

# Investigating the Unification of LOFAR-detected Sources in Boötes

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UNIVERSITY OF  
OXFORD



RAS Specialist Discussion Meeting  
Radio Galaxies in the Local Universe

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# Active Galactic Nuclei (AGN)

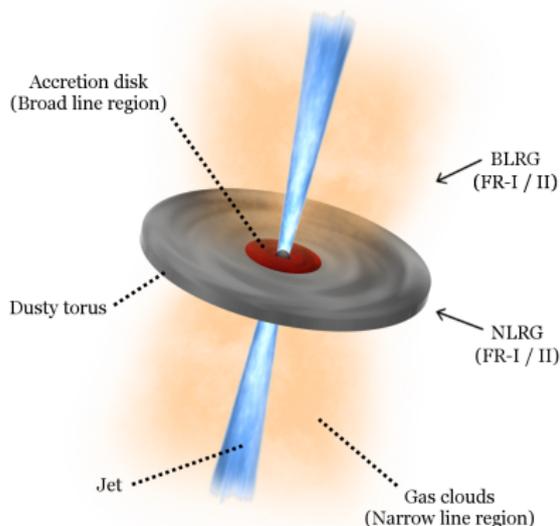


Image courtesy J. Harwood

Characteristics can include:

- radio emission
- high luminosities
- strong emission lines
- X-ray detections
- polarised light

# Unification Theory

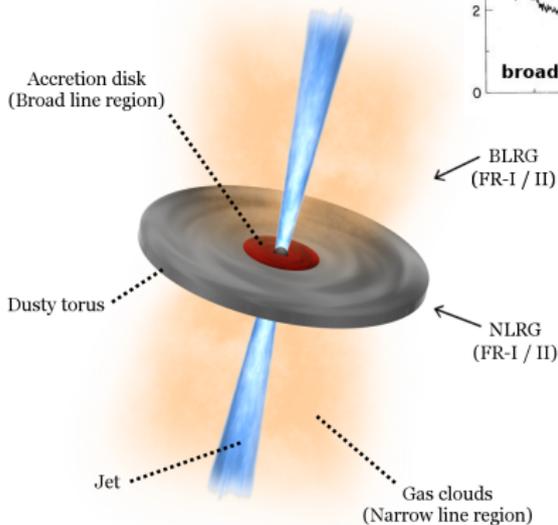
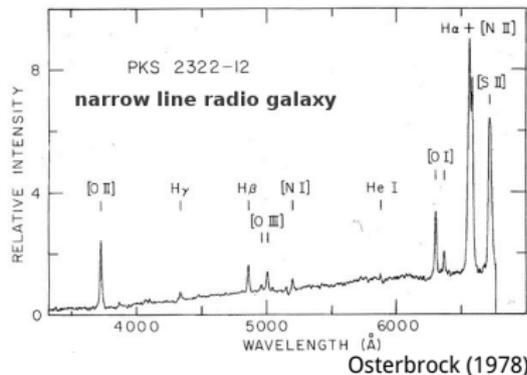
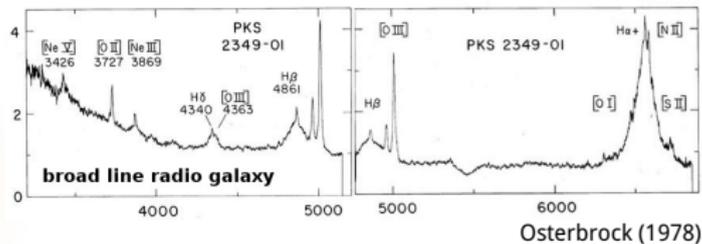


Image courtesy J. Harwood



# Unification Theory

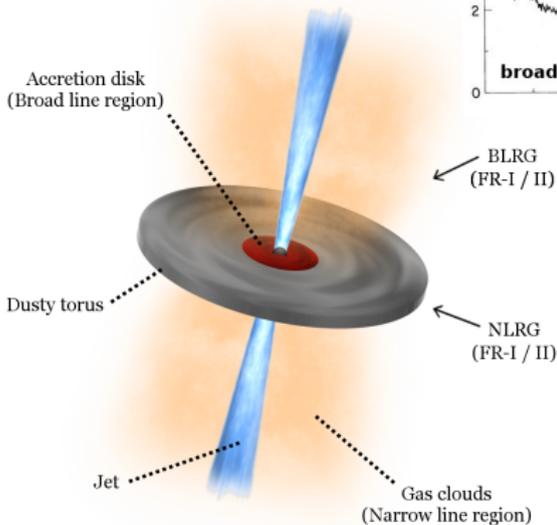
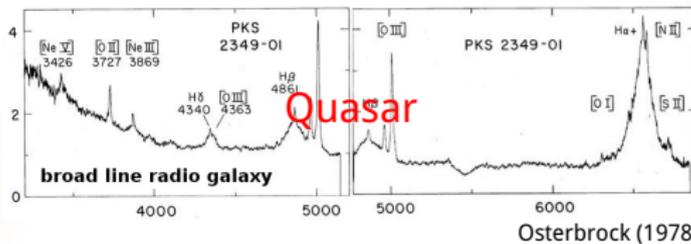
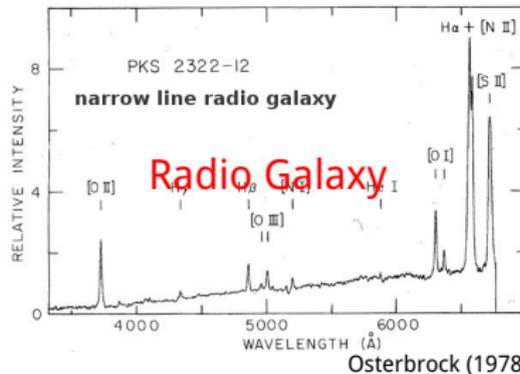


Image courtesy J. Harwood

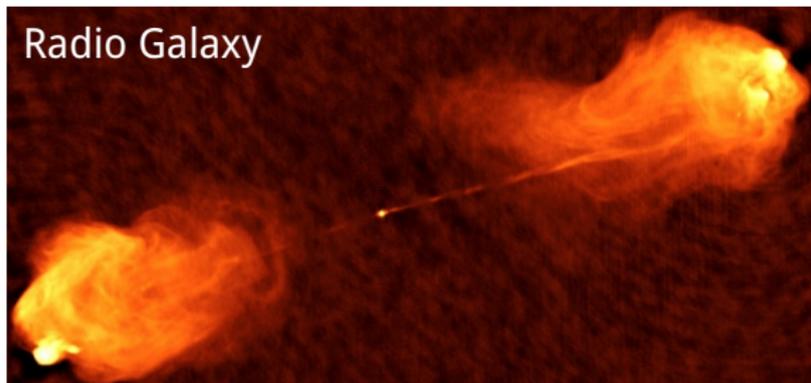


BLRG  
(FR-I / II)

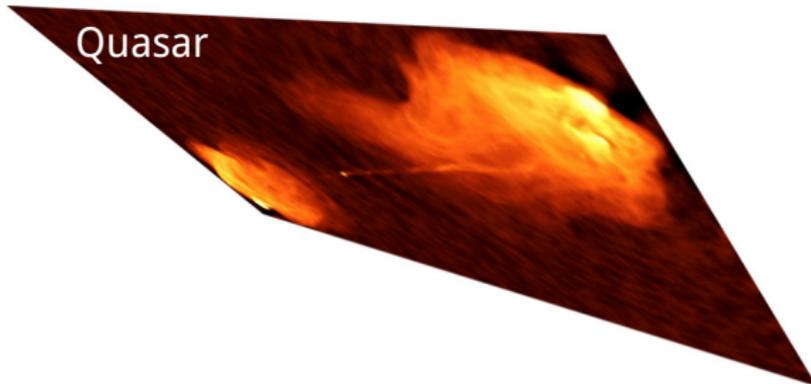
NLRG  
(FR-I / II)



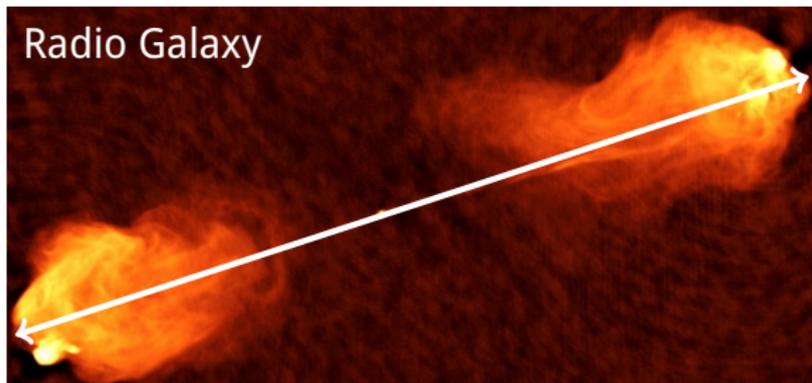
# Testing Unification Theory



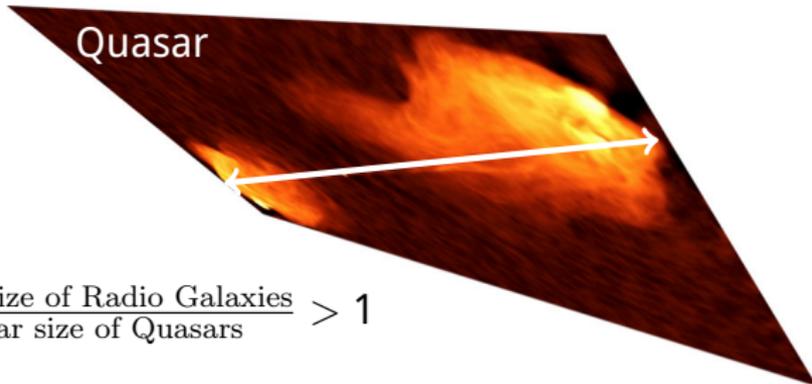
NRAO/IAU



# Testing Unification Theory

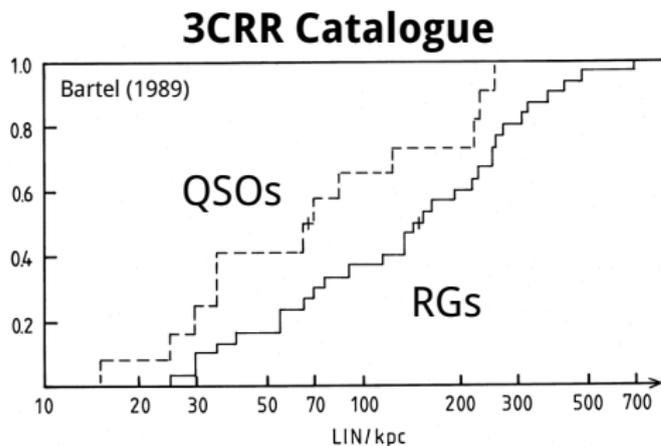


NRAO/IAU



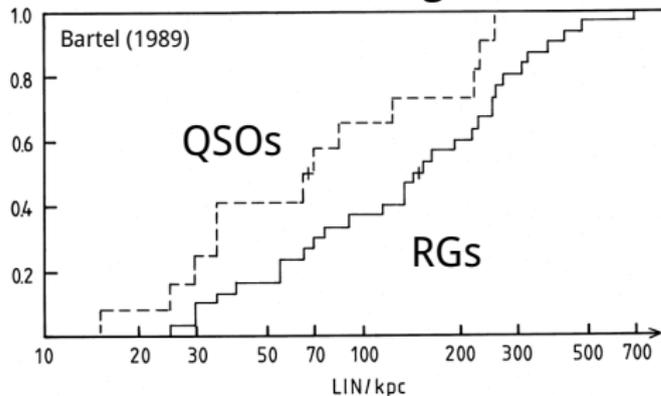
$$R = \frac{\text{linear size of Radio Galaxies}}{\text{linear size of Quasars}} > 1$$

# The Evidence

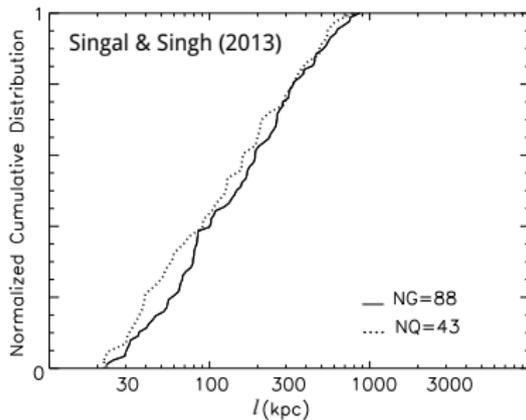


# The Evidence

## 3CRR Catalogue

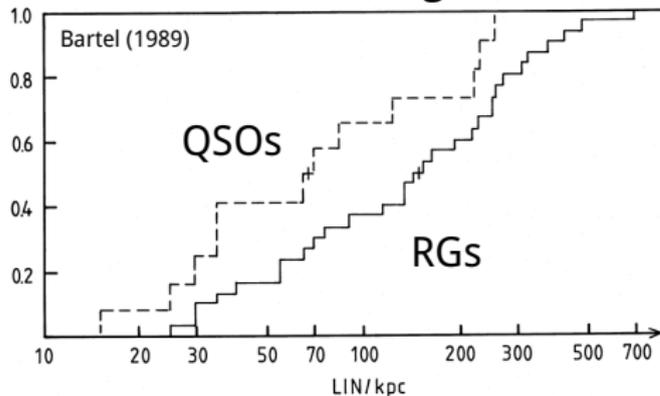


## MRC



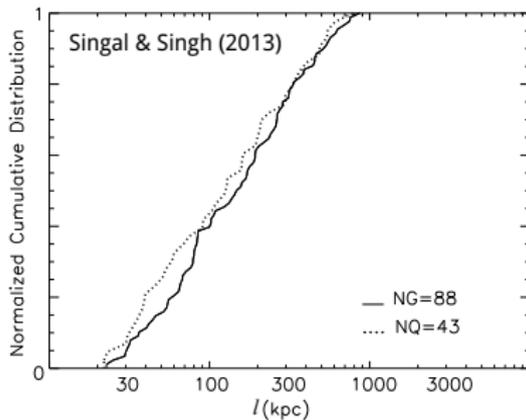
# The Evidence

## 3CRR Catalogue



**FOR**

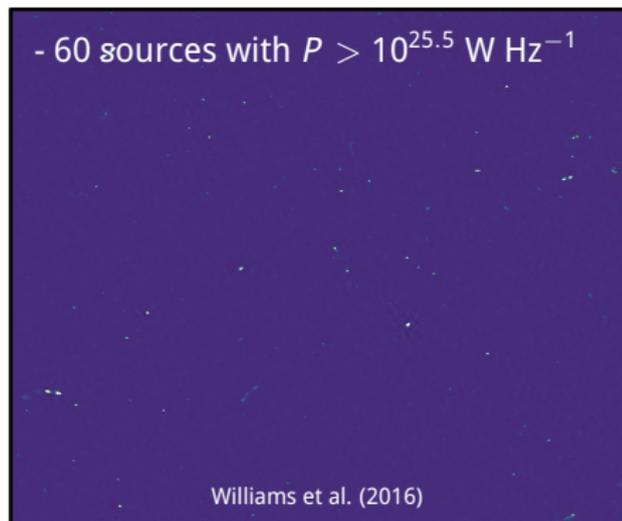
## MRC



**AGAINST**

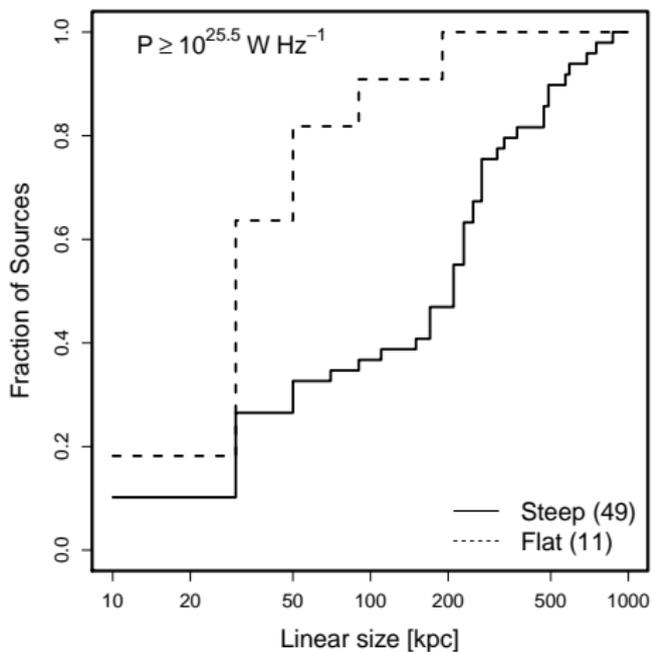
# Collecting more evidence

- Boötes LOFAR Survey at 150 MHz
- Spectroscopic redshifts from AGES (Kochanek et al. 2012)
- Quasar/Radio Galaxy identification from AGES



# LOFAR Boötes Results

## Flat vs. Steep Spectrum

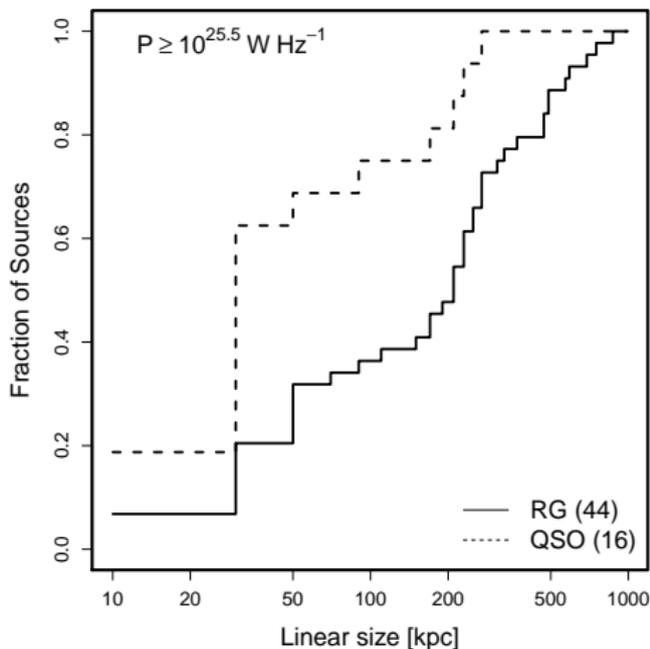


$$R = 4.4 \pm 1.4$$

$$\theta_c = 35^\circ$$

# LOFAR Boötes Results

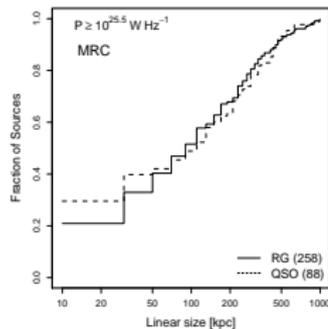
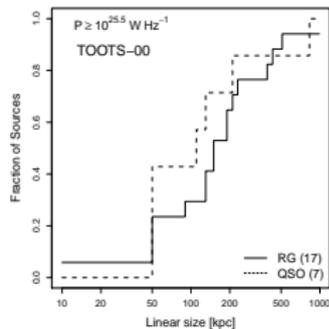
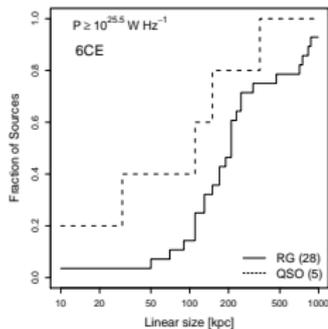
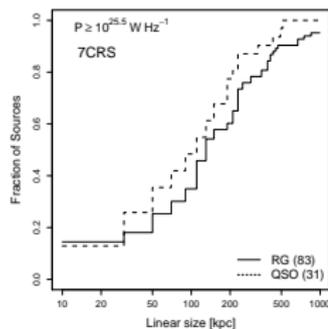
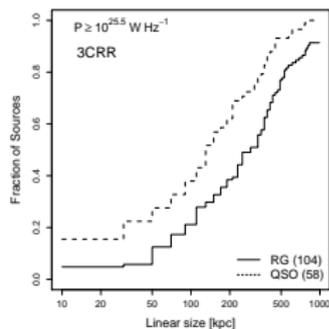
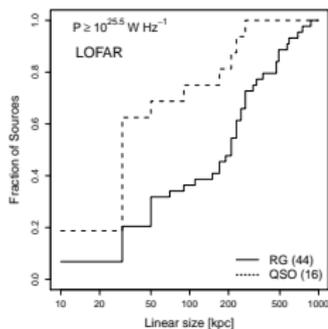
## Radio Galaxies vs. Quasars



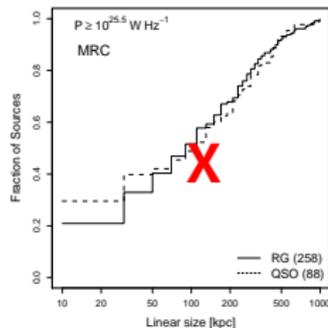
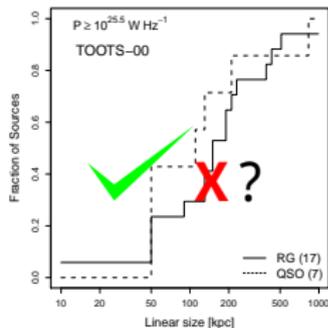
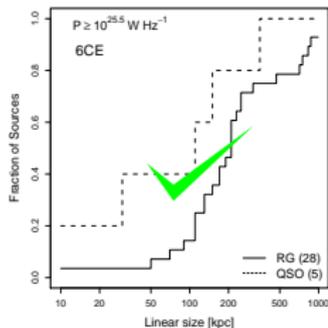
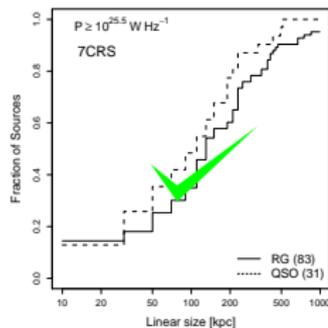
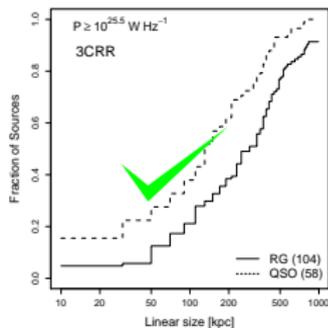
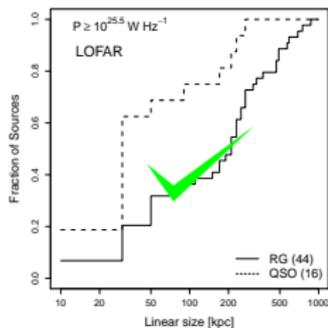
$$R = 3.1 \pm 1.0$$

$$\theta_c = 43^\circ$$

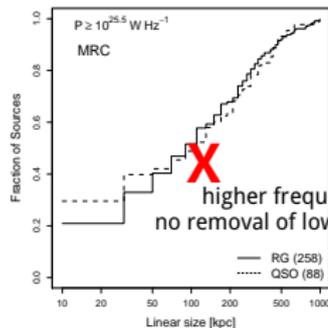
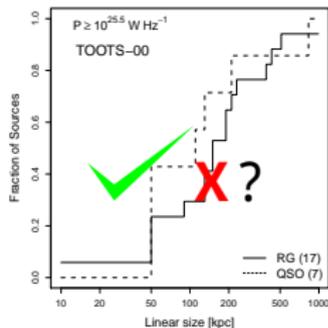
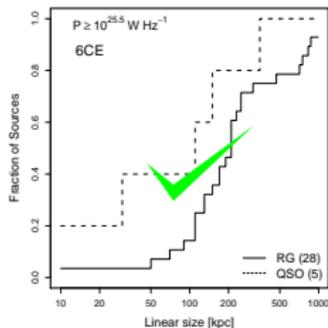
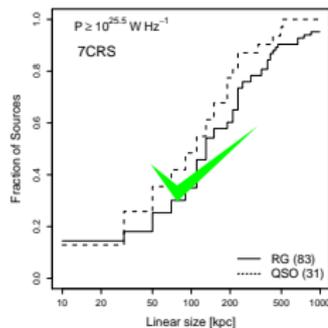
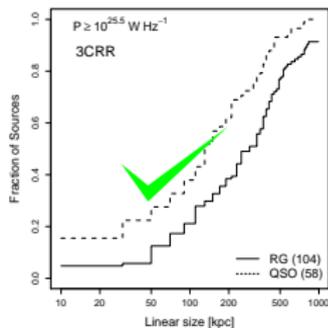
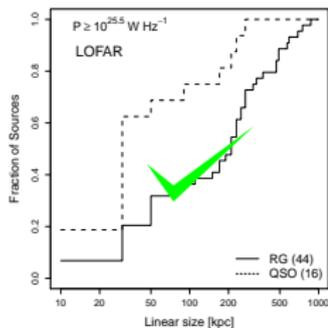
# Other low-frequency Surveys



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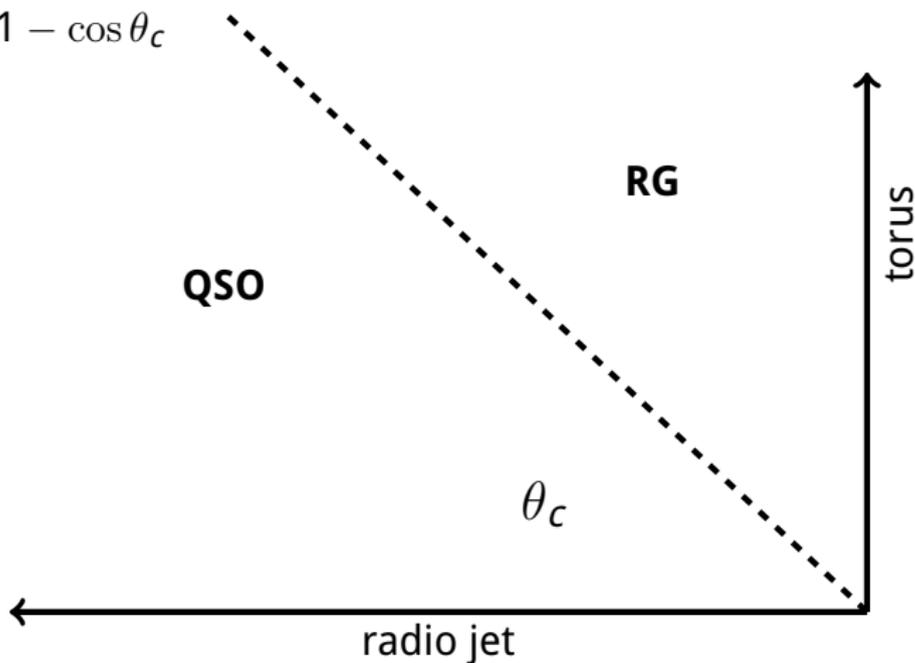
# Other low-frequency Surveys



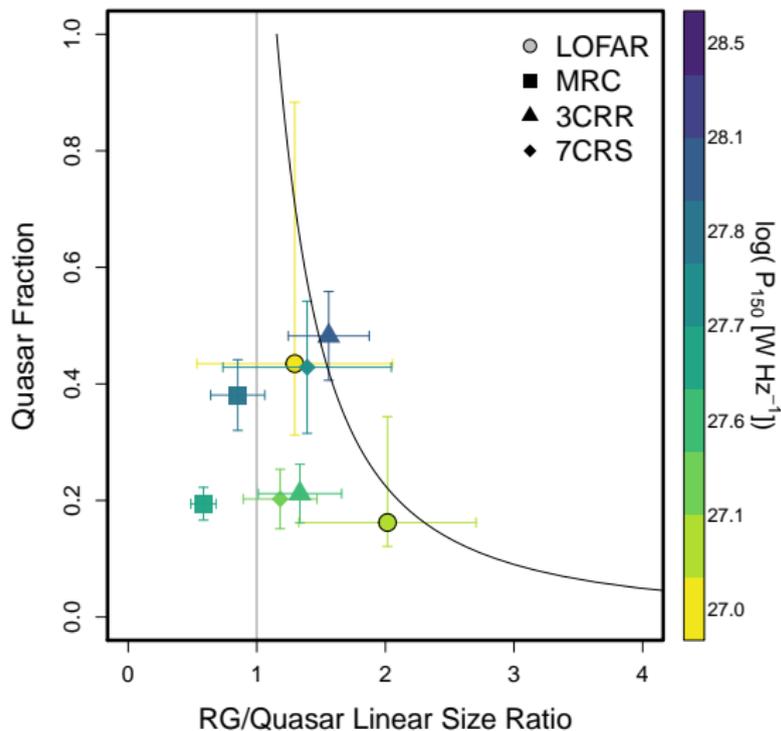
# Unification Predictions

$$R = \frac{\sin(\cos^{-1}(\frac{\cos\theta_c}{2}))}{\sin(\cos^{-1}(\frac{1+\cos\theta_c}{2}))}$$

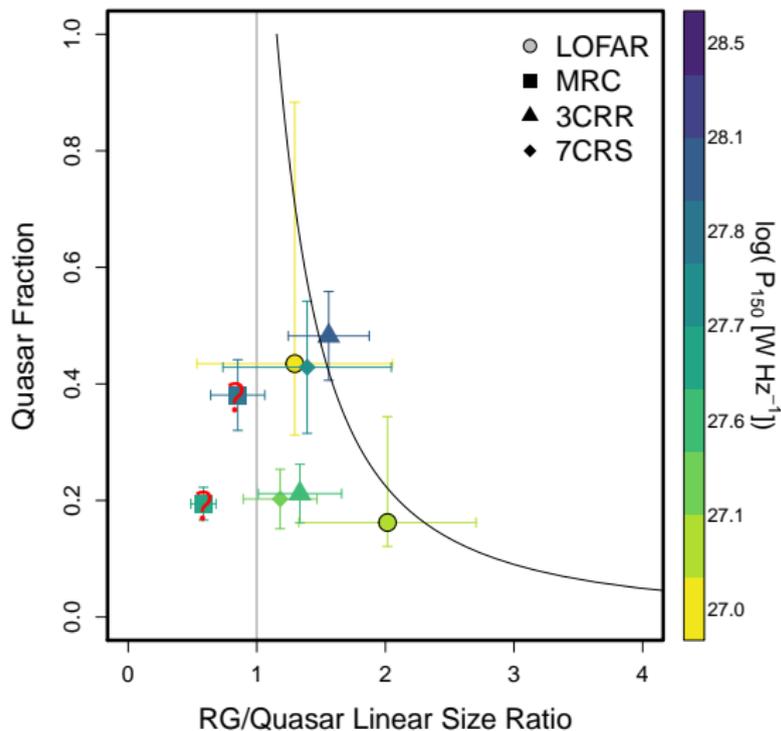
$$P(\theta < \theta_c) = 1 - \cos\theta_c$$



# Comparison with Predictions



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# Conclusions + Future Outlook

- \* Projected linear sizes of radio galaxies are  $3.1 \pm 1$  times larger than those of quasars in LOFAR Boötes Survey
- \* Overall, the data are consistent with Unification ...
- \* Evolutionary scheme still possible ...

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- \* Overall, the data are consistent with Unification ...
- \* Evolutionary scheme still possible ...

... but more data is needed!

LOFAR Tier 1 Survey will provide sources to fill the  $P - z$  plane and definitively explore Unification Theory.

