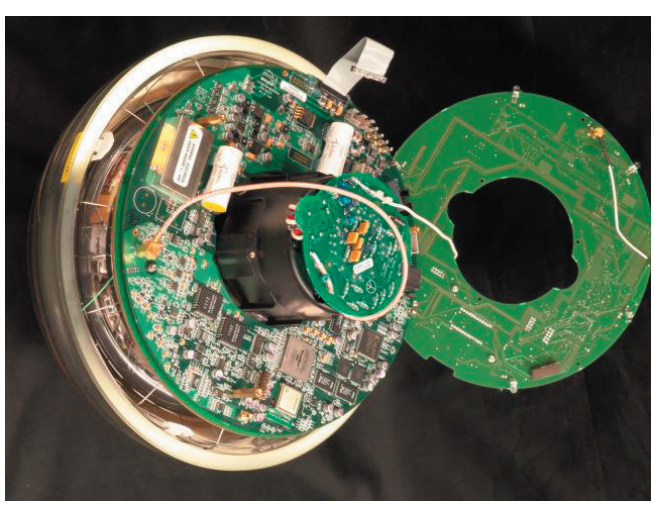
Today at Berkeley Lab

Wednesday, March 26, 2008

Celebrating IceCube

In mid-March Berkeley Lab scientists and engineers met to celebrate the completion of 5,693 “main boards” that are key components of the unique IceCube observatory—the giant neutrino telescope now under construction deep beneath the South Pole. Main boards are self-contained data-acquisition electronics systems carried inside each of the 60 Digital Optical Modules (DOMs), which are suspended on IceCube’s cables, or “strings,” reaching as deep as 2,450 meters (one and a half miles) down into the clear Antarctic Ice.

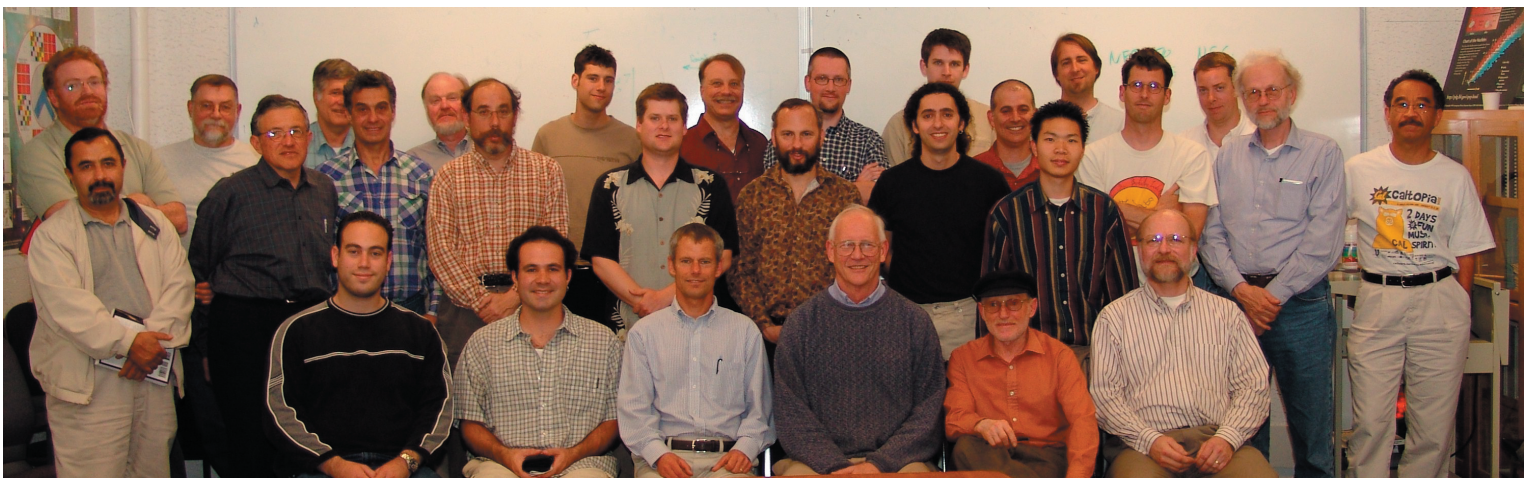
When completed, IceCube will consist of some 80 strings suspended in holes drilled in the ice by hot water and spaced over a square kilometer of surface area. The 60 DOMs carried by each string are suspended at intervals between 1,450 and 2,450 meters deep—thus the detector’s total volume is a cubic kilometer of ice. Each basketball-sized, clear-glass DOM contains a photomultiplier tube to detect flashes of Cherenkov radiation emitted by particles moving at faster than the speed of light in ice.



When completed, IceCube will suspend 80 strings of Digital Optical Modules (DOMs), here pictured before sealing, in the Antarctic ice to detect cosmic neutrinos and other exotic particles. DOM design and production were headed at Berkeley Lab.

Signals are caused by various events including background noise, but those of primary interest to IceCube scientists are muons from energetic neutrinos that have traveled all the way through the Earth, and thus are traveling upward through the detector. The job of the main-board electronics in each DOM is to select signals from these and other events of interest (for example, the appearance of exotic dark matter particles, or even miniature black holes) from among millions of others, and from ubiquitous noise. Main-board components slice the output of the photomultiplier tube into segments of a few nanoseconds, each marked by a time stamp. If other modules nearby on the string record similar pulses within a microsecond, the pulse is considered genuine, and after further processing it is transmitted up the cable to the surface.

Berkeley Lab researchers pioneered the DOM technology, including the main boards, beginning in the mid-1990s; in 2001, after rigorous tests, IceCube’s collaboratoring organizations, led by the University of Wisconsin, chose the DOM technology over competing designs. To date 2,560 modules have been deployed at the South Pole, with 99 percent of them meeting or exceeding specifications -- which are stringent, considering that once lowered into the ice and sealed in place by pouring water into the hole, which then freezes, they are utterly inaccessible. In fact the DOMs will not see daylight again until the ice sheet carries them all the way across the continent to the ocean, some 25,000 years in the future. With 40 strings in the ice, IceCube is now half finished and on schedule for completion in 2010. Eighteen strings of DOMs were installed during the mid-October to mid-February Antarctic summer drilling season just ended.



Berkeley Lab’s IceCube contingent as of 2006: front row from left, Michael Harris, Billy Robbins, Bill Edwards, Bob Stokstad, Mike Solarz, and Jerry Przbylski; middle row, Akbar Mokhtarani, Ed Kujawski, Joshua Sopher, Howard Matis, Martin Stoufer, Spencer Klein, Azriel Goldschmidt, George Chao, Arthur Jones, Dave Nygren, Jimmie Johnson; back row, Simon Patton, Chris Day, John Wolf, Churck McParland, (unknown), Brad Bingham, Tom McCauley, Dima Chirkin, John Joseph, Keith Beattie, and David Hayes. Not pictured, Thorsten Stezelberger and Chinh Vu.

More than 30 Berkeley Lab researchers have been involved with the design and construction of IceCube’s DOMs. Robert Stokstad of the Nuclear Science Division (NSD) is the project director, John Joseph of Engineering is the project manager, and Bill Edwards of Engineering was former project manager. The ability to digitize a torrent of data within each DOM was made possible by a custom data-processing chip developed in the 1990s by Stuart Kleinfelder, then of the Engineering Division. The DOMs’ principal designers were Engineering’s Jozsef Ludvig, no longer at Berkeley Lab, and Bob Minor, retired; designers included Engineering’s Robert Minor, retired, and Thorsten Stezelberger, plus Jerry Przybylski of Physics. Production was directed by Joseph, Przybylski, and Azriel Goldschmidt of NSD. Members of the Information Technologies and Services Division and the National Energy Research Scientific Computing Center (NERSC) also played key roles in designing the DOM technology.

Spencer Klein of NSD heads the physics analysis team for Berkeley Lab’s IceCube participation. Even though IceCube is only half done, it has been doing science since deployment of the first sensors. “We look forward to announcing our first major results at conferences this summer,” Klein says.

—Paul Preuss

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