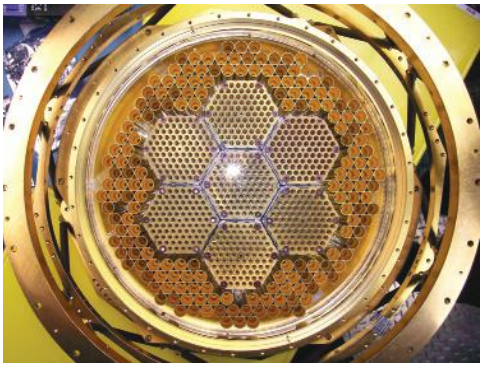
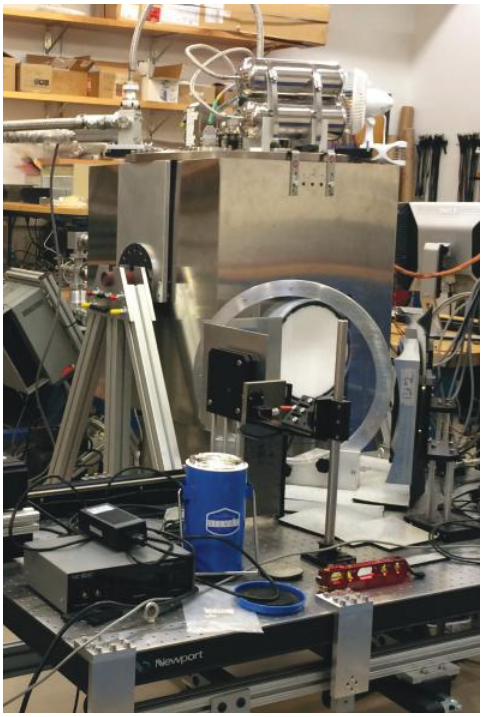
South Pole Telescope (SPT). Image: Jason Austermann



SPT polarization focal plane during initial deployment in early 2012. Images: Jason Austermann



A Fourier transform spectrometer being used to measure the spectral response of detectors located inside the Model 104 ADR cryostat at CU-CASA

How Lab-Based ADR Cryostats Support Our Quest to Understand the Universe

by Charlie Danaher, Vice President, High Precision Devices, cdanaher@hpd-online.com

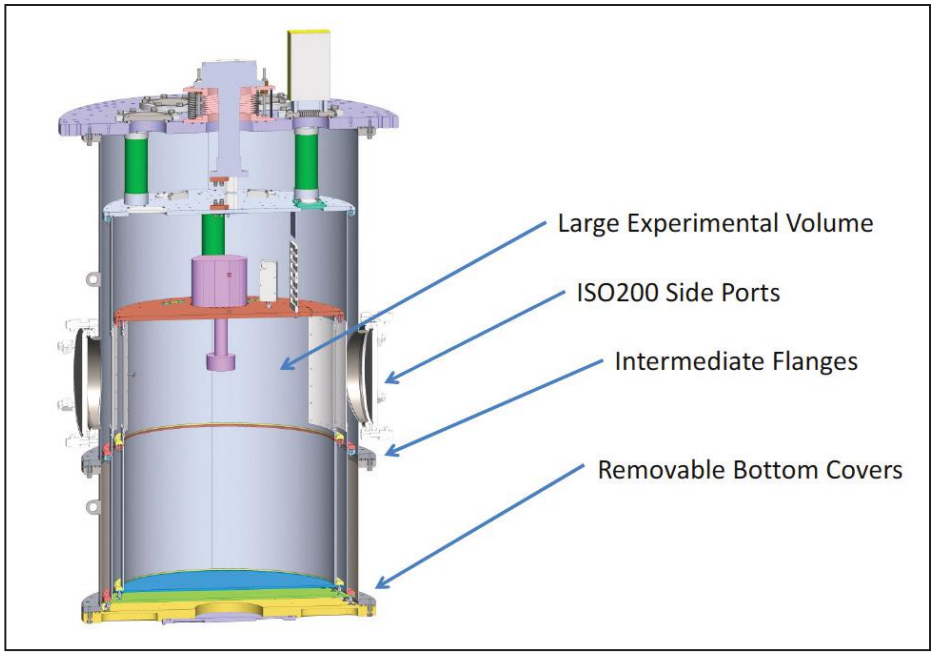
Astronomers and cosmologists are eternally curious about our universe. This curiosity motivates ever more sophisticated observation methods. Land-based telescopes continue to be one of the main instruments employed to study the sky.

The receivers (or cameras)—the part of the instrument where the light is converted to electrical signals—on these telescopes is where many of the advances in hardware are taking place. Some of the recent work has been concentrated on developing cryogenic polarimeters and multi-chroic pixels. Scientists have developed large arrays of such detectors, which are extremely sensitive to light coming from the sky.

These advances are pursuing better measurements of the polarization and amplitude of the cosmic microwave background (CMB) radiation. These improved measurements can lead to a more complete understanding of aspects of the universe such as neutrino physics, inflation and gravitational waves, to name just a few.

But long before these sensitive detector arrays are deployed in telescopes around the globe, years of development and testing occurs in the laboratory. Prototype components—including cryogenic detectors, feedhorn-waveguide assemblies and thevarious electronics—are placed into laboratory cryostats for characterization and testing.

The HPD Model 104 Olympus ADR cryostat has been used extensively at the University of Colorado by the Center for Astrophysics and Space Astronomy (CU-CASA, one of the collaborating institutions working at the South Pole Telescope [SPT]). The most attractive feature of the Olympus cryostat is its large experimental volume. Inside the 3K radiation shield, scientists can take advantage of a volume measuring 17" in diameter and 23" in height. The Model 104 commonly configured is a two-stage adiabatic demagnetization refrigerator (ADR) with base temperatures near 30mK, and typical operating temperature around 100mK.



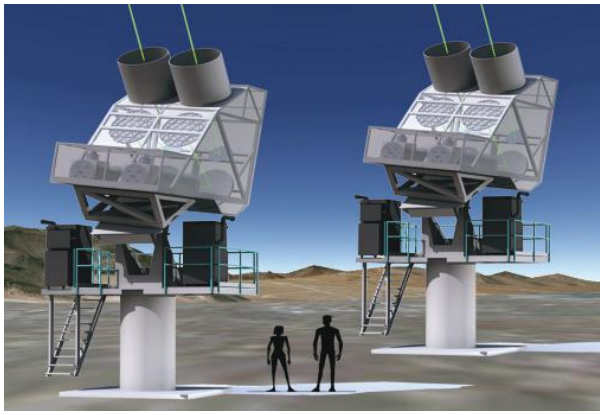
Section view of HPD Model 104 Olympus

Among the telescope observatories pursuing such research, and which have been either directly or indirectly supported by research at CU-CASA, are the SPT, a 10-meter-diameter telescope located at the Amundsen-Scott South Pole Station, Antarctica; the Atacama Cosmology Telescope (ACT), a six-meter telescope on Cerro Toco in the Atacama Desert in the north of Chile; and POLARBEAR, a CMB polarization experiment also located in the Atacama Desert.

Improved detector designs lead to compressed observation runs

One of the biggest pushes in detector advancement is toward the goal of compressing observation time. If a telescope can collect the same amount of information as before but in a fraction of the time, or if more information can be gathered for a given observation period as compared to a previous setup, such improvement can both reduce exploration costs as well as bring closer a more complete understanding of the universe. Multi-chroic pixels, having several detectors each, multiply the amount of information gathered, for a given time period, without any cryogenic cost.

The Cosmology Large Angular Scale Surveyor (CLASS) is an array of microwave telescopes currently under construction at Johns Hopkins University that will be deployed to a high-altitude site in the Atacama Desert as part of the Parque Astronómico de Atacama in 2015. The CLASS experiment aims to test the theory of cosmic inflation and distinguish between inflationary models of the very early universe by making precise measurements of the polarization of the CMB.



Computer-generated rendering of the future CLASS experiment deployed to a high-altitude site in the Atacama Desert of Chile. Image: CLASS collaboration

CLASS scientists at Johns Hopkins University have employed the Model 104 ADR cryostat to test and guide the development of a new design of detectors that will eventually be employed in the CLASS telescopes.

In a just a few years, novel detector arrays currently being validated in the laboratory will see their first implementation at these telescopes. Their observation data will advance our knowledge of the structure and history of the universe. HPD is proud to contribute to this noble effort by providing physicists with the basic instruments needed to perform such exciting research. ■

Model 104 hosting optical testing of detectors at John Hopkins University. Image: David Larson, CLASS collaboration