CMB-S4 Chile & South Pole Integration & Commissioning Plan for Large Aperture Telescope System

CMBS4-doc-730

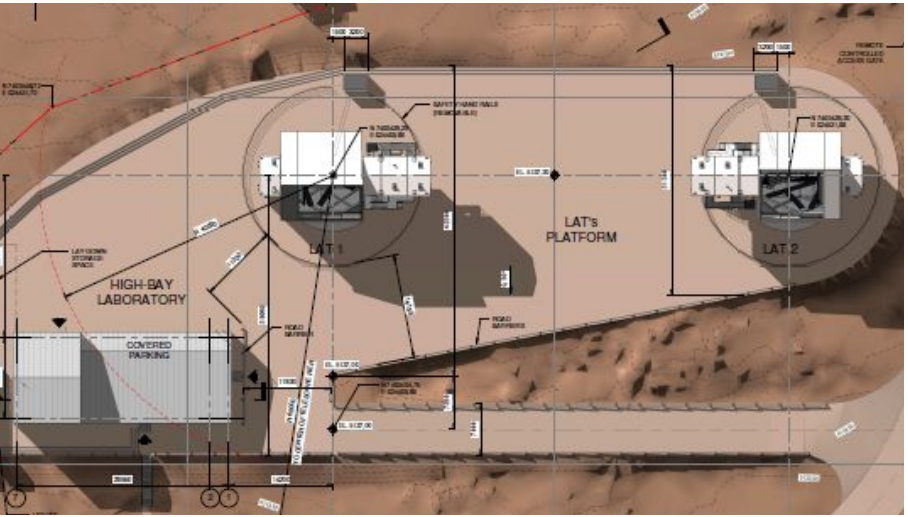
May 12, 2022

Tyler Natoli

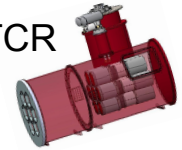
CMB-S4

Quick Chile LAT Review

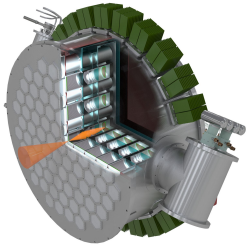
- Two LATs, 6m Cross-Dragone telescope copies
- Two LATR copies
  - 85 optics tubes each
- One LATCR
- High Bay for LATR assembly



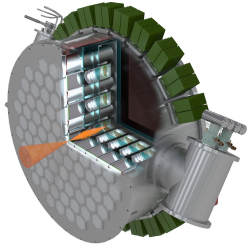
LATCR



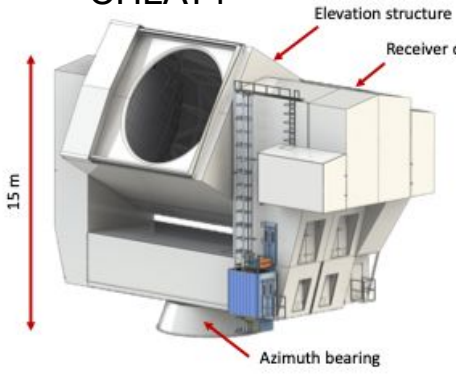
LATR1



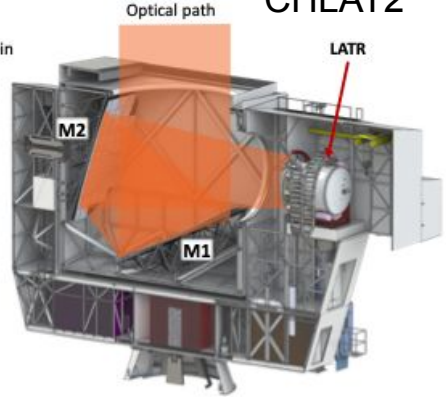
LATR2



CHLAT1

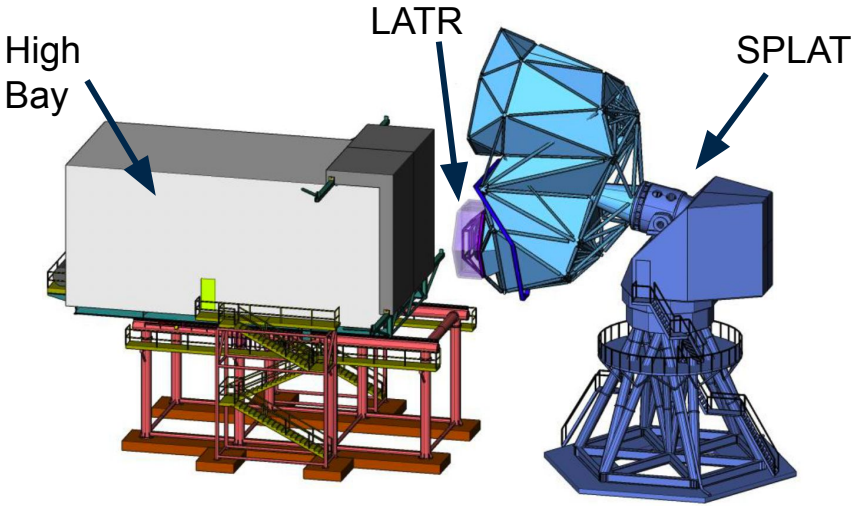


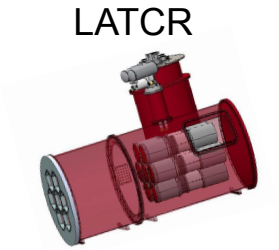
CHLAT2

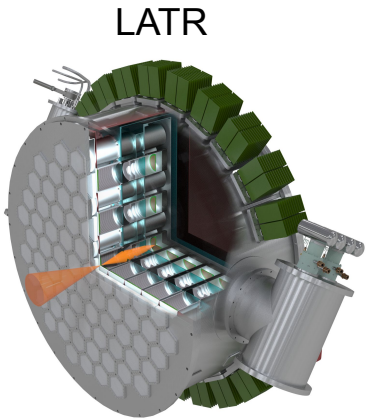


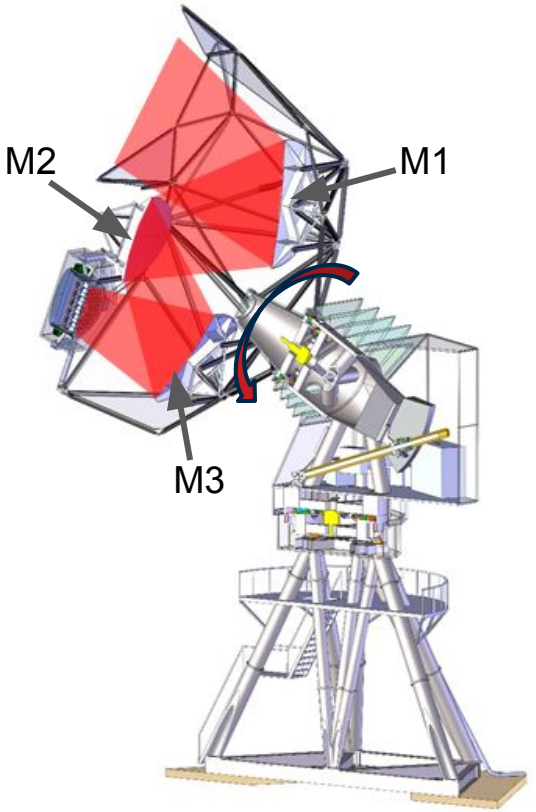
Quick LAT & High Bay Overview

- Three Mirror Anastigmat (TMA) design
- Full boresight rotation
- ~5m monolithic (gapless) mirrors
- LATR with 85 optics tubes
- LATCR with 4-7 populated optics tubes









Organization of Document

- Prerequisites
  - LAT Test Builds
  - LATCR North American Testing
    - Wafer/SQUID/Readout performance reports
  - LATR North American Testing
    - Wafer/SQUID/Readout performance reports
  - Site High Bay
  - DM / DAQ
- LATCR I&C
- LATR I&C
  - Assembly & Cooldown
  - Ground Commissioning
  - Integrated Commissioning
    - Extended Commissioning
- Task-Based Schedule

Produced in correlation with LAT L2 Group

Based on generation 3 experience, projected using current LAT/LATR designs

Written for a single LATR, for Chile the same procedure will happen twice

Prerequisites

- Describe tests done with the LAT/LATR prior to on site LATR I&C
- Describe the state of the LAT, DM, DAQ prior to LATR I&C

SAMPLE PREREQUISITE

3.3 North American LATR Verification

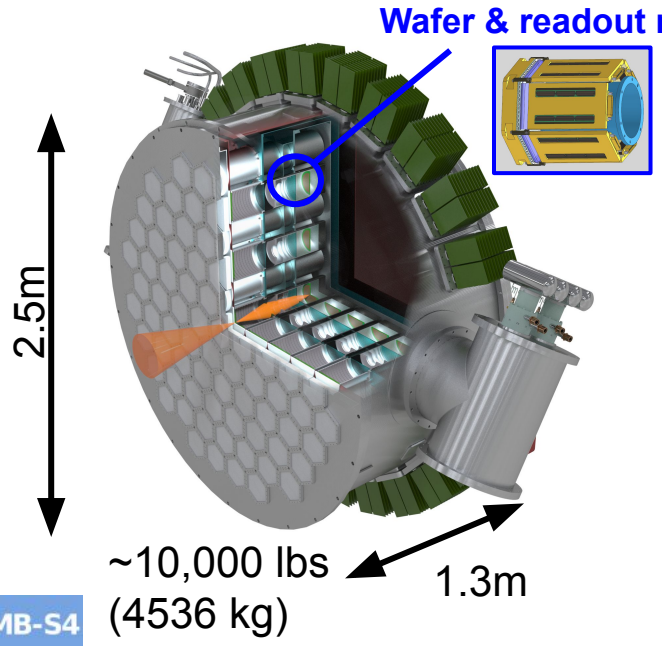
3.3.3 Final North American Verification

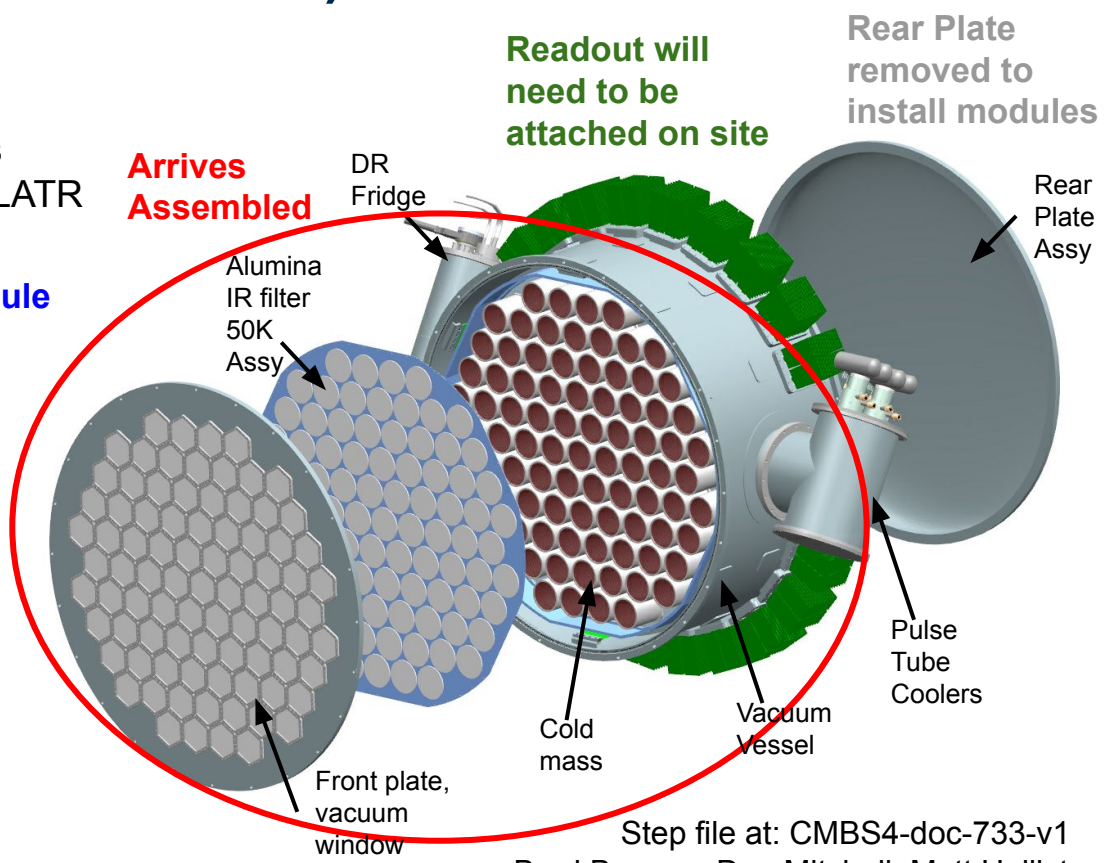
- A full report of running the exact system being sent to Site
  - Cooling curves from 300 K to base temperature (100 mK for the focal plane)
  - All SQUIDs & detectors tuned and operated using the calibration TES transition
- A full accounting of every detector/SQUID
  - Did it tune?
  - Was it operated?
  - Did it successfully see a chopped thermal source?
- Data from each thermometer that will be in the LATR on Site during the final North American cooldown from 300 K down to base temperature (100 mK for the focal plane) and back up to 300 K

LATR Assembly (Conceptual Model)

Site Assembly Procedure

- Remove rear plate and install modules
  - Optics tubes will ship inside the LATR
- Install and connect all readout





Step file at: CMBS4-doc-733-v1

Brad Benson, Don Mitchell, Matt Hollister

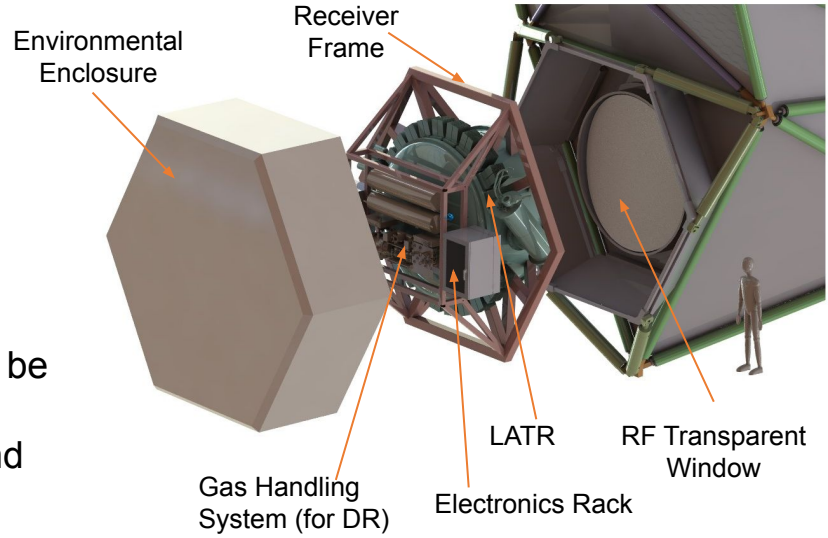
LATR Commissioning

Split into two parts: (following CMBS4-doc-730:South Pole Commissioning Plan for Large-Aperture Telescope)

- **Ground Commissioning** (in the high bay)
  - Test things that would require the LATR to be opened up
    - Vacuum pressure, thermal issues, observing band shifts, etc.
  - Confirm the LATR performance matches North American results for yield and temperatures (RISK-371)

--- Install LATR on LAT —

- **Integrated Commissioning** (On-Sky)
  - Reconfirm ground performance (yield, thermal, vacuum)
  - Test mechanical and optical systems that can only be probed with the LAT integrated
    - Full optical system, mechanical vibrations and heating, etc.



Example LATR I&C Test 1

All quantitative values are within these requirements

Integrated Commissioning

6.3.4 Optics

6.3.4.1 Pointing

Goal: Verify that the Absolute pointing error during CMB observation scan with the LATR installed meets the set requirement.

Relevant Requirements:

- SPSITE-IC-0070 - Integrated Telescope Pointing
- LAT-SPLAT-MNT-009 - Scan pointing knowledge
- LAT-SPLAT-MNT-044 - Scan Following Error
- LAT-CHLAT-MNT-009 - Scan following error
- LAT-CHLAT-MNT-044 - Scan pointing knowledge

Included Tests:

- Scan over bright quasars spread throughout all potential observation azimuths and elevations.

Example LATR I&C Test 2

A lot of the relevant requirements are from LAT & Sites,
- but many from Detectors, Modules, & L1 requirements also

Most of the “Included tests” will eventually have longer procedure documentation outside of this I&C document

Integrated Commissioning

6.3.2.2 Calibrator Observations

Goal: Verify that the Calibrator is fully functional and characterize the amount and quality of the response of every detector to the Calibrator. Characterize the time constant of every detector with the Calibrator.

The Calibrator is a chopped thermal source that can be seen by all detectors. For the SPLAT the calibrator is behind a 1 inch hole in the primary mirror. Every detector must register a high signal-to-noise response to the Calibrator for the relative detector calibration to function properly. These tests ensure that both the Calibrator and the detectors are functioning within the specified ranges.

Relevant Requirements:

- LATCH-004 - Time constant and gain calibrator
- LATULF-0060 - Time Constant in transition
- LATLF-0060 - Time Constant in transition
- LATMF-0060 - Time Constant in transition
- LATHF-0060 - Time Constant in transition

Included Tests:

- There will be “Calibrator Stare” observations taken with the calibrator chopping at a fixed speed at a variety of LAT elevation pointings to assess the linearity of detectors over various elevation ranges.
- There will be “Calibrator Sweep” observations taken where the LAT will maintain a constant elevation while the frequency of the calibrator is stepped to evaluate the time constants of the detectors.

Summary

- **Purpose**:
  - Describe the state of the LAT System prior to when on-site LATR I&C begins
  - Describe the I&C process for LATR:
    - Assembly
    - Ground Commissioning
    - Integrated Commissioning
  - Describe the detailed task-based schedule for the I&C process
- **Scope**:
  - The described LATR I&C process is for both the Chile and South Pole Sites. Major site specific differences in the I&C process are pointed out.
- **Status**:
  - This documented version of the LATR I&C process has been developed over the last year and includes the agreed upon I&C process by the LAT (& LATR), South Pole, and Chile L2 groups.
  - The plan in this document reflects most current LATR/LAT designs and Site plans

The LAT System I&C document is very mature and is on track for approval by the project office