# Low-z Distortions

- In the absence of absolute experiments (e.g., PIXIE), what should we do with *differential* measurements?

  - Space (**30-arcmin beam**; LiteBIRD, 15 bands from 40 to 400 GHz)

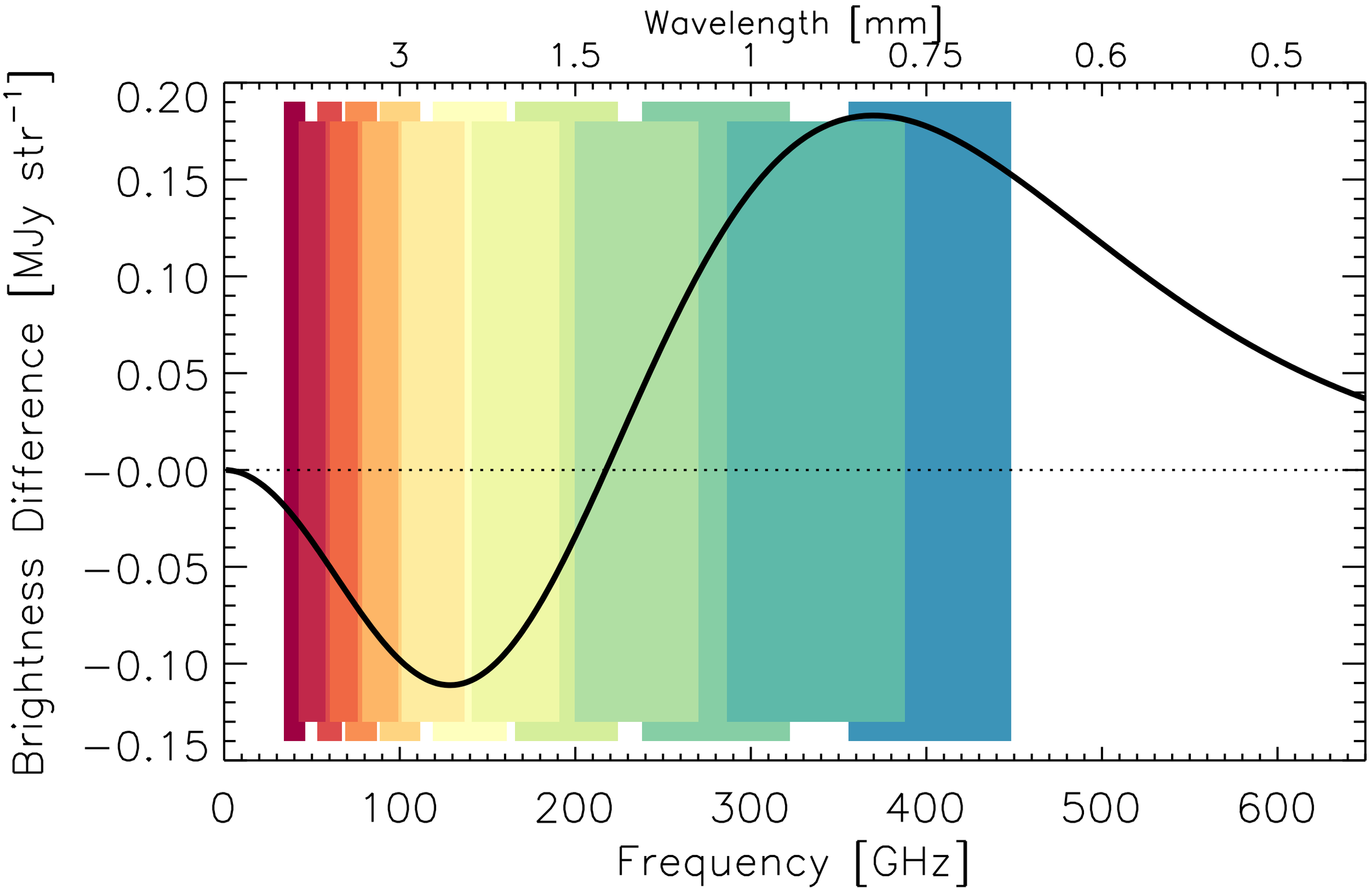
  - Ground (**1-arcmin beam**; Advanced ACT, SPT-3G, Simons Observatory, 30 to 270 GHz + CCAT-p up to 400GHz)

  - Balloons (angular resolution better than LiteBIRD; worse than ground; higher freq than ground)

  - FTS for differential measurements

- **Lots of cross-correlations!** eROSITA, Euclid, LSST, …

# LiteBIRD


Wavelength [mm]
3
1.5
1
0.75
0.6
0.5
Brightness Difference [MJy str$^{-1}$]
0.20
0.15
0.10
0.05
−0.00
−0.05
−0.10
−0.15
0
100
200
300
400
500
600
Frequency [GHz]

# Relativistic Corrections

- Purely for my own interest for LiteBIRD
  - Can we do a relativistic correction map of diffuse SZ at 30-arcmin resolution?
  - We have lots of channels…

# Polarization from low-z distortions?

- It would be a pity to waste polarization capabilities!

# “Elevator Pitch”?

- Case for “Minimal-PIXIE”? “Mini-PIXIE?” (e.g., PRISTINE) Science case?
  - Can we be happy just getting **sigma(y) ~ $10^{-7}$**?
    - How cheap can it be? Maybe not that cheaper…
      - Sweet spot in terms of cost/sensitivity/technology?
  - **“Getting the average thermal energy of the Universe”**
  - Much less requirements for foreground
  - (No guaranteed relativistic correction [degeneracy in thermodynamics]; no guaranteed mu distortion…)

# Low-nu distortion from balloons?

# Low-z Distortion

- Fundamental vs Astrophysics?

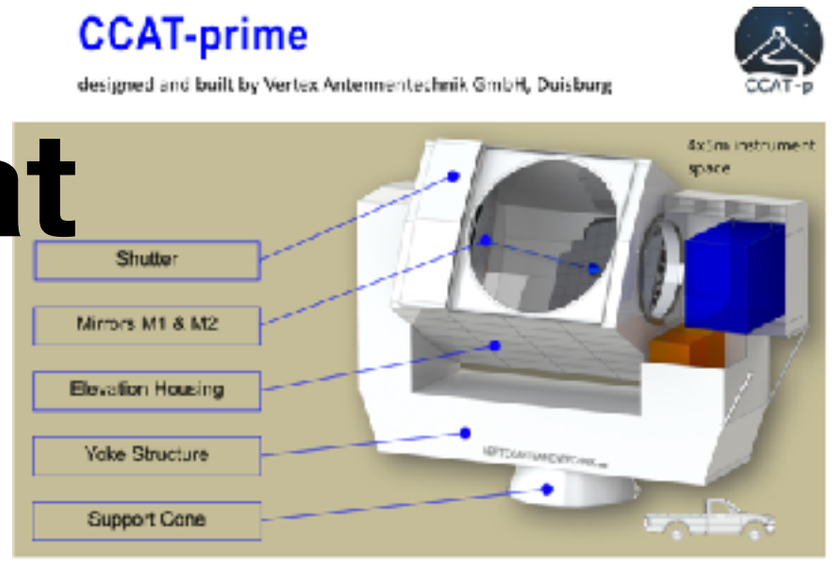
- When can we do $\sigma_8$ from SZ? We need to know B to 5% (say; B=1.5 ± 0.1 by other means)

- Understanding and subtracting the astrophysical foreground to get primordial distortions?

    - Subtract Compton y correlated with galaxies/lensing

# A Game Changer

- **CCAT-p**: 6-m, **Cross-dragone** design, on Cerro Chajnantor (5600 m)




- **Germany makes great telescopes!**

- Initial design study completed, and the contract has been signed by “VERTEX Antennentechnik GmbH”

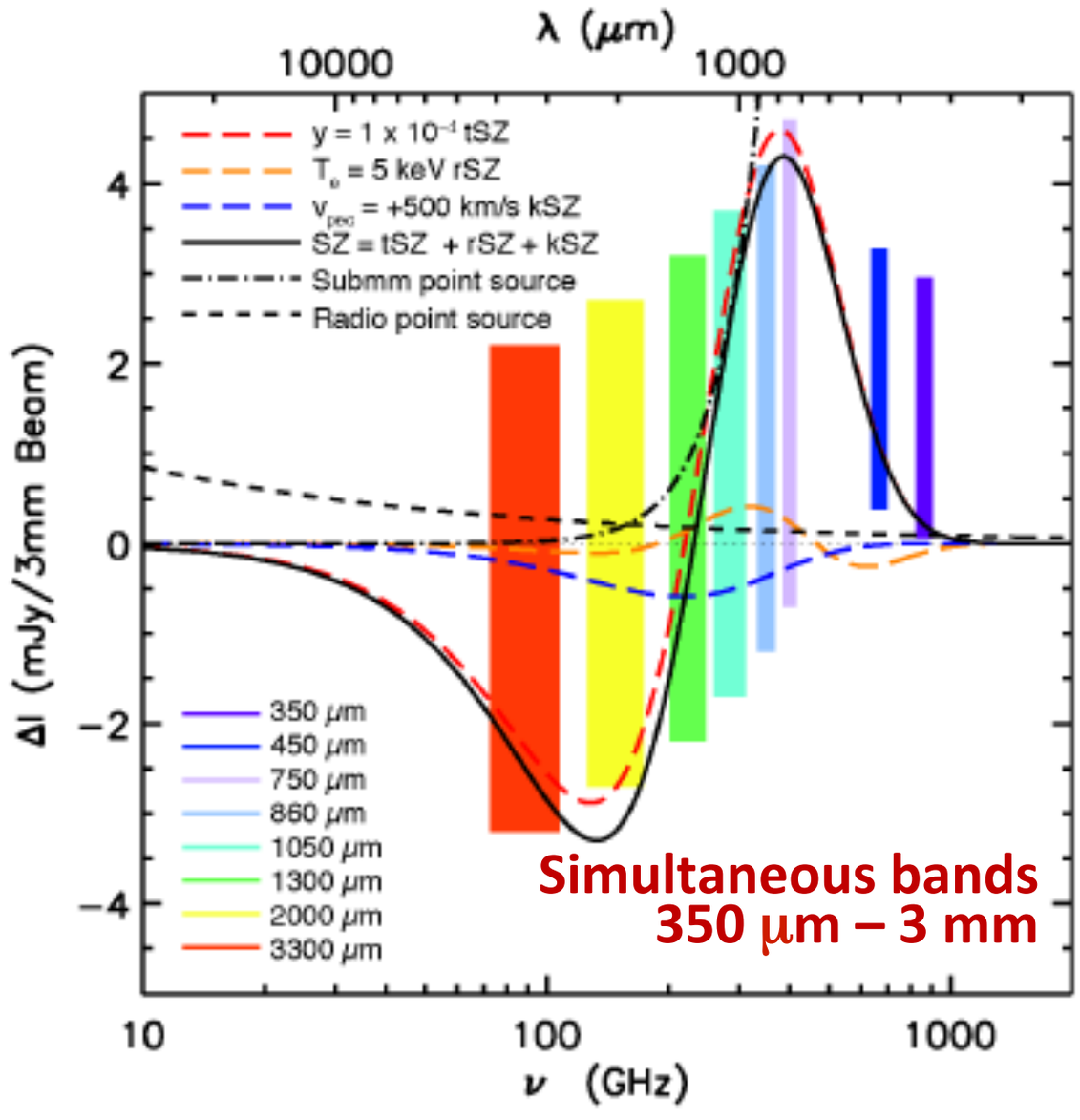
    - CCAT-p is a great opportunity for Germany to make <u>significant contributions</u> towards the CMB S-4 landscape (both US and Europe) by providing telescope designs and the “lessons learned” with prototypes.

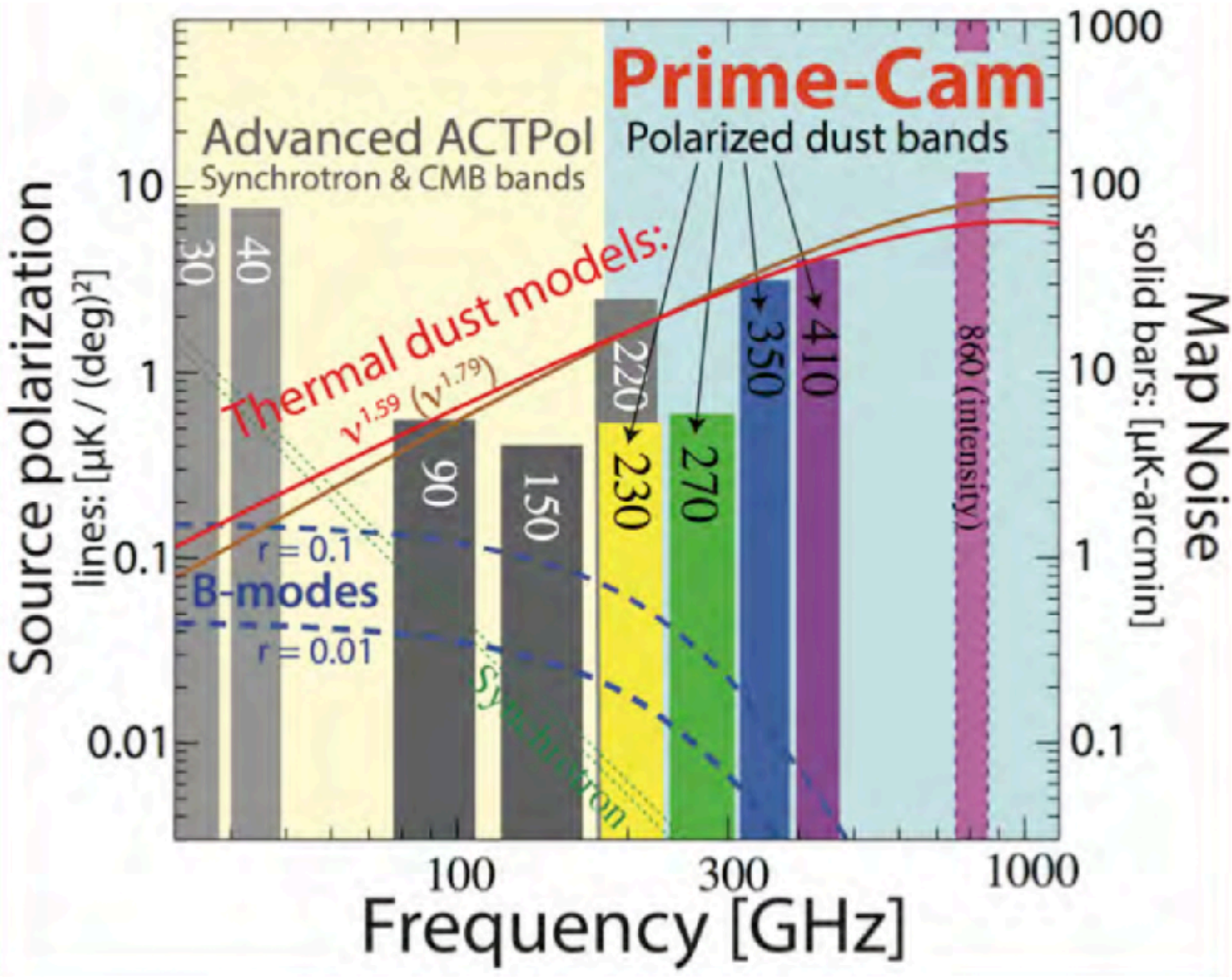
# First light science case:

## Precision measurements of galaxy clusters via the Sunyaev-Zel'dovich (SZ) Effects

**tSZ**: thermal SZ **red**
**rSZ**: relativistic SZ **orange**
**kSZ**: kinetic SZ **blue**

- Challenge to characterize and remove CMB, tSZ, bright submm galaxies and radio sources
  - Observations over wider range of λs inc. submm
  - Better sensitivity and resolution than Planck

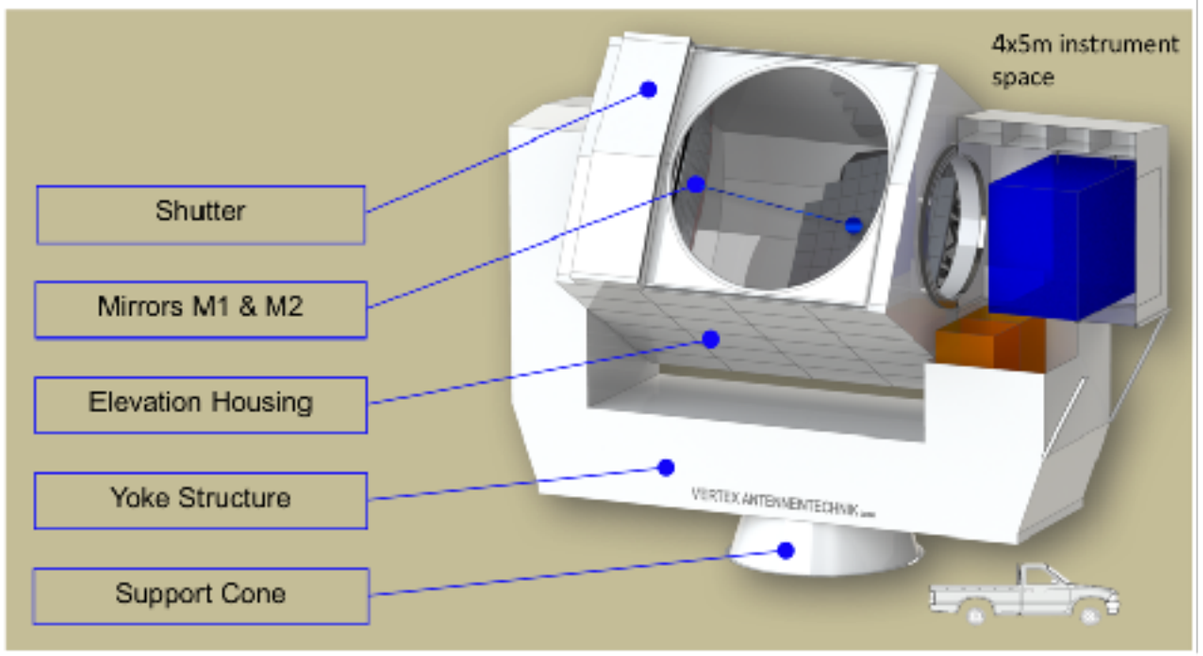


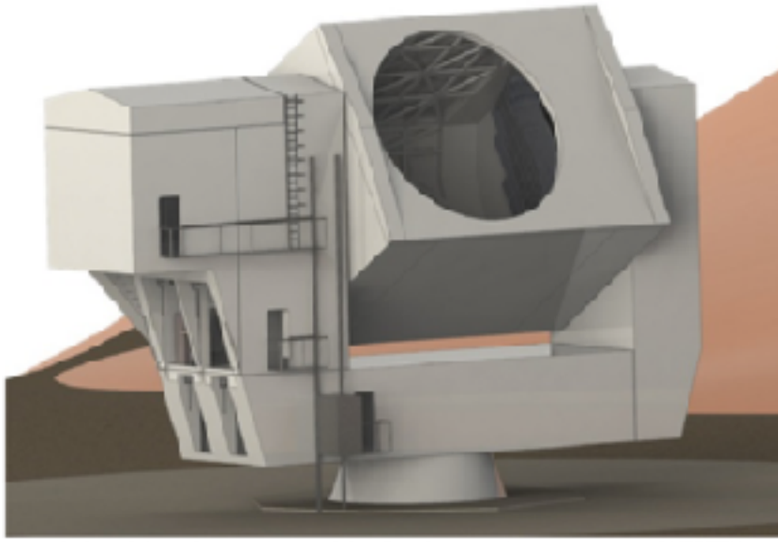

Prime-Cam
Polarized dust bands
Advanced ACTPol
Synchrotron & CMB bands
Thermal dust models:
$\nu^{1.59}$ ($\nu^{1.79}$)
r = 0.1
B-modes
r = 0.01
Synchrotron
30
40
90
150
220
230
270
350
410
860 (intensity)
Source polarization lines: [μK / (deg)²]
Map Noise solid bars: [μK-arcmin]
10
1
0.1
0.01
1000
100
10
1
0.1
100
300
1000
Frequency [GHz]

## CCAT-prime

designed and built by Vertex Antennentechnik GmbH, Duisburg

CCAT-p



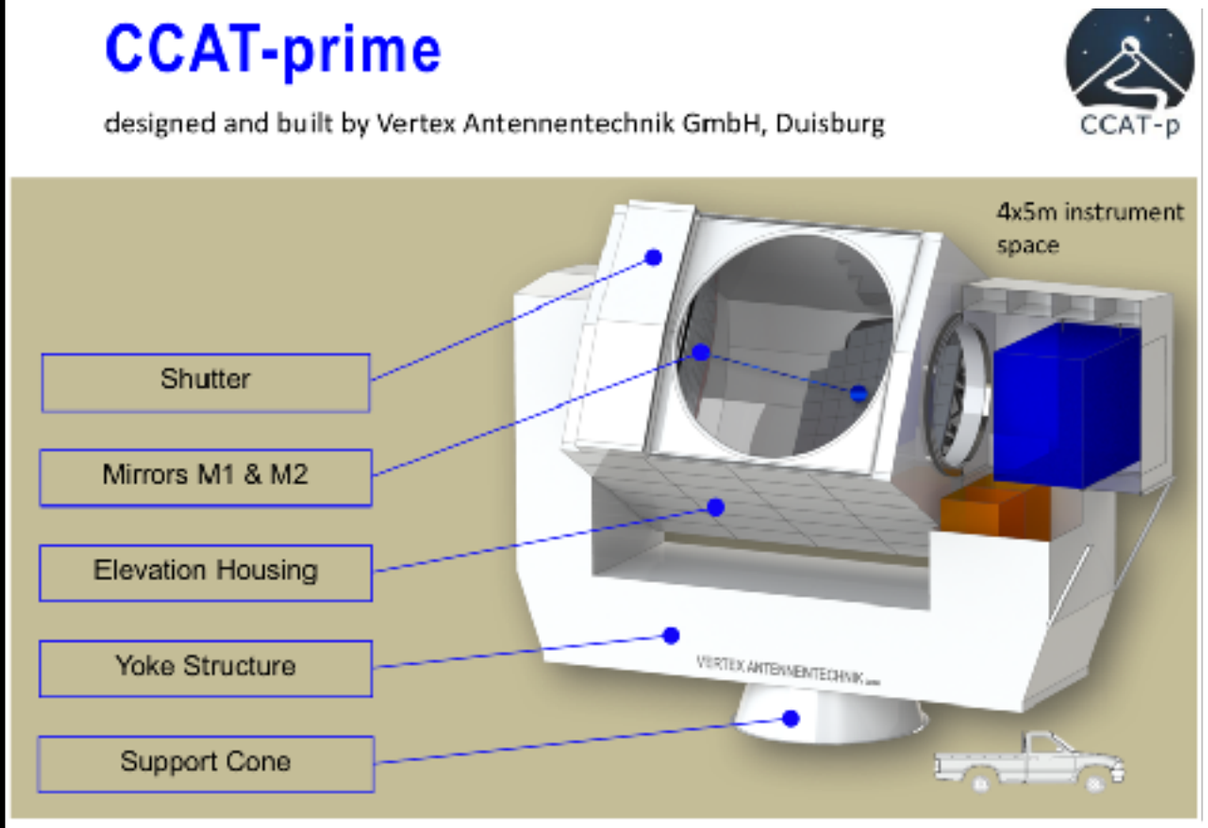
*A rendering of the unique and powerful radio telescope. Image courtesy of VERTEX ANTENNENTECHNIK.*

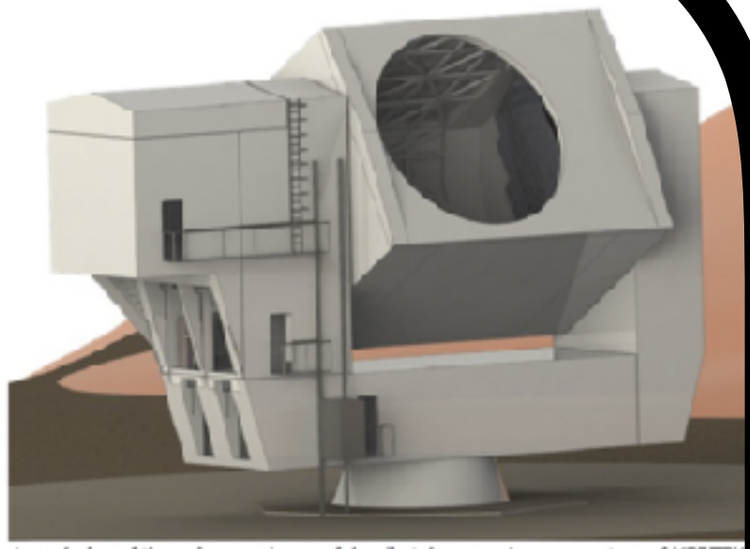
## Simons Observatory (USA)

in collaboration

## South Pole?

# This could be “CMB-S4”



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**South Pole?**