THE ATLAS-SPT SURVEY OF CLUSTER GALAXIES

A Progress Report

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The Many Facets of Extragalactic Radio Surveys
Bologna, ITALY

EMU and Pathfinders

	ATCA – ATLAS (2006-2013) 6 antennas single-pixel	7 sq. deg rms = 15 μJy 6000 galaxies
	ATCA – ATLAS-SPT (2013-2015) 6 antennas single-pixel	100 sq. deg rms = 80 μJy 20,000 galaxies
	ASKAP – EMU early (2015-2016) 12 antennas MkII PAF	1000 sq. deg rms = 30 μJy 0.5 million galaxies
	ASKAP – EMU (2016-2018) 30-36 antennas MkII PAF	3π sr rms = 10 μJy 70 million galaxies
	SKA1-SURVEY (2022-????) 96 antennas MkIII PAF	3π sr rms = 2 μJy 500 million galaxies?

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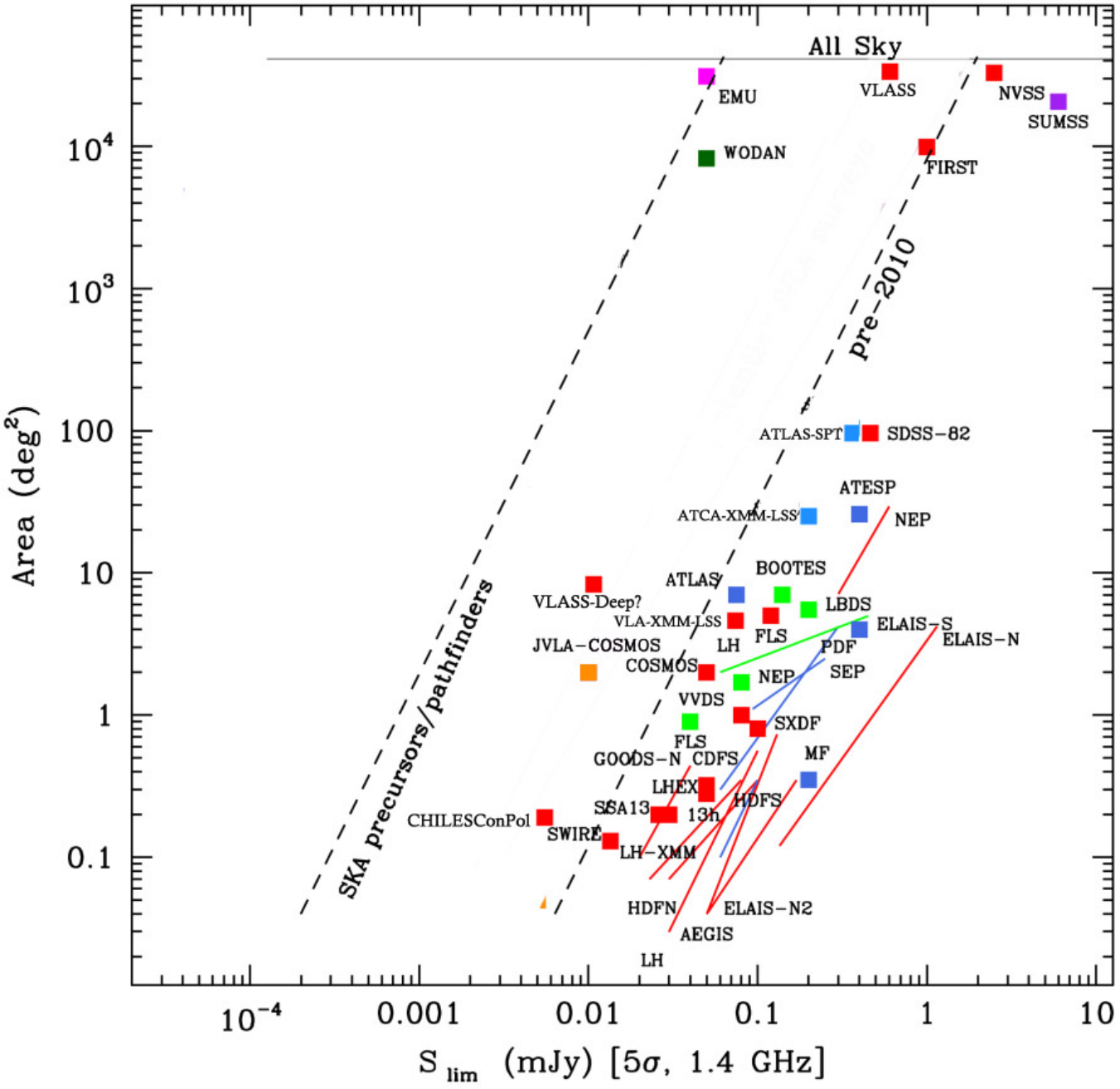
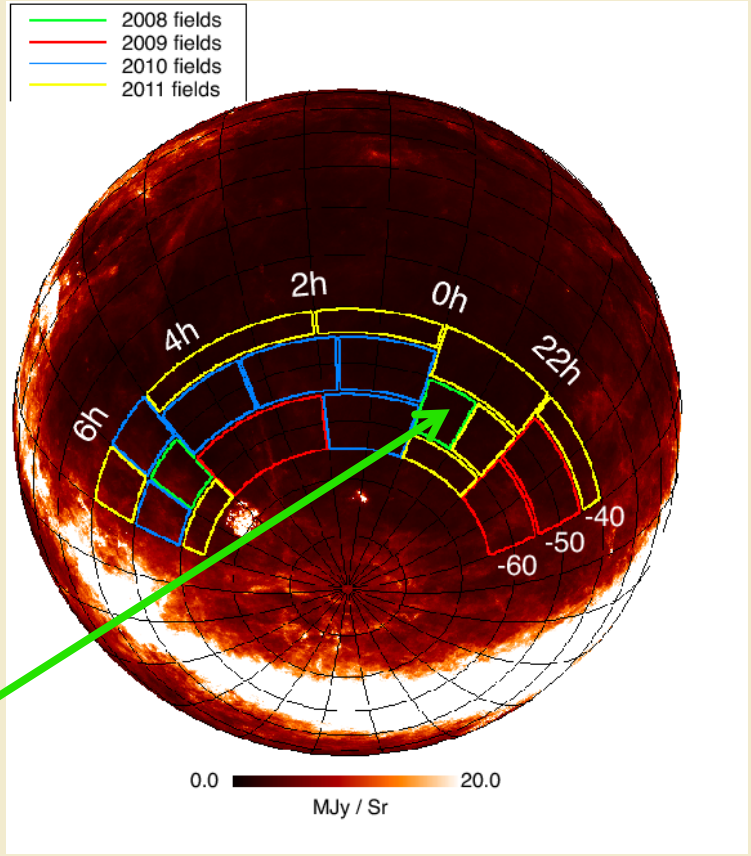


Surveys at other frequencies have been converted to 1.4 GHz equivalent assuming $S \propto \nu^{-0.7}$

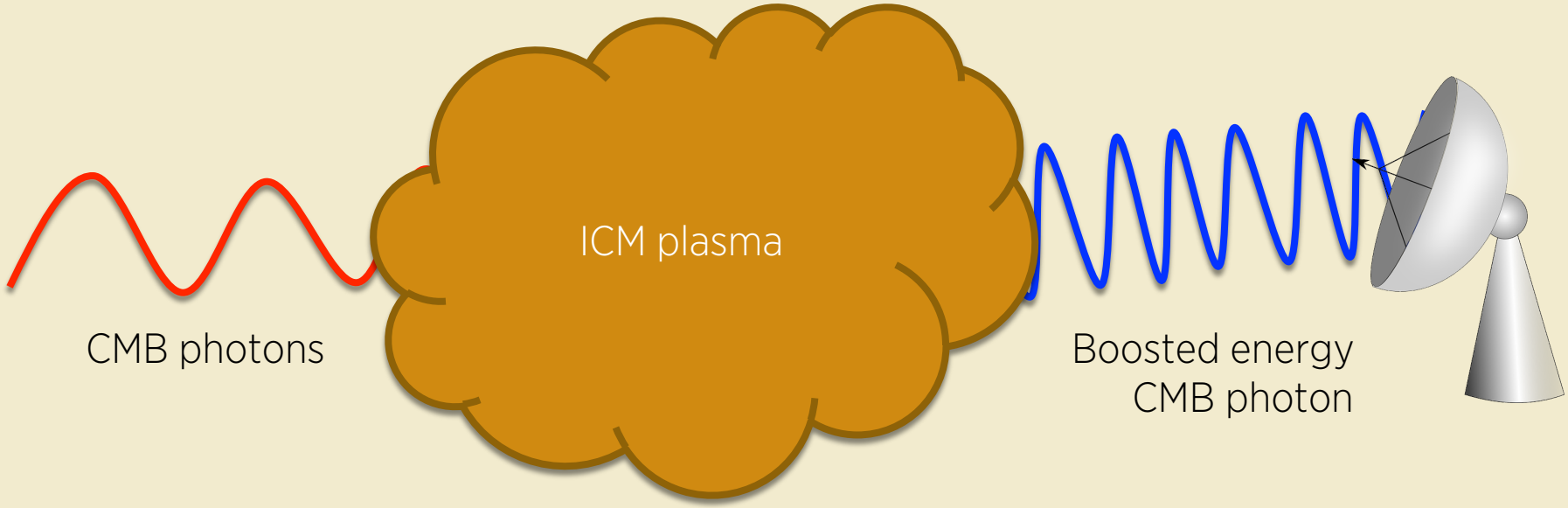
The South Pole Telescope Survey

- 2,500 sq. deg. mm-wavelength survey
- SZ cluster catalogue
  - 677 cluster candidates
  - Maximum z > 1.4
- Deep Field: prioritised 100 deg^2 survey



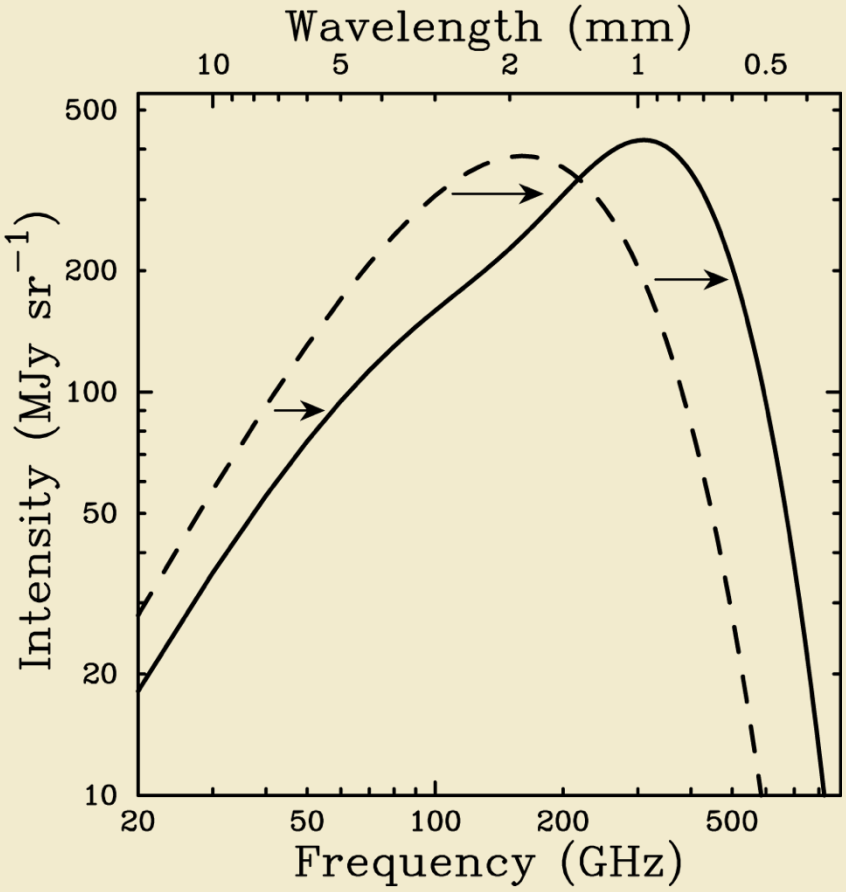
Story et al. (2013)

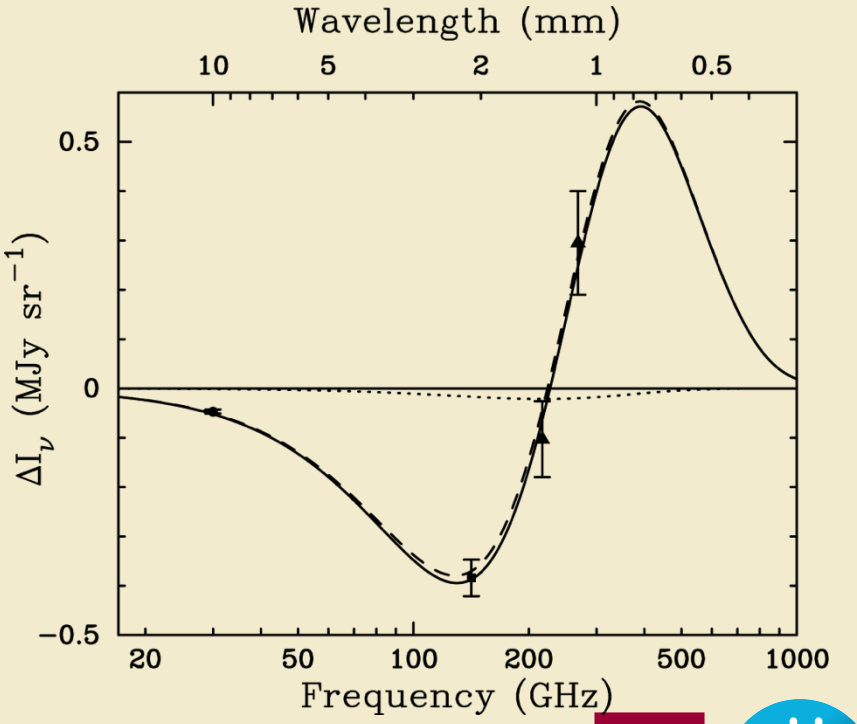
The Sunyaev-Zel'dovich Effect



The Sunyaev-Zel'dovich Effect

- Spectral distortion

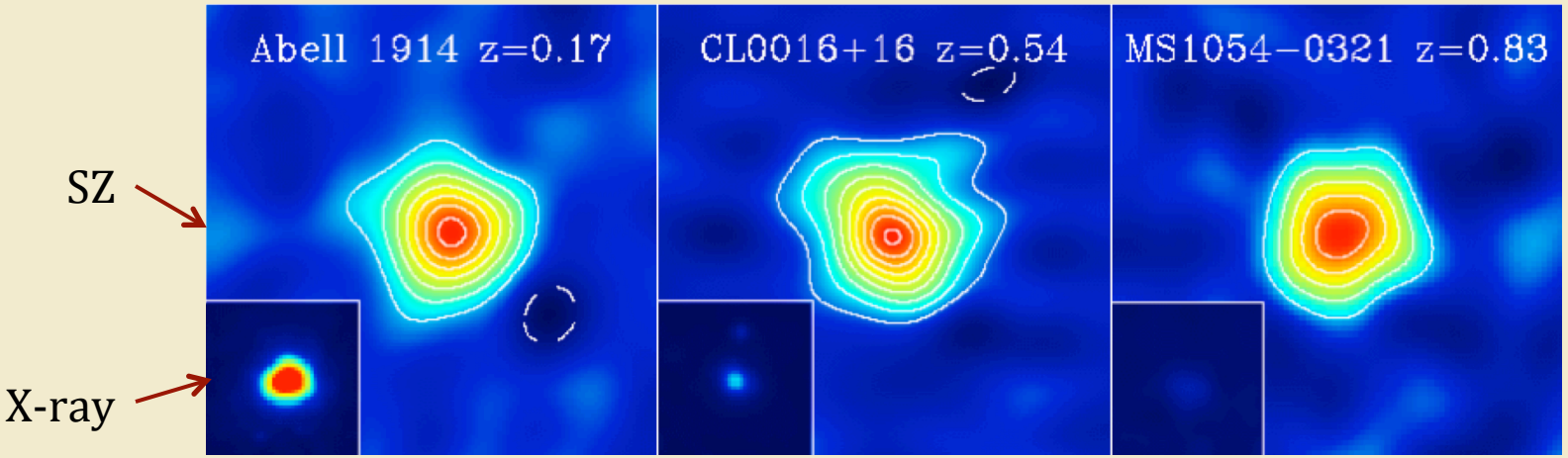




Carlstrom et al. (2002)

The Sunyaev-Zel'dovich Effect

- Direct, z independent measurement of the ICM
- SZ signal strength consistent over wide z range



Mohr & Carlstrom

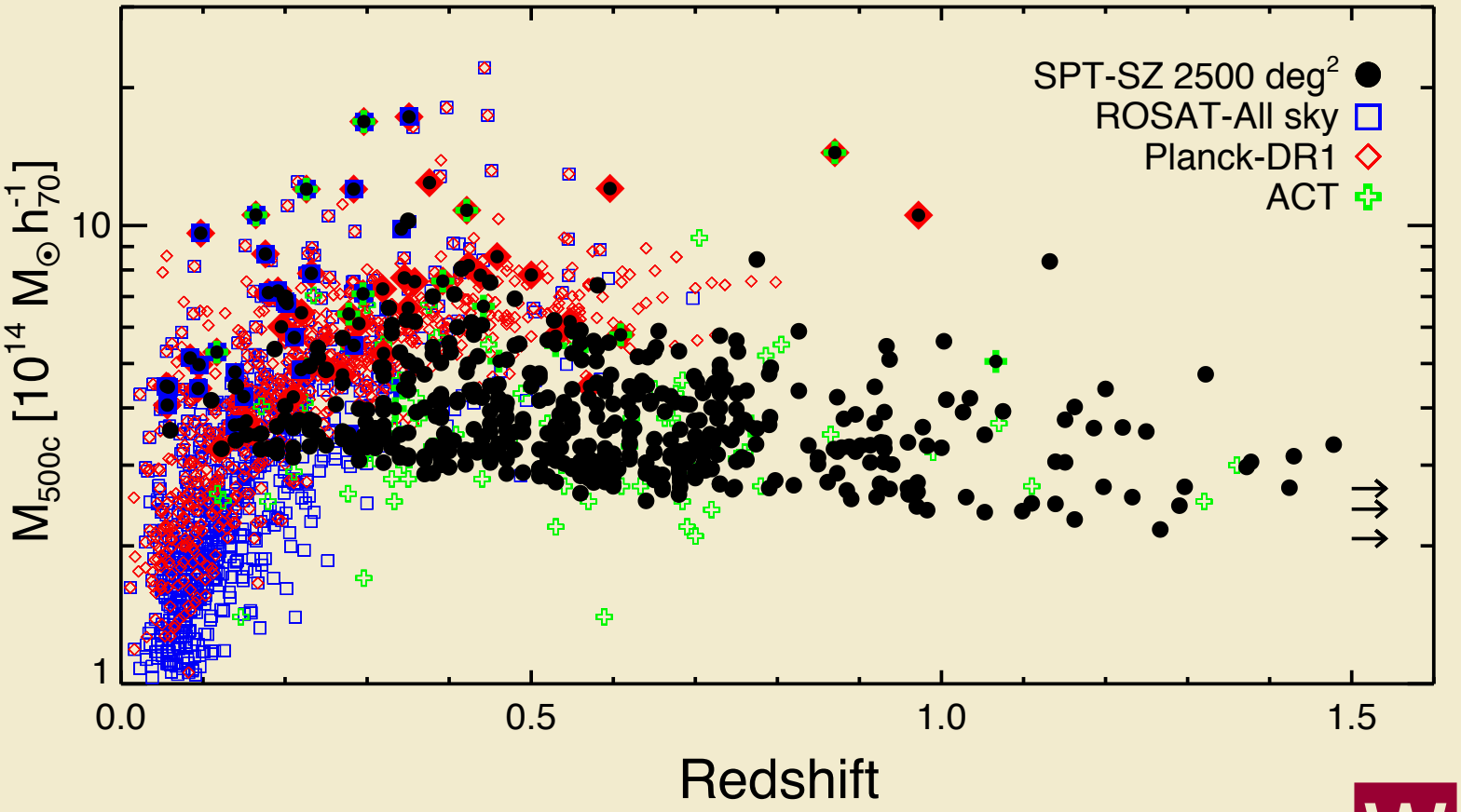
SZ Effect caveats

- SZ signal difficult to detect with strong radio sources
  - Can be overcome with source subtraction
- AGN fraction higher in clusters at high-z
- Implied bias toward high mass clusters

- Potential bias to radio-quiet, high-mass clusters

SPT-SZ Cluster Catalogue

Bleem et. al. (2015)



SPT-DF Multi-wavelength Coverage

- **X-ray** from XMM-Newton (25%)
- **Optical** from Blanco & DES
- **Near-IR** from VISTA
- **Mid-IR** from Spitzer and WISE
- **Far-IR** from Herschel
- **Low-frequency radio** from MWA
- **Centimetre radio** from ATCA
  - ATLAS-SPT & XMM-XXL

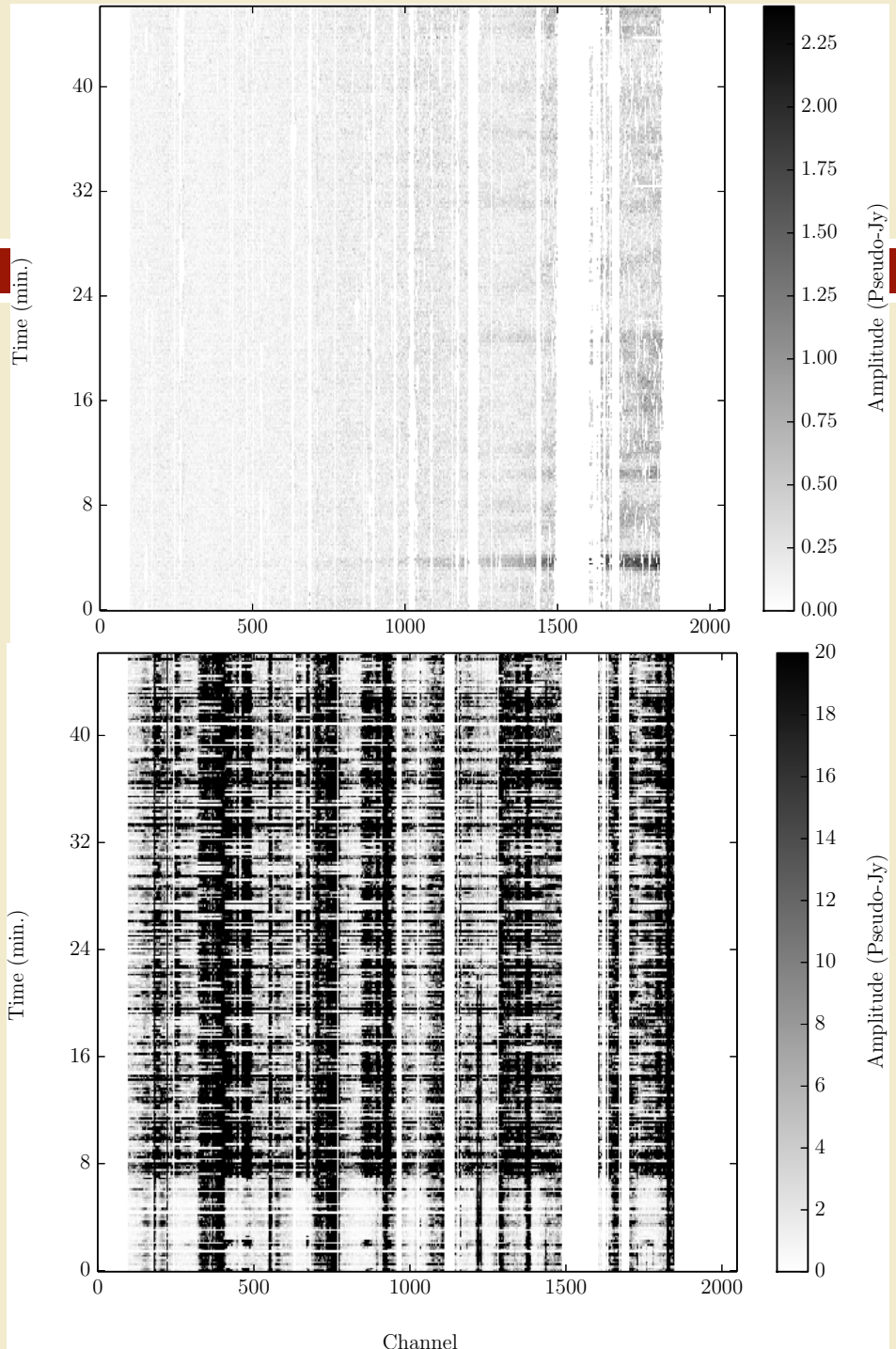
The ATLAS-SPT Survey

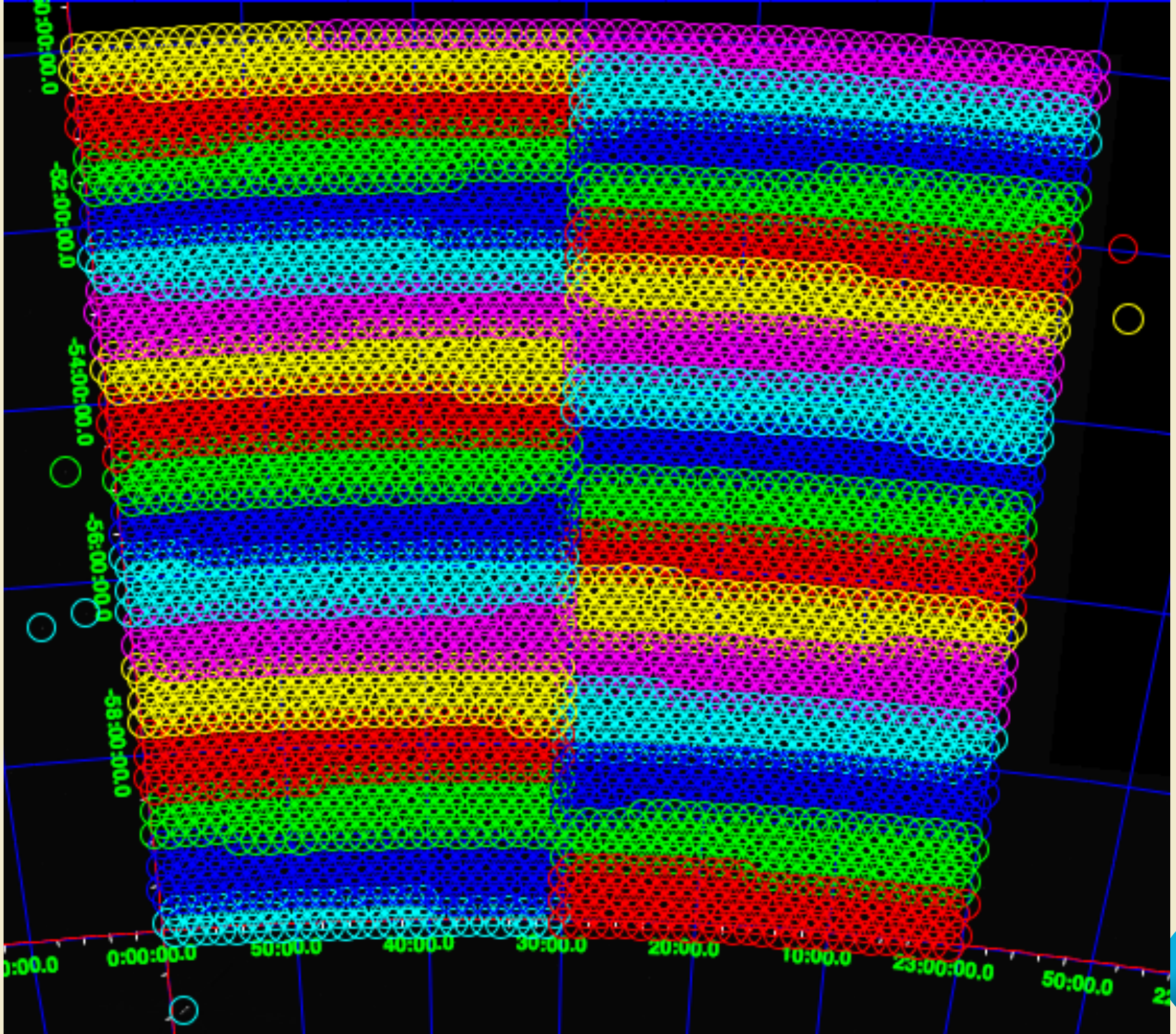
The ATLAS-SPT Survey

- 1.1-3.1 GHz radio continuum survey of the 100 deg^2 SPT-DF with the ATCA
- 6 km array configuration
  - ~ 7” synthesised beam resolution
  - ~ 23’ primary beam FWHM
  - Short-baseline survey time awarded for December
- RMS ≤ 80μJy – 0.4 mJy flux threshold (5σ)
- ~ 20,000 sources
  - Mostly AGN, some star forming galaxies
- Investigate radio cluster properties
  - Impact of cluster environments on radio galaxies
  - Detection of clusters using radio observations

The Observations

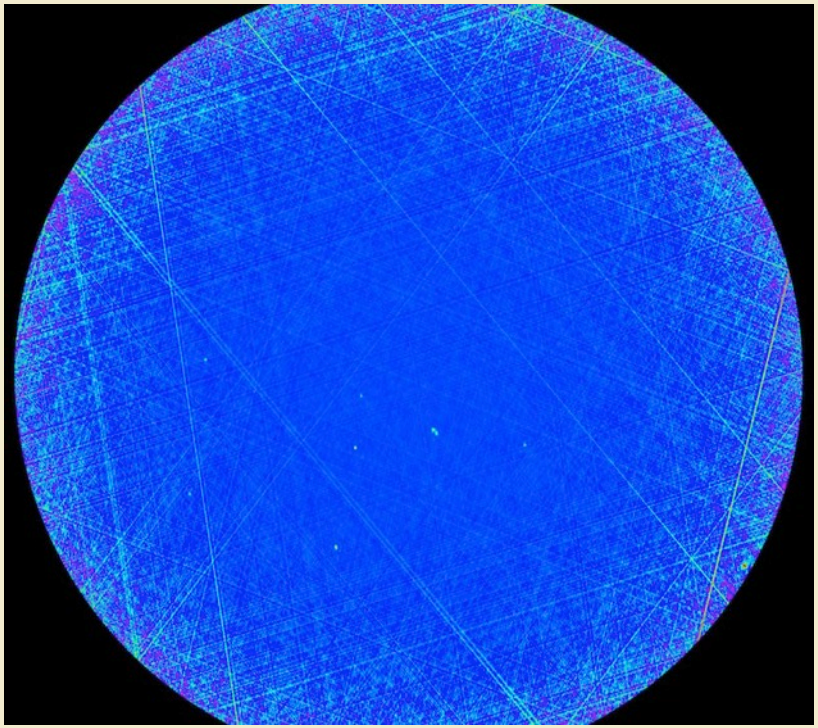
- Granted 243 hours
- Hexagonal mosaic of 4,786 pointings
- Observed May-June 2013
- Lost data due to intense interference
  - Re-observed effected pointings in Feb 2014




-52:00:00.0
-54:00:00.0
-56:00:00.0
-58:00:00.0
0:00:00.0
50:00.0
40:00.0
30:00.0
20:00.0
10:00.0
23:00:00.0
50:00.0

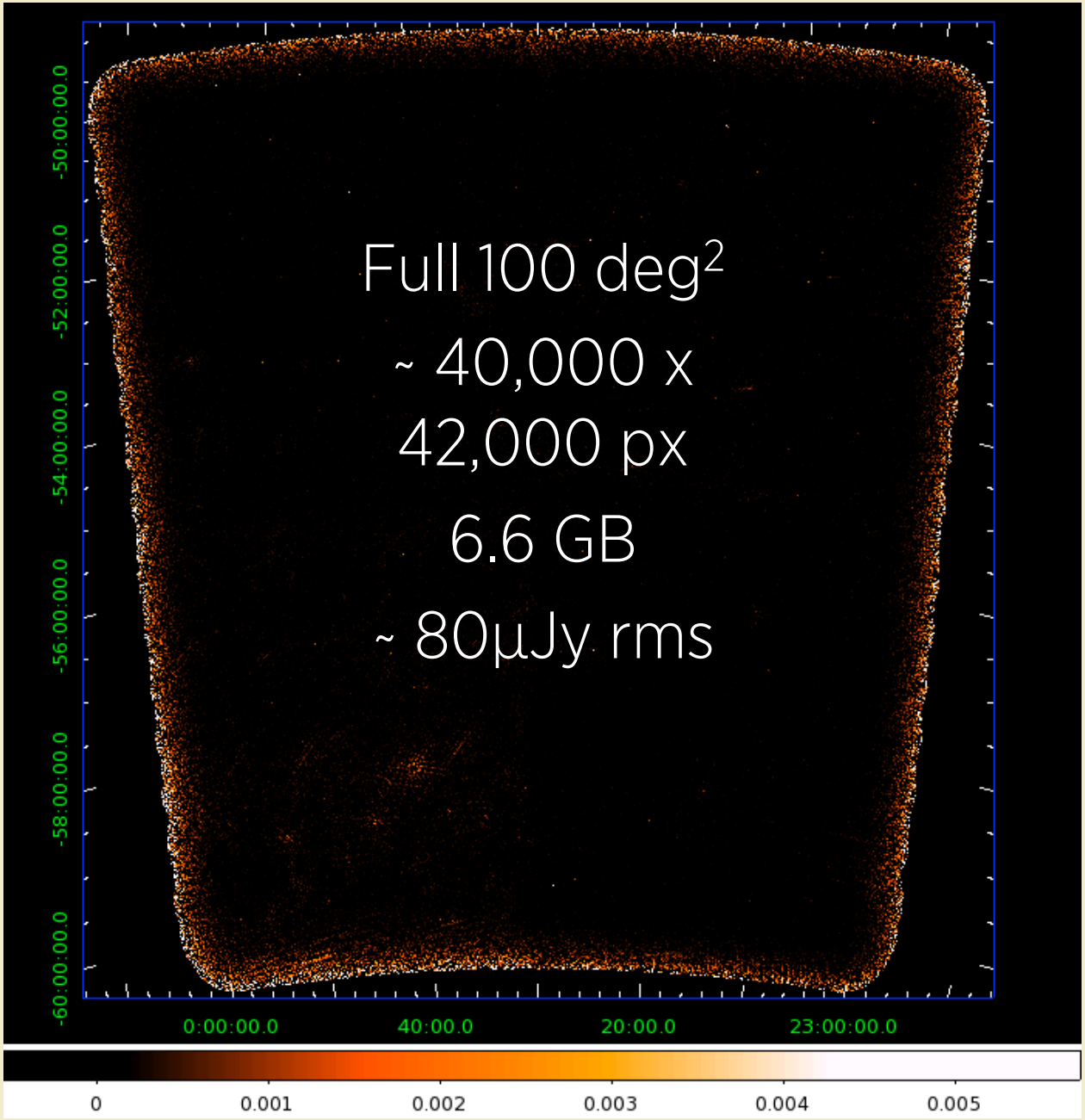
Processing Challenges

- Flux from outlying sources dominates cleaned image due to sparse uv coverage
  - Resolved using custom pipeline to image and subtract outlier sources
- Image processing time consuming x 4,787
  - Mitigated using Galaxy supercomputer
- Mosaicked image size exceeds software limitation
  - Mosaic overlapping sub-regions



Lesson Learned

- Do not do a large area survey at 2.1 GHz with the ATCA


Full 100 deg²
~ 40,000 x
42,000 px
6.6 GB
~ 80μJy rms
-50:00:00.0
-52:00:00.0
-54:00:00.0
-56:00:00.0
-58:00:00.0
-60:00:00.0
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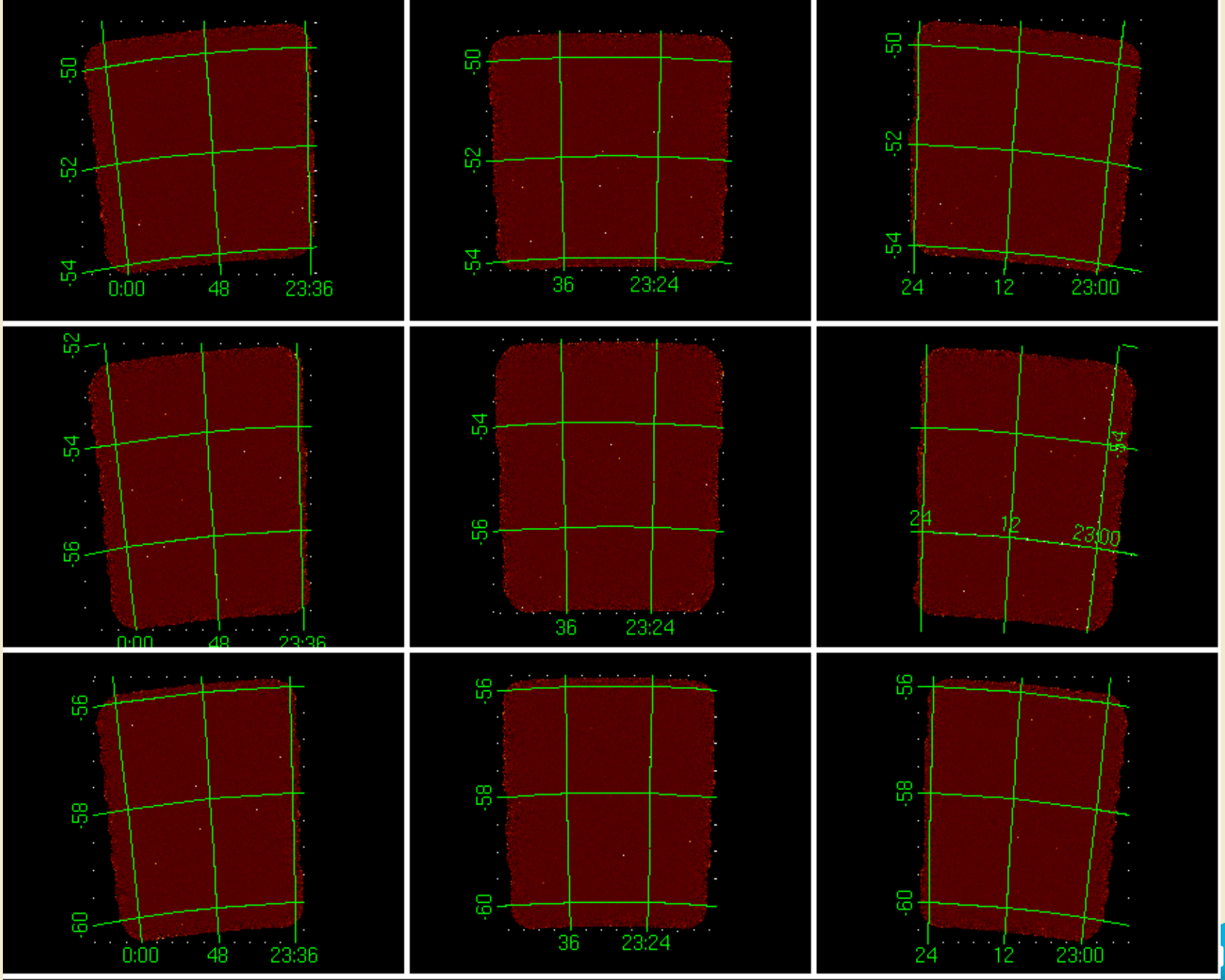
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-56
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24
12
23:00
-0.00040
0.00020
0.00080
0.00140
0.00200
0.00260
0.00320
0.00380
0.00440

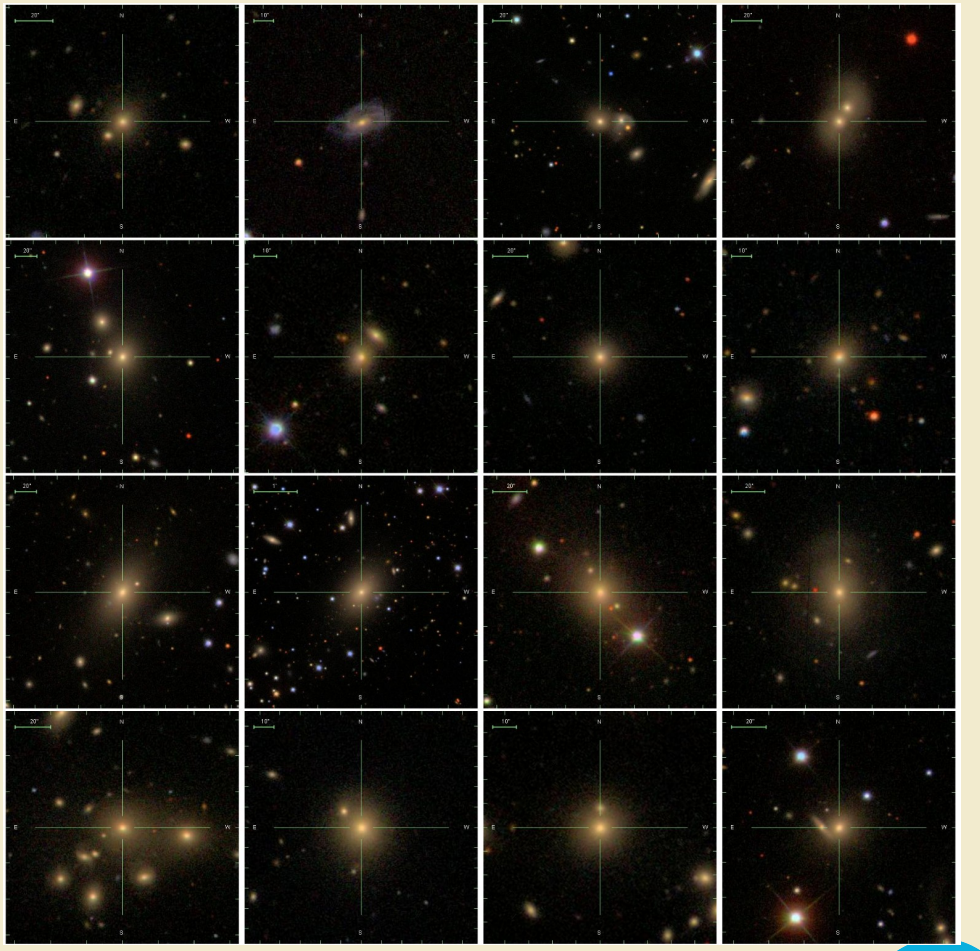
Radio source catalogue

- Use automated source extractors
  - Aegean (Hancock+, 2012), PyBDSM (Mohan & Rafferty, 2015)
  - Active field of research & development
  - Compare with selection of manual source extraction
  - Test-bed for future large surveys
- Catalogue source positions, fluxes, spectral indices
- Match to SPT-SZ clusters
- Useful for other projects e.g.
  - More accurate source positions
  - Radio cross-identifications (fluxes, luminosities)
  - Photometric redshifts

Brightest Cluster Galaxies

Brightest Cluster Galaxies

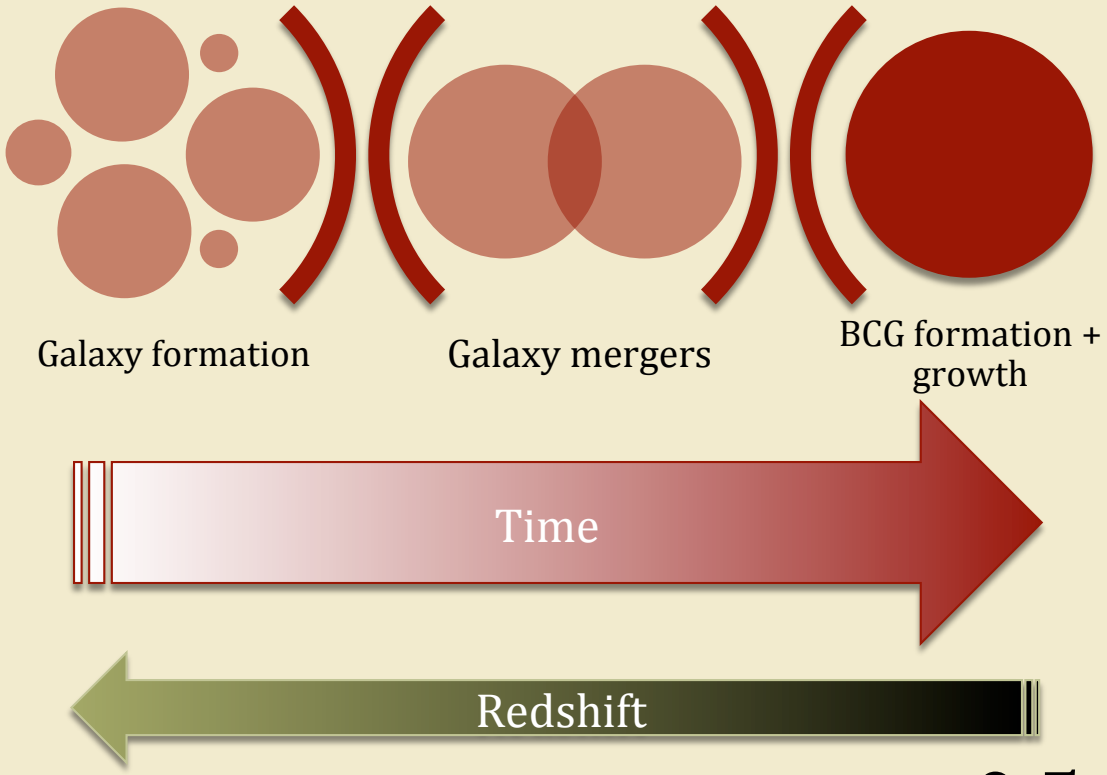
- Extremely luminous
- Bottom of gravitational potential well



von der Linden (2007)

Brightest Cluster Galaxies

- Within the Millennium Simulation…



BCG Radio Properties

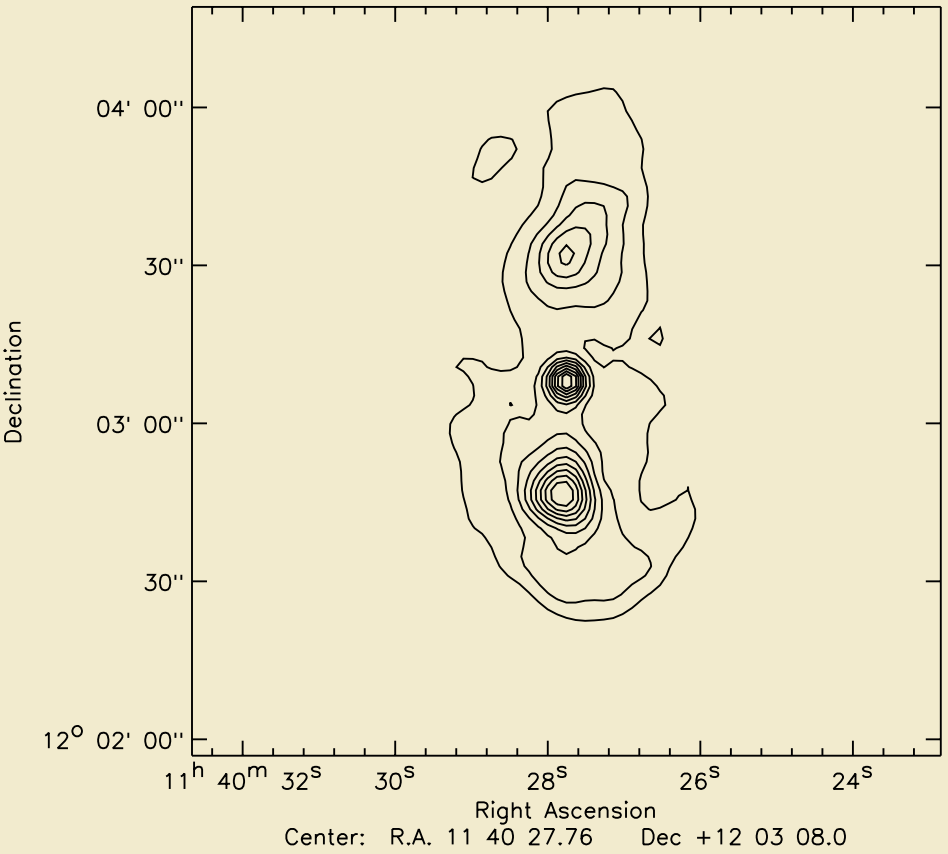
- More likely to be radio luminous than other cluster ellipticals (Burns et al. 1981; Valentijn & Bijleveld 1983; Burns 1990)
- More likely to host radio-loud AGN than other galaxies (Best et al. 2007; von der Linden 2007)

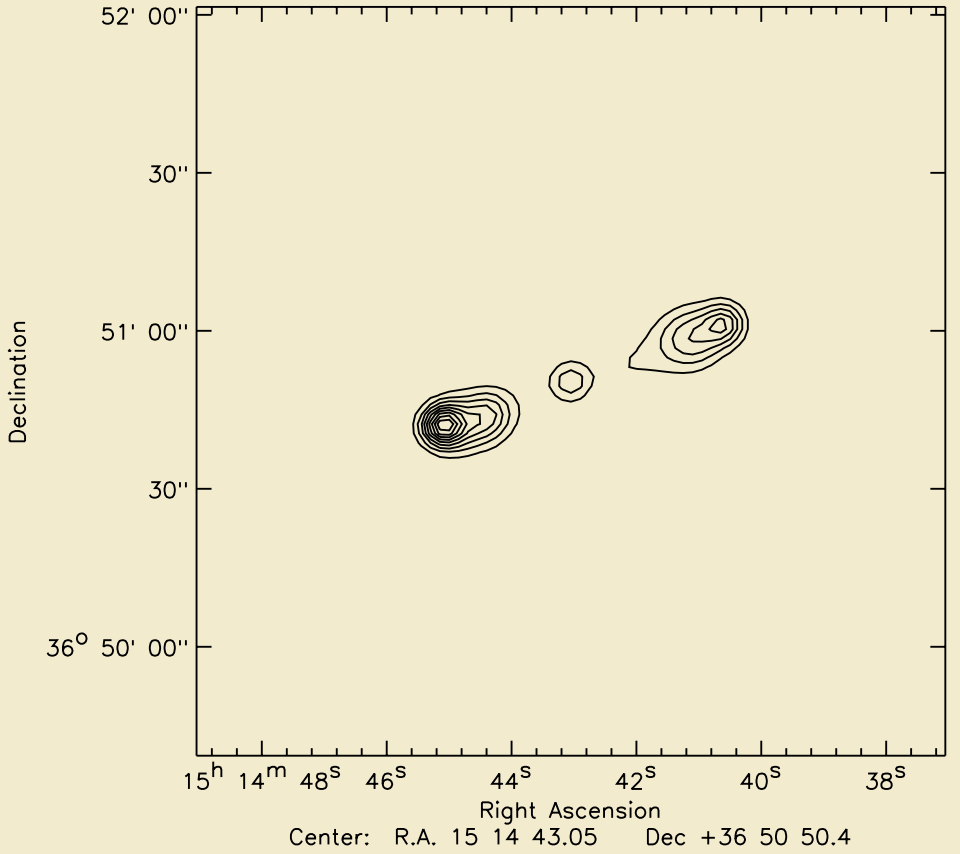
- These previous studies used a optical/X-ray cluster samples with $z < 0.1$
  - BUT simulations predict BCG formation estimated to start at $z \sim 0.5$
  - Extend radio properties of BCGs study out to $z \sim 2$

Bent-lobe sources

Wide-angle and Narrow-angle Tailed AGN

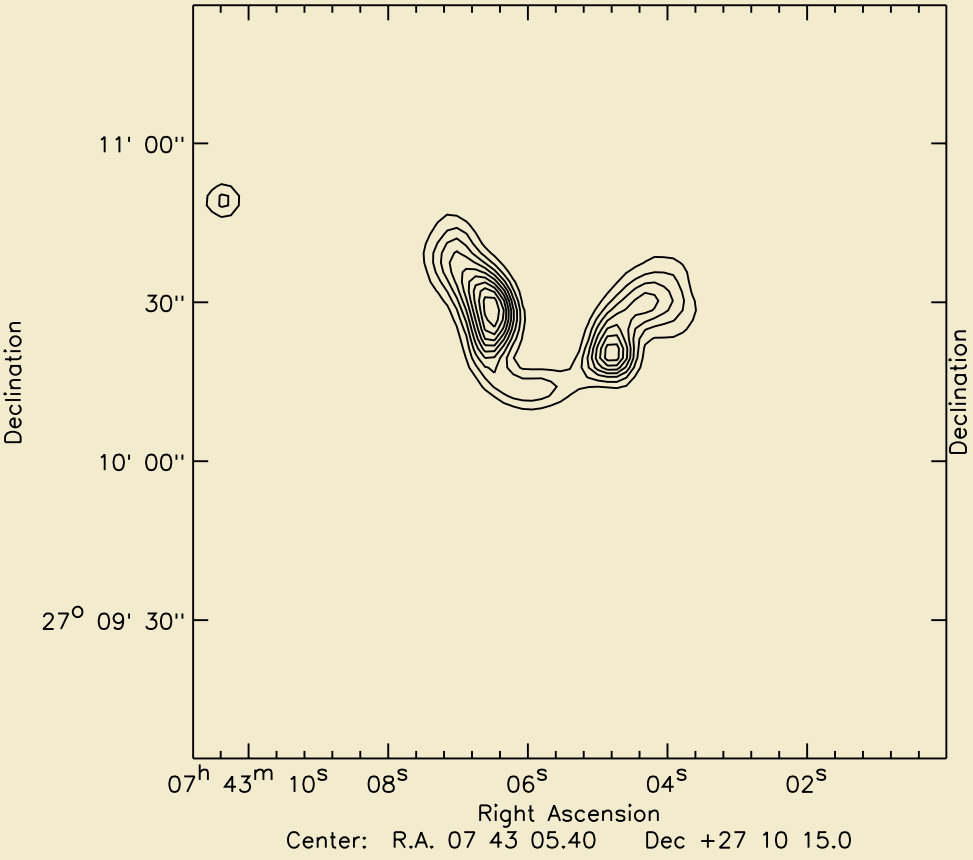
Straight-lobe sources

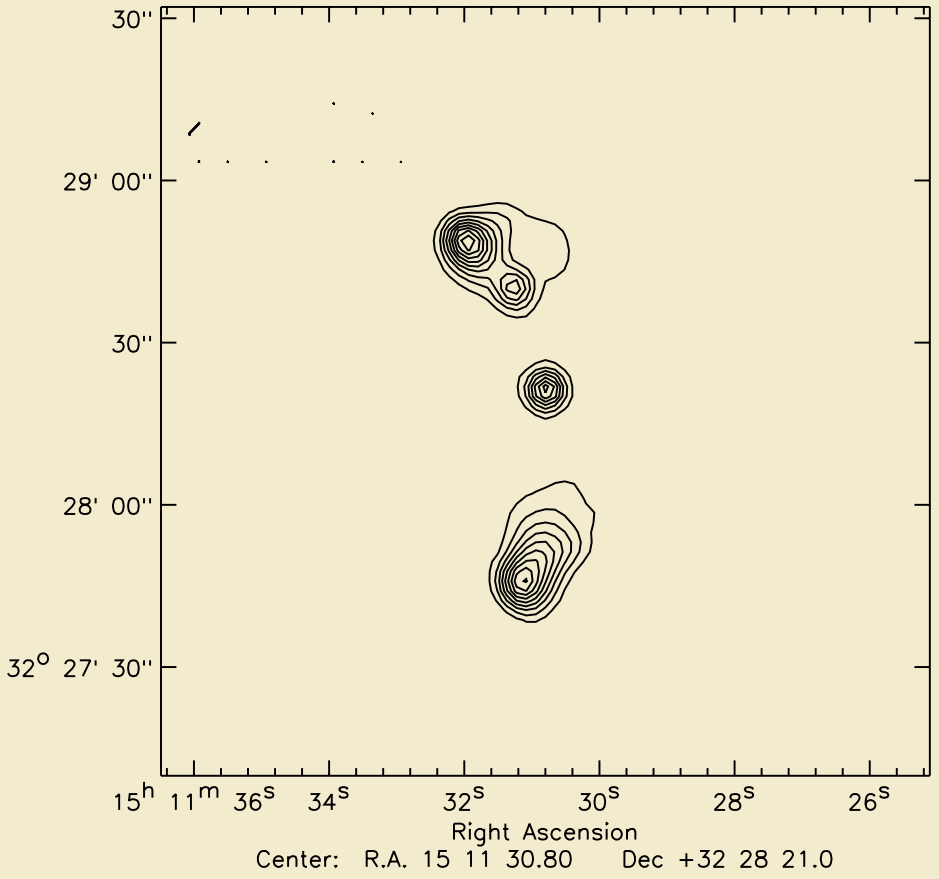




Wing & Blanton (2011)

Bent-lobe sources

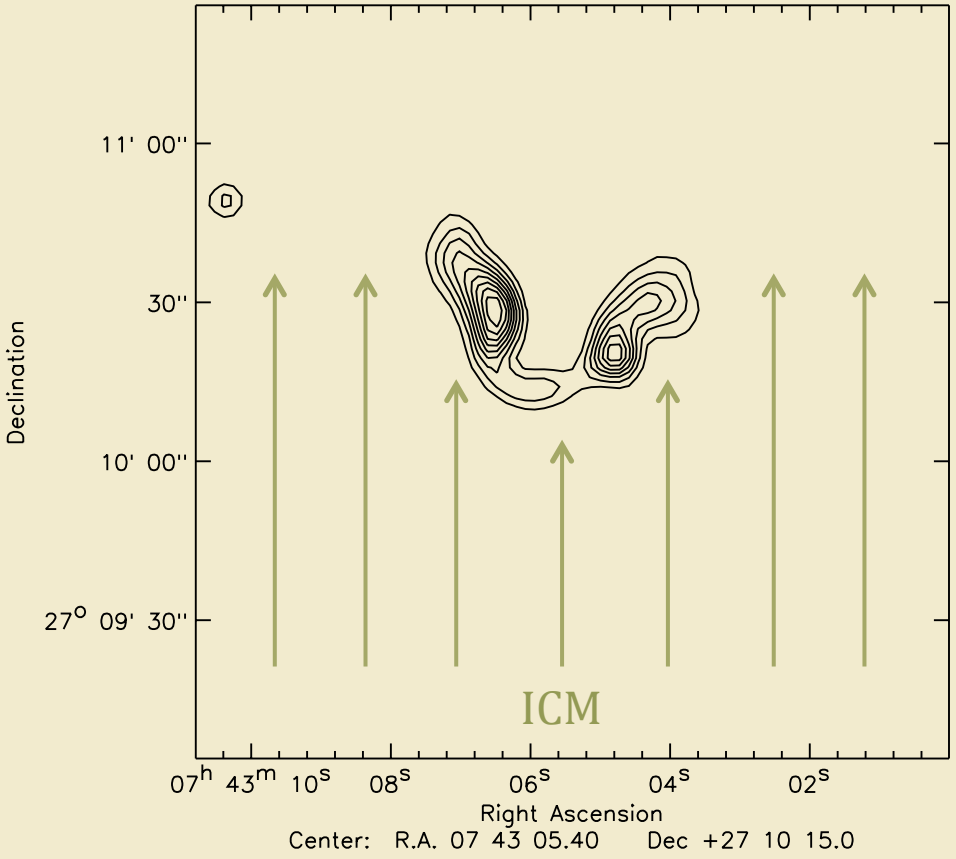




Wing & Blanton (2011)

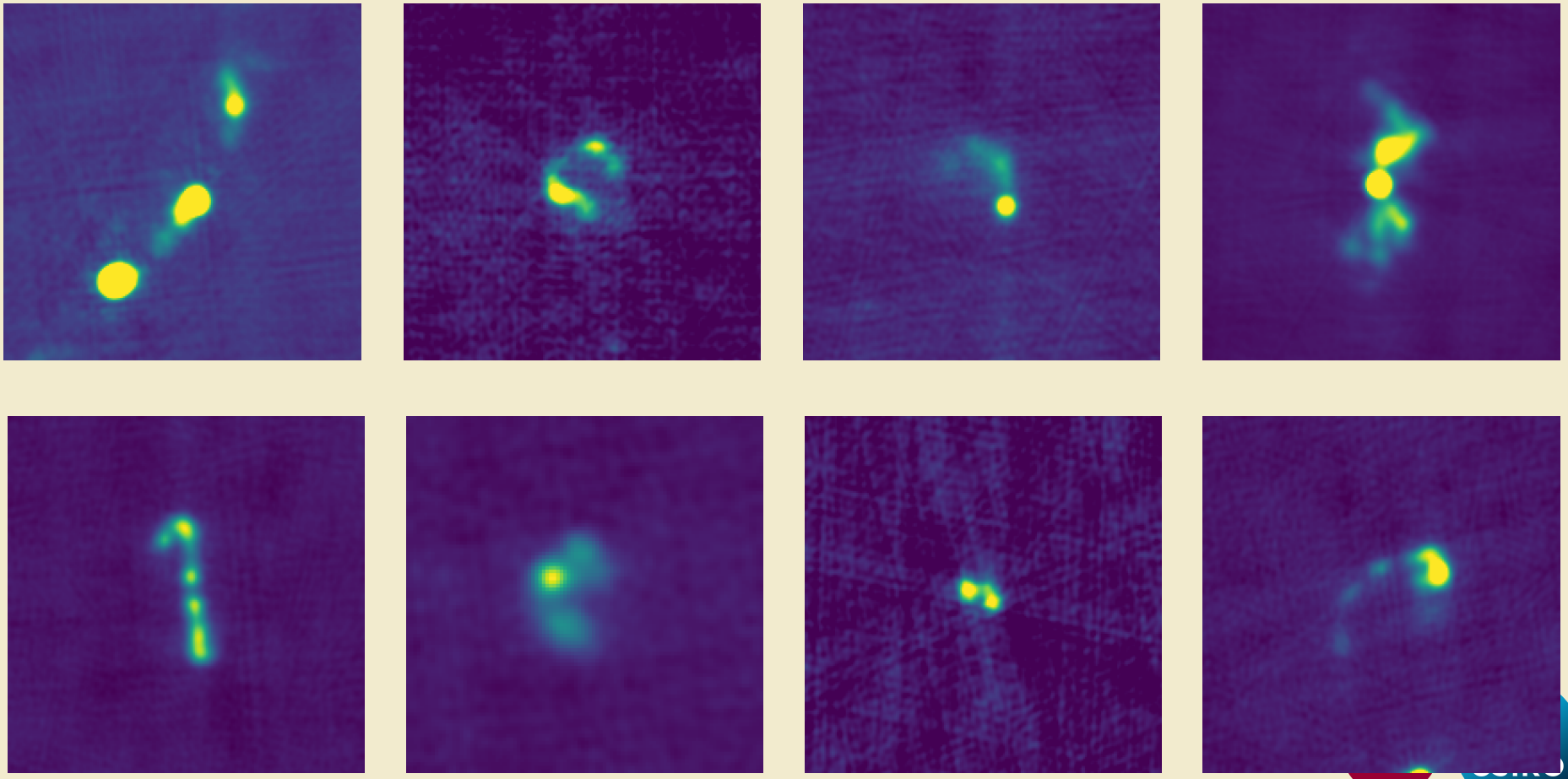
Bent-lobe sources

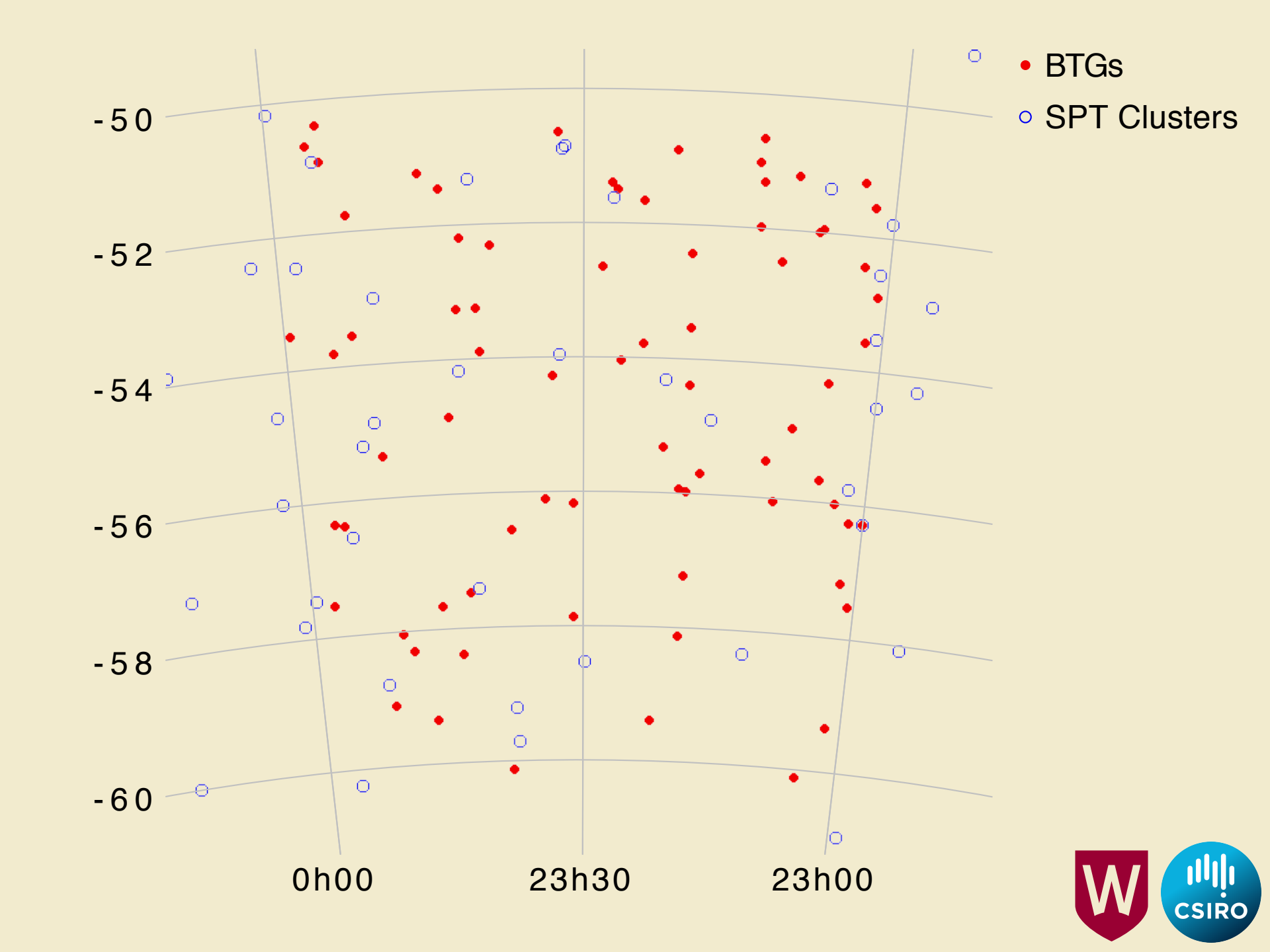
- Locally ($z < 0.1$) found almost exclusively in high density regions (Mao et al. 2009)
- Distant Universe, believed to signify large-scale structure with associations persisting out to $z \sim 2$ (Dehghan et al. 2011)
- Result of ram pressure due to relative motion to ICM (Gunn & Gott 1972; Miley et al. 1972)



Bent-lobe sources in ATLAS-SPT

- Detected 75 candidates




BTGs
SPT Clusters
-50
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-54
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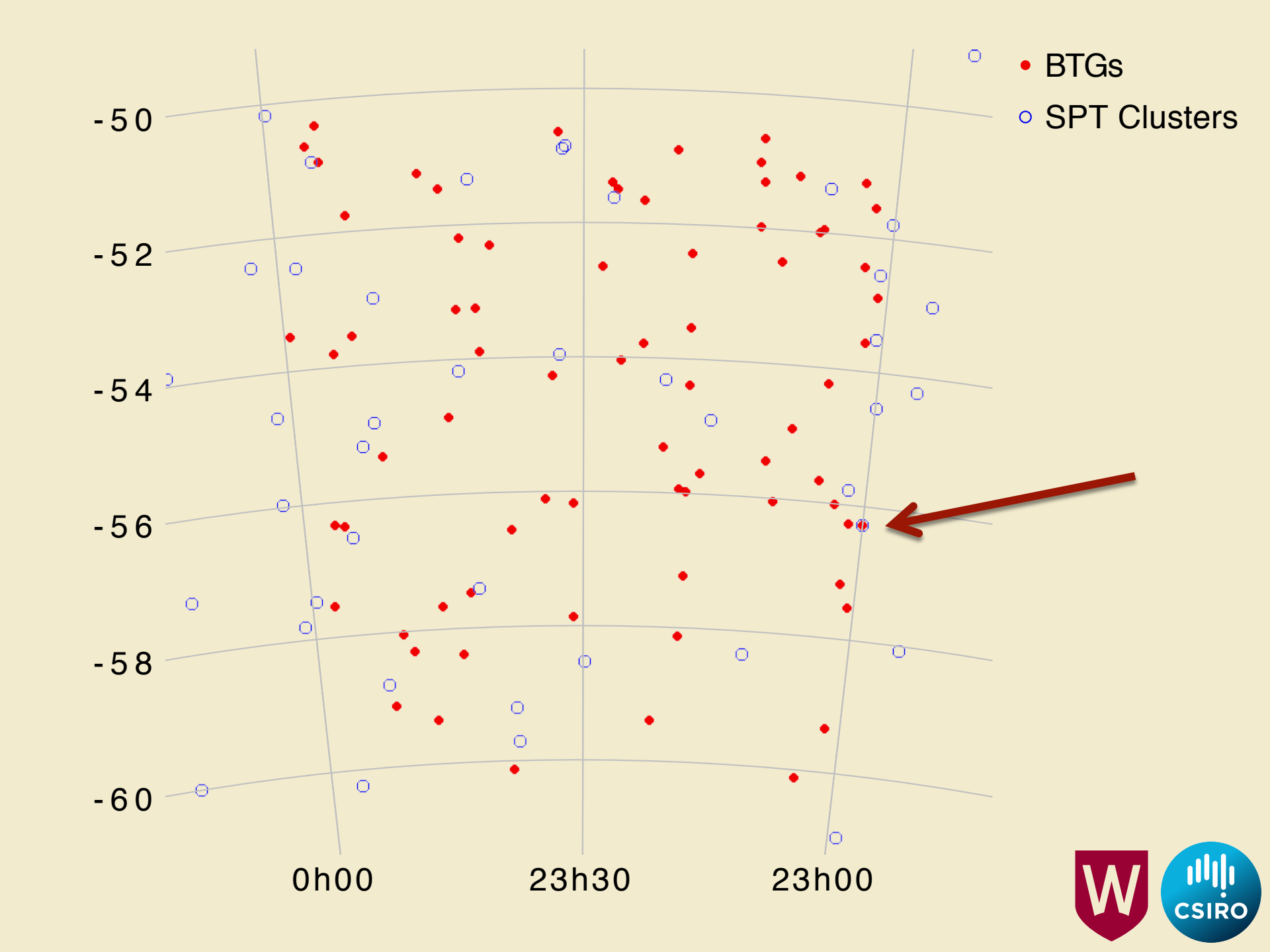
23h00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-52
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