The ILD Detector Concept and the LoI Process

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SILC Collaboration Meeting
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ILC is precision experiment -> consequences for the detector

Focus on individual particles, focus on detailed reconstruction of particles

The Goal

™ M. Thomson, Cambridge
Events at the ILC:

- multi jet final states
- leptons, often in jets
- forward going physics
Jet energy resolution is the (one) key to success at the ILC detector

The “ultimate” in precision requirements:

Measurement of the Higgs Self Coupling

- Multi Jets in the final state
- Need excellent jet-energy resolution to get decent measurement
Physics itself is the main background

Though there are some challenges from Beamstrahlung
- Vertex detector occupancy
- Very forward direction

Significant work done, seem to be manageable

Number of background induced hits in VTX vs. radius
Detector Requirements

- Excellent vertexing as close as possible to the IP
- Robust, three dimensional tracking high efficiency, do not forget the low energy tracks
- Powerful calorimeter good photon identification
- Hermeticity

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Excellent vertexing as close as possible to the IP
Robust, three dimensional tracking high efficiency, do not forget the low energy tracks
Powerful calorimeter good photon identification
Hermeticity
**Requirements: Tracking**

**Vertexing:** excellent vertexing capabilities, thin!

- Key issues:
  - measure impact parameter for each track
  - space point resolution < 5 µm
  - smallest possible inner radius $r_i \approx 15$ mm
  - transparency: $\approx 0.1\% X_0$ per layer

\[ = 100 \, \mu m \text{ of silicon for 5 layers} \]

- stand alone tracking capability
- full coverage $|\cos \Theta| < 0.98$
- modest power consumption < 100 W

**Tracking:** High Precision, high efficiency, robust tracking

Comparison of TPC (left) and SI based hit pattern at the ILC

Goal:

\[ \frac{p}{\bar{p}} = 5 \times 10^{-5} \]
Higgs recoil mass measurement:

- clear case for excellent momentum resolution (...?)
- CMS Energy has much stronger effect

Tracker Benchmarks

Be aware of single benchmarks - have to look at the complete system!
The real challenge:

design an integrated system, which is powerful and thin at the same time!

Proposed layout of the LDC central tracking system

Special Focus on:

Robustness/Redundancy

Excellent precision
Pixel detector:

- Low occupancy needed
- Challenge in the ILC environment

Many different technologies under discussion
A TPC Tracker for ILD

- Many space points
- True 3D points
- Excellent Pattern Recognition
- Large volume coverage

Proposed solution:
- Based on micro-pattern (MP) gas detectors
- GEM/micromegas
- Mechanically potentially simpler
- Less material
- Less systematic effects (potentially)
- Not yet proven in large scale projects
Silicon Based Tracking

Addition to the TPC based tracking:

- SI strip detectors to complement the TPC
- A few high precision points replace inside (and outside)

Possible Layout of the SI tracker module

- Improved momentum resolution
- Impact on material budget needs to be studied
Tracking behind the TPC is an issue:
- Needed?
- How good?
- Where?
- Impact on calorimetry?
- Technology

Potentially very powerful forward tracking system but careful evaluation of performance is missing.
A ZHH event at the ILC

Track reconstruction is only part of the story

ZHH-\rightarrow qqbbbbb event at 500 GeV

many jets (6)

lots of tracks

but still much cleaner than any hadron collider can dream of

ZHH \rightarrow qqbbbbb
Excellent jet reconstruction needed

SiD
- Individual particles
- Particle identification
- “Calculation” of total jet energy/mass

LDC
- Individual jets
- Hardware compensation
- “Measurement” of total jet energy

GLD

4th

ILD is very much concentrated on particle flow!

Event Reconstruction
What is Particle Flow

For LC energies: tracker is most precise
Utilize the precise tracker as much as possible

5 GeV electron: 0.002 GeV
photon: 0.2 GeV
neutron: 1.1 GeV

Resolution tracker - Calorimeter

E(GeV) vs \sigma(E)/E

120 GeV
370 GeV

ECAL
HCAL
tracker
What do we want?

Traditional ILC goal: 30%/\sqrt{E}

Derived from physics studies, but needs to be interpreted with care

Clearly a too simplistic view:
- Constant term becomes dominant at high energies
- Simple scaling produces unrealistic resolutions

More realistic goal:
30%/\sqrt{E} (\sqrt{GeV}) + C(\%) \text{ with } C=2-4\%
The ideal PFLOW calorimeter

- Extremely dense (small Moliere Radius)
- Extremely granular (particle separation)

Traditional energy resolution is important but not so critically

containment

Granularity and longitudinal sampling

As deep as possible

Granularity: “tracking”

HCAL becomes very important for ultimate precision
W is absorber material
SI detectors as active medium
30 layers, 24 $X_0$ (20 cm), 1x1 cm$^2$ cells
Alveolar structure, carbon wrapped W
9720 channels – in an (18 cm)$^3$ cube
HCAL Options

- **Scintillators**
  - Trade amplitude resolution against granularity: analogue or semi-digital readout
  - Goal: Detector architecture with embedded sensors and electronics

- **Gaseous: Glass RPC or GEM foils**
  - Natural choice for finest granularity
  - Digital readout for 50 million channels?
Major effort to test
- Technologies
- Shower physics

Combined ECAL/ HCAL/ Tailcatcher test beam at CERN (2006/7) FNAL (2007/8)

2 track event recorded at the CERN test beam with reconstruction run on the data
Results

Measured energy resolution in the ECAL
Not fully corrected data

Energy resolution HCAL with partial instrumentation
(½ number of layers)

Lots of data accumulated, analyses are very preliminary
Expect many new and interesting results in the near future
The latest LDC

LDC starting point for the ILD design

but

ILD will look different in a few months time

Weight ~7700t
VTX detector can be serviced
Hall Cross Section

40-t crane has to cover Pacman,

Pacman can sit and slide on the floor

On the beam
Detector Platform for Push Pull?

- Detector itself should be rigid
- Platform is major “beast”
- Needs to carry the QDO support and the service cryostat!
  ➔ 20m wide

Charming!
- disentangles transverse and longitudinal movement
- Good solution for cables and supply lines
- But: is it really needed?

N. Meyners, DESY
GLD $\oplus$ LDC = ILD
The roadmap for detectors at the ILC;

2007 2008 2010

Call for letters of intent

Letters of intent collect groups willing to contribute to a EDR for the concept

Prepare an engineering design report (light) in step with the collider

A complete concept some engineering support of the concept a reliable costing demonstration: we can start if we may
Towards the LOI

At LCWS2007: LDC and GLD decided to join forces to write a common LOI

- Detectors are similar
- Intense collaboration on R&D level exists already at all levels
- Resources needed to write yet another report (LOI) and to do serious engineering are rather limited

In our understanding:
- The LOI is rather heavy on performance evaluation
- We want to understand the optimum for an GLD/LDC like detector
- We are convinced we can go much further if we collaborate than if we start a competition
LDC has been a European dominated effort so far

with ILD this will change (but here I restrict myself mostly to LDC)

Who does what in LDC
ILD Organisation

Joint Steering Group

Yasuhiro Sugimoto
Hitoshi Yamamoto

Ties Behnke
Henri Videau

Graham Wilson
Dean Karlen

Working groups:

optimization
Mark Thomson
Tamaki Yosioka

MDI/ integration
Karsten Buesser
Toshiaki Tauchi

costing
Akira Maki
Henri Videau

Soon to be established: contacts to the different R&D collaborations
Where is the conventional structure (sub-detector groups, etc???)

- ILD working groups
  - Vertex detector R&D
  - LC-TPC
  - CALICE
  - FCAL
  - others?

Will soon need to identify names of people who are the liason

This is enough for the moment, need to revisit after the LOI
ILD Plans

... are still evolving, but

1) working groups are on track:
   regular phone/video meetings
   special emphasis at the moment is put on the optimization group

2) based results from the optimization group, work out an “optimal” set
   of parameters for ILD, which are not just (LDC+GLD)/2

3) Spring 2008: form sub-system groups, charged with preparing the
   relevant parts of the LOI

4) submit LOI summer/ fall 2008
14-16 January 2008 at DESY Zeuthen
ILD is the new kid around the block

though it is based on “old” and very experienced parents

ILD is very open and democratic, and lightweight in organization

ILD will try to do a real optimization – we want to be a heavyweight in results

ILD will try to make the case for a “large” detector at the ILC with redundant precision tracking and an emphasis on particle flow

ILD offers many exciting and challenging areas where people can contribute even with limited resources

ILD has many of the tools needed to make contributions (see talk by Frank)

ILD has a WEB page: http://www.ilcild.org