Component separation

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Objective

- We must make sure that the CMB polarization sensitivity is limited by the instrumental noise and ***NOT*** by astrophysical confusion

- We have to fight ***at least*** two foregrounds
  - Synchrotron
  - Dust

- The more sensitive the mission, the more likely it is that we must deal with additional components

Validation of detected B-modes

- The only way to guarantee that any excess of power that we see is CMB emission is to check that its color is right

- Hence we need several CMB channels

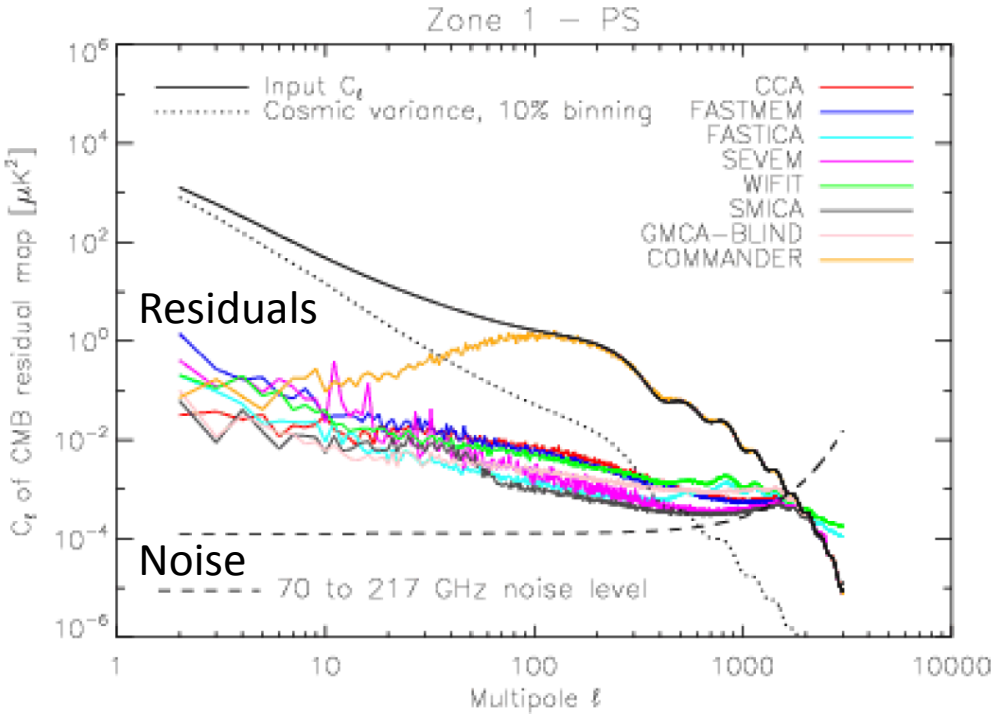
- For a sensitive CMB B-mode mission we need at least 6 channels to monitor foregrounds, and at least 3 CMB channels (to get more than 1 cross-spectrum).

All FG could be polarised up to a fraction of a percent !

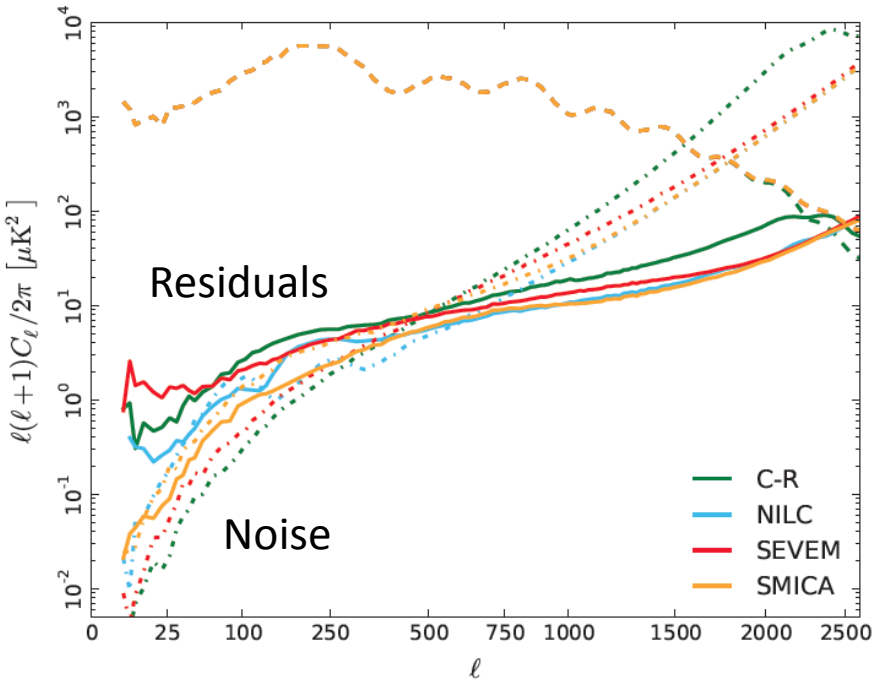
More than 9 channels is better

- With 9 channels, component separation is a limitation to Planck performance.

Leach et al. (2008)



Planck 2013 results. XII



Impact of FG emission on r=T/S

Betoule et al. (2009)

case	r	noise-only σ_r/r	noise-only $\sigma_r^{\ell\leq 20}/r$	noise-only $\sigma_r^{\ell>20}/r$	known foregrounds σ_r/r	known foregrounds $\sigma_r^{\ell\leq 20}/r$	known foregrounds $\sigma_r^{\ell>20}/r$	SMICA σ_r/r	SMICA $\sigma_r^{\ell\leq 20}/r$	SMICA $\sigma_r^{\ell>20}/r$	$r^{\rm est}$	$l_{\rm min}-l_{\rm max}$	$f_{\rm sky}$	D^3
PLANCK	0.3	0.075	0.17	0.084	0.1	0.2	0.12	0.15	0.22	0.2	**0.26**	2 - 130	0.95	3
	0.1	0.17	0.25	0.22	0.23	0.34	0.32	0.29	0.34	0.55	0.086			
EPIC-LC	0.01	0.019	0.084	0.019	0.05	0.18	0.053	0.079	0.18	0.1	**0.0098**	2 - 130	0.86	4
	0.001	0.059	0.15	0.064	0.27	0.4	0.38	0.37	0.43	0.82	0.00088			
EPIC-2m	0.01	0.016	0.083	0.016	0.027	0.12	0.027	0.032	0.11	0.036	**0.0096**	2 - 300	0.87	4
	0.001	0.051	0.14	0.055	0.14	0.25	0.16	0.16	0.24	0.24	**0.001**			
EPIC-CS	0.01	0.017	0.084	0.017	0.029	0.12	0.03	0.036	0.11	0.041	**0.0096**	2 - 300	0.87	4
	0.001	0.058	0.15	0.063	0.15	0.27	0.19	0.18	0.26	0.29	**0.00098**			
Ground-based	0.1	0.083	–	–	0.15	–	–	0.24	–	–	**0.11**	50 - 300	0.01	2
	0.01	0.18	–	–	0.8	–	–	1.6	–	–	0.018			
Grnd-based+Planck	0.01	0.18	–	–	0.51	–	–	0.69	–	–	0.0065	50 - 300	0.01	2
Deep field mission	0.001	0.082	–	–	0.1	–	–	0.13	–	–	**0.00092**	50 - 300	0.01	4

EPIC-LC	7 channels	34’ at 135 GHz	$\sigma_{r=0.001} \times 6$	
EPIC-CS	8 channels	3.1’ at 150 GHz	$\sigma_{r=0.001} \times 3$	
EPIC-2m	9 channels	5’ at 150 GHz	$\sigma_{r=0.001} \times 3$	
Ground	3 channels	5.5’ at 150 GHz	$\sigma_{r=0.01} \times$ 4-9	(1% of sky)

Counting components

- Polarization
  - Synchrotron: 3
  - Dust: 3+
  - CMB: 1
  - Redundancy: 2

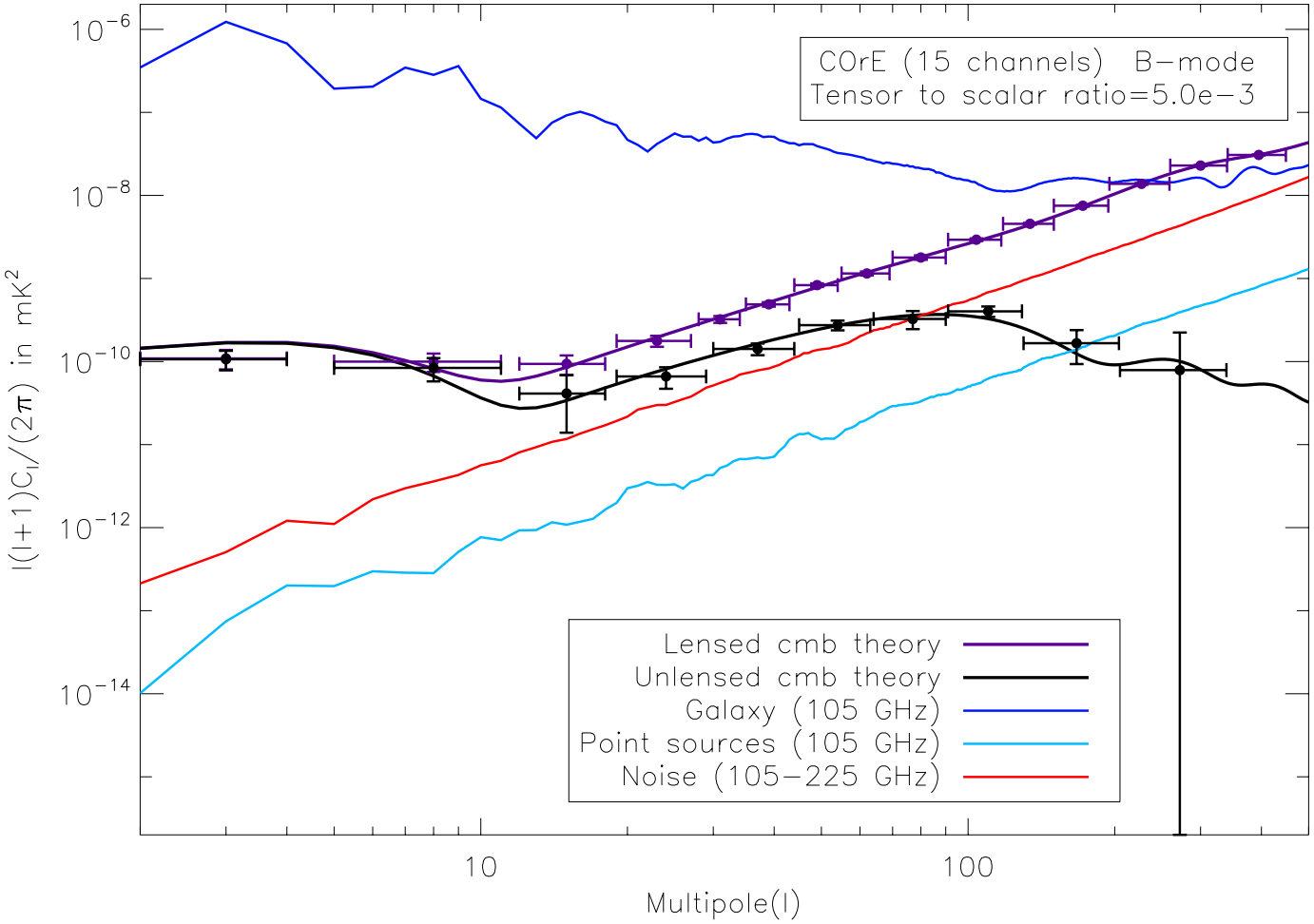
9+ CHANNELS

- Intensity
  - Synchrotron: 3
  - Dust: 3+
  - CMB: 1
  - SZ: 2
  - Free-free: 1-2
  - Spinning dust: 1-3
  - CO: 0-2
  - CIB: 5-10
  - Redundancy: 3

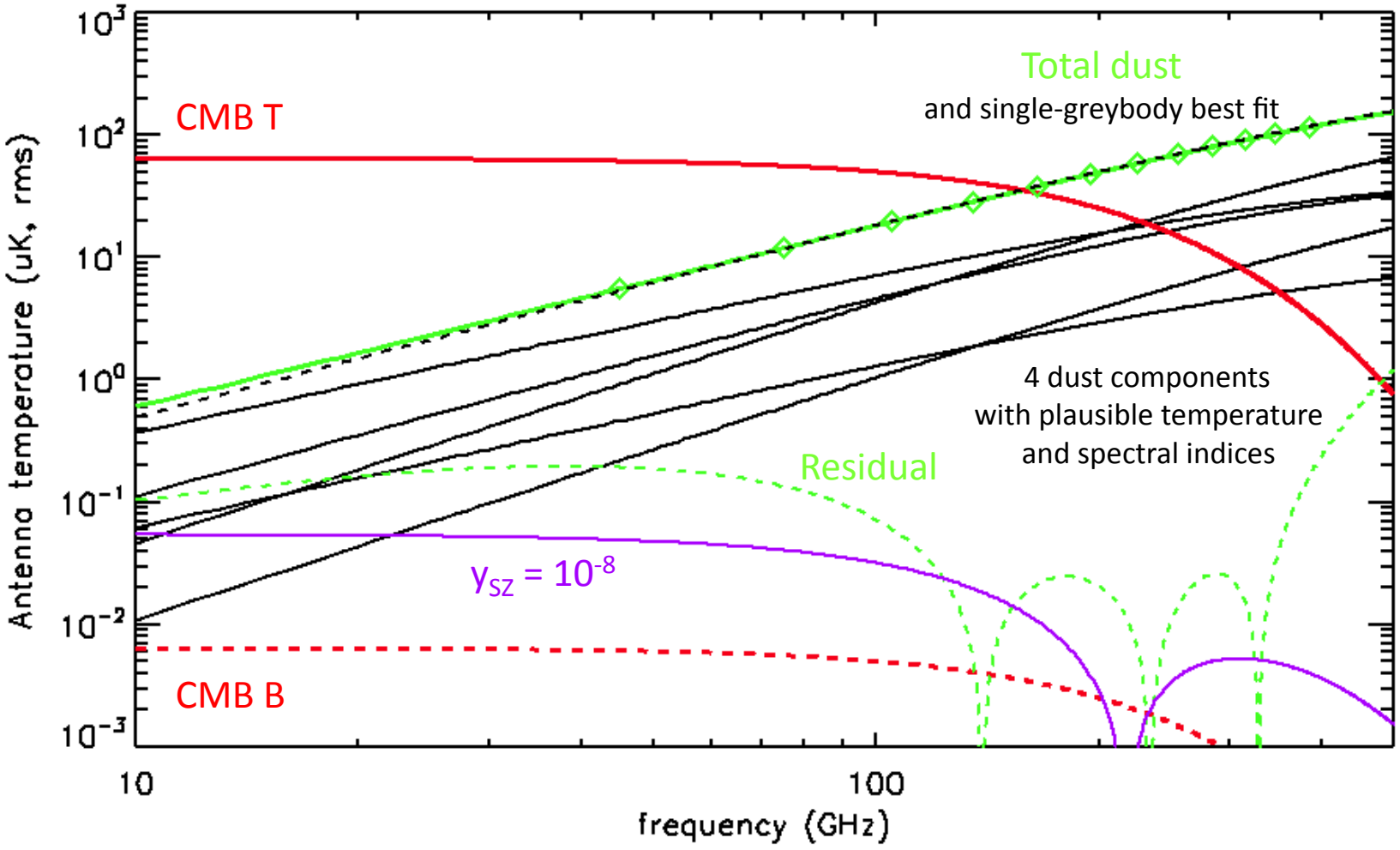
18+ CHANNELS

All FG could be polarised up to a fraction of a percent !

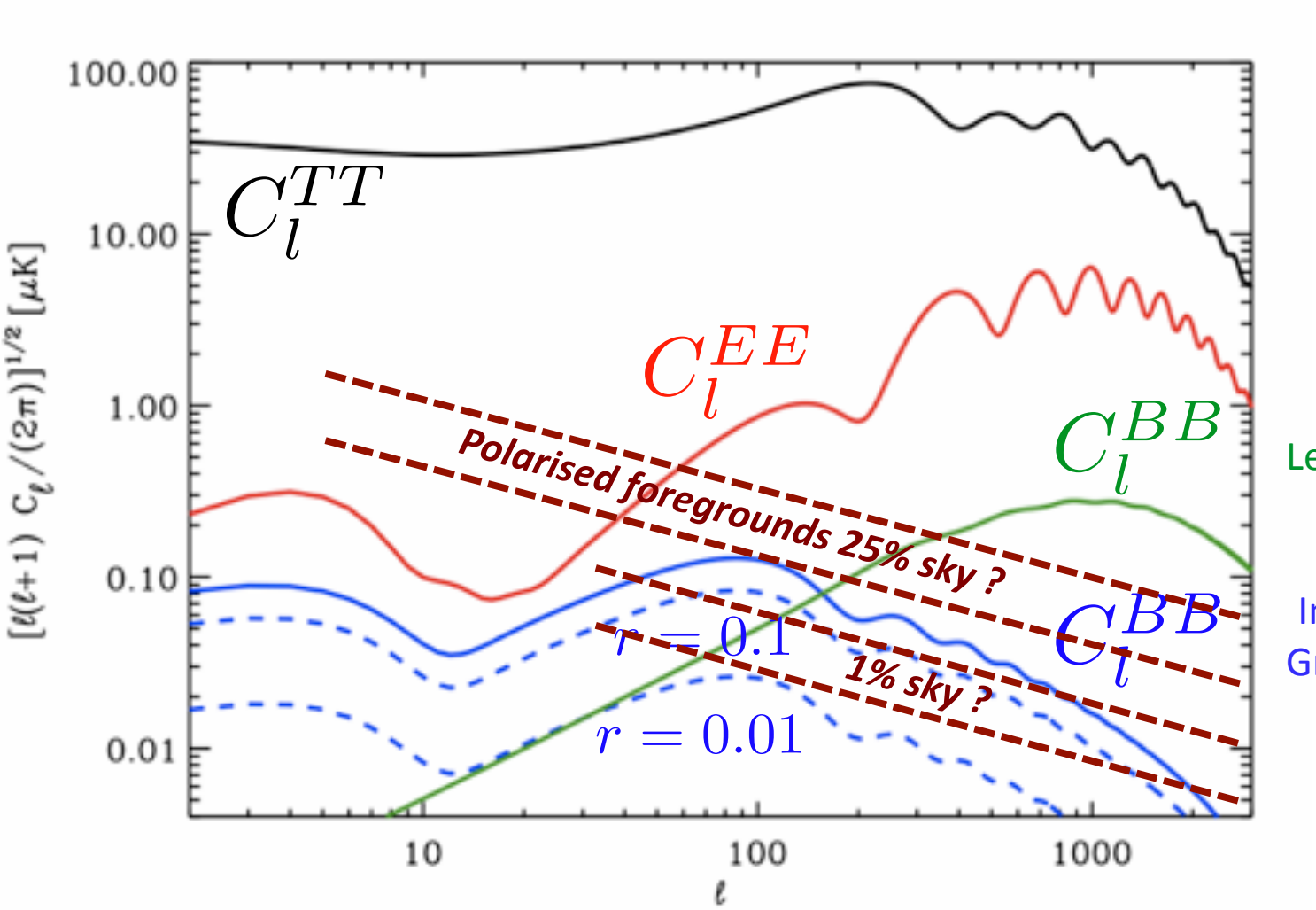
COrE proposal



Beware fitting emission laws



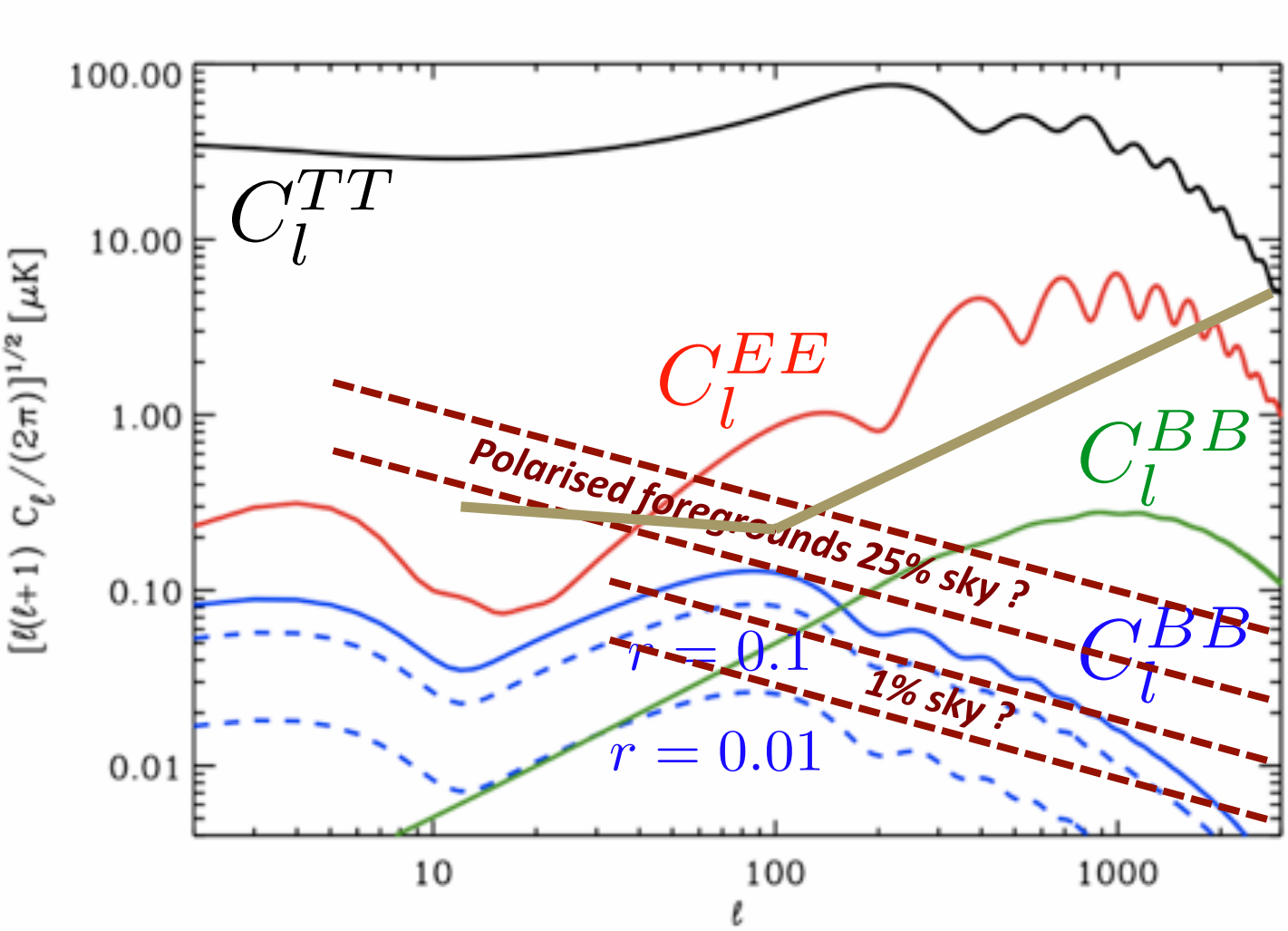
Foregrounds (150 GHz)



Lensing of EE

Inflationary Gravitational Waves

Foregrounds (150 GHz)

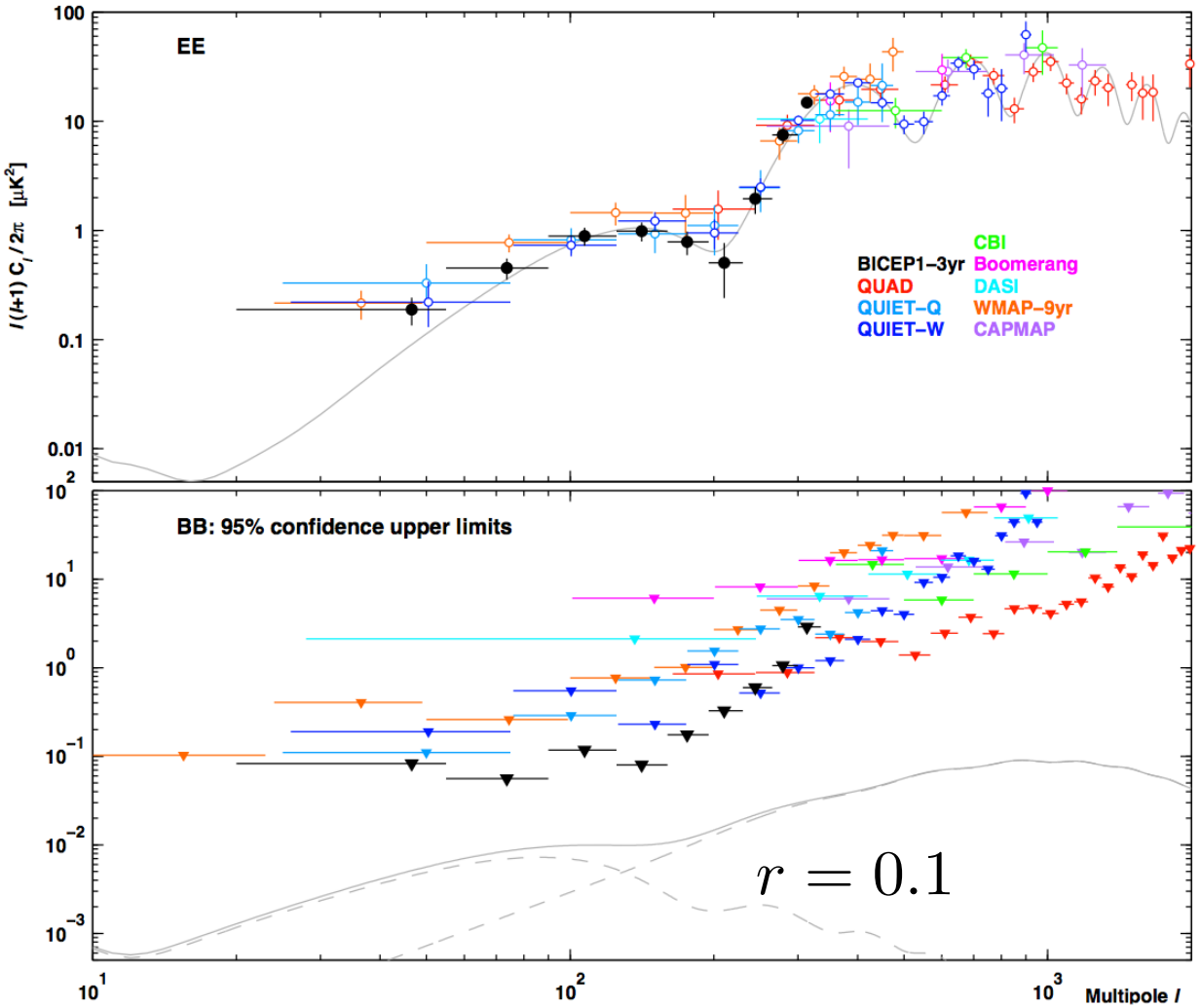


Current pol. 95% upper limits

Lensing of EE

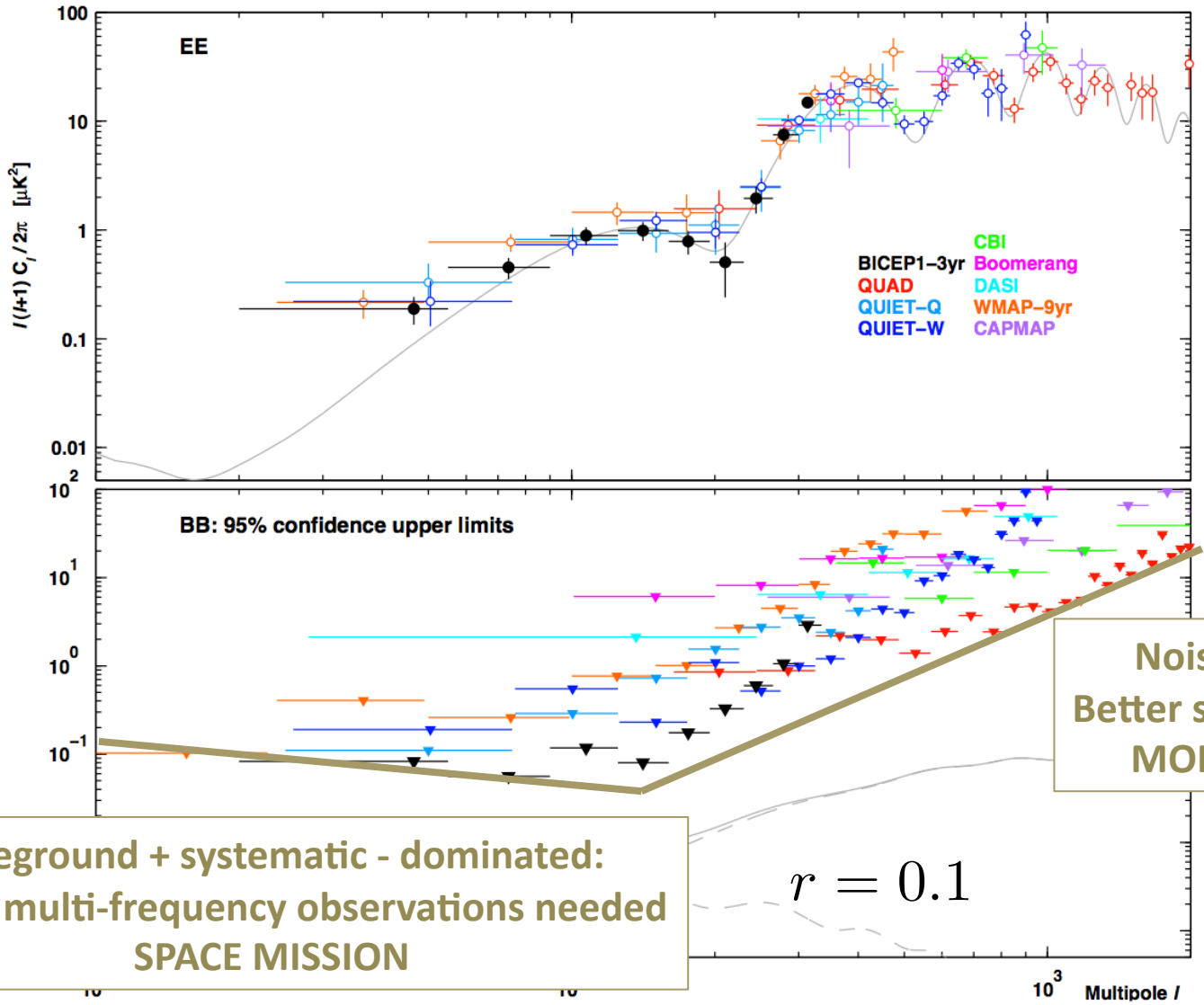
Inflationary Gravitational Waves

Foregrounds (150 GHz)



BICEP collaboration, Barkats et al., arXiv 1310.1422

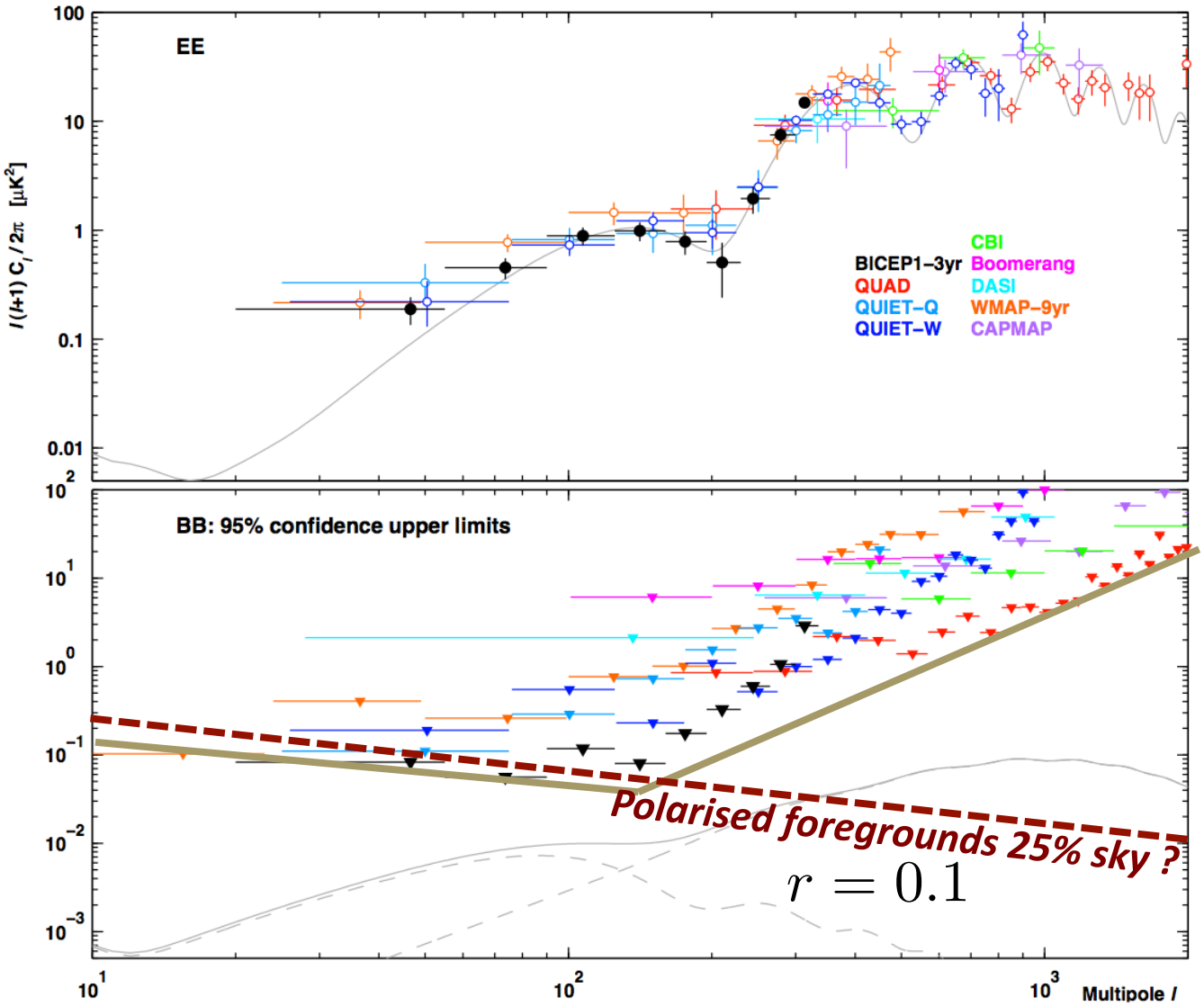
Current measurements



Noise-dominated:
Better sensitivity needed
MORE DETECTORS

Foreground + systematic - dominated:
Better, multi-frequency observations needed
SPACE MISSION

Current measurements

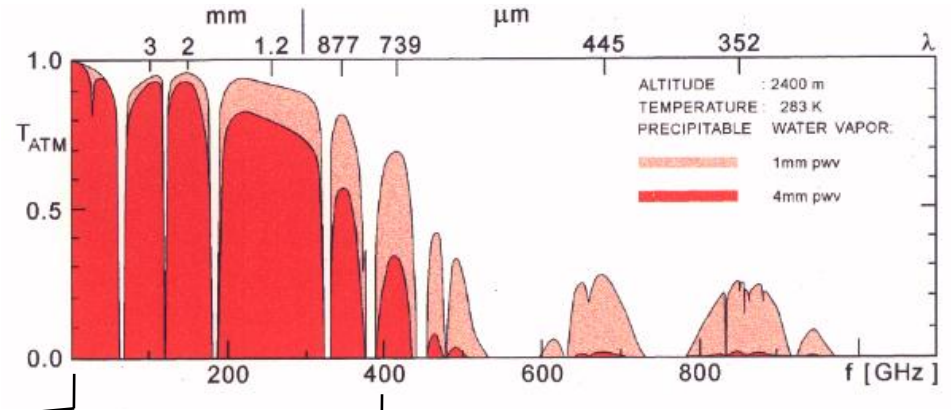


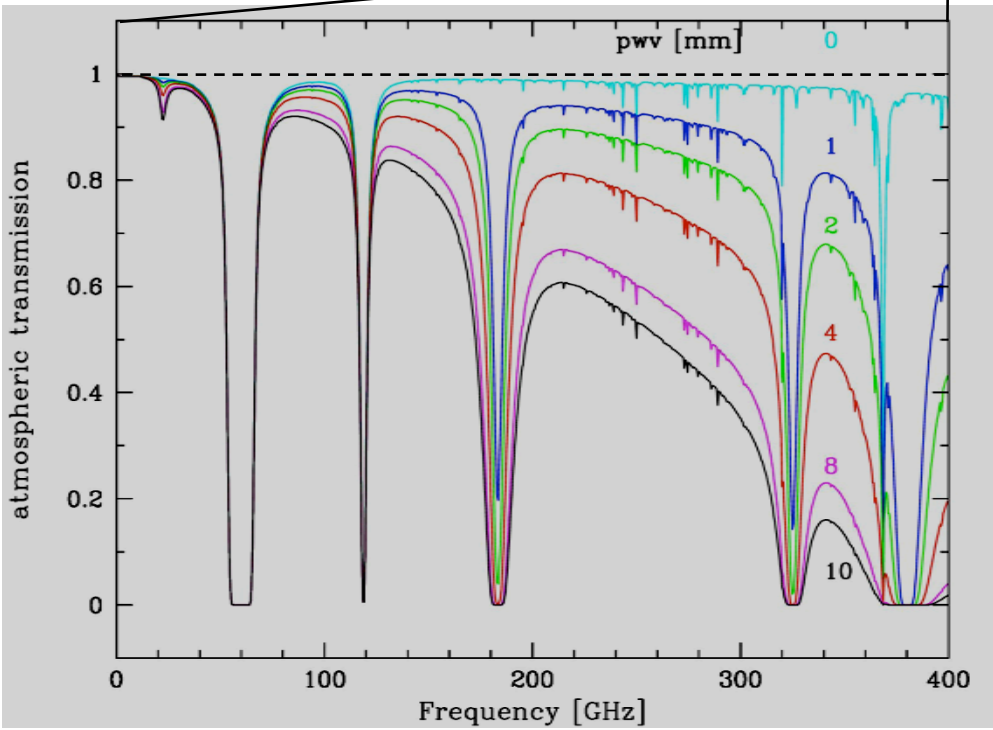
Atmosphere

Atmospheric transmission and emission

Systematics

Complete survey





At 150 GHz a Planck detector is ≈10 × more sensitive than ground-based detectors at ATACAMA or South Pole in good observing conditions.

Factor of 100-400 in observing time.

The situation is much worse for ground-based observations at higher frequency.

Conclusion

- Plan at least 10 channels, preferably more
- ***COrE***: 15 channels, but not enough on the low frequency end
- ***PRISM***: 20 channels in the frequency range useful for the CMB, + line monitors

- Proposed mission baseline: 15-20 frequency channels with optimised number of detectors

- None of this is possible from the ground !