Swift Monitoring of Fermi Blazars and Other Sources

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Other Multiwavelength Collaborators: H. Aller, M. Aller, A. Ariel, M. Beilicke, D. Burrows, N. Gehrels, M. Boettcher, P. Coppi, P. Giommi, E. Hoversten, H. Krawczynski, H. Krimm, K. Lee, S. Thibadeau, P. Roming, Swift-XRT Team, VERITAS Collaboration

Fermi "Sources of Interest"

0208-512
0235+164
PKS 0528+134
PKS 0716+714
0827+243
OJ 287
Mrk 421
W Com
3C 273
3C 279
1406-076
H 1426+428
1510-089
PKS 1622-297
1633+383
Mrk 501
3EGJ1733-1313
1ES 1959+650
PKS 2155-304
BL_Lacertae
3C 454.3
1ES 2344+514
LS I +61 303

- For a list of 23 "sources of interest," light curves and some reduced data are being released
- Flaring sources also receive ATELs followed by public release of data
- Most of these sources are blazars

  (one X-ray/TeV binary: LS I +61303)

Why Study these HE-VHE Blazars?

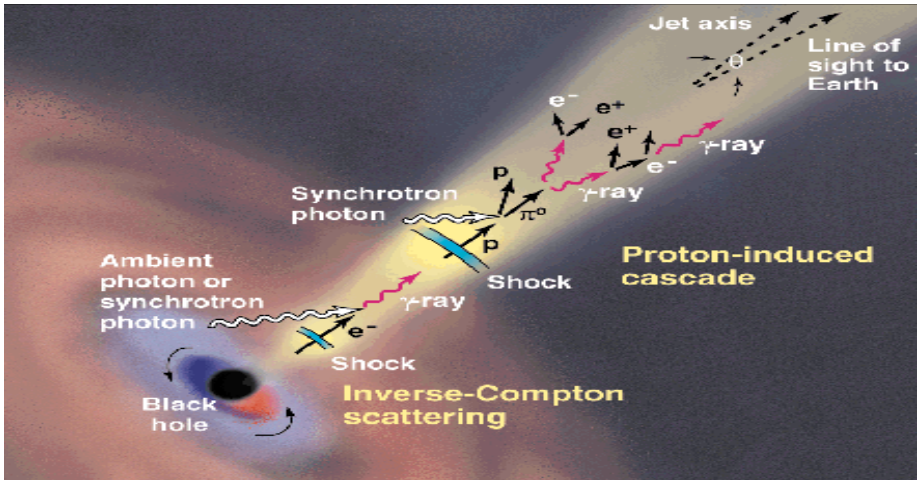
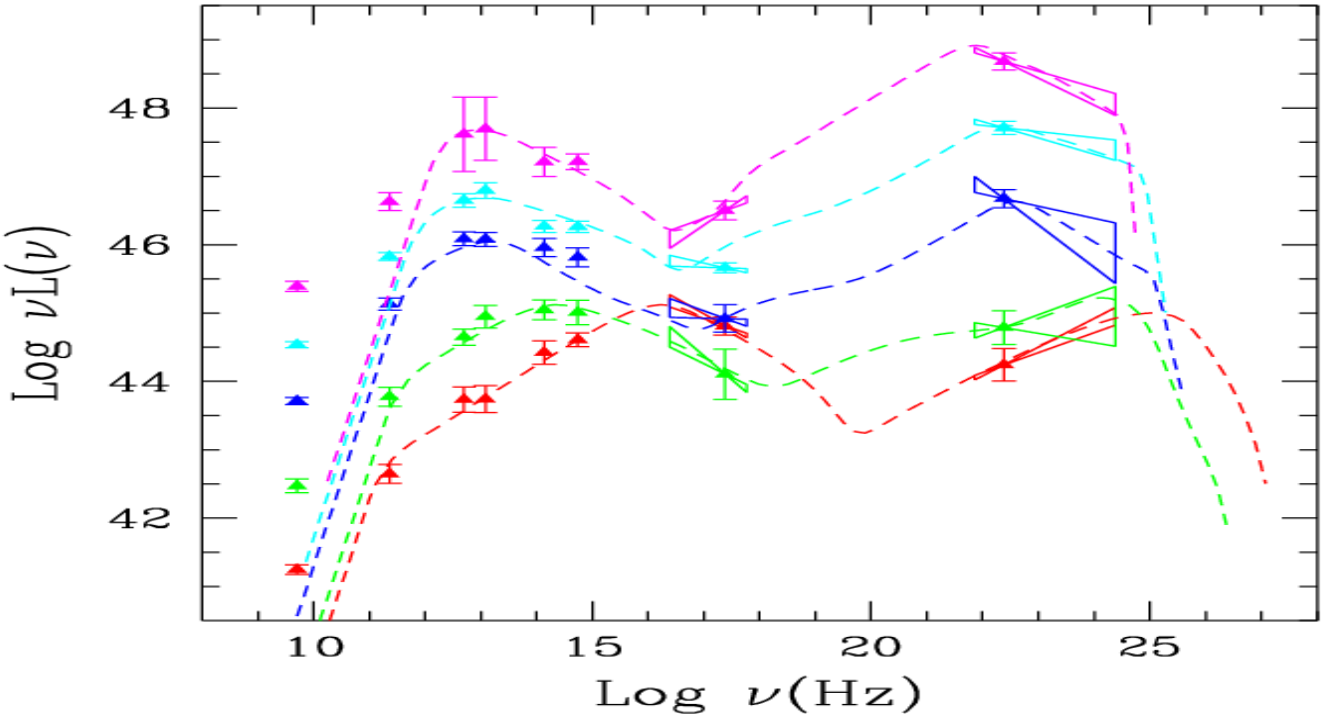


Figure from J.Buckley 1998

- Need to understand acceleration mechanisms capable of producing large luminosity at very high energies and below:
  - SSC? (Maraschi et al. 92, Tavecchio et al 98, …)
  - External IC? (Dermer & Schlickeiser 2002, …)
  - Proton cascades? (Mannheim 93, …)
  - Proton synchrotron? (Muecke & Protheroe 2000, Aharonian 2000, …)
- Constrain blazar environment characteristics: Doppler factor, seed populations, photon vs. magnetic energy density, accel. and cooling timescales, …
- Need to understand blazar development and evolution
- Potential sources of cosmic ray acceleration
- Constrain models of extragalactic infrared background
- Potentially enable studies of Lorentz Invariance and quantum Gravity

Blazar Sequence and Categories

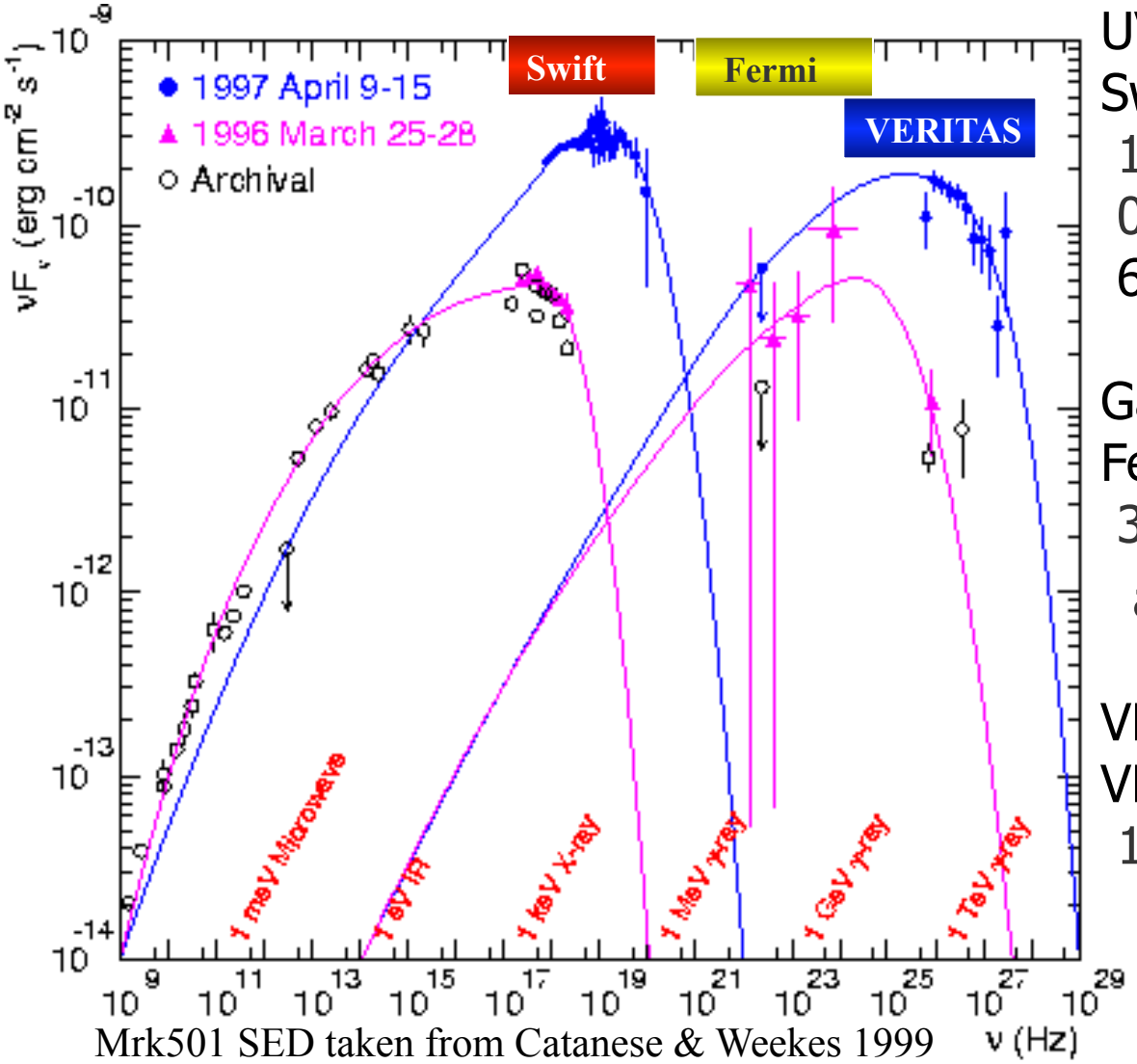
- FSRQ Vs. BL Lac
- Low Peaked Vs. High Peaked



• Is the "blazar sequence" strictly a luminosity effect, or is it complicated by e.g. source selection effects, time variability, Doppler boosting dependence, …?

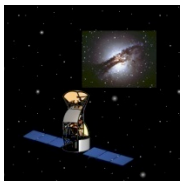
See: Fossati et al. 1998, Ghisselini et al. 1998, Nieppola et al., 2008,
Giommi et al. 2009 (these proceedings), Lee et al. 2009 (these proceedings)

Importance of Broadband Simultaneous Coverage



Mrk501 SED taken from Catanese & Weekes 1999

UV/optical & X-ray Spectrum:
Swift,...
15 keV - 150 keV
0.2 keV – 10 keV
650 nm - 170 nm

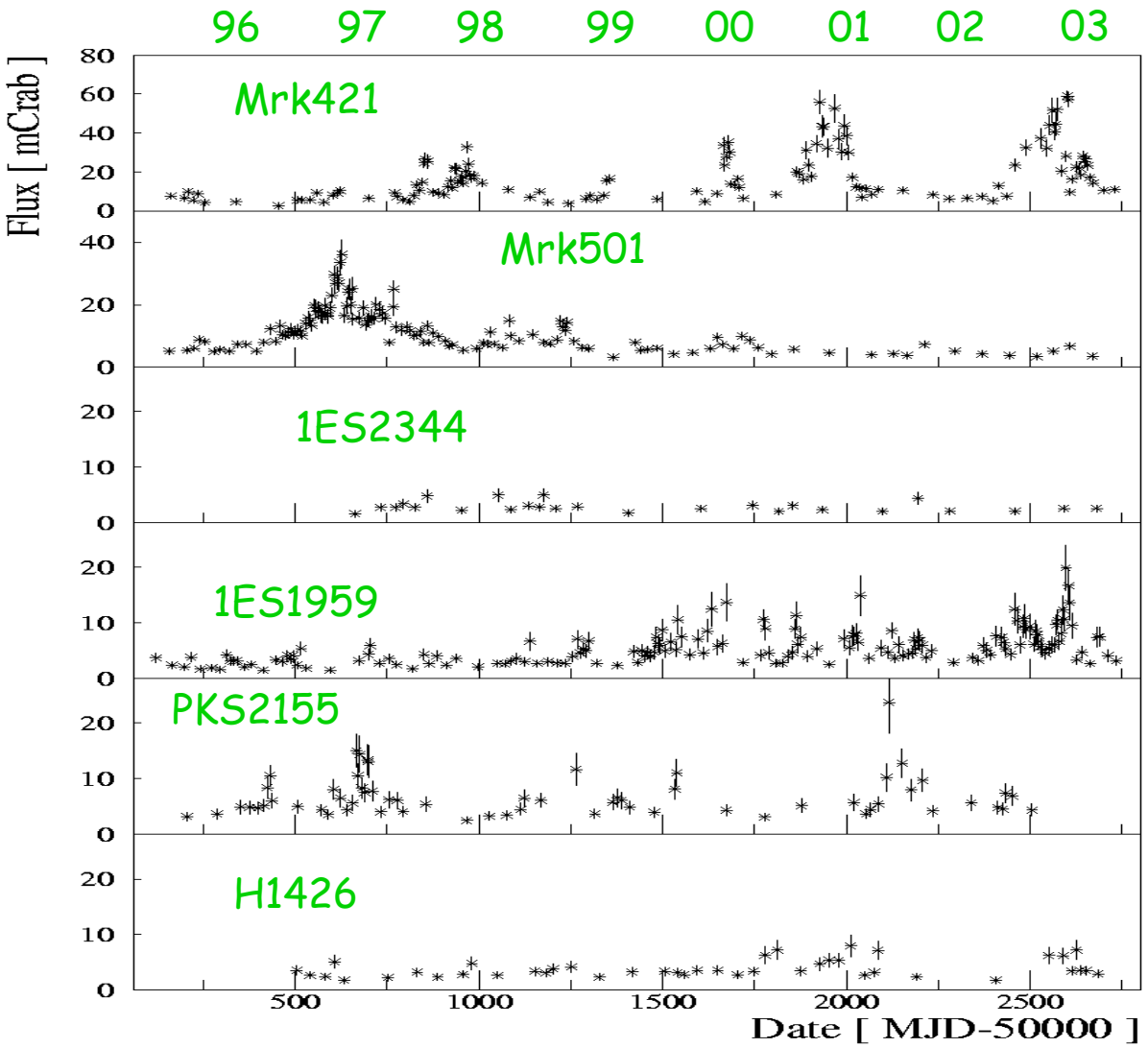


Gamma ray:
Fermi, AGILE,...
30 MeV – 300 GeV
all sky

VHE:
VERITAS, HESS, MAGIC, ...
100 GeV – 50 TeV

Myriad Variability Timescales

→ We need *monitoring* AND simultaneous observations



2-10 keV

Krawczynski et al. 2003

Swift Monitoring Program

- Swift is monitoring each of these "sources of interest" with ~1 ksec pointed observations 1/week for 4 months/year

  → Sensitive X-ray and optical spectra with XRT & UVOT

- Swift increases frequency of monitoring in the event of flaring and/or other ToOs or campaigns
- An automated web page has been created at:

  http://www.swift.psu.edu/monitoring

- *This web page has near-real-time light curves and hardness ratios of all sources, along with downloadable reduced data files*

Swift Observations of LAT Monitored Sources

http://www.swift.psu.edu/monitorir

Most Visited

Swift Observations of LAT Monito...

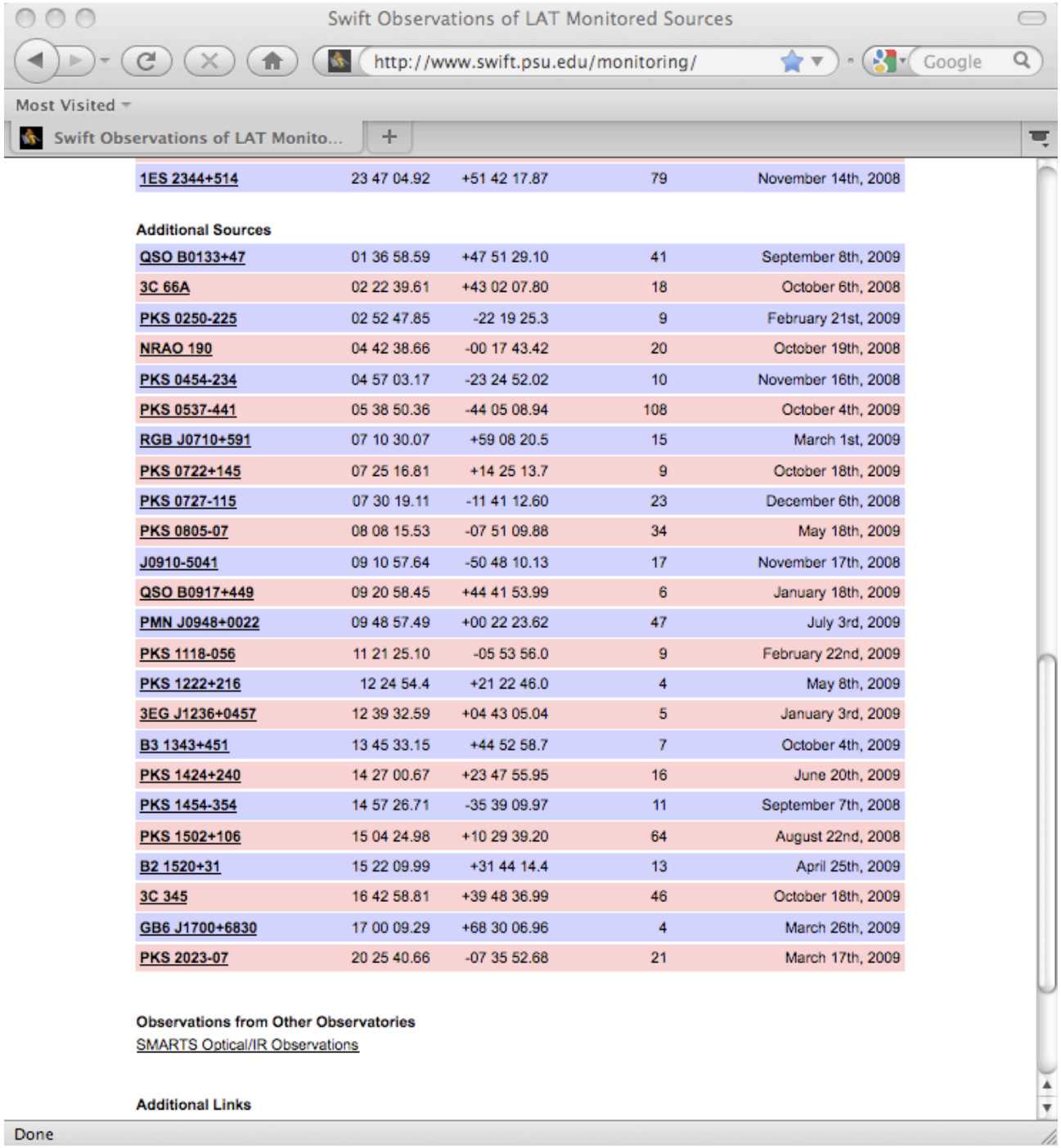
The results presented on this page are from a preliminary analysis of the *Swift*-XRT data. The analysis procedure is described in this README file. Since the analysis is performed using automated scripts and the results are not always reviewed by human eyes, we recommend that these data be reviewed by hand before use in publications.

For questions or requests for more detailed analysis, please contact Abe Falcone and Michael Stroh at xrtmonitoring@astro.psu.edu. This web site is under construction so please report any web site related problems to the email address listed above.

HEASARC Last Queried: October 29, 2009, 09:55:26 EST

Target	RA (J2000)	Dec (J2000)	Duration (ks)	Last Observation
PKS 0208-512	02 10 46.20	-51 01 01.89	82	October 28th, 2009
PKS 0235+164	02 38 38.93	+16 36 59.28	97	October 13th, 2009
LSI+61 303	02 40 31.67	+61 13 45.60	201	October 26th, 2009
PKS 0528+134	05 30 56.42	+13 31 55.15	80	September 24th, 2009
S5 0716+714	07 21 53.45	+71 20 36.36	89	October 16th, 2009
QSO B0827+243	08 30 52.09	+24 10 59.82	21	April 10th, 2009
OJ 287	08 54 48.87	+20 06 30.64	111	October 28th, 2009
Mrk 421	11 04 27.31	+38 12 31.80	438	May 27th, 2009
W Com	12 21 31.69	+28 13 58.50	83	May 22nd, 2009
3C 273	12 29 06.70	+02 03 08.60	105	May 11th, 2009
3C 279	12 56 11.17	-05 47 21.52	347	August 2nd, 2009
1Jy 1406-076	14 08 56.48	-07 52 26.67	19	June 9th, 2009
H 1426+428	14 28 32.60	+42 40 29.00	118	June 24th, 2009
PKS 1510-089	15 12 50.53	-09 05 59.83	180	August 30th, 2009
PKS 1622-297	16 26 06.02	-29 51 26.97	13	July 17th, 2009
1Jy 1633+38	16 35 15.49	+38 08 04.50	50	July 21st, 2009
Mrk 501	16 53 52.22	+39 45 36.61	170	October 27th, 2009
PKS 1730-130	17 33 02.71	-13 04 49.55	59	August 7th, 2009
1ES 1959+650	19 59 59.85	+65 08 54.65	71	September 26th, 2009
PKS 2155-304	21 58 52.07	-30 13 32.12	114	October 21st, 2009
BL Lacertae	22 02 43.29	+42 16 39.98	150	October 27th, 2009
3C 454.3	22 53 57.74	+16 08 53.57	294	October 25th, 2009
1ES 2344+514	23 47 04.92	+51 42 17.87	79	November 14th, 2008

Done



1ES 2344+514	23 47 04.92	+51 42 17.87	79	November 14th, 2008

Additional Sources

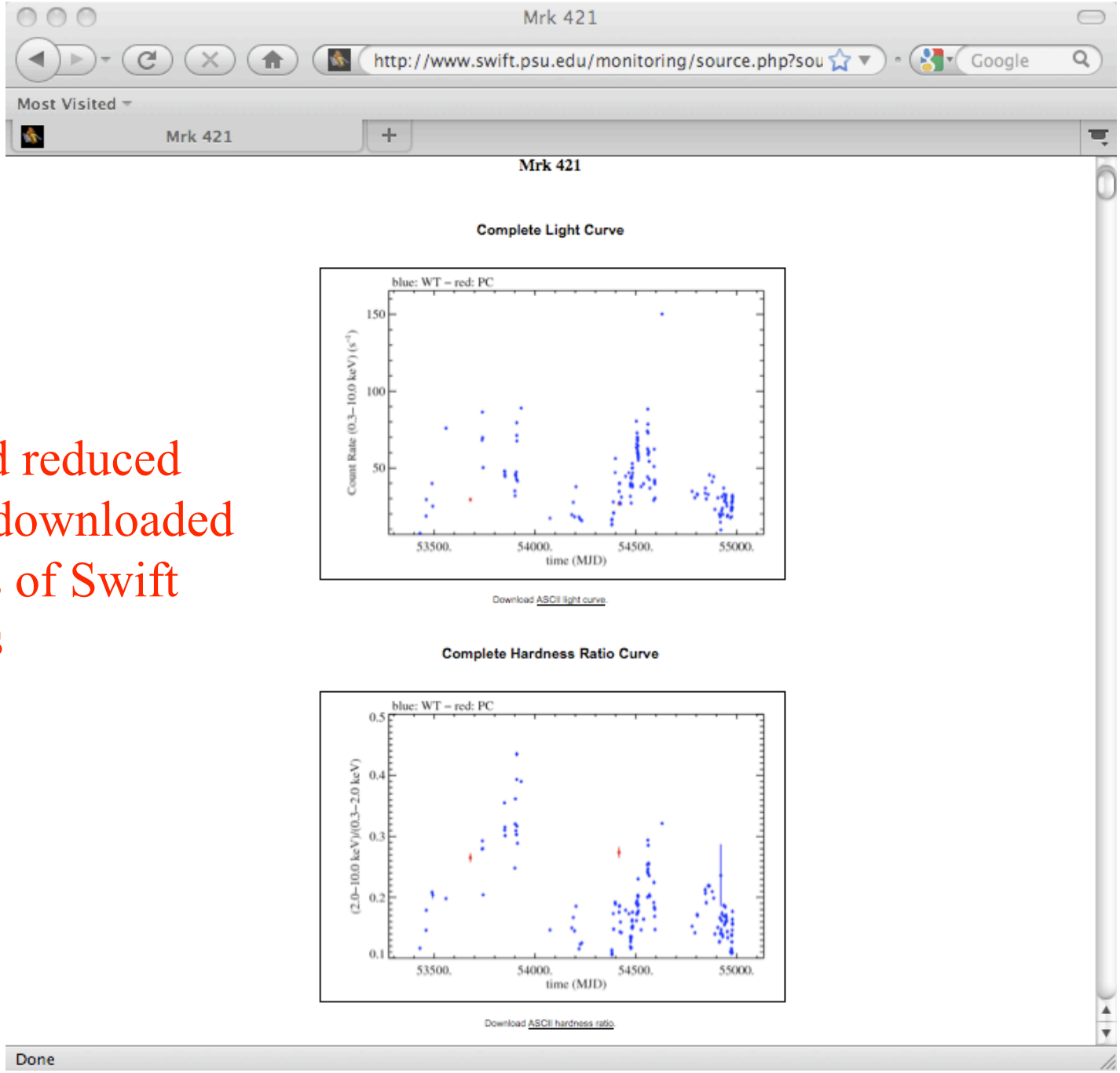
QSO B0133+47	01 36 58.59	+47 51 29.10	41	September 8th, 2009
3C 66A	02 22 39.61	+43 02 07.80	18	October 6th, 2008
PKS 0250-225	02 52 47.85	-22 19 25.3	9	February 21st, 2009
NRAO 190	04 42 38.66	-00 17 43.42	20	October 19th, 2008
PKS 0454-234	04 57 03.17	-23 24 52.02	10	November 16th, 2008
PKS 0537-441	05 38 50.36	-44 05 08.94	108	October 4th, 2009
RGB J0710+591	07 10 30.07	+59 08 20.5	15	March 1st, 2009
PKS 0722+145	07 25 16.81	+14 25 13.7	9	October 18th, 2009
PKS 0727-115	07 30 19.11	-11 41 12.60	23	December 6th, 2008
PKS 0805-07	08 08 15.53	-07 51 09.88	34	May 18th, 2009
J0910-5041	09 10 57.64	-50 48 10.13	17	November 17th, 2008
QSO B0917+449	09 20 58.45	+44 41 53.99	6	January 18th, 2009
PMN J0948+0022	09 48 57.49	+00 22 23.62	47	July 3rd, 2009
PKS 1118-056	11 21 25.10	-05 53 56.0	9	February 22nd, 2009
PKS 1222+216	12 24 54.4	+21 22 46.0	4	May 8th, 2009
3EG J1236+0457	12 39 32.59	+04 43 05.04	5	January 3rd, 2009
B3 1343+451	13 45 33.15	+44 52 58.7	7	October 4th, 2009
PKS 1424+240	14 27 00.67	+23 47 55.95	16	June 20th, 2009
PKS 1454-354	14 57 26.71	-35 39 09.97	11	September 7th, 2008
PKS 1502+106	15 04 24.98	+10 29 39.20	64	August 22nd, 2008
B2 1520+31	15 22 09.99	+31 44 14.4	13	April 25th, 2009
3C 345	16 42 58.81	+39 48 36.99	46	October 18th, 2009
GB6 J1700+6830	17 00 09.29	+68 30 06.96	4	March 26th, 2009
PKS 2023-07	20 25 40.66	-07 35 52.68	21	March 17th, 2009

Observations from Other Observatories

SMARTS Optical/IR Observations

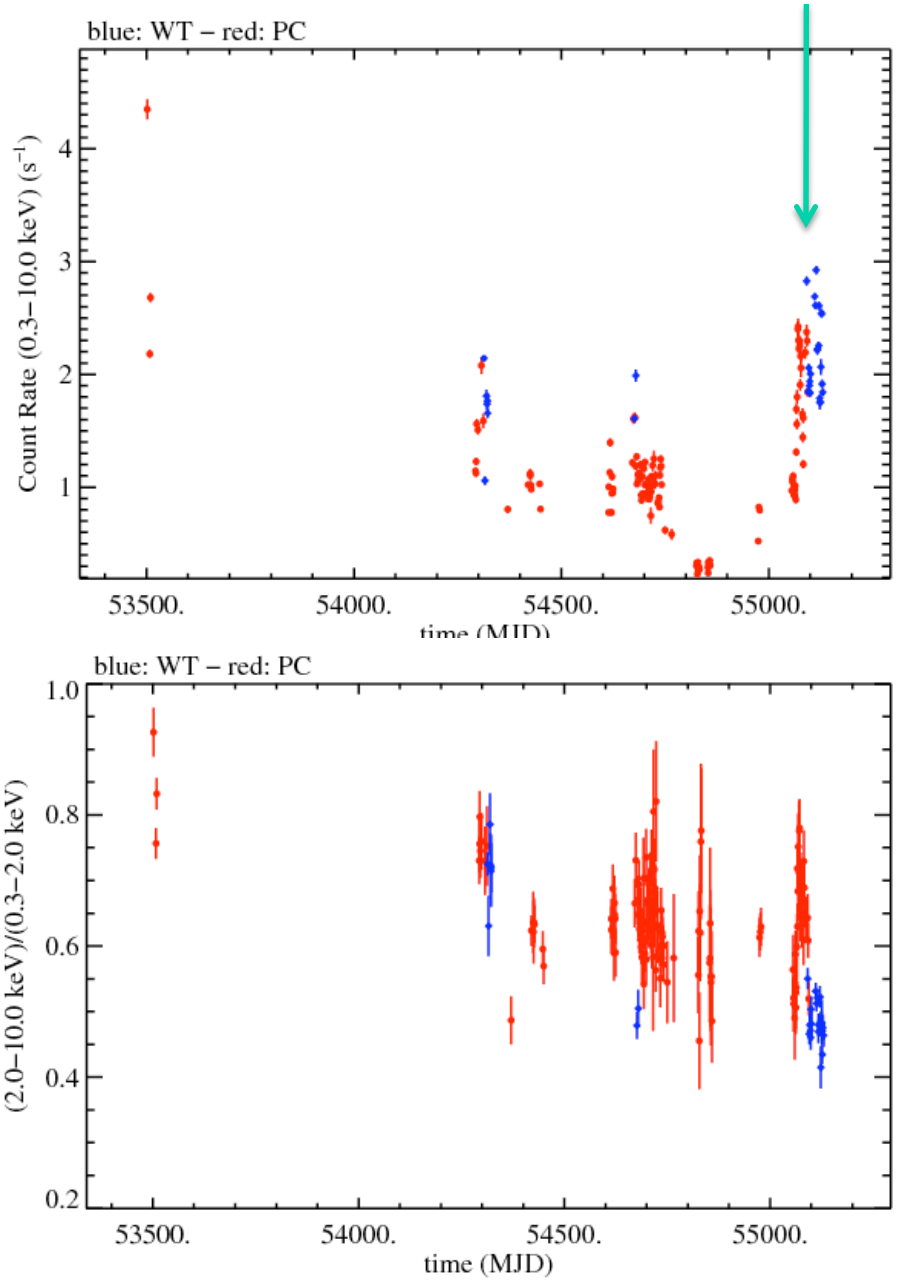
Additional Links

All plots and reduced data can be downloaded within hours of Swift observations



An example: 3C454.3

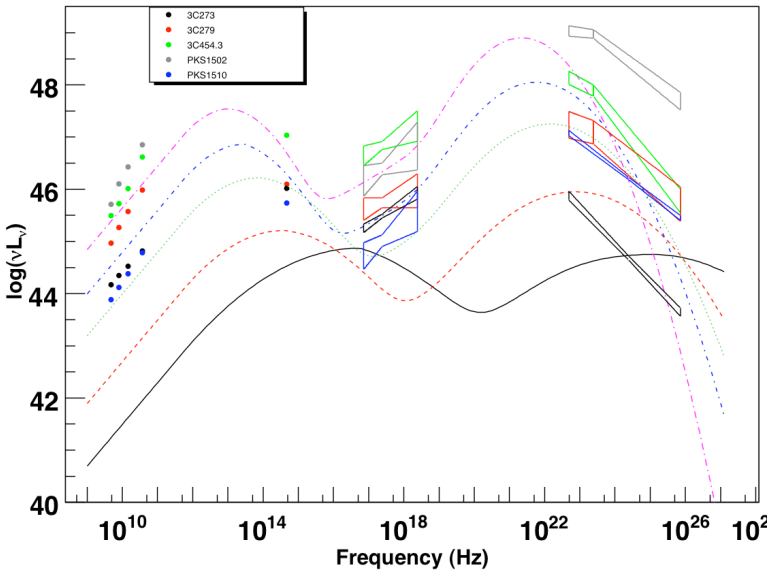
- Fermi ATEL issued for high gamma ray state on 15 Sep 2009
- This was part of a continuing (>100 days) rise in activity level measured at X-ray energies
- At some of the active times, the X-ray hardness is decreasing as the flux in both X-rays and gamma rays is increasing, possibly indicating a shift in L & ν_{peak}

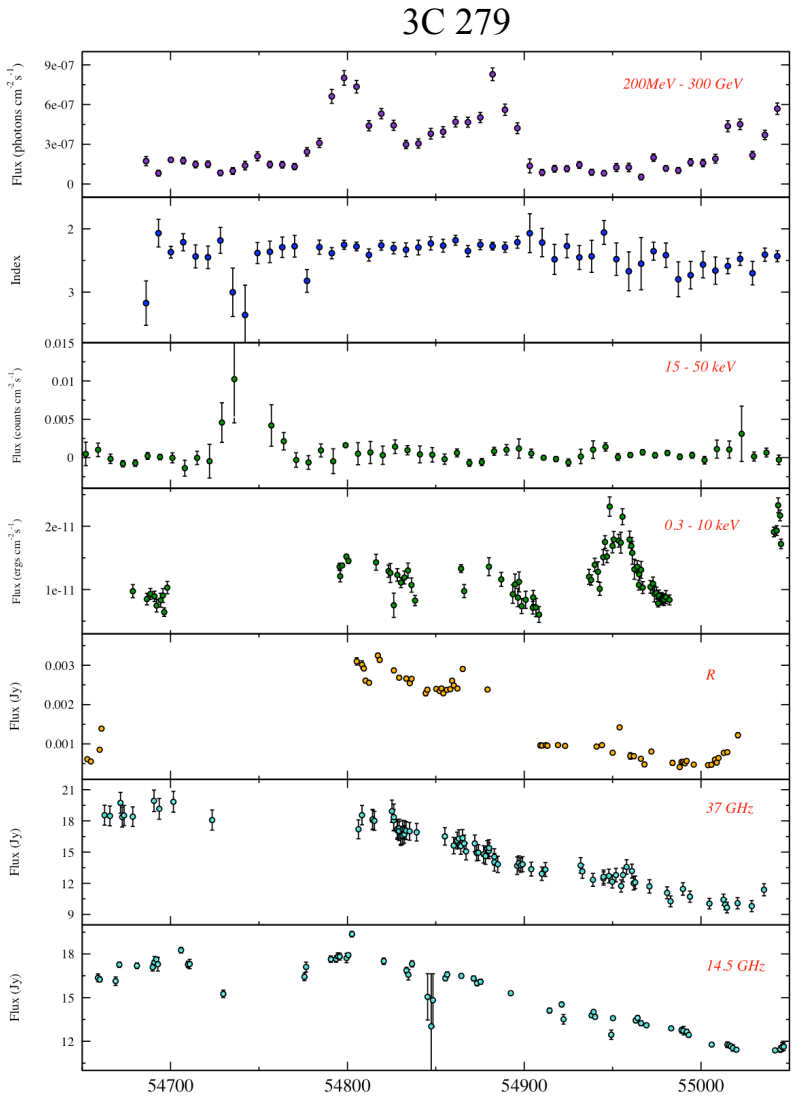


Time dependent Blazar SEDs

These Swift and Fermi monitoring data are being used, in conjunction with other multiwavelength data, to systematically study all monitored blazars SEDs and locate them within the "blazar sequence" and the time variability of the ν_{peak} location relative to flux

(poster: Lee et al., these proceedings)



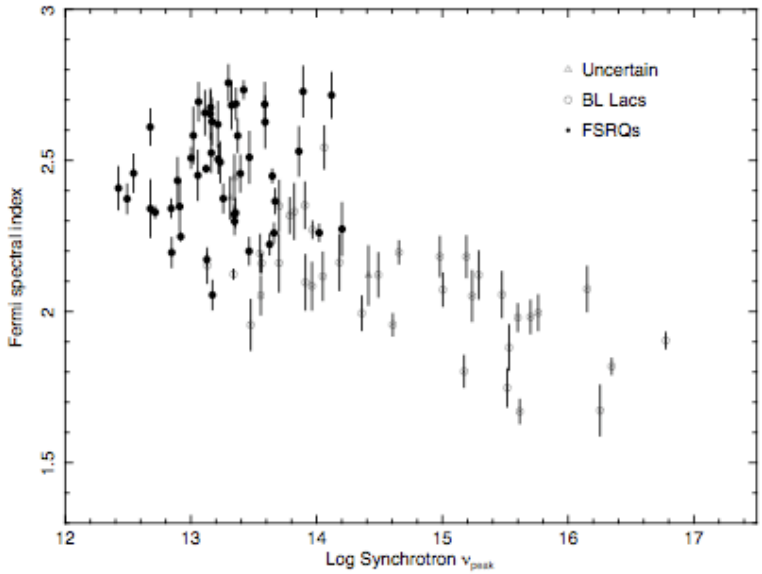


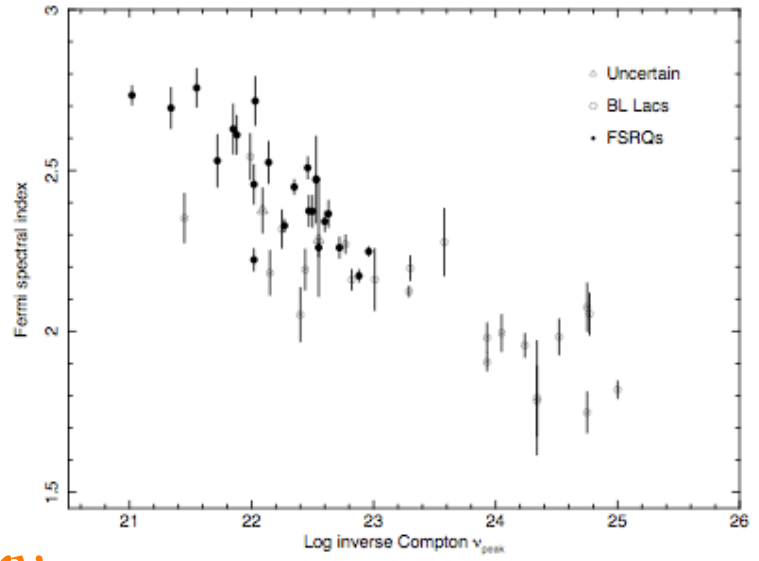
preliminary

Blazar Sequence Study

- These monitoring observations have been combined with more extensive monitoring to study relationships between X-ray and gamma-ray spectra for large samples

(see talk by Giommi et al. in these proceedings; and Abdo et al., in preparation)

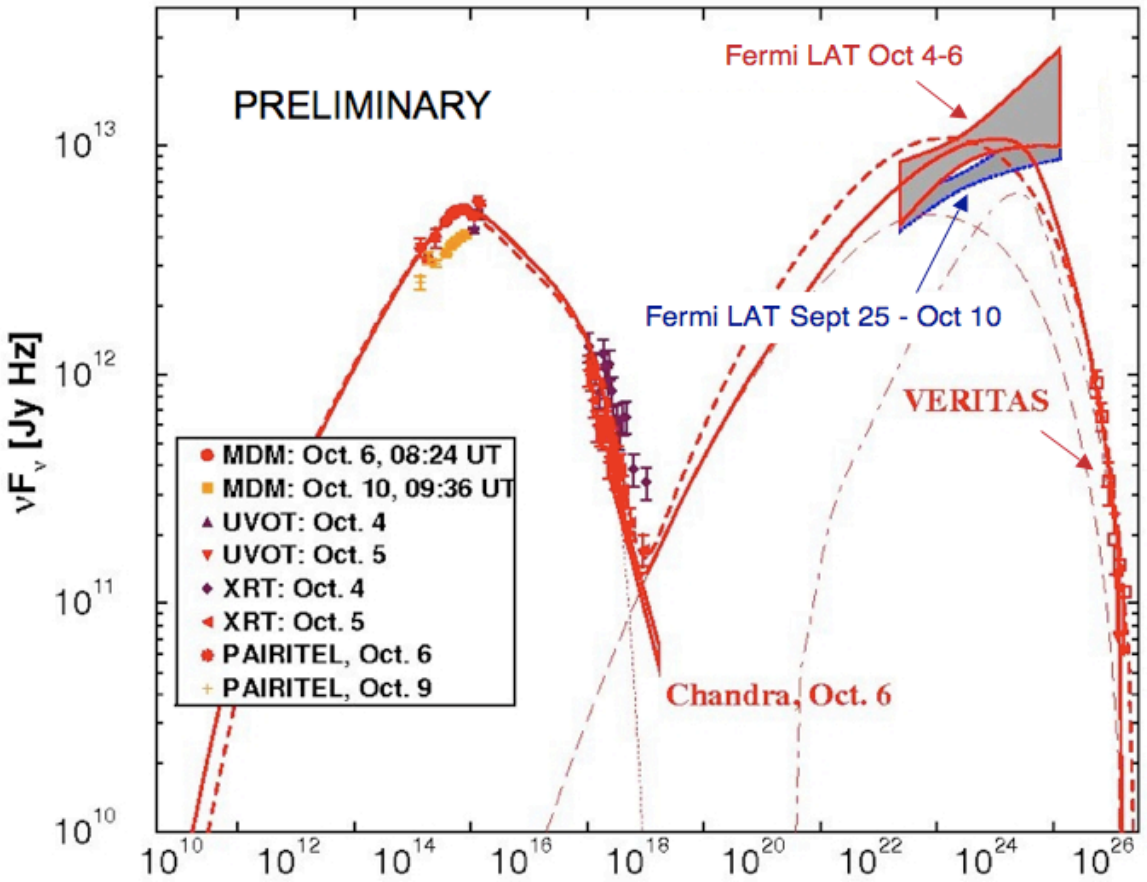




preliminary

3C 66A

- Swift and Fermi spectral data during high state on Oct 4-6, as well as time averaged spectra during TeV observations by VERITAS resulting in broadband spectra
- Due to broadband coverage, including both peaks, spectrum can be tightly constrained
- Model including an external Compton component is favored

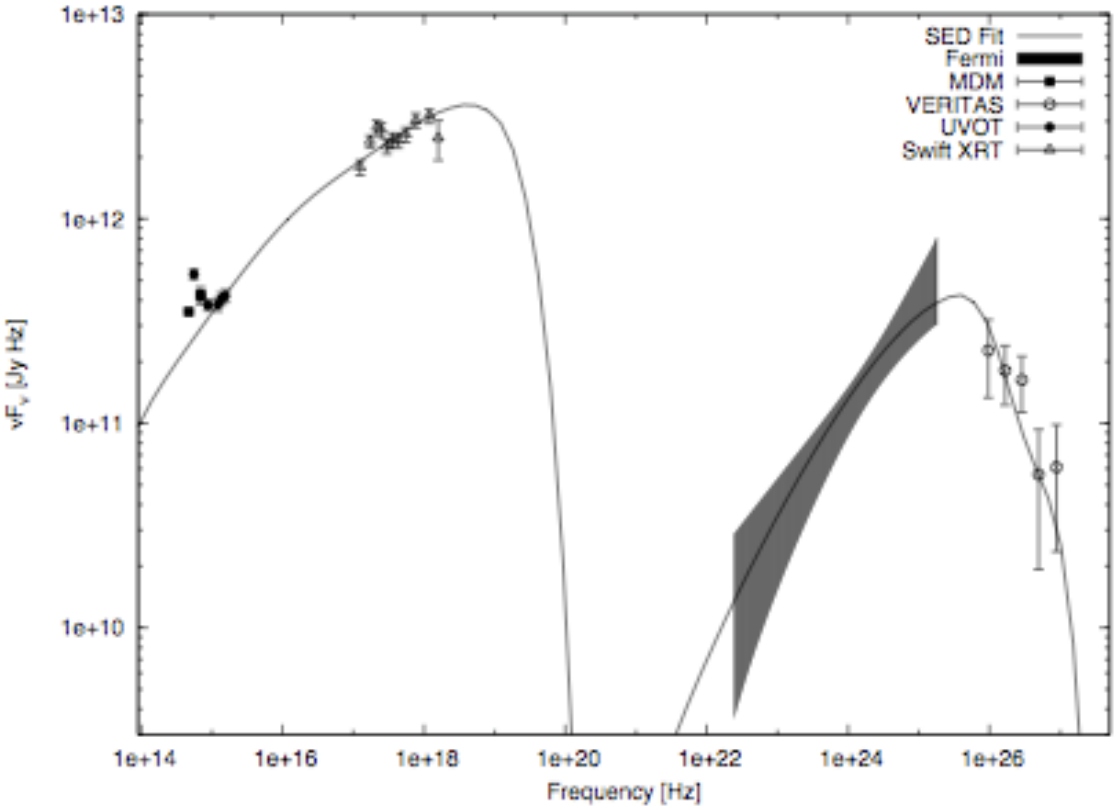


Dashed line: pure SSC, solid line: SSC+EC

See: Reyes et al. 2009, ICRC proc.
Benbow et al. 2009 (poster, these proc.)

RGB J0710+591

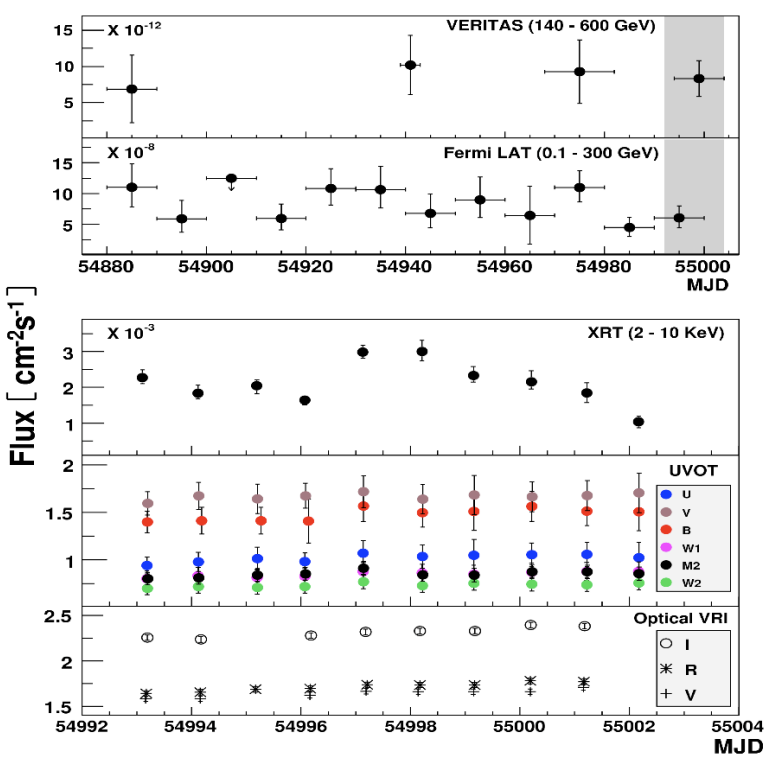
- New VERITAS detection with contemporaneous Swift, Fermi, & VERITAS data
- A SSC model fits data nicely, and EC is allowed, but does not improve fit. Model of Chiang & Boettcher (2002) is used with TeV photon absorption model of Franceschini et al. (2008).
- Low, sub-equipartition magnetic field is implied by the fit (~10 mG)
- A remarkably hard electron injection spectrum (q ~ 1.5) is required.

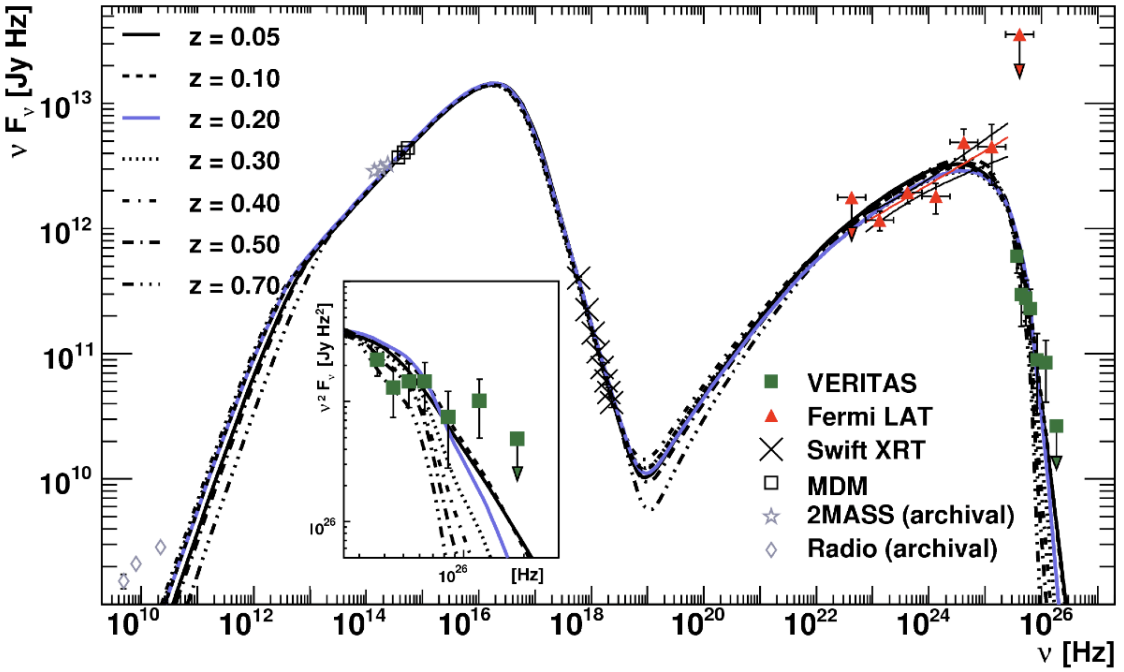


See poster by Fortin, Perkins, et al. (and upcoming paper)

PKS 1424+240

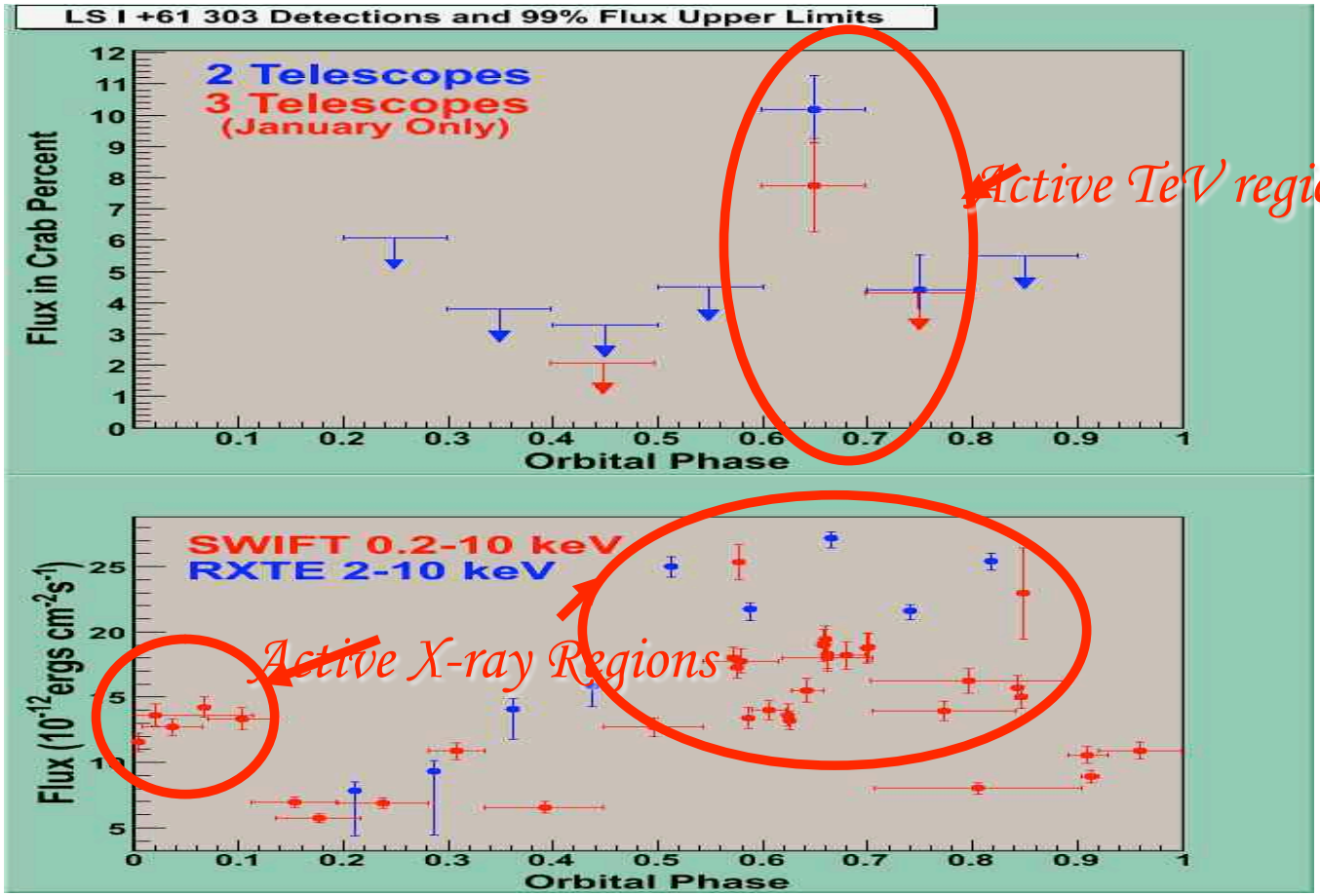
- New VERITAS detection with contemporaneous Swift, Fermi, & VERITAS data
- SSC model fitting shown at right, with different model curves corresponding to differing redshifts

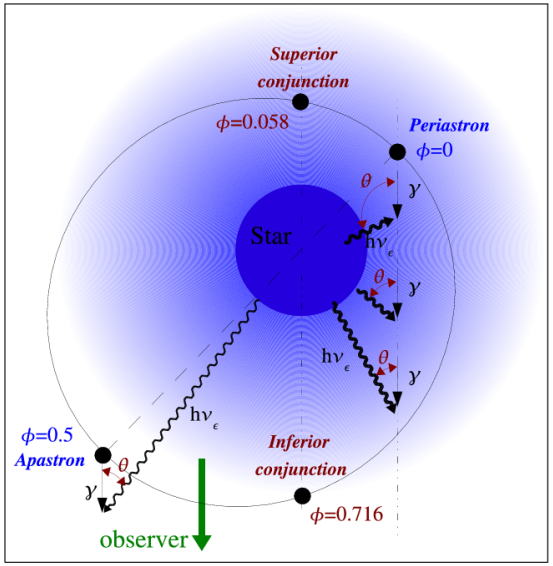




See poster by Furniss et al.
(and Acciari et al. 2009, submitted)

LSI+61303: X-ray binary (Microquasar or wind-driven??)





Holder, Falcone, Morris 2007; Smith et al. 2007; Esposito et al. 2007; Acciari et al. 2009

Recent X-ray observations show incredibly fast flaring events (Smith et al. 2008; astro-ph/0809.4254)

More multiwavelength monitoring observations are necessary!

Conclusions

- Fermi is obtaining monitoring data at high energies and releasing data to public for ~23 "sources of interest" and additional flaring sources

- Swift has capitalized on the "free" multiwavelength opportunity and committed to taking regular pointed monitoring data

  These data are released as light curves and hardness curves in near-real-time

  see: **http://www.swift.psu.edu/monitoring**

- Due to the intrinsic double-peaked SED nature of many of these sources, simultaneous multiwavelength coverage in the UV-X-ray band is critical

- Due to variability of many sources, flexible scheduling is desired when a high state is seen by Swift, Fermi, TeV telescopes, etc.

- The versatility of Swift allows it to provide these data, which are scientifically important for studies of blazars, the IR background, cosmic rays, Lorentz Invariance violation, and X-ray binary studies