Master's Thesis

Spring 2026

Are you fascinated by the ever-expanding possibilities of Artificial Intelligence (AI) and passionate about unraveling the mysteries of physics?

→ **Join us in exploring how AI can help tackle complex physics challenges!**

Sensitivity improvement using Deep Neural Networks

AI has the potential to uncover patterns that traditional algorithms cannot detect. In this work, you will improve the sensitivity of Imaging Atmospheric Cherenkov Telescopes (IACTs), such as the H.E.S.S. experiment in Namibia, which features 5 telescopes with mirror diameters of up to 28 meters.

By developing state-of-the-art methods with support from the machine learning group at ECAP, you will work at the forefront of AI research in physics and validate your algorithm using observation data from the H.E.S.S. telescopes.

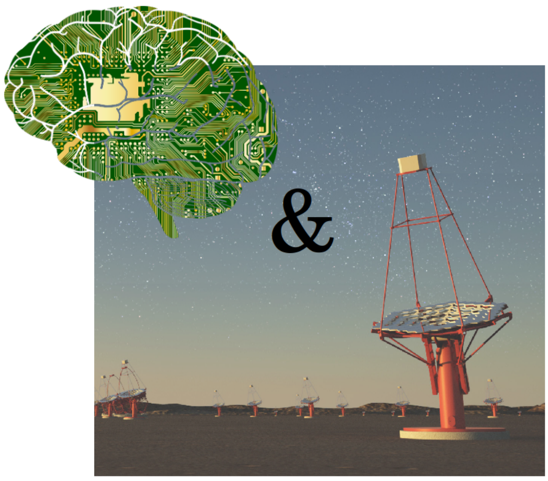
As part of our research group, you will collaborate with physicists who have a strong background in machine learning and statistics, enabling you to gain extensive expertise in data science, AI, and cosmic-ray physics. During the project, we will provide you with access to powerful computing resources, including NVIDIA A100 GPUs and H100, and the necessary tools to execute your research effective and efficiently.

Physics topics related to this work:

- Development of deep learning / AI algorithms
- Experimental detection of astroparticles

Skills acquired during this work:

- Expertise in machine learning, AI, and data science
- Python coding skills



Modification of private work by G. Perez, IAC

https://www.pngwing.com/en/free-png-bppox

Interested? Please get in touch:

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ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

Bachelor / Master’s thesis
in Hardware Development

The Cherenkov Telescope Array Observatory (CTAO) is the next generation of telescope systems to observe high-energy gamma rays. In line with CTAO, the ECAP/work group of Stefan Funk takes an active part in the development of a front-end electronics, based on the sampling (CTC) and trigger (CT5TEA) ASIC (application-specific integrated circuit) TARGET (TeV array readout and Event Trigger). This is to take over the digitization of silicon photomultiplier signals in the Small Size Telescope Cameras (SSTCam).

Bachelor thesis

- Optimization of the Trigger Threshold Lookup Generation for the SSTCam TARGET Modules
- Verification of Alternative Timing Parameter Set

Master’s thesis

- Design and Characterization of a Gold-Standard TARGET Module for Future Software and Firmware Development firmware development
- SSTCam, from the Lab to the Sky

Physics topics related to this work

- Ground based gamma ray telescopes
- State-of-the-art electronics

Skills acquired during this work

- Statistical analysis of data
- Programming in Python
- Understanding of electronics instruments

Interested? Please get in touch!

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Erlangen Centre for Astroparticle Physics

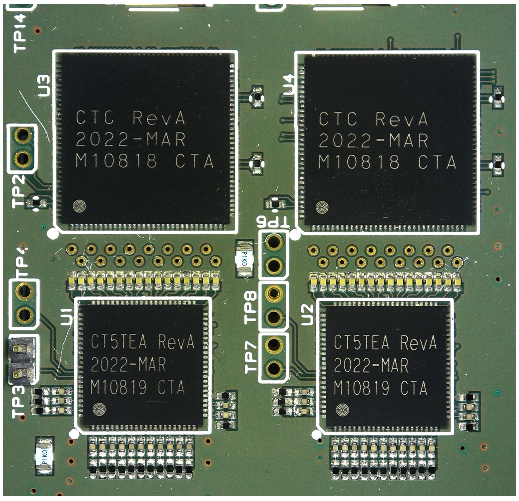
Bachelor thesis
in Hardware development

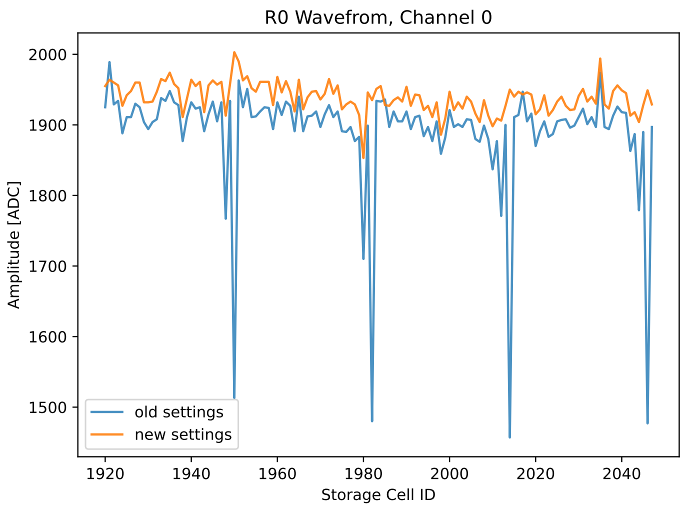
Optimization of the Trigger Threshold Lookup Generation for the SSTCam TARGET Modules

For CTAO, the ECAP will produce, commission, and calibrate approximately 1,600 TARGET modules for the envisaged 42 SST cameras. One of the main calibration tasks is the generation of the trigger threshold lookup table. Efficient routines and/or novel methods are required to significantly reduce the time needed for this calibration step.

Verification of Alternative Timing Parameter Set

To avoid uncontrollable amounts of data, the CTC ASIC employs a ring buffer to temporarily store the data before digitization in the event of a trigger. One issue of this ring buffer is that the 31st sample modulo 32 exhibits different behavior, which limits the resolution of the analog-to-digital converter and, consequently, the overall resolution of the SSTCam. A new set of timing parameters has recently been identified that resolves this issue. The impact on the charge resolution must now be studied.





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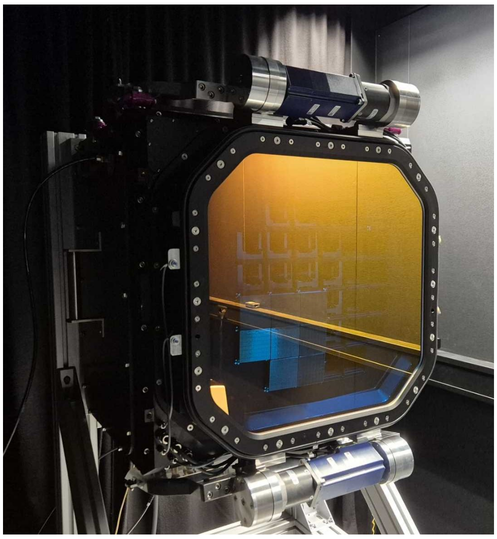
Master’s thesis
in Hardware development

Design and Characterization of a Gold-Standard TARGET Module for Future Software and Firmware Development

This work focuses on the design and detailed characterization of a Gold-Standard TARGET module intended to serve as a reference platform. The module provides a reliable hardware benchmark for the development and validation of future software and firmware implementations. It will comprise a pulsed and continuous-wave (CW) light source, a silicon photomultiplier, front-end electronics, a TARGET module, and a backplane mock-up.

SSTCam, from the Lab to the Sky

This study investigates the performance of the SSTCam through the analysis of recorded data with respect to photon intensity and temporal resolution. Emphasis is placed on the camera’s ability to accurately capture and reconstruct events over time. Various calibration methods and test scenarios, including different operating temperatures and background illumination levels, are employed to assess the system response and stability. The results provide insight into the camera’s precision and its suitability for CTAO. This characterization forms the basis for future optimizations and system integration. In addition, the camera performance will be compared with on-sky data acquired by the first SST in Chile, expected to become available from autumn 2026 onward.



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Erlangen Centre for Astroparticle Physics

Bachelor / Master's thesis

Differentiable Simulation and Optical Astronomy with IACTs

Differentiable programming is transforming how we approach inverse problems in physics. By making simulation pipelines differentiable, we can use gradient-based optimization to infer physical parameters from observational data faster and more efficient than ever before. The ECAP group is developing these methods for Imaging Atmospheric Cherenkov Telescopes (IACTs), with a focus on applying the method to optical night sky simulations.

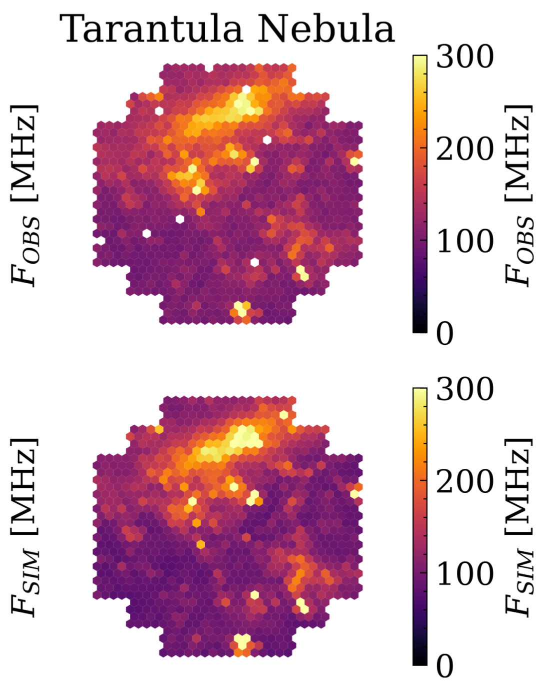
If you are interested in topics such as differentiable programming, simulation work, atmospheric science or the intersection of astroparticle physics and optical astronomy, these are the right topics for you!

Bachelor thesis

- Verify Lunar Model used for NSB simulation in IACTs
- Simulating Stellar Occultations in IACTs

Master's thesis

- Atmospheric Modelling and Validation
- Differential Rendering for IACTs



Comparison between real and simulated night sky background (NSB)

Physics topics related to this work:

- Ground-based gamma-ray telescopes
- Atmospheric physics and radiative transfer
- Optical Astronomy

Skills acquired during this work:

- (Differentiable) Programming in Python / JAX
- Statistical analysis and optimization methods
- Simulation and forward modelling

Interested? Please get in touch:

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ecap
Erlangen Centre for Astroparticle Physics

Bachelor thesis

Optical Astronomy with IACTs

Verify Lunar Model used for NSB simulation in IACTs

The Moon is a major contributor to the night sky background in IACTs, affecting trigger rates and energy thresholds. You would implement and validate a model that predicts the lunar contribution to the night sky background (NSB) in IACTs. Ideally, the model would be integrated in an existing differential simulation pipeline. You would then test the model against measured NSB data from IACT cameras and evaluate its accuracy.

Stellar Occultations in IACTs

When objects such as asteroids or Kuiper belt bodies pass in front of stars, the resulting light curves encode information about the occulting object's size, shape, and potentially atmosphere. Making use of an existing differentiable simulation at ECAP, you would examine the sensitivity of IACTs to different types of occultations (e.g. asteroid occulations or TNOs) and the likelihood of serendipitous observations in an existing IACT dataset.

The night sky during moonlight at the H.E.S.S. site.
Credit: ATOM@HESS

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