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Research Result Report
ICRR Inter-University Research Program 2023

Research Subject:

Development of a background reconstruction toolbox for the LST1 prototype and the upcoming CTA

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Summary of Research Result：

In the last fiscal year, FY 2023, we finished drafting the background modeling software for the data of the Cherenkov Telescope Array (CTA) and particularly for the data of the CTA-Large-sized telescope (LST) 1 prototype. We called the program pybkgmodel.

The code of the software is publicly available at the github repository of the CTA Consortium: https://github.com/cta-observatory/pybkgmodel

As outlined in the proposal, the code was introduced within the LST Collaboration. It saw its first application to data taken by LST on the Galactic Center. Using pybkgmodel, we could correctly model the hadronic background in the region and obtain spectra agreeing with previous publications. This is true also for the diffuse emission in the region indicating that the background model works well across the entire FoV [1]. The results of the diffuse analysis were presented at the ICRC 2023. For this project we can thus move forward to studying the structure of the diffuse emission in the central molecular zone around the Galactic Center in greater detail. At the ICRC 2023 we also presented the software itself to the wider community [2].

The application to real data were an important step. It showed that the output of the software works well together with the gammapy package for the high-level data analysis of CTA data. Nonetheless, It also highlighted shortcomings of the software as well as inconveniences for the user. We currently update the software to remove issues and improve the usability of the software. Due to this process the validation of the software packages is not concluded yet, but foresee it for the beginning of the FY 2024.

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Moreover, we improved the adaptability of the software towards additional reconstruction algorithms, improved of the its run-time, and started to develop methods for dealing with the non-detection of background events. The latter is important for high energies, where the event statistics is limited.

In addition to the LST1 data, we started using the code to generate background models for the analysis of diffuse emission observed with MAGIC data. This enables us to cross-check the obtained models agains the ones reconstructed with the established SkyPrism package of MAGIC.

In summary, the application of the software to real LST data is a milestone. While the validation of the software is not yet concluded due to bugs found, overall the software underwent a major improvement. Hence, for FY 2024 we can look forward to the first publication of the Galactic Center data using pybkgmodel and the software moving from its beta stage to the first major release.

[1] Abe, S., Ohtani, Y., Strzys, M., Teshima, M., and Vovk, I. for the CTA-LST project; “Galactic Center Studies with CTA-LST-1”; 37th International Cosmic Ray Conference (ICRC2021), 38:574, Jul. 2023
[2] Strzys, M., Abe, S., de Bony de Lavergne, M., Hütten, M., Mender, S., and Vovk, I. for the CTA consortium and the CTA-LST project; “Pybkgmodel - a background modelling toolbox for the CTA”; 37th International Cosmic Ray Conference (ICRC2021), 38:894, Jul. 2023