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

![Graph showing frequency vs. brightness difference (Mjy sr\(^{-1}\)) with wavelength in millimeters on the x-axis and frequency in GHz on the y-axis.](image)
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 $\sigma(y) \sim 10^{-7}$?
    - 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; $B=1.5 \pm 0.1$ 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 significant contributions 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 $\lambda$s inc. submm
  - Better sensitivity and resolution than Planck

**Simultaneous bands**
350 $\mu$m – 3 mm
CCAT-prime

designed and built by Vertex Antennentechnik GmbH, Duisburg

Simons Observatory (USA) in collaboration

South Pole?
This could be “CMB-S4”