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A wide and collimated radio jet in 3C84 on the scale of a few hundred gravitational radii

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Supplementary Note: Short history of the radio source 3C 84 The central galaxy of the Perseus cluster of galaxies, NGC 1275, harbours a bright, FR-I type radio source 3C 84 that has been studied extensively since the early days of radio astronomy. At low resolution the radio emission is extended and diffuse with a halo-core structure. Inside the central 10 parsecs, there is a bright core region and two symmetric lobes, with evidence for free-free absorption in the northern one¹. These "mini-lobes" were probably formed by

the jet activity originating in the 1959 radio outburst². At higher angular resolution, the bright core region is resolved into a compact core and a one-sided complex jet emission.

The radio flux has been monitored since 1960, and episodes of violent flux increase have been reported^{3,4}. In the mid-1980s, the radio flux became exceptionally bright, more than 60 Jy at centimetre wavelengths, and then it subsequently decreased to ~ 10 Jy by the early 2000s (ref. 5). Around 2005, it was reported that the radio flux had started to increase again⁶. VLBI observations revealed that this flux density increase originated in the central parsec and it was accompanied by an ejection of a new jet component that was named "C3".

3C 84 was detected in γ -rays by the Fermi Large Area Telescope (LAT) in August 2008 (ref. 6). This detection is particularly noteworthy, because the source was not detected by the Energetic Gamma Ray Experiment Telescope (EGRET) of the Compton Gamma Ray Observatory in the 1990s (ref. 7). The new γ -ray flux density is about seven times higher than the upper limit from the EGRET observations. Intriguingly, the higher γ -ray emission coincides with the increase of the radio flux density.

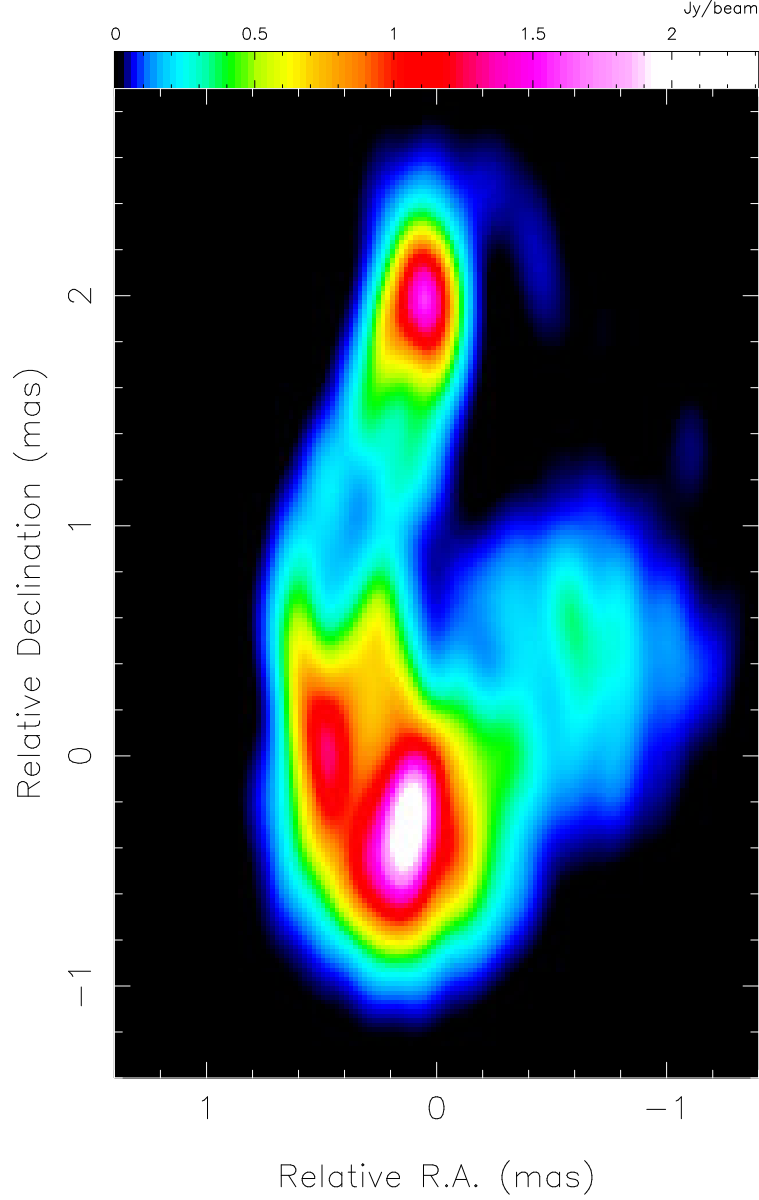
High resolution 43 and 86 GHz VLBI images taken at the epochs before 2005 (ref. 8), show a core (C1) and a nearby bright knot separated by 0.5 mas at a position angle $\sim 160^\circ$. Beyond 0.5 mas, there is an abrupt bend in the jet toward a position angle of 235° , where a diffuse component (C2 or D; ref. 8) is present at a distance of 1.2 mas. In the first 4 epochs (from 2006/134 to 2007/258) of the multi-epoch monitoring presented by Nagai et al.⁹, the source structure is the same and similar to that seen in the γ -ray quiet phase. A clear change in the source structure is evident after the 2007/258 image when the new component C3 has emerged from the central core. VLBI monitoring shows that this new component was ejected from the core after 2003 November 20th (ref. 10). The component C3 is advancing with an increasing apparent velocity ($0.1c$ in November 2003, $0.47c$ in November 2008) toward a position angle of $\sim 170^\circ$. This direction is

clearly unrelated to that of the component C2. We note that in the previous images^{8,11,12} the jet morphology was centrally peaked while the morphology of present jet (connected to C3) is limb-brightened.

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Supplementary Figure 1: Uniformly weighted 22 GHz image of the central parsec in 3C 84 obtained with the ground-VLBI array excluding the *RadioAstron* baselines. The beam size is 0.42×0.16 mas at $\text{PA} = -1.5^\circ$. The noise level is 1.0 mJy/beam and the peak intensity is 2.3 Jy/beam. The structure is very similar to the 43 GHz VLBA images from the same year¹³. As described in the Methods, this image was used as a source model in the final rounds of fringe-fitting of the *RadioAstron* data.