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C. Charbonnel, F. Combes and R. Samadi (eds)

HESS-II PERFORMANCE IN THE LOW-ENERGY DOMAIN

Becherini, Y.[1], Djannati-Atai, A.[1] and Punch, M.[1]

Abstract. In mid-2009 a notable upgrade of the H.E.S.S. telescope system will take place: a new telescope with a 600 m^2 mirror area and very-high-resolution camera (0.07°) will be positioned at the centre of the present configuration, with the aim of lowering the threshold and enhance its sensitivity in the 100 GeV to several TeV energy range. HESS-II will permit the investigation of the lower energy γ-ray spectra in various cosmic accelerators, giving information on the origin of the γ-rays observed, and will detect AGNs with a redshift greater than 0.2 (being less affected by absorption by Extragalactic Background Light - EBL - in this energy range) and will search for new classes of very high energy γ-ray emitters (pulsars, microquasars, GRB, and dark matter candidates).

1 Introduction

By the end of 2009 the H.E.S.S. experiment will enter its Phase II and at that time the data taking configuration will consist of the four current telescopes (here called T1, T2, T3 and T4) plus the new very large HESS-II telescope (here called T5, see Deil et al.). We have developed a shower reconstruction strategy for the events hitting the very large telescope alone which consists of several consecutive steps: first of all we clean the images and evaluate the shower direction, then, knowing the basic parameters of the images and of the showers we can optimise and apply a cut for hadron rejection and a cut on the shape of the images, finally we estimate the event energy with the sample of selected events with a Neural Network (NN) approach.

2 Low-energy performance

We simulated gamma and proton showers between 20 and 150 GeV at a zenith angle of 18° assuming an optimal optical efficiency in the five telescopes. The γ-ray source is simulated on the optical axis, so the source is projected at the centre of the cameras, and the simulations are carried out over 500 m from the centre of the array. The local trigger configuration used in this analysis can be summarised as follows: for T1, ..., T4 we required a pixel threshold of 4 p.e. and a minimum number of pixels of 2.5, while for T5 we raised these values to 5 and 3.5 respectively. The event is then kept only if it has at least one telescope satisfying the local trigger condition.

Images are cleaned with the following filtering rule: a pixel is accepted if it has at least a charge of 7 p.e. and some neighbouring pixels having a charge greater than 5 p.e., then for the reconstruction of the shower parameters with the filtered pixels we use the Hillas algorithm, see Werner et al. . For pure Mono-telescope events, the shower direction has to be estimated from the measured parameters using relations derived from Monte Carlo simulations.

Analysis cuts. The optimisation of the background rejection cut (*cut 1*) for the pure T5 Mono events has been performed with the Fisher algorithm implemented in a multi-variate analysis. An additional cut (*cut 2*) is required in order to reject the events giving images at the border of the camera, and to reject the events hitting the telescope too close to the source direction, which give non-elliptical images.

Angular resolution. The angular resolution, defined as 68% containment radius for all the pure T5 Mono events after trigger and image filtering, is shown in Fig. 1 on the left with the upper continuous line, while the resulting curve after the background rejection cut and cut 2 is shown with the lower continuous line. The angular resolution for the pure T5 events after cuts $(1 + 2)$ is of the order of 0.25°.

[1] APC, AstroParticule et Cosmologie, CNRS - Univ. Paris VII, 10, rue A. Domon et L. Duquet, 75205 Paris Cedex 13, France

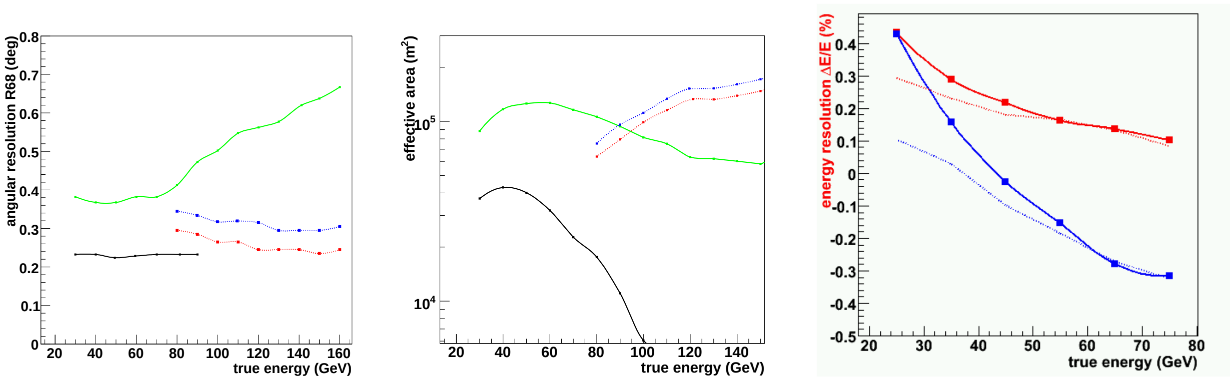

Fig. 1. Left: Angular resolution for the different HESS-II detection regimes: the upper continuous line shows the curve for the pure T5 Mono events after trigger and image filtering, while the lower continuous line shows the curve after the background rejection cut (cut 1) and cut 2. The remaining curves are obtained in the case of the semi-Stereo plus full-Stereo events at trigger and image filtering level (the upper dotted line is for the Hillas case while the lower dotted line is for the Model3D case, see Lemoine-Goumard et al.) and no analysis cuts were applied; the final stereo angular resolution is expected to be much better. Center: Effective area given in m^2 for the different HESS-II detection regimes: after trigger and image filtering (upper continuous line) and after cuts (lower continuous line) for the pure T5 events; after trigger and image filtering for the semi-Stereo and full-Stereo events for two different stereo reconstruction algorithms, the upper dotted line represents the results obtained with the *Hillas* algorithm, while the lower dotted line represents the *Model3D* resulting curve. Right: Energy resolution (upper continuous line) and bias curve (lower continuous line) obtained with a neural network approach in the case of the pure T5 Mono events. The dotted curves represent the resolution and the bias for the events having an impact parameter smaller than 130 m.

Effective area. For the calculation of the effective area, another quality cut on the squared angular deviation between the source position and the reconstructed direction θ^2 (*cut 3*) is applied: we select all the events having a $\theta^2 < 0.13$ deg^2. The effective area resulting after the three cuts is shown at the centre of Fig. 1: it has a maximum around 40 GeV then it drops dramatically at about 80 GeV where the semi-Stereo and full-Stereo detection regimes take over.

Energy resolution and bias. A dedicated study for the evaluation of the energy of the pure T5 events has been carried out using a NN approach trained with the events passing the three cuts mentioned. The resulting energy resolution defined as $\Delta E/E$ and bias defined as $< E > /E$ are shown in Fig. 1 on the right.

3 Conclusions

From our preliminary study of the performance of the HESS-II telescope we found the angular resolution for the pure T5 events to be of the order of 0.25° in the [30 GeV, 90 GeV] energy range after the hadron rejection and image shape cuts. The effective area after the additional cut on the angular resolution is found to be 4×10^4 m^2 at the maximum value of 40 GeV. Our current evaluation of the energy resolution varies from 40% to 20% as a function of the energy, while the bias spans from +40% to −40%: a more detailed study is needed in order to suppress this effect which is essentially due to the events having a large impact parameter.

References

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