

Gravitational Fixed Points and Virtual–Graviton Signals

Tilman Plehn

MPI für Physik & University of Edinburgh

Madison, 5/2007

Dave's Comments on Majorana Neutralinos

Tilman D. Plehnwater

MPI für Physik & University of Edinburgh

Madison, 5/2007

Outline

WBF and SUSY

Stable Charginos

Stable Scalars

Stable Vectors

Outlook

WBF and Supersymmetry

Simplest Model: Stable Charginos

Alternative Spin 1: Stable Scalars

Alternative Spin 2: Stable Vectors

Outlook

Old post–Pythia SUSY questions for LHC

(1) MSSM fermions Majorana or Dirac?

- gluino identifiable with help of bottom cascades [Cambridge; Alves, Eboli, TP; Florida,...]
- neutralino in cascades entangled with slepton couplings
- neutralino in $\tilde{q}\tilde{q}^* t$ channel swamped by gluino

(2) weakly interacting particles observable outside cascades? [Smadgraph release]

- Drell–Yan processes killed by W, Z backgrounds
- WBF pair production rate limited [$1/(16\pi^2) \ll 1$]

⇒ **WBF $W^\pm W^\pm \rightarrow \chi^\pm \chi^\pm$ with t -channel neutralino**

Reminder: MSSM coupling structure

- $\chi^0 \chi^0 Z$: Higgsinos–Higgsino
- $\chi^\pm \chi^\mp Z$: Higgsino–Higgsino and gaugino–gaugino
- $\chi^0 \chi^\pm W^\mp$: Higgsino–Higgsino and gaugino–gaugino
- $\chi \chi H$: gaugino–Higgsino mixing

⇒ maybe some information on Higgsino or gaugino fraction [dark matter]

⇒ still generally: WBF processes better for light gauginos [cross section $\mathcal{O}(fb)$]

Old post–Pythia SUSY questions for LHC

(1) MSSM fermions Majorana or Dirac?

- gluino identifiable with help of bottom cascades [Cambridge; Alves, Eboli, TP; Florida,...]
- neutralino in cascades entangled with slepton couplings
- neutralino in $\tilde{q}\tilde{q}^* t$ channel swamped by gluino

(2) weakly interacting particles observable outside cascades? [Smadgraph release]

- Drell–Yan processes killed by W, Z backgrounds
- WBF pair production rate limited [$1/(16\pi^2) \ll 1$]

⇒ **WBF $W^\pm W^\pm \rightarrow \chi^\pm \chi^\pm$ with t -channel neutralino**

Some backgrounds

- SM background: WBF WW production, small but decay dependent [neglected]
- SUSY background: $\tilde{q}\tilde{q}^*$ via t -channel gluino, neutralino, etc
- production rates in SPS9 [bino–chargino mass 198 GeV]

$\chi_1^+ \chi_1^+ + \text{jets}$	WBF cuts	30 GeV around $m_{\tilde{q}}$	50 GeV around $m_{\tilde{q}}$
all EW	1.138 fb	0.847 fb	0.786 fb
WBF	0.825 fb	0.766 fb	0.724 fb
EW non-WBF	0.261 fb	41.4 ab	23.1 ab
QCD	0.439 fb	14.7 ab	6.19 ab

Joe Lykken's Motivation at FNAL

Early running of LHC

- plenty of evidence for a new physics
- not enough useful cascade events [rate? jet energy scale?...]
- ⇒ how do we need to get an ILC without waiting forever?
- ⇒ this talk volunteered by Dave R

- WBF process: (1) charginos and neutralinos light
- WBF process: (2) charginos and neutralinos interesting
- ⇒ might not see weakly interacting stuff in WBF,
but if yes, it's a case for instantaneous ILC

Simplest Model: Stable Charginos

Starting point: (meta-) stable charginos

- simplest test case: no chargino decays [decays: lower rate, more information, technically trivial]
- AMSB: neutralino–chargino mass difference tiny
- massive stable like–sign leptons (muons) [Cambridge]
- similar to Higgs–coupling analysis [TP, Rainwater, Zeppenfeld; Hankele, Klamke, Figy]
 - (1) trigger on charginos or forward jets
 - (2) analyze jet distributions

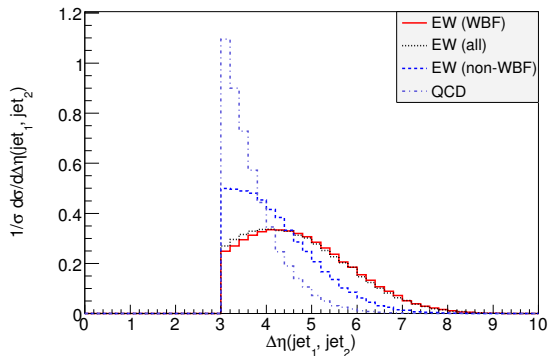
Few details

- all distributions normalized
- only WBF–jet cuts
- final–state mass 197 GeV

Jet Distributions

Normalized distributions for WBF signal

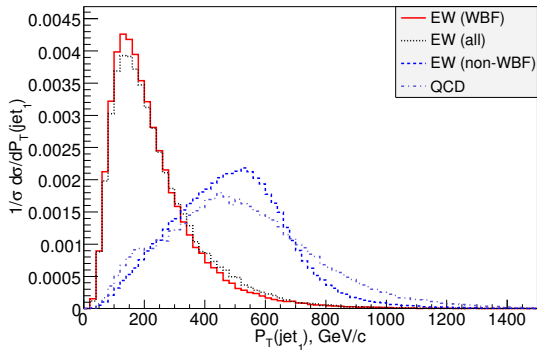
- separated forward jets for WBF signal
- $p_{T,j}$ not fixed by m_W [$d/dp_T p_T / (p_T^2 - m_W^2) = 0$]
- $\Delta\phi_{jj} \sim \pi/2$ preferred [not just $g_{\mu\nu}$ in $WW\chi\chi$ coupling]
- every single QCD distribution very different (and mass-peaked)



Jet Distributions

Normalized distributions for WBF signal

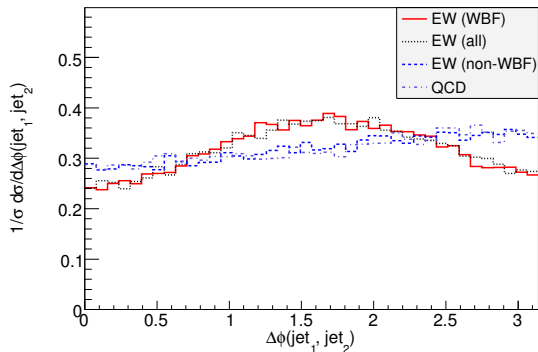
- separated forward jets for WBF signal
- $p_{T,j}$ not fixed by m_W [$d/dp_T p_T / (p_T^2 - m_W^2) = 0$]
- $\Delta\phi_{jj} \sim \pi/2$ preferred [not just $g_{\mu\nu}$ in $WW\chi\chi$ coupling]
- every single QCD distribution very different (and mass-peaked)



Jet Distributions

Normalized distributions for WBF signal

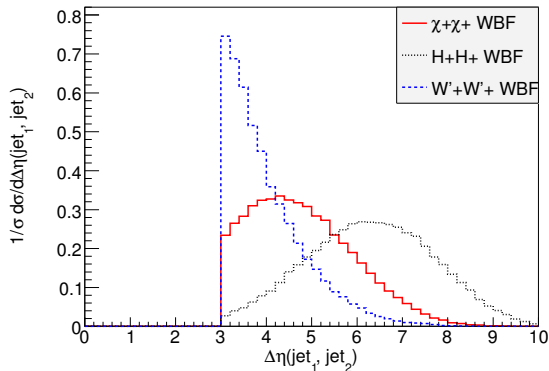
- separated forward jets for WBF signal
- $p_{T,j}$ not fixed by m_W [$d/dp_T p_T / (p_T^2 - m_W^2) = 0$]
- $\Delta\phi_{jj} \sim \pi/2$ preferred [not just $g_{\mu\nu}$ in $WW\chi\chi$ coupling]
- every single QCD distribution very different (and mass-peaked)



Alternative Spin: Stable Scalars

Stable charged Higgs [only toy hypothesis]

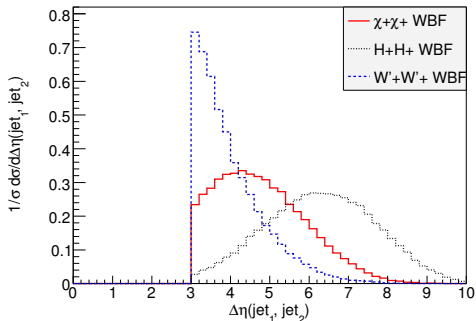
- MadEvent simulation as 2HDM with (meta-) stable H^\pm
 - $WW \rightarrow H^\pm H^\pm$ natural via t -channel H^0
 - t channel Z forbidden or suppressed by ρ parameter
- \Rightarrow all $H^\pm H^\pm$ jet distributions like 500 GeV H^0



Alternative Spin: Stable Vectors

Something like Little Higgs with T Parity [only toy hypothesis]

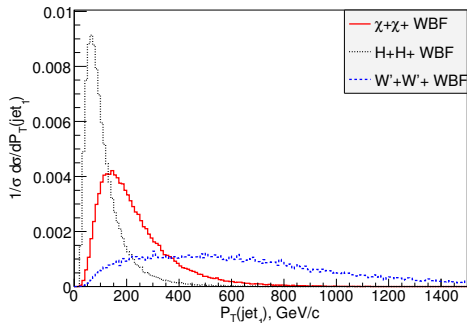
- MadEvent: heavy W' , Z' bosons, (meta-) stable for now
 - no fermionic couplings of W' , Z'
 - unitarity of $W^+W^- \rightarrow W'^{\pm}W'^{\mp}$: add t -channel H'
 - compute WBF $W'^{\pm}W'^{\pm}$ production with t -channel H' , Z'
- ⇒ **clearly distinctive for fermion, scalar, vector**



Alternative Spin: Stable Vectors

Something like Little Higgs with T Parity [only toy hypothesis]

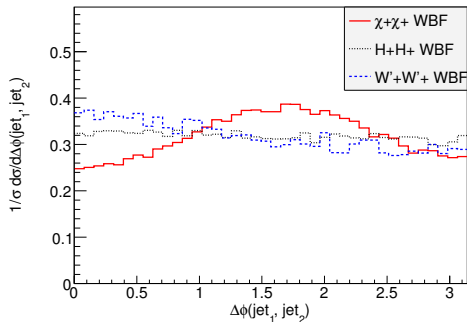
- MadEvent: heavy W' , Z' bosons, (meta-) stable for now
 - no fermionic couplings of W' , Z'
 - unitarity of $W^+W^- \rightarrow W'^{\pm}W'^{\mp}$: add t -channel H'
 - compute WBF $W'^{\pm}W'^{\pm}$ production with t -channel H' , Z'
- ⇒ clearly distinctive for fermion, scalar, vector



Alternative Spin: Stable Vectors

Something like Little Higgs with T Parity [only toy hypothesis]

- MadEvent: heavy W' , Z' bosons, (meta-) stable for now
 - no fermionic couplings of W' , Z'
 - unitarity of $W^+ W^- \rightarrow W'^{\pm} W'^{\mp}$: add t -channel H'
 - compute WBF $W'^{\pm} W'^{\pm}$ production with t -channel H' , Z'
- ⇒ **clearly distinctive for fermion, scalar, vector**



Outlook

WBF and new physics

- maybe far shot depending on MSSM parameters...
- ...but exciting measurements of weak new-physics sector
- MSSM: Majorana nature of neutralinos from like-sign leptons
- scalars, fermions, vectors different in jet observables
- backup channel for heavy strongly interacting particles [Giudice, Han, Wang, Wang]
- **definitely a case for an ILC**
- any good idea why the W' looks the way it does???

Dave's Comments
on Majorana
Neutralinos

Tilman D.
Plehnwater

WBF and SUSY

Stable Charginos

Stable Scalars

Stable Vectors

Outlook