Current status of J-PARC accelerator infrastructure

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J-PARC Center, Japan Atomic Energy Agency (JAEA)

Joint Project between KEK and JAEA

2017/10/17
Outline

- J-PARC Overview

- Accelerator Infrastructure
  - What Accelerator Infrastructure?
  - Building - Water Cooling - Air Conditioning
  - When Maintenance? - Manpower?
  - How much Electric Power?

- Fault prediction
  - Circulation pump for cooling water

- Summary
Rapid Cycling Synchrotron (RCS)
3 GeV (25 Hz, 1MW)

Linac400MeV

Center Control Room

Neutrino Experimental Facility

To Kamiokande

Materials and Life Science Experimental Facility (MLF)

Main Ring Synchrotron (MR)
30 GeV (0.75 MW)

Hadron Experimental Facility
What is Accelerator Infrastructure?

Experiment Facility
(MLF, HD, NU)

Accelerator
(Magnet, RF, etc.)

Infrastructure
(Building, Electric Power,
Water cooling, Air conditioning)

Achievements
High-Performance Availability
Not Break
Not Stop
Not Change

But not enough money...

Good Maintenance, Enough Spare
You can never be too prepared!!
LINAC Building

Typical Cross Sectional View
RCS Building

Typical Cross Sectional View
MR Building

Typical Cross Sectional View
Problems of Our site

- Many Earthquakes
  - Floor Deformation
  - Cracks of Concrete Structure
- Ground Water
  - Damage to Equipment due to Water Leakage
- Near Coast
  - Damage by the Briny Air
Earthquake !!

Number of seismic observations by year in Tokai Village

Japanese earthquake class

LINAC

We achieved beam operation restoration on Dec.22 in 2011!!

http://jis.in.jpn.org/stat-tokai.html
Linac building deformed continuously ⇒ Need Alignment of beam line per 2 years
Ground Water

Linac, RCS, MR Tunnel cross section

Water Leakage from RCS Sub tunnel ceiling

Damage to high voltage cable
**Water Cooling – LINAC case**

Typical LINAC Cooling Water system ⇒ Precious control (27±0.1 or 0.2 °C) for Acc. Cavity tuning
Water Cooling – LINAC, RCS, MR

LINAC:
- Electric Power: 8MW
- Cooling Water Ability: 6.2MW
- Loop (1st Heat Exchanger): 10sets
- Cooling Air Ability (MAX.): 4.0MW

RCS:
- Electric Power: 20MW
- Cooling Water Ability: 26MW
- Loop (1st Heat Exchanger): 3sets
- Cooling Air Ability (MAX.): 5.2MW

MR:
- Electric Power: 18MW
- Cooling Water Ability: 32MW
- Loop (1st Heat Exchanger): 9sets
- Cooling Air Ability (MAX.): 2.2MW
Air Conditioning and etc.

1. Electrical substation
   - Primary Volt.: 6.6kV
   - Secondary Volts: 400V, 200V, 100V
   - Commercial PS. Trans. Station
   - 50Hz

2. Emergency PS.
   - Dynamo
   - Engine
   - To 2~6 System

3. Air Discharger
   - Filter Unit

4. Air Conditioner
   - Refrigerator:
     - Basic Chiller
     - Centrifugal Chiller

5. Air Compressor
   - Air Tank
   - Comp.

6. Waste water treatment
   - Normal discharge water
   - RI water to Tank lorry

Radioactive Area

Commerical PS.
Trans. Station

Primary Volt. 6.6kV
Trans.
Secondary Volts:
400V, 200V, 100V

Dynamo
Engine

To 2~6 System

Filter Unit

Air Dumper
Fan
Pump
Air Conditioning – RCS Tunnel case

**RCS:**
- Tunnel Temp. 30 ± 2°C
- Humidity <60%

**LINAC:**
- Tunnel Temp. 27 ± 2°C
- Humidity <60%

**ACC. Operation mode**
- If not Negative pressure in Tunnel, Stop Operation!
- In Operation, No release Radioactive Air!
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  - When Maintenance? - Manpower?
  - How much Electric Power?

- Fault prediction
  - Circulation pump for cooling water

- Summary
Long-term Maintenance ⇒ 3 months in Summer

<table>
<thead>
<tr>
<th>Accelerator Status</th>
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</table>

**Tight schedule...**

When can we maintain for Infrastructure?

- Inspection, Replacement, Adjustment..
- Electrical power distribution equipment
- Air conditioning devices
- Water cooling device (Circulation pump)

Supported by many Maintenance companies!! Need Big money!!
When can we maintain for Infrastructure?

**Short-term Maintenance ⇒ 1 day per 2 weeks**

### 2017: Accelerator Operation Schedule

| Month | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Linac |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| RCS   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| MLF   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| MR    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

**Legend:**
- **Maintenance**
- **Long shutdown/ Maintenance**
- **Tuning & Study**
- **Linac, RCS Half-day Study**
- **User operation**
- **Half day beam delivery**
- **MLF user operation**
- **MLF half day user operation**
- **MR user operation**
- **MR half day user operation**

Run #74: 2017 Apr.
Run #75: 2017 Apr. - Jul.
Manpower for Acc. Infrastructure ⇒ Total: 27 + 62

Main Stuffs
- JAEA: 11 + 5 + 3
- KEK: 6 + 2
⇒ 27

Subcontracting Stuffs
- JAEA: 9 + 19
- KEK: 34
⇒ 62

More Stuffs!!
Not included:
- Trans. of E. Power
- Water supply
- Back-end waste
- Building repair etc.
⇒ JAEA supports
**Infrastructure – Electric Power amount**

**Electric energy amount per month (MLF & NU) 201703**

<table>
<thead>
<tr>
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<th>LINAC</th>
<th>RCS</th>
<th>MLF</th>
<th>MR</th>
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<th>HD</th>
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**Electric energy amount per month (MLF & HD) 201706**

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<tr>
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<th>LINAC</th>
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<th>MLF</th>
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</table>

- **Peak MAX.** 64MW
- **Total (2016FY)** ~ 320GWh/year
  - Cost/year
    - 4.4 billion JPY
    - 33 million EUR
    - 39 million USD
  - Near 30% of all annual fee..
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- **Fault prediction**
  - Circulation pump for cooling water

- **Summary**
Fault prediction – Water pump case

Expendable Parts

Need replacement
Bearing -> per 2 years
Mechanical Seal -> per 2 years
Shaft -> if damage

Variations due to individual differences for pump ⇒ Maintenance skill is very important!
Fault prediction — Water pump violation measurement

For example

Vibration raw data

Special frequency peak

Bearing trouble prediction

Prepare Maintenance for it quickly!
Enhance monitoring system

Time series visualization of operation parameter (Flow, Pressure, Temperature, etc.)

- day
- week
- month

Vibration measurement of rotating equipment (Pump, Fan, Motor, etc.)

Vibration data: displacement, velocity, acceleration

- FFT analysis

Water quality monitoring

Water conductivity -> Ion detection in water

Dust trapping by Filter

-> Micro particle detection

Dust trapping by hollow fiber filter

Fault prediction — 3 efforts (Water cooling system case)
Summary

- Infrastructure and problems in J-PARC accelerators (Building, Water cooling, Air conditioning)

- For Infrastructure
  ⇒ When Maintenance? Manpower?
  Electrical power amount and cost?

- Efforts for Fault prediction
  ⇒ Water cooling system case
Acknowledgement

Thank you very much for your worthwhile discussions.

- Operations support section
  H. Yoshikawa, K. Chida, T. Takasu, S. Yamamoto, Y. Tamaki
- Accelerator Division
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- Accelerator section 4
  K. Suganuma, K. Fujirai, K. Kikuchi, K. Kaminaga, F. Hiroki
- Accelerator section 1
  H. Oguri, T. Morishita
- Accelerator section 2
  N. Tani, K. Yamamoto

Then .. For All Accelerator Stuffs!

Please check his 2 presentations for J-PARC Accelerator in detail.

“Reliability of J-PARC” (Wed.18 poster)

“Effort for the Reliable Operation in J-PARC Rapid Cycling Synchrotron” (Thu.19 16:30)
Thank you for your attention!

Merci de votre attention!
APPENDIX
Accelerated particles: \text{H- (negative hydrogen)}
Energy: \text{400 MeV}
Peak current: \text{50 mA for 1MW at 3GeV}
Repetition: \text{25 Hz}
Pulse width: \text{0.5 msec}

Front-end = IS + LEBT + RFQ + MEBT

Front-end (7 m)
DTL (27 m)
SDTL (84 m)

3 MeV 50 MeV 181 MeV

400 MeV

90-deg dump
100-deg dump
30-deg dump
0-deg dump

400 MeV

ACS (109m)
RCS (Rapid Cycling Synchrotron)

Circumference 348 m
No of bunch 2
Injection energy 400 MeV
Extraction energy 3 GeV
Repetition rate 25 Hz
Output beam power 1MW
### MR (Main Ring Synchrotron)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<td>Extraction energy</td>
<td>30 GeV</td>
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<tr>
<td>Repetition rate</td>
<td>0.40 Hz (2.48 sec)</td>
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</table>

- **Fast extraction section**
  - 3-50 GeV beam bump
    - (7.5 kW)
- **RF cavities**
- **Neutrino beam line**
- **Injection section**
- **RCS**
- **BT collimators**
- **Ring collimators**
- **To Super-Kamiokande**
- **Slow extraction section**
- **Hadron beam line**
- **Hadron experimental hall**
Fault prediction - Fan bearing damage

Ball Bearing

Scratch on the outer ring surface

Vibration measurement

Power spectrum for acceleration intensity of vibration

It is a common problem for all rotating equipment!