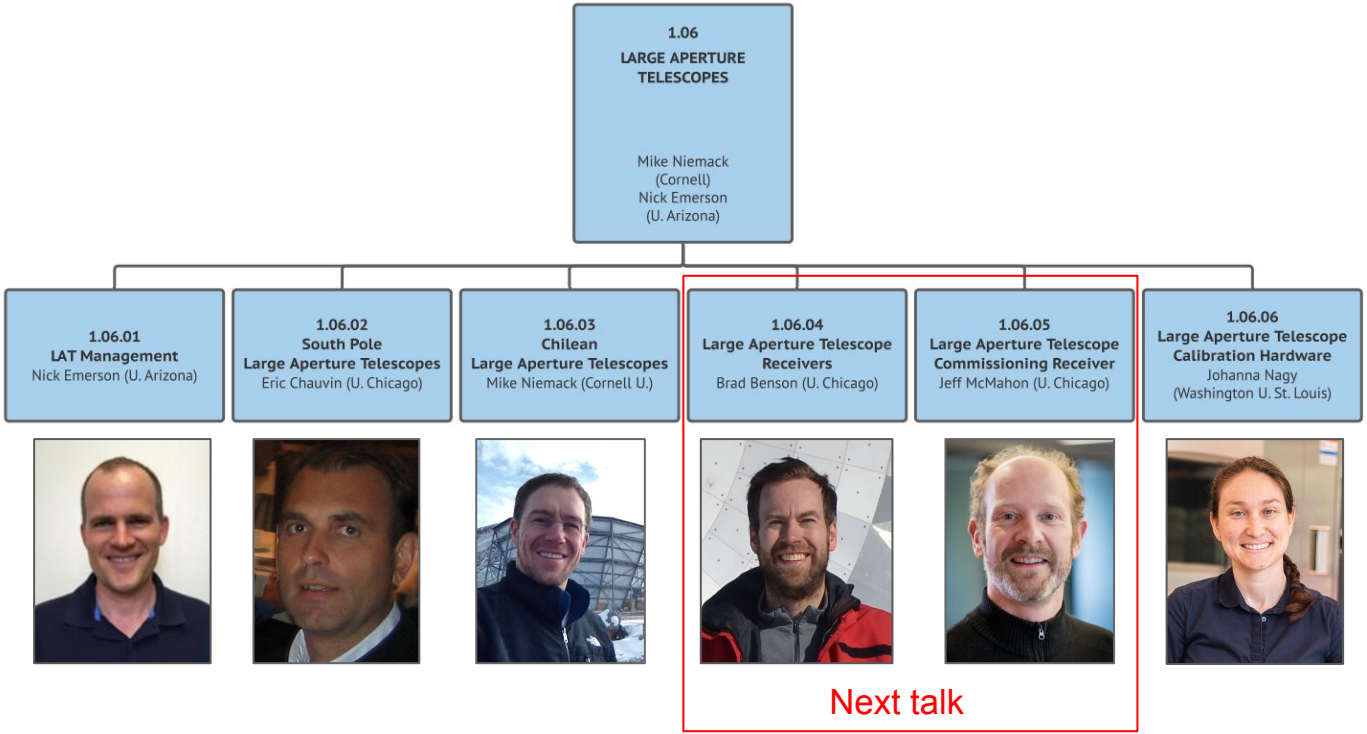
Large Aperture Telescopes (LAT) Status - WBS 1.06

Mike Niemack

CMB-S4 Collaboration Meeting
April 3-6, 2023

LAT Team



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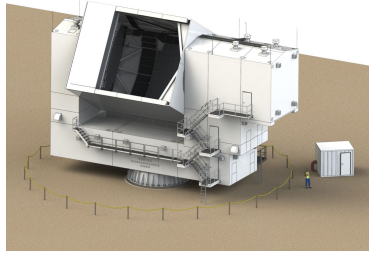
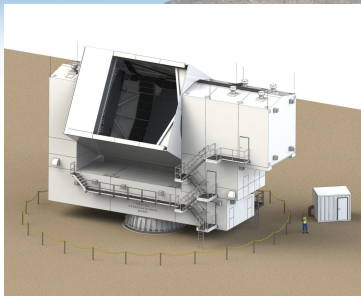
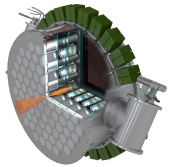
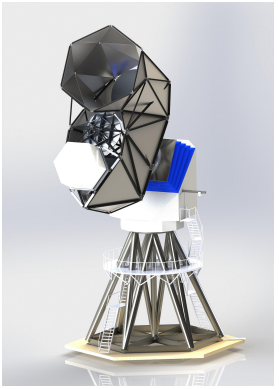
LAT Scope - Why 2 Designs?

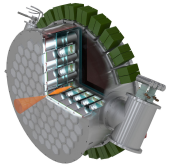
- Chile - Legacy Survey (> 50% sky)
  - Two 6m aperture telescopes in Chile (CHLAT) to achieve **1.4' resolution at 150 GHz at required sensitivity**
  - Two receivers to illuminate detectors on those telescopes
  - **Based on mature design for CCAT-prime project and Simons Observatory LATs being built in Chile**
- South Pole - Delensing B-mode Survey (~3% sky)
  - 5m aperture telescope at South Pole (SPLAT or SPTMA) to achieve **1.6' resolution at 150 GHz**
  - Receiver to illuminate detectors on that telescope
  - **Critical Delensing B-mode Survey features:**
    - **Survey uniformity enabled by TMA optics**
    - **Gapless mirrors to prevent B-mode contamination**
    - **Boresight rotation to verify polarization systematics**
- Commissioning Receivers
- Calibration Hardware

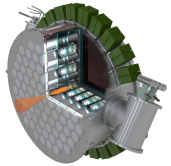










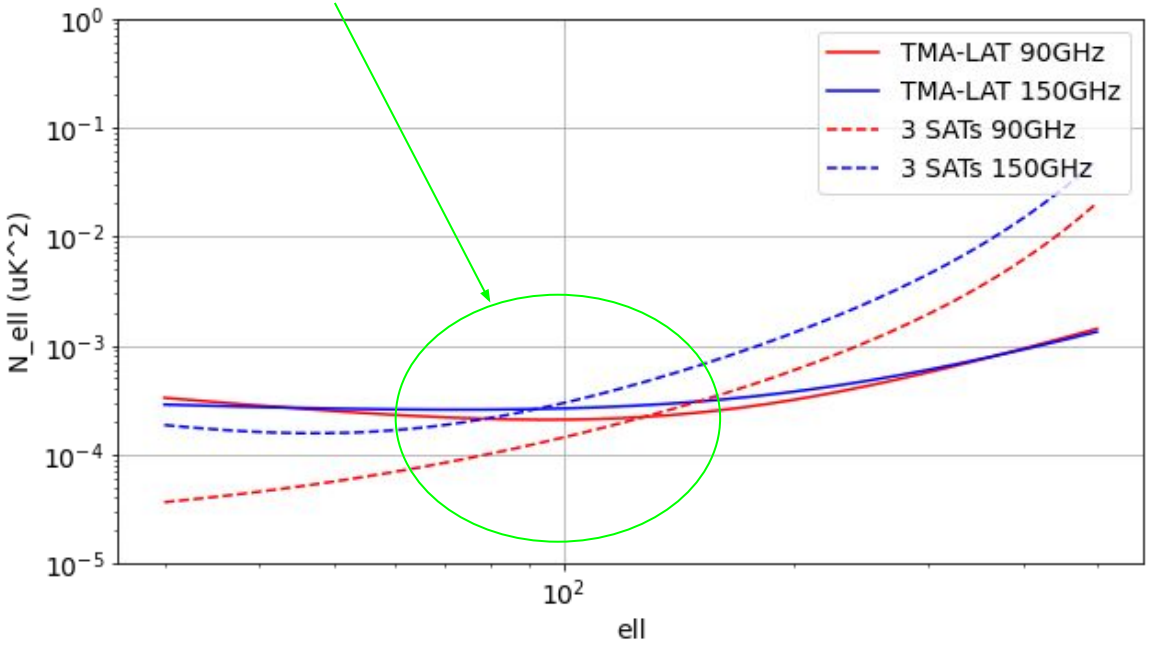


LAT Overview in Gallardo et al. 2022 SPIE Proceedings

LAT Analysis of Alternatives Considerations

B-mode Science: *SPLAT sensitivity at low-ell is significant*

For SPLAT (TMA design) and 3-SATs (Alternative 1),
the N_ells cross at ell ~120 (~90) for 90 (150) GHz, respectively.

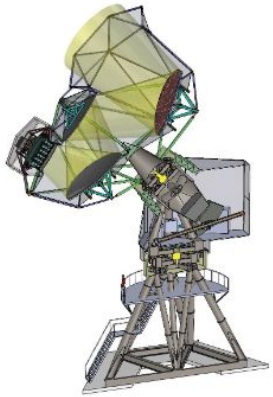


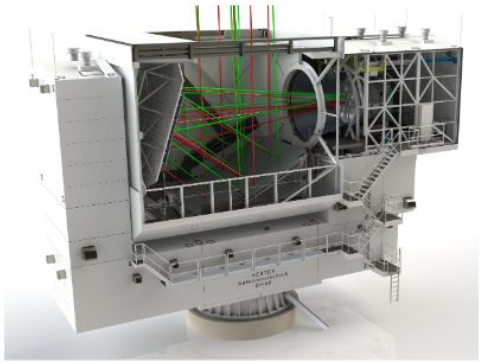
More details in
LAT AoA slides
=> No significant LAT changes in AoA recommendations

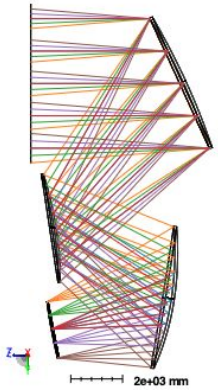
SPLAT should contribute to low-ell BB in complementary ways to SP SATs.

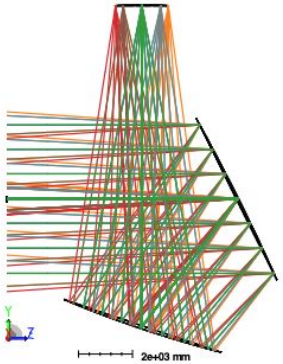
Technical Progress - Simons Observatory CHLAT test build!

Technical Progress - Summary of LAT Designs published

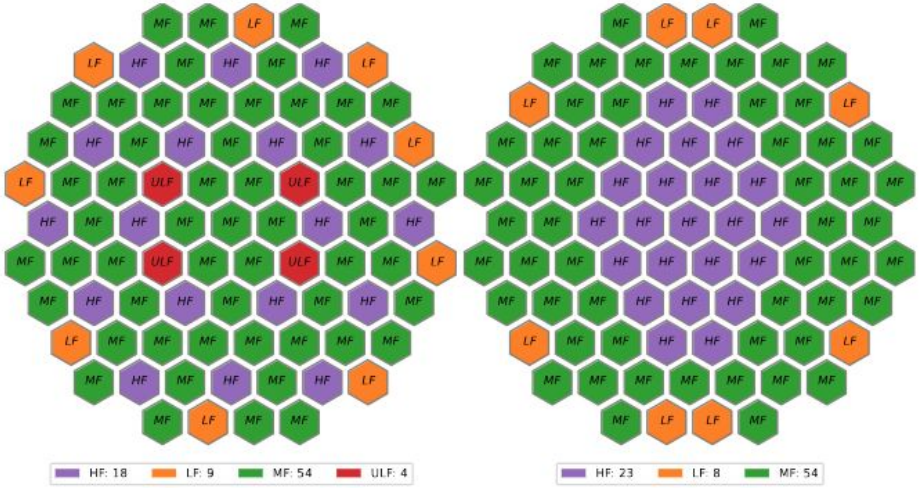








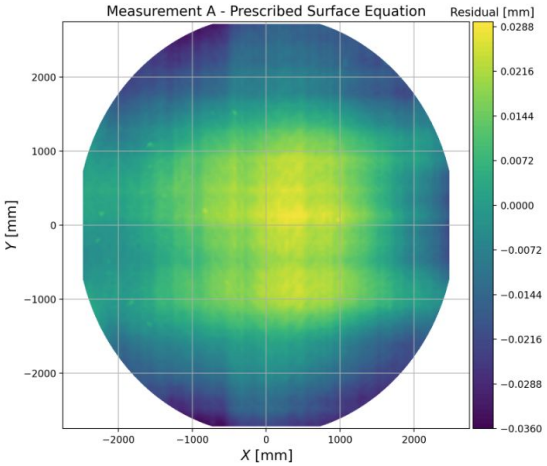
[Gallardo et al. 2022 SPIE Proceedings]

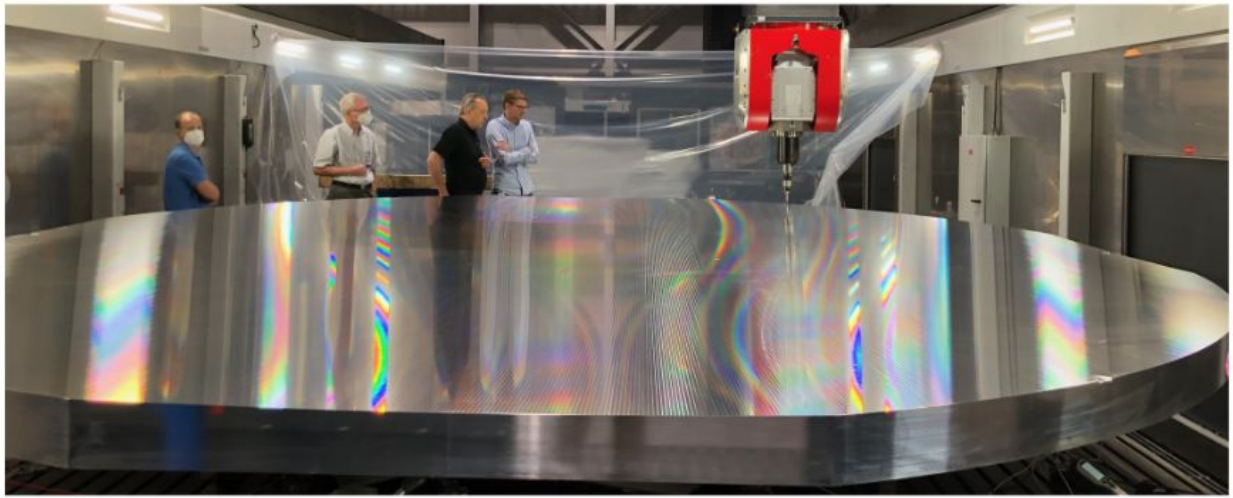


- Comparison of Three Mirror Anastigmat and Crossed-Dragone optical performance
- LATR frequency distribution to account for different survey strategies/sites and optics

Technical Progress - 5-meter aperture gapless mirror fabricated

- Preliminary measurements better than predicted!
- **Natoli et al** Publication in review at Applied Optics
- Final measurements this year in Chicago

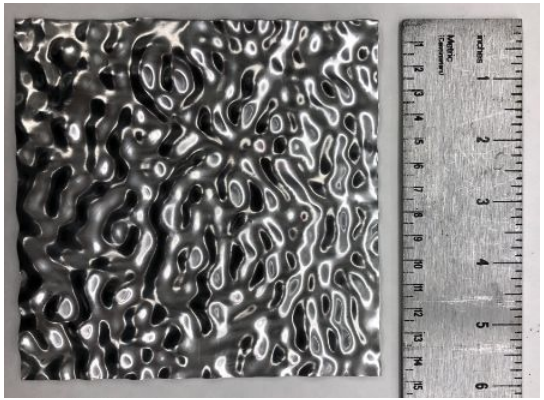




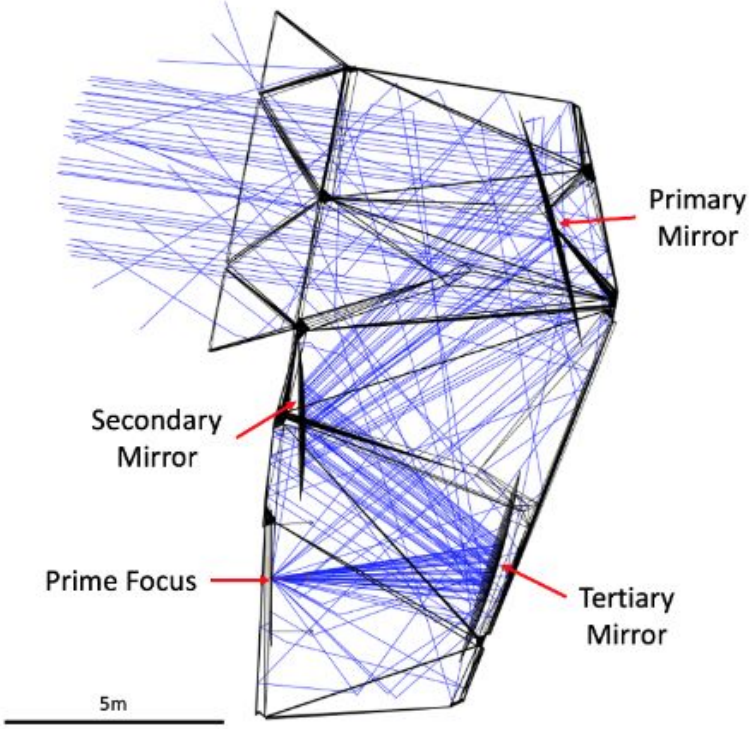
Type	RMS [μm]
Manufacturing error	14.1
Repeatability	1.7
Systematic error	4.0
Calibration error	6.0
Total error	**17.4**

Technical Progress - TMA sidelobe analyses and baffling

- Analysis of sidelobes due to scattering from structural supports and baffles
- Comparison of different baffle finishes (absorbing, reflective, scattering)
- Scattering surfaces appear to be a promising approach for suppressing ground pickup
- Prototype scattering surface could be implemented on a large scale for LATs



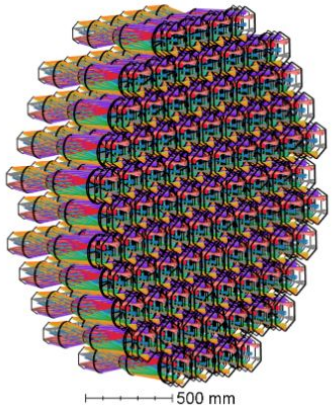
[Gullett et al. 2023 arXiv:2302.10971]

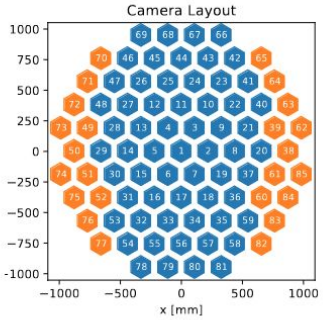


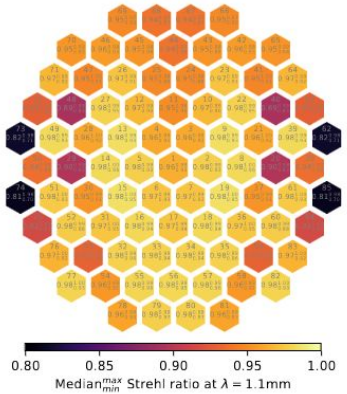
Technical Progress - TMA and receiver optics optimization

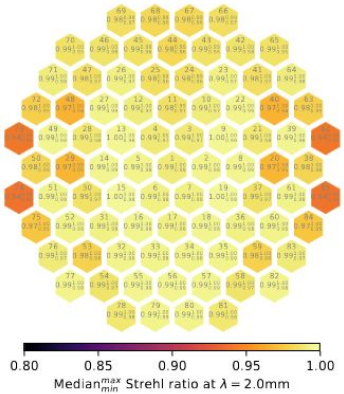
- Substantial progress on TMA and receiver optics optimization and analysis
  - Gravitational & thermal deformation of mirrors
  - Optimization of all 85 cameras
  - Tolerancing analyses
  - Gallardo et al. 2023 *now* in collaboration review

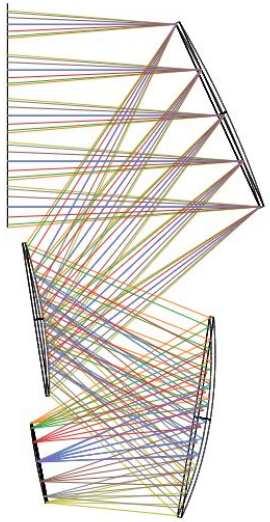
Deformation	Min Strehl [-]	Max Strehl [-]	Defocus [mm]
Nominal	0.96	0.99	0
Thermal	0.96	0.99	-9.69
Gravity	0.94	0.99	-1.36
Thermal + Grav.	0.92	0.99	-10.24

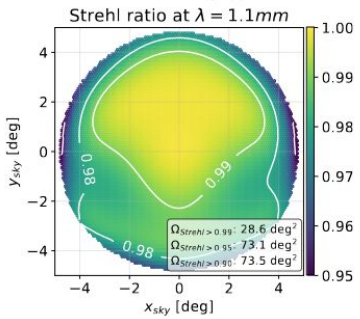












Near term plans

- Continued focus on LATR design (see next talk)
- Pursuing NSF funding for continued LAT development
- Continued focus on requirements
  - Significant progress made recently on LATR requirements, but more to be done
  - Reviewing LAT requirements again soon

Summary

- Great progress has been made on “CHLAT prototypes” by SO and CCAT-prime
- AoA strongly supports development of SPLAT
- Design and prototyping progress described in multiple publications
  - LAT overview - **Gallardo et al. 2022 SPIE Proceedings**
  - Gapless mirror prototype - **Natoli et al. in review at Applied Optics**
  - TMA sidelobes and baffling prototype - **Gullett et al. 2023 arXiv:2302.10971**
  - SPLAT TMA and LATR Optics design - **Gallardo et al. 2023 in collaboration review**