Gran

UF's partnership in the world's largest telescope opens a universe of scientific opportunities

By Aaron Hoover

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King Juan Carlos I & Queen Sophia

Most of the time, the observatory at the peak of the Roque de los Muchachos is as empty as it is otherworldly. A single dormitory houses the astronomers who work on the 17 outsized telescopes sprinkled across the mountaintop. Few tourists bother to visit the tiny island of La Palma, home to one of the European Northern Observatory's two bases in the Canary Islands. Fewer still brave the 90-minute drive up the narrow road that climbs in hairpin turns past the island's stucco homes and a thick forest before summiting at nearly 8,000 feet amid an eerie profusion of silvery telescopes.

But on the morning of July 24, 2009, a steady stream of buses snaked up the mountain, disgorging bleary-eyed, formally dressed passengers into a crowd that rapidly grew into the hundreds. Dignitaries, government officials and leading astronomers from Europe, South America and the United States gathered at a makeshift amphitheater facing a flag-draped stage overlooking the mountain and ocean beyond. Two gleaming white helicopters thumped into view, delivering the king and queen of Spain and their retinue.

Few events in science would draw this kind of star power, especially to a flyspeck of a tropical island in the eastern Atlantic Ocean about 1,000 miles from Madrid. But this occasion was one of them: the inauguration of the world's largest telescope, the Gran Telescopio Canarias — a $180-million, 147-foot-tall behemoth that took nine years to build and likely won't be rivaled by a larger telescope for a decade.

With its 31.4-foot primary mirror, the GTC, as it is widely known, has 65 square feet more light-collecting area than any of the roughly one dozen largest 26- to 33-foot telescopes worldwide. That gives it the ability to gather extraordinarily faint light from more distant cosmic objects than any other

Telescopio Canarias

CANARICAM

Aaron Hoover

Rafael Guzman

Aaron Hoover

Several members of UF's Hispanic Alumni Association attended the dedication.

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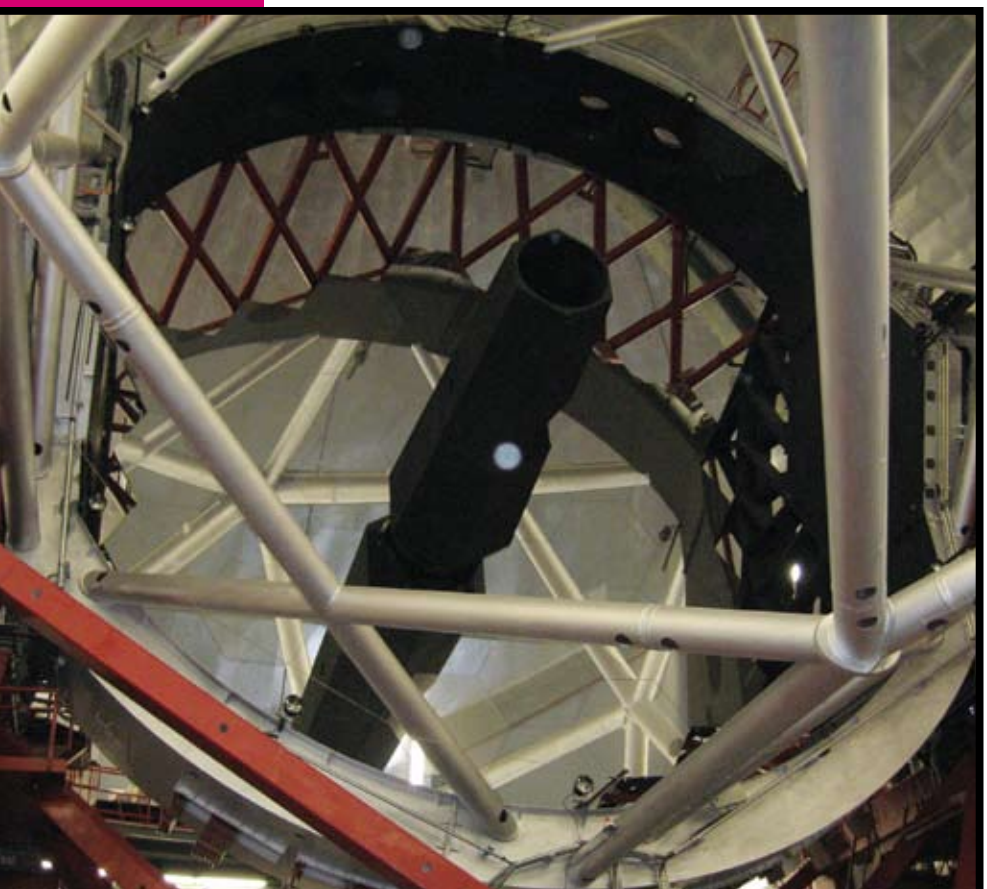
Remarks by Spain's King Juan Carlos I were broadcast on a big screen above the stage.

A close-up view of the GTC's primary mirror.



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telescope. But the GTC also has another unique quality: ultra-keen resolution. Motors keep the 36 polished hexagonal segments that compose its mirror perfectly aligned, maintaining its perfect bowl shape despite the effects of nature — gravity, temperature, movement. Its size and precise control give the telescope the power to detect an ordinary candle from 20,000 miles away — and determine the precise width of its flame from six miles away.

The GTC's opening was a grand occasion for astronomy, as King Juan Carlos I and the others at the ceremony made clear in speeches. But it was also a milestone for the three partners who brought the project to fruition — Spain, Mexico and, seemingly incongruously, the University of Florida.

Although Spain and Mexico have rich histories in astronomy dating to Moorish and Mayan times, in the modern era neither the two countries nor Florida's largest public university have been known as powerhouses in astronomy. That was a painful irony for Spain, which did not own a single one of the dozens of telescopes in the European Northern Observatory on its own islands of La Palma and Tenerife.

But thanks to an unlikely collaboration — one that involved UF painstakingly building an international reputation in the design and construction of astronomical instruments — all can now count themselves among the "big observers."

LIKE A SWISS WATCH

It doesn't take an expert to appreciate the GTC.

Glinting silver in the sunlight, its 147-foot-high dome dominates the 16 other telescopes on the mountaintop. Inside, the telescope rotates silently on horizontal and vertical axes to track celestial targets. Standing beneath its mirror, one can practically feel the telescope's 400 tons. Yet its fine movements belie the telescope's bulk. The GTC seems part tank, part reflecting pool, part Swiss watch.

When light entering the telescope's dome hits the primary mirror, it bounces to a smaller, secondary mirror. That mirror sends the light to yet a third mirror, which distributes its beams for analysis.

The GTC may have the largest, most sophisticated light-capturing mirror on Earth, but the mirror is only one piece of this technological masterpiece. Like a lens on a digital camera, the GTC still requires sensitive instruments to interpret its light. That requirement is what prompted the telescope's cross-Atlantic link with the University of Florida.

Remote, clear and far from urban light, La Palma and Tenerife are among the best places on Earth to observe the heavens. Yet until the

FLAMINGOS-2 TRACKS BLACK HOLES

The Tarantula Nebula in the Large Magellanic Cloud, the largest satellite galaxy circling the Milky Way.

The Gran Telescopio Canarias is not the only large telescope employing UF-built detectors to probe the universe.

In September, a team led by astronomy Professor Stephen Eikenberry captured the first images of the cosmos ever made with a UF-designed and built camera/spectrometer affixed to the Gemini South telescope in Chile.

The handful of "first light" images include a yellow and blue orb-like structure that depicts our Milky Way galaxy, home to thousands of black holes — including, at its core, a "supermassive" black hole thought to be as massive as 4 million suns put together.

"We plan to use this instrument to provide the first accurate tracking of the growth and evolution of this black hole over the last 4 billion years," Eikenberry said.

Installation of the instrument, called FLAMINGOS-2, caps a seven-year, $5 million effort involving 30 UF scientists, engineers, students and staff.

Astronomers will use FLAMINGOS-2 (FLAMINGOS is short for the Florida Array Multi-object Imaging Grism Spectrometer) to hunt the universe's first galaxies, view stars as they are being born, reveal black holes and investigate other phenomena.

FLAMINGOS-2 "sees" near-infrared or heat-generated light beyond the range of human vision. It is unusual in its ability to also act as a spectrometer, dividing the light into its component wavelengths. Astronomers analyze these wavelengths to figure out what distant objects are made of, how hot or cold they are, their distance from Earth, and other qualities.

Uniquely, FLAMINGOS-2 can take spectra of up to 80 different objects simultaneously, speeding astronomers' hunt for old galaxies, black holes or newly forming stars and planets.

"At a cost of $1 per second for operating the Gemini telescope, it will make a huge gain in the scientific productivity and efficiency of the observatory," Eikenberry said. "What would take an entire year previously can now be done in four nights. This is a real game changer."

Eikenberry will have at least 25 observing nights annually at Gemini South. He will use the time to contribute to three large studies, or surveys, of the sky headed by UF astronomers.

The first is aimed at learning more about the thousands of black holes and neutron stars at the Milky Way's center. The second will probe the formation and evolution of galaxies across time, while the third will investigate the birth of new stars.

The original FLAMINGOS, a smaller prototype that pioneered the approach used successfully in the larger version, was designed and built by the late UF astronomy Professor Richard Elston. Elston was at work on the early stages of FLAMINGOS-2 when he died of cancer in 2004 at age 43.

TELESCOPES CONTRIBUTE EVEN SMALLER

Francisco Reyes

The dome of the 30-inch telescope at UF's Rosemary Hill Observatory in Bronson, Fla.

While all of the attention goes to the world's biggest telescopes, in the right hands even a modest telescope closer to home can reveal new discoveries.

At about the same time UF astronomers were inaugurating the world's largest optical telescope on a nearly 8,000-foot mountaintop 3,480 miles from Gainesville, their colleagues were making their own contributions to astronomy at a far smaller, older observatory in rural Levy County .

Three UF astronomers are among the authors of a paper in *Astrophysical Journal*, the leading journal in astronomy, pinning down the extravagantly unusual orbit of HD 80606b, a Jupiter-sized planet nearly 200 light years away. The astronomers made observations of the planet eclipsing its star from a 41-year-old telescope at the department's Rosemary Hill Observatory 30 miles west of Gainesville in Bronson.

Knicole Colón, a UF astronomy doctoral student who made the observations with UF associate scientist and Rosemary Hill director Francisco Reyes, said the two were blessed with cooperative clouds.

"It was fairly cloudy, and we were somewhat disappointed," she said. "But it turned out that throughout the night, there was a hole in the cloud cover, right where our star was."

The Rosemary Hill Observatory was founded in 1967 on an 80-acre site in Levy County less than 140 feet above sea level. It has two telescopes, the larger of which is a 30-inch Tinsley reflecting telescope.

The events of the night of June 4, 2009, however, proved that small, simple telescopes can still play starring roles.

On that night, Reyes and Colón joined teams at about a dozen different observatories spread from Massachusetts to Hawaii to observe the planet eclipse its host star, HD 80606.

"You are staring at a star as a planet crosses in front of it, which is pretty amazing," she said. "It's definitely a unique experience that you can't get from the remote observing that I do."

Knicole Colón, knicole@astro.ufl.edu

Former UF mechanical engineer Jeff Julian inspects CanariCam after its arrival at the GTC.

DERMOTT DECIDED TO TRY A CREATIVE BUT RISKY APPROACH: MAKE THE UF DEPARTMENT A CENTER FOR DESIGNING AND BUILDING ASTRONOMICAL INSTRUMENTS.

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Visitors tour the GTC on inauguration day.

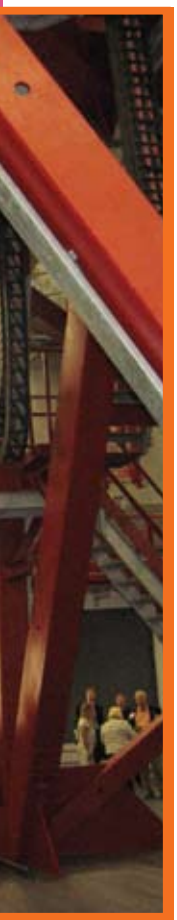
GTC, Spain's main contribution to the European observatory there was its land.

UF's astronomy department, meanwhile, had a decent reputation but did not own even a medium-sized telescope, much less one of the coveted giants.

From the time he became department chair in 1993, Stan Dermott was painfully aware that his small department could never afford to buy observation time on the world's biggest telescopes. Yet these large telescopes were essential to observing very-faint, very-distant objects in the universe — stars in their gestational stages, galaxies as they are coming into being, the first objects to populate the infant universe, and so on. At the time, research into such "origins" was rapidly becoming one of the hottest pursuits in astronomy.

So Dermott decided to try a creative but risky approach: make the UF department a center for designing and building astronomical instruments.

As astronomy has moved toward more precise observations of more and more obscure and distant objects, astronomers have come to rely on sophisticated instruments that "see" in spectra the human eye can't. The most prominent of these is infrared, or heat-generated, light, which is invisible to the human eye but has the useful quality of beaming through the dust and debris that permeate space.



Dermott's plan: use UF-built infrared instruments to barter for time on the biggest telescopes.

"There was a push to understand origins, and the origins of stars, and they originate in the dusty regions of our galaxy and telescopes with infrared capability were favored, and that was the reason we went into infrared research," he says.

Dermott hired astronomer Charlie Telesco, who already had a reputation in infrared astronomy, in 1995. Telesco promptly put together UF's first instrument — a mid-infrared or heat-sensing camera called OSCIR — for the Infrared Telescope Facility in Hawaii. His second instrument, T-ReCS, an infrared imager and spectrograph, went on the 8-meter Gemini South telescope in Chile.

Spanish astronomers planning the GTC noticed UF's emerging instrument expertise and came to UF to build a third instrument, known today as CanariCam.

The Spanish paid more than $3 million for the instrument and promised Telesco 35 nights on the GTC when it was completed. But, recognizing UF's ambitions and needing its expertise, the Spanish also offered UF an ownership stake in the GTC.

"Building instruments is a very high-risk game," Dermott says. "So is building a 10-meter telescope."

UF signed on as a GTC owner in 2000, kicking in $5 million in exchange for a guarantee of an additional 20 nights annually for UF astronomers. With CanariCam included, that meant UF had 55 nights, which were likely to be supplemented when UF astronomers collaborated with Spanish and Mexican astronomers who had their own time on the telescope set aside.

"We did achieve access through instrument-building," Dermott says. "It also turned out to be the route to buying in to a larger telescope."

TIME MACHINES

UF astronomers say they will use the telescope to probe the origins of galaxies, stars and planets. Those investigations will accelerate in 2010, when Telesco's CanariCam goes online.

CanariCam is unique in its abilities to determine the direction of polarized light and block very bright light from stars. That means it can reveal new planets that are small, cool and hard to find, as well as probe the mysterious, but likely critical, role of magnetic fields in planet formation.

That role "is a black area for which there is a very small amount of data," Telesco says. "Magnetic fields almost assuredly have an effect of some significance, but we don't really know anything about it."

He added that while astronomers have learned a great deal about how planets form in the discs of dust around young stars, they need to know more about how the planets affect the discs.

"What we want to be able to do is look at the structure of discs very carefully and see the effects the planets are having," Telesco says.

Other UF astronomers will probe the origins of galaxies, black holes and so-called "Population 3" stars — the first stars that formed after the Big Bang some 14 billion years ago. Some of those investigations will involve CanariCam, but UF researchers are also at work on other instruments set to be deployed in future years.

A UF team is currently at work on CIRCE, short for the Canarias Infrared Camera Experiment, now in the design and manufacturing stage. UF researchers will also contribute to instruments built elsewhere and used on the GTC.

"We want to detect and we want to study the very first stars and how the very first stars became the very first galaxies, and how those galaxies evolved into the galaxies we see today," says Raphael Guzman, a professor of astronomy who recently succeeded Dermott as department chair.

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