Threshold resummation for pair-production of coloured heavy particles at hadron colliders

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Outline

- Introduction and motivation
- Coulomb and threshold-logarithm resummation
- Squark-antisquark cross section at NLL
- Conclusions

Pair-production of heavy particles at hadron colliders

$$p_i(r_i) + p_j(r_j) \longrightarrow H(R)H^{'}(R') + X \qquad H, H' \equiv t,\ \tilde{q},\ \tilde{g},\ \ldots$$

Partonic cross section for pair-production of heavy particles at hadron colliders contains terms kinematically enhanced in the partonic threshold region $\hat{s} \sim 4\bar{m}^2$, $\bar{m} \equiv (m_H + m_{H'})/2$.

- **Coulomb singularities**: $\sim \alpha_s^n/\beta^n$, $\beta = \sqrt{1 - 4\bar{m}^2/\hat{s}}$ $\Leftrightarrow$ Coulomb interactions of slowly-moving particles
- **Threshold logarithms**: $\sim \alpha_s^n \ln^{2n} \beta^2$ $\Leftrightarrow$ soft-gluon exchange

Small coupling but effectively "non-perturbative" dynamics $\Rightarrow$ Must be resummed to all orders when the partonic threshold region dominates the total hadronic cross section!

- Absolute normalisation of the total cross section
- Generally observed to reduce factorisation-scale dependence

Resummation in Mellin-moment space

In recent years threshold resummation has been applied to several different processes:

- $t\bar{t}$ [Catani et al. '96; Bonciani et al '98; Kidonakis et al '01; Moch, Uwer '08; Czakon, Mitov '08]
- Squarks, gluinos [Kulesza, Motyka '08; Langenfeld, Moch '09]
- Colour-octet scalars [Idilbi, Kim, Mehen, '09]

The theoretical basis for resummation is the factorisation of hard and soft contributions in the threshold region (more generally for $Q^2 \sim \hat{s}$, even if $Q^2 \neq 4\bar{m}^2$)

$$\hat{\sigma} = H \otimes S$$

- Resummation traditionally performed in Mellin-moment space:

$$H \otimes S \Rightarrow H(N)S(N) \qquad \alpha_s^n \ln^{2n} \beta \Rightarrow \alpha_s^n \ln^{2n} N$$

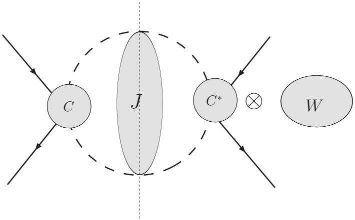
- Threshold logs exponentiated by solving evolution equations for $H(N)$ and $S(N)$.
- Requires numerical inversion of the Mellin transform and prescription to deal with Landau poles in the integrand

Resummation in momentum space

In this talk: apply formalism proposed by [Neubert and Becher '06] to resummation of the total cross section for $p_i p_j \to HH' + X$.

- Based on effective-theory description of the process (SCET+NRQCD)
- Threshold resummation performed directly in momentum space

Extra factorisation of the cross section near the true partonic threshold $\hat{s} \sim (m_H + m_{H'})^2$



$$\hat{\sigma} = |C|^2 \times W \otimes J$$

- Hard function C: depends on the precise nature of the physics model
- Process-independent soft function W: analogous to S in usual factorisation formula
- Potential function J encoding Coulomb interactions

J and W depend only on $SU(3)$ representation of p_i, p_j, H, H' !

The formalism

Near threshold ($\beta \ll 1$) partonic cross section receives contributions from hard ($k^2 \sim \bar{m}^2$) and long-distance ($k^2 \lesssim \bar{m}^2 \beta^2$) dynamical modes:

Long-distance modes

- **collinear**: $k_- \sim m$, $k_+ \sim m\beta^2$, $k_\perp \sim m\beta$
- **potential** : $k_0 \sim m\beta^2$, $|\vec{k}| \sim m\beta$ ($\Leftrightarrow$ Coulomb singularities)
- **soft**: $k_0 \sim |\vec{k}| \sim m\beta^2$

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- **soft**: $k_0 \sim |\vec{k}| \sim m\beta^2$

The full theory is matched on an effective Lagrangian from which hard modes are removed.

$$\mathcal{L}_{\text{full}} \longrightarrow \mathcal{L}_{\text{SCET}} + \mathcal{L}_{\text{PNRQCD}}$$

- $\mathcal{L}_{\textbf{SCET}}$: describes interactions of collinear (ξ_c, A_c) and soft (A_s) modes

$$\mathcal{L}_c = \bar{\xi}_c \left(in\cdot D + i\not{D}_{\perp c} \frac{1}{i\bar{n}\cdot D_c} i\not{D}_{\perp c} \right) \frac{\not{\bar{n}}}{2}\, \xi_c - \frac{1}{2}\,\text{tr}\left(F_c^{\mu\nu} F^c_{\mu\nu} \right)$$

- $\mathcal{L}_{\textbf{PNRQCD}}$: contains interactions of potential ($\psi, \psi^{'}, A_p$) and soft (A_s) modes

$$\begin{aligned}\mathcal{L}_{\text{PNRQCD}} = {} & \psi^\dagger \left(iD_s^0 + \frac{\vec{\partial}^2}{2m_H} + \frac{i\Gamma_H}{2} \right) \psi + \psi'^\dagger \left(iD_s^0 + \frac{\vec{\partial}^2}{2m_{H'}} + \frac{i\Gamma_{H'}}{2} \right) \psi' \\ & + \int d^3\vec{r}\, \left[\psi^\dagger \mathbf{T}^{(R)a} \psi \right](x+\vec{r}) \left(\frac{\alpha_s}{r} \right) \left[\psi'^\dagger \mathbf{T}^{(R')a} \psi' \right](x)\end{aligned}$$

Structure of EFT amplitudes and soft-gluon decoupling

$$\mathcal{A}_{\{a\}}(pp' \to HH'X) = \sum_{\ell,i} c^{(i)}_{\{b\}}\, C^{(\ell,i)}_{pp'}(4\bar{m}^2,\mu)\, \langle H_{a_3} H'_{a_4} X | \mathcal{O}^{(\ell)}_{pp',\{b\}}(0) | p_{a_1} p'_{a_2} \rangle$$

- Tower of hard coefficients encoding the short-distance structure of the pair-production process
- $\mathcal{O}^{(0)}_{pp',\{b\}} \sim \phi_{\bar{c},b_2}\phi_{c,b_1}\psi'_{b_4}\psi_{b_3}$, with $\phi_c = \{W_c\xi_c, \mathcal{A}_c\}$.
- Matrix element evaluated using the EFT Lagrangian $\Rightarrow$ soft gluons interacting with everything and Coulomb interactions between the two heavy particles

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At leading order in PNRQCD soft gluons can be removed from the effective Lagrangian via a field redefinition involving soft Wilson lines:

$$\begin{aligned}
\phi_c(x) &= S_n^{(r_i)}(x_-)\phi_c^{(0)}(x) \\
\psi(x) &= S_v^{(R)}(x_0)\psi_b^{(0)}(x) \\
S_n^{(r_i)\dagger}(in\cdot D)S_n^{(r_i)} &\Rightarrow in\cdot D_c \\
S_v^{(R)\dagger}(iD_s^0)S_v^{(R)} &\Rightarrow i\partial^0
\end{aligned}$$

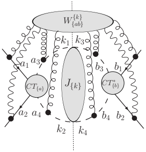
Factorisation formula

After soft-gluon decoupling:

$$\hat{\sigma}_{pp'}(\hat{s},\mu) = \frac{1}{2\hat{s}N_{pp'}} \sum_{i,i',\ell,\ell'} \sum_{R_\alpha} C_{pp'}^{(\ell,i)} C_{pp'}^{(\ell',i')*} \int d\omega\, J_{R_\alpha}^{(\ell,\ell')}(E - \tfrac{\omega}{2})\, W_{ii'}^{R_\alpha}(\omega,\mu)$$

Colour structure of the factorisation formula

- Hard coefficients $C_{pp'}^{(l,i)}$ is decomposed on a basis of colour operators $o_{\{c\}}^{(i)}$
- Potential function $J_{R_\alpha}^{(\ell,\ell')}$ is projected over irreducible representations of the final state: $R \otimes R' = \sum_\alpha R_\alpha$
- $W_{ii'}^{R_\alpha}$ is given by a set of matrices acting on the vector space spanned by $o_{\{c\}}^{(i)}$



$$W_{ii'}^{R_\alpha}(\omega,\mu) = P_{\{k\}}^{R_\alpha} c_{\{a\}}^{(i)} c_{\{b\}}^{(i')*} \int \frac{dz_0}{4\pi} e^{i\omega z_0/2} \langle 0|\bar{\mathrm{T}}[S^\dagger_{n,ib_1} S^\dagger_{\bar{n},jb_2} S_{v,b_4,k_4} S_{v,b_3,k_3}](z)$$
$$\mathrm{T}[S_{\bar{n},a_2 j} S_{n,a_1 i} S^\dagger_{v,k_1 a_3} S^\dagger_{v,k_2 a_4}](0)|0\rangle$$

Different soft function $W_{ii'}^{R_\alpha}$ for each irreducible representation R_α!

All-order colour structure of $W_{ii'}^{R_\alpha}$ for $3 \otimes \bar{3}$ (I)

Consider pair production of particle-antiparticle in the fundamental representation (ex. $t\bar{t}$, $\tilde{q}\bar{\tilde{q}}$)

$$3 \otimes \bar{3} = 1 \oplus 8$$

Projectors on the irreducible representations: $P^S_{\{k\}} = \frac{1}{N_C}\delta_{k_1k_2}\delta_{k_3k_4}$ $\quad P^8_{\{k\}} = 2T^A_{k_2k_1}T^A_{k_3k_4}$

- **Quark-antiquark channel:** $q\bar{q} \to H^{(3)}H^{(\bar{3})}$

$$c^{(1)}_{\{a\}} = \frac{1}{N_C}\delta_{a_1a_2}\delta_{a_3a_4} \qquad c^{(2)}_{\{a\}} = \frac{2}{\sqrt{N_C^2-1}}T^A_{a_2a_1}T^A_{a_3a_4}$$

$$\begin{aligned} W^S_{ii'}(z,\mu) &= \text{diag}\left(W_{DY}, 0\right) \\ W^8_{ii'}(z,\mu) &= \text{diag}\left(0, \frac{1}{(N_C^2-1)}\langle 0|\text{Tr}[\overline{\text{T}}[S_n^\dagger T^a S^{(8)}_{v,ac}S_{\bar{n}}](z)\text{T}[S_{\bar{n}}^\dagger S^{(8),\dagger}_{v,cb}T^b S_n](0)]|0\rangle\right) \end{aligned}$$

- $W^{S/8}_{i\neq i'}(z,\mu) \propto \text{Tr}[T^A] = 0$
- $W_{DY} = \frac{1}{N_C}\langle 0|\text{Tr}\overline{\text{T}}[S_n^\dagger S_{\bar{n}}](z)\text{T}[S_{\bar{n}}^\dagger S_n](0)|0\rangle$.
- Conventional soft function $W_{ii'} = \sum_\alpha W^{R_\alpha}_{ii'} = \text{diag}(W_{DY}, W^8_{22})$

All-order colour structure of $W_{ii'}^{R_\alpha}$ for $3 \otimes \bar{3}$ (II)

- **Gluon-gluon channel:** $gg \to H^{(3)} H^{(\bar{3})}$

$$c_{\{a\}}^{(1)} = \frac{1}{N_C D_A} \delta_{a_1 a_2} \delta_{a_3 a_4} \quad c_{\{a\}}^{(2)} = \frac{1}{\sqrt{2 D_A B_F}} D_{a_2 a_1}^A T_{a_3 a_4}^A \quad c_{\{a\}}^{(3)} = \sqrt{\frac{2}{N_C D_A}} F_{a_2 a_1}^A T_{a_3 a_4}^A$$

$$\begin{aligned} W_{ii'}^S(z,\mu) &= \mathrm{diag}\left(W_{DY}, 0, 0\right) \\ W_{ii'}^8(z,\mu) &= \mathrm{diag}\left(0, \frac{1}{4 D_A B_F} \langle 0 | \mathrm{Tr}[\overline{\mathrm{T}}[S_n^\dagger D^a S_{v,ac}^{(8)} S_{\bar{n}}](z) \mathrm{T}[S_{\bar{n}}^\dagger S_{v,cb}^{(8),\dagger} D^b S_n](0)] | 0 \rangle, \right. \\ &\qquad \left. \frac{1}{N_C D_A} \langle 0 | \mathrm{Tr}[\overline{\mathrm{T}}[S_n^\dagger F^a S_{v,ac}^{(8)} S_{\bar{n}}](z) \mathrm{T}[S_{\bar{n}}^\dagger S_{v,cb}^{(8),\dagger} F^b S_n](0)] | 0 \rangle \right) \\ W_{ii'}(z,\mu) &= \mathrm{diag}\left(W_{DY}, W_{22}^8, W_{33}^8\right) \end{aligned}$$

All-order colour structure of $W^{R_\alpha}_{ii'}$ for $3 \otimes \bar{3}$ (II)

- **Gluon-gluon channel:** $gg \to H^{(3)} H^{(\bar{3})}$

$$c^{(1)}_{\{a\}} = \frac{1}{N_C D_A} \delta_{a_1 a_2} \delta_{a_3 a_4} \quad c^{(2)}_{\{a\}} = \frac{1}{\sqrt{2 D_A B_F}} D^A_{a_2 a_1} T^A_{a_3 a_4} \quad c^{(3)}_{\{a\}} = \sqrt{\frac{2}{N_C D_A}} F^A_{a_2 a_1} T^A_{a_3 a_4}$$

$$\begin{aligned}
W^S_{ii'}(z,\mu) &= \mathrm{diag}\,(W_{DY}, 0, 0) \\
W^8_{ii'}(z,\mu) &= \mathrm{diag}\left(0, \frac{1}{4 D_A B_F} \langle 0|\mathrm{Tr}[\overline{\mathrm{T}}[S_n^\dagger D^a S^{(8)}_{v,ac} S_{\bar{n}}](z) \mathrm{T}[S_{\bar{n}}^\dagger S^{(8),\dagger}_{v,cb} D^b S_n](0)]|0\rangle,\right. \\
&\qquad \left. \frac{1}{N_C D_A} \langle 0|\mathrm{Tr}[\overline{\mathrm{T}}[S_n^\dagger F^a S^{(8)}_{v,ac} S_{\bar{n}}](z) \mathrm{T}[S_{\bar{n}}^\dagger S^{(8),\dagger}_{v,cb} F^b S_n](0)]|0\rangle\right) \\
W_{ii'}(z,\mu) &= \mathrm{diag}\left(W_{DY}, W^8_{22}, W^8_{33}\right)
\end{aligned}$$

- At threshold soft function for $r_i + r_j \to R + R'$ is reduced to sum of soft functions for $r_i + r_j \to R_\alpha$, where $R \otimes R' = \sum_\alpha R_\alpha$
- Conventional soft function $W_{ii'} = \sum_\alpha W^{R_\alpha}_{ii'}$ for $t\bar{t}/\tilde{q}\bar{\tilde{q}}$ at threshold is diagonal to all order in α_s in the same colour basis that diagonalises the one-loop soft function
(Extends recent results for the two-loop massive soft anomalous dimension in the threshold limit [Mitov et al. '09; Neubert et al. '09])

Resummation of threshold logarithms

Factorisation-scale independence of the total cross section translates into evolution equations for hard matching coefficient and soft function

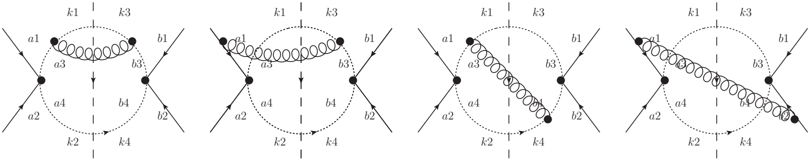
$$\frac{d}{d\ln\mu} C^{i}_{pp'}(4\bar{m}^2,\mu) = \left[\frac{1}{2}\left(\Gamma^r + \Gamma^{r'}\right)\ln\left(-\frac{4\bar{m}^2}{\mu^2}\right) + \gamma^C\right]_{ij} C^{j}_{pp'}(4\bar{m}^2,\mu)$$

$$\frac{d}{d\ln\mu}\mathbf{W}^{R_\alpha}(\omega,\mu) = -\int_0^\omega d\omega\left(\frac{1}{\omega-\omega'}\right)_{[\mu]}\left[\Gamma_{R_\alpha}\mathbf{W}^{R_\alpha}(\omega',\mu) + \mathbf{W}^{R_\alpha}(\omega',\mu)\Gamma^\dagger_{R_\alpha}\right] -\gamma^S_{R_\alpha}\mathbf{W}^{R_\alpha}(\omega,\mu) - \mathbf{W}^{R}(\omega,\mu)\gamma^{S\dagger}_{R_\alpha}$$

$$\sum_\alpha \Gamma_{R_\alpha} = \Gamma^r + \Gamma^{r'} \qquad \sum_\alpha \gamma^S_{R_\alpha} = \gamma^S$$

- Γ^r and Γ_{R_α} control resummation of double logs, γ^C_{ij}, γ^{S,R_α} resum single logs.
- In general mixing of different colour structures. With suitable choice of colour basis reduce to set of decoupled equations for $W^{R_\alpha}_{ii}$

One-loop soft function and anomalous dimensions



One-loop soft function for arbitrary initial and final-state particles:

$$W_{ij}^{R_\alpha,(1)}(L) \quad = \quad \frac{\alpha_s}{4\pi}\left[\frac{\Gamma^{r,(0)}_{R_\alpha,ij}+\Gamma^{r',(0)}_{R_\alpha,ij}}{4}\left(\frac{2}{\epsilon^2}+\frac{2}{\epsilon}L+L^2+\frac{\pi^2}{6}\right)-\gamma^{S,(0)}_{R_\alpha,ij}\left(\frac{1}{\epsilon}+L+2\right)\right]$$

$$L = 2\ln\left(\frac{iz_0\mu e^{\gamma_E}}{2}\right)$$

For R_α relevant for $t\bar{t}/\tilde{q}\bar{\tilde{q}}$ one obtains:

$q\bar{q}$ **channel**		gg **channel**	
$\Gamma_S^{3,(0)} = \text{diag}(4C_F, 0)$	$\gamma_S^{S,(0)} = \text{diag}(0,0)$	$\Gamma_S^{8,(0)} = \text{diag}(4N_C, 0, 0)$	$\gamma_S^{S,(0)} = \text{diag}(0,0,0)$
$\Gamma_8^{3,(0)} = \text{diag}(0, 4C_F)$	$\gamma_8^{S,(0)} = \text{diag}(0, -2N_C)$	$\Gamma_8^{8,(0)} = \text{diag}(0, 4N_C, 4N_C,)$	$\gamma_8^{S,(0)} = \text{diag}(0, -2N_C, -2N_C)$

$\sum_\alpha \Gamma^{r,(0)}_{R_\alpha}$, $\sum_\alpha \gamma^{S,(0)}_{R_\alpha}$ gives the usual one-loop cusp and soft anomalous dimensions!

Resummed soft function and matching coefficient

Threshold logarithms are resummed by renormalising $C^{i}_{pp'}$ and $\mathbf{W}^{R_\alpha}$ at a hard scale μ_h and a soft scale μ_s respectively, and evolving them to the common scale μ.

$$C^{i,\mathrm{res}}_{pp'}(4\bar{m}^2,\mu) = \exp[2S(\mu_h,\mu) - a_i^C(\mu_h,\mu)]\left(-\frac{4\bar{m}^2}{\mu_h^2}\right)^{-a_\Gamma(\mu_h,\mu)} C^{i}_{pp'}(4\bar{m}^2,\mu_h)$$

$$W^{R_\alpha,\mathrm{res}}_{ii}(\omega,\mu) = \exp[-4S_i^{R_\alpha}(\mu_s,\mu) + 2a_i^{S,R_\alpha}(\mu_s,\mu)]\tilde{s}^{R_\alpha}_{ii}(\partial_\eta,\mu_s)\frac{1}{\omega}\left(\frac{\omega}{\mu_s}\right)^{2\eta}\theta(\omega)\frac{e^{-2\gamma_E\eta}}{\Gamma(2\eta)}$$

$$S(\nu,\mu) = -\int_{\alpha_s(\nu)}^{\alpha_s(\mu)} d\alpha_s \frac{\Gamma^r(\alpha_s)+\Gamma^{r'}(\alpha_s)}{2\beta(\alpha_s)}\int_{\alpha_s(\nu)}^{\alpha_s}\frac{d\alpha_s'}{\beta(\alpha_s')}$$

$$a_\Gamma(\nu,\mu) = -\int_{\alpha_s(\nu)}^{\alpha_s(\mu)} d\alpha_s \frac{\Gamma^{(0)r}(\alpha_s)+\Gamma^{r'}(\alpha_s)}{2\beta(\alpha_s)}$$

$$a_i^X(\nu,\mu) = -\int_{\alpha_s(\nu)}^{\alpha_s(\mu)} d\alpha_s \frac{\gamma_i^X(\alpha_s)}{\beta(\alpha_s)}$$

μ_h and μ_s must be chosen such that fixed-order perturbative expansions of $C^{i}_{pp'}(4\bar{m}^2,\mu_h)$ and $W^{R_\alpha}_{ii}(\omega,\mu_s)$ are well behaved.

Resummed Coulomb corrections

Well known from quarkonia physics! $J^{(\ell,\ell')}_{R_\alpha}$ related to zero-distance Green function of Schrödinger operator $-\vec{\nabla}^2/(2m_{\rm red}) - \alpha_s(-C_{R_\alpha})/r$:

$$J^{(\ell,\ell')}_{R_\alpha}(E) \leftrightarrow \mathrm{Im}\, G^{(0)}_{\mathrm{C,R}_\alpha}(0,0;E) \qquad E = \sqrt{s} - 2\bar{m}$$

In the $\overline{\mathrm{MS}}$

$$G^{(0)}_{\mathrm{C,R}_\alpha}(0,0;E) = -\frac{(2m_{\rm red})^2}{4\pi}\left\{\sqrt{-\frac{E}{2m_{\rm red}}} + \alpha_s(-C_{R_\alpha})\left[\frac{1}{2}\ln\left(-\frac{8\,m_{\rm red}E}{\mu^2}\right) - \frac{1}{2} + \gamma_E + \psi\left(1 - \frac{\alpha_s(-C_{R_\alpha})}{2\sqrt{-E/(2m_{\rm red})}}\right)\right]\right\}$$

with $C_{R_\alpha} = (-C_F, 1/(2N_C))$ for $R_\alpha = (S, 8)$.

Finite width effects can be implemented by the replacement $E \to E + i\Gamma_H$
(see also **Stefano Actis' talk** tomorrow)

Squark-antisquark production at the LHC ($\sqrt{s} = 14\,\text{TeV}$)

In the rest of this talk:

$$PP \longrightarrow \tilde{q}\bar{\tilde{q}} + X$$

Perform NLL resummation of soft-gluon corrections + Coulomb singularities:

- Two-loop cusp anomalous dimension Γ and QCD β-function
- One-loop soft anomalous dimension γ^S
- Tree-level fixed-order matching coefficient $C^i_{pp'}$ and soft functions $W^{R_\alpha}_{ii'}$

μ set by default to $m_{\tilde{q}} \Rightarrow$ no need to resum the hard matching coefficient $C^i_{pp'}$

The effective-theory resummed cross section is matched onto the full NLO result [Zerwas et al., '96]

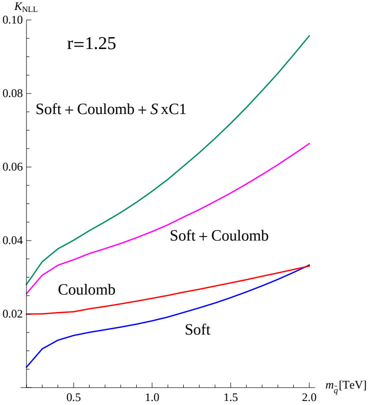
$$\hat{\sigma}^{\text{match}}_{pp'}(\hat{s},\mu_f) = \left[\hat{\sigma}^{\text{NLL}}_{pp'}(\hat{s},\mu_f) - \hat{\sigma}^{\text{NLL}}_{pp'}(\hat{s},\mu_f)|_{\text{NLO}}\right] + \hat{\sigma}^{\text{NLO}}_{pp'}(\hat{s},\mu_f)$$

Full NLO result computed using fitted scaling functions provided by [Langenfeld, Moch, '09]

NLL corrections to $\tilde{q}\bar{\tilde{q}}$ production [PRELIMINARY]

$$K_{\rm NLL} - 1 = \frac{\sigma^{\rm match}}{\sigma^{\rm NLO}} - 1$$

- Use MSTW2008 PDFs
- $\Gamma_{\tilde{q}} \to 0$
- μ set to $m_{\tilde{q}}$
- $r \equiv m_{\tilde{g}}/m_{\tilde{q}} = 1.25$
- $\mu_s = \bar{\mu}_s$, where $\bar{\mu}_s$ chosen such that one-loop soft corrections are minimised [Becher, Neubert, Xu '07]



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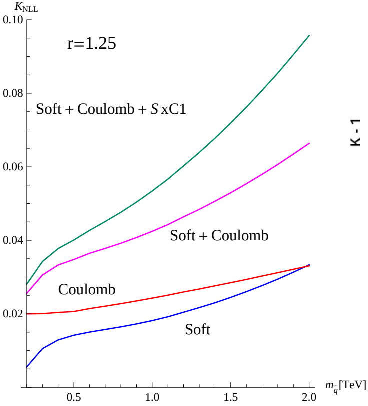
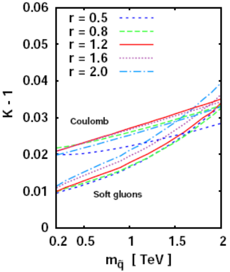
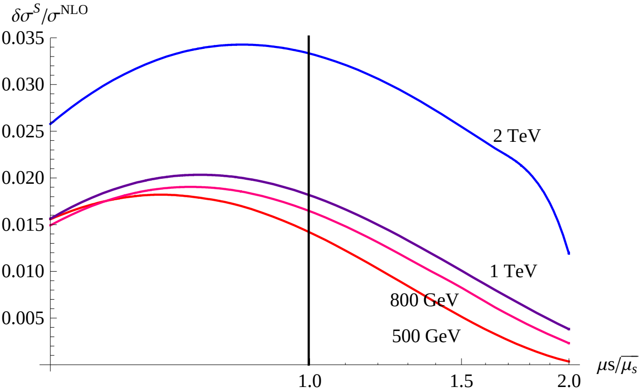




[Kulesza '08]

Soft-scale dependence

Resummation introduces extra scale μ_s $\Rightarrow$ How does the resummed result depend on μ_s?

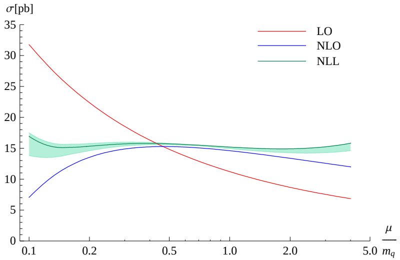


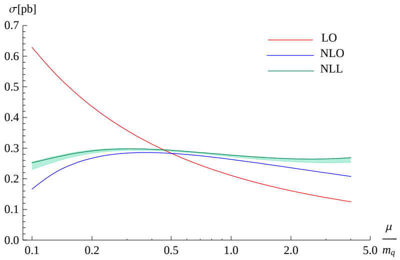
In the traditional Mellin-space resummation this is not visible (soft scale implicitly fixed to $\mu_s = 2m_{\tilde{q}}/N$)

Factorisation-scale dependence

Resummation of threshold logarithms sensibly reduces the factorisation-scale dependence of the cross section

$m_{\tilde{q}} = 500\,\text{GeV}$ $m_{\tilde{q}} = 1\,\text{TeV}$





Green band obtained by varying $\bar{\mu}_s/2 < \mu_s < 2\bar{\mu}_s$

Conclusions and Outlook

- Momentum-space resummation based on effective-theory framework works well and is in good agreement with analogous results in moment space
- Formalism allows for all-order generalisation of known one-loop and two-loop results ($\mathbf{W}^{R_\alpha}$ diagonal to all-order in α_s)
- For squark-antisquark production resummation effects beyond NLO amount to $3-10\%$ in the range $0.2-2\,\mathrm{TeV}$
- Even for small squark masses resummation dramatically improves factorisation-scale dependence of the cross section

Outlook

- Formalism can be applied to arbitrary final states (squark-squark, squark-gluino, gluino-gluino, etc...)