

Polarization angle calibration using the Crab nebula for the Korean VLBI Network (KVN)

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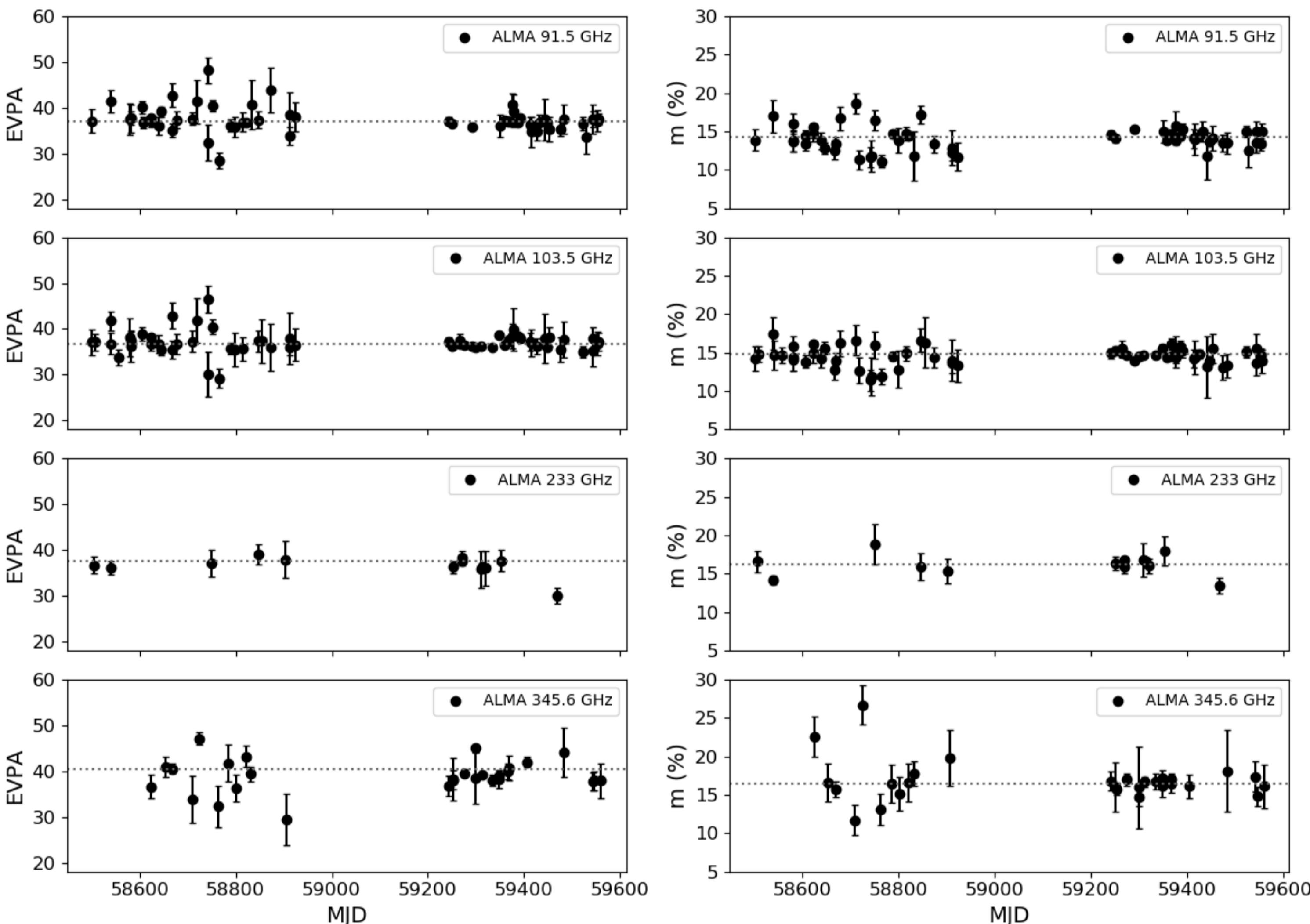
Abstract

The instruments using circular polarization (CP) receiver cannot directly measure polarization angles because of an offset in the angle introduced by part of the CP receiver system. To calibrate the offset, it is necessary to observe a polarization angle calibrator. Here we present the electric vector position angle (EVPA) of the Crab nebula seen by KVN obtained by observing and comparing the Crab nebula and 3C 286.

Primary EVPA calibrator for KVN

An ideal absolute EVPA calibrator should satisfy three conditions – stability, compactness, and brightness. The AGN 3C 286 is considered as the source which best satisfies these three conditions (Agudo et al. 12, Perley & Butler 13a,b), but it is not bright enough for KVN. The Crab nebula, another EVPA calibrator, is much brighter and more suitable for KVN. However, it is not compact enough for KVN. This results in different integrated EVPA at different frequencies (resolutions) of KVN. One way to find the EVPA of the Crab nebula seen by KVN is comparing the EVPA of 3C 286.

Polarization of 3C 286 (ALMA)



Polarization measurements of 3C 286 with ALMA.

ν [GHz]	m [%]	χ [°]	s_m^a [%]	$\langle \varepsilon_m \rangle^b$ [%]	s_χ^c [°]	$\langle \varepsilon_\chi \rangle^d$ [°]
91.5	14.3 ± 0.1	37.0 ± 0.1	1.5	1.2	2.8	2.1
103.5	14.7 ± 0.1	36.8 ± 0.1	1.2	1.3	2.4	2.2
233	16.3 ± 0.2	37.5 ± 0.2	1.3	1.3	2.1	2.2
346.5	16.5 ± 0.2	40.5 ± 0.3	2.7	2.0	3.6	2.6

^a Standard deviation of the fractional polarization.

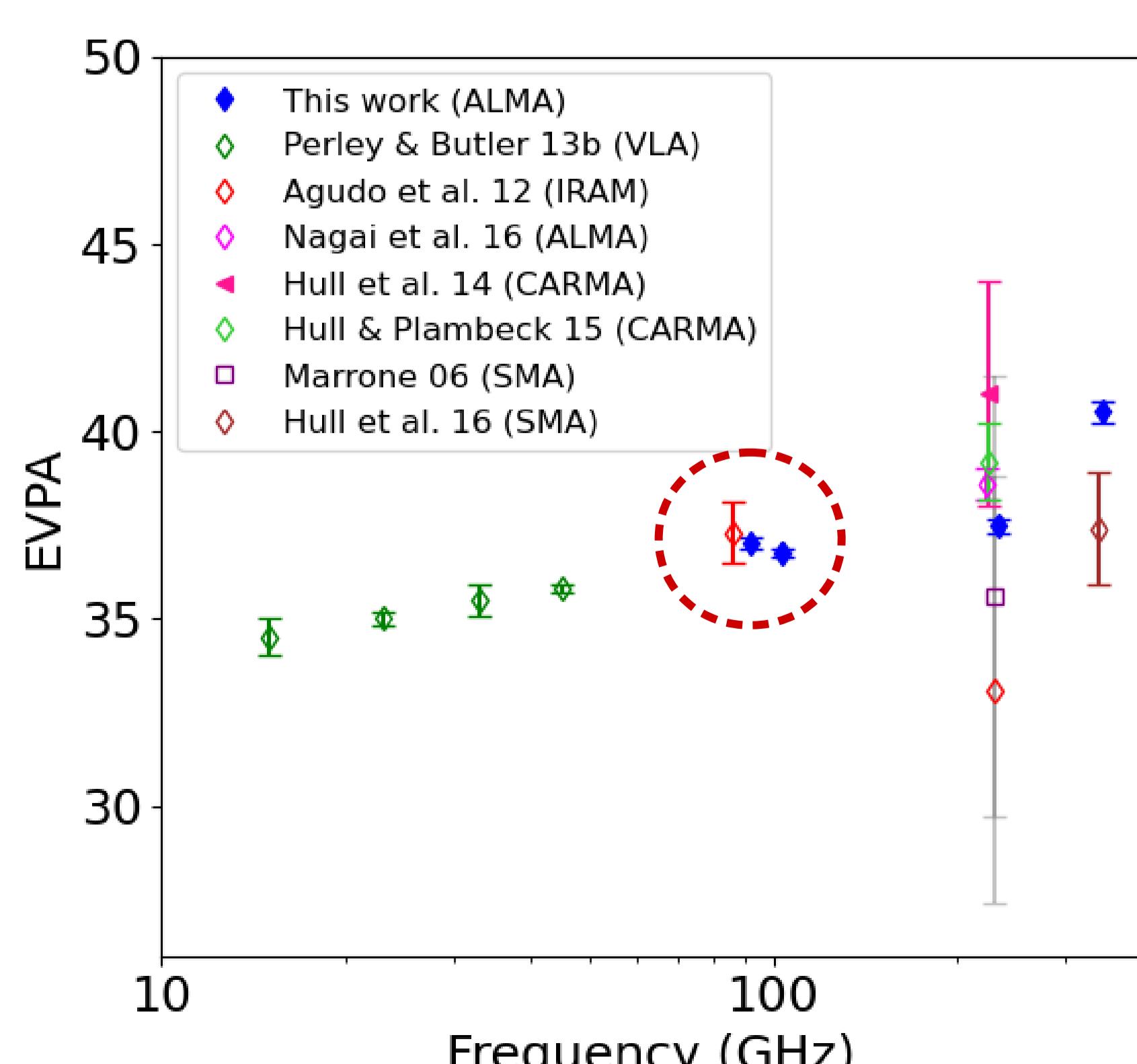
^b Mean fractional polarization error.

^c Standard deviation of the EVPA.

^d Mean EVPA error.

The standard deviation and the average of polarization error are consistent. These results suggest that the polarization of 3C 286 is stable at all ALMA frequencies within the 3-year observation period.

Stability of 3C 286



ALMA 91.5 GHz (This work)

- Jan.2019 – Dec.2021
- $\chi = 37.0^\circ \pm 0.1^\circ$

IRAM 86 GHz (Agudo et al. 12)

- Sep.2006 – Jan.2012
- $\chi = 37.3^\circ \pm 0.8^\circ$

EVPA values obtained with the two different instruments are consistent despite the time gap of more than 10 years (at least for KVN frequency range).

Data information

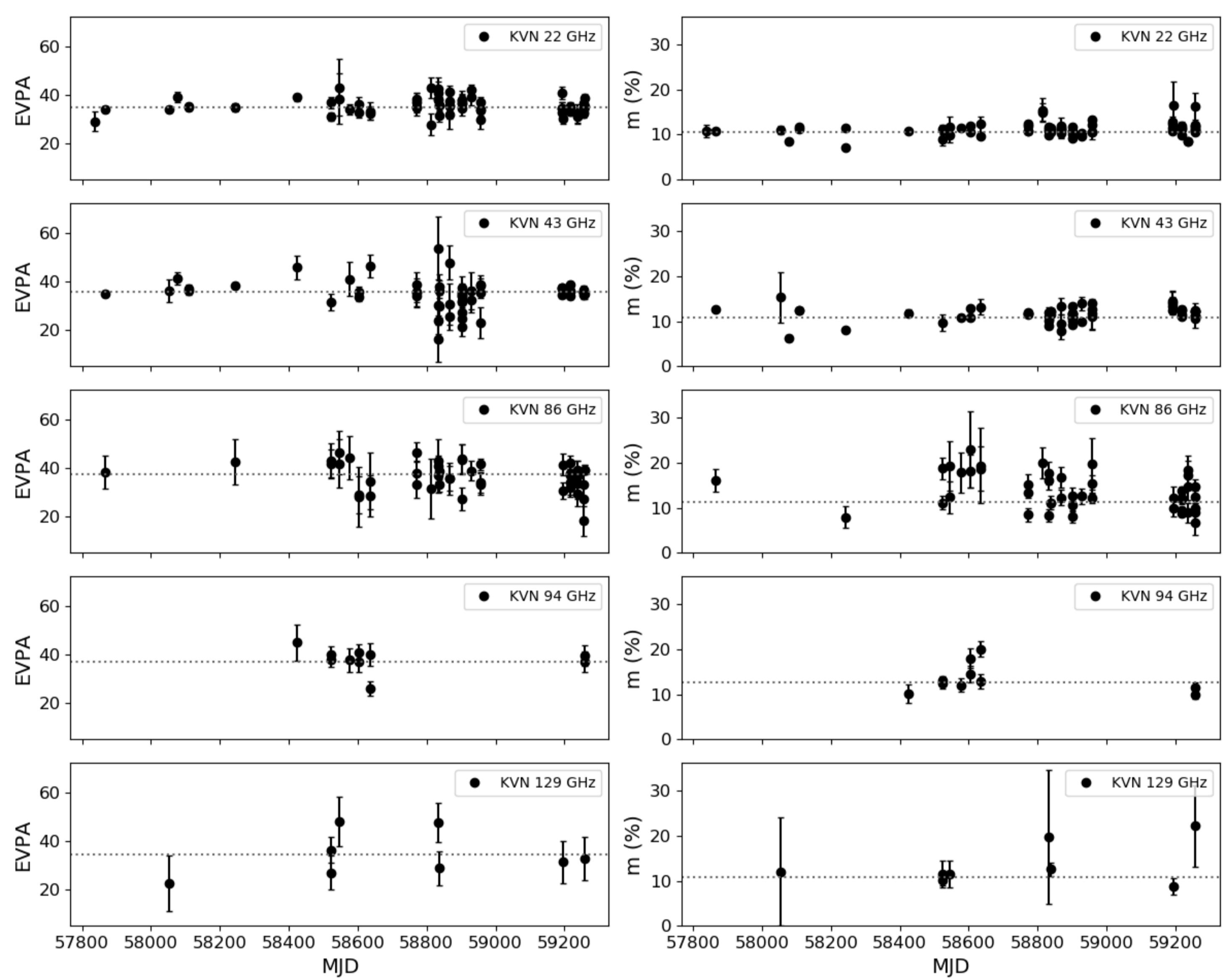
1. KVN single-dish data

Period : February 2017 ~ February 2021
Frequency : 21.4 / 43.0 / 86.2 / 94.0 / 129.4 GHz

2. The ALMA Calibrator Source Catalog

Period : January 2019 ~ December. 2021
Frequency : 91.5 / 103.5 / 233 / 346.5 GHz

Polarization of 3C 286 (KVN)



Polarization measurements of 3C 286 with KVN.

ν [GHz]	m [%]	χ [°]	s_m^a [%]	$\langle \varepsilon_m \rangle^b$ [%]	s_χ^c [°]	$\langle \varepsilon_\chi \rangle^d$ [°]
22.4	10.5 ± 0.1	—	1.6	0.8	3.3	2.4
43.0	10.9 ± 0.1	—	1.6	1.0	6.0	3.3
86.2	11.3 ± 0.2	—	4.0	2.5	6.1	5.6
94.0	12.6 ± 0.4	—	3.1	1.5	4.3	3.6
129.3	10.9 ± 0.8	—	4.4	5.8	9.1	7.6

^a Standard deviation of the fractional polarization.

^b Mean fractional polarization error.

^c Standard deviation of the EVPA.

^d Mean EVPA error.

After checking the stability of 3C 286, we collected the EVPA of 3C 286 obtained with KVN to compare it with the reference values of 3C 286, to find the offset in the KVN data, and to find the EVPA of the Crab nebula seen by KVN.

EVPA of the Crab nebula seen by KVN

Our EVPA values for the Crab nebula (both I-peak and pulsar position) for KVN, along the reference values for 3C 286.

ν [GHz]	$\chi_{3\text{C}286}$ [°]	χ_{peak} [°]	χ_{pulsar} [°]
22.4	35.0 ± 0.2^a	154.4 ± 0.9	154.7 ± 0.9
43.0	35.8 ± 0.1^b	151.0 ± 1.1	150.7 ± 1.2
86.2	37.3 ± 0.8^c	149.4 ± 1.6	148.4 ± 1.6
94.0	37.0 ± 0.1^d	149.6 ± 2.2	—
129.4	—	149.0 ± 1.6^e	150.2 ± 2.0^e

^a VLA 23 GHz (Perley & Butler 2013b)

^b VLA 45 GHz (Perley & Butler 2013b)

^c XPOL 86 GHz (Agudo et al. 2012)

^d ALMA 91.5 GHz (this work)

^e XPOL 86 GHz (Ritacco et al. 2018)

We obtained the EVPA at the total intensity peak position and the pulsar position at different frequencies of KVN.

References

1. Agudo, I. et al. 2012, A&A, 541, A111
2. Perley & Butler 2013a, ApJS, 204, 19
3. Perley & Butler 2013b, ApJS, 206, 16
4. Ritacco et al. 2018, A&A, 616, A35