T 36: Gamma astronomy 2

Time: Tuesday 16:00–18:00 Location: Geb. 30.22: kl. HS A

T 36.1 Tue 16:00 Geb. 30.22: kl. HS A

Automatized Pulsar Analysis for the MAGIC Telescopes — •Jan Lukas Schubert and Stefan Fröse for the MAGIC-Collaboration — TU Dortmund University, Dortmund, Germany

The MAGIC telescopes are Imaging Air Cherenkov Telescopes which are used for gamma-ray detection in the GeV to TeV range. Thanks to an analog trigger system, dubbed Sum-Trigger-II, low-energy observations with a threshold as low as ~15 GeV can be made, enabling the MAGIC telescopes to perform comparably low energetic analyses such as pulsar analyses. These data requires a dedicated treatment adapted to the low energies. The automatization of the analysis of Sum-Trigger-II data was implemented in the autoMAGIC project, which aims to automatize the entire MAGIC analysis chain. It produces DL3 data, which represent a standard data format for gamma-ray astronomy.

A workflow for the pulsar timing and the pulsar analysis based on DL3 files produced with autoMAGIC was implemented and delivers results comparable to the currently used pulsar analysis tools in MAGIC. In the future, the automatization of the analysis of Sum-Trigger-II data could be used for further optimizations of the low-energy analysis as well as for comparisons of low-energy data from MAGIC and the LST. Combined with the automatic pulsar analysis, this will enable the possibility of performing long-term pulsar analyses with comparably little effort.

T 36.2 Tue 16:15 Geb. 30.22: kl. HS A

Optimizing the analysis of very-large zenith-angle observations with MAGIC — •Juliane van Scherpenberg, David Green, and Razmik Mirzoyan for the MAGIC-Collaboration — Max-Planck-Institut für Physik, Boltzmannstr. 8, 85748 Garching

The pursuit of Galactic PeVatrons remains a focal point in high-energy astrophysics, with these sources expected to emit gamma rays beyond 100 TeV. Recent progress, particularly with hybrid water cherenkov and air shower detectors like LHAASO, has identified multiple potential PeVatron candidates in the Galaxy. The MAGIC Telescopes are the only Imaging Atmospheric Cherenkov Telescopes (IACTs) that have detected gamma rays up to 100 TeV so far by conducting observations close to the horizon at very-large zenith-angles (VLZA). IACTs have superior energy and angular resolutions compared to air shower arrays. This advantage allows for a more detailed study of PeVatron candidates. However, VLZA observations come with challenges. The reduction in size of the shower images, crucial for discriminating between hadrons and gamma rays, complicates the separation of the hadronic background from the gamma-ray signal. To address this, I present approaches to enhance background rejection during VLZA observations with MAGIC. These methods leverage not only the geometrical properties of the shower images but also incorporate information on their temporal development.

T 36.3 Tue 16:30 Geb. 30.22: kl. HS A

Deep-Learning-Based Gamma/Hadron Separation in the Southern Wide-field Gamma-ray Observatory — •Martin Schneider, Jonas Glombitza, Christopher van Eldik, and Markus Pirke for the SWGO-Collaboration — ECAP, FAU Erlangen-Nürnberg

The Southern Wide-field Gamma-ray Observatory (SWGO) is a next-generation ground-based observatory in the R&D phase. It will feature a large array of water-Cherenkov detectors (WCD) at high elevations in South America, enabling gamma-ray observations at energies from ~100GeV up to the PeV region. The primary challenge in gamma-ray observations is the rejection of hadronic showers to ensure a high signal-to-noise ratio. Various tank designs and layouts are currently evaluated for their gamma/hadron separation capabilities. This talk will explore the application of a deep-learning-based classification algorithm that processes low-level station information via graph neural networks, demonstrating the effective operation across various configurations.

T 36.4 Tue 16:45 Geb. 30.22: kl. HS A

Modelling Supernova Remnant Spectra to Predict their Detectability by the Southern Wide-field Gamma-ray Observatory — •Nick Scharrer, Alison Mitchell, and Vikas Joshi for the SWGO-Collaboration — Erlangen Centre for Astroparticle Physics (ECAP) Friedrich-Alexander-Universität Erlangen-Nürnberg, Nikolaus-Fiebiger-Str. 2, 91058 Erlangen

Supernova remnants (SNRs) remain prime candidates for hadronic particle acceleration within our galaxy. Detecting and identifying Cosmic Ray particle accelerators is achieved via the associated gamma-ray emission they produce. Future facilities such as the Southern Wide-field Gamma-ray Observatory (SWGO) will be of crucial importance in identifying new candidate SNRs. We develop a model of the expected SNR gamma-ray emission and validate it for sources that have been observed with current-generation instruments using a Markov chain Monte Carlo (MCMC) approach for energies above 1 GeV. Furthermore, we compare our model predictions to the anticipated SWGO sensitivity to explore the SNR emission phase space and quantify detection prospects for SWGO.

T 36.5 Tue 17:00 Geb. 30.22: kl. HS A

Optimization of the image cleaning performance of H.E.S.S. telescopes — •Jelena Celic[1], Stefan Funk[1], Rodrigo Guedes Lang[1], Simon Steinmassl[2], and Jim Hinton[2] for the H.E.S.S.-Collaboration — [1]ECAP, FAU Erlangen-Nürnberg, Deutschland — [2]MPIK, Heidelberg, Deutschland

One of the challenges in the analysis of Imaging Atmospheric Cherenkov Telescope (IACT) data is minimizing the impact of night sky background (NSB) light. The goal is to reduce this noise while retaining a maximum amount of shower light to reconstruct the the physical quantities of the primary particle. Among the current generation of IACTs, the High Energy Stereoscopic System (H.E.S.S.) is the only southern hemisphere IACT system. Comprising five telescopes in Namibia, H.E.S.S. commonly uses a two-threshold image cleaning technique referred to as tailcut cleaning. However, this established method has drawbacks, particularly in dealing with low-energy shower events. These events produce fainter images near the pixel noise level. The upgraded H.E.S.S. cameras, which provide more accurate pixel timing information, inspired the introduction of a novel time-based image cleaning method. This method aims to optimize the retention of shower event light while efficiently cleaning NSB pixels. This presentation evaluates the performance of both traditional two-threshold and novel time-based image cleaning techniques in various image cleaning properties. Additionally, it establishes a new pipeline for optimizing the image cleaning performance at early data processing to achieve a better sensitivity with H.E.S.S. at lower energies.

T 36.6 Tue 17:15 Geb. 30.22: kl. HS A

A hybrid machine learning-likelihood approach to event reconstruction for IACTs — •Georg Schwefer[1], Robert Parsons[2], and Jim Hinton[1] for the CTA-Collaboration — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany

The imaging atmospheric Cherenkov technique currently provides the highest angular resolution achievable in astronomy at very high energies. High resolution measurements provide the key to progress on many of the key questions in high energy astrophysics. The huge potential of the next generation Cherenkov Telescope Array (CTA) in this regard can be realised with the help of improved algorithms for the reconstruction of the air-shower direction and energy. Hybrid methods combining maximum-likelihood fitting techniques with neural networks represent a particularly promising approach.

Here, we present the FreePACT algorithm, a hybrid machine-learning likelihood reconstruction method for IACTs. In this, the analytical likelihood used in traditional image-likelihood fitting techniques is replaced by a neural network that approximates the charge probability density function for each pixel in the camera. The performance of this improved algorithm is demonstrated using simulations of the planned CTA southern array.

T 36.7 Tue 17:30 Geb. 30.22: kl. HS A

Providing Uncertainty Predictions for Reconstructed CTA Events Using Neural Networks — •Cyrus Walther and Maximilian Linhoff for the CTA-Collaboration — TU Dortmund University, Dortmund, Germany

The Cherenkov Telescope Array (CTA) is the next generation of ground-based, gamma-ray astronomy experiments. The multi-telescope arrays in La Palma, Spain, and Paranal, Chile, will outperform the state-of-the-art imaging atmospheric Cherenkov Telescopes (IACTs) by one order of magnitude in sensitivity. In the event analysis of IACTs, the reconstruction of the energy and direction of the primary particle is crucial. Many analysis methods do not provide reliable uncertainty estimations on the reconstructed energy and direction. Based on successful work in the IceCube collaboration, we want to overcome this challenge with a neural network approach. Using a gaussian likelihood loss function, a prediction of uncertainties in energy and direction on CTA simulation data is performed and assessed.

T 36.8 Tue 17:45 Geb. 30.22: kl. HS A

Ultra-Fast Generation of Air Shower Images for Imaging Air Cherenkov Telescopes using Generative Models — •Christian Elflein, Jonas Glombitza, and Stefan Funk for the H.E.S.S.-Collaboration — ECAP, Erlangen, Germany

Resource-aware simulation is an important aspect in many fields of modern physics, including astroparticle physics. The continuous progress in machine learning in this day and age and the successful application of generative models to various tasks in particle and astroparticle physics motivate our application of generative models to the simulation of air shower images in gamma astronomy.

In this contribution, we present a novel technique for the fast generation of gamma-ray air shower images from the FlashCam camera of the CT5 telescope, which is part of the High Energy Stereoscopic System (H.E.S.S.). The generative model used for the generation of images with more than 1500 pixels is based on a Wasserstein Generative Adversarial Network (WGAN) and trained using H.E.S.S. simulations. We show that our framework, in comparison to the standard simulation method, speeds up the image generation by up to five orders of magnitude while keeping a competitive image quality. The visual similarity to simulated images and the representation of physical properties in the generated images is verified by analysing several low-level and high-level parameters and their correlations.

Following this work, we additionally investigate diffusion models, which are state-of-the-art generative deep-learning models, as an alternative way to generate air shower images.