Exploring the remnant radio galaxy population with LOFAR

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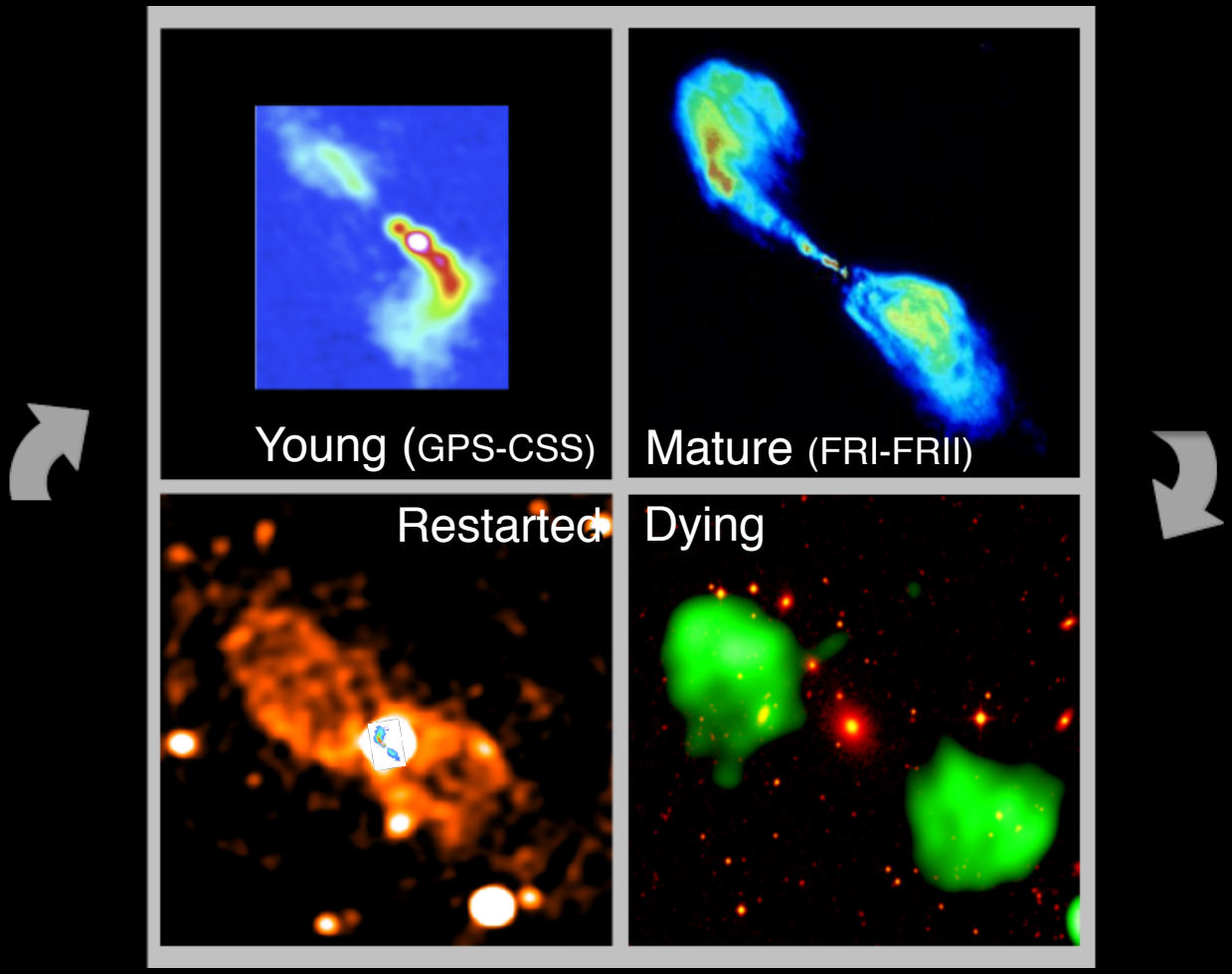
Supervision: Morganti R., Godfrey L.



Why remnant radio galaxies?

- Spectral study of radio plasma allows timing of the activity phases
- Constrain duty-cycle of radio galaxies as a function of power, environment, triggering mechanism..
- Quantify feedback of radio galaxies on host galaxy and IGM

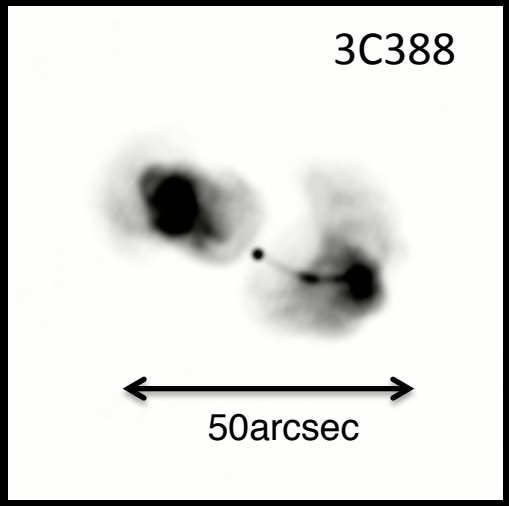
Serendipitous discovery of remnant radio galaxy in LOFAR 3C380 field

OUTLINE

- Discovery
- Data reduction
- Science
- Implications for future studies

Observations and Preprocessing

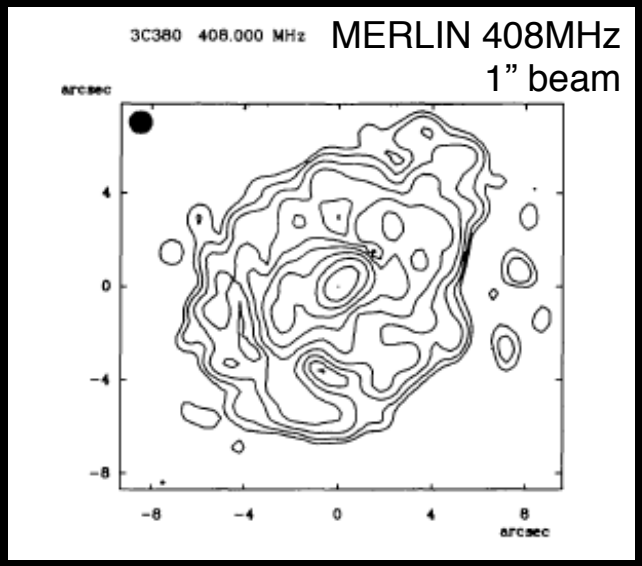
- Cycle 1 as part of the KSP-Using LOFAR for detailed studies of AGN and AGN physics (LC1_034, PI:Morganti)
- Target 3C388 (18h44m02.4s +45d33m30s) – Calibrator 3C380
- Dual beam observation – 8h integration time
- Dutch array
- Central frequency 146 MHz
  Bandwidth 60 MHz (SB 80-390)
- CygA demixed (14 degrees distance)
- Time averaging 5sec – Frequency averaging 4 channels



Gain calibration

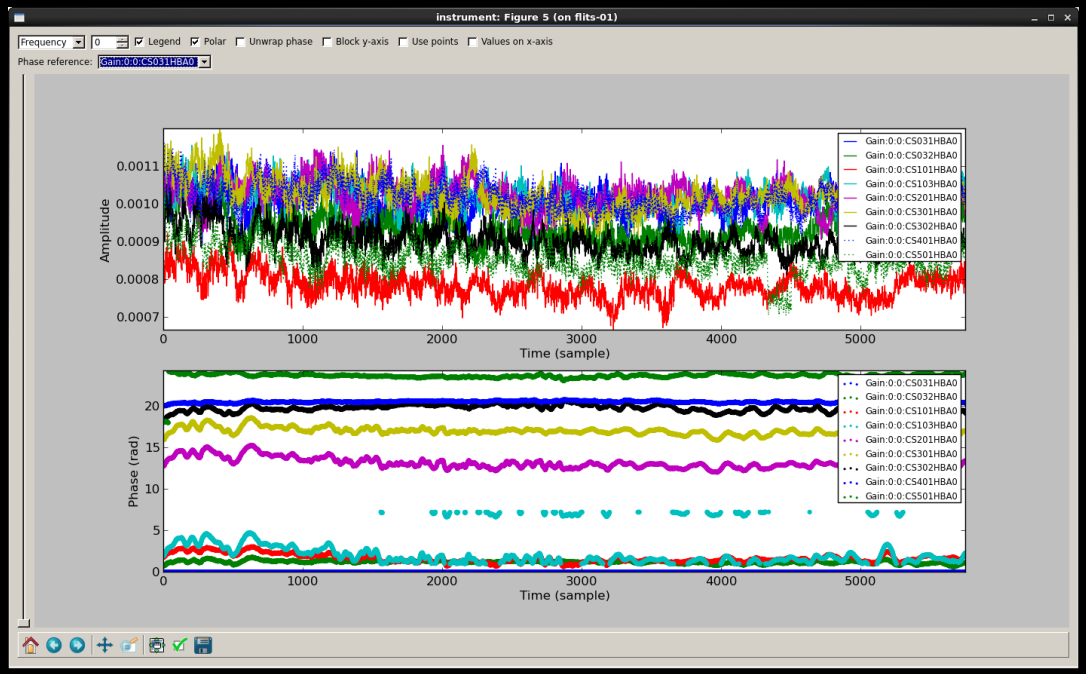
Observatory pipeline
GSM SKYMODEL

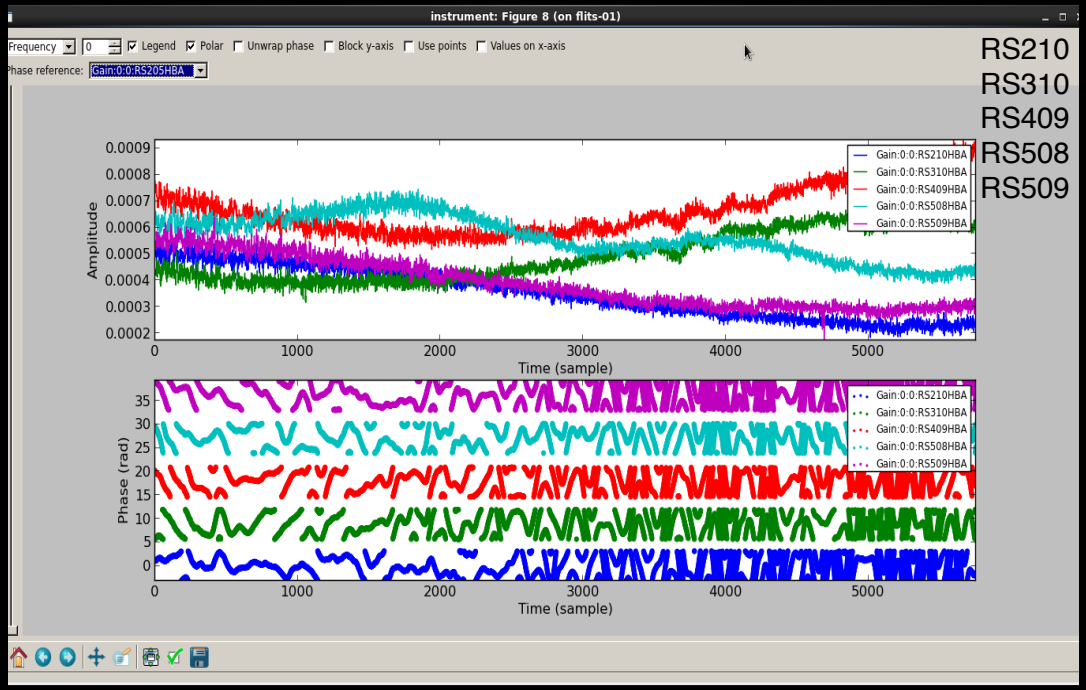
3C380

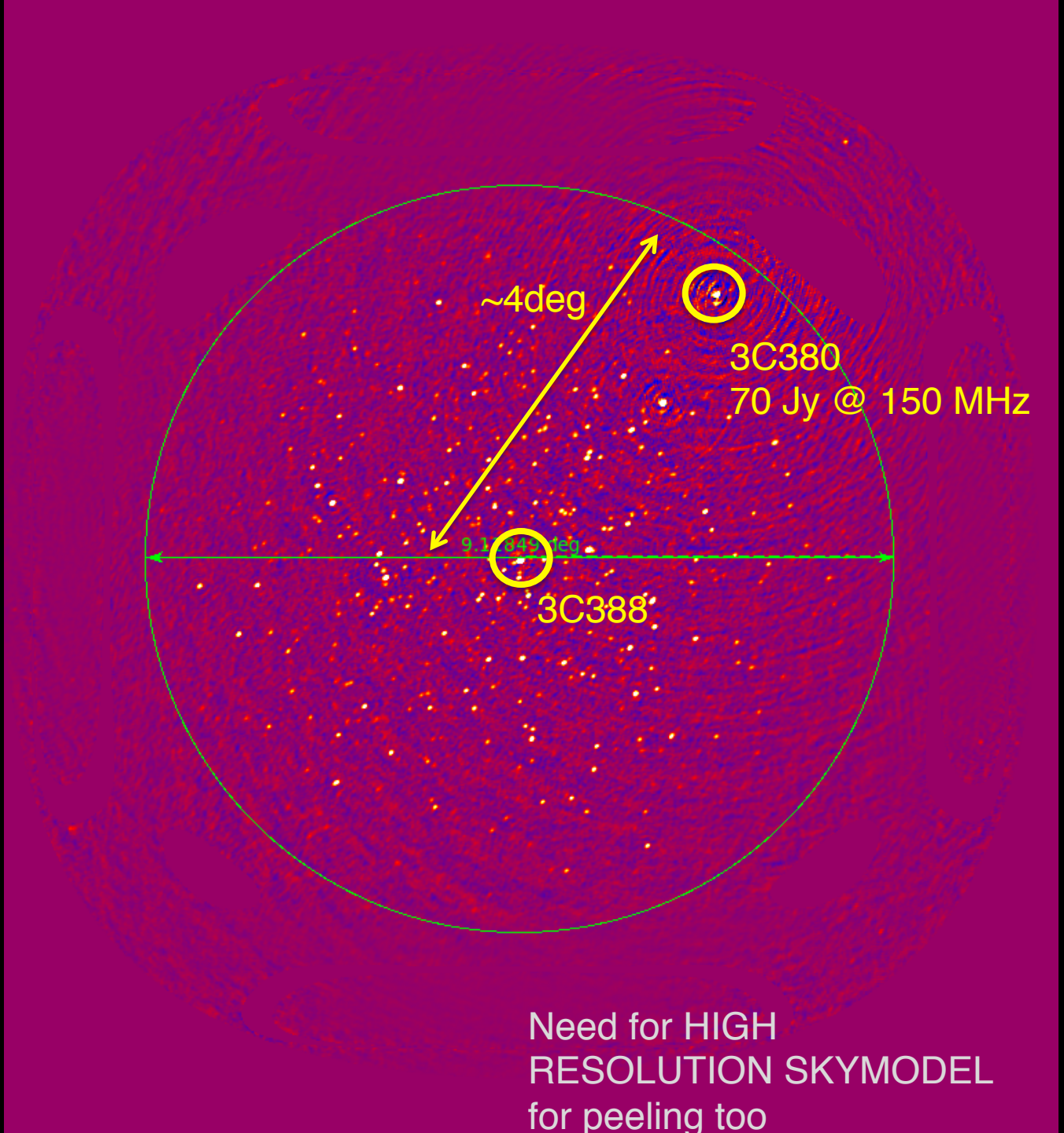


10" size = resolved with
long Dutch baselines

need for HIGH RESOLUTION
SKYMODEL



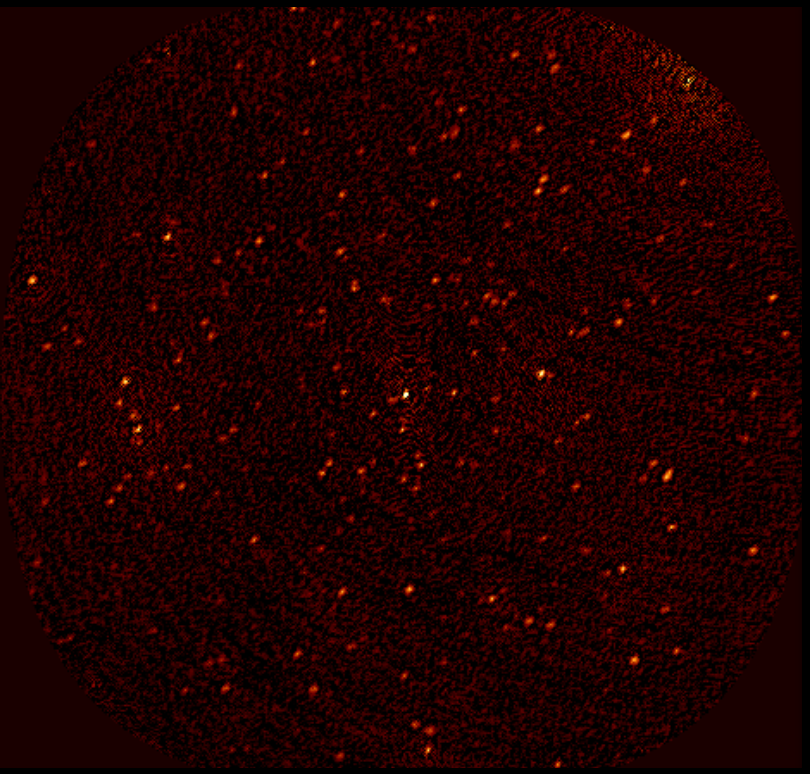




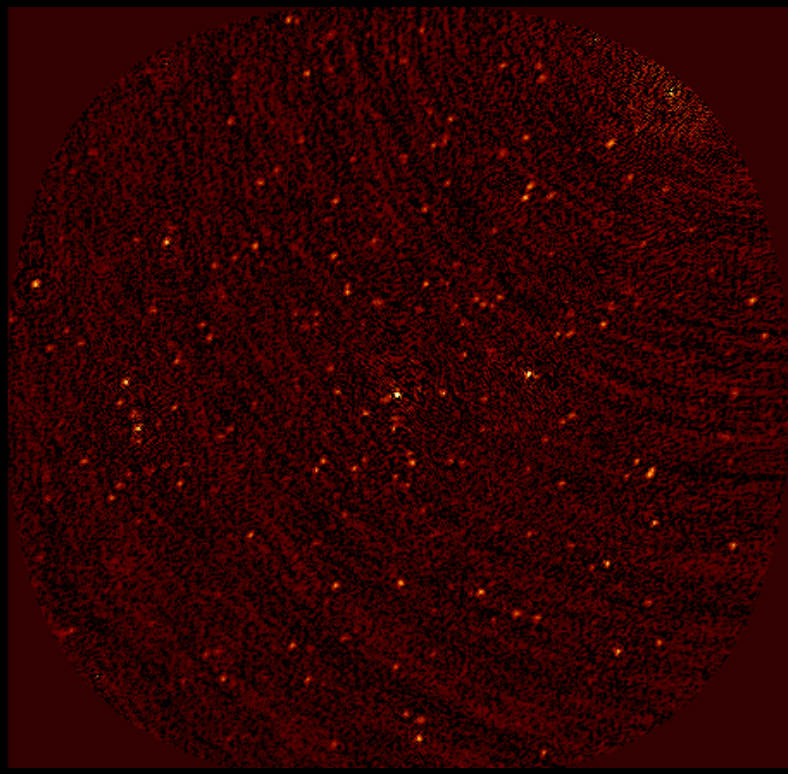
Need for HIGH RESOLUTION SKYMODEL for peeling too

Self-calibration with annulus subtraction

by Nicolas Vilchez



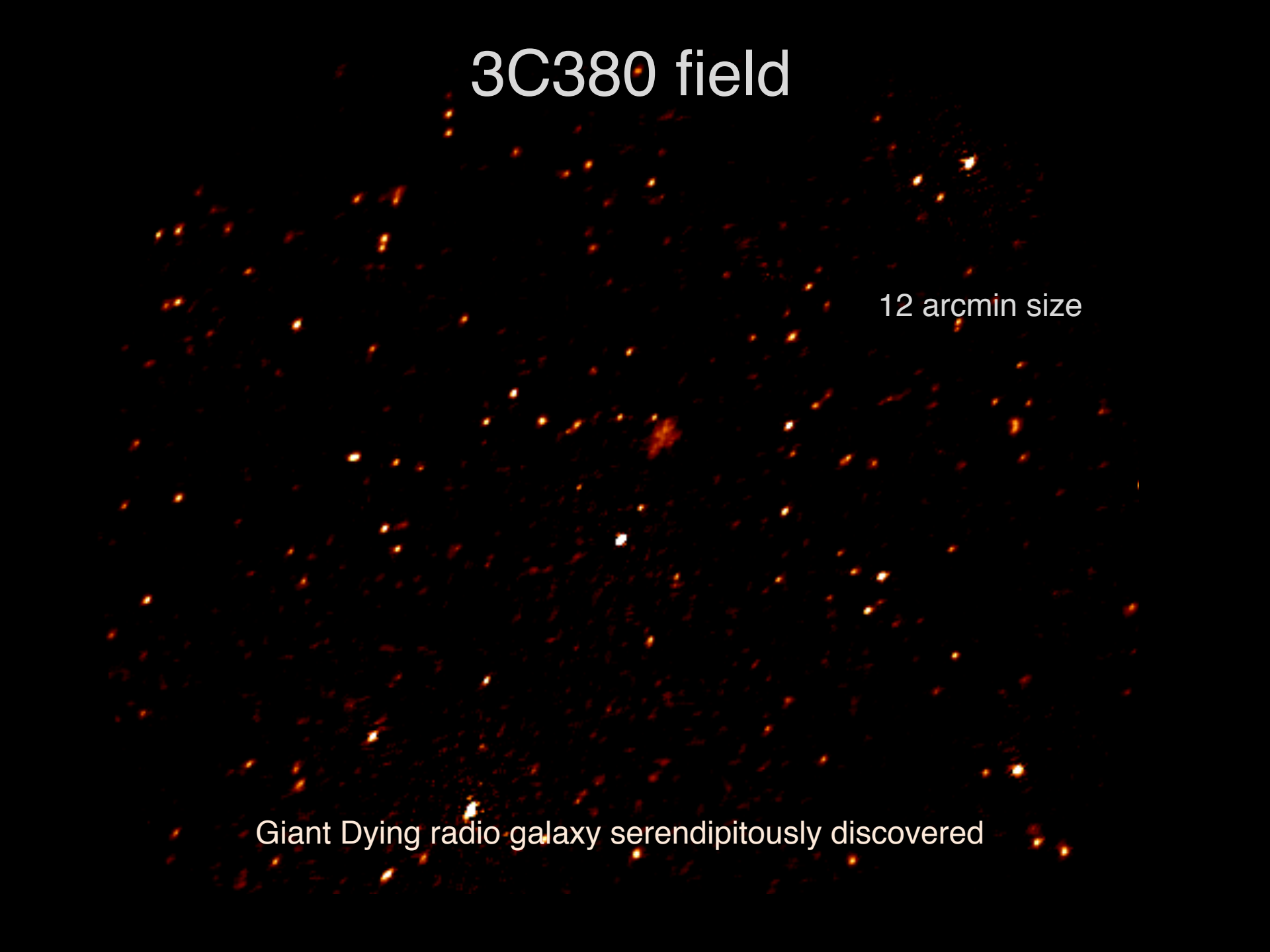
AFTER



BEFORE

20 SB – 40 arcsec beam

3C380 field



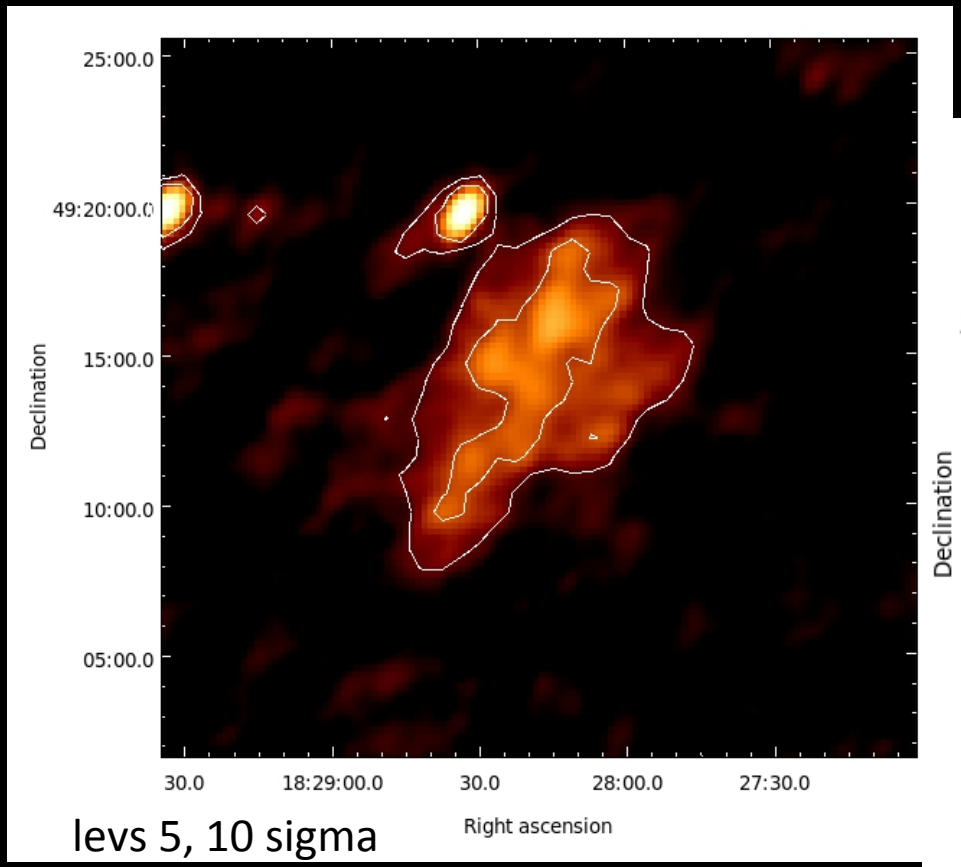
12 arcmin size

Giant Dying radio galaxy serendipitously discovered

Self-calibration

- mergeSB.py – 20 SB and 1 channel per SB
- selfcal.py pipeline – 5 cycles
  resolution vector (100,90,70,40,30)
  gsm skymodel at start
  4 pixels/beam
  Uvmin=0
  (not interested inhigh resolution)
- 3 maps of 20 SB at 116, 130, 155 MHz

Multi-frequency

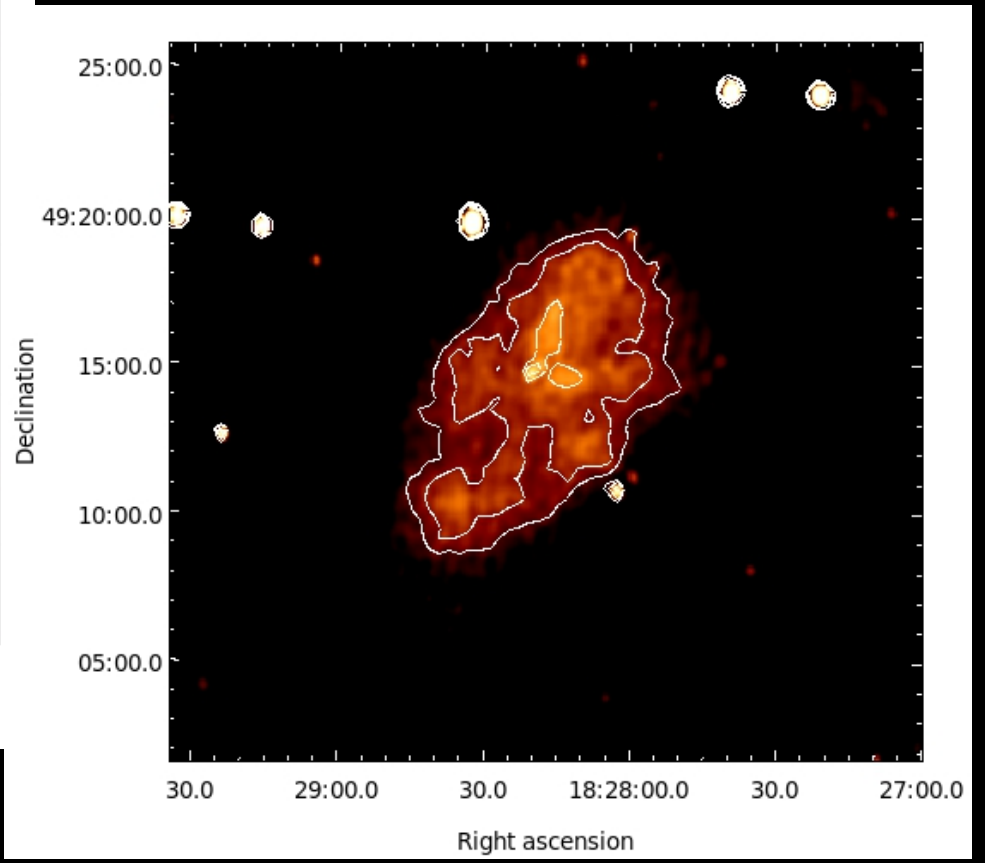


levs 5, 10 sigma

LOFAR 116 MHz 1.5' beam
noise = 6mJy/arcmin^2
Mean surf bright = 20 mJy/arcmin^2

+ WENSS 325 MHz
+ GB6 non-detection 4850 MHz

Not detected by any 1.4 GHz survey
FOLLOW UP

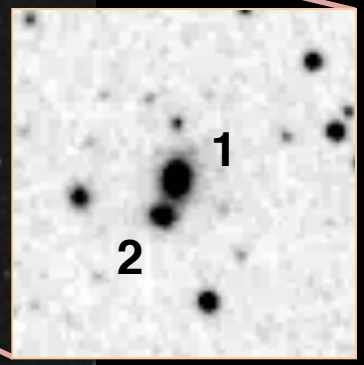


WSRT 1400 MHz 35" beam
noise = 3e-5 µJy/arcsec^2
Mean surf bright = 4 mJy/arcmin^2

Host galaxy and environment

z_phot,1 = 0.053±0.006
z_phot,2 = 0.050±0.006

Linear size ≈ 700 x 400 kpc



Merger?
waiting for WHT observations..
(triggering/shut down + wide angle jet)

POSSII image with WENSS contours

Any known
galaxy cluster

Morphology

Diffuse extended emission of about 700x400 kpc
- Axial ratio 1.8

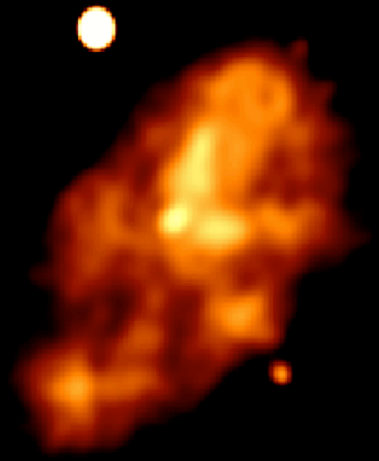
Compact component in the center
- Fading/restarting core?
(VLA 5GHz proposal)

Filament of emission in north & west directions
- outflows?

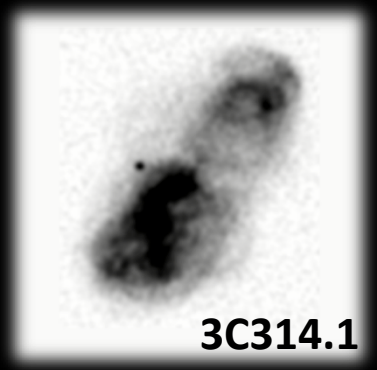
No signs of hot spots

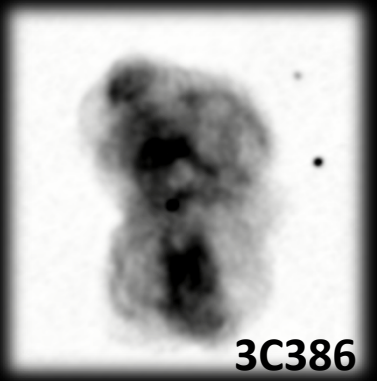
$L_{1.4GHz} = 1.4x10^{24}$ W/Hz

Core prominence at 1.4GHz
$L_{core}/L_{extended} \approx 10^{-3}$



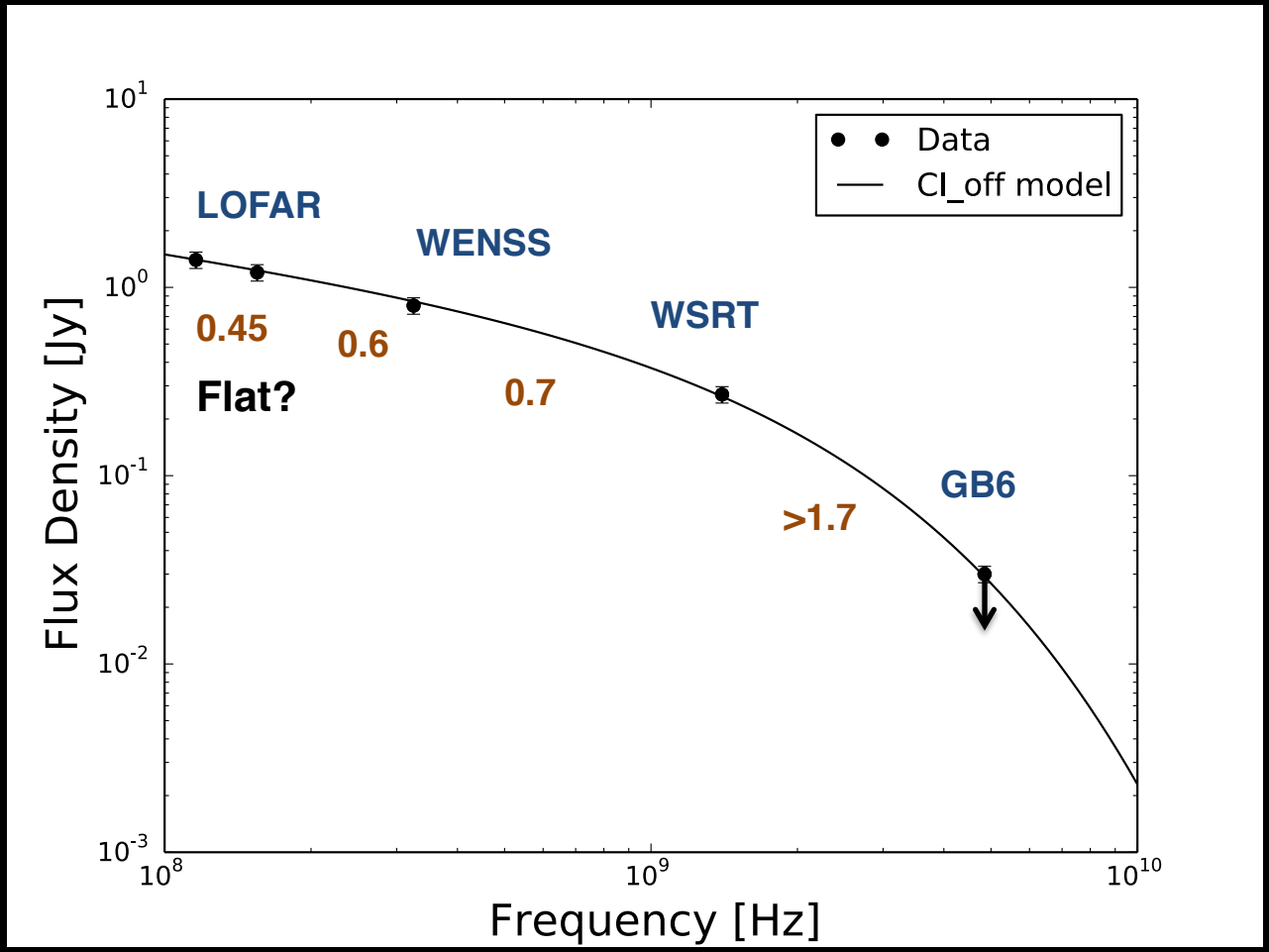
WHICH PROGENITOR?





Spectral modeling : CIOFF (Komissarov et al. 94)

CONTINUOUS INJECTION + DYING PHASE



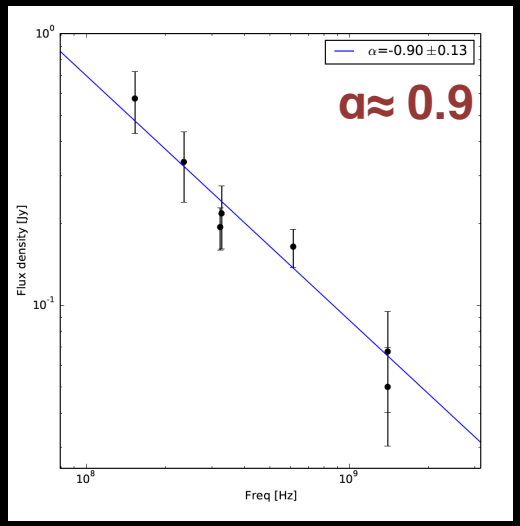
$t_s = t_{on} + t_{\_off}$

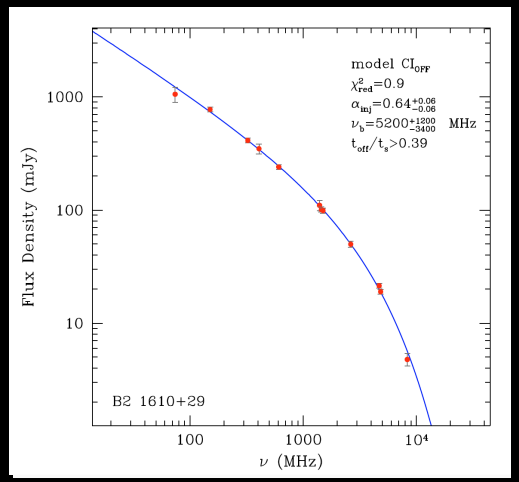
$t_{off}/t_s = (\nu_{b,low}/\nu_{b,high})^{0.5}$

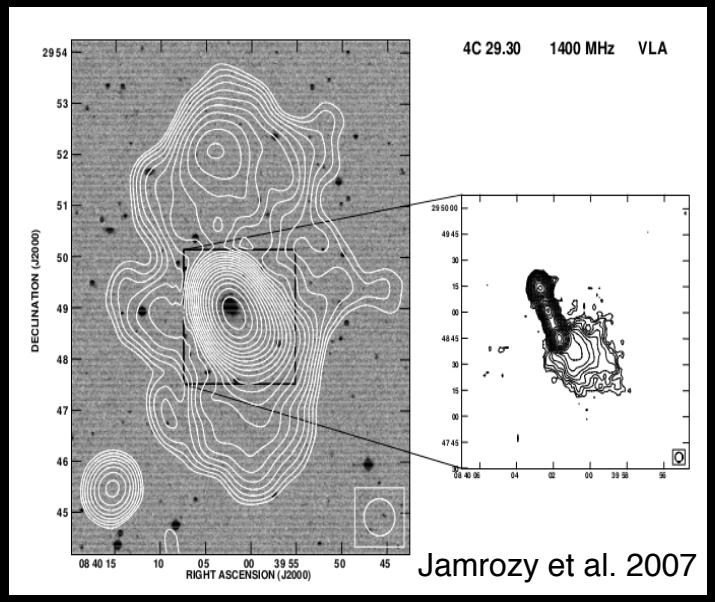
B_{eq}= 1μG
α_{inj}= 0.45
t_{off} = 60 Myrs
t_s = 80 Myrs

Pressure equilibrum with IGM?

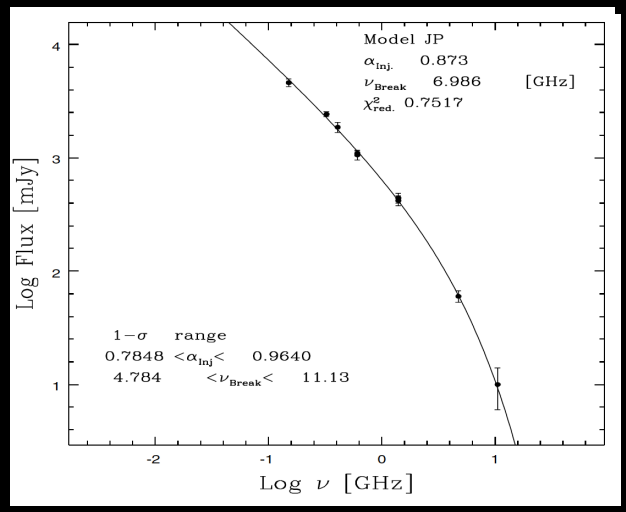
A variety of morphologies and spectral shapes

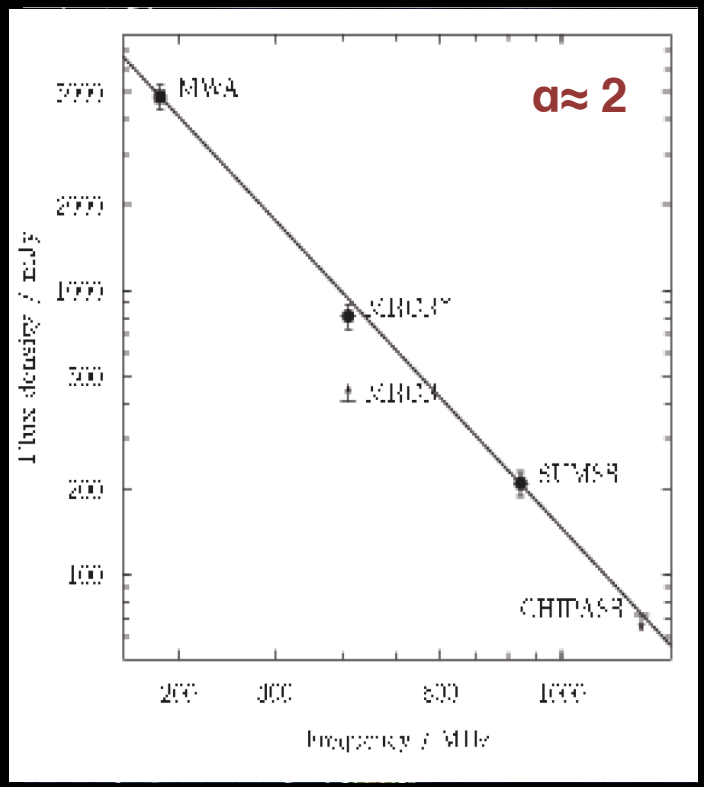


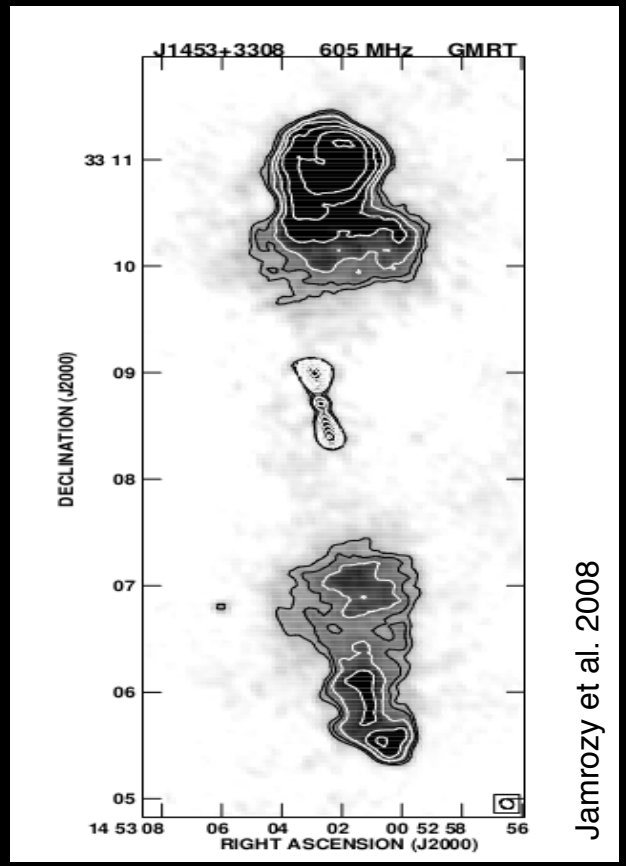




Jamrozy et al. 2007







Jamrozy et al. 2008

Preparing for surveys..

Systematic search and bigger complete samples for statistical studies
> new generation deep surveys

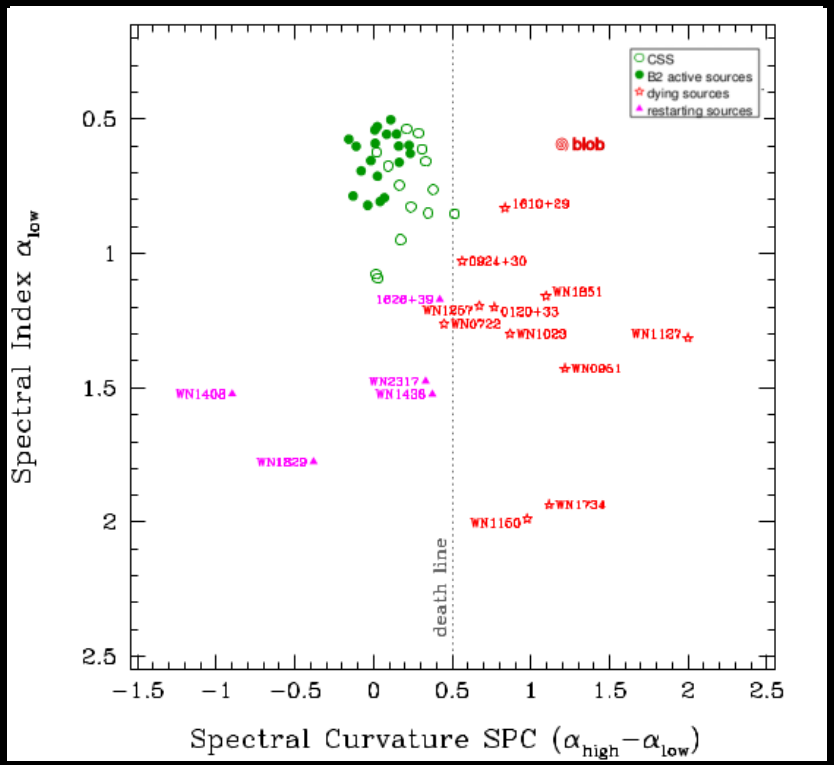
SELECTION CRITERIA

- Steep low frequency spectral indices ($\alpha > 1.3$) Dwarakanath 2009, Parma 2007, Murgia et al. 2011

- Spectral curvature = α_{high}-α_{low} (SPC > 0.5) Murgia et al. 2011

- Morphology = Low surface brightness - lack of compact features like hot-spots and jets

  Saripalli et al. 2012



LOFAR!

SUMMARY

- Investigation of late stages of radio galaxy evolution
- Serendipious discovery of remnant radio galaxy with LOFAR – implications for source selection
- Preparation to upcoming surveys: selection criteria

Morphology vs Spectra