THE GUY WHO BUILDS STUFF

Mark Devlin's Photo Album of the History of the Universe

by Mark Wolverton

Some cosmologists don't do anything more physical than scribbling equations on a blackboard or tapping data into a computer. They ponder the universe from the comfort of an office or book-filled study. But Mark Devlin, the Reese W. Flower Professor of Astronomy and Astrophysics, finds cushy surroundings boring. You're more likely to find him crawling inside the frame of a car-sized telescope, soldering gun in hand, or standing on the windswept ice of Antarctica preparing to send that high-tech appliance to the very edge of space on a NASA balloon.

Which is just what he was doing a few days before Christmas 2006. Devlin and his team of graduate students and international collaborators launched BLAST, the Balloon-borne Large Aperture Submillimeter Telescope. BLAST is a unique, hand-built, multi-million-dollar scientific instrument that literally hangs by a string 25 miles above the Earth. It drifted around the South Pole at an altitude of 130,000 feet, scrutinizing primeval galaxies at the edge of the visible universe and signs of star formation within our own Milky Way galaxy. You just don't get to do such things sitting in front of a computer.

"The overriding theme behind all of my experiments is cosmology, understanding the formation and evolution of the universe," says Devlin. He compares it to studying the development and growth of an individual human being: "If you were to show an alien a fertilized human egg and then show them a 75-year-old man and you say, 'Well, this is how it started and this is how it ended,' they'd say, 'Well, what's going on here? How can this possibly happen?' So to fully study this you've got to take snapshots of the whole thing, the whole process, from toddler to teenager, middle age and so forth. And as you get all those snapshots, you get a full picture of how it evolved from something so simple to something big." Devlin's work, and the mission of BLAST, essentially involves taking snapshots of the history and development of the universe.

Now 41, Devlin grew up in New Brunswick, where his father, a particle physicist, taught at Rutgers. Later the elder Devlin worked at Fermilab, one of the world's major high-energy physics labs, helping in the search for the elusive top quark. Young Mark spent his childhood immersed in the culture of scientists.

Devlin fully intended to follow in his dad's footsteps and become a particle physicist, and after majoring in physics at the University of Wisconsin, he pursued his doctorate at the University of California at Berkeley. But his focus shifted from the very small to the very big. "I kind of saw the light, so to speak, and got converted to astrophysics while I was there, and started research in the cosmic microwave background," he says. That meant building instruments and taking them to high altitudes, whether by flying them on balloons or installing them on telescopes on mountaintop observatories 17,000 feet above sea level in Chile. After a stint at Princeton, where he designed and built another balloon telescope, Devlin joined the Penn faculty in 1996, already an experienced experimentalist and dedicated hands-on guy. "The telescope I built at Princeton was converted into a ground-based telescope, which I then took to the high altitude plains of Chile," he says. "At the time, that was actually the highest telescope observing ever, and we got some very good data from there."

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Gaelen Marsden

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The idea for BLAST came together around 1999, as the next step in Devlin's quest to explore the early universe. BLAST wasn't designed to see back to the very beginning but to record a later era characterized by rampant star and galaxy formation. Galaxies, and the stars that comprise them, come together in huge clouds of gas and dust that tend to absorb visible light. The giant cloud gets warmed up and releases energy at longer wavelengths – the submillimeter range that BLAST detects – and carries precious information about what's going on inside those primordial dust clouds.

That might seem like good news, but explains Devlin, those wavelengths are "incredibly difficult to observe, because our atmosphere doesn't transmit submillimeter light. So you have to go above the atmosphere." Flying into space on a satellite or the space shuttle is expensive and requires years of waiting, which is why NASA maintains a robust scientific balloon program. BLAST would be carried above most of the Earth's thick atmosphere by a huge helium balloon.

Even for a scientist used to building sophisticated equipment, BLAST was a challenge. The telescope consists of a big two-meter-diameter primary mirror that focuses light into arrays of highly sensitive radiation detectors called bolometers, which have to be kept super cold with cryogenic equipment. Onboard computers stored the collected data, while all the electronic equipment had to be protected from the extreme temperatures and differences in atmospheric pressure that BLAST would encounter on its voyage. The entire apparatus couldn't weigh much more than 4,000 pounds, had to fit inside a gondola that could be turned and pointed at different areas of the sky, and had to be able to operate more or less on its own while drifting along at the top of the atmosphere.

After a one-day test flight in the New Mexico desert in the fall of 2003, BLAST made its maiden scientific flight from Sweden in June 2005. It was a true baptism of fire: first, bad weather and technical glitches delayed the balloon launch for weeks. When BLAST landed four days later in the Northwest Territories of Canada, Devlin and his team (accompanied by an Inuit hunter to keep the scientists safe from prowling polar bears) discovered that the telescope mirror had broken during the journey. Devlin recovered some data on Milky Way star formation, but the telescope failure made it impossible to

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collect anything on the fainter extragalactic sources that were BLAST's primary target.

He next took BLAST to McMurdo Station, a research center in Antarctica, in late 2006. The experience in Sweden paid off. Operations proceeded more smoothly this time. For 11 days after launch, BLAST flew a textbook mission. At journey's end, though, everything went wrong again. According to plan, to bring the instrument down, explosive bolts were fired to separate the balloon from the gondola, which then would

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descend by parachute. Once the gondola touched down, another set of explosives was fired to detach the parachute. Devlin recalls what happened: "It hit the ground, laid on its side with the parachute, and NASA fired the explosive bolt. Nothing happened. So the wind picked up and dragged it for about 120 miles." For a day, merciless Antarctic winds pulled BLAST across the hard-packed ice like a kite skittering across a parking lot.

"The recovery airplane came back the next day and followed this big scar in the ice," Devlin recalls. "You can picture that after 120 miles there was nothing left – no data, no mirror, no detectors, no nothing. Just the frame." It wouldn't have made much difference if Devlin had the data. But he didn't. He had nothing.

"The problem is the high rate we collect data with our detectors: it cannot be transmitted to the ground. It's all stored onboard." All the observations collected by BLAST, the entire objective of the project, were stored on hard drives inside an equipment

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capsule aboard the gondola. The container was lying somewhere along that 120-mile gash in the ice in the farthest, most hostile place on Earth. To make things worse, the data capsule was painted white. It would be almost impossible to see against the ice and snow.

Disheartened, nobody expected to find the capsule, but they had to try. "We went back another day with a lot of people and circled a bunch of times and just by pure chance, they happened to see, only 2 miles away out of 120, the data vessel sitting there," says Devlin, still sounding awed by the fact. To everyone's astonishment and relief, the data were recovered, and BLAST now has the distinction of completing the widest submillimeter extragalactic survey to date. Analysis of the data from the 2006 flight is just being completed and promises to keep Devlin's more theoretically inclined colleagues busy for years to come.

Meanwhile, Devlin is building a new and improved BLAST that he hopes to fly as early as 2009. Back in South America, he's working at a high-altitude observatory on the Atacama Cosmology Telescope. "We just finished building a six-meter diameter telescope in the same place in Chile where I did my first experiment at Penn. That's a huge experiment: it's got a thousand detectors." If that wasn't enough, his group at Penn has also built an instrument for the Green Bank radio telescope in West Virginia, the largest pointable radio telescope in the world. Both research projects will examine clusters of galaxies at very high resolution.

That work may not keep him out of town as long as the BLAST flights. "I have two kids, one just turned six and one's about to turn eight, so they were

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a year and a half younger when I was away working on BLAST," he says. "It's pretty hard being away that much." Weekends are family time now whenever he's at home in Pennsylvania. The rest of the time, though, there's no doubt that Mark Devlin will be keeping busy and, more than likely, building something. For Devlin, real science happens on the frontier and in the field, tools in hand. As he puts it, "I'm the guy who builds stuff."

For more information on BLAST, visit http://www.blastexperiment.info.

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BLAST Goes to the Movies

Mark Devlin

As if being one of the world's foremost and busiest experimental cosmologists isn't enough, Mark Devlin has just added another occupation to his C.V.: movie star. It's all the fault of his brother, Paul. Rather than follow in the Devlin family scientific tradition, Paul became an award-winning documentary filmmaker, television director and editor, winning five Emmy Awards for his work on NBC's Olympics broadcasts and CBS's coverage of the Tour de France.

When Mark was preparing BLAST for its first science flight from Sweden, he invited his filmmaker brother along to document the proceedings. "I'd been bugging him to come and film one of our launches, just so I could have it," says Mark.

At first, Paul wasn't too enthused, particularly after the not-very-successful Swedish flight. Mark laughs, "We didn't do very well there, so he thought it was kind of a crappy movie." But Mark convinced his brother to continue filming the next chapter of the BLAST story in Antarctica. The dramatic turn of events there convinced Paul that BLAST "was pretty good movie stuff," as Mark puts it. The dedicated documentarian had found his next subject. The result is *BLAST*, a feature-length documentary that tells a story of science on the edge. Paul captures the day-to-day process of working scientists and grad students: the big and little successes and failures, the petty frustrations and major problems, the personal and professional interactions, and the jubilation of a major scientific achievement.

The film has already been sold to the BBC for broadcast and is being considered by various other outlets, while being shown in several major film festivals, including the prestigious Hot Docs documentary festival in Toronto. It may not be long before Dr. Mark Devlin will be appearing on a television or theater screen near you. "Makes me nervous," he admits.

For more information on BLAST, the movie, visit http://www.blastthemovie.info.