ILC WG4
Beam Delivery

Andrei Seryi, Grahame Blair, Tomo Sanuki

Most of my slides are produced by our colleagues

Contents:
1. What we have done
2. What we will do
ILC WG4

- Every thing after Main Linac
  - Beam delivery
  - Interaction region
  - Beam diagnostics
  - Feedback system
  - Beam dump
  - …
What we have done

Optics
Instrumentation
Beam Test
WG4:
(Beam Delivery, Interaction Region, …)

SUMMARY

Grahame Blair, Tomoyuki Sanuki, Andrei Seryi

On behalf of WG4 participants

15 November 2004

First ILC Workshop at KEK, November 13-15, 2004
ILC BDIR design choices

- **Crossing Angle**
  - Head on
  - Very small vertical crossing angle
  - Small horizontal or crossing angle (~2 mrad)
  - Large horizontal crossing angle (7-20 mrad, ~35 mrad)

- **Final Doublet Technology**
  - Compact SC or PM quad, or large bore SC

- **L**
  - e.g. 3, 4, 5 m

- **Detector VXD inner radius**

- **Instrumentation Choices**

- **MPS Questions**

- **Detector Questions**

- **Collimation Choices**

- **Beam Stabilization choices**

- **Risk Mitigation**
Options

- **Gamma-gamma**
  - In particular, consequence of ~35 mrad crossing angle on e+e- luminosity

- e- e-
- e+ polarized
- Above 1 TeV running
- Consequence of simultaneous running of both IRs
Recommendations from the WG4

• Having considered and discussed the critical design choices,
• the Working Group came to consensus on the recommendation for the working hypotheses on the BDIR configuration
• With the final decision to be remained to be made by GDI,
• the proposed configuration is the direction where WG4 will focus its work
Recommendations from the WG4
Tentative, not frozen configuration, working hypotheses, “strawman”

- **Urgent work for next 8 month**
  - Improve and enhance communication within groups working on the design, and with detector community
  - **Complete optics design** for both IRs with all diagnostics and extraction
  - Request the physics community to **evaluate physics impact** of the “strawman” configuration
  - Evaluate how detector concepts affect optimization of L*, and what FD technologies are suited best
  - Develop civil engineering plans, including provision for option possible at 1st or 2nd IR at maximum energy
Recommendations from the WG4
Tentative, not frozen configuration, working hypotheses, “strawman”

- Urgent work for next 8 month (continued)
  - Reevaluate background tolerances of the detectors
  - Develop engineering design of crab cavity with electronics
  - Energy deposition and accidental beam loss studies, reevaluate the beam-beam induced loads in IR
  - Evaluate parameter changes options considered by WG1 (e.g. smaller IP beta-functions, bunch charge, separation) and parameters needed for (smaller x size)
  - Make more realistic simulations of feedbacks and diagnostics
Summary of the summary

• A lot of interest, resources and ongoing work focused on BDIR in many regions and labs
• WG4 made significant progress and was able to come with recommendations on the working hypotheses for the BDIR configuration
• Good communication prior and at this meeting was one of the keys, and enhanced communication will help to make rapid further progress
• The urgent work needed in the next 8 month, to become closer to the complete design, and in many cases the people who will do the work, have been identified
• The MDI workshop (January 6-8, SLAC), the LCWS, and BDIR workshop (Spring 05, Oxford), will be our milestones to bring us to Snowmass (August) with a major progress towards detailed design
After 1st ILC Workshop at KEK

- Nano-project at ATF in December
- MDI & ATF2 WS in January
- LCWS in March
- ATF2 meeting in May
- Nano-project at ATF in May
- Numerous video/phone meetings, e-mail
- BDIR WS at RHUL in June
A one-week ILC European Regional meeting will be hosted by the Oxford/RHUL John Adams Institute at Royal Holloway, University of London, UK from 20-23 June, 2005. The meeting will support in parallel the following international workshops:

- ILC-BDIR WG4 Interim Workshop
- Annual EUROTeV Workshop
- CARE/ELAN Workshop

Last minute information on how to get to RHUL, location of meetings etc.

Payment instructions

Photos
The ILC Beam Delivery System, plans for Snowmass, Reference Design Report and beyond

Grahame Blair, Tomoyuki Sanuki, Andrei Seryi
Beam Delivery Workshop, RHUL
June 20, 2005
Recommendations from the WG4
Tentative, not frozen configuration, working hypotheses, “strawman”

International BDS group is working hard to turn the Strawman tentative configuration into real design
Collimation / Final Focus (20 mrad crossing)
ILC IR and Extraction Line Magnet CHALLENGES

Two possible extraction schemes (with SiD)

Disrupted beam  
Beamstrahlung  
Incoming beam

Mostly superconducting magnets

Incoming beam

Disrupted beam

Various types of magnets

0.36m

18 m

20 mrad

2 mrad

SiD detector

These boxes represent just apertures. ~0.1m between the 2 beams

QD0  SD0  QF1  SF1  SEXF1  QFEX1  QFEX1B
A  B  C

QD0  SD0  QF1  SF1  SEXF1  QFEX1  QFEX1B
A  B  C

QD0  SD0  QF1  SF1  SEXF1  QFEX1  QFEX1B
A  B  C

IP

20 mrad  2 mrad  18 m  60 m

Cherrill Spencer, SLAC and Brett Parker, BNL
20mrad IR, extraction & compact SC quads

- Based on compact SC quads
- Latest achievements in BNL direct wind technology => even tighter bend radius => quad is more compact => extraction quad has same L* as QD0
- Sixth final layer wound on the QD0 prototype at BNL last week. Next => tests
2mrad IP Extraction Line in Geant

Shared Large Aperture Magnets

Disrupted beam & Sync radiations

Q,D,QF1

Incoming beam

60 m

Beamstrahlung

No beam & losses for nominal parameters

Rutherford cable SC quad and sextupole

Pocket coil quad

Super Septum Quad, B.Parker et al.
or

Warm Panofsky septum quad (C.Spencer)
Neutron Production – Cross Section

Origins of neutrons (blue ones reach the TPC)
Pairs at $Z = 300$ cm

20 mrad

Y (cm)

2 mrad

X (cm)

Y (cm)

Pair energy in BeamCal

2 more energy in 20 mrad
2mrad extraction line with diagnostics chicane

Plot from Yuri Nosochkov

Talk by R. Appleby
Talk by E. Torrence on behalf of Ken Moffeit
Gas Dump: First Thoughts

One atomic noble gas core (Ar, Xe) is surrounded by solid material (Fe)

gas core acts as scattering target (only small amount of energy deposition)
and distributes energy **longitudinally over ~ 1km** into surrounding material

low energy densities, no sweeping, small spot size possible, no radiolysis

surrounding material takes main part of energy

\( Z = 20 \) reduced tritium production

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**First Attempt (not optimized)**

- air
- water, 4cm
- Fe, 52cm thick
- Ar core, 8cm @ normal conditions

**Energy density (1 electron 400GeV), dE/dV [GeV/cm³]**

\( r \)-bin=1cm, \( z \)-bin=10m

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**Basic Idea**

tunnel
gas dump 1.2m, ~1km

Talk by M. Schmitz
Before/At BDIR WS

- We have a “transition”:
  - Concepts (Strawmann)
  - Optics
  - Engineering design
BDS Reference Design Report for Snowmass

• From now to Snowmass: Suggest to create web-based description with main features of baseline, R&D for baseline, and options with their R&D

• After Snowmass, turn this description into a document according to common standard

• At this workshop, need to work on this document
  – A very rough draft is shown on next pages

• The Reference Design Report is based on assumption of two interaction regions. The particle physics output and cost of two IRs vs single IR will be evaluated in details
## BDS Reference Design Report for Snowmass

<table>
<thead>
<tr>
<th>BDS Baseline</th>
<th>Baseline R&amp;D</th>
<th>Option and Option R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>One of IRs with 20±mrad crossing, separate incoming and extraction lines</td>
<td>Many. See specific items below.</td>
<td>15-25mrad</td>
</tr>
<tr>
<td>One of IRs with ~2mrad crossing, first FD magnets shared</td>
<td>Many. See specific items below.</td>
<td>Head-on with electrostatic separator or RF kicker; Or same 20mrad for 2\textsuperscript{nd} IR</td>
</tr>
<tr>
<td>Compact SC direct wind quads for 20mrad, separate cryostats for QD0 &amp; QEXF</td>
<td>Prototype compact SC QD0</td>
<td>Common cryostat SC quads, other technology?</td>
</tr>
<tr>
<td>FF optics based on local chromatic correction</td>
<td>Get experience with compact FF at AFT2</td>
<td>Traditional FF with non-interleaved sextupole pairs</td>
</tr>
<tr>
<td>2mrad extraction beamline with E and polarization diagnostics, with separation of e+ and after first extraction line doublet</td>
<td>Prototype SC super septum quads or Panofsky style septum quads</td>
<td>Other ideas for magnets?</td>
</tr>
<tr>
<td>Large bore SC magnets for 2mrad, minimal external size, with antisolenoid and movers inside?</td>
<td>Prototype needed?</td>
<td>Alternative SC materials which allow larger aperture, but brittle in manufacturing</td>
</tr>
<tr>
<td>Crab cavity based on 1.3 or 3.9GHz located near FD in 20mrad IR and near SD4 in 2mrad IR</td>
<td>Prototype crab cavity with proper damping of high order modes</td>
<td>Crab cavity based on warm RF cavity</td>
</tr>
<tr>
<td>Main beam dumps based on water vortex scheme rated for 18MW beam. Common e+- and dump for 20mrad, separate dump for 2mrad</td>
<td>Prototype and tests of beam dump window?</td>
<td>Elliptical wide window.</td>
</tr>
<tr>
<td>Betatron collimation based on collimation in FD and IP phase, with survivable spoilers</td>
<td>Measurements of collimator wakefields. Beams damage studies at ESA.</td>
<td>Betatron collimation with consumable spoilers. Their prototype.</td>
</tr>
</tbody>
</table>

IR magnet support with passive vibration protection  
IR prototype at ESA  
Active stabilization of FD support
<table>
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<tbody>
<tr>
<td>IR magnet support with passive vibration protection</td>
<td>IR prototype at ESA</td>
<td>Active stabilization of FD support</td>
</tr>
<tr>
<td>Antisolenoid as part of detector in 20mrad IR</td>
<td>Do we need prototype or design studies sufficient?</td>
<td>No antisolenoid, only skew quad correction</td>
</tr>
<tr>
<td>Antisolenoids as part of large bore QD0</td>
<td>Prototype QD0, solve decoupling force on solenoid from the quad</td>
<td>No antisolenoid, only skew quad correction</td>
</tr>
<tr>
<td>Detector solenoid with Detector Integrated Dipole for both 20mrad and 2mrad</td>
<td>Design studies sufficient, no prototypes</td>
<td>No DID</td>
</tr>
<tr>
<td>Incoming beamline BPMs are cavity based submicron resolution</td>
<td>Prototype large aperture cavity BPMs</td>
<td>Stripline BPMs?</td>
</tr>
<tr>
<td>Diagnostics with orthogonal coupling correction section followed by a 4-wire-scanner 2D (projected) emittance measurement section with laser wire system with beam sizes &gt; 17*1.5 microns</td>
<td>Prototype laser wire at PETRA and ATF/ATF2, achieve needed resolution of micron beam</td>
<td>Lengthened diagnostics section with larger beam sizes at laser wire scanners</td>
</tr>
<tr>
<td>Fast intra-train digital feedback system with BPMs on the IP face of FD and kickers near FD</td>
<td>Prototype intratrain feedback at ATF and ATF2, beamtest of BPMs in background conditions at ESA</td>
<td>No other options? Analog feedback is an option?</td>
</tr>
<tr>
<td>FD movers for 2mrad IR: movers are located inside of the cryostats of the large aperture magnets.</td>
<td>Prototype the movers. Piezo or magnetostrictive technology?</td>
<td>Other techniques?</td>
</tr>
<tr>
<td>FD movers for 20mrad IR: mechanical movers for each magnet individually, located outside cryostats, based on FFTB scheme</td>
<td>Prototype at ESA: IR mockup?</td>
<td>Other techniques?</td>
</tr>
<tr>
<td>Energy spectrometer based on high resolution cavity BPMs with variable</td>
<td>Prototype at ESA for BPMs, precise magnets, movers, survey system</td>
<td></td>
</tr>
<tr>
<td>BDS Reference Design Report for Snowmass</td>
<td></td>
<td></td>
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<tr>
<td>------------------------------------------</td>
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<tr>
<td>BDS: to Snowmass &amp; beyond 29    June 20, 2005</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Prototype/Test Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical movers for each magnet individually, located outside cryostats, based on FFTB scheme</td>
<td></td>
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<tr>
<td>Energy spectrometer based on high resolution cavity BPMs with variable chicane for upstream beamlines</td>
<td>Prototype at ESA for BPMs, precise magnets, movers, survey system</td>
<td></td>
</tr>
<tr>
<td>Polarimeter for upstream beamlines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream energy spectrometer based on synchrotron stripe monitor</td>
<td>Prototype at ESA</td>
<td></td>
</tr>
<tr>
<td>Collider halls separated by about hundred meters, size w<em>l</em>h meters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mover system for main beamline magnets based on FFTB scheme</td>
<td>Mover system based on 6D movable system (SBIR 1, possible SBIR 2)</td>
<td></td>
</tr>
<tr>
<td>Tail folding octupoles based on SC magnets with five magnets in each FF branch</td>
<td>Prototype strong octupoles</td>
<td></td>
</tr>
<tr>
<td>Muon and personnel protection wall based on magnetized iron, two per FF branch, 9m and 18m long</td>
<td>Single muon protection wall may be sufficient for lower halo population and higher tolerance for muon background</td>
<td></td>
</tr>
<tr>
<td>Emittance diagnostics and correction system upstream of beam switchyard, common system for both IRs</td>
<td>Separate diagnostics in each branch?</td>
<td></td>
</tr>
<tr>
<td>Fast luminosity and pairs monitors based on … technology…</td>
<td>Prototype and test at ESA</td>
<td></td>
</tr>
<tr>
<td>IR with cryo-pumping by cold bore magnets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP BPMs …</td>
<td></td>
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</tbody>
</table>
What we have done

Optics
Instrumentation
Beam Test
BDS design supported by R&D work at these facilities

• Proposed End Station A at SLAC
  – Study Interaction Region issues and instrumentation
  – Mockup of full IR

• Existing ATF at KEK (DR and BDS related studies)
  – Instrumentation (Nano-BPM, laser wires, optical anchor)
  – Fast Intra-train feedback (FONT/Feather)
  – nm resolution BPM test & demonstration
  – Preparation of ‘ATF-2’

• Proposed ATF-2 at KEK
  – BDS facility, use very low emittance ATF beam
End Station A Test Facility
For Prototypes of Beam Delivery and IR Components
http://www-project.slac.stanford.edu/ilc/testfac/ESA/esa.html

Collimator design, wakefields (T-480)
BPM energy spectrometer (T-474)
Synch Stripe energy spectrometer (T-475)
IP BPMs, kickers
EMI (electro-magnetic interference)
IR Mockup

PAC05 paper/poster: SLAC-PUB-11180
e-Print Archive: physics/0505171

<table>
<thead>
<tr>
<th>CCLRC</th>
<th>LLNL</th>
<th>QMUL</th>
<th>UCL</th>
<th>U. of Bristol</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERN</td>
<td>Lancaster U.</td>
<td>SLAC</td>
<td>UC Berkeley</td>
<td>U. of Oregon</td>
</tr>
<tr>
<td>DESY</td>
<td>Manchester U.</td>
<td>UMass Amherst</td>
<td>U. of Cambridge</td>
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<tr>
<td>KEK</td>
<td>Notre Dame U.</td>
<td>U. of Birmingham</td>
<td>TEMF TU Darmstadt</td>
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</tbody>
</table>
ATF2 design & goals

Address luminosity challenges of ILC
Follow up on FFTB, create facility
to train young generations of accelerator physicists

(A) **Small beam size**
    Learn to obtain $\gamma \sim 35\text{nm}$
    and maintain for long time

(B) **Stabilization of beam center**
    Learn to keep it stable at IP within $< 2\text{nm}$
    using nano-BPM and bunch-to-bunch feedback
    of ILC-like train

ATF2 collaboration, presently >88 people
from 21 labs and institutions and growing

KEK, Tsukuba
IHEP, Beijing
BINP, Novosibirsk
CCLRC/DL/ASTeC, Daresbury
CEA, Gif-sur-Yvette
CERN, Geneva
Hiroshima University
Kyoto ICR, Kyoto
LAL, Orsay
LLNL, Livermore
NIRS, Chiba-shi
North Carolina A&T State University
Oxford University
Pohang Accelerator Laboratory
Queen Mary University of London
Royal Holloway, University of London
DESY, Hamburg
SLAC, Stanford
UCL, London
University of Oregon
University of Tokyo

ATF2 proposal will be released
during this BDIR workshop in London
ATF2 Proposal

ATF2 Collaboration

August 11, 2005
Items to be discussed

- Layout & Optics
- Magnets
- IR design and MDI issues
- Collimation & Background
- Beam dumps
- Instrumentation & Feedback & Crab Cavity
- WG4/WWS/Detectors
- Joint with WG1:
  - BDS tuning, alignment, ground motion...
Summary

- ILC BDS:
  - concepts => optics => engineering design
- Designing IR
  - Layout (Magnet etc.)
  - Collimation & Background (MC)
  - Beam Dump