Study of young AGN jet candidate NVSS J112914-052856 positionally coincident with γ-ray source

Kyohei FUJIMOTO, Kotaro NIINUMA, Kenta FUJISAWA (Yamaguchi university)

< Background & Motivation >

- Problem: The unified γ-ray emission mechanism of AGN is still unclear.
- The key to solve the problem → ■ **To reveal the nature of *un-associated* γ-ray sources (hereafter *UAGs*)**
- Previos observational works: *UAGs* was classified by various methods (Fujinaga et al. 2016, Massaro et al. 2016, Schinzel et al. 2017). **In Yamaguchi university**, 22 radio sources were successfully identified as AGN candidates within the each positional error of 19 *UAGs* by One-baseline VLBI consisting of Yamaguchi 32m and Hitachi telescopes (hereafter Ym32-Ht32), which is sub-array of the Japanese VLBI Network (JVN) at 8.4 GHz in 2015 March.
- This study: We performed VLBI follow-up observation for the AGN candidate to clarify their **radio spectrum**, **sub-pc scale structures**, and **monthly to yearly scale variability**. In this presentation, we report on the our recent result obtained by VLBI observations for the brightest source; NVSS J112914-052856 (hereafter J1129-0528), which is one of the 22 γ-ray AGN candidates.

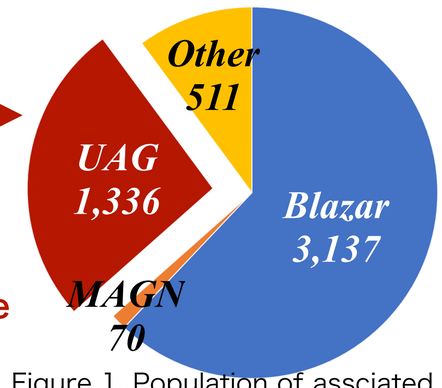


Figure 1. Population of assciated source in the latest γ-ray catalog (4FGL; Abdollahi et al. 2020)

MAGN: Mis-aligned AGN

< Observation >

It is necessary to clarify the nature of AGN candidates by the dedicated VLBI observations. We executed VLBI observation in 2-steps.

(1) Imaging monitor with KVN and VERA Array (KaVA) at 23/43 GHz quasi-simultaneously

(2) Flux monitor with JVN (Ym32-Ht32) at 8.4 GHz

Target: J1129-0528 which is only located within the positional error of **4FGL J1129.2-0529** (corresponding to 2FGL J1129.0-0532)

Table 1. Parameters of our observation

Epoch	Frequency	Array	On source time
17 Feb. 17	23 GHz	KaVA(without Ulsan)	~ 120 min
17 May 25	23 GHz	KaVA	
18 Feb. 05	23 GHz	KaVA(without Tamna)	
18 Feb. 06	43 GHz	KaVA	
18 Jun 06	23 GHz	KaVA	
18 Jun 07	43 GHz	KaVA	
20 Jul. 15	8.4 GHz	JVN(Ym32-Ht32)	~ 6 min
20 Oct. 05	8.4 GHz	JVN(Ym32-Ht32)	

< Results >

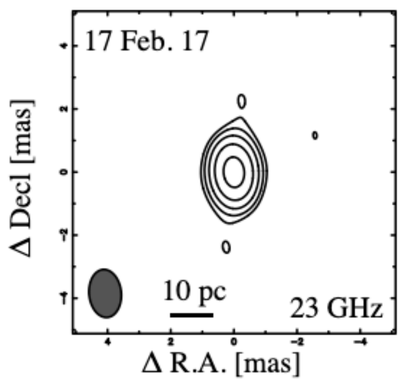
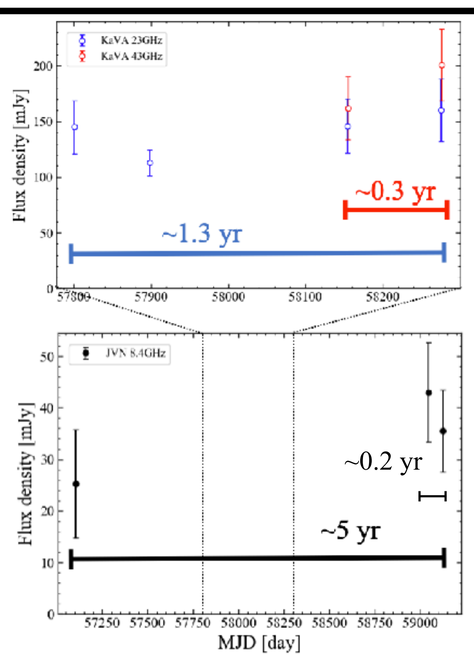


Figure 2. KaVA image of J1129-0528 in 2017 Feb. 17.

Table 2. The brightness temperture and the doppler factor at each epoch.

Epoch	Total flux mJy	Size mas	T_B $\times 10^{10}$ K	δ
17 Feb. 17	145±23.8	0.23	1.05	0.33
17 May 25	113±11.7	< 0.10 *	> 4.8	> 1.80
18 Feb. 05	146±24.5	0.18	1.72	0.54
18 Feb. 06	162±28.2	0.073	3.41	1.08
18 Jun 06	160±28.1	0.12	4.34	1.37
18 Jun 07	201±32.1	0.098	2.30	0.73

*For the 2nd epoch, the model size is the minimum resolvable size (i.e., upper limit) of a component, which was estimated by the way described in Lee et al. (2008)



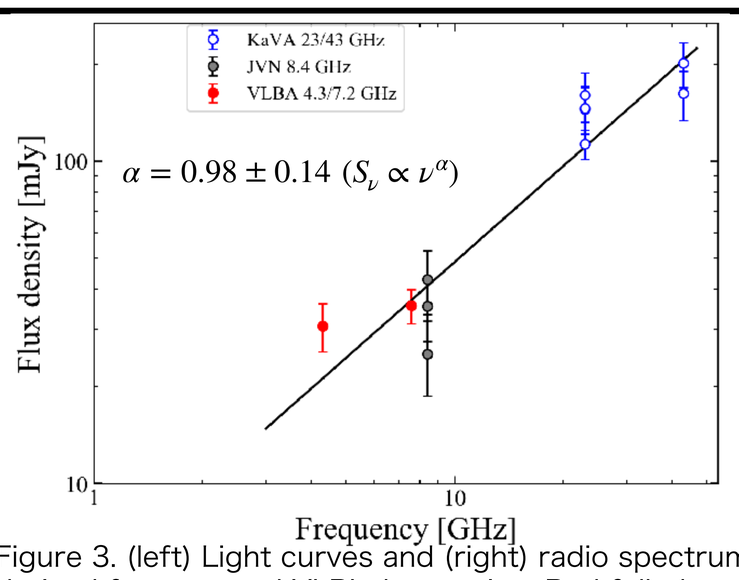


Figure 3. (left) Light curves and (right) radio spectrum derived from several VLBI observation. Red fulled marker is VLBA 4.3/7.6 GHz data from rfc_2020 catalog.

< Classification of J1129-0528 and γ-ray source association >

The observed inverted radio spectrum between a few GHz and several dozens of GHz suggests that either **blazar** or **High Frequency Peaker (HFP; one of the young AGN jet class)** , which are possible feature of J1129-0528.

Table 3. The characters J1129-0528 have shown in VLBI observation

	Radio structure	Variability	Radio Spectrum	Doppler factor
J1129-0528	Point like (0.7 pc**)	No significant variability at 23 GHz for 1.3 yr, at 43 GHz for 0.3 yr, at 8.4 GHz for 0.2 yr	Inverted ($\alpha = 0.98 \pm 0.14$)	0.33-1.37 (exclude 2nd epoch)
HFP	Classical double	No	Convex	Small
Blazar	Core jet	Yes	Flat	Large

At 8.4 GHz, the flux density does not change between 2015 Mar. to 2020 Aug.

→ no significant variability at 8.4 GHz for 5 yr ??

There is possibility that the classification of **J1129-0528 is HFP rather than blazar**. Futhermore, this source is possibly an extreme case compared to other HFPs already found by previous studies because J1129-0528 has the highest peak frequency (> 23 GHz).

** $z = 0.920 \pm 0.001$ (peña-Herazo et al. 2017)

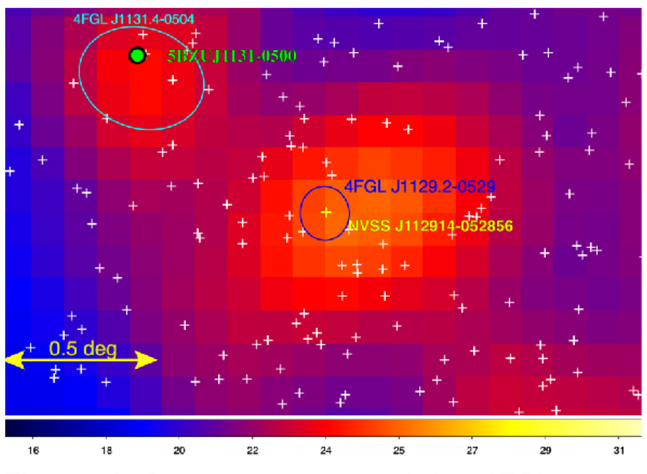


Figure 4. Count map around the 4FGL J1129.2-0529 at the energy range of 0.1-300 GeV with the pixel size of 0.1 deg/pixel. Cross shows the NVSS radio source position.

← No blazar candidate have been reported within the positional error of 4FGL J1129.2-0529 (Massaro et al. 2015). This facts also supports that J1129-0528 is possibly the non-blazar like γ-ray emitting object.

We applied the theoretical γ-ray emitting model of young AGN jet (Stawarz et al. 2008) to the results of KaVA.

$$\frac{(\epsilon S_\epsilon)_{\rm IC/UV}}{10^{-12}\ {\rm erg/cm^2\ s}} \sim 3.2 \times \frac{\eta_e}{\eta_B} \left(\frac{L_j}{10^{45}\ {\rm erg/s}}\right)^{1/2} \left(\frac{LS}{100\ {\rm pc}}\right)^{-1} \left(\frac{L_{\rm UV}}{10^{46}\ {\rm erg/s}}\right) \left(\frac{\epsilon}{1\ {\rm GeV}}\right)^{-0.25} \left(\frac{d_L}{100\ {\rm Mpc}}\right)^{-2}$$

d_L: Luminosity distance to the object, LS: Linear size of source structure

The same assumption in Stawarz et al. (2008) as follows -> $\eta_e/\eta_B = 10$: ratio of lobe parameter, $L_{\rm UV} = 10^{46}$ erg/s: UV luminosity

L_j is the jet luminosity which is estimated from the radio luminosities of 2.8×10^{44} erg/s at 43 GHz. As the result, the estimated γ-ray flux is calculated as $S_{1\ \rm GeV} = 6.8 \times 10^{-13}$ erg/cm^2/s. These is not discrepancy with the observed γ-ray flux of 7.2×10^{-13} erg/cm^2/s for 4FGL J1129.2-0529 reported in 4FGL catalog.

Conclusion

→ There is a possibility that J1129-0528 is the first γ-ray emitting HFP!!

Reference

Abdollahi, S., Acero, F., Ackermann, M., et al. 2020, ApJs, 247, 33; Fujinaga, Y., Niinuma, K., Kimura, A., et al. 2016, PASJ, 68, 70; Massaro, E., Maselli, A., Leto, C., et al. 2015, Ap&SS, 357, 75; Massaro, F. & D'Abrusco, R. 2016, ApJ, 827, 67; peña Herazo, H. A., Marchesini, E. J., Àlvarez Crespo, N., et al. 2017, APSS, 362, 228; Schinzel, F. K., Petrov, L., Taylor, G. B., et al. 2017, ApJ, 838, 139; Stawarz, L., Ostorero, L., Begelman, M. C., et al.2008, ApJ, 680, 911