ILC DBD
Common simulation and software tools

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Introduction

- Software tools for ILC have been developed by ILD and SiD independently but with good communication

- For DBD studies,
  - IDAG has requested us to study benchmark processes based on common generator samples
    - ➔ Common generator samples
  - Some software tools

    Common work are desirable for saving resources and better tools
    - ➔ Common software tools

Common generator samples

- LOI era: by Whizard 1.40, generated at SLAC, shared by 4 concept groups through FTP
- Improvements for DBD
  - Whizard 1.95 with new features such as
    - full CKM matrix, complete τ polarization treatment, stores more information in generated files.
  - Physsim for tth & 8 f background processes
  - Sample generations at SLAC, DESY, KEK and common files are placed on ILC VO GRID.
  - Common format for generator meta info. (process ID, names, cross sections, file names, …) and kept on webs.
  - Beam-beam effects : based on sets of TDR parameters 1TeV_B1b_ws , 500GeV_TDR_ws (nominal Lumi.)

Whizard 1.95 generator

- Tree calculation of 2→n processes with multiple ISR γ's.
  Hadronization and decay of final n particles by Pythia. Tauola for τ.
- All (e^+e^-, $e^+\gamma$, γe^-, $\gamma\gamma$) → n processes (n=2~6 particles) and e^+e^- → $f\bar{f}h$
  $e^{\pm}$: Luminosity spectrum by GuineaPig
  γ : nearly real Weizsacker-Williams photons (Whizard) or
  beamstrahlung photons(GuineaPig).
- ISR: Whizard default (order 3 LLA., include Pt of remnants)
- FSR by Pythia : QED for μ and τ, QCD&QED for quarks.
  No QED FSR of e (∵ Can not give correct q^2 to Pythia.)
- Higgs : $f\bar{f}h$ process m_H=125GeV.
  h decays by Pythia with BRs given by a LHC WG.
  Other processes m_H=2TeV
- Amplitude with a gluon propagator in Whizard : OFF.
  ➔ Pythia simulate gluon splitting.
  ➔ No interferences between QCD and EW amplitude. ≤ 10% effect

Physsim generator for $t\bar{t}h$

- It was hard to generate processes with 8 fermions or more by Whizard, because too many CPU time and memory requirements due to many channels involved.
- Physsim calculates only a limited number of diagrams. Saves CPU time.

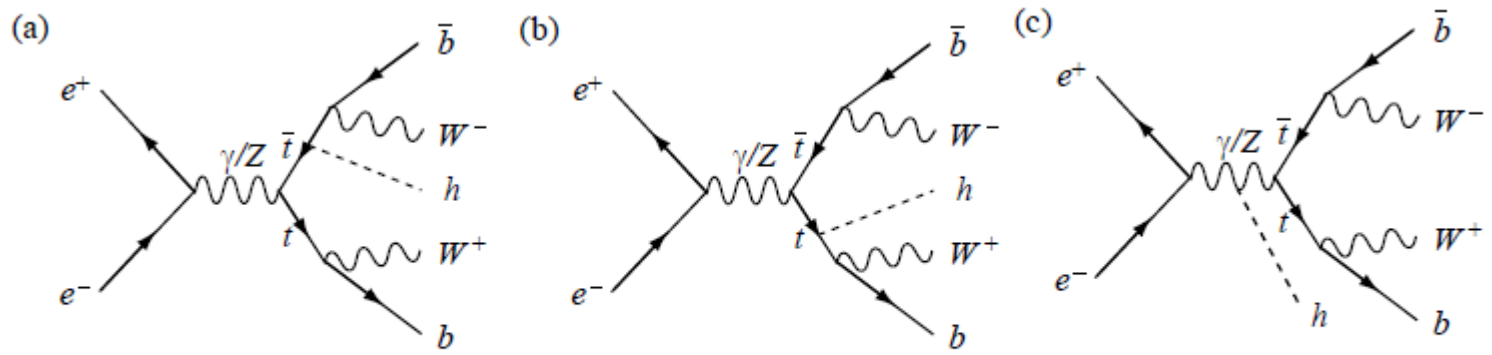


Figure 2.2.1: Feynman diagrams for the $e^+e^- \to t\bar{t}h$ process.

- Used for generating $e^+e^- \to t\bar{t}h$, $t\bar{t}Z\left(Z \to f\bar{f}\right), t\bar{t}g^*\left(g^* \to b\bar{b}\right)$
- $Z \to q\bar{q}$ and $g^* \to b\bar{b}$ in $t\bar{t}Z$ and $t\bar{t}g^*$ hadronize independently w. $t\bar{t}$
- $e^+(e^-)$ luminosity spectrum, ISR, hadronization/decay : same as Whizard samples.

Hadronization tuning

- Hadronization parameters for the LOI : Pythia default.
  LEP data suggest Pythia default parameters over-estimates neutral and long-lived hadrons
  - ➔ direct impact on jet energy resolution, because neutral hadron energy is the component measured with least precision.

- Parameters for DBD

Table 2.2.1: Predicted average numbers of various particle species in e^+e^- collisions at 92 GeV, for default Pythia settings or OPAL settings compared to LEP data

	Standard tune	OPAL tune	LEP combined data
All charged	20.6246	20.5685	20.9400 ± 0.1900
π^0	9.6814	9.8866	9.3800 ± 0.4500
π	17.1178	17.5467	17.0500 ± 0.4300
K	2.2879	2.1108	2.3600 ± 0.1100
p	1.2190	0.9110	0.9750 ± 0.0870
n	1.1661	0.8664	-
K_S^0	1.1168	1.0150	1.0040 ± 0.0150
K_L^0	1.1057	1.0164	-

LEP data indicates less neutral hadrons than Pythia default

Summary of generated samples

event-type	process
1f	$e^{\pm}\gamma \to \gamma e$
2f	$e^{+}e^{-} \to f\bar{f}$
3f	$e^{\pm}\gamma \to (e \text{ or } \nu) + 2f$
4f	$e^{+}e^{-} \to 4f$
5f	$e^{\pm}\gamma \to (e \text{ or } \nu) + 4f$
6f	$e^{+}e^{-} \to 6f$
aa_2f	$\gamma\gamma \to 2f$
aa_4f	$\gamma\gamma \to 4f$
aa_minijet	$\gamma\gamma \to$ hadron mini-jets
aa_lowpt	$\gamma\gamma \to$ lowpt hadrons
eepairs	beam induced low p_t $e^{\pm}$ pairs
higgs	$e^{+}e^{-} \to f\bar{f}h$
tt$h$	$e^{+}e^{-} \to t\bar{t}h, t\bar{t}Z,$ and $t\bar{t}g^{*}(g^{*} \to b\bar{b})$

Whizard
- $e^{\pm}$ polarizarion=±100%
- γ source: Weizsacker Williams/ Beam-strahlung

Pythia in Whizard (γ_{point})

Peskin & Pythia (gluon in γ)

GuineaPig (for Overlay)

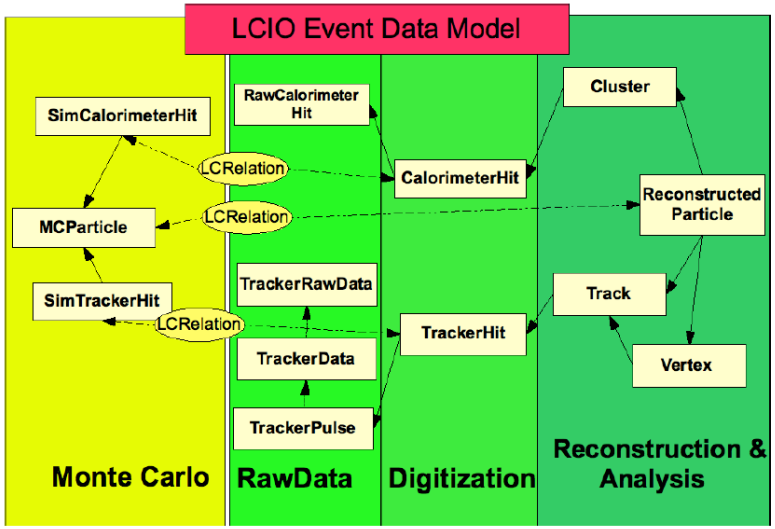
Whizard (Mh=125 GeV)

Physsim

- ✓ Samples are grouped by “aliasing” and “process grouping”: 1675 proc./~20k files
- ✓ m_q=0, m_{jj}>10GeV
- ✓ No Lorentz boost for crossing angle. No smearing of IP position

Common Sim./Rec. tools : LCIO

- Both ILD and SiD have developed their software tools based on LCIO.
- LCIO provides
  - Common event data model.
  - Common file format
- Development has started since 2003.
- New developments since LOI
  - LCIO : 1.x → 2.x
  - Random access to records (crucial for BKG overlay)
  - Extends Track class to hold
    - Multiple track states at IP, at First/LastHits, at Calorimeter
    - 1D Tracker hits for correct treatment of Si-Strip detectors
  - Support ROOT
  - etc.



Common Tools : PFA and LCFIPlus

- Particle Flow Algorithm (PFA)
  - A key package for excellent jet measurements. PandoraPFA was successfully used for LOI study in ILD framework
  - For DBD
    - Re-coded as a standalone library with essentially no external dependencies. ➔ adaptation to each concept is easy.
    - Improved performance

- LCFIPlus
  - Heavy quark tagging is crucial for ILC physics
  - In LOI, LCFIVertex : Originally developed for SLD Z physics (optimized for 2-jet events. Flavour tagging after jet clustering)
  - For DBD, LCFIPlus
    - Aimed for multi-jet environments :
      Vertexing → Jet Clustering → Tagging
    - TMVA based flavor tagging : allows analysis dep. tagging condition

Summary

- Event samples and software tools for DBD have been prepared with common efforts between SiD and ILD

- New issues appears during DBD exercise

  Common software group has started to discuss issues post DBD era.