Planck-Swift and Fermi simultaneous observations of blazars
- A multi-selection sample-oriented approach -

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*On behalf of many collaborators*
Planck early results: Planck, Swift and Fermi simultaneous observations of X and $\gamma$-ray selected blazars


To be submitted soon

(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,
  $\gamma$-ray (TS + Flux limited)
  Radio
- Fermi-LAT integrations:
  simultaneous (~1week),
  2 months,
  27 months
Photon index vs luminosity

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

* Total Fermi-LAT sample (TS limited),
** Flux limited Fermi-LAT sample \( F(E > 100\text{MeV}) > 8 \times 10^{-8} \text{ph cm}^{-2} \text{s}^{-1} \)
Fig. 15.— The SED of 0FGL J1058.9+5829 = GB6 J1058+5828 (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 PKS0047-398 (J0426-2726, left side) and of PKS0051+352 (J0033+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 PKS0456-234 (left side) and of PKS0551-35 (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+131), left side) and of PKS0537-441 (J0538-4405, 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.
Measured from the 48 SEDs using 3rd degree polynomial functions
The synchrotron/invc peak frequencies $\nu_{\text{peak}}$ and intensities $f(\nu_{\text{peak}})$ measured from the 48 SEDs using 3rd degree polynomial functions.
Summary of γ-ray detections (TS > 25) in 27 month Fermi-LAT data.

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

PRELIMINARY
Separating jet emission from other types of radiation
The importance of simultaneity
The importance of simultaneity
The importance of simultaneity

PRELIMINARY
\[ \langle \nu_{\text{peak}}^s \rangle = 10^{13.1 \pm 0.1} \text{ Hz} \]
The Compton dominance
The diagram illustrates the distribution of FSRQs and BL Lacs with respect to the Compton Dominance parameter. The X-axis represents the Log of the Compton Dominance, ranging from -0.5 to 2.0. The Y-axis shows the normalized fraction, ranging from 0 to 0.6 for BL Lacs and from 0 to 0.3 for FSRQs.

- **FSRQs**:
  - Normalized fraction from 0.2 to 0.4 for Log(\(\nu_{\text{peak}}^s\)) < 14.0.
  - Normalized fraction from 0.3 to 0.6 for Log(\(\nu_{\text{peak}}^s\)) > 14.0.

- **BL Lacs**:
  - Normalized fraction from 0.2 to 0.4 for Log(\(\nu_{\text{peak}}^s\)) < 14.0.
  - Normalized fraction from 0.0 to 0.2 for Log(\(\nu_{\text{peak}}^s\)) > 14.0.

The RASS sample is indicated by a blue line for Log(\(\nu_{\text{peak}}^s\)) < 14.0 and red line for Log(\(\nu_{\text{peak}}^s\)) > 14.0.
**Fig. 10.** The SED of the blazar PKS0003-066 as an example of estimation of the upper limits on $\nu_{\text{peak}}^{\text{IC}}$ and on $\nu_{\text{peak}}^{\text{IC}} F(\nu_{\text{peak}}^{\text{IC}})$ combining the X-ray data with the 27 month *Fermi*-LAT upper limits.
The Compton dominance - 3

PRELIMINARY
The γ-ray flare of PKS 1222+21
The Compton dominance - 3

PRELIMINARY
Testing the simplest scenario: homogeneous SSC

\[
\frac{\nu_{\text{peak}}^{\text{IC}}}{\nu_{\text{peak}}^{\text{SSC}}} \approx \frac{4}{3} (\gamma_{\text{peak}}^{\text{SSC}})^2
\]

\[
\gamma_{\text{peak}}^{\text{SSC}} = \sqrt{\frac{3}{4} \cdot \nu_{\text{peak}}^{\text{IC}} / \nu_{\text{peak}}^{\text{SSC}}}
\]

(Thomson regime)
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 $<\alpha> = 0.73$ for FSRQs and $<\alpha> = 0.51$
• 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 $\sim 2$ in radio and $\sim 10$ or more in X-ray and $\gamma$-ray data.
Conclusions-2

• The distribution of synchrotron peak energy is the same in all FSRQs samples $\langle \nu_{\text{peak}}^S \rangle \approx 10^{13.1\pm0.1} \text{ Hz}$
• 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 $\gamma$-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