Redshifted Kα Line from the Peculiar Gamma-ray Source PMN J1603–4904

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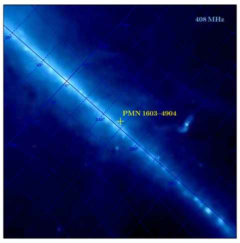
Abstract

Location of PMN J1603–4904:



408 MHz continuum survey (Haslam+1982)

The Southern Hemisphere AGN monitoring program TANAMI* provides regular VLBI monitoring (at 8 and 22 GHz) and multiwavelength coverage of extragalactic jets south of $-30°$ declination. Here we focus on our latest results on the bright, hard-spectrum γ-ray source PMN J1603–4904. Our VLBI observations reveal a symmetric brightness distribution with the brightest, most compact component at the center of the emission region. No significant apparent motion is detected. Long-term monitoring with ATCA in the radio (5-40 GHz) and in the γ-rays by *Fermi*/LAT shows only mild variability and no major outbursts. Its broadband spectral energy distribution and other multiwavelength properties point to either a very atypical blazar or can be explained as a source seen edge-on, possibly a young radio galaxy. The latter would make PMN J1603–4904 the first young radio galaxy detected in γ-rays, so additional confirmation is sought. Our recent *Suzaku* and *XMM* observations detect a narrow iron line, which results in the first redshift measurement of the system ($z = 0.18 \pm 0.01$). This result suggests that the source is observed at a larger angle to the line of sight than expected for blazars, and allows us to constrain the linear extent of the arcsec-scale structure to be smaller than $\sim$3 kpc, which in the two-sided jet scenario is in agreement with the small linear scales characteristic of young radio galaxies.

*http://pulsar.sternwarte.uni-erlangen.de/tanami and see Ojha+2010

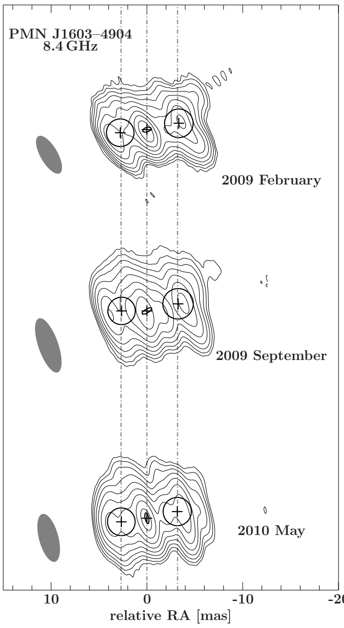


Figure 1: Time evolution of the milliarcsecond structure of PMN J1603–4904 at 8 GHz. Contours indicate the CLEAN images, while the positions and FWHMs of Gaussian modelfit components are overlaid as black ellipses. No significant apparent motion or brightness temperature variability of the individual components is detected. PMN J1603–4904 appears as a very stable source over $\sim$ 15 months of VLBI observations. The FWHM of the corresponding synthesized beam is shown as a gray ellipse at the lower left corner of each image (Müller+2014, A&A, 562, A4).

Facts on the source PMN J1603–4904:

- Associated with the bright, hard-spectrum γ-ray source detected by *Fermi*/LAT 2FGL J1603.8–4904 ($\Gamma_\gamma = 2.04$, $F_{1-100\,\mathrm{GeV}} = 1.3 \times 10^{-08}\,\mathrm{ph/cm^2/s}$)
- Classified as a low peaked BL Lac object (Nolan+2012, Shaw+2013)
- Among the 30 γ-ray brightest 2LAC objects
- Only very mild broadband variability, no γ-ray flares
- $\leq$1.2% polarization at 20 GHz (Murphy+2010)
- TANAMI VLBI observations: symmetric radio morphology with $\sim$15 milliarcseconds extension at 8 GHz with the brightest, most compact component in the center of the emission region (Fig. 1)
- Very stable source over 15 months of TANAMI observations (Fig. 1): no superluminal motion, no flux density variability
- Spectral information with 22 GHz TANAMI data: the central region has flattest spectral index and highest brightness temperature ($T_B \sim 9 \times 10^9$ K at 8 GHz)
- Multifrequency ATCA spectrum (5.5 GHz to 40 GHz): total spectral index $\alpha \sim -0.4$ (with $S_\nu \sim \nu^{+\alpha}$)
- ATCA monitoring ($>$10 years): only mild variability
- The broadband study reveals a bright infrared excess in the SED (Fig. 3), which can be modeled with a blackbody (T$\sim$1600 K). This component could be associated with a dusty torus, host galaxy stellar emission, and/or contributions from starburst activity.
- *Swift*/XRT reveals very a faint X-ray counterpart (Müller+2014) $\Rightarrow$ new *XMM* and *Suzaku* (Fig. 2): significant detection of a redshifted Fe Kα line (rest-frame energy 6.4 keV) $\Rightarrow$ first redshift measurement of the system: $z = 0.18 \pm 0.01$.

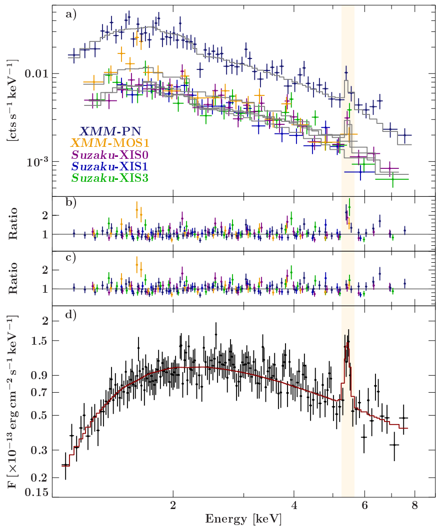


Figure 2: Quasi-simultaneous *XMM-Newton* and *Suzaku* observations, performed in the framework of the TANAMI program. The data were best fitted ($\chi^2/dof = 183/162$) by an absorbed power law component ($N_\mathrm{H} = 2.05^{+0.14}_{-0.12} \times 10^{22}\,\mathrm{cm}^{-2}$, $\Gamma = 2.07^{+0.04}_{-0.12}$, $F_{2-10\,\mathrm{keV}} = (4.39 \pm 0.17) \times 10^{-13}\,\mathrm{erg\,s^{-1}\,cm^{-2}}$) with an emission line at $\sim$5.44 $\pm$ 0.05 keV.
(a): Count spectrum for all detectors fitted with an absorbed power law and a Gaussian emission line (models shown in gray). Ratio of data to model for a fit of an absorbed power law *(b)* and including a Gaussian emission line *(c)* *(d):* Unfolded, combined spectrum of all data sets with the best-fit model (red). The shaded region highlights the position of the emission line. (Müller+2015)

Broadband Spectral Energy Distribution

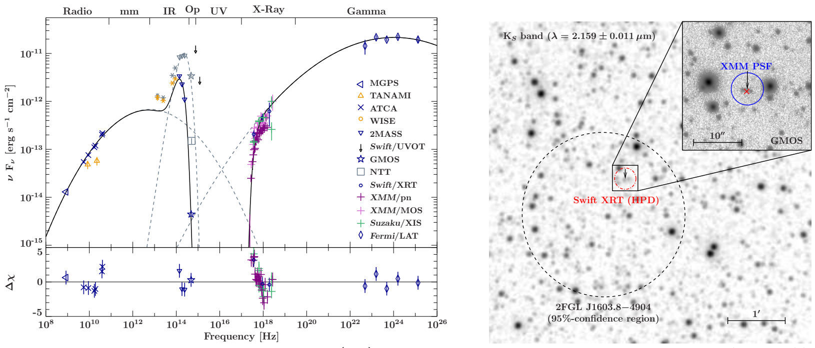


Figure 3: Broadband spectral energy distribution (*left*) of PMN J1603–4904 including TANAMI, ATCA, WISE, 2MASS, GMOS, *Swift*/XRT, *Suzkau*, *XMM* and *Fermi*/LAT data (2FGL). Sky region from 2MASS and GMOS and the associated multiwavelength counterparts are shown at the *right*. Black arrows point toward the position of the radio source. The broadband data are fitted with two logarithmic parabolas, as well as the photoelectric absorption at X-ray energies, an extinction model for the optical and a black body model at infrared frequencies (corrected data shown in gray). Besides the high Compton dominance, the most striking feature in this SED is the strong excess in the IR band, which is fitted with a black body of $T \sim 1600$ K. This could be associated with a dusty torus, the host galaxy or starburst activity.

SUMMARY & CONCLUSION

PMN J1603–4904 shows multiwavelength properties which are **very unusual for a blazar. We consider an alternative classification as a system seen edge-on, possibly a γ-ray loud young radio galaxy**.

- mas-scale structure at 8 GHz and spectral index distribution: brightest component (with flattest spectrum) at center of **symmetric brightness distribution**
- no or only mild multiwavelength variability
- low degree of polarization
- infrared excess in broadband spectrum: indication of starburst emission
- **X-ray emission line** - not expected in blazar spectra! (Müller+2015, A&A 547, 117)
- *Suzaku* and *XMM* observations: **first redshift measurement of system ($z = 0.18 \pm 0.01$)**
- large scale structure $<$3 kpc
- $L_\gamma \sim 8 \times 10^{45}\,\mathrm{erg\,s^{-1}}$ comparable to brightest γ-ray loud misaligned sources (Abdo+2010)

OUTLOOK

- caveat: no young radio galaxy detected in γ-rays so far, but expected from theoretical predictions (e.g., Stawarz+2008)
- *Chandra* & HST observations in 2015
- ongoing TANAMI VLBI monitoring: mas-scale kinematics, better constraints on spectral index distribution
- further check of association of γ-ray source required

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