ILD Concept

Ties Behnke, DESY, for the ILD concept group
http://www.ilcild.org

Letter of intent (2009)

Evaluation
Readiness
Flexibility

Detailed Baseline Document (DBD) 2012

Solid and reliable design
Detector Layout

- Multi-purpose detector
- Precision tracking
  - High efficiency, high precision
- Precision calorimetry granularity
- Precision muon system
- Hermetic
ILD concept

Detector optimized for particle flow:
- Robust tracking (TPC + SI), optimized for efficiency and solid angle coverage
- Fine-grained calorimetry, optimized for topological reconstruction

Detector optimized for precision:
- Excellent vertexing, close to IP
- Excellent tracking resolution
- Full solid angle coverage

Strong basis in Europe and Asia, less so in US
LOI: some 600 authors from 130 Institutes
Subdetector R&D in ILD: heavily depend on the R&D collaborations

CALICE/ LC-TPC/ FCAL/ SILC/ …

R&D collaborations have the resources and manpower
- no explicit support for concept work in many areas
- many third party funds go to R&D collaborations (EUDET, AIDA in Europe)
- many synergies with other projects are more apparent/ easier in R&D then in concepts
- optimize resource sharing among concepts

ILD does not (always) control the planning: planning becomes more difficult
Goals of ILD until 2012

- Define a detector with options, which are considered “ready” by the R&D groups and ILD
- Include list of alternatives which are less advanced, but are promising candidates
- Improve based on real engineering the integration of the detector and its overall realism
- Improve the integration of the detector into the machine context
- Improve our understanding of costing of these detectors
ILD baseline

Subdetector Systems

Options within the baseline

Alternatives

14.5.2010 PAC meeting Valencia
ILD: simulation baseline

To be used for a large scale production of physics events!

Subdetector Systems

Options within the baseline

Alternatives

14.5.2010 PAC meeting Valencia
ILD base lines

- **Simulation base line SBL**
  - a unique set of sub-detectors with reality
  - includes detailed detector model
  - will be defined in 2010/ early 2011

- **Detector base line DBL**
  - realistic technical solutions for sub-detectors
  - discuss with R&D group
  - will have a readiness review in early 2012
ILD: simulation

Fairly complete and performant software system is in place

Data model and persistency framework: LCIO

Have produced a few 100 Mio Events for Letter of Intent physics and optimization studies
ILD Simulation baseline

- Major work needed to improve software
  - tracking code
  - ghost hits in tracker
  - background overlay (forward)
  - details in sub-detector cables, services, material, cracks,
  - calorimeter difference
- to evaluate physics performance

Improve level of realism
Main Milestones

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- **Milestone Finalise procedure**: 14.5.2010
- **Milestone Define Simulation detector**: PAC meeting Valencia
- **Milestone Define hardware based detector**: 11
Main Milestones

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R&D

- Hardware reviews
- Detector integration
- Detector optimization
- Simulation Software
- Reconstruction Software
- Large Scale Production 1
- Reconstruction Software
- Large Scale Production 2
- Review Options
- Review Alternatives
- Define Detector
- Write DBD

Milestone:
Simulation/ Integration workshop July 6-8, 2010 in DESY Hamburg

Physics analyses

Milestone: Define Simulation detector

Milestone: Define hardware based detector

14.5.2010 Finalise procedure
Subdetector Technologies

A global trend: larger and larger segmentation

LHC/ sLHC: deal with large occupations and backgrounds

ILC:

need extreme precision
deal with backgrounds (Vertex Detector)
do “tracking with a calorimeter”

Driven by technology: price ~ area, not # of channels

ILD examples of proposed granularity:

- Silicon Tungsten Calorimeter  $9 \times 10^7$ cells (5x5 mm$^2$)
- Vertex Detector  $9 \times 10^9$ pixels (20x20 μm$^2$)

Without the technology the physics will suffer
Vertexing

Pixel detector:

Many different technologies under discussion
Resolution - dead area - material - speed
CCD - MAPS - FPCCD - ISIS - others

5/6 pixel layers, as small inner radius as possible, low material

Low mass structure
readout speed

R&D:
Development of low mass ladder prototype (→ 2012)
Material in the Tracker

Low material tracker is key goal of R&D in the next few years

Goal: very light tracking system:

- total material before calorimeter < 10% X0 in the barrel
- <30% (or less) in the endcap

including all services, all support structures, cables, etc.

Realistic (but optimistic) estimates make this believable...
PLUME
Pixelated Ladder with Ultra-low Material Embedding

Geometry for an ILD vertex detector, 2009-2012

Objectives:
- achieve a doublesided ladder prototype for an ILD vertex detector by 2012 (DBD)
- material budget: $< 0.3\% X_0$ (final goal for 2012 prototype)
- quantify power pulsing and air-flow cooling effects on final sensor spatial resolution
- evaluate benefits of double-sided concept (mini-vectors)

Baseline:
- MIMOSA-26 CMOS sensor (developed for EUDET-Telescope)
- Power pulsing (< 200ms period, ~1/50 duty cycle) and power dissipation (100mW/cm²)
- Air cooling

Current concept:
- 6 x MIMOSA-26 thinned down to 50μm
- Kapton-metal flex cable
- Silicon carbide foam (8% density) stiffener, 2mm thickness
- Wire bonding for flex - outer world connection
- Digital readout

PLUME collaboration:
- Bristol University
- Oxford University
- DESY (Hamburg)
- IPHC (Strasbourg)

14.5.2010
PLUME status

**Goal:** develop technology for ultra-thin VTX detectors

- 2 x MIMOSA-20 analog sensors, thinned down to 50 um with 1 x 4 cm$^2$ sensitive area
- Material budget ~ 0.6 % X0 (SiC foam 0.18%, sensors 0.11%, glue 0.2%, flex 0.29 %)
- Tested @ SPS-CERN
- Preliminary mini-vector study
- Study binary chip (Mimosa26 design)
- Power pulsing studies

From November 2009 beam test data
**PLUME status**

**Goal:** develop technology for ultra-thin VTX detectors

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The recently approved AIDA project will contribute key infrastructure (a la EUDET telescope) to this research
TPC

Design (goal) of ILD TPC

- Micro patter gas detector (MPGD) as the TPC endcap detector
- \(0.4m < R < 1.8m, |Z|=2.15m\)
- \(\sigma_{\text{point}}(r\Phi)<100\mu m\)
- \(\sigma_{\text{point}}(z)\sim0.5mm\)
- Two-hit resolution \(\sim 2mm(r\Phi), 6mm(z)\)
- Material budget \(\sim 4\%X_0\, (r), 15\%X_0\, \text{(endplate)}\)
- Momentum resolution:
  - \(\delta(1/p_t)\sim9E^{-5}/\text{GeV/c} \, \text{(TPC only)}\)
  - \(\delta(1/p_t)\sim2E^{-5}/\text{GeV/c} \, \text{(all trackers)}\)
Large area Silicon trackers

Total area: 180 m²
Total Channels Nb: $10^7$
Based on a unique Si sensor size
(except very forward disks FTD)

Large area Silicon based tracking
- inside the TPC (SIT)
- outside the TPC (external Si tracker)
- forward Silicon disks

B=3.5 T
Silicon tracker status

- disk (very forward) & barrel/endcap
- silicon strip sensor: 6’ to 8’
- alignment
  - improve laser trans. 20 to 70%
  - new method ready
- edgeless sensor dev.
- FE and RO electronics
- direct connection
- DAQ
- Beam Test processing, synchronization,
ILD: Calorimetry is done by the CALICE collaboration:
A number of different options are pursued.
Most CALICE options are also in ILD.
PFLOW ECAL

Sampling calorimeter, Tungsten - Silicon diode readout
Typical granularity for ECAL: 0.5cm x 0.5cm to 1cm x 1cm,

- 30 layers, 24 $X_0$

CALICE prototype

Normal analogue ECAL segmentation:

Allows “tracking” in the calorimeter

Very detailed shower images
Typical granularity for ECAL: 0.5cm x 0.5cm to 1cm x 1cm, SI detectors, Tungsten absorbers

- 30 layers, 24 $X_0$

Extreme segmentation: MAPS sensors in the ECAL

Allows “tracking” in the calorimeter

Even more detailed shower images
HCAL plays crucial role in a particle flow calorimeter

Simulation of hadronic shower is problematic

Typical cell sizes 3x3 cm² with analogue readout

Digital option investigated (smaller cells, 1bit readout)

Major effort (CALICE) to prototype such a calorimeter for the ILC
An Interface example:

Transition region barrel endcap:

- Distance barrel – endcap?
- How much material?
- Services from other detector?
  - TPC cables and services
  - TPC support
  - ETD services
  - Forward tracking?
  - Others?

Many interfaces between detectors are ill defined:
- Geometrically
- Functionally
An Interface example:

Transition region barrel endcap:

- Distance barrel – endcap?
- How much material?
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  - Others?

Many interfaces between detectors are ill defined:
- Geometrically
- Functionally

Have setup a small WH to address these issues and bring together integration – physics - technology
Performance

Measured energy resolution without (black) with (red) reweighting

Simulated jet-energy resolution for different energies:
Goal of 30%/√E reached for E(jet)<100 GeV

Proposed detector seems to deliver promised performance
# Sub-detector schedule

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*Note: not all activities are already funded, schedule is funding driven*
Push-Pull

The ILD detector

As proposed inside the hall in push-pull configuration

- Understand implications of push pull on detector design
- Agree with SiD on a common push-pull design
- Coordinate detector activities with the GDE activities
- Add some real engineering
Push-Pull

The ILD detector

As proposed inside the hall in push-pull configuration

- Understand implications of push pull on detector design
- Agree with SiD on a common push-pull design
- Coordinate detector activities with the GDE activities
- Add some real engineering

Push pull might have a major impact on the detector design!
Conclusion

ILD has proposed a plan how to advance the detector design towards the DBD

DBD will include

- detector options (have passed readiness review)
- detector alternatives (hold promise, have not advanced enough)

ILD community is still active
R&D on components is done intensely (R&D collaborations)
Funding issues become increasingly important

Increasingly we see synergies between ILC developments and other experiments.