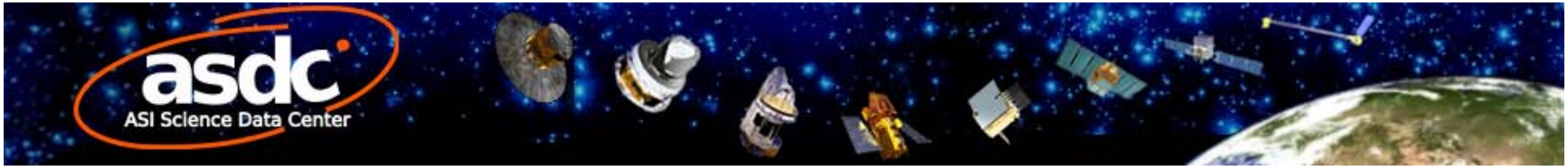
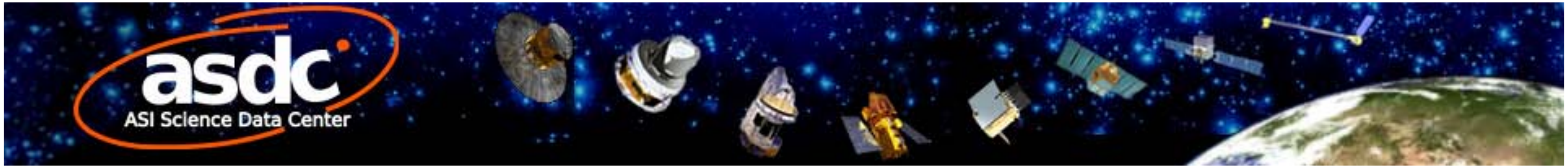


Planck-Swift and Fermi simultaneous observations of blazars

- A multi-selection sample-oriented approach -

Paolo Giommi
ASDC, Agenzia Spaziale Italiana

On behalf of many collaborators

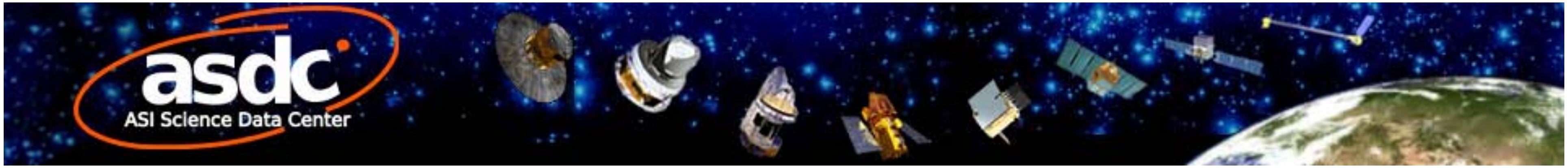


Planck early results: *Planck*, *Swift* and *Fermi* simultaneous observations of X and γ-ray selected blazars

P. Giommi[1], G. Polenta[1,2], A Lähteenmäki[3], D.J. Thompson[4], M. Capalbi[1], S. Cutini[1], D. Gasparrini[1], J. Gonzalez-Nuevo[9], J. Leon-Tavares[3], M. Lopez-Caniego[21], M.N. Mazziotta[16], C. Monte[16,18], M. Perri[1], S. Rainò[16,18], G. Tosti[32,33], A. Tramacere[34], F. Verrecchia[1], H. F. Aller[6], M. F. Aller[6], E. Angelakis[5], D. Bastieri[38,39], A. Berdyugin[7], A. Bonaldi[8], L. Bonavera[9], F. R. Bouchet[44], S. Buson[39], C. Burigana[10], D.N. Burrows[11], E. Cavazzuti[1], G. Chincarini[12,13], S. Colafrancesco[2,14], L. Costamante[22], F. Cuttaia[10], F. D'Ammando[37], G. De Zotti[8], M. Frailis[15], L. Fuhrmann[5], S. Galeotta[15], F. Gargano[16], N. Gehrels[17], N. Giglietto[16,18], F. Giordano[16,18], M. Giroletti[50], E. Keihänen[19], O. King[20], T.P. Krichbaum[5], A. Lasenby[41,40], N. Lavonen[3], C. Leto[1], E. Lindfors[7], M. Massardi[8], W. Max-Moerbeck[20], P.F. Michelson[22], M. Mingaliev[23], P. Natoli[24,25,1], I. Nestoras[5], E. Nieppola[3,26], K. Nilsson[7], B. Partridge[27], V. Pavlidou[20], T. J. Pearson[55,49], P. Procopio[10], J.-L. Puget[57], J.P. Rachen[28], A. Readhead[20], R. Reeves[20], A. Reimer[29,22], R. Reinthal[7], S. Ricciardi[10], J. Richards[20], D. Riquelme[30], J. Saarinen[7], A. Sajina[27], M. Sandri[10], P. Savolainen[3], A. Sievers[30], A. Sillanpää[7], Y. Sotnikova[23], M. Stevenson[20], G. Tagliaferri[13], L. Takalo[7], J. Tammi[3], D. Tavagnacco[15], L. Terenzi[10], L. Toffolatti[31], M. Tornikoski[3], C. Trigilio[35], M. Turunen[3], G. Umana[35], H. Ungerechts[30], F. Villa[10], J. Wu[36], A. Zacchei[15], J.A. Zensus[5], and X. Zhou[36]

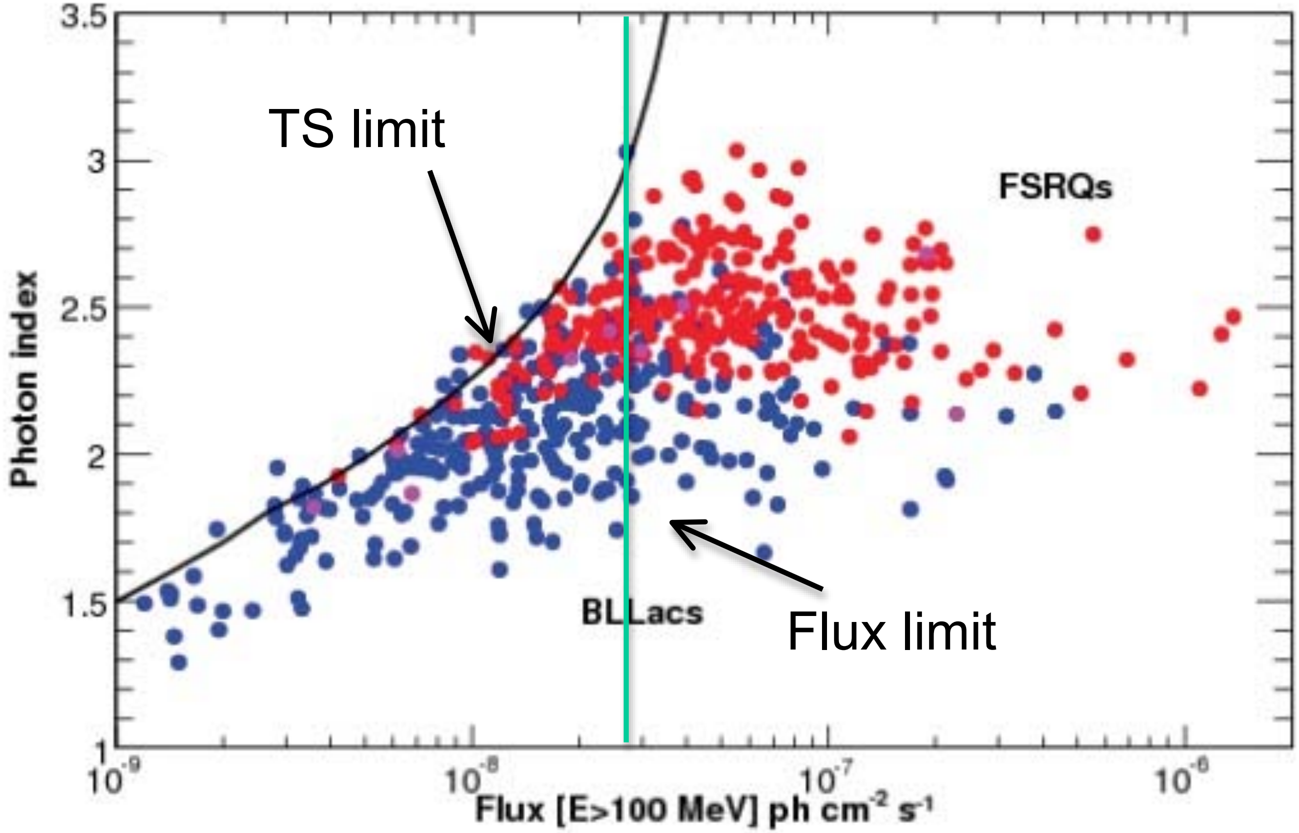
To be submitted soon

Significant improvement compared to Abdo et al. 2010, ApJ, 716, 30 (Quasi simultaneous SED of 48 Fermi bright blazars)



- Large number of sources:
  175 blazars observed by Swift when they were in the FOV of Planck: ~160 Swift ToOs
- Truly simultaneous Planck Swift Fermi + ground data,
- Multi selection approach. Four flux limited samples.
  - Soft X-ray,
  - Hard X-ray,
  - γ-ray (TS + Flux limited)
  - Radio
- Fermi-LAT integrations:
  - simultaneous (~1week),
  - 2 months,
  - 27 months

Photon index vs luminosity



Sample	Selection band	No. of sources	Blazars FS/BL/Unc.
RASS	Soft X-ray	43	15/16/11
BAT	Hard X-ray	34	21/7/6
Fermi-LAT *	γ-ray	50	28/16/6
Fermi-LAT FL**	γ-ray	40	27/8/5
Total this paper		105	52/32/20
Radio	radio	104	73/18/10

* Total *Fermi*-LAT sample (TS limited),

** Flux limited *Fermi*-LAT sample F(E >100MeV) > 8×10^{-8} ph cm^{-2} s^{-1}

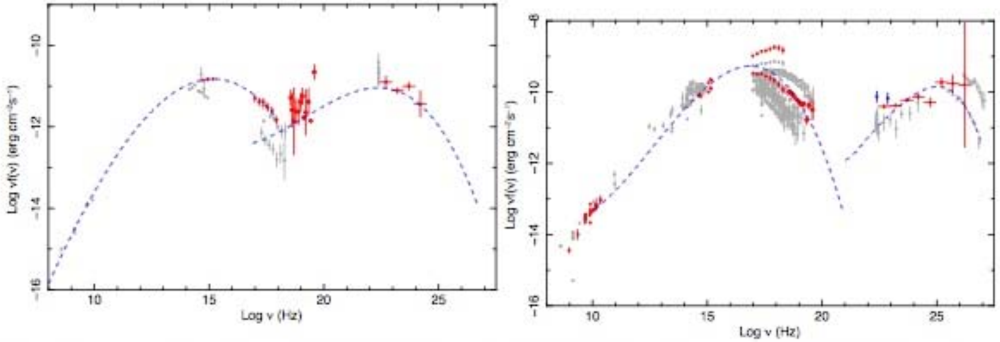


Fig. 15.— The SED of 0FGL J1058.9+5629 = GB6 J1058+5628 (left) and of 0FGL J1104.5+3811 = Mkn 421 (right)

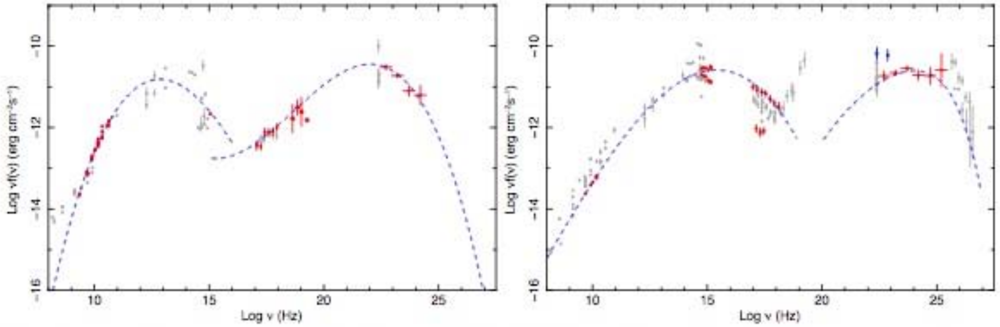


Fig. 16.— The SED of 0FGL J1159.2+2912 = 4C29.45 (left) and of 0FGL J1221.7+2814 = ON231= W Comae (right)

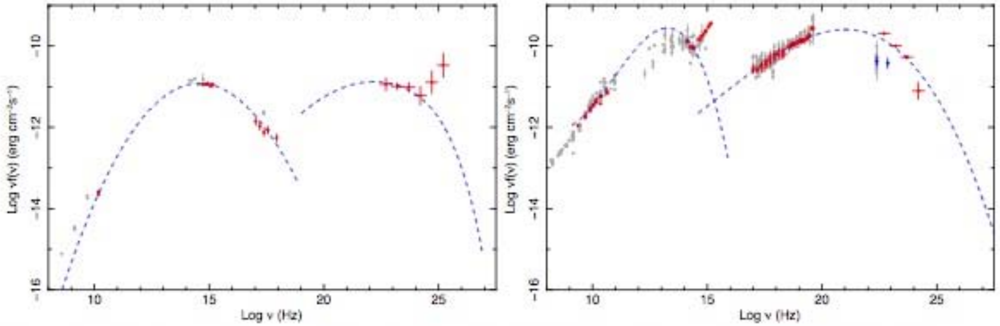


Fig. 17.— The SED of 0FGL J1248.7+5811 = PG 1246+586 (left) and of 0FGL J1229.1+0202 = 3C273 (right)

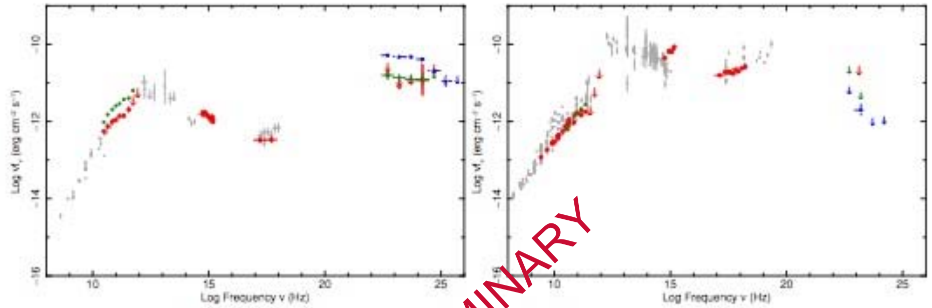


Fig. 34. The SED of PKS0426-380 (J0428−3756, left side) and of 3C120 (J0433+0521, right side). Simultaneous data are shown in red; quasi-simultaneous data, i.e. *Fermi* data integrated over 2 months, *Planck* ERCSC and non-simultaneous ground based observations are shown in green; *Fermi* data integrated over 27 months are shown in blue; literature or archival data are shown in light gray.

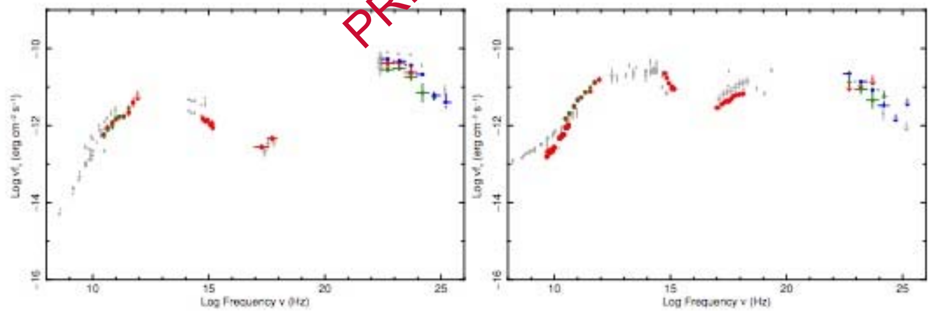


Fig. 35. The SED of PKS0454-234 (left side) and of PKS0521-36 (right side). Simultaneous data are shown in red; quasi-simultaneous data, i.e. *Fermi* data integrated over 2 months, *Planck* ERCSC and non-simultaneous ground based observations are shown in green; *Fermi* data integrated over 27 months are shown in blue; literature or archival data are shown in light gray.

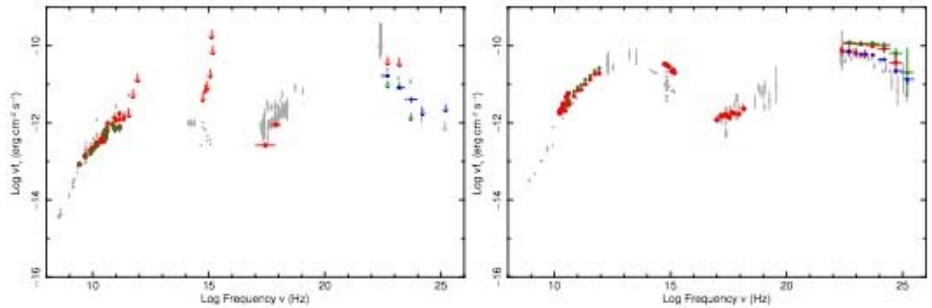
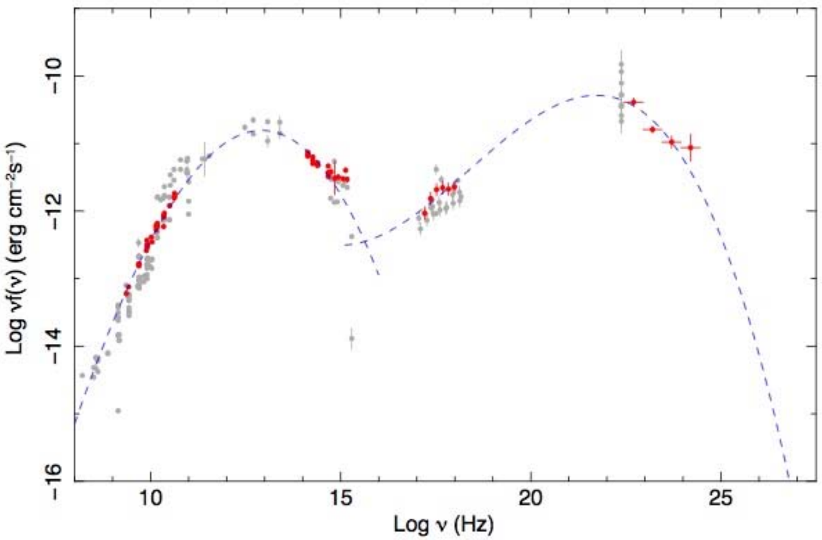
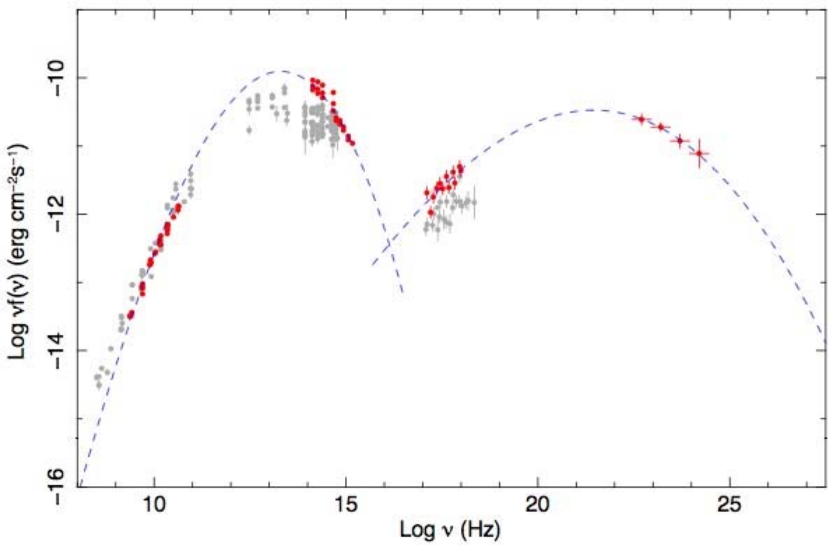


Fig. 36. The SED of PKS0528+134 (J0530+1331, left side) and of PKS0537-441 (0538−4405, right side). Simultaneous data are shown in red; quasi-simultaneous data, i.e. *Fermi* data integrated over 2 months, *Planck* ERCSC and non-simultaneous ground based observations are shown in green; *Fermi* data integrated over 27 months are shown in blue; literature or archival data are shown in light gray.

The synchrotron/invC peak frequencies ν_{peak} and intensities ν_{peak} f(ν_{peak})

Measured from the 48 SEDs using
3rd degree polynomial functions





The synchrotron/invC peak frequencies ν_{peak} and intensities $\nu_{peak}f(\nu_{peak})$

Measured from the 48 SEDs using
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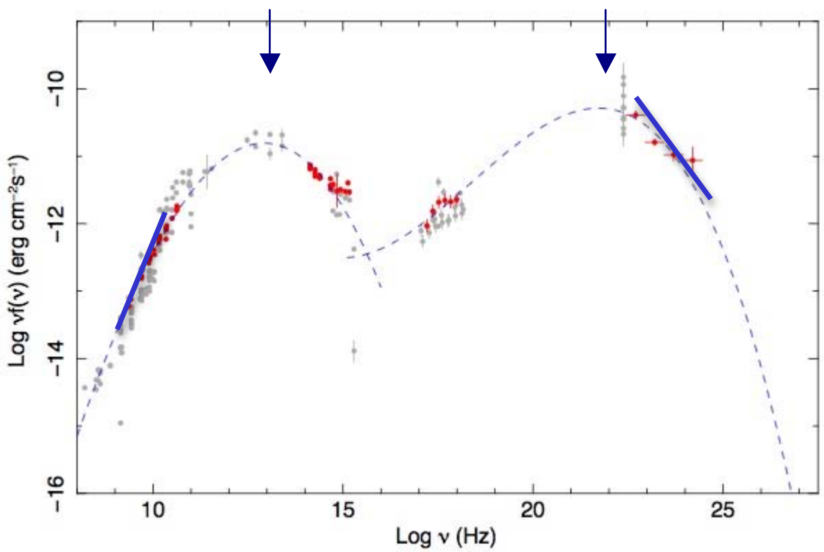
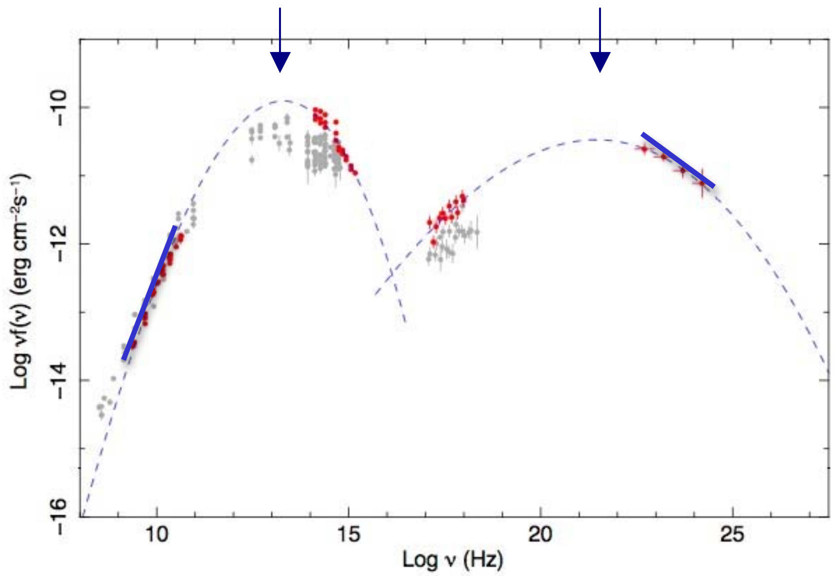
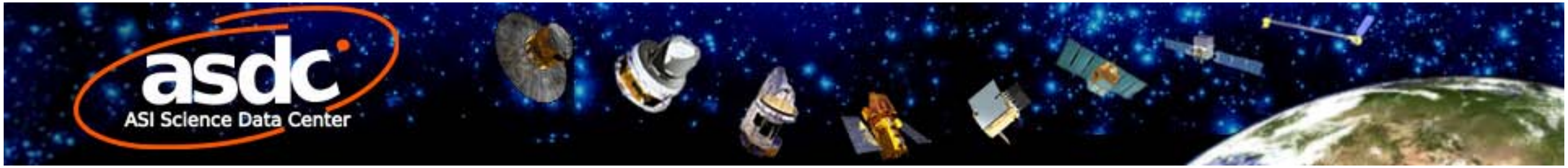




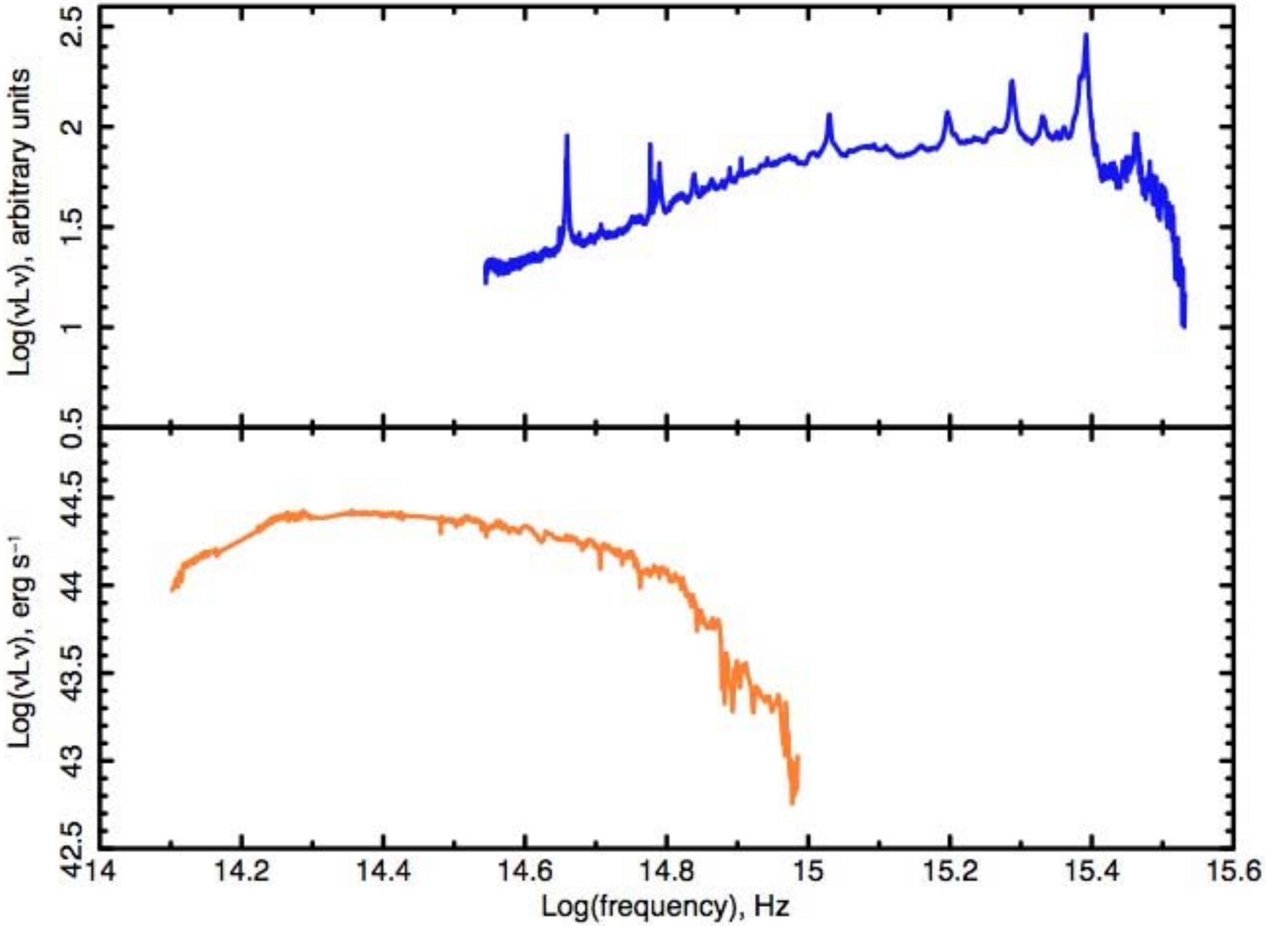


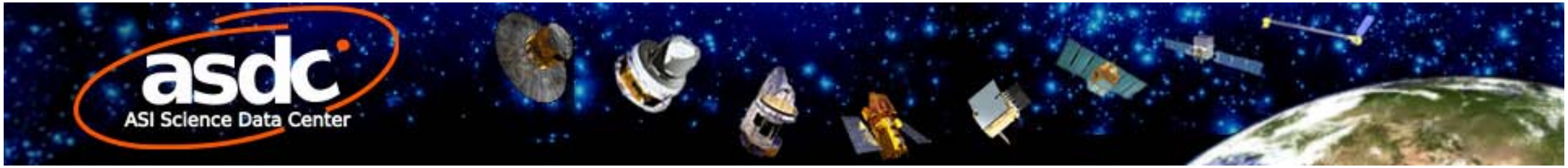
Summary of γ-ray detections (TS > 25) in 27 month Fermi-LAT data.

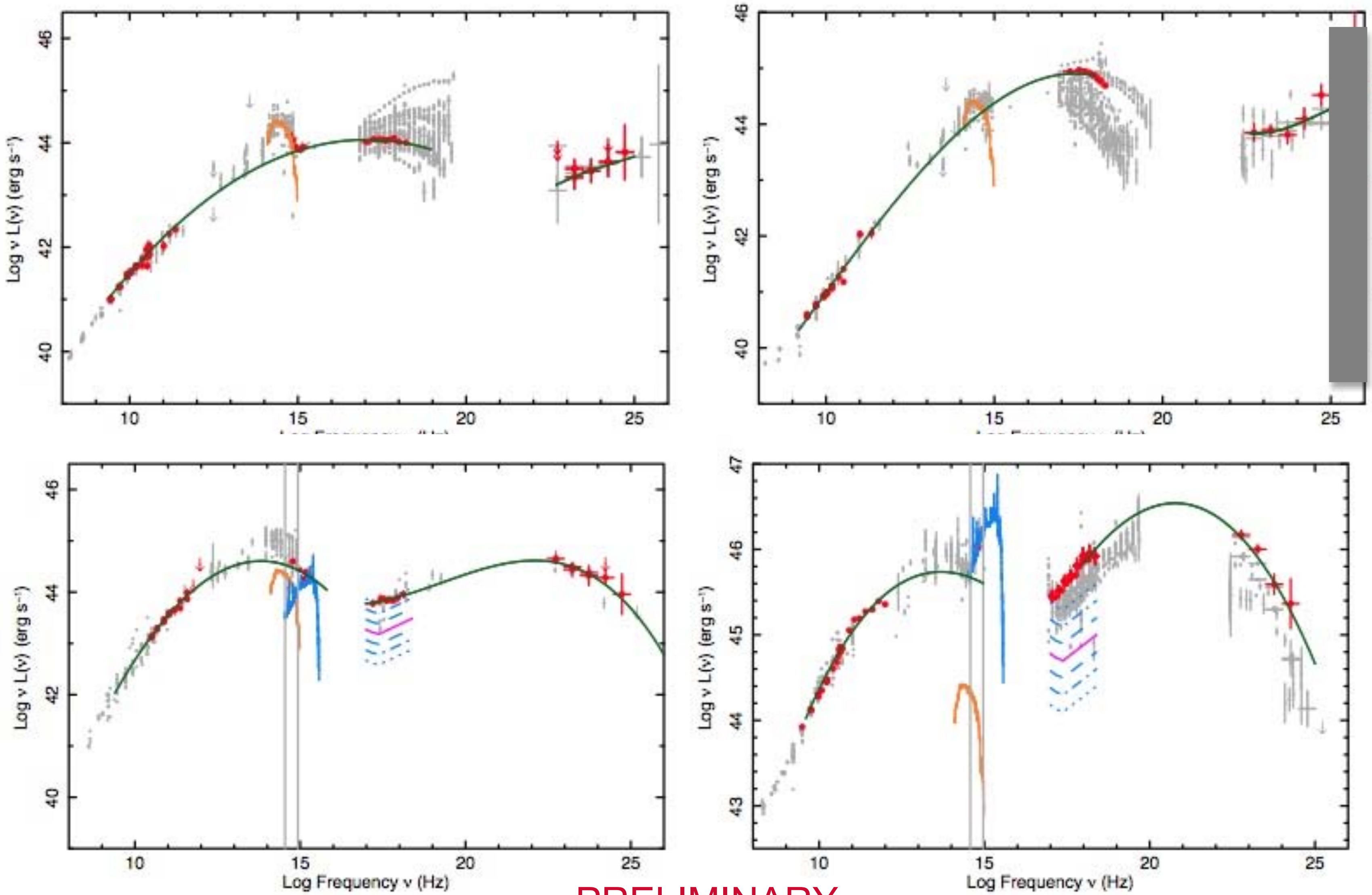
Sample	No. of detected sources		
	FSRQs	BL Lacs	Uncertain
Fermi-LAT	28 (100%)	14 (100%)	8 (100%)
Swift-BAT	17 (63%)	7 (100%)	3 (50%)
Rosat/RASS	8 (53%)	14 (88%)	2 (17%)
Radio	48 (72%)	16 (100%)	9 (64%)

PRELIMINARY

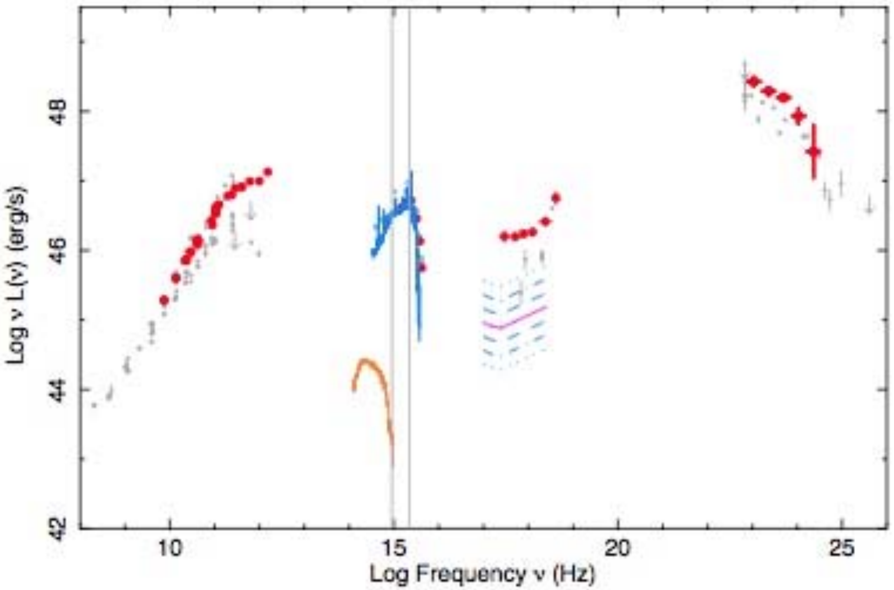
Separating jet emission from other types of radiation

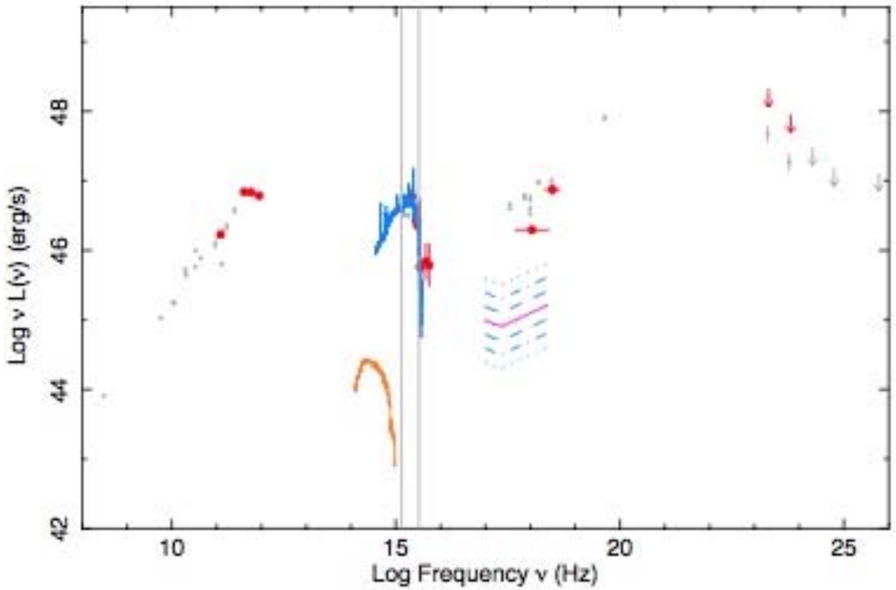






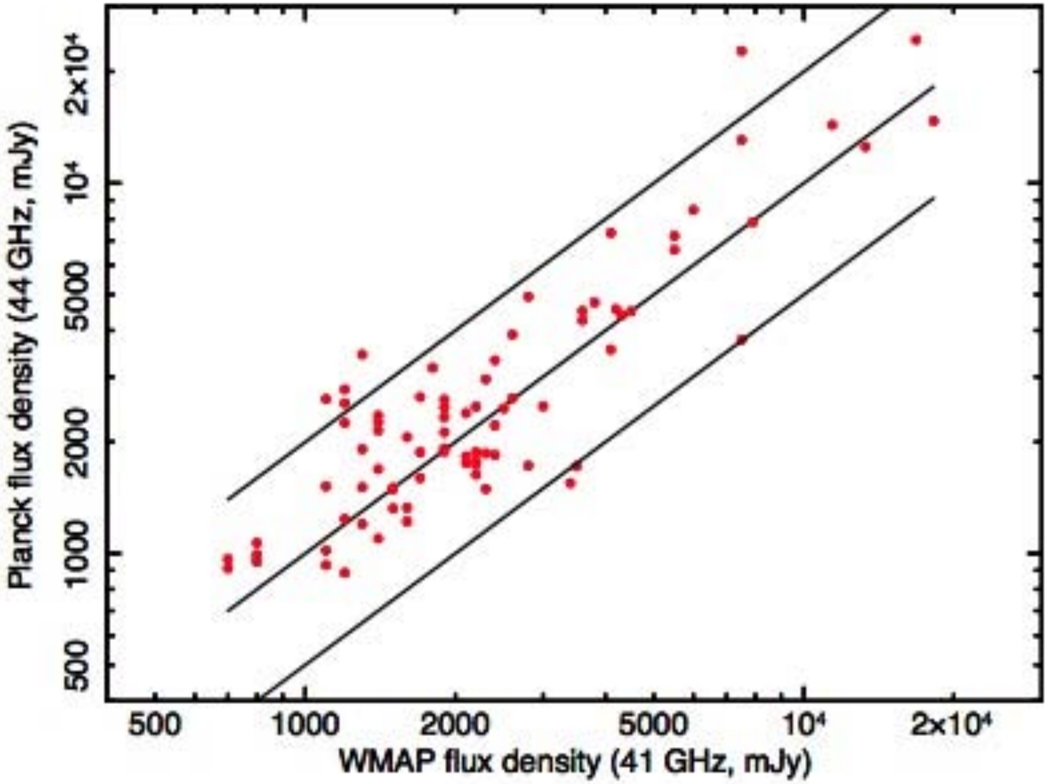
PRELIMINARY



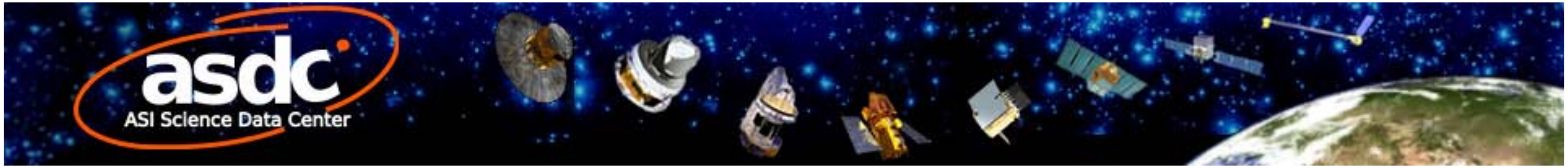


PRELIMINARY

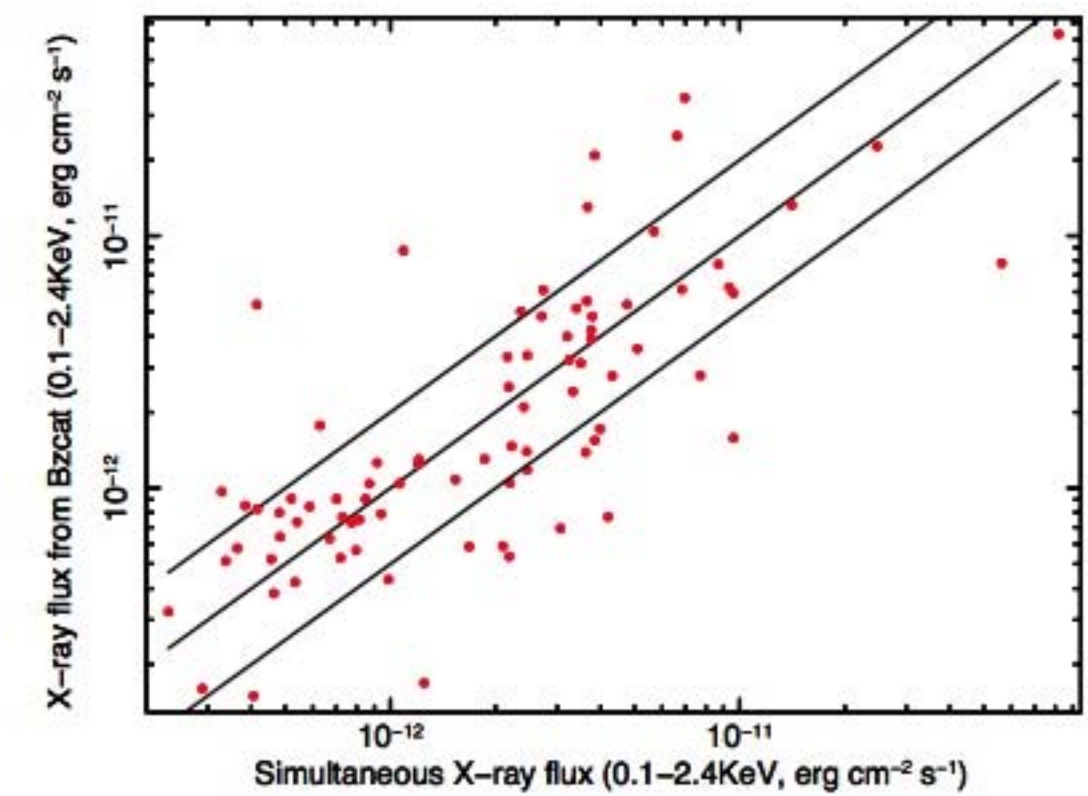
The importance of simultaneity



PRELIMINARY

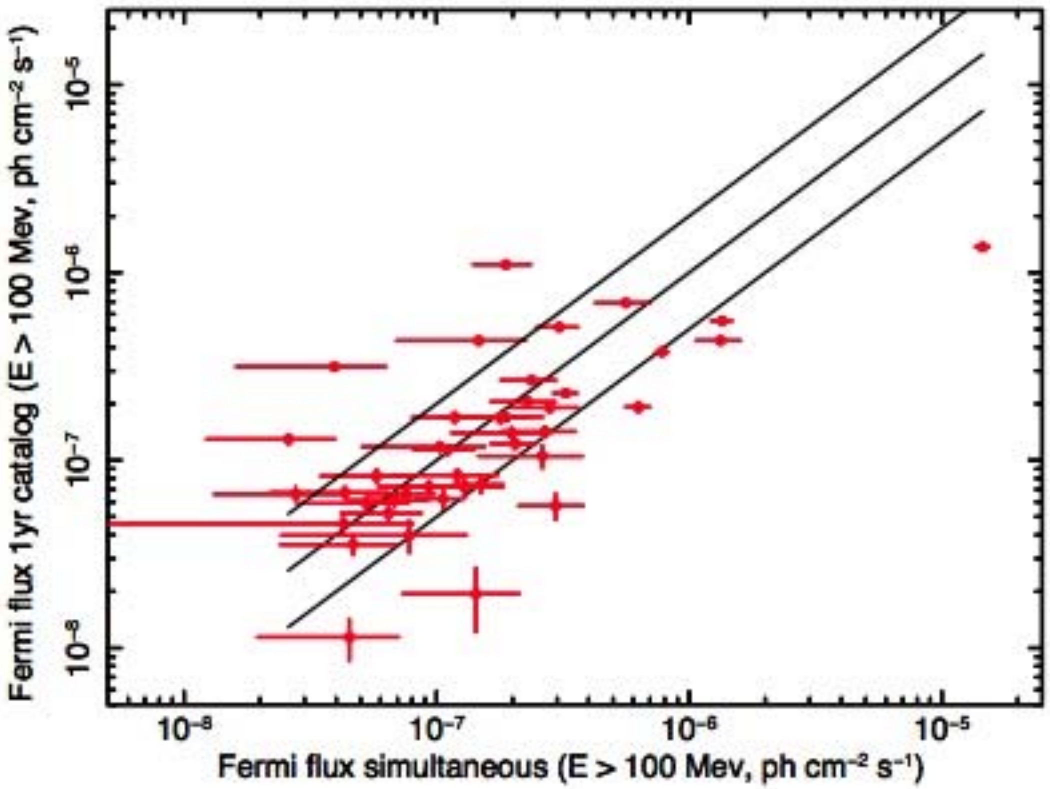


The importance of simultaneity



PRELIMINARY

The importance of simultaneity



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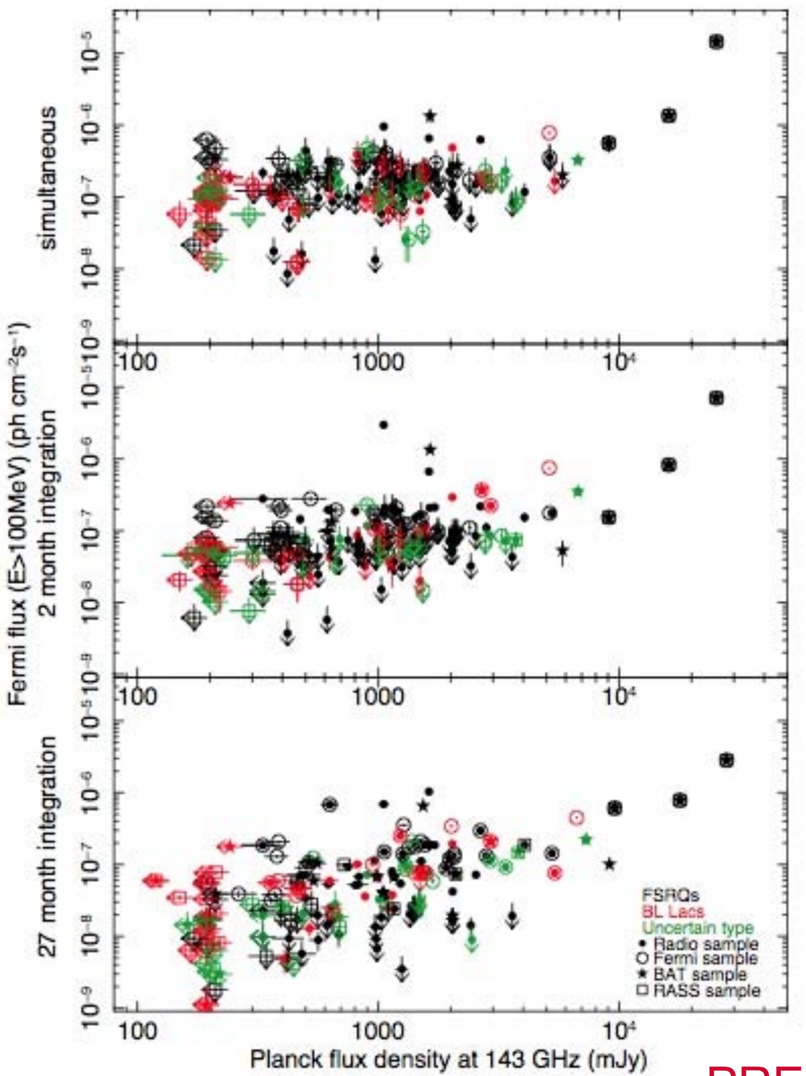

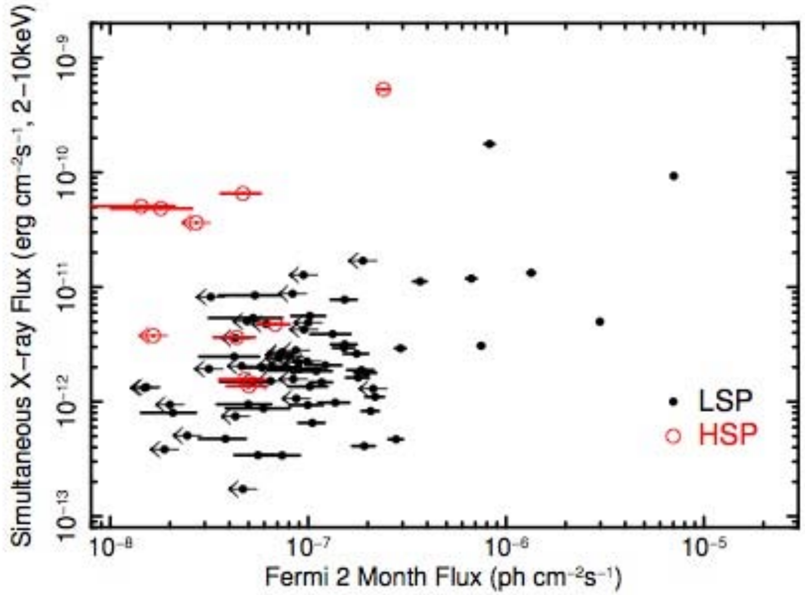

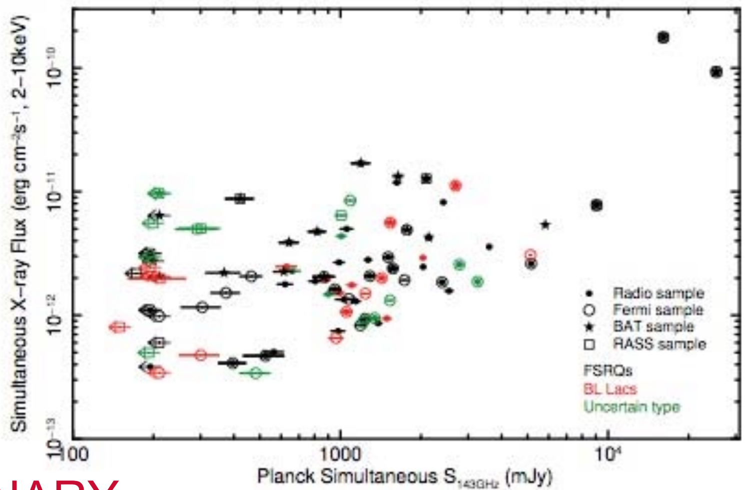

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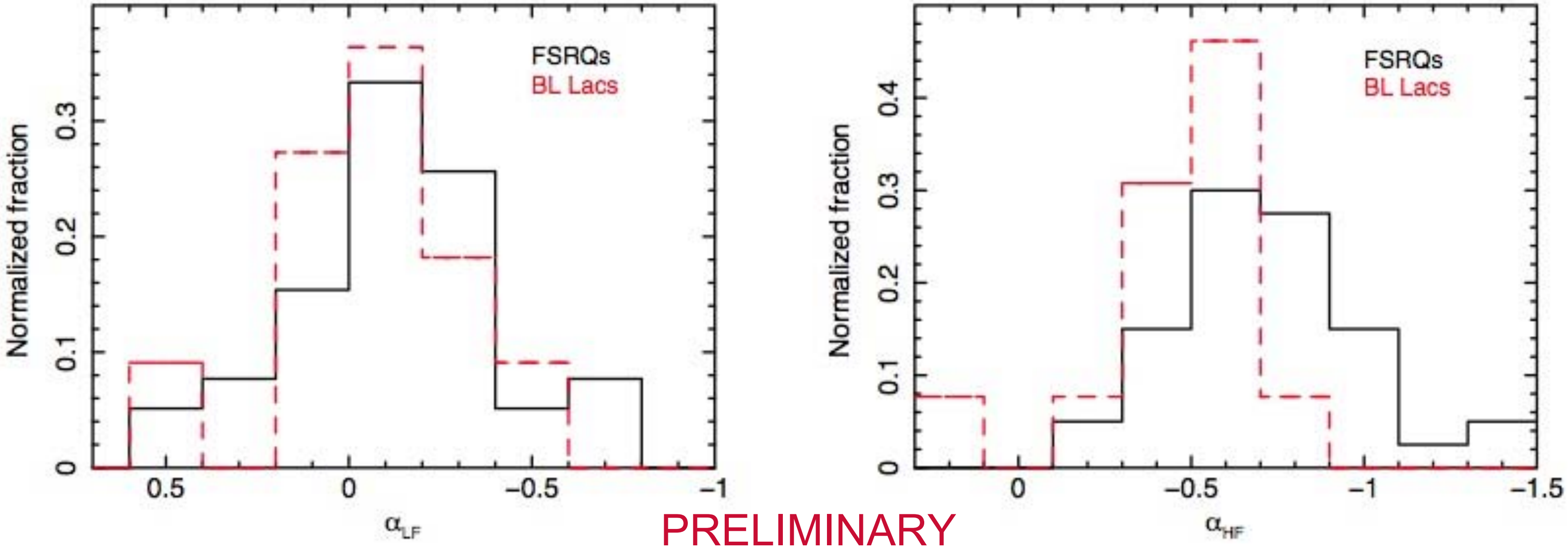
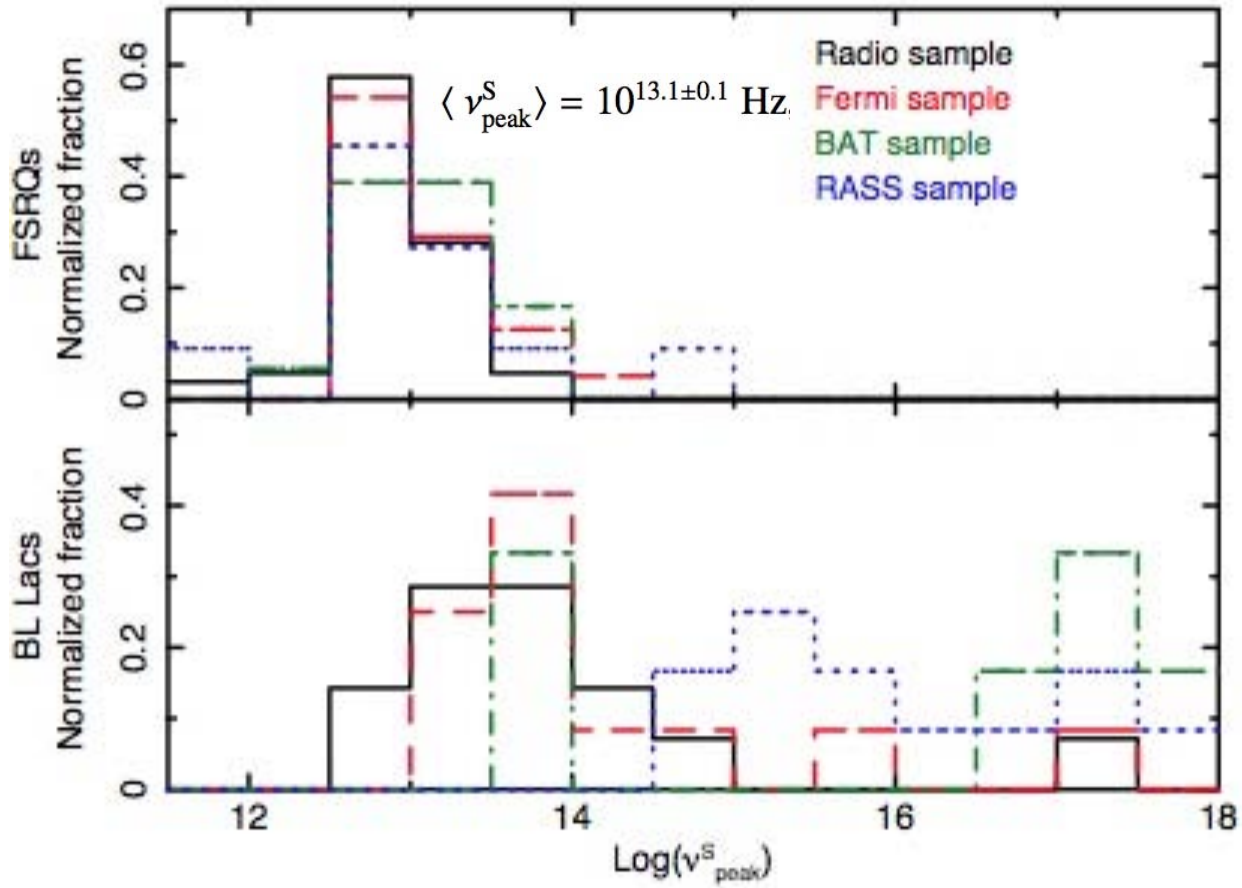


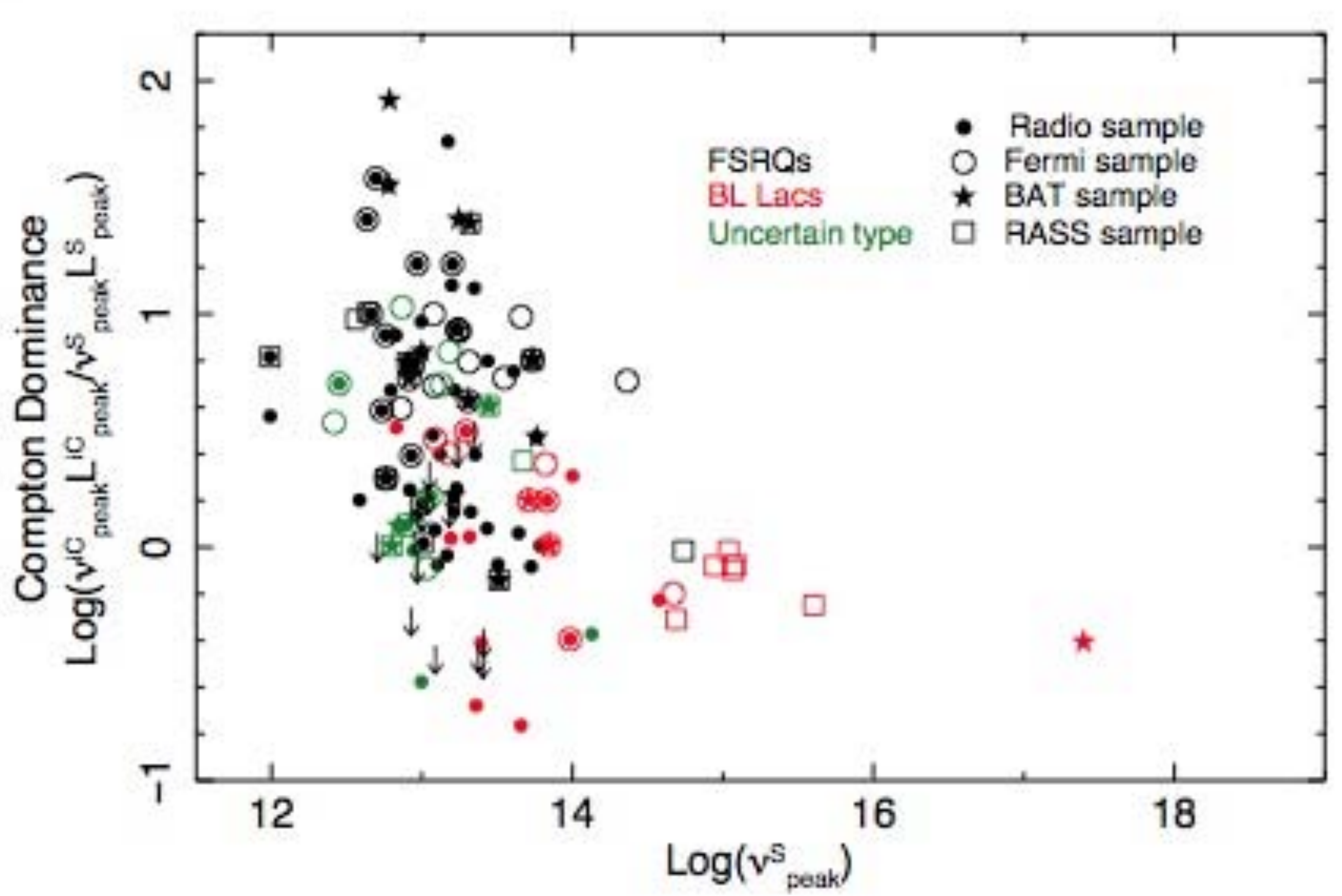
PRELIMINARY

ν_{Break}	n. of frequency	Class	n. of sources LF	$\langle\alpha_{LF}\rangle$	σ_{LF}	n. of sources HF	$\langle\alpha_{HF}\rangle$	σ_{HF}
30	3	ALL	47	0.00± 0.04	0.27	69	−0.51± 0.04	0.30
30	5	ALL	46	0.00± 0.04	0.27	57	−0.49± 0.03	0.26
44	3	ALL	47	−0.02± 0.04	0.25	66	−0.64± 0.03	0.26
44	5	ALL	47	−0.02± 0.04	0.25	47	−0.62± 0.03	0.22
70	3	ALL	63	−0.08± 0.03	0.28	66	−0.67± 0.03	0.28
70	5	ALL	47	−0.02± 0.04	0.25	35	−0.65± 0.04	0.22
100	3	ALL	65	−0.11± 0.03	0.27	48	−0.56± 0.04	0.26
100	5	ALL	47	−0.02± 0.04	0.24	15	−0.52± 0.05	0.19
70	3	FSRQ	39	−0.11± 0.04	0.28	40	−0.73± 0.04	0.27
70	3	BL Lac	12	−0.08± 0.08	0.29	14	−0.51± 0.07	0.27
70	3	Unc. Type	12	−0.02± 0.08	0.29	12	−0.64± 0.07	0.25

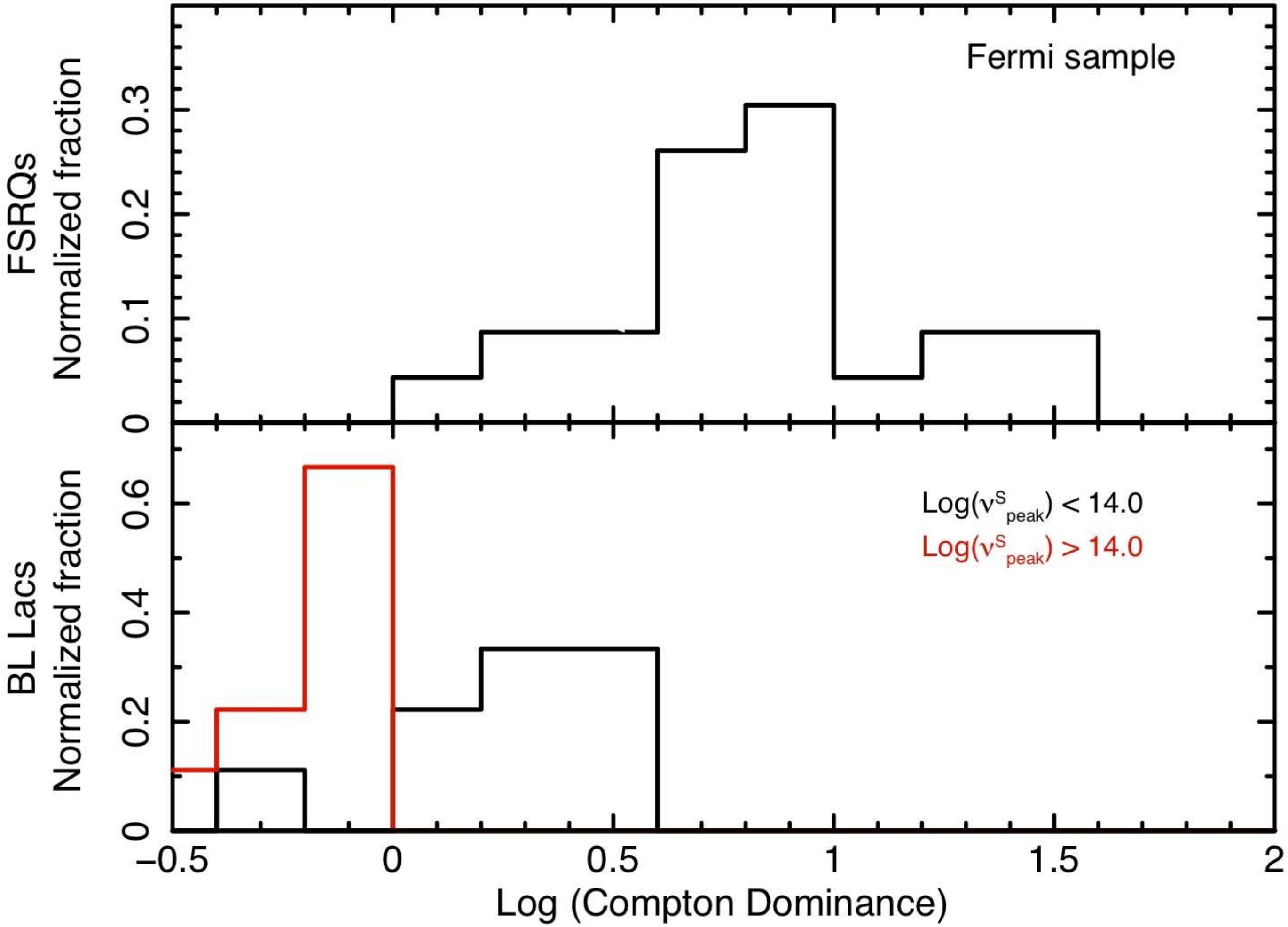


PRELIMINARY

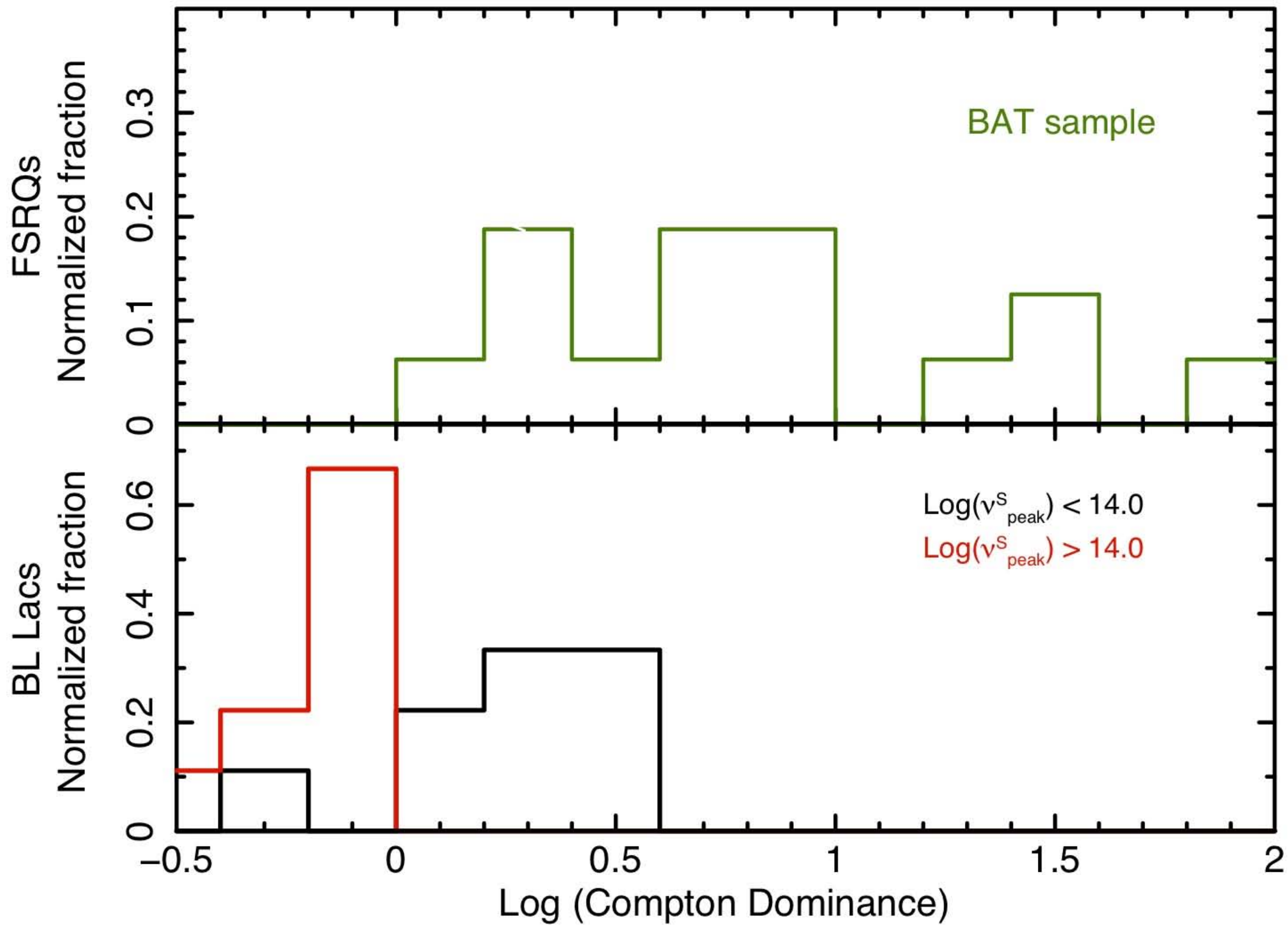
The Compton dominance



PRELIMINARY



PRELIMINARY



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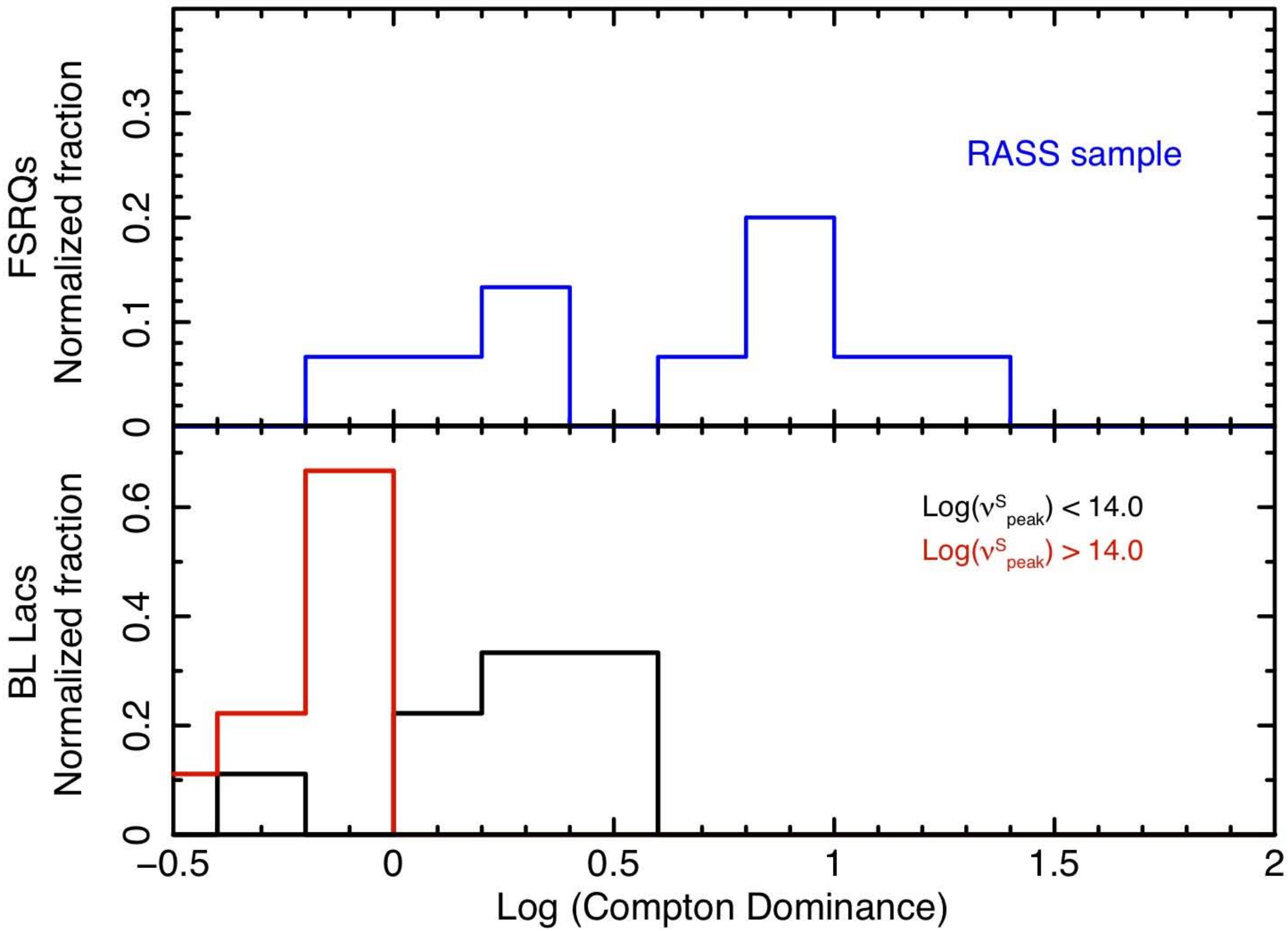

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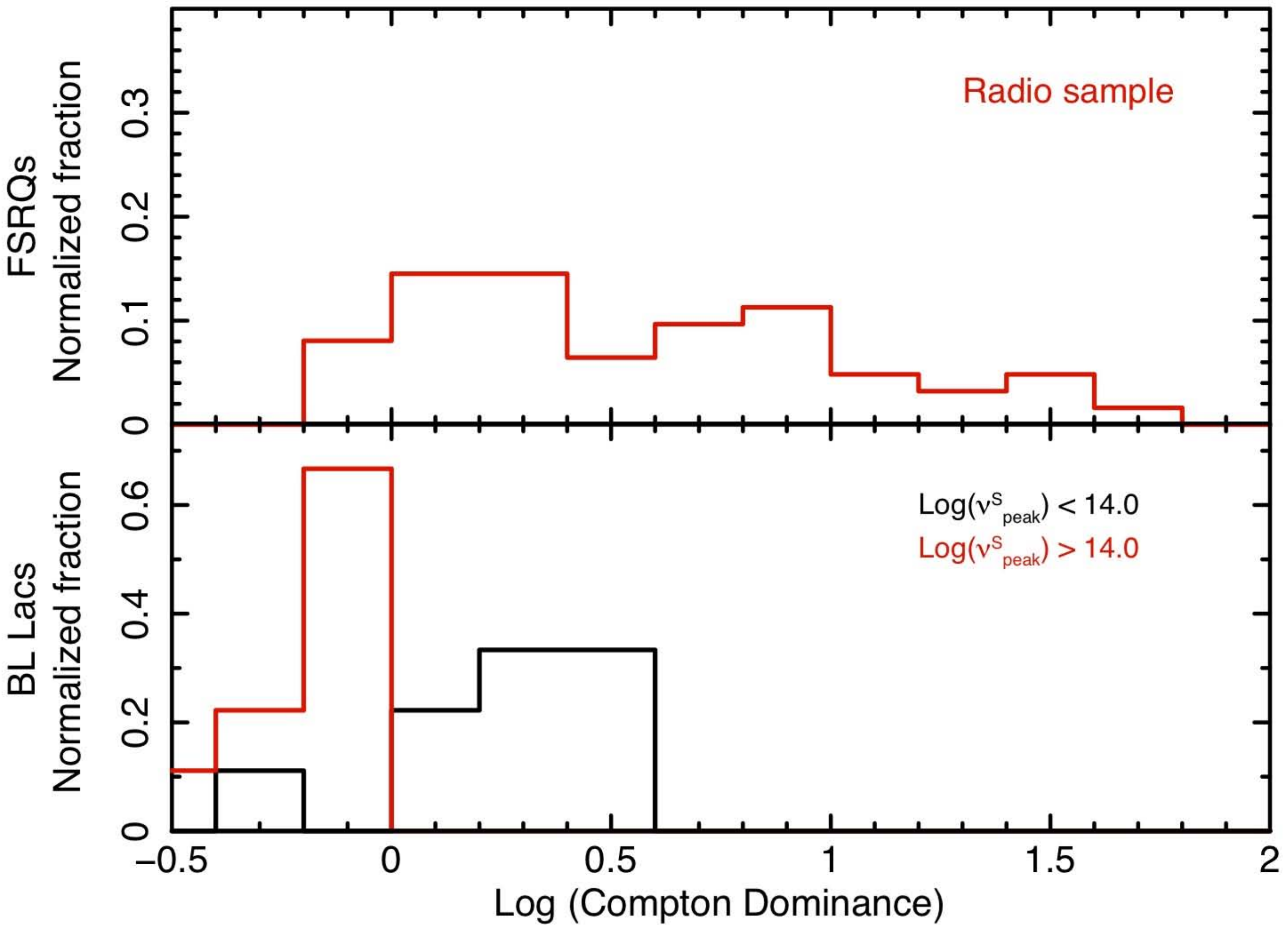

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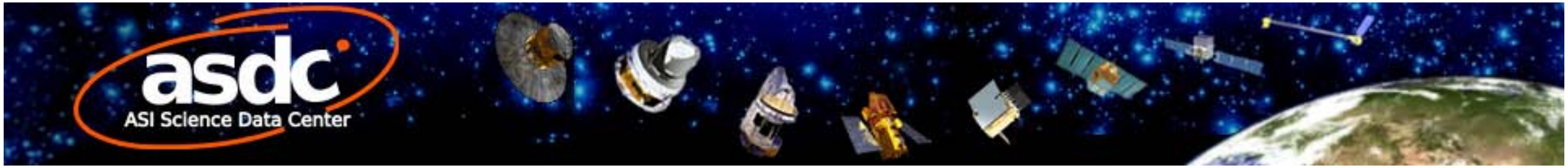


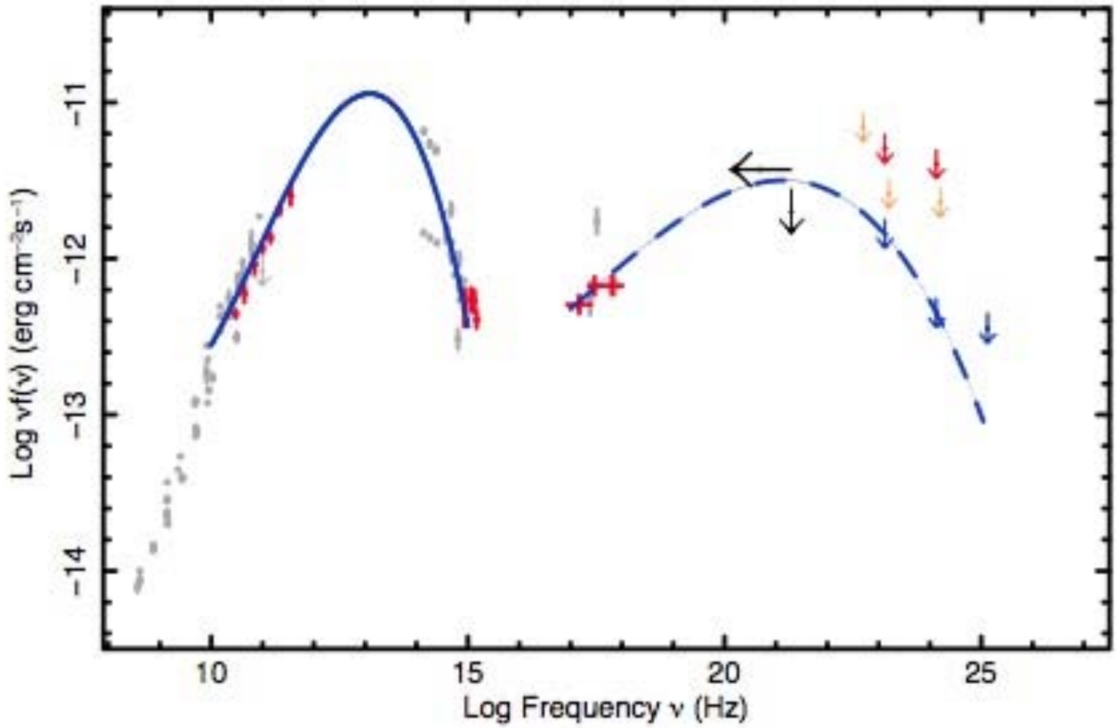
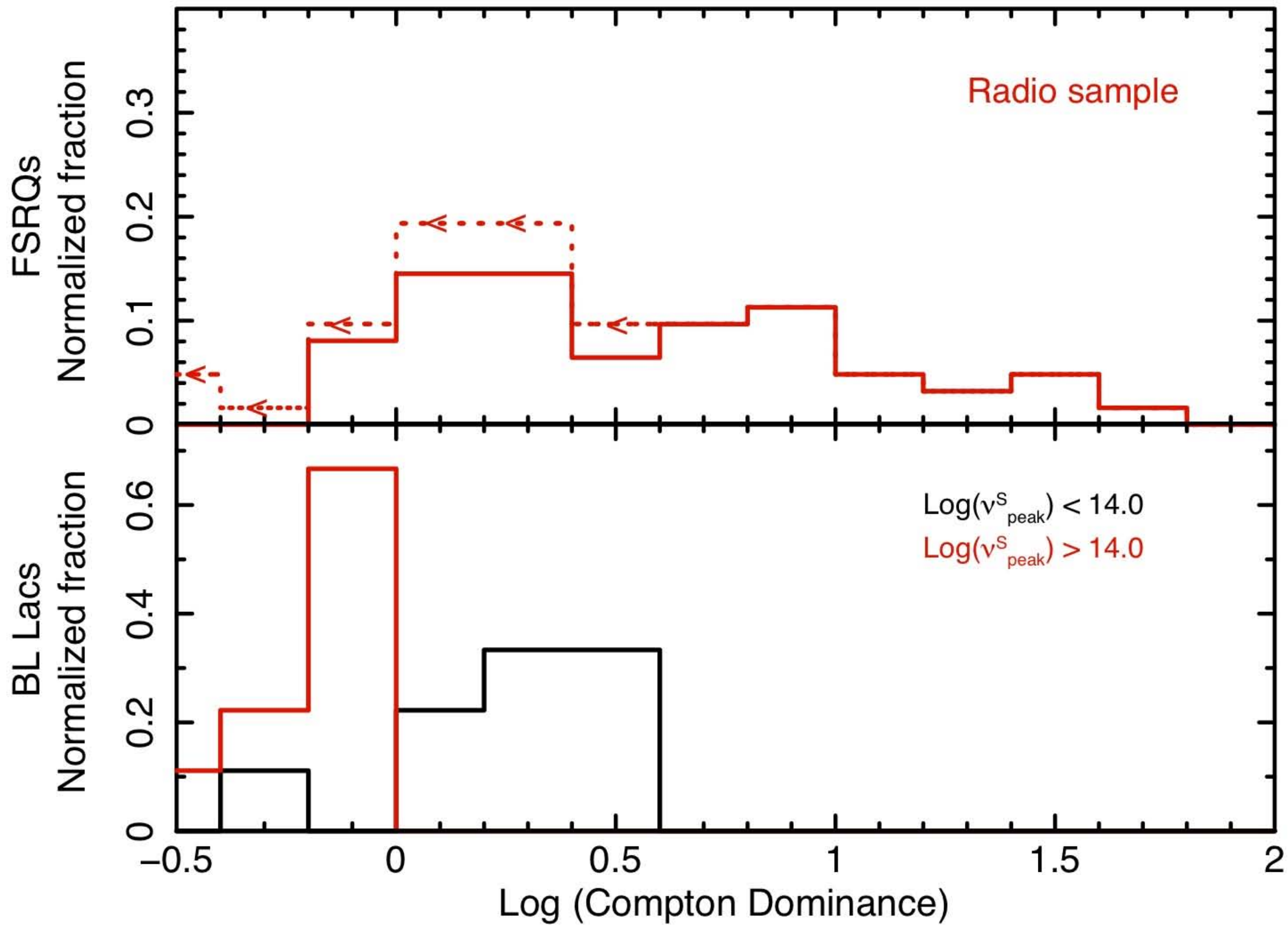


Fig. 10. The SED of the blazar PKS0003-066 as an example of estimation of the upper limits on ν^{IC}_{peak} and on $\nu^{IC}_{peak}F(\nu^{IC}_{peak})$ combining the X-ray data with the 27 month *Fermi*-LAT upper limits.

PRELIMINARY



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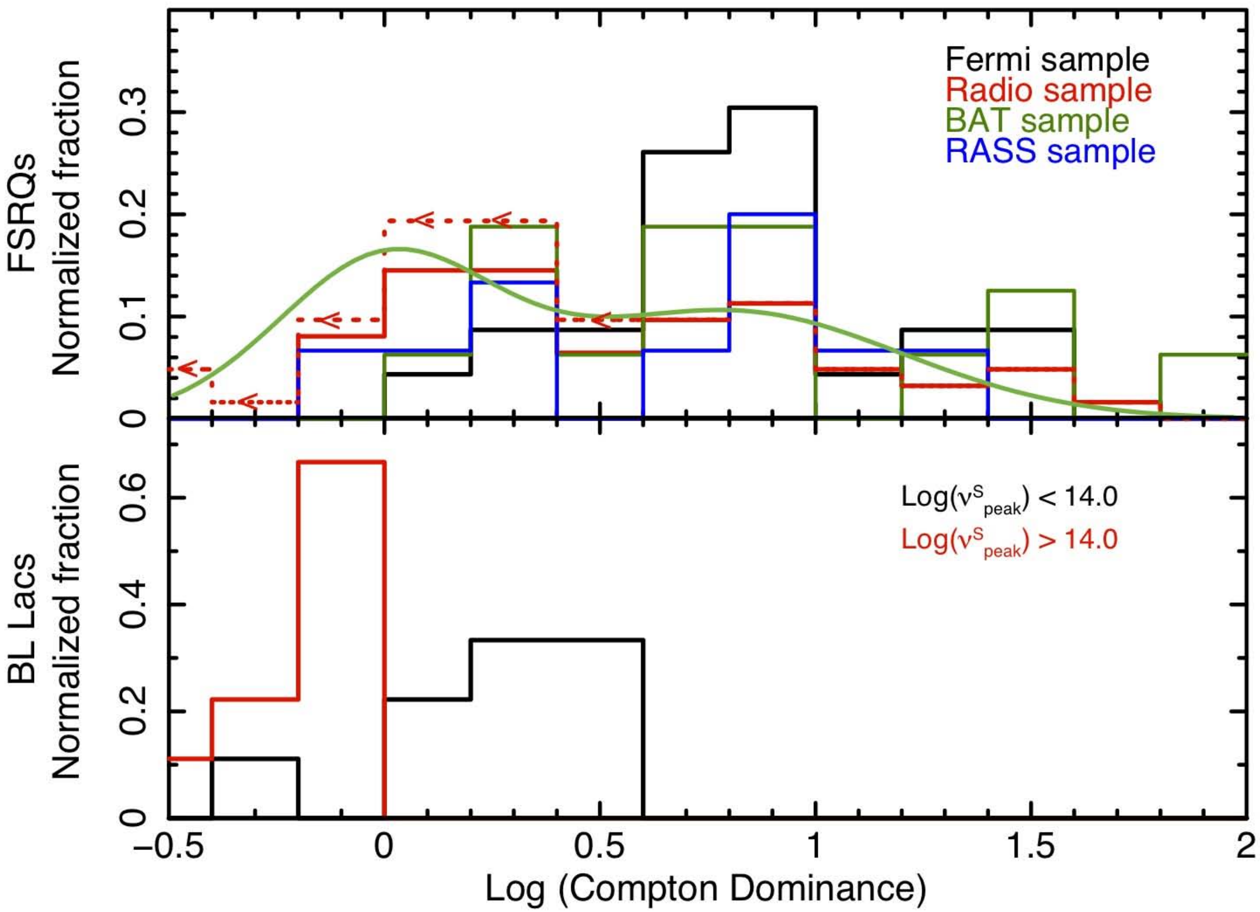
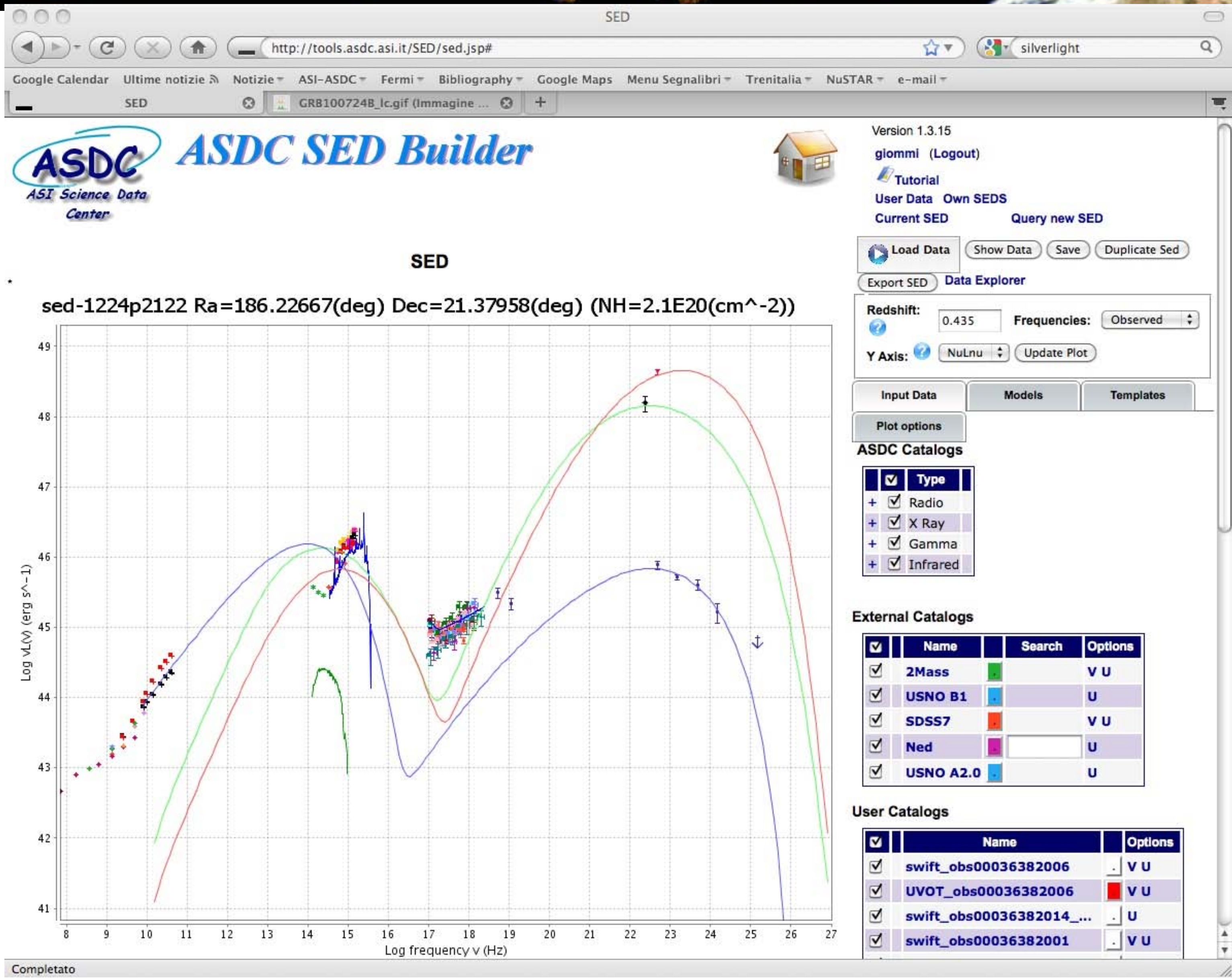
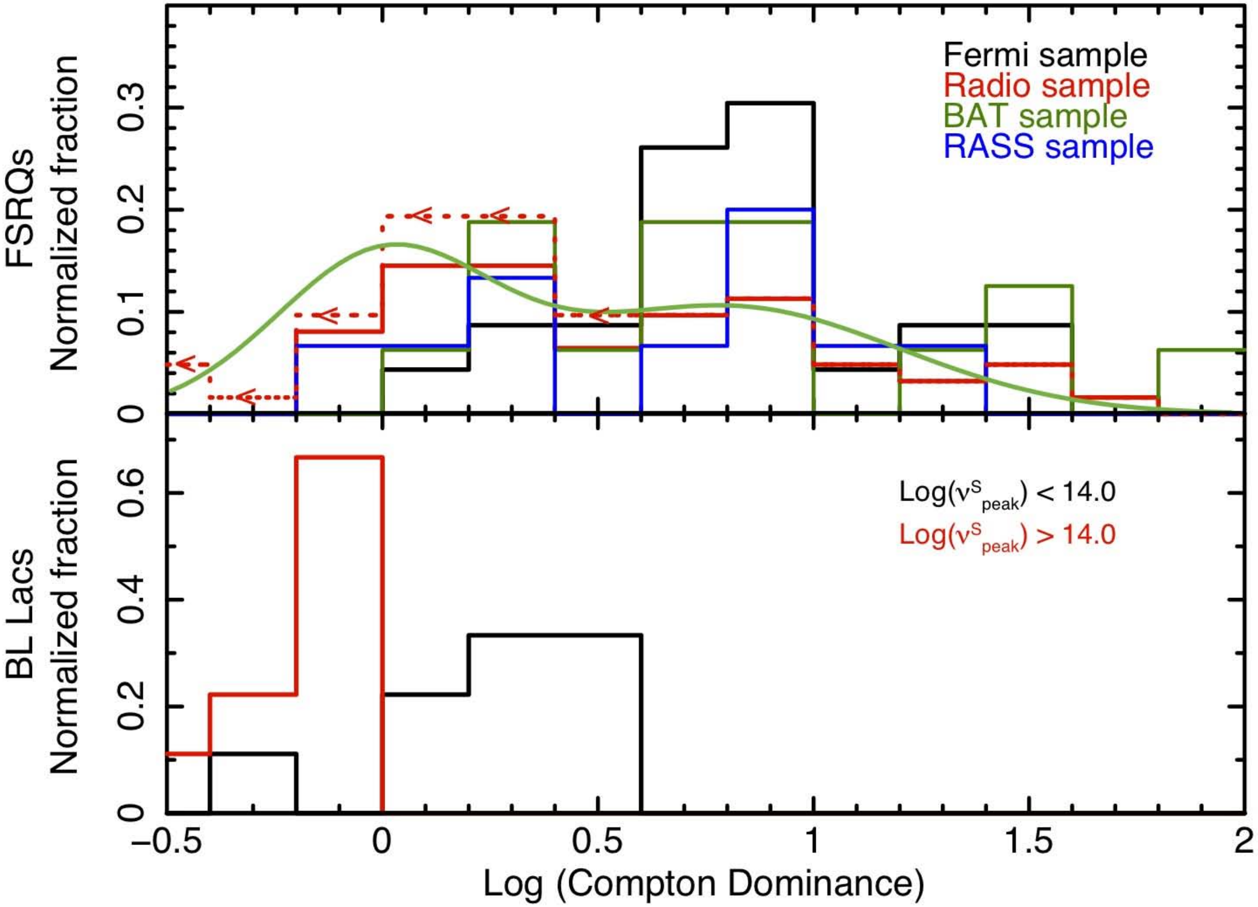


PRELIMINARY

The γ-ray flare of PKS 1222+21



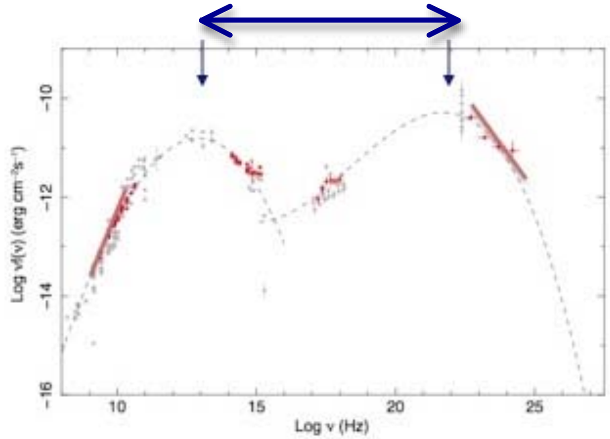


PRELIMINARY

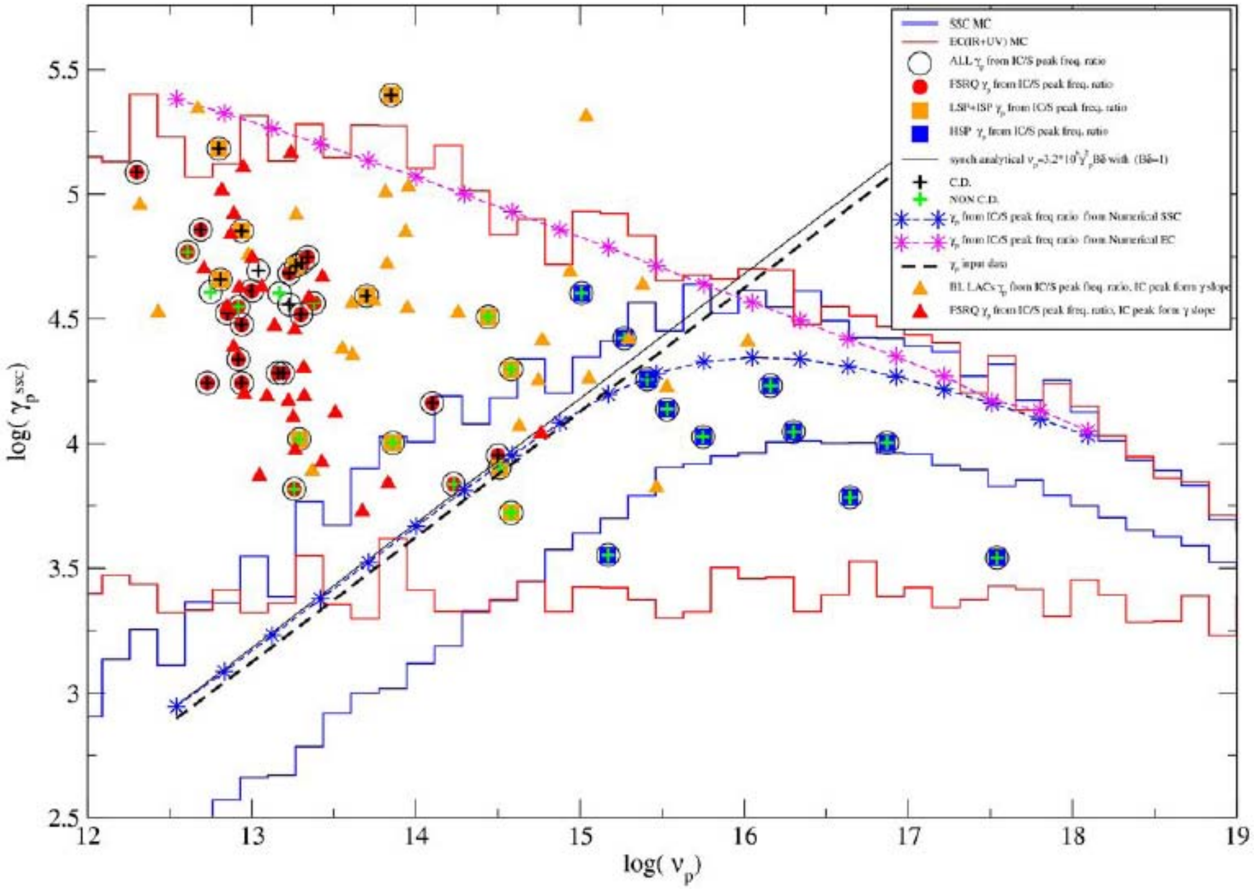
Testing the simplest scenario:
homogeneous SSC

$$\frac{\nu_{peak}^{IC}}{\nu_{peak}^{S}} \simeq \frac{4}{3}(\gamma_{peak}^{SSC})^2$$

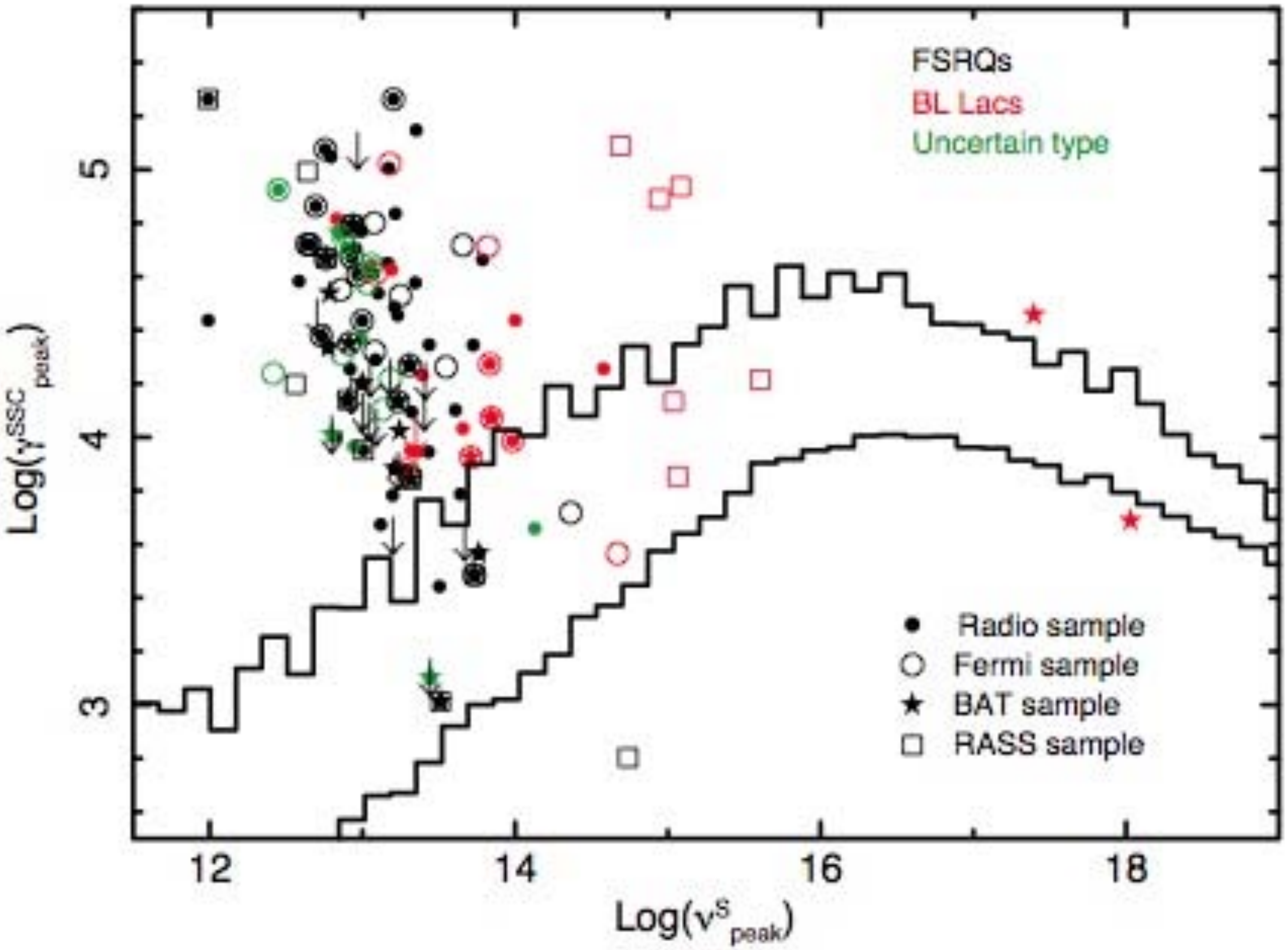
(Thomson regime)



$$\gamma_{peak}^{SSC} = \sqrt{3/4 \cdot \nu_{peak}^{IC} / \nu_{peak}^{S}}$$

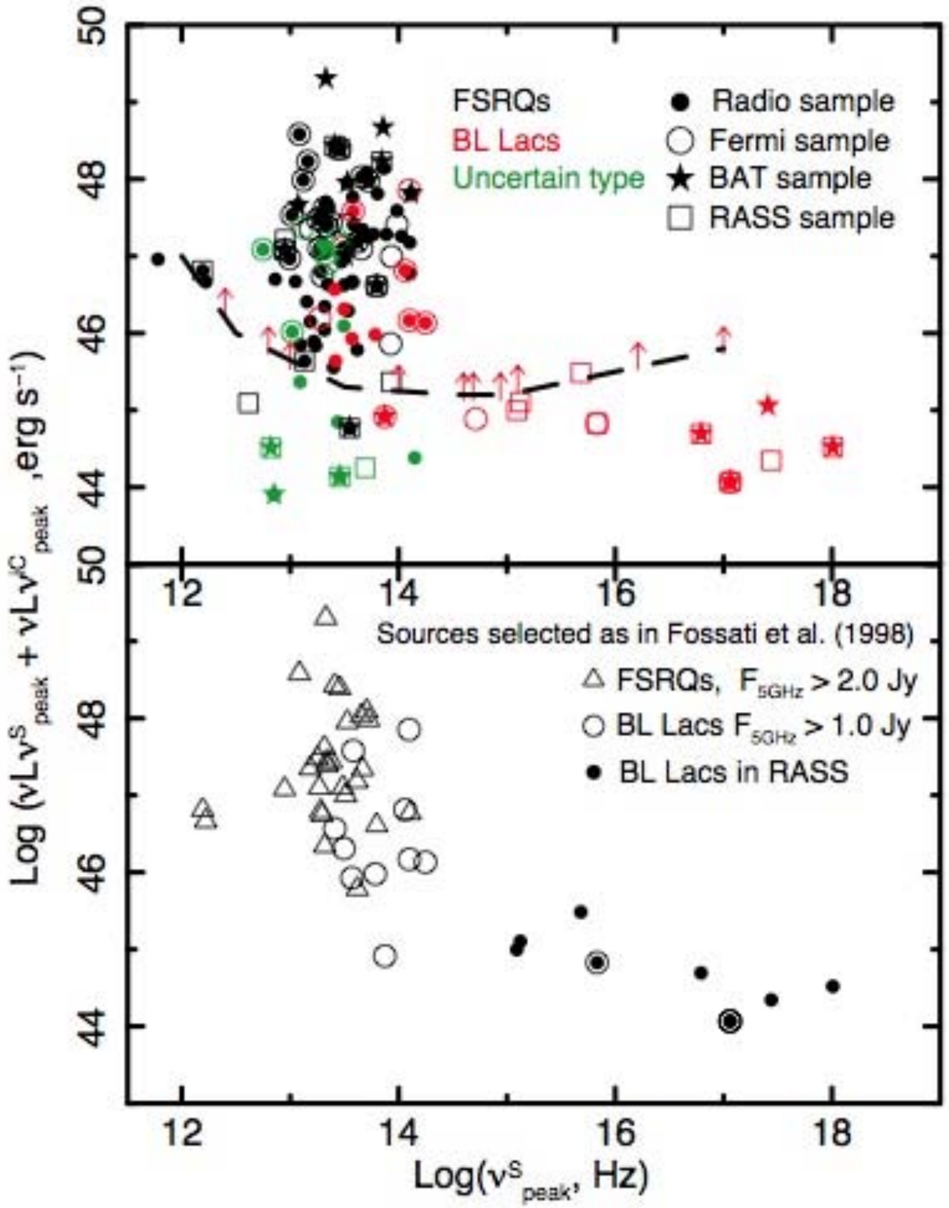


Abdo et al. 2010, ApJ, 716, 30



PRELIMINARY

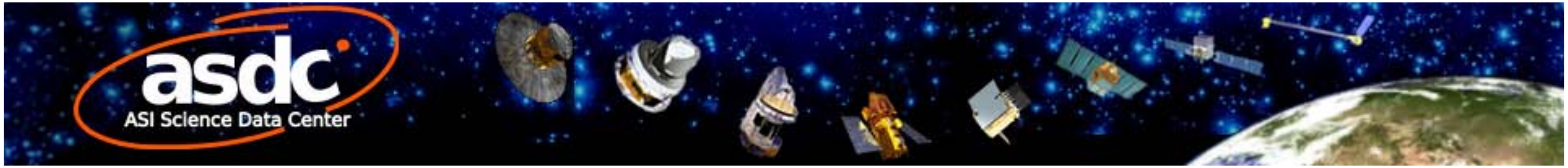
The blazar sequence



Conclusions-1

- **Selection effects play a crucial role in sample composition and induce heavy biases on parameters estimation:**

  Controlling biases is mandatory to understand blazars as a population
- **Almost all BL Lacs have been detected while 30-40% of FSRQs are undetected by Fermi after 27 months**
- **The radio-mm spectral slope of blazars is $\alpha \sim 0$ up to 70 GHz then $\langle\alpha\rangle=0.73$ for FSRQs and $\langle\alpha\rangle=0.51$**
- **Contamination from accretion/disk radiation is important in a significant fraction of FSRQs**
- **The use of simultaneous data removes variations of up to a factor of ~2 in radio and ~10 or more in X-ray and γ-ray data.**



Conclusions-2

- **The distribution of synchrotron peak energy is the same in all FSRQs samples** $\langle \nu^{S}_{\mathrm{peak}} \rangle \approx 10^{13.1\pm0.1}$ Hz
- **BL Lacs show higher peak energies with a distribution heavily dependent on the selection method.**
- **Simple SSC models cannot explain the observed SEDs of most γ-ray detected blazars, the 30/40% of blazars not detected by Fermi-LAT are likely consistent with simple SSC.**
- **Our data Challenge the blazar sequence**