THE STATUS OF J-PARC PROJECT

H. Yokomizo, JAERI, Tokai-mura, Naka-gun, Ibaraki, 319-1195, Japan

Abstract

The J-PARC promotes advanced sciences in 21 century based on high intensity proton accelerators. This includes three big accelerators and four major research facilities. The construction of them was started from 2001 and will be completed in 2007. The site was developed to be flat and accelerator tunnels are under construction. The buildings for the research facility will be started soon. The devices of the accelerator and spallation neutron source are under fabrication in many manufacturers. The initial beam test of a negative ion source up to DTL was successfully achieved 30mA with the energy of 20MeV.

INTRODUCTION

Japan Atomic Energy Research Institute (JAERI) and High Energy Accelerator Research Organization (KEK) are jointly constructing J-PARC facilities in Tokai site of JAERI[1,2]. The J-PARC will cover a wide variety of advanced science and technology such as material science, life and pharmaceutical science, an accelerator-driven nuclear waste transmutation technology, particle physics, nuclear physics and a long-baseline neutrino physics. Table 1 shows the major parameters of J-PARC accelerators and facilities and figure 1 shows an illustration of J-PARC.

The scale of J-PARC project is so big that it was classified into two parts of 1st and 2nd phase program as shown in figure 2. The 1st phase program had been financially approved by the government and its construction was started from 2001. J-PARC of 1st phase is composed of three large accelerators[3]; a 400MeV linac, a 3GeV rapid cycling synchrotron (RCS) and a 50GeV synchrotron. However the linac energy was recently reduced to 181MeV due to a shortage of the budget at the day-one operation and it is planed to recover to 400MeV within 3 years after the day-one operation. The linac beam is provided to the RCS with beam qualities of 50mA peak current, 0.5msec pulse length and 25Hz repetition rate, and to the transmutation experimental facility, alternately. The linac energy will be upgraded to 600MeV in 2nd phase using the super-conducting linac from 400MeV to 600MeV at the same time the transmutation experimental facility will be constructed.

The RCS accelerates the proton energy from 400MeV to 3GeV with the rate of 25Hz. An average beam current is 0.333mA in RCS. The output beam power of RCS is 1MW in the case of 400MeV injection, 0.6MW in the case of 200MeV. The proton beam from RCS is provided to the 50GeV synchrotron by sequential four pulses (5%) among 25Hz pulses during 3.3sec and the rest of pulses (95%) are provided to the material/life science

Table 1: Major parameters of J-PARC

Accelerators			
1) 400MeV Linac	Peak current Pulse length Repetition	50 0.5 50	mA msec Hz
2) 3GeV Synchrotron	Beam power Current Repetition	1 0.333 25	MW mA Hz
3) 50GeV Synchrotron	Beam power Current Repetition	0.75 0.015 0.3	MW mA Hz
Experimental Facilities			
1) Material/Life Science	function of life, new drug, overcome of obstinate disease, new magnetism, super conductivity.		
2) Nuclear and Particle Physics	hypernuclei, neutrino oscillation, K rare decay.		
3) Nuclear Transmutation Technology	new technology for nuclear waste. 10W for sub-critical exp.(2nd phase)		

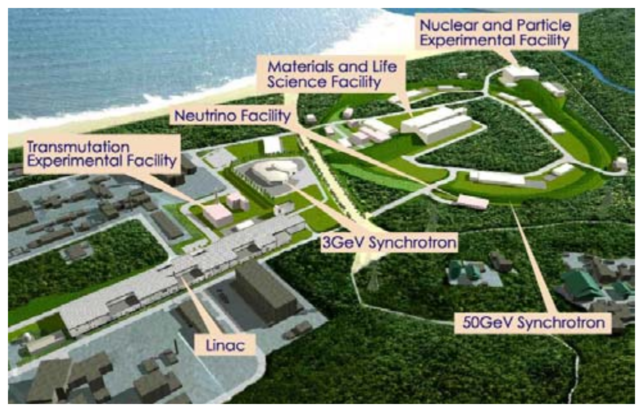

Figure 1: Illustration of J-PARC

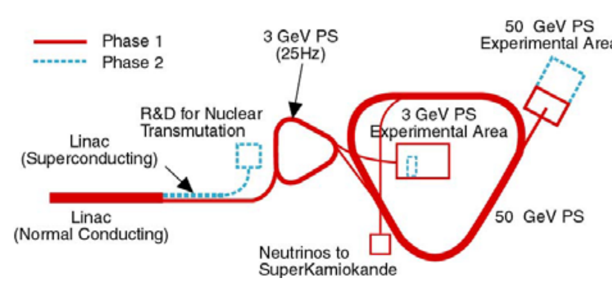

Figure 2: 1st and 2nd phase programs of J-PARC

experimental areas. 50GeV synchrotron is planed to operate 30GeV at the day-one and it will be upgraded to be 50GeV in 2nd phase. The output power of 50GeV synchrotron is 750 kW at 50GeV operation. The beam is extracted to kaon experimental facility in the way of a slow extraction and to the neutrino facility in the way of a fast extraction.

USER FACILITIES

The material/life science facility has two targets; muon target and spallation neutron target located in series[4]. About 10% of beam power is used at the muon target region and four muon beam lines will be available for the experiments. The remaining 90 % beam is led onto the pulse neutron generator of mercury and 23 neutron beam lines will be available for the various experiments. The layout of the material/life science facility is shown in figure 3. The letter of intent (LOI) was called in the field using the spallation pulse neutron source as the first step for the preparation of the experimental instruments. 18 LOIs were submitted in fall of 2002. 9 LOIs among them were recommended to move into the next detail proposals. Further LOIs were also called in 2003. This procedure calling LOI will be performed every year.

The construction of the nuclear and particle experimental facility will be partly started from 2004 fiscal year. The initially approved part is the area of first target of K1.8 and movable beam dump as shown in figure 4. At 2nd phase, the building and experimental space will extended backward and other targets will be installed. The LOI in the nuclear and particle field was also called and 30 LOIs were submitted in early 2003. They are covered in the wide range of physics and as many as 500 scientists are included in these proposals and two third of them are from outside Japan. The review work are carried out in the committee for nuclear and particle experimental facility. The budget for the neutrino facility was newly approved starting from 2004 fiscal year after a scientific interim review of the project. The neutrino facility was used to be allocated in the 2nd phase project and was changed into the 1st phase due to the recent scientific progress of neutrino physics. The completion of construction of the neutrino facility will be 2008, which is one year behind compared with other 1st phase facilities of J-PARC.

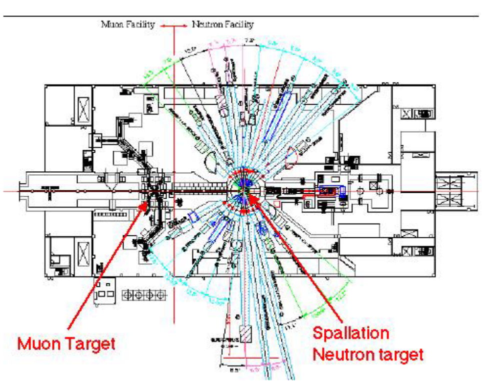

Figure 3: Layout of Material/life Science Facility

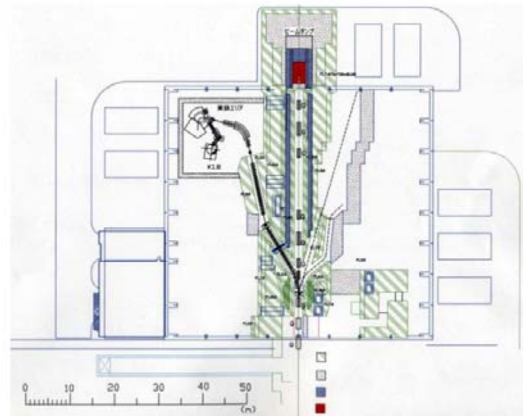

Figure 4: Nuclear and particle experimental facility

The nuclear waste transmutation facility is assigned in the 2nd phase project. The design work and R&D works are carried out now intensively. This facility includes two experimental buildings; one is a physics experimental facility using a low power proton beam with nuclear fuel, and another is a material test facility using a high power proton beam without radioactive fuel.

PROGRESS OF ACCELERATORS

The main components of accelerators were ordered and under construction. Some of devices are under testing.

The linac is composed of 70kV ion source, 3MeV RFQ, 50MeV DTL and 190MeV SDTL(separated DTL) and 400MeV ACS(annularly coupled structure) with a total length of 250m as shown in figure 5. A high intensity negative ion source, 324MHz high power klystron, RFQ, DTL should be developed to be reliable and stable in a long time operation. In the R&D test of the ion source, a beam current was achieved to be more

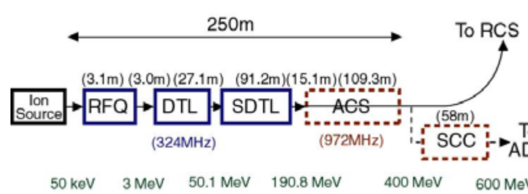

Figure 5: Layout of Linac

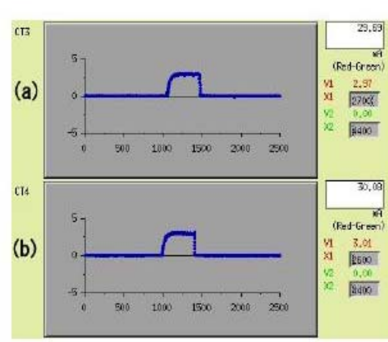

Figure 6: Beam current at the entrance(a) and the exit(b) of DTL

than 60mA with Cs seeded negative ion source and 38mA without Cs type. The 30mA negative Hydrogen was successfully accelerated to 20MeV through a RFQ and first DTL in November 2003. The beam transmission through DTL is achieved 100% within the measurement error as shown in figure 6.

The lattice of RCS[5] is designed to have three fold symmetry as shown in Figure 7. The circumference is 348m. Three dispersion-free straight sections are dedicated to the injection, extraction and RF cavity systems. The arc section consists of two modules of three FODO cells. This arrangement of the bending magnets makes momentum compaction factor tunable and also provides long straight sections. The maximum field strength of the bending magnets is 1.1T, the maximum field gradient of quadrupole and sextupole magnets is 5T/m and 25T/m^2, respectively. The RCS is required to have a large physical aperture for high intensity accumulation so that the gap of bending magnets becomes 210mm and diameters of quadrupole and

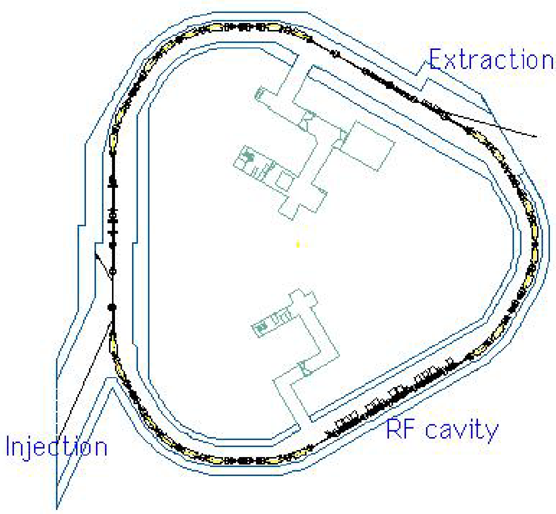

Figure 7: 3GeV synchrotron (RCS)

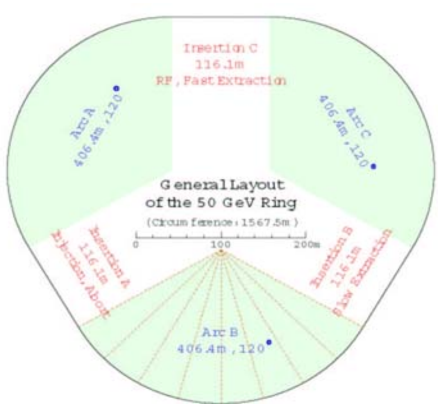

Figure 8: 50GeV synchrotron

sextupole magnets are about 400mm. The fringing field is carefully analyzed and the temperature increase is estimated less than 100 degrees in the end plate. The coils for magnets are selected of stranded conductors in order to reduce an eddy current through the coils. For a rapid cycling 25Hz operation, ceramic vacuum ducts are chosen to eliminate the eddy current induced by changing magnetic field. A large bore and long length of ceramic beam duct have been developed. The brazing method of capper wires was developed on the outside surface of the ceramic duct for RF shielding and TiN coating on the inside surface are successfully tested for reducing secondary electron emission.

The lattice of 50GeV synchrotron is designed to have three fold symmetry as shown in Figure 8. The circumference is 1568m. Three dispersion-free straight sections are dedicated to an injection and an abort systems, a slow extraction system, RF cavities and a fast extraction system. The magnets are composed of 96 bending magnets with maximum field strength of 1.9 T and length of 5.9m, 216 quadrupole magnets with a maximum field gradient of 18 T/m, 72 sextupole magnets with a maximum field gradient of 230 T/m^2. Two third of the bending magnets were already fabricated and their field measurement will be started soon. Many power supplies, vacuum ducts and other components were fabricated and stored in stock room.

The control system is also under construction based on the ALARA (as low as reasonably achievable) radiation principle [6].

BUILDING CONSTRUCTION

The site of J-PARC faces the Pacific and the altitude of the ground is in the range of 5m to 15m. The beam tunnel is basically under the ground. The beam altitude of the linac and RCS is 3.2m above the sea level and 50GeV synchrotron is –1.1m (below the sea level). The material/life science facility is 8.0m and nuclear and particle experimental facility is 1.8m above the sea level. The beam height is 1.2m above the floor.

The tunnel size is designed in taking account of the hand-maintenance as well as reasonable building cost so that the typical cross section is width 7m x height 5.5m for the linac, 6m x 3.9m for RCS and 5m x 3.5m for 50GeV synchrotron, respectively. The tunnel width is wider to be 8-10m at the ion source area, the injection and extraction sections, switching yard for bigger devices and reserving extra radiation shield if necessary. The beam tunnel will be covered by the soil of more than 5m. The beam loss and the radiation protection are important issues in the high intensity accelerator like J-PARC for human access for the maintenance, as well as from point of view of the construction cost. In our design, the value of 1W/m is used for uncontrollable beam loss at any places, except the intended loss points.

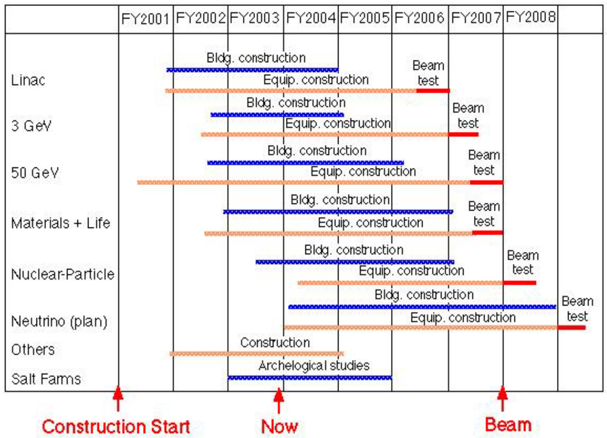

Figure 9: Construction schedule

The linac tunnel haxs been almost completed and was buried by the soil and the klystron building is under construction on the ground of 15m altitude above the beam tunnel. The RCS tunnel and its power supply building are under construction. One forth of 50GeV synchrotron tunnel is almost constructed and the rest of them get under the way. The user facilities are in the preparation for construction. Ancient salt farms were founded in the area of 50GeV synchrotron and the excavation work is carried out so that the construction schedule is slightly modified.

SCHEDULE AND MANAGEMENT

The construction schedule was extended by one year in the negotiation of 2004 budget with the government due to financial situation. The completion of the 1st phase facilities will be in 2007 except the neutrino in 2008 as shown in figure 9. The beam commissioning will be started from middle 2006 in the linac and early 2007 in RCS and middle 2007 in 50GeV synchrotron. The low power beam test will started early 2008 in the material and life science facility and the normal operation for user experiment will started in 2009. The proton beam power will be gradually increased and reach to the design power in a few years later.

The J-PARC project team is jointly organized by two organizations of JAERI and KEK as shown in figure 10 for the smooth construction and about 350 persons are now working in this project team. Nine groups are formed under one project director and 7 committees and a safety review committee are supporting and advising to the director. International advisory committee, accelerator and neutron technical advisory committees are annually held and other committees are more frequently opened.

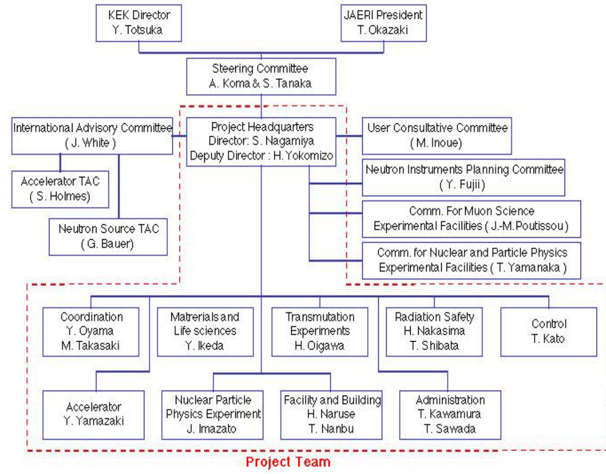

Figure 10: Project team

CONCLUSION

The construction of J-PARC is smoothly progressing. more than 90 % of budget is already approved by the government and major parts of the buildings and devices were ordered and are under construction. The neutrino facility is newly approved by the government in 2004 budget of 1st phase program. The construction schedule was extended by one year from original 2006 to 2007 due to a shortage of annual budget.

REFERENCES

[1] http://j-parc.jp

[2] The joint project team of JAERI and KEK, “The joint project for high-intensity proton accelerators”, JAERI-Tech 99-056/KEK Report99-4, 1999.

[3] High-intensity proton accelerator project team, “Accelerator Technical Design Report for High-Intensity Proton Accelerator Facility Project, J-PARC”, JAERI-Tech, 2003-44/KEK Report 2002-13(2003).

[4] Y. Ikeda, et al., “High-Intensity Proton Accelerator Project (J-PARC) Technical Design Report of Materials and Life Science Experimental Facility”, JAERI-Tech, 2004-001(2004).

[5] H. Suzuki, “Rapid Cycling Synchrotron of J-PARC”, this conference.

[6] H. Sakaki, et al., “The control system for J-PARC”, this conference.`