

Science Task List

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This document is put together by the Science Council with input from the Analysis Working Groups. It seeks to enumerate tasks that need to be completed as we design, construct, and field the CMB-S4 instruments. This is a living document and will change as our understanding evolves.

- **Generic tasks:**
 - Advancing theory/prediction codes to the necessary accuracy
 - Building forecasting software for the science cases
 - Building analysis pipeline software components
 - Running pipelines on data management data challenge outputs
 - Cosmological simulation efforts, especially those that support CMB-S4 cross-correlation studies (with external collaborations)
 - Studies of systematics robustness for science goals
 - Foreground modeling
- **Low-ell BB:**
 - Improving/exploring foreground models (for both SATs and LAT)
 - Studying impact of high-ell non-Gaussianity on lensing reconstruction and delensing
 - Improving and refining Fisher forecasting:
 - Incorporating more realism on LAT/delensing from existing experiments
 - Generating improved high realization count simulations (for both SATs and LAT)
 - Including the effects of timestream filtering
 - Establishing the ability to re-analyze these more realistic simulations which have missing modes due to filtering
 - Quantification of systematic effects
 - SAT: Adding pickup/sidelobe systematics to the simulations and exploring the residuals when filtered and re-analyzed
 - SAT + LAT: Exploring the effects of bandpass related systematics
 - LAT: effects of beam shape variation on delensing
 - Developing alternate re-analysis algorithms and pipelines
 - Refining the extrapolation of sensitivity from existing experiments
 - Testing the developing CMB-S4 pipelines on existing datasets
- **Clusters:**
 - Understanding mass calibration
 - Study of using stacked lensing analysis from DESC/Rubin
 - Going beyond LCDM for the halo mass function
 - Building hydrodynamical simulations with multiple parameters that govern baryon physics, or a baryon pasting scheme calibrated to hydro sims
 - Exploring the usefulness of CMB-halo lensing

- Understanding the selection function
- Studying evolution effects on the selection function
- Studying impacts of dust/foreground residuals
- Building a combined likelihood for cluster counts and cluster clustering
- **Maps To Power Spectra:**
 - Pipeline work on simulations, increasing realism with each generation
 - Building power spectra pipeline tools
 - Exploring strategies for handling systematics in beams, gains
 - Studying of the above for delensing
 - Combining data for different statistics, combined likelihoods, joint analysis
- **Maps To Other Statistics:**
 - Lensing / Neutrino Mass
 - Optimal lensing autospectrum pipeline development and detailed testing
 - Characterization of galactic dust and synchrotron-induced biases for optimal polarization lensing pipelines (+ potential development of mitigation strategies); application and further development of non-Gaussian small scale foreground simulations
 - Likelihoods for joint neutrino mass constraints from lensing + other probes
 - SZ constraints on baryon distribution
 - Develop + test component separation pipelines to mitigate e.g. CIB contributions
 - Develop stacking and cross-correlation analysis pipelines to extract information about electron density and pressure profiles
 - Develop models for the joint distribution of baryons and galaxies from LSS surveys + further work to connect to weak lensing observables
 - Reionization and Optical Depth (τ)
 - Develop kSZ 4pt pipeline; find strategies to mitigate lensing, CIB, SZ... "foregrounds"
 - Develop modeling and likelihood codes to combine kSZ power and 4pt; connect with neutrino mass constraints
 - Forecast + develop case for synergies of different reionization observables: patchy τ/B , kSZ power, Compton-y, kSZ-4pt...
 - Broader cross-correlation science
 - Growth of structure from lensing-galaxy cross correlations:
 - Develop cross-correlation pipelines
 - Investigate polarization lensing x galaxy biases due to dust extinction?
 - Develop higher-order bias modeling infrastructure to go from kg, gg -> s8
 - Joint-probes Nx2 likelihood development
 - Primordial non-Gaussianity (f_{NL}) from cross-correlations:
 - Develop cross-correlation pipelines + investigate systematics for lensing x galaxies and kSZ velocity reconstruction
 - Develop simulations for all of above

- **Sources and Transients:**

- Theoretical modeling and forecasting for protoclusters
- New techniques for cross matching external catalogs and source classification and characterization
- Theoretical predictions for transients
- Optimal source finding