ASTRONOMY

# Europe's Black Hole Hunter Is Ready to Fly

The most turbulent and cataclysmic events of the universe should soon give up their high-energy secrets to Europe's Integral observatory

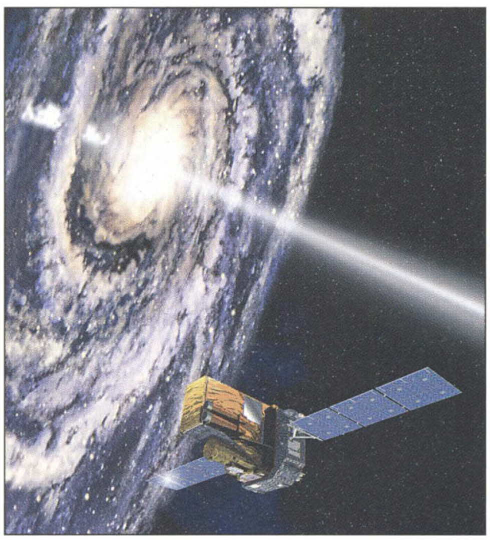
**UTRECHT, THE NETHERLANDS**—Supernovas, gamma ray bursts, black holes, neutron stars, active galactic nuclei, and sites of massive matter-antimatter annihilation: They're among the universe's most violent scenes of mayhem. Astronomers are falling all over themselves to get a good look at these unsavory neighborhoods, hoping for fresh insights into everything from the origin of the heavy elements to the death throes of massive stars.

Later this month, if all goes according to plan, astronomers should have an orbiting observatory in place that will provide the best views yet: Europe's International Gamma-Ray Astrophysics Laboratory, or Integral. It will be "the first spacecraft to make detailed gamma ray images of the sky," says Neil Gehrels of NASA's Goddard Space Flight Center in Greenbelt, Maryland, who is U.S. mission scientist for Integral. Anticipation is running so high that the first year of observing time is already oversubscribed—by a factor of 20.

The $600 million Integral, 9 years in the making, carries the heaviest set of instruments ever lofted by the European Space Agency (ESA). Following its planned launch by a Russian Proton rocket, slated for 17 October, Integral will carry on where NASA's Compton Gamma Ray Observatory left off. Compton, which ended its life in a fiery reentry 2 years ago, carried out sky surveys at all kinds of gamma ray energies. Integral, in contrast, will focus on low- and midenergy gamma rays with much higher sensitivity, more acute vision (comparable to the human eye's), and better spectroscopic precision.

Gamma rays are the most energetic photons in the universe—about a million times more energetic than visible light. They emerge only from the most extreme environments. Despite their power, gamma rays are rare and hard to catch: They don't penetrate Earth's atmosphere and are impossible to focus with lenses or mirrors. Instead, gamma ray astronomers must rely on elaborate space-based pinhole cameras known as coded mask apertures and sensitive semiconductor detectors that must be cooled to low temperatures and heavily shielded from background radiation.

Integral carries four wide-angle instruments: a gamma ray camera, a gamma ray spectrometer, an x-ray camera, and an optical telescope. Project manager Kai Clausen of the European Space and Technology Centre (ESTEC) in Noordwijk, the Netherlands, calls the technology of the gamma ray instruments "mind-boggling." For instance, the French-Italian camera contains more than 20,000 individual cadmium telluride and cesium iodide detectors, each measuring a few millimeters across and outfitted with its own set of miniature amplifiers. The French-German spectrometer is 100 times as sensitive as similar instruments flown in the past and has 19 semiconductor detectors of ultrapure germanium. To protect all these delicate instruments, Integral must lug around massive detector shields, made of bismuth germanate oxide crystals.



**Close encounter.** Integral is depicted near one of its targets: an active galaxy.

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In all, Integral measures 5 meters high and 3.7 meters in diameter and weighs 4.1 tons. Like ESA's XMM-Newton x-ray satellite, launched in 1999, Integral will be placed in a very elongated orbit, spending 90% of its time well outside the noisy environment of Earth's radiation belts. During its first year in orbit, the researchers who built the instruments will get 35% of Integral's observing time; 26% of the remainder is earmarked for Russian astronomers, in return for the free launch Russia is providing.

Much of the time, Integral's instruments will be pointed in the general direction of the center of the Milky Way, where more than half of the galaxy's transient high-energy sources are located—predominantly neutron stars and black holes in binary systems. "Integral is a true black hole hunter," says acting project scientist Arvind Parmar of ESTEC. "Every Monday morning, it will scan the galactic plane, looking for new sources." As soon as a new burst is detected, a dedicated follow-up campaign will commence. The observations will shed light on the way these bizarre objects influence their immediate environment.

Thanks to its high spectral resolution, Integral will also be able to look for the fingerprint of radioactive atoms that are produced in the aftermath of supernova blasts. "By precisely determining the amount of decaying elements like titanium and cobalt, we will learn more about the way heavy elements are synthesized during supernovas," says Wim Hermsen, an Integral mission scientist at the Space Research Organization Netherlands in Utrecht. He adds that Integral will reveal the true supernova rate in our galaxy, as it will detect all young supernova remnants in the Milky Way that have escaped detection at other wavelengths.

Farther from home, the new observatory will focus on the supermassive black holes in the cores of active galaxies and their relativistic jets of ejected material, shed light on the origin of ultrahigh-energy cosmic rays, and uncover major matter-antimatter annihilation sites, such as the one found near the huge black hole at the center of the Milky Way. Also, scientists expect a yearly catch of about 20 gamma ray bursts: titanic explosions of giant stars that probably signal the birth of black holes. Because Integral's instruments always look in the same direction, new bursts will be observed simultaneously at optical, x-ray, and gamma ray wavelengths.

Although Integral ignores the highest energy gamma rays, that gap will soon be filled by the Gamma-ray Large Area Space Telescope, which NASA will launch 4 years from now. ESA plans to operate Integral for at least 2 years, but it is likely to extend the mission through 2007, so the two observatories might operate in parallel for at least a year. "Especially for the study of active galactic nuclei, this would be a very nice capability," says Gehrels.

—GOVERT SCHILLING

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