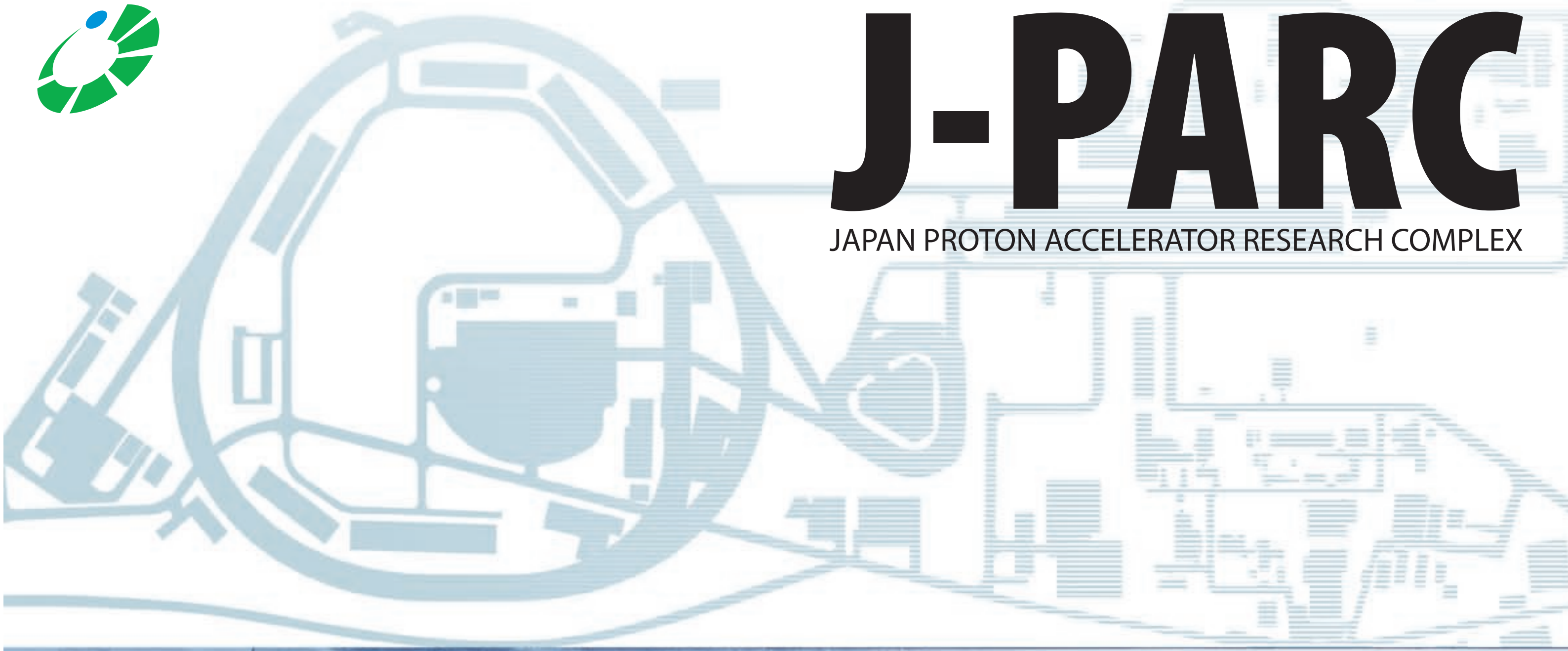
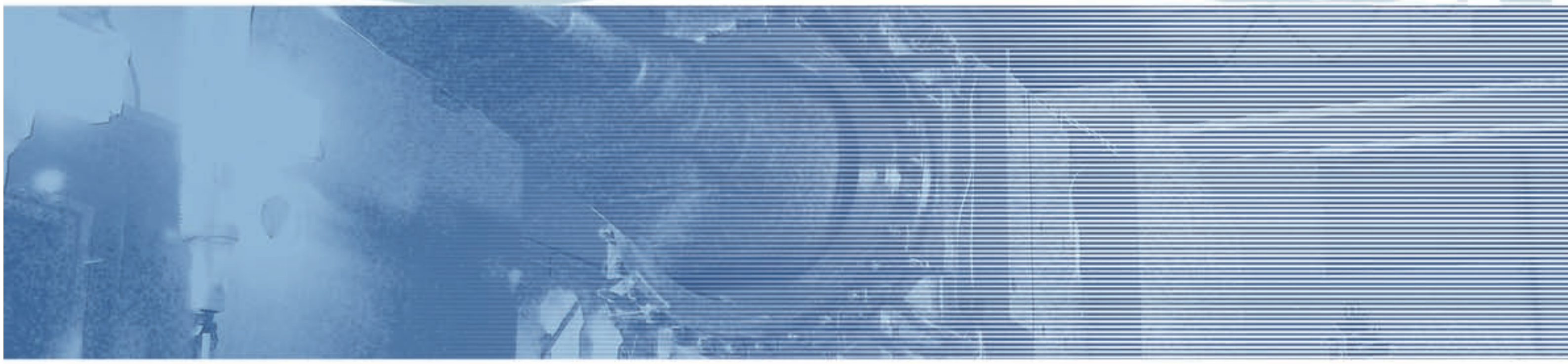
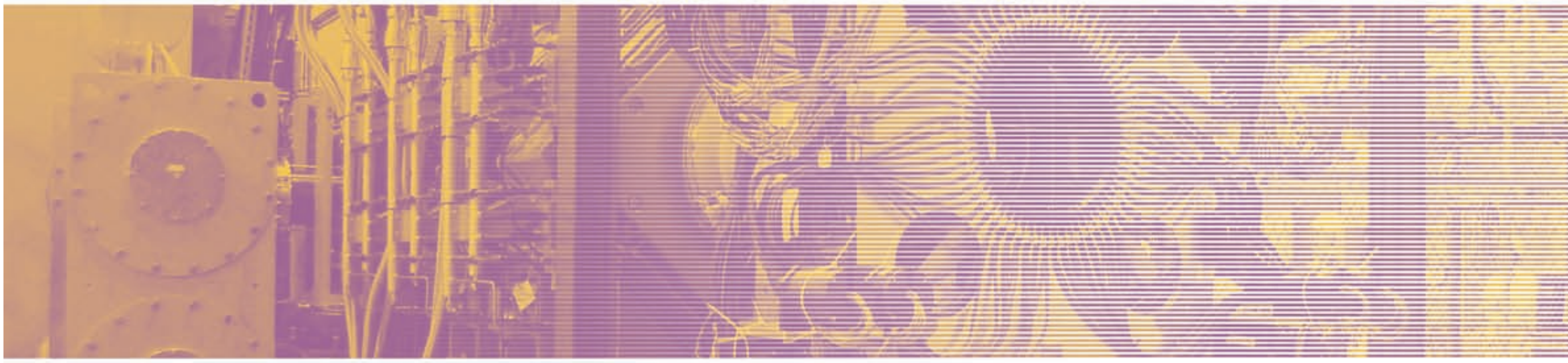
J-PARC

JAPAN PROTON ACCELERATOR RESEARCH COMPLEX

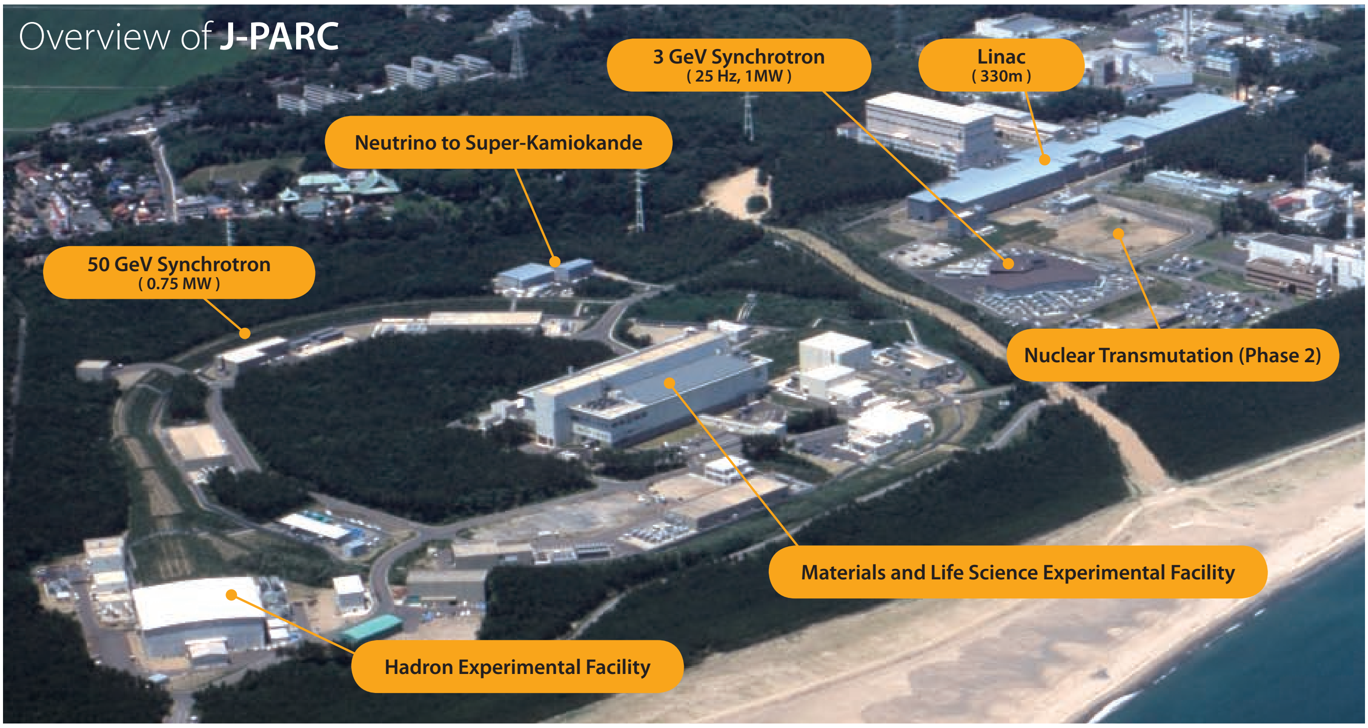






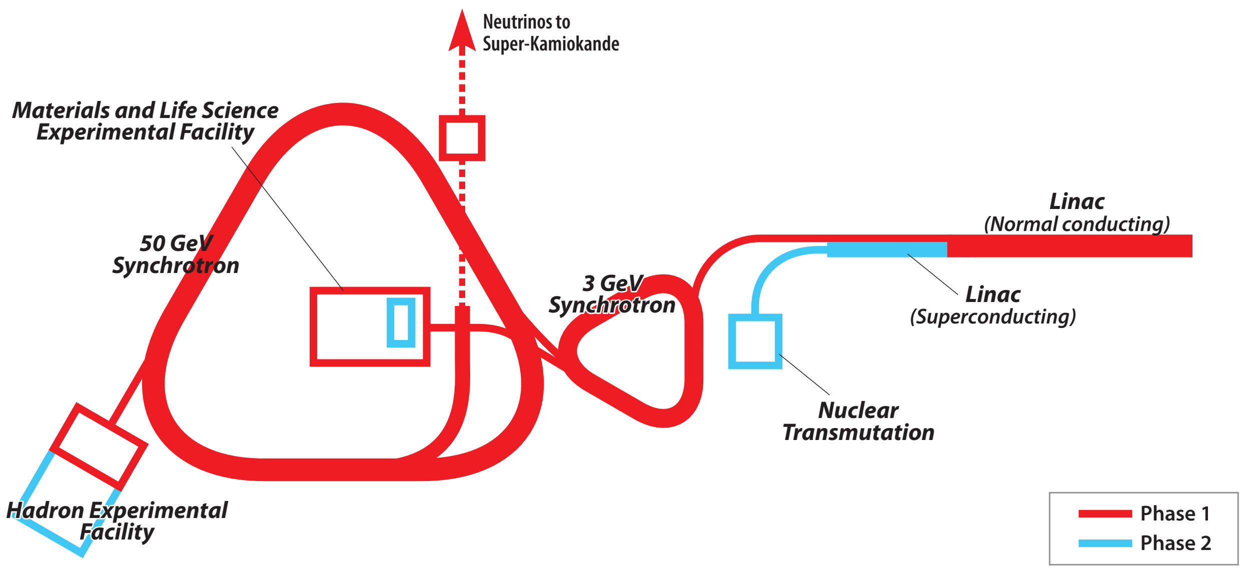
Facilities at **J-PARC**

The J–PARC stands for Japan Proton Accelerator Research Complex and it is a new and exciting accelerator research facility in Japan. J-PARC has three proton accelerators and three research facilities with using MW-class high power proton beams, which generate neutrons and mesons, to underlie the development of advanced science.



The area of J-PARC is 65 ha (160 acre). It is 14 times as large as a baseball stadium.

Accelerator layout in **J-PARC**



J-PARC is a joint project between two organizations, High Energy Accelerator Research Organization (KEK) and Japan Atomic Energy Agency (JAEA). The facility is located in Tokai village in the northern region of Ibaraki prefecture, JAPAN.

Construction started in April 2001, and in the spring of 2009 (end of JFY2008) the Phase 1 project was completed after eight years of construction period.

Science at **J-PARC**

Our universe has a hierarchic structure of matter. For example, all of materials are consist of atoms. Atoms can also be divided into atomic nuclei, and nuclei be divided into nucleons (protons and neutrons), and finally quarks. Naturally, many questions come to mind: "How did the dawn of life occur from collections of atoms?", "What are the extreme constituents of matter?", etc.

J –PARC will throw light on the mysteries of the creation and structure of our universe by investigating matters at all levels, from quarks to atoms, with using various kinds of particle beams.

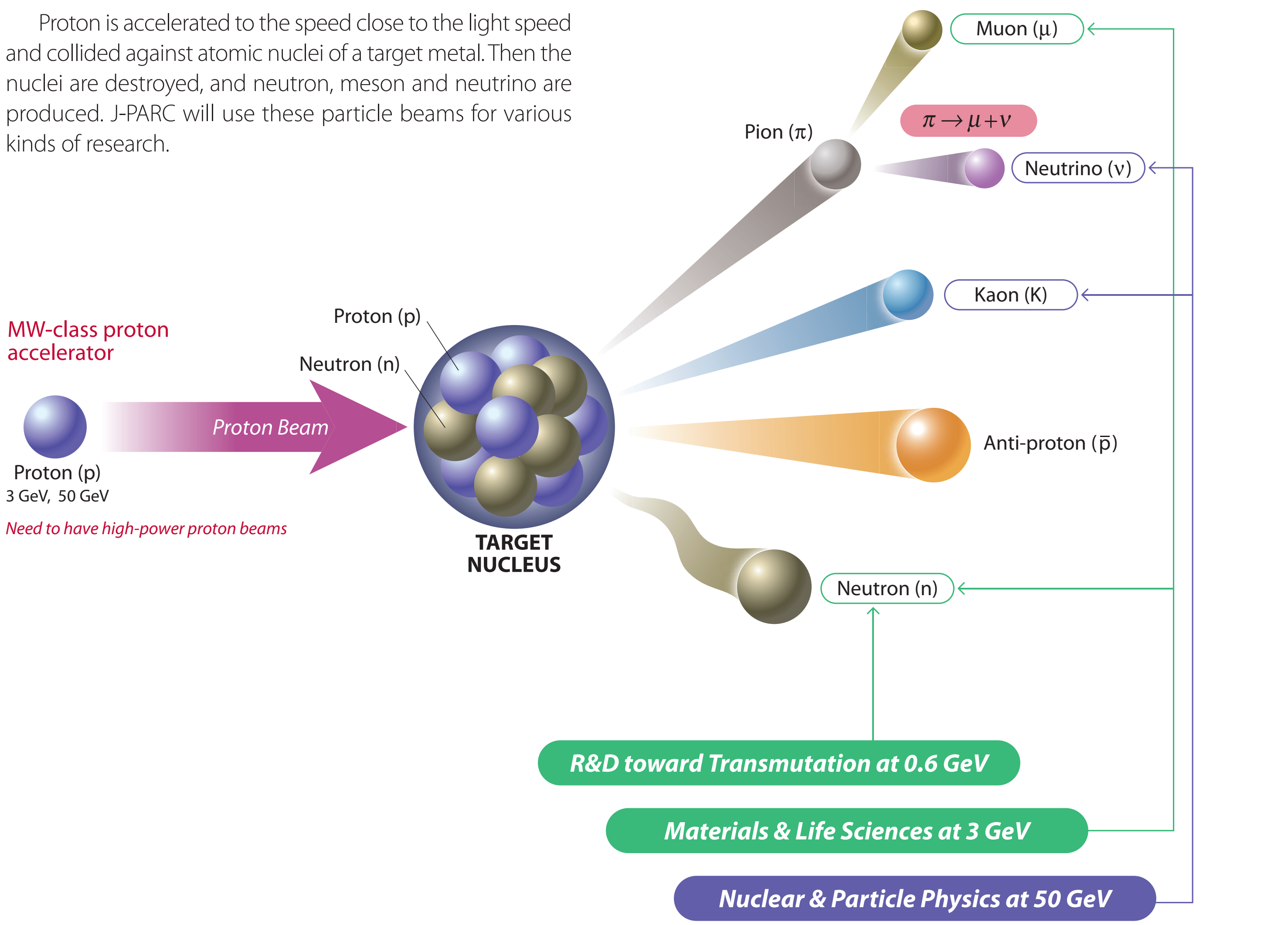
The usage of various secondary particle beams (neutrons, muons, kaons, neutrinos, etc.) that are produced in proton-nucleus reactions (nucleus spallation) is the prime purpose at the J-PARC.

With these secondary particle beams, three major scientific goals will be attained:

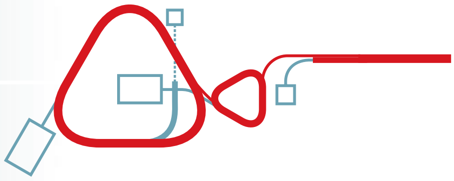
- nuclear particle physics
- materials and life sciences
- R&D for nuclear transmutation (later, in Phase 2)

Secondary beams produced with high-intensity proton beam

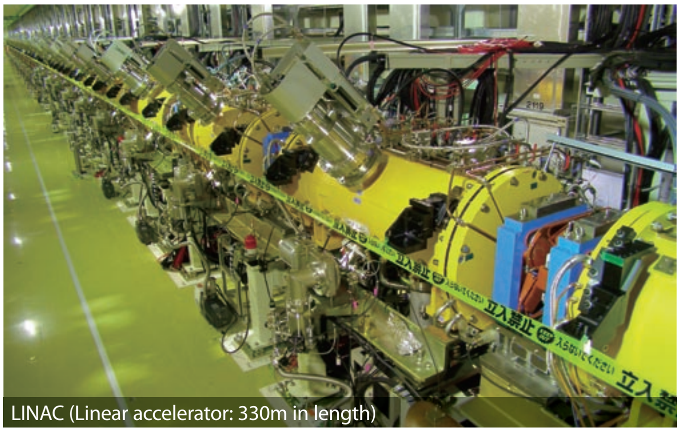
Proton is accelerated to the speed close to the light speed and collided against atomic nuclei of a target metal. Then the nuclei are destroyed, and neutron, meson and neutrino are produced. J-PARC will use these particle beams for various kinds of research.



Accelerators of J-PARC



The J-PARC consists of the following accelerators:
• 400-MeV linear accelerator (Linac). It is about 330m in length.
• 3-GeV rapid-cycling synchrotron (RCS), which provides proton beams at 333μA (1MW). It is about 350m in circumference, and can accelerate protons up to about 97% of light speed.
• 50-GeV synchrotron, which provides proton beams at 15μA (0.75 MW) . It is about 1600m in circumference, and can accelerate protons up to about 99.98% of light speed.
(Phase 2, we have a plan for construction of superconducting Linac, to increase the energy from 400 to 600-MeV)


LINAC (Linear accelerator: 330m in length)

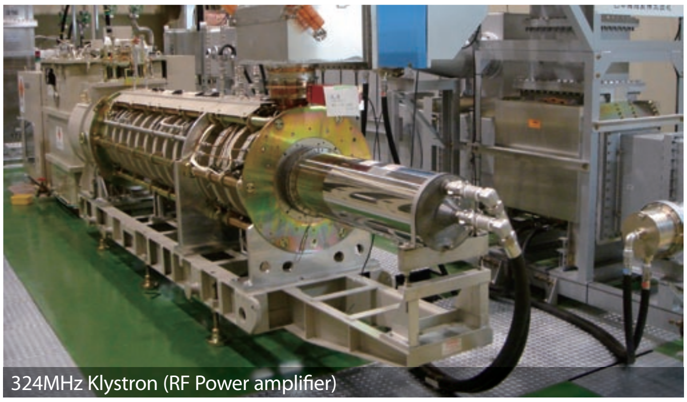

3GeV synchrotron (It is 350m in circumference)


50GeV synchrotron (It is 1600m in circumference)

Many new technologies have been invented and developed for the J-PARC accelerator. As accelerators are a precision machine, they are installed within a tolerance of 0.1 mm. All of J-PARC accelerators are placed in the tunnel established underground. The tunnel is made with thick steel-framed reinforced concrete.

The proton speed is very important for nucleus spallation, thereby producing neutrons and mesons to be used in study. The RF (radio frequency) accelerating system is used for the acceleration. Finally, the proton beam is accelerated nearly to the light speed.


RF Cavity

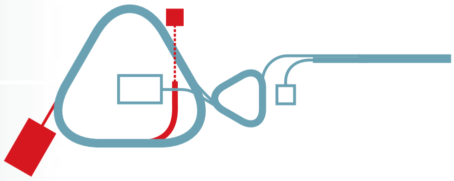

324MHz Klystron (RF Power amplifier)

? Why?

Why J-PARC's synchrotron is not a precise circle, but a triangle with having rounded corners?

Synchrotron accelerator is a round type accelerator. Many large electromagnets are set to bend and squeeze the proton beam. Note that J-PARC's synchrotron is a triangle with having rounded corners. The reason why we have this shape is that it is necessary to get the proton beam in and out from the accelerators through a linear part. There is one inlet and two outlets for 50GeV synchrotron for the proton beam, thus, these three linear lines make a triangle.

Nuclear and Particle Physics Facility



At the 50GeV Synchrotron, nuclear and particle physics experiments are performed using high-intensity beams such as the kaon beam, pion beam, neutrino beam as well as the primary proton beam.

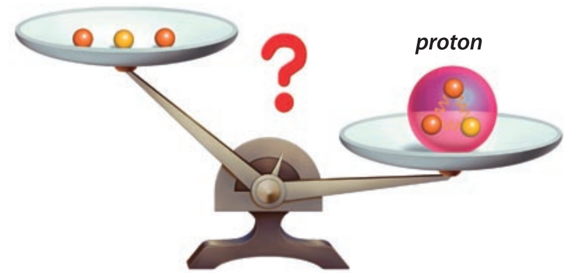
In these research fields one looks for answers to the very fundamental questions such as;"What are the extreme constituents of matter?", "What are the fundamental interactions or forces acting between particles?" and "What is the origin of mass of elementary particles?" In order to study these questions, the experiments with high precision, with very new phenomena or with exotic states will be pursued using the high-intensity beams.

The Hadron (Hadron; an aggregate of quarks) Experimental Hall uses the slow extracted proton beam from the 50GeV Synchrotron. There are several secondary beam lines, where secondary particles, such as pions (pi mesons) and kaons (K mesons), produced at the production target are transported for experiments.

Studies on "hyper-nuclei", nuclei with "strange" particles inside, are being conducted at the K1.8 beam line using kaons, whose goal is to understand the fundamental interactions between hadrons.

Rare kaon decays are studied at the KL beam line to investigate the so-called "CP violation", a key to understand our universe where matter dominates over anti-matter. An experiment is planned with the proton beam to investigate the origin of the hadron mass.

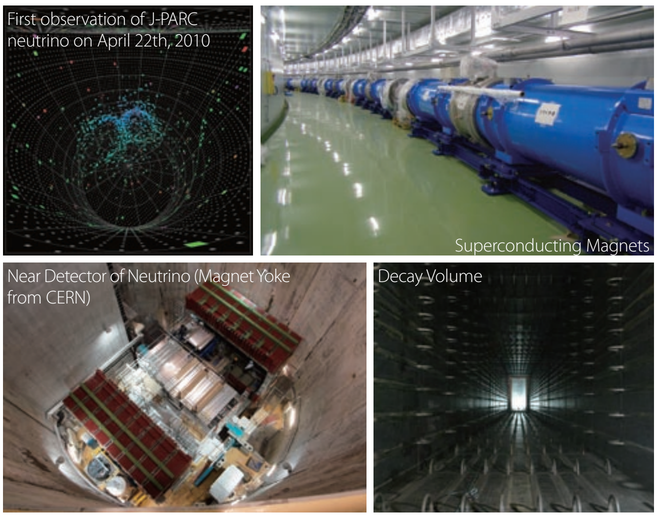
Hadron Experimental Hall



Why is a proton, which consists of 3 quarks, 100 times heavier than the sum of 3 bare quarks?

T2K experiment

Tokai to Kamioka (T2K) is a Japanese-led multinational physics experiment. High-intensity neutrino beams are directed from the J-PARC at Tokai village towards Super-Kamiokande—the world's largest underground neutrino detector—located in Hida city, Gifu Prefecture. As the neutrinos traverse the Japanese Archipelago at virtually the speed of light, a change occurs in an essential characteristic—the generation or flavor—of the neutrinos. This phenomenon is known as neutrino oscillation. By investigating neutrino oscillation, we can uncover the mysterious characteristics of neutrinos. In particular, we can determine their relative lightness, as compared to other elementary particles such as electrons or quarks, and also the extent of mixing of neutrino flavors. These are fundamental issues in the field of elementary particle physics, which may provide the key to understand the evolution of our matter-dominated universe.



First observation of J-PARC neutrino on April 22th, 2010

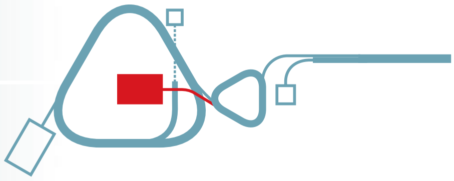
Superconducting Magnets

Near Detector of Neutrino (Magnet Yoke from CERN)

Decay Volume

Neutrino traveling long-distance from J-PARC to Super-Kamiokande

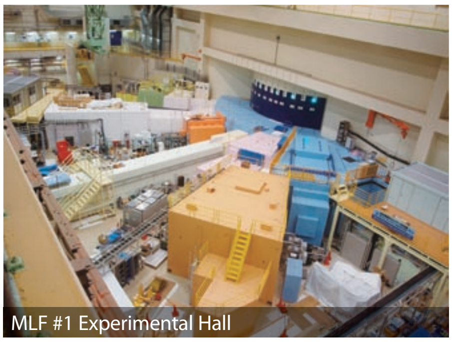
Materials and Life Science Experimental Facility

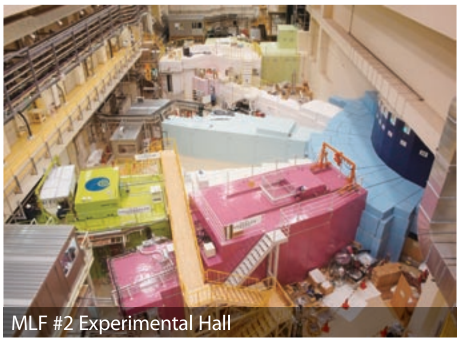



Mercury Target for Neutrino Production

Extensive scientific programs covering condensed-matter physics, materials sciences, industrial applications, structural biology and nuclear/particle physics, will be carried out at the Materials and Life Science Experimental Facility (MLF).

The MLF provides the world's highest flux of neutrons and muons by proton-impact nucleus spallation reactions with a 3GeV proton synchrotron of 1MW beam power. The proton beam cascades the graphite target for muons and reaches to the mercury target for neutrons. 23 neutron beam lines and 4 muon beam lines are planned and will be installed in the MLF building. Synergetic use of neutrons and muons at the world's highest flux will be enabled at MLF, where will be a center of materials and life science researches.

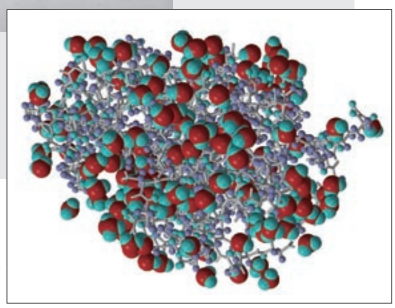

MLF #1 Experimental Hall


MLF #2 Experimental Hall

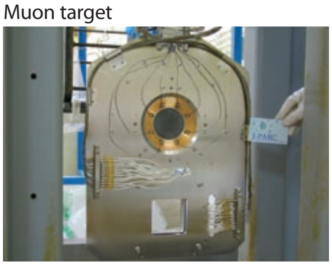

Neutron Beam Line #19 "TAKUMI"

Since the neutron has a mass that is similar to that of the hydrogen atom, a magnetic moment but no electric charge, and a high penetrating power, the neutron can sensitively probe spin correlations, and the location and motions of atoms, especially hydrogen atoms, in materials. These characteristics of the neutron make neutrons play crucial roles in many subjects like studies of the locations and motions of hydrogen atoms in biological cells, which is of particular interest in life science.

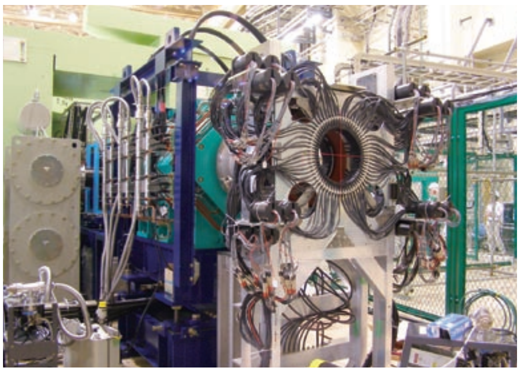
Neutron Radiography of lily


Hen Egg-White Lysozyme Structure
(Water molecules observed with neutrons)

Muon target



Hard disk


Muon beam line

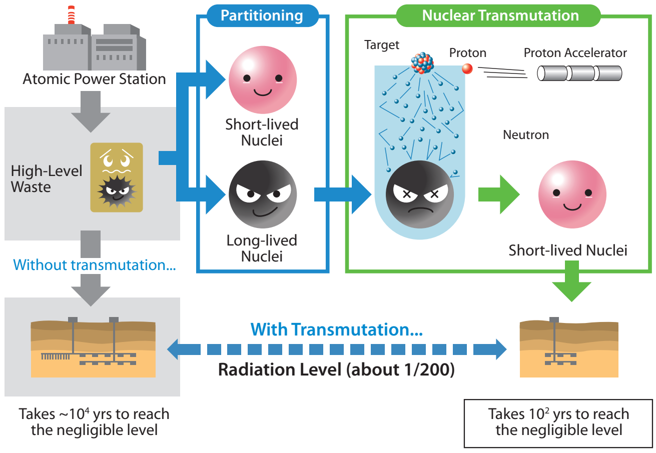
The positive muon (μ+) behaves as a light radioisotope of the proton in matter. Because of its large magnetic moment (up to three times that of proton), implanted positive muons have a wide variety of applications to materials science and biology in a fashion similar to nuclear magnetic resonance (μSR). Even more importantly, the μSR technique provides truly complementary information to that obtained from neutron diffraction on the same object.

Transmutation Experimental Research (Phase 2)

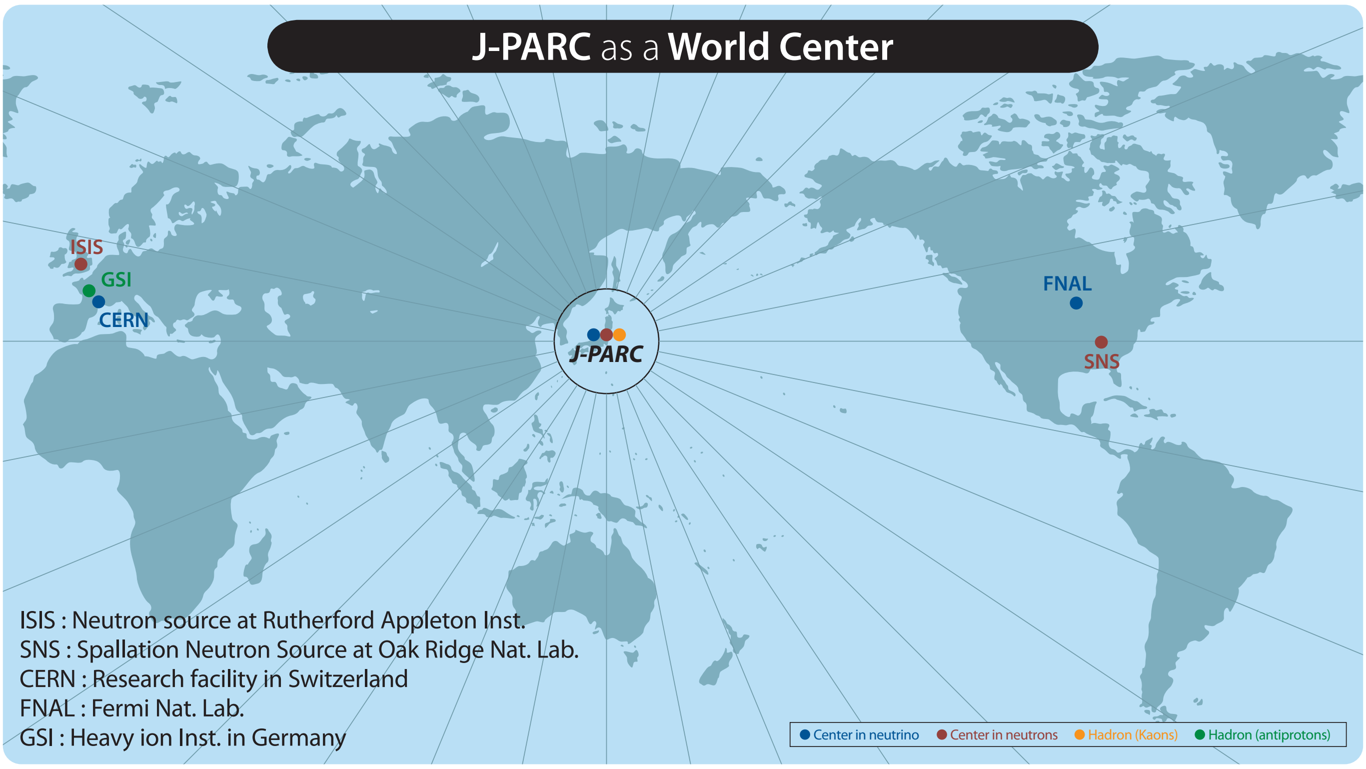
Nuclear transmutation is a physical phenomenon where a target nuclide transmutes to another one by a nuclear reaction. In the present fuel cycle system for commercial nuclear power plants, the reprocessing of the spent fuels produces High-Level Nuclear Wastes (HLWs) including long-lived nuclides.

If the long-lived nuclides can be converted to short-lived or stable ones by the transmutation technique, the management period for geological disposal of HLWs could be much shorter than expected, and this leads to a reduction of the burden of geological disposal.

At phase 2, J-PARC plans to construct the Transmutation Experimental Facility (TEF) for the basic study of radioactive waste management. J-PARC will contribute to basic research and development of transmutation technique.



Nuclear Transmutation experiment



J-PARC is used by researchers and scientists from all over the world. Many domestic and overseas researchers gather and use it for their study. J-PARC will be a world center of science research.

For the purpose of their easy access and convenience, Users Office and laboratory offices are provided in Ibaraki Quantum Beam Research Center, which is near J-PARC.

We believe that J-PARC will contribute to obtain the most-advanced science and technology, which resulting to the development and prosperity of humankind in the future.

KEK / JAEA J-PARC Center

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