

Status of the Japan Hadron Facility

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1. INTRODUCTION

The Japan Hadron Facility (JHF) is the nuclear and particle physics facility of the Japan Particle Accelerator Research Complex (J-PARC), which has been approved officially by Japanese Government in March 2001 as a joint project of High Energy Accelerator Research Organization (KEK) and Japan Atomic Energy Research Institute (JAERI). The 50 GeV Proton Synchrotron (50 GeV-PS) is the main accelerator of the JHF in J-PARC. The high intensity 50 GeV proton beam of 15 μ A will be accelerated and delivered for the nuclear and particle physics experiments through the intense production of kaons, pions, antiprotons and many other unstable elementary particles. Thus the experimental facility for the 50 GeV proton beam, i.e. the JHF, is the first real Kaon Factory in the world.

Two experimental facilities will be constructed as the JHF. The first one is prepared for counter experiments with slow-extraction beam and is named NP-Hall of the JHF. The study of the strangeness-included nuclear reactions such as the production of multi-strangeness hypernuclei, will be the main subject of the NP-Hall. Rare decay experiments using intense charged and/or neutral kaons will be performed intensively at the NP-Hall, also. The other facility is prepared for the neutrino beam with fast-extraction beam and is named JHF-v. The main subject of the JHF-v is to shoot neutrinos to the Super KAMIOKANDE cosmic neutrino observatory at Kamioka mine, which is 290 km away from the JHF, for the long baseline neutrino oscillation experiment.

The other accelerators of the J-PARC are the 3 GeV-333 μ A Rapid-Cycle Synchrotron (3GeV-RCS) and the 400 MeV linear accelerator (LINAC). The 3GeV-RCS is the injector/booster accelerator for the 50GeV-PS. However the most remaining beam from 3GeV-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 3GeV-RCS. The beam from the LINAC will be used solely for the basic study of the Accelerator-Driven nuclear-waste-transmutation System (ADS). For this purpose, however, the beam energy of the LINAC should be increased up to 600 MeV in the near future. The superconducting-cavity technology will be employed to extend the beam energy from 400 MeV to 600 MeV. All the accelerators will be constructed at the Tokai campus of JAERI.

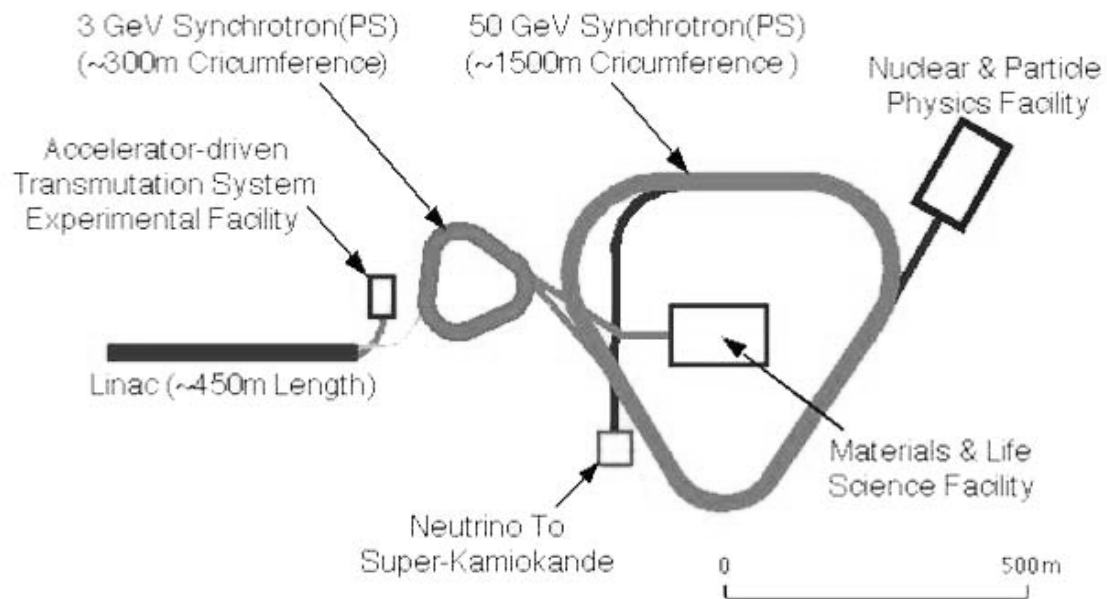


Fig. 1; General Layout of the J-PARC. Nuclear and Particle Physics Facility and Neutrino Beam Facility are the Japan Hadron Facility (JHF) of the J-PARC.



Fig. 2: Artist's impression of the J-PARC constructed in the pine forest near the sea coast.

The construction was divided to two phases mainly because of the budget allocation problem. The first half, the Phase 1, of the construction has been financed at the same time of the approval of the full project and started in 2001. The Phase 1 includes most of accelerators and some fractions of NP-Hall and MLSF. The ADS facility and the JHF-v have been postponed to the Phase 2, unfortunately. The first beam for the Phase 1 is expected in the early 2008. The general layout of the J-PARC as well as JHF is shown in Fig.1. The artist's impression also is indicated in Fig. 2. The J-PARC is constructed in the pine forest near the seashore of the Pacific Ocean.

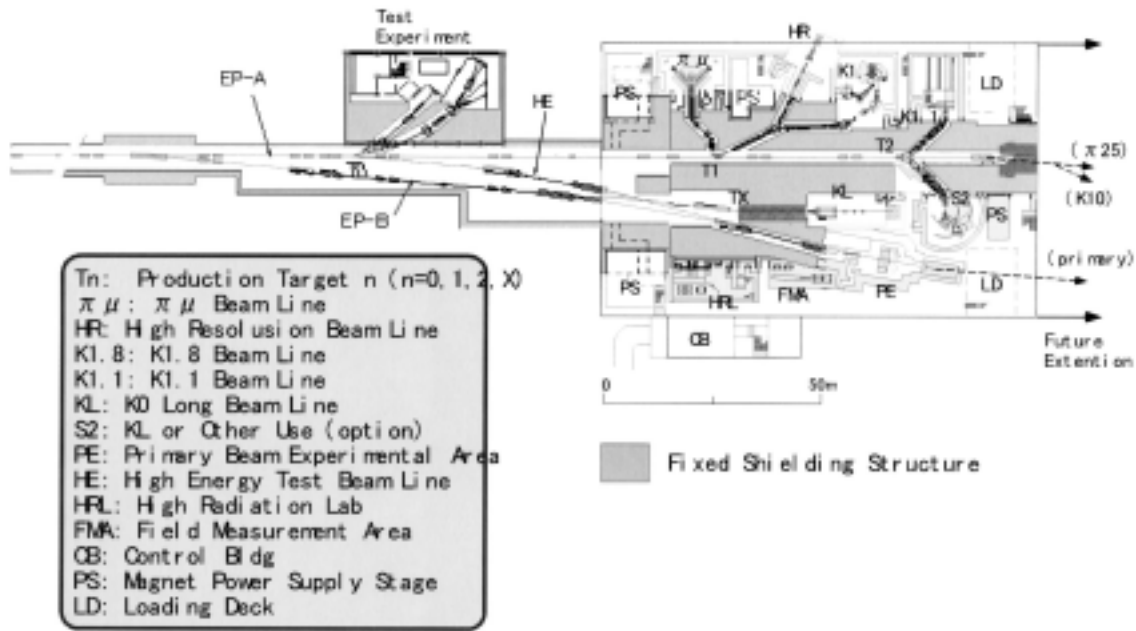


Fig. 3: The schematic layout of the NP-Hall at the end of the Phase 2 construction.

2. NP-Hall

The schematic layout of the NP-Hall at the end of Phase 2 is shown in Fig. 3. One primary proton beam line (A-line) is prepared to introduce full 50 GeV-15 μ A proton beam from the 50GeV-PS to the NP-Hall. The most part of the A-line is installed in the 200m-long switchyard. Main production target, T1, is located at the upstream part of the NP-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 hypernuclear 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 NP-Hall is 60 m wide and 100m long along the primary beam. However at the Phase 1, the size is only 60m x 56m and the full beam dump of

750kW will be built at the outside of the hall. The beam dump has to be moved to the downstream at the extension for the Phase 2. Then the second target, T2, will be prepared at the Phase 2. Each target dissipates up to 30% of the incident protons.

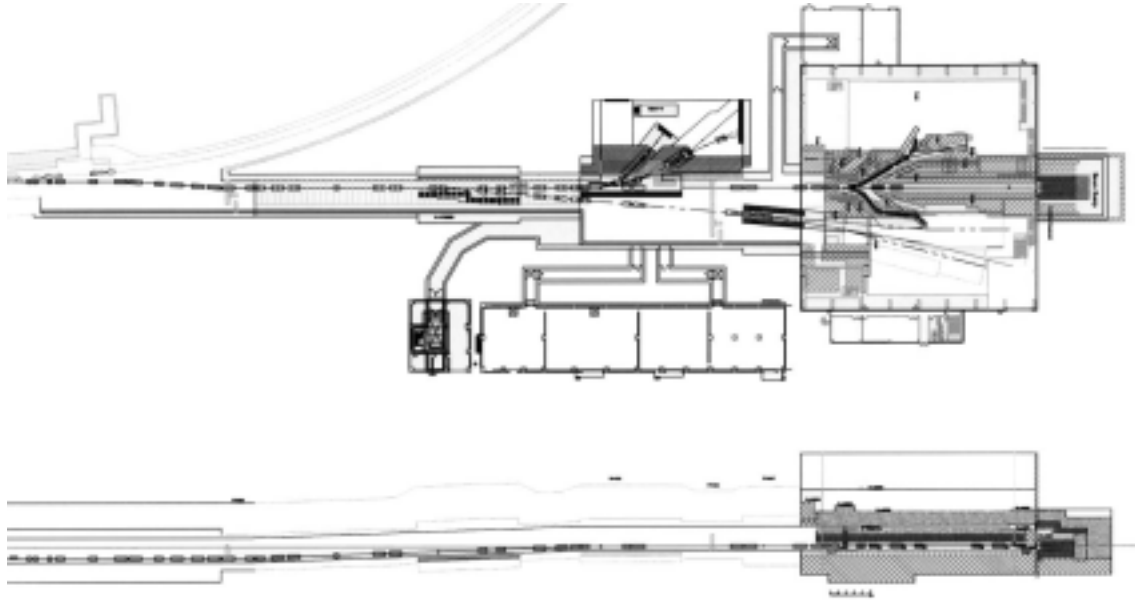


Fig. 4: NP-Hall and Beam Switch Yard at the Phase 1 construction.

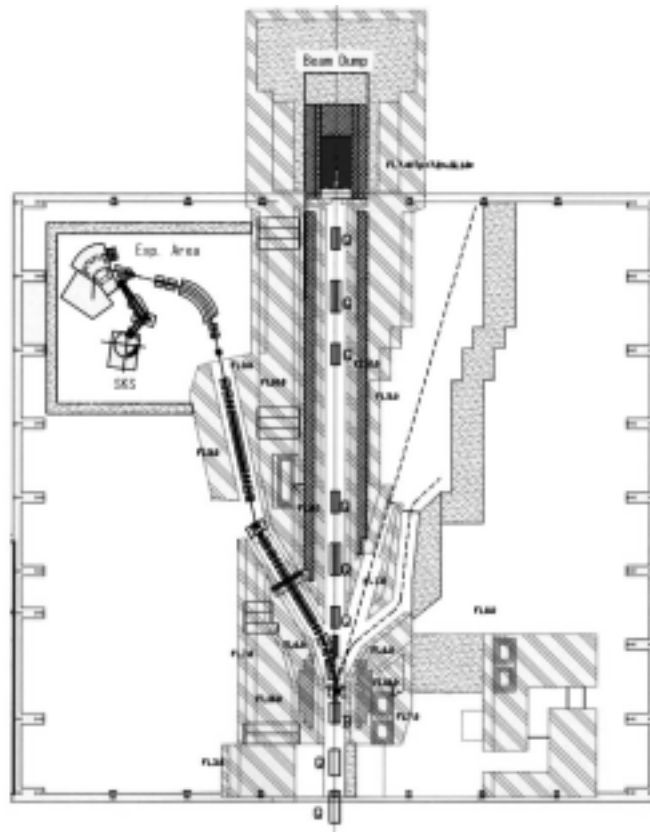


Fig. 5: NP-Hall at the Phase 1 and K1.8 beam line.

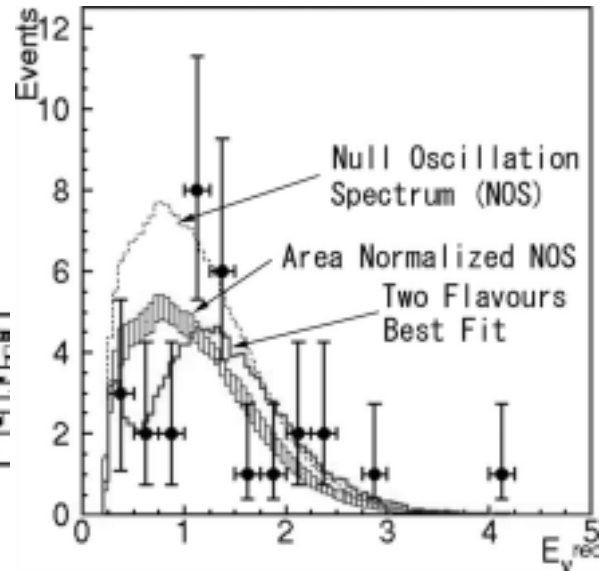
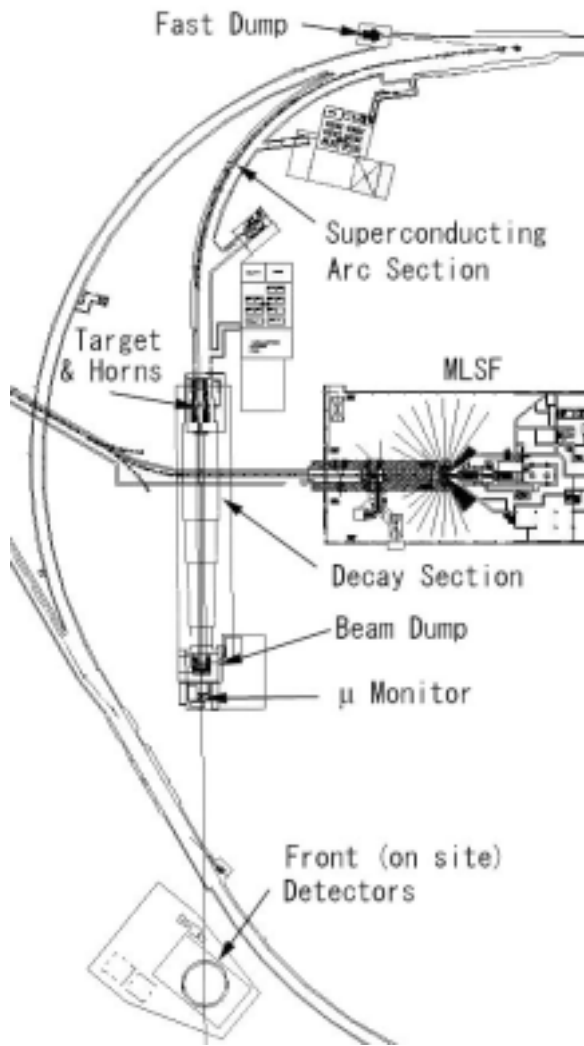
The small production target, T0, will be prepared in the switchyard. Several test beam lines will be connected to the T0. The T0 will use just 0.5% of the incident protons. At the upstream point of the switchyard, one more beam loss point, SM1, is prepared and 2% of the primary protons can be dissipated there. At the SM1, a set of beam splitter magnets 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 $\times 10^{11}$ 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 by putting small 2% loss target at the SM1.

3. JHF- ν

The neutrino beam will be generated by the fast extraction beam. The extraction point is the east-straight section of the triangular ring as shown in Fig. 1. The bend direction of the beam is to the inside of the ring. Therefore the super-conducting magnets should be used at the arc section of the neutrino beam line. The magnets at the most upstream part (matching section) and the most downstream part (final focus section) are conventional warm, however radiation resistant, magnets. The basic structure of the JHF- ν is shown in Fig. 6

The off-axis beam configuration will be employed in order to shoot “narrow band” beam to the Super KAMIOKANDE, i.e. the 50 kt water-Cherenkov cosmic neutrino observatory locating 290 km away from the JHF site. The small near detectors will be prepared on site for the neutrino beam monitoring. A middle distance detectors will be located at 2km distance from the JHF site in order to establish the neutrino beam energy spectrum. At the Phase 2 of the neutrino program, 1 Mt water-Cherenkov detector, the hyper KAMIOKANDE, will be constructed.

We would like to show some demonstrations of the physics of the JHF- ν . Even at present we are shooting neutrinos to Super KAMIOKANDE from the neutrino beam facility of the KEK-PS for more than two years. This experiment is K2K. Though the beam power concerning the K2K is just 5kW, we could observe 56 manmade-neutrino events at the Super KAMIOKANDE whereas 81 events should be expected if we assume no neutrino oscillation. Then the mass-less neutrino hypothesis can be rejected with 99% confidence level. The neutrino energy spectrum reconstructed among the observed events at super KAMIOKANDE is shown in Fig. 7. The neutrino energy spectrum observed by near (on-site) detectors is also shown. Then some discrepancy may be seen at 0.6 GeV region. From this date the Δm^2 is concluded to be 2.8×10^{-3} eV with 90 % confidence level for the maximum mixing angle of $\sin^2 2\theta = 1$. This level of the data accumulation will be performed within 2 weeks at the JHF- ν .



Up

Fig. 7: The neutrino energy spectrum reconstructed among the observed events at super KAMIOKANDE.

Left

Fig. 6: The basic structure of the JHF-v.

4. Future Options

As the Phase 3 of the JHF/J-PARC Project, several extension options are seriously considered. One of the most promising option is to construct one more pulsed proton beam line from the fast extraction kickers and to prepare new target station. The PRISM project, i.e. the muon accumulation ring based on the FFAG accelerator technology, is one of the key facilities which will be connected to the new target. The μ -e conversion experiment and the measurement of the electric dipole moment of muons will be connected to the PRISM. The PRISM will be used for the first accumulation ring of the neutrino factory, also. The g-2 ring and the antiproton accumulation ring are the other candidates which may be connected to the new target. The R/D of the real high power target technology aiming to 4MW beam will be constructed at some appropriate location of the new proton beam line. A very schematic illustration of the Phase 3 option is shown in Fig. 7

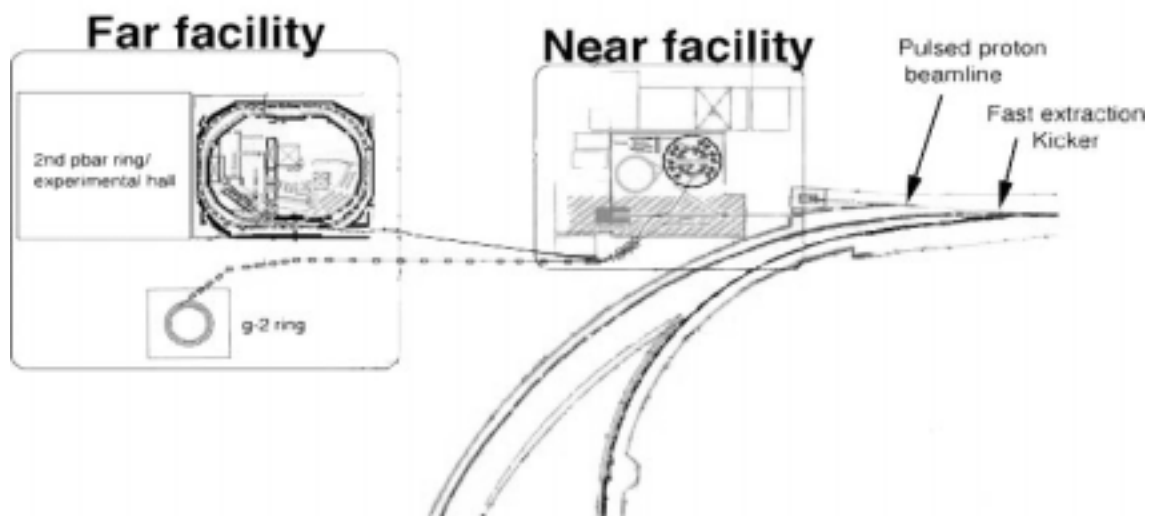


Fig. 7: New pulsed proton beam line as a future extension option.

REFERENCES

- 1, The latest references of the J-PARC Project can be found at <http://j-parc.jp/index.html>
- 2, The status of the Nuclear Particle Physics Facility of the J-PARC, i.e. the JHF, can be seen at http://www-ps.kek.jp/jhf-np/index_e.html
- 3, The status of the technical R/D for the JHF can be summarized at <http://psux1.kek.jp/~jhf-np/hadronbeam/presentation/index-en.html> and <http://psux1.kek.jp/~jhf-np/target-monitor/index-en.html>
- 4, The status of the JHF-v is http://www-nu.kek.jp/jhfnu/index_e.html
- 5, The Letter of Intent for Nuclear and Particle Physics Experiments at the J-PARC, which have already been submitted to Nuclear and Particle Physics Facility Committee (NPFC) are summarized at <http://psux1.kek.jp/~jhf-np/LOIlist/LOIlist.html>
- 6, The accelerator design report is, <http://hadron.kek.jp/member/onishi/tdr/index.html>
- 7, The status of the K2K experiment is, <http://neutrino.kek.jp/index-e.html>