ILC Technical Design Report

Physics and Detectors – *Detailed Baseline Design*

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Outline and Organization of the Document

- General Introduction to the DBD report (*3 pages*)
- The physics and detector challenges of the ILC (*31 pages*)
- Description of common tasks and common issues (*55 pages*)

  Next talks by: W. Lohrmann, K. Buesser, C. Clerc, A. Miyamoto
- The Silicon Detector, SiD (*195 pages*)

  Next talks by: A. White, T. Barklow, M. Stanitzki
- The International Large Detector, ILD (*206 pages*)

  Next talk by: Y. Sugimoto
- Summary and future plans (*4 pages*)

Outline and Organization of the Document

Introduction to the Detailed Baseline Design report

- Description and layout of the document
- General presentation of each chapter and short discussions on main isues

1. The physics and detector challenges of the ILC

1.1 Physics goals of the International Linear Collider (M. Peskin, being revised)

- 1.1.1 What is missing from the Standard Model ?
- 1.1.2 Study of the Higgs Boson
- 1.1.3 Beyond the Higgs Boson
- 1.1.4 Virtues of the ILC collider experiments

1.2 Detector challenges and performance requirements (J. Brau)

- 1.2.1 Machine backgrounds
- 1.2.2 Beam Instrumentation
- 1.2.3 Two detectors

1.3 Physics benchmarks studies (J. Brau)

- 1.3.1 Definition of the first set of benchmark processes (250, 500 GeV) for the LOI
- 1.3.2 Definition of the second set of benchmark processes (1 TeV) for the DBD

1.4 The physics and detector study of the International Linear Collider (S. Yamada)

- 1.4.1 Call for LOIs
- 1.4.2 The management formation
- 1.4.3 Organization of detector activity
- 1.4.4 The LOIs and their validation
- 1.4.5 Works for the detailed baseline designs
- 1.4.6 Common Task Groups
- 1.4.7 Other working groups

2. Description of Common Tasks and common issues

2.1 ILC Detector Research and Development (M. Demarteau, W. Lohrmann)

- 2.1.1 ILC Physics, Detector and Machine
- 2.1.2 Vertex Detector Technologies
- 2.1.3 Tracking Detector
- 2.1.4 Calorimetry
- 2.1.5 Forward Calorimetry
- 2.1.6 Beam Tests

2.2 Common simulation and software tools (A. Yamamoto, N. Graf, F. Gaede)

- 2.2.1 Common generator samples
- 2.2.2 Common simulation and reconstruction tools

2.3 Machine Detector Interface (K. Buesser)

- 2.3.1 The push-pull concept
- 2.3.2 Detector motion system
- 2.3.3 Shielding
- 2.3.4 Detector installation schemes and timelines
- 2.3.5 Experimental area layout
- 2.3.6 Detector services

2.4 Beam Instrumentation (J. List, E. Torrence)

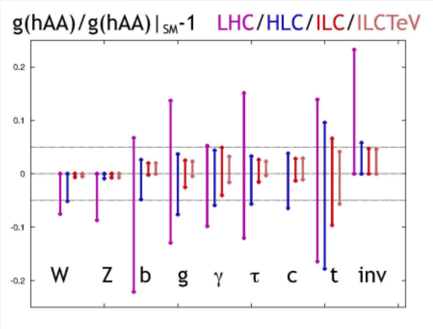
- 2.4.1 Beam Energy Measurements
- 2.4.2 Polarization Measurements
- 2.4.3 Luminosity weighted averages and correlations

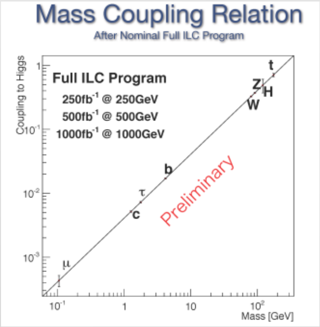
2.5 Common Engineering Tools (C. Clerc)

2.6 Detector Costing Methodology (S. Yamada)

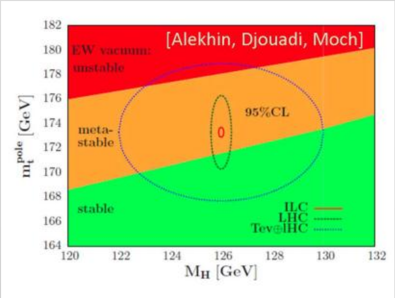
Physics at Linear Colliders from 0.25 TeV to 1.0 TeV

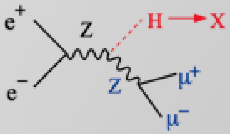
- **Physics case for the International Linear Collider:**
  - Higgs physics (SM and non-SM)
  - Top
  - SUSY
  - Higgs strong interactions
  - New Z' sector
  - Extra dimensions
  - ….

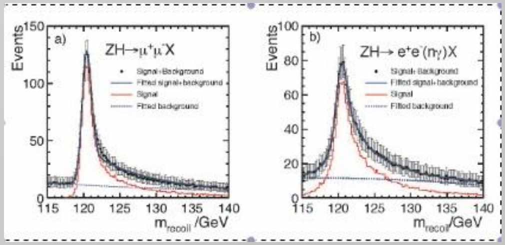


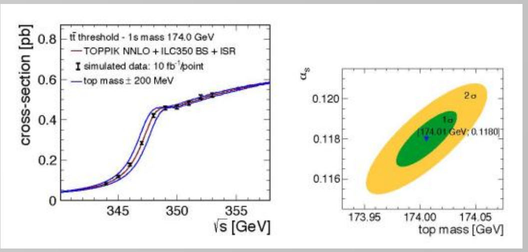


- **Main messages in this section (summary of physics volume)**
  - Rich physics program covering Higgs but not only !
  - Model independent measurements
  - Large number of possible final state topologies
  - The benefits of flexibility of the machine:
    - Energy staging
    - Polarization
  - Need for very performing detectors: vertex, tracking, calorimetry, PFA, etc..
  - Necessary to understand next step in particle physics









Physics at Linear Colliders from 0.1/0.25 TeV to 1.0 TeV

Flexibility ↓

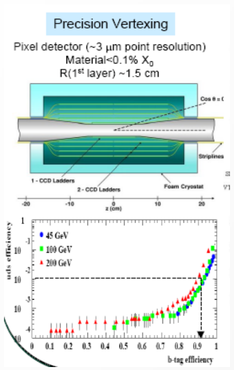
Complexity & Large number of final states ↓

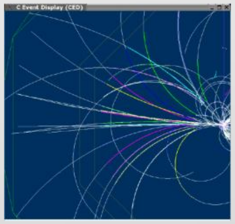
Rich physics program ↓

Flexibility ↓

Energy	eaction	ysics Goal	olarization
91 GeV	$e^+e^- \to Z$	ultra-precision electroweak	**A**
160 GeV	$e^+e^- \to WW$	ultra-precision W mass	**H**
250 GeV	$e^+e^- \to Zh$	precision Higgs couplings	**H**
350–400 GeV	$e^+e^- \to t\bar{t}$	top quark mass and couplings	**A**
	$e^+e^- \to WW$	precision W couplings	**H**
	$e^+e^- \to \nu\bar{\nu}h$	precision Higgs couplings	**L**
500 GeV	$e^+e^- \to f\bar{f}$	precision search for Z'	**A**
	$e^+e^- \to t\bar{t}h$	Higgs coupling to top	**H**
	$e^+e^- \to Zhh$	Higgs self-coupling	**H**
	$e^+e^- \to \tilde{\chi}\tilde{\chi}$	search for supersymmetry	**B**
	$e^+e^- \to AH, H^+H^-$	search for extended Higgs states	**B**
700–1000 GeV	$e^+e^- \to \nu\bar{\nu}hh$	Higgs self-coupling	**L**
	$e^+e^- \to \nu\bar{\nu}VV$	composite Higgs sector	**L**
	$e^+e^- \to \nu\bar{\nu}t\bar{t}$	composite Higgs and top	**L**
	$e^+e^- \to \tilde{t}\tilde{t}^*$	search for supersymmetry	**B**

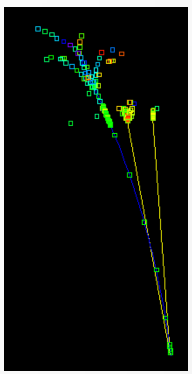
Challenges for ILC (0.25 TeV - 1.0 TeV) detectors





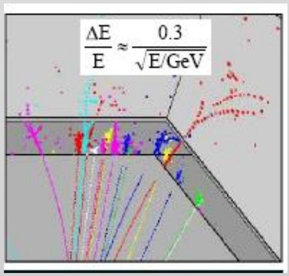
- Vertex, "flavour tag" (heavy quark and lepton identification)

  ~1/5 $r_{beampipe}$, ~1/30 pixel size (ILC wrt LHC),



$$(h \to b\bar{b}, c\bar{c}, \tau^+\tau^-)$$

$$\sigma_{ip} = 5\mu m \oplus 10\text{-}15\mu m / p\sin^{3/2}\theta$$

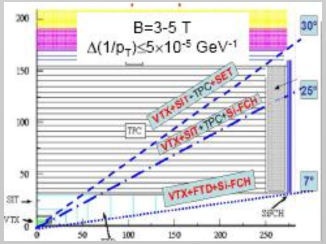


- Tracking, "recoil mass" $(e^+e^- \to Zh \to \ell^+\ell^- X)$

  ~1/6 material, ~1/7 resolution (ILC wrt LHC),

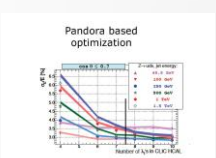
  B=3-5 T

$$\sigma(1/p) \leq 2 \times 10^{-5}\,\mathrm{GeV}^{-1}$$

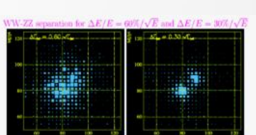


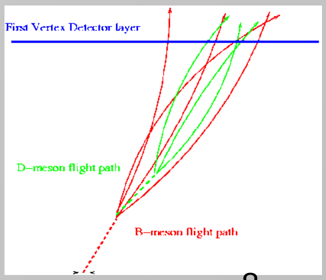
- Particle Flow, Jet Energy Rec. → Tracker+Calo.

  Di-jet mass Resolution, Event Reconstruction, Hermitcity, Detector coverage down to very low angle



$$\sigma_E / E = 0.3/\sqrt{E(\mathrm{GeV})}$$





Machine induced backgrounds

- e+e- pair background produced at the interaction region
- γ-background also produced in the interaction region
- Synchroton radiation
- Beam halo muons

Source	#particles per bunch	$< E >$ (GeV)
Disrupted primary beam	2×10^{10}	244
Bremstralung photons	2.5×10^{10}	244
e^+e^- pairs from beam-beam interactions	75K	2.5
Radiative Bhabhas	320K	195
$\gamma\gamma \to$ hadrons/muons	0.5 events/1.3 events	–

Benchmarks for ILC (0.25 TeV - 0.5 TeV) detectors

$e^+e^- \to Zh \to \ell^+\ell^- X$

M_h=120 GeV, E_{cm}= 0.25 TeV. Higgs mass and cross section.
Testing: momentum resolution, material budget, photon ID

$e^+e^- \to Zh \to n\bar{n}c\bar{c} / n\bar{n}m^+m^-$

M_h=120 GeV, E_{cm}= 0.25 TeV. Measure Higgs BR.
Testing: Vertex reconstruction, multi-jet final state, c-tagging, uds anti-tagging

$e^+e^- \to Zh \to q\bar{q}c\bar{c}$

M_h=120 GeV, E_{cm}= 0.25 TeV. Measure Higgs BR.
Testing: jet resolution, confusion uds-c

$e^+e^- \to t^+t^-$

E_{cm}= 0.5 TeV. Measure τ tagging, A_{fb}, Pτ.
Testing: t reconstruction, Part. Flow, π^0 reconstruction, track separation

$e^+e^- \to t\bar{t}; t \to bW^+; W^+ \to q\overline{q'}$

M_t=175 GeV, E_{cm}= 0.5 TeV. Measure cross section, $A_{fb,}$ M_t.
Testing: jet recosntruction, Part. Flow, b.tagging, lepton-tagging, trcking in hihg multiplicity environment

$e^+e^- \to X^+X^- / X_0^2 X_0^2$

M_t=175 GeV, E_{cm}= 0.5 TeV. Measure SUSY parameters, masses, etc.
Testing: Part. Flow, WW-ZZ separation, multi-jet final states

Benchmarks for ILC (1.0 TeV) detectors- scaling in Energy

$e^+e^- \rightarrow Zh \rightarrow n\bar{n}h$

M_h=125 GeV, E_{cm}= 1.0 TeV. All Higgs BRs.
Goal: Detector performance at 1 TeV to compare with lower energy

$e^+e^- \rightarrow W^+W^-$

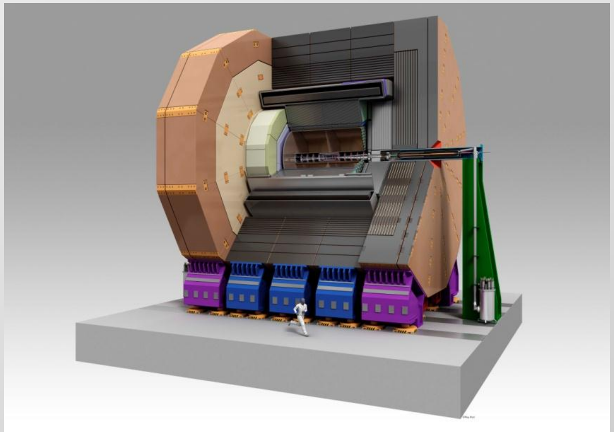
M_h=125 GeV, E_{cm}= 1.0 TeV. Measure leptonic and hadrinic W decays.
Testing: polariaztion measurements

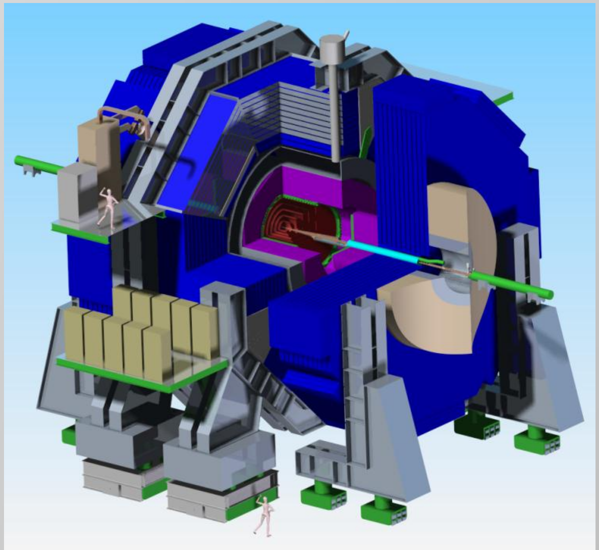
$e^+e^- \rightarrow t\bar{t}h$

M_h=125 GeV, E_{cm}= 1.0 TeV and Higgs decays to bbar. Measure top Yukawa.
Testing: Multi-jet finl state, 8 jets or 6 jets+ one lepton & missing energy

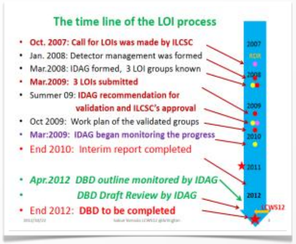
Validated ILC Detectors: SiD & ILD

Both, ILD and SiD, are 4π detectors with complementary designs	
Common Systems	Thin pixel vertex detectors Si-W Electromagnetic Calorimeter
ILD	TPC tracking aided with silicon detectors
	Scintillator-Steel hadron calorimeter
	Excellent tracking and calorimetry performance for best possible event reconstruction
SiD	Silicon tracking
	Gaseous (RPC) digital hadron calorimeter
	Fast tracking and calorimeter for robustness



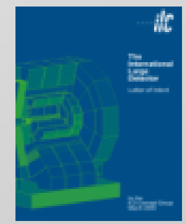


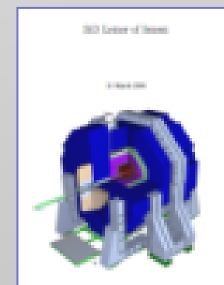
ILC Physics and Detector Roadmap & Organization

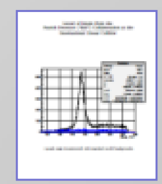


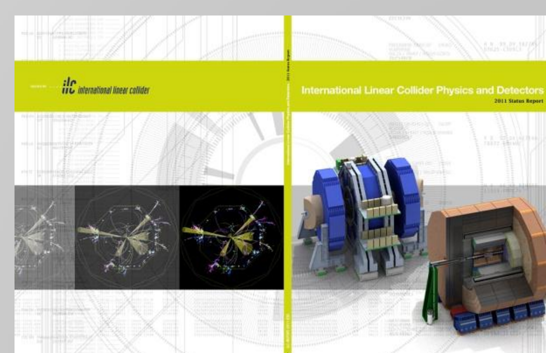
S. Yamada

Aug. 2007	Detector Concept Report, Four detector concepts: LDC, GLD, SiD, 4th
Oct. 2007	ILCSC calls for LOIs and appoints Research Director (RD)
Jan. 2008	RD forms detector management
Mar. 2008	IDAG formed, Three LOIs grous identified
Mar. 2009	Three LOIs submitted (detector description, status of R&D, GEANT4 simulation, benchmark process, costs..)
Mar. 2009	IDAG began monitoring the progress
Aug. 2009	IDAG recommends validation of two (2) and ILCSC approves
Oct. 2009	Work plan of the validated groups
End 2011	Interim Report being produced (http://www.linearcollider.org/about/Publications/interim-report)
End 2012	Detailed Baseline Design Report (ILD TDR Volume 3) Including physics case for the ILC









Are you sure ?

Carmen García, IFIC-Valencia