LHCXS WG3: MSSM

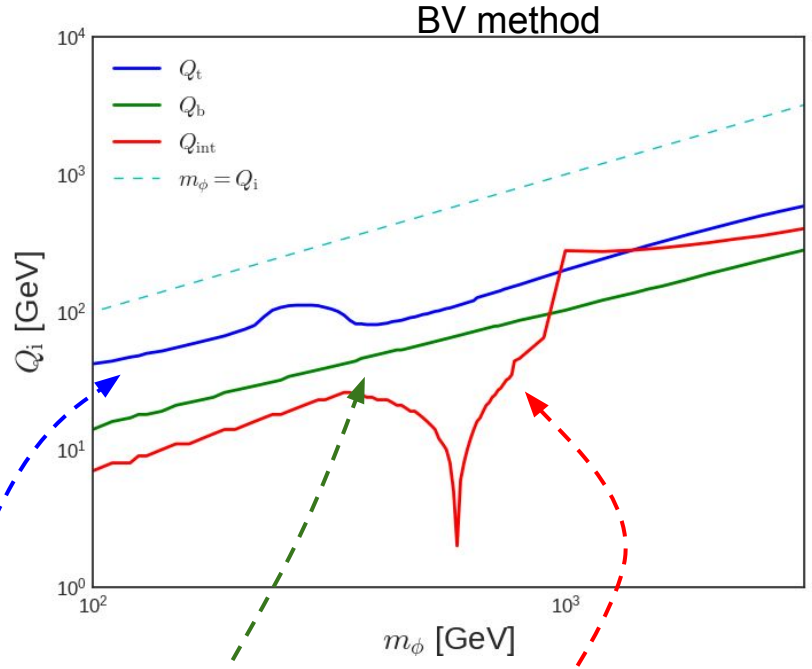
Conveners meeting - 17 Oct

Guillermo Hamity
University of Sheffield

MSSM ggH pT reweight

Higgs p_T in gluon fusion

- Higgs boson pT at fixed order has **logarithmic divergences as $p^{\phi}_{T} \to 0$**
- Resummation at all orders of α_s matched with order at **matching scale**
- Relevant: **t- , b-loops** and **interference**
- Determination of resummation scales discussed in YR4



Resummed result

$$\frac{\mathrm{d}\sigma}{\mathrm{d}p_T^{\phi}} = \frac{\mathrm{d}\sigma_{\mathrm{t}}}{\mathrm{d}p_T^{\phi}}\bigg|_{\mu_{\mathrm{t}}} + \frac{\mathrm{d}\sigma_{\mathrm{b}}}{\mathrm{d}p_T^{\phi}}\bigg|_{\mu_{\mathrm{b}}} + \frac{\mathrm{d}\sigma_{\mathrm{int}}}{\mathrm{d}p_T^{\phi}}\bigg|_{\mu_{\mathrm{int}}}$$

Prescription for A, H, h p_T in MSSM

- Detailed in presentation by Yuta
- For any $\mathbf{m_\phi}$, **pT** distribution is sum of **t-only, b-only** and **int** distributions
  - Relative yields of each component depends on tanB

presentation by Yuta

Procedure

- Code provided by Andrew on git
- Generate three $\mathbf{p^\phi_T}$ templates in POWHEG-BOX/ggH-2HDM (ME) +PYTHIA(PS) for each $\mathbf{m_\phi}$
- Reweight relative contributions of templates by MSSM/2HDM Yukawa rescaling

Full Formula

top-only

$$\left(\frac{Y_{t,\mathrm{MSSM}}}{Y_{t,2\mathrm{HDM}}}\right)^2 \sigma^t_{2\mathrm{HDM}}(Q_t) + \left(\frac{Y_{b,\mathrm{MSSM}}}{Y_{b,2\mathrm{HDM}}}\right)^2 \sigma^b_{2\mathrm{HDM}}(Q_b)$$

bottom-only

t+b interference

$$+ \left(\frac{Y_{t,\mathrm{MSSM}}}{Y_{t,2\mathrm{HDM}}}\frac{Y_{b,\mathrm{MSSM}}}{Y_{b,2\mathrm{HDM}}}\right)\left\{\sigma^{t+b}_{2\mathrm{HDM}}(Q_{tb}) - \sigma^t_{2\mathrm{HDM}}(Q_{tb}) - \sigma^b_{2\mathrm{HDM}}(Q_{tb})\right\}$$

Rescaling to MSSM

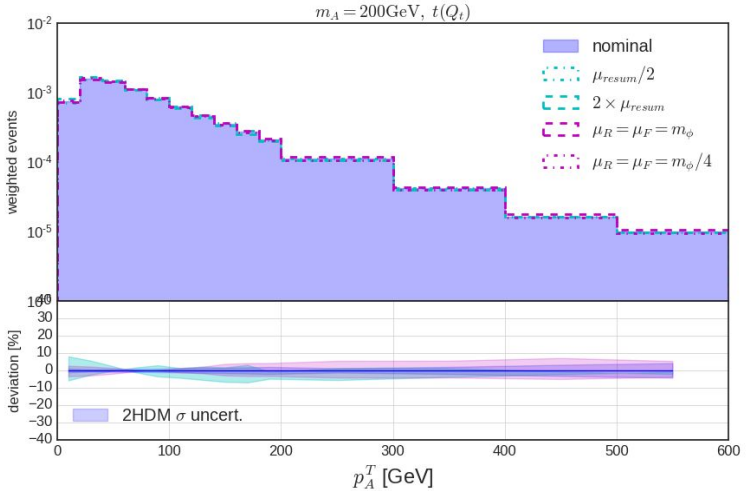
Produce 5 samples in Powheg 2HDM

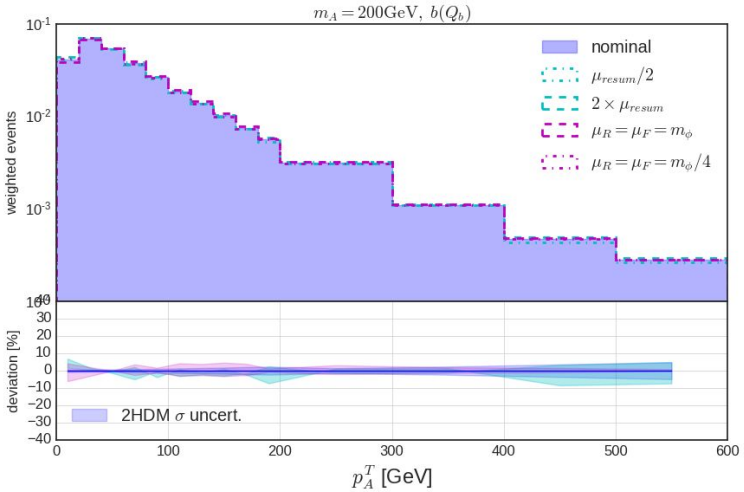
p_T templates in 2HDM

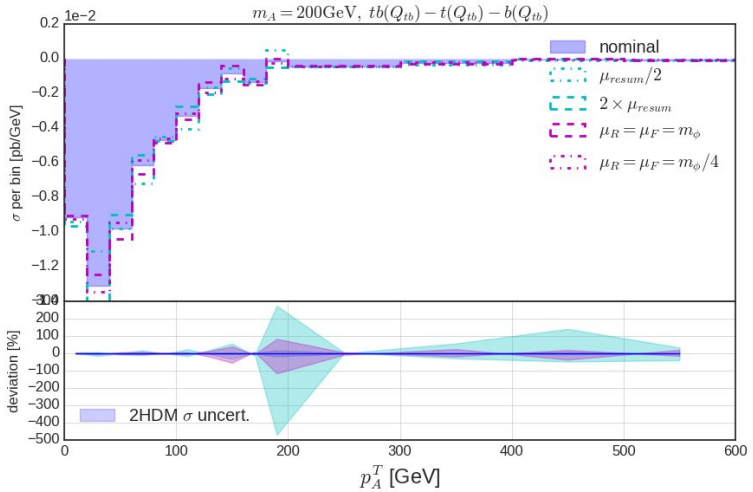
10^5 events per distribution (t + b + 3x int = $5x10^5$/mass)
Root histograms: Oct08_hpt_root.tar.bz2 (900 MB compressed)

Uncertainties

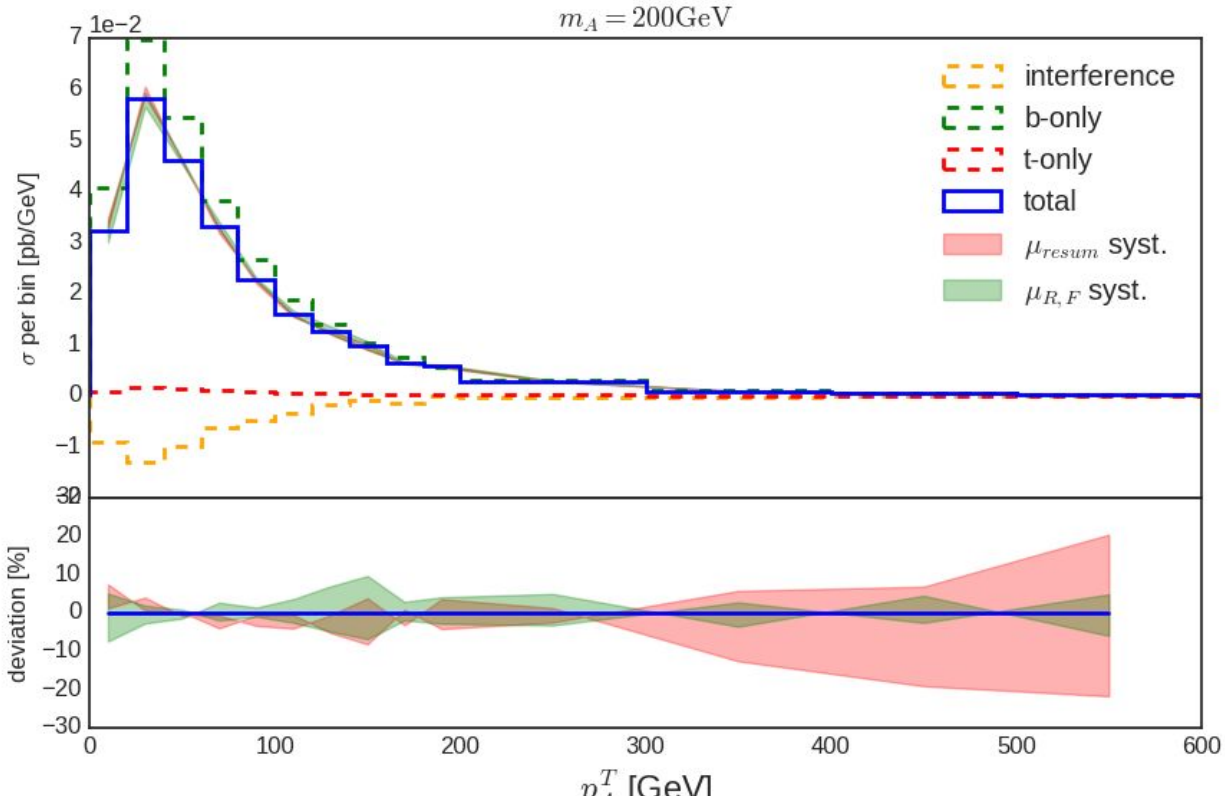
- Store weights for different scale variations at ME level. (recently implemented in my fork)
- Resummatiation Scale:
  mu_res={0.5, 1**(Nominal)**, 2} x $\boldsymbol{\mu}$
- Fact/Renorm Scales:
  mu_F=mu_R={0.25, 0.5**(Nominal)**, 1} x $\mathbf{m_\phi}$

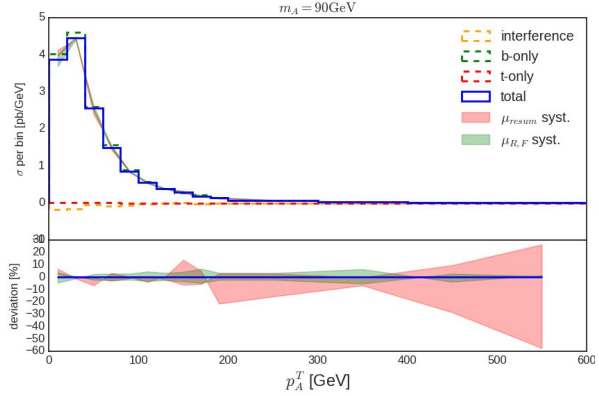


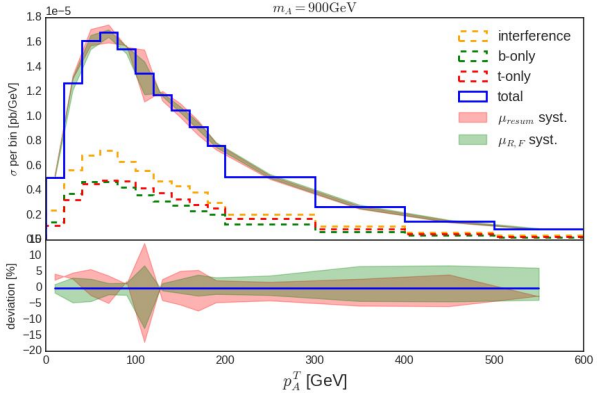


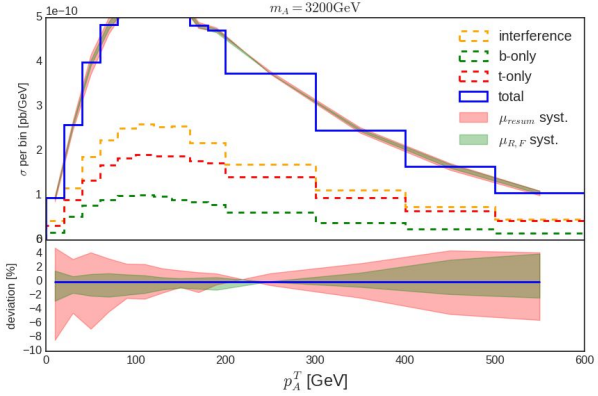


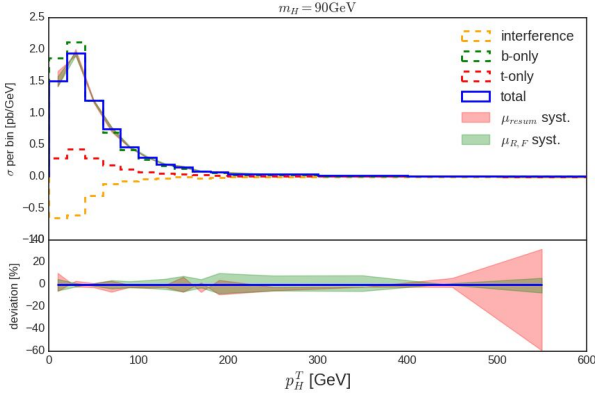
Total p_T template in 2HDM

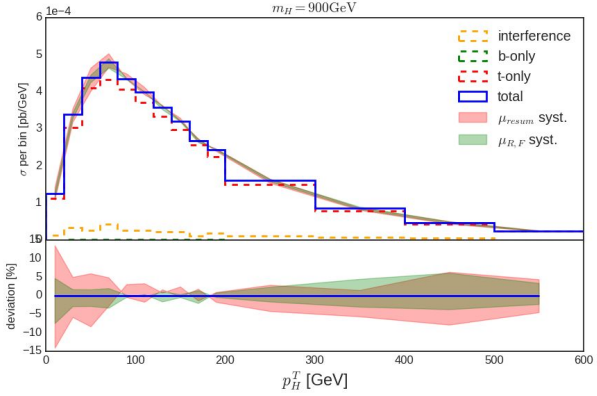


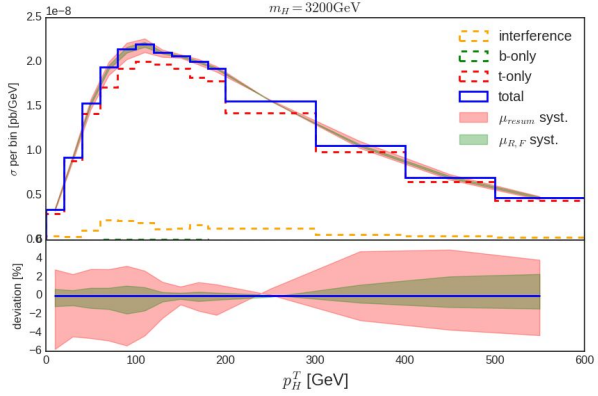

$m_A = 90$GeV
interference
b-only
t-only
total
μ_{resum} syst.
$\mu_{R,F}$ syst.
σ per bin [pb/GeV]
deviation [%]
p_A^T [GeV]


$m_A = 900$GeV
1e−5
interference
b-only
t-only
total
μ_{resum} syst.
$\mu_{R,F}$ syst.
σ per bin [pb/GeV]
deviation [%]
p_A^T [GeV]


$m_A = 3200$GeV
1e−10
interference
b-only
t-only
total
μ_{resum} syst.
$\mu_{R,F}$ syst.
σ per bin [pb/GeV]
deviation [%]
p_A^T [GeV]


$m_H = 90$GeV
interference
b-only
t-only
total
μ_{resum} syst.
$\mu_{R,F}$ syst.
σ per bin [pb/GeV]
deviation [%]
p_H^T [GeV]


$m_H = 900$GeV
1e−4
interference
b-only
t-only
total
μ_{resum} syst.
$\mu_{R,F}$ syst.
σ per bin [pb/GeV]
deviation [%]
p_H^T [GeV]


$m_H = 3200$GeV
1e−8
interference
b-only
t-only
total
μ_{resum} syst.
$\mu_{R,F}$ syst.
σ per bin [pb/GeV]
deviation [%]
p_H^T [GeV]

Summary and Next Steps

- pT distributions for 2HDM Higgs available for large range (50 GeV to 3.2 TeV)
- Scale variations have been implemented. Some spikes in uncertainties need to be followed up.
- Working in parallel on building workspace which can be used by analyses for the reweighting. These will require Yukawa factors from the new benchmarks as well.

General status

General plans

- Main priority is to generate ROOT files for new benchmarks, currently converging on prescription.

Updates of the ROOT files will:
✗ use the matched $bb\phi$ predictions and include $\mathrm{N^3LO}$ precision for $gg \to \phi$.
✗ contain updated SM input.
✗ contain fragments to get p_T distributions.

- Once ROOT files are available, should asses sensitivity of different analyses.

Presented several times

Classic scenarios: see Stefan's Presentation
✓ M_h^{125}: MSSM/2HDM with moderately heavy SUSY (Δ_b)
✓ $M_h^{125}(\tilde{\tau})$: MSSM with light $\tilde{\tau}$ (BR$(h \to \gamma\gamma)$, $H/A \to \tilde{\tau}\tilde{\tau}$)
✓ $M_h^{125}(\tilde{\chi})$: MSSM with light $\tilde{\chi}$ ($H/A/H^{\pm} \to \tilde{\chi}_i\tilde{\chi}_j$)
✓ hMSSM: as before
New aspects:
✓ M_h^{125} (alignment): MSSM with lower values of m_A not excluded by 125 GeV
✓ M_H^{125}: MSSM with the heavy Higgs being the state at 125 GeV ($H^{\pm} \to W^{\pm}h$)
✓ $M_{h_1}^{125}$ (CPV): MSSM with CP violation and interference effects