JLC Site Study

T. Tauchi, KEK

1. History/ Overview
2. Site Criteria
3. Site Candidates (Area)
4. "Seismic" condition in Japan
5. Ground Motion Measurement at KEK
6. Summary

This is an interim or preliminary report.
1. History/ Overview

**First Stage** (Sep. 2000 - Aug. 2001)

A committee of investigating site criteria has been formed by first council for promotion of JLC in September, 2000.

A key issue was to summarize tolerances of ground motion with consideration of accelerator performances from a scientific view point.

A report was published in August, 2001, which is written in Japanese. After the completion of the report, the committee was dissolved.

**Second Stage** (Sep. 2001 - )

A new group of site investigation, i.e. site study group, was formed as one of sub-groups of JLC promotion committee in September, 2002.

The site study focuses on looking for possible site candidates in Japan.

Two different view points for the candidates:
(a) Geology of least ground motion and also ideal for a technique of tunnel boring machine (TBM).
(b) National projects of science city and development bases for research etc. , focused on infrastructure.

A report will be completed in this summer.
## 2. Site Criteria

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Motion</td>
<td>&quot;All vertical movement&quot;</td>
<td>Underground at least 30m below the surface to avoid seasonal change of the ground temperature.</td>
</tr>
<tr>
<td>Long term stability:</td>
<td>Relative displacement between 2 points separating ~100m shall be less than 300(\mu)m for three months : (A &lt; 1.0 \times 10^{-16} \text{ m/sec}).</td>
<td>Alignment needs several days at least</td>
</tr>
<tr>
<td>Slow vibration:</td>
<td>Tolerance (\frac{E}{e}) (&lt; 0.1) (AT(\propto \frac{E}{e}))</td>
<td>Main LINAC : (\beta = \sim 60\text{ m} \sqrt{E/250(}\text{GeV}))</td>
</tr>
<tr>
<td>Fast vibration:</td>
<td>Main LINAC : Relative random displacement between 2 points separating for 30m shall be less than 10nm at (f &gt; 10\text{Hz}).</td>
<td>Main LINAC : Simple correction, based on a determinant of all-Q BPMs, takes about 10 sec. Balakin's magnet mover system will significantly improve the time interval.</td>
</tr>
<tr>
<td></td>
<td>Main LINAC : rms(random)&lt; 250 (40) nm for (~10\text{ sec}) while the simple correction, (A &lt; 0.5 \times 10^{-15}\text{m/sec}), assuming structures are (not) always aligned with (\pm 5\mu)m. (Final Focus: (AT&lt;1.0 \times 10^{-12}\text{m}).)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Main LINAC : Orbit correction can be applied at 10 Hz in 5 diagnostic sections.</td>
<td></td>
</tr>
</tbody>
</table>
Layout of JLC

parameter list for 500GeV JLC-I

Number of electrons per bunch $7.5 \times 10^9$
Number of bunches per pulse 192
Repetition frequency 150
Bunch separation 1.4 ns
R.M.S. bunch length 110 μm
Horizontal normalized emittance $3.0 \times 10^{-6}$ radm
Vertical normalized emittance $2.0 \times 10^{-8}$ radm
R.M.S. horizontal beam size at IP 243 nm
R.M.S. vertical beam size at IP 3.0 nm
Peak luminosity $2.5 \times 10^{34}$ cm$^{-2}$ s$^{-1}$
Tolerance of Random Displacement at Main Linac

AT (m) Random displacement

Give up region

Advanced

Simple correction

Pulse-to-pulse FB

a few mm

9 × 10^{-10} (A < 9 × 10^{-14} m/sec)

0.5 × 10^{-14} (A < 0.5 × 10^{-15} m/sec)

10 nm

300 nm

250 nm

0.1 sec 10 sec hours (10^4 sec)

Tolerance of Random Displacement at Main Linac < 10%

Give up region
## 2. Site Criteria

<table>
<thead>
<tr>
<th>Geology</th>
<th>Field research on geology, lineament (fault), soil condition on the rock.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform hard rock area is preferable for stability, TBM, large experimental hall under the ground.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geography</th>
<th>Field research on access-road, tunnels, rivers, dams, hot springs, national monument, rare animals and land use.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access tunnel/shafts for TBM-machine (every ~5km) and utility of electric power and water-cooling (every ~2km). On the ground, an area of ~1,000m² is necessary at each access.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Earthquake</th>
<th>No destruction of tunnel and other facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>No seismic center close to the site</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Active fault</th>
<th>same as earth quake</th>
</tr>
</thead>
<tbody>
<tr>
<td>No active fault close to the site</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volcano</th>
<th>same as earth quake</th>
</tr>
</thead>
<tbody>
<tr>
<td>No volcano close to the site</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Criteria</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Central Lab.</td>
<td>Exp. Hall (40m x 40m x 100m), Buildings on the ground</td>
</tr>
<tr>
<td>Total Length</td>
<td>20km at least (30km is favor), double tunnels of 4.5m² and 3m² separating by ~4m, preferable to incline gently for drain water for TBM.</td>
</tr>
<tr>
<td>Tunnel depth</td>
<td>at least 30m to avoid seasonal change of ground temperature</td>
</tr>
<tr>
<td>AC power</td>
<td>Power line of 154~275kV close to the site</td>
</tr>
<tr>
<td>Cooling water</td>
<td>sources (ground water, river)</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Criteria</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>environmental protection</td>
<td>rare animal, cultural property, historical site, temple, shrine, hot spring, national park</td>
</tr>
<tr>
<td>life environmental protection</td>
<td>ground water, scenery, quarry, disposal of waste soil</td>
</tr>
<tr>
<td>promotion</td>
<td>community and regional support</td>
</tr>
</tbody>
</table>

Regional infrastructure both for researchers and families

- **Research**
  - Science city, labor, supply companies, **proximity to a High Energy Physics Lab. (KEK)**, international air port, port, domestic transportation (highway road, railroad)
  - National project of development bases for research

- **Culture**
  - Social, cultural and recreational resources, **proximity to city for rural site.**
  - (international) schools, housing and accommodations, hospitals,

- **Life**
  - emergency services, **job opportunities for families**, **proximity to city for rural site.**
3. Site-candidate Area

(a) Good geology and terrain

yellow circles : candidate area
white : good geology
grey : bad geology
red : zone of active faulting
green: high elevation area of more than 1000m
Granite in pink area
3. Site-candidate Area

(b) National projects (Science cities) area > 1000ha

Blue circles: candidate area

- Rokkasho
- Tomakomai
- KEK
- SPring8
- To-no Aichi
- Okinawa
4. "Seismic" condition in Japan

Hi-net System of NIED

High Sensitivity Seismograph Network
National Research Institute for Earth Science and Disaster Prevention (NIED)

防災科学技術研究所の高感度地震観測網（平成12年度末）
note: corrected by $f^{-2}$ at $f<1$Hz
2002.6.11, 2am
Hi-net, NIED

note: corrected by f^2 at f<1Hz
2002.6.11, 3pm
Hi-net, NIED
note: corrected by f^{-2} at f<1Hz
F-net System of NIED
Broadband Seismic Network Laboratory
National Research Institute for Earth Science and Disaster Prevention (NIED)
4 (~granite)  okinawa (sand)  kagoshima (granite)

5 (granite)  8 (metamorphic)  3 (shale)

kagoshima  rokkasho (andesite)  4 (shale)

2002, 6.3, 2pm  F-net, NIED
5. Ground Motion Measurement at KEK
Configuration of 3 boring holes

GM and geology are measured.

30 minute/ measurement
(at 4:00 a.m. / 10:00 a.m. / 4:00 p.m. / 10:00 p.m.)
Ground Motion

Measurement points; 4 in total
   GL(surface, 29m above sea level)
   underground( -6m, -14m, -34m, -100m )
Directions; north-south(NS), east-west (EW )
   and up-down (UD)
Time at 4am, 10am, 4pm(16), 10pm(22)
Time duration; 30 minutes
Sampling at 1 KHz
Low pass filter of 25 Hz On/OFF (< 100Hz )
Servo accelerometer;
   ( 57mm x x 309mm, 5mV/gal )
Resolution of measurement system ;
   5 mV, which corresponds to 1 mgal

Problem: 1mgal is not enough !
   amplitude = 1mgal / (2π f)^2
   = 25 µm at f= 0.1Hz
   = 250nm at f=1 Hz
   = 2.5nm at f=10 Hz
Power spectrum (acceleration)

- No. 1
- Up/down
- 22:00

"Catalog Resolution"

N. Uchida, JPS, March, 2002
Integrated Amplitude

\[ \text{IAmp}_{ii}(f) = \sqrt{\int P_{ii}(f) \, df} \]

Note: Resolution is not enough!
Coherence

\[ \text{Coh}_{ij}(f) = \frac{\left| P_{ij}(f) \right|}{\sqrt{P_{ii}(f)} \sqrt{P_{jj}(f)}} \quad (i \neq j) \]

\[ P_{ij}(f) = \lim_{T \to \infty} \frac{1}{T} F_i^*(f) F_j(f) \]

GL -006m  Coherence  
22:00  U-D  #1 #2

- GL -6m
- Up/down
- 22:00
- No. 1 and 2
Amplitude (m/Hz ^ 0.5)

Integrated Amplitude (m)

Frequency (Hz)

1E-11 1E-10 1E-9 1E-8 1E-7 1E-6 1E-5 1E-4 1E-3 1E-2 1E-1 1

0.01

0.1

1

1E-12 1E-11 1E-10 1E-9 1E-8 1E-7 1E-6 1E-5

1993.07.12 16:30

measured by N. Yamamoto, T. Matsui

Fuji

10nm 40nm 250nm
<table>
<thead>
<tr>
<th>Soil Type</th>
<th>D2~10mm</th>
<th>D2~30mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravel D2~10mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silty sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
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<td>Gravel D2~30mm</td>
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</table>

Diagram showing stratigraphic layers with elevation and depth markers.
6. Summary

(a) Site criteria have been evaluated from scientific viewpoint, especially on tolerance of ground motion.

(b) Site candidate area has been selected for further study, where 8 areas are based on good geology and 4 areas are based on "national project on science/technology city".

(c) Seismic conditions around the candidate areas have been investigated by using Hi-net and F-net of NIED. No negative result has been obtained.

(d) Ground motion measurement will be re-tried with improved method at KEK (close to the main road "Higashi-Odori").

A report will be published by JLC site study group in this summer.