

Radio Imaging of RS Oph

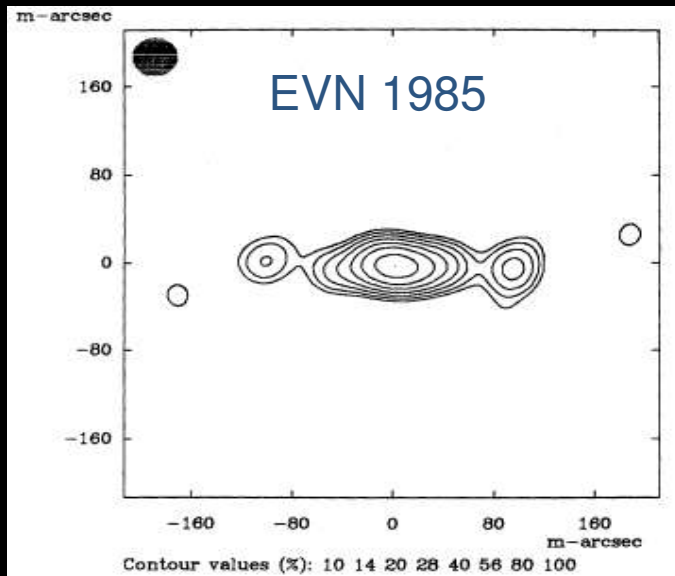
Tim O'Brien

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Bode (Liverpool), Porcas (MPIfR),
Muxlow, Beswick, Garrington, Vaytet, Davis (Manchester),
Eyres, Rushton (Central Lancs), Evans (Keele)

Radio observations in 1985

- Jodrell MkIa-MkII Interferometer from $t = 18d$, VLA, European VLBI Network
Padin et al (1985), Hjellming et al (1986), Porcas et al (1987), Taylor et al (1989)

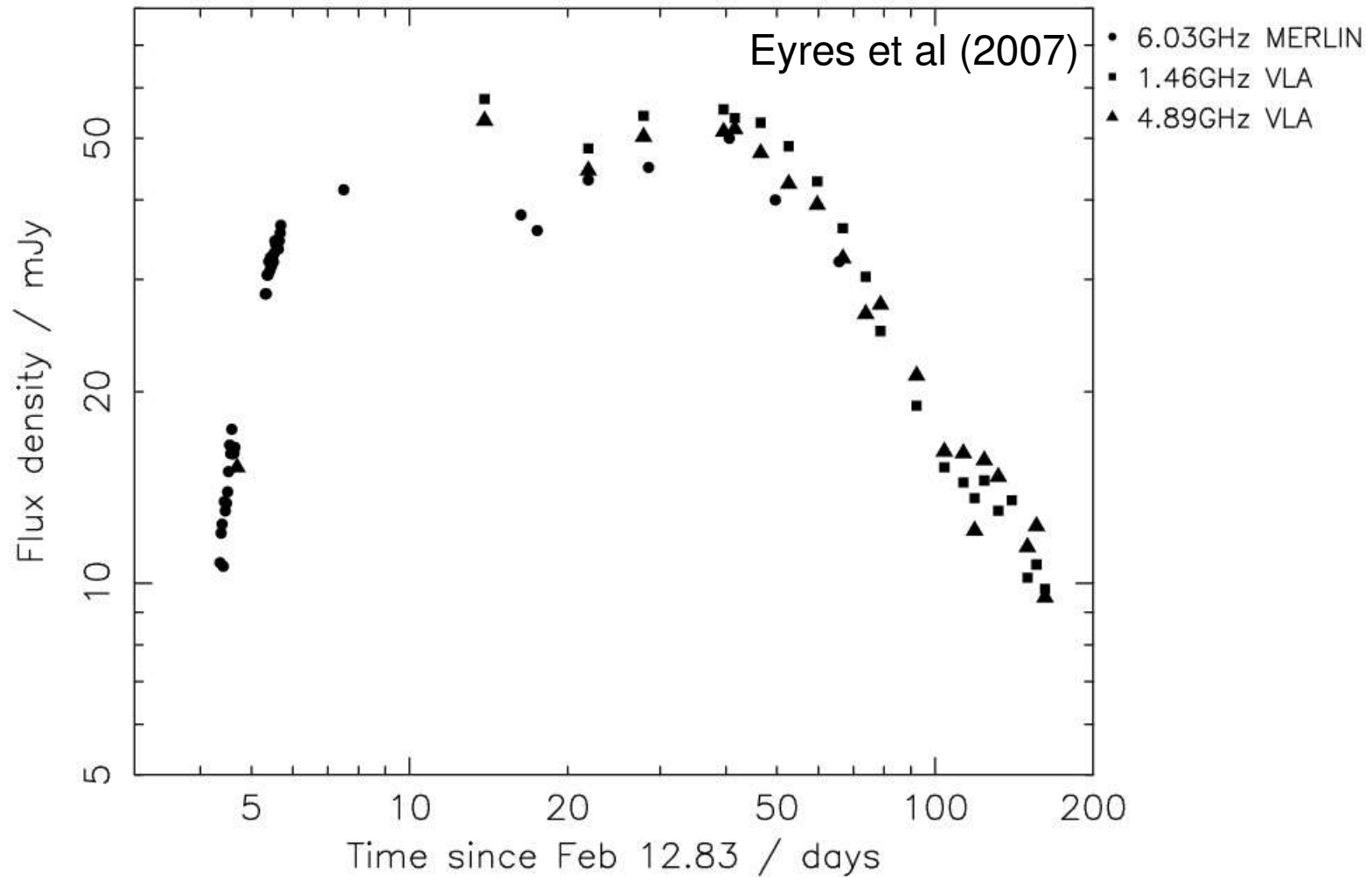


Effelsberg, Jodrell, Westerbork,
No fringes on JB-Wb

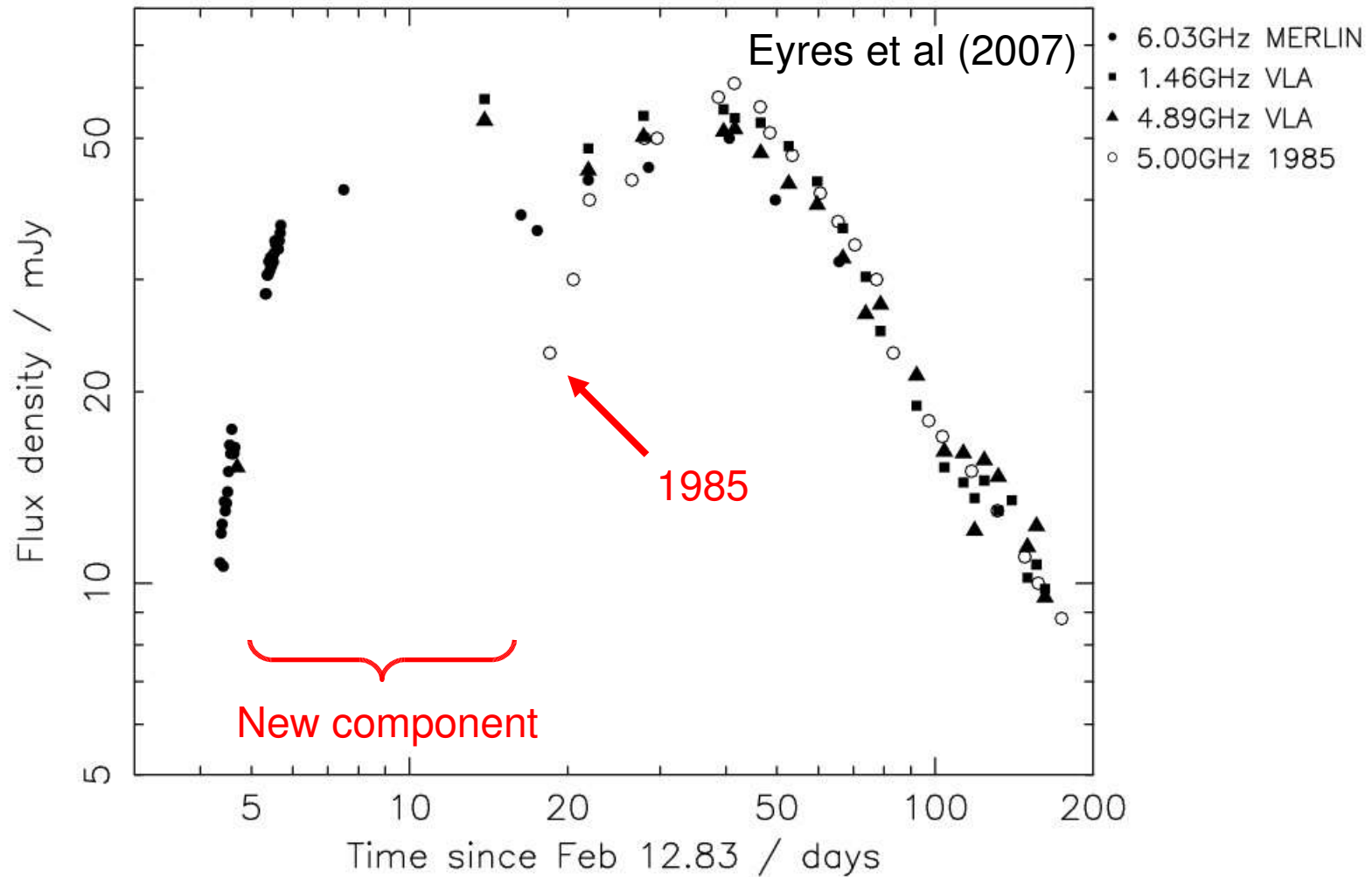
2006

- Monitoring from day 4.5 onwards with MERLIN, VLA, VLBA, and EVN (also GMRT & OCRA).

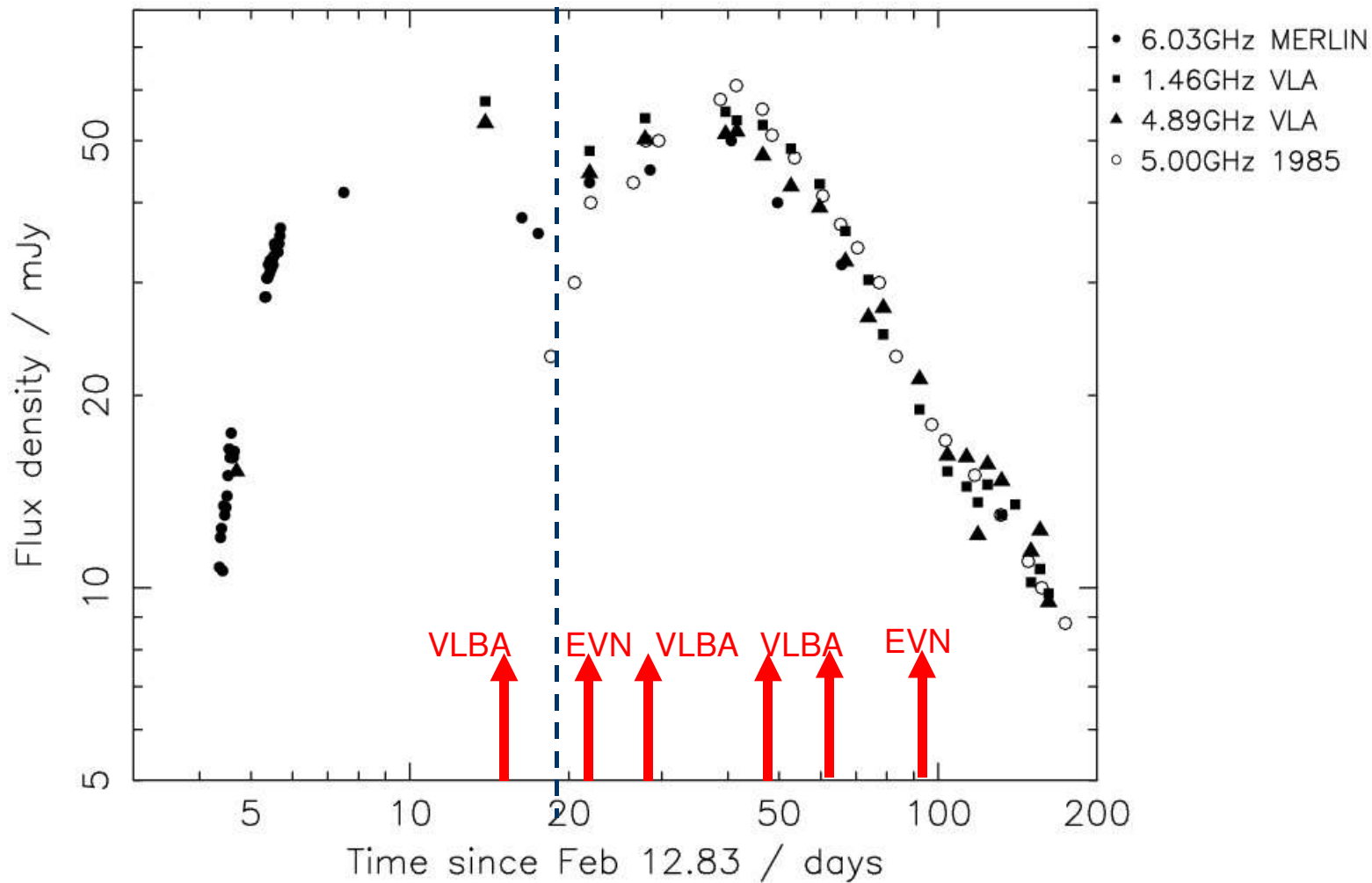
L/C-Band Lightcurve



L/C-Band Lightcurve



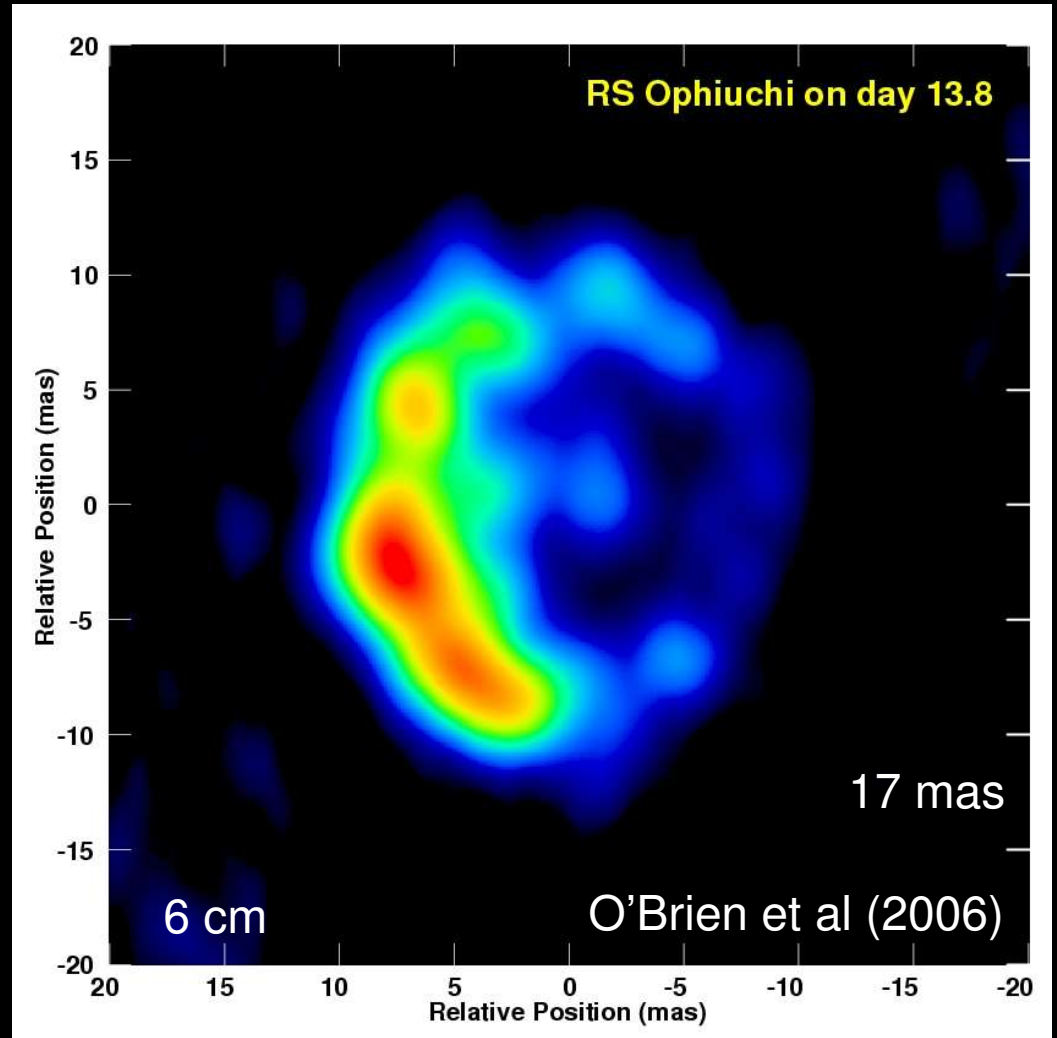
VLBI Imaging



First VLBI image – Day 13.8

VLBA image reveals the shock wave in RS Oph for the first time. Earliest resolution of structure in any such explosion.

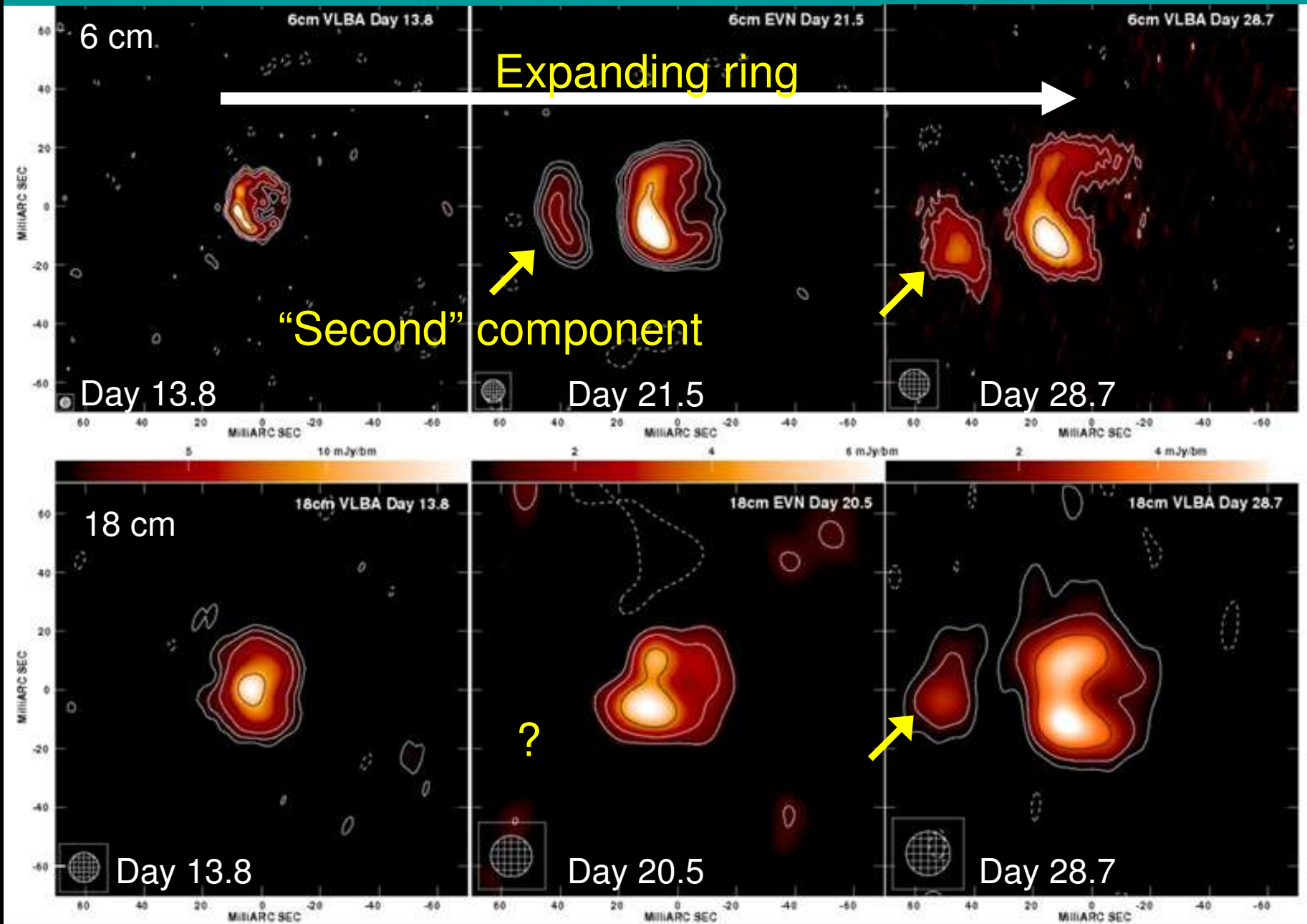
Res'n ~ 3 mas (5 AU)
Peak $T_b \sim 4 \times 10^7 \text{K}$
Non-thermal.



VLBA

EVN

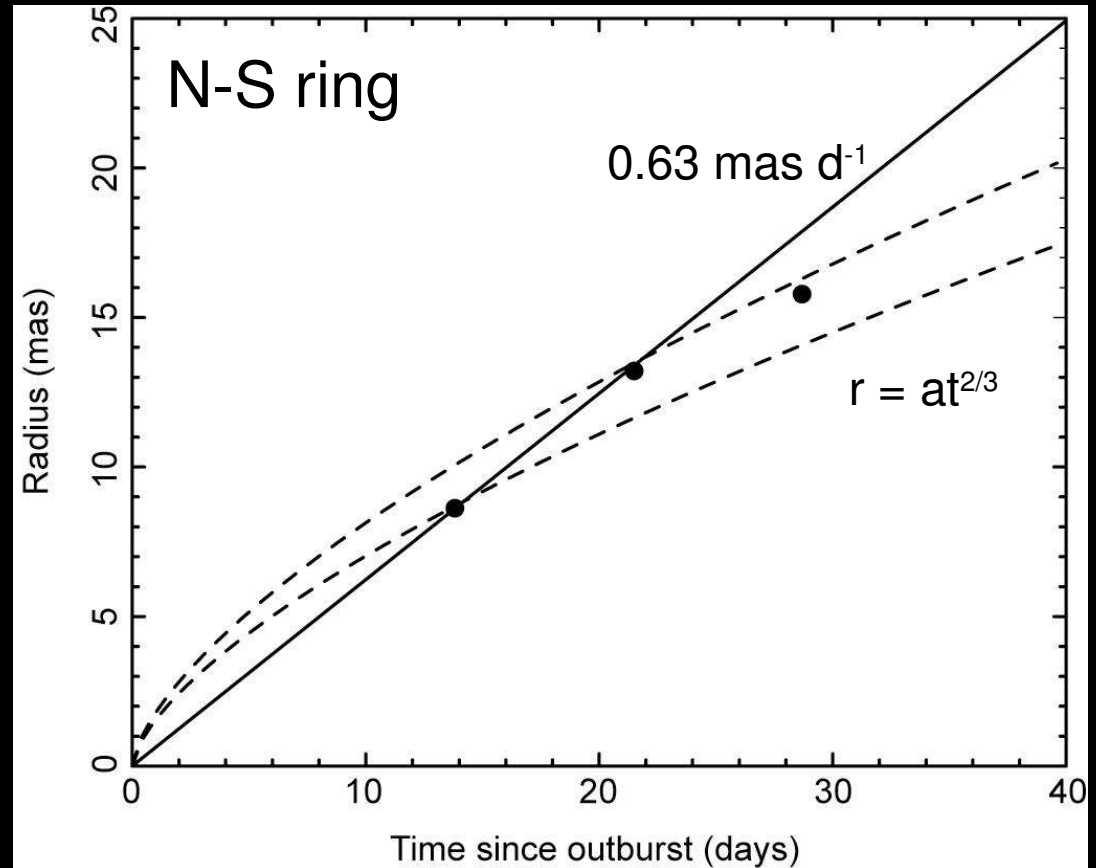
VLBA



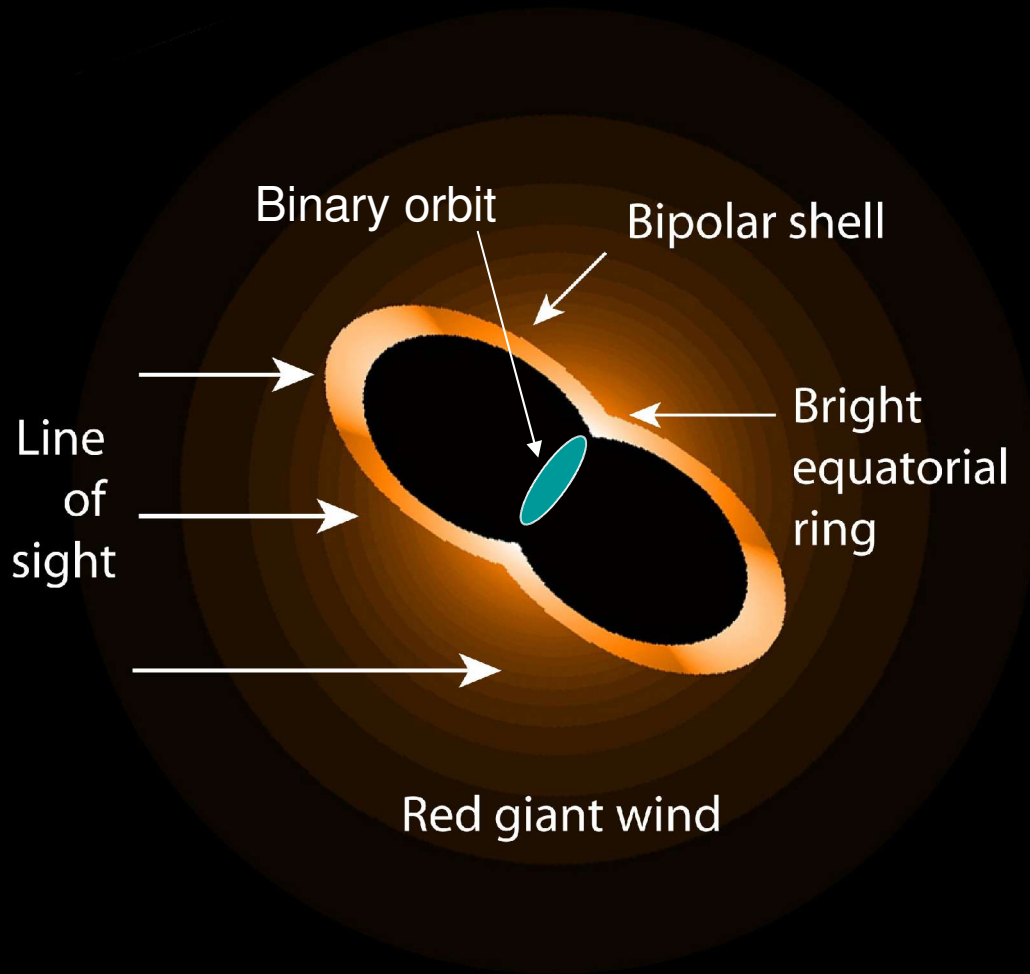
Expansion velocity

N-S ring =
0.63 mas/d
= 1750 km s⁻¹ at
1600 pc
Consistent with
X-ray temp's.

2nd component =
4000 km/s in
plane of sky



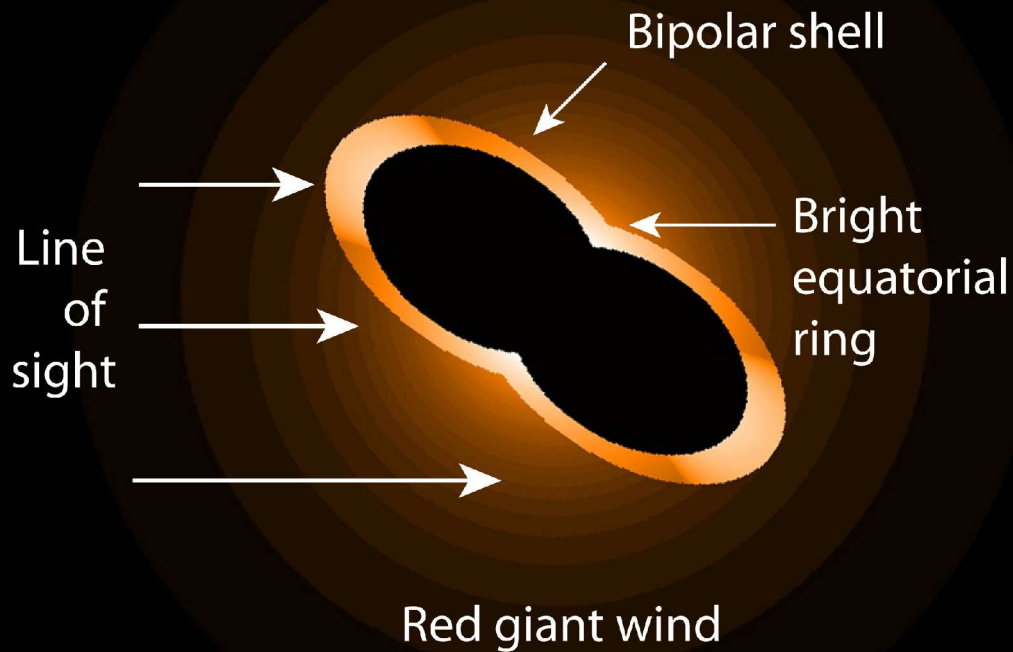
A simple model



Bipolar shell viewed at the (known) inclination of the binary orbit and partially obscured by the overlying red giant wind.

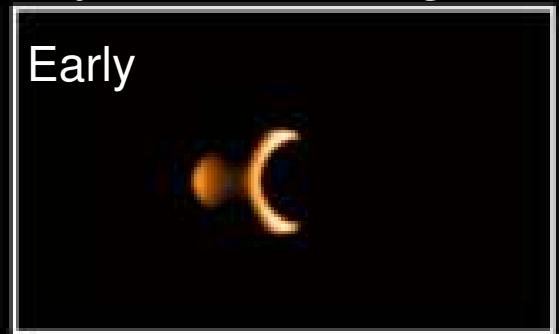
A simple model

As the source expands the overlying free-free absorption is reduced and it becomes symmetrical.

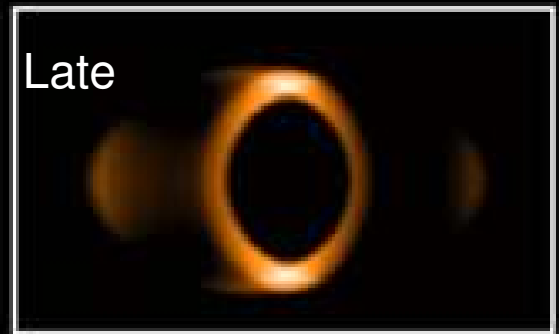


Synthetic images

Early



Late



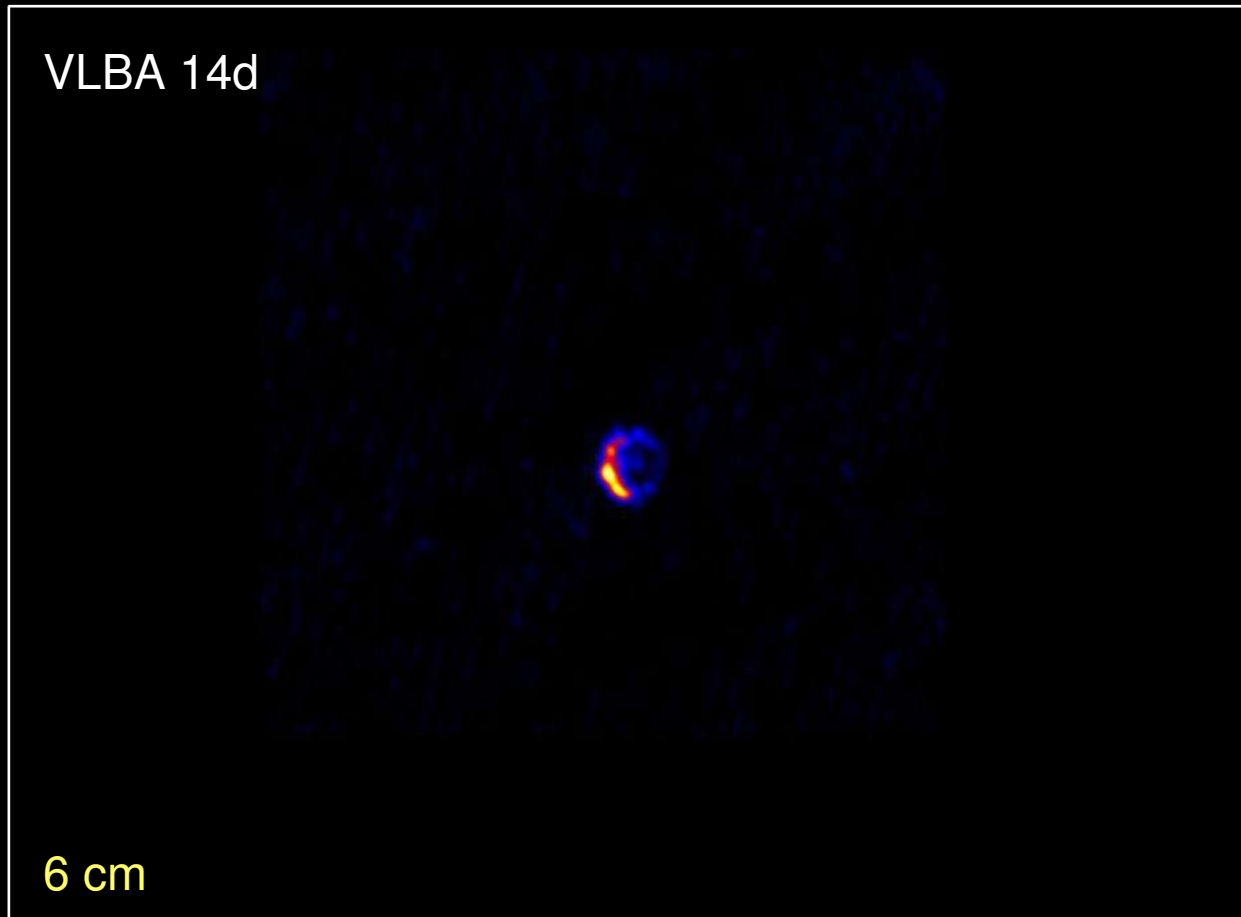
MERLIN imaging

- Second component to east clearly visible from day 21 onwards.
- Third component to west visible around day 50.
- Source evolves into E-W structure.

MERLIN Radio observations
of the 2006 outburst of
RS Ophiuchi

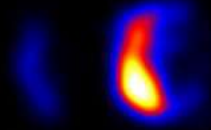
(O'Brien, Muxlow,
Beswick et al)

VLBI Sequence



VLBI Sequence

EVN 22d

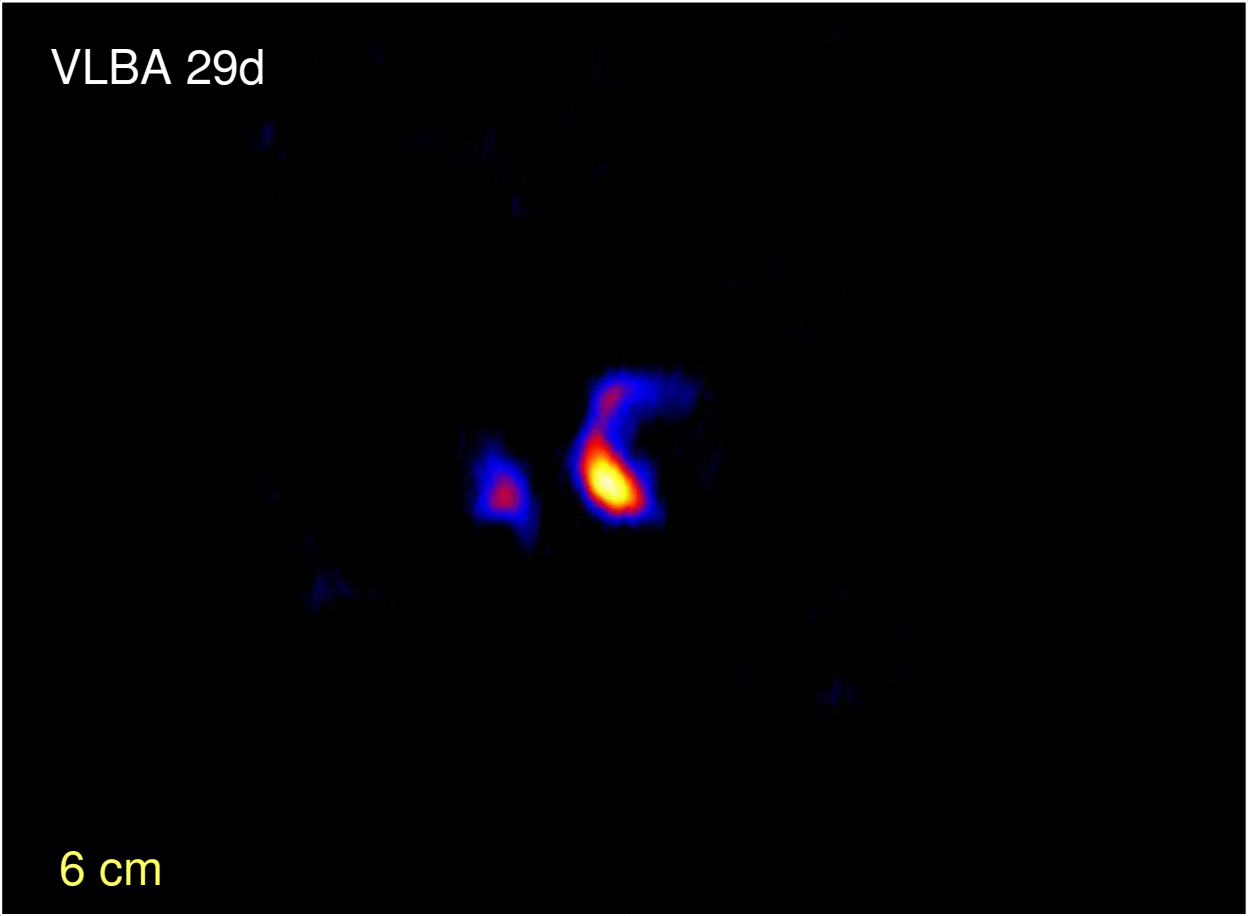


6 cm

VLBI Sequence

VLBA 29d

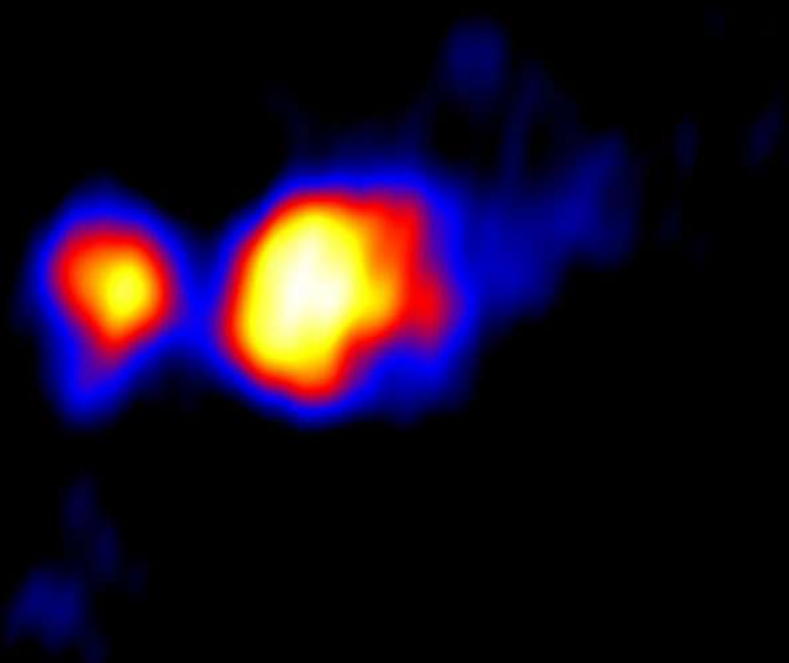
6 cm

A VLBI image showing a bright source with a jet-like structure. The image is a color map where the brightest part is yellow, transitioning to red and then blue. The source is located in the center-right of the frame. There is a smaller, fainter source to its left. The background is dark with some faint blue spots.

VLBI Sequence

VLBA 49d

18 cm



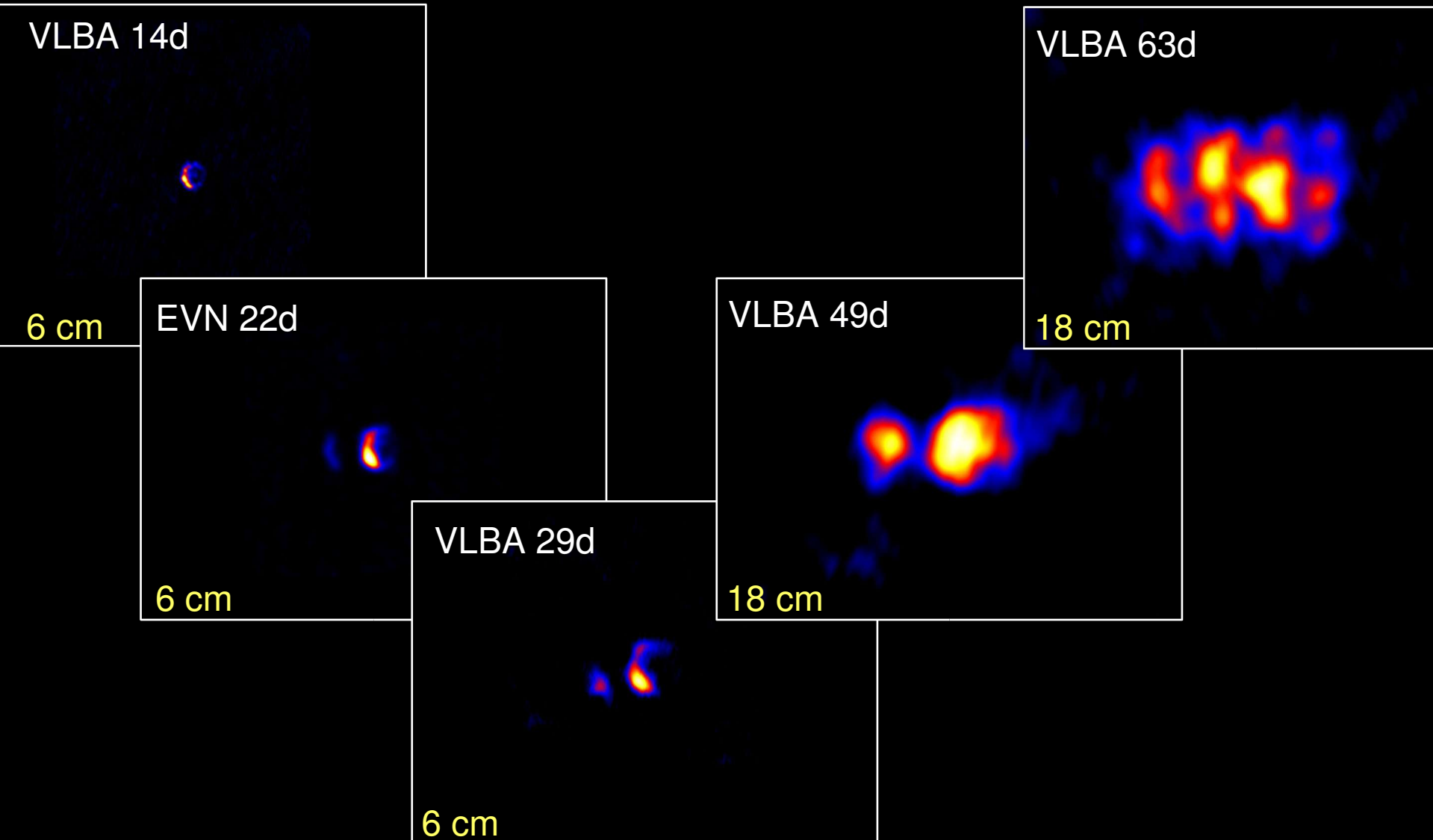
VLBI Sequence

VLBA 63d

18 cm

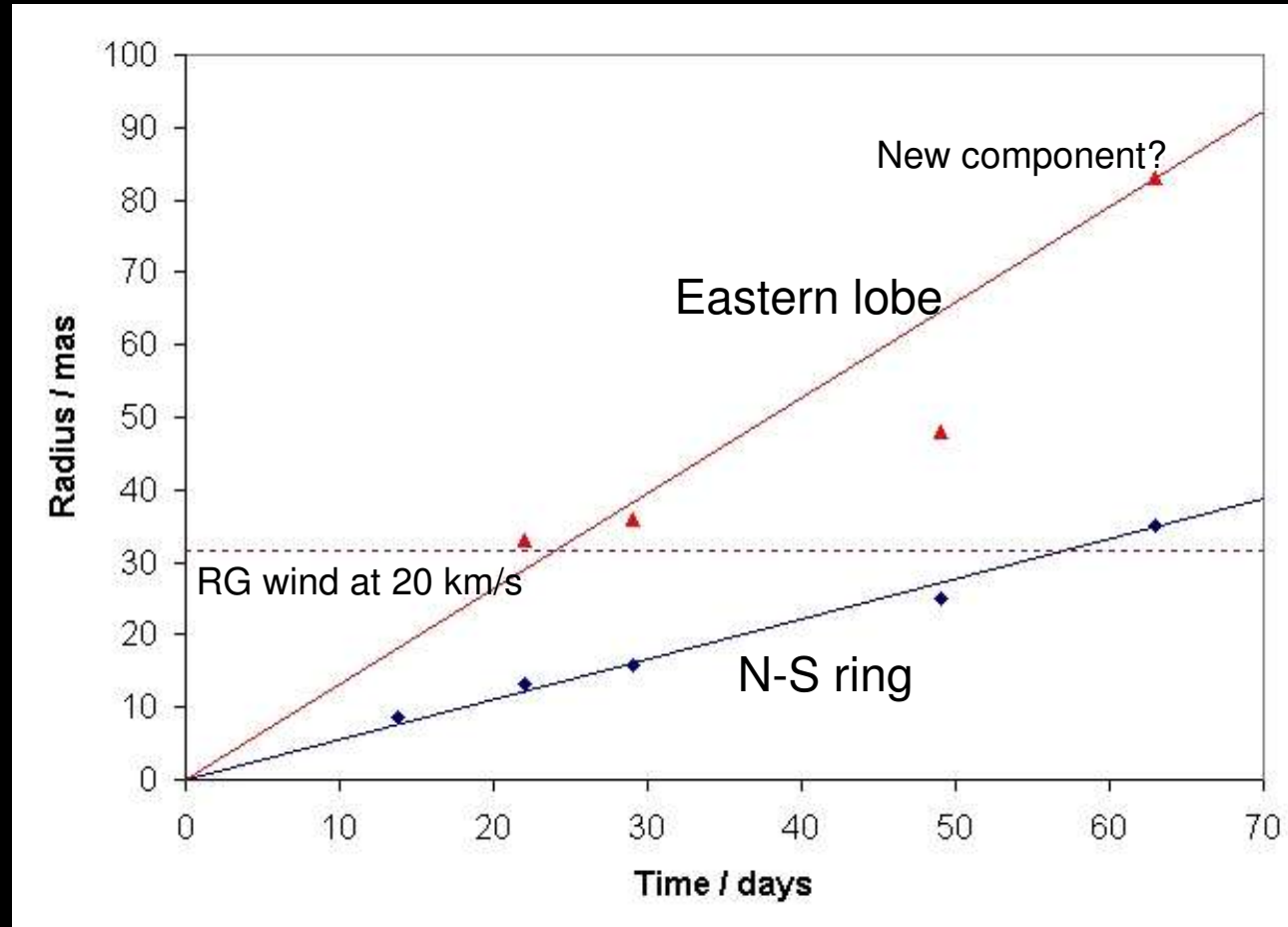
A VLBI image showing a complex structure of bright yellow and red spots against a dark blue background. The image is labeled "VLBA 63d" in the top left and "18 cm" in the bottom left. The structure consists of several bright, elongated spots, with the most prominent ones being yellow and red, indicating high intensity. The spots are arranged in a roughly horizontal line, with some smaller, less intense spots scattered around them. The overall appearance is that of a complex, multi-component radio source.

VLBI Sequence



Expansion revisited

E lobe:
 $v \sim 1.3 \text{ mas/d}$
 $= 3700 \text{ km/s}$
 $= 6400 \text{ km/s}$
(corrected for
inclination)



Summary

- First direct imaging of synchrotron-emitting shock wave.
- Size consistent with X-ray temperature.
- Very asymmetric.
- Develops into E-W structure (cf 1985).
- Is this evidence for collimated ejecta (jets) or confinement by equatorial RG wind?
- Simple bipolar model obscured by RG wind or something more complex?