The LAGO capabilities for detecting Gamma Ray Bursts

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Latin America Giant Observatory
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Abstract

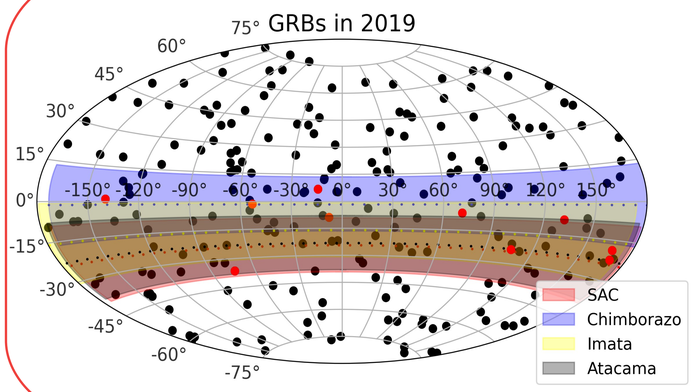
The Latin American Giant Observatory (LAGO) consists of a network of small water Cherenkov detectors (WCD) located at different sites in Latin America. It is a large aperture observatory sensitive to high energy gamma rays and due to its high duty cycle, LAGO constitutes a facility to detect transient events from the ground. Gamma Ray Bursts (GRBs) are of the brightest transients detected, with typical energies in their prompt phase ranging from keV to MeV, but theoretical models predict emissions at higher energies in the early times of the afterglow emission, and recently GRB190114C was the first GRB detected at TeV energies by the MAGIC experiment. In this work, we present the results of the expected sensitivity of LAGO for possible events like GRB190114C. We performed simulations in four of the high altitude LAGO sites projected to assess the sensitivity of the Observatory for this kind of events, using the ARTI toolkit. We simulate photon showers with different spectral slopes and energies from 0,2 TeV to 1 TeV using the parameters presented by MAGIC for the recorded event. We also present a map for the FOV of the studied sites with the detected GRBs from 2019, 2020 and 2021 by Fermi-GBM.

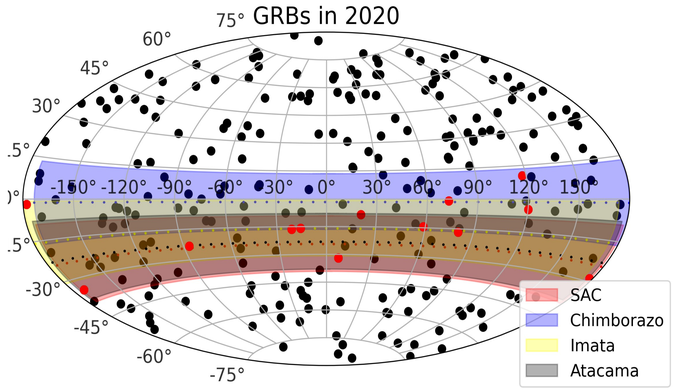
Motivation and previous studies

- The MAGIC Collaboration has recently reported the first unambiguous detection from the ground of a GRB at energies between 200 GeV to 1TeV, GRB 190114C.
- Also, GRB 180720B was reported by the H.E.S.S. telescope with emission detected in the energy band of 100-440 GeV and around ten hours after the prompt emission.

Country	Site	Altitude [m a.s.l.]	Latitude [deg]	Longitude [deg]
Argentina	SAC	4500	24.23 S	66.32 W
Chile	Atacama	5100	23 S	67.76 W
Ecuador	Chimborazo	5000	1.47 S	78.82 W
Perú	Imata	4600	15.84 S	71.10 W

- LAGO has shown that using the so-called "single particle technique" (SPT) it was feasible to observe an increase in expected secondary cosmic ray flux using WCDs.
- Previous simulations of photon-initiated air shower in the energy range of 1 GeV to 1 TeV showed a significant amount of electromagnetic particles arriving with energies averaging 10 MeV for the Chacaltaya and Sierra Negra sites.
- High altitude LAGO sites (h>4000 m) are designed and operated mainly for the search of high energy components of GRB. Such sites are chosen to diminish the atmospheric absorption.

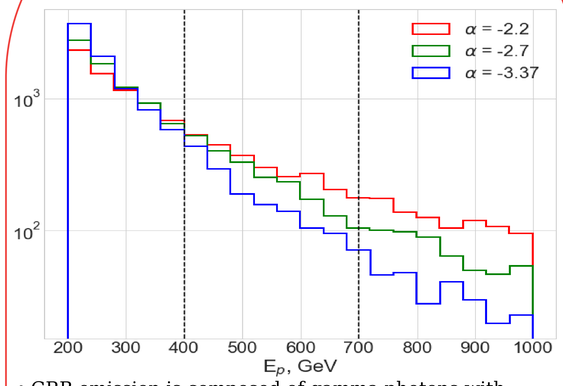




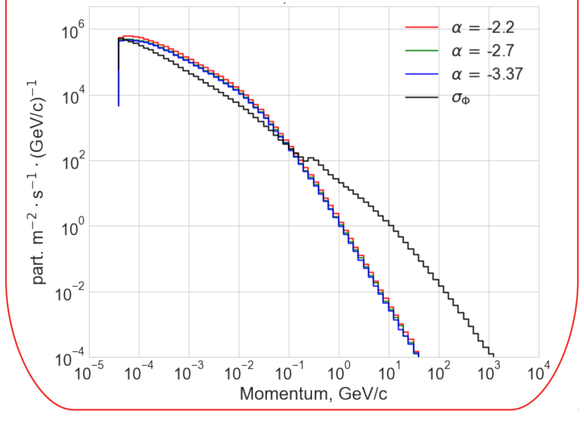
FOV

- GRBs are detected from all directions in the sky and GBM reports a rate of detection of ~240 GRBs per year.
- We present the bursts observed by GBM in the years 2109 and 2020.
- The FOV band considering a 15° aperture is projected as the colored bands for each site
- In red circles it can be seen the GRBs that were in the field of view (FOV) of the LAGO high altitude sites (above 4000 m.a.s.l.).

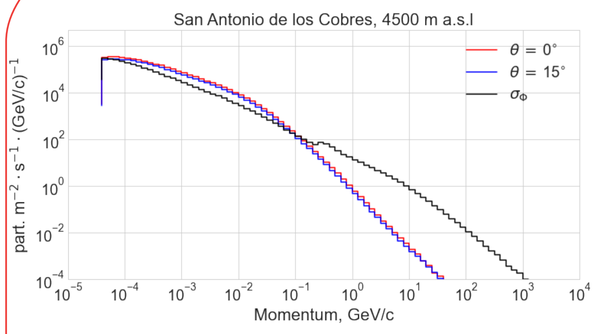
GRB Model

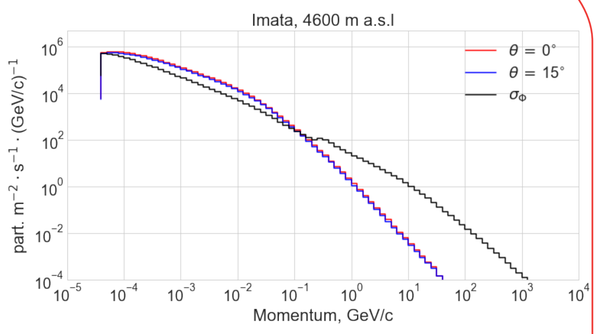


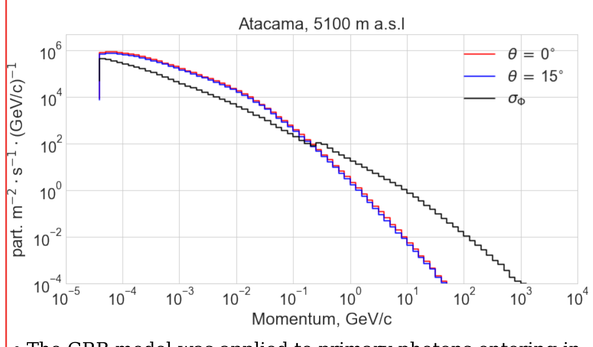
- GRB emission is composed of gamma photons with energy 0.2 TeV–1TeV. We defined three energy intervals as show in the top figure.
- For each interval and spectral index, we performed 50,000 simulations and computed the flux of secondaries arriving at ground level and the average weighted by he contribution of each component.
- Flux of secondaries for the three values of spectral index (bottom figure). The black line is the total radiation background, in this case: Imata.

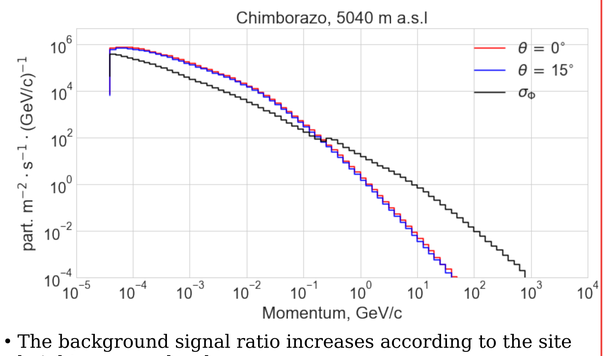


Background–Signal ratio









- The GRB model was applied to primary photons entering in the atmosphere with zenith angles of 0° and 15°.
- The similar behavior between events whose zenith angle is 0° and 15° is because the secondary flux has a performance as cos² θ and begins to decrease steeply after 30º.
- The background signal ratio increases according to the site height over sea level.
- This figures shows the comparison between the background flux and the secondary fluxes generated by the GRBs modeled in each site studied. As can be seen in all cases, the flux exceeds the background in an energy region where LAGO's WCD have high efficiency.

Results

- In this work, we have revisited the detection capabilities of the LAGO network at high altitude sites (h>4000 m a.s.l.) of the high energy component of the GRBs, based on recent observations of GRB photons with energy up to ≤1 TeV, and new developments on the synthetic reproduction of EAS developments, including new high and low energy interaction models, realistic atmospheric profiles and improved detector responses.