Localising the HESS Galactic Centre point source

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Abstract. Observations by the H.E.S.S. system of imaging atmospheric Cherenkov telescopes provide the most sensitive measurement of the Galactic Center region in the energy range 150 GeV - 30 TeV. The vicinity of the kinetic centre of our galaxy harbours numerous objects which could potentially accelerate particles to very high energies (VHE, > 100 GeV) and thus produce the γ-ray flux observed. The centroid of the point-like emission measured by H.E.S.S. was found to be in good agreement with the position of the supermassive black hole Sgr A* and the recently discovered PWN candidate G359.95-0.04. Given a systematic pointing error of about 30", a possible association with the SNR Sgr A East could not be ruled out with 2004 H.E.S.S. data. In this contribution an update is given on the position of the H.E.S.S. Galactic Centre source using 2005/2006 data. The systematic pointing error is reduced to 6" per axis using guiding telescopes for pointing corrections, making it possible to exclude with high significance Sgr A East as the source of the VHE γ-rays.

1. Introduction

The centre of the Milky-Way is the most violent and active region in our galaxy. While dust along the line of sight prevents observation in visual light, observations at radio, infrared, X-Ray and hard X-Ray/soft γ-ray energies established the existence of a 2.6×10⁶M☉ black hole at the kinematic centre of our galaxy. It is commonly identified with the bright radio source Sgr A* and surrounded by a massive star cluster, a bright supernova remnant shell, and giant molecular clouds (see e.g. [17, 11] for recent reviews).

VHE γ-ray emission from the direction of the Galactic Centre (GC) was reported by several ground-based γ-ray observatories [14, 19, 1, 8]. A recent deep exposure by H.E.S.S. [4] revealed two discrete VHE γ-ray sources on top of diffuse emission along the inner 300 pc of the Galactic Centre ridge. One of the sources, HESS J1747-281 [2], is identified with the pulsar wind nebula (PWN) associated with the supernova remnant (SNR) G09+0.1. The position of the second source, HESS J1745-290, is within errors coincident with the kinematic centre of our galaxy.

A firm identification of HESS J1745-290 is difficult because the GC region is densely packed with sources of non-thermal radiation possibly emitting VHE γ-rays. In its direct vicinity several different objects are discussed as possible counterparts of HESS J1745-290. First, various models predict VHE γ-ray production near the super-massive black hole itself (see e.g. [7]), including annihilation of dark matter halo particles which could contribute to the observed VHE γ-ray flux [6]. The bright, shell-like radio emission of the SNR Sgr A East [16] surrounding Sgr A* is another favoured candidate counterpart. In addition, a deep Chandra survey recently revealed the candidate PWN G359.95-0.04 [21], located only 8.7” away from Sgr A*.
2. H.E.S.S. observations of the Galactic Centre region

Previous results on the position of HESS J1745-290 are based on a 50 h exposure carried out in 2004. Within a statistical error of 14", the best-fit position of HESS J1745-290 was found [3] to coincide with the position of Sgr A*. The systematic pointing error of the H.E.S.S. telescope system for this data set is about 28".

The results reported here are based on data recorded in 2005 and 2006 with a total good-quality exposure of 73.2 h (live time). Data were analysed with the standard H.E.S.S. calibration and reconstruction chain [5]. A strong excess of 1300 \( \gamma \) events is seen [10] within 0.1\( ^\circ \) of the GC. Its position and flux are in agreement with published results based on 2004 data [3].

3. Precision pointing

To determine the telescope orientation, H.E.S.S. uses a position-dependent model that is based on calibration measurements on bright stars and achieves a precision of about 20" per axis [12] on the observation direction. For the 2005-2006 data presented here, the systematic error is reduced further using guiding cameras mounted on each telescope. During \( \gamma \)-ray observations, stars in the field of view (0.3\( ^\circ \) x 0.5\( ^\circ \)) of these cameras are recorded and their reconstructed positions matched to the Hipparcos and Tycho star catalogues. From this information, position-dependent corrections in right ascension and declination are calculated for the individual H.E.S.S. telescopes. Additionally, the position of the Cherenkov camera is monitored by a central CCD camera. With this method, the systematic error of the telescope orientation is reduced to 6" per axis for observations with the full H.E.S.S. array ([9], details will be published elsewhere).

The procedure was extensively tested on VHE \( \gamma \)-ray point sources of known position. Fig. 1 shows a representative study on the position of the high-frequency peaked BL Lac PKS 2155-304. Excellent agreement with the nominal position of the source is found even when splitting the data into different "wobble offsets" (data taken towards a position offset from the source).

4. Position of HESS J1745-290

The best-fit position of HESS J1745-290 in Galactic coordinates as presented in [10] is \( l = 359^\circ 56^\prime 41.1^\prime\prime \pm 6.4^\prime\prime \) (stat), \( b = -0^\circ 2^\prime 39.2^\prime\prime \pm 5.9^\prime\prime \) (stat). These results are preliminary and are subject to final checks. Fig. 2 shows the new H.E.S.S. position measurement on top of a 90 cm VLA radio image of the inner 10 pc region of the GC. The position of HESS J1745-290 is coincident within 7.3" \pm 8.7" (stat.) \pm 8.5" (syst.) with the radio position of Sgr A* [18], and is also consistent with the position reported from the 2004 data set [3]. While the latter was marginally consistent with the radio emission from Sgr A East, the result obtained in this analysis does rule out Sgr A East as the counterpart of HESS J1745-290 with high significance.

The position of HESS J1745-290 agrees well with the location of the other two counterpart candidates, Sgr A* and G359.95-0.04, which are separated by only 8.7". Since the pointing precision obtained in this work is at the limit of an instrument such as H.E.S.S., the remaining source confusion will have to be solved differently. The most convincing signature of a connection between the VHE source and Sgr A* would be the detection of correlated flaring in X-rays and VHE \( \gamma \)-rays. Such searches have been presented in [20, 13].

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Figure 1. Position of the centroid of VHE γ-ray emission from PKS 2155-304 relative to its nominal position, with statistical errors. The red open circle marks the position derived from the full 2005/2006 data-set, the four black markers show positions based on subsets with different wobble offsets. Note that the available live time for the RA+ wobble data is reduced because no bright stars were found in the field of view of the guiding telescopes.

Figure 2. Smoothed 90 cm VLA radio image (reproduced from [15]) of Sgr A East in Galactic coordinates. The positions of Sgr A* and G359.95-0.04 are marked with a cross and a star, respectively. Best fit positions and total error (68% CL) are marked by triangles and circles (blue: 2004 data set [3], red: this analysis). The red square marks the expected reconstructed position if the VHE γ-ray emission followed the observed radio flux from Sgr A East.

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