# FERMI GBM CAPABILITIES FOR MULTI-MESSENGER TIME-DOMAIN ASTRONOMY

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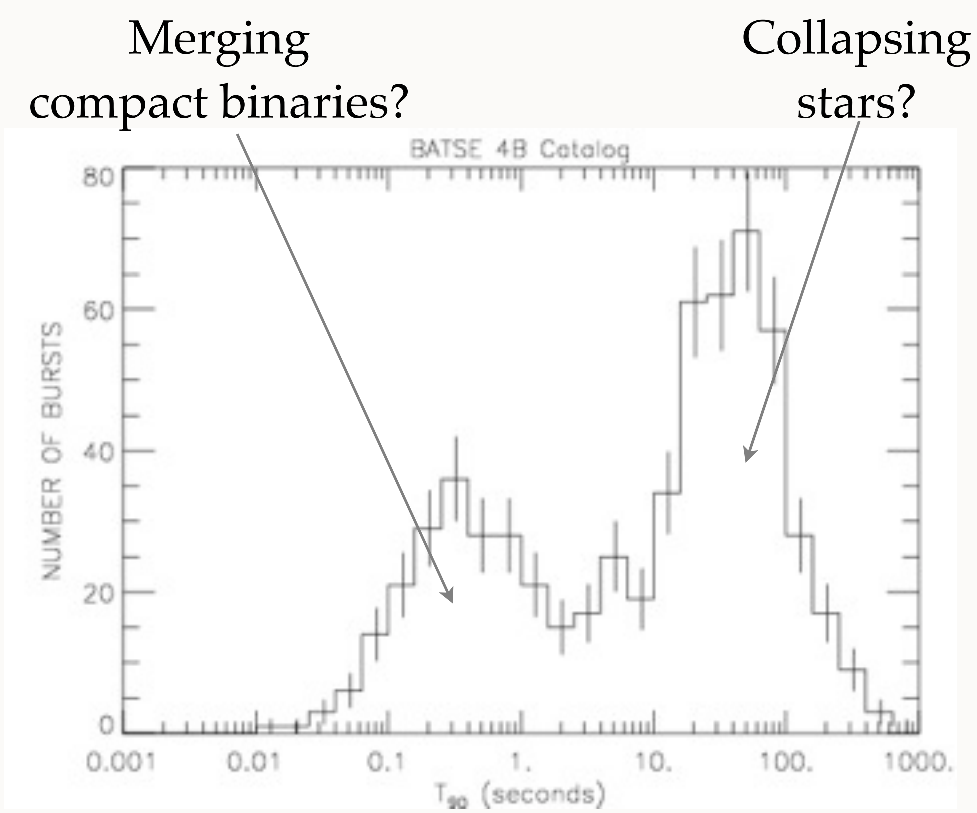
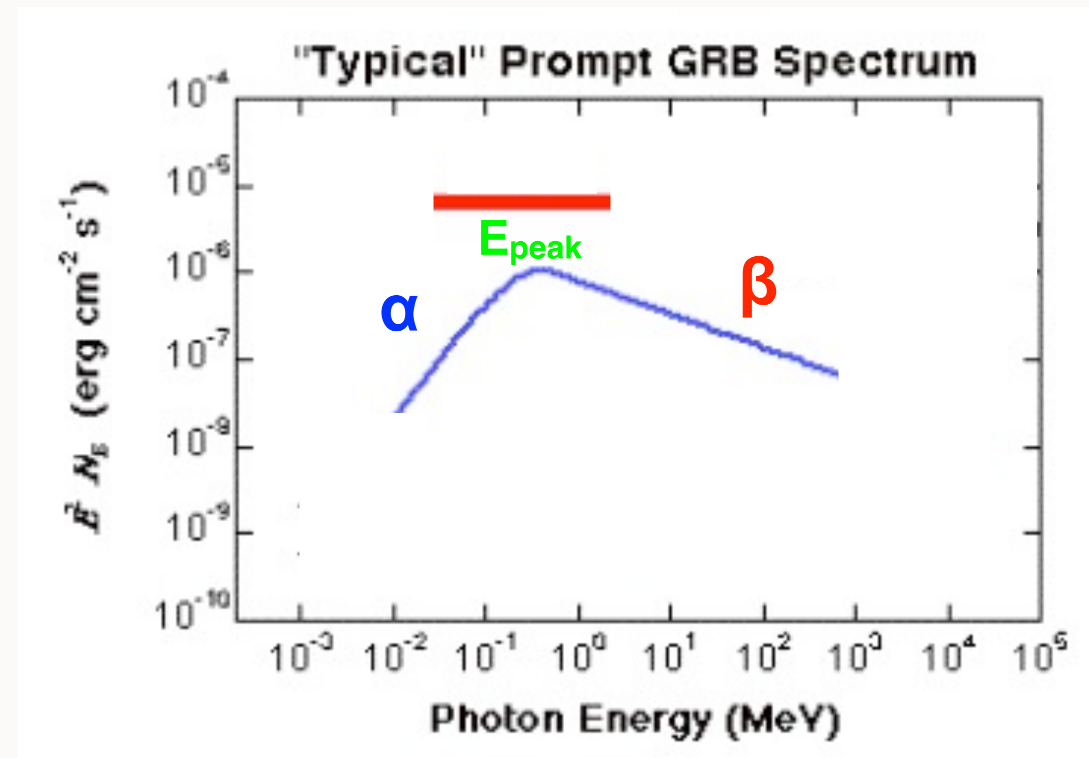
# GRB PRIMER




Duration of Prompt emission

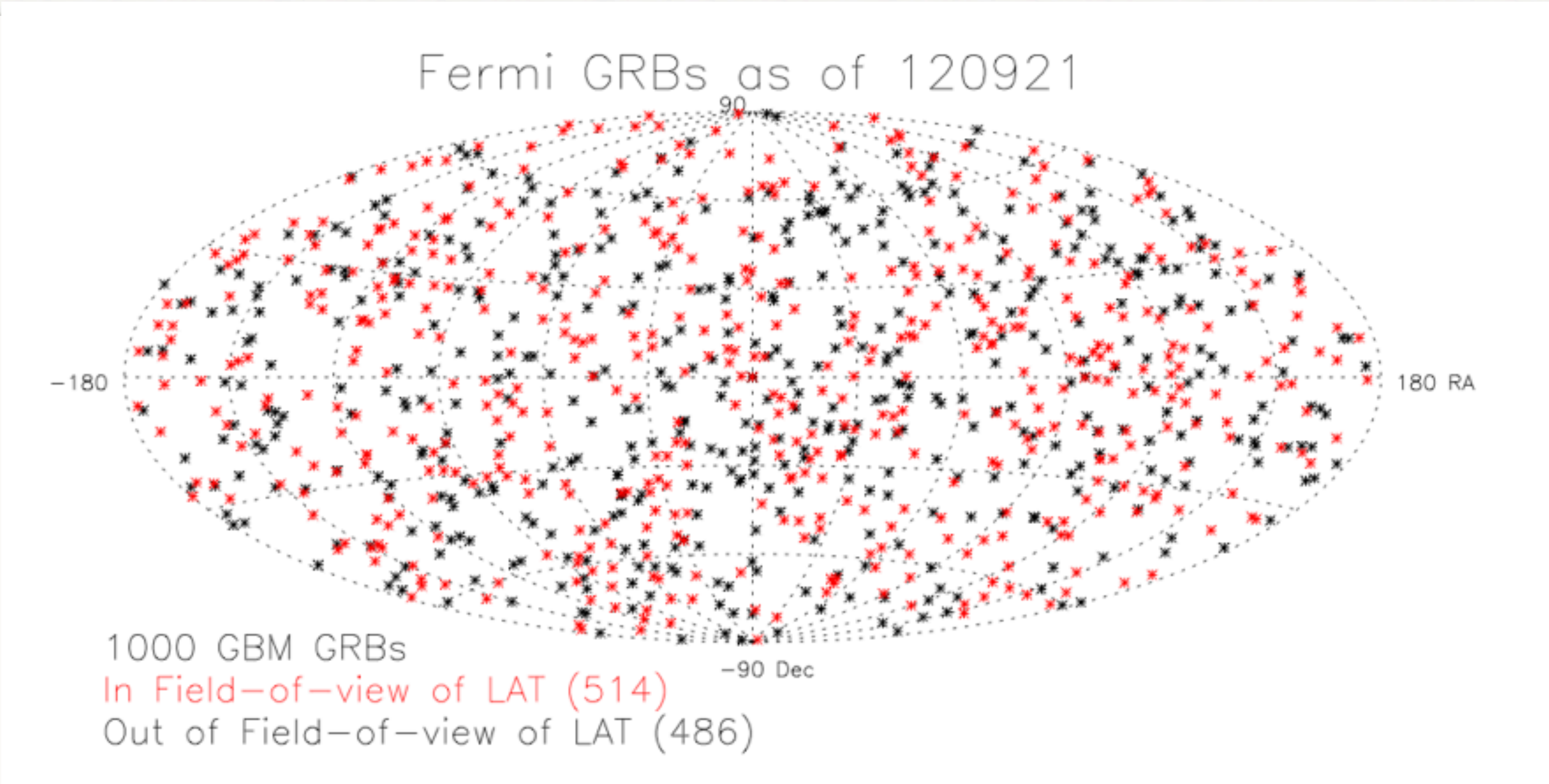



Energy Spectrum

GRBs also have afterglow emission
lasting days at lower E

Cosmological fireball
Relativistic outflows
γ from internal shocks?

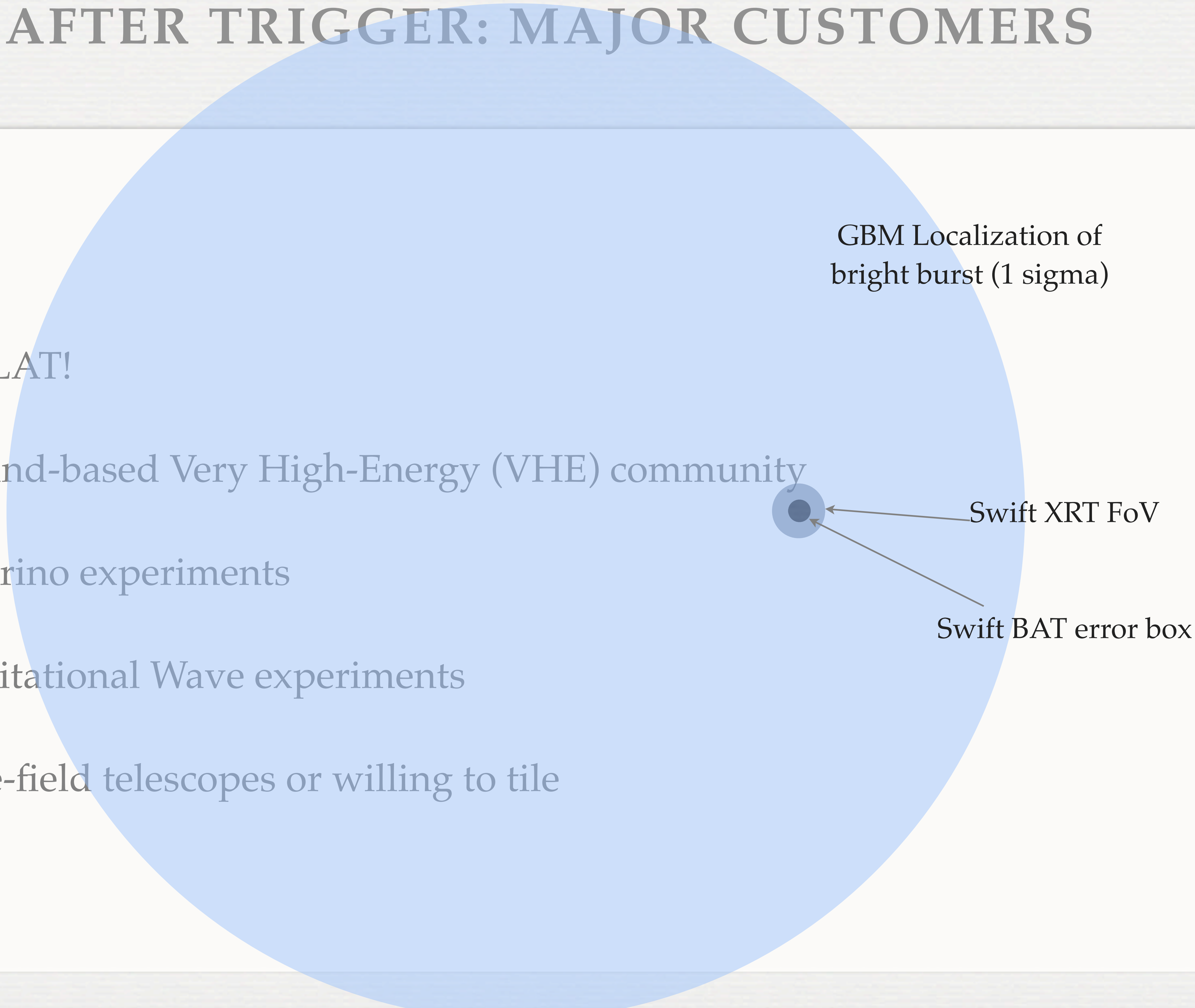
# GBM SEES LOTS OF BURSTS BECAUSE OF ITS WIDE SKY COVERAGE - 1000TH GRB 4.2 YEARS INTO MISSION!




- Not as sensitive as Swift => GBM GRBs are brighter and probably on average closer (long GRBs).

# GBM LOCATION NOTIFICATIONS SECONDS AFTER TRIGGER: MAJOR CUSTOMERS

- The LAT!
- Ground-based Very High-Energy (VHE) community
- Neutrino experiments
- Gravitational Wave experiments
- Wide-field telescopes or willing to tile

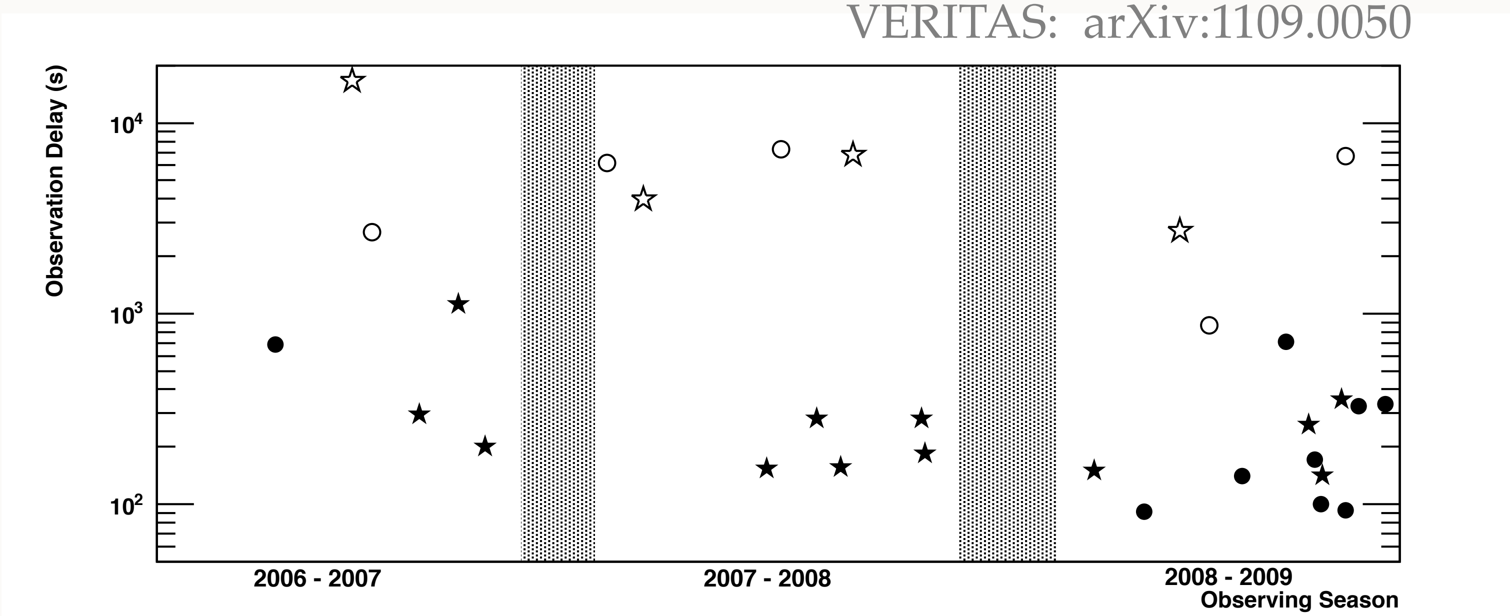


# REQUIREMENTS FOR VHE (IACT) COUNTERPART HARVEST

- Bright in $\gamma$ rays (observer frame)
- Nearby in cosmological terms (EBL)
- Lots of GRBs (duty cycle, duration distribution)
- Moderate localization accuracy

# HOPE FOR IACT GRB DETECTIONS?

VERITAS: arXiv:1109.0050



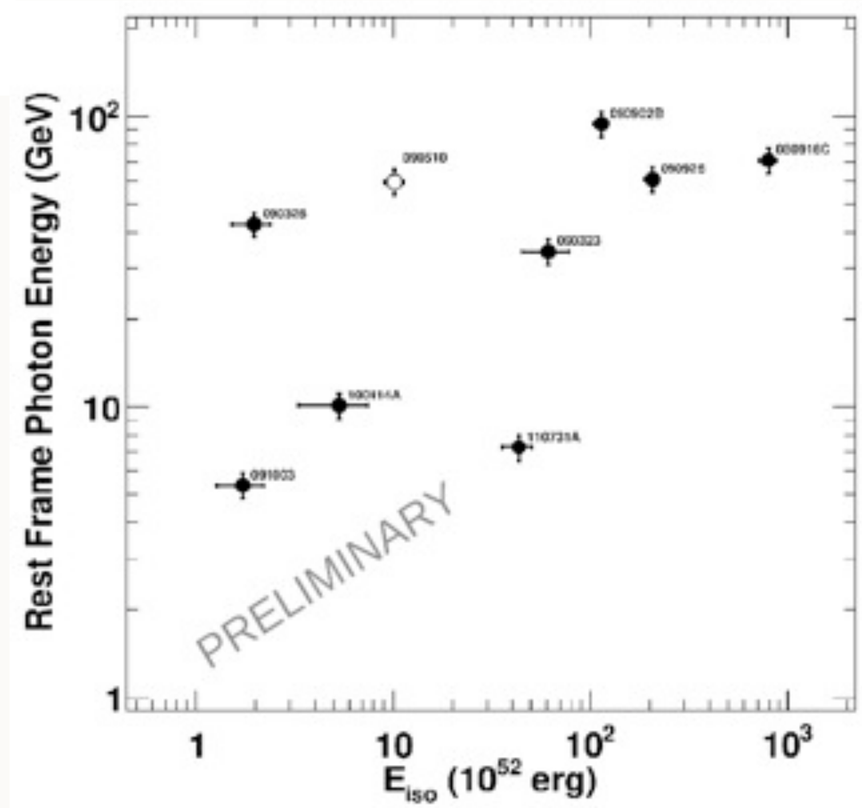

20 years of upper limits:

-- Duty Cycle

-- Field-of-view

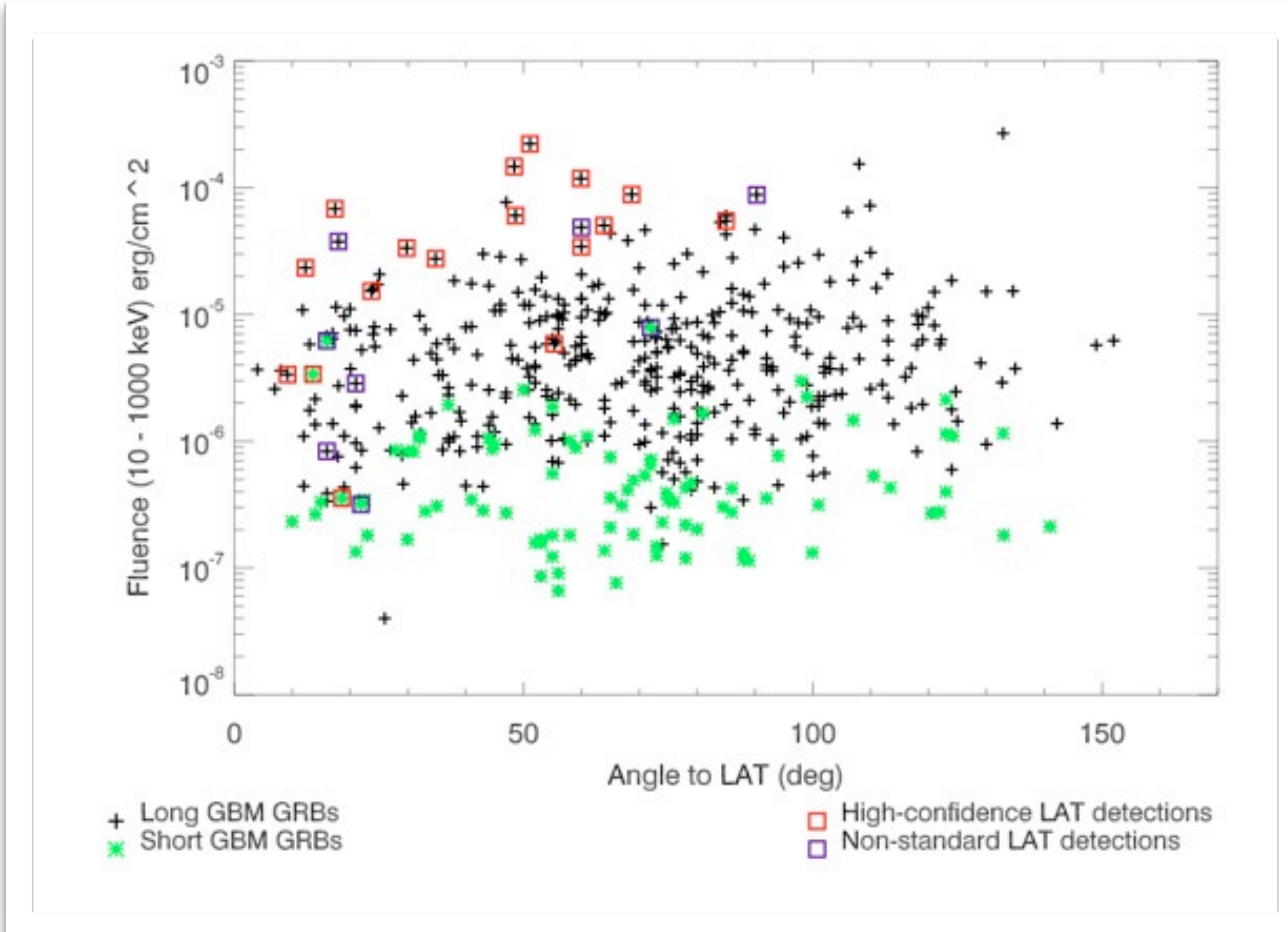
-- Slew time

-- Redshift



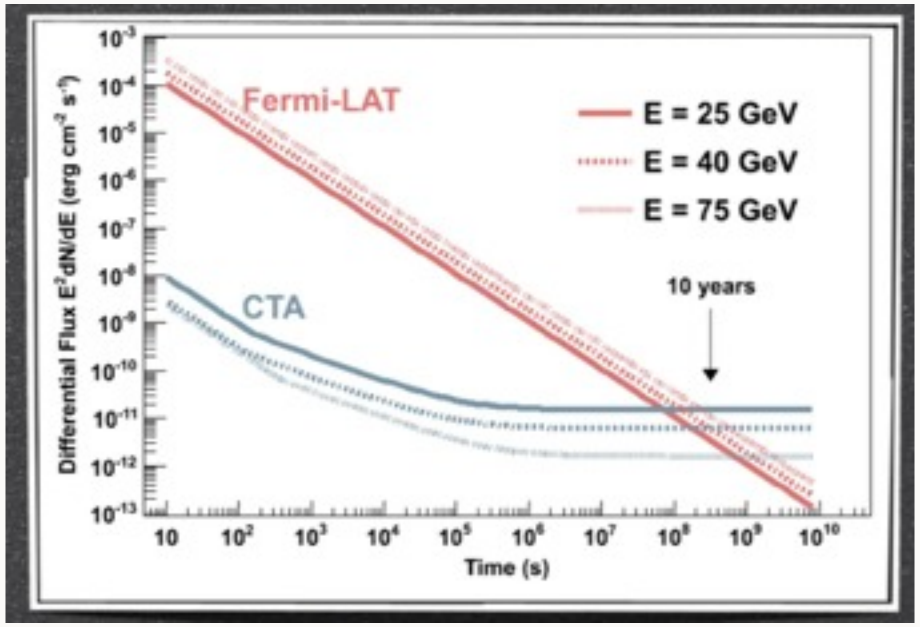

... but we know (especially) from Fermi LAT that GRBs have HE emission...

# ARE LAT-DETECTED BURSTS "SPECIAL"?

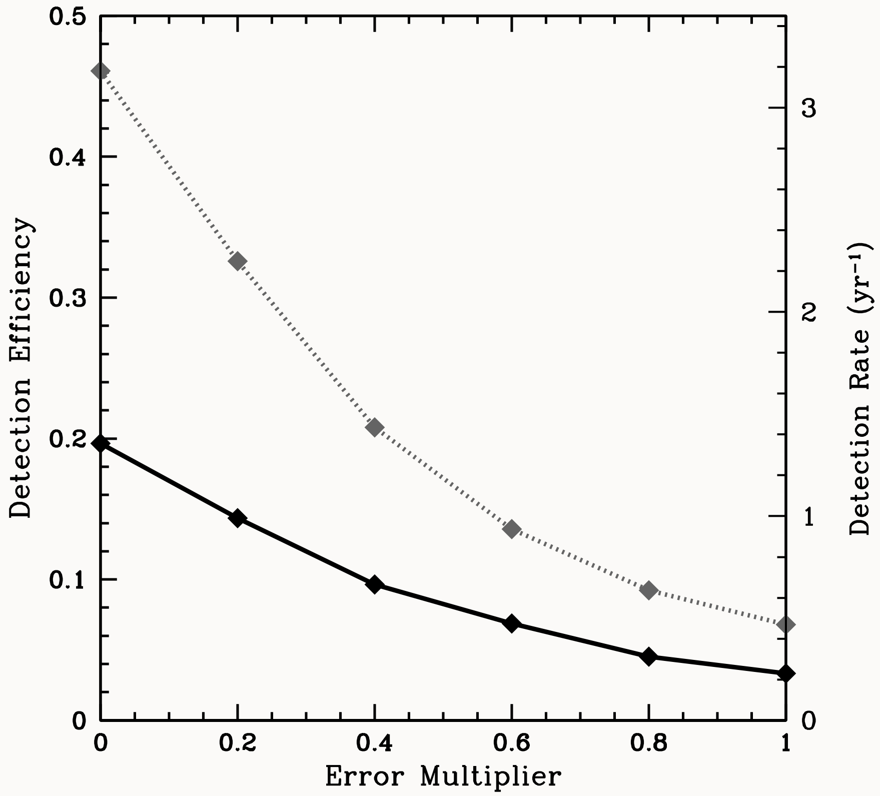



LAT sees bright, on-axis GRBs

# CTA PROSPECTS FOR GRBS




... fold in duty cycle, field-of-view, localization of GRB, slew time, GRB duration distribution, extrapolation from MeV to TeV, redshift distribution, EBL model




Kakuwa et al. 2012, Gilmore et al. 2012

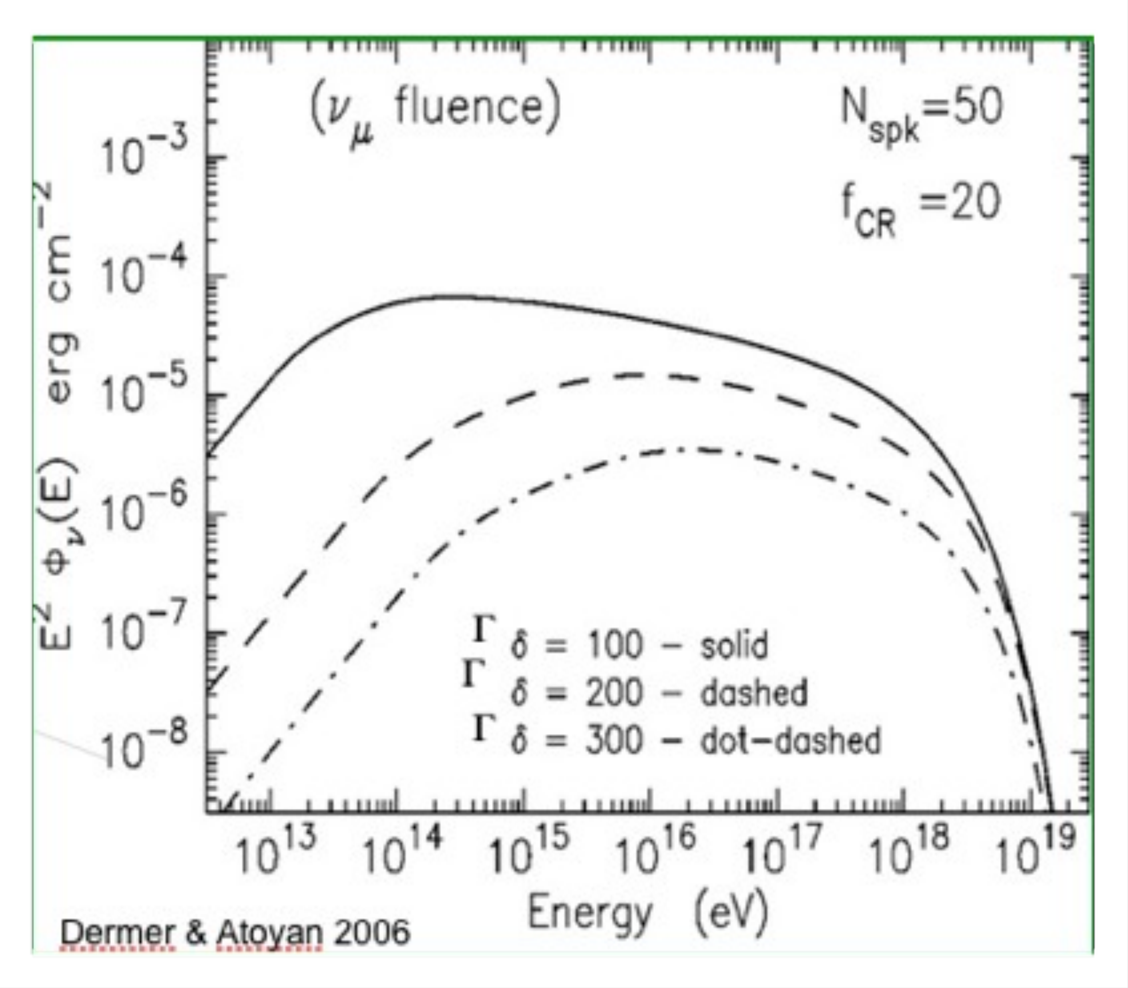
| Instrument | DE (bandex) | DE (fixed) |
|---|---|---|
| CTA (baseline) | 0.0744 | 0.115 |
| CTA (optimistic) | 0.163 | 0.328 |
| CTA (baseline; LST only) | 0.0732 | 0.110 |
| CTA (baseline; MST only) | 0.0231 | 0.0310 |
| VERITAS ($E_{th} = 65$ GeV) | 0.0241 | 0.0281 |
| VERITAS ($E_{th} = 100$ GeV) | 0.0216 | 0.0235 |

# HIGH ALTITUDE WATER CERENKOV (HAWC): A WATER CERENKOV EXPERIMENT

- A similar predictive analysis to Gilmore et al (2012) for CTA is in progress

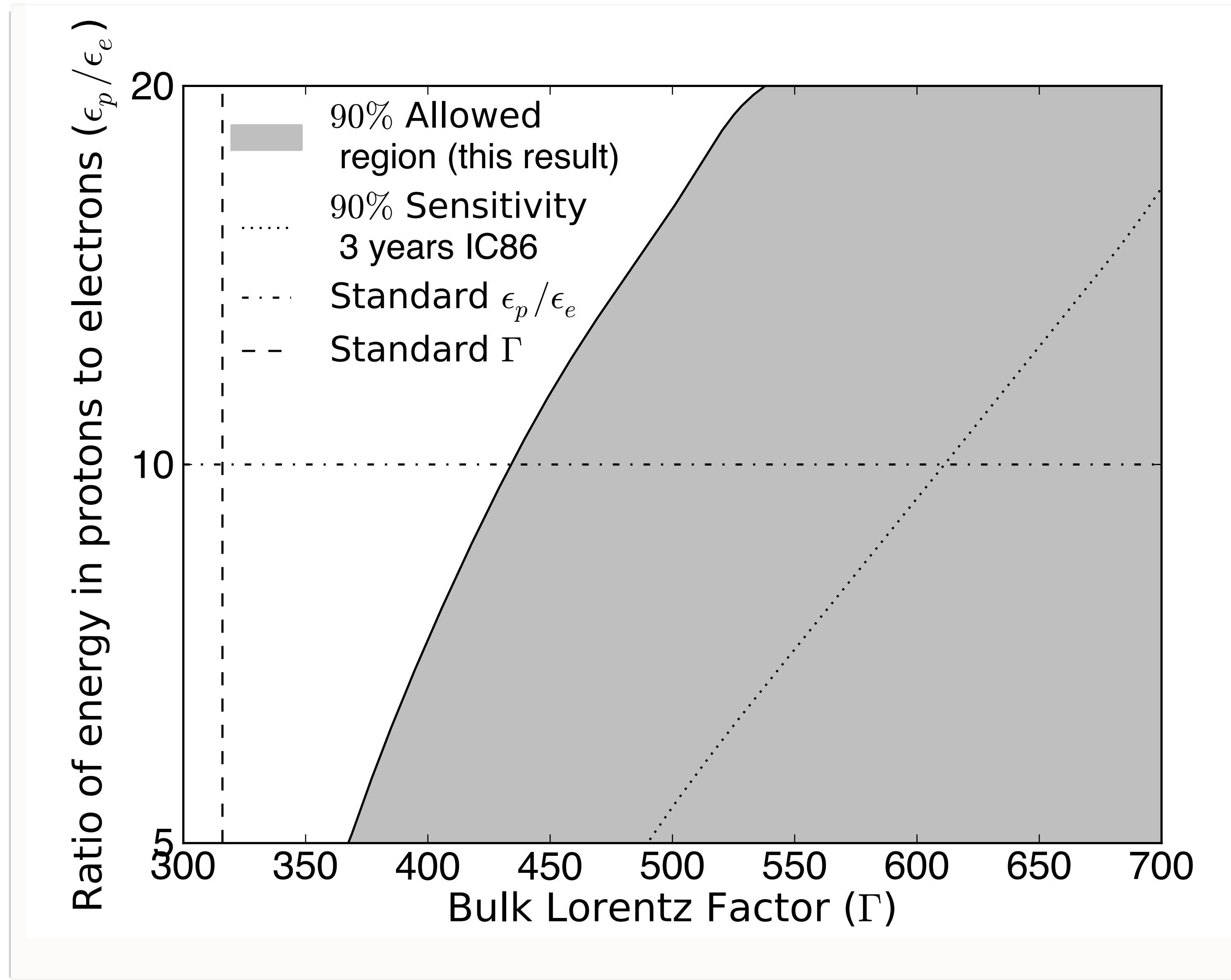
# REQUIREMENTS FOR NEUTRINO HARVEST FROM GRBS

- Bright in $\gamma$ rays (observer frame)
- Low Bulk Lorentz factor
- Lots of bursts

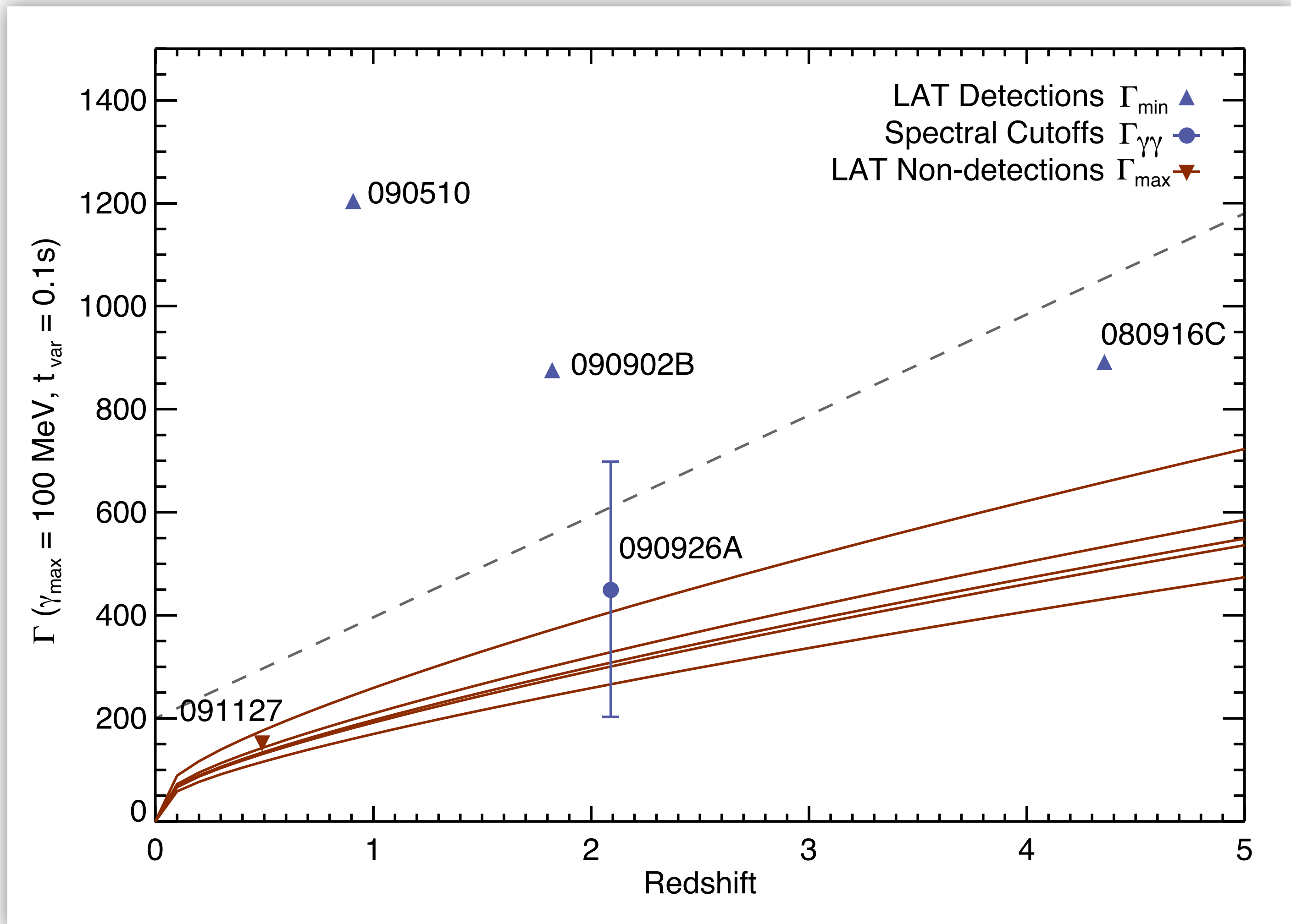


# IMPLICATIONS OF NON-DETECTIONS OF NEUTRINOS FROM BRIGHT GRBS

- Abbasi et al. (2012): 196 GRBs.
- Gao, Asano, and Meszaros (2012) provide more GRB scenarios and ν pathways.



# IS THERE A DISTRIBUTION OF BULK LORENTZ FACTORS?




Ackermann et al. 2011

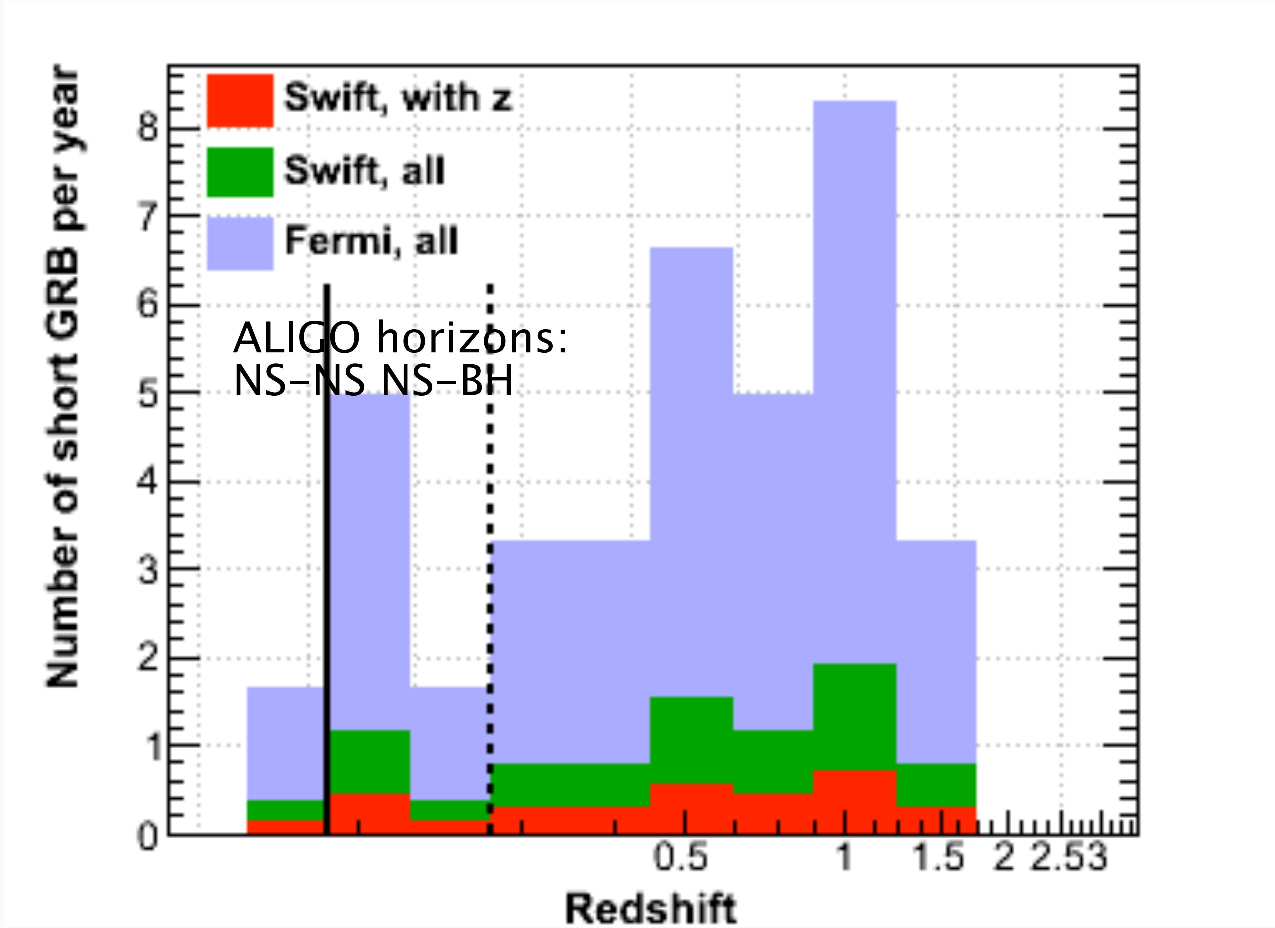
# REQUIREMENTS FOR GRAVITATIONAL WAVE HARVEST

- Short GRB indicating merger progenitor
- Nearby: within GW experiment horizon
- Lots of bursts

# GBM-ALIGO YEARLY HARVEST

- Assuming z-distribution of short Swift GRBs without z is same as those with z, and z distribution of Fermi GBM short GRBs is same.
- EM allows sub-threshold search in GW data. GW candidate allows sub-threshold search in GBM.
- see also Metzger & Berger (2011) and Kelley, Mandel, & Ramirez-Ruiz (2012).

Short Burst Redshift Distribution

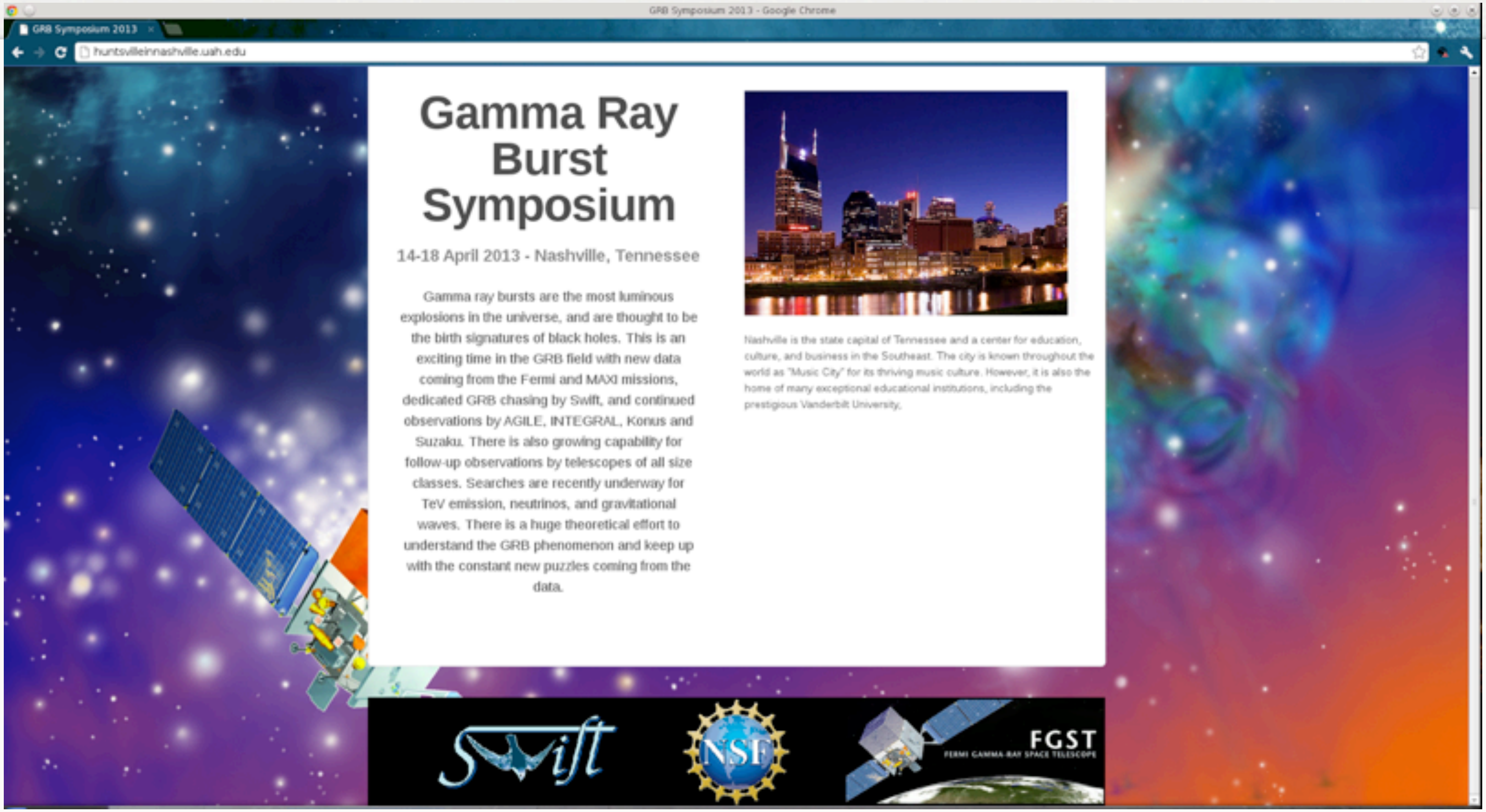



Based on horizons from Abadie et al. 2010 and Swift GRBs with known z.

# THE GOOD NEWS FROM GBM FOR THE MULTI-MESSENGER ERA

- GBM sees lots of GRBs - ~250 per year
- VHE: long, bright, nearby, high $\Gamma$
- Neutrinos: long, bright, low $\Gamma$
- Gravitational waves: short, nearby

# HUNTSVILLE IN NASHVILLE: THE 7TH HUNTSVILLE GRB SYMPOSIUM 14-18 APRIL 2013.




- Organizers: Michael Briggs, Valerie Connaughton, and Neil Gehrels.
- http://huntsvilleinnashville.uah.edu Contact: grb2013@uah.edu

# TRADITIONAL AFTERGLOW SEARCHES

- Pandey et al. 2010: Observations of GBM error box for 090902B gave ROTSE the early afterglow measurements hours before the LAT detection/XRT follow-up.