FONLL official code usage development

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QCD meeting
28.01.2021

FONLL[‖]

- **FONLL** calculation: **NLO+NLL**
- $d\sigma_I^{FONLL} = d\sigma_Q^{FONLL} \otimes D^{NP}_{Q\to H_Q} \otimes g^{weak}_{H_Q\to I}$
- predict to bottom and charm production by default;

  bottom:
  $D^{NP}_{Q\to H_Q} = (\alpha+1)(\alpha+2)x^{\alpha}(1-x)$ (Kartvelishvili)
  with one paramter $\alpha = 24.2$ ($m_b = 4.75$ [GeV]) for all B mesons

  charm:
  use BCFY[†] for each $D^{NP}_{c\to D^*}$, $D^{NP}_{c\to D^+}$ and $D^{NP}_{c\to D^0}$

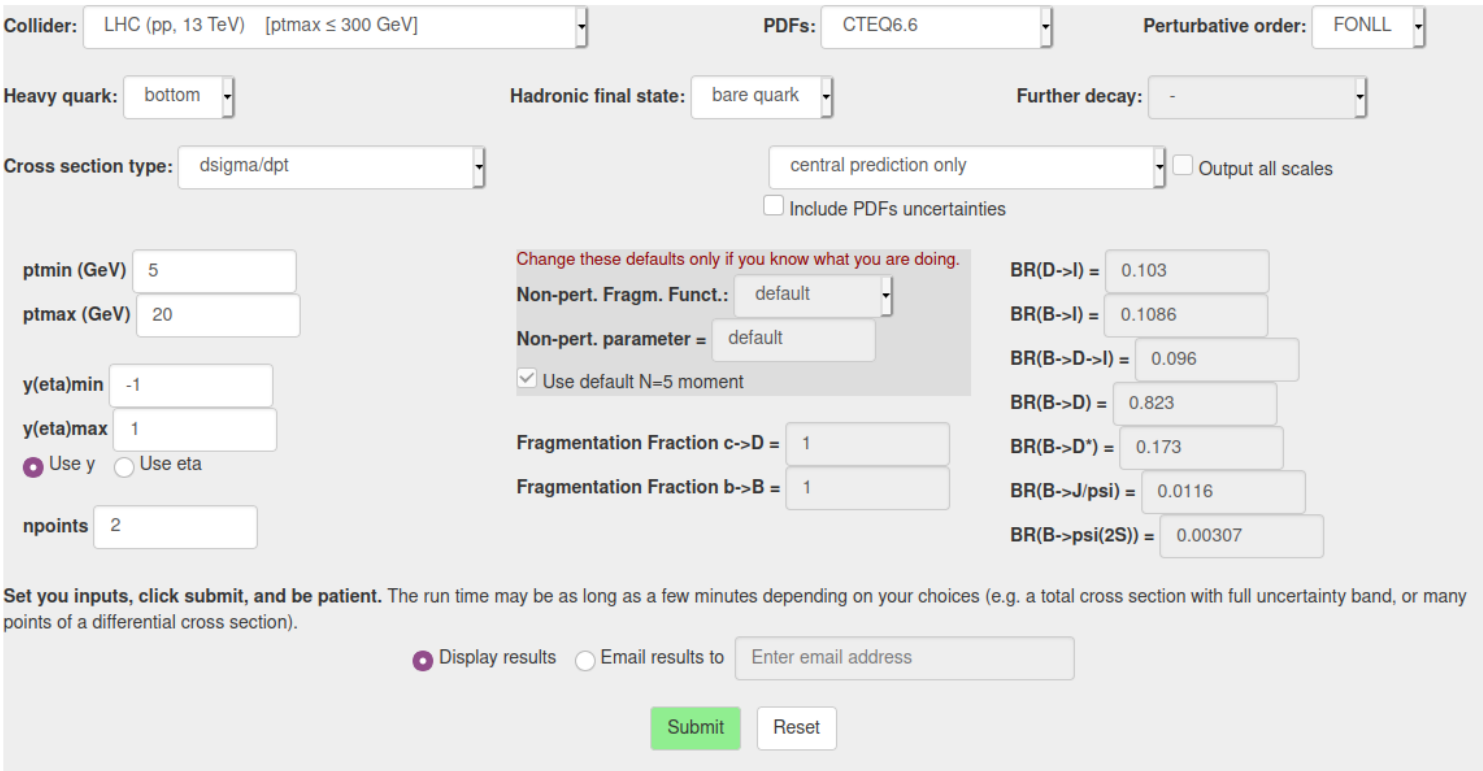
- uncertainty: $\triangle_{\pm} = \sqrt{\triangle^2_{\pm,scales} + \triangle^2_{\pm,mass} + \triangle^2_{\pm,PDF}}$

[‖] Cacciari, M., Frixione, S., Houdeau, N. et al. Theoretical predictions for charm and bottom production at the LHC. J. High Energ. Phys. 2012, 137 (2012)

[†] M. Cacciari, P. Nason, JHEP 0309 (2003) 006

Why not the FONLL web[§]

Grid is fixed in the web; collider type, PDF sets, quark masses are fixed.



→ use the **FONLL official code**[¶]; user need to **create grid and convolute them with proper non-perturbative fragmentation functions(NFF)**

[§] http://www.lpthe.jussieu.fr/ cacciari/fonll/fonllform.html

[¶] https://cacciari.web.cern.ch/cacciari/fonll/

Bare Quark Production - grid creation

Grid example:

	Bottom ($m_b = 4.75$ GeV)		Charm ($m_c = 1.5$ GeV)	
Collider	7 TeV (LHC)			
Scale	$\mu_F = \mu_R = m_b$		$\mu_F = \mu_R = m_c$	
PDF set	CTEQ6.6	PROSA_2019_VFNS	CTEQ6.6	PROSA_2019_VFNS
Phase space	$2 \leq p_T \leq 50$, $0 \leq y \leq 2.6$		$1 \leq p_T \leq 15$, $0 \leq y \leq 2.6$	
Grid size	$(n_{p_T} = 25) \times (n_y = 27) = 675$		$(n_{p_T} = 15) \times (n_y = 27) = 405$	

$\rightarrow$ **relatively time consuming process** (the FONLL web uses pre-created grid) but once it is properly created fit to user's purpose, **this grid can be re-used** to every hadronic productions of same hard scattering process

Bare Quark Production - grid creation

Charm quark pair production:

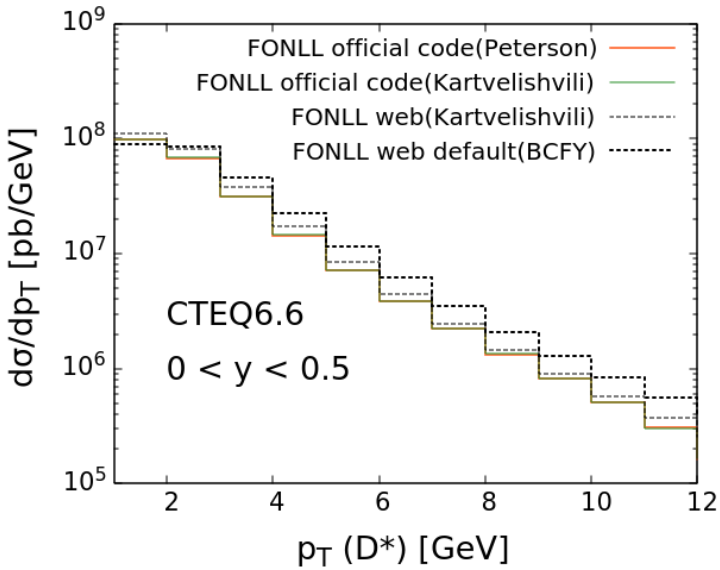
p_T [GeV]	FONLL web [pb]		FONLL code† [pb]	difference [%]
	original result ($\frac{1}{\pi}\frac{d\sigma}{dp_T^2 dy}\big\|_{y=0}$)	$\frac{d\sigma}{dp_T^2 dy}\big\|_{y=0}$‡	$\frac{d\sigma}{dp_T^2 dy}\big\|_{y=0}$‡	
1.00	1.8949×10^7	5.95300×10^7	5.95373×10^7	0.01
2.00	1.3488×10^7	4.23738×10^7	4.23804×10^7	0.02
3.00	5.9135×10^6	1.85778×10^7	1.85826×10^7	0.03
4.00	2.4596×10^6	7.72706×10^6	7.73305×10^6	0.08
5.00	1.0733×10^6	3.37187×10^6	3.37100×10^6	0.03
6.00	5.0342×10^5	1.58154×10^6	1.58248×10^6	0.06
7.00	2.5406×10^5	7.98153×10^5	7.98244×10^5	0.01
8.00	1.3614×10^5	4.27696×10^5	4.27816×10^5	0.03
9.00	7.6848×10^4	2.41425×10^5	2.41439×10^5	0.01
10.00	4.5349×10^4	1.42468×10^5	1.42511×10^5	0.03
11.00	2.7812×10^4	8.73740×10^4	8.73979×10^4	0.03
12.00	1.7637×10^4	5.54083×10^4	5.54283×10^4	0.04

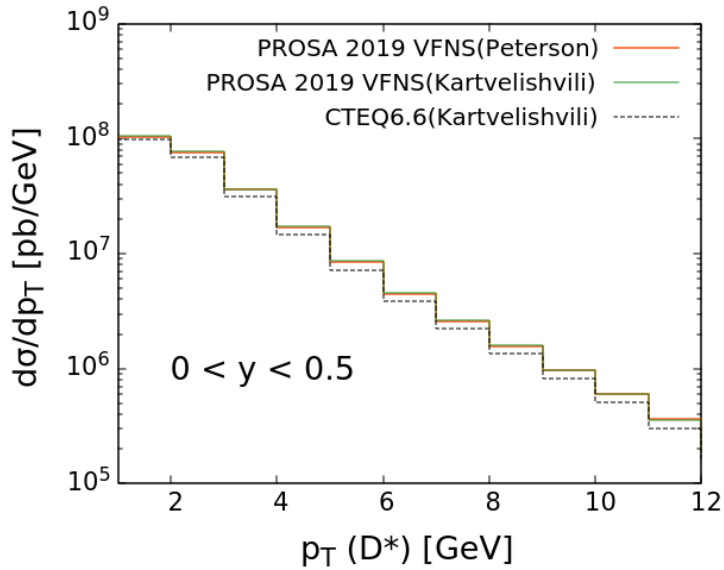
$\Lambda_5 = 0.226$
PDF set: CTEQ6.6

‡matched cross section

D Meson Production - convolution with NFF

Non-perturbative fragmentation function: **Peterson** (which is given by parameter: 0.035*), **Kartvelishvili** (is given by parameter: 4.2*) and **BCFY** (which is default of the FONLL web)
PDF sets: CTEQ6.6 (which is available in the FONLL web) and **PROSA_2019_VFNS**





→ *need to distinguish between matched cross section and hadronic massive cross section*

*R. Akerset al.(OPAL), Z. Phys.C67, 27 (1995)

Next plan

- So far only central predictions considered $\rightarrow$ next obtain predictions also with the uncertainty
- Obtain predictions for other D mesons besides D* and for B hadron productions
- Collect results to interface for decay productions