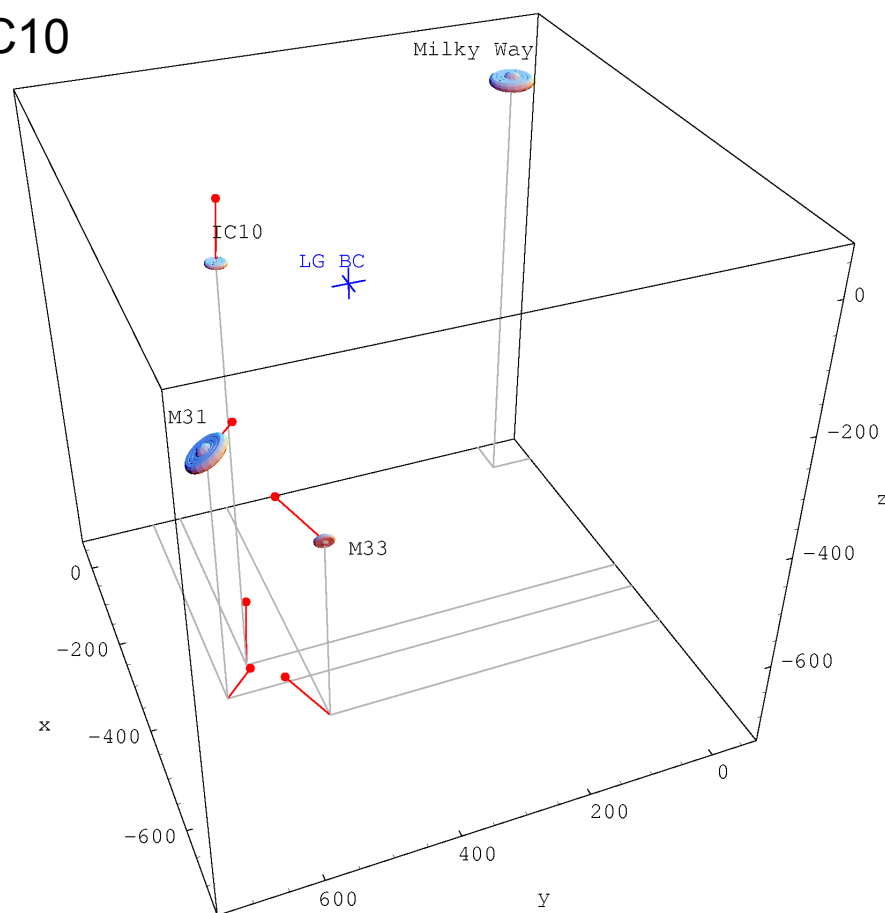


# Two new radio supernovae in M82 !?

A. Brunthaler, K.M. Menten, M.J. Reid, C. Henkel,  
G.C. Bower, & H. Falcke

# Proper Motions in the Local Group

- VLBI astrometry can reach microarcsecond accuracies
- allows proper motion measurements of external galaxies
- First targets: Water masers in M33 and IC10



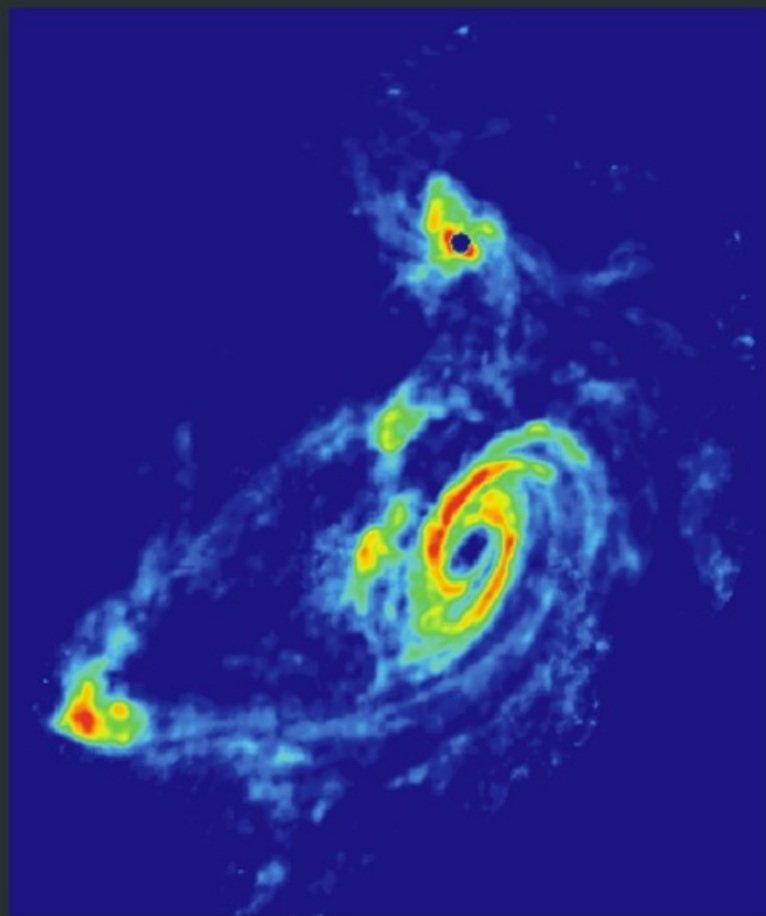
# M81 Group of Galaxies

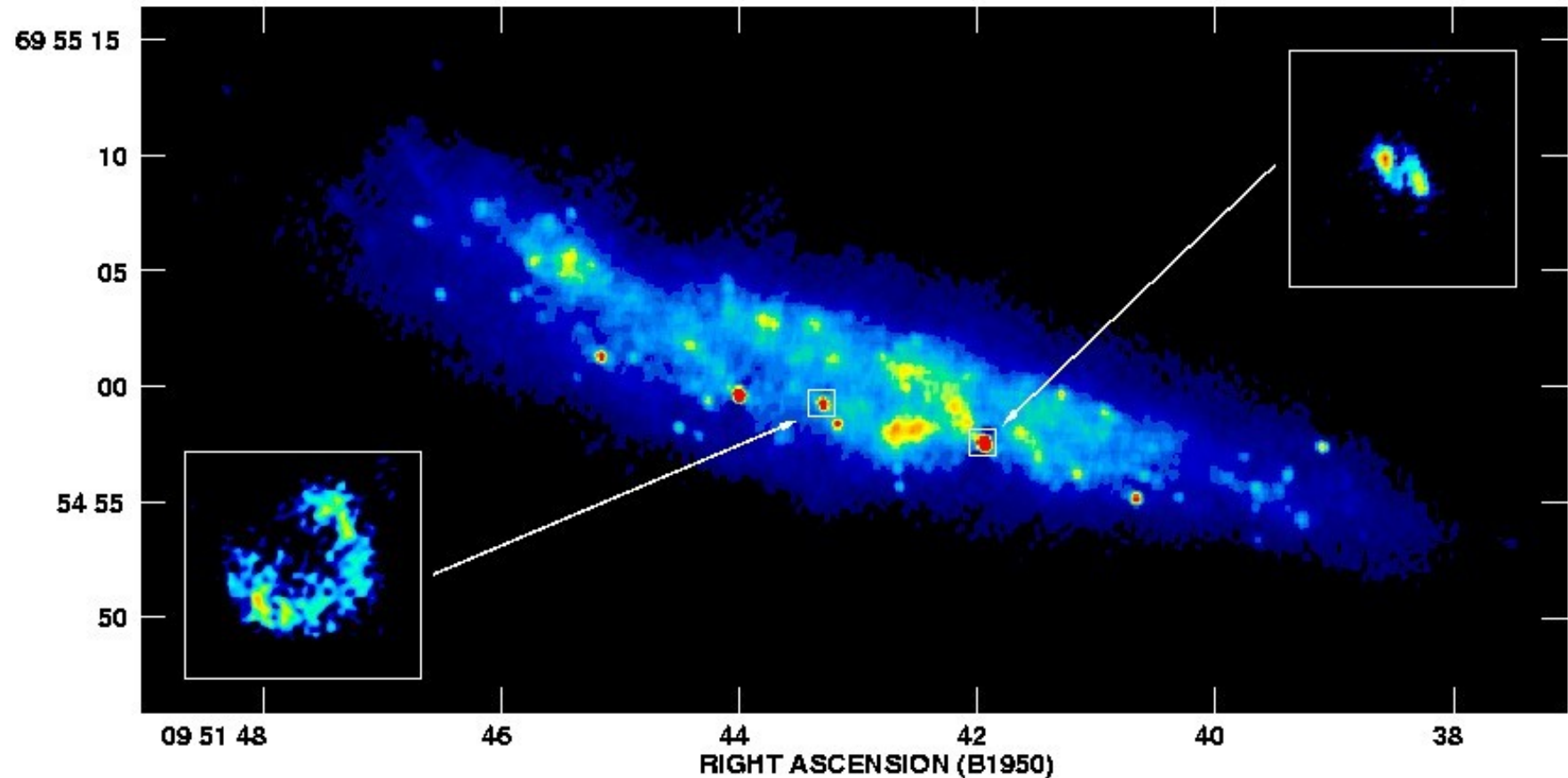
## TIDAL INTERACTIONS IN M81 GROUP

Stellar Light Distribution



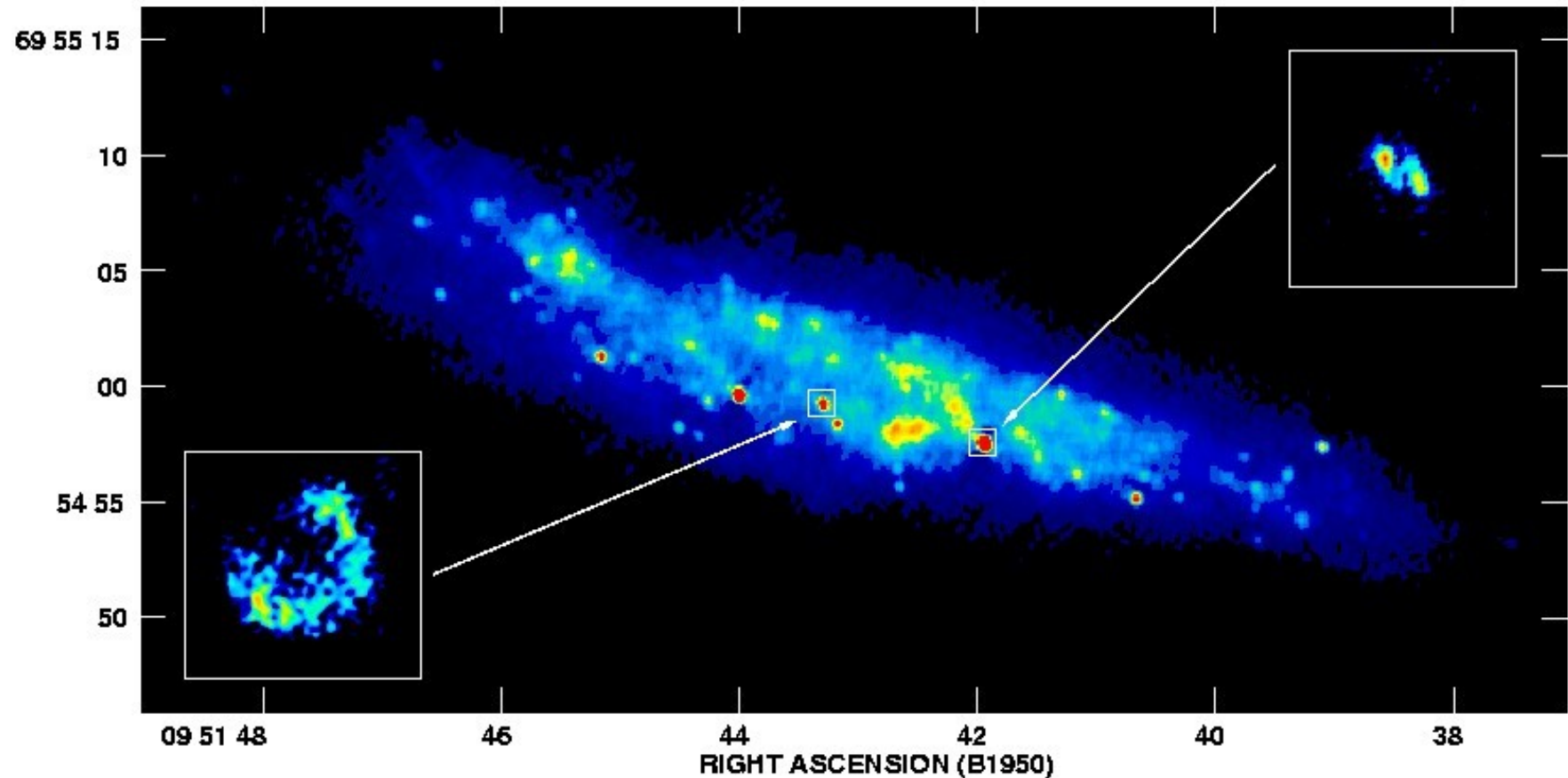
21 cm HI Distribution



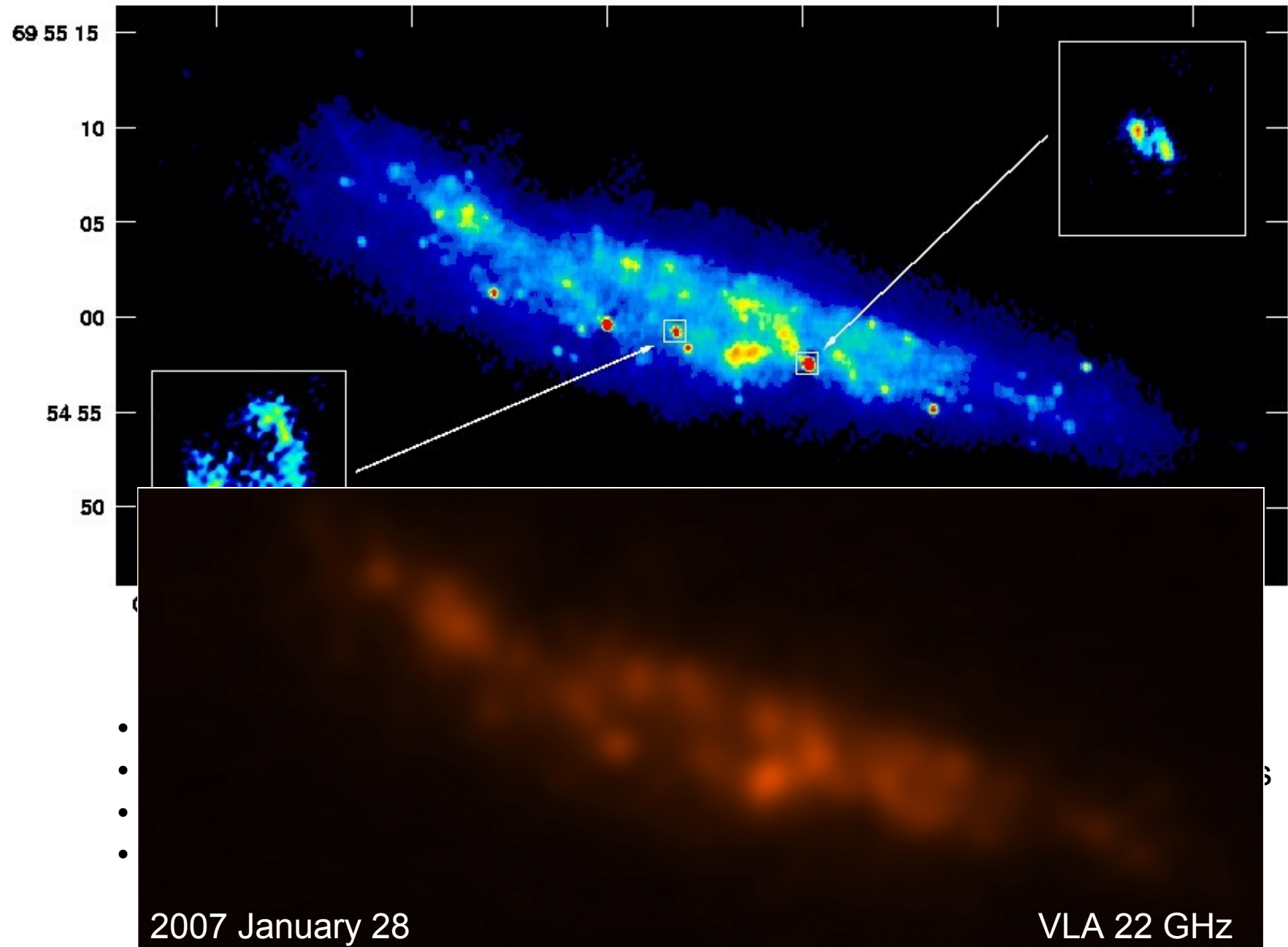


MERLIN and VLA composite at 5 GHz (Muxlow et al.)

- extensively studied over last decades in the radio (Kronberg et al. 1985, 2000; Muxlow et al. 1994; Beswick et al. 2006)

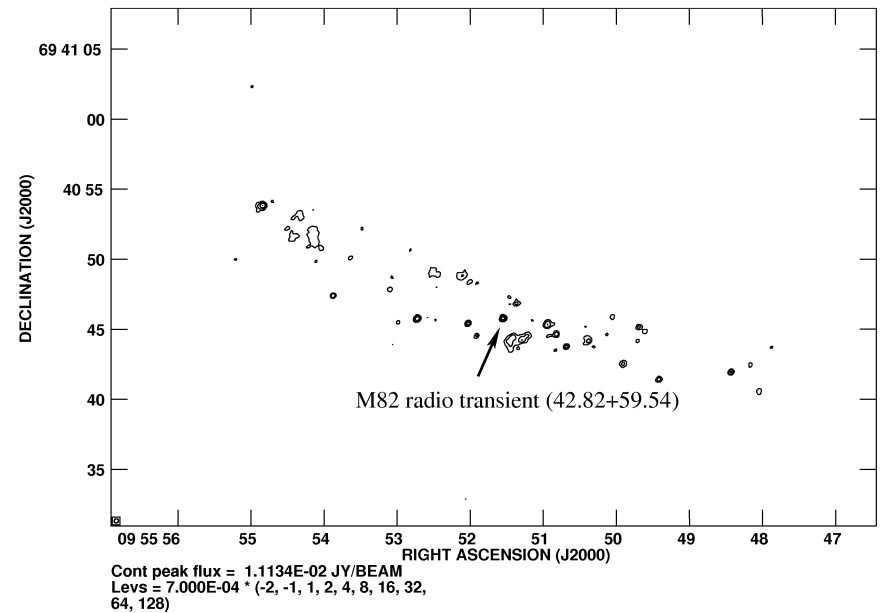
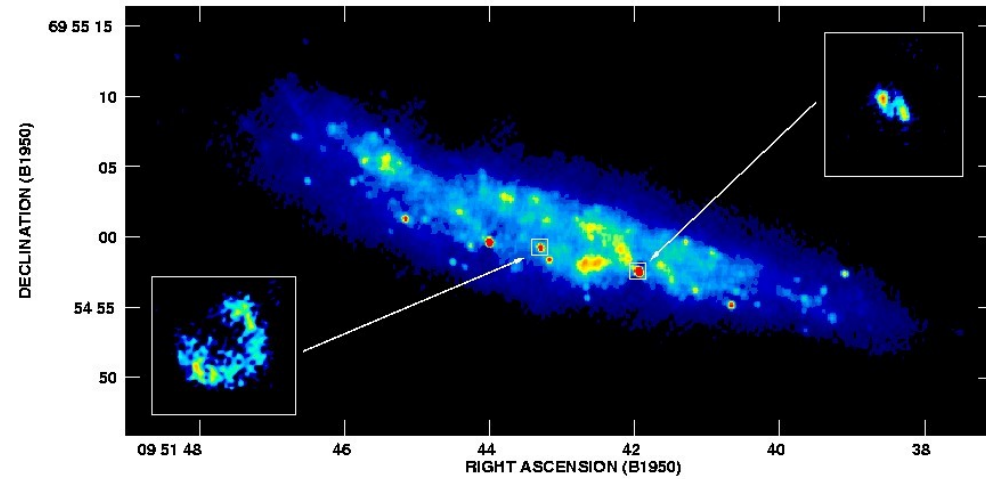


- started astrometric observations in January 2007
- water masers in M82, the nucleus of M81, and three background quasars
- using the VLBA, phased VLA, GBT, Effelsberg
- one epoch each year



Third epoch: 2009 April 08

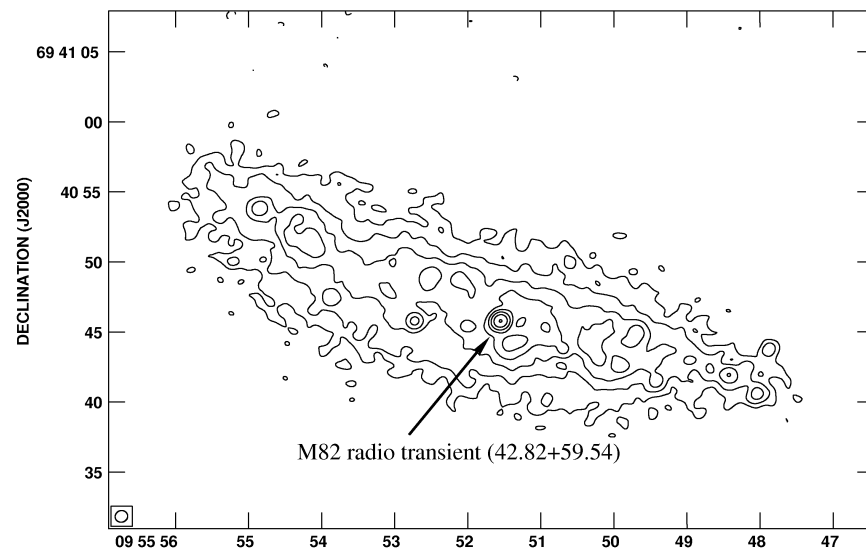
New source:  $\sim 10$  mJy





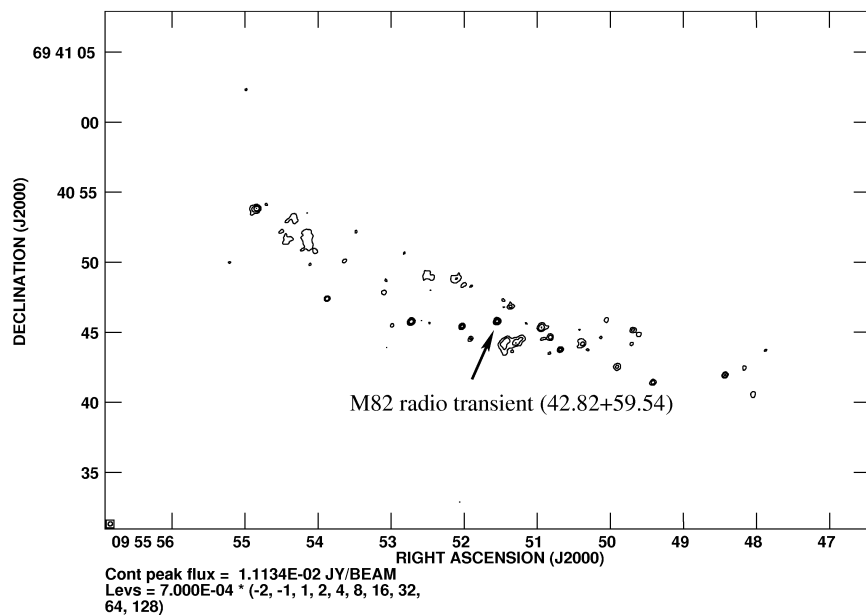
Second epoch: 2008 May 24

New source:  $\sim 90$  mJy



Third epoch: 2009 April 08

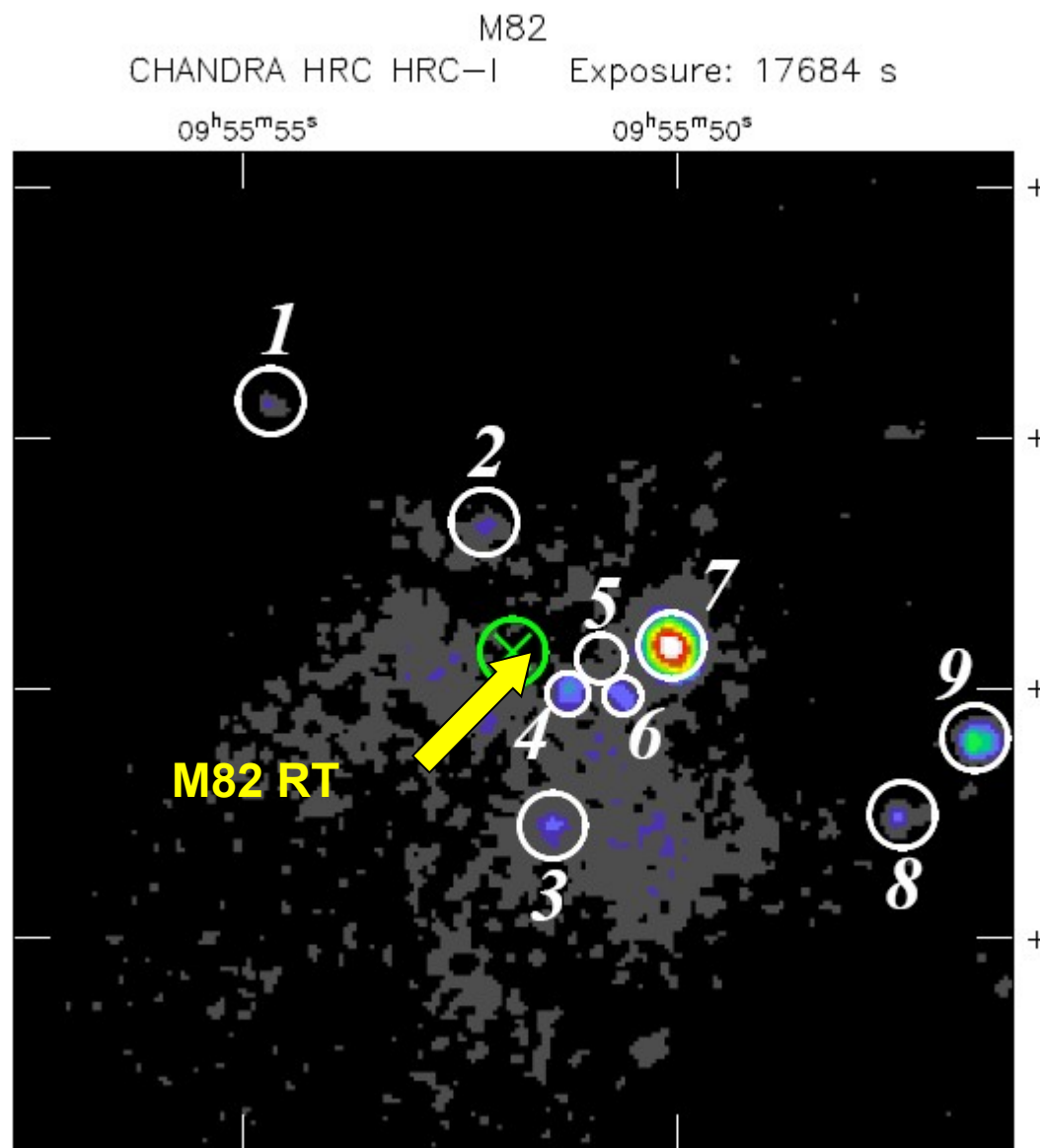
New source:  $\sim 10$  mJy





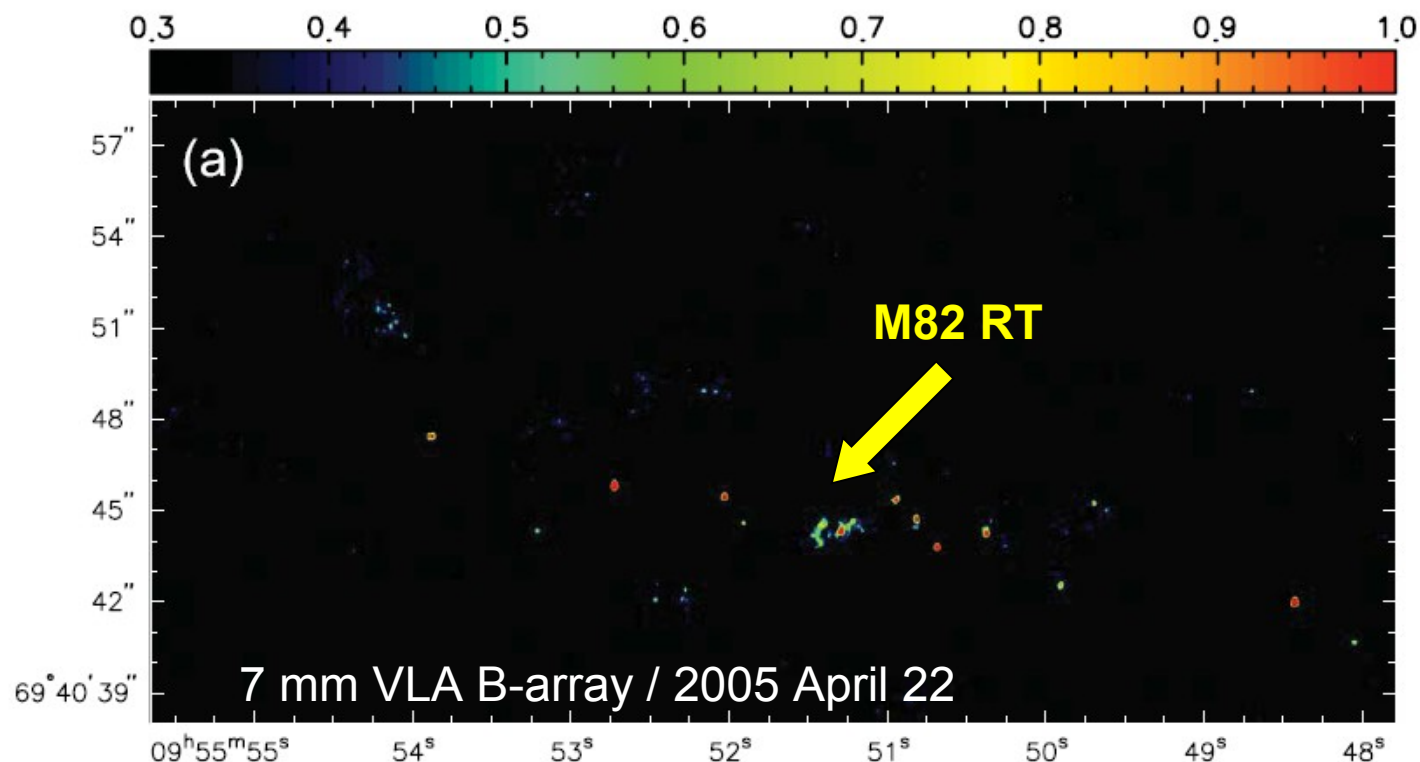
# Transient in M82

- No previously known X-ray source (Matsumoto et al. 2001)



# Transient in M82

- No previously known X-ray source (Matsumoto et al. 2001)
- No previously known radio source at cm wavelengths ( $> 17 \mu\text{Jy}$ ) (e.g. Körding et al. 2005, Fenech et al. 2008)
- No source at mm wavelengths (Tsai et al. 2009)



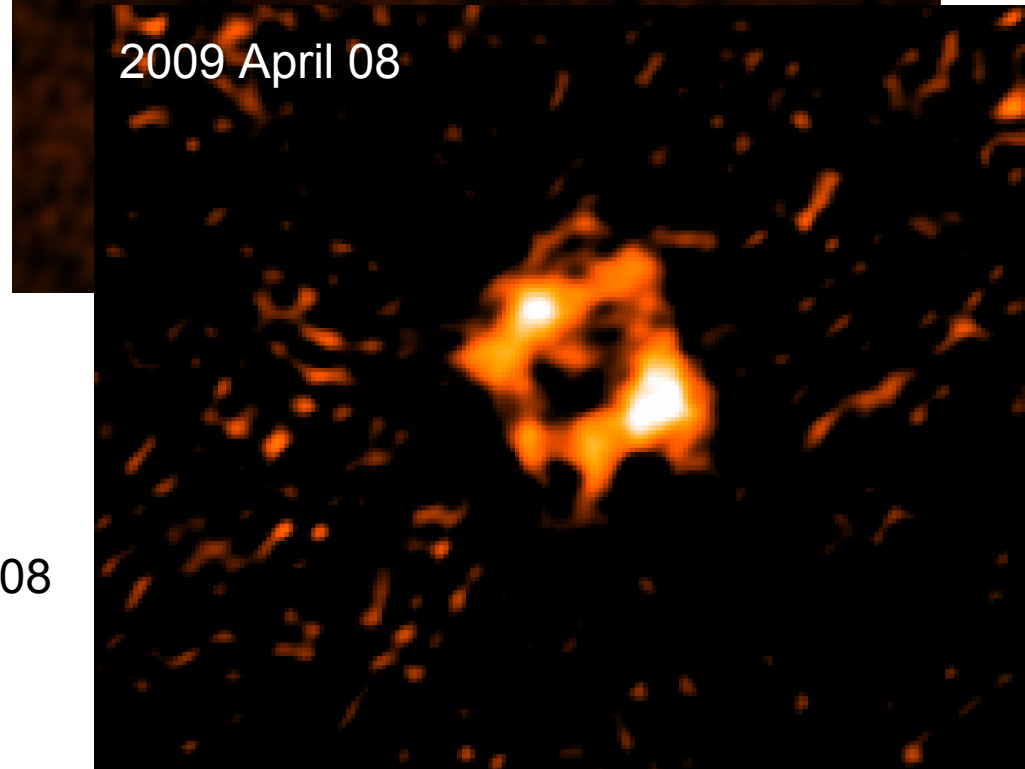
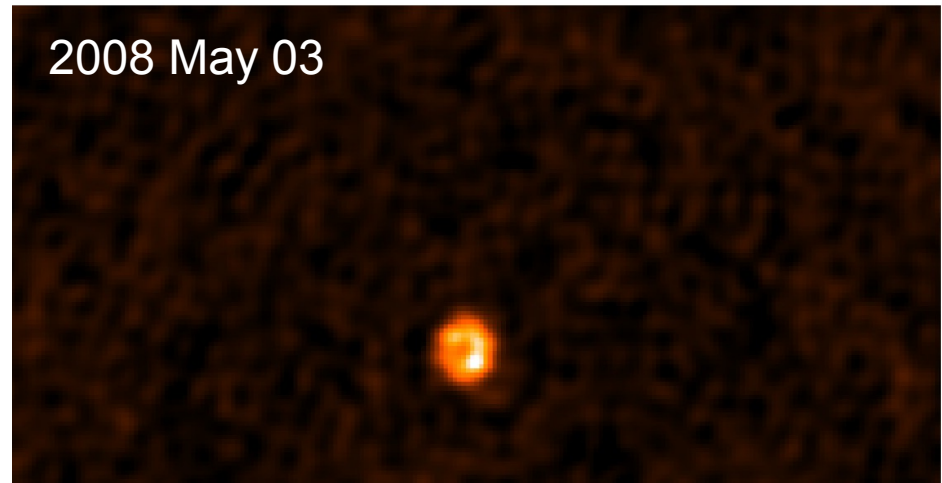
- No previously known X-ray source (Matsumoto et al. 2001)
- No previously known radio source at cm wavelengths ( $> 17 \mu\text{Jy}$ ) (e.g. Körding et al. 2005, Fenech et al. 2008)
- No source at mm wavelengths (Tsai et al. 2009)
- Archival VLA Data:
  - bright source on 2008 March 24 (22 GHz) ( $\sim 100 \text{ mJy}$ )
  - nothing on 2007 October 29 (4.8 GHz)

# VLBI on Transient in M82

- RT in 2" FoV of VLBI obs.
- radius = 0.18 mas (650 AU)

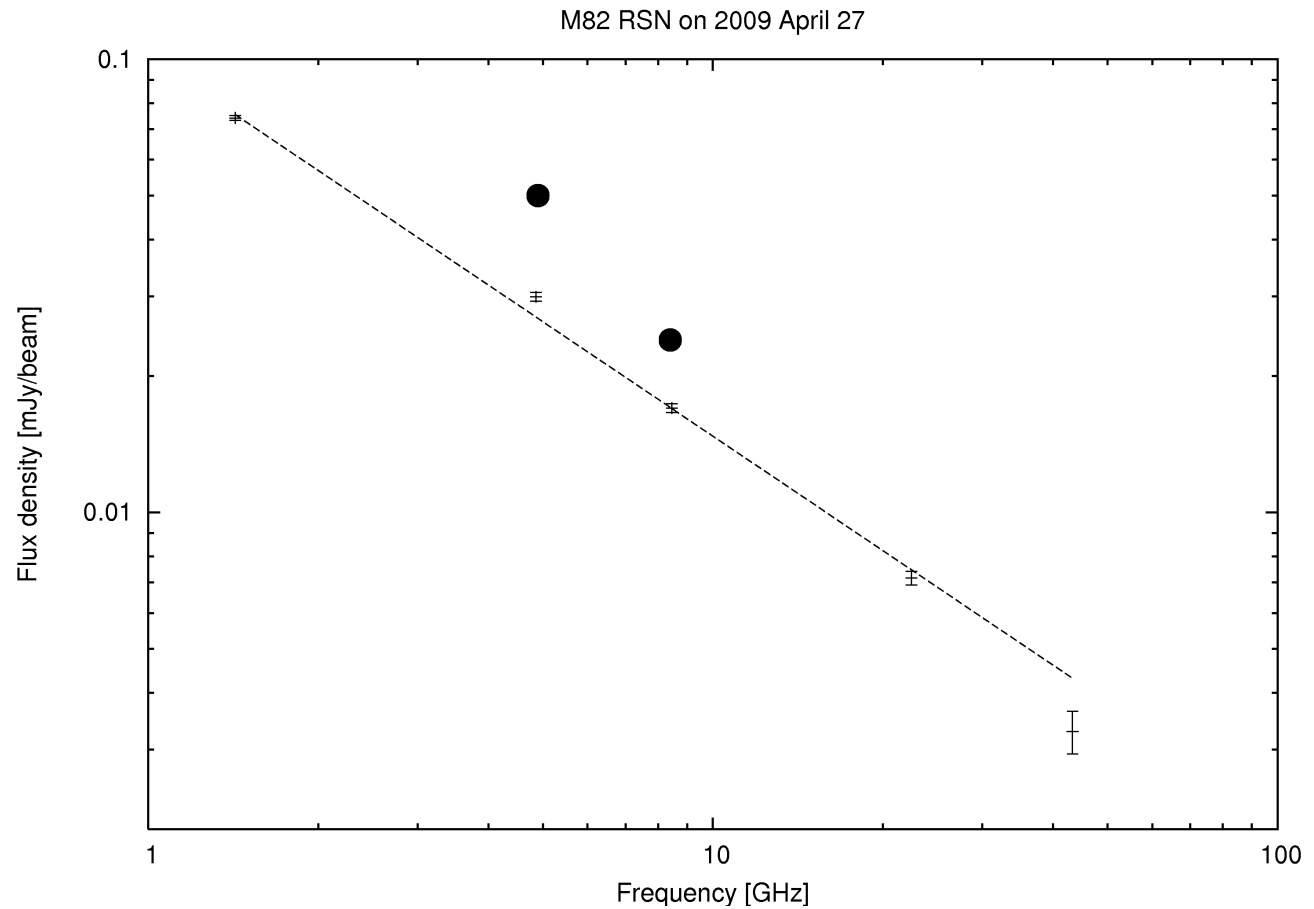
=> clearly a Supernova!

- radius = 0.9 mas (3250 AU)
- Expansion rate  $\sim 0.79$  mas/yr  
or  $\sim 13,000$  km/s
- Explosion date: January/February 08



# Radio Supernova in M82

- VLA (and WRST) spectrum on 2009 April 27: Power law with  $\alpha = -0.84$
- typical for type II SN



- Closest Supernova in 5 years!
- No detection in the optical (there was an unrelated optical transient 1' away in May 2008)
- No detection in Swift X-ray and UV data from May 2008
- Nothing *obvious* in NIR from April 2009 (PARITEL)
- SN 1993J in M81 had magnitude of  $\sim 10$
- The supernova is highly obscured by gas and dust in the ISM!
- MERLIN data taken between 2008 May 1 and 3 at 5 GHz also shows the source with  $\sim 117$  mJy and rising (Beswick et al. ATel #2060)

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## SUPERNOVA 2008iz IN M82

A. Brunthaler, K. M. Menten, and C. Henkel, Max-Planck-Institut fuer Radioastronomie; M. J. Reid, Harvard-Smithsonian Center for Astrophysics; G. C. Bower, University of California, Berkeley; and H. Falcke, University of Nijmegen and ASTRON, report the discovery of a radio supernova in M82. The position of 2008iz is R.A. = 9h55m51s.55, Decl. = +69°40'45".8 (equinox 2000.0), which is 2".0 west and 1".3 south of the radio kinematic center (Weliachew et al. 1984, A.Ap. 137, 335). SN 2008iz was first discovered as a bright radio transient of unknown origin (cf. <http://www.astronomerstelegram.org/?read=2020>; also, Brunthaler et al. 2009, A.Ap., in press, with a pre-publication version posted at <http://lanl.arxiv.org/abs/0904.2388>). VLBI images taken with the NRAO Very Long Baseline Array, the phased Very Large Array, the Green Bank Telescope, and the Effelsberg 100-m telescope on 2008 May 3 and 2009 Apr. 8 at 22 GHz show (at sub-milliarcsecond resolution) a ring-like structure with an expansion velocity of roughly 11000 km/s (for an assumed distance of 3.6 Mpc). This confirms the supernova nature of this source. The measured expansion rate indicates an explosion date in late January 2008. Very Large Array observations on 2009 Apr. 27 at 1.4, 4.8, 8.4, 22, and 43 GHz indicate an optically thin synchrotron spectrum with a spectral index of -0.8 (typical for type-II supernovae).

NOTE: These 'Central Bureau Electronic Telegrams' are sometimes superseded by text appearing later in the printed IAU Circulars.

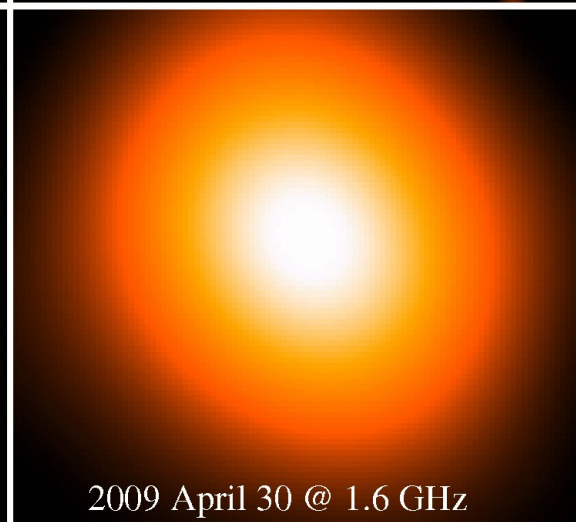
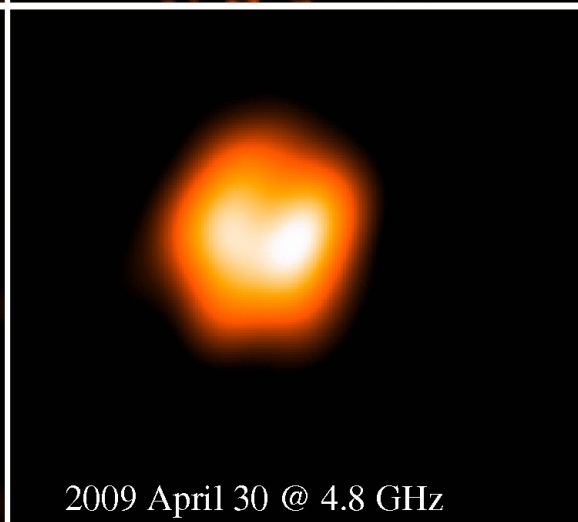
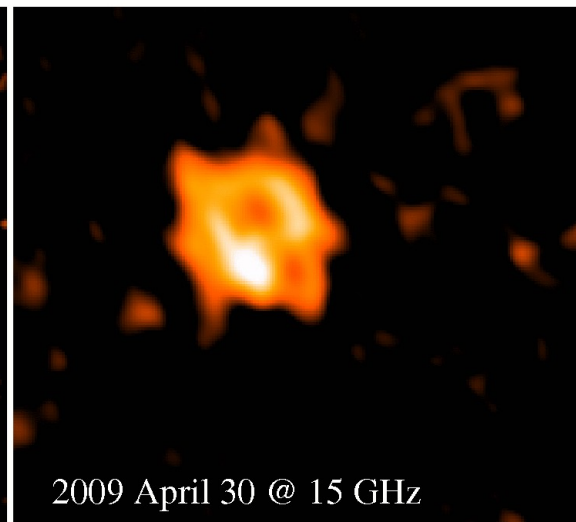
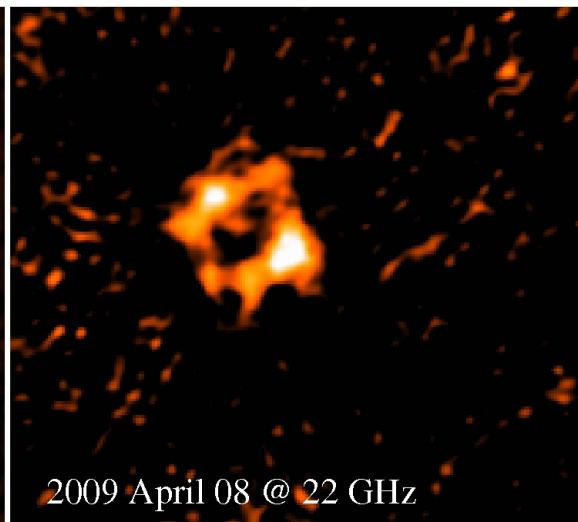
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(CBET 1803)

2009 May 15

Daniel W. E. Green

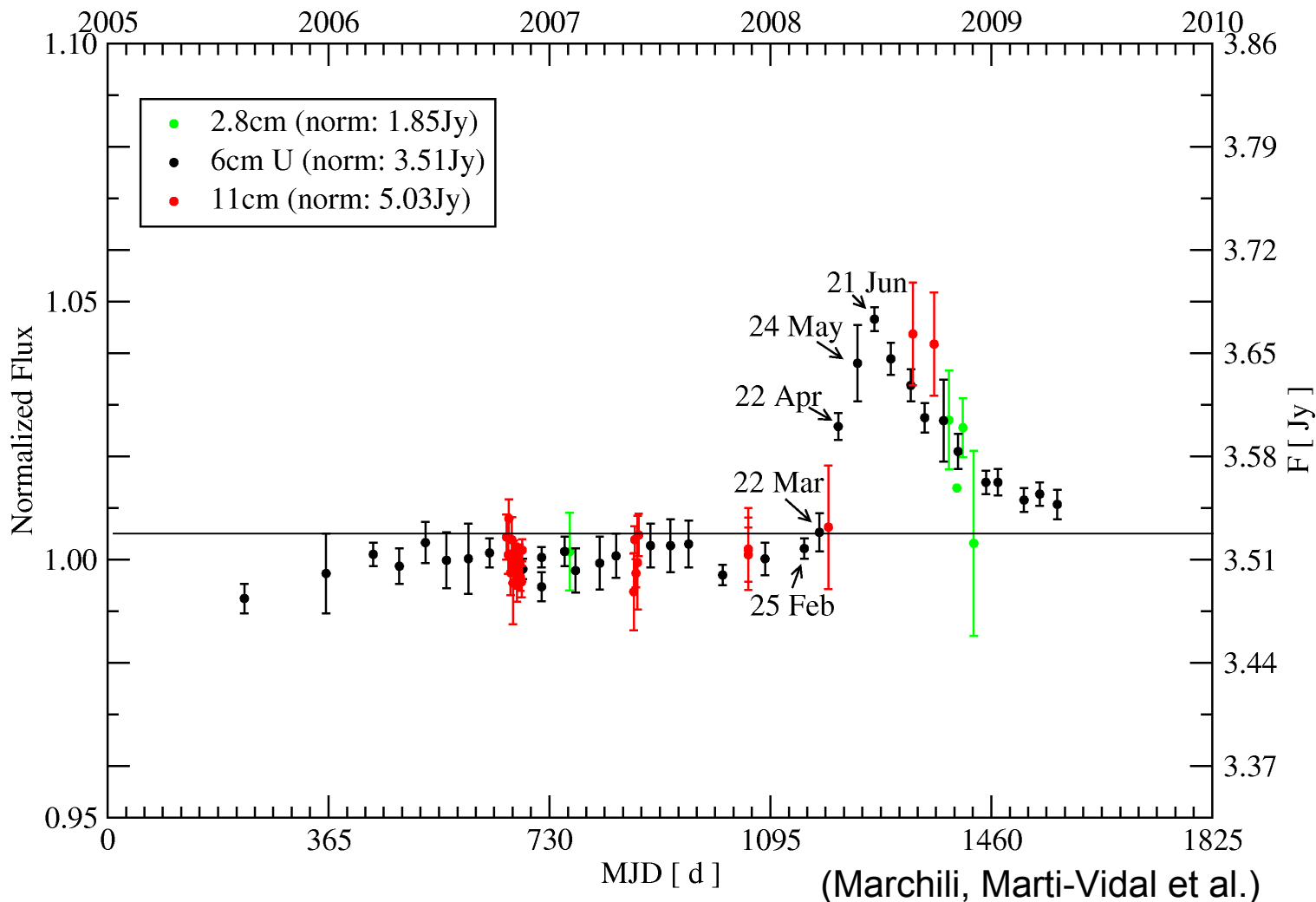


- preliminary maps of SN 2008iz from 1.6 – 15 GHz with the VLBA on 2009 April 30
- also eVLBI data from April and May 2009 at 1.6 GHz (unresolved)



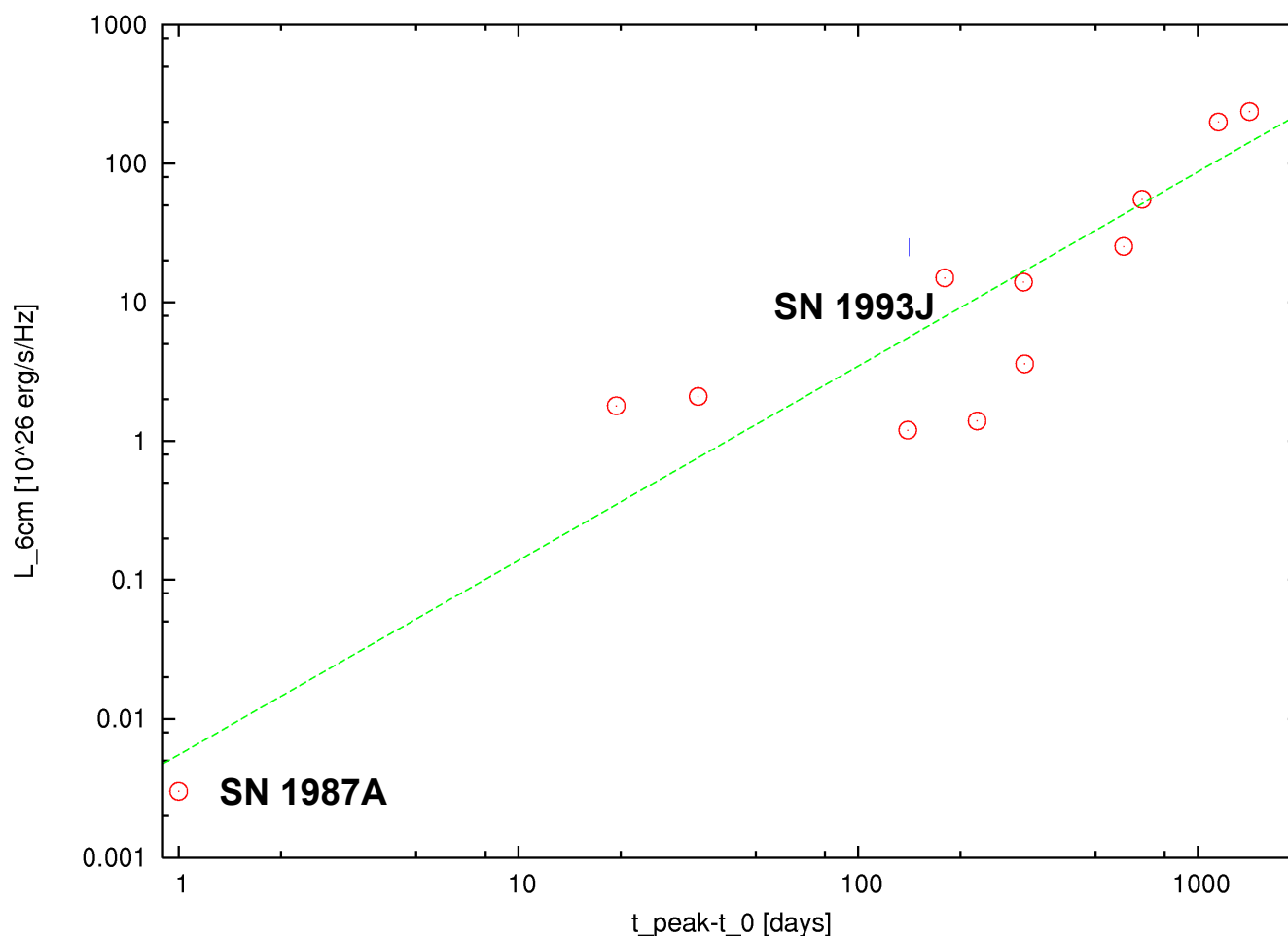
# Light curve of SN 2008iz

- Flux monitoring of IDV sources with Urumqi telescope (Krichbaum et al.)
- M82 was used as calibrator



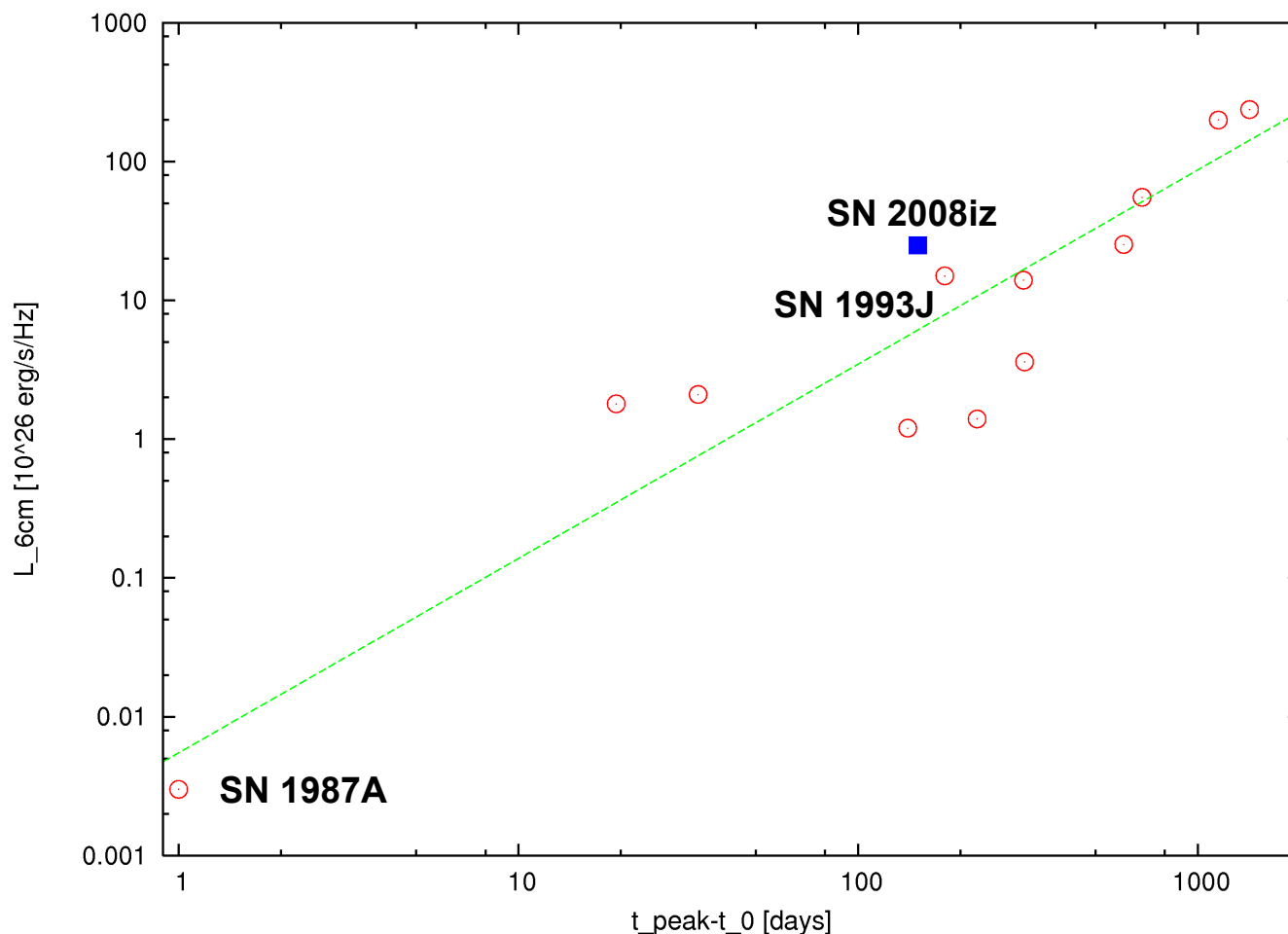
# Light curve of SN 2008iz

- Flux density monitoring of IDV sources with the Urumqi telescope
- M82 was used as calibrator
- Weiler et al. (1998) find relation between rise time and peak luminosity for type II



# Light curve of SN 2008iz

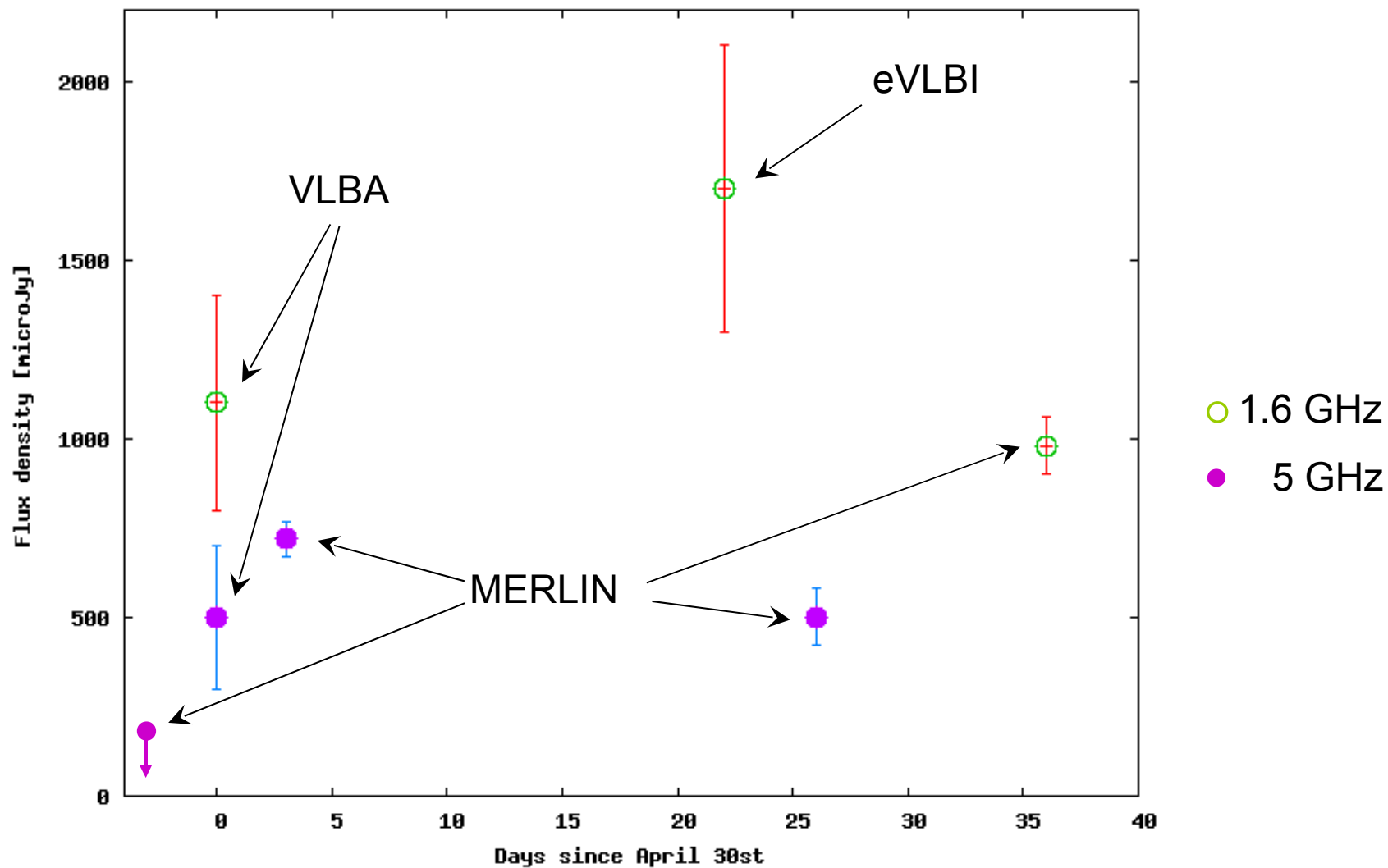
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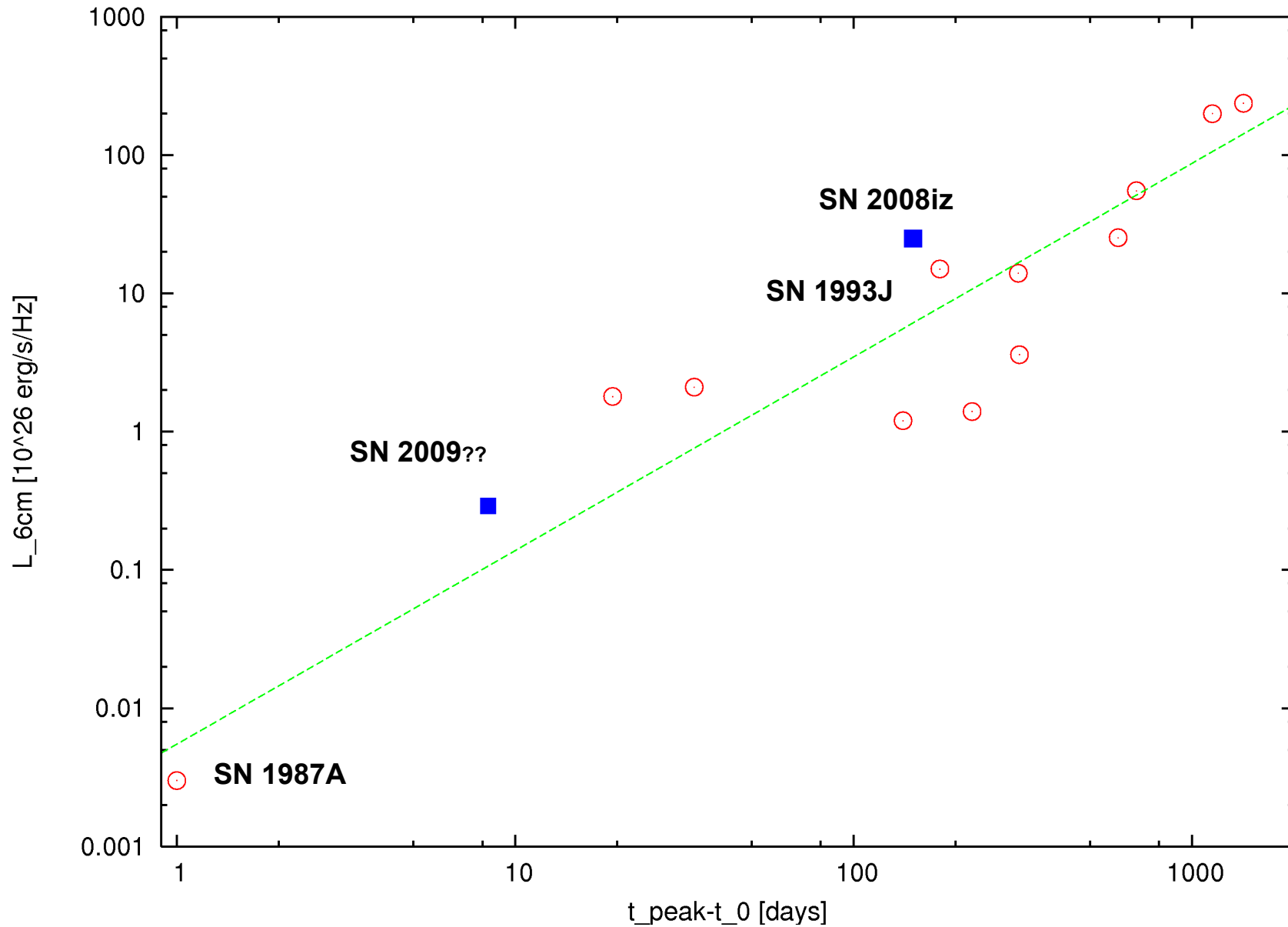
# Another RSN in M82?

- Muxlow et al. 2009 (ATel 2073) find a new radio transient in M82
- seen with MERLIN at 5 GHz during May 1-5 ( $720 \pm 50 \mu\text{Jy}$ ),  
but not during April 24-27
- still seen with MERLIN at 1.6 GHz on June 5-6 ( $980 \pm 80 \mu\text{Jy}$ )
- Also seen in our VLBA data from April 30 at 1.6 GHz ( $1.1 \pm 0.3 \text{ mJy}$ )  
and 4.8 GHz ( $0.5 \pm 0.2 \text{ mJy}$ ),
- eVLBI at 1.6 GHz on May 20 : detection ( $1.7 \pm 0.4 \text{ mJy}$ )

# Another RSN in M82?

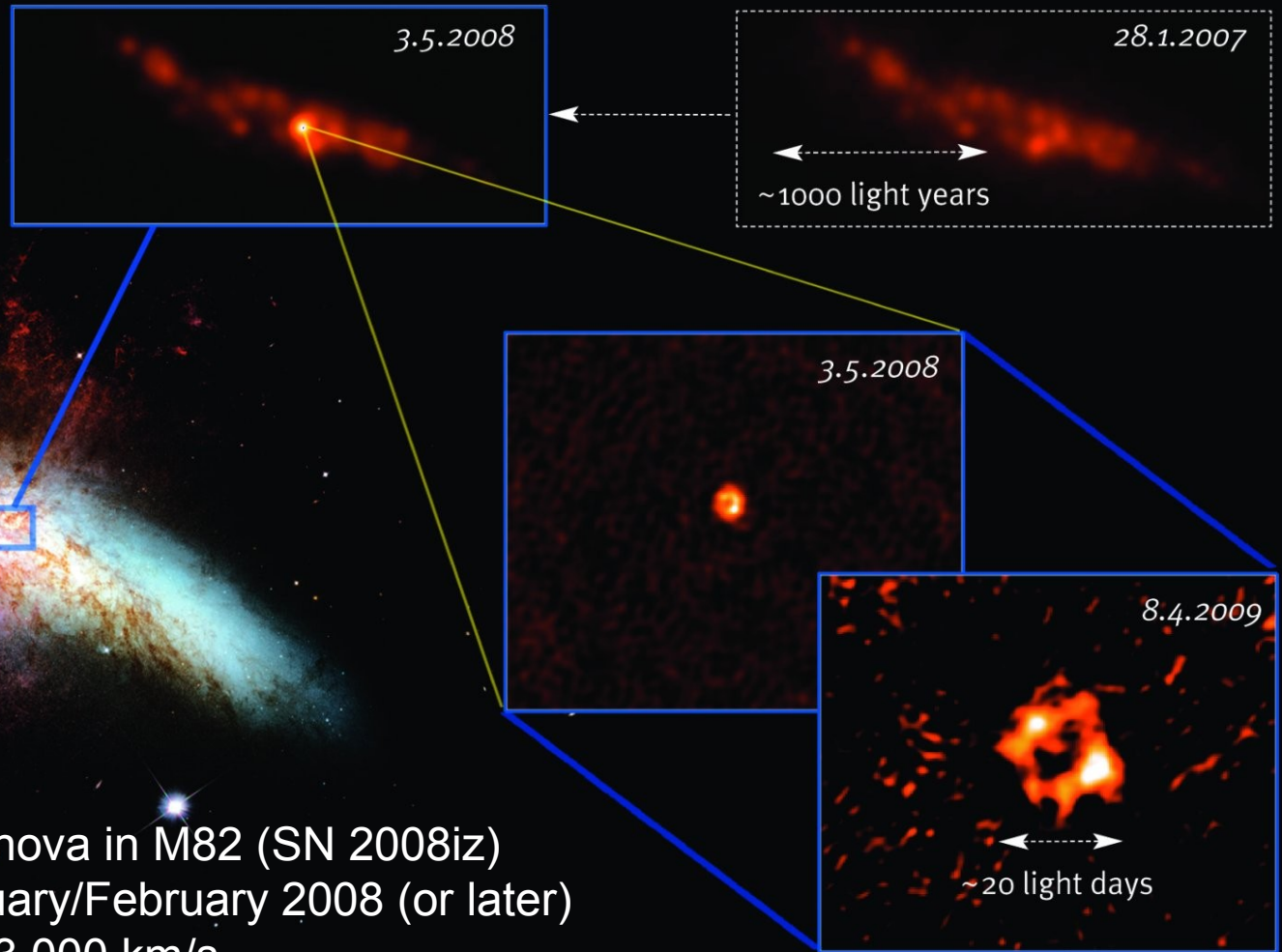


# Another RSN in M82?



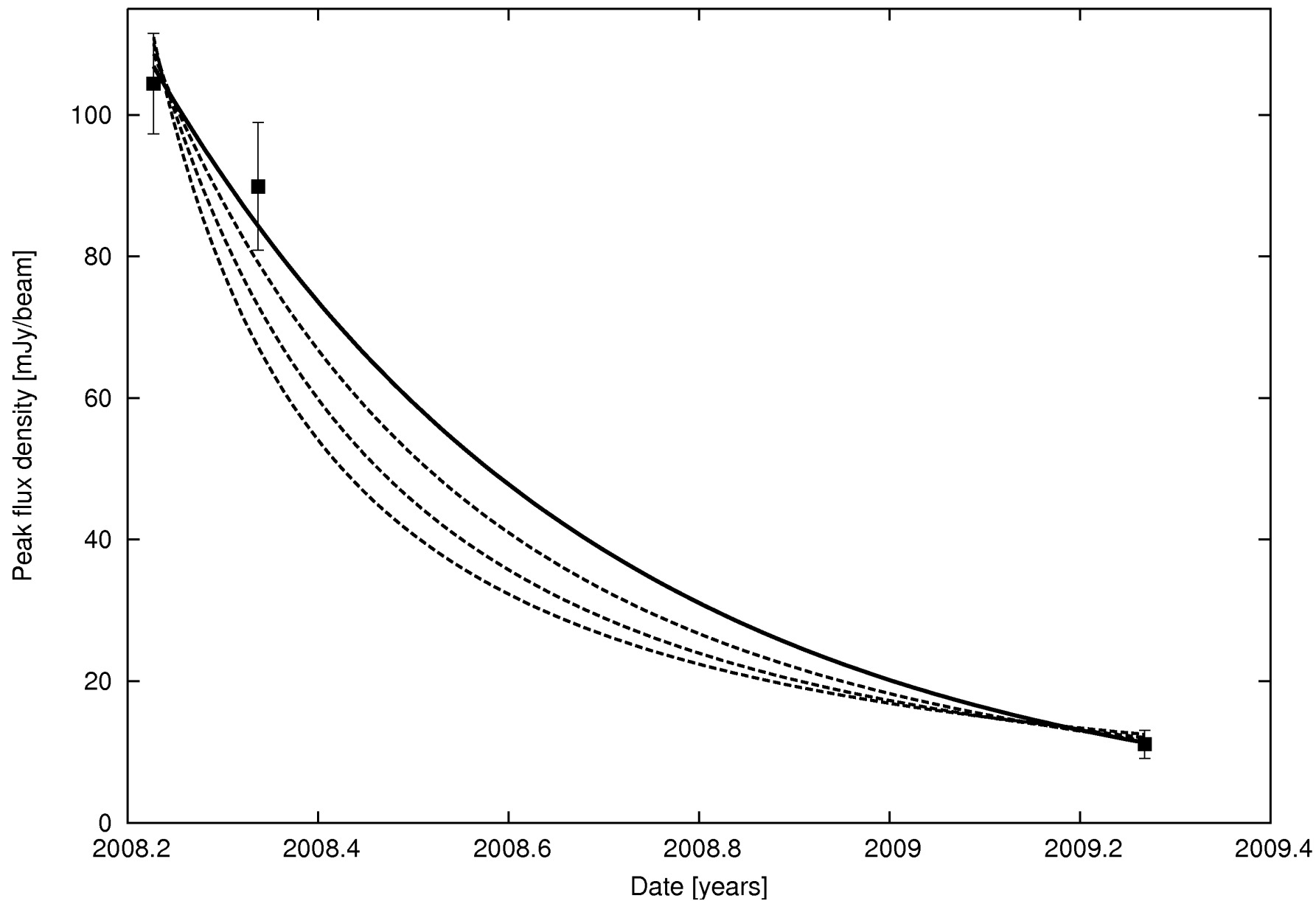


# Summary



- A new radio supernova in M82 (SN 2008iz)
- It exploded in January/February 2008 (or later)
- It expands with  $\sim 13,000$  km/s
- spectral index  $\alpha = -0.84$ , probably type II
- Radio lightcurve recovered from Urumqi monitoring
- So far, no detection at other wavebands
- Possibly another RSN this year!
- more to come....

# Transient in M82

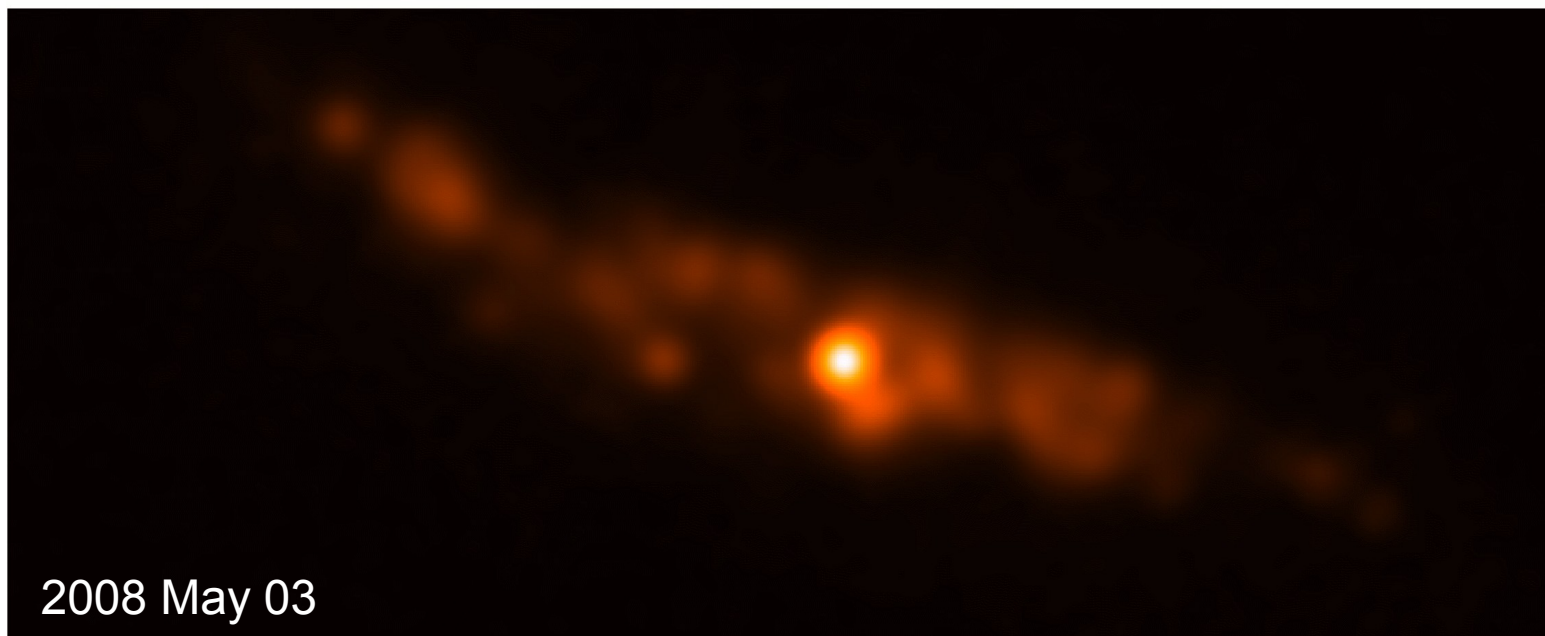
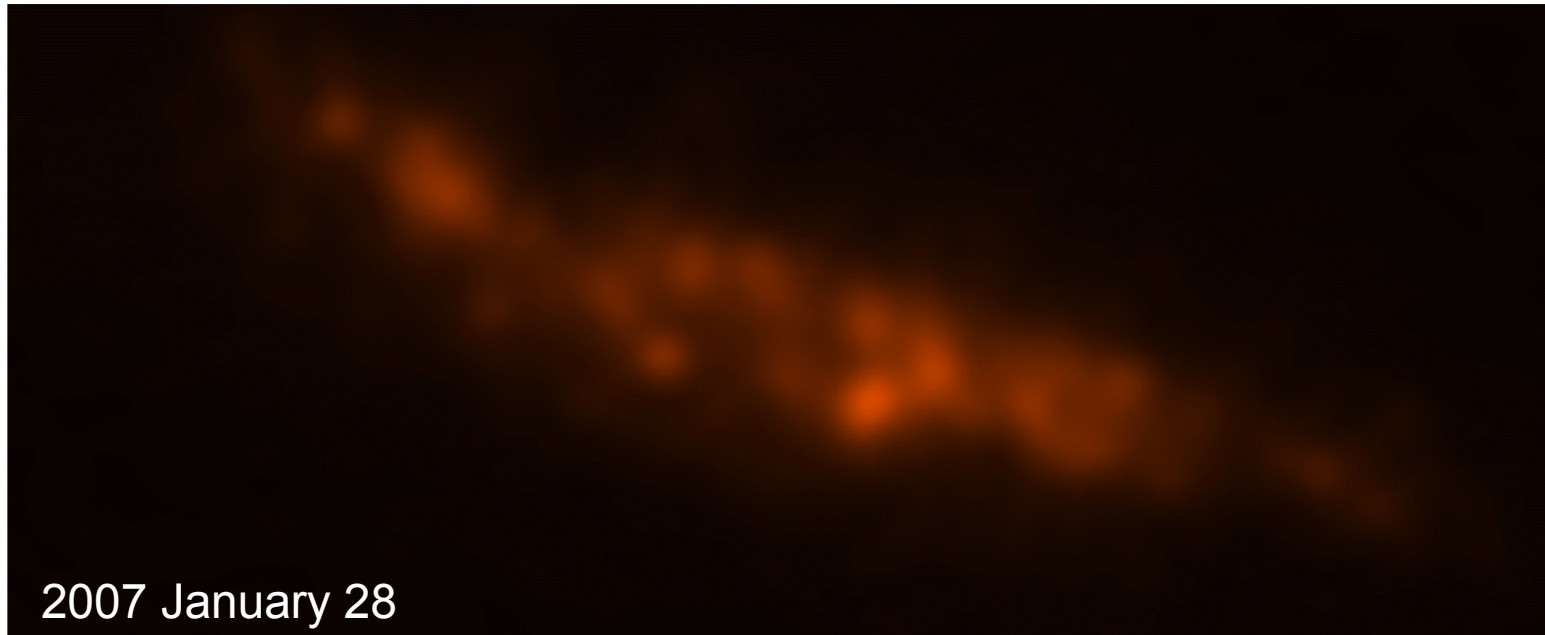


# M82: *Exploding Galaxy*





# Transient in M82



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LETTER TO THE EDITOR

## Discovery of a bright radio transient in M 82: a new radio supernova?

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### ABSTRACT

In this Letter, we report the discovery of a new bright radio transient in M 82. Using the Very Large Array, we observed the nuclear region of M 82 at several epochs at 22 GHz and detected a new bright radio source in this galaxy's central region. We find a flux density for this flaring source that is  $\sim 300$  times larger than the upper limits determined in previous observations. The flare must have started between 2007 October 29 and 2008 March 24. Over the past year, the flux density of this new source has decreased from  $\sim 100$  mJy to  $\sim 11$  mJy. The lightcurve (based on only three data points) can be fitted better with an exponential decay than with a power law. Based on the current data we cannot identify the nature of this transient source. However, a new radio supernova seems to be the most natural explanation. With its flux density of more than 100 mJy, it is at least 1.5 times brighter than SN1993J in M 81 at the peak of its lightcurve at 22 GHz.

**Key words.** stars: supernovae: general – radio continuum: general – galaxies: individual: M 82