CMB physics

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5. Data Analysis

Key

- Tool: healpy
- Pixel, alm, mask, apodization, beam, noise
- WMAP, Planck
- NASA Lambda, Wayne Hu’s homepage

5.1 Data — Forecast

Key

1. beam and noise
2. noise added power spectrum vs. theoretical spectrum
3. CAMB running

$$\hat{C}_\ell = C_\ell b_\ell^2 + N_\ell$$

beam instrumental noise

Q: why beam is multiplicative, instrumental noise is additive?

beam $b_\ell = e^{-\ell(\ell+1)\theta^2_{\rm FWHM}/8\log 2}$ eg. FWHM=11 arcmin

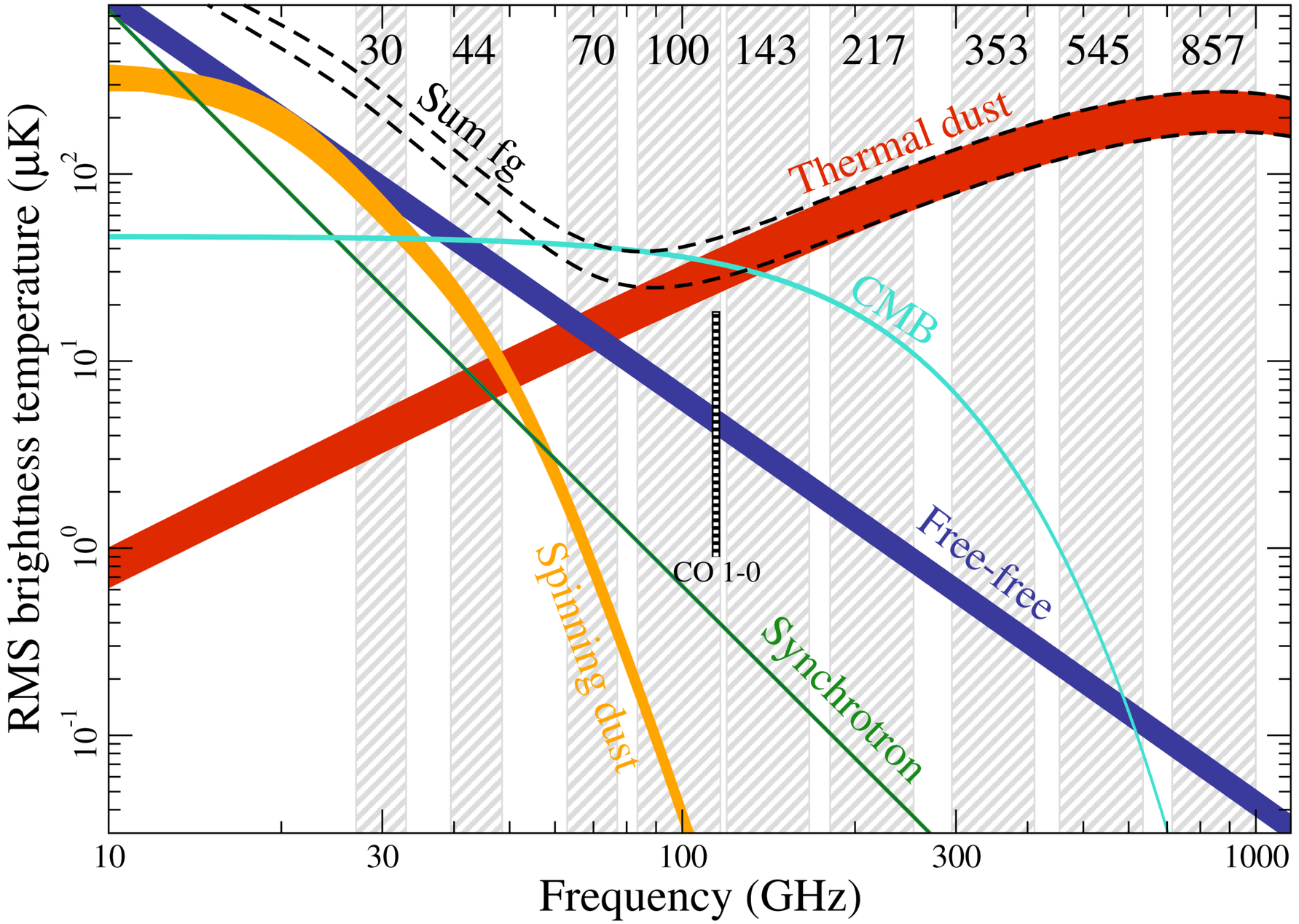
noise $N_\ell = w^{-1} = (\sigma_{\rm pix} * \theta_{\rm FWHM})^2$ normally, we use $w^{-1/2}$

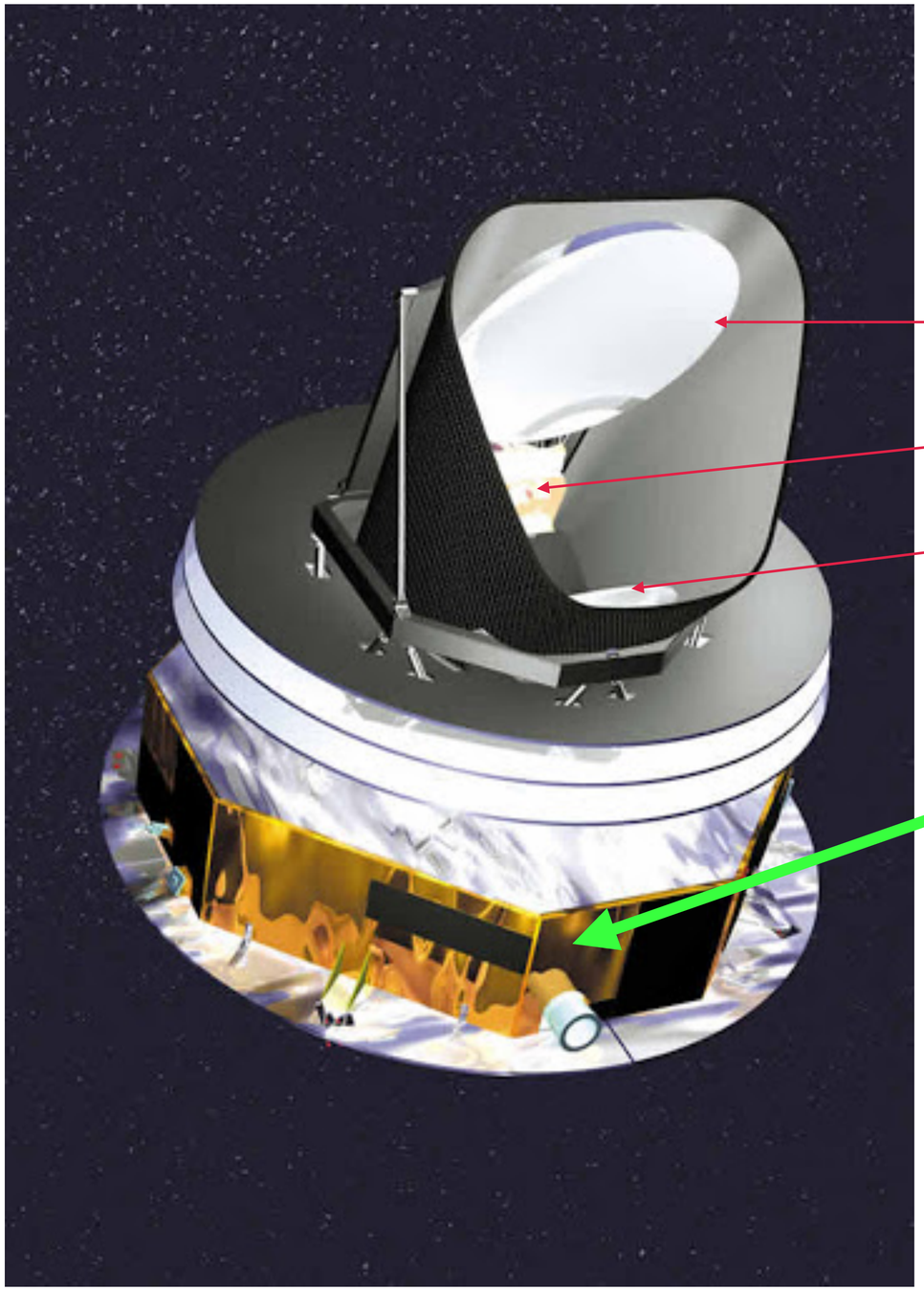
noise per pixel

eg. $w^{-1/2}$ =10 uK*arcmin

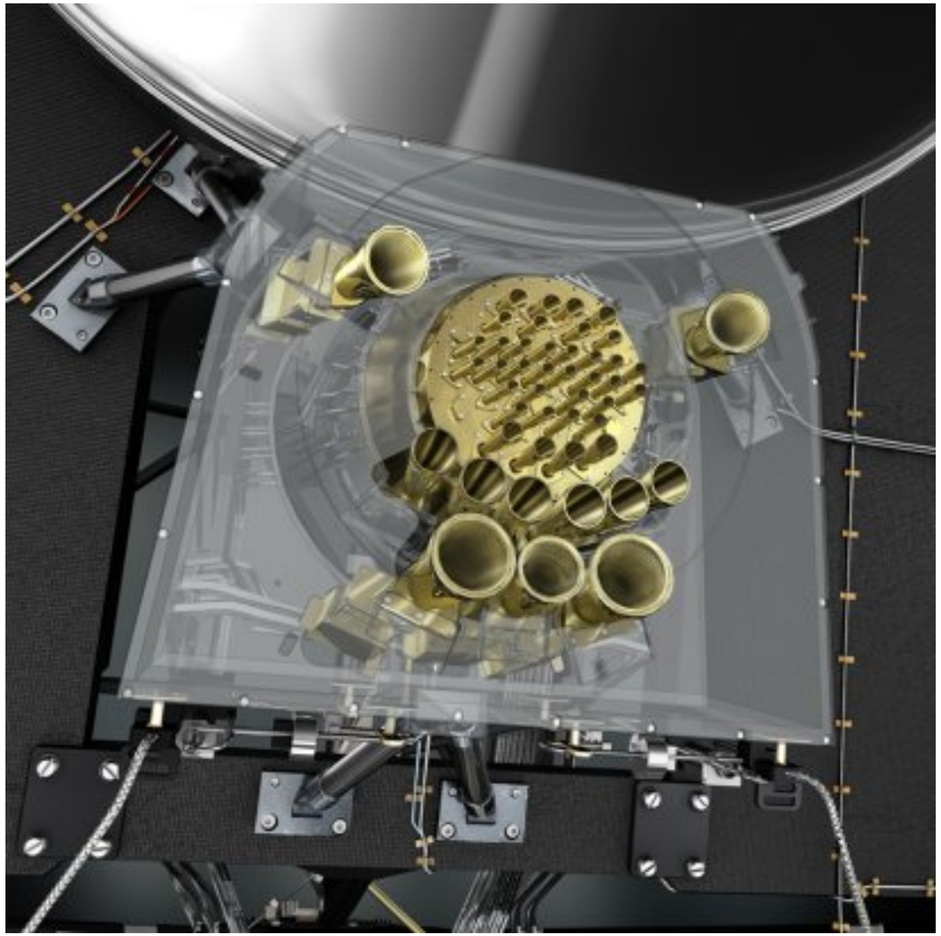
ν/GHz	90	60	40	
θ_{fwhm}	$18'$	$23'$	$32'$	
$\sigma_{\mathrm{pix}}/10^{-6}$	13	9.9	7.3	[uK]
$w^{-1}/10^{-15}$	4.5	4.5	4.5	[uK²*arcmin²]
l_s	465	345	255	

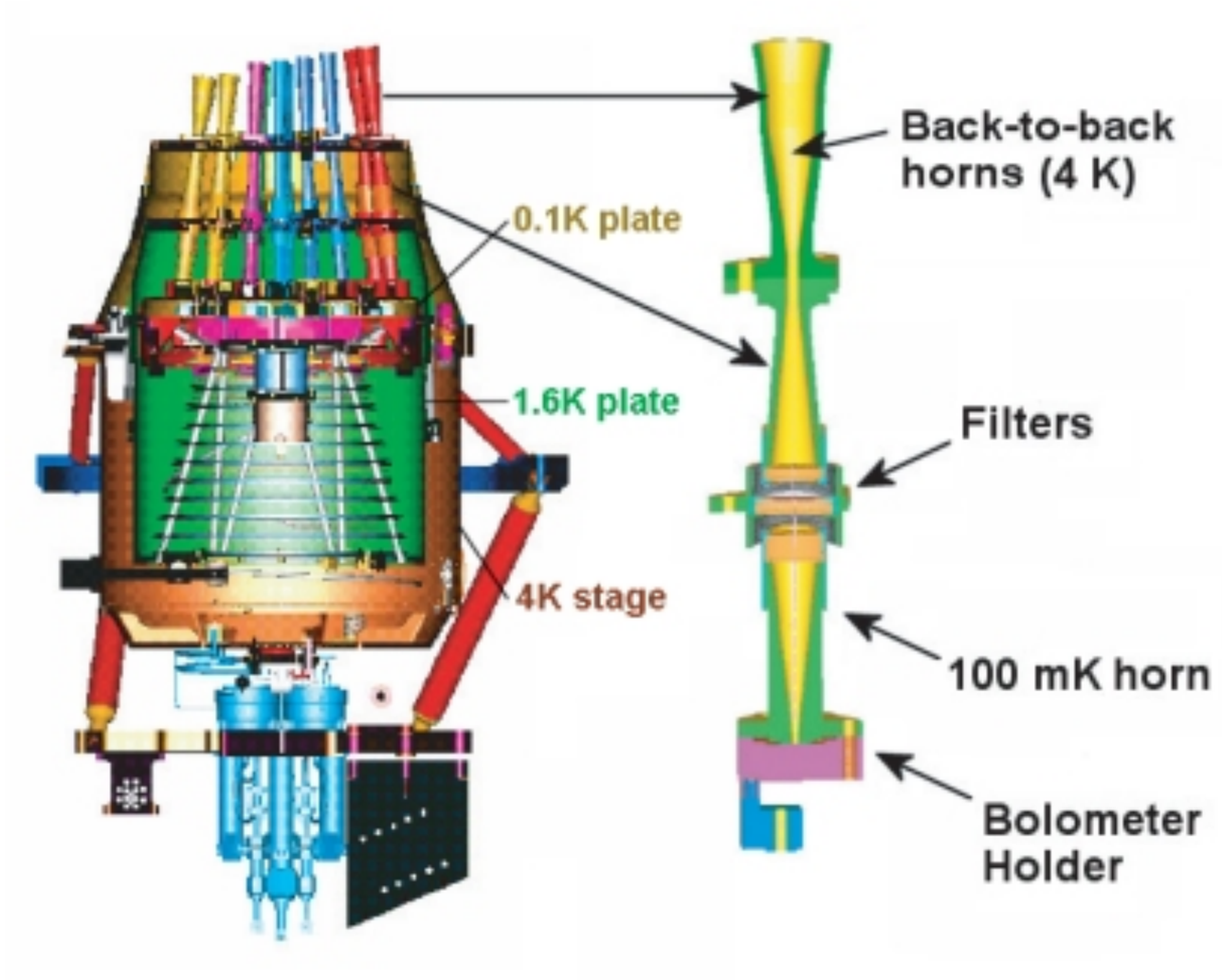
WMAP 3 channels


30
44
70
100
143
217
353
545
857
Sum fg
Thermal dust
CMB
Free-free
Synchrotron
Spinning dust
CO 1-0
RMS brightness temperature (μK)
10^{-1}
10^{0}
10^{1}
10^{2}
10
30
100
300
1000
Frequency (GHz)

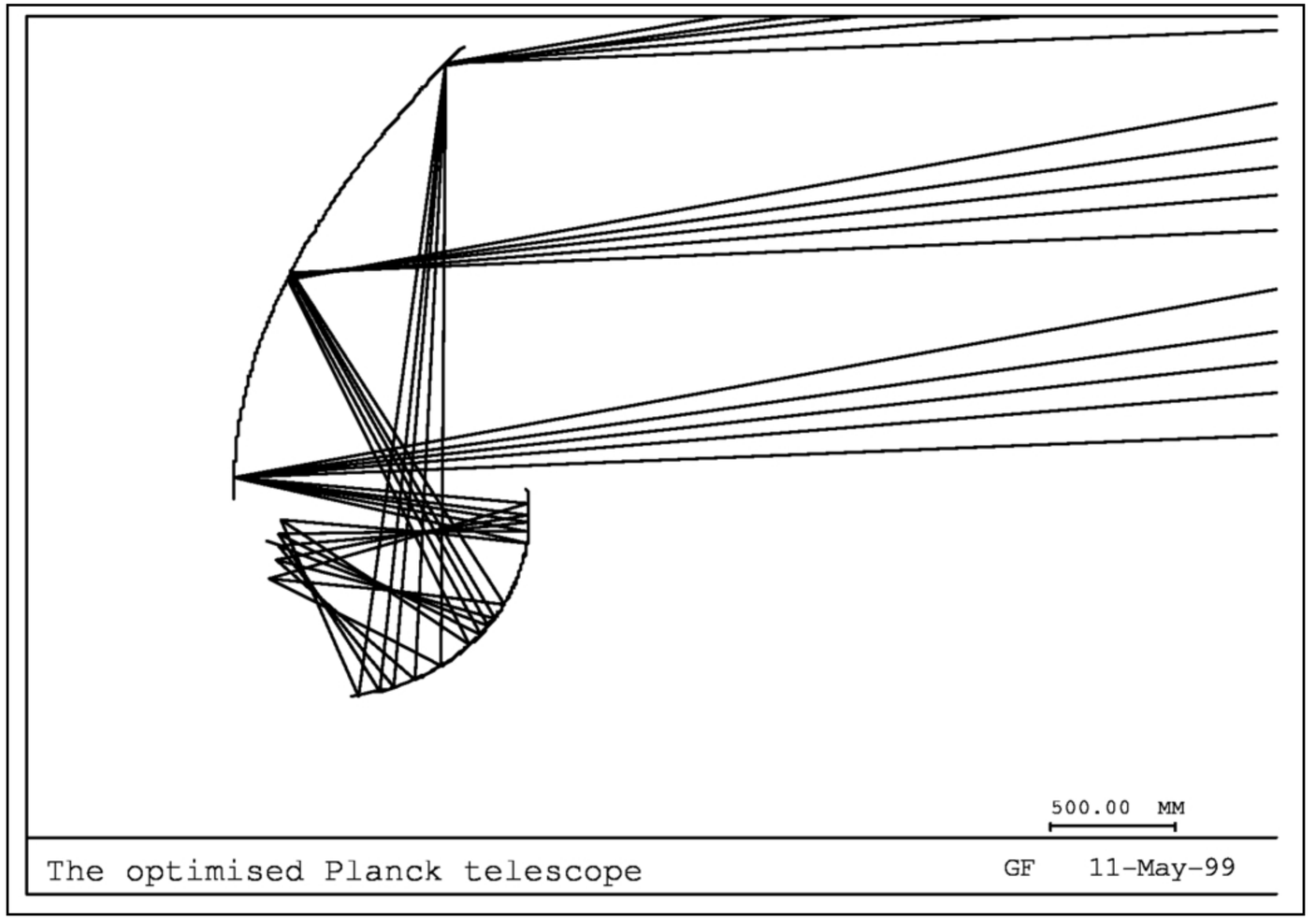

主镜面
焦平面
次镜面
4K液氦箱

Planck Focal Plane

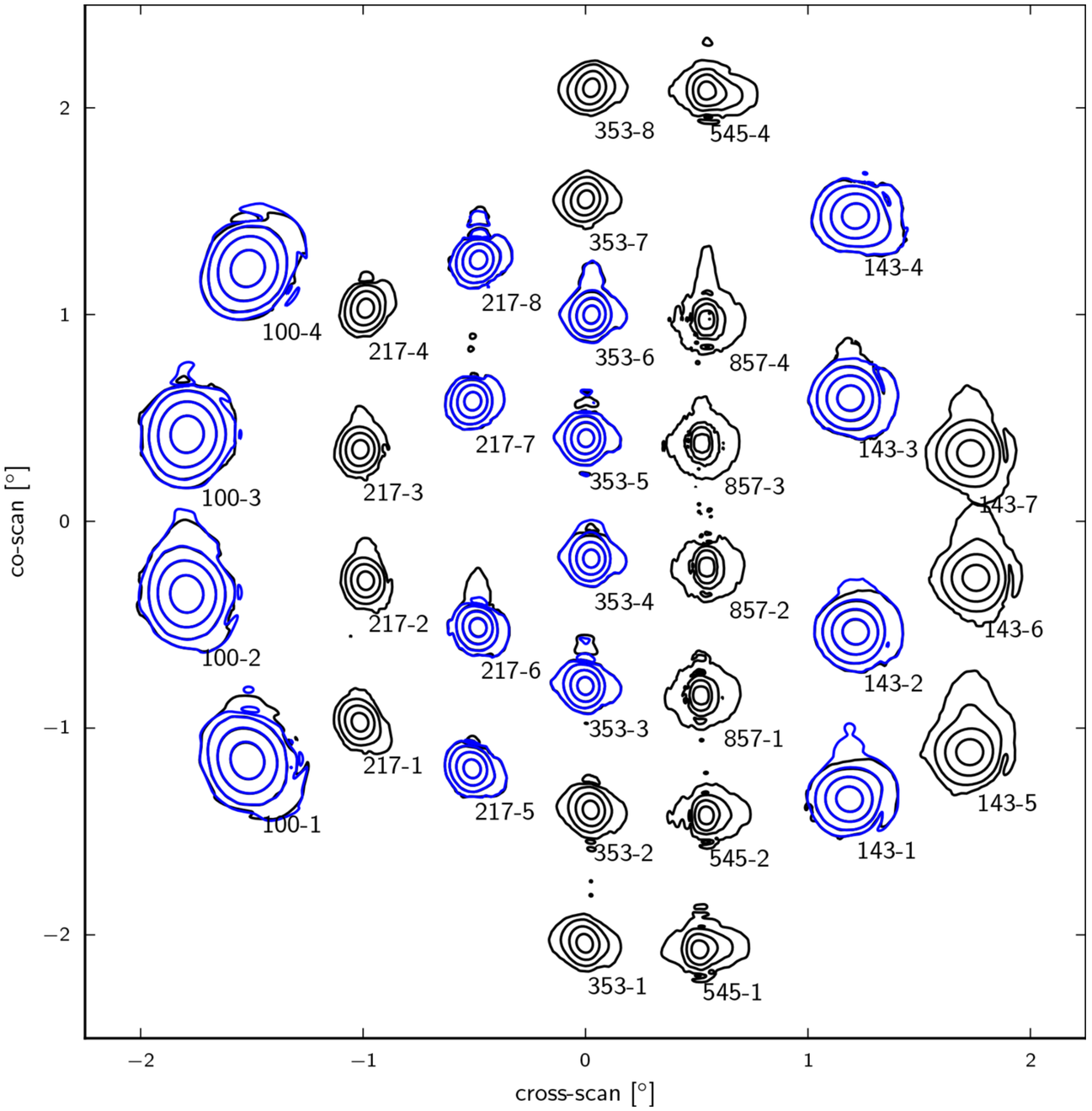


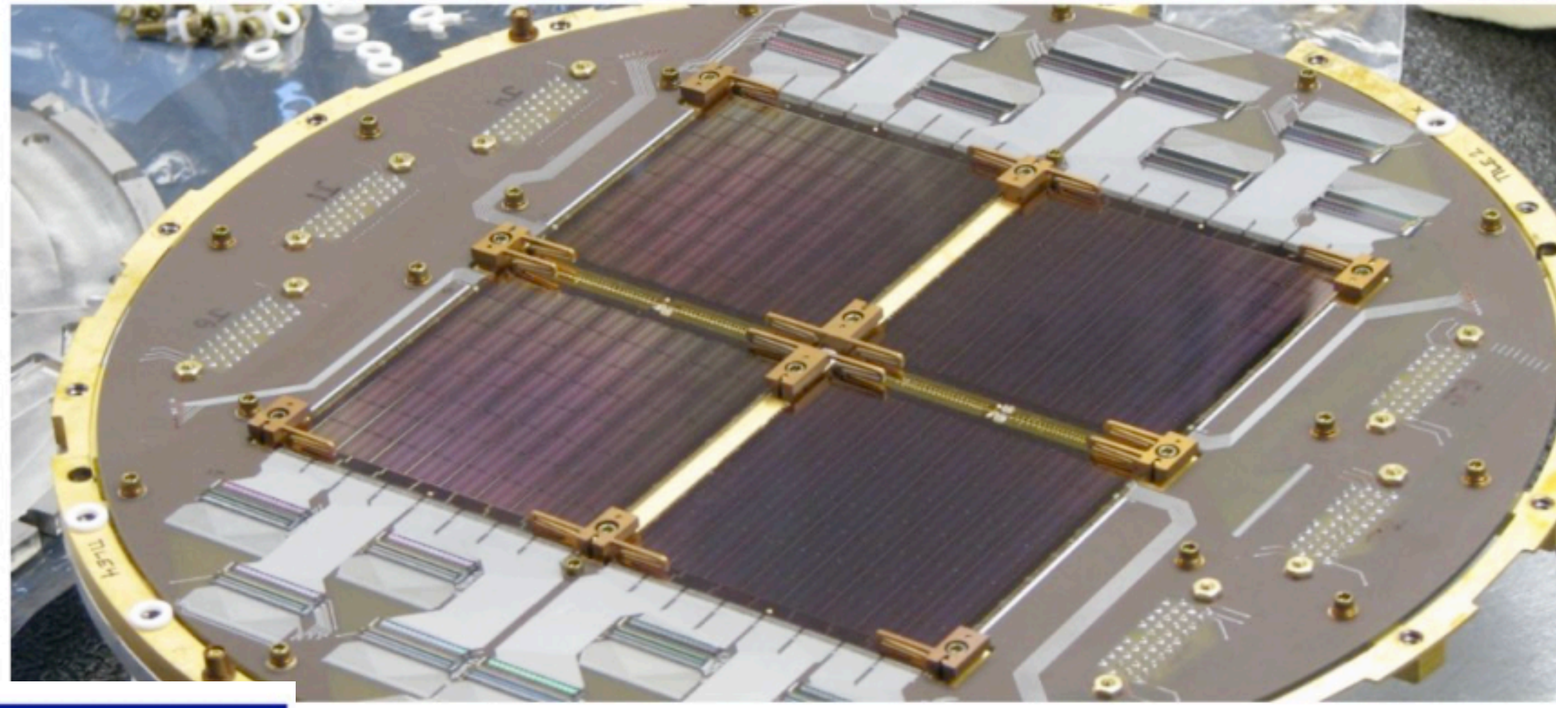


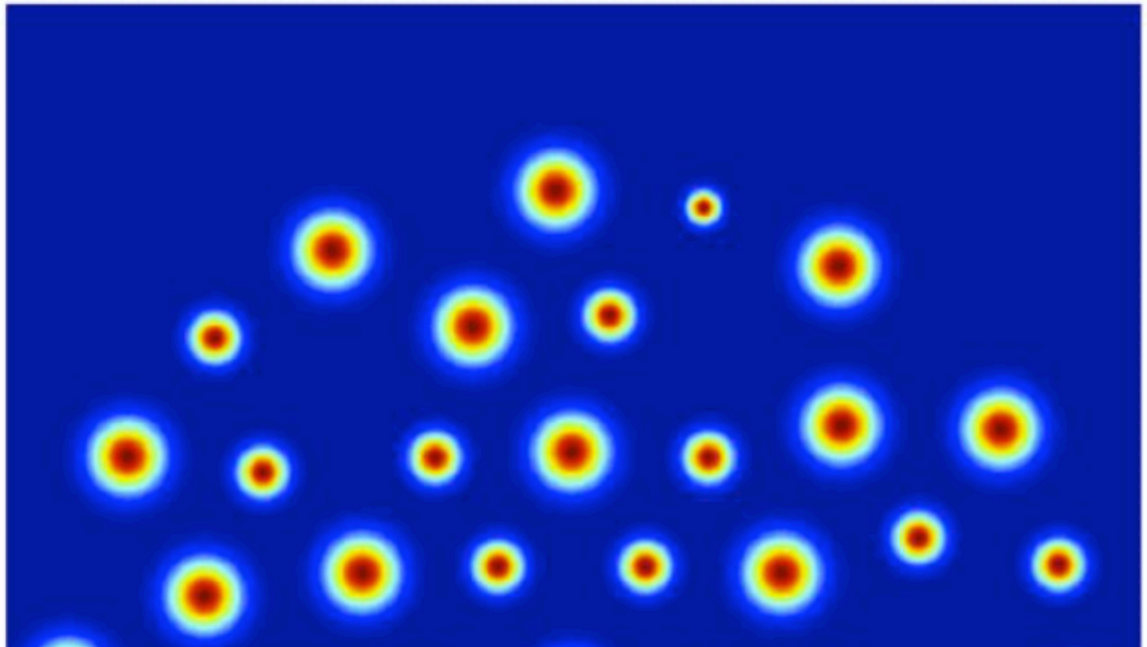
Planck optics



Planck beam pattern





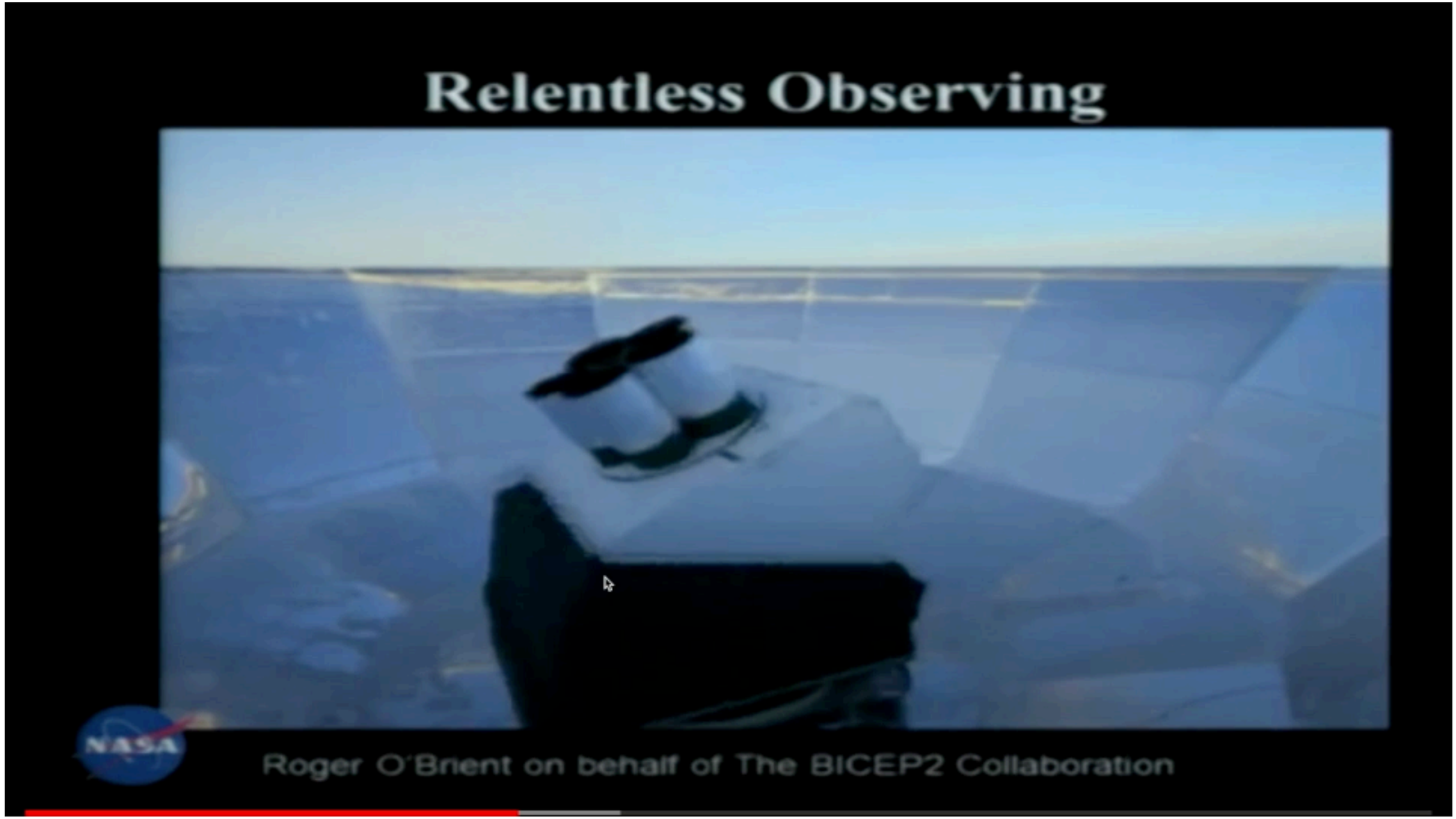


Isotropic Gaussian beam: m independent, merely ell dependence.

Due to unparallel in-coming ray.

Detector noise: generated in the detectors.

BICEP2: constant elevation scanset



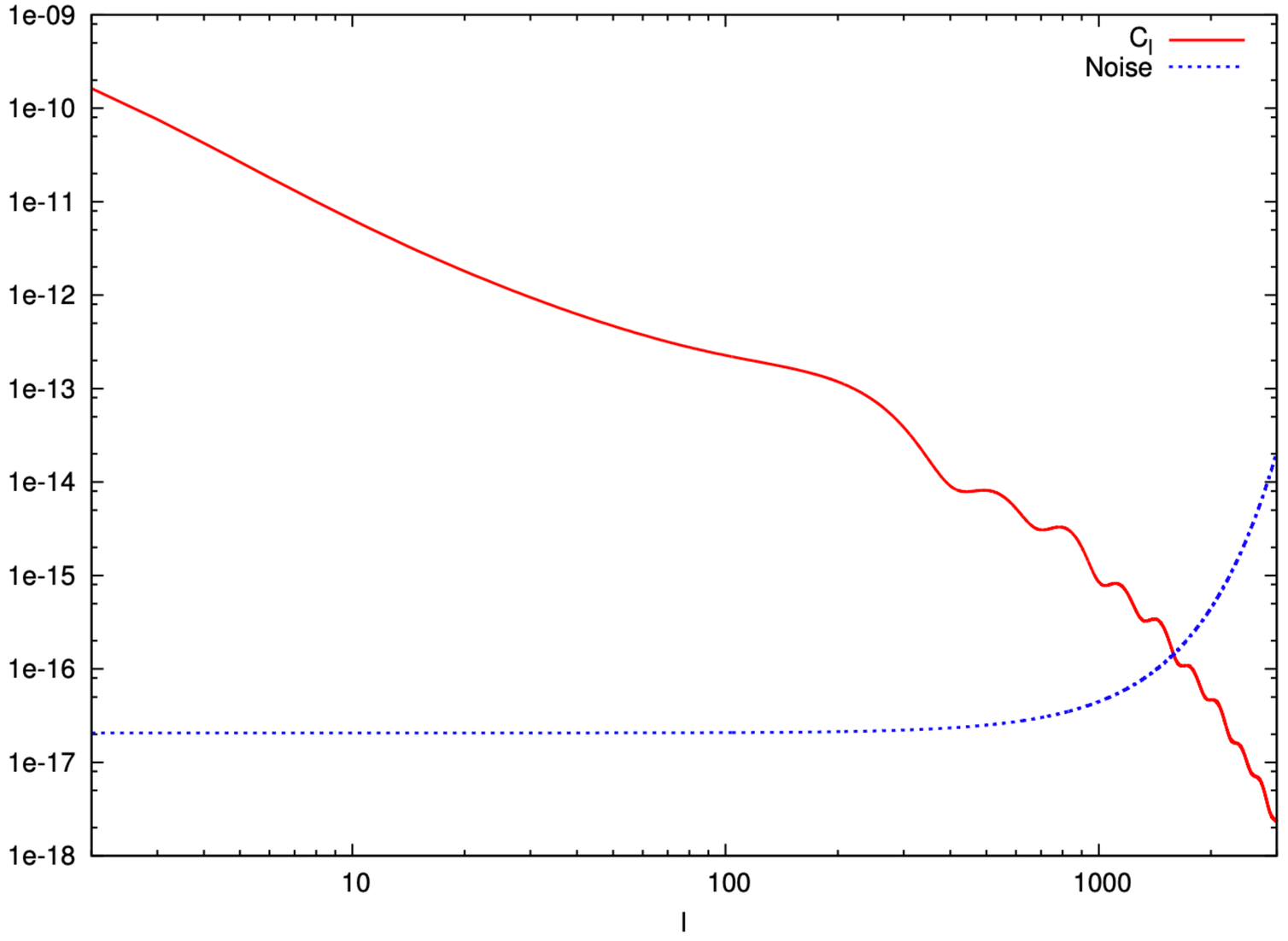


Figure 8: Singal_noise amplitude for Planck channel 143Hz.

hands-on: CAMB running

5.2 Data — Maps

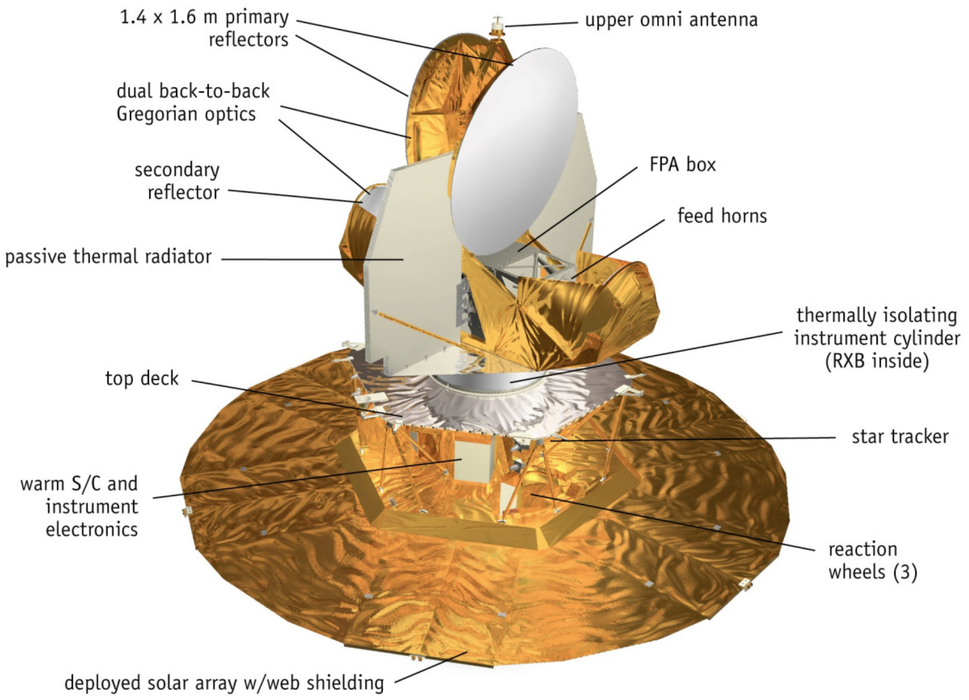
Key

1. healpy: readmap, plotmap, ring/nest, nside, etc.
2. generate random realisation (JY's code)
3. beam convolved spectrum vs. theoretical spectrum (JY's code)

hands-on: haply readmap, plot map, ring/nest, nside.

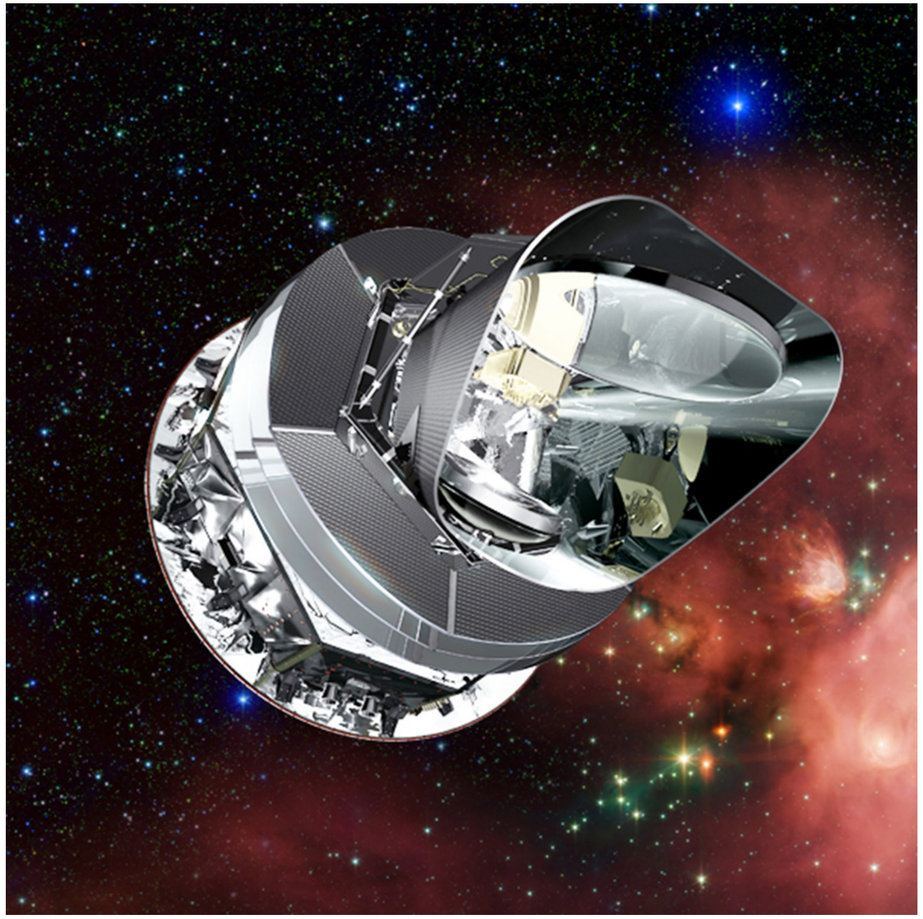
via: ipython

5.3 Experiment Overview



1. WMAP

2. Planck



5.4 Online resources

1. W. Hu’s homepage
2. NASA Lambda