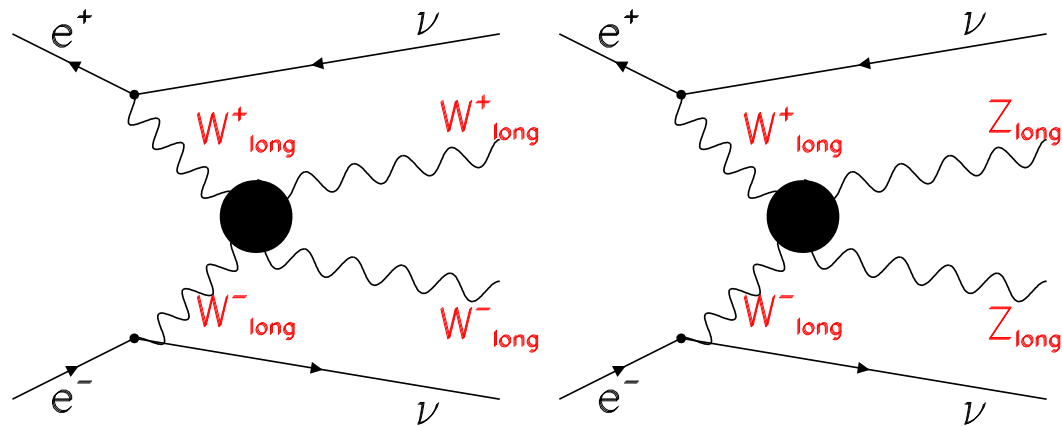


Full Detector Simulation of WW Scattering

David Ward and Wenbiao Yan



Motivation

- Electroweak symmetry breaking
 - Light Higgs boson: weakly interacting model
 - * SM + extensions
 - * unitarity problem for WW scattering \Leftarrow Higgs
 - No light Higgs boson: strongly interacting model
 - * model is non-renormalizable \implies new physics at $\Lambda = 4\pi\nu = 3.1$ TeV
 - * new physics needed at TeV scale to restore unitarity for WW scattering
- WW scattering provides information on the electroweak symmetry breaking
- EW interactions at low energies can be described by EW Chiral Lagrangian
 - has operators of higher dimensions and introduce anomalous couplings
- For WW scattering, there are two 4D operators at $SU(2)_c$ conserving case
$$L_4 = \frac{\alpha_4}{16\pi^2} \text{tr}(V_\mu V_\nu) \text{tr}(V^\mu V^\nu) \quad L_5 = \frac{\alpha_5}{16\pi^2} \text{tr}(V_\mu V^\mu) \text{tr}(V_\nu V^\nu)$$
anomalous couplings α_4 & α_5 are related to the scale of new physics. α_4 & α_5 are zero in the SM, and are model dependent

Motivation

- Sensitivity of α_4 & α_5 at linear collider ? **TESLA Fast simulation**
 - LC-PHSM-2001-038: SIMDET for TESLA @ 800 GeV
 - hep-ph/0604048: SIMDET for TESLA @ 1000 GeV
 - Andres F. Osorio's thesis: SIMDET for TESLA @ 800 GeV

- Motivation for this work

- WW/ZZ separation
- Extract α_4 & α_5 :

- * **Detector model: LDC00, LDC00Sc, LDC01, LDC01Sc**

$$\left. \begin{array}{l} \text{LDC00Sc vs. LDC00} \\ \text{LDC01Sc vs. LDC01} \end{array} \right\} \implies \text{Analog Hcal vs. Digital Hcal}$$

$$\left. \begin{array}{l} \text{LDC00Sc vs. LDC01Sc} \\ \text{LDC00 vs. LDC01} \end{array} \right\} \implies \text{different detector size}$$

- * **PFA: PandoraPFO PFA vs. Wolf PFA vs. Track based PFA**

Detector models

- LDC00Sc vs. LDC01Sc

- Ecal

- * LDC00Sc: 30X 1.4mm + 10X 4.2 mm as W radiator

- * LDC01Sc: 20X 2.1mm + 10X 4.2 mm as W radiator

- Detector size

- * LDC00Sc: `tpcOuterRadius = 1690`; `TPC_Ecal_Hcal_barrel_halfZ = 2730`

- * LDC01Sc: `tpcOuterRadius = 1580`; `TPC_Ecal_Hcal_barrel_halfZ = 2200`

- LDC00Sc vs. LDC00

- LDC00Sc is exactly the same as LDC00, but with scintillators as sensitive material for the Hcal. LDC00 has RPC

- LDC01Sc vs. LDC01

- LDC01Sc is the same as LDC01, but with scintillators as sensitive material for the Hcal

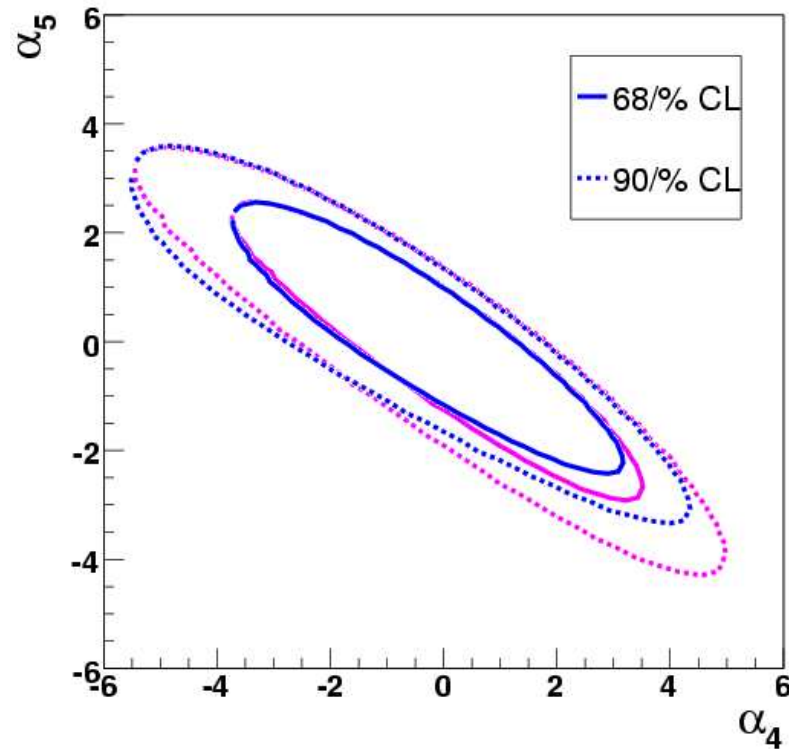
WW/ZZ MC production

- $\sqrt{s} = 800$ GeV; polarization RL 40% 80%; with ISR; w/o beamstrahlung

Channel	σ_{800GeV} (fb)	Generator
$\nu_e\bar{\nu}_e WW \rightarrow \nu_e\bar{\nu}_e q\bar{q}q\bar{q}$	8.55	Whizard 1.50
$\nu_e\bar{\nu}_e ZZ \rightarrow \nu_e\bar{\nu}_e q\bar{q}q\bar{q}$	3.97	Whizard 1.50
$\nu_e\bar{\nu}_e q\bar{q}q\bar{q}$ (background)	5.46	Whizard 1.50
$e\nu_e WZ \rightarrow e\nu_e q\bar{q}q\bar{q}$	38.75	Whizard 1.50
$ee WW/ZZ \rightarrow ee q\bar{q}q\bar{q}$	289.43	Whizard 1.50
$t\bar{t} \rightarrow X$	299.63	PYTHIA 6.1
$\nu_e e W \rightarrow \nu_e e q\bar{q}$	108.59	Whizard 1.50
$\nu_{\mu,\tau}\bar{\nu}_{\mu,\tau} WW/ZZ \rightarrow \nu_{\mu,\tau}\bar{\nu}_{\mu,\tau} q\bar{q}q\bar{q}$	8.85	Whizard 1.50

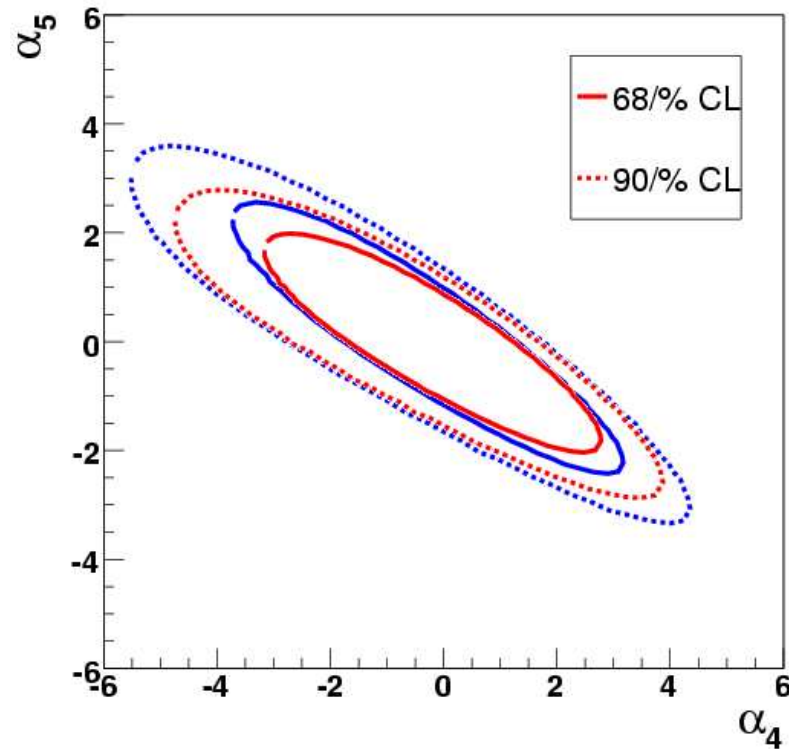
- processes with $\sigma < 100$ fb: sample with $\mathcal{L} = 1000 \text{ fb}^{-1}$
- processes with $\sigma > 100$ fb: sample with $\mathcal{L} = 500 \text{ fb}^{-1}$

Likelihood from combined WW/ZZ @ 800 GeV



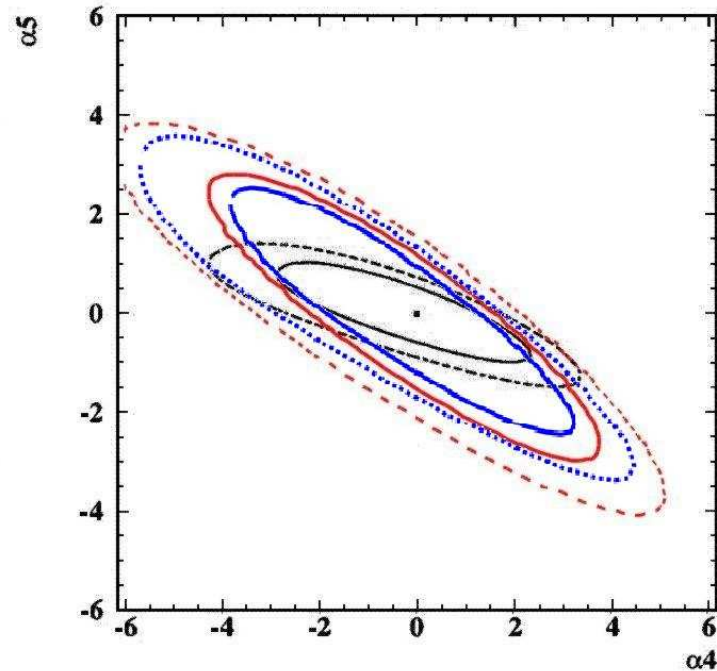
- LDC00Sc vs. LDC01Sc
- Blue: Pandora PFA @ LDC00Sc
- Pink: Pandora PFA @ LDC01Sc

Likelihood from combined WW/ZZ @ 800 GeV



- Perfect Pandora PFA vs. Pandora PFA @ LDC00Sc
- Blue: Pandora PFA @ LDC00Sc
- Red: Perfect Pandora PFA @ LDC00Sc

Likelihood from combined WW/ZZ @ 800 GeV



- Blue: results using LDC00Sc detector model; full detector simulation
- Red: Predrag Krstonosic's results @ LCWS 2005 using TESLA fast simulation
- Black: LC-PHSM-2001-038 using TESLA fast simulation

Summary and outlook

- We study WW scattering with LDC00Sc/LDC01Sc detector models, and extract α_4 & α_5 , which are comparable with that of TESLA fast simulation.
- Ongoing works
 - Track finding: TrackCheater → full LDC tracking
 - Different PFAs: Pandora PFA vs. Wolf PFA vs. Track based PFA
 - Different detector models: LDC00Sc, LDC01Sc, LDC00 and LDC01
 - WW scattering at $\sqrt{s} = 1000$ GeV