WBF at 100TeV

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Weak boson fusion at 100 TeV

Phys. Rev. D 95, 095011, D. Gonçalves, T. Plehn and JT

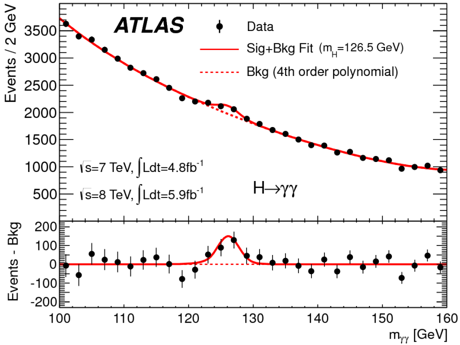
Higgs Couplings 2017

Overview

Higgs boson

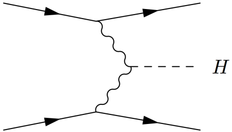
Fig. from Phys. Let. B 716 (2012) 1-29, auxilliary materials

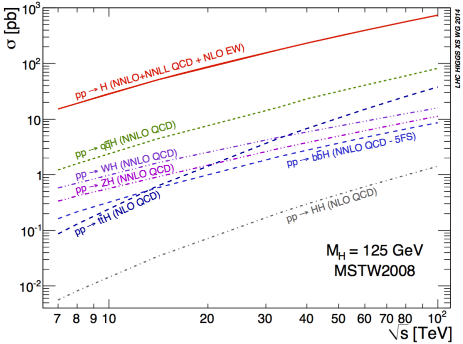
- Higgs boson discovery in 2012
- Many couplings still to be constrained



WBF production

- second-most dominant production channel
- characteristic forward jets





Rare Higgs decay channels

- $H \rightarrow$inv
  $\longrightarrow$ possible decay to BSM particles
  $\longrightarrow$ increase BR($H \rightarrow$inv)
  $\longrightarrow$ SM: $H \rightarrow ZZ^* \rightarrow 4\nu$
  $\longrightarrow$ Need jets/weak boson for the Higgs to recoil against
- $H \rightarrow \mu^+\mu^-$
  $\longrightarrow$ μ Yukawa coupling $\rightarrow$ BR$(H \rightarrow \mu^+\mu^-) = 2.2 \times 10^{-4}$
  $\longrightarrow$ μ resolution is very good ($\mathcal{O}(2\%)$ at LHC)

LHC status

- $H\to$inv
  $\longrightarrow$ currently at LHC: $\sim 30\%$
  $\longrightarrow$ High-lumi reach: $\sim 2\%$
- $H\to\mu^+\mu^-$
  $\longrightarrow$ $H\to\mu\mu$ is difficult, but possible, at the LHC
  $\longrightarrow$ $\mathrm{BR}(H\to\mu^+\mu^-)/\mathrm{BR}(H\to\mu^+\mu^-)_{\mathrm{SM}} < 7$

$\longrightarrow$ Possible next collider: 100 TeV pp collider, L=20 ab^{-1}
$\longrightarrow$ What is its potential for Higgs couplings?

Monte Carlo Simulation

SHERPA

Loops ($gg \rightarrow H$) calculated with OpenLoops

OpenLoops

$\longrightarrow$ merged samples up to 3 jets + parton shower
$\longrightarrow$ hadronisation effects

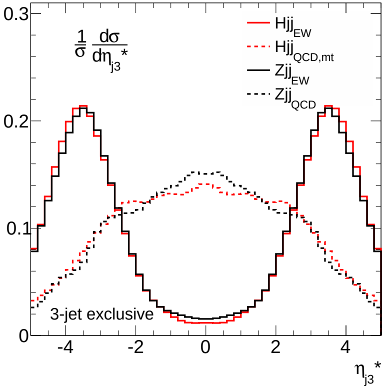
WBF cuts @ 100 TeV

cut	value
$p_{Tj_{1,2}}$	> 40 GeV
$\lvert\eta_{j_{1,2}}\rvert$	< 5
$\Delta\eta_{j_1,j_2}$	> 5
$\eta_{j_1} \cdot \eta_{j_2}$	< 0
$\Delta\phi_{j_1,j_2}$	< 1
m_{j_1,j_2}	> 1200 GeV
$p_{Tj_3} > p_{T\text{veto}}$	20 GeV
$\lvert\eta^*_{j_3}\rvert = \lvert\eta_{j_3} - \frac{\eta_{j_1}+\eta_{j_2}}{2}\rvert$	> 3

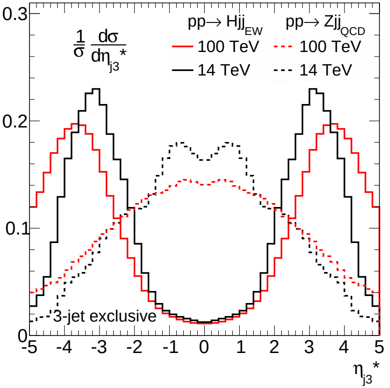
$H \to$inv: $N_{\text{leptons}} = 0$, $E_T^{\text{miss}} > 100$ GeV
$H \to \mu\mu$: $E_T^{\text{miss}} < 40$ GeV $\longrightarrow$ 2 and 3 jet regions

η^*_{j3} distributions

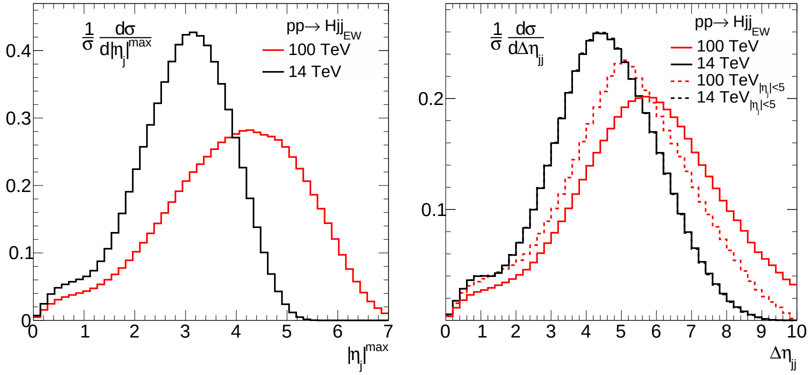
Signal vs. Background



14 TeV vs. 100 TeV

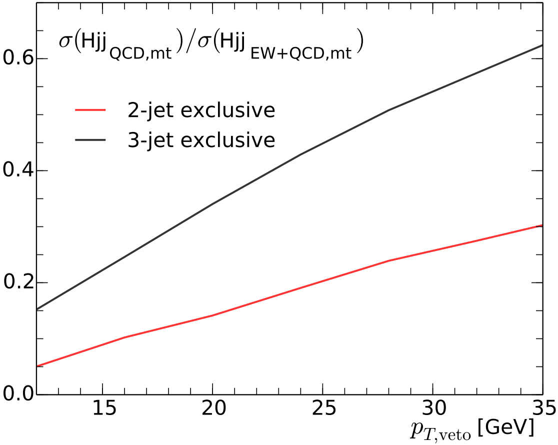


η reach at 100 TeV

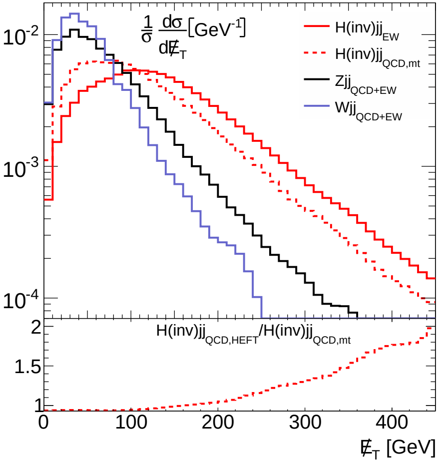


$\longrightarrow |\eta_j| < 5$ significantly restricts the phase-space at 100 TeV

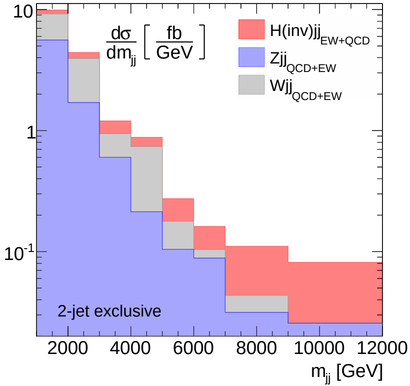
Gluon fusion contribution to signal region

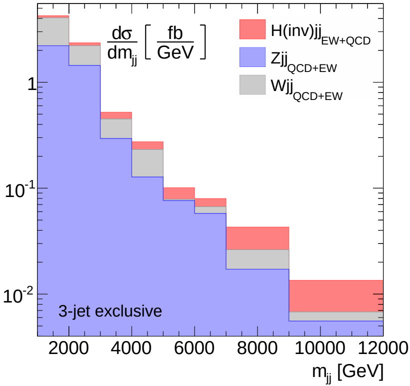


$H\to$inv kinematics

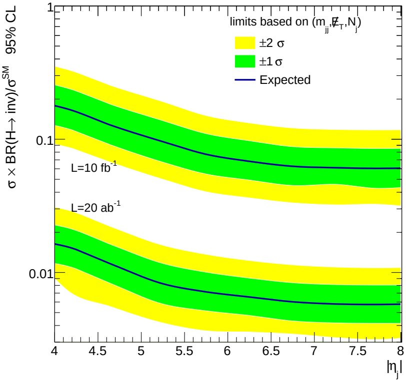


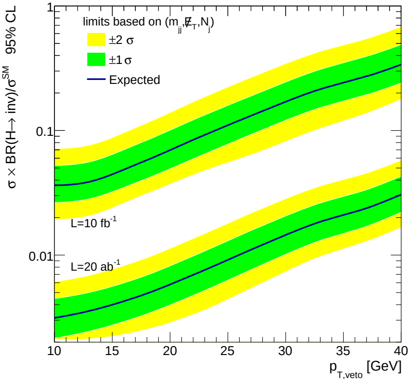
$H \to$inv kinematics 2





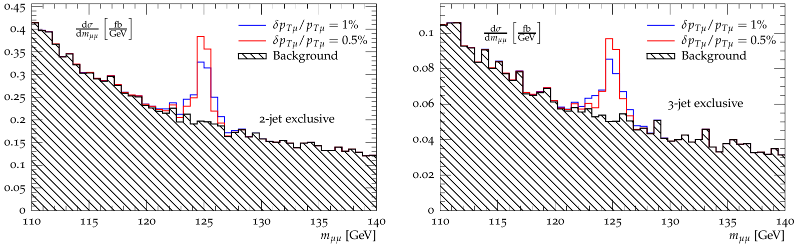
$H \to$inv sensitivity





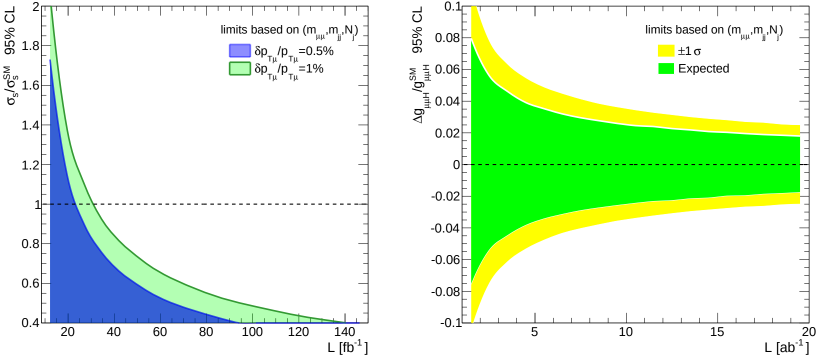
$\longrightarrow$ best for large $|\eta_j|$ and low $p_{T,\text{veto}}$

μ resolution affects



$\longrightarrow$ Good sensitivity in both 2- and 3-jet channels

$H \rightarrow \mu^+\mu^-$ sensitivity



$\longrightarrow$ for L=20 ab^{-1}, can exclude down to $\Delta g_{\mu\mu H}/g^{SM}_{\mu\mu H} = 2\%$

Conclusions

- 100 TeV collider a good environment for precision physics
- Can largely imporve on LHC sensitivity
- Ideally include η_j coverage up to 6
- Is sensitive to rare Higgs decays:
  $\longrightarrow H \rightarrow \text{inv} \sim 0.5\%$
  $\longrightarrow H \rightarrow \mu^+\mu^- \sim 2\%$