

Back in 1967...

Do you know ....

the true nature of these mysterious objects; something like holes in the Universe?



**Einstein**

In 1915, the legendary scientist Albert Einstein established the theory of general relativity.

$E=mc^2$

Dr. John Wheeler

And...

$ds^2 = -\left(1 - \frac{2GM}{c^2 r}\right) c^2 dt^2 + \frac{dr^2}{1 - \frac{2GM}{c^2 r}} + r^2(d\theta^2 + \sin^2\theta d\phi^2)$

$r=0$  特点

$r=R_s = \frac{2GM}{c^2}$

It is difficult...

in 1916, a physicist Karl Schwarzschild found a weird but interesting solution to Einstein's equation.

**Karl Schwarzschild**

His solution shows that it is theoretically possible for something to have such strong gravity that ...

even light cannot escape.

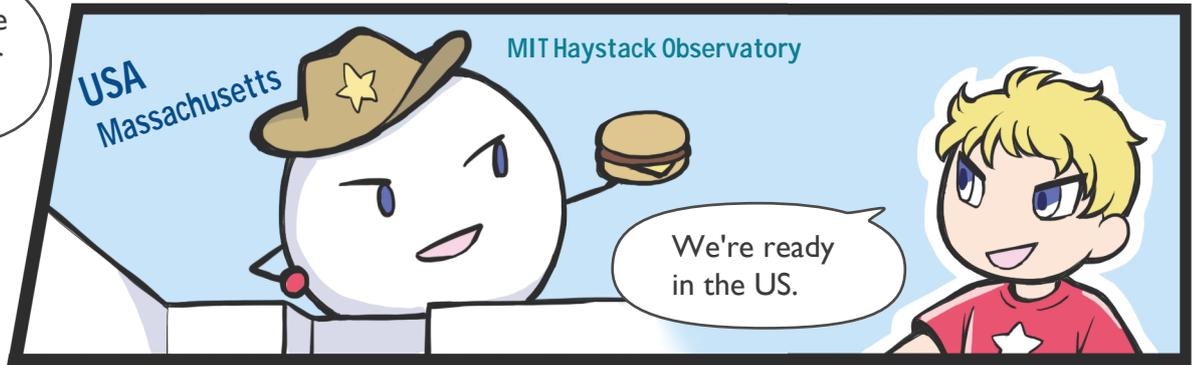
It is something like a bottomless hole in the Universe. Now we call this...

a "BLACK HOLE."

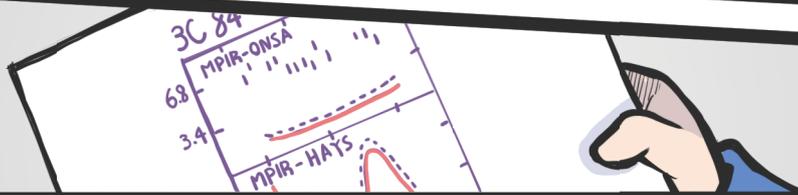
In 1982...

... this is only the first try,

but it could enhance the capability of our radio telescope

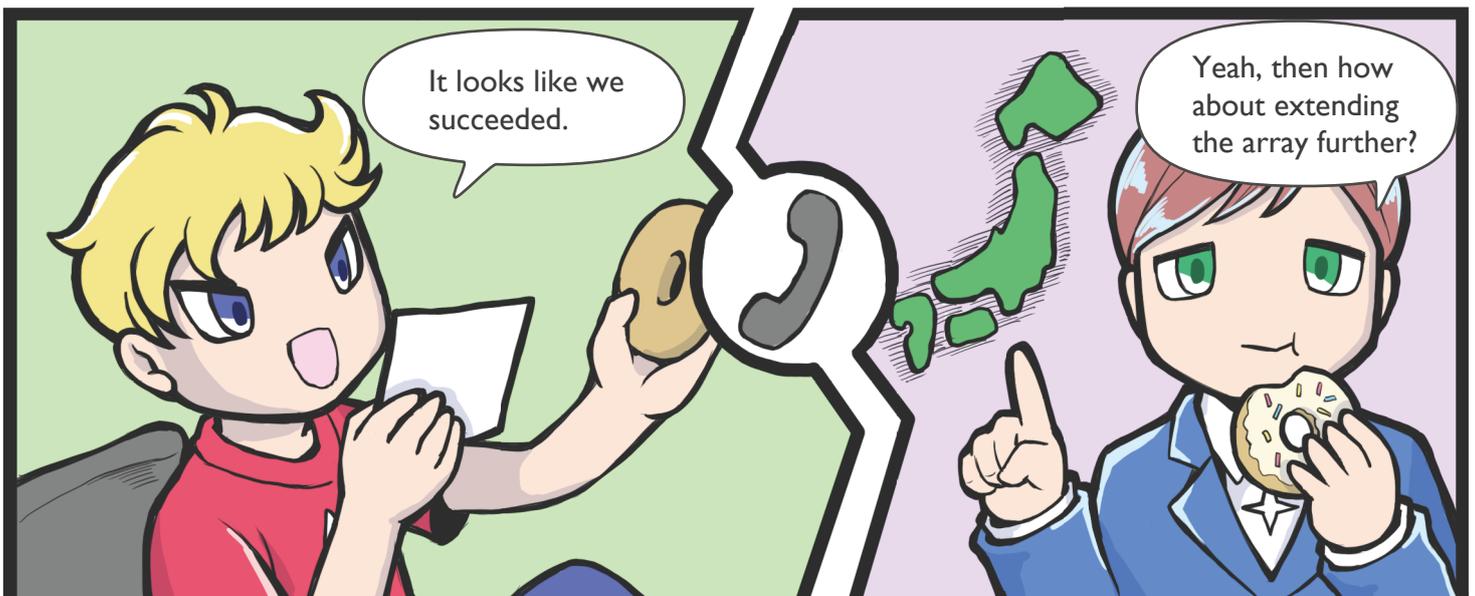


Well done!



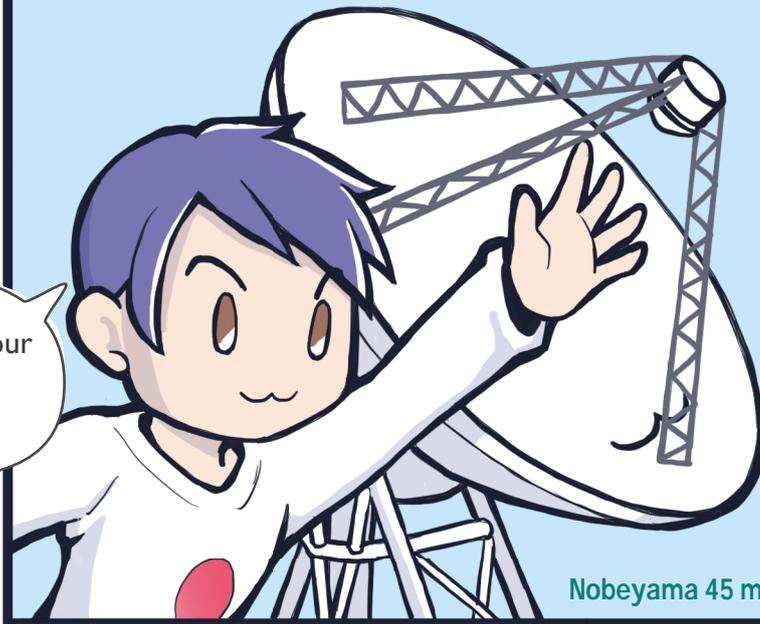
It looks like we succeeded.

Yeah, then how about extending the array further?



In 1985...

We'll help with our Nobeyama 45 m telescope!



Welcome, Japan!

We succeeded in making transatlantic observations, so the next step is to go global.

Japan

Nobeyama 45 m Telescope



Let's include an Asian telescope to enhance the telescope power.



We now have new telescopes too.

OVRO 40m



Good!

We got even higher resolution!



The future of this project is really promising.

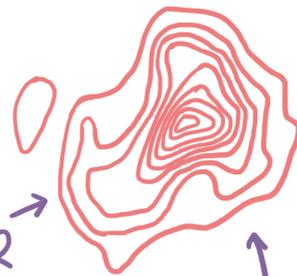


3C84

J2

J1

0.04 pc  
100 μas



Hey, we can go much further!



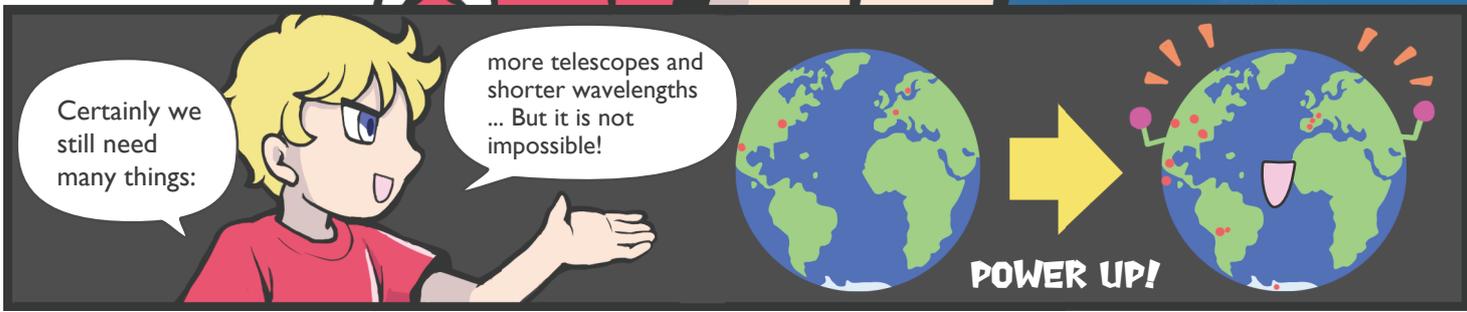
What?



Our goal is a ...

BLACK HOLE!

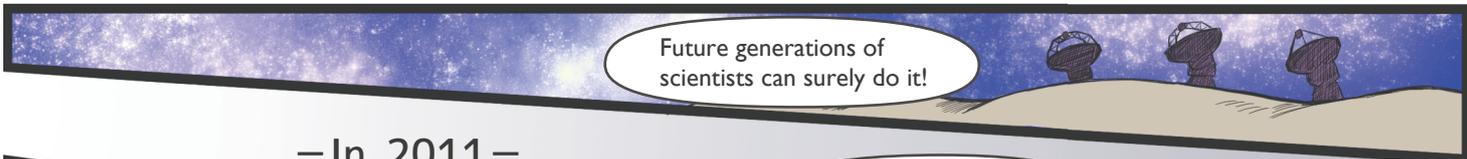
Cool!



Certainly we still need many things:

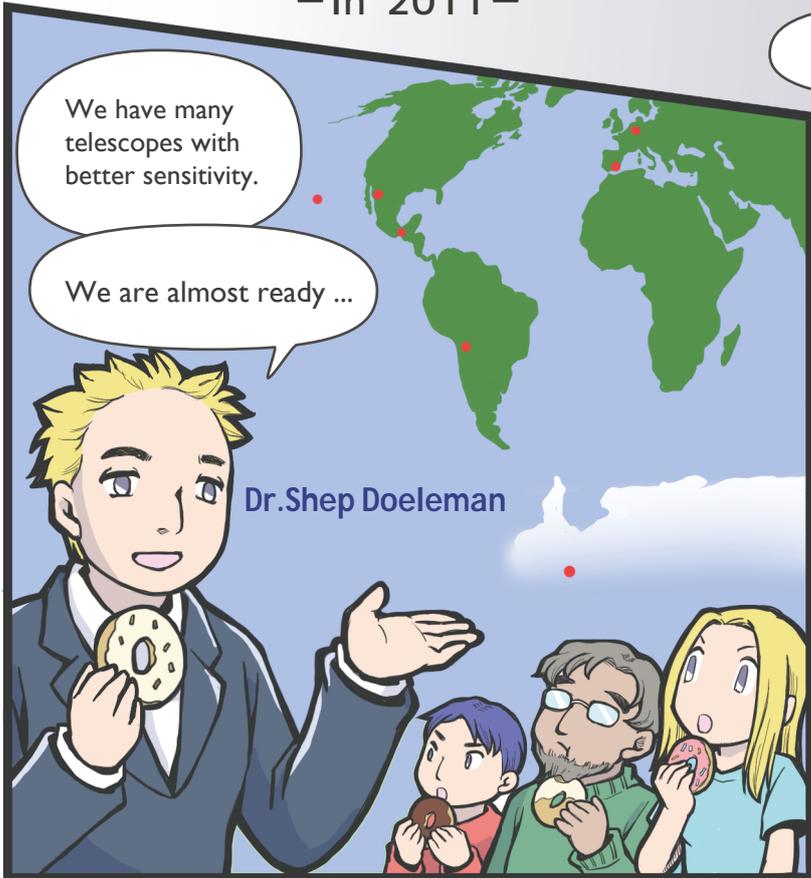
more telescopes and shorter wavelengths ... But it is not impossible!

POWER UP!



Future generations of scientists can surely do it!

— In 2011 —



We have many telescopes with better sensitivity.

We are almost ready ...

Dr. Shep Doeleman

Now, is the time!



to take the very first image of a ...

BLACK HOLE!



Finally!

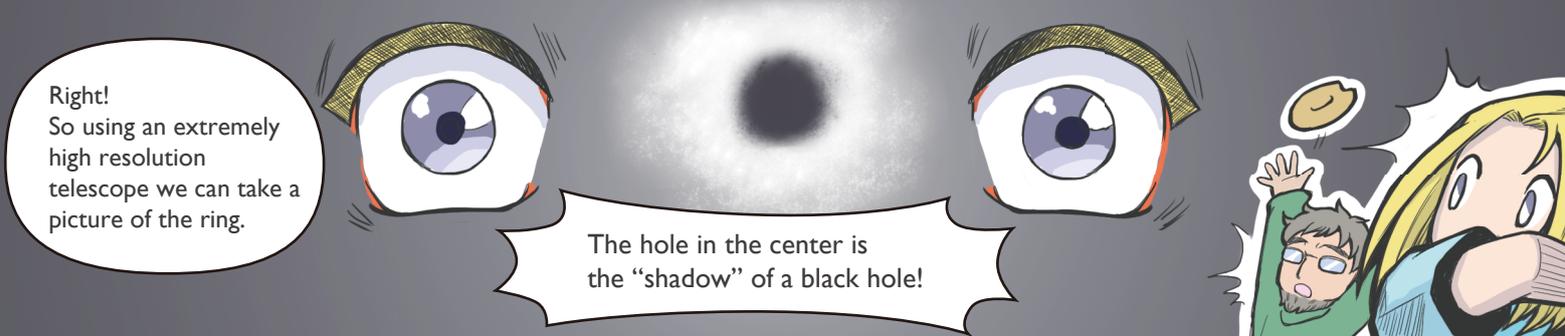
Wait, even light can not escape from a black hole. How can we take an image of such an invisible hole?

Good question! But there is no problem.



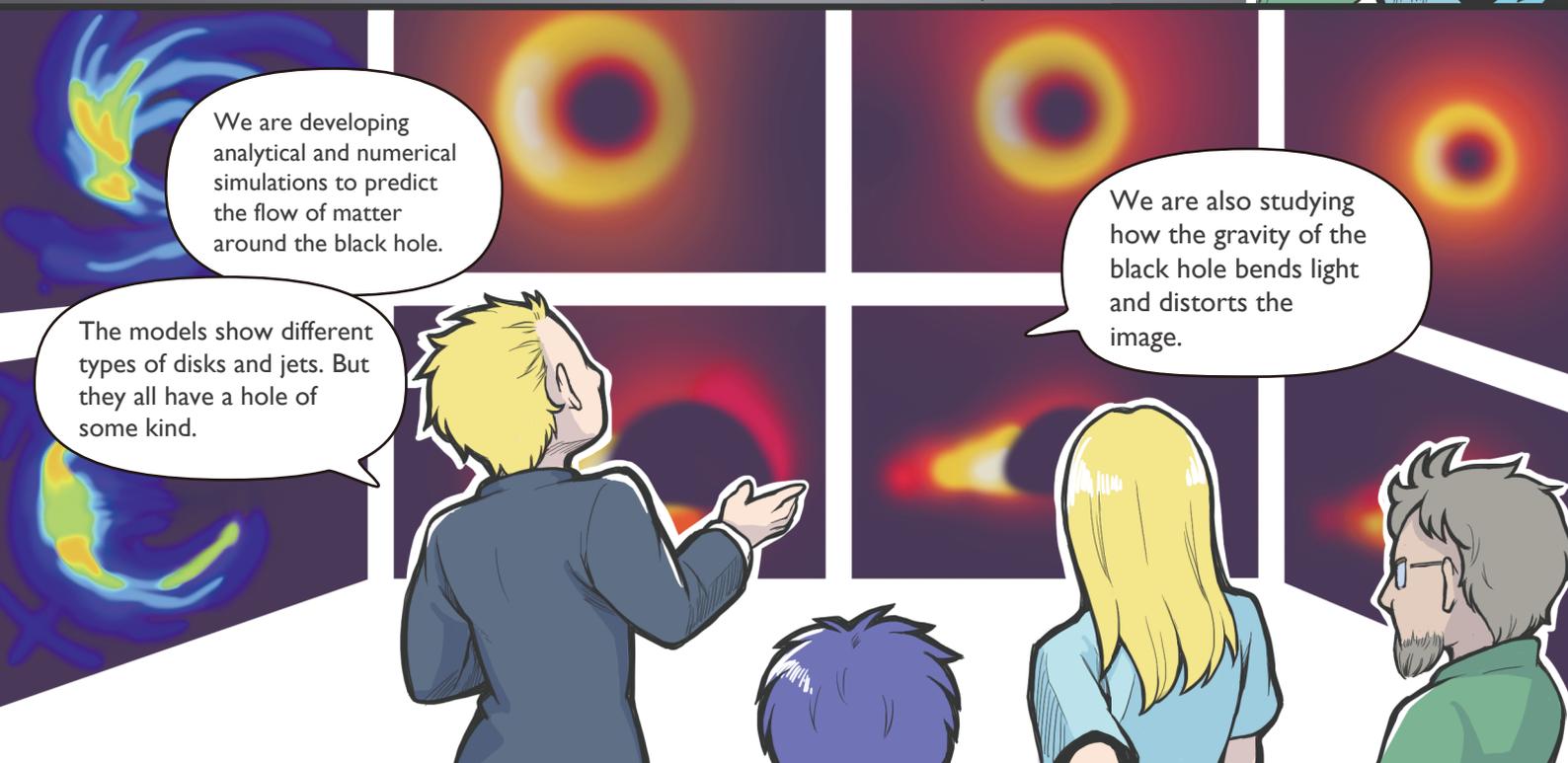
There should be a disk of hot gas around a black hole.

Aha, then the disk will emit radio waves.



Right! So using an extremely high resolution telescope we can take a picture of the ring.

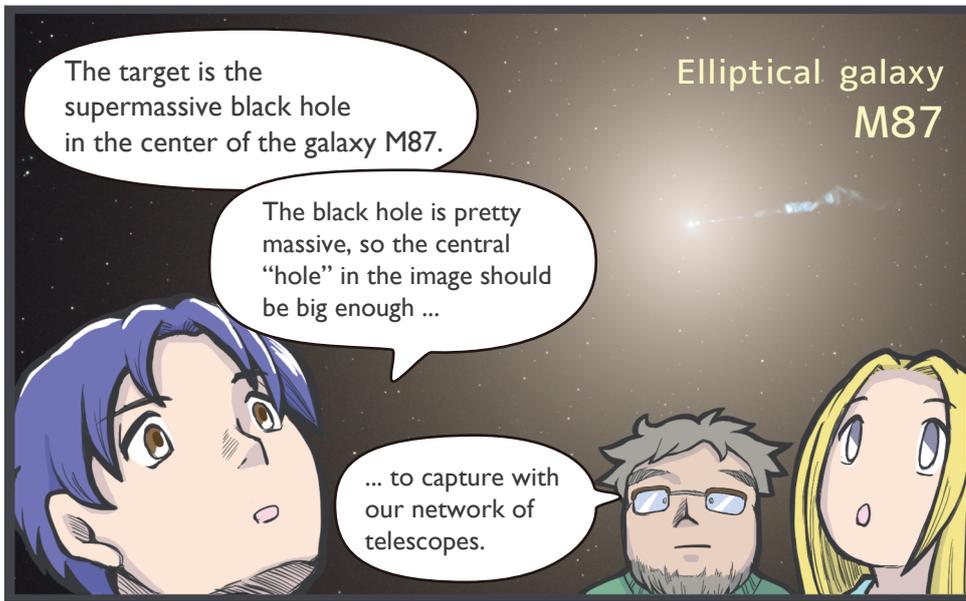
The hole in the center is the "shadow" of a black hole!



We are developing analytical and numerical simulations to predict the flow of matter around the black hole.

The models show different types of disks and jets. But they all have a hole of some kind.

We are also studying how the gravity of the black hole bends light and distorts the image.

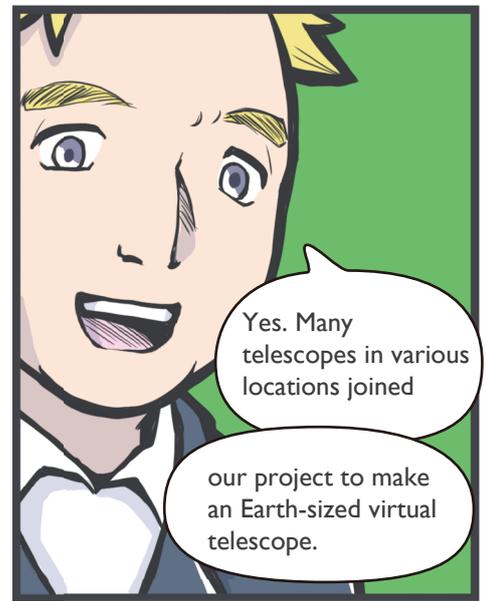


Elliptical galaxy  
M87

The target is the supermassive black hole in the center of the galaxy M87.

The black hole is pretty massive, so the central "hole" in the image should be big enough ...

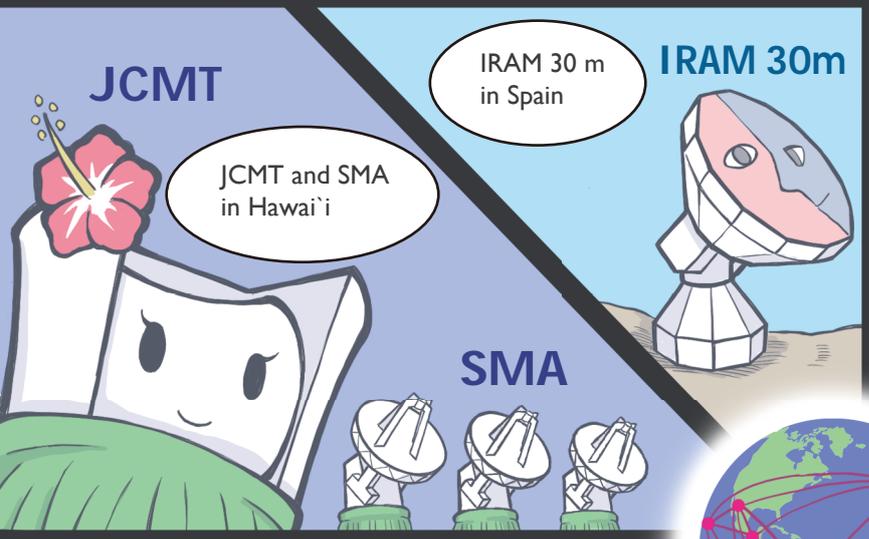
... to capture with our network of telescopes.



Yes. Many telescopes in various locations joined

our project to make an Earth-sized virtual telescope.

Credits: NASA, ESA and the Hubble Heritage Team (STScI/AURA); Acknowledgment: P. Cote (Herzberg Institute of Astrophysics) and E. Baltz (Stanford University)



JCMT

JCMT and SMA in Hawai'i

IRAM 30 m in Spain

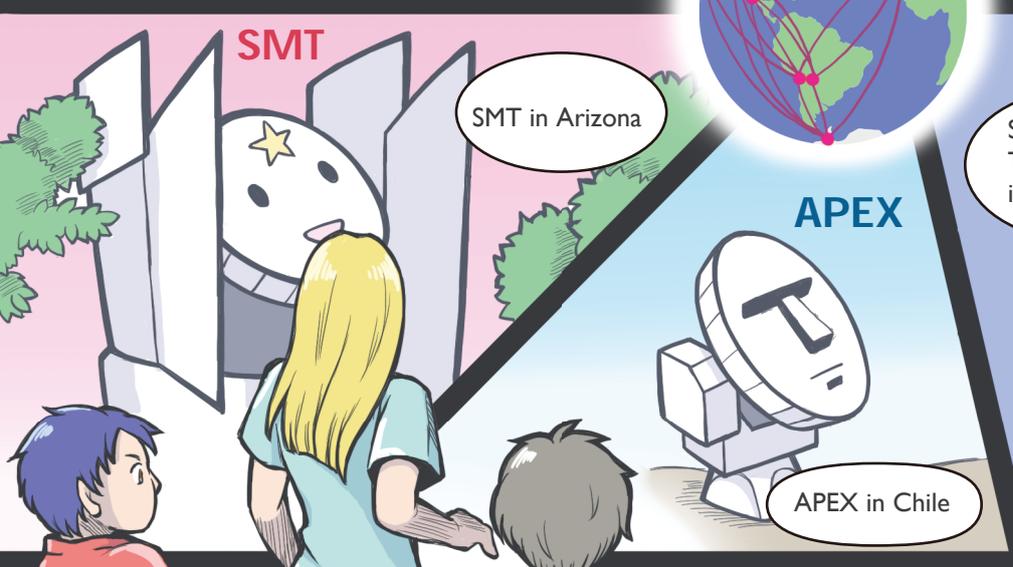
IRAM 30m

SMA



LMT

LMT in Mexico

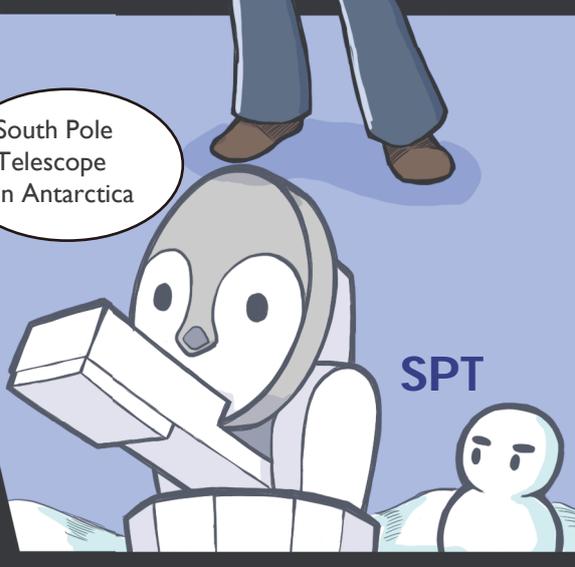


SMT

SMT in Arizona

APEX

APEX in Chile



South Pole Telescope in Antarctica

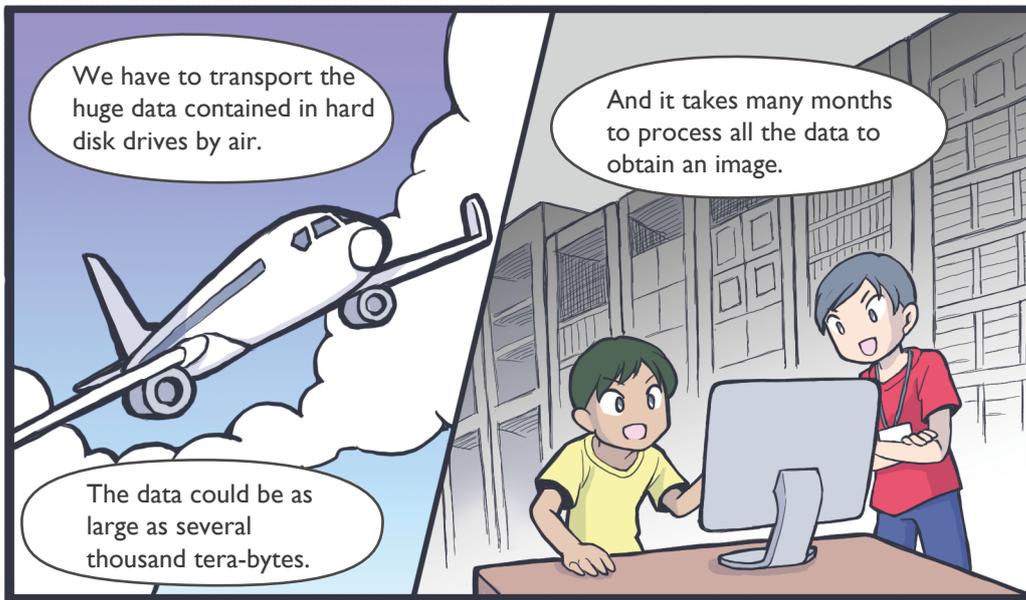
SPT



ALMA

And the brandnew ALMA in Chile.

It is not an easy job coordinating all the telescopes.



We have to transport the huge data contained in hard disk drives by air.

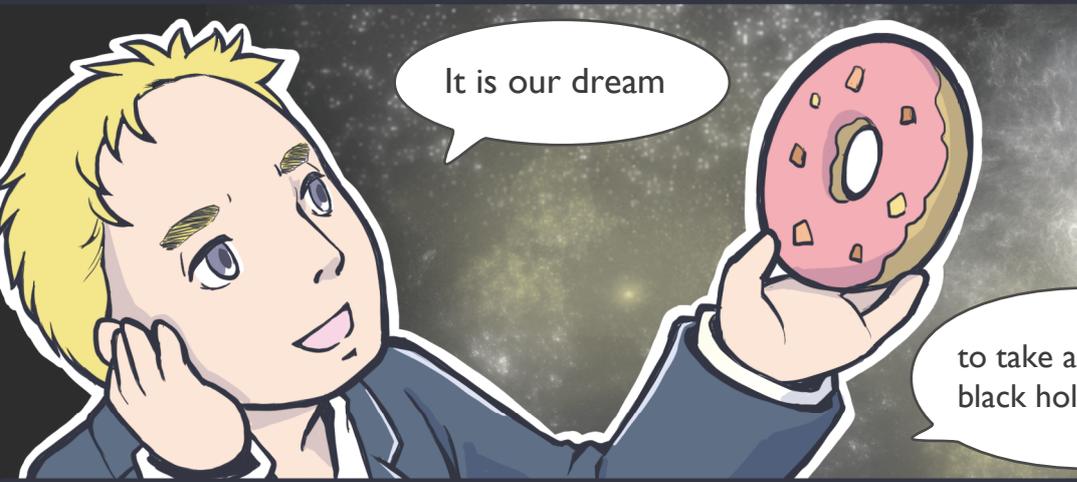
And it takes many months to process all the data to obtain an image.

The data could be as large as several thousand tera-bytes.



We have many things to overcome.

But, it is worth it!



It is our dream

to take a real photo of a black hole and ....



it will be a giant leap for mankind, not only in astronomy.



—In 2019—

Yes, we got the image, but this is just the beginning.

Right!

Hey guys!

We can do more!



How about starting a BLACK HOLE doughnut shop?

**BLACKHOLE Doughnut**



That's "one" thing we can do.