Improving MC@NLO simulations

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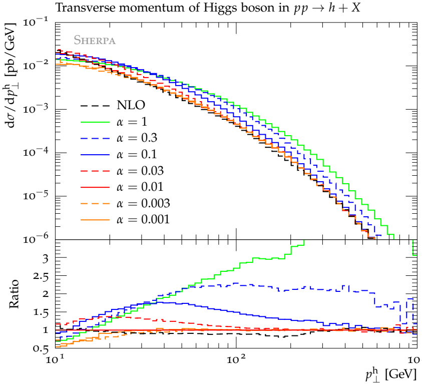
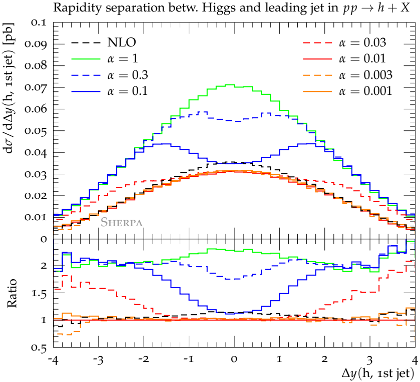
Choice of exponentiated phase space

from Stefan's talk: limit phase space for exponentiation by α



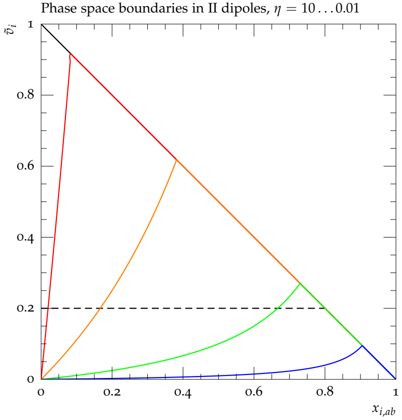


however, α no sensible parameter w.r.t. exponentiation region

$\to$ restricts emissions to small opening angle wrt. beam

$\to$ bias towards hard collinear emissions

Choice of exponentiated phase space



Real emission phase space

$$\tilde{v}_i = \frac{p_a \cdot k}{p_a \cdot p_b} \qquad x_{i,ab} = 1 - \frac{(p_a + p_b) \cdot k}{p_a \cdot p_b}$$

- restriction in α permits very hard ($x_{i,ab} \to 0$), not too collinear radiation at larger $\tilde{v}_i$
- restriction in $\mathbf{k}_\perp^2 = Q^2 \, \tilde{v}_i \, \frac{1 - x_{i,ab}}{x_{i,ab}}$ permits only very soft ($x_{i,ab} \to 1$) radiation at larger $\tilde{v}_i$

Choice of exponentiated phase space

$$\langle O \rangle = \int d\Phi_B \, \bar{\mathrm{B}}^{(\mathsf{A})} \left[\Delta^{(\mathsf{A})}(t_0, \mu_Q^2) \, O(\Phi_B) + \int_{t_0}^{\mu_Q^2} d\Phi_1 \, \frac{\mathrm{D}^{(\mathsf{A})}}{\mathrm{B}} \, \Delta^{(\mathsf{A})}(t, \mu_Q^2) \, O(\Phi_R) \right] + \int d\Phi_R \left[\mathrm{R} - \mathrm{D}^{(\mathsf{A})} \right] O(\Phi_R)$$

with

$$\bar{\mathrm{B}}^{(\mathsf{A})} = \mathrm{B} + \tilde{\mathrm{V}} + \mathrm{I}^{(\mathsf{S})} + \int d\Phi_1 \left[\mathrm{D}^{(\mathsf{A})} - \mathrm{D}^{(\mathsf{S})} \right]$$

- maintain $\mathrm{D}^{(\mathsf{A})} = \mathrm{D}^{(\mathsf{S})}$ scheme
- to recover physical resummation phase space
  $\rightarrow$ limit phase space in PS evolution variable $t = \mathbf{k}_\perp^2 < \mathbf{k}_\perp^{\mathsf{max}\,2} = \mu_Q^2$

$$\mathrm{D}^{(\mathsf{A})} = \mathrm{D}^{(\mathsf{S})} \longrightarrow \mathrm{D}^{(\mathsf{S})} \Theta(\mathbf{k}_\perp^{\mathsf{max}} - \mathbf{k}_\perp)$$

Choice of exponentiated phase space

Assessment of uncertainties

- limit discussion to $gg \to h$ because effects are largest and cleanest here (large NLO k-factor, very simple colour/dipole structure)
  $\to$ large rate difference for $\mathbb{S}$ and $\mathbb{H}$ events
- setup: $k_\perp$-ordered parton shower based on Catani-Seymour dipoles
  $\to$ highlights what happens at resummation scale $\mathbf{k}_\perp^{\text{max}}$
- renormalisation scale $\mu_R = m_h$, $\mu_R^{\text{exp}} = \sqrt{\frac{1}{1/p_\perp^2 + 1/\mu_R^2}} \xrightarrow{p_\perp \to \infty} \mu_R$
- vary resummation scale $\mathbf{k}_\perp^{\text{max}}$, i.e. starting conditions of MC@NLO-shower
- starting conditions of POWHEG-shower fixed at $\mathbf{k}_\perp^{\text{max}} = \frac{1}{2}\sqrt{s_{\text{had}}}$
  - effect of suppression function not investigated
  - introduces arbitrary free parameter (not fixed to be of order of m_h)
  - uncertainties as large as with α variation
    $\to$ investigated in Alioli et.al. JHEP04(2009)002

$\Rightarrow$ uncertainties in (N)LL-LO matching in MC@NLO and POWHEG

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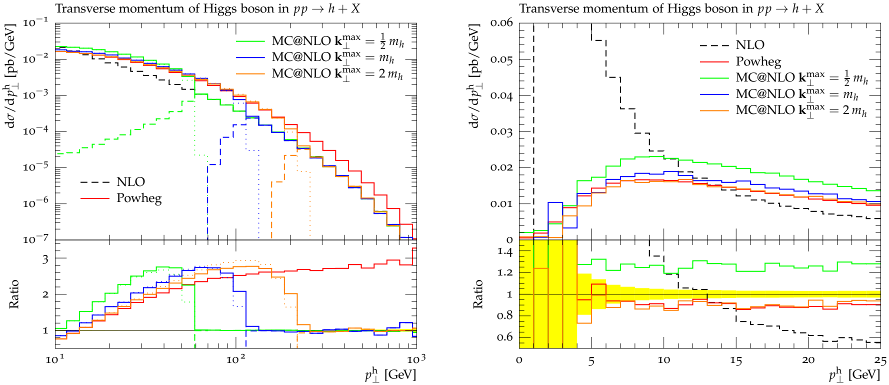
Choice of splitting kernel – $\mathrm{D}^{(\mathsf{A})}/\mathrm{B}$

traditional MC@NLO and POWHEG choices of splitting kernels



- large uncertainties when varying $\mathbf{k}_\perp^{\max}$
- driven by diff. in normalisation of $\mathbb{S}$- and $\mathbb{H}$-events and size of $\ln^2(\mathbf{k}_\perp^2/\mu_Q^2)$
- shape difference driven by unitarity constraint

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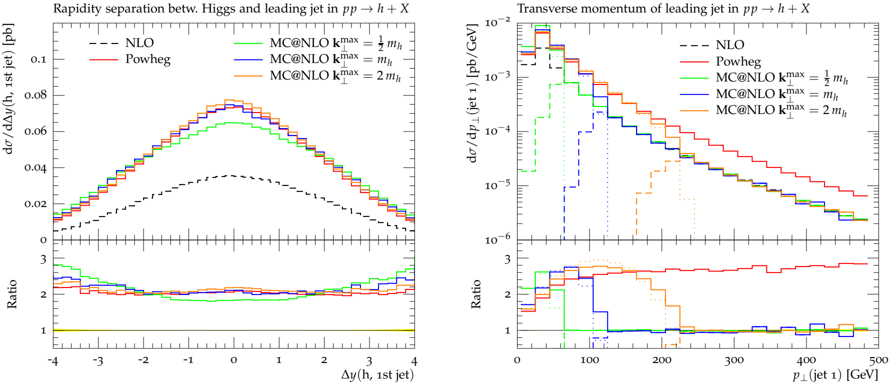
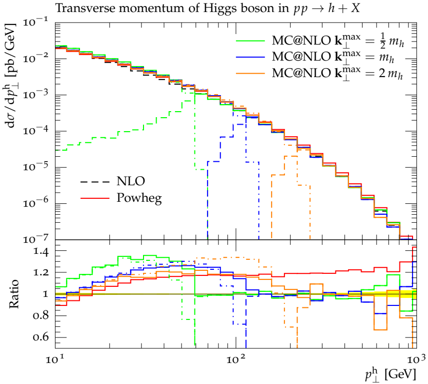
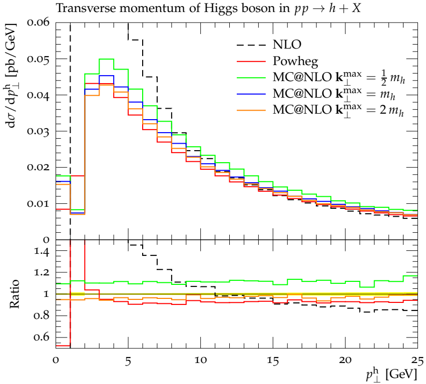


- uncertainty on jet rates with $p_\perp \sim 100$GeV: 2.5
- no dip in Δy $\to$ originates in HERWIG's radiation pattern

Choice of splitting kernel – $\mathrm{D}^{(\mathbf{A})}/\bar{\mathrm{B}}^{(\mathbf{A})}$

here: change splitting kernels $\mathrm{K} \longrightarrow (1 + \alpha_s \cdot \text{const.})\,\mathrm{K}$





- uncertainties much lower, smooth transition at μ_Q^2
- much closer to NLO fixed order result for "hard" emissions
- price of spuriously large LL prefactor → Sudakov peak differs

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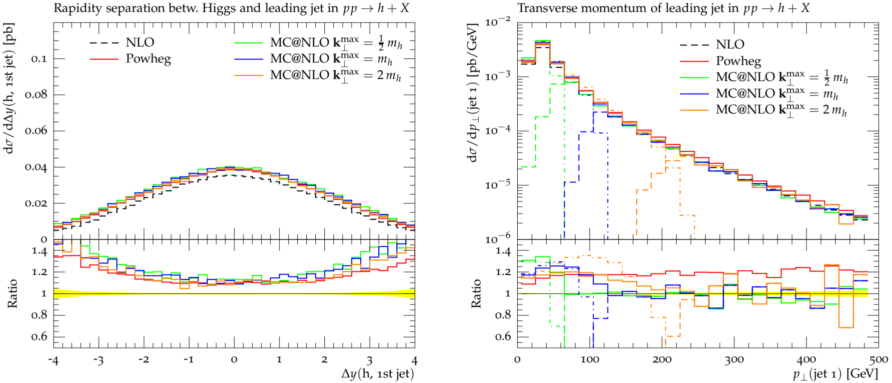

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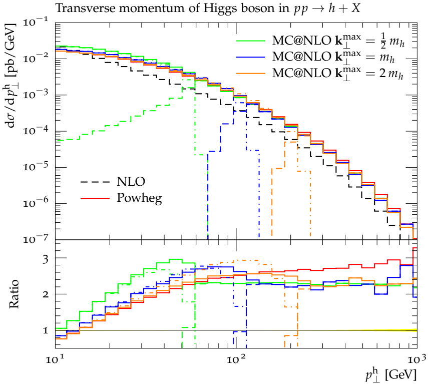
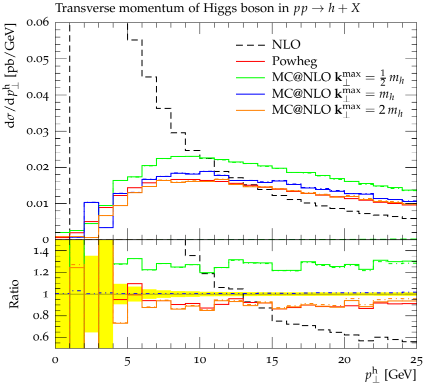
Choice of higher order correction – $\bar{\mathrm{B}}^{(\mathrm{A})}/\mathrm{B} \cdot \mathbb{H}$

here: modify $\mathbb{H}$-term with arbitrary higher order corrections $\mathbb{H} \to \frac{\bar{\mathrm{B}}^{(\mathrm{A})}}{\mathrm{B}}\,\mathbb{H}$





- PS resummation left void of higher order terms
- equivalent to MENLOPS prescription in Höche et.al. JHEP04(2011)024
- uncontrolled $\mathcal{O}(\alpha_s^2)$ terms in $\mathbb{H}$-events

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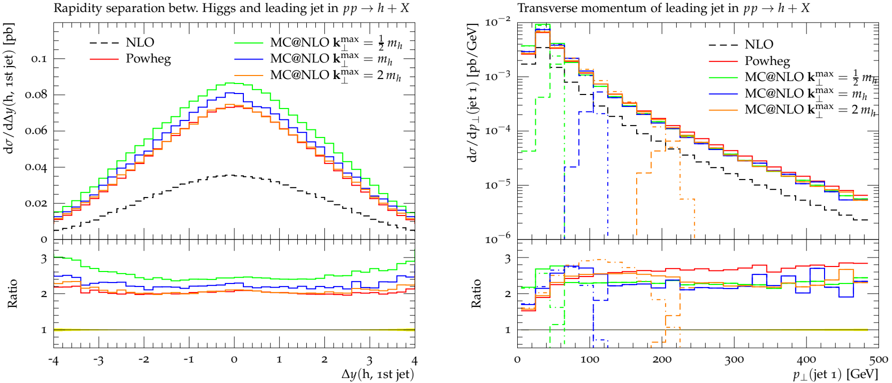

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Conclusions

- uncertainties studied occur in every process and are inherent to methods
  $\rightarrow gg \rightarrow h$ just presents a clean environment

- exploit freedom left at the respective level of accuracy
  $\rightarrow$ each with merrits and drawbacks

- choices constrained by adding higher order calculations
  - (N)NLL resummation
  - NNLO corrections
  - NLO$\otimes$NLO merging with $Q_{\text{cut}} < \mu_Q^2$