## b quark mass effects in associated production

Davide Napoletano, HiggsTools Final Meeting, 14/09/2017

## Intro

- $\mathfrak{m}_{\mathrm{b}}$ somewhere in $\Lambda_{\mathrm{QCD}}<\mathfrak{m}_{\mathrm{b}}<\mathfrak{m}_{\mathrm{V}, \mathrm{H}, \mathrm{t}}$

- main production through $g \rightarrow b \bar{b}$
- Problems so far are only theoretical/MC


## $4 F S$ vs 5 FS

## 4F Scheme : VH



- $m_{b} \neq 0$ (Everywhere)
- $\sim \alpha_{S} \log \frac{m_{b}^{2}}{q^{2}}$, can be $O(1)$
- $g \rightarrow b \bar{b}$, no problem


## 4FS vs 5FS

## 5F Scheme: VH



- $\mathrm{m}_{\mathrm{b}}=0$
- Logs resummed in b-pdf
- $g \rightarrow b \bar{b}$, depends on PS


## Running...

4FS vs 5FS: running coupling


## 4FS vs 5FS: $\mathrm{g} \operatorname{PDF}(\mathrm{x}=0.01)$



## 



- Compare against Zbb data to understand Hbb

- As in Zbb, good shape agreement among schemes


## Mass effects



- There are regions in which they are important
- The two massless description disagree with 4FS


## Massive 5FS

- Flavour scheme with 5 active flavour, with massive-bs
- Problem(s):
- Factorisation and IR cancellation beyond NLO
- PDFs (must include massive splitting kernels)
- Same for shower


## Fixed Order

## $\mathrm{b} \overline{\mathrm{b}} \rightarrow \mathrm{H}$ @ NLO:



Fixed Order


## MC@NLO

$$
\mathrm{d} \sigma^{\mathrm{MC} @ \mathrm{NLO}}=\mathrm{d} \Phi_{N} \overline{\mathcal{B}}\left(\Phi_{N}\right)\left[\Delta_{N}\left(t_{0}, \mu_{Q}^{2}\right)+\int_{t \in\left[t_{0}, \mu_{Q}^{2}\right]} \mathrm{d} \Phi_{1} \mathrm{~K}_{N}\left(\Phi_{1}\right) \Delta_{N}\left(t\left(\Phi_{1}\right), \mu_{Q}^{2}\right)\right]+\mathrm{d} \Phi_{N+1} \mathcal{H}\left(\Phi_{N+1}\right)
$$

$$
\begin{aligned}
& \mathbf{k}_{\perp}^{2}=\frac{2 y(1-x-y) p_{a} \cdot p_{b}-(1-x-y)^{2} m_{a}^{2}-y^{2} m_{b}^{2}}{1-\frac{m_{a}^{2} m_{b}^{2}}{\left(p_{a} \cdot p_{b}\right)^{2}}} \\
& \frac{\mathrm{~d} \mathbf{k}_{\perp}^{2}}{\mathbf{k}_{\perp}^{2}}=\frac{1-x-2 y+(1-x-y) \frac{m_{a}^{2}}{p_{a}}-y \frac{m_{a}^{2}}{p_{\cdot} \cdot p_{2}}}{1-x-y-\frac{(1-x-y)^{2}}{2 y} \frac{m_{\cdot}^{2}}{p_{a} \cdot p_{b}}-\frac{y}{2} \frac{m_{a}^{2}}{p_{a} \cdot p_{b}}} \frac{\mathrm{~d} y}{y} \\
& \mathcal{J}\left(x, y ; \mathbf{k}_{\perp}^{2}\right)=\frac{1-x-y-\frac{(1-x-y)^{2}}{2 y} \frac{m_{a}^{2}}{p_{a} \cdot b_{b}^{2}}-\frac{y}{2} \frac{m_{a}^{2}}{p_{a} \cdot p_{b}}}{1-x-2 y+(1-x-y) \frac{m_{a}^{2}}{p_{a} \cdot p_{b}}-y \frac{m_{a}^{2}}{p_{a} \cdot p_{b}}} \frac{s_{a b}}{\sqrt{\lambda_{a b}}} \frac{1}{x} \frac{f_{a}(\eta / x)}{f_{a}(\eta)} \\
& \Delta_{I I}\left(\mathbf{k}_{\perp, \text { max }}^{2}, \mathbf{k}_{\perp, 0}^{2}\right)=\exp \left\{-\sum_{a k} \sum_{b \neq a k} \frac{1}{\mathcal{N}_{s p e c}} \int_{\mathbf{k}_{\perp, 0}^{2}}^{\mathbf{k}_{\perp, \text { max }}} \frac{\mathrm{d}_{\perp}^{2}}{\mathbf{k}_{\perp}^{2}} \int_{x_{-}}^{x_{+}} \mathrm{d} x \mathcal{J}\left(x, y ; \mathbf{k}_{\perp}^{2}\right) \mathbf{V}^{a k, b}\left(p_{a}, p_{b}, p_{k}\right)\right\}
\end{aligned}
$$

MC@NLO


## MC@NLO



