Disclaimer

I am not advocating a zero degree crossing angle, but since the possibility of a 1-2 T·m kicker was raised at the January '05 MDI Workshop, it begged the question of what the extraction line might look like.

Compare ILC with the SLC zero degree crossing:

1. The SLC pulsed kicker was “easy”, L=4.0 m, B=0.05 T, => \[\int B dl = 0.2 \text{T\cdot m}\]

2. The ILC disrupted beam has 100x more power, much larger energy spread (up to -50% \(\Delta E/E\)), and a large vertical average deflection angle (200 \(\mu\text{rad}\)) under some conditions.

3. The ILC has a \(\approx 400 \text{ kW}\) beamstrahlung flame with non-negligible angular spread.
RF Kicker Concept
See Y. Iwashita talk at the MDI Workshop, Jan. 2005

DC+3MHz (+9MHz)

$L=2\text{m}$

$2\text{cm} \times 6\text{cm} \times 2\text{m}=0.0024\text{m}^3$

Stored Energy $W\sim 1200\text{[J]}@1\text{T}$

$8/9 - \cos \omega t + \cos 3\omega t /9$

$\approx 45 \text{m}$
Assumptions and Constraints for ILC Head-on Collisions

1) A stable and reliable RF kicker with $\int Bdl = 1.0 \, \text{T} \cdot \text{m}$ (1.2 mrad bend @ 250 GeV/c).

2) NLC FF optics is needed to allow early separation of the outgoing beamstrahlung from the incoming beam as early as possible. The first soft bend starts about 90 m from the IP.

3) Assume final doublet apertures are as in NLC optics.

4) No change in bunch spacing when upgrading to higher energy.

5) No attempt has been made to design extraction line optics for an energy or polarization measurement.
Beamstrahlung in the horizontal plane for two ILC bunch crossing positions

- $dx=0, dy=5$ nm, 463 kW (132 kW outside $\pm 0.16$ mrad)
- $dx=0, dy=0$, 367 kW (110 kW outside $\pm 0.16$ mrad)
Beamstrahlung in the vertical plane for two ILC bunch crossing positions

- $dx=0, dy=5 \text{ nm}$, 463 $\text{kW}$, 33 $\text{kW}$ outside $\pm 0.16 \text{ mrad}$
- $dx=0, dy=0$, 367 $\text{kW}$, 0.2 $\text{kW}$ outside $\pm 0.16 \text{ mrad}$
Disrupted beam energy for two ILC bunch crossing positions

- $dx = 0$, $dy = 200$ nm, 330 kW with energy < 80% $E_{\text{beam}}$
- $dx = 0$, $dy = 0$ nm, 190 kW with energy < 80% $E_{\text{beam}}$
Disrupted Beam, E vs. Xprime

dx=0, dy= 200 nm
dx=0, dy=200 nm

Note large vertical beam deflection causes trouble if left to drift too far in the extraction line
Tunnel Layout for ILC Head-on Collisions – Zero Degree Extraction
Tunnel Layout for ILC Head-on Collisions – Zero Degree Extraction

[Diagram showing the tunnel layout with various beamstrahlung regions labeled: Beamstrahlung (0–0.16 mrad) and Beamstrahlung (0.18–0.50 mrad).]
TURTLE runs for two examples of disrupted beam
Start 35,000 particles, each case

<table>
<thead>
<tr>
<th>Beam Element</th>
<th>dx0-dy0</th>
<th>dx0-dy200</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># lost</td>
<td>Power lost</td>
</tr>
<tr>
<td>Kicker (2 cm gap)</td>
<td>0</td>
<td>0 kW</td>
</tr>
<tr>
<td>Horizontal slit 6.0 cm wide</td>
<td>303</td>
<td>71 kW</td>
</tr>
<tr>
<td>(1) Must add ≈120 kW beamstrahlung power loss to the disrupted beam loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical slit 2.8 cm high</td>
<td>4</td>
<td>0.1 kW</td>
</tr>
<tr>
<td>QF1ext</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>QF2ext</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(1) Must add ≈120 kW beamstrahlung power loss to the disrupted beam loss
(2) If the vertical slit opens to 4.0 cm, get large losses on QF1ext and QF2ext
1) Reduced kick, undisrupted bunches (380µ x 32µ) hit protection collimator, => 50 °C/bunch temp. rise in solid aluminum. May be OK in an aluminum plate/water collimator.

2) No kick, undisrupted bunches go backward through incoming line. If this happened in SLC, the incoming arc had an energy taper, so the backward bunch was lost in the arc and may have caused an ion chamber trip.

3) Kicker at wrong phase so the incoming bunch gets a kick (A. Seryi) => severe damage potential - see next slide.

4) Incoming dark current bunches see non-zero kicker field and hit elements in the IR (A. Seryi) => potential for large backgrounds in the detector.
Kicker out-of-phase for incoming main bunches or dark current bunches (A. Seryi)
Summary of Requirements and Issues for Zero Degree Extraction

1) **Dipoles B1 and B2 are C-magnets.**

2) The three relatively weak quadrupoles within the B1 and B2 dipole strings must be narrow on one side.

3) Need a high power aluminum/water protection collimator at $Z = 90 \text{ m}$ for wide angle beamstrahlung and disrupted beam $< 80\% \ E_{\text{beam}}$.

4) Need a $\approx 3 \text{ cm}$ diameter beam pipe through the main beamstrahlung dump at $Z = 320 \text{ m}$.

5) Neutron backgrounds to the detector from the protection collimator.

6) Non-zero kicker field at the time of the incoming bunches.

7) A number of machine protection issues and dark current background.

8) Haven’t looked at 90 GeV CM or 1 TeV CM.