Sunyaev Zel'dovich Array Observations of Strong Lensing Galaxy Clusters

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Strong Lensing Galaxy Clusters

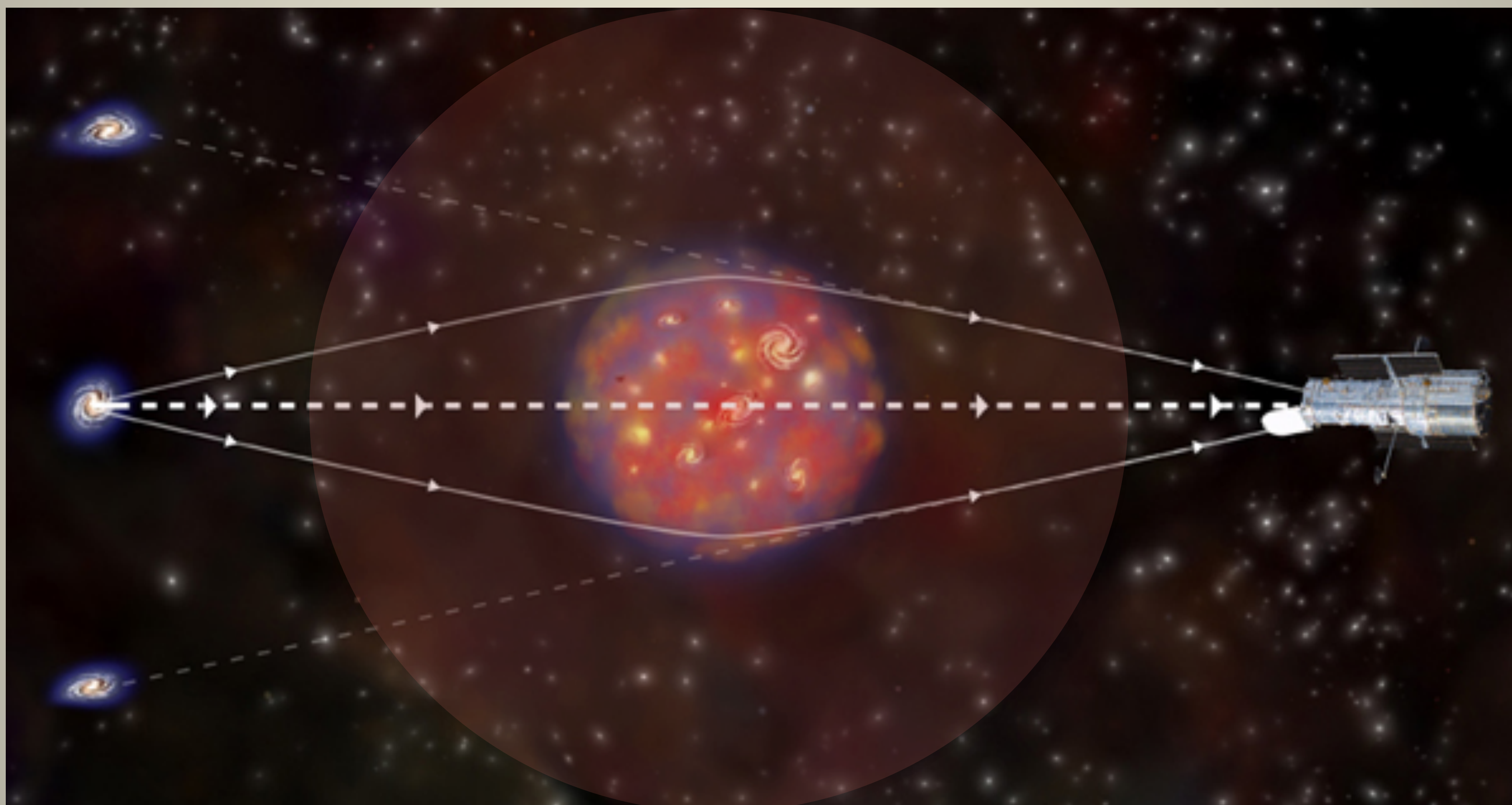


Illustration: NASA/CXC/M.Weiss

Strong lensing selection

- Ingredients that increase your strong lensing chances:
  - Mass
  - Concentration
  - Line of sight elongation
  - Substructure
  - BCG mass
  - Baryonic physics
  - Surrounding large scale structure

Mass, Concentration, Line of sight elongation: Hennawi, et al. 2007

Substructure: Meneghetti et al. 2007

BCG mass: Meneghetti et al. 2003

Baryonic physics: Rozo et al. 2008

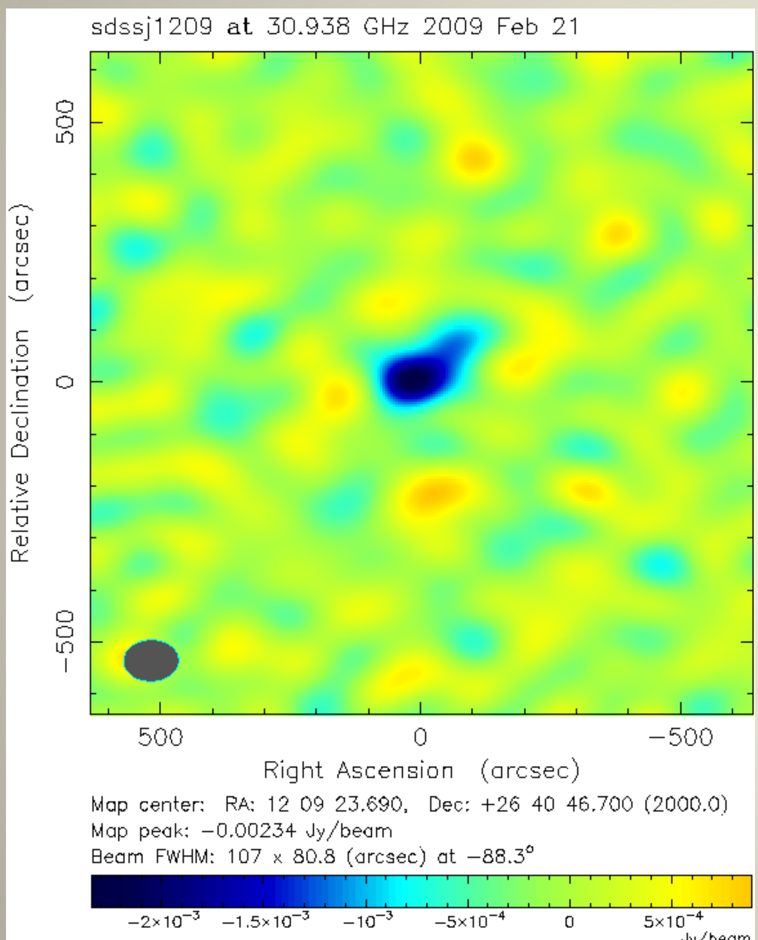
Surrounding large scale structure: Puchwein & Ewald 2009

The problem: A mismatch between theory and observations?

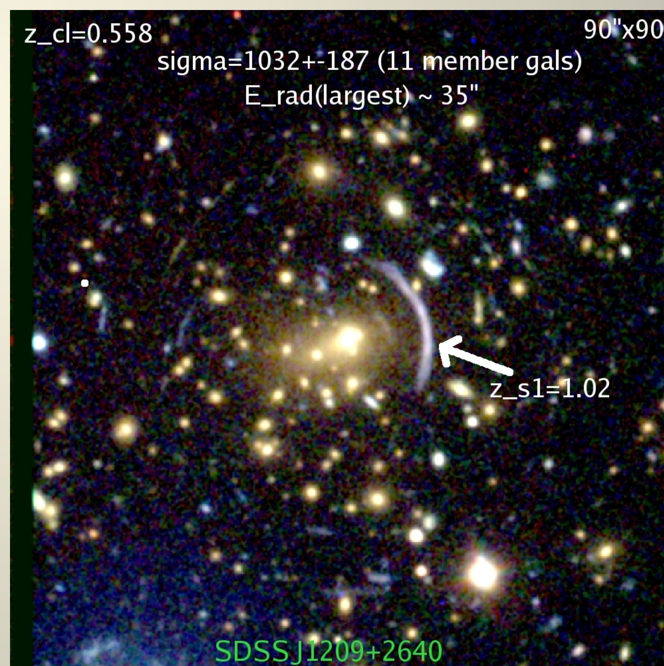
- Overconcentration problem:
  - Oguri et al. (2005) compared CDM predictions for halo triaxiality with A1689 lensing measurements: found 6% of cluster halos can match A1689 at 2σ
  - Hennawi et al. (2007) used simulations to predict average concentrations of lensing clusters. Observations of lenses indicated higher concentrations than predicted
  - Problem persists with larger samples: eg., Oguri et al. (2009)
  - But for the few clusters studied to date, this is not undisputed: eg., Limousin et al. (2008); Morandi et al. (2010)
- Broadhurst & Barkana (2008) recast this from concentration measurement to comparison between virial masses and core masses. They showed that observed Einstein radii for 4 well-studied clusters lie well beyond predicted distribution in the standard Λ-CDM cosmology

Strong lensing clusters in our sample

SZA observations of SDSSJ1209

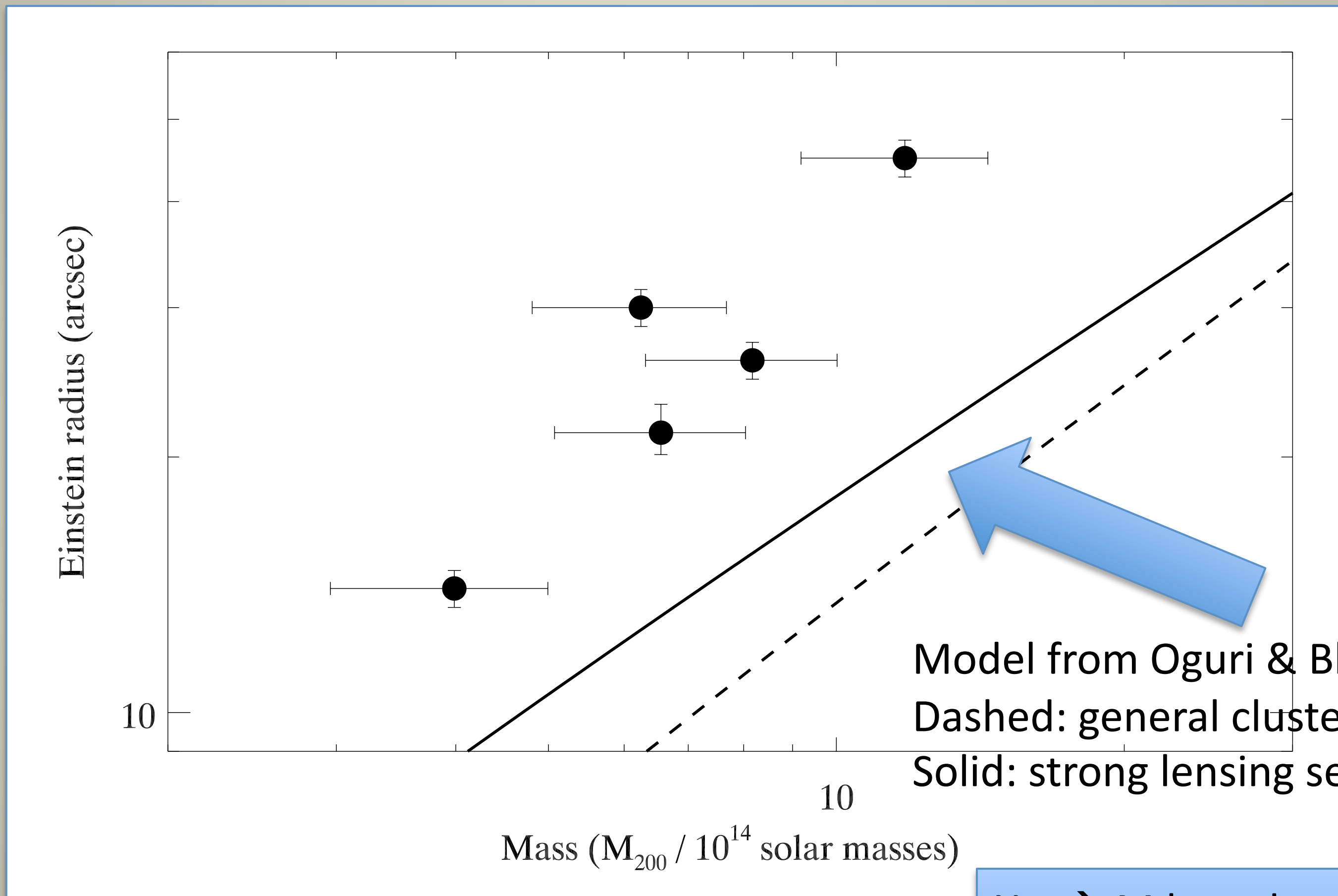


30 GHz SZ observations. 2 off-center point sources removed from map. 11.3 hours of on-source, un-flagged observing time



Discovery paper: Ofek, Seitz & Klein (2008)

Masses of lenses

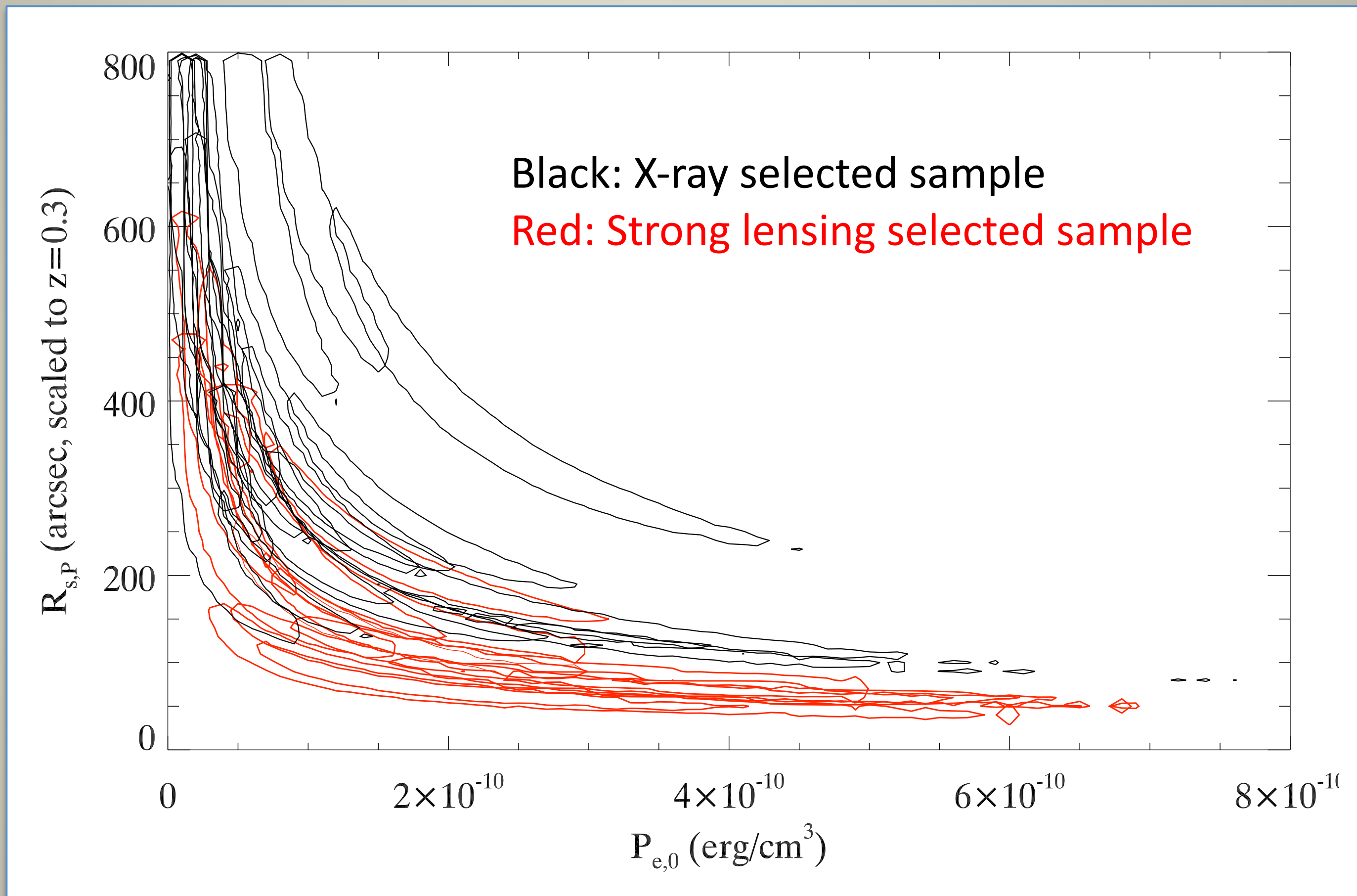


Model from Oguri & Blandford (2009)
Dashed: general cluster population
Solid: strong lensing selected clusters

Theory and observations do not agree!

Y_{SZ} → M based on
scaling relation using LOCUSS
Weak lensing: Okabe et al.
SZ: Marrone et al.

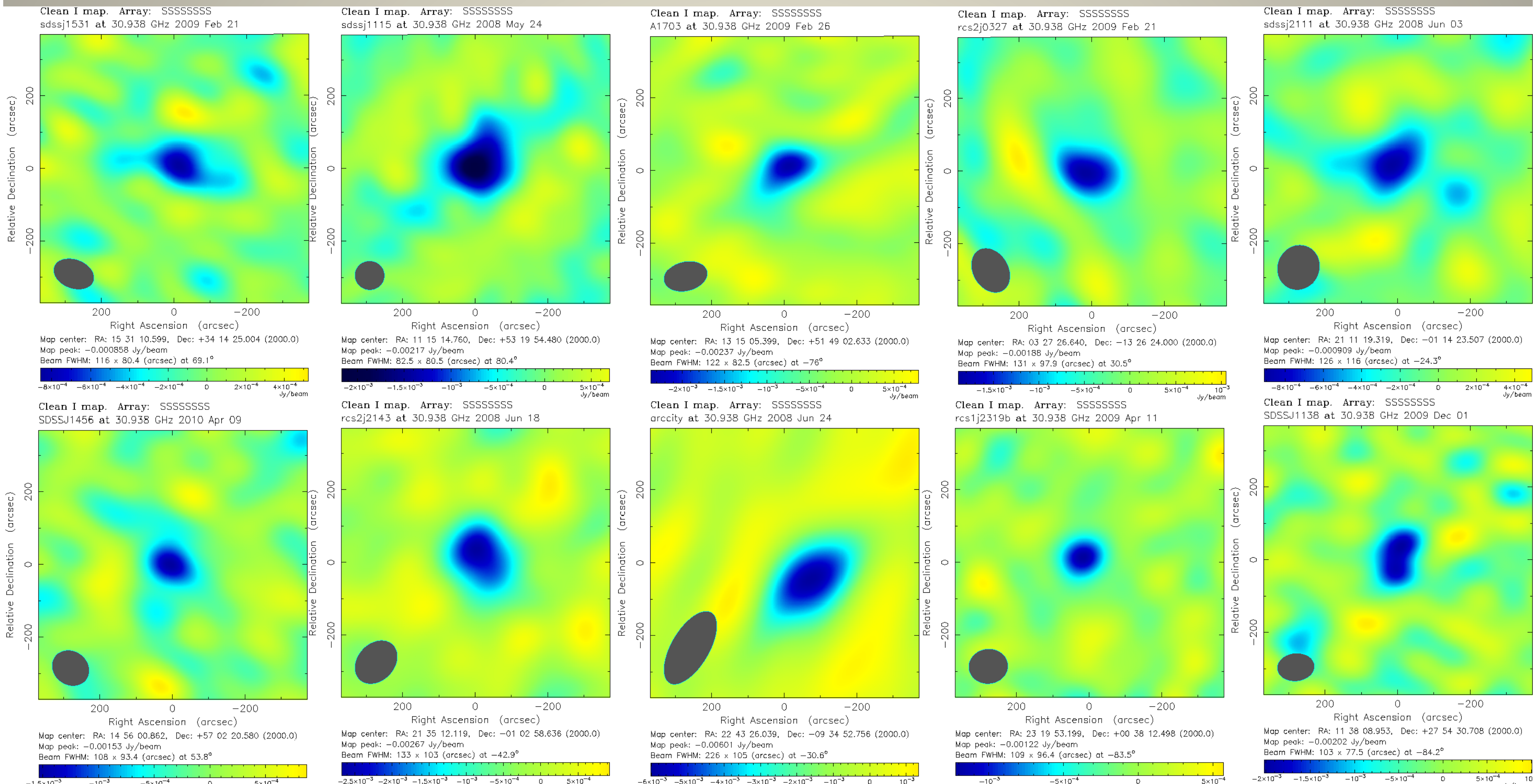
Strong Lensing Selection in the SZ Data



The SZ data indicate that for a given pressure (→mass), strong lensing selected clusters have smaller scale radii (higher 2D concentration) than X-ray selected clusters

Conclusions

- SZ observations indicate that strong lensing clusters have smaller scale radii
- We find that strong lensing selected clusters of a given mass are more efficient strong lenses than theory predicts
- Future work:
  - Observing a subsample at 90 GHz to better constrain shapes of pressure profiles at higher angular resolution
  - Combining with archival X-ray data, particularly to test for elongation along the line of sight
    - Have analyzed data for SDSSJ1115 and find line of sight elongation 1.6


Clean I map. Array: SSSSSSSS
sdssj1531 at 30.938 GHz 2009 Feb 21
Map center: RA: 15 31 10.599, Dec: +34 14 25.004 (2000.0)
Map peak: −0.000858 Jy/beam
Beam FWHM: 116 x 80.4 (arcsec) at 69.1°
Clean I map. Array: SSSSSSSS
sdssj1115 at 30.938 GHz 2008 May 24
Map center: RA: 11 15 14.760, Dec: +53 19 54.480 (2000.0)
Map peak: −0.00217 Jy/beam
Beam FWHM: 82.5 x 80.5 (arcsec) at 80.4°
Clean I map. Array: SSSSSSSS
A1703 at 30.938 GHz 2009 Feb 26
Map center: RA: 13 15 05.399, Dec: +51 49 02.633 (2000.0)
Map peak: −0.00237 Jy/beam
Beam FWHM: 122 x 82.5 (arcsec) at −76°
Clean I map. Array: SSSSSSSS
rcs2j0327 at 30.938 GHz 2009 Feb 21
Map center: RA: 03 27 26.640, Dec: −13 26 24.000 (2000.0)
Map peak: −0.00188 Jy/beam
Beam FWHM: 131 x 97.9 (arcsec) at 30.5°
Clean I map. Array: SSSSSSSS
sdssj2111 at 30.938 GHz 2008 Jun 03
Map center: RA: 21 11 19.319, Dec: −01 14 23.507 (2000.0)
Map peak: −0.000909 Jy/beam
Beam FWHM: 126 x 116 (arcsec) at −24.3°
Clean I map. Array: SSSSSSSS
SDSSJ1456 at 30.938 GHz 2010 Apr 09
Map center: RA: 14 56 00.862, Dec: +57 02 20.580 (2000.0)
Map peak: −0.00153 Jy/beam
Beam FWHM: 108 x 93.4 (arcsec) at 53.8°
Clean I map. Array: SSSSSSSS
rcs2j2143 at 30.938 GHz 2008 Jun 18
Map center: RA: 21 35 12.119, Dec: −01 02 58.636 (2000.0)
Map peak: −0.00267 Jy/beam
Beam FWHM: 133 x 103 (arcsec) at −42.9°
Clean I map. Array: SSSSSSSS
arccity at 30.938 GHz 2008 Jun 24
Map center: RA: 22 43 26.039, Dec: −09 34 52.756 (2000.0)
Map peak: −0.00601 Jy/beam
Beam FWHM: 226 x 105 (arcsec) at −30.6°
Clean I map. Array: SSSSSSSS
rcs1j2319b at 30.938 GHz 2009 Apr 11
Map center: RA: 23 19 53.199, Dec: +00 38 12.498 (2000.0)
Map peak: −0.00122 Jy/beam
Beam FWHM: 109 x 96.4 (arcsec) at −83.5°
Clean I map. Array: SSSSSSSS
SDSSJ1138 at 30.938 GHz 2009 Dec 01
Map center: RA: 11 38 08.953, Dec: +27 54 30.708 (2000.0)
Map peak: −0.00202 Jy/beam
Beam FWHM: 103 x 77.5 (arcsec) at −84.2°
Right Ascension (arcsec)
Relative Declination (arcsec)
Jy/beam