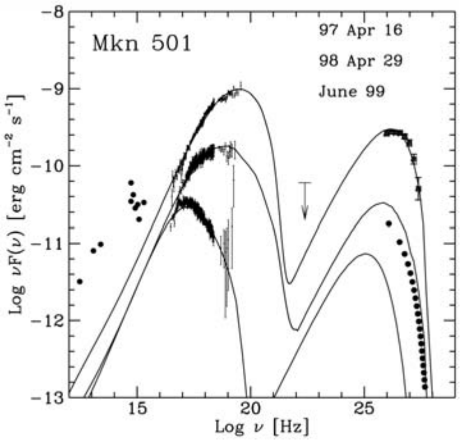
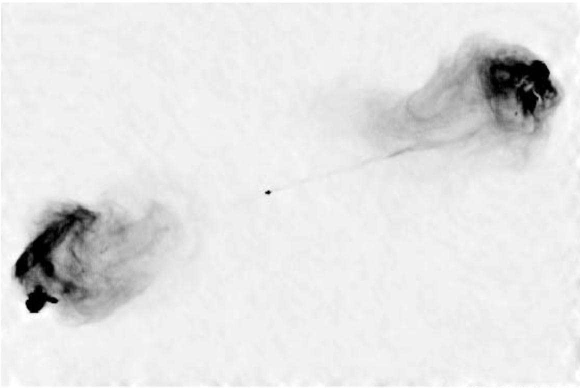




A simplified view of blazars: why BL Lacertae is actually a quasar in disguise*

Paolo Padovani, ESO, Germany

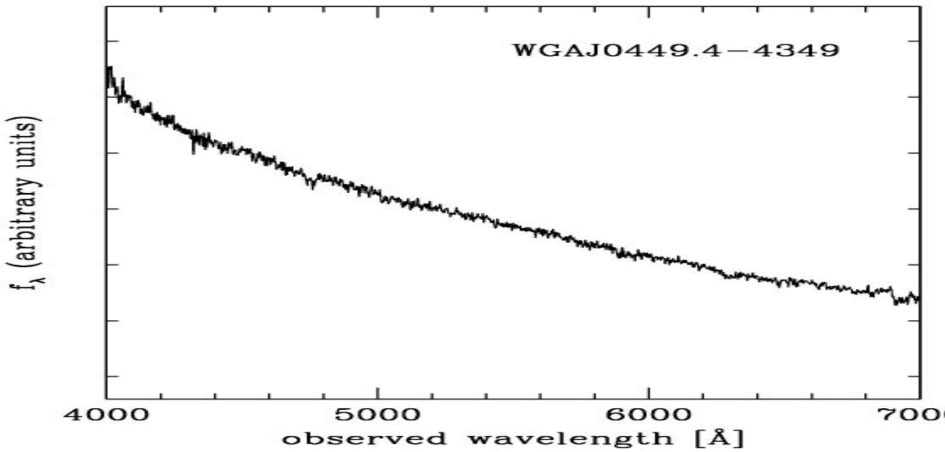
P. Giommi, G. Polenta, S. Turriziani, V. D' Elia (ASDC), S. Piranomonte (INAF)

- The two blazar classes
- A new, simplified hypothesis tested by numerical simulations
- Results and implications

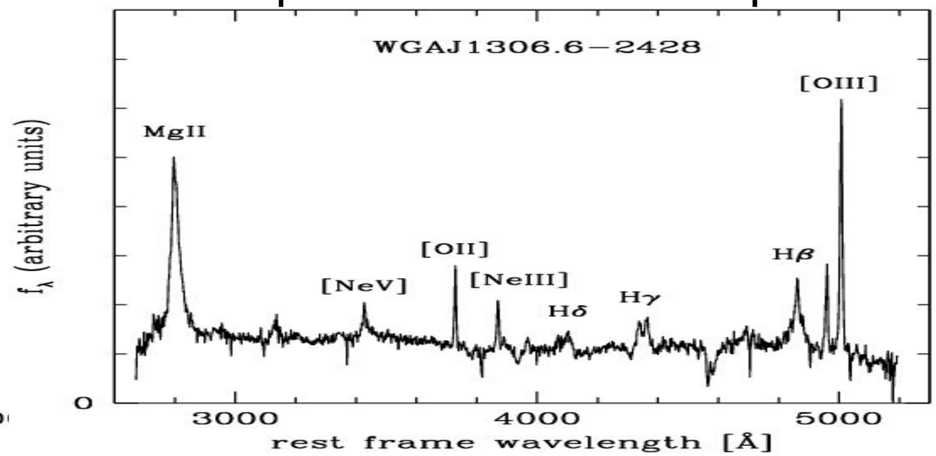
* Based on Giommi, Padovani, et al., (2011), MNRAS, in press (arXiv:1110.4706)

The two blazar classes

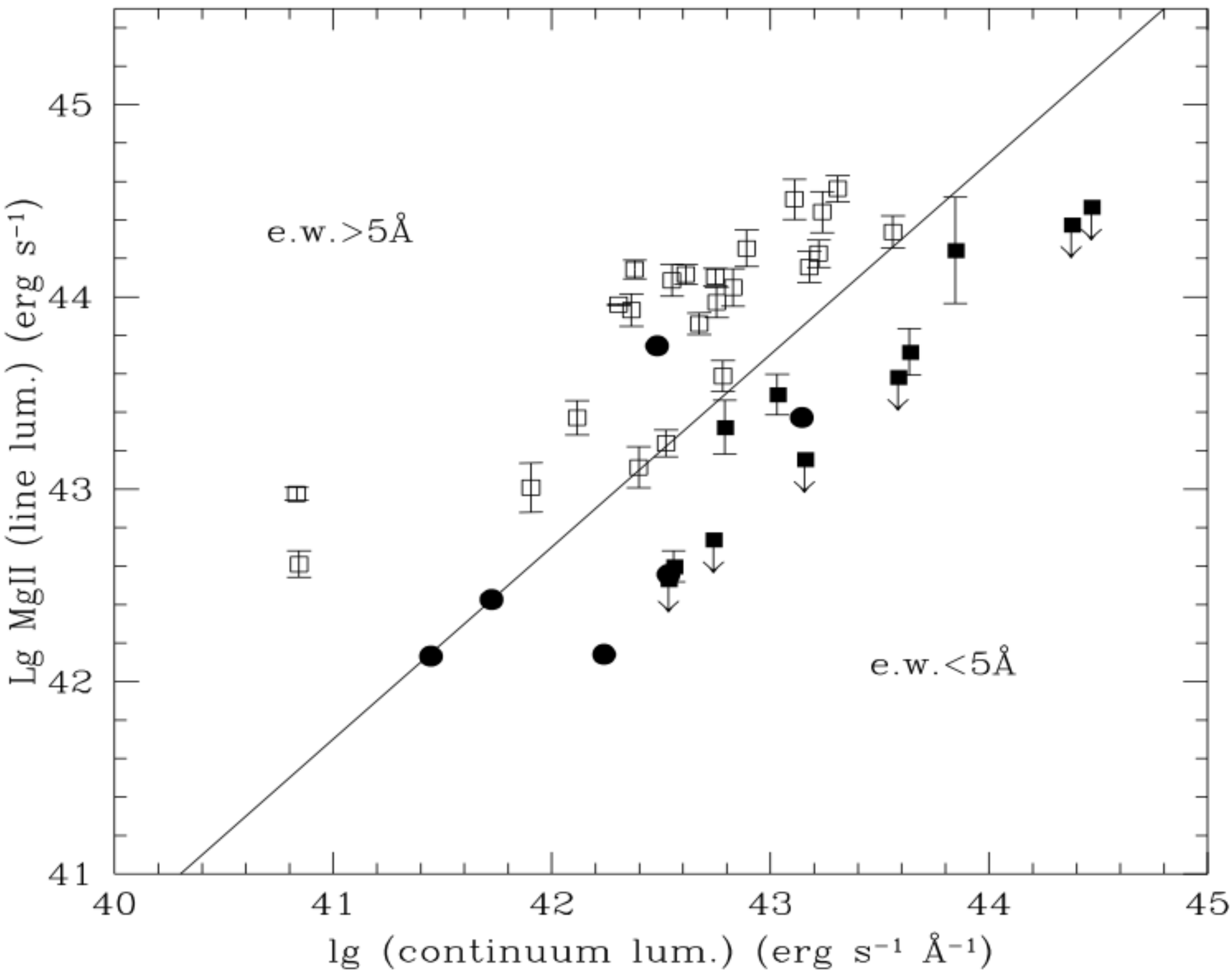
BL Lac



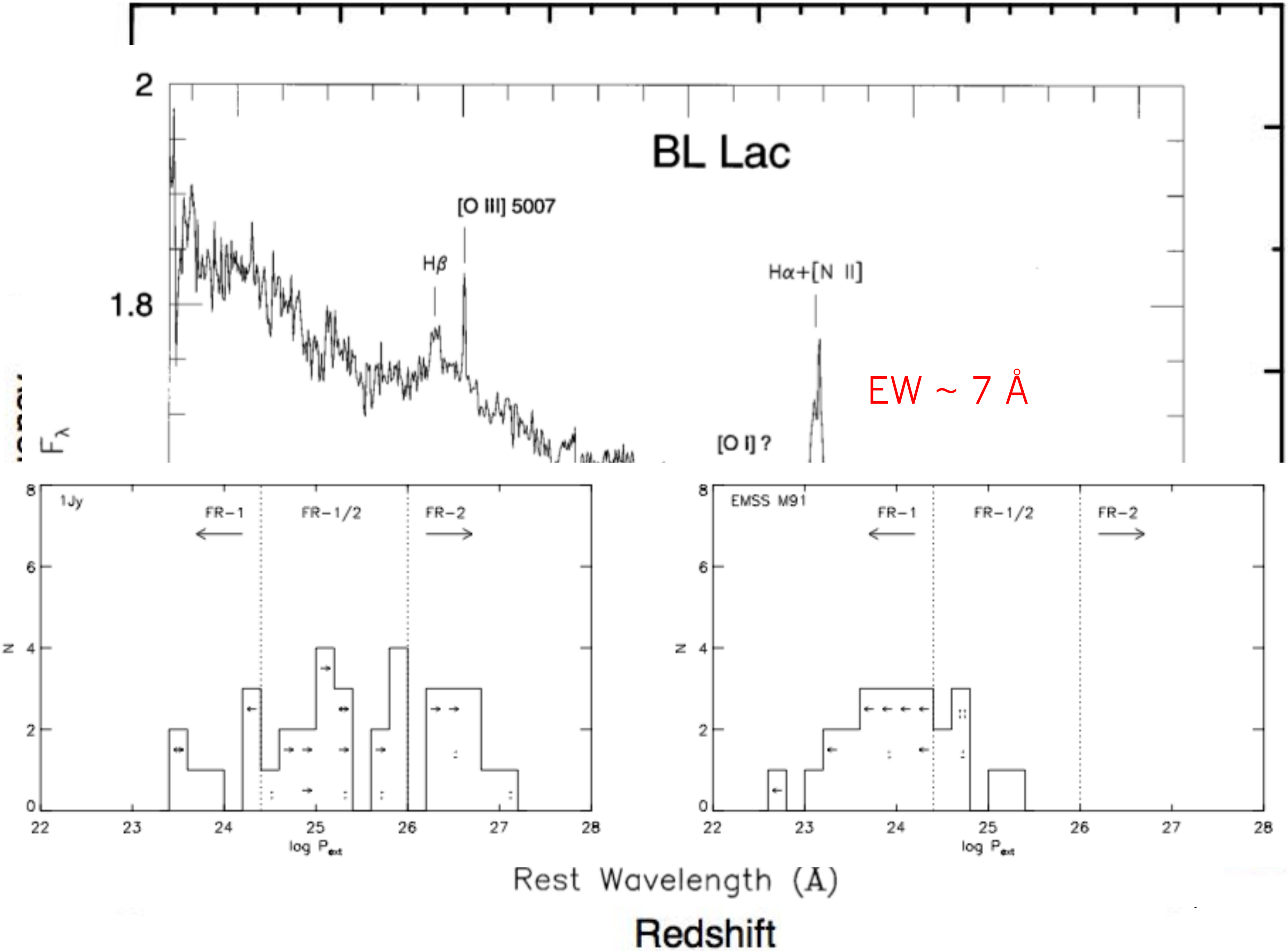
Flat spectrum radio quasar



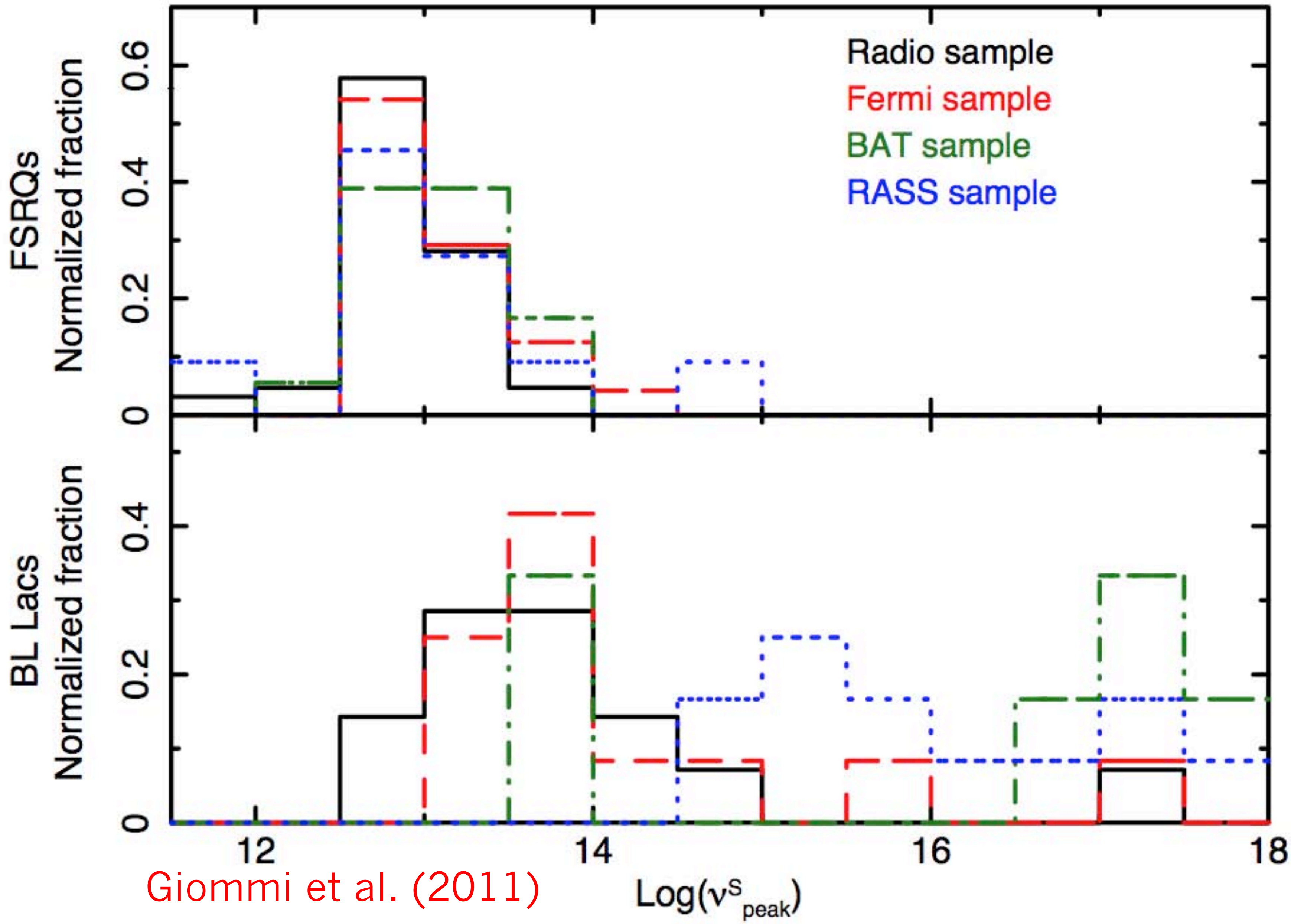
- What's the dividing line between BL Lacs and FSRQs?
- And when does a radio galaxy become a BL Lac?



Lg MgII (line lum.) (erg s⁻¹)
lg (continuum lum.) (erg s⁻¹ Å⁻¹)
e.w.>5Å
e.w.<5Å
41
42
43
44
45
40



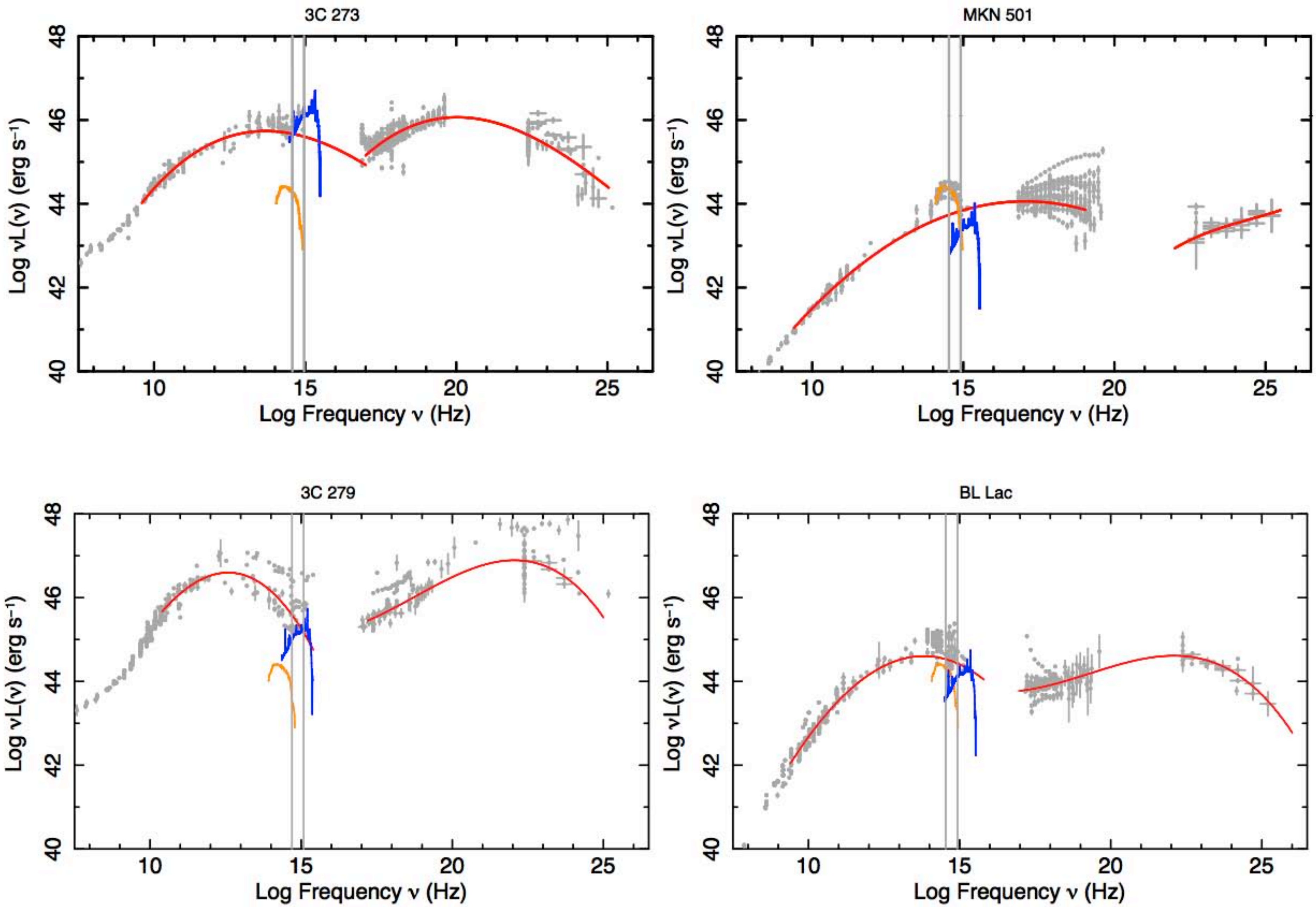
BL Lac
[O III] 5007
Hβ
Hα+[N II]
[O I] ?
EW ~ 7 Å
2
1.8
Fλ
1Jy
EMSS M91
FR−1
FR−1/2
FR−2
N
log P_ext
Rest Wavelength (Å)
Redshift



Giommi et al. (2011)

A new scenario

- Some of these differences explained by unified schemes: BL Lacs ←→ FR Is and FSRQs ←→ FR IIs
- However, no explanation for (e.g.,):
  - ✓ transition objects
  - ✓ different evolution of radio- and X-ray-selected BL Lacs
  - ✓ widely different ν_{peak} distributions for FSRQs and BL Lacs
- Our approach: start from unified schemes and add dilution and selection effects as new important components
- Observed optical spectrum is result of:
  - ✓ three components:
    - non-thermal, jet-related
    - thermal, accretion-disk related
    - host galaxy


3C 273
MKN 501
3C 279
BL Lac
Log νL(ν) (erg s⁻¹)
Log Frequency ν (Hz)
40
42
44
46
48
10
15
20
25

Monte Carlo simulations

- Two samples simulated (10,000 sources each):
  - ✓ radio-selected, $f \geq 0.9$ Jy (matched to WMAP5)
  - ✓ X-ray selected, f_x (0.3-3.5 keV) $\geq 5\ 10^{-13}$ c.g.s. (≈ matched to EMSS)
- Source classification:
  - ✓ FSRQ: EW_{rest} of *any* line in the observer's window (3,800 – 8,000 Å) > 5 Å
  - ✓ BL Lac: EW_{rest} of *all* lines in the observer's window < 5 Å; non-measurable z if EW_{rest} < 2 Å or $f_{jet} > 10 \times f_{galaxy}$
  - ✓ Radio Galaxy: Ca H&K break > 40%

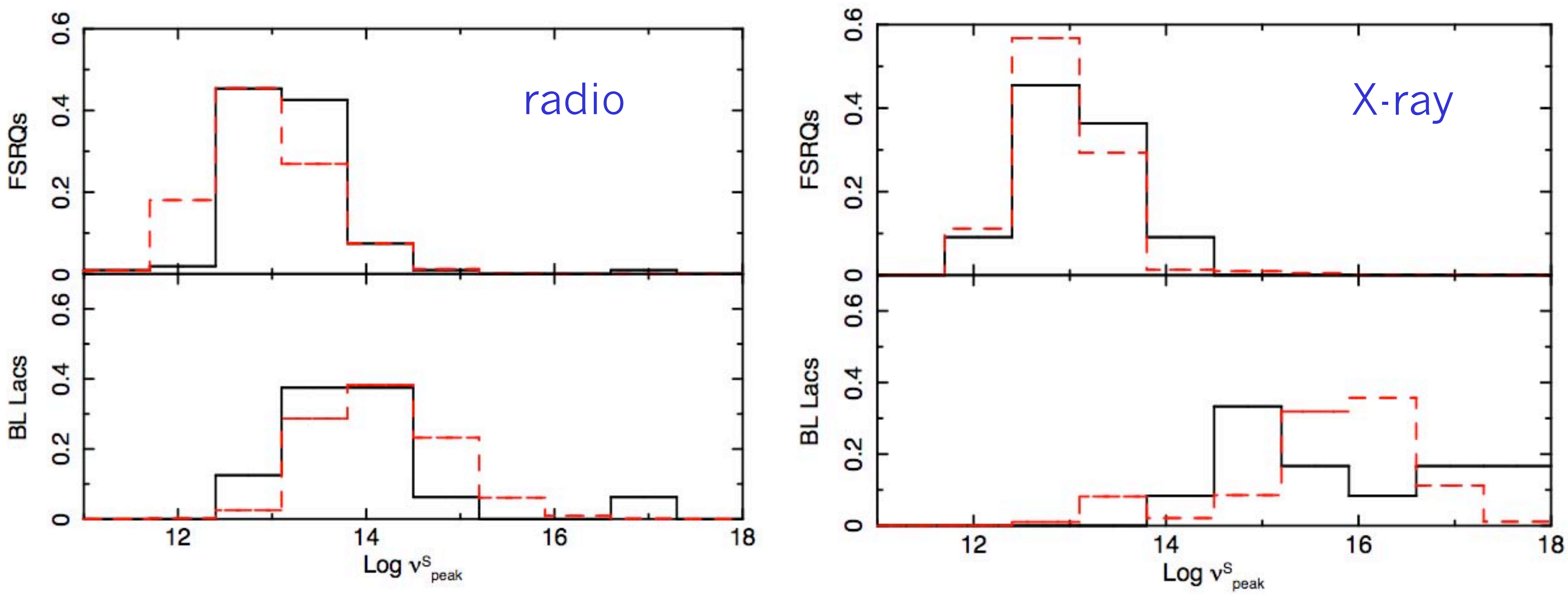
Goal: to *keep assumptions down to a minimum and obtain robust results* (not to reproduce perfectly ALL observables)

Simulations have also predictive power!

Main Results

Table 1. Results from a simulation of a radio flux density limited survey (0.9 Jy)

- Properties … -selected blazar sam…



-

✓ <δ> (fr… …ce on P_r

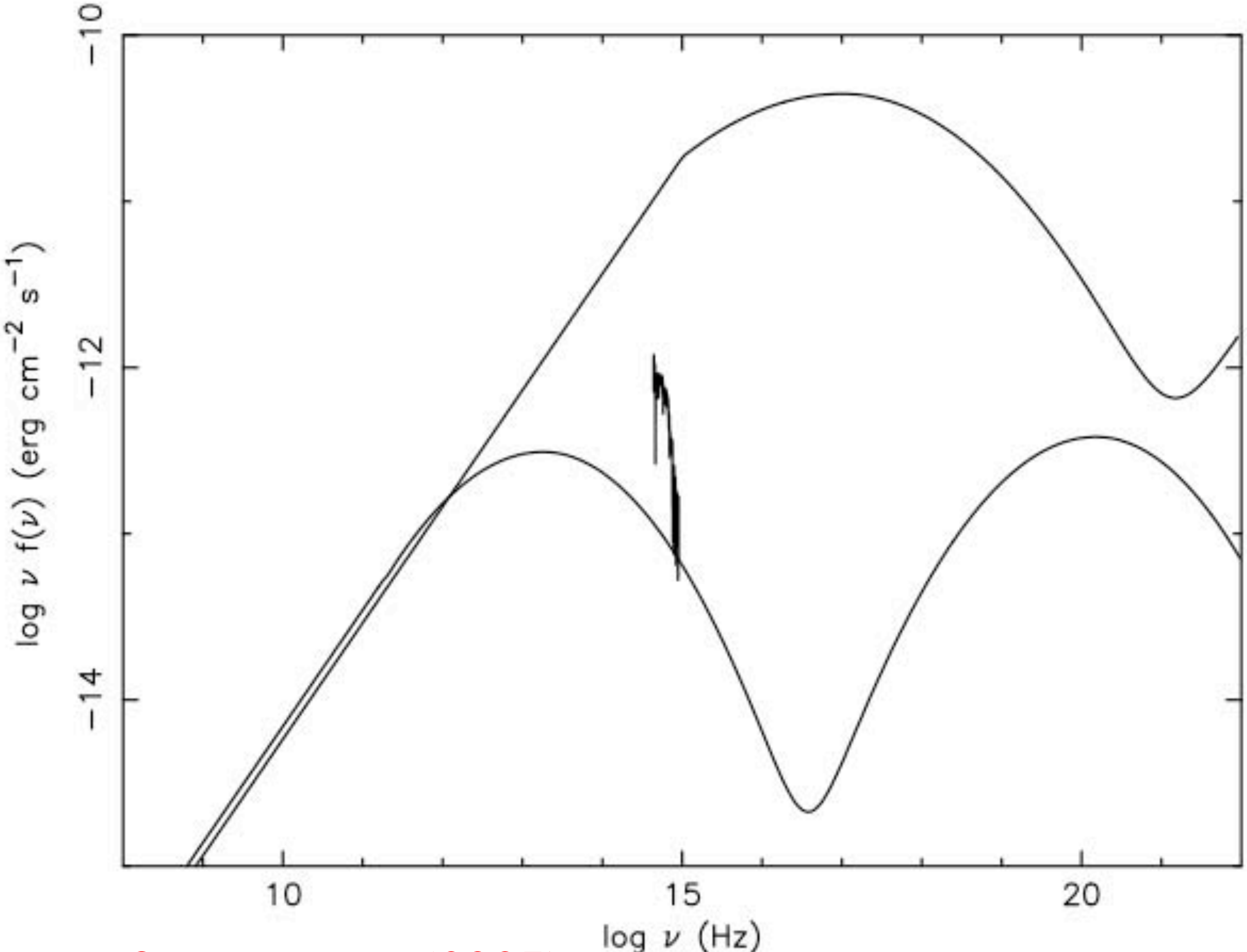
Source type	Number of sources	$\langle z \rangle$	$\langle V/V_m \rangle$
BL Lacs ($\log \nu^S_{peak} > 17$)	185 (177)	0.34	0.34
Radio galaxies	1,542	0.04	0.48
Total	10,000	0.58	0.55

Implications

- 80% of radio-selected BL Lacs have *an accretion disk:*
  - ✓ emission lines *in observer's window* swamped by jet
  - ✓ $EW_{rest}(H\alpha) > 5$ Å! ($H\alpha$ outside the window for $z > 0.22$) → FSRQs with strong IR lines
- 30% of X-ray selected BL Lacs have *an accretion disk;* indeed, fewer EMSS BL Lacs with lines than 1 Jy BL Lacs
- 5 – 15% of our sources classified as radio-galaxies: blazars with non-thermal component swamped by host galaxy. Agrees with Dennett-Thorpe & Marchã (2000), Giommi et al (2002, 2005), Anton & Browne (2005)

Implications

- BL Lacs belong to two physically different classes:
  - ✓ intrinsically weak lined objects
  - ✓ beamed FSRQs with diluted emission lines
- BL Lacertae is not a BL Lac!
- There are *only* two blazar types: non-evolving LERGs and evolving HERGs



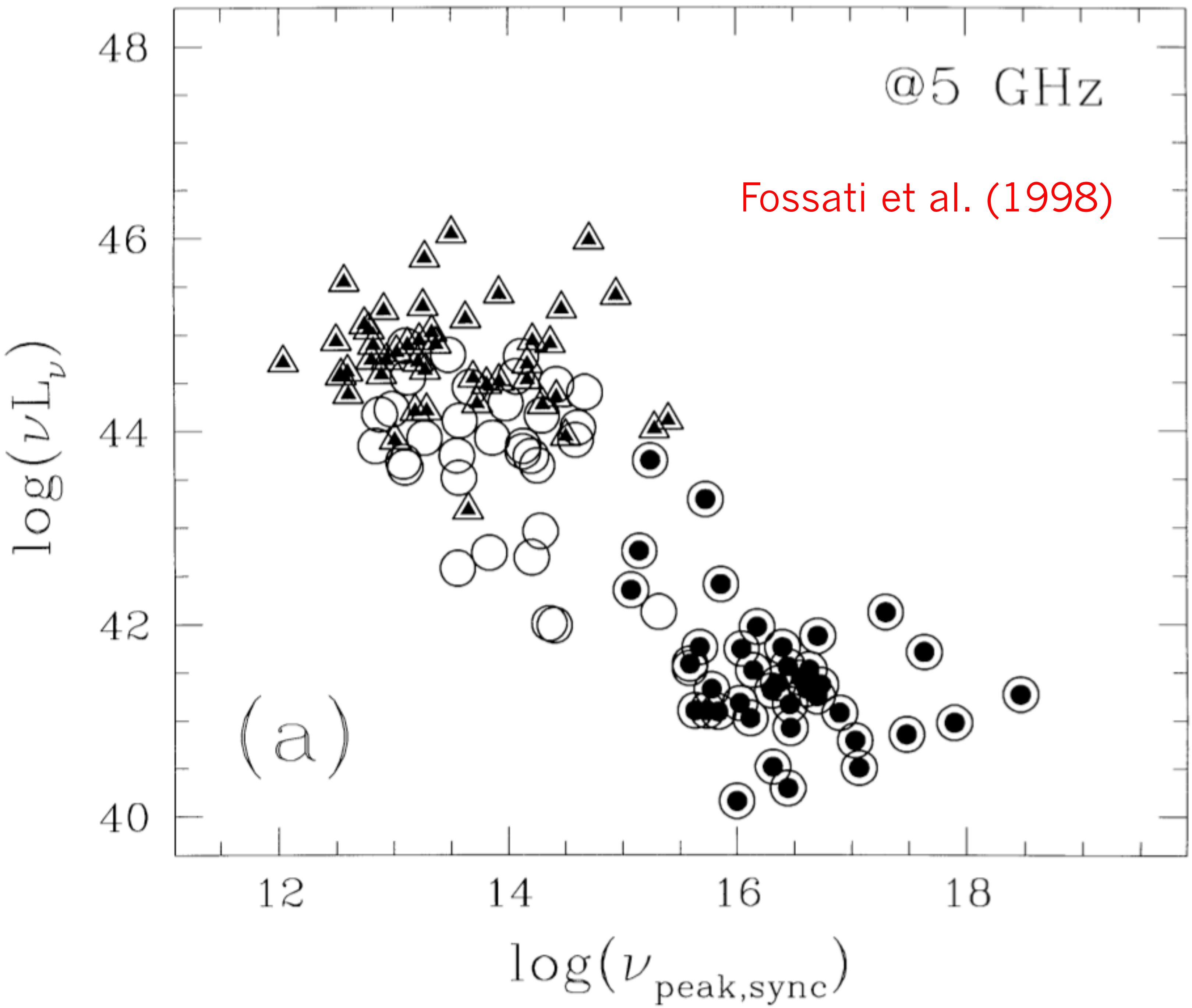
Giommi et al. (2005)

•

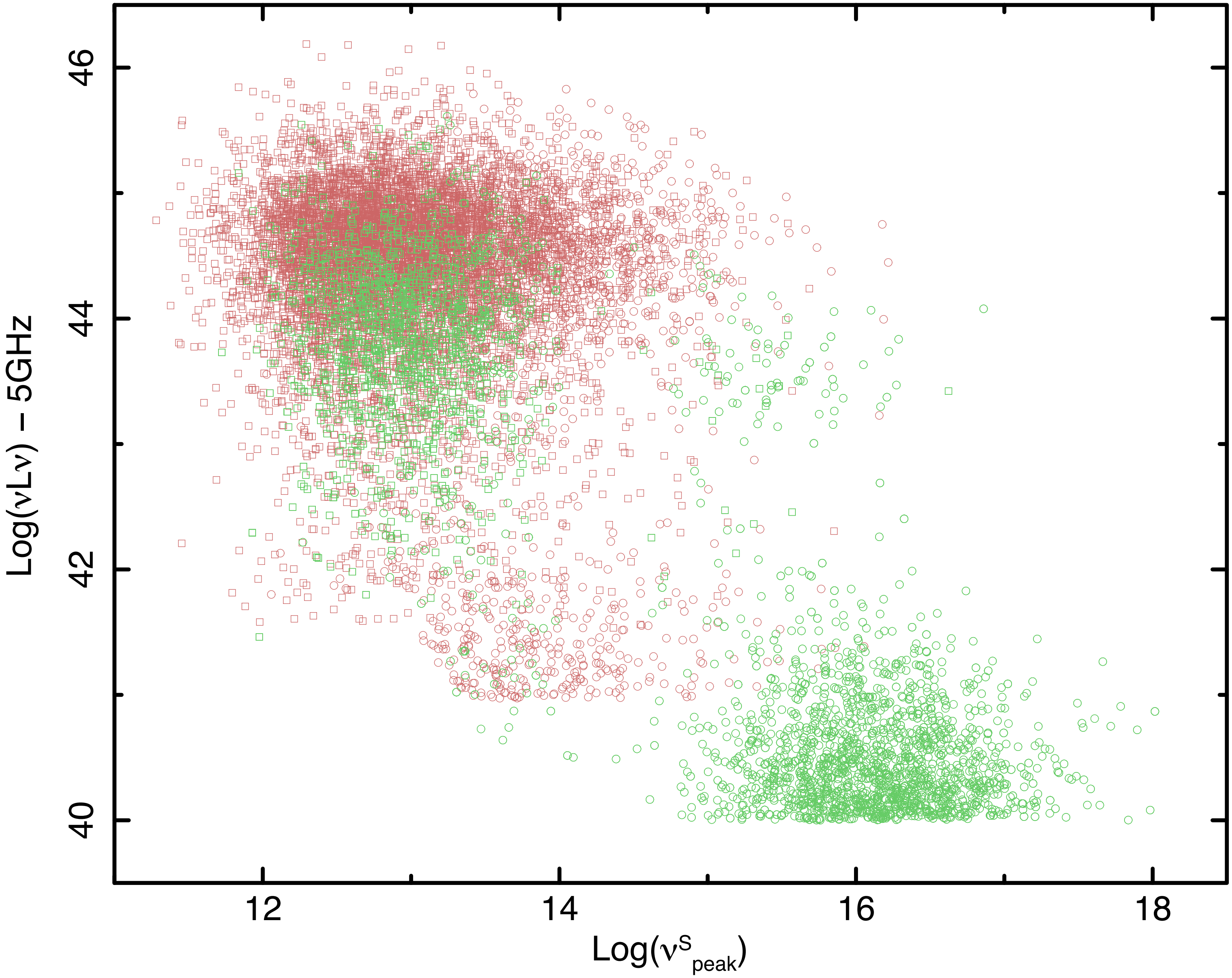
•

e

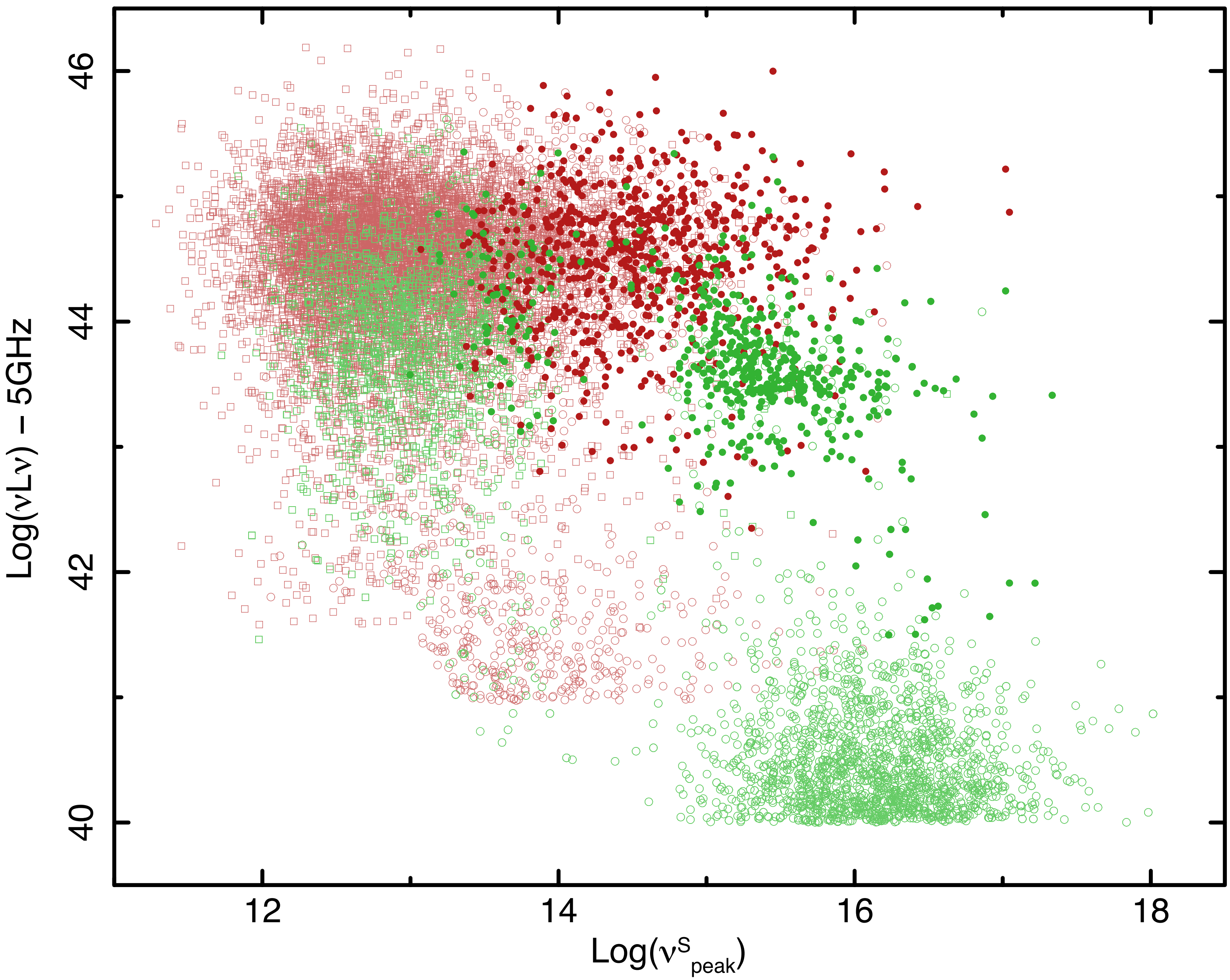
k



@5 GHz
Fossati et al. (1998)
(a)
48
46
44
42
40
12
14
16
18
$\log(\nu L_\nu)$
$\log(\nu_{\mathrm{peak,sync}})$



46
44
42
40
12
14
16
18
Log(νLν) – 5GHz
Log(ν^S_peak)



46
44
42
40
12
14
16
18
Log(νLν) – 5GHz
Log(ν^S_peak)

Summary

- We have put together many pieces of a puzzle which has been in the making for the past 20 years or so
- Starting point: two populations
  - ✓ high-excitation (standard accretion disk), high P_r, evolving
  - ✓ low-excitation, low P_r, non-evolving
- Add non-thermal (jet), thermal (accretion), and host galaxy components

Summary

- Main results:
  - ✓ blazar properties (incl. BL Lac/FSRQ differences) explained
  - ✓ BL Lacs are of two types:
    - ○ beamed FSRQs with swamped emission lines (HERGs) ["fake BL Lacs"]: → need to be grouped with FSRQs!
    - ○ weak-lined radio sources with strong jet (LERGs) ["real BL Lacs"]
  - ✓ some optically classified radio-galaxies are still blazars
  - ✓ blazar sequence due to selection effects
  - ✓ featureless BL Lacs → high ν_{peak} & high P_r, $\langle z \rangle \approx 1.4$

Stay tuned for more results for the γ-ray band!

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A simplified view of blazars: clearing the fog around long-standing selection effects

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ABSTRACT

We propose a scenario where blazars are classified as flat-spectrum radio quasars (FSRQs), BL Lacs, low synchrotron, or high synchrotron peaked objects according to a varying mix of the Doppler boosted radiation from the jet, the emission from the accretion disk, the broad line region, and the light from the host galaxy. In this framework the peak energy of the synchrotron power ($\nu^S_{\rm peak}$) in blazars is independent of source type and of radio luminosity. We test this new approach, which builds upon unified schemes, using extensive Monte Carlo simulations and show that it can provide simple answers to a number of long-standing issues including, amongst others, the different cosmological evolution of BL Lacs selected in the radio and X-ray bands, the larger $\nu^S_{\rm peak}$ values observed in BL Lacs, the fact that high synchrotron peaked blazars are always of the BL Lac type, and the existence of FSRQ/BL Lac transition objects. Objects so far classified as BL Lacs on the basis of their *observed* weak, or undetectable, emission lines are of two physically different classes: intrinsically weak lined objects, more common in X-ray selected samples, and heavily diluted broad lined sources, more frequent in radio selected samples, which explains some of the confusion in the literature. We also show that strong selection effects are the main cause of the diversity observed in radio and X-ray samples, and that the correlation between luminosity and $\nu^S_{\rm peak}$, that led to the proposal of the "blazar sequence", is also a selection effect arising from the comparison of shallow radio and X-ray surveys, and to the fact that high $\nu^S_{\rm peak}$ - high radio power objects have never been considered because their redshift is not measurable.

Key words: BL Lacertae objects: general — quasars: emission lines — radiation mechanisms: non-thermal — radio continuum: galaxies — X-rays: galaxies

arXiv:1107.4706

1 INTRODUCTION

Once considered rare sources, blazars, a type of radio loud active galactic nuclei (AGN) pointing their jets in the direction of the observer (see e.g. Blandford & Rees 1978; Urry & Padovani 1995), are now being detected in increasingly larger numbers. Recent results from the *Wilkinson Microwave Anisotropy Probe* (WMAP), the *Planck* and *Fermi* satellites have established that blazars are the most common type of extragalactic sources found at microwave and γ-ray energies (Giommi et al. 2007; Abdo et al. 2010a; Planck Collaboration 2011). So far about 3,000 blazars are known (Massaro et al. 2009, 2011), but their number is steadily growing thanks to the *Fermi* (Abdo et al. 2010b, 2011), the optical Sloan Digital Sky Survey (SDSS: Plotkin et al. 2010), and the *Planck* (Planck Collaboration 2011) surveys. Some faint blazars are also being detected as serendipitous sources in *Swift*-XRT images (Turriziani 2010, 2011).

While all blazars share the same property of emitting variable, non-thermal radiation across the entire electromagnetic spectrum, they also display diversity. Namely, they come in two main subclasses, whose major difference is in their optical properties: 1) Flat Spectrum Radio Quasars (FSRQs), which show strong, broad emission lines in their optical spectrum, just like radio quiet QSOs;

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