BSM review

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HXSWG kick-off meeting on FXS

BSM Higgs

SM Higgs → a scalar couples to particles as mass → trivial kinematics

BSM Higgs → admixture with pseudo-scalar? BSM induces higher-order effects (e.g. EFT)? → modified kinematics

BSM Higgs and FXS

Part of the FXS motivation

Higgs is quite SM-like

BUT

best sensitivity to NP may come from *extreme* kinematic regions

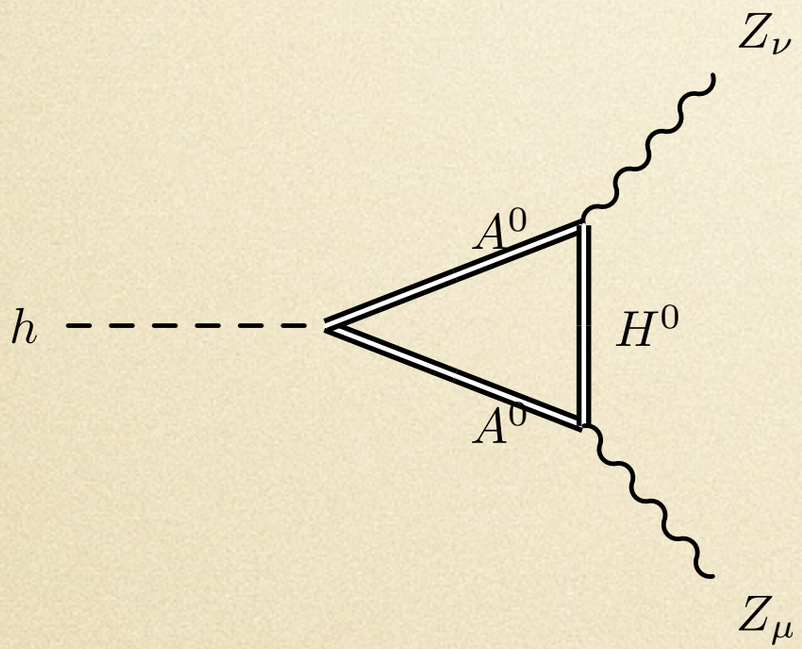
AND

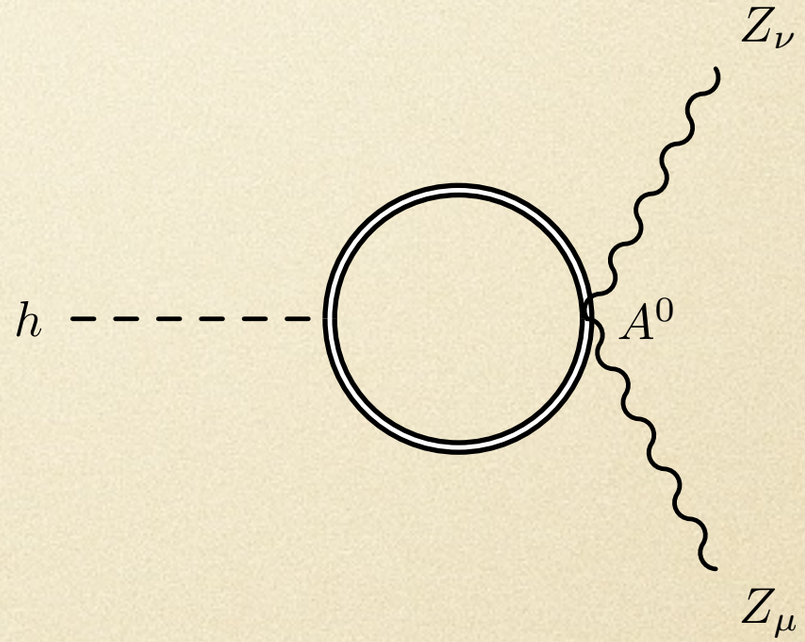
same NP may affect the BGs to the Higgs signals

BSM Higgs and FXS

take the EFT approach

e.g. effects of heavy scalars





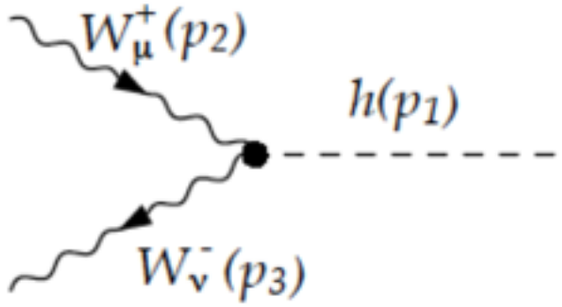
The effect below the mA mass is operators of the type

$$\frac{ig}{m_W^2}\bar{c}_W\left[\Phi^\dagger T_{2k}\overleftrightarrow{D}^\mu\Phi\right]D^\nu W^k_{\mu\nu}$$

$$\frac{2ig}{m_W^2}\bar{c}_{HW}\left[D^\mu\Phi^\dagger T_{2k}D^\nu\Phi\right]W^k_{\mu\nu}$$

Gorbahn, No, VS. 1502.07352

BSM Higgs and FXS



$$i\Big[\eta^{\mu\nu}\left(gm_W + g^{(1)}_{hww}p_2\cdot p_3 + g^{(2)}_{hww}(p_2^2+p_3^2)\right) - g^{(1)}_{hww}p_2^\nu p_3^\mu - g^{(2)}_{hww}\left(p_2^\nu p_2^\mu + p_3^\nu p_3^\mu\right) - \epsilon^{\mu\nu\rho\sigma}\tilde{g}_{hww}p_{2\rho}p_{3\sigma}\Big]$$

Alloul, Fuks, VS. 1310.5150

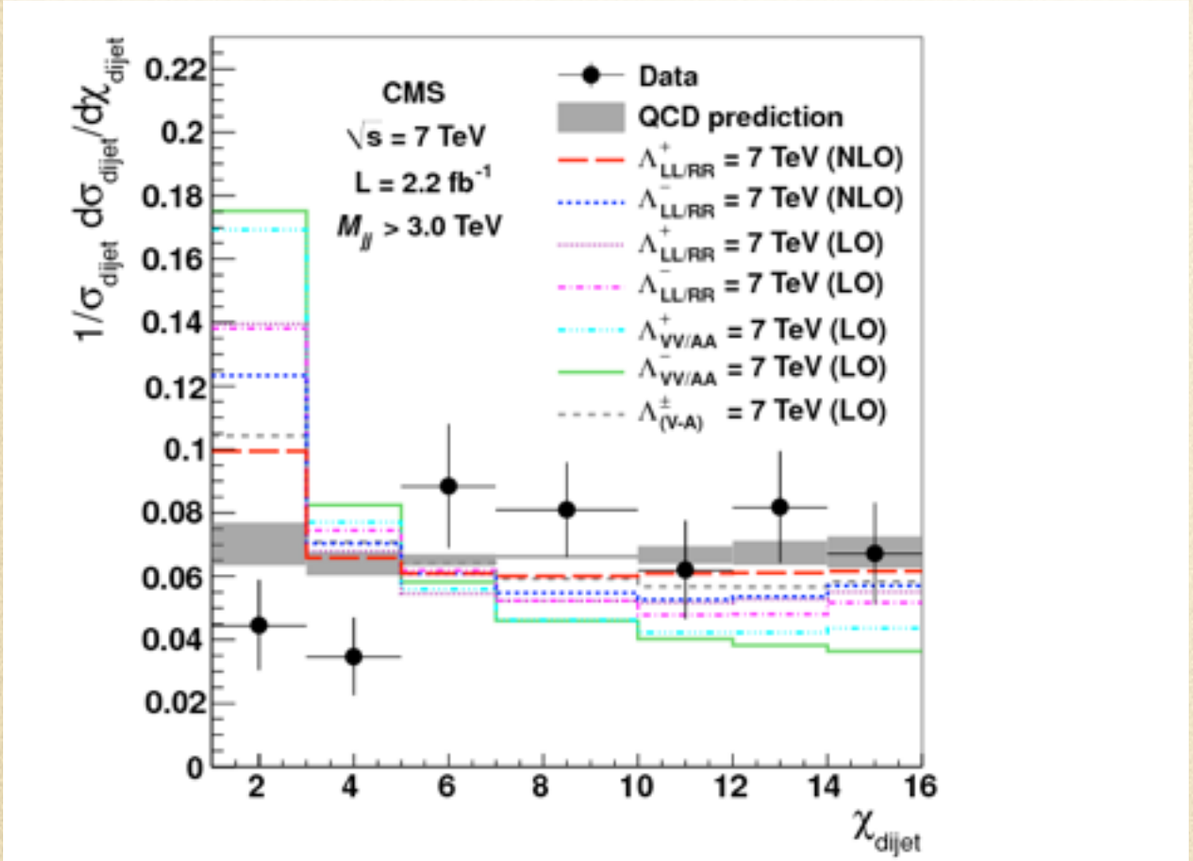
$$g^{(1)}_{hww} = \frac{2g}{m_W}\bar{c}_{HW}$$

$$g^{(2)}_{hww} = \frac{g}{m_W}\Big[\bar{c}_W + \bar{c}_{HW}\Big]$$

$$\tilde{g}_{hww} = \frac{2g}{m_W}\tilde{c}_{HW}$$

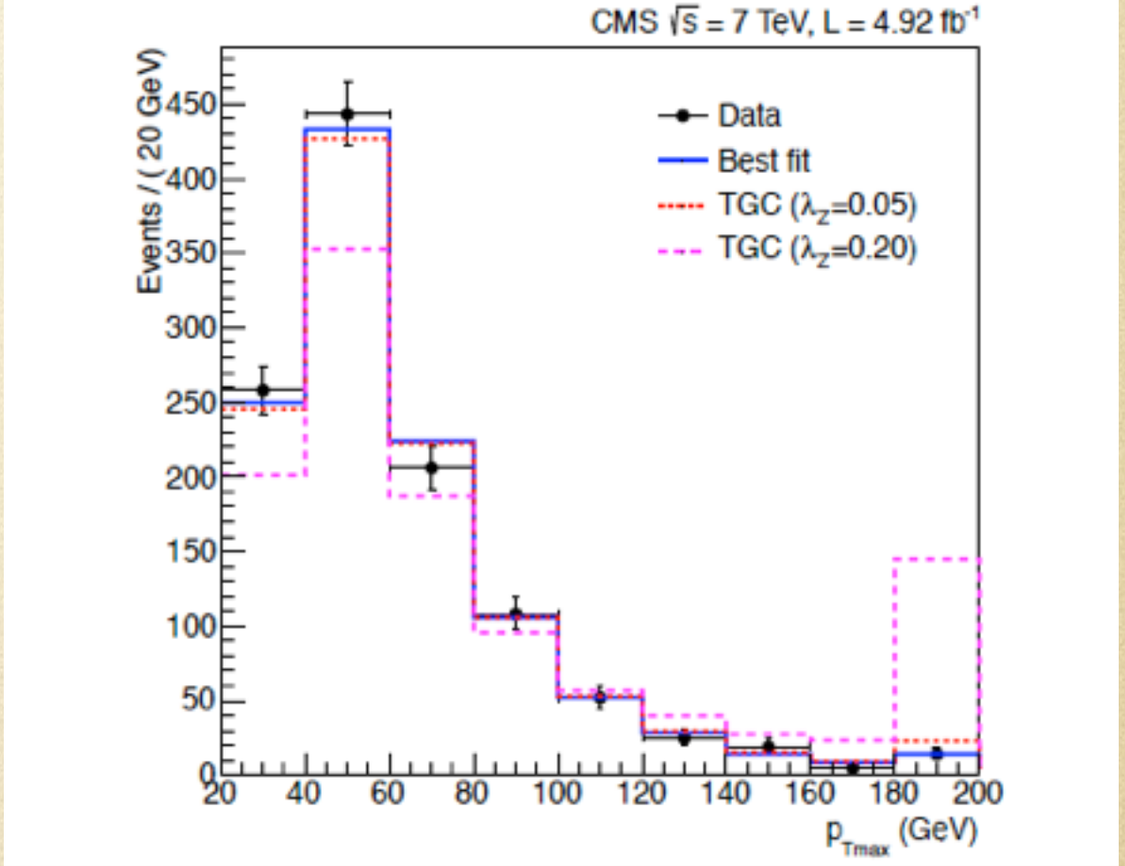
EFT affects momentum dependence: angular, pT and inv mass distributions

dijet searches



Dijet angular distribution

TGCs



leading lepton pT

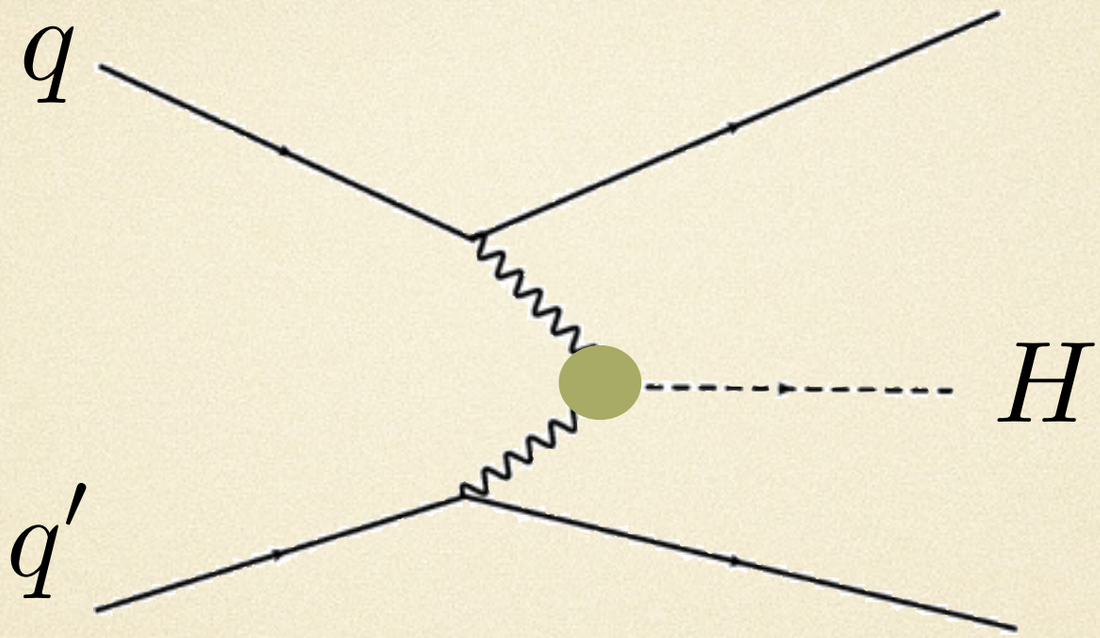
Run1 constraints

one-by-one global

Operator	Coefficient	LHC Constraints Individual	Marginalized
$\mathcal{O}_W = \frac{ig}{2}\left(H^\dagger \sigma^a \overleftrightarrow{D^\mu} H\right) D^\nu W^a_{\mu\nu}$ $\mathcal{O}_B = \frac{ig'}{2}\left(H^\dagger \overleftrightarrow{D^\mu} H\right) \partial^\nu B_{\mu\nu}$	$\frac{m_W^2}{\Lambda^2}(c_W - c_B)$	$(-0.022, 0.004)$	$(-0.035, 0.005)$
$\mathcal{O}_{HW} = ig(D^\mu H)^\dagger \sigma^a (D^\nu H) W^a_{\mu\nu}$	$\frac{m_W^2}{\Lambda^2} c_{HW}$	$(-0.042, 0.008)$	$(-0.035, 0.015)$
$\mathcal{O}_{HB} = ig'(D^\mu H)^\dagger (D^\nu H) B_{\mu\nu}$	$\frac{m_W^2}{\Lambda^2} c_{HB}$	$(-0.053, 0.044)$	$(-0.045, 0.075)$
$\mathcal{O}_{3W} = \frac{1}{3!} g \epsilon_{abc} W^{a\,\nu}_{\mu} W^b_{\nu\rho} W^{c\,\rho\mu}$	$\frac{m_W^2}{\Lambda^2} c_{3W}$	$(-0.083, 0.045)$	$(-0.083, 0.045)$
$\mathcal{O}_g = g_s^2 \lvert H\rvert^2 G^A_{\mu\nu} G^{A\mu\nu}$	$\frac{m_W^2}{\Lambda^2} c_g$	$(0, 3.0) \times 10^{-5}$	$(-3.2, 1.1) \times 10^{-4}$
$\mathcal{O}_\gamma = g'^2 \lvert H\rvert^2 B_{\mu\nu} B^{\mu\nu}$	$\frac{m_W^2}{\Lambda^2} c_\gamma$	$(-4.0, 2.3) \times 10^{-4}$	$(-11, 2.2) \times 10^{-4}$
$\mathcal{O}_H = \frac{1}{2}(\partial^\mu \lvert H\rvert^2)^2$	$\frac{v^2}{\Lambda^2} c_H$	$(-0.14, 0.194)$	$(-, -)$
$\mathcal{O}_f = y_f \lvert H\rvert^2 \bar{F}_L H^{(c)} f_R + \text{h.c.}$	$\frac{v^2}{\Lambda^2} c_f$	$(-0.084, 0.155)(c_u)$ $(-0.198, 0.088)(c_d)$	$(-, -)$ $(-, -)$

Ellis, VS and You. 1404.3667, 1410.7703

The example of VBF



total rates depend on NP effects

e.g. one operator

Run1 $\bar{c}_W \in [-0.01, 0.002]$

selection cuts

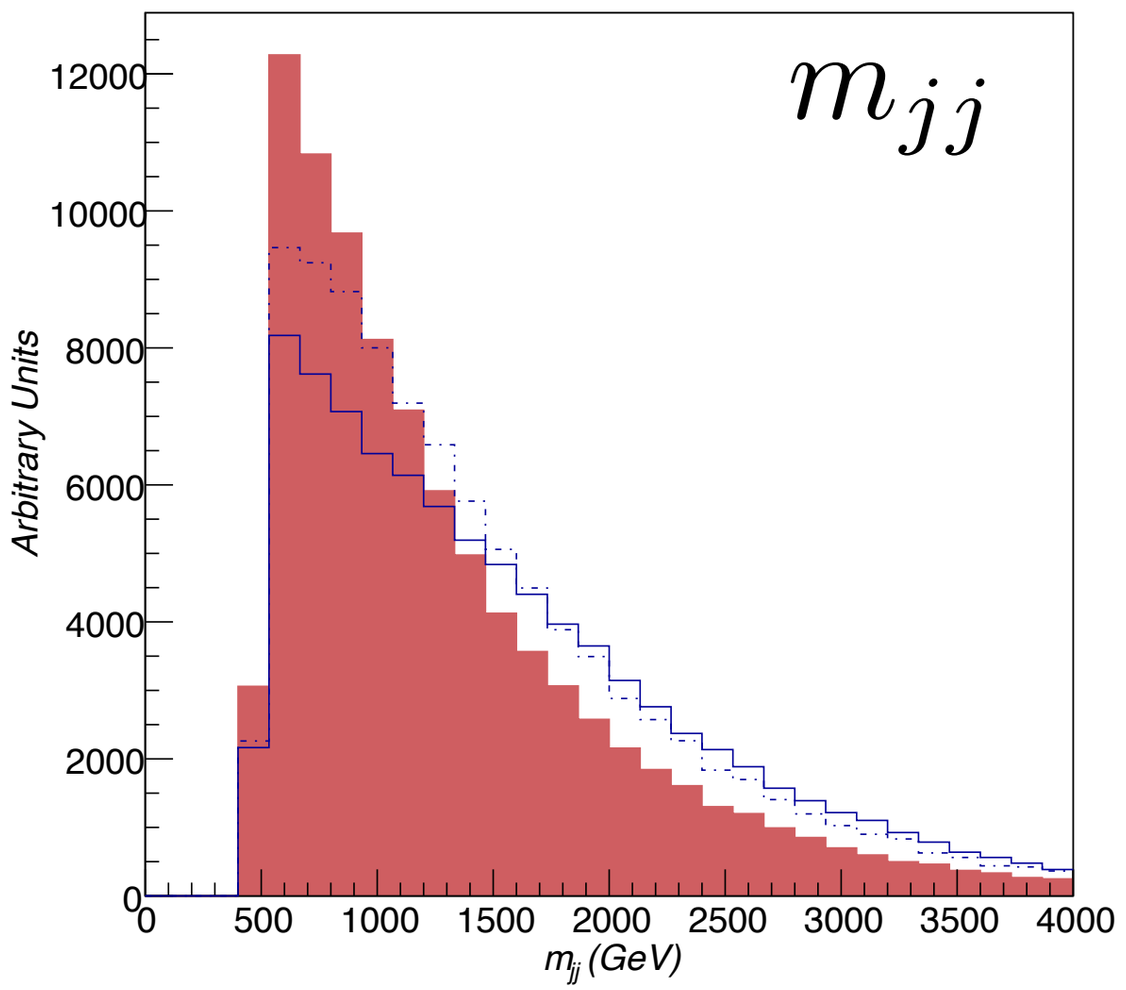
$\Delta\eta_{jj} > 3$

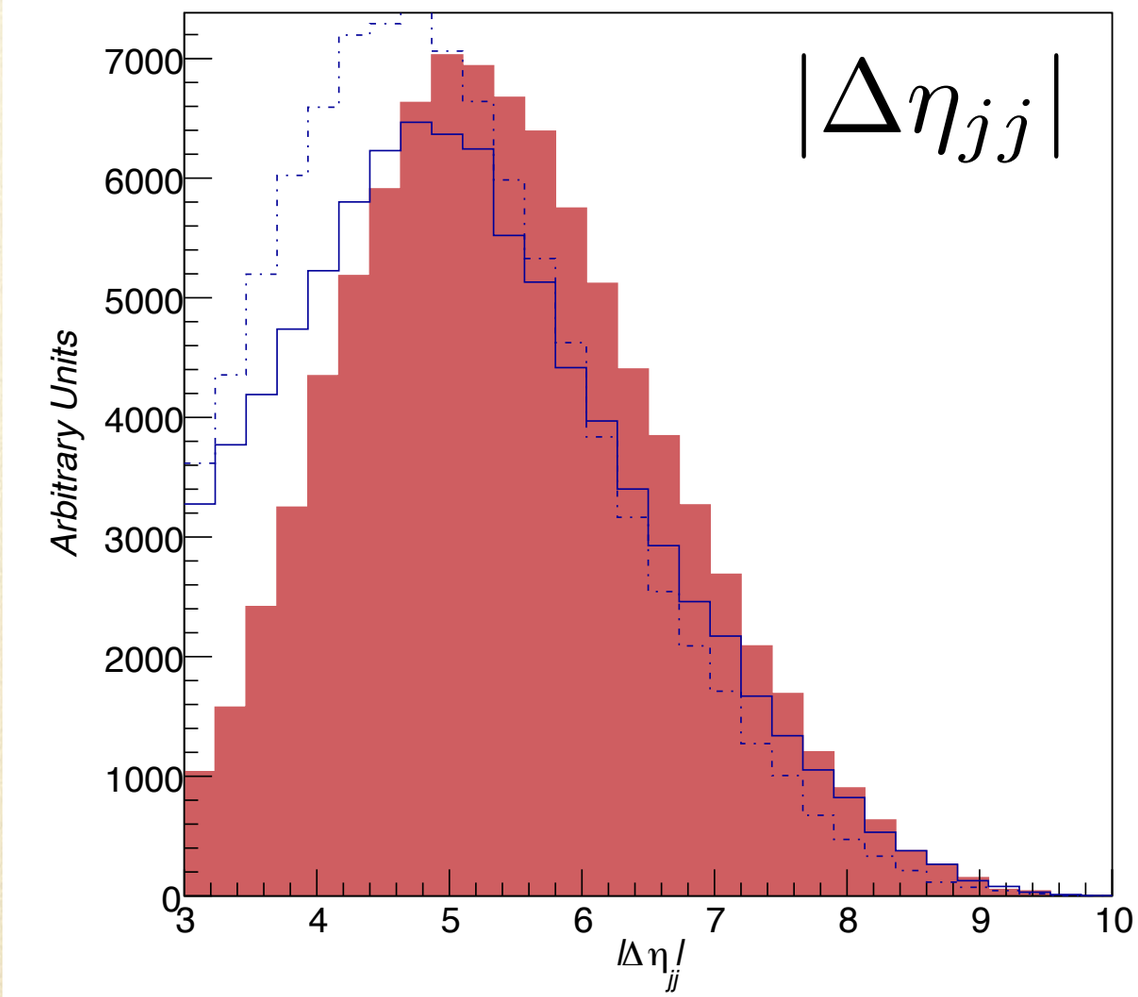
$m_{jj} > 500$ GeV

$$\mu_{VBF} = 1 - 8.2\,\bar{c}_W$$

The example of VBF

kinematics





normalized to same area

values outside Run1 limits

for illustration only

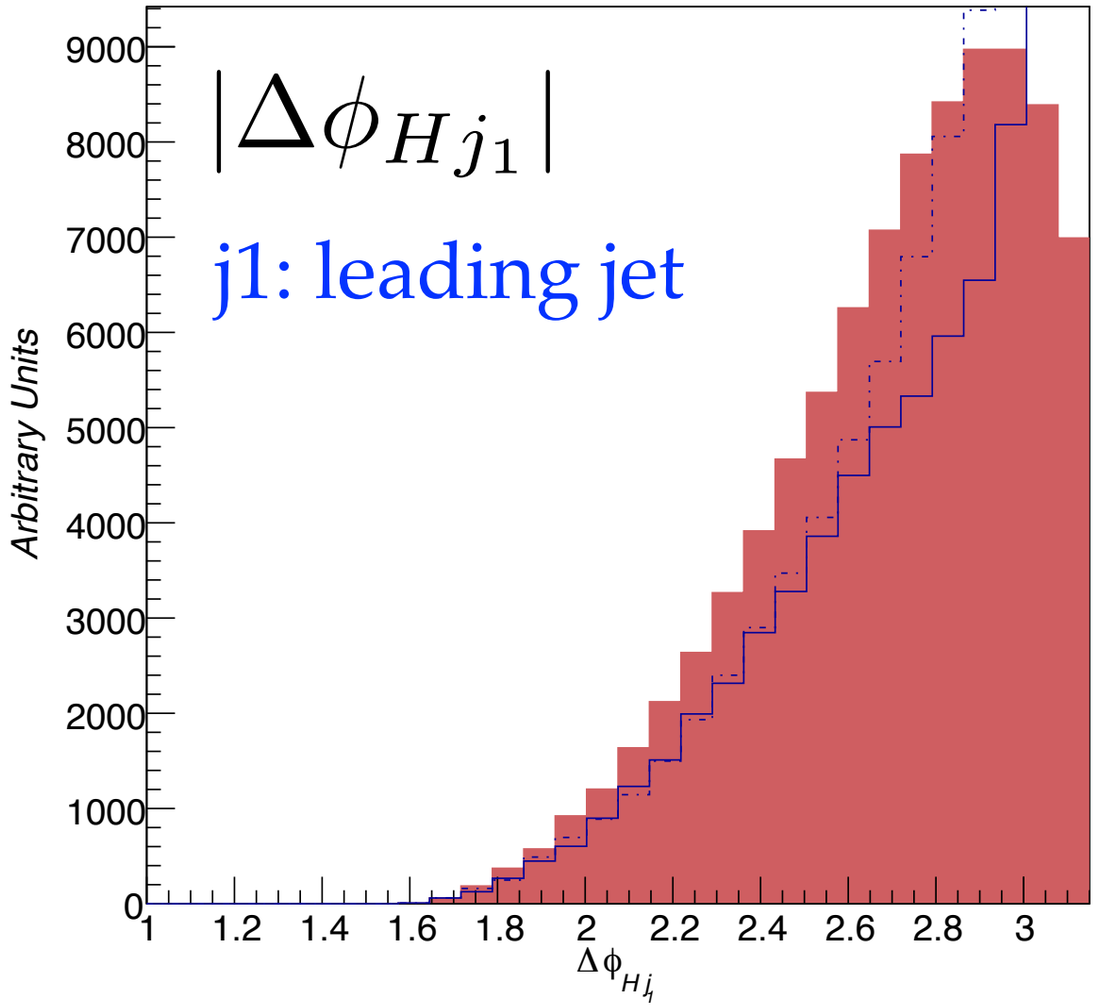
SM

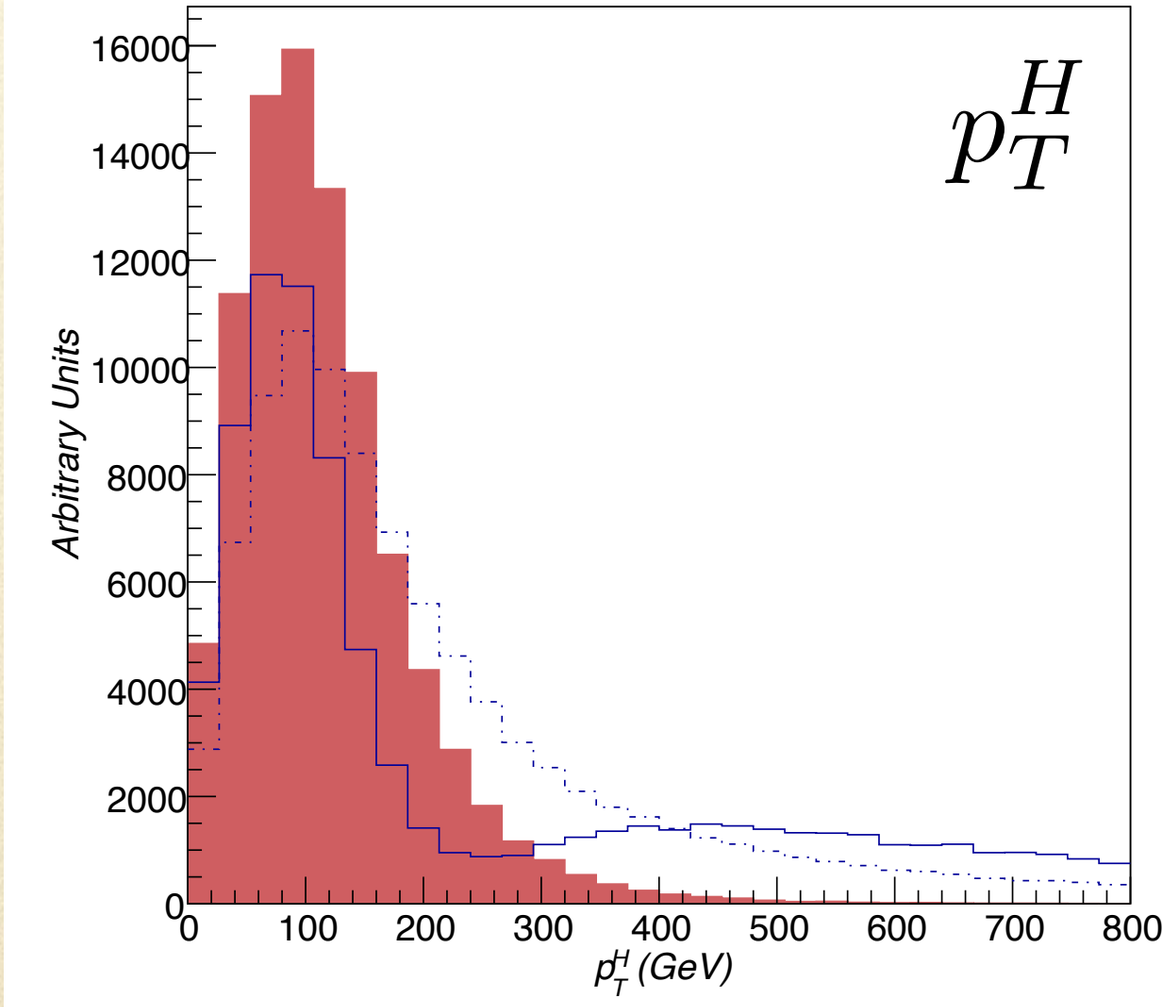
$\bar{c}_W = -0.1$

$\bar{c}_W = 0.1$

The example of VBF

kinematics





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SM

$\bar{c}_W = -0.1$

$\bar{c}_W = 0.1$

The example of VBF

Comments:

Plots are LO, NLO on its way

I haven't discussed Njet bins, but also important: migration due to modified kinematics

Regions with no SM background, but syst estimates are also very useful

Background contamination by BSM

In VBF Higgs

important background VV+jets

BUT

trilinear and quartic gauge couplings

are also modified by the same EFT

$$g_1^Z = 1 - \frac{1}{c_W^2}\left[\bar{c}_{HW} - (2s_W^2 - 3)\bar{c}_W\right] \;, \quad \kappa_Z = 1 - \frac{1}{c_W^2}\left[c_W^2\,\bar{c}_{HW} - s_W^2\,\bar{c}_{HB} - (2s_W^2 - 3)\bar{c}_W\right]$$

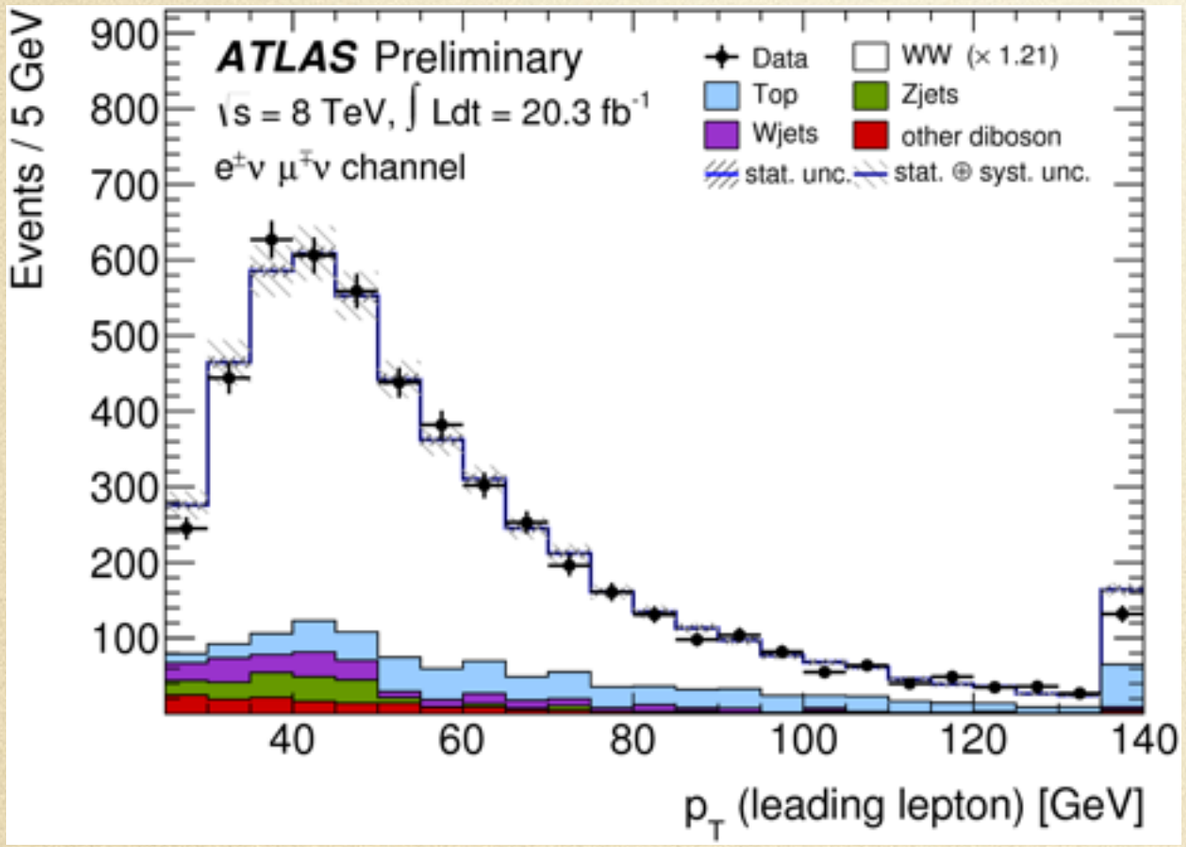
TGCs $\quad g_1^\gamma = 1 \;, \quad \kappa_\gamma = 1 - 2\,\bar{c}_W - \bar{c}_{HW} - \bar{c}_{HB} \;, \quad \lambda_\gamma = \lambda_Z = 3\,g^2\,\bar{c}_{3W}$

Gorbahn, No, VS. 1502.07352

and these gauge anomalous couplings lead to modified BG distributions as well

Background contamination by BSM

diboson production



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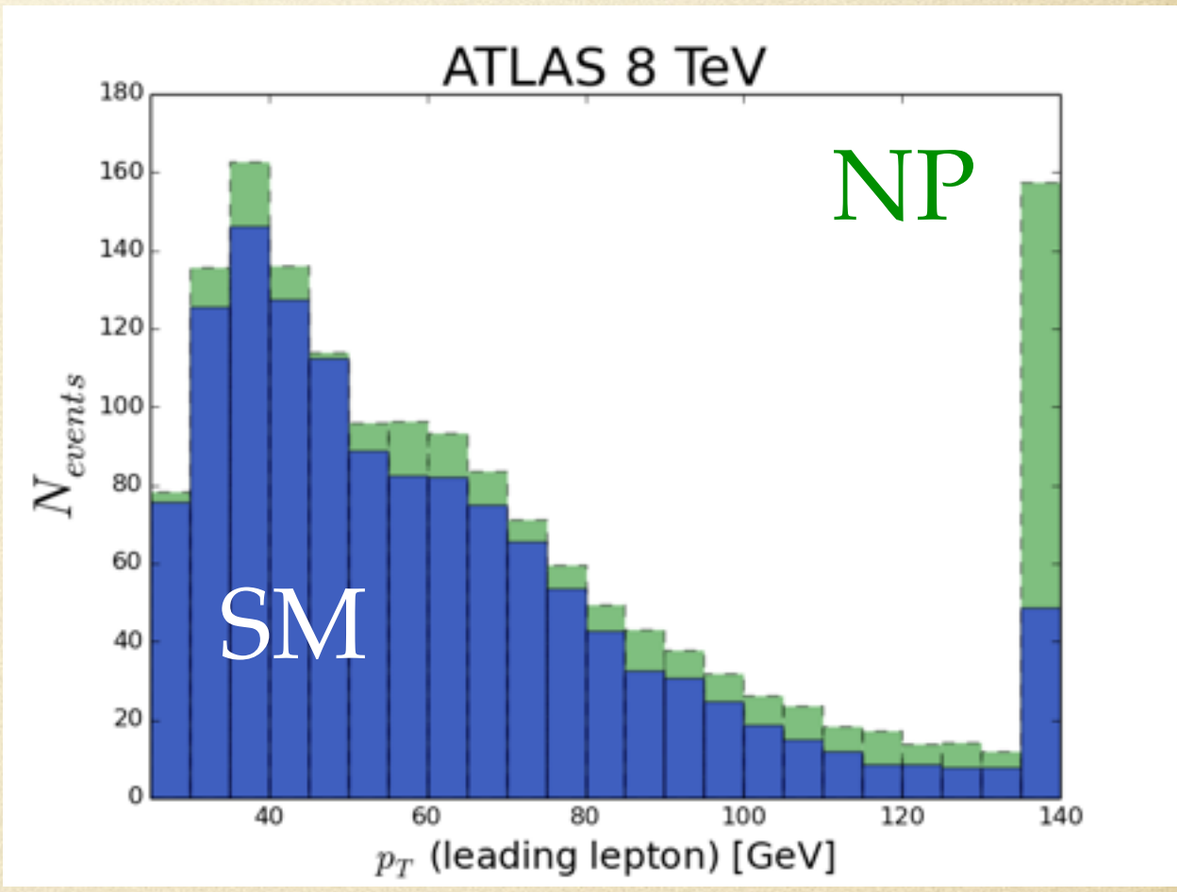


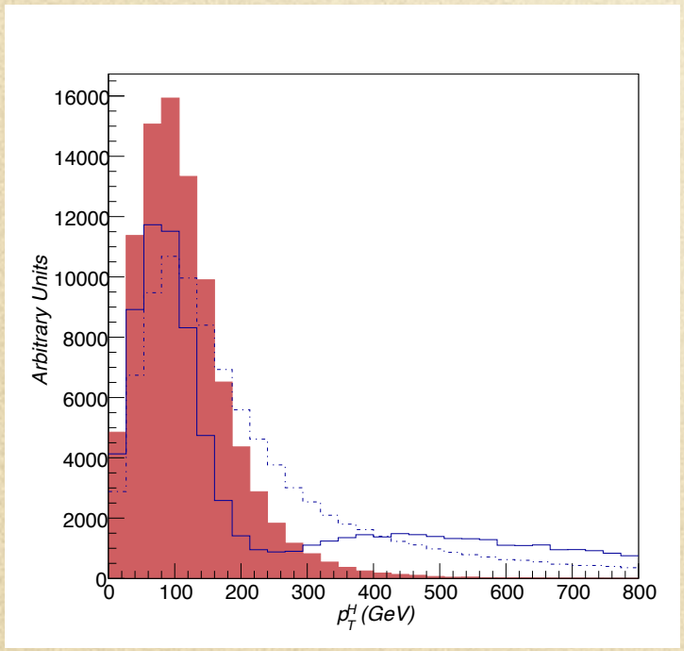
Ellis, VS and You. 1404.3667, 1410.7703

Wrapping up

The BSM Higgs changes total rates,
but is more BSMish in specific kinematic regions
-> fiducial region? include BSM reach

Backgrounds to Higgs signal are also subject to NP effects

I think we need more studies on optimal binning
for BSM sensitivity (EFT, pseudo, other BSM)
within boundaries of current limits

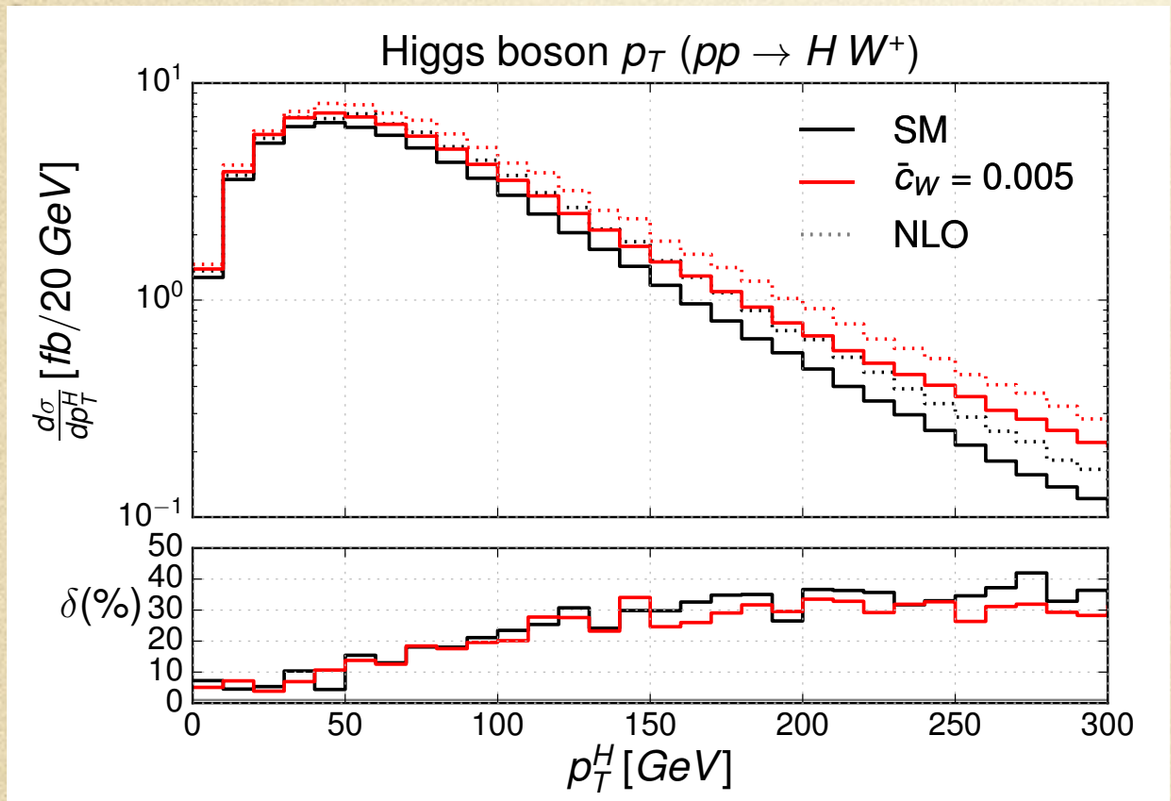


e.g. pTH in VBF, 200 GeV

Need to clarify how pseudo-XS (BG-substracted, VBF/ggF contamination) will be dealt with consistently

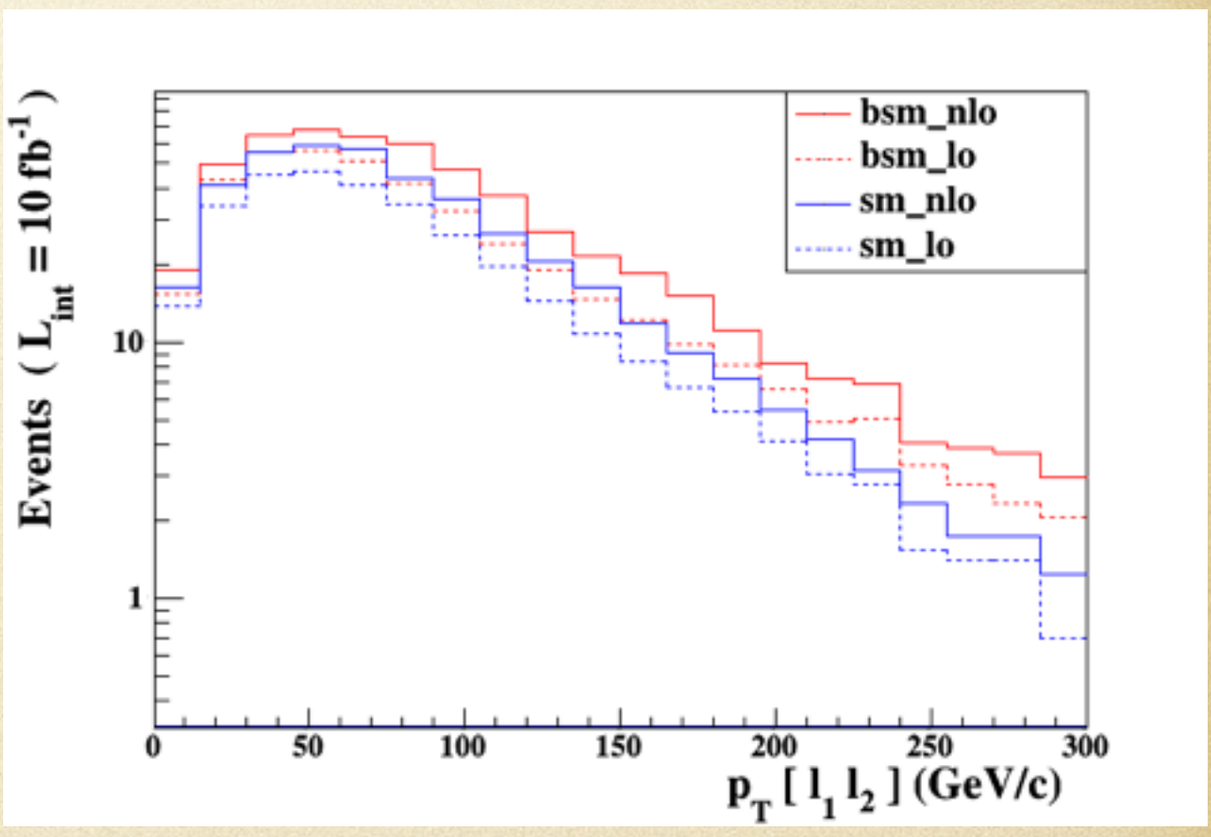
EFT NLO QCD

MCFM&POWHEG



Mimasu, VS, Williams. in prep

aMC@NLO



deGrande, Fuks, Mawatari, Mimasu, VS. in prep

timeline

general HXSWG meeting mid-July