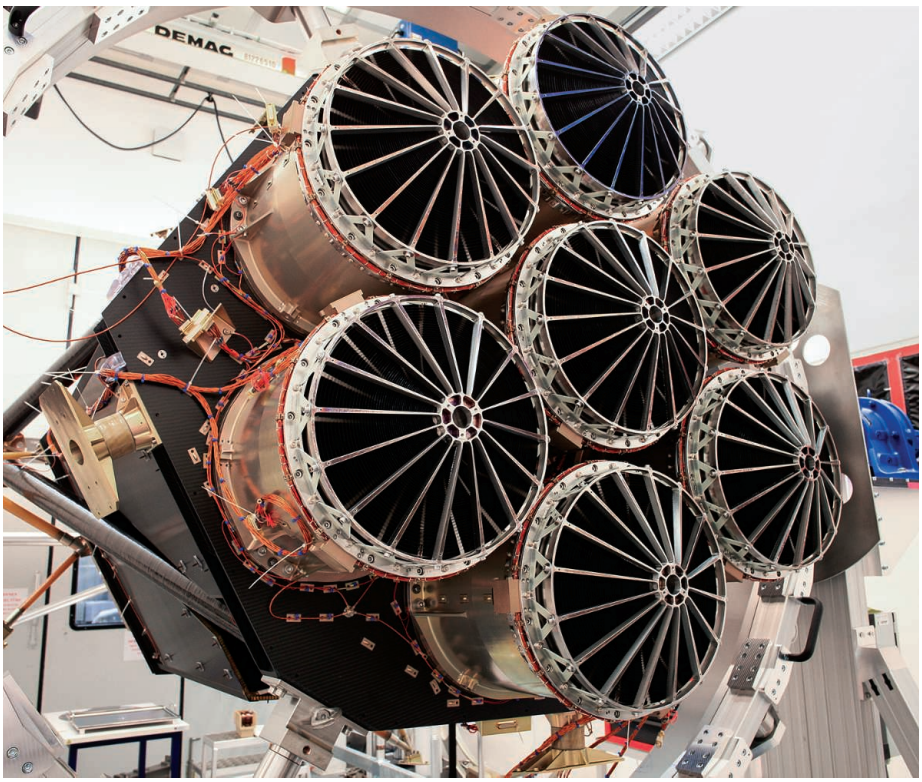


A German survey instrument on Spektr-RG contains seven x-ray telescopes, each with 54 nested mirrors.

ASTRONOMY

# X-ray telescope keeps Russia's space science hopes alive

## Spektr-RG, designed to study the effect of mysterious dark energy on galaxies, will be nation's only space observatory

*By* **Daniel Clery**

Russia's beleaguered space science program is hoping for a rare triumph this month. Spektr-RG, an x-ray satellite to be launched on 21 June from Kazakhstan, aims to map all of the estimated 100,000 galaxy clusters that can be seen across the universe. Containing as many as 1000 galaxies and the mass of 1 million billion suns, the clusters are the largest structures bound by gravity in the universe. Surveying them should shed light on the evolution of the universe and the nature of the dark energy that is accelerating its expansion.

First proposed more than 30 years ago as part of a Soviet plan for a series of ambitious "great observatories" along the lines of NASA's Hubble Space Telescope, Spektr-RG fell victim to cost cutting in cash-strapped, post-Soviet Russia. But the roughly €500 million satellite, which will carry German and Russian x-ray telescopes, was reborn early last decade with a new mission. Its original goal was to scan the sky for interesting x-ray sources, such as supermassive black holes gorging on infalling material; now, by mapping galaxy clusters, it would find out what makes the universe tick. The new goal meant further delays. "There have been many ups and downs," says Peter Predehl, leader of the team at the Max Planck Institute for Extraterrestrial Physics (MPE) in Garching, Germany, that built one of the satellite's two telescopes. "Whenever we thought we were out of the woods, a new one came along."

Spektr-RG was born in the late 1980s. Glasnost was encouraging Soviet researchers to collaborate with Western colleagues, and studies of SN 1987A, the nearest supernova in modern times, had demonstrated the power of x-rays for tracing such violent events. Rashid Sunyaev of Moscow's Space Research Institute (IKI) proposed an x-ray observatory to orbit above Earth's atmosphere, which blocks x-rays. The 6-ton mission soon bristled with five telescopes and involved 20 institutes in 12 countries, including the United States. But after the collapse of the Soviet Union, Roscosmos, Russia's space agency, struggled to keep its Mir space station aloft and contribute to the growing International Space Station (ISS). "They told us the spacecraft was too large for Russia, too ambitious," says Sunyaev, now at the Max Planck Institute for Astrophysics in Garching. "It just died."

Resurrection began in 2003 with plans for a smaller mission that would carry a U.K.-built all-sky x-ray monitor and MPE's x-ray survey telescope, called ROSITA—which had been destined for the ISS but was grounded by the Challenger space shuttle disaster. The new impetus was cosmology. Studies of distant supernovae in the 1990s had revealed that the expansion of the universe is accelerating. Researchers wanted to know more about dark energy, the mysterious force that was causing it, and whether it varied in space or over time. Galaxy clusters are among the best indicators, says x-ray astronomer Andrew Fabian of the Institute of Astronomy (IoA) in Cambridge, U.K. "Clusters are the most massive objects in the universe, the pinnacle of galaxy formation, and are very sensitive to cosmological models."

They are best seen in x-rays because the gaps between galaxies are filled with gas that is heated to millions of degrees as the galaxies jostle together in a cluster. By mapping the clusters, Spektr-RG "will study the evolution of the structure of the universe," says Esra Bulbul, of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, who recently joined the MPE team.

The challenge was to boost the capabilities of the existing ROSITA telescope, which could only garner up to 10,000 galaxy clusters. Discussions led to a €90 million "extended" eROSITA, paid for by MPE and the German Aerospace Center, DLR. It is an array of seven identical telescopes with five times the effective collecting area of the original instrument. Russia and Germany signed an agreement in 2007 with launch penciled in for 2012.

But mission development was not smooth. The U.K. instrument failed to win funding and was replaced with a Russian telescope that will complement eROSITA by detecting scarcer "hard" x-rays. Though harder to collect, those higher energy photons are particularly useful for seeing the supermassive black holes at galactic cen-

ters, because they pierce the clouds of gas and dust that shroud them.

Making the mirrors for eROSITA posed another challenge. Because x-rays would penetrate a flat telescope mirror, focusing them requires cylindrical mirrors that gather the photons in glancing, low-angle reflections off inner surfaces. Each of eROSITA's seven scopes contains 54 gold-plated cylindrical mirrors, nested inside one another, that must be shaped precisely to bring the photons to a focus. Making them proved so hard that the MPE team had to fire its main contractor part way through. "It almost killed us," Predehl says.

A decision to site the telescope at a stable, gravitationally balanced point beyond the moon, outside the shelter of Earth's magnetic field, meant electronics had to be hardened against solar radiation. Incompatibility between the German and Russian electronics delayed the launch, as did problems with the spacecraft's communications system and a change in launch rocket.

Now that Spektr-RG is finally ready, expectations are high. "It's going to be revolutionary in terms of numbers," says IoA astronomer George Lansbury, taking x-ray studies into "the big data regime."

It may also be a rare high point for Russia's great observatories program. Previously, only one has made it into orbit: 2011's Spektr-R, a radio astronomy mission that fell short of expectations and could not be revived after malfunctioning earlier this year (*Science*, 29 July 2011, p. 512).

Astronomers may face a long wait for Spektr-RG's successors: the ultraviolet telescope Spektr-UV and Spektr-M, a millimeter-wave radio telescope. Spektr-UV has survived moments of near-death, most recently in 2014 when Russia's annexation of Ukraine's Crimean peninsula caused major Ukrainian partners to withdraw. The mission is now slated for a 2025 launch, but, Sunyaev says, some collaborators, including a German team supplying a spectrograph, have dropped out. Spektr-M, which would come next, is not yet fully funded, he says. And in the meantime, rival telescopes launched by other countries may scoop up the science the Russian missions aim to do.

"Russia is doing as much as possible with the budget available," says Spektr-RG chief Mikhail Pavlinsky of IKI. He notes that Roscosmos's lean budget, worth $20.5 billion over 10 years, faces multiple demands. Russia is building the landing system for the European ExoMars rover, due to launch next year, and like other countries it hopes to return to the moon, with the Luna 25 lander in 2021. For Russia's astrophysicists, Pavlinksy says, "It means slow progress." ■

CLINICAL TRIALS

# *Experimental drug holds off type 1 diabetes*

## Two weeks of therapy delays disease for average of 2 years

*By* **Jennifer Couzin-Frankel**

Culminating a 33-year odyssey, scientists this week reported a milestone in type 1 diabetes: evidence that it can be held off. At the American Diabetes Association meeting in San Francisco, California, and in *The New England Journal of Medicine*, researchers reported that 2 weeks of an experimental drug delayed disease by an average of about 2 years in young people at very high risk.

"These data are the first to show it is possible to prevent the progression of type 1 diabetes," says Lucienne Chatenoud at Hôpital Necker-Enfants Malades in Paris, who wasn't involved in this study.

Type 1 diabetes is an autoimmune disease that requires constant blood sugar monitoring and can lead to heart disease and kidney failure. Years before diagnosis, the sentries of the immune system, T cells, attack β cells in the pancreas. But those insulin-secreting cells remain largely intact, offering a window for intervening.

> ***"... it is possible to prevent the progression of type 1 diabetes."***
>
> **Lucienne Chatenoud**, Hôpital Necker-Enfants Malades

Decades ago, Kevan Herold, an endocrinologist now at Yale University, turned to an antibody drug designed by Jeffrey Bluestone, an immunologist now at the University of California, San Francisco. It shuts down activated T cells by targeting a molecule on the cells' surface called CD3. In the 1990s, they and a French team co-led by Chatenoud showed that anti-CD3 could prevent or reverse diabetes in a mouse model. Small clinical trials in newly diagnosed people also looked promising.

But two large trials in new-onset patients proved disappointing. "That was devastating," Bluestone says of the results, announced in 2010. Still, he, Herold, and others stayed hopeful, believing those trials used doses that were too low or included participants who didn't have the autoimmune form of diabetes.

Herold convinced a diabetes clinical trials network called TrialNet to break new ground: Support a study of the drug in people who didn't yet have diabetes. Starting in 2011, the trial recruited those with an estimated 75% chance of getting diabetes in the next 5 years, based on unstable blood sugar and antibodies in their blood that indicated attacks on the pancreas.

Forty-four volunteers received teplizumab, as the drug Bluestone helped design is now called, intravenously every day for 14 days. Another 32 got a placebo. The difference was stark. In the treatment group, the median time to a diabetes diagnosis was just over 4 years; in the placebo group, it was 2 years. Forty-three percent of those who got teplizumab developed diabetes after 5 years versus 72% of controls. Side effects were mild and resolved within weeks.

"To gain 2 years of an insulin-free life … that's significant," says Mark Atkinson, a pathologist at the University of Florida in Gainesville. "You have to think of mom or dad having 2 years less of getting up at night" to check their child's blood sugar, he says, along with a potentially lower risk of complications.

The big question now is what's next. Carla Greenbaum, chair of TrialNet and an endocrinologist at Benaroya Research Institute in Seattle, Washington, hopes researchers will probe whether other immune therapies can also delay disease. She also wonders whether a second dose of teplizumab would extend its efficacy.

Given the striking results, a larger placebo-controlled prevention trial of teplizumab might be hard to justify. And although the volunteers in Herold's trial all had a first-degree relative with diabetes, at least 85% of patients don't—so only widespread screening would reach everyone at risk. "Will the public even participate?" Atkinson wonders.

Still, Herold hopes his study marks a turning point. As he was finalizing the data, he noticed that the trial's first volunteer had disappeared. Herold found out later that the young man had gotten teplizumab. "I called him up and said, 'What's going on?'" Herold recalls. Not much, the volunteer admitted; he had forgotten to stay in touch. "That's terrific," Herold thought. Forgetting is what someone with diabetes can't do—so for this man, who is disease free, it meant everything. ■

# X-ray telescope keeps Russia's space science hopes alive

Daniel Clery

*Science* **364** (6445), 1020-1021.
DOI: 10.1126/science.364.6445.1020