High redshift blazars:

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with

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What is a blazar?

A jetted AGN, whose jet is relativistic (Γ~10) and is "pointing at us".

To be more quantitative:

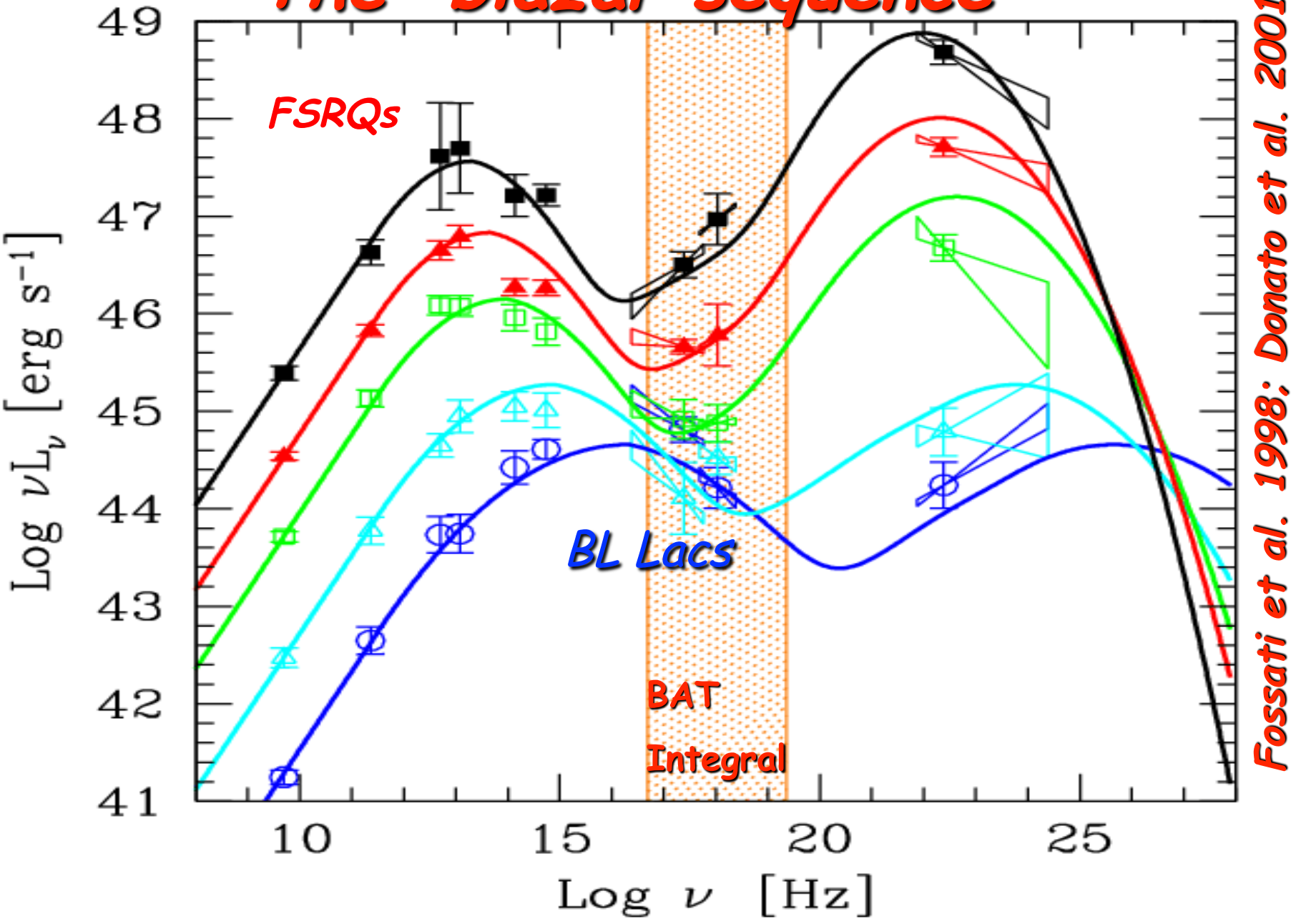
$$\Theta_{view} < 1/\Gamma$$

→For each blazar, $2\Gamma^2$ radio-loud AGN pointing elsewhere: FR I and FRII radio-galaxies

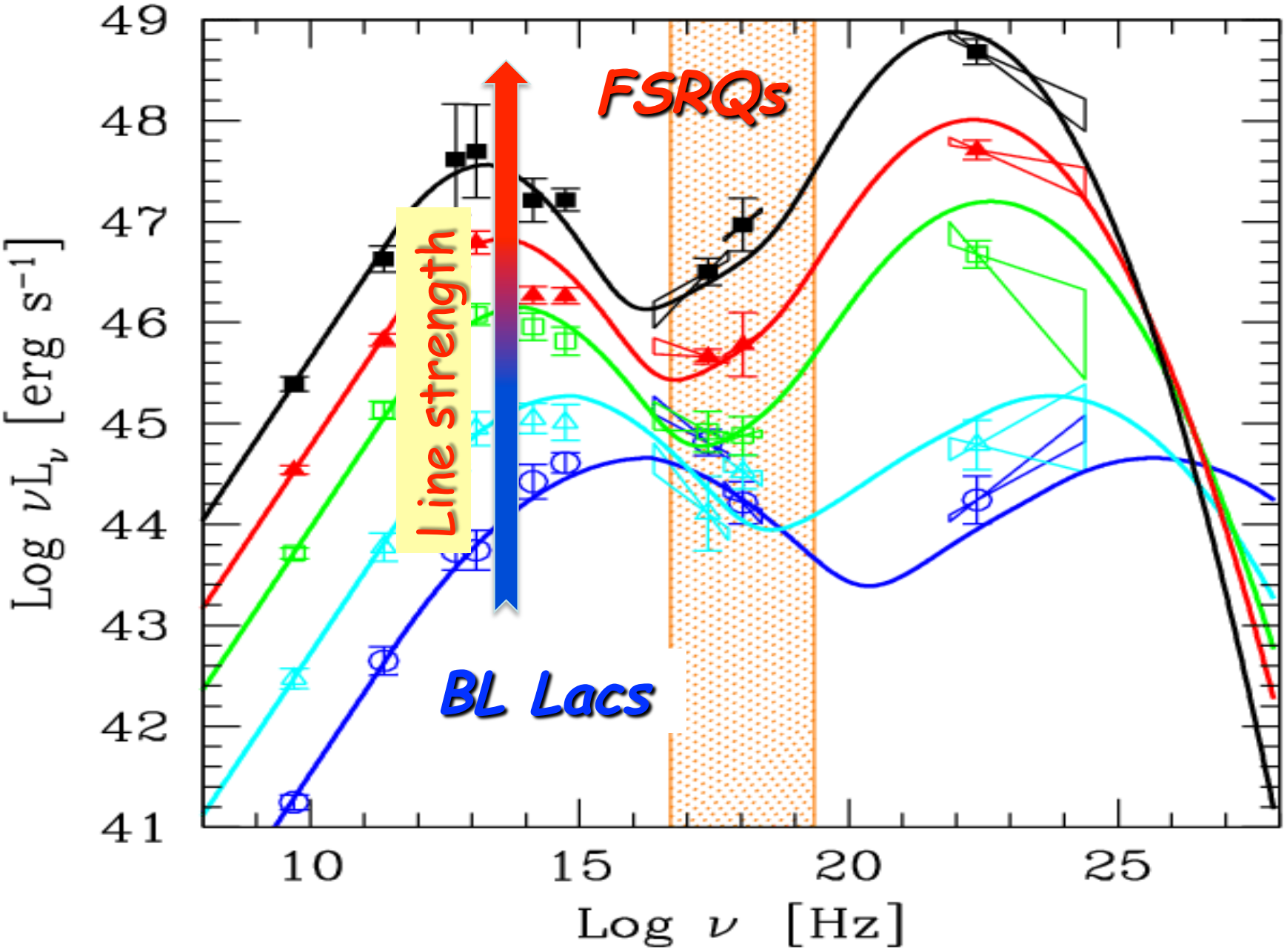
Goals

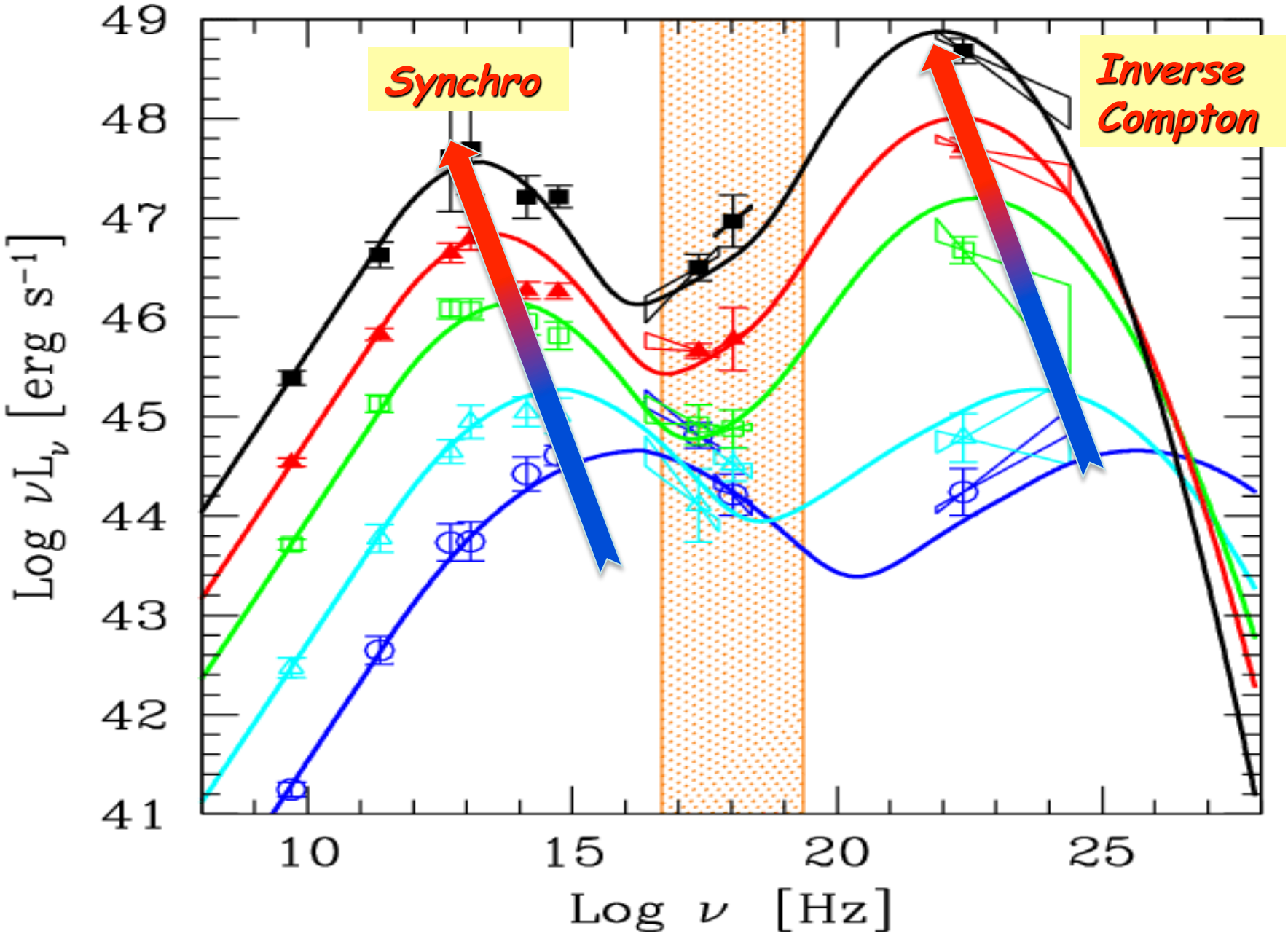
- Relativistic jets as the most efficient engines
- Black holes in radio loud sources are big
- Blazars can be seen at high redshifts
- Especially in hard X-rays
- Search of heavy black holes in the young Universe

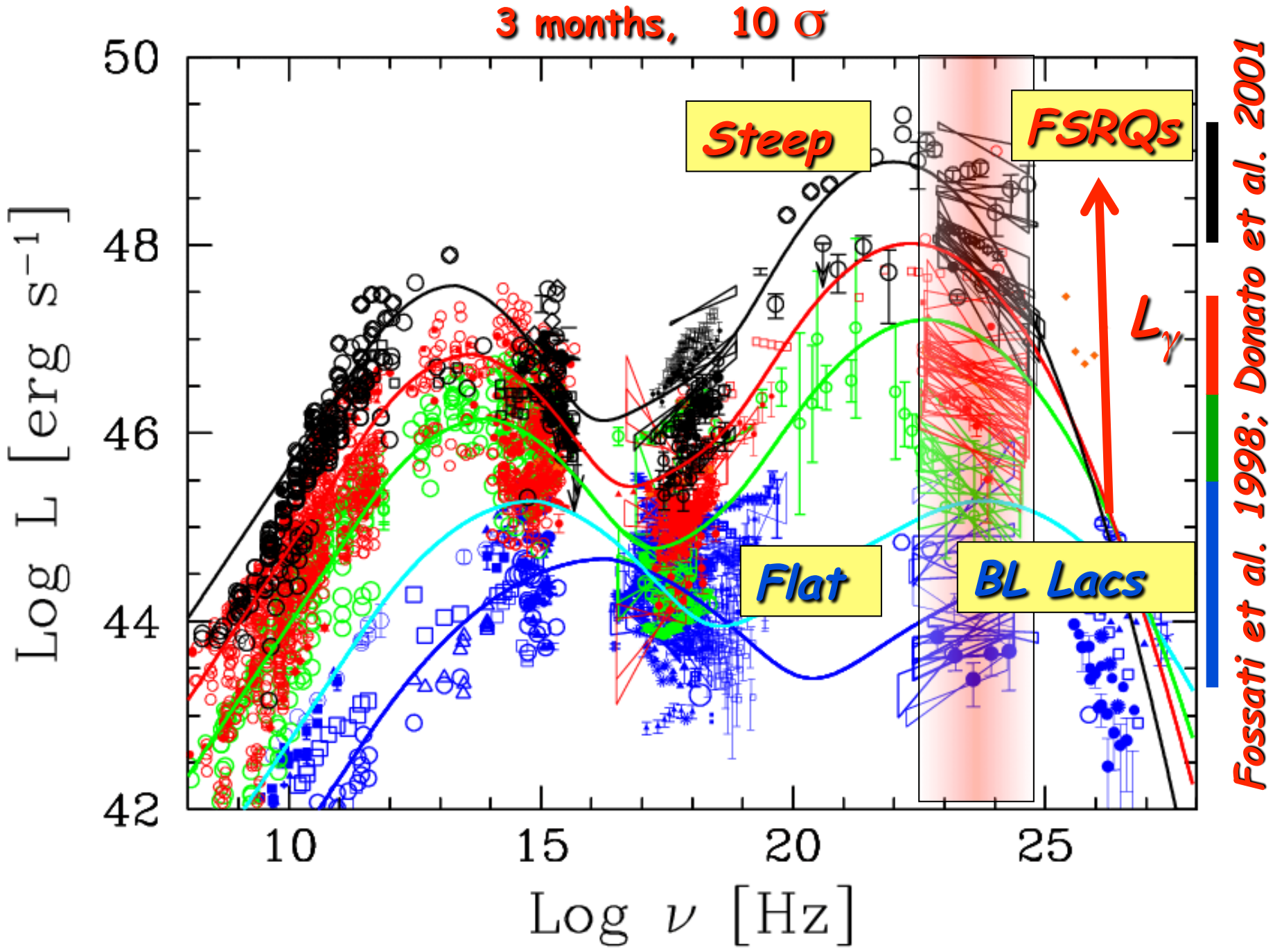
The "blazar sequence"

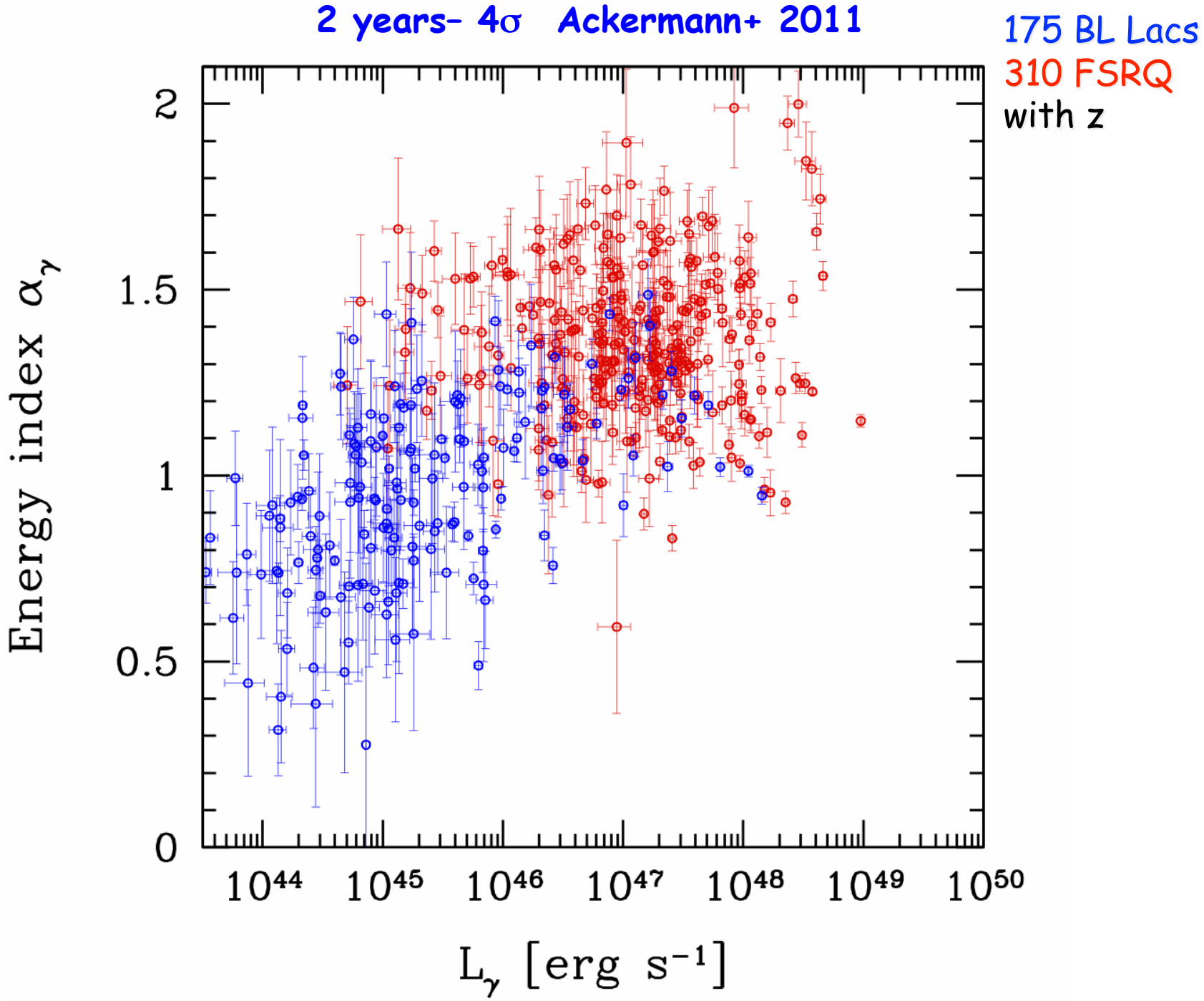


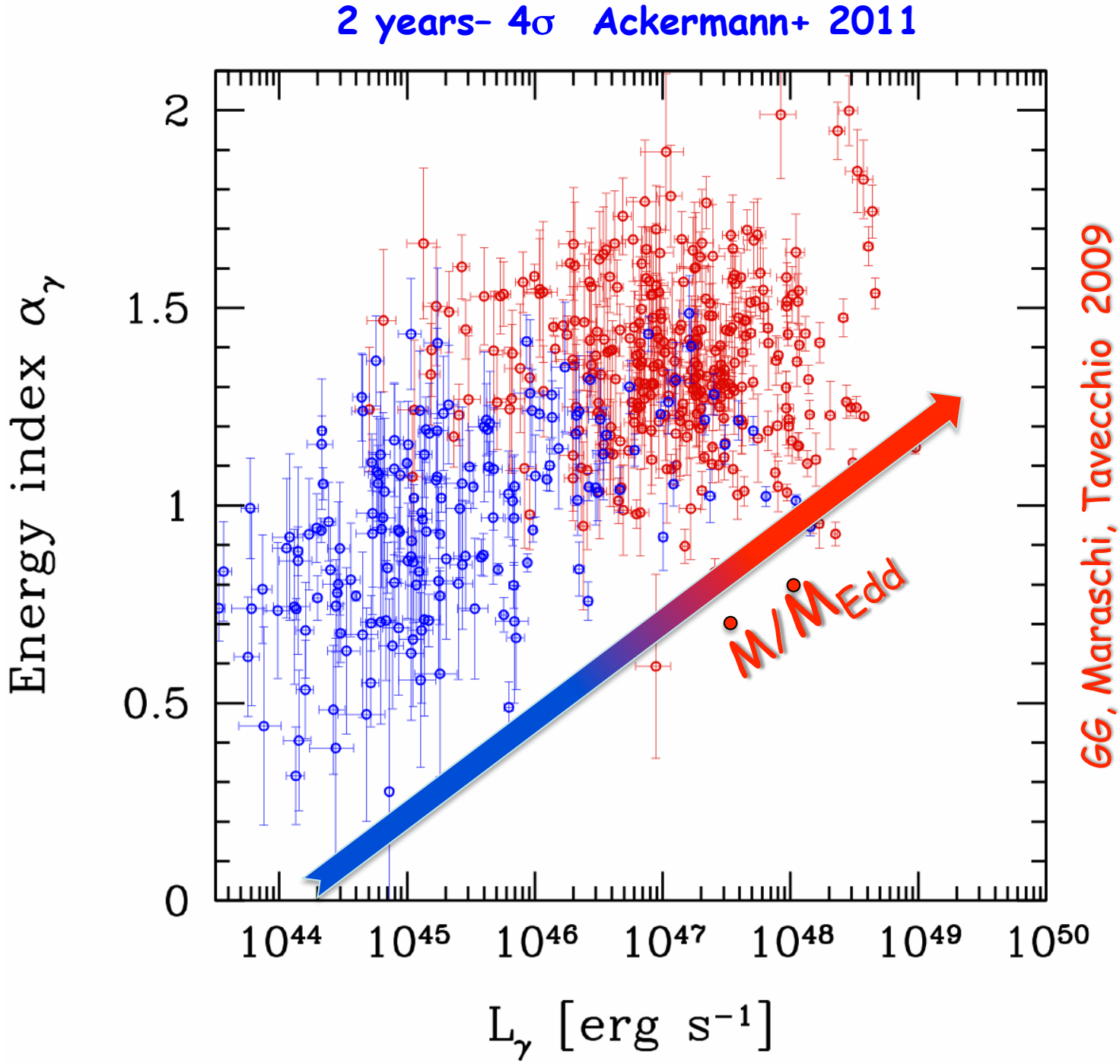
Fossati et al. 1998; Donato et al. 2001

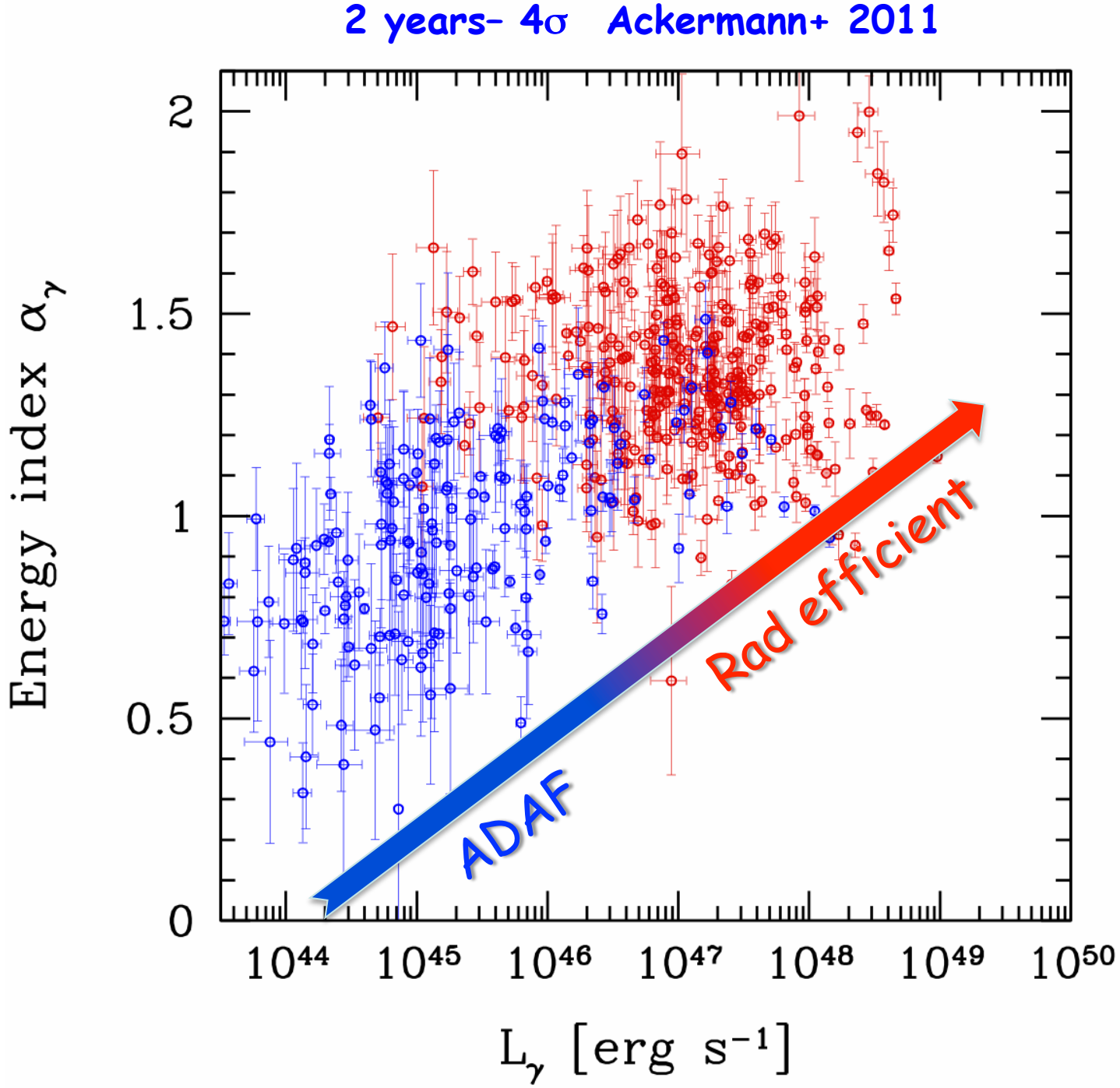

FSRQs
Line strength
BL Lacs
Log νL_ν [erg s^{-1}]
Log ν [Hz]
49
48
47
46
45
44
43
42
41
10
15
20
25

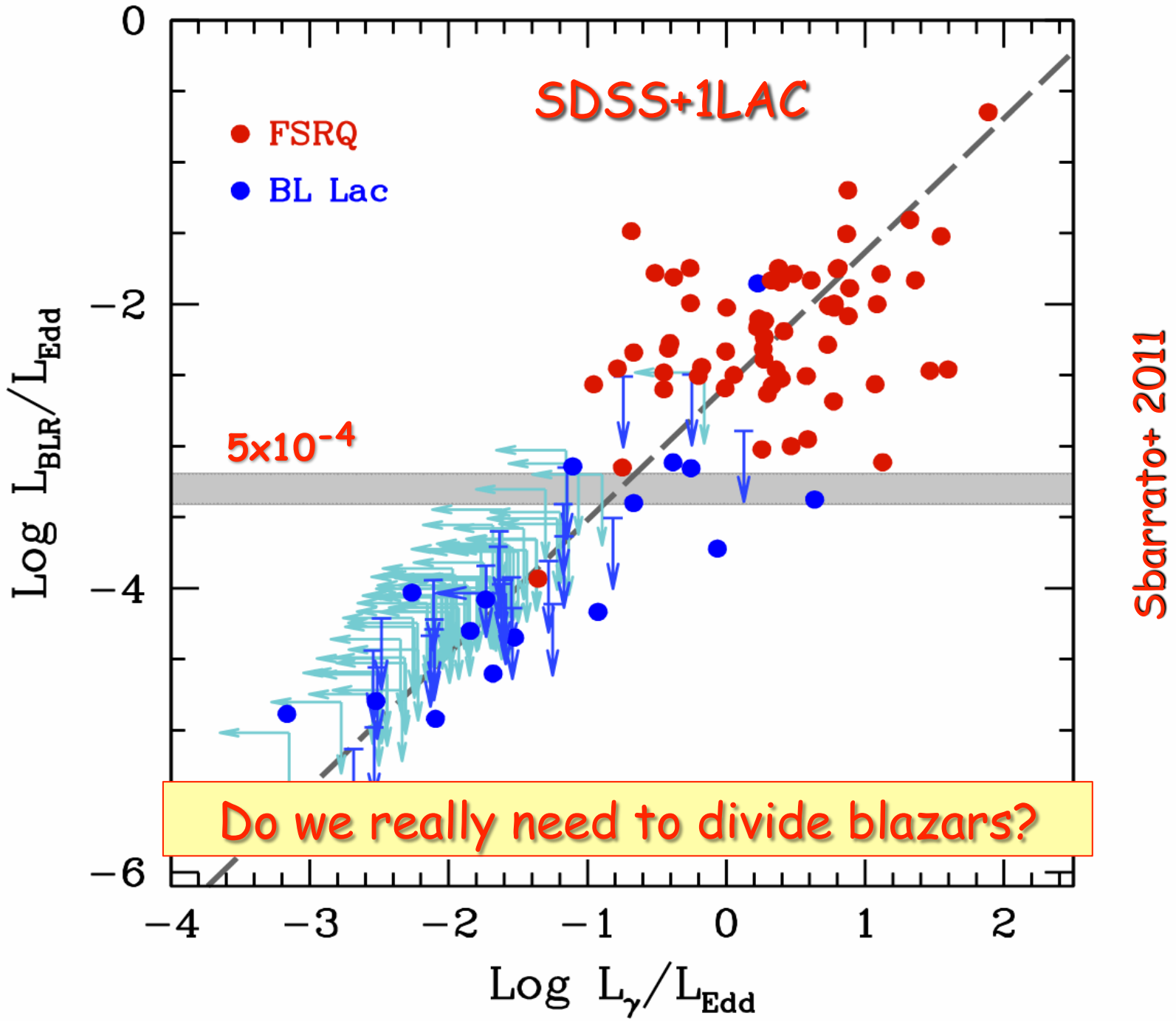

Synchro
Inverse Compton
Log νL_ν [erg s^{-1}]
Log ν [Hz]
49
48
47
46
45
44
43
42
41
10
15
20
25


3 months, 10 σ
Steep
FSRQs
Flat
BL Lacs
L_γ
Log L [erg s^{-1}]
Log ν [Hz]
50
48
46
44
42
10
15
20
25
Fossati et al. 1998; Donato et al. 2001

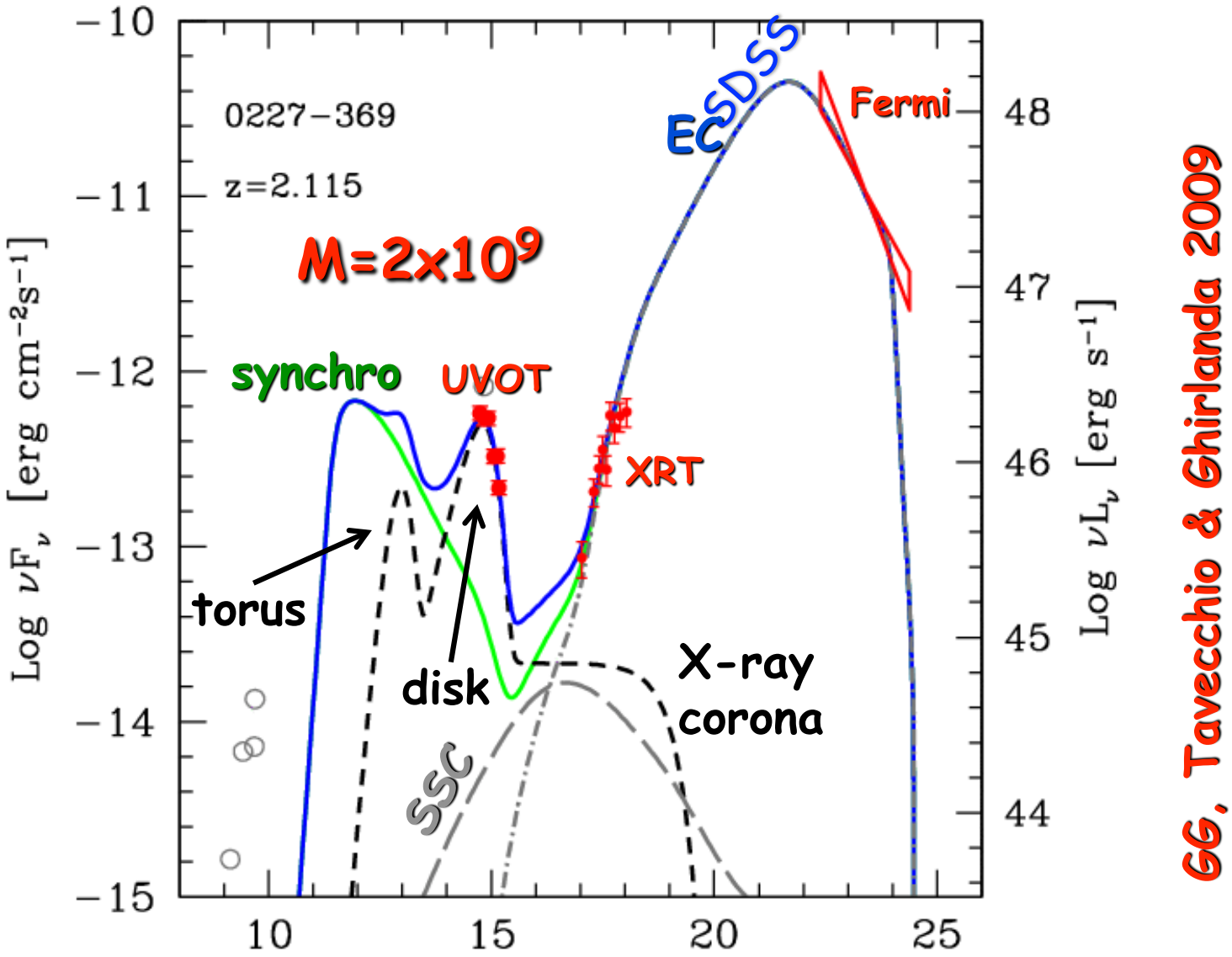

2 years- 4σ Ackermann+ 2011
175 BL Lacs
310 FSRQ
with z
Energy index α_γ
0
0.5
1
1.5
2
10^{44}
10^{45}
10^{46}
10^{47}
10^{48}
10^{49}
10^{50}
L_γ [erg s^{-1}]


2 years– 4σ Ackermann+ 2011
Energy index α_γ
0
0.5
1
1.5
2
10^{44}
10^{45}
10^{46}
10^{47}
10^{48}
10^{49}
10^{50}
L_γ [erg s^{-1}]
$\dot{M}/\dot{M}_{Edd}$
GG, Maraschi, Tavecchio 2009


2 years- 4σ Ackermann+ 2011
Energy index α_γ
0
0.5
1
1.5
2
10^{44}
10^{45}
10^{46}
10^{47}
10^{48}
10^{49}
10^{50}
L_γ [erg s^{-1}]
ADAF
Rad efficient


SDSS+1LAC
FSRQ
BL Lac
5x10^{-4}
Do we really need to divide blazars?
Sbarrato+ 2011
Log L_{BLR}/L_{Edd}
Log L_{γ}/L_{Edd}
0
−2
−4
−6
−4
−3
−2
−1
0
1
2

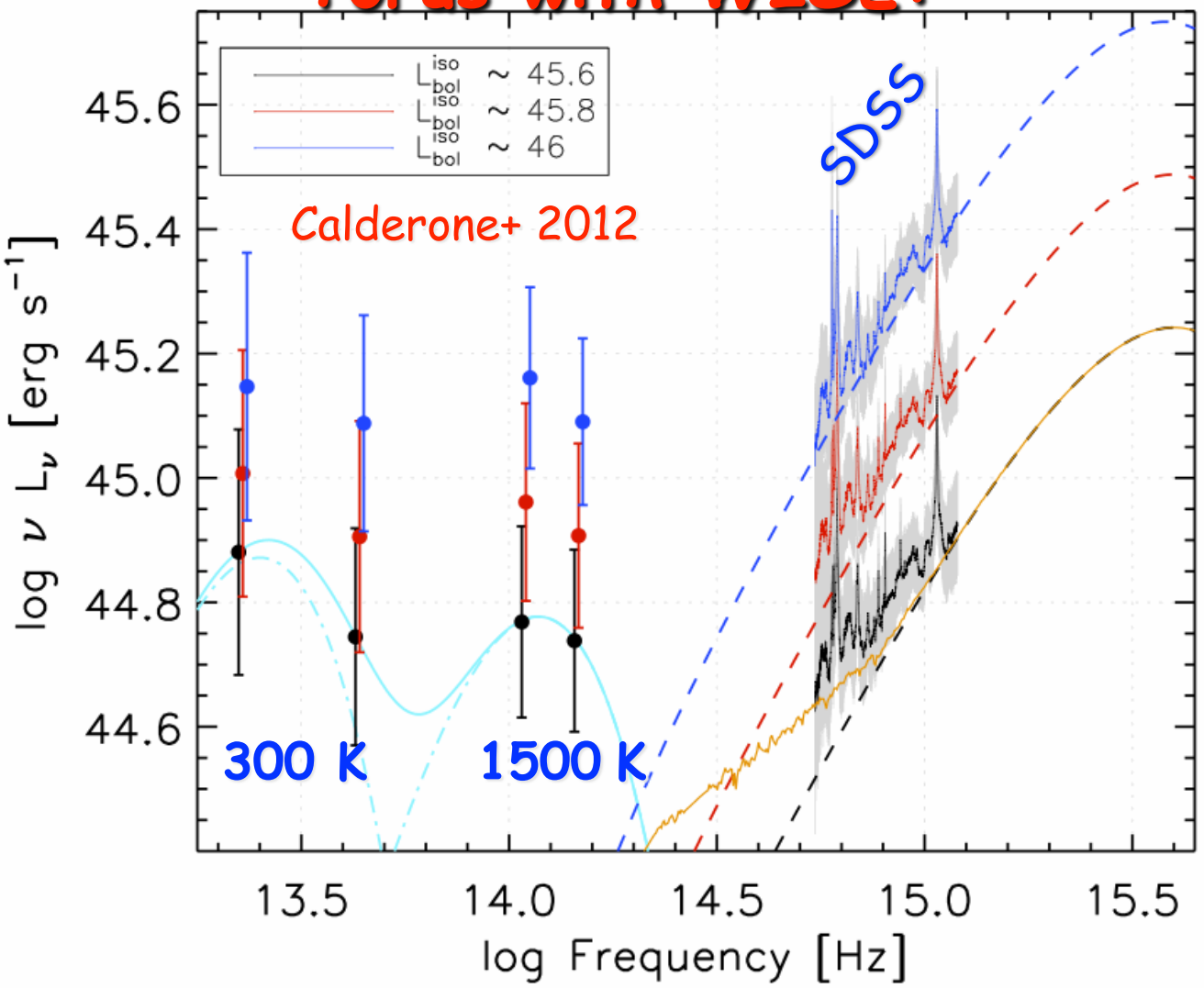
Fermi big blazars: powerful, with emission lines

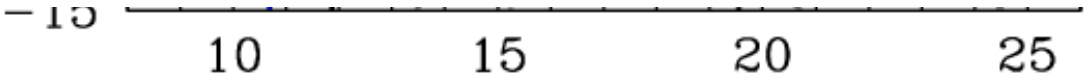


GG, Tavecchio & Ghirlanda 2009

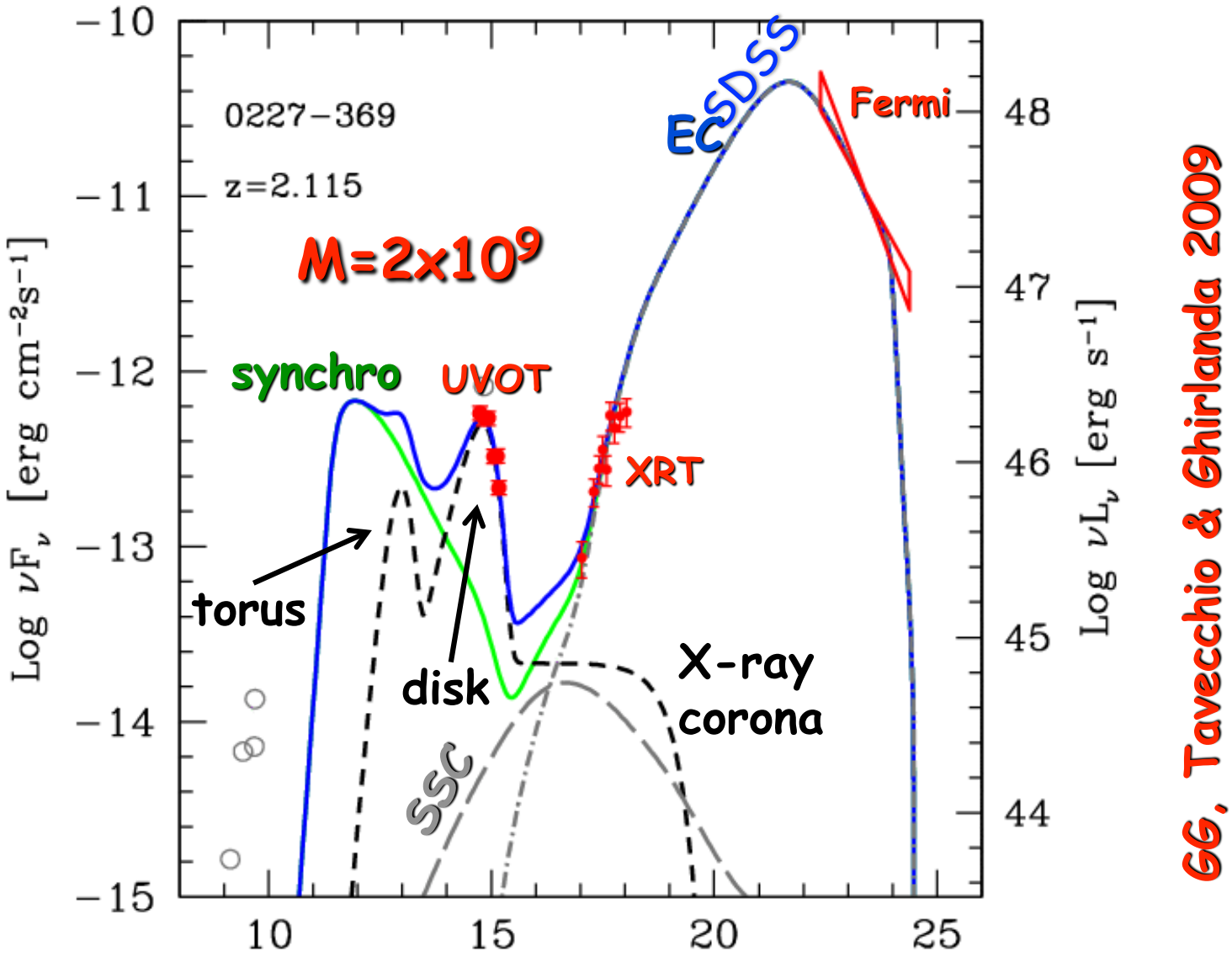
Low energy synchro peak:
leave the disk naked!

Torus with WISE:



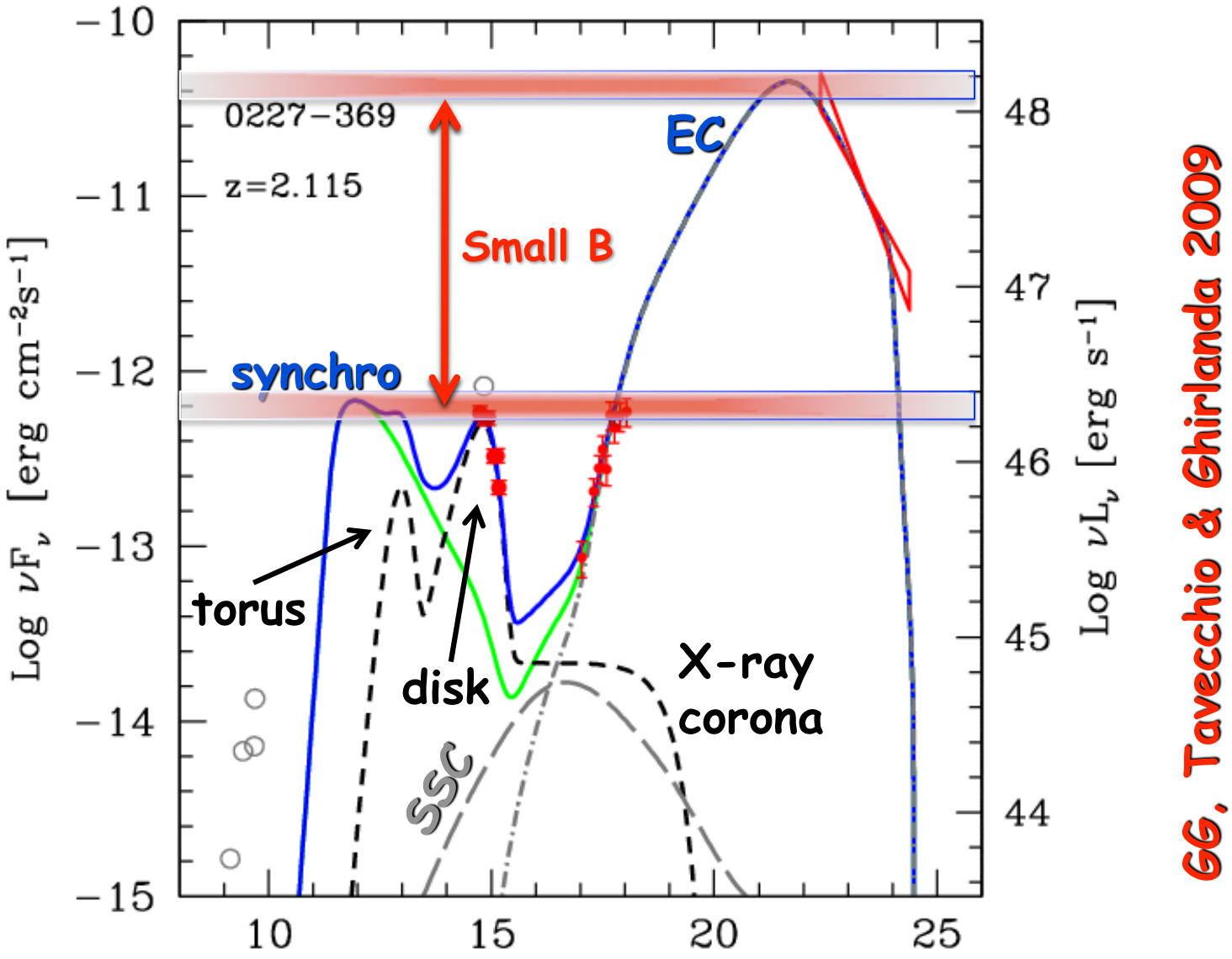


Low energy synchro peak: leave the disk naked!



GG, Tavecchio & Ghirlanda 2009

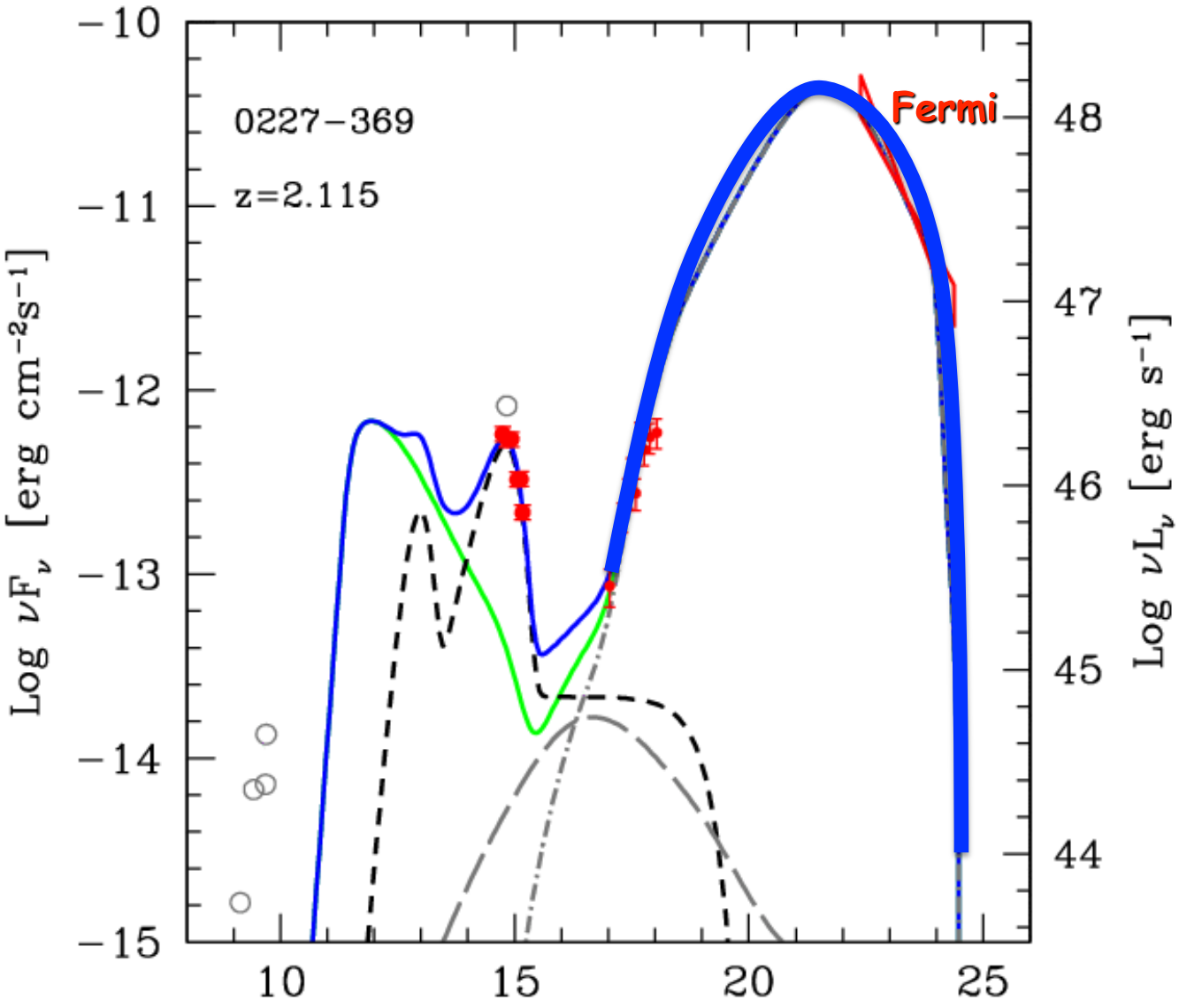
Low energy synchro peak:
leave the disk naked!

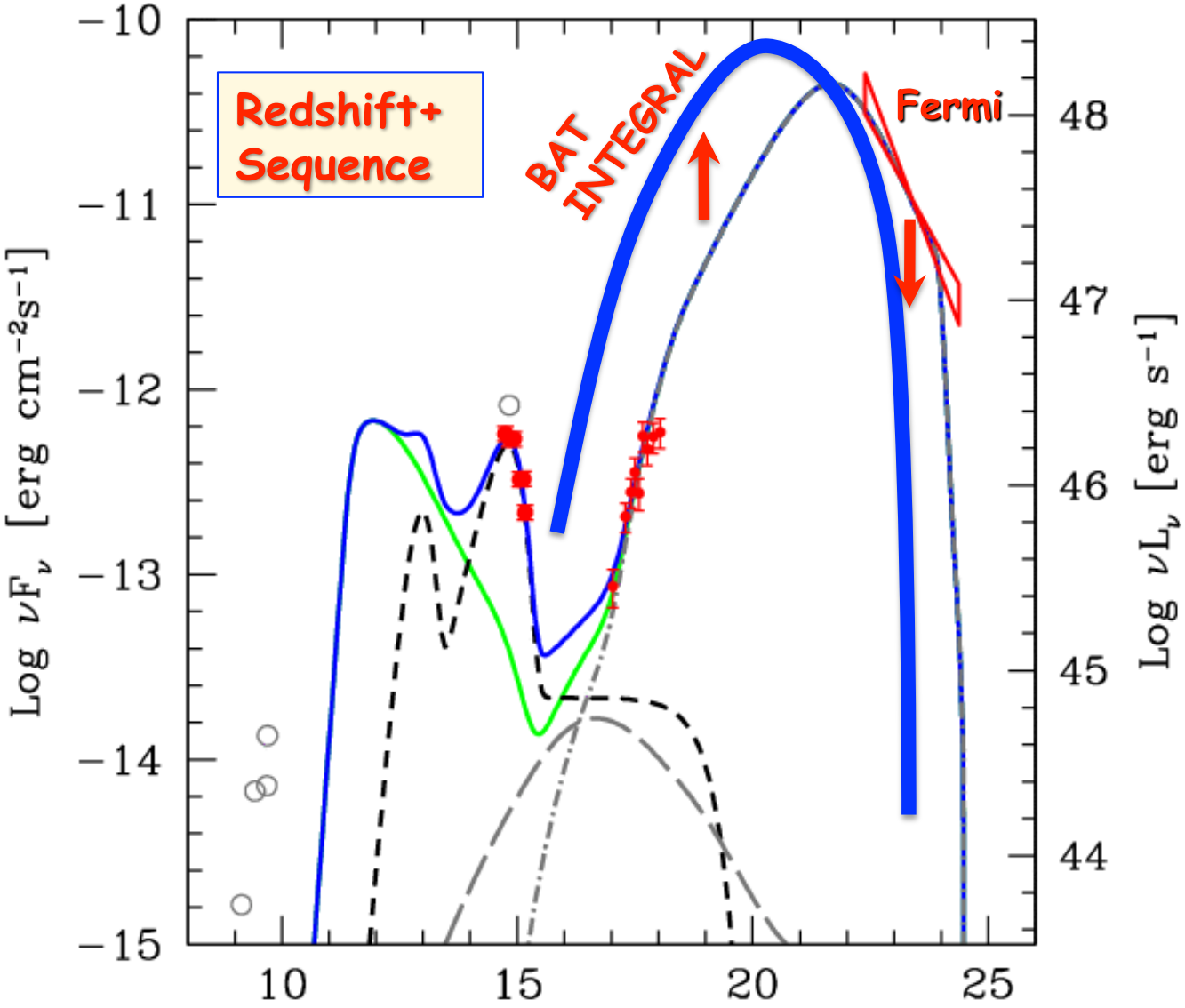


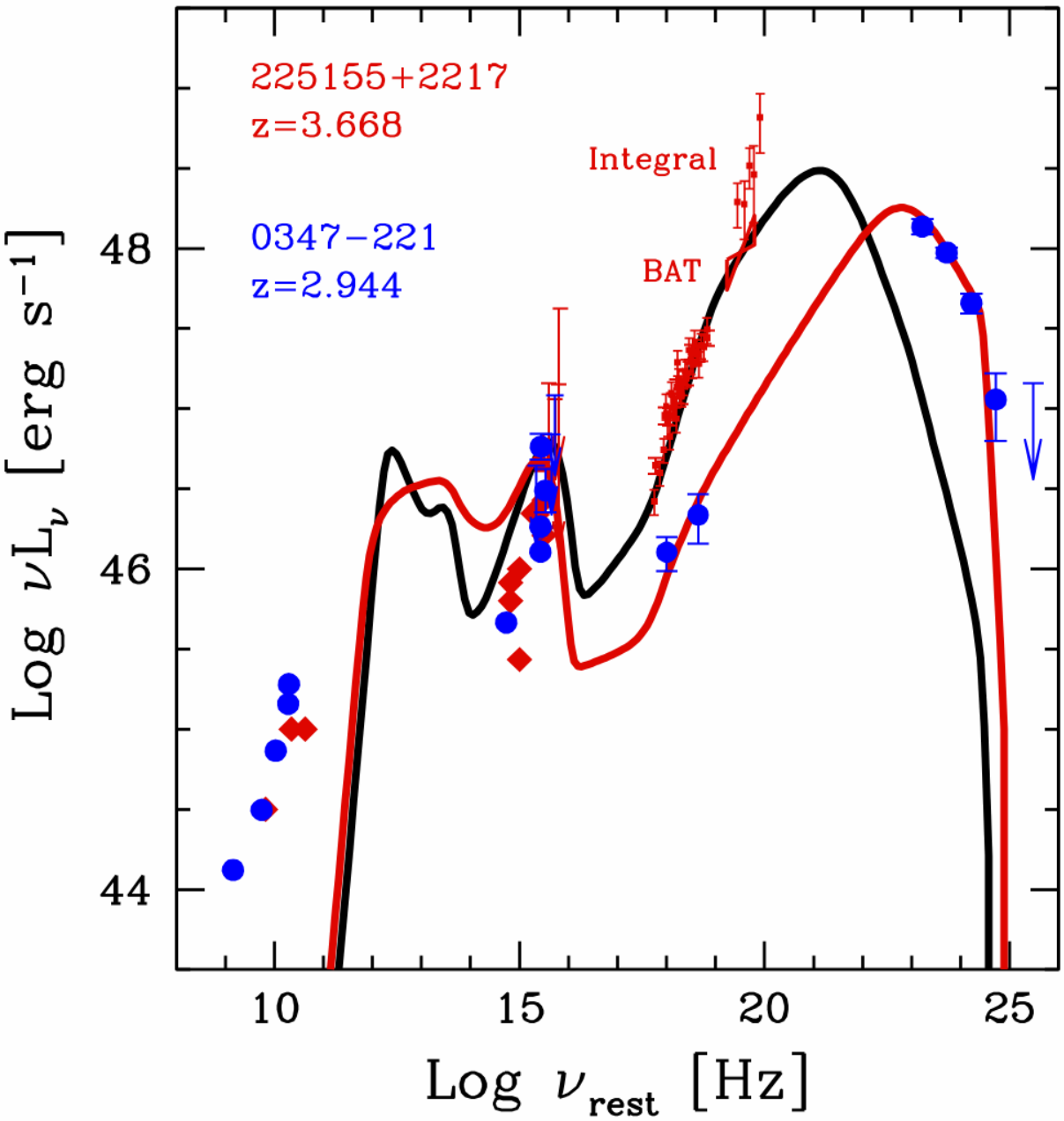
GG, Tavecchio & Ghirlanda 2009

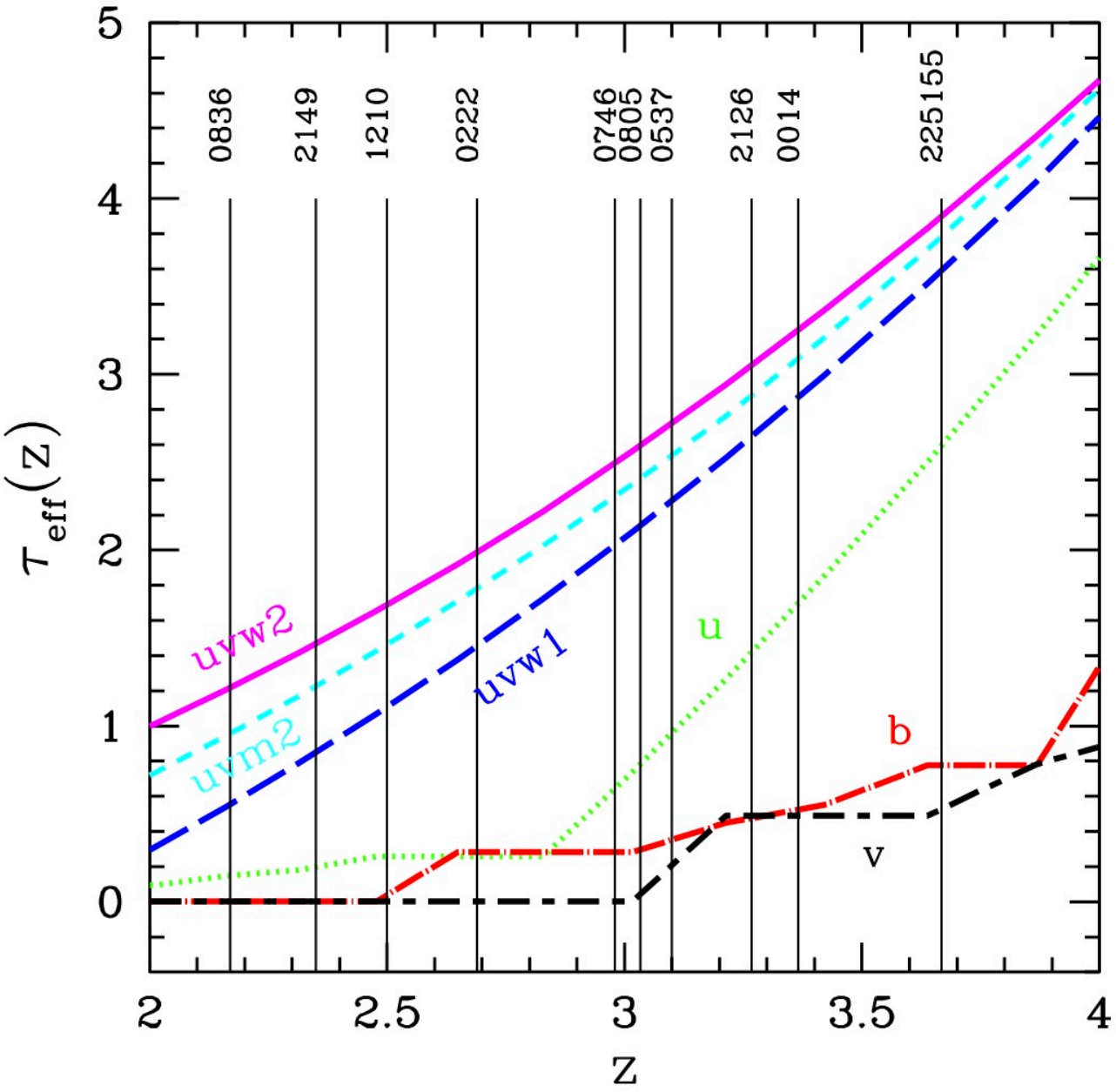
The most luminous blazars

BAT and INTEGRAL even bigger blazars: z up to ~4 (compare with Fermi: z<3)

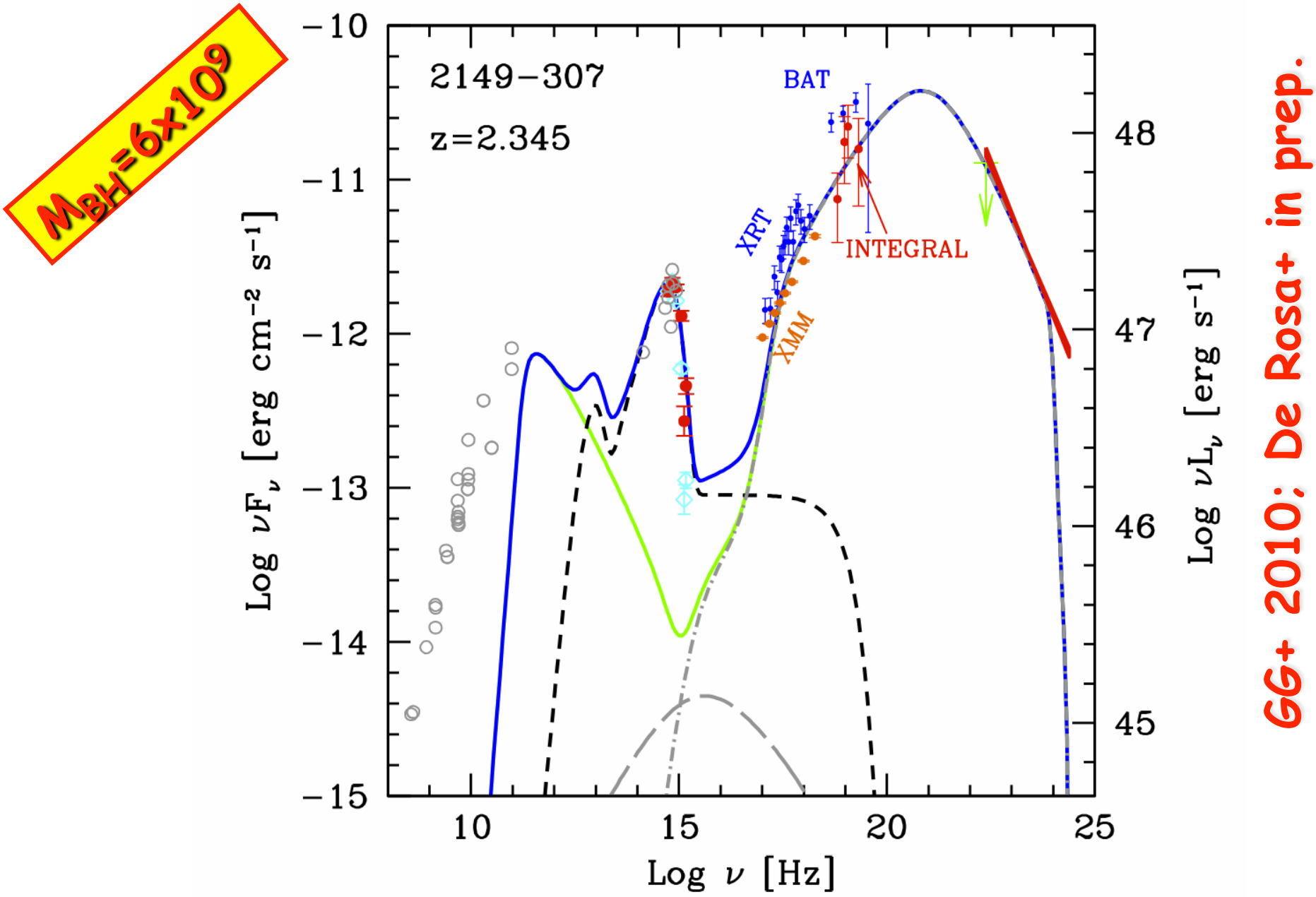

0227−369
z=2.115
Fermi
Log νF_ν [erg cm^-2 s^-1]
Log νL_ν [erg s^-1]
−10
−11
−12
−13
−14
−15
48
47
46
45
44
10
15
20
25


Redshift+
Sequence
BAT
INTEGRAL
Fermi
Log νF_ν [erg cm⁻²s⁻¹]
Log νL_ν [erg s⁻¹]
−10
−11
−12
−13
−14
−15
48
47
46
45
44
10
15
20
25


225155+2217
z=3.668
Integral
BAT
0347−221
z=2.944
48
46
44
10
15
20
25
Log νL_ν [erg s^{-1}]
Log ν_{rest} [Hz]

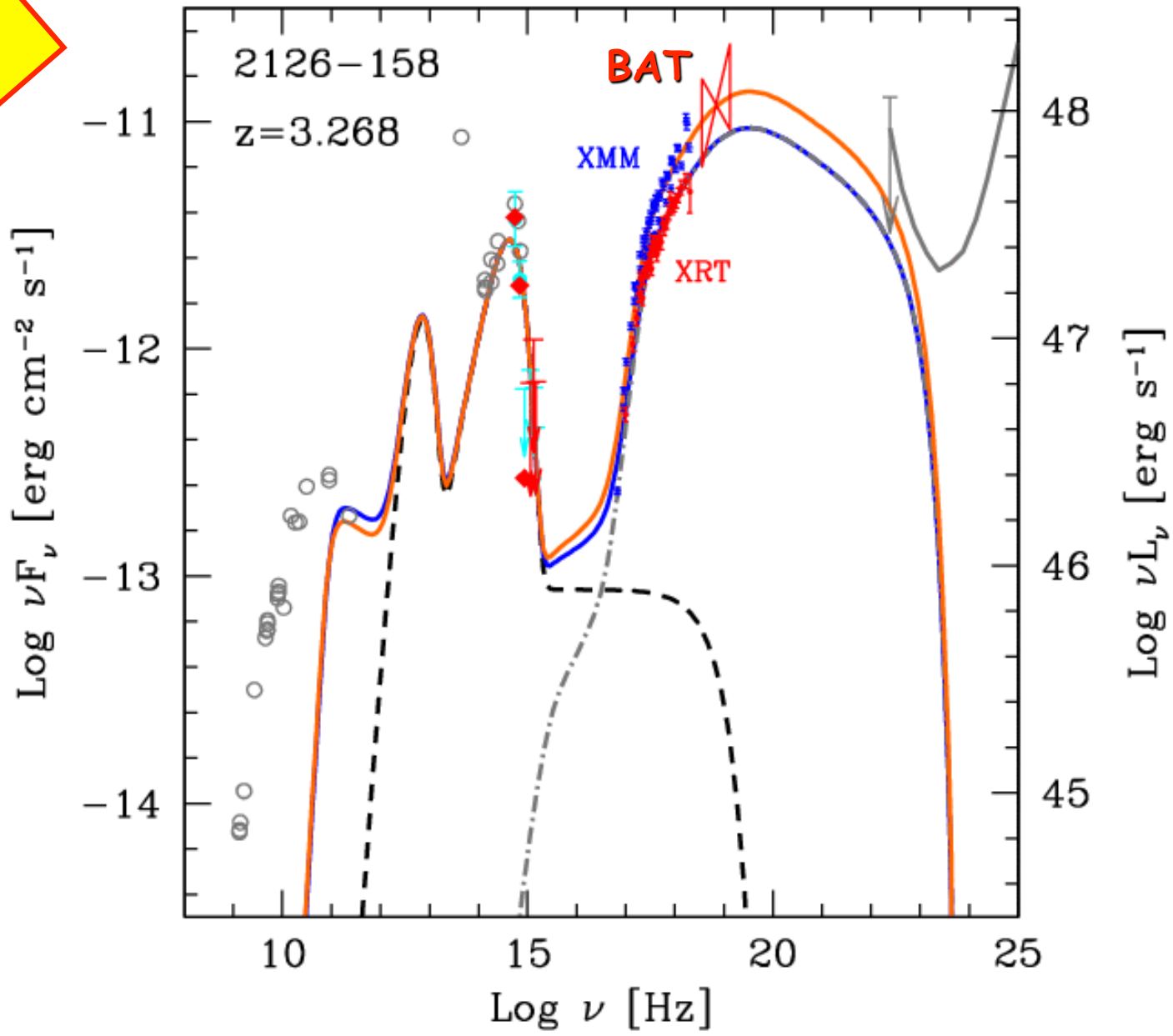

0836
2149
1210
0222
0746
0805
0537
2126
0014
225155
uvw2
uvm2
uvw1
u
b
v
$\tau_{eff}(z)$
z
0
1
2
3
4
5
2
2.5
3
3.5
4

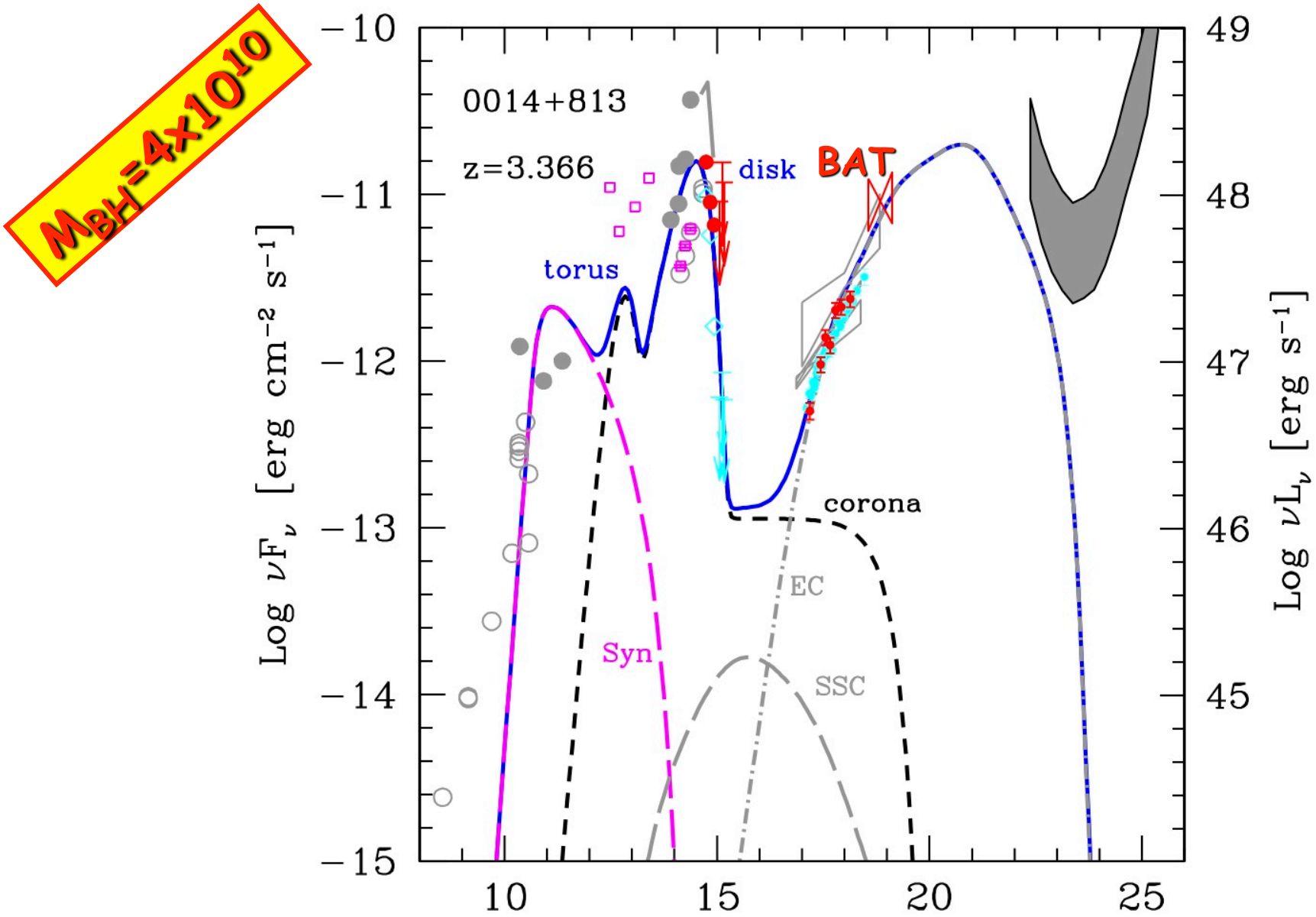
GG+ 2010



GG+ 2010; De Rosa+ in prep.

$M_{BH}=10^{10}$


2126−158
z=3.268
BAT
XMM
XRT
−11
−12
−13
−14
48
47
46
45
10
15
20
25
Log νF_ν [erg cm⁻² s⁻¹]
Log νL_ν [erg s⁻¹]
Log ν [Hz]


$M_{BH}=4x10^{10}$
0014+813
z=3.366
disk
BAT
torus
corona
EC
Syn
SSC
Log νF_ν [erg cm^-2 s^-1]
Log νL_ν [erg s^-1]
−10
−11
−12
−13
−14
−15
49
48
47
46
45
10
15
20
25

jet power and accretion luminosity

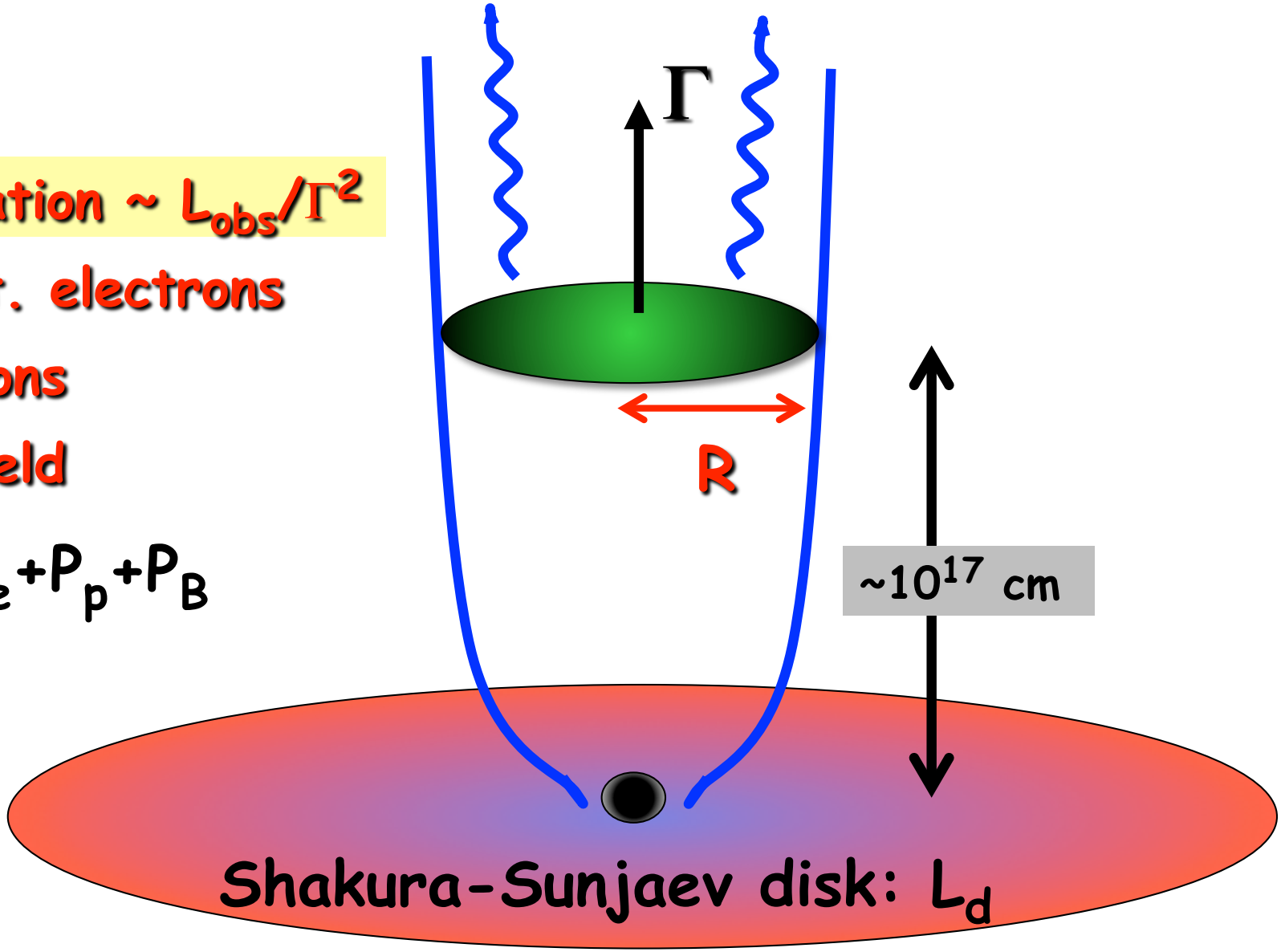
P_r = radiation ~ L_{obs}/Γ^2

P_e = relat. electrons

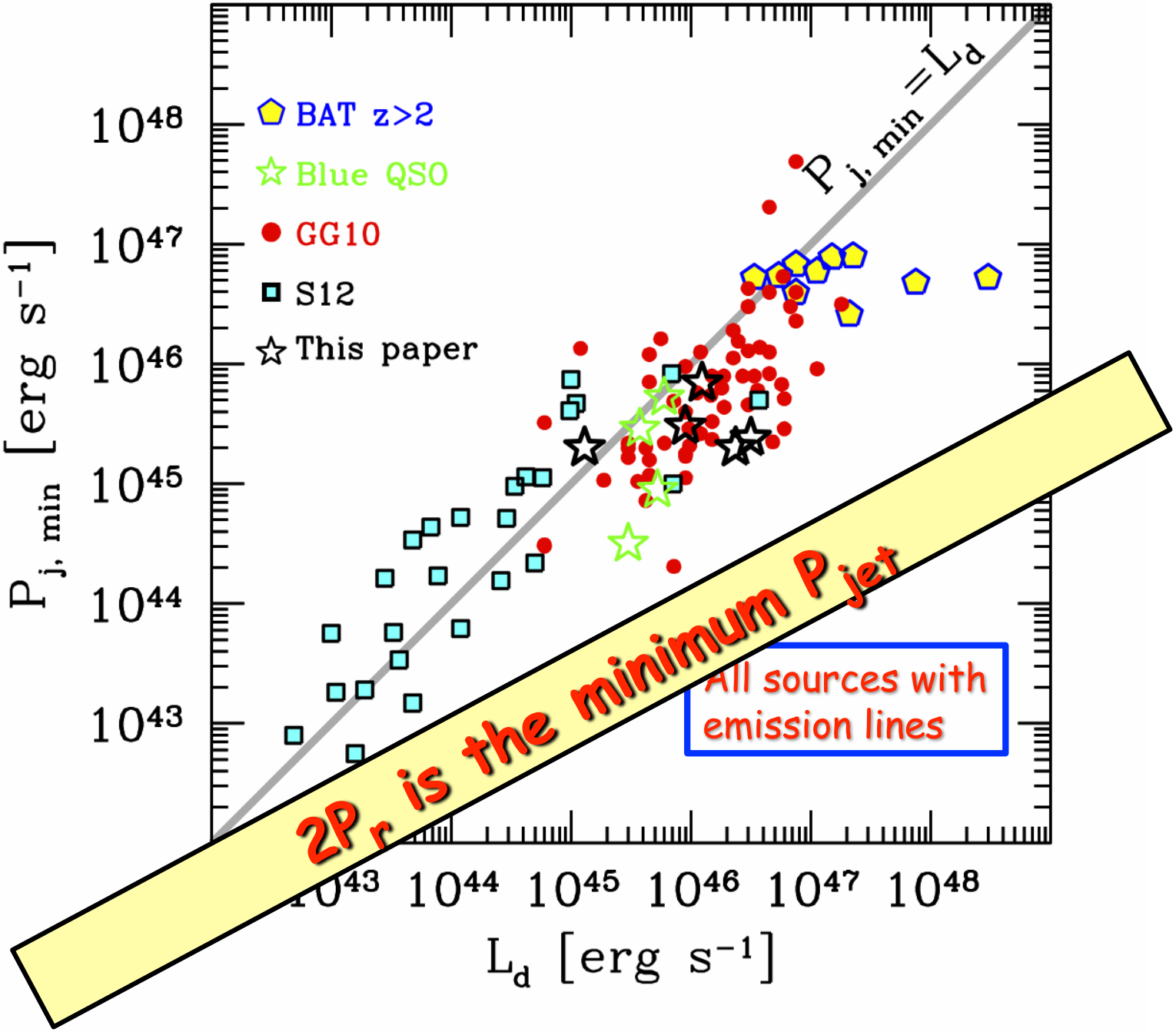
P_p = protons

P_B = B-field

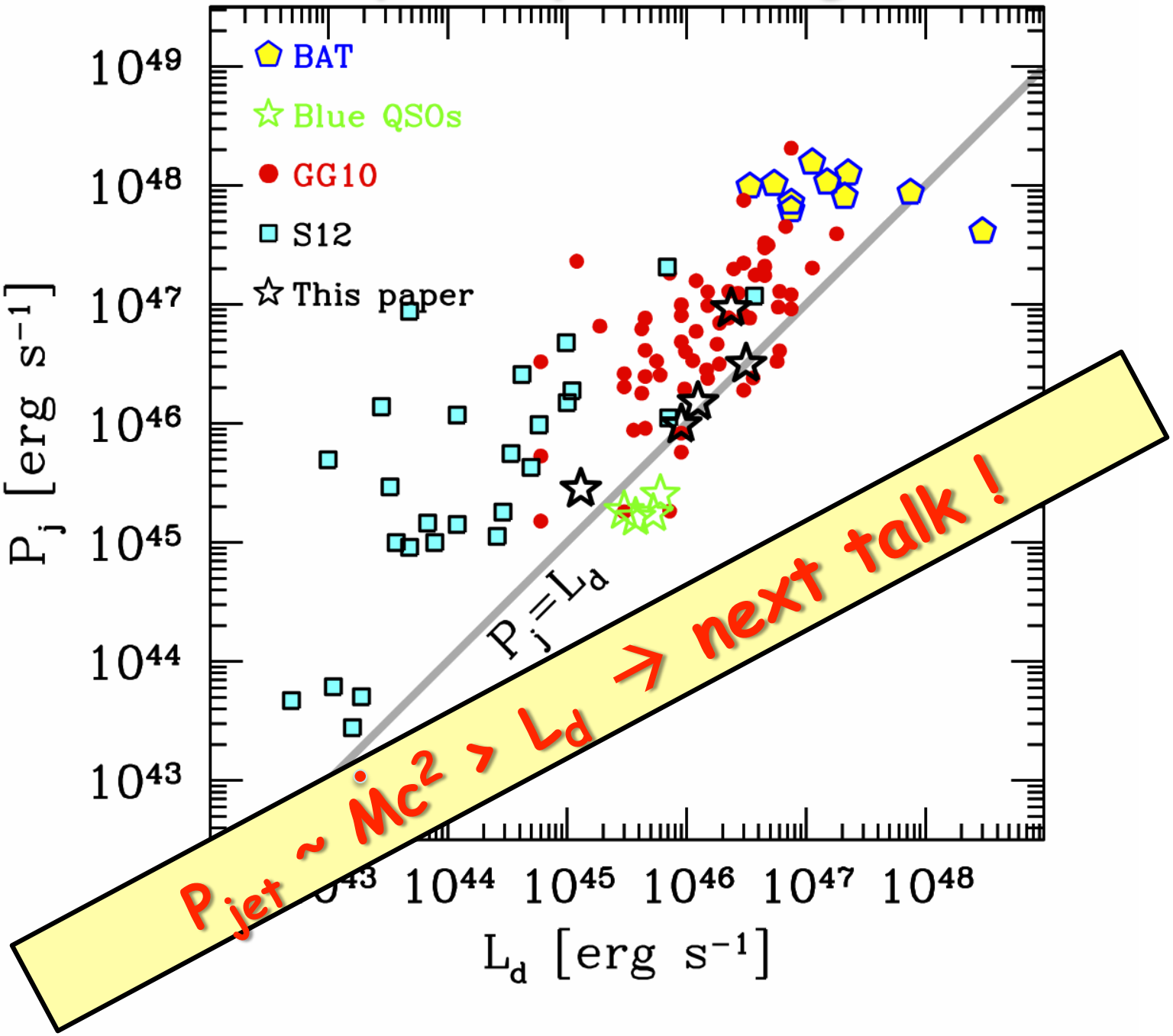
$P_{jet} = P_e + P_p + P_B$



$P_{min} = 2P_r \sim 2L_{obs}/\Gamma^2$ "model independent"



If one proton per *emitting* electron



Pause

- $P_{jet} \sim \dot{M}c^2$, even larger than L_d
- For *all* $\dot{M}/\dot{M}_{Edd}$
- BL Lacs→ ADAF FSRQs → SS
- L_{BLR}/L_{Edd} divides BL Lacs from FSRQs
- Matter, not magnetic, dominated

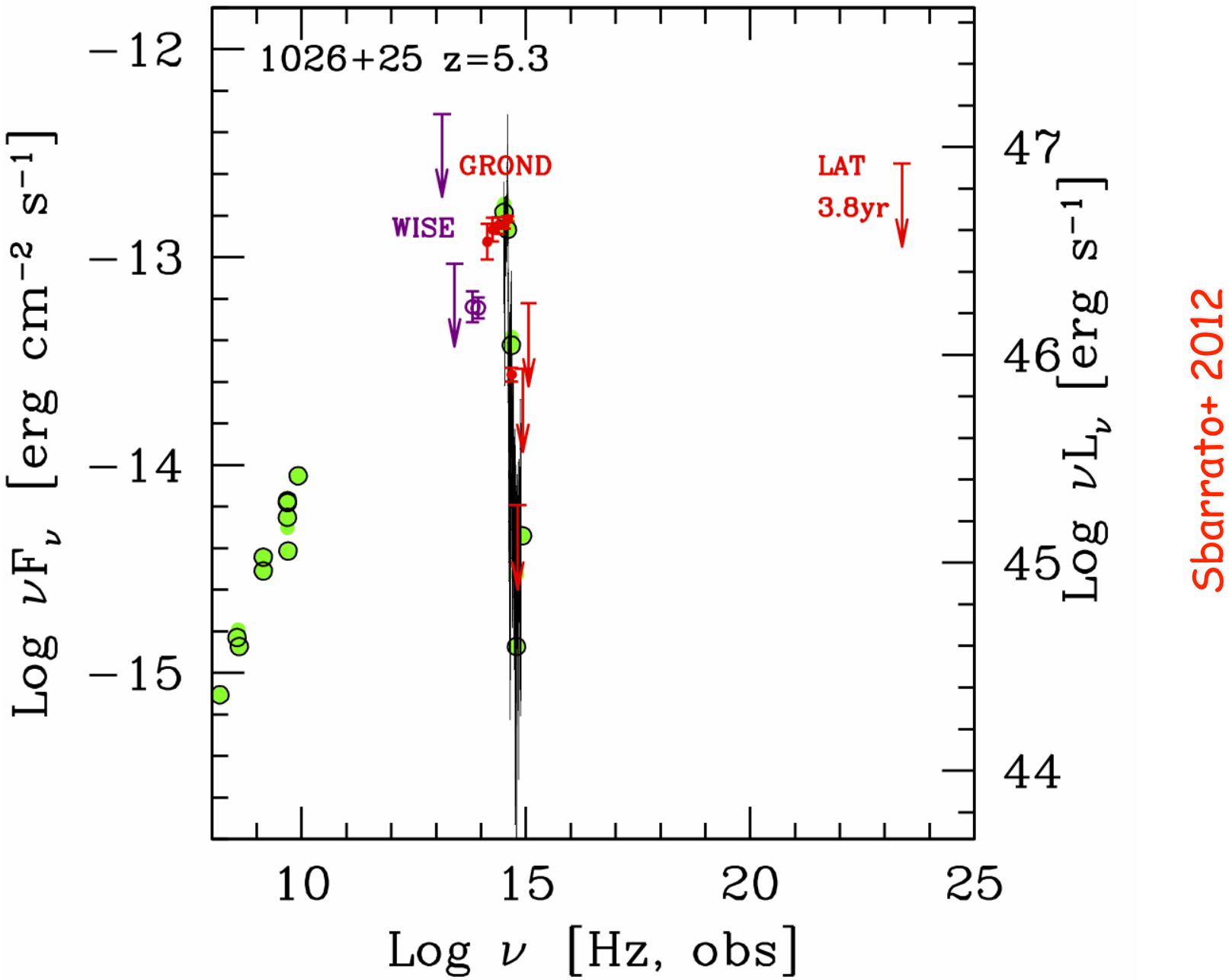
The second most distant blazar: z=5.3
B2 1023+01 = SDSS J1026+254

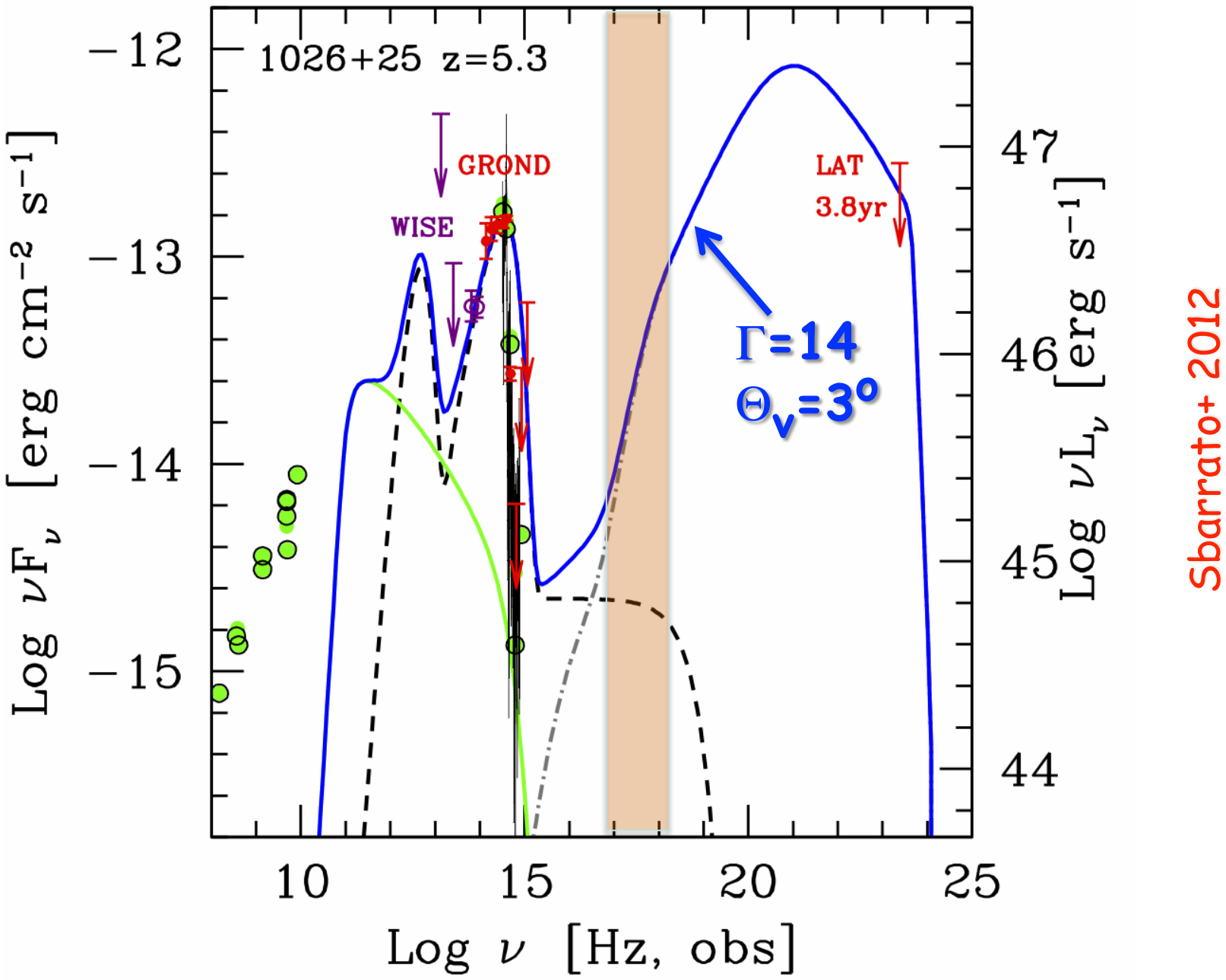
One of the 31 AGNs with radio-loudness R>100 and z>4 in the SDSS (DR7)

Strong radio (~200 mJy @ 1.4 GHz)

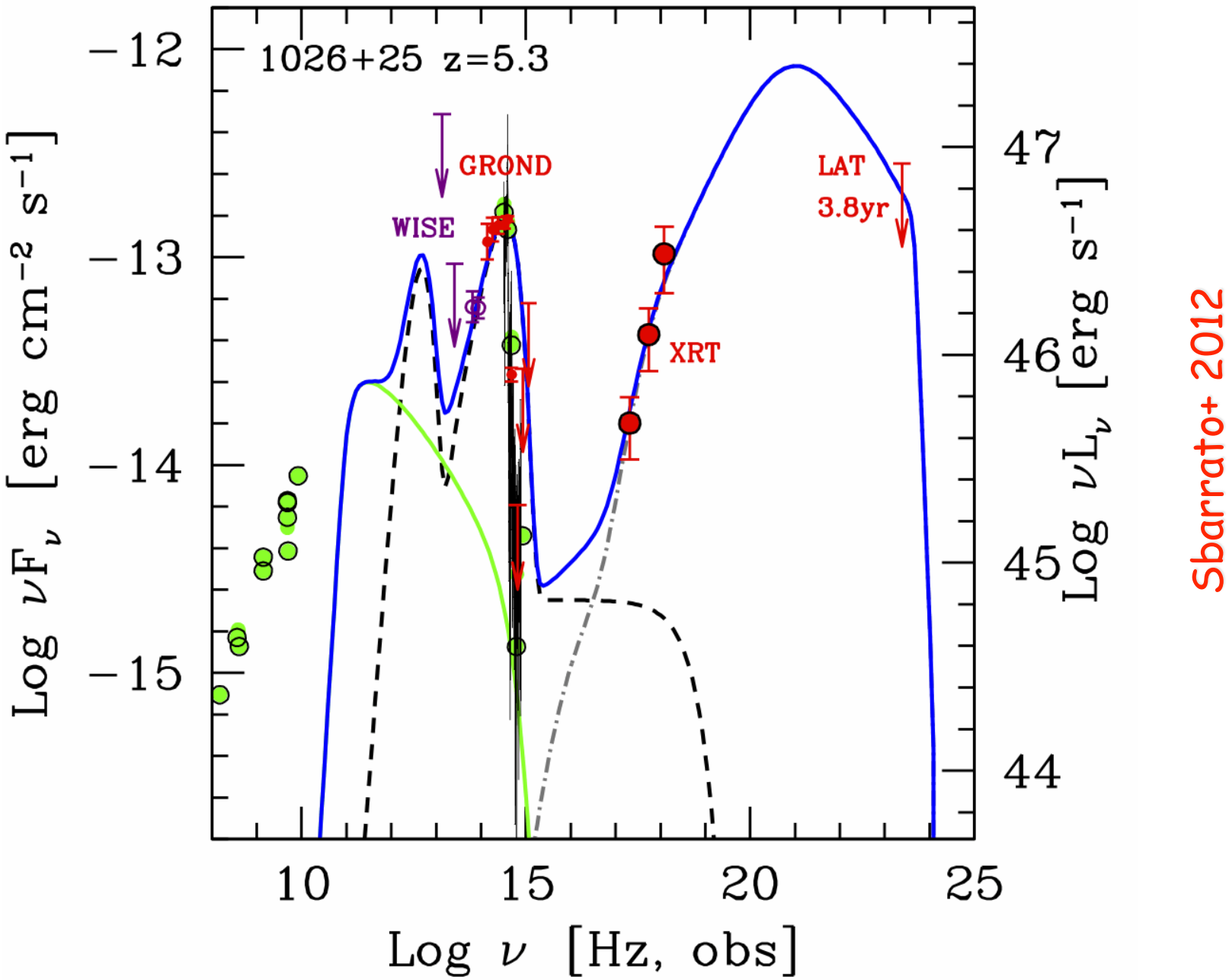
Large radio-loudness (R~5000)

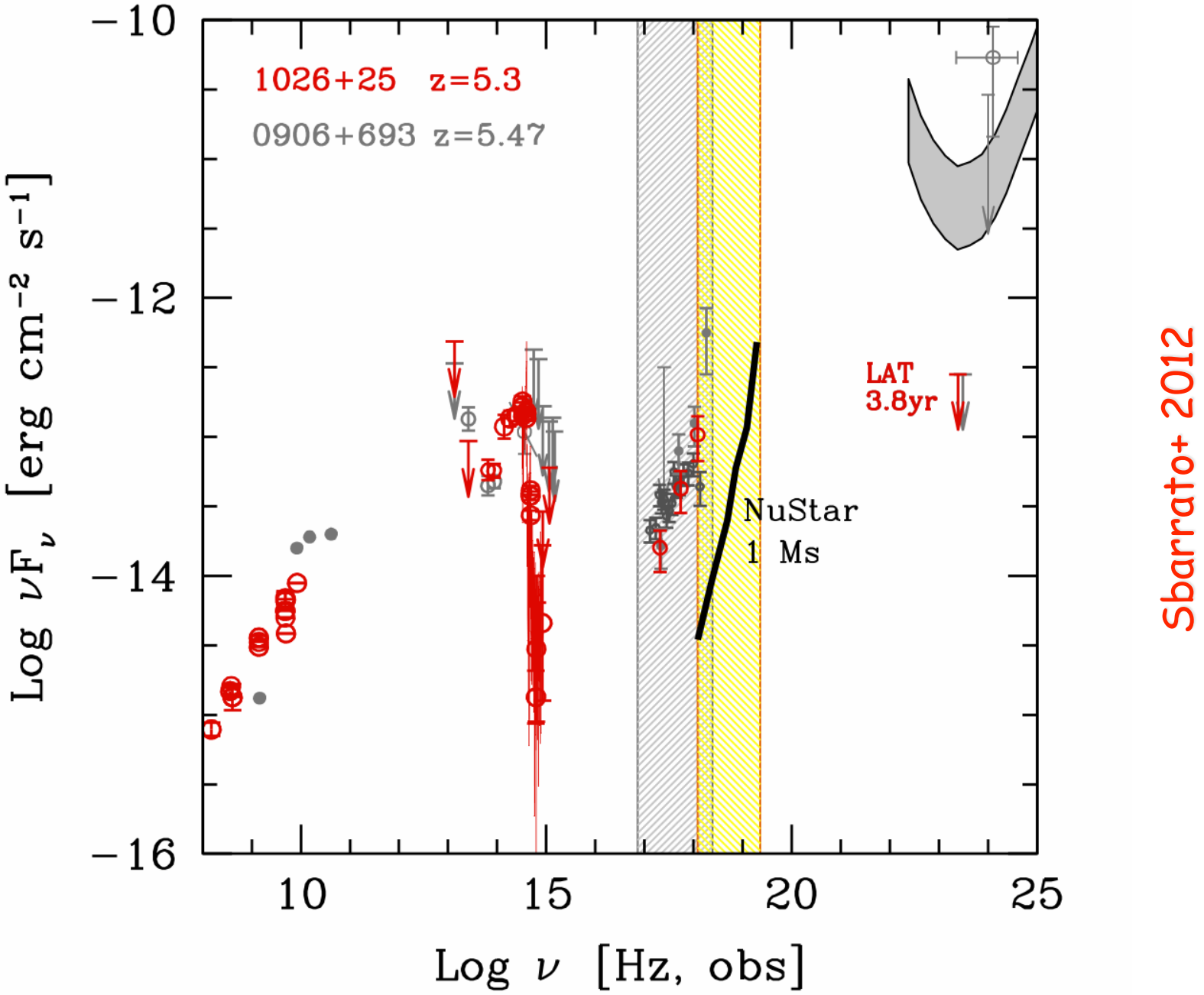
GROND (simult. photometry in 7 opt-IR filters)


1026+25 z=5.3
GROND
WISE
LAT
3.8yr
−12
−13
−14
−15
47
46
45
44
10
15
20
25
Log νF_ν [erg cm^−2 s^−1]
Log νL_ν [erg s^−1]
Log ν [Hz, obs]
Sbarrato+ 2012

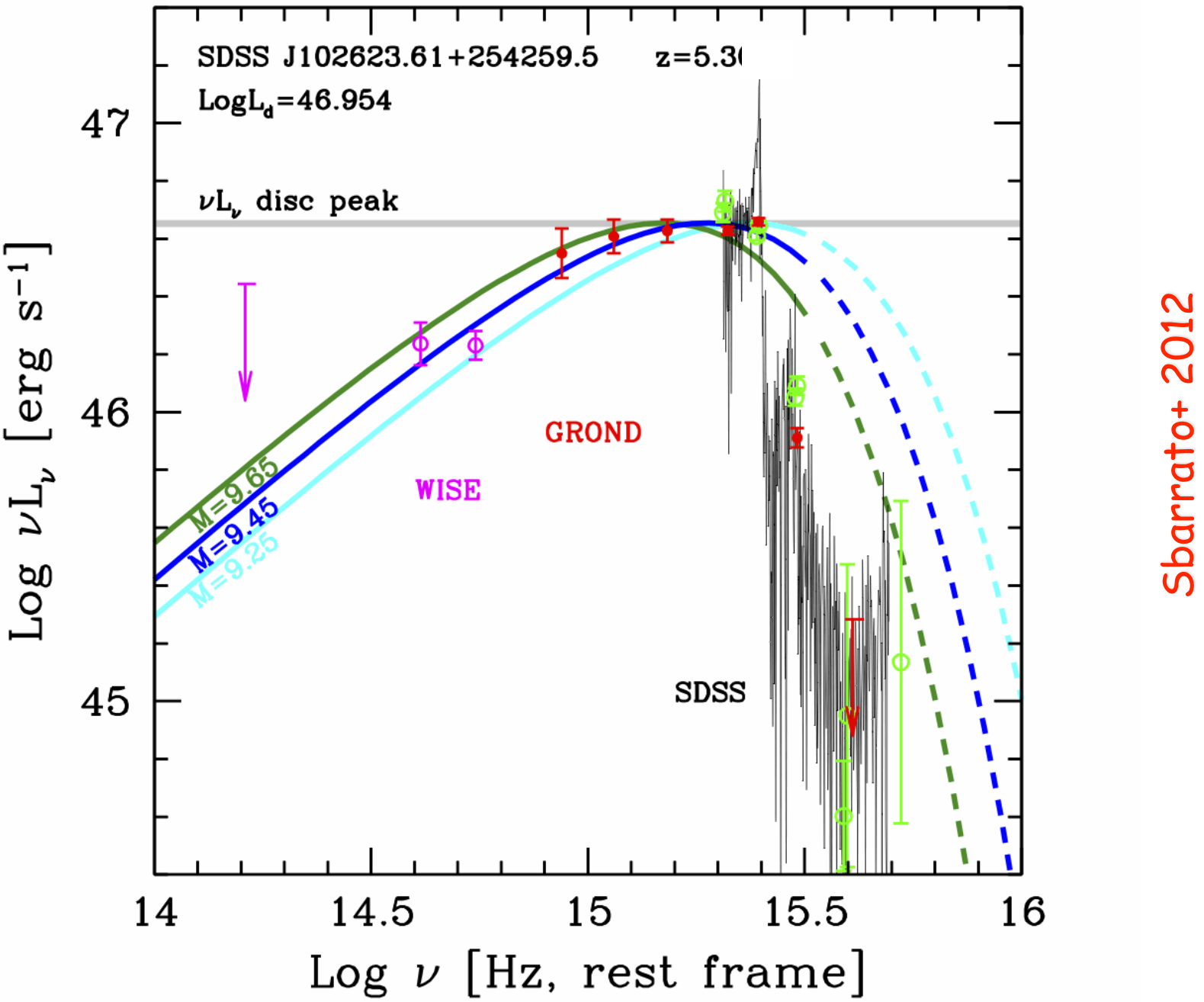


Sbarrato+ 2012


1026+25 z=5.3
GROND
WISE
LAT
3.8yr
XRT
−12
−13
−14
−15
47
46
45
44
10
15
20
25
Log νF_ν [erg cm^−2 s^−1]
Log νL_ν [erg s^−1]
Log ν [Hz, obs]
Sbarrato+ 2012



Sbarrato+ 2012

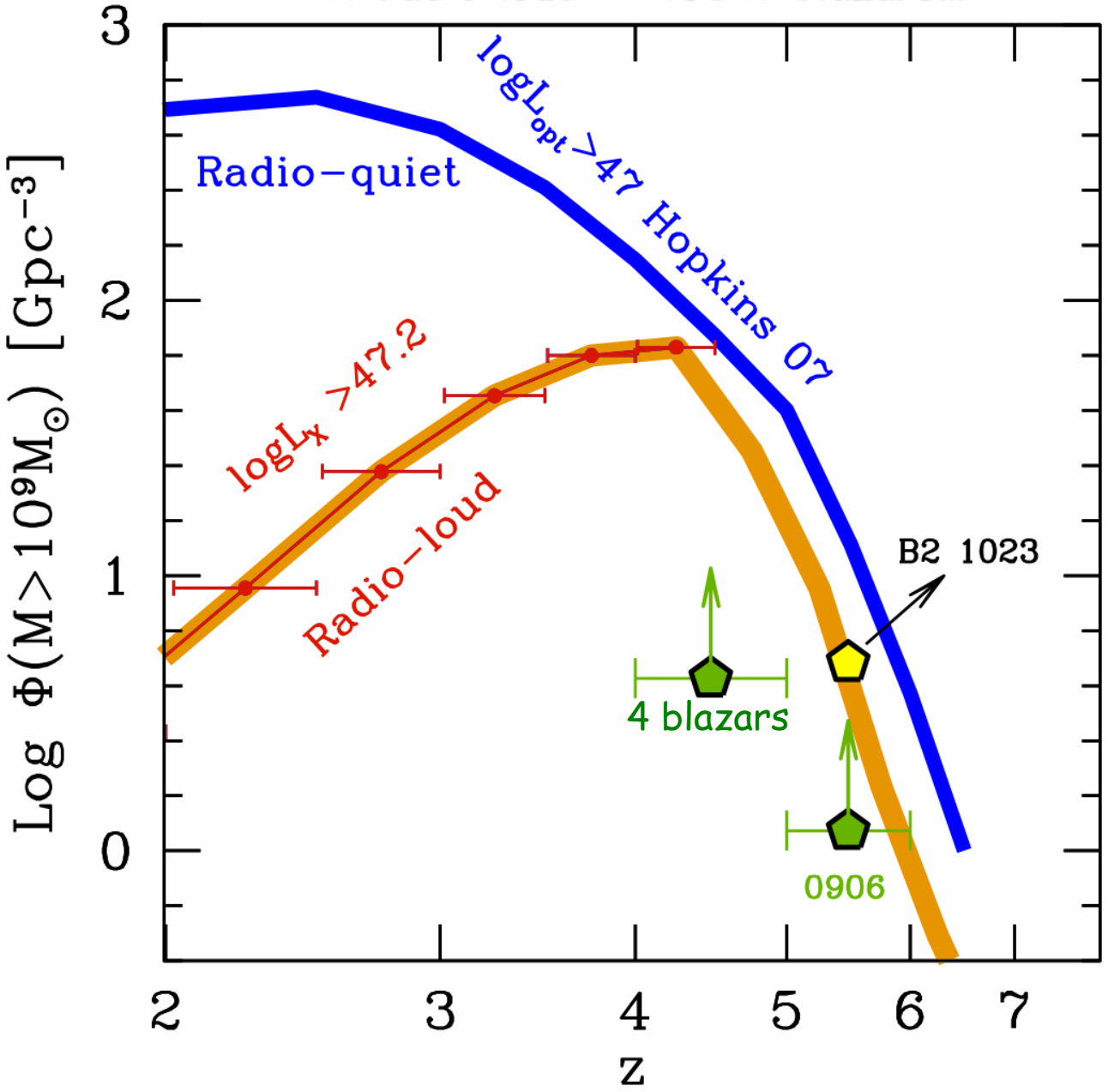


Sbarrato+ 2012

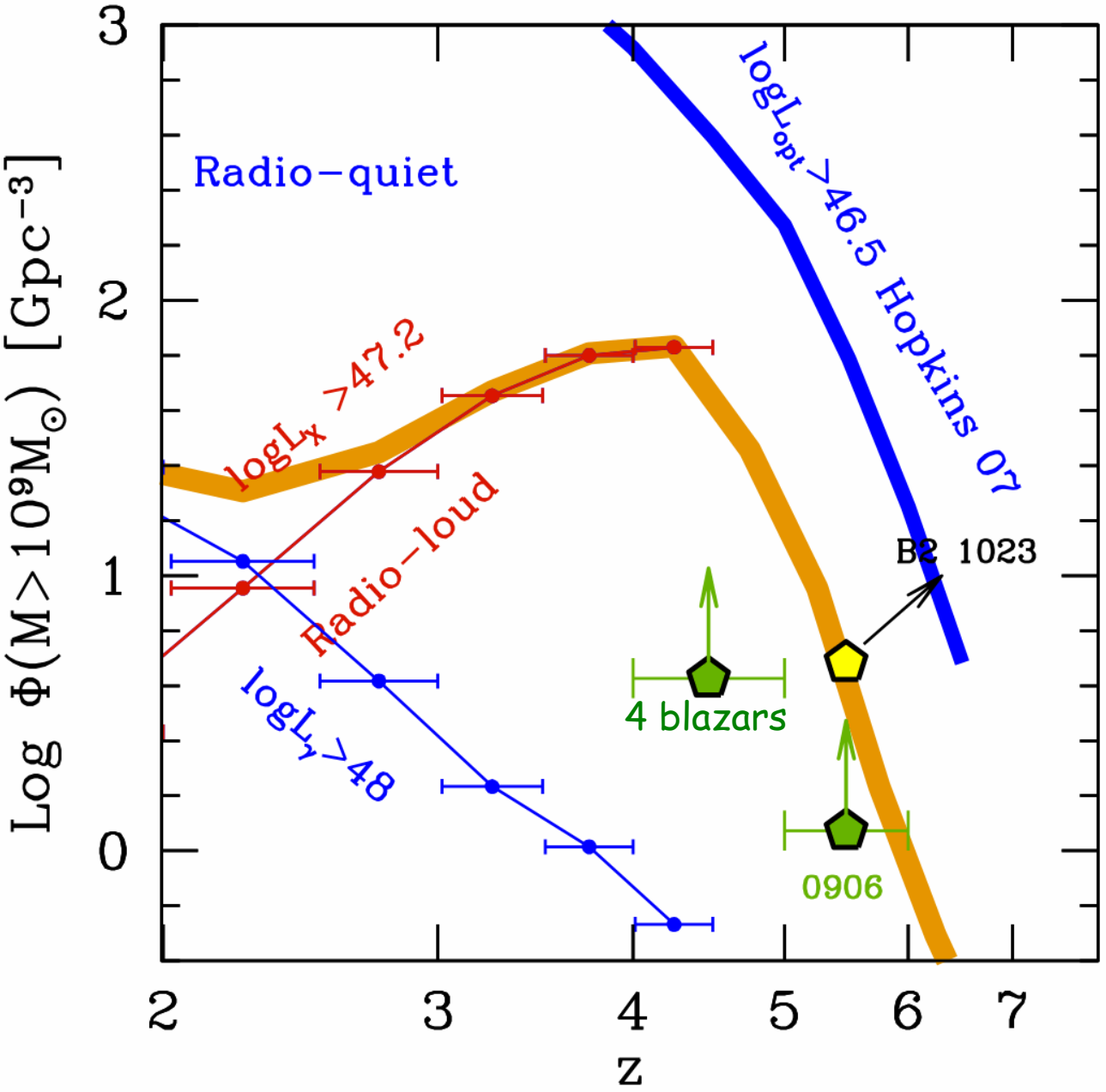
$$1 = 2\Gamma^2$$

$$\sim 200\text{-}500$$

radio-loud = 450 # blazars...



Ajello+ 2009; Volonteri+ 2011...


Radio−quiet
logL_opt >46.5 Hopkins 07
logL_X >47.2
Radio−loud
logL_γ >48
4 blazars
B2 1023
0906
Log Φ(M>10⁹M⊙) [Gpc⁻³]
z
3
2
1
0
2
3
4
5
6
7

Conclusions

- BL Lac – FSRQ divide at $L_{disc}/L_{Edd} \sim 10^{-2}$
- Jets are powerful, matter dominated
- Search for early and heavy black holes → blazars
- One means ~ 400
- X-rays better than γ-rays