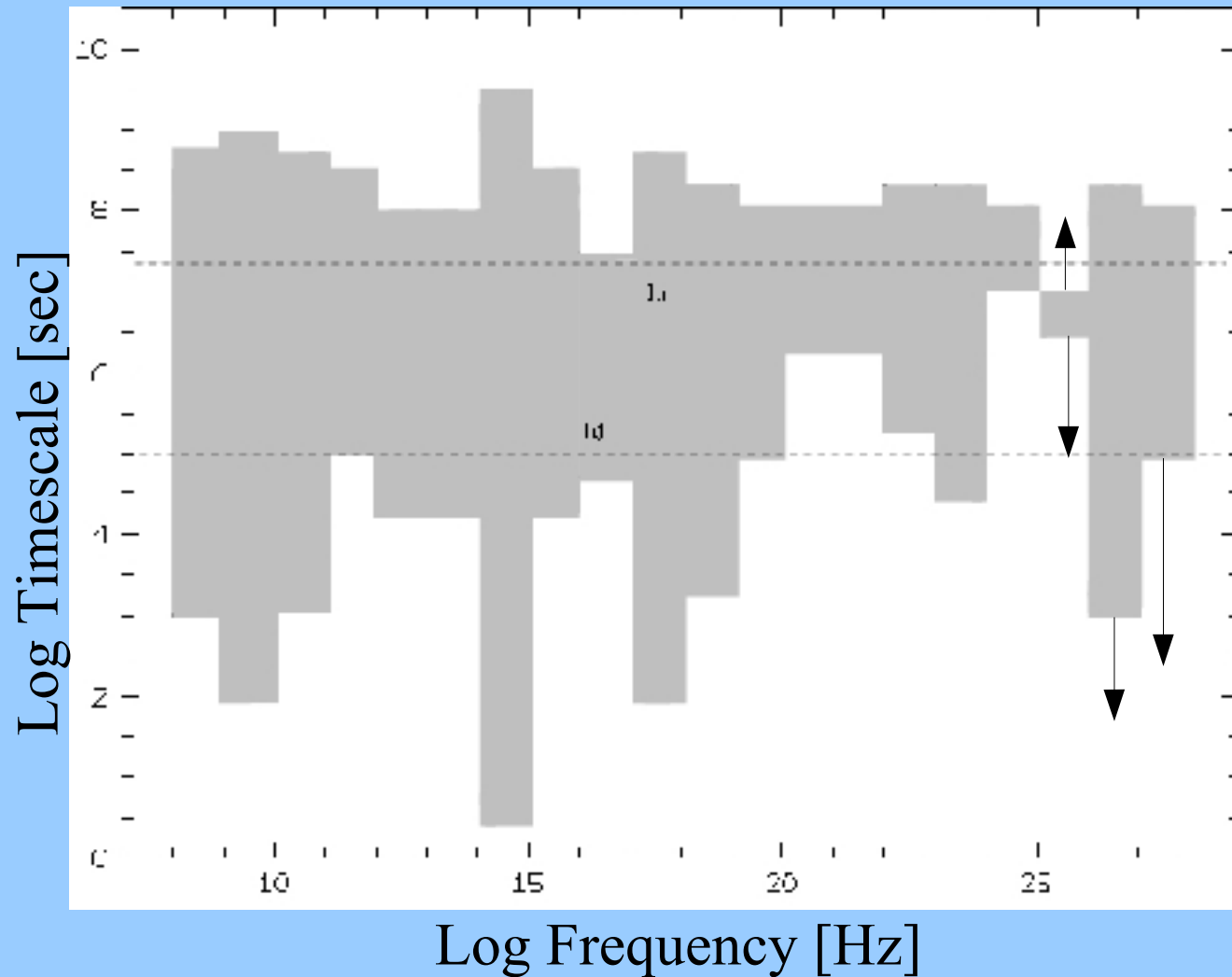


Parameter space of variability

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Additions at very high energies

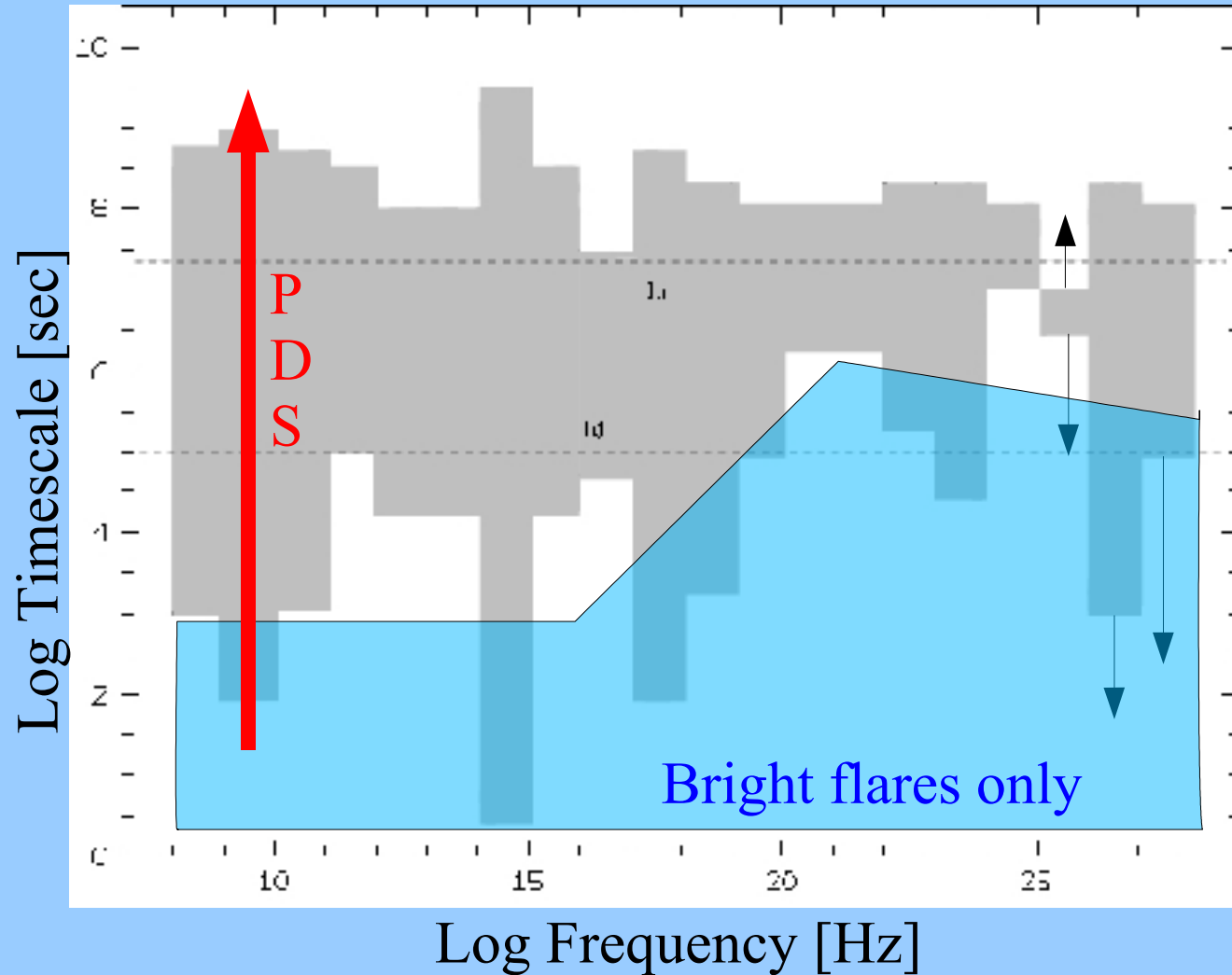


Parameter space of variability

AGN variability

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Measure PDS
PDS-SED-plane

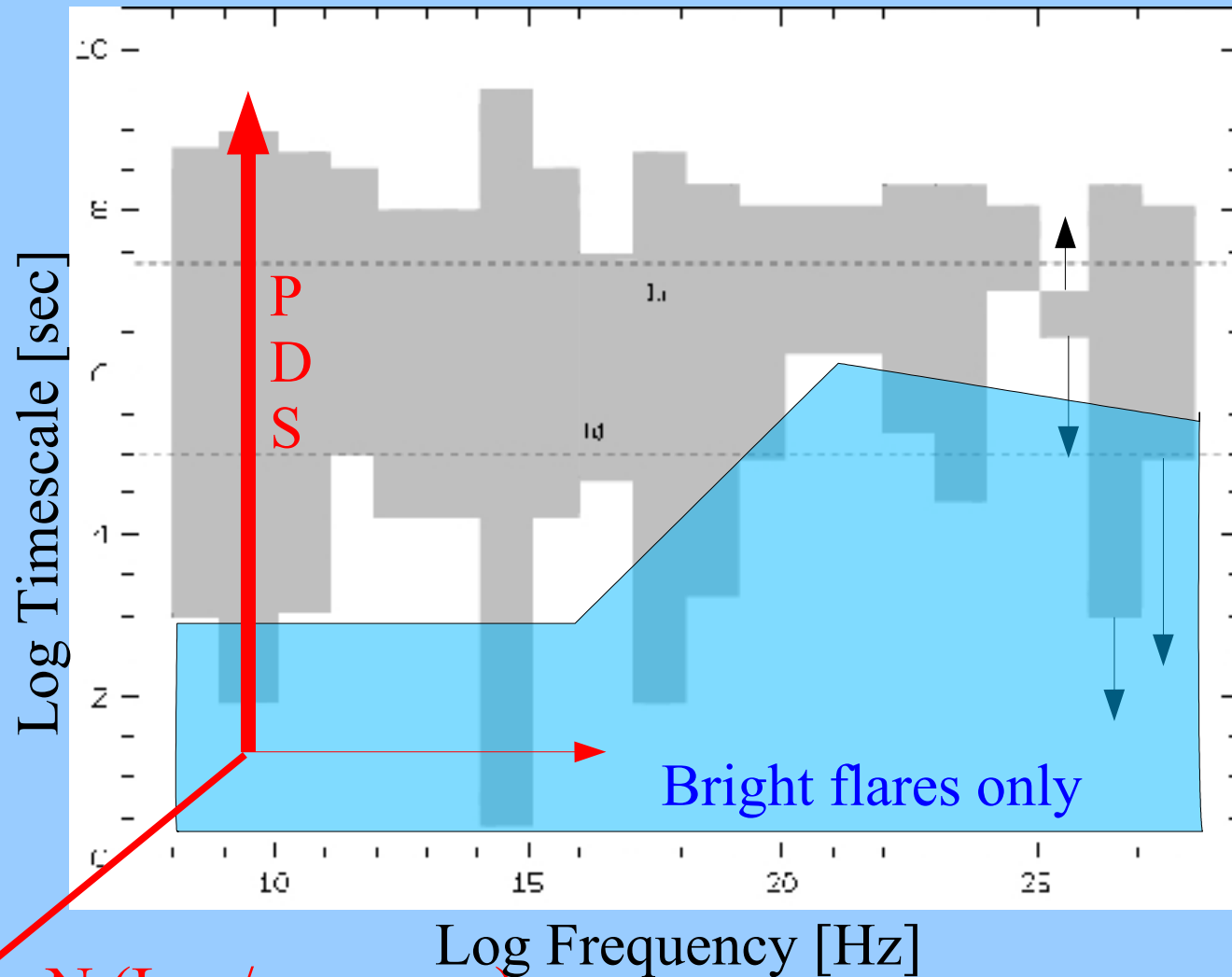


Parameter space of variability

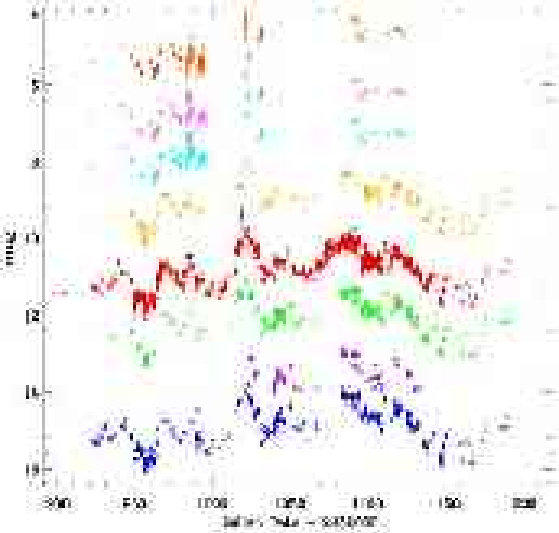
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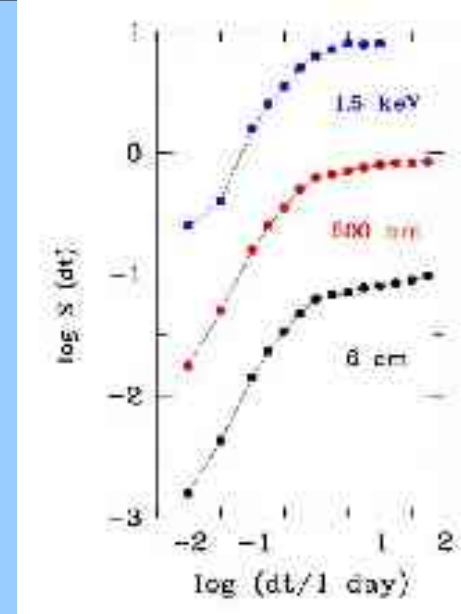
Measure PDS
PDS-SED-plane
for many objects



$N(L, v/c, m_{\text{BH}}, \dots)$



Temporal signatures



0716+714

Ostorero et al., 2007

Monochromatic studies:

Wagner, 2003

Rich variability spectra

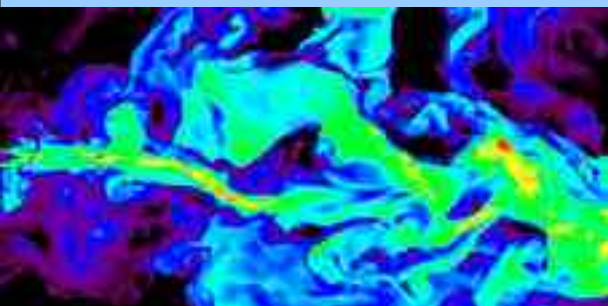
Broad Power Density Spectra/Structure Functions

Breaks at time-scales of ~ 100 ksec (IDV), flat beyond
(Similarities in different energies)

PDS slopes/breaks in GeV and TeV Blazars are similar

PDS of EGRET data limited (biases and poor statistics)

Mapping onto turbulence?

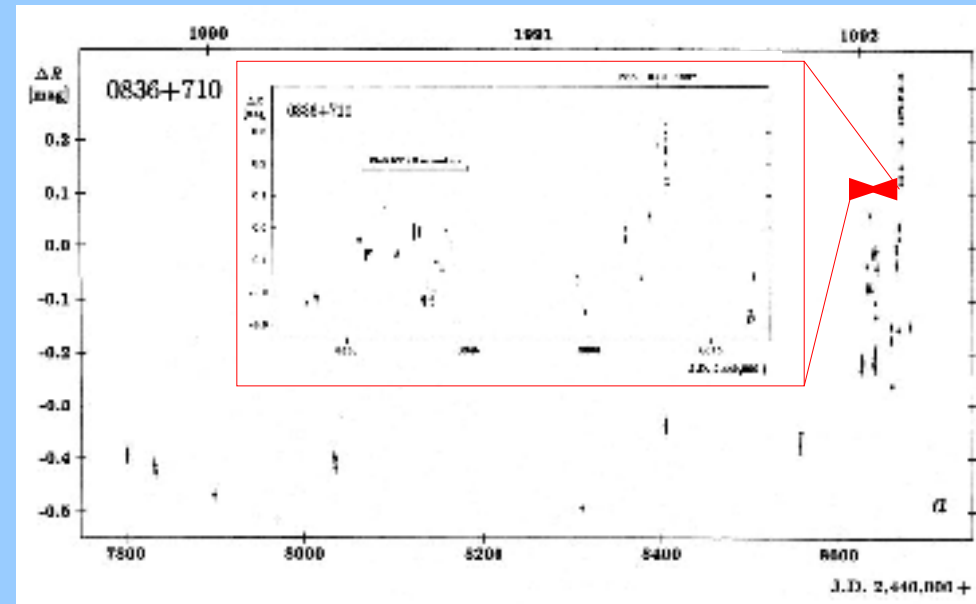
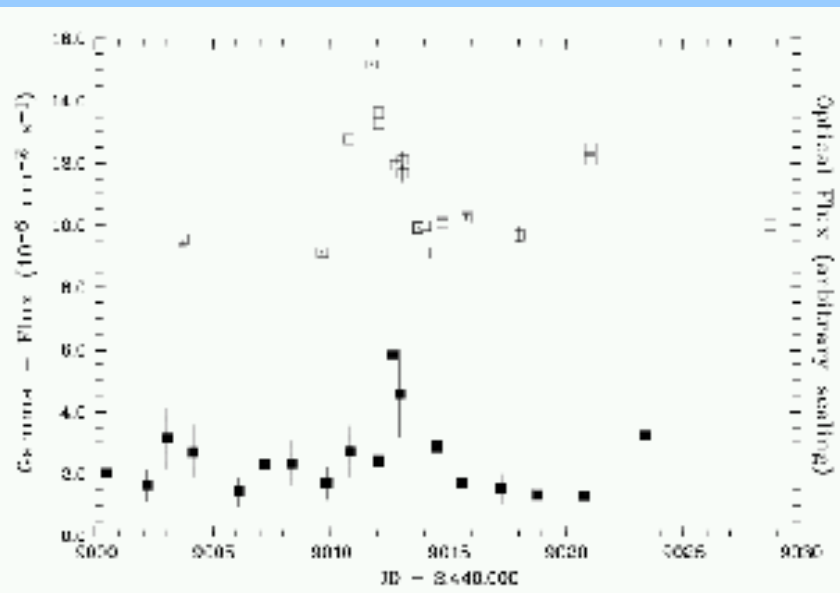


Broad-band studies:

Correlations and lags

Correlations and Lags

1980s and 1990s:
Correlations within synchrotron
Radio-Optical, Optical-Xrays



Gamma-Synchrotron
following EGRET:
eg. 0836+710, PKS 0528+134,
PKS 0420-014, S5 0954+65, ...

detailed studies: PKS 1406-076, 3C279, PKS 1622-297

Mixed results, poor statistics, little repeatability

TeV Blazars

M87	0.004	current VHE Blazars (Whipple, HEGRA, HESS , MAGIC)
Mrk 421	0.031	a few additional sources not yet confirmed
Mrk 501	0.033	Many more to come (HESS , MAGIC , VERITAS)
Mrk 180	0.034	
2344+514	0.044	new, more distant, southern Blazars
1959+650	0.047	
0548-322	0.069	see talk Djannati-Atai, P1.2
2005-489	0.071	
2155-304	0.116	
1426+428	0.129	
0229+200	0.139	see talk Djannati-Atai, P1.2
2356-309	0.165	
1218+304	0.182	
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1553+113	???	

TeV Blazars

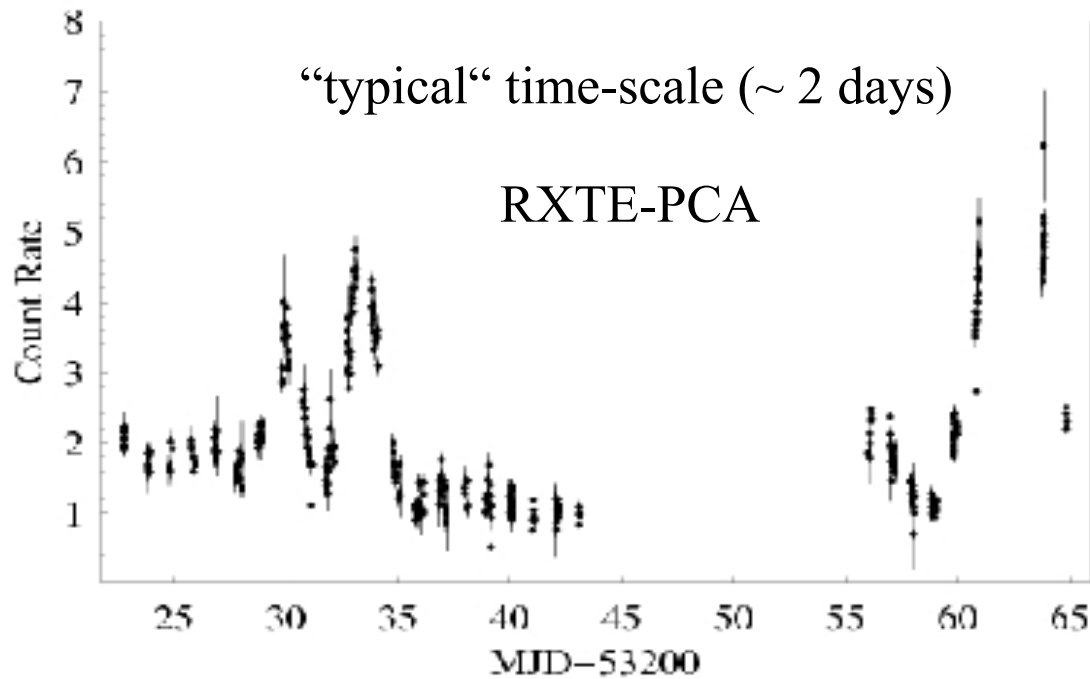
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Small fov, targeted
variability studies

brightest source,
best candate

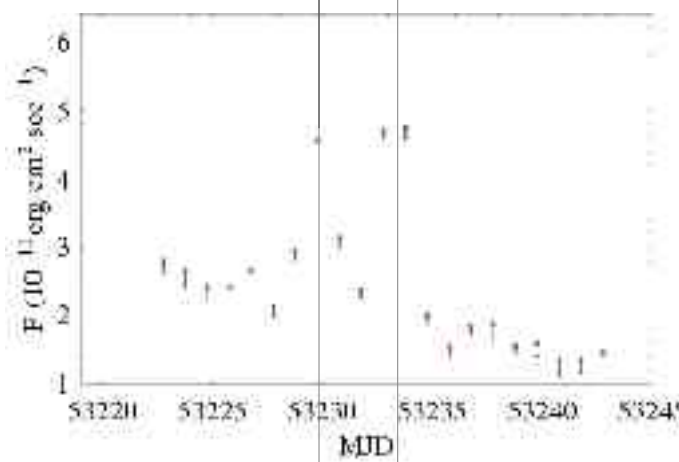
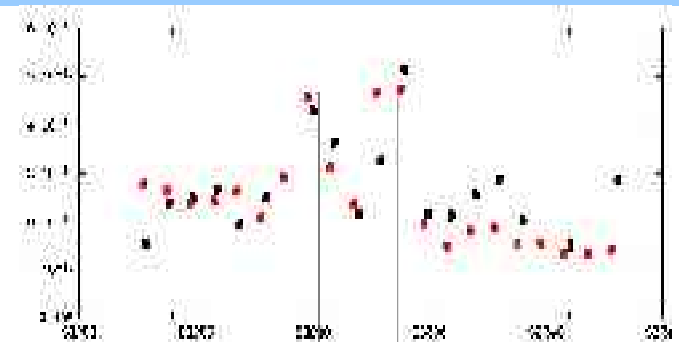
Correlations

PKS 2155-304 pre-planned

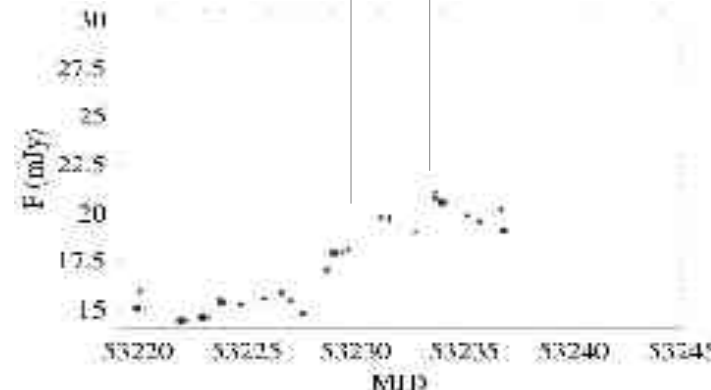


VHE
(HESS)

X-rays
XTE-PCA
(daily averages)

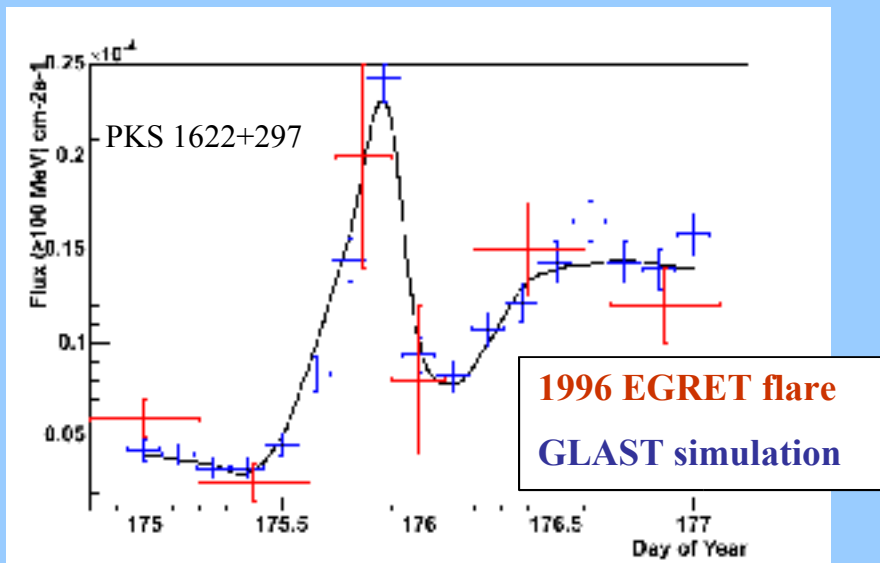


optical



close match 2 keV- 2 TeV (no lag)
spectral evolution in synchrotron
exploit GLAST energy range!

Implications for GLAST



Fast time-scales unexpected

How fast can variations be
in the GeV range?

Statistical tools in the
range of 1 photon/orbit

One event in ~ 200 source-hours of observation.

Small-number statistics [cf. Mkn 421 (Gaidos et al., 1996),
Mkn 501 (Paneque see P1.4 and astro-ph/0702008)]
suggest that this is more common than bright flare in
PKS 1622-297 (Mattox & Wagner, 1996)

Implications for correlations

Wide range in amplitude ratios (Gamma/Synchrotron).
Are 'orphan flares' (gamma-flare without synch. counterpart)
just too low in synchrotron domain? Why?

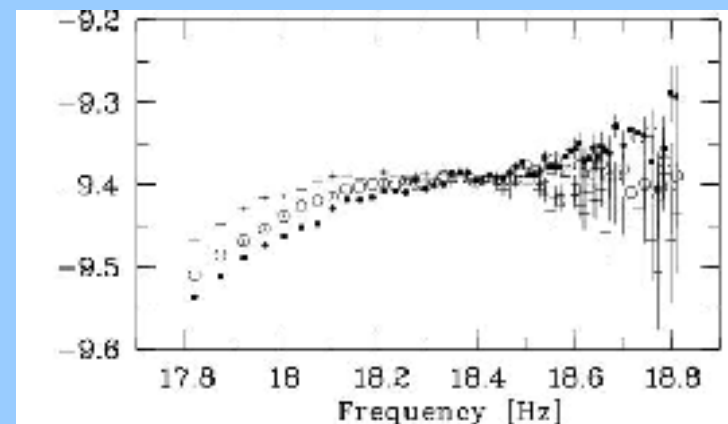
Huge range in Compton dominance among PWNe,
possibly an explanation for unidentified TeV sources
(large $L_{\text{VHE}} / L_{\text{X-ray}}$) – different magnetic fields?

Different particle momentum spectra?

Different (variable) \min factors?

Fast evolution of spectra in Mkn 501

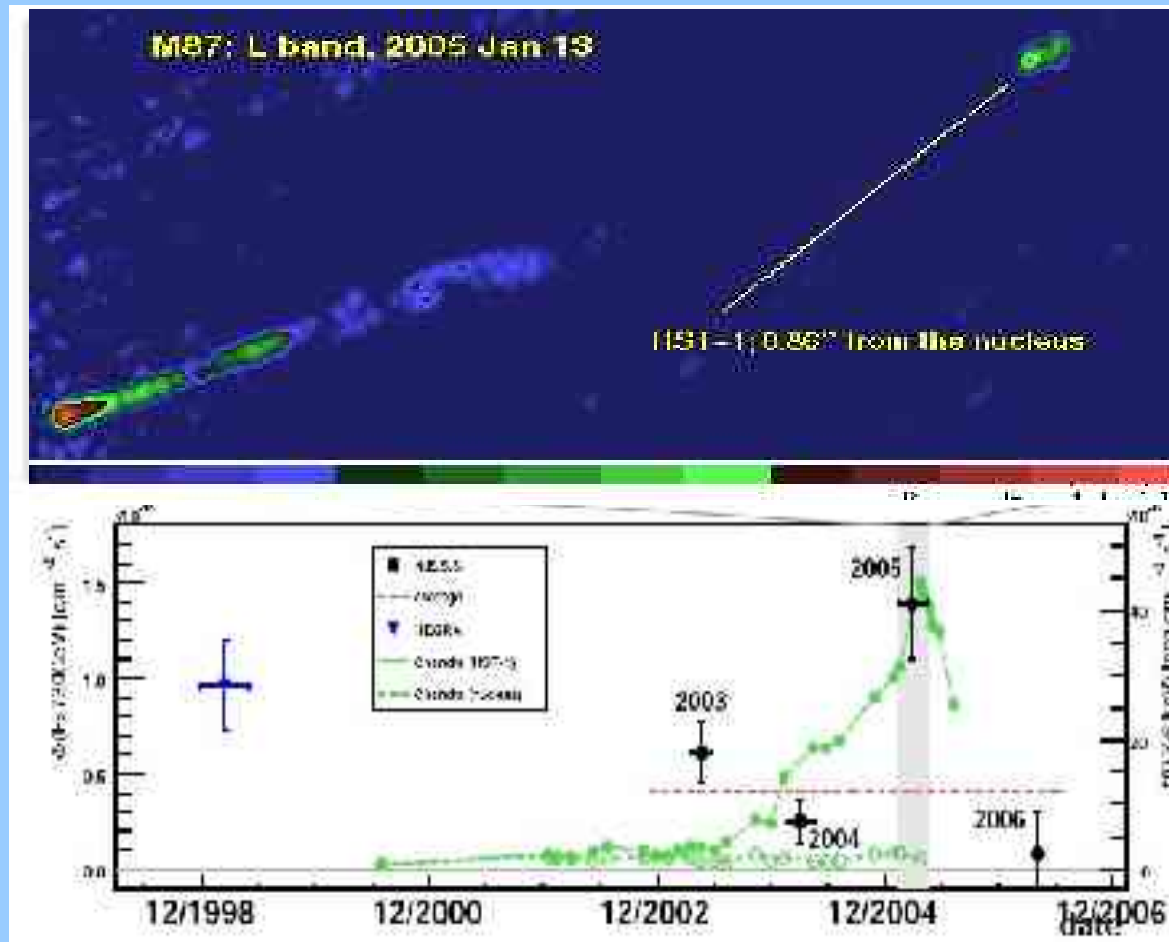
(Lamer and Wagner)



Implication on Models

different time-scales –
different sites ?
The case of M87
(M. Beilicke, talk P1.1)

annual averages:
VHE \sim X-rays HST1
g-rays from extended jet?



HST-1 Radio (Cheung et al.) X-rays (Harris et al.) TeV Gamma-Rays

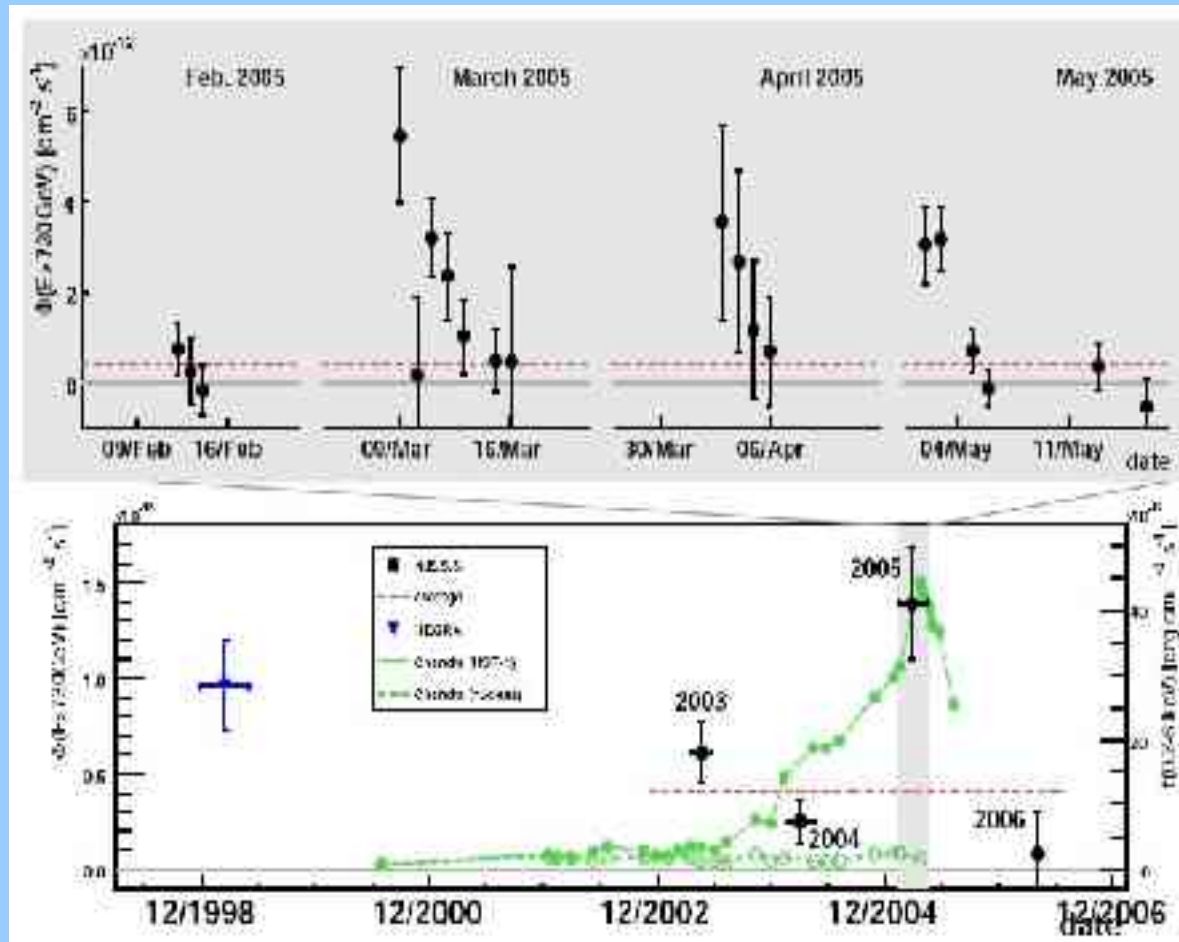
Where are the emission regions?

different time-scales –
different sites ?

The case of M87
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annual averages:
VHE \sim X-rays HST1

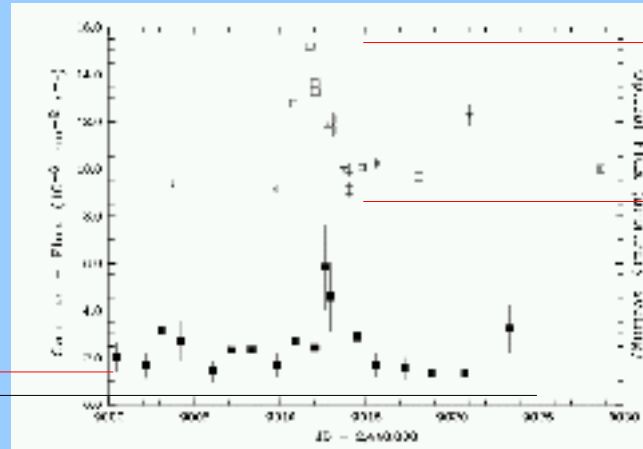
fast variability (\sim 2 days)
compact component
(nucleus?)
no correlation with X-ray



Flares vs. Flicker

PKS 1406-076

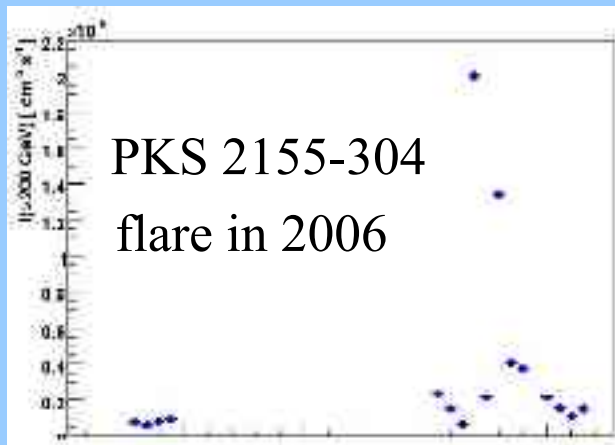
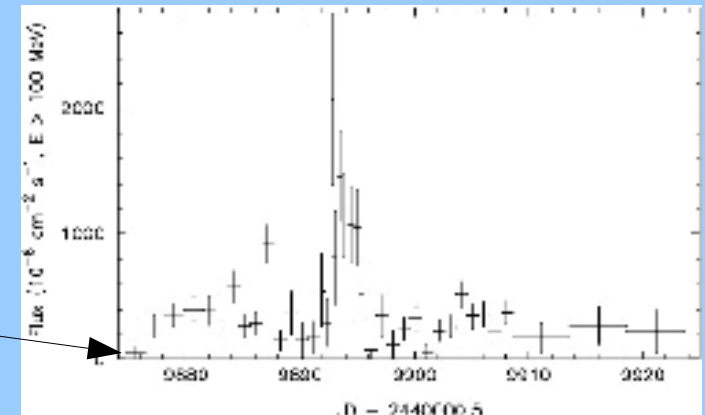
level in VP
before flare
average level



optical flare

longterm level
(several years)

PKS 1622-297
VP that caused
repointing



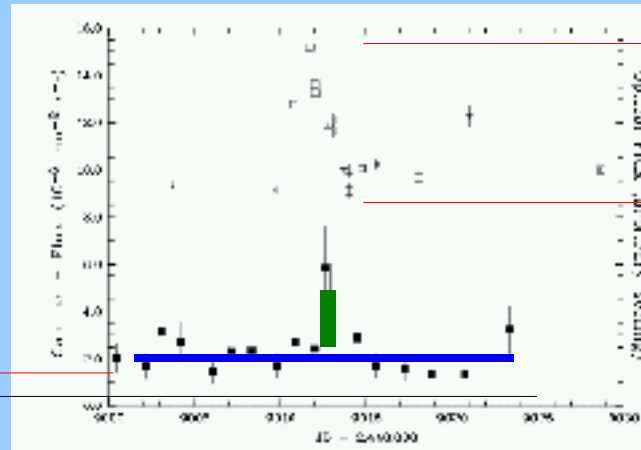
PKS 2155-304
flare in 2006

different events (mechanisms)?
... or power-law spectrum of flares

Flares vs. Flicker

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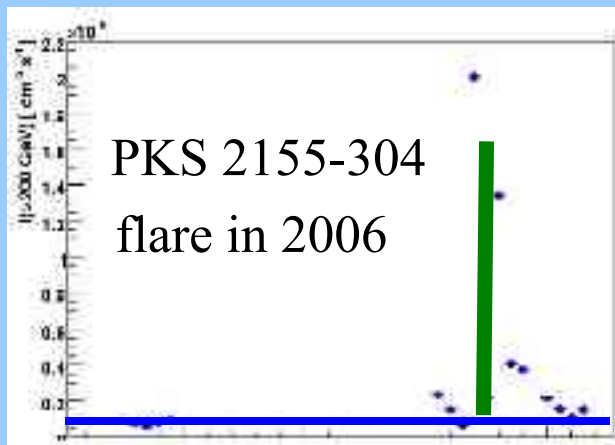
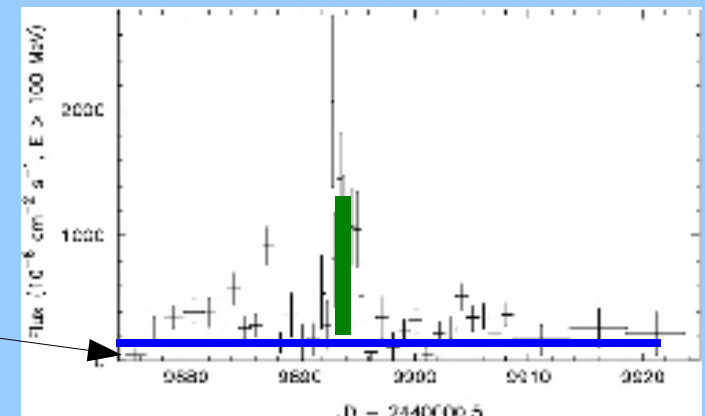
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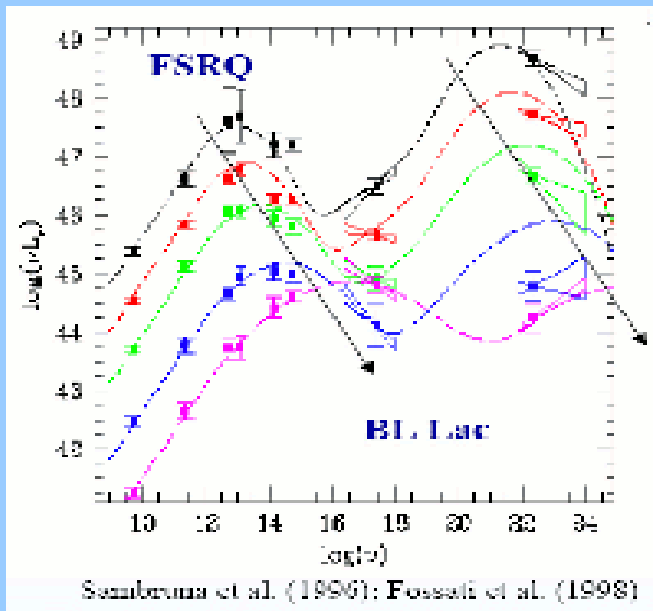
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The Blazar population



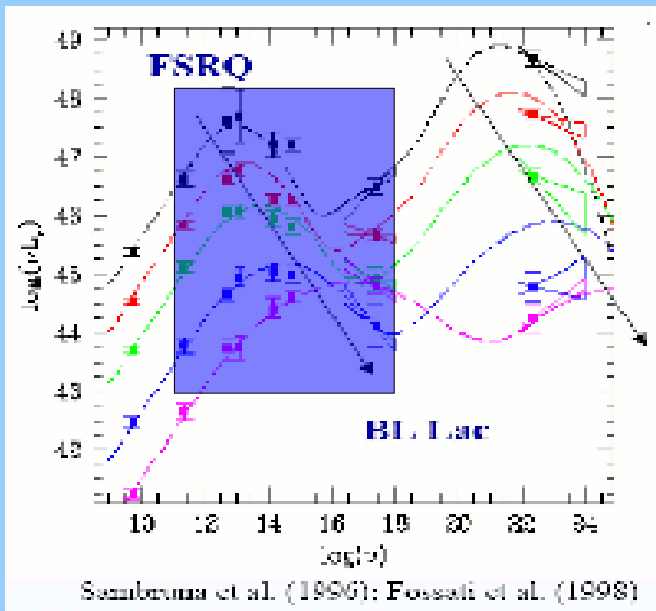
Fossati; Ghisellini; Maraschi, et al. (1997-2007)

Many incarnations of the
Blazar sequence:

Luminosity correlates with $\log(r)_{\text{max}}$

Compton dominance correlates with $\log(L)_{\text{max}}$

The Blazar population



Fossati; Ghisellini; Maraschi, et al. (1997-2007)

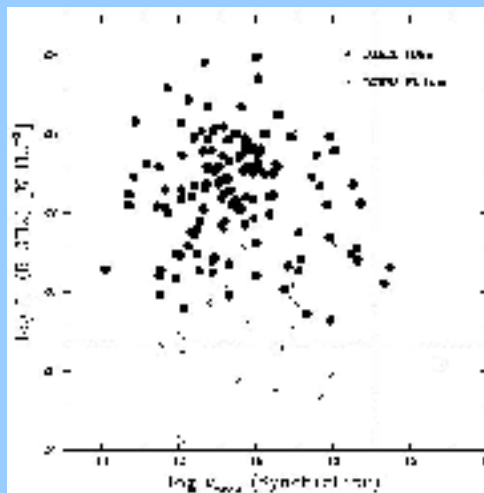
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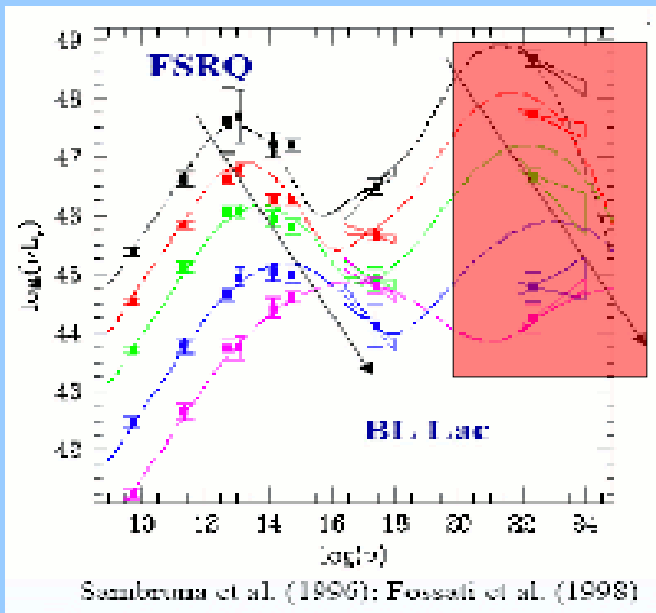
Compton dominance correlates with γ_{max}

In **Synchrotron domain** only the
1st relation can be checked.

Padovani (2006) finds selection biases



The Blazar population

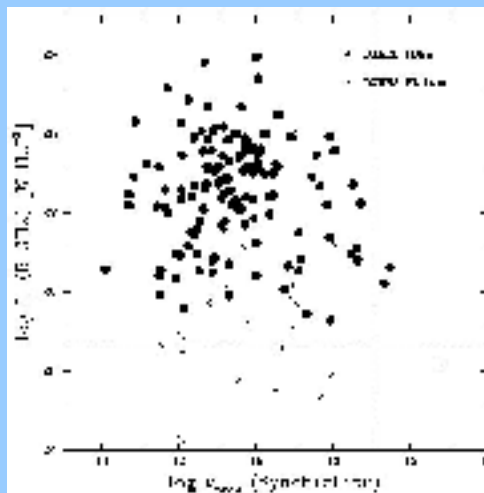


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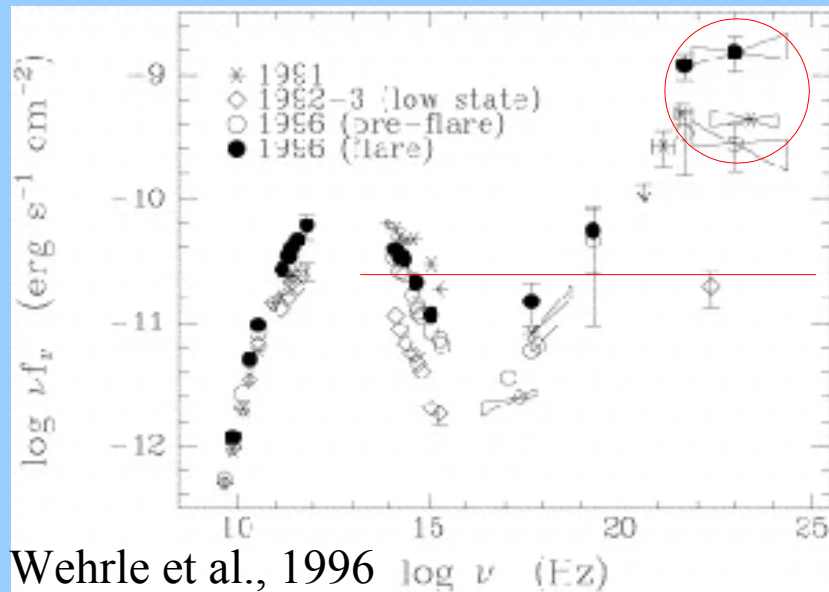
Luminosity correlates with γ_{max}
Compton dominance correlates with γ_{max}

In Synchrotron domain only the
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In the **Compton-domain**
selection biases due to variability
need to be considered

Variability Bias and Blazar sequence

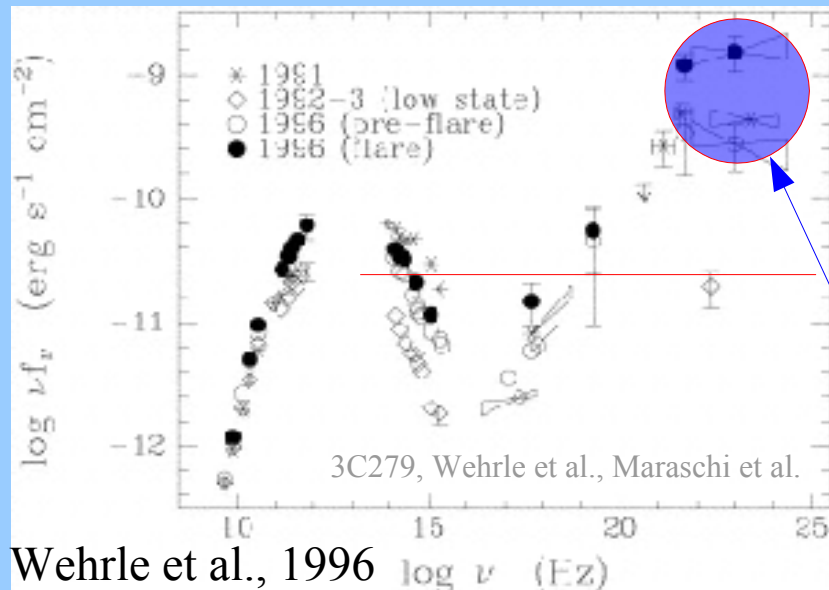


Wehrle et al., 1996

High flux/Compton dominance
in flares of short duration

Longterm average, low dominance

Variability Bias and Blazar sequence



Wehrle et al., 1996

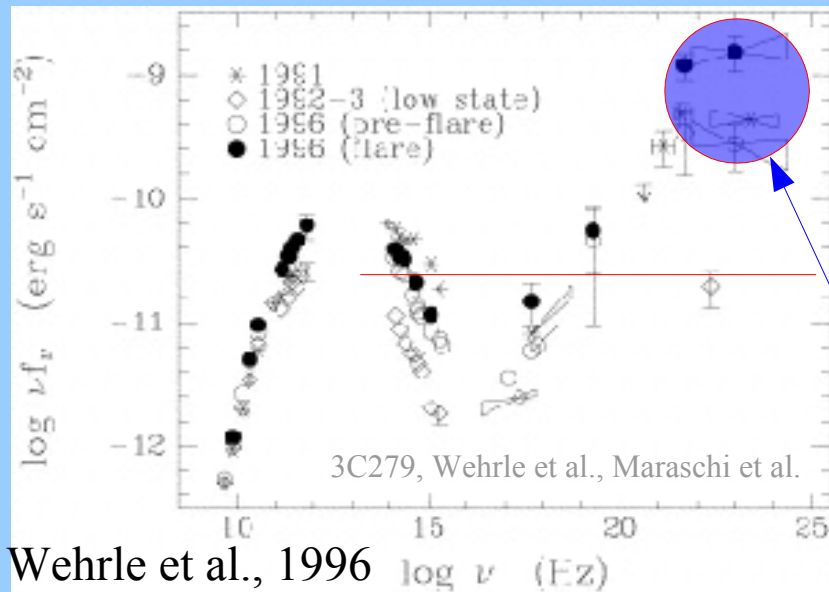
High flux/Compton dominance
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Longterm average, low dominance

Sources are only detected during
flares (wide-field instrument)

Beware of time-averaged SEDs if detection is biased to flares

Variability Bias and Blazar sequence

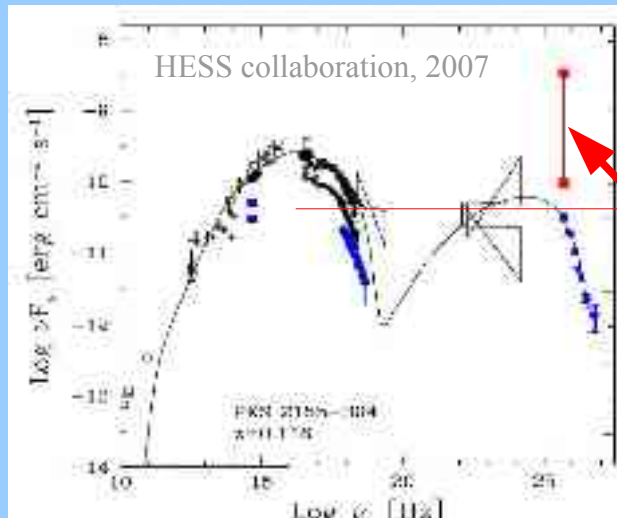


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Longterm average, no dominance

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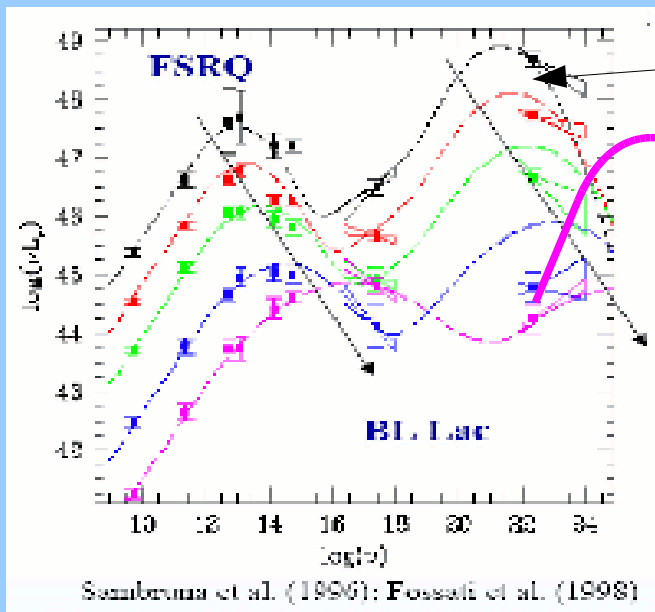


Similar pattern in VHE Blazars

no dominance in low state
(source detected in quiescence)

Compton dominance in flares

Variability Bias and Blazar sequence



Few flares in many years
of all-sky experiment

Bright flare in narrow-fov experiment

Compton-dominance independent of
max if variability is taken into account?
(these are very few events/sources !)

luminosity — max relation subject to variability.

Note also that VHE Blazars are from volume-limited sample,
and hence biased against bright sources.

The identification of biases does not falsify the explanation!

Summary

Variability on all time-scales in all bands

Wide range in gamma/synchrotron ratios

Very fast variations in VHE Blazars:
Important constraints – Implications for GLAST?

Different time-scales (flares vs. flicker) – different mechanisms/sites/properties?

Variability-induced biases affect population studies

Reserve

