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Book of Abstracts

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Rapid talks / **1**

Investigating Cherenkov Telescope Array Observatory capability to detect gamma-ray emission from simulated neutrino sources identified by KM3NeT

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Gamma-ray observations of astrophysical neutrino sources are crucial for understanding neutrino production in extreme cosmic environments. The Cherenkov Telescope Array Observatory (CTAO), the first open-access ground-based gamma-ray observatory, is under construction in both hemispheres, CTAO-North in La Palma (Spain) and CTAO-South in the Atacama Desert (Chile). Covering an energy range from 20 GeV to 300 TeV, CTAO will offer unprecedented sensitivity to transient multi-messenger sources.

In this study, we use the open-source Python code FIRESONG (FIRst Extragalactic Simulation Of Neutrino and Gamma-ray) to simulate a population of neutrino-emitting sources, including both steady and flaring blazars sources. The simulations incorporate various astrophysical input parameters, such as local source density, neutrino luminosity and stellar evolution models. We then assess CTAO's capability to identify gamma-ray counterparts to these simulated neutrino sources, which may also be detectable by KM3NeT, another next-generation instrument. The KM3NeT collaboration is deploying the ARCA neutrino telescope in the Mediterranean Sea, 80 km off Capo Passero, Italy, at a depth of 3,500 m, to enhance sensitivity to high-energy neutrinos in the Southern Sky.

A previous study by CTAO's Neutrino Target of Opportunity program, based on IceCube data, provided valuable insights into possible neutrino sources in the northern sky. Our simulations suggest that the combined capabilities of CTAO and KM3NeT significantly increase the chances of identifying multi-messenger sources in the entire sky for the first time. In particular, the southern sky, which has been less explored with IceCube, will benefit greatly from the increased sensitivity of the Large Telescopes (LSTs) planned for CTAO-South.

This study is an important step in evaluating for the first time the potential of CTAO in detecting the very high-energy gamma-ray counterparts of neutrino sources in the entire sky.

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SS433 tens TeV resurgence twin beams by beta decay in flight of tens PeV neutron jet

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The understanding of microquasars in our galaxy is one of the frontiers of high energy astrophysics. Their models are based on a capturing mass Black Hole, with a nearby spiraling binary companion star. The companion star mass feeds the accretion disk around the Black Hole. This energy also fuels an orthogonal precessing X gamma jets. The spiral precessing tail of such microquasars, as the SS433 system, is due to an ultra-relativistic jet, spraying nucleons and electrons at relativistic speeds. The up-down jet is observable in radio, X, gamma spectra. Its long spirals are spread and diluted within a light-year distance. The source is inside the W50 supernova remnant nebula , whose asymmetry reflects the past and present role of the SS433 jet. Very recently HESS, HAWC discovered, surprisingly at a much far disconnected distance from the SS433, the resurgence of a twin gamma beam tail. Nearly 75 years light distance far away from the source. We show the frame of a possible model based on tens PeV jet whose beta decay in flight fit the TeV signals. CTAO might test soon this model.

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Sensitivity of CTAO to axion-like particles from blazars: a machine learning approach

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Axion-like particles (ALPs) are a common prediction of several extensions of the Standard Model and could be detected through their coupling to photons, which enables ALP-photon conversions in external magnetic fields. This conversion could lead to two distinct signatures in gamma-ray spectra of blazars: a superimposition of energy-dependent "wiggles" on the spectral shape, and a hardening at high (multi-TeV) energies, due to the ALP beam eluding absorption by the extragalactic background light (EBL). The enhanced energy resolution and point-source sensitivity of the Cherenkov Telescope Array Observatory (CTAO) with respect to present ground-based gamma-ray telescopes make it an ideal instrument to probe such phenomena. In this contribution, we explore an approach based on the use of machine learning (ML) classifiers and compare it to the standard method of likelihood-ratio tests, previously applied in CTAO sensitivity studies for ALP signatures. Our preliminary 2σ exclusion regions on the ALP parameter space suggest that both techniques yield consistent results, with the ML-based method offering broader coverage and potentially extending the CTAO sensitivity beyond existing constraints.

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Long-term multiwavelength view and broadband modeling of the blazar B2 1811+31

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The intermediate synchrotron-peaked BL Lac B2 1811+31 (z=0.117) underwent a period of high activity from the optical to the very high-energy (VHE; 100 GeV < E < 100 TeV) gamma ray band in 2020. Following a high-state detection by the Large Area Telescope (LAT) on board the Fermi Gamma-ray Space Telescope in the high-energy gamma-ray band (HE; 100 MeV < E < 100 GeV), a dedicated multiwavelength (MWL) campaign was organized. During the course of the campaign, the MAGIC Telescopes detected for the first-time VHE gamma ray emission from the source. To put this high state into the context of the long-term emission of the source, we employed an extensive MWL dataset spanning over 18 years from the radio and optical/UV bands to X rays and HE gamma rays.

In this contribution, we present the long-term MWL behaviour of B2 1811+31, with particular emphasis to the high state. We resolve long-term correlated evolution on timescales ranging from years to weeks in the optical and HE gamma-ray band, as well as variability on timescales of few hours at HE gamma rays during the highest activity period. We observed a significant shift of the

synchrotron peak frequency during the flaring activity, which led the source to a borderline state between intermediate and high synchrotron-peaked BL Lac.
We discuss the evolution of the source MWL emission in terms of particle acceleration and cooling within multiple regions active in the jet and propose a self-consistent leptonic model to interpret the broadband emission during the high state.

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Multi-Wavelength Study of Gamma-Ray Burst Afterglows from X-rays to VHE gamma-rays.

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The early X-ray afterglows of Gamma-Ray Bursts (GRBs), observed with the Swift X-ray Telescope (XRT; 0.3–10 keV) onboard the Neil Gehrels Swift Observatory, have revealed distinct temporal features beyond those predicted by the standard forward shock afterglow model. Components in the XRT light curve, such as steep decay, flares, and plateaus, suggest more complex afterglow physics. These observations highlight the need for a multi-wavelength, systematic study of the early afterglow's temporal and spectral evolution.
In this study, we analyzed GRB afterglows across a wide energy range, from 0.3 keV to 100 GeV, using data from Swift/XRT, Swift/BAT (15–150 keV), and the Fermi Large Area Telescope (LAT; 30 MeV–300 GeV). Our sample includes GRBs with significant high-energy gamma-ray emissions. Our analysis reveals that the broad-band GRB spectral evolution exhibits double-peaked spectral energy distributions. We discuss the implications for the microphysics of X-ray and GeV emission production sites and the underlying forward shock in the synchrotron self-Compton scenario.
These results also emphasize the importance of very high-energy (VHE; >100 GeV) gamma-ray observations in understanding the GRB emission mechanisms behind these anomalies and determining whether VHE GRBs are unique. I will also briefly discuss the prospects of these observations through upcoming facilities, such as the Cherenkov Telescope Array Observatory (CTAO), offering a more complete picture of the spectral evolution of GRBs. By integrating multi-wavelength datasets and focusing on the VHE regime, our research contributes to the broader effort of understanding the complex physics of GRBs.

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Insights from W51C-B on supernova remnant-molecular cloud interactions with CTAO and ASTRI Mini-Array

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Supernova remnants (SNRs) are key cosmic ray (CR) sources, as strongly supported by extensive γ-ray observations of the characteristic pion bump, particularly by AGILE-GRID and Fermi-LAT, which confirmed them as hadronic accelerators. LHAASO recently detected >100 TeV γ-rays from several Galactic sources, including some regions containing SNRs. However, current theoretical models suggest that SNRs can only accelerate CRs up to PeV energies within their first ~100 years,

while known SNRs associated with LHAASO sources are much older. A possible explanation of the detected PeV emission is runaway CRs interacting with nearby molecular clouds (MCs) in regions of suppressed diffusion.

LHAASO observed ~200 TeV γ-ray emission from the W51 region, that includes the star forming regions W51A, W51B, and the middle-aged SNR W51C, which interacts with MCs in W51B. We investigate the W51C-B region to examine possible SNR-MC interactions. Our focus is on a direct SNR-MC shock interaction, investigating its role in accelerating particles to high energies and evaluating whether CR acceleration-compression can account for the observed UHE emission. We will also present simulations of W51C-B for CTAO and ASTRI Mini-Array, highlighting their potential role in spatially resolving the UHE emission from the interaction region.

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Neutrino-Emitting Seyfert candidates in the VHE gamma-ray sky

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The Seyfert galaxies NGC 1068 and NGC 4151 have emerged as the most promising counterparts of 4.2σ and 3.0σ neutrino excesses detected by IceCube in the TeV energy range.
Gamma rays and neutrinos are co-produced at the same flux level via hadronic interactions between the parent proton population and the ambient matter and radiation in the neutrino-emitting region.Observations of NGC 1068 with the MAGIC telescopes have set stringent upper limits on its very-high-energy (VHE, E>100 GeV) gamma-ray flux, revealing the presence of a gamma-ray obscured accelerator.
With the latest MAGIC observations, similar evidence is found in NGC 4151. In this talk, I will present the first results from MAGIC observations of NGC 4151, which led to the estimation of stringent upper limits on its VHE emission. These upper limits are used to constrain the neutrino-emitting region to the vicinity of the SMBH, to about ~10^3 Schwarzschild radii of the SMBH at the center of NGC 4151, using relatively model-independent opacity arguments derived from multi-wavelength observations.
These findings strongly suggest that, like NGC 1068, NGC 4151 harbors a neutrino production site that is optically thick to gamma rays, reinforcing the idea that Seyfert galaxies could be a new class of hidden cosmic-ray accelerators.

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CTAO: An Advanced Frontier in the Study of Extreme Phenomena in Misaligned Jetted AGN

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It is now well established that active galactic nuclei (AGN) are the dominant class of extragalactic sources in the gamma-ray sky. Among them, blazars—AGN with jets oriented toward the observer—constitute the majority. In contrast, misaligned AGN, or radio galaxies, account for only about 2% of the 4LAC-DR2 catalog of AGN detected by Fermi in the gamma-ray band. At TeV energies, only six radio galaxies have been detected so far.
Recently, the Large High Altitude Air Shower Observatory (LHAASO) reported the first detection of a low-luminosity AGN with a compact radio jet, NGC 4278, at TeV energies. This discovery suggests that even low-power, compact jets can efficiently accelerate particles up to TeV energies, potentially revealing a new class of TeV-emitting sources.
In this contribution, I will discuss the main properties of these subdominant classes of gamma-ray emitters. The source statistics at very high energies will be significantly improved by the forthcoming Cherenkov Telescope Array Observatory (CTAO), thanks to its unprecedented sensitivity. These advancements will help us better understand the particle acceleration and radiative processes occurring in extragalactic jets.

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Exploring the high energy spectral cut-off in intermediate and high-redshift FSRQs using CTAO

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A power-law distribution with a high energy cut-off can typically describe the gamma-ray energy spectrum for Active Galactic Nuclei (AGNs). The Fermi Large Area Telescope (LAT) can probe many of these objects for which this cut-off sits in the GeV domain. However, measurement of the spectral energy cutoff requires large photon statistics, which are not always available because of Fermi-LAT's limited sensitivity above 100 GeV. The Cherenkov Telescope Observatory (CTAO) will provide a wider energy range, larger effective area, and better angular resolution and flux sensitivity in comparison to any existing gamma-ray detector. An energy threshold as low as 20 GeV will allow CTAO to study more distant AGNs, which are not seen by the other ground-based gamma-ray facilities.
In our study, we chose five flat-spectrum radio quasars (FSRQs) located at intermediate and high-redshift (z=0.3 - 1) observed by Fermi-LAT and with different Cherenkov telescopes during flaring periods.
We combined Fermi-LAT data and CTAO simulated observations between 0.1 GeV and 10 TeV, and obtained constraints on the cutoff energy parameter under the assumption that a power law with an exponential cutoff describes the spectral energy distribution of the sources in this energy range.
We compared the joint Fermi-LAT and simulated CTAO dataset for different CTAO configurations: 4 Large-Sized Telescopes (LSTs), 4 LSTs and 9 Middle-Sized Telescopes (MSTs) for Northern hemisphere FSRQs, and 14 MSTs for Southern hemisphere sources. We also consider the additional 11 Schwarzschild-Couder Telescopes (SCTs) in a scenario beyond the Alpha configuration in the southern hemisphere.
We fitted each dataset with different physically motivated models, employing the Akaike Information Criterion (AIC) and the maximum likelihood ratio test, to assess the effectiveness of the various CTAO configurations for spectral studies.

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Study on future GW - VHE GRB detection synergies with the CTAO

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The event GW170817, which was for the first time associated to the e.m. event GRB 170817A, proved that at least a portion of Gamma-Ray Bursts (GRBs) are counterparts of Gravitational Wave (GW) events involving a neutron star. Despite the incredible amount of follow up detections of GW170817, though, no other event of this kind has been later observed. Of great importance is to set up a joint analysis between GWs and very-high energy (VHE) gamma-ray observatories, such as the CTAO, since in these extreme events we may obtain fundamental hints for the investigation of the acceleration processes and the environment near compact objects. These kind of observatories, moreover, have a small field of view and need to be pointed to the source, and the information on the sky localization provided by GW detectors is crucial for a low latency detection.
In our work we have considered a binary neutron star (BNS) population and associated to each event a GW signal and a GRB. We then built two different analysis pipelines, considering a joint detection between CTAO and the two cases of current and third generation (such as the Einstein Telescope) GW observatories. Even in this preliminar work we still get interesting results on the joint detection prospects, which serves as a basis for our ongoing work.

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Probing axion-like particles with LST-1 observations of blazars

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Axion-like particles (ALPs) are theoretical particles proposed in several extensions of the Standard Model of elementary particles. Aside from being viable dark matter candidates, their predicted interaction with photons in external magnetic fields makes them particularly relevant in observations of very-high-energy (VHE) gamma-ray sources. Specifically, this interaction is expected to leave imprints in the observed spectra, altering the spectral energy distribution (SED) of the target and causing energy-dependent oscillations in the photon flux.
In the presence of magnetic fields with strengths on the order of microgauss (O(μG)) and for ALP masses in the neV range, these oscillations emerge in the GeV energy band, coinciding with the highest energy sensitivity of LST-1. Our study focuses on LST-1 observations of blazars, including Mrk 421, Mrk 501, 1ES 1959+650, and BL Lac. Tests on the ALP hypothesis are conducted using more than 100 ALP models, with constraints computed via the likelihood-ratio method and further combined at the test statistic level.
This study is the first to constrain ALP parameters by combining datasets from multiple sources, providing a unique opportunity to explore combined constraints on the ALP parameter space while highlighting the challenges and advantages of this approach.

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Probing axion-like particles with multimessenger observations of neutron stars mergers

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Axion-like particles (ALPs) can be copiously produced in binary neutron star (BNS) mergers via nucleon-nucleon bremsstrahlung, provided the ALP-nucleon coupling g_{aN} is sufficiently large. If ALPs also couple to photons through the coupling $g_{a\gamma}$, they can convert into gamma rays in the presence of strong magnetic fields, such as those surrounding the merger remnant and in the Milky Way. This process could generate a short gamma-ray burst coincident with the gravitational-wave signal from the merger, offering a novel multi-messenger signature of ALPs.

In this talk, I will present a study of the sensitivity of current and proposed MeV gamma-ray instruments to detect such a signal. I will show that future detectors could probe photon couplings down to $g_{a\gamma}$
$gtrsim$few $\times 10^{-13}$ GeV^{-1} for ultralight ALPs with m_a
$lesssim 10^{-9}$ eV comparable to constraints from SN~1987A. These results highlight the exciting potential of combining gravitational-wave and gamma-ray observations to search for new physics in the ALP sector.

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Axion-like particles as probes of the SN core

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Pseudo-scalar particles, like QCD axions and Axion-like-Particles (ALPs), emerge in many extension of the Standard Model and have been recognized to be among the best Dark Matter candidates. Even if very weakly-interacting, ALPs can be copiously in the core of massive stars at the end of their life. In this regard, Core-Collapse Supernovae (SNe) are expected to be powerful sources of novel exotic particles. Thus, a future Galactic SN may represent a
once-in-a-lifetime opportunity for the detection of such Dark Matter candidate. In this talk, I will discuss how ALPs with masses < 1 neV may be efficiently produced in SN cores by means of their coupling to nucleons. Then, they can leave the star unimpeded and convert into photons inside galactic magnetic fields, giving rise to an ALP-induced -ray burst at energies , which might be detectable in the Fermi-LAT experiment.
Moreover, since ALP production mechanisms are sensitive to the conditions of the inner regions of the SN core, I will argue how ALPs can be employed to probe some important properties of Proto-Neutron Stars (PNS). In particular, I will show that the detection of the ALP burst may provide some insights about the presence of a relevant fraction of pions in SN cores and, eventually, lead to the reconstruction of the temperature in the inner region of the PNS.

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Hundred PeV neutrino by Tau air-shower at horizons: A new Astronomy beyond the corner?

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Recent Km3, ARCA, neutrino detector discover of a hundreds PeV event on February 2023 , if confirmed, is very probably the UHE signature of UHECR secondary trace by GZK cut off. We show the expected rate of such neutrino induced air-shower by largest Telescope Array as CTAO while pointing downward the sea horizons. Such proposal had been considered long time ago by Magic telescopes.Our estimates assumed the exact inner Earth density profile, and the best analytical model for UHE neutrino interaction in Earth cord at Earth (water or rock) edges. We show the rate and the noise for such fundamental, but rare, events.

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VHE Supernovae: state of the art and latest observations with the CTAO-LST1

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Supernovae (SNe) are explosive phenomena known to emit across the entire electromagnetic spectrum, up to soft gamma-rays. Very high energy (VHE) gamma-rays are expected to be produced through shock interactions between dense circumstellar material and the supernova ejecta. However no clear detection has been achieved so far by past or current generation of imaging atmospheric Cherenkov telescopes (IACTs). One of the main suppressing factors is gamma-gamma absorption, caused by low energy photons from the SN photosphere. Current models predict that with the upcoming Cherenkov Telescope Array Observatory (CTAO) we will be able to detect a very bright source up to 10 Mpc.

In this contribution, I will present the current state of the art of SNe observations at VHE, focusing on the latest results obtained with the first CTA- Large Sized Telescope. Despite not achieving any significant detection, gamma-rays upper-limits still offer a valuable insight into the event, providing useful constraints on the mass loss history of the progenitor star and the nature of the supernova explosion.

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Short review on PKS 2155-304: past observations and prospects

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PKS 2155-304 is a high-frequency peaked BL Lac object (HBL) located at z = 0.116. In 2006, it experienced an extreme very-high-energy (VHE) flare observed by H.E.S.S., which revealed minute-scale

variability and posed challenges for standard emission models. Since then, it has become a key target for probing Lorentz Invariance Violation (LIV) and extragalactic background light (EBL) absorption.

The source has been observed in recent years by several VHE instruments, including MAGIC and LST-1, with complementary data available from multiwavelength partners such as Swift, Fermi-LAT, and optical telescopes. These observations include episodes of heightened activity and follow-up monitoring, motivating continued efforts to build a coherent, broadband picture of the source.

In this contribution, we will revise the key features that make PKS 2155-304 interesting for VHE and multiwavelength studies, with emphasis on its relevance for probing extreme variability and testing fundamental physics. We will also comment on recent observational efforts and their potential to advance our understanding of the source's emission processes.

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A time-resolved, systematic approach to gamma-ray burst physics

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The Fermi mission is a space-based observatory designed to study the gamma-ray sky. It consists of two main instruments: the Large Area Telescope (LAT) and the Gamma-ray Burst Monitor (GBM), covering a broad energy range from ~10 keV to >300 GeV. Among its core scientific goals is the detection and characterization of Gamma-ray Bursts (GRBs), although the mechanisms driving their prompt emission and the precise location of the emission sites remain open questions.
A joint spectral analysis of GRBs simultaneously detected by both LAT and GBM enables the characterization of their prompt emission over several decades in energy, allowing for a detailed investigation of spectral evolution. In this work, we perform the first systematic, time-resolved spectral study of the complete sample of GRBs jointly observed by both Fermi instruments. We present preliminary results from the joint fits and quantitatively assess the impact of high-energy emission on the inferred spectral parameters by comparison with GBM-only analyses. Leveraging Fermi's broadband capabilities, this study provides new insights into GRB physics.

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Line emission search from Dark Matter annihilation in the Galactic Centre with LST-1

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Dark Matter (DM) remains a great mystery in modern physics. Among various candidates, the weakly interacting massive particles (WIMPs) scenario stands out and is under extensive study. The detection of the hypothetical gamma-ray emission from WIMP annihilation could act as a direct probe of electroweak-scale interactions, complementing DM collider searches and other direct DM

detection techniques. At very high energies (VHE), WIMP self-annihilation is expected to produce gamma rays together with other Standard Model particles. The Galactic Centre (GC), due to its relative proximity to the Earth and its high expected DM density, is a prime target for monoenergetic line searches. Imaging Atmospheric Cherenkov Telescopes (IACTs) have placed strong constraints on the DM properties at the GC, with the Major Atmospheric Gamma-ray Imaging Cherenkov (MAGIC) providing the most stringent limits from 20 TeV to 100 TeV exploiting Large Zenith Angle (LZA) observations. However, the limited field of view (FoV) of the MAGIC telescopes (< 3.5°) prevented a detailed study of the extended region around the GC in which an enhanced DM density is expected. The first Large-Sized Telescope prototype (LST-1) of the Cherenkov Telescope Array Observatory (CTAO), located at the Roque de Los Muchachos Observatory (La Palma, Spain) close to the MAGIC site, has been observing the GC since 2021. With its wide FoV of 4.5°, LST-1 could contribute significantly to the WIMPs search at the GC. The observations are performed at LZA (ZA > 58°), which, while required due to the source's low altitude, also optimizes the detection of gamma rays up to 100 TeV and beyond. Here we present the first WIMP line emission search with LST-1. We provide a comprehensive study of the LST-1 instrument response functions for LZA observations and a detailed study of the background rejection in monoscopic observations. We present the most updated results based on simulated data demonstrating improved statistical analyses and new methodologies for spectral line search.

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Studying young massive stellar clusters at VHE: current status and prospects

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In recent years, Young massive stellar clusters (YMSCs) have been identified as Galactic CR factories. In clusters younger than 3 Myr, stellar winds are expected to drive CR acceleration through different mechanisms, such as acceleration at the collective cluster wind termination shocks (WTS). Understanding the contribution of YMSC and stellar winds to the production of Galactic CRs is currently one of the hottest topics of high-energy astrophysics. Theoretical models and recent gamma-ray observations demonstrated that at least in a few extreme YMSCs (e.g. Cygnus OB2, Westerlund 1, 30 Dor C), CRs can be accelerated up to PeV energies. However, most of YMSCs (with masses between $10^3 - 10^4$ MSun) are believed to accelerate particles below hundreds of TeV and to show a cutoff in their gamma-ray spectrum between hundreds of GeV and tens of TeV. In this energy range, LST1, MAGIC and the upcoming LST-subarray can play a crucial role. This contribution will give an overview of the current status of the observation of YMSCs at Very High Energy (VHE). Prospects for LST-1, MAGIC and the CTAO Northern array will be outlined.

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Search for gamma-ray emission from Jupiter with 15 years of Fermi-LAT data

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Fermi-LAT is one of the major gamma-ray observatories in the hundreds of MeV to few TeV energies. In this work, we searched for gamma-ray emission from Jupiter using 15 years of Fermi-LAT data in the energy range from 100 MeV to 2 TeV.
Jupiter's path on the sky was partitioned into 1202 steps, each one corresponding to a 0.5 deg displacement and a likelihood analysis was performed at each step. Afterwards all steps were stacked. No gamma-ray signal was detected and flux upper limits were derived.
Finally, under the assumption that dark matter annihilation is happening inside Jupiter and is the only possible source of gamma-ray photons, we derived constraints on the dark matter –nucleon cross section.

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CTAPLUS, from the status of the project to the scientific outcome expected

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Status of the LST1-4 project

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LST-1 (and MAGIC) scientific results

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