ILC Experience and Recommendations

Tim Barklow (SLAC)
Jul 09, 2010

LOI Benchmarks

Reaction	Detector parameter tested	Measurements
$e^+e^- \to Z(\to l^+l^-)H$ $m_H = 120$ GeV, $\sqrt{s} = 250$ GeV	p resolution material distribution γ recovery	m_H σ
$e^+e^- \to ZH(H \to c\bar{c}, Z \to \nu\bar{\nu})$ $m_H = 120$ GeV, $\sqrt{s} = 250$ GeV	heavy flavor tagging secondary vertex reconstruction particle id.	$BR(H \to c\bar{c})$
$e^+e^- \to ZH(H \to c\bar{c}, Z \to q\bar{q})$ $m_H = 120$ GeV, $\sqrt{s} = 250$ GeV	same as for $e^+e^- \to ZH(H \to c\bar{c}, Z \to \nu\bar{\nu})$ confusion resolution capability	$BR(H \to c\bar{c})$
$e^+e^- \to Z \to \tau^+\tau^-$ $\sqrt{s} = 500$ GeV	τ reconstruction particle flow π^0 reconstruction tracking of close tracks	σ A_{FB} τ polarization
$e^+e^- \to t\bar{t}(t \to bqq')$ $m_t = 175$ GeV, $\sqrt{s} = 500$ GeV	multi jets particle flow b tagging lepton tagging tracking	σ A_{FB} m_t
$e^+e^- \to \chi^+\chi^-/\chi_2^0\chi_2^0$ $\sqrt{s} = 500$ GeV	particle flow WW, ZZ separation multi jets	σ masses

Monte Carlo Production

- WHIZARD Monte Carlo is used to generate all 0,2,4,6-fermion and t quark dominated 8-fermion processes.
- 100% electron and positron polarization is assumed in all event generation. Arbitrary electron, positron polarization is simulated by properly combining data sets.
- Fully fragmented MC data sets are produced. PYTHIA is used for final state QED & QCD parton showering, fragmentation, particle decay.

SM Final States

0-fermion

$e^+e^- \rightarrow$	$\gamma\gamma$
	$\gamma\gamma\gamma$
	$\gamma\gamma\gamma\gamma$
	$\gamma\gamma\gamma\gamma\gamma$

2-fermion

$e^+e^- \rightarrow$	ff	$f \neq \nu$
	$\nu\nu\gamma$	
	$\nu\nu\gamma\gamma$	
	$\nu\nu\gamma\gamma\gamma$	
$e^-\gamma \rightarrow$	$e^-\gamma$	
$\gamma e^+ \rightarrow$	$e^+\gamma$	

4-fermion

$e^+e^- \rightarrow$	$\nu\nu\nu\nu\gamma$	6 total
	$u_j\overline{d}_j d_k\overline{u}_k$	25 total
		$\nu_e e^+ e^- \overline{\nu}_e$
		$\nu_e e^+ \mu^- \overline{\nu}_\mu$
		$\nu_e e^+ \tau^- \overline{\nu}_\tau$
		$\nu_e e^+ d\overline{u}$
		.
		.
		$c\overline{s}s\overline{c}$
	$u_j\overline{u}_j u_k\overline{u}_k$	9 total
	$u_j\overline{u}_j d_k\overline{d}_k$	25 total
	$d_j\overline{d}_j d_k\overline{d}_k$	21 total
$\gamma\gamma \rightarrow$	$f\overline{f}$	8 total
$e_L^-\gamma \rightarrow$	$\nu_e d_k\overline{u}_k$	5 total
$e^-\gamma \rightarrow$	$e^- f\overline{f}$	10 total
$\gamma e_R^+ \rightarrow$	$\overline{\nu}_e u_k\overline{d}_k$	5 total
$\gamma e^+ \rightarrow$	$e^+ f\overline{f}$	10 total

6-fermion

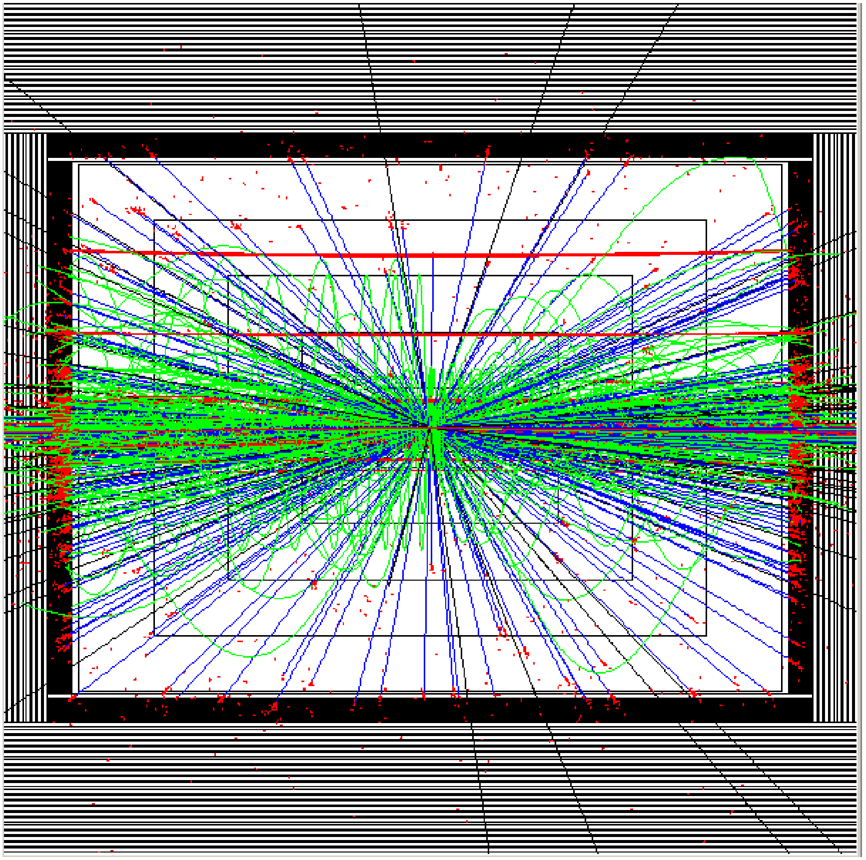
$e^+e^- \rightarrow$	$u_i\overline{u}_i u_j\overline{d}_j d_k\overline{u}_k$	125 total
	$d_i\overline{d}_i u_j\overline{d}_j d_k\overline{u}_k$	150 total
	$u_i\overline{u}_i u_j\overline{u}_j u_k\overline{u}_k$	25 total
	$u_i\overline{u}_i u_j\overline{u}_j d_k\overline{d}_k$	65 total
	$u_i\overline{u}_i d_j\overline{d}_j d_k\overline{d}_k$	75 total
	$d_i\overline{d}_i d_j\overline{d}_j d_k\overline{d}_k$	56 total
$\gamma\gamma \rightarrow$	$u_j\overline{d}_j d_k\overline{u}_k$	25 total
	$u_j\overline{u}_j u_k\overline{u}_k$	9 total
	$u_j\overline{u}_j d_k\overline{d}_k$	25 total
	$d_j\overline{d}_j d_k\overline{d}_k$	21 total
$e_L^-\gamma \rightarrow$	$\nu_e u_j\overline{u}_j d_k\overline{u}_k$	25 total
	$\nu_e d_j\overline{d}_j d_k\overline{u}_k$	30 total
$e^-\gamma \rightarrow$	$e^- u_j\overline{d}_j d_k\overline{u}_k$	20 total
	$e^- u_j\overline{u}_j u_k\overline{u}_k$	10 total
	$e^- u_j\overline{u}_j d_k\overline{d}_k$	20 total
	$e^- d_j\overline{d}_j d_k\overline{d}_k$	21 total
$\gamma e_R^+ \rightarrow$	$\overline{\nu}_e u_j\overline{d}_j u_k\overline{u}_k$	25 total
	$\overline{\nu}_e u_j\overline{d}_j d_k\overline{d}_k$	30 total
$\gamma e^+ \rightarrow$	$e^+ u_j\overline{d}_j d_k\overline{u}_k$	20 total
	$e^+ u_j\overline{u}_j u_k\overline{u}_k$	10 total
	$e^+ u_j\overline{u}_j d_k\overline{d}_k$	20 total
	$e^+ d_j\overline{d}_j d_k\overline{d}_k$	21 total

8-fermion

$e^+e^- \rightarrow$	$f\overline{f}t\overline{t}$
$\gamma\gamma \rightarrow$	$t\overline{t}$
$e^-\gamma \rightarrow$	$e^- t\overline{t}$
	$\nu_e b\overline{t}$
$\gamma e^+ \rightarrow$	$e^+ t\overline{t}$
	$\overline{\nu}_e t\overline{b}$

Beam-Beam Background

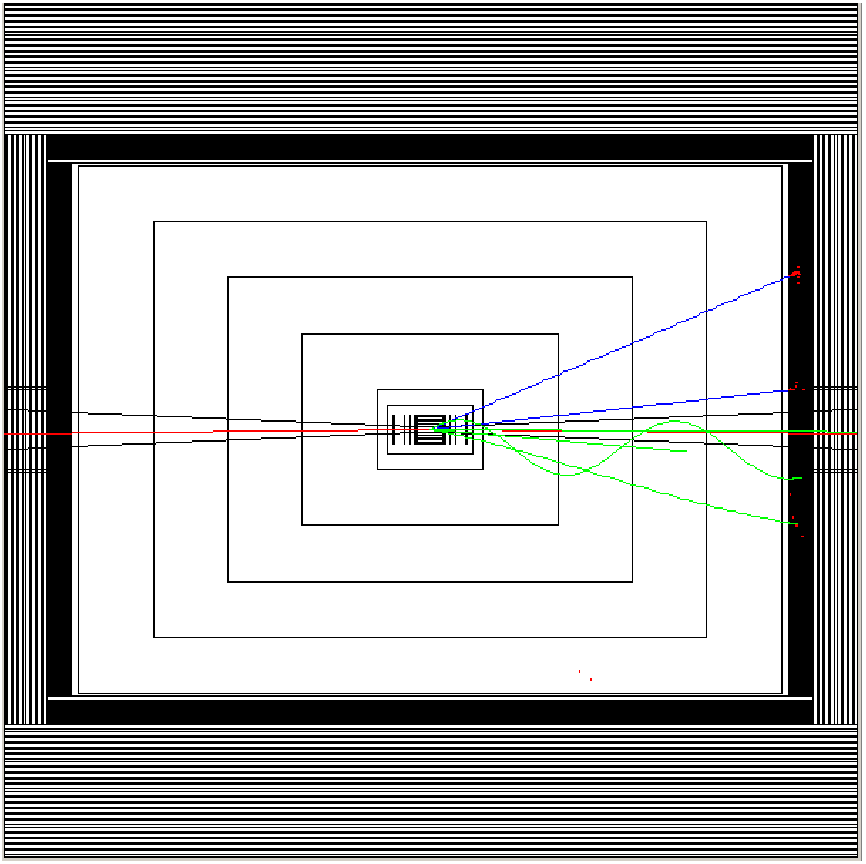
Process	$\gamma\gamma \to e^+e^-$ $p_T > 115$ MeV	$\gamma\gamma \to \mu^+\mu^-$ $p_T > 115$ MeV	$\gamma\gamma \to hadrons$
σ(fb), $\sqrt{s}$ = 500 GeV	1.10×10^9	1.36×10^9	4.61×10^8



Yellow = muons   Red = electrons   Green = charged hadrons

Black = Neutral Hadrons   Blue = photons with E > 100 MeV

150 bunch crossings (5% of train)



1 bunch crossing

γ spectrum identical to that used in WHIZARD generation of $\gamma\gamma \to n$ fermions

However, after the γ energies have been chosen,

$\gamma\gamma \to hadrons$ is simulated using PYTHIA

There are currently 14 MC production groups:

- 0-2-4-fermion
- 6-fermion/ddi-udj-duk
- 6-fermion/eminus-gamma
- 6-fermion/gamma-eplus
- 6-fermion/gamma-gamma
- 6-fermion/uui-udj-duk
- 6-fermion/zzz_1
- 6-fermion/zzz_2
- 8-fermion/
- bench-point-5
- ffh
- ffhh
- tesla_bosons
- tth

For each Production Group There are 5 Steps Needed to Produce (Raw) MC Stdhep Data Sets: (corresponding shell script is shown in italics)

1. Generate Executable

   /nfs/slac/g/lcd/mc/prj/sw/dist/whizard/v1r4p0/whizard-v1r4p0/remake_process_class
2. Submit MC Integration Jobs

   /afs/slac/g/nld/whizard/ILC/multiple_whiz_ini
3. Repair MC Integration Jobs

   /afs/slac/g/nld/whizard/ILC/multiple_whiz_ini_cleanup
4. Submit MC Event Generation Jobs

   /afs/slac/g/nld/whizard/ILC/multiple_whiz_run
5. Repair MC Event Generation Jobs

   /afs/slac/g/nld/whizard/ILC/multiple_whiz_run_repair

New ILC Common Data Sample Subgroup was formed recently to deal with ILC MC event generation issues . Members are : Akiya Miyamoto, Mikael Berggren and Tim Barklow

Near term goals for MC generator improvements:

- Include full CKM matrix when simulating processes with Wff' vertices
- Include gluon intermediate states when simulating processes with final state quarks
- Replace W/Z/t resonance-based color flow guess with correct color flow calculation from WHIZARD
- Use TAUOLA to perform polarized tau decay for all taus produced by WHIZARD & PYTHIA
- Store final state helicity and color flow information in stdhep file
- Upgrade to PYTHIA 6.422 and include optimum LEP fragmentation tune
- Improve Bhabha generation using GRACE
- Reevaluate SUSY generators and identify the best one for ILC physics

Near term goals for MC event generation improvements:

- Determine if WHIZARD can sum over many fermion flavors in a single run so that we don't have to submit a process intergation and event generation job for every distinct final state fermion combination (see next slide). The current method works, but is time-consuming, especially for six-fermion final states. It may be impossible without flavor summation to submit a job for every distinct 8-fermion combination (needed for tth background).
- Import SLAC's MC integration and MC event generation scripts to KEK so that KEK and SLAC can generate events in an identical manner
- Develop a common data base that is updated automatically whenever a MC event generation job completes at SLAC, KEK or DESY.
- Automate MC event generation job submission and batch job repair at SLAC using FERMI pipeline system. If successful implement something like it at KEK.

9

Observations

- The WHIZARD Monte Carlo offers several advantages for linear collider event generation:
  - The same Monte Carlo framework can be used for background generation and most signal event generation.
  - Initial state polarization is always available
  - It is straightforward to include beamstrahlung effects, and these effects are identical across all signal and background event generation.
  - Final state polarization effects are automatically included when one specfies the n-fermion final state (e.g. $e^+e^- \rightarrow uDsC$ instead of $e^+e^- \rightarrow W^+W^-$)

- The WHIZARD Monte Carlo is used for both LHC and linear collider event generation, and is well supported by its authors.

- CLIC might want to take advantage of the software ILC has written to interface WHIZARD to PYTHIA and Guinea-Pig and to generate a full set of background events in a systematic manner.

- Both ILC and CLIC could benefit from future software written to utilize WHIZARD.