Deep Blazar surveys with Swift

P. Giommi
Agenzia Spaziale Italiana
+ many collaborators:
Swift team, S. Puccetti, M. Capalbi, M. Perri, D. Gasparrini,
E. Cavazzuti, (ASDC), S. Colafrancesco, E. Massaro, P. Padovani.
$3C \, 279$
MKN 421: an HBL Blazar
GLAST-LAT - 1 year simulation

- 3,000-10,000 detected blazars
- significant contribution to CGB from unresolved blazars with radio/μ-wave flux <~ 100 mJy
The large majority of bright WMAP foreground sources are blazars or radio galaxies.

Planck will be in a very similar situation to that of GLAST - LAT (thousands of detected blazars + contribution to unresolved flux).
All microwave selected blazars are X-ray sources.

FSRQ + BL Lacs

BL Lacs only
Swift XRT serendipitous sources in GRBs pointings: the "perfect" serendipitous survey

~1 blazar/field expected with radio flux > 10 mJy!
Swift XRT serendipitous survey in GRB deep fields: status as of end of January 2007

130 deep (4x10⁴-6x10⁵ seconds) GRB exposures analyzed
~11,000 sources detected with positional uncertainty of 4-6 arcsecs.
90 fields are at |bII| > 20 : ~8,000 sources
164 radio/X-ray matches (blazar candidates)
Swift J101724.4+432905: FSRQ, z=1.1735
$f_X \sim 6 \times 10^{-14} \text{erg/cm}^2/\text{s}, \ 197 \ \text{mJy @ 1.4 GHz}$
Swift J015700.6+085403:
$f_X \sim 5 \times 10^{-14} \text{erg/cm}^2/\text{s}, \; 122 \text{ mJy @ 1.4 GHz}$
Blazars @ waves frequencies: the 3-year WMAP data

Results of $\langle V/Vm \rangle$ test
($\Omega_m=0.3$, $\Omega_\Lambda=0.7$)

<table>
<thead>
<tr>
<th>Sample</th>
<th>$\langle V/Vm \rangle$</th>
<th>Flux limit @41 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSRQ (145)</td>
<td>0.63 +/-0.023</td>
<td>1000 mJy</td>
</tr>
<tr>
<td>BL Lacs (27)</td>
<td>0.62 +/-0.055</td>
<td>1000 mJy</td>
</tr>
</tbody>
</table>
Radio flux limits
50-100 mJy
X-ray flux limits
2.e-14/5.e-13 0.3-2 keV

Table 1. Complete sample composition.

<table>
<thead>
<tr>
<th>Class</th>
<th>Total</th>
<th>Newly identified</th>
<th>Previously known</th>
<th>No redshift</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSRQ</td>
<td>129</td>
<td>79</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>BL Lacs</td>
<td>24</td>
<td>13</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>BL Lacs, $\alpha_r &gt; 0.5$</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>SSRQ$^a$</td>
<td>33</td>
<td>24</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Radio Galaxies$^a$</td>
<td>17</td>
<td>9</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified, $\alpha_r &gt; 0.5$</td>
<td>6</td>
<td>6</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

$^a$The SSRQ and radio galaxies samples are obviously incomplete, as our radio spectral index cut excludes by definition the majority of these sources.
Fig. 7.— The banded $(\bar{V}/V_0)$ statistic, ($(V_i - V_0)/(V_i - V_0)$) versus $z$, for DXRQS PSRQs. The horizontal dashed line indicates the value of $0.5$ expected under the null hypothesis of no evolution. The statistical error bars, given by $(12N)^{0.5}$, where $N$ is the number of objects in the subsample with $z > z_0$, are shown for selected redshifts.
CMB spectrum contamination
Dark matter-blazar angular power spectrum

Blazars
Dark matter
GLAST expected signal
Deep Blazars survey in Swift GRB fields
Conclusions and prospects

• ~200 Swift deep GRB fields available today (20 sq deg of sky)
  (300 at the end of 2007)
• 150-200 blazars in radio flux limited sample \( f_{5\text{GHz}} = 10 \text{ mJy} \)
  ~ 400-500 blazars with radio flux down to ~ 1 mJy
• Extensive multi-frequency data available (in principle)
  (from GRB follow-up observations)

• Radio LogN-LogS to 10 mJy, radio LF + Cosmological evolution
• Volume-limited X-ray survey to \( z=0.5 \) for \( L_x > 5.\times\text{e}^{42} \text{ erg/s} \)
• Tight constraints to microwave and gamma-ray backgrounds.