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Monitoring the pointing of the prototype LST-1 using star reconstruction in the Cherenkov camera

L. Foffano,[a,*] A. Carosi,[a] M. Dalchenko,[a] M. Heller,[a] D. Della Volpe[a] and T. Montaruli[a] for the CTA LST project

[a] *University of Geneva, quai Ernest Ansermet 24, Geneva, Switzerland*

E-mail: luca.foffano@unige.ch, alessandro.carosi@unige.ch

The first Large Size Telescope (LST-1) proposed for the forthcoming Cherenkov Telescope Array (CTA) has started to operate in 2019 in La Palma. The large structure of LST-1 - with a 23 m mirror dish diameter - imposes a strict control of its deformations that could affect the pointing accuracy and its overall performance. According to CTA specifications that are conceived to resolve e.g. the fine structure of galactic sources, the LST post-calibration pointing accuracy should be better than 14 arcseconds. To fulfill this requirement, the telescope pointing precision is monitored with two dedicated CCD cameras located at the dish center. The analysis of their images allows us to disentangle different systematic deformations of the structure. In this work, we investigate a complementary approach that offers the possibility to monitor the pointing of the telescope during the acquisition of Cherenkov data. After properly cleaning the events from the Cherenkov showers, the reconstructed positions of the stars imaged in the camera field of view are compared to their nominal expected positions in catalogues. This provides a direct measurement of the telescope pointing, that can be used to cross-check the other methods and as a real-time monitoring of the optical properties of the telescope and of the pointing corrections applied by the bending models. Additionally, this method benefits from not relying on specific hardware or dedicated observations. In this contribution we will illustrate this analysis and show results based on simulations of LST-1.

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Executive summary

The considerable size of the Large Size Telescopes (LSTs) implies the unavoidable presence of structure deformations. Such deformations are usually small, but they need to be taken into account in order to achieve the high pointing accuracy of 14 arcseconds that represents one of the requirements that LST has to fulfill.

In order to accomplish this, the monitoring of the pointing accuracy is traditionally obtained by disentangling the possible different deformations with specific devices such as the starguider camera (SG), the camera displacement monitor (CDM), and some distance meters. These devices monitor the deformations and the mispointing during the data taking, and their information is used to apply corrections to the data. On the other hand, the online corrections rely on the elaboration of a specific bending model, that represents a set of instructions applied to the drive system during the observations in order to automatically compensate for deviations due to the structure bending.

In this work, we present the "star tracking" method. Among the several possible applications, this method represents a complementary and more direct method to monitor the telescope pointing accuracy and to provide an independent cross-check of the corrections applied with the bending model. At this scope, the star tracking method uses the stars in the FoV during the data taking and that contribute to the background of the events. During the observations of a given source, the stars in the field of view (FoV) oscillate along a partial circular trajectory around the average pointing of the telescope. Such trajectories can be used to monitor the actual pointing of the telescope (*low-frequency approach*). Alternatively, the information on the stars position can be used also to analyse short time intervals, i.e. when the rotation of the stars is negligible: the comparison between the measured position of the stars in the FoV and their expected positions as from the catalogues provides an estimation of the pointing of the telescope (*high-frequency approach*).

By means of dedicated simulations, we show that the precision of the method under good-quality dark observations and simplified configurations of stars respect the CTA requirements on the pointing accuracy of the telescope. Further studies are being developed in order to understand the resolution of the method also under more general configuration of stars and relative star intensities.

Among the several advantages of this method, the star tracking method is currently applied to the raw data of the telescope, but it can be applied also as a real-time data analysis. Additionally, since the information coming from the star light lies in the raw data of the telescope, also a retroactive analysis of the data provides information about the historical improvements of the telescope pointing. Finally, thanks to the fact that the method does not require any additional hardware or specific technical observation, the application to other telescopes of the Cherenkov Telescope Array represents an interesting opportunity to be investigated.