GLAST and Ground-based γ-ray astronomy

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http://www-glast.stanford.edu/

Abstract. The launch of the Gamma-ray Large Area Space Telescope (GLAST) in 2007 will open the possibility of combined studies of astrophysical sources with existing ground-based VHE γ-ray experiments such as H.E.S.S., VERITAS and MAGIC. Ground-based γ-ray observatories provide complementary capabilities for spectral, temporal, spatial and population studies of high-energy γ-ray sources. Joint observations cover a huge energy range, from 20 MeV to over 50 TeV. The LAT will survey the entire sky every three hours, allowing us to perform long-term monitoring of variable sources under uniform observation conditions and to detect flaring sources promptly. Imaging atmospheric Cherenkov telescopes (IACTs) will complement these observations with high-sensitivity pointed observations on regions of interest.

Keywords: GLAST, γ-ray astronomy, H.E.S.S., Supernova remnants

Up to know the last largely unexplored window in the electromagnetic spectrum lies in the future overlap between GLAST sensitive to high energy (HE) γ-rays (100 MeV – 300 GeV) and the ground-based IACTs operating in the VHE γ-ray range ($>$ 100 GeV). For adequate understanding or correct identifcation of the realized emission processes in a high-energy gamma-ray sources, joined spectral coverage through HE and VHE energies provide most sensitive constraints. Such broad coverage will be possible for the first time with the launch of GLAST in late 2007. However, the importance of joint observations goes beyond a simple overlap in energy coverage. Additional synergy between HE and VHE instruments is provided by complementary capabilities in sky monitoring, source resolution and localisation and variability studies. Table 1 compares the most important technical properties of different classes of instruments. In the following section we will highlight some selected science topics that can benefit from joint observations.

TABLE 1. Comparison of properties of the GLAST-LAT and ground-based IACTs.

	GLAST-LAT	**IACTs**
Energy Range	20 MeV – 300 GeV	$\sim$ 100 GeV – 100 TeV
Energy Resolution	$<$ 10%	15%
Duty Cycle	$\sim$ 80%	$\sim$ 15%
Field of view	2.2 sr	2.4×10^{-2}sr ($\sim 5^\circ$)
Angular resolution	0.1°@10 GeV	0.1°
Effective area	$\sim 1\text{m}^2$	$\sim 10^5\text{m}^2$
Point source sensitivity	1.5×10^{-10} cm^{-2} s^{-1} (E $>$ 10 GeV)	10^{-11} cm^{-2} s^{-1} (E $>$ 100GeV)

Galactic γ-ray sources

The study of Galactic sources will form an important part in the investigations of the GLAST γ-ray sky. While EGRET found a large number of sources located along the Galactic plane, only a handful of those could be identified in other wavebands through their characteristic periodicity – the pulsars. Several other sources were noticed for intriguing spatial coincidences with potential γ-ray emitters: OB-associations, Supernova remnants and Pulsar Wind Nebulae, Wolf-Rayet stars, pulsars too weak to establish γ-ray periodicity, AGN shining through the Plane, etc. However, source confusion caused by rather poor angular resolution and the dominant Galactic diffuse emission component prevented individual identifications for most of the Galactic EGRET sources. Recent advances in the VHE γ-ray band above $\sim$ 100 GeV by IACTs such as H.E.S.S. have revealed a clearer picture about the nature of typical γ-ray sources in our Galaxy. These include PWN, SNRs, and microquasars, as well as Giant molecular clouds acting as passive material illuminated by cosmic rays. The identifications of these sources, made possible by the good angular resolution of Cherenkov instruments, provide a clean way of predicting flux levels in the GLAST-LAT regime above 20 MeV if

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viable multi-frequency models can be found for the individual sources. In the light of these predictions and the large number of presumable Galactic EGRET sources, it is evident that the study of Galactic sources together with VHE instruments represents a large and yet unexplored scientific potential and promises to yield a large scientific return.

Gamma-ray bursts

GLAST-LAT observations will provide important measurements of the γ-ray emission up to a ~ 100 GeV during both the prompt and afterglow phases of a large number of γ-ray bursts (GRBs). IACTs can extend these measurements (especially of the afterglow) up to the TeV range. These measurements will allow us to gain deeper insights into the properties of the emission from GRBs and internal properties such as the bulk Lorentz factor, acceleration physics, UHECRs, and hadronic processes. GRBs detected on-board the LAT within an IACT FoV will be a rather uncommon ($\sim$ 1/year) opportunity. Nevertheless, immediate follow-up observations of such GRBs will be extremely valuable and should be performed with high priority. MAGIC has already demonstrated to be able to observe a γ-ray $\sim$ 40s after the burst-alert. IACTs can also provide sensitive observations of GRB afterglows. Assuming a LAT GRB detection rate of 50 GRB/year, $\sim 5-10$ GRB per year could be followed up by IACTs for afterglow observations.

Active Galactic Nuclei

AGN are the most populous and best studied known class of high-energy γ-ray sources. One distinctive feature in some AGN is extreme variability down to sub-hour timescales, and measurements of AGN spectra on short timescales will provide a crucial tool for understanding AGN physics. The LAT will measure time-averaged spectra for thousands of blazars. Although a substantial fraction of these will be flat-spectrum radio quasars with little emission in the VHE γ-ray energy band, many will be high-energy-peaked BL Lacs (HBLs) for which the VHE γ-ray emission might be appreciable. For HBLs like Markarian 501, joint observations between IACTs and the GLAST-LAT are needed to completely cover the high-energy part of the SED, allowing the peak to be tracked even if it shifts in energy with flux level. Measuring the full shape of the high-energy peak will reveal important properties of individual AGNs such as the overall energy budget and the relative contributions of the SSC and SC cooling mechanisms.

Interactions with the IR-optical-UV background radiation

High-energy γ-rays interact via pair-production with photons of the Extragalactic Background Light (EBL). So far, only VHE γ-ray observations of low-redshift BL Lacs have been available to study these attenuation effects. The future combination of LAT-data and IACT-data will allow for a deeper understanding of the EBL in various ways. GLAST-LAT and IACTs will probe different parts of the EBL spectrum. While γ-rays detected by the LAT in the $\sim 10\ \mathrm{GeV} < \mathrm{E} < 300$ GeV energy range are attenuated by UV-optical photons of the EBL, γ-rays detected by IACTs with energies above ~ 100 GeV are absorbed by optical to infrared EBL photons. Thus, LAT and ground-based observations complement each other by measuring different parts of the EBL. The GLAST-LAT and IACTs will additionally allow for independent studies of EBL attenuation. The analysis of the large sample of GLAST-blazars (>1000) will provide a powerful tool to study EBL absorption and to distinguish extragalactic attenuation from intrinsic peculiarities in individual blazar spectra, although the evolution of blazars and their associated radiation field will introduce ambiguities in the interpretation of such signatures (A.Reimer, these proceedings). Independently, blazar emission models will be refined by studying multi-frequency spectra of individual blazars. In addition, the LAT has access to the region of the γ-ray spectrum below 10 GeV that is only little affected by EBL-attenuation (at any redshift). Observations in the range below ~ 1 GeV will lead to improved predictions for the intrinsic source spectra.

Summary

In summary the combination of data taken with the GLAST-LAT as part of the all-sky-survey and in dedicated observation with IACTs promises a rich yield of scientific insights into the processes responsible for the acceleration of relativistic particles and the emission of γ-rays at this extreme energies.