Multi-frequency, radio circular and linear polarization monitoring of OJ 287

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OJ 287
short profile

$z = 0.306$

$\theta_{obs} \sim 3°$

$M \sim 2 \times 10^{10}\ M_{\odot}$

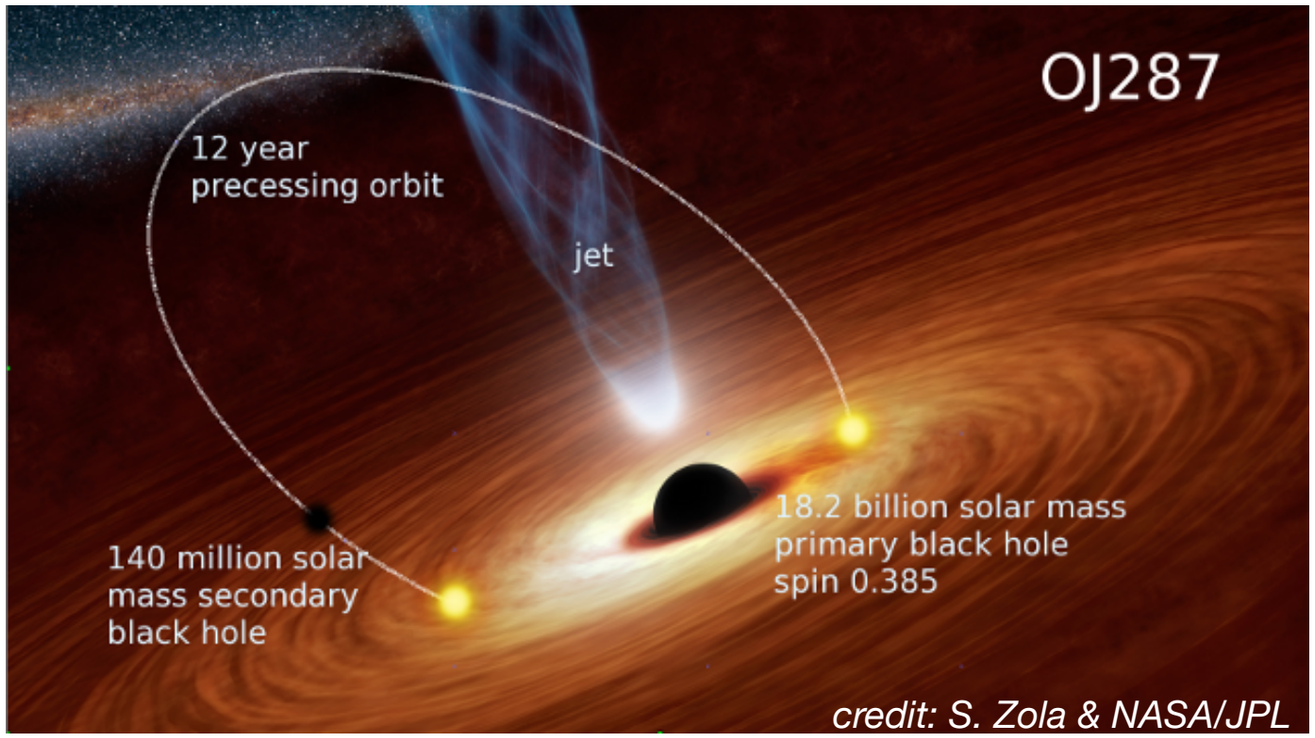
SMBBH candidate
- galaxy formation and evolution
- BH demographics and growth

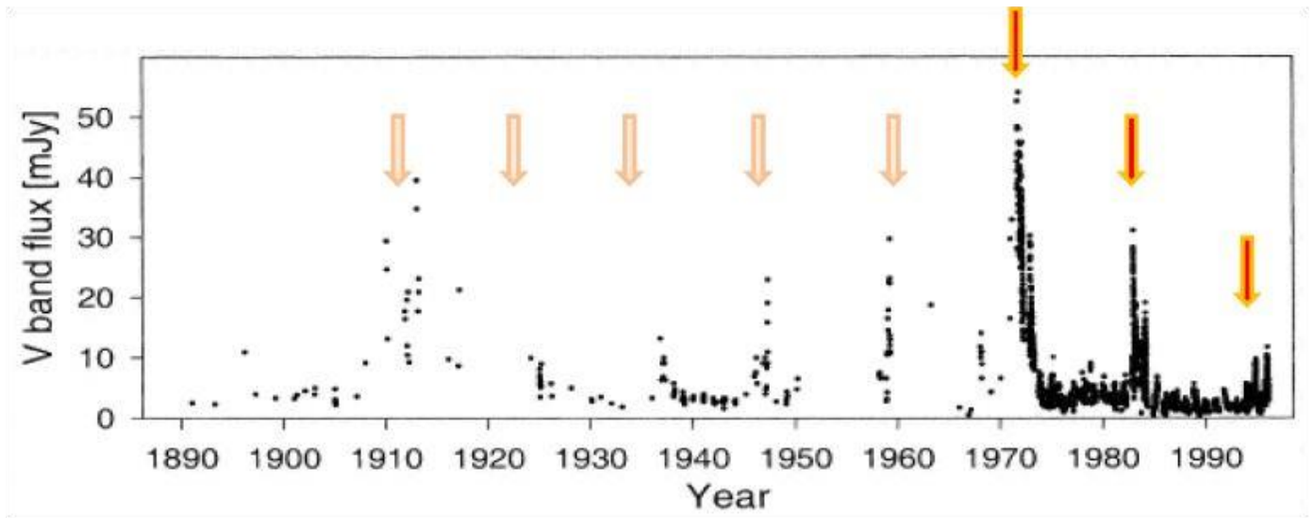
Extremely close merger

Dense optical data

Sparse radio data

(esp. around opt. maxima)

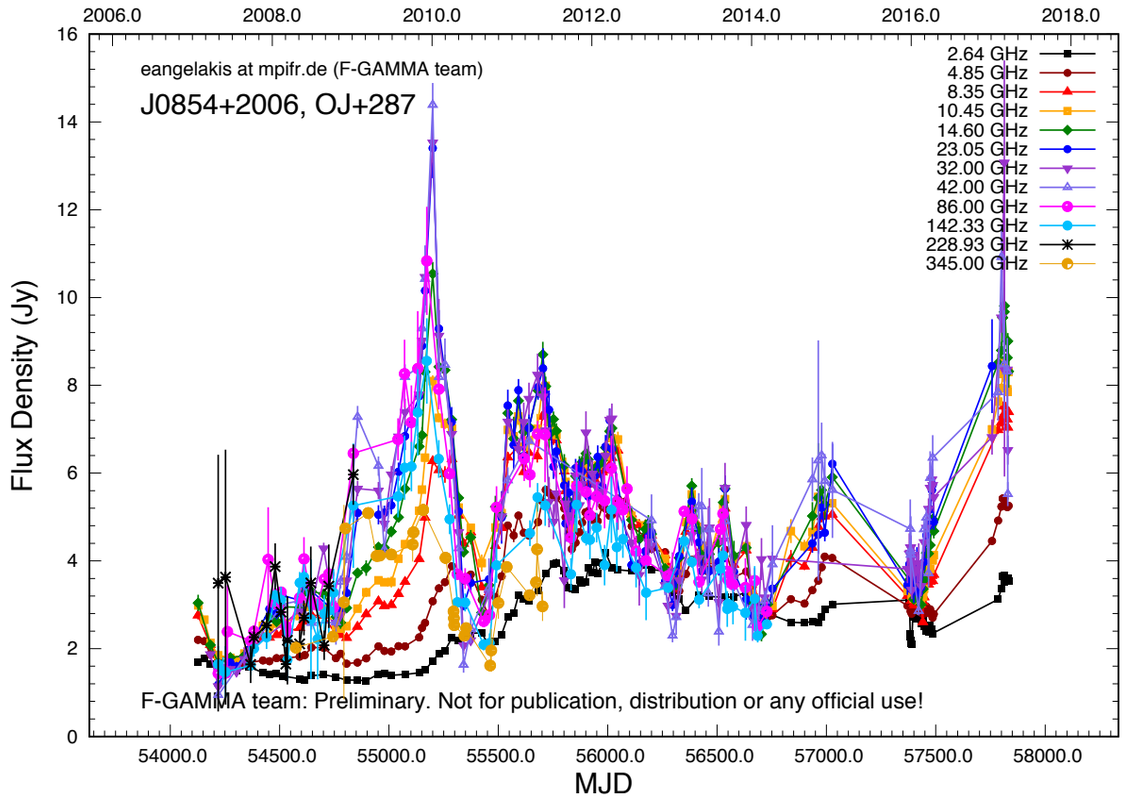


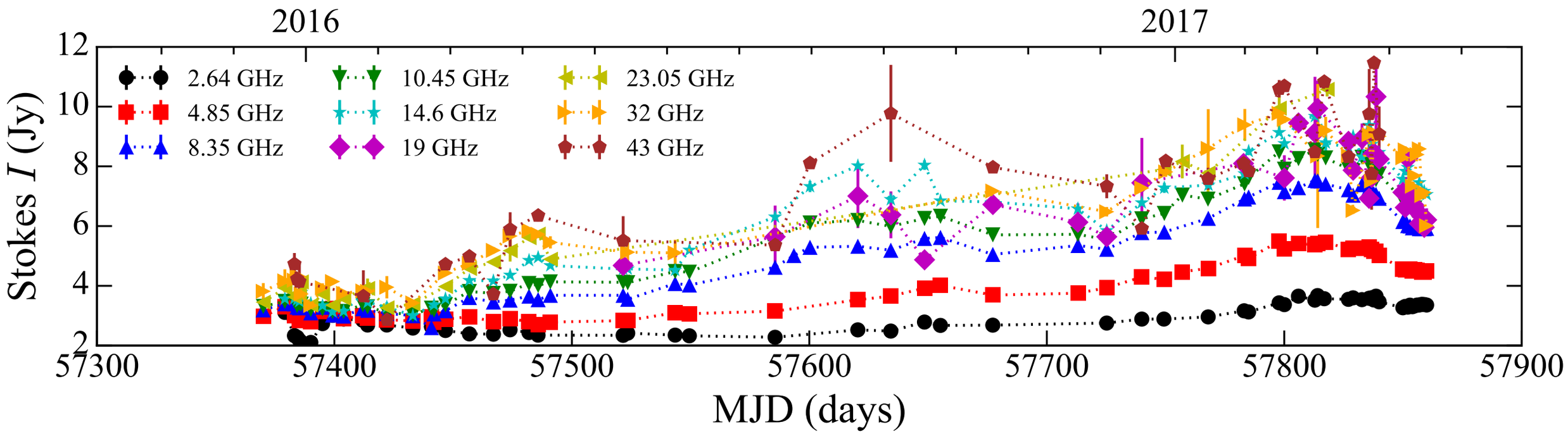


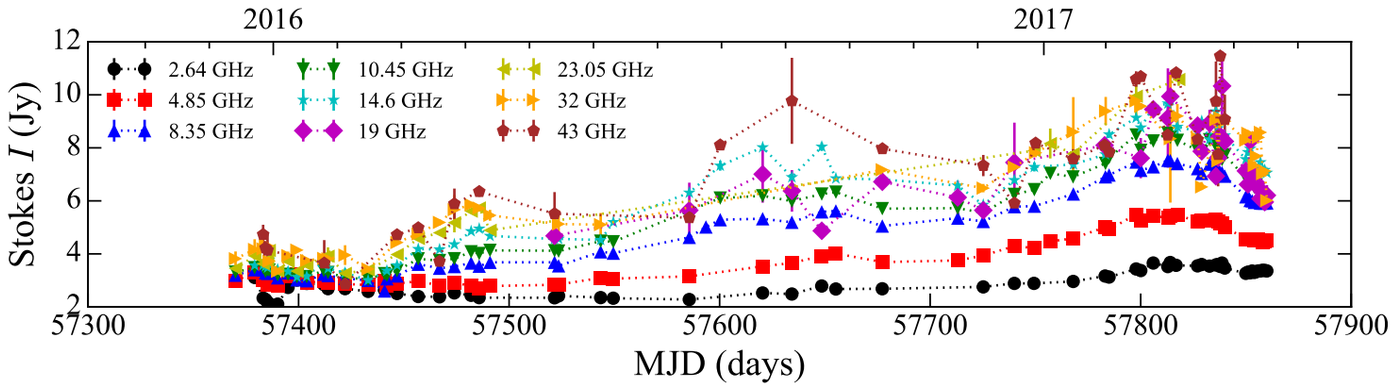
Ongoing, full-Stokes, high-cadence monitoring

F-GAMMA
- Jan 2007 — Jan 2015
- mean cadence: 1.3 months
- 2.64–345 GHz at 12 frequency steps
- LP (~2.5 %) and CP (~0.2 %)

Dec 2015 - now (~500 days)
- mean cadence: 8 days
- 2.64–43 GHz at 8 frequency steps
- New full-Stokes data analysis pipeline
  Myserlis et al. 2017, A&A, in press
- LP at 2.64, 4.85, 8.35 and 10.45 GHz
- CP at 4.85 and 8.35 GHz




2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
14.6 GHz
19 GHz
23.05 GHz
32 GHz
43 GHz
Stokes I (Jy)
12
10
8
6
4
2
57300
57400
57500
57600
57700
57800
57900
MJD (days)



Stokes *I*

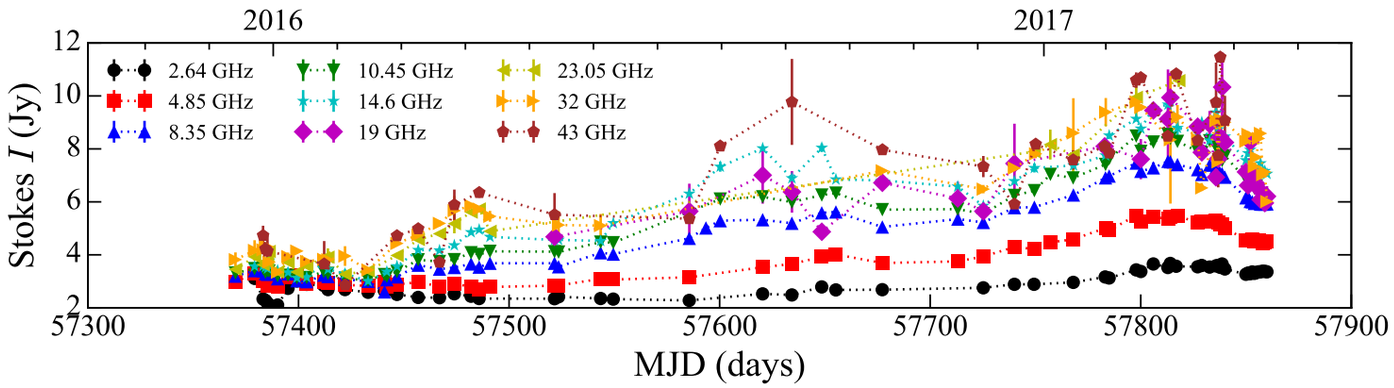
range: 2–11.5 Jy

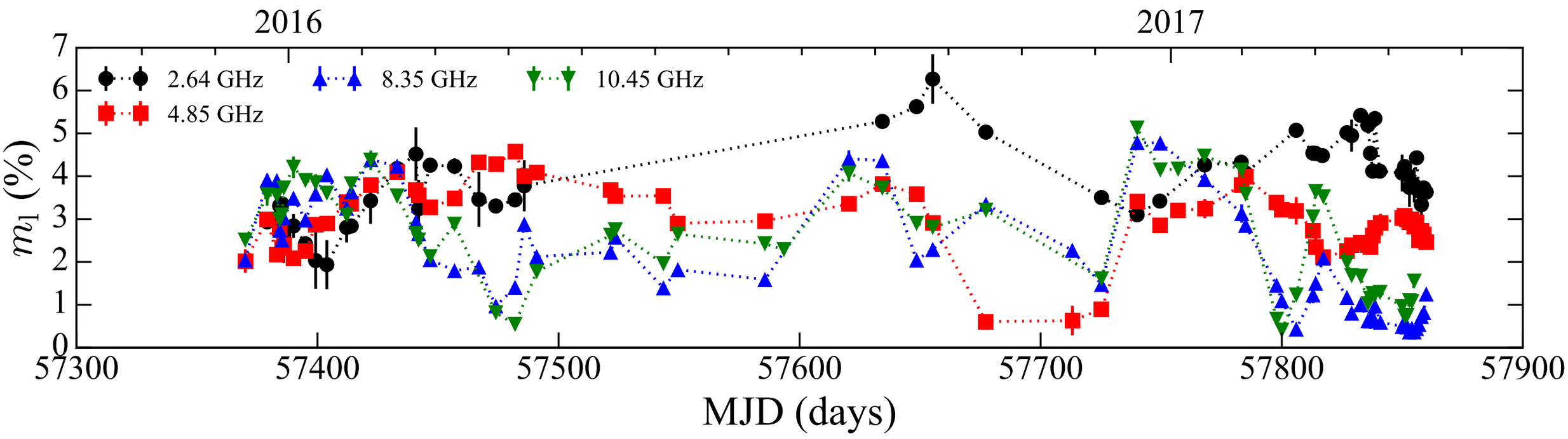
activity increased since mid-Feb 2016

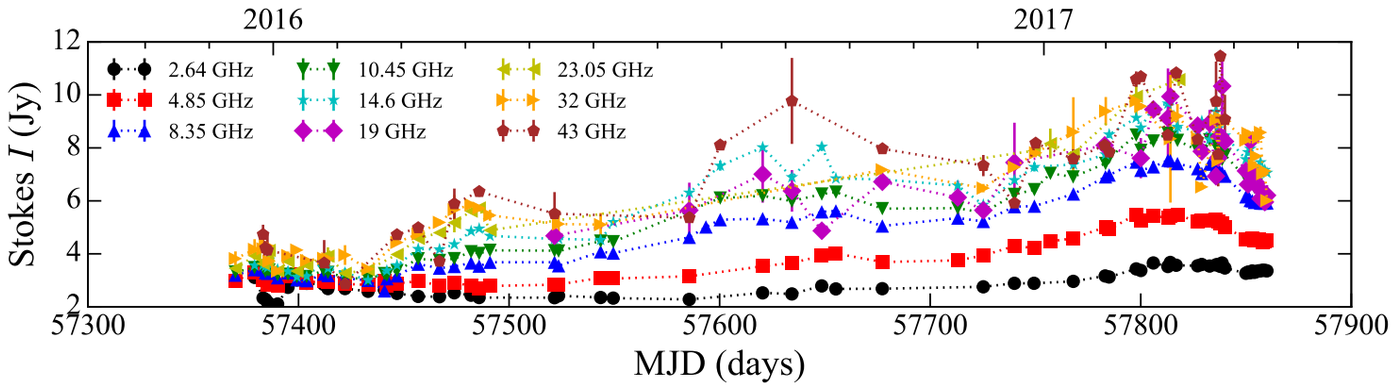
- correlated with frequency

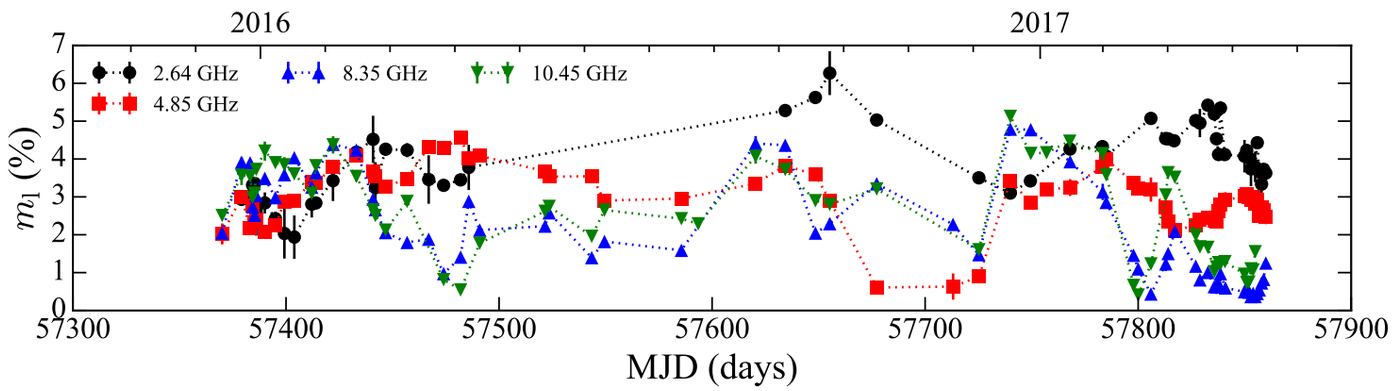
spectrum always inverted

(highest) maximum: mid-Feb to mid-Mar 2017


2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
14.6 GHz
19 GHz
23.05 GHz
32 GHz
43 GHz
Stokes I (Jy)
MJD (days)


2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
m_1 (%)
MJD (days)



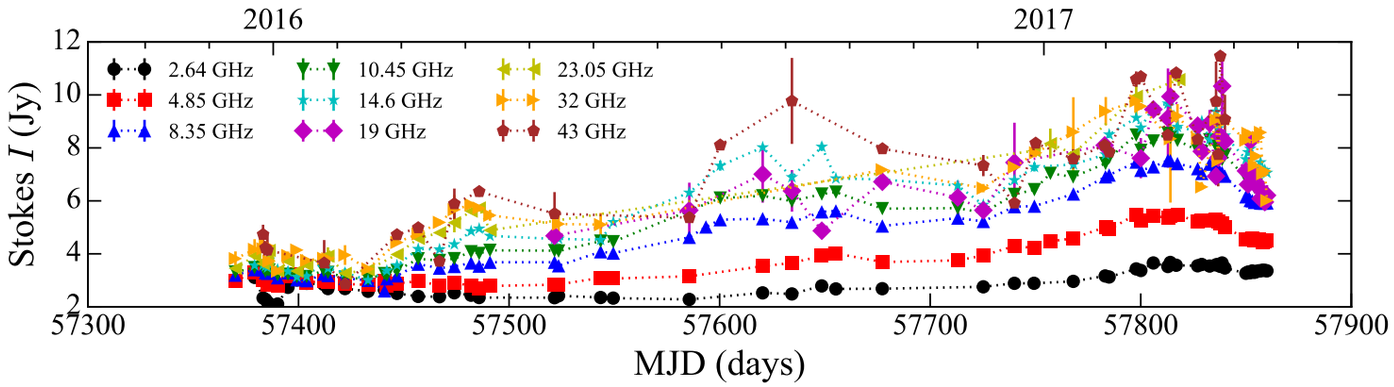


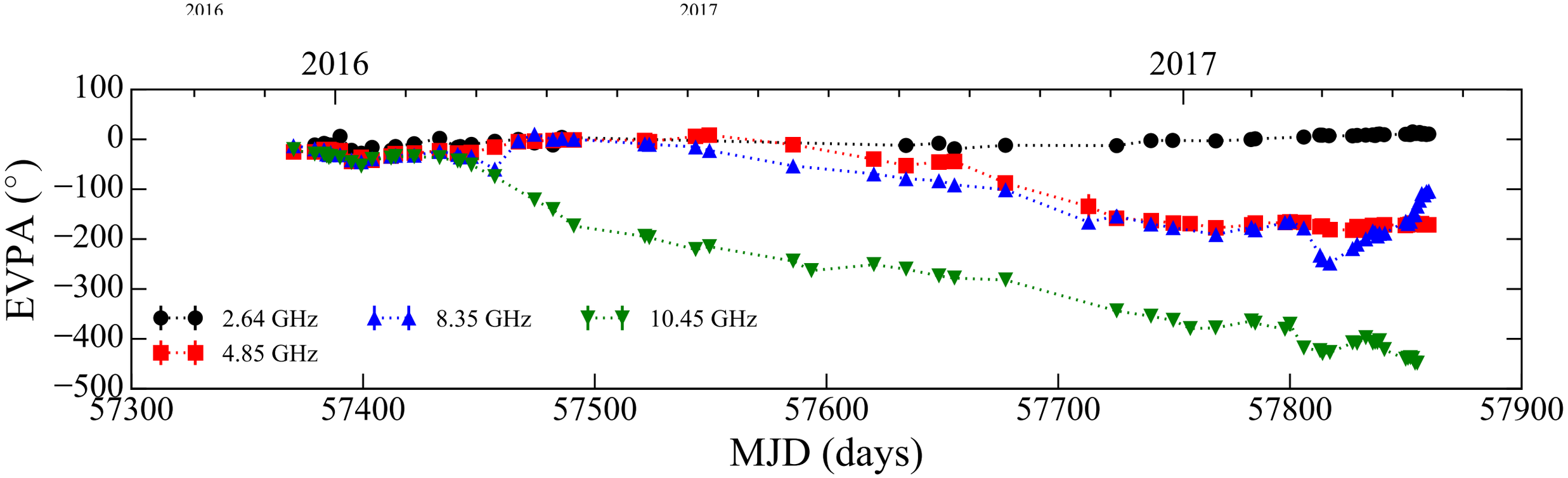
m_l

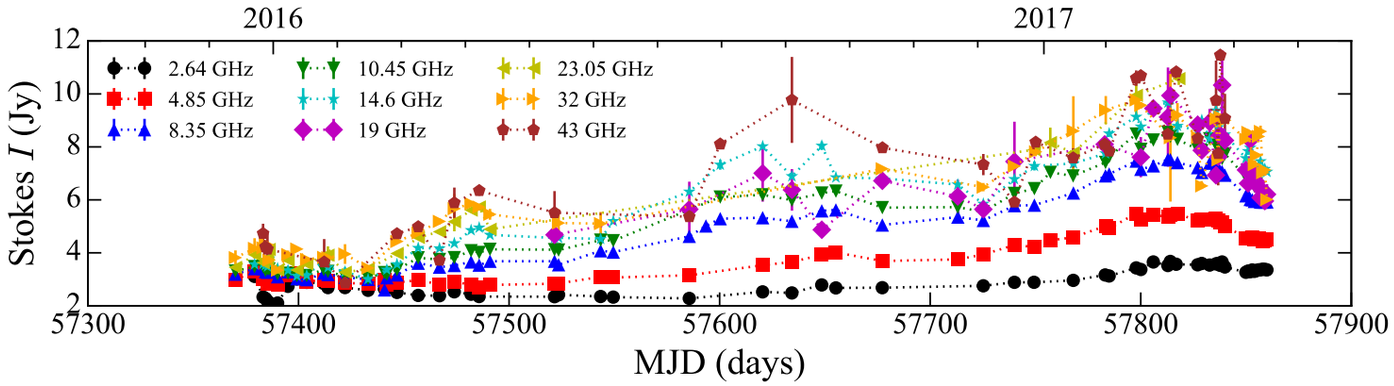
range: 0.4–6.3 %
median: 2.7 %

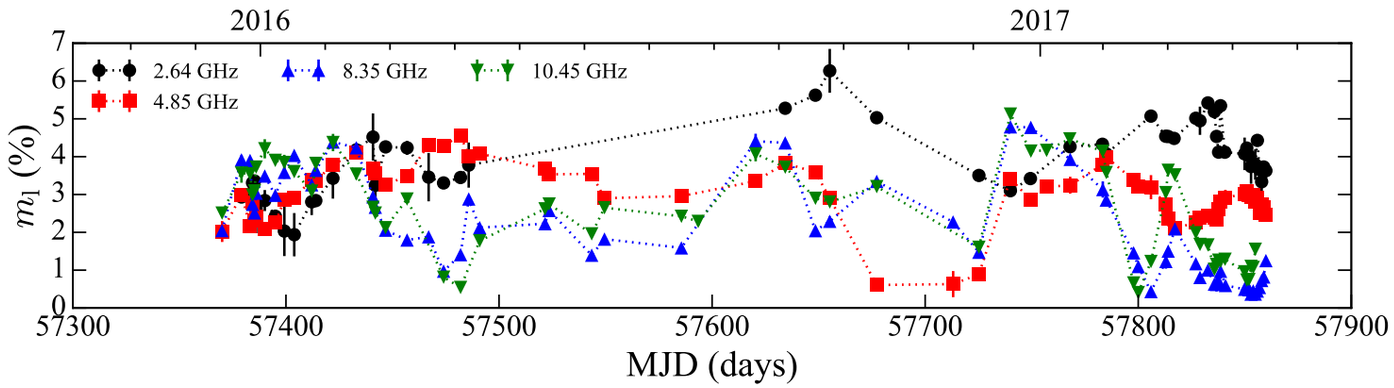
<m_l> anti-correlated with freq.
variations correlated with freq.

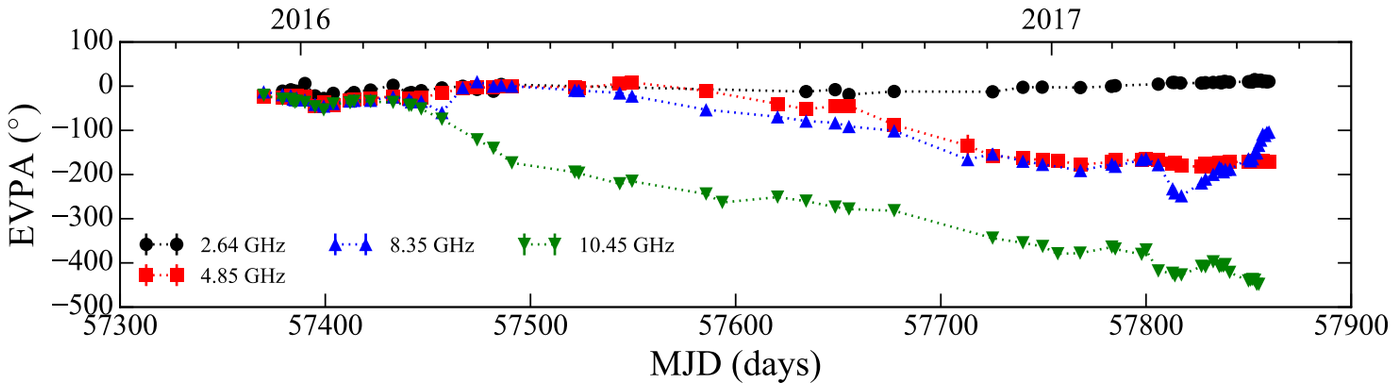
simultaneous m_l and I peaks
- except around MJD 57800


2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
14.6 GHz
19 GHz
23.05 GHz
32 GHz
43 GHz
Stokes I (Jy)
MJD (days)


2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
EVPA (°)
MJD (days)







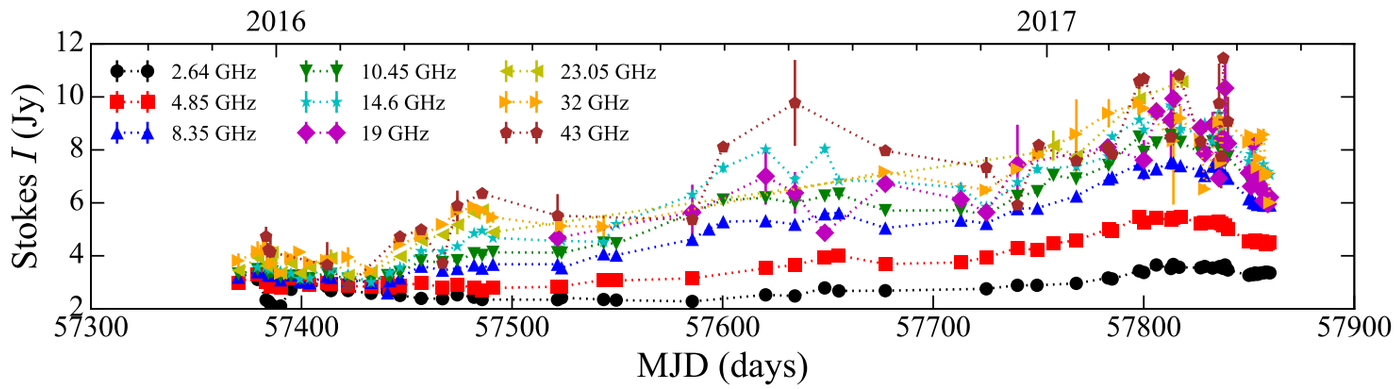
EVPA

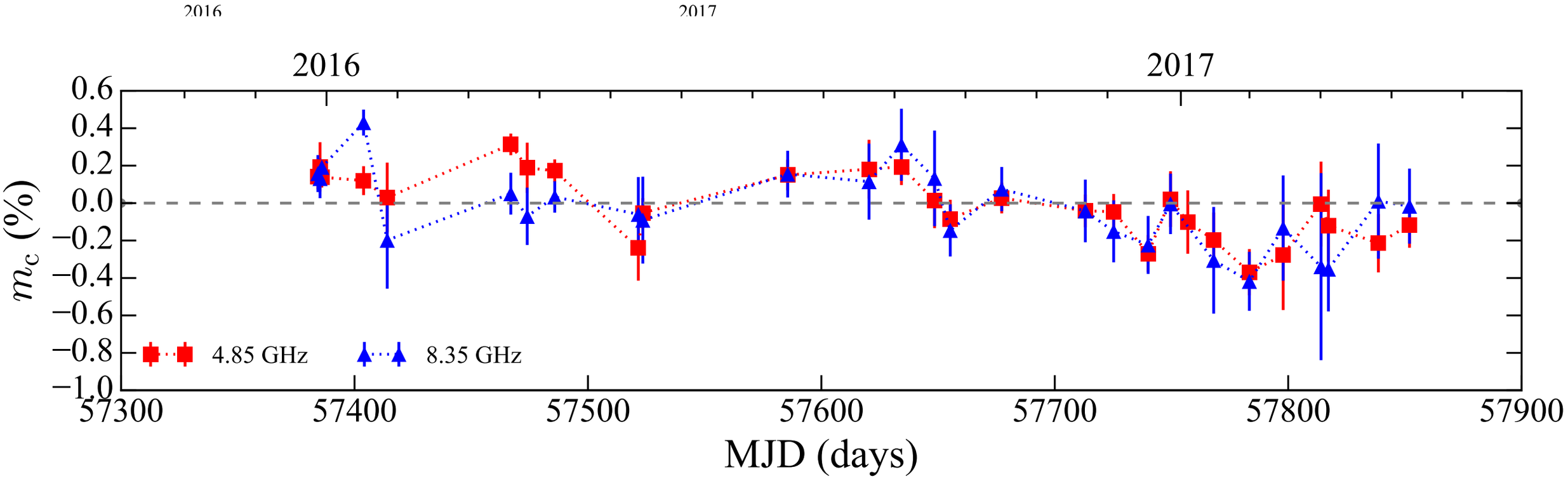
CCW rotations

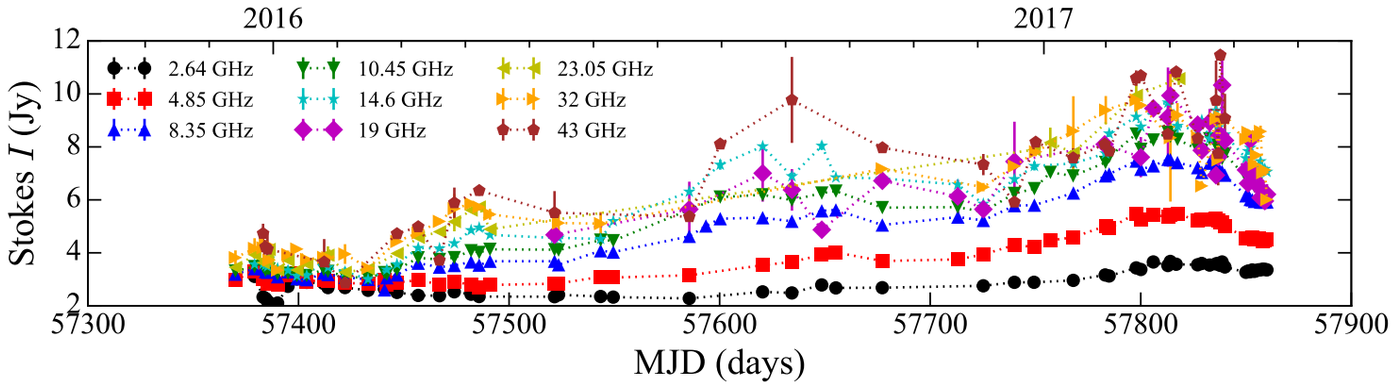
amplitude
- correlated with freq.
- range: ~190°–430°

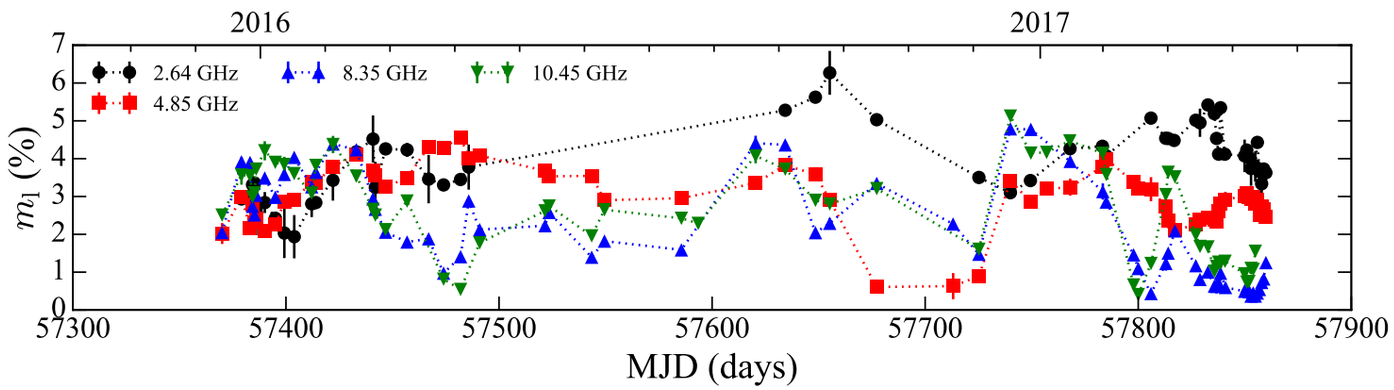
rate
- correlated with freq.
- range: 0.5–1.2 °/day

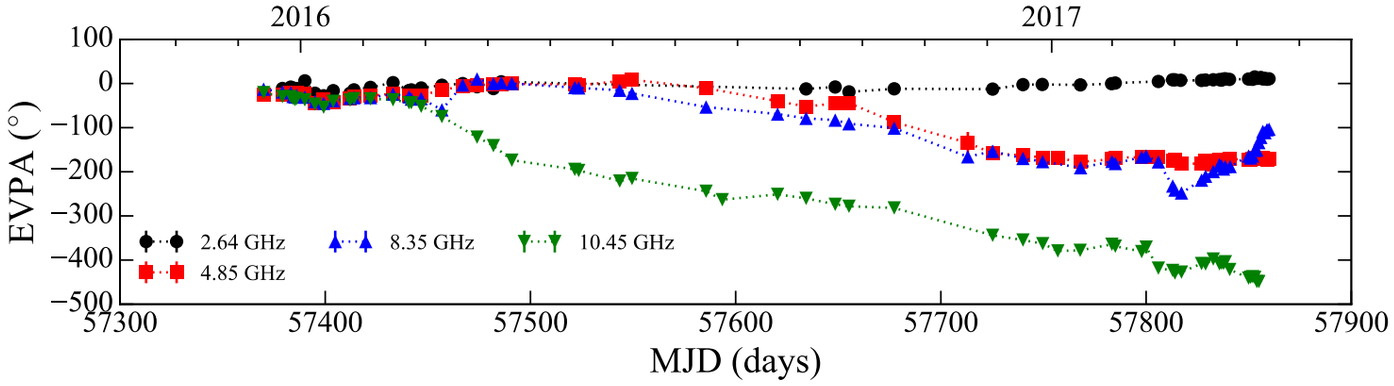
rotation evolution
- smooth until Feb 2017
- opposite senses btw 8.35 and 10.45 GHz afterwards

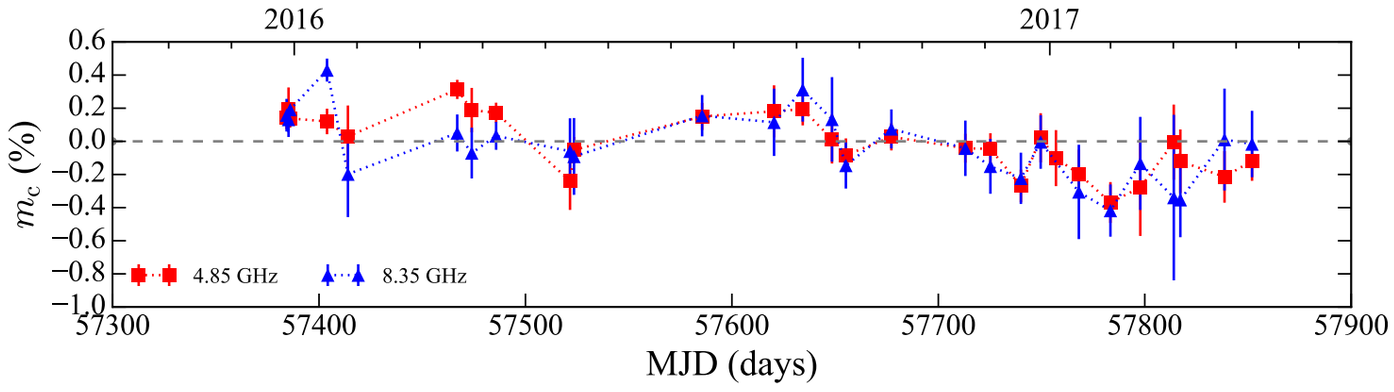

2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
14.6 GHz
19 GHz
23.05 GHz
32 GHz
43 GHz
Stokes I (Jy)
MJD (days)


2016
2017
m_c (%)
4.85 GHz
8.35 GHz
MJD (days)







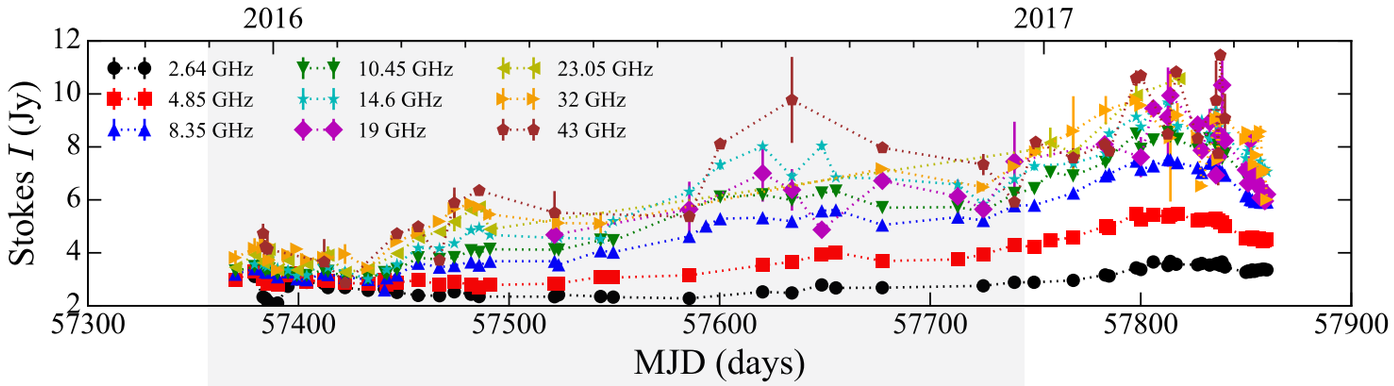


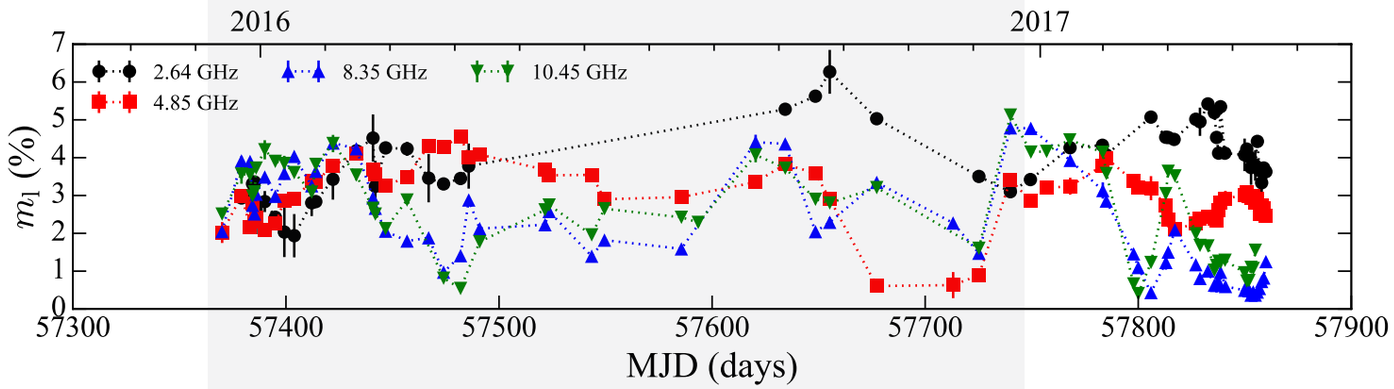
m_c

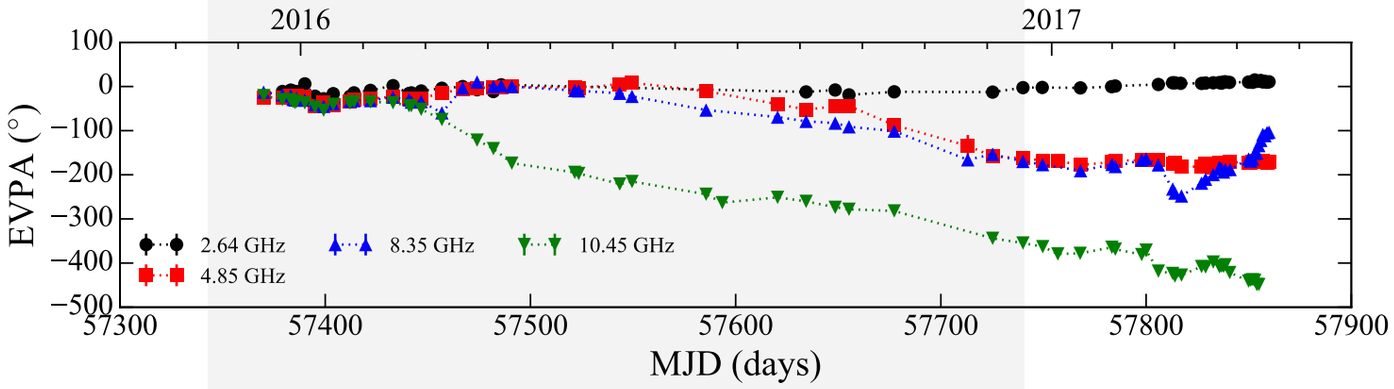
cadence: 17 days

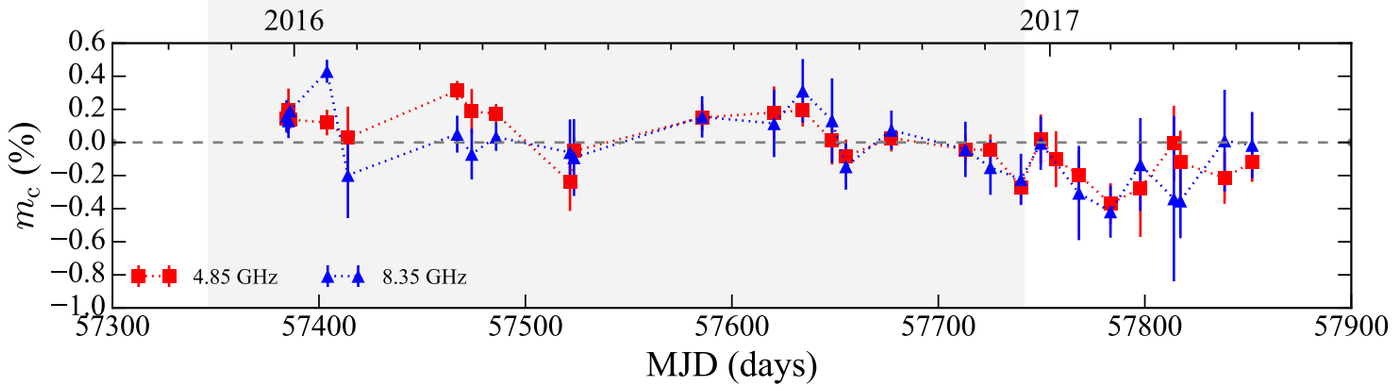
range: -0.4 – 0.3 %
mean: 0 % (0.2 % lm_cl)

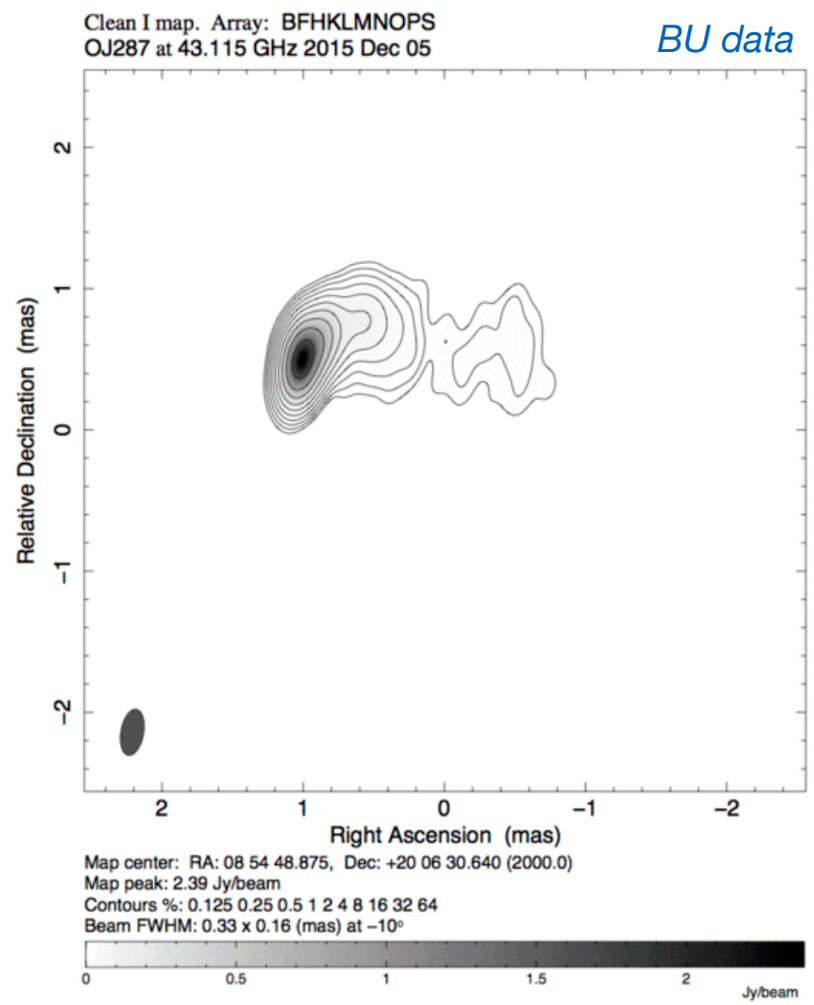
m_c peak at (highest) I max.
- 0.4 %
- LH

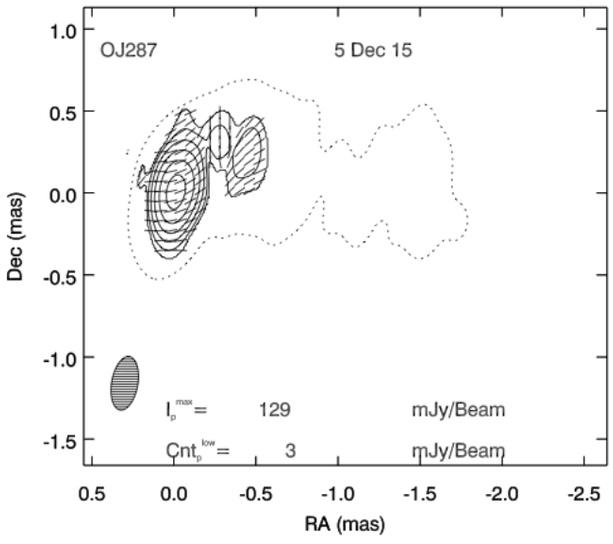

2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
14.6 GHz
19 GHz
23.05 GHz
32 GHz
43 GHz
Stokes I (Jy)
MJD (days)

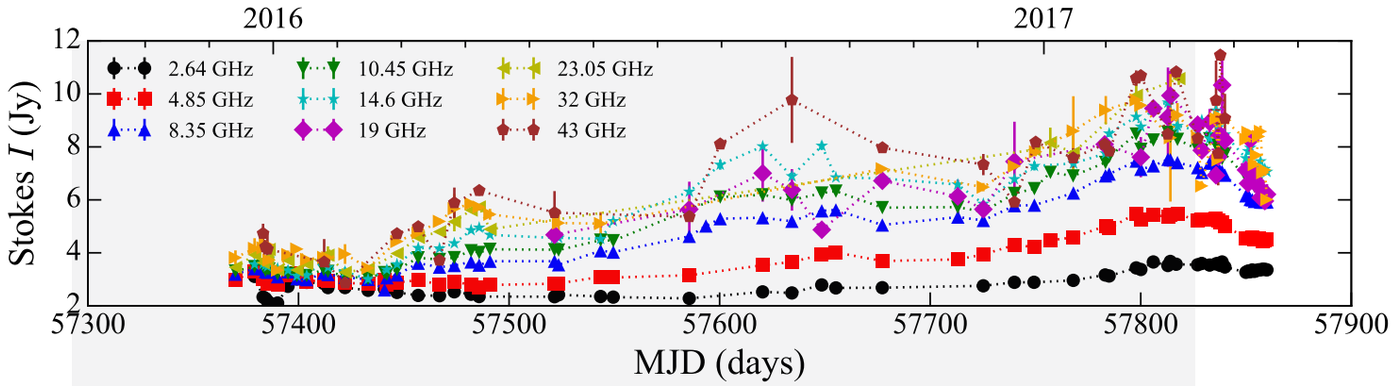

2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
m_l (%)
MJD (days)

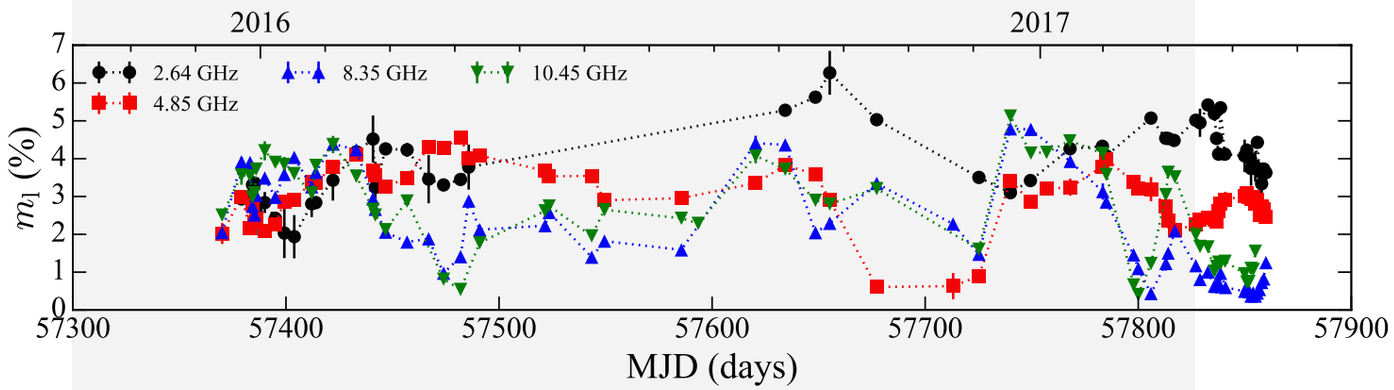

2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
EVPA (°)
MJD (days)

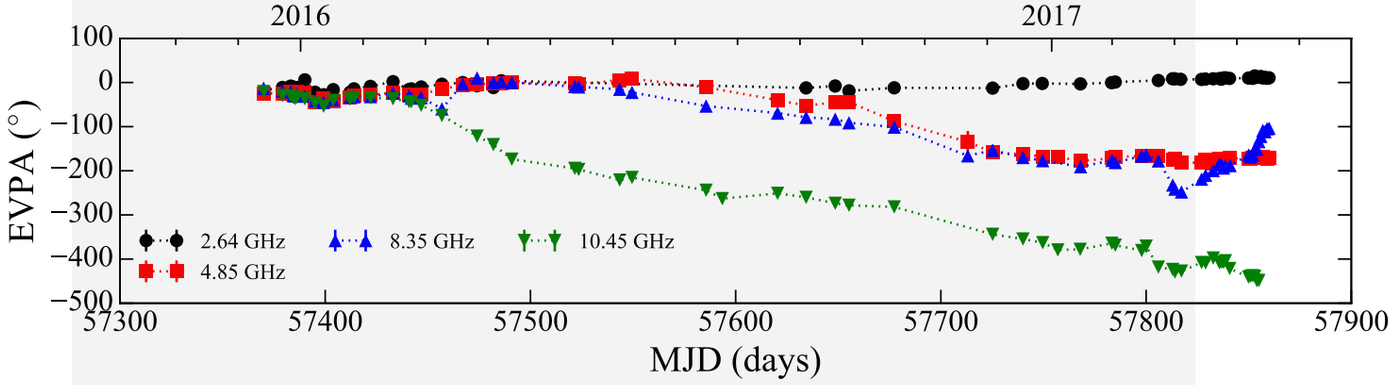

2016
2017
4.85 GHz
8.35 GHz
m_c (%)
MJD (days)

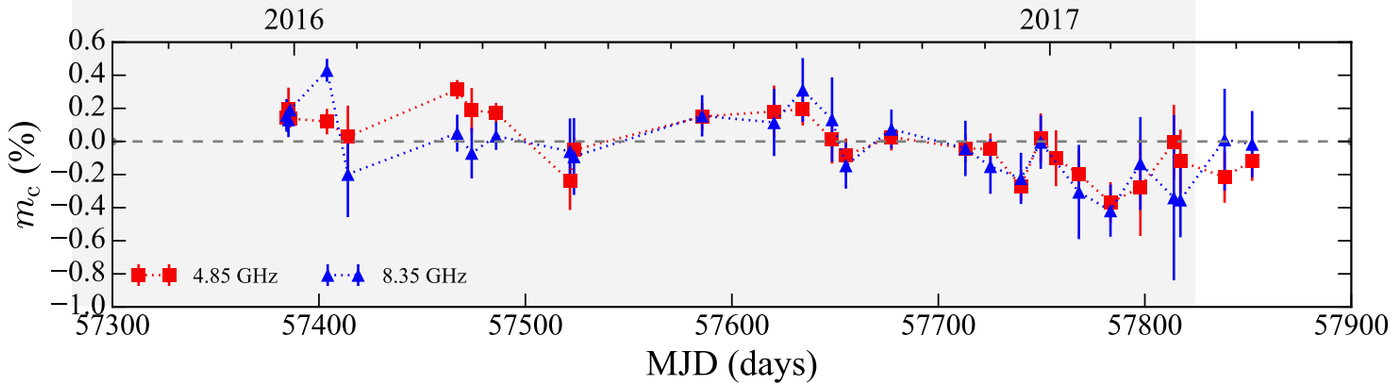

Clean I map. Array: BFHKLMNOPS
OJ287 at 43.115 GHz 2015 Dec 05
BU data
Relative Declination (mas)
Right Ascension (mas)
Map center: RA: 08 54 48.875, Dec: +20 06 30.640 (2000.0)
Map peak: 2.39 Jy/beam
Contours %: 0.125 0.25 0.5 1 2 4 8 16 32 64
Beam FWHM: 0.33 x 0.16 (mas) at −10°
Jy/beam

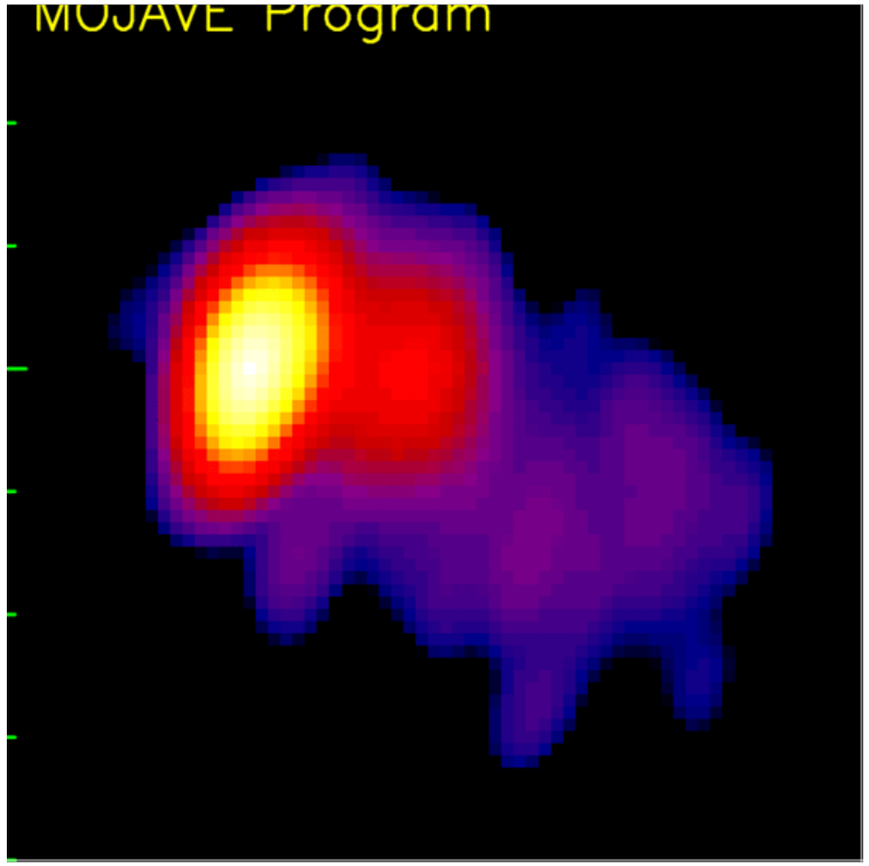

OJ287
5 Dec 15
I_p^{max} = 129 mJy/Beam
Cnt_p^{low} = 3 mJy/Beam
Dec (mas)
RA (mas)

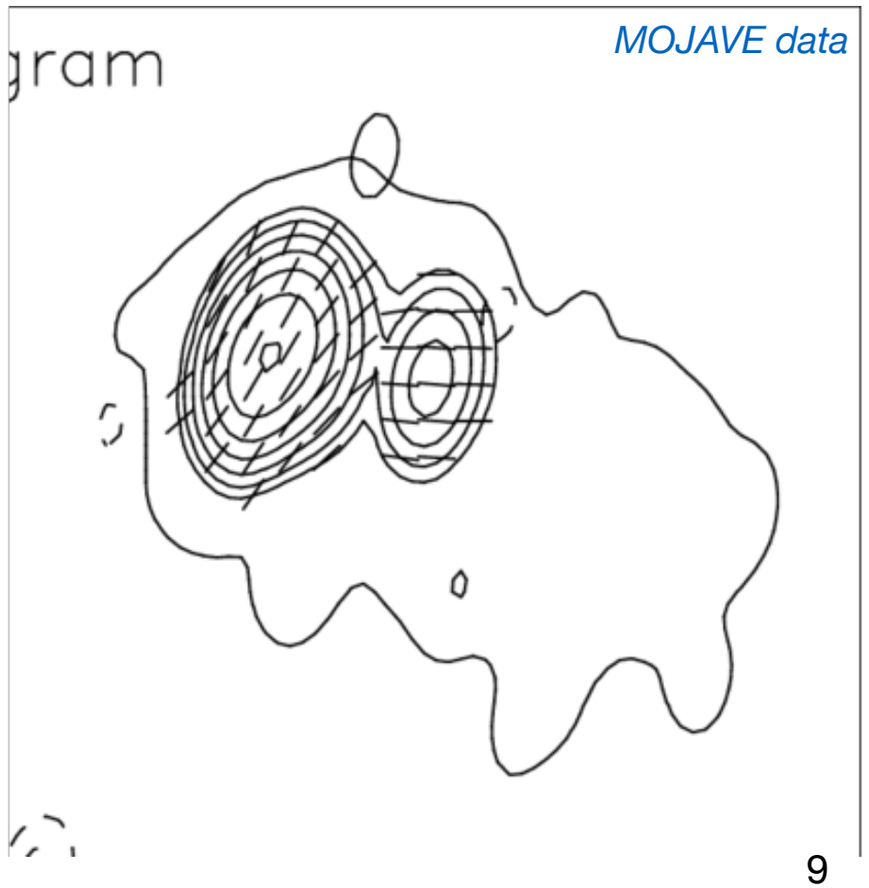

2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
14.6 GHz
19 GHz
23.05 GHz
32 GHz
43 GHz
Stokes I (Jy)
MJD (days)

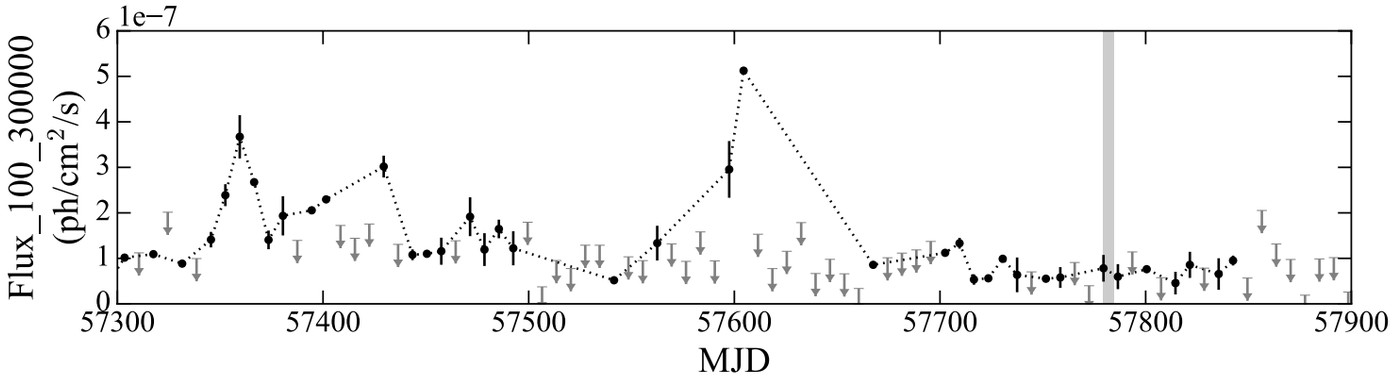

2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
m_l (%)
MJD (days)

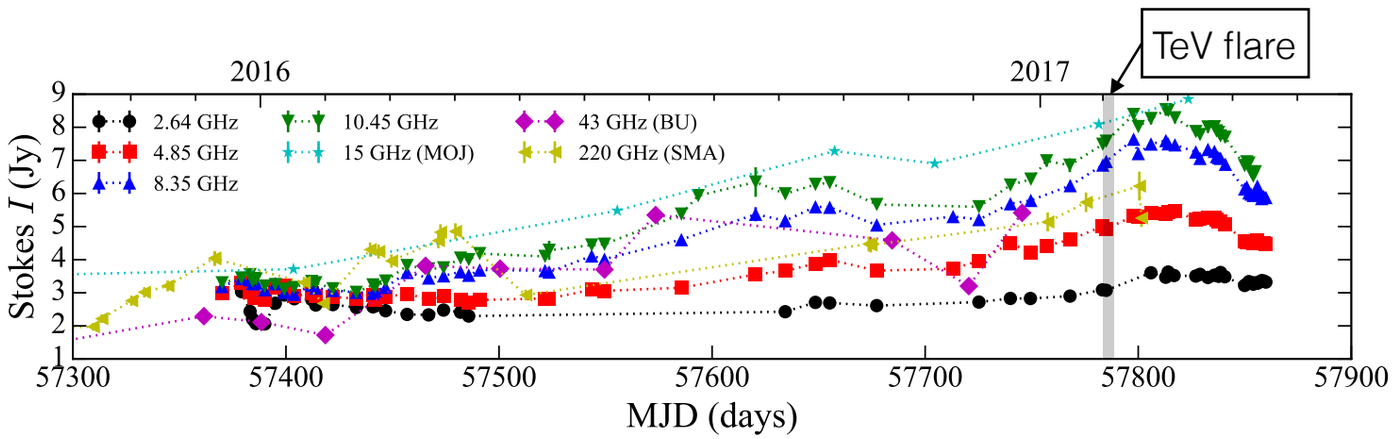

2016
2017
2.64 GHz
4.85 GHz
8.35 GHz
10.45 GHz
EVPA (°)
MJD (days)

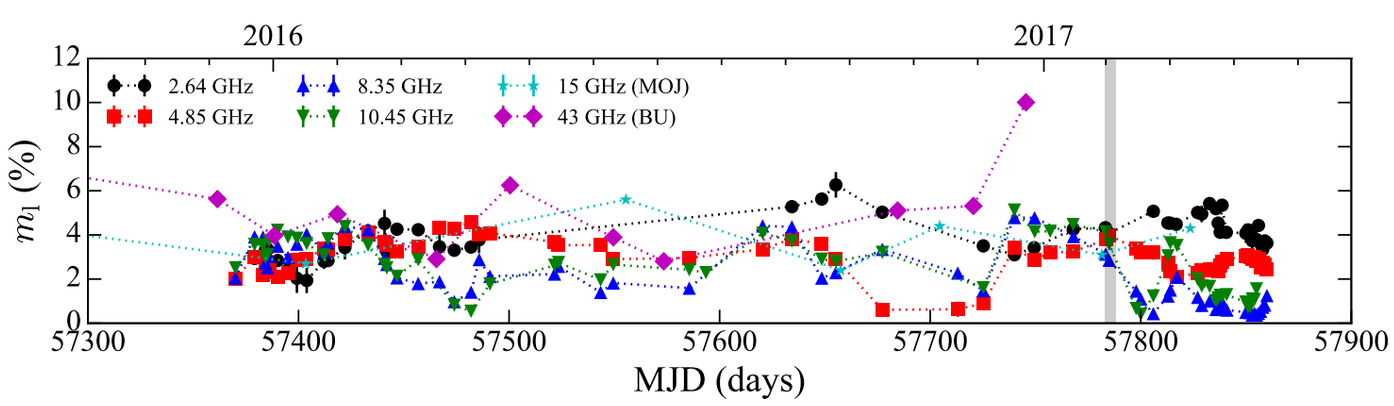

2016
2017
4.85 GHz
8.35 GHz
m_c (%)
MJD (days)

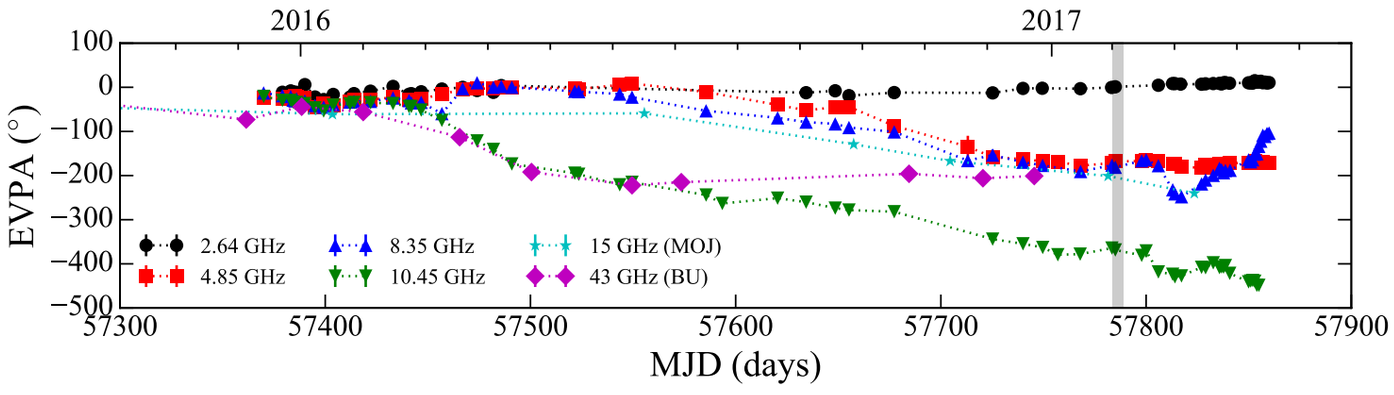

MOJAVE Program


gram
MOJAVE data







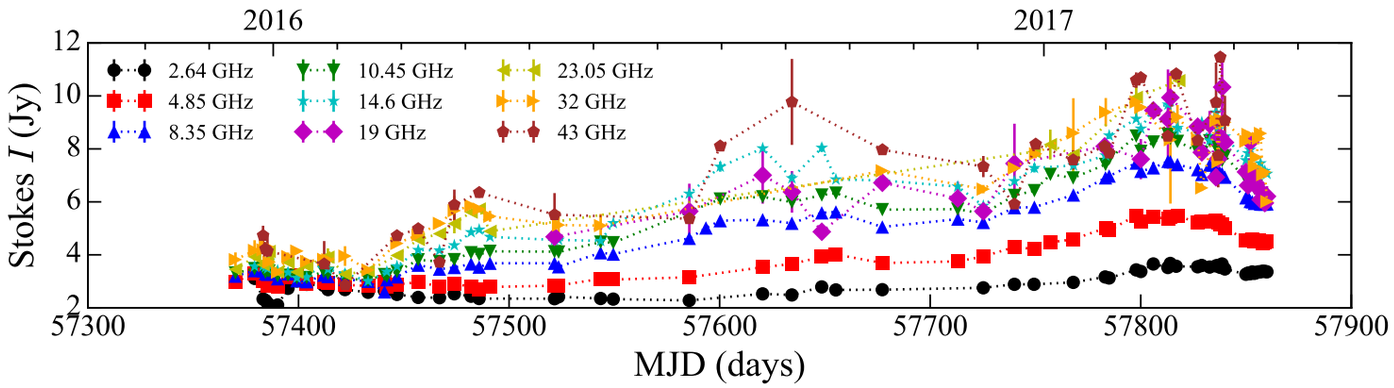


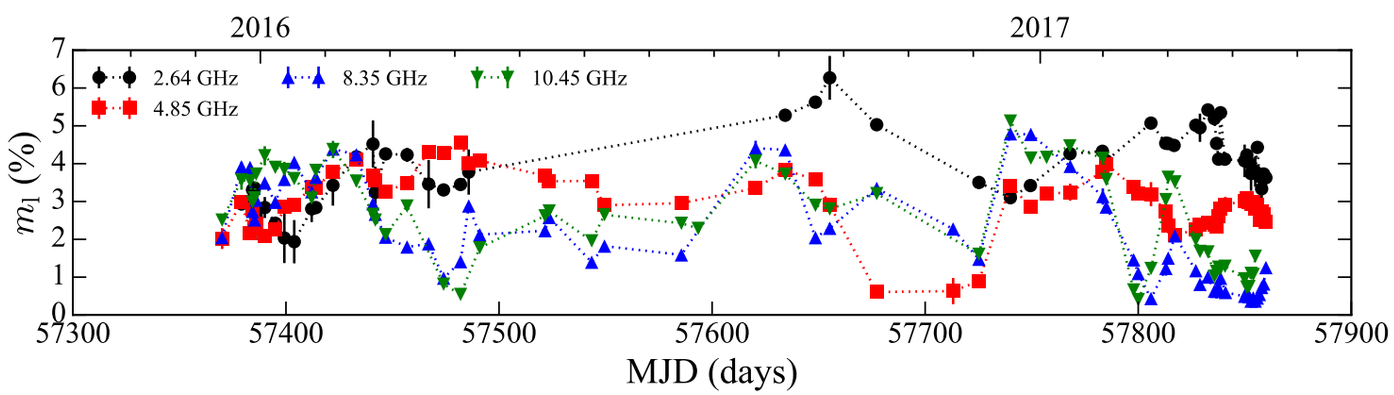
Other bands

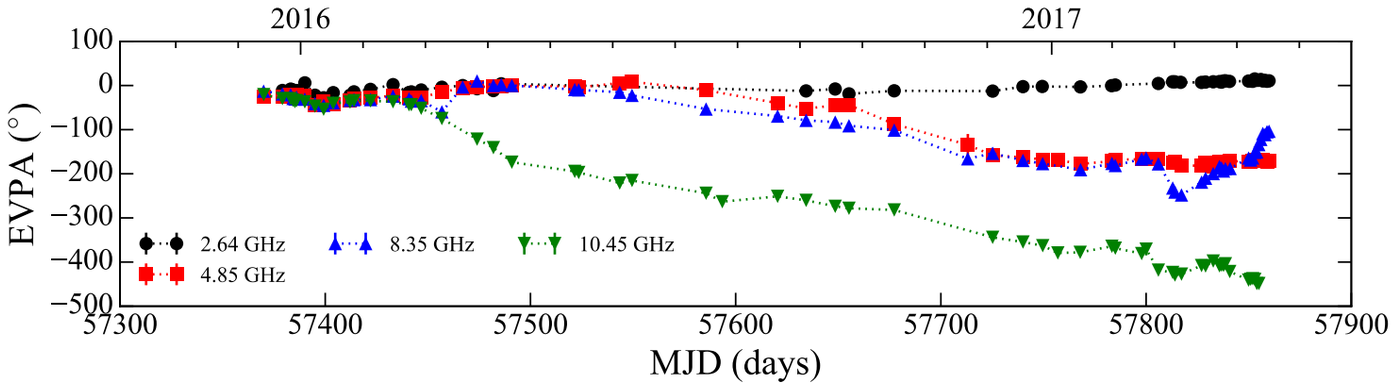
220 GHz (1mm) from SMA
- similar evolution
- lower flux density
  - steep spectrum at mm

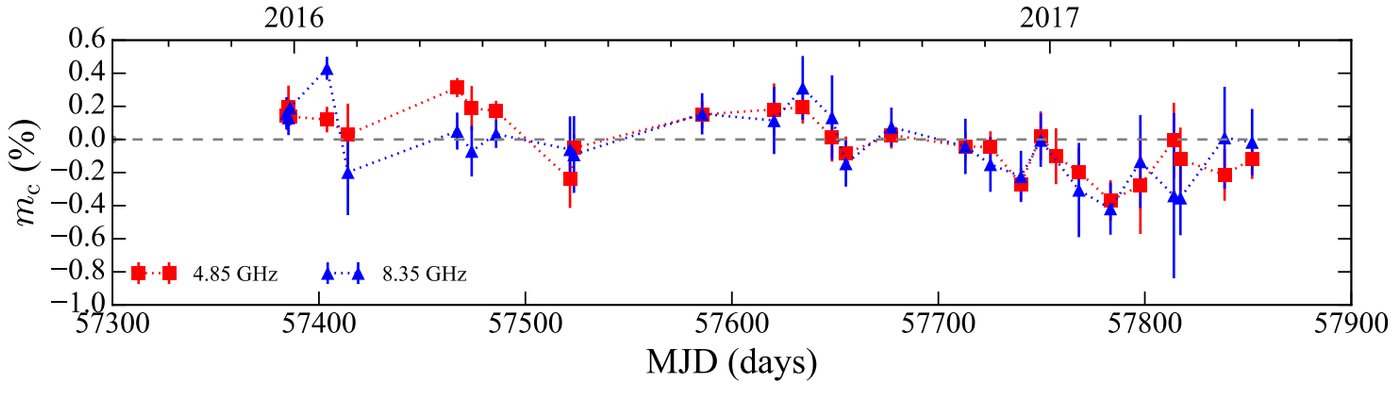
Fermi
- flare at MJD ~57600, simultaneous with a local I maximum
- no flare at (highest) I maximum

TeV
- flare at (highest) I maximum
- first detection









Interpretation (?)

Stokes I increase with flare at MJD ~57800

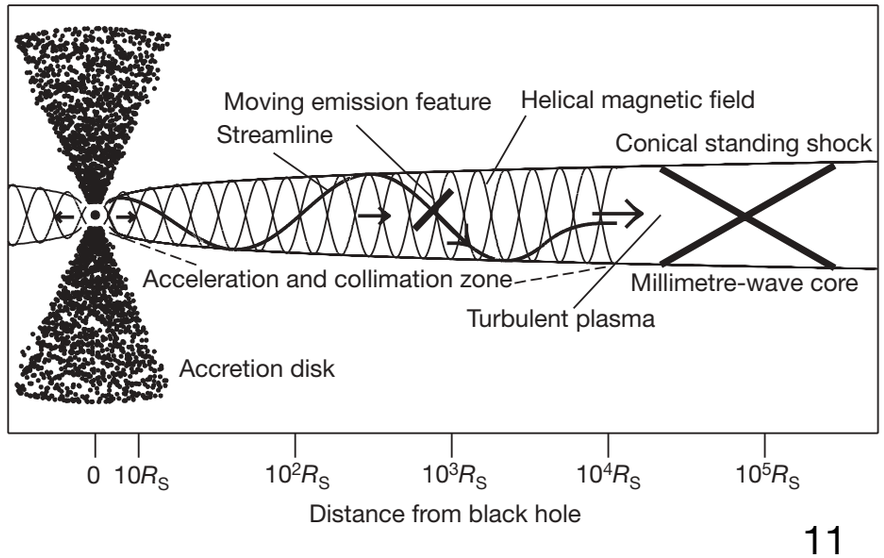
simultaneous LP and I peak(s)

extremely long EVPA rotation

simultaneous CP and I peak

emerging component (?)
EVPA rotation of VLBI core

Marscher et al. 2008, Nature, 452, 966



Summary

High-cadence, full-Stokes monitoring with Effelsberg

- Dec 2015 – now
- mean cadence: 8 days
- LP at 4 frequencies: 2.64, 4.85, 8.35 and 10.45 GHz
- CP at 2 frequencies: 4.85 and 8.35 GHz

Stokes I flare in mid-Feb to mid-Mar 2017
Simultaneous LP and I peaks
opacity transition signature around MJD 57800
Long (up to 430°), CCW EVPA rotation
CP peak at Stokes I flare

BU & MOJAVE: new core component and EVPA rotation

Interpretation

- tracing the helical path or helical B-field component within the core
- opacity transition when the component emerges from the core