Arp 299-A: More than "just" a prolific supernova factory

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The hidden population of SNe in LIRGs

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

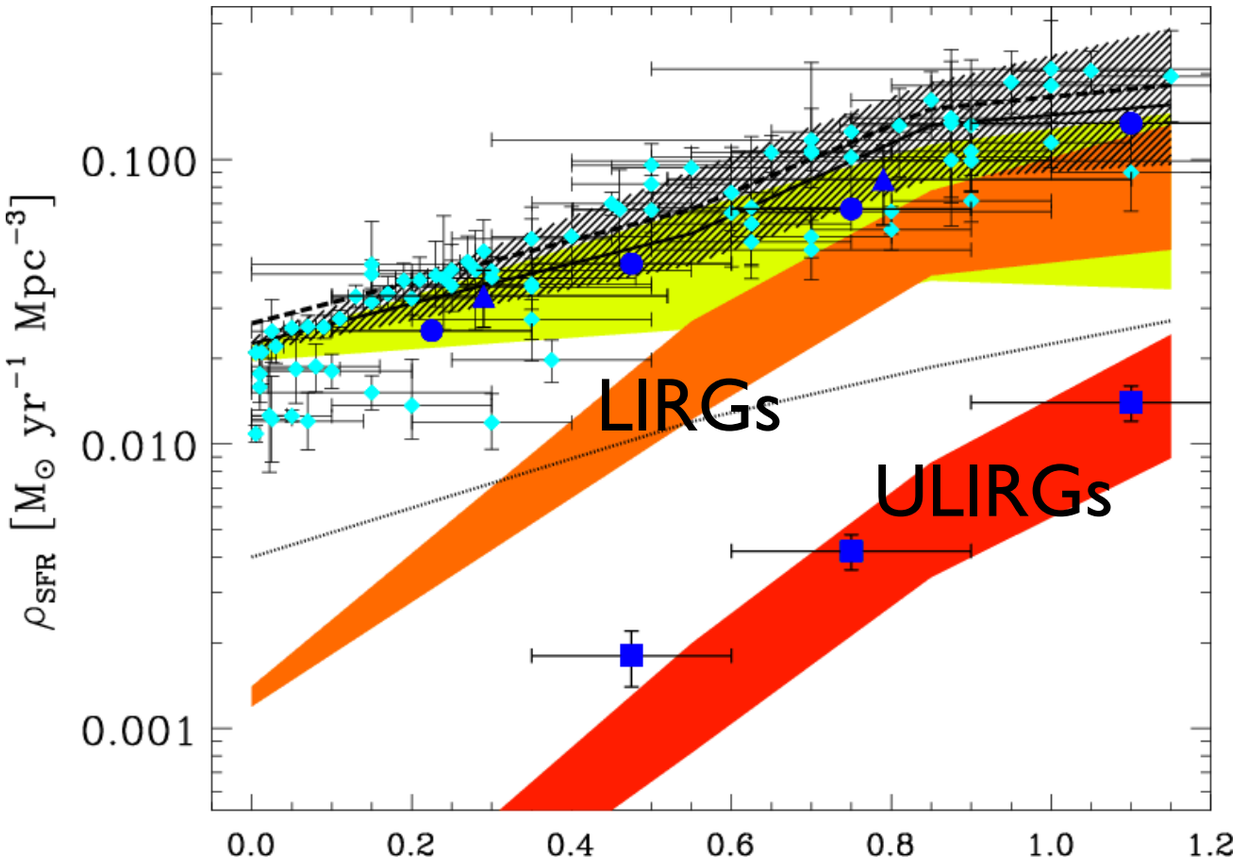
- Significant fraction of the SF at high-z took place in LIRGs/ULIRGs

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

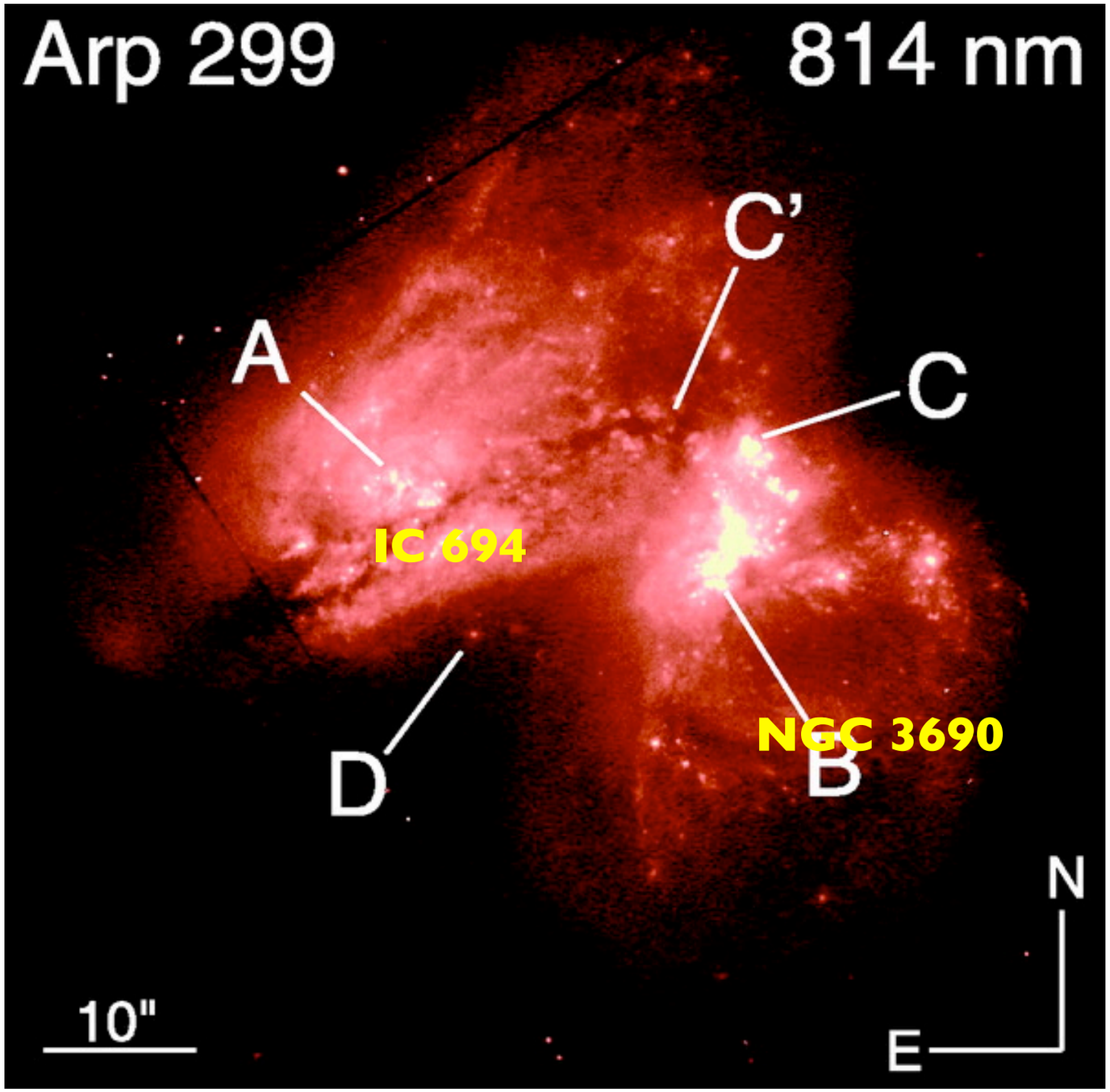
- Detection of SNe crucial for revising CCSN rates both locally and at high-z

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

SFR density vs. redshift



Magnelli+09



Merger in an early state.

D ~ 45 Mpc

1" ~ 220 pc

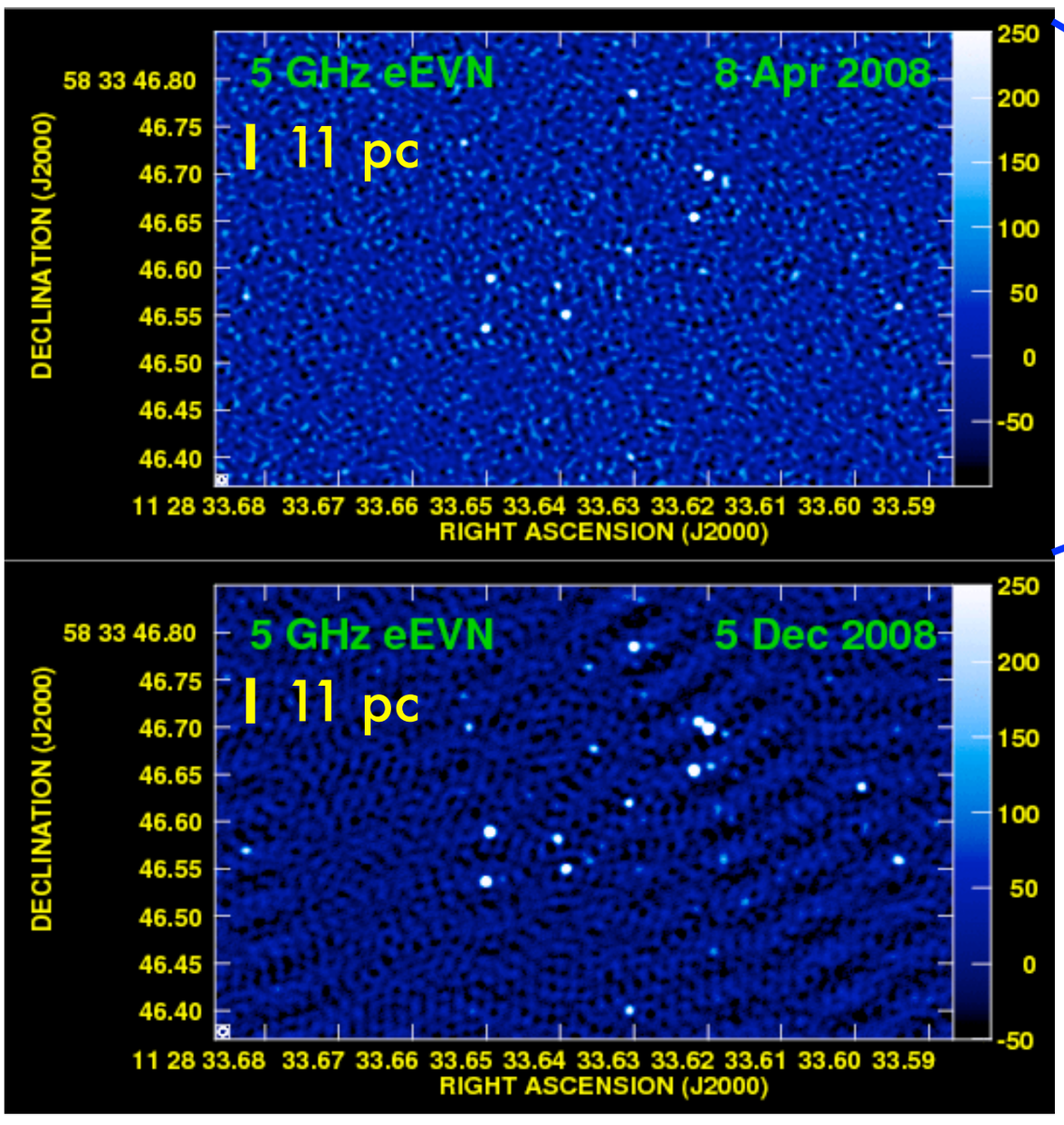
L_{IR} ~ 6.5 x 10^{11} L_sun

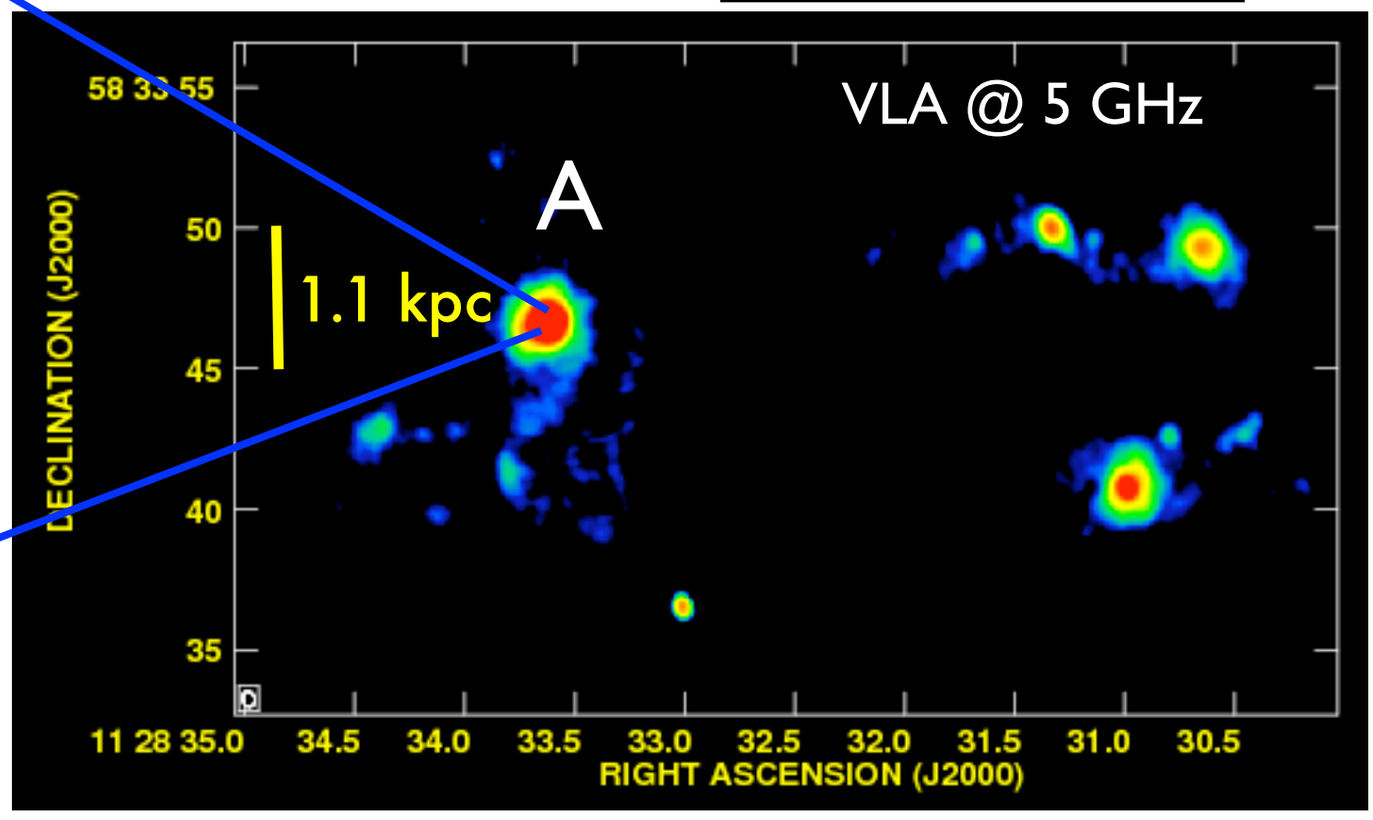
About half of this Luminosity is in component A. Corresponding CCSN rate is about 0.9 SN/yr

HST WFPC2 814 nm image of Arp 299 (from Neff+ 2004)

First e-EVN observations of Arp 299-A

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

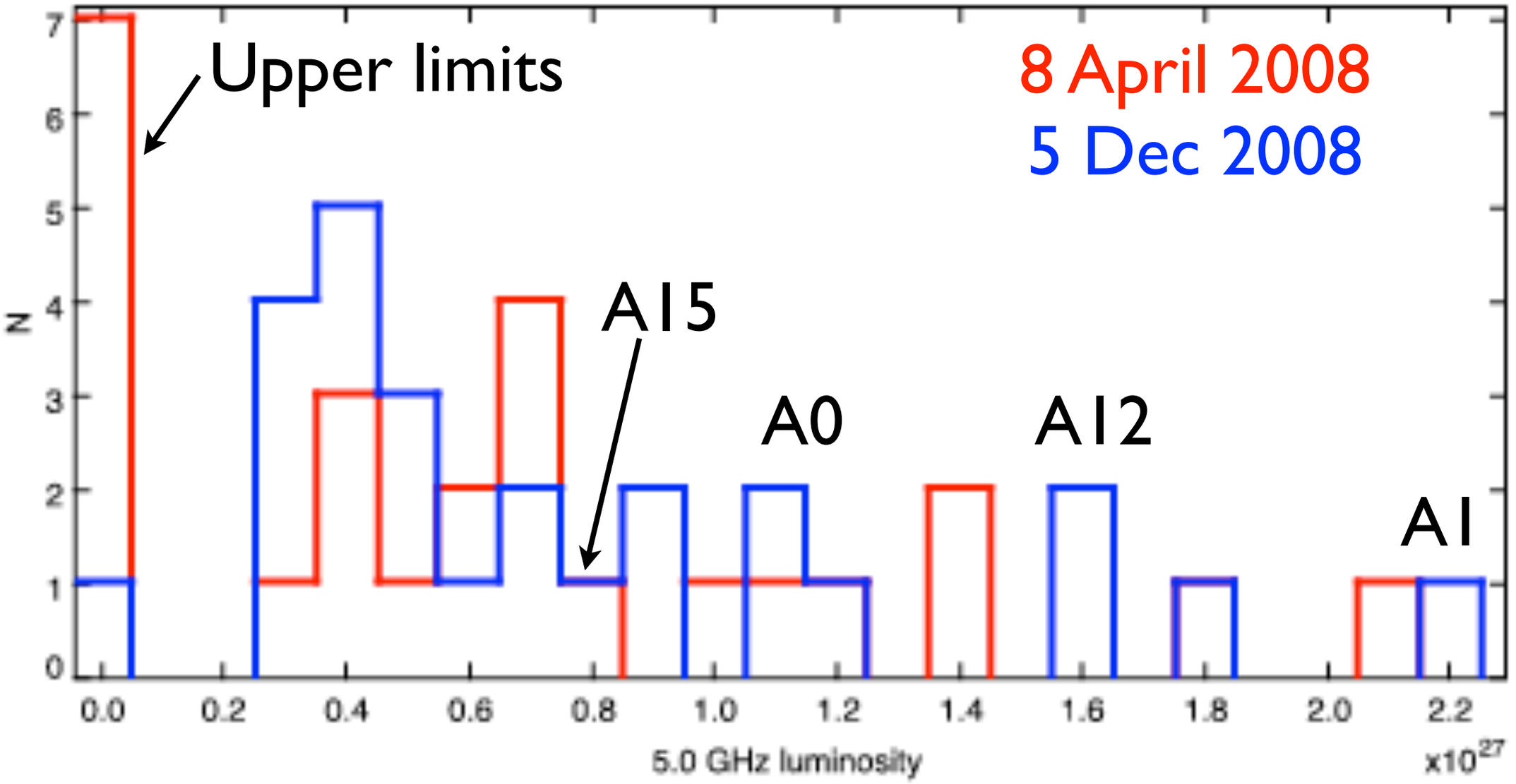




★ Discovery of a rich cluster of compact radio emitting sources in the central (150 x 80) pc of the nuclear region in Arp 299A.

5.0 GHz luminosity histogram of the VLBI components

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

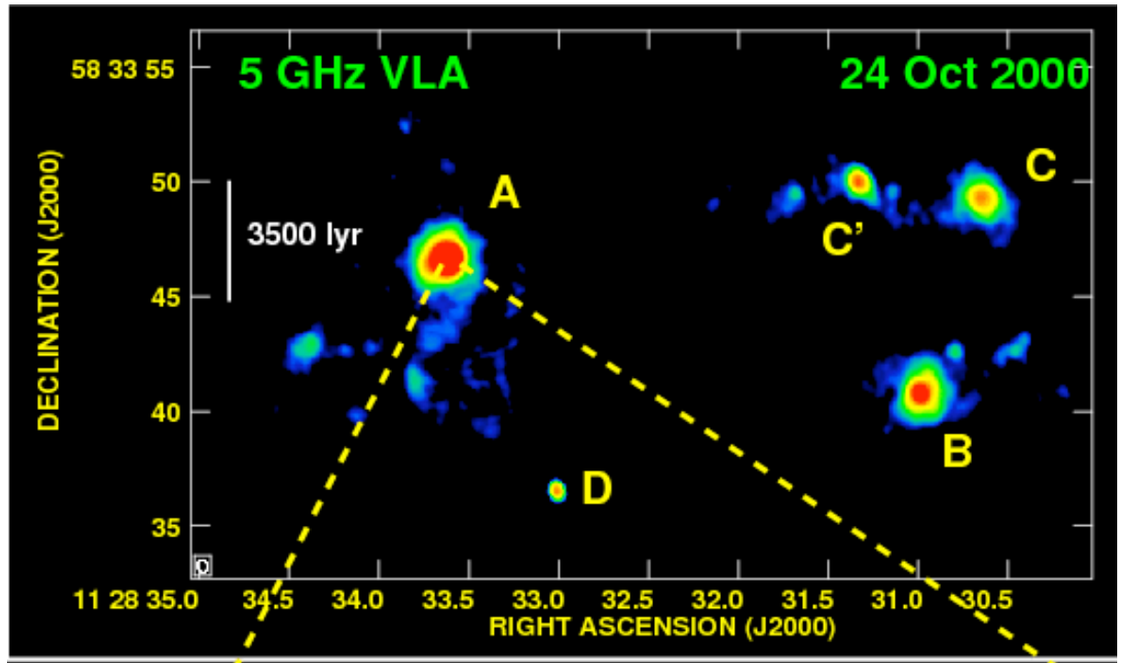


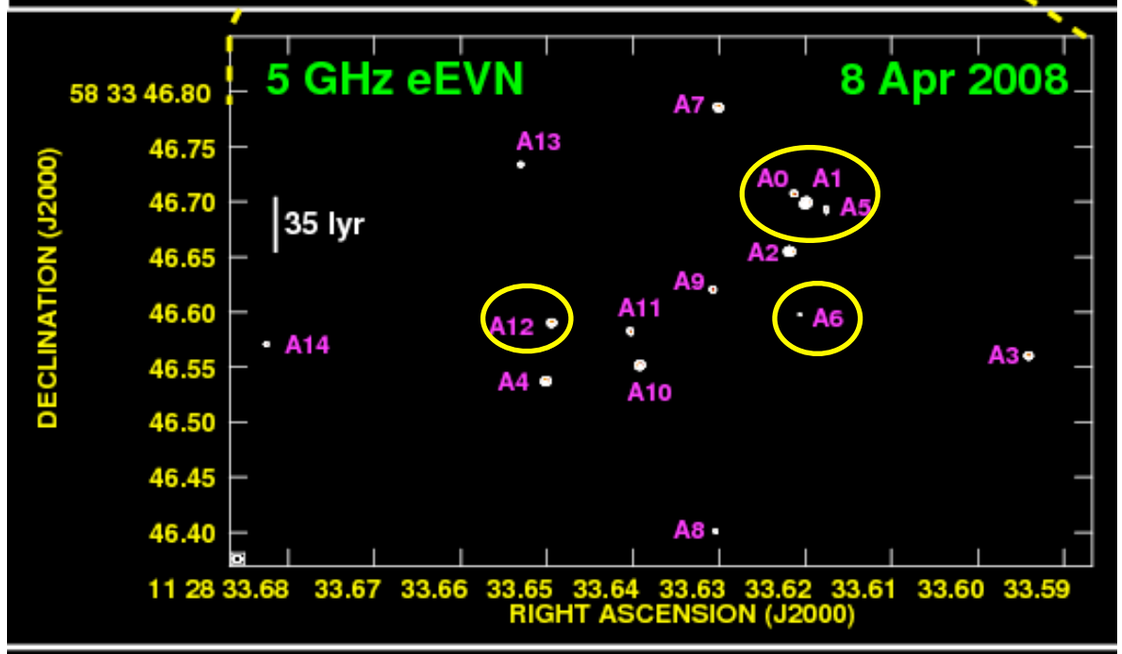
Radio emission levels are moderate to high, and typical of Type II RSNe

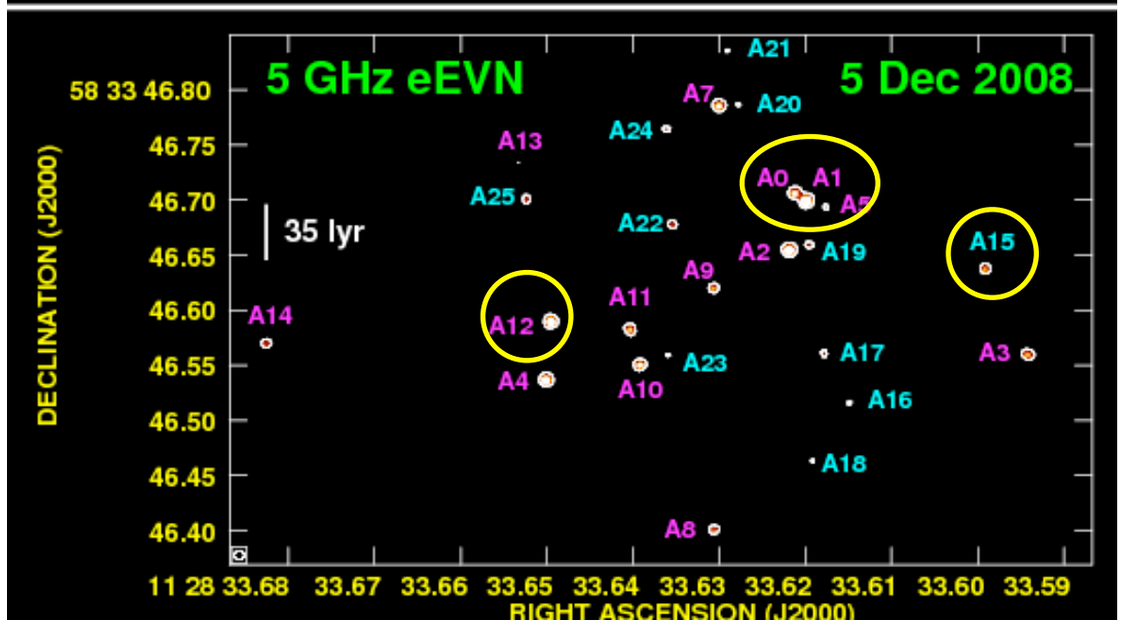
An extremely prolific SN factory in Arp 299-A revealed with the eEVN

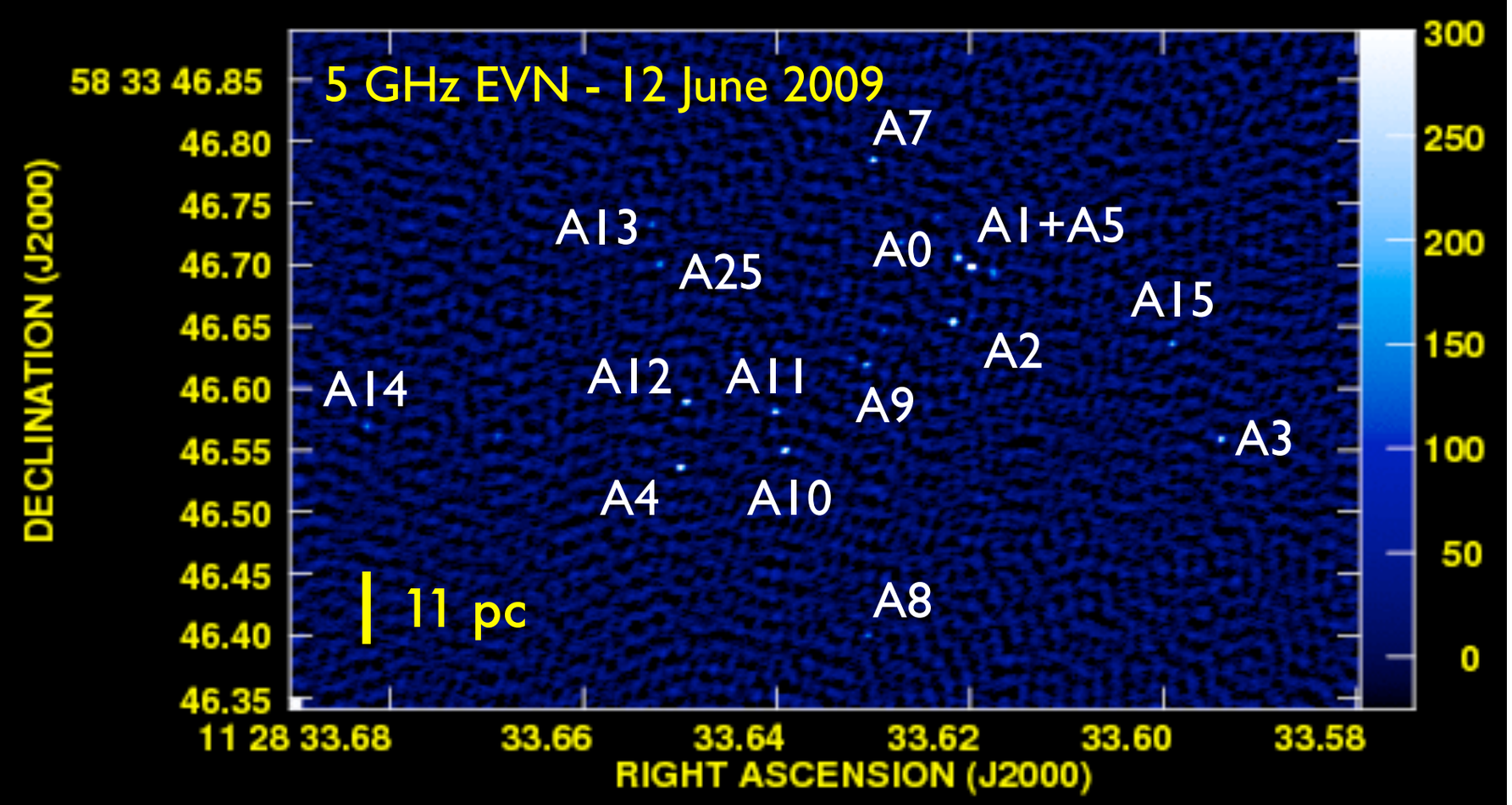
- ★ SNe and/or SNRs, likely embedded in SSCs.
- ★ Evidence of at least three RSNe (A0, A12 and A15), plus a likely one (A6, although it could be an X-ray binary).
- ★ All of the three RSN are relatively young, slowly evolving, long-lasting SNe.
- ★ Very suggestive of the local CSM playing a main role in shaping the radio behaviour of RSNe.
- ★ Moderate to high radio emission levels (typical of Type II SNe)
- ★ All of these results provide support for a recent (< 10-15 Myr) starburst in the inner 150 pc of Arp 299A

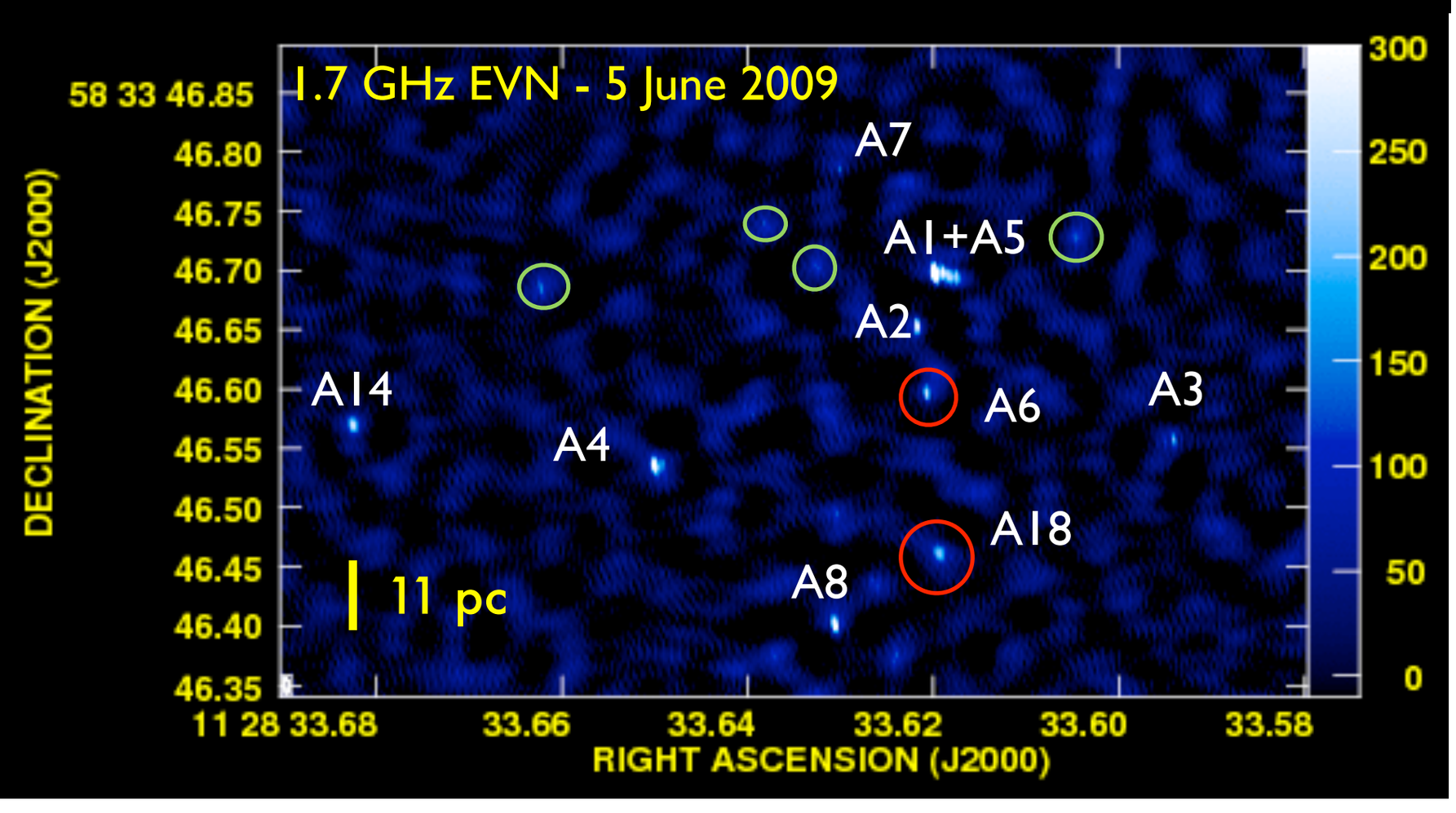
Pérez-Torres et al. (Letters to A&A, 2009)











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

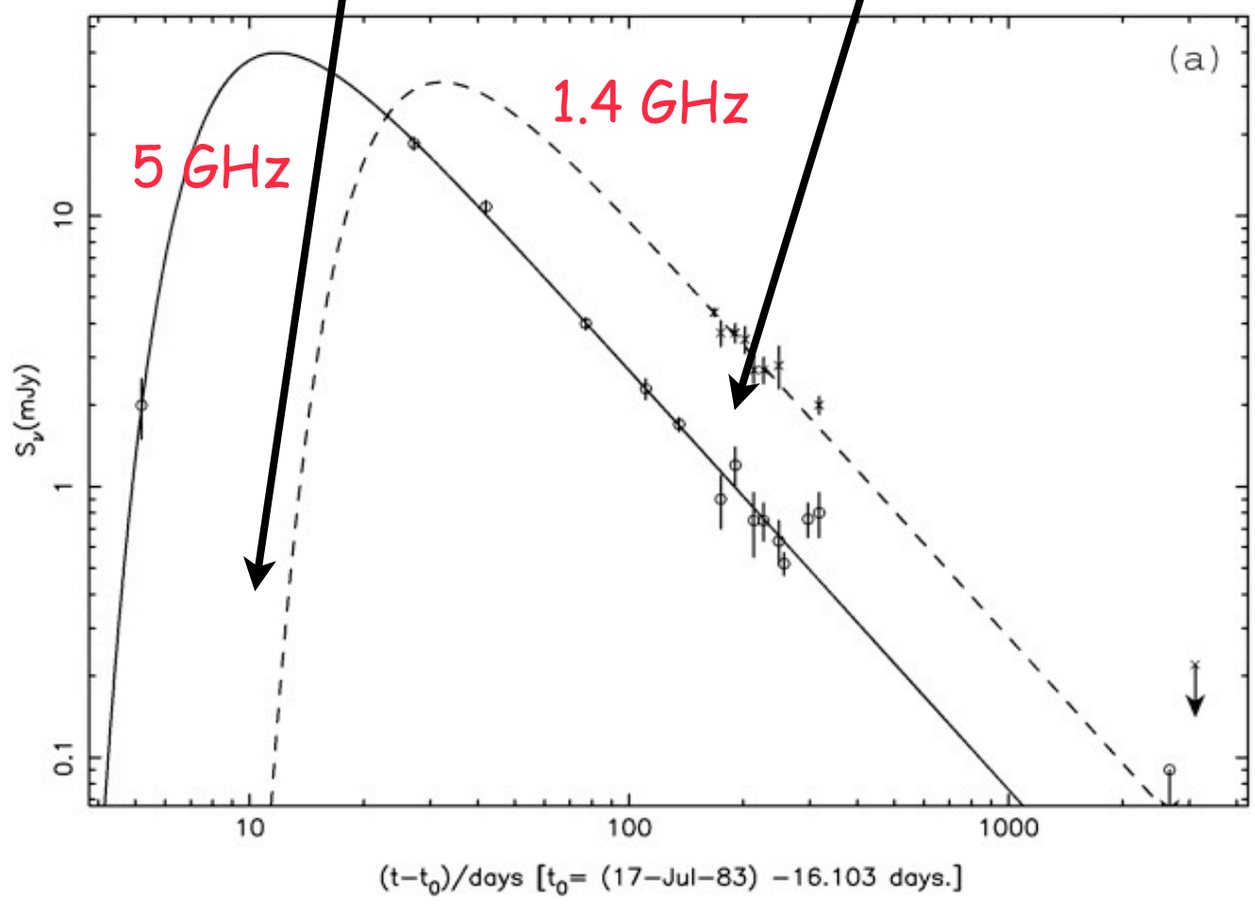
Pérez-Torres+ in preparation

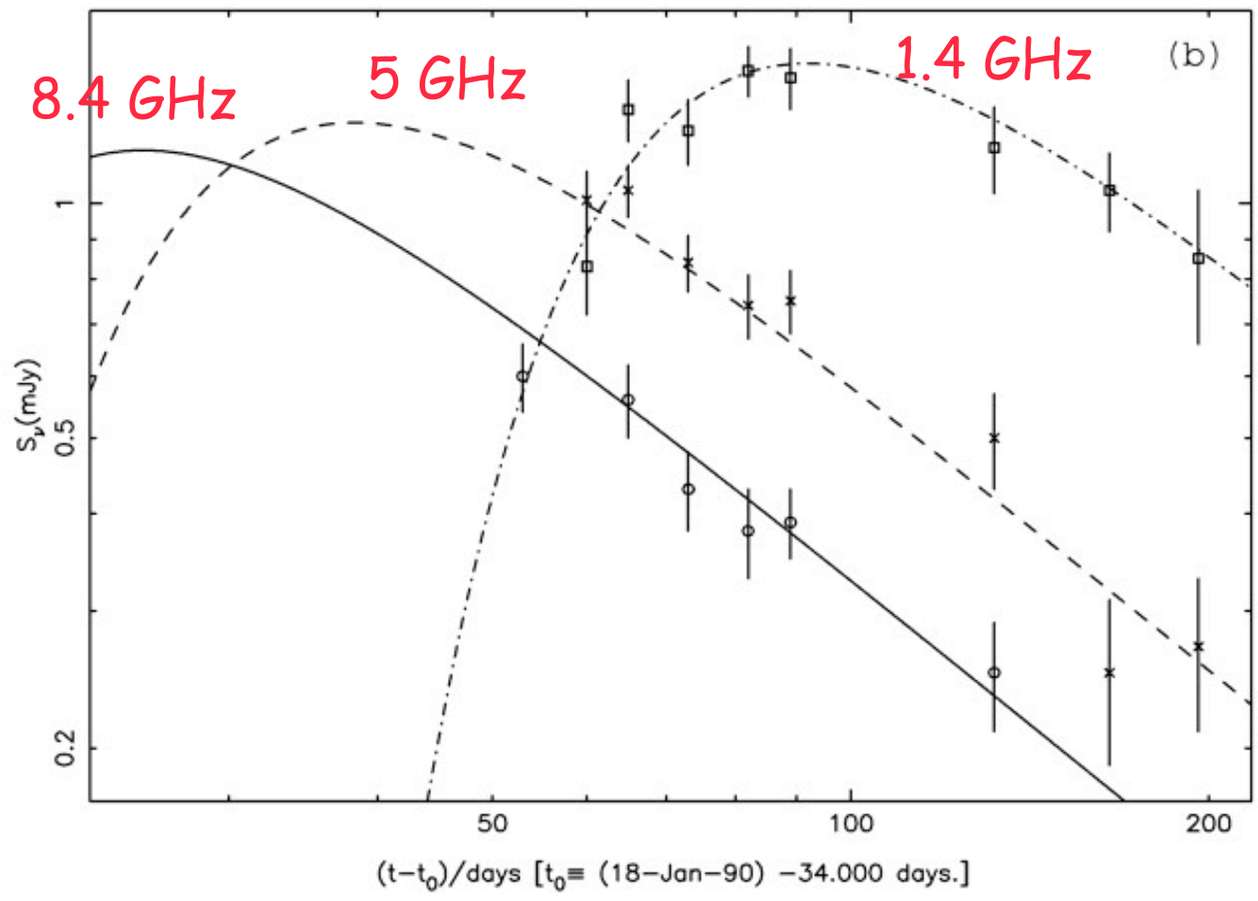
Radio light curves & spectra from SNe

Optically thick phase:
alpha >> 0.0

Optically thin phase
alpha << 0.0

$$S_\nu \propto \nu^\alpha$$

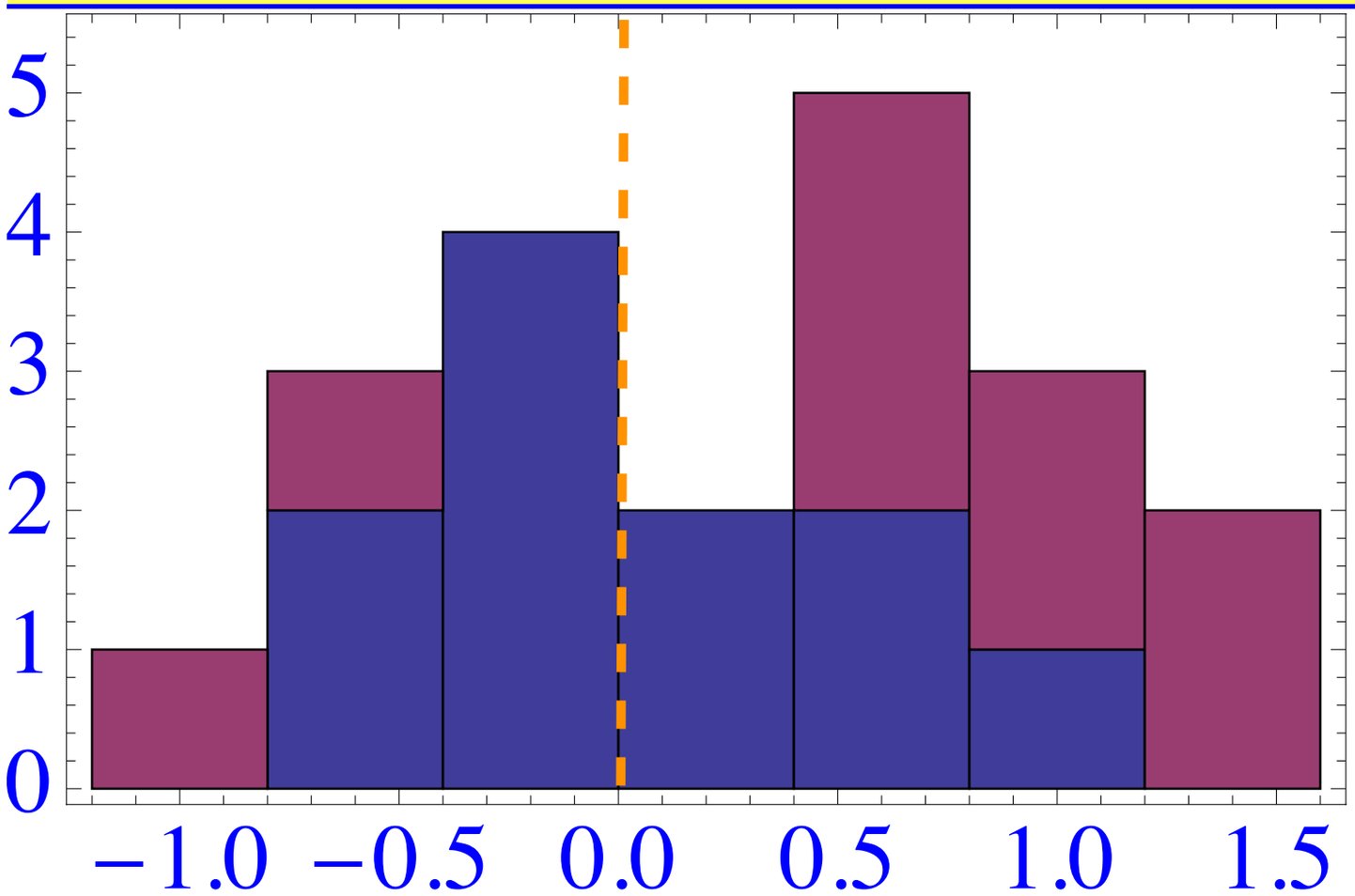




Very inverted spectra (alpha >> 0.0) suggest (very) young RSNe
Very steep (alpha << 0.0) suggest RSNe in their optically thin phase

Source Spectra in Arp 299A

Spectral Index Distribution for Arp 299A



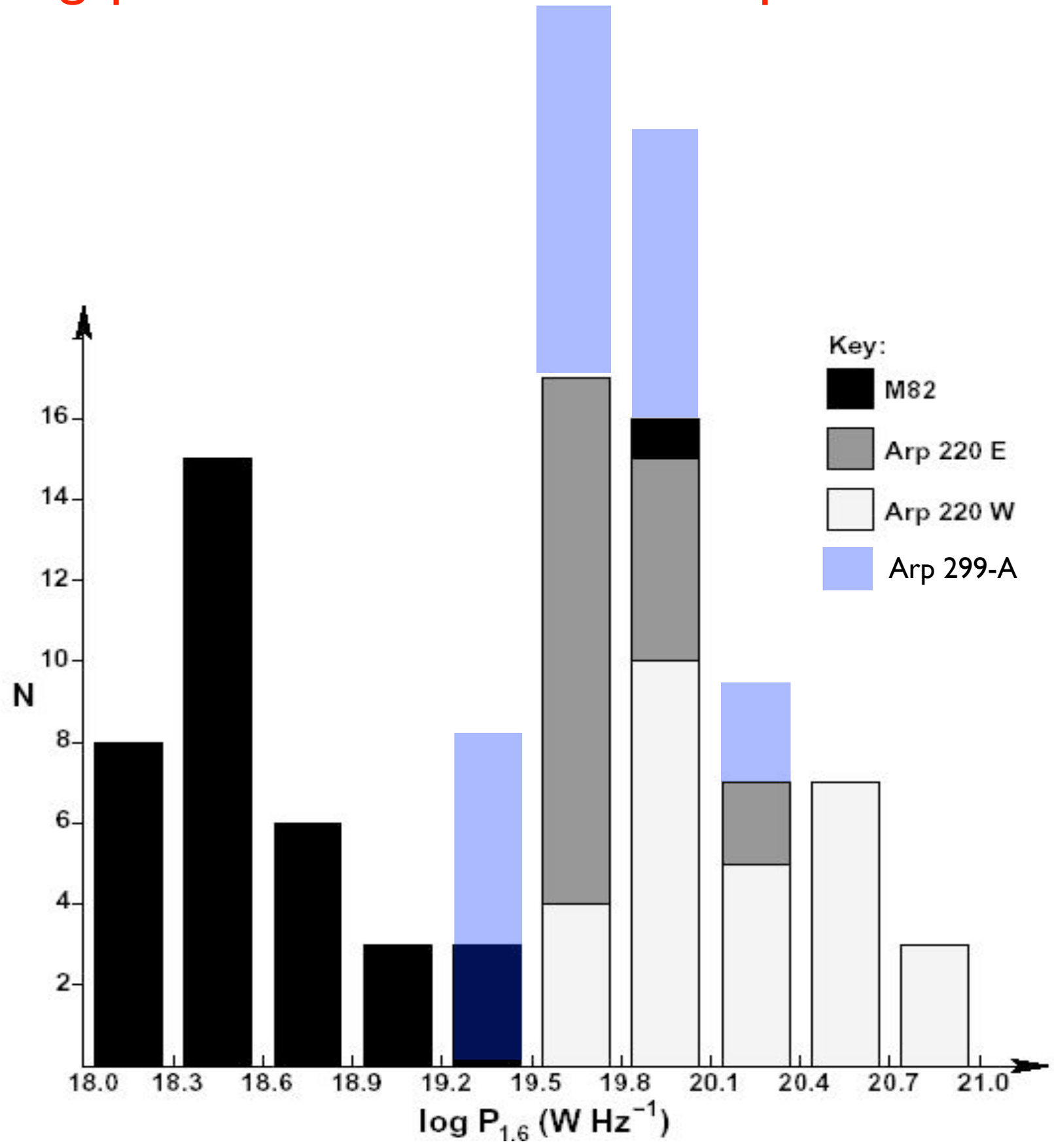
Blue - sources detected at both 1.7 and 5.0 GHz

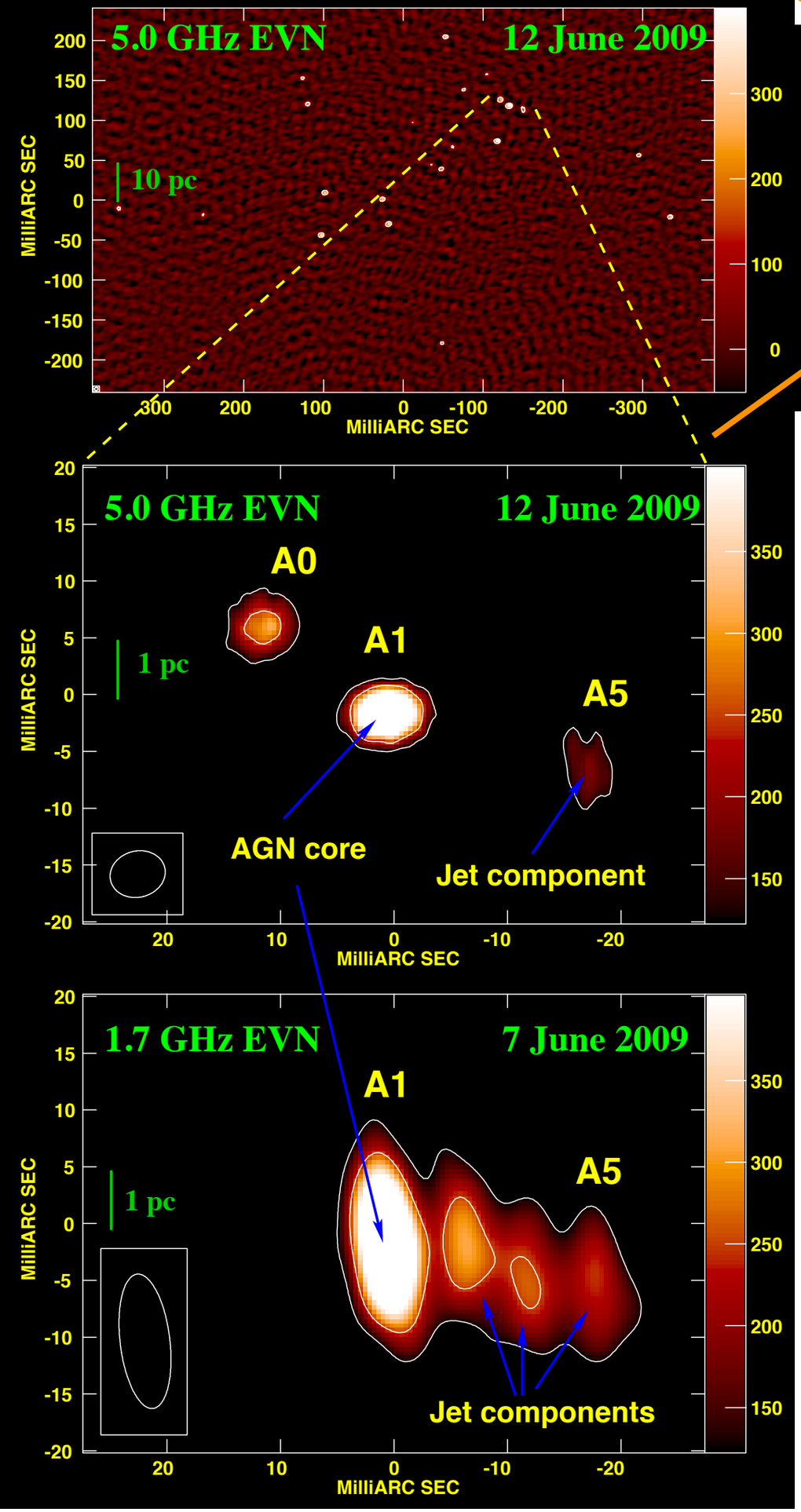
Magenta - sources detected only at 1.7 GHz (alpha < 0.0), or at 5.0 GHz (alpha > 0.0)

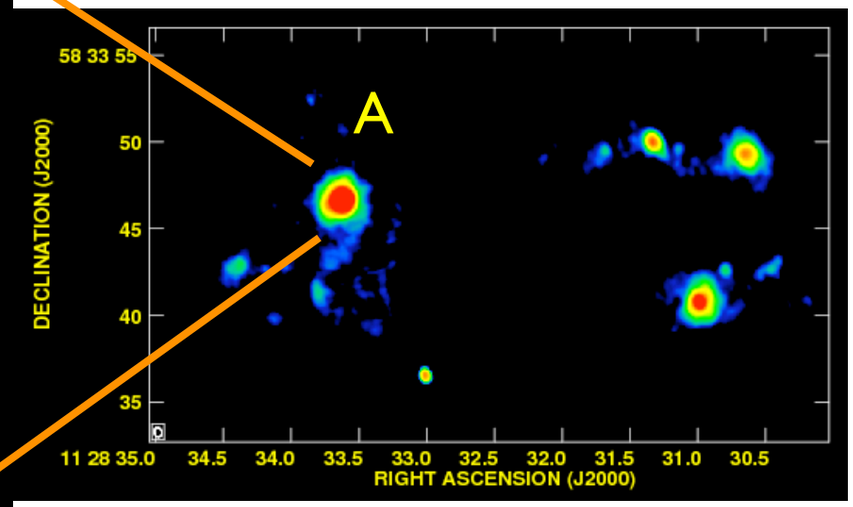
Evidence for RSNe in their optically thick phase (VERY YOUNG), as well as in their opt. thin phase (RELATIVELY YOUNG).

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

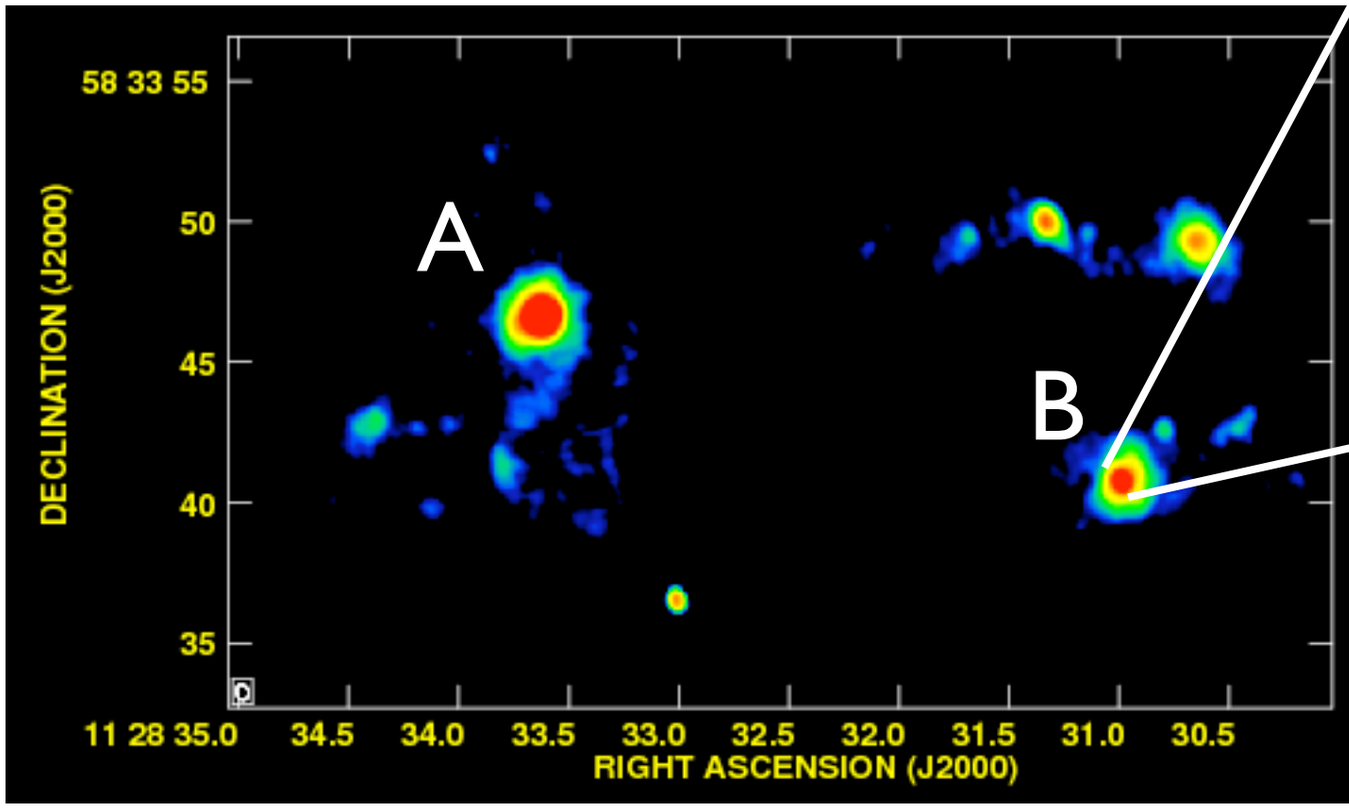
Ratio of (5 GHz*L_5)/L_X => A1 is an LLAGN

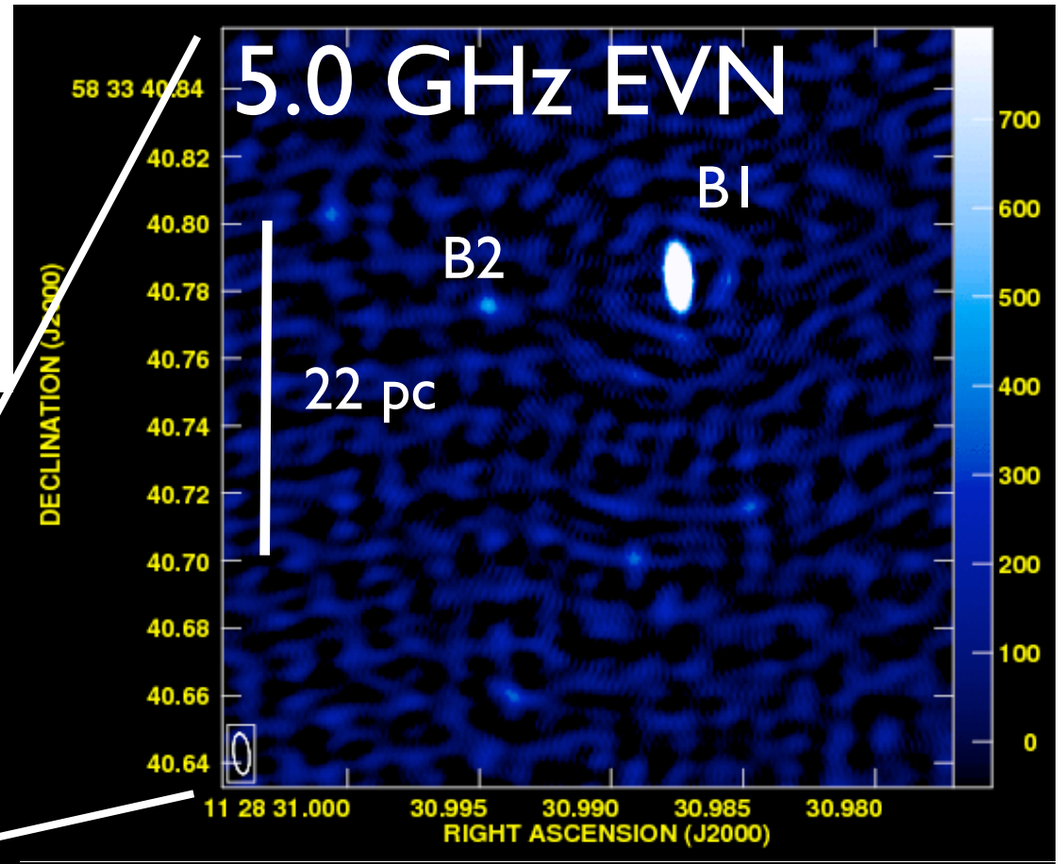
A0 - A RSN just 2 pc away from a SMBH!! Is SB activity hindering BH accretion, and thus => LLAGN?

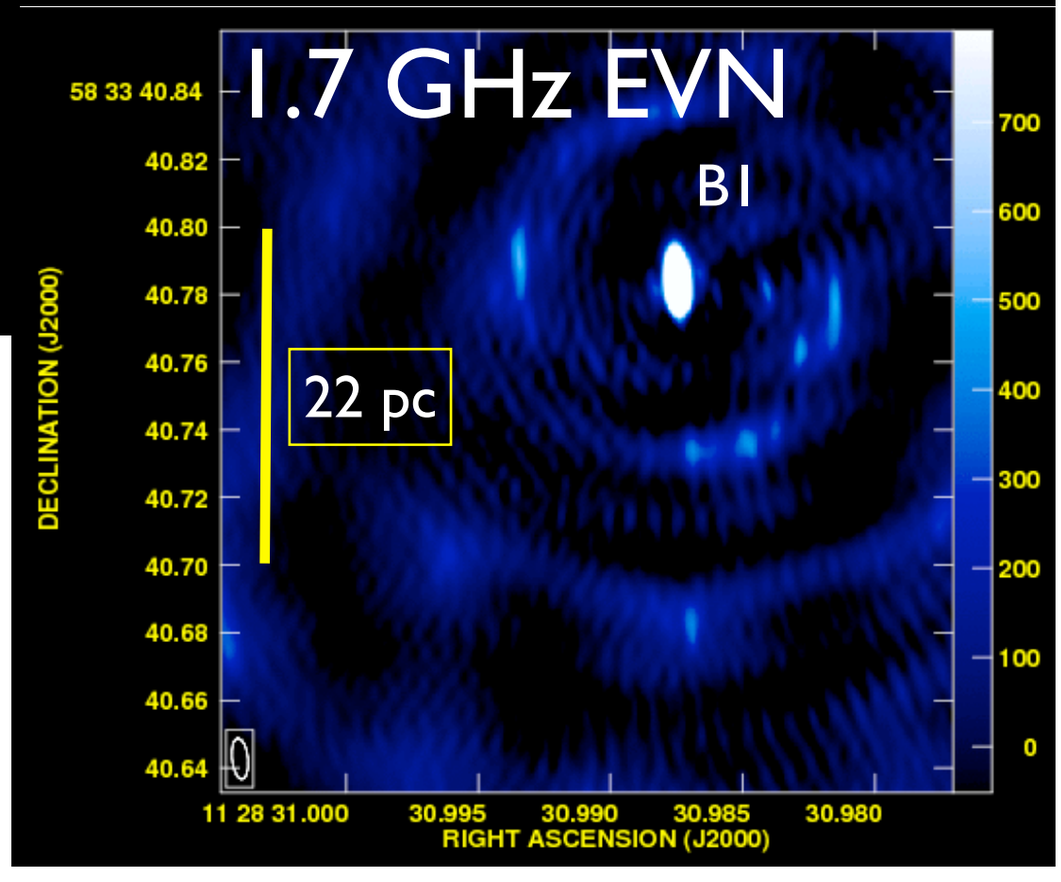
Pérez-Torres et al. (2010, Letters to A&A, Vol. 519)

A RSN in Arp 299-B1?

(and where is the AGN?)





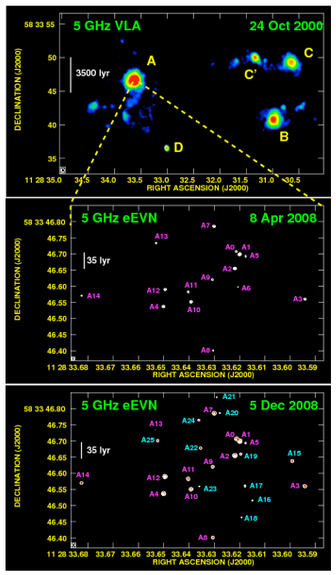


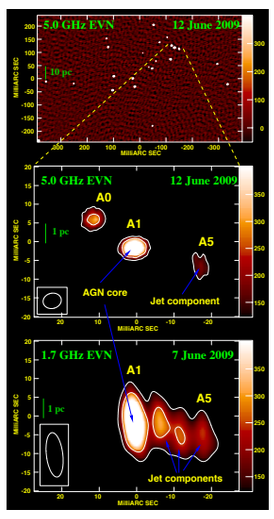
alpha(B1-1) = -0.35
P(1.7 GHz) = 1.7e21 W/Hz
P(5.0 GHz) = 1.2e21 W/Hz

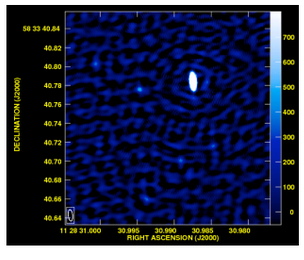
B1: Very bright, slowly evolving RSN?
Similar to A0 in Arp 299-A.
B2: Bright object, with very slow evolution, too.
alpha(B1-2) >= 0.75; it's a puzzle

eEVN does not currently allow multiple correlation passes, so EVN was the best choice.

Summary







- Large number of compact radio sources found in 6/18 cm observations of Arp 299-A with the eEVN & EVN. Must be SN and SNRs, likely embedded in SSCs => Evidence for a recent SB
- SN radio luminosities indicate the CCSNe must be Type IIb/P, or Type IIL SNe.
- Possible microquasar detection (A6) and at least two new RSNe in the last few years (A12 and A15). Other relatively young RSNe indicate a population of bright, long-lasting, slowly evolving RSNe in Arp 299A => CSM and ISM much denser than in normal gals.
- Arp 299-A fills in a gap between M82 and Arp 220. Support Arp 299A monitoring for new exciting news!
- We have discovered the long-sought AGN in Arp 299-A. It is a LLAGN => "Cohabitation" of SB and AGN
- Confirmation for a very bright RSN detected in the nucleus of B1... but where's the AGN, if there is any?
- Stay (e)EVN and fully-EVN tuned!!

The Super Stars' Cluster in the Southern Hemisphere

A1 - The elusive AGN

Young SNe

Young SNe

A6 - The microquasar

A5 - The hidden jet

... and the Supernova Remnants

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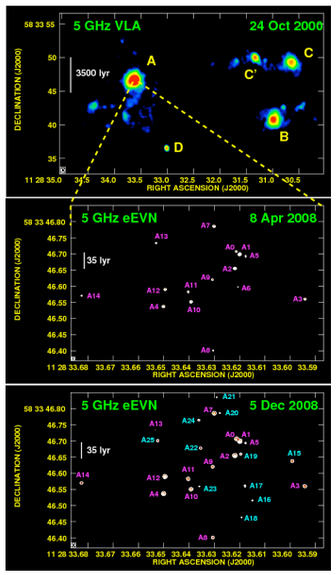

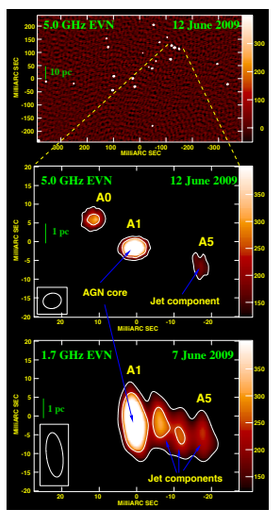

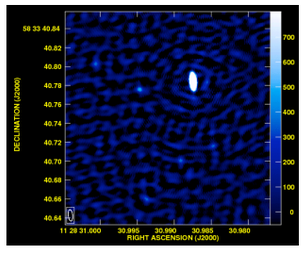

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