Transient Alert Follow-up Planned for CCAT

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Abstract

CCAT is a sub-millimeter telescope to be built on Cerro Chajnantor in Chile near the ALMA site. The remote location means that all observing will be done by remote observers with the future goal of fully autonomous observing using a dynamic scheduler. The fully autonomous observing mode provides a natural means for accepting transient alert notifications for immediate follow up.

1 Introduction

CCAT [28, 7, 13] is a 25 m diameter sub-millimeter telescope to be built on Cerro Chajnantor in Chile near the ALMA site at an altitude of 5600 m. The additional height above the ALMA array results in significant improvements in transparency across all observing bands (Fig. 1), and 1.64 times better than the ALMA site at 350 μm [23]. CCAT will initially operate from 350 μm to 2 mm but will be capable in the future of operating at 200 μm in the very best weather.

The CCAT project has identified four major first generation instruments to achieve its science goals. SWCam [25] will be the first-light camera having of order 60,000 detectors operating mainly at 350 μm with additional detectors out to 2 mm. CHAI [8] will be a large format heterodyne array operating in two bands with the backend able to process spectra with a bandwidth of 4 GHz and 64,000 channels. LWCam [9] is a dedicated long-wave camera operating in 5-6 bands between 750 μm and 2.1 mm with a long-wavelength goal of 3.3 mm. X-Spec [2] is a multi-object spectrometer with $\sim$100 beams on the sky, each covering a frequency range of 190-520 GHz in two bands simultaneously with a resolving power of $400 - 700$.

2 The Case for Transient Follow up

In the sub-millimeter, variable sources are sometimes monitored regularly as part of general observatory operations of flux calibrators [e.g. 16] and of pointing sources such

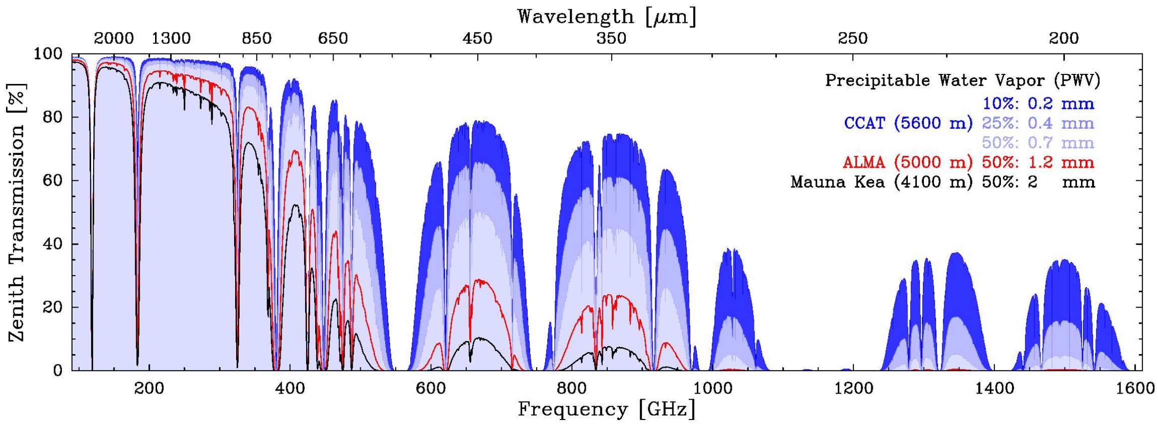

Figure 1: Atmospheric transmission for exceptional (10%), excellent (25%), and median conditions at CCAT and for median conditions at ALMA and at Mauna Kea [ATM model; 21]. Water vapor (PWV) distributions determined from 350 μm tipper measurements [23]. (figure credit: S. Radford).

as blazars [15]. Bright, time-varying sources do not generally require the ability to respond rapidly to time-sensitive alerts and can be observed as part of a monitoring program or as a general target of opportunity. Detecting the afterglows of gamma ray bursts (GRBs) in the sub-millimeter has proven to be difficult with the current generation of instrumentation [see e.g. 4] and the sooner that a telescope can get on target the more chance there is to see the peak of the light curve in the sub-millimeter. GRB 120422A [24] failed to detect any emission in the sub-millimeter despite being on source within 45 minutes and observing for nearly 2 hours with SCUBA-2 [11]. GRB 130427A, the brightest GRB in nearly 30 years [22], was not observed in the sub-millimeter but radio data and modeling suggests that the 850 μm flux would have been approximately 1 mJy after 2 days but more than 10 mJy if it had been observed within 4 hours of detection. First generation CCAT instruments such as SWCam will be able to observe an area of 0.15 sq deg to a depth of 1 mJy in only an hour in good weather. This is significantly better performance than current sub-millimeter instrumentation and indicates that the chances of detecting GRBs will increase considerably.

In addition to GRBs, LSST [12] will be coming online at around the same time as CCAT and will begin publishing millions of alerts per night. Some of these will be of interest to sub-millimeter astronomers and require reasonably fast follow up observations.

Once instrumentation has sufficient sensitivity to be useful, the main issue associated with time-sensitive alerts is how to respond to them in a timely manner. This is especially important for a common-user telescope designed for survey and P.I. observations.

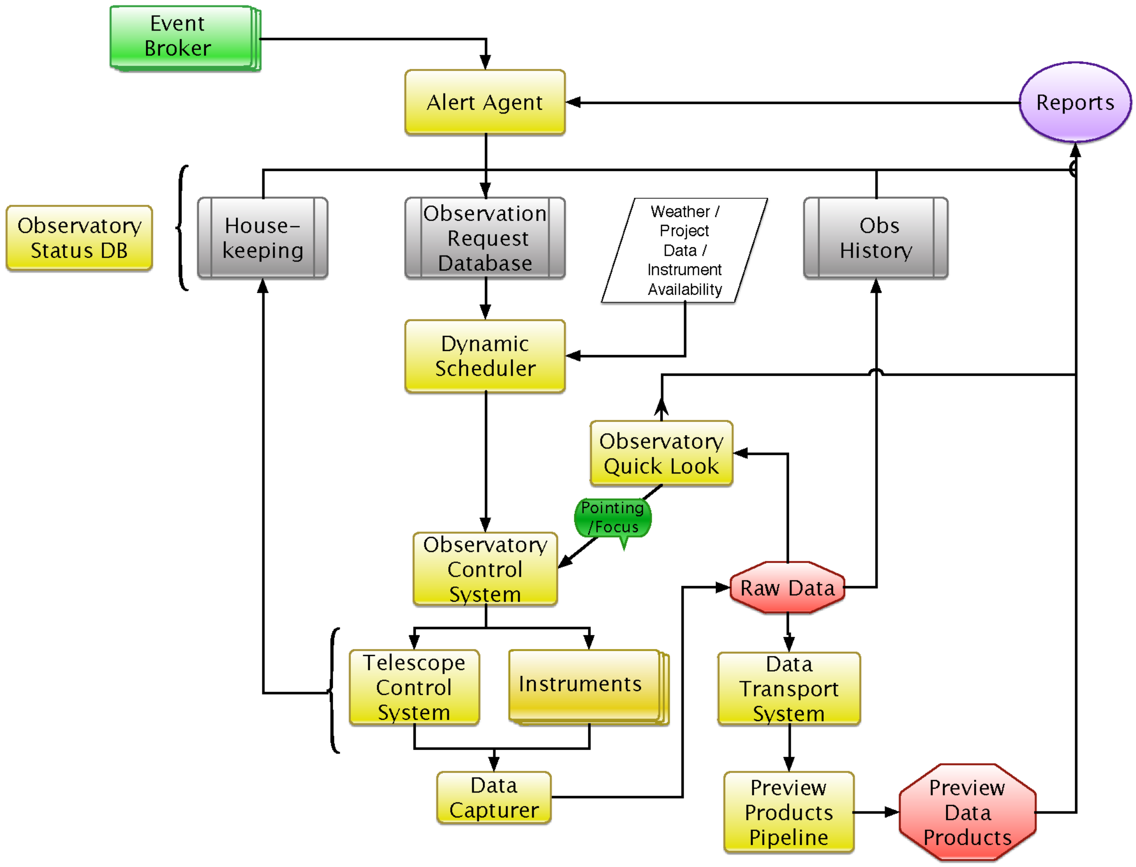

Figure 2: Flow chart of the CCAT software system from the perspective of processing transient alerts.

3 Reacting to Alerts

The CCAT observation scheduler will initially be a dynamic JIT ('just in time') scheduler determining the best observation block to observe at the current time. The system will be similar to that used by ALMA [18] and the James Clerk Maxwell Telescope [6]. A human operator, based either in San Pedro or at a remote observing location, will use the scheduler to guide the observing program and make the final choice of targets and associated calibrations.

The infrastructure being designed as part of the observation management system provides easy programmatic interface to the observation request database. The system architecture is shown in Fig. 2. The concept is that an alert broker, for example something like the ANTARES broker [20, 19], will send a VOEvent message [e.g. 27] to an alert agent. The alert agent will be run by an interested astronomer, possibly at their home institution. If the alert is of interest an observation will be submitted to the observation request database at the telescope. Once this minimum scheduleable block has been submitted to the database the standard system will be used and the data will be processed in the normal way. Quality Assurance information and, possibly, flux measurements, will be fed back to the alert agent to allow the astronomer or agent to schedule follow up observations automatically.

This design is similar to that implemented at the UKIRT telescope [5, 14] which responded to a GRB alert within a few minutes [26] using the eSTAR system [1].

4 Post Commissioning

The goal, following telescope commissioning of the base system, is to upgrade the scheduler to fully autonomous operation [see e.g. 17, for background] where the observing queue will be monitored continuously and observations submitted as needed, calibrations will be scheduled when appropriate and observation blocks will be accepted or rejected automatically based on quality assurance data from the instrument pipelines. In the sub-millimeter it is sometimes the case that a flux calibrator will not be available until later in the night and so care must be taken to keep track of calibration data that are required for observations that have already been taken. This scheduling ability would allow would allow time-sensitive followups to be inserted directly into the queue and observed without human intervention, similar to a fully robotic telescope such as LCOGT [3, 10].

Acknowledgments The CCAT Submillimeter Observatory (CCAT) is owned and operated by a consortium of universities and non-profit organizations located in the United States, Canada and Germany. Specifically the CCAT Consortium is comprised of: Cornell University, California Institute of Technology (Caltech), University of Colorado at Boulder, University of Cologne, University of Bonn, Dalhousie University, McGill University, McMaster University, University of British Columbia, University of Calgary, University of Toronto, University of Waterloo, University of Western Ontario and Associated Universities, Incorporated. The CCAT Engineering Design Phase was partially supported by funding from the National Science Foundation via AST-1118243.

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