Key words: Supermassive Black Hole, General Relativity

ESOcast 173: First Confirmation of Einstein's General Relativity Near Supermassive Black Hole	
00:00 **1. [Visual starts]** *"this happens only once in sixteen years"* *"It will be so close to the black hole that the speed of it will reach almost 3% of the speed of light"* *"I said to my wife 'I have to tell you something — it's really there' "*	**00:00**
00:20 **2. ESOcast intro**	**00:00** ESOcast introduction
00:32 **3. [Narrator]** Since Einstein published his theory of general relativity in 1915 scientists have embarked on a hundred-year crusade to prove him right.... ..or wrong.	
00:49 **4. [Narrator]** In pursuit of this goal, ESO has been training its telescopes on a hidden monster in the heart of the Milky Way for over a quarter of a century.	

01:03 **5. [Narrator]** This cosmic colossus is a supermassive black hole, four million times the mass of the Sun, surrounded by a tightly-bound group of stars.	
01:20 **6. [Narrator]** Now**,** after an epic 26-year observing campaign, the effects of Einstein's general relativity have been clearly seen for the first time around this supermassive black hole.	
01:37 **[Narrator]** **7.** However**,** astronomers aren't only interested in finding out if Einstein was right. They also want to use these measurements to test our most fundamental understanding of the Universe.	
01:51 **8. Statement** **Françoise Delplancke-Ströbele:** "*The whole theories about the formation of the Universe — how the Universe is evolving — are based on one philosophical and fundamental assumption, which is that the laws of physics are valid everywhere in the Universe and at any time in the Universe."*	
02:05 **9.Statement** **Françoise Delplancke-Ströbele:** **"***While here on Earth we can only prove these laws of physics now and under certain circumstances. So it's very important in astronomy to also check that those laws of physics are still valid where the gravitational fields are much stronger"*	
02:25 **10. [Narrator]** Preparations for this breakthrough began in early 2018, when astronomers travelled to ESO's Paranal observatory to make	

measurements of one of the most extreme gravitational laboratories.	
02:42 **11. Statement Reinhard Genzel:** "*Well you see the centre of our Milky Way, where we suspect there is a black hole, has stars orbiting this central black hole. And these stars are measurement objects, if you like. They test the gravity of the object"* *" There's one star in particular which we've been following now — believe it or not — for 25 years."*	
03:05 **[Narrator]** **12.** This star, called S2, recently passed very close to the black hole at a speed greater than 25 million kilometres per hour. Astronomers were ready and waiting to make the most of this unique opportunity with ESO's cutting-edge instruments.	
03:26 **13. Statement Stefan Gillessen:** "*In spring 2018, one of our best stars which flies around the black hole in the galactic centre actually comes closest to the black hole and that is what we want to observe and that's the event we want to follow."*	
03:40 **[Narrator]** **14.** Making these measurements pushed the power of ESO's Very Large Telescope to the limits.	
03:48 **15. Statement Frank Eisenhauer:** "*You need to get very sharp images, and the best way we can get sharp images is to make big telescopes"*	

03:55 **[Narrator]** **16.** Even with the impressive size of the Very Large Telescope, the only way to precisely measure the path of S2's high-speed trip around the supermassive black hole took some innovative telescope teamwork.	
04:11 **17. Statement Frank Eisenhauer:** *"We create a super telescope — in this case which is 130 metres in diameter."*	
04:18 **18. [Narrator]** Light from all four Unit Telescopes of the Very Large Telescope was combined by the GRAVITY instrument — giving astronomers the sensitivity they needed.	
04:31 **19:Statement Odele Straub:** "*We have all four telescope working together."* *"This combines the light from all four telescopes and this is GRAVITY"* **04:40** **Statement** **Françoise Delplancke-Ströbele:** *"It measures movement which is the equivalent of an astronaut on the Moon moving a flashlight by about 10 cm"*	
04:49 **[Narrator]** **20:** GRAVITY worked with another two of ESO's state-of-the art instruments to reveal an effect called gravitational redshift. This is visible when light from the star is stretched to longer wavelengths by the very strong gravitational field of the black hole.	

05:11 **21: Statement** **Françoise Delplancke-Ströbele:** "*For the discovery a combination of three instruments of ESO were used, NACO, SINFONI and GRAVITY, and all three of those are unique."*	
05:21 **22: [Narrator]** However, capturing the fine details of gravitational redshift was no easy task.	
05:29 **23: Statement Reinhard Genzel:** *"Uh. That was a long path. It was very, very difficult."* **05:33** **Statement** **Françoise Delplancke-Ströbele:** *"It's a long story — very bumpy! Not always easy, but very challenging."*	
05:39 **[Narrator]** **24:** This is the first time that this deviation from the predictions of simpler Newtonian gravity has been observed in the motion of a star around a supermassive black hole, and is the result of years of collaboration between ESO and other institutions.	
06:03 **25: Statement Linda Tacconi:** "*This is one of the huge benefits of ESO, and the way ESO works is that there is always a very strong collaboration between ESO and institutes in its member states, which is very unique in the world because it enables ESO and the ESO Members to undertake projects like GRAVITY"*	

06:27 **[Narrator]** **26.** Thanks to ESO's international collaborations and instruments, astronomers were able to witness the spectacle of a star hurtling past a supermassive black hole — providing a perfect cosmic experiment to test our understanding of physics.	
06:47 **[Narrator]** **27.** More than one hundred years after he published the paper setting out the equations of general relativity, Einstein has been proven right once more — in a more extreme laboratory than he could have possibly imagined!	
07:13 **[Outro]**	*Produced by ESO, the European Southern Observatory.* *Reaching new heights in Astronomy.*

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