

Coordination with TeV Telescopes



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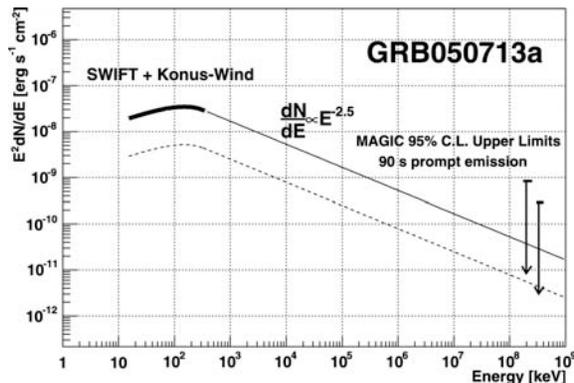
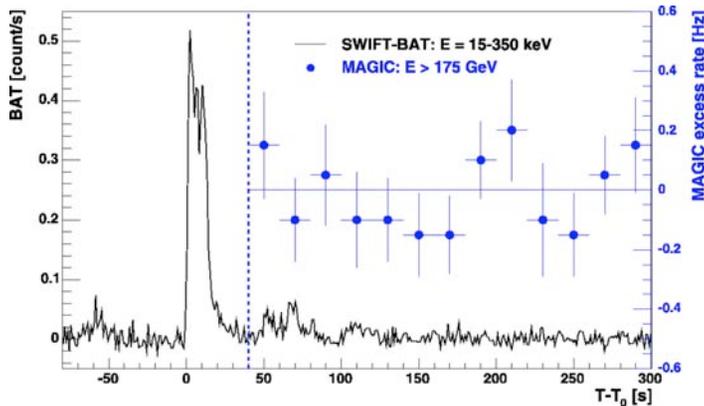
With input from:
Luigi Costamante (HESS)
Abe Falcone (Swift/VERITAS)
Jamie Holder (VERITAS)
Dieter Horns (HESS)
Antonio Stamerra (MAGIC)



First, Do No Harm



TeV Observatories eagerly await GRB alerts
Need low z bursts to elude $\gamma\gamma \rightarrow e^+e^-$ absorption



MAGIC TeV observations starting 40 s
after T_0
J. Albert *et al.* 2006, ApJL 641, L9

VERITAS Follow-up of Swift GRBs

•VERITAS-1

- ✓ GRB 050402, 19 min, $z=??$
- ✓ GRB 050412, 23 min, $z=??$
- ✓ GRB 050505, 4.5 hour*, $z=4.27$
- ✓ GRB 050509b, 22 min, $z=0.226?$

•VERITAS-2

- ✓ GRB 060501, 14 min, $z=??$
- ✓ GRB 060502a, 4 hour*, $z=1.51$

•VERITAS-3

- ✓ GRB 061222a, 10 min, $z=??$
- ✓ GRB 070223, 4.6 hour*, $z=??$
- ✓ GRB 070419a, 5 min, $z=0.97$

*Burst occurred during daylight or moonlight

GLAST GRBs



- Many of the GLAST GBM positions will be larger than the VHE camera FoV
 - ✓ Swift probably can't help with that
- Interpretation of TeV results needs redshift
 - ✓ GLAST LAT positions probably good enough for Swift follow up, at least in some cases
 - ✓ LAT detected bursts will be most interesting TeV candidates
 - ✓ Swift X-ray and optical afterglows could improve chances of redshift

Modes of TeV/Swift Coordination



- Swift Detection Triggers TeV Observations
 - ✓ GRB
 - ✓ HMXB SAX J2103.5+4545

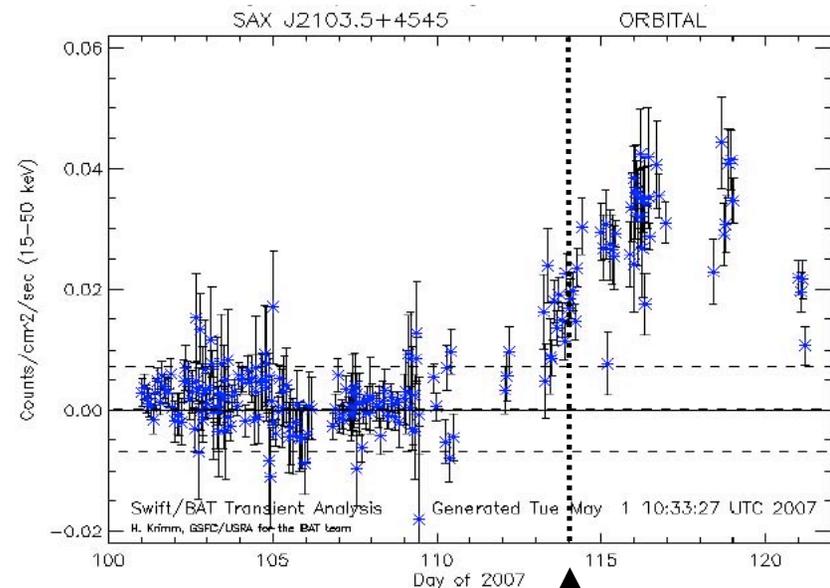
SAX J2103.5+4545 — HMXB



- BAT “GRB” triggers on April 23 and 25
- Rising light curve in BAT transient monitor



- VERITAS ToO Observations April 24 and 25
- Swift ToO Observations April 25 and 26
- Simultaneous on April 25
- INTEGRAL IBIS/ISGRI Detection (ATel #1063)



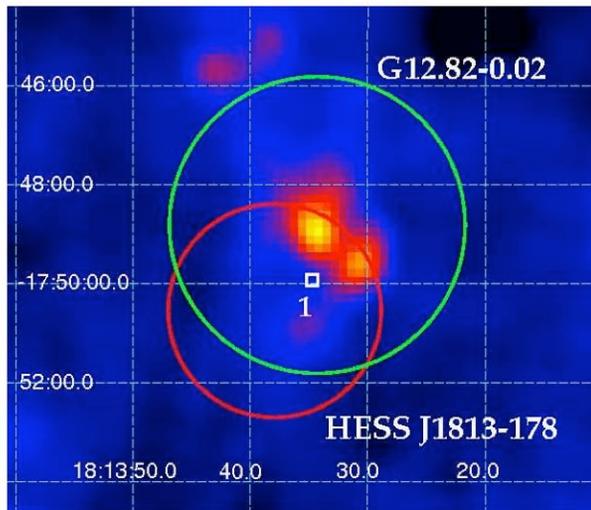
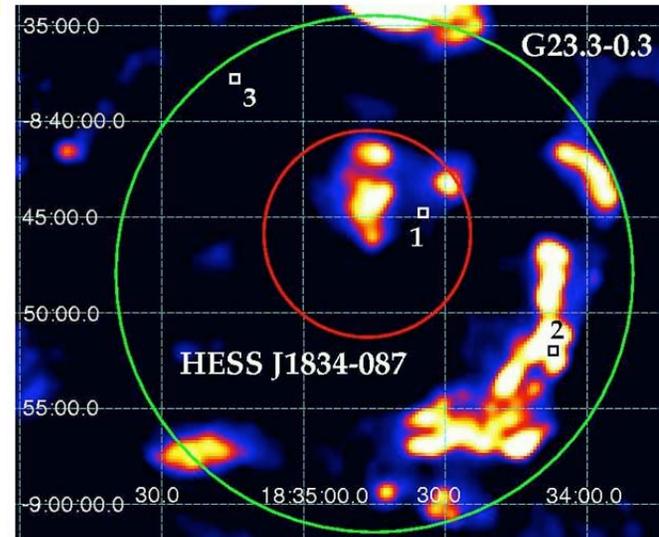
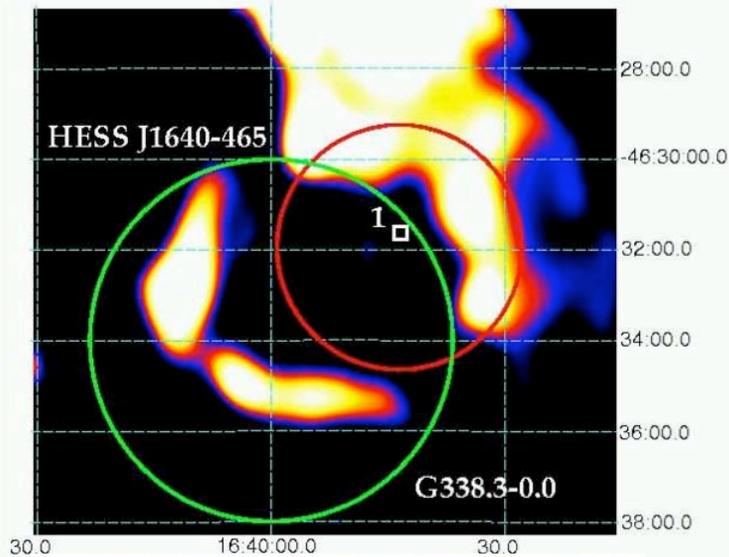
↑
April 24

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- Swift Follow-up of TeV Detections
 - ✓ “Swift XRT Follow-up Observations of TeV Sources of the HESS Inner Galaxy Survey,” R. Landi *et al.* 2006, ApJL 651, L190
 - ✓ “Swift observations of TeV BL Lac objects,” A. Tramacere *et al.*, astro-ph/0611276
 - ✓ LSI +61303 – VERITAS ToO request
 - ✓ PKS 2155-304 – HESS ToO request

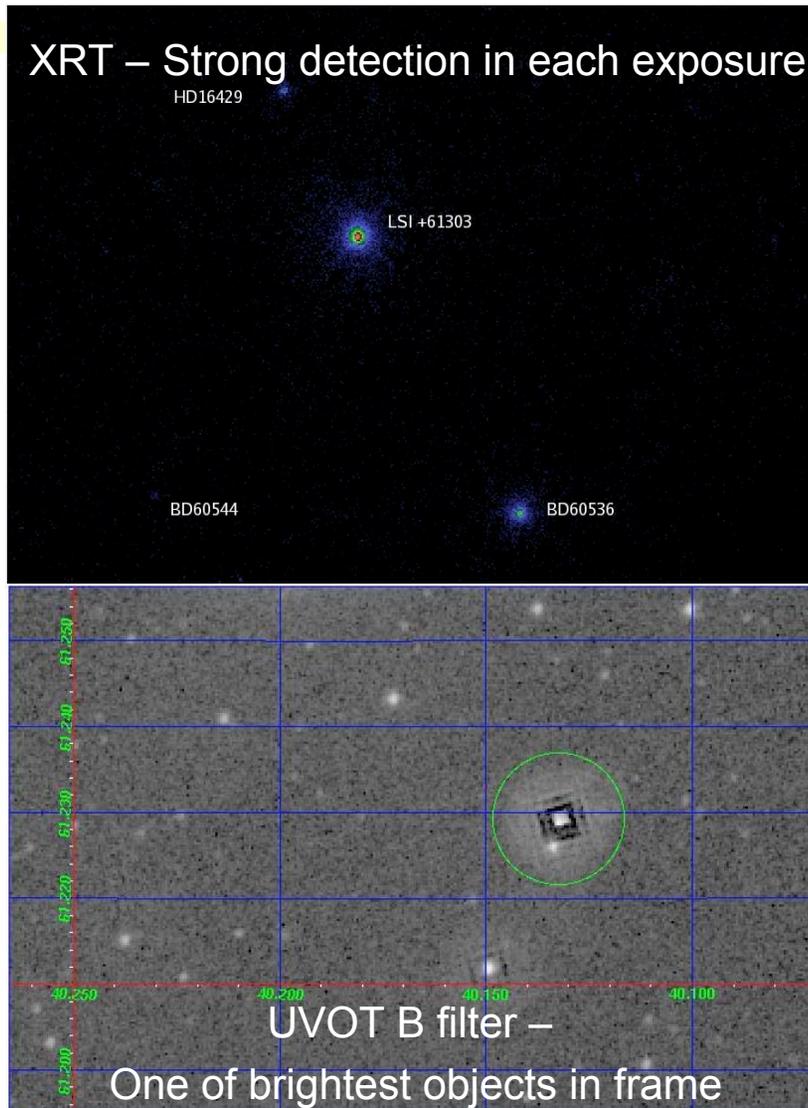
HESS UnID Sources → PWN



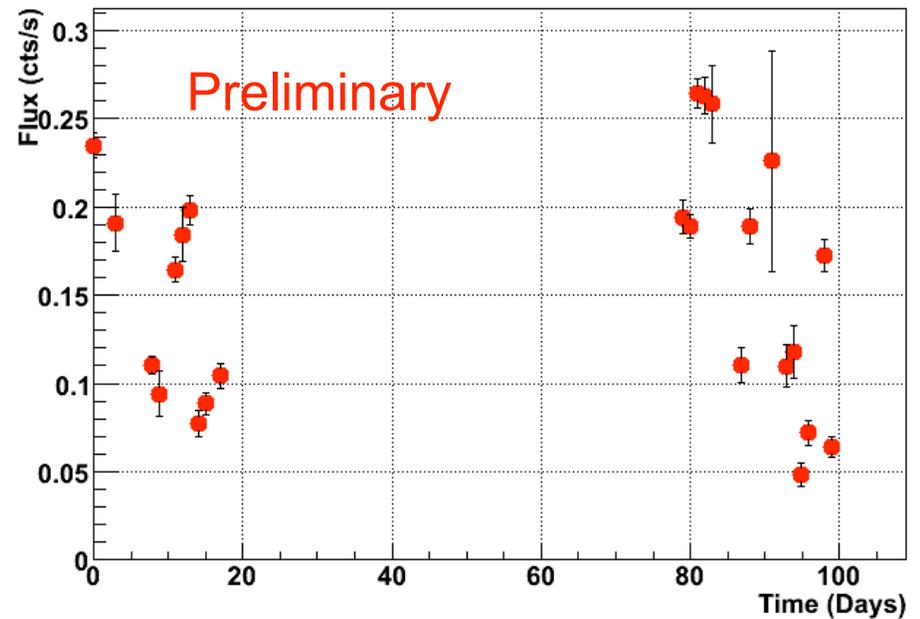
MOST and NVSS radio images
SNR from Green 2004 or Brogan 2005
HESS UnID extent
1 → XRT point source

R. Landi *et al.* 2006, ApJL 651, L190

LSI +61303 — HMXB



LSI+61303 Swift Lightcurve



- Factor ~ 5 variability in XRT
- MAGIC and VERITAS results show strong variations with orbital phase
- Analysis continuing

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 - ✓ LSI +61303 – VERITAS ToO request
 - ✓ PKS 2155-304 – HESS ToO request
- MW Campaigns: Planned/ToO
 - ✓ 3C 279 – MAGIC ToO request
 - ✓ Mrk 501 – ToO request for HESS, MAGIC, Suzaku campaign
- Swift Monitoring of TeV Candidates
 - ✓ BAT Transient Monitor
 - ✓ Fill-in observations of many candidates

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 - Swift Monitoring of TeV Candidates
 - ✓ BAT Transient Monitor
 - ✓ Fill-in observations of many candidates
- ~5 minute TeV variability

Swift Well Matched to TeV Sources



- Swift is becoming the “go to” instrument for X-ray observations of TeV candidates
 - ✓ Synchrotron peak of TeV sources in X-ray band
 - ✓ X-ray data crucial to constrain synchrotron peak, test SSC and EC models
 - ✓ Rapid TeV variability (as short as a few minutes) means **simultaneous** observations essential
 - ✓ Our old workhorse RXTE will likely be put out to pasture
- Swift pointing constraints allow ~anti-solar observations
 - ✓ Truly simultaneous X-ray/TeV observations
 - ✓ Typically the only satellite capable to observe, esp. on short notice, when sources best visible to TeV atmospheric Cherenkov telescope (ACTs)
 - ✓ Solar avoidance similar to ACT requirements
- No penalty for many slews, short observations
 - ✓ Need frequent observations, not deep ones
- User Friendly and Responsive ToO Procedure
- BAT Transient Monitor covers stronger candidates

Improving TeV/Swift Coordination



- XRT/UVOT fill-in observations have been somewhat ad hoc
 - ✓ Coordinate with TeV community to improve source selection and increase overlap with TeV observations
 - ✓ Check visibility to TeV telescopes, e.g.
<http://www.mpi-hd.mpg.de/hfm/HESS/public/Visibility.html>
 - ✓ Not all Swift's fault: TeV groups tend to hold many of their cards close to their chest
- More formal monitoring campaigns of TeV candidates
 - ✓ Catch flares to trigger high state ToOs – high state fluxes enable the most detailed spectral measurements, light curves and modeling
 - ✓ Long-term MWL campaign on one or two bright TeV sources to probe variability time scales (1–2 ks Swift observation every few days)
- Have designated Swift MWL coordinator(s)
 - ✓ A known point of contact would be useful for orchestrating the above

Swift is Superb for the Study of TeV Sources



- Many observations already, most still being analyzed
- Rapid GRB notifications needed by the most sensitive (narrow FoV) TeV instruments — low z bursts most prized
- ToO program is **outstanding**. Be careful not to break it!
- Some untapped opportunities in the realm of planned multiwavelength campaigns and long term monitoring of TeV sources/candidates