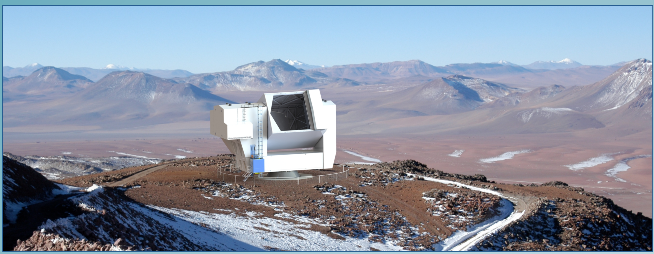
Observatory Control Software for CCAT-prime

Reinhold Schaaf[1], Mike Nolta[2], Ronan Higgins[3], Thomas Nikola[4]

1: Universität Bonn, Germany; 2: CITA, University of Toronto, Canada;
3: Universität zu Köln, Germany; 4: Cornell University, USA



VERTEX ANTENNENTECHNIK

The CCAT-prime observatory

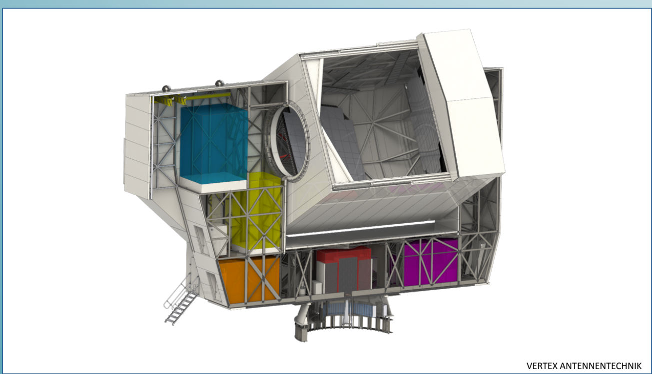
CCAT-prime, presently under construction at VERTEX ANTENNENTECHNIK (first light 2021), will be a 6-meter diameter telescope with a surface accuracy of 10 microns, operating at submillimeter to millimeter wavelengths and sited at 5600m elevation on Cerro Chajnantor in the Atacama desert of northern Chile overlooking the ALMA site. The novel "crossed-Dragone" optical design will deliver a high-throughput wide-field-of-view telescope capable of illuminating more than 100,000 millimeter wavelength detectors so that large areas of the sky can be scanned rapidly. The high altitude, dry site offers superb observing conditions, yielding routine access to the 350 micron window as well as improved performance at longer wavelengths. Under the best conditions, observations in the 200 micron window will be possible. Deployment of CCAT-prime on Cerro Chajnantor will provide operational experience at high altitude, reducing risk for the future construction of a 25-meter submillimeter telescope.

CCAT-prime is specifically designed to measure the kinematic Sunyaev-Zel'dovich effect of galaxy clusters, to trace the appearance of the first population of star-forming galaxies through intensity mapping of their [CII] emission in the epoch of reionization, and to probe multiple spectral line tracers of the ISM over a range of environments in the Milky Way, Magellanic Clouds and other nearby galaxies. It will also be a next-generation Cosmic Microwave Background observatory.

CCAT-prime's first light instruments will be:

CHAI: A dual frequency Heterodyne receiver at 490 and 800 GHz, focussing on Atomic Carbon [CI] and Carbon monoxide [CO] mapping in the Milky Way, the Magellanic Clouds,and other nearby galaxies. The 65,536 spectral channels for 2*64 pixels will be sampled with upto 10 Hz, resulting in a maximum datarate of ~170 MByte/s.

Prime-Cam: A modular instrument, consisting of five camera modules and two spectrometer modules, each equipped with large arrays of direct-detection detectors, covering the frequency range between 220 GHz and 850 GHz. Prime-Cam's main science drivers are the study of the Epoch of Reionization and the Sunyaev-Zel'dovich effect. Prime-Cam will map the sky on-the-fly, slewing quickly (up to 3 deg/s) across several degree size regions. Maximum datarates for Prime-Cam are expected to be ~50 MByte/s.



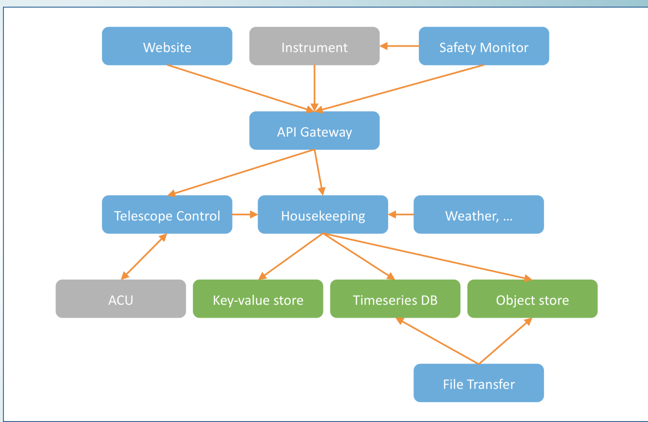
VERTEX ANTENNENTECHNIK

IT Challenges

While streaming the raw data to disk (we plan to use He-filled HDDs that are known to operate well at 5000 meters) will be no problem, raw data will accumulate with a rate of several hundred TByte per year, and transfering the data from the summit of Cerro Chajnantor to their destinations in North America and Germany will require a sufficiently fast network connection. It is currently unclear whether CCAT-prime's budget will allow a fibre connection. A fall-back solution is shipping HDDs; however, this would require frequent trips to the telescope site which must be kept at a minimum.

Another challenge are the often harsh environmental conditions at the telescope site that will make the telescope frequently inaccessible. Even when access to the telescope is possible, the presence of persons there must be kept to a minimum in order to avoid the health hazards of high altitude.

As a consequence, CCAT-prime's hardware and software infrastructure must allow the observatory to be operated remotely. The pre-requisite for this is of course network connection to the summit of Cerro Chajnantor, ideally the fibre connection mentioned above. If this connection would not be available, we plan for either a microwave link to San Pedro de Atacama or for a satellite link. One of these links will be implemented regardless as a backup for the fibre connection.



OCS Layout

CCAT-prime's Observatory Control System (OCS) will give instrument teams the responsibility to control observations. While the traditional approach is to have a central OCS for coordinating the telescope, instruments, and all the various subsystems, we believe that this model is a poor fit for CCAT-prime: The observatory will operate in campaning mode, giving the teams of the multiple instruments full responsibility of scientific operations during their allocated operations period. Furthermore, instrument teams have significant investments in software they want to preserve.

Given these constraints, we have settled on the approach shown in the above figure where blue boxes indicate components to be developed by the CCAT-prime development team, while green boxes indicate Off-The-Shelf (OTS) components. Grey boxes indicate components provided by instrument teams or the telescope manufacturer. Arrows indicate initialization of requests.

Currently, we are evaluating OTS systems for use in the OCS. Candidates are Kafka and Redis for the Key-value store, InfluxDB and TimestremDB for the Timeseries DB, and Kapacitor and Icinga for the Safety Monitor.

www.CCATObservatory.org

Acknowledgements: CCAT-prime funding has been provided by Cornell University, the Fred M. Young Jr. Charitable Fund, the German Research Foundation (DFG) through grant number INST 216/733-1 FUGG, the Univ. of Cologne, the Univ. of Bonn, the Canadian Atacama Telescope Consortium, and the Max Planck Institute for Astrophysics.

Canadian Atacama Telescope Consortium