MACE telescope

The MACE collaboration has reported the commissioning and first observations with the gamma-ray Cerenkov telescope of the strong source in Crab Nebula region[1]. The successful commissioning of the world-class MACE telescope is an impressive achievement that will boost astronomy research in India.

Since the telescope aims to be at the frontier of gamma-ray astronomy, one expects a certain rigour in the scrutiny and scientific analysis of its observation data. I want to point out an issue that is contrary to this expectation. If it is an inadvertent slip, it should be scrutinized and explained.

The extended (235 min) Crab data from January 2022 clearly show an excess of up to 20° statistical bin (figure 5), whereas the collaboration chose to ignore it and claim excess only up to 10° angular scale. This claim, ignoring what is striking and obvious in the data, seems biased by the standard view that the angular size of the Crab source is 10°. With less than 100 counts statistical deviation in the 10° background bins, the next 10° bin adjacent to the claimed '10 deg source' also has an excess of 4–5 sigma of counts. I might have missed something known only to experts, but I get the impression that the collaboration ignored the clear excess to 'fit' a standard impression about the Crab source. The bias is evident in the sentence (referring to the first shorter observation data and figure 4): 'Beyond 10°, the distribution is relatively flat, which indicates the cosmic-ray background domain or OFF-source region'[1]. With the sub-degree resolution of the MACE telescope, this claim of 'flatness' is not justified, as evident in the longer data from January 2022.

If the prevalent view about the source influenced the decision to claim gamma-ray excess only in the 10° bin, then such biases are detrimental to new discoveries. On the other hand, if the source is truly of only 10° extent, the data imply as much as ±10° jitter in the pointing of the telescope (which would be surprising). Either way, one expects better scrutiny of the data obtained and an explanation for the excess extending to the 20° bin.

1. Yadav, K. K. *et al*., *Curr. Sci.*, 2022, **123**(12), 1428–1435.

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Response:

We thank Unnikrishnan for his interest in our article and appreciate his concerns. However, the results reported in our article have not been appropriately interpreted by him. In the following, we give a brief reply to his comments.

The ground-based gamma-ray telescopes like MACE indirectly detect high-energy photons based on the imaging atmospheric Cherenkov technique. A well-established procedure for segregating the gamma-ray signal from the huge isotropic cosmic-ray background is plotting the alpha parameter's frequency distribution.

The alpha distribution for gamma-like events, coming from the direction of a point source, is expected to peak at smaller values, whereas it is flat for isotropic cosmic-ray background events. Ideally, the value of the alpha parameter should be close to zero for gamma-ray events and between 0° and 90° for cosmic-ray events. However, for practical purposes, the range of the alpha parameter for gamma-like events is derived from the detailed Monte-Carlo simulations and is less than 10° for MACE. The alpha bin next to the signal region is generally omitted to avoid the contribution of spilt-over events from the signal region due to uncertainty in its estimation using experimental data.

The results reported in our article are preliminary in nature, as they have been derived from the very first observations with the telescope. Simple static cuts are used to extract the signal. These results have been significantly improved after rigorous optimization of the telescope performance and operation parameters. Concerning the result shown in Figure 5 of our article, as pointed out by Unnikrishnan, excess events in the bin next to 10° correspond to nearly 3.5-sigma (which is not statistically significant according to the standard in gamma-ray astronomy). They can be attributed to several factors, including mispointing the telescope due to large zenith-angle observations on a particular night. This feature is not statistically prominent in Figure 4.

Referring to the angular size, the angular extent of the Crab Nebula is about 6 arcmin, and it is considered a point source for ground-based gamma-ray telescopes. Therefore, its angular size is not related to the width of the signal region in the alpha distribution plot. Also, the angular extent of a typical gamma-ray source is ~1°, which is much smaller than the total field-of-view of the telescope. For a single telescope based on alpha analysis, a mispointing up to 0.1° can be tolerated without drastic loss in its performance.

A manuscript on the first light of the MACE telescope, involving extensive data analysis, mispointing corrections (if any) and detailed simulation studies, is under preparation and is expected to be published soon. We hope the readers will find all the microscopic details in the upcoming article.

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