The International Linear Collider
Background Simulations & the Impact on SiD

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Table of contents

1 The SiD Detector
   • Overview
   • SiD Detector Variants

2 Background Simulations & the Impact on SiD
   • Background Sources & Simulation Tools
   • Background from High Cross Section ILC Processes
     • FCAL Occupancy
     • BeamCal Reconstruction Efficiency
     • Vertex Detector Occupancy
     • Vertex Detector Hit Time
     • Pair background envelopes
   • Muons from the BDS

3 Further Ongoing Background Studies
   • Neutrons from the Beam Dumps

4 Summary and Outlook
**SiD - Silicon Detector**

**General Specifications**
- Height: $\sim 14$ m, length: $\sim 11$ m
- Weight: $\sim 10,100$ t
- Superconducting solenoid field: 5 T

**Convincing design**
- Compact and robust
- Full silicon vertex detector and tracker
- Vertex detector:
  - $< 5 \mu m$ resolution
  - Momentum resolution $\sim 2 \times 10^{-5}$ GeV$^{-1}$
  - $\sim 0.1\% \ X_0$ per layer
  - $\cos(\theta) \approx 0.984$

- Highly granular calorimetry optimized for Particle Flow (ECAL: radiation length $= 26 \ X_0$)
SiD detector model: Vertex/Tracker detector (red), ECAL (green), HCAL (pink), Muon system (blue)
1 The SiD Detector
   - Overview
   - SiD Detector Variants

2 Background Simulations & the Impact on SiD

3 Further Ongoing Background Studies

4 Summary and Outlook
Anti-DiD Field, $L^*$, and the BeamCal “plug”

$L^*$ - Distance between IP and QD0
- BeamCal attached to QD0 support structure
- $L^*$ change from 3.5 m to 4.1 m
- Resulting distance between IP and BeamCal: 3.265 m

Anti-DiD Field
- Directing pair background particles into the outgoing beam pipe
- Potentially suppress BeamCal backgrounds

BeamCal “plug”
- Region around beampipe holes in BeamCal
- Three proposed designs for the plug region:
  - Instrumentation of the full plug region
  - Wedge-cutout
  - Circle-cutout
The SiD Detector

Background Simulations & the Impact on SiD
- Background Sources & Simulation Tools
  - Background from High Cross Section ILC Processes
  - Muons from the BDS

Further Ongoing Background Studies

Summary and Outlook
Background sources

In order to minimize the effect of the background on the detectors and the measurements, the different background sources need to be modeled in great detail, also wrt a possible optimization of the Final-Focus layout.

The main sources of background:

- **Beam-beam interactions:**
  - Pair background
  - Bhabha scattering
  - $\gamma\gamma \rightarrow \text{hadrons}$

- **Machine background:**
  - Muons from the Beam Delivery System
  - Neutrons from the Beam Dumps
Generator/Simulation tools

The background is first modeled with different simulation tools:

- **GuineaPig**
  (Generator of background events from beam-beam interactions)
- **WHIZARD**
  (Generic MC integration and event generation package)
- **FLUKA**
  (Fully integrated particle physics MonteCarlo simulation package)
- **MUCARLO**
  (Fortran tool to generate muons from the ILC Beam Delivery System)

The background events are then simulated in a full detector simulation with a Geant4 toolkit.

WIRED4 event display of the pair background of one bunch crossing in SiD.
The SiD Detector

Background Simulations & the Impact on SiD

- Background Sources & Simulation Tools
- Background from High Cross Section ILC Processes
  - FCAL Occupancy
  - BeamCal Reconstruction Efficiency
  - Vertex Detector Occupancy
  - Vertex Detector Hit Time
  - Pair background envelopes
- Muons from the BDS

Further Ongoing Background Studies

Summary and Outlook
With a **buffer depth of 4** in the currently foreseen SiD electronics design, $\sim 0.3\%$ of all hits will be lost because of full buffers.

The fractional loss is clearly dependent on the radial position of the hit, so that this study suggests to **increase the number of buffers to 6** to reduce the fractional hit loss to below at least $10^{-3}$ at any radius.

Study done by B. Schumm and students at UCSC
The pair background is a specific background to the detection of individual high-energy $e^+$ and $e^-$ in the BeamCal. Especially at small radii, the overall BeamCal reconstruction efficiency improves with:

- an increase of $L^*$ from 3.5 m (blue/yellow) to 4.1 m (red/green)
- including the anti-DiD field (green and yellow)

Dedicated physics studies need to be undertaken in order to fully assess the advantage of including the anti-DiD field.
Study of the **pair** background occupancy in the **VXD** in dependency of the SiD design choices:

<table>
<thead>
<tr>
<th>L* 4.1 m</th>
<th>BeamCal “plug” design</th>
<th>anti-DiD</th>
</tr>
</thead>
<tbody>
<tr>
<td>red</td>
<td>instrumented</td>
<td>×</td>
</tr>
<tr>
<td>green</td>
<td>instrumented</td>
<td>✓</td>
</tr>
<tr>
<td>blue</td>
<td>circle cutout</td>
<td>×</td>
</tr>
<tr>
<td>turquoise</td>
<td>wedge cutout</td>
<td>×</td>
</tr>
</tbody>
</table>

Overall occupancies are small & show little dependency on design.

Study done by B. Schumm and students at UCSC
VXD - Pair background hit time

Timing of the pair background hitting the VXD wrt the bunch crossing

The vertex detector gets hits up to $\sim 50\,\text{ns}$ after the bunch crossing. This is an opportunity to apply \textit{time gates $\rightarrow$ background reduction}!
Timing of the pair background hitting the VXD wrt the bunch crossing

The vertex detector gets hits up to \( \sim 50 \text{ ns} \) after the bunch crossing. This is an opportunity to apply time gates \( \rightarrow \) background reduction!
As expected, the pairs originate from the IP and the inner part of the detector.
Pair background - Particle origins

Particle origins of particles hitting the vertex detector in $[10\,\text{ns}; 20\,\text{ns}]$

The number of hits decreased, but there are still particles originating from the IP.
The pairs have travelled towards the detector endcaps and have backscattered there.
Pair background - Particle origins

Particle origins of particles hitting the vertex detector in $[30 \text{ ns}; 50 \text{ ns}]$

The particles still originate from the IP, the detector barrel and the endcaps.
Distribution of the time of creation (relative to the instant of the bunch crossing) of pair background particles (from 1312 bunches) that hit the endcaps of the VXD. At the time of the bunch crossing about $1.6 \times 10^6$ particles are created (underflow bin).

<table>
<thead>
<tr>
<th>Overall pairs</th>
<th>Primary pairs [0 ns;11 ns]</th>
<th>Late pairs [11 ns;50 ns]</th>
<th>Out-of-time backscatter pairs [50 ns;554 ns]</th>
<th>Out-of-time backscatter pairs [554 ns;1000 ns]</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sim 1.9 \times 10^6$</td>
<td>87.33%</td>
<td>12.38%</td>
<td>0.16%</td>
<td>0.029%</td>
</tr>
</tbody>
</table>
Pair background - $P_T$

Since their $P_T$ ranges between 0 and 2 GeV, they form helix tracks in the solenoid field. The tracks extend to the inner detector layers, and leave up to several tens of hits.

**Diagram:**

- **$p_T$ vs hit time of primaries hitting the SiVertexEndcapSiVertexBarrel**
- **Table:**
  - **p_T vs hit time**
  - Entries: 3441763
  - Mean x: 1.058
  - Mean y: 0.02457
  - Std Dev x: 1.762
  - Std Dev y: 0.03348

**Graph:**

- x-axis: Hit time [ns]
- y-axis: $p_T$ [GeV]
- Color gradient: Hit time and $p_T$ values
Due to their momentum distributions, the envelopes of all pair background helixes have a characteristic shape. At any given point the beam pipe is at least 4 mm away from 99.9% of all pair particle tracks.
Pair background envelopes - 350GeV

\[ e^{-}: \Delta p/p = 0.158\%, \ e^{+}: \Delta p/p = 0.100\% \]
\[ \beta_x^* = 16 \text{ mm}, \ \beta_y^* = 0.34 \text{ mm} \]
\[ \sigma_x^* = 683.5 \text{ nm}, \ \sigma_y^* = 5.9 \text{ nm} \]
$e^{-}: \Delta p/p = 0.190\%$, $e^{+}: \Delta p/p = 0.152\%$

$\beta^*_x = 13\text{ mm}$, $\beta^*_y = 0.41\text{ mm}$

$\sigma^*_x = 729\text{ nm}$, $\sigma^*_y = 7.7\text{ nm}$

Possibility to reduce the beam pipe & VXD radius by $\sim 2\text{ mm}$.

Study of possible improvement in physics event reconstruction needed, whilst looking at the increase in the background level at smaller radii.
Possibility to **reduce the beam pipe & VXD radius** by ~2 mm.

*Study of possible **improvement in physics event reconstruction** needed, whilst looking at the increase in the background level at smaller radii.*
The SiD Detector

Background Simulations & the Impact on SiD
- Background Sources & Simulation Tools
- Background from High Cross Section ILC Processes
- Muons from the BDS

Further Ongoing Background Studies

Summary and Outlook
The Beam Delivery System (BDS) contains the Final Focus System, and therefore focusses the beam on its way to the Interaction Point (IP).
Muons are created along the BDS, when the beam halo interacts with the beam line material.
The two suggested shielding scenarios:

- **5 Spoilers**
  - 70 cm radius, 5 m long
  - magnetized iron
  - at 5 locations along the BDS

- **5 Spoilers + Wall**
  - 4 m x 5 m, 5 m long
  - magnetized iron
  - close to the interaction region
1 train’s worth of muons (\(\sim 515\) muons) from the positron line only:

Together with the muons from the e\(^-\) line, there will be \(\sim 900\) muons per train in the ’5 Spoilers + Wall’ scenario.
1 train’s worth of muons (\(\sim 2961\) muons) \textbf{from the positron line only}:

Together with the muons from the e\(^-\) line, there will be \(\sim 5600\) \textbf{muons per train in the '5 Spoilers' scenario}.

The spatial distribution is due to the tunnel shape and its shielding effects.
A readout cell is “dead” when all buffers of the sensor are already filled. No more hits can be stored.

The current SiD electronics design has a buffer depth of 4, i.e. $10^{-6} - 10^{-4}$ of all hits are dead in the ECAL endcaps.
With the shown results from the occupancy analysis of the muons from the current MUCARLO simulations, the SiD group prefers to keep the magnetized wall in order to keep the occupancy in the SiD detector as low as possible.

This will also allow access to the detector parking garage, since the wall represents a tertiary containment device against not only muons but also photons and neutrons from the machine background.
Further Ongoing Background Studies

1. The SiD Detector

2. Background Simulations & the Impact on SiD

3. Further Ongoing Background Studies
   - Neutrons from the Beam Dumps

4. Summary and Outlook
**FLUKA simulation of the ILC Beam Dump**

The 16 MW beam is dumped into a water tank after collision. Neutrons ($\lesssim 10^{10} \text{ cm}^{-2} \text{ yr}^{-1}$) are emitted that radiate the surroundings, and travel back towards the detectors.

Concern about the safety and the functionality of the beam dump design.

**Simulation step 1**

Simulating the neutrons from the beam dump with FLUKA, using the design drawings by B. Smith [1] to model the dump and the surrounding.
**FLUKA simulation of the ILC Beam Dump**

**Simulation step 2**

With Benno List (DESY): Python program to plug the real extraction line lattice into FLUKA. Realistic simulation of the interaction between the neutrons and the lattice.

**Simulation step 3**

Simulating the neutrons reaching the interaction point in a full detector simulation.

FLUKA simulation model of one of the ILC EXT lattice quadrupoles.
Beam dump simulation goals

All goals of this study in an overview:

- Simulating the neutron flux,
- the number of neutrons reaching the IP,
- the neutron occupancy in SiD,
- the dose of the beam dump surrounding,
- the influence of the water composition (amount of deuterium),
- the influence of the steel composition of the tank container,
- the amount of tritium produced in the water,
- the effect of the beam dump design.

1. The SiD Detector

2. Background Simulations & the Impact on SiD

3. Further Ongoing Background Studies

4. Summary and Outlook
Finished and ongoing background studies:

- Studies of the **background occupancies in the FCAL and Vertex Detector** → Occupancy low, but increase in the buffer depth of the SiD sensors should be considered
- Looking at the **impact of the SiD design choices on the reconstruction efficiency of the BeamCal** → Anti-DiD field has a positive effect
- Study of the **timing and origin of pair background and backscattering particles** → possible reduction of background with time gates
- **Pair helix envelopes** for 500, 350 and 250GeV ILC staging scenarios → suggested reducing the radius of beam pipe and vertex detector
- Comparison between two different **muon shielding possibilities** and the muon occupancy in SiD → Spoilers + magnetized wall is preferred shielding option
- **Modellation of the main beam dump and the EXT line with FLUKA** in collaboration with Benno List (DESY). FLUKA simulations of the neutron fluxes from the beam dump
Thanks!
References


A. Schuetz Pair Background Envelopes in the SiD Detector, arXiv:1703.05737


Additional Material

1. **ILC**
   - ILC parameters

2. **SiD - Subdetector Specifications**

3. **Background from High Cross Section ILC Processes**
   - FCAL Occupancy
   - Pair background timing
   - Pair background helixes

4. **Muons from the BDS**
## The beam parameters of the ILC

<table>
<thead>
<tr>
<th></th>
<th>Baseline 500</th>
<th>Lumi Upgrade</th>
<th>TeV Upgrade</th>
<th>LHC 25ns</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{CM}$ [GeV]</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>14000</td>
</tr>
<tr>
<td>$n_b$</td>
<td>1312</td>
<td>2625</td>
<td>2450</td>
<td>2808</td>
</tr>
<tr>
<td>$\Delta t_b$ [ns]</td>
<td>554</td>
<td>366</td>
<td>366</td>
<td>25</td>
</tr>
<tr>
<td>$N$</td>
<td>$2.0 \times 10^{10}$</td>
<td>$2.0 \times 10^{10}$</td>
<td>$1.74 \times 10^{10}$</td>
<td>$11.5 \times 10^{10}$</td>
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<tr>
<td>$q_b$ [nC]</td>
<td>3.2</td>
<td>3.2</td>
<td>2.7</td>
<td>18.4</td>
</tr>
<tr>
<td>$\sigma_x^*$ [nm]</td>
<td>474</td>
<td>474</td>
<td>481</td>
<td>16700</td>
</tr>
<tr>
<td>$\sigma_y^*$ [nm]</td>
<td>5.9</td>
<td>5.9</td>
<td>2.8</td>
<td>16700</td>
</tr>
<tr>
<td>$\sigma_z$ [mm]</td>
<td>0.3</td>
<td>0.3</td>
<td>0.25</td>
<td>0.755</td>
</tr>
<tr>
<td>$L$ [cm$^{-2}$ s$^{-1}$]</td>
<td>$1.8 \times 10^{34}$</td>
<td>$3.6 \times 10^{34}$</td>
<td>$3.6 \times 10^{34}$</td>
<td>$1.0 \times 10^{34}$</td>
</tr>
</tbody>
</table>
## ILC baseline parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$E_{CM}$</th>
<th>GeV</th>
<th>Baseline 500 GeV Machine</th>
<th>1st Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre-of-mass energy</td>
<td></td>
<td></td>
<td>250 350 500</td>
<td>250</td>
</tr>
<tr>
<td>Collision rate</td>
<td>$f_{rep}$</td>
<td>Hz</td>
<td>5 5 5</td>
<td>5</td>
</tr>
<tr>
<td>Electron linac rate</td>
<td>$f_{linac}$</td>
<td>Hz</td>
<td>10 10 10</td>
<td>10</td>
</tr>
<tr>
<td>Number of bunches</td>
<td>$n_b$</td>
<td></td>
<td>1312 1312 1312</td>
<td>1312</td>
</tr>
<tr>
<td>Bunch population</td>
<td>$N$</td>
<td>$10^{10}$</td>
<td>2.0 2.0 2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Bunch separation</td>
<td>$\Delta t_b$</td>
<td>ns</td>
<td>554 554 554</td>
<td>554</td>
</tr>
<tr>
<td>Pulse current</td>
<td>$I_{beam}$</td>
<td>mA</td>
<td>5.8 5.8 5.8</td>
<td>5.8</td>
</tr>
<tr>
<td>Main linac average gradient</td>
<td>$G_a$</td>
<td>MV m$^{-1}$</td>
<td>14.7 21.4 31.5</td>
<td>31.5</td>
</tr>
<tr>
<td>Average total beam power</td>
<td>$P_{beam}$</td>
<td>MW</td>
<td>5.9 7.3 10.5</td>
<td>5.9</td>
</tr>
<tr>
<td>Estimated AC power</td>
<td>$P_{AC}$</td>
<td>MW</td>
<td>122 121 163</td>
<td>129</td>
</tr>
<tr>
<td>RMS bunch length</td>
<td>$\sigma_z$</td>
<td>mm</td>
<td>0.3 0.3 0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Electron RMS energy spread</td>
<td>$\Delta p/p$</td>
<td>%</td>
<td>0.190 0.158 0.124</td>
<td>0.190</td>
</tr>
<tr>
<td>Positron RMS energy spread</td>
<td>$\Delta p/p$</td>
<td>%</td>
<td>0.152 0.100 0.070</td>
<td>0.152</td>
</tr>
<tr>
<td>Electron polarisation</td>
<td>$P_-$</td>
<td>%</td>
<td>80 80 80</td>
<td>80</td>
</tr>
<tr>
<td>Positron polarisation</td>
<td>$P_+$</td>
<td>%</td>
<td>30 30 30</td>
<td>30</td>
</tr>
<tr>
<td>Horizontal emittance</td>
<td>$\gamma \epsilon_x$</td>
<td>$\mu$m</td>
<td>10 10 10</td>
<td>10</td>
</tr>
<tr>
<td>Vertical emittance</td>
<td>$\gamma \epsilon_y$</td>
<td>nm</td>
<td>35 35 35</td>
<td>35</td>
</tr>
<tr>
<td>IP horizontal beta function</td>
<td>$\beta_x^*$</td>
<td>mm</td>
<td>13.0 16.0 11.0</td>
<td>13.0</td>
</tr>
<tr>
<td>IP vertical beta function</td>
<td>$\beta_y^*$</td>
<td>mm</td>
<td>0.41 0.34 0.48</td>
<td>0.41</td>
</tr>
<tr>
<td>IP RMS horizontal beam size</td>
<td>$\sigma_x^*$</td>
<td>nm</td>
<td>729.0 683.5 474</td>
<td>729</td>
</tr>
<tr>
<td>IP RMS vertical beam size</td>
<td>$\sigma_y^*$</td>
<td>nm</td>
<td>7.7 5.9 5.9</td>
<td>7.7</td>
</tr>
<tr>
<td>Luminosity</td>
<td>$L$</td>
<td>$10^{34}$ cm$^{-2}$s$^{-1}$</td>
<td>0.75 1.0 1.8</td>
<td>0.75</td>
</tr>
<tr>
<td>Fraction of luminosity in top 1%</td>
<td>$L_{0.01}/L$</td>
<td>%</td>
<td>87.1% 77.4% 58.3%</td>
<td>87.1%</td>
</tr>
<tr>
<td>Average energy loss</td>
<td>$\delta_{PS}$</td>
<td>%</td>
<td>0.97% 1.9% 4.5%</td>
<td>0.97%</td>
</tr>
<tr>
<td>Number of pairs per bunch crossing</td>
<td>$N_{pairs}$</td>
<td>$10^3$</td>
<td>62.4 93.6 139.0</td>
<td>62.4</td>
</tr>
<tr>
<td>Total pair energy per bunch crossing</td>
<td>$E_{pairs}$</td>
<td>TeV</td>
<td>46.5 115.0 344.1</td>
<td>46.5</td>
</tr>
</tbody>
</table>
1. **ILC**

2. **SiD - Subdetector Specifications**

3. **Background from High Cross Section ILC Processes**

4. **Muons from the BDS**
Table 1: Key parameters of the baseline SiD design, including the measures of the subdetectors, and their readout cell dimensions. The given readout cell dimension are the pixelation cell sizes used for the full detector Geant4 simulation.

<table>
<thead>
<tr>
<th>SiD Barrel</th>
<th>Technology</th>
<th>Readout cell dimensions [mm²]</th>
<th>Inner radius [cm]</th>
<th>Outer radius [cm]</th>
<th>z extent [cm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertex detector</td>
<td>Silicon pixels</td>
<td>0.05 x 0.05</td>
<td>1.4</td>
<td>6.0</td>
<td>±6.25</td>
</tr>
<tr>
<td>Tracker</td>
<td>Silicon strips</td>
<td>0.05 x 0.05</td>
<td>21.7</td>
<td>122.1</td>
<td>±152.2</td>
</tr>
<tr>
<td>ECAL</td>
<td>Silicon pixels-W</td>
<td>3.5 x 3.5</td>
<td>126.5</td>
<td>140.9</td>
<td>±176.5</td>
</tr>
<tr>
<td>HCAL</td>
<td>RPC - steel</td>
<td>10 x 10</td>
<td>141.7</td>
<td>249.3</td>
<td>±301.8</td>
</tr>
<tr>
<td>Solenoid</td>
<td>5 T SC</td>
<td>-</td>
<td>259.1</td>
<td>339.2</td>
<td>±298.3</td>
</tr>
<tr>
<td>Flux return</td>
<td>Scintillator-steel</td>
<td>30 x 30</td>
<td>340.2</td>
<td>604.2</td>
<td>±303.3</td>
</tr>
<tr>
<td>SiD Endcap</td>
<td>Technology</td>
<td>Readout cell dimensions $[\text{mm}^2]$</td>
<td>Inner $z$ [cm]</td>
<td>Outer $z$ [cm]</td>
<td>Outer radius [cm]</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>-----------------------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Vertex detector</td>
<td>Silicon pixels</td>
<td>0.05 x 0.05</td>
<td>7.3</td>
<td>83.4</td>
<td>16.6</td>
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<tr>
<td>Tracker</td>
<td>Silicon strips</td>
<td>0.05 x 0.05</td>
<td>77.0</td>
<td>164.3</td>
<td>125.5</td>
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<tr>
<td>ECAL</td>
<td>Silicon pixel-W</td>
<td>3.5 x 3.5</td>
<td>165.7</td>
<td>180.0</td>
<td>125.0</td>
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<td>HCAL</td>
<td>RPC - steel</td>
<td>10 x 10</td>
<td>180.5</td>
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<td>140.2</td>
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<td>Flux return</td>
<td>Scintillator-steel</td>
<td>30 x 30</td>
<td>303.3</td>
<td>567.3</td>
<td>604.2</td>
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<td>LumiCal</td>
<td>Silicon- W</td>
<td>3.5 x 3.5</td>
<td>155.7</td>
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<td>BeamCal</td>
<td>Semicond.- W</td>
<td>3.5 x 3.5</td>
<td>326.5</td>
<td>344</td>
<td>14.0</td>
</tr>
</tbody>
</table>
1. **ILC**

2. **SiD - Subdetector Specifications**

3. **Background from High Cross Section ILC Processes**
   - FCAL Occupancy
   - Pair background timing
   - Pair background helixes

4. **Muons from the BDS**
Number of hits per channel during a full ILC bunch train (∼2600 bunch crossings).

Study done by B. Schumm and students at UCSC
1. **ILC**

2. **SiD - Subdetector Specifications**

3. **Background from High Cross Section ILC Processes**
   - FCAL Occupancy
   - Pair background timing
   - Pair background helixes

4. **Muons from the BDS**
Distribution of the time of creation (relative to the bunch crossing) of pair background particles (from 1312 bunches) that hit the endcaps of the VXD. At the time of the bunch crossing about $1.6 \times 10^6$ particles are created (underflow bin).

The creation time is plotted for pair background particles hitting the vertex endcaps only. This is to avoid double counting of particles that would hit both, the barrel and the endcaps.

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall pairs</td>
<td>$\sim 1.9 \times 10^6$</td>
<td>87.33%</td>
</tr>
<tr>
<td>Primary pairs [0 ns;11 ns]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late pairs [11 ns;50 ns]</td>
<td></td>
<td>12.38%</td>
</tr>
<tr>
<td>Out-of-time backscatter pairs</td>
<td></td>
<td>0.16%</td>
</tr>
<tr>
<td>Out-of-time backscatter pairs</td>
<td></td>
<td>0.029%</td>
</tr>
<tr>
<td>[50 ns;554 ns]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[554 ns;1000 ns]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Momentum distribution of particles hitting the VXD

Distributions of the pair background particle momenta of pair background particles from 1312 bunches that will hit the barrel and the endcaps of the vertex detector. The plots show the histograms of the total and the transverse momenta of the particles hitting the vertex detector, in certain time intervals.
ILC

SiD - Subdetector Specifications

Background from High Cross Section ILC Processes
- FCAL Occupancy
- Pair background timing
- Pair background helixes

Muons from the BDS
Comparison of $P_T$ and $P_z$ of the ILC pairs

Comparison between pairs from ILC 500, 350 and 250 GeV
$P_T$ vs. $P_z$ of the pairs from ILC 500, 350 and 250 GeV
Explanation of helix track calculations

\[ \mathbf{B} \]

\[ \mathbf{p}_x \]

\[ \mathbf{p}_y \]

\[ \mathbf{p}_T \]
1. **ILC**

2. **SiD - Subdetector Specifications**

3. **Background from High Cross Section ILC Processes**

4. **Muons from the BDS**
The Muons in SiD - Spatial Distribution

> Beam pipe is curved
> Beam pipe close to floor
  - High tunnel ceiling

Spoil: Beam pipe is curved

Ground: Beam pipe close to floor

SiD: High tunnel ceiling

Air: Tunnel ceiling

Tunnel floor
The number of hits in the different SiD subdetectors for both shielding scenarios ("5 Spoilers" and "5 Spoilers + Wall") is not evenly distributed. The number of hits depends on the effective area of the subdetector system.
The current SiD electronics design has a buffer depth of 4:

\[ \sim 1 \times 10^{-6} - 4 \times 10^{-6} \] of all hits are dead in the **HCAL barrel**
\[ \sim 2 \times 10^{-4} - 1 \times 10^{-3} \] of all hits are dead in the **HCAL endcaps**
The current SiD electronics design has a buffer depth of 4, i.e. $10^{-8} - 10^{-7}$ of all hits are dead in the Tracker endcaps.
The energy distribution of the muons from the “5 Spoilers + Wall” scenario does not reach the same maximum energy. The muons are decelerated and stopped within the magnetized wall.