RevMexAA (Serie de Conferencias), **23**, 68–76 (2005)

THE *FIRST* FLAT SPECTRUM SAMPLE

G. Fossati[1]

RESUMEN

Se reseña el estado de la investigación de "blazares", enfocando los temas relativos a los esquemas de unificación y se presenta una visión general de nuestro proyecto en curso, Muestra FIRST de Espectro Plano (FFSS). El objetivo del FFSS es esclarecer la verdadera naturaleza y propiedades físicas de los AGNs radio-fuertes mediante la demografía de los blazares, y resolver la incertidumbre sobre la naturaleza de la relación entre potencia, colores y tipos espectrales. El FFSS ha sido diseñado para darnos un censo (más) verdadero de los blazares. Para lograrlo, es crucial intentar seleccionar, sin prejuicios, todos los "sabores" de blazares (es decir, no distinguir a priori entre BL Lac y FSRQ), y tener sensibilidad a la totalidad del -amplio- intervalo de los "colores" SED.

ABSTRACT

We give an overview of the status of blazar research, focusing on the issues concerning unification schemes, and present an overview of our on-going FIRST Flat Spectrum Sample (FFSS) project. The goal of the FFSS is to shed light on the true nature and physical properties of radio-loud AGN through the understanding of the demographics of blazars, resolving the long standing uncertainty about nature of the relationship among power, colors and spectral types. The FFSS is "designed" to give us a true(r) census of blazars. In order to do so, it is crucial to strive to select in an unprejudiced way all "flavors" of blazar (e.g. not distinguish a priori between BL Lac and FSRQ), and to be sensitive to the whole -broad- range of the SED "colors".

Key Words: **BL LACERTAE OBJECTS: GENERAL — GALAXIES: ACTIVE — QUASARS: GENERAL**

1. INTRODUCTION

Blazars are core-dominated, *flat-radio-spectrum* radio–loud AGN. Their extreme variability and luminosity are successfully interpreted in terms of non-thermal radiation from relativistic jets (Blandford & Rees, 1978), and this interpretation constitutes the basis for the unified scheme of radio-loud AGN. The basic paradigm based on the existence of jets and accretion disk has been very successful in bringing coherence to the "zoo" of radio-loud AGN, linking radio galaxies to quasars and blazars through orientation angle (Antonucci 1993; Urry & Padovani 1995).

In blazars, because of relativistic beaming, jets greatly outshine the host galaxy, thus making them ideal and unique laboratories for exploring the deepest parts of jets/BH systems. The study of the physical properties of blazars is indeed one of the main avenues to investigate how jets form and grow, how the black hole powers them, and what is the connection between the observed jets and the –putative– accretion disk.

In the next sections we are going to summarize the current status of research in this field, which has been rapidly maturing, nurtured by (i) a new –"theoretical"– unified view of the blazar phenomenon based on some physical grounds, and (ii) the concurrent availability of large area deep surveys, in several wavelengths, completed in the last few years.

2. BACKGROUND ON BLAZARS

Blazars emit strongly at radio through γ-ray wavelengths. Their broad band Spectral Energy Distributions (SED) consist primarily of two components (see Fig. 1). Their correlated variability strongly supports the hypothesis that they may be produced by the same electrons (e.g., Ulrich et al. 1997; Fossati et al. 2004). The most widely accepted interpretation of blazars' SED is that the first component is due to synchrotron radiation and the second to inverse Compton scattering of low energy photons. The low-energy seed photons may be synchrotron photons (*synchrotron self-Compton*: Maraschi et al. 1992) or other external radiation fields such as broad emission lines (*external Compton*: Sikora, Begelman & Rees 1994; Ghisellini and Madau 1996).

At a heuristic level, what we observe is interpreted in the context of a model where relativistic electrons are accelerated at shocks taking place in the jets ("internal shocks") where the jet bulk kinetic

[1]Rice University, Houston, TX, U.S.A.

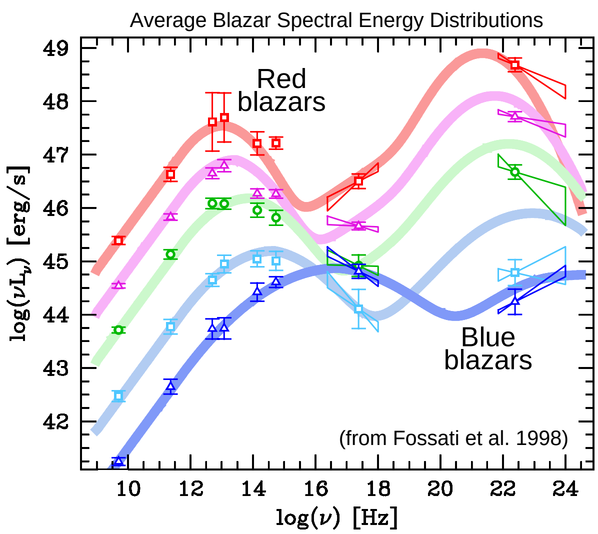

Fig. 1. The family of blazar spectra. The characteristic double-peaked SEDs showing a trend with luminosity.

energy (or Poynting flux) is partially converted into random particle motion (e.g., Spada et al. 2001).

2.1. *On blazar "sequences"*

Although the two-component SED seems to be a universal property of blazars, their characteristics vary significantly throughout the blazar population, implying a large range of underlying jet properties.

The frequency of the synchrotron peak (in νF_ν) has emerged as (one of) the most important observational distinction across the blazar family (e.g., Sambruna et al. 1996; Fossati et al. 1998). Blazars whose synchrotron peak lies in the mm-IR range are referred to as "red" blazars, and those whose peaks fall in the optical-UV, or even x-ray band, as "blue" blazars (see Fig. 1).

There are important differences in other observed properties across the full range of blazars phenomenology (see Urry & Padovani 1995 for a review). The most relevant are the following:

❏ *Color & Power* – Fossati et al. (1998) showed that the SEDs of blazars seem to change systematically with luminosity in the sense of a shift of the emission peaks towards higher frequencies with decreasing luminosity (see Fig. 1). The most powerful objects are "red", while "blue" SEDs are exclusively found in relatively weak sources. Observations of high redshift ($z > 4$) blazars (Fabian et al. 2001a, 2001b), and of low power BL Lac objects (Costamante et al. 2001) have extended the blazar sequence at both the high and low luminosity ends, resulting in agreement with the original trend.

❏ *Optical emission lines* – Blazars emission line properties range from sources having a featureless optical spectrum[2], called *BL Lacertæ objects*, to sources which have a typical quasar–like (broad) emission line spectrum, called *Flat Spectrum Radio Quasars* (FSRQ). This has been the most fundamental observational distinction among blazars for two decades, and it has been set aside only recently. It is of paramount importance to stress that spectroscopic surveys have shown that the distinction in line luminosity between FSRQ and BL Lacs is one of degree rather than a fundamental bimodality (Scarpa & Falomo 1997, but see Landt et al. 2004). Current observations, however, also show a trend where "red" blazars systematically have stronger emission lines than "blue" blazars (with these latter thus almost coinciding with BL Lacs).

❏ *Cosmological evolution* – There have never been studies considering blazars as a class. Studies on BL Lacs yield different results for "red" and "blue" objects, namely samples dominated by "blue" objects show negative evolution, whereas "red samples" have no, or marginally positive, evolution (Stickel et al. 1991; Morris et al. 1991; Wolter et al. 1994; Bade et al. 1998; Giommi et al. 1999; Rector et al. 2000; Caccianiga et al. 2002a). FSRQs seem to follow the same trend of other powerful quasars, i.e. strong positive evolution (e.g., Wall & Jackson 1997).

Several observational properties seem to be all tightly connected to each other, e.g. through a common correlation with the SED color, despite the fact that in principle they depend on largely, if not completely, a priori independent physical properties of the sources. They are summarized in Table 1.

2.2. *The physical blazar paradigm*

The first scenario for a unitary *and physical* understanding of the vast range of blazar properties was proposed by Fossati et al. and Ghisellini et al. (1998). The idea is that blazars indeed constitute a spectral sequence. *Source power is the unique fundamental parameter*, and it regulates the intensity of the diffuse radiation surrounding the jet, and in turn the SED "color" via a feedback mechanism, revolving on the cooling of the radiating particles (Ghisellini et al. 1998). According to the proposed paradigm (and in agreement with observations), "red" blazars would then have a stronger "thermal" emission component than "blue" blazars, and these differences should correlate with luminosity. This hypothesis in turn would imply the existence of a connection

[2]The "typical" spectroscopy criterion to separate between BL Lacs and FSRQ was line equivalent width $W_\lambda \lesssim 5$Å.

TABLE 1

BLAZAR OBSERVATIONAL PROPERTIES SHOWING A "CORRELATED BEHAVIOR", AND THEIR CORRESPONDING PUTATIVE DRIVING PHYSICAL PARAMETERS.

SED type	Maximum/typical energy of particles accelerated at the emission sites (shocks) in the jet.
SED Luminosity	Jet composition, and kinetic-to-internal energy conversion.
Jet Power	Extraction of energy from the BH.
Emission lines	"Thermal" properties of the system, namely of the accretion disk (e.g., rate).
Evolution	History of fueling/growth of the black hole in the host galaxy.

between jet and disk, that is another –fundamental– open question.

The jet/disk connection – The issue of the existence of a connection between the power channeled into the jet and the power going into the "thermal" component was first tackled by Rawlings & Saunders (1991), who found a good correlation between the two for a sample of radio-galaxies. This result has been confirmed with improved samples by Willott et al. (1999), and Xu, Livio & Baum (1999). Recent works modeling the SEDs of well observed bright objects suggest a substantial equality of the jet and accretion powers, which could hold for all blazars (e.g., Celotti et al. 1997; D'Elia et al. 2003; Maraschi & Tavecchio 2003; Tavecchio et al. 2004; Wang, Luo & Ho 2004). The available evidence seems to suggest that the main parameter governing the total power and the ratio between jet and accretion luminosity is the *accretion rate* (e.g., Maraschi & Tavecchio 2003; Wang, Luo & Ho 2004). High luminosity blazars (or more generically FSRQ) owe their properties to a near-critical (Eddington) accretion rate, which accounts at the same time for the presence of bright accretion disks and of powerful jets.

Cosmological evolution – In this framework, it may be possible to explain also the different cosmological evolution of BL Lacs and FSRQs. Cavaliere and collaborators (1999, 2002) and Böttcher and Dermer (2002) speculate that the blazar spectral sequence also traces an evolutionary sequence, where FSRQs would turn into BL Lac object, that would represent evolved sources depleted of gas, with faint nuclear emission and low power jets.

3. FUNDAMENTAL ISSUES

From the observational point of view, there is a strong suggestion that the "true dimensionality" of blazars' parameter space is reduced to just one or two key phenomenological properties. The recognition of a blazar spectral sequence appears indeed to be an important breakthrough in our understanding and it is therefore vital to check if the result holds when a wider range of parameter space is explored. Despite the nice convergence between observations and modeling, there is the distinct possibility that this apparent internal coherence is spurious, induced by observational biases. The reality of the sequence is indeed a very controversial issue.

We want to test the luminosity-based blazar paradigm, observationally. As it is currently formulated, this unifying framework is eminently testable by virtue of the peculiarity of its predictions, deriving for instance by the connection between "spectral type" and luminosity. Several observational findings could falsify it (see §5.5).

On a more "constructive" side, the viability of the sequence hypothesis must be tested by comparing its predictions for survey samples with data for a broad range of observations (e.g., Fossati et al. 1997). This has not been done beyond very embryonic attempts (e.g., Fossati 2001), in large part because of the lack of large and wide-ranging samples.

4. JET CENSUS

The demographics of blue and red jets is indeed poorly known. The interpretation of SED color distribution depends on the complicated sensitivity of diverse surveys to a range of spectral types.

Historical perspective: a patchwork – Until a few years ago, only a few small samples, adding up to a few 100s blazars, were available[3]. These were all "specialized" samples, either because of selection effects, or for specific design. Historically, the selection has been done either for or against BL Lacs, and often in an inconsistent way. Samples of FSRQs and BL Lac objects were developed and treated separately, thus hampering our ability of addressing the most interesting issues concerning the physical properties of

[3]The most renown are: EMSS (x-ray, Morris et al. 1991; Rector et al. 2000), Slew (x-ray, Perlman et al. 1996), 1 Jy (radio, Stickel et al. 1991; Rector & Stocke 2001) for BL Lacs, and the 2 Jy sample (radio, Padovani 1992) for FSRQs.

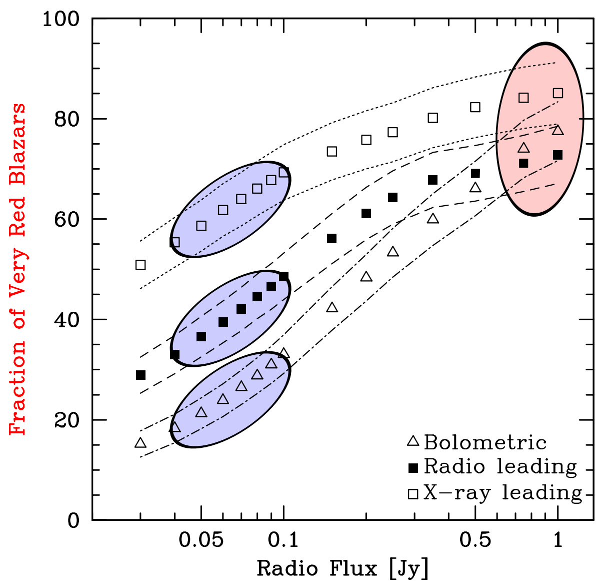

Fig. 2. Example of the variation of the fraction of "very red" blazars predicted by three different unifying models as a function of radio flux limit, with an additional cut at m_V <19. Uncertainties are scaled to a sample of 200 objects. The scenarios represented here are the same discussed by Fossati et al. (1997), and span a broad range of input hypotheses about the intrinsic ratio between red and blue blazars: namely, the *radio-leading* and *x-ray leading* models posit a ratio of 10:1 in favor of "red" and "blue" sources, respectively. The *bolometric* models instead have a color–power relationship. The ellipses highlight the fact that with deeper samples it will become possible to discriminate the scenarios. On the other hand these three scenarios are not distinguishable with a radio survey with a high limit.

jets and their surroundings (e.g., accretion disk). Because of the characteristics and range of blazar SEDs, *shallow* radio or x-ray surveys sample only the tip of the population, and only in selected "corners" of the parameter space, thus yielding almost exclusively one of the two extreme types: the "red" objects in radio samples and the "blue" in x-ray samples (Ledden & O'Dell 1985; Stocke et al. 1985; Padovani & Giommi 1995).

The "modern" era – With the advent of *ROSAT* and larger, more sensitive, surveys, it has become clear that the SED color distribution is not bimodal, and that there is a sizeable population of blazars with intermediate properties, both from the point of view of the SED color, and of the properties of their optical spectra (e.g., Laurent-Muehleisen et al. 1999; Perlman et al. 1998). In fact, quantitative simulations show that intrinsically continuous distributions can be made to look bimodal (i.e., "red" vs. "blue") simply because of selection effects (Fossati et al. 1997; Laurent-Muehleisen et al. 1999; Fossati 2001).

Despite this progress, comparisons of observations with a set of possible unification scenarios (Fossati et al. 1997 and 2001, see also Fig. 2), allowing the intrinsic ratio between "red" and "blue" blazars to vary, show that the ratio of "red" to "blue" blazar types could not be constrained to better than *10:1 either way*—an uncertainty of two orders of magnitude!

This means that we do not know which kind of BH/jets engines ("red" or "blue") Nature preferentially makes. We also do not know whether they evolve differently and/or if "red" blazars dominate at high redshift and evolve into "blue" blazars at low redshift, and what is the relationship between the "non-thermal" and "thermal" power/components. This emphasizes the need for an accurate quantitative jet census.

4.1. *Checklist for improved samples*

We need to extend the coverage of the observational parameter space, and be more inclusive with respect to all facets of the blazar phenomenology. These are the main directions for improvement:

- ❏ It is crucial that any sample includes in an unprejudiced way "red" and "blue" blazars.
- ❏ BL Lac and FSRQ must not be distinguished a priori. This is particularly important towards the goal of exploring the jet/disk connection.
- ❏ Be "weak-blazar aware". We might be missing weak BL Lac nuclei in bright host galaxies (Browne & Marchã 1993; Marchã et al. 1996; Anton & Browne 2005).
- ❏ Go deeper in flux limit and cover a large area, because blazars are rare objects. The differences between the predictions of different models that are subtle for the current –shallow– samples will be "exposed" by deeper samples (e.g., Fig. 2).

5. THE *FIRST FLAT SPECTRUM SAMPLE*

With Sally Laurent-Muehleisen and Meg Urry, we have been working on the first and only sample designed according to these guidelines.

The *FIRST Flat Spectrum Sample* (FFSS) is a deep, radio-selected, *blazar sample* based on the FIRST radio survey (White et al. 1997). The FIRST survey is particularly suitable as a primary database because it has large area ($\simeq$10,000 deg^2), and yields positions accurate to $\simeq 1''$, enabling the unambiguous identification of optical and x-ray counterparts. It is also worth noting that the FIRST sky coverage coincides with that of the Sloan Digital Sky Survey.

TABLE 2

COMPARISON OF THE COMPOSITION OF THE FFSS WITH OTHER "MAJOR" SAMPLES

Sample	#	ID %	$F_{R,lim}$ mJy	Opt.[a]	$F_{X,lim}$[b]	Red[c] %	*Int.*[c] %	Blue[c] %	FSRQ #	BL Lac #	Gal. #
FFSS	580	93	35	19.0	n/a	30	36	34	376	88	75
CLASS	302	70	30	17.5	n/a	18	21	61	114	42	63
XB-REX	239	95	5	20.5	$4 \cdot 10^{-13}$	6[d]	16[d]	78[d]	95	55	66
DXRBS	165	95	50/100	24.0	$5 \cdot 10^{-14}$	76	15	9	134	31	8

[a] Magnitude limits are for different bands: O for FFSS, B for REX, R for CLASS.

[b] *ROSAT* flux in the 0.5–2 keV band.

[c] "Red" are objects with $\alpha_{\rm RO} \geq 0.55$; "Blue" are those with $\alpha_{\rm RO} \leq 0.45$. For sources for which we have the x-ray information, that enables a more precise determination of the SED color (e.g., Fossati 1998), the distribution of colors and of $\alpha_{\rm RO}$ are consistent, and so the fractions reported here are probably reliable.

[d] Multiwavelength data published only for the 55 BL Lac subsample.

5.1. *Selection and Status*

We have $\simeq$580 candidates brighter than $F_{\rm 20cm}$= 35 mJy and B=19.0 mag, and with radio spectral index between 20cm (FIRST) and 6cm (GB6, Condon et al. 1994) flatter than 0.5 ($\nu^{-\alpha}$). Unlike typical quasar searches, *candidates were not excluded based on their optical color or morphology.*

❏ Optical: To date we have obtained optical spectra for more than 200 objects (Laurent-Muehleisen et al. in preparation). Optical identification is $\approx$93% complete. As expected, most objects are blazars. We have complete information on the optical properties, including emission line equivalent widths and fluxes, and strength of the Calcium break, which provides a sensible measure of the relative contribution of the non–thermal and thermal components (e.g., Landt et al. 2002, 2004).

❏ SDSS: As of DR4[4] it includes 459 FFSS (264 with spectroscopy, 67 new redshifts). At the current rate, we expect SDSS spectroscopic data for about 400 objects, with possibly about 100 new redshifts, and homogeneous 5-band photometry for *all* the FFSS.

❏ InfraRed: The 2MASS yields 328 matches (60%), 305 with detections in all three JHK bands.

❏ X–ray: The *ROSAT* All Sky Survey (RASS) (Voges et al. 1999) and the WGACAT (White, Giommi & Angelini 1994) yield 279 reliable identifications. We observed 31 targets with *Chandra*, and another 15 with *XMM*. Overall, including the archive *Chandra* or *XMM*, data are available for about 75 FFSS objects. The total number of x-ray observed sources is now $\gtrsim$ 340.

[4] http://www.sdss.org/dr4; Abazajian et al. 2005; $\simeq$87% ($\simeq$66%) of photometric (spectroscopic) survey.

5.2. *The FFSS is a "blazar sample"*

As anticipated, the unique feature of the FFSS is that it is the first *blazar sample.* In Table 2 we report a few numbers supporting this statement. The FFSS sources seem to span across the range of blazar phenomenology in a remarkable way (see also Fig. 3):

❏ In its present status (93% identified) the FFSS comprises $\simeq$90 BL Lacs, $\simeq$370 FSRQs, $\simeq$75 "galaxies" (mostly radio-galaxies).

❏ The coverage of SED "colors" is also very good, as "measured" by means of $\alpha_{\rm RO}$ (e.g., Fossati et al. 1998, for $\alpha_{\rm RO}$ as proxy for SED color).

This sample is ideal for studying the transition between FSRQs and BL Lacs, and the sizeable galaxy subsample will allow objective investigation of the existence and properties of weak AGN, whose recognition has been often overlooked. *With the FIRST Flat Spectrum Sample the jet physics is accessible across the full range of jet power.*

5.3. *The FFSS vs. other blazar samples*

We would like to compare the FFSS with three projects being developed to address the questions about the blazar unification (see also Table 2, and Fig. 4).

CLASS – (Myers et al. 2003; Marchã et al. 2001; Caccianiga et al. 2002b, 2004) The *Cosmic Lens All Sky Survey* blazar sample is similar to the FFSS, for they have (i) comparable radio flux limits, (ii) selection on radio spectrum flatness, and (iii) it does not require an x-ray detection. The identification is still lagging, and the moderately bright optical flux limit, imposed for identification purposes, introduces a marked shift towards blue SEDs.

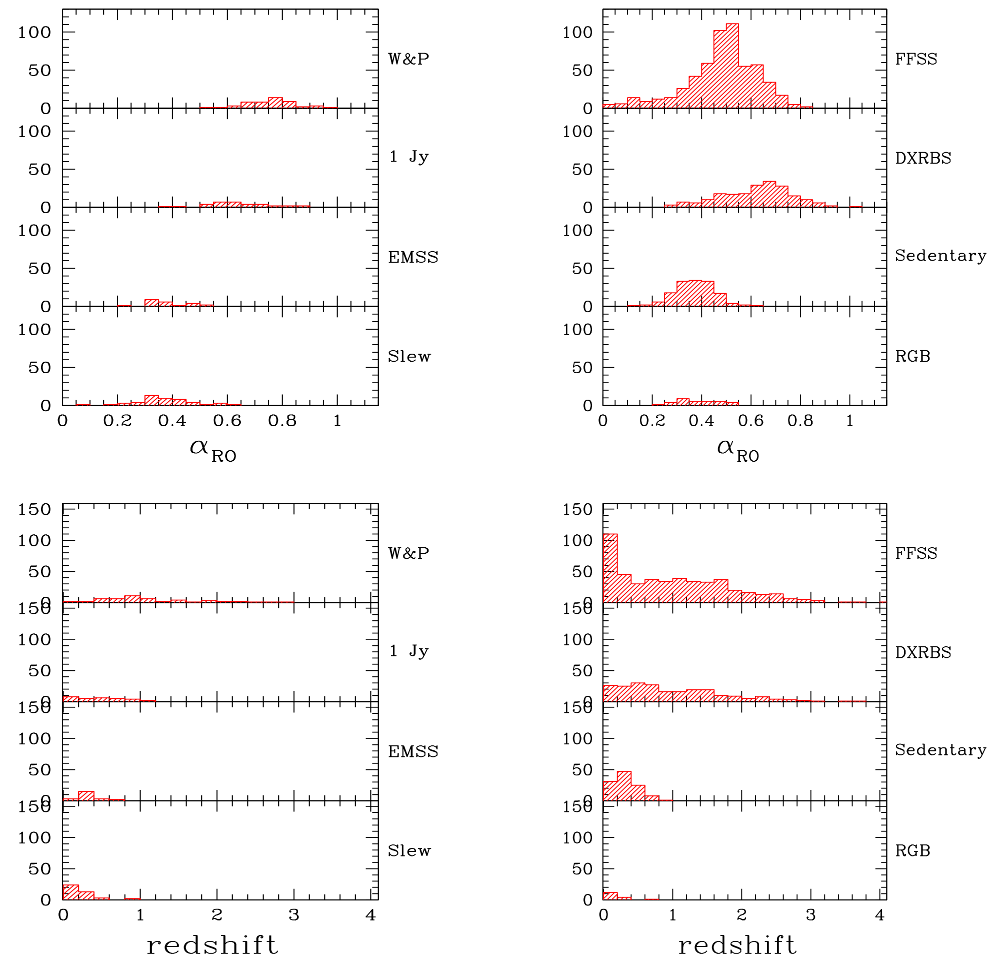

Fig. 3. SED color (left panels, using α_{RO} as proxy) and redshift (right panels) distributions for some "classical" and recent samples. Histograms are not normalized to give an immediate impression of the large difference in sampling afforded by each sample.

XB-REX – (Caccianiga et al. 1999, 2002b). The X-ray Bright portion of the *Radio Emitting X-ray* source sample results from the correlation of the radio NVSS survey (Condon et al. 1998) with serendipitous sources in the *ROSAT* pointed observations. The main positive feature is the very low radio flux limit. Unfortunately, the high x-ray limit favors a bias towards blue SED colors, canceling this benefit. On the negative side there are the limited areal coverage, yielding a lower number of objects, and most importantly the selection in both radio and x-ray.

DXRBS – (Perlman et al. 1998; Landt et al. 2001; Padovani et al. 2003). The *Deep X-ray Radio Blazar Survey* is the project at the most advanced stage. The source selection is by radio-flatness and cross-correlation of radio and x-ray catalogs: GB6, PMN (Griffith & Wright 1993) and NORTH20CM (White & Becker 1992) for the radio, WGACAT for the x-rays. It covers both the northern and southern skies, but with different flux limits. While this has the advantage of expanding the areal coverage, it introduces a further degree of inhomogeneity. A unique feature of the DXRBS is that optical identification has been pushed down to magnitude 24.

The main differences between FFSS and DXRBS (and REX) are the following: (i) The DXRBS (and REX) is *defined* by the cross–correlation of a radio *and* an x-ray catalog, thus imposing a priori the requisite for sources to be x-ray detected. From the summary given above on the detection rate of FFSSs by WGACAT, we see that only about 50% of the FFSS would have been "discovered" by this approach. (ii) The FFSS dataset has a much more "uniform" selection, because the DXRBS (and

REX) is affected by the x-ray flux dependent sky coverage of the survey compiled from the public archive of *ROSAT* pointed observations (WGACAT for DXRBS). DXRBS also has different radio flux limits in its north and south sections. (iii) The breakdown by color and type (Table 2) shows that the DXRBS (and REX) does not provide a well sampled picture of the blazar variety. (iv) The complete DXRBS (REX) sample comprises only 165 (239) blazars overall, less than a third of the FFSS size.

We argue that the FFSS is superior to all of these alternatives. The CLASS, REX and DXRBS samples are however good samples, and their complementarity with respect to the FFSS may play an important role in constraining the unification models.

5.4. *Future (observational) plans*

Radio – Substantial work is going to be devoted to the detailed analysis of the radio properties, e.g. comparison of the core and extended emission. The latter is thought to be a good tracer of the "isotropic" properties of the source, thus providing a good calibrator for the intrinsic power of the jet. Where the FIRST morphology is complex it may be necessary to obtain additional higher resolution observations at 5 GHz to better match the components.
Optical – The completion of the optical identification will be facilitated by the aforementioned wealth of data that is becoming available from the SDSS. The accurate measure of the "thermal" properties of these transitional objects is particularly important for the study of the jet/disk connection, and so we are taking great care in determining line EWs and Ca-break strength. It will likely be necessary to perform extra spectroscopy follow up for the sources at the borderline between a blazar/galaxy, and between BL Lac/FSRQ.
Millimeter/FIR – Data in this band can be of paramount importance in order to be able to estimate accurately the position of the peak of the synchrotron component (one of the prime parameters that we want to study). Fortunately, two major facilities are going to become available in the near future, and will have an impact on the FFSS project. The first is the Large Millimeter Telescope (LMT), a Mexican–USA effort, a 50-m single dish telescope that will have sub-mJy sensitivity at $\lambda = 1-3\,$mm in few-minute exposures (with BOLOCAM). First light is expected at the end of 2007 (see Hughes, this Proceedings). The second is ASTRO-F (Pearson et al. 2004), a Japanese-European IR space-telescope that will perform an *all sky* survey in the mid- to far-IR ($9-200\mu$m), at least a factor of 100 deeper than the one performed by IRAS (1000 at mid-IR). It is due for launch in early 2006. We expect that about 2/3 of the FFSS sources will be detected.
X–ray – We are proceeding with an incremental strategy, identifying successive "milestone" samples that preserve as much as possible the general properties of the FFSS. We have recently completed the x-ray characterization of a 160-object complete subsample[5] obtained by imposing (i) a cutoff in redshift at $z \leq 1$, (ii) a higher flux limit, 100 mJy. The next milestone will be a subsample of 254 sources, derived by lowering the radio flux limit (x-ray data are missing for 35 objects, a manageable number). It is worth noting that we may gather a sample of serendipitously detected large scale jets. In this respect, the FFSS sample provides indeed an excellent opportunity for studying the occurrence of this phenomenon without the a priori requirement for a radio or optical jet (as is the case with the other jet observations currently being made with *Chandra*; e.g., Sambruna et al. 2004). This provides the only possibility to find x-ray-bright but radio- or optical-weak jets.

5.4.1. *Extending multi-λ coverage to higher energy*

Two recent/future missions are worth mentioning because they will contribute to the coverage of the FFSS sources at higher energies, important because it will enable us to have a full picture of the energetics of the jet emission.
Swift – (Gehrels et al. 2004) It is currently operational. Over the course of its planned lifetime it will perform the most sensitive all-sky hard x-ray survey ever made, and the first since HEAO1 A-4 (Levine et al. 1984). This dataset will constitute a great addition to our lower energy x-ray data.
GLAST – (Gehrels & Michelson 1999) The Gamma-ray Large Area Space Telescope will be launched in 2007. Its predecessor, EGRET on board CGRO, revolutionized our knowledge of radio-loud AGNs (Hartman et al. 1999), and GLAST's capabilities bear the promise of further surprising discoveries. The planned all-sky survey will be a factor of 50 more sensitive than EGRET's typical observation. A pilot study on a master–list of about 500 known blazars (a merging of all main samples) shows that GLAST may detect all of them during the survey. We expect that all FFSS sources will be detected in the all-sky survey.

5.5. *"Lethal" observations*

As anticipated, because it is very structured, the model proposed by Fossati, Ghisellini et al. (1998)

[5]This sample is already as large as the complete DXRBS.

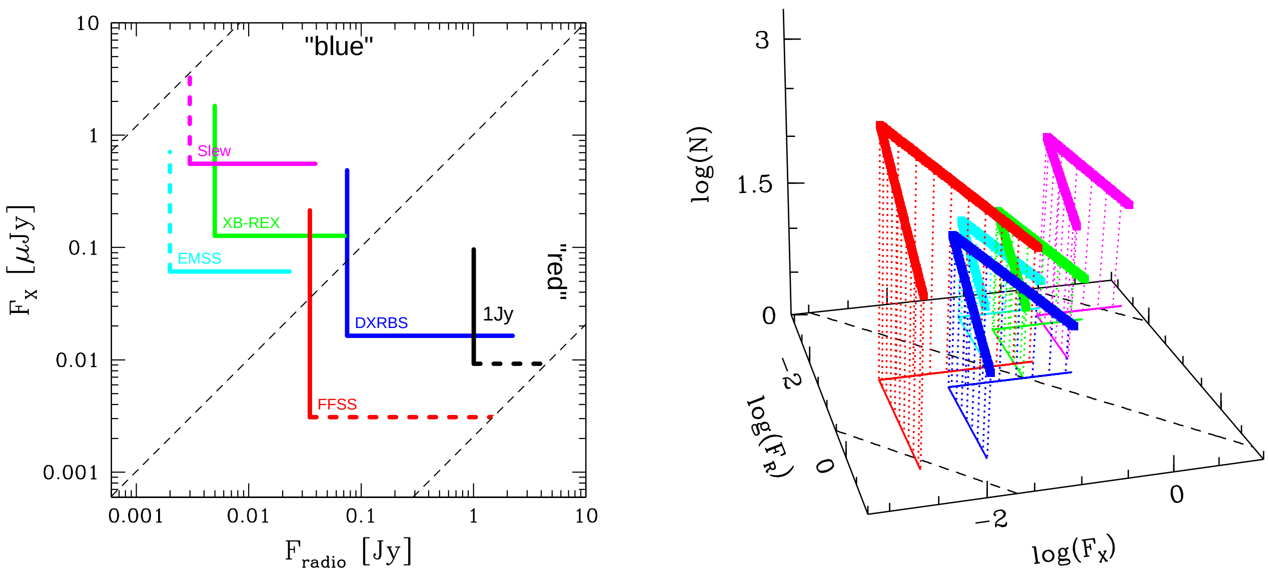

Fig. 4. X-ray and radio flux plane diagrams showing the flux limits (in some cases approximate) for a set of "classic" and "modern" BL Lac/FSRQ samples. The right panel tries to convey the effect of the steep count distribution and of the area coverage.

offers several "points of attack", observations that would falsify it. The two most evident are the following: (i) For what concerns the color/power relationship, the blazar sequence "rests" on the observational lack of low-power "red" sources. (ii) On the jet-power/disk-power facet, the most sought after targets are low-power blue blazars with strong emission lines (blue FSRQ).

This type of low-power sources may have simply escaped detection, instead of being intrinsically absent. Different groups have searched for these peculiar sources (e.g., Sambruna et al. 2000; Padovani et al. 2003; Caccianiga & Marchã 2004). Padovani and collaborators find a set of candidate blue FSRQs in their DXRBS sample[6]. However, while these results constitute a serious challenge, given the large uncertainties in the source classification, and their small number, we deem it fair to say that to date no convincing falsifying evidence has been found for the unifying scenario that we proposed.

The search for this kind of "lethal" sources will be a by-product of the work on the FFSS sample. Given the inherent difficulty of finding and correctly recognizing them, accompanied by the higher-than-average potential impact, extra effort will be devoted to their analysis, and additional observations will be proposed as necessary, especially in the millimeter and x-ray bands to confirm the SED shape.

6. SUMMARY

The intrinsic demographics of blazar jets are poorly understood, and yet that is the essential first step toward understanding how Nature produces and powers jets. We are addressing this problem by developing a new large sample (600) of blazars, the *FIRST Flat Spectrum Sample* (FFSS) that will afford us an unprecedented, comprehensive view of the blazar phenomenology. We want to precisely define the radio to x-ray continuum of the FFSS sources, and their optical emission line properties, and ideally also estimate the mass of their black holes.

Despite the major advancement of the FFSS with respect to other samples of blazars, and the unprecedented tally of the jet census that will be available, selection biases not can be completely avoided. We are developing population synthesis models to test possible phenomenological and physical unification models, that will enable us to constrain the characteristics of the viable models for jet, black hole and disk formation and evolution.

This project is partially supported by grants SAO GO3-4147X and GO5-6115X (*Chandra*), NASA NNG05GJ10G and NNG05GK68G (XMM).

[6] Padovani et al. (2003) report that ≈ 20% of the FSRQ in the combined DXRBS and RGB samples fall inside the *"blue SED"* region of the α_{RO} *vs.* α_{OX} diagram.

REFERENCES

Abazajian, K. et al. 2005, AJ, 129, 1755
Antonucci, R. 1993, ARA&A, 31, 473
Antón, S. & Browne, I. W. A. 2005, MNRAS, 356, 225
Bade, N. et al. 1998, A&A, 334, 459
Blandford, R. D. and Rees, M. J., 1978, in Proc. of Pittsburgh Conference on BL Lac Objects, Pittsburgh (PA), 328.
Böttcher, M. & Dermer, C. D., 2002, ApJ, 564, 86
Browne, I. W. A. & Marchã, M. J. M. 1993, MNRAS, 261, 795
Caccianiga, A., Maccacaro, T., Wolter, A., Della Ceca, R. & Gioia, I. M. 1999, ApJ, 513, 51
Caccianiga, A., Maccacaro, T., Wolter, A., Della Ceca, R. & Gioia, I. M. 2002a, ApJ, 566, 181
Caccianiga, A., et al. 2002b, MNRAS, 329, 877
Caccianiga, A. & Marchã, 2004, MNRAS, 348, 937
Cavaliere, A. & Malquori, D. 1999, ApJ, 516, L9
Cavaliere, A. & D'Elia, V. 2002, ApJ, 571, 226
Celotti, A., Padovani, P., Ghisellini, G., 1997, MNRAS, 286, 415
Condon, J. J. et al. 1994, AJ, 107, 1892
Condon, J. J. et al. 1998, AJ, 115, 1693
Costamante, L. et al. 2001, A&A, 371, 512
D'Elia, V., Padovani, P., & Landt, H. 2003, MNRAS, 339, 1081
Fabian, A. C., et al. 2001a MNRAS, 323, 373
Fabian, A. C., Celotti, A., Iwasawa, K. & Ghisellini, G. 2001b, MNRAS, 324, 368
Fossati, G., et al. 1997, MNRAS, 289, 136
Fossati, G., et al. 1998, MNRAS, 299, 433
Fossati, G., 2001, in ASP Conf. Series, 227, Blazars Demographics and Physics, eds. P. Padovani & C. M. Urry (San Francisco: ASP), 218
Fossati, G., Buckley, J., Edelson, R. A., Horns, D., & Jordan, M. 2004, New Astronomy Reviews, 48, 419
Gehrels, N. & Michelson, P., 1999, Astropart. Phys., 11, 277
Gehrels, N., et al. 2004, ApJ, 611, 1005
Ghisellini, G. & Madau, P., 1996, MNRAS, 280, 77
Ghisellini, G., Celotti, A., Fossati, G., Maraschi, L. & Comastri, A. 1998, MNRAS, 301, 451
Griffith, M. R. & Wright, A. E., 1993, AJ, 105, 1666
Hartman, R., et al. 1999, ApJS, 123, 79
Landt, H., et al. 2001, MNRAS, 323, 757
Landt, H., Padovani, P. & Giommi, P. 2002, MNRAS, 336, 945
Landt, H., Padovani, P., Perlman, E. & Giommi, P. 2004, MNRAS, 351, 83
Laurent-Muehleisen, S. A., et al. 1999, ApJ, 525, 127
Ledden, J. E. & O'Dell, S. L. 1985, ApJ, 298, 630
Levine, A. M., et al. 1984, ApJS, 54, 581
Maraschi, L., Ghisellini, G., Celotti, A., 1992, ApJ, 397, L5
Maraschi, L. & Tavecchio, F., 2003, ApJ, 593, 667
Marchã, M. J. M., Browne, I. W. A., Impey, C. D. & Smith, P. S. 1996, MNRAS, 281, 425
Marchã, M. J. M., et al. 2001, MNRAS, 326, 1455
Morris, S. L., et al. 1991, ApJ, 380, 49,
Myers, S. T., et al. 2003, MNRAS, 341, 1
Padovani, P. 1992, MNRAS, 257, 404
Padovani, P. & Giommi, P., 1995, ApJ, 444, 567
Padovani, P., et al. 2003, ApJ, 588, 128
Pearson, C. P., et al. 2004, MNRAS, 347, 1113
Perlman, E., et al. 1996, ApJS, 104, 251
Perlman, E., et al. 1998, AJ, 115, 1253
Rawlings, S. & Saunders, R. 1991, Nature, 349, 138
Rector, T. A., et al. 2000, AJ, 120, 162
Rector, T. A. & Stocke, J. T, 2001, AJ, 122, 556
Sambruna, R., Maraschi, L. & Urry, C. M., 1996, ApJ, 463, 444
Sambruna, R., Chou, L. L. & Urry, C. M. 2000, ApJ, 533, 650
Sambruna, R., et al. 2004, ApJ, 608, 698
Scarpa, R. & Falomo, R., 1997, A&A, 325, 109
Sikora, M., Begelman, M. C. & Rees, M. J. 1994, ApJ, 421, 153
Spada, M., et al. 2001, ApJ, 325, 1559
Stickel, M., Padovani, P., Urry, C. M., Fried, J. W. & Kühr, H., 1991, ApJ, 374, 431
Stocke, J. T., et al. 1985, ApJ, 298, 619
Tavecchio, F., et al. 2004, ApJ, 614, 64
Ulrich, M.-H., Maraschi, L. & Urry, C. M., 1997, ARAA, 35, 445
Urry, C. M. & Padovani, P., 1995, PASP, 107, 803
Voges, W., et al. 1999, A&A, 349, 389
Wall, J. V. & Jackson, C. A., 1997, MNRAS, 290, L17
Wang, J.-M., Luo, B. & Ho, L. C. 2004, ApJ, 615, L9
White, R. L. & Becker, R. H. 1992, ApJS, 79, 331
White, N. E., Giommi, P. & Angelini, L. 1994, BAAS, 185, 4111
White, R. L., et al. 1997, ApJ, 475, 479
Willott, C. J., Rawlings, S., Blundell, K. & Lacy, M. 1999, MNRAS, 309, 1017
Wolter, A., et al. 1994, ApJ, 433, 29
Xu, C., Livio, M. & Baum, S. 1999, AJ, 118, 1169

G. Fossati: Physics & Astronomy Dept., Rice University, 6100 Main St., Houston, TX 77005 (gfossati@rice.edu).