Exploring the Evolution of pc-scale Jets with Compact Symmetric Objects

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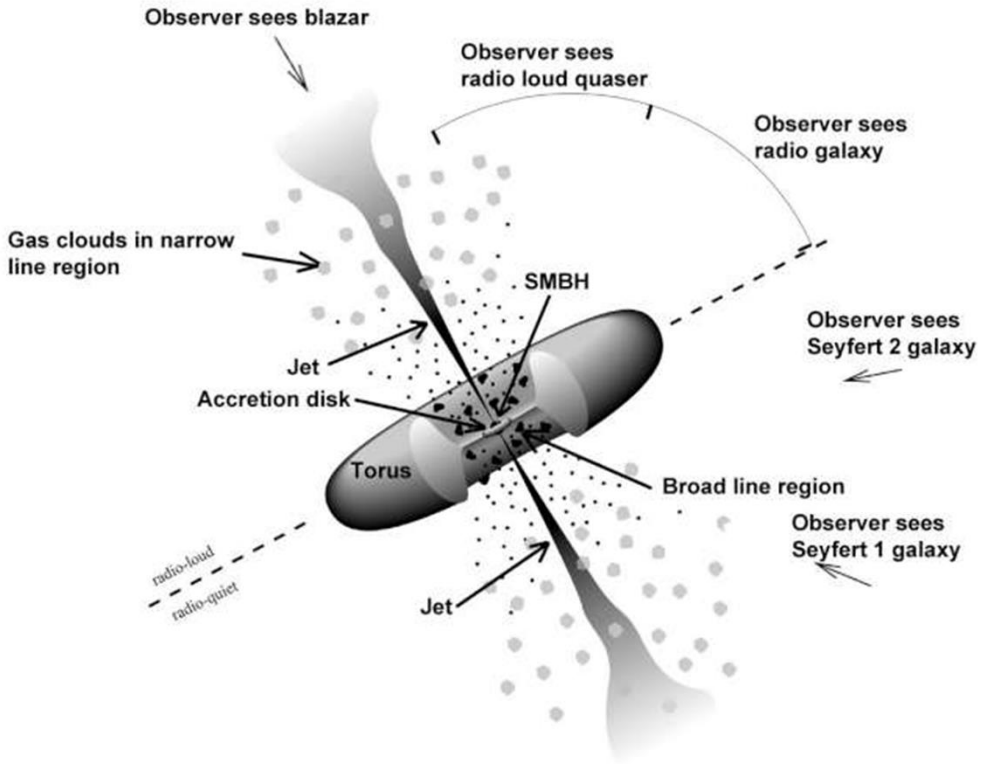
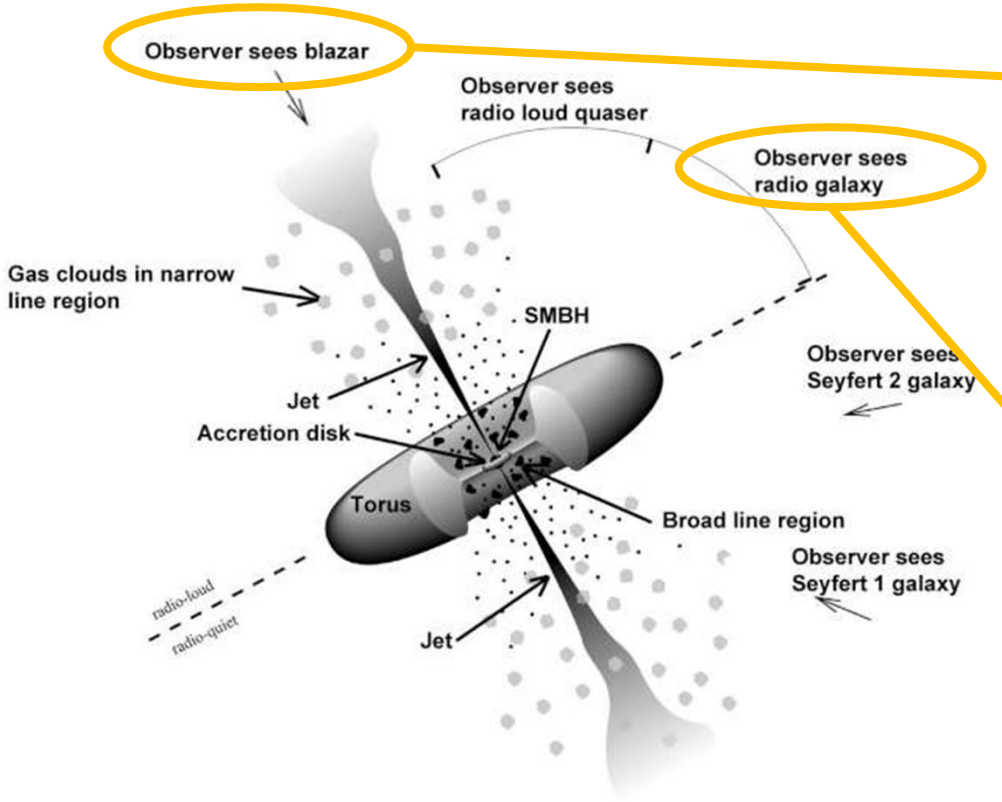
NRAO Reber Fellow

Anatomy of an AGN



https://fermi.gsfc.nasa.gov/science/eteu/agn/

Anatomy of an AGN



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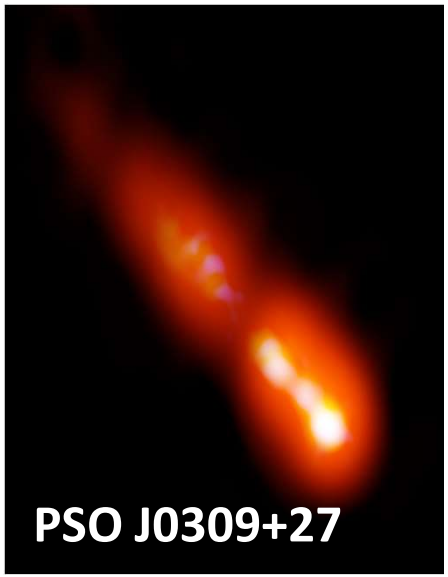
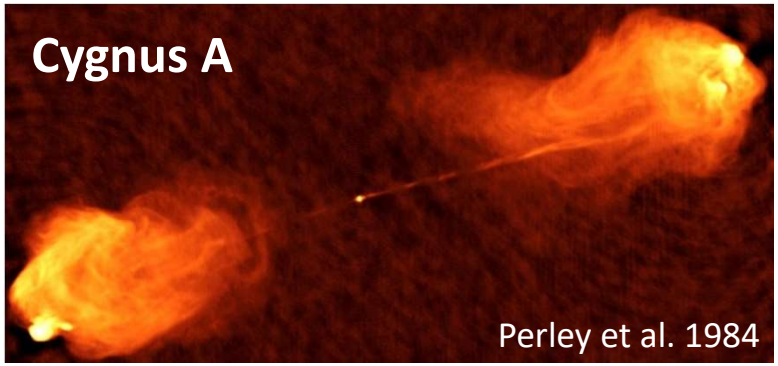
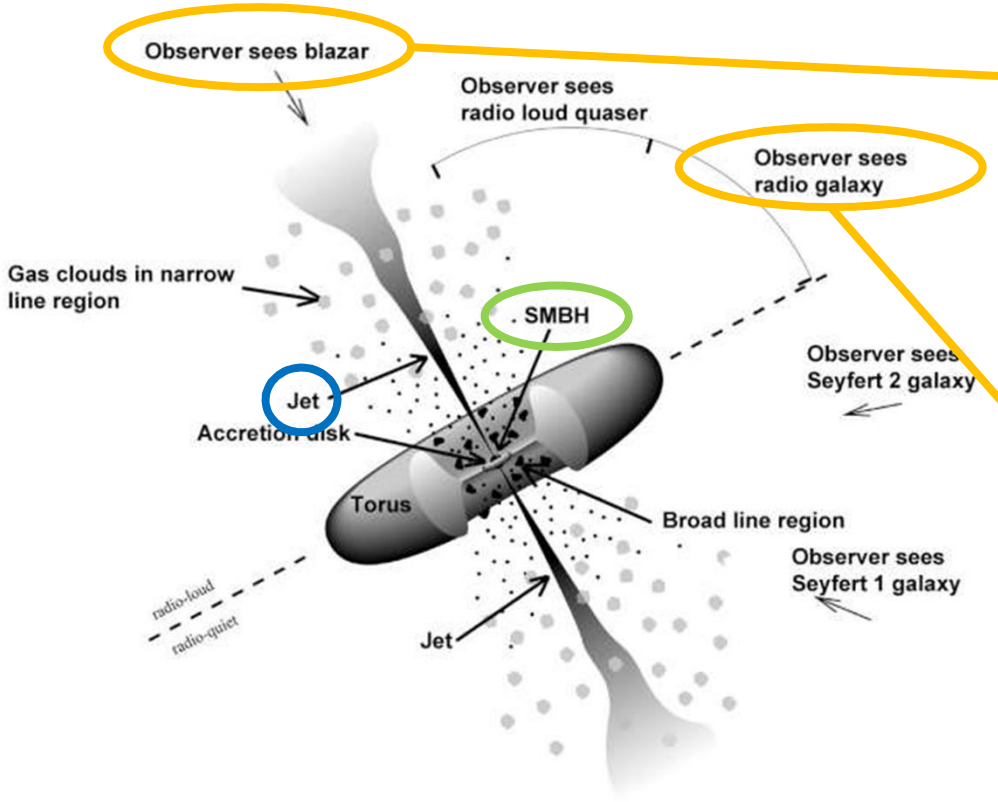


Spingola et al. 2020



Anatomy of an AGN



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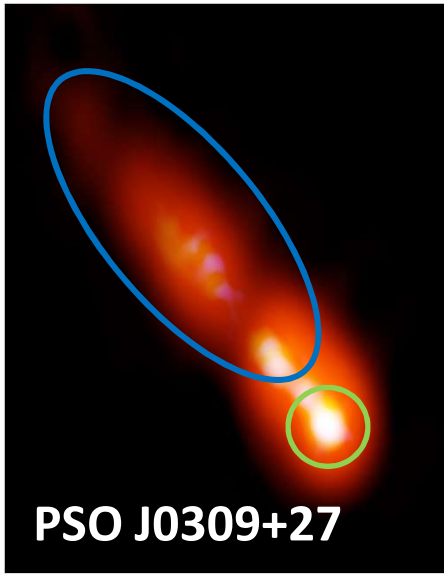

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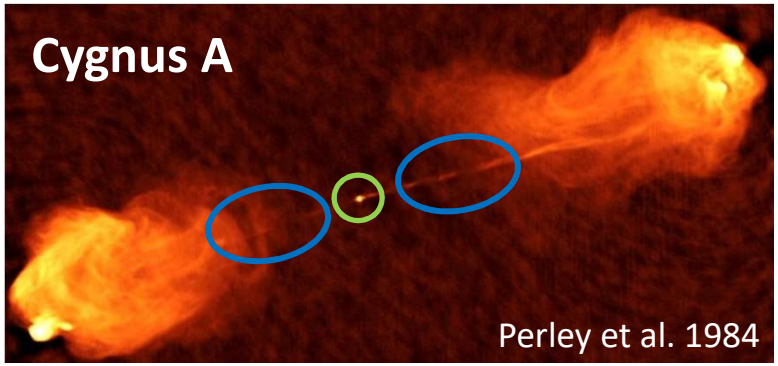
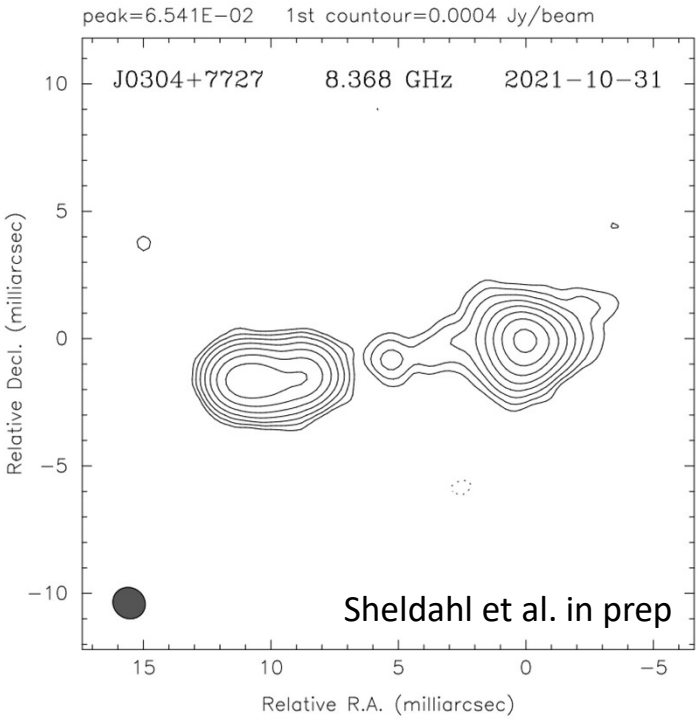


What is a CSO?

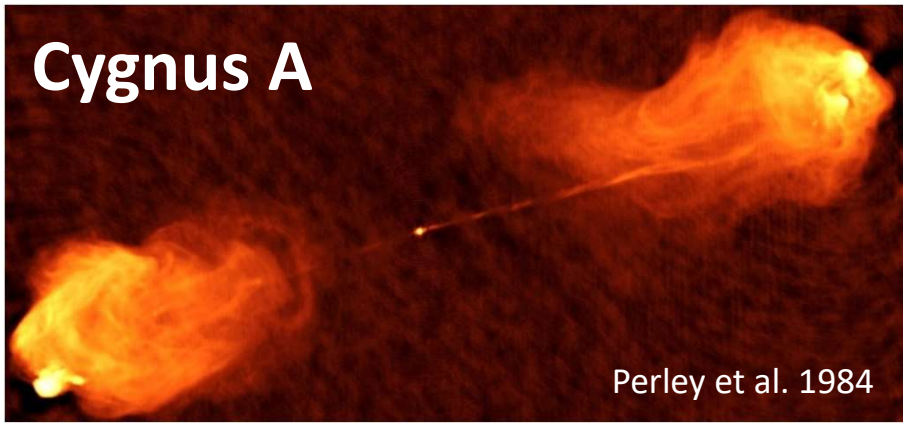
1. < 1 kpc
2. Emission symmetrical about center of activity
3. **Flux variability < 20%/yr**
4. **v_{app} < 2.5c**



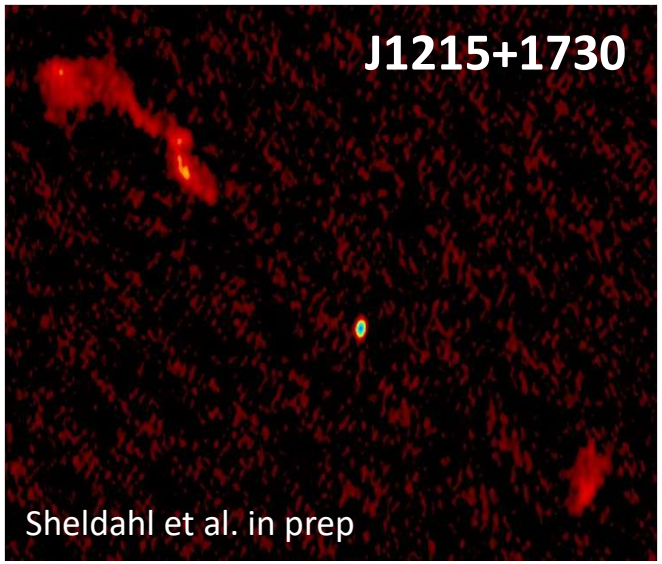
To avoid blazars

(Kiehlmann et al. 2024a)

“Mini Cygnus A’s”



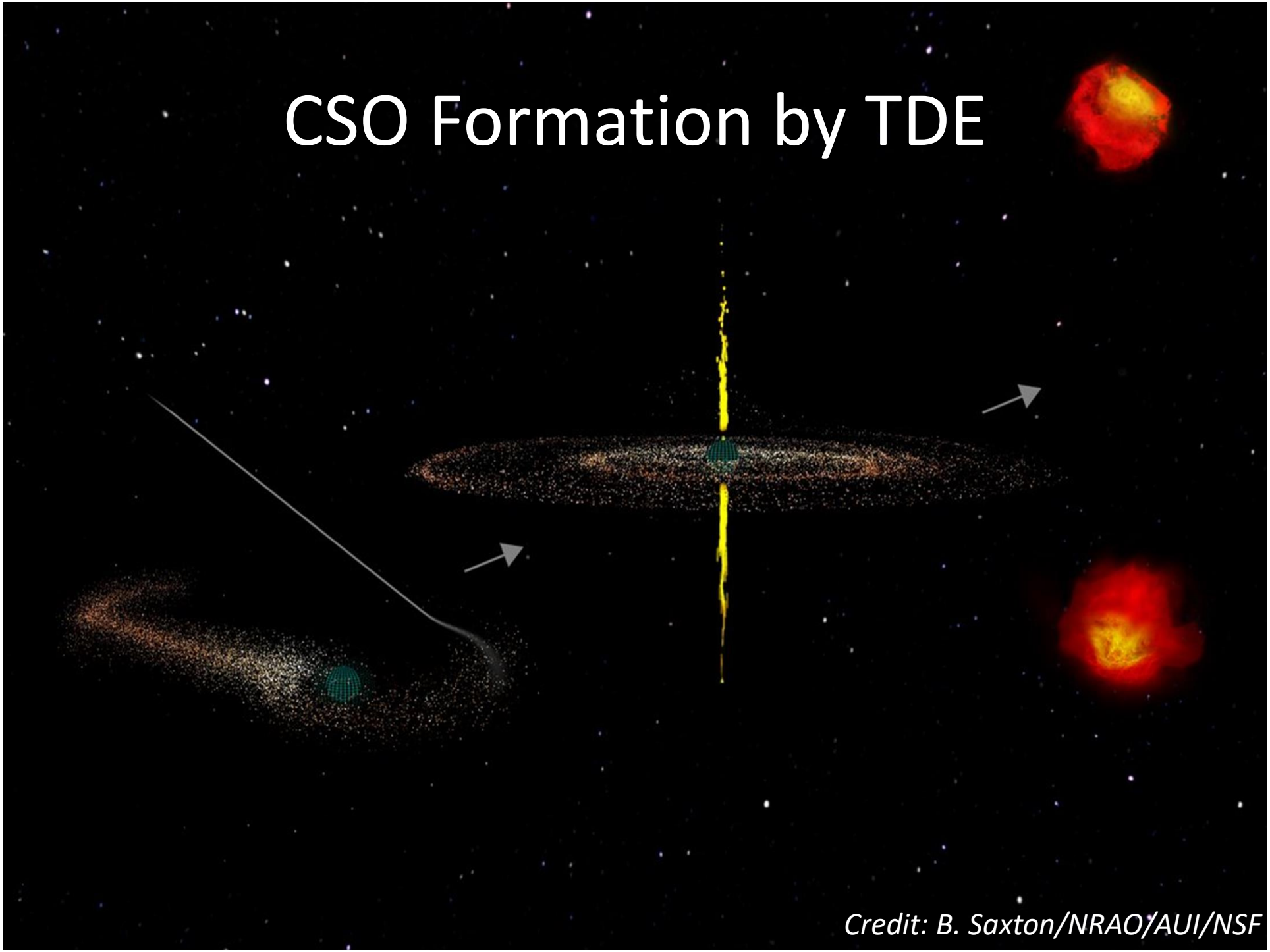
Total extent: ~120 kpc



Total extent: 0.413 kpc

Fueling mechanisms are likely different

CSO Formation by TDE



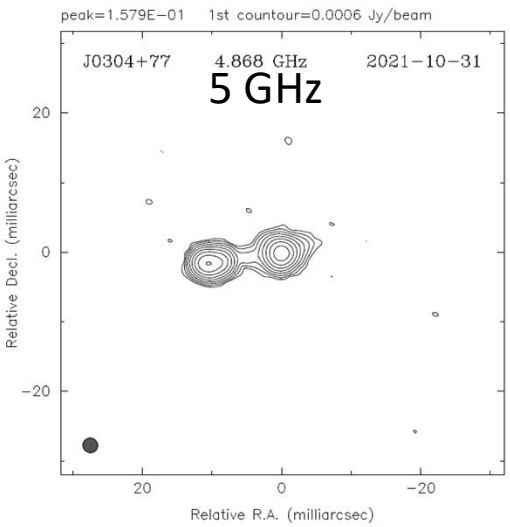
Credit: B. Saxton/NRAO/AUI/NSF

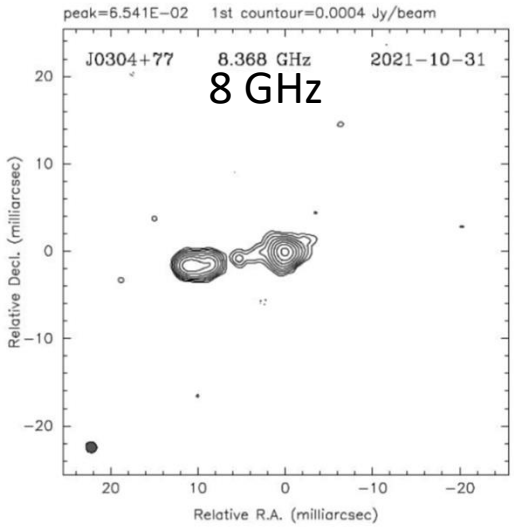
What Makes CSOs Special?

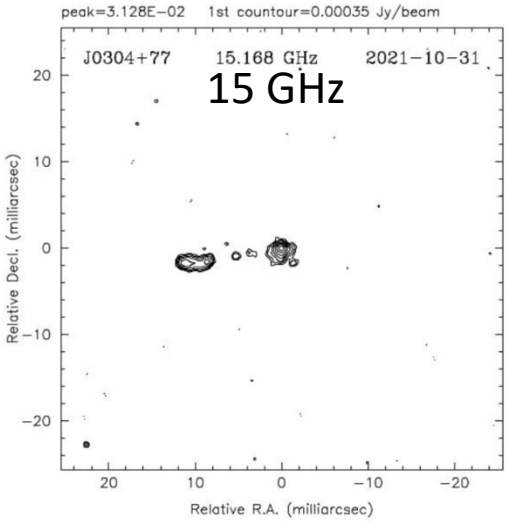
- Class driven (mostly) by morphology
- Short-lived emission (TDEs)
  - Can give insight into newly birthed jets
  - Kinematic changes on human time scales
- Too abundant (in complete samples)
  - Few grow to larger scales
  - Completely separate population of radio AGN?

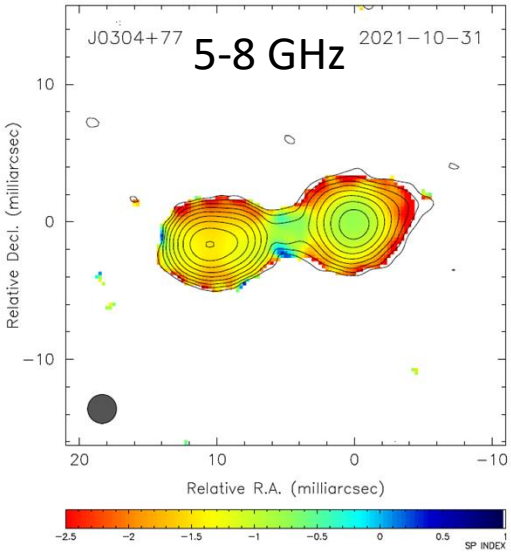
How Do We Find CSOs?

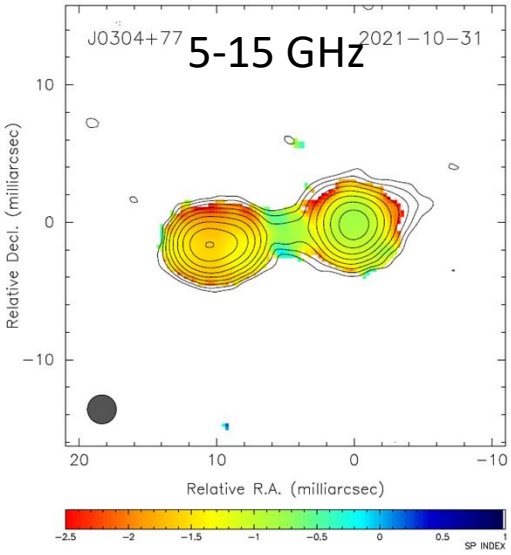
- Need VLBI at multiple frequencies
- Selected candidates with:
  - VLBI surveys
  - Literature search for GPSs, CSSs, CSO candidates
- Compiled catalog of 3175 sources
  - https://www.cv.nrao.edu/MOJAVE/cso/
- VLBA study of 167 candidate sources (Sheldahl et al. in prep)

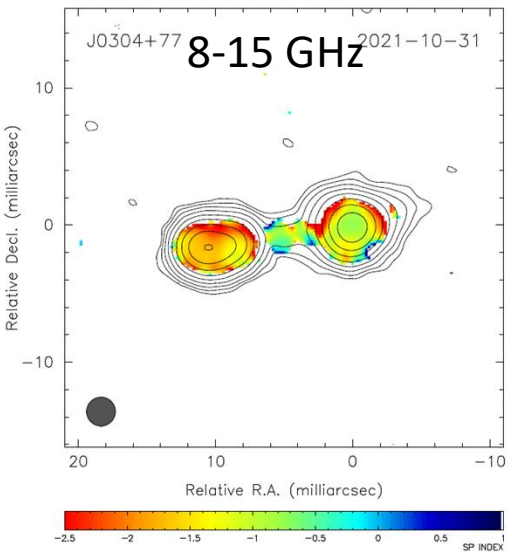












Core: flat/inverted **Lobe: steep**

Sheldahl et al. in prep

Final Numbers

CSOs	65 (38.9%)
Rejects	56 (33.6%)
Indeterminates	46 (27.5%)

72.5% definitively classified

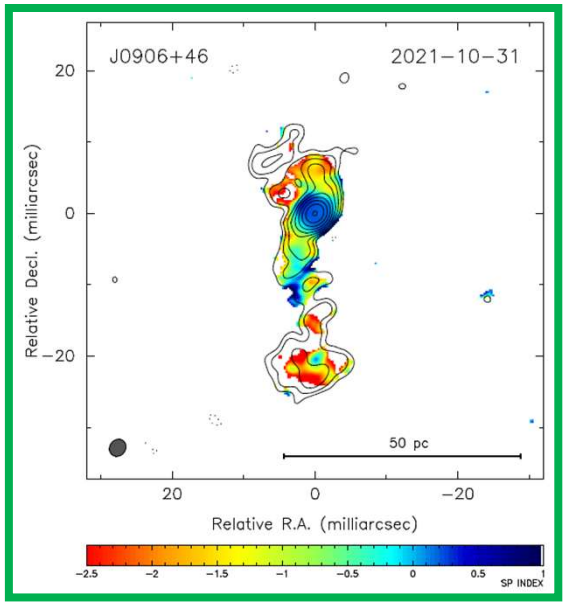
Total Verified to Date: 144

Sheldahl et al. in prep

CSO Classes

CSO 1

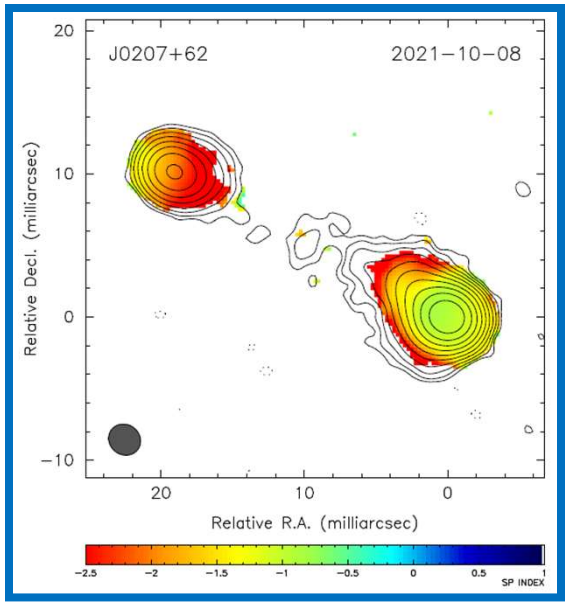
Edge-dimmed



CSO 2

Edge-brightened

Divided into 2.0s, 2.1s, and 2.2s



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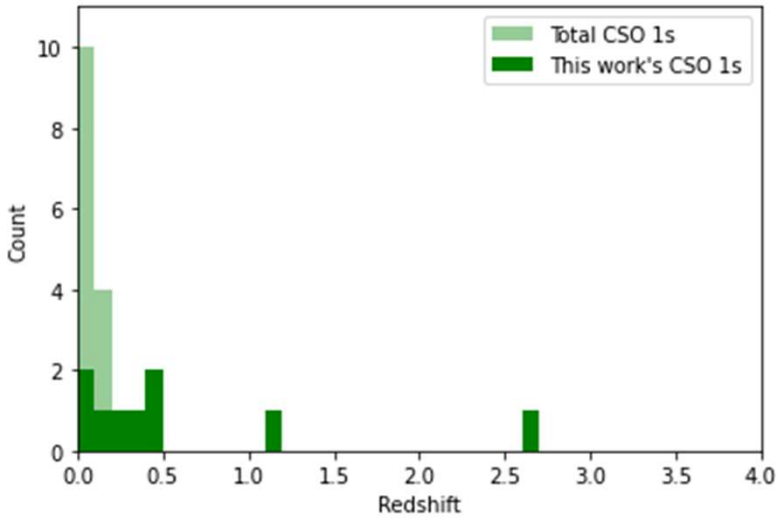
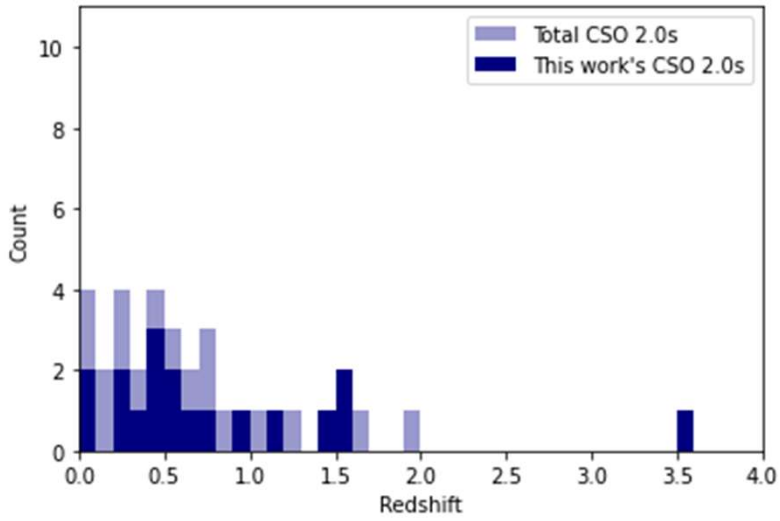
Redshift Distribution

- Probing dimmer, higher z sources
- Most (but not all) CSO 1s lower z





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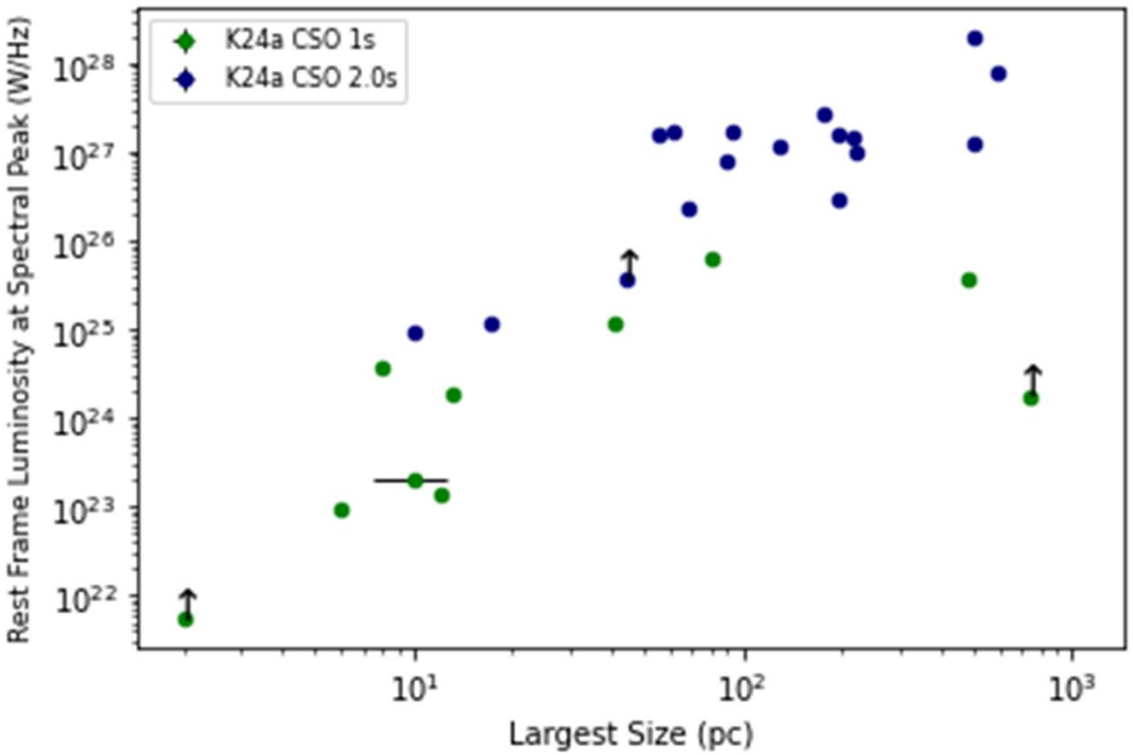
CSO 1s: A Diverse Source Type?



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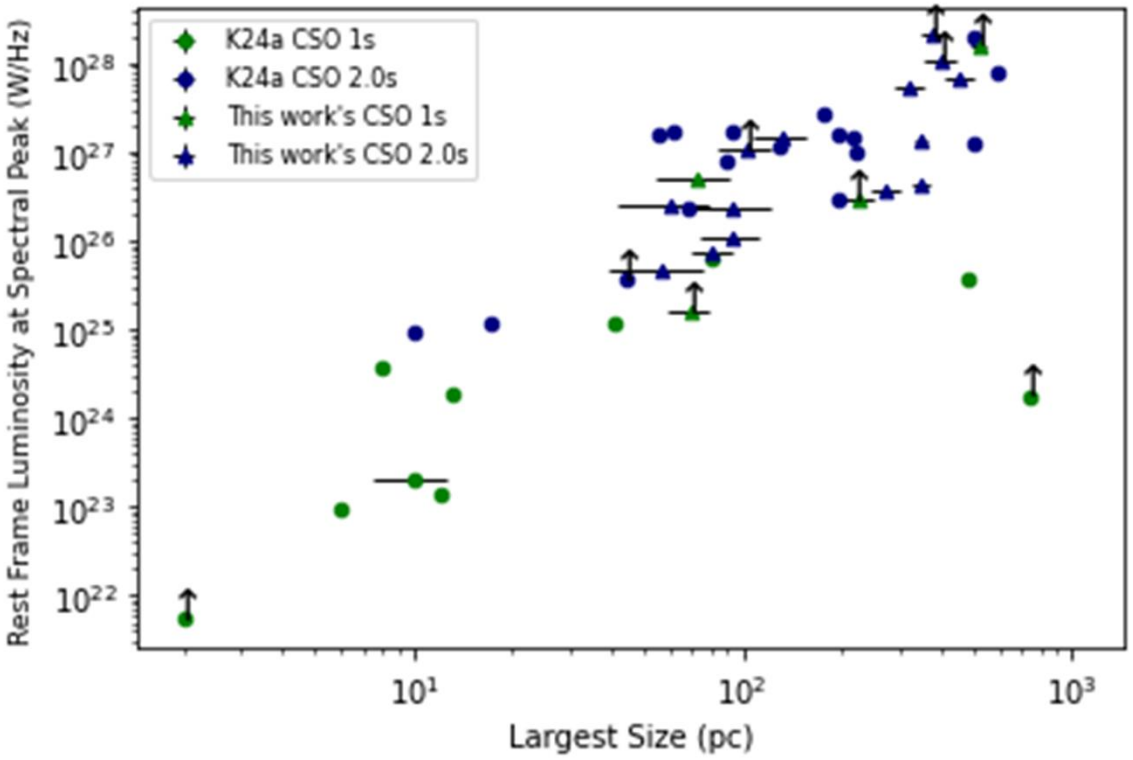

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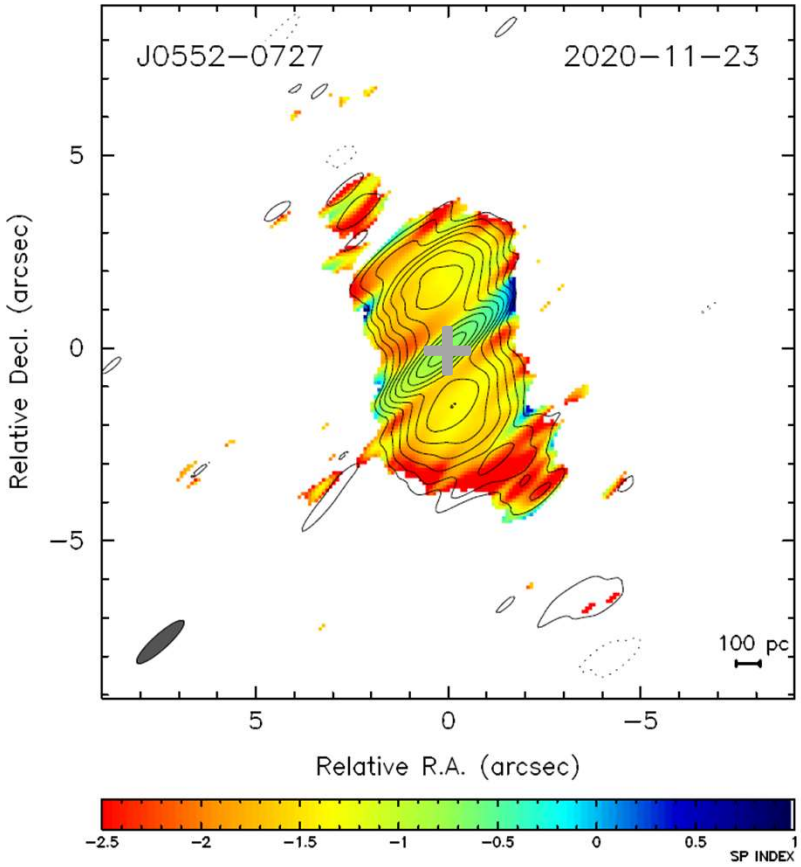
J0552-0727: A Very Low-z CSO



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Second lowest z CSO!

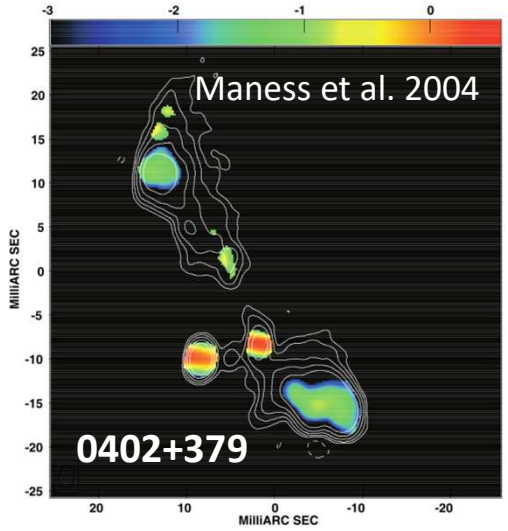
z = 0.008039

Size = 978 $\pm$ 53 pc

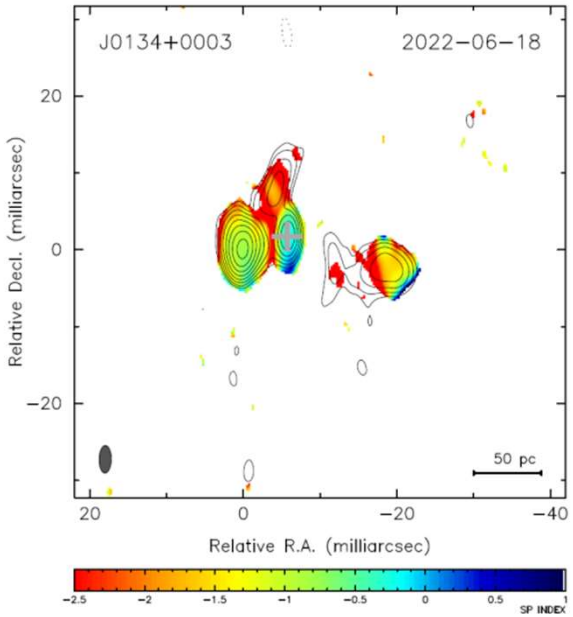
Observed with VLA

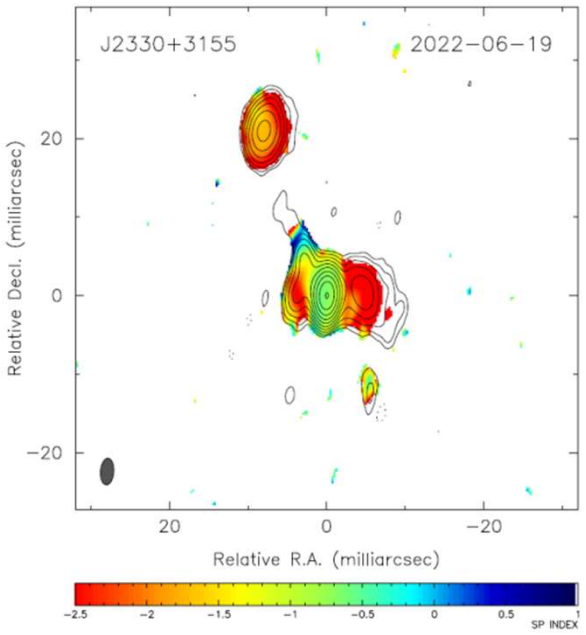
CSO 1

SBBH Candidates



- Looking for:
  - Emission that can't easily be traced back to center
  - Multiple flat spectrum components





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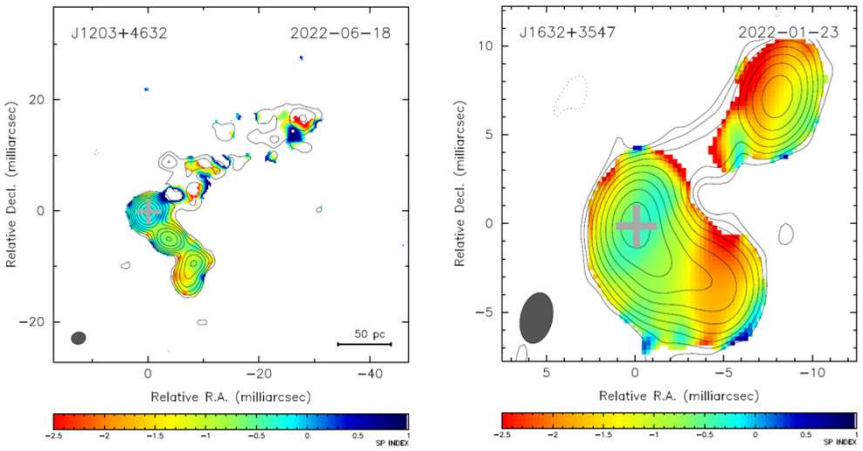
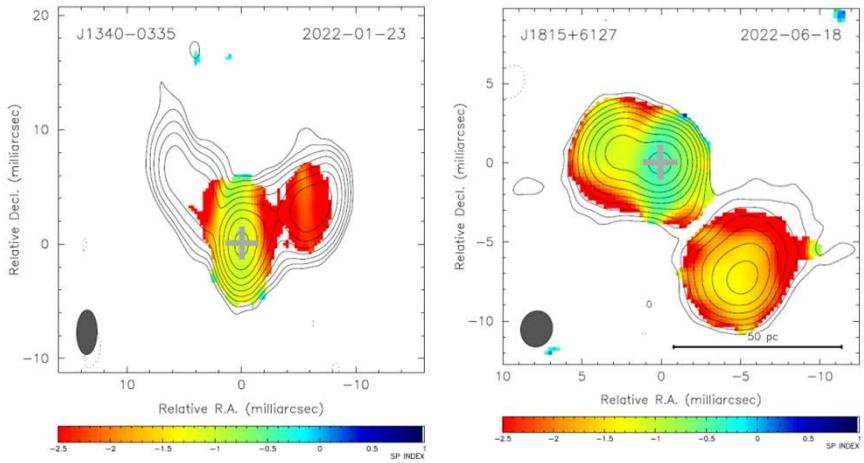
Head-Tail Candidates

- Transverse velocity relative to ICM
- Not expected in cores of AGN



Narrow Angle Tail (NAT)

$\theta < 90°$



Wide Angle Tail (WAT)

$90° < \theta < 180°$

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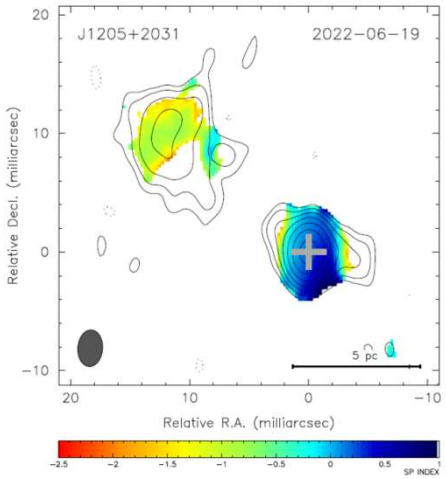
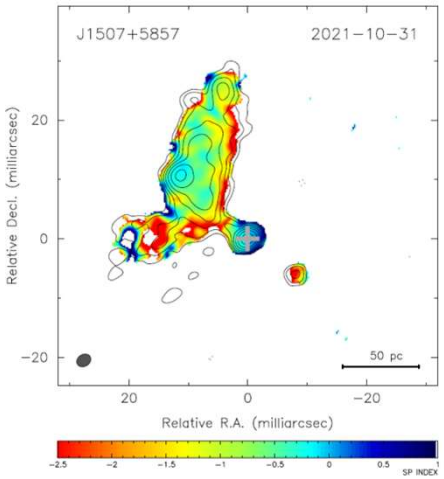
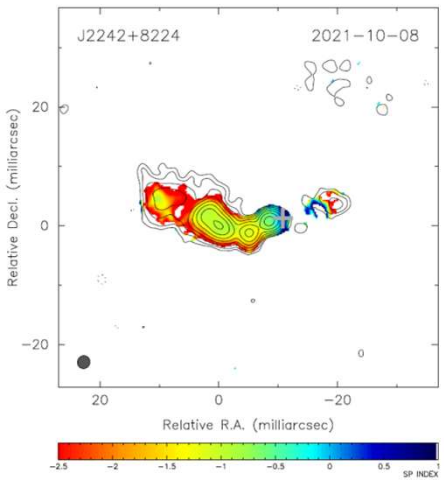
Not So Symmetric?

- High flux discrepancy in lobes
- Likely boosted, but need light curve monitoring







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Summary

- VLBA observations of 167 CSO candidates
  - Verified 65 CSOs, including a low-z one
- CSO 1s may be a more diverse sample than expected
- Many CSOs with unique morphology, will be interesting to study further