

Resumming jet veto logs for Higgs + 1jet @ LHC

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with Frank Petriello

Jet issues in Higgs physics '12



Outline

- Motivation
- Results
- Conclusion and Outlook

Motivation

- Cross section with jet bins
 - Higgs + 0-j, 1-j, >2-j
 - W+2-j, 3-j
 - BSM searches

Motivation

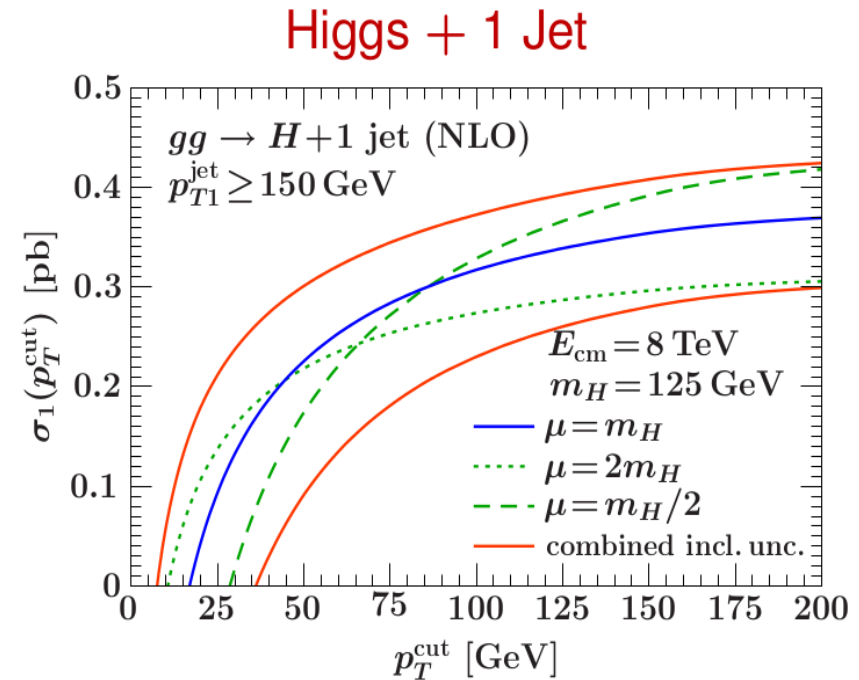
- Cross section with jet bins
 - Merits
 - Beat the backgrounds $p_T^{veto} \approx 25\text{GeV} - 30\text{GeV}$

Motivation

- Cross section with jet bins

- Problems

- Sudakov Logarithms $\sum_{n,m} C_{n,m} \alpha_s^n L^{2n-m}$, $L = \log \frac{p_T^{\text{veto}}}{Q}$
 - Breakdown of fixed-order calculations
 - Unreliable uncertainty estimation (Stewart and Tackmann '11)



Results

- Previous efforts

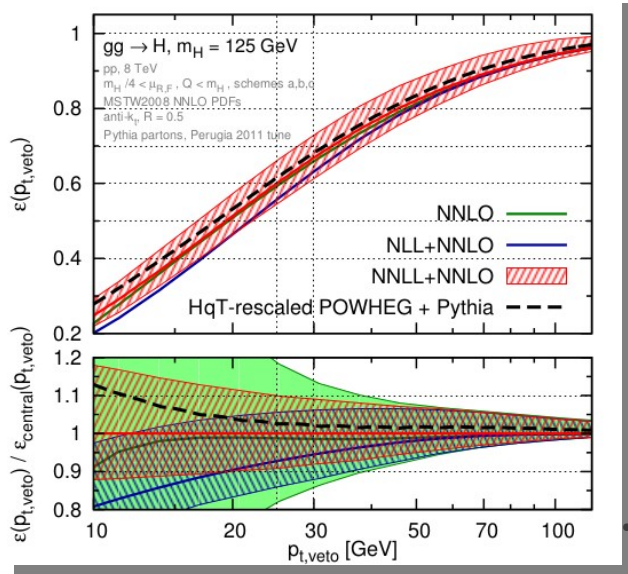
- Higgs + 0-j

- NNLO+NLL (part NNLL results) (Banfi, Salam and Zanderighi '12)

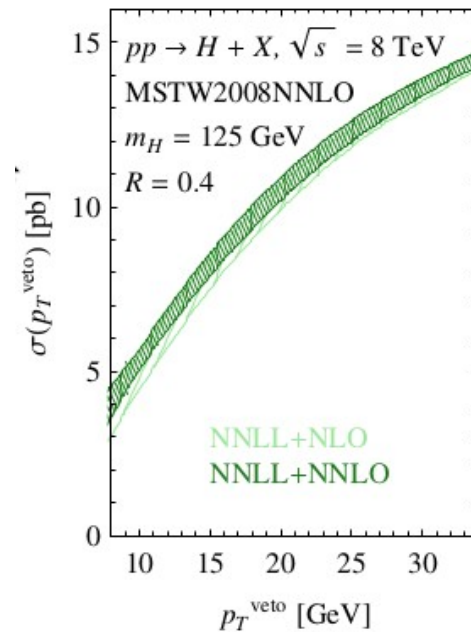
- NNLO+NNLL (Becher and Neubert '12)

- NNLO+NNLL (Banfi, Monni, Salam and Zanderighi '12)

- Clustering logs (Tackmann, Walsh and Zuberi '12)



(Banfi, Monni, Salam and Zanderighi '12)



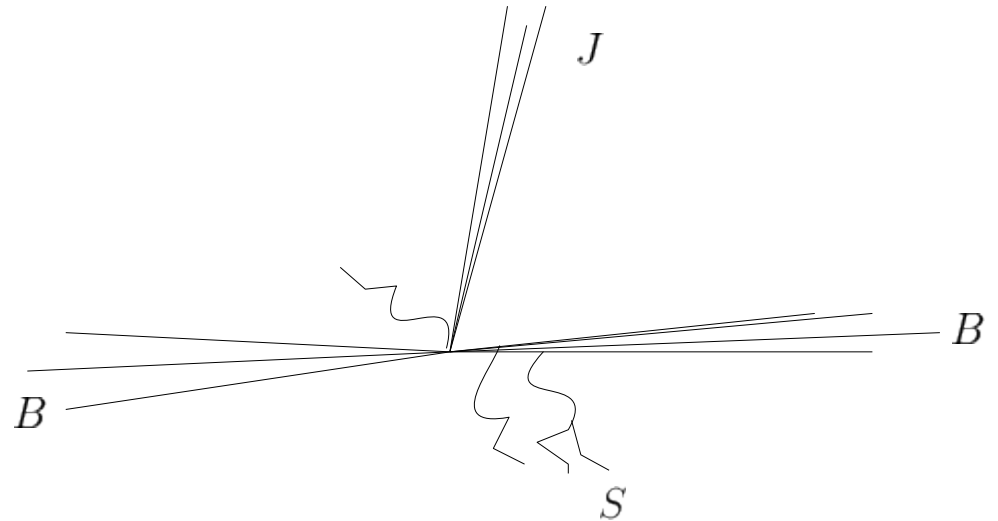
(Becher and Neubert '12)

Results

- $N(H/W/Z) + n-j$ (XL and Petriello, '12)

– Factorization

- SCET II $\lambda \sim p_T^{veto} / \sqrt{\hat{s}}$
- anti-kT
- $R \sim 0.4 - 0.5$
- $p_T^{J_i} \sim \sqrt{\hat{s}}$
- $p_T^{J_i} \gg p_T^{veto}$

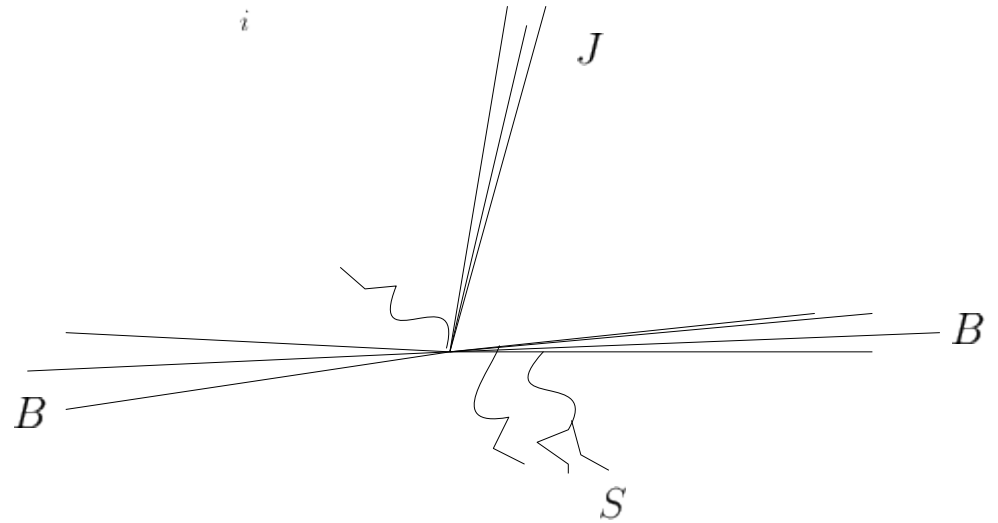


Results

- $N(H/W/Z) + n-j$ (XL and Petriello, '12)
- Factorization

$$d\sigma = d\Phi_N d\Phi_{J_i} \mathcal{F}(\Phi_N, \Phi_{J_i}) \sum_{a,b} \int dx_a dx_b \frac{1}{2\hat{s}} (2\pi)^4 \delta^4 \left(q_a + q_b - \sum_i^n q_{J_i} - q_N \right)$$

$$\times \sum_{\text{spin}} \sum_{\text{color}} \text{Tr}(H \cdot S) \mathcal{I}_{a,i_a j_a} \otimes f_{j_a}(x_a) \mathcal{I}_{b,i_b j_b} \otimes f_{j_b}(x_b) \prod_i^n J_{J_i}(R)$$



Results

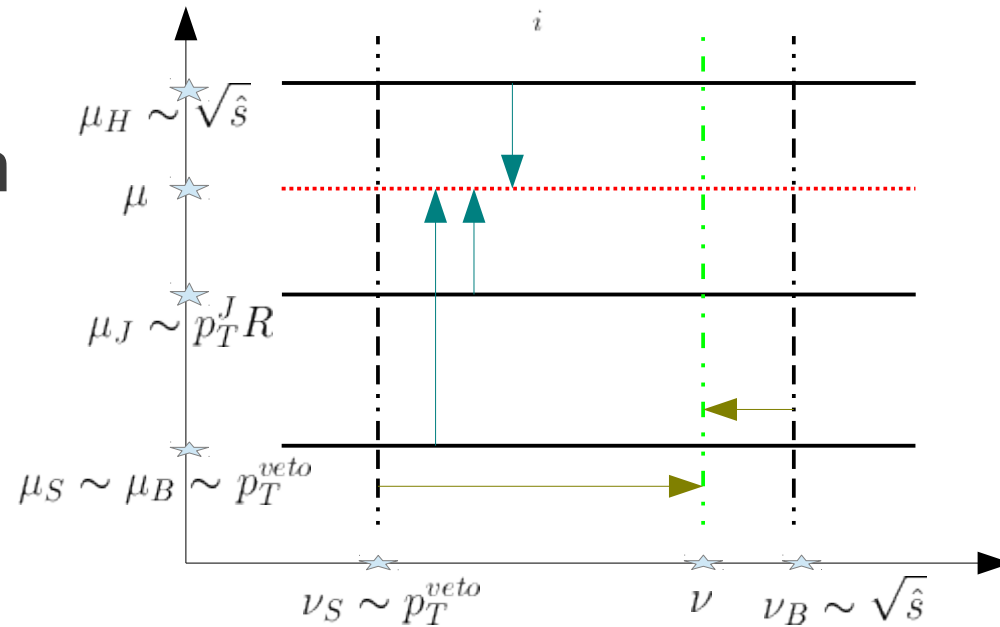
- $N(H/W/Z) + n-j$ (XL and Petriello, '12)

– Factorization

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$$\times \sum_{\text{spin}} \sum_{\text{color}} \text{Tr}(H \cdot S) \mathcal{I}_{a,i_a j_a} \otimes f_{j_a}(x_a) \mathcal{I}_{b,i_b j_b} \otimes f_{j_b}(x_b) \prod_i^n J_{J_i}(R)$$

– Resummation



Results

- $N(H/W/Z) + n-j$ (XL and Petriello, '12)

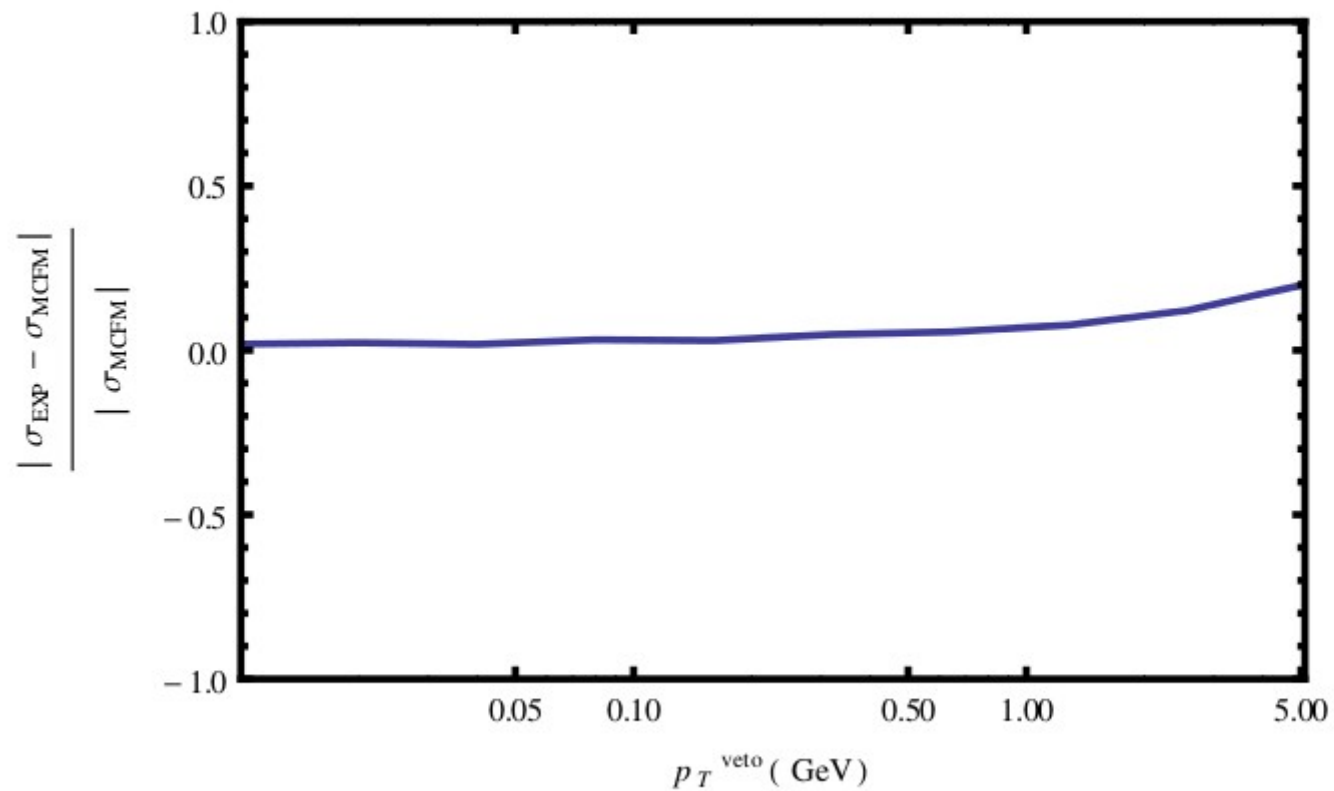
– NLL

$$d\sigma_{\text{NLL}} = \sum_{ab} \int dx_a dx_b \text{Tr} \left[H_{\text{LO}}^{ab \rightarrow N\{J_i\}}(\mu_H) S U_{H,\{J_i\}}(\mu, \mu_H) U_{S,\{J_i\}}(\mu, \nu, \mu_S, \nu_S) \right] \\ \times f_a(\mu_B, x_a) f_b(\mu_B, x_b) \mathcal{I}_{B,a,b}(\mu, \nu, \mu_B, \nu_B, x_a, x_b) \prod_i \mathcal{R}_{J_i}(\mu, \mu_J, R).$$

- Resummation at the fully differential cross section level
- Very compact analytic expressions (examples in the backup slides)
- Easy to supplement MCFM with these corrections

Results

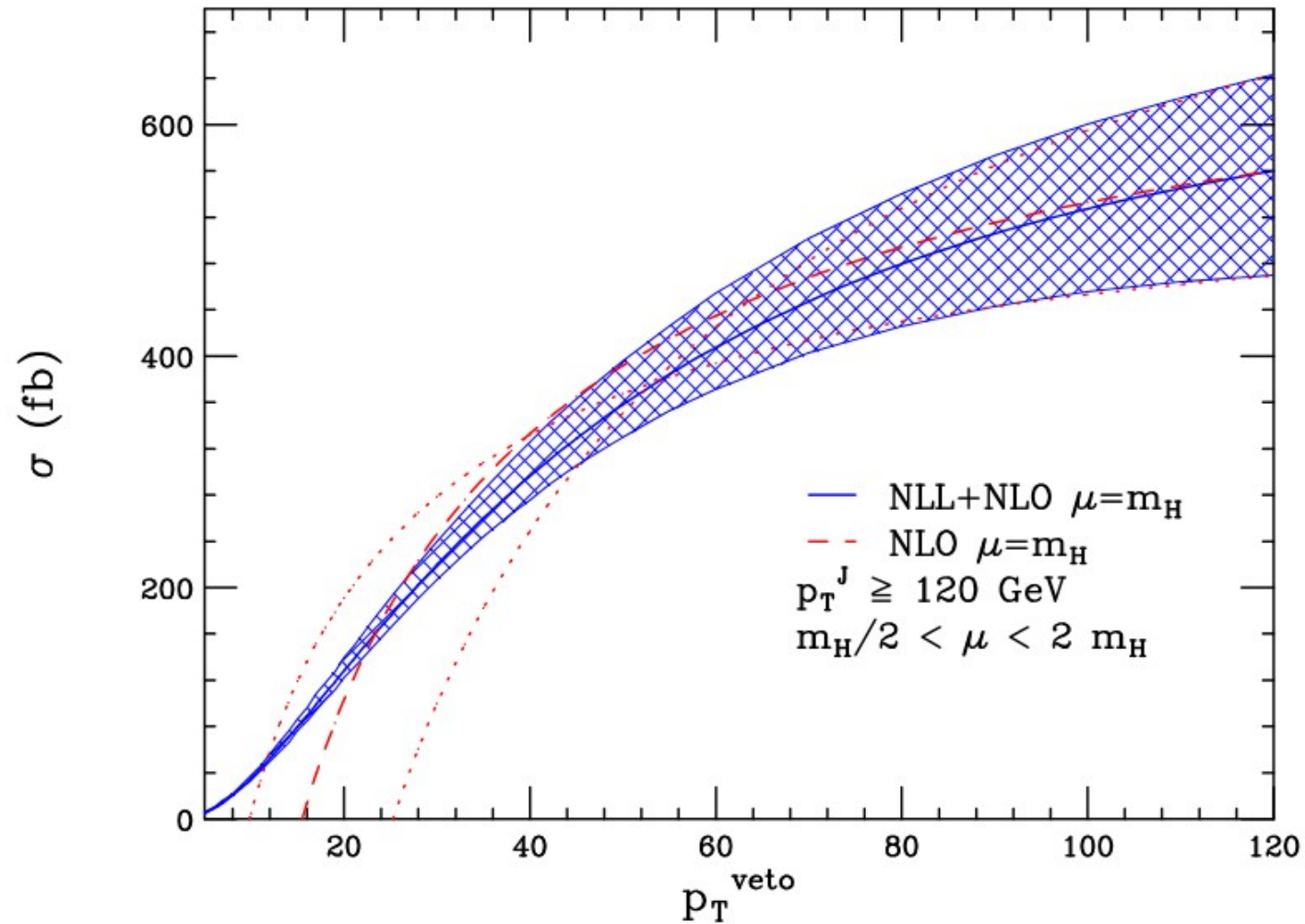
- Higgs + 1-j (XL and Petriello, '12)
 - Catches the NLL structures



Results

- Higgs + 1-j

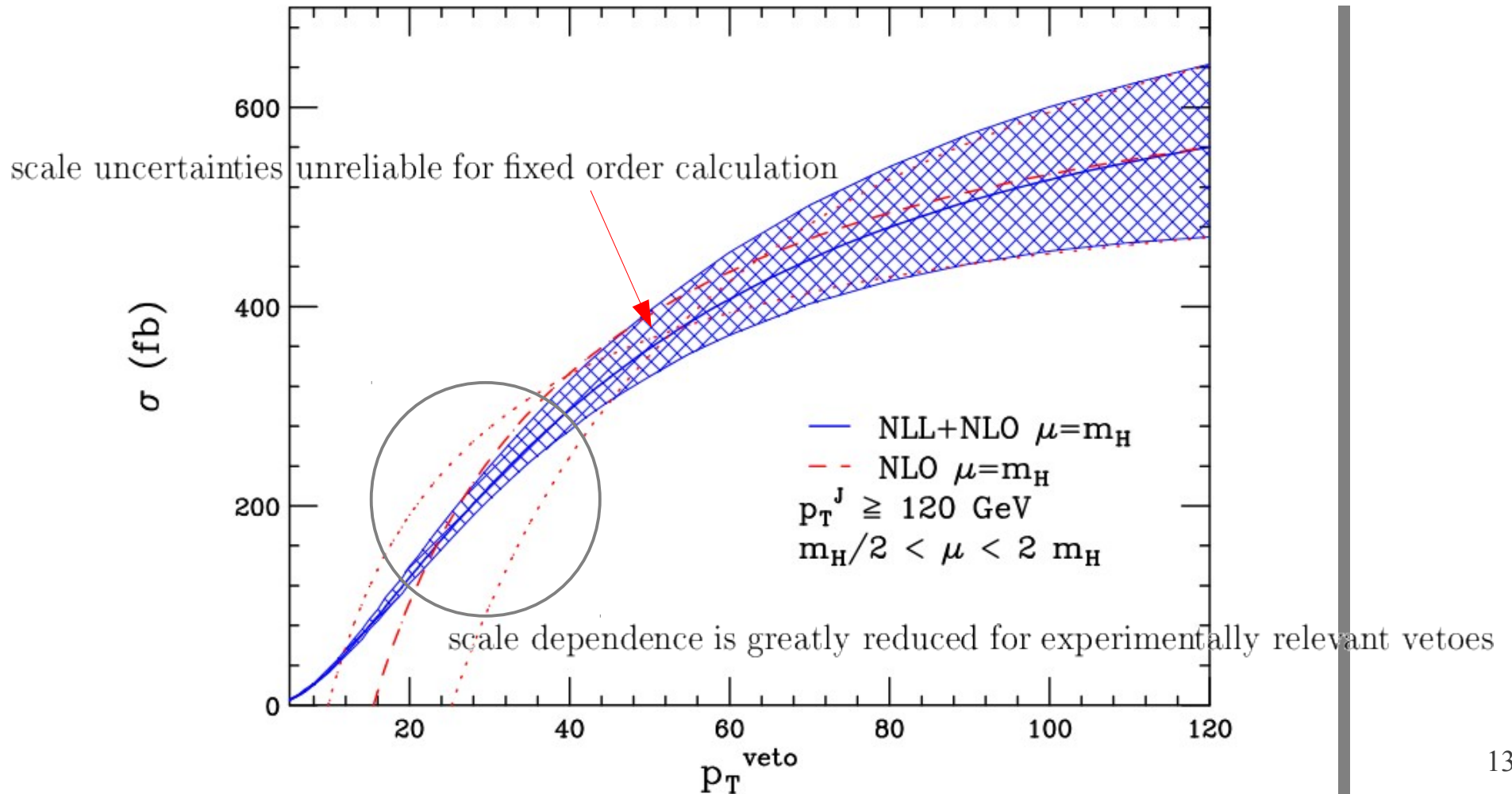
(XL and Petriello, '12)



Results

- Higgs + 1-j

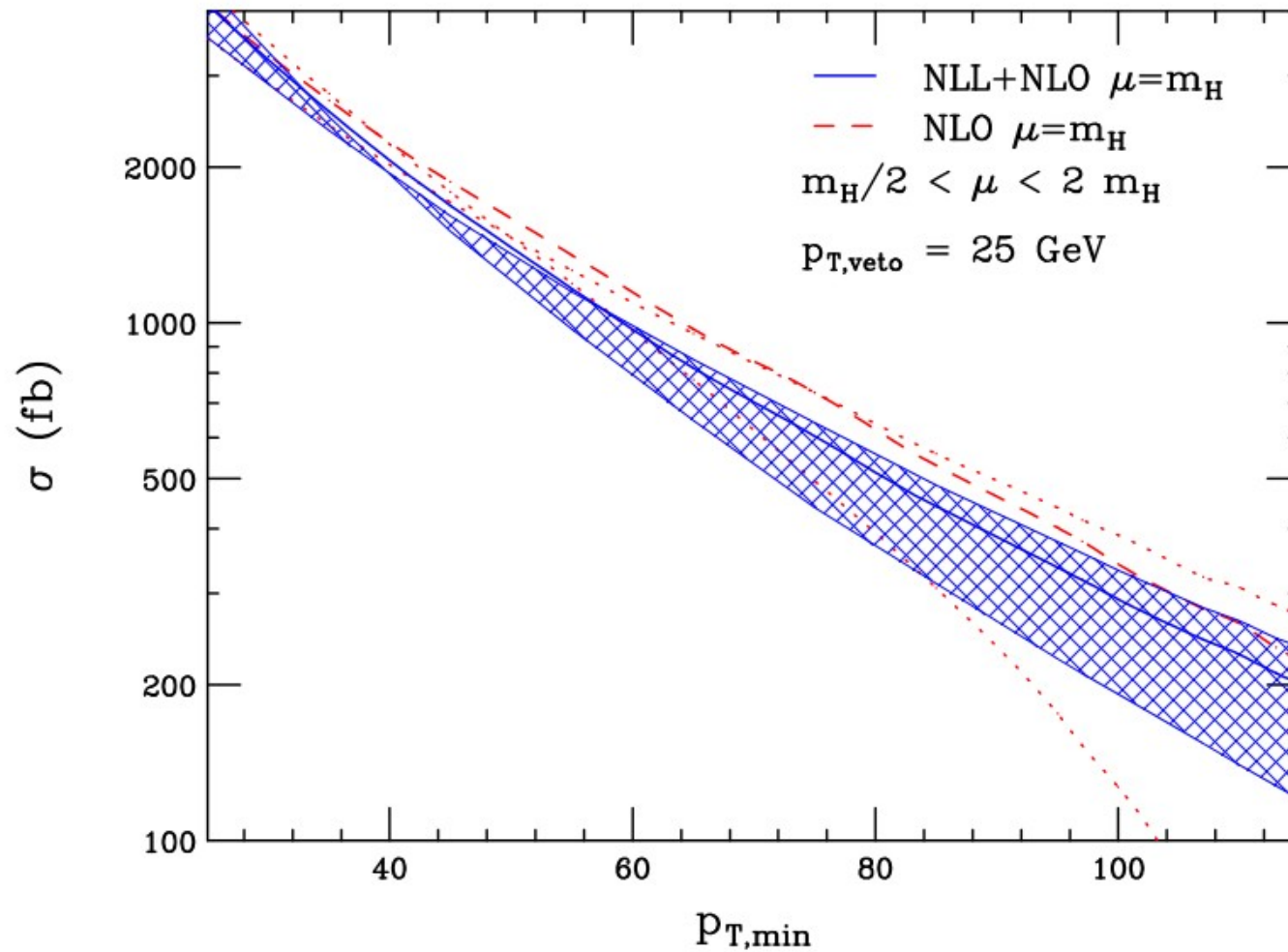
(XL and Petriello, '12)



Results

- Higgs + 1-j

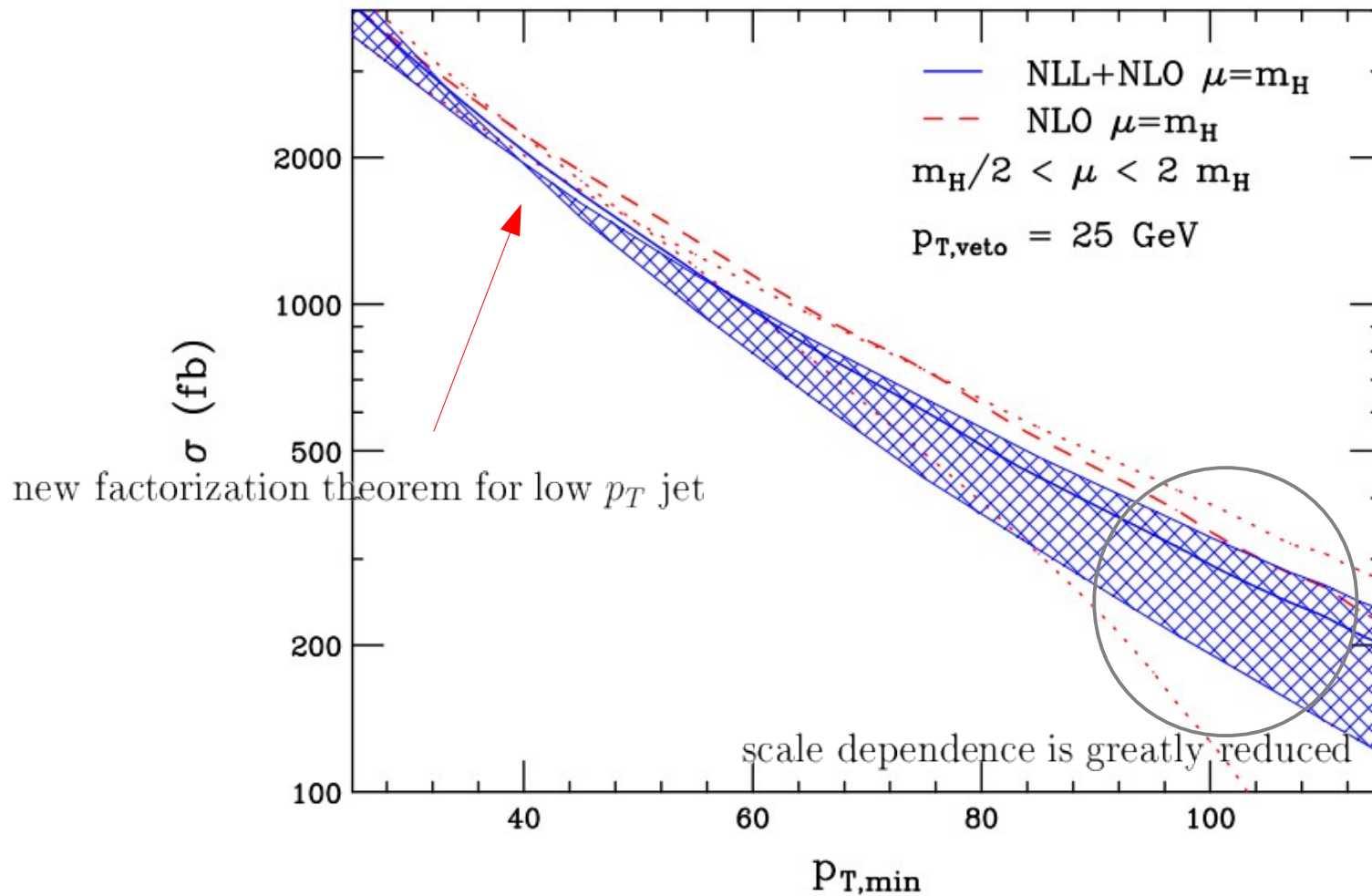
(XL and Petriello, '12)



Results

- Higgs + 1-j

(XL and Petriello, '12)



Conclusion and Outlook

- Resum NLL for multi-jets events
 - Neat analytic expressions
 - Reliable prediction
 - Reduced scale dependence
- Things to do
 - Entire spectrum (low jet p_T)
 - Matching scheme and uncertainties
 - Compare with parton shower

Thanks

Backup

- Neat expressions

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$$\mathcal{R}_{J_i} = \exp \left[-2T_i^2 S(\mu_J, \mu) - A_{J_i}(\mu_J, \mu) \right] \left(\frac{\mu_J}{p_T^{J_i} R} \right)^{-2T_J^2 A_\Gamma(\mu_J, \mu)},$$

For the NLL resummation, we need

$$A_\Gamma(\mu_i, \mu_f) = \frac{\Gamma_0}{2\beta_0} \left\{ \log r + \frac{\alpha_s(\mu_i)}{4\pi} \left(\frac{\Gamma_1}{\Gamma_0} - \frac{\beta_1}{\beta_0} \right) (r - 1) \right\}, \quad (38)$$

and

$$S(\mu_i, \mu_f) = \frac{\Gamma_0}{4\beta_0^2} \left\{ \frac{4\pi}{\alpha_s(\mu_i)} \left(1 - \frac{1}{r} - \log r \right) + \left(\frac{\Gamma_1}{\Gamma_0} - \frac{\beta_1}{\beta_0} \right) (1 - r + \log r) + \frac{\beta_1}{2\beta_0} \log^2 r \right\}, \quad (39)$$

Backup

- Log counting

	matching (singular)	nonsingular	γ_x	Γ_{cusp}	β	PDF
LO	LO	LO	-	-	1-loop	LO
NLO	NLO	NLO	-	-	2-loop	NLO
NNLO	NNLO	NNLO	-	-	3-loop	NNLO
LL	LO	-	-	1-loop	1-loop	LO
NLL	LO	-	1-loop	2-loop	2-loop	LO
NNLL	NLO	-	2-loop	3-loop	3-loop	NLO
NLL'+NLO	NLO	NLO	1-loop	2-loop	2-loop	NLO
NNLL+NNLO	(N)NLO	NNLO	2-loop	3-loop	3-loop	NNLO
NNLL'+NNLO	NNLO	NNLO	2-loop	3-loop	3-loop	NNLO
N ³ LL+NNLO	NNLO	NNLO	3-loop	4-loop	4-loop	NNLO

Table from Berger, Marcantonini, Stewart, Tackmann and Waalewijn '11
see also, Becher, Neubert and Xu '06