Young radio sources and the duty-cycle of the radio emission

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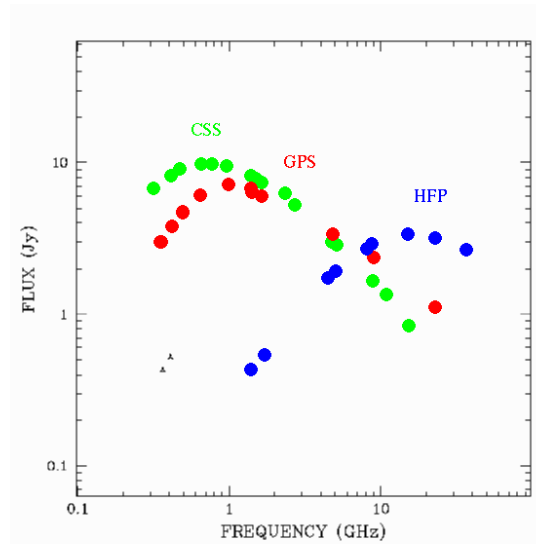
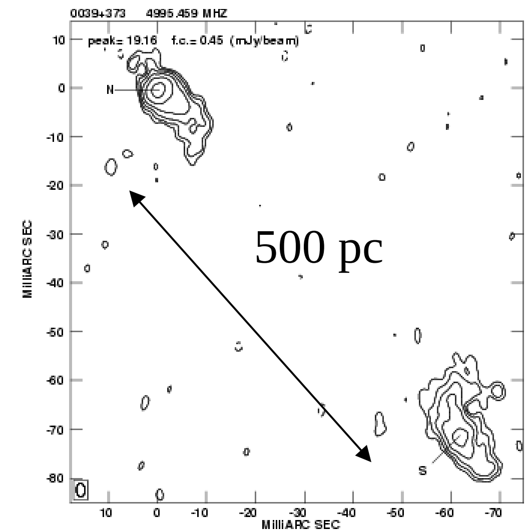
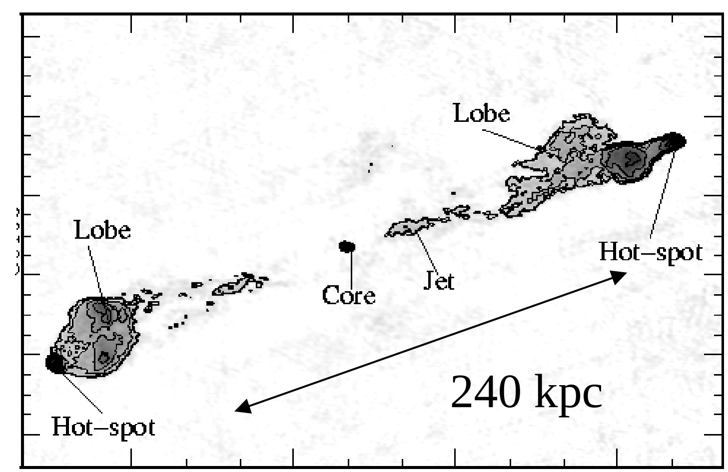
Compact radio sources

- Powerful $L_{1.4\ GHz} > 10^{25}$ W/Hz;
- Steep spectrum $\alpha > 0.7$;
- ν_p~100 MHz to a few GHz
- Compact size LS < 1 – 20 kpc
- High fraction (15%-30%) in flux-density limited catalogues
- Low (<10%) variability

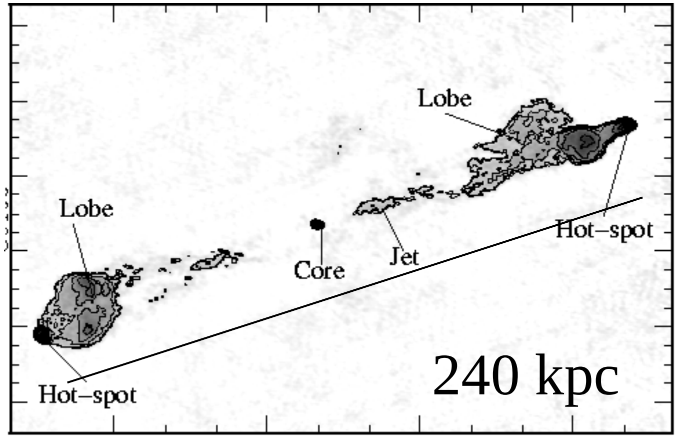






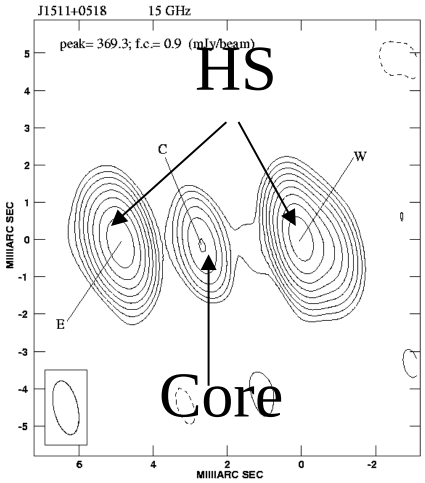
Youth: Radio morphology

Scaled-down version of the extended radio sources. They should represent the young stage in the radio source evolution

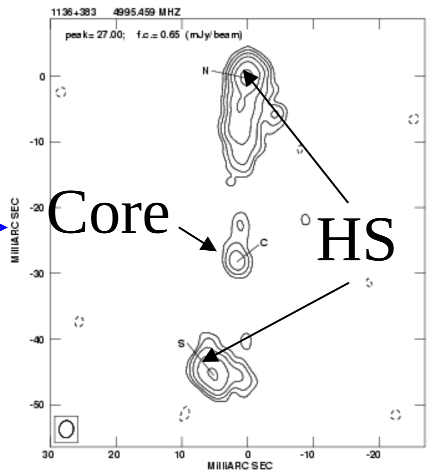


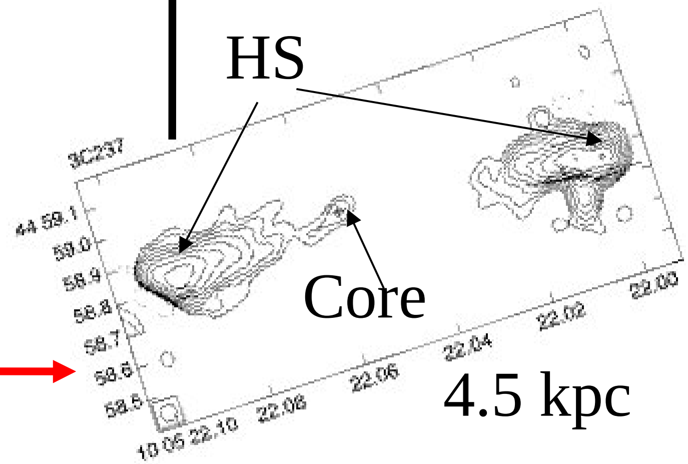
Phillips&Mutel82

7 pc



350 pc





The youth scenario

Compact ⟶ **Young**

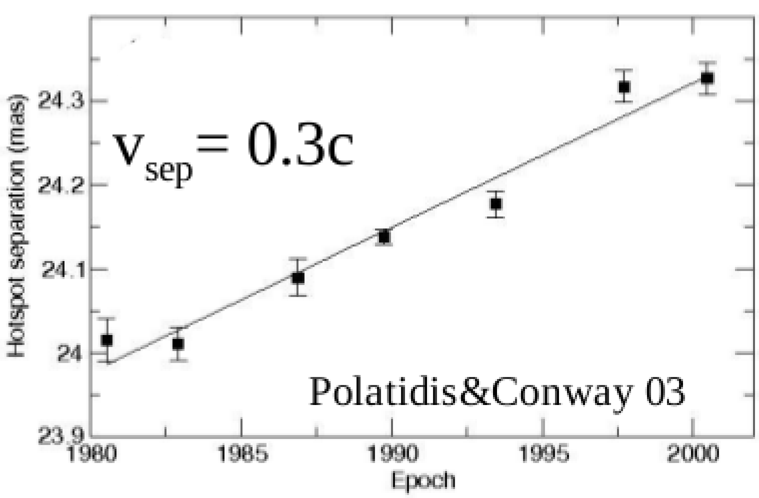
Radiative ages

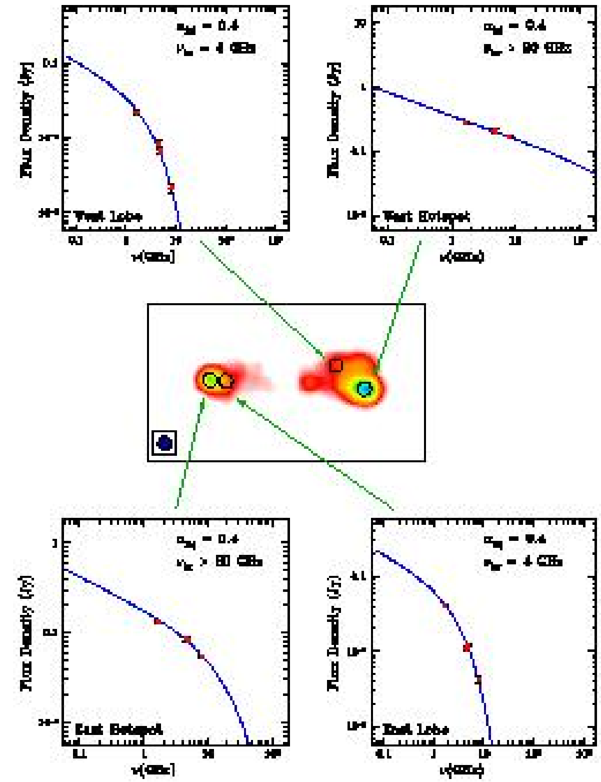
Murgia 2003

Kinematic ages

Polatidis&Conway 2003

$10^3 – 10^4$ yr

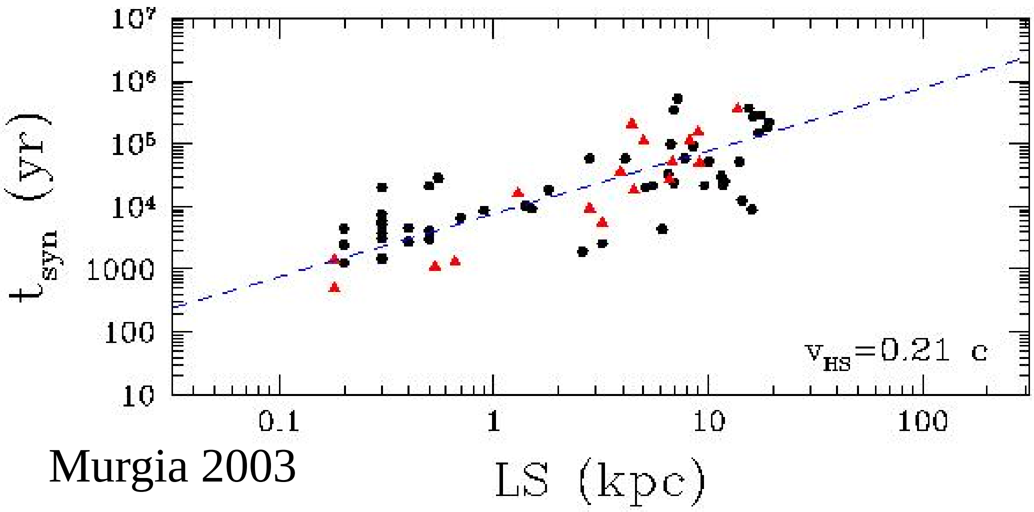




Compact ⟶ **Frustrated**

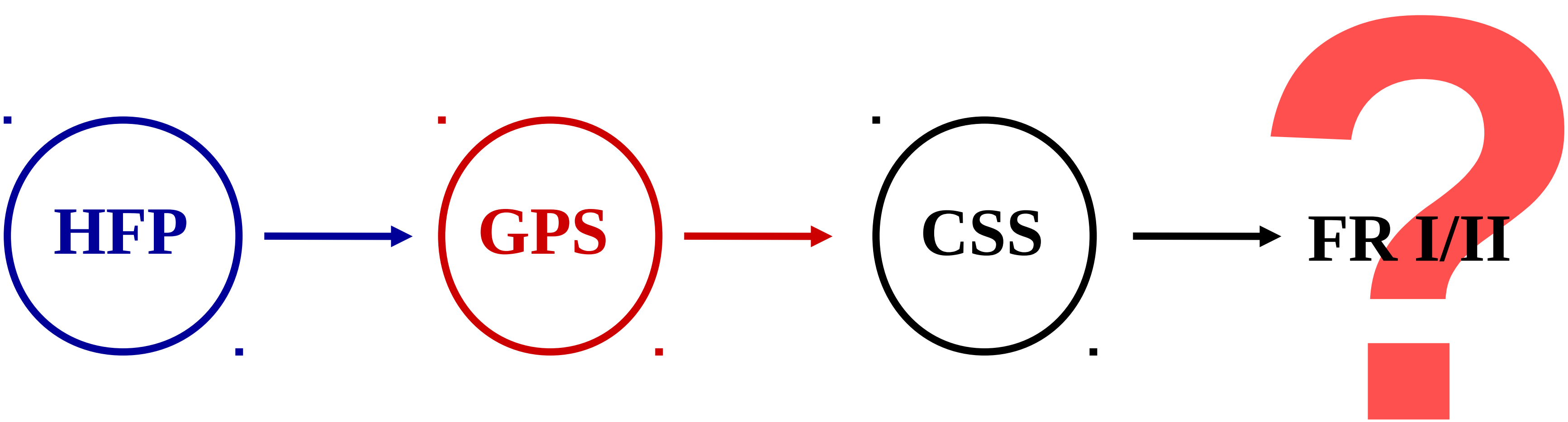
No clear evidence of a particularly dense ISM able to frustrate the source expansion for its lifetime

Evolutionary stages



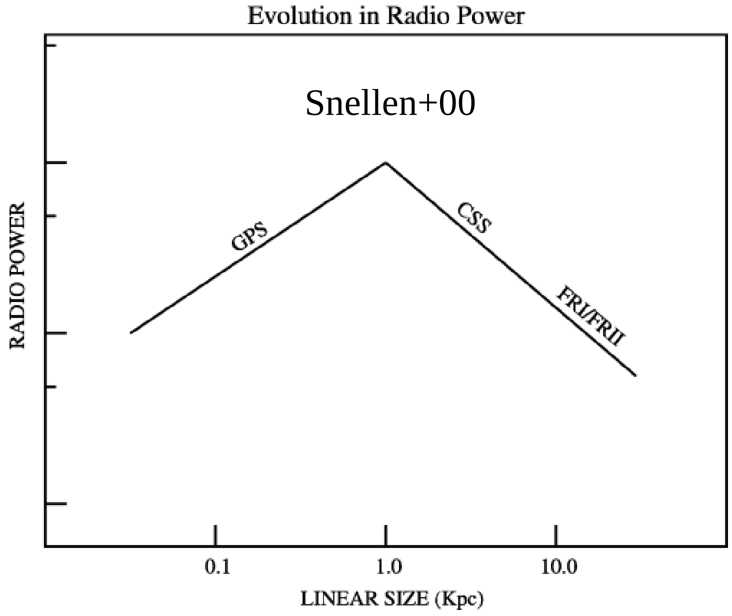
Murgia 2003

The higher the turnover frequency, the smaller and younger the source is.

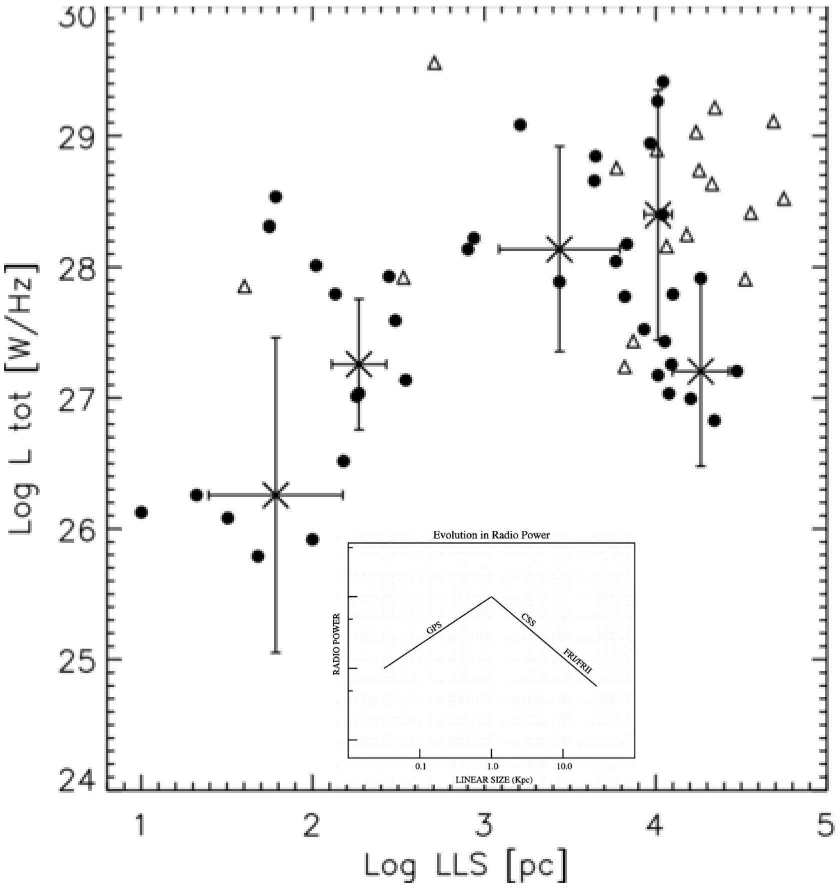


Luminosity evolution

Young radio sources represent a large fraction (15% -30%) of the sources in flux-density-limited catalogs.



Orienti&Dallacasa+14

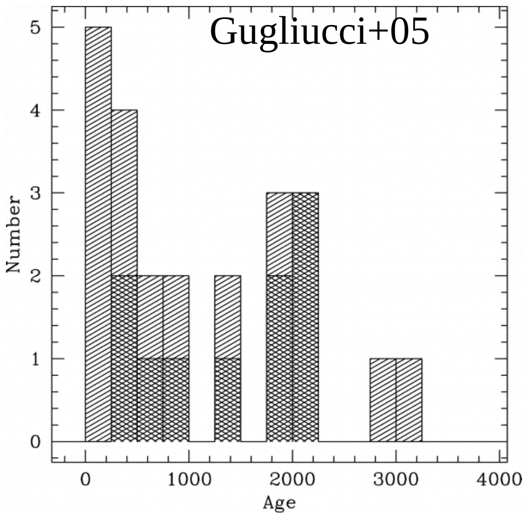


Luminosity increases for LS < ~ kpc

Fading/recurrent radio emission?

The large fraction of young radio sources may be explained in terms of short-lived and/or recurrent radio sources

The age distribution of a sub-sample of 13 CSS peaks ~500 yr.



Low statistics

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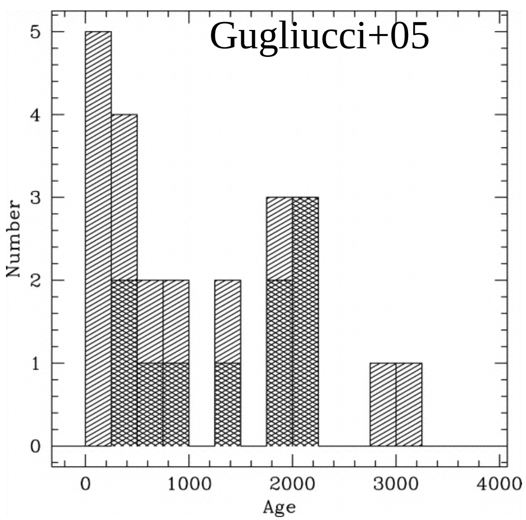
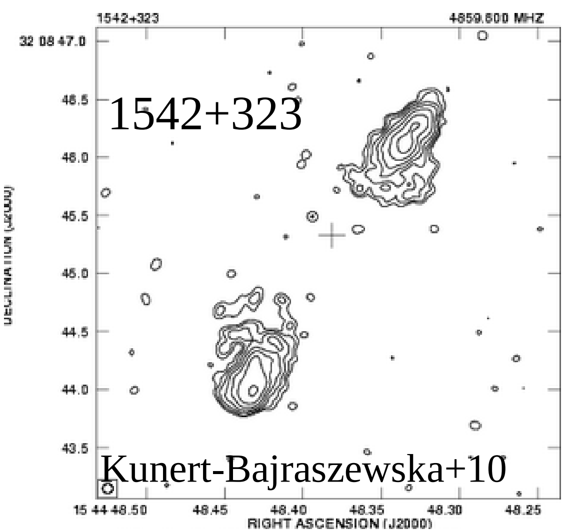


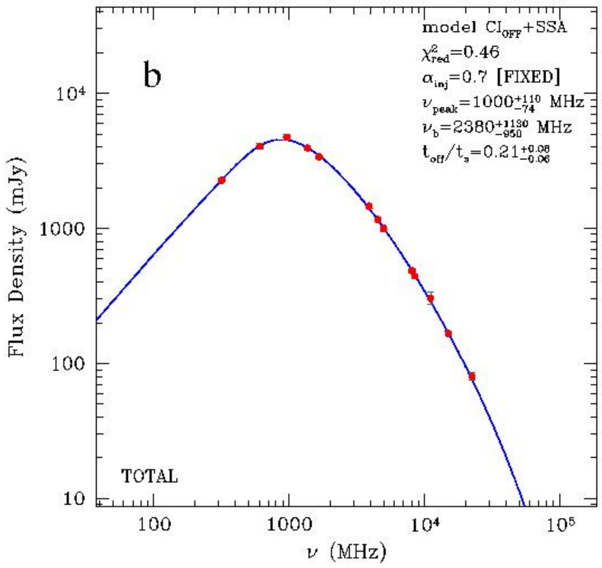
Low statistics

Discovery of young ($t \sim 10^3$ yr) but fading objects



Majority lack sub-arcsec spectral index studies

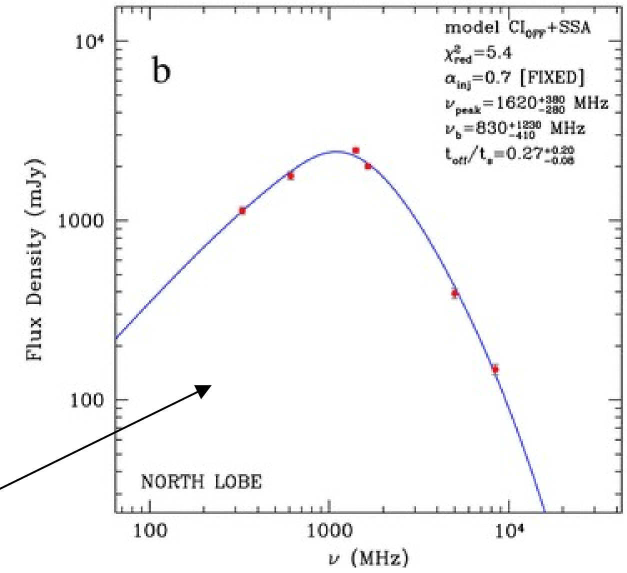
PKS 1518+047: a case study



• Lack of hot spots and core components

• Steep spectrum across the whole source

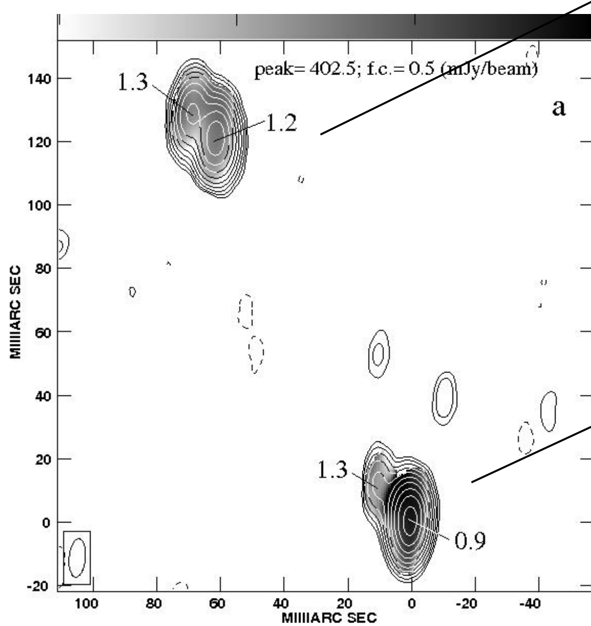
• No injection of fresh particles

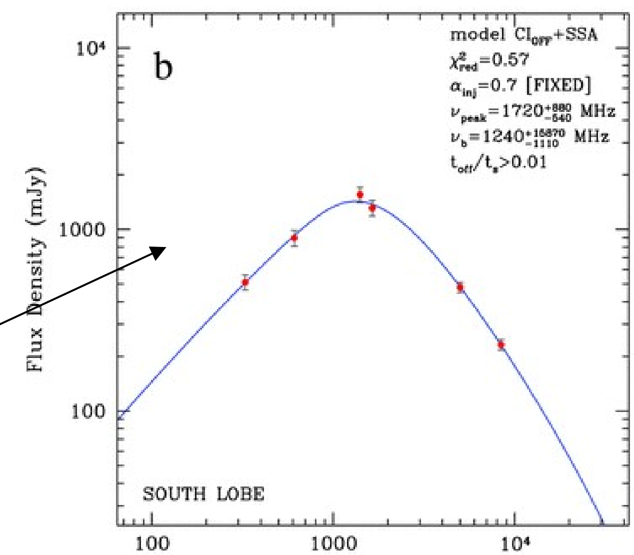


• VLBA observations from 0.3 to 8.4 GHz

• t_{age} = 2700±600 yr

• t_{OFF} = 550±100 yr





Orienti et al.10

Fading/recurrent radio emission?

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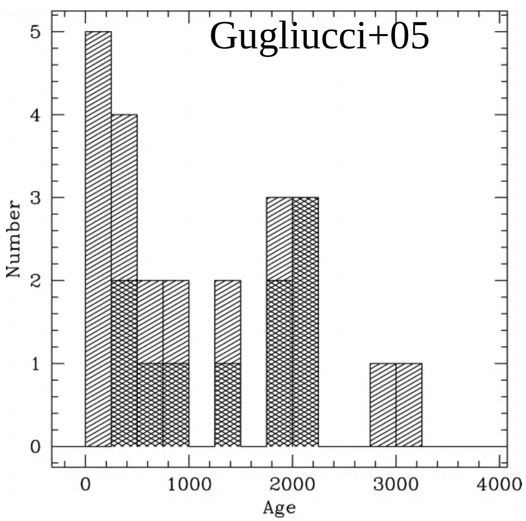
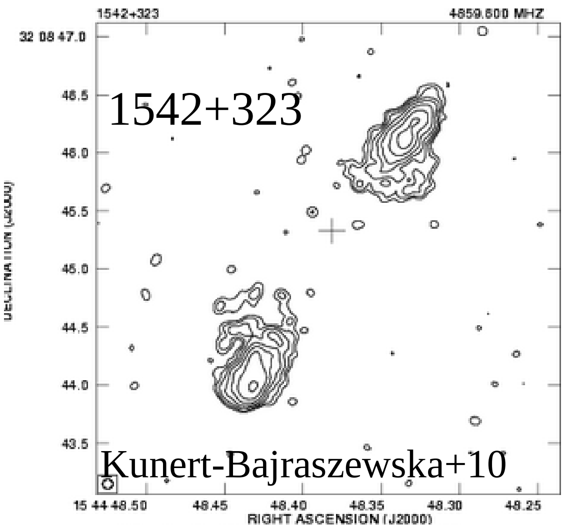


Low statistics

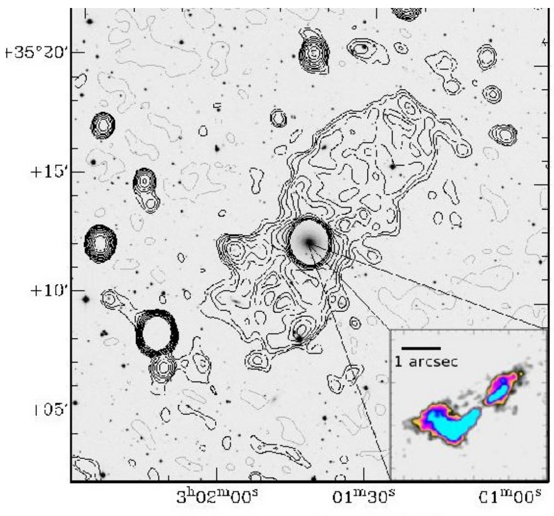
Discovery of young (t~10^3 yr) but fading objects



Majority lack sub-arcsec spectral index studies

Recurrent activity

Shulevski+12

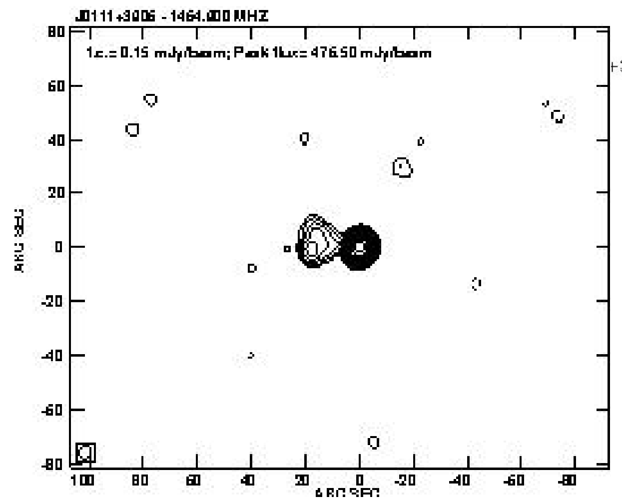


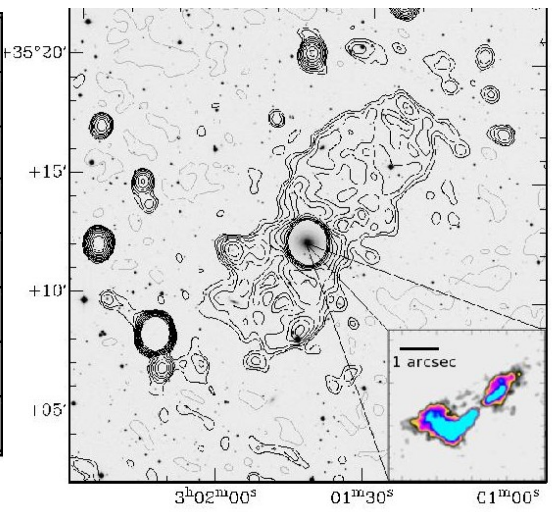
Old steep-spectrum emission hard to find

Recurrent activity?

- On kpc scales:
  - J0111+3906: 128 kpc
  - B2 0258+35: 160 kpc

$t_{relic} \sim 10^7 - 10^8$ yr



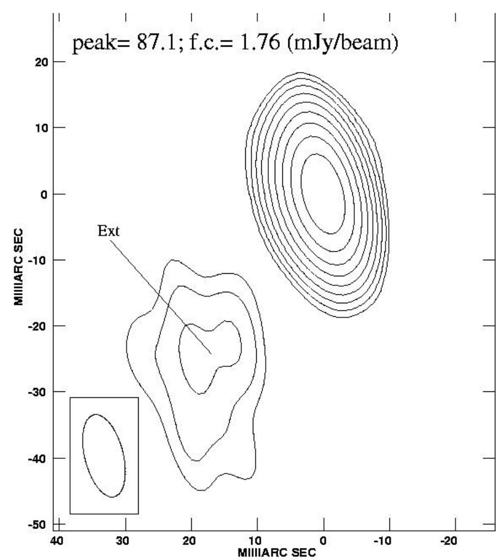


(Baum+90; Tinti+05, Shulevski+12)

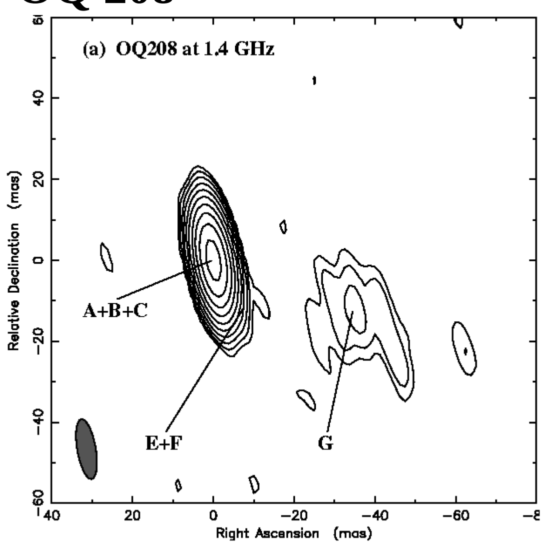
- On pc-scales:
  - J1511+0518: 50 pc
  - OQ208: 43 pc

$t_{relic} \sim 10^3 - 10^4$ yr

J1511+0518



OQ 208



(Orienti&Dallacasa08, Lu+07)

Searching for faders

To determine the incidence of short-lived objects we selected a sub-sample of candidate fading objects from the B3-VLA CSS sample by Fanti et al. (2001). The B3-VLA CSS sample is made of sources with linear sizes (i.e. ages) from 100 pc (10^3 yr) to 15 kpc (10^5 yr).

The selection criteria are:

- Steep optically-thin spectrum with α>1.0
- No evidence of active regions (i.e. core, HS)

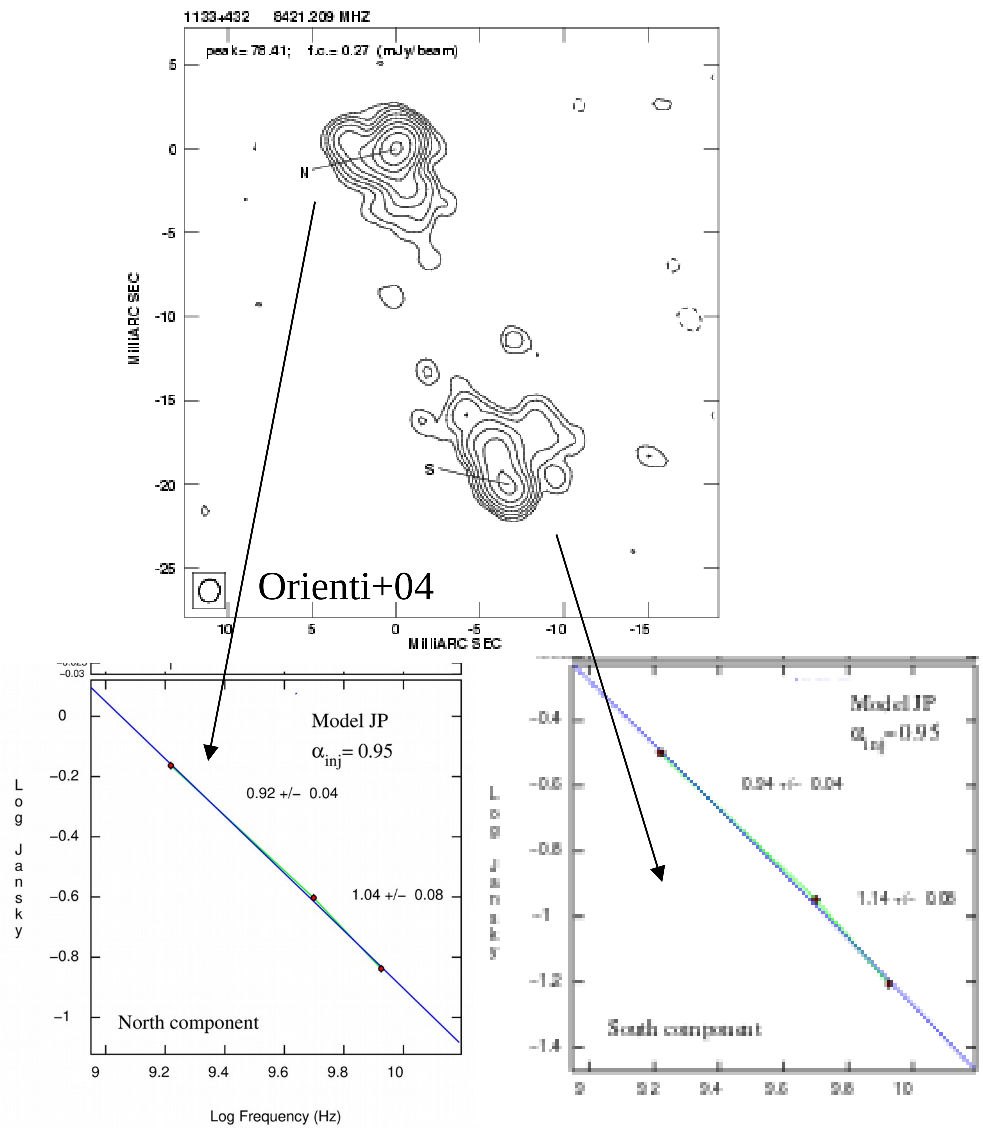
We ended up with a sample of 18 objects.

- 6 sources with LS < 1 kpc
- 12 sources with LS > 1 kpc

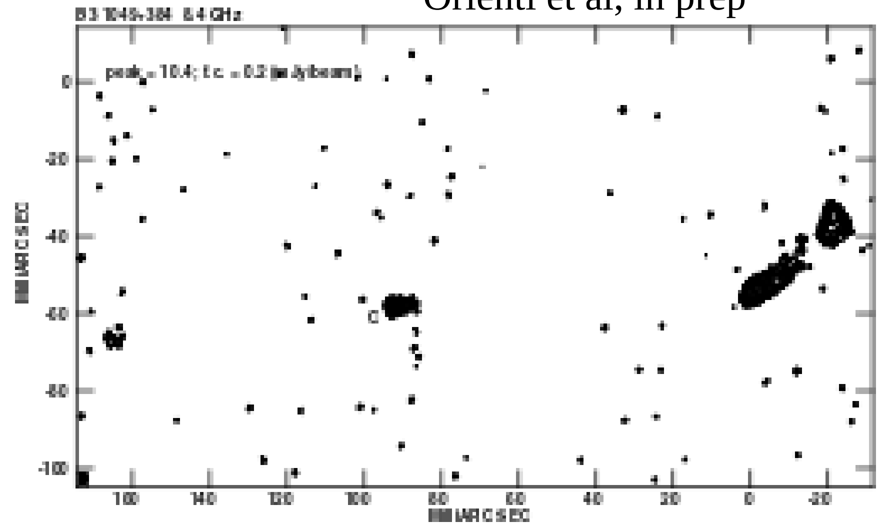
Smaller sources: new multi-frequency VLBA observations are scheduled
Larger sources: archival multi-frequency VLA data have been retived

LS < 1 kpc: preliminary results

VLBA observations at 1.4, 5, 8.4 GHz



Orienti et al, in prep



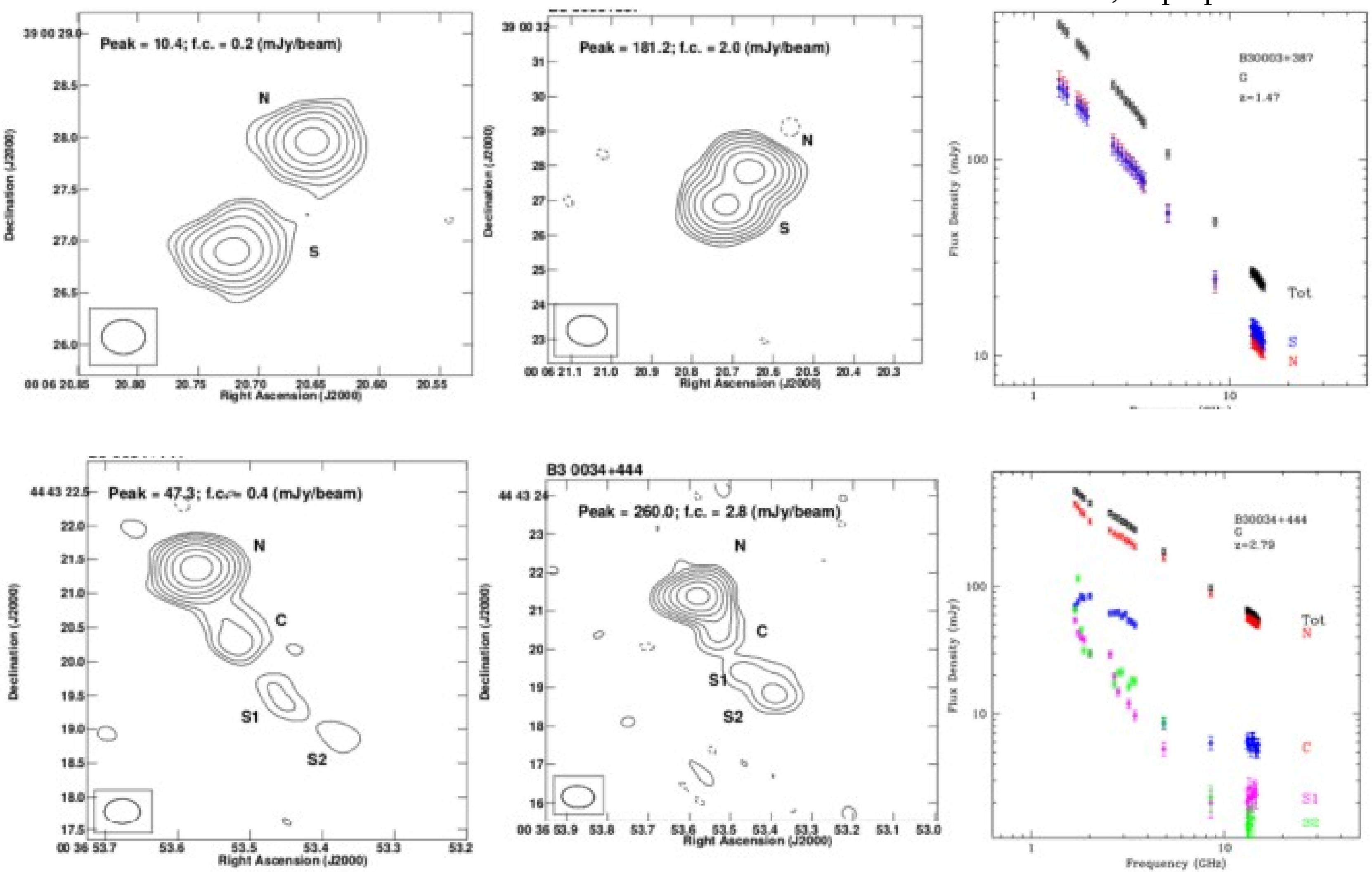
4 source with no active regions

2 source with clear detection of the core

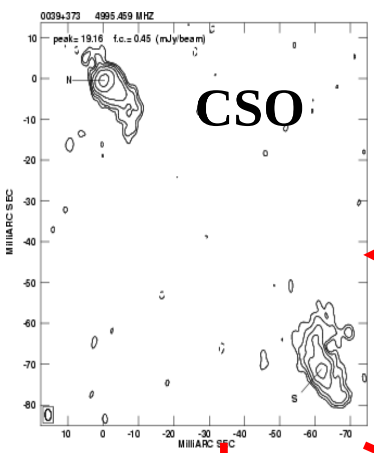
LS > 1 kpc: preliminary results

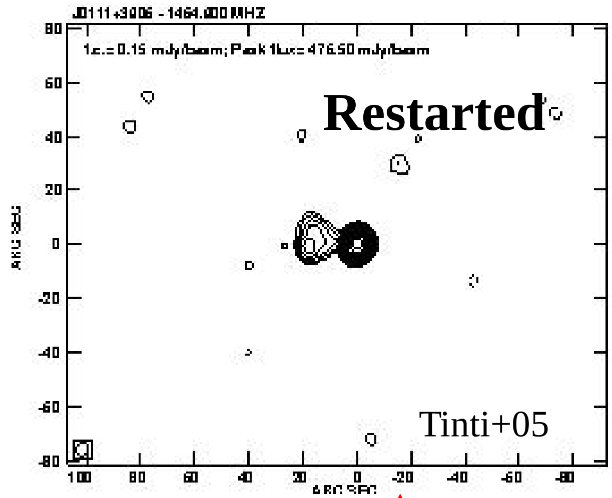
VLA observations from 1 to 17 GHz

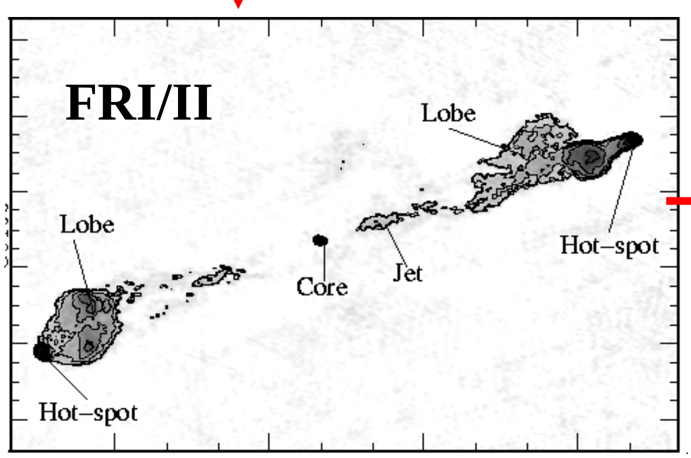
Orienti et al, in prep

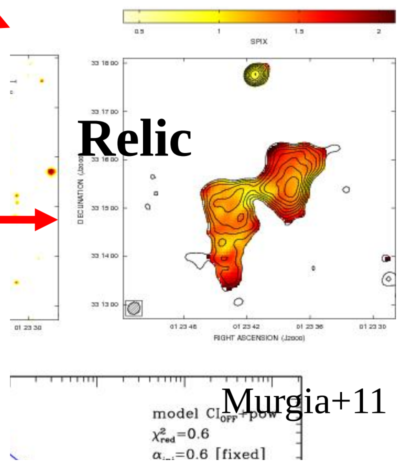


The duty-cycle of the radio emission



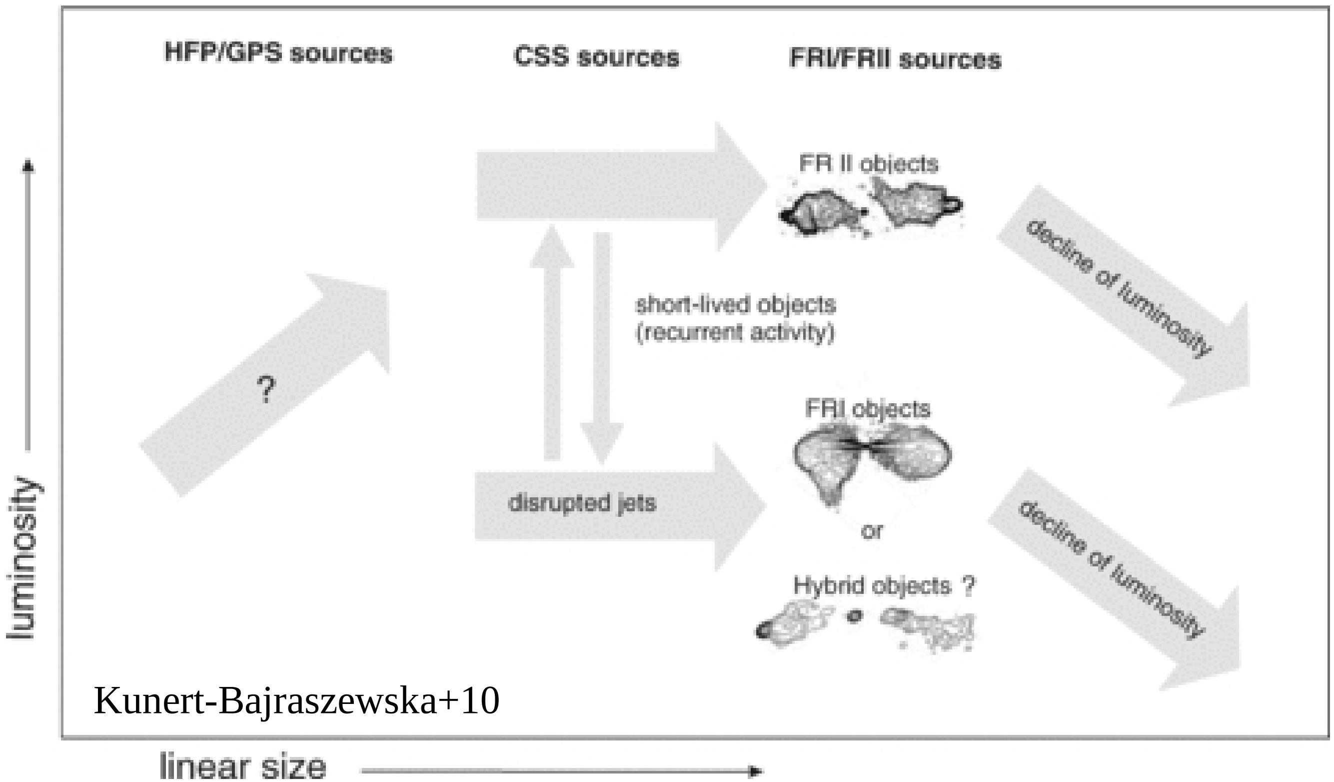






High angular resolution at low frequency is necessary to detect remnant from previous radio activity around young radio sources to find how many and how long the various phases may last

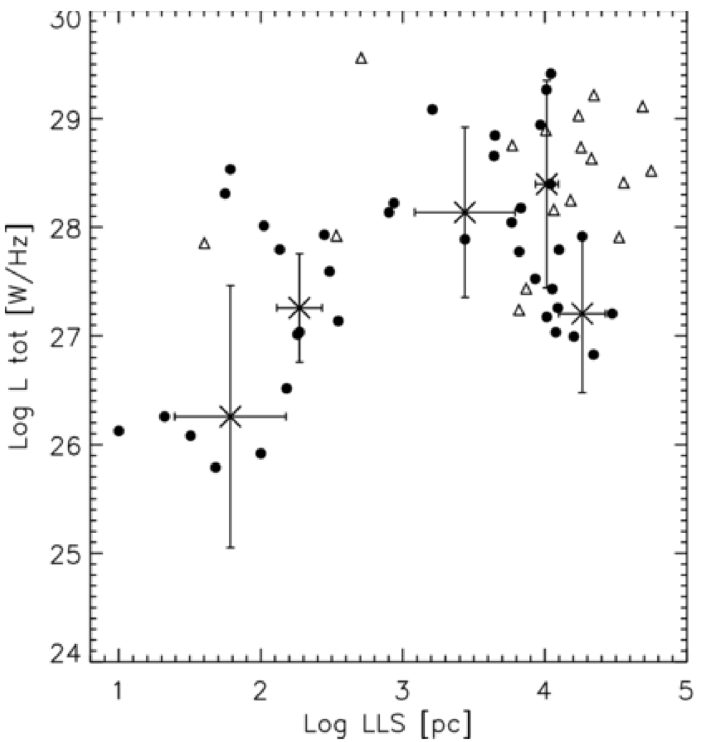
The duty-cycle of the radio emission



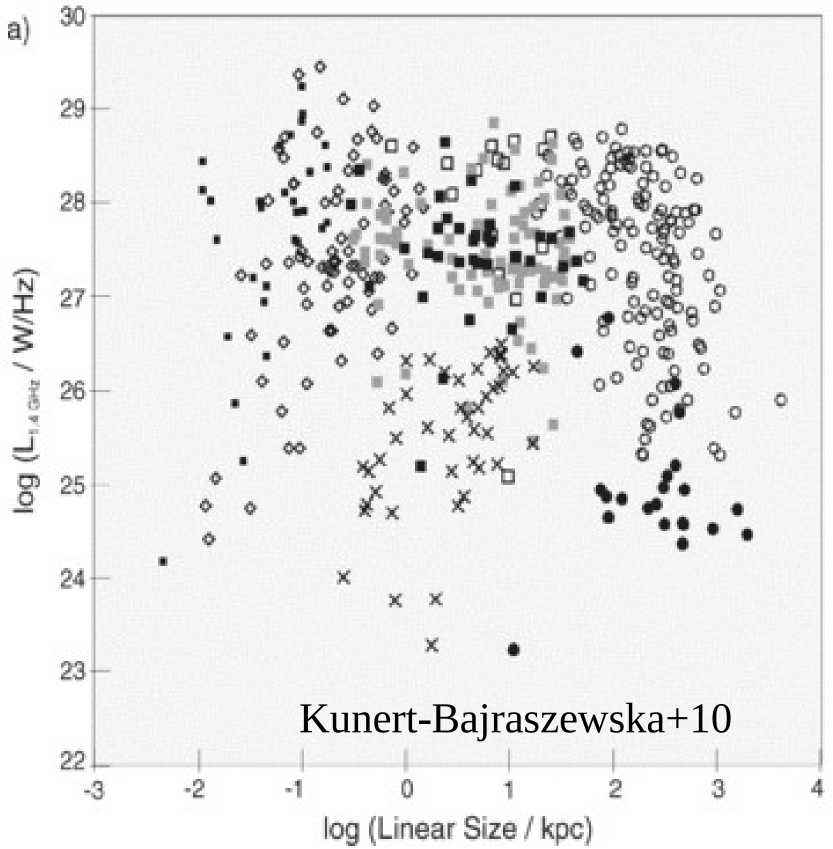
Kunert-Bajraszewska+10

The situation becomes even more complicated when low-luminosity sources are taken into consideration (see e.g. simulation by Perucho et al.)

Radio source evolution



Orienti&Dallacasa+14



Low-luminosity CSS

Conclusions

- **Young radio galaxies represent a high fraction of the objects in flux-limited sample**

- **Luminosity evolution is not enough to explain the large source counts, and short-lived objects must be present**

- **Fading young radio sources are difficult to pick up in flux-limited catalogues, due to their low luminosity at the conventional radio frequencies**

- **Detection of relics of previous radio emission support the idea of recurrent bursts of radio activity**

- **Future telescopes with good sensitivity and resolution as LOFAR and SKA will be critical for the knowledge of the duty-cycle of the radio emission**