SiD and the Roadmap for ILC Detectors

SLAC Users Organization Annual Meeting
June 7, 2007
John Jaros
A Lot is Happening in the ILC Detector World

- **ILC Reference Design Report (RDR)** and Cost were unveiled in February.
- **International Linear Collider Steering Committee** has charged the Detector Community to Propose a **Detector Roadmap**.
- A draft **Detector Concept Report (DCR)**, the companion document to the RDR which makes the case for ILC physics and detectors, was released in May. The RDR and DCR go public in August.
- Plans for the Machine **Engineering Design Report** and first steps for the **Detector Roadmap** were announced at the LCWS last week.
Guide to ILC Speak

ILCSC  International Linear Collider Steering Committee, chartered by ICFA to realize the ILC. ILCSC chose the technology, established the GDE, hired the Director, facilitates getting support, and provides oversight.

GDE  Global Design Effort. Under Barry Barish’s direction, the GDE is the international team designing, developing, and now engineering the ILC. Next step, Machine EDR.

WWS  World Wide Study (of Physics and Detectors for the Linear Collider). Grass Roots organization of the detector and physics communities, led by Brau, Richard, and Yamamoto. WWS organizes detector R&D and detector concept studies, and has developed a detector roadmap.

RDR/DCR  The Reference Design Report, outlining the machine baseline design and costs and the Detector Concept Report, making the case for ILC physics and detectors.

EDRs  Engineering Design Reports for the machine and detector, due 2010, which will serve as the proposal to World Governments to construct the ILC and its Detectors.
A Compelling Physics Case Has Been Established

- The LHC will open Terascale Physics with exciting discoveries
- The ILC will elucidate the full meaning of Terascale physics
  - Understanding the Mechanism of Electroweak Symmetry Breaking
  - Exploring the detailed properties of new particles and interactions
  - Opening windows to higher energy scales with precision measurements
Collider Progress

- Reference Design with cost released in Beijing in February
  - Two 11km SC linacs operating at 31.5 MV/m for 500 GeV
  - Centralized injector
    - Circular damping rings for electrons and positrons
    - Undulator-based positron source
  - Single IR with 14 mrad crossing angle
  - Dual tunnel configuration for safety and availability
Subject: Letter to WWS Co-Chairs

• 26 February 2007
• To: Co-Chairs of the WWS International Organizing Committee
• From: ILCSC

The realization of the International Linear Collider has taken major steps forward in recent years. This could not have happened without the leadership taken coherently by the particle physics community, within the framework of ICFA. Unprecedented collaborative steps have been necessary, and the community has adapted successfully to what, in some regions, required major redirections of traditional accelerator R&D effort.

Two major milestones, the selection of the main-linac RF technology and the GDE’s announcement of the RDR budget and associated design choices, keep the GDE on pace to complete a construction-ready engineering design for the ILC accelerator-complex by 2010.

Maintaining this momentum requires also that the equivalent strategic decisions and the level of technical maturity for the two ILC detector proposals keep pace with the accelerator schedule. Major progress in this regard is ongoing under the auspices of WWS. In addition, a definite plan together with milestones is needed to have detector designs of a maturity similar to that of the accelerator by 2010. This needs an enhanced effort by the community. ILCSC will support the formation of an International Detector Advisory Group to assist this effort. ICFA looks forward to receiving such a plan from WWS at the June 1, 2007 ILCSC meeting at DESY.
The key elements of the roadmap proposal are:

• A call for LOIs by ILCSC this summer, due summer 2008
• These LOIs will provide a description of the proposed detector and its performance, and will note the intent of those planning to collaborate on developing the EDR.
• LOIs will be reviewed by the IDAG, an International Detector Advisory Group of experts chosen by ILCSC.
• IDAG will facilitate the definition of two, complementary and contrasting detector designs, and report the result to ILCSC.
• The result of this process should be two proto-collaborations operating by the beginning of 2009 to produce EDR documents by end 2010.
The Roadmap, as implemented by ILCSC

- Issue Call for Detector LOIs summer 2007.
- Search for, and appoint a Research Director, to oversee the experimental program for the ILC, coordinate reviews of the LOIs, facilitate the selection of two, complementary detector designs, help generate support for the two detector EDRs, and monitor EDR development.

...establishing the IDAG, and further defining the process, are still under discussion by ILCSC. More to come.
Roadmap Implications

- **Calling for LOIs signals a Phase Change for the Detector Concepts.** Detector “Design Studies” are becoming “Detector Collaborations.”

- **Calling for LOIs also sends signals to the ILC Detector R&D Community.** Now’s the time to align with a detector concept, participate in the optimization process, and contribute to the LOIs.

- **Four goes to Two.** The four ILC detector concepts, plus any that emerge within the next year, must eventually contract to two, suitable for full engineering design.
  - Spontaneous Coalescence (e.g., LDC and GLD)
  - Induced Coalescence?
  - Shotgun Marriage?
• Traditional Solenoid Designs  B=5,4,3 Tesla
• Si vs TPC Tracking
• “Particle Flow” Calorimeters
ILC Detector Concepts, continued

- Dual Solenoid Design for Flux Return, Muon ID
- Compensating, Dual Readout Tower Calorimetry
- TPC Tracking
SLAC’s Role in ILC Detector Development

- **Coordinates the SiD Design Study** with Fermilab, BNL, Argonne, many US Universities, and international partners from KEK, Tokyo, Annecy, and Oxford

- **Designs and studies the Machine-Detector interface** and IP Instrumentation

- **Provides Computing-Simulation-Analysis infrastructure** for the US ILC Detector Effort

- **Pursues detector R&D**, especially Si/W Calorimetry, Readout electronics, and Si Tracking

- **Optimizes SiD Design and Benchmarks** SiD performance
SiD Design Rationale

- Jet energy resolution goal is $\Delta E/E = 3-4\%$ to distinguish hadronic decays of W’s and Z’s. Particle Flow Calorimetry requires a dense, highly segmented, SiW Ecal and Hcal.

- High magnetic field limits radius and cost of calorimeters and solenoid and maintains $BR^2$.
  \[ B = 5 \text{ Tesla} \]

- Si strip tracker for excellent momentum resolution and robust performance \( \Delta p_t/p_t^2 \leq 5 \times 10^{-5} \text{ GeV}^{-1} \)

- VX Tracker at minimum possible radius with max $\Omega$
  \[ \Delta \delta = 5 \oplus 10/\text{psin}^{3/2} \theta \mu \text{m} \]

- Instrumented flux return for muon identification
Particle Flow Calorimetry
Promises Improved Dijet Mass Resolution

Measure the energy of every particle, not the energy deposited in calorimeter modules.

High transverse and longitudinal segmentation is needed to distinguish individual particles.
SiD Starting Point

- **Vertex detector:** 5 barrels, 4 disks; $R_{in} = 1.4$ cm
- **Si tracking:** 5 layers; $R_{in} = 20$ cm
- **HCAL Fe:** 34 layers; $R_{in} = 138$ cm
- **Solenoid:** 5 T; $R_{in} = 250$ cm
- **EMCAL Si/W:** 30 layers; $R_{in} = 125$ cm
- **Flux return/muon:** $R_{in} = 333$ cm, $R_{out} = 645$ cm
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SiD @ SLAC: ECAL

- KPiX ASIC Readout Chip Development
- Calorimeter Simulation Studies
- Particle Flow Algorithm Development
- Starting Ecal Mechanical Design

$\alpha$ Vs Neutral Hadron Energy for Various absorber thicknesses
SiD @ SLAC: Tracking

- Microstrip Sensor Design
- Sensor Module Design
- Geant4 tracker simulation
- Pattern Recognition Code
- Tracker Design/Optimization
SiD @ SLAC: Simulation/Reconstruction

• Supports SiD, ALCPG, and international simulation effort with Tutorials, Workshops, WWS Working Groups
• Provides physics simulation and data samples for physics analysis
e.g. 1 ab-1 sample of all SM Processes at 500 GeV
  http://www.lcsim.org/datasets/ftp.html
• Provides full detector simulation in Geant4. Runtime detector description in XML, making it easy to study design variations.
• Provides Java-based reconstruction & analysis framework
• Developing Tracking and Calorimeter reconstruction code
SiD @ SLAC: MDI

- Evaluate Detector backgrounds for new ILC parameters
- Design IRs for 2, 14, 20 mr crossing angles
- Design/test beam energy spectrometers
- Investigate EMI (electro-magnetic interference)
- Design exit beamlines to accommodate polarimetry and energy spectrometers
SiD @ SLAC: Physics Benchmarking

- Evaluating Detector Performance Requirements
- Full MC Physics Analyses

\[ \text{ZH} \rightarrow \mu\mu X \]
Ongoing SiD Activities. Help Needed!

- **Optimize Detector Design.**
  Move beyond the Starting Point: Fix Radius and Length of Tracker, B Field, Depth of Hcal.

- **Detail and Integrate the Subsystem Designs.**
  No forward tracking design yet!
  Ecal and Hcal mechanics just getting started.

- **Develop Design Tools. Study Performance.**
  PFAs running; full tracking pattern recognition.

- **Analyze physics with Full MC**
Why Get Involved in SiD Now?

- During the next ~3 years, it is imperative for the ILC community to develop two optimized, complementary, and well understood detector designs that demonstrate the ability to carry out a compelling physics program
  - Hard to imagine the ILC can be approved without this

- SiD will be one of these two detectors
  - The precision, speed, and robustness of silicon detectors is unmatched by the competing technologies

- You can make a significant contribution in shaping the SiD detector design
  - The software tools needed for optimizing the detector design are either in place or well advanced, but the process of using these tools to optimize the detector design has barely started
  - An active detector R&D program is essential to make informed technical choices, develop detailed detector designs, and demonstrate the feasibility of these designs through simulations, prototypes, and test beam studies
How to Get Involved in SiD

A 3 step program for getting involved in SiD

1. Identify an area in SiD where you would like to contribute
2. Talk with SiD leadership about your interests and our needs
3. Start attending meetings and begin contributing to SiD

Rich Partridge
**SiD@SLAC: People**

<table>
<thead>
<tr>
<th>SiD Department</th>
<th>Marty Breidenbach</th>
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<tr>
<td></td>
<td>John Jaros</td>
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<td>SiD Sim/Recon</td>
<td>Norman Graf</td>
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<td>Ron Cassell</td>
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<td>Tony Johnson</td>
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<td>Jeremy McCormick</td>
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<td>SiD Tracking</td>
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<td>Rich Partridge</td>
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<td>SiD MDI/Polarization</td>
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<td>Takashi Maruyama</td>
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<td>SiD Benchmarking</td>
<td>Tim Barklow</td>
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<td>SiD Vertex Detector</td>
<td>Su Dong</td>
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SLAC USERS@SiD

U Colorado  S. Wagner
           U. Nauenberg
UC Davis    M. Tripathi
           R. Lander
U Iowa      M. Charles
           U. Mallik
Mississippi L. Cremaldi
           J. Reidy
           H. Zhao
MIT         R. Cowan
           P. Fisher
           D. Yamamoto
U Oregon    J. Brau
           R. Frey
           N. Sinev
           D. Strom
           J. Strube
UCSC        B. Schumm
Wisconsin   H. Band

Plus Growing International Participation:
          Annecy
          KEK
          Tokyo
          RAL
          Oxford
          IHEP Beijing
The Silicon Detector Design Study is developing the SiD Detector Concept for the ILC into a detailed, optimized, and fully integrated detector design. The SiD concept incorporates Si/W electromagnetic calorimetry and all-Si tracking in a detector design which attempts to optimize physics performance, constrain costs, and be robust against physics and machine backgrounds.

### Organizational Chart

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<tr>
<td><strong>SiD Workshop at Fermilab</strong></td>
<td>April 9-11, 2007</td>
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<td><strong>LCWS07 at DESY</strong></td>
<td>May 30-June 3, 2007</td>
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<th>Recent Meetings:</th>
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<tr>
<td><strong>Fermilab Test Beam Workshop</strong></td>
<td>Jan 17-19, 2007</td>
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<td><strong>ACFA Beijing Meeting</strong></td>
<td>Feb 4-7, 2007</td>
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<td><strong>SiD Detector versions simulated</strong></td>
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<td><strong>Weekly Meetings via Teleconference</strong></td>
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<td><strong>SiD Tracking Meetings</strong></td>
<td>10/04 - 4/05</td>
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<td><strong>SiD Calorimeter Meetings</strong></td>
<td>before 9/28</td>
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