

Radio spectra of compact sources in Arp220

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Objectives

- To present my research.
- To teach you a little!!

The Initial Mass Function (IMF)

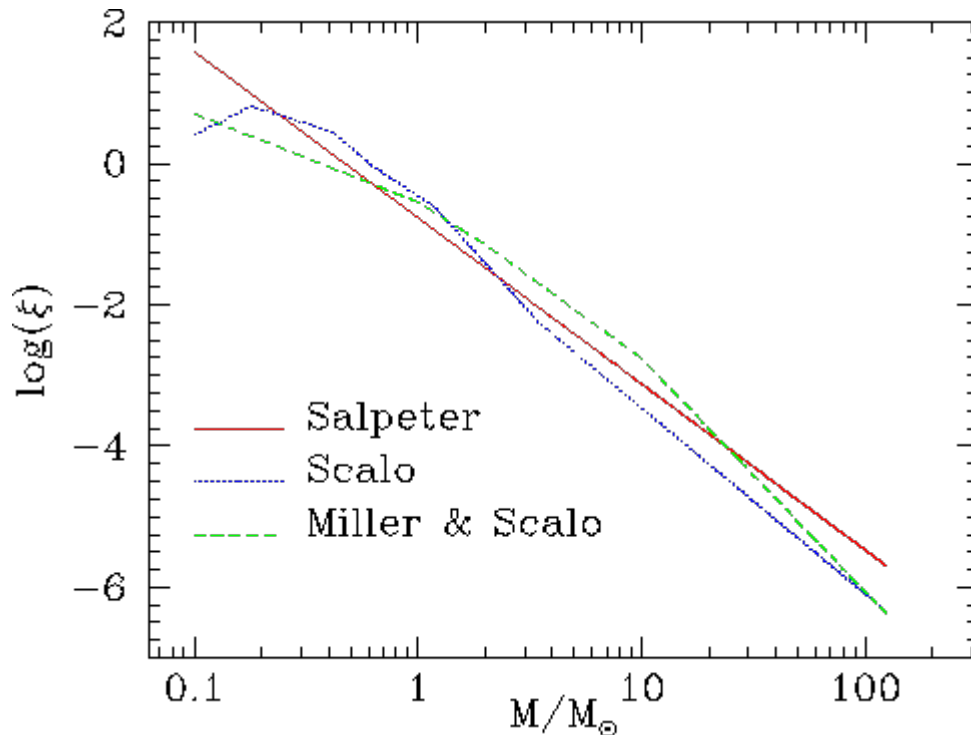
- The distribution of stellar masses that form in one star formation event in a given volume of space is called the initial mass function (IMF).
- Star formation: gas \rightarrow stars.
- BDs - $0.072 (M_{\text{sol}})$ - do not fuse H to He. Very-low-mass stars (0.072 to $0.5 M_{\text{sol}}$). Low-mass stars (0.5 to $1 M_{\text{sol}}$). Remove gas from the interstellar medium (ISM), locking-up an increasing amount of the mass of galaxies over cosmological time scales.
- Intermediate-mass stars (1 to $8 M_{\text{sol}}$).
- Massive stars ($m > 8 M_{\text{sol}}$).

The Initial Mass Function (IMF)

- Intermediate and high mass stars enrich the ISM upon death (SN) with heavy elements, energy.
- So very important to quantify the relative numbers of stars in different mass ranges and to find systematic variations of the IMF with different star-forming conditions.
- Identifying systematic variations of star formation would allow us to understand the physics involved in assembling each of the mass ranges i.e. different initial conditions have a preference for forming different stellar types , and thus to probe early cosmological events.

The Initial Mass Function (IMF)

- The IMF specifies the distribution in mass of a newly formed stellar population and it is frequently assumed to be a simple power law:

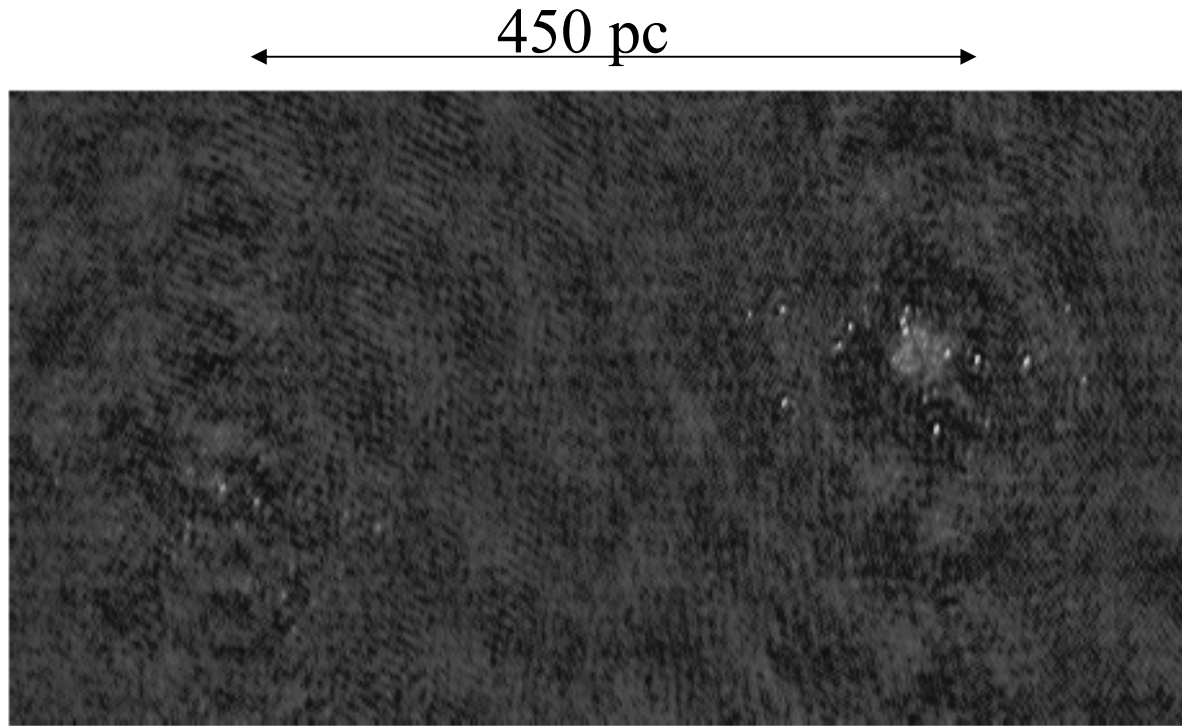


Original work by
Salpeter (1955), IMF
A simple power law
With exponent of 1.35

The Initial Mass Function (IMF)

- Astronomy → Earns us a living → Often tedious, eg AIPSing → Important to keep in mind the **BIG** picture → IMF

18cm Global VLBI – A starburst revealed



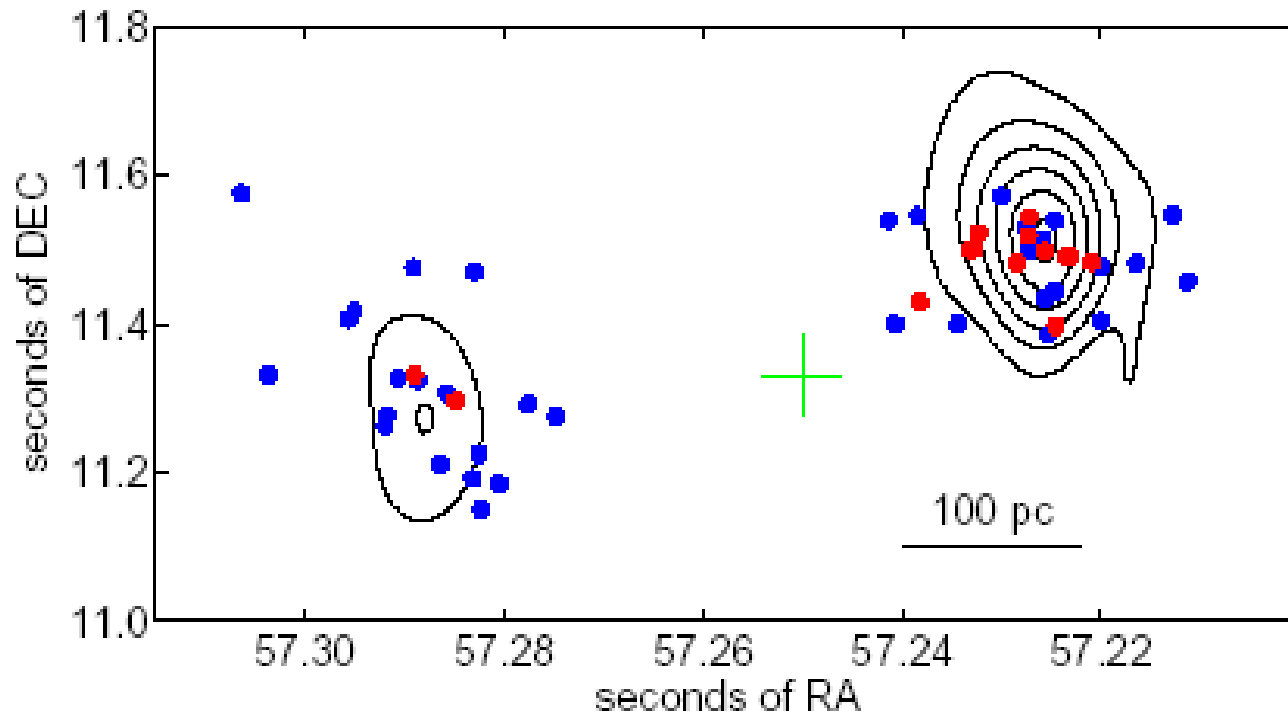
Smith et al (1998), Rovilos et al (2003), Lonsdale et al (2006)

Arp220, 77 Mpc, East and West Nucleus. Prototype ULIRG.

Pretty picture-but why important?

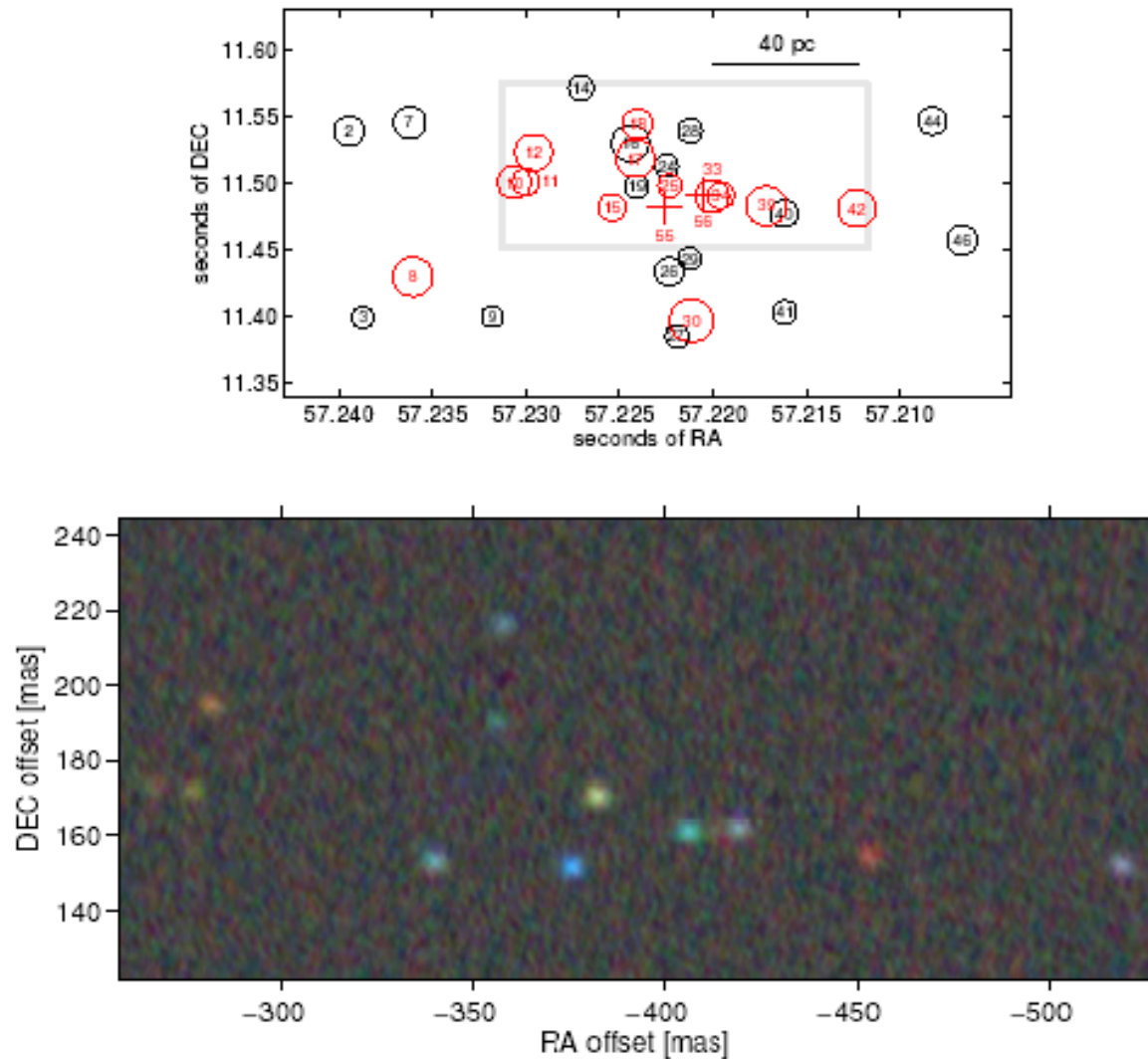
- Arp220 is closest ULIRG ($L_{\text{fir}} > 10^{11} L_{\text{sol}}$). If we don't understand this we don't understand nuclear SF.
- SNe and SNR can probe respectively stellar evolution and act as in-situ probes of ISM Pressure/density.
- Probe top end of IMF and can constrain it in regions with 100's mag of optical extinction.
- Are ULIRGs just scaled up disk star-formation? (fashionable idea) or fundamentally different?
- How much can we trust standard SF indicators of FIR, diffuse radio continuum for etc converting to SFR in M_{sol}/yr ?
Impacts big questions like star-formation history of universe.

6 cm Eb–Wb–Ar @ 1 Gbit/s COLA Sample

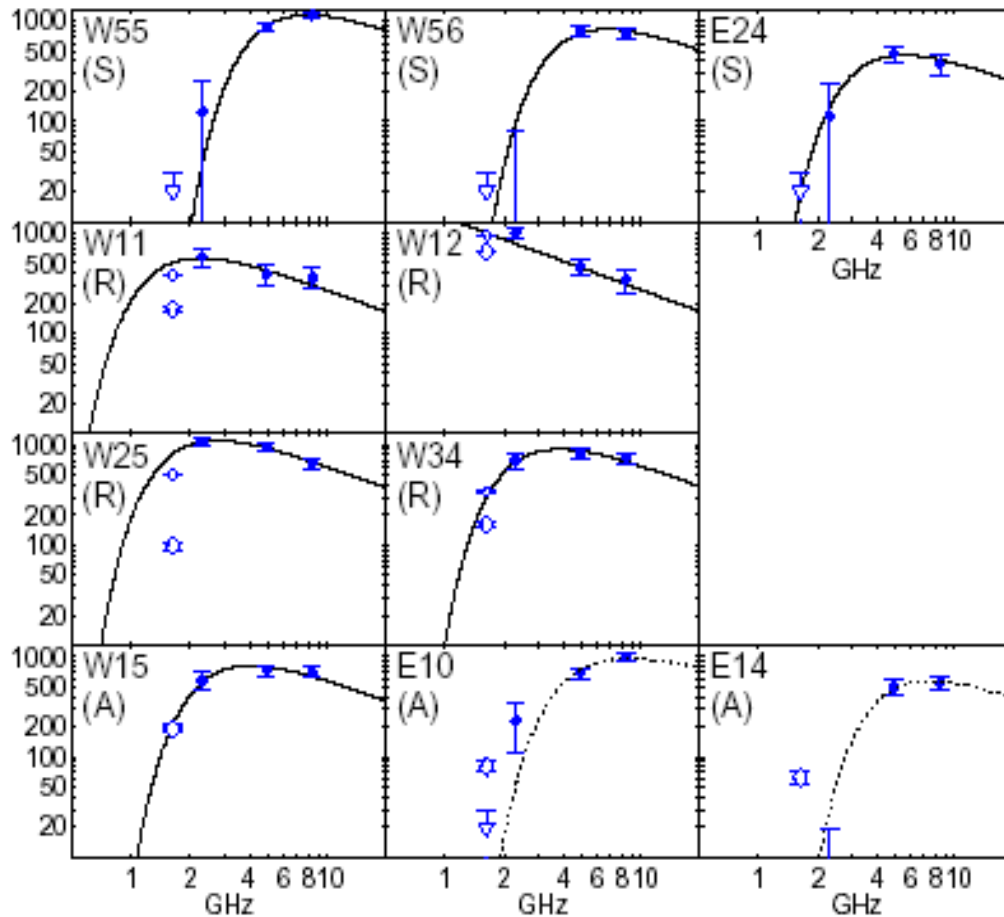


10mins of data, contours show delay-rate map. Dots are Lonsdale et al compact sources.

13, 6 and 3.6 cm VLBA, January 2006



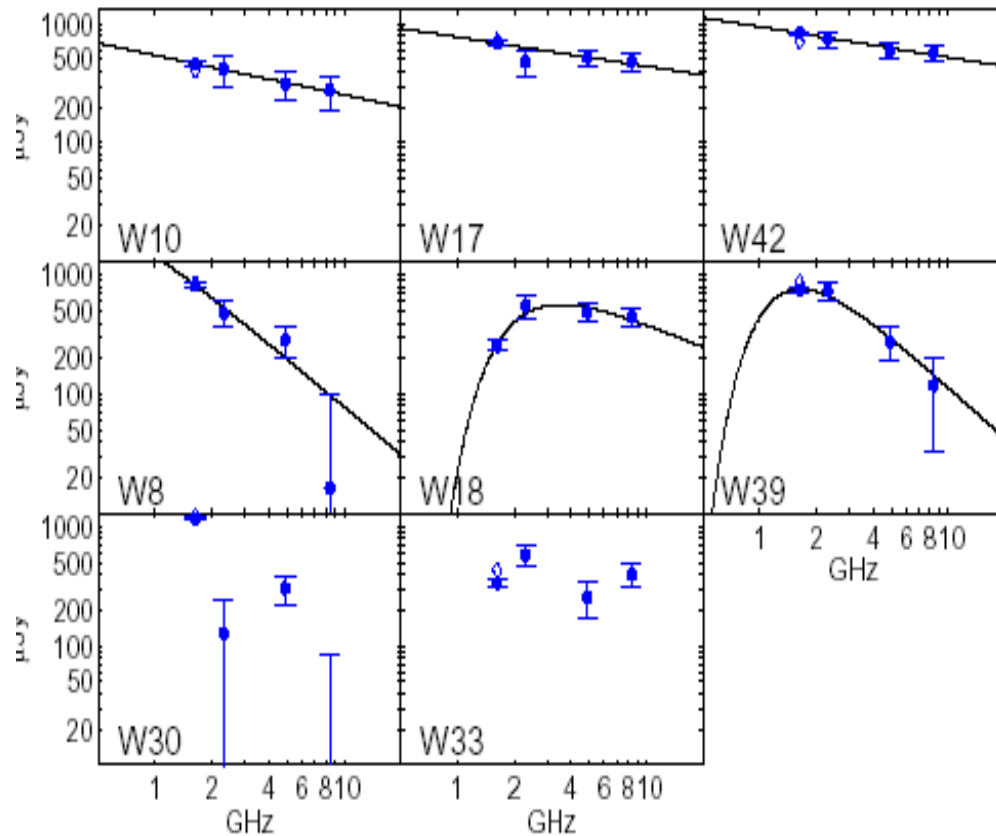
RGB (13,6,4cm bands respectively) composite image of the central region of the western nucleus (Parra et al. 2007, ApJ 658,314). Also three sources detected in Eastern nucleus.



New sources since Smith et al (1998) which are also detected at high frequency. Model as power law plus free-free absorption-evolution consistent with SNe, evolving in progenitor wind bubbles.

SNe rate, SFR, IMF

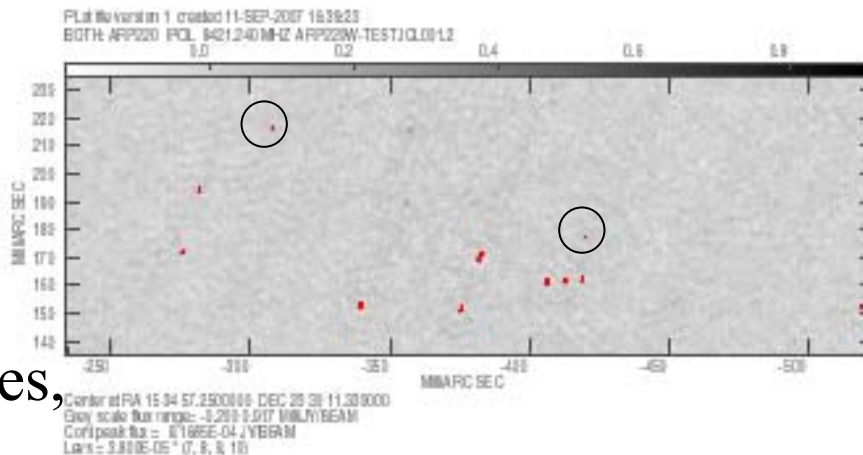
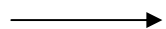
- From FIR luminosity estimate a star formation rate of 110 M_{sol}/yr .
- For a standard (Saltpeter) IMF implies a total core collapse SNe rate of 2 per year.
- We see on average two new bright radio sources per year, but they are of the most luminous class type II_n, which in disks account for only 2% of core collapse SNe.! (possibly progenitors $>80M_{\text{sol}}$).
Oops mismatch of 50!
- Parra et al proposed very top heavy IMFs, weird stellar evolution, very short bursts.
- Possible general implications for extragalactic astronomy – nuclear starbursts not just scaled up galactic star-formation – can we trust the SFR indicators used in cosmological studies?



Long lived sources since Smith et al, variety of spectra, Most SNRs?
 Plerions (SN1986J)? Possible AGN candidates (Downes and Eckart
 2007 mm/submm continuum and kinematic evidence for AGN)

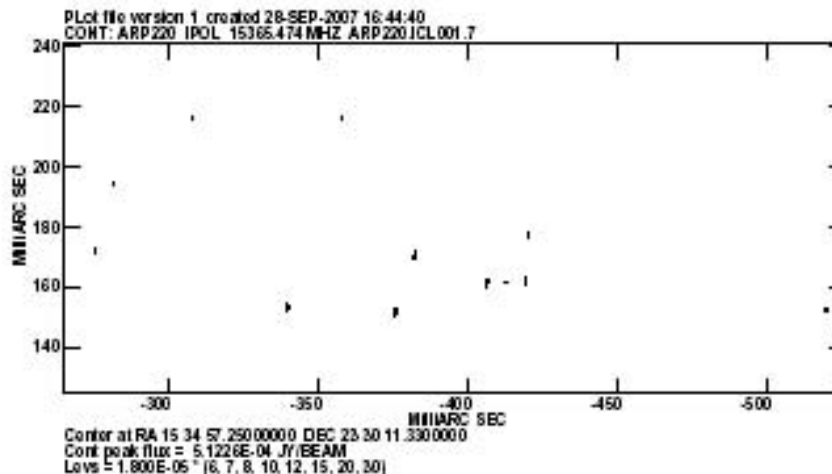
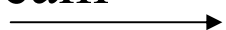
New VLBI data, 3.6cm (global) and 2cm (HSA), Nov/Dec 2006, three to four times deeper than VLBA only epoch 11 months earlier.

3.6cm, 28
microJy/beam

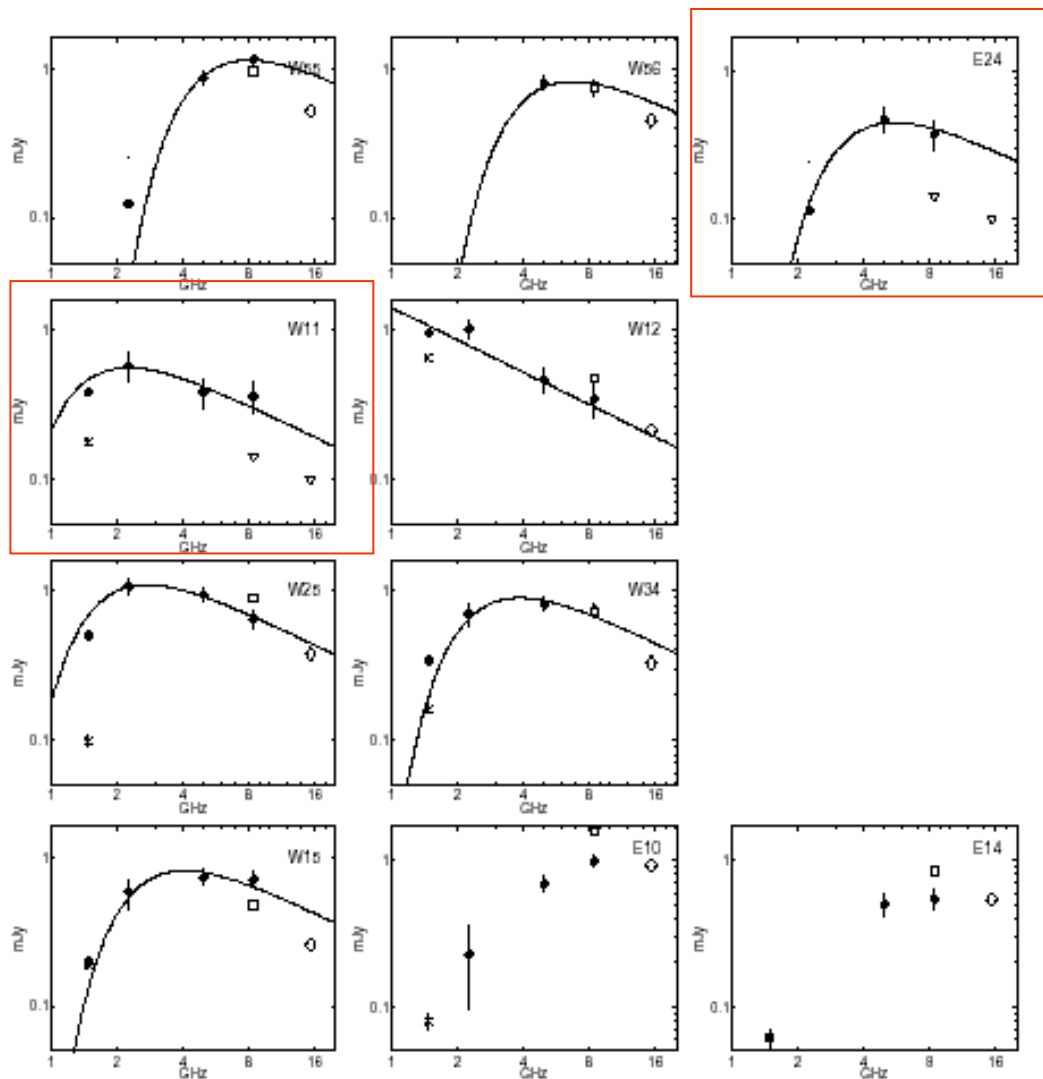


Two newly detected sources,
3.6cm, 2cm. No 18cm
counterparts but below
previous epoch 3.6 cm.
detection limit

2cm, 20 microJy/beam

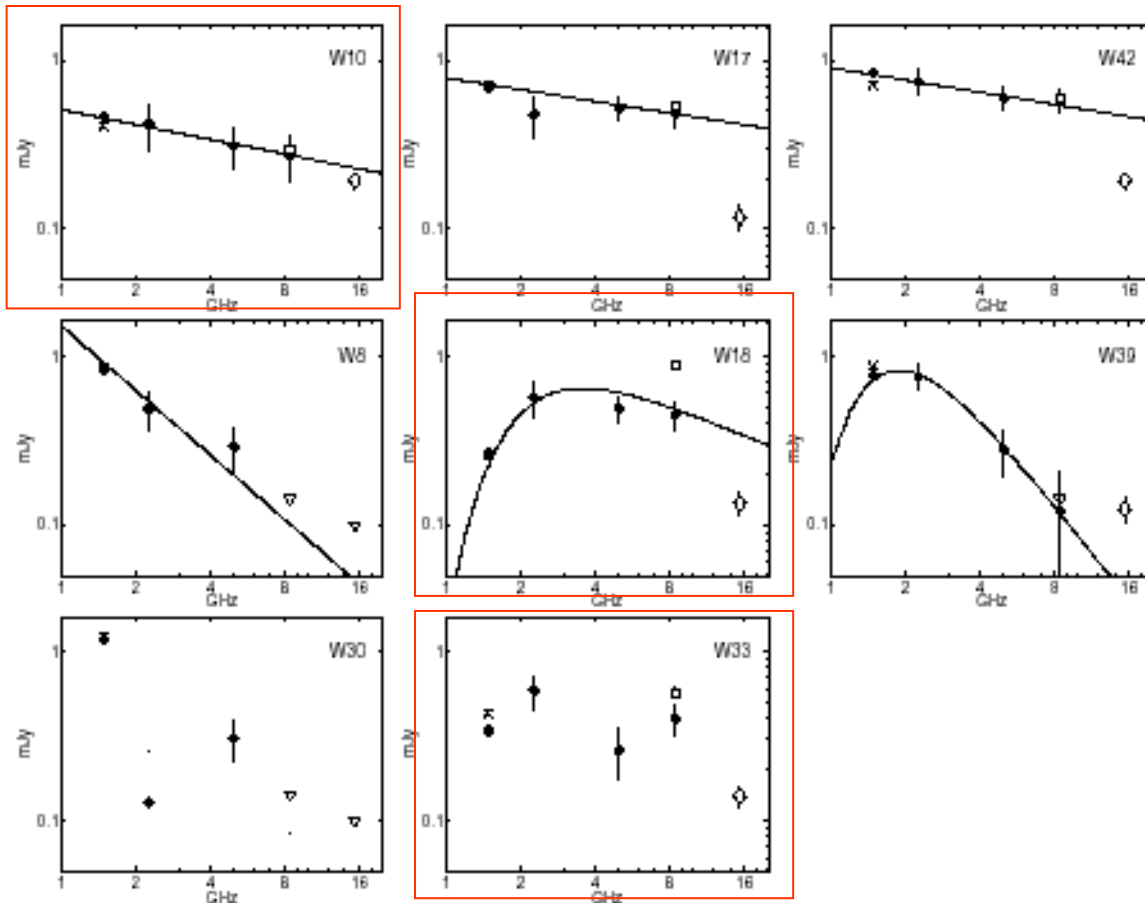


Two sources in East, 16
detections in total



Revised/extended
spectra for
'recent' sources
appearing after
1995

Two sources, have
faded in 11 months
- only upper limits
at 4cm and 2cm



Updated spectra
of long lived
sources

Two sources show
high variability
and/or weird
spectra. One is
still flat to 2cm

Future

- Look for source resolution, 10,000km/s gives 0.055mas/yr so 0.55mas diameter in 10 years, some sources maybe resolved in our new data, but needs more careful work.
- Applied for multi-frequency VLBI monitoring every 4 months
- In 1 hour, at 5GHz -8GHz, SKA could detect Arp220 SNe/SNR out to 30 times distance, i.e. $z=0.5$.
- Problem is confusion, hard to separate individual sources at this z . Need 3000km-6000km baselines and higher frequency.

Conclusions

- SNe/SNR can be used to probe IMF, SFR and ISM pressure/density in LIRGS/ULIRGS
- Results may point to a problem with the rate of new sources, implications for IMF and FIR to SFR calibration?
- Most sources behave like standard SNe/SNR but a few oddballs, plerions?, AGN?, new classes of object?