Discovery of the VHE gamma-ray source HESS J1641-463

A new TeV source, HESS J1641-463, has been serendipitously discovered in the Galactic plane by the High Energy Stereoscopic System (H.E.S.S.) at a significance level of 8.6 standard deviations. The observations of HESS J1641-463 were performed between 2004 and 2011 and the source has a moderate flux level of 1.7% of the Crab Nebula flux at E > 1 TeV. HESS J1641-463 has a rather hard photon index of 1.99 +/- 0.13$_{stat}$ +/- 0.20$_{sys}$. HESS J1641-463 is positionally coincident with the radio supernova remnant SNR G338.5+0.1, but no clear X-ray counterpart has been found in archival Chandra observations of the region. Different possible VHE production scenarios will be discussed in this contribution.

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H.E.S.S. analysis and results

- Observations have been performed between 2004 and 2011 for a total acceptance-corrected livetime of 72 h. Data were analyzed with the Hillas analysis technique [1].
- A new source dubbed HESS J1641-463 has been discovered near the strong gamma-ray source HESS J1640-465 [2], with a significance of 8.6σ above 4 TeV (see Fig. 1).
- The emission of HESS J1640-465/HESS J1641-463 has been modeled with a double Gaussian function convolved with the instrument point spread function (PSF), showing a clear increase of the second source with increasing energy (Fig. 2).
- Preliminary best-fit position at E>4 TeV: RA: $16^h41^m1.7^s \pm 3.1^s_{stat} \pm 1.9^s_{sys}$, DEC =−46° 18' 11" ± 35"$_{stat}$ ± 20"$_{sys}$ (J2000).
- Preliminary power law fit [0.64 - 30 TeV] reveals a hard spectrum with a photon index of 1.99 ± 0.13$_{stat}$ ± 0.20$_{sys}$ and a flux density of 1.9 ± 0.2$_{stat}$ 10^{-12} erg cm^{-2} s^{-1} above 1 TeV. (1.7 % Crab nebula flux at this energy.)

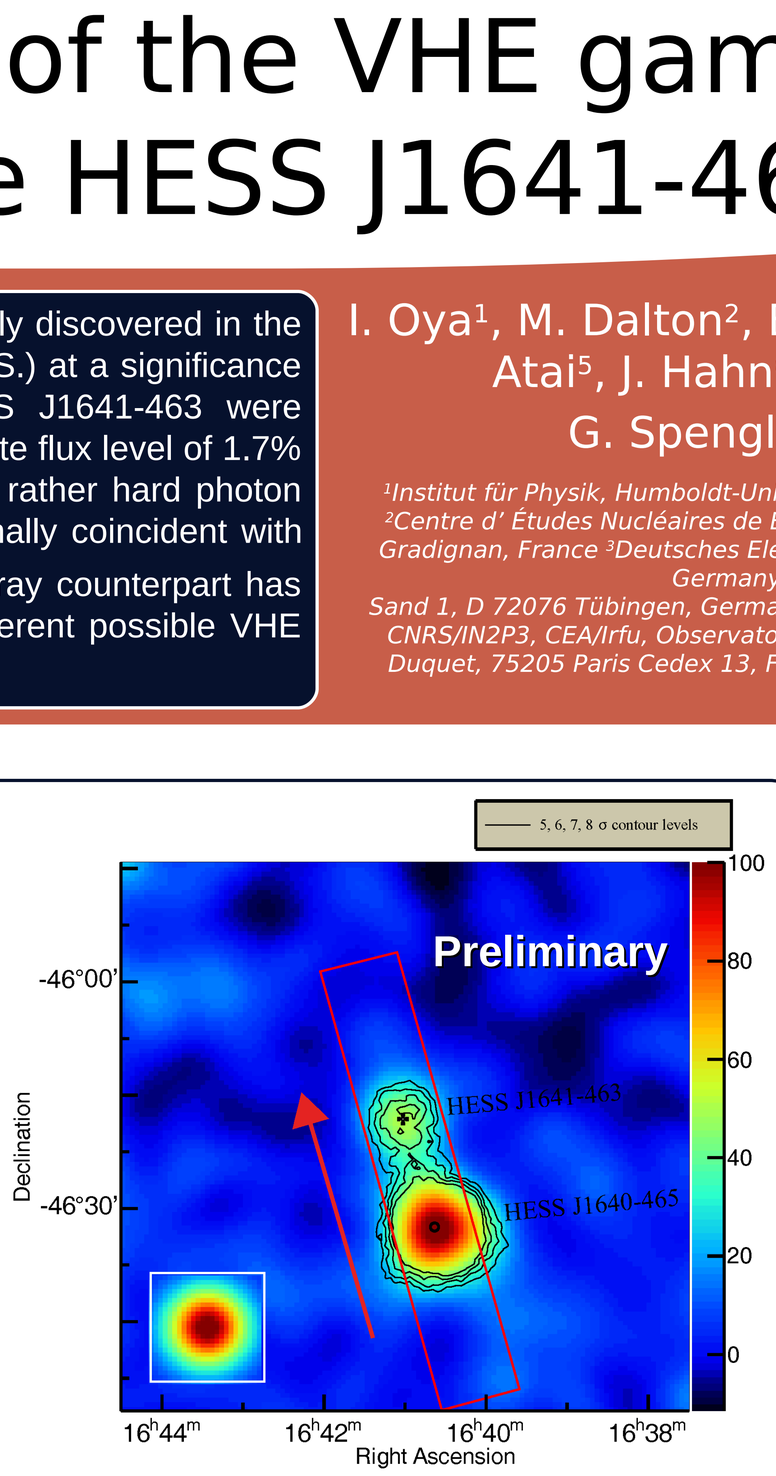

Fig. 1: VHE gamma-ray map of the field around HESS J1640-465 and HESS J1641-463 for E>4 TeV. The inset illustrates the PSF of the instrument.

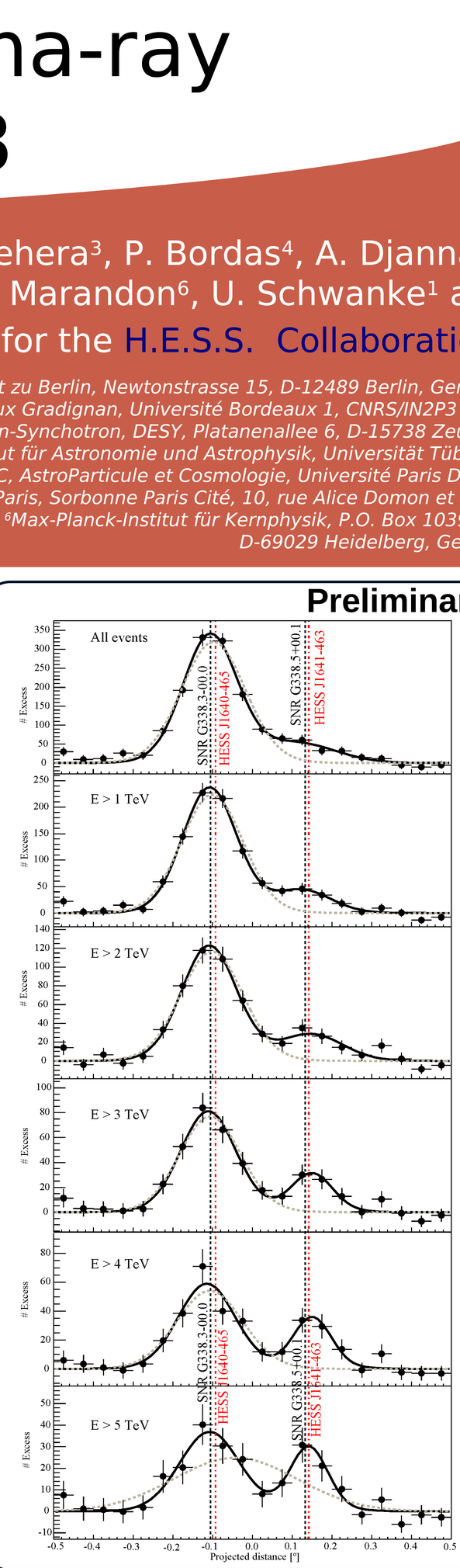

Fig. 2: Distribution of gamma-ray flux along the slice indicated in Fig 1. Full lines model a double Gaussian (compared with a single Gaussian indicated with the dashed line).

Searching for a MWL counterpart

- HESS J1641-463 is found within the bounds of SNR G338.5+0.1 [3], see Fig 3. SNR G338.5+0.1 has a roughly circular morphology, and shows a flux density at 1 GHz of 12 Jy and an angular size of 0.15°. The distance to the SNR is estatimated to be 11 kpc [4], indicating that it has a physical size of ~30 pc.
- No X-ray source or massive star counterpart is found in the calalogues within 0.03° of the best fit position of HESS J1641-463. No Fermi source is located in the area, besides the nearby 2FGL J1640.5-4633, associated with HESS J1640-465.

Chandra observations

- Two archival Chandra observations cover the region of interest (Tab 1.). Data were recalibrated and analyzed with CIAO 4.4 and CALDB 4.4.7 versions.
- Area at a distance < 0.1° to HESS J1641-463 was scanned with CIAO `wavdetect`, `celldetect` and `vtpdetect` tools. Sources filtered by requesting a S/N > 3, and a positive hardness ratio of counts of 2-10 keV over 0.3 – 2 keV.
- 2 sources were revealed (Fig 4). within 0.03° of the best-fit position of HESS J1641-463 (see tab 2.). Flux densities [0.3 - 10 keV] were calculated with the CIAO command `calc_energy_flux`.

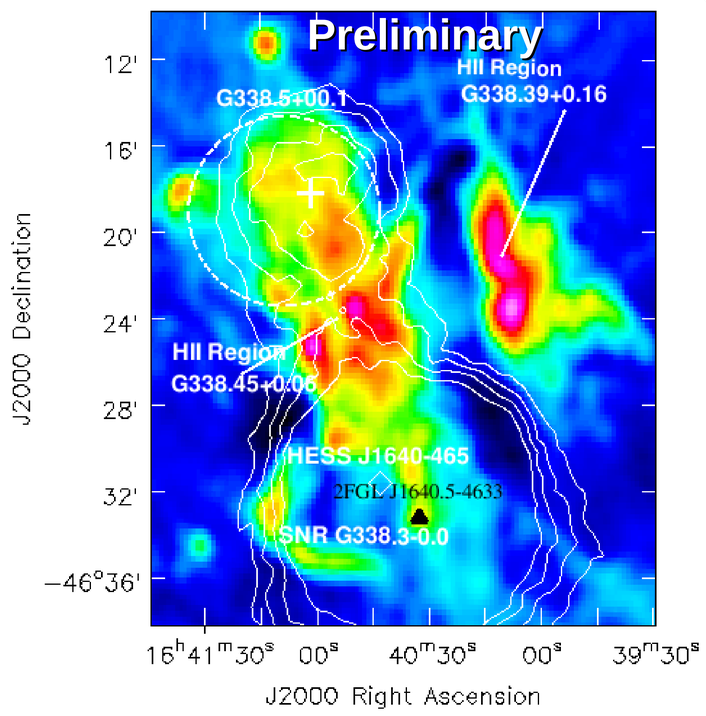

Fig. 3: Radio view (MOST 843 MHz) of the ROI. The white solid contours indicate the significance of the emission at E> 4 TeV at the 5σ, 6σ, 7σ and 8σ levels. The white cross indicates the best fit position of HESS J1641-463, and the black triangle the location of 2FGL J1640.5-4633.

Obs ID	Original Target	Exposure time	Mode	Chips with ROI
11008	Mercer 81	40.0 ks	VFaint	I2 and I3
12508	Norma	18.8 ks	VFaint	S3

Tab. 1: Chandra X-ray observations

Source ID	Ra (J2000)	Dec (J2000)	Net counts	Flux density [erg cm^-2 s^-1]
L	16:40:58.9	-46:17:02.8	15.2±5.1	1.5 10^{-13}
G	16:40:57.2	-46:19:30.7	20.7±5.0	4.2 10^{-14}

Tab. 2: X-ray sources within the possible extension of HESS J1641-463.

Fig. 4: Exposure corrected smoothed (10 arcsec) image from Chandra Obs 11008 (left) and 12508 (right) of the area near HESS J1641-463 (black cross indicating the best fit and black circle a region of 0.03° radius around it, blue dashed contours indicating the significance of the emission at E> 4 TeV at the 5σ to 8σ levels). Red circles indicate the detected sources, while blue circles in the right panel indicate sources only detected in the observations displayed in the left panel.

Discussion

- The larger extension of SNR G338.5+0.1 as compared to HESS J1641-463, and the relativelly old age of the SNR inferred from its physical size of ~30 pc suggests that the emission might not be necessarily connected with the SNR but rather with a pulsar wind nebula at its center, driven by an yet undetected pulsar. From energy considerations, any of the faint X-ray sources of the area near HESS J1641-463 can be its counterpart in this scenario.
- Another possibility could be a binary system, similar to HESS J0632+057 [5], even if no variability is detected at VHE so far. A flux of ~10^{-14} erg cm^{-2} s^{-1} may be expected from an X-ray faint binary system similar to HESS J0632+057 if located at the estimated distance of SNR G338.5+0.1 (11 kpc).

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