Design of the Beam Delivery System for the International Linear Collider

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for BDS team
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Design of BDS for ILC
WEOCAB01

• Single IR push-pull BDS, upgradeable to 1TeV CM in the same layout, with additional bends
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (linac exit to IP distance)/side</td>
<td>m</td>
<td>2226</td>
</tr>
<tr>
<td>Length of main (tune-up) extraction line</td>
<td>m</td>
<td>300 (467)</td>
</tr>
<tr>
<td>Max Energy/beam (with more magnets)</td>
<td>GeV</td>
<td>250 (500)</td>
</tr>
<tr>
<td>Distance from IP to first quad, L*</td>
<td>m</td>
<td>3.5-(4.5)</td>
</tr>
<tr>
<td>Crossing angle at the IP</td>
<td>mrad</td>
<td>14</td>
</tr>
<tr>
<td>Nominal beam size at IP, $\sigma^*$, x/y</td>
<td>nm</td>
<td>639/5.7</td>
</tr>
<tr>
<td>Nominal beam divergence at IP, $\theta^*$, x/y</td>
<td>$\mu$rad</td>
<td>32/14</td>
</tr>
<tr>
<td>Nominal beta-function at IP, $\beta^*$, x/y</td>
<td>mm</td>
<td>20/0.4</td>
</tr>
<tr>
<td>Nominal bunch length, $\sigma_z$</td>
<td>$\mu$m</td>
<td>300</td>
</tr>
<tr>
<td>Nominal disruption parameters, x/y</td>
<td></td>
<td>0.17/19.4</td>
</tr>
<tr>
<td>Nominal bunch population, N</td>
<td></td>
<td>$2 \times 10^{10}$</td>
</tr>
<tr>
<td>Beam power in each beam</td>
<td>MW</td>
<td>10.8</td>
</tr>
<tr>
<td>Preferred entrance train to train jitter</td>
<td>$\sigma_y$</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Preferred entrance bunch to bunch jitter</td>
<td>$\sigma_y$</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Typical nominal collimation aperture, x/y</td>
<td></td>
<td>8–10/60</td>
</tr>
<tr>
<td>Vacuum pressure level, near/far from IP</td>
<td>nTorr</td>
<td>1/50</td>
</tr>
</tbody>
</table>
Global Design Effort

BDS beamline

Diagnostics

Sacrificial collimators

β-collimator

E-collimator

BSY

Tune-up dump

grid: 100m*1m

FF

14mr IR

Main dump

Extraction

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ILC BDS 5
BDS optics for incoming beam

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BSY Polarimeter β-collim. Diagnostics

E-collimator E-spectrometer FF

PAC 2007 ILC BDS 6
Optics for outgoing beam

Extraction optics can handle the beam with ~60% energy spread, and provides energy and polarization diagnostics.
Beam dump

- 17MW power (for 1TeV CM)
- Rastering of the beam on 30cm double window
- 6.5m water vessel; ~1m/s flow
- 10atm pressure to prevent boiling
- Three loop water system
- Catalytic H₂-O₂ recombiner
- Filters for 7Be
- Shielding 0.5m Fe & 1.5m concrete
Collimators & muon walls

- Collimators: spoiler-absorber pairs
- In Final Doublet & IP phase
- Spoilers can survive direct hit of two bunches
- Can collimate 0.1% of the beam
- Muons are produced during collimation
- Muon walls reduce muon background in the detectors

Magnetized muon wall

Collimator
Crab cavity design

- Based on FNAL design of 3.9GHz CKM deflecting cavity
- Initial design been optimized now to match ILC requirements on damping of parasitic modes, and to improve manufacturability
- Design & prototypes been done by UK-FNAL-SLAC collaboration

FNAL 3.9GHz 9-cell cavity in Omega3p. K.Ko, et al

3.9GHz cavity achieved 7.5 MV/m (FNAL)

WEPMS050
L. Xiao, et al

WEPMN079
G. Burt, et al
Crab cavity LLRF

- LLRF phase and synchronization stability
- Required: ~67fsec or 0.094° for <2% luminosity loss (7 cell 1.5GHz cavity at JLab achieved 37fsec)

- Design features: digital phase detector, RF interferometer
- Simulations predict that specs can be met

WEPMN080
G. Burt, et al
500GeV => 1TeV CM upgrade
example for BSY

Magnets and kickers are added in energy upgrade

M. Woodley et al

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Concept of single IR with two detectors

Detector A may be accessible during run.

Detector B is accessible during run.

The concept is evolving and details being worked out.

Concept of detector systems connections

**Detector**
- sub-detectors
- solenoid
- antisolenoid
- FD

**Detector Service Platform**
- fixed connections
- move together

- low V DC for electronics
- 4K LHe for solenoids
- 2K LHe for FD
- high I DC for solenoids
- high I DC for FD
- gas for TPC
- electronics I/O

**Long Flexible Connections**
- low V PS
- high I PS
- electronic racks
- 4K cryo-system
- 2K cryo-system
- gas system

**Fixed Connections**
- high V AC
- high P room T He
- supply & return
- chilled water
- for electronics
- fiber data I/O

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IR integration

Final doublet magnets are grouped into two cryostats, with warm space in between, to provide break point for push-pull.
- Interaction region uses compact self-shielding SC magnets
- Independent adjustment of in- & out-going beamlines
- Force-neutral anti-solenoid for local coupling correction

**THPMS091 Brett Parker, et al**
cancellation of the external field with a shield coil has been successfully demonstrated at BNL.
IR integration

- Detailed engineering design of IR magnets and their integration has started
• CMS detector assembled on surface in parallel with underground work, lowered down with rented crane
• Adopted this method for ILC, to save 2-2.5 years that allows to fit into 7 years of construction
ILC Interaction Region Engineering Design Workshop

September 17-21, 2007
Stanford Linear Accelerator Center
Menlo Park, California

Please join us to review and advance the design of the subsystem of the Interaction Region of ILC, focusing in particular on their integration, engineering design and arrangements for push-pull operation.

http://www-conf.slac.stanford.edu/ireng07/
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IR alternatives, 0mrad

- FD: NbTi @ 500GeV CM (250T/m, 7T/bore); Nb$_3$Sn @ 1TeV CM (~370T/m, 10.5T/bore)
- Separator: $\Delta=12\,\text{mm}$ at 55m from IP (to control parasitic crossing beam-beam instability) => 2.6MV/m ($\pm$130kV over 100mm gap) & *2 at 1TeV CM), split gap, overlapped with dipole field; low spark rate is essential
- Challenges: intermediate ~1MW dump, possible back shine to detector; design of downstream diagnostics

**THPMN005 Olivier Napoly, et al**

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IR alternatives, 2mrad

- Focus of latest optics work: trying to design minimal system, shortest, most economical, without downstream diagnostics (added later if new ideas found)
- FD reoptimized with new ILC parameters: SC QD0/SD0 & warm QF1/SF1
- FD is NbTi at 500GeV CM (225T/m, 6.3T/bore) and Nb$_3$Sn at 1 TeV CM (350T/m, 8.8T/bore)
- Beamline downstream of FD to be designed & studied. Study feasibility of downstream diagnostics, study beam & SR losses and evaluate backscattered background

THPMN077 Robert Appleby, et al
Test facilities: ESA & ATF2

ESA: machine-detector tests; energy spectrometer; collimator wake-fields, etc.
ATF2: prototype FF, develop tuning, diagnostics, etc.
Summary

- Beam delivery system for ILC has been designed
- R&D and prototyping for critical subsystems is ongoing
- Detailed engineering design of BDS subsystems is starting