

The changing morphology of the radio outflow of HESS J0632+057 along its orbit

B. Marcote¹, J. Moldón², M. Ribó¹, J. M. Paredes¹, Z. Paragi³

¹Departament d'Astronomia i Meteorologia, Institut de Ciències del Cosmos, Universitat de Barcelona

²ASTRON Netherlands Institute for Radio Astronomy, Dwingeloo, The Netherlands

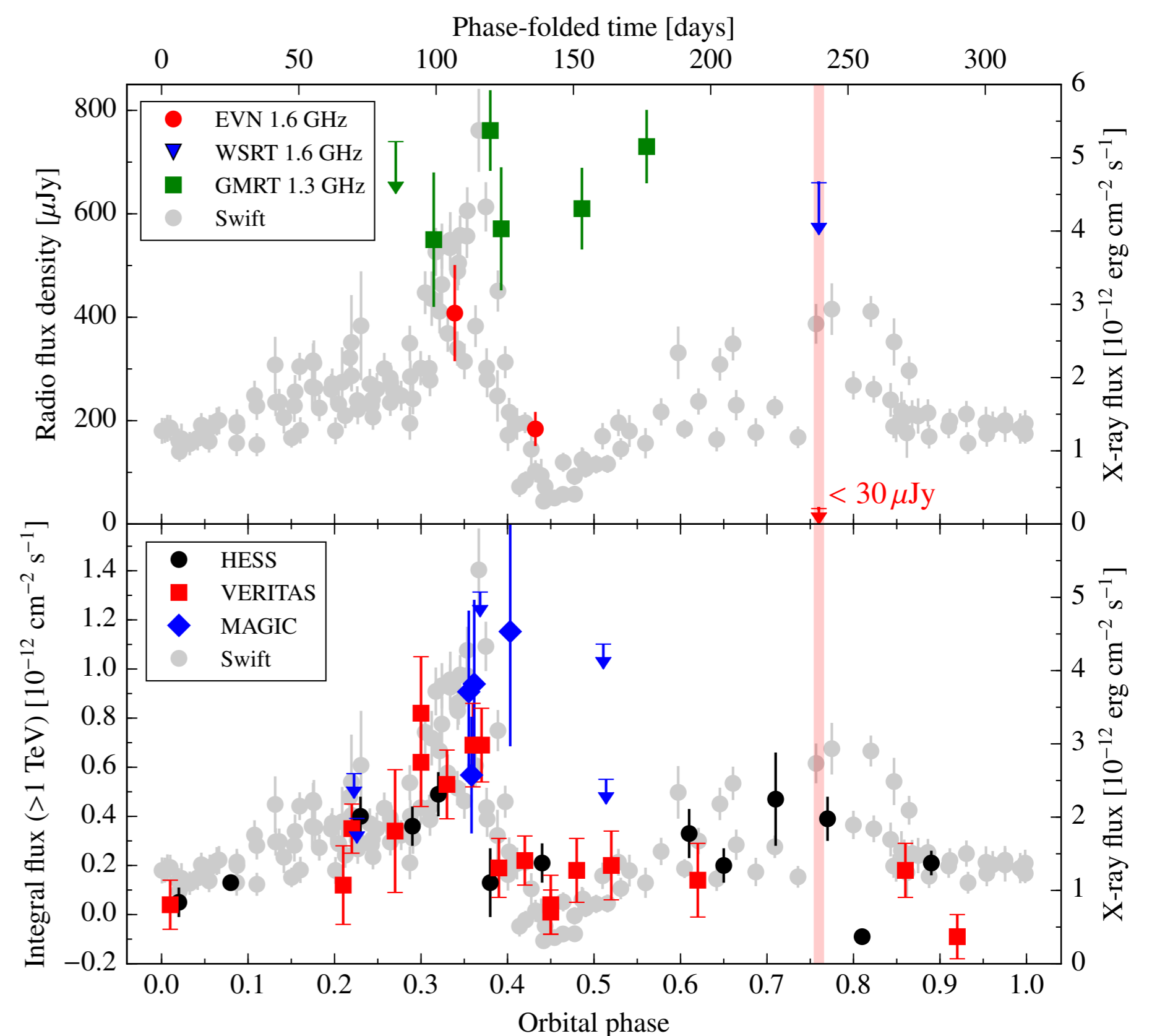
³Joint Institute for VLBI in Europe, Dwingeloo, The Netherlands



Abstract

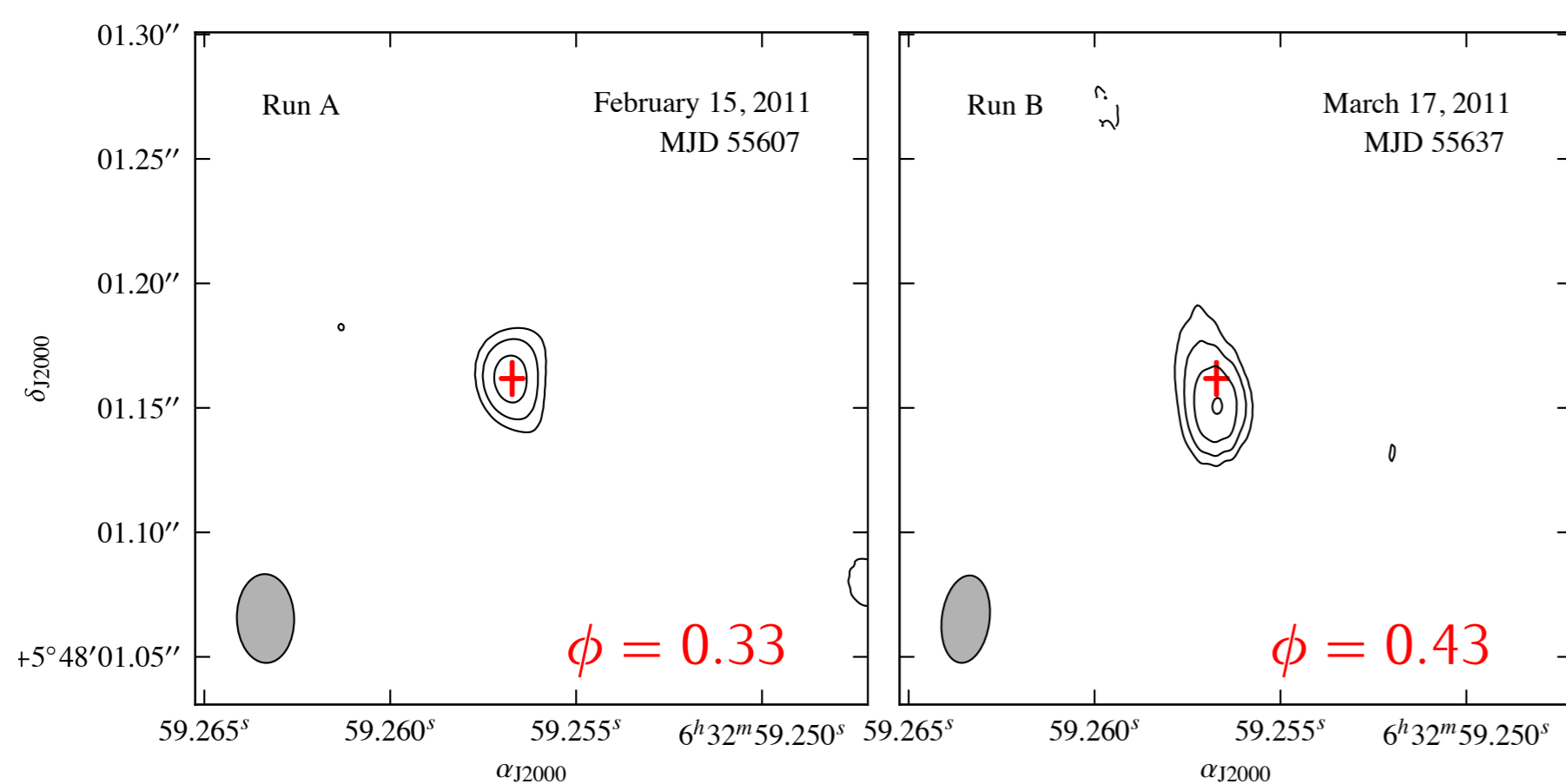
The gamma-ray binary HESS J0632+057 exhibits an orbitally modulated X-ray light-curve with a main and a secondary X-ray outburst. Previous EVN observations in 2011 just after the main X-ray outburst reveal an extended radio emission and a decay on the total flux density. We observed the source around the secondary X-ray outburst at orbital phase $\phi = 0.76$ (on 20 Feb. 2014) with the EVN and simultaneously with WSRT to determine the evolution of the radio emission at different scales. A radio outflow from this period was expected. Two non-detections from the WSRT and EVN data point out a strong decrease in the radio emission at this orbital phase.

HESS J0632+057 is one of the latest additions to the population of gamma-ray binaries. It was discovered by H.E.S.S. Collaboration as a point-like, variable, TeV source (Aharonian et al. 2007; Acciari et al. 2009). The source shows a variable X-ray and radio emission (Hinton et al. 2009; Acciari et al. 2009; Skilton et al. 2009). The X-ray light-curve exhibits a main X-ray outburst at orbital phase ~ 0.35 and a secondary X-ray outburst at phase ~ 0.8 . The system is located at ~ 1.4 kpc (Aragona et al. 2010) and shows a periodicity of 315_{-4}^{+6} days (Aliu et al. 2014).



Light-curve of HESS J0632+057. The radio emission is shown on top and TeV emission on bottom. The gray circles represent the X-ray emission. The triangles represent the $3\text{-}\sigma$ upper-limits.

EVN Observations in 2011

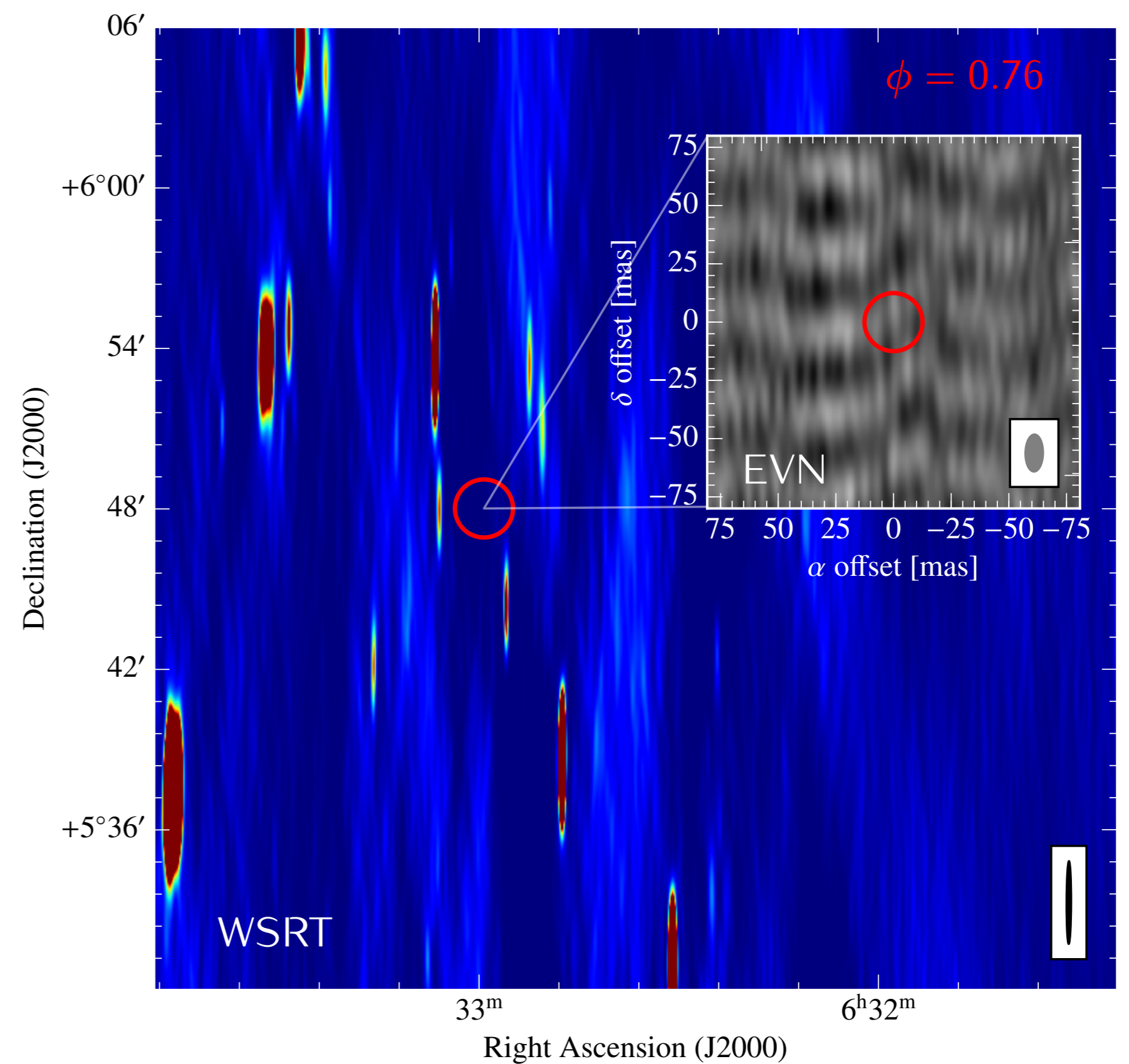


EVN observations from Moldón et al. (2011). Contours start at $3\text{-}\sigma$ noise level, with $\text{rms} = 50$ (left) and $13 \mu\text{Jy beam}^{-1}$ (right). The source is detected during the main X-ray outburst ($\phi \sim 0.3\text{--}0.4$).

The EVN non-detection in 2014 reveals a strong decay in the radio emission of HESS J0632+057 during the secondary period of strong X-ray emission. Considering the non-simultaneous X-ray data from *Swift*, the radio emission is at least 1 order of magnitude fainter than expected from the X-ray/radio ratio observed in 2011:

$$\frac{F_{\text{radio}}}{F_{\text{X-ray}}} = \begin{matrix} \sim 10^{-6} & \lesssim 10^{-7} \\ \text{(Feb./Mar. 2011)} & \text{(Feb. 2014)} \end{matrix}$$

EVN Observation on 20 Feb. 2014



We conducted a 10-hr EVN observation with the full array on 20 Feb. 2014 at 1.6 GHz using the JIVE correlator. We show the WSRT and EVN images around HESS J0632+057 (red circles). The simultaneous WSRT data reveals a non-detection with a $\text{rms} \sim 0.2 \text{ mJy beam}^{-1}$. The EVN image sets a very strong upper-limit of $30 \mu\text{Jy beam}^{-1}$ at $3\text{-}\sigma$ level (see light-curve).

Acciari, V. A., et al. 2009, ApJ, 698, L94
Aharonian, F. A., et al. 2007, A&A, 469, L1
Aliu, E., et al. 2014, ApJ, 780, 168
Aragona, C., et al. 2010, ApJ, 724, 306

Hinton, J. A., et al. 2009, ApJ, 690, L101
Moldón, J., et al. 2011, A&A, 533, L7
Skilton, J. L., et al. 2009, MNRAS, 399, 317

Results: Radio emission (2014 observation) at least one order of magnitude fainter than expected from the 2011 EVN observations.
Possible explanations:

- Different e^- population producing the X-ray and radio emissions?
- The radio observation was obtained before the secondary X-ray outburst was produced? (no simultaneous *Swift* data available)
- X-ray emission much lower than in previous orbital cycles?



B.M., M.R. and J.M.P. acknowledge support by the MINECO under grants AYA2013-47447-C3-1-P and FPA2013-48381-C6-6-P. B.M. acknowledges financial support from MINECO under grant BES-2011-049886.