Key words: EHT, black hole image, Sgr A*, Milky Way centre

What it Takes to Image a Black Hole (ESOcast Episode 255)	
00:00 **[Visual starts]** **New ESOcast intro**	New ESOcast introduction
Title: What it Takes to Image a Black Hole	
1. Imaging a black hole seems like an impossible dream. After all, they are black and do not emit light, so how can we see them?	
2. Well, with a telescope big enough, we could at least see the immediate surroundings of the largest black holes — the supermassive ones that are millions or even billions of times heavier than our Sun — and then unveil some of the mysterious secrets these monsters hide.	
3. Except that, when you do the maths, you find that to observe even the closest supermassive black holes you'd need a telescope the size of the Earth, something beyond our wildest dreams. Or maybe not?	

4. A few years ago, 300 astronomers from nearly 80 institutes across the globe joined forces and found a way to create a telescope as large as our planet. And they did it without using new mirrors, screws or steel — their Event Horizon Telescope, or EHT, is not a real telescope, but a virtual one.	
5. The stroke of genius of the EHT collaboration was in using powerful radio telescopes that already exist, including ALMA and APEX, co-owned by ESO. They combined their observations with a technique called very-long-baseline interferometry, in a way no one had ever attempted before.	
6. This may sound like sci-fi, but it actually works, as the EHT team showed back in 2019. That's when they revealed the supermassive object at the centre of the M87 galaxy to the world, 55 million light years away — the very first image of a black hole! To understand exactly how hard that was let us drop in some facts.	
7. First of all, you should know that the EHT telescopes could not "see" the black hole itself, as it is invisible. Rather, they picked up the radio signals from the hot, glowing gas around it and imaged the shadow the black hole casts on it.	
8. Moreover, the telescope antennas in the EHT array had to be pointed to *exactly* the same position in the sky at *exactly* the same time. The EHT can tell if one of its telescopes, which are located thousands of kilometers apart, is off by just a millimetre and if the timing is shifted by a trillionth of a second.	

9. Further, imaging the black hole in M87 required combining the observations of *all* telescopes in the network, to allow astronomers to get a clear picture.	
10. On top of that, interferometry works best if you have many telescopes, which wasn't the case. The team had 8, though now the network has grown to 11. So the EHT team had to develop special algorithms to be able to fill in the gaps and reconstruct their image. It was like staring at a puzzle with most pieces missing, trying to figure out what the whole image would look like.	
11. To determine if the result was scientifically bullet-proof they used a variety of methods: computer simulations to identify errors introduced by their telescope network, different teams working in isolation on reconstructing the image in different ways, new techniques and software… It took years of work until they were sure they had done it right. Only then did they show their image to the world.	
12. The result was like peering at the black hole in M87 with a telescope almost the size of the Earth. An instrument so powerful that it could see details as small as a donut on the Moon.	
13. So what's next for the EHT? The team have already pointed their telescopes to their next target: Sgr A*, the supermassive black hole at the heart of the Milky Way — *our* black hole.	
14. Sgr A* is much closer to Earth than the supermassive black hole in M87, so you may think that imaging it is a piece of cake in	

comparison. Sorry to disappoint you, it's even more difficult.	
15. First, the centre of the Milky Way is obscured to us by clouds of dust and hot gas that scatter the radio signals coming from around the black hole.	
16. More, because Sgr A* is about 1500 times less massive than its brother in M87, its radio signals change far more rapidly in time. It has blobs of plasma orbiting around it every few minutes, whereas those of M87 orbit it every few days. This forces astronomers to adapt their algorithms and develop new techniques to get stable images. A bit like trying to read the brand on a basketball while spinning it on your finger!	
17. In the end the EHT Team did manage to overcome all these obstacles. So here it is: The first image of Sgr A* – the black hole at the centre of the Milky Way.	
06:55 **[Outro]**	*Produced by ESO, the European Southern Observatory.* *Reaching new heights in Astronomy.*
	Also interesting: https://www.youtube.com/watch?v=rIQLA6lo6R0 and https://www.youtube.com/watch?v=omz77qrDjsU