Observatories on La Palma

by Jürgen Winterberg, ASPE

Some months ago, when traveling was still possible, I went to La Palma—one of the Canary Islands belonging to Spain but located much closer to the African continent. The island's highest mountain, Roque de los Muchachos (literally, Rock of the Boys) has an elevation of almost 8000 ft (2400 m). As the atmosphere there is almost free of particles, it is an ideal place to build telescopes and observatories, and several have been built there since the 1980s. Roque de los Muchachos Observatory is now part of the European Northern Observatory (as opposed to the European Southern Observatory with observatories in Chile).

Due to its uncommon shape, the telescope shown in Figures 1 and 2 attracted my attention. Named LST-1, it is a prototype of a Large-Sized Telescope (LST). In the future, LST-1 will become a part of the Cherenkov Telescope Array (CTA), which is currently under development. Named after Russian Nobel laureate Pavel Alekseyevich Cherenkov, CTA will consist of several telescopes of three different sizes (small, medium, and large; or SST, MST, and LST). These different sizes are intended to catch gamma rays (high-energy electromagnetic photons from different sources in the cosmos) of differing energy ranges. Because LST has the largest diameter, it is able to catch the low-energy range from 20 to 150 GeV. While this is called "low range," keep in mind that the fission of one atom of uranium-235 releases around 200 MeV, which is less than 1% of CTA's low range.[1] CTA is

Figure 1: Large-sized telescope, LST-1. During the daytime, it is in a safety position facing north.
(photograph by Jürgen Winterberg)

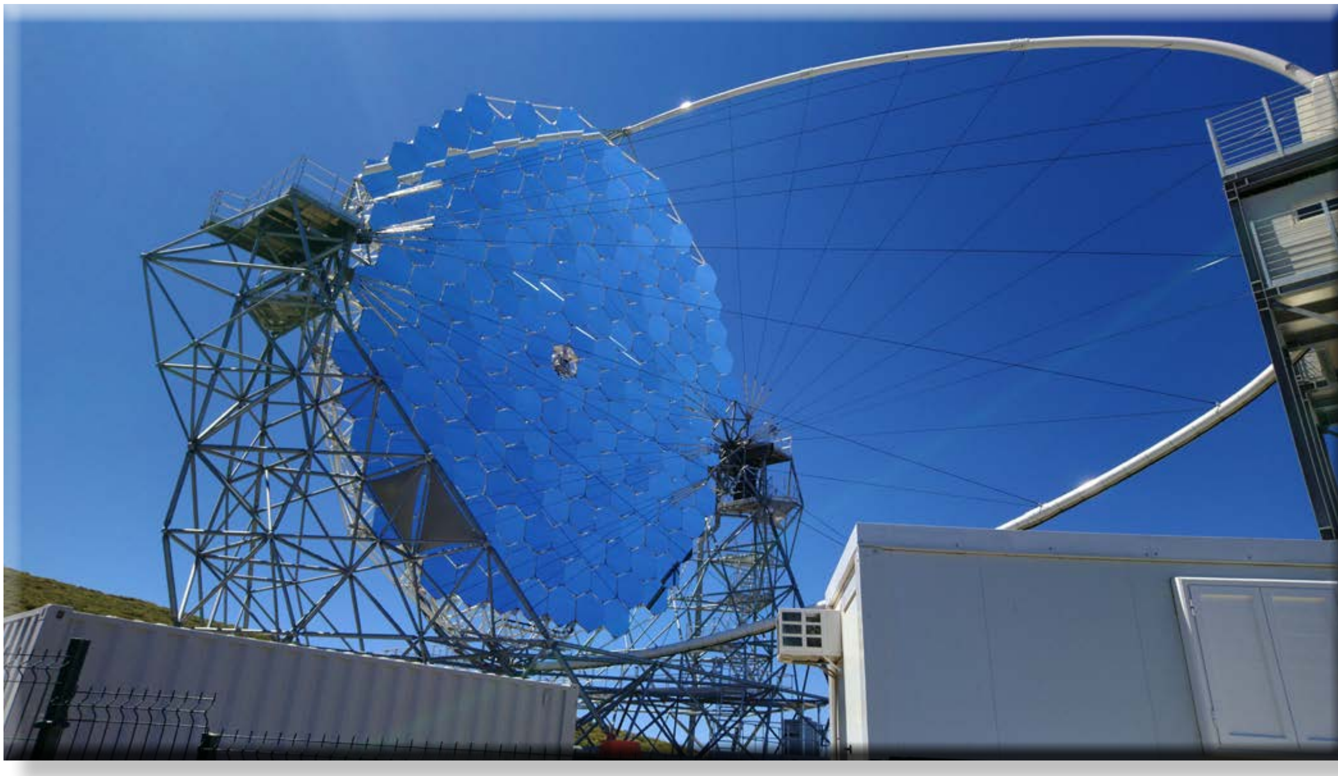

Figure 2: Mirror of LST-1, consisting of several hexagons which can be positioned individually. The mirror has a diameter of 75 ft (23 m). *(photograph by Jürgen Winterberg)*

intended to be the next generation for ground-based gamma-ray astronomy. Its construction is expected to begin in 2022 and be completed in 2025.[2] CTA may allow us to better understand the nature of gamma-ray bursts and even dark matter.

Gamma rays normally cannot be observed directly, as they are absorbed by Earth's atmosphere. But when the gamma photons interfere with other molecules in the atmosphere, they can be observed indirectly from the ground. The collision of gamma photons with other molecules results in a secondary particle shower in the atmosphere, which then emits Cherenkov light that can finally be captured by the CTA.

You may have seen pictures of Cherenkov light, as this is the blue light that can be seen in the water basins of nuclear reactors.[3] This blue light occurs when electrically loaded particles (nuclear radiation) travel faster than light in their surrounding media. Of course, no particle can travel faster than c (the physical constant representing the speed of light of around 186,000 mi/sec or 300,000 km/sec); however, the constant "c" refers to the speed of light in a vacuum only. In water or air, the speed of light is lower than c. The acoustical analogy is a sonic boom. Like sound waves, photon waves are compressed (thus, the spectrum changes to lower wavelengths, which explains the blue color) and form a shock wave. The same phenomenon happens with the secondary gamma-ray particle shower. Particles still travel at a speed of c, whereas light has a speed below c. Cherenkov light is captured by photosensors in the telescope's camera (the white box in the middle right of Figure 1).

Figure 3: Dome housing GranTeCan. The dome is approximately 100 ft (30 m) in diameter. *(photograph by Jürgen Winterberg)*

Even long-duration gamma-ray bursts last an average of only 30 seconds.[4] So, it is difficult to detect them, and it is often not the burst itself but its afterglow that is recorded. Fortunately, the FGST (Fermi Gamma-ray Space Telescope) and other satellites are constantly checking the sky for gamma-ray bursts, and this information is publicly available in real-time.[5] For instance, there was a gamma-ray burst on May 24, 2020, at 05:04 UTC, [6] of which subscribed researchers and systems worldwide were notified immediately through a system called GCN (Gamma-ray Coordinates Network). Once this type of information is received, LST-1 is able to reposition itself within 20 seconds, even though it has a mass of 100 tonnes.[7]

A few steps ahead of LST-1 is the Gran Telescopio Canarias, or GranTeCan (see Figure 3). I had the opportunity to visit the dome inside. Unfortunately, GranTeCan is open only during the nighttime to accredited researchers who follow a strict research schedule, so it was not under operations when I was there.[8]

Presently, GranTeCan is the world's largest single-aperture optical telescope, with a mirror of 34 ft (10.4 m) in diameter.[9] As with LST-1, the mirror is built of several hexagons, which you can see in Figure 4.

Finally, if you found this discussion interesting, I suggest visiting the following website, which has a real-time picture of the location in the sky to which GranTeCan is pointing: http://grantecan.es/en/gtc-live.

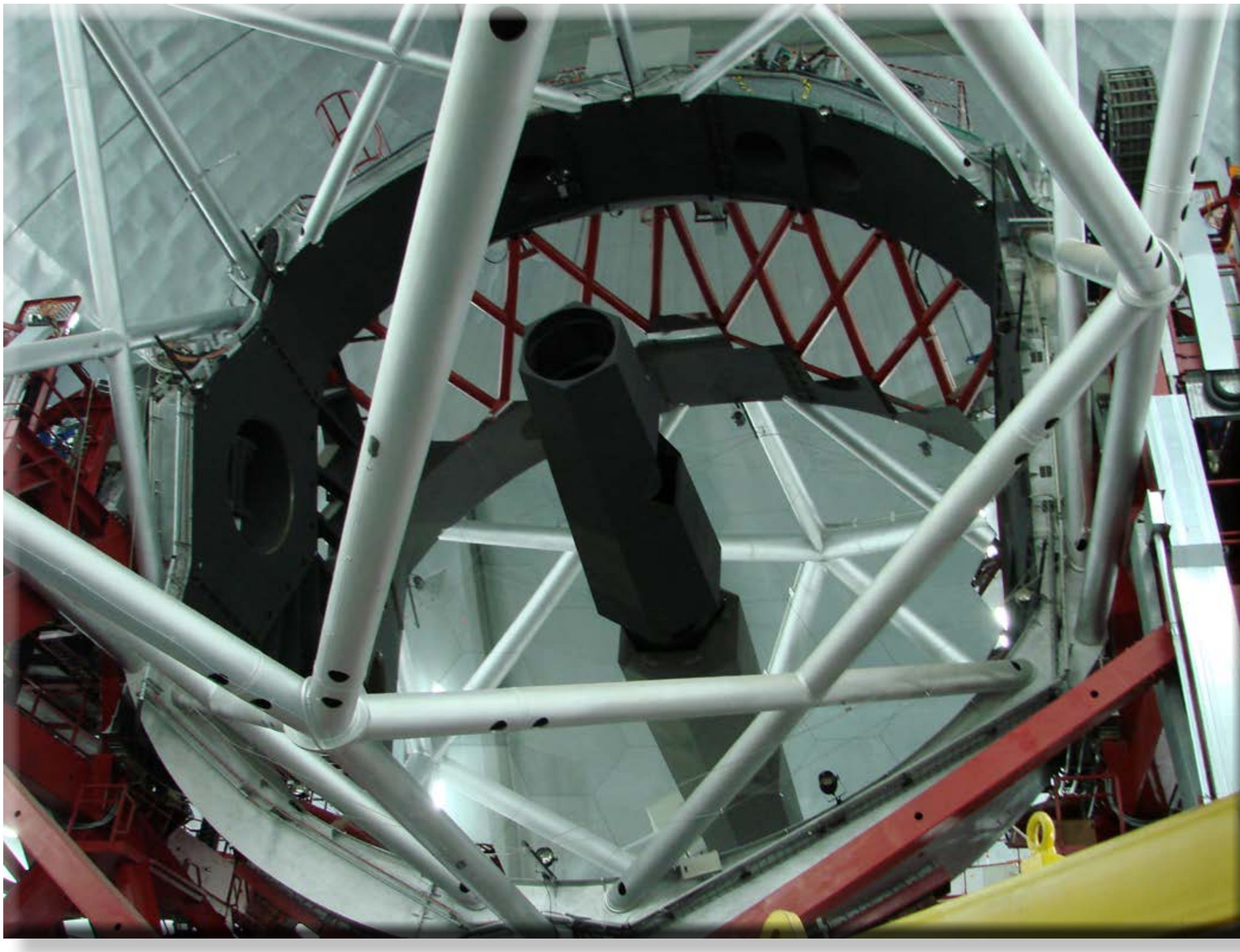

Figure 4: Mirror of GranTeCan, consisting of several hexagons. The mirror is 34 ft (10.4 m) in diameter. *(photograph by Jürgen Winterberg)*

NOTES

1. Wikipedia contributors, “Uranium-235,” Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/wiki/Uranium-235#Fission.

2. “Status: Current Progress Toward Construction and the First Telescopes on Site,” Cherenkov Telescope Array, https://www.cta-observatory.org/project/status/.

3. “Visit Purdue University’s Reactor Number One (PUR-1),” Purdue University, Nuclear Engineering, https://engineering.purdue.edu/NE/research/facilities/reactor_html.

4. “Gamma-Ray Bursts,” NASA Goddard Space Flight Center, https://imagine.gsfc.nasa.gov/science/objects/bursts1.html.

5. “Burst-n-Transient Information (Current and Archives),” NASA Goddard Space Flight Center, https://gcn.gsfc.nasa.gov/burst_info.html; see the Fermi, Swift, or Integral GRB information links, for instance.

6. “GCN/FERMI NOTICE,” NASA, https://gcn.gsfc.nasa.gov/other/611989445.fermi.

7. “Large-Sized Telescope,” Cherenkov Telescope Array, https://www.cta-observatory.org/project/technology/lst/.

8. “GTC Calendar Viewer,” Gran Telescopio Canarias, http://gtc-phase2.gtc.iac.es/science/calendar/calendar.php; at the time of this writing, they were already scheduled three months ahead.

9. With the completion of ELT (Extremely Large Telescope) or GMT (Giant Magellan Telescope) in Chile, GranTeCan will lose this ranking. **Ω**

“For nature gives to every time and season
some beauties of its own;
and from morning to night,
as from the cradle to the grave,
it is but a succession of changes
so gentle and easy that
we can scarcely mark their progress.”
—Charles Dickens