Studies of Cosmic Ray Anisotropies with DAMPE

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Introduction

The arrival direction of charged cosmic rays (CRs) at near the Earth is highly isotropized by the interstellar magnetic field, and a small ($O10^{-4}$—10^{-3}) anisotropy in the CR flux is consistently detected by various ground-based instruments[1,2,3], shedding light on the origin and propagation of the CRs, which, however, remains an open question of fundamental significance in astrophysics. Mainly limited by their much smaller acceptance, the space-born detectors that usually cover a wider sky area with higher space and energy resolution and also with the ability of particle discrimination, however, have not been able to detect the CR anisotropy, but providing revealing constrains on the anisotropies, together with an effective procedure in doing the anisotropy analysis [4,5].

The Dark Matter Particle Explorer (DAMPE) has collected more than 10 billion CR events above GeV during its stable on-orbit operation up to now. We introduce in this poste our studies of RC anisotropies based on the DAMPE data, focusing on two key issues that are critical to the sensitivity of the anisotropy analysis, the events selection and the stability of the detector response.

Events Selection

Main event selection criteria:

- The best STK track within 15° of the BGO track
- A minimum BGO energy deposition of 100 GeV
- An off-axis angle smaller than 55°
- No particle discrimination

We make use of the DAMPE data of 5 completed years from April 2016 to April 2021 to mitigate the possible influence of Compton-Getting effect. The usage of the best STK track within 15° of the BGO track eliminates the tail in the PSF of the STK direction measurements. A CR sample of 44.4 million events are formed for anisotropy analysis.

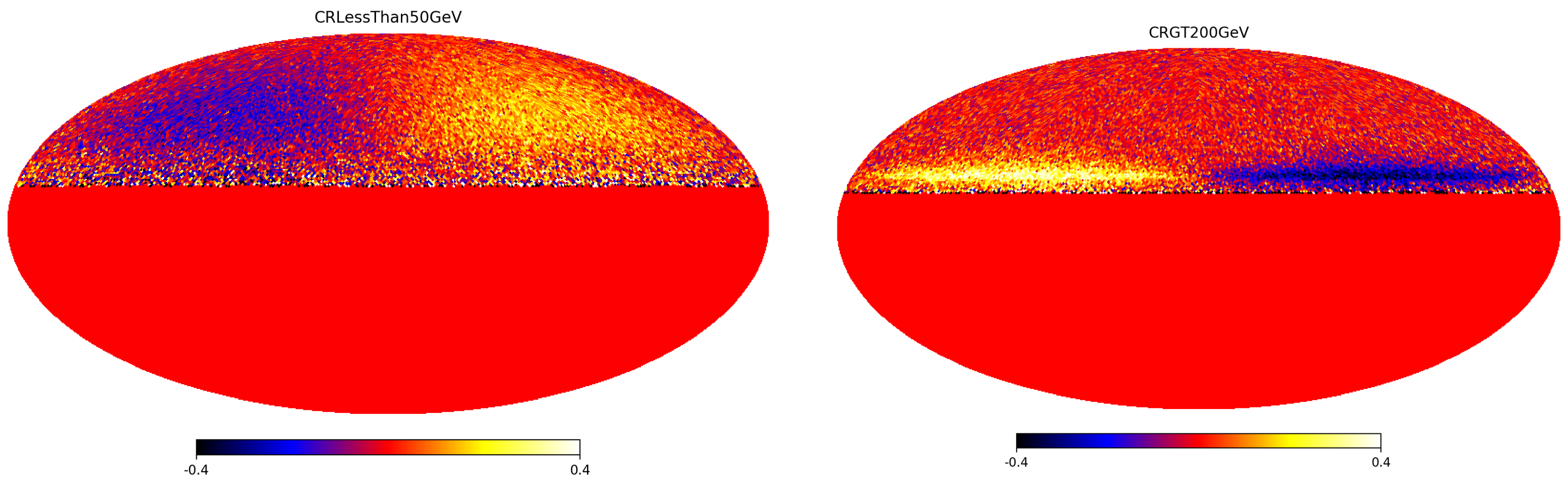

Fig. 1: Sky maps in altitude-azimuth coordinate. For low energy CR particles (with BGO energy <50 GeV), the East-West effect is clearly visible in the left map for almost all incident angle, while for high energy particles (with BGO energy >200 GeV), this effect is only seen in the right map for the events coming form bottom of the detector at around the Earth shadowing angle (but here wrongly inverted and show at around 68° altitude) .

References

[1] B. Bartoli, et al., ApJ, 861, (2018) 93
[2] D. E. Soldin, et al., PoS (ICRC2019) 14
[3] A. U. Abeysekara, et al., ApJ, 871, (2019) 96
[4] M. Ajello, et al., ApJ, 883, (2019) 33
[5] M. Munoze et al., PoS (ICRC2019), 113
[6] S. J. Lei et al., PoS ICRC2021) 125

Detector Response Stability

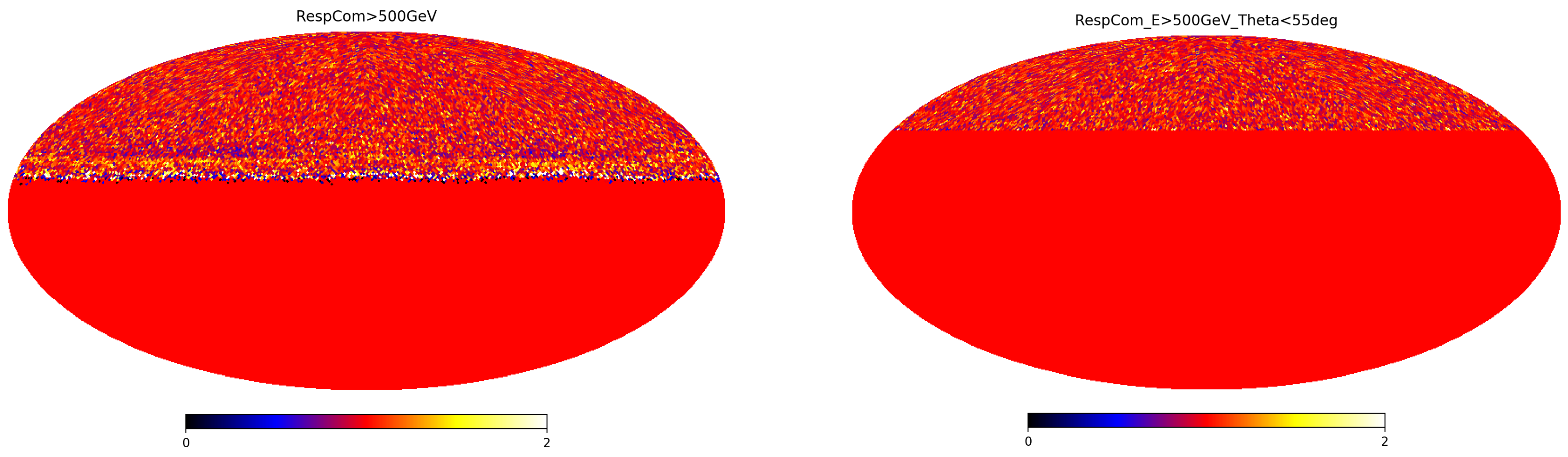

Fig. 2: Each map is produced by comparing the detector response at high latitude (satellite position within 20 degrees around the north and south pole) and at low latitude (satellite position within 20 degrees around the Equator) in the detector coordinate. Some differences are clearly seen in the left map at large off-axis angle even for the event of BGO energy >500 GeV. A maximum off-axis angle of 55° ensures that there is no notable position dependence in the detector response as shown in the right map.

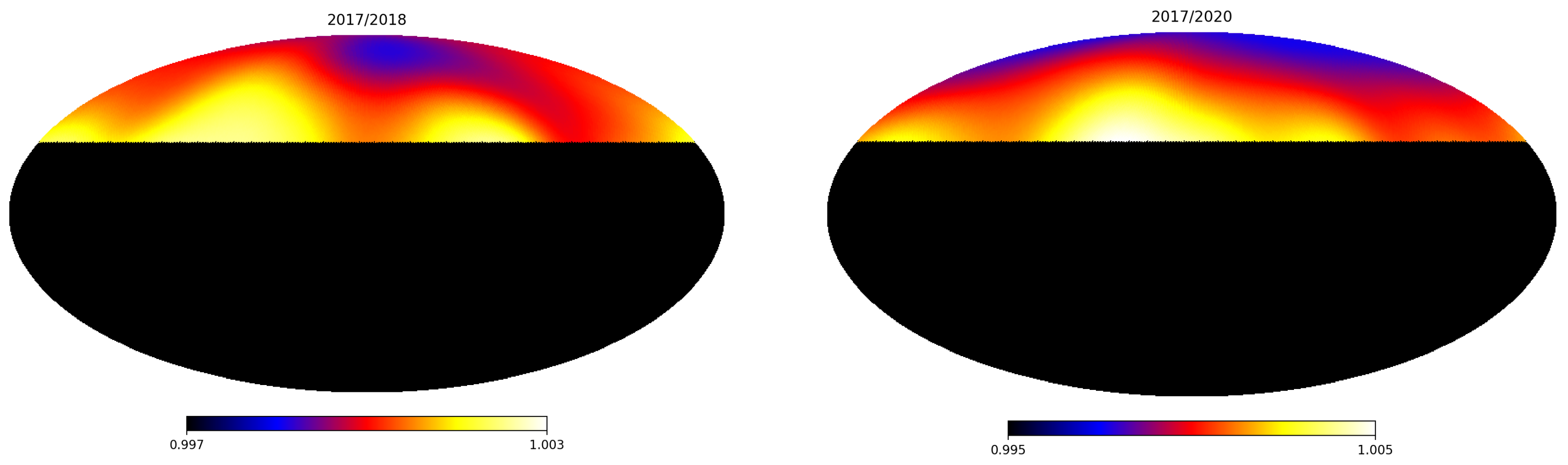

Fig. 3: Each map is produced by comparing the detector response at different years. The left panel shows that the variation of the response is well limited to within 2×10-3 for two consecutive year s (2017 vs 2018), while the right panel shows that the difference could reach ~4×10^{-3} for the response several years apart (2017 vs 2020). Given this fact, we split the whole data set of 5 years into 5 subsets, each contain the data of a whole year. The reference maps are then produced for each 1-year period to mitigate the time dependence of the response and the differentiate maps are the summed up for the final analysis. The choose of a whole year period for the subset also minimized the possible influence of the Compton-Getting effect due to the Earth revolution around the Sun.

Results

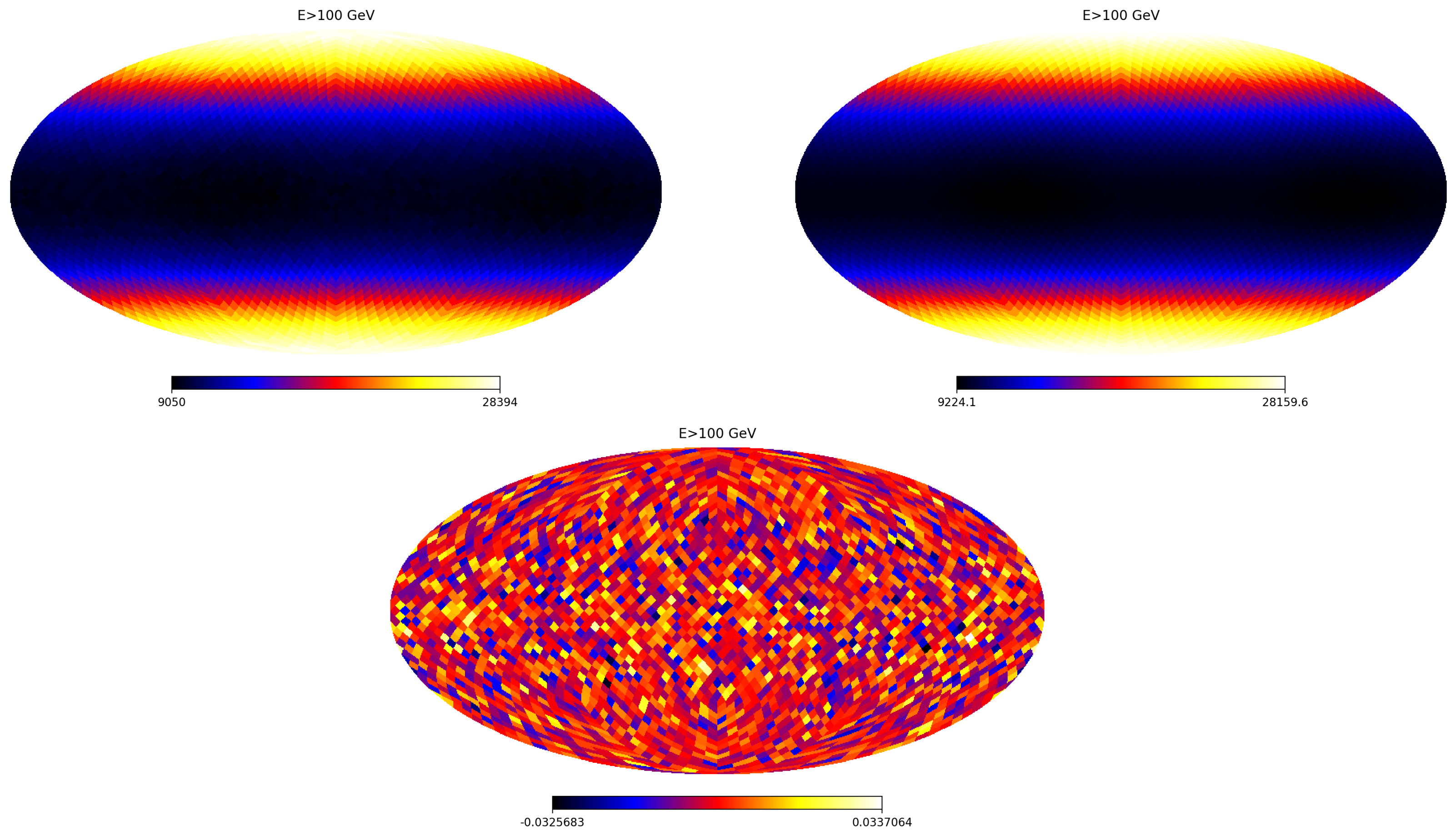

Fig. 4: Data (top-left) and reference sky map (top-right) in equatorial coordinate (J2000) for all events in the date set. A comparison of the two maps results into the sky map of relative intensity (bottom). Spherical harmonic analysis shows that the result is consistent with a null hypothesis, i.e., isotropic sky, and provides a 95% CL upper limit on the dipole amplitude at a minimum BGO energy of 100 GeV of 1.2×10^{-3}. See the proceeding for more details about this work [6].