The W49 region as seen by H.E.S.S.

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Abstract

The W49 region is a prime target for ground-based Cherenkov imaging telescopes such as H.E.S.S. since it hosts a star forming region (W49A) and a supernova remnant interacting with molecular clouds (W49B). The 10^6 $M_\odot$ Giant Molecular Cloud W49A is one of the most luminous giant radio HII regions in our Galaxy and hosts several active, high-mass star formation sites. The mixed-morphology supernova remnant W49B has one of the highest radio surface brightness of all the SNRs of this class in our Galaxy and is one of the brightest ejecta-dominated SNRs in X-rays. Infrared observations evidenced that W49B is interacting with molecular clouds and Fermi recently reported the detection of a coincident bright, high-energy gamma-ray source. Observations by the H.E.S.S. telescope array resulted in the significant detection of VHE gamma-ray emission from the W49 region, compatible with gamma-ray emission from the SNR W49B. The results, the morphology and the origin of the VHE gamma-ray emission will be presented in the multi-wavelength context and the implications on the origin of the signal will be discussed.

The W49 region

• The W49 region hosts the star forming region **W49A** and the mixed morphology supernova remnant **W49B.**

• **W49B :**
- IR and X-rays observations : W49B's progenitor was a super-massive star that created a wind-blown bubble in a dense molecular cloud in which the explosion occured[6].
- Mid-IR lines from shocked molecular hydrogen : **W49B is interacting with molecular clouds[6].**
  - Distance : **8 kpc < D < 12 kpc[3]**
  - Age : **~ 1000 - 4000 yrs[8]**
  - Shell diameter (Radio) : **~ 4'**
- W49B is detected by the Fermi-LAT at a level of 38σ with 17 months of data[1].

•**W49A :**
- 10^6 $M_\odot$ Giant Molecular Cloud of 100 pc in size.
- Contains numerous active, high-mass star formation sites. Emissions are equivalent to the presence of ~ 100 O-type stars[3].
- Distance : 11.4±1.2 kpc[4]

H.E.S.S. Observations and Analysis Results

•A standard run selection procedure was used to remove bad quality observations. This resulted in a dataset comprising **60 hours** of observations (live time) on W49B.
• Analysis regions : circles of 0.1° centered on the nominal position of W49A and W49B.

• Model analysis[7] with the standard cuts : including a minimum charge of 60 p.e. resulting in an energy threshold of 260 GeV.
• Results confirmed by independent analysis such as those described in (2) or (9)

W49B is detected by H.E.S.S. at a level of **8.8σ**

An excess on **W49A** has a significance of at least **4.4σ**

H.E.S.S. & MWL SkyMaps

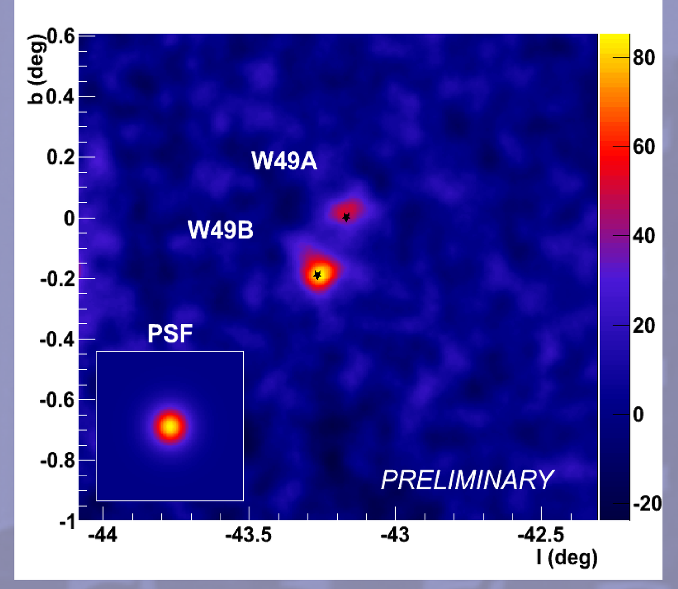

Fig. 2 : H.E.S.S. excess map of the W49 region obtained with the *Model Analysis*. The map is smoothed to the H.E.S.S. PSF shown in the caption. The stars marks W49B and W49A nominal positions.

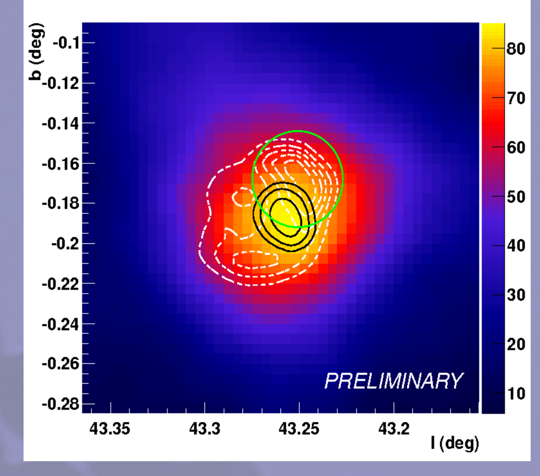

Fig. 3 : Detail of Fig. 2 centered on W49B. The blue contours are the error contours at 68%, 95% and 99% of the fitted position. The green circle is the Fermi-LAT fitted position at 95% C.L. The white contours show the radio emission as seen by NVSS.

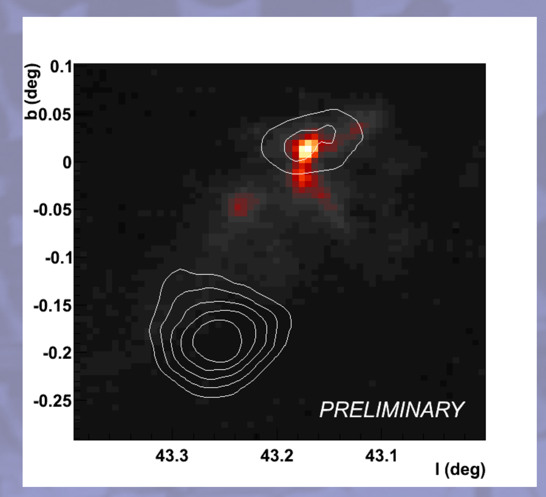

Fig. 4 : Integrated Map of the $^{13}CO(J=1-0)$ Galactic Ring Survey between v_{LSR} = 0 km/s and 20 km/s. This velocity range corresponds to W49A. The white contours are from the H.E.S.S. excess map (Fig. 2).

• Best Fit position of the TeV emission towards **W49B** is:

l = 43.258°±0.008°
b = -0.188°±0.01°

• TeV gamma-ray emission is well coincident with the brightest radio part of the **W49B** remnant and with the GeV emission fitted position of (l = 43.251°, b = -0.168°), with an error radius of 0.024° at 95% C.L.[1] (cf. Fig. 3).

• The TeV excess visible towards **W49A** is in good coincidence with the densest part of the molecular cloud as observed by the ^{13}CO Galactic Ring Survey[5] (cf. Fig. 4).

W49B H.E.S.S. & Fermi Spectrum

Differential energy spectrum of the VHE gamma-ray emission was derived above the energy threshold of 260 GeV.

The selected events were taken inside a circular region of 0.1° around W49B's nominal position.

The spectrum obtained for W49B is well described (χ^2/dof = 39.6/38) by a power-law model defined as

$$dN/dE = N_0(E/1\mathrm{TeV})^{-\Gamma}$$

with the parameters below:

Index : $\Gamma = 3.1 \pm 0.3_{stat} \pm 0.2_{syst}$
$N_0 = 2.3 \pm 0.4_{stat} \pm 0.5_{syst} \cdot 10^{-13}$ cm^{-2}s^{-1}TeV^{-1}
I (>1TeV) = $1.1 \pm 0.3_{stat} \pm 0.3_{syst} \cdot 10^{-13}$ cm^{-2}s^{-1}

This integral flux corresponds to ~ 0.5% of the Crab nebula flux above the same energy.

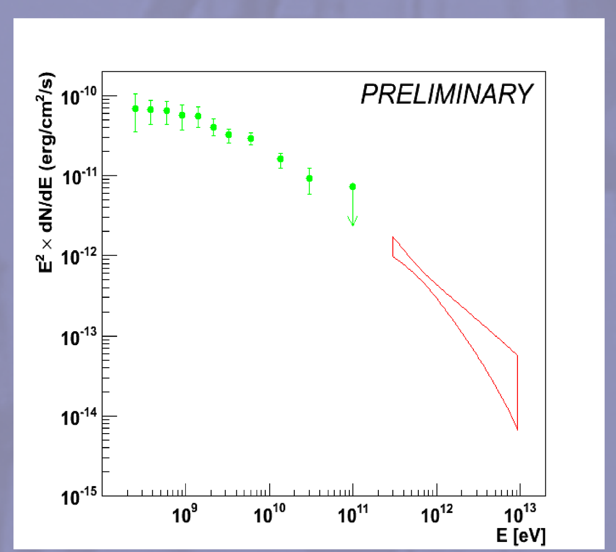

Fig. 5 : GeV and TeV spectrum obtained by the Fermi-LAT (green) and H.E.S.S. (red). The H.E.S.S. spectrum was extracted from a circular region of 0.1° around the nominal position of W49B.

GeV[1] and TeV gamma-ray spectra are in remarkably good agreement.

Interpretations

W49B :

• No observations suggest the presence of a pulsar or pulsar wind nebula in W49B. The most likely origin for the gamma-ray emission, in the TeV as well as in the GeV band is then particle acceleration at the SNR shock, as predicted for instance by Diffusive Shock Acceleration (DSA).

• The large GeV gamma-ray luminosity[1] of ~ 1$\cdot 10^{36}$ erg s^{-1} implies that IC scattering is disfavored. The shock is observed to be interacting with the molecular cloud (with densities of the order of ~ 100 - 1000 cm^{-3}) in which the supernova exploded. Thus π^0-decay or electron bremsstrahlung models could explain GeV and TeV emission[1].

• More detailed studies are in progress to understand and constrain the emission processes in W49B.

W49A :

• Star forming regions are potential acceleration sites of VHE particles. This can occur at the shocks created by the strong winds of the numerous massive stars they generally host.

• Recently[10], evidences for the presence of two expanding shells which seem to have a common origin and an energy of 10^{49} ergs were found in W49A. Evidences of gas ejections which are likely to have the same origin as the expanding shells and a total energy of a few times 10^{50} ergs were also found.

Conclusions

The W49 region was observed by the H.E.S.S. telescope array, yielding **~ 60 h** of good quality data.

Observations of the W49 region led to the significant detection of TeV gamma-ray emission coincident with the supernova remnant **W49B** at a significance level of **8.8σ**.
The position of the emission is compatible with the brightest part of the radio emission as well as with the GeV emission.
Spectra in the GeV and TeV bands are in very good agreement. Given the very high GeV luminosity and that the SNR is interacting with dense material, the Inverse Compton seems unlikely whereas electron Bremsstrahlung as well as π^0-decay scenarios could explain the observed data.

These observations resulted in evidence for gamma-ray emission in the direction of the star forming region **W49A.** Analyses are still ongoing in order to confirm this promising preliminary result.

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