Star formation vs. accretion in ~~Active Galaxies~~ LIRGs

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The hidden population of SNe in LIRGs

SFR density vs. redshift

- Typical SFRs are a few x10-100 M_sun/yr => CCSN rates a few x0.1-1 SNe/yr

- Significant fraction of the SF at high-z took place in LIRGs/ULIRGs

  (Also Tom Muxlow's talk on e-MERGE - Tier 1)

- Detection of SNe crucial for revising CCSN rates both locally and at high-z

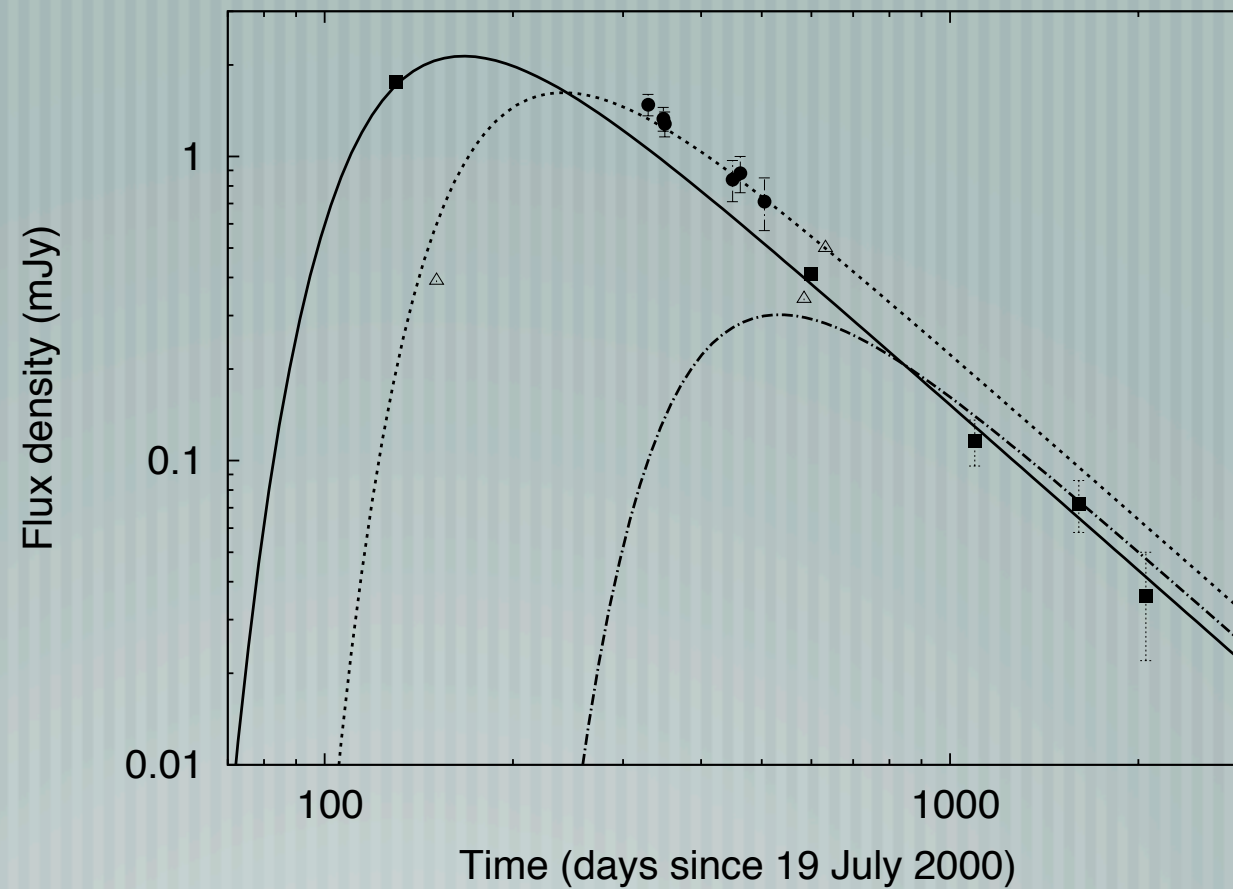 **(See also Cristina Romero-Cañizales poster for RSNe searches in more distant ULIRGs; and Fabian's talk on Arp 220)**
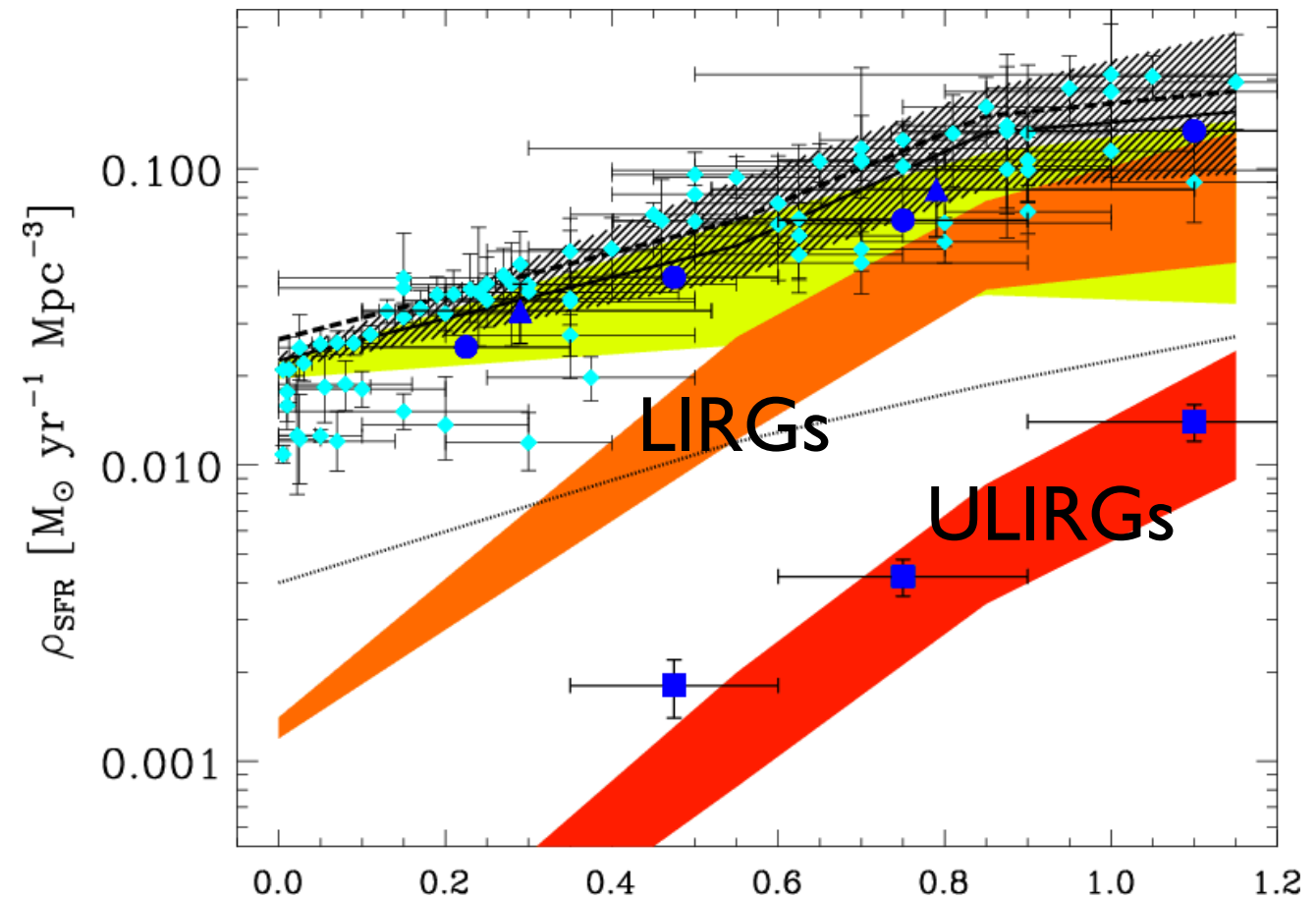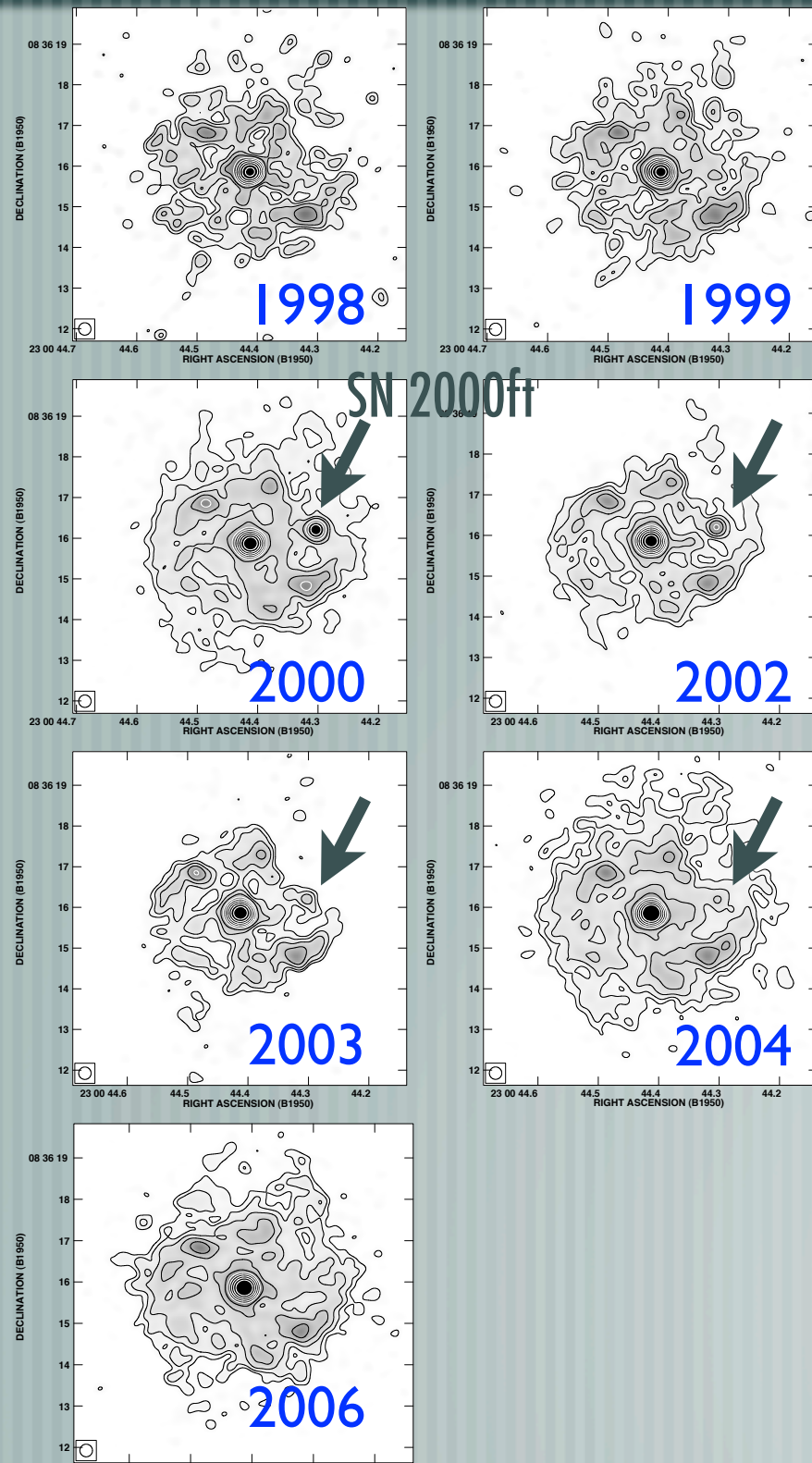

Magnelli+09

High resolution & sensitivity (VLA-A)
SN 2000ft in the LIRG NGC 7469 (D=70 Mpc)

1998

1999

SN 2000ft

2000

2002

2003

2004

2006

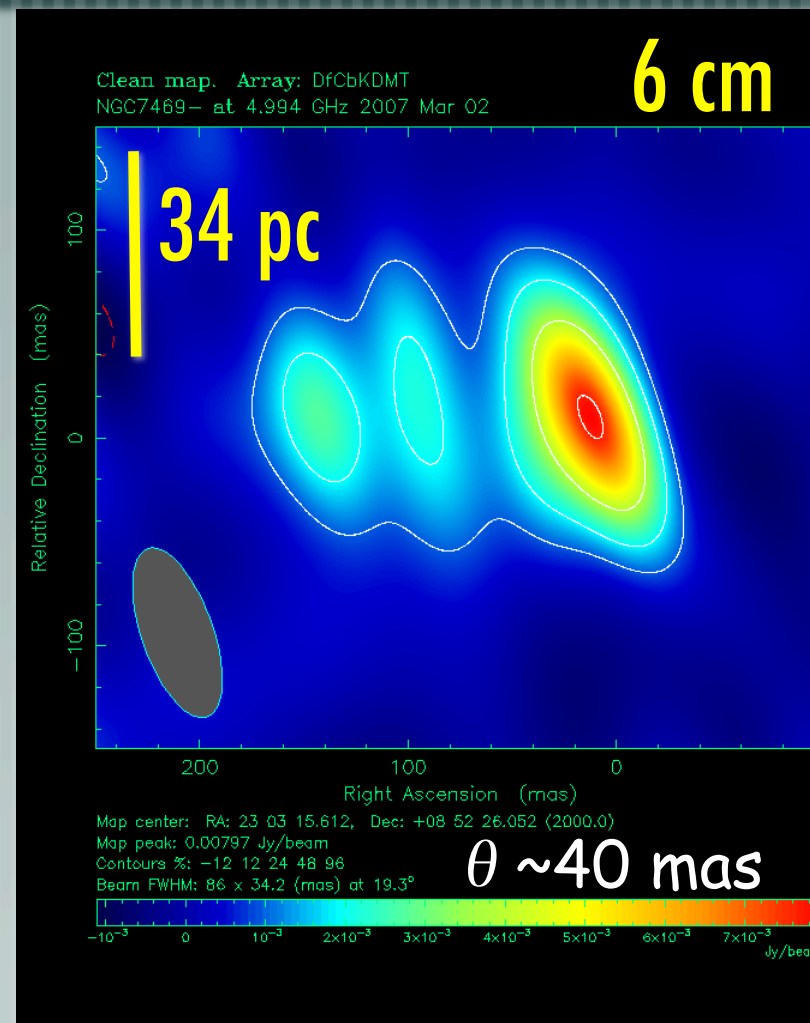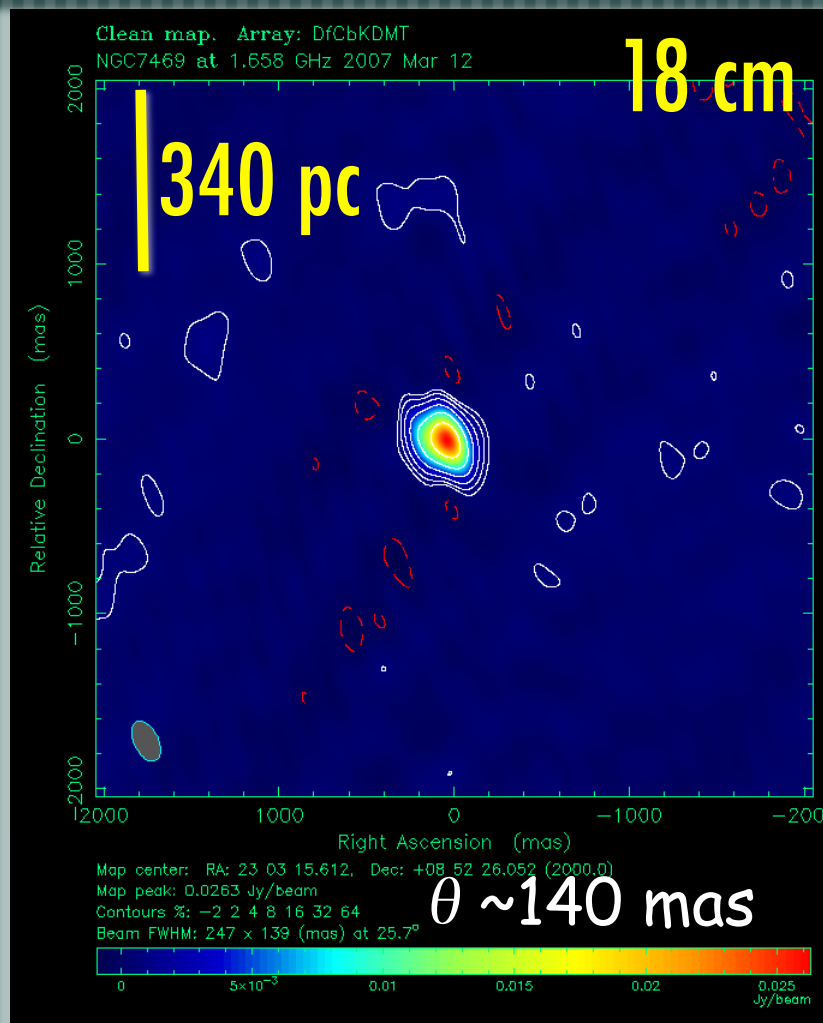

(Pérez-Torres et al. 2009, MNRAS)

Radio emission is being powered by interaction with CSM

If P_ISM = P_M82, then radio emission will be powered by ISM around 2015

High resolution & sensitivity
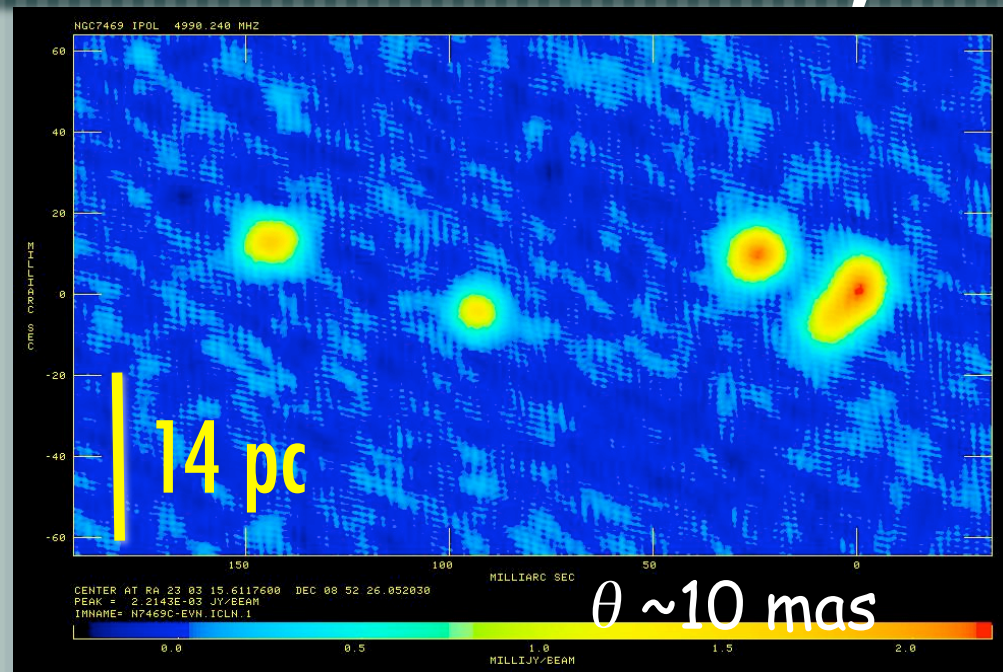## The nuclear region of NGC 7469 (MERLIN)

High resolution - Needed to resolve the nuclear region of NGC 7469
High sensitivity - To discern relatively faint radio supernovae from the nucleus

MERLIN obs-ns at 6 and 18 cm - March 2007
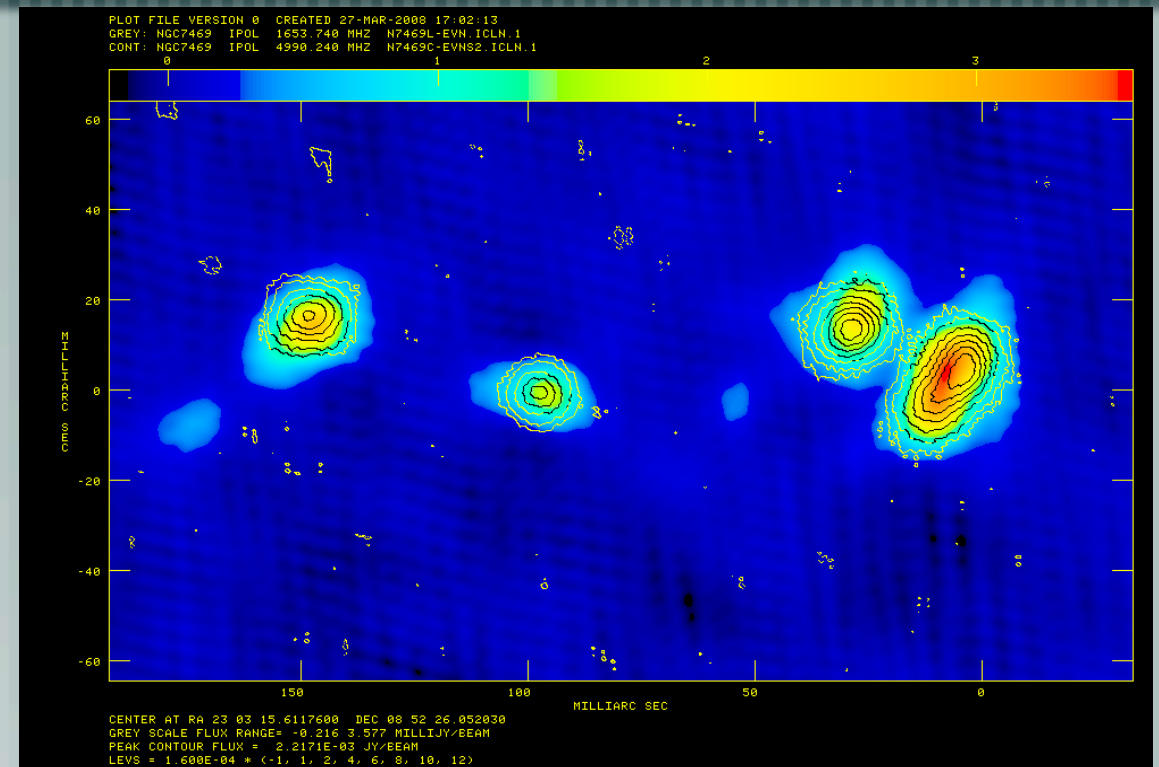(Alberdi et al., in prep.)

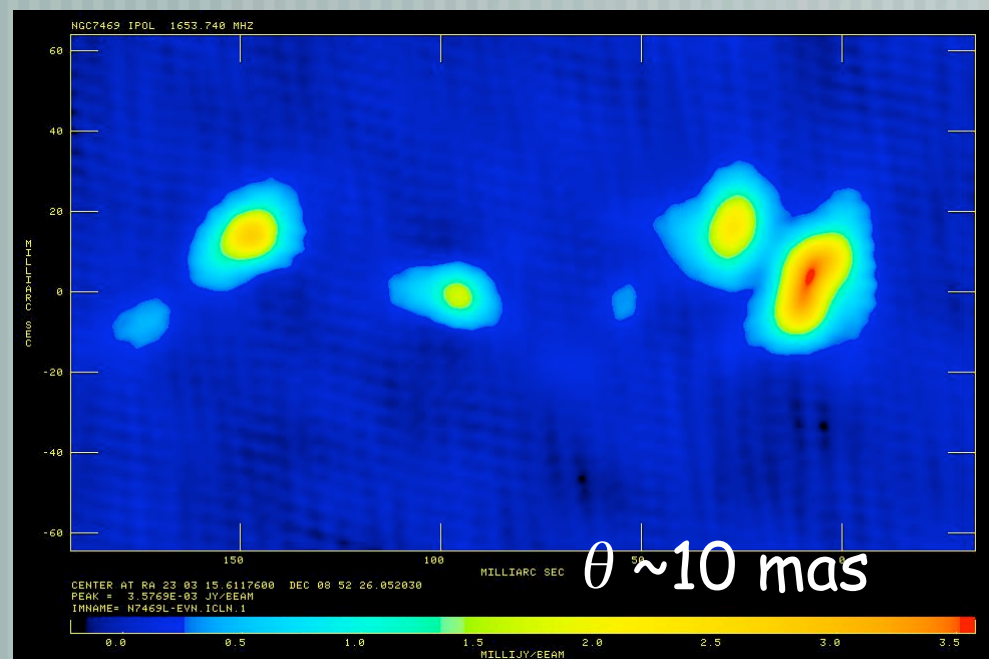# The nuclear region of NGC 7469: AGN-, or SB-dominated?

EVN @ 6cm   (Alberdi et al., in prep.)
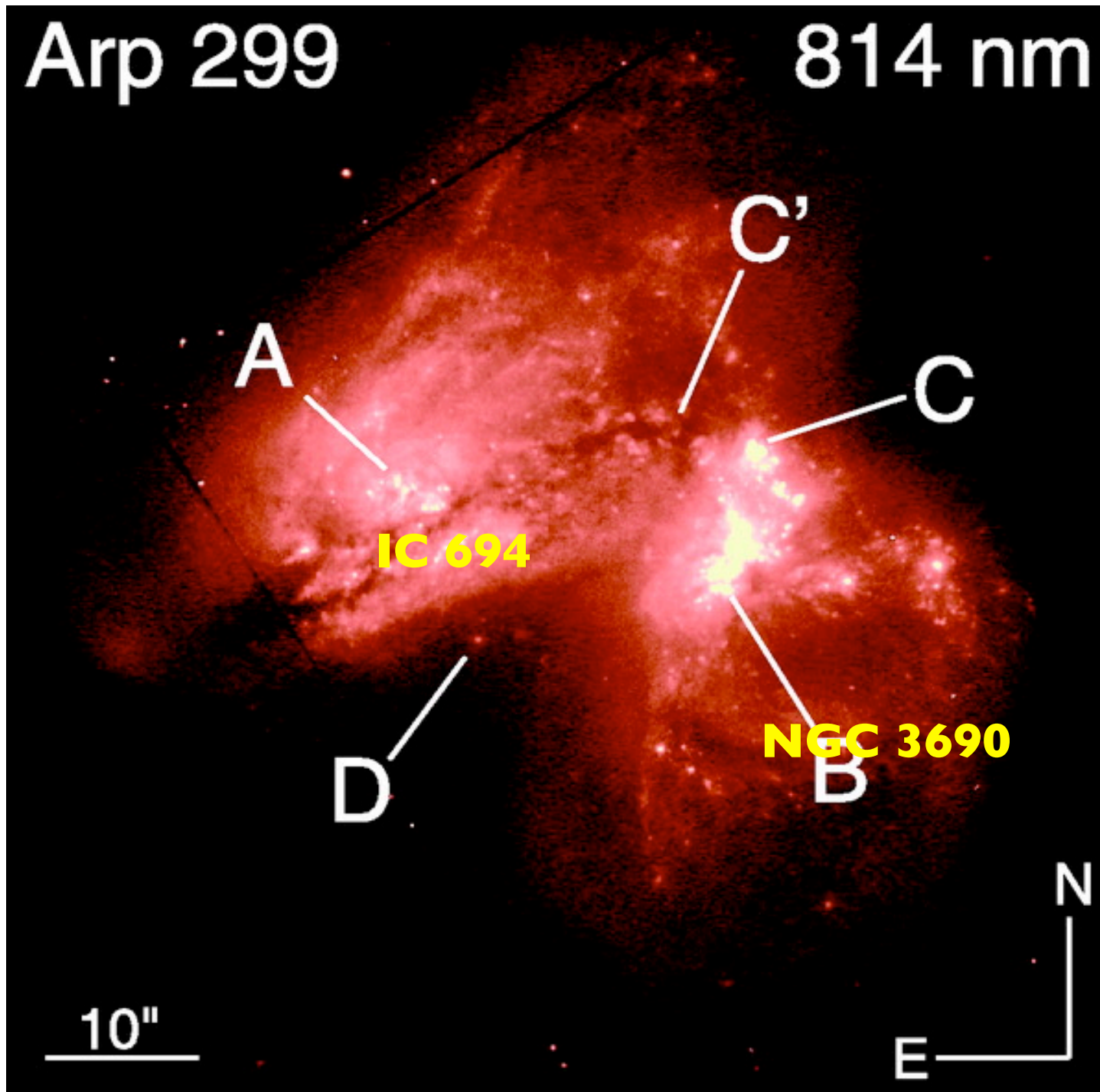
Overlay of EVN 6/18 cm

EVN @ 18cm

θ ~10 mas

VLBI @ 18cm (Jan 1995)
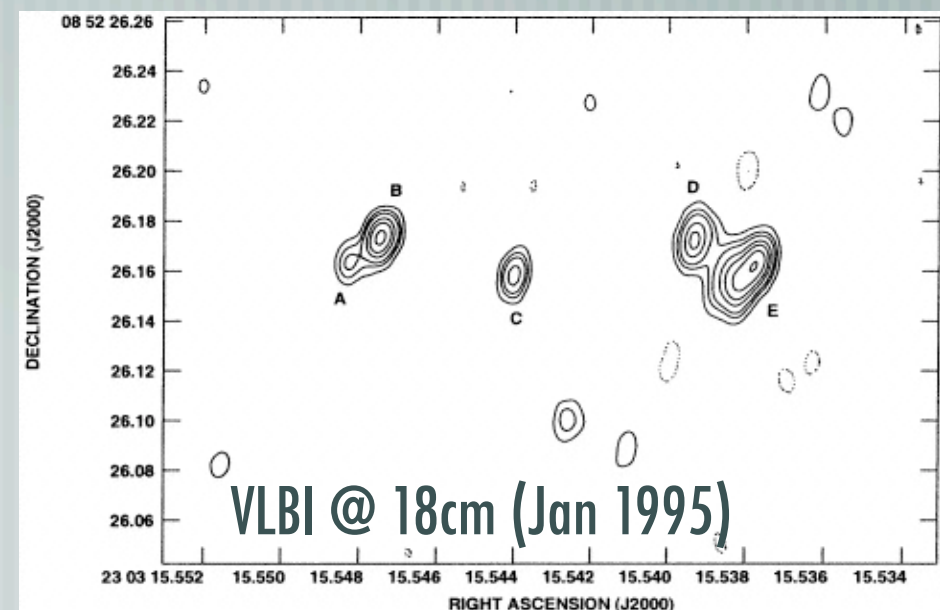
(Lonsdale et al. 2003)

Merger in an early state.

$D \sim 45$ Mpc

$1'' \sim 220$ pc
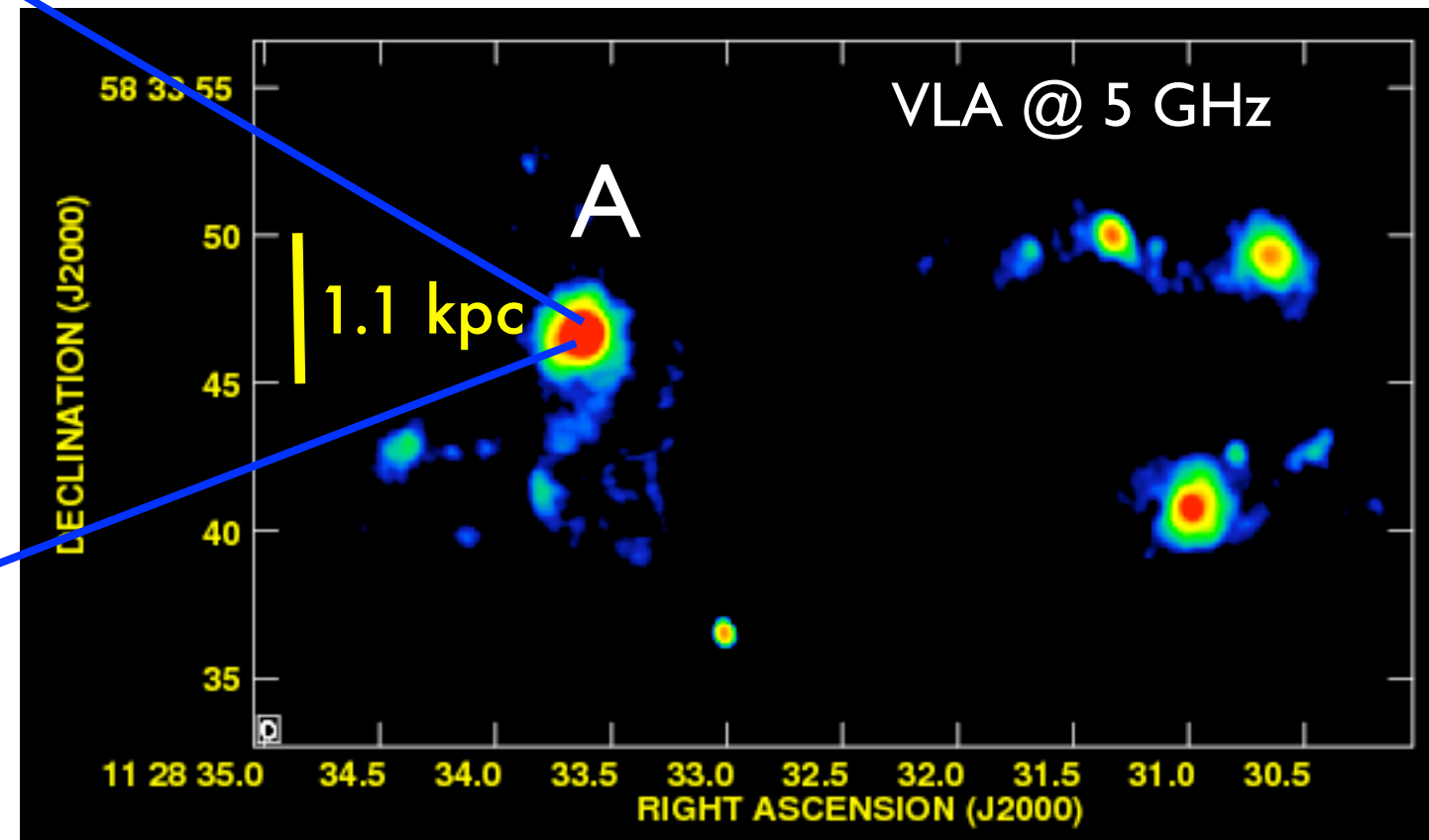
$L_{IR} \sim 6.5 \times 10^{11}$ L_sun

About half of this Luminosity is in component A. Corresponding CCSN rate is about 0.9 SN/yr

First e-EVN observations of Arp 299-A

Pérez-Torres et al. (Letters to A&A, 2009)

5 GHz eEVN   8 Apr 2008
11 pc

5 GHz eEVN   5 Dec 2008
11 pc

VLA @ 5 GHz
A
1.1 kpc
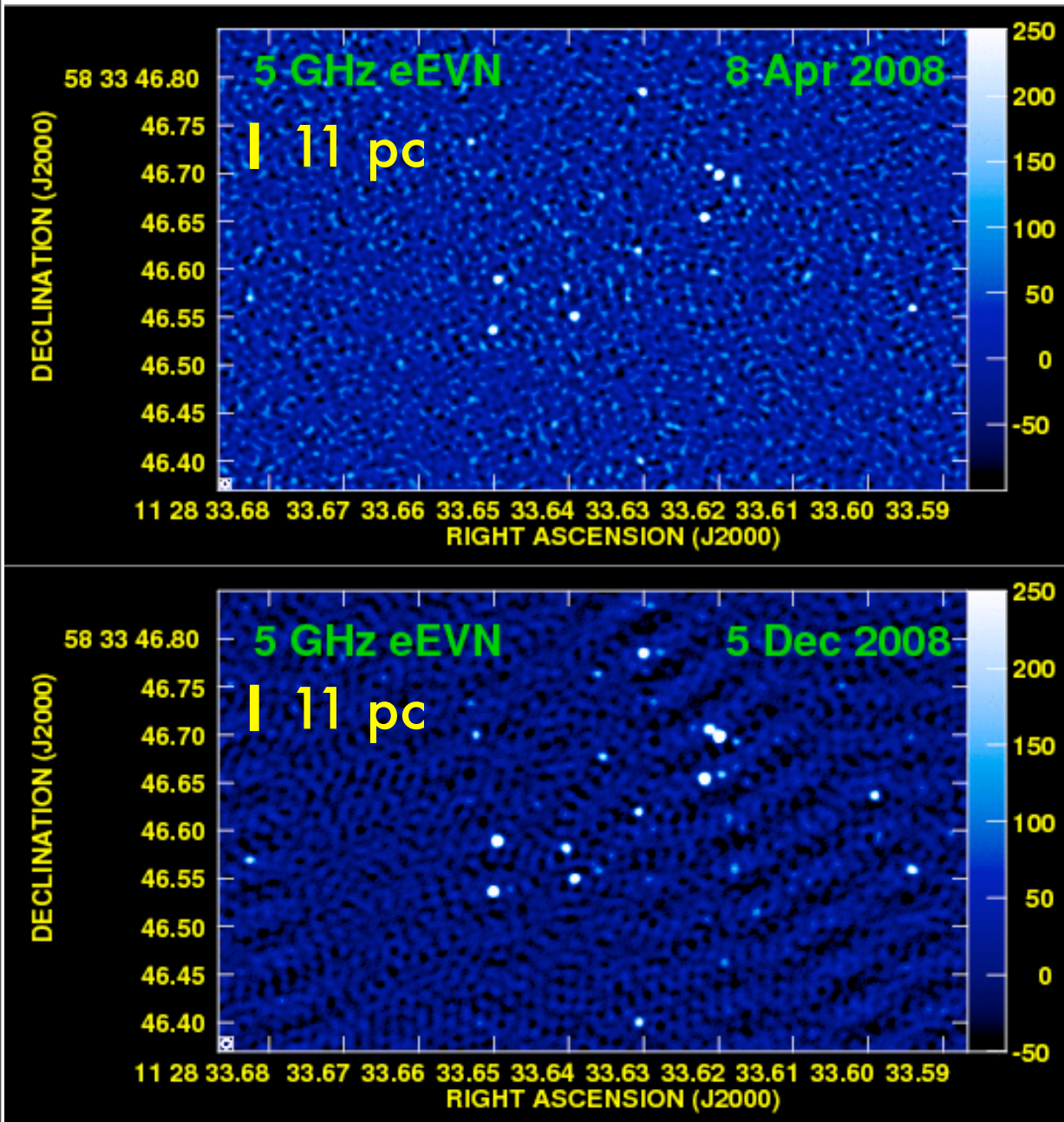
★ Discovery of a rich cluster of compact radio emitting sources in the central (150 x 80) pc of the nuclear region in Arp 299A.

★ But where is the long-sought (and suggested to be) AGN? (See, e.g., Ballo+ 2004)
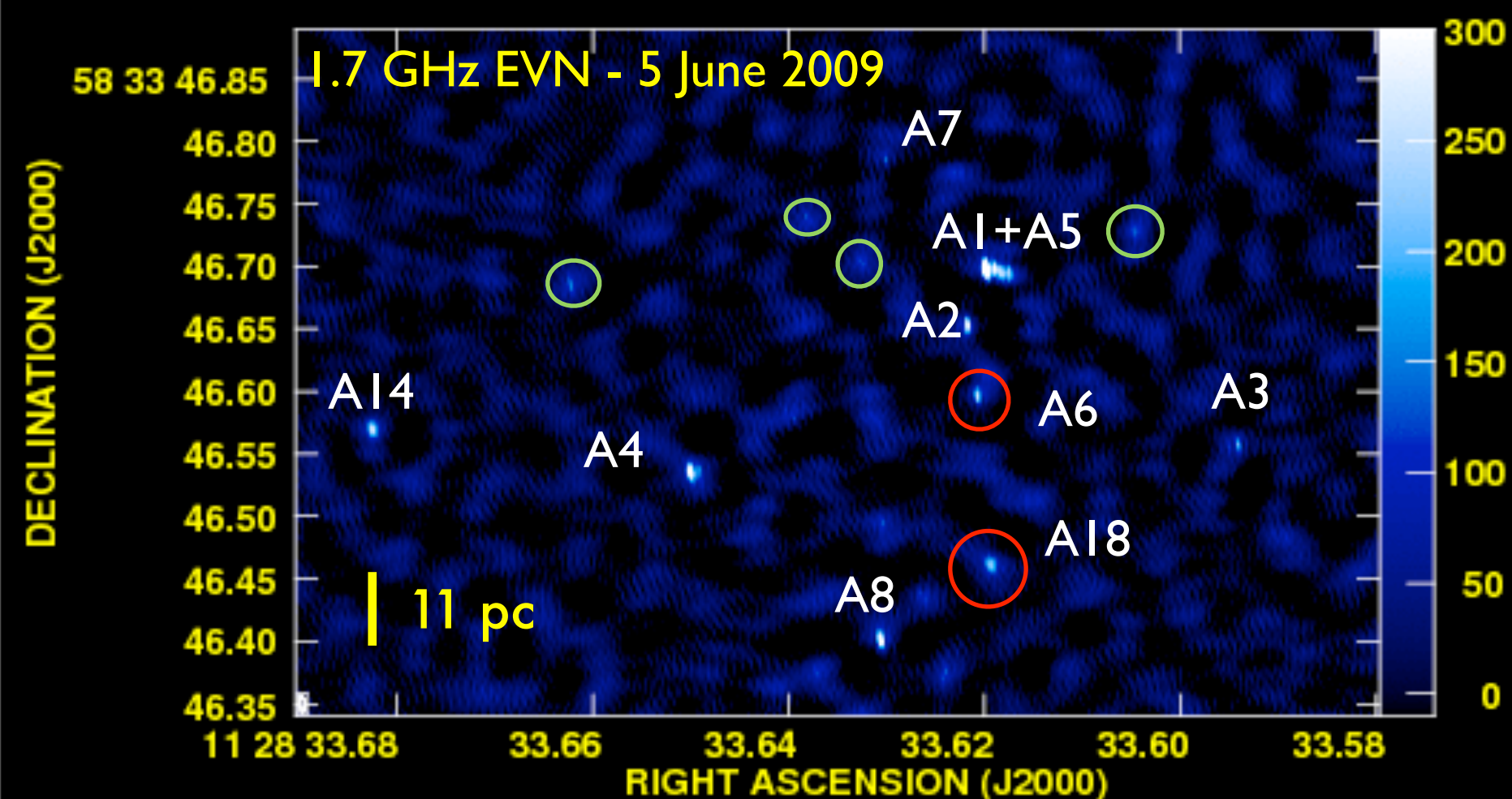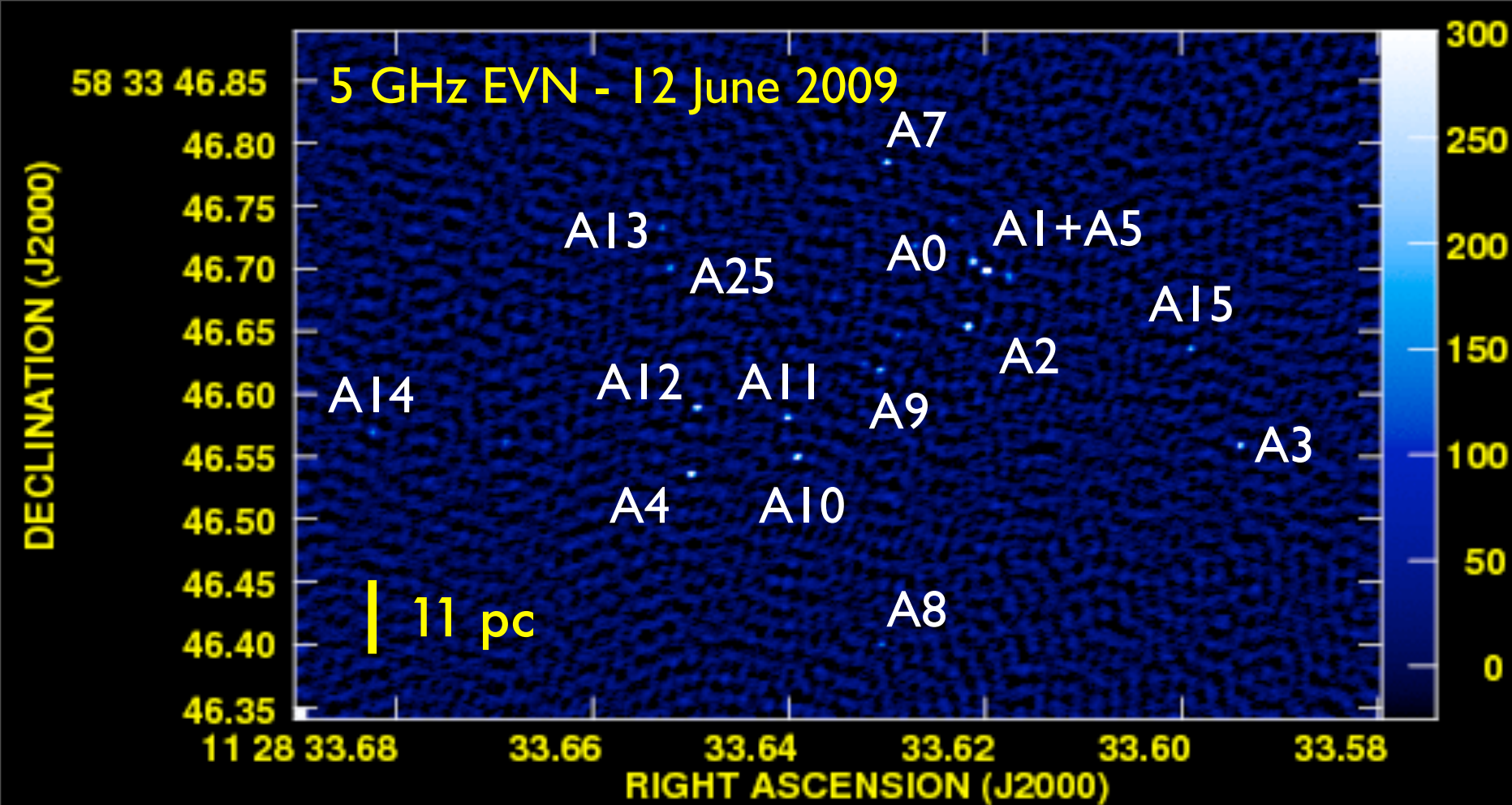
New, Full EVN observations at 1.7 and 5.0 GHz

=> Precious spectral info!

• 20 sources coincident with previously detected sources.

• 11 sources detected at both frequencies
• 2 detected only at 1.7 GHz
• 6 detected only at 5.0 GHz

• 4 new sources (detected only at 1.7 GHz)
• A12 and A15 confirmed as a recent SN
• A6 - A strong microquasar candidate

Pérez-Torres+ in preparation

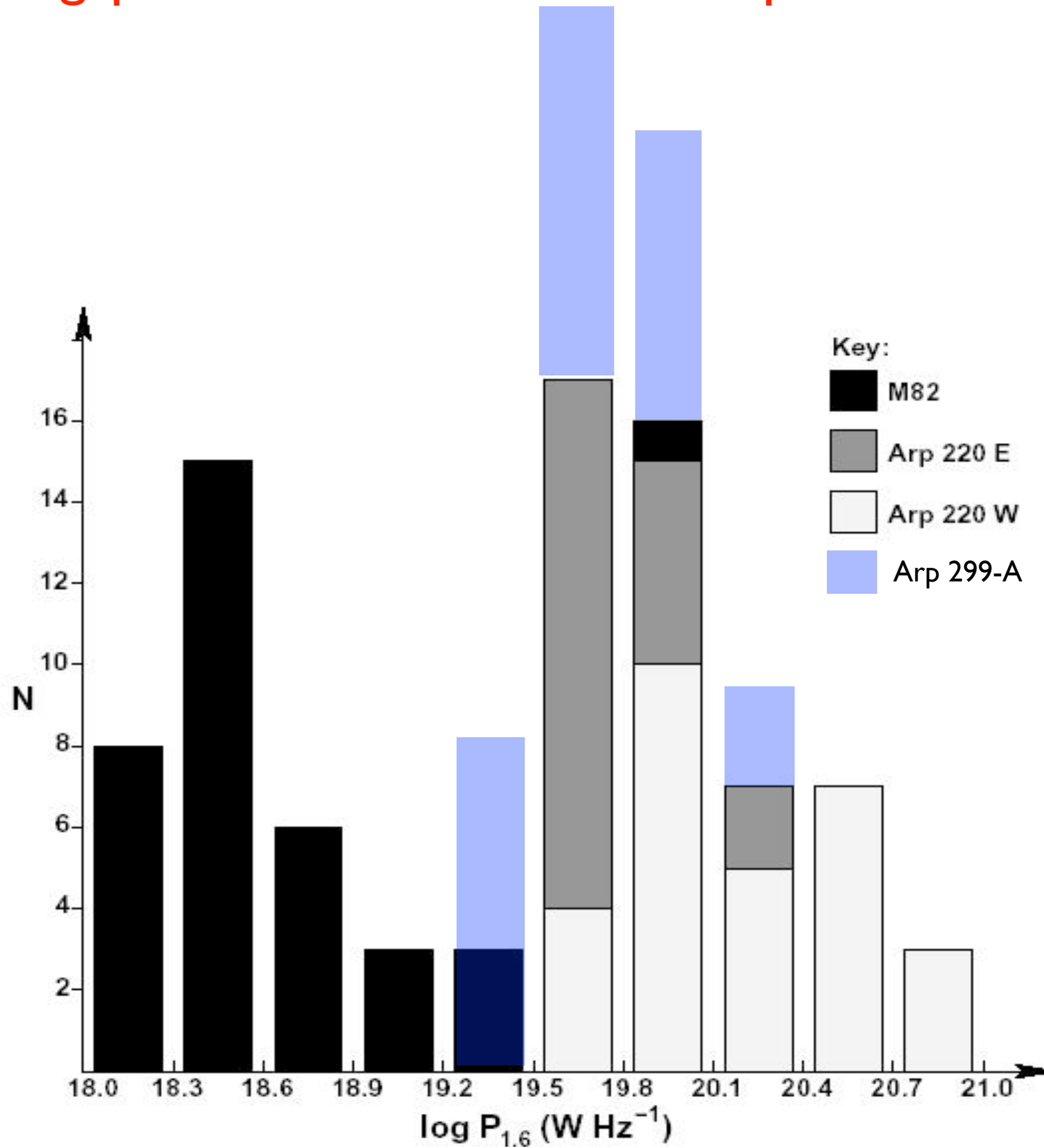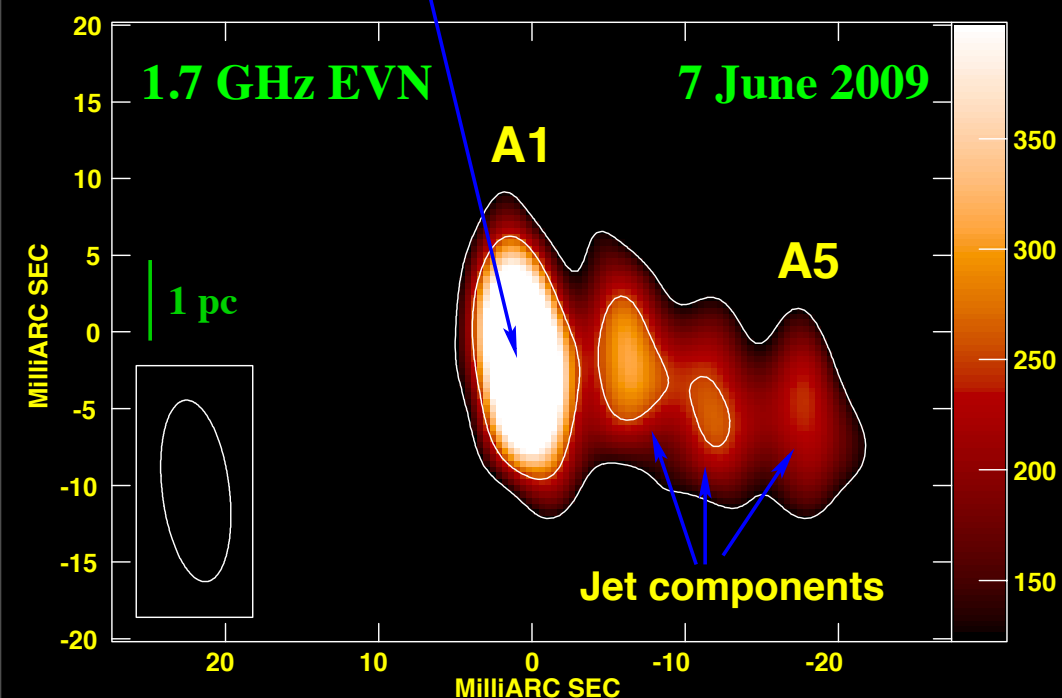# The Arp 299-A starburst in context - Filling the gap between M82-like and Arp 220-like SBs
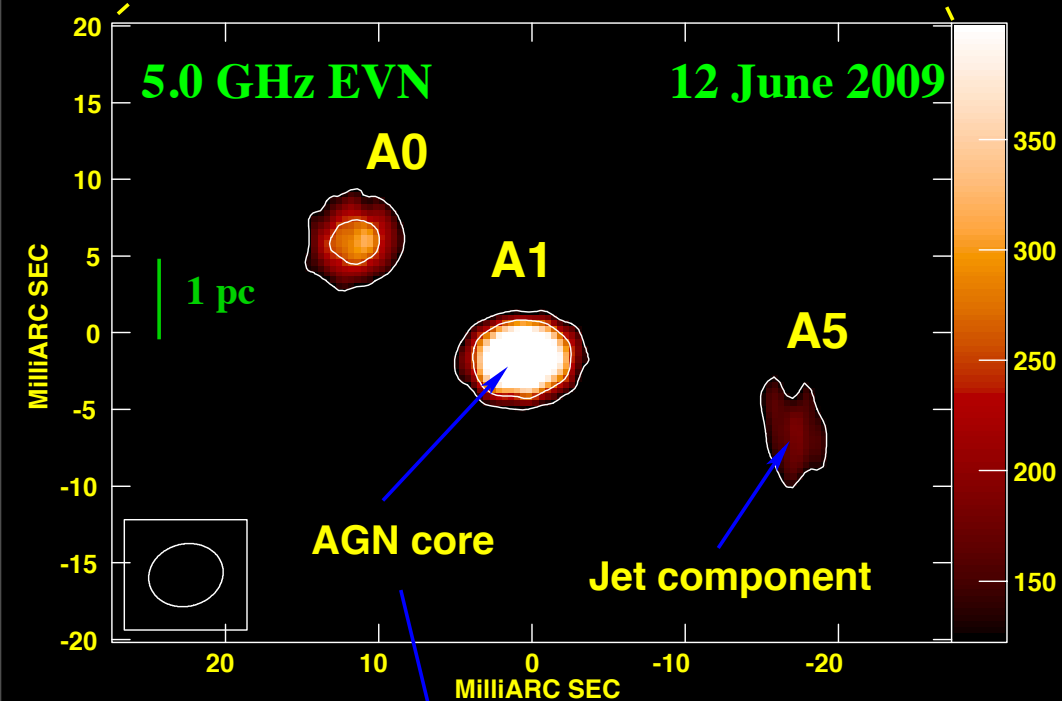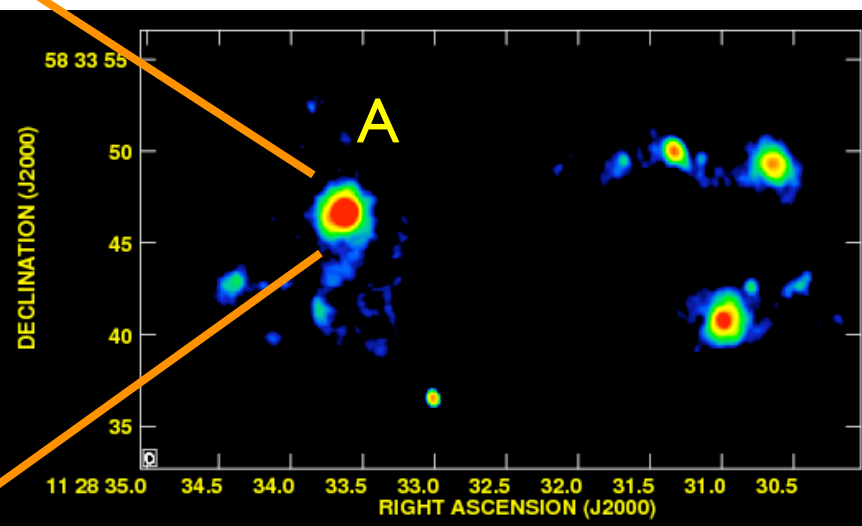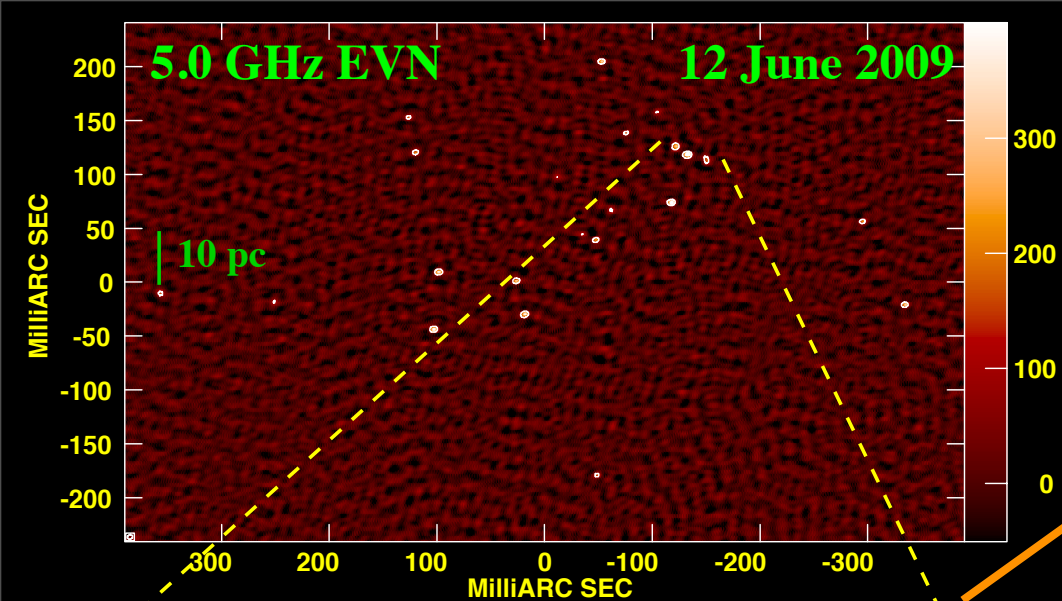
Serendipitous discovery of a dusty-buried AGN in the starbust galaxy Arp 299-A

Quasi-simultaneous 1.7 and 5.0 GHz European VLBI Network (EVN) observations of the central 8 pc of Arp 299-A. (1 Gb/s; ~25 uJy/b)

A1-A5 cannot be SNe and/or SNRs in SSCs.

A1-A5 displays a core-jet morphology, and spectrum of an AGN

Ratio of (5 GHz*L_5)/L_X => A1 is an LLAGN

A0 - A RSN just 2 pc away from a SMBH!! Is SB activity hindering BH accretion, and thus => LLAGN?

Pérez-Torres et al. (2010, Letters to A&A, Vol. 519)

ULIRG sample (EVN+MERLIN @ 6/18 cm)

	D (Mpc)	Log(L_ir/L_sun)	CCSN/yr
IRAS 07251-0248	344	12,32	8
IRAS 19295-0406	338	12,37	9
IRAS 19542+1110	257	12,04	4
IRAS 23365+3604	252	12,13	5

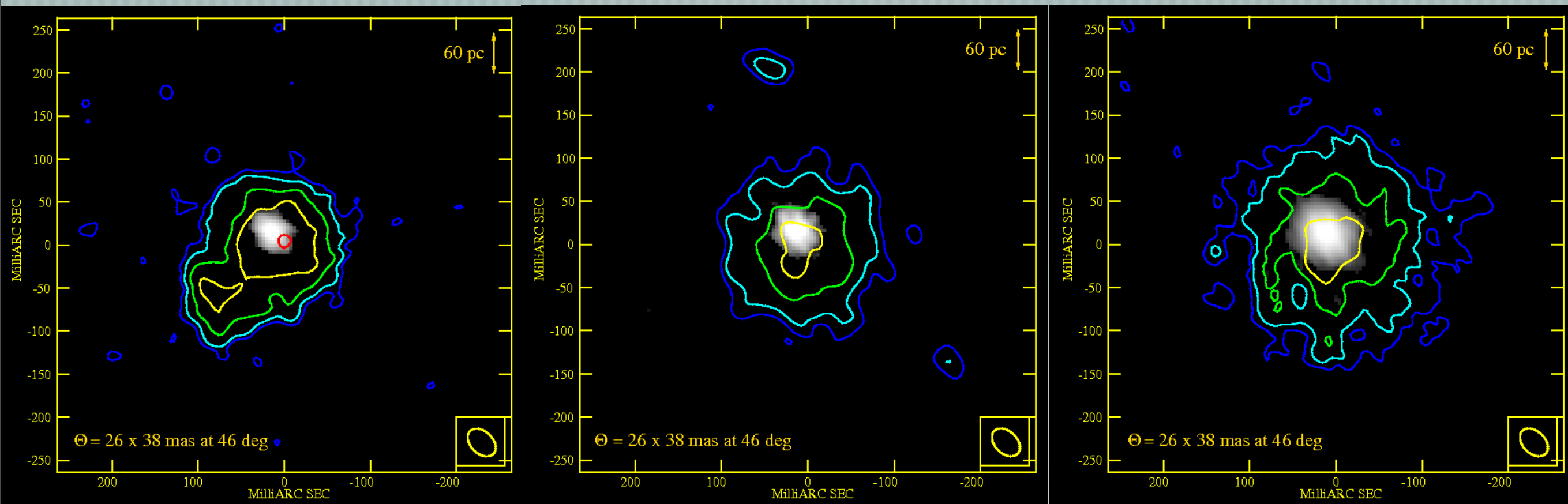Brightest and farthest ULIRGs in the local universe ever imaged with VLBI

Resolution ranging from 1-3 mas (EVN@ 6cm), up to 150 mas (MERLIN @ 18 cm), or 4 pc up to 200 pc @ 250 Mpc. EVN+MERLIN cover intermediate resolutions, too

Expected number of RSNe:

IRAS 23365+3604 @ 250 Mpc

EVN obs-ns at 1.7 and 5.0 GHz

- Nuclear starburst is <= 200 pc in size
- 18cm region is >> 6 cm (synchrotron aging + diffusion)

The eMERLIN legacy project LIRGI
(PIs: John Conway and Miguel Pérez-Torres)

- Legacy survey observations of 42 of the most luminous northern LIRGs selected from IRAS (Sanders+ 2003)

- It will use 6 and 18 cm eMERLIN obsn-s for LIRGs with Dec > 8 deg; log (L_fir/L_sun) >= 11.4; D< 200 Mpc).

- Sources have angular sizes well matched to eMERLIN

- RMS of 4 microJy/b for t_int ~ 4 hr (including Lovell).

- Complementary to GOALS legacy obs-ns.

- Data to be combined with upcoming radio/mm/sub-mm facilities.

- Granted ~ 353 hr (at both 6 and 18 cm). First observing slot around autumn-winter 2010, hopefully. (Rubén Herrero's PhD Thesis.)

The eMERLIN legacy project LIRGI
Overall goals

- Sample spans the range of FIR luminosity from the upper end of LIRGs (log (L_fir/L_sun) >= 11.4) to ULIRGs, most of which are mergers, or post-mergers.

- Our local (D < 200 Mpc) have properties of area star formation densities, gas and radiation densities similar to SF galaxies at high-z.

- A major goal of future radio/mm/sub-mm facilities: To use high-z objects to trace the SF (and galaxy assembly) history of the universe.

- => Understanding the physics of similar local objects.

- => Crucial to understand how accurately radio continuum flux densities can be converted into SFRs. For example, if the IMFs in ULIRGs are top-heavy, the calibration of SFR from SF tracers can be affected.

Concluding remarks

Radio observations at the highest resolution and sensitivity (EVN, or EVN +MERLIN/global VLBI) are currently one of the MOST RELIABLE WAYs to discern SB from AGN driven activity in the innermost regions of (U)LIRGs in the nearby universe, to determine their CCSN rate.

 Further eEVN obs-ns of Arp 299 to determine its true CCSN rate (1 SN/yr ?)

Two additional EVN (+MERLIN) epochs of our ULIRG sample to confirm/rule out RSN candidates, and so determine their CCSN rate and unveil their putative AGN.

The LIRGI eMERLIN legacy project will allow us to tackle the SB vs. AGN relevant issue in a STATISTICALLY meaningful way. Stay tuned!!

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