【Grant-in-Aid for Scientific Research (S)】

Precision Verification of Lepton Universality with High Resolution Xenon Detector and High Intensity Pion Beam

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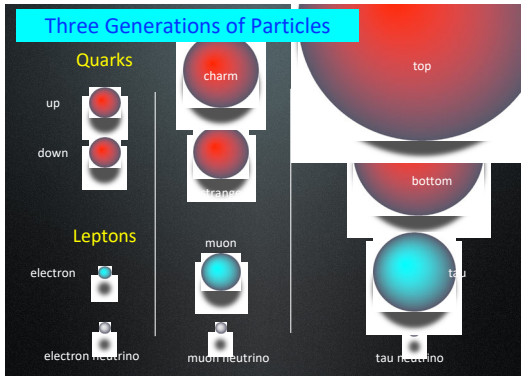
Purpose and Background of the Research

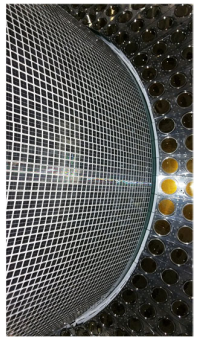
●Outline of the Research

All matter in the Universe is composed of just 4 elementary particles. They are electron, electron neutrino, up and down quarks. In addition, heavier particles of the second and third generations were discovered at accelerators (Right Fig.).

Particles of different generations have exactly same properties except their masses, because of symmetries of the theory. This is most precisely examined among leptons by experiment, which is called "**Lepton Universality**" (LU).

Three Generations of Particles





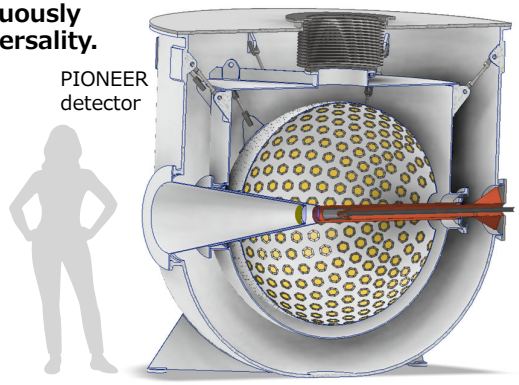
3-ton liquid xenon detector with arrays of high sensitivity photo-sensors

Even a slight deviation from LU would immediately indicate existence of new theory or particles. In fact, several experimental results obtained at KEK and CERN a few years ago suggested breakings of LU, but they have never been conclusive and considered to require further verification.

Our team studied in Grant-in-Aid for Scientific Research (A) a more decisive LU experiment based on the technology developed for the world's first high resolution liquid xenon detector (Left Fig.). The xenon technology has been widely used in lepton flavor physics, dark matter searches, medical imaging, etc.

We formed an international research team and completed an experimental proposal, which was approved by PSI, Switzerland. **This research aims at performing a conclusive experiment at PSI to unambiguously verify Lepton Universality.**

PIONEER detector

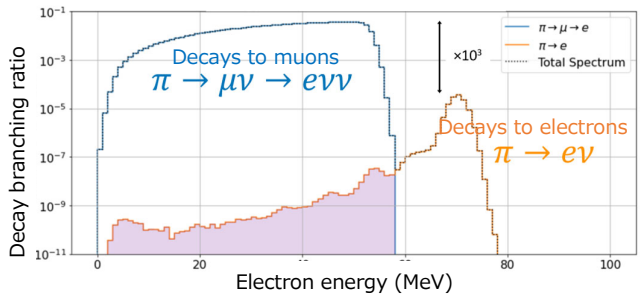


●Exceeding Large Colliders

By precisely examining LU with xenon detector, the experiment has a sensitivity to many new particles that are beyond reach of the large collider experiments at CERN.

We lead the international team that consists of physicists from Japan, U.S., Canada, Switzerland, etc.

Expected spectrum of pion decays (simulation)



●Measuring pion decays

A pion is often called Yukawa particle as Dr. Yukawa was awarded Nobel Prize for predicting its existence.

Pions decay almost always into muons (second-generation electrons) but also rarely into electrons. LU can be precisely verified by comparing these two decays (Left Fig.).

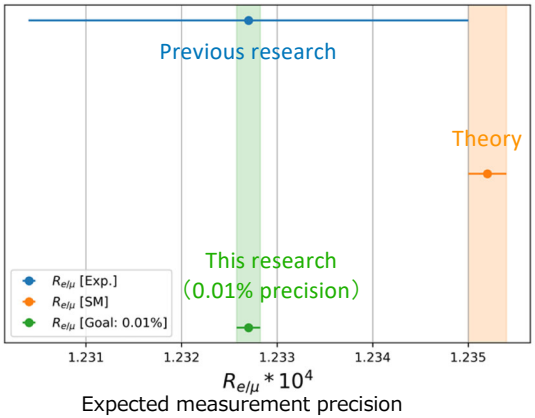
Expected Research Achievements

●Verification of LU with 0.01%

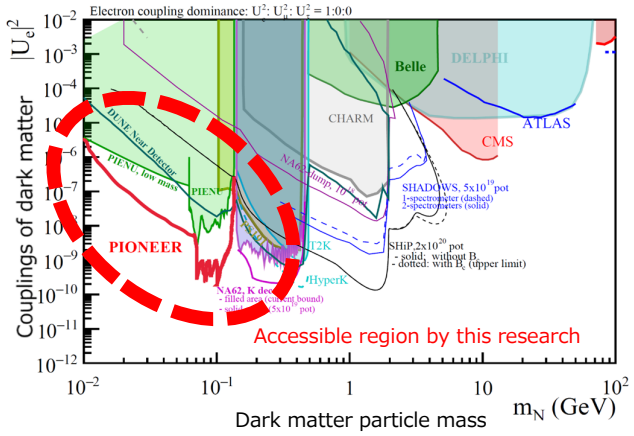
The pion decays are unambiguously predicted by theory with a precision of 0.01%.

This research aims at measuring the decay with the same 0.01% accuracy (Right Fig.). PSI can provide enough many pions for such precision.

It will enable a great sensitivity to new phenomena that go far beyond the existing large collider experiment.



Expected measurement precision



●Search for dark matter

Recent dark matter searches are focusing more on lighter particles.

This research is sensitive to dark matter particles that are light enough to be produced in pion decays. Its sensitivity is 10 times higher than previous efforts.

Homepage Address, etc.	https://pioneer.triumf.ca, https://www.psi.ch/en/pioneer https://www.icepp.s.u-tokyo.ac.jp/research/meg.html https://www.icepp.s.u-tokyo.ac.jp/meg