Practical Radiation Control at KEK
Scope of this talk
Radiation Control
(1) Exposure control
   KEK, Government
(2) Controlled area

Activation of beam line
12GeV-PS and the Utilizing Facilities
   Extraction beam line
   EP1, Neutrino Beam Line, Target Station
   500MeV Beam Transport Line

Another speaker will give more information:
Professor Satoh  Maintenance scenario
Professor Kawakubo  Practical maintenance experience
   Radio-activities and radiation exposure from the maintenance
• **Proton Accelerators**

  45MeV Linear Acc. ~ 30μA
  500MeV Synchrotron ~ 6–10μA (3–5kW)
  12GeV Synchrotron ~ 0.3–0.7μA (~3–8kW)

    168h/w, 2186h/3m (5000~ 6 0 0 0 h/y)

• **Experimental Hall (168h/w, 2186h/3m (4500h/y))**

  12 GeV Protons ~ 0.58μA (~7kW)

    North Counter Hall (EP1 and Neutrino Beam Line)
    East Counter Hall (EP2 Beam Line)

  500 MeV Protons ~ 10μA (~5kW)
### Electrons and Positrons Accelerators

<table>
<thead>
<tr>
<th>Linear Accelerators</th>
<th>10GeV 0.625μA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF-AR Synchrotron</td>
<td>8GeV 0.25A</td>
</tr>
<tr>
<td>PF Synchrotron</td>
<td>3GeV 0.6 A</td>
</tr>
<tr>
<td>KEKB Synchrotron</td>
<td>10GeV 1A</td>
</tr>
<tr>
<td></td>
<td>5GeV 1A</td>
</tr>
</tbody>
</table>

168h/w, 2186h/3m (6000~7000h/y)
Radiation Exposure Control
-Japanese Law Criteria-

Radiation Worker  100 mSv per 5 years
                 50 mSv per year

Women            5 mSv per 3 months
Pregnant Women   (Gestation after Declaration of Pregnancy)

Internal Exposure 1 mSv
External Exposure  2 mSv
Radiation Exposure Control
-KEK Criteria-

Man
20 mSv per year

Women
2 mSv per 3 months
6 mSv per year

Pregnant Women
(Gestation after Declaration of Pregnancy)
Internal Exposure 1 mSv
External Exposure 2 mSv

Please inform the Radiation-Safety Supervisor of pregnancy
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Gender</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Day</td>
<td>Man</td>
<td>less than 0.5 mSv</td>
</tr>
<tr>
<td></td>
<td>Woman</td>
<td>less than 0.3 mSv</td>
</tr>
<tr>
<td>1 Week</td>
<td>Man</td>
<td>less than 1.0 mSv</td>
</tr>
<tr>
<td></td>
<td>Woman</td>
<td>less than 0.5 mSv</td>
</tr>
<tr>
<td>1 Year</td>
<td>Man</td>
<td>less than 7 mSv</td>
</tr>
<tr>
<td></td>
<td>Woman</td>
<td>less than 2 mSv</td>
</tr>
</tbody>
</table>
## Design Value for Radiation Shielding

<table>
<thead>
<tr>
<th>Area</th>
<th>KEK Design Value</th>
<th>Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Boundary</td>
<td>&lt; 50 Sv/y</td>
<td>&lt; 250 Sv/3m</td>
</tr>
<tr>
<td>General Area</td>
<td>&lt; 0.2 Sv/h</td>
<td></td>
</tr>
<tr>
<td>Warning Area</td>
<td>&lt; 1.5 Sv/h</td>
<td></td>
</tr>
<tr>
<td>General Radiation Controlled</td>
<td>&lt; 20 Sv/h</td>
<td>&gt; 1.3mSv/3m (2.6 Sv/h) &lt; 1mSv/w</td>
</tr>
<tr>
<td>Restricted Radiation Controlled Area</td>
<td>&lt;100mSv/h</td>
<td></td>
</tr>
<tr>
<td>Forbidden Radiation Controlled Area</td>
<td>&gt;100mSv/h</td>
<td></td>
</tr>
</tbody>
</table>

Ground Water activation

10 Sv/y at site boundary from drinking water
Forbidden
>100 mSv/h

20 mSv/h < Restricted < 100 mSv/h

1.5 mSv/h < General < 20 mSv/h

0.2 mSv/h < Warning < 1.5 mSv/h

Free on Site ≤ 0.2 mSv/h

Site Boundary < 50 mSv/y

Public
Appendix 1,
Radiation Controlled Areas in KEK
(2001)
Daily Radiation Control
(1) Radiation Dose
(2) Access Control
(3) Radioactive Material Control
(4) Exposure Control

Control Scheme is different
during operation,
during maintenance after operation
During Operation

High energy neutrons (1〜100MeV) in the experimental area. Access to the beam line is strictly controlled by interlock system.

Radiation controlled area, experimental hall, are monitored continuously to watch the radiation level.

Radiation workers and experimentalists, who enter radiation controlled area, are recorded automatically by card system.
After stopping operation,
  Maintenance inside beam line must be restricted.
Procedure to start maintenance inside beam line:
1) measure radiation dose along beam line,
2) write proposal for maintenance
    who, where, when, how
3) if the maintenance is at a high radiation place,
    permission from radiation officer,
    a person in charge of the facility,
    plan to proceed the maintenance to avoid high exposure,
    shielding, individual working time,
    many people to distribute exposure,
    key person must be away from radiation work till
    necessary.
4) Every one must carry an alarm dosimeter,
    The responsible person must control and organize.
Induced Radio-activities and Radiation Field

12 GeV PS Ring and Related Facilities
  Extraction Septum Magnets
    $3 \times 10^{12}$ pps (5.7 kW) for EP1 Fast Extraction
    $1 \times 10^{12}$ pps (1.9 kW) for EP1 Slow Extraction
  Counter Hall
    T5 and T6 Target (PT6cm) $1 \times 10^{12}$ pps
  Neutrino Target station
    Neutrino Production Target (AL 65cm) $3 \times 10^{12}$ pps

500 MeV Utilizing Facility
  Neutron and Meson Laboratory (NML)
  Beam Transport Line
  P4 Line for slow muon Production
EP1 Extraction (25/12/’02)

EP2 Extraction (25/12/’02)
3 weeks cooling

EP1

EP2
North Counter Hall
(K5 and K6 Experimental Area)

EP1 Beam Line, Neutrino Beam Line
EP1-A, Experiment Utilizing Primary Proton Beam
12GeV; 0.16nA (1.0×10⁹ pps)
EP1-B, 1) Production of Secondary Particles, π, K
Target T5(PT6cm): K5 Exp. Area
Target T6(PT6cm): K6 Exp. Area
2) Transmit Proton Beam to Neutrino Target Station

Neutrino-TS
AL target 65cm 2cm diameter
12GeV;Max 0.576μA (3.6×10¹² pps,6.9kW)
12GeV Protons $1.0(3.0)E+12$ P/s for 30 days irradiation on PT(AL) (MARS calculation)

Dose Rate (mSv/h) vs Time (hours)

Na-24
Na-22

AL-65cm
PT-6cm
Neutron and Meson Science Laboratory,
NML Beam Line
500MeV, MAX:9.6µA (6.0×10^{13} pps)

Neutron Experimental Hall
Production Target W with Ta clad 2.9cm × 4

Meson Experimental Hall
Meson No.1 Laboratory
Meson No.2 Laboratory (P-4 Beam Line)
## Dose rate created by induced activities

<table>
<thead>
<tr>
<th></th>
<th>Dose Rate (mSv/h)</th>
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<tbody>
<tr>
<td></td>
<td>Beam Loss</td>
</tr>
<tr>
<td>12GeV-PS extraction</td>
<td>400W</td>
</tr>
<tr>
<td>septum magnets</td>
<td>580W</td>
</tr>
<tr>
<td></td>
<td>10~20</td>
</tr>
<tr>
<td>Target (EP1) in 12GeV-PS Related Facilities</td>
<td></td>
</tr>
<tr>
<td>PT (6cm)</td>
<td>960W</td>
</tr>
<tr>
<td>Near Target</td>
<td>50~100</td>
</tr>
</tbody>
</table>
KEK Working Level of Exposure Control

**Close Contact**

- 0.5 mSv/d
- 30 minutes/d at 1 mSv/h
- 3 minutes/d at 10 mSv/h

Planning maintenance
- 1 ~ a few hours

1 mSv/w 2 days/w
7 mSv/y 7 weeks/y