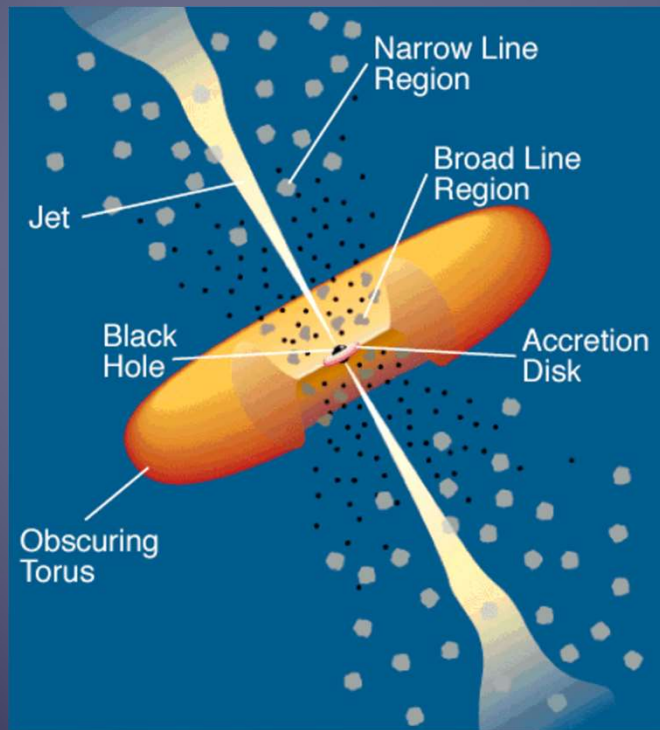




Identifying Compact Symmetric Objects using High-Resolution VLBA Imaging

Evan Sheldahl, Greg Taylor, Sebastian Kiehlmann, Yannis Liodakis, Matt Lister, Sandra O'Neill, Tim Pearson, Anthony Readhead, Aneta Siemiginowska, Peter Wilkinson

What Are Active Galactic Nuclei (AGN)?

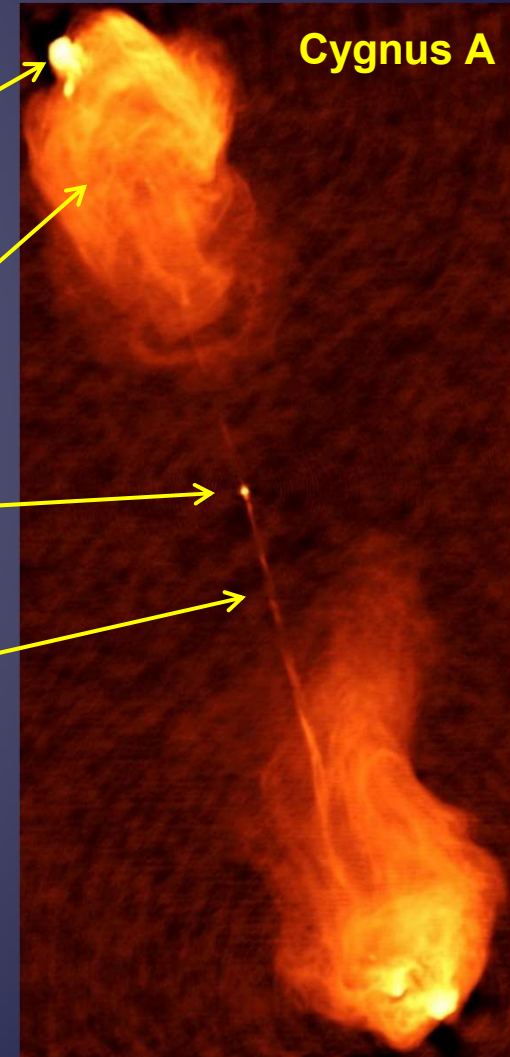


Radio hotspot

Radio lobe

Central Core
(Black Hole)

Jet

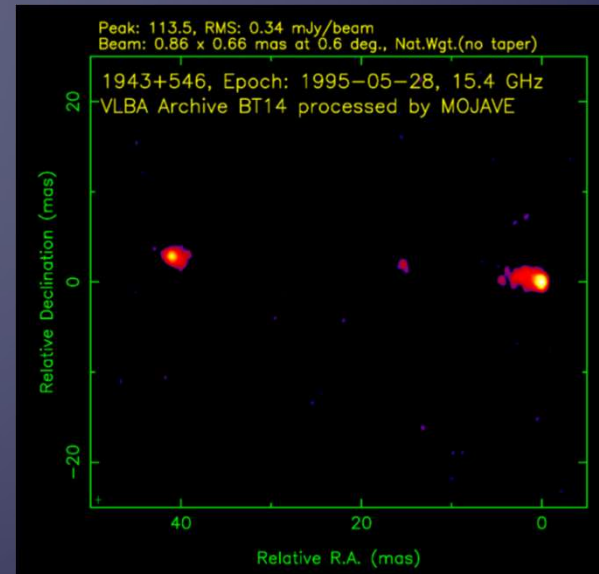
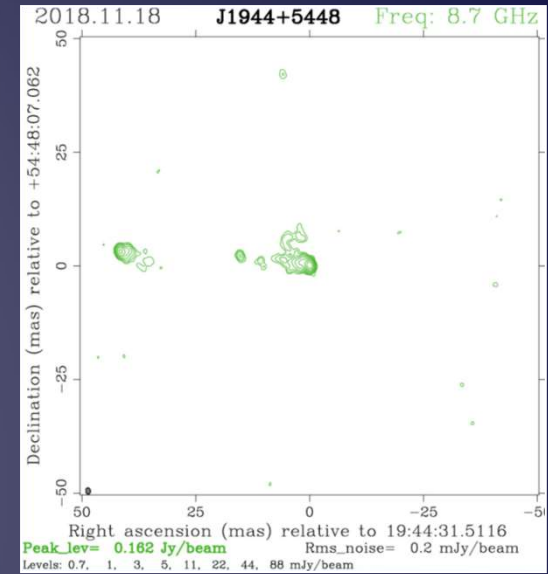
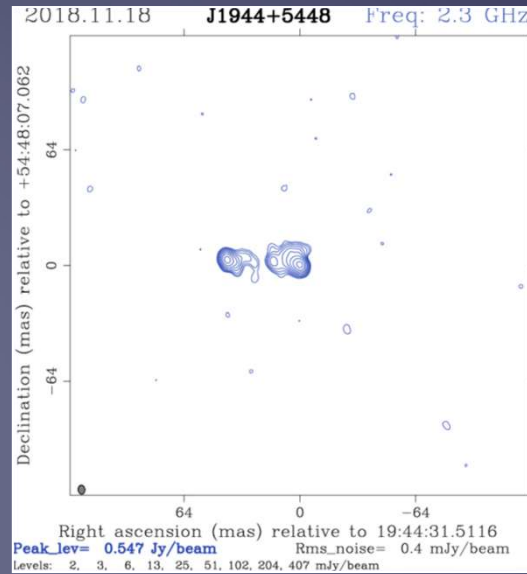


What Are Compact Symmetric Objects (CSOs)?

Vetting Criteria:

1. Compact (<1 kpc)
2. Symmetric (around core)
3. Low variability
4. $v_{\text{app}} < 2.5c$

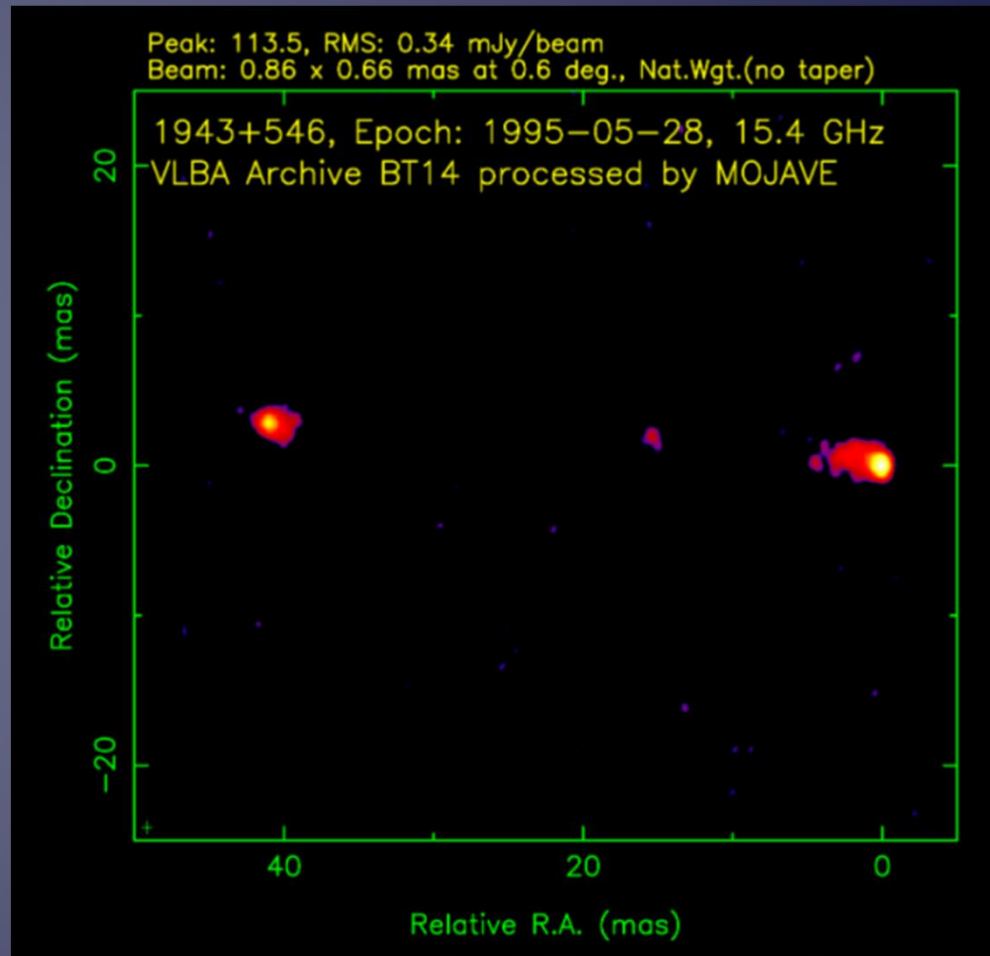
Kiehlmann et al. in prep



What Are Compact Symmetric Objects (CSOs)?

Vetting Criteria:

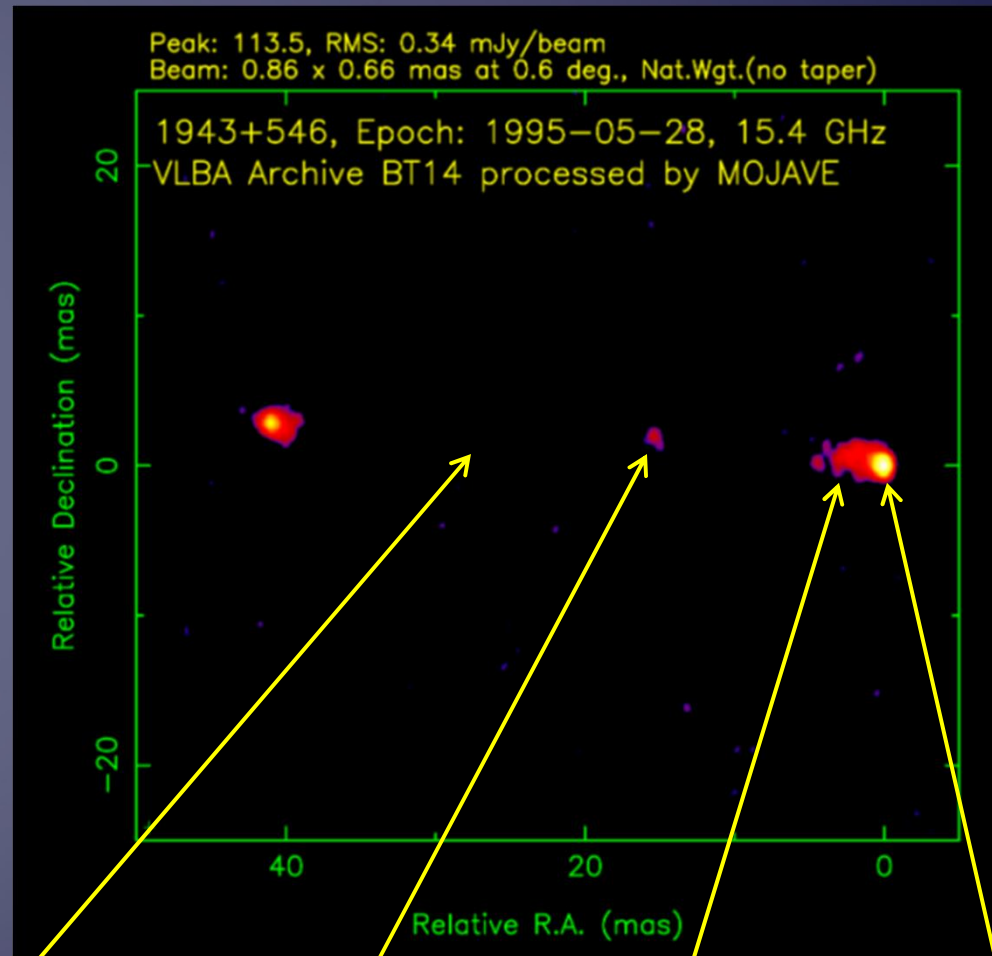
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Kiehlmann et al. in prep



What Are Compact Symmetric Objects (CSOs)?

Vetting Criteria:

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2. Symmetric (around core)
3. Low variability
4. $v_{\text{app}} < 2.5c$
Kiehlmann et al. in prep



Jet (not visible)

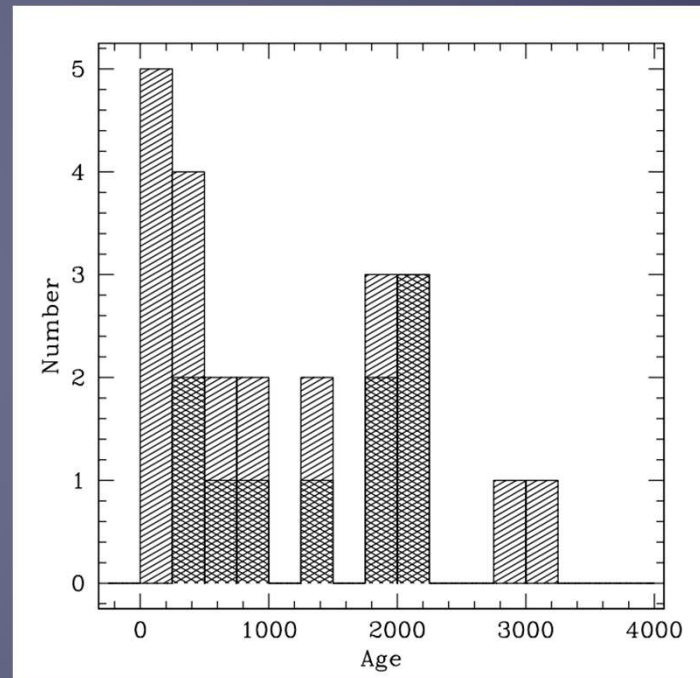
Central Core
(Black Hole)

Radio lobe

Radio hotspot

Other Traits of CSOs

- Short-lived

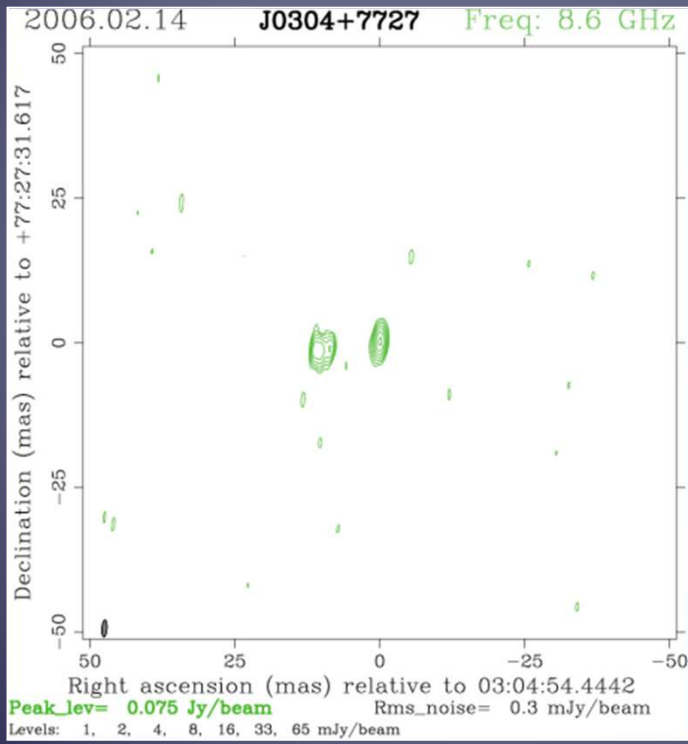


Gugliucci et al. 2005

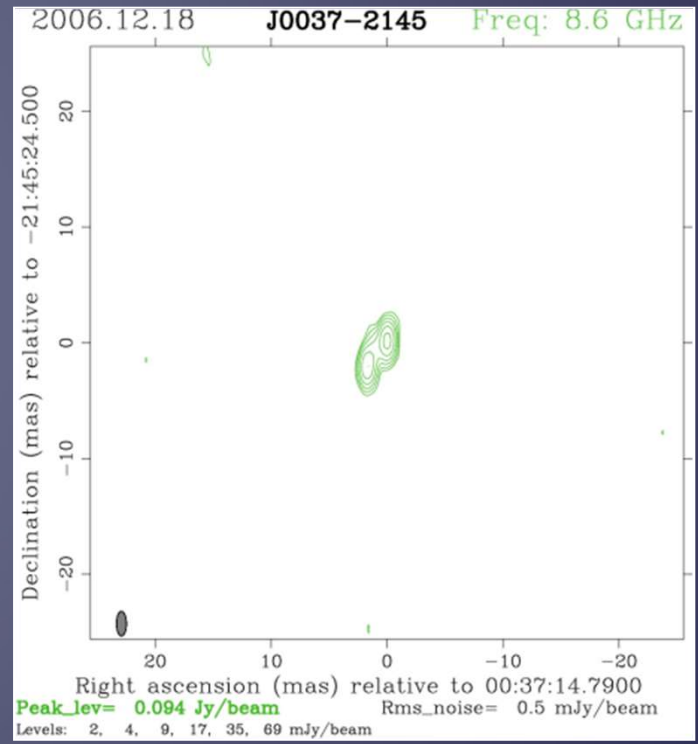
CSOs Observed In
the Northern Sky
(COINS)

- Recurrent activity
- Ideal for studying galaxy evolution

Usually harder to tell...



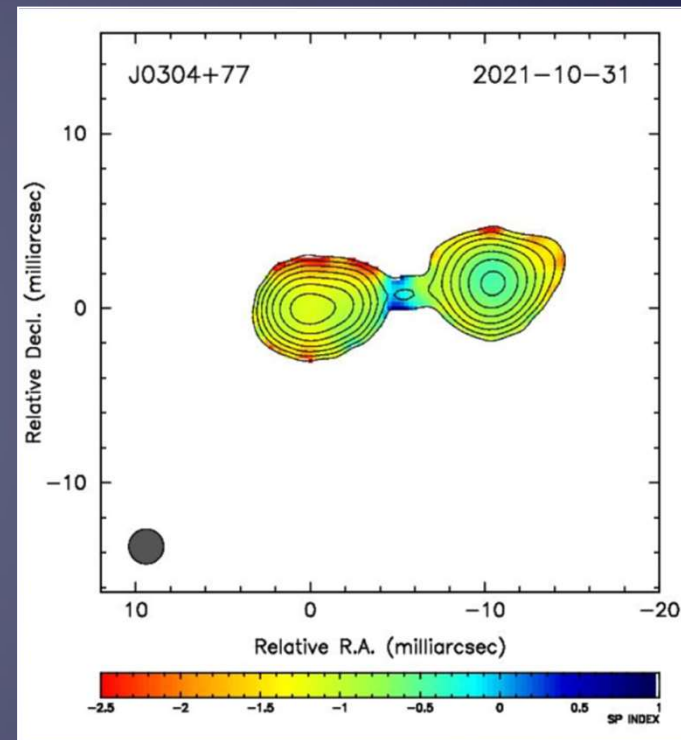
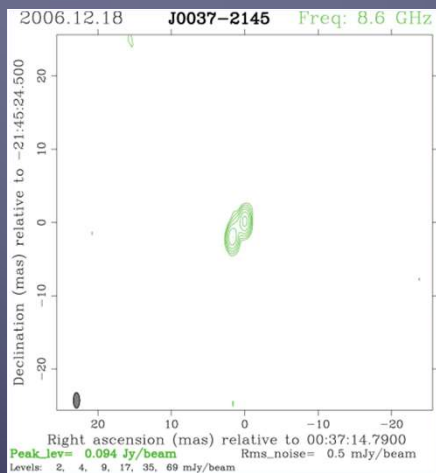
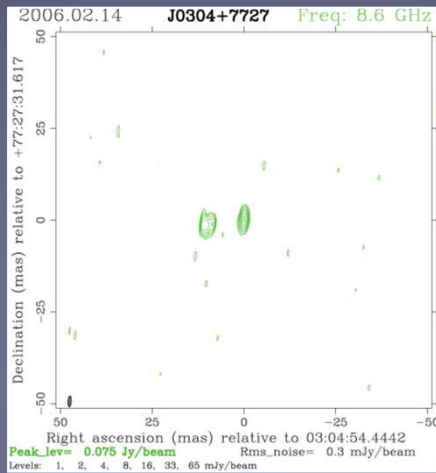
J0304+7727, 8 GHz



J0037-2145, 8 GHz

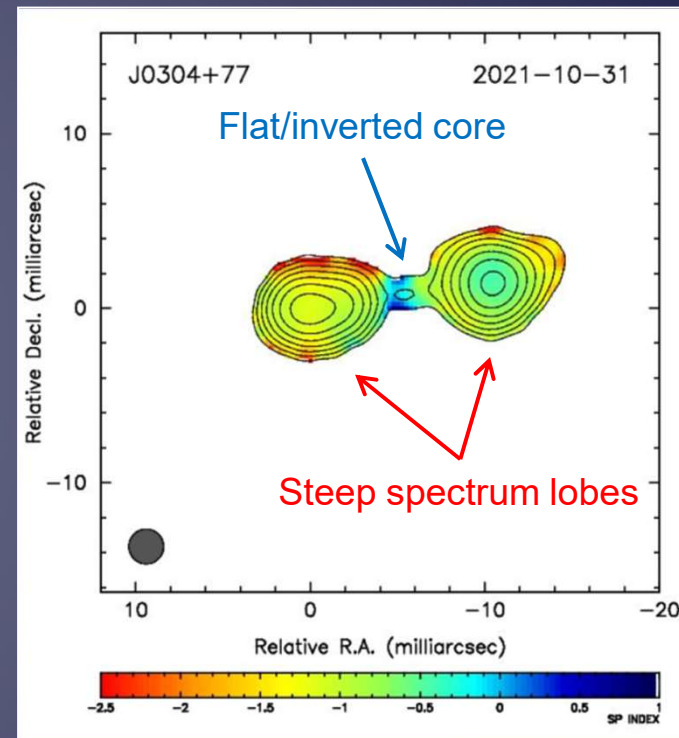
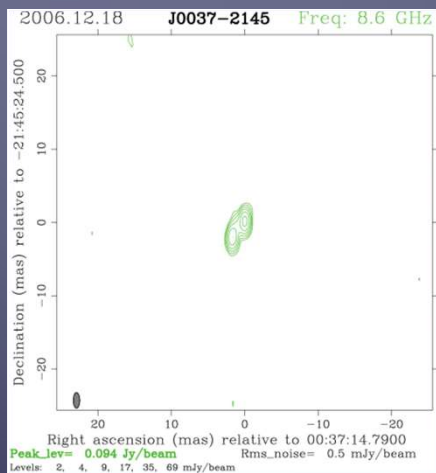
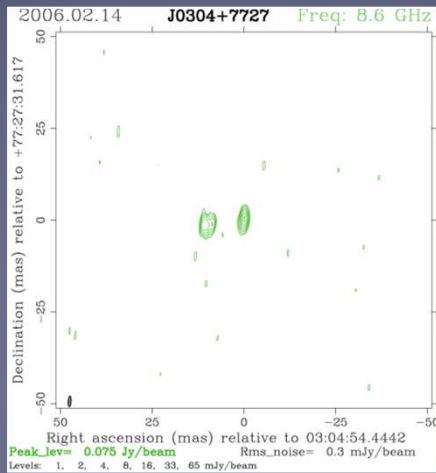
Core-jet or
bona fide?

Usually harder to tell...



Spectral index maps!

Usually harder to tell...



Spectral index maps!

The Very Long Baseline Array (VLBA)



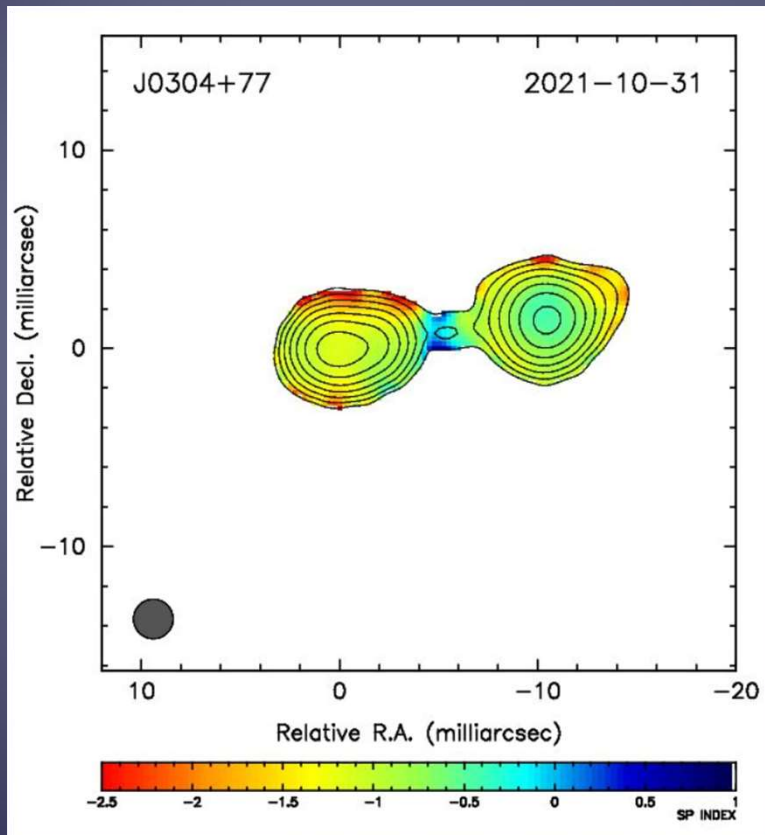
- 10 antennas, max baseline 8600 km from Mauna Kea, HI to St. Croix, VI
- 312 MHz – 96 GHz observing frequency
- Milliarcsecond scale resolution

CSO Candidate Sample

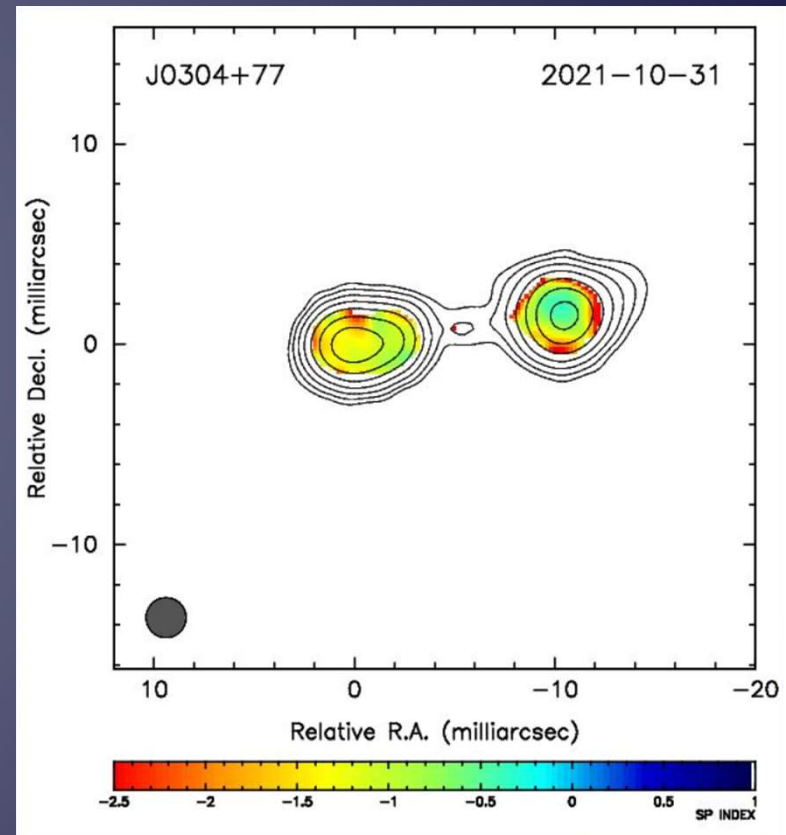
- 167 candidate sources
- Three frequency ranges spanning 5-15 GHz
- Calibration, spectral index maps with Astronomical Image Processing System (AIPS)
- Stokes I (total intensity) images in Difmap (Shepherd 1997)

Spectral Index Maps

5-8 GHz

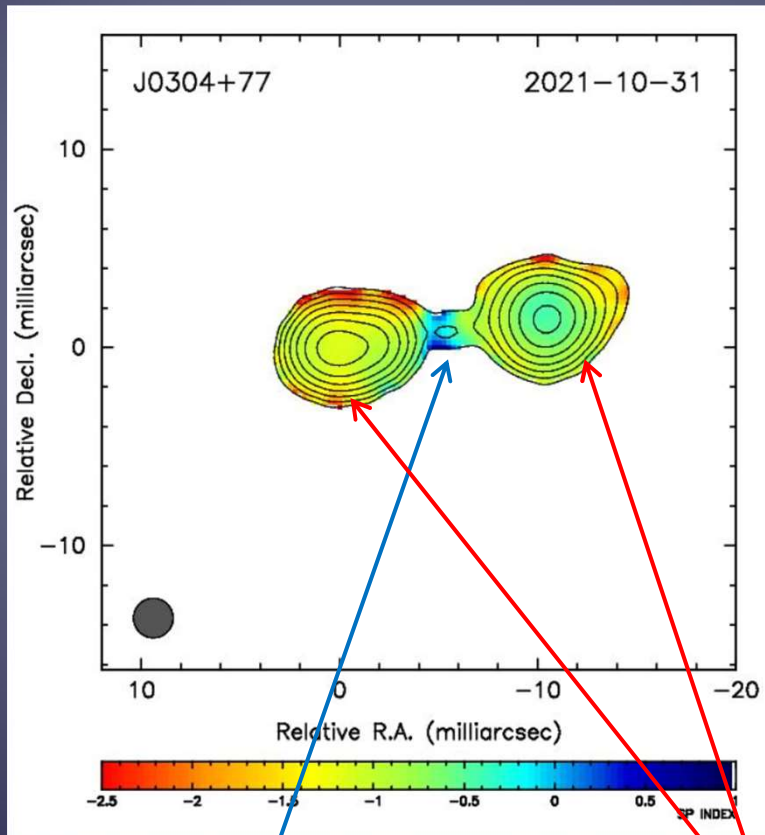


8-15 GHz

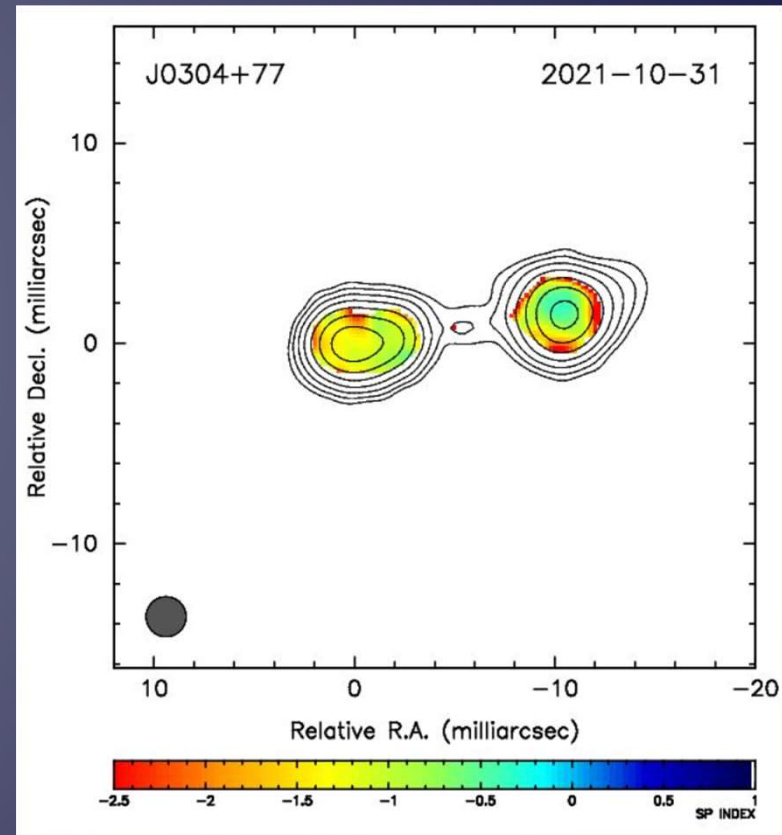


Spectral Index Maps

5-8 GHz



8-15 GHz

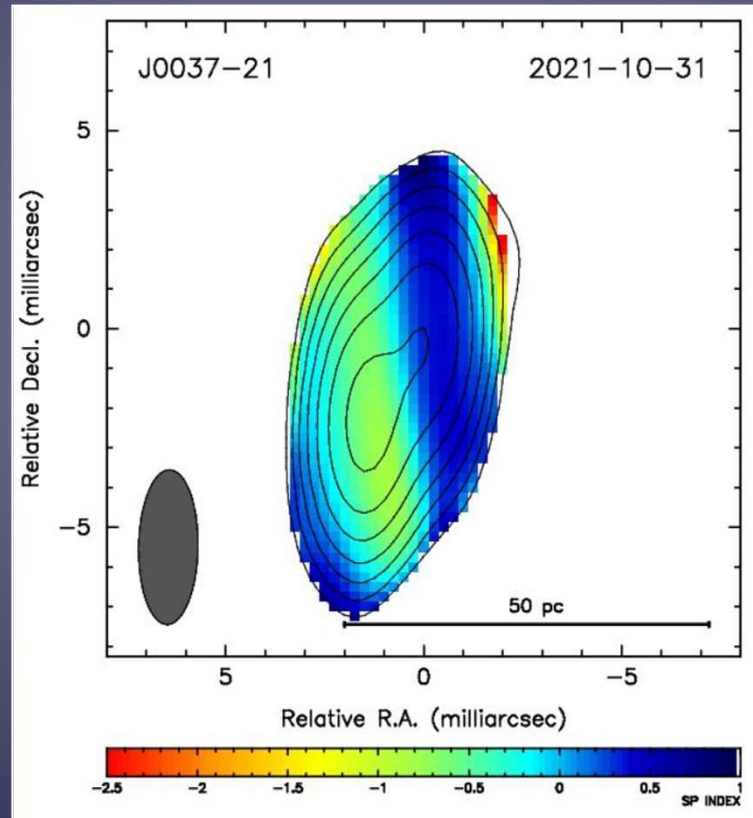


Flat/inverted core

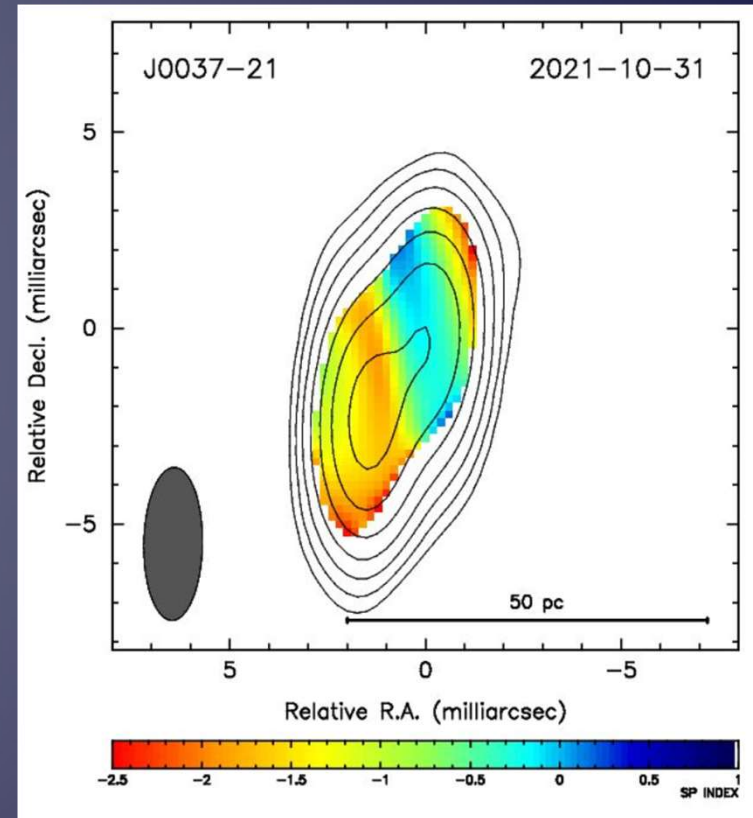
Steep spectrum lobes

Spectral Index Maps

5-8 GHz



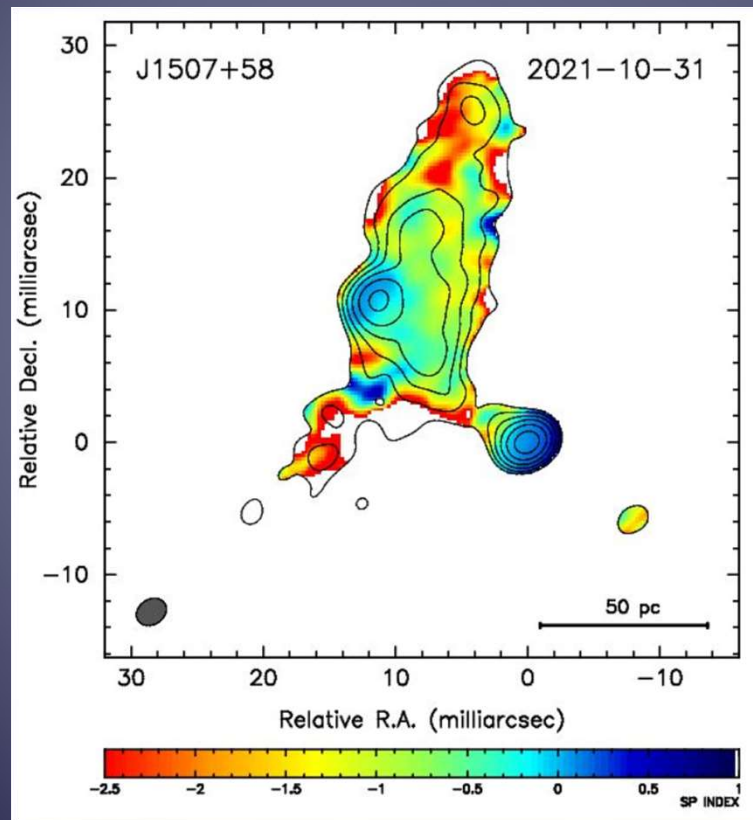
8-15 GHz



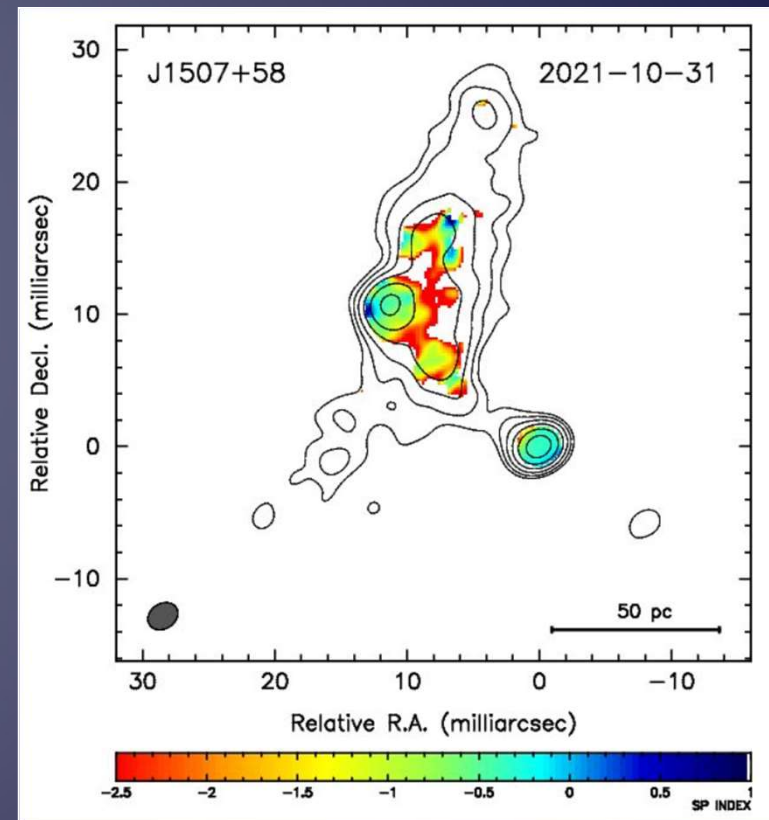
Spectral break

Spectral Index Maps

5-8 GHz



8-15 GHz



Summary

- CSOs are important for understanding galaxy evolution
- With Stokes I and spectral index maps, can assess the validity of a source as a CSO
 - Higher frequencies show us smaller scale structure
 - CSOs brighter at lower frequencies
- Looking for dual lobe structure with obvious or suggested center of activity

Supplementary VLA Analysis

- Using the Very Large Array (VLA), observed 213 sources from 1-15 GHz
- CSOs make good phase calibrators, and source data will be available as a VLA memo (Sheldahl et al. in prep)
- Also looked for extended emission from bona fide CSOs as evidence of recurrent activity, but found none