Highlights from the WG: Machine Detector (and Physics) Interface

Four main themes:
1. IR design and crossing-angle choices
2. Very forward instrumentation
3. Machine backgrounds
4. Energy precision, stability, calibration
1. P. Bambade Summary of crossing-angle-or-not January 19 workshop
2. R. Appleby Alternative IR geometries for TESLA with small crossing angles
3. T. Aso Study of beam background at GLC including estimation by the BDS simulation from the exit of the LINAC to the beam dump
4. A. Stahl Beam-induced backgrounds in TESLA with l*=4.1m optics and new masking scheme, with/without 2*10mrad crossing-angle.
5. T. Markiewicz IR design (collimation, backgrounds, crossing-angle)
6. K. Desch Physics impact of beam-beam hadron background
7. W. Lohmann Summary of Prague workshop on very forward instrumentation
8. V. Drugakov Detection of very forward Bhabha events and electron ID algorithm
10. N. Delarue Beamstrahlung monitor
11. H. Yamamoto Pair (beam profile) monitor
12. M. Hildreth Energy spectrometers
13. T. Barklow Energy spread effects; energy precision
14. K. Kubo Energy spectrum measurement at the extraction line
15. S. Boogert Energy spectrum extraction from Bhabha events
16. All Discuss future inter-regional collaboration & working groups
1 - IR design and X-ing angle

- **NLC-GLC**: X-ing angle mandatory to avoid parasitic crossings at every 20 cm (1.4 ns) or 40 cm (2.8 cm)

20 mrad NLC IR from T. Markiewicz
New Development: Compact SC Quad Design

Flexible cable ⇒ small bore radius

Flexible cable ⇒ small bore radius

$\tau_{\text{Quench}} \sim L \sim N^2$

# turns = $N$ limited by quench protection

Inner Beam Tube 20 mm ID

Outer Cryostat Tube 114 mm OD

Cryostat Outer Surface

Heat Shield

Vertical Support

Horizontal Support

G10, S-Glass & Epoxy

LHe Flow Space

QDO Coil Parameters

| Inner Quad   | 63 T/m |
| Outer Quad   | 81 T/m |
| Total Quad   | 144 T/m |

Design Concept: Two independent coil windings. Integrated helium flow. Copper inside inner coil support tube.
Crossing Angle Choices for TESLA

- **TESLA**: problem with beam and \(\gamma\) losses in septum region

\(~15\ kW\) of beam and beamstrahlung loss in realistic conditions

→ 3 options

1. 300 \(\mu\)rad collision + quadruplet to reduce beam losses

   Suggestion: vertical crossing angle \(~0.3\) mrad at IP

   \[\text{D. Angal-Kalinin, R. Appleby, R. Brinkmann}\]

**Not a choice** if no progress on 50 kV/cm reliable electro-static separators (20-30 m long)
Crossing Angle Choices for TESLA (cont.)

2. 2 mrad Xing angle: no electrostatic separators, 15% Lumi loss compensated by angular dispersion @ IP (~ crab-crossing)

3. 20 mrad Xing angle: NLC like final focus (cf. US-LC study), implies RF cavity crab crossing

⇒ Detector and Physics Implications (later)
2 - Very Forward Instrumentation

Forward Calorimeter has a dual function:

- **MACHINE**: Fast luminosity monitor, *keystone* of the collider (cf. SLC 1997 run). Can be used as a beam profile monitor.
- **DETECTOR**: Low angle e± tagging: removes photon-photon background events.

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from H.Yamamoto
Highly Segmented Detector

\( N_{\text{tot}} \) or \( E_{\text{tot}} \propto \text{Luminosity} \)

\[ \sigma_y \quad \Delta \sigma_y \]

3.5 % \quad 11 %

from A Stahl

250 GeV Electron detection efficiency ~ 1

from N. Graf, T. Maruyama

La Casse, Luxembourg
Detector Design

from W. Lohmann

Heavy crystals

Diamond-W Sandwich

Si W

from N. Graf, T. Maruyama

Technology Comparison made by J. Hauptman

from H. Yamamoto

from W. Lohmann

3D Pixel Sensor

Olivier Napoly,
CEA/Saclay, DAPNIA

LCWS04 - MDI Summary -
24/04/04
3 - Machine and Beam-Beam Backgrounds

Impact on warm vs. cold technology choice ?

via

– Crossing angle : ~ 0 mrad vs. 7 mrad vs. 20 mrad
– Bunch Crossing : 1.4 ns vs. 2.8 ns vs 337 ns
Hit density on Vertex Detector from e+e- pairs: contradicting studies?

Hit density on 1st Layer
GLC study, from T. Aso

<table>
<thead>
<tr>
<th>Crossing Angle</th>
<th>VTX Radius</th>
<th>Solenoid Field</th>
<th>Hit density /mm²/train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-on</td>
<td>15mm</td>
<td>4Tesla</td>
<td>0.99</td>
</tr>
<tr>
<td>7mrad</td>
<td>15mm</td>
<td>4Tesla</td>
<td>1.00</td>
</tr>
<tr>
<td>7mrad</td>
<td>24mm</td>
<td>3Tesla</td>
<td>0.38</td>
</tr>
<tr>
<td>20mrad</td>
<td>15mm</td>
<td>4Tesla</td>
<td>1.03</td>
</tr>
<tr>
<td>20mrad</td>
<td>15mm</td>
<td>3Tesla</td>
<td>1.71</td>
</tr>
</tbody>
</table>

Clear Dependence on VTX radius and B field.
No dependence on crossing angle.

Azimuthal dependence
TESLA study, from K. Büsser

TPC occupancy 2 times larger from 0 to 20 mrad crossing angle but
All backgrounds so far studied are still on tolerable levels
• Energy deposition is twice as large in the 20 mrad x-angle case → impact on e – tagging efficiency

• Origin of azimuthally asymmetric VTX pair hits
Bunch Crossing : $\gamma\gamma \rightarrow$ hadrons background

Mass measurement of light Higgs boson ($m_H=120$ GeV)

$H \rightarrow bb, \ Z \rightarrow qq \Rightarrow 4$ jets reconstruction

Integrating over several BX hadronic backgrounds reduces the resolution on $\Delta m_H$ from 75 MeV (1BX) to 92 MeV (18 BX)

NLC, GLC and TESLA have about the same $L/\text{BX}$

Olivier Napoly
CEA/Saclay, DAPNIA

LCWS04 - MDI Summary - 24/04/04
4 - Energy Precision

Beam instrumentation goals

- Top mass: 200 ppm (35 MeV)
- Higgs mass: 200 ppm (25 MeV for 120 GeV Higgs)
- W mass: 50 ppm (4 MeV)
- ‘Giga’-Z $A_{LR}$: 200 ppm (20 MeV) (comparable to ~0.25% polarimetry)
  50 ppm (5 MeV) (for sub-0.1% polarimetry with $e^+$ pol)

Progress on Spectrometer measurement: $\langle E_{\text{beam}} \rangle$

BUT: Machine bias to $E_{\text{CM}}$ measurement: $\langle \sqrt{s} \rangle_{\text{lumi}} \neq \langle E_{\text{beam}} \rangle$

Progress at Zeuthen
  from H.J. Schreiber
and at SLAC + …
  from M. Hildtretth
Example of Lumi-weighted Energy Bias related to Beam Energy Spread at NLC-500 from T. Barklow, M. Woods

For energy bias study, turn off beamstrahlung and only consider beam energy spread.

$$\langle E_{\text{Bias}}^{\text{CM}} \rangle = \frac{\langle \sqrt{s'} \rangle - 500 \text{ GeV}}{500 \text{ GeV}} \approx 500 \text{ppm}$$

Bhabha acolinearity analysis alone won’t help resolve this bias.

Olivier Napoly, CEA/Saclay, DAPNIA

LCWS04 - MDI Summary 24/04/04
Kink instability and $E_{CM}$ Bias

from T. Barklow, M. Woods

(larger for NLC) (larger for TESLA) (comparable at NLC, TESLA)

Wakefields + Disruption $\rightarrow$ Kink instability

E-Spread + E-z correlation + Kink instability $\rightarrow$ $E_{CM}$ Bias

$E_{CM}^{Bias} = \frac{\langle E_{1} \rangle + \langle E_{2} \rangle - \langle E_{CM}^{lum-wt} \rangle}{\langle E_{1} \rangle + \langle E_{2} \rangle}$, $E_{1}$ and $E_{2}$ are beam energies measured by the energy spectrometers

Summary of $E_{CM}^{bias}$

<table>
<thead>
<tr>
<th>LC Machine Design</th>
<th>Collider Mode</th>
<th>$&lt;E_{CM}^{bias}&gt;$ ($\Delta y = 0$)</th>
<th>$\sigma(E_{CM}^{bias})$ ($\Delta y = 0$)</th>
<th>Max($E_{CM}^{bias}$) vary $\Delta y$, $\eta_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLC-500</td>
<td>$e^+e^-$</td>
<td>+520 ppm</td>
<td>170 ppm</td>
<td>+1000 ppm</td>
</tr>
<tr>
<td>TESLA-500</td>
<td>$e^+e^-$</td>
<td>+50 ppm</td>
<td>30 ppm</td>
<td>+250 ppm</td>
</tr>
</tbody>
</table>
Conclusions

• Many studies attempting to address the Cold / Warm technology comparison

• Trans-oceanic collaborations (even trans-Channel !!)

• Proposal to convene a specialized MDPI workshop in fall 2004