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Background Calculations

Takashi Maruyama
(SLAC)

OUTLINE

- Beam-beam Backgrounds
  ABEL vs. Guinea-pig
  JLC ABEL pairs
    Photon backgrounds in tracking chamber

- Neutron Backgrounds

- Summary
Detector background simulations

Beams: 1 TeV $0.95 \times 10^{10} \text{e}^-/\text{bunch}$ x 90 bunches

Sources
- $e^\pm$ pairs from beam-beam interaction
  \[ \sim 1 \times 10^5 e^\pm/\text{bunch} \]
- Sync. Radiation
  Soft bend
  Quads
  collimated $\rightarrow$ No backgrounds
- Disrupted Beams

Criteria
- CCD vertex detector
  $e^\pm$ hit density $<1/\text{mm}^2/\text{train}$
  $3 \times 10^9$ neutron hits/cm$^2$
- Drift chamber tracker
  Total photons $<10^4/\text{train}$

\begin{align*}
\text{SLD CDC} & \\
& 2\% \text{ conversion} \\
& \times 2 \text{ hits} \\
10^4 \text{ns} & \rightarrow 400 \text{ hits/5000 wires} \\
& 8\% \text{ occupancy}
\end{align*}
M1 Mask  Tapered Tungsten Cone beginning at $z=0.5$ m and ending at $z=2.0$ m, with inner and outer angles of 100 and 150 mr, respectively.

M2 Mask  Tungsten annulus with 10-cm wall and inner radius 20 cm, $2.0 < z < 5.0$ m.

QFTA.IN/OUT  Incoming/Outgoing Sm2Co17 FF quads rotated 10 mr in $x$-$z$ plane.
QFTA.IN - Inner/Outer radii = 4.5/20.0 mm
QFTA.OUT - Inner/Outer radii = 7.5/20.0 mm
Longitudinally divided into three 1-cm-long segments with 2.0-cm gaps. $L^* =$ line at 10 mr to IP is 2.0-m long.

Q1.IN/OUT  Superconducting magnet with Q1.IN aperture = 5 mm; Q1.OUT aperture = 8 mm. Extends from 3.5 to 5.0 m.

Beam Pipe  750-$\mu$m Be beam pipe with 100-$\mu$m Titanium liner at 1.0 cm, at $z \pm 2.1$ cm, which is joined onto a 500-$\mu$m Stainless sectioned flared at 451 mr until $r = 7.56$ cm, after which it proceeds to the M1 mask and follows its inner contour.

RF Shield  200-$\mu$m Cu extension at $r = 2.75$ cm, $z = 2.1$ cm, extending at constant radius to $z = 165$ cm, then proceeding via two “legs” to join electroplated inner radius of in-/out-going quads.

SEPTUM  200-$\mu$m Cu cone beginning at $z = 189$ cm and proceeding to $z = 2.0$ m at an angle $\theta$, where $\theta = \arctan((20 \text{ mm} - 7.5 \text{ mm})/11 \text{ cm})$.

LUM  10-cm Tungsten with back end at 195 cm, outer radius tapered at 150 mr at M1, inner radius tapered at 10 mr at radius of outgoing quad.

All calculations are for trains of 90 bunches at 1 TeV.
Beam-beam simulations

- **ABEL for ZDR**
  - $E_{e^+} > 10$ MeV
  - $\theta > 2$ mrad

- **Guinea-pig**
  - $E > 5$ MeV
  - No angle cut

- **JLC ABEL for JLC Design Report**
  - $E > 5$ MeV
  - No angle cut

1000 GeV

1000 GeV - B

500 GeV - B

500 GeV
Beam-beam backgrounds

- ABEL and Guinea-pig are consistent

- Hit densities in CCD vertex detector

  \[10 \text{ hits/mm}^2/\text{train} \text{ at } r = 1 \text{ cm}\]

  \[< 1 \text{ hits/mm}^2/\text{train} \text{ at } r > 2 \text{ cm}\]

- No. of photons hitting tracking chamber at \(r = 30 \text{ cm}\)

  \[40k/\text{train} \Rightarrow \text{too high for drift chamber}\]

- JLC ABEL pairs in NLC IR
  Comparison with the JLC Design Study (KEK-REPORT-97-1)

  - \(e^+/e^-\) hit densities are consistent

  \begin{align*}
  & \text{JLC Report (2 Tesla Solenoid)} \\
  & 100 \text{ DC hits/train } \Rightarrow 2500 \text{ photons/train} \\
  & \text{NLC IR (2 Tesla Solenoid)} \\
  & 370 \text{ k photons/train}
  \end{align*}
Beam-Beam Backgrounds

(Guinea_pig)

Hit Density (hits/m²/train)

- • pairs 500 GeV
- • pairs 1000 GeV
- ○ photons 500 GeV
- ○ photons 1000 GeV

Radius (cm)
Beam-Beam Backgrounds  (JLC ABEL)

![Graph showing hit density vs radius]
KEK visit (Dec. 7 – 12, 1998)
- Investigate the photon background difference between NLC and JLC.
- Run NLC Geant4-pg pairs in JLC IR.
- Run JLC ABE@ pairs in JLC IR
- Discussion on neutron backgrounds
- Learn JLC Detector simulation
Photons into Tracking Chamber at r = 30cm

Input: JLC ABEL pairs Ebeam = 250 GeV 2 Tesla

Tauchi

ID=3002, N=826
photons: Z: rrr = 30 cm

ID=3004, N=826
photons: energy (MeV)

T.M.

ID=1000000
Entries: 839
Mean: 0.3405 ± 0.05
RMS: 0.1934 ± 0.05

839 x 90 = 76 K/train

826 x 90 = 74 K/train

0.02 x 2 = 3 K h⁻¹ f⁻¹
NLC Guinea-pig pairs, $E_{\text{beam}} = 500\text{ GeV}, 2\text{ Tesla}$ in JLC IR

 photons $Z$ at $r=30\text{ cm}$

 photons $Z$ energy (MeV)

$3993 \times 90 = 359 \text{ K/train}$
\[ R_{\text{max}} \text{ vs } L \]

6 Tesla
$y \text{ vs } x \text{ at } z = 200 \text{ cm}$
Neutron sources

- $e^+/e^-$ pairs from beam-beam interaction
  
  \[ 88 \text{ k } e^+/e^-/\text{bunch with } <E> = 10.5 \text{ GeV} \]

- Beamstrahlung photons
  
  \[ 1.5 \times 10^{10} \text{ photons/bunch with } <E> = 30.3 \text{ GeV} \]

- Disrupted beams
  
  \[ 3 \times 10^{23} \text{ neutrons/year produced in the dump at 110 m from IR} \]

  neutron density at IR without any shielding
  \[ \rightarrow 2 \times 10^{14} \text{ neutrons/cm}^2/\text{year} \]

  need $10^6$ reduction
  - 165 cm concrete
  - 228 cm iron
Neutron productions

- $e^\pm$ pairs from beam-beam interaction
  \[ <n> = 494 \text{ neutrons} / \text{bunch} \]
- Sync. Radiation
  \[ <n> = 90 \text{ neutrons} / \text{bunch} \]

Neutron hit density
\[ \sim 3 \times 10^{-3} \text{ hits/cm}^2/\text{train} \]
\[ \times 120 \text{ pps} \times 3 \times 10^7 \text{ sec/year} \]
\[ = 1.1 \times 10^7 \text{ hits/cm}^2/\text{year} \]

CCD limit: $3 \times 10^9 \text{ hits/cm}^2$ (Damerell)
Neutron production in the dump

500 GeV $e^-$

$3^m\Phi \times 8^m$ long Water
Z distribution of neutrons

14.5 neutrons / 500 GeV e^-

z (cm)
\[ \epsilon = \frac{n_{\text{out}}}{n_{\text{generated}}} = 1.1 \times 10^{-7} \]
Neutron attenuation along the extraction line.
Neutron background at IR

- Total neutrons generated in the dump: \(1 \times 10^{23}\) /year
- Neutrons coming out of the dump (\(E = 1.1 \times 10^{7}\)): \(1.1 \times 10^{16}\) /year
- Neutrons at IR
  \(E = 2 \times 10^3\) in \(r = 1.5\) m: \(3 \times 10^8\) /cm²/year
Summary

- Beam-beam backgrounds
  ABE and GP are consistent
  Hit density in CCD vertex detector
  \(10 \text{ hits/mm}^2/\text{train} \text{ at } r=1\text{cm}\)
  \(<1 \text{ hit/mm}^2/\text{train} \text{ at } r>2\text{cm}\)
  Photons into tracking chamber
  - 40K/\text{train}
  - NLC and JLC are in agreement.
  - Photon conversion in drift chamber needs further study (JLC)

- First attempt at calculating neutron background from the dump