Steep-spectrum radio sources and the duty-cycle of the radio emission

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Overview

1. Young radio sources and their evolution

2. Dying radio sources and the intermittent activity

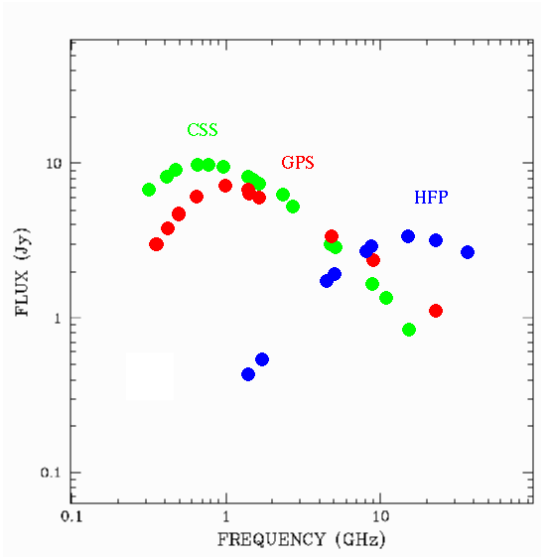
3. Searching for short-lived objects and their role in the duty-cycle of the radio emission

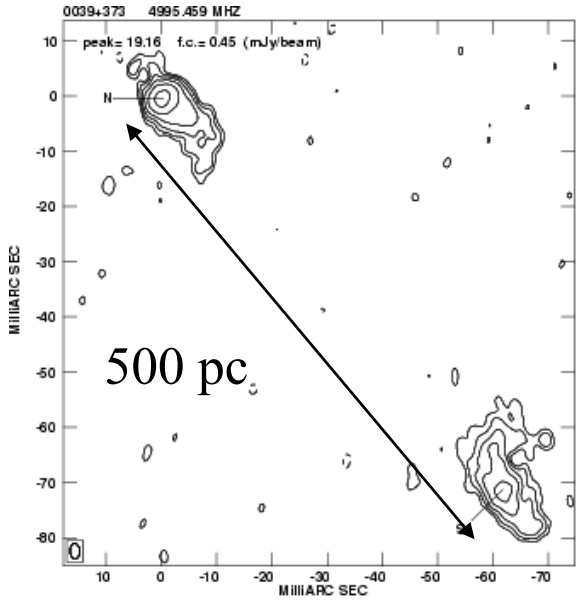
Young Radio Sources

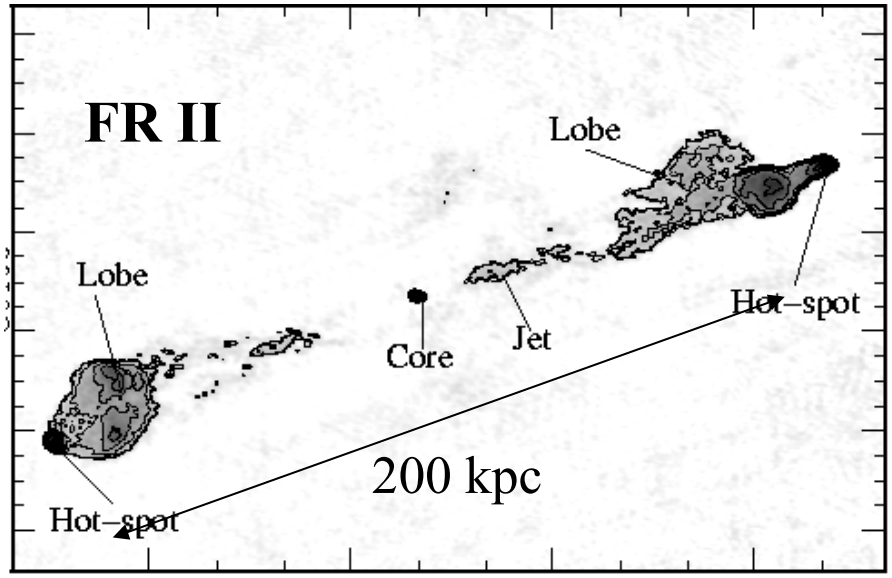
- $P_{1.4\ GHz} > 10^{25}$ W/Hz
- LS < 1 – 20 kpc

- Convex radio spectrum
- ν_{peak}~100 MHz - few GHz

- Scaled down version of the large classical radio galaxies







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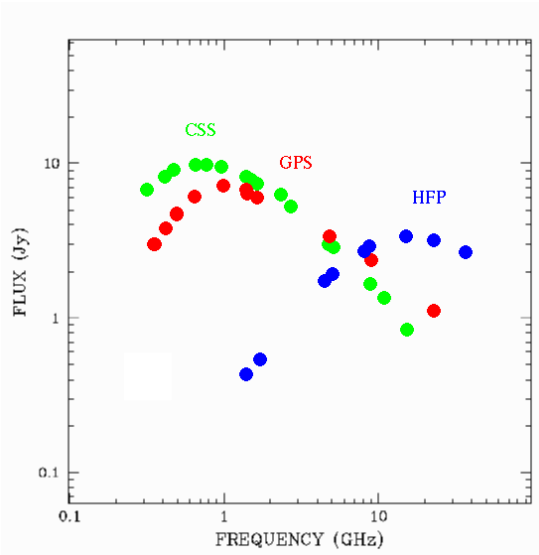
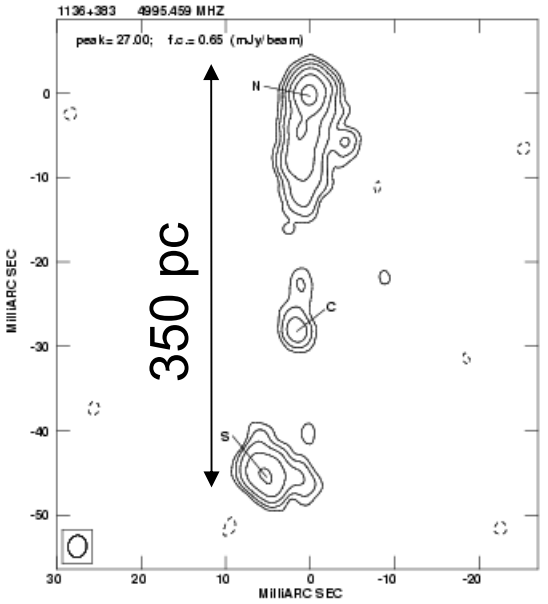
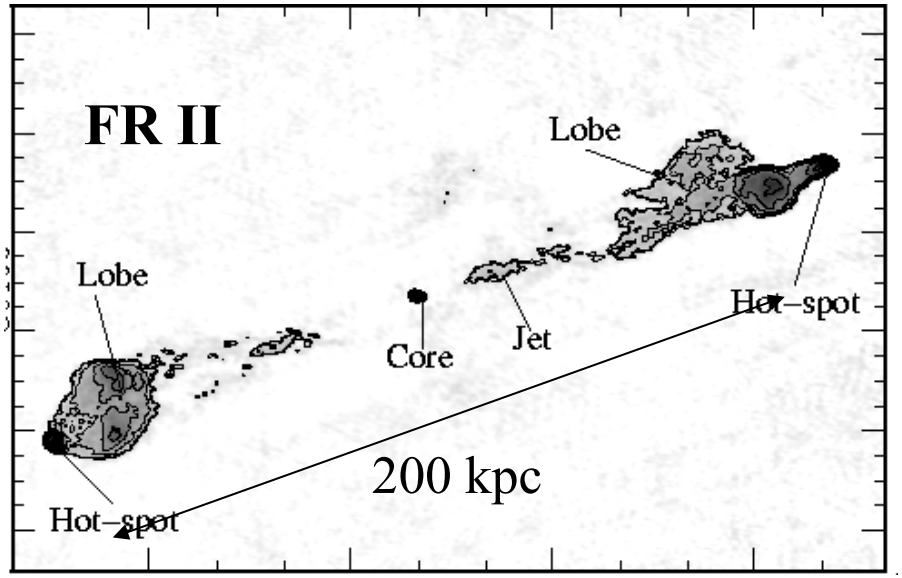






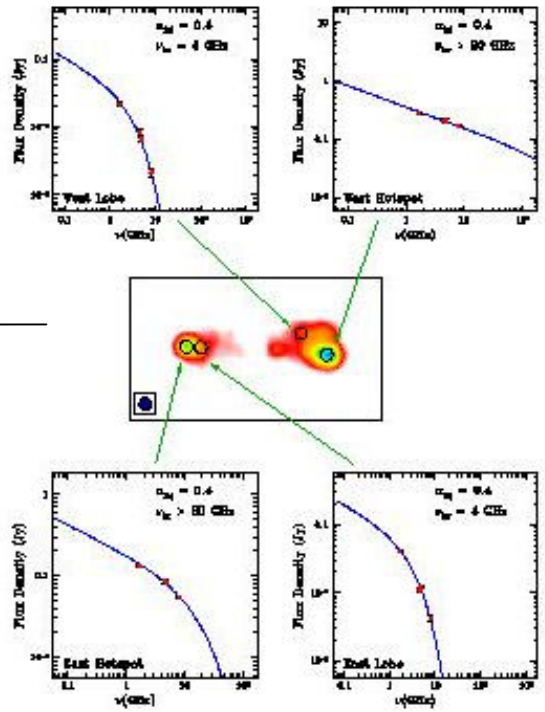
The youth scenario

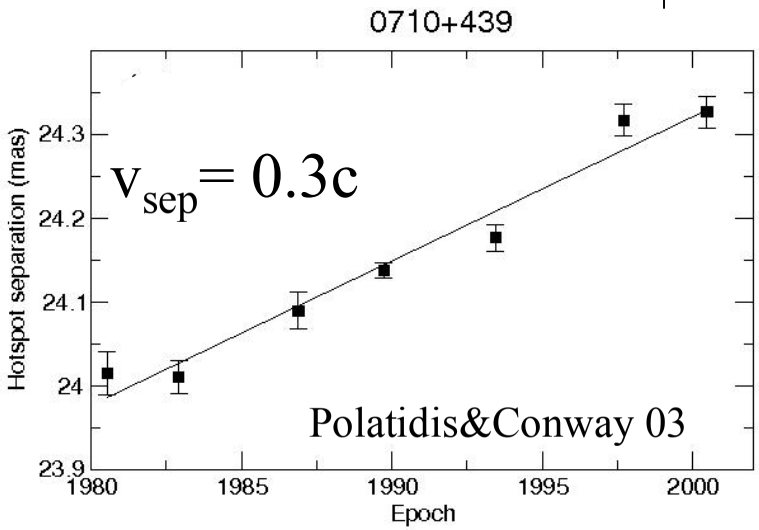
Compact ⟶ **Young**

Radiative ages
Murgia 2003

Kinematic ages
Polatidis&Conway 03

10^3 - 10^4 yr

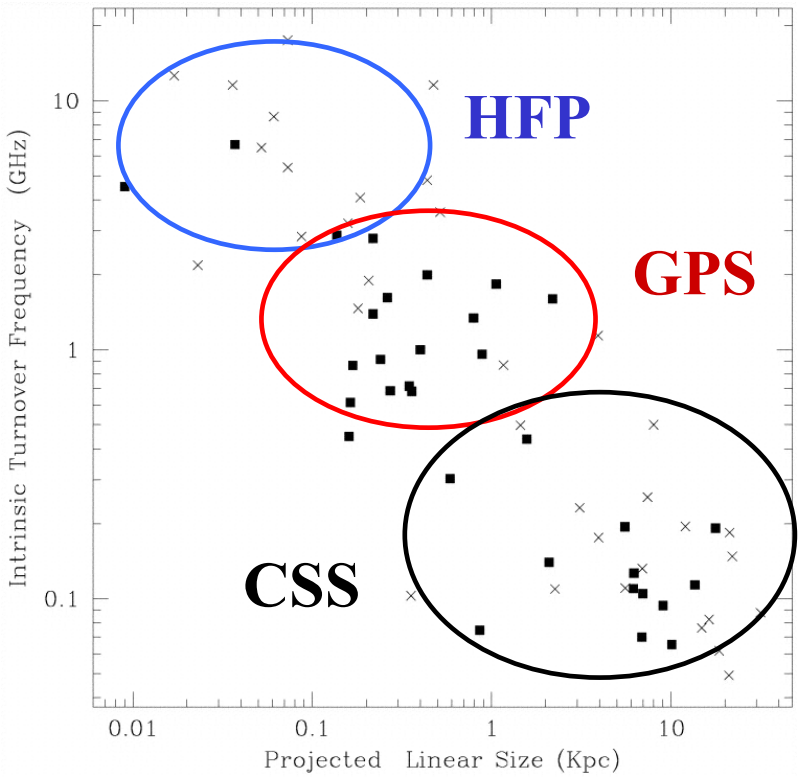




Compact ⟶ **Frustrated**

No evidence of particularly dense ISM
Fanti+ 00, Siemiginowska+ 05

Evolutionary scenario



O'Dea & Baum (1997) found an empirical anti-correlation between the peak frequency and the linear size (i.e. age)

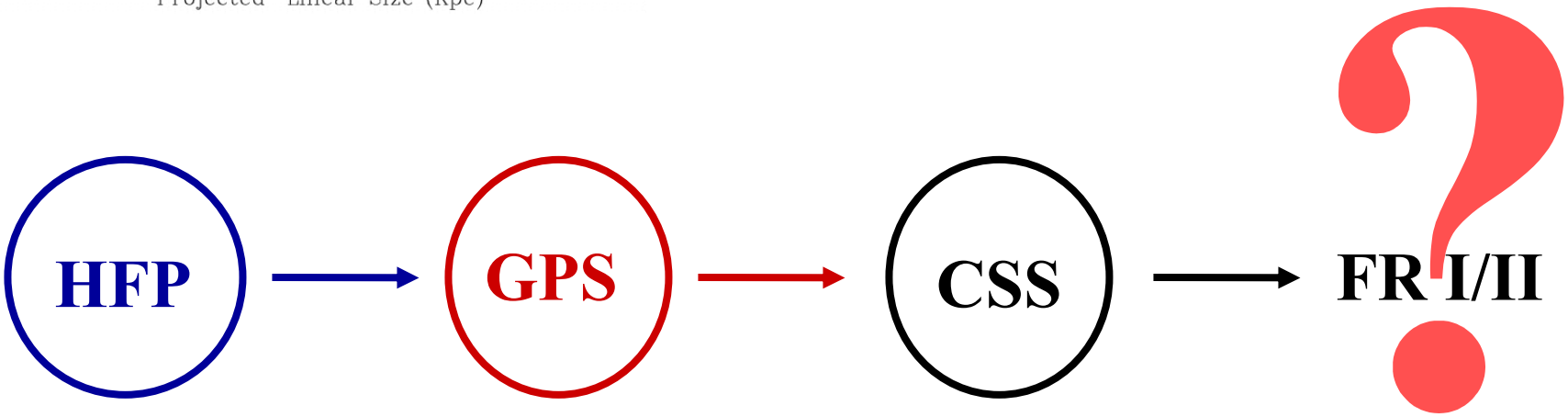
Higher the peak frequency

↓

Smaller the linear size

↓

Younger the source

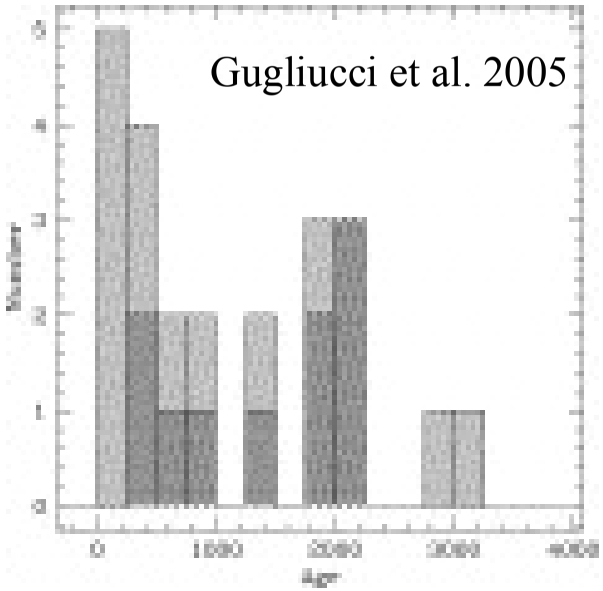


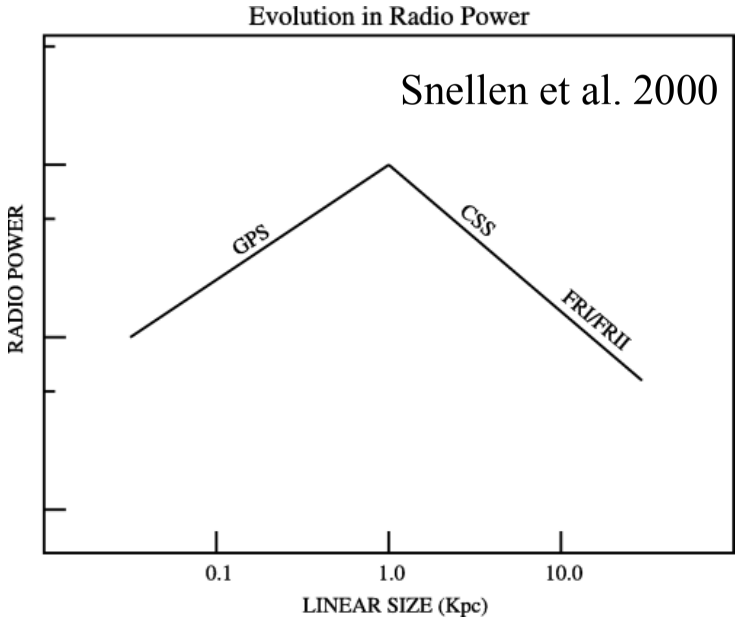
Fading radio sources?

Young radio sources represent a large fraction (15%-30%) of the objects selected in flux-limited samples

↓

Luminosity evolution





The age distribution of young radio sources sharply peaks below 500 yr

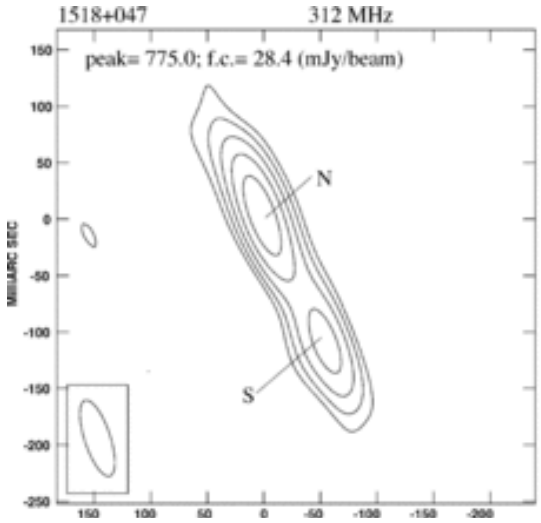
↓

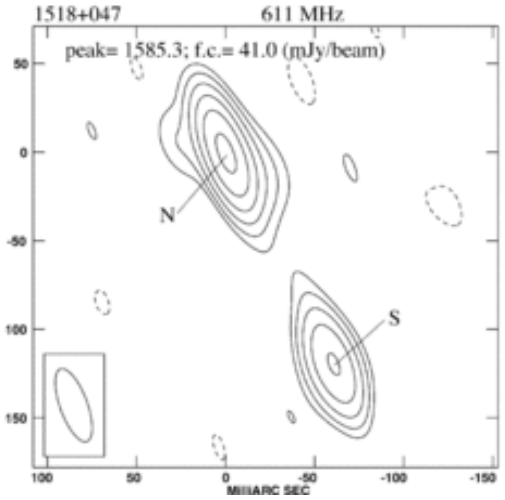
Young but fading radio sources?

Kunert-Bajraszewska et al. 2006, Marecki et al. 2006

PKS 1518+047: a study case

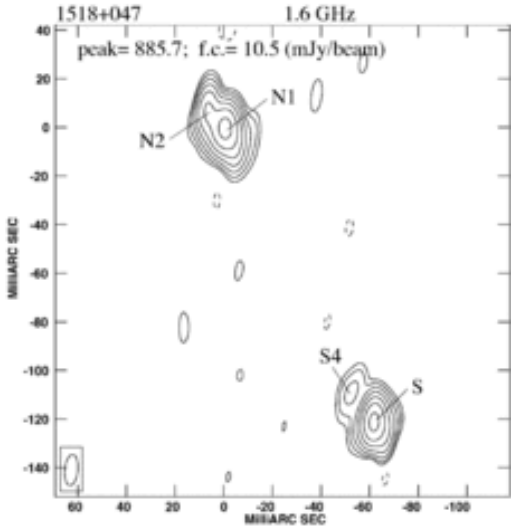
Multi-frequency VLBA observations at 0.327, 0.611, 1.4 and 1.6 GHz were carried out to study optically-thick emission. Archival VLBA data at 4.9 and 8.4 GHz were analysed to constrain the overall spectral properties.

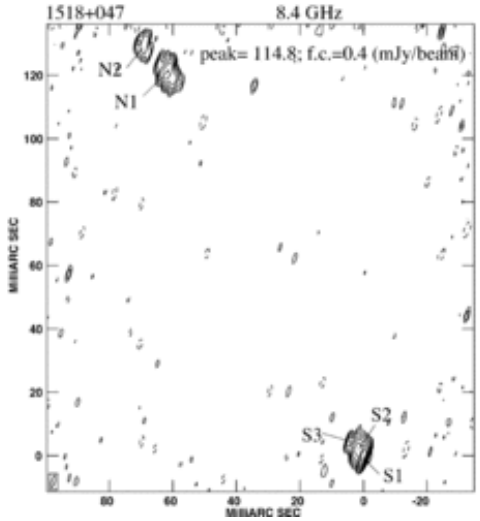


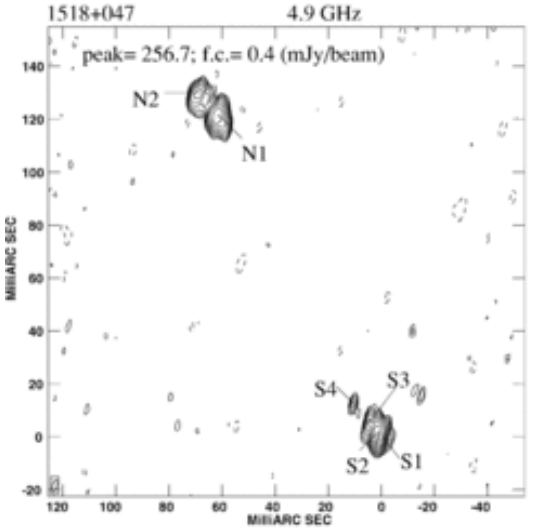


- Quasar at z=1.269
- Double radio structure
- ν_p = 1.0 GHz
- Steep spectrum α=1.0
- ν_b < 1.0 GHz

Orienti et al. 2010





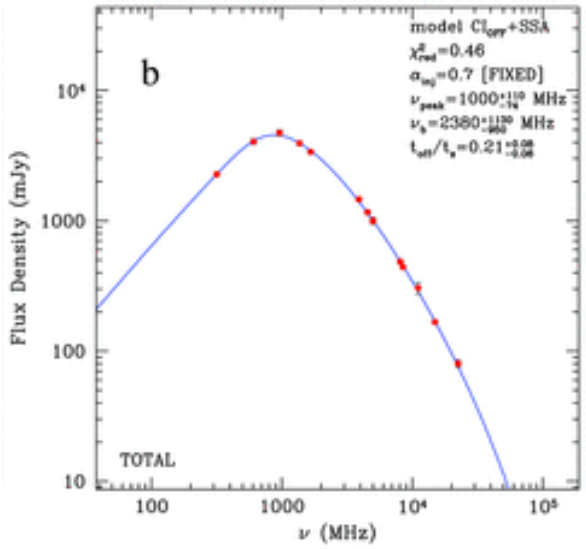


PKS 1518+047: a fading source?

t_{syn} = 2700±600 years

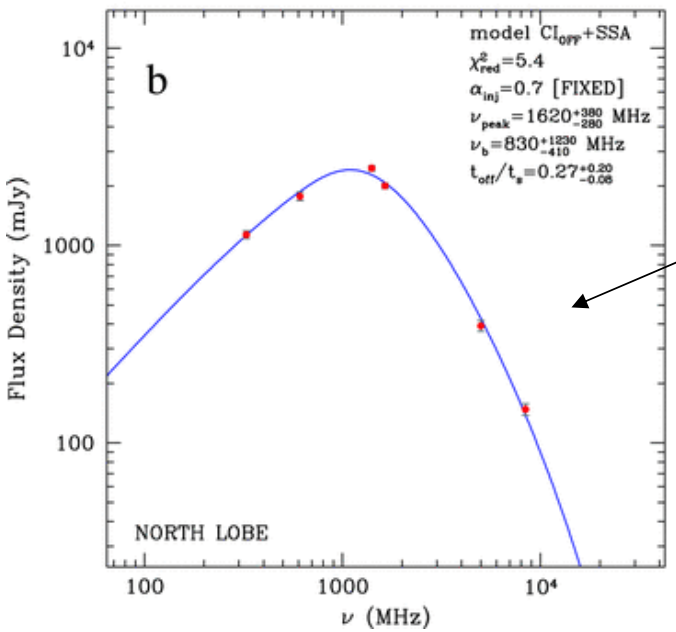
$\gamma \leq 600$;

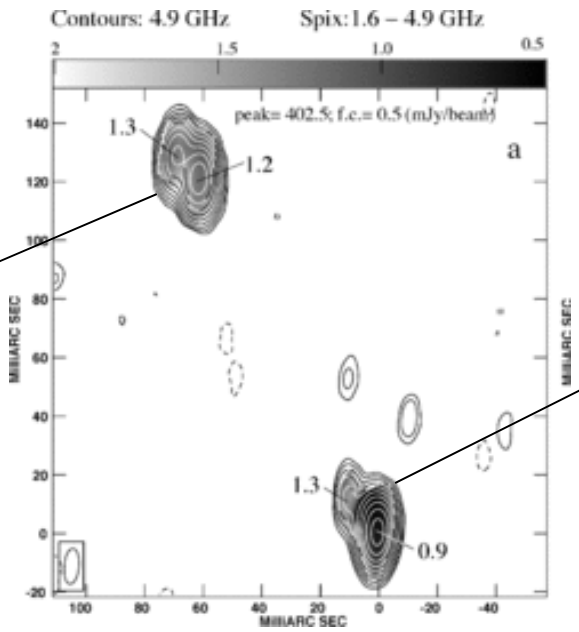
t_{OFF} = 550±100 years

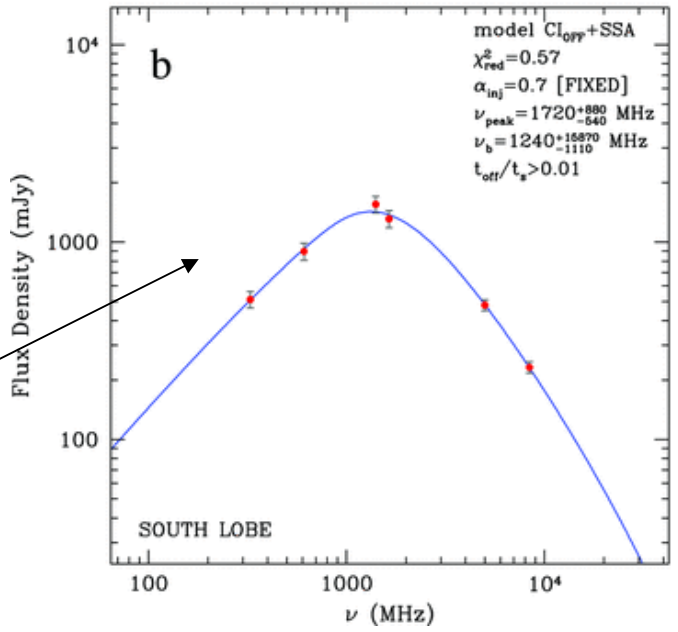


No injection/acceleration of fresh particles!

Orienti et al. 2010





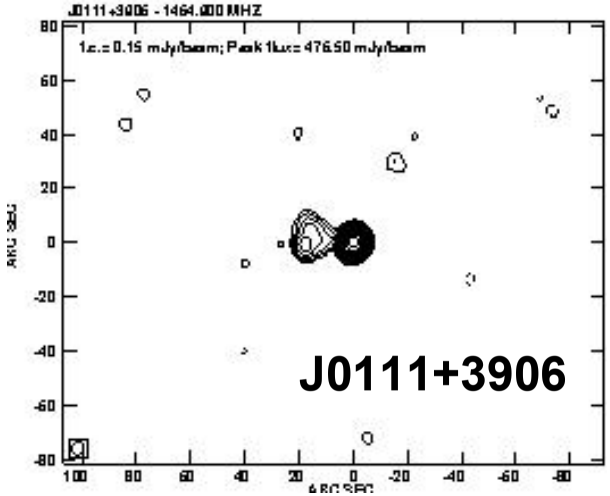


Fossils from past activity

- On kpc scales:
  - J0111+3906: 128 kpc

$t_{relic} \sim 10^7–10^8$ yr

(Baum et al. 1990; Tinti et al. 2005)

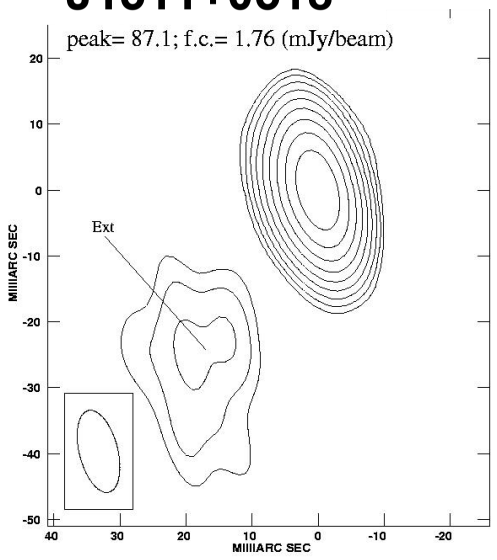


- On pc-scales:
  - J1511+0518: 50 pc
  - OQ208: 43 pc

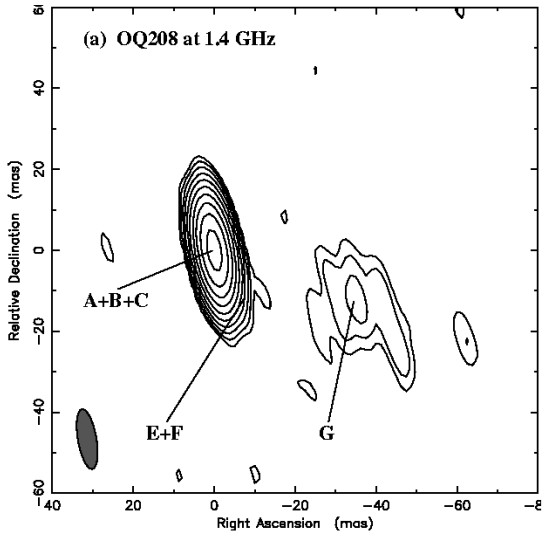
$t_{relic} \sim 10^3 – 10^4$ yr

(Orienti&Dallacasa 2008, Luo et al. 2007)

J1511+0518



OQ 208



Recurrent activity?

The large fraction of young radio sources may be explained assuming the existence of short-lived objects with intermittent activity.

At the very beginning of the radio activity several cycles of subsequent short bursts may occur before the development of the classical large Double galaxies (Orienti et al. 2008)

Recurrent activity may be caused by radiation pressure instability within the accretion disk (Czerny et al. 2009).

Low accretion rate: 10^3 yr

Eddington accretion rate: 10^8 yr

Searching for fading objects

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 $\alpha > 1.0$
- No evidence of active regions (i.e. core, HS)

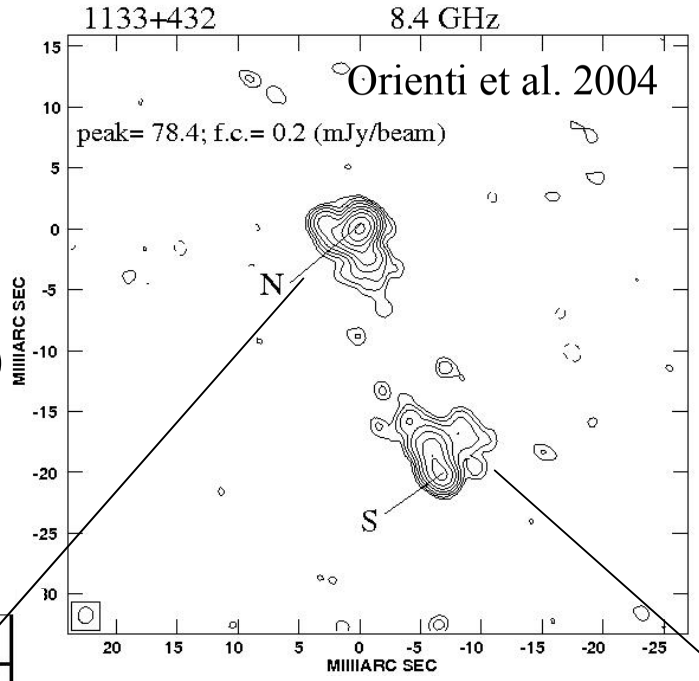
We ended up with a sample of 18 objects.

- 9 sources with LS < 1 kpc
- 9 sources with LS > 1 kpc

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

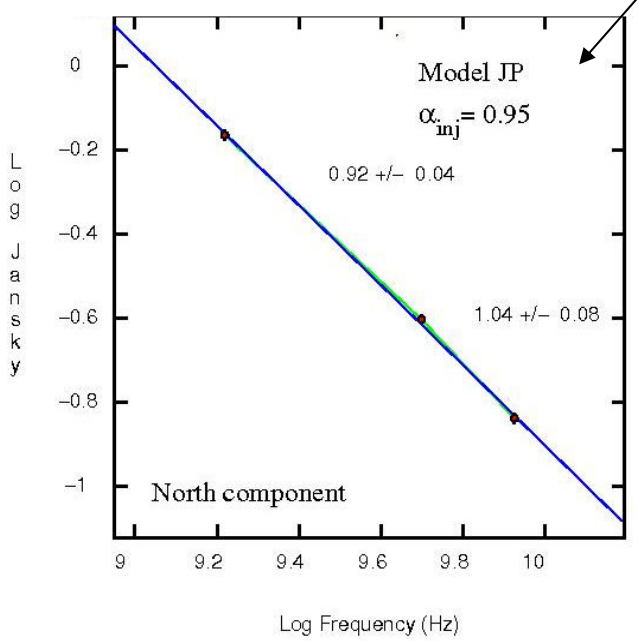
Preliminary results: B1133+432

- Empty field
- LAS = 35 mas
- LLS = 150 pc (z = 1.0)
- $\alpha = 1.0$



Northern lobe

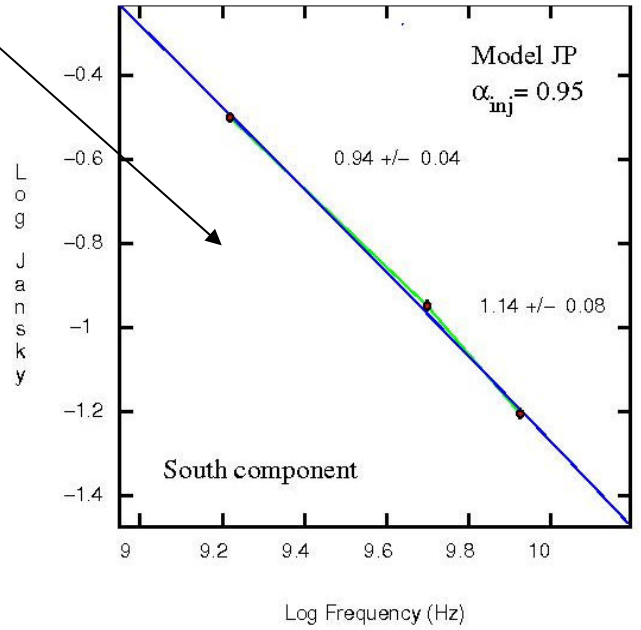
- Single-injection model
- $\alpha_{inj} = 0.95$
- $\nu_b < 1.4$ GHz



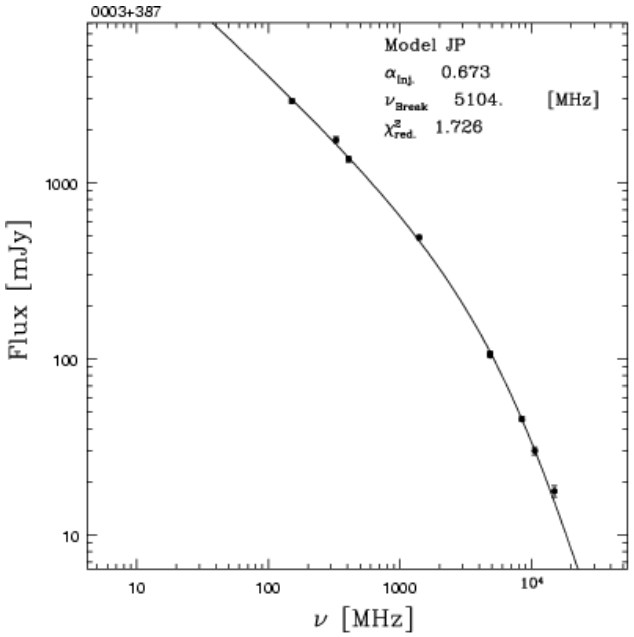
Southern lobe

- Single-injection model
- $\alpha_{inj} = 0.95$
- $\nu_b < 1.4$ GHz

No active regions



The "large" sources



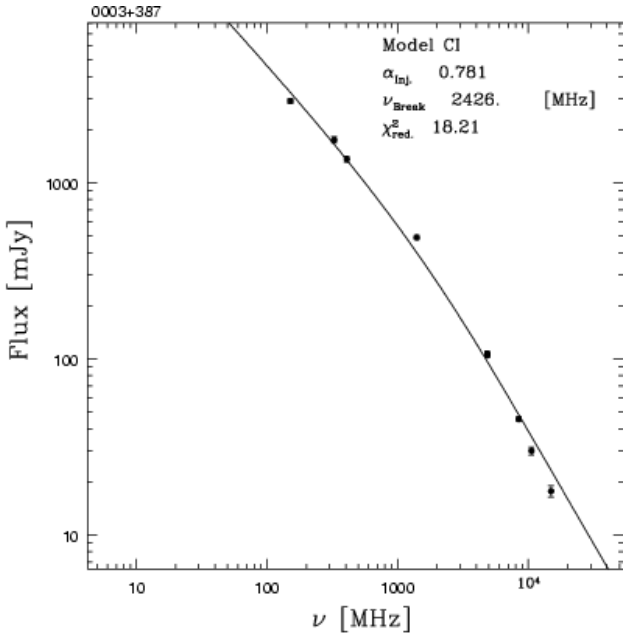
B0003+387

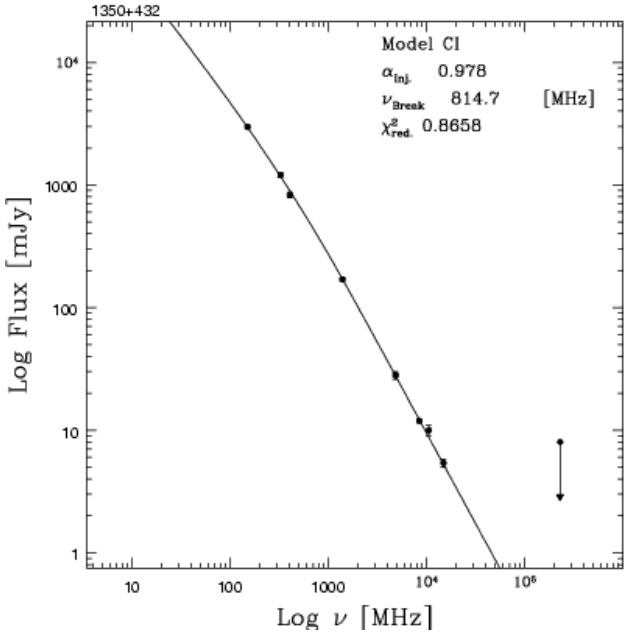
α_{thin}=1.4

α_{inj}=0.7

ν_{br}=5.1 GHz

Single-injection model



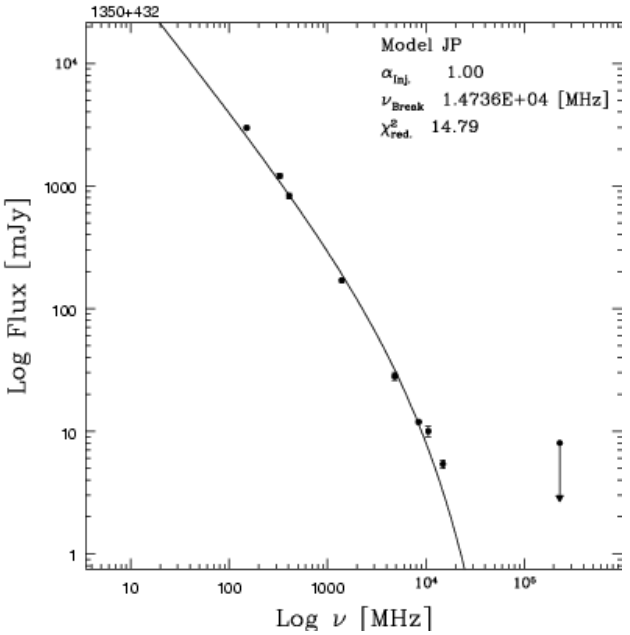


B1350+432

α_{inj}=1.0

ν_{br}<0.3 GHz

CI-OFF model: no active regions in the source?



Rossetti et al. 2006

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**

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Misaligned structures

Merger/accretion event resulting in a renewing activity with a re-orientation of the jet axis (e.g. Lal et al. 2008)

J1511+0518 (Orienti&Dallacasa 2008)

Well-aligned structures

Perturbation in the accretion rate within the existing accretion disk causing recurrent activity along the same axis.

B0925+420 (Brocksopp et al. 2007)