





## b quark mass effects in associated production

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

## Intro

•  $m_b$  somewhere in  $\Lambda_{QCD} < m_b < m_{V,H,t}$ 

### • main production through $g \rightarrow bb$

Problems so far are only theoretical/MC





## 4FS vs 5FS



### $m_b \neq 0$ (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



### • $m_b = 0$

### Logs resummed in b-pdf

### • $g \rightarrow b\bar{b}$ , depends on PS

## Running...

### 4FS vs 5FS: running coupling





## $pp \rightarrow VH(b\bar{b})$

arXiv:1612.04640



 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

![](_page_8_Figure_1.jpeg)

![](_page_8_Picture_2.jpeg)

## Fixed Order

![](_page_9_Figure_1.jpeg)

## MC@NLO

$$\mathrm{d}\sigma^{\mathrm{MC}@\mathrm{NLO}} = \mathrm{d}\Phi_N \,\overline{\mathcal{B}}(\Phi_N) \,\left[ \Delta_N(t_0, \mu_Q^2) + \int_{t \in [t_0, \mu_Q^2]} \mathrm{d}\Phi_1 \,\mathrm{K}_N(\Phi_1) \,\Delta_N(t(\Phi_1), \mu_Q^2) \right] + \mathrm{d}\Phi_{N+1} \,\mathcal{H}(\Phi_{N+1})$$

$$\mathbf{k}_{\perp}^{2} = \frac{2 y \left(1 - x - y\right) p_{a} \cdot p_{b} - (1 - x - y)^{2} m_{a}^{2} - y^{2} m_{b}^{2}}{1 - \frac{m_{a}^{2} m_{b}^{2}}{(p_{a} \cdot p_{b})^{2}}}$$

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$$\frac{\mathrm{d}\mathbf{k}_{\perp}^2}{\mathbf{k}_{\perp}^2} = \frac{1 - x - 2y + (1 - x - y)\frac{m_a^2}{p_a \cdot p_b} - y\frac{m_b^2}{p_a \cdot p_b}}{1 - x - y - \frac{(1 - x - y)^2}{2y}\frac{m_a^2}{p_a \cdot p_b} - \frac{y}{2}\frac{m_b^2}{p_a \cdot p_b}} \frac{\mathrm{d}y}{y}$$

$$\mathcal{J}(x,y;\mathbf{k}_{\perp}^{2}) = \frac{1-x-y-\frac{(1-x-y)^{2}}{2y}\frac{m_{a}^{2}}{p_{a}\cdot p_{b}} - \frac{y}{2}\frac{m_{b}^{2}}{p_{a}\cdot p_{b}}}{1-x-2y+(1-x-y)\frac{m_{a}^{2}}{p_{a}\cdot p_{b}} - y\frac{m_{b}^{2}}{p_{a}\cdot p_{b}}} \frac{s_{ab}}{\sqrt{\lambda_{ab}}} \frac{1}{x} \frac{f_{a}(\eta/x)}{f_{a}(\eta)}$$

$$\Delta_{II}(\mathbf{k}_{\perp,max}^2,\mathbf{k}_{\perp,0}^2) = \exp\left\{-\sum_{ak}\sum_{b\neq ak}\frac{1}{\mathcal{N}_{spec}}\int_{\mathbf{k}_{\perp,0}^2}^{\mathbf{k}_{\perp,max}}\frac{\mathrm{d}\mathbf{k}_{\perp}^2}{\mathbf{k}_{\perp}^2}\int_{x_{-}}^{x_{+}}\mathrm{d}x\,\mathcal{J}(x,y;\mathbf{k}_{\perp}^2)\,\mathbf{V}^{ak,b}(p_a,p_b,p_k)\right\}$$

## MC@NLO

![](_page_11_Figure_1.jpeg)

## MC@NLO

![](_page_12_Figure_1.jpeg)

![](_page_12_Figure_2.jpeg)

![](_page_12_Figure_3.jpeg)