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HAWC J2227+610: a potential PeVatron candidate for the CTA in the northern hemisphere

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Recent observations of the gamma-ray source HAWC J2227+610 by Tibet AS+MD and LHAASO confirm the special interest of this source as a galactic PeVatron candidate in the northern hemisphere. HAWC J2227+610 emits Very High Energy (VHE) gamma-rays up to 500 TeV, from a region coincident with molecular clouds and significantly displaced from the nearby pulsar J2229+6114. Even if this morphology favours an hadronic origin, both leptonic or hadronic models can describe the current VHE gamma-ray emission. The morphology of the source is not well constrained by the present measurements and a better characterisation would greatly help the understanding of the underlying particle acceleration mechanisms. The Cherenkov Telescope Array (CTA) will be the future most sensitive Imaging Atmospheric Cherenkov Telescope and, thanks to its unprecedented angular resolution, could contribute to better constrain the nature of this source. The present work investigates the potentiality of CTA to study the morphology and the spectrum of HAWC J2227+610. For this aim, the source is simulated assuming the hadronic model proposed by the Tibet AS+MD collaboration, recently fitted on multi-wavelength data, and two spatial templates associated to the source nearby molecular clouds. Different CTA layouts and observation times are considered. A 3D map based analysis shows that CTA is able to significantly detect the extension of the source and to attribute higher detection significance to the simulated molecular cloud template compared to the alternative one. CTA data does not allow to disentangle the hadronic and the leptonic emission models. However, it permits to correctly reproduce the simulated parent proton spectrum characterized by a $\sim$ 500 TeV cutoff.

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1. Introduction

The search for galactic PeVatrons, astrophysical particle sources capable of accelerating cosmic rays (CR) up to PeV energies, is an ambitious challenge of the multi-wavelength and the multi-messenger astronomy of this century. In the field of gamma-ray astronomy several experiments are currently contributing to detect galactic gamma-ray sources significantly above hundreds of TeV. These sources indicate the presence of highly energetic charged particles, which may suggest the presence of a PeVatron accelerator nearby. In 2020, the HAWC observatory has detected a significant emission above 100 TeV in the direction of VER J2227+608 [1], associated with the supernova remnant (SNR) G106.3+2.7 [2]. Other recent observations performed by Tibet AS+MD [3] and by the LHAASO [4] experiments have highlighted the particular interest of this source from which gamma photons up to 500 TeV were detected. Not only ground based experiments, but also the Fermi-LAT satellite [5] had earlier significantly detected this source in the 3-500 GeV energy range. The observed gamma-ray emission had been proven to be spatially extended ($\sim 0.2°$) and interestingly correlated with the molecular clouds in the SNR region. This morphological feature, together with a significant angular displacement ($\sim 0.4°$) of the Very High Energy (VHE) emission region from the nearby pulsar PSR J2229+6114, appears to favour a hadronic origin of the observed gamma-radiation. Nevertheless, the current VHE data allow for both hadronic or leptonic interpretation of the underlying emission mechanism. Similarly the morphology of the source is not well constrained due to the not optimal angular resolution of the current gamma-ray instruments.

In this work, we investigate the potential of the future Cherenkov Telescope Array (CTA) [6] for the morphological and spectral characterization of HAWC J2227+610. This source will only be observable from the CTA-North site, located in La Palma (Canary Islands). The array is currently under construction and it is foreseen to reach a first construction configuration (*alpha*) and than to be enlarged in a full-scope configuration (*omega*) characterized by a greater number of telescopes. It is worth mentioning that in the *omega* configuration, the CTA-North array is expected to have more than four times better sensitivity (at 1 TeV) compared to VERITAS and a factor two better angular resolution ($\sim 0.04°$ at 10 TeV).

Future observations of HAWC J2227+610 with the CTA-North array have been simulated considering the most recent fitted models of the VHE emission. The study is divided into two parts, the first centered on the morphological characterization of the source (Sec. 3.1) and the second on its spectral modeling (Sec. 3.2). Conclusions and perspectives are presented in Sec. 4.

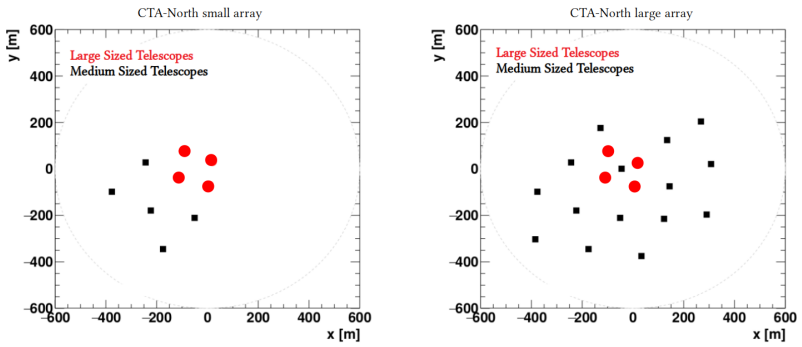

Figure 1: CTA-North layouts considered in this work: *small* (left) and *large* (right) configurations.

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2. Simulations and analysis

The present study is based on the future CTA science tool, `gammapy` (v18.2) [7], which allows to build a full analysis workflow, starting from the simulation of synthetic data to the production of high level scientific results such as sky-maps, spectra and flux points.

The source is simulated in a $2^\circ \times 2^\circ$ field of view, centered on the position of VER J2227+608, with a spatial bin size of 0.01°. The emission is studied in a 30 GeV - 160 TeV energy window, 10 bins per decade. For simulation and analysis the *prod3b* CTA Instrument Response Functions (IRFs) have been used [8] in which a *small* configuration corresponds to 9 telescopes (4 Large Sized Telescopes and 5 Medium Sized Telescopes with mirrors of 23 m and 12 m diameter respectively) and a *large* configuration amounts to 19 telescopes (4 Large and 15 Medium-Sized), as shown in Fig. 1. These configurations do not correspond to the final CTA design, which is still in a finalisation phase. IRFs include the effective area, the angular and energy resolution, and the background rate from cosmic rays mis-reconstructed as gammas. HAWC J2227+610, observed from the La Palma site location, culminates at almost $50^\circ/60^\circ$ altitude above the horizon, therefore we consider IRFs with 40° zenith angle pointing direction. In addition to the proton mis-reconstructed background, we include a background from diffuse gamma-rays adopting the model used for the CTA Galactic Plane Survey [9]. We assume that the observed gamma-radiation from HAWC J2227+610 is produced by the interaction of relativistic protons with the molecular clouds in the neighbourhood of the source, via the pion decay channel. The hadronic modeling is performed with `Pythia8` parametrization provided by the package `naima` (v0.9.1) [10] that computes non-thermal radiation from relativistic particle populations. We adopt the model fitted by the Tibet AS+MD on multi-wavelength data in the energy range 3 GeV - 114 TeV [3]. They obtained a power law proton distribution with a spectral index of 1.79 and an exponential cutoff at 499 TeV. The fitted total proton energy above 1 GeV is $W_p = 5 \times 10^{47}$ erg for a target density of 10 cm^{-3}. They assumed a source distance of 800 pc. The morphology of the source is modeled using the radio template map of molecular hydrogen in the direction of HAWC J2227+610, obtained through the ^{12}CO(J=1-0) emission lines. The radio data considered in this work have been obtained from the FCRAO survey [11]. We consider the two maps associated to the Fermi gamma-emission and the VERITAS gamma-emission, which are obtained integrating the radio cube in two different doppler velocity windows: $[-4, -6]$ km/s and $[-5.59, -7.23]$ km/s, respectively. The source spatial templates are obtained selecting map regions with density above 2×10^{20} cm^{-2}, from which we assume the gamma emission arises. The resulting source shape is the area of the maps contained inside the black contours. In the following, we will refer to the two shapes as Template A (Fig. 2-left) and Template B (Fig. 2-right).

Three observation times, 50, 100 and 200 hours, are taken into account. In each configuration we produce a Monte Carlo sample of 100 simulations which is then analysed in order to statistically characterize the morphological and spectral features of the observed source.

We perform a 3D map based analysis. The simulated counts are stored in data cubes with longitude and latitude coordinates along two axes and energies along the third dimension. We test several model hypothesis performing 3D fits that take into account the spectral and morphological model at the same time. The fit is performed with the `sherpa` (v4.12.0) backend and the `simplex` optimization algorithm [12]. The hypothesis test is based on the cstat statistics [13] defined as $C = 2 \times \log L$, where L is the fit likelihood. The change in cstat from one fitted model to another,

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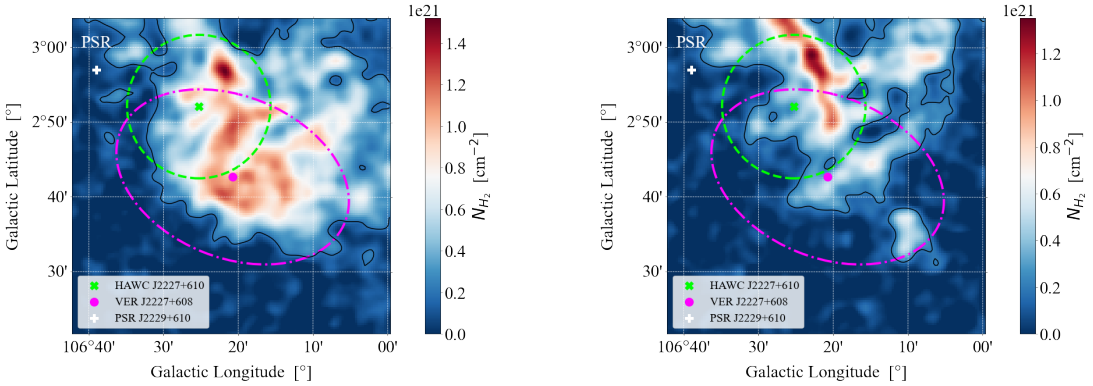

Figure 2: Column density maps from FCRAO survey [11] obtained integrating the measured brightness temperature over two different doppler velocity windows: $[-4,-6]$ km/s (left) and $[-5.59,-7.23]$ km/s (right). The dashed and dashed-dotted lines encompass the gamma-ray emission detected by HAWC and VERITAS, respectively. The HAWC circle marks the uncertainty of the fitted position whereas the ellipse represents the best fitted elongated shape found by VERITAS. The position of the nearby pulsar is also shown as a white cross. The black contours mark the $2 \cdot 10^{20}$ cm^{-2} column density level which enclose the template area used for modeling the source. They are referred in the text as Template A (left) and Template B (right).

ΔC, is used for statistical test of alternative hypothesis. To be able to interpret the results in this sense, after the fit we evaluate the cstat in re-binned data cubes in order to increase the count statistics per bin. Thus, for the comparison between the various morphological models we integrate the counts along the energy axis leaving the spatial matrix unchanged. Dealing with the spectral characterization, instead, we sum up the counts on the two spatial axes, maintaining a maximum number of 18 energy bins between 30 GeV and 160 TeV. The results obtained from the morphological and spectral study of HAWC J2227+610 are described in Sec. 3.

3. Results

3.1 Morphological Study

As described in Sec. 2, the hadronic emission is assumed to be spatially coincident with the position of the molecular clouds and simulated with the templates A and B. The data cubes are then fitted with the following spatial model: templates A and B, point source, symmetric and asymmetric gaussian and disk. For each model ΔC is computed with respect to a null hypothesis which includes only background data (mis-reconstructed protons and diffuse gammas). Fig. 3 shows the average ΔC of 100 realizations for both templates, the point source and the symmetric gaussian alternative hypothesis, as a function of the observation time and the *small* and the *large* array. As expected, the highest test statistic is obtained, in all cases, using as alternative hypothesis the simulated template, while the lowest ΔC is obtained with a point source hypothesis. The point source hypothesis is indeed excluded, with a 5σ confidence level, if compared, as null hypothesis, to the (nested) gaussian or disk models. Thus, the extension of the source is clearly detected. The gaussian and disk models, both symmetric and asymmetric, achieve equivalent detection significance with respect to the simulated molecular cloud template (in Fig. 3 we show only results from the symmetric gaussian model), while the alternative molecular cloud template reaches significantly lower ΔC values. Hence, the spatial

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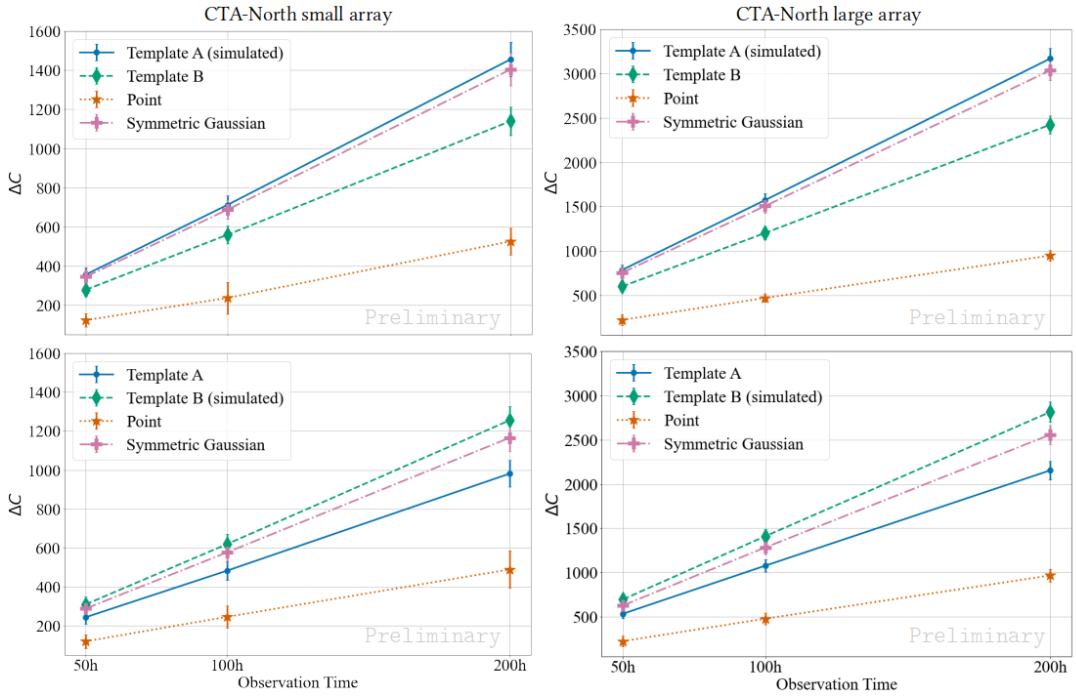

Figure 3: Mean values of ΔC from 100 realisations as a function of the observation time. Error bars mark the standard deviations of each distribution. Results are shown for the *small* (left) and *large* (right) array, and for the simulated template A (top) and the simulated template B (bottom).

fit does not permit to identify without ambiguity the original source morphology, but it permits to attribute higher detection significance to the simulated molecular cloud template, disfavouring the alternative one. Fig. 4 presents one example of simulated excess map and its best fitted symmetric gaussian extension, obtained with the *small* or *large* arrays, after 200 hours of observation. The averaged fitted standard deviation for the gaussian model is $\sigma = 0.145^\circ \pm 0.001^\circ$ and the disk radius is $r = 0.243^\circ \pm 0.002^\circ$, with the large array.

3.2 Spectral Study

The spectral study is performed simulating only the Template A spatial model and, as previously, assuming the hadronic spectral model proposed by Tibet AS+MD. As for the morphology study, we fit the observed data considering different alternative hypothesis: an hadronic model, a leptonic model and three simple gamma-ray emission hypothesis that do not involve underlying physical assumptions for the radiative mechanism: a power law (PL), a power law exponential cutoff (PLEC) and a LogParabola. The leptonic fit is performed with the model defined by Tibet AS+MD, which assumes a PLEC energy distribution for the parent electrons and their interaction with the CMB and infrared photon fields.

The parameter distributions obtained with the hadronic fit of the 100 simulations are centred on the true simulated parameters with the relative dispersion shown in Tab. 1 for all parameters and simulated configurations. The precision of the fit is increasing of about a factor two from 50 to 200 hours of observation time while the larger layout permits to improve the precision of

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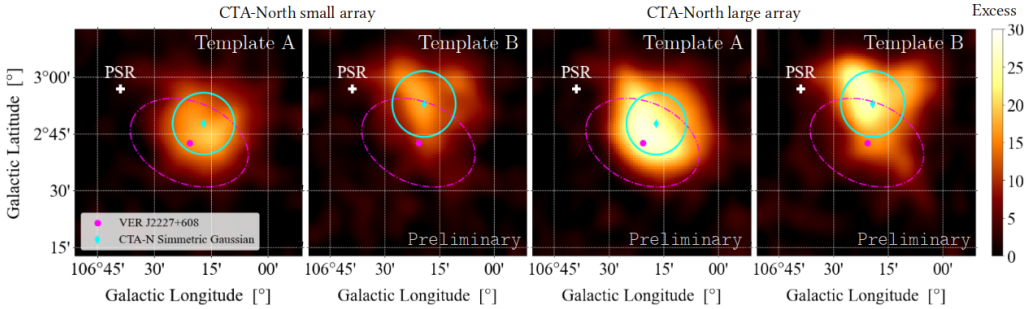

Figure 4: 200 hours simulated excess maps of HAWC J2227+610 observed by CTA-North in the *small* (**left**) and *large* (right) configurations. The maps are smoothed with a 0.05° gaussian sigma corresponding to the CTA angular resolution at 1 TeV. The employed spatial template is indicated in each figure. The solid circle marks the best fit of the source extension (standard deviation) assuming a symmetric gaussian model. The dashed-dotted ellipse encompasses the gamma-ray emission detected by VERITAS. The position of the nearby pulsar is also shown as a white cross.

less then a factor two. Similarly, the leptonic fit permits to recover the Tibet AS+MD leptonic fit

	amplitude		spectral index		energy cutoff	
	small	*large*	*small*	*large*	*small*	*large*
50 h	4.4%	3.0%	2.4%	2.0%	36.0%	20.7%
100 h	2.9%	2.3%	1.6%	1.5%	20.1%	15.2%
200 h	2.0%	1.6%	1.3%	0.8%	14.2%	10.6%

Table 1: Relative dispersion (standard deviation over mean) of the fitted parameters in the case of the hadronic model, as a function of the array configurations (*small*, *large*) and observation times (50, 100 and 200 hours).

parameters, which reflects the degeneration between the two models. In fact, Fig. 5 shows that the average test statistic ΔC obtained with the different alternative hypothesis is equivalent for all hypothesis, except for the PL model, which achieves slightly lower average ΔC above 50 hours of observation. Indeed, if we quantify the significance of the presence of a spectral curvature (cutoff) considering the (nested) PLEC and LogParabola models as alternative hypothesis to the PL model (null hypothesis), the alternative hypothesis proves to be preferable, at more than 5σ confidence level, for almost all configurations and observation times, as shown in Fig. 6. The cutoff fitted with PLEC is around 50 TeV. Finally, Fig. 7 presents an example of flux points, as measured by the *small* and *large* arrays for 50 hours of observation, together with the spectral points measured by the other experiments.

4. Conclusions and outlook

In the present work we have investigated the CTA potentiality in constraining the morphology and the spectrum of HAWC J2227+610, a source recently detected at energies above 100 TeV by several experiments. For its spectral and spatial characteristics, HAWC J2227+610 is a strong PeVatron candidate, therefore a particularly interesting target for the future CTA. The simulations

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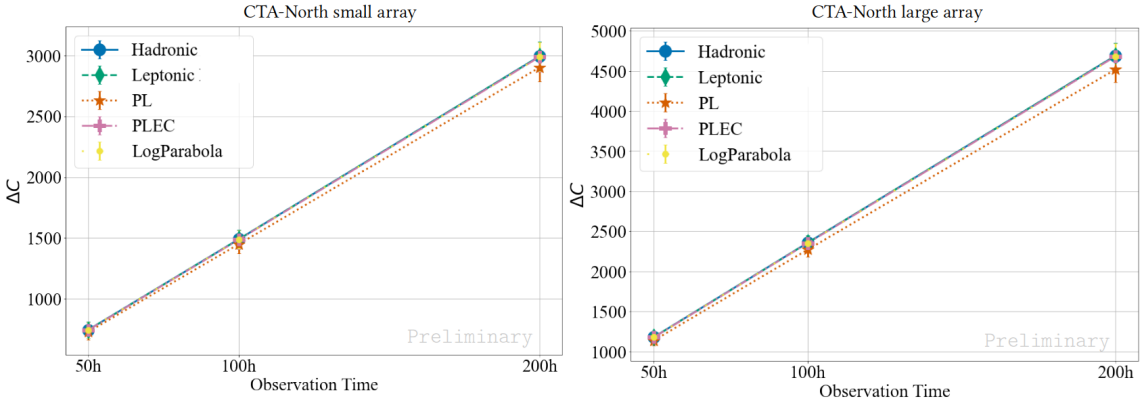

Figure 5: Average ΔC of 100 realizations for the hadronic, leptonic, power law (PL), power law exponential cutoff (PLEC) and LogParabola alternative hypothesis, as a function of the observation time for the *small* and *large* array.

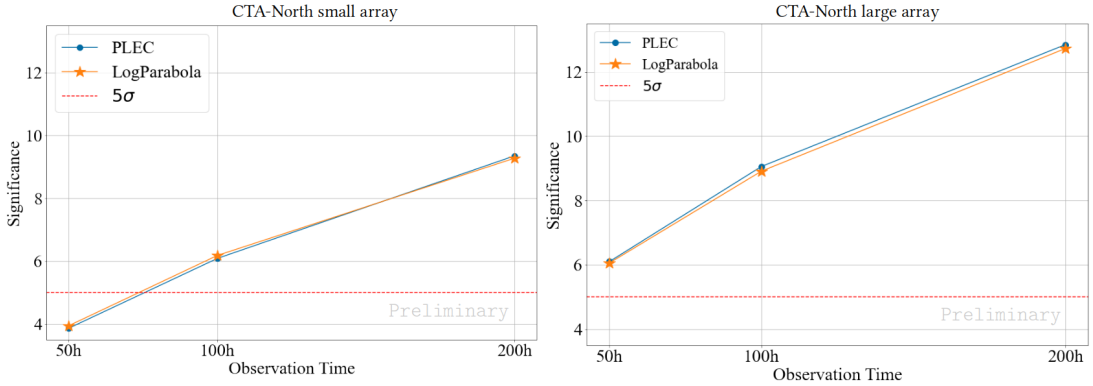

Figure 6: Significance (expressed in number of σ) of a spectral cutoff as a function of the observation time. The alternative power law exponential cutoff (PLEC) and LogParabola hypothesis are tested versus the power law (PL) model. The significance is evaluated assuming a χ^2 distribution for the test statistic with 1 degrees of freedom for the PLEC or 2 degrees of freedom for PLEC and LogParabola hypothesis.

and the analysis were performed using the CTA science tool, `gammapy`, assuming an hadronic emission model and two spatial models, extracted from the source nearby molecular cloud maps. Two layouts for the CTA-North array (*small* and *large*) and different observations times (50, 100 and 200 hours) have been considered. In all these configurations, the source is significantly detected over the background (well above a 5σ confidence level). The extended spatial hypothesis is significantly preferred over a simple point source hypothesis. The fitted standard deviation and radius, in the case of a symmetric gaussian and disk model, are $\sim 0.14°$ and $\sim 0.24°$, respectively. The simulated molecular cloud models obtain detection significance similar to simple parametric models (gaussian and disk). However, they achieve significantly higher test statistic values with respect to the alternative molecular cloud model, which is encouraging for future morphological studies. Regarding the spectral study, CTA-North is not able to disentangle the hadronic emission assumed in this work from a leptonic one. However, it is able to correctly reproduce the parameters of the simulated hadronic model and to detect a ~50 TeV exponential cutoff in the gamma-ray

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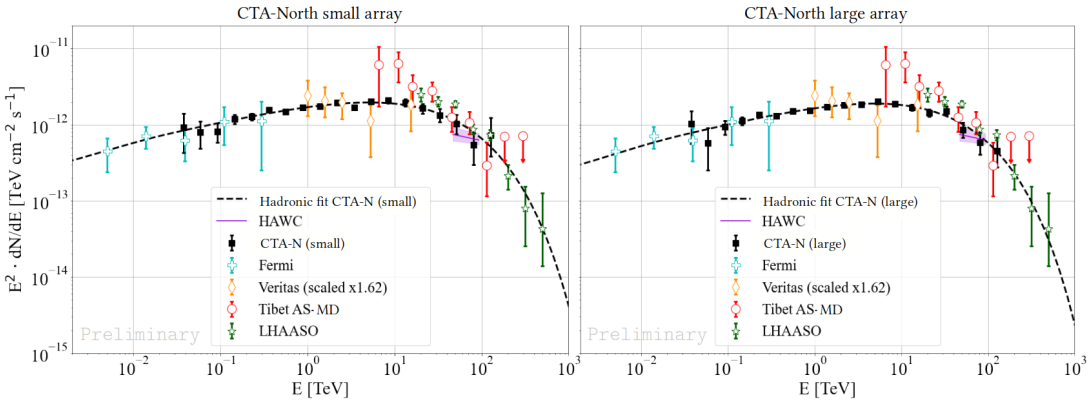

Figure 7: Flux points of HAWC J2227+610 as seen by CTA-North in the *small* and *large* configurations after 50 hours of observation. They are obtained assuming the best fitted hadronic model which is shown as a dashed black line. The flux points from Fermi-LAT, VERITAS, Tibet AS+MD and LHAASO are also shown.

spectrum with more than 3σ confidence level.

Acknowledgments

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References

[1] V. A. Acciari et al. The Astrophysical Journal Letters, 703, L6-L9 (2009)

[2] A. Albert et al. ApJ, 896, L29 (2020)

[3] M. Amenomori et al. Nature Astronomy, 5, 460–464 (2021)

[4] Z. Cao et al. Nature, 594, 33–36 (2021)

[5] Y. Xin et al. The Astrophysical Journal, 2, 162 (2019)

[6] B.S. Acharya et al. Astroparticle Physics, 43, 3-18, (2013)

[7] A. Donath et al. Proc. of International Cosmic Ray Conference, 789 (2015)

[8] G. Maier et al. Proc. of International Cosmic Ray Conference, 733 (2019)

[9] Q. Remy et al. Proc. of this conference (2021)

[10] V. Zabalza Proc. of International Cosmic Ray Conference, 922 (2015)

[11] M.H. Heyer et al. The Astrophysical Journal Supplement Series, 115, 241-258 (1998)

[12] B. Refsdal et al. Proc. of the 10th Python in Science Conference, 10-16 (2011)

[13] W. Cash The Astrophysical Journal, 228, 939-947 (1979)

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Bajtlik[49], A. Baktash[50], C. Balazs[7], M. Balbo[38], O. Ballester[41], J. Ballet[4], B. Balmaverde[44], A. Bamba[51], R. Bandiera[22], A. Baquero Larriva[11], P. Barai[19], C. Barbier[45], V. Barbosa Martins[52], M. Barcelo[53], M. Barkov[54], M. Barnard[1], L. Baroncelli[21], U. Barres de Almeida[40], J.A. Barrio[11], D. Bastieri[55], P.I. Batista[52], I. Batkovic[55], C. Bauer[53], R. Bautista-González[56], J. Baxter[2], U. Becciani[29], J. Becerra González[32], Y. Becherini[57], G. Beck[58], J. Becker Tjus[59], W. Bednarek[60], A. Belfiore[61], L. Bellizzi[62], R. Belmont[4], W. Benbow[63], D. Berge[52], E. Bernardini[52], M.I. Bernardos[55], K. Bernlöhr[53], A. Berti[64], M. Berton[65], B. Bertucci[23], V. Beshley[66], N. Bhatt[67], S. Bhattacharyya[67], W. Bhattacharyya[52], S. Bhattacharyya[68], B. Bi[69], G. Bicknell[70], N. Biederbeck[46], C. Bigongiari[28], A. Biland[36], R. Bird[71], E. Bissaldi[72], J. Biteau[73], M. Bitossi[74], O. Blanch[41], M. Blank[50], J. Blazek[33], J. Bobin[75], C. Boccato[76], F. Bocchino[77], C. Boehm[78], M. Bohacova[33], C. Boisson[20], J. Boix[41], J.-P. Bolle[52], J. Bolmont[79], G. Bonanno[29], C. Bonavolontà[24], L. Bonneau Arbeletche[80], G. Bonnoli[12], P. Bordas[81], J. Borkowski[49], S. Bórquez[35], R. Bose[82], D. Bose[83], Z. Bosnjak[47], E. Bottacini[55], M. Böttcher[1], M.T. Botticella[84], C. Boutonnet[85], F. Bouyjou[75], V. Bozhilov[86], E. Bozzo[38], L. Brahimi[39], C. Braiding[43], S. Brau-Nogué[87], S. Breen[78], J. Bregeon[39], M. Breuhaus[53], A. Brill[9], W. Brisken[88], E. Brocato[28], A.M. Brown[5], K. Brügge[46], P. Brun[89], P. Brun[39], F. Brun[89], L. Brunetti[45], G. Brunetti[90], P. Bruno[29], A. Bruno[91], A. Bruzzese[6], N. Bucciantini[22], J. Buckley[82], R. Bühler[52], A. Bulgarelli[21], T. Bulik[92], M. Bünning[52], M. Bunse[46], M. Burton[93], A. Burtovoi[76], M. Buscemi[94], S. Buschjäger[46], G. Busetto[55], J. Buss[46], K. Byrum[26], A. Caccianiga[95], F. Cadoux[17], A. Calanducci[29], C. Calderón[3], J. Calvo Tovar[32], R. Cameron[96], P. Campaña[35], R. Canestrari[91], F. Cangemi[79], B. Cantlay[31], M. Capalbi[91], M. Capasso[9], M. Cappi[21], A. Caproni[97], R. Capuzzo-Dolcetta[28], P. Caraveo[61], V. Cárdenas[98], L. Cardiel[41], M. Cardillo[99], C. Carlile[100], S. Caroff[45], R. Carosi[74], A. Carosi[17], E. Carquín[35], M. Carrère[39], J.-M. Casandjian[4], S. Casanova[101,53], E. Cascone[84], F. Cassol[27], A.J. Castro-Tirado[12], F. Catalani[102], O. Catalano[91], D. Cauz[103], A. Ceccanti[64], C. Celestino Silva[80], S. Celli[18], K. Cerny[104], M. Cerruti[85], E. Chabanne[45], P. Chadwick[5], Y. Chai[105], P. Chambery[106], C. Champion[85], S. Chandra[1], S. Chaty[4], A. Chen[58], K. Cheng[2], M. Chernyakova[107], G. Chiaro[61], A. Chiavassa[64,108], M. Chikawa[2], V.R. Chitnis[109], J. Chudoba[33], L. Chytka[104], S. Cikota[47], A. Circiello[24,110], P. Clark[5], M. Çolak[41], E. Colombo[32], J. Colome[13], S. Colonges[85], A. Comastri[21], A. Compagnino[91], V. Conforti[21], E. Congiu[95], R. Coniglione[94], J. Conrad[111], F. Conte[53], J.L. Contreras[11], P. Coppi[112], R. Cornat[8], J. Coronado-Blazquez[14], J. Cortina[113], A. Costa[29], H. Costantini[27], G. Cotter[114], B. Courty[85], S. Covino[95], S. Crestan[61], P. Cristofari[20], R. Crocker[70], J. Croston[115], K. Cubuk[93], O. Cuevas[98], X. Cui[2], G. Cusumano[91], S. Cutini[23], A. D'Aì[91], G. D'Amico[116], F. D'Ammando[90], P. D'Avanzo[95], P. Da Vela[74], M. Dadina[21], S. Dai[117], M. Dalchenko[17], M. Dall' Ora[84], M.K. Daniel[63], J. Dauguet[85], I. Davids[48], J. Davies[114], B. Dawson[118], A. De Angelis[55], A.E. de Araújo Carvalho[40], M. de Bony de Lavergne[45], V. De Caprio[84], G. De Cesare[21], F. De Frondat[20], E.M. de Gouveia Dal Pino[19], I. de la Calle[11], B. De Lotto[103], A. De Luca[61], D. De Martino[84], R.M. de Menezes[19], M. de Naurois[8], E. de Oña Wilhelmi[13], F. De Palma[64], F. 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