A detailed study of the nuclear region of Mrk 273

Marco Bondi – IRA Bologna

Daniele Dallacasa - Dep. of Astronomy, Bologna, Italy
Miguel-Angel Pèrez Torres – IAA CSIS, Granada, Spain
Tom Muxlow – NRAL, Jodrell Bank, U.K.

Thanks to H. Bignall at JIVE & A. Richards at JBO

Ultra Luminous IR Galaxies

- $$L_{\rm IR}(8-1000\mu m) \simeq L_{\rm Bol} \geq 10^{12} L_{\odot}$$ Soifer et al. (1984)

- Signs of strong interactions & mergers (e.g. Sanders & Mirabel 1996)
- Large amount of dust and gas obscuring the nuclear region
- Significant class of objects in the local Universe (Soifer et al. 1997) and perhaps at high z as well (Lilly et al. 1999)
- Are ULIRGs powered by dust enshrouded AGN or starbursts?
- Best evidence for ULIRGs harbouring SB is provided by VLBI observations of Arp 220 (Smith et al. 1998)

Markarian 273

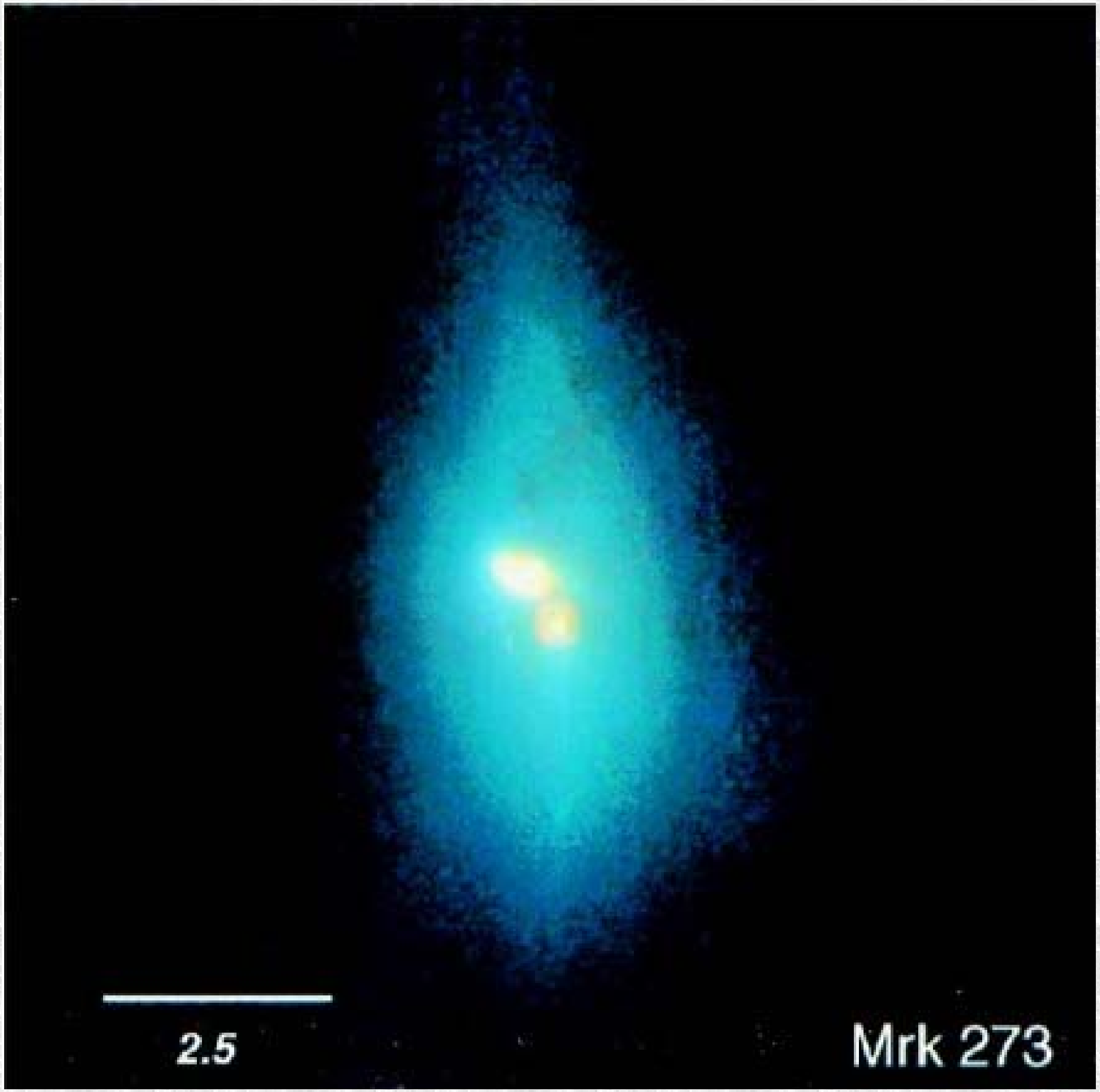
- Distance 150 Mpc (z=0.0377, H0=75),

1 mas=0.7 pc

$$L_{\rm IR} = 1.3 \times 10^{12} L_\odot$$

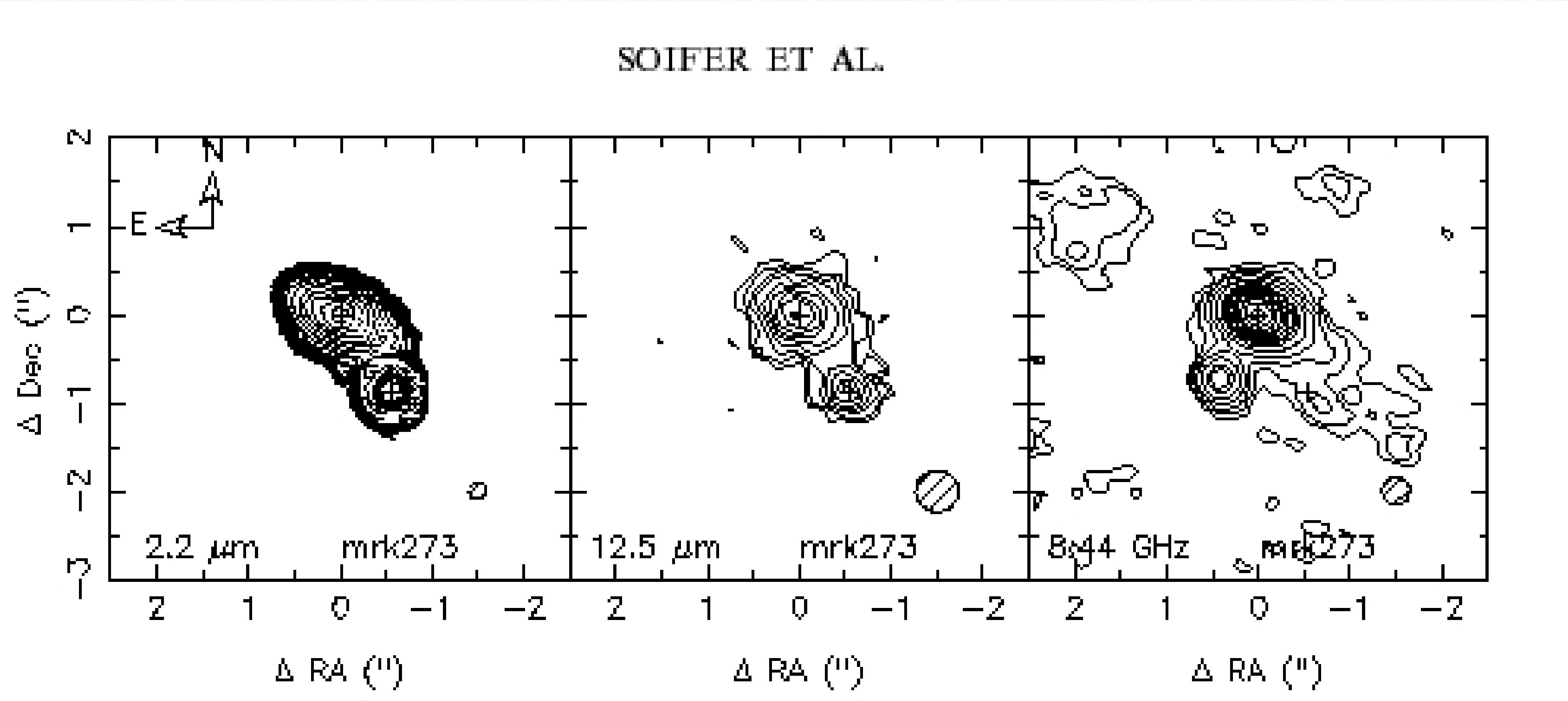
- Disturbed morphology: tidal tails (40 kpc)
- Optical classification: Liner (Colina et al. 1999)

Mrk 273 NICMOS Image



Scoville et al 2001

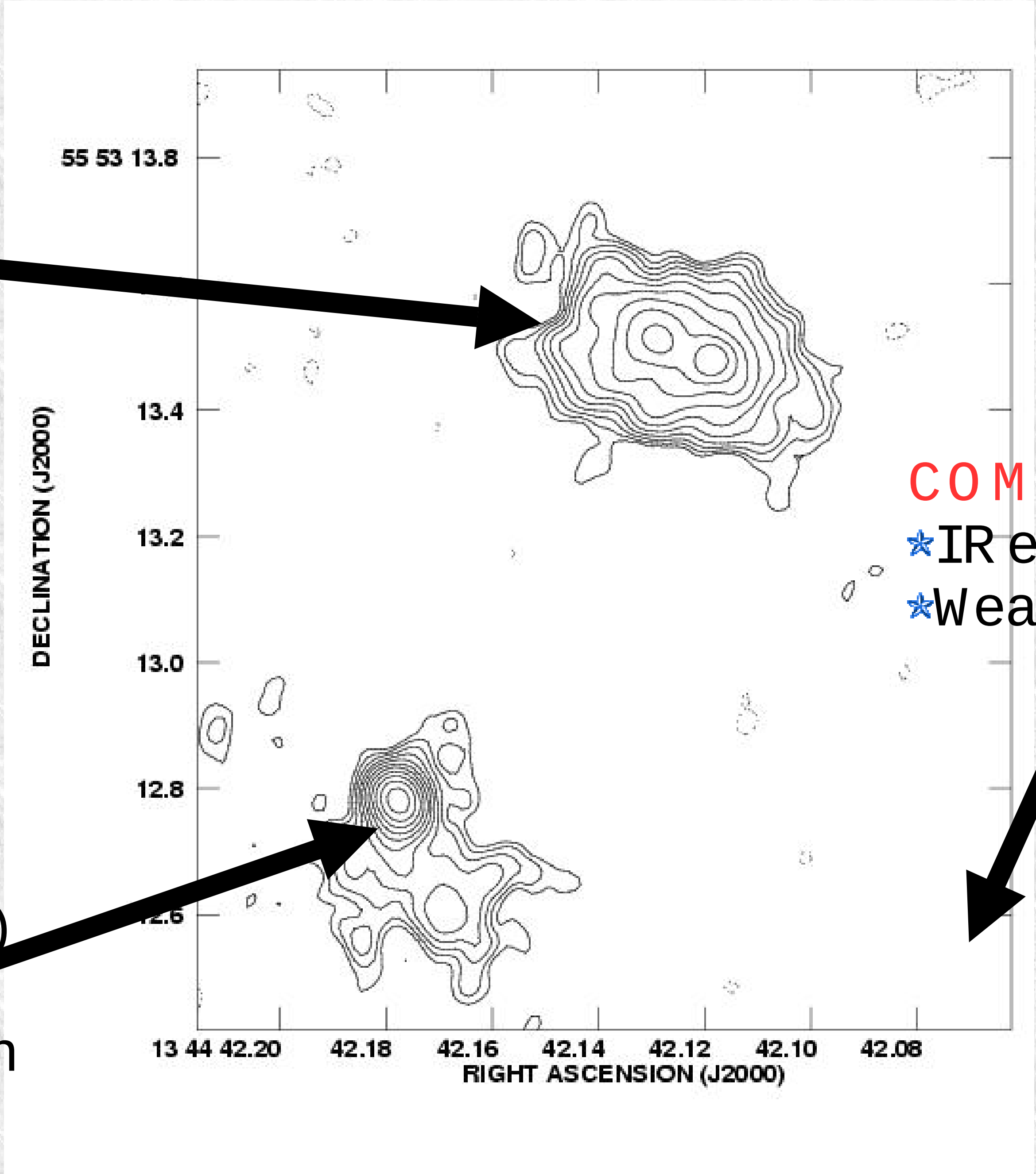
Mrk 273: IR, MIR, Radio



Soifer et al. (2000)

VLBA+Y27 1.4GHz 50 mas resolution image
(Carilli & Taylor 2000)

COMPONENT N
- IR and radio emission
- Peak of CO emission
- HI absorption (disk)
- OH megamaser spots
- Hard X-ray source



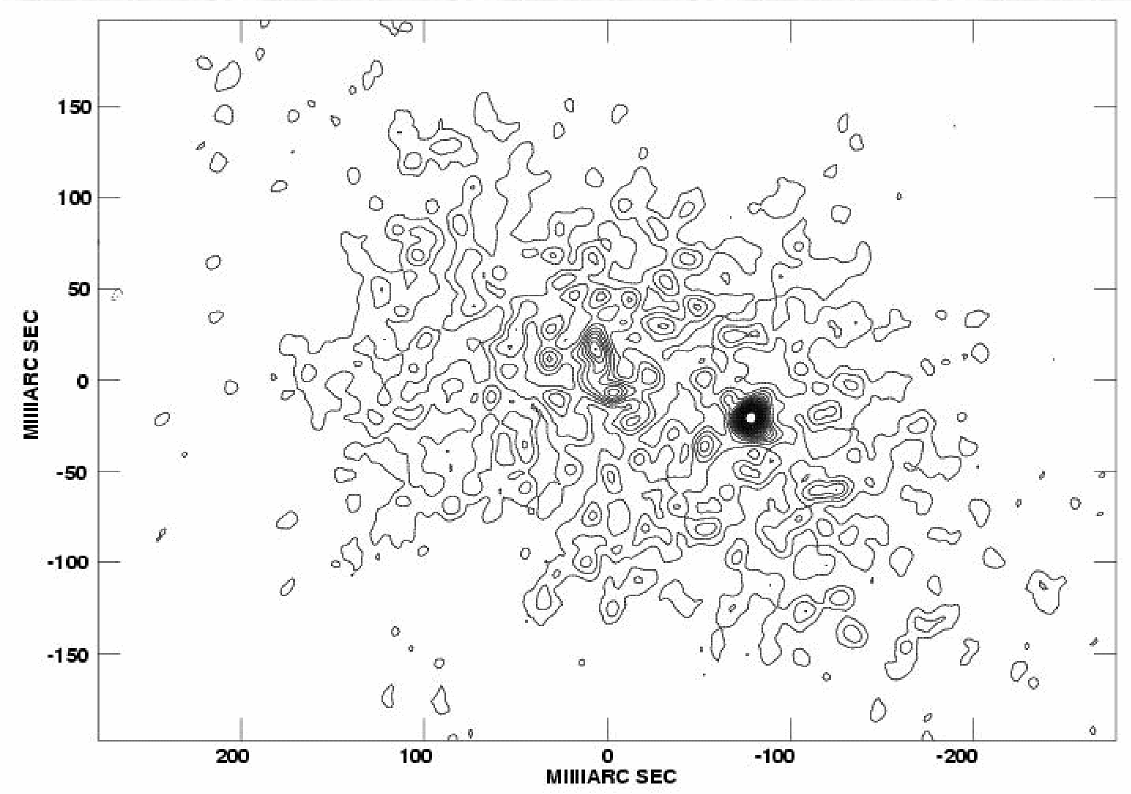
COMP. SW
- IR emission
- Weak radio

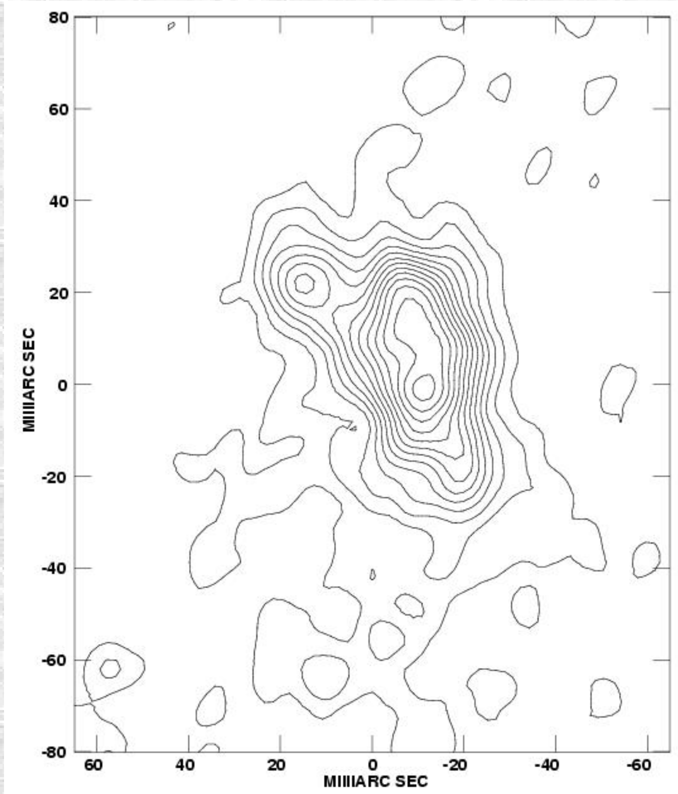
COMPONENT SE
- Optical counterpart (?)
- Radio emission
- No CO or IR emission
- HI absorption (infall)

VLBI Observations of Mrk 273

State of the art: 1.4 GHz VLBA+Y27 obs., noise 36 microJy, 10 mas

Comp. N (Carilli & Taylor 2000) Comp. SE





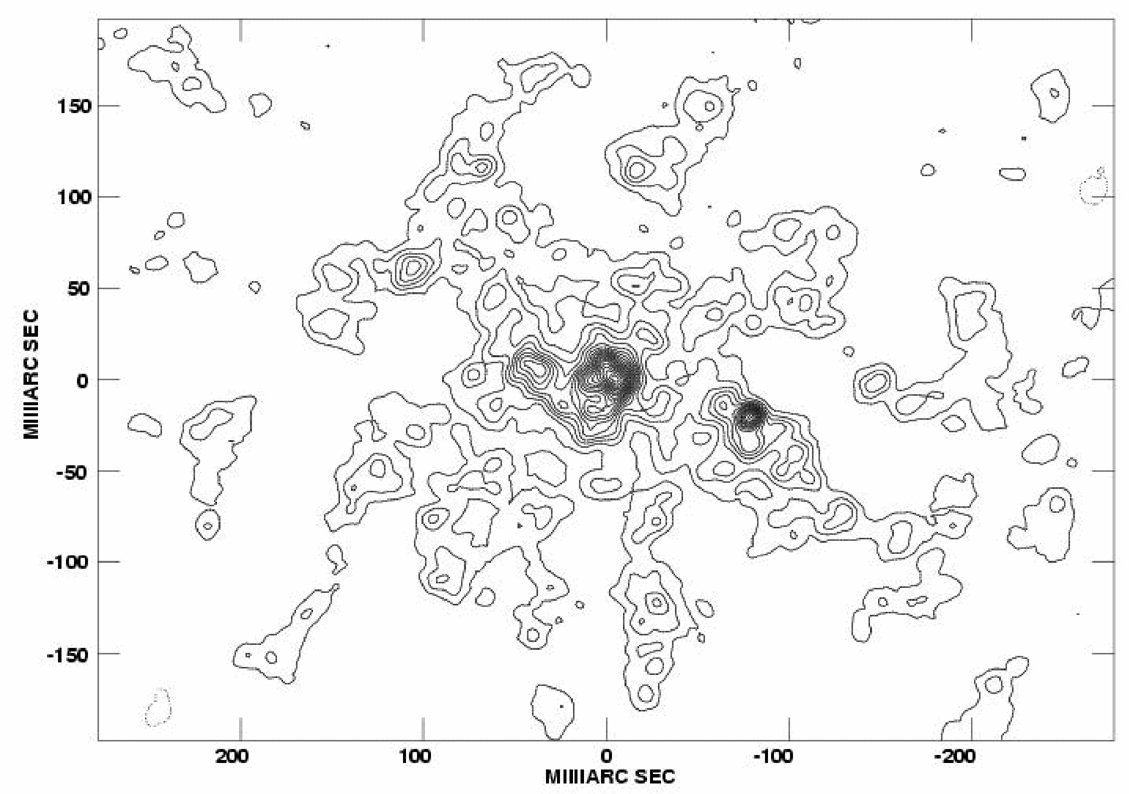
February 2004: EVN+MERLIN 4.9 GHz, 512 Mbit/s, 9hrs, Lovellin

EVN only 1.6 GHz, 512 Mbit/s, 9hrs

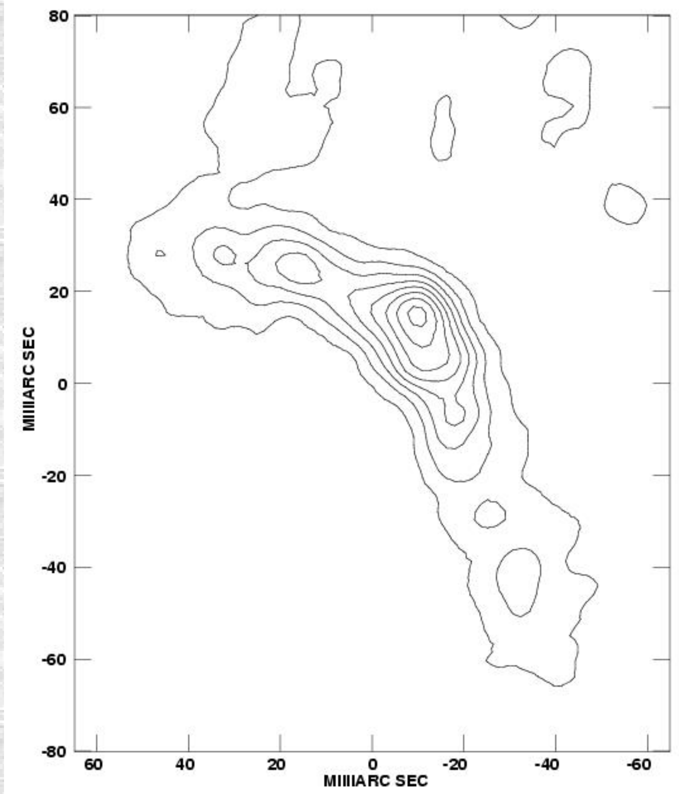
EVN+MERLIN 4.9 GHz: Results

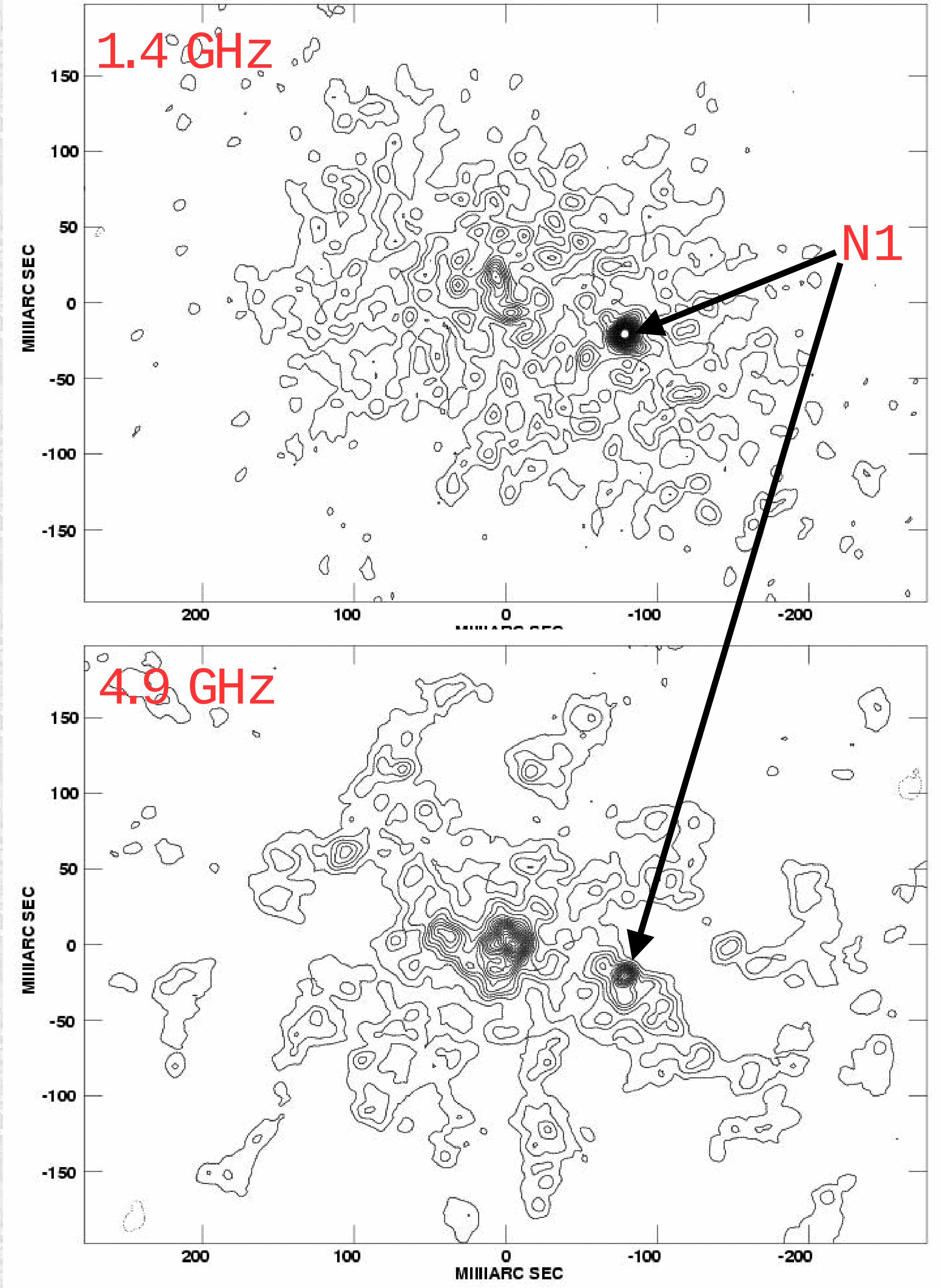
Noise 15 microJy/beam, circular beam 10 mas, peak 0.7 mJy/beam

Comp. N



Comp. SE





N1: single dominant component

AGN ?? RSN ?? SNR ??

$$\alpha \simeq 1.2 \quad \text{with} \quad (S \propto \nu^{-\alpha})$$

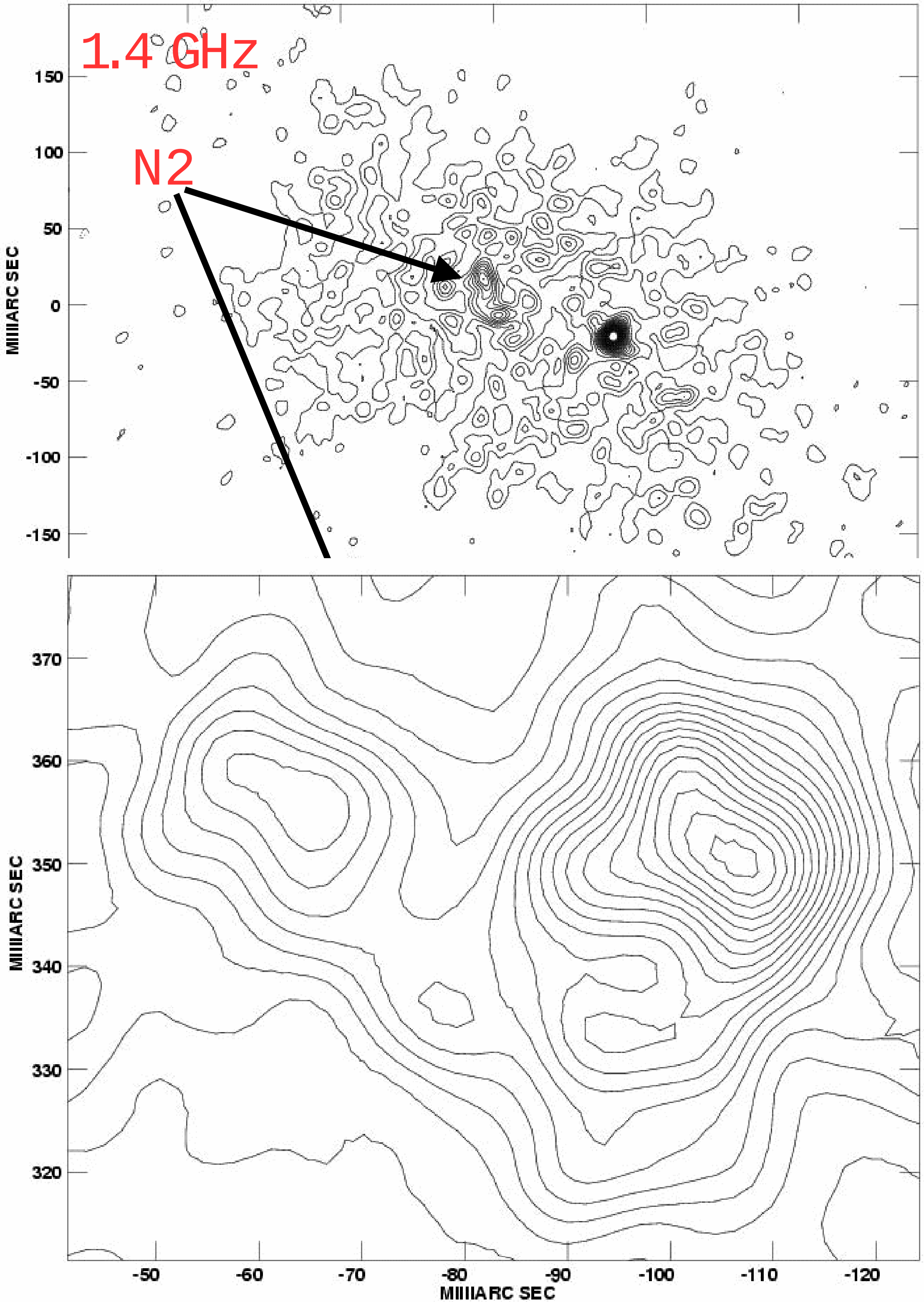
$$P \simeq 7 \times 10^{21} \ \mathrm{W/Hz}$$

Normal RSNe:

$$< P_{\max} > \sim 10^{20} \ \mathrm{W/Hz}$$

Luminous Type II RSN (SN1986J)

$$P_{\max} \simeq 1.4 \times 10^{21} \ \mathrm{W/Hz}$$



N2: complex morphology, multiple components

$$\alpha \simeq 0.15 \quad \text{with} \quad (S \propto \nu^{-\alpha})$$

Possible interpretations:

1) Several overlapping components peaking at GHz + free-free absorption (nested SNRs).
2) Thermal emission.

Core of extremely rich SF region (Downes & Solomon 1998)

The extended emission in Mrk 273 N

$$\alpha \simeq 0.8 \quad \text{with} \quad (S \propto \nu^{-\alpha})$$

Following Condon (1992), the FIR flux of component N can be used with simple heuristic models to derive the SFR, the frequency of SNe, and the non-thermal luminosity.

Observed: $L_{\rm FIR} \simeq 6 \times 10^{11} L_\odot$

Parameters: $m_1 = 5 M_\odot, \;\; m_{\rm u} = 28 M_\odot, \;\; \Delta T_{\rm SB} \simeq 10^8 \; {\rm yr}$

$$\frac{L_{\rm FIR}}{L_\odot} \simeq 1.5 \times 10^{10} \frac{\dot{m}}{M_\odot {\rm yr}^{-1}} \Rightarrow \dot{m} \sim 40 M_\odot {\rm yr}^{-1}$$

$$\nu_{\rm SN} \sim \frac{\dot{m}}{3} \frac{(m_{\rm SN}^{-1.5} - m_{\rm u}^{-1.5})}{(m_1^{-0.5} - m_{\rm u}^{-0.5})} \sim 2 \; {\rm yr}^{-1}$$

$$L_{\rm NT} \sim 1.3 \times 10^{23} \nu^{-\alpha} \nu_{\rm SN} \sim 2 \times 10^{23} \; {\rm WHz}^{-1}$$

$$L_{\rm obs} \simeq 2.2 \times 10^{23} \; {\rm WHz}^{-1}$$

Conclusions

1) N1, single component, has a steep spectral index (1.2). Problems to reconcile with the AGN scenario. Very high luminosity for being a SN (5 times SN1986J).

2) N2 is partly resolved in several compact radio sources. The integrated spectral index of this region is flat (0.15). Possible interpretations are consistent with N2 being the core of an extremely strong star forming region.

3) The spectral index of the extended emission in component N is typical of non-thermal optically thin radio emission (0.8), and the luminosity is consistent with being produced by electrons diffused away from SNR in a luminous starburst.

4) The SE component has a very steep spectral index (1.4), with no compact high brightness component