Common Generator Tools for LC

Topics
- Common generator tools for DBD
- Issues in post DBD era

Akiya Miyamoto
KEK

LCWS13 @ Tokyo

Introduction

- Role of common generator tools
  - Provide common generator programs and samples to ILD and SiD & ILC and CLIC
  - Allow performance evaluation with same footings
  - Minimize duplication of efforts for tool developments and sample productions

- History
  - Working group formed after ILC LOI.
  - Common tools have been used for ILC DBD & CLIC CDR and so on

  - Generator group consists of
    - Tim Barklow, Mikael Bergren, Philip Roloff, AM.

DBD era : 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. (neglect $f\bar{f}f\bar{f}\,h$)
  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

DBD era : 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.

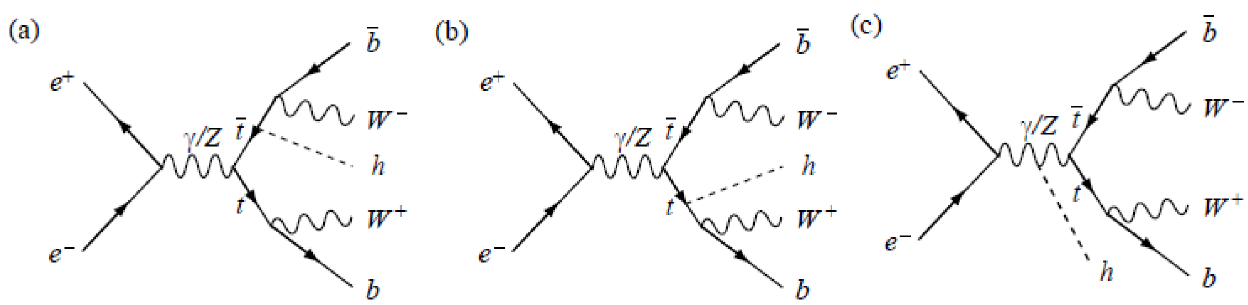


Figure 2.2.1: Feynman diagrams for the $e^+e^- \to t\bar{t}h$ process.

- Used for generating $e^+e^- \to t\bar{t}h, t\bar{t}Z(Z \to f\bar{f}), t\bar{t}g^*(g^* \to b\bar{b})$
- $Z \to q\bar{q}$ and $g^* \to b\bar{b}$ in $t\bar{t}Z$ and $t\bar{t}g^*$ hadronize independently w. tt̄
- $e^+(e^-)$ luminosity spectrum, ISR, hadronization/decay : same as Whizard samples.
- Full 8-fermion generator is desirable.

DBD Processes

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	$\gamma\gamma \to$ low $\mathrm{p_t}$ hadrons
eepairs	beam induced low $\mathrm{p_t}$ $e^{\pm}$ pairs
higgs	$e^{+}e^{-} \to f\bar{f}h$
tt$h$	$e^{+}e^{-} \to t\bar{t}h, t\bar{t}Z,$ and $t\bar{t}g^{*}(g^{*} \to b\bar{b})$

General feature of DBD sample

- 1 TeV and 500 GeV samples with ILC TDR beam parameters
- $1ab^{-1}$ except high σ processes,
- $e^{\pm}$ fully polarized
- Mh=2 TeV except "higgs"
- γ = brems. or beam-strahlung γ generated by GunieaPig
- $\gamma\gamma$_minijet: hadron prod. by point_like γ using Pythia

- File format: stdhep, stdhp4 for pol. info.
- Samples were generated at SLAC, DESY & KEK. Common samples are kept on ILC VO GRID (LCG & DIRAC catalog). ~ 500MB each
  - SiD: pre-mixed, ILD: use as it is.
- Common format for meta info. (process ID, file name, cros section, …) were defined and kept on Web
- Source files are maintained on SVN

Samples after DBD (for Snowmass)

250 GeV	350 GeV
$e^+e^- \to 2f, 4f, f\bar{f}h$	$e^+e^- \to 2f, 4f, 6f, f\bar{f}h$
$e^+\gamma/\gamma e^- \to 1f, 3f$	$e^+\gamma/\gamma e^- \to 1f, 3f, 5f$
$\gamma\gamma \to 2f$, *mini-jet, low_pt*	$\gamma\gamma \to 2f$, 4f, *mini-jet, low_pt*
eepairs	*eepairs*
	$e^+e^- \to t\bar{t}$ *(w. thresh. effect by Physsim)*

- $e^{\pm}$ fully polarized. 1 ab^{-1} except high σ processes
- ffh files were sub-divided depending on the Higgs decay mode
- ~ 1 G events, 6k files (except low_pt hadrons and eepairs)
- Files are on ILC VO GRID (LCG & DIRAC catalog)

$\gamma\gamma \rightarrow$ hadron generators

- $\gamma\gamma \rightarrow$ low_pt hadrons : with X-section formula by Peskin. Using Pythia for q/g collisions.
  There was a problem in getting $\gamma\gamma$ luminosity from e+e- lumi.

Ecm (GeV)	Old#	# used for ILD Production	New# (correct)
250	0.33	0.20	0.25
350	0.54	0.33	0.40
500	1.7	1.7	1.2
1000	4.1	4.1	2.7

of $\gamma\gamma \rightarrow$ low_pt hadron events per bunch crossing

Whizard1 to Whizard2

- Support for Whizard1 by authors will go away at the end of the year
- Whizard2 new feature
  - new simplified user interface
  - matching & merging of photon and gluon shower
  - treatment of 8f might be possible
  - τ polarization

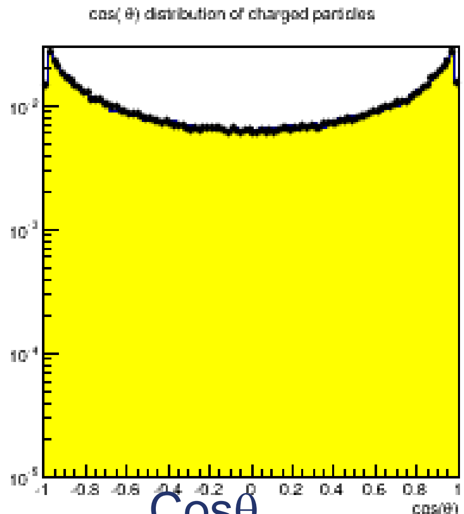
- But, but thorough validation by user is necessary.

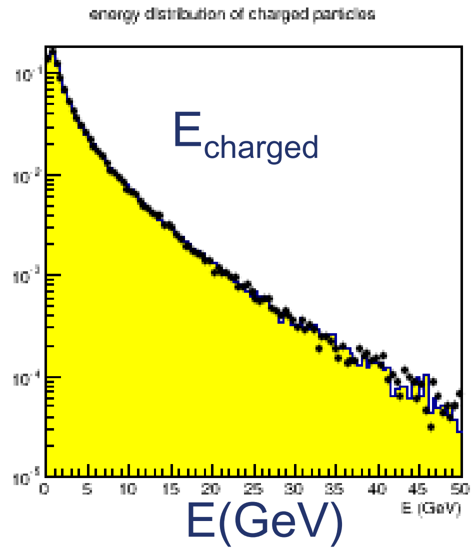
- Whizard1: several features (beam spectrum, output info, …) were implemented by users (LC community)
  Whizard2: Hope to be implemented in Whizard itself by the authors.

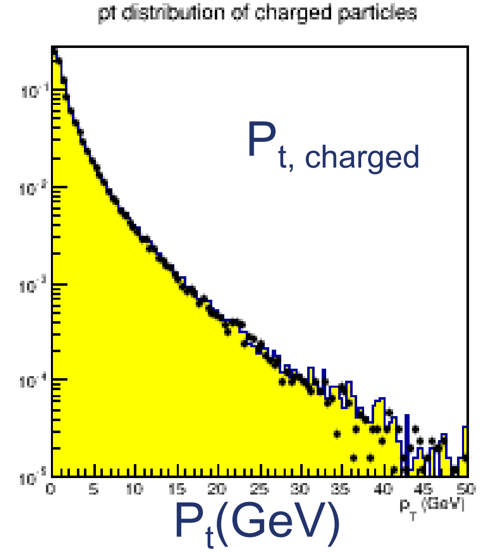
E250-TDR_ws.eL.pR
e+e- → b B
Final state particles

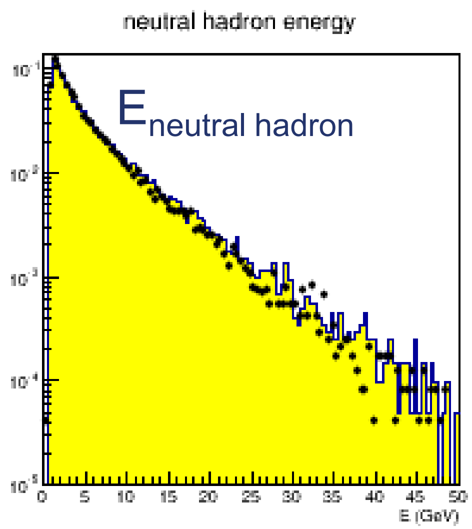
Whizard 1.95 vs Whizard2.1.1 : Comparison by Jan

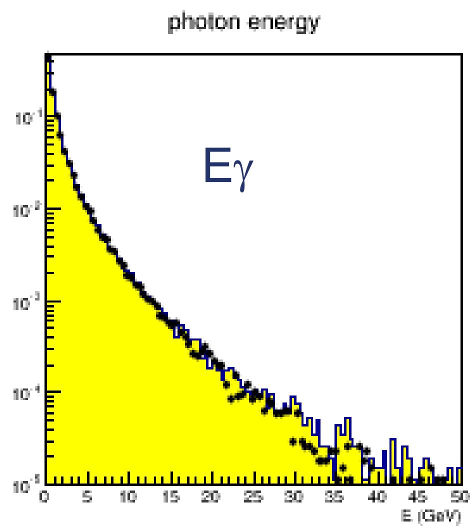
ISR only (No BS)
hadronization: pythia w LEP tune vs Whizard2

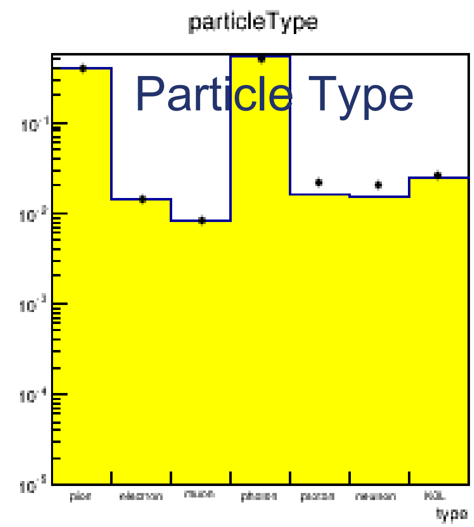












Whizard2 issues

- ILC beam spectrum must be implemented correctly and validated.
- Output format
  - stdhep : keep same format as the DBD version; intermediate particles and pol. info
  - move to lcio ? middle/long term goal

- tau polarization
- hadronization
- cross-section consistency
- generation of 6f/8f processes
- include t tbar resonance effects

➔ Serious validation efforts by user side are essential

➔ After LCWS13, we'd like to work together with Whizard authors to address these issues

Conclusion

- Common generator tools and samples are important for
  - consistent studies
  - minimize unnecessary duplicated efforts

- Needs for common generator tools and samples will continue for physics and optimization studies in future

- Several generator issues have been identified during the DBD era. We hope to be able to solve them in coming months.
  - Current main focus : Whizard 1.95 to Whizard 2.x.
  - Other generators (QED generator, for example) would be necessary eventually
- Participation of many users are important for these activities.