J-PARC Project and Spin Physics

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J-PARC Facility

Joint Project between KEK and JAEA
Location of J-PARC at Tokai

TOKYO
KEK
JAERI
NARITA
KAMIOKA
Tsukuba
Tokai
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)

Materials & Life Sciences at 3 GeV
Nuclear & Particle Physics at 50 GeV
R&D toward Transmutation at 0.6 GeV
Materials and Life Experimental Facility

Facility similar to SNS in the US

Number of Users: about 3,000
Example of Neutron Scattering

X-rays interact with electrons.
→ X-rays see high-Z atoms.
Neutrons interact with nuclei.
→ Neutrons see low-Z atoms.

X-Ray Measurement

Hen Egg-White Lysozyme

Neutron Measurement

H₂O

Tentatively Approved Instruments

Life Science

Versatile powder diffractometer - JAEA
Protein Dynamics Analysis Instrument (DIANA) - JAEA
Cold Neutron Double Chopper Spectrometer (CNDCS) - JAEA

Materials Science

Super High Resolution Powder Diffractometer (SHRPD) - KEK
4d Space Access Neutron Spectrometer (4SEASONS) - Grant-in-Aid for Specially Promoted Research, MEXT,
High-intensity SANS (0H-SANS) - JAEA
Neutron Reflectometer with Horizontal-Sample Geometry - KEK

Proton beam

Engineering Diffractometer - JAEA
Neutron Resonance Spin Echo spectrometers - KUR, Kyoto University
High-intensity Versatile Neutron Total Diffractometer - KEK
Hadron Experimental Facility

Number of Users: about 600
(about 1/3 from Japan)

Experiments with Intense K-Meson Beams (Kaon Factory)

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Pion Implantation

Inside nuclear matter the order parameter for pion could be reduced by 1/3 (i.e., partial restoration of chiral symmetry)

\[ f_{\pi}^2 / f_{\pi}^2 \approx 0.64 \]

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\[ f_\pi^*(\rho)^2 / f_\pi^2 \approx 0.64 \]


These will be possible Day-1 experiments at J-PARC!

Strangeness Implantation

\[ K^- + ^4He \rightarrow "K^-pnn" + p \]

Deeply bound \[ ^3He \] at \[ E_B \approx 194 \text{ MeV} \]


At Frascatti, a bound state of \( K^- \) in \(^3\text{He}\) was discovered recently.

M. Agnello, et al. (2005)

K- in \(^3\text{He}\)

K-Meson

Theory by Y. Akaishi, et al. (2002)

Hyper nucleus

Nuclear shrinkage is also observed for \( \Lambda \) implantation inside the nucleus.

← K. Tanida, et al. (2001)
Neutrino Experimental Facility

Number of Users: about 400
(about 1/4 from Japan)

Experiments with Intense Neutrino Beams

T2K Experiment

T2K = Tokai to Kamioka

Intense neutrino beam by 100 times at KEK 12 GeV PS

Muon neutrino beam

Disappearance of $\nu_\mu \leftrightarrow$ High Statistics T2K
(Five year data at KEK-PS can be measured within a few weeks at J-PARC)

Detection of $\nu_e$ at Super Kamiokande $\leftrightarrow$ Totally new experiment
### From K2K to T2K

**K2K = KEK to Kamioka**

- 107 events observed (151 events expected without any oscillations)
- $99.99\%$ confident that $\nu$ carries a finite mass.

**Number of Users: about 400**
(about 1/4 from Japan)

**T2K = Tokai to Kamioka**

- Measurement of $\theta_{13}$

Flux ($\nu_\mu$) at J-PARC 50 GeV PS
$> 100 \times$ Flux ($\nu_\mu$) at KEK 12 GeV PS

### Layout for Neutrino Experiment

- **Muon monitors @ ~140m**
  - spill–by–spill monitoring of $\pi$–beam direction/intensity
- **First Front detector @ 280m**
  - 0 degree definition
  - High stat. neutrino inter. studies
- **Second Front Detector @ ~2km**
  - Ultimate systematics
  - Now fixing the site
- **Far detector @ 295km**
  - Super–Kamiokande (50kt)

**Neutrino spectra at diff. dist**

- Dominant Systematic Error in K2K
- $0.28\text{km}$
- $1.5\text{km}$
- $295\text{km}$
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Asian Map

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Accelerator-Driven Transmutation (ADS)

Atomic Power Station
High-Level Waste
Without transmutation

Partition
Short-lived Nuclei
Long-lived Nuclei

Transmutation
Without transmutation:
Radiation Level (about 1/200)
Takes $10^4$ yrs to reach the negligible level

With Transmutation:
Takes $10^2$ yrs to reach the negligible level

Phase 2 Project

Beijing
Seoul
JAERI
Kamioka
Phase 1 and Phase 2

- 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%).

Budget Profile

- Construction Start
- Budget Year
- Phase 1 Completion
- Neutrino Completion
- Now
### J-PARC Construction Schedule

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#### Construction Status of J-PARC

- **3GeV Synchrotron (Circumference 350m)**
- **Materials and Life Experimental Hall**
- **Hadron Experimental Hall**
- **Linac (330m)**
- **Neutrino First Detector**
- **50GeV Synchrotron (Circumference 1600m)**
Linac Area

Drift Tube Linac

Transport Line from Linac to 3 GeV

Klystrons + Electric Powers

50 GeV Synchrotron Tunnel

3 GeV Synchrotron Area

Installation of 3 GeV Magnets

From 3 GeV to Life & Materials Experimental Hall
Hadron Experimental Hall

Installation of Neutrino Decay Volume

From 50 GeV to Neutrino Line

Last Construction of the 50 GeV Tunnel

Muon Beamline Extraction Area

Materials and Life Experimental Hall

Installation of Outer Liner

Extraction Area for Neutron Beamlines
About 70% of the facilities were completed.
Archeological studies on the site were completed in August, 2004.
World Centers

- Materials and Life Science: One of three world neutron centers.
- Nuclear and Particle Physics: World unique Kaon Factory. One of three world neutrino centers. For antiprotons, GSI will form a center.
- For transmutation, a world unique center.

ISIS
CERN
J-PARC
FNAL
SNS

Center for neutrons
Center for neutrinos
Antiprotons

About 2 years before the J-PARC completion!

Upgrade Plans for 50 GeV

- Power beyond 1 MW (neutrinos to study CP violation in the leptonic sector)
  - Design study was advanced to 1.3 MW.
  - Possibility up to 2.7 MW is in progress by the Accelerator group.
  - Users want up to 4 MW.
- Muon Storage Ring (LFV, muon g-2, etc.)
  - Need additional extraction beam line.
  - Exit was already prepared.
  - Anti-protons together with muons?
- Polarized Protons
  - Study group was formed.
  - Installation of Siberian snakes seems possible.
- Heavy Ion Acceleration
  - Interest exists among users.
  - Need technical studies.
  - 
  - 
  - 
  - 

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Polarized Proton Beams at J-PARC

50 GeV polarized protons for slow extracted beam primary fixed target experiments
Low intensity (~ $10^{12}$ ppp), low emittance (10 π mm mrad) beams

Pol. H\textsuperscript{+} Source
180/400 MeV Polarimeter
Rf Dipole
25-30\% Helical Partial Siberian Snakes

Possible Locations of Partial Snakes

Polarized beam acceleration at J-PARC is possible with a rf dipole in the 3 GeV and two strong partial Siberian snakes in the 50 GeV Ring.

First 30\% snake
Second 30\% snake
Expansion of Hadron Experimental Hall

Current Experimental Area

Future Extension

Experimental Hall

Test Exp.

A

B

0 50 m

Control/User’s BLDG

Apron Stage (E.)

Apron Stage (W.)

J-PARC Center (Organization for Operation)

J-PARC Center: To operate the entire J-PARC by one responsible organization.

[Construction team: Two institutions carry full responsibilities for funded items.]

The first Agreement was signed on August 8, 2005.

Expected numbers;

330 Employees
280 Outsourcing

These groups started in February, 2006 (62 members)

S. Nagamiya

T. Miura

Y. Yamazaki

Y. Yamazaki

Y. Oyama

M. Murasawa

Coordination

Accelerator

Materials and Life Science

Facility Basic (Computer, etc.)

Safety

Assistant Administration

Nuclear Particle Physics

Transmutation

Building Maintenance

Users Office

JAEA President

International Advisory Committee

Steering Committee

Safety Committee

User Advisory Committee

Director: J-PARC Center

KCK Director

S. Nagamiya

T. Miura

Y. Yamazaki

Y. Oyama

M. Murasawa
Actual Start of the J-PARC Center on February 17, 2006

Summary

- Uniqueness of the Project - Multipurpose Facility
  - Variety of secondary beams + Variety of frontier sciences.
- International Research Center
- News during the Past One Year
  - Construction for both equipments and facilities: A slight delay, but almost on schedule.
    - Peak in the construction budget in JFY2006 (good news to us).
  - J-PARC Center started.
  - An external review on the operational budget.
  - Birth of JAEA.
  - Shutdown of KEK-PS from JFY2006
  - First call for proposals for 50 GeV. Three proposals out of 20 were on Stage 2 full approval.
- Issues
  - Timely completion of the construction.
  - How to grow the organizational structure at the operational stage (J-PARC Center).
  - Realistic operational budget.
  - PAC (time and place), Budget for experimental facilities, Power Users, Beamtime Fee, etc.
  - Linac energy recovery, Phase 2 funding, etc.

Would like to welcome the participation in J-PARC from the world!