Swift Contributions to Blazar Studies

Rita Sambruna
NASA’s GSFC
Swift as a multiw “slave”

- Many blazar campaigns initiated by Fermi LAT and/or TeV detections
- Fermi-supported GI programs (e.g., XRT, PI Falcone)
- Previous multiwavelengths campaigns for flaring sources, e.g., 3C454.3
- Centered on XRT and UVOT
Swift-driven: BAT

- Discovery of MeV-peaked blazars
- Blazar contribution to the MeV background
- BAT, LAT, and the blazar family

Fill-in projects, XRT/UVOT: X-ray selected FSRQs, MOJAVE sources, SDSS-selected BL Lacs, ...
Many Thanks to:

- My jet collaborators - D. Donato, M. Ajello, L. Maraschi, F. Tavecchio, M. Gliozzi, T. Cheung
- The BAT Team at GSFC
- The Swift Team
- Neil Gehrels
Blazars

- "Blazar" Viewing down the jet
- "Quasar / Seyfert 1" Viewing at an angle to the jet
- "Radio Galaxy / Seyfert 2" Viewing at 90° from the jet

- Black Hole
- Accretion Disk
- Torus of Neutral Gas and Dust
- Radio Jet

Compact jet physics
Open questions

- Origin of high-energy emission
- Acceleration processes
- Launching processes
- What causes variability
- Jet composition, power
- Jet-disk connection: how much accretion luminosity into jets?
Emission Processes

Chandra jet

EC

Synchr

SSC

BLR

Blazar

JET

$10^{-22-24}$ cm

$10^{18}$ cm

$10^{17}$ cm

$3 \times 10^{14}$ cm

Log $v/f_0$

Log Frequency (Hz)
The Blazar Family

Donato et al. 2004

LBLs + HBLs = BL Lacs
The family at gamma-rays

Ghisellini
Et al. 2009
High-energy continua

- Generally poorly known above 10 keV
- Where is the Compton peak in the various classes? How much luminosity? Variability?
BAT discovery of MeV Blazars

RMS et al. 2006
\[ P_{\text{jet}} = 1 - 10 \, L_{\text{disk}} \sim M_{\dot{\text{mass}}} \]
The Jet-Disk Connection

Ghisellini et al. 2009
MeV Blazars

- Hard BAT spectrum implies IC peak around a few MeV in SEDs of individual quasars
- Confirm blazar sequence expectations
- Set constraints on jet-disk models

Can MeV blazars account for the CXB above 100 keV?
The MeV background “resolved”

Ajello et al. 2009
Assumptions: double powerlaw FSRQs with peak at ~MeV.

FSRQS: *Hard* BAT & *soft* LAT continua (Ajello et al. 2009)

Confirmed by LAT 3 months Bright AGN List (Abdo et al. 2009)
A BAT-LAT Cross study

- BAT 36 months survey: 38 blazars, 5sigma
- LAT three months Bright AGN list: 99 blazars, 10 sigma
- Intersection: 22 sources
  - 12 FSRQs
  - 10 BL Lacs (4 TeV sources)

First hard X-ray/gamma-ray selected sample of blazars; no optical or radio bias
No redshift bias
Trend of Shapes

RMS et al. 2010
Luminosity Dependence

Significant at 97% with MC simulations

RMS et al. 2010
For increasing luminosity:

**BAT continuum harder**
**LAT continuum softer**

RMS et al. 2010
Interpretation

We recover the blazar family at the higher energies AND With a high-energy selected sample
An unbiased way to classify

High-energy continua sufficient to distinguish classes of blazars

Looking forward to many more years of BAT-LAT synergy!
Conclusions

In 5 years of operations, the BAT has:

◆ Discovered a new class of blazars - the MeV blazars
◆ Resolved the mystery of the CXB background in 15-100 keV
◆ Validated and extended our knowledge about the blazar family
◆ … and more (with the help of XRT and UVOT)
Happy Anniversary, Swift!

Live Long & Fly Well
LAT bias effect