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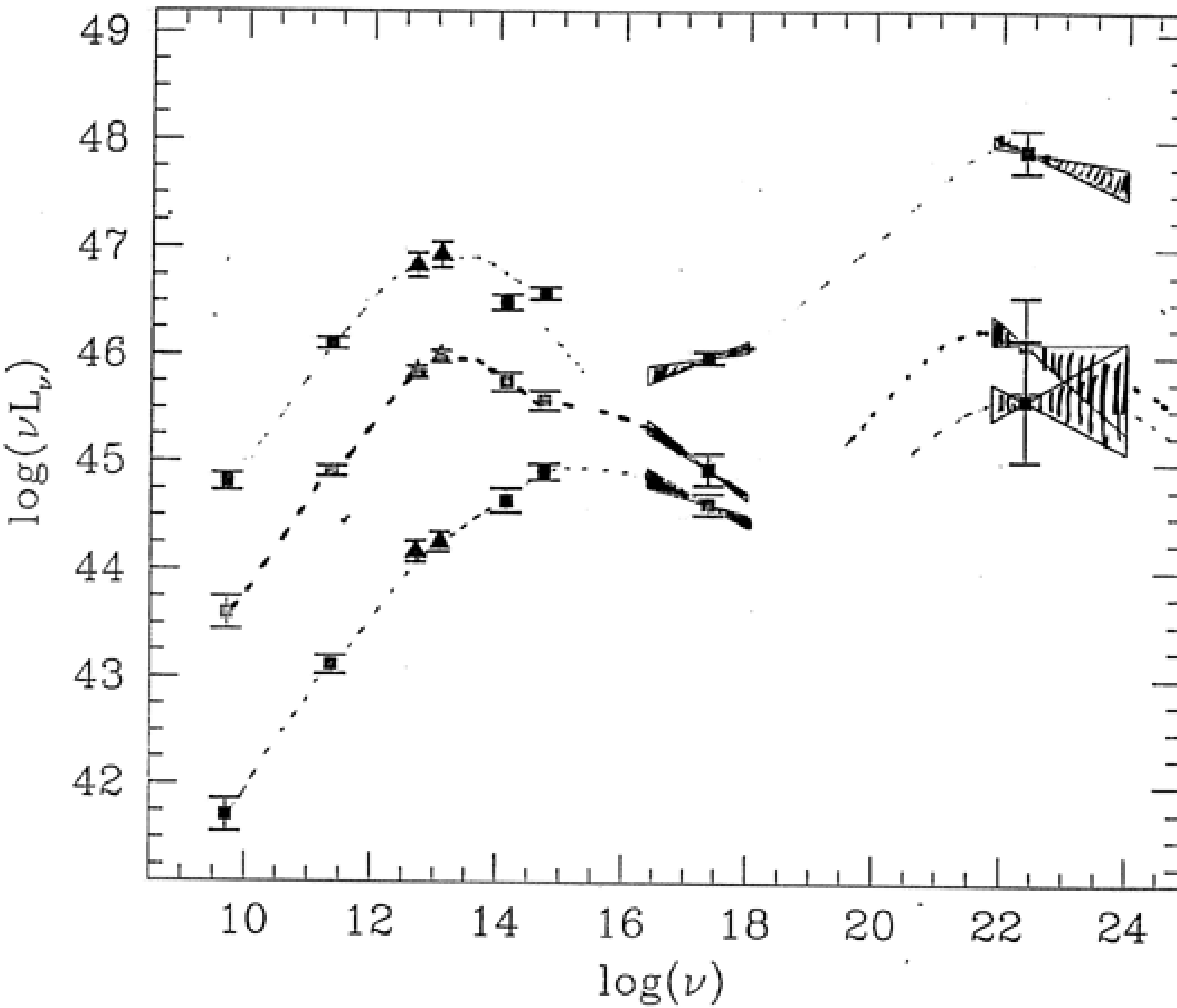
"A GLOBAL VIEW OF BLAZARS"

(what we know now
what we expect from GLAST)

- Trends in the "average" SEDs
- Variability of 3C279
- Variability of Mkn 501/421
- Flat Spectrum Radio Quasars

— HPQ (FSQ) from 2 Jy sample. (50, 19 γ)
— BL Lacs from 1 Jy sample (34, 9 γ)
— BL Lacs from Slew Survey sample (48, 8 γ)

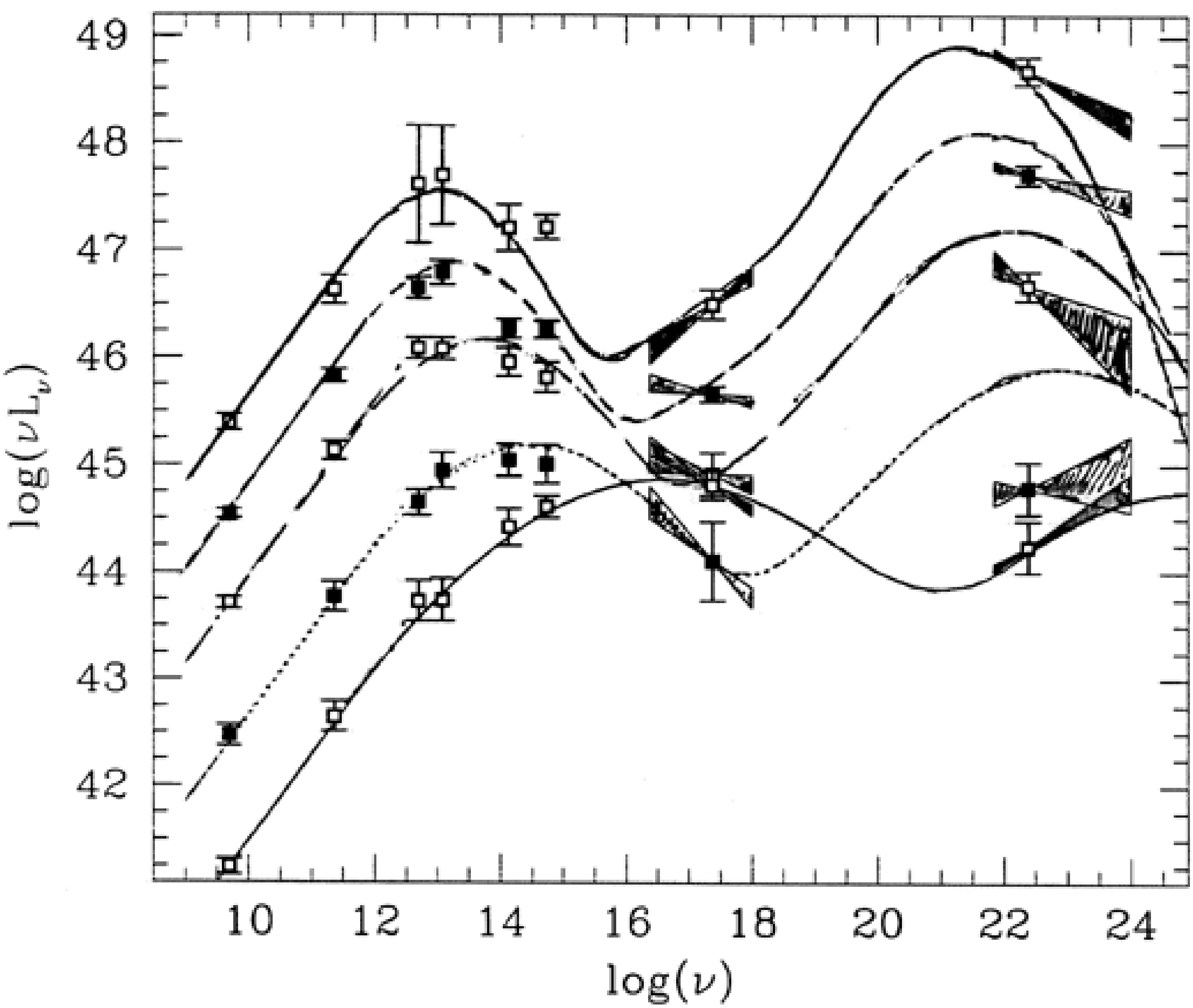
Fossati et al. 1997



The higher ν_s the higher ν_c !

A "UNIFIED" VIEW

Fossati et. al. 1998



High luminosity blazars are "red"

Low luminosity blazars are "blue"

A 1 parameter spectral sequence ?

GENERAL UNDERSTANDING

1st peak → synchrotron rad
2nd peak → IC radiation
↑
phot external to the jet → seed photons ← (synchrotron rad)

SAME ELECTRONS RADIATE AT THE PEAKS

⇓

Correlation of variability close to the peaks

IR-opt-UV ↔ GeV γ-rays   X-rays ↔ TeV γ-rays

L_2/L_1 increasing with L implies U_{rad} increasing with L

The spectral "similarity" suggests the same rad mech. are active in all objects but with different phys. param.

synchrotron ⟷ IC correlation means

opt-UV ⟷ GeV γ-rays for red blazars

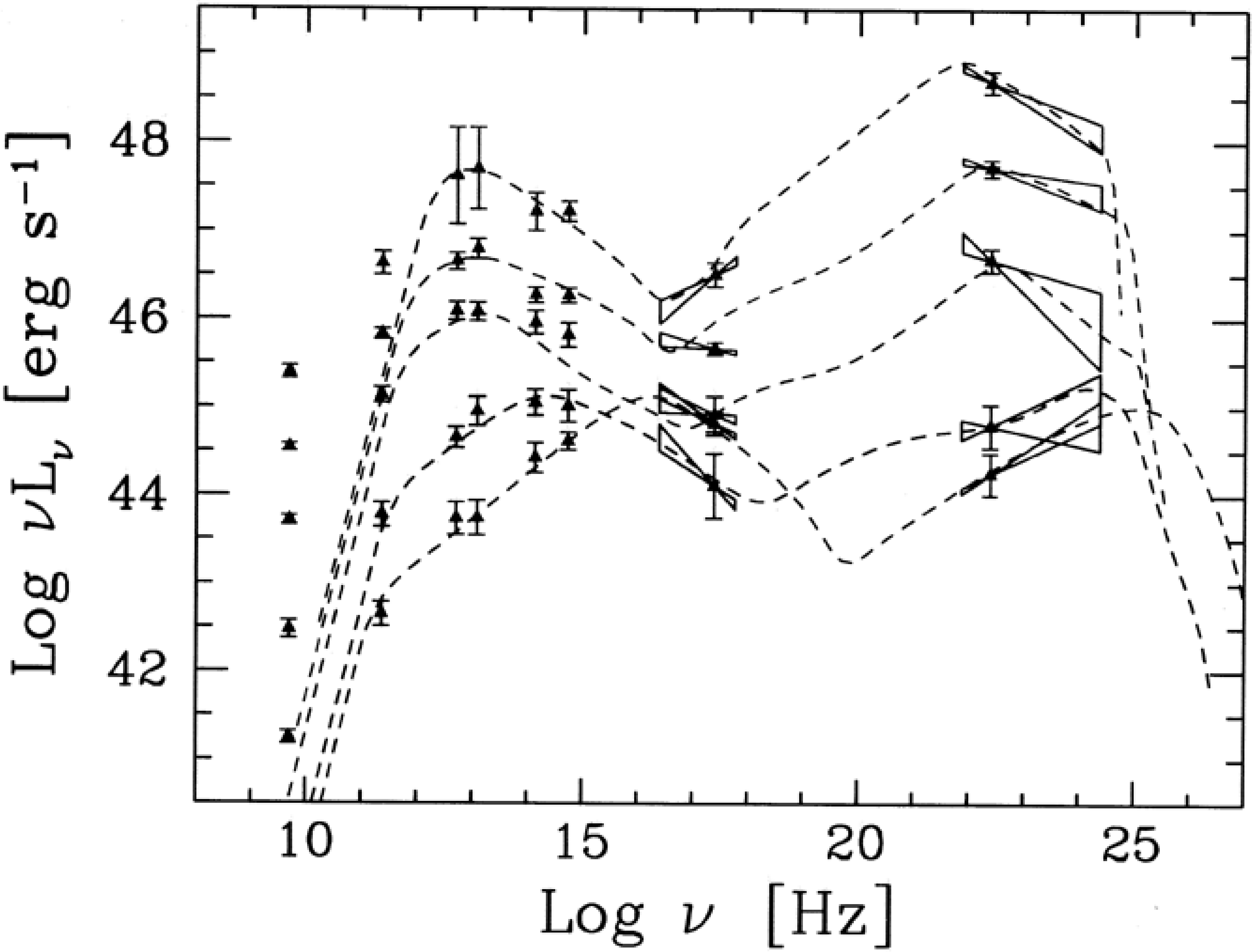
X-rays ⟷ TeV γ-rays for blue blazars

The lower ν_{peak} in high luminosity objects may be due to higher radiation losses in sources with higher external radiation density (therefore higher EC dominance with respect to SSC).

F. Q. and BL Lac objects contain "similar" jets suggesting same central engine but different scales

[illegible] is to understand the role played by fundamental parameters: M $\dot{M}$ J governing the luminosity sequence and the thermal / non thermal ratio -

From Ghisellini et al. 1998 MNRAS submitted!



3C 279

OPTICAL/IR – X-Ray – γ-Rays

are

"generally" correlated

✱ variability amplitude in

γ-rays

much larger

than at optical/IR or X-ray frequencies

lependence of the Compton flux on the relevant parameters for the
sible sources of seed photons

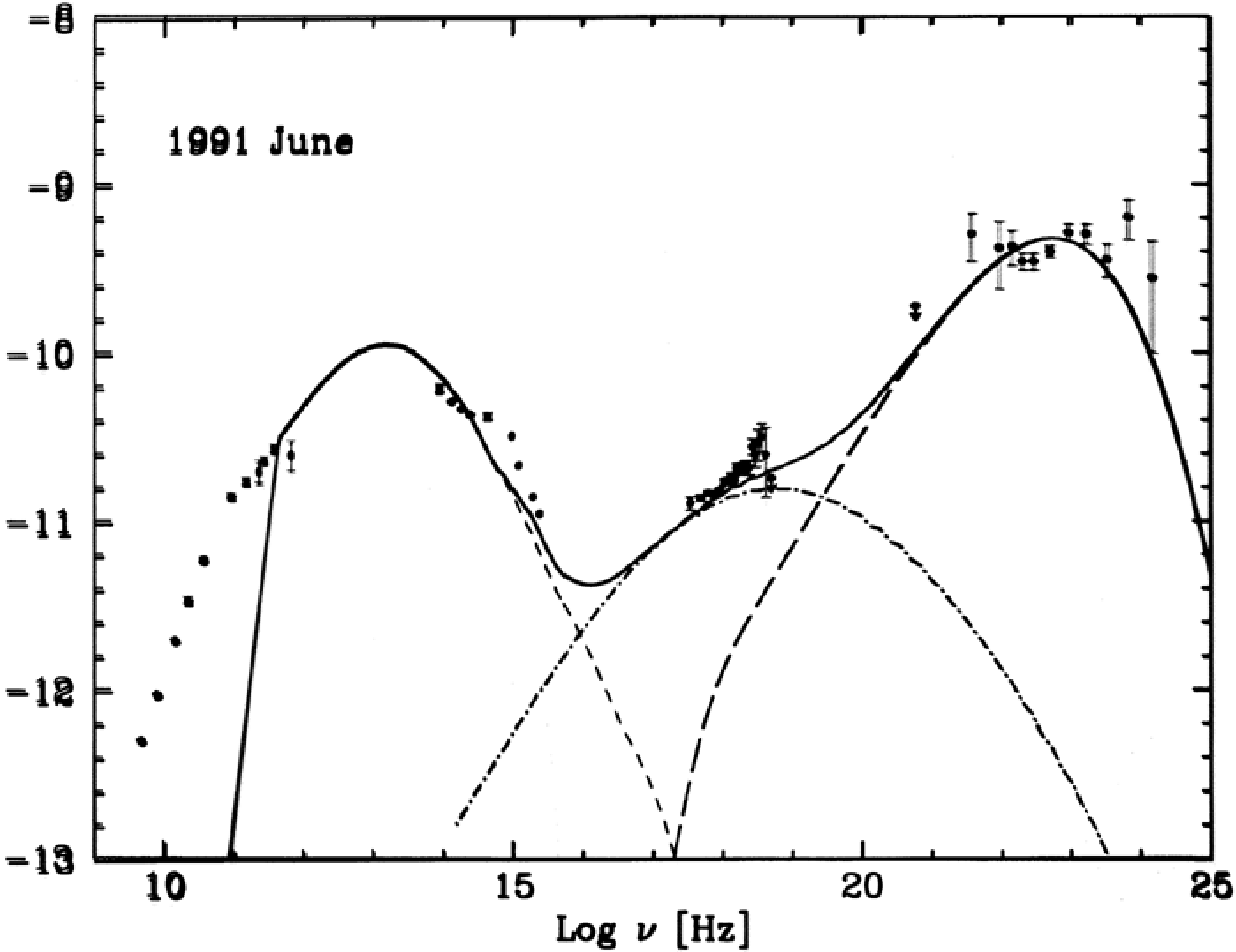
$$F_{\rm SSC} \propto \Gamma^4 N_{\rm el}^2 B^2, \qquad (7)$$

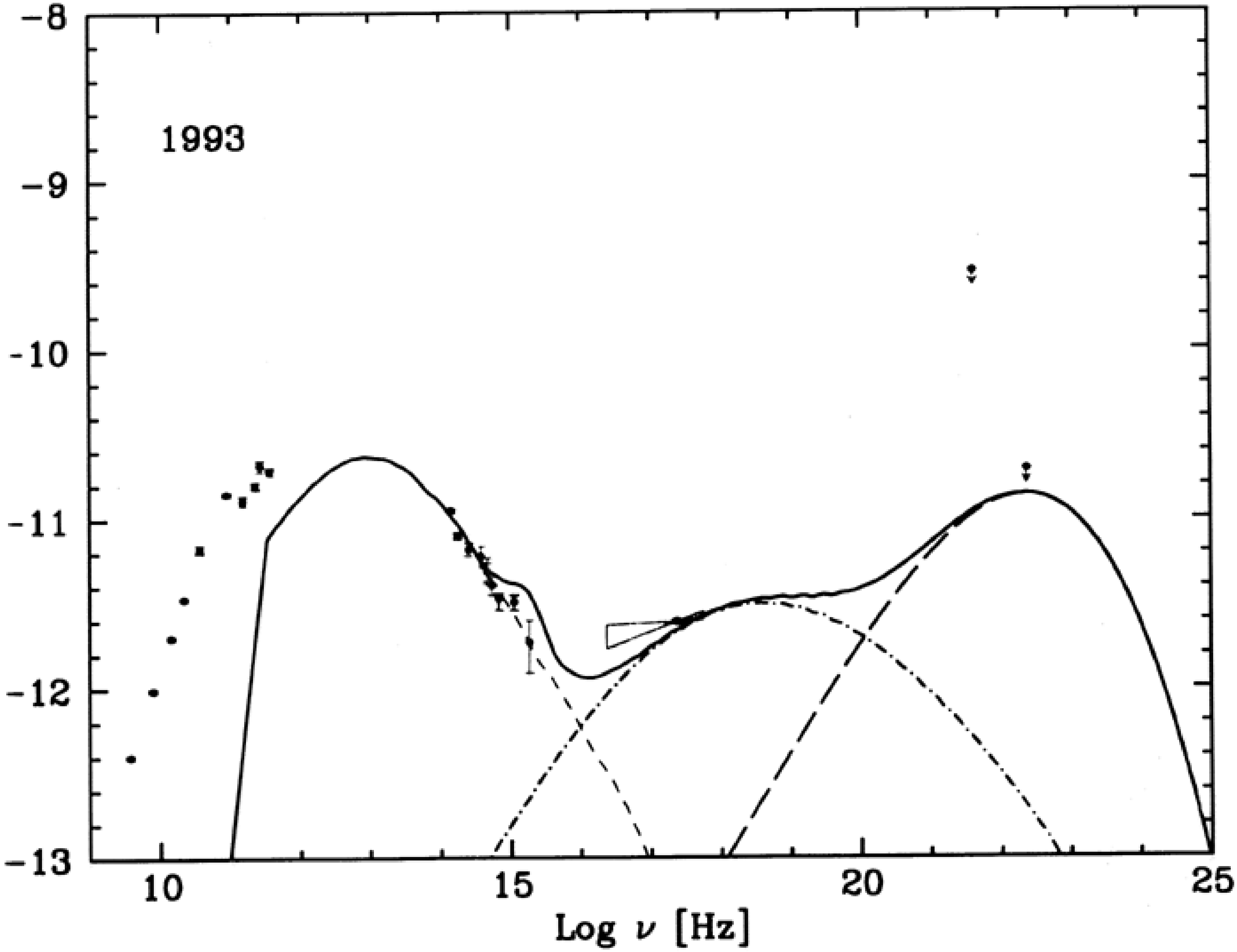
$$F_{\rm EC} \propto \Gamma^6 N_{\rm el} U_{\rm ext}\,, \qquad (8)$$

$$F_{\rm MC} \propto \Gamma^8 N_{\rm el}^2 B^2, \qquad (9)$$

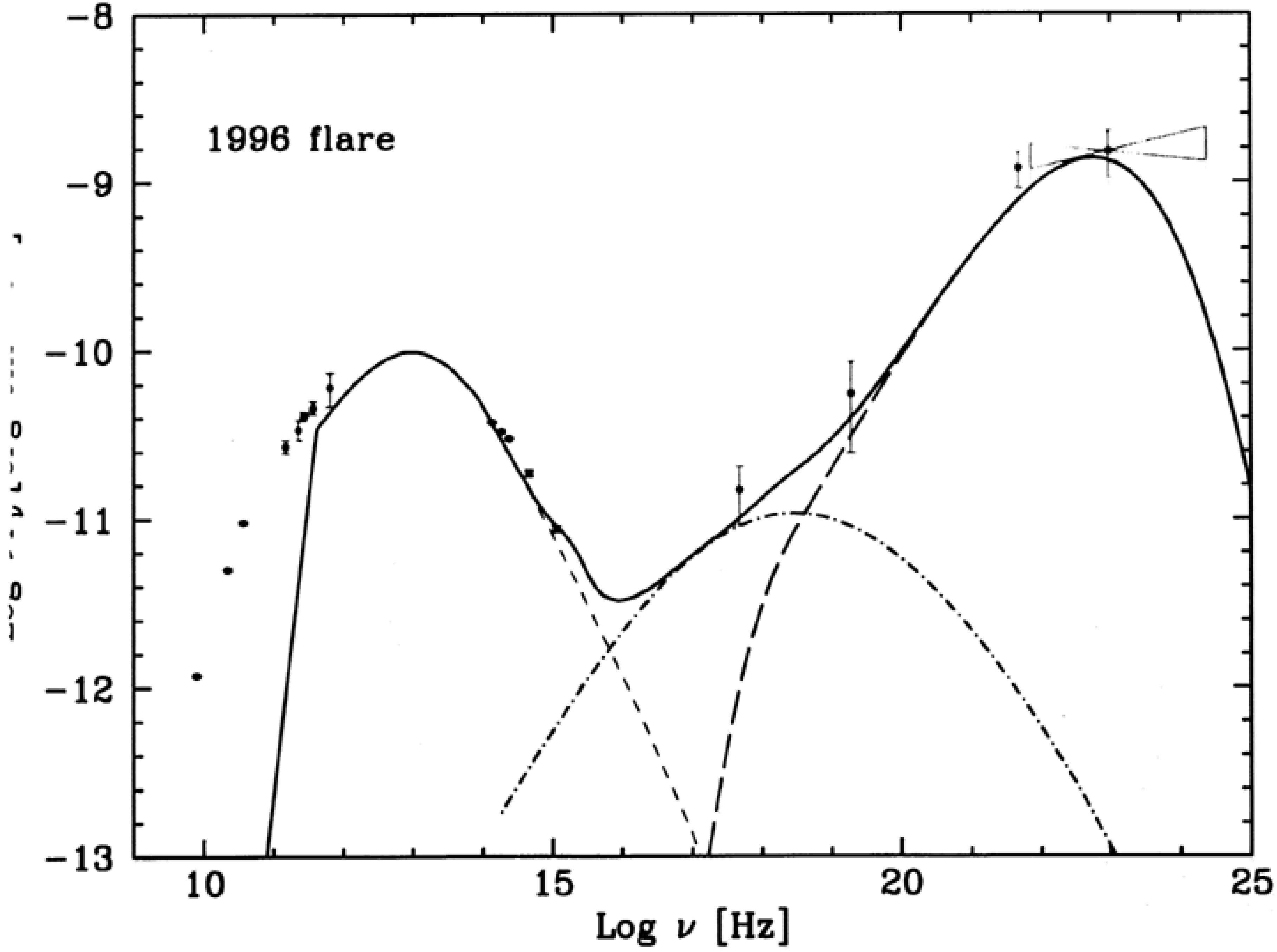
e 1. Correlations between synchrotron and Compton fluxes

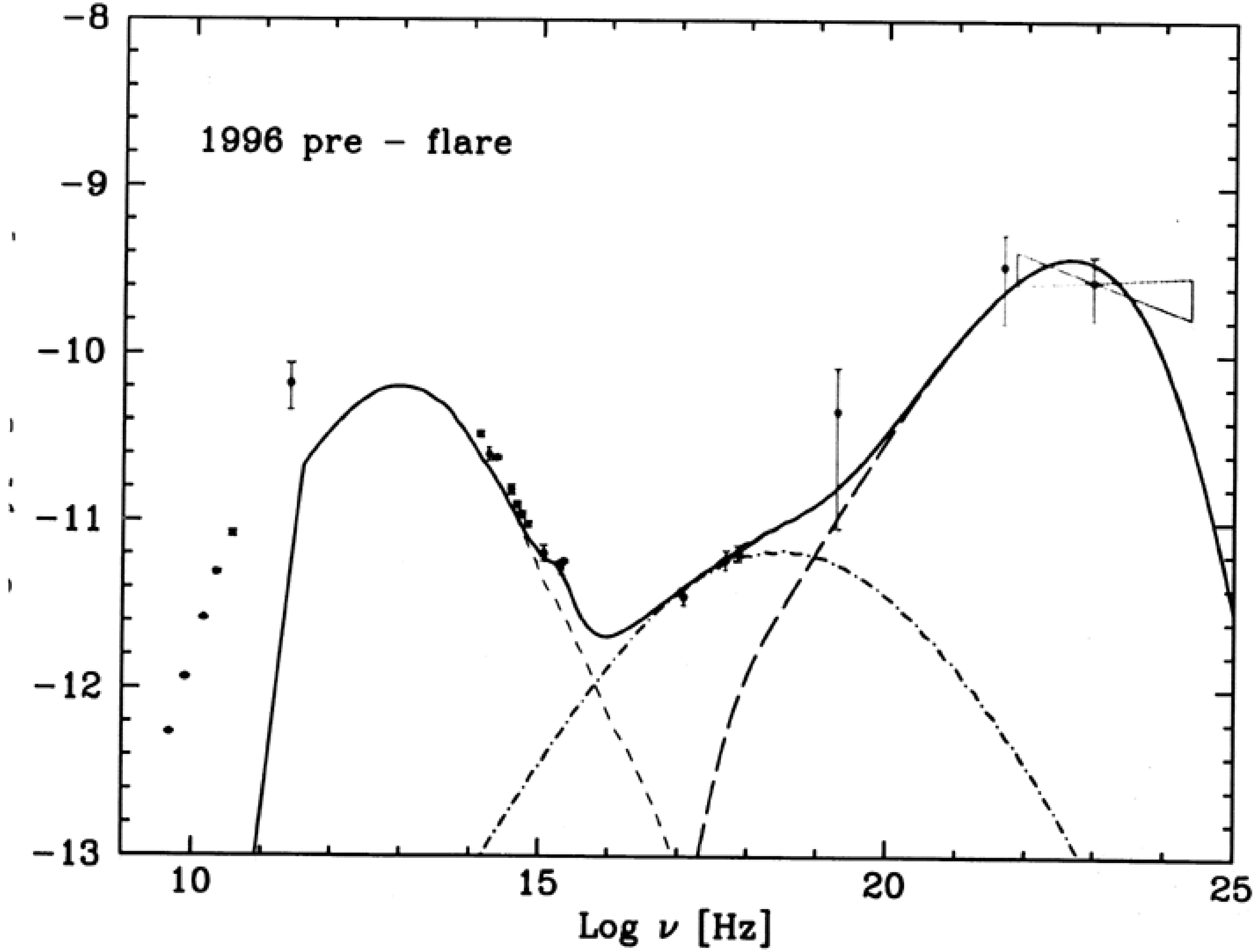
	$N_{\rm el}$	B	Γ	$U_{\rm ext}$
SSC	$F_{\rm C} \propto F_{\rm S}^2$	$F_{\rm C} \propto F_{\rm S}$	$F_{\rm C} \propto F_{\rm S}$	$F_{\rm S}$ = const. $F_{\rm C}$ = const.
EC	$F_{\rm C} \propto F_{\rm S}$	$F_{\rm C}$ = const. $F_{\rm S} \propto B^2$.	$F_{\rm C} \propto F_{\rm S}^{3/2}$	$F_{\rm C} \propto U_{\rm ext}$ $F_{\rm S}$ = const.
MC	$F_{\rm C} \propto F_{\rm S}^2$	$F_{\rm C} \propto F_{\rm S}$	$F_{\rm C} \propto F_{\rm S}^2$	$F_{\rm C}$ = const. $F_{\rm S}$ = const.


1991 June
-8
-9
-10
-11
-12
-13
10
15
20
25
Log ν [Hz]

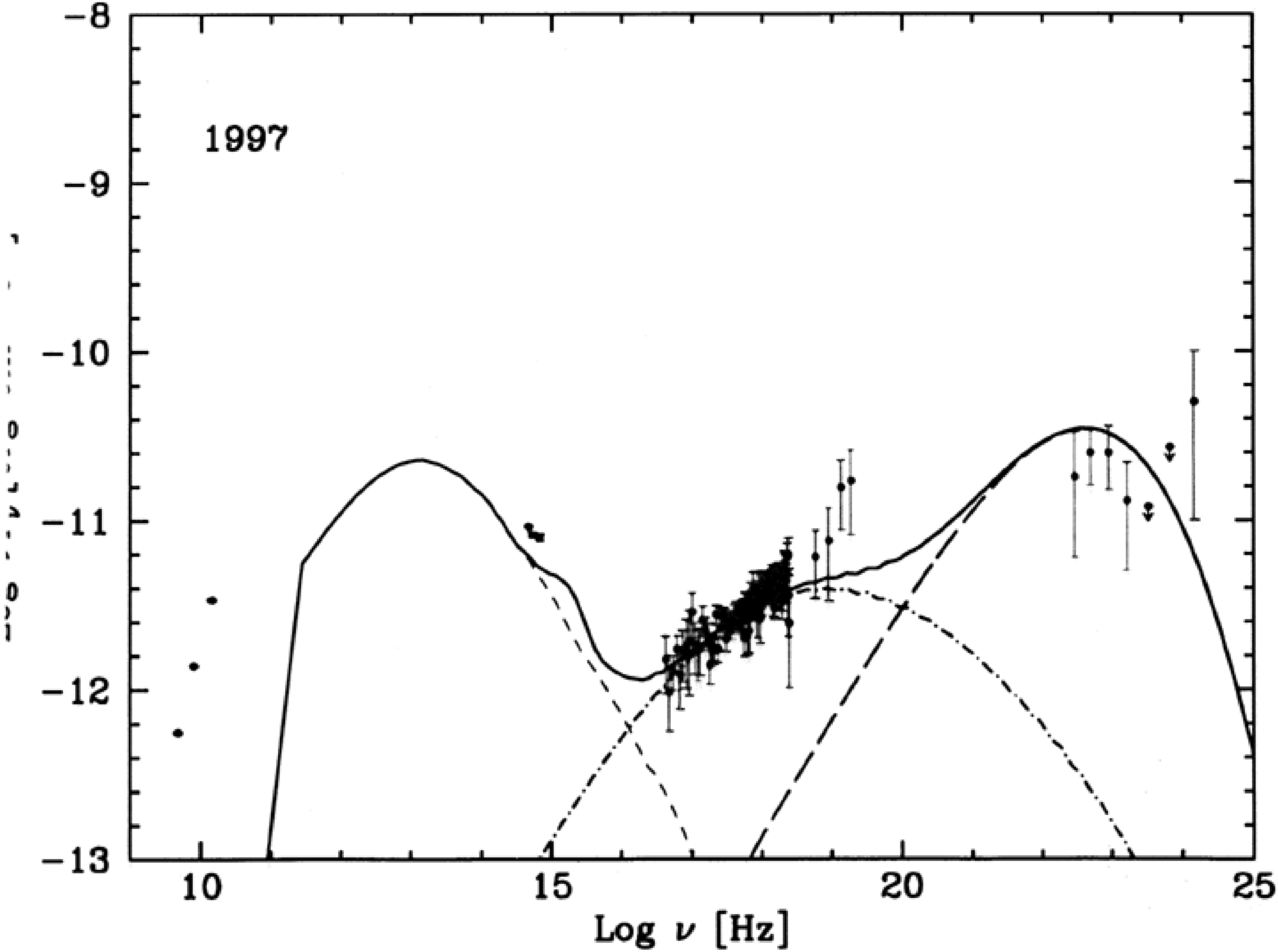


1993
-8
-9
-10
-11
-12
-13
10
15
20
25
Log ν [Hz]


1996 flare
Log ν [Hz]
10
15
20
25
−8
−9
−10
−11
−12
−13



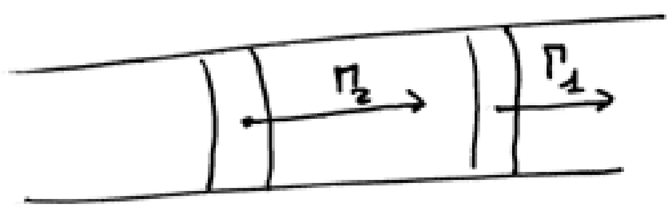
1996 pre – flare
−8
−9
−10
−11
−12
−13
10
15
20
25
Log ν [Hz]


1997
−8
−9
−10
−11
−12
−13
10
15
20
25
Log ν [Hz]

Γ	B (G)	γ_b $(\times 10^2)$	γ_{max} $(\times 10^4)$	n_1	n_2	k $(\times 10^3)$
1991 June						
15	0.7	5.7	5.0	1.6	4.7	5.5
1991 October						
13	0.7	5.7	5.0	1.6	4.7	5.5
1993						
9	1.0	4.5	5.0	1.6	4.4	5.8
1996 pre - flare						
15	0.6	4.9	5.0	1.6	4.7	5.2
1996 flare						
18	0.5	4.9	5.0	1.6	4.7	5.5
1997						
10	0.7	6.0	5.0	1.6	4.4	5.0

The "internal shock" model for Blazars

Spada Ghisellini Lazzati Celotti (2000 submitted)



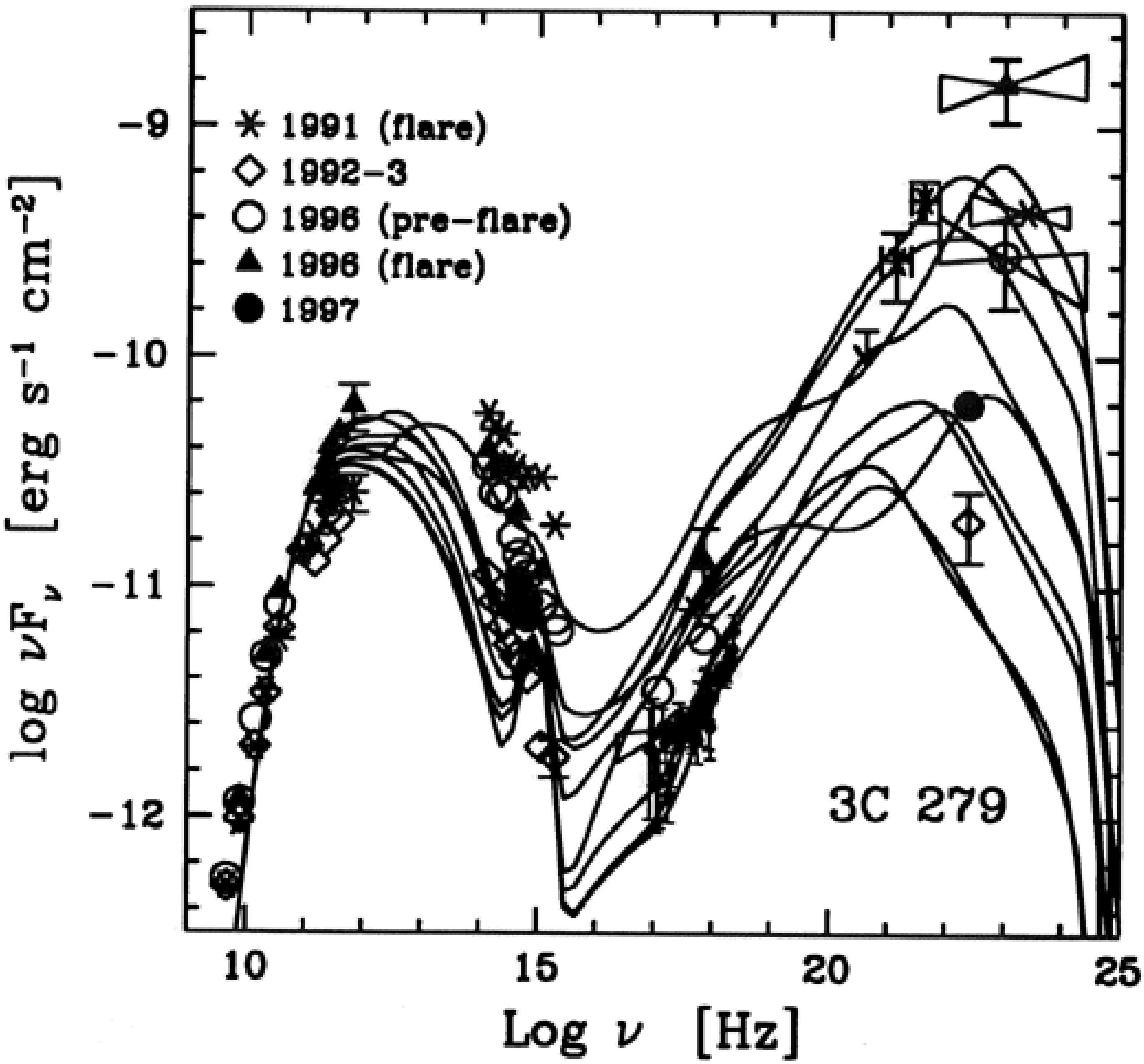
Dissipation (radiation) occurs at shocks formed by the collision of two shells

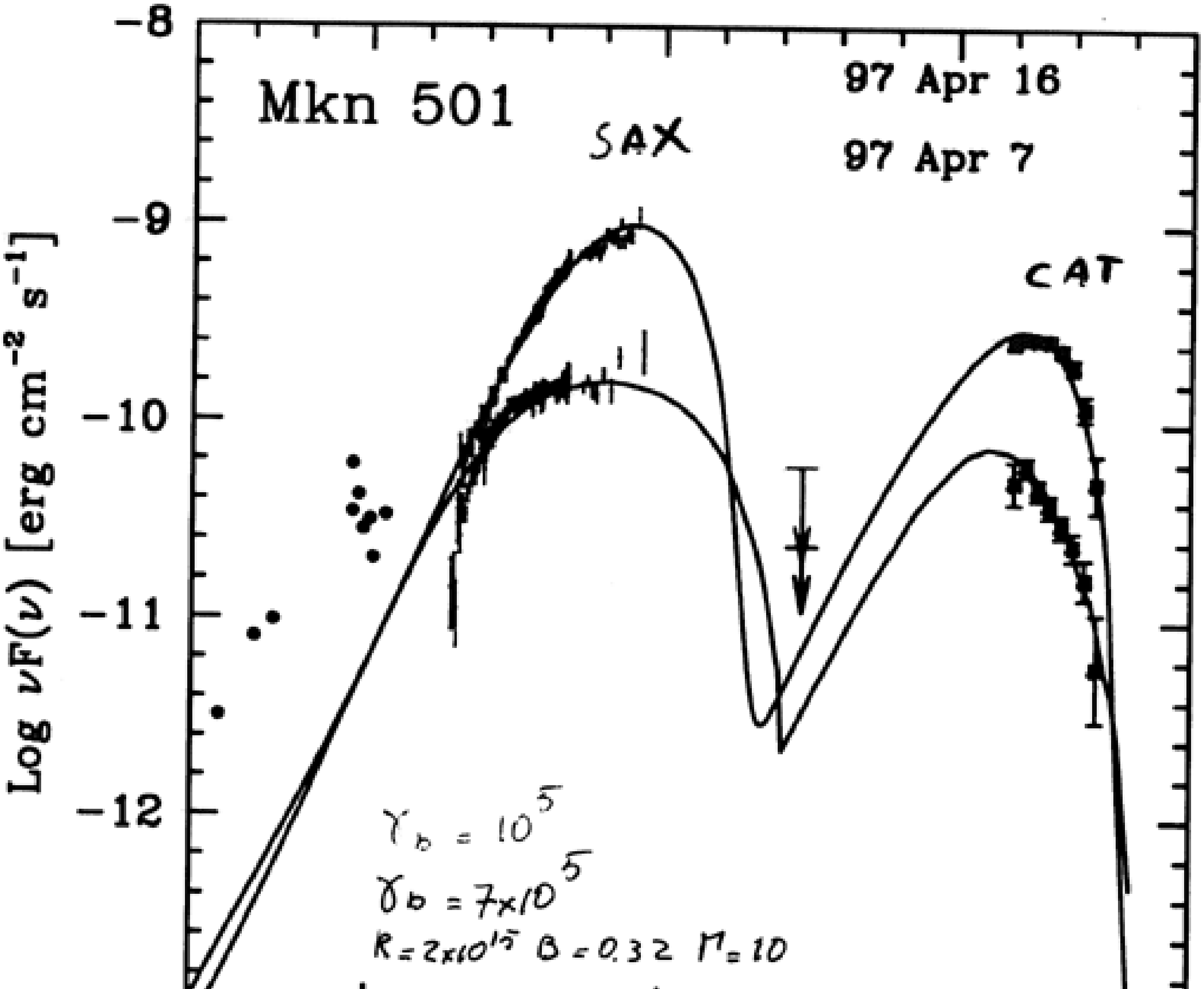
- "Average" location of the first collision

$$R_0 \Gamma^2$$

- Efficiency ~ 10% at first collision

Spada Ghisellini Lazzeti Celotti
2000 MNRAS submitted

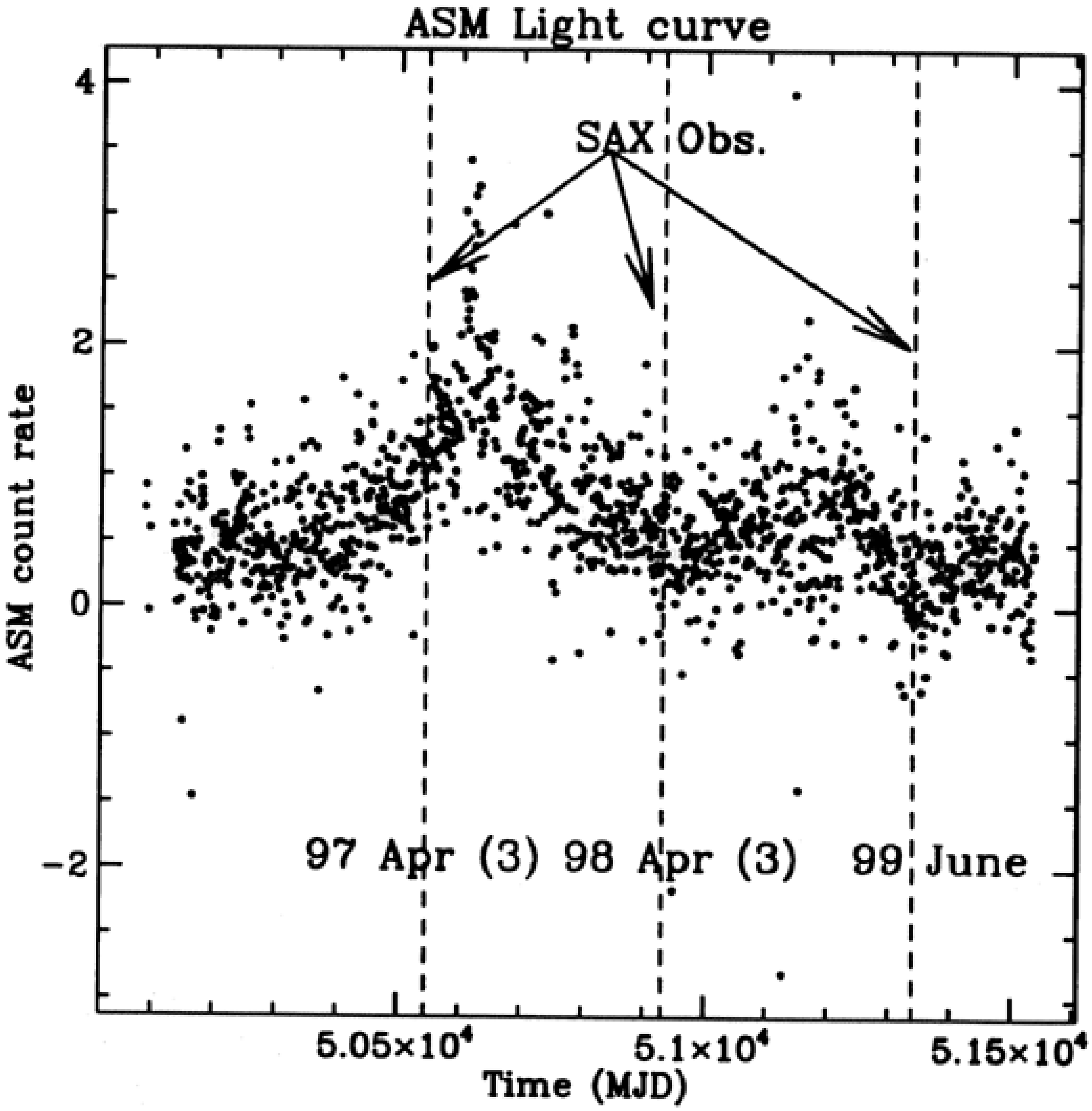


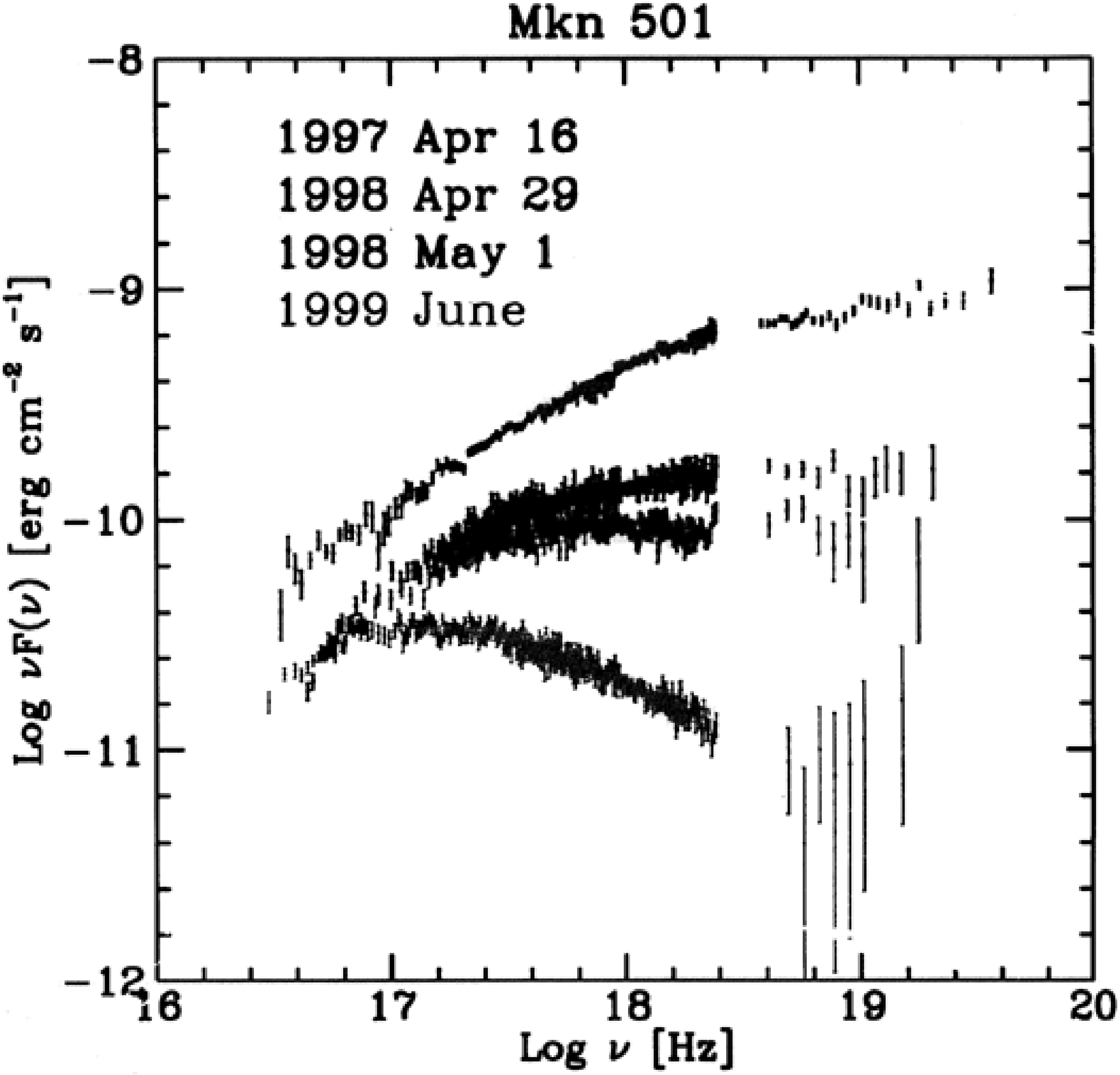


Tavecchio et al. submitted (2000)

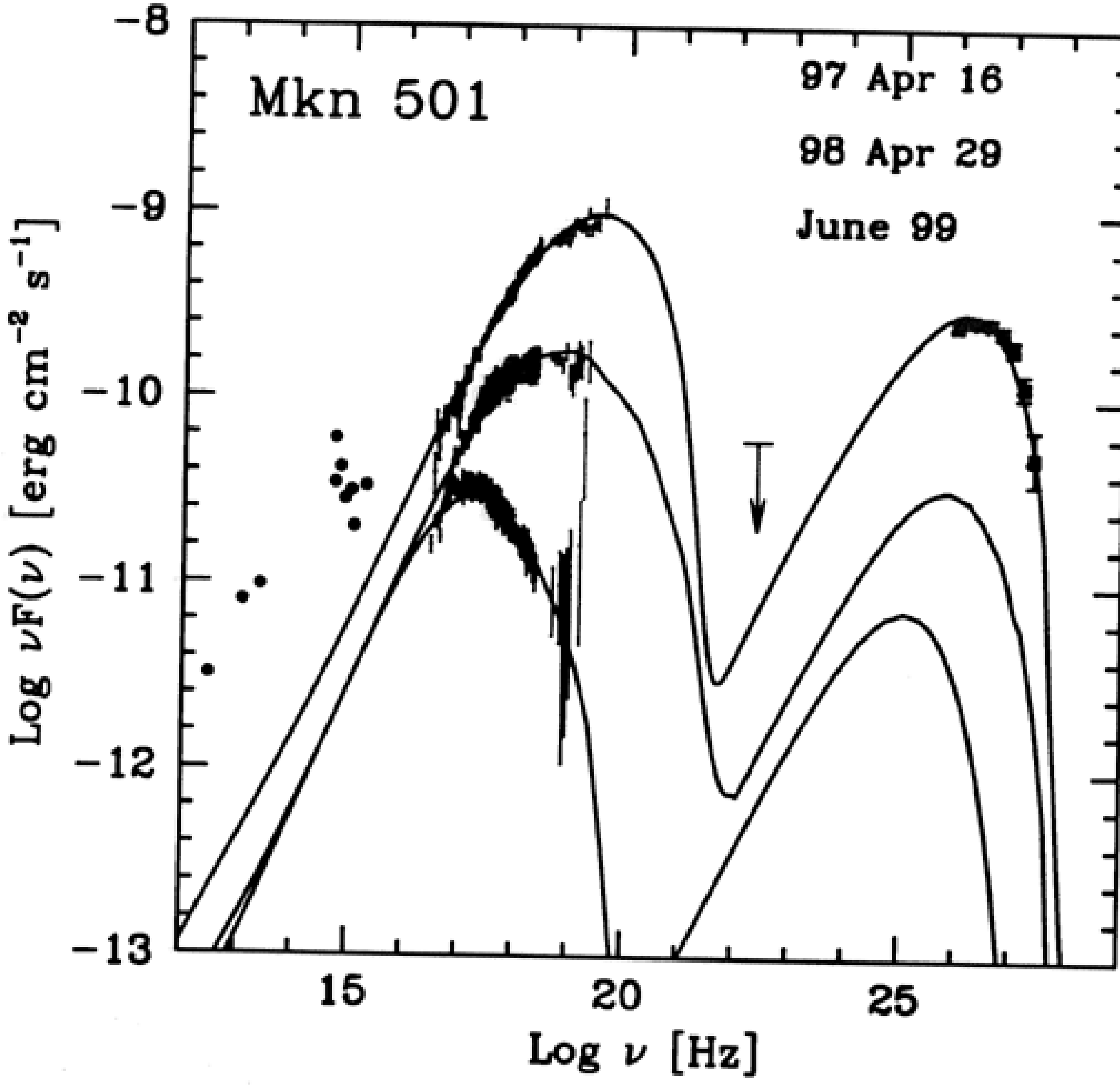
Mkn 501

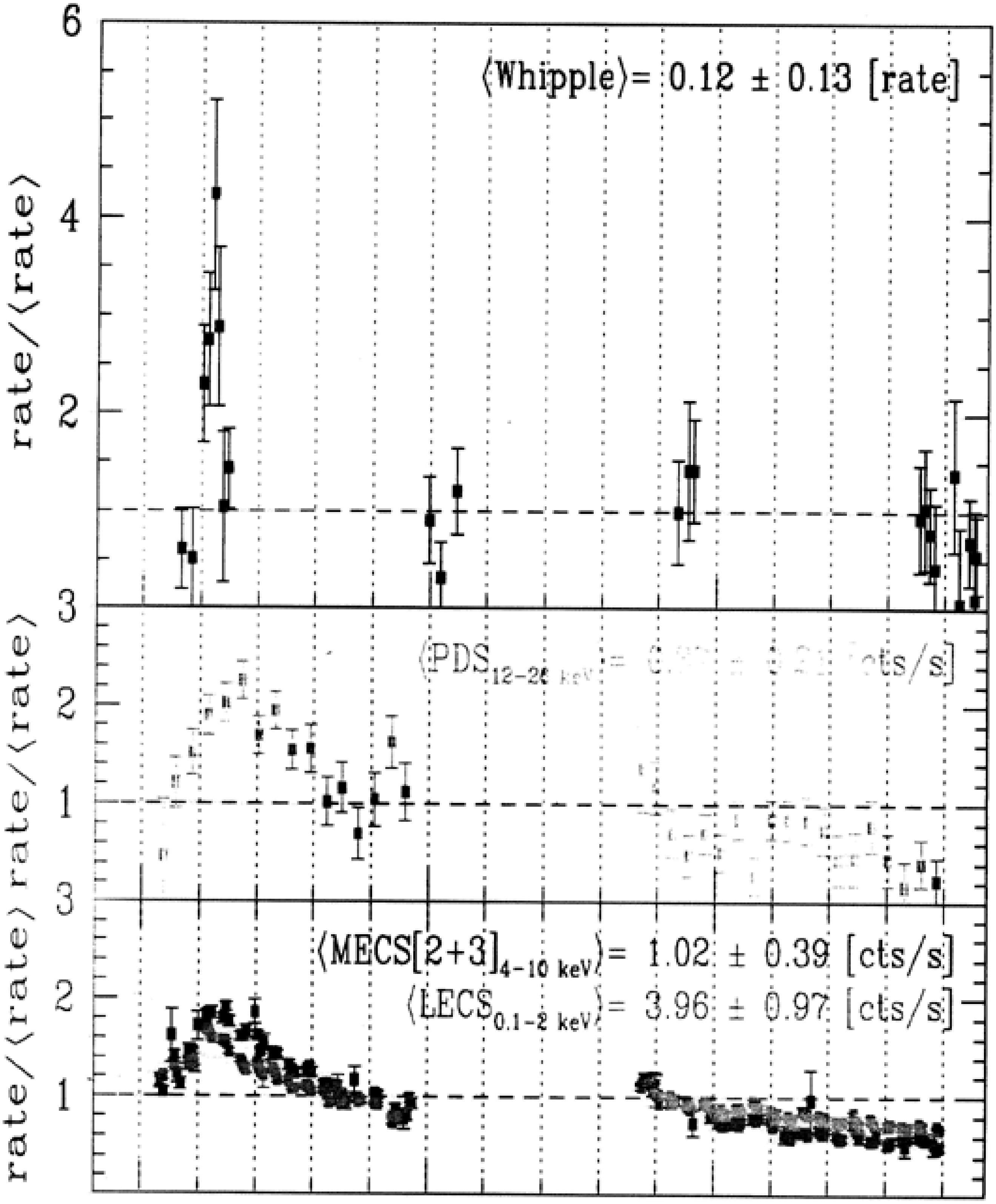
Tavecchio et al. 2001

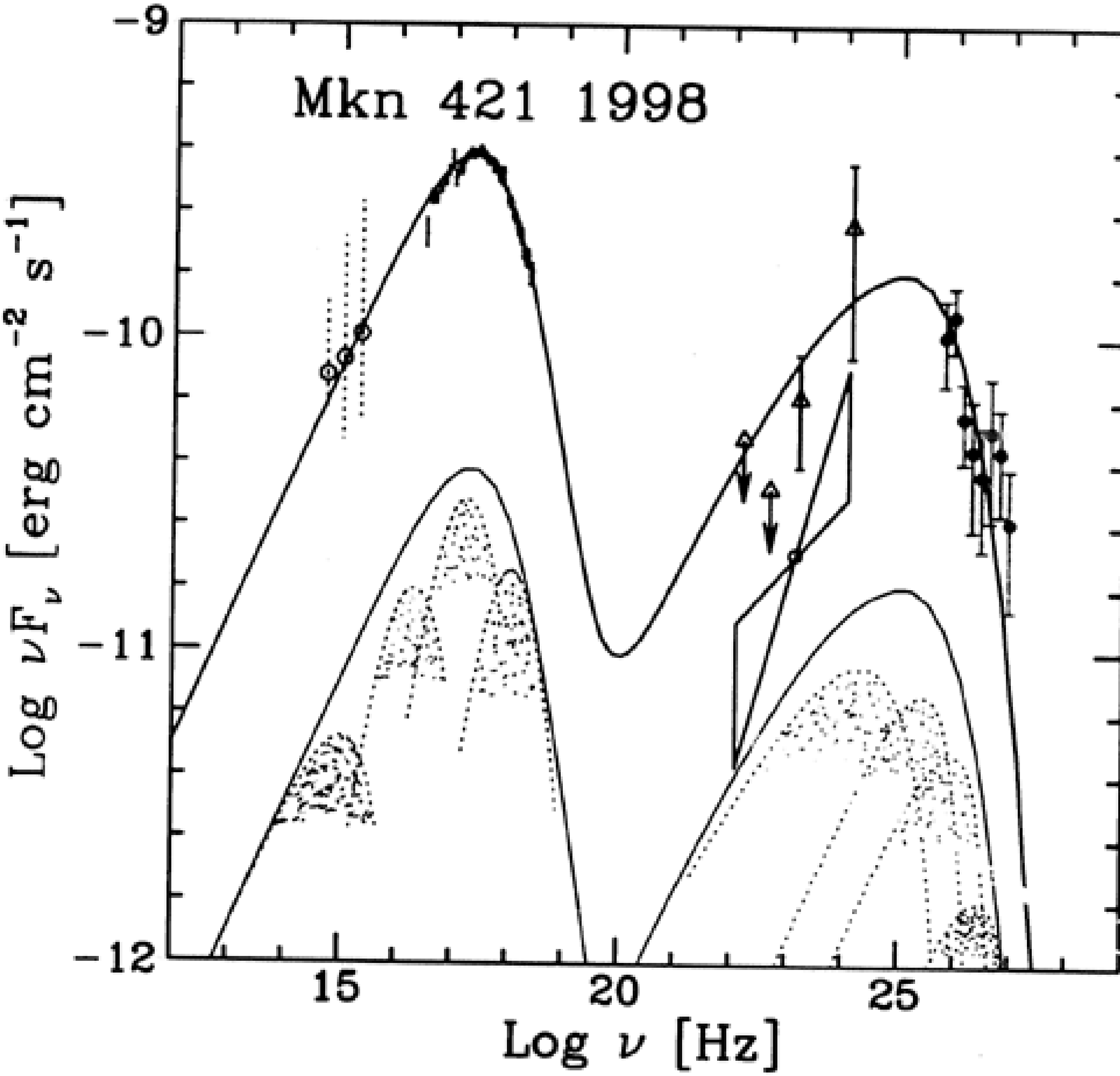




Tavecchio et al. submitted

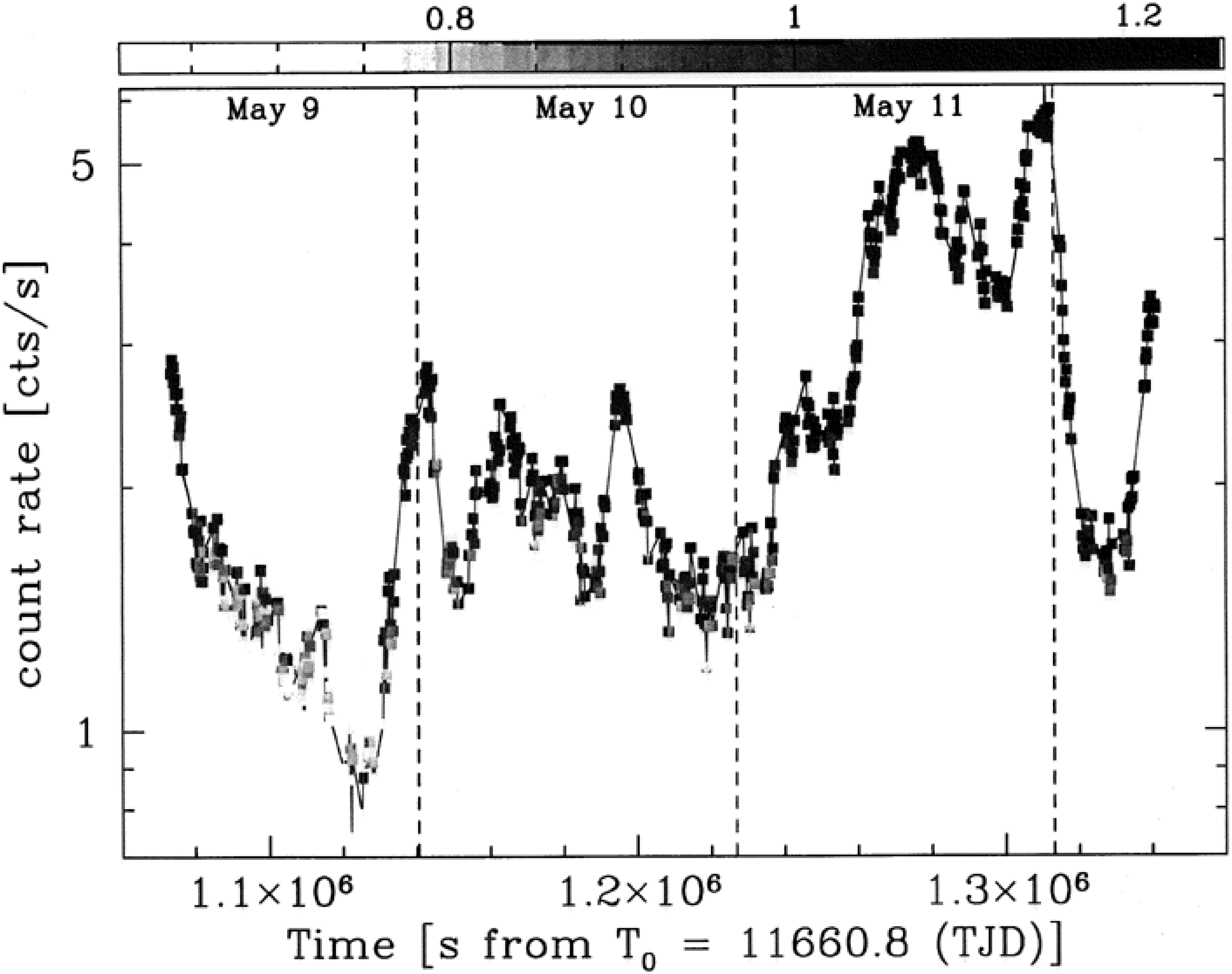

Mkn 501
97 Apr 16
98 Apr 29
June 99
Log νF(ν) [erg cm^{-2} s^{-1}]
Log ν [Hz]
-8
-9
-10
-11
-12
-13
15
20
25

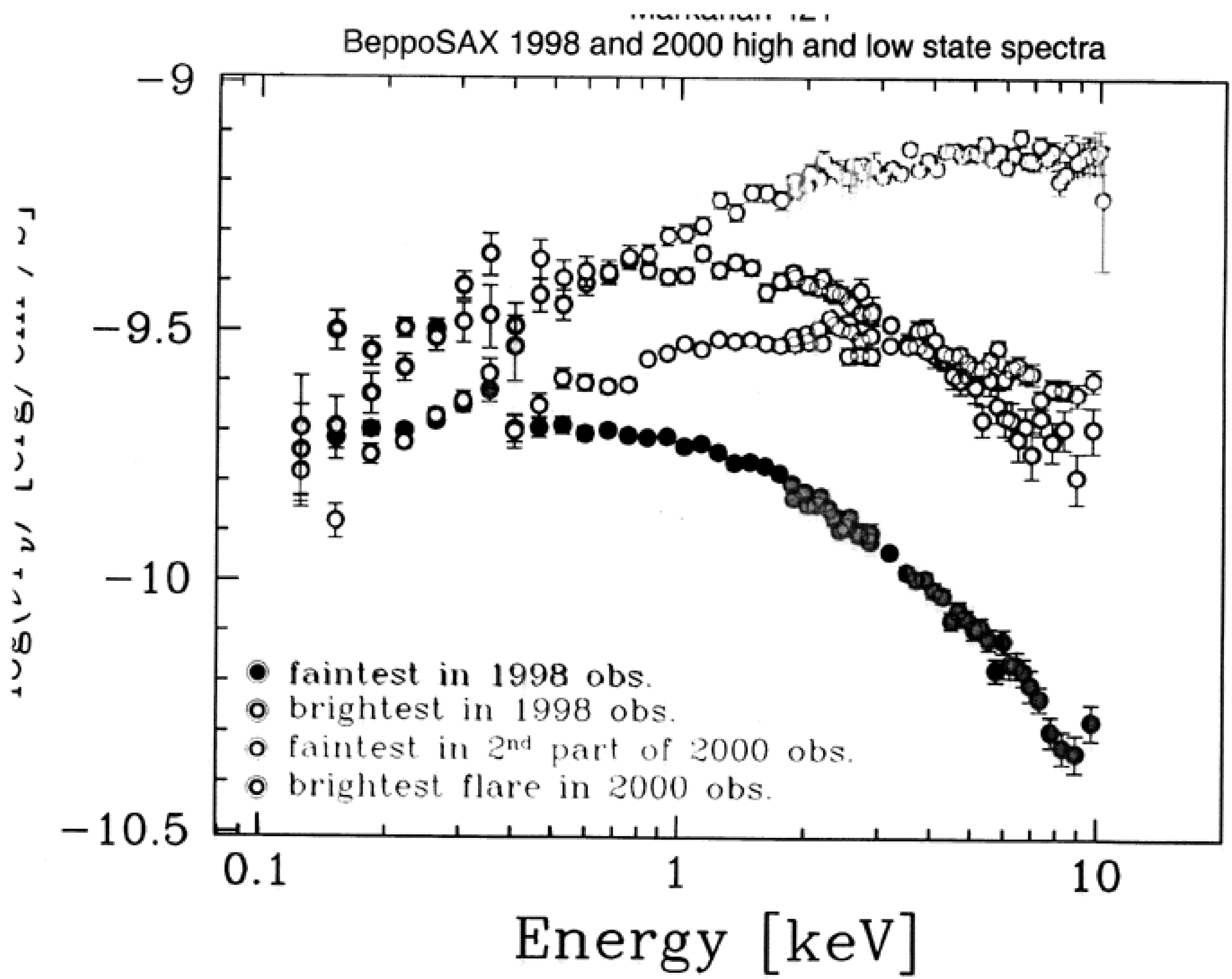

⟨Whipple⟩= 0.12 ± 0.13 [rate]
rate/⟨rate⟩
6
4
2
3
⟨PDS12-28 keV⟩
cts/s]
rate/⟨rate⟩
2
1
3
⟨MECS[2+3]4-10 keV⟩= 1.02 ± 0.39 [cts/s]
⟨LECS0.1-2 keV⟩= 3.96 ± 0.97 [cts/s]
rate/⟨rate⟩
2
1



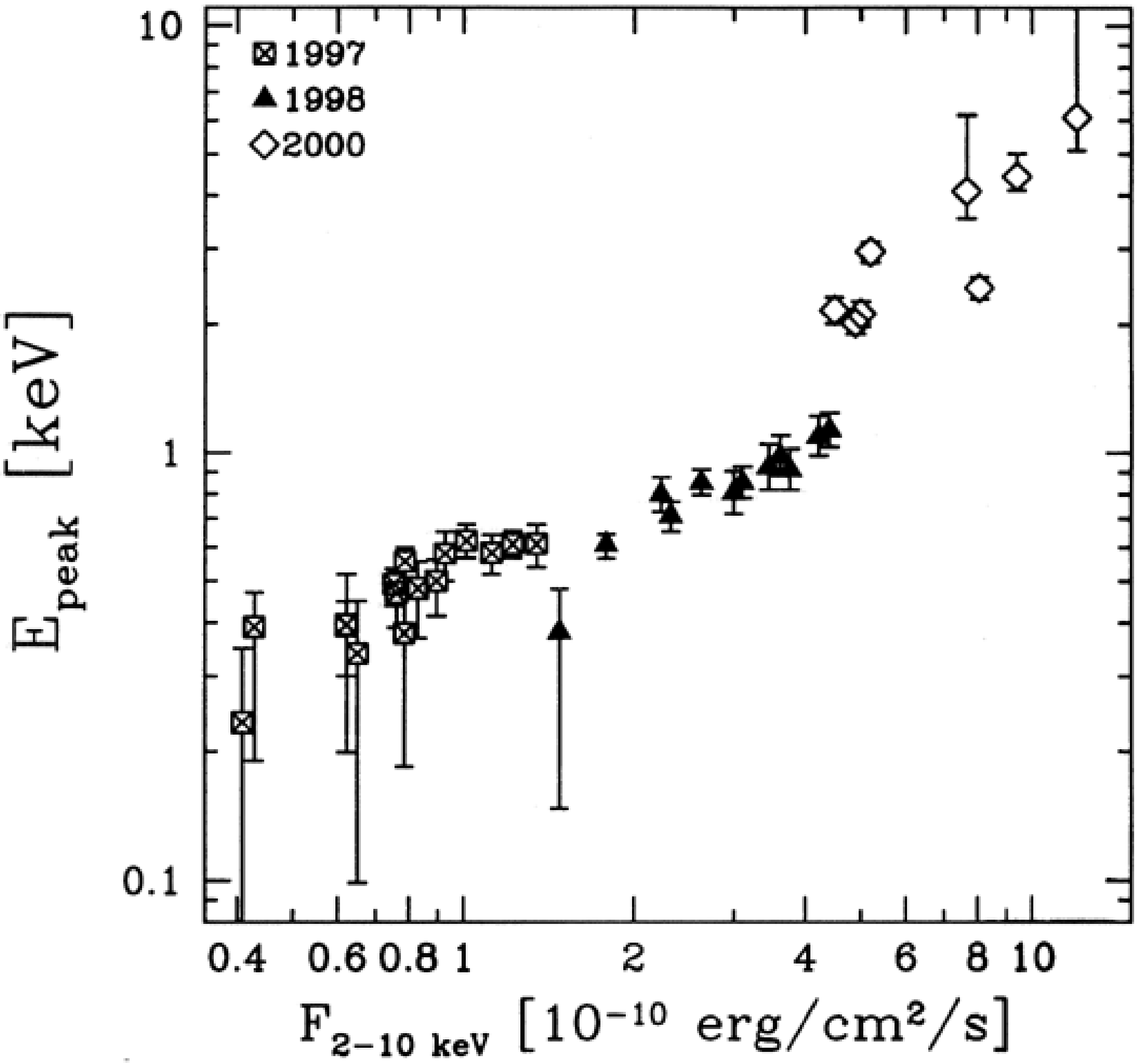
$\delta = 20$ B = 0.06 G γ_b = [illegible]

Maraschi et al. 99 ApJ Lett. in press


0.8
1
1.2
May 9
May 10
May 11
5
1
count rate [cts/s]
1.1×10^6
1.2×10^6
1.3×10^6
Time [s from T_0 = 11660.8 (TJD)]

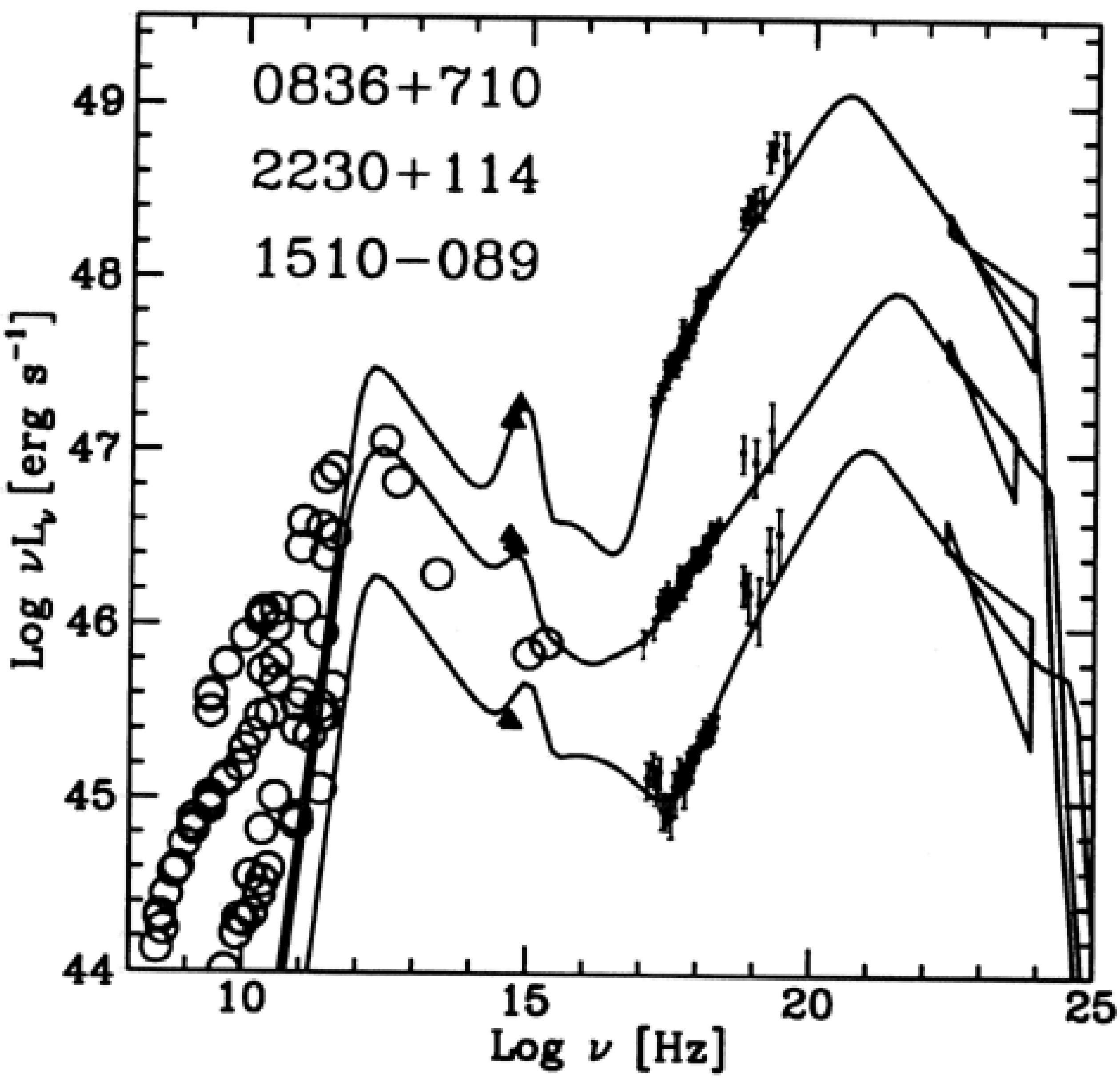

BeppoSAX 1998 and 2000 high and low state spectra
−9
−9.5
−10
−10.5
0.1
1
10
Energy [keV]
faintest in 1998 obs.
brightest in 1998 obs.
faintest in 2nd part of 2000 obs.
brightest flare in 2000 obs.

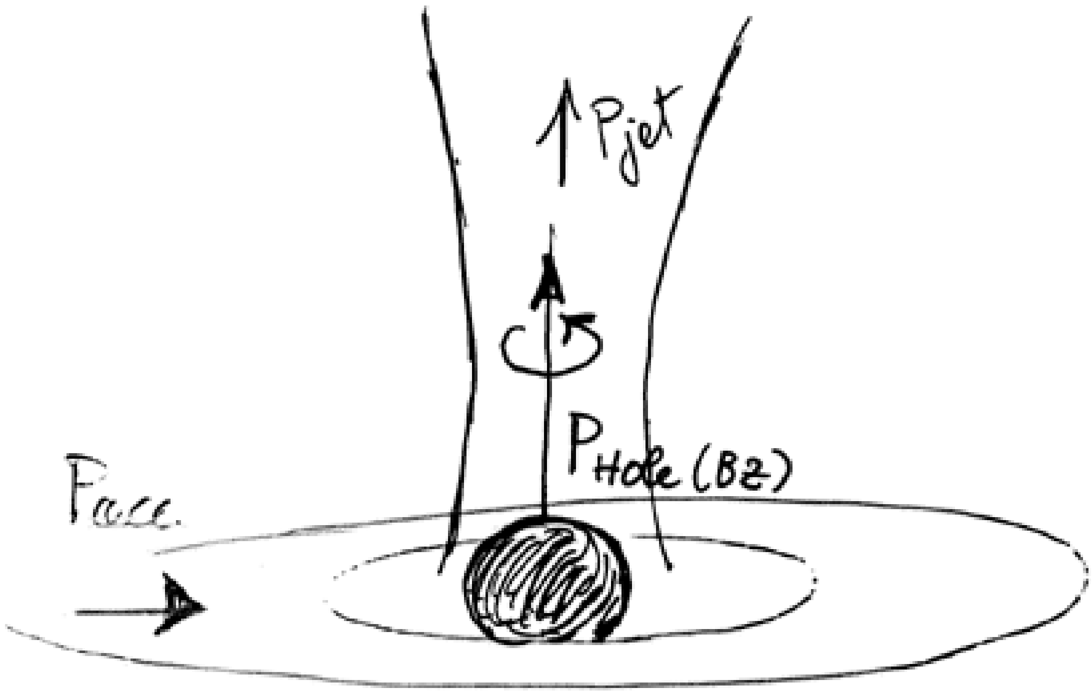
Mkn 421



1997
1998
2000
10
1
0.1
E_peak [keV]
0.4
0.6
0.8
1
2
4
6
8
10
F_2-10 keV [10^-10 erg/cm²/s]

Tavecchio et al. 2000 ApJ. ~~submitted~~ in press





$$P_{acc} = \dot{M}c^2 \qquad P_{MHD} = f\dot{M}c^2$$

$$P_{Hole} = B_0^2 r_g^2 a^2 c = g P_{acc} a^2$$

$$P_{jet} = P_{Hole} + P_{MHD}$$

$$L_{jet} = \eta P_{jet} \qquad L_{disk} = \varepsilon P_{acc}$$

$$L_{jet} = \frac{\eta(g+f)}{\varepsilon} L_{disk}$$

SPECTRAL SEQUENCE → a single blazar family

3C279 → Variability due to change in bulk flow (Γ)
Peak shifts ?

501/421 → ν_{peak} increases with luminosity
(change in part accel. timescale)
Can be reconciled with "sequence"?

FSRQ → Reliable estimates of P_{jet} and P_{disk}
relation with M_{BH}, $\dot{M}$, a_{BH} ...

GLAST BLAZAR SURVEY

→ gamma-ray fluxes (+spectra) for large numbers of blazars of different types

time" average properties

high redshift objects expected

important for AGN evolution

Blazar monitoring in SURVEY

→ γ-ray light curves PER SE useful

Duty cycles of activity

Amplitude of variability

Structure function etc.

GLAST AND M.W. MONITORING

few brightest objects

3C279-like need IR/OPT and X-rays

dense sampling

trigger from γ-flare too late

trigger from opt. bright state better

to determine peak shifts (if any)

spectral evolution during flare

possible lags

Mkn 421-like need X-rays, hard X-rays and TeV

define γ- to TeV spectra and evolution

possible lags

KRONOS ? ASTRO-E 2 ?