bbH in aMC@NLO_MG5+PY8: *uncertainties in the acceptance due to the shower scale; a first look*

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LHCHXSWG/bbH group meeting,

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We are talking about parameters α, f_1,f_2 in eq.(3.5) of arXiv:1409.5301 defining the range of shower scale Q_{sh}

mally of NNLO and beyond can still contribute to the cross section. In order to assess this higher-order systematics of MC origin (which in MC@NLO is tantamount to the matching systematics), in MadGraph5_aMC@NLO one is given the possibility of setting the value[3] of $Q_{\rm sh}$; this value is actually picked up at random in a user-defined range:

$$\alpha f_1 \sqrt{s_0} \le Q_{\rm sh} \le \alpha f_2 \sqrt{s_0}\,, \tag{3.5}$$

so as to avoid possible numerical inaccuracies due to the presence of sharp thresholds; more details can be found in sect. 2.4.4 of ref. [27] (see in particular eq. (2.113) and the related discussion). In eq. (3.5), s_0 is the Born-level partonic c.m. energy squared, and α, f_1, and f_2 are numerical constants whose defaults are 1, 0.1, and 1 respectively. The

As in the paper, I keep

f_1=0.1, f_2=1,

take

α = ¼ and 1

and see how kinematical acceptance is changing

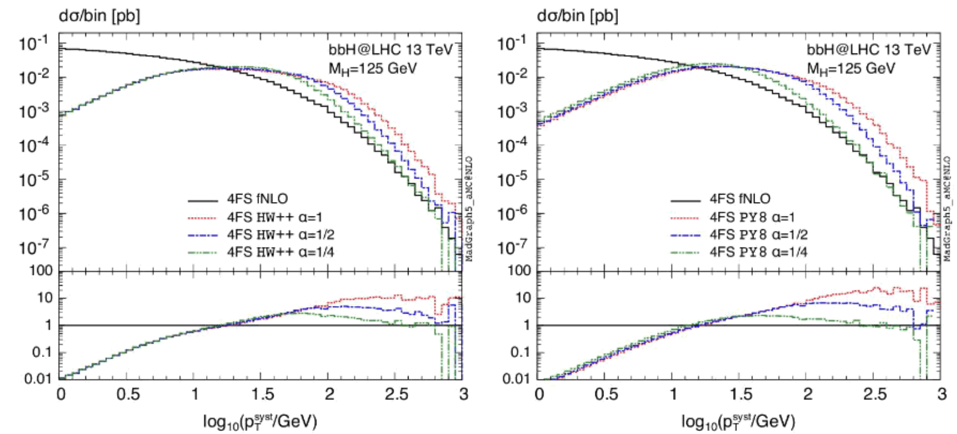


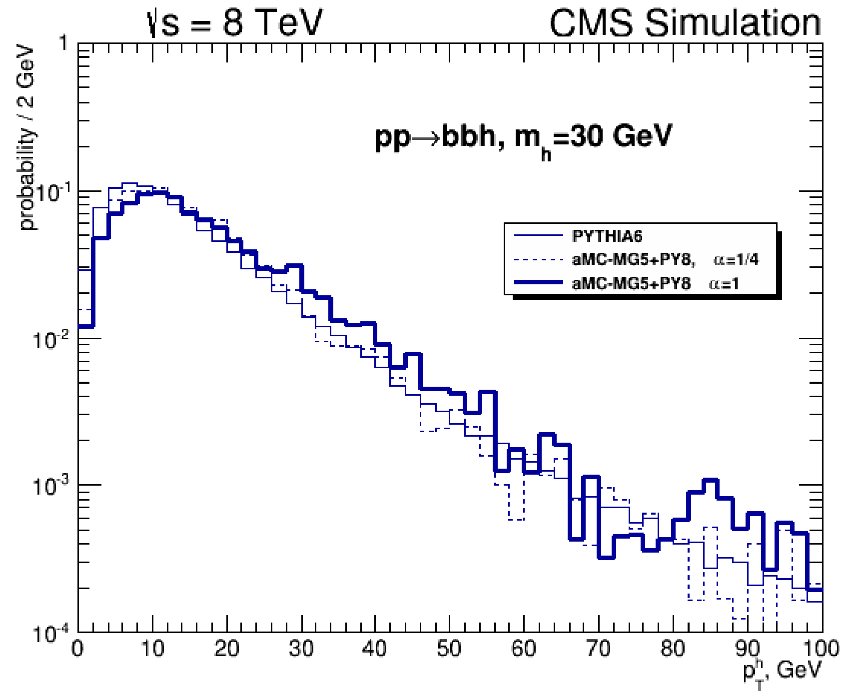
Figure 5: Transverse momentum of the $b\bar{b}H$ or BBH system, in the 4FS at fNLO (black solid), and at NLO+PS with $\alpha = 1$ (red dotted), $\alpha = 1/2$ (blue dot-dashed), and $\alpha = 1/4$ (green dash-double-dotted). Left panel: Herwig++; right panel: Pythia8.

- **Consider two values of m_H with selections used in the CMS analyses:**
  - **m_A=30 GeV, 2HDM pp->bbA, A->$\mu\mu$ analysis**
    - **$p_T^{\mu 1,2}$ > 25, 5 GeV, $|\eta^{\mu 1,2}|$<2.1, 2.4**
    - **>=1 b-jet, p_T > 30 GeV,* $|\eta|$<2.4**
  - **m_A=400 GeV, MSSM pp->bbA, A->$\tau_h\tau_h$ analysis**
    - **p_T^{τ} > 45 GeV**, $|h^{\tau}|$ < 2.4****
    - **>=1 b-jet p_T>30 GeV*, $|\eta|$<2.4**
    - **no other jets p_T > 30 GeV, $|\eta|$<4.7**

All selections are at the parton level; parton jets anti-kt 0.5 are reconstructed

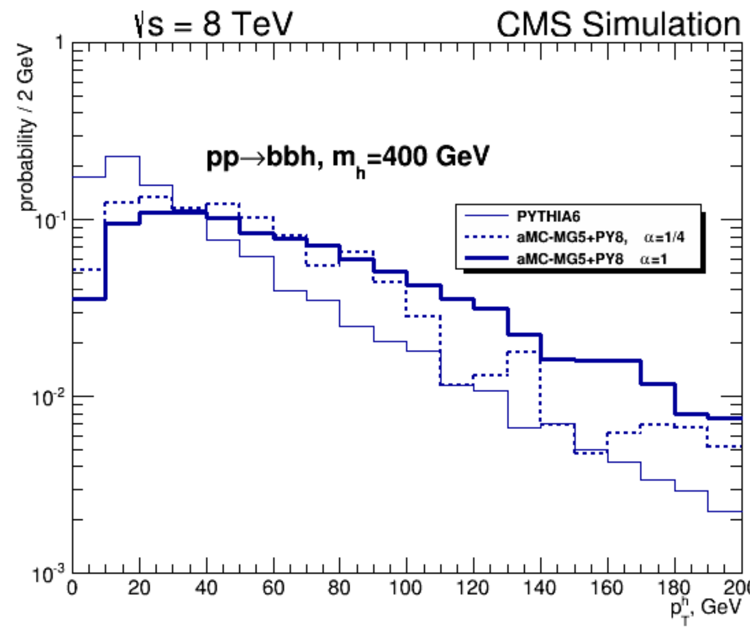
- * in CMS actual cut used is 20 GeV
- ** in CMS we cut on p_T/η of τ_h

m_A=30 GeV



MC generator	PY6	aMC@NLO_MG5 + PY8	
Parton level selections		Shape parameters: Eq 3.5 arXiv:1409.5301	
		0.025-0.25 (α=1/4)	0.1-1.0 (α=1)
$p_T^{\mu1,2}$> 25, 5 GeV $\|\eta^{\mu1,2}\|$ < 2.1, 2.4 ΔR(μ-j)>0.5	0.102	0.106	0.147
>=1 b-jet p_T^b > 30 GeV, $\|\eta^b\|$ < 2.4	0.400	0.283	0.356

m_A=400 GeV



MC generator	PY6	aMC@NLO_MG5 + PY8	
Parton level selections		Shape parameters: Eq 3.5 arXiv:1409.5301	
		0.025-0.25 (α=1/4)	0.1-1.0 (α=1)
p_T^{τ}> 45, $\lvert\eta^{\tau}\rvert$ < 2.4 $\Delta R(\tau\text{-}j)$>0.5	0.860	0.895	0.894
>= 1b-jet p_T^b > 30 GeV, $\lvert\eta^b\rvert$< 2.4	0.346	0.383	0.468
1 b-jet, no other jets p_T > 30 GeV, $\lvert\eta\rvert$<4.7	0.579	0.379	0.296

Conclusions

- **A first look at acceptance uncertainty due to the shower scale parameters in pp->bbA process modelling with aMC@NLO_MG5+PY8**
  - **considerable change of Higgs p_T is observed with the variation of the shower scale parameters**
  - **for low mass Higgs 30 GeV the change in the acceptance**
    - **~ 50 % with lepton p_T selections**
    - **~ 20 % with b-jet p_T selections**
  - **for high mass Higgs 400 GeV the change in the acceptance**
    - **negligible for τ p_T selection (since cuts on $p_T << m_A$)**
    - **~ 20 % with b-jet p_T selection**
    - **~ 20 % with additional jet veto requirement**

bbH generation in CMS: status and plans

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LHCHXSWG/bbH group meeting,

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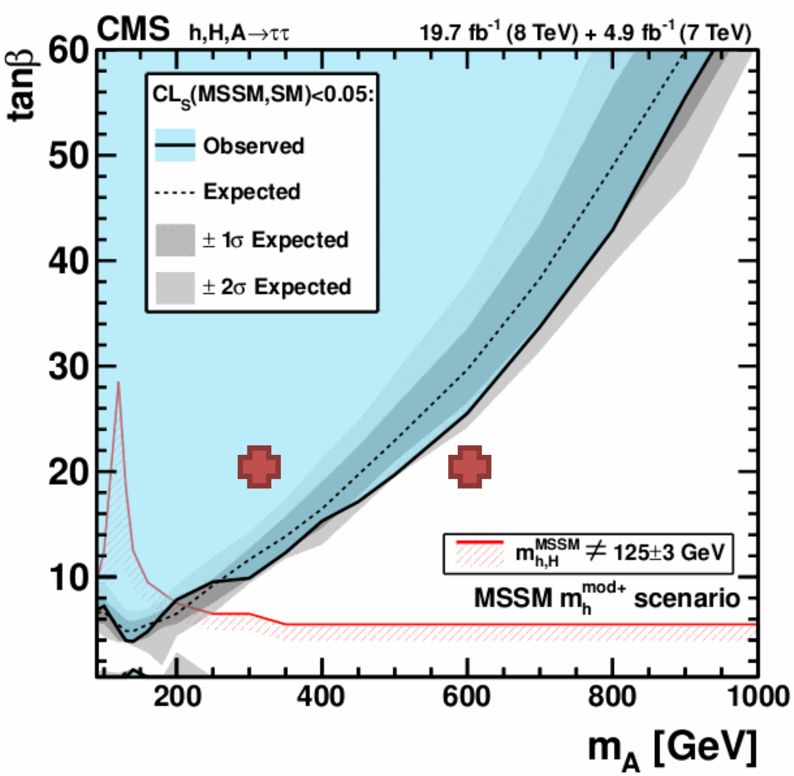
- **MSSM H->μμ,ττ analyses used so far the bb(H+A) generation with PY6**
  - **bbH contribution is dominant at high tanβ**



- **Start recently 2HDM pp->bbA->μμ,ττ analyses with light A, 20 < m_A < 70 GeV**
  - **again bbA is generated with PY6**

- **Selections for b-tagged event category:**
  - one b-jet p_T > 20 (or 30 GeV), $|\eta| < 2.4$
  - Jet veto: <= 1 jet p_T > 30 GeV, $|\eta| < 4.7$
- **Let's compare efficiency given by PY6 and the recent bbH implementation in MG5_aMC@NLO by Marius Wiesemann et al. arXiv:1409.5301 for two cases:**
  - MSSM heavy H in pp->bbH, H->$\tau_h\tau_h$, m_H = 400 GeV
  - 2HDM light A in pp->bbA, A->$\mu\mu$, m_A = 30 GeV

Signal selection efficiencies MG5_aMC@NLO+PY8 vs PY6 pp->bba, a->$\mu\mu$, m_a=30 GeV

	Selection on muon p_T, GeV $\|\eta\|$ < 2.1 for both muons					
	10		15		20	
	NLO+PY8	PY6	NLO+PY8	PY6	NLO+PY8	PY6
Muon kinematics	0.368	0.379	0.059	0.057	0.013	0.014
>= 1 b-jet after μ's sel. p_T >30 GeV, $\|\eta\|$<2.4	0.114	0.106	0.307	0.379	0.613	0.731
Following efficiencies are relative to muon and >= 1 b-jet selection; jets p_T^j > 30 GeV						
1 b-jet no other jets $\|\eta\|$<2.4	0.454	0.799	0.336	0.776	0.184	0.708
1 b-jet >=1 light jet $\|\eta\|$<2.4	0.464	0.090	0.562	0.118	0.694	0.166
2 b-jets + X	0.081	0.111	0.102	0.106	0.122	0.125
1 b-jet no other jets $\|\eta\|$< 4.7	0.402	0.751	0.298	0.722	0.171	0.640

Conclusion from comparison of pp->bbA, A->μμ process m_A=30 GeV in PY6 and MG5_aMC@NLO+PY8

- comparable efficiency for muon and b-jet selections
- Dramatic difference for jet veto selections !
  - aMC@NLO is much more “jetty”
  - If one uses jet veto in the analysis the signal should be generated with aMC@NLO_MG5

Signal selection efficiencies MG5_aMC@NLO+PY8 vs PY6 pp->bbA, A->$\tau\tau$, m_A=400 GeV

	Selection on τ_h p_T and η for both τ_h used in CMS MSSM H->$\tau_h\tau_h$ analysis (still need to apply on τ_h but not to τ)	
	p_T^{τ} >45 GeV, $\vert\eta^{\tau}\vert$ < 2.4, DR(τ-j) > 0.5	
	NLO+PY8	PY6
Tau kinematics	0.895	0.860
>= 1 b-jet after μ's sel. p_T >30 GeV, $\vert\eta\vert$<2.4	0.383	0.346
Following efficiencies are relative to muon and >= 1 b-jet selection; jets p_T^j > 30 GeV		
1 b-jet no other jets $\vert\eta\vert$<2.4	0.466	0.660
1 b-jet >=1 light jet $\vert\eta\vert$<2.4	0.378	0.194
2 b-jets + X	0.155	0.147
1 b-jet no other jets $\vert\eta\vert$< 4.7	0.379	0.579

Conclusion from comparison of pp->bbA, A->$\tau\tau$ process m_A=400 GeV in PY6 and MG5_aMC@NLO+PY8

- comparable efficiency for τ and b-jet selections
- ~ 30 % difference for jet veto selections
  - aMC@NLO is much more “jetty”
  - If one uses jet veto in the analysis the signal should be generated with aMC@NLO_MG5

Plans

- **More detailed analysis of the PY6 vs MG5_aMC@NLO+PY8 differences in the selection efficiency for pp->bbH process**
  - **Evaluation of the acceptance uncertainty with aMC@NLO**
- **13 TeV Higgs signal request incudes pp->bbH process to be generated with MG5_aMC@NLO+PY8**
  - **need to understand how to setup Higgs width in MSSM**
- **Consider gg->H+g->bb contribution to pp->bbH**

123	HIG (Yuta Takahashi) tautau group	SUSY : ggH + H->tautau	Pythia
124	HIG (Yuta Takahashi) tautau group	SUSY : ggH + H->tautau	Powheg
125	HIG (Yuta Takahashi) tautau group	SUSY : bbH + H->tautau	Pythia
126	HIG (Yuta Takahashi) tautau group	SUSY : bbH + H->tautau	Madgraph5_aMCatNLO (NLO)
127	HIG (Yuta Takahashi) tautau group	SUSY : ggH (H->hh->2tau2b)	Pythia
128	HIG (Yuta Takahashi) tautau group	SUSY : bbH (H->hh->2tau2b)	Pythia
129	HIG (Yuta Takahashi) tautau group	SUSY : A->Zh (Z->ll, h->tautau)	Madgraph5
130	HIG (Yuta Takahashi) tautau group	SUSY : A->Zh (Z->ll, h->bb)	Pythia
131	HIG (Yuta Takahashi) tautau group	nMSSM bba1 + a1->tautau	Pythia
132	HIG (Yuta Takahashi) tautau group	nMSSM bba1 + a1->tautau	Madgraph5_aMCatNLO (NLO)