# Simulated and real blazar surveys

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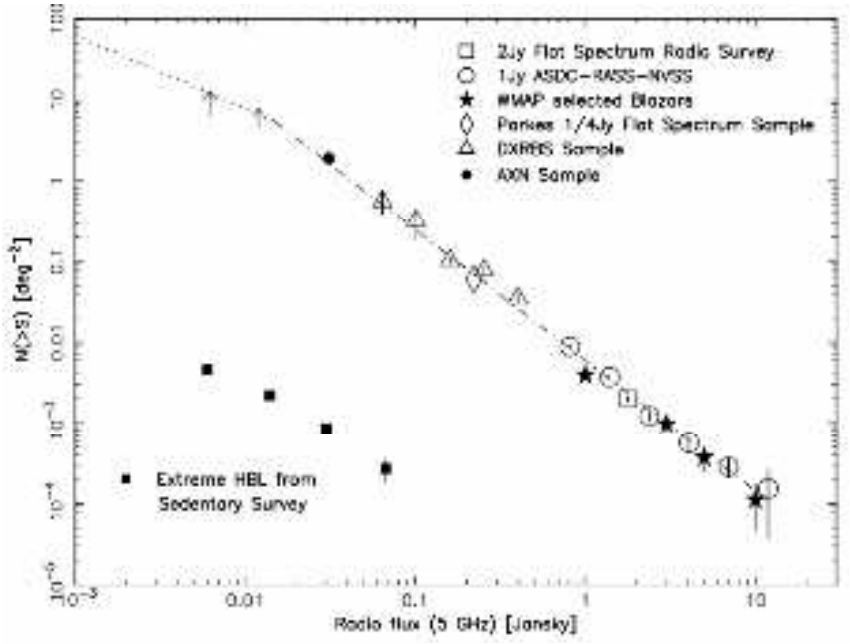
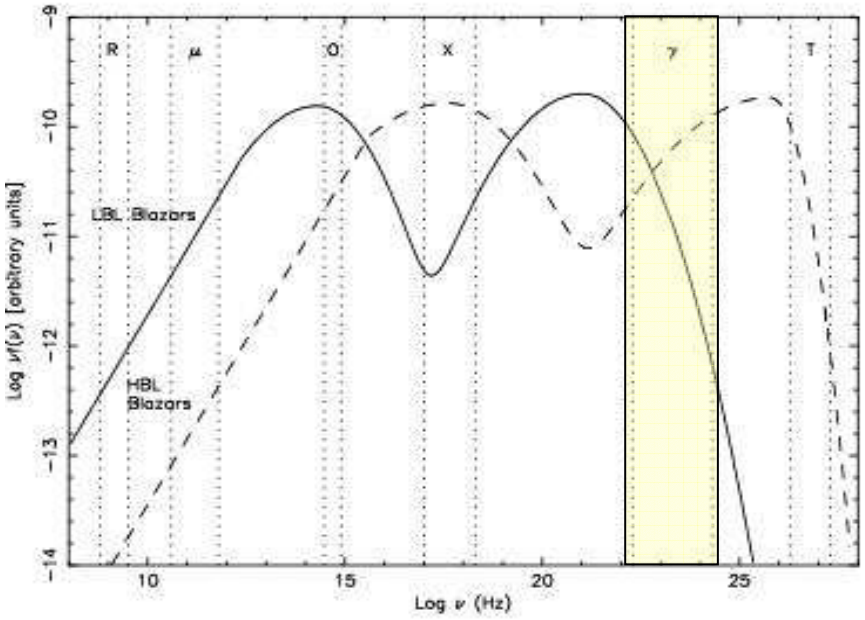
# Software for blazar survey simulations

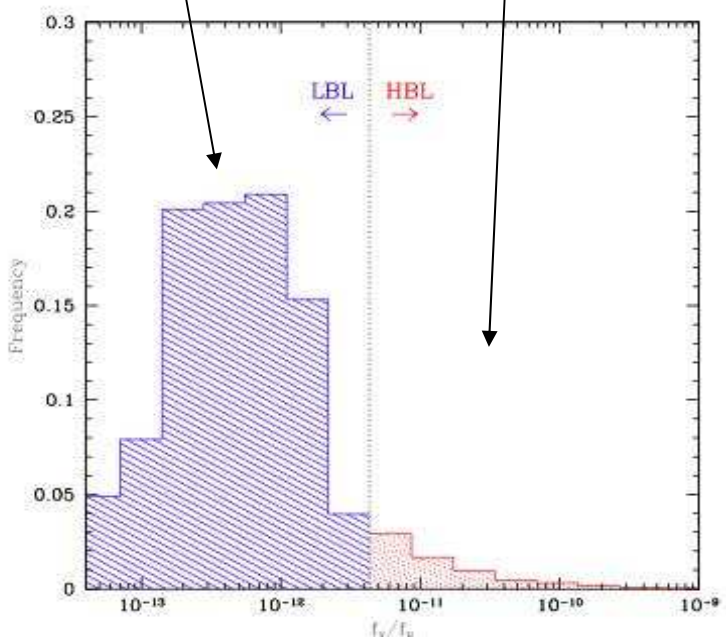
## Main properties and parameters

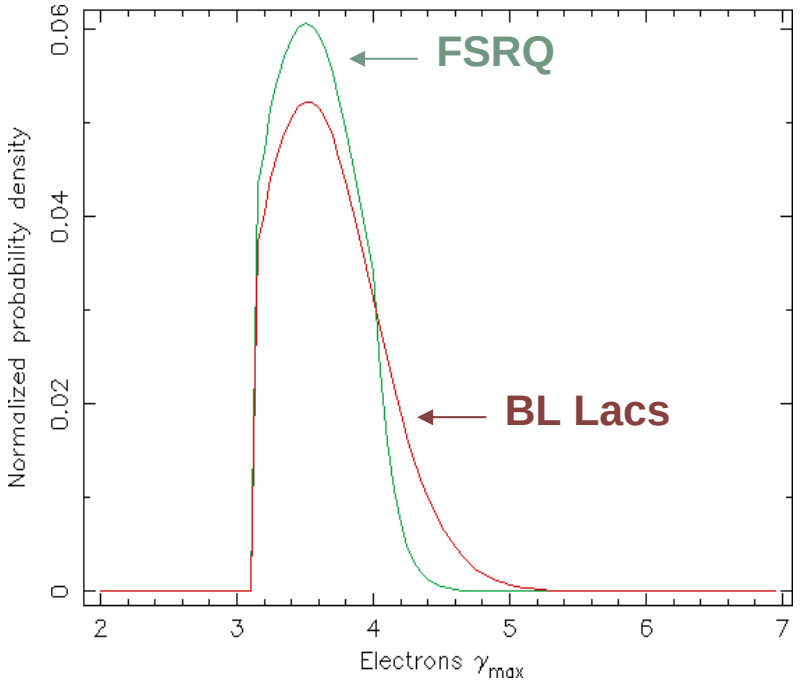
- Starts from a radio Luminosity function + Cosmological evolution
  - Monte Carlo simulation of redshift and radio luminosity
- Radio luminosity of each source is extrapolated to other energy bands (micro-wave, optical, X-ray, gamma-ray) based on SSC model + and randomized based on observed distributions.
- Gamma-ray flux simulated taking into account of duty cycle and GRB constraints (see Giommi et al. 2005 A&A in press, astro-ph/0508034)
- Sources are accepted above a set of flux limits (radio, opt , X-ray etc.) that can be a function of the position in the sky
- Results are written to a DBMS or to a FITS file

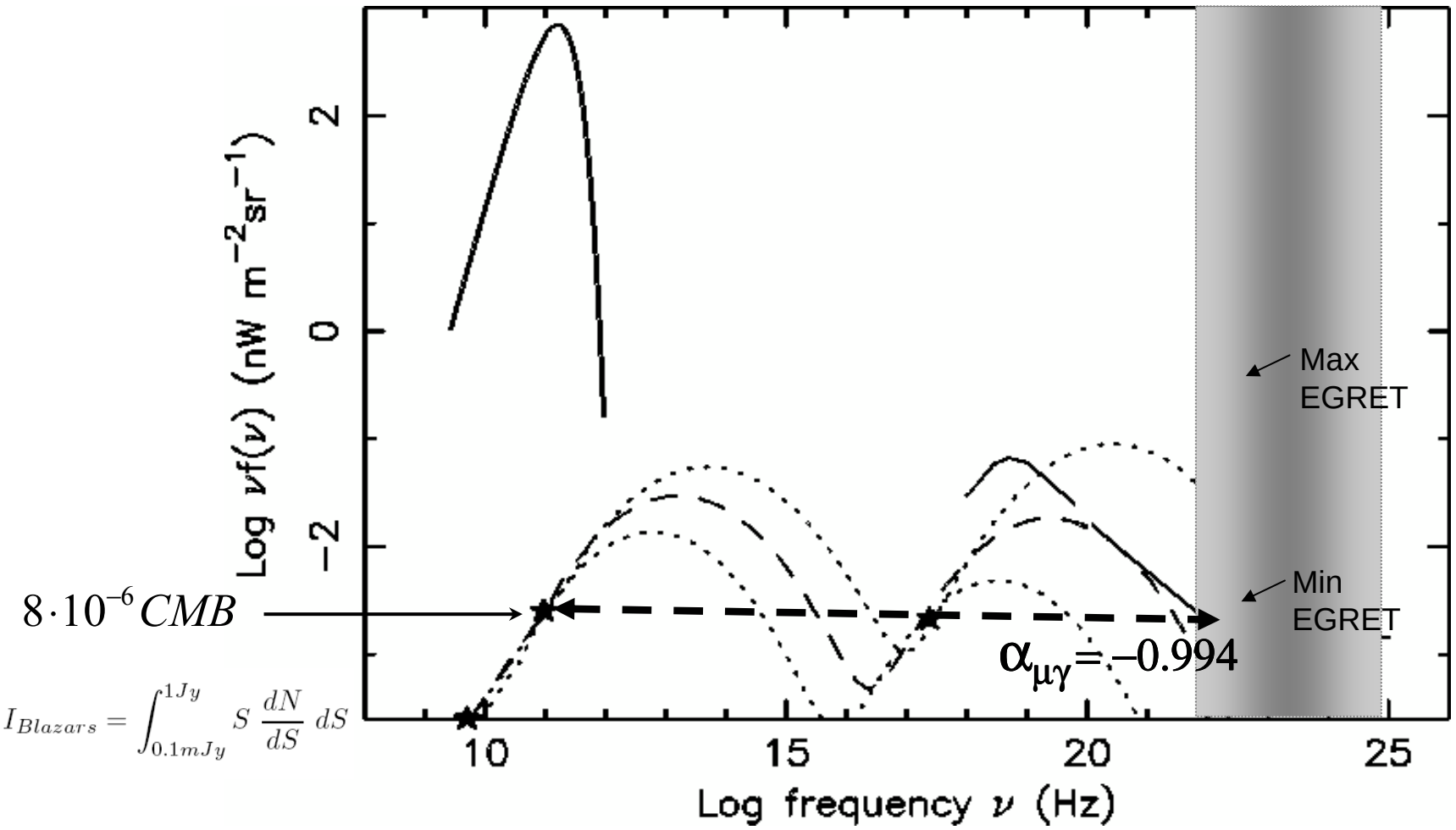


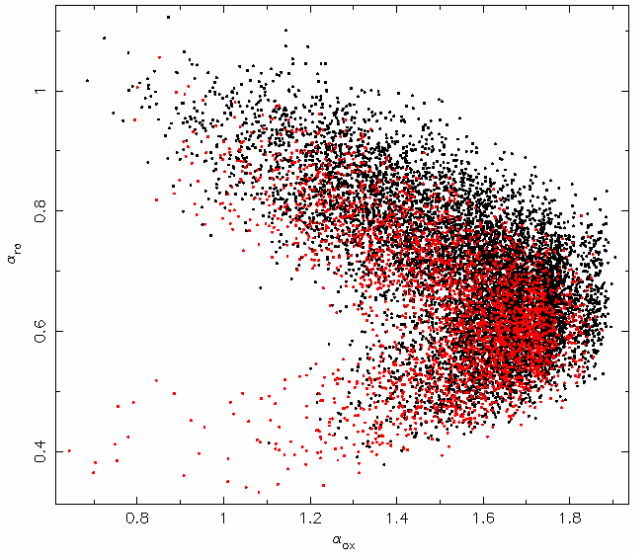

**FSRQ + BL Lacs** **BL Lacs only**

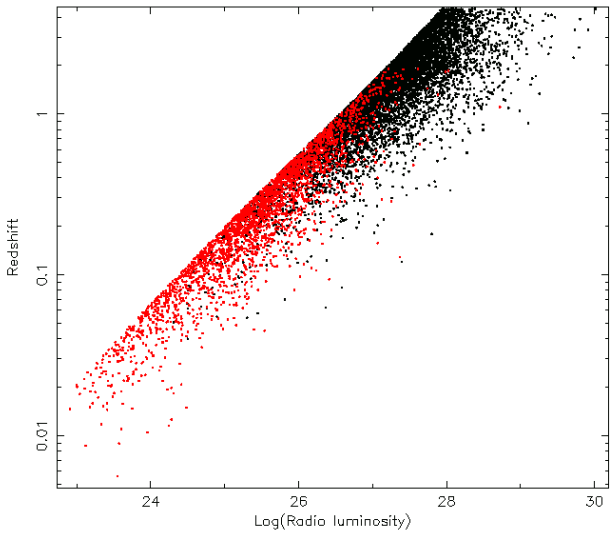


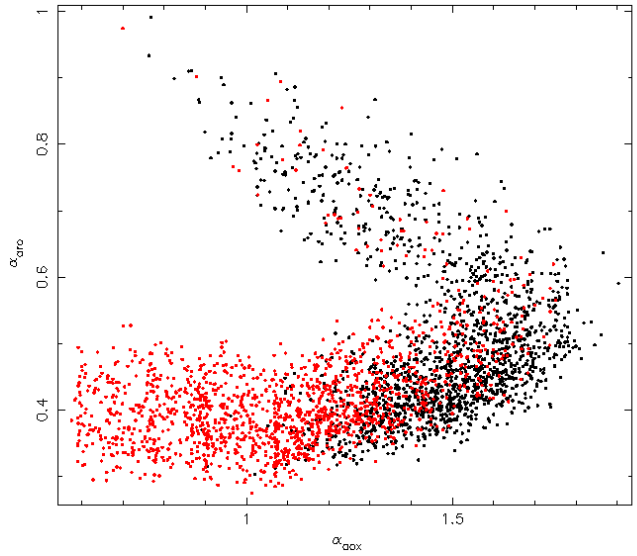

Log νf(ν) (nW m⁻²sr⁻¹)
2
0
−2
10
15
20
25
Log frequency ν (Hz)
Max EGRET
Min EGRET
$\alpha_{\mu\gamma}$=–0.994
$8 \cdot 10^{-6} CMB$
$I_{Blazars} = \int_{0.1mJy}^{1Jy} S \frac{dN}{dS} dS$

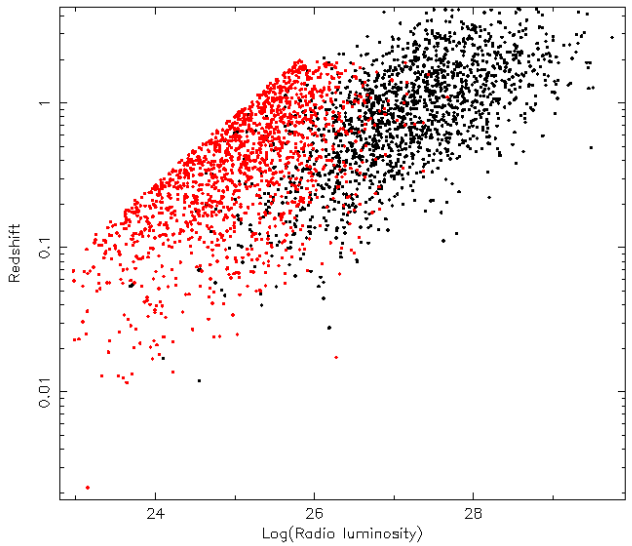
# Radio flux limited survey




# Radio+X-ray+optical flux limited survey



# Recent Improvements

- Inclusion of $\Omega_M$ - $\Omega_\Lambda$ cosmology
- Red-shift dependant cosmological evolution for the case of FSRQs.

# Still to do

- New radio luminosity function from DXRBS survey

(Padovani, Giommi, Landt and Perlman, To be submitted in March 2006)

- Luminosity-dependant (density) evolution

# Cosmological evolution

No evolution for BL Lacs

Pure luminosity evolution for FSRQs

$$L(z)=L(0)*e^{C*z/(1+z)}$$

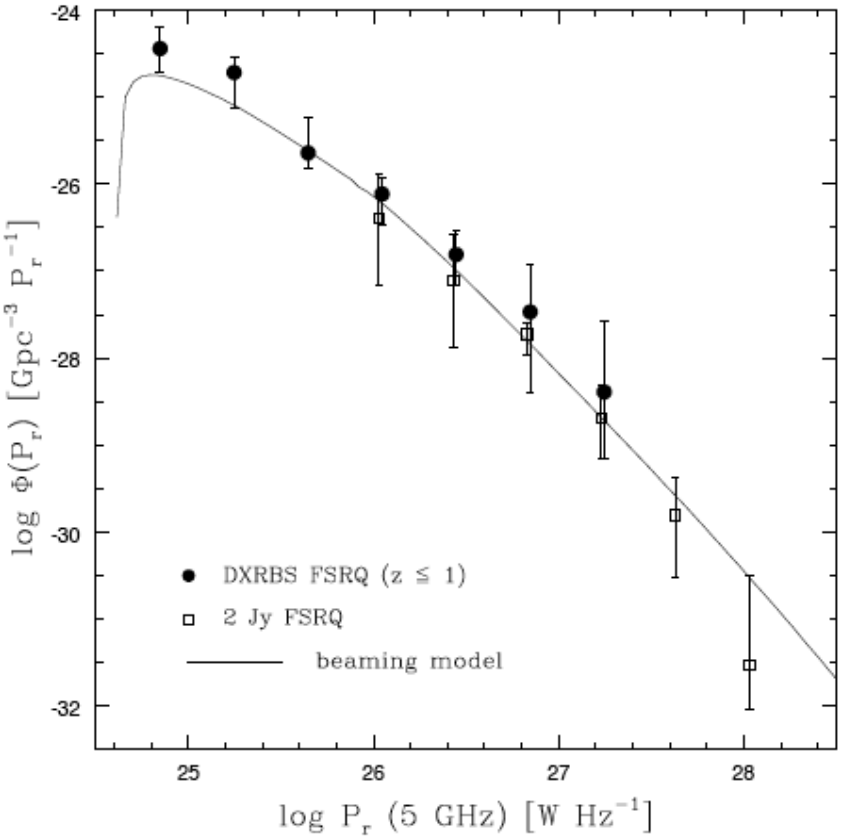
C=evolution parameter

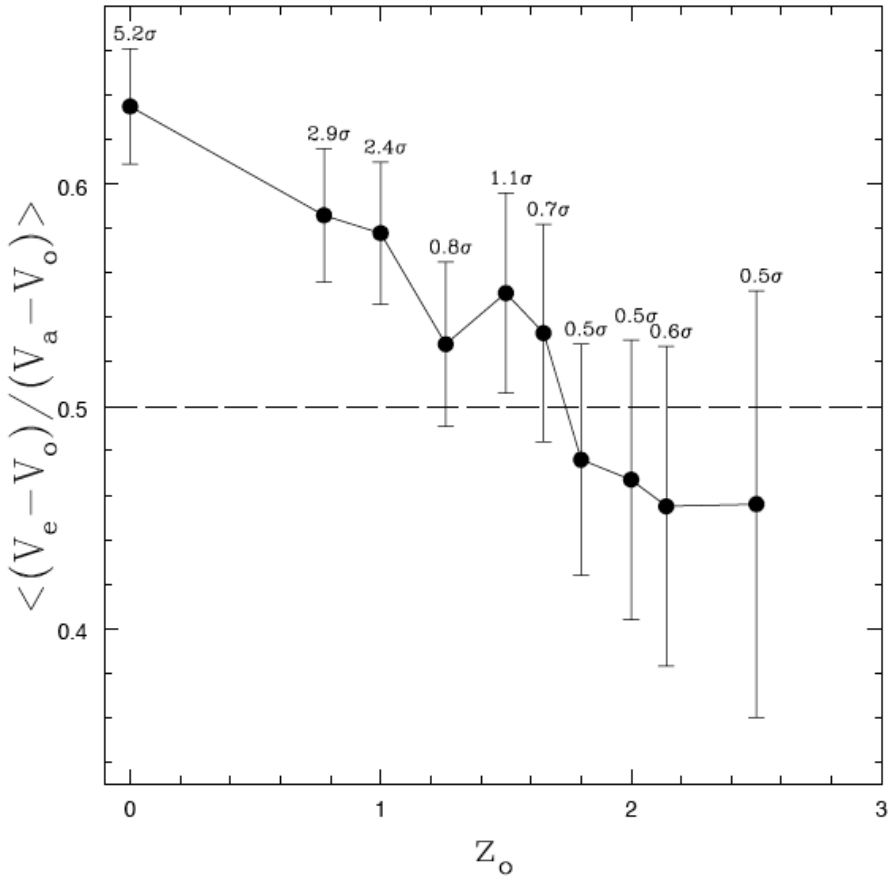
New result from DXRBs survey :

Evolution parameter (c) depends on redshift

(Padovani, Giommi, Landt & Perlman 2006, in preparation)

# New results from the DXRBS survey (Padovani et al. 2006, in prep)



# Checking the simulations against real blazar surveys :

## the Radio Optical X-ray ASDC Blazar sample: ROXA

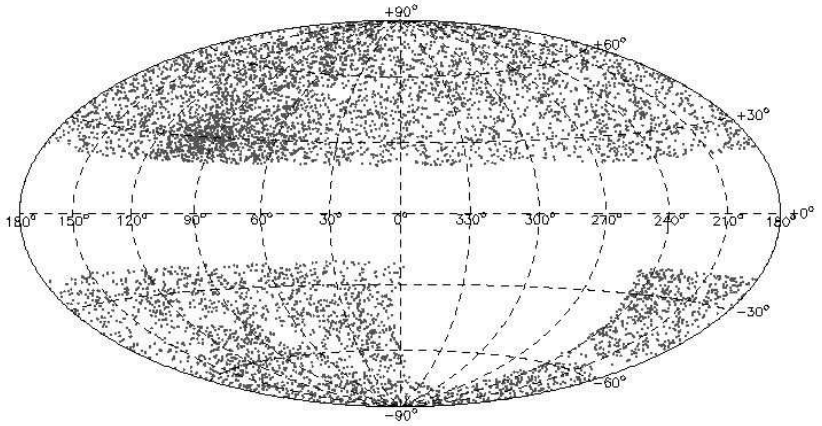
**Initial set of candidates:**

**Over 7600 Blazar candidates**

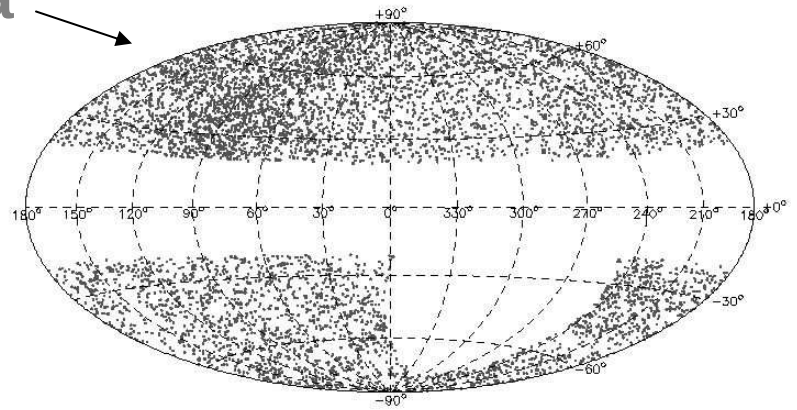
**Cross-correlation between NVSS (radio) and RASS (X-ray) surveys.**

**Optical magnitudes from GSC2**
**(assuming Jmag < 19.5 when no counterpart is found in GSC2)**

**Real data**




**Simulated data**

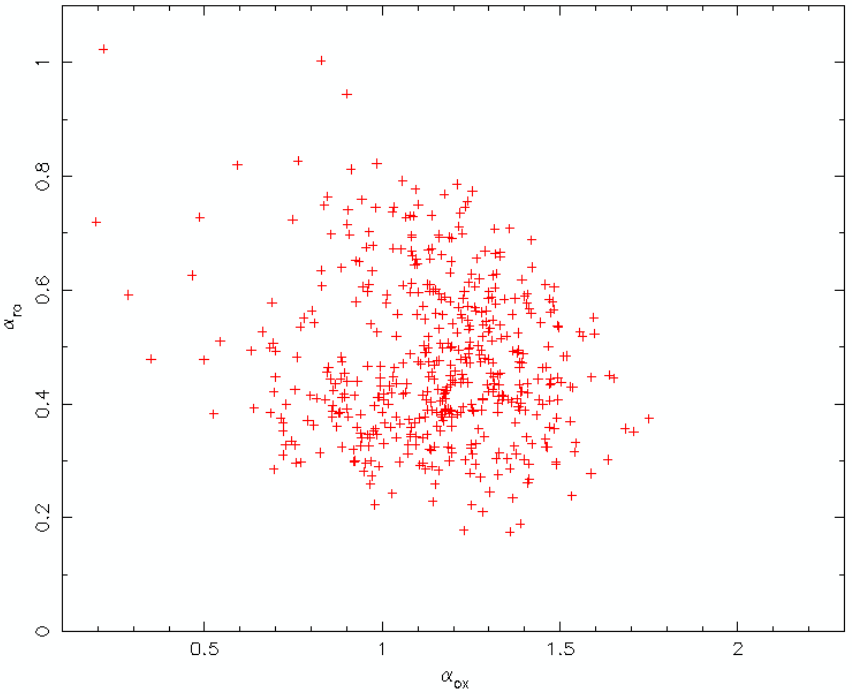



- $\Delta_{r\text{-}x} < 2.5\ \sigma_{r\text{-}x}$ **- and < 0.8 '**
- $\alpha_{ox}$ **and** $\alpha_{ro}$ **within Blazar area**

## The ROXA blazar sample: Identification through optical spectroscopy using SDSS-DR4 + 2dF spectra. Turriziani, Cavazzuti, Giommi et al, 2006 in prep.

Of the ~7600 candidates 2646 sources have optical counterparts in SDSS-DR4, 2dFGRS and 2dFQSO surveys. We have considerered the sub-sample of 819 objects for which optical spectra are available.

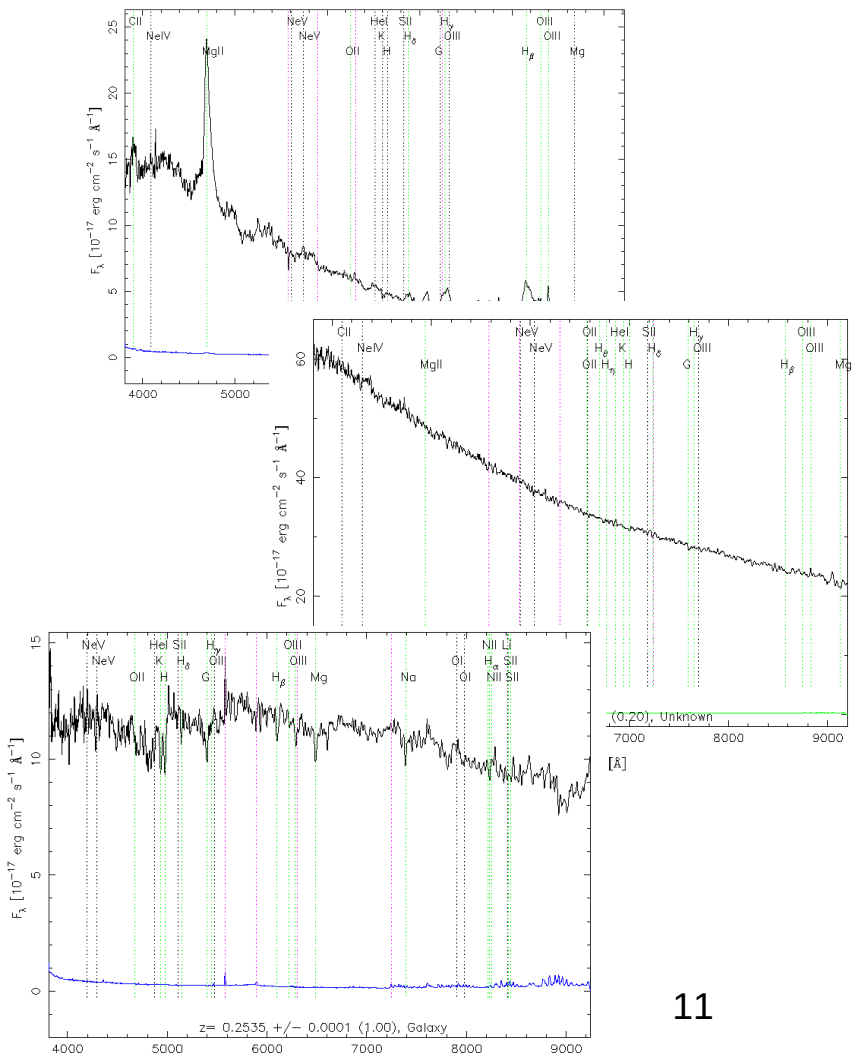
- analysis of the optical spectra
- evaluation of the Ca H&K for BL Lac / R. G. transition class:
  Ca H&K > 0.4 AND
  $5 \times 10^{43} < L_x < 10^{44}$ erg cm$^{-2}$ s$^{-1}$
- SED construction for all the objects to evaluate the radio spectral slope



# The ROXA blazar sample: Identification through optical spectroscopy using SDSS-DR4 + 2dF spectra. Turriziani, Cavazzuti, Giommi et al, 2006 in prep. http://www.asdc.asi.it/roxa

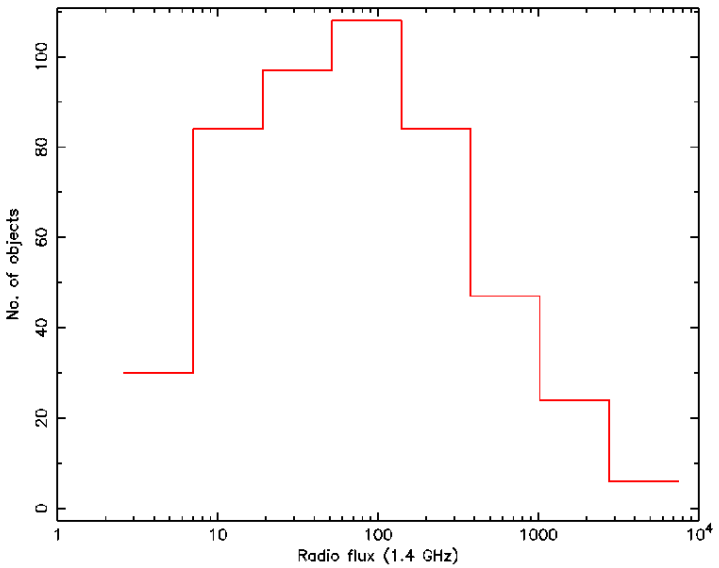
- SDSS-DR4 + 2dF spectra
- 245 BL LACS
- 248 FSRQs
- 118 QSOs (no radio spectral info)
- 107 SSRQs
- 34 Radio gal/BL Lac transition objects
- 24 Radio galaxies
- 43 Other

~ 60% confirmed blazars (BL Lacs or FSRQ) (286 ~ 58% new ID)
~ 14% are candidate blazars with QSO optical spectrum but with no radio spectral information.
~ 18% are SSR QSOs
~ 8% other AGN types

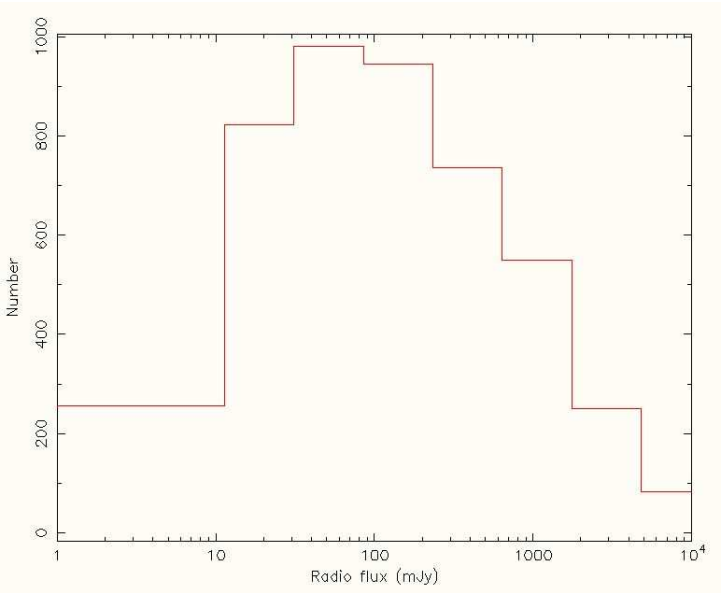


# Radio flux distributions

Data from RASS-NVSS-SLOAN
Blazar Sample

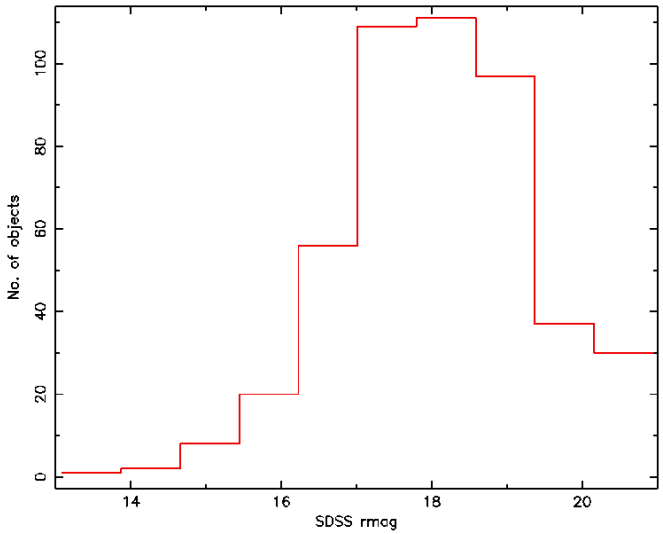



Simulation

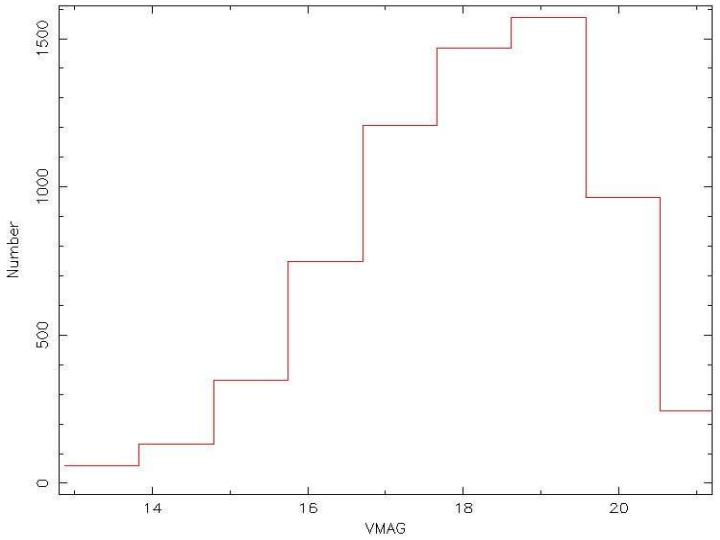


# Magnitude distributions

Data from RASS-NVSS-SLOAN
Blazar Sample

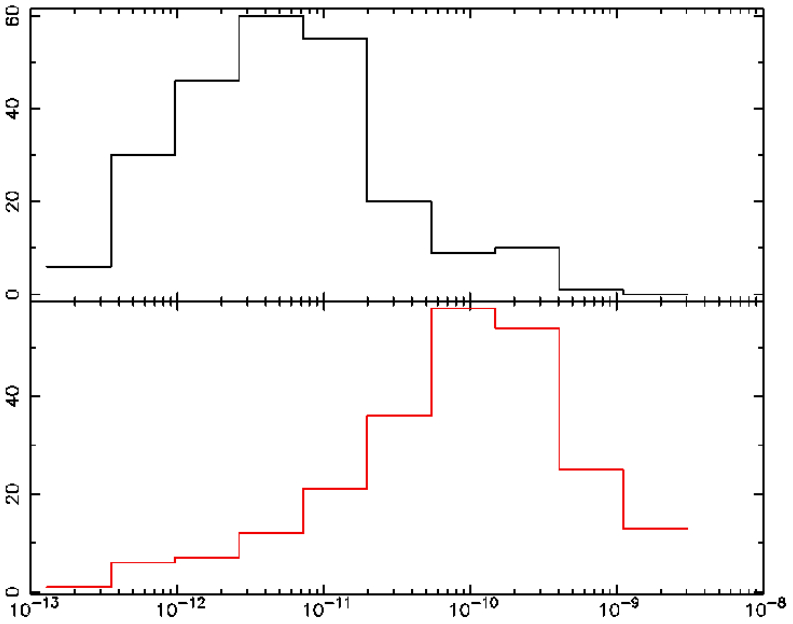



Simulation

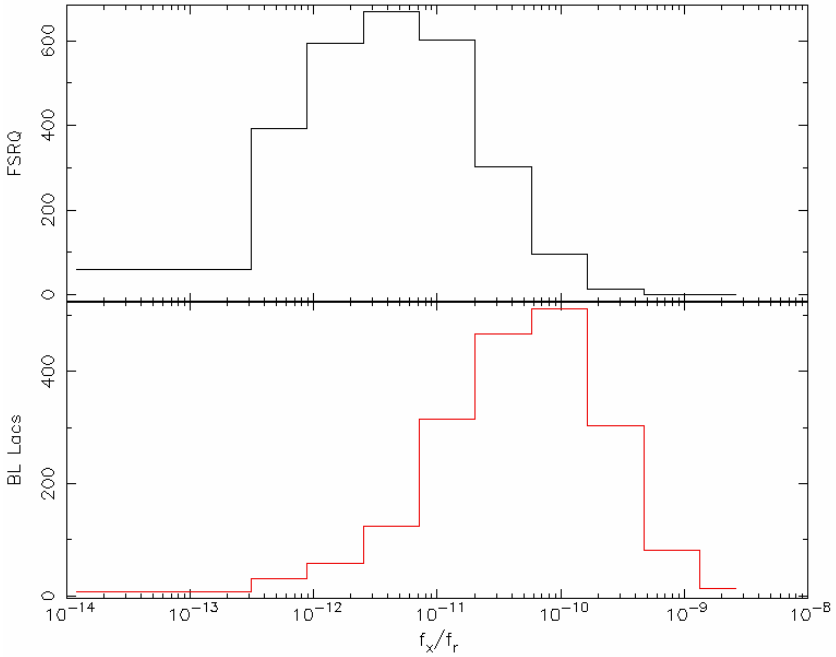


# fx/fr distributions

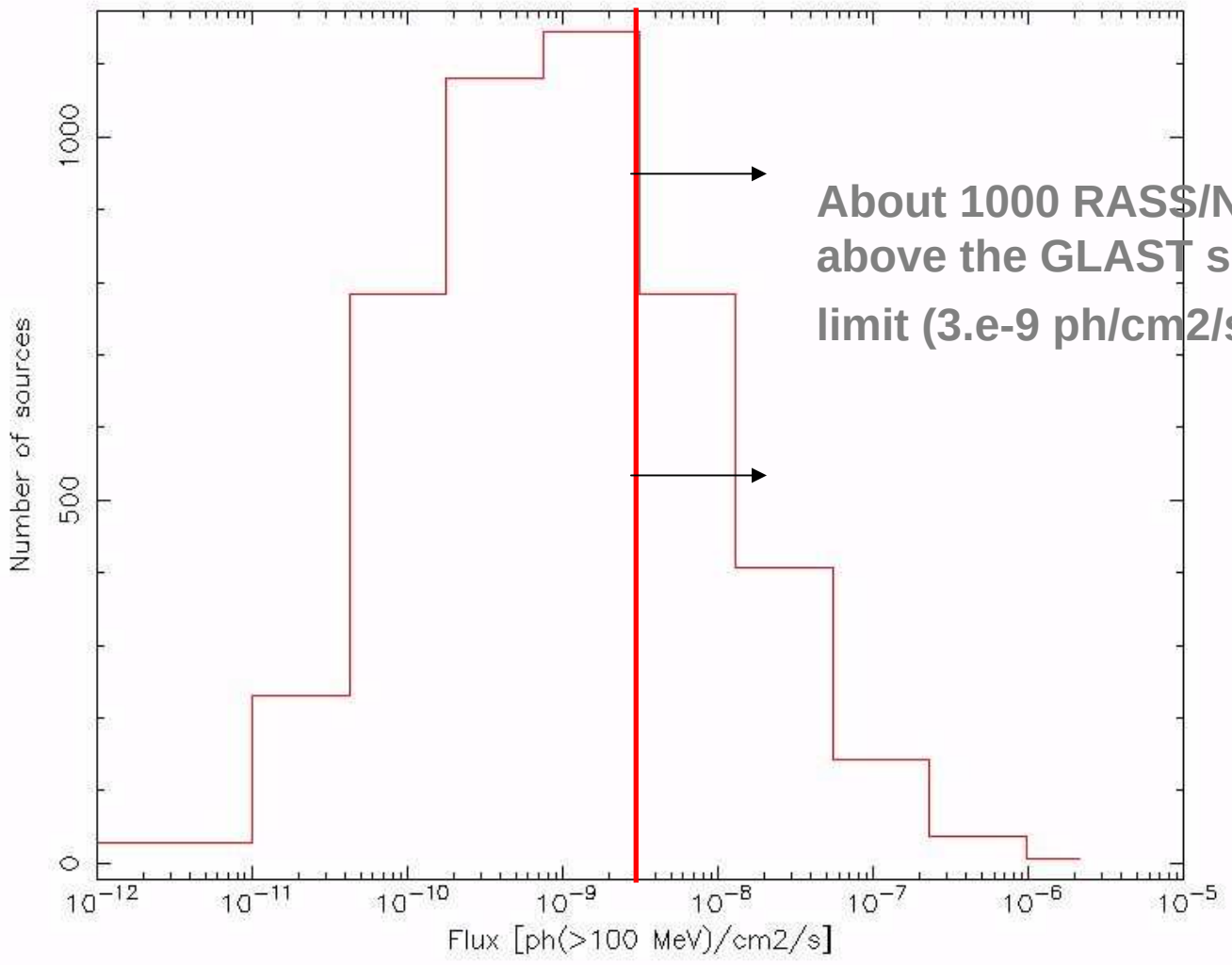
Data from RASS-NVSS-SLOAN
Blazar Sample




Simulation



# Predicted distribution of gamma-ray fluxes in ROXA blazar sample




**About 1000 RASS/NVSS sources above the GLAST sensitivity limit (3.e-9 ph/cm2/s)**

# Checking the simulations against real blazar surveys :

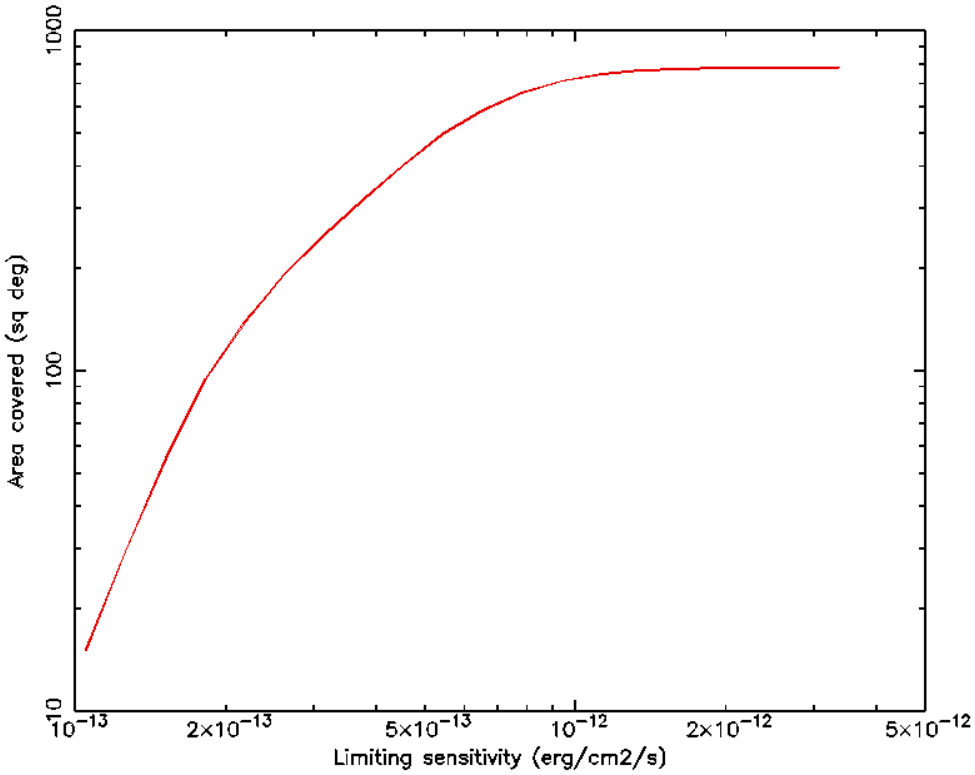
## the *Einstein* Medium Sensitivity Survey: EMSS

EMSS, real data
X-ray selection
835 objects
427 AGN : 113 RL 314 RQ

35 BL Lacs,
23 FSRQs,
18 SSRQ,
37 QSO with no radio spectrum

EMSS, simulated data
63 Blazars
32 BL Lacs,
31 FSRQs

EMSS Sky Coverage

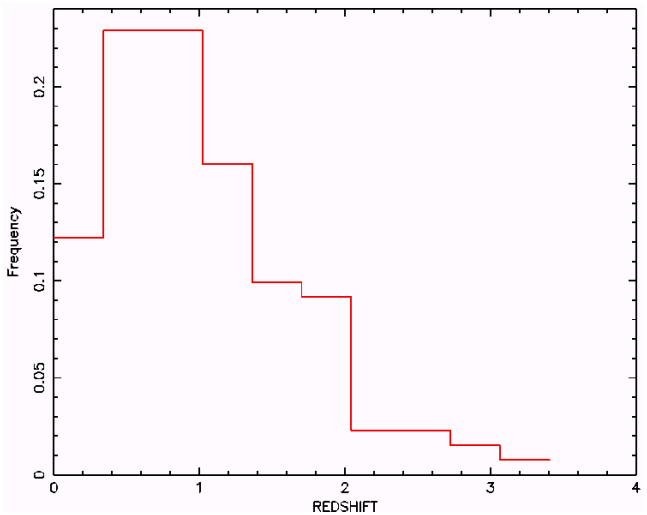


# Checking the simulations against real blazar surveys :

## the WMAP sample of bright foreground blazars

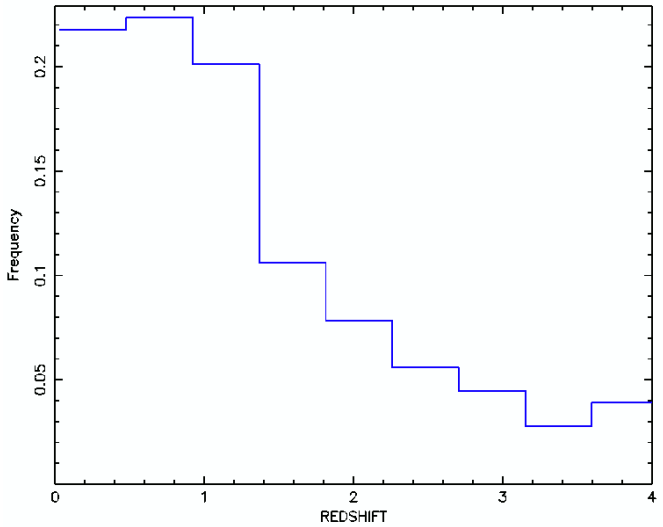
WMAP, real data
Microwave selection

141 FSRQs
23 BL Lacs,
13 radio galaxies
5 SSRQ,
17 unidentified




WMAP, simulated data

171 FSRQs
34 BL Lacs,



# Checking the simulations against real blazar surveys :

## the DXRBS survey (Padovani et al. 2006, in prep)

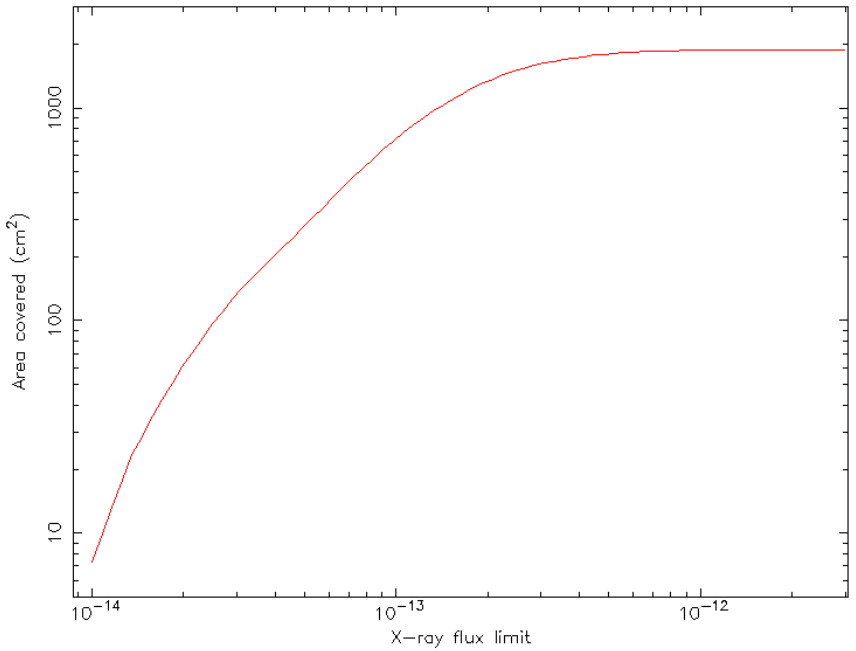
DXRBS, real data (90% complete)

Rosat-WGA/radio cats/$\alpha_r$<0.5,
several flux limits
124 FSRQs
39 BL Lacs,
21 radio galaxies
21 SSRQ,
16 unidentified

DXRBS, simulated data

166 FSRQs
55 BL Lacs,

DXRBS Sky Coverage




+ radio cuts at different frequencies and sky areas

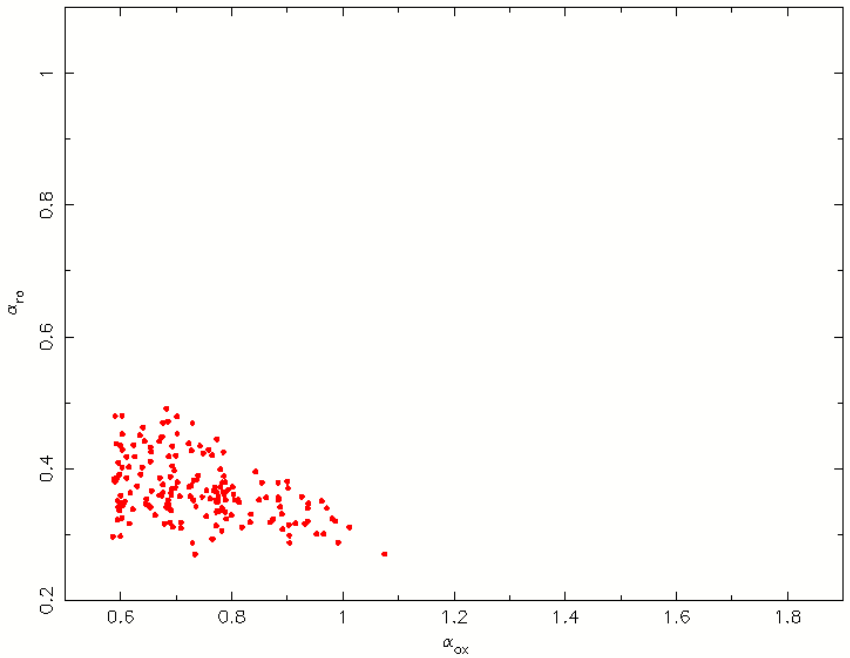
# Checking the simulations against real blazar surveys :
## the Sedentary Survey (Giommi et al. 1999,2005)

Sedentary survey, real data (100% complete)
RASS-BSC/NVSS/
$f_x/f_r>3x10^{-10}$erg/cm2/s/Jy,

150 extreme HBL BL Lacs,

Sedentary survey, simulated data

160 extreme HBL BL Lacs,



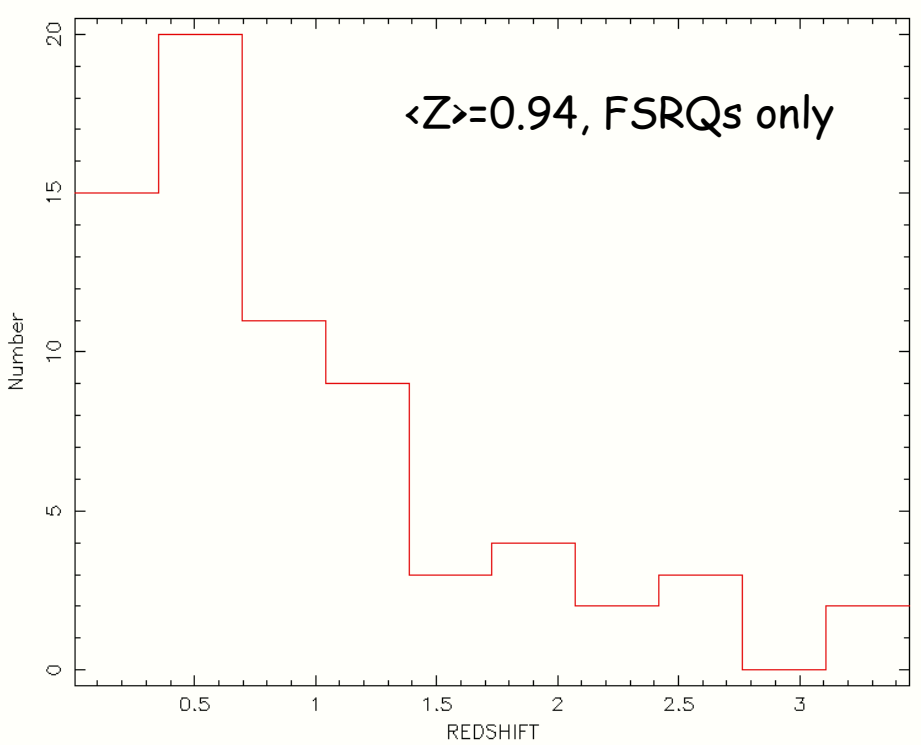
# Checking the simulations against real blazar surveys :
## EGRET detected sources

EGRET detected sources, real data
NOT a real flux-limited survey!

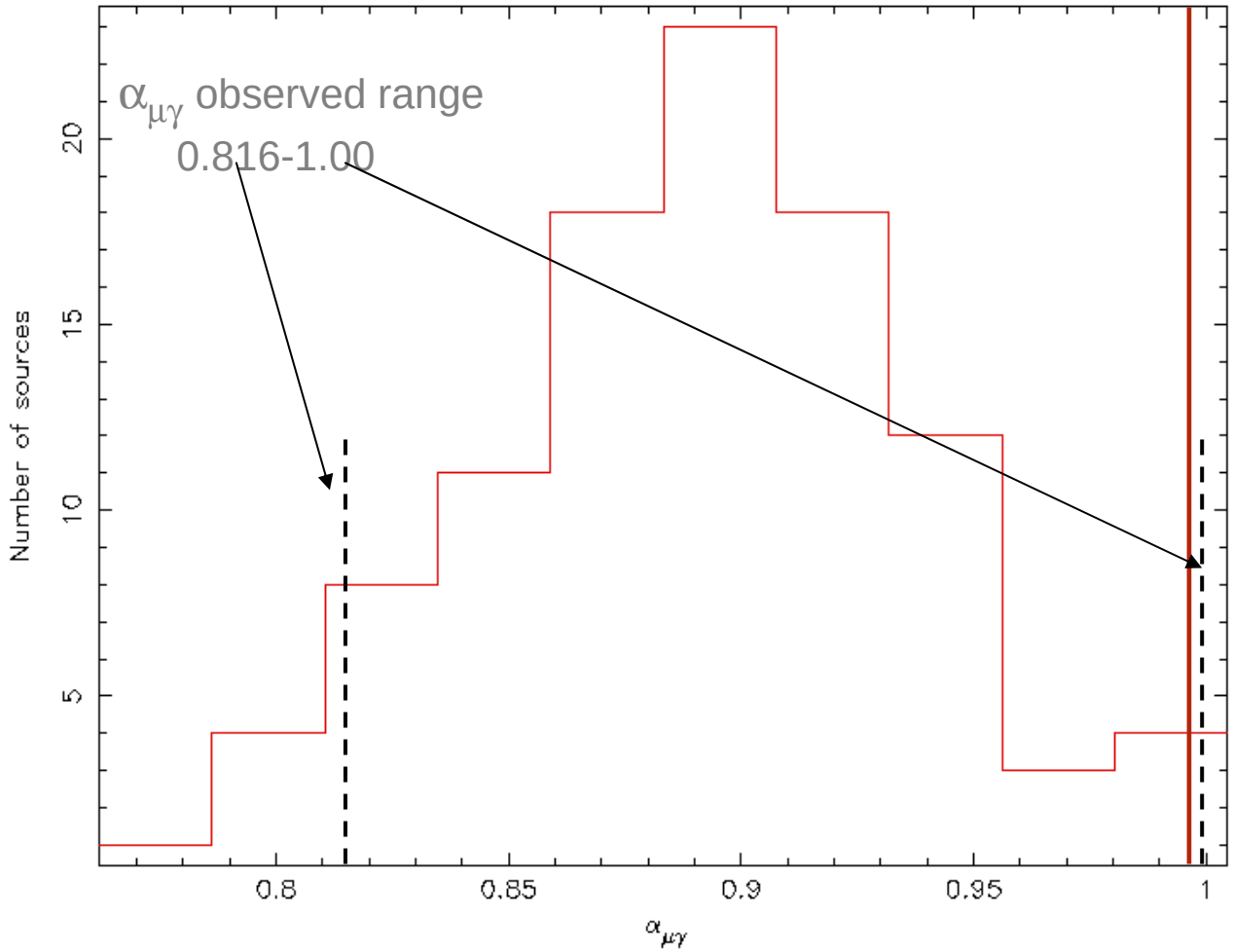
xx FSRQ
yy BL Lacs

EGRET detected sources, simulated data
f(>100 MeV) > $1 \times 10^{-7}$ ph/cm2/s

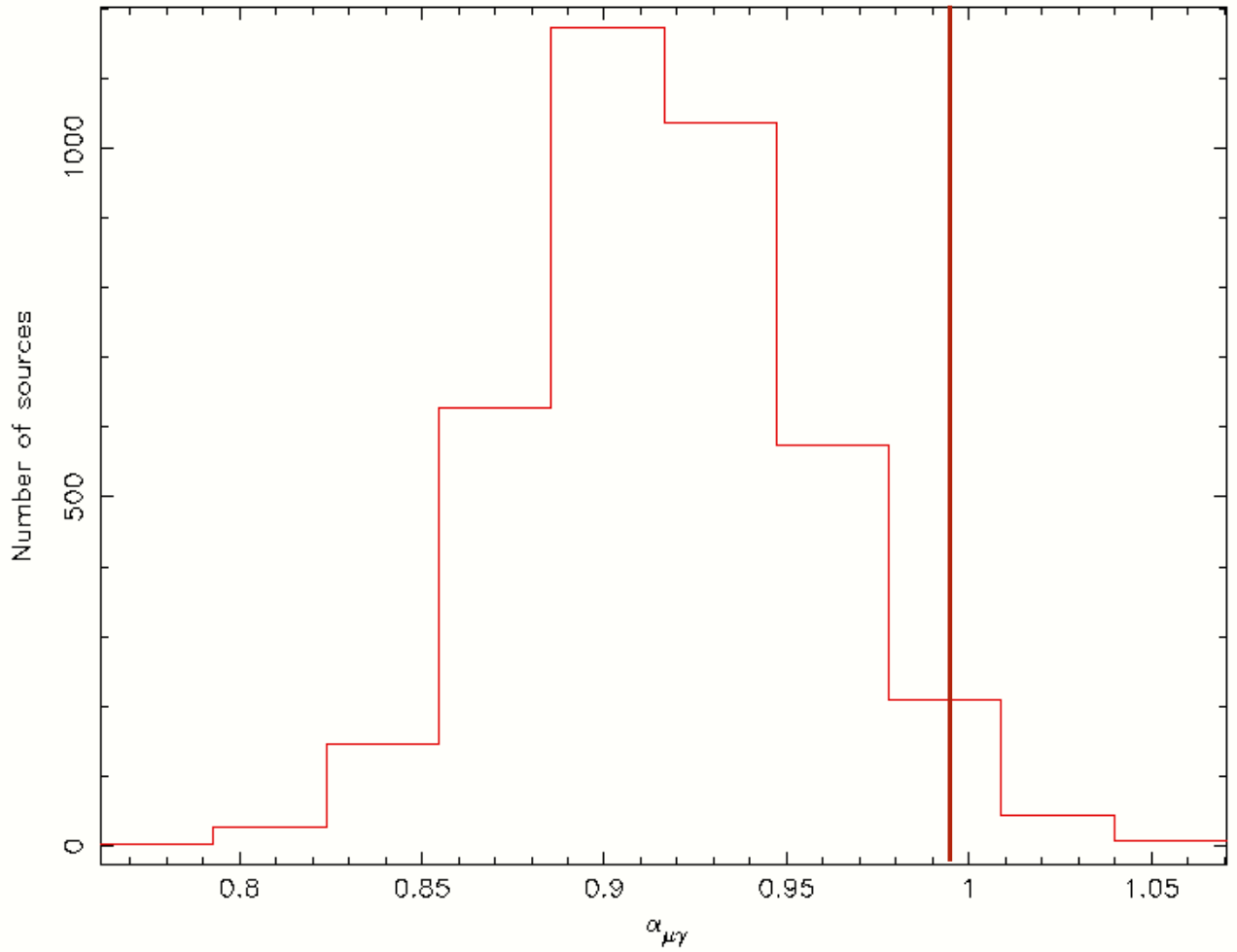
60 FSRQs
15 BL Lacs,



Expected distribution of microwave/gamma-ray spectral index ($\alpha_{\mu\gamma}$)
in the subsample of EGRET detected ($f_\gamma$>1x10$^{-7}$ ph/cm2/s > 100 MeV)
in the 10 mJy simulated radio survey (50-100 blazars)



Expected distribution of microwave/gamma-ray spectral index ($\alpha_{\mu\gamma}$)
in the subsample of GLAST detected ($f_\gamma > 3\times10^{-9}$ ph/cm2/s > 100 MeV)
in the 10 mJy simulated radio survey



# Improvements

- Add $\Omega_M$ - $\Omega_\Lambda$ cosmology
- Add red-shift dependant cosmological evolution for the case of FSRQs.
- Complete comparison with all statistically well-defined surveys to constrain simulation parameters.