

Physics and Detectors for the International Linear Collider - Charge to the 2007 Linear Collider Workshop (LCWS07)

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As the 2007 Linear Collider Workshop met at DESY, significant milestones had been achieved. The ILC Reference Design Report has been completed, the detector R&D is progressing, a detector roadmap is being defined, a Research Director is being appointed, and a call for Letters of Intent for ILC detectors to be engineered is being announced.

1 Introduction

We meet this year at DESY for the tenth workshop in the series that dates back to 1991. I remind you the previous workshops have been

1. Saariselka, Finland, 1991
2. Hawaii, USA, 1993
3. Morioka, Japan, 1995
4. Sitges, Spain, 1999
5. Fermilab, USA, 2000
6. Jeju Island, Korea, 2002
7. Paris, France, 2004
8. Stanford, USA, 2005
9. Bangalore, India, 2006

and now

10. DESY, Germany - May 30 - June 3, 2007

A compelling physics case has been established for the International Linear Collider, in part through the preparation and discussions of these workshops. The LHC will soon open Terascale physics. What is found in that initial exploration promises to reveal deep understanding of fundamental physics. The nature of Electroweak Symmetry Breaking should be more clear. We may even learn of new symmetries of space and time, hidden extra dimensions, or dark matter particles. Whatever the discoveries, the ILC will be needed to explore and elucidate the nature of the Terascale. In particular, the precision exploration that the ILC offers will further the understanding of Terascale physics.

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The World Wide Study for Physics and Detectors at Future electron-positron Colliders (WWS) was formed in 1998 at the Vancouver International Conference on High Energy Physics, and has organized this series of workshops ever since. The founding co-chairs were Charles Baltay (Yale), Sachio Komamiya (Tokyo), and David Miller (Univ. College London). The World Wide Study was recognized early by the International Committee on Future Accelerators (ICFA), and in 2004 its responsibility to organize and coordinate international activities on linear collider physics and detector studies was endorsed by ICFA and the International Linear Collider Steering Committee (ILCSC).

Specifically, the World Wide Study carries forward the following functions:

World Wide Study Functions

- Recognizes and coordinates studies on whole detector concepts, and works toward interregional detector engineering design reports;
- Interacts with the Global Design Effort (GDE), especially on machine detector interface (MDI) issues;
- Maintains a register of R&D relevant to the ILC experimental program, identifying those that are vital or missing, and ensuring peer review of R&D proposals;
- Organizes interregional meetings and workshops; and
- Reports to the ILCSC and ICFA on the matters above.

The efforts of the WWS are led by an organizing committee, consisting of 6 members from each of the three regions. These members are

Asia

Atul Gurtu, Tata Institute (India)
Yee Bob Hsiung, National Taiwan University (Taiwan)
Wei Guo Li, IHEP Beijing (China)
Akiya Miyamoto, KEK (Japan)
Hwanbae Park, Kyungpook National University (Korea)
Hitoshi Yamamoto, Tohoku University (Japan) - co-chair

Europe

Tiziano Camporesi, CERN
Michael Danilov, ITEP (Russia)
Rolf Heuer, U. Hamburg /DESY (Germany)
David Miller, U. C. London (UK)
Francois Richard, LAL/Orsay (France) - co-chair
Ron Settles, Munich (Germany)
Jan Timmermans, NIKHEF (Netherlands)

Americas

Jim Brau, University of Oregon (USA) - co-chair
John Jaros, SLAC (USA)
Dean Karlen, Victoria (Canada)
Andreas Kronfeld, Fermilab (USA)
Mark Oreglia, University of Chicago (USA)
Ritchie Patterson, Cornell (USA)

The World Wide Study web page is <http://physics.uoregon.edu/~lc/wwstudy>

2 ILC Reference Design Report

This year we have achieved a significant milestone toward realization of the ILC. In February, the ILC Reference Design[6], with costs, was released during the ACFA Linear Collider Workshop in Beijing. Among the features of the design are two 11 kilometer superconducting linacs operating at 31.5 MV/m for 500 GeV, a centralized injector, circular damping rings for electrons and positrons, an undulator-based positron source, a single IR for two detectors in a push-pull arrangement with a 14 mrad crossing angle, and a dual tunnel configuration for safety and availability. The layout is illustrated in Figure 1

The decision to design for a single IR in the push-pull configuration for the two detectors resulted from the large cost savings. A task force lead by Andrei Seryei, and including membership from both the WWS and the GDE has studied the push-pull configuration and concluded that there are no show-stoppers. However, very serious and thorough design efforts are needed to prove feasibility. A “quick” switch-over is needed to allow moving each of the two detectors onto the beamline a few times a year. The configuration envisioned allows access to the detector which is out of the beam, with shielding of about one-half meter of concrete on five sides. A platform which moves with the detector for electronics and services of about 10m by 8m by 8m should provide the needed ease of movement. It also provides vibration isolation. The two IR option should remain as a studied alternative.

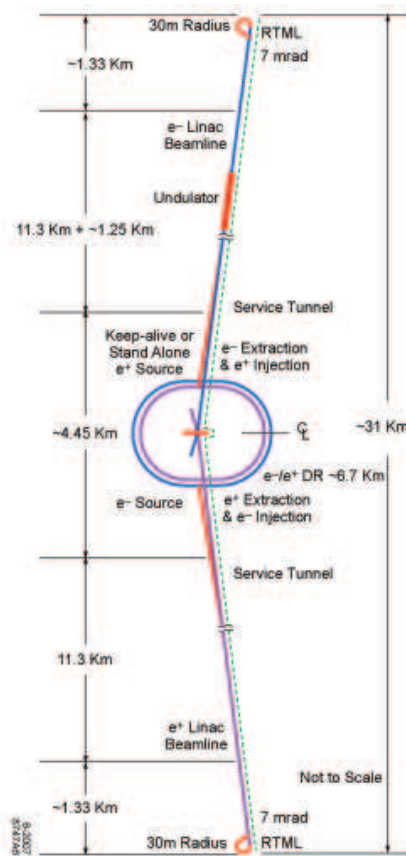


Figure 1: Layout of the ILC[6]

3 Detector R&D

Two years ago, beginning at the Snowmass ILC Workshop, an R&D Panel was created with the following charge:

WWS Detector R&D Panel Charge

- Surveys ILC detector R&D
- Maintains registry of ongoing ILC detector R&D
- Critically reviews the status of ILC detector R&D
- Registers the regional review processes

- Organizes global reviews of ILC detector R&D

The panel appointed by the WWS-OC in 2005 consists of three members from each region:

Asia: Tohru Takeshita, HonJoo Kim, Yasuhiro Sugimoto,

Europe: Chris Damerell (chair), Jean-Claude Brient, Wolfgang Lohmann,

Americas: Dean Karlen, Harry Weerts, Ray Frey.

Dean Karlen replaced Dan Peterson following the initial surveys, for which Dan devoted enormous effort in creating the web based registry.

The detector R&D program is motivated by the demanding detector performance requirements of ILC physics program. Advances beyond the state-of-the-art in detector technology are required. These include:

Detector R&D Goals

- Development of calorimeters with of the order of 100 million cells to achieve particle flow reconstruction of jets;
- Development of pixel vertex detectors with a billion pixels, sensitive to the full one millisecond bunchtrain of the ILC, without being overwhelmed by background hits, and achieving a better than four micron point resolution and an impact resolution of

$$5\mu\text{m} \oplus 10\mu\text{m}/p \sin^{3/2}\theta ;$$

- Tracking resolution, based on either a TPC tracker augmented by silicon, or a purely silicon tracker, of

$$\sigma(1/p) \leq 5 \times 10^{-5} \text{GeV}^{-1} ;$$

- Development of high field solenoids of up to 5 Tesla field strength;
- Development of high quality forward tracking; and
- Development of triggerless readout.

These, and other requirements, will only be achieved with a strong R&D program. The discovery potential of the ILC is great, but it is limited by the detectors. The cross sections are small, and excellent discrimination between signals and backgrounds will yield scientific payoff.

This year the WWS initiated a series of R&D reviews, organized by the WWS R&D Panel. The first review was held during the February ACFA Linear Collider Workshop in Beijing. Tracking was reviewed. A committee of nineteen, including eight external reviews, conducted the review. The report for this review is posted on the WWS web page[2] and the ILC wiki. Calorimetry is being review during this workshop, and vertex detection will be reviewed in October during the ALCPG Workshop at Fermilab.[3] A fourth in this trial series of reviews will be held in Sendai (Tohoku University) during the ACFA Linear Collider Workshop (TILC08) in March, 2008.

	Tracker Tech.	Calorimeter Tech.	Solen'd Field (Tesla)	Solen'd Radius, Length (m)	Vertex Radius (mm)	ECAL Barrel Radius, Half- Length (m)	Overall Radius, Half- Length (m)
GLD	TPC	SiW ECal Pb/Scin Hcal	3	4 9.5	20	2.1 2.8	7.65 8.0
LDC	TPC	Scin/W ECal Dig. or Anlg. HCal	4	3 6.6	15.5	1.58 2.3	5.98 5.60
SiD	Silicon	SiW ECal Dig. HCal (RPC, .)	5	2.5 5.5	14	1.27 1.27	6.45 5.89
4 th	TPC	Crystal EM dual-fiber Hcal	3.5	3 8	15	1.5 1.8	5.5 5.5

Table 1: Some key parameters of the four detector concepts.

4 ILC Detector Concepts

Progress in the development of the four[4] detector concepts has been good over the past year. Each concept (GLD, LDC, SiD, and 4th) published a Detector Outline Document in the Spring of 2007.[5] Some features of these three detectors are summarized in Table 1.

The WWS wrote a Physics Report and a Detector Concepts Report, which have been published along with the release of the Reference Design Report for the ILC accelerator.

The editors were:

Physics: A. Djouadi, J. Lykken, K. Moenig, Y. Okada, M. Oreglia, and S. Yamashita.

Detectors: J. Jaros, A. Miyamoto, T. Behnke, and C. Damerell.

A formal review has been conducted by a review team composed of K. Abe, J. Bagger, T. Camporesi, D. Marlow, T. Matsuda, J. Timmermans, R. Tschirhart, S. Y. Choi, and P. Zerwas. The detector cost estimates were reviewed by J.E. Augustin, P. Garbincius, and S. Yamada.

The community owes a great deal to the excellent efforts of the editors, and of the reviewers. The four volume set of documents (1. Executive Summary, 2. Physics, 3. Detectors, and 4. Accelerator) was published in August, 2007.[6]

5 Detector Roadmap

The Detector effort must keep pace with progress on the accelerator. Synchronization of the timelines is called for. With this in mind, the ILCSC and ICFA sent a message to the WWS co-chairs on February 28, 2007 asking the WWS to prepare a roadmap plan. Specifically, that message says:

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.

Responding to this request, the WWS co-chairs initiated a series of discussion via telephone with a *Roadmap Panel* consisting of two representatives from each of the four concepts, the WWS R&D Panel chair, and the WWS co-chairs. This request was also discussed by the WWS Organizing Committee. A web page was created to collect community comments, and a session was organized during LCWS08 to discuss the “roadmap.”

The outcome of this discussion was to propose to the ILCSC that a Research Director, reporting to the ILCSC, be appointed to guide the enhanced effort by the community, and to serve as a single point of contact with the GDE management. It was also recommended that a call for Letters of Intent go out soon, for groups to present in about one year “proposals” to conduct engineering designs for detectors by 2010, and that two groups be recognized by the end of 2008 to carry through these engineering designs. It was recommended that an International Detector Advisory Group (IDAG) be formed to assist the Research Director in defining the process for the LOIs, and the review and recognition process. These recommendations were favorably received during LCWS08 by the ILCSC, and a search committee for the Research Director was created. Subsequently Sakue Yamada was nominated, and accepted an appointment by the ILCSC to serve as Research Director through the completion of the detector engineering design phase. At the time this is being written (October, 2007) a call for LOIs has been released to the community by ILCSC chair Shin-ichi Kurokawa, and the membership of the IDAG is being considered.

6 Conclusion

Significant progress continues on ILC physics and detector studies. By the time of LCWS08 in North America the Letters of Intent will have been submitted, and the process of beginning the detector engineering work will be underway. Much work is needed in the coming year to reach that important milestone. Judging from the pace of efforts over the past year, we will do well.

7 Acknowledgments

The World Wide Study is grateful to DESY for hosting the very well run LCWS07, and particularly to Ties Behnke, who coordinated all of our requests, and the many unseen aspects of such a large meeting.

References

- [1] Slides:
<http://ilcagenda.linearcollider.org/contributionDisplay.py?contribId=6&sessionId=1&confId=1296>
- [2] <http://physics.uoregon.edu/~lc/wwstudy/detrdrev.html>
- [3] Reports of the R&D Panel Reviews were given at LCWS07 by C. Damerell and W. Lohmann.

- [4] GLD and LDC announced in the fall of 2007 that they are merging efforts, and call their new detector ILD.
- [5] <http://physics.uoregon.edu/~lc/wwstudy/concepts/>
- [6] Reference Design Report <http://linearcollider.org>