Experimental Particle Physics

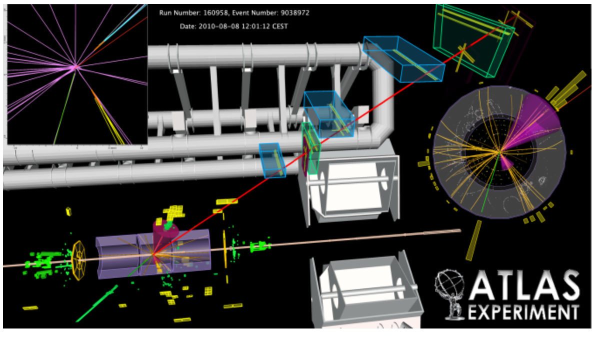
Kiyotomo KAWAGOE, Professor
Junji TOJO, Tamaki YOSHIOKA, Associate Professor
Susumu ODA, Taikan SUEHARA, Hidetoshi OTONO, Assistant Professor
17 graduate students, 8 undergraduate students
URL : http://epp.phys.kyushu-u.ac.jp

Our group is conducting experimental research projects using state-of-the-art accelerators for understanding of the fundamental law of the universe. Our current projects are as follows:

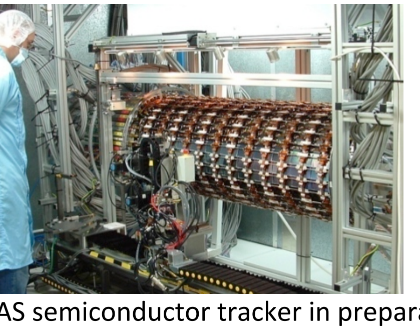
1. The ATLAS experiment at the LHC
2. The International Linear Collider project
3. Particle physics experiments using high-intensity muon beams at J-PARC
4. Fundamental physics experiments using low energy neutrons at J-PARC

1. The ATLAS experiment at the LHC

We participate in the ATLAS experiment at the CERN Large Hadron Collider (LHC), the world largest and most powerful particle collider. You may know that the ATLAS experiment, together with the CMS experiment, discovered the Higgs particle, the origin of particle masses, in proton-proton collisions at center of mass energies of 7-8 TeV (Run 1) in 2012. After a long shutdown, the LHC started its Run 2 operation in 2015, with a center of mass energy of 13 TeV. We contribute to the ATLAS experiment both in physics analysis (measurement of the Higgs boson properties and searches for new particles) as well as detector operation and upgrade (the Semiconductor tracker). Currently two faculty members and a graduate student from our group are resident at CERN for this experiment. We hope to send more graduate students to CERN in future.



A Higgs candidate event at Run 1

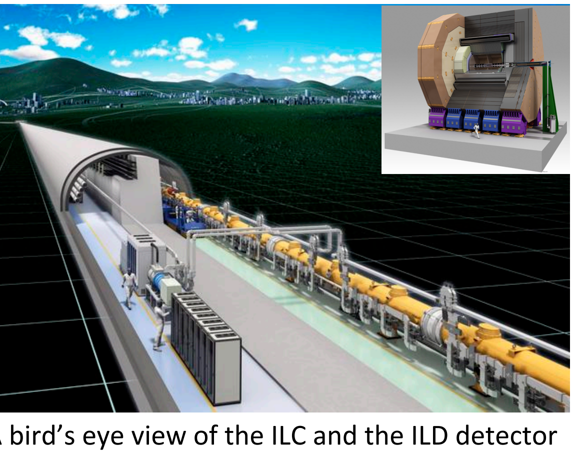


The ATLAS semiconductor tracker in preparation

2. The International Linear Collider project

The International Linear Collider (ILC) is the next generation energy-frontier electron-positron collider being designed by a world-wide collaboration. The ILC can discover new physics beyond the Standard Model of particle physics with precise measurements of the Higgs boson and the top quark, as well as direct searches for new particles. The ILC will be operated at center of mass energies of 250-500 GeV, and upgradable to 1 TeV. Japan is now seriously considering to host the ILC project at the governmental level.

Our group is heavily involved in the detector R&D for the ILC experiment, especially for the electromagnetic calorimeter (ECAL) under a framework of the CALICE international collaboration. We are aiming to achieve unprecedented jet energy resolution using a highly granular ECAL. We are developing silicon sensors and readout electronics for the ECAL. We also participate in the ILD detector concept group, where we work on the detector optimization and physics simulation studies at the ILC. Prof. Kawagoe is the deputy spokesperson of the ILD group.

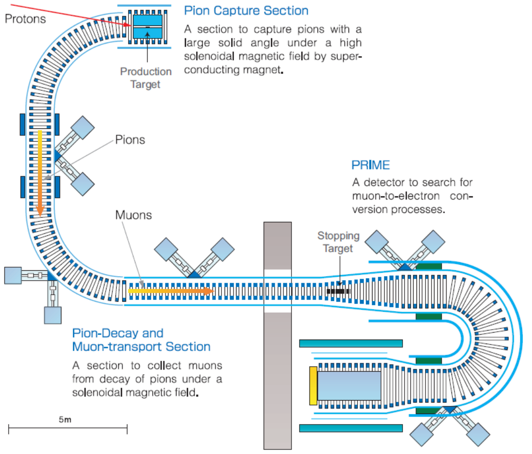


A bird’s eye view of the ILC and the ILD detector

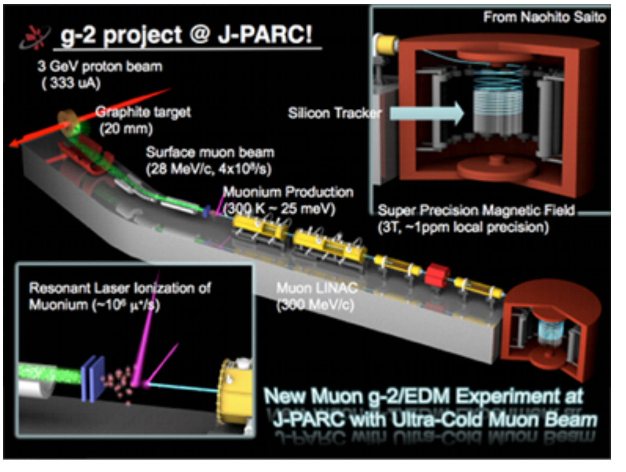
In addition to energy-frontier collider experiments, our group is conducting several experiments at Japan Proton Accelerator Research Complex (J-PARC) in Tokai, Japan. Thanks to the high-intensity proton accelerator at J-PARC, a variety of unique experiments can be realized.

3. Particle physics experiments using high-intensity muon beams at J-PARC

① Search for the lepton flavor violation: the mu-e conversion is a process that violates the lepton flavor conservation and strictly prohibited within the Standard Model. Discovery of the process will be an unambiguous evidence for the physics beyond the Standard Model. We participate in the COMET experiment that aims to have 100 times and 10000 times better sensitivity than the previous experiment in the first phase and second phase, respectively. We are developing several detector components; the electromagnetic calorimeter, the trigger counter and the straw tube tracker. ② Precise measurement of muon anomalous magnetic moment (g-2) and electric dipole moment (EDM): We participate in an experiment that is aiming to simultaneously measure the g-2 and EDM with a novel technique. Our group is responsible for the development of the positron tracker composed of silicon strip sensors.



A schematic view of the COMET experiment at J-PARC



A schematic view of the muon g-2/EDM experiment at J-PARC

4. Fundamental physics experiments using low energy neutrons

A neutron is electrically neutral and has a long lifetime compared to other unstable hadrons. In addition, strengths of three fundamental interactions, i.e. the gravitational, electromagnetic, and strong interactions, are a same order of magnitude for neutrons. Combination of these remarkable features enables us to perform unique experiments for fundamental physics. Our group is currently conducting the following experiments at J-PARC: ① Precise measurement of the neutron lifetime : it is highly desired to precisely determine the neutron lifetime because it is an important input parameter for the Big-Bang Neucleosynthesis. However, there is a 3.9σ disagreement between two historical experiments with different methods. We therefore aim to measure the neutron lifetime with a 0.1% precision by a new experimental method. ② Search for time reversal violation via the nuclear reaction: Large time reversal violation is theoretically predicted in the compound nucleus resonance. We plan to search for the violation by measuring the neutron scattering cross section in the forward region.

A snapshot of the neutron beam line (BL05) at J-PARC