The CCAT Software System

Tim Jenness, Adam Brazier, Kevin Edwards, Gaelen Marsden, Thomas Nikola, Volker Ossenkopf, Steve Padin, Jack Sayers, Reinhold Schaaf, Martin Shepherd

CCAT will be a 25-meter telescope for submillimeter astronomy located at 5600 m altitude on Cerro Chajnantor in northern Chile. CCAT will combine high sensitivity, a wide field of view, and a broad wavelength range (0.35 to 2.1mm) to provide an unprecedented capability for deep, large-area multicolor submillimeter surveys. It is planned to have a suite of instruments including large format KID bolometer cameras, a large format heterodyne array and a KID-based direct detection multi-object spectrometer. The remote location drives a desire for fully autonomous observing coupled with data reduction pipelines and fast feedback to principal investigators.

CCAT SOFTWARE

The key drivers for the software design are:

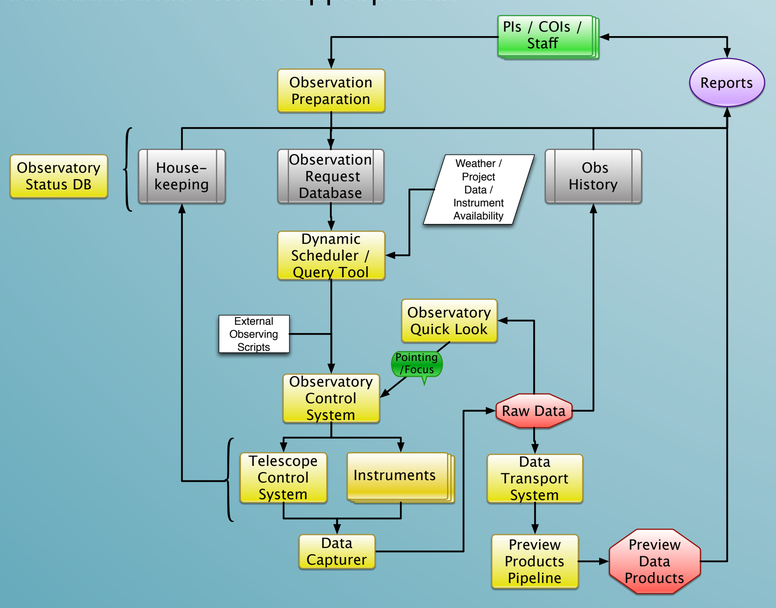
Instrument Data Rates: Next generation sub-millimeter bolometer cameras with 40,000 to 65,000 bolometers and reading out at 3 kHz can generate data at a peak rate of ~ 7 Gbps and generate 30 to 60 TB per day.

Remote Location: The observatory is located on Cerro Chajnantor above the ALMA plateau at an altitude of 5600m. Given the remoteness of the site, the Observatory is designed to operate autonomously to the extent possible and support remote control from the base facility in San Pedro and/or partner sites.

System Components

Observation Preparation: CCAT is exploring the feasibility of building onto existing submillimeter observation preparation tools such as the ALMA-OT, the JCMT-OT and Herschel-Spot. OT support of CCAT's planned multi-object spectrograph instrument will require adding new capability to whichever OT solution is chosen.

Dynamic Scheduler: CCAT is a flexibly-scheduled telescope and will use a dynamic scheduler to determine what should be observed next. The OT will populate the Observation Request Database with Minimum Schedulable Blocks (MSBs). The Scheduler will have a manual mode allowing an observer to query the system but the aim is for the scheduler to continually monitor the telescope environment and observing queue and ensure that the best MSB for the current conditions is always observed and the telescope is never idle. One complication in the sub-millimeter is the paucity of flux calibrators in the sub-millimeter sky. This sometimes requires that the flux calibrator is observed some time after the observation that requires it. The scheduler must keep track of the calibrations requirements and schedule them when appropriate.



Observations are prepared and stored by the OT and queried by the scheduler. The OCS executes observations and the Data Capturer collates the resulting data. The files are then transferred to the base facility and preview products generated for review by the PI.

Observation Execution: The Observatory Control System (OCS) provides command and control and monitoring of all observatory systems relating to observing. It has an integrated observing queue and uses a lightweight scripting execution engine with guaranteed latencies. The OCS is influenced by experience from earlier telescopes such as CBI, QUIET and the OVRO 40m.

Data Capturer: The Data Capturer (DC) takes the output from the instruments, telescope control system and other systems and collates them into output data files. The large data rates, and the need to support simultaneous acquisition by multiple instruments, led us to a distributed approach where each subsystem writes its own data files to disk and the DC writes a small header file with hierarchical linkage to the individual files.

Data Transport: There will only be limited disk space at the summit and data will immediately be transferred to the Base Facility over a fiber connection.

Preview Products Pipeline: Raw data will be shipped to the CCAT Data Archive on disks as network bandwidth is prohibitive. To provide data quality assessment a pipeline will run at the Base Facility to generate usable products suitable for remote observation quality assessment.

Survey Pipeline: Processing of survey data will be coordinated through the CCAT Data Archive (CDA). Reduced data products will be archived permanently and will be made available via VO protocols once the proprietary period expires.

Data Reduction Challenges: Reducing data from bolometer cameras with data rates 100 times larger than current instruments such as SCUBA-2 will be challenging. Some thoughts on this can be found in poster P14 (Marsden et al). Similarly CHAI has a data rate 64 times larger than the HARP instrument on JCMT.

Observation Management: The remote autonomous operation requires that there is a robust system in place for tracking Minimum Schedulable Blocks and associated observations. Time accounting will be automated by default with the ability to reject observations either automatically, via QA assessment, or from human intervention. PIs will be able to track the status of their project at any time and modify their Science Program based on feedback from observations already taken.

Observatory Status: All information generated by the observatory will be logged permanently in an Observatory Status Database. The OSD will store instrument house keeping data (possibly 0.5 TB/day), observation management information, calibration history and other digital data.

CCAT INSTRUMENTS

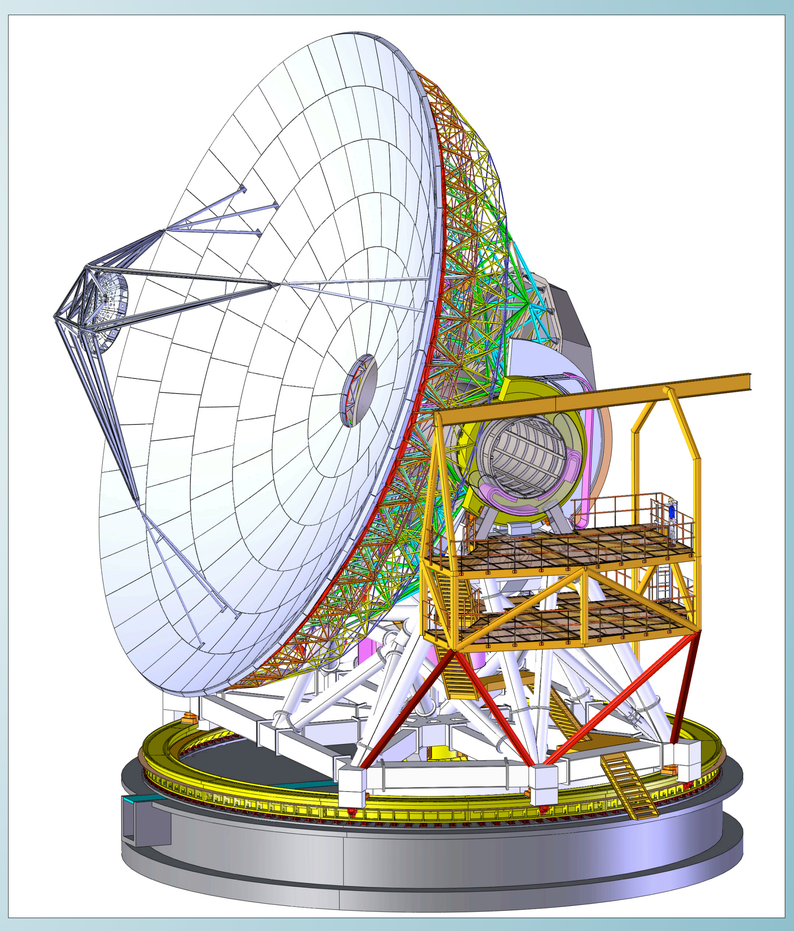
The CCAT project has identified four major instruments to achieve its science goals.

SWCam: A 50,000 – 70,000 bolometer camera operating in the 350µm and 450µm windows with a goal of 200µm.

LWCam: A 40,000 bolometer camera operating in 5 – 6 bands between 750µm and 2.1mm with a goal of 3.3mm.

X-Spec: A multi-object spectrometer with ~ 100 beams on the sky, each covering a frequency range of 190-520 GHz in two bands simultaneously with spectral resolutions between 400 and 700.

CHAI: A 2x64-element heterodyne array operating in the 600 µm and 350 µm bands.



Performance Specifications

Aperture	25 m diameter
Wavelength	350−2100 µm
Field of view	1°
Angular Resolution	3.5” (λ/350 µm)
Pointing Stability	0.35’’ (λ/350 µm)
Half wavefront error	12.5 µm rms

CCAT Engineering Design Phase is partially supported by funding by the National Science Foundation's Division of Astronomical Sciences

www.CCATObservatory.org

Canadian Consortium