Locating the TeV-excess from the Galactic Centre region

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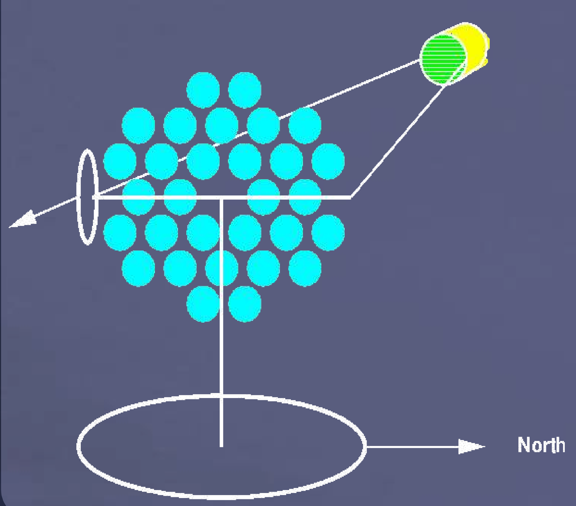
Abstract

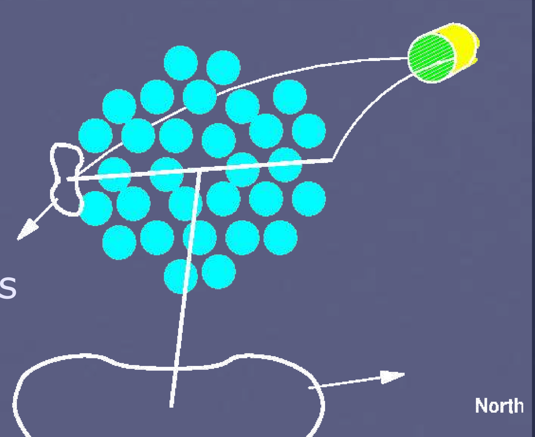
Gamma-ray experiments using the imaging atmospheric Cherenkov technique have an angular resolution of typically 0.07° per event. The centroid of a point-source emitter, however, can be determined with higher precision, down to a few arcseconds for strong sources. This is of special interest when an excess could be due to several potential sources in the field of view. Here it is demonstrated that H.E.S.S. achieves a pointing precision of 10 to 20 arcseconds by means of a mechanical pointing model. This is demonstrated by reconstructing the position of the AGN PKS 2155-304. The high precision allows to show that the TeV signal from the galactic centre region is consistent with the position of the galactic centre Sgr A*.

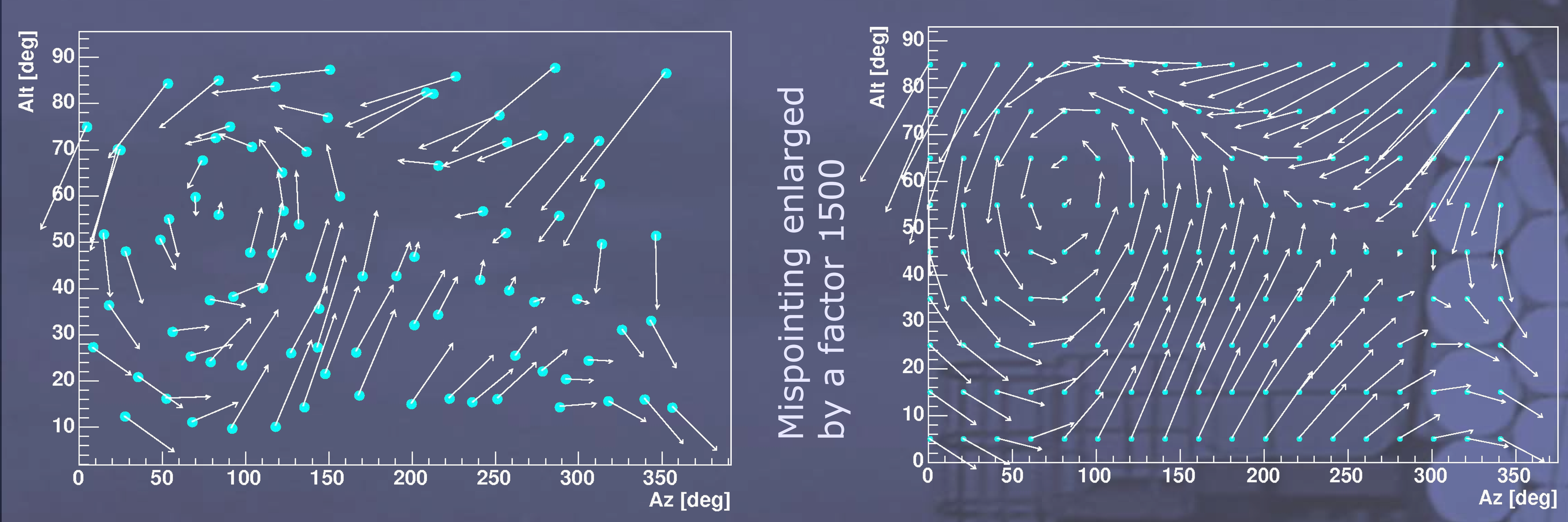
A real telescope always shows pointing errors.



Several mechanical effects make a real telescope deviate from the behaviour of an ideal telescope:

- The camera arms bend due to gravity.
- The azimuth axis is tilted away from verticality.
- The altitude axis is misaligned.
- The offsets of the shaft encoders are not known perfectly.
- and many more





The pointing deviations of each telescope are modelled.

The left plot shows the mispointing of one H.E.S.S. telescope as function of azimuth and altitude, measured by means of a CCD-camera looking at stars in the focal plane. The systematic error between the star positions and the TeV sky is roughly 15 to 20 arcseconds, currently still influenced by the precision with which the location of the pixel grid is known.

The right plot shows a graphical representation of the model constructed from the data. The model uses 14 mechanically motivated parameters. The mean deviation between model and data is less than 10 arcseconds.

The current conservative estimate of the pointing error is 20''.

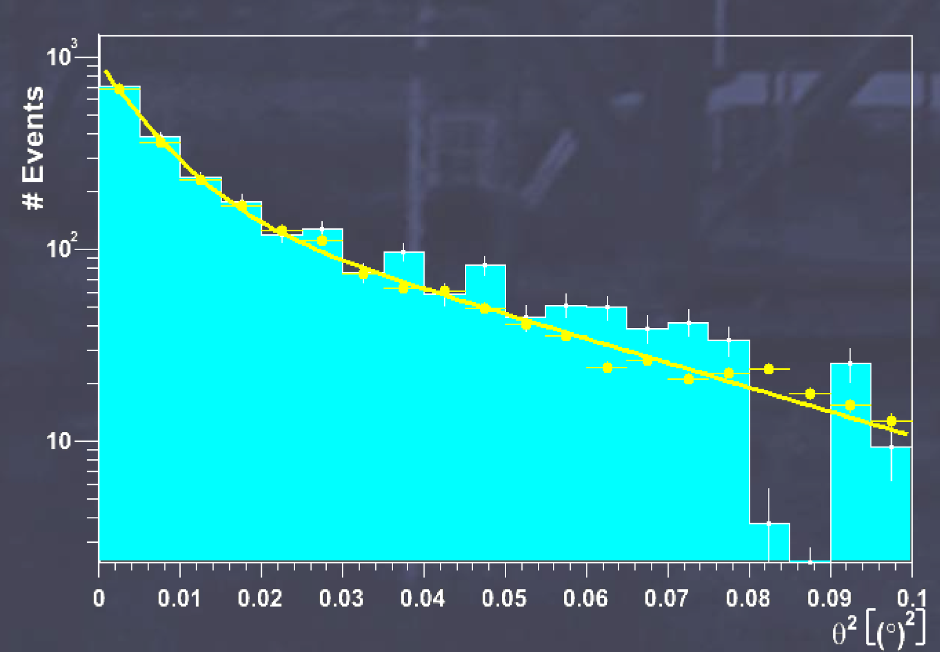
Adding the uncertainty of the model and the systematic error between optical and TeV sky, an estimate of the pointing error after correction is 20'' per axis.

The expected point spread funtion is taken from MC simulations.

The best estimate for a position is obtained by fitting the expected point spread funtion (psf) to an excess. The psf changes with the zenith angle of the observation and the source spectrum as well as with the detector configuration.

Therefore the psf is generated by MC simulations. The simulations used agree very well with the actual data.

The histogram to the left shows a logarithmic θ^2-plot of the Crab nebula data obtained in autumn 2003. Plotted on top is a MC simulation for a point source with a Crab-like spectrum and the given observation conditions (points). The curve is a fit to the MC data, using a sum of two Gaussian functions.

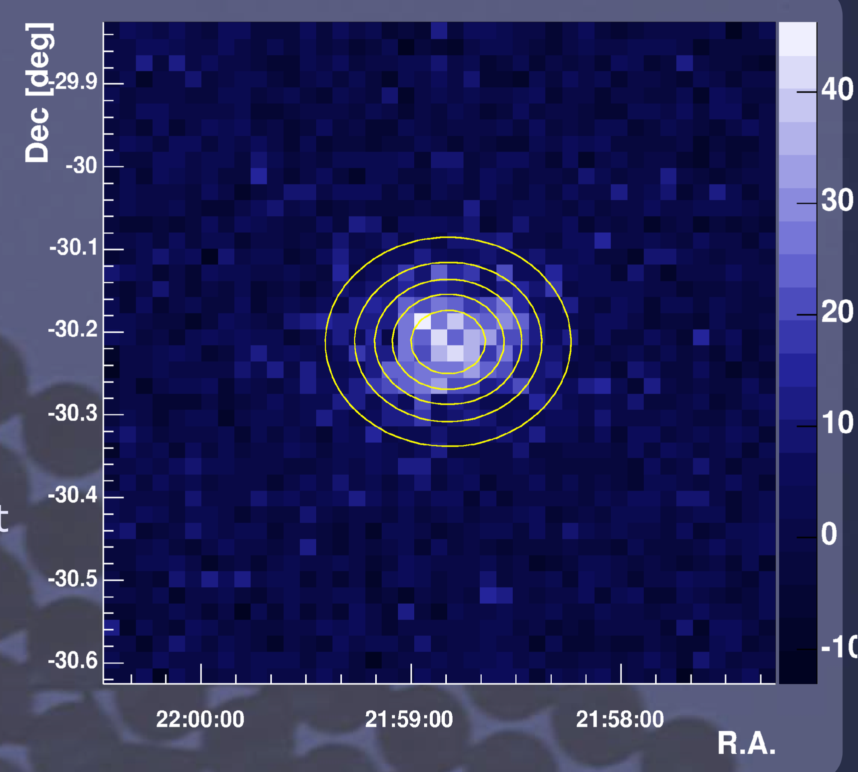


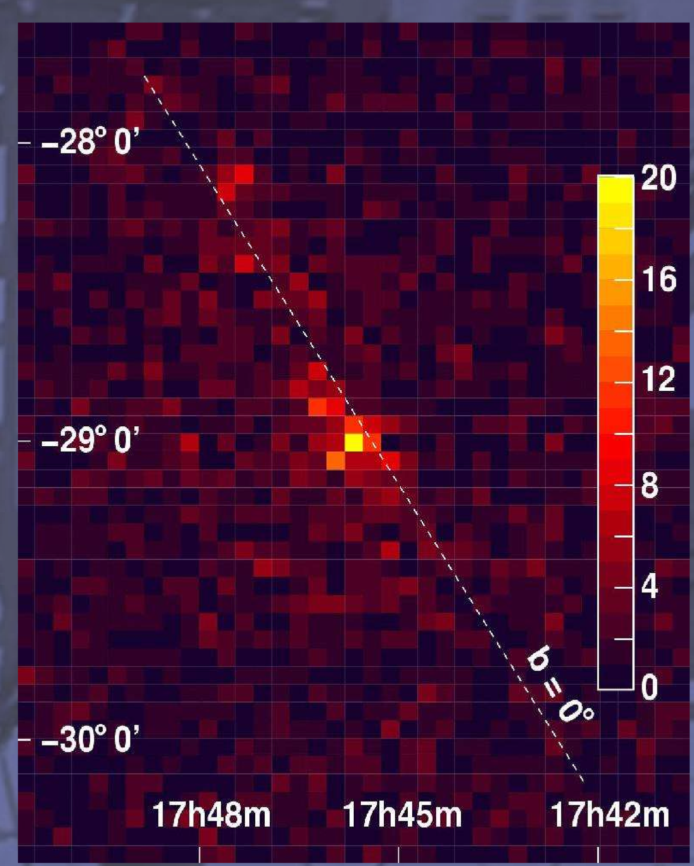
The TeV position of PKS 2155-304 agrees with the catalog position.

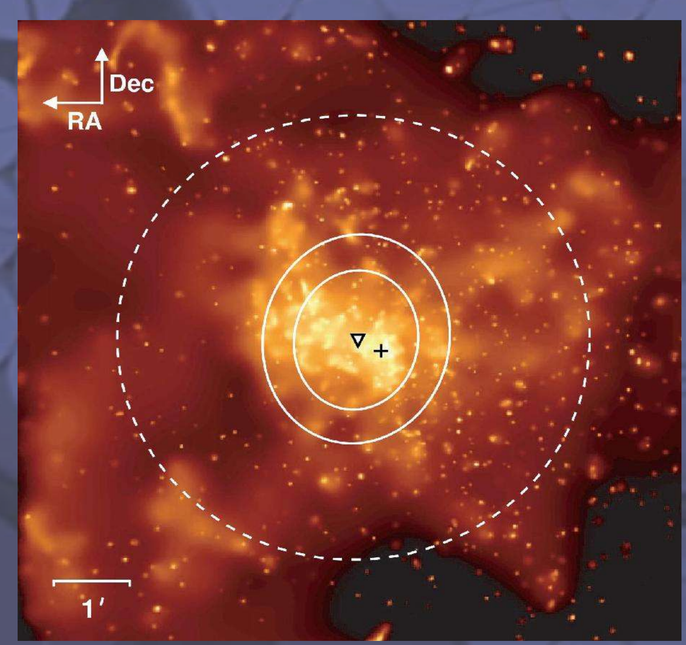
The plot shows an uncorrelated excess map of the H.E.S.S. data obtained in July and August 2003 on the point source emitter PKS 2155-304. Here, it serves as a test source with known position.

Superimposed as yellow contour lines is the result of the position fit, which uses the point spread function as generated from Monte Carlo simulations. The difference to the nominal position is

$\Delta\alpha = 9'' \pm 12''$
$\Delta\delta = 14 \pm 10''$







The position of the excess from the Galactic Center region is consistent with Sgr A*.

Top: The signal from the galactic center (GC) region as it was observed in sunmer 2003 with H.E.S.S. The plot shows the angular distribution of γ-ray candidates for a 3° field of view centered on Sgr A*. The dashed line gives the direction of the galactic plane. The significance of the feature extending along that plane is under investigation.

The excess is located at

$\alpha = 17^h\,45^m\,41.3^s \pm 2.0^s$
$\delta = -29°\,00'\,22'' \pm 32''$.

Its distance to the GC in galactic coordinates is

$\Delta l = 12'' \pm 30''$
$\Delta b = 14'' \pm 30''$.

Bottom: The centre of gravity of the VHE signal (triangle) is superimposed on a 8.5' by 8.5' Chandra X-ray map of the GC. The location of Sgr A* is indicated by a cross. The contour lines indicate the 68% and 95% confidence regions for the source position, taking into account systematic pointing errors of 20''. The white dashed line gives the 95% confidence upper limit on the rms source size. The resolution for individual VHE photons - as opposed to the precision for the centre of the VHE signal - is 5.8' (50% containment radius).

In future the systematic error will be lowered to 5''.

Currently the issue of the imprecisely known position of the pixel grid is adressed in order to be able to relate positions of shower images to the position of stars with an accuacy of very few arcseconds.

Furthermore a guide CCD (arrow) has been installed and brought into operation. For the current data, however, it was not used as the dominant error was given by the uncertainty of the position of the pixel matrix.

Alltogether the first tests show that a pointing error less than 5'' should be possible.

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