Prospects for VHE monitoring of Gamma-ray Bursts with SWGO

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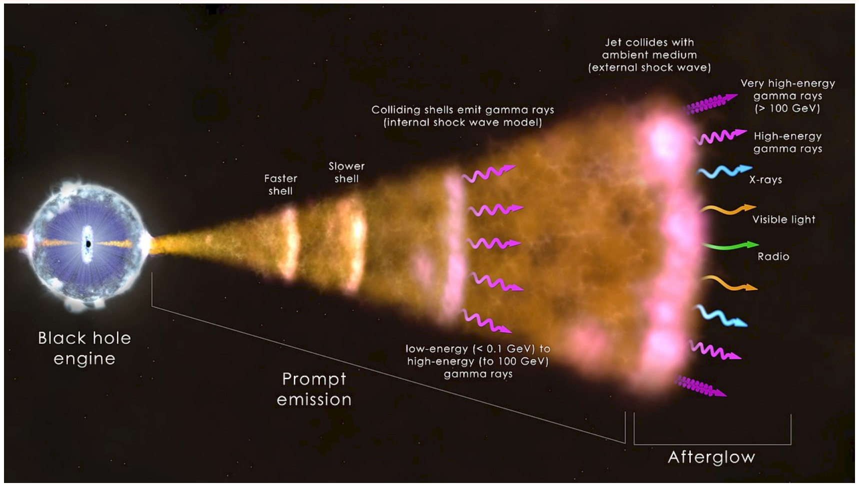
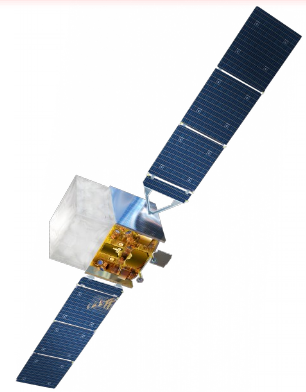
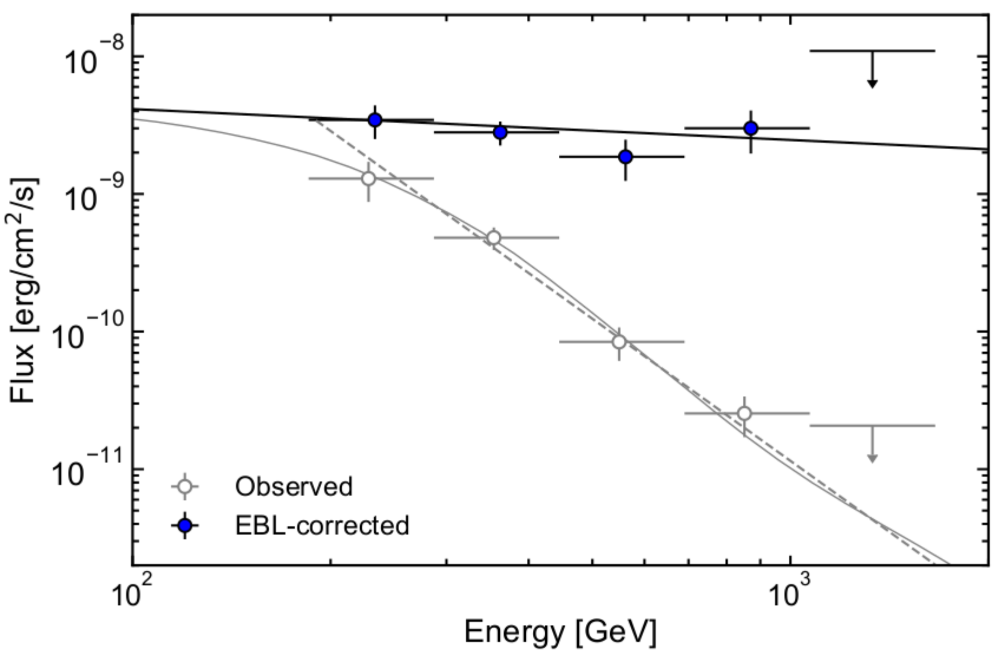
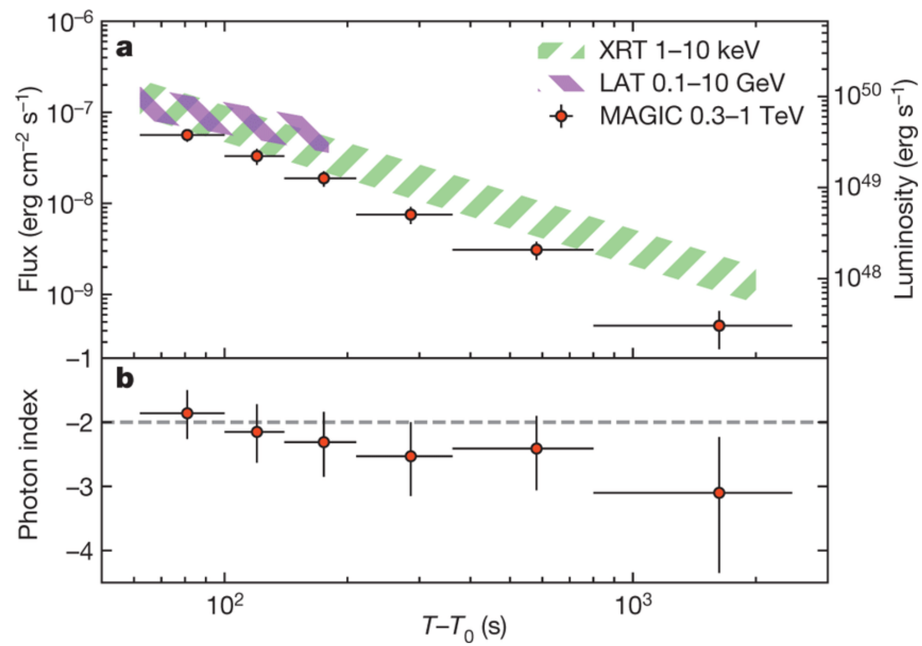
XVI Marcel Grossmann Meeting, July 5-10, 2021

VHE detection of GRBs





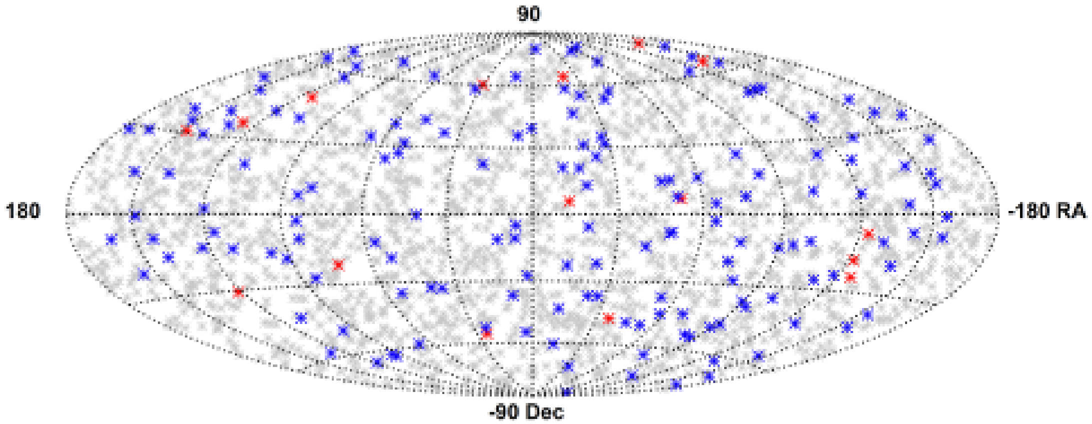




VHE spectrum (left) and multi-frequency light-curve (right) of GRB 190114C as seen by *MAGIC*, *Fermi*-LAT and *Swift*-XRT (MAGIC Coll., 2019, Nat., 575, 455)

HE properties of LAT GRBs

Gamma-Ray Burts have been firmly detected as VHE sources. Due to intrinsic spectral characteristic and to pair-production opacity effects, the low expected photon fluxes can only be observed using large instrumented areas (~10^5 m^2)



Fermi-LAT detected long (blue stars) and short (red crosses) GRBs, together with the *Fermi*-GBM triggers collected between July 14, 2008 and July 31, 2018 (gray stars).

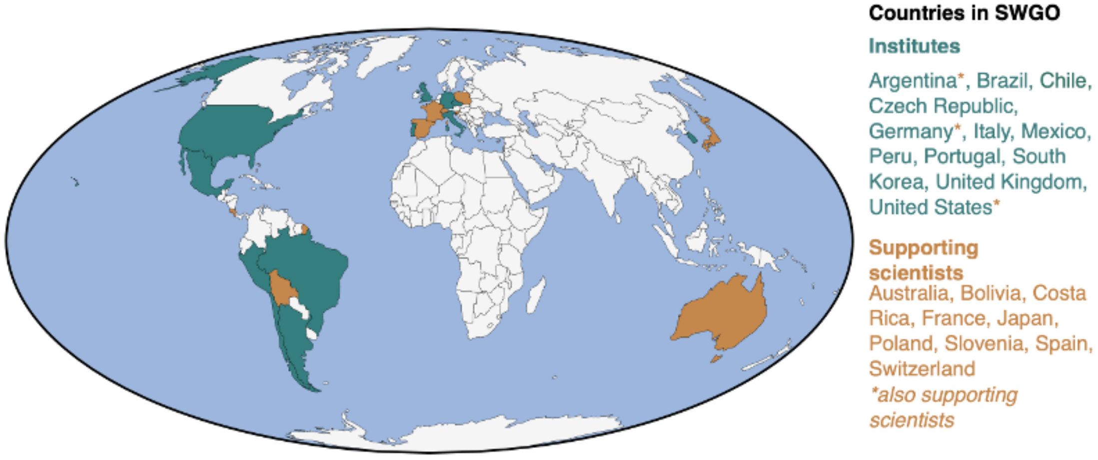
Figure from Ajello et al. (2019, ApJ, 878, 52)

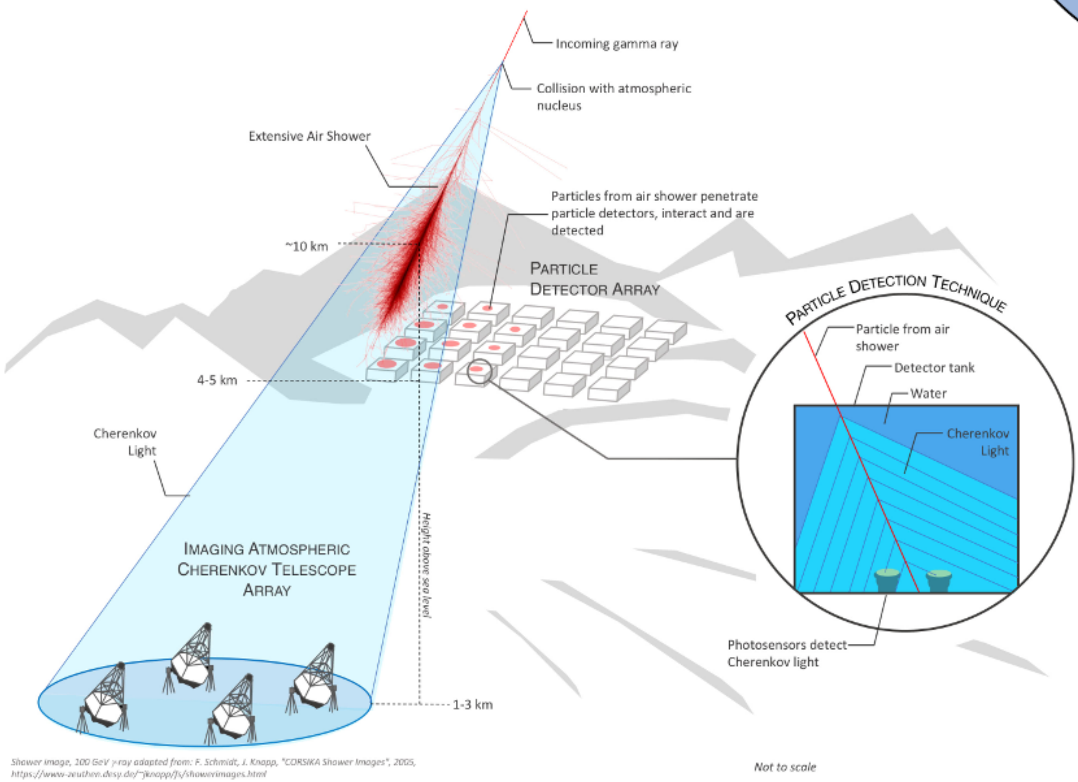
Reported cases of VHE emission:

- **GRB 201216C (MAGIC)**
- **GRB 190114C (MAGIC)**
- **GRB 190829A (H.E.S.S.)**
- **GRB 180720B (H.E.S.S.)**
- **GRB 160821B (MAGIC)**
- **GRB 130427A (*Fermi*-LAT)**

VHE transients with SWGO

The **Southern Wide-field-of-view Gamma-Ray Observatory** (SWGO) is a collaboration aiming to design and construct a VHE EAS array of Water Cherenkov Detectors (WCD) in the Southern Hemisphere.



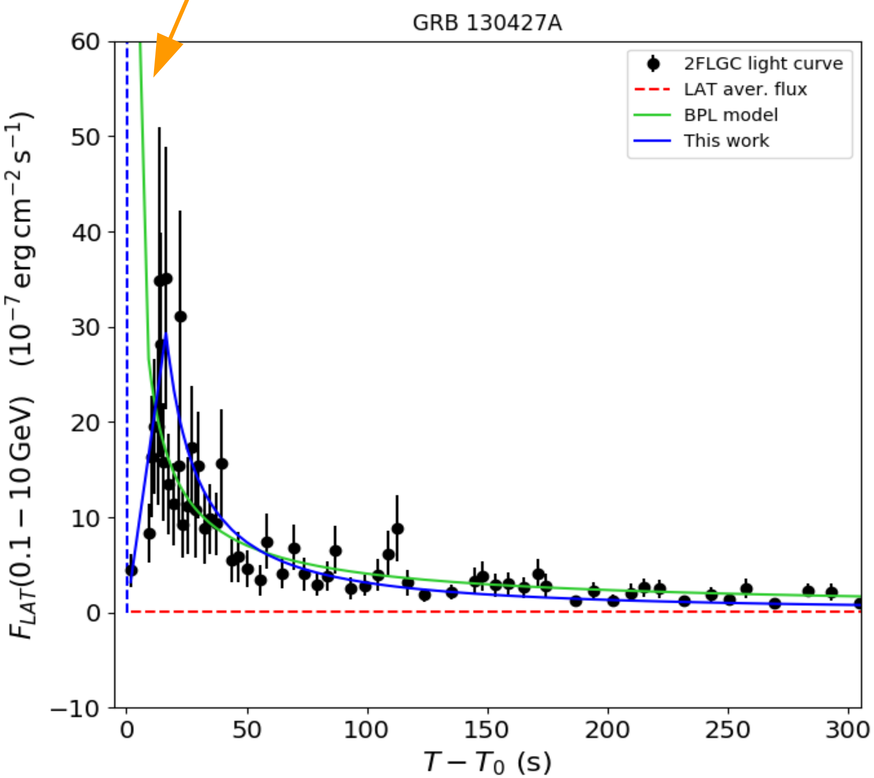


SWGO will use air-shower tracking to provide continuous monitoring of a large field of view at energies above 100 GeV. It is designed as a monitoring instrument and an alert system for IACTs. It will cover unaccessible sky regions for HAWC and LHAASO.

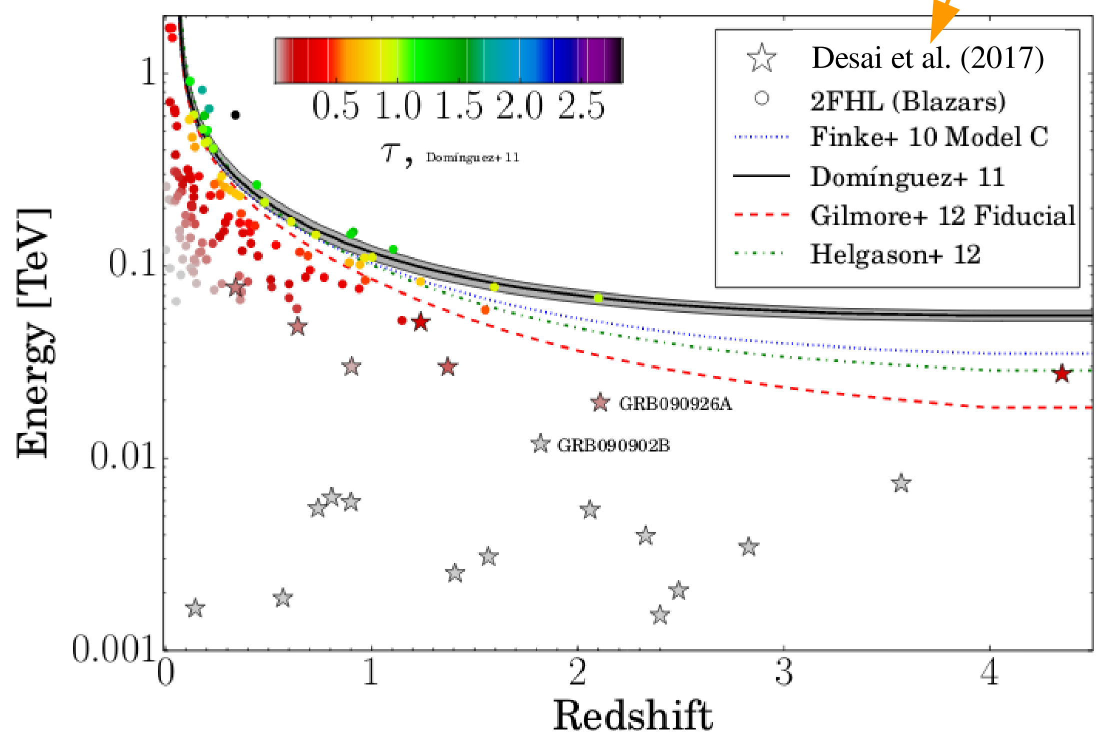
Website: https://www.swgo.org

GRBs at Very High Energies

Very little information on the early evolution (virtually none on prompt emission)



Radiation above 100 GeV subject to Extragalactic Background Light (EBL) opacity

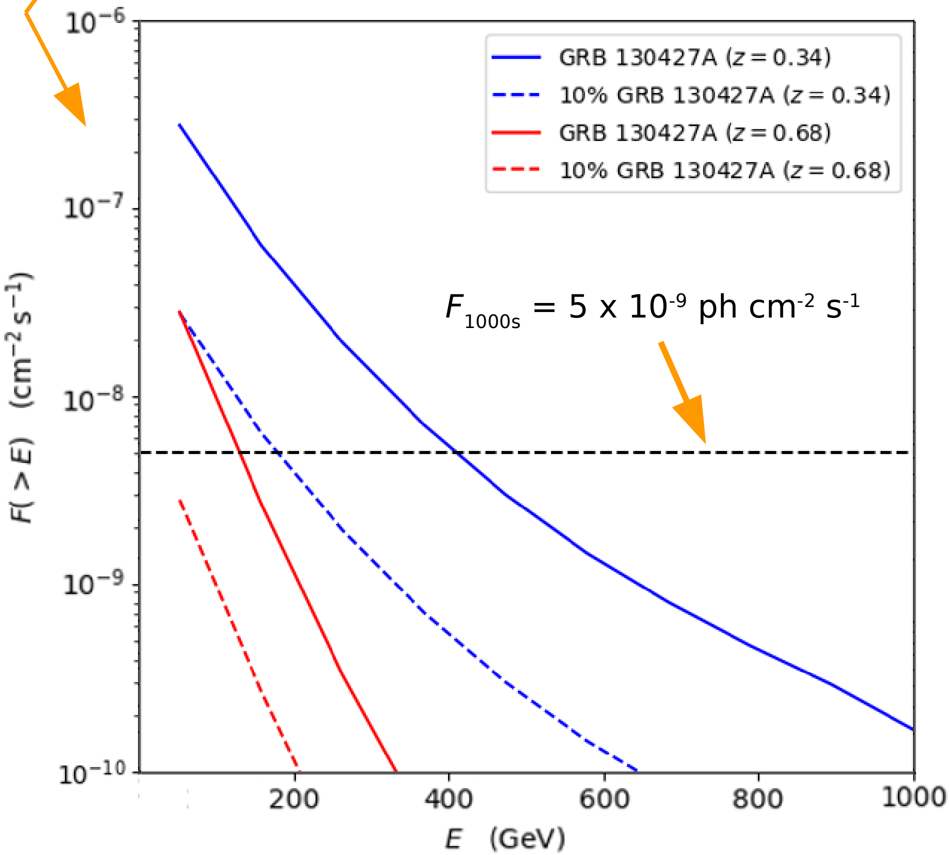


The visibility of GRBs in the VHE domain is controlled by multiple parameters: intrinsic source properties (GRB model); EBL opacity (redshift and Cosmology); spectral evolution (prompt and afterglow emission).

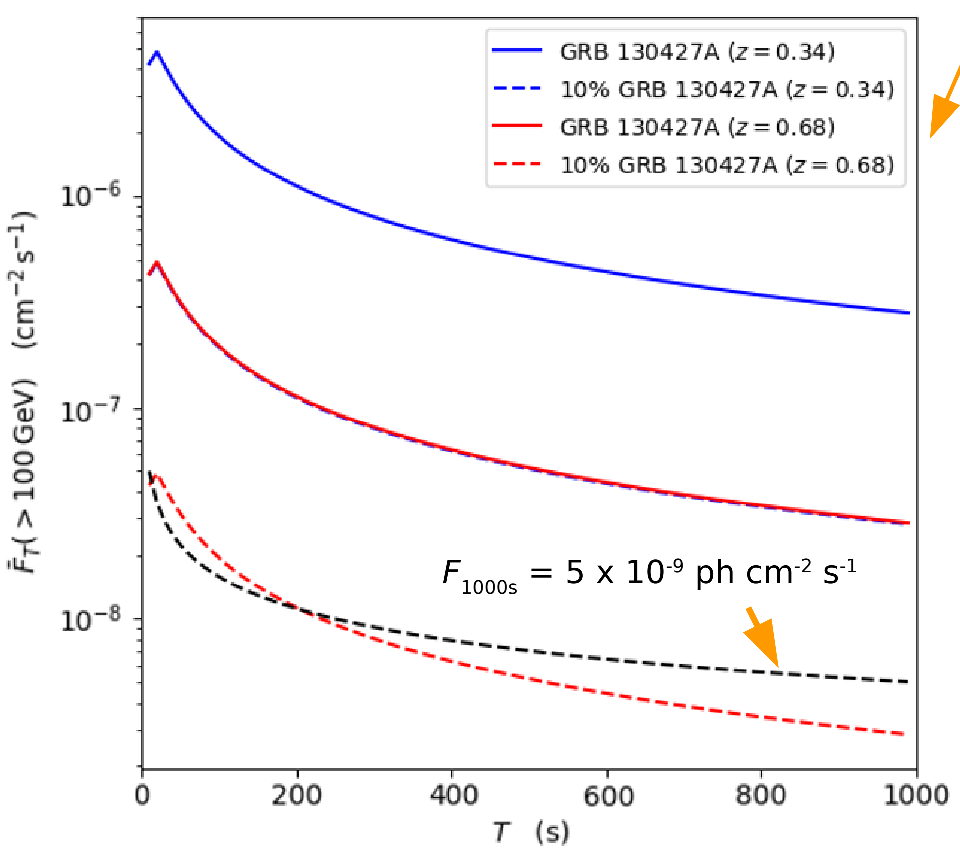
Only a large FoV (~1 sr) high duty cycle (~99%) instrument can effectively probe the earliest properties.

Models and observations

Average integrated photon flux in 1000s for observed and modelled GRBs vs. Energy threshold

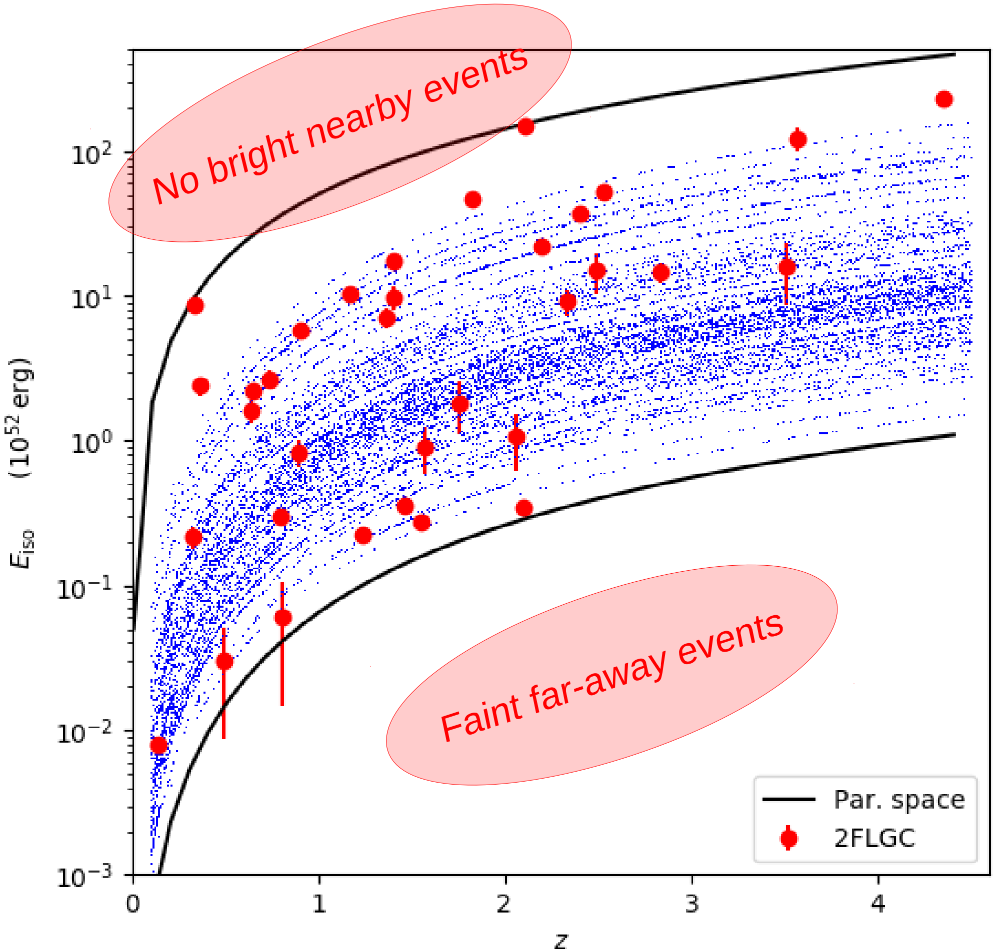


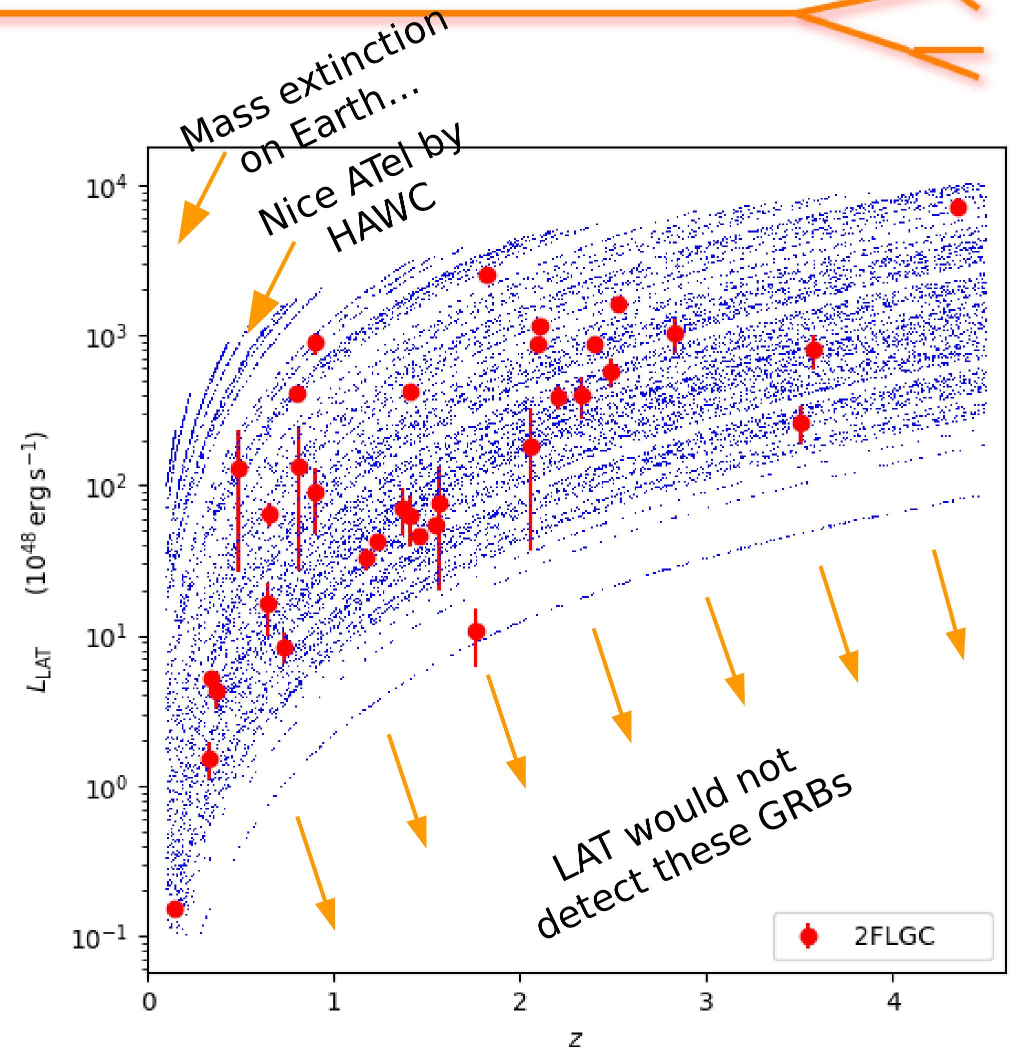
Instantaneous photon fluxes, as a function of time, compared with an integral sensitivity of $5x10^{-9}$ ph cm^{-2} s^{-1}



The available observations suggest that VHE emission from GRBs exceeds the extrapolation of the energetic component (E > 1 GeV) that *Fermi*-LAT detected in the brightest bursts observed during its first 10 years of monitoring.
This suggests the possibility that LAT detected GRBs may be used to estimate the frequency of VHE detectable events at different redshifts.

Estimating redshift effects

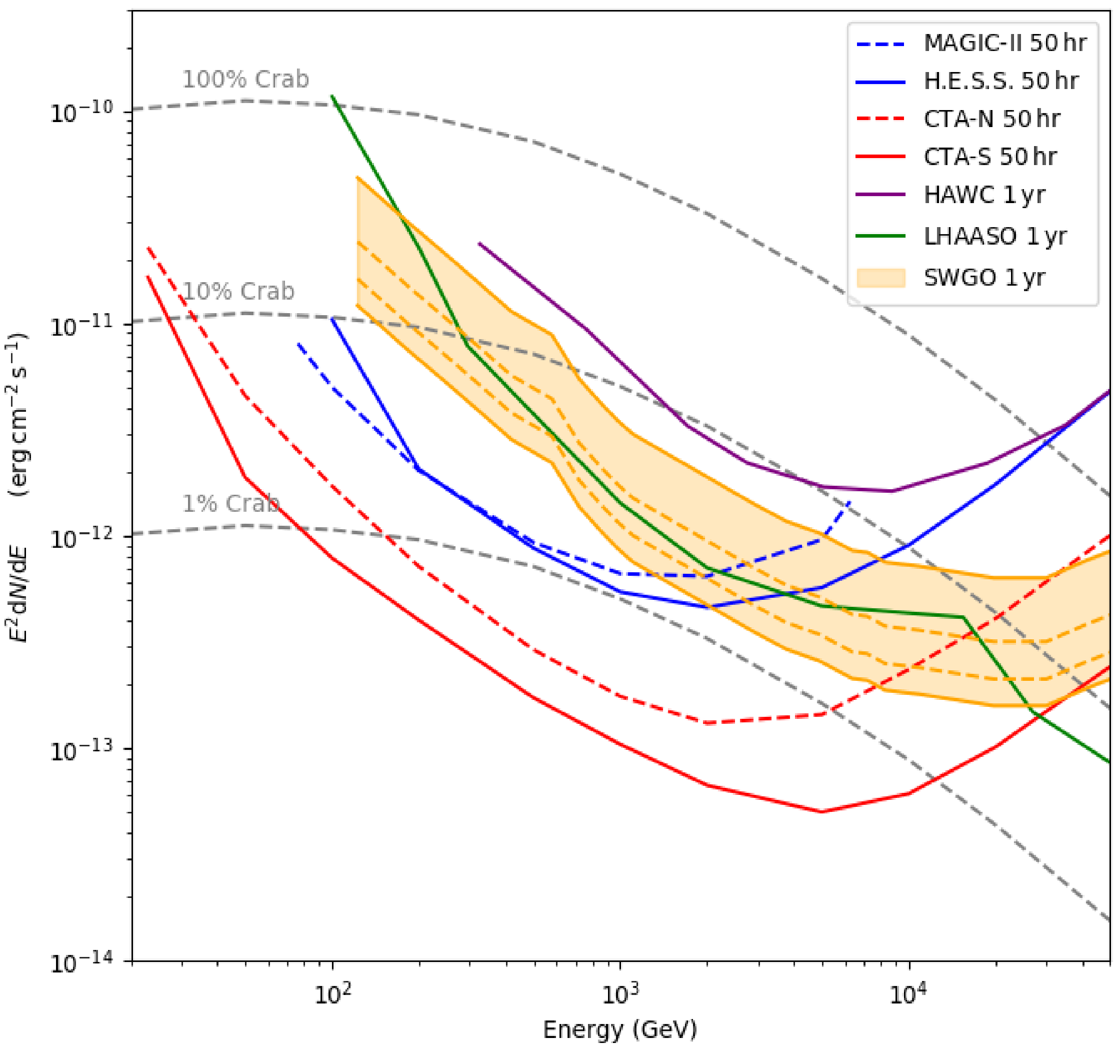




For GRBs with unknown z, we simulated 1000 distributions, constraining E_{iso} between the minimum fluence detected by LAT and 10^{54} erg.

$$E_{iso}=\frac{4\pi d_L^2}{1+z}(T_1-T_0)\int_{E_1/(1+z)}^{E_2/(1+z)} E\frac{dN}{dE}dE$$

Instrument performance sets

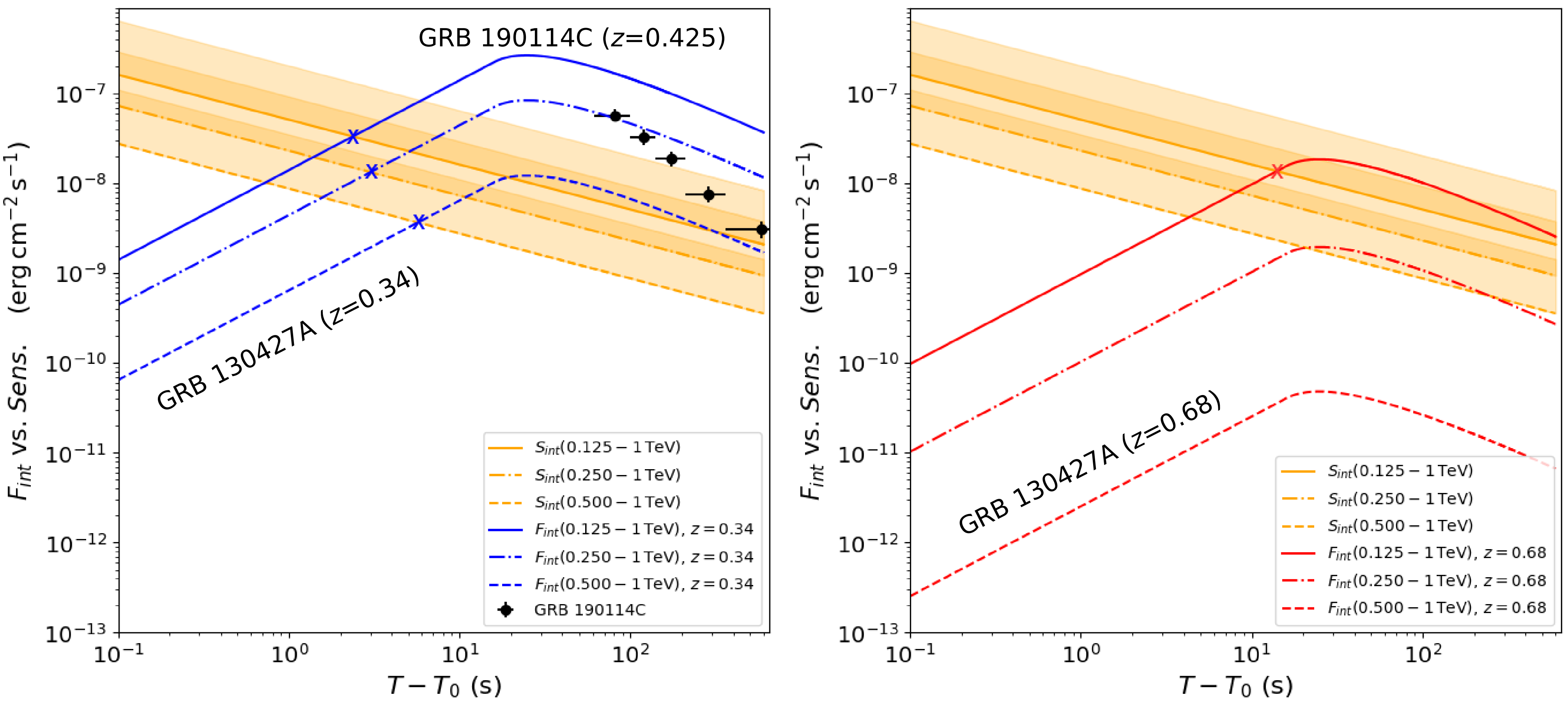


The detection of the predicted photon fluxes can be tested with a set of instrument performance estimates, designed to *bracket* the expected outcome.

The design is based on a 5σ detection threshold from a set of preliminary simulations using a 80,000 m^2 array.

Uncertainties and FoV effects are accounted for by alteration of energy threshold and sensitivity normalization.

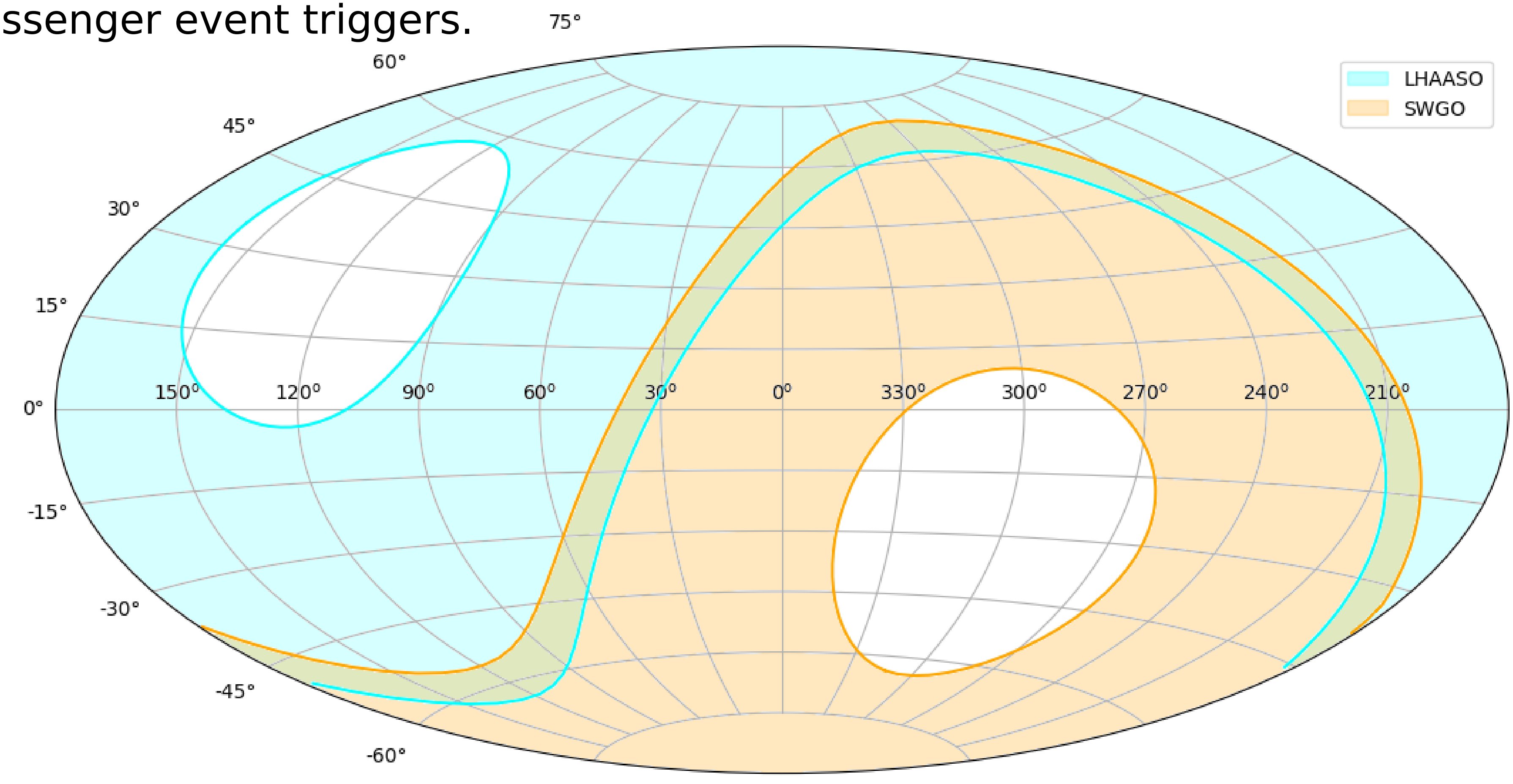
Event detection testing



We test for source visibility combining assumptions on instrument performance as a function of time with information on the observable spectrum and light-curve. Detailed analysis of the redshift distribution and comparison with more advanced performance estimates are currently in progress.

Fast transient monitoring

High altitude monitoring facilities, based on EAS detector arrays, can grant access to the observation of the sub-TeV spectral domain. The result is an unprecedented possibility to monitor the sky for VHE transient sources. The combined FoV of facilities, such as LHAASO and SWGO, will provide extensive sky coverage of both hemispheres, offering an invaluable integration to the search for new Multi-Messenger event triggers.



SWGO
The Southern Wide-field
Gamma-ray Observatory

Acknowledgements

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

REPÚBLICA PORTUGUESA

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TÉCNICO LISBOA

Fermi
Gamma-ray Space Telescope