APEX stuff – 4 Feb 2003

Martin White

Department of Physics

Department of Astronomy

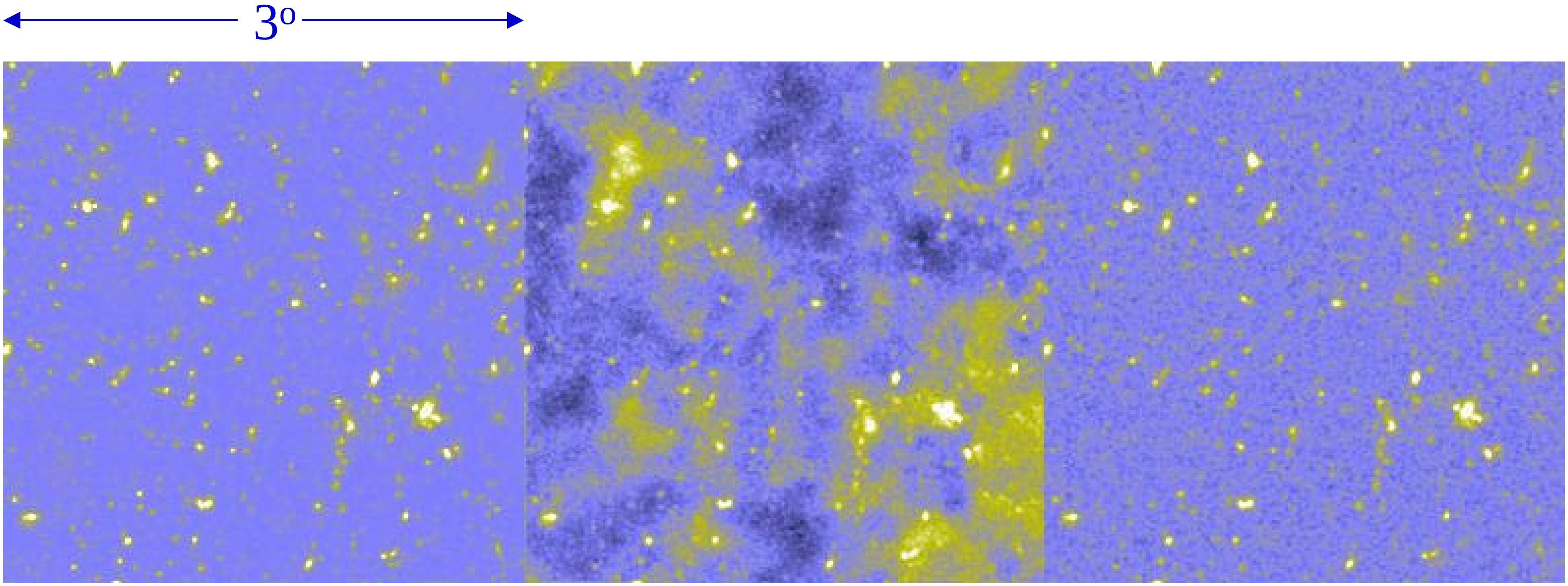
UC Berkeley

Lawrence Berkeley National Lab

Some points

- CMB confusion is quite an issue – two frequencies are better than one.
- dN/dz curves are smooth, for most cosmology don't need very accurate z's.
- If SCUBA counts are correct, foregrounds may be an issue.
- WFS is only visible 8h per day.
- Map making (drift scanning) is currently under investigation!

CMB confusion



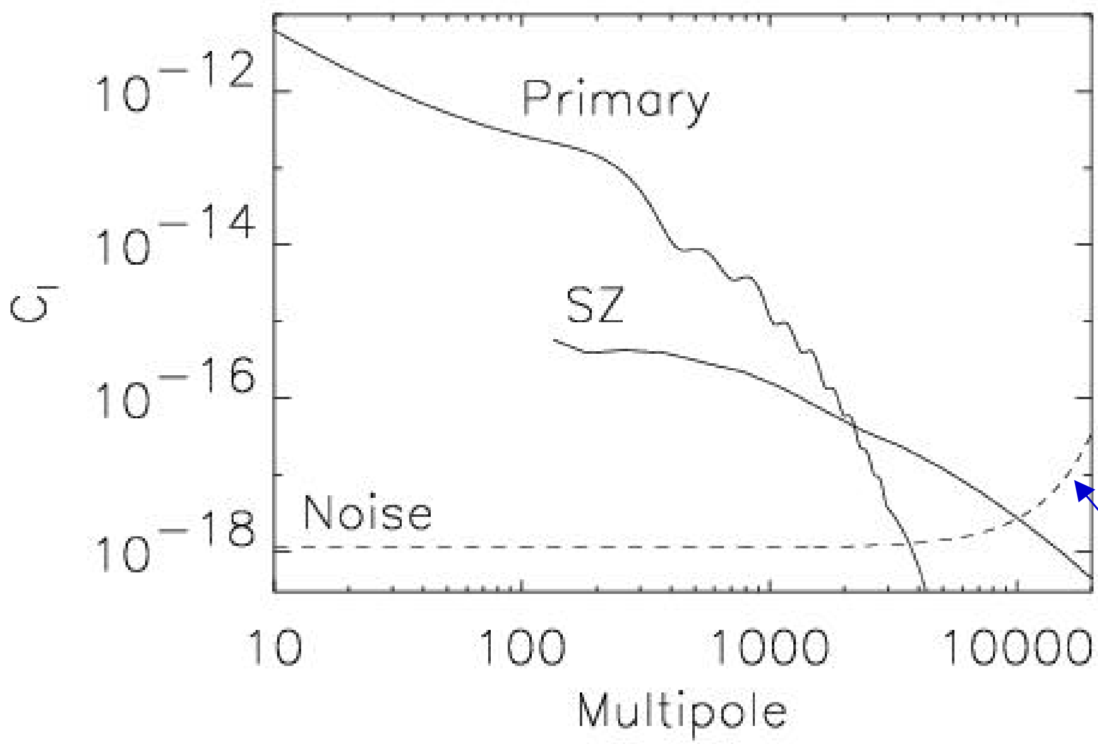
Signal

Signal+CMB+noise

Signal+noise

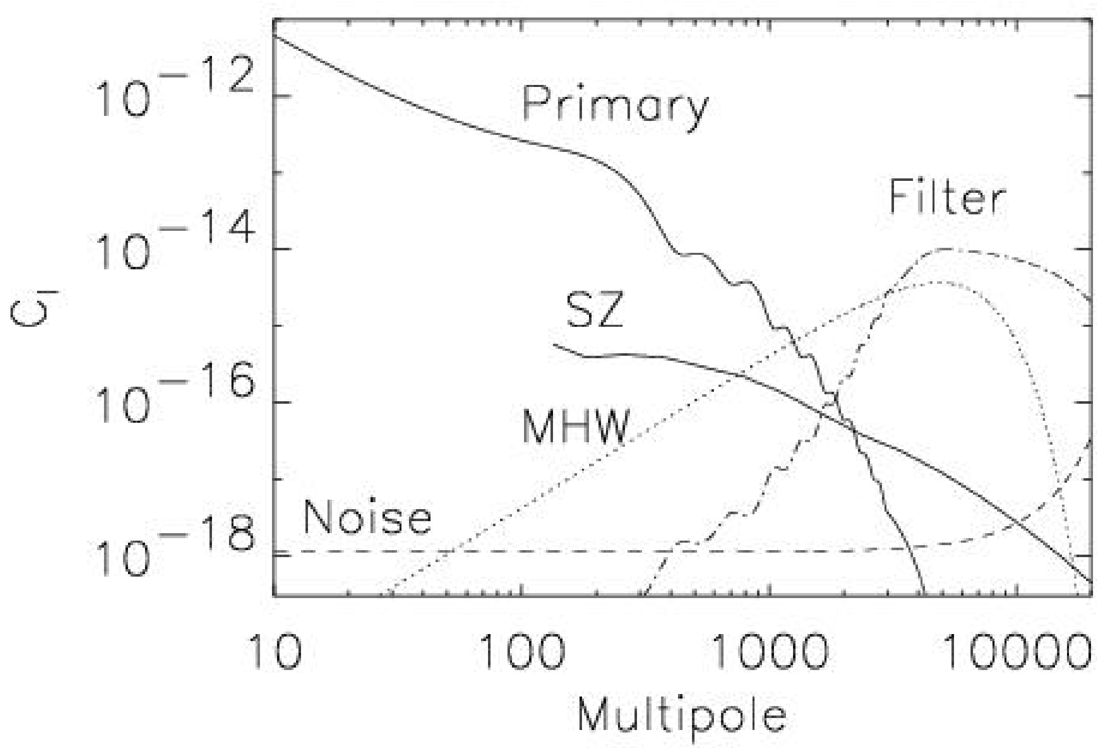
Linear color scale: -100μK to +100μK

Filtering to find sources



Effects of beam

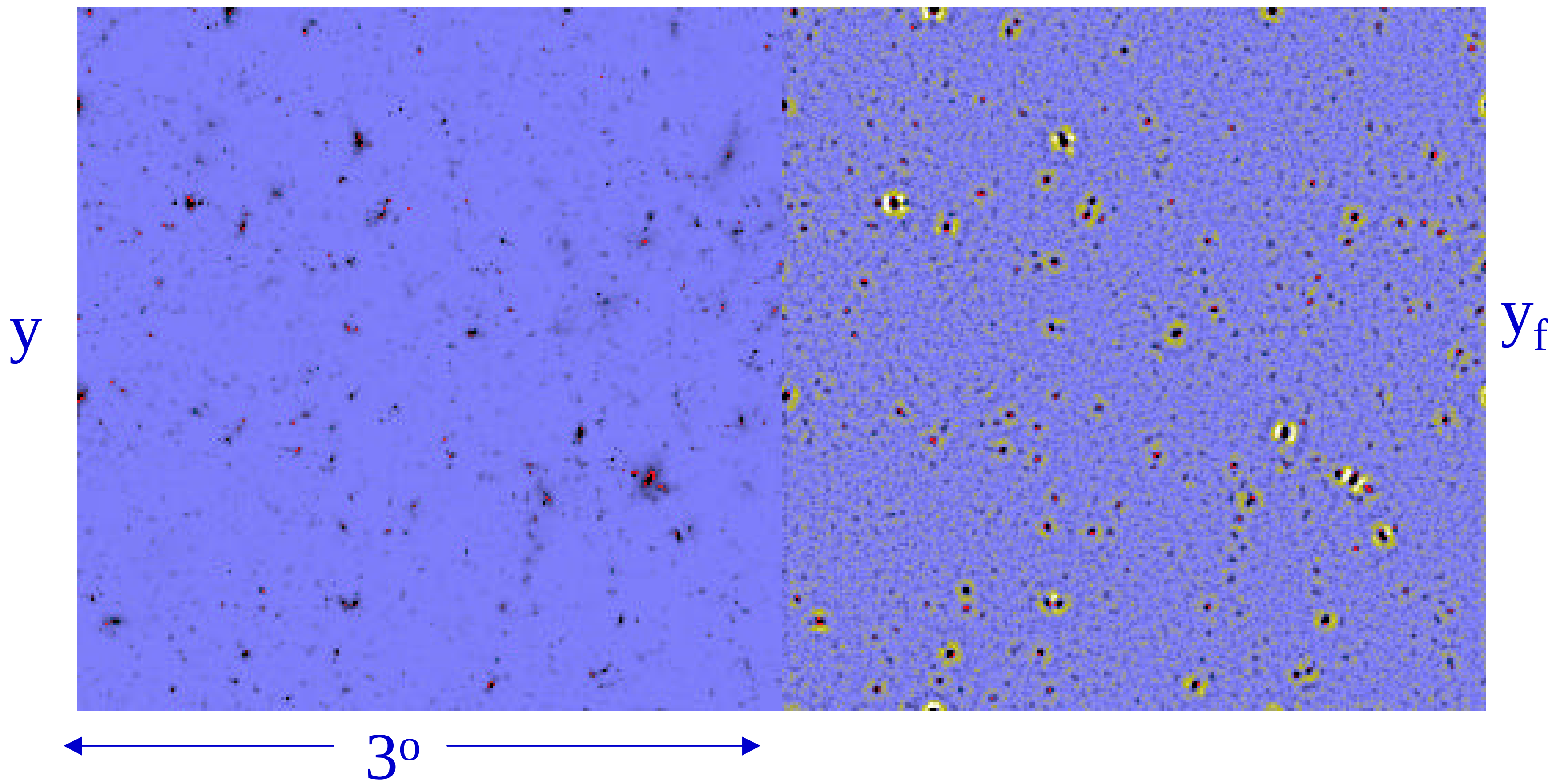
Filtering to find sources



Optimal~$1/C_l B_l$ MHW~ $l^2\, e^{-l^2}$

The drawbacks of "optimal" filtering

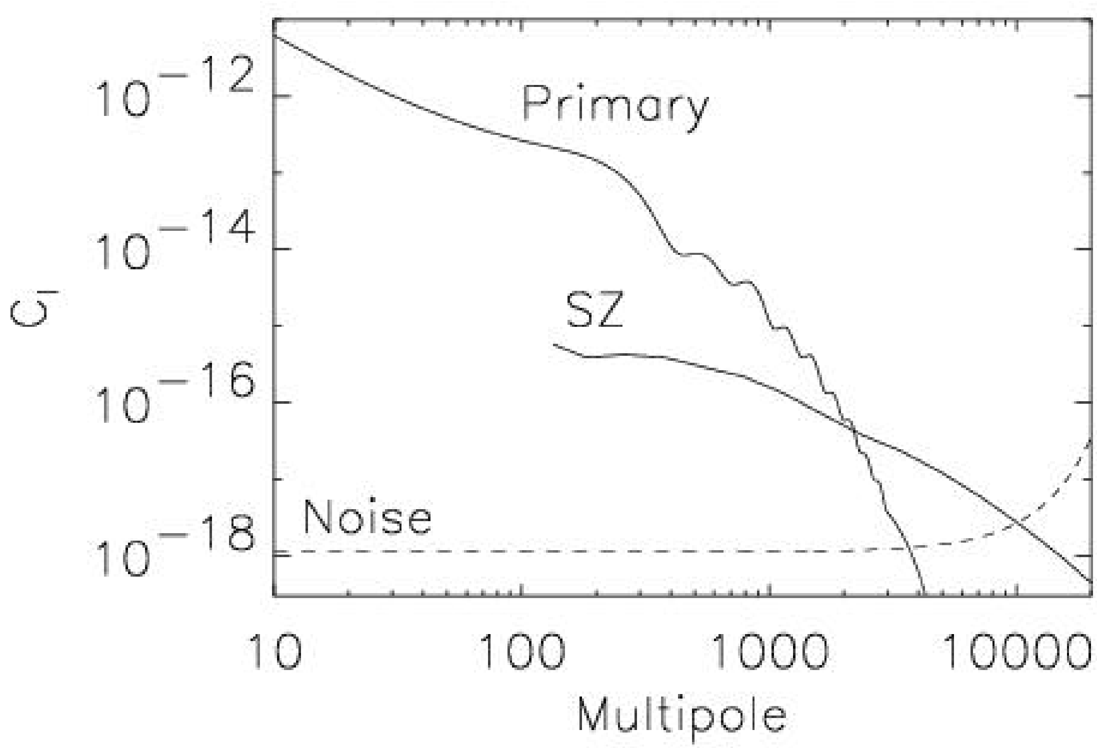
When sources are well separated and/or the background does not contribute much power on the scales of interest, filtering is relatively easy. In our situation …



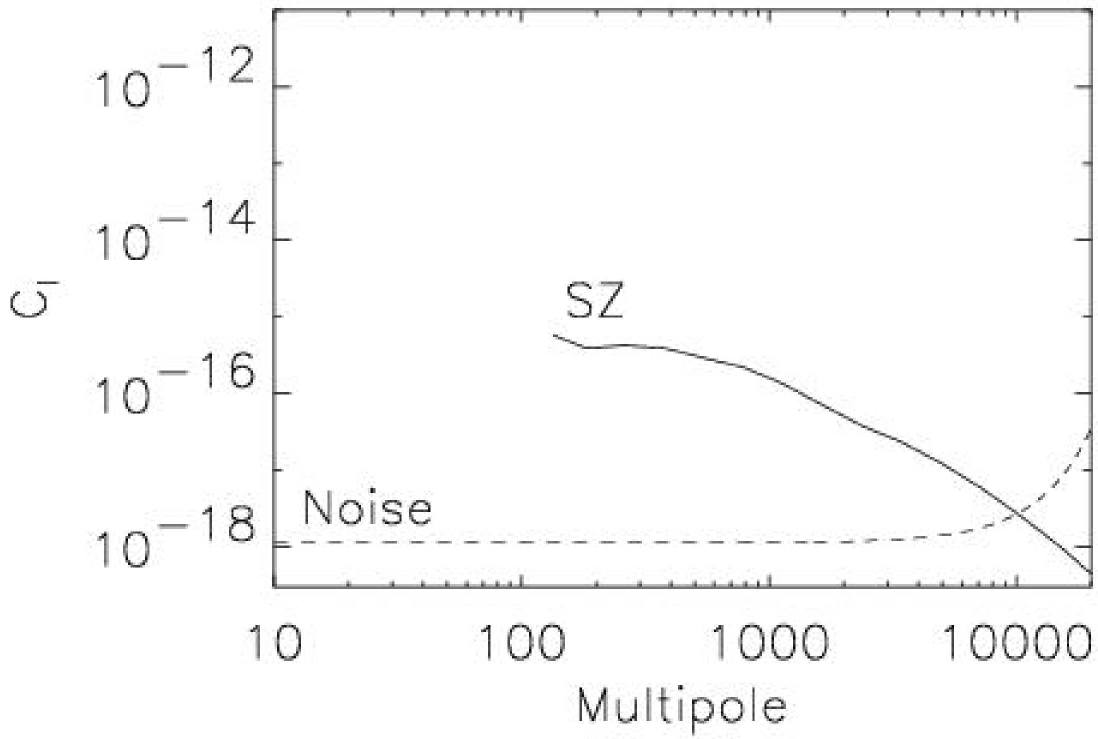
For high resolution experiments

- When the source density is high, want to avoid filters which are narrow in Fourier space … they "ring" in real space.
- But need a compensated filter to suppress slowly varying background.
- Difficult optimization problem!
- For SZ, where we know the spectrum, multi-frequency observations offer significant advantages!

Multifrequency observations turn this ….



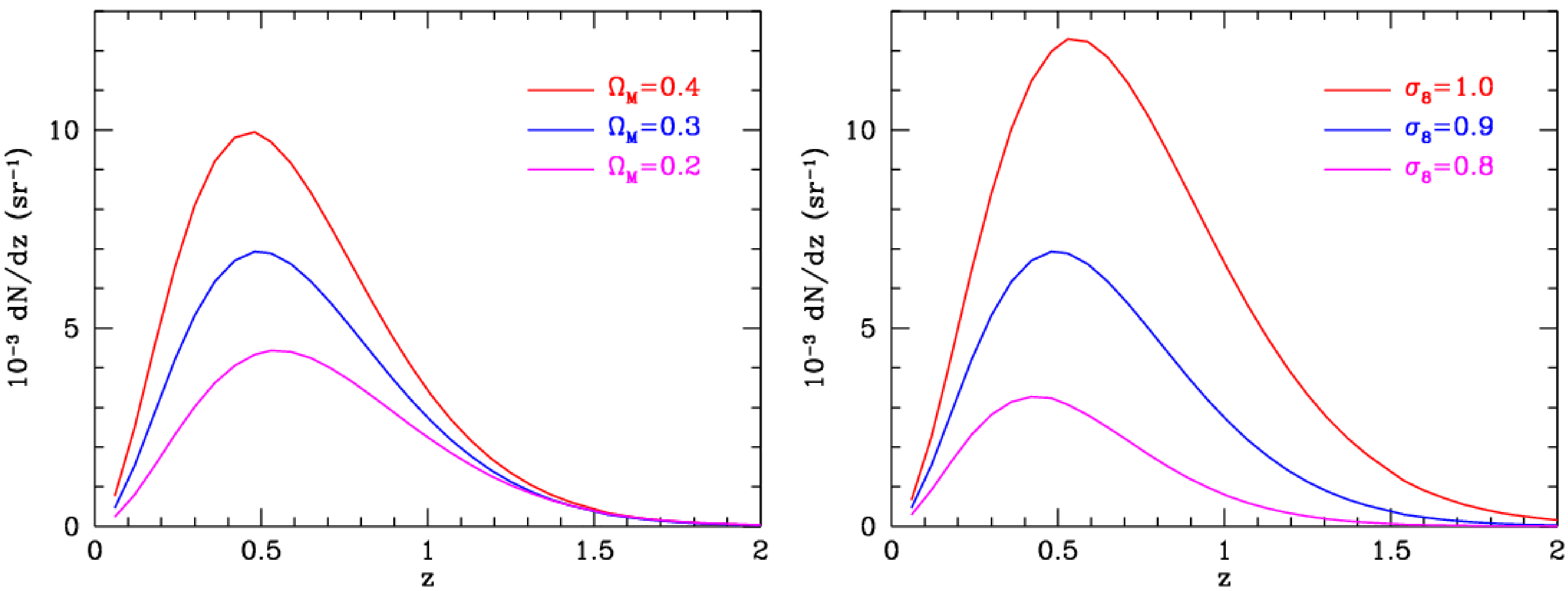
… into this!



… plus foregrounds!

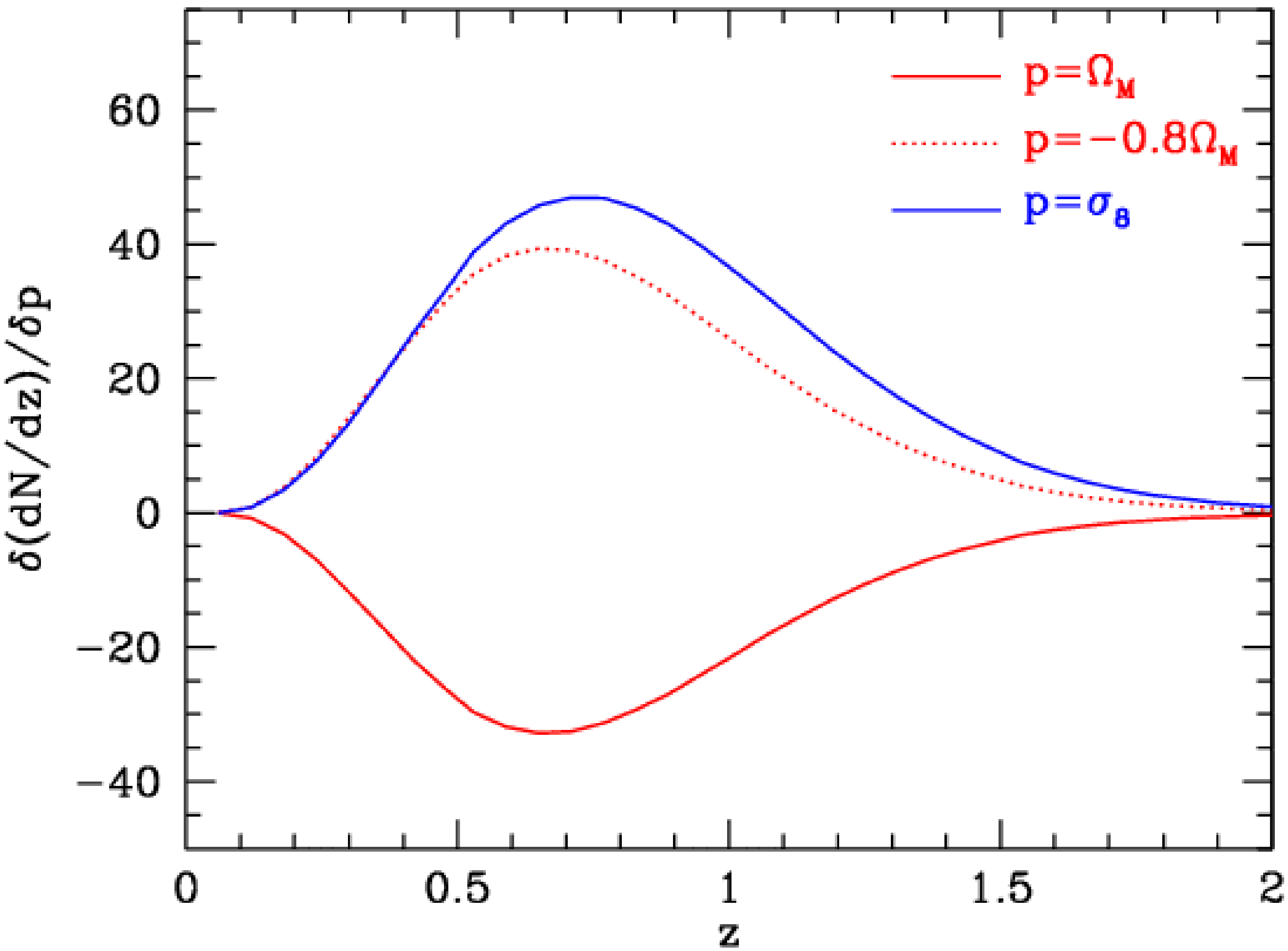
Cosmology dependence

Cluster counts are most sensitive to the matter density
and the normalization of the power spectrum.



Local abundance not held fixed!

Derivatives

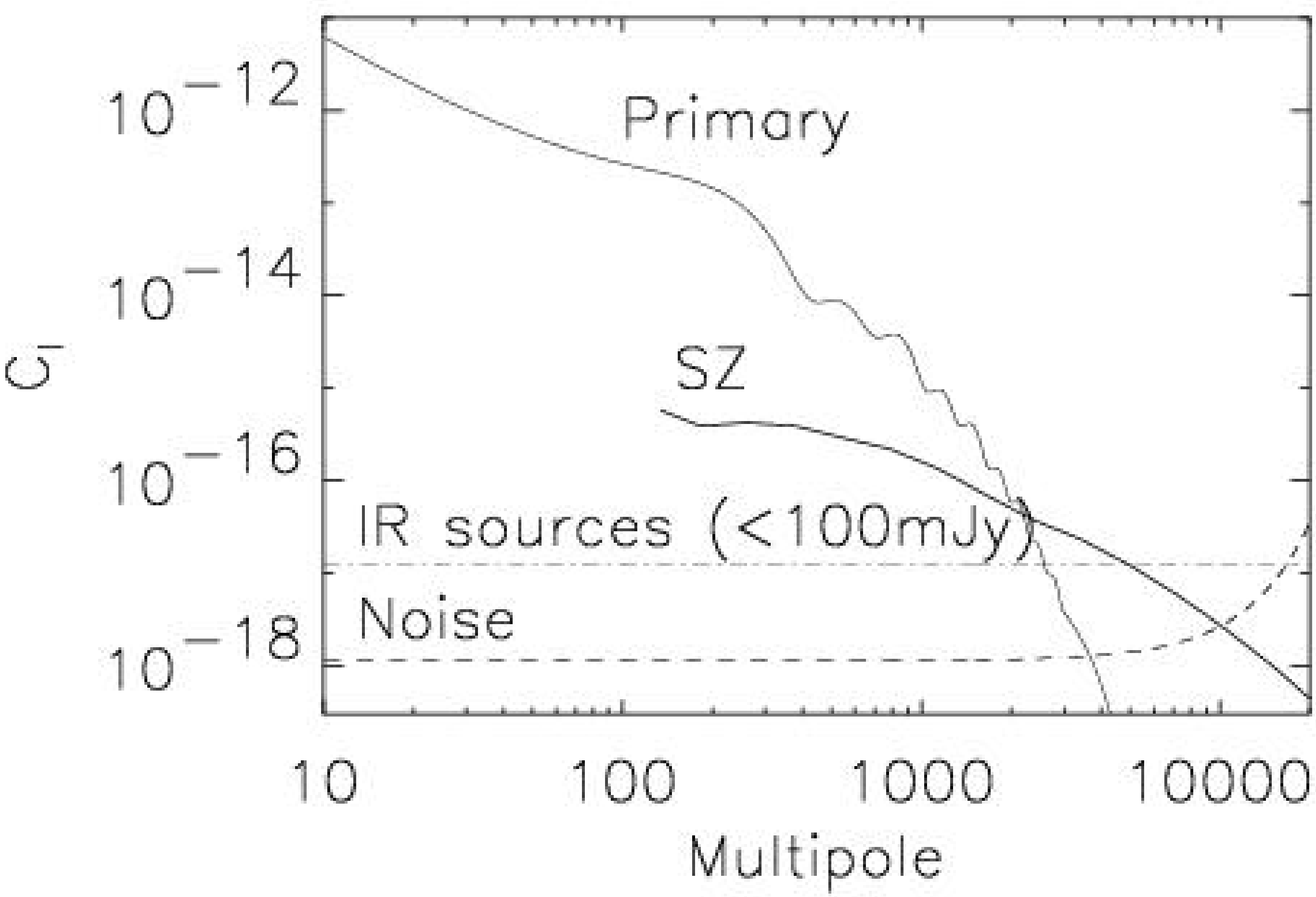


Derivatives are smooth over Δz~0.1 – don't need good redshifts!

IR point sources

- Numerous IR models exist.
- Can scale from SCUBA counts at 350GHz.
- Scale this to lower frequencies assuming signal ~ $(\nu/350)^{2.5}$

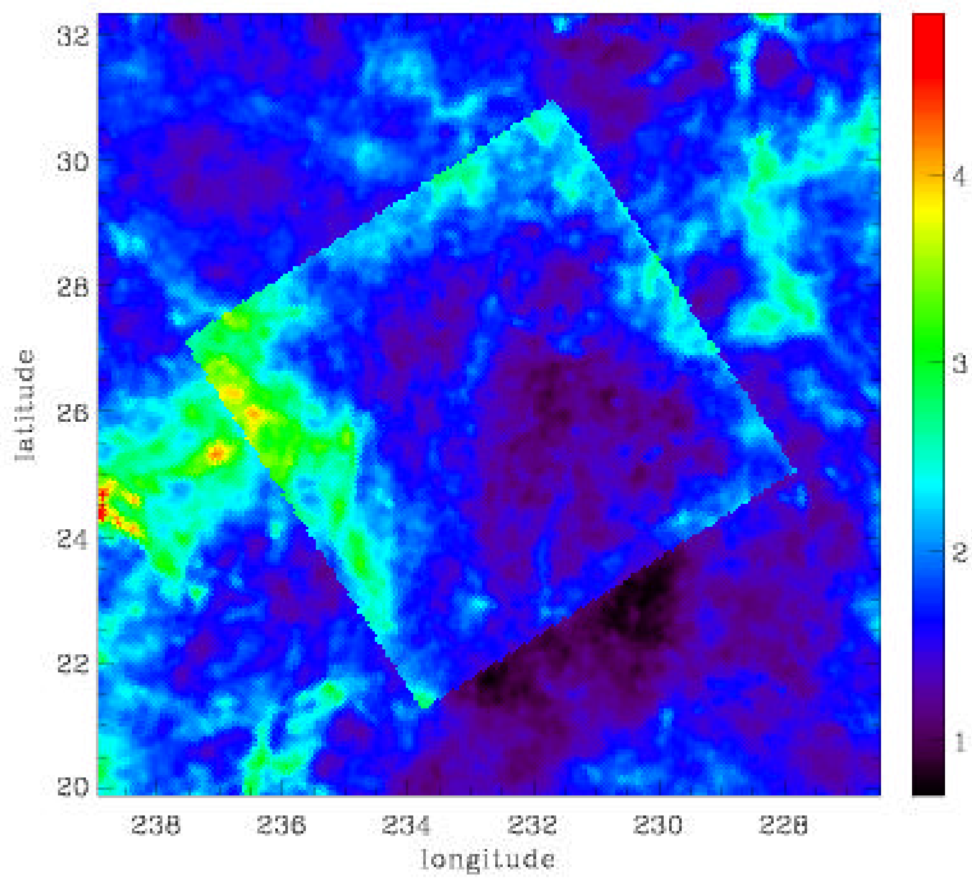
Compared to signal & noise



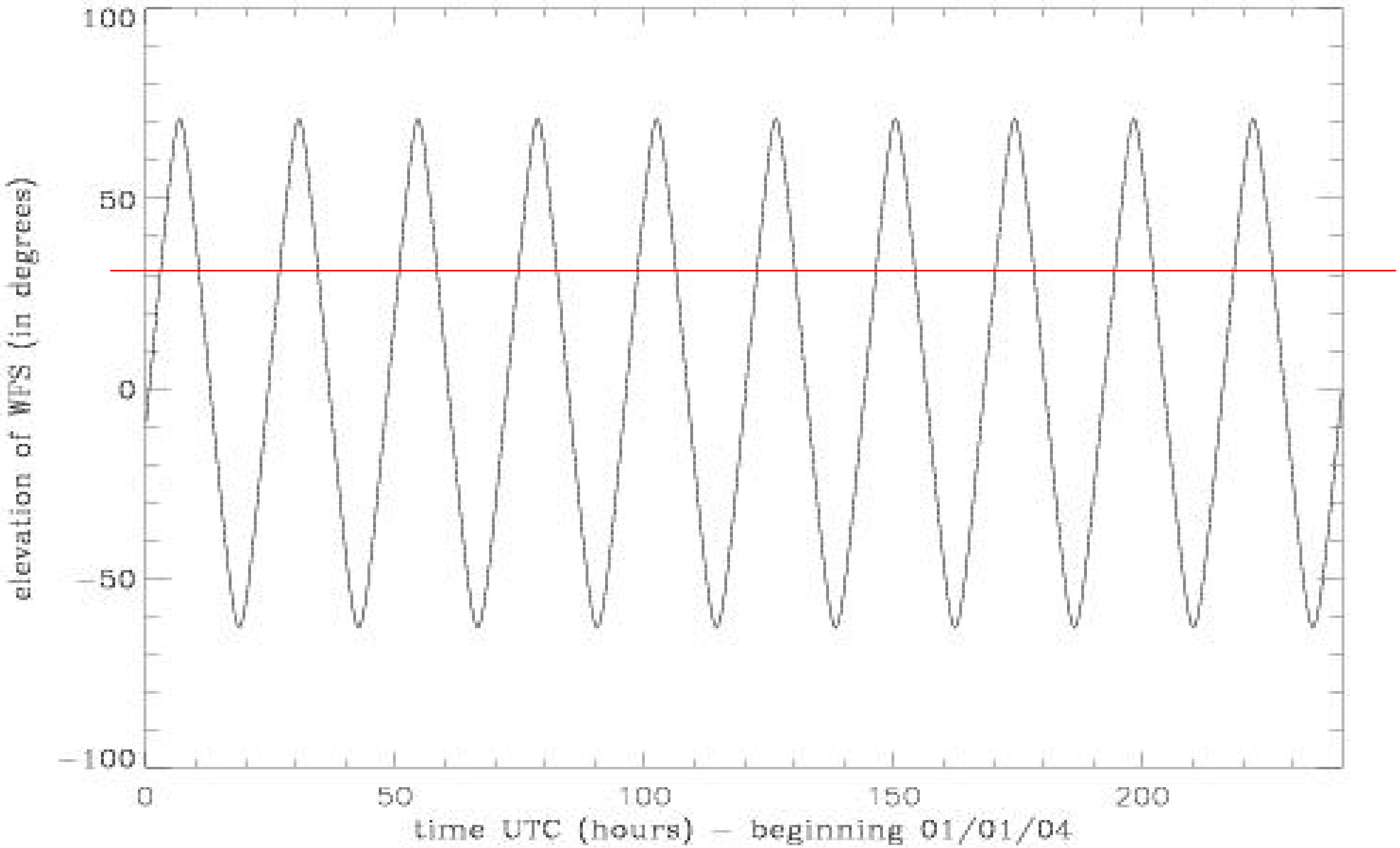
+clustering

“77SNF” field @ (9h,-4d).

IRAS 100μm map (mK)

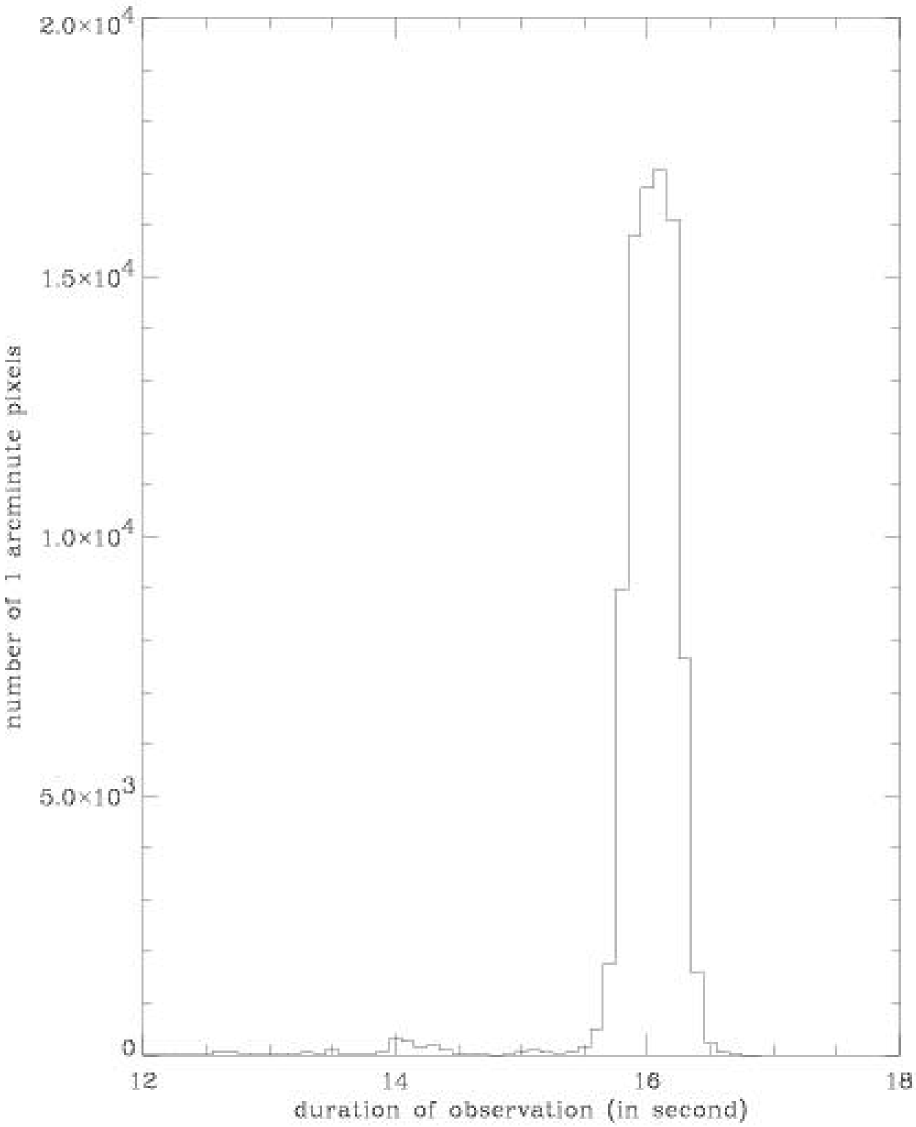


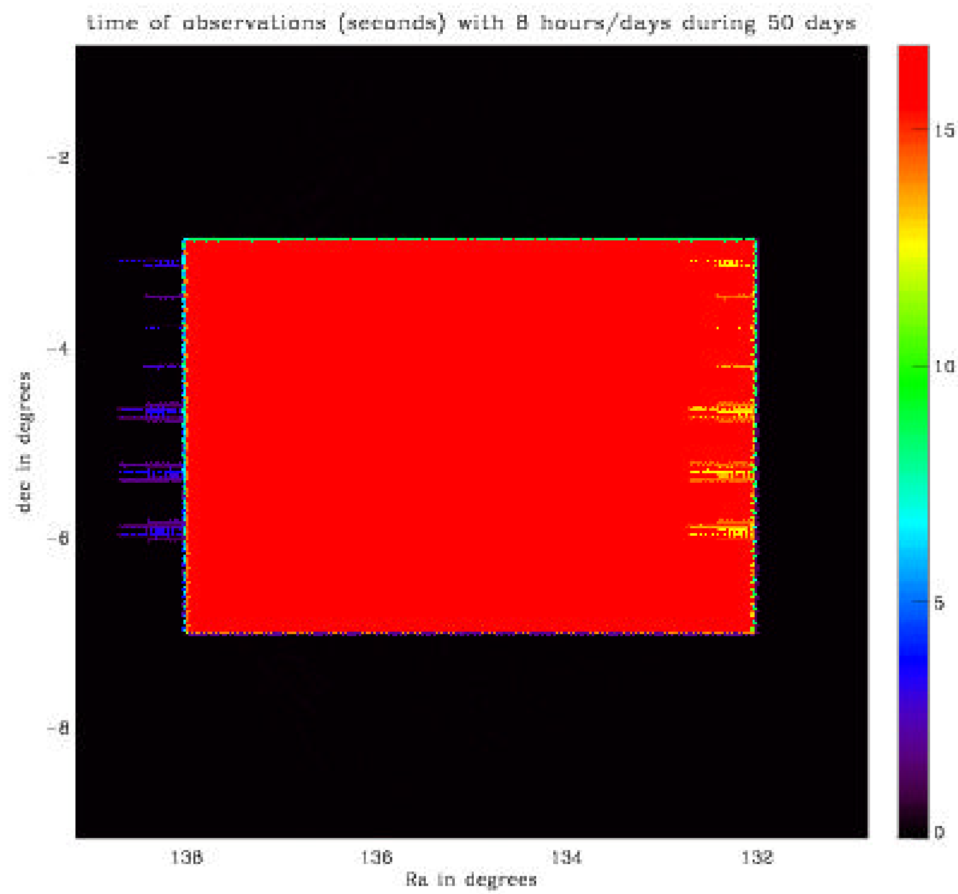
Elevation of 77SNF (above 30 for 8h/d)



The sun is not "in" this field in Jan '04.

Coverage in drift scanning mode





30 minute drift scans for 50 days
(~400 hours total)

Map making

- Alex Amblard is currently investigating scanning strategies and map making issues.
- Compare drift scanning, chopping, etc.
- Can we get some real data with atmosphere in it to learn from?

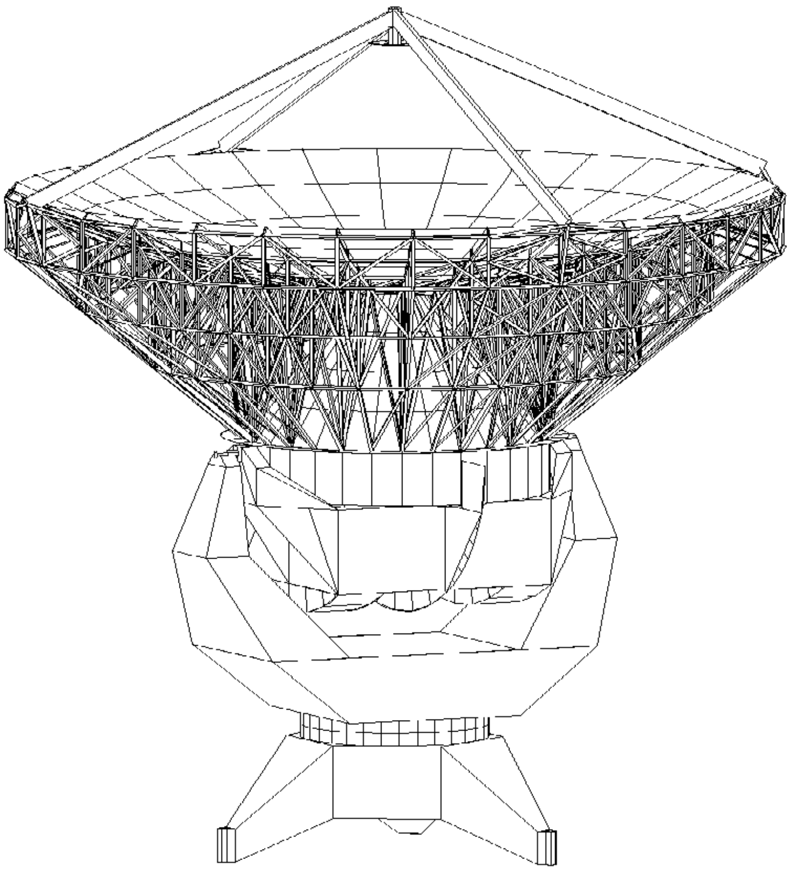
STOP

New observational handles …

Name	Type	Beam (arcmin)	Cluster Yield
ACBAR	Bolo	4	Few
Bolocam	Bolo	1	10's
SZIE	HEMT	1	100's
CBI	HEMT	4	100's
AMI	HEMT	1	100's
Amiba	HEMT	1	100's
APEX	Bolo	0.75	5,000
SPT	Bolo	1	20,000
Planck	Bolo	5	10,000
ALMA	HEMT	--	--

ALMA pathfinder experiment (APEX)

MPIfR/ESO/Onsala/Berkeley



Telescope Specifications:

- 12 m on-axis ALMA prototype.
- 45’’ at 150 GHz/ 30’ field of view.
- Use in drift scanning mode.
- Located at 16,500 ft in the Andes.
- Telescope and receiver fully funded.

Receiver Specifications:

- 300 element bolometer array
- 300 $\mu K\ s^{1/2}$
- **1 pixel @ 10μK in 3 sec!!**

On line, late 2004

25% of telescope time will be dedicated to SZ survey

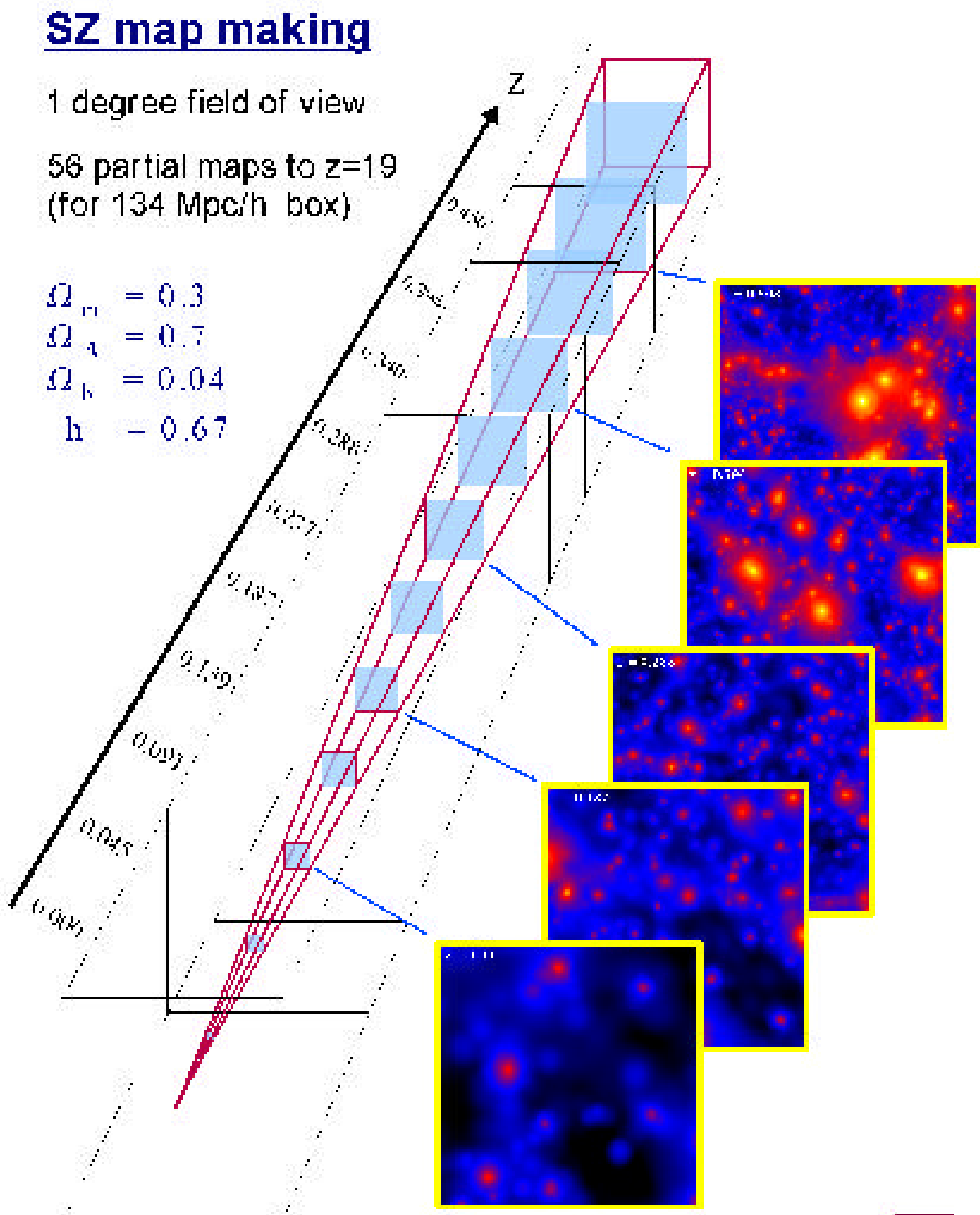
Simulation programme

… with Volker Springel & Lars Hernquist

- The SZ effect is the “best” problem for numerical hydrodynamics.
- Series of simulations designed to study SZE
  - Adiabatic hydrodynamics
    - Box size, particle number, force softening.
  - Artificial pre-heating
  - Cooling only
  - Cooling and feedback (and winds)

Simulations with adiabatic hydrodynamics trace shock heating of gas in the IGM and in halos

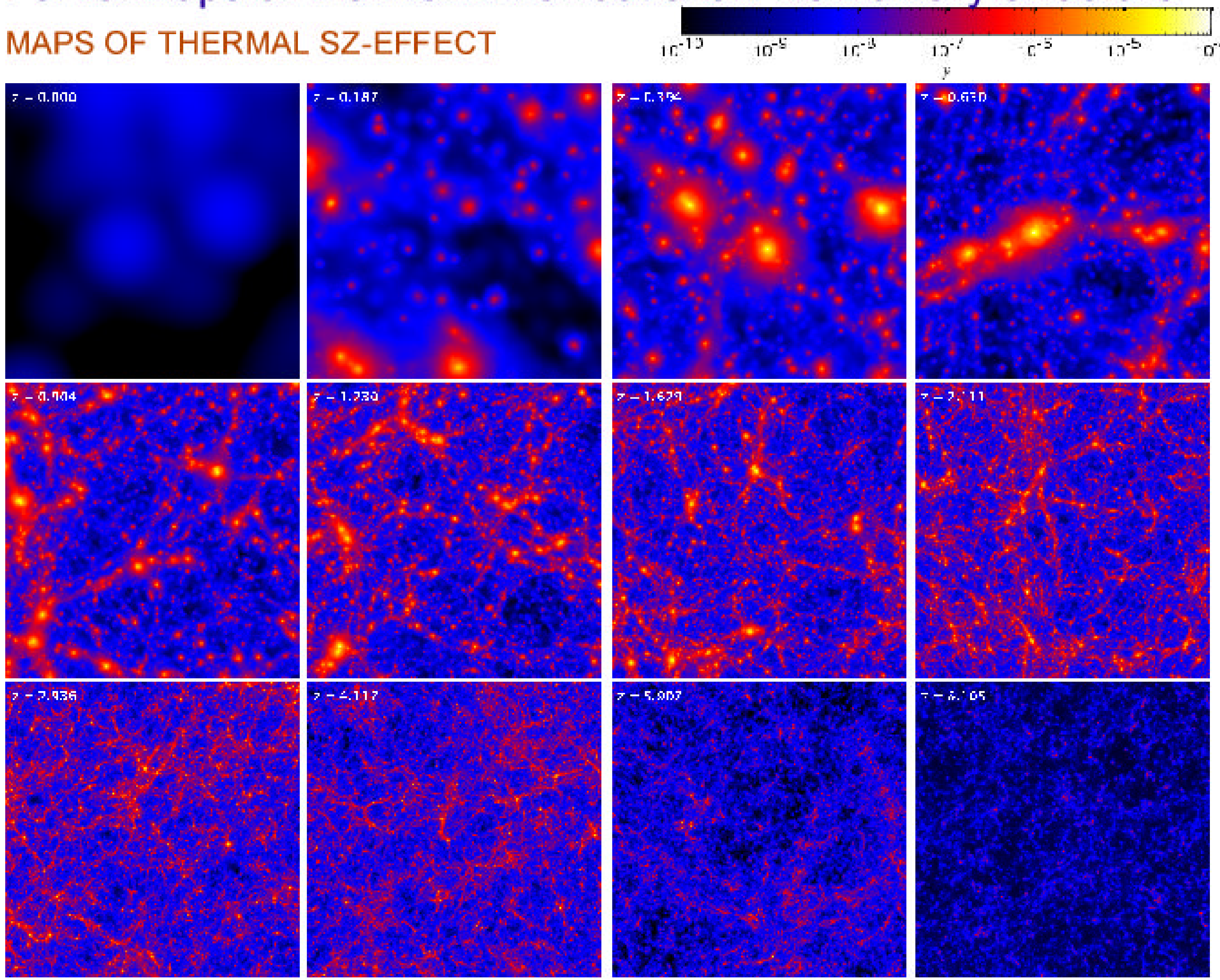
RAY-TRACING CAN BE USED TO OBTAIN PREDICTIONS FOR SECONDARY ANISOTROPIES OF THE CMB



V. Springel, M. White & L. Hernquist (2000)

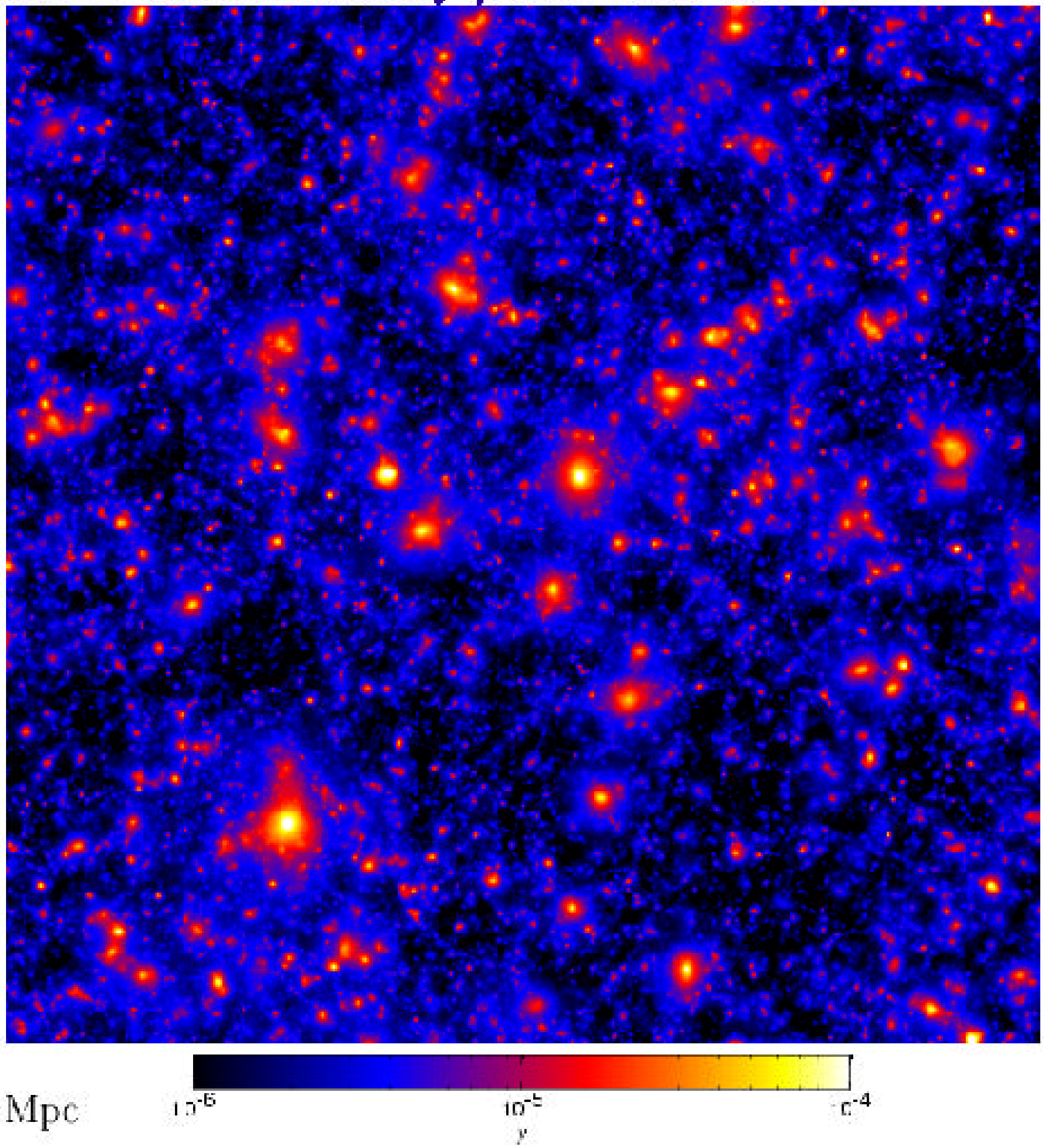
Partial maps of thermal SZ-effect show filamentary structure

MAPS OF THERMAL SZ-EFFECT



The thermal SZ effect is dominated by point sources

COMBINED MAPS



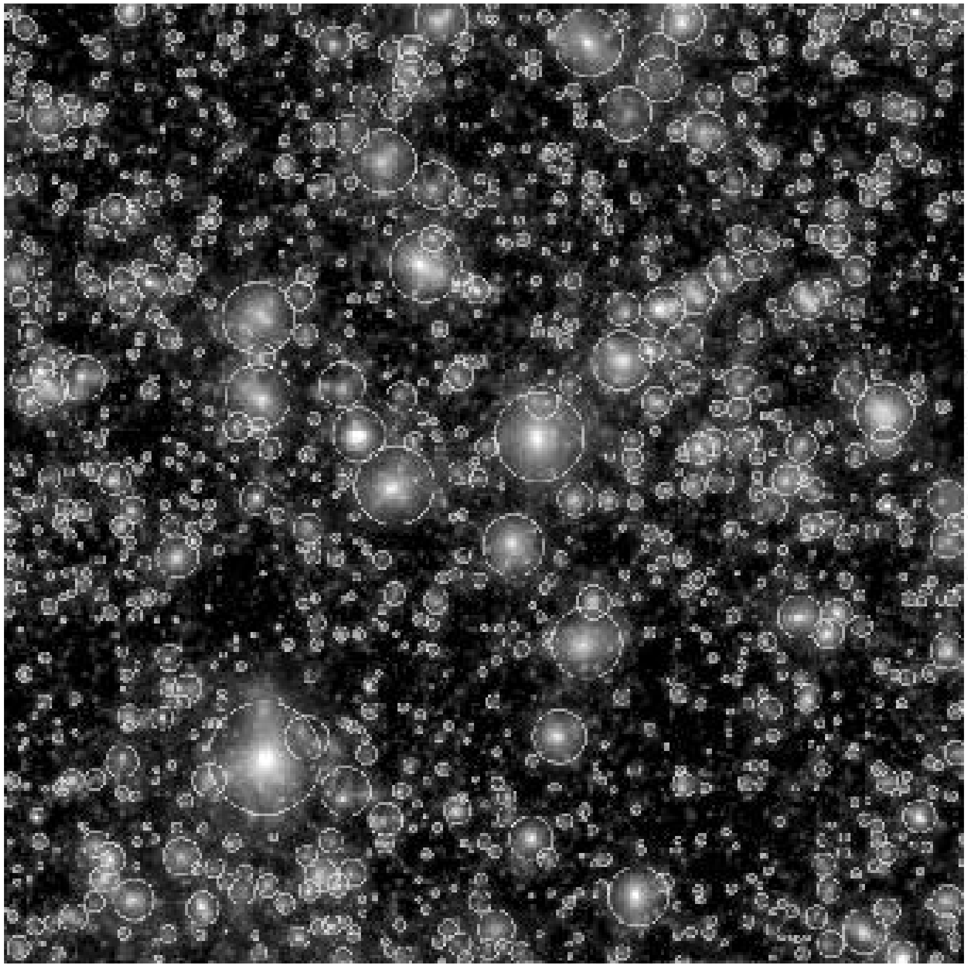
$1^{\circ} \times 1^{\circ}$ field, ΛCDM
$N = 2 \times 224^3$, $L = 134\,h^{-1}$Mpc

What have we learned?

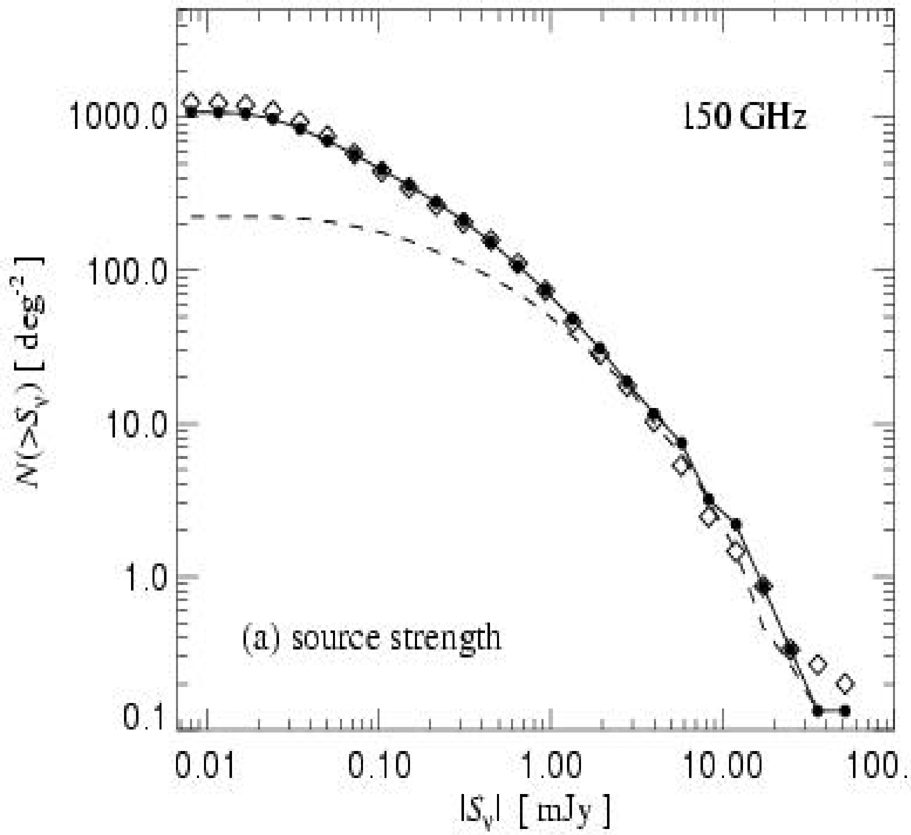
- Effect is dominated by “sources” – projection erases filaments.
- Most of the effect comes from gas at overdensities O (10^2) times the mean density.
- The maps are quite non-gaussian.
- Significant Y-M scatter.
- Cooling and feedback are small effects.
- CBI deep field results suggest high σ_8
- Numerical and semi-analytic work disagree(s).

Probing massive halos …

Sources found with Sextractor



1°



What have we learned?

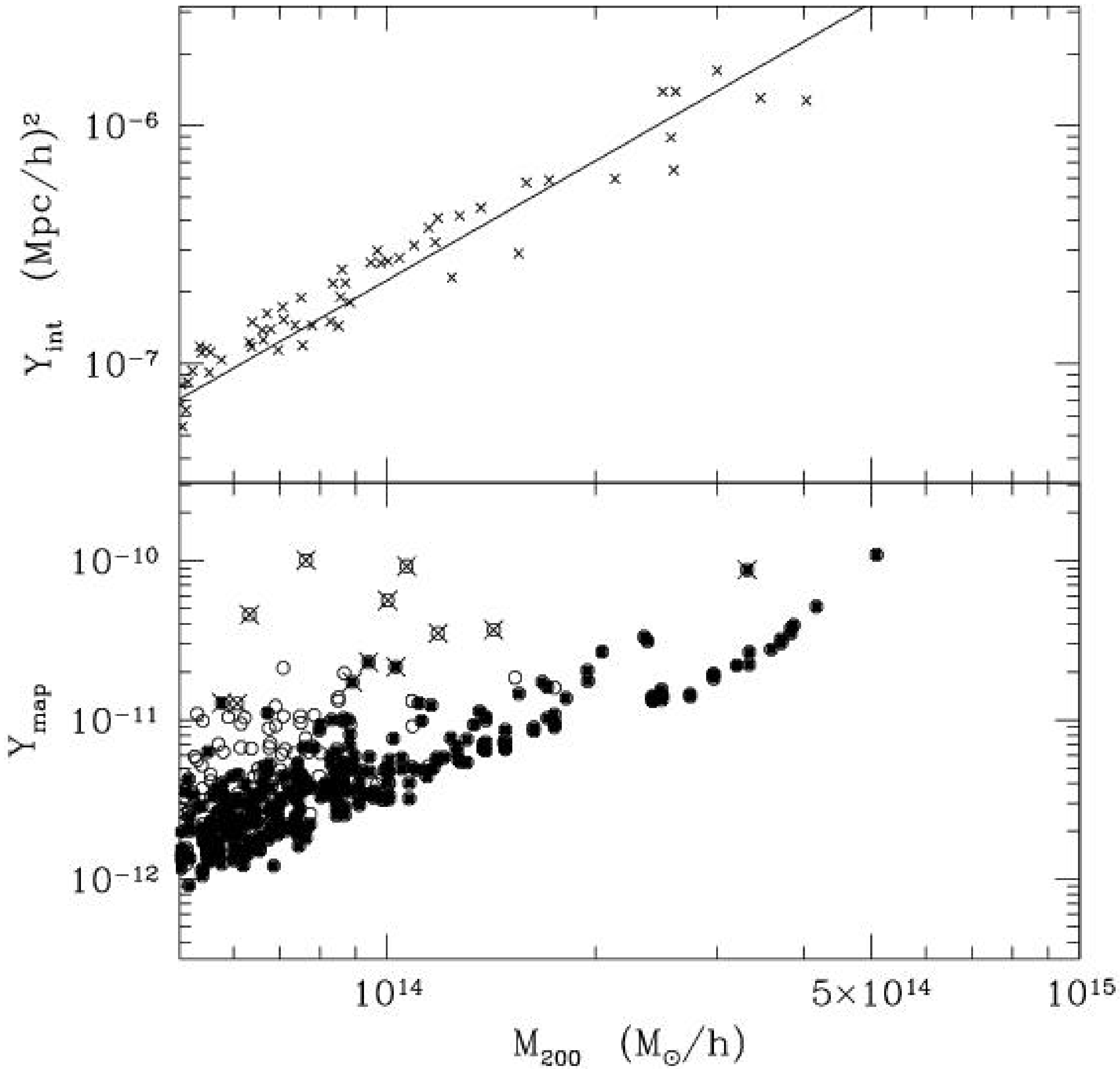
- Effect is dominated by “sources” – projection erases filaments.
- Most of the effect comes from gas at overdensities $O\ (10^2)$ times the mean density.
- The maps are quite non-gaussian.
- Significant Y-M scatter.
- Cooling and feedback are small effects.
- Numerical and semi-analytic work disagrees.
- CBI deep field results suggest high σ_8

SZ projection effects …

$Y \sim M \times T$
$\sim M^{5/3}$

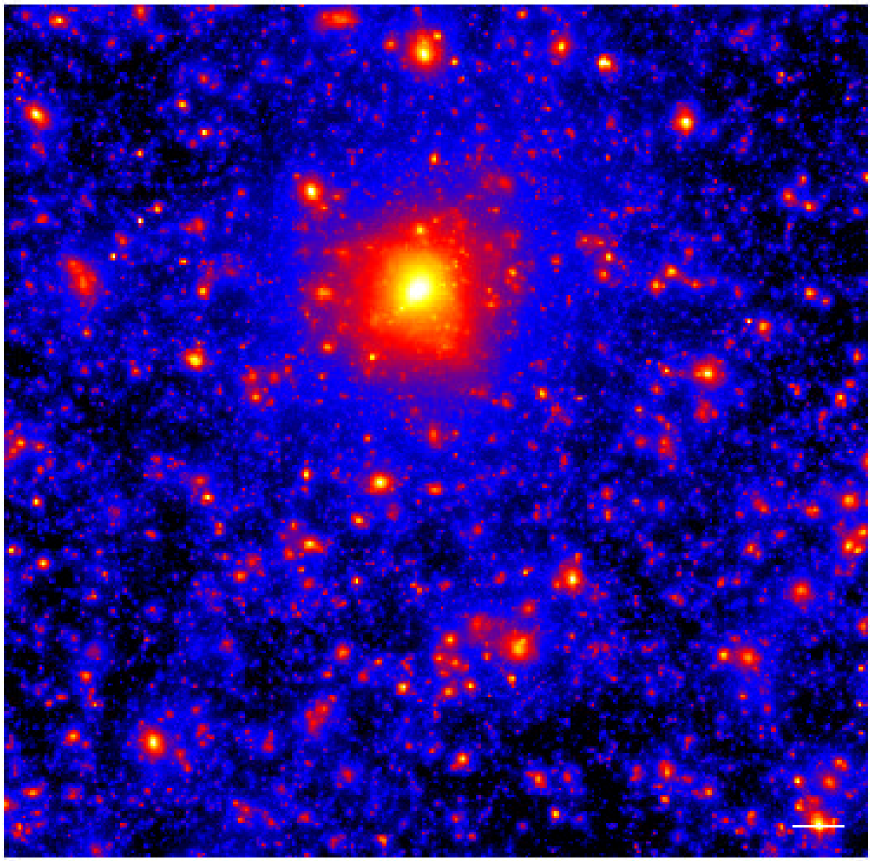
Effect is indep. of distance!

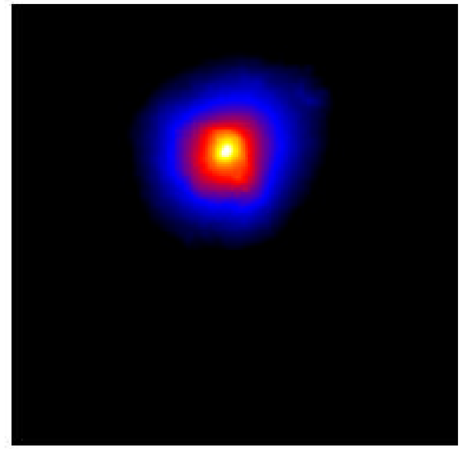
c.f. optical richness



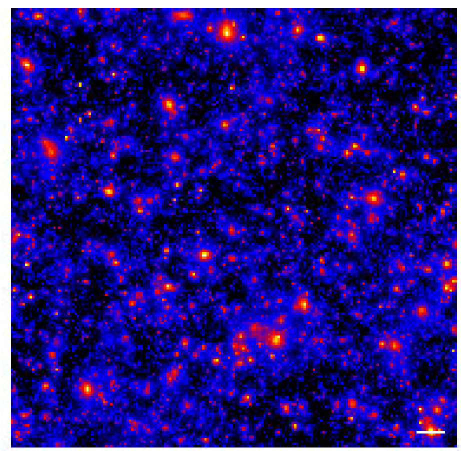
Nearby clusters are huge SZ sources on the sky

A FIELD WITH A NEARBY CLUSTER

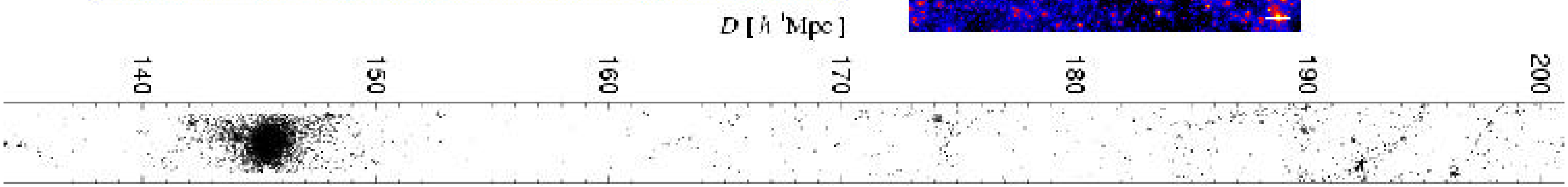




partial map containing the cluster



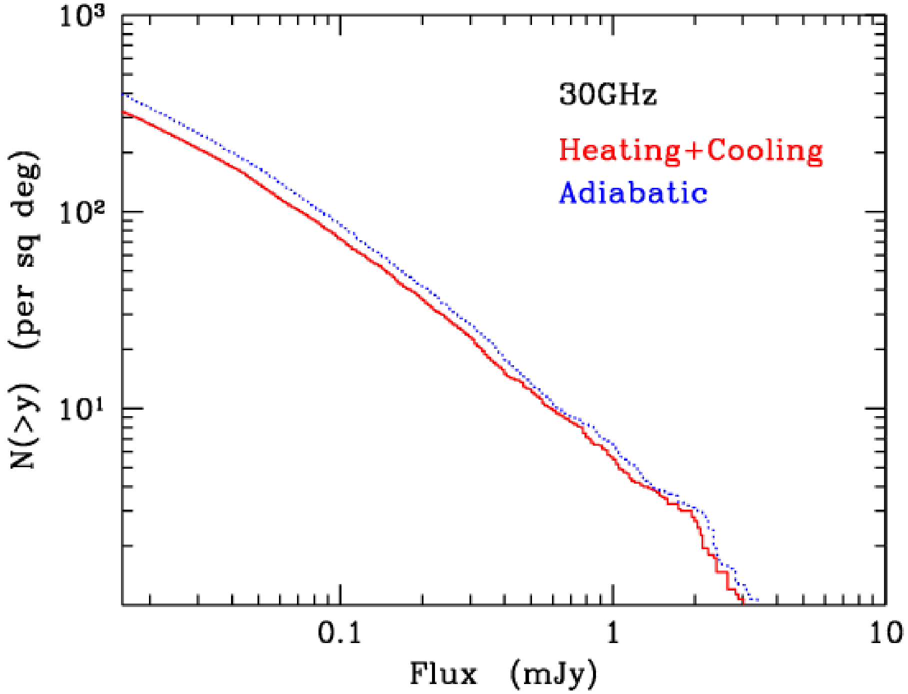
all partial maps in the fore- and background



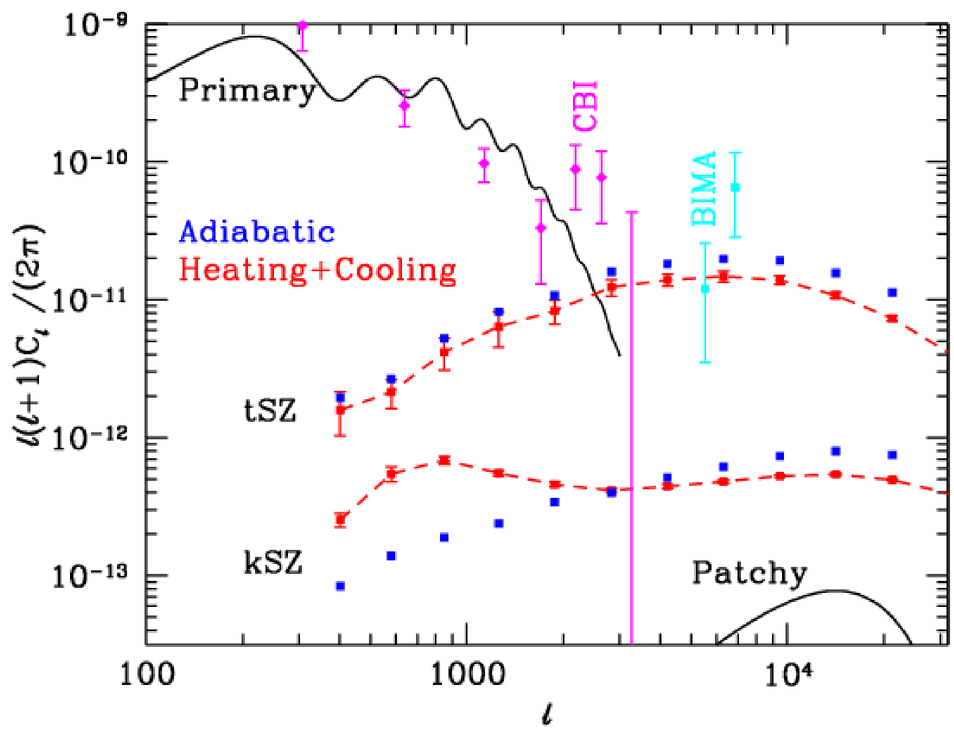
What have we learned?

- Effect is dominated by “sources” – projection erases filaments.
- Most of the effect comes from gas at overdensities $O\ (10^2)$ times the mean density.
- The maps are quite non-gaussian.
- Significant Y-M scatter.
- Cooling and feedback are small effects.
- CBI deep field results suggest high σ_8
- Numerical and semi-analytic work disagree(s).

Insensitive to "extra" physics

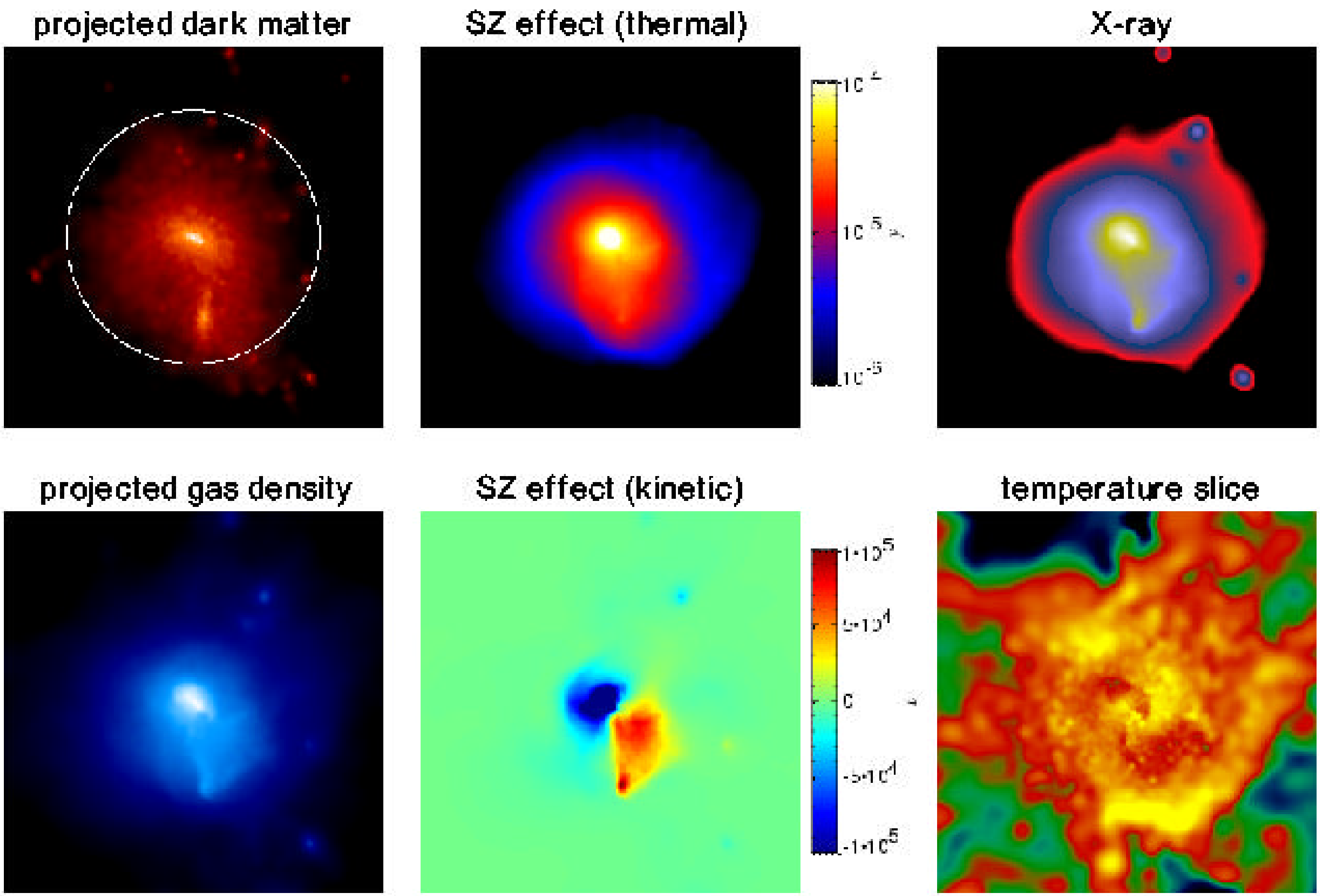


Heating or cooling alone can cause big shifts, but when combined in a self-consistent model …



Combined measurements of X-ray, and thermal & kinetic SZ are powerful tools to study the structure of clusters

A CLUSTER SEEN IN DIFFERENT WAYS



Observation time.

Atacama is at –23° so only sky with δ<-67° can be observed all day.

Elevation	Duration
0	12.4h
5	11.7h
10	10.9h
15	10.2h
20	9.5h
25	8.7h

Plus lost time for sun, moon, …