Fireslides:
Monday, 25 Mar 2024

10:45 – 11:15 am PDT
Moderator: Evan Grohs (he/him/his)

Order for speakers:

1. Anton Baleato Lizancos
2. Boris Bolliet
3. James Cornelison
4. Will Coulton
5. Elena de la Hoz
6. Kyle Ferguson
7. Andrei Frolov
8. Helena Garcia
9. Darby Kramer
10. Ola Kusiak
11. Scott Mackey
12. Asmaa Mazoun
13. Yogesh Mehta
14. Joel Meyers
15. Bhaskar Mondal
16. Mike Niemack & Eve Vavagiakis
17. Srinivasan Raghunathan

Antón Baleato Lizancos, postdoc at BERKELEY CENTER *for* COSMOLOGICAL PHYSICS

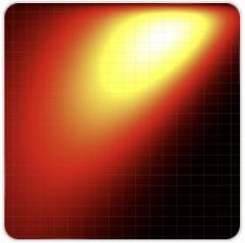
CMB lensing auto- & cross-correlations

- Pixel- & aliasing-free cross-correlations with galaxies [**ABL** & White 24]
- Model-agnostic variance cancellation in CMB lensing cross-correlations [**ABL** & Ferraro 23]
- Impact of anisotropic dN/dz's on cross-correlations [**ABL** & White 23]
- Halo model for tSZ & CIB biases to lensing auto- & cross- & delensing [**ABL**, Coulton, Challinor & Sherwin (in prep)]

B-mode delensing

- Co-lead of SO delensing working group [Namikawa, **ABL** + 22]
- Biases from extragalactic foregrounds [**ABL** & Ferraro 22]
- Limitations of delensing with a B-mode template [**ABL**, Challinor & Carron 21a]
- Internal delensing biases from mode-overlap [**ABL**, Challinor & Carron 21b]
- Biases from CIB & dust non-Gaussianity when delensing with CIB [**ABL**, Challinor, Sherwin & Namikawa 21]
- Impact of matter & biasing non-linearities when using external tracers [Wang, **ABL** & Bernal (in prep)]

Boris Bolliet (Cambridge)



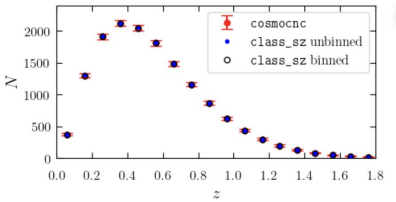
https://github.com/CLASS-SZ

CLASS-SZ

Optimized CMB x LSS code in Python and C

Bolliet, Kusiak, McCarthy, Sabyr, Surrao, Hill et al arxiv.org/2310.18482

- Neural network accelerated Boltzmann calculations with class (Lesgourgues et al.) and cosmopower (Spurio-mancini et al.)
- tSZ, kSZ, CMB lensing, galaxy/galaxy-lensing, CIB, ISW, custom tracer in Fourier/harmonic and position space
- Check tutorial notebooks at https://github.com/CLASS-SZ/notebooks



- **NEW**: cluster counts with inigozubeldia/cosmocnc

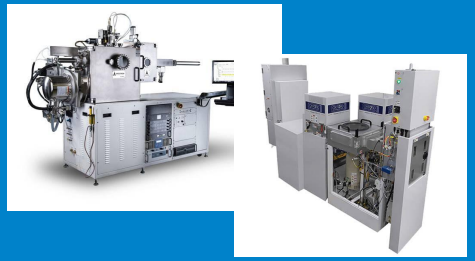
Zubeldia & Bolliet arXiv.org:2403.09589

Development of low-loss materials for mm-wave superconducting devices

J. Cornelison and the ANL Detector Group

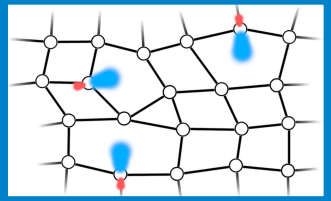
Motivation: Dielectric and conductor losses directly affect device design, optical efficiency, spectrometer resolution, etc.

Goal: Explore new devices, processes and materials to improve overall performance in future mm-wave CMB experiments.



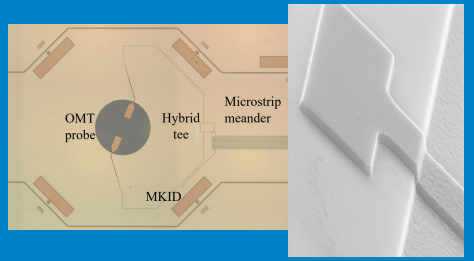
Development Plan

- Fabrication Processes
  - Deposition (IBAS vs CVD)
  - Lithography (etch vs. liftoff)
- Materials
  - Conductor Interface (NbO_2, NbN)
  - Dielectrics (Si-rich SiN, a-Si:H, a-SiC)
- Devices
  - Create test devices that optimize sensitivity of specific fab/material choices



Quality Control Procedures

- Fabrication parameters change over time!
- Formulate quality control metrics to monitor system degradation
- Establish thresholds for parameter adjustments and servicing



Impact

- Improved sensitivity, higher pixel densities, tighter spectrometer channels
- Smaller performance variation across devices and over longer periods

U.S. DEPARTMENT OF ENERGY

Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.

Contact: jcornelison@anl.gov

Argonne NATIONAL LABORATORY

Detection of patchy screening with the Atacama Cosmology Telescope

Will Coulton with Theo Schutt, Abi Maniyar, Manu Schaan and the ACT collaboration (Schutt et al & Coulton et al. 2024)

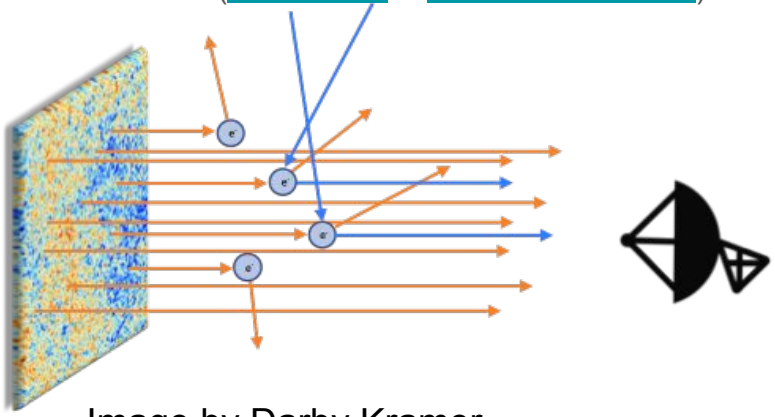
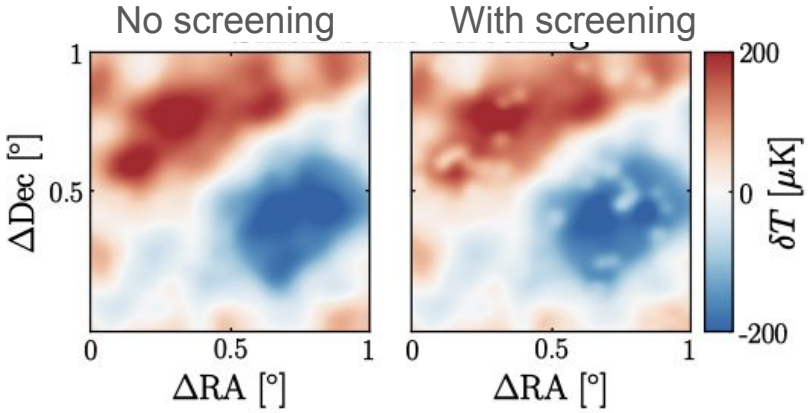
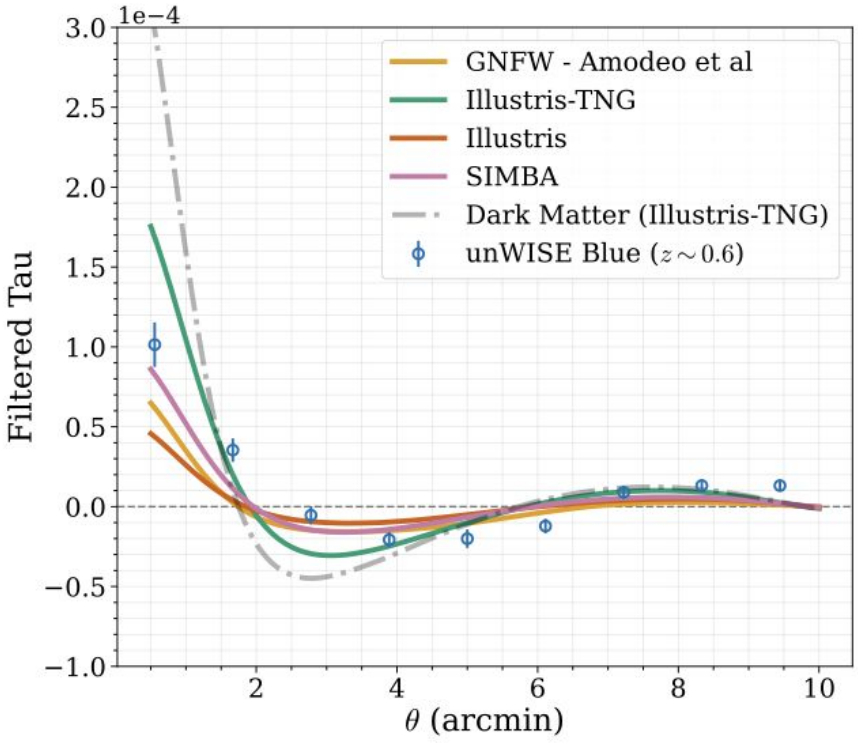


Image by Darby Kramer



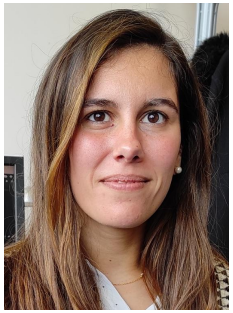
Measurement of optical depth around unWISE galaxies via the patchy screening effect



ACT DR6 Compton-y maps available (here)

CNRS • Berkeley

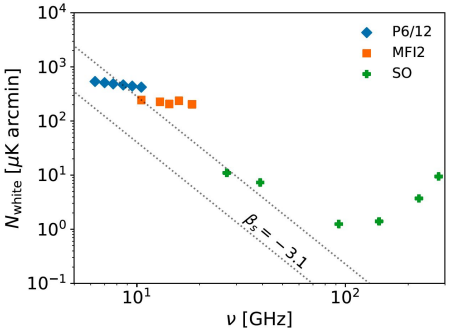
Centre Pierre Binétruy

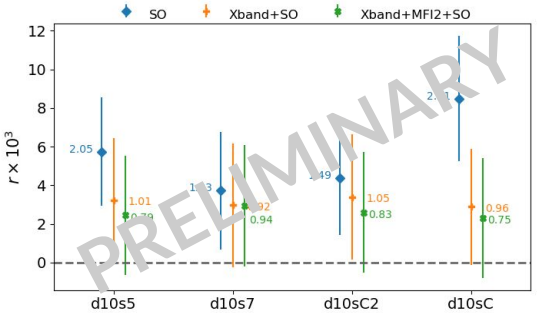


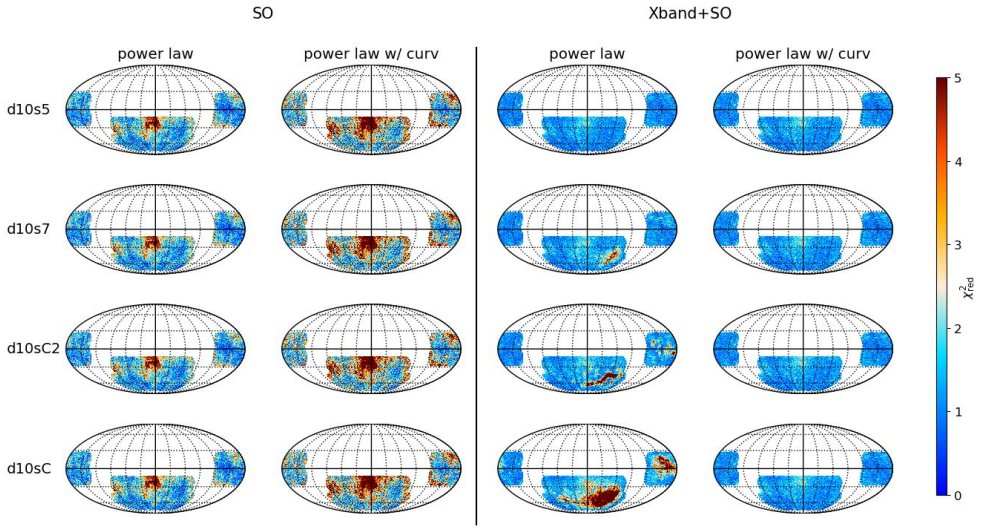
Elena de la Hoz

ELFS on SA

- Proposal to replace the **Simons Array**'s (SA's) **220/280 GHz receiver** with a **Europe**-supplied **low-frequency** receiver.
- Plan is to install a **C-BASS-like 6–12 GHz** receiver **(Xband)** first, and add a second european receiver **10–20 GHz (QUIJOTE MFI2)** later.
- This instrument will shed light on the **synchrotron's SED**.
- Helpful complement for **CMB-S4** . Let us know if the **20 GHz channel** is essential for a **successful experiment.**

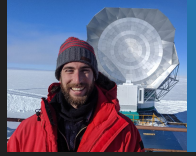






Visual analysis of mKIDs

Kyle Ferguson (SPT, he/him/his)
kferguson@physics.ucla.edu



UCLA

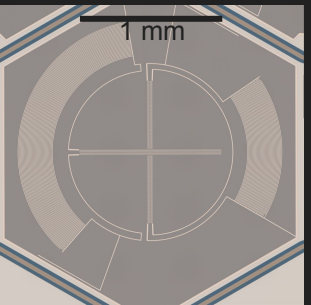
Argonne NATIONAL LABORATORY

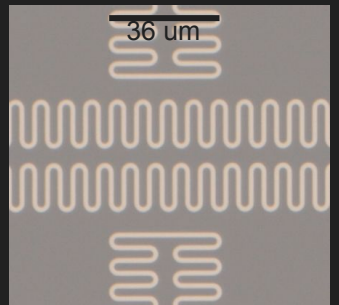
Motivation:

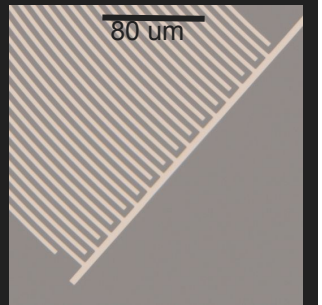
- S4 will have ~500,000 detectors
- Want a relatively quick way to spot-check wafers at room temperature

Method:

- Image detectors under a microscope
- Use visual information to predict cryogenic performance
- Computer vision techniques to find detector position/orientation, analyze features

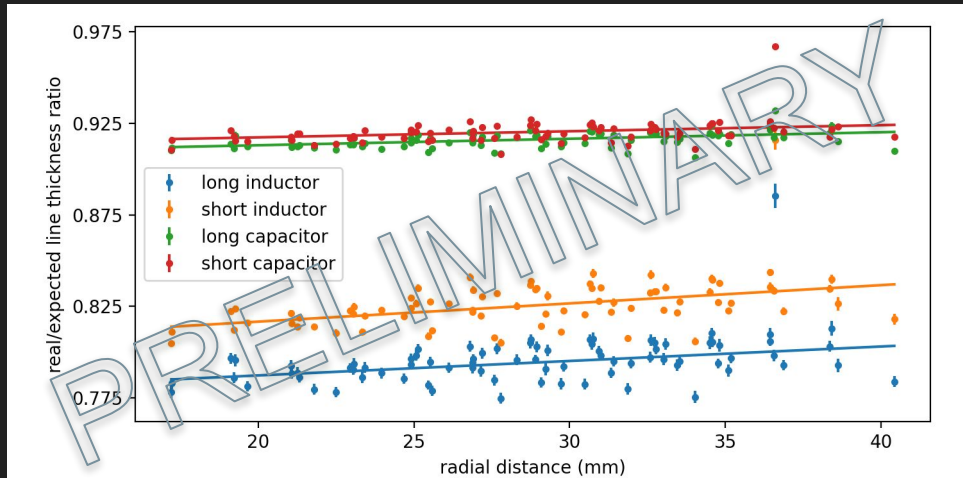




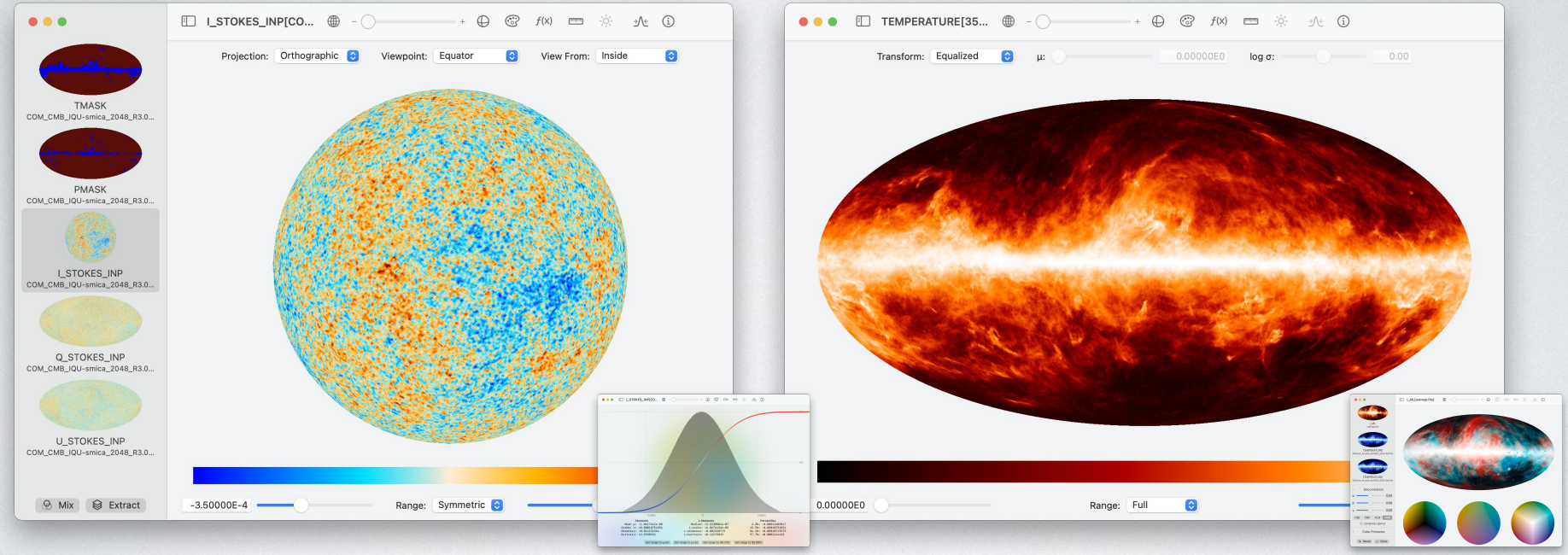


Specifically, our algorithm uses SPT-3G+ detectors; it is designed to:

- Detect fabrication defects (i.e., breaks in conducting lines)
- Measure line thickness → estimate shift in resonant freq.



HEALPIX VIEWER - arXiv:2305.11507

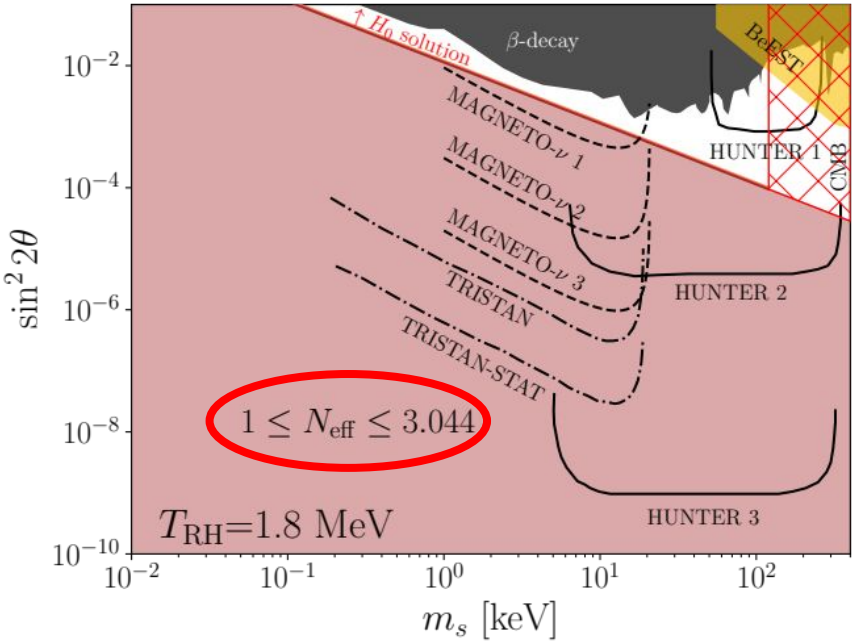


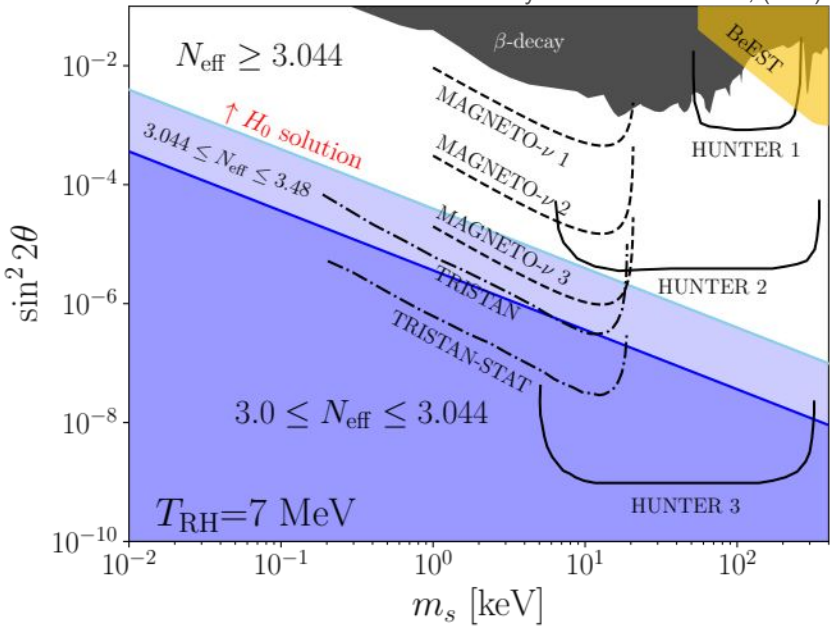
https://github.com/andrei-v-frolov/healpix-viewer

Download on the Mac App Store

Synergy of cosmological & laboratory probes of novel dark radiation thermalization

Helena García Escudero
garciaeh@uci.edu
University of California Irvine, (UCI)





-LRT universes + new neutrino physics ➡ broad new observationally-consistent & novel cosmologies!

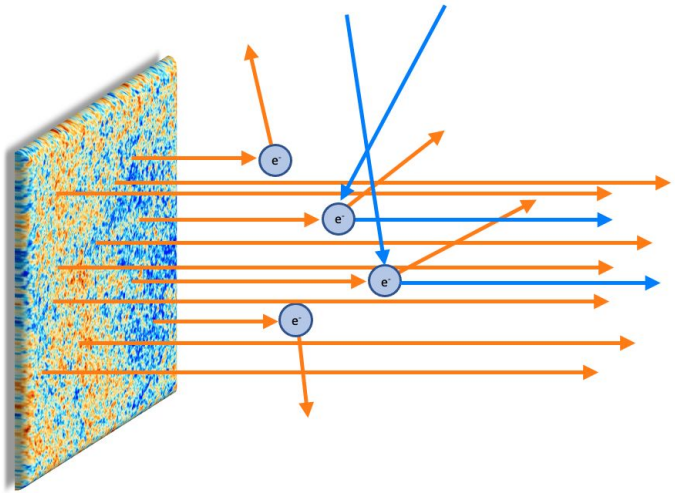
-DR can be a combination of thermal + non thermal radiation ➡ novel CMB signature!

- ↑ $N_{\rm eff}$ ➡ alleviation of the H_0 tension!

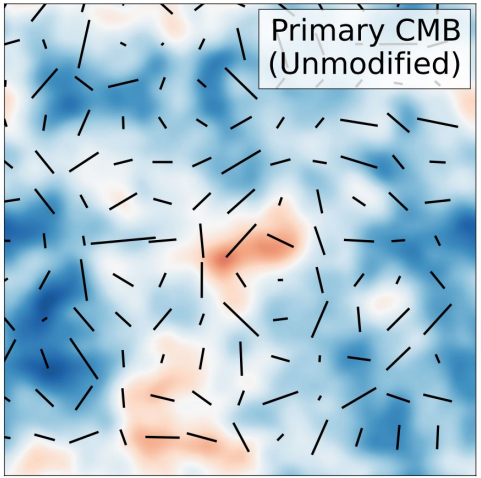
https://arxiv.org/pdf/2309.11492.pdf

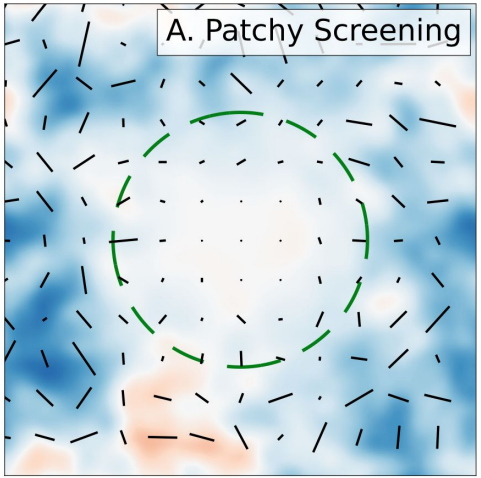
Reconstructing Patchy τ from CMB data

Darby Kramer, 4th year ASU PhD Candidate
with Alex van Engelen



CMB photons scatter off **free electrons**
- **Reionization**
- **Low-Redshift Halos**





Screening effect on CMB maps with optical depth τ

Exploring cross-correlations with galaxies and kSZ

Figure by Alex van Engelen ->

dmkrame1@asu.edu

Ola Kusiak
Columbia→ Cambridge

Measuring tSZ x galaxy with ACT DR6

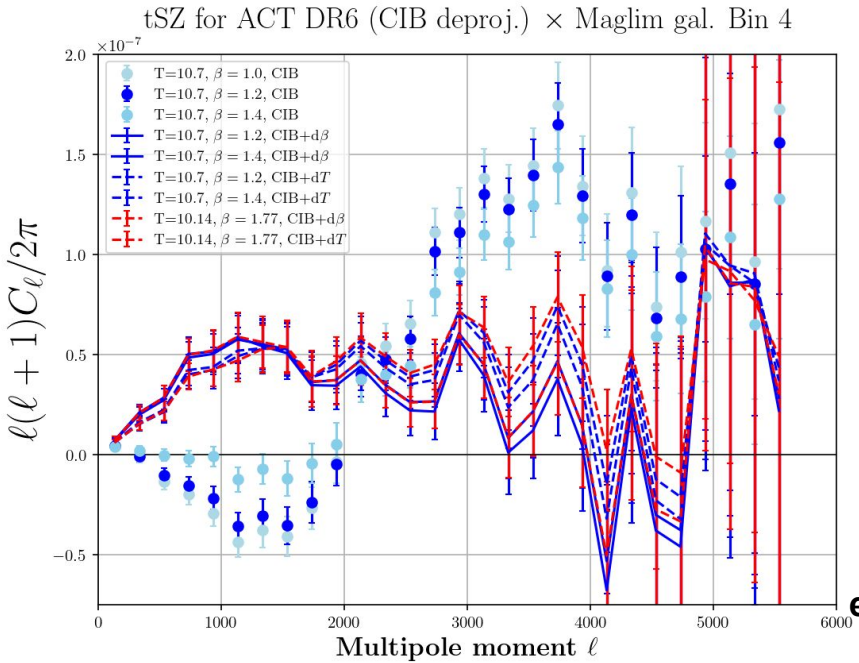
With Colin Hill, Boris Bolliet, Shivam Pandey, Will Coulton ++, ACT & DES Collaboration

w/ DES Maglim galaxies

- DES Y3 **Maglim** galaxies
- DES Y3 shear
- **ACT DR6** Compton-y maps from Coulton et al.

↓

See [DR6 notebooks] on how to work with the new y-maps



Main worry is the **CIB contamination**:

- can deproject CIB=modified blackbody parametrized by β and T:

MBB:

$$I_\nu^{\rm CIB}(\hat{n}) = \left(\frac{\nu}{\nu_0}\right)^{\beta+3} \frac{1}{e^{x_{\rm CIB}}-1} A^{\rm CIB}(\hat{n})$$

→ large variations in the final cross-correlation

- deproject CIB, but also **first-moment** of the SED parameters (Chluba+ 2017, McCarthy & Hill 2023, Coulton+ 2023)

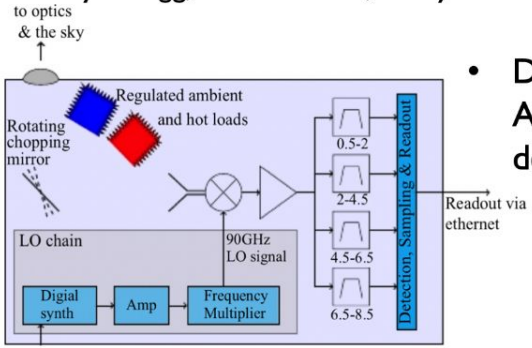
→ **final cross-correlation insensitive to exact value of β and T**

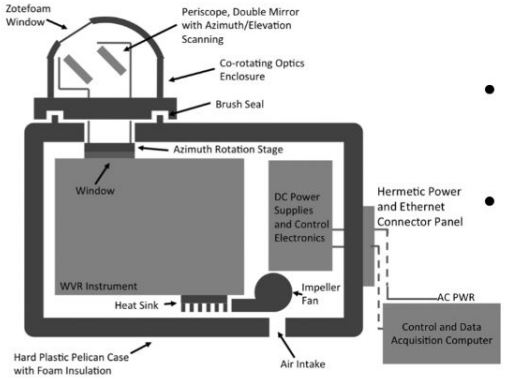
Goal: Constrain pressure profile of Maglim galaxies (+HOD)

A 183 GHz Water Vapor Radiometer for Chile

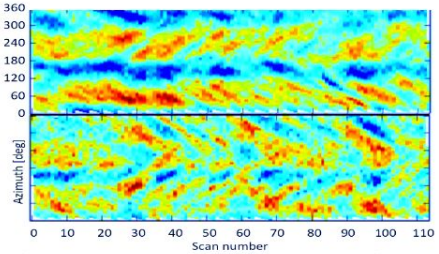
Scott Mackey, PhD Student in Abigail Vieregg's Group, University of Chicago

With Abby Vieregg, Denis Barkats, Darcy Barron, Ian Birdwell

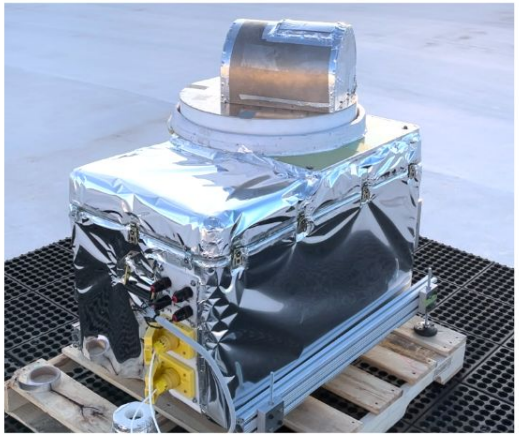




- Dicke-switched radiometer originally designed for ALMA with a custom "periscope" optics assembly developed by John Kovac's group at Harvard



- Will produce atmogram maps and precipitable water vapor data
- Twin unit already at South Pole will allow for future direct comparisons of atmospheric conditions between South Pole and Chile sites



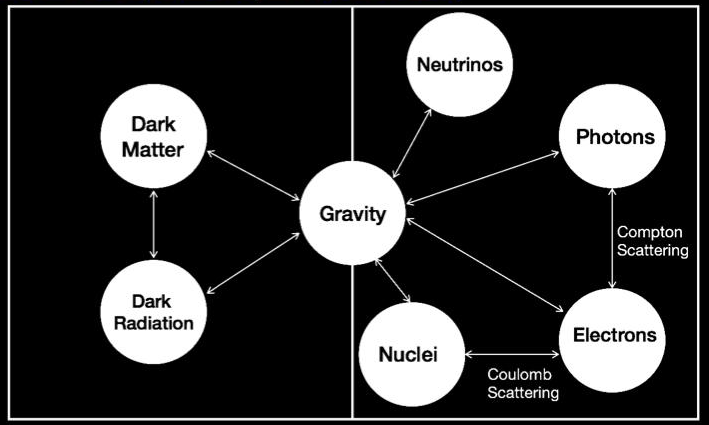
Currently at the University of New Mexico for pre-deployment testing

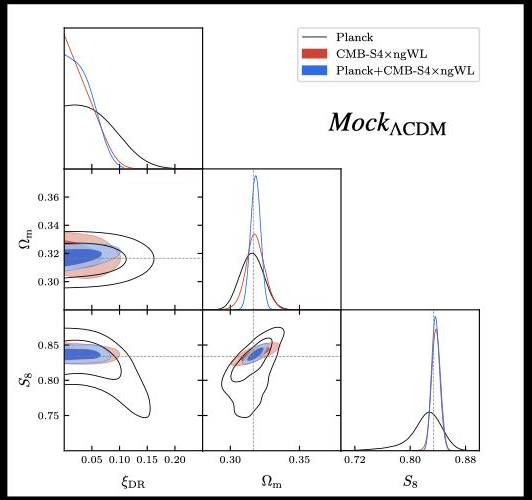
Targeting deployment for this May to the CLASS site on Cerro Toco

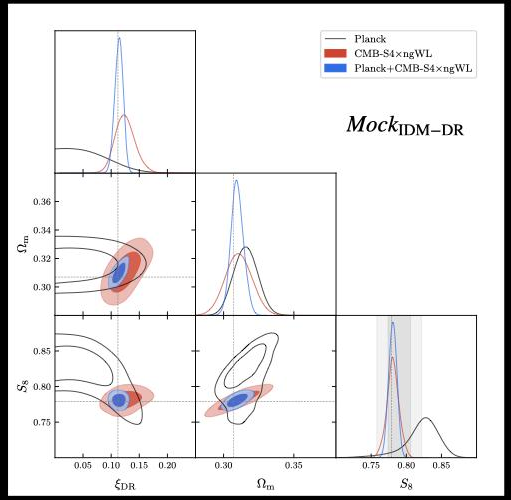
Asmaa Mazoun (LMU/TUM Munich)

Forecasting CMB-S4×ngWL constraints on IDM-DR model: beyond-CDM model

- Interacting dark matter with dark radiation model (IDM-DR) has a suppression effect on the structure formation.
- This model offers a possible solution to the S_8 tension.
- CMB-S4 clusters data detected via thermal SZ effect combined with next-generation weak lensing data (ngWL), like the one from Euclid or Rubin, will be able to distinguish between IDM-DR model and a ΛCDM one.

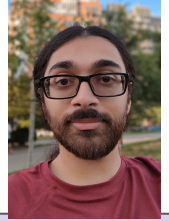






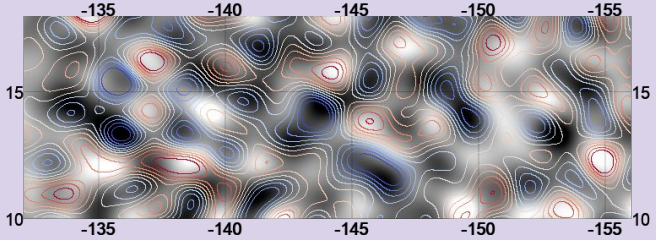
arXiv: 2312.17622

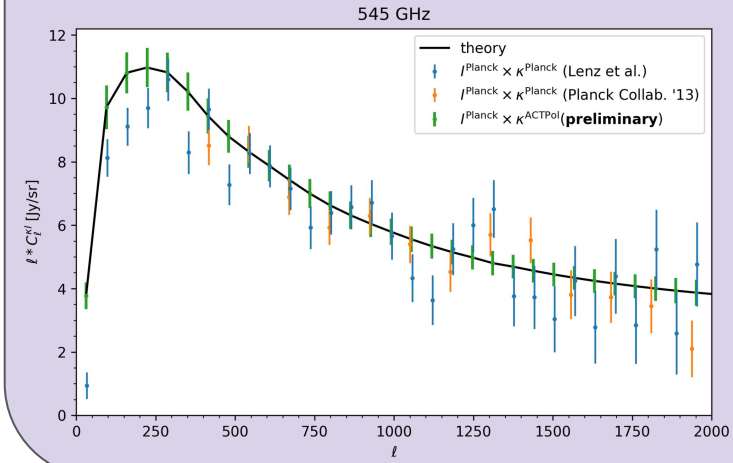
Yogesh Mehta (he/him)
ymehta3@asu.edu
Arizona State University



Planck CIB x ACT DR6 CMB Lensing

Alexander van Engelen, Fiona McCarthy, Boris Bolliet, ACT collaboration





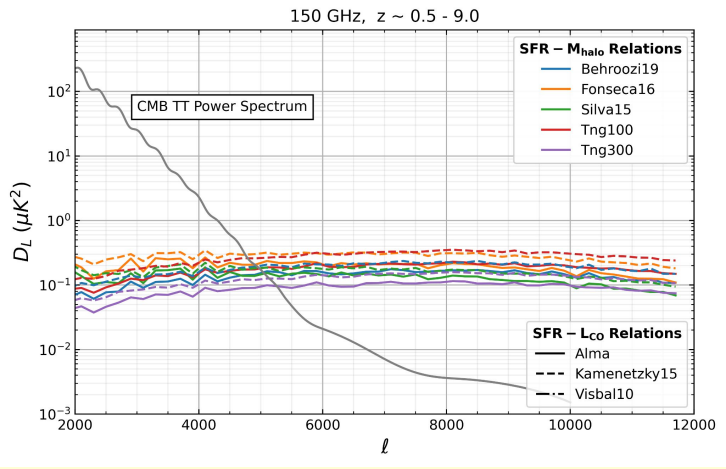
- Highly correlated LSS tracers
- Modelling with **CLASS-SZ** (https://github.com/CLASS-SZ)

Constrain:

- CIB modeling
- Star formation history
- Local type f_{NL}

CO in CMB

Alexander van Engelen, Anirban Roy, Simon Foreman, Nicholas Battaglia



- Measure range of theoretical CO auto/cross spectra with other FG's in simulations
- Calculate effect of CO on CMB lensing science

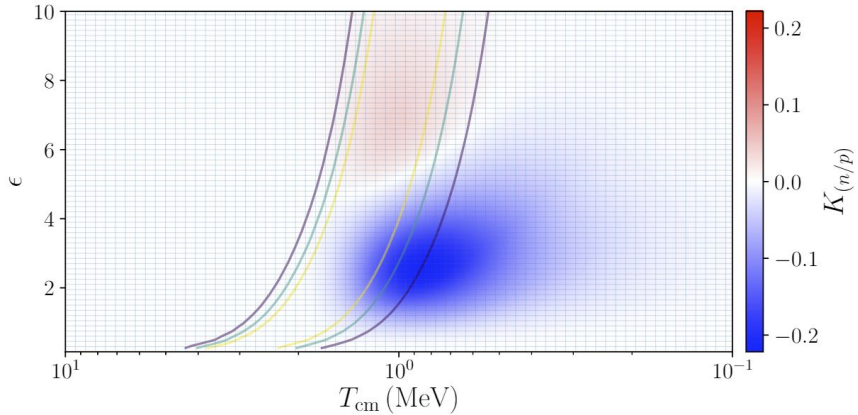
Cosmic Neutrino Decoupling and its Observable Imprints: Insights from Entropic-Dual Transport

Joel Meyers

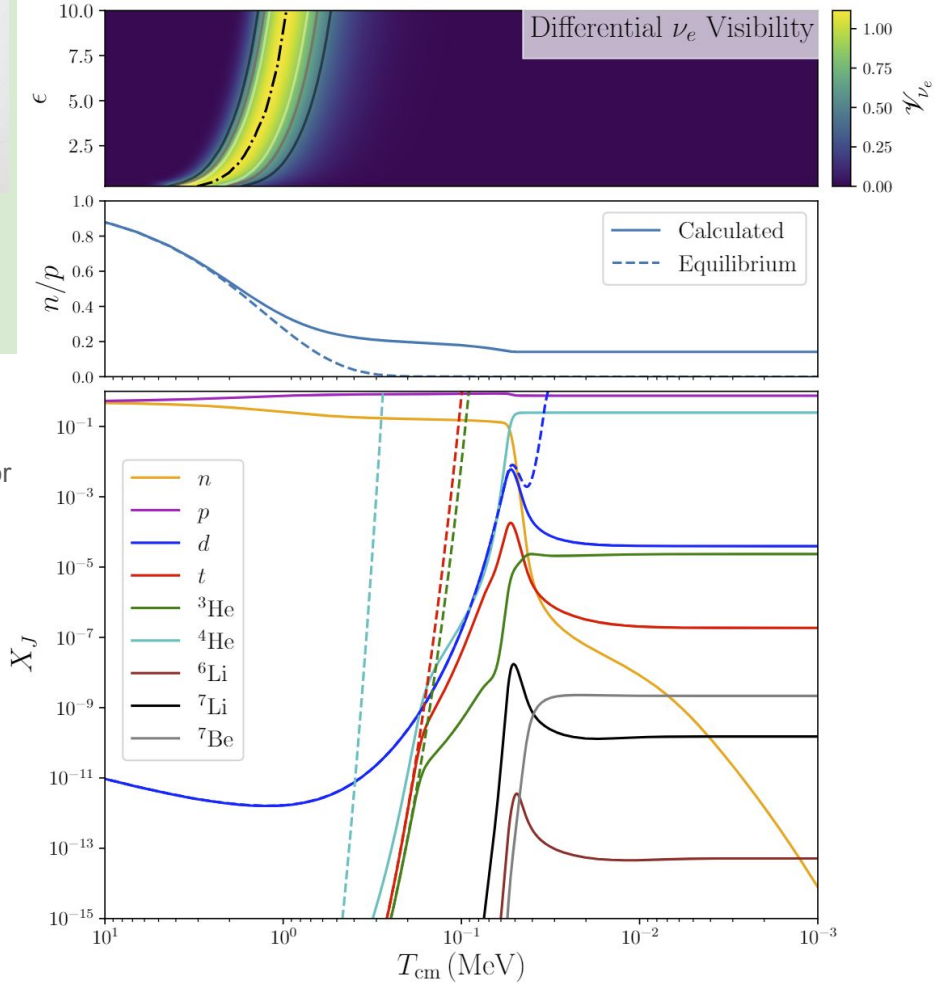
Bond, Fuller, Grohs, JM, Wilson

Appearing on arXiv this week!

- Compact and precise description of cosmic neutrino decoupling
- Convenient formulation of impact on CMB and primordial abundances
- Useful framework for studying BSM scenarios impacting neutrino sector



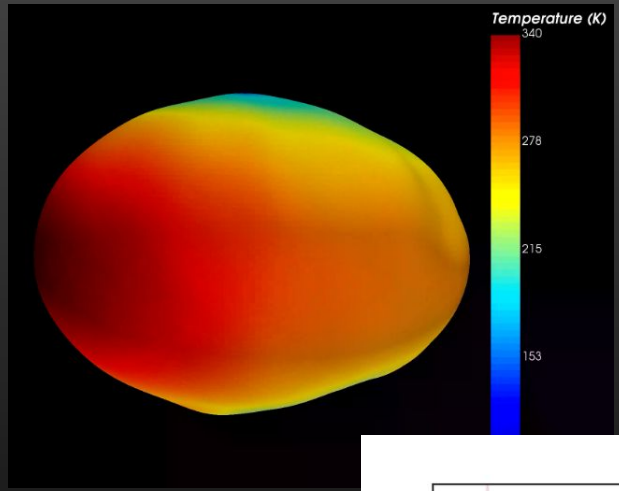
Neutron-to-proton response to CνB spectral distortions

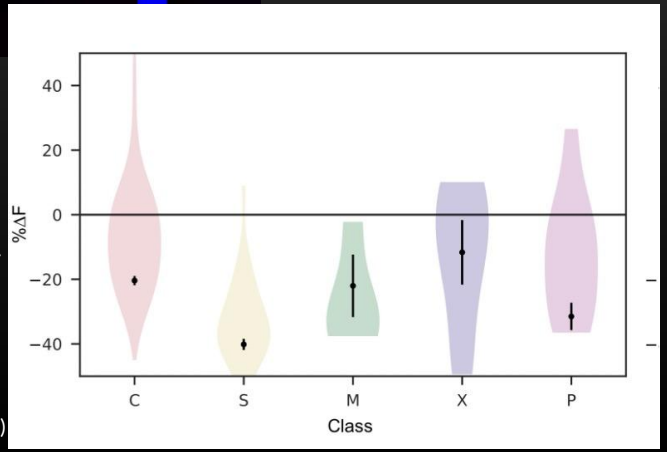


Bhaskar Mondal

PhD Student, Aerospace Engineering
University of Illinois at Urbana-Champaign
Email: bmondal3@illinois.edu

- GPU accelerated thermophysical modeling of asteroids.
- Estimation of Yarkovsky effect and other non-gravitational forces on asteroids.
- Currently trying to understand the flux deficit in asteroid observations in microwave.
- Will be exploring the observability and discoverability of asteroids and other Solar System objects in the context of CMB-S4.

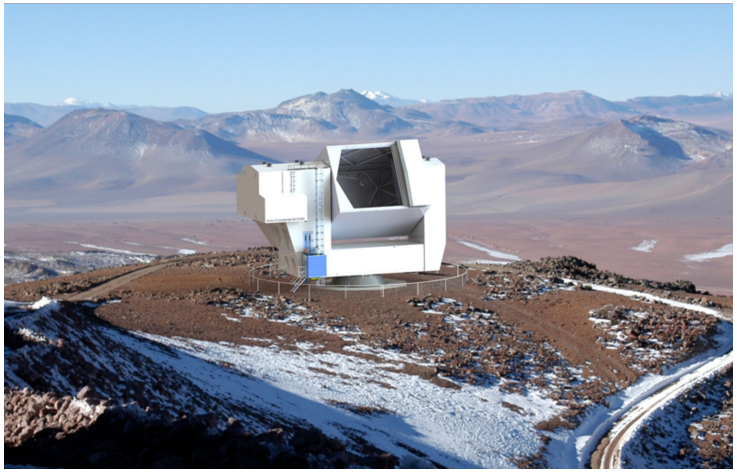




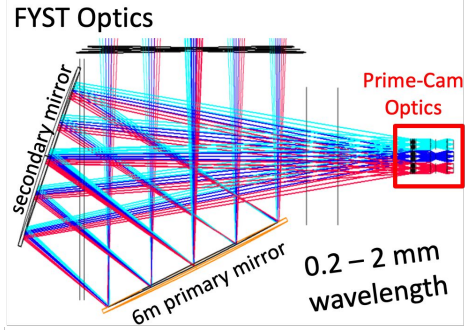
From Orlowski-Scherer et al. (2023)

CCAT Observatory

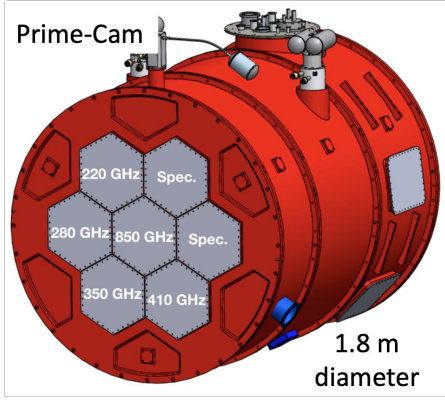
Eve Vavagiakis (ev66@cornell.edu) → Duke 7/24
Mike Niemack (niemack@cornell.edu)
For the CCAT Collaboration www.ccatobservatory.org



FYST Optics

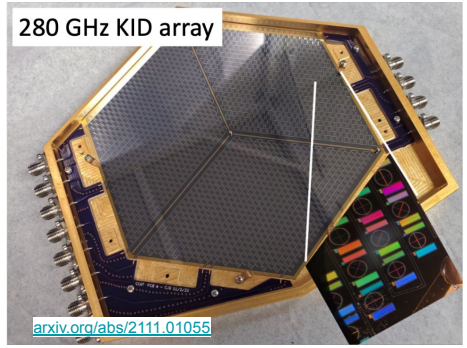


Prime-Cam

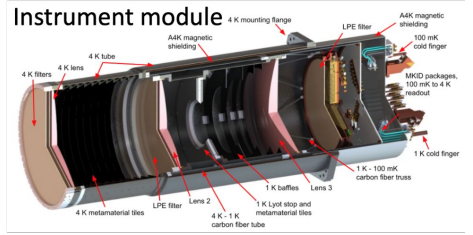


Prime-Cam Science Goals and Forecasts: arxiv.org/abs/2107.10364

280 GHz KID array



Instrument module



2024 Status

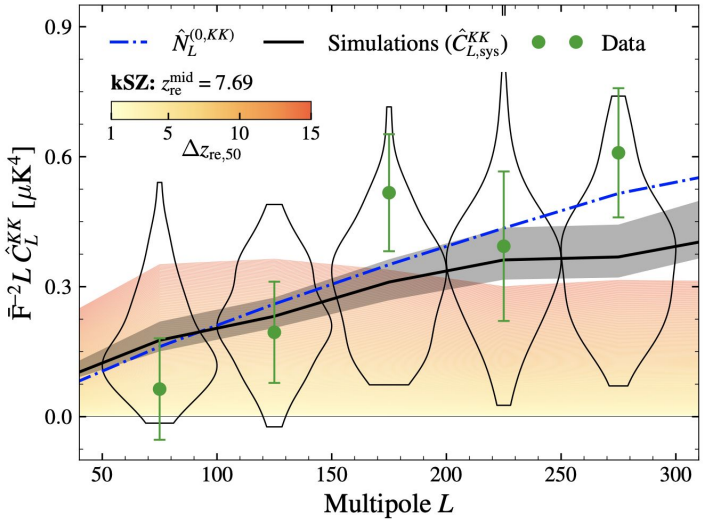
- CCAT is building the Fred Young Submillimeter Telescope (FYST)
- FYST test build underway in Germany, deployment in 2025
- Chilean site preparations nearly done
- Prime-Cam construction underway
- Mod-Cam testing progressing well
- Aiming to deploy > 100,000 KIDs in Prime-Cam

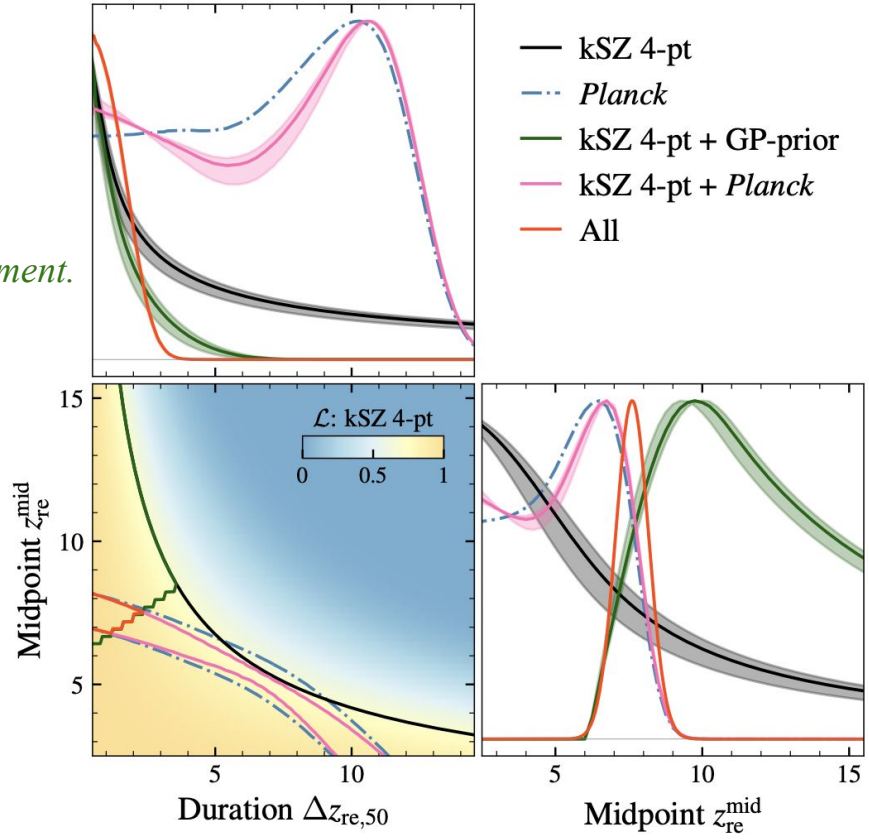
Mod-Cam

First Constraints on Reionization Using the kSZ trispectrum from the South Pole Telescope

Srinivasan Raghunathan and the SPT Collaboration (arXiv: 2403.02337)

- Patchy reionization → non-Gaussian kinematic Sunyaev–Zeldovich (kSZ) signal → kSZ (4-pt) trispectrum (See Smith & Ferraro 2016, arXiv: 1607.01769).
  - **Direct probe of the physics of reionization.**
- Less prone to assumptions about the low-z kSZ, unlike kSZ 2-pt.
- Measurement dominated by CMB lensing + FG.
- kSZ 4-pt + Gunn-Peterson trough:
  - **Duration of reionization Δz < 4.5 (95% C.L.).**
  - *Independent but consistent with Planck's optical depth measurement.*





Fireslides:
Wednesday, 27 Mar 2024

09:00 – 09:15 am PDT

Moderator: Evan Grohs (he/him/his)

CMB-S4

Order of speakers:

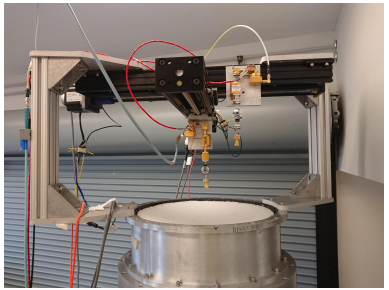
1. Matthew Petroff
2. Erik Rosenberg
3. Murali Saravanan
4. Lauren Saunders
5. Shabbir Shaikh
6. Cynthia Trendafilova
7. Sophie Vogt
8. Florian Keruzore
9. Bruce Partridge
10. Shamik Ghosh
11. Jacques Delabrouille

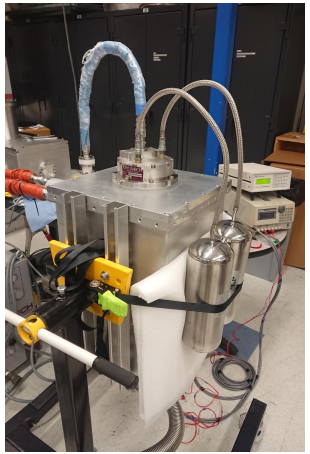
Precursor Small Aperture Telescope (PreSAT)

Matthew Petroff — Center for Astrophysics | Harvard & Smithsonian

- Aims to test candidate CMB-S4 SAT technologies in a BICEP Array receiver, enabling full-stack laboratory testing and early risk retirement for CMB-S4 technical developments
- 90 GHz / 150 GHz dichroic receiver
- Prototype optics stack, detectors, readout
- Comparative testing, ideally on sky at Pole, with Stage III hardware

- Current ongoing in lab testing:
  - Magnetic pickup testing for both SQUIDs and receiver-level shielding
  - Pulse tube efficiency testing
  - Holography for in-lab focus measurements (and possibly beam characterization)



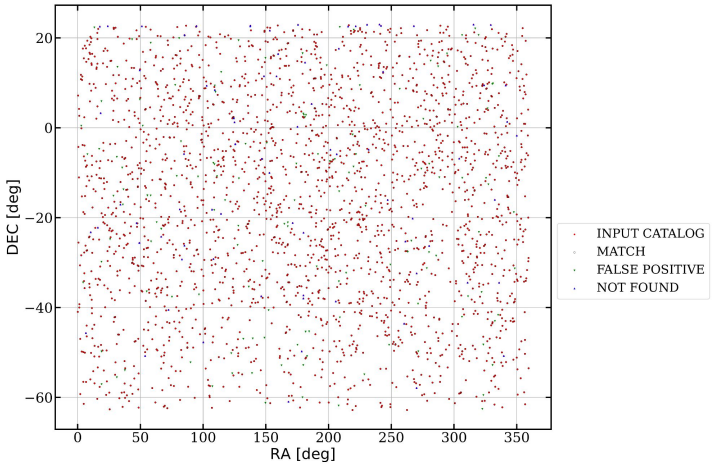


tSZ Cluster Finder Challenge

Erik Rosenberg – PDRA, University of Manchester
With Íñigo Zubeldia, Boris Bolliet, Jean-Baptiste Melin, Sigurd Næss, Matt Hilton, and Jens Chluba

Goal: Rigorously test and compare cluster finding codes on SO-like simulations

- Nemo (M Hilton, ACT)
- MMF3 (JB Melin, *Planck*)
- Sauron (S Næss)
- SZiFi (Í Zubeldia)

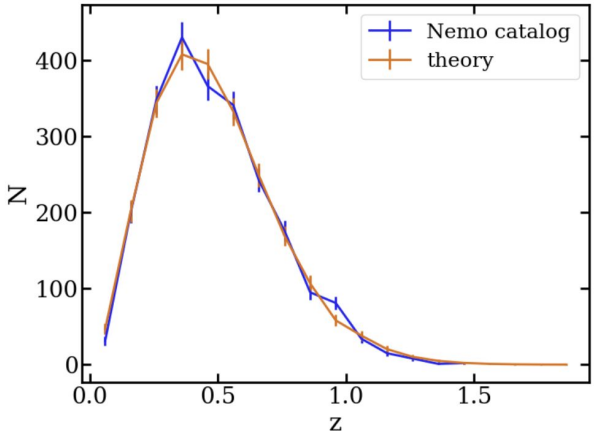


Status

- Made CMB + white noise + cluster maps at 6 frequencies, 26,400 deg^2 (f_{sky} = 0.64)
- Recovered cluster catalogues for 3/4 finders

Next Steps

- Repeat with more complex simulations (e.g. correlated noise, blended clusters)

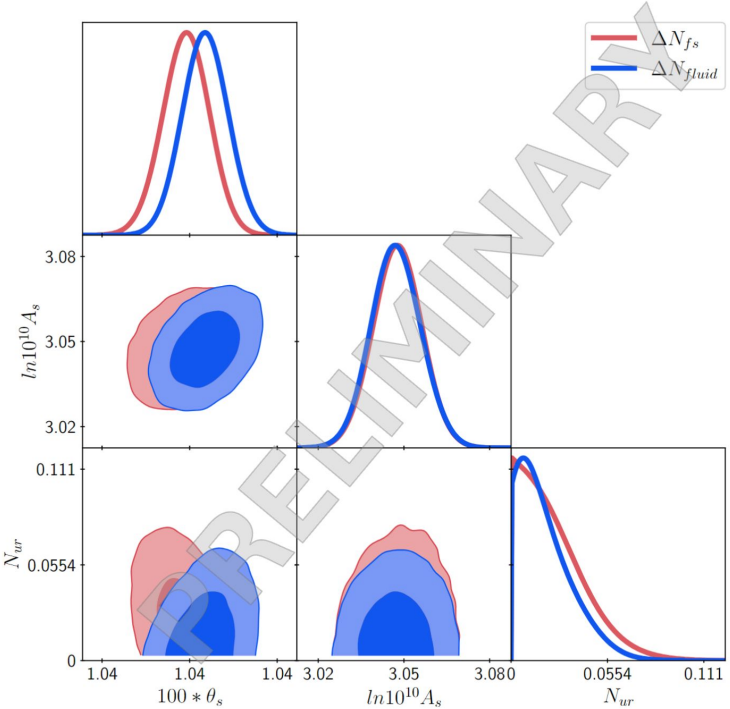


Forecasting Dark Radiation with CMB-S4

Murali Saravanan, 4th year PhD Student at University of Washington
work with Marilena Loverde, to appear soon

- BSM physics tend to include potential light thermal relics that could be free-streaming (like SM neutrinos) or fluid-like (non-free-streaming) if sufficient self-interaction
  - Leads to differences in the amplitude and peak locations in damping tail
- **Goal:** Understand parameter degeneracy in models with additional radiation density assuming a baseline amount of Neff = 3.044

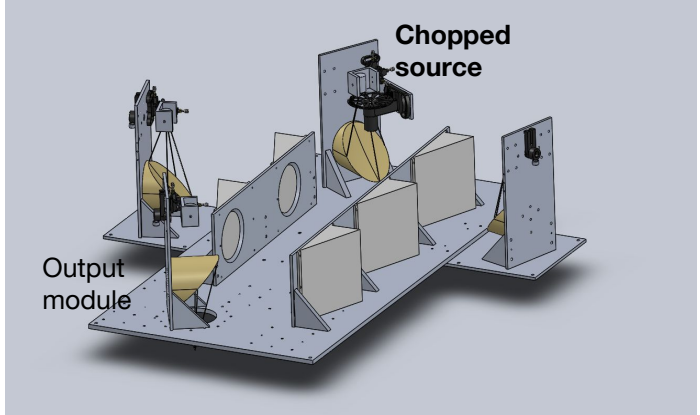
	$\Delta N_{\rm fs}$	$\Delta N_{\rm fld}$	$\sigma\left(Y_{\rm He}\right)$
Planck 2018 (BBN YHe)	< 0.27	< 0.31	
Planck 2018 (Free YHe)	< 0.54	< 0.58	0.015
CMB-S4 (BBN YHe)	< 0.06	< 0.05	
CMB-S4 (Free YHe)	< 0.19	< 0.17	4.3×10^{-4}

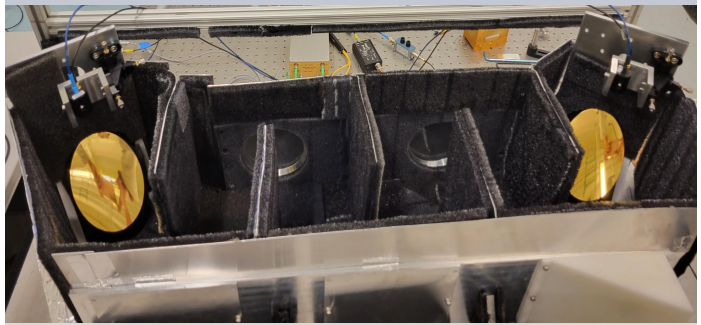


msarav@uw.edu

Frequency-selectable Laser Spectrometer (FLS)

Lauren Saunders (she/her), Postdoc at Fermilab





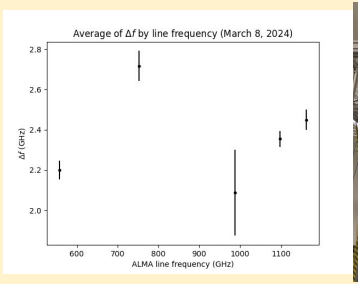
Top: Drawing of the FLS assembly. The laser source is the TeraScan 1550 system from Toptica photonics. 5 nylon prisms attenuate the signal power by ~95% each.
Bottom: Full FLS assembly
Images by Shreya Sutariya

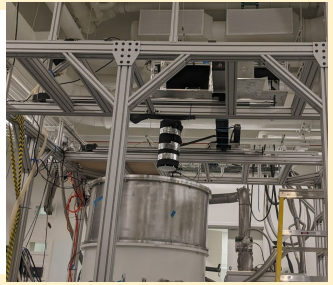
We aim to use the FLS for detector bandpass calibration.

- Initial prototype developed and tested by Shreya Sutariya (UChicago)
- Laser frequency tuning is higher-resolution than an FTS.
- Power attenuation with prisms should improve band edge determination over FTS.
- **Improved bandpass calibration over FTS capabilities is needed for CMB-S4**

Current status:

- Studying frequency calibration of the FLS laser
- Working toward improvements to the system





Upcoming tests with the SPT SLIM receiver in the works for this spring/summer!

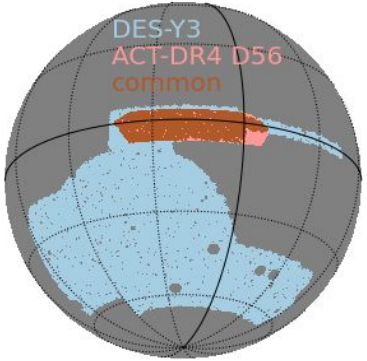
Shabbir Shaikh (Postdoc at ASU, sshaik14@asu.edu)

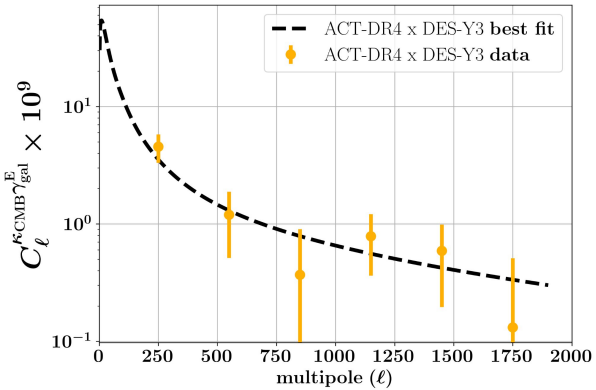
NNRAS arxiv:2309.04412

Constraints on S_8 using cross-correlations

ACT DR4 CMB Lensing x DES Y3 Cosmic Shear

SS, Ian Harrison, Alex van Engelen, Gabriela Marques, ACT and DES Collab.



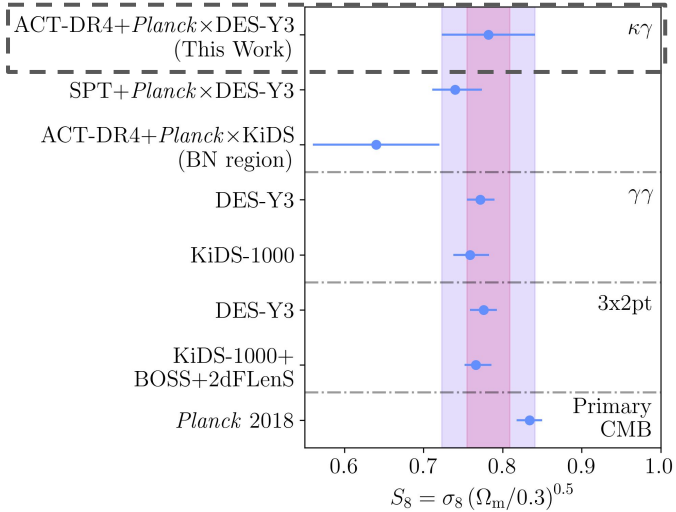


Marginalise:
Photo-z uncertainty, multiplicative shear bias,
Intrinsic Alignment

ACT DR4 x DES Y3 constraints:

$$S_8 \equiv \sigma_8(\Omega_{\rm m}/0.3)^{0.5} = 0.782 \pm 0.059$$

Error forecast with ACT DR6 lensing map



Center for Astrophysical Surveys
NATIONAL CENTER FOR SUPERCOMPUTING APPLICATIONS | NCSA

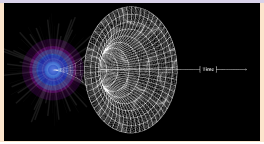
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

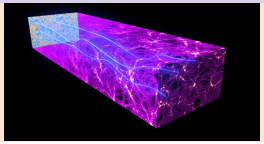
New Frontiers with Future CMB Experiments

Cynthia Trendafilova (they/them, she/her)

Improving Constraints on Inflation with CMB Delensing

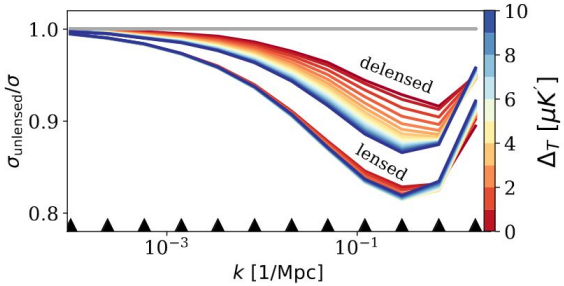
arXiv:2312.02954 - **CT**, Selim C. Hotinli, Joel Meyers



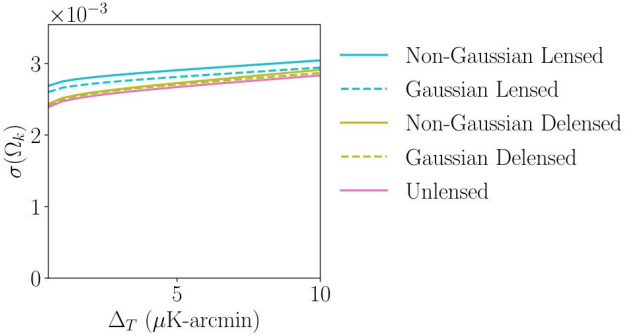


The inflationary period is theorized to have taken place in the early universe at very high energies, inaccessible to terrestrial tests. We can use observations of the CMB to gain insight into the dynamics of inflation:

- Primordial power spectrum $P_\zeta(k)$
- Single-field consistency condition
- Spatial curvature
- Isocurvature



- In many cases, delensing can recover almost all of the constraining power contained in unlensed spectra. This is especially valuable when error bars are not expected to improve much with decreasing experimental noise.



FisherLens

https://github.com/selimhotinli/class_delens/

https://github.com/ctrendafilova/FisherLens/

CMB-S4

- Light relics forecasts and design validation
- Studies of high-\ell systematics
- DRAFT forecasting tool

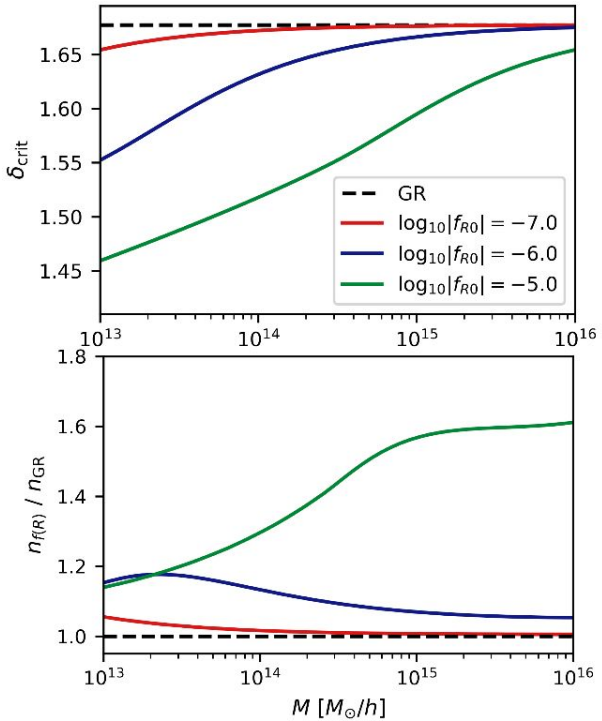
SOUTH POLE TELESCOPE

- Studies of BSM extensions
- Likelihoods & parameter estimation

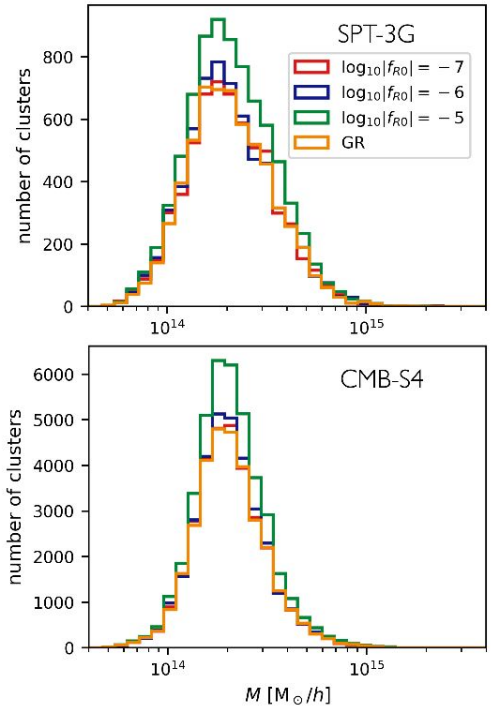
Sophie Vogt

f(R) gravity forecast from CMB-S4 and SPT-3G cluster abundance

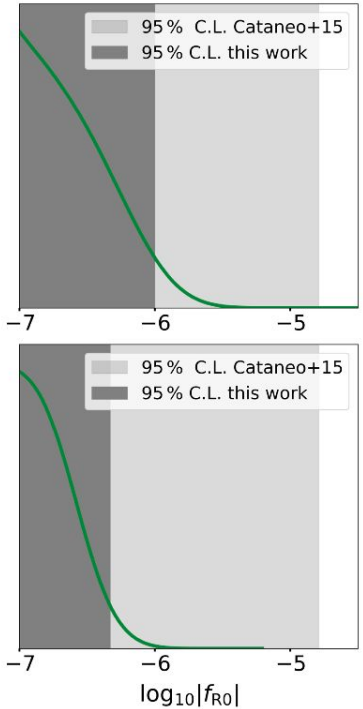
$f(R)$-gravity: scale dependent growth



Mock catalogues for SPT-3GxngWL and CMB-S4xngWL



Strong constraints from future clusterxWL data



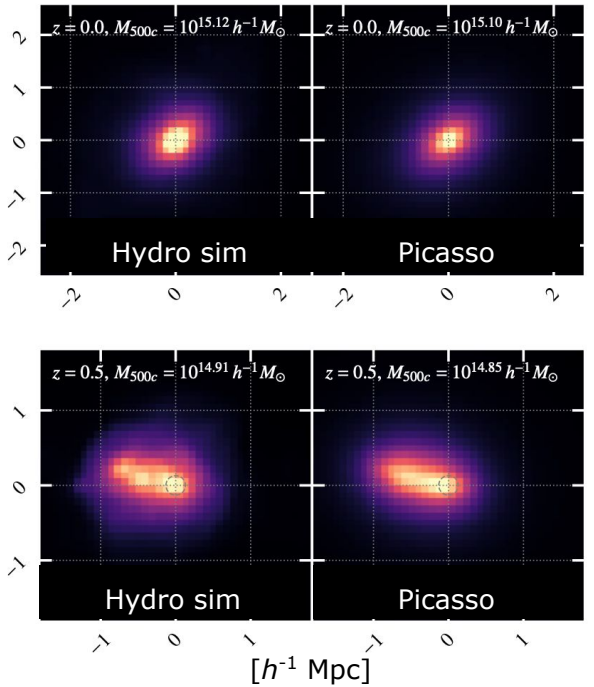
Contact: s.vogt@physik.lmu.de

Vogt+2024: arXiv:2401.09959

Picasso: tSZ sky maps from ANL sims

Florian Kéruzoré, Argonne National Laboratory

- Picasso: train a model to "paint" intracluster gas on halos in gravity-only (G-O) simulations
  - Exploiting synergy between hydro/G-O sim pairs with same initial conditions
  - First iteration using Ostriker+05 model
    (Kéruzoré+23; arXiv:2306.13807)
  - New developments using more flexible, AI-based gas model
- tSZ maps for ANL G-O sims expected within ~months:
  - Last Journey (5 Gpc, m_{dm}= 4 10^9 $M_\odot$) *(Heitmann+21)*
  - Outer Rim (4 Gpc, m_{dm}= 2.6 10^9 $M_\odot$, LSST DC2) *(Heitmann+19)*
- Interested in integrating to CMB-S4 Data Challenges!



(Kéruzoré+23; arXiv:2306.13807)

S4 Ombudspersons 2024-26

(fireslide by Bruce Partridge)

Erminia Calabrese (Cardiff) calabresee@cardiff.ac.uk [note double ee at end]

Bruce Partridge (Haverford College) bpartrid@haverford.edu +1-610-715-0212(cell)

For specific Ombuds issues, use ombudspeople@cmb-s4.org

Role:

- completely confidential advice and guidance
- impartial, non-judgmental advice and guidance
- informal; entirely independent of S4 structures and procedures
- but can help to decide on, evaluate and manage formal procedures
- mediation, if desired
- note and report to ET systemic concerns

Scope:

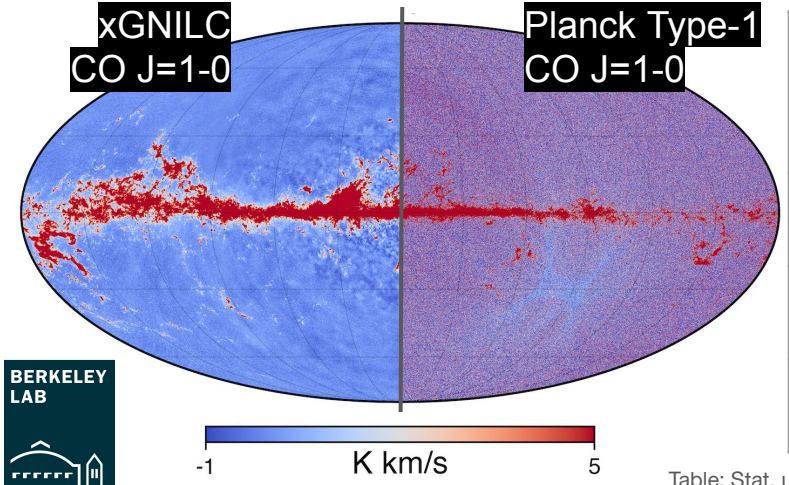
- personal conflicts
- harassment
- issues of proper recognition (e.g. authorship)
- work load issues
- other issues (including yours)

Planck CO revisited

arXiv:2312.07816

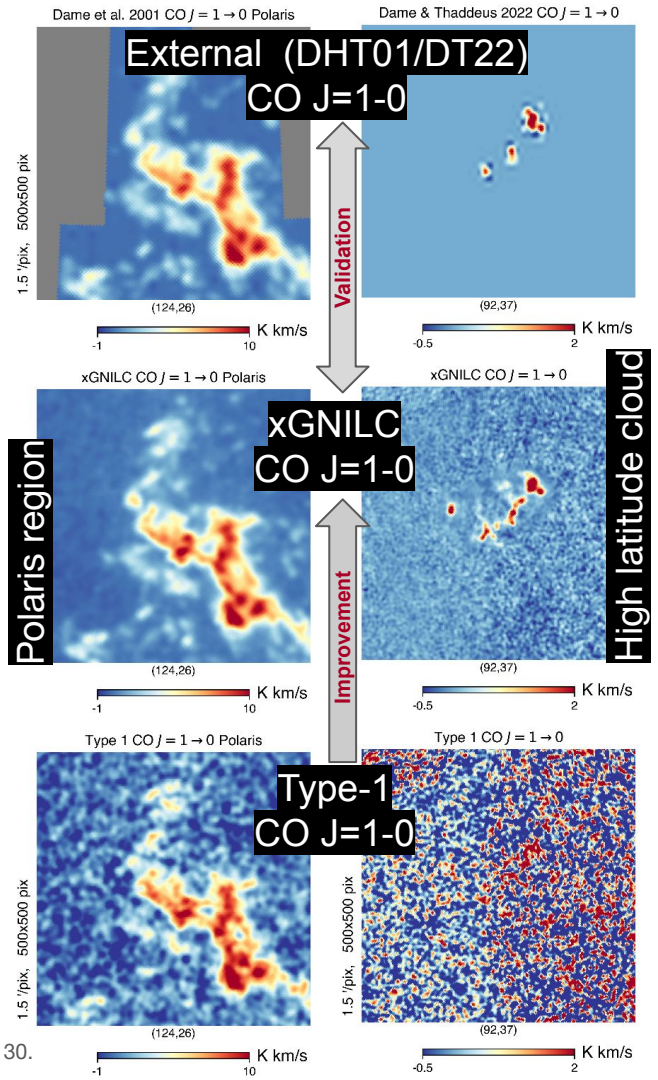
Shamik Ghosh (LBNL), Mathieu Remazeilles and Jacques Delabrouille

- New maps of Galactic CO line emissions produced by reprocessing Planck Type-1 and Type-2 CO data products with an extended GNILC pipeline (xGNILC).
- These new maps have much lower noise compared to any existing Planck CO data products. They are also well characterized.
- The **Planck Revisited** CO line emission data products are publicly available from: portal.nersc.gov/project/cmb/Planck_Revisited/co/



Line	$\sigma_{\text{Type-1}}$ (K km/s)	σ_{xGNILC} (K km/s)
J=1-0	4.3	0.24
J=2-1	0.91	0.13
J=3-2	0.91	0.053

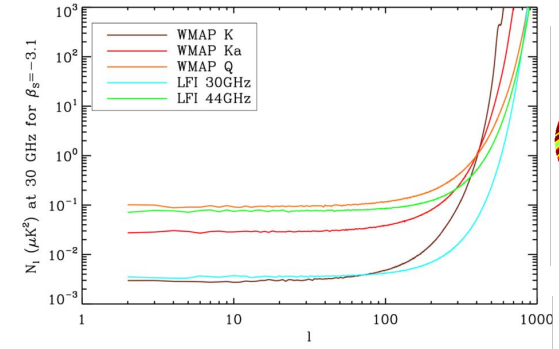
Table: Stat. uncertainty at 10' resolution for region above |b| > 30.



Planck Synchrotron Q and U revisited

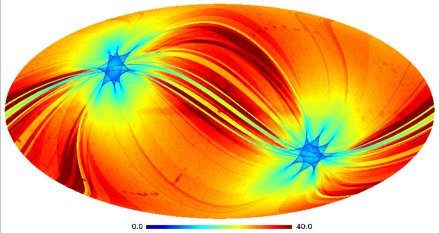
Jacques Delabrouille (Centre Pierre Binétruy and LBNL)

- New full-sky maps of synchrotron polarization are produced by near-optimal combination of WMAP and Planck observations.
- Low noise is obtained using scale-dependent, pixel-dependent, and polarization-dependent linear combinations of the observations. Maps are well characterized : 1 degree beam ; Monte Carlo errors.
- The *Planck Revisited* data products are publicly available from: https://portal.nersc.gov/project/cmb/Planck_Revisited/

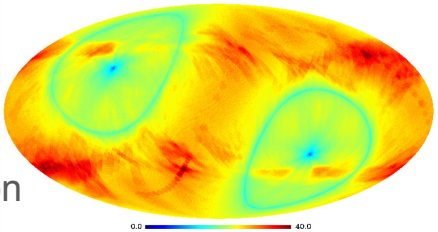


Noise levels depend on
- Scale
- Sky pixel
- Polar orientation

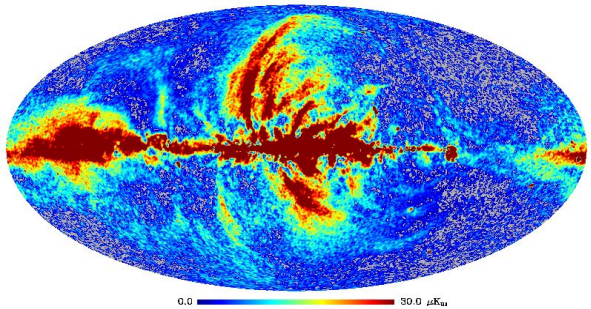
Planck 30GHz noise level



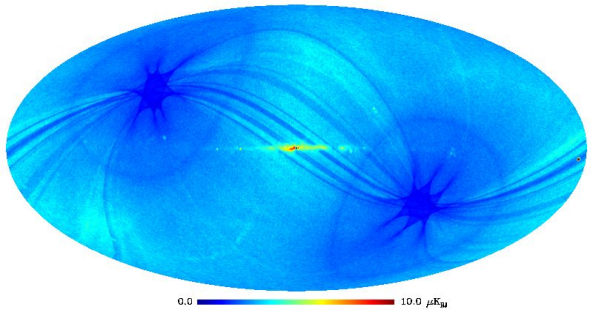
WMAP K noise level



Synchrotron Polarised Intensity at 30 GHz



Synchrotron polarisation amplitude total error



Uncertainties are fully described with a set of simulated *additive* and *multiplicative* error maps.

Publication submitted to A&A (on arXiv soon).