

# A short-term VLBI analysis of selected IDV sources

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für  
Radioastronomie



# Aim of experiment

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Observe IDV sources with VLBI on different timescales (one day to two weeks)

—————→ origin of the variations?

Search for:

- Compare single dish results with VLBI. Where does IDV take place?
- IDV related structural changes on VLBI scales on timescales of days to weeks.
- Rapid polarisation and EVPA changes in stationary and moving components.

# The sample

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Four IDV sources were selected for observations based on following criteria:

- Average flux density  $S_{5\text{GHz}} > 1 \text{ Jy}$
- Flat or inverted spectrum with  $\alpha < 0.5$
- Declination  $\delta > 60 \text{ deg.}$
- Well known, IDV type II

Sources:

Name	ID	Z
0716+714	BL Lac	$> 0.3$
0954+658	BL Lac	0.37
0917+624	QSO	1.446
0346+800	QSO	---

# Observations

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- VLBI observations at 5 GHz with
- Simultaneous flux density monitoring at Effelsberg

Source were observed on a total of four epochs on:

- December 3-4, 2000 (A & B)
- December 17-18, 2000 (C & D)

Observations performed with a global of 10 VLBA antennas, each observation lasted 8 hours. Each epoch calibrated and imaged separately using the VLBI Caltech Software Package DIFMAP and AIPS.

# About 0716+714

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- (one of most studied blazars)
- BL Lac with unknown redshift ( $z > 0.3$ )
- (With archetypical behaviour for a blazars)
- Almost always active with a high duty cycle across the electromagnetic spectrum.
- Radio/optical correlation observed by Quirrenbach et. al 1991.
- VLBI structure highly polarised.

# Lightcurve - 0716+714

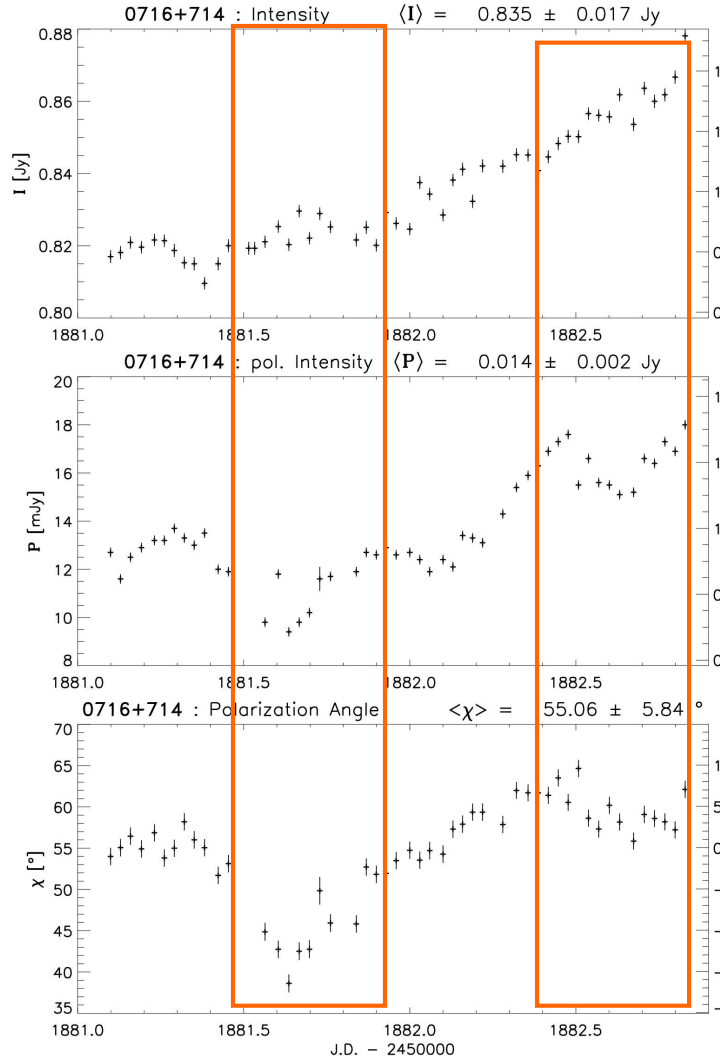
$$m = 2\% X_2^2 = 90.5$$

$$m = 16\% X^2 = 120$$

$$m = 1\% X_2^2 = 16.4$$

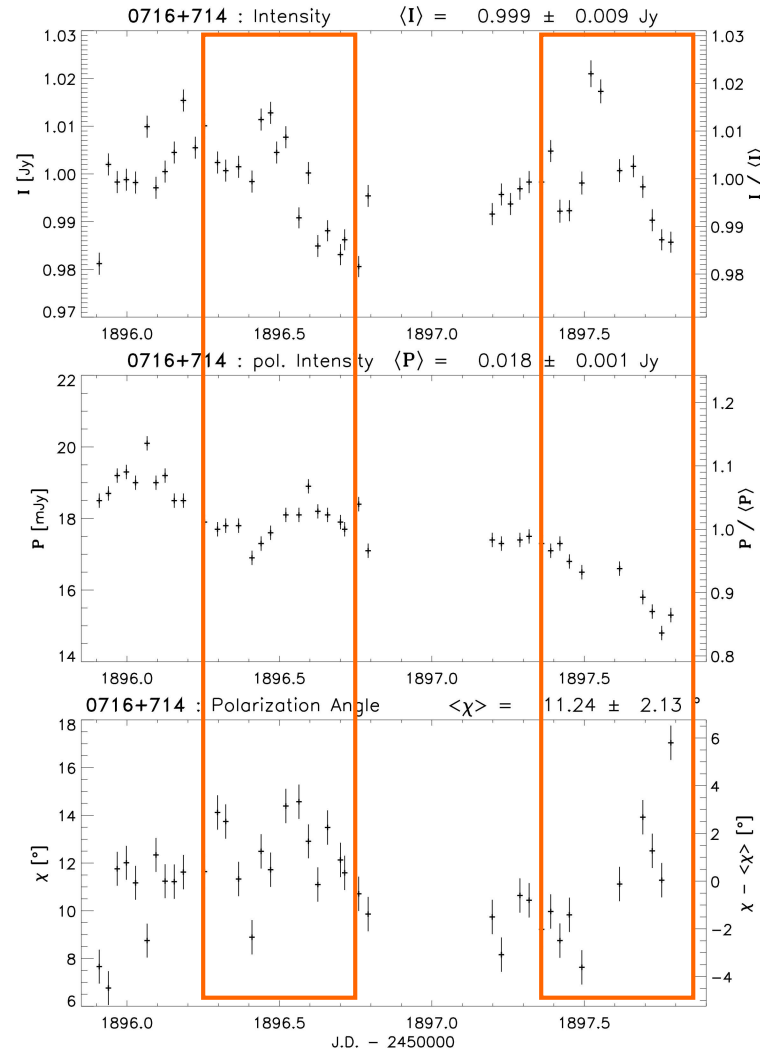
$$m = 6.5\% X^2 = 32.5$$

VLBA day3-4  $\lambda = 6\text{cm}$



A

B



C

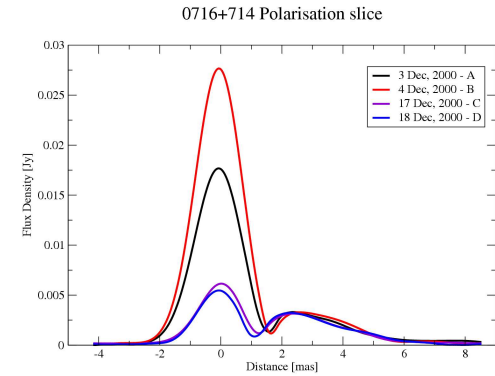
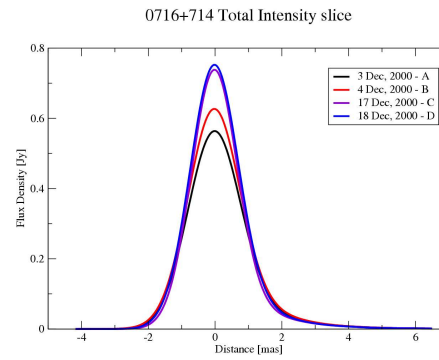
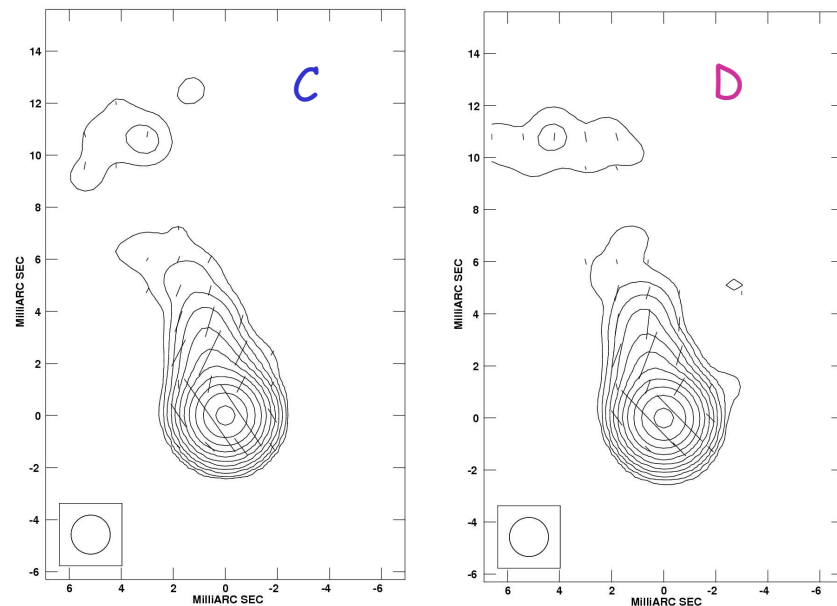
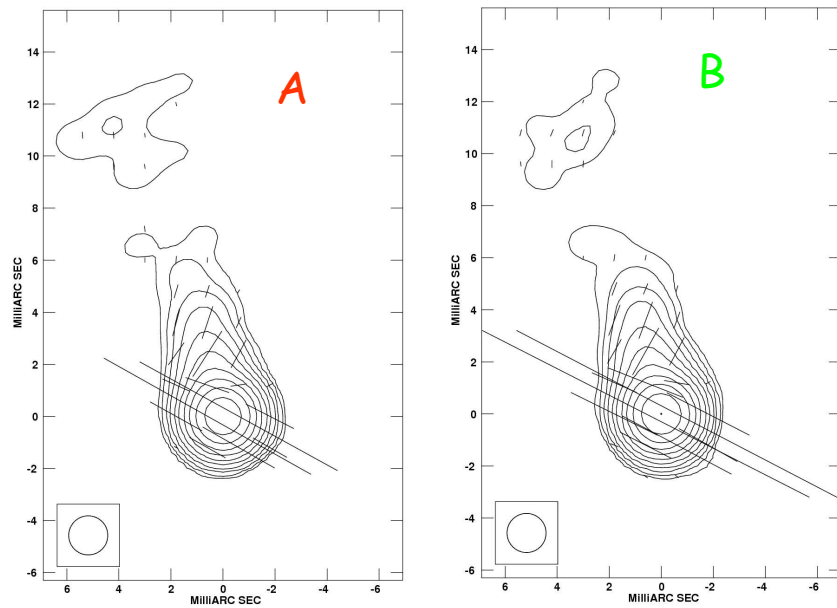
D

- Total flux density rise of 25% from A to C.

- 40 % peak-to-peak flux density increase in polarisation from A to B.

- $40^\circ$  polarisation angle variation between B & C.

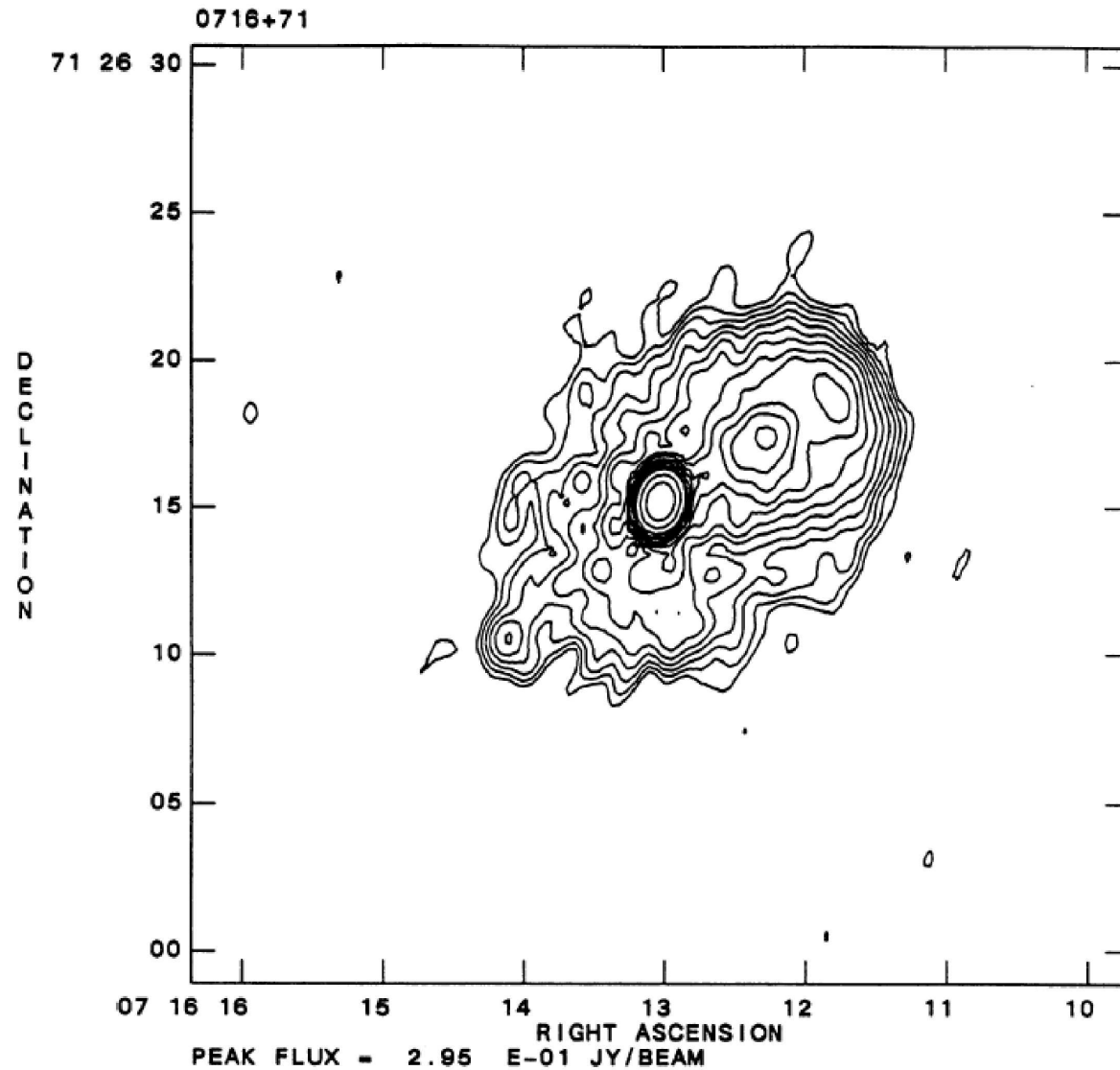
# VLBI-0716+714



- No significant structural changes.
- Total flux density increase from  $0.7 \pm 0.04$  Jy to  $0.94 \pm 0.05$  Jy.
- Polarised flux density:
  - \* increase by 60% in the core from A to B
  - \* decreases from  $32.2 \pm 1.5$  mJy to about  $9.0 \pm 0.05$  mJy in C and D.
- $40^\circ$  EVPA rotation between C and D (from  $55 \pm 5^\circ$  to  $15 \pm 5^\circ$ )

# 0716+714 VLA map

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Antonucci et al. 1986



# About 0917+624

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- Quasar with redshift of  $z = 1.446$
- Pronounced IDV property until 1998, with usual amplitude variations on a 10-15 % level
- Fast variability also observed in linearly polarised flux density and polarisation angle with:
  - large fractional amplitudes (factor 2 in polarised flux density)
  - A 180-degree change observed (Quirrenbach et. al 1989)
- Since September 1998 fast variability ceased
- During February 1999 source appeared to have returned to usual variability but stopped again in 2000.
- Possible annual modulation (Rickett et al. 2001, Jauncey & Macquart 2001, Fuhrmann 2004).

# Lightcurve - 0917+624

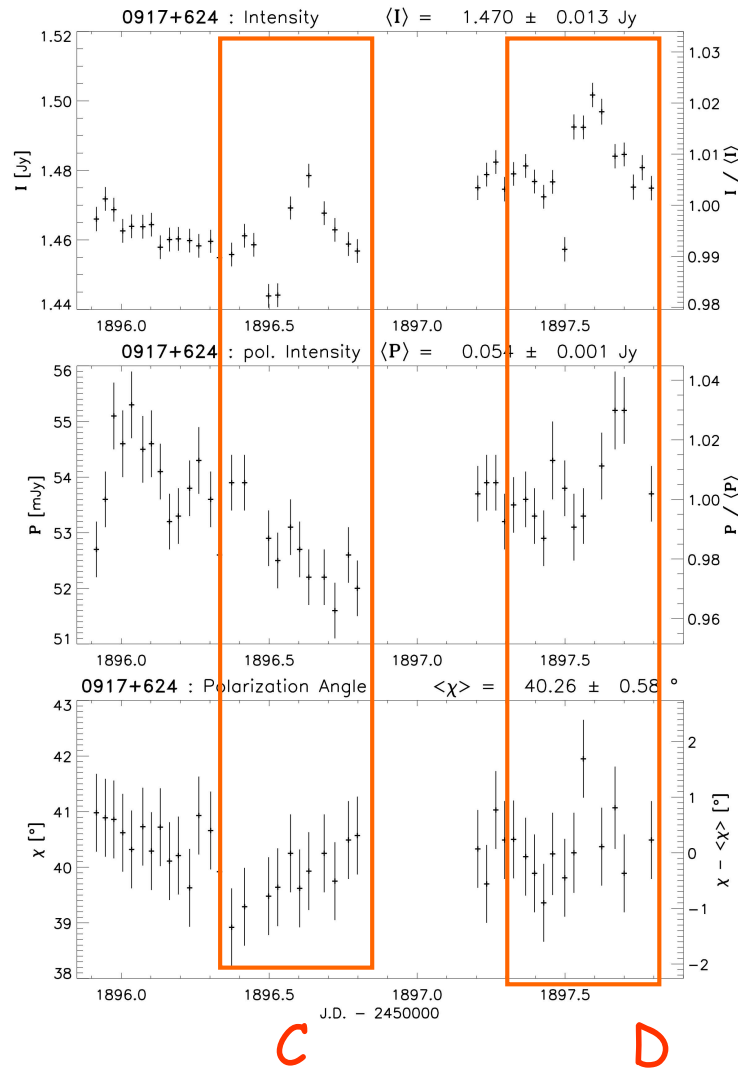
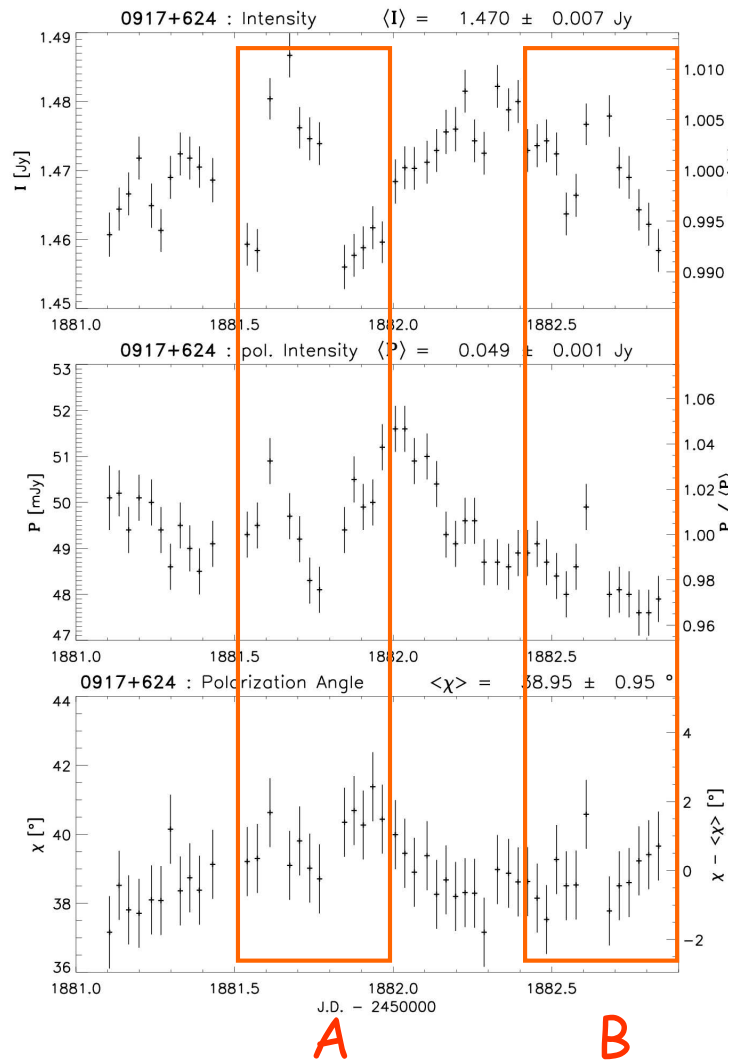
$$m = 0.5\% X^2 = 1.4$$

$$m = 2\% X = 4$$

$$m = 0.9\% X^2 = 14$$

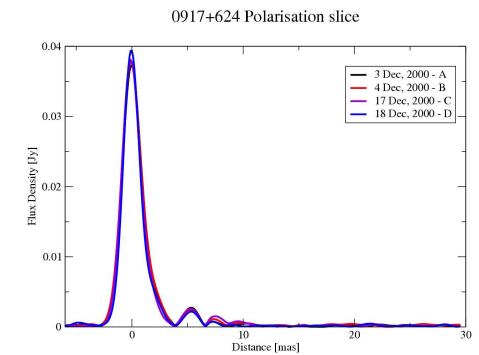
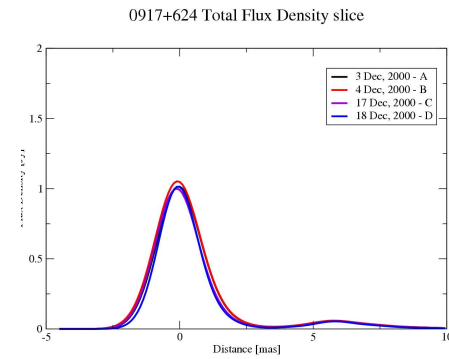
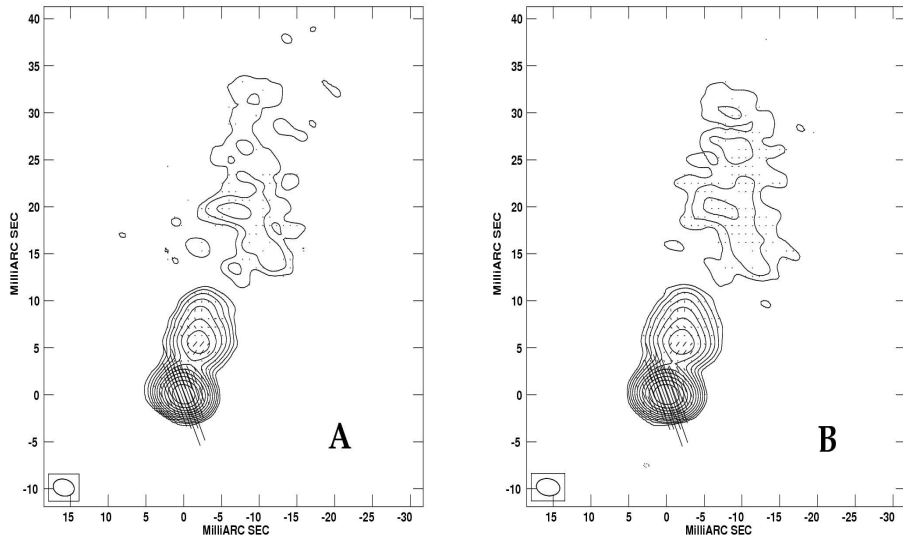
$$m = 1.7\% X = 2.7$$

VLBA day3-4  $\lambda = 6\text{cm}$



- Total flux density variations of about 15%
- max 20% variation in polarised flux density.
- EVPA constant at about  $40^\circ \pm 3$  in all epochs.

# VLBI - 0917+624

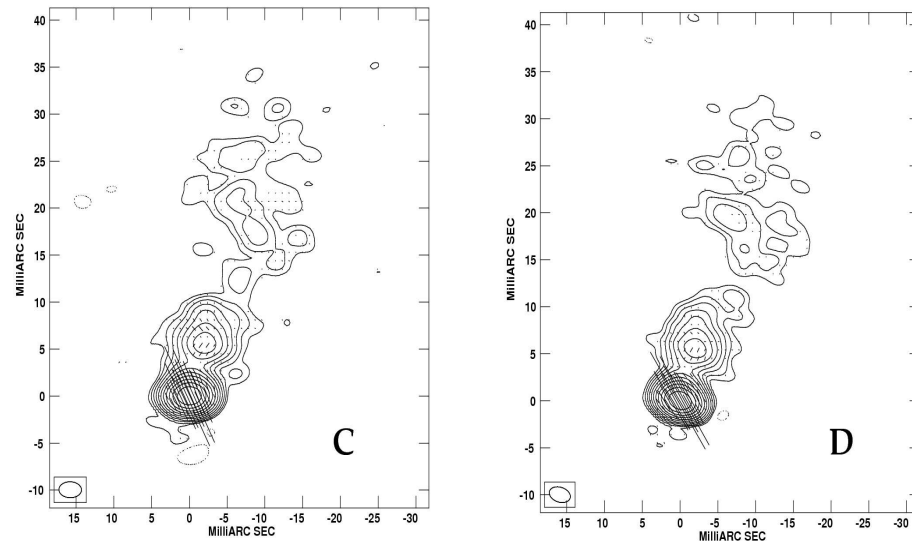


- Total flux density constant at about  $1.17 \pm 0.05$  Jy

- Polarisation also constant in all epochs at  $44 \pm 2$  mJy

- EVPA at  $30 \pm 5^\circ$

- No detectable changes in the four VLBI epochs



# About 0954+658

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- Classified as a BL Lac for its nearly featureless spectrum.
- Redshift  $z = 0.367$
- Has been reported to show IDV in both total and polarised flux density (Wagner & Witzel 1992).
- Coordinated observations showed possible correlations between radio and optical (Wagner et. al 1993).
- An extreme scattering event observed (Fiedler et al. 1987)
- Radio flux variations of the order of 30-50% on two days explained as ‚single‘ scattering event (G. Cimò 2002) – (some of the variation not intrinsic.)

# Lightcurve - 0954+658

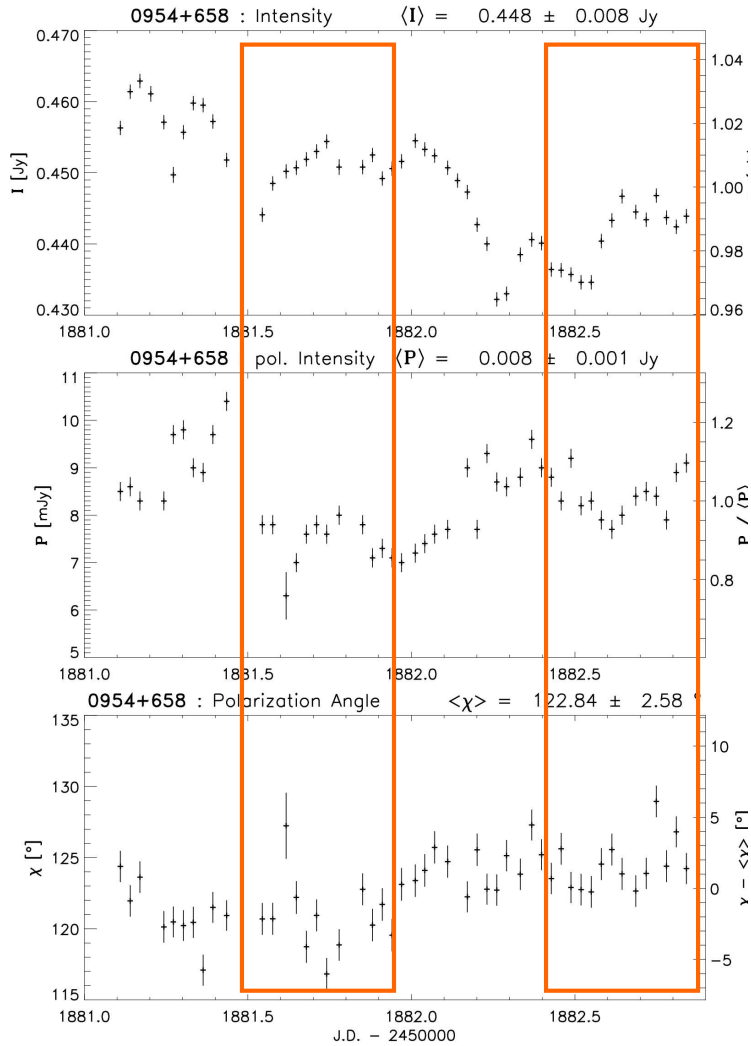
$$m = 1.8\% \quad X^2 = 62.5$$

$$m = 10.5\% \quad X = 16.6$$

$$m = 1.4\% \quad X^2 = 33$$

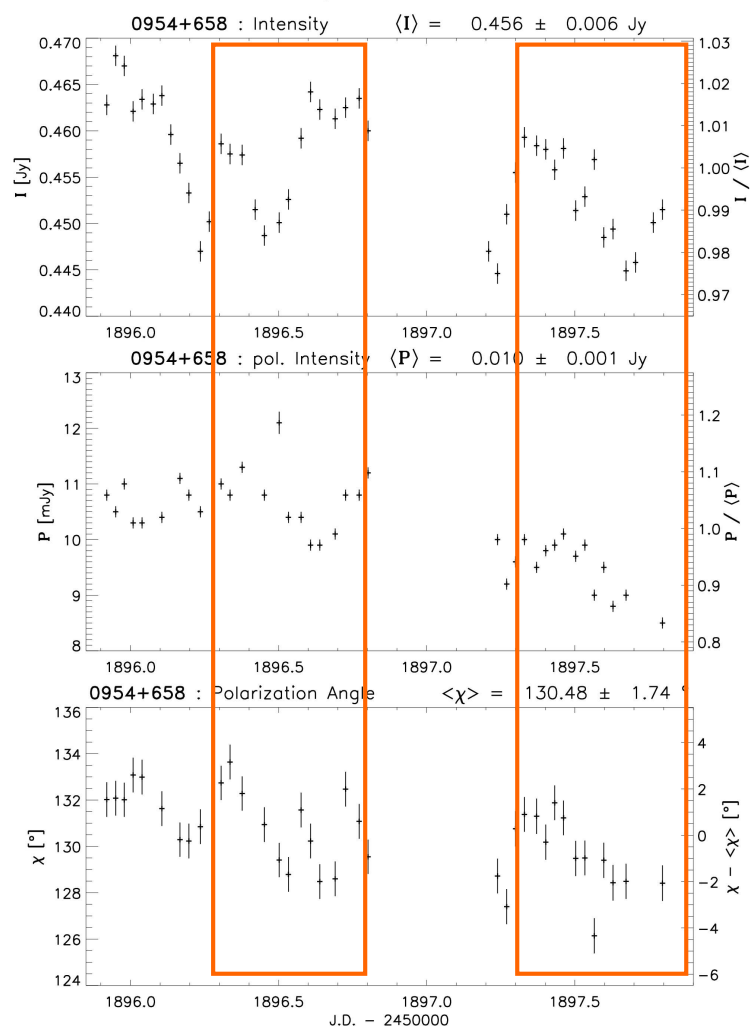
$$m = 7.5\% \quad X = 51.8$$

VLBA day3-4  $\lambda = 6\text{cm}$



A

B



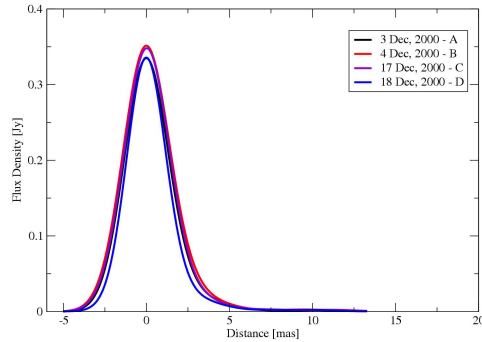
C

D

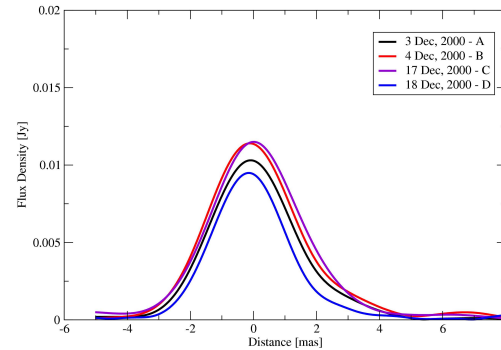
- Total intensity variations of the order of 5%
- Polarisation variations of order of 25%.
- EVPA of  $125 \pm 3$

# VLBI - 0954+658

0954+658 Total Flux Density slice



0954+658 Polarisation slice

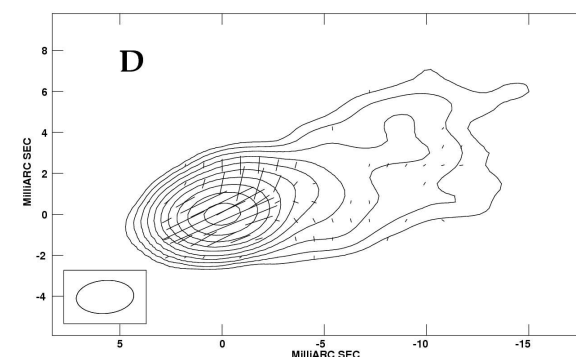
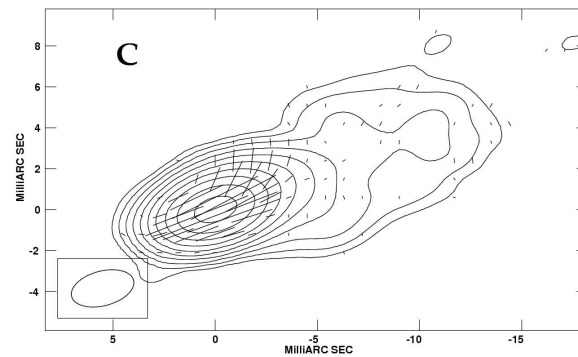
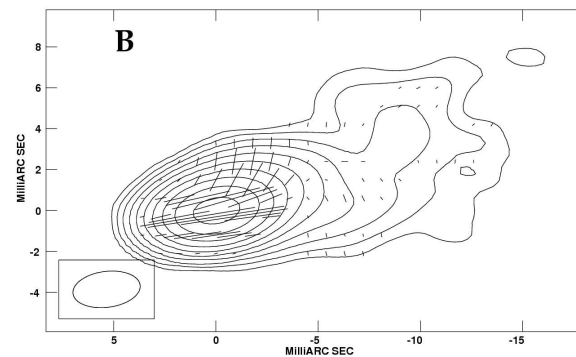
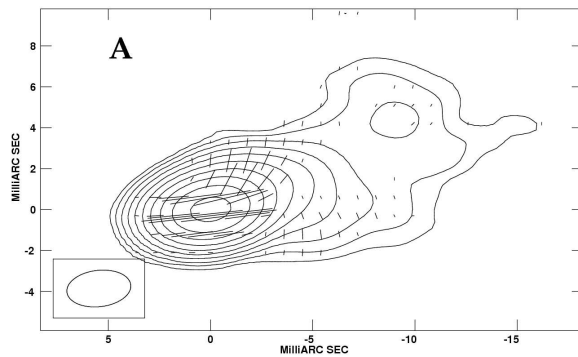


- Total flux density increase of 5% between A & B
- Subsequent 8% decrease in last epoch ( $0.34 \pm 0.02$  Jy).

- Changes relative mostly to the core but within errors.

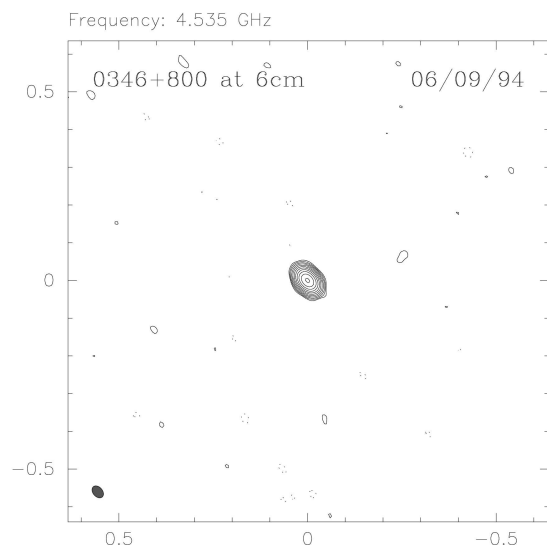
- 20% polarised flux variations.

- $15^\circ$  turn in EVPA from B to C (from  $-73 \pm 3^\circ$  to  $-57 \pm 2^\circ$ )



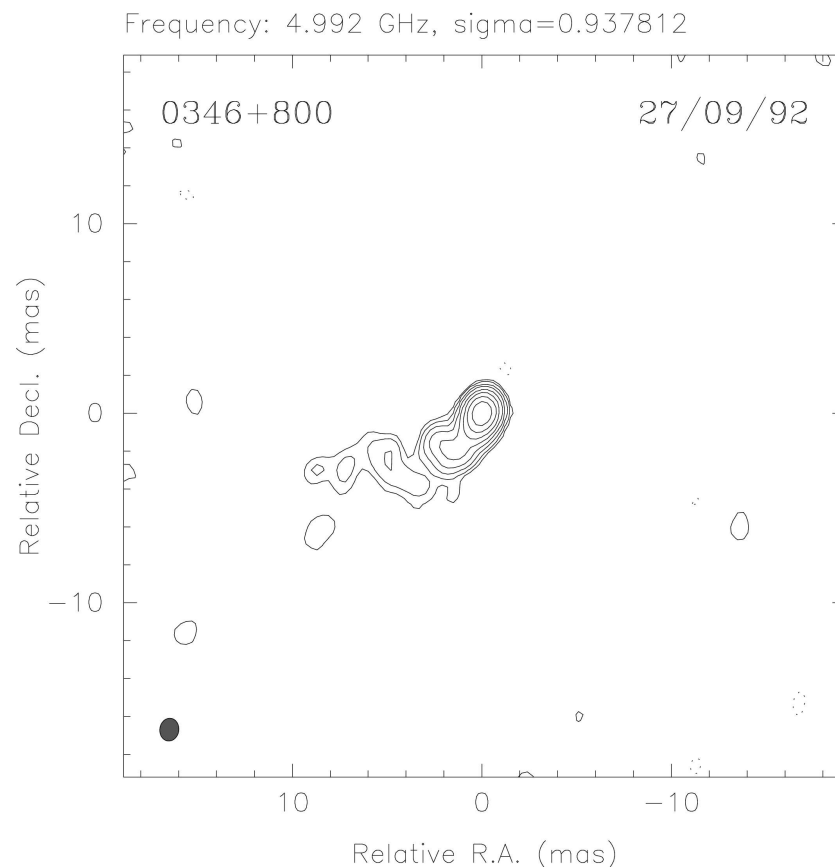
# 0346+800

- (from VLBA calibrator list)
- No redshift known (source weak, no lines)
- Spectral index 0.44
- Source relative compact with a flat high frequency spectrum (should show IDV?)



Maximum: 0.4489 JY/BEAM  
Contours (%): -0.09 0.09 0.18 0.36 0.71 1.43 2.85 5.70 11.41 22.81  
Contours (%): 45.63 91.25  
Beam: FWHM 0.04 x 0.03 arcmin, p.a. 41.4°  
File: 0346+800.1.fits (20-Apr-1995 15:09)

VLA image



Maximum: 0.2617 JY/BEAM  
Contours (%): -0.40 0.40 0.80 1.60 3.20 6.40 12.80 25.60 51.20  
Beam: FWHM 1.21 x 1.00 mas, p.a. -7.6°  
File: 0346+800.cmp\_n (29-Sep-1994 19:41)  
MAPPLOT (v5.1 - 1994 Nov 10) run by gbt [bottom], 4-Jan-1995 08:42:5

CJ Survey

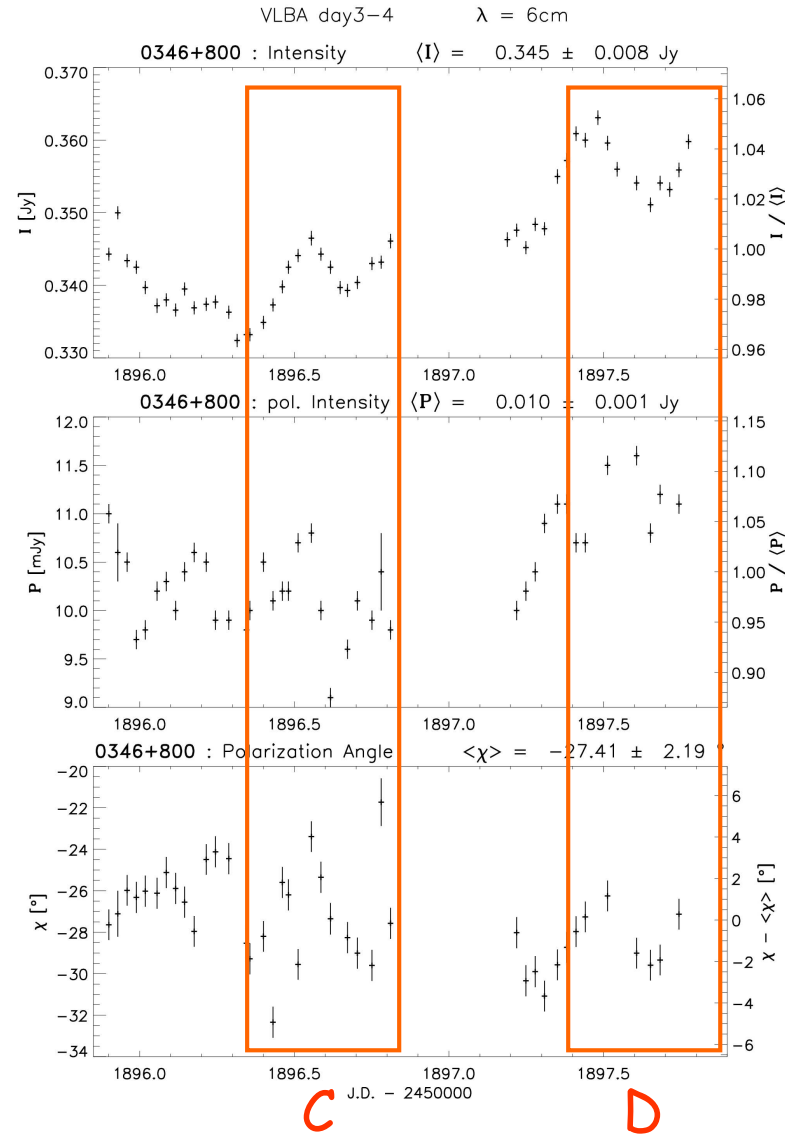
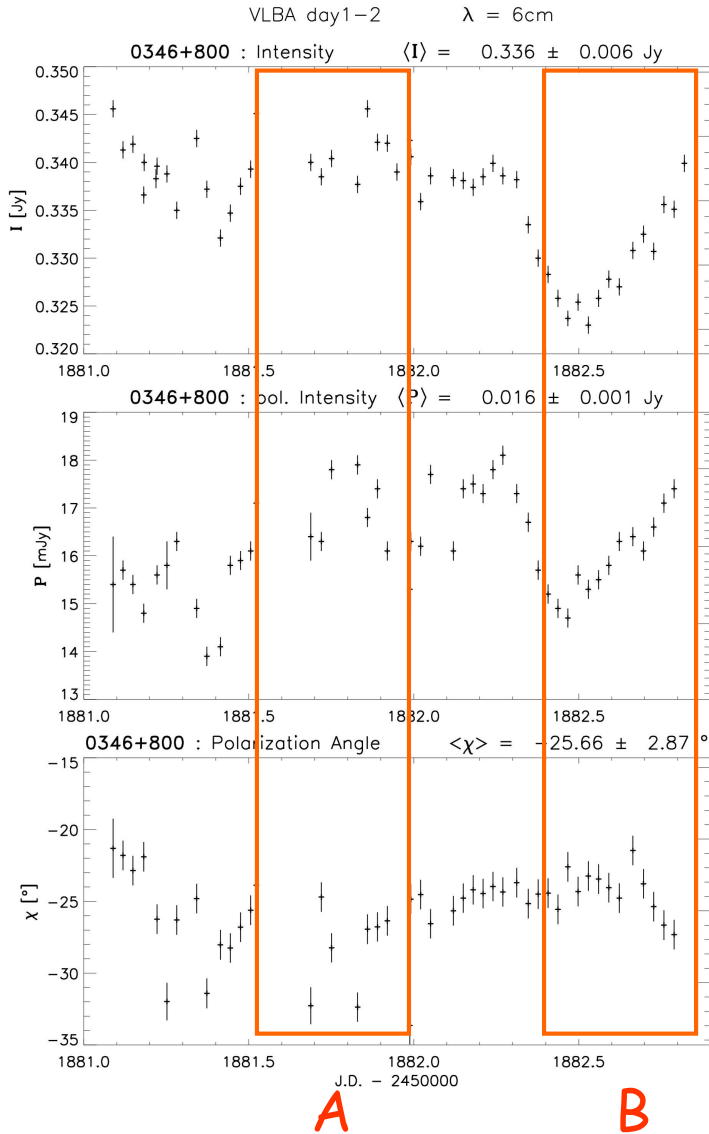
# Lightcurve -0346+800

$$m = 1.7\% \quad X^2_2 = 42$$

$$m = 6.3\% \quad X^2 = 25$$

$$m = 2\% \quad X^2_2 = 76$$

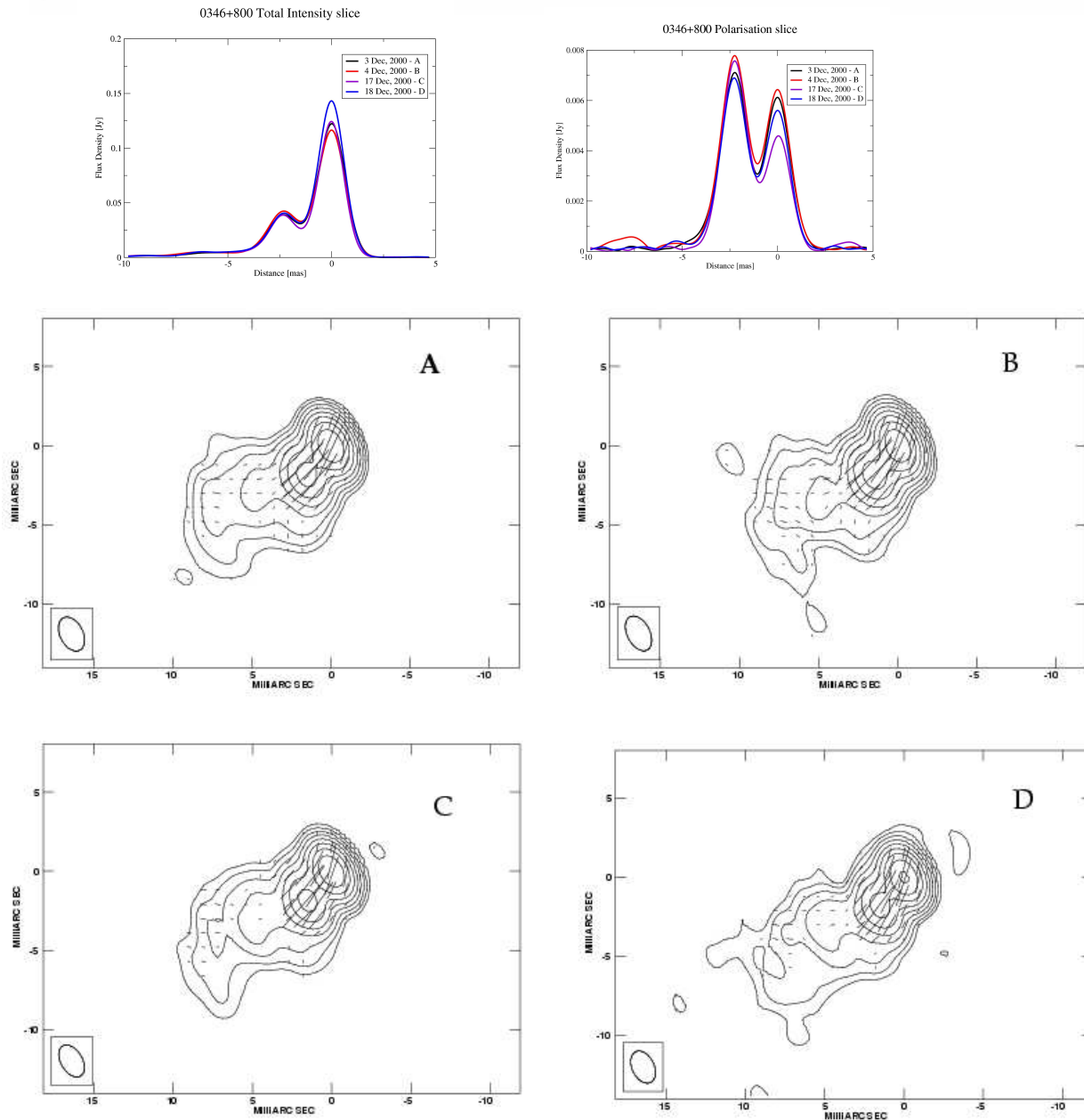
$$m = 5.2\% \quad X^2 = 29$$



- 3% decrease in total flux (A to B)
- 10% rise in C and D.
- Polarisation decreases from  $17 \pm 2 \text{ mJy}$  in A&B to  $10 \pm 1 \text{ mJy}$  in C& D.
- No changes in EVPA at  $-25 \pm 2$  deg.



# VLBI- 0346+800



- Total flux density drop from A to B
- 10% rise in C and D (from  $0.12 \pm 0.01$  Jy to  $0.2 \pm 0.017$ )
- Variations related to VLBI core.
  
- 40% variations in polarised flux density in VLBI core.
  
- EVPA change from  $-31 \pm 4$  in A and B to  $-25 \pm 3$  in C and D.

# Conclusions

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- For the first time known IDV sources were observed with the VLBI on daily up to weekly timescales in connection with single dish measurements
- Variations on a 5-10% level detected in both total intensity and polarisation in almost all sources and are attributed to the core of the sources.
- No changes in the structure and position of the components was detected within two weeks in any of the sources.
- Most variability in 0716+714 with a 40% rise in polarization measured with Effelsberg was also confirmed with VLBI maps.
- 30 deg rotation in position of electric vector in the core of 0716+714 on a timescale of two weeks.
- All variations related to IDV occur in the unresolved VLBI core of the maps
  - are changes due to multiple components?
- Higher resolutions observations needed to resolve the VLBI core.