Role of Swift in TeV Astrophysics and Characterization of TeV Unidentified Objects

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The TeV Sky Now

Diverse Categories of TeV Gamma-ray sources:

GALACTIC

- Pulsar Wind Nebulae (18)
- SNR (7)
- Binaries (4)

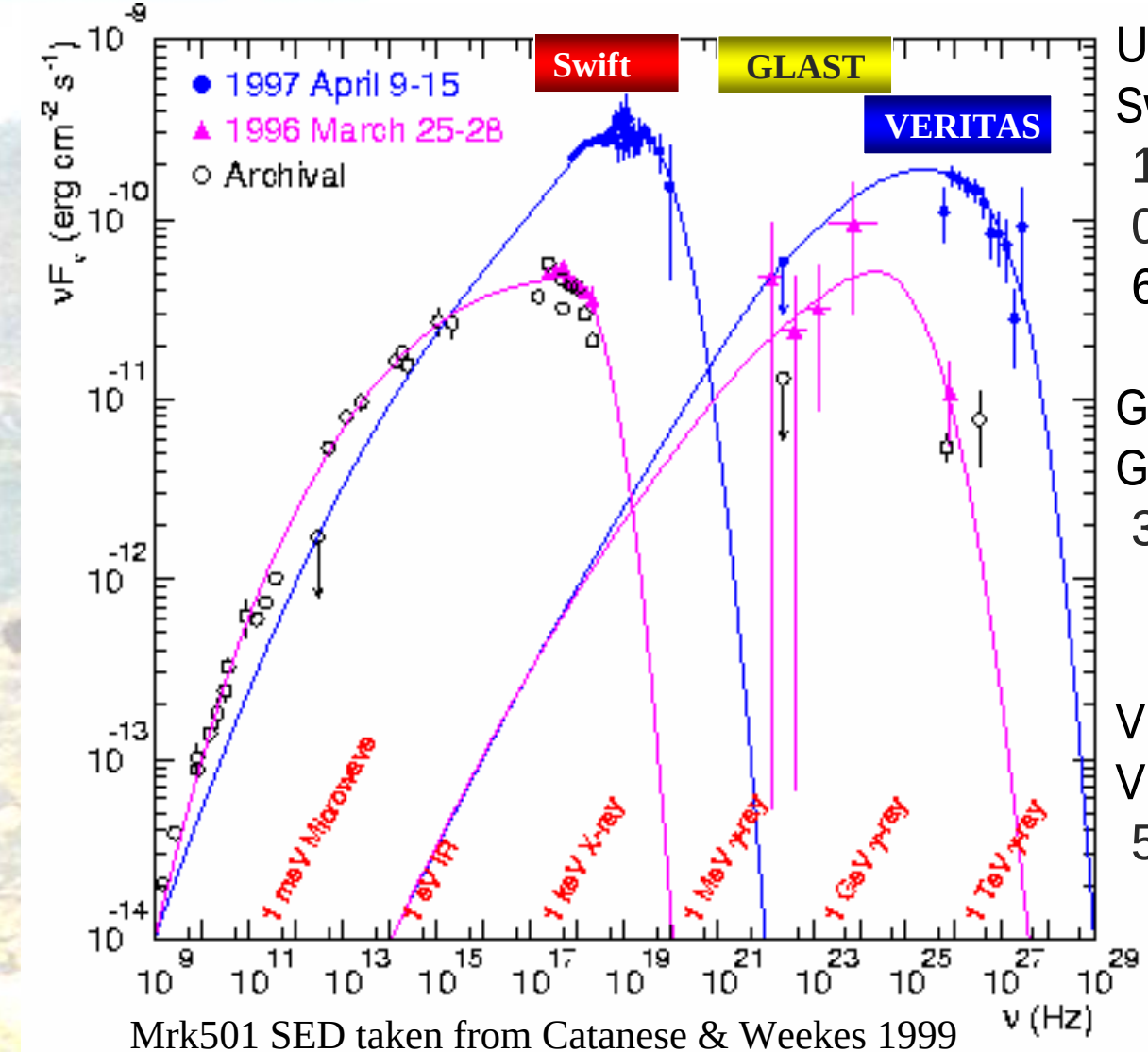
EXTRAGALACTIC

- AGN (20)

Unidentified Sources (~23)

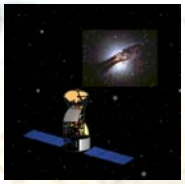
....and growing.... !!!

Importance of Broadband Simultaneous Coverage



Mrk501 SED taken from Catanese & Weekes 1999

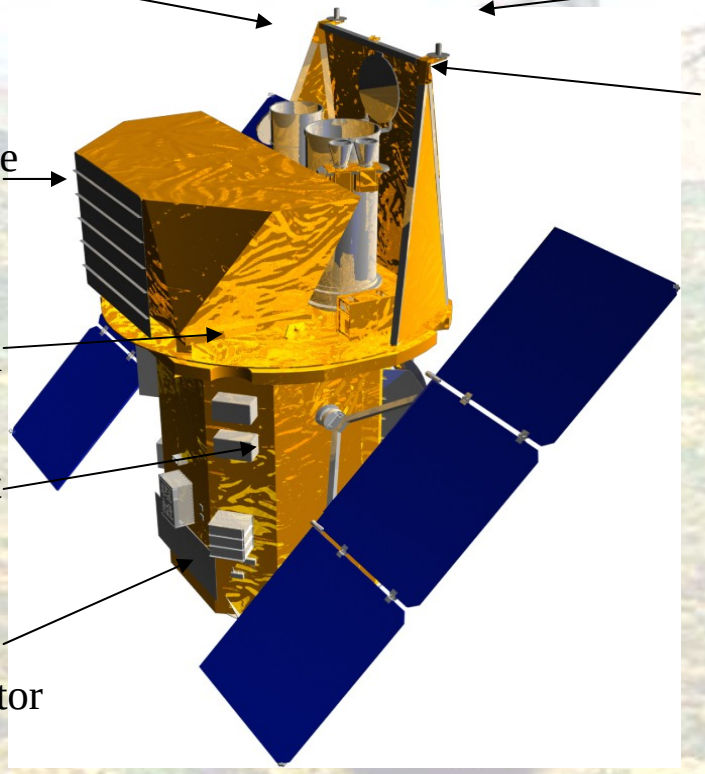
UV/optical & X-ray Spectrum:
Swift,...
- 15 keV - 150 keV
- 0.2 keV – 10 keV
- 650 nm - 170 nm



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

VHE:
VERITAS, HESS, MAGIC, ...
- 50 GeV – 50 TeV
  - (5 mCrab, 50 hours)

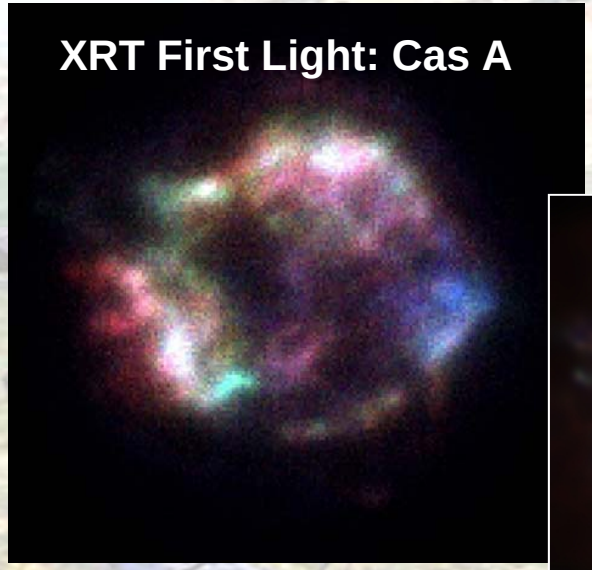
Swift



- Multiwavelength campaigns with one observatory
- Three instruments on-board
- Versatile scheduling and response to ToOs

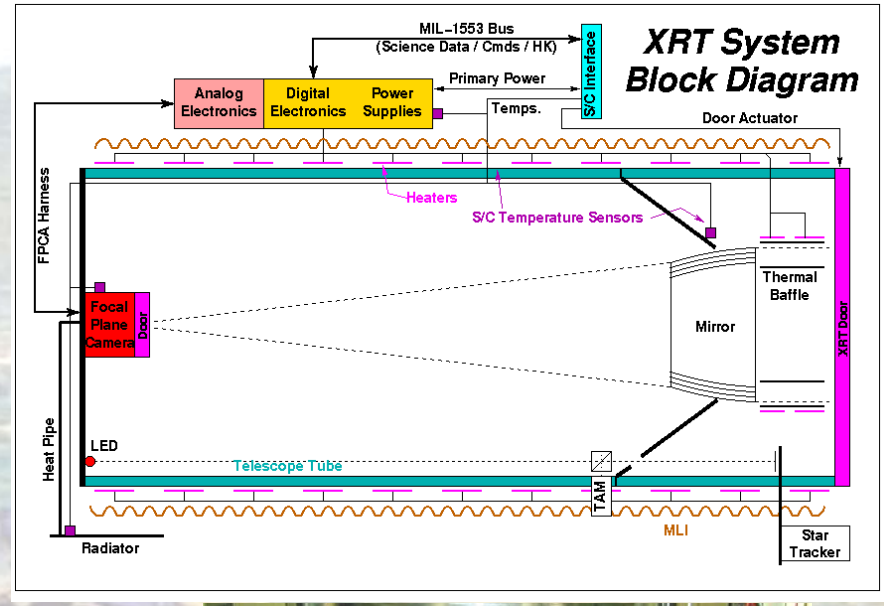
The Swift Observatory

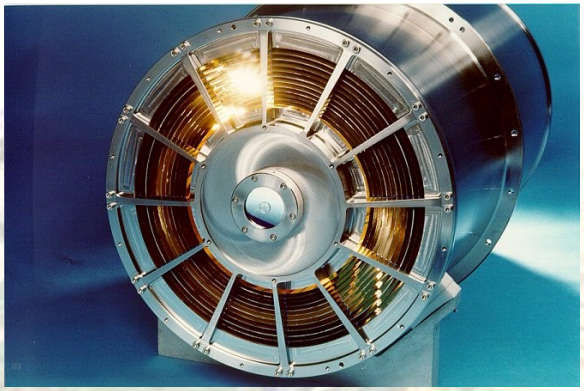
- BAT First Light: 3 December 2004
- XRT First Light: 11 December 2004

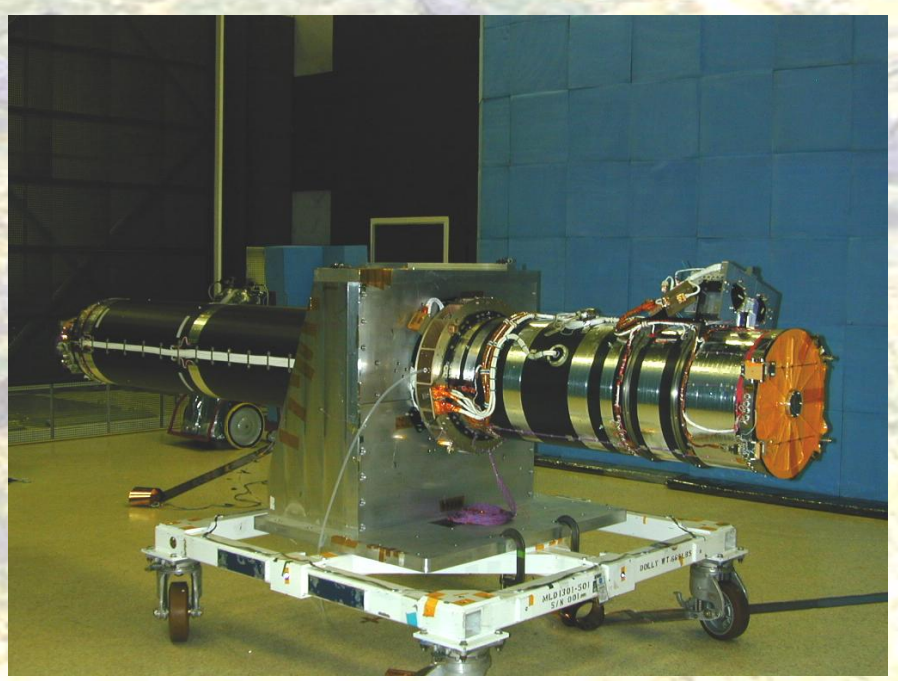


- First BAT Burst: 17 December 2004
- First XRT Afterglow: 23 December 2004
- UVOT First Light: 12 January 2005
- All data public since 5 April 2005

The X-Ray Telescope



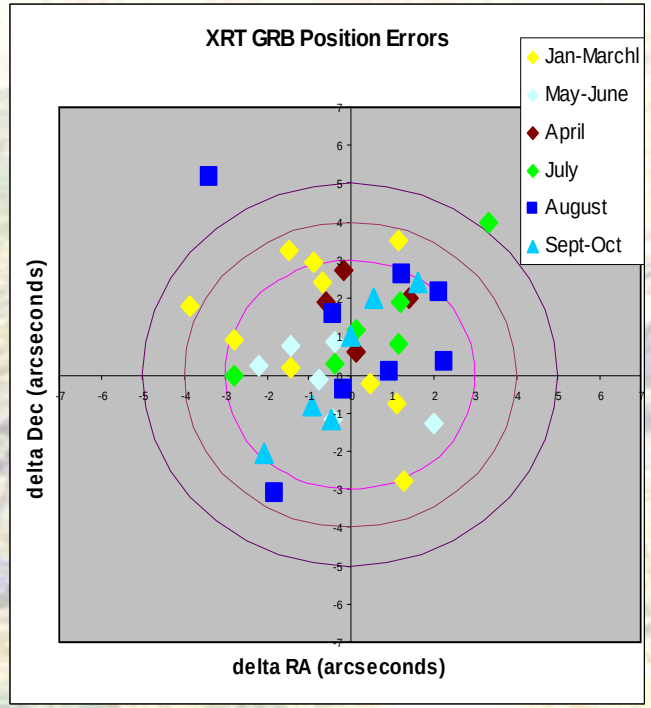




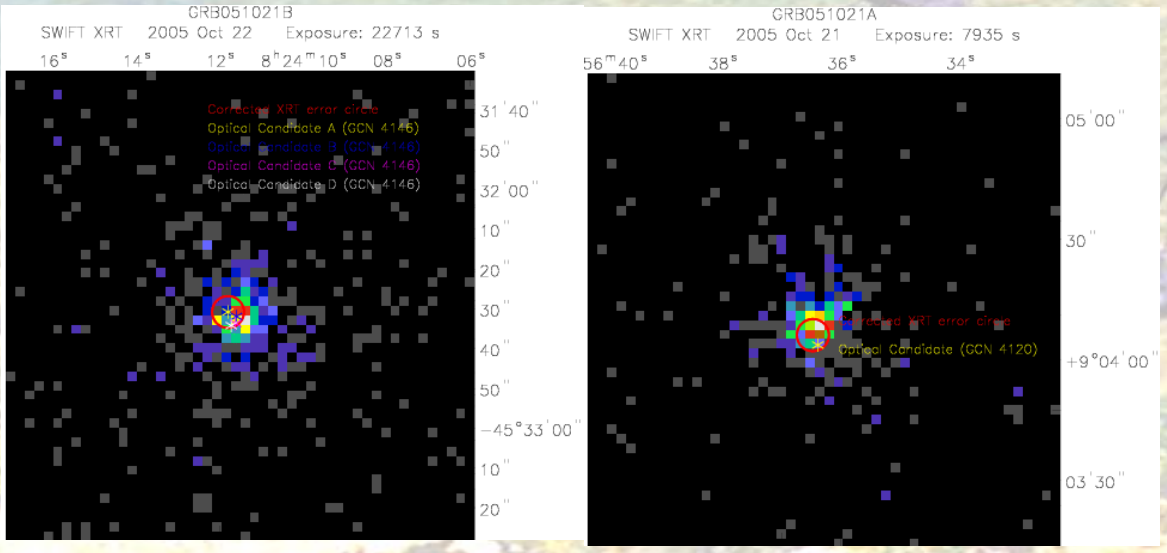
XRT Positional Accuracy

The XRT point spread function has a half-power diameter of approximately 18 arcsec, which results in typical source positions accurate to within 6 arcsec (gets even better for bright sources)

for instance, for GRBs:

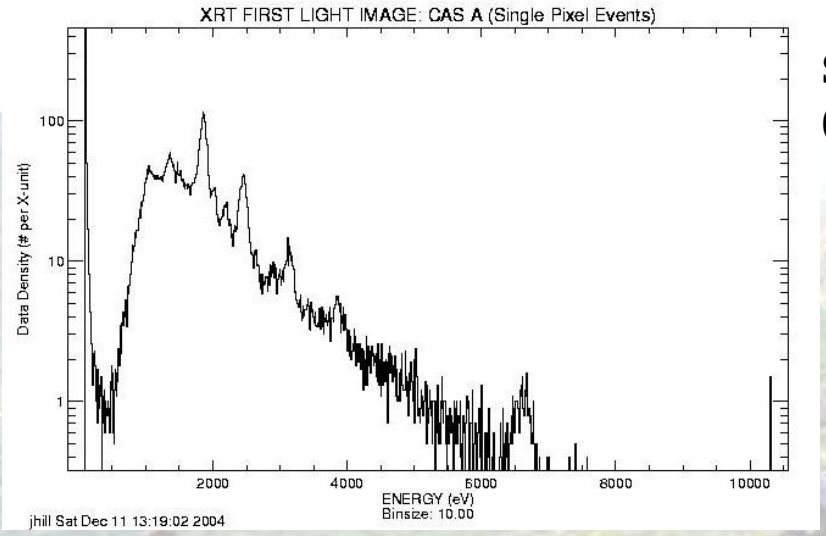


Average: 2.3” 90%: 4”



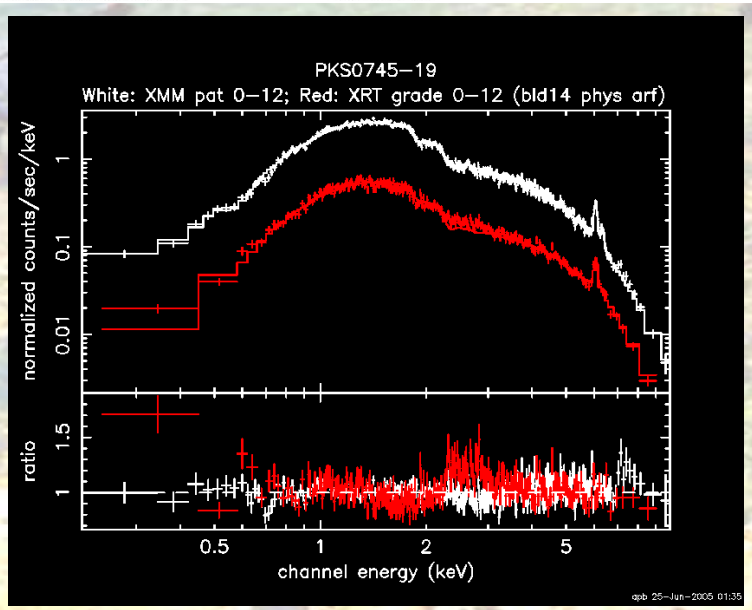
Moretti et al. 2005, A&A

The X-Ray Telescope



Spectroscopy
(example from first light on Cas A)

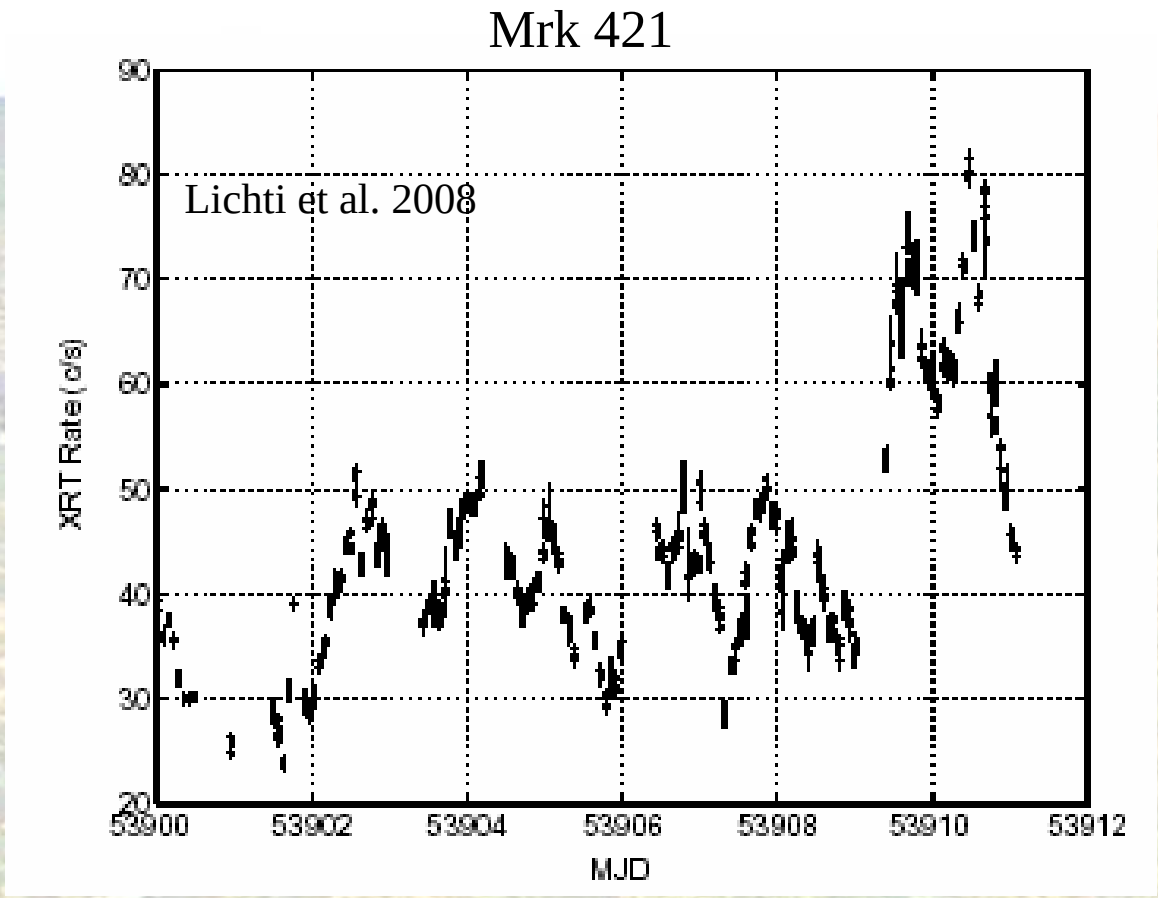
Flux limit ~10^{-15} erg/cm2/s



Example AGN spectrum

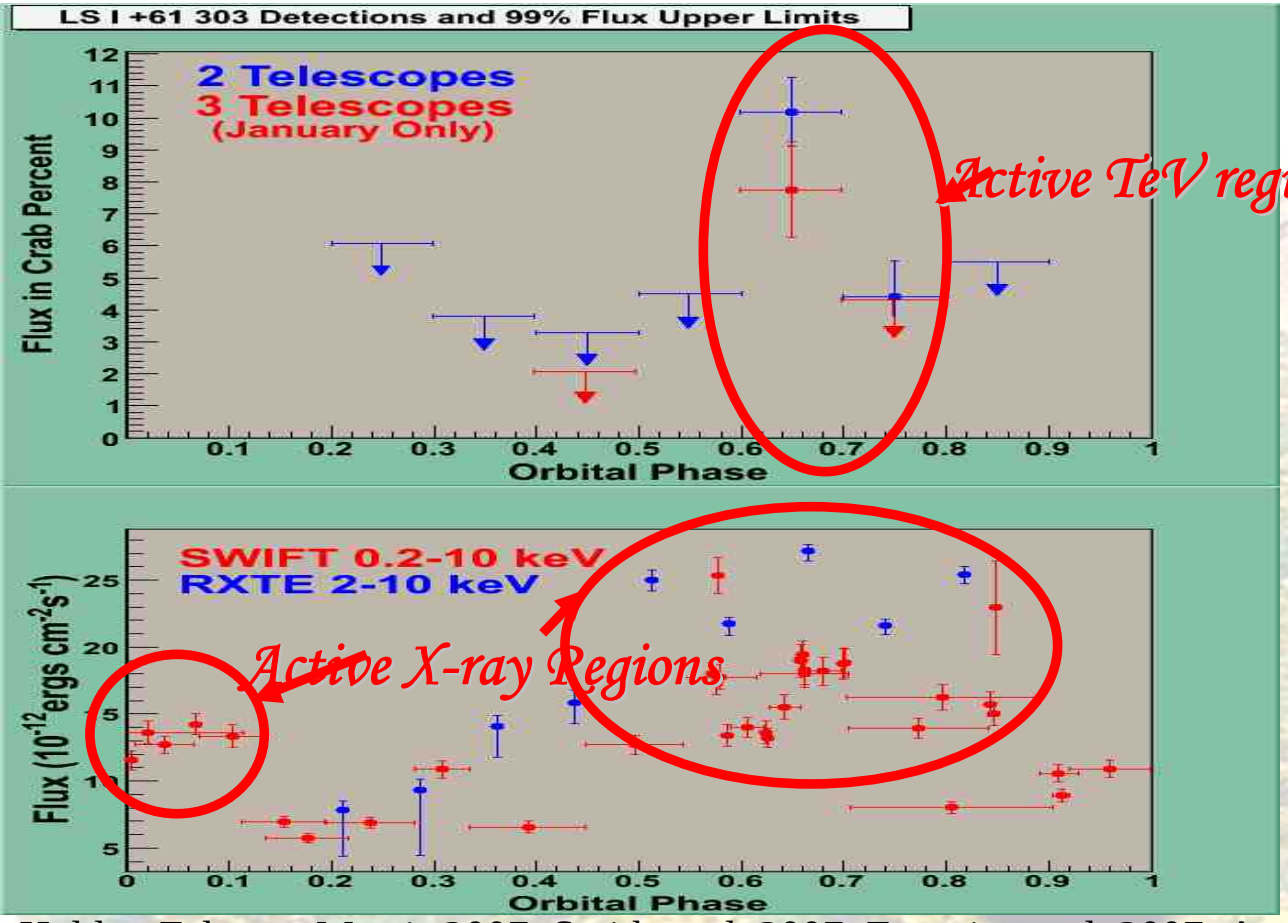
==> We can see Fe Lines
(when they are there) !!!

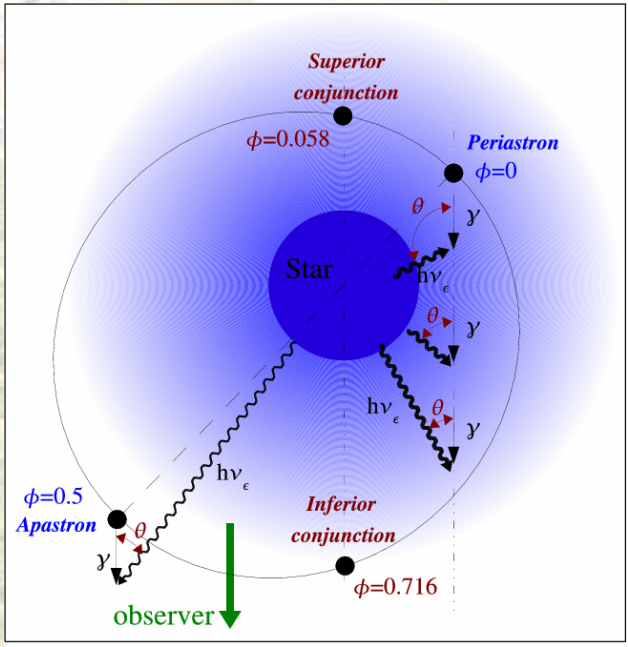
Rapid and strong variability from Jets



Swift can provide monitoring on multiple timescales to search for rapid non-periodic variability (such as that from blazar jets) as well as periodic variability (such as that from X-ray binaries and pulsars)

LSI+61303: (Microquasar?, pulsar wind-driven shock?, or both ??)

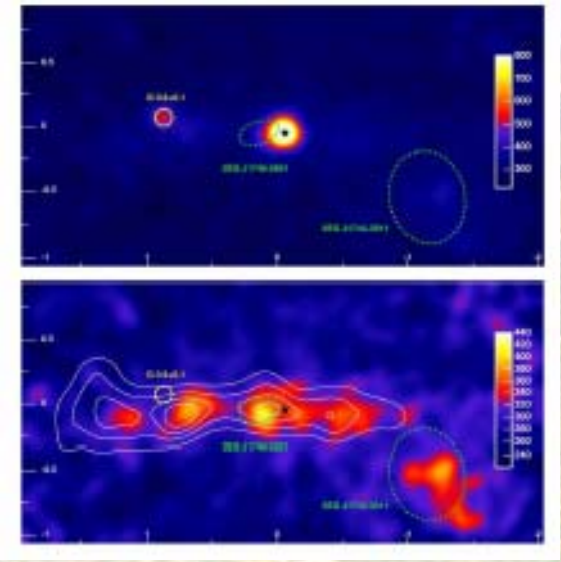




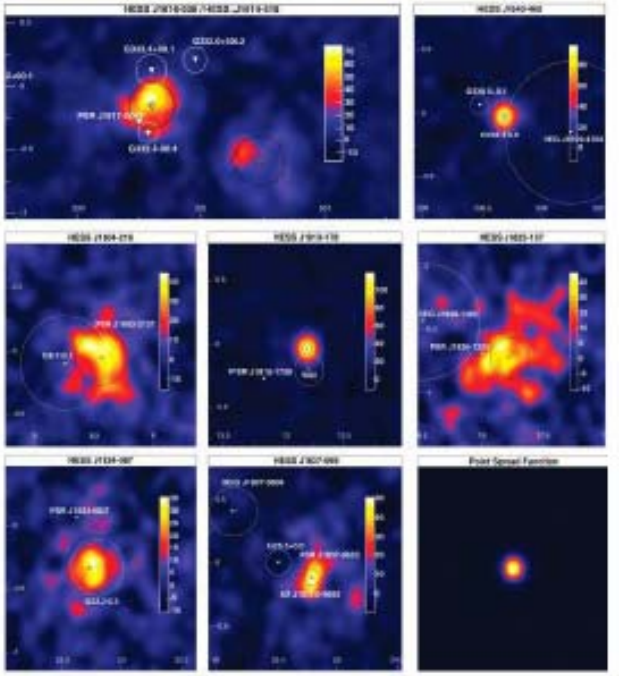
Holder, Falcone, Morris 2007; Smith et al. 2007; Esposito et al. 2007; Acciari et al. 2008

- These observations are from combined ToOs
- There have been more observations in 2007-2008 which more completely sample several orbital periods....

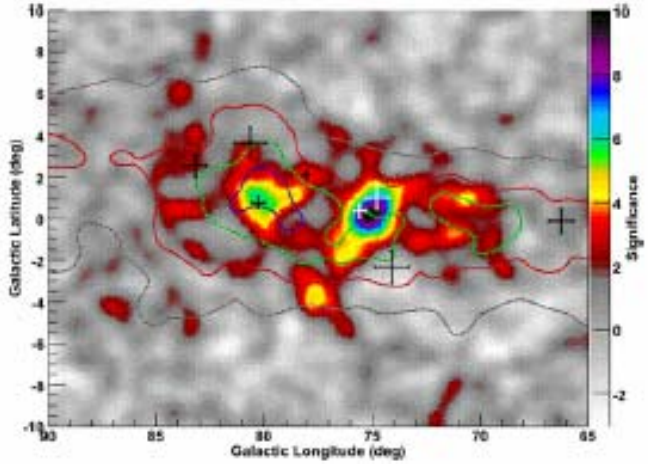
Unidentified TeV Objects Follow-up



Gal Center, Aharonian et al. 2006



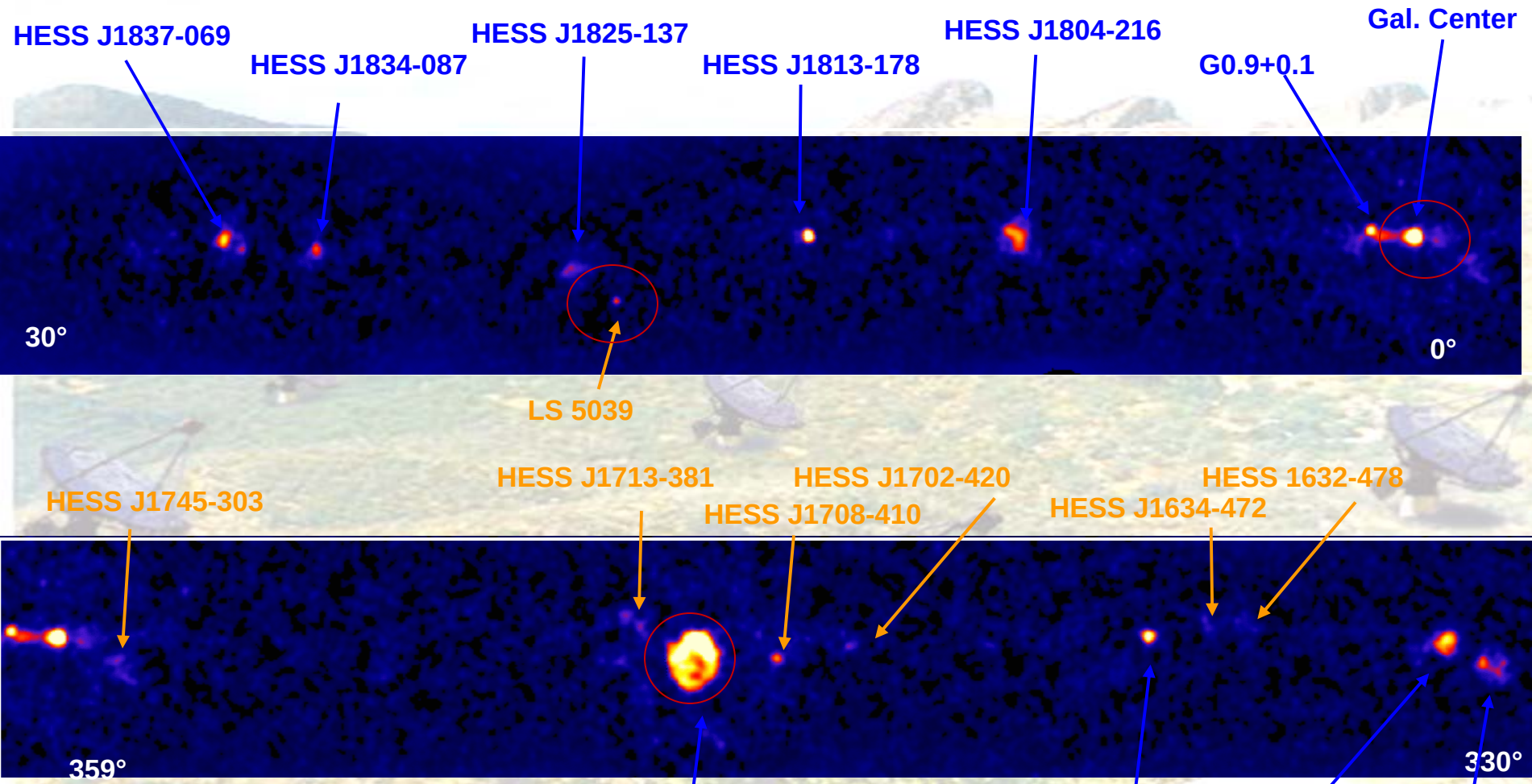
Selected TeV UnID sources, Aharonian et al. 2005, 2008



Milagro Diffuse near TeV 2032, Abdo et al 2007

- ~ 20 TeV objects waiting for identification
- SWIFT, GLAST, radio, and optical follow-up can help!

HESS Survey of Inner Galaxy

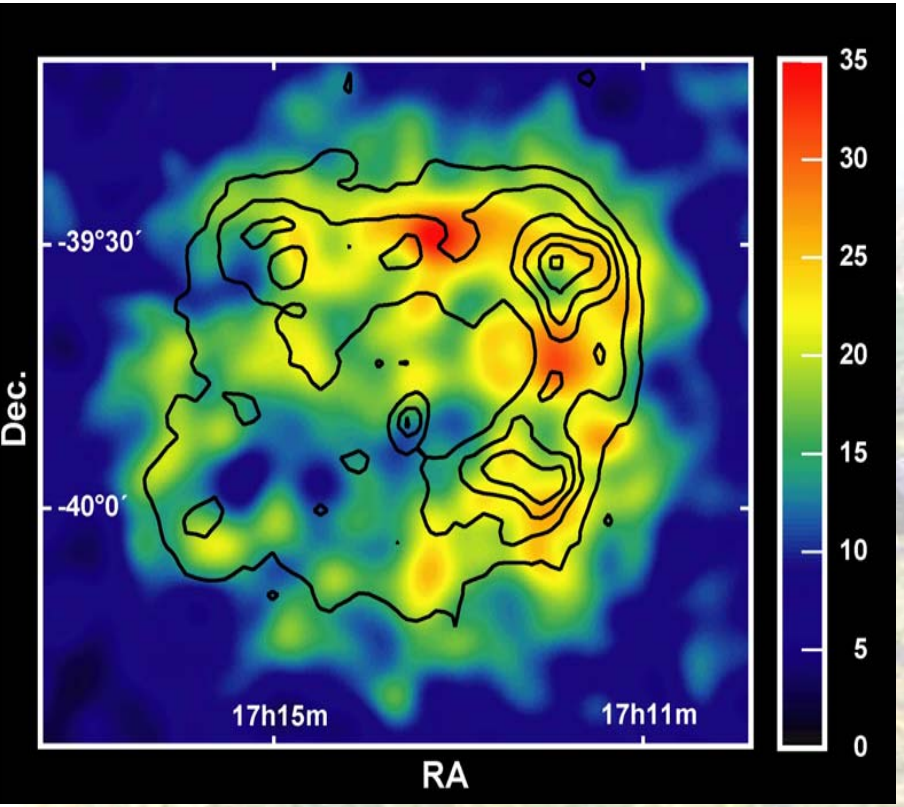


Aharonian et al.

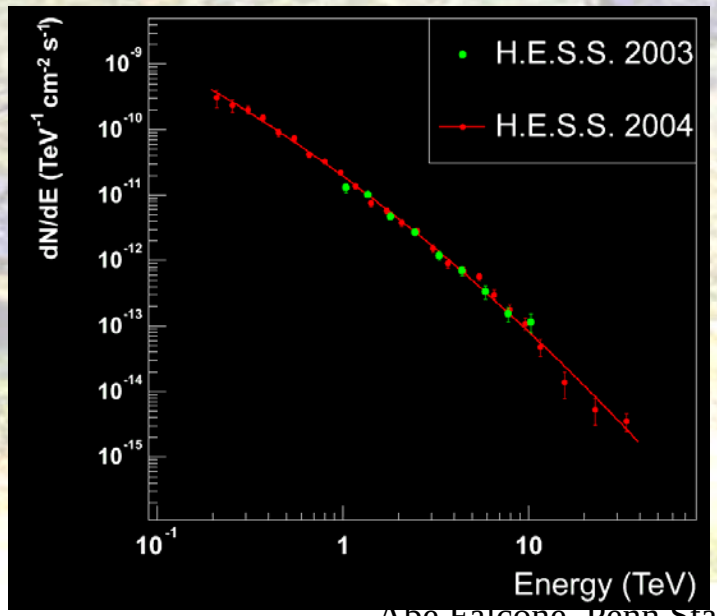
RX J1713-394

Shell Supernova Remnant

Cosmic Ray Source?



HESS Gamma: color
ASCA X-ray: Lines



Hard spectrum $\Gamma \sim 2$
Not a simple power-law.

So far...

- *Systematic* follow-up of TeV unidentifieds with Swift is just beginning. A few observations are already in:

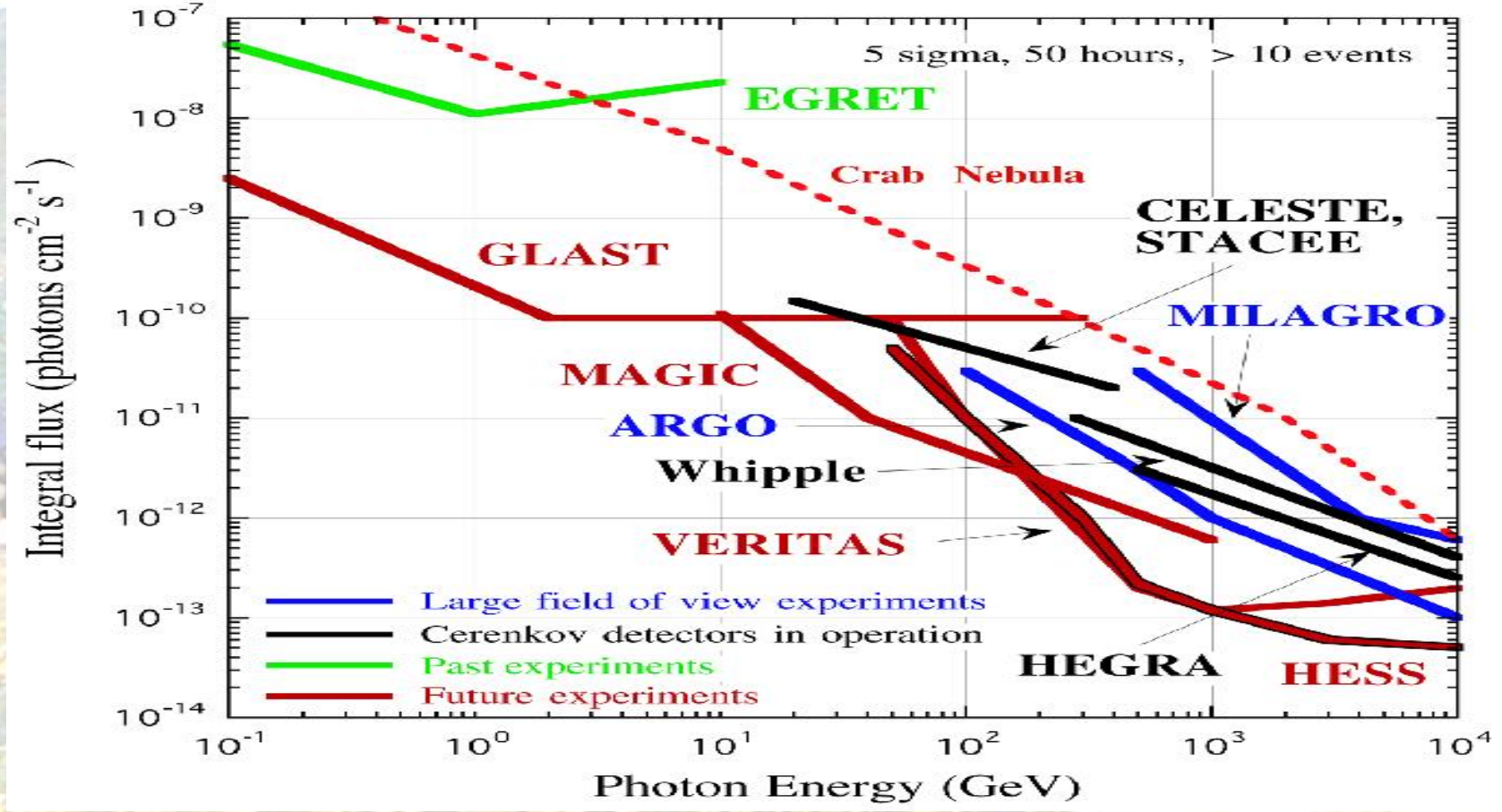
MGRO J1908+06/HESS J1908+063
MGRO J2030+37
HESS J1813-178
HESS J1303-631
HESS J1614-518
HESS J1837-069
HESS J1841-055
HESS J1857+026
TEV J2032+4130
HESS J1804-216
HESS J1616-508
HESS J1834-087

More on the way...

Conclusions

- TeV gamma ray astronomy has entered a new era with many new sources (>70), including various classifications (X-ray binaries, AGN, SNRs, PWN) and many unidentifieds
- 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
- The versatility of Swift allows it to provide these critical data for multiwavelength characterization of TeV unidentifieds
- TeV follow-up programs with Swift have begun. The Swift team welcomes collaborations and suggestions

Relative Sensitivity



GLAST and next generation VHE instruments complement one another well