A Study of Backgrounds at JLC - IR

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Outline

- Update on JLC Beam Delivery System
- Synchrotron Radiation (Geant4 full-simulation study)
- Muons/Pairs/Neutrons (Summary of previous study)
- Conclusion
Big Bend (7 mrad, 200 m)

Collimator (1200 m)
Momentum: chicane $\Delta p/p < \pm 2\%$
Transverse: nonlinear collimator $6\sigma_x \times 40\sigma_y$

Longitudinal separation = 200 m
Transv. sep = 20 m

IP1
IP2

Crossing angle (8 mrad) with crab crossing

Final Focus (1600 m)
Asymmetric dispersion
Momentum acceptance: $\pm 1\%$

JLC: Beam Delivery System

V1997
Collimator design V1997

Expand (only) tails and scrape them.

$\frac{\Delta p}{p} = \pm 2\%$

$(\pm 6\square_x, \pm 40\square_y)$
Beam Delivery System in geant4

New Design V2002

sp1, sp2, sp3, sp4
0.6 x 0.6 mm
sp5
0.84 x 0.6 mm
spE
3.2 x 8 mm
ab2, ab3, ab4
aper 1 mm
ab5,
aper 1.4 mm
abE
6.8 x 8 mm
ab10
aper 5.6 mm
ab9
aper 8.6 mm
ab7
aper 8.8 mm

SP, AB

E-slit

quad

bend

1434m
JLC BDS Design V2002

250 GeV Gaussian beam into BDS

Only with quad, sext, oct, dec, SP, AB

incident beam parameters

$\varepsilon_x = 6.132 \times 10^{-12} \text{ m}$
$\varepsilon_y = 6.132 \times 14 \text{ m}$

$\sigma_x = 14.8 \mu\text{m}$
$\sigma_x = 0.413 \mu\text{rad}$
$\sigma_y = 658 \text{ nm}$
$\sigma_y = 0.093 \mu\text{rad}$
$\Delta E/E = 0.003$

focus $x$  $y$

$L^* = 3.51 \text{ m}$
Synchrotron radiations

SR from nominal beam

photon energy at IP

\[ N_g(E>1\text{eV}) \approx 3.4/\text{Ne} \]
\[ (E>10\text{keV}) \approx 2.6/\text{Ne} \]

\[ <E_g> \approx 1.9 \text{ MeV} \]
Distribution of nominal-beam SR photons \textit{without} any masks

Beam pipe radius is >10mm.
Muon Attenuator

- Collimator
- e^ beam
- \( \mu^+ \) and \( \mu^- \)
- \( 120 \) m (mean range of a 250GeV muon)

Muon Spoiler

- Spoiler-1
- Spoiler-2
- Tunnel height = 3.0 m
- Tunnel width = 3.0 m
- 9.1 m along z weight = 750 tons

L. Keller, LC 93
Previous study on muon background

1 muon in $16 \times 16 \times 16$ m$^3$ at IP

No. of electrons to produce one muon ($e^+N \rightarrow e^+\mu^-N$)

8 attenuators

$10^{10}$ (e's/bunch) $\times 10^2$ (bunches/train) $\times 10^3$ (Halo fraction) = $10^9$ e's/train
**Muon background after collimator**

- Options exist to get rid of them.
- Depends critically on halo fraction. If pre-linac collimation further reduces beam halo, this background should not be a problem.
- Full simulation study on the way.
Pair backgrounds

2 Tesla, L* = 2m

Current JLC baseline detector has 3 Tesla.
Pair backgrounds (cont’d)

Geant3+FLUKA

3 T, L*=4.3m
Neutrons produced in extraction/dump

Study with V2000 optics:
About 100 m long extraction line produces $\sim 4 \times 10^{11} \text{n/cm}^2/\text{yr}$ at IP with no shielding.

CCD radiation tolerance $\sim 10^{10} \text{n/cm}^2/\text{yr}$ => Requires $\sim$ a factor of 100 reduction

Full simulation with V2002 ($\sim 140$ m long) optics required.

Bumps correspond to beam loss locations.
Conclusion/comments

Geant4-based full simulation study has been launched.

- Some results on BDS/SOR.
- Past study indicates that there are solutions to keep muon/pair/neutron background level low enough for experiments.
  - A new FF optics with L*~4m is available.
- Repeat simulation with updated BDS design to further quantify the above statement.
- Requires even closer international collaboration.
Road Map collimation and final focus system design

\[ \sqrt{\frac{1}{\beta}} \quad (\text{in m}) \]

- quad
- SPAB
- sext, oct, dec

focus

\[ x \quad y \]

\[ s \, [\text{m}] \]

IP
Previous study on synchrotron radiation

The collimation depth is set by $L^*$ and the final Q aperture. The then conclusion is SR will not be a problem.

Full simulation (including backscattering) for a new optics is under way.

$r_{\text{beam pipe}} = 20$ mm
Final Focus, Synchrotron Radiation and Collimation depth

- Strong focusing:
- Chromatic dilution of beam size:
- New NLC02-type non-linear optics:

\[ s = \frac{eb}{E} \]

\[ \frac{L^*}{\Delta L^*} \) can be very large.

\[ E (\text{energy spread } 0.1 \%-1\%), \]

\[ L^* (\text{free drift length to IP } 2 \text{ m to } 4 \text{ m}) \]

\[ L^* = 4.3 \text{ m instead of } 2 \text{ m or so.} \]
IP Backgrounds

- Disrupted primary beam (very forward)
- Beamstrahlung photons (very forward)
- Radiative Bhabhas
- Hadrons from $gg$ int. (underlying event like background?)
- e+e- pairs from beam-beam int.
  - This is believed to be most serious and has been studied most.
  - Simulated using GEANT3 plus FLUKA (for secondary neutrons back-scattered).
  - Detector solenoidal field (curls) and $L^*$ (backscattering) are important parameters.
Pair backgrounds (cont’d)

Effect of Low-Z Mask

- Low-Z (graphite/polyethylene) mask at B~0 is very effective to absorb backscattered low energy e^+/e^-

- Low-Z mask works as a neutron shield

~1/10 attenuation with 20cm CH\textsubscript{2}
Boron-loaded CH\textsubscript{2} is available
Extraction line/Beam dump

Extraction line transports the spent/disrupted beams and collision debris (e+e-pairs/beamstrahlung photons) to beam dumps.

- Crossing angle of new design is 6mrad.

**FIG. 1:** Optics of the new dump line.