AMI: The Arcminute Microkelvin Imager

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AMI – SMALL ARRAY

- AMI Small Array: ten 3.7m dishes
- $\nu = 15$ GHz, $\Delta\nu = 6$ GHz over 8 channels
- 5 – 18 m baselines
- Ground screen to prevent radio interference

AMI– LARGE ARRAY

- AMI Large Array: upgraded Ryle Telescope.
- Eight 12.8m dishes – 10 times the collecting area of the Small Array.
- 18 – 110 m baselines but *identical frequencies* to Small Array

ADVANTAGES OF INTERFEROMETRY FOR SZ

- No scanning and measures only correlated signals:
  — not susceptible to scan-synchronous systematics
  — antenna pointing and primary beam shape not major concerns

- Automatically removes low spatial-frequency signals on sky
  rejection of atmospheric signal
  rejection of amplifier total power
  rejection of 2.7K CMB *and* of first (four) primordial acoustic peaks

- Required resolution achievable without building a big expensive antenna

- Gives superb astronomical fringe rate filtering

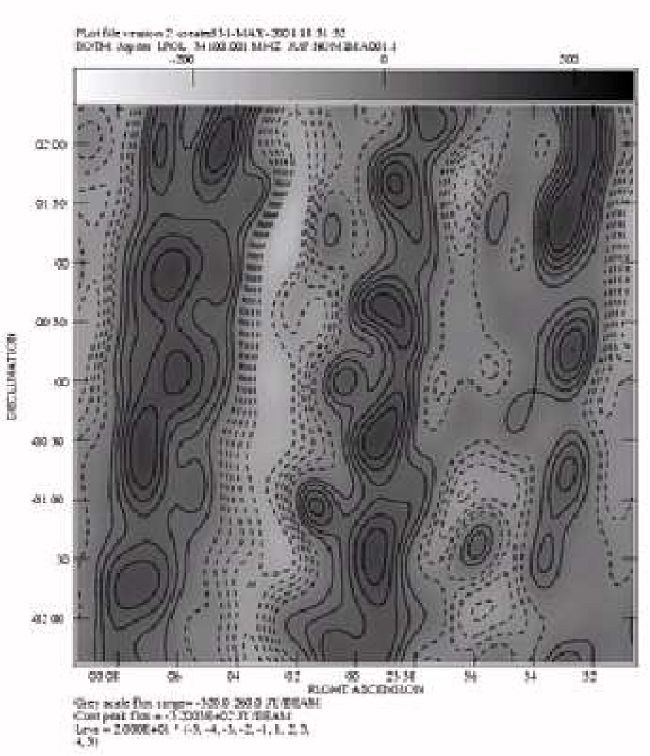
- BUT since interferometer of baseline d measures FT of sky on scale λ/d, need *correct range* of baselines

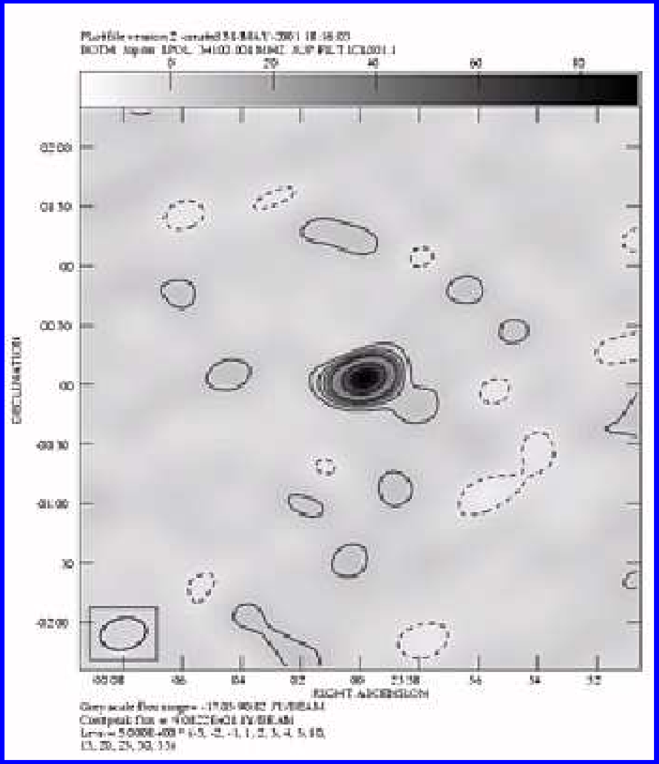
- AND need high sensitivity to detect faint (low mass) clusters.

FRINGE-RATE FILTERING

- Due to changing path-difference to antenna pairs, sky signal modulated at known astronomical fringe rate.

⇒ can filter out signals that do not come from the part of the sky being observed





- Can also filter out ground-spill and cross-talk.

SURVEYING FOR CLUSTERS WITH SZ

- Measure $\frac{\mathrm{d}n(M,z)}{\mathrm{d}z}$ to constrain cosmology

— probes volume-redshift relation
— probes abundance evolution
— cluster structure and evolution

- SZ surface brightness independent of z

⇒ **Can detect clusters out to high z**

- SZ effectively measures cluster total energy

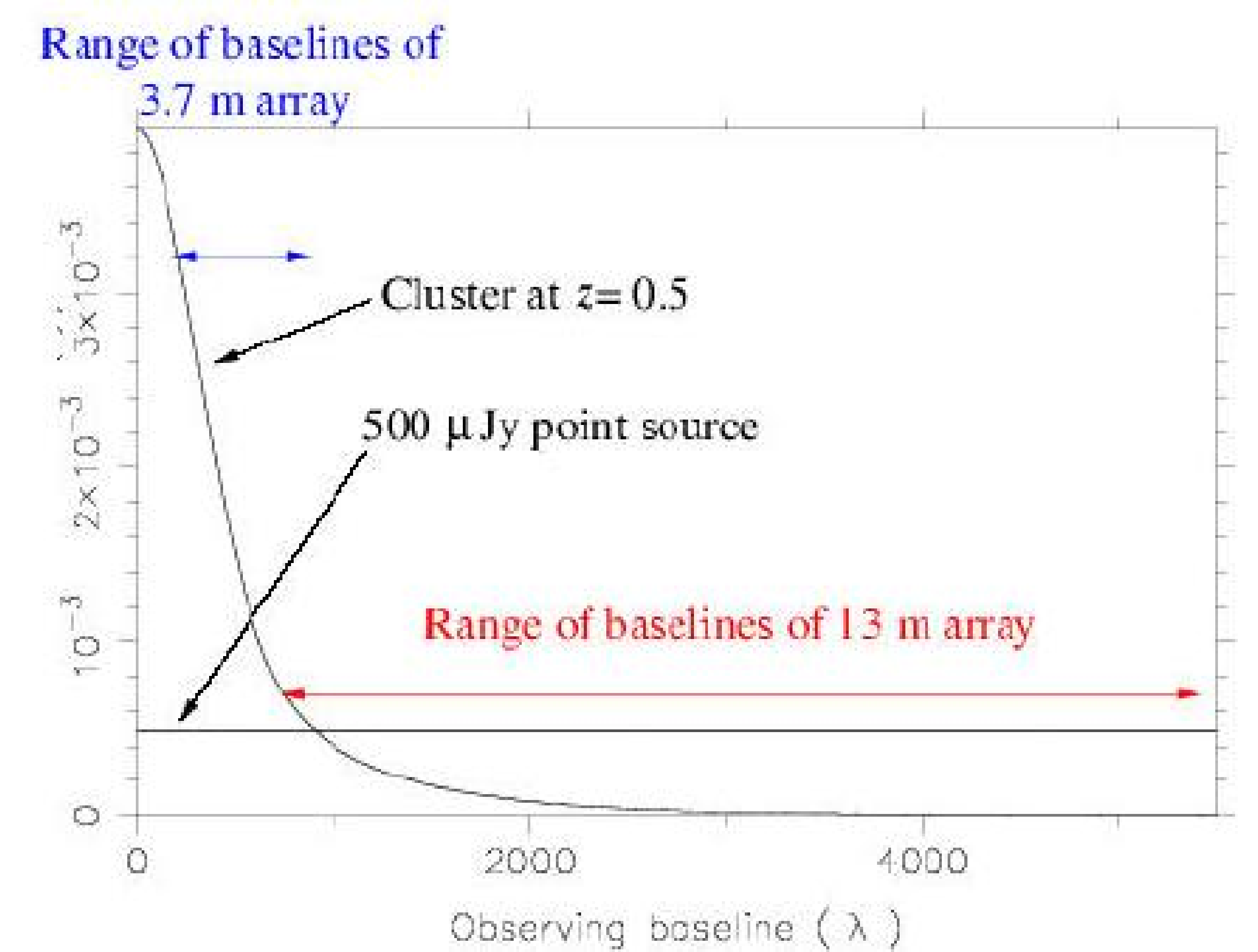
$$S_{\mathrm{SZ}} = \int \Delta T \mathrm{d}\Omega \propto \frac{1}{D_{\mathrm{A}}^2} \int n_{\mathrm{e}} T_{\mathrm{e}} \mathrm{d}V \propto M T_{\mathrm{e}}$$

⇒ **Cluster selection has mild, simple bias**

- With temperature (from X-ray or scaling relation)

⇒ $S_{\mathrm{SZ}} \propto M^{5/3}$ **is a direct measure of mass.**

WHY TWO ARRAYS?



- Background radio sources are dominant contaminant
- Sources are also variable
- Spectral discrimination *across 6 GHz band* also helps

WHY 15 GHZ?

- In R-J region, SZ spectrum $I_\nu \propto \nu^2$.
- Radio sources are (*usually*) falling spectrum $I_\nu \sim \nu^{-0.5}$.

$\Rightarrow$ Go for as high a frequency as possible.

BUT:

- $T_{atmos} \sim 5$ K @ 15GHz but $T_{atmos} \sim 30$ K @ 30 GHz and rising fast
- T_{HEMT} worsens with frequency.

SO:

- 15 GHz feasible for SZ but need lots of longer-baseline flux sensitivity to subtract radio sources...
- ...and the 13-m dishes of the old RT are fine for this – form the basis of the Large Array

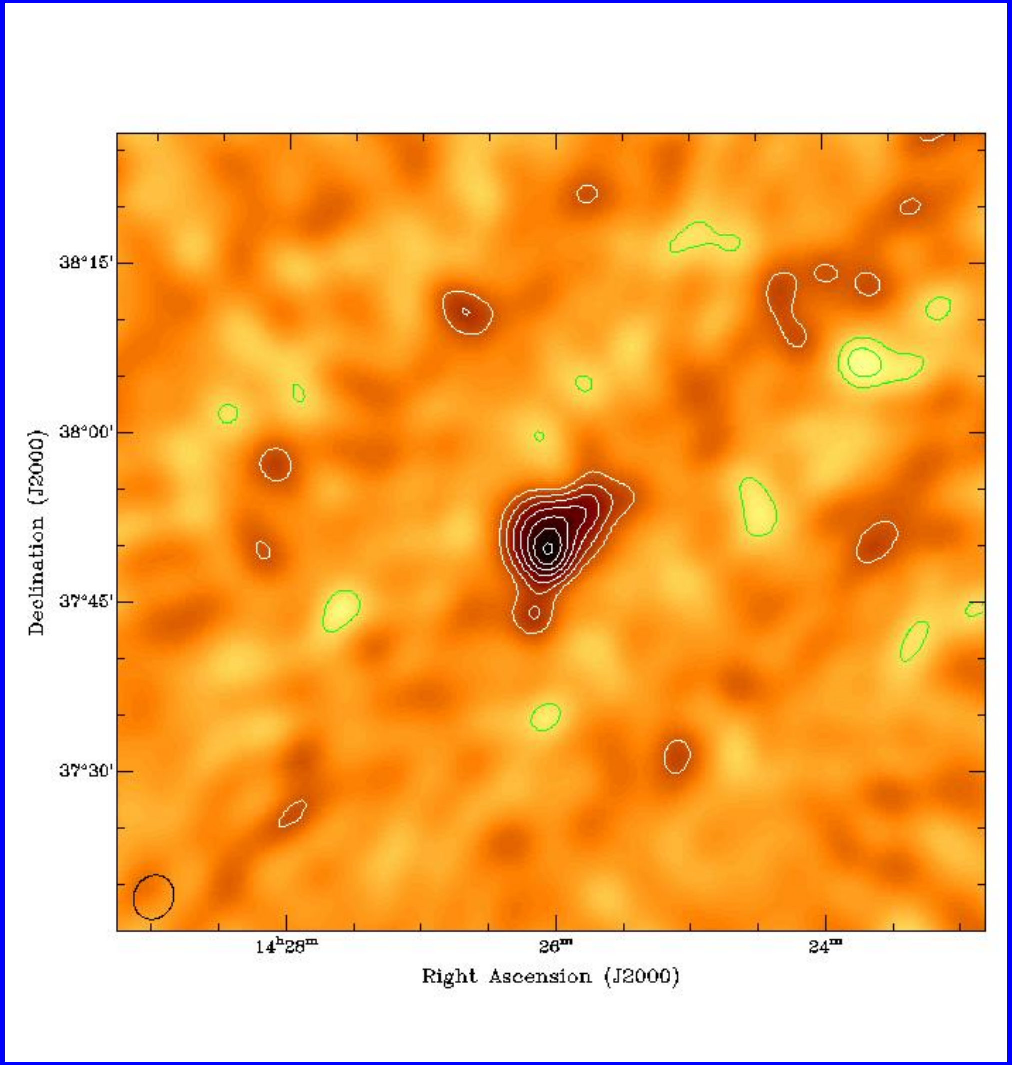
RYLE TELESCOPE ANTENNA MOVE

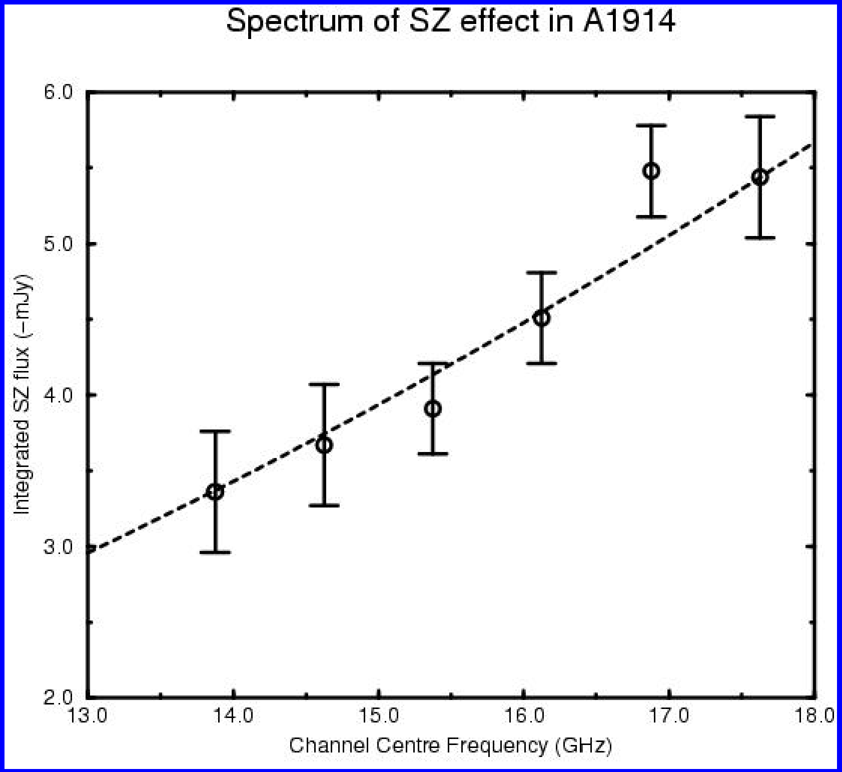
- Need long baselines – upgraded Ryle Telescope (baselines 18 – 110m).
- Move antennas 6, 7 and 8 of Ryle Telescope

→ compact array (filling factor) with north-south baselines (low dec observations).

RYLE TELESCOPE ANTENNA MOVE

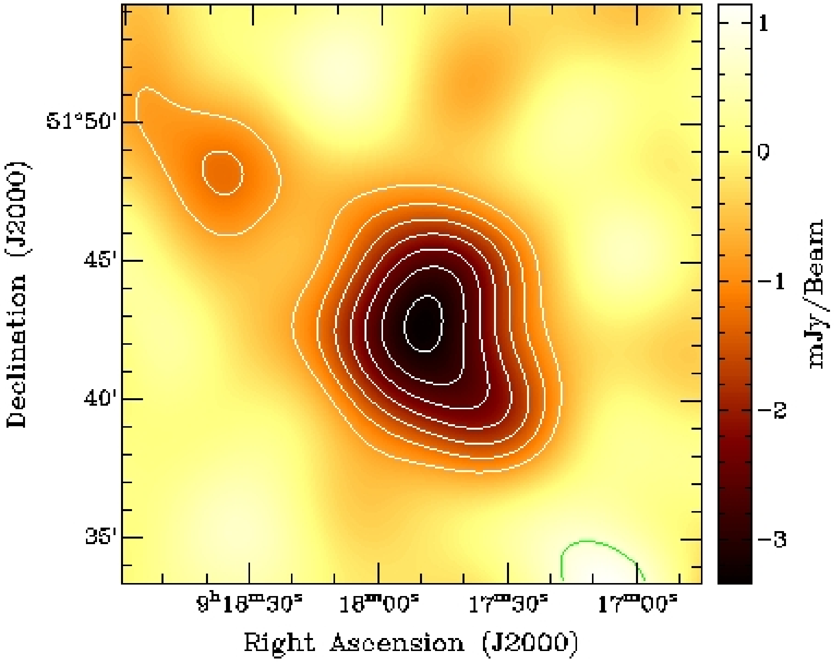
FIRST AMI SZ EFFECT – SMALL ARRAY ONLY



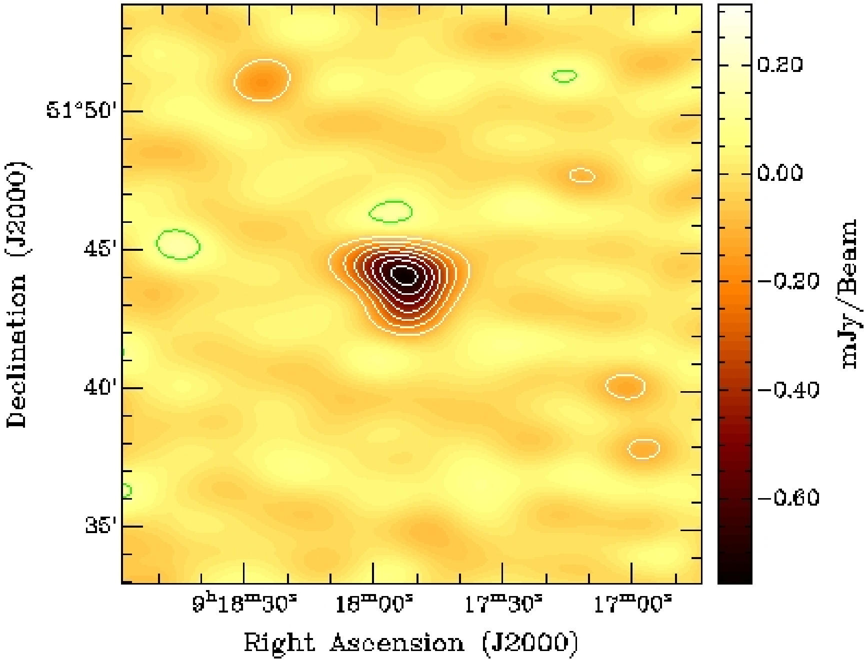

Spectrum of SZ effect in A1914

- A1914, $z = 0.17$ (MNRAS 369L, 1)

SZ EFFECT IN A773 – COMPARISON TO RT



6 hour AMI image

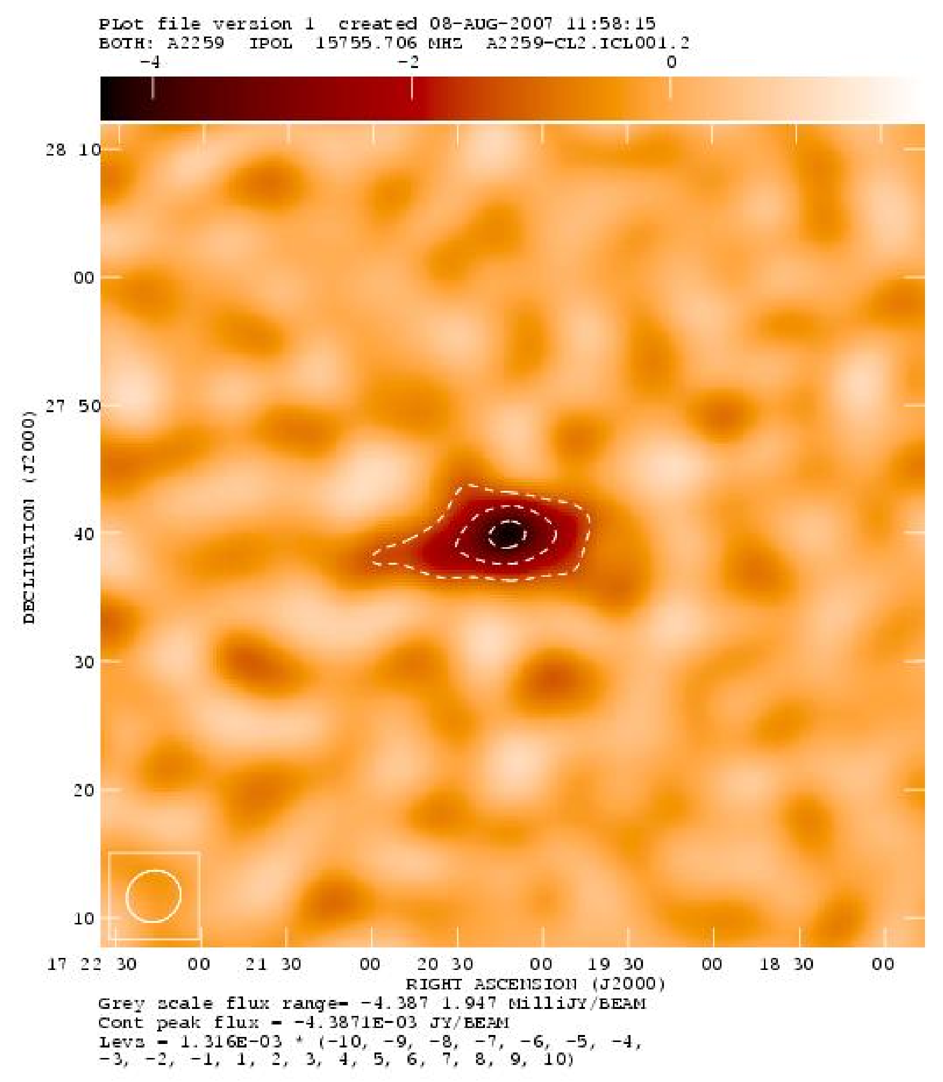


460 hour RT image

- Outer regions of gas now being detected.
- Telescope sensitivity matches theoretical prediction.

⇒ 10^3 improvement in survey speed over RT.

SZ IN A2259 – SMALL ARRAY ONLY



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PLot file version 1  created 08-AUG-2007 11:58:15
BOTH: A2259  IPOL  15755.706 MHZ  A2259-CL2.ICL001.2
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Grey scale flux range= -4.387 1.947 MilliJY/BEAM
Cont peak flux = -4.3871E-03 JY/BEAM
Levs = 1.316E-03 * (-10, -9, -8, -7, -6, -5, -4,
-3, -2, -1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
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AMI SENSITIVITY TO CLUSTER MASS

Have Small Array observations of 180 known clusters. Large Array shortly to come into operation. Then have full SZ capability.

Using *actual* Small Array SZ performance and measured Large Array sensitivity, and assuming $T_e \propto M^{2/3}$, estimate:

- 5σ detection of $3 \times 10^{14} M_{\odot}$ high-z cluster in 8 hours
- 5σ detection of $2 \times 10^{14} M_{\odot}$ high-z cluster in 50 hours

AMI SURVEYING REGIMES (N.B. DEC MUST BE >-10 DEG

MEDIUM depth / medium area. Starting with the first of these: 10 1-sq-deg CFHR R and z' fields and XMM-LSS. 1 sq deg in 12x24hr 5σ detections of $3 \times 10^{14} M_\odot$ high-z clusters.

SHALLOW depth / wide area. Depends in part on what we finf in MEDIUM.

DEEP depth / small area. The 5σ detection of $2 \times 10^{14} M_\odot$ in 50 hr is at the confusion limit due to unsubtracted sources *assuming* the measured source counts at 5 mJy are simply extrapolated to 0.05 mJy; the real situation must be better than this.

FINALLY, FOR XMM PROPOSAL

Good X-ray survey as well as SZ means you can really understand all the biases *and* you can get to grips with the scaling relations etc etc

BUT ALSO need X-ray pointed observations of SZ-discovered clusters

AND, X-RAY ASTRONOMERS:

Twenty five percent of AMI time is *open* after first year of survey