Preliminary Studies of Radiation Safety Issues for E160 Experiment in the ESA

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Two operation modes in E160 experiment:

1. Use electron beams to produce photon beams for E160 experiment.

2. Use electron beams to calibrate SEQ quantameter
1. Electron beam parameters in the A–line when the photon beam is produced:

To produce the photons, an electron beam hits a diamond crystal, and is bent to an electron dump located at the end of A–line by the four dump magnets (B33, B34, B35, and B36).

Electron beam energy:

\[ 20 \text{ --- } 48.3 \text{ GeV} \]

Beam power:

\[ 6 \times 10^{10} \text{ e}^- /\text{pulse} @ 120 \text{ pps}, 23 \text{ kW} - 56 \text{ kW}. \]

Diamond crystal: Up to 1 mm thick, 0.01 r1

Located downstream of ST29.
Table 1. Nominal dump magnet setting for 48.3 GeV Beam when the photon beam is produced

<table>
<thead>
<tr>
<th>Magnet Field</th>
<th>Dipole B33</th>
<th>Dipole B34</th>
<th>Dipole B35</th>
<th>Dipole B36</th>
<th>Sweep Magnet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet Field</td>
<td>56.3 kG–m</td>
<td>56.3 kG–m</td>
<td>56.3 kG–m</td>
<td>56.3 kG–m</td>
<td>50 kG–m</td>
</tr>
<tr>
<td>Polarit y</td>
<td>e⁻ to ground</td>
<td>e⁻ to ground</td>
<td>e⁻ to ground</td>
<td>e⁻ to ground</td>
<td>μ⁻ to ground</td>
</tr>
</tbody>
</table>
2. Electron beam parameters in the A–line when the electron beam is used to calibrate Quantameter (SEQ):

An electron beam is delivered into the ESA to calibrate the SEQ Quantameter. The four dump magnets (B33, B34, B35, and B36) and Sweep magnet are off. All magnets in the ESA are off. The electron beam parameters for the calibration are listed as follows:

Electron beam energy: 15 --- 48.3 GeV
Electron beam power: Up to 1 kW.
The beam time in this operation mode is less than 5 % of E160 running time.
3. Photon beam parameters for E160:

The produced photon beam parameters are listed as follows:

Primary photon beam energy: 15 --- 35 GeV

Maximum photon beam power: < 1 kW

Nominal running photon beam power to SEQ: 200 W for two months.

E160 targets: Be to Au, up to 0.12 rl.
Table 2. Nominal E160 spectrometer magnet setting

<table>
<thead>
<tr>
<th></th>
<th>Dipole 3D2</th>
<th>Dipole 3D3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet Field</td>
<td>&lt; 50 kG–m</td>
<td>75 kG–m</td>
</tr>
<tr>
<td>Polarity (Hor. Plane)</td>
<td>North or south</td>
<td>North or south</td>
</tr>
</tbody>
</table>
4. Compton Polarimeter (to be designed):

A Compton polarimeter is needed to measure the circular polarization of the photon beam for E159 and E161. It will be used to measure the photon spectrum of E160. The polarimeter consists of a Moller target, a magnet and a detector. The polarimeter magnet field strength is less than 40 kG–m, and bends the electrons to north.
5. Beam Losses in Nominal running condition

<table>
<thead>
<tr>
<th></th>
<th>Energy deposition by photon beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collimator C37</td>
<td>&lt; 700 W</td>
</tr>
<tr>
<td>Collimator 3DC2</td>
<td>10 W</td>
</tr>
<tr>
<td>E160 target</td>
<td>20 W</td>
</tr>
<tr>
<td>Beam pipe</td>
<td>&lt; 10 W</td>
</tr>
<tr>
<td>SEQ</td>
<td>200 W</td>
</tr>
</tbody>
</table>
6. Radiation Shielding

a. Shielding for electron the dump

b. The existing E158 concrete tunnel inside the ESA provides very good shielding for E160 Experiment as well. It is planned to keep most part of E158 concrete tunnel in the ESA to meet requirements of both radiation safety and earthquake protection.

c. Shielding for photon dump (1’ lead on the northside of the dump, 7” lead on the top of the dump, 2’ at the downstream of the dump, keep the E158 sandbags at SSRL region in place)

Table 3  Beam Containment system (BCS) for the E160
<table>
<thead>
<tr>
<th>Beam Containment System</th>
<th>Protection Devices</th>
<th>Status</th>
<th>Setting</th>
<th>Electron dump</th>
<th>Collimator</th>
<th>Luminosity Monitor</th>
<th>Photon dump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Current monitor IL, H1, I28</td>
<td>Two flow switches</td>
<td>existing</td>
<td>Limit the beam power to 60 kW</td>
<td>100 kW, water cooling</td>
<td>Collimator 3C1</td>
<td>Luminosity Monitor 3LC</td>
<td>5 kW, water cooling</td>
</tr>
<tr>
<td>3LION1A</td>
<td>Two ion chambers</td>
<td>existing</td>
<td>Ion Chamber 3C1A/B setting</td>
<td>5 kW, water cooling</td>
<td>2 kW</td>
<td>Collimator 3LC</td>
<td>2 kW</td>
</tr>
<tr>
<td>3LION2A</td>
<td>Two ion chambers</td>
<td>existing</td>
<td>Ion Chamber 3C8A/B setting</td>
<td>Lions</td>
<td>2 kW</td>
<td>Collimator 3LC</td>
<td>2 kW</td>
</tr>
<tr>
<td>3LION1B</td>
<td>Two ion chambers</td>
<td>existing</td>
<td>Ion Chamber setting</td>
<td>El158</td>
<td>Two flow switches</td>
<td>Collimator 3LC</td>
<td>One BTM</td>
</tr>
<tr>
<td>3LION2B</td>
<td>Two ion chambers</td>
<td>existing</td>
<td>Ion Chamber setting</td>
<td></td>
<td>New</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3LION3</td>
<td>New</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3LION4</td>
<td>New</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Failure analysis:

1. Mis-steering condition: 2 kW

2. Maximum credible accident: 1300 kW
## Radiation Dose during E160 Experiment

<table>
<thead>
<tr>
<th></th>
<th>Requirement</th>
<th>Design goal*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counting House</td>
<td>&lt; 100 mrem one year</td>
<td>50 mrem for two months</td>
</tr>
<tr>
<td>Around ESA</td>
<td>&lt; 0.5 mrem/hr</td>
<td>&lt; 0.1 mrem/hr</td>
</tr>
<tr>
<td>SSRL</td>
<td>100 mrem from all operations for one year</td>
<td>20 mrem from E160 for two months</td>
</tr>
<tr>
<td>Mis-steering</td>
<td>&lt; 400 mrem/hr</td>
<td>&lt; 40 mrem/hr</td>
</tr>
<tr>
<td>Max. Accident</td>
<td>&lt; 25 rem/hr</td>
<td>&lt; 25 rem/hr</td>
</tr>
</tbody>
</table>

* Design goal considered ALARA (as low as reasonably achievable)