Stefano Frixione

Higgs in MC@NLO

ggF group

CERN, 20/12/2012

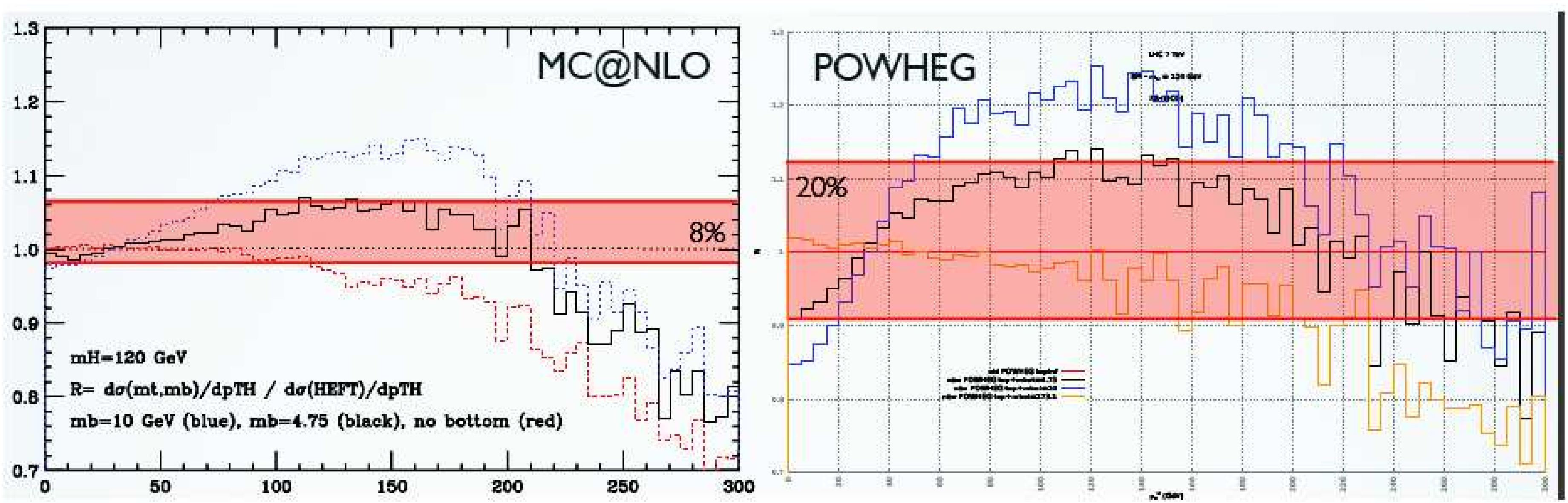
$gg \to H$ in MC@NLO

Up to v4.07 only HEFT results available (Born can retain the exact m_t dependence)

From v4.08 (June 2012), the real and virtual matrix elements have been included that feature the exact m_t *and* m_b dependence

These matrix elements have been typed in from the published results of Aglietti, Bonciani, Degrassi and Vicini, and found to give identical results at the NLO *without* MC matching

Higgs p_T spectrum

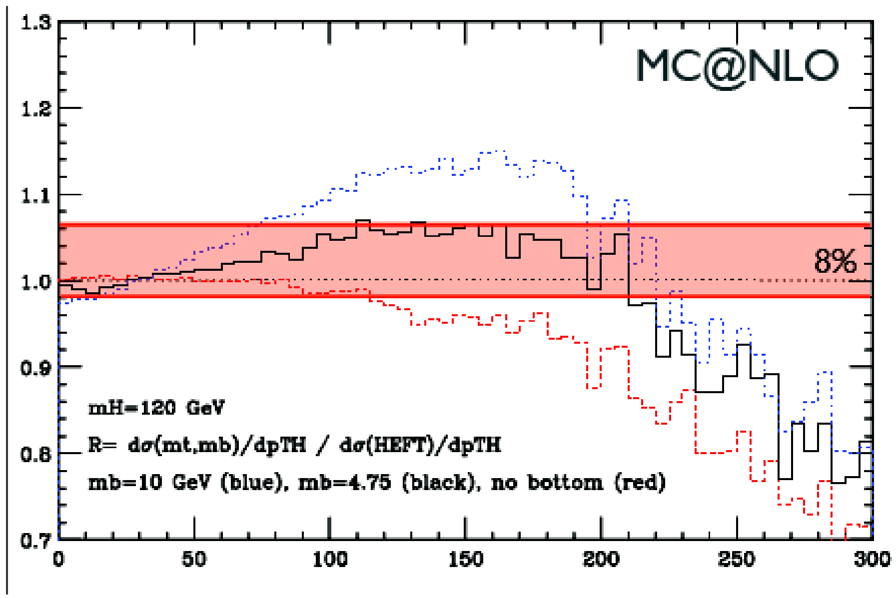


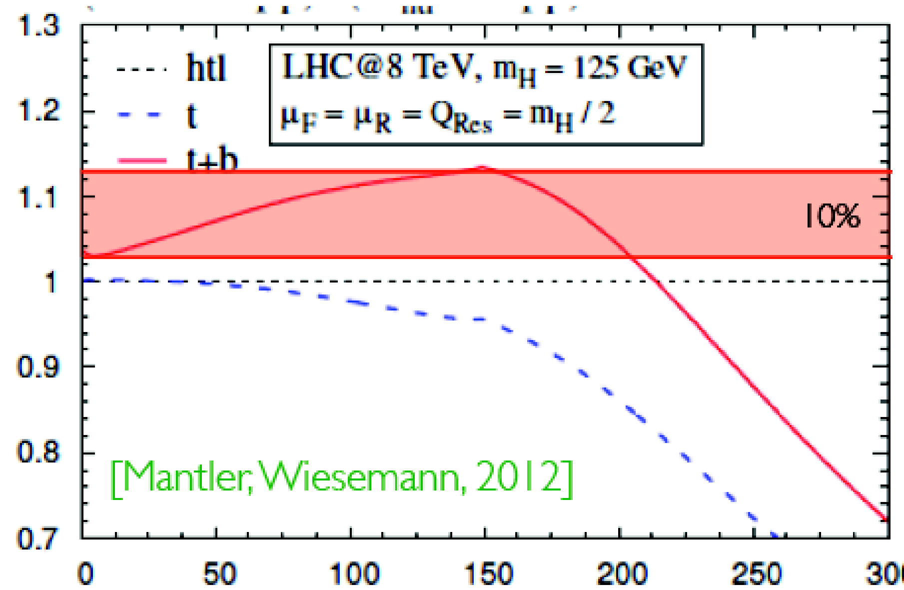
m_t and m_b effects, relative to HEFT, in $gg \to H^0$ at $\mathcal{O}(\alpha_S^3)$

MC@NLO v4.08

POWHEG 1111.2854 (Bagnaschi, Degrassi, Slavich, Vicini)

The two codes use the same matrix elements. Absolute normalization disregarded in this comparison





m_t and m_b effects, relative to HEFT, in $gg \to H^0$ at $\mathcal{O}(\alpha_S^3)$

MC@NLO v4.08

Analytic resummation 1210.8263 (Mantler, Wiesemann)

The two codes use the same matrix elements. Absolute normalization disregarded in this comparison. Choice of inputs in 1210.8263 not exactly the same as in MC@NLO and POWHEG

I stress again: the differences here are in shape.

Absolute normalization has not been taken care of

- Is this theoretical "systematics" included in experimental analysis?
  Note that on the theory side it is not clear what is going on
  (e.g., is the b-loop resolved? Does it lead to a smaller resummation scale?
  If so, I'd expect a softer, not harder, behaviour)

- Does `hfact` affect the POWHEG results also at small
  and intermediate p_T's in this case? Has this been checked?

- In general, are `hfact` variations treated as systematics?

Some considerations

- Keep in mind: "higher orders" means $\mathcal{O}(\alpha_S^4)$ here. Neither POWHEG nor MC@NLO has any information on NNLO matrix elements
- This implies that in the expansion

$$\sigma = a_2\alpha_S^2 + a_3\alpha_S^3 + a_4\alpha_S^4 + \ldots$$

  all contributions to a_i with $i \geq 4$ are arbitrary unless of "MC origin" (i.e., logarithmically enhanced in a Sudakov-type structure)
- Since too large or too small a value of a_4 may screw up the perturbative expansion, it is important to understand its origin
- In MC@NLO, all non-MC contributions to a_i, $i \geq 4$, are set to zero

Some considerations

It is clear that m_b effects are large in a_3 (as e.g. seen from pure NLO results), and likely due to boxes. However:

- If they are not associated with logs, they just should not contribute to a_4, except for a re-normalization effect of the coefficients of the "usual" Sudakov logs
- If they are associated with logs, one has to prove that the structure of such logs will lead to their exponentiation
- It is not clear to me why the b-loop effects at $\mathcal{O}(\alpha_S^3)$ should imply a smaller resummation scale (of the usual resummation). This seems a crude approximation at best, unless one can prove that this happens order by order

A study of the $\mathcal{O}(\alpha_S^3)$ matrix elements in the $p_T(H) \to 0$ limit appears to be necessary