

The SPT-SZ Cluster Survey

Tom Crawford (U. Chicago /
KICP) for the SPT Collaboration

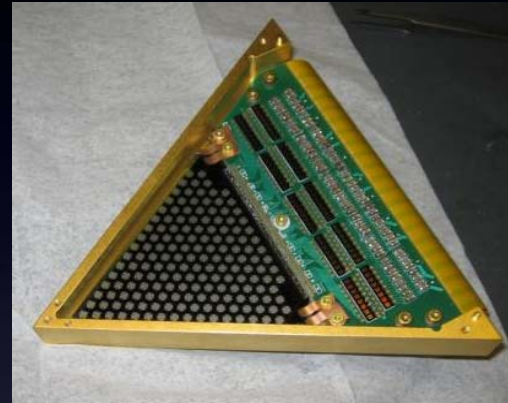
10m South Pole Telescope

- Big! (At least by CMB standards)
 - 10 meter clear aperture, ~7.5 meters illuminated
 - 1' FWHM @ 150 GHz
 - 1 sq. deg. FOV
- Clean!
 - Off-axis Gregorian
 - ~20um RMS surface
 - 3 levels of shielding
 - under-illuminated primary, co-moving shields, large groundscreen (2009)
- Fast!
 - up to 4°/s scanning



1st-Generation Camera

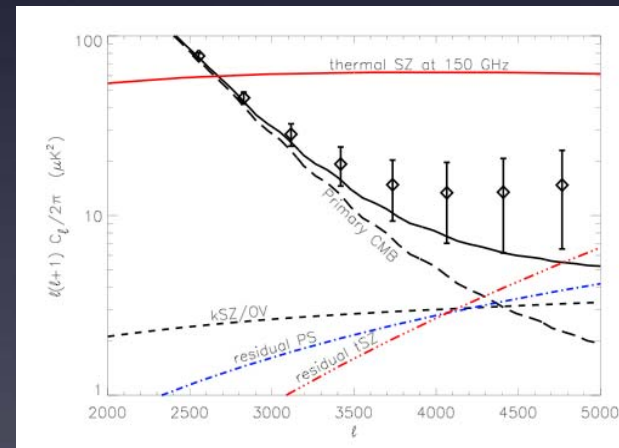
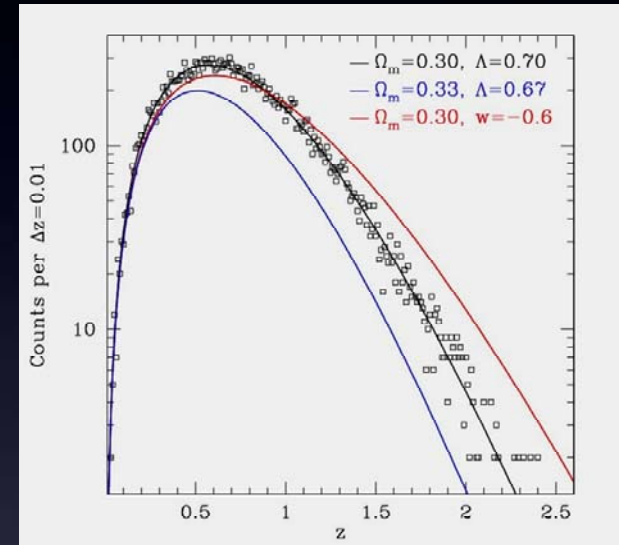
- 6 wedges of 160 bolometers each.
 - 90, 150, 220 GHz
- Cooled secondary mirror and baffles for control of loading & spillover.
- Detectors & receiver cryostat by UCB, readout by LBL, cold optics by Case/Chicago.



SPT Science Goals

- Find galaxy clusters through the Sunyaev-Zel'dovich Effect (SZE), constrain properties of Dark Energy.
- 4000 sq. deg. + 10uK-arcmin = find thousands of clusters (complete to $\sim 2.5 \times 10^{14}$ solar masses), measure w to ~ 0.1 .
- Measure small-scale Cosmic Microwave Background (CMB) anisotropy.

Figure courtesy of G. Holder



T. Crawford, SPT-SZ Cluster Survey, XMM-XXL Paris 2008

SPT Collaboration



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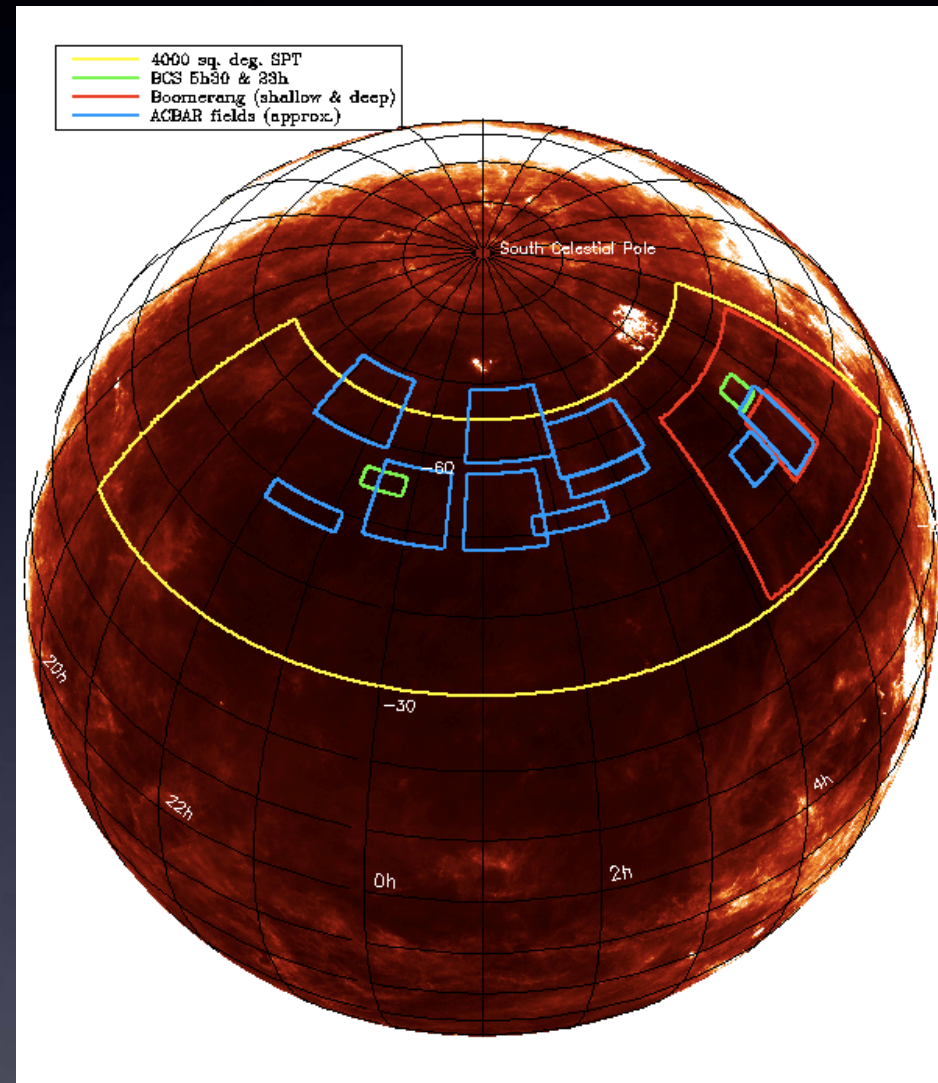


Lloyd Knox

Jason Dick

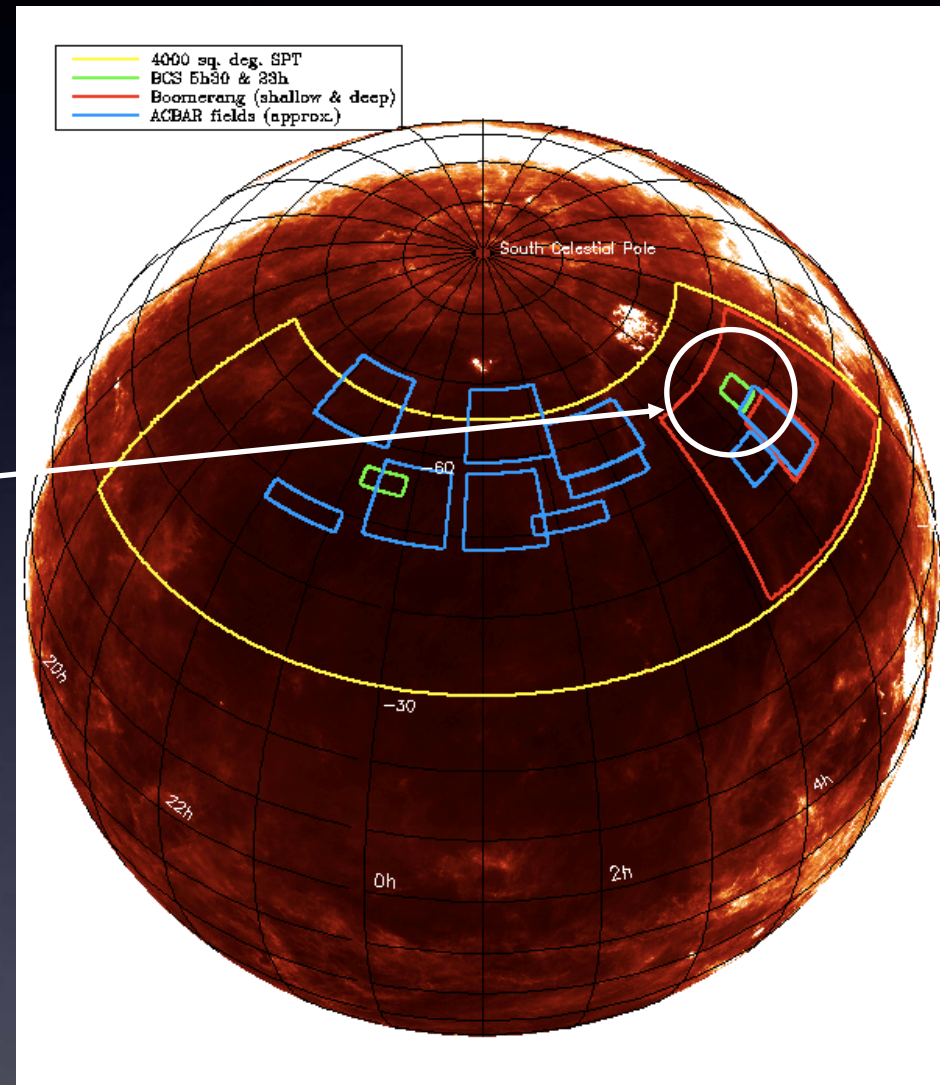
The Survey

- Limited to Southern Celestial Hemisphere.
- Galactic dust emission drives to $20\text{h} < \text{RA} < 7\text{h}$.
- Atmospheric emission drives to observing elevations $> 30\text{deg}$.
- Leaves us ~ 4000 contiguous square degrees.



The Survey

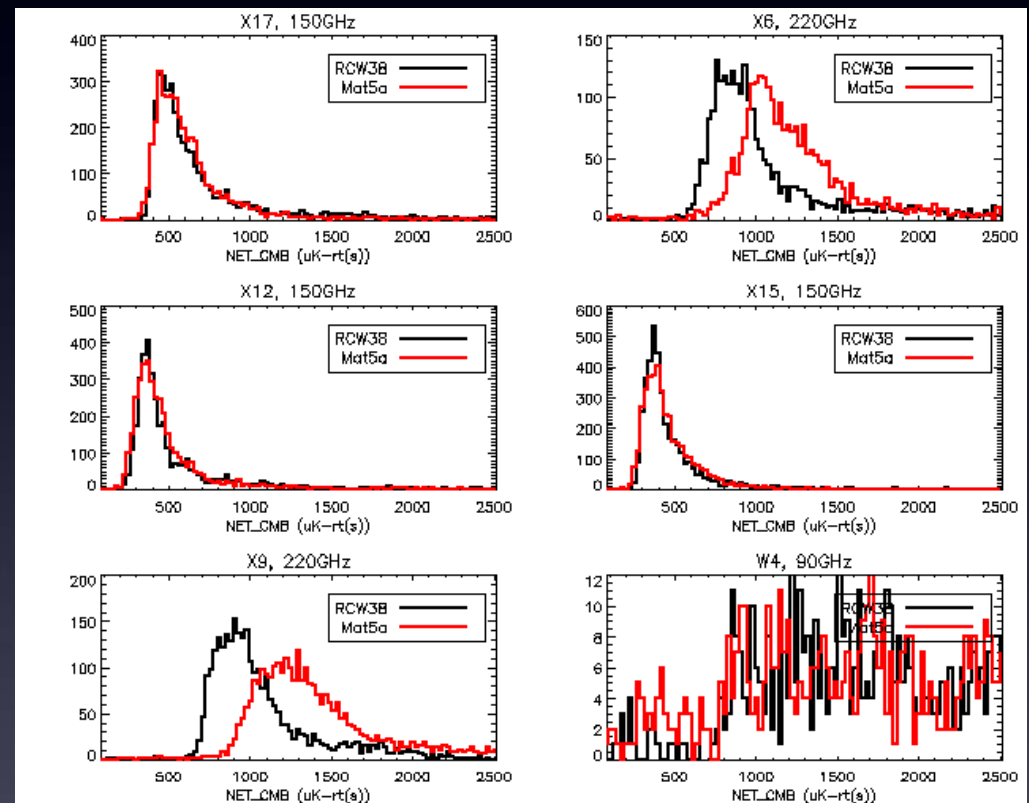
- Expected survey duration: Now - September, 2011.
- Currently going deep on 100 sq. degrees (RA=5h30, dec=-55) to check systematics. (Field includes optical and CMB “follow-up.”)
- Time available in survey for other deep fields (hint, hint).



2008 Receiver performance

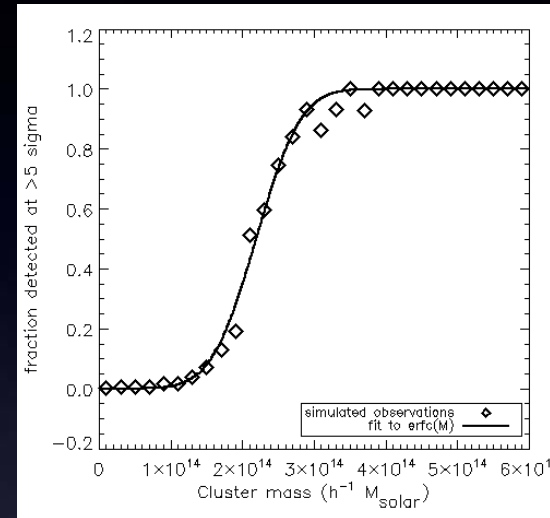
ν_c (GHz)	$\Delta\nu$ (GHz)	T	R (W)	G (m ² /K)	NET_{11} (μ K \sqrt{s})	$NET_{1, \text{var}}$ (μ K \sqrt{s})	$\theta_{r, \text{var}}$ (arcmin)	NEFD (mJy \sqrt{s})
15	24	0.064	8.1	2×10^{13}	221	278	1.58	14.6
150	38	0.082	0.8	2×10^{12}	150	259	1.00	9.9
219	35	0.069	1.0	2×10^{12}	184	351	0.69	12.2
274	67	0.050	24.5	4×10^{12}	156	774	0.56	10.5
345	27	0.044	22.3	4×10^{13}	425	4975	0.44	28.1

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95	30	1.58	248	304	16.0	24.6	17.4
150	38	1.00	172	297	11.4	24.0	17.0
219	40	0.69	184	606	13.4	49.1	34.7

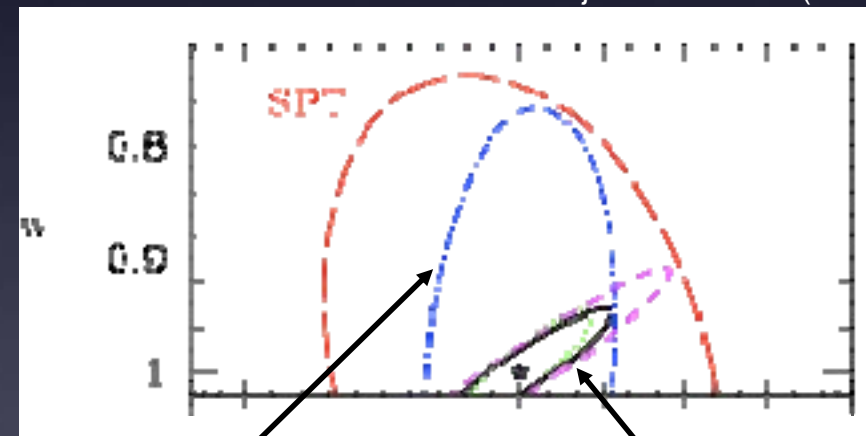


The Survey

- Simulated observations (including many levels of non-idealities) show full survey should be 90% complete at $\sim 2.5 \times 10^{14} M_{\text{sun}}/h$.
- BUT: Mass/SZ relation needs to be calibrated (including scatter & redshift evolution). Self-calibration methods are greatly improved by complementary mass estimates of even a small fraction of clusters.



Majumdar & Mohr (2003)



No follow-up

100 clusters

Summary

- 10-meter South Pole Telescope + 1st Generation Camera deployed & operating.
- >1000 sq. deg SZ cluster survey is underway.
- Survey science yield can be improved by independent cluster mass estimates from a survey such as the XMM-XXL Extragalactic Survey.

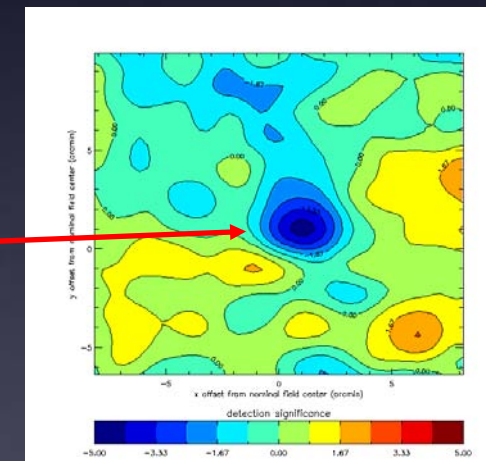
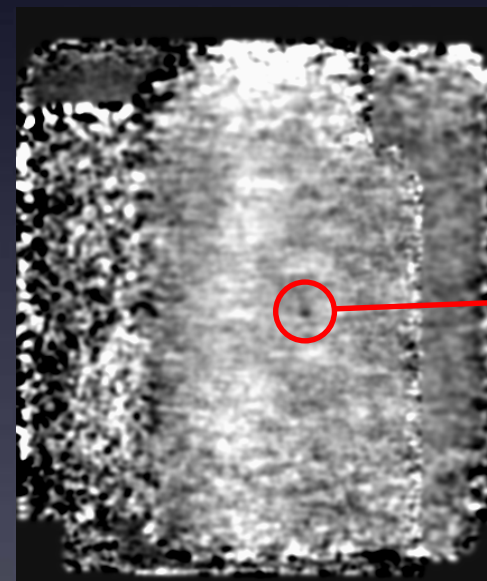
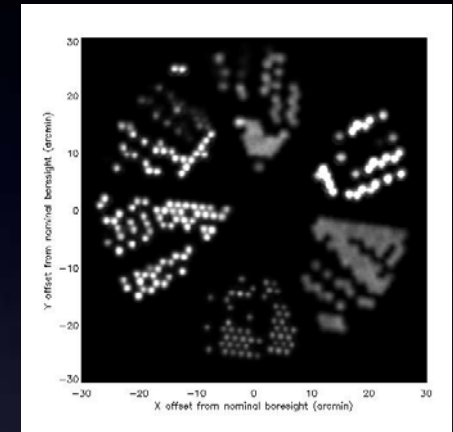
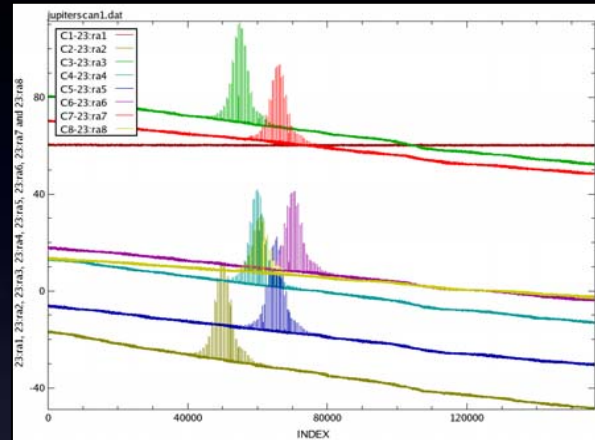
Fin

Deploying the SPT



First Light / Early Observations

- First Light February 16, 2007, scans across Jupiter.
- Detector positions & beams characterized, focus found with planet scans (Jupiter & Mars).
- Abell cluster AS1063 observed ($>5\sigma$ decrement in ~ 1 hr).
- Rest of season: survey of tens of sq. deg. on fields with optical/X-ray/IR coverage.



T. Crawford, SPT-SZ Cluster Survey, XMM-XXL Paris 2008

Scan Strategy: Why does it matter?

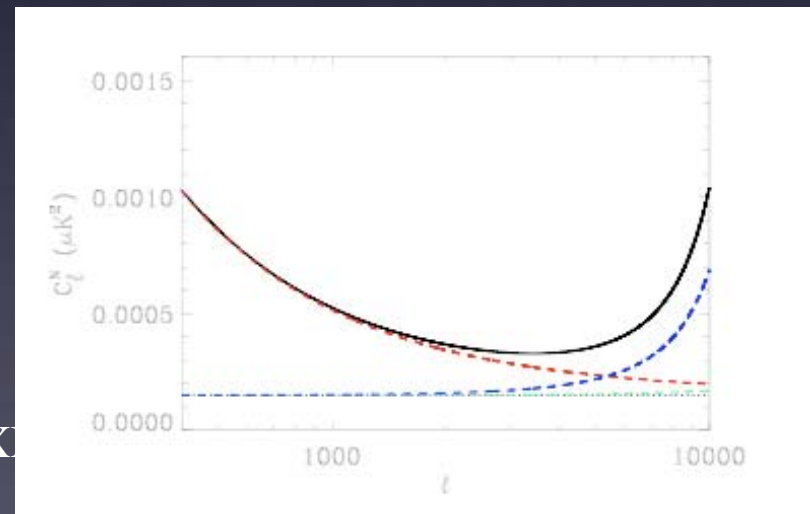
- Efficiency:
 - finite acceleration \rightarrow finite time spent “turning around.
 - - holds for single-pixel and array instruments.
 - uniformity of coverage:
 - - array instruments have non-uniform borders.
- Matching signal spectrum to instrument noise or response:
 - e.g., $1/f$ noise in detectors or amplifiers, finite detector response time.

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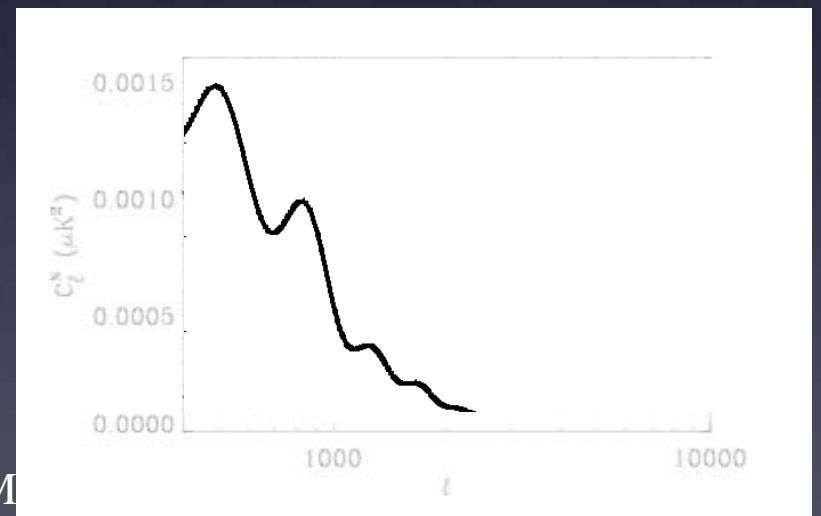
Scan Strategy: Signal Spectrum Placement

- Scan strategy maps noise(f) into noise(vector(\mathbf{k})) - exact and analytically tractable for some scans.
 - e.g., for raster-scanning, $f(\mathbf{k}) = \left| \frac{k_x v_s}{2\pi} \right|$ (astro-ph/0702608)
- average appropriately to get noise(scalar(\mathbf{k}))
- Place signal in sweet spot:



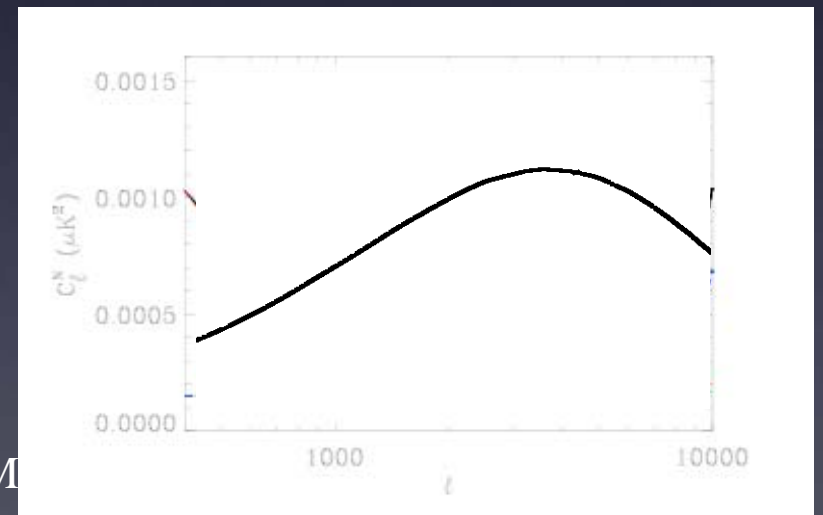
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Implications for Mapmaking

- Can make naive maps with well-understood noise properties.
- Can investigate benefits of more complicated scan strategies, e.g. cross-linking.

