Status of the J-PARC

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J-PARC Center
High Energy Accelerator Research Organization (KEK)
Japan Atomic Energy Agency (JAEA)
Joint Project between KEK and JAEA

Nuclear Transmutation (Phase 2)

Materials and Life Science Experimental Facility

Hadron Beam Facility

Neutrino to Kamiokande

J-PARC Facility

500m

Linac (330m)

3 GeV Synchrotron (25 Hz, 1MW)

50 GeV Synchrotron (0.75 MW)

J-PARC = Japan Proton Accelerator Research Complex
Location of J-PARC at Tokai

- KAMIOKA
- JAEA
- Tokai
- J-PARC
- KEK
- Tsukuba
- TOKYO
- NARITA

Distance:
- 295 km
- 1 hour
Goals at J-PARC

- Need to have high-power proton beams
- MW-class proton accelerator (current frontier is about 0.1 MW)
- R&D toward Transmutation at 0.6 GeV
- Nuclear & Particle Physics at 50 GeV
- Materials & Life Sciences at 3 GeV
Bird’s eye photo in January of 2008

J-PARC Facility
(KEK/JAEA)

North to South

50 GeV Synchrotron

500 m

3 GeV Synchrotron

Linac

Accelerators

CY2007 Beams

JFY2008 Beams

Bird’s eye photo in January of 2008
Superconducting magnets for the neutrino beamline

Linac (330 m)

3 GeV Synchrotron (350 m)

50GeV Synchrotron (1600 m)

Superconducting magnets for the neutrino beamline
– Phase 1 + Phase 2 = 1,890 Oku Yen (= $1.89 billions if $1 = 100 Yen).
– Phase 1 = 1,527 Oku Yen (= $1.5 billions) for 8 years.
– JAEA: 860 Oku Yen (56%), KEK: 667 Oku Yen (44%).
J-PARC Construction Schedule

- **Linac**
  - JFY2001: Building Design
  - JFY2002: Building Design
  - JFY2003: Building Construction
  - JFY2004: Equipment, Drawing, Fabrication, Installation
  - JFY2005: Equipment, Drawing, Fabrication, Installation
  - JFY2006: Beam
  - JFY2007: Operation
  - JFY2008: Operation
  - 2009+: Operation

- **3GeV RCS**
  - JFY2001: Building Design
  - JFY2002: Building Design
  - JFY2003: Building Construction
  - JFY2004: Equipment, Drawing, Fabrication, Installation
  - JFY2005: Equipment, Drawing, Fabrication, Installation
  - JFY2006: Beam
  - JFY2007: Beam
  - JFY2008: Beam
  - 2009+: Beam

- **50GeV MR**
  - JFY2001: Building Design
  - JFY2002: Building Design
  - JFY2003: Building Construction
  - JFY2004: Equipment, Drawing, Fabrication, Installation
  - JFY2005: Equipment, Drawing, Fabrication, Installation
  - JFY2006: Beam
  - JFY2007: Beam
  - JFY2008: Beam
  - 2009+: Beam

- **MLF**
  - JFY2001: Building Design
  - JFY2002: Building Design
  - JFY2003: Building Construction
  - JFY2004: Equipment, Drawing, Fabrication, Installation
  - JFY2005: Equipment, Drawing, Fabrication, Installation
  - JFY2006: Beam
  - JFY2007: Beam
  - JFY2008: Beam
  - 2009+: Beam

- **Hadron**
  - JFY2001: Building Design
  - JFY2002: Building Design
  - JFY2003: Building Construction
  - JFY2004: Equipment, Drawing, Fabrication, Installation
  - JFY2005: Equipment, Drawing, Fabrication, Installation
  - JFY2006: Beam
  - JFY2007: Beam
  - JFY2008: Beam
  - 2009+: Beam

- **Neutrino**
  - JFY2001: Building Design
  - JFY2002: Building Design
  - JFY2003: Building Construction
  - JFY2004: Equipment, Drawing, Fabrication, Installation
  - JFY2005: Equipment, Drawing, Fabrication, Installation
  - JFY2006: Beam
  - JFY2007: Beam
  - JFY2008: Beam
  - 2009+: Beam

- **Infrastructure**
  - JFY2001: Design
  - JFY2002: Design
  - JFY2003: Drawing, Fabrication, Installation
  - JFY2004: Investigation, Booking
  - JFY2005: Investigation, Booking
  - JFY2006: Beam
  - JFY2007: Beam
  - JFY2008: Beam
  - 2009+: Beam

- **Salt Farm Assets**
  - JFY2001: Investigation, Booking
  - JFY2002: Investigation, Booking
  - JFY2003: Investigation, Booking
  - JFY2004: Investigation, Booking
  - JFY2005: Investigation, Booking
  - JFY2006: Beam
  - JFY2007: Beam
  - JFY2008: Beam
  - 2009+: Beam

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Construction Start (J-PARC Center started)

Time when this schedule was created

Now

Open to Users
**Number of Beam Particles**

Beam Flux at the Full Power Proton Beams

<table>
<thead>
<tr>
<th></th>
<th># of particles per one proton</th>
<th># of particles per second</th>
<th>Typical number of particles at one beamline*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron</td>
<td>80</td>
<td>$10^{17}$</td>
<td>$10^8$</td>
</tr>
<tr>
<td>Muon</td>
<td>$10^{-4}$</td>
<td>$10^{11}$</td>
<td>$10^7$</td>
</tr>
<tr>
<td>Kaon</td>
<td>$10^{-4}$</td>
<td>$10^{10}$</td>
<td>$10^6$</td>
</tr>
<tr>
<td>Neutrino</td>
<td>6</td>
<td>$10^{15}$</td>
<td>$3 \times 10^7$</td>
</tr>
</tbody>
</table>

*) Number listed here is at Super Kamiokande.
Materials and Life Experimental Facility

Facility similar to SNS in the US and to ISIS in the UK
Materials & Life Experimental Facility

- Muon Experimental Area
- Neutron Scattering Area
- Neutron Beam Lines (23 total)
- Target Station
- Scattered Neutrons
- Proton Beam
- Experimental Devices

Proton Beam
The 1st Hall

Muon Production Area

Container

Rail

Mercury Target for Neutrons

Experimental Hall

The 2nd Hall

Neutron Source

Muon Hall
The 1
st Hall (Neutron Area)

2008.5.30. First Neutrons
2008.12. Open to Users
Preparation of Neutron Equipments

- 23 beam lines are available.
- Application for equipment open to public.
- About 10 equipments within JFY2008.

- Super High Resolution Powder Diffractometer (SHRPD) - KEK
- IBARAKI Biological Crystal Diffractometer - Ibaraki Prefecture
- Protein Dynamics Analysis Instrument (DIANA) – JAEA
- Nuclear Interaction (Hokkaido, JST)
- IBARAKI Materials Design Diffractometer - Ibaraki Prefecture
- High-intensity Versatile Neutron Total Diffractometer - KEK, NEDO
- 4d Space Access Neutron Spectrometer (4SEASONS) - Grant-in-Aid for Specially Promoted Research, MEXT
- High-intensity SANS (HI-SANS) - JAEA
- Neutron Reflectometer with Horizontal-Sample Geometry - KEK
- Engineering Diffractometer - JAEA

Life Science
Materials Science
Example of Test Results in June, 2008

Bragg Diffraction

2008.06.21 (8.3Hz 1.5hour)
Si単結晶
分解能 0.0353+-0.0003%

Obtained at KEK KENS
Result at J-PARC (world record)
New Invention for Moderator

Neutron Source

Moderator Type#1

- Neutrons from Reflector
- Neutron beams
- Hydrogen
- Toward beamline
- AIC Decoupler (blue) covers around the entire surface

Other two types of moderators have been prepared.

Ag, In, Cd
Muon Beam Area
Muon Lifetime and Muon Rotation

September 26, 2008

Lifetime = 2.2 μs

Muon Spin Rotation in a Magnetic Field
Expected Power vs. Actual Power

**Expected Beam Power at 3 GeV**

- **Power at KEK-Booster = 3 kW**

- **November of 2003**

- **KEK PS Power**

- **Completion of 200 MeV Linac**

- **Completion of T2K**

- **400 MeV installation in 2008-2010**

- **1.5 years ahead**

**Actual**

- **JFY2007**
- **JFY2008**
- **JFY2009**
- **JFY2010**
- **JFY2011**
- **JFY2012**
Recent Major Events

2008

2
Beam power of 5 kW/pulse (130 kW equiv.), 50 kW extracted at 3 GeV

3

4

5
Injection, RF capture and extraction with 3 GeV beams at MR (5/22)
Production of neutrons (5/30)

6

7

8

9
Beam power of 12 kW/pulse (300 kW equiv.), 210 kW extracted at 3 GeV
Production of muons (9/26)

10

11

12
Acceleration of Beams at the 50 GeV MR
Neutrons + Muons: Beam Usage for General Users
Neutrino Experimental Facility

Number of Users: about 400
(about 1/6 from Japan)

Experiments with Intense Neutrino Beams
Neutrino Oscillation (T2K) Experiment

For example

100 neutrinos

Disappearance of neutrinos

150 neutrinos

Finite Mass

Electron neutrinos

Mu neutrinos

θ_{13}  

Mixing between the 1st and 3rd generation

CP violation experiment later by increasing intensity

100 times sensitivity as compared with K2K

KamLAND, SNO

T2K

Kamio\(\text{kande}\), K2K, MINOS, etc.

Competition with Diya Bay, FNAL, etc.
Neutrino Beamline

Target-Horn System

Target Station

Muon Monitoring Pit

295km to Super-Kamiokande

To confirm the neutrino production

Near Neutrino Detector

Beam Dump

Decay Volume

SCFM at ARC Section

Final Focusing Section

Muon

\( p + A \rightarrow \pi \) + Focusing

\( \pi \rightarrow \mu + \nu \)

On-site Detector

Proton Beam

Near Neutrino Detector

Beam Dump

Decay Volume

SCFM at ARC Section

Final Focusing Section

Muon

\( p + A \rightarrow \pi \) + Focusing

\( \pi \rightarrow \mu + \nu \)
Beam Transport System

- Installation completed
- Cooling of the magnets will start in Jan. of 2009.

Superconducting Magnets
Production Area and Decay Volume

Production Area
(p + A $\rightarrow \pi$)

Decay volume
($\pi \rightarrow \mu + \nu$)

Buried under the ground

Neutrino Area
Beams in JFY2009
Hadron Experimental Facility

Number of Users: about 600

Experiments with Intense K-Meson Beams (Kaon Factory)
Nuclear Physics with Kaon Beams

Strange nuclei are detected via pions, photons, etc.

Kaon beam

Implantation of strange baryon

Strange nuclei are detected via pions, photons, etc.

Hyper Nucleus

Study of the origin of the hadron mass by implanting mesons inside the nucleus!

Nuclei far in the universe!

From impurity physics to bulk matter physics!

Nuclear shrinkage due to Implantation of kaons

High density nuclear matter exists only in the far universe.

Day-1 Experiments at Hadron Facility.
Hadron Experimental Hall

- 30~50 GeV primary beam
- Production target (T1)
- Beam Dump
- KL
- K1.1 S-type
- K0.8 C-type
- K1.8BR
- K1.8

T1 target

J-PARC
Hadron Experimental Hall

Summer in 2007

Now

Hadron Area
Beam within JFY2008
Major Upgrades under Discussions

- Neutrons and Muons
  - Neutron equipments: How to fill the 23 beamlines (so far about 10 lines were funded)?
  - Muon equipments: Among four beamlines, only one beamline will be in operation in 2008. Others have to be funded.

- Hadrons
  - Must construct several kaon beamlines plus a primary beamline.
  - Hadron hall expansion (Phase 2: 60m in length to 100m): Necessary to accommodate many user groups (Many requests on this at the Int. Workshop (NP08) held on 5-7 March of 2008).

- Neutrinos
  - Power upgrade (to 1.7 MW).
  - The third detector (at 2 km from J-PARC or at Okinoshima/Korea).

- Nuclear Transmutation
  - The major item for Phase 2 … Main Goal for JAEA.

- Others
  - Energy upgrade to 50 GeV.
  - Third fast extraction line or a fast extraction line at Hadron Hall?
  - Polarized protons, heavy-ions, ….
Phase 2 Expansion of the Hadron Hall

Example: High Resolution Beam Line

Future expansion: High-p, μ-e, g-2, …

Primary Beam Line

Phase 2 Area
- Materials and Life: One of three world centers, in particular, in Asia.
- Hadron physics: A unique kaon factory in the world.
- Neutrino physics: As a world leader among the three.

World leading accelerator facility is about to be completed.
Internationalization is, however, the urgent issue to solve!

Formation of the world center is the next issue!

ISIS: 英国ラザフォード研究所の中性子源、SNS: 米国オークリッジ国立研究所の中性子源
CERN: 欧州合同原子核研究機構、FNAL: 米国フェルミ国立研究所、GSI: ドイツ重イオン研究所
Summary

Unique Accelerator Project  Multi-purpose facility
- World class proton facility → Variety of secondary beams
  Multipurpose
- Broad fields in Science (materials and Life, Nuclear and Particle,
  Nuclear Industrial, etc.) → Interdisciplinary facility
- Big facility with small users (over 1000 user groups)
- Open to users for Materials and Life in December of 2008. Start to use

Open the Facility to International Scientific Communities
and Domestic Industries
- Internationalization is still not sufficient. Need to improve this aspect.
- Open to industries in the area of neutron sciences.

Future Issues: Production of Top-Level Scientific Results
- Production of world leading results.
- Operation of the facility as the User Facility.
- International facility. Open to any countries in the world.
- Easier access by the industries.