X-ray and gamma-ray observations of the inner region of MGRO J2019+37

UNIVERSITAT DE BARCELONA

V. Zabalza and J.M. Paredes

Departament d'Astronomia i Meteorologia and Institut de Ciències del Cosmos (ICC), Universitat de Barcelona (UB/IEEC)

Contact: `vzabalza@am.ub.es`

Institut de Ciències del Cosmos

Abstract

In order to better understand the puzzling extended TeV source MGRO J2019+37, we have performed a multiwavelength campaign from radio to X-ray covering most of its extent. Here we present an X-ray mosaic including a new observation and two archival observations performed by the X-ray observatory *XMM-Newton*. We have also observed the source with the gamma-ray observatory AGILE. We discuss new point like and extended X-ray sources we have found in the field that could help elucidate the physics behind MGRO J2019+37.

MGRO J2019+37

The galactic very-high-energy (VHE) γ-ray sources discovered during these last years by the new generation of Ĉerenkov telescopes (HESS, MAGIC, VERITAS, MILAGRO) are currently a hot topic in modern high-energy Astrophysics. Of the $\sim$75 detected sources, nearly half of them still remain unidentified, even though recently a lot of them have been identified with gamma-ray pulsars by *Fermi* (e.g., Abdo et al. 2010).

One of the most recent additions to the population of TeV extended unidentified sources has been reported by MILAGRO collaboration, with the discovery in the Cygnus region of the most extended TeV source ever known (Abdo et al. 2007a). The TeV emission from this area covers several square degrees and includes diffuse emission and at least a new source, MGRO J2019+37. The origin of these emissions and their association to any astrophysical counterpart is unknown. It is not clear whether the emission originates from either a single extended source or a combination of several point sources. MGRO J2019+37 is positionally coincident with the EGRET sources 3EG J2021+3716 and 3EG J2016+3657 . These sources could be the GeV counterparts to the TeV source, which may be a multiple source. Only one of them, 3EG J2021+3716, appears in the bright gamma-ray source list recently published by the *Fermi Gamma-ray Space Telescope* (Abdo et al. 2009). Previous observations with *AGILE* revealed its pulsar nature and allowed for an association of this source with PSR J2021 +3651 (Halpern et al. 2008).

To better understand this peculiar object, we have performed a multi-wavelength campaign comprising a radio survey at 610 MHz, infrared observations in the Ks band, an XMM-Newton X-ray mosaic and gamma ray AGILE observations. Radio and infrared results have been reported by Paredes et al. (2009) and here we present the data from the X-ray and gamma-ray bands.

X-ray and AGILE observations

To obtain an X-ray mosaic of the region we have used three XMM-Newton archival observations (two of them pointing towards PWN G75.3+0.1, reported by Roberts et al. (2008), and one pointing towards an INTEGRAL transient). We also performed a 65 ks observation with XMM-Newton towards the north of the centroid. We used the Extended Source Analysis Software package (XMM-ESAS), bundled with SAS 9.0, to clean and stack the data to obtain a 1-8 keV image of the region. The image was adaptatively smoothed introducing an exposure dependence on the smoothing radius since the four observations range from 14 ks to 65 ks and artifacts appeared if not taken into account.

During AGILE AO1 we were awarded the gamma-ray data of 3EG J2016+3657. However, this source has not been detected during the one year survey. In this region the only source detected by AGILE has been AGL J2020.5+3653, positionally consistent with 3EG J2021+3716. The detection of a pulsed component has allowed to identify the pulsar PSR J2021+3651 as the clear counterpart (Halpern et al. 2008).

PSR J2021+3651 / PWN G75.3+0.1

AGILE detected the source AGL J2020.5+3653 at energies above 100 MeV range, which shows pulsations and has been associated to the pulsar PSR J2021+3651 (Halpern et al. 2008). The photon spectrum of the source can be fitted with a power-law of photon index $\Gamma = 1.86 \pm 0.18$ in the range 100–1000 MeV, while a turn-down is seen above 1.5 GeV.

In the XMM-Newton observations we have found a hard point source surrounded by a faint extended component with a size of up to $\sim 20' - 25'$. The addition of the two westward observations confirms than the extended emission does not have a size comparable to the TeV emission.

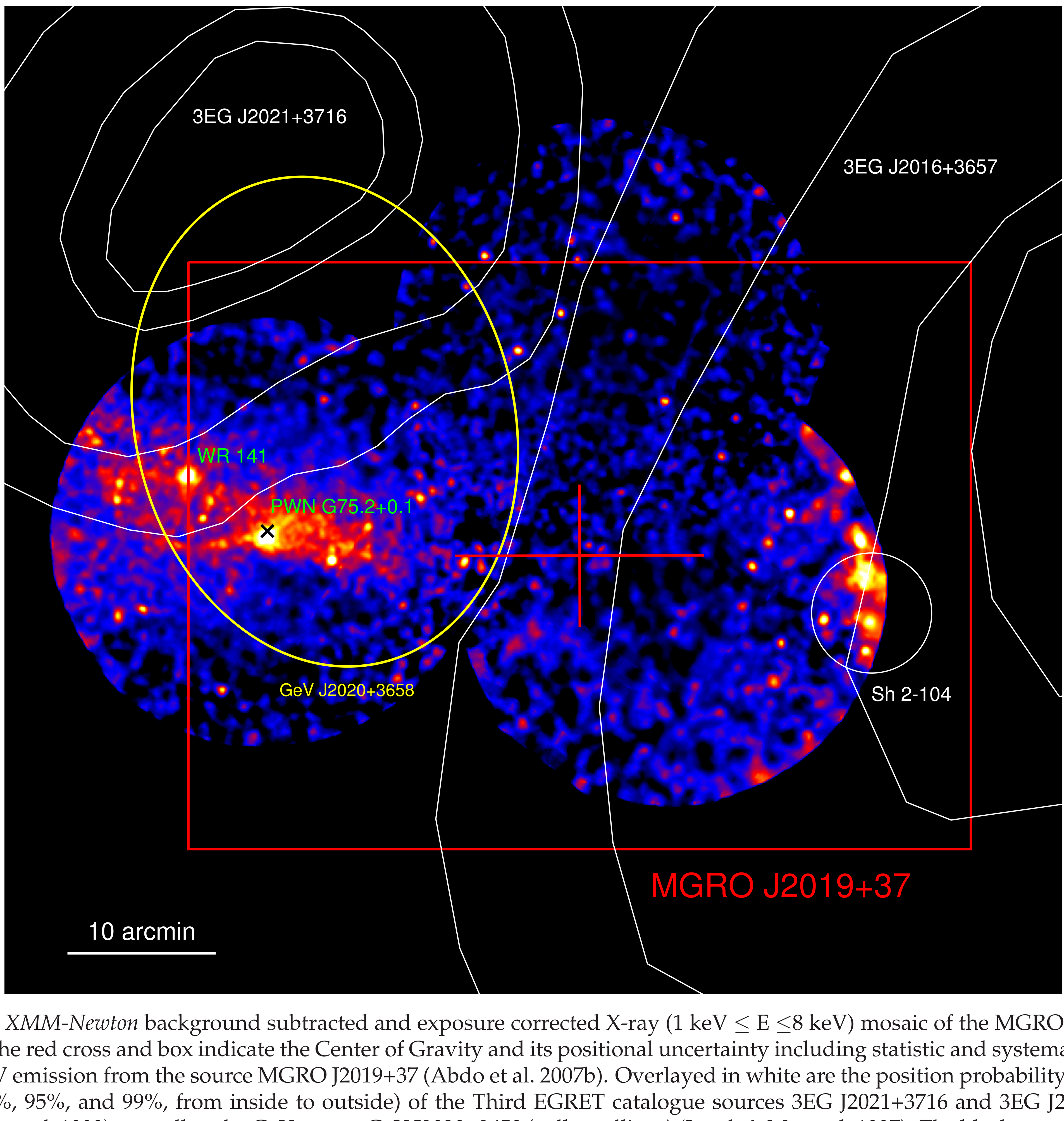

Figure 1: *XMM-Newton* background subtracted and exposure corrected X-ray (1 keV ≤ E ≤8 keV) mosaic of the MGRO J2019+37 region. The red cross and box indicate the Center of Gravity and its positional uncertainty including statistic and systematic errors of the TeV emission from the source MGRO J2019+37 (Abdo et al. 2007b). Overlayed in white are the position probability contours (50%, 68%, 95%, and 99%, from inside to outside) of the Third EGRET catalogue sources 3EG J2021+3716 and 3EG J2016+3657 (Hartman et al. 1999), as well as the GeV source GeV J2020+3658 (yellow ellipse) (Lamb & Macomb 1997). The black cross indicates the position of the pulsar wind nebula PWN G75.2+0.1. Also labeled are the HII region Sh 2-104 and the Wolf-Rayet star WR 141. North is up and East is left.

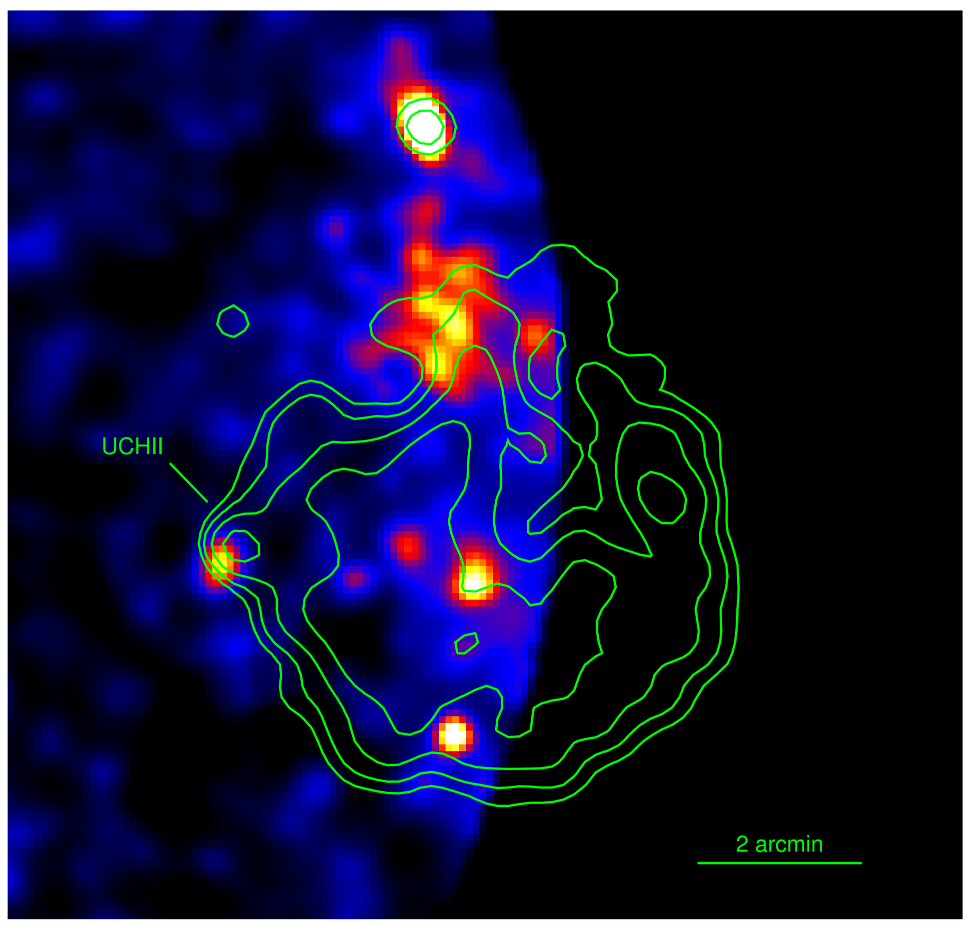

Figure 2: Background subtracted and exposure corrected X-ray image of Sh 2-104 with the GMRT radio contours (Paredes et al. 2009) overlaid in green.

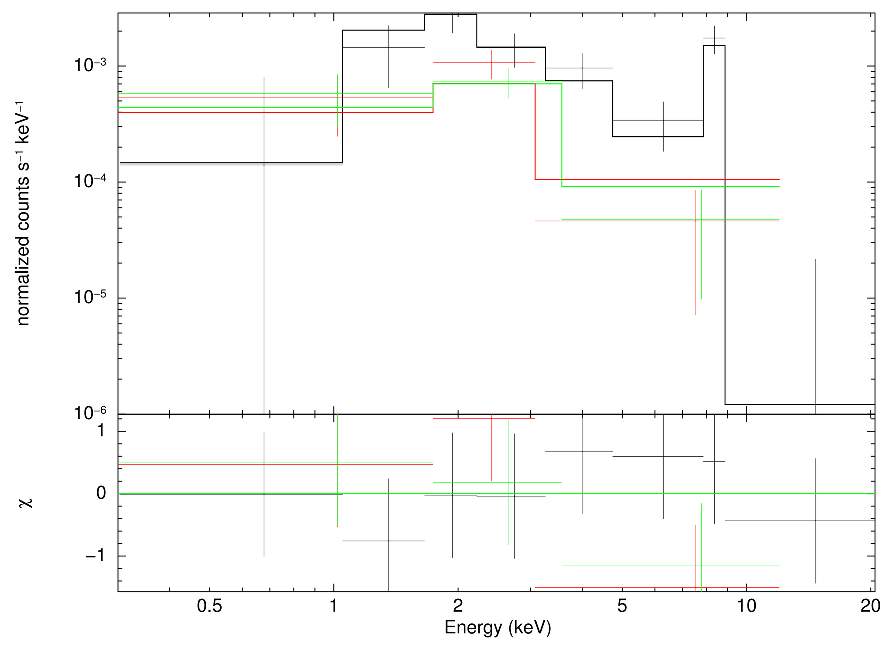

Figure 3: UCHII region XMM-Newton pn (black), MOS1 (red) and MOS2 (green) spectra.

Sh-2 104

Sh 2-104 is an optically visible HII region of $7'$ diameter at a distance of 4.0±0.5 kpc (Deharveng et al. 2003). There is a central O6 V star that was suspected to be responsible for ionizing the region and we have found a star cluster besides this star (Paredes et al. 2009). The radio images show the presence of an ultra compact HII (UCHII) region at the eastern border which is not visible in the optical image. The interaction between the expanding HII region Sh 2-104 and the UCHII region may be responsible for triggered star formation in the latter, resulting in a deeply embedded young cluster.

This source is placed near the edge of one of the X-ray observations used to map the MGRO J2019+37 region, and the X-ray background subtracted and exposure corrected map, along with the radio emission contours, can be seen in Fig. 2. We have found an X-ray counterpart of the UCHII region, a preliminary spectral analysis of which shows a spectrum compatible with a very absorbed optically thin plasma with $N_{\rm H} = 2.7^{+0.9}_{-0.7} \times 10^{22}$ cm^{-2} and $kT = 1.8^{+0.6}_{-0.4}$ keV. The high absorption is the result of the gas surrounding the UCHII region. The pn, MOS1 and MOS2 spectra can be seen in Fig. 3.

References

Abdo, A. A. et al. 2007a, ApJ, 658, L33

—. 2007b, ApJ, 664, L91

—. 2009, ApJS, 183, 46

—. 2010, ApJS, 187, 460

Deharveng, L. et al. 2003, A&A, 408, L25

Halpern, J. P. et al. 2008, ApJ, 688, L33

Hartman, R. C. et al. 1999, ApJS, 123, 79

Lamb, R. C. & Macomb, D. J. 1997, ApJ, 488, 872

Paredes, J. M. et al. 2009, A&A, 507, 241

Roberts, M. et al. 2008, AAS/HEAD, 10, 41.04

Acknowledgements The authors acknowledge support by DGI of the Spanish Ministerio de Educación y Ciencia (MEC) under grant AYA2007-68034-C03-01.