Neutron Background from QC1 at JLC

Background Source

\[ \text{e}^+\text{e}^- \text{ pair background} \]
\[ \downarrow \]
\[ \text{EM shower in QC1} \]
\[ \downarrow \]
\[ \gamma + A \rightarrow n + X \]

Generation of \( \text{e}^+\text{e}^- \) pair

Calculation using ABEL

Beam \( E = 250 \text{ GeV} \)

Energy spectrum \( \rightarrow \) see Fig. 1

\[ 1.8 \times 10^4 \text{e}^+\text{e}^- / \text{bunch} \]

Average energy \( \div 6.5 \text{ GeV} \)

Simulation

\[ \gamma + A \rightarrow n + X \text{ process coded by} \]
T. Maruyama is implemented into
GEANT3-based JLC detector simulator JIM.

Cross section is artificially increased by \( \times 100 \).
Fig. 2(a) and Fig. 2(b) illustrate components of the Luminosity Monitor and Beam Profile Monitor, along with the SC-Compensation Magnet. The diagrams also show the positioning of Carbon Mask and Vertex detector in relation to the Support Tube and Beam pipe. Distances such as 30 cm, 1.0 m, and 2.0 m are indicated to provide scale.
Results of the Simulation

z-coordinate of the production point (Fig. 3(a)) and kinetic energy (Fig. 3(b)) of the generated neutron.
R distribution of neutrons passing z=0 plane

Fig.4(a) shows the R distribution of neutrons at z=0 for the geometry shown in Fig.2(a). A bump can be seen at small R corresponding to holes and thin regions of the mask.

Fig.4(b) is the close-up of Fig.4(a) for R<30cm. There are 187 entries in 0.4 bunch crossing. Taking 100 times larger cross section into account, the neutron intensity near R=0 is

\[
\left( \frac{187}{0.4\text{bunch}} \right) \times 85\text{bunch} \times 150\text{Hz}/(\pi \times (30\text{cm})^2)/100 = 21/\text{cm}^2/\text{s}
\]

\[
= 2.1 \times 10^8/\text{cm}^2/\text{year}(=10^7\text{sec})
\]
Fig. 5(a) and (b) are the same plot as Fig. 4(a) and (b), respectively but for the geometry shown in Fig. 2(b). Since hydrogen atoms in CH$_2$ effectively stop neutrons, the bump seen in Fig. 4 becomes quite small. The neutron intensity in this case is $6 \times 10^7$/cm$^2$/year.
CDC background hits by neutrons

Neutrons make background hits in CDC (45cm<R<230cm, -230cm<Z<230cm, gas mixture is CO\textsubscript{2}/isoC\textsubscript{4}H\textsubscript{10}=90/10)

From Fig. 6, the hit rate in the gas volume of the CDC is found to be

\[(364/100/0.4\text{bunch})\times85\text{bunches/train} \div 800 \text{ hits/train}\]
CDC background hits by $\gamma$

To see the contribution from $\gamma$ background to the CDC hits shown in Fig.6, simulation without neutron production is also made and the result is shown in Fig.7(a). Comparing this figure with Fig.6, the $\gamma$ contribution to Fig.6 is found to be less than 10% (Note that the cross section of neutron production is multiplied by 100 in Fig.6).

From Fig.7, on the other hand, the CDC hits by $\gamma$ is estimated as

$$35/\text{bunch} \times 85\text{bunch/train} = 3000/\text{train}!$$

Original energy of $\gamma$ which made the CDC hits are plotted in Fig.7(b). It can be seen that most of the $\gamma$ come from annihilation $\gamma$ and tungsten K X-ray ($\div 60$ keV).
Fig. 7
Summary

$e^\pm$ pair background:
$1.9 \sim 10^4/ \text{bunch}$
$\langle E \rangle = 6.5 \text{ GeV} \rightarrow E_{\text{tot}} = 1.2 \times 10^8 \text{ MeV}$

Neutron yield:
$E_{\text{tot}} \rightarrow 1.2 \times 10^4 \text{ n/bunch is expected}$
Simulation $\rightarrow 2.0 \times 10^3 \text{ n/bunch}$
\underline{Not all the energy is absorbed}

Neutron flux near IP:
$\frac{\text{Yield}}{(4 \pi r^2)} \rightarrow 50 \text{ n/cm}^2/\text{sec is expected}$
Simulation $\rightarrow 20(6) \text{ n/cm}^2/\text{sec}$
\underline{Shielded by the target itself and mask}

$2 \times 10^8 \text{ n/10}^7 \text{ sec} \rightarrow \text{No problem for CCD}$

CDC background hits:
$800/\text{train by n}$
$3000/\text{train by } \gamma \rightarrow \text{More shield is needed}$

Background from downstream (beam dump etc.)
is not estimated yet