Discovery of Anomalous Microwave Emission (AME)

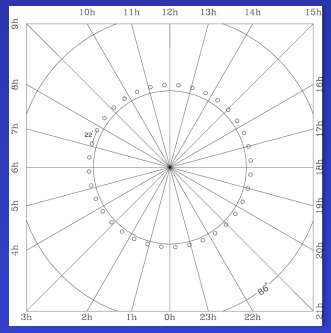
Erik M. Leitch

AME Workshop, 02 July 2012

RING5M Experiment

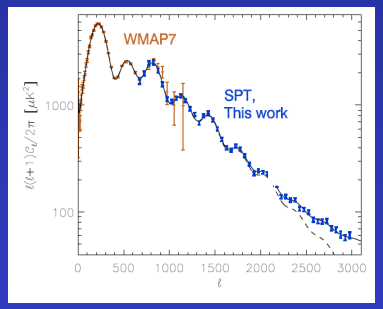
Early ground-based CMB anisotropy measurement

Fields observed near the NCP for continuous observation

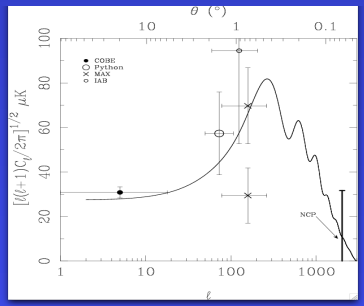


Switched beam experiment to remove ground contamination

3 years of observation, just to detect the CMB!



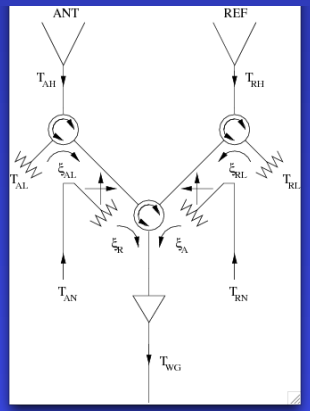
2011

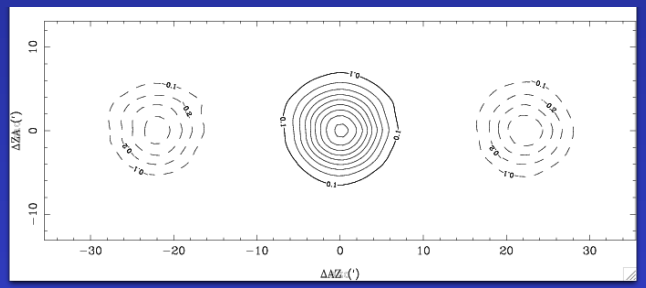


1993

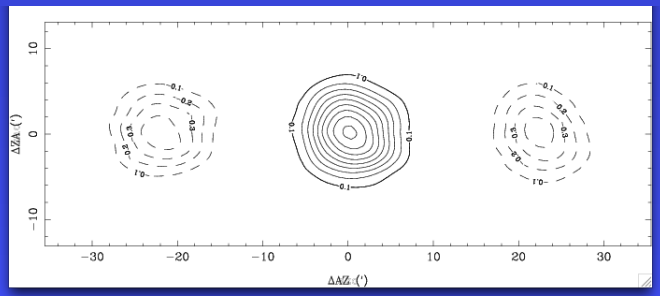
Receivers

Dual-frequency





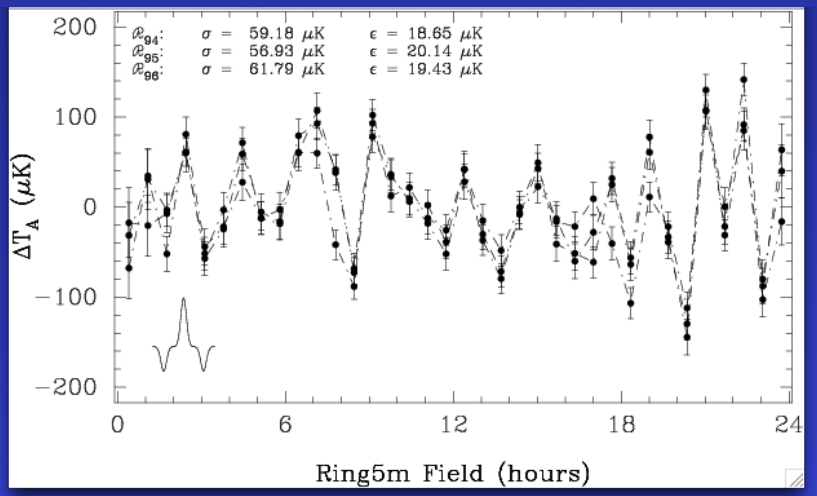
Beam-matched

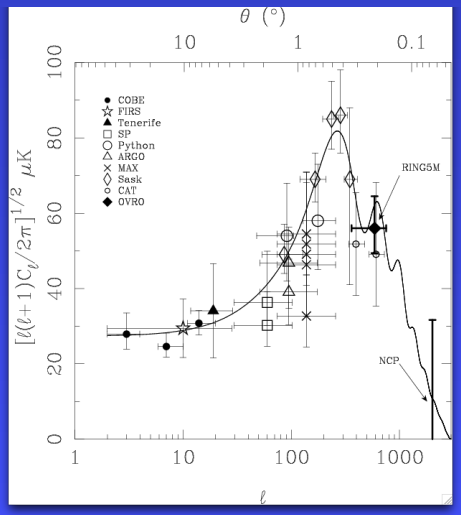


Results

Significant dectection of CMB anisotropy

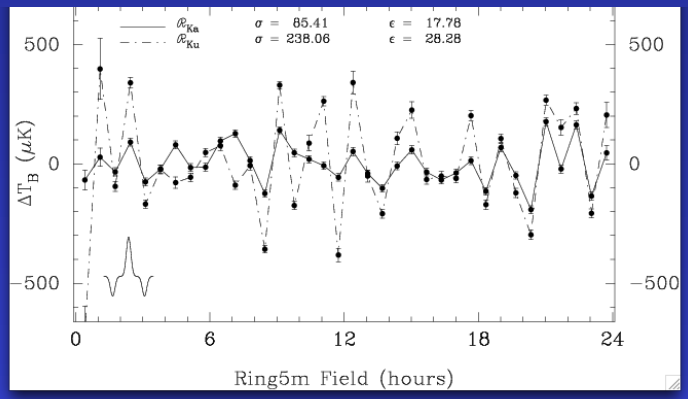
And excellent agreement over 3 years of observation



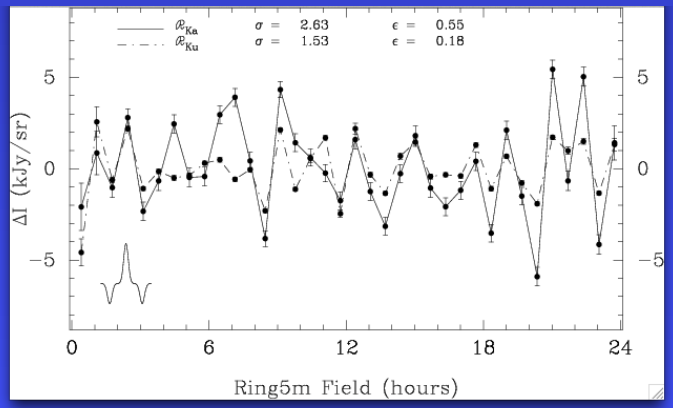


Achieved sensitive measurement of CMB power near l ~ 600

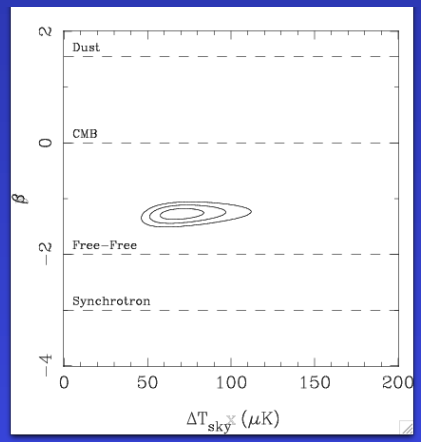
Spectral Index of the Ring5M



15 and 30 GHz, source-subtracted plotted in μK

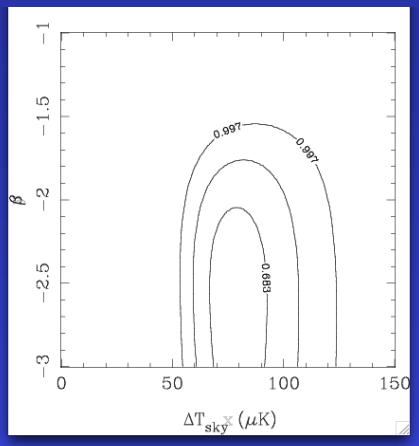


15 and 30 GHz, source-subtracted plotted in intensity



Spectral index looks like a mix between CMB and steep-spectrum ($\beta < 0$) foreground

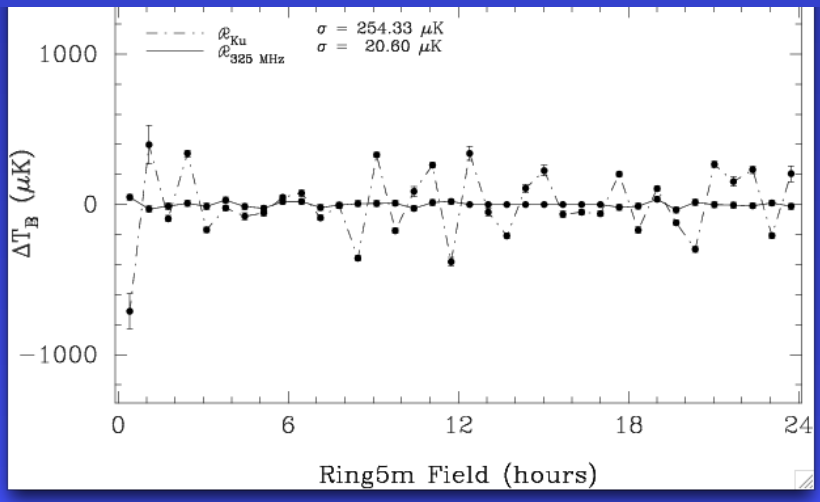
Spectral index of the foreground?



Two frequency channels can only provide a weak constraint β < -2 on single foreground models

But comparison with WENSS data can rule out β > -2.2

Unlikely to be synchrotron, unless high-energy injection of electrons is flattening the spectrum



Free-Free?

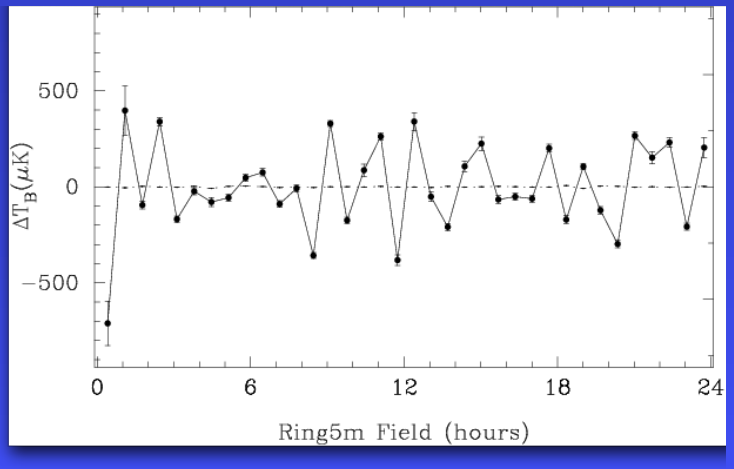
WHAM maps predicted rms at 15 GHz that is too low by 2 orders of magnitude

Largest signal is $\Delta I \sim 0.2R$, while signals at 15 GHz predict $\Delta I \sim 10\ R$

But note that recombination coefficients scale as:

$$\alpha \sim T^{-0.9} \quad (T < 2.6 \times 10^4)$$
$$\alpha \sim T^{-1.2} \quad (T > 2.6 \times 10^4)$$

So H-α can be suppressed at high temperatures.



Unlikely to be free-free, unless it is from an unusually high-temperature component of the WIM

Extracted Components

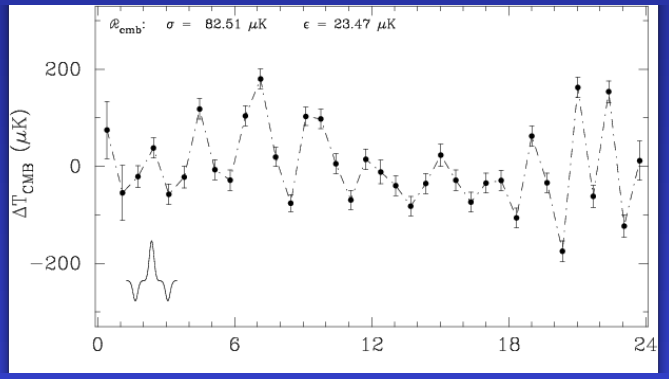
Unlikely to be synchrotron

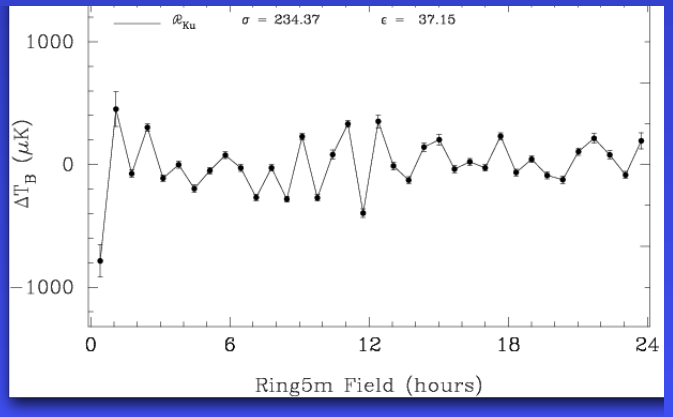
Unlikely to be free-free

Single power-law foreground is a reasonable assumption

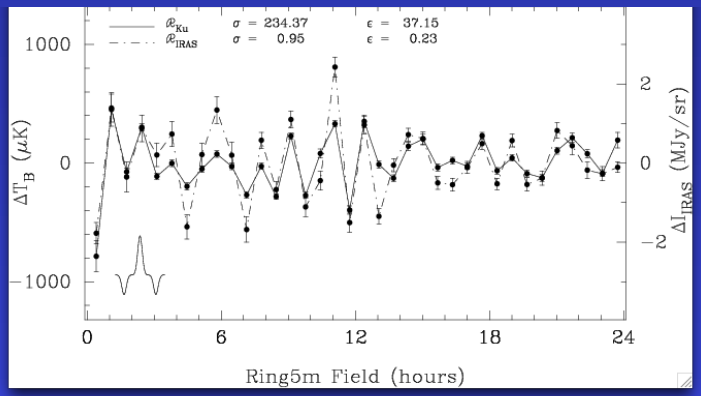
Assuming β = -2.2, we can separate into CMB + 'pure' foreground

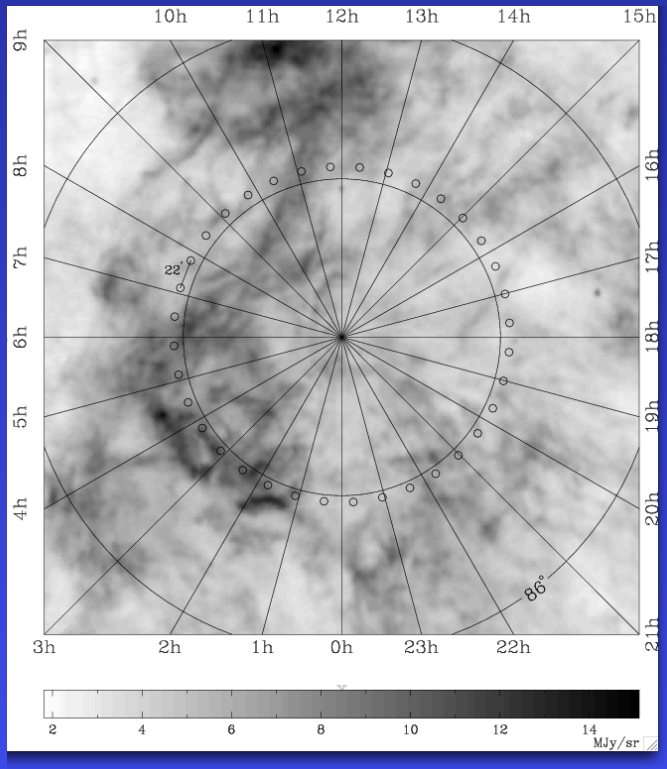
(These residuals show no significant correlation)





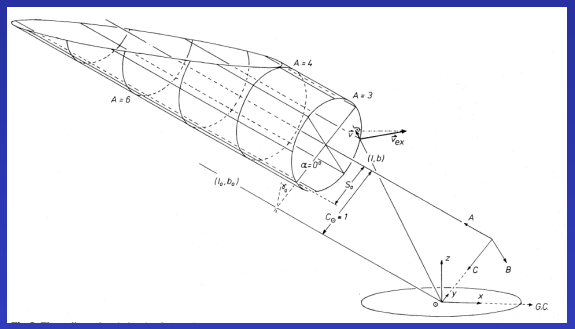
Fishing Expedition





IRAS 100 μm map shows a remarkable correlation!

NCP Loop

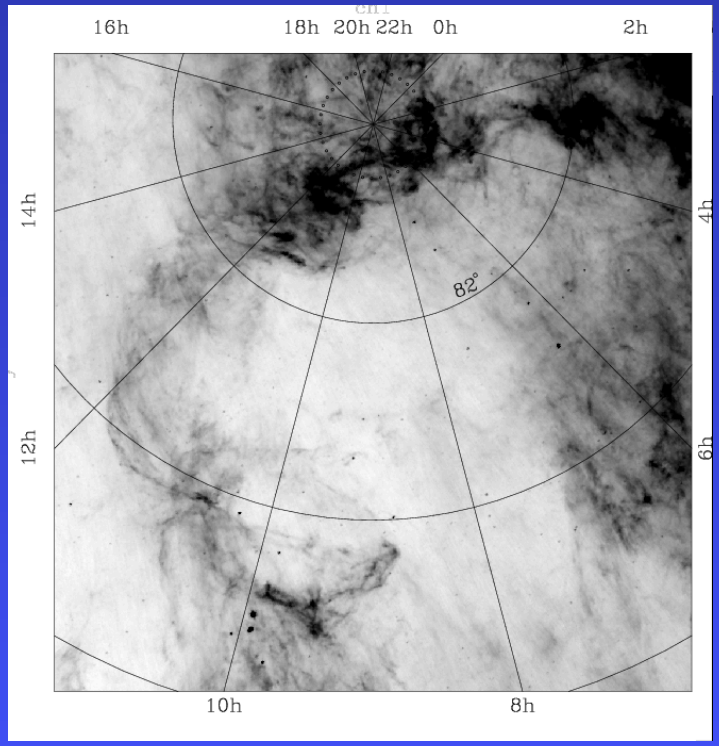


Cylindrical shock model best fits data

Cavity in HI emission, molecular abundances in clouds indicate non-steady-state conditions

Depletion of non-thermal radio continuum at 408 MHz indicates reduced magnetic field, while enhanced field is indicated in the shell (5 times local Galactic field strength)

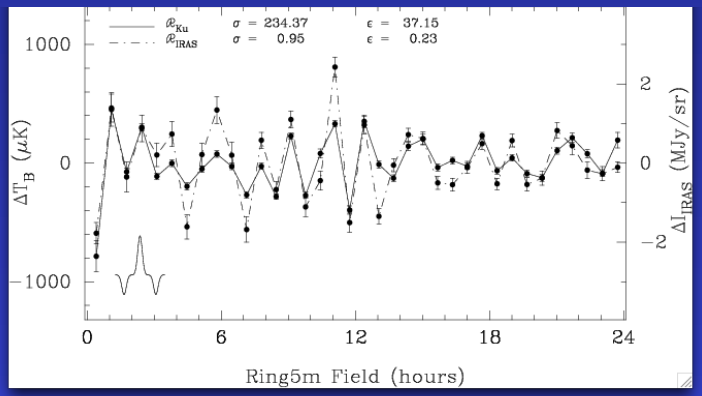
Enhancement of soft X-rays indicating hot ionized interior (~3 x 10^5 K)



Summary

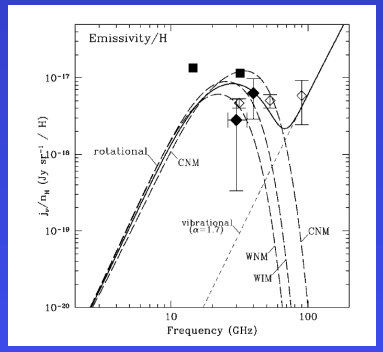
Detected an unexpected foreground component with β ~ -2.2

Extracted component shows a significant correlation with IRAS 100 μm map



HI, non-thermal emission, X-rays all indicate that this region is unusual, so there are a range of possible explanations, including flat-spectrum synchrotron, high-temperature free-free

Spinning dust models may provide the most natural explanation, and can reproduce the foreground levels detected in the Ring5M at 30 GHz, but probably not most of the signal seen at 15 GHz.



First description of Anomalous Emission. (COBE and Saskatoon detected a large-scale dust-correlated component, but amplitude is consistent with standard free-free)