Introducing the accelerator for the future!

The International Linear Collider
An accelerator with the best view on the Big Bang
Is it coming to Japan?

international linear collider

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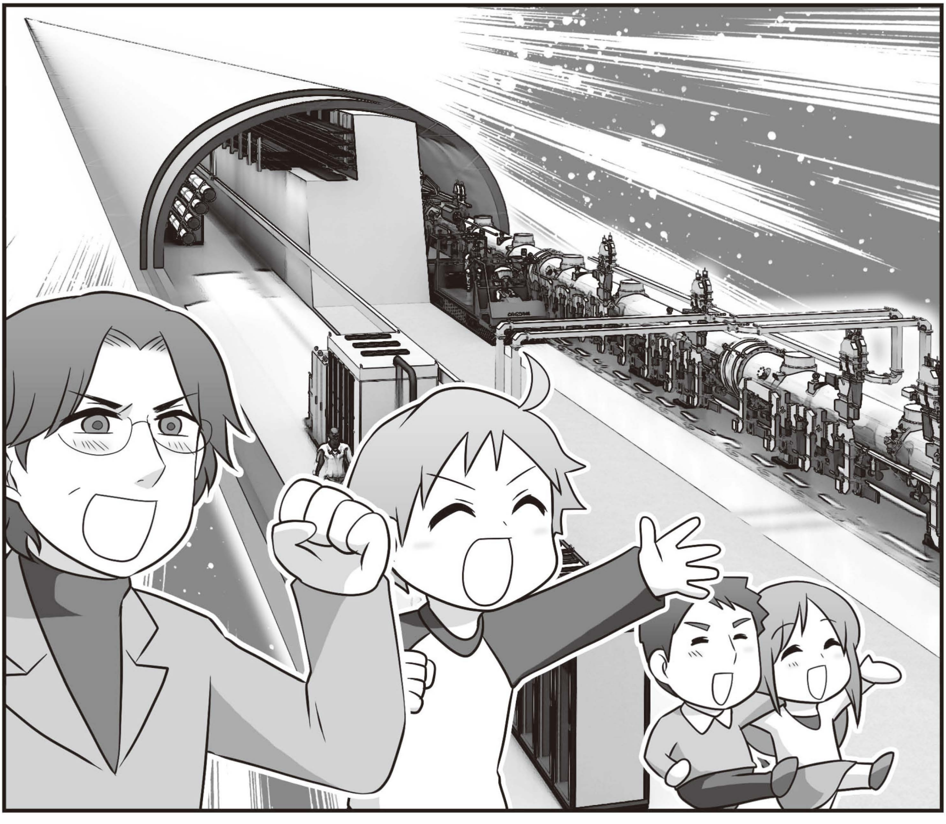

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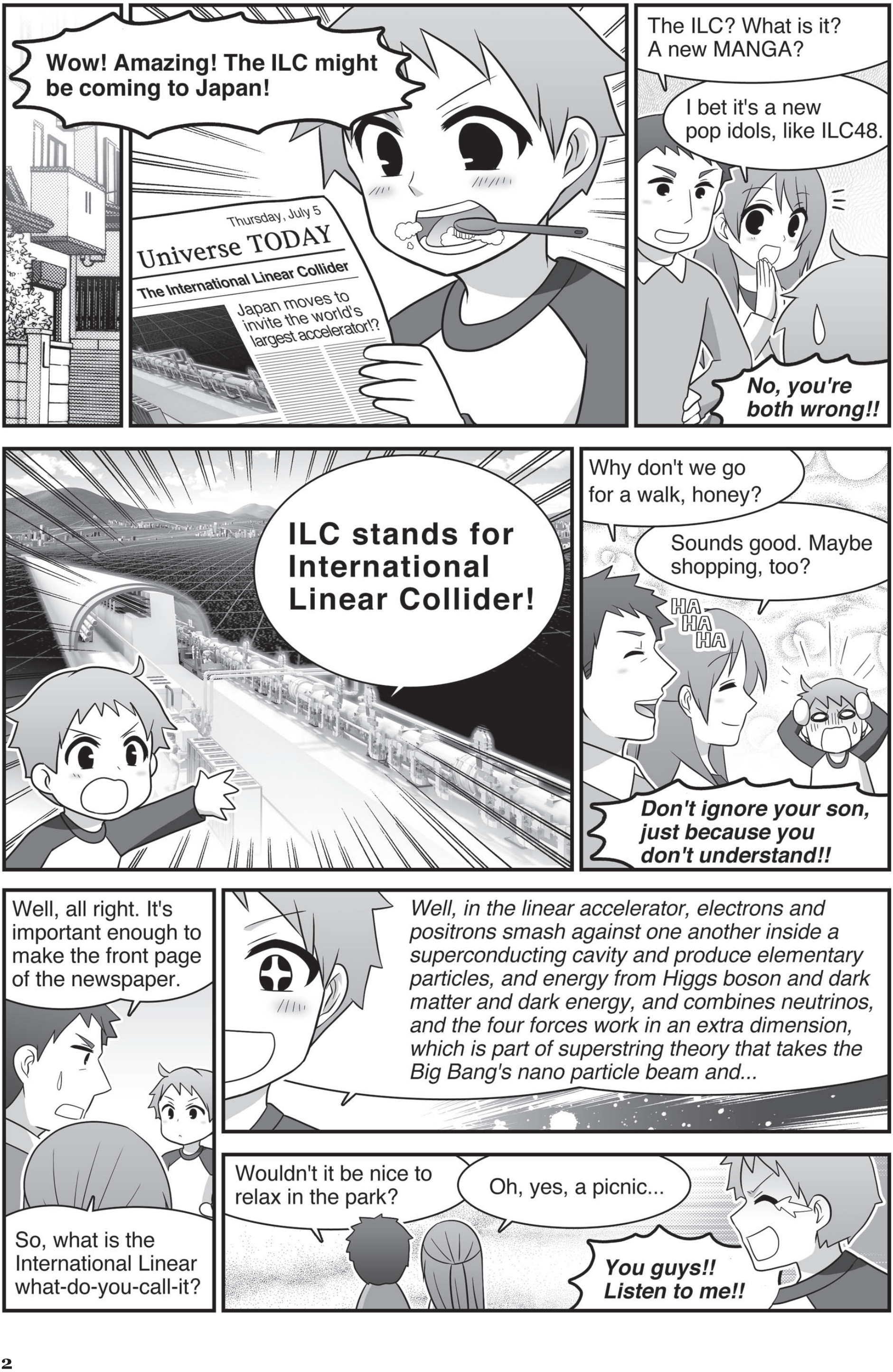
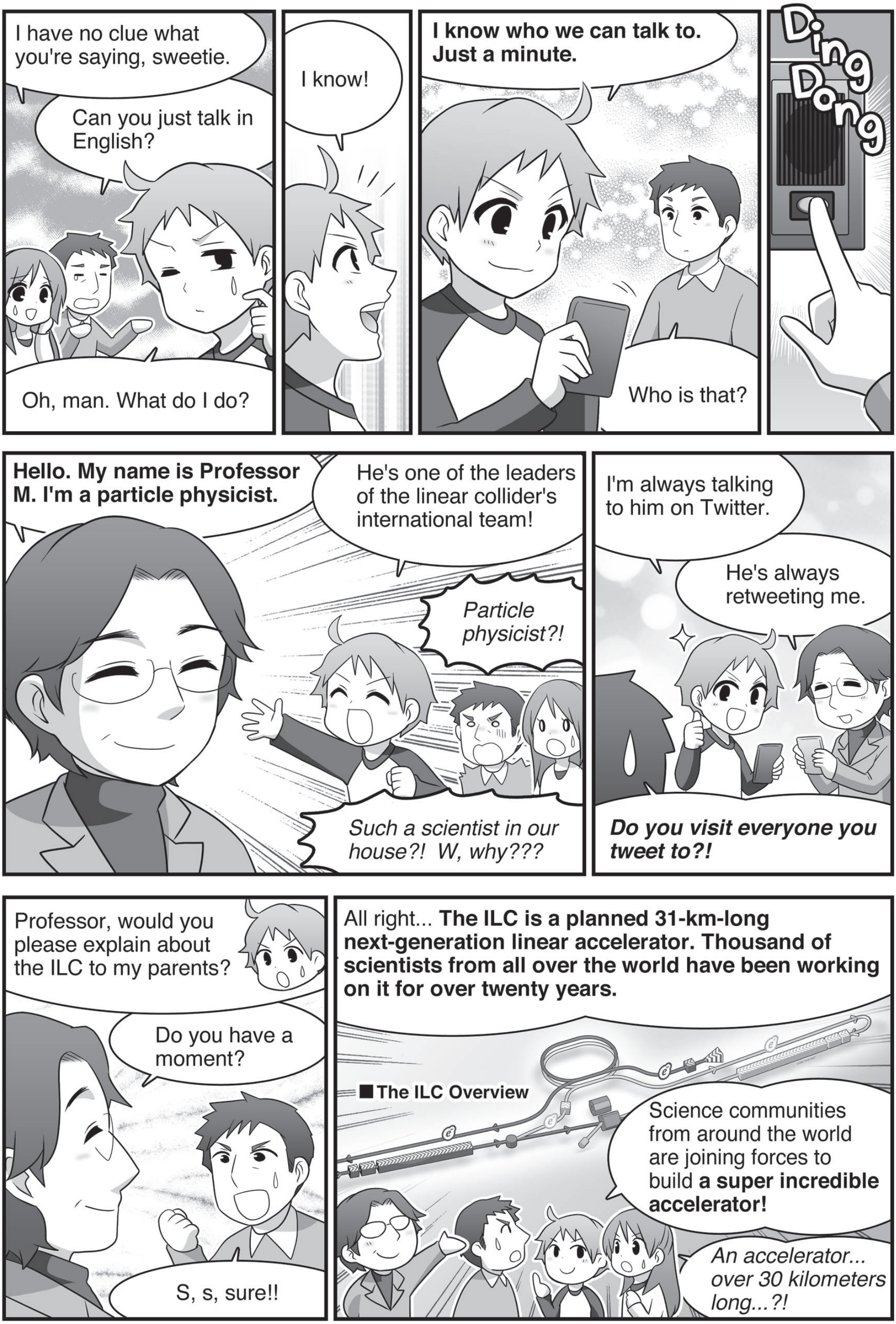
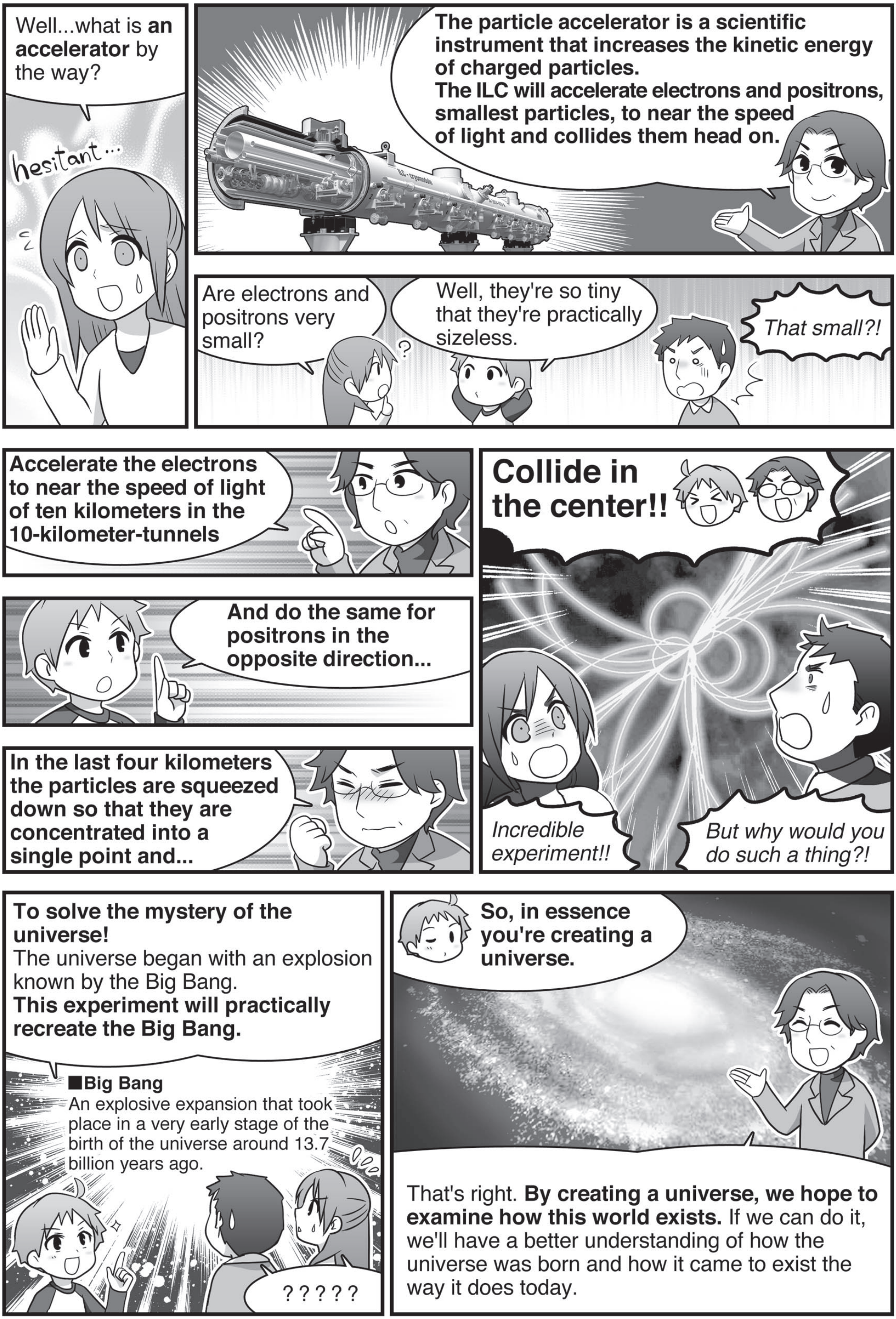
Production : Uruno Creative Office

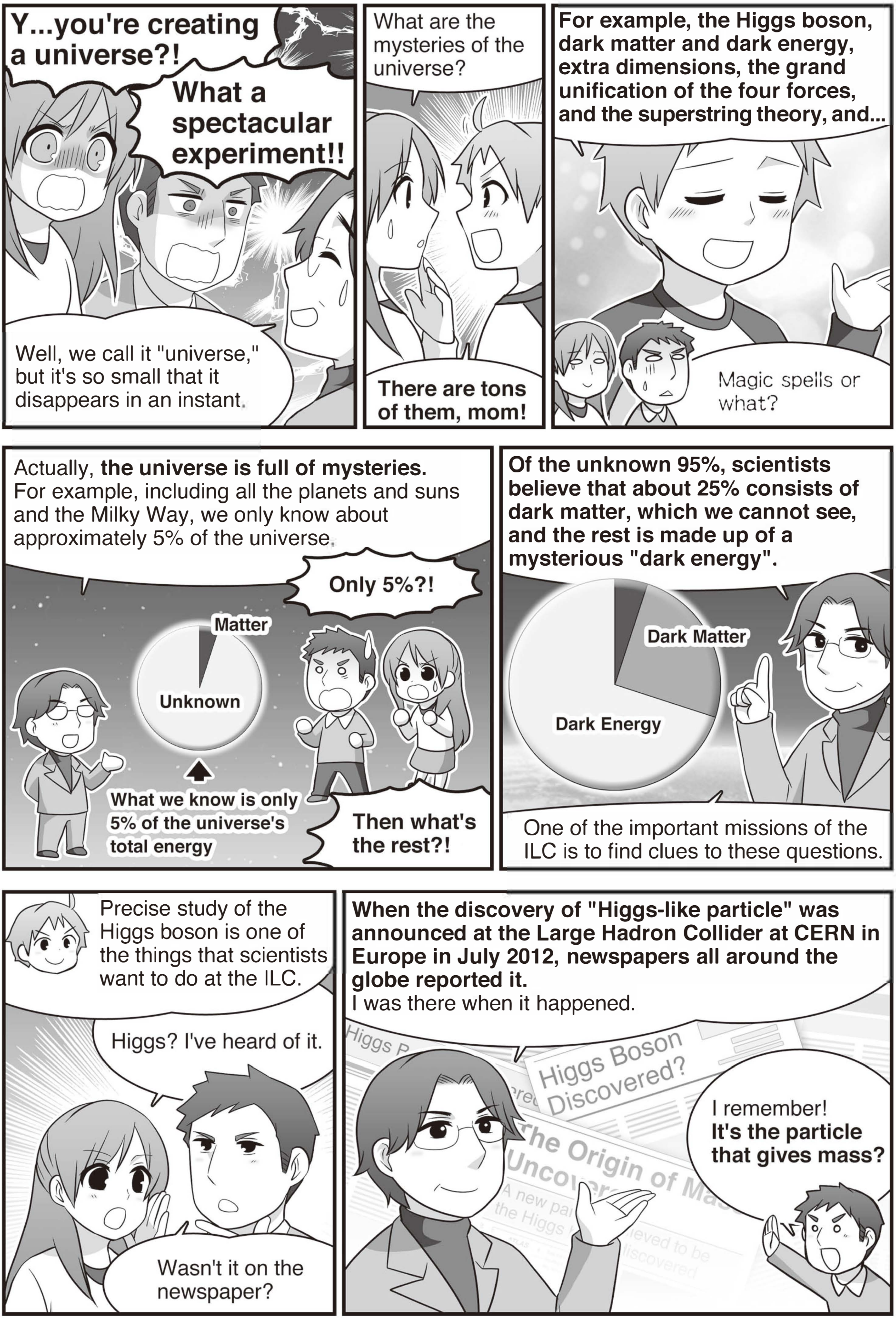


Wow! Amazing! The ILC might be coming to Japan!
Thursday, July 5
Universe TODAY
The International Linear Collider
Japan moves to invite the world's largest accelerator!?
The ILC? What is it? A new MANGA?
I bet it's a new pop idols, like ILC48.
No, you're both wrong!!
ILC stands for International Linear Collider!
Why don't we go for a walk, honey?
Sounds good. Maybe shopping, too?
HA HA HA
Don't ignore your son, just because you don't understand!!
Well, all right. It's important enough to make the front page of the newspaper.
So, what is the International Linear what-do-you-call-it?
Well, in the linear accelerator, electrons and positrons smash against one another inside a superconducting cavity and produce elementary particles, and energy from Higgs boson and dark matter and dark energy, and combines neutrinos, and the four forces work in an extra dimension, which is part of superstring theory that takes the Big Bang's nano particle beam and...
Wouldn't it be nice to relax in the park?
Oh, yes, a picnic...
You guys!! Listen to me!!

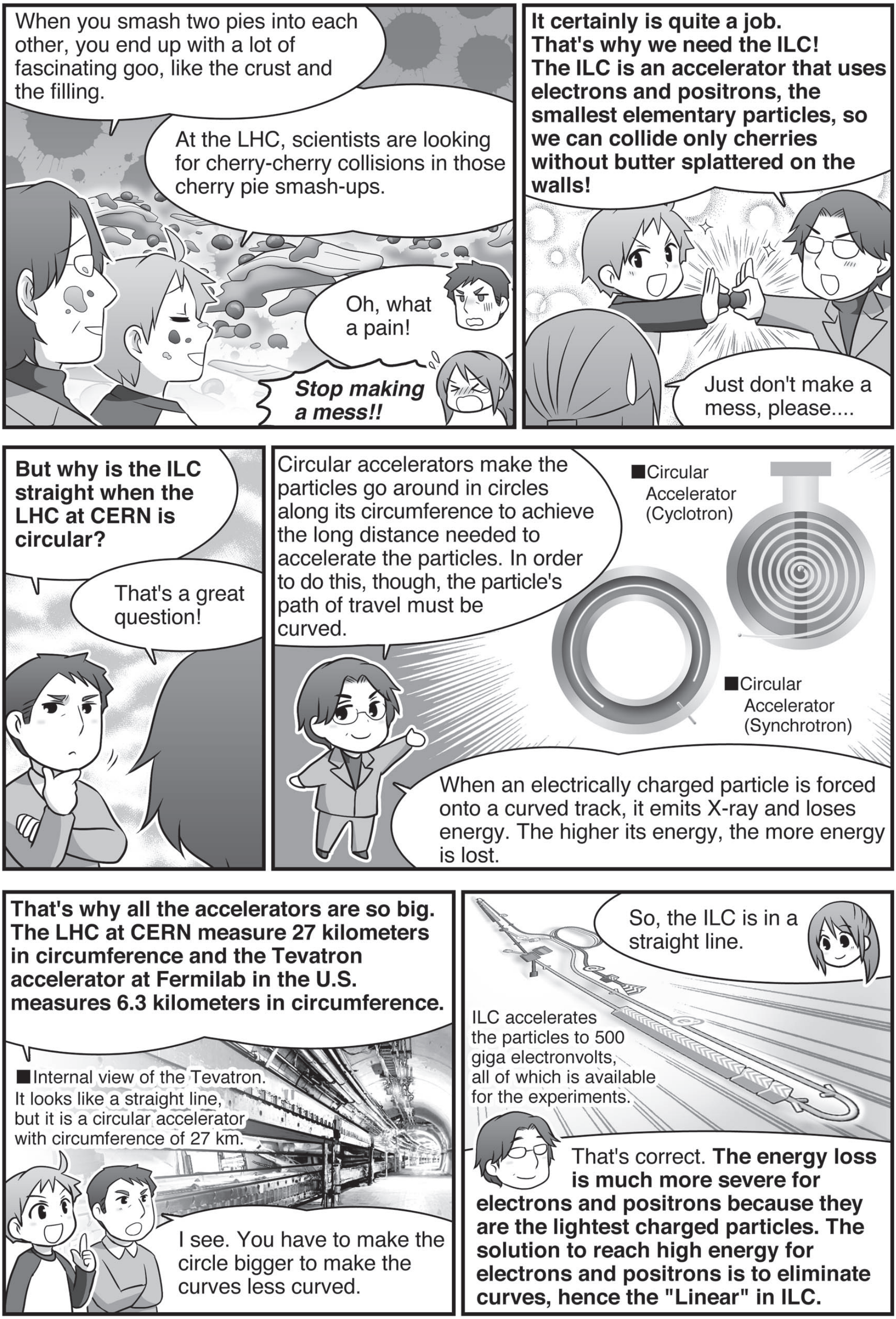

I have no clue what you're saying, sweetie.
Can you just talk in English?
Oh, man. What do I do?
I know!
I know who we can talk to. Just a minute.
Who is that?
Ding Dong
Hello. My name is Professor M. I'm a particle physicist.
He's one of the leaders of the linear collider's international team!
Particle physicist?!
Such a scientist in our house?! W, why???
I'm always talking to him on Twitter.
He's always retweeting me.
Do you visit everyone you tweet to?!
Professor, would you please explain about the ILC to my parents?
Do you have a moment?
S, s, sure!!
All right... **The ILC is a planned 31-km-long next-generation linear accelerator. Thousand of scientists from all over the world have been working on it for over twenty years.**
■ The ILC Overview
Science communities from around the world are joining forces to build **a super incredible accelerator!**
An accelerator... over 30 kilometers long...?!

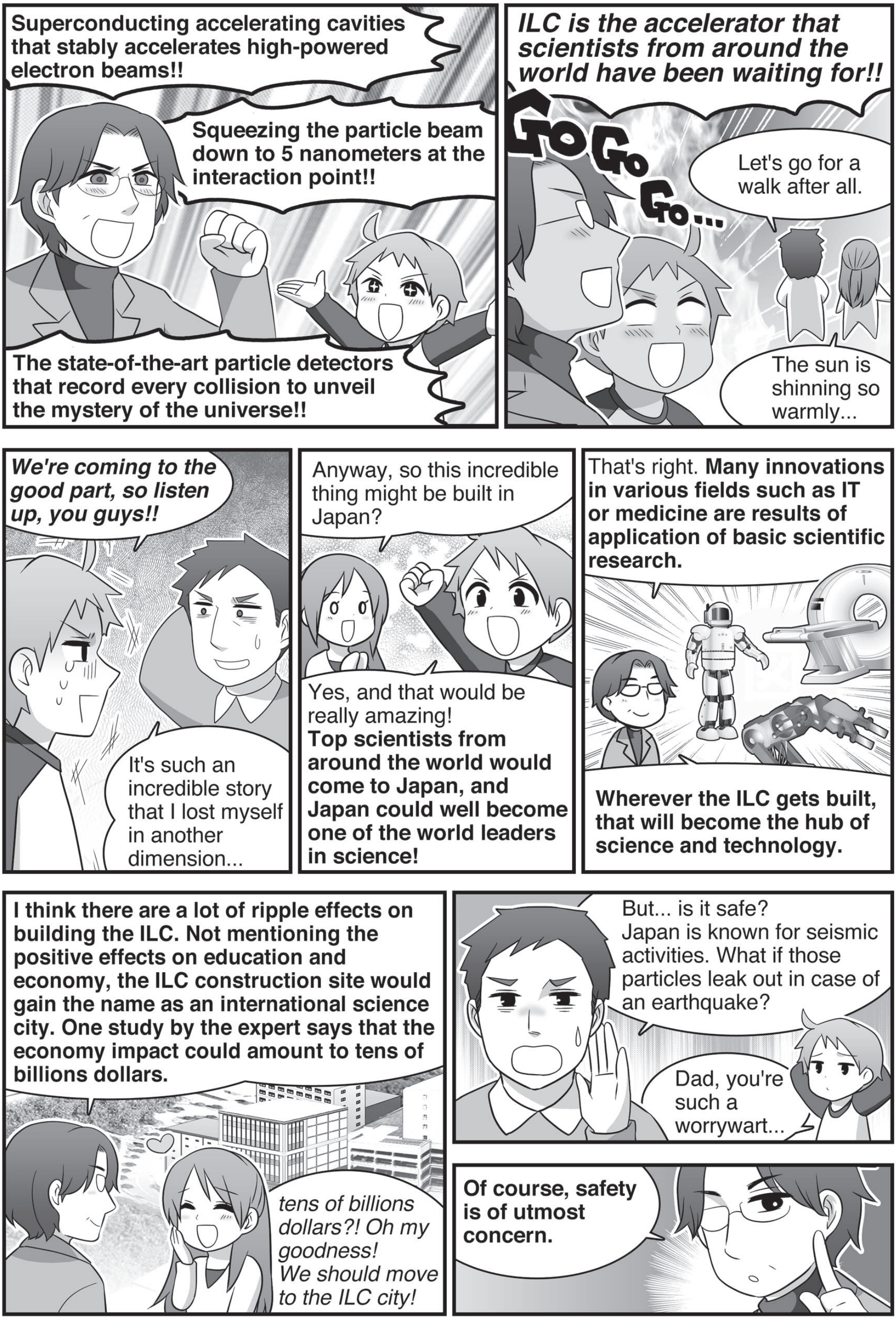


Well...what is **an accelerator** by the way?
hesitant...
The particle accelerator is a scientific instrument that increases the kinetic energy of charged particles.
The ILC will accelerate electrons and positrons, smallest particles, to near the speed of light and collides them head on.
Are electrons and positrons very small?
Well, they're so tiny that they're practically sizeless.
That small?!
Accelerate the electrons to near the speed of light of ten kilometers in the 10-kilometer-tunnels
And do the same for positrons in the opposite direction...
In the last four kilometers the particles are squeezed down so that they are concentrated into a single point and...
Collide in the center!!
Incredible experiment!!
But why would you do such a thing?!
To solve the mystery of the universe! The universe began with an explosion known by the Big Bang. **This experiment will practically recreate the Big Bang.**
■**Big Bang**
An explosive expansion that took place in a very early stage of the birth of the universe around 13.7 billion years ago.
?????
So, in essence you're creating a universe.
That's right. **By creating a universe, we hope to examine how this world exists.** If we can do it, we'll have a better understanding of how the universe was born and how it came to exist the way it does today.

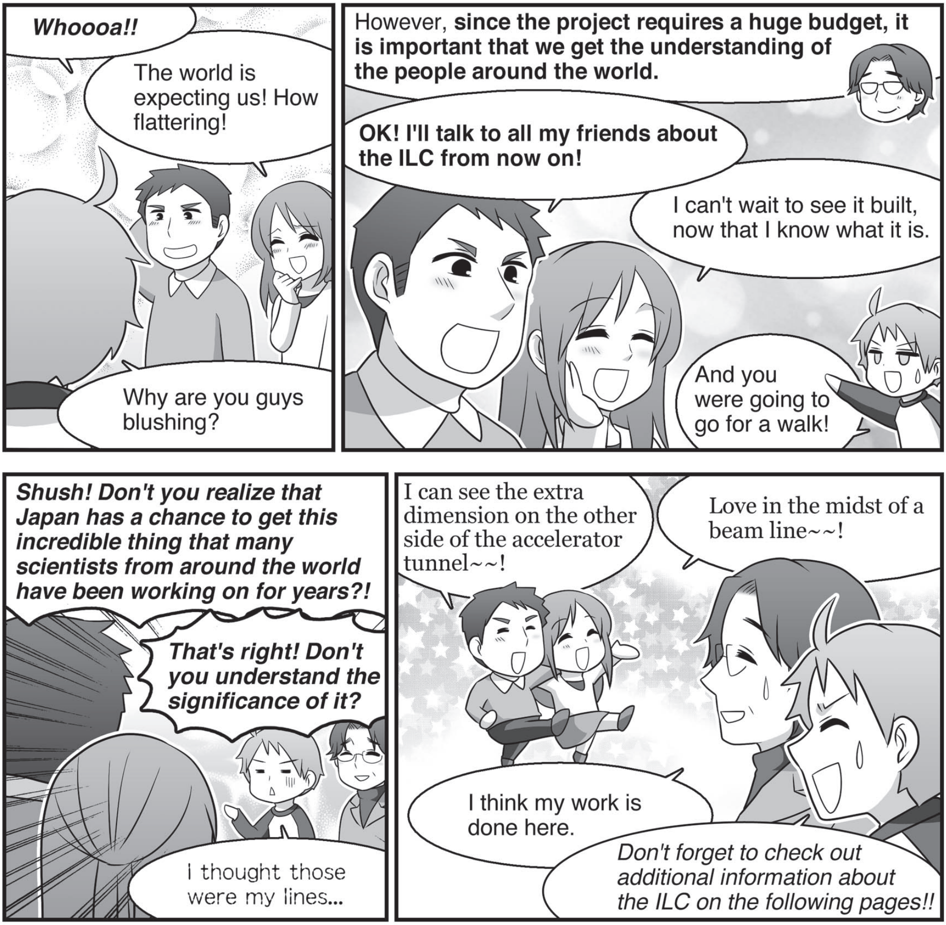

Y...you're creating a universe?!
What a spectacular experiment!!
Well, we call it "universe," but it's so small that it disappears in an instant.
What are the mysteries of the universe?
There are tons of them, mom!
For example, the Higgs boson, dark matter and dark energy, extra dimensions, the grand unification of the four forces, and the superstring theory, and...
Magic spells or what?
Actually, the universe is full of mysteries. For example, including all the planets and suns and the Milky Way, we only know about approximately 5% of the universe.
Only 5%?!
Matter
Unknown
What we know is only 5% of the universe's total energy
Then what's the rest?!
Of the unknown 95%, scientists believe that about 25% consists of dark matter, which we cannot see, and the rest is made up of a mysterious "dark energy".
Dark Matter
Dark Energy
One of the important missions of the ILC is to find clues to these questions.
Precise study of the Higgs boson is one of the things that scientists want to do at the ILC.
Higgs? I've heard of it.
Wasn't it on the newspaper?
When the discovery of "Higgs-like particle" was announced at the Large Hadron Collider at CERN in Europe in July 2012, newspapers all around the globe reported it. I was there when it happened.
Higgs Boson Discovered?
I remember! It's the particle that gives mass?

That's right. It's because of the Higgs boson (the Higgs field) that matter has mass.
Without the Higgs boson, the particles that make up our bodies would scatter at the speed of light.
Yikes!!
Thank goodness it was discovered!
But just discovering the Higgs boson is not enough.
We call it the Higgs particle, like only one particle exist, but it poses a lot of possibilities. It could be that there can be more than one Higgs boson. The slightest differences in the Higgs' characteristics are critical information that might unlock the mysteries of the universe.
That's why we need the ILC!
Isn't the accelerator in Europe enough?
Well, the LHC is also a wonderful accelerator, but...
The LHC uses protons, which are complex particles.
What do you mean?
In other words...
Think of them as cherry pies, which are made up of many ingredients....
The cherries in the pie represent the elementary particles.
We want to know what happens when the elementary particles, that is, the cherries, collide with one another...
So...
We collide them!!
BAM!!
Yes!!
Whoa!!


When you smash two pies into each other, you end up with a lot of fascinating goo, like the crust and the filling.
At the LHC, scientists are looking for cherry-cherry collisions in those cherry pie smash-ups.
Oh, what a pain!
Stop making a mess!!
It certainly is quite a job. That's why we need the ILC! The ILC is an accelerator that uses electrons and positrons, the smallest elementary particles, so we can collide only cherries without butter splattered on the walls!
Just don't make a mess, please....
But why is the ILC straight when the LHC at CERN is circular?
That's a great question!
Circular accelerators make the particles go around in circles along its circumference to achieve the long distance needed to accelerate the particles. In order to do this, though, the particle's path of travel must be curved.
■Circular Accelerator (Cyclotron)
■Circular Accelerator (Synchrotron)
When an electrically charged particle is forced onto a curved track, it emits X-ray and loses energy. The higher its energy, the more energy is lost.
That's why all the accelerators are so big. The LHC at CERN measure 27 kilometers in circumference and the Tevatron accelerator at Fermilab in the U.S. measures 6.3 kilometers in circumference.
■Internal view of the Tevatron. It looks like a straight line, but it is a circular accelerator with circumference of 27 km.
I see. You have to make the circle bigger to make the curves less curved.
So, the ILC is in a straight line.
ILC accelerates the particles to 500 giga electronvolts, all of which is available for the experiments.
That's correct. The energy loss is much more severe for electrons and positrons because they are the lightest charged particles. The solution to reach high energy for electrons and positrons is to eliminate curves, hence the "Linear" in ILC.


Superconducting accelerating cavities that stably accelerates high-powered electron beams!!
Squeezing the particle beam down to 5 nanometers at the interaction point!!
The state-of-the-art particle detectors that record every collision to unveil the mystery of the universe!!
ILC is the accelerator that scientists from around the world have been waiting for!!
GO Go Go...
Let's go for a walk after all.
The sun is shinning so warmly...
We're coming to the good part, so listen up, you guys!!
It's such an incredible story that I lost myself in another dimension...
Anyway, so this incredible thing might be built in Japan?
Yes, and that would be really amazing! Top scientists from around the world would come to Japan, and Japan could well become one of the world leaders in science!
That's right. Many innovations in various fields such as IT or medicine are results of application of basic scientific research.
Wherever the ILC gets built, that will become the hub of science and technology.
I think there are a lot of ripple effects on building the ILC. Not mentioning the positive effects on education and economy, the ILC construction site would gain the name as an international science city. One study by the expert says that the economy impact could amount to tens of billions dollars.
tens of billions dollars?! Oh my goodness! We should move to the ILC city!
But... is it safe? Japan is known for seismic activities. What if those particles leak out in case of an earthquake?
Dad, you're such a worrywart...
Of course, safety is of utmost concern.


Compared to other accelerators, the ILC is large in scale, but the facility itself is similar to other accelerators already exist. In Japan there are over 1400 accelerators ranging from small to large, and they're all being operated quite safely.
Also, since the ILC is planned to be built 100 meters underground in bedrock, the effect of earthquakes should be quite small.
Bedrock
100 meters underground
ILC
Also, if there ever was an earthquake, the operation will stop immediately.
Well, it does sound like it's pretty sturdy.
But wouldn't it be dangerous if the accelerator breaks?
It's true that during an experiment, an accelerator emits electromagnetic waves and radiation. However, when the operation is stopped, the radiation stops immediately, too.
Plus, it is designed so that the electrical supply will stop immediately also, so we believe the risk of fire is very low.
What about power? A facility of that magnitude must use lots of electricity.
Indeed. The power needed to operate the ILC is about 160,000 kilowatts. This is approximately 4 times of the electric power as Roppongi Hills building complex can produce using their own power generator.
×4=ILC
However, it has been verified and confirmed that the present power supply is more than enough for the operation. Also, the ILC will not be operated during peak seasons, so there's nothing to worry about.
To avoid power blackouts, electricity is always produced in excess. But since we cannot save it, there's always surplus power. This is why there will be enough power to operate the ILC.
Do you think it will be built here in Japan?
I see. So there's no need to build a new power plant.
I do!
Naturally, Japan isn't the only candidate, but since Japan is one of the leading countries for particle physics and accelerator technology, so other countries are expecting Japan to come forward.

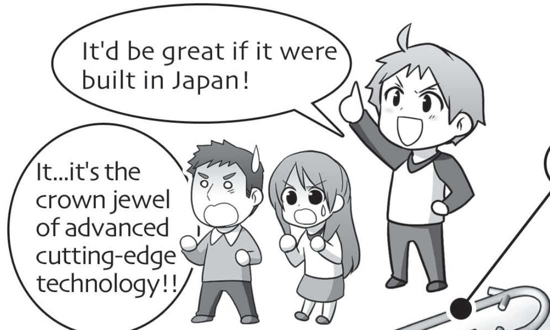

Whoooa!!
The world is expecting us! How flattering!
Why are you guys blushing?
However, **since the project requires a huge budget, it is important that we get the understanding of the people around the world.**
OK! I'll talk to all my friends about the ILC from now on!
I can't wait to see it built, now that I know what it is.
And you were going to go for a walk!
Shush! Don't you realize that Japan has a chance to get this incredible thing that many scientists from around the world have been working on for years?!
That's right! Don't you understand the significance of it?
I thought those were my lines...
I can see the extra dimension on the other side of the accelerator tunnel~~!
Love in the midst of a beam line~~!
I think my work is done here.
Don't forget to check out additional information about the ILC on the following pages!!

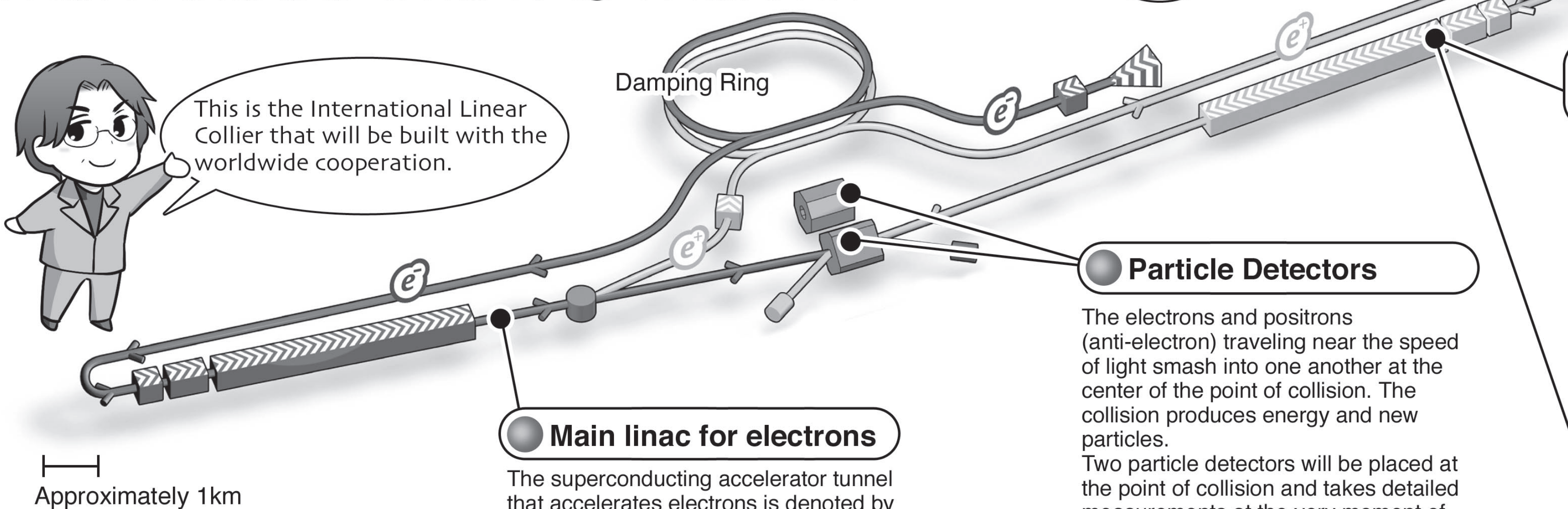

Create the Universe?!
Are you serious?!

ILC

31 km in length!
The word's largest accelerator!
International Linear Collider

How does the ILC work?





Main linac for positrons

The superconducting accelerator tunnel that accelerates positron is denoted by the light gray line.

Superconducting accelerating cavities

Shaped like a string of donuts, the superconducting accelerator cavity can generate high electrical fields using only small amounts of power. It can give large amounts of energy to particles in short distances.

Particle Detectors

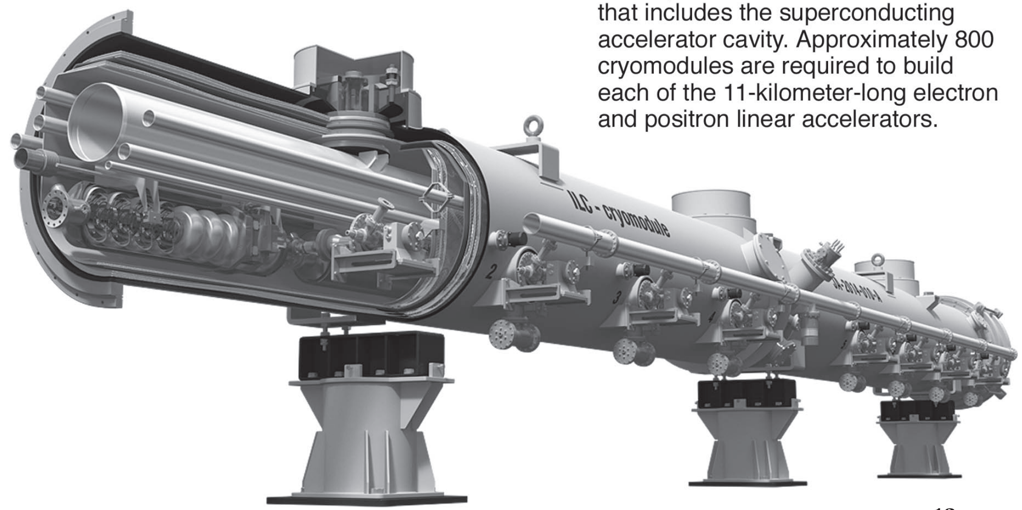
The electrons and positrons (anti-electron) traveling near the speed of light smash into one another at the center of the point of collision. The collision produces energy and new particles.
Two particle detectors will be placed at the point of collision and takes detailed measurements at the very moment of collision. The ILC uses two different types of detectors.

Main linac for electrons

The superconducting accelerator tunnel that accelerates electrons is denoted by the gray line.

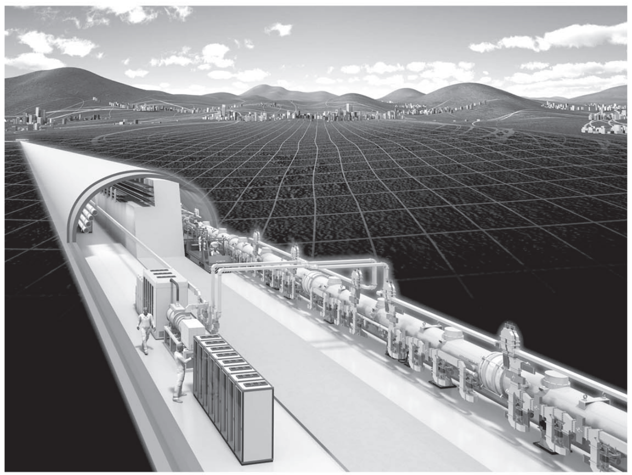
Cryomodule

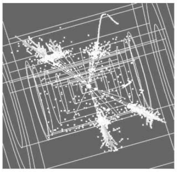
The cryomodule is an accelerator unit that includes the superconducting accelerator cavity. Approximately 800 cryomodules are required to build each of the 11-kilometer-long electron and positron linear accelerators.



The future created by the ILC

Researchers from all the around the globe will gather here in Japan when the ILC is built. Technologies that are essential to our lives, including various industries, medicine, and IT, have their roots in particle physics, and the ILC will become a global knowledge base.
As the site of the ILC, Japan will become the global leader in technology, culture, and education. The ILC will also have a positive effect on local and national economies, such as job creation.





The ILC Glossary

Accelerator and Collider

An accelerator is a device that accelerates particles by giving them energy using electromagnetic waves. A collider accelerator - or simply collider - is a type of accelerator that smashes particles together in order to observe various other particles that gush out of the ball of energy that is produced in the collision. The faster the particles, the more energy is produced in the collision, creating more exotic particles. The ILC accelerates electrons and positrons to near the speed of light, attaining super high energy, and leading the world to the beginning of the universe.

Superconducting Acceleration

When certain materials are cooled down to extreme temperatures, a state of zero electrical resistance, or "superconductivity," is created. Superconductive acceleration used by the ILC utilizes this phenomenon to accelerate particles.Microwaves are sent to the cavity, made of a superconducting rare metal niobium, to create electrical fields, helping accelerate beams of electrons and positrons. When the internal surface of the cavity is cooled down to -264-C (the ILC will operate at -271-C), the electrical resistance of the surface becomes zero and a state of superconductivity is created. Because there is no loss of power or increase in heat, huge amounts of energy can be given to the particles using only a small amount of electric power and in relatively short distances.

Generating and Controlling Nano Beams

The ILC's nano beam is shaped like an incredibly thin ribbon and contains 10 billion electrons and positrons. The width of the beam is 5 nanometers or 5 millionths of a millimeter, near the point of collision, which is the equivalent of about 100 hydrogen atoms lined up side by side. The beam is squeezed down to a tiny size to increase the density of particles within the beam and so to increase the intensity of collisions. Although 10 billion sounds like a big number, the beam is still quite "empty" as electrons and positrons are so very small.Making these super small beams and controlling the collision position of the beams with nanometer accuracy require unprecedented technologies that are matched by none in the world.

Elementary Particles and the Higgs Boson

Today's science considers elementary particles to be the most fundamental building blocks of the universe. These are the smallest unit of matter that cannot be divided any further. There are 17 types of elementary particles that appear in the Standard Model. They are grouped by particles that make up matter, particles that conduct energy, and the Higgs boson that give mass.

The fact that matter has mass (weight) is actually a mystery. Our weight is kinetic energy that is produced by a family of the particles, called quarks, flying around inside the atom that makes up our body. We also know that electrons have mass. However, electrons are elementary particles and can't be broken down, so they can't and don't contain anything. Therefore electrons don't contain kinetic energy.

Without kinetic energy how do electrons have mass? Scientists theorize that the Higgs bosons that are found in vacuum get in the way of electrons, slowing down their movement, thus giving electrons their mass.

(Remember $E=mc^2$?) If the Higgs boson really exists in vacuum, one must be able to expel it by applying a large amount of energy.

This is precisely what the ILC experiments will do.

The Higgs boson is totally different from other particles. One such character is that it has no spin. Why is the Higgs boson that way? Are there others that are like it? The ILC with its super high performance is needed to unlock the mysteries of the Higgs boson.

Theories Beyond the Standard Model

The Standard Model is the most widely accepted theoretical framework in particle physics today. Among the particles that have been theorized, the Higgs boson is the very last piece of the puzzle that has not been discovered. On July 4, 2012, news of the discovery of a new particle resembling the Higgs boson came from the European Organization for Nuclear Research (CERN).

"If the last piece has been found, do we know all there is to know about elementary particles?"

Not so. The Standard Model explains today's universe quite well, but it is still full of inconsistencies. We need a new theory beyond and surpassing the Standard Model to understand the physical phenomena of the universe.There are a number of important theories that go beyond the Standard Model that involve supersymmetry, composite particles, and extra spatial dimensions. The experiments at the ILC will be instrumental in shaping the future of these theories.

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■Publication date : April 30, 2014

■Planning : KEK

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