

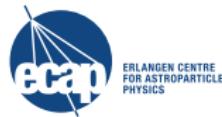
# The compact symmetric radio structure of the peculiar $\gamma$ -ray source **PMN J1603–4904**

Cornelia Müller

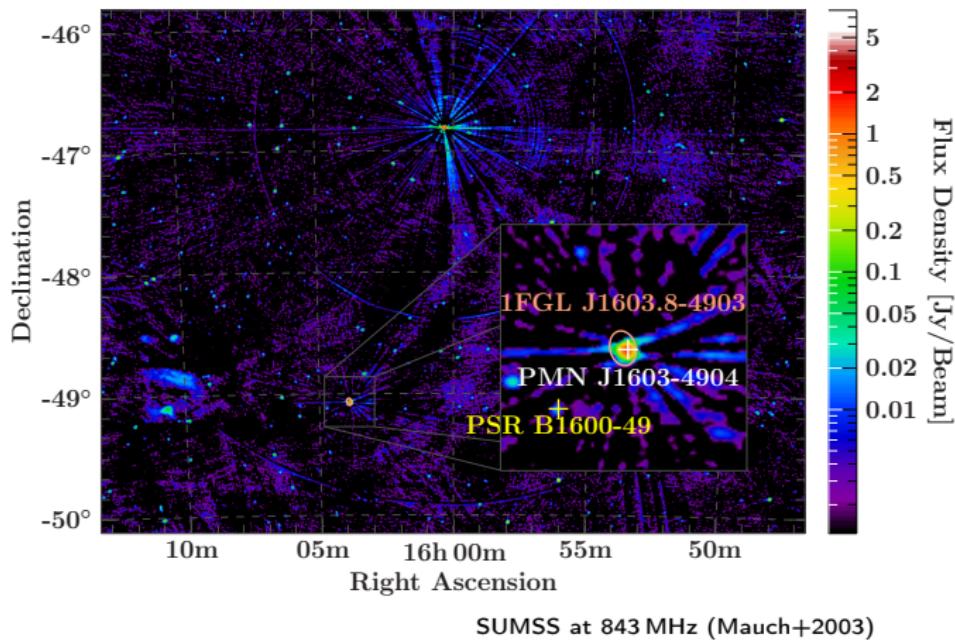
JMU Würzburg, Remeis Observatory Bamberg & ECAP, FAU Erlangen/Nürnberg

in collaboration with

M. Kadler, R. Ojha, F. Krauß, M. Böck, T. Beuchert, B. Carpenter, M. Dutka,  
T. Dauser, P.G. Edwards, A. Kreikenbohm, W. McConville, E. Ros, R. Schulz,  
J. Stevens, G. Taylor, J. Wilms & the TANAMI Team



# The compact symmetric radio structure of 2FGL 1603.8–4904

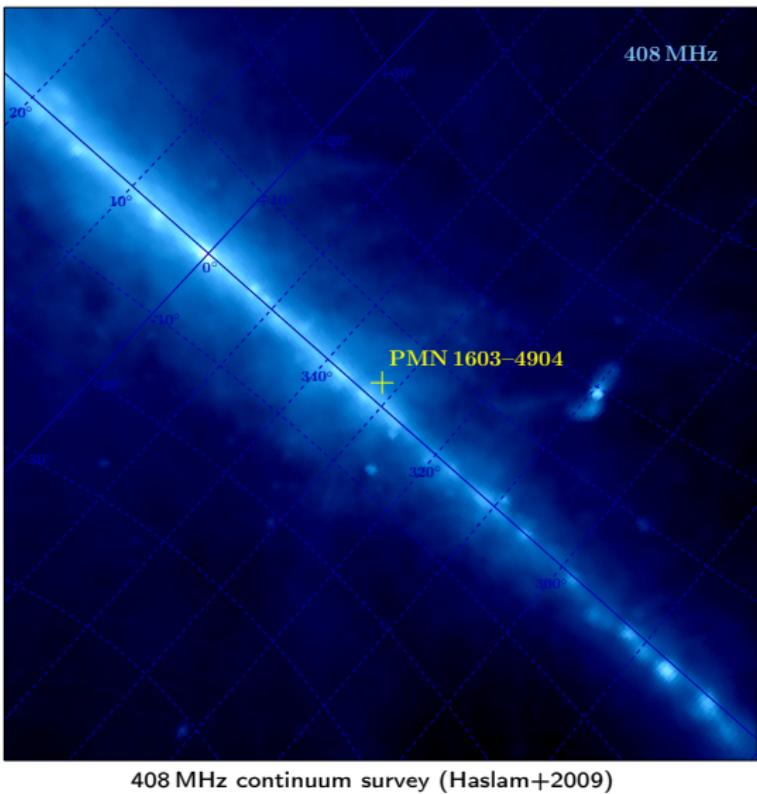


# The compact symmetric radio structure of **2FGL 1603.8–4904**

Alternative classification:  
edge-on system,  
possible  $\gamma$ -loud young radio galaxy?!

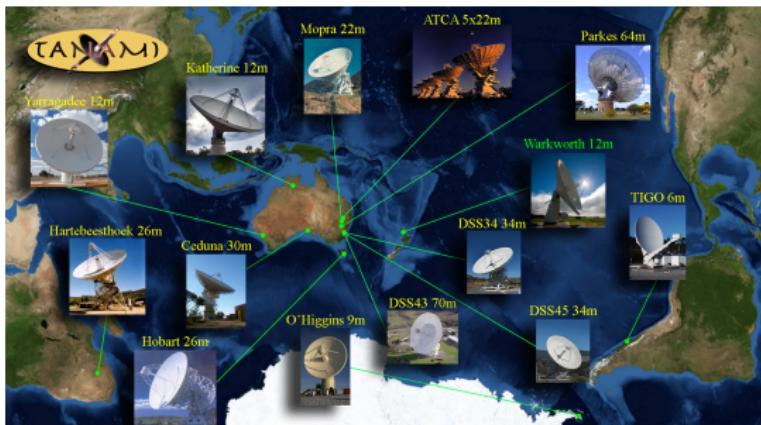
# PMN J1603–4904

- associated with bright  $\gamma$ -ray source 2FGL 1603.8–4903
- classified as BL Lac object (Abdo+2010, Shaw+2013)
- no redshift known



# PMN J1603–4904

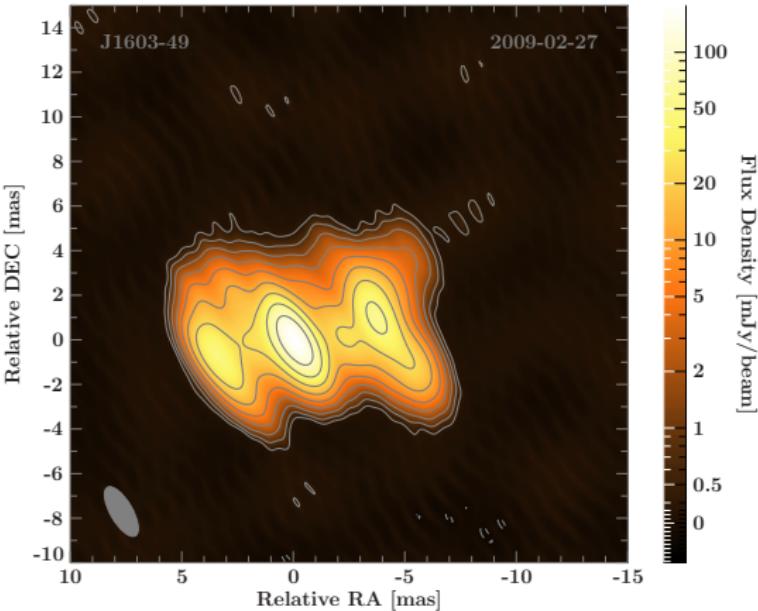
- associated with bright  $\gamma$ -ray source 2FGL 1603.8–4903
  - classified as BL Lac object (Abdo+2010, Shaw+2013)
  - no redshift known
- first-ever VLBI observation at 8.4 & 22.3 GHz with **TANAMI**



→ see also: poster F25 on Centaurus A & talk by F. Krauß!  
<http://pulsar.sternwarte.uni-erlangen.de/tanami>

# PMN J1603–4904

- associated with bright  $\gamma$ -ray source 2FGL 1603.8–4903
  - classified as BL Lac object (Abdo+2010, Shaw+2013)
  - no redshift known
- first-ever VLBI observation at 8.4 & 22.3 GHz with **TANAMI**
- very unusual milliarcsecond-scale structure for blazar!
- Müller et al. 2014, A&A 562, A4



# Context

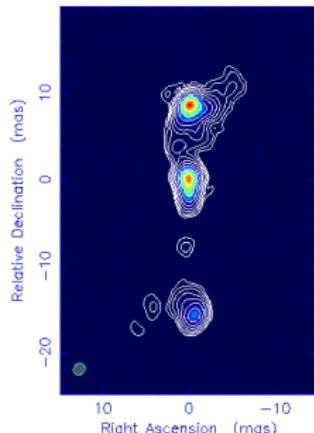
- $\gamma$ -ray emission in beamed sources: blazars ✓
- $\gamma$ -ray emission in unbeamed (“misaligned”) sources:  
radio galaxies ✓ (Abdo+ 2010)
- starburst galaxies ✓ (Abdo+ 2010)

# Context

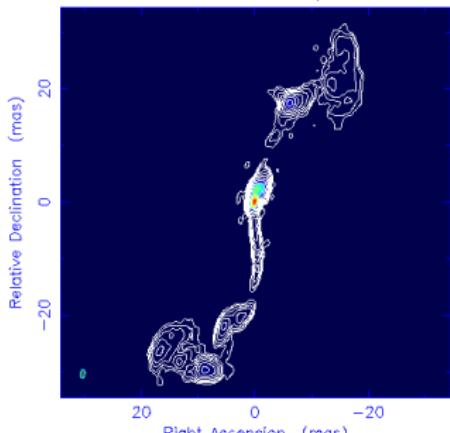
- $\gamma$ -ray emission in beamed sources: blazars ✓
- $\gamma$ -ray emission in unbeamed (“misaligned”) sources: radio galaxies ✓ (Abdo+ 2010)
- starburst galaxies ✓ (Abdo+ 2010)
- young radio sources or “Compact Symmetric Objects” (CSOs, e.g., O’Dea+1998)?  
compact (<few kpc), excess of young objects in flux limited samples
  - predicted by models (Stawarz+2008, Kino+2011, Orienti+2011)
  - but: not confirmed yet!
  - test broadband emission models

# Young and evolved radio galaxies

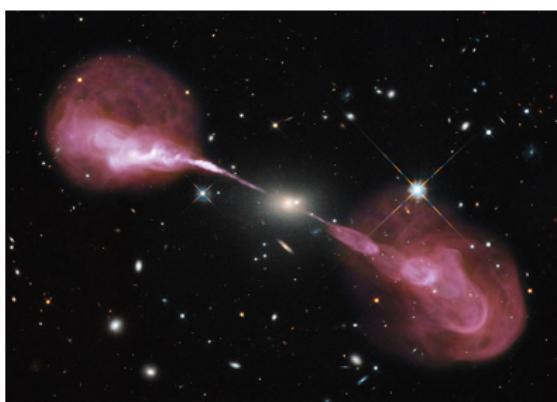
0710+439 at 4.991 GHz 1997 Sep



2352+495 at 4.991 GHz 1997 Sep 18



Hercules A



Credit: Owsianik+1998, 1999

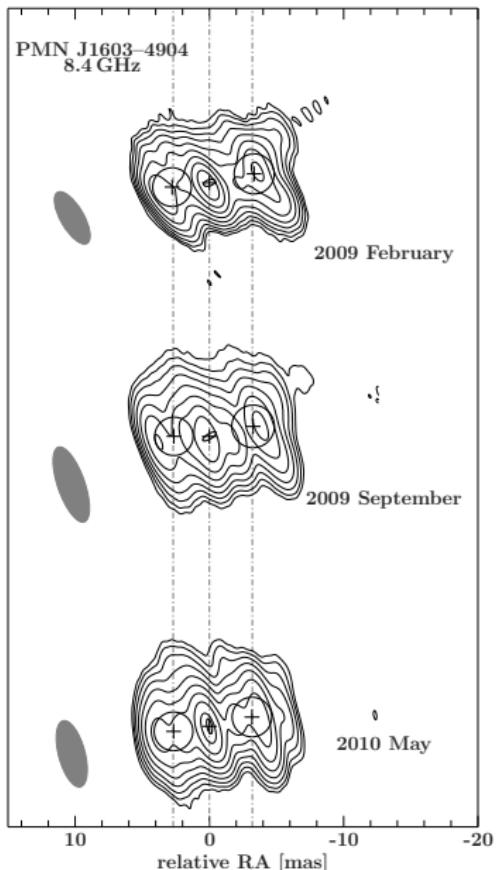
Credit: NASA/ESA/S.Baum&C.O'Dea(RIT)/  
R.Perley&W.Cotton(NRAO/AUI/NSF)  
Hubble Heritage Team (STScI/AURA)

Compact Symmetric Objects (CSO)  
( $\lesssim 1\text{--}10 \text{ kpc}$ )

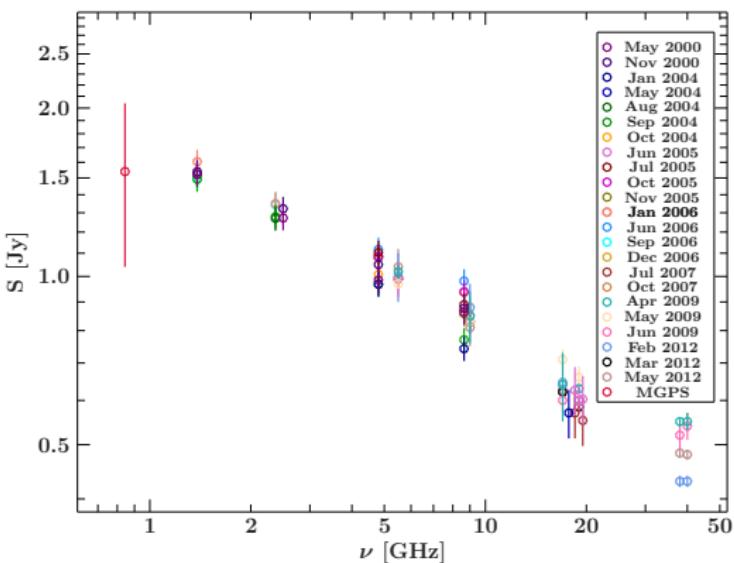
Radio Galaxy  
( $\sim 500 \text{ kpc}$ )

# Results

# Variability and radio spectrum of PMN J1603–4904

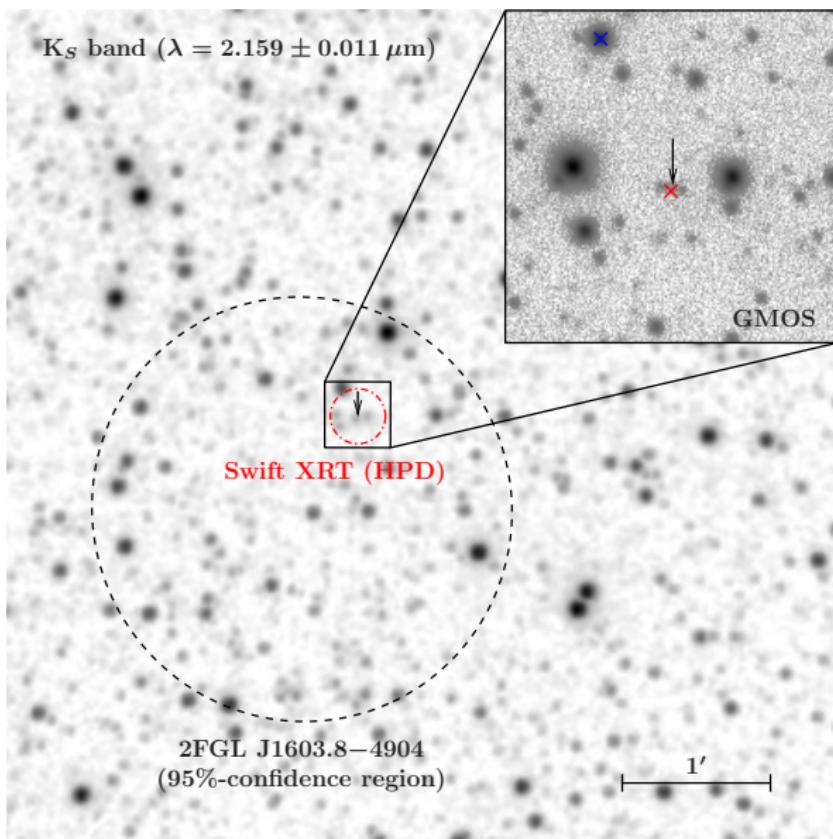


- no significant apparent motion
- central component: brightest, flat spectrum
- steep eastern/western components
- overall spectral index  $\alpha \sim -0.4$
- only mildly variable in  $\gamma$ -rays and in radio



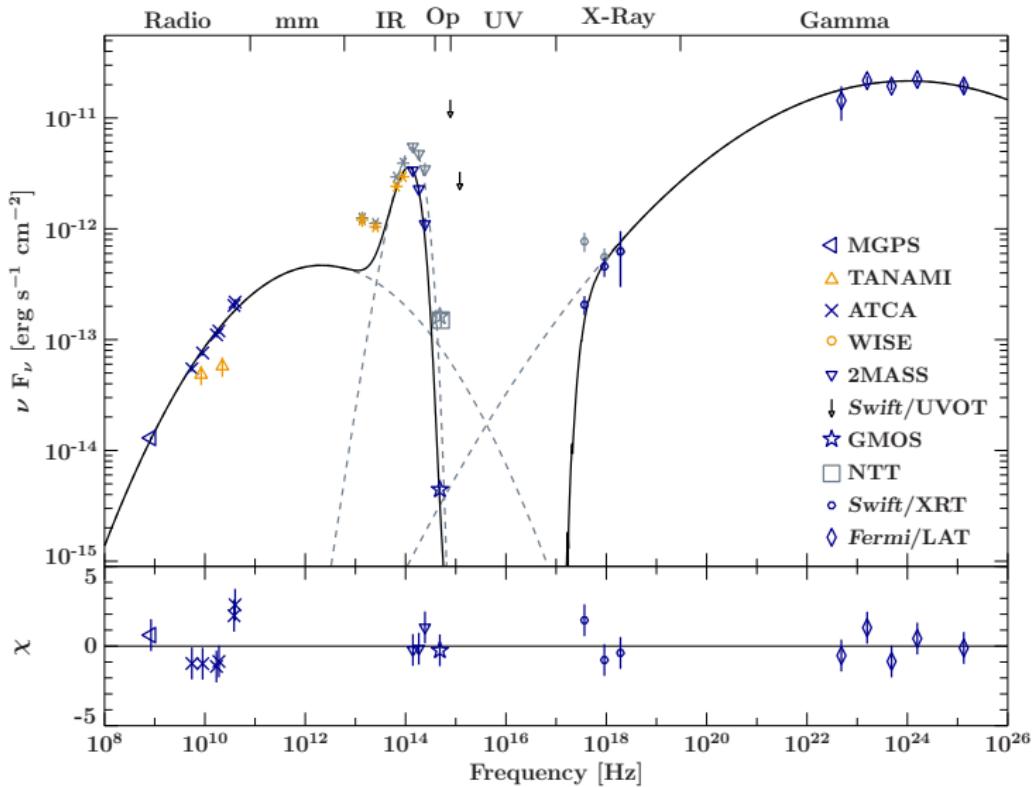
Müller+2014

# The multiwavelength counterparts



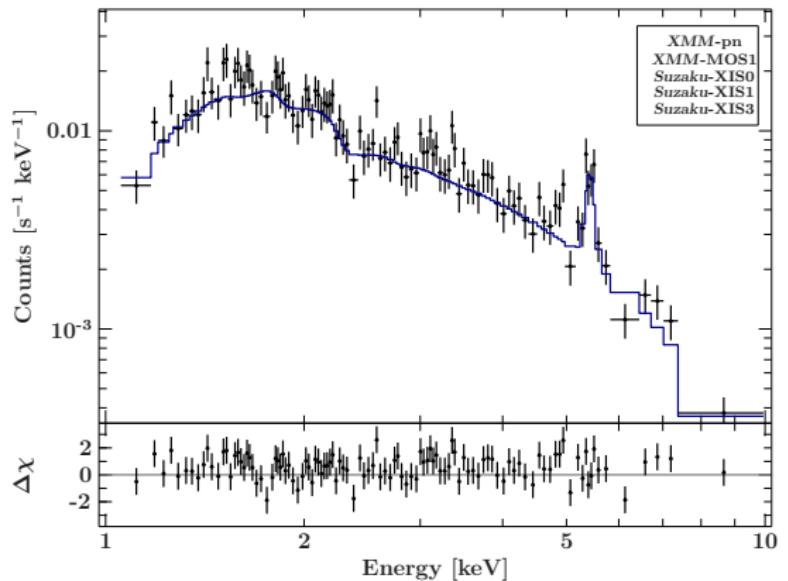
Müller+2014

# The broadband spectral energy distribution (SED)

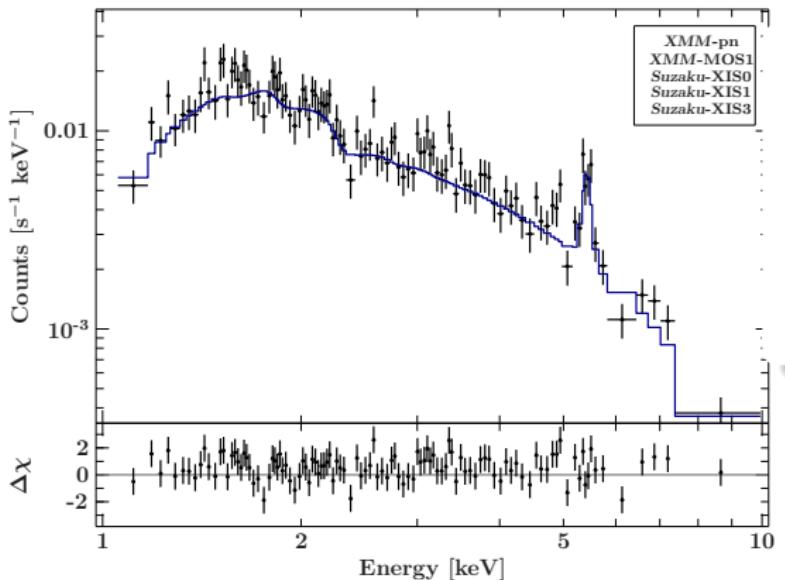


Non-simultaneous! (Müller+2014)

# Quasi-simultaneous X-ray spectrum with *XMM* and *Suzaku*

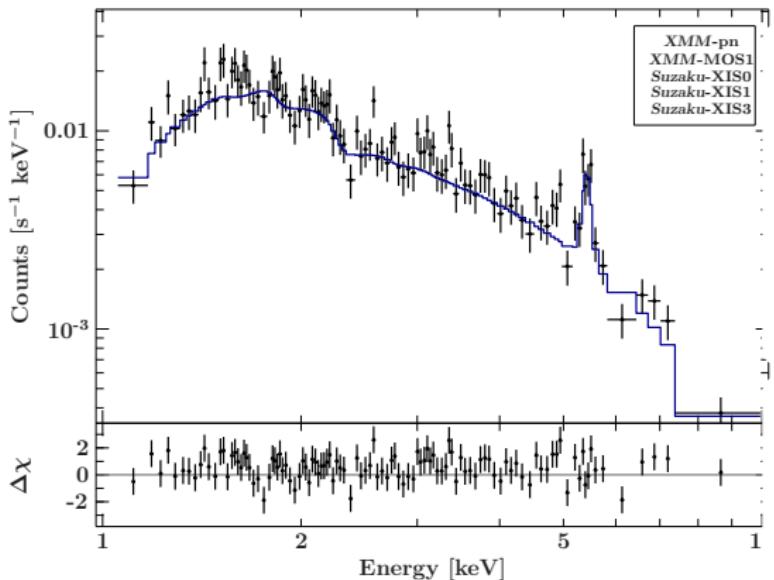


# Quasi-simultaneous X-ray spectrum with *XMM* and *Suzaku*



$$\begin{aligned}\Gamma &\sim 2.06 \\ N_{\text{H}} &\sim 2.14 \times 10^{22} \text{ cm}^{-2} \\ S &\sim 5.8 \times 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1} \\ E_{\text{Gauss}} &\sim 5.43 \text{ keV} \\ EW &\sim 367 \text{ eV} \\ \chi^2/\text{d.o.f.} &= 494.76/540\end{aligned}$$

# Quasi-simultaneous X-ray spectrum with *XMM* and *Suzaku*



$$\Gamma \sim 2.06$$

$$N_{\mathrm{H}} \sim 2.14 \times 10^{22} \text{ cm}^{-2}$$

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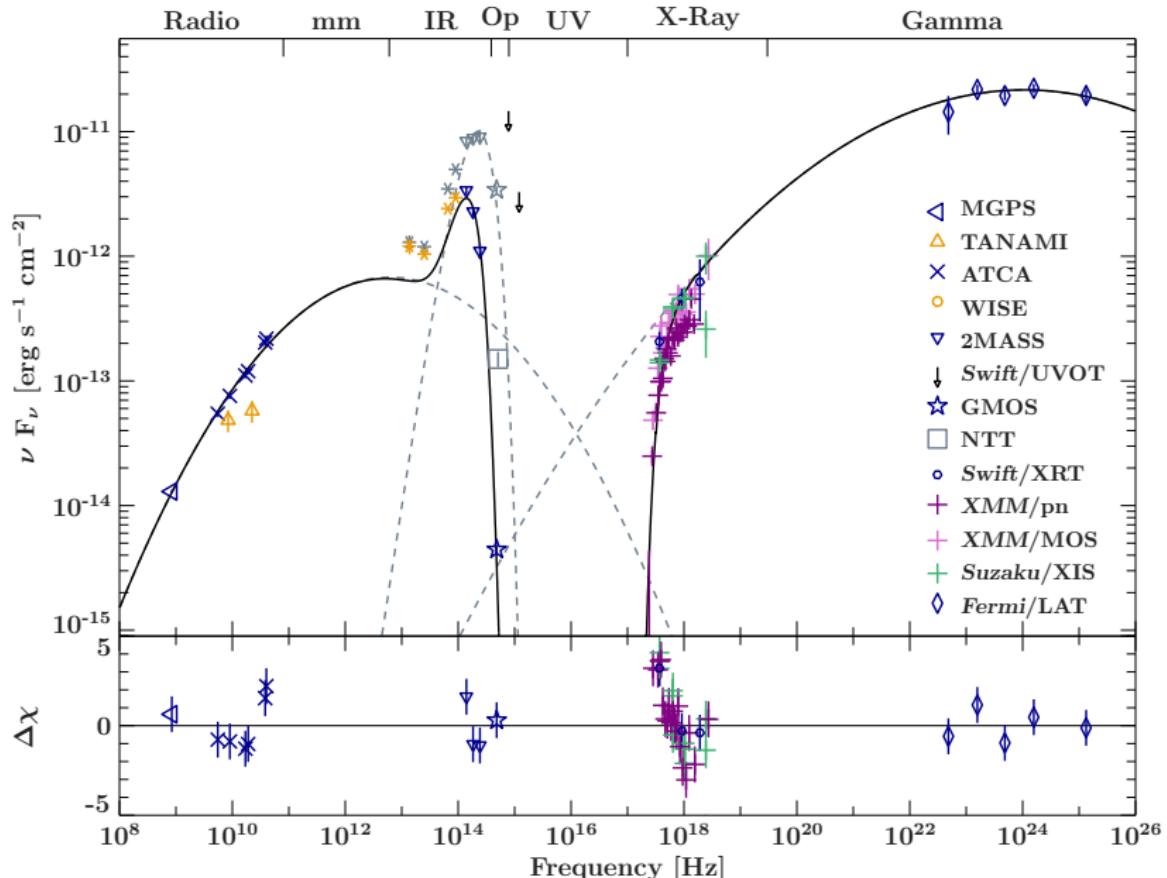
$$\chi^2/\text{d.o.f.} = 494.76/540$$

Redshifted Fe K $\alpha$  line:

$$\Rightarrow z \sim 0.18$$

$$L_X \sim 5.2 \times 10^{43} \text{ erg s}^{-1}$$

# SED including *XMM* & *Suzaku* data



# PMN J1603–4904: the facts

- no superluminal motion, only mild variability
- symmetric brightness distribution at pc-scales
- flat spectral component with highest brightness temperature at center
- polarization of < 1.2% (Murphy+2010)
- IR excess, black body  $T \sim 1600\text{ K}$  → starburst, hot torus?
- redshifted Fe K $\alpha$  line
- intrinsic absorption of  $N_{\text{H}} \gtrsim 2 \times 10^{22} \text{ cm}^{-2}$
- $\gamma$ -ray luminosity of  $\sim 1.2 \times 10^{46} \text{ erg s}^{-1}$ , hard index ( $\Gamma_{\gamma} \sim 2$ )
- high Compton dominance

# PMN J1603–4904: very unusual blazar

- no superluminal motion, only mild variability
- symmetric brightness distribution at pc-scales
- flat spectral component with highest brightness temperature at center
- polarization of < 1.2% (Murphy+2010)
- IR excess, black body  $T \sim 1500\text{ K}$
- redshifted Fe K $\alpha$  line
- intrinsic absorption of  $N_{\text{H}} \gtrsim 2 \times 10^{22}\text{ cm}^{-2}$
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- high Compton dominance

## Alternative classification

System seen under a high inclination angle, possible young radio galaxy?!

- iron emission line
- IR excess
- no superluminal motion, only mild variability
- symmetric brightness distribution at pc-scales
- maximum size  $\lesssim 3 \text{ kpc}$
- intrinsic absorption of  $N_{\text{H}} \gtrsim 2 \times 10^{22} \text{ cm}^{-2}$

## Summary

- PMN J1603–4904 has very unusual structural and spectral properties for a blazar (Müller+2014, A&A 562, A4)
- associated with one of the brightest, hard-spectrum  $\gamma$ -ray sources
- recent *XMM* and *Suzaku* observations: redshifted K $\alpha$  line  
(Müller+, in prep.)

## Summary

- PMN J1603–4904 has very unusual structural and spectral properties for a blazar (Müller+2014, A&A 562, A4)
- associated with one of the brightest, hard-spectrum  $\gamma$ -ray sources
- recent *XMM* and *Suzaku* observations: redshifted K $\alpha$  line  
(Müller+, in prep.)
- properties challenge blazar-classification → more broadband information required
- alternative: edge-on system, possible CSO
- important for: broadband emission models, interaction of jets with ambient medium, AGN evolution