Title: High-ell CMB with CBI

Date: Nov 10, 2006 03:30 PM

URL: http://pirsa.org/06110051

Abstract:


Maple 7
SSH File Trans
Shortcut to putty
Nero StartSmart
Thunderbird
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PCFriendly DVD
U2K.NET
0611198.tar
Picasa2
Recycle Bin
PowerDVD
Skype
QuickTime
0507092
SSH Client
0603205

CMB at High-ℓ

- imary CMB fluctuations low past ℓ~2000
- gnal expected to arise from secondary anisotropies – SZ galaxy usters, point sources...
- igh power level seen in CBI (30 GHz, ℓ~2000), BIMA (30 GHz, 6000). ACBAR (150 GHz, ℓ~2000) sees level consistent with 3I if due to SZ (but also consistent with nothing?)
- bserved level much(?) larger than expected, especially in light WMAP3.
- Z clusters expected to be dominant (non-point source) mponent, but models/sims suggest level is very sensitive to , preferably ~0.9-1, unlike 0.77 in WMAP3.

Vhat is the dominant source of signal at high-? We don't know. Might even be interesting.

Why Do We Care?

Lots of excitement about using clusters in cosmology, especially in SZ which doesn't care about density fluctuations (only pressure, which is much smoother).

If excess is from clusters, then there's something we need to understand better. Both because clusters are interesting, and we'd like to nail this down before using clusters for *w*, *w′* etc. (requires ~1% accuracy).

If it's not clusters (and not point sources), then it's something weird and completely unexpected. That's fun!

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The Instrument

3 90-cm Cassegrain antennas
- 78 baselines

-meter platform
- Baselines 1m – 5.51m

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- HEMT amplifiers (NRAO)
- Cryogenic 6K, Tsys ~25 K

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- 780 complex correlators

eld-of-view 44 arcmin
- Image noise 4 mJy/bm 900s

esolution 4.5 – 10 arcmin
~400<ℓ<2000+)

The CBI Adventure…

3I located at 5080 meters in
acama desert, Chile.

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The CBI Adventure…

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- Volcan Lascar (~30 km away) erupts in 2001

CBI Dataset(s)

CBI has 2 distinct datasets. Partly overlap, so correlations must be done. Observing patterns differ.

I observes 4
tches of sky – 3
saics & 1 deep strip
pol'n, 3 mosaic, 1
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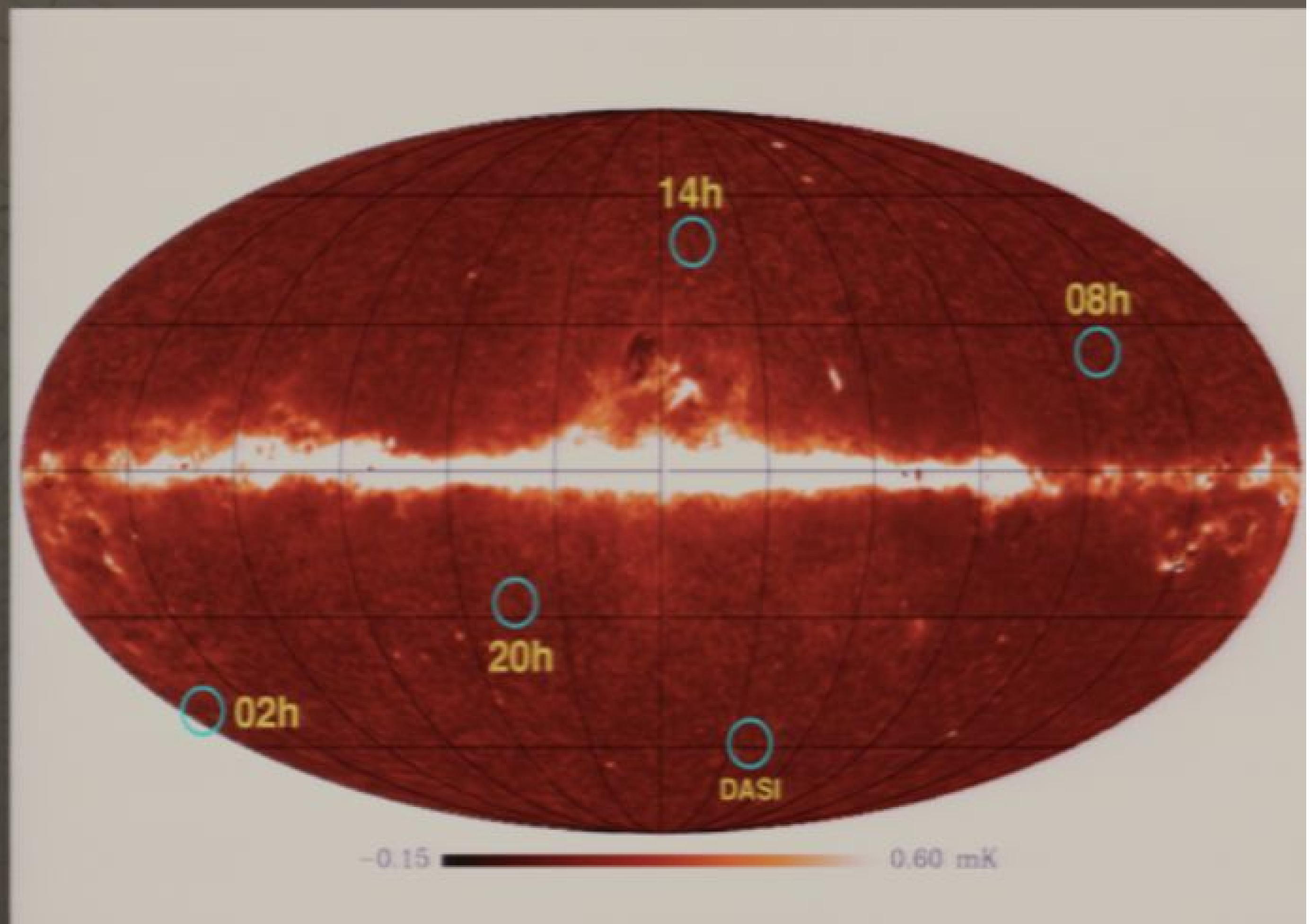
years of data, Jan
– Apr 05.



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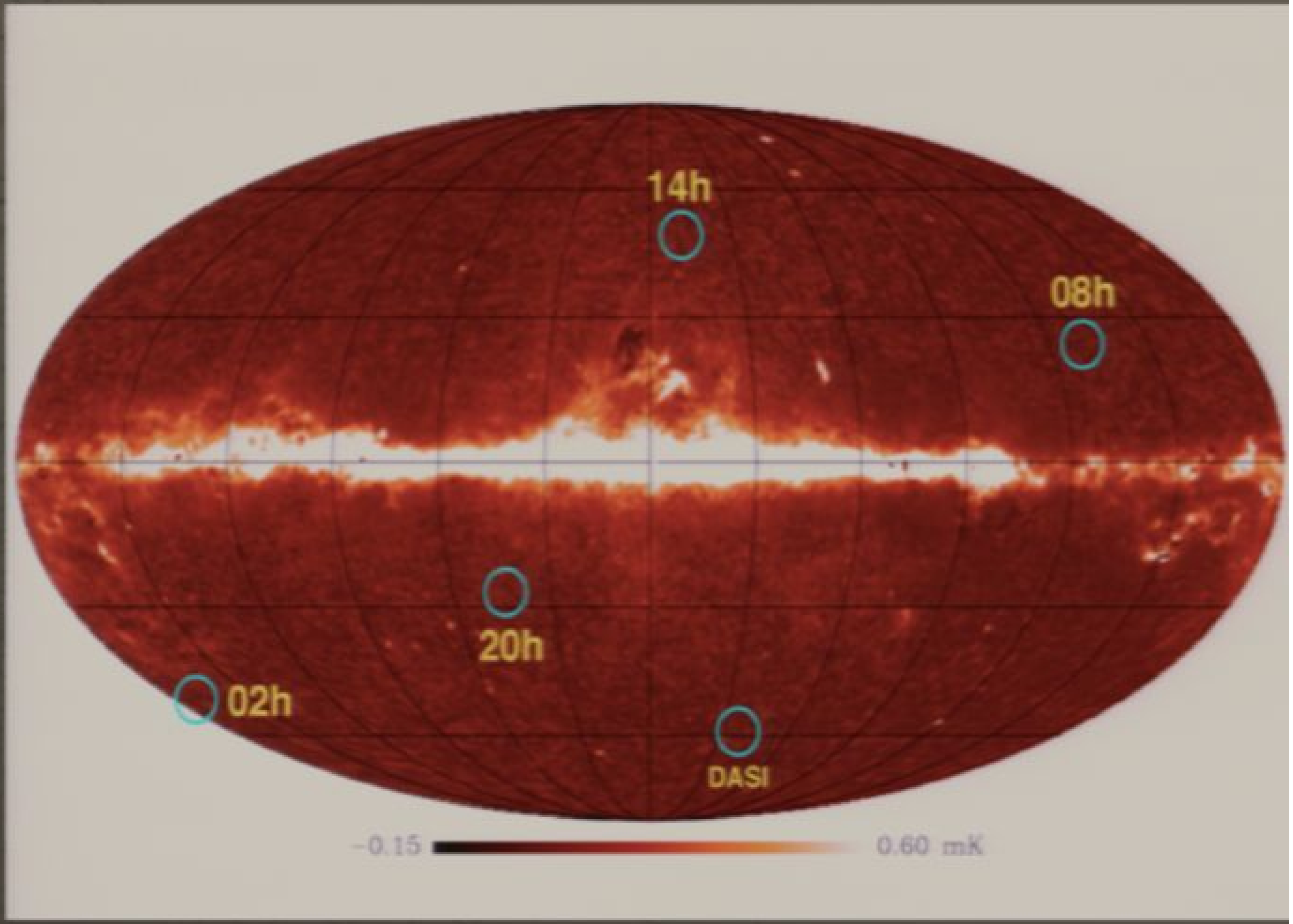
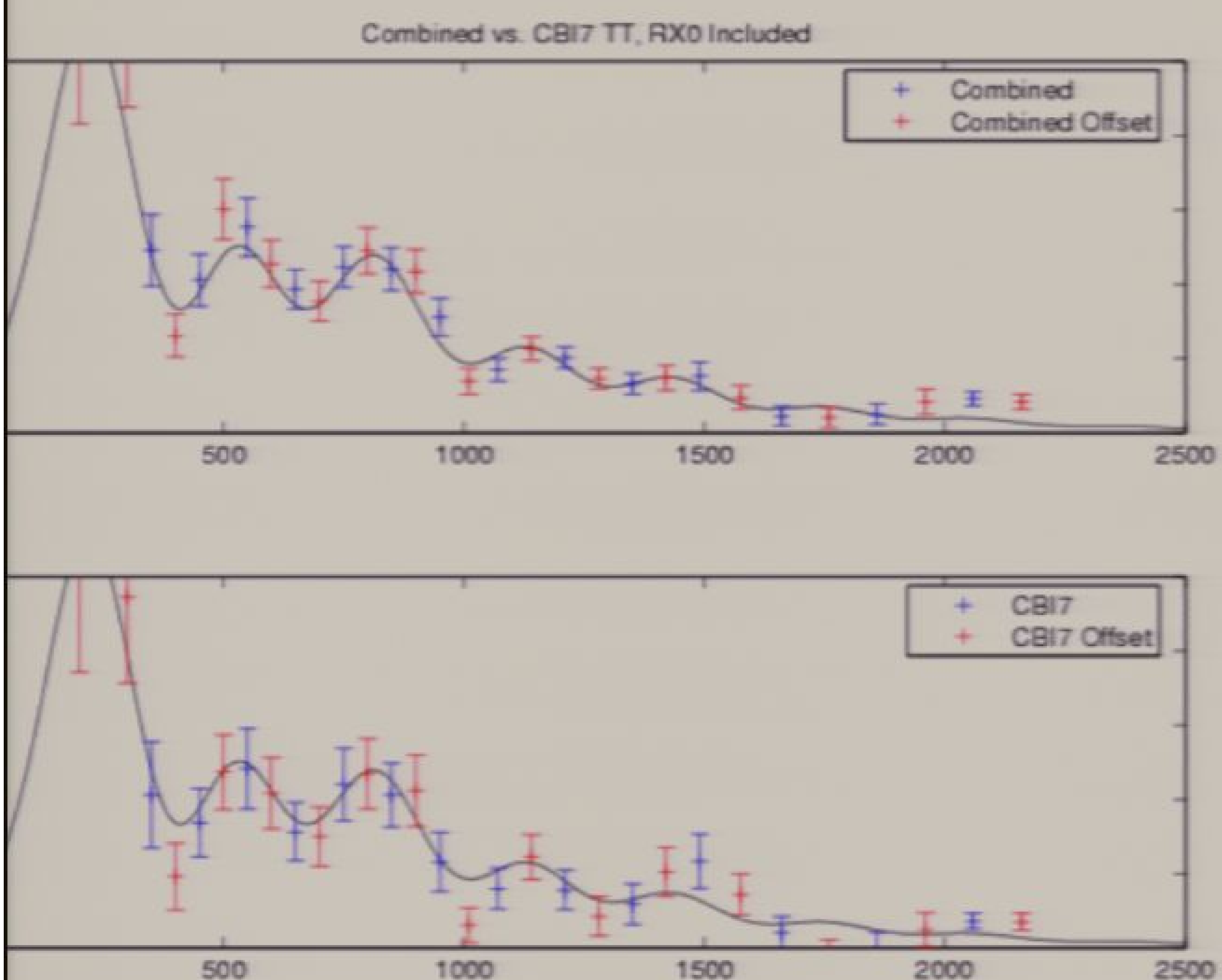


Combining CBI Datasets

- ave 2 datasets. Partly overlap, observing strategy very different.
- ake matrix that maps CMB sky (Fourier plane version thereof) to data for each dataset. (code written by Steve Myers)
- lue matrices together, then outer product gives correlated expected signal.
- eed signal into maximum likelihood pipeline, get optimal spectrum.
- un on CITA MacKenzie beowulf cluster. Takes few hours to do signals, 10 min to then get spectrum.

Current Best CBI Spectrum (vs. Old)

Top panel – new spectrum! Will be published soon.
Data on which current excess results based.



Bottom – old best TT spectrum.

Top – current best spectrum.

For most of ell range, errors down by ~40%. CBI in compact config. in polarization, so little high-ell data. Highest bin only ~10% smaller.

NB: two binnings shown. Red/blue points *not*

CBI (+ACBAR?+BIMA) Excess

SZ clusters should contribute to the CMB power spectrum in a frequency-dependent way.

Signal level very sensitive to σ_8 – roughly $\sigma_8^7\Omega_M^2$.

CBI currently detects excess at 4.1σ (vs. primary CMB) in overall level, fold in uncertainty due to faint point source contributions, goes to 2.9σ.

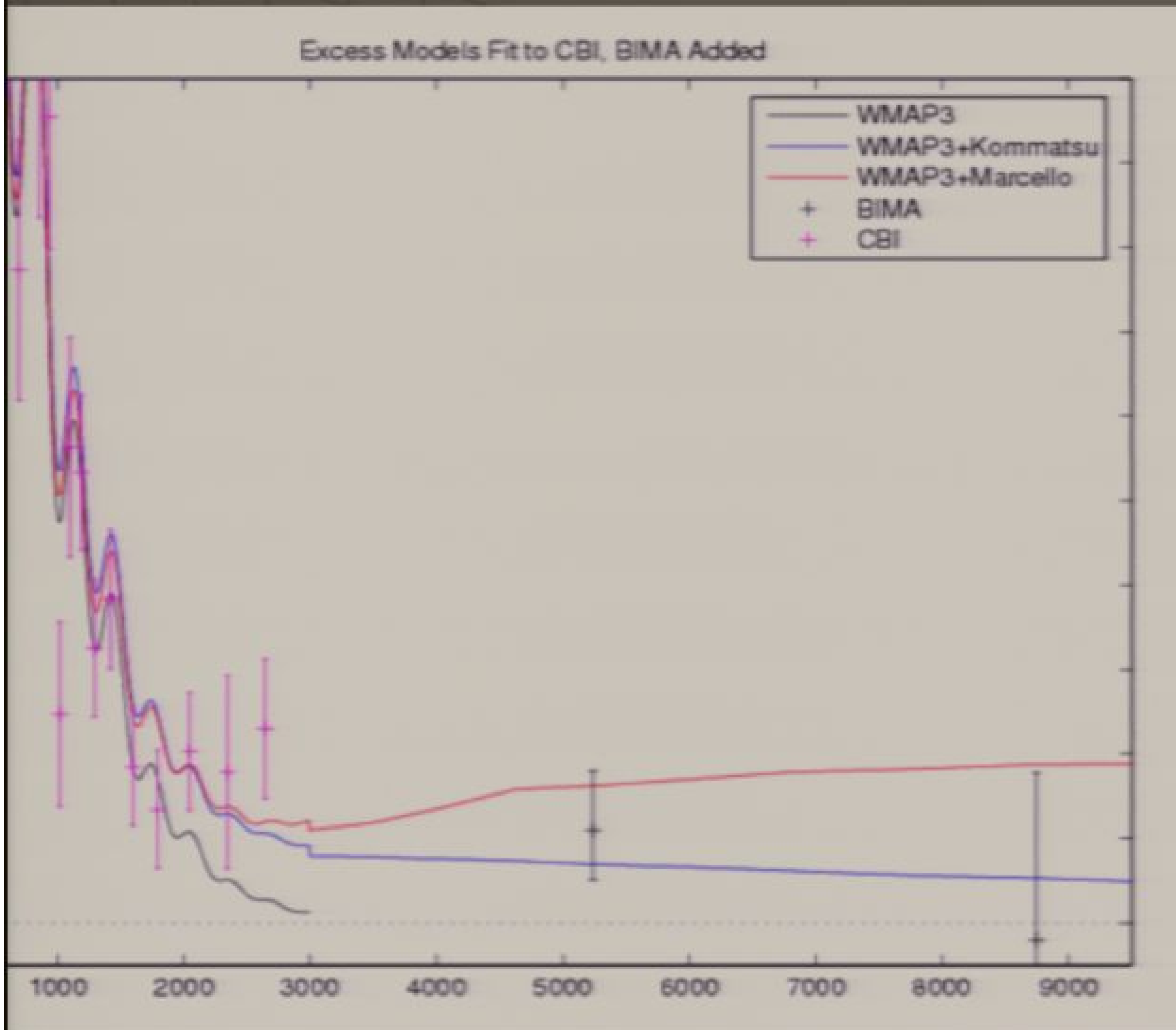
Currently observing radio point sources with GBT. Gets us more data, plus better knowledge of faint sources (currently 50% uncertainty).

CBI excess wants σ_8~1 (if level from old sims).

BIMA also detects power at a level consistent with CBI if SZ. ACBAR has suggestion of detection, consistent with CBI+BIMA (150 GHz gets ¼ power of 30 GHz) - but pure CMB not ruled out.

Modeling expected level still a tricky business.

Current CBI+BIMA PS



Fit CMB+Excess model to CBI data (using raw data, not a fit to the power spectrum). Red curve SPH simulation-based template (Bond et al.), blue curve analytic (Komatsu&Seljak, Spergel et al.).

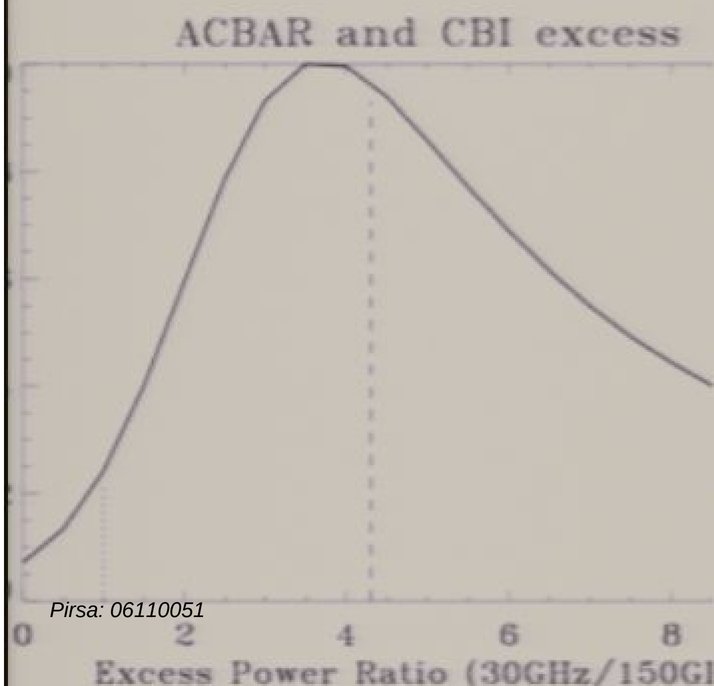
Magenta points latest CBI w/ finer binning. Black points latest BIMA.

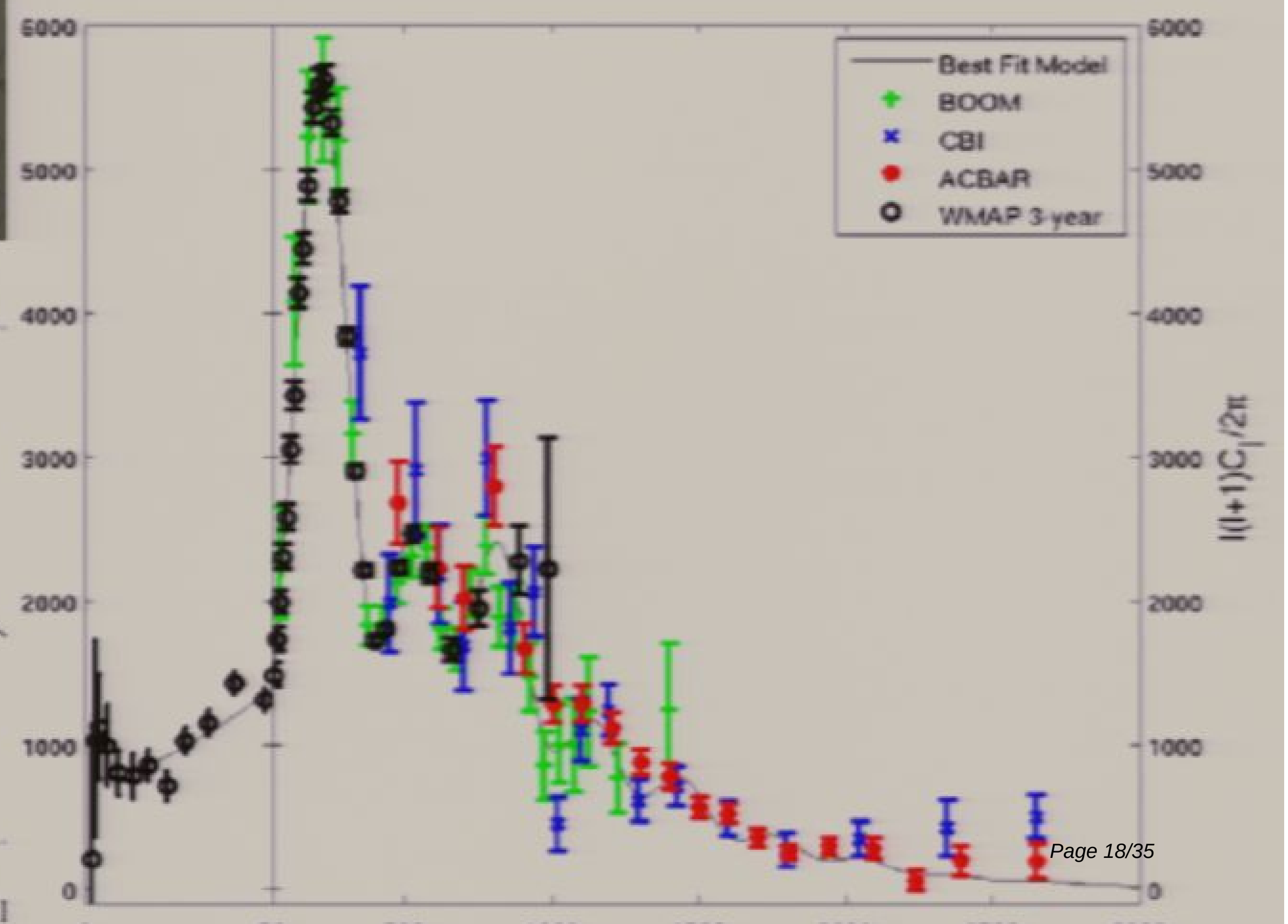
Models extrapolated to BIMA points – not a fit. Differences between analytic/simulation templates of factor of 2, implies σ_8 model

I excess were due to unexpected source

New ACBAR (this week!)

CBAR observes same ℓ range as CBI, at 150 GHz. Due to spectrum f SZ, expect 4 times the power in CBI as in ACBAR if excess from usters. Peak likelihood of ratio=4.3, 5 times more likely than 1.





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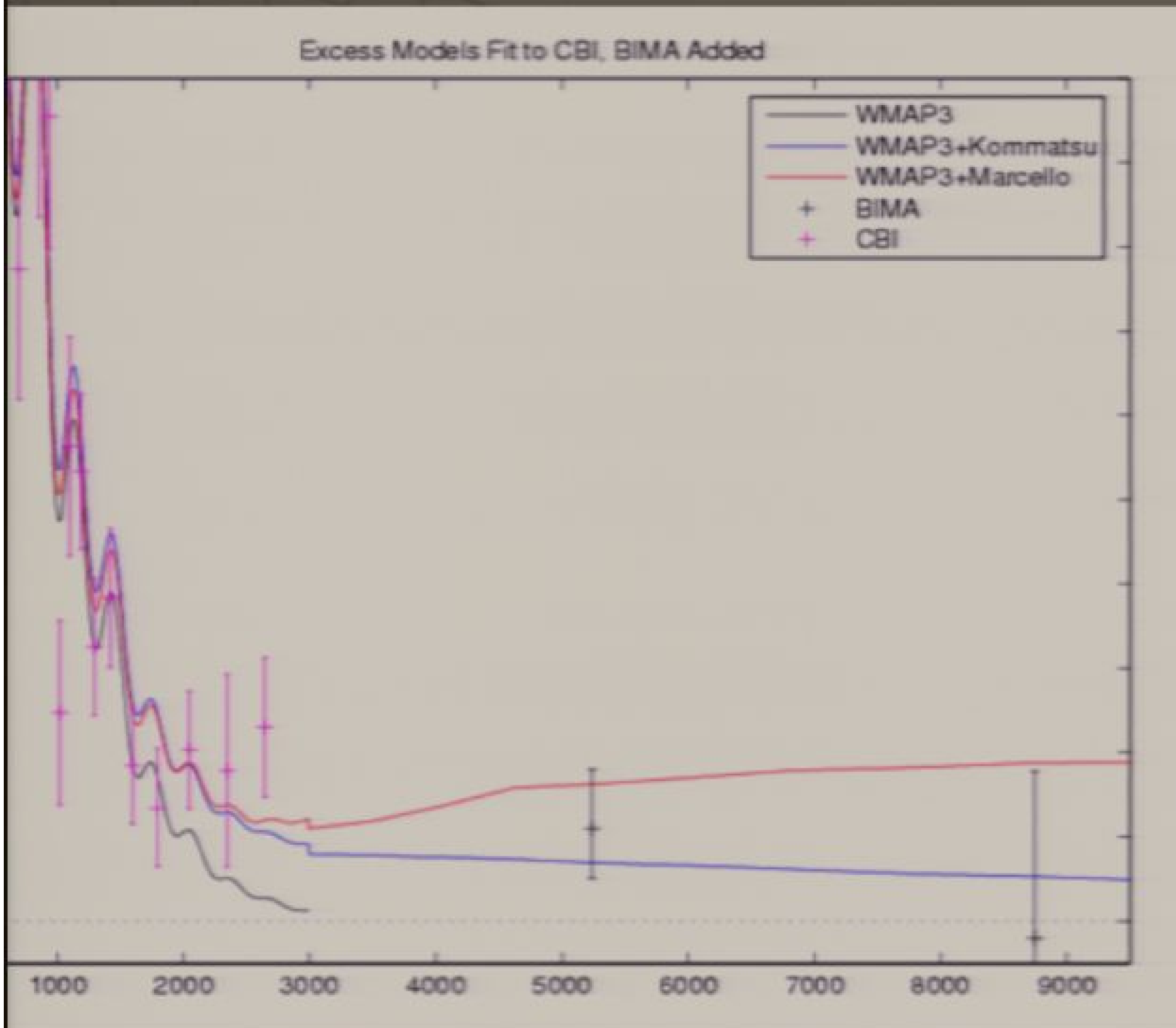

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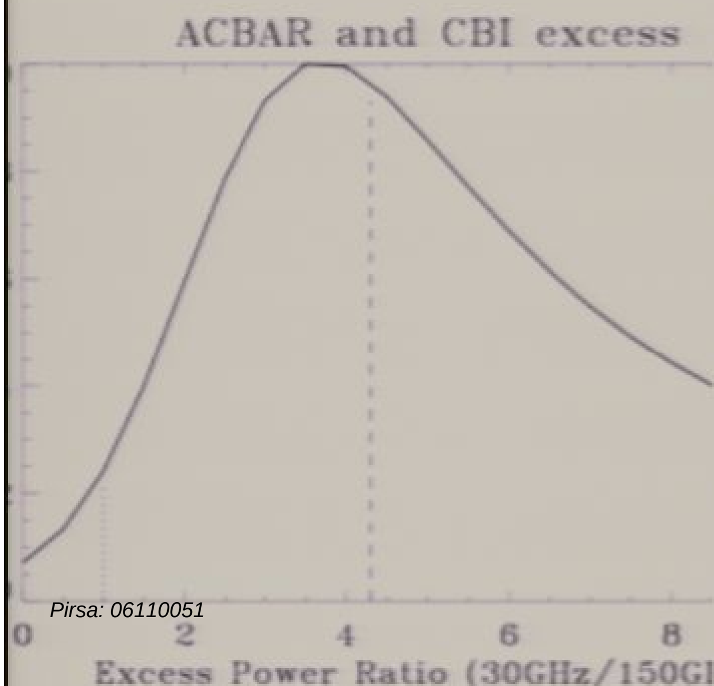
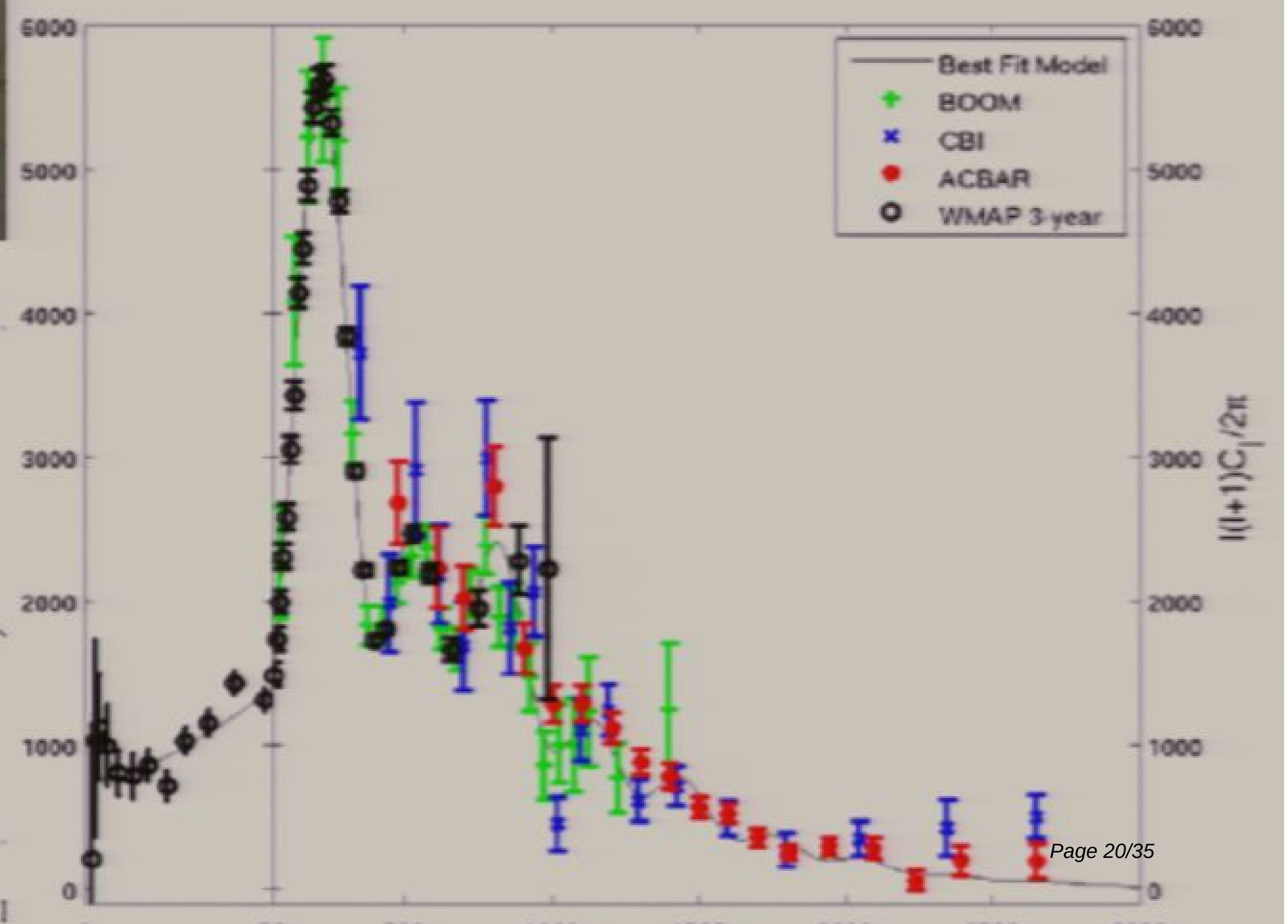
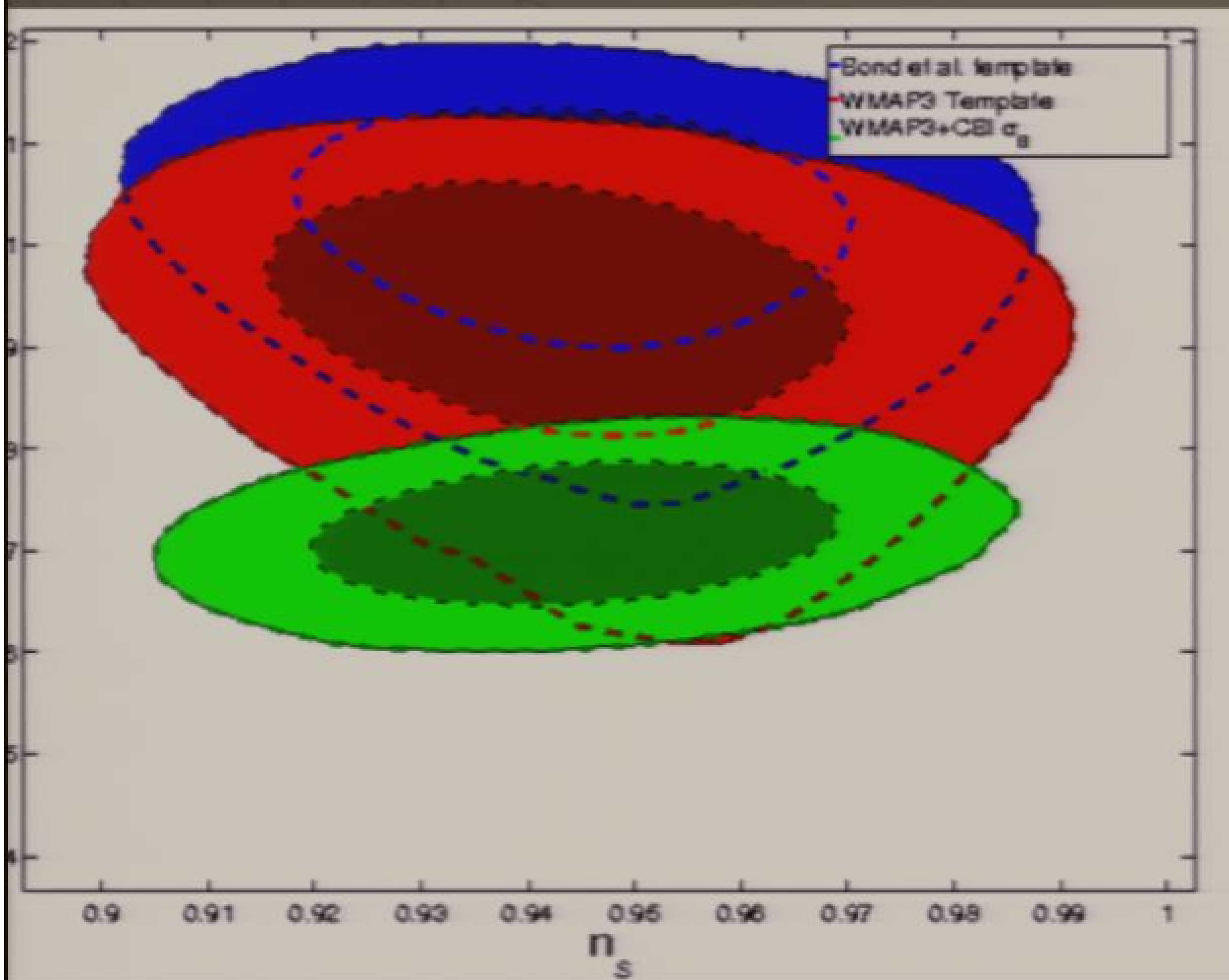




Actual σ_8 From Chains



Do full parameter analysis with all CMB (including latest CBI, WMAP3).

Inferred σ_8 for Bond et al. template is 1.00±0.1, for Komatsu & Seljak is 0.93±0.1.

Komatsu & Seljak somewhat consistent with latest Chandra M-T relation (Vikhlinin et al.), but uncertanties still important (low-mass kink, etc.) Subha Majumdar working on prediction.

s assume Gaussian noise in PS only. Doesn't
le errors from non-Gaussianity of clusters,

How to Proceed?

f excess is from clusters, should be optical-radio correlation. ;ignal clear since clusters are negative in radio, unlike :verything else in the sky. We have obtained CFHT images of :BI deep fields, doing correlation now.

3etter source observations. 30 GHz faint source counts ıncertain at ~50%. Leads to 25% uncertainty in excess level. ;BT 30 GHz system working – we are observing faint sources in IVSS to nail down 1.4-30 spectral index distribution.

.ook at clusters in more detail. CCCP (PI Henk Hoekstra) a ›rogram to do weak lensing of ~50 X-Ray bright clusters. CBI vill get SZ of ~20 – will help with prediction of SZ amplitude.

\nd, of course, BETTER DATA! CBI being upgraded – 1.4m lishes being installed as we speak. CBI2 will be 5-20 times as :fficient at excess/cluster observations as original CBI. Should ıave much better spectrum in a year.

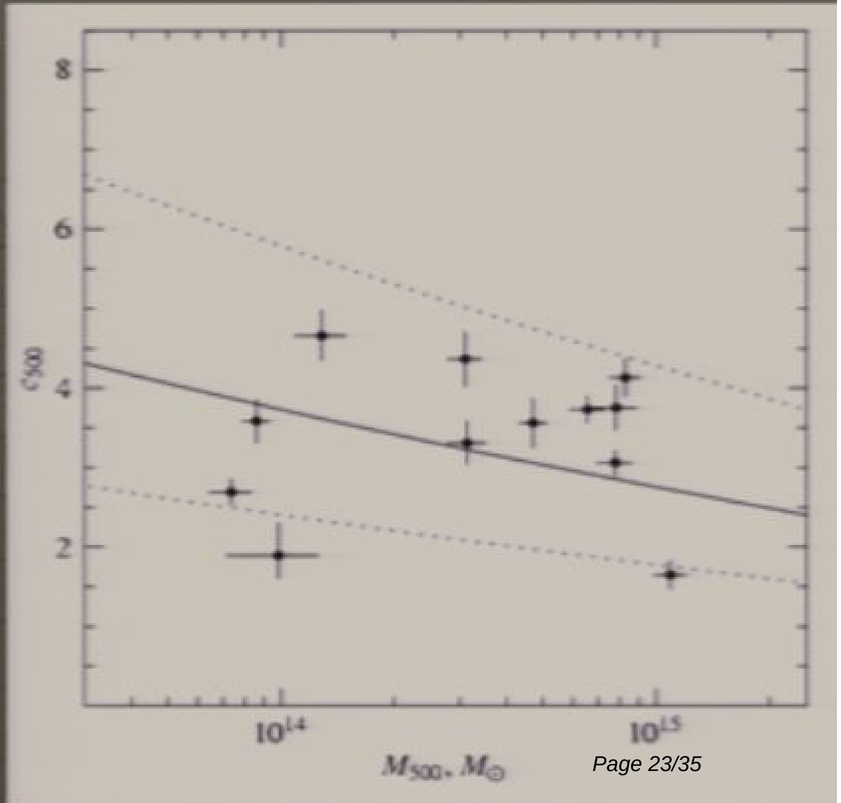
3etter understand how power spectrum from clusters depends ›n cosmology, i.e. use best M-T/cluster profiles (Subha).

M-T+Cluster Structure

Clusters expected to have relation between temperature, mass. $T=M/R$, $M=R^3\rho$, $T=M^{2/3}\rho^{1/3}$. If clusters collapse to similar densities, then T and M are tightly correlated.

Theoretically expected, observationally seen that concentration mostly independent of mass. Leads to good M-T relation.

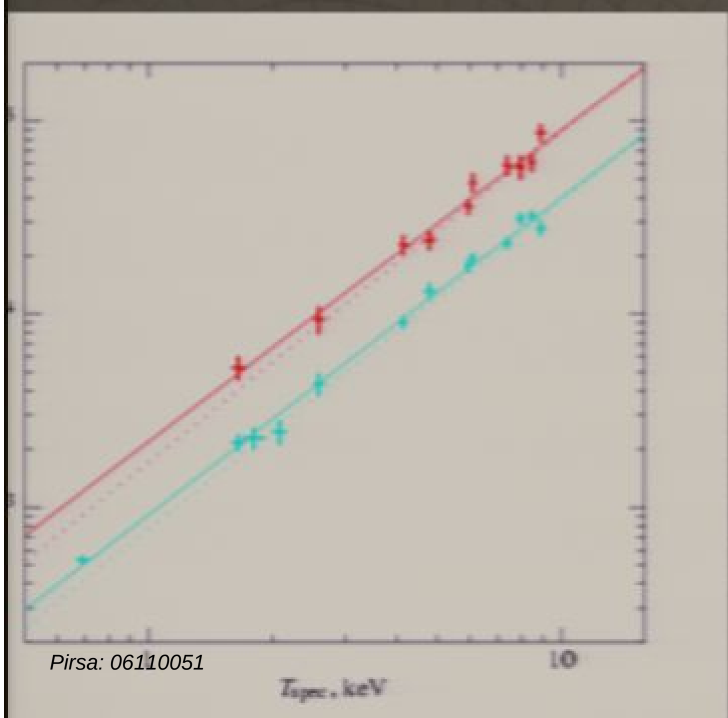
XMM, Chandra get $T=M^{2/3}$ (big ones).

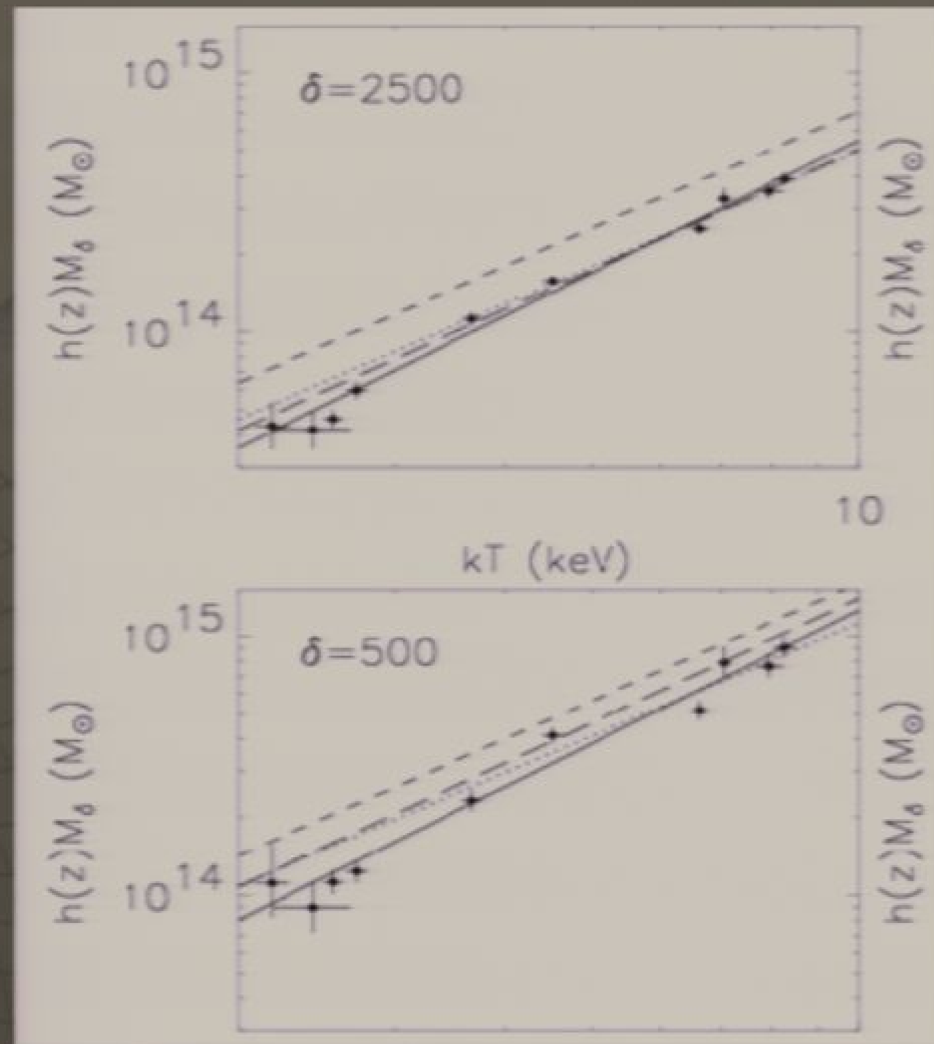


ecially for faint clusters, baryon ysics is important. Below a few keV, nperature seems to saturate (Arnaud al.). Makes low-mass clusters more portant. Gas profile in outer regions o important for SZ spectrum. M-T malization goes directly into SZ plitude, structure into SZ shape. oha Majumdar working on this, upshot t SZ prediction likely will go up.

X-Ray M-T Obs.

from Chandra, XMM. Both get 2/3
iassive clusters (dotted line in
). X-Ray data typically gives
er T's than sims. Adiabatic (short
ed) or cooling (long dash). Faint
ers clearly much hotter than 2/3
rom massive clusters in XMM.



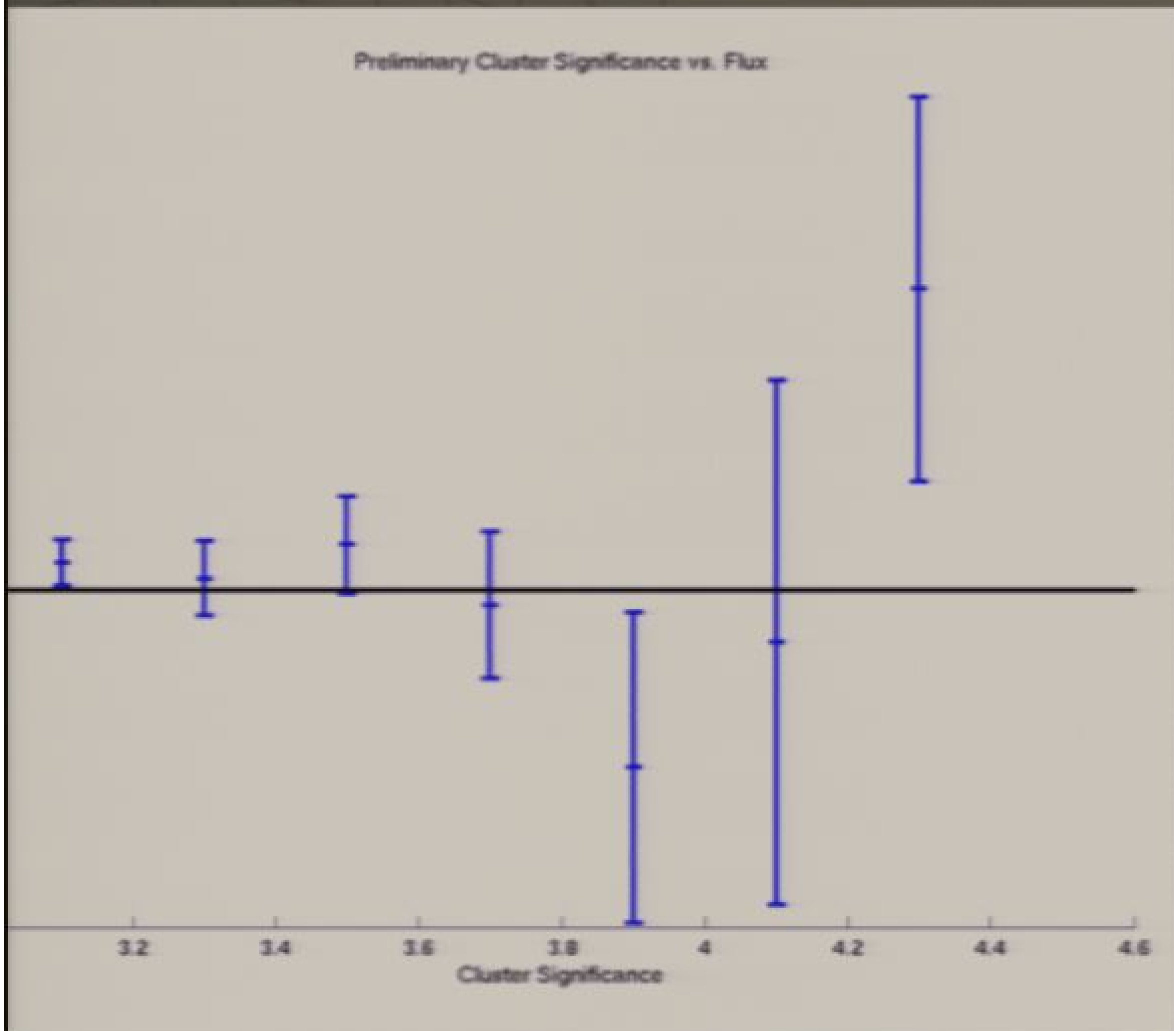


XMM (Arnaud et al.)

Where did the missing baryons go?

Very, Very Preliminary Optical-CMB

ı up clusters, measure CMB power vs.
ster "size". SZ should be negative.



ɛ - sources in low-significance clusters

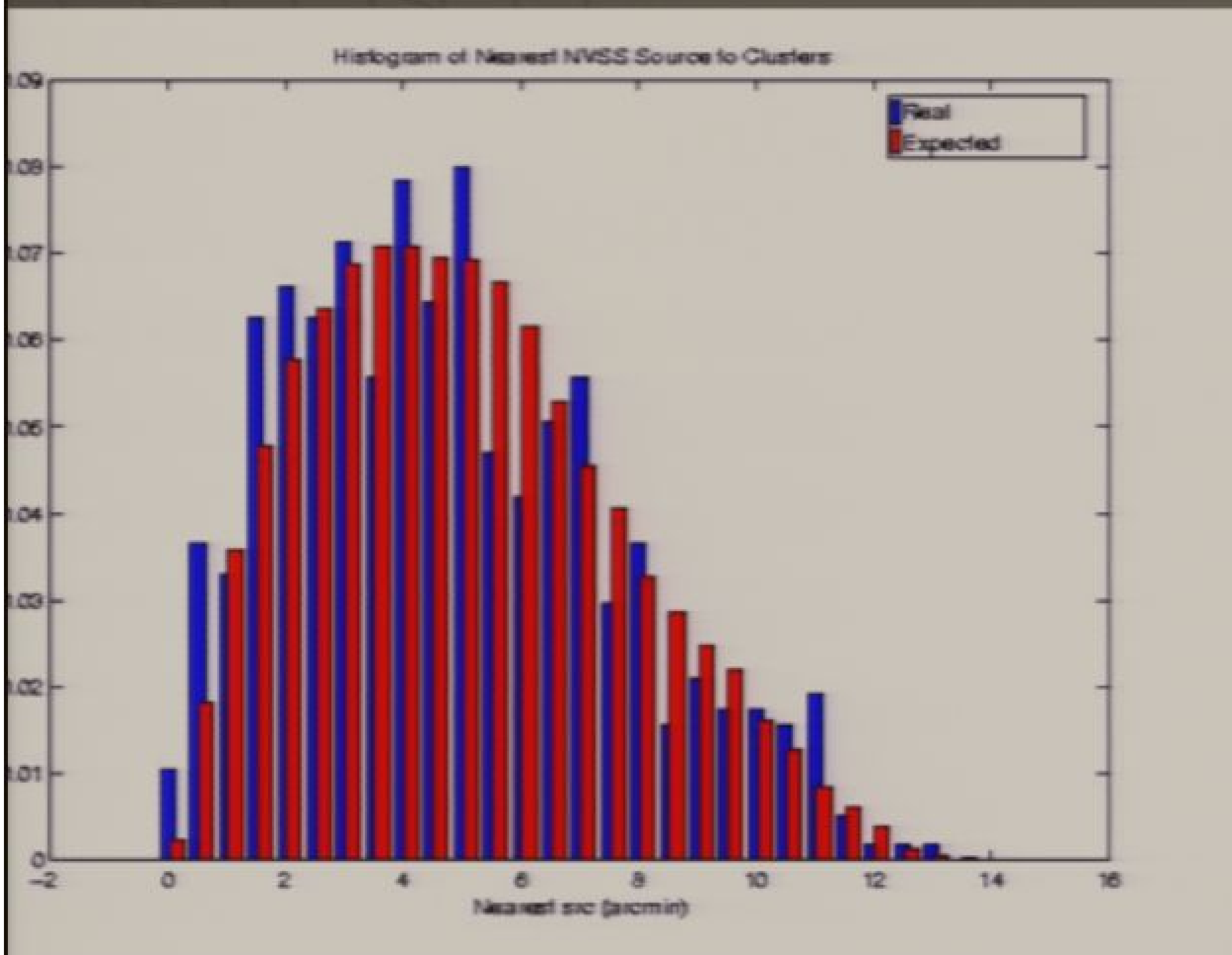
Don't have masses yet from RCS guys – only significance on ~50% of data. ***Very*** noisy. Want mass to ~50%.

If substantial fraction of faint guys dominated by previously unkown sources, then analysis gets more complicated.

(NB, only 2 clusters in highest bin, 5 in second-highest)

Field galaxies should show positive correlation (some are radio sources). Explains low-significance

Optical-CMB cont. NVSS sources



Radio sources might live in clusters. How important is this?

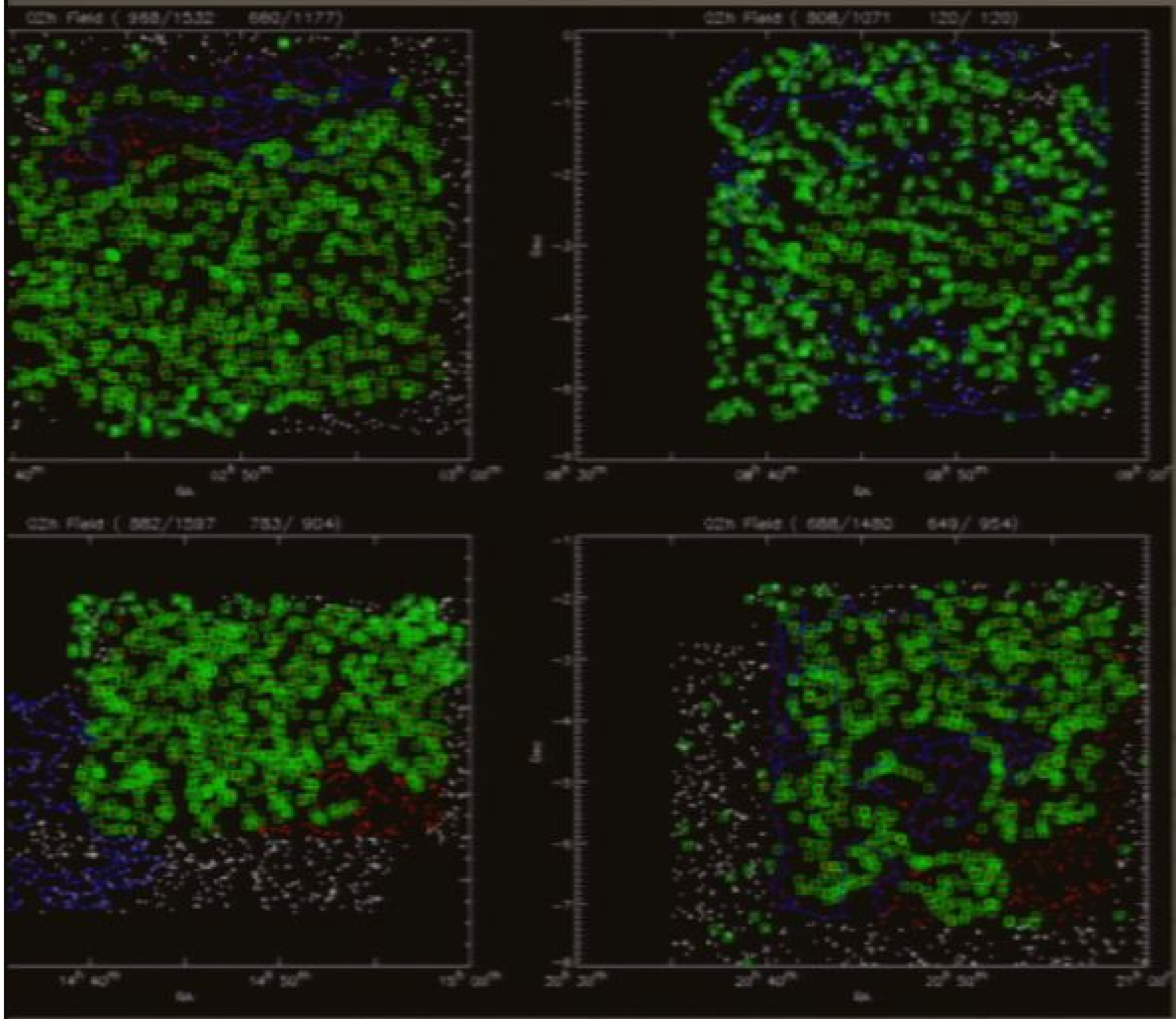
Take cluster positions, measure distance to nearest NVSS source.

Roughly 5% of CBI cluster candidates appear to have NVSS source in them over expected due to chance.

Blue = Distand to real clusters
Red = Expected random distribution

Most CBI clusters do *not* have NVSS sources. Fainter ones?

Sources w/ GBT



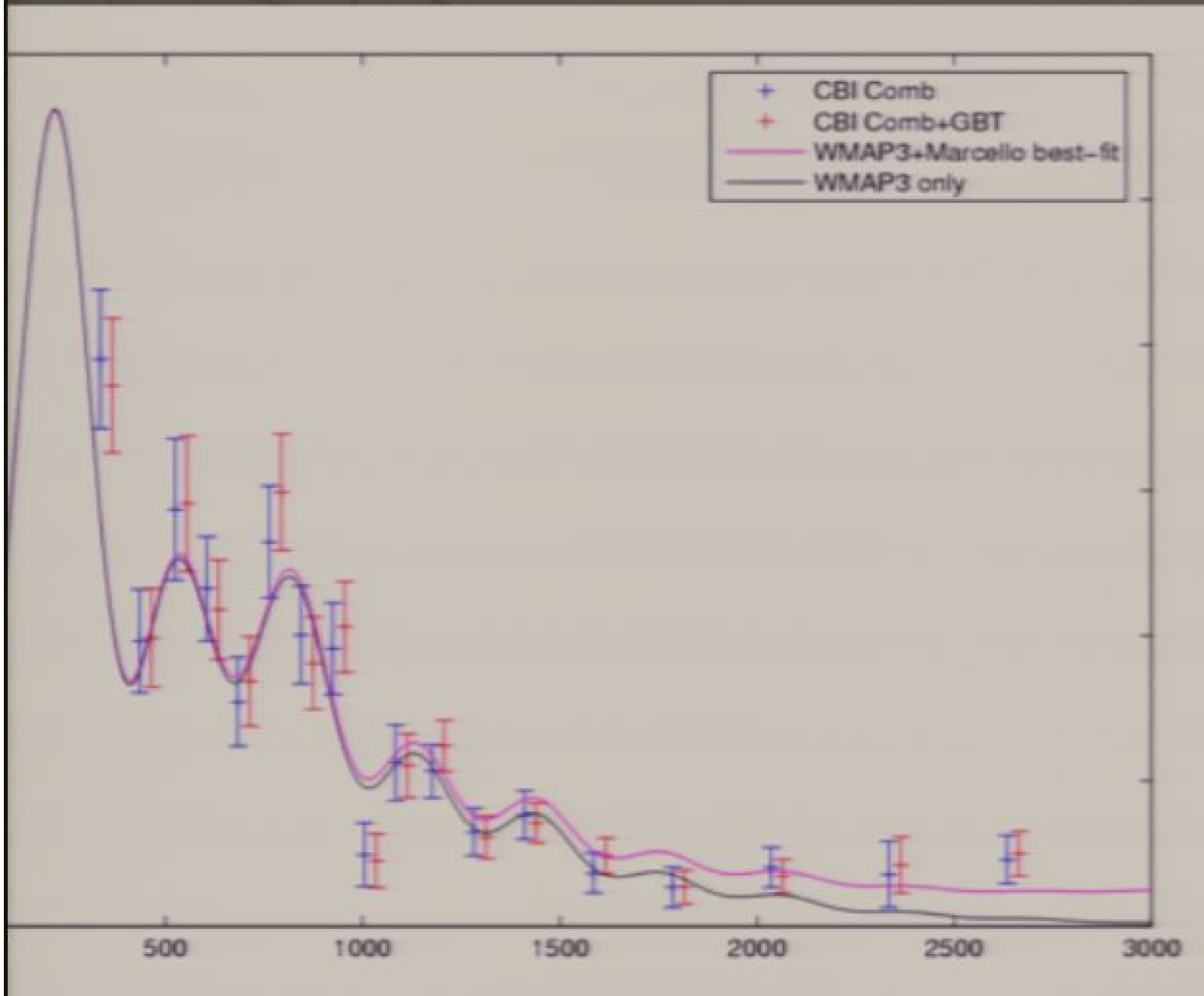
Observing NVSS sources in CBI fields in 2-prong strategy.

First: veto survey to measure all sources to see which ones matter at 30 GHz (large majority don't).

Second: deep obs. of faint NVSS sources to measure Ka counts. Are startbursts synchotron or Free-Free at 30?

= NVSS sources in CBI fields.
= observed by GBT as part of veto survey.
Increases by 50-100% CBI data.

~1/3 of CBI Sources Measured



Use measured sources from GBT to make new spectrum. Do not project out sources now known to be faint at 30 GHz. Unmeasured+bright sources still projected. Error bars down by ~15% (about what expected from 1/3 of sources).

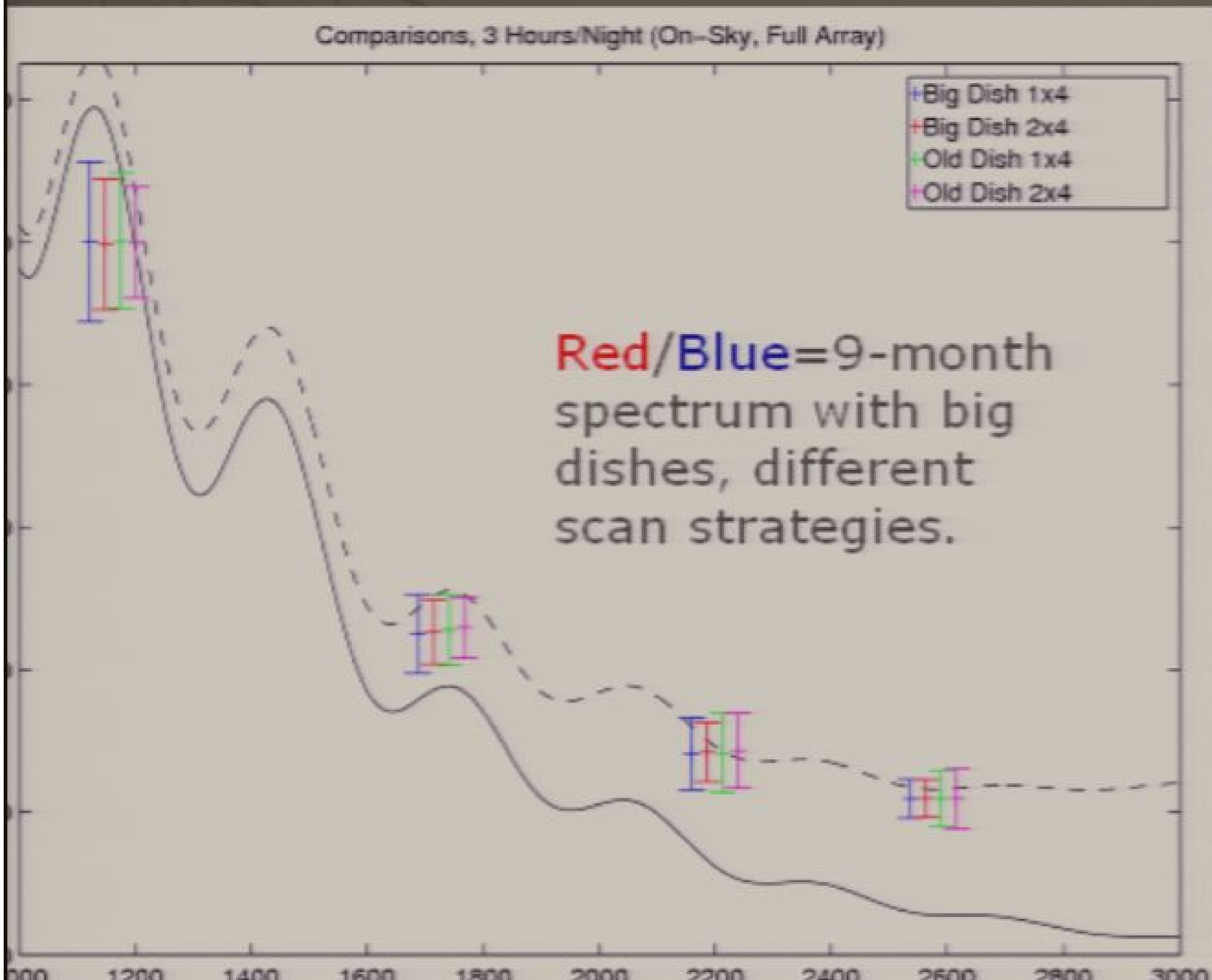
No strong trend in level of spectrum as sources added – means GBT levels are pretty good.

Preliminary source list but pretty close.
Observations + analysis of faint ongoing, but

is month: CBI2!

- 9m --> 1.4m dishes
- ound Shield (eventually)
- asure the excess
- ch better SZ sensitivity.
- strument is ready to go, nsitivity good, just need pump out gens.

CBI2 Forecast – 9 Months on CMB



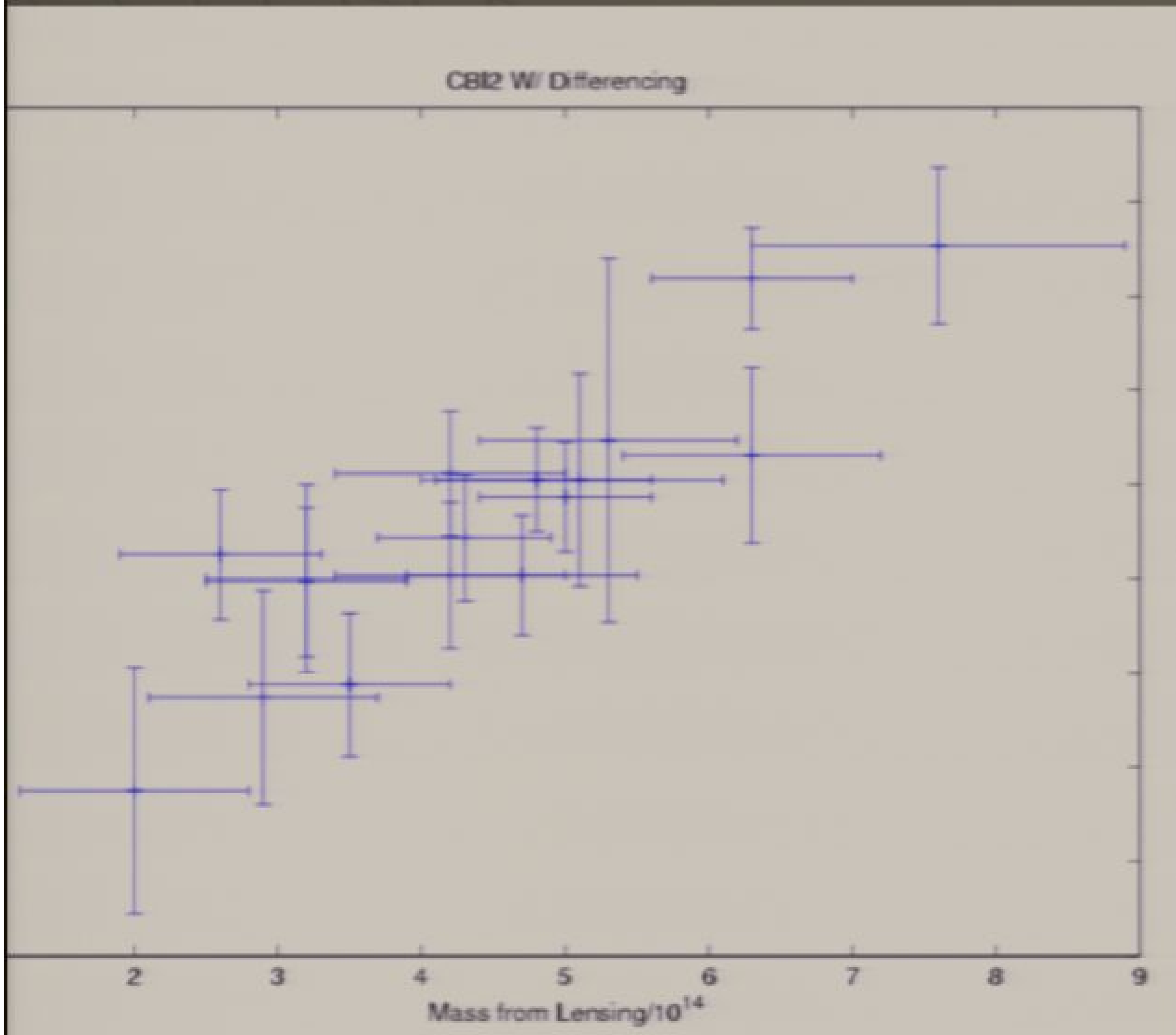
Forecast gives 12% error on current excess, assuming level doesn't change.

Should be able to get GBT follow-up observations.

CBI2 fields all are in areas where multi-wavelength data is available. Weak-lensing definitely, also some X-Ray, IR...

Weak Lensing vs. SZ/X-Ray Masses

(~15 total nights observing time on CBI2)



Simple CBI2 forecast. Assume 130 uK error (differencing – worst case). Fold in errors on X-Ray temp., see what errors on mass come out.

Does not include shape uncertainties, point sources... Assumes same shape for everybody.

Simultaneous X-Ray, SZ, weak lensing pipeline just done (Mahdavi).

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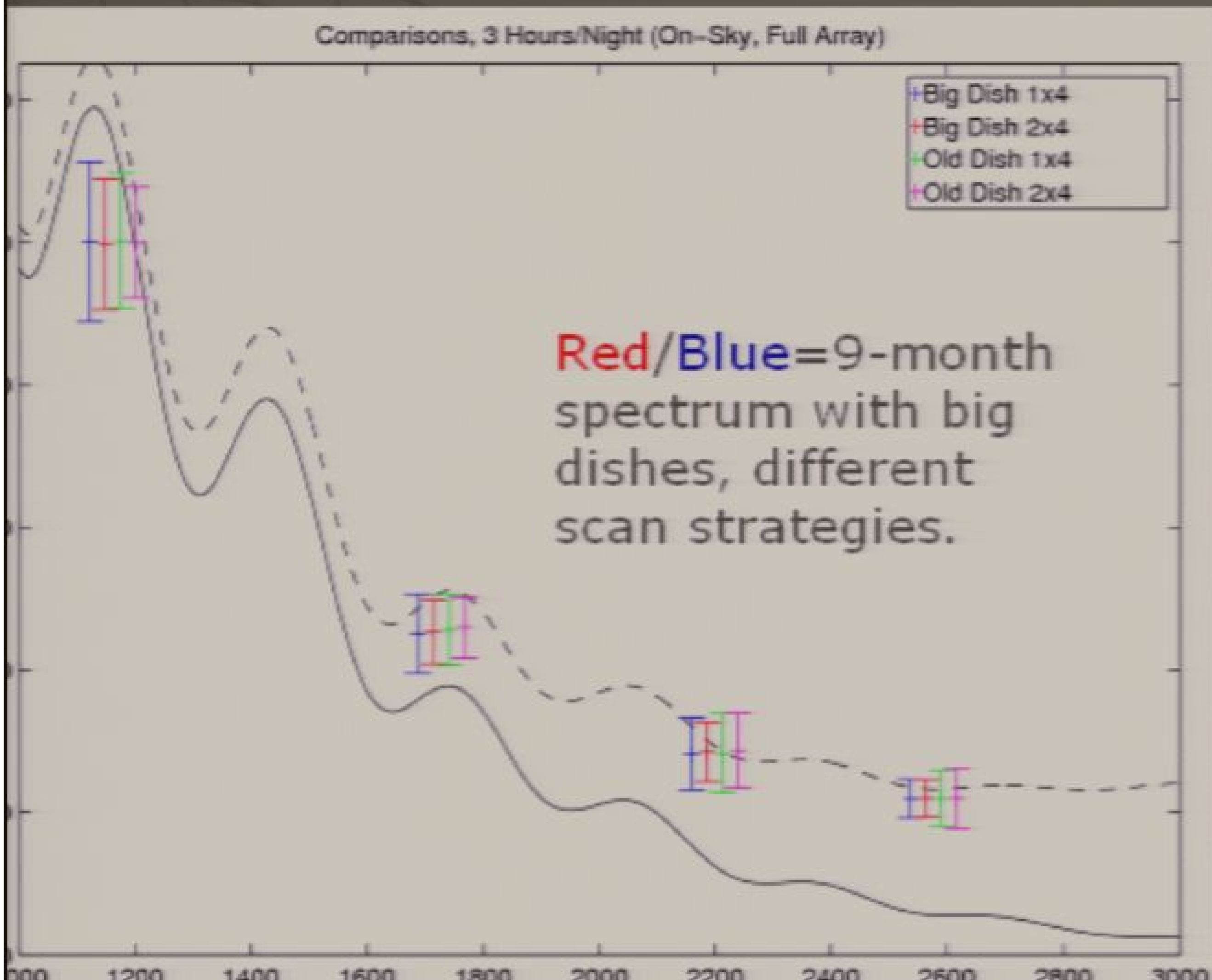

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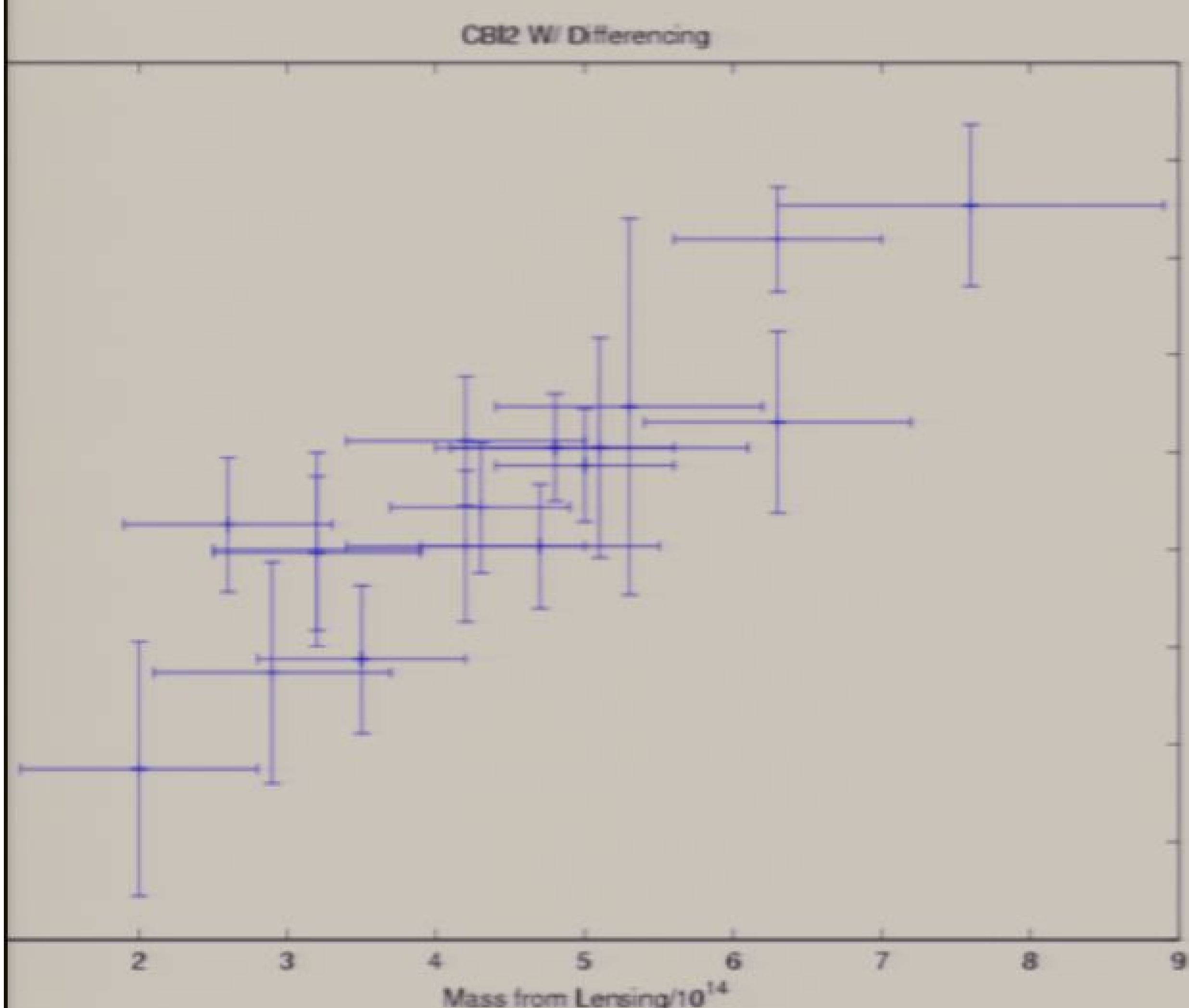

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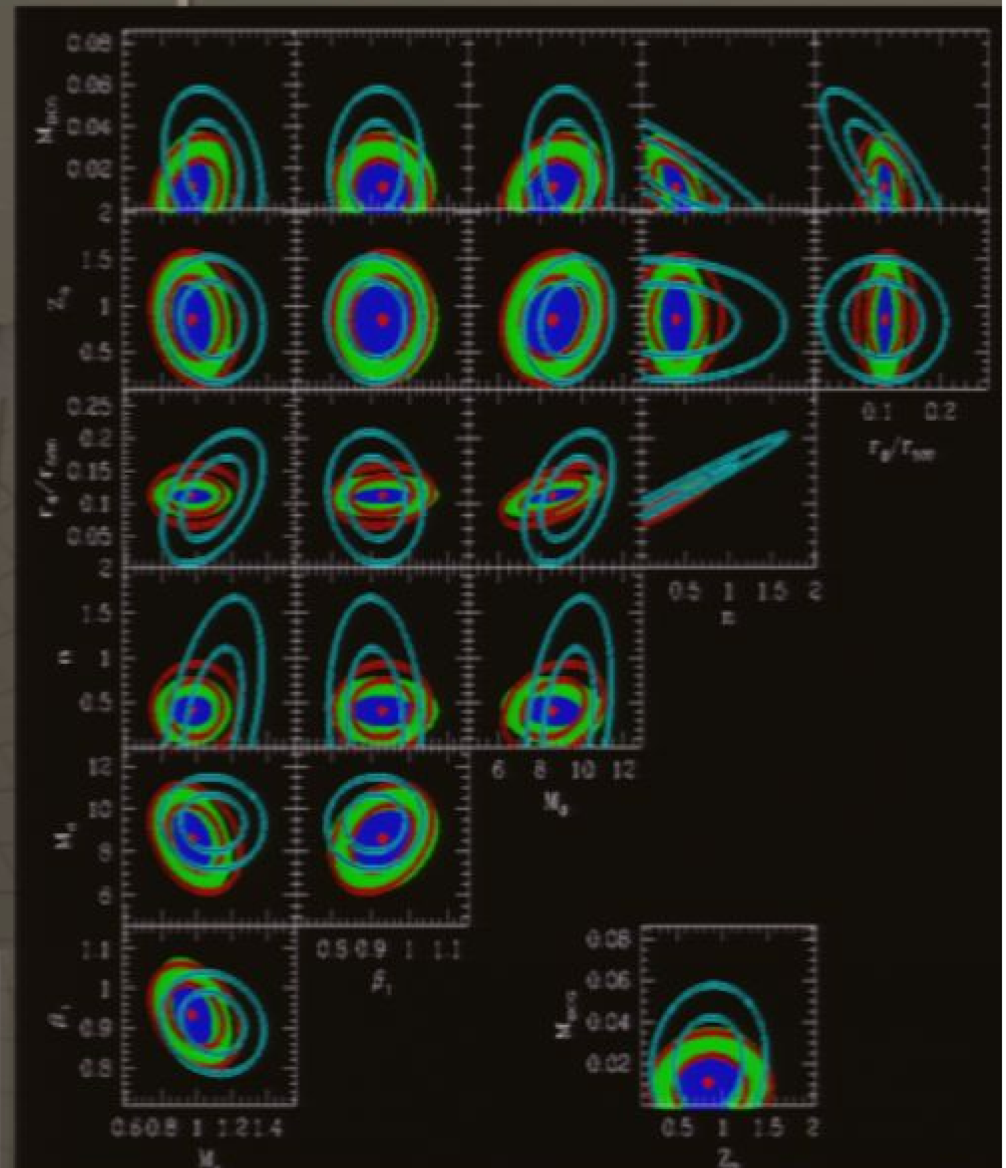
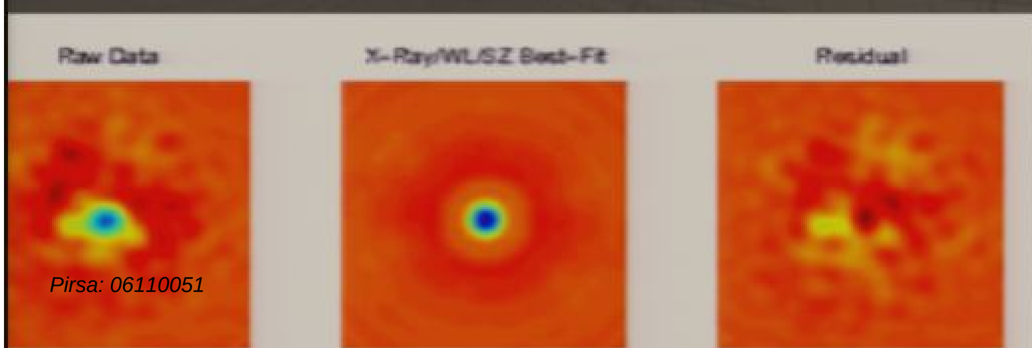
Cluster Analysis Pipeline

multaneous X-Ray/Weak lensing/SZ
peline (Mahdavi et al. 2006) is done.
e have run A478 as a test case.
orks well, and the combination is
werful. In particular, SZ breaks
generacy in outer cluster structure.

rmal uncertainty in M_{2500} is 3%.
peline assumes hydrostatic
uilibrium, spherical symmetry (for
w), so real error likely larger.





Blue=X-Ray
Red=X-Ray+WL

Summary

Combined CBI dataset gives much better CMB power spectrum, modest improvement at highest ell.

CBI detects excess power at $\ell>2000$ at 3σ. Will go to $\sim 5\sigma$ (assuming level doesn't change) with GBT data (most of which is in hand).

Working on CMB/Optical correlation, results should come soon.

CBI2 will do much better on high-ℓ excess. Important even with other expts. due to l-range, frequency. (new ACBAR has done same ℓ range at 150, SZA will do higher-ℓ. SPT, ACT coming before too long.)

CBI2 will do major SZ cluster program - ~70 clusters to 10-15% (we hope, but haven't started science obs. yet).

Science observations taking place imminently!