

OVERVIEW OF THE STATUS OF J-PARC

Shoji Nagamiya, J-PARC Center, Tokai-Mura, 319-1195, Japan

Abstract

About ten years ago (2001) a new accelerator project to provide high-intensity proton beams proceeded into its construction phase. This project is called the J-PARC (Japan Proton Accelerator Research Complex), and it was completed about a year ago in 2009. The construction was performed under a cooperation of two institutions, KEK and JAEA. The goal of the accelerator power is 1MW proton beams at 3 GeV, with 400 MeV Linac injector, and 0.75 MW beams at 50 GeV.

Three experimental facilities are presently available: 1) the Materials and Life Experimental Facility where pulsed neutrons and muon beams from 3 GeV are produced and utilized, 2) the Hadron Experimental Facility where kaon beams are produced, with a slow extraction mode from the 50 GeV (currently, 30 GeV is used), and 3) the Neutrino Experimental Facility with fast extraction mode from the 50 GeV ring.

The current status of the accelerators and experimental facilities, in particular, under the emphasis of what are actually going on in regard to experimental programs.

J-PARC GENERAL

J-PARC consists of three accelerators and three experimental facilities.

In calendar year of 2007 the linac was and the 3 GeV synchrotron were completed. Then, in fiscal year of 2008 the 50 GeV synchrotron and two experimental facilities, the materials and life experimental facility with neutron and muon beams, and the hadron experimental facility with primarily kaon beams, were completed. Finally, in fiscal year of 2009, which is the last year, the neutrino facility to send the neutrino beams to Superkamiokande was completed. The entire facility is shown in Figure 1.

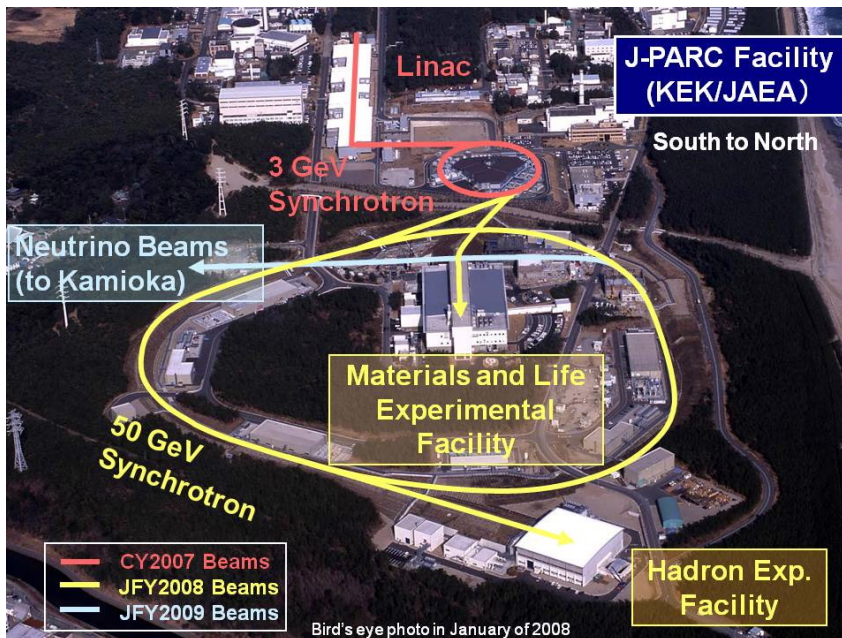


Figure 1: J-PARC Facility as viewed from sky.

When a high-energy proton hits the nucleus, many particles are emitted: pions, kaons, neutrons, etc. The pion decays into muon and neutrino. The entire purpose of the J-PARC is to use these secondary particles as “beams”. Muons and neutrons will be used for materials and life sciences and neutrinos and kaons will be used for nuclear and particle physics. Later, neutrons will be used for nuclear transmutation. For this purpose, we need high

power proton beams and, therefore, MW class proton accelerator is needed.

When we proposed this facility the entire cost was about 2 billion dollars. Therefore, the government asked us to cut down to about 1.5 billion dollars, for the construction period of 8 years.

In regard to the share of the construction cost, JAEA covered 56% of the budget and KEK covered 44%.

JAEA covered upstream portion of the project and KEK covered the downstream portion of the project.

LINAC AT THE J-PARC

The injector to the 3 GeV ring is a Linac, as shown in Figure 1. Currently, the beam energy at the Linac is 181

MeV. This portion is composed by ion source, RFQ, drift tube linac (DTL) in which quadrupole lens is included in the interior of linac, and finally, separated drift-tube linac (SDTL). The construction up to 400 MeV is in progress, and it will be completed in JFY2012.

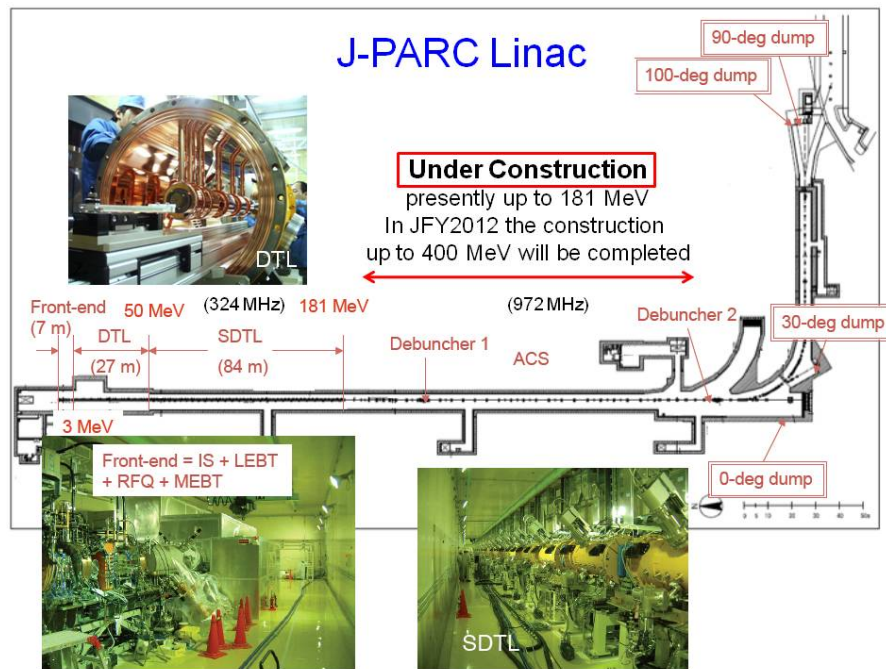


Figure 2: Linac at J-PARC.

THE POWER AT THE J-PARC

The entire accelerators started to run last year. All experimental facilities are now in operation for J-PARC.

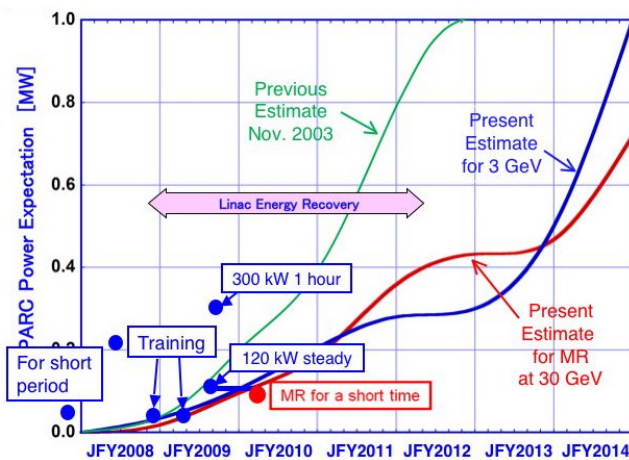


Figure 3: Power capabilities from 3 GeV RCS and 50 GeV MR at J-PARC.

Figure 3 explains power capability for J-PARC. Many different expectations are written here. At the beginning we had, for a short time period, about 200 kW. Therefore, we were very excited about it. Subsequently, however, we encountered a trouble on REQ in Linac, but this problem was fixed during the summer shutdown 2009. In November of 2009 we reached a very stable operation of 120 kW at 3 GeV. We also achieved 300 kW for a short period. Since then, we have been running 120 kW at 3 GeV at a very stable mode (90-95% availability).

At the main ring of 50 GeV, 30 GeV is currently in operation, and we recently achieved 100 kW, for a short time, to a neutrino beamline. Slow extraction to hadron hall is still very low, to the level of 5 kW. Soon we will go up to 30 kW operation in this slow extraction mode.

NEUTRINO PROGRAM

We have two major programs in particle and nuclear physics programs at the main ring, one for fast extracted beams on neutrinos and the other for slow extracted beams on hadrons.

For neutrino program, as shown in Figure 4, the muon neutrino beams are being created at J-PARC. First, disappearance experiment will be done, which was

already confirmed at KEK-PS [1]. High statistics run is planned here. Second, electron neutrino will be measured to measure θ_{13} , a missing angle between the 1st and the 3rd neutrinos. This is a brand new approach for this parameter. Later, if θ_{13} is significantly large, then a CP violation experiment is planned, using neutrino beams and anti-neutrino beams. Clearly, there is strong competition with other facilities such as DiyaBay and Fermilab in regard to the determination of θ_{13} .

For a disappearance experiment of muon neutrinos, the ultimate goal is to detect θ_{23} to the level of 0.01 and mass-square to the level of 10^{-4} . For an appearance experiment of electron neutrinos, the goal is to improve the current limit of θ_{13} to the level of 0.01 (current upper limit is 0.2).

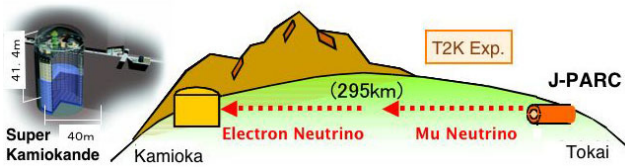


Figure 4: T2K (Tokai to Kamioka neutrino experiment).

The neutrino beam is created like in what follows. First, proton beams were bent by a superconducting magnet to the target area. Then, pions are produced at the target, focused through electromagnetic horn, and finally, sent to the decay volume to produce neutrinos. Once neutrino beams were produced, they are sent to the “On-Site”

detector to confirm the neutrino production. On February 24 the first neutrino event was detected at Super Kamiokande. By the end of July, they already collected 33 events.

HADRON PROGRAM

On the other hand, the hadron experimental hall has many experiments, as shown in Figure 5. Proton beam produces various kaon beam lines. Indicated in Figure 5 as K=1.8 means kaon beam line with momentum of 1.8 GeV/c. At the 1.8 lines a spectrometer called SKS is prepared and, there, hypernuclear spectroscopy will be performed for a variety of nuclei. In particular, searches for double hypernucleus and pentaquark are the highlights in this spectrometer. In K=1.8BR, kaon implantation is planned. When kaon is implanted inside the nucleus, there is a possibility that high density matter is created. Kaonic atom and kaonic nucleus will therefore be studied. On the right-hand side, a neutral kaon line is being prepared to study CP violation. Another beam line (K=1.1BR) is for T-violation experiment. Finally, the high-momentum primary beamline, which is not yet completed, is dedicated to the study of chiral symmetry measurement, namely, the mass generation mechanism of bound quarks.

The first beam test was performed. By using the kaon separator the kaon is clearly separated. All experiments are now waiting for beams in the fall of 2011. Therefore, unfortunately, I cannot show any data at this conference.

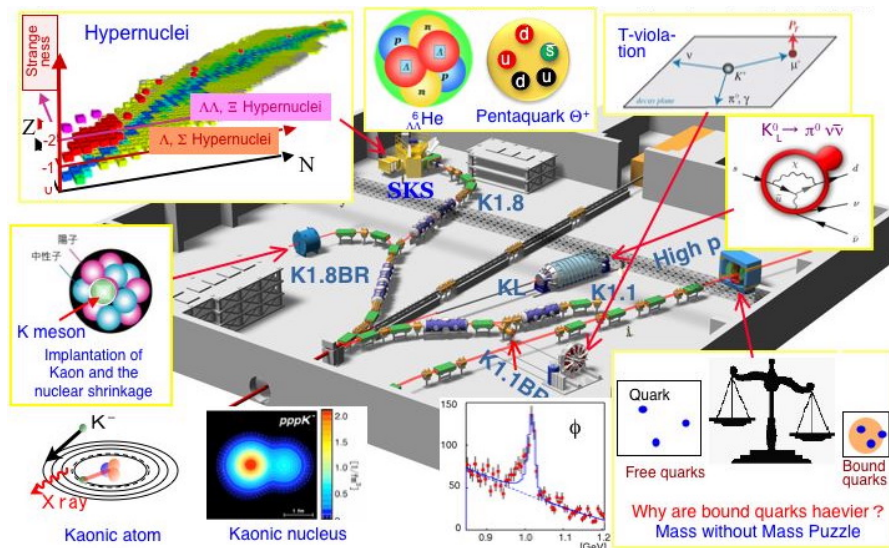


Figure 5: Hadron experimental facility at J-PARC.

MATERILAS AND LIFE PROGRAM

One of the most useful aspects in the research at J-PARC is a broad application by using neutron beams.

The 3 GeV RCS provides 25 Hz proton beams. This means that the pulsed neutron beam can be obtained 25 pulses per second. The goal of the beam power is 1 MW, while 120 kW is the current operational level.

Shown in Figure 6 is a beamline arrangement for neutron equipment. Already 18 beamlines out of 23 were funded, so that there is a strong competition among users to have the remaining 5.

The neutron beam carries many unique features. First, the neutron penetrates through the matter. This feature is unique, as compared to X-rays, since X-rays are easily reflected by a metallic substance, whereas neutrons go through any metallic materials. For example, the Bragg peak for superconducting has been measured precisely. In the second, the neutron interacts with atomic nucleus instead of electron the neutron observes very sensitively atoms with small atomic number Z . In order to measure hydrogen, water, etc. with small Z , therefore, the neutron beam is extremely powerful. Already, many protein

structures with hydrogen's have been observed and identified. In the third, the neutron carries a magnetic moment. The magnetic structure of a crystal or any material can be studied with neutron beams. In particular, simultaneous measurements of spin wave and quantum fluctuation were already published [2], and this paper was selected as "Editor's Choice" of that journal. Finally, high-intensity neutron beams are very powerful for the study of the movement of atoms. This unique feature allows us to study a "function" of a protein in addition to the "structure" of the protein.

At this experimental hall, there are muon beams as well and they are powerful in studying magnetic structure of materials.

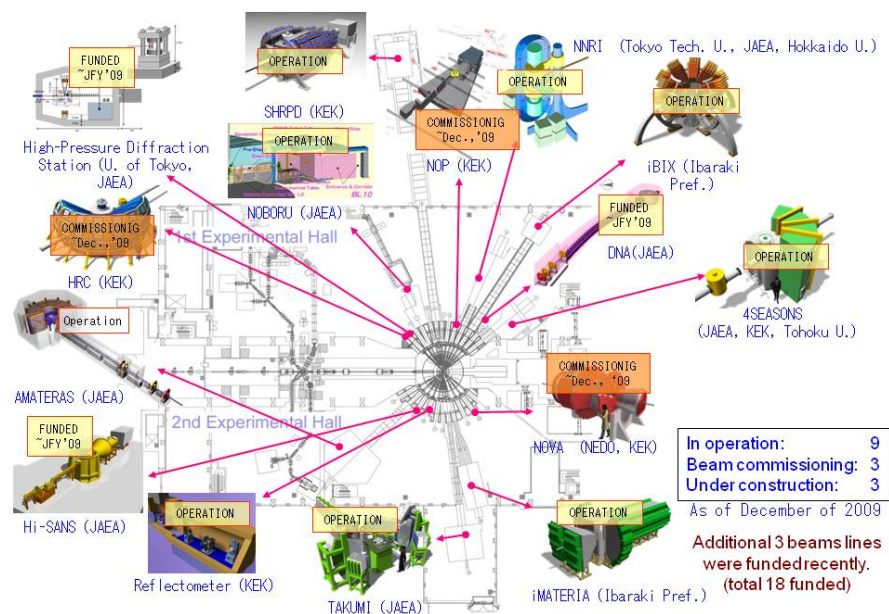


Figure 6: Layout for neutron beamlines.



Figure 7: J-PARC Users and the Mayor of the Tokai Village.

J-PARC AS A USER FACILITY

J-PARC is a user facility. It attracts many people. Already 3000 persons x day per month are at J-PARC (3000 persons x day per month is about 100 visitors/day). This number excludes visitors, committee members, and in-house users. Among these visitors, half is from outside Japan. Therefore, it is urgent to arrange our institute as an international organization.

We have communications with and supports from the local village and the local Government. A photo of Mayor with visitors is shown in Figure 7.

We must prepare lodging for users. We must arrange infrastructure to fit to the foreign style. We must have in-house-restaurant, etc. etc. We are working hard on this aspect.

SUMMARY

- The entire facility was completed in JFY2009.
- Beam power is steadily increasing: 120kW now, 300kW in the near future. Goal is 1 MW.

- Neutrino Facility: Started to take data at Super Kamiokande.
- Hadron Facility: About ready to run for many experiments.
- Materials and Life Facility: Neutron and muon beams already produced many fruitful data and the results are being published.
- Need more efforts towards “international usage” and “industrial usage”.
- We sincerely welcome international users more in the future!!!

REFERENCES

- [1] The K2K collaboration, M. H. Ahn, et al. Phys. Rev. D74 (2006) 072003.
- [2] M. Nakamura, R. Kajimoto, Y. Inamura, F. Mizuno, M. Fujita, T. Yokoo, and M. Arai, J. Phys. Soc. Japan, 78 (2009) 093002.