Construction Status of the J-PARC Hadron Beam Facility

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1. INTRODUCTION

The construction of Japanese high-intensity Proton Accelerator Research Complex (J-PARC) [1] started in 2001 at the Tokai campus of the Japan Atomic Energy Research Institute (J AERI) [2] since the J-PARC is the joint project of the High Energy Accelerator Research Organization (KEK) [3] and J AERI. The construction will be completed by the end of 2008 and experiments will start in the early 2009 as soon as the beam study is completed. The latest photograph of the J-PARC construction site is shown in Fig. 1.

The main accelerator of the J-PARC is the 50 GeV proton synchrotron (50 GeV-PS), whose beam intensity designed is 15 µA. Then the beam power of the J-PARC 50 GeV-PS reaches 750 kW, which is approximately 10 times higher than the existing multi-GeV proton accelerators in the world. The main usage of this high-power 50 GeV proton beam is the intense production of kaons, pions, and many other unstable and/or rare elementary particles such as antiprotons for the drastic progress of both nuclear and particle physics. Therefore the J-PARC 50 GeV-PS is the first real KAON Factory [4] accelerator in the world.

Two experimental facilities will be constructed as the J-PARC 50 GeV-PS. The first one is for counter experiments with slow-extraction beam and is named Hadron beam Facility (Hd-Hall) [5]. The study of the strangeness-included nuclear reactions such as the production of S=2 (or more) hypernuclei, will be the main subject of the Hd-Hall. The production of charmed hypernuclei also is in our scope. Rare K-decay experiments will be the most important counter part of the Hd-Hall as the particle physics experiments. The second facility is prepared for the neutrino experiment with fast-extraction beam and is now named as J-PARC-ν [6]. The main purpose of the J-PARC-ν is the T2K, i.e. Tokai to Kamioka long baseline neutrino
oscillation experiment which will shoot neutrinos to the Super KAMIOKANDE cosmic neutrino observatory at Kamioka mine. The flight distance is approximately 290 km. The parameter determination of the mixing $q_{13}$ in the lepton sector will be the first goal of the T2K.

The other accelerators of the J-PARC are the 3 GeV-333 $\mu$A Rapid-Cycle Synchrotron (3 GeV-RCS) and the 400 MeV linear accelerator (LINAC). The 3 GeV-RCS is the injector/booster accelerator for the 50 GeV-PS. However, the most beam from 3 GeV-RCS will be used for the materials structure studies and biomedical researches through the production of pulsed neutrons and pulsed muons at the Materials and Life Sciences Facility (MLSF). The LINAC is the injector to the 3 GeV-RCS. Unfortunately, the beam energy of the LINAC is just 188 MeV at the first operation of the J-PARC because of the budgetary problems. Thus the beam intensity of 3 GeV-RCS and 50 GeV-PS will be just 60% of their design values, i.e. 9 $\mu$A for the 50 GeV-PS instead of 15 $\mu$A and 200 $\mu$A for the 3 GeV-RCS instead of 333 $\mu$A, respectively. The very tight budgetary situation forces us also to start the lower beam energy of the 50 GeV-PS. The experiments at the Hd-hall will have to be started with 30 GeV proton beam and J-PARC-$\nu$ will be started with 40 GeV.
proton beam. These are due to the delay of the receiving electricity facility for the J-PARC 50 GeV-PS.

The artist’s impression of the Hd-Hall is indicated in Fig. 2. The J-PARC is constructed in the pine forest near the seashore of the Pacific Ocean.

Fig. 2: Artist’s impression of the Hd-Hall of the J-PARC, which is constructed in the pine forest near the sea coast facing the Pacific Ocean.

2. Hd-Hall

The schematic layout of the hadron beam facility (Hd-Hall) is shown in Fig. 3 and Fig. 4. One primary proton beam line (A-line) is prepared to introduce full 50 GeV-15 µA proton beam from the 50 GeV-PS to the Hd-Hall. The most part of the A-line is installed in the 200m-long switchyard as shown in Fig. 3. Main production target, T1, is located at the upstream part of the Hd-Hall and several secondary beam lines will be connected to the T1. The main secondary beam line from the T1 is K1.8, which provides electro-statically separated pure kaon beam to the hyper nuclear and kaon physics. The notation “1.8” indicates the maximum momentum of the beam line. Several other beam lines such as K1.1, K0.8 and neutral kaon beam line will be prepared at T1. The size of the Hd-Hall built by the initial construction (Phase 1) budget is only 60m (wide) x 56m (along the beam), and the full beam dump of 750kW will be built at the outside of the hall. However the
original design of the Hd-Hall is 60 m wide and 100 m long. This full size construction will be realized in the Phase 2 by extending the Phase 1 building along the primary proton beam direction. For this purpose the beam dump has been designed to be moved to the downstream side. Then the second target, T2, will be prepared at the Phase 2. Each target dissipates up to 30% of the incoming primary protons. The movable beam dump allows us to extend the Hd-Hall as long as possible to the beam direction, if necessary.
The small production target, T0, of 0.5% beam loss will be prepared in the switchyard. Several test beam lines will be prepared in connection with the T0. At the upstream point of the switchyard, one more beam loss point so called “Split Point (SP)” is prepared and 2% of the primary protons can be dissipated there. At the SP a set of beam splitter devices can be placed and some small fraction of the primary beam can be divided to the second primary beam line, B. At present just several x10^{11} protons can be split to B line. For higher proton intensities, further technical study should be necessary. This B-line can be used for the high momentum secondary beam line “High-p” by putting 2% loss target at the SP.

The latest photograph of the Hd-Hall construction is indicated in Fig. 5.

Fig. 5: The photograph of the Hd-Hall construction taken on the June 29th in 2006. The concrete structure at the left hand side is the beam dump cave where full 750 kW dump will be installed. The roof of the Hd-Hall is completed the day. The height of the roof is just 18m above the land surface. However the experimental floor is 6m below the surface. Then total height in the experimental facility is 24 m, which is high enough to handle huge concrete shields and versatile experimental setup.

Now the KAON factory is showing its shape. Then the strangeness physics, which was one of the most favorable subject of the late professor Ken-ichi Kubo, who was the longest Japanese member of the Varenna Conference, will be played on the
stage there as the highlight of the playhouse. It may be too late for Prof. Kubo but not too late for the physicists in the world, who are following his works at present.

REFERENCES

1. The latest references of the J-PARC Project can be found at http://j-parc.jp/index-e.html
2. JAERI can be reached at http://www.jaea.go.jp/english/index.shtml
3. The KEK homepage is http://www.kek.jp/intra-e/index.html
4. KAON factory is seen at TRIUMF, “KAON Factory Proposal”, 1985
5. The status of the Hadron Beam Facility (Hd-Hall) of the J-PARC can be seen at http://www-ps.kek.jp/jhf-np/index_e.html
6. The status of the J-PARC-ν is found at http://www-nu.kek.jp/jhfnu/index_e.html
   http://neutrino.kek.jp/jhfnu/