OVERVIEW OF RESUMMATION

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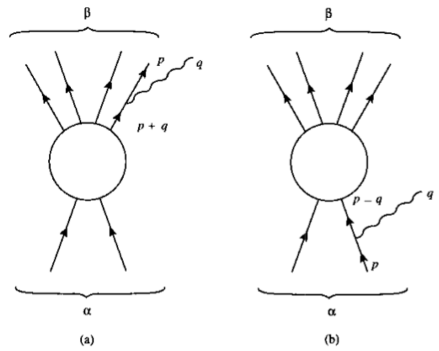
PARTON SHOWERS AND RESUMMATION

LUND, JUNE 4, 2018

WHERE IT ALL COMES FROM:
EIKONAL EMISSION...



EMISSION OF A SOFT $(q^\mu \to 0)$ GAUGE PARTICLE FROM EXTERNAL LINE

$$\sigma(\alpha \to \beta) \to \sigma(\alpha \to \beta)\frac{ep^\mu}{p\cdot q - i\epsilon}$$

(Bloch, Nordiseck, 1937; Yenni, Frautschi, Suura, 1955; Weinberg, 1964)

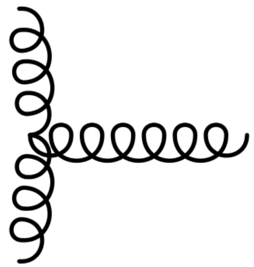
- SOFT EMISSION $\Rightarrow$ EIKONAL FACTOR
- CROSS SECTION FOR SINGLE (DOUBLE. . .) EMISSION INFRARED DIVERGENT; DIVERGENCE CANCELLED BY VIRTUAL CORRECTIONS
- 1,2,. . . ,N EMISSIONS EXPONENTIATE $\Rightarrow \Gamma \sim \exp - \left[\alpha \ln^2\left(1 - \frac{M_\beta^2}{s}\right)\right]$ (Sudakov, 1956)
- AFTER CANCELLATION, LEFTOVER SOFT LOGS: $\sigma(\alpha \to \beta) \to \sigma(\alpha \to \beta)\ln^2\left(1 - \frac{M_\beta^2}{s}\right)$

...AND RESUMMATION

- EXPONENTIATION OF LEFTOVER LOGS $\Rightarrow$
  THRESHOLD RESUMMATION OF $\alpha_s \ln^2(1-x)$, $x = \frac{M^2}{s}$
- LOGS COME IN PAIRS: SOFT+COLLINEAR $\longrightarrow \ln p_t$ WHEN INTEGRAL OVER p_t NOT PERFORMED$\Rightarrow$
  TRANSVERSE MOMENTUM RESUMMATION OF $\alpha_s \ln^2 \frac{q_T^2}{M^2}$
- IN GLUON CHANNEL SYMMETRY OF THE TRIPLE GLUON VERTEX $\longrightarrow$ LARGE LOGS ALSO WHEN THE EXCHANGED GLUON IS SOFT: NO COLLINEAR CONTRIBUTION, SINGLE LOGS $\longrightarrow \ln \frac{s}{Q^2} \Rightarrow$
  HIGH ENERGY RESUMMATION OF $\alpha_s \ln \frac{1}{x}$

GLUON RADIATION

$$\sigma(\tau, M^2) = \int_y^1 \frac{dy}{y} P\left(\frac{x}{y}\right) \int_{\mu^2}^{(s-M^2)^2/s} \frac{dk_t^2}{k_t^2} \hat{\sigma}(y, M^2)$$



THE GLUON SPLITTING FUNCTION:

$$P_{gg}(x) = 2C_A \left[\frac{x}{(1-x)_+} + \frac{1-x}{x} + x(1-x)\right] + \beta_0 \delta(1-x)$$

LOGARITHMICALLY ENHANCED TERMS

- INFRARED LOGS: $\int_\tau^1 dy \frac{1}{1-y}_+ \sim \ln(1-\tau)$
- UV LOGS: $\int_\tau^1 dy \frac{1}{y} \sim \ln(\tau)$
- COLLINEAR LOGS: $\int_{\mu^2}^{(s-M^2)^2/s} \frac{dk_t^2}{k_t^2} \sim \ln\left[\frac{Q^2}{\mu^2}\frac{(1-\tau)^2}{\tau}\right] = \ln\frac{Q^2}{\mu^2} + \ln(1-\tau)^2 + \ln\tau$

RESUMMATION: A TIMELINE

EARLY

- Balitski, Fadin, Kuraev, Lipatov, 1976-1978 STRUCTURE OF HIGH-ENERGY LOGS
- Dokshitzer, Dyakonov, Troyan, 1979 STRUCTURE OF p_T LOGS
- Parisi, Petronzio, 1979 LL TRANSVERSE MOMENTUM RESUMMATION
- Parisi, 1980; Curci, Greco, 1980 LL SOFT GLUON RESUMMATION
- Jaroszewicz, 1980 LL HIGH ENERGY RES. OF ANOMALOUS DIMENSIONS

CLASSIC

- Collins, Soper, Sterman, 1984 TRANSVERSE MOMENTUM: GENERAL STRUCTURE & ARGUMENT AND NLL RESULT (DRELL-YAN)
- Sterman, 1987: THRESHOLD: GENERAL STRUCTURE & ARGUMENT
- Catani, Trentadue, 1989 SOFT GLUON: NLL RESULT (DY, DIS)
- Catani, Ciafaloni, Hautmann, 1990 HIGH ENERGY: GENERAL FORMALISM FOR PURE GLUE
- Catani, Hautmann, 1993 HIGH ENERGY: GENERAL FORMALISM INCLUDING QUARKS

THE STRUCTURE OF RESUMMED EXPRESSIONS
THRESHOLD RESUMMATION

LOG COUNTING

$$C_{\rm res}(N,\alpha_s) = g_0(\alpha_s)\exp\left[\frac{1}{\alpha_s}g_1(\alpha_s\ln N) + g_2(\alpha_s\ln N) + \alpha_s g_3(\alpha_s\ln N) + \dots\right];$$

$g_0(\alpha_s) = 1 + \alpha_s g_{0,1} + \alpha_s^2 g_{0,2} + \mathcal{O}(\alpha_s^3)$; $g_1(\lambda) = \sum_{k=2}^{\infty} g_{1,k}\lambda^k$, $g_i(\lambda) = \sum_{k=1}^{\infty} g_{i,k}\lambda^k$ FOR $i \geq 2$

LOG APPROX.	XSECT ACCURACY	EXP. ACCURACY: $\alpha_s^n L^k$	g_0 ACCURACY: α_s^i
LL	$k = 2n$	$k = n + 1$	0
NLL	$2n - 2 \leq k \leq 2n$	$k = n$	1
NNLL	$2n - 4 \leq k \leq 2n$	$k = n - 1$	2

THE RESUMMED EXPONENT

$$S\left(M^2, \frac{M^2}{N^2}\right) = \int_{M^2}^{M^2/N^2} \frac{d\mu^2}{\mu^2}\bar\gamma\left(\alpha_s(\mu^2), \frac{M^2}{N^2\mu^2}\right)$$
$$= \int_{M^2}^{M^2/N^2} \frac{d\mu^2}{\mu^2}\left[-A(\alpha_s(\mu^2))\ln\left(\frac{M^2/N^2}{\mu^2}\right) + B[\alpha_s(\mu^2)]\right].$$

- A, B ARE POWER SERIES IN α_s
- A IS UNIVERSAL, COEFFICIENT OF $\ln N$ IN (DIAGONAL QUARK OR GLUON) ANOMALOUS DIMENSION AT EACH ORDER
- B CONTAINS PROCESS-DEPENDENT TERMS, STARTS AT NLL

THE STRUCTURE OF RESUMMED EXPRESSIONS
P_t RESUMMATION
THE CROSS SECTION

- PARTONIC DIFFERENTIAL p_T DISTRIBUTION: $\Sigma = \sum_n \alpha_s^n(M^2)\,\Sigma^{(n)}(p_T, M^2)$;
$\Sigma^{(n)}(p_T, M^2) = \left[\frac{P_n(\ln(p_T^2/M^2))}{p_T^2/M^2}\right]_+ + Q_n(p_T^2/M^2) + D_n\delta(p_T^2/M^2)$
- DIVERGES AS $p_T \to 0$ TO ANY FINITE ORDER

RESUMMATION

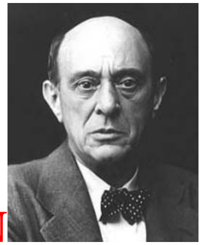
- PHASE-SPACE FACTORIZATION: LONGITUDINAL $\leftrightarrow$ MELLIN; TRANSVERSE $\leftrightarrow$ FOURIER
- $\Sigma(\alpha_s, p_t^2/M^2) = \frac{M^2}{2\pi}\int d^2b\, e^{-i\vec{p}_T\cdot\vec{b}}\,\Sigma(\alpha_s, \alpha_s L) = \int_0^{+\infty} db\, b\, J_0(bq_T)\,\Sigma(\alpha_s, \alpha_s L)$;
$\alpha_s = \alpha_s(M^2)$;, $L \equiv -\ln b^2 M^2$
- EXPONENTIATION:$\Sigma(\alpha_s, \alpha_s L) = \exp S(\alpha_s, \alpha_s L)$

THE RESUMMED EXPONENT

$$S(\alpha_s, \alpha_s\, L) \equiv -\int_{\frac{1}{b^2}}^{Q^2} \frac{d\mu^2}{\mu^2}\left[\ln\frac{Q^2}{\mu^2}\, A(\alpha_s(\mu^2)) + B(\alpha_s(\mu^2))\right],$$
$$\Rightarrow \Sigma(\alpha_s, \alpha_s\, L) = H(\alpha_s)\exp\left[Lg^{(1)}(\alpha_s L) + g^{(2)}(\alpha_s L) + \dots\right]$$

- A, B ARE POWER SERIES IN α_s
- A CONTAINS SOFT CONTRIBUTIONS, B PURELY COLLINEAR (FLAVOR-CONSERVING) CONTRIBUTIONS
- RESUMMATION SET UP SO THAT A AND B ARE PROCESS-INDEPENDENT (ONLY DEPEND ON QUARK VS GLUON) (Catani, de Florian, Grazzini, 2000)

RESUMMATION TIMELINE II

MODERN 

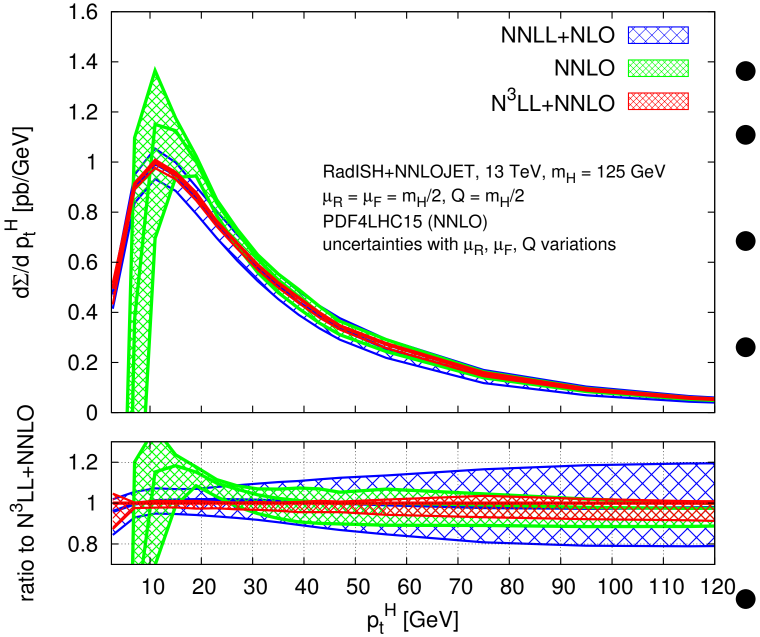
- Catani, Mangano, Nason, Trentadue, 1996 SOFT RESUMMATION FORMALISM FOR HADRONIC PROCESSES
- Contopanagos, Laenen, Sterman, 1997 GENERAL RG ARGUMENT FOR SUDAKOV RESUMMATION
- Altarelli, Ball, SF, 2001 HIGH ENERGY RESUMMATION IN DGLAP EQUATION

CONTEMPORARY 

- Catani, de Florian, Grazzini, 2001 TRANSVERSE MOMENTUM RESUMMATION UNIVERSALITY
  & FORMALISM FOR HADRONIC PROCESSES
- Manohar, 2003 SCET APPROACH TO THRESHOLD RESUMMATION
- Ciafaloni, Colferai, Salam, Stasto, 2004 FULL HIGH ENERGY RESUMMATION OF SPLITTING FUNCTIONS (PURE GLUE)
- Altarelli, Ball, SF, 2008 HIGH ENERGY RESUMMATION FOR PHYSICAL PROCESSES

RESUMMATION NOW

HIGGS p_t SPECTRUM (EFT)



(Bizon, Chen, Gehrmann-De Ridder, Gehrmann, Glover, Huss, Monni, Re, Rottoli, Torrielli, 2018)

- SCET VS. DQCD NOT AN ISSUE
- THRESHOLD RESUMMATION
  $\Rightarrow$ IMPROVE FIXED ORDER
- MATCHING OF p_t RESUMMATION TO FIXED ORDER STANDARD FOR p_T SPECTRA
- IMPLEMENTED IN SEVERAL PUBLIC CODES: E.G. **xFitter/APFEL** (Bertone, 2016-2017), **TROLL, HELL** (Bonvini, 2016-2018), **TOP++** (Czakon, Mitov, 2016-2018), **iHixs** (Anastasiou, Bühler, Dulat, Herzog, Lazopoulos, Mistlberger 2012-2018), ...
- PROGRESS
  - HIGHER ORDERS, MORE PROCESSES
  - COMBINED, CONSISTENT & MORE EXCLUSIVE

SIX GREAT IDEAS ABOUT RESUMMATION

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MOMENTUM-SPACE RESUMMATION

MELLIN/FOURIER
THE PROBLEM:

- RG ARGUMENT FOR RESUMMATION NATURALLY FORMULATED IN FOURIER-MELLIN:
  - MELLIN $\Rightarrow$ LONGITUDINAL MOMENTUM CONSERVATION (UNDOES CONVOLUTION)
  - FOURIER $\Rightarrow$ TRANSVERSE MOMENTUM CONSERVATION (FACTORIZES k_t DELTA)
- EIKONAL EMISSION FACTORIZES $\Rightarrow$ CAN RESUM (BOTH SOFT & p_t) IN MOMENTUM SPACE
- SCHEMATIC BEHAVIOUR (FIXED COUPLING)

  $K^{\rm res} \sim \frac{d}{dp_t} \exp - \left[\alpha_s \ln^2 Q^2/p_t^2 F\left(\alpha, \ln \frac{Q^2}{p_t^2}\right)\right]$

  $\Rightarrow$ ZERO RADIUS OF CONVERGENCE! (DIVERGES FASTER THAN ANY POWER OF LOG)
- EXPANSION AT LL, NLL... LEADS TO CONVERGENT RESULT,

  FINITE RADIUS OF CONVERGENCE: $K^{\rm res} \sim \frac{d}{dp_t} \exp - \left[\alpha_s \ln^2 Q^2/p_t^2\right] \frac{\Gamma\left(1-2\alpha_s \ln \frac{Q^2}{p_t^2}\right)}{\Gamma\left(1+2\alpha_s \ln \frac{Q^2}{p_t^2}\right)}$

  $\Rightarrow$ BAD PERTURBATIVE EXPANSION

MOMENTUM SPACE

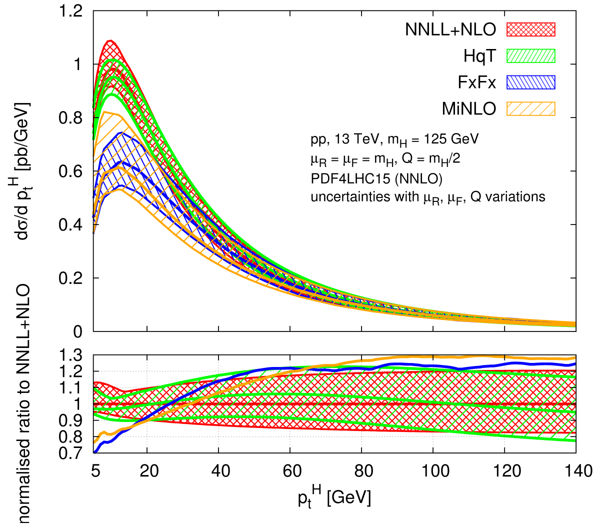
A SOLUTION

(Monni, Re, Torrielli, 2016; also Ebert, Tackmann, 2017)

DIVERGENCE & SINGULARITIES WHEN EXPONENTIATING INDEPENDENT SMALL p_t EMISSION DUE TO THE NEGLECT OF CONFIGURATIONS WHERE p_t SMALL DUE TO CANCELLATIONS
$\Rightarrow$ DOMINANT AS $p_t \to 0$ (Parisi, Petronzio, 1979)

- CONSTRUCT CUMULATIVE CROSS-SECTION $\Sigma(p_t) = \int_0^{p_t} dp'_t \frac{d\sigma(p'_t)}{dp'_t}$
- DIVERGENT $\Leftrightarrow$ EXPANDING EMISSIONS k_t^i ABOUT p_t
- ORDER EMISSIONS IN k_t, EXPAND ABOUT LARGEST k_T^1
- CAN DEFINE ITERATIVELY n-EMISSION CUMULANT IN TERMS OF $n-1$
- CAN PROVE EQUIVALENCE TO STANDARD FORMALISM UP TO SUBLEADING CORRECTIONS; SINGULAR TERMS SHIFTED TO HIGHER ORDERS

HIGGS p_t SPECTRUM



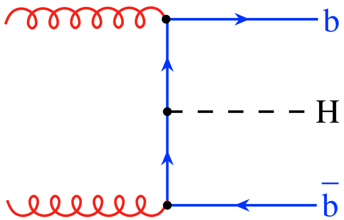
(Monni, Re, Torrielli, 2016)

MASSIVE EVOLUTION

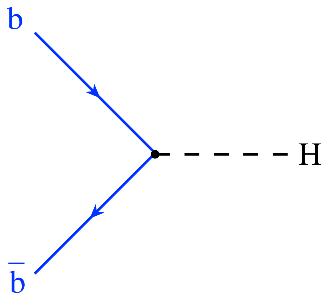
AN OLD PROBLEM: MASSIVE QUARK SCHEMES

EXAMPLE: $b\bar{b} \to H$

LO 4 FLAVORS



LO 5 FLAVORS



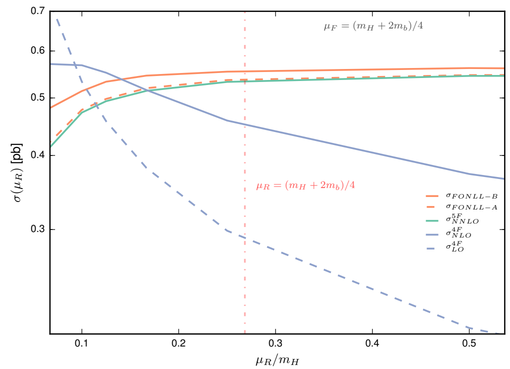
- 4FS $\Rightarrow$ MASSIVE B, NO b IN DGLAP EVOLUTION AND β FUNCTION
- 5FS $\Rightarrow$ Mb IN DGLAP EVOLUTION AND β FUNCTION BUT b MASS NEGLECTED

CLASSIC SOLUTION: MATCHED SCHEMES

- COLLINEAR FACTORIZATION ALSO HOLDS FOR MASSIVE QUARKS (Collins, 1998)
- RE-EXPRESS 4FS IN TERMS OF 5FS (OR VICE-VERSA)
- COMBINE & SUBTRACT DOUBLE COUNTING
- $b\bar{b}H$: PERTURBATIVE INSTABILITY OF 4FS REMOVED BY RESUMMATION
- MASS CORRECTIONS NEEDED FOR PERCENTAGE ACCURACY, EVEN FOR TOTAL XSECTS

4FS, 5FS VS MATCHED (FONLL)

RENORM. SCALE DEP.



WHAT'S THE PROBLEM?

- CUMBERSOME, ESPECIALLY FOR DIFFERENTIAL OBSERVABLES
- NOT EASY TO IMPLEMENT/INTERFACE IN MONTECARLOS

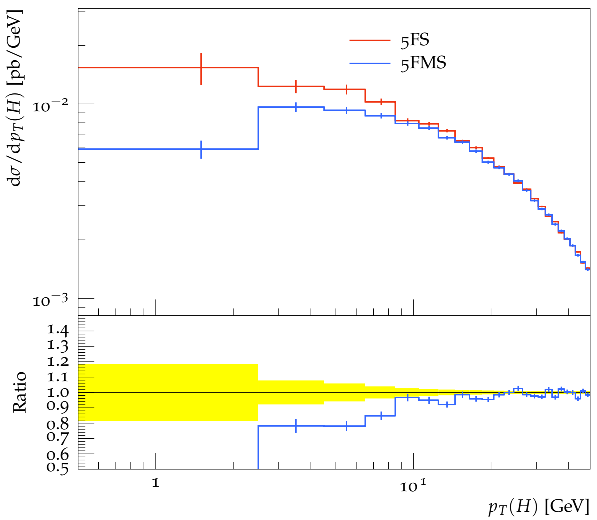
SOLUTION: MASSIVE 5FS

((Krauss, Napoletano, 2018)

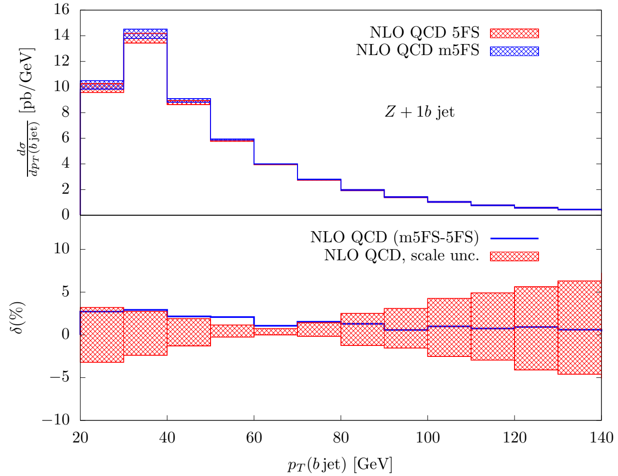
- MASSIVE SPLITTING FUNCTION
- SUBSET OF UNIVERSAL INITIAL-STATE MASS CORRECTIONS RESUMMED
- SUBSET OF MATCHED SCHEME CAPTURED, BUT RESUMMED TO ALL ORDERS

5FS VS MFS

$b\bar{b} \to H$



Z+B: p_t SPECTRUM OF B JET



(Figueroa, Honeywell, Quackenbusch, Reina, Reuschle, Wackeroth, 2018)

MIXED QCD-EW EVOLUTION

THE PROBLEM OF EW SUDAKOVs

- KLN CANCELLATION OF IR SINGULARITIES HOLDS IN QED
- IN NONABELIAN CASE, CANCELLATION ONLY FOR GAUGE GROUP SINGLET
- PROTON IS NOT EW SINGLET $\Rightarrow$ IR MASS SINGULARITIES DO NOT CANCEL BETWEEN REAL AND VIRTUAL
- EXPLICIT MASS DEPENDENCE IN VIRTUAL CORRECTION,
  REAL CONTRIBUTION HAS NO + PRESCRIPTION
  $\Rightarrow$ SINGULAR SPLITTING FUNCTIONS (M. Ciafaloni, P. Ciafaloni, Comelli, 2000-2005):
  $P_V \sim \delta(1-x) \ln \frac{Q^2}{k_t^{2\,\mathrm{max}}}$,
  $P^R \sim \frac{1}{1-x}$;
  $\frac{d}{d \ln Q^2} F(x, Q^2) = \int_x^{y^{\mathrm{max}}} P f(\frac{y}{x}, Q^2); \quad P = P^V + P^R$
- DOUBLE LOGS $\alpha_{EW} \ln^2 \frac{Q^2}{M_W^2}$ TO ALL ORDERS

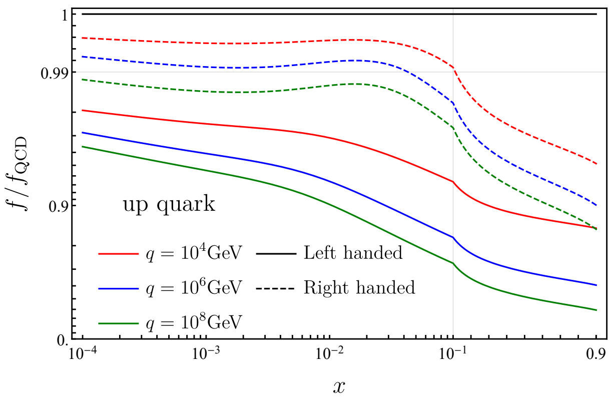
A PRACTICAL SOLUTION
SOLVING SM EVOLUTION EQUATIONS

(Bauer, Ferland, Webber, 2017)

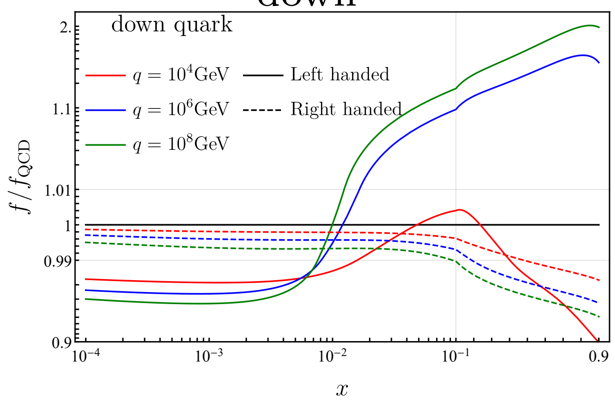
- SOLVE EVOLUTION EQUATIONS IN THE FULL STANDARD MODEL
- MATCH RESULTS TO FIXED ORDER CALCULATIONS
- INITIAL GAUGE BOSON PDF CAN BE DETERMINED BY THE LUX METHOD (Fornal, Manohar, Waalewijn, 2019)

FULL SM PDF EVOLUTION: RATIO TO QCD

UP

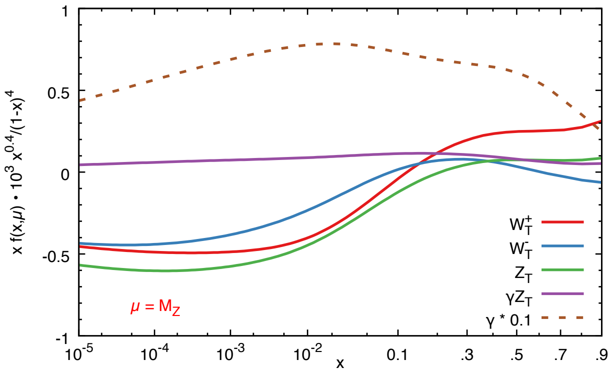


down

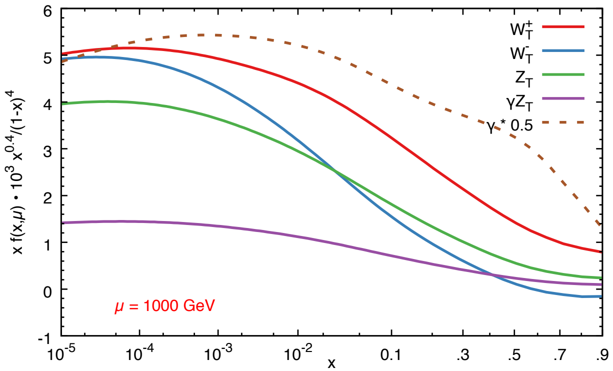


"LUX" TRANSVERSE W PDFS

$Q = M_z$



$Q = 1$ TeV



NEXT-TO LEADING POWER

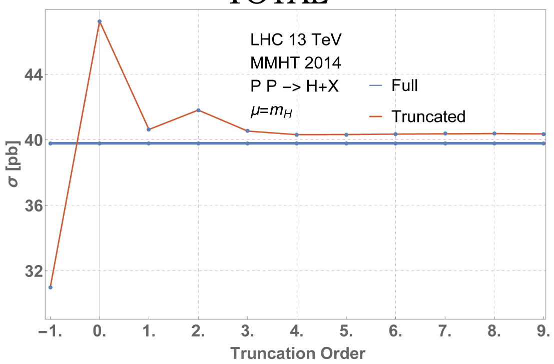
SOFT EXPANSION(s)

- BOTH IN THRESHOLD AND HE LIMIT: RESUMMATION ⇒
  - IMPROVEMENT OF FIXED ORDER
  - APPROXIMATE HIGHER ORDER (HQ MASS DEP, MULTISCALE)
- NEXT-TO-LEADING POWER LOGARITHMICALLY ENHANCED:
  $C^{(n)}(x) \underset{x\to 1}{=} \alpha_s^n \frac{\ln^{2n-1}(1-x)}{1-x_+} + \delta(1-x) + \ln^{2n}(1-x) + \ldots$
- LL, NLP RESUMMATION ⇔ DGLAP SPLITTING FUNCTION EXPANDED TO NLP
- NLP GOOD APPROX, ESPECIALLY IF RESCALED

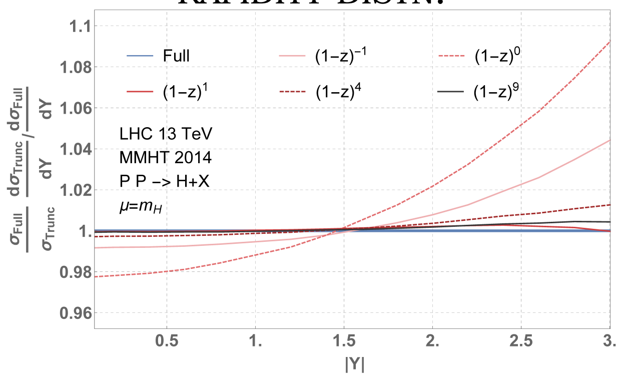
NNLO HIGGS IN GLUON FUSION: SOFT EXPANSION

(Dulat, Mistlberger, Pelloni, 2018)

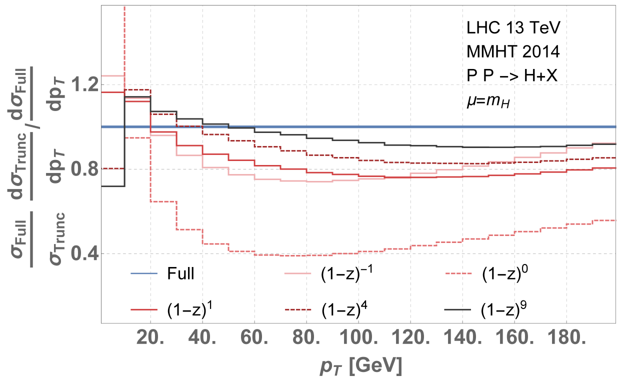
TOTAL



RAPIDITY DISTN.



p_t SPECTRUM



NLP PROGRESS

- METHOD OF REGIONS (Laenen et al, 2013....)
  - SEPARATE INTEGRATION REGIONS OVER MOMENTA THROUGH SCALING
  - COMBINE WITH FACTORIZATION $\Rightarrow$ CLASSIFY EMISSION FROM INTERNAL BLOBS DRESSED WITH RADIATION FROM EXTERNAL LINES

- RAPID RECENT PROGRESS BOTH USING DQCD & SCET, BOTH IN HE & SOFT LIMIT

NLO NLP UNIVERSALITY

(Del Duca, Laenen, Magnea, Vernazza, White, 2018)

- NEXT-TO-SOFT THEOREM (E. Casali, 2014; Bonocore et al, 2015)
  $\Leftrightarrow$ EIKONAL-LIKE NLP EMISSION FORMULA

- EFFECTIVELY, NLP OBTAINED FROM SHIFT IN BORN KINEMATICS:
  Born: $p_1 + p_2 \to X$; NLP NLO $p_1 \to p_1 - \frac{1}{2}\left(p_1 \frac{p_2 \cdot k}{p_1 \cdot p_2} - p_2 \frac{p_2 \cdot k}{p_1 \cdot p_2} + k\right)$, & SIMILAR FOR p_2

- NLP NLO: $C(x) = K(x, \varepsilon) C^{\text{Born}}(xs)$;
  $K(x, \varepsilon) = \left(\frac{\mu^2}{s}\right)^{\varepsilon} \left[\frac{2 - 2D_0(x)}{\varepsilon} + 4D_1(x) - 4\ln(1-x)\right]$;
  $D_n(x) = \left(\frac{\ln^n(1-x)}{1-x}\right)_+$

- HIGGS IN GLUON FUSION:
  - ALL NLO LOG DEPENDENCE COMES FROM UNIVERSAL NLP FACTOR $K(x, \varepsilon)$
  - FULL m_t DEPENDENCE INCLUDED THROUGH BORN FUNCTION $F(x\tau, \epsilon)$, $\tau = \frac{m_H^2}{s}$,
    $F(\tau, \varepsilon) = \frac{9}{4} \frac{1}{\tau^2} \left|1 + \left(1 - \frac{1}{\tau}\right) \arcsin^2(\sqrt{\tau})\right|^2 + O(\varepsilon)$

DIVERGENT OBSERVABLES

RESUMMING DIVERGENCES

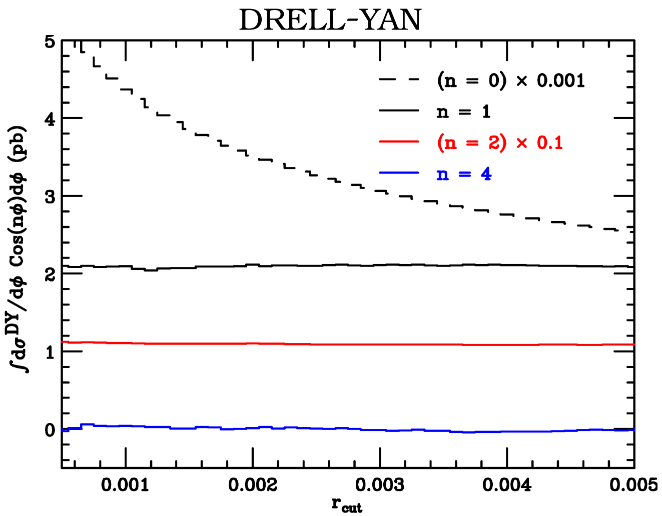
- DIVERGENCES AT KINEMATIC BOUNDARIES ROUTINELY REMOVED BY RESUMMATION
- IRC SAFE BUT DIVERGENT OBSERVABLES MADE FINITE BY RESUMMATION

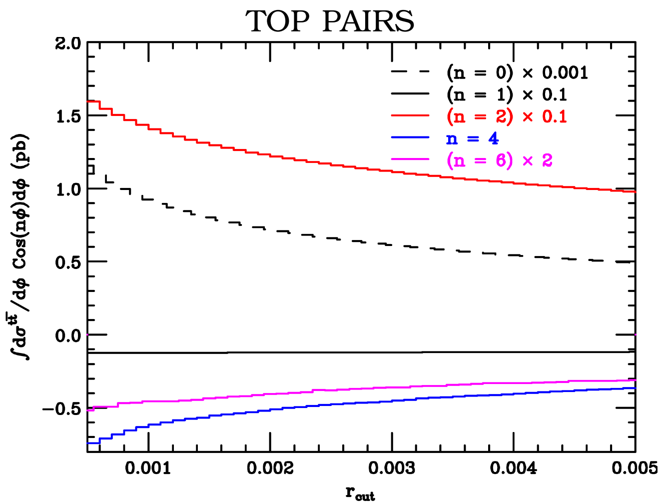
AZIMUTHAL VARIABLES

(Catani, Grazzini, Sargsyan, 2017)

- $h(p_1)h(p_2) \to F(p_3, p_4) + X \Rightarrow$ DY INTO DILEPTONS, TOP PAIRS, ...
- FINAL-STATE KINEMATICS M, p_T, y OF F; θ, ϕ OF p_3 IN COLLINS-SOPER FRAME (REST FRAME OF F)
- $\frac{d\sigma}{d\phi dp_t} \Rightarrow$ NONINTEGRABLE SINGULARITY AS $p_t \to 0 \Rightarrow \frac{d\sigma}{d\phi}$ DIVERGENT IF EITHER
  - INITIAL STATE GLUON (SOMETIMES)
  - COLORED FINAL STATE (ALWAYS)

AZIMUTHAL ANGULAR HARMONICS INTEGRATED DOWN TO $p_t = r_{\rm cut}$





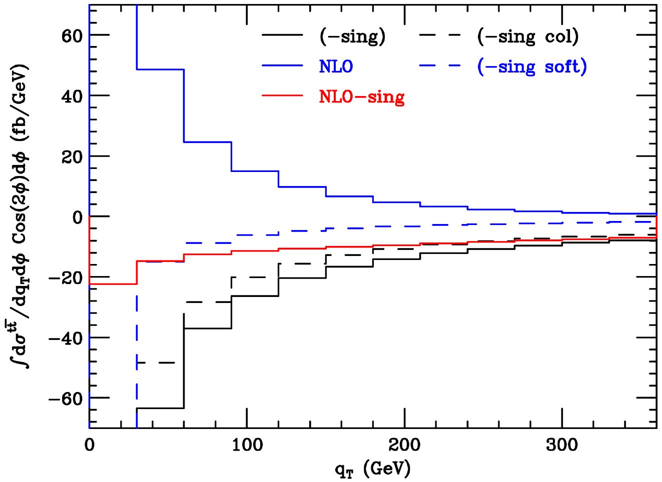
RESUMMING DIVERGENCES

(Catani, Grazzini, Sargsyan, 2017)

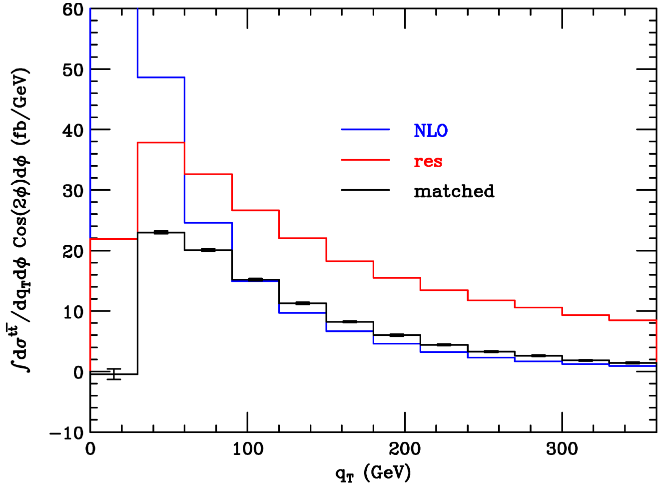
- DIVERGENCE DUE TO MISMATCH BETWEEN VIRTUAL & REAL AT FIXED ORDER
- VIRTUAL CANNOT LEAD TO AZIMUTHAL CORRELATION ⇒ CANNOT CANCEL
  - SINGULAR REAL CONTRIBUTIONS DUE TO COLLINEAR SPIN-CORRELATIONS (INITIAL-STATE GLUONS)
  - LARGE-ANGLE RADIATION FROM FINAL-STATE PARTICLES (FINAL-STATE COLORED STATES)
- RESUMMATION REMOVES THE DIVERGENCE THROUGH SUDAKOV SUPPRESSION

TOP PRODUCTION: FIRST HARMONIC

FIXED ORDER: SINGULAR CONTRIBNS.



RESUMMED VS. NLO & MATCHED



RESUMMED PDFs

WHAT ABOUT PDFS?

$$\Delta_N(Q^2) = \frac{W_N(Q^2)}{[F_N(Q^2)]^2},$$

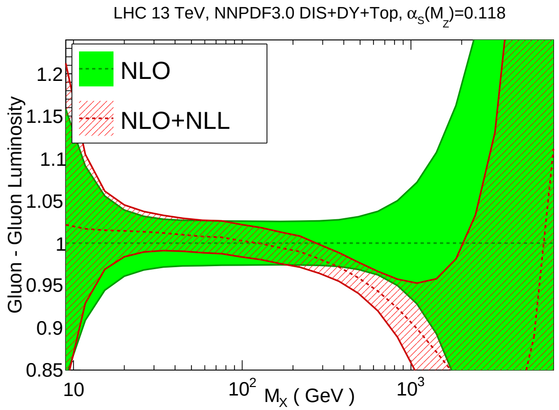
(Catani, Trentadue, 1987)

- RATIO OF PHYSICAL PROCESSES ⇒ RESUMMATION
- THE PDF IS THE DENOMINATOR
- BUT NOT RESUMMED IN AVAILABLE PDF SETS
- KEPT UNDER CONTROL WITH CUTS

PDFs WITH THRESHOLD RESUMMATION

EFFECTS ARE SMALL

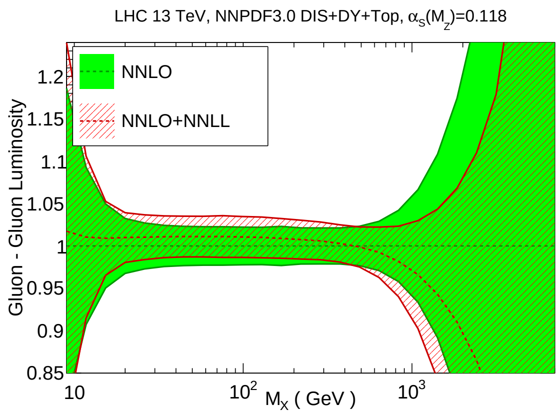
GLUON: NLO VS NLL



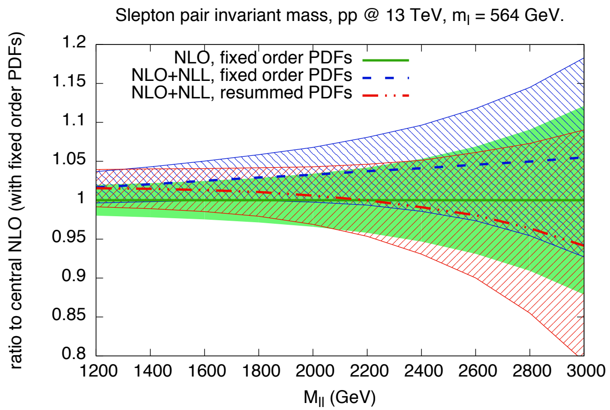
- FIRST SET: `NNPDF3.0resum`
- EFFECT ON PDFS COMPARABLE TO EFFECT ON MATRIX ELEMENT, ANTICORRELATED TO IT
- RESUMMATION INCLUDED IN FIT (DIS, DY, TOP DATA), EFFECTS VISIBLE AT NLO, LARGE x
- PERHAPS RELEVANT FOR NEW PHYSICS SEARCHES

(Bonvini et al., 2015)

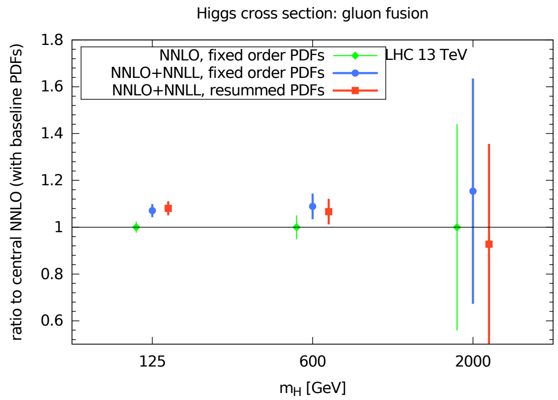
GLUON: NNLO VS NNLL



SLEPTON PAIR PRODUCTION

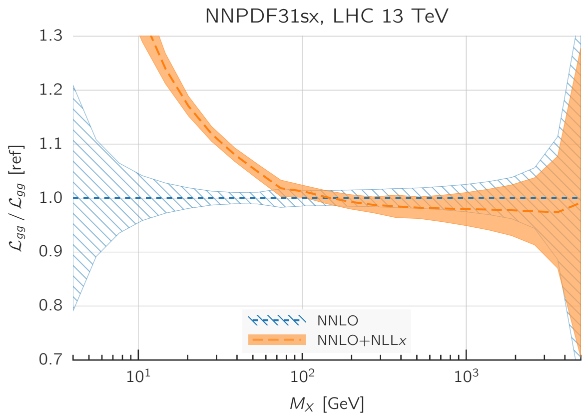


HIGGS IN GLUON FUSION VS m_H



PDFs WITH HIGH ENERGY RESUMMATION

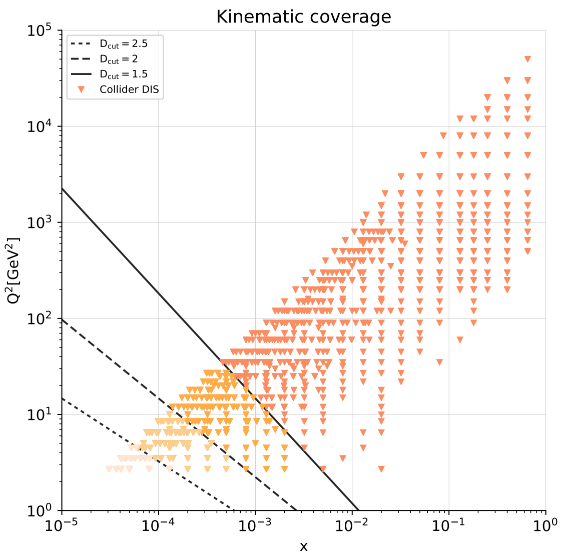
GLUON LUMINOSITY



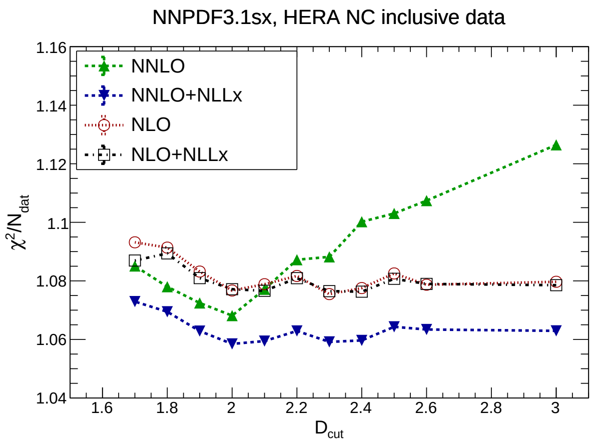
- FIRST SET: `NNPDF3.0sx`
- HIGH ENERGY RESUMMATION INCLUDED IN GLAP EVOLUTION& FOR DIS COEFFICIENT FUNCTIONS
- STABILIZES PERTURBATIVE EXPANSION
- VISIBLE EFFECTS FOR LIGHT FINAL STATES (b PRODUCTION AT LHC)
  & FOR FUTURE COLLIDERS

(Ball et al., 2017)

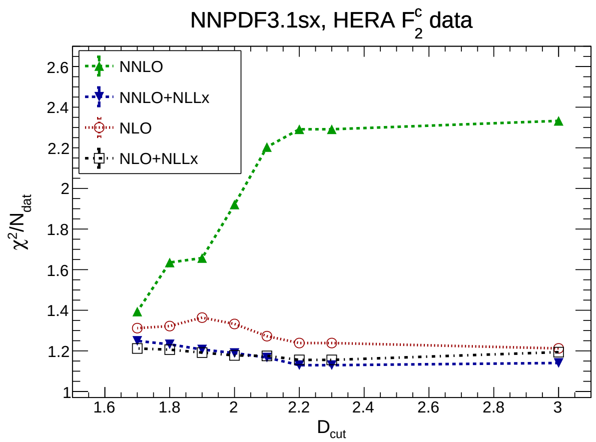
KINEMATIC CUTS



INCLUSIVE F_2 FIT QUALITY



CHARM F_2^c FIT QUALITY



AN OUTLOOK?

A RESUMMATION WISHLIST

- CONSISTENT, FULLY EXCLUSIVE SOFT RESUMMATION (GGHIGGS, DRELL-YAN, TOP, INCLUSIVE JETS): DIFFERENTIAL IN p_T, RAPIDITY, ALWAYS THRESHOLD-RESUMMED UPON INTEGRATION
- NEXT-TO-LEADING LOG HIGH-ENERGY FACTORIZATION AND RESUMMATION FOR HADRONIC PROCESSES (GLUON-INDUCED: HIGGS, HEAVY QUARKS)
- MULTISCALE RESUMMATION WITH HEAVY QUARKS (GGHIGGS p_t SPECTRUM $\ln \frac{m_b}{p_t}$)
- THE LIMITS OF FACTORIZATION: WHEN DOES IT BREAK DOWN?
- ...