Hunting for High redshift Radio Galaxies

with LOFAR

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Structure of presentation

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  - HzRGs
- Research
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  - Results
    - Spectra
    - Source Counts
    - Spectral indices
- Future work/Conclusion

LOFAR (1)

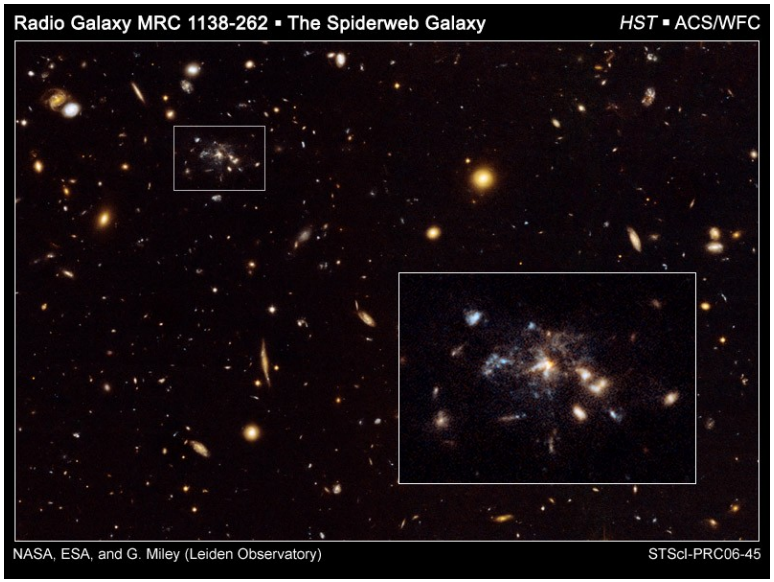

Darlington
Leeds
Hull
Sheffield
Grimsby
Nottingham
Derby
Peterborough
Norwich
Leicester
Northampton
Luton
Ipswich
Chelmsford
Swindon
London
Southend-on-Sea
Woking
Gillingham
Brighton
Portsmouth
Eastbourne
Calais
Dunkerque
Brugge
Brussel
Bruxelles
België
Belgique
Belgium
Lille
Amiens
Saint-Quentin
Le Havre
Beauvais
Caen
Rouen
Évreux
Paris
Reims
Saint-Malo
Rennes
Laval
Le Mans
Orléans
Troyes
Blois
Angers
Tours
Nantes
Cholet
Châteauroux
Bourges
Poitiers
Niort
France
Luxembourg
Kiel
Neumünster
Lübeck
Rostock
Bremerhaven
Hamburg
Schwerin
Neubrandenburg
Lüneburg
Groningen
Assen
Emmen
Bremen
Alkmaar
Almere
Almelo
Amsterdam
Osnabrück
Hannover
Braunschweig
Berlin
Potsdam
Den Haag
Nederland
Netherlands
Hildesheim
Bielefeld
Detmold
Dessau
Rotterdam
Nijmegen
Recklinghausen
Paderborn
Göttingen
Halle
Eindhoven
Essen
Dortmund
Kassel
Leipzig
Düsseldorf
Wuppertal
Deutschland
Germany
Maastricht
Köln
Siegen
Gera
Chemnitz
Aachen
Bonn
Marburg
Jena
Gießen
Fulda
Zwickau
Koblenz
Frankfurt
am Main
Wiesbaden
Darmstadt
Würzburg
Bamberg
Bayreuth
Plzeň
Kaiserslautern
Mannheim
Nürnberg
Saarbrücken
Karlsruhe
Heilbronn
Regensburg
Nancy
Baden-Baden
Stuttgart
Ingolstadt
Strasbourg
Aalen
Reutlingen
Ulm
Augsburg
Villingen-Schwenningen
München
Salzburg
Freiburg im
Breisgau
Basel
Konstanz
Dijon
Zürich
St. Gallen
Innsbruck
Besançon
Liechtenstein
Schweiz
Suisse
Svizzera
Lausanne
Switzerland
100 mi

LOFAR (2)

- Frequency range: 10 – 240 MHz
- High sensitivity
- Flexible: multiple beams

HzRGs

- HzRG: High redshift Radio Galaxy

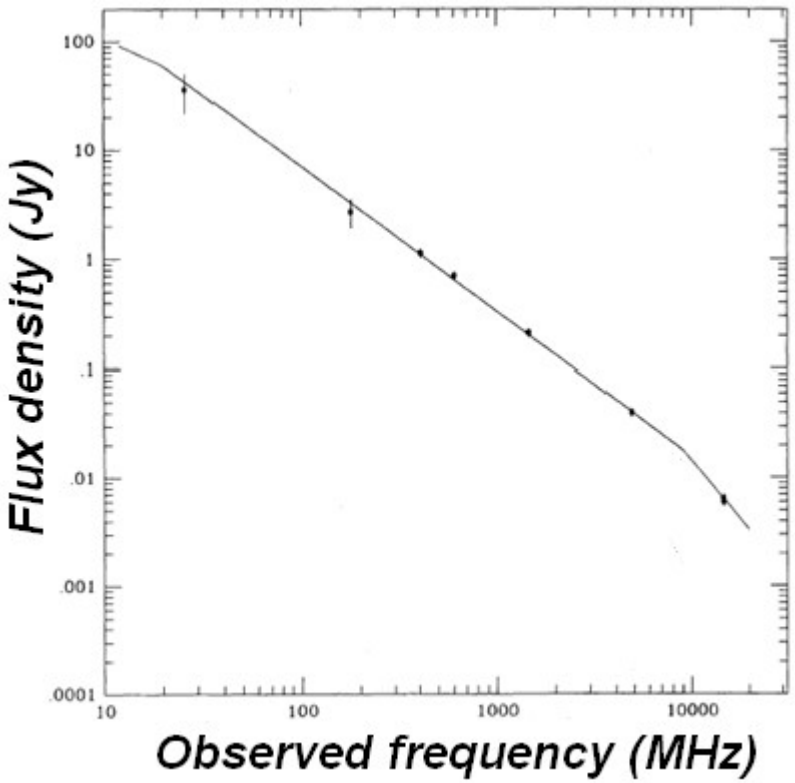


- HzRGs are among the largest, most luminous and most massive objects in the Universe

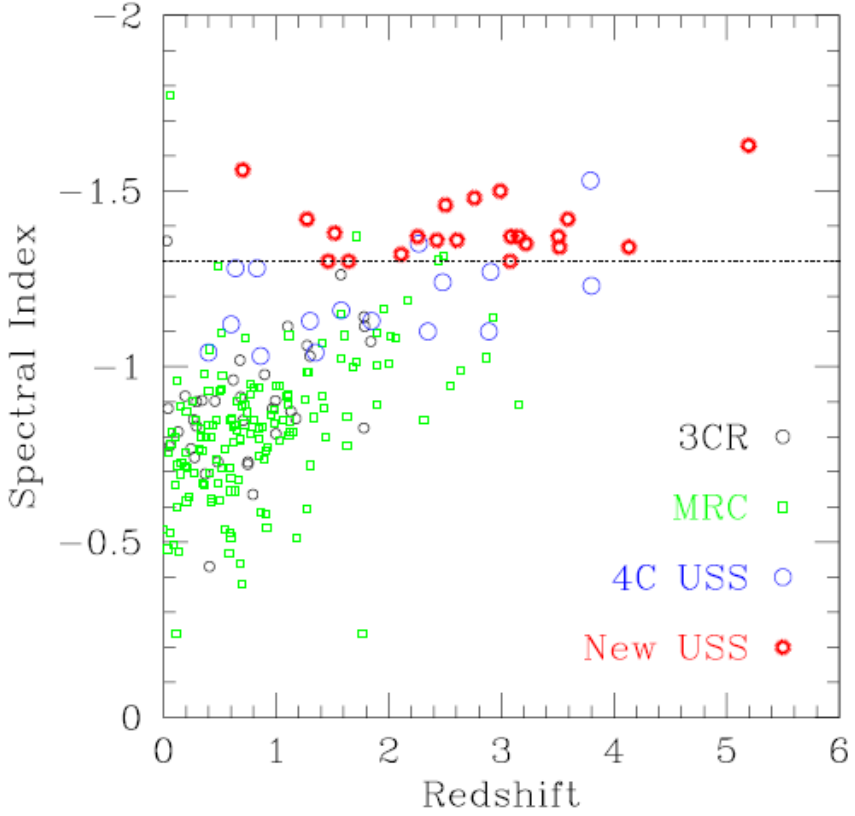
- Play an important role in the evolution of galaxies and the emergence of large scale structure

z - α correlation for HzRGs

$$S_\nu \propto \nu^{\alpha}$$



De Breuck et al., 2000



Hunting for HzRGs

1) Filter out probable HzRGs from huge number of radio sources in low-frequency surveys
   - Criterion: extremely steep spectrum

1) Discard bright nearby objects

2) Refine positions to arcsec accuracy (optical/near IR)

3) Spectroscopic observation of HzRG candidates

Aim of research

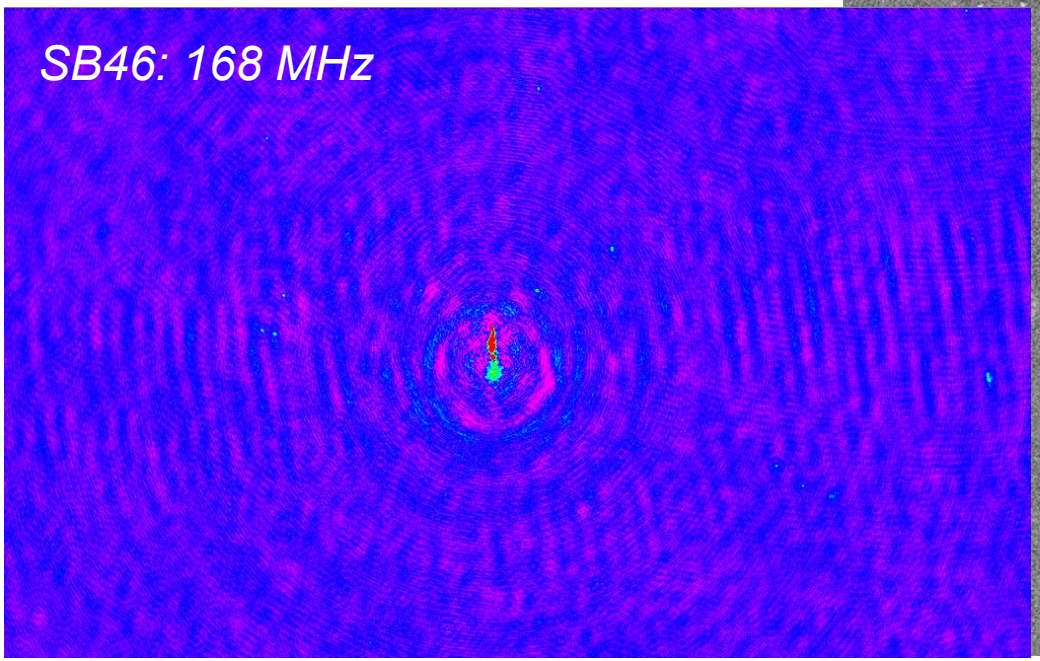
- Investigate 'goodness' of LOFAR- data/calibration

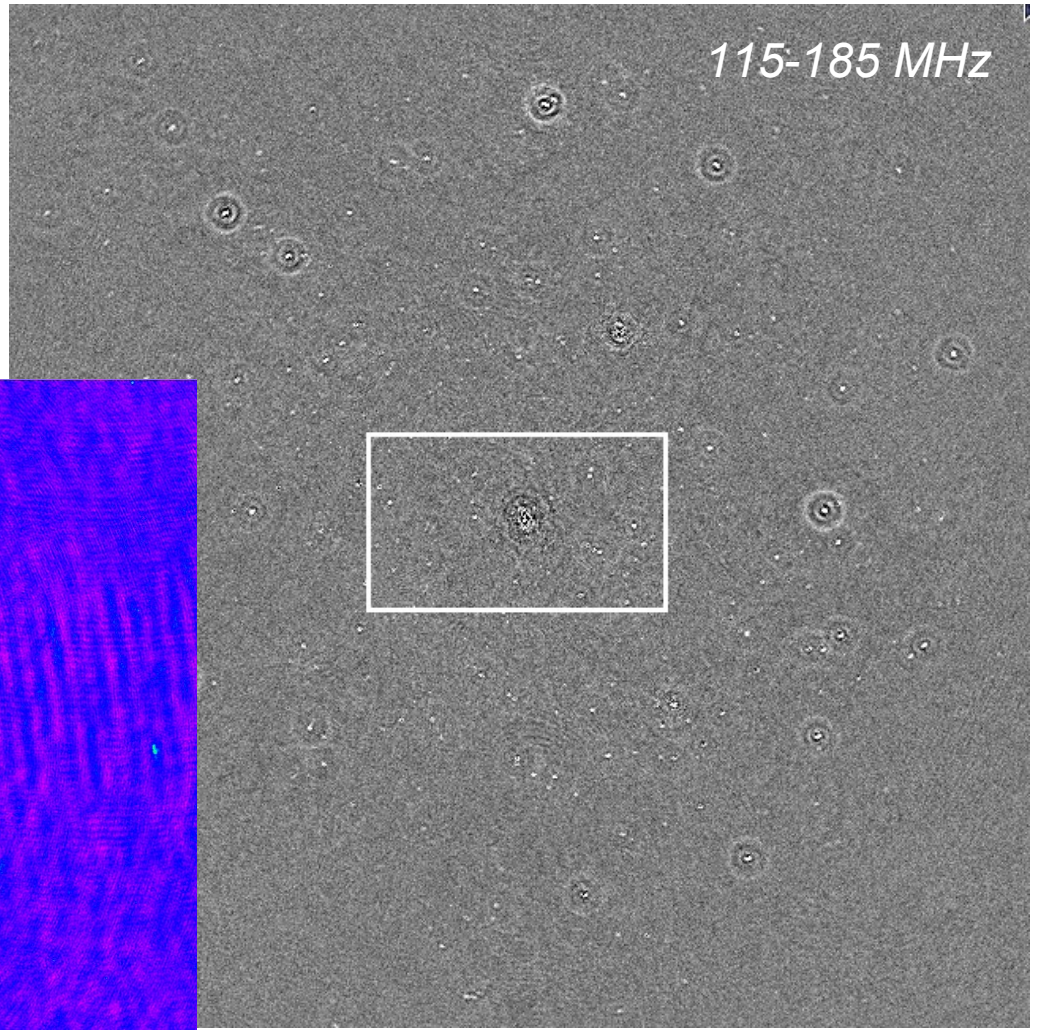
- Search for steep spectrum sources in LOFAR data to find HzRGs canditates with high z (up to z~8)

Data

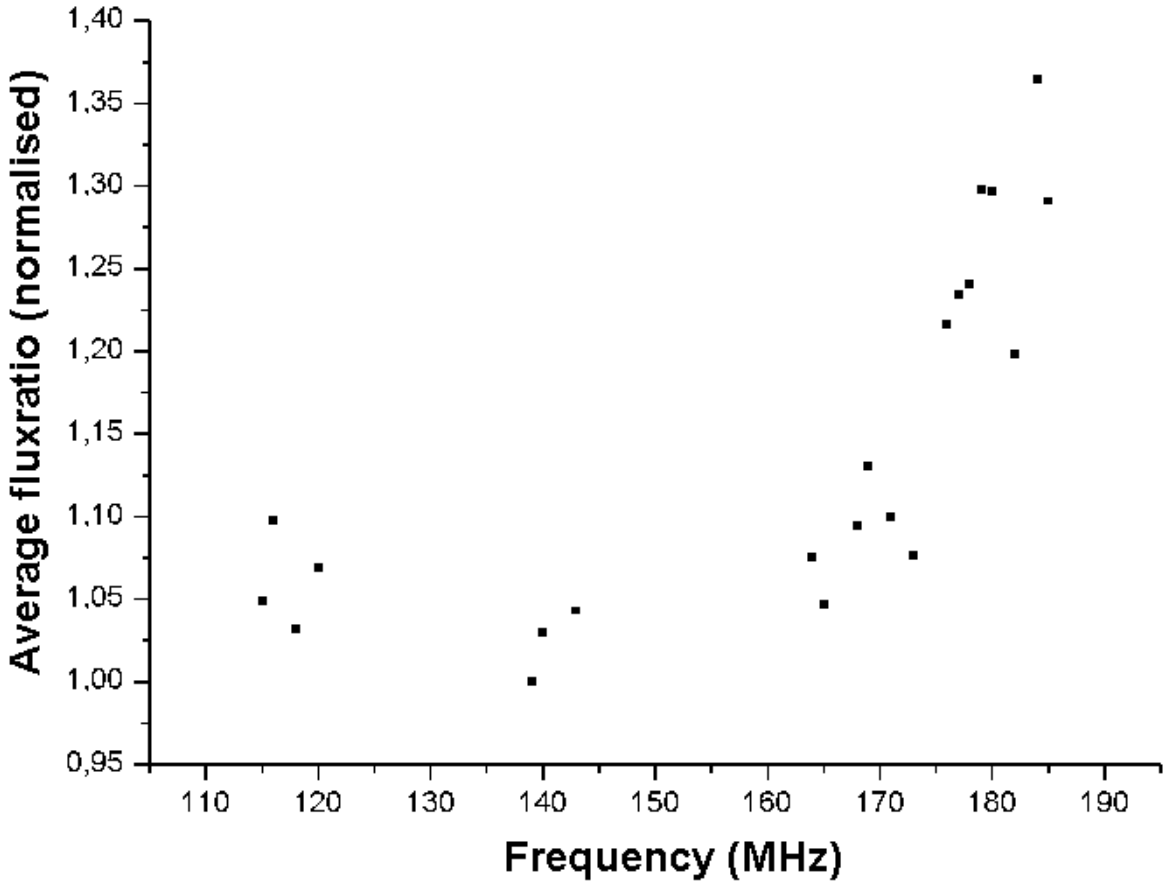
Visibilities → Calibration →

↓



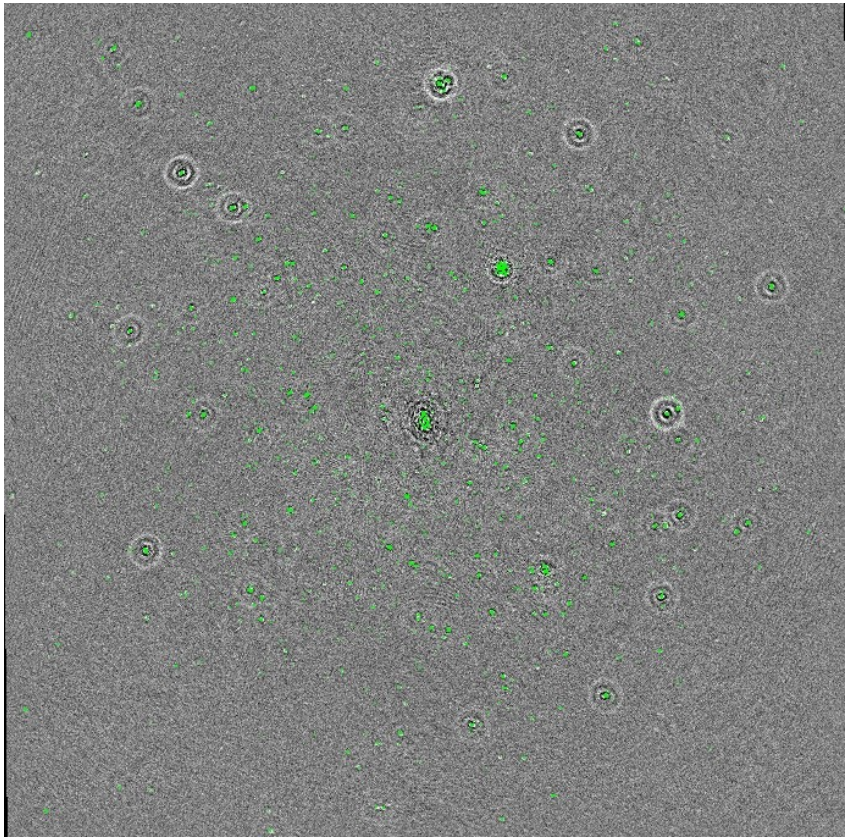


Average fluxratio -> Primary beam

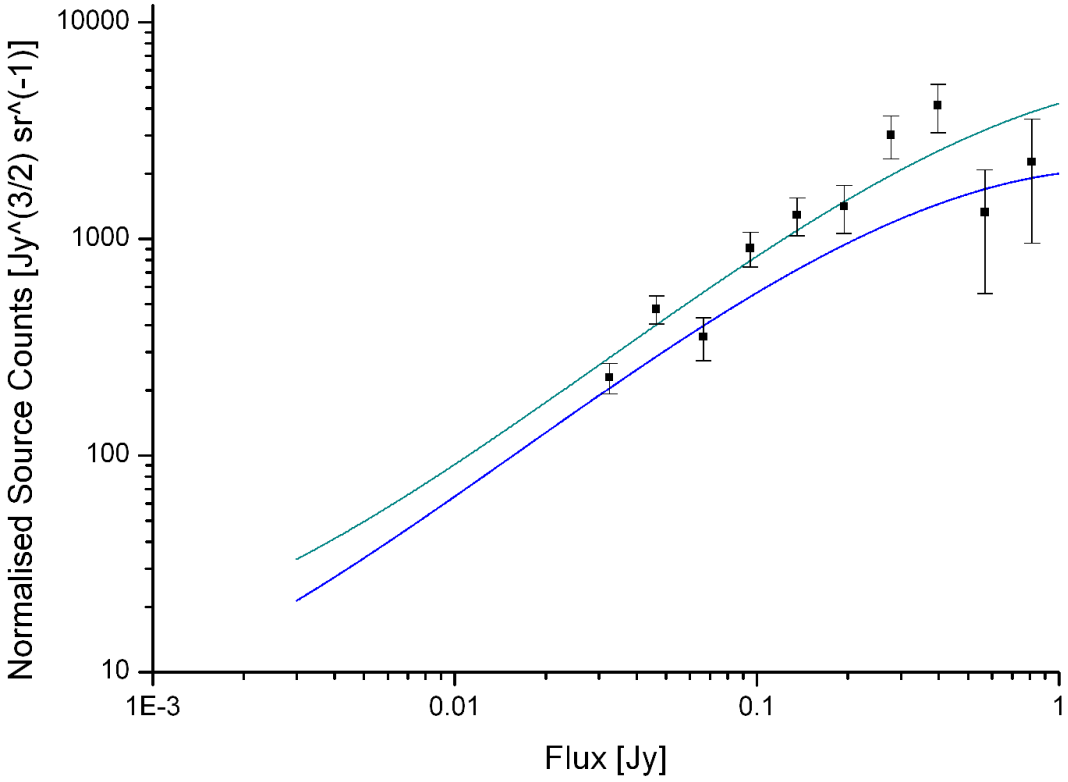


Source Counts (1)

- Image: 115-185 MHz
- Euclidian space $\rightarrow N \sim S^{-3/2}$



Source Counts (2)

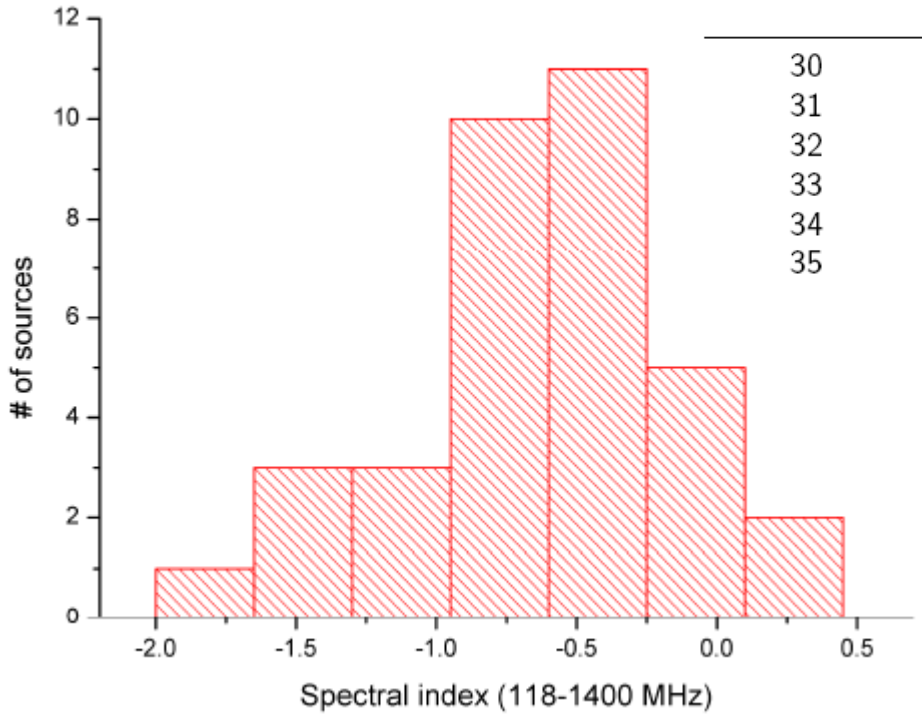


Spectral indices (1)

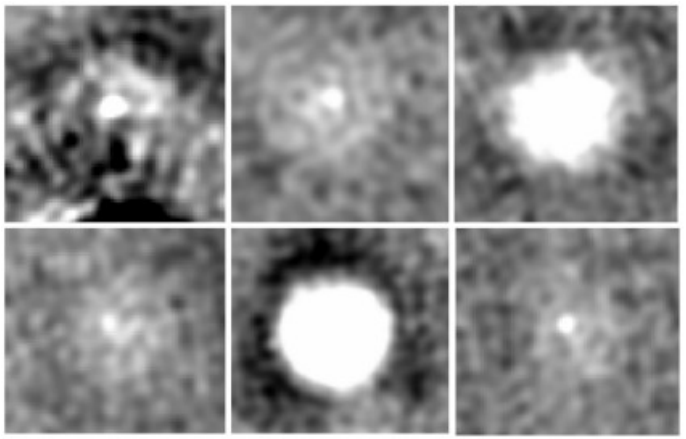
- Use: 118-185 MHz LOFAR image + NVSS (1400 MHz)

$\longrightarrow$ α (118-1400 MHz)

Spectral indices (2)



Association number	Flux at 118 MHz (Jy)	Flux at 1400 MHz (Jy)	Spectral index α_{1400}^{118}	RA (degrees)	dec (degrees)
30	0.1626	0.0087	-1.183	13.0371	86.2651
31	3.7850	0.1627	-1.272	23.0180	86.1732
32	0.3009	0.0094	-1.401	16.3738	86.3624
33	0.4211	0.0087	-1.568	11.0511	86.5591
34	0.2981	0.0055	-1.614	12.9865	86.1926
35	0.6384	0.0066	-1.848	17.3234	87.6884



Future work

- Improve quality of images
  - Exactly determine beam dependence and integrate in calibration mechanism
  - Try different calibration methods
  - As experience increases, quality increases

- Then associate again, and hope good spectra to come out!

Still just a small step in a long procedure!!

Summary/Conclusion

- HzRGs are interesting
  - Use z – α correlation to find them
- Use LOFAR data
  - Source counts indicate data is good
- Determine α from LOFAR subband images
  - Spectra not good due to calibration
- LOFAR + NVSS gives 6 steep spectrum sources in 3C61-field

References

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- Thompson, A. Richard (1986) '*Interferometry and synthesis in radio astronomy*'
- Miley M, De Breuck C (2008) Distant radio galaxies and their environments. Astron Astrophys Rev 15:67-144
- Klamer IJ et al. (2006) A search for distant radio galaxies from SUMSS and NVSS – III. Radio spectral energy distribution and the z-α correlation. Mon Not R Astron Soc 371:852-866
- Verkhodanov OV, Khabibullina ML (2010) On the spectral index of distant radio galaxies. Astron Let 36:7-13