Recent results from the APEX-SZ Experiment

Kaustuv moni Basu

People in AIfA, Bonn Univ.
Martin Nord, Florian Pacaud, Frank Bertoldi, Reinhold Schaaf

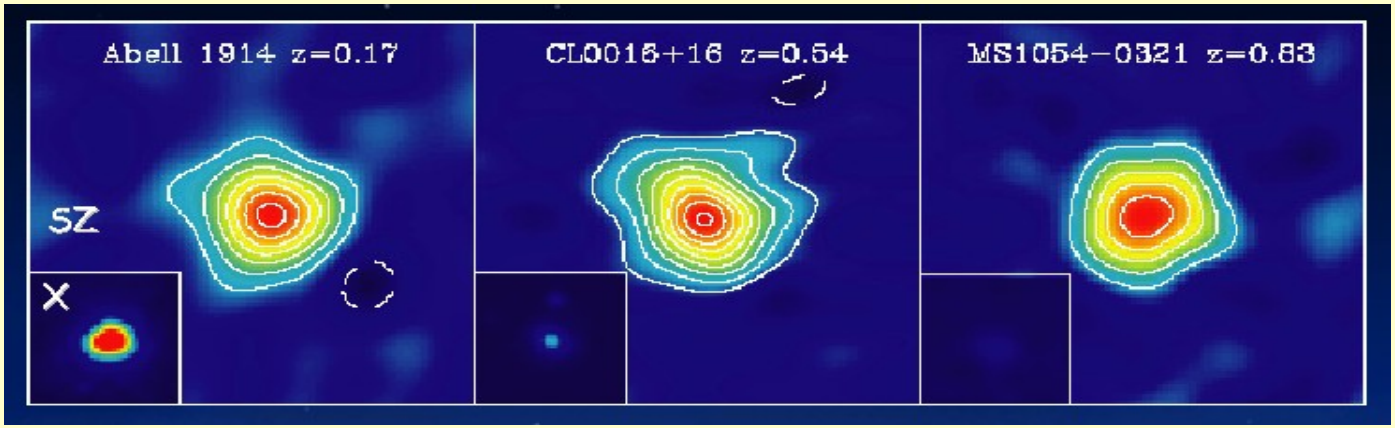
Sunyaev-Zel'dovich Effect

Thermal SZE is a small (<1 mK) distortion in the CMB caused by inverse Compton scattering of the CMB photons

$$\frac{\Delta T}{T_{\rm CMB}} = g(x) \int n_e(l) \frac{k_{\rm B} T_e(l)}{m_e c^2} \, dl$$

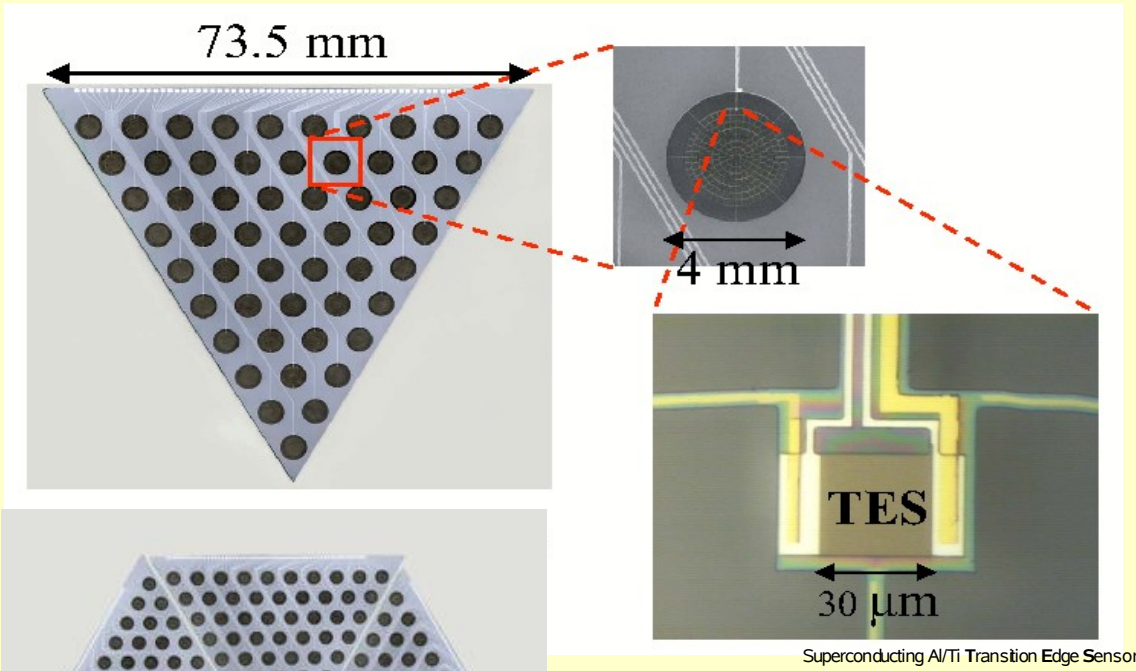
Total cluster flux density, as if SZE luminosities increase as $(1+z)^4$

$$\Delta S_\nu = \int \Delta I_\nu \, d\Omega \propto \frac{\int n_e T_e \, dV}{D_{\rm A}^2} \propto \frac{f_{\rm gas} M_{\rm tot} T_e}{D_{\rm A}^2}$$

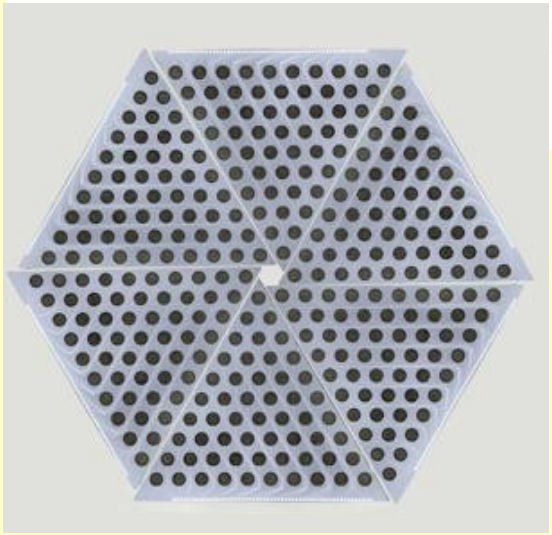


Carlstrom et al.

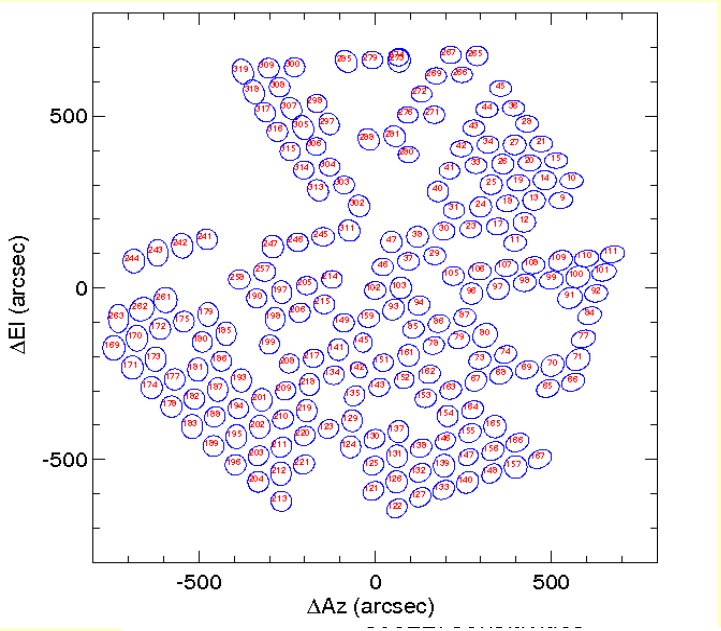
The APEX-SZ Bolometer Camera

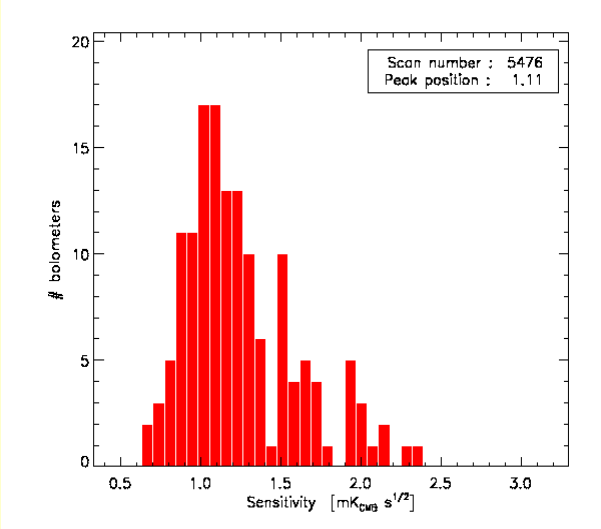


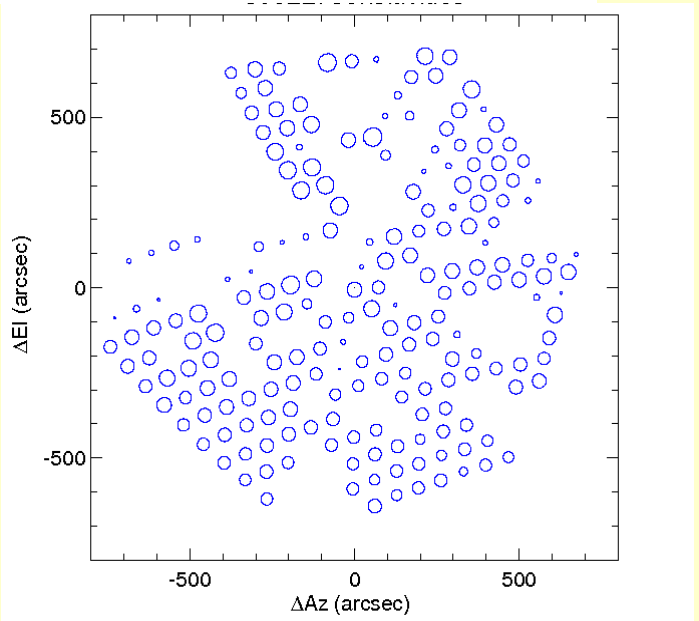
Superconducting Al/Ti Transition Edge Sensor



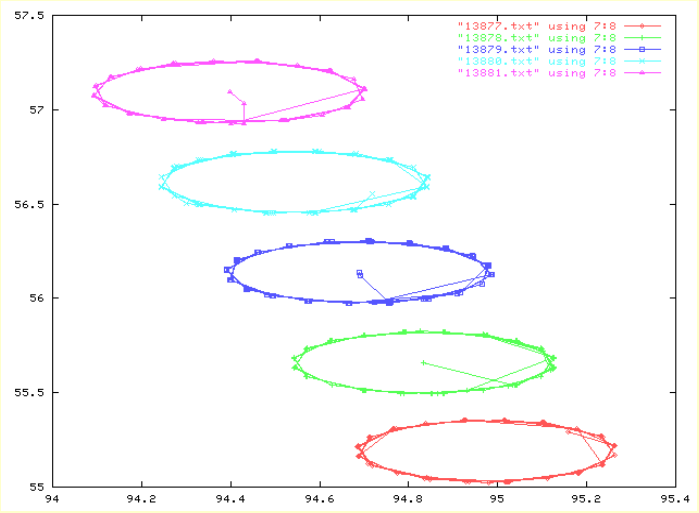
24' FOV, 1' beam FWHM
@ 150 GHz

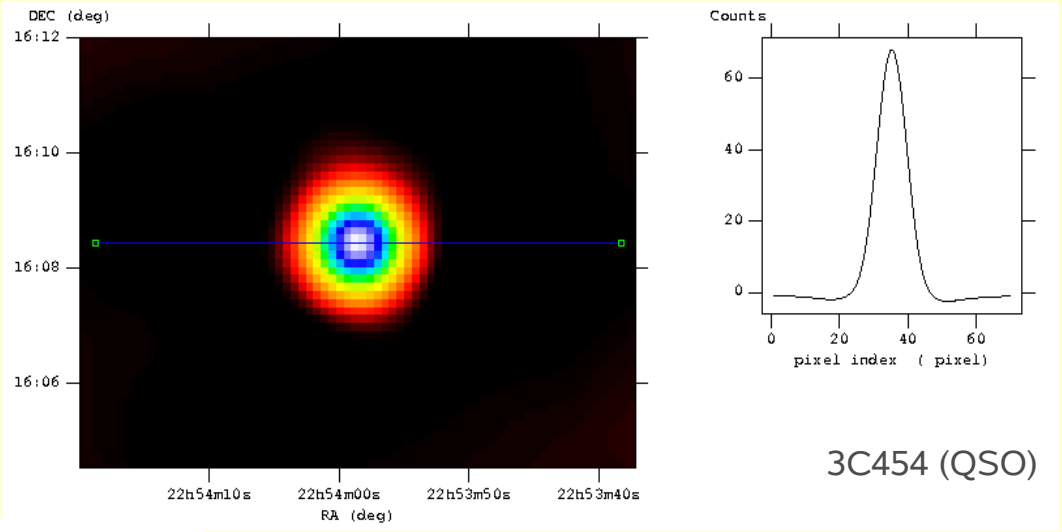




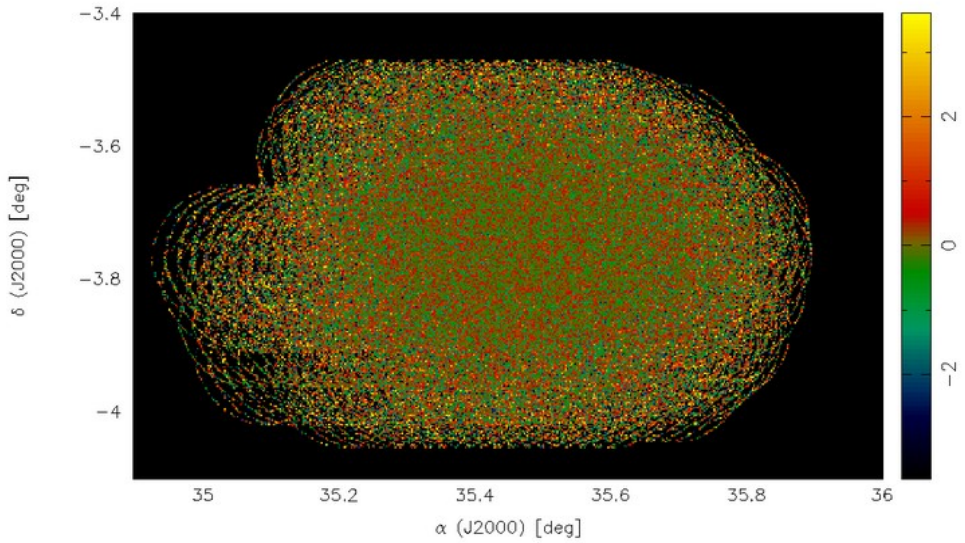


Observation in Aug-Sep 2007





3C454 (QSO)



First science observing run – 8 clusters observed in total

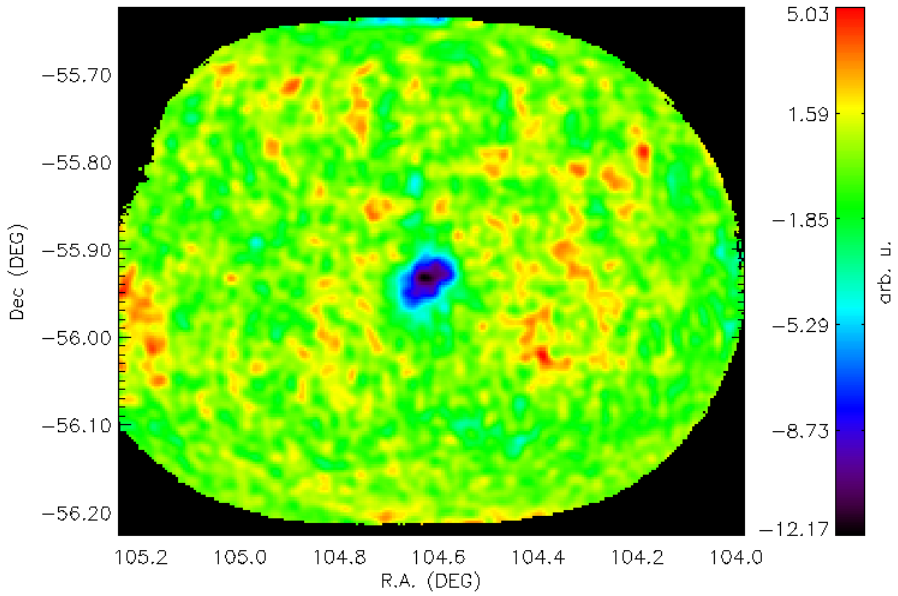
(Commissioning of full array was done in April 2007)

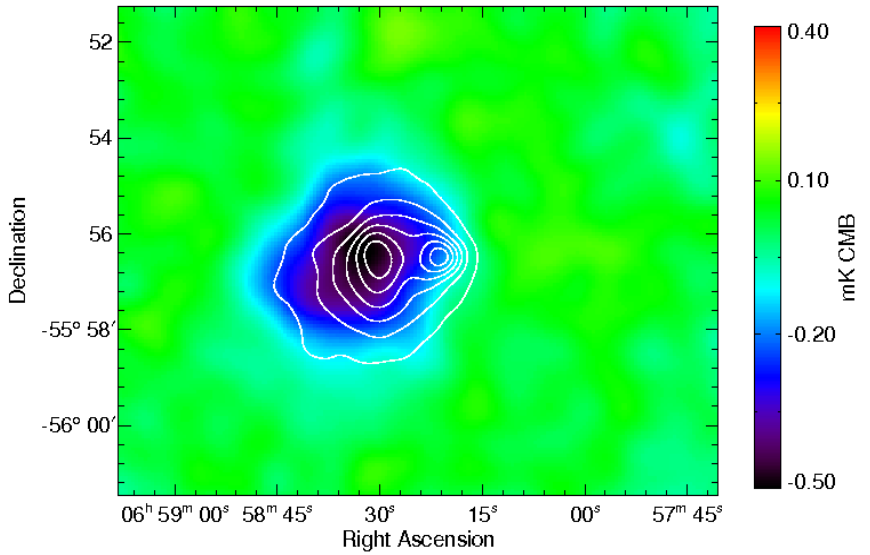
Total 11 nights

10 – 15 hours / night

Circular track-drift scans

Bullet cluster





Merging system at z=0.3, consisting of a less massive *(T ~ 6 keV)* subcluster, and a more massive *(T ~ 14 keV)* main cluster.

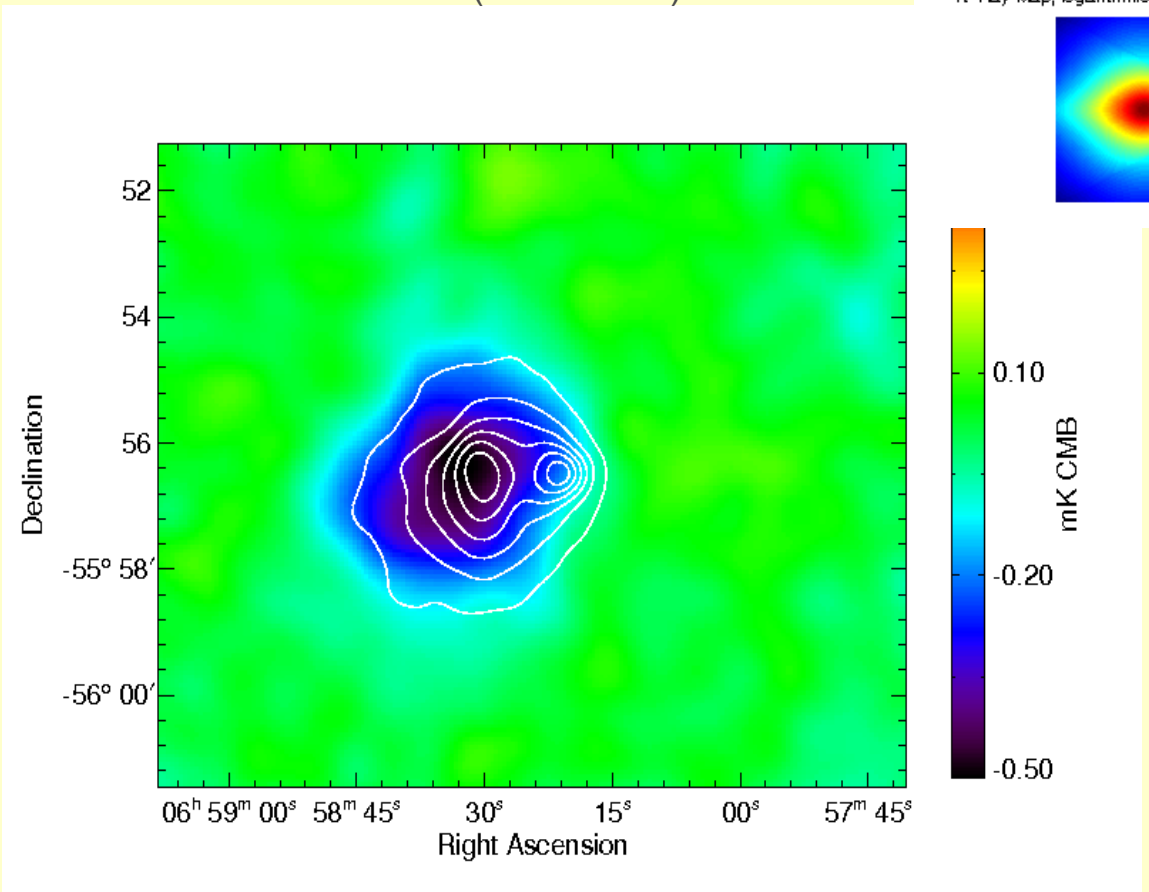
APEX-SZ observation ~10 hours

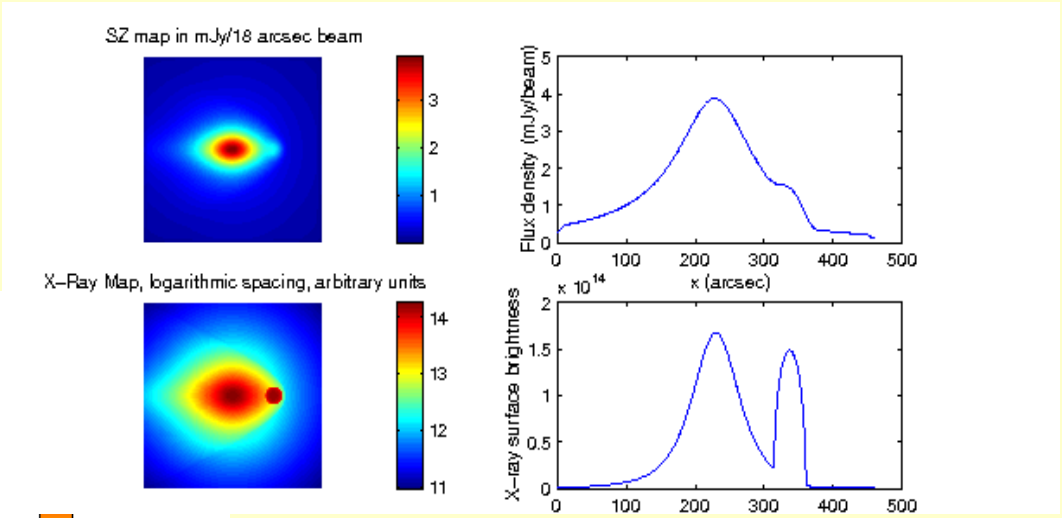
LABOCA observation (350 GHz) in progress

Bullet cluster

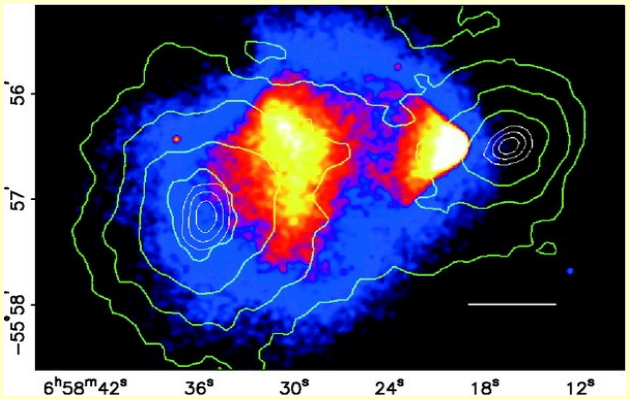
Models show almost continuous pressure profile – difficult to detect the *"Bullet" in SZE*

Central decrement consistent with ACBAR measurement (4.5' beam)



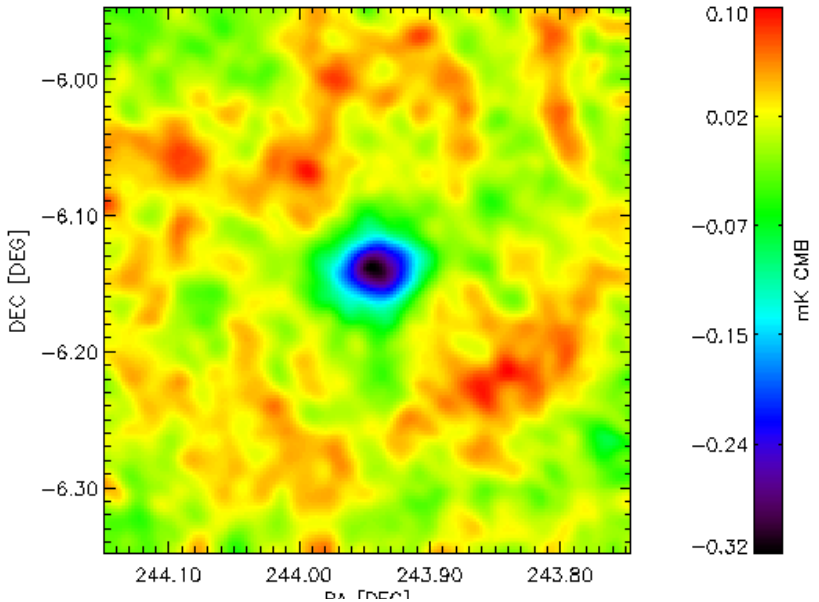


Nicolas Traubert's Masters Thesis, OSO



Clowe et al. 2006

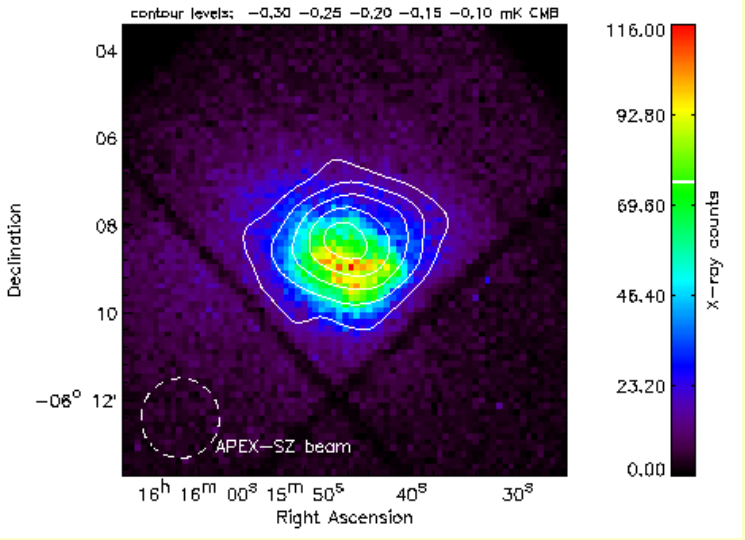
Abell 2163

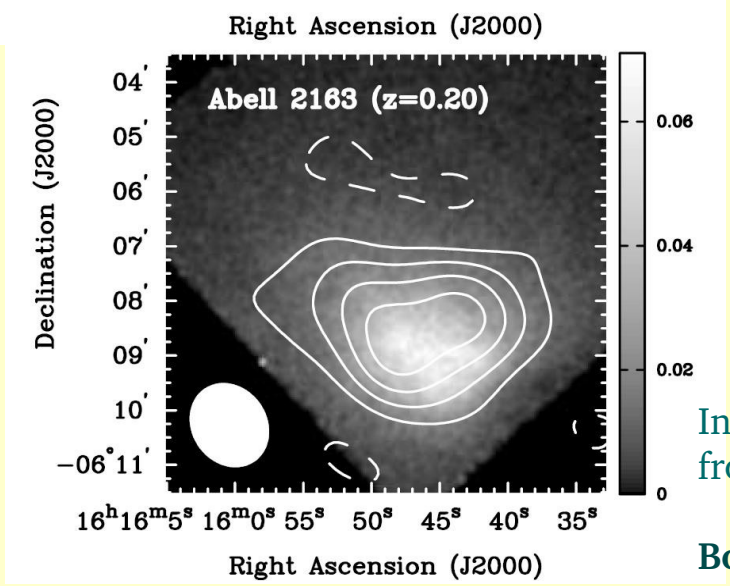


Rich galaxy cluster at z = 0.2, popular target for SZE observation (X-ray luminous, T_e ~ 14 keV)

Previous detection with SuZIE I/II, OVRO/BIMA, DIABOLO etc.

APEX-SZ confirms previous results, and provides first wide-field total pressure map

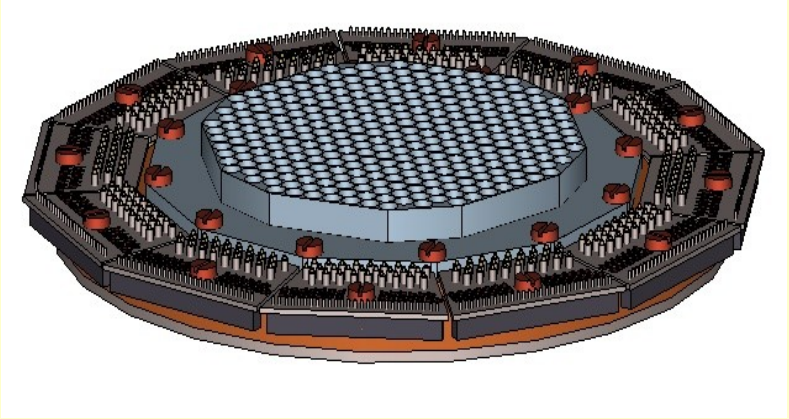




Interferometric Image from OVRO/BIMA

Bonamente et al. 2006

Detour I: LABOCA SZ observation @ 350 GHz

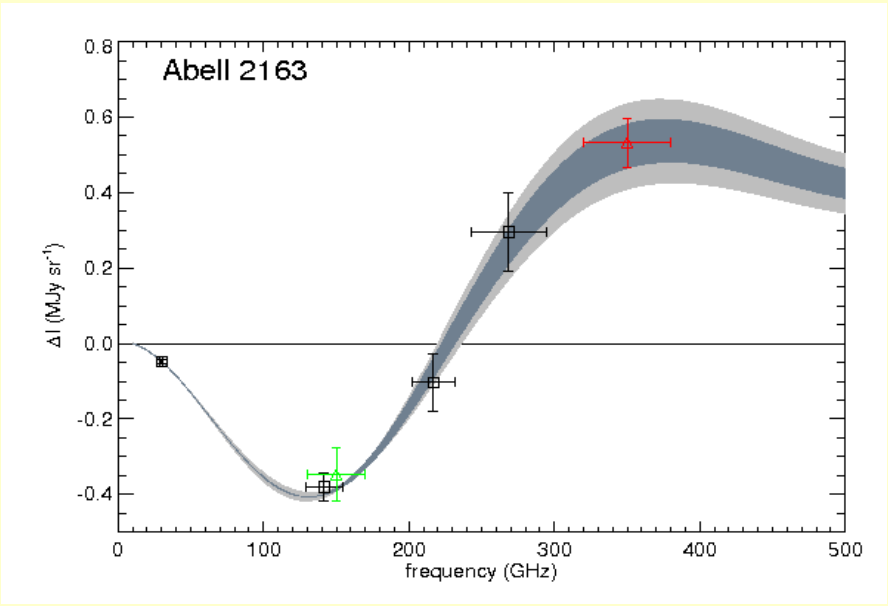


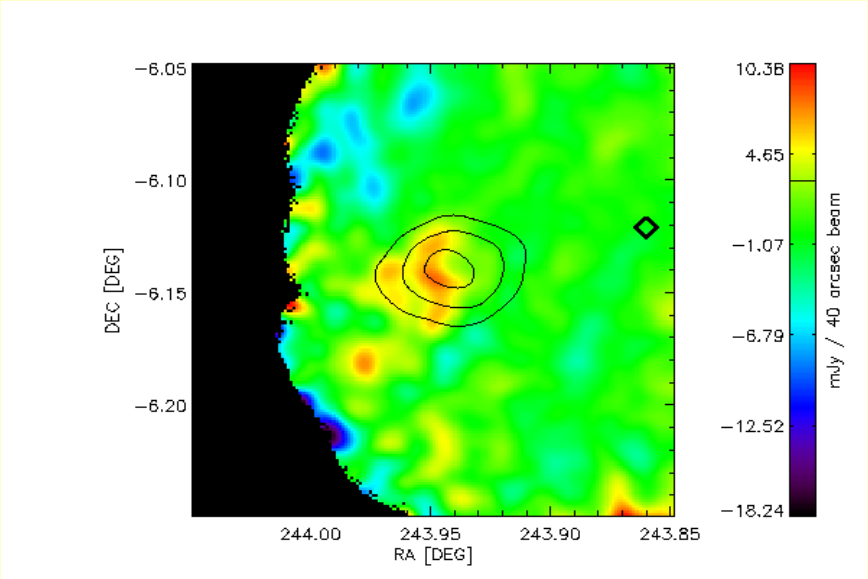
Max-Planck bolometer camera with 295 elements –
18" resolution at 350 GHz

Great new possibilities for SZE!

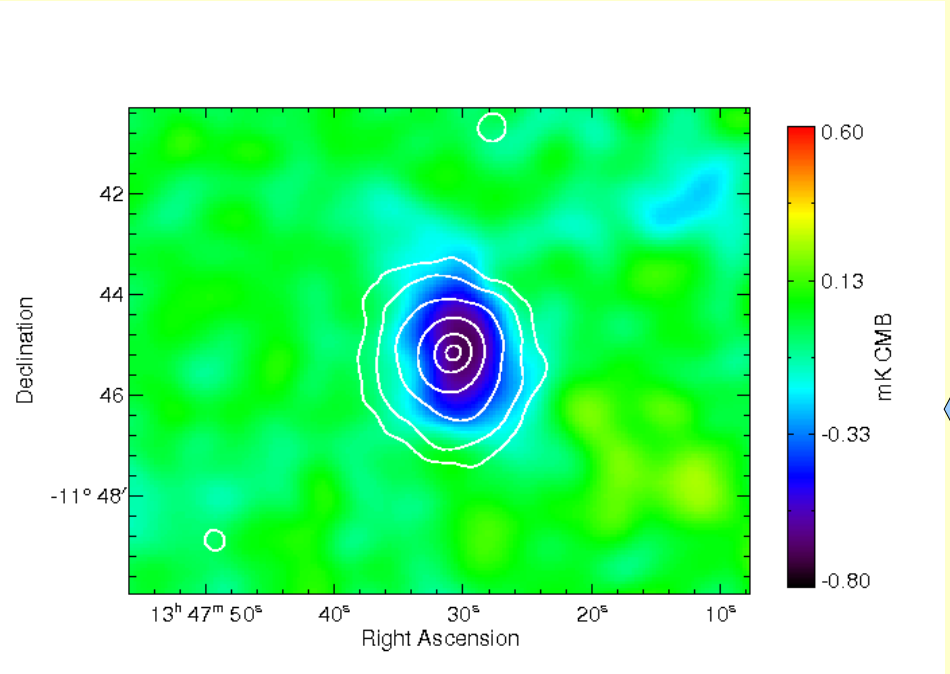
Increment measurement: Better constraints on peculiar motion and Comptonization parameter

High-resolution imaging: Direct comparison with strong lensing, accurate measurement of the gas-to-mass ratio





Other Cluster Detections: **RXJ1347**



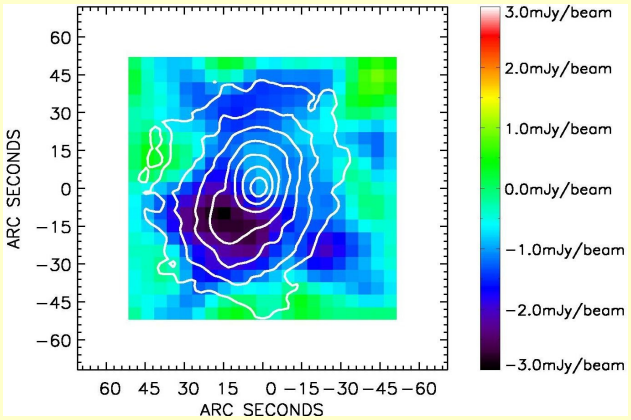
Most X-ray luminous cluster in the sky
(T_X ~ 12.7 keV, z = 0.45)

Central SZE intensity (y_0~10^{-3}) more than twice as large as other bright clusters

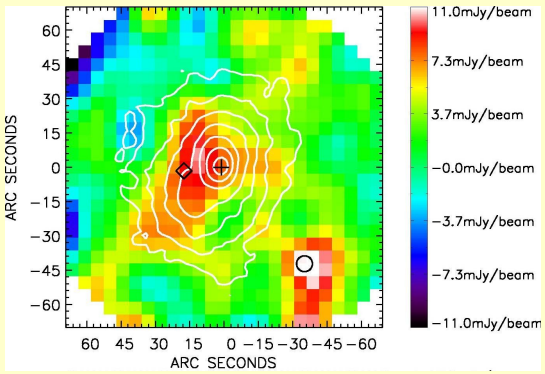
Map from data taken in September (~3 hours)

Bright IR sources make 350 GHz SZE analysis problematic

At 150 GHz central radio source ~ 4 mJy



(Kitayama et al. 2004) **150 GHz**

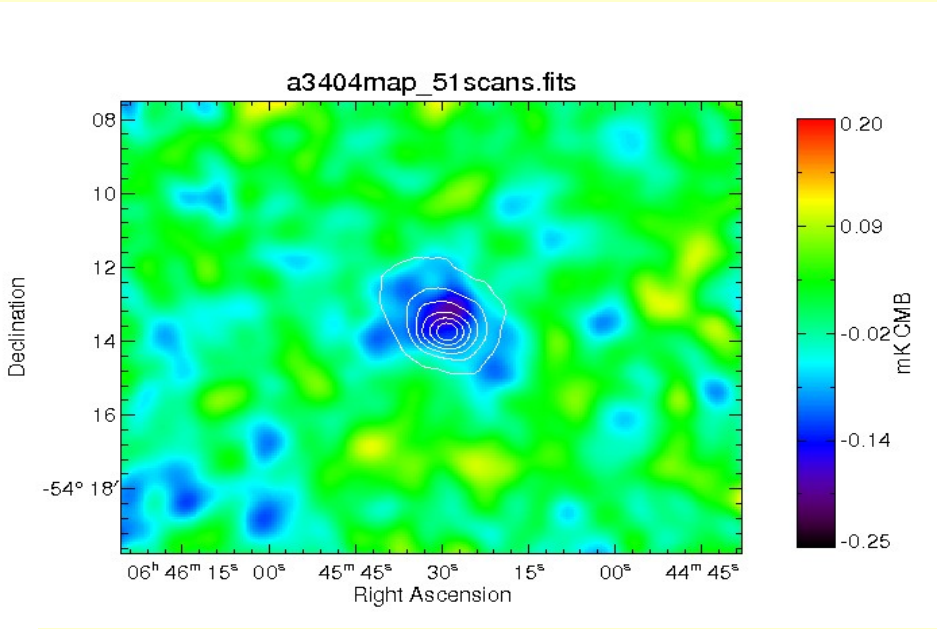


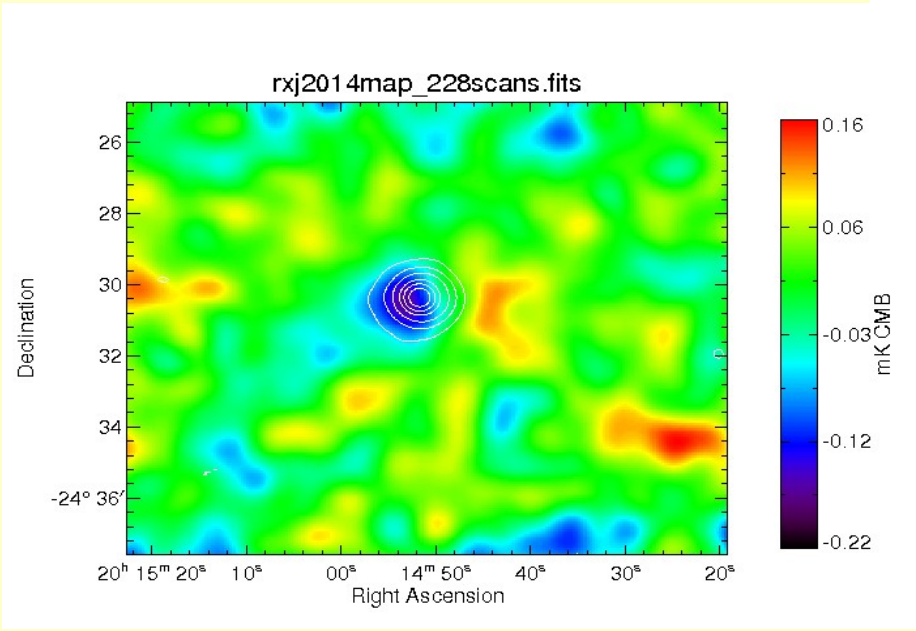
350 GHz

Abell 3404 & RXJ2014

Abell 3404 is a nearby (z = 0.16) cluster with large gas radius R_{500} = 7.3 arcmin, T_X = 7 keV

Extended, and relatively bright, for SZE measurement up to large radius – **confusion with CMB**





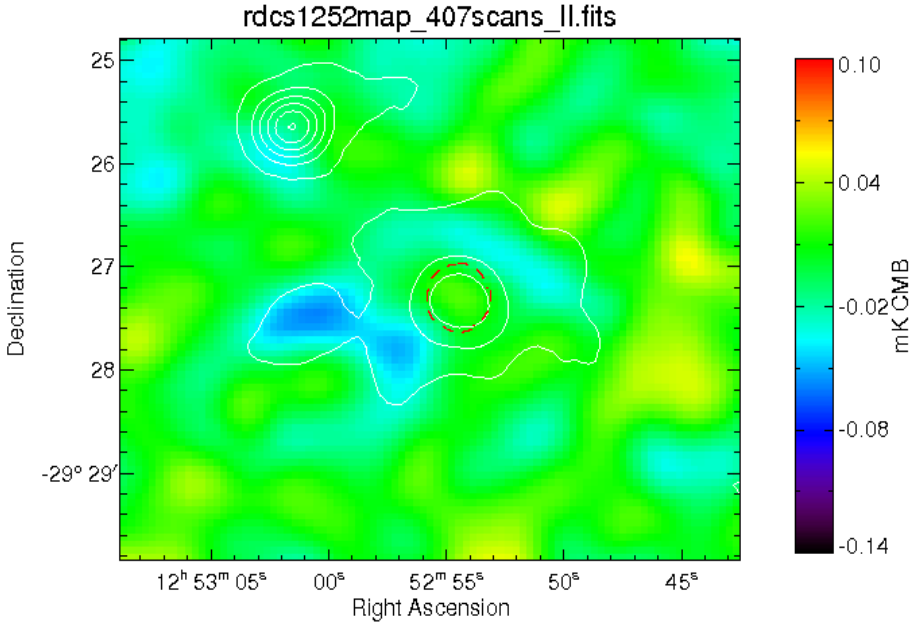
RXJ2014 is also a X-ray bright (T = 8 keV) cluster at z = 0.16

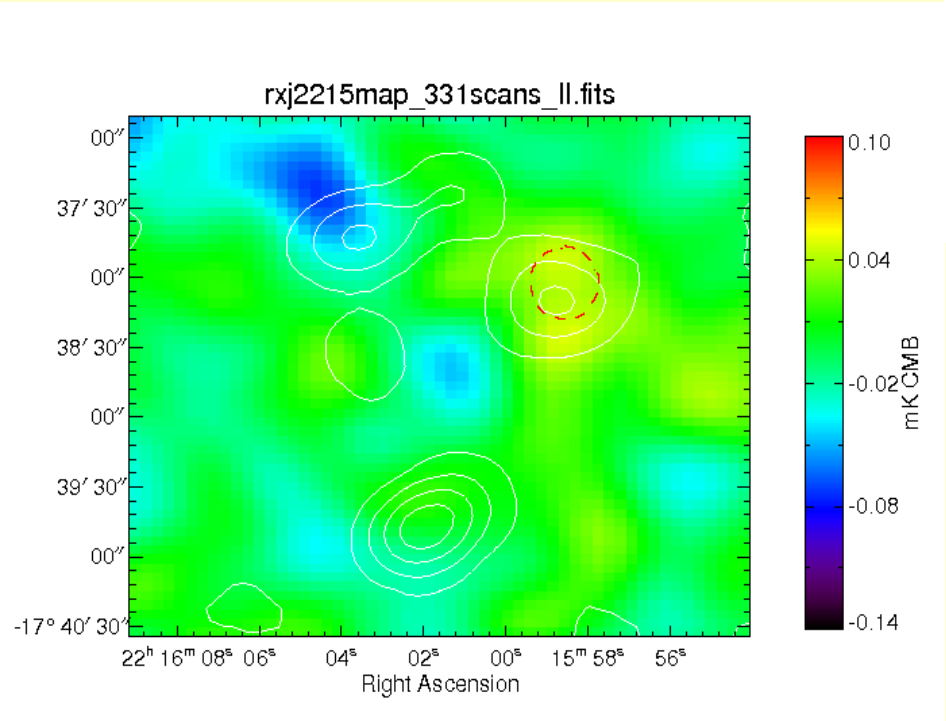
APEX-SZ observation done in LST ranges when high-priority sources were not available

... and Non-Detections

Observation of two high-redshift faint clusters have (so far) yielded negative results. *Analysis in progress*

RDCS 1252 (z = 1.24)

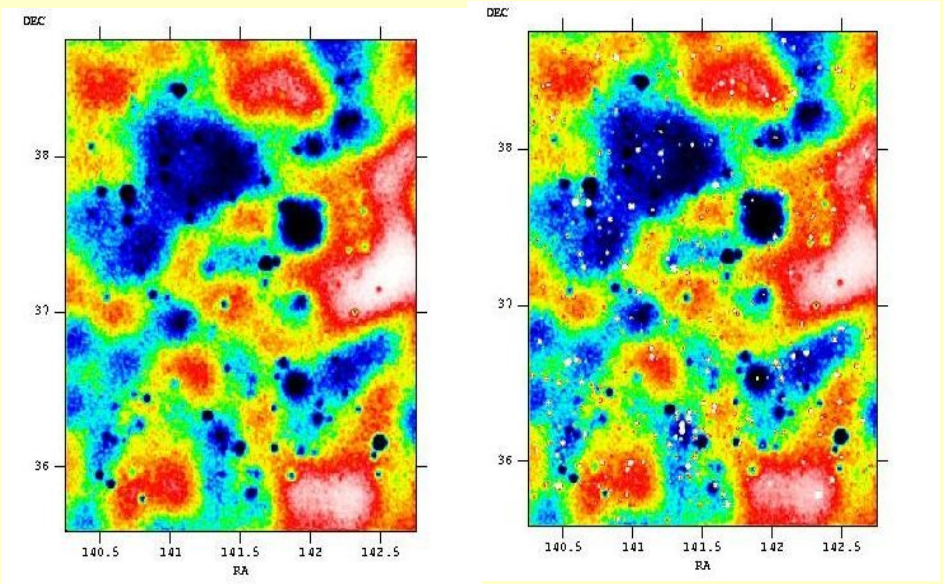




RXC J2215 (z = 1.45)

Map rms 30 microK, expected temperature decrement 50 – 100 microK

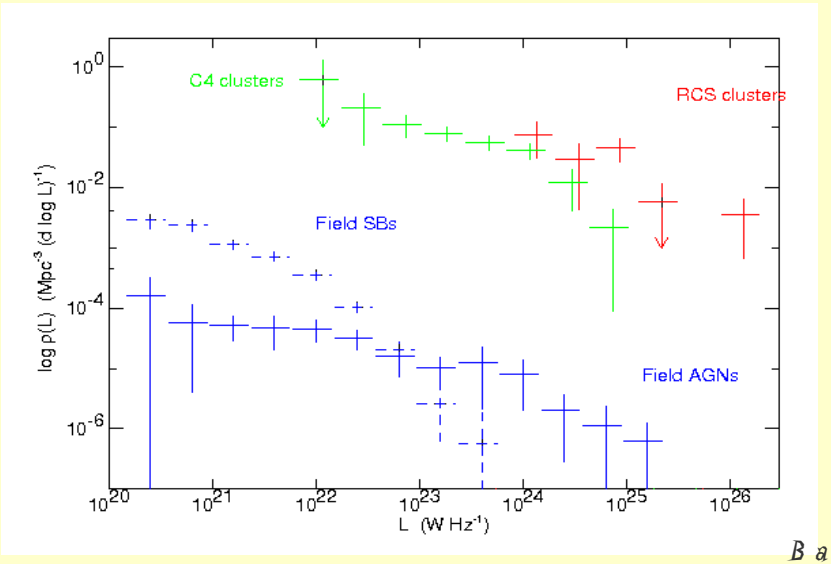
Detour II: Radio Point Sources in Galaxy Clusters



Martin Nord

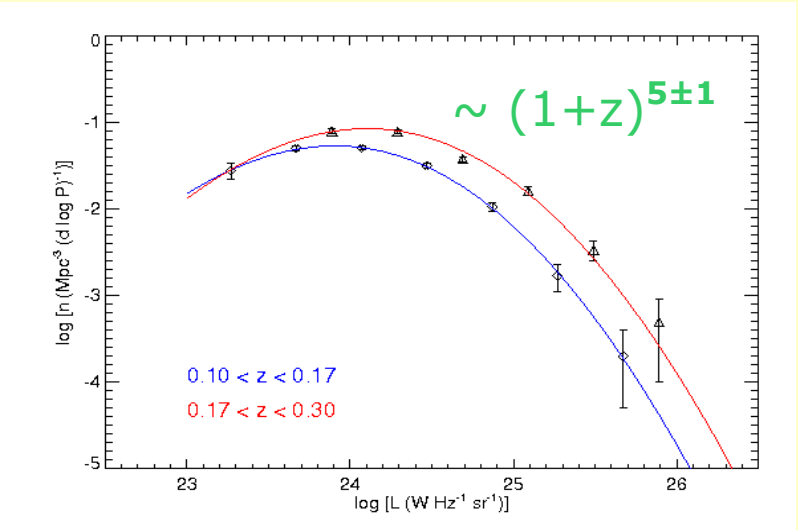
We are trying to quantify the contamination from unresolved radio point sources:

- Observation with Effelsberg and PdBI
- Simulated SZ skymap with point sources
- Theoretical modeling of cluster radio LF



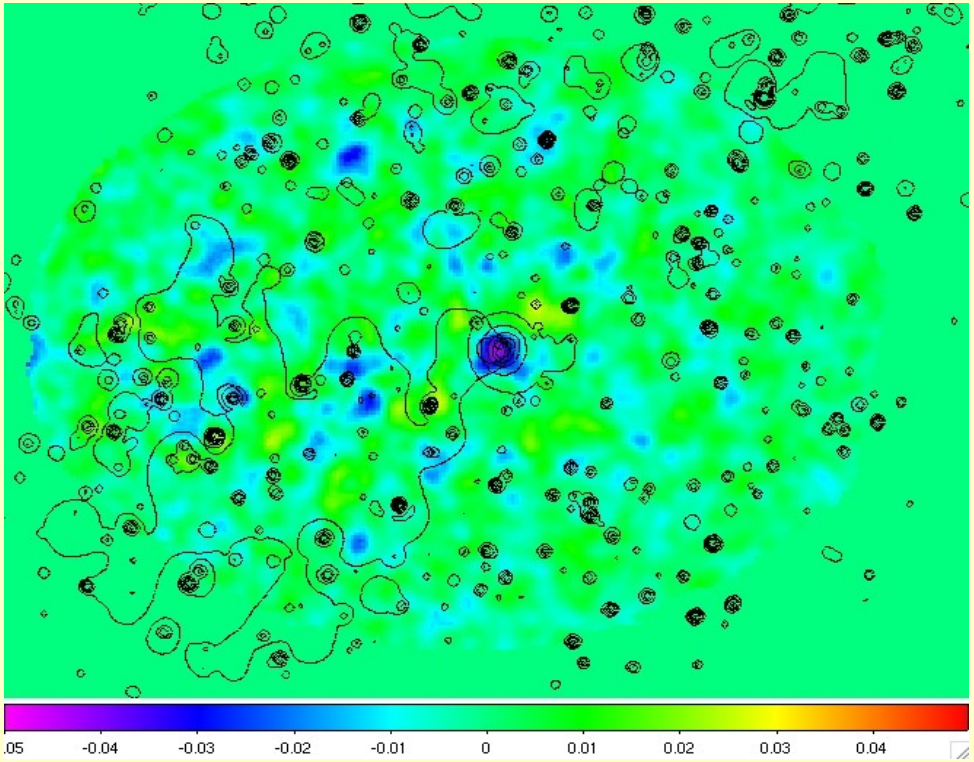
Basu et al. 2007

Data: MaxBCG clusters (Koester et al.)



XMM-LSS Field

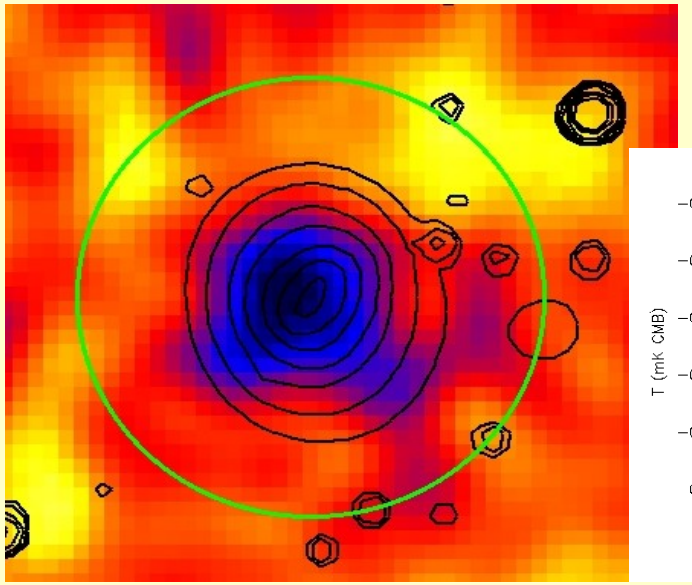
Deep observation (~60 hours) of part of the XMM-LSS field (area ~0.3 sq.deg.) containing one known cluster

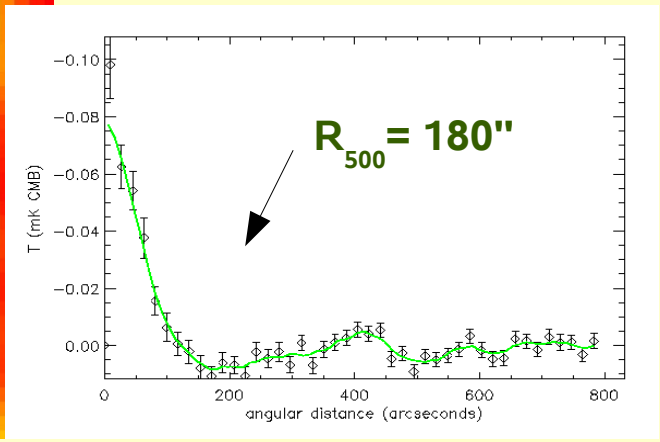


X-ray image: Florian Pacaud

XLSSC 006: z = 0.43, T_e = 5 keV

The coolest cluster ever detected through SZE

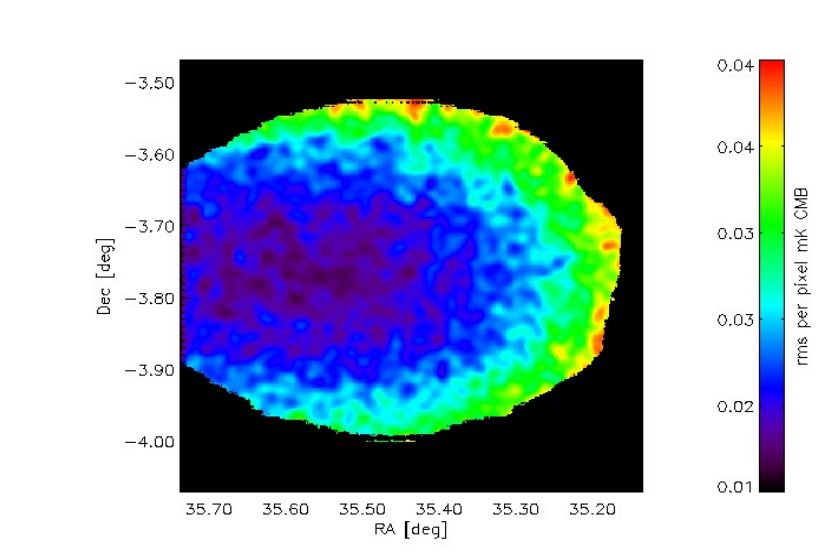




Further XMM observation planned – ICM profile up to R_{500}

Determine M_{gas} , M_{500} , Y_X with high accuracy (high-z / low-T system)

XMM-LSS Field

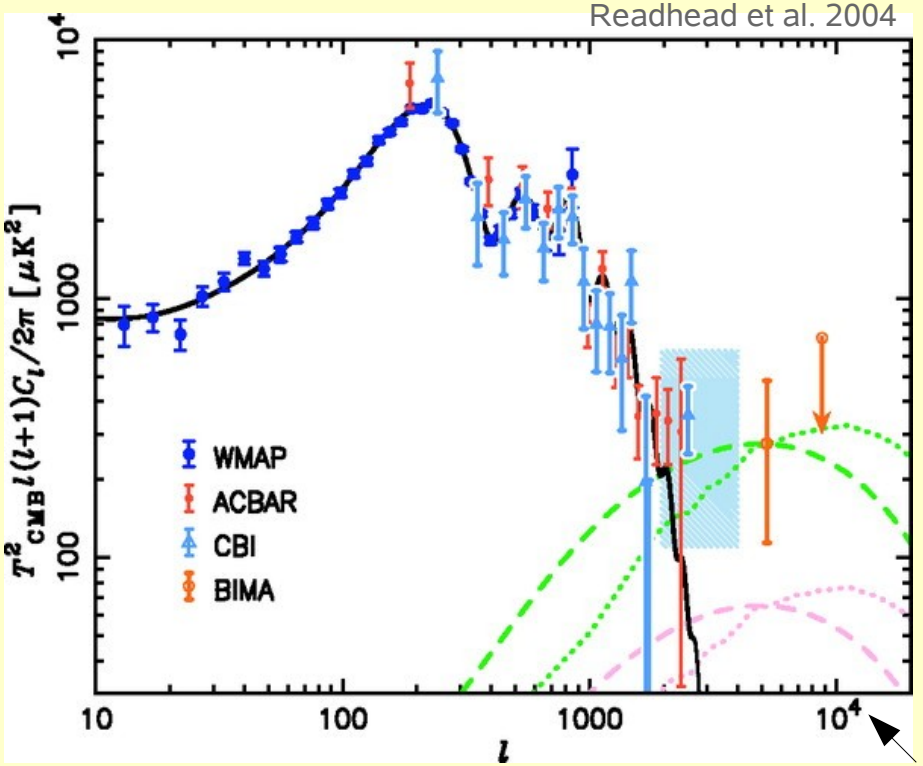


Rms < 15 microK in ~0.15 sq degrees area

– take FFT corrected for noise

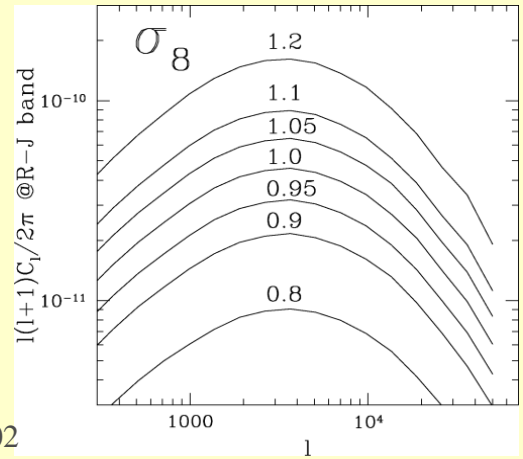
– **SZ Power Spectrum!**

Readhead et al. 2004



SZ power spectrum very sensitive to cosmology

$$C_l \sim \sigma_8^{\ 7}$$



Komatsu & Seljak 2002

Living in interesting times

- Next round of observation in December 2007 (XMM-LSS, follow-up of z>1 clusters, more targeted observation)
- Systematics under control, blind survey starting soon **(ACT, SPT !!)**
- High S/N map of several nearby clusters obtained, analysis under progress
- Possible serendipitous discovery of cluster(s) in the XMM-LSS field – X-ray and optical follow-up observation planned
- Good data set for analyzing SZ power-spectrum at 150 GHz – interesting constraints on cosmology
- Better understanding of astrophysical contaminants for single-frequency SZ survey – simulations & radio observation