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Impact of PDFs on global interpretations

Celine Degrande

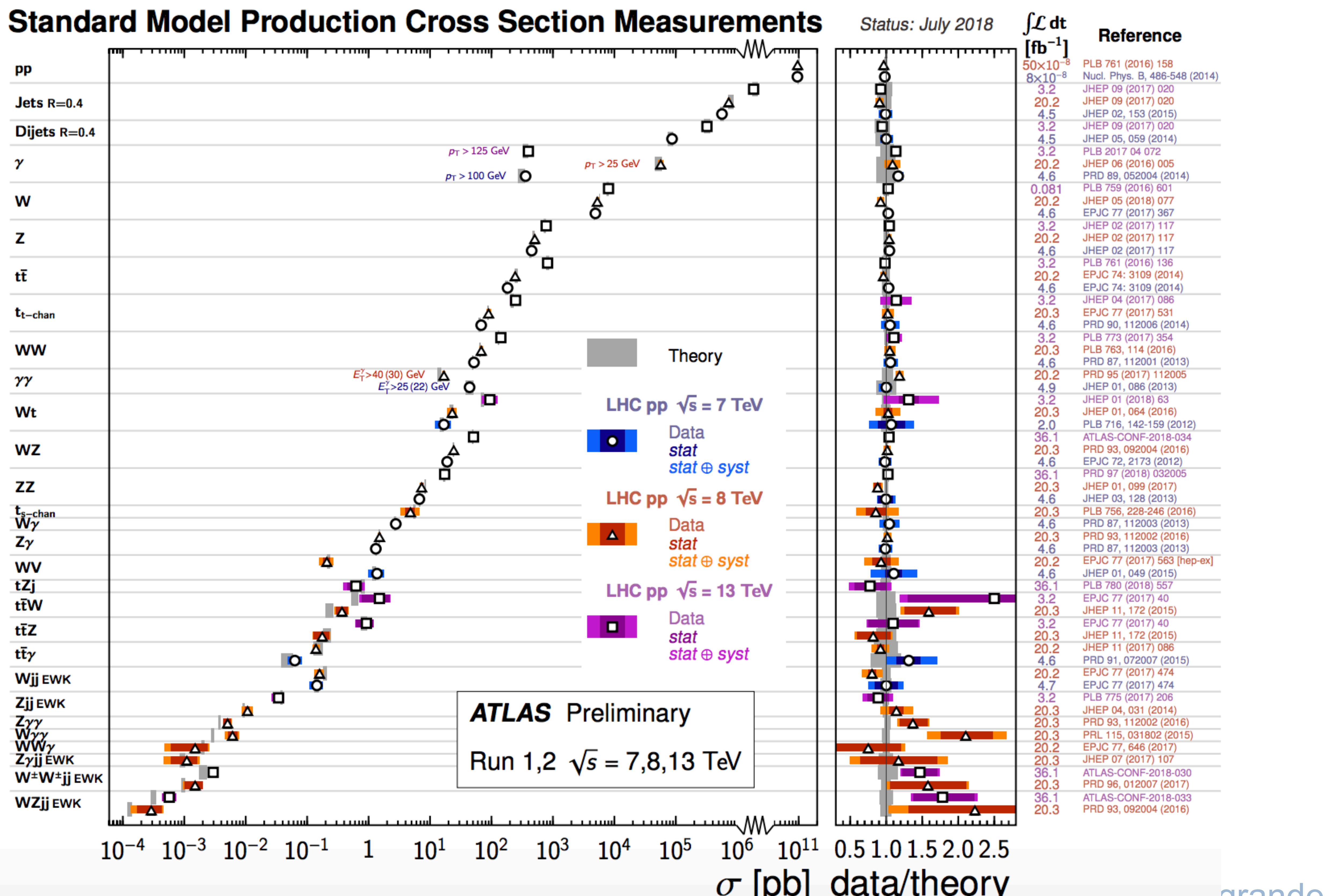
Plan

- Introduction
- PDF
- EFT
- PDF and EFT
- Outlook

PRL 123 (2019) no.13, 132001 with S. Carrazza, S. Iranipour, J. Rojo and M. Ubiali

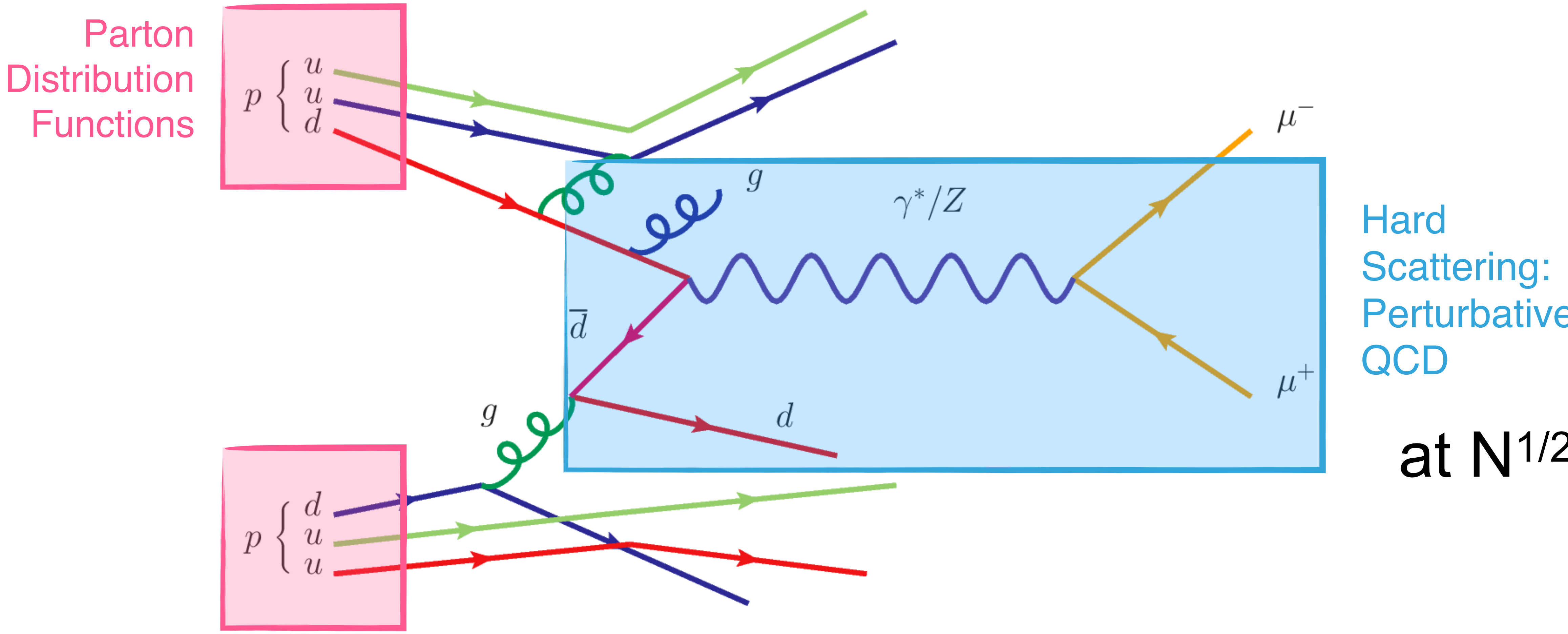
Introduction

Precision era at the LHC



PDF

Precise predictions



at N$^{1/2/3}$LO

$$d\sigma^{pp\to ab} = \sum_{i,j} \boxed{f_i \otimes f_j} \otimes \boxed{d\hat{\sigma}^{ij\to ab}} + \ldots$$

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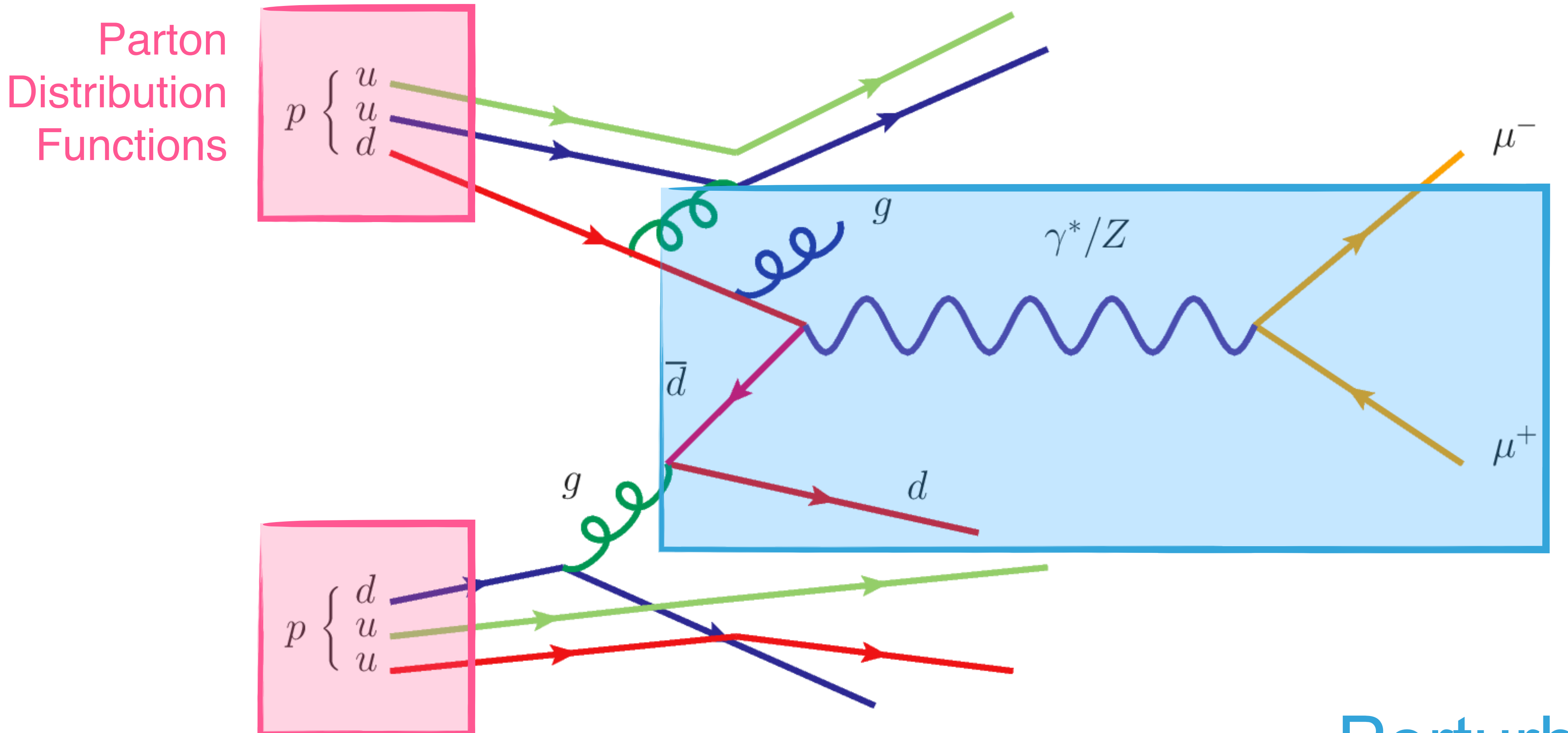
Precise predictions



at $N^{1/2/3}LO$

Perturbative QCD

$$d\sigma^{pp\to ab} = \sum_{i,j} \boxed{f_i \otimes f_j} \otimes \boxed{d\hat{\sigma}^{ij\to ab}} + \ldots$$

$$f_i(x, \mu)$$

data

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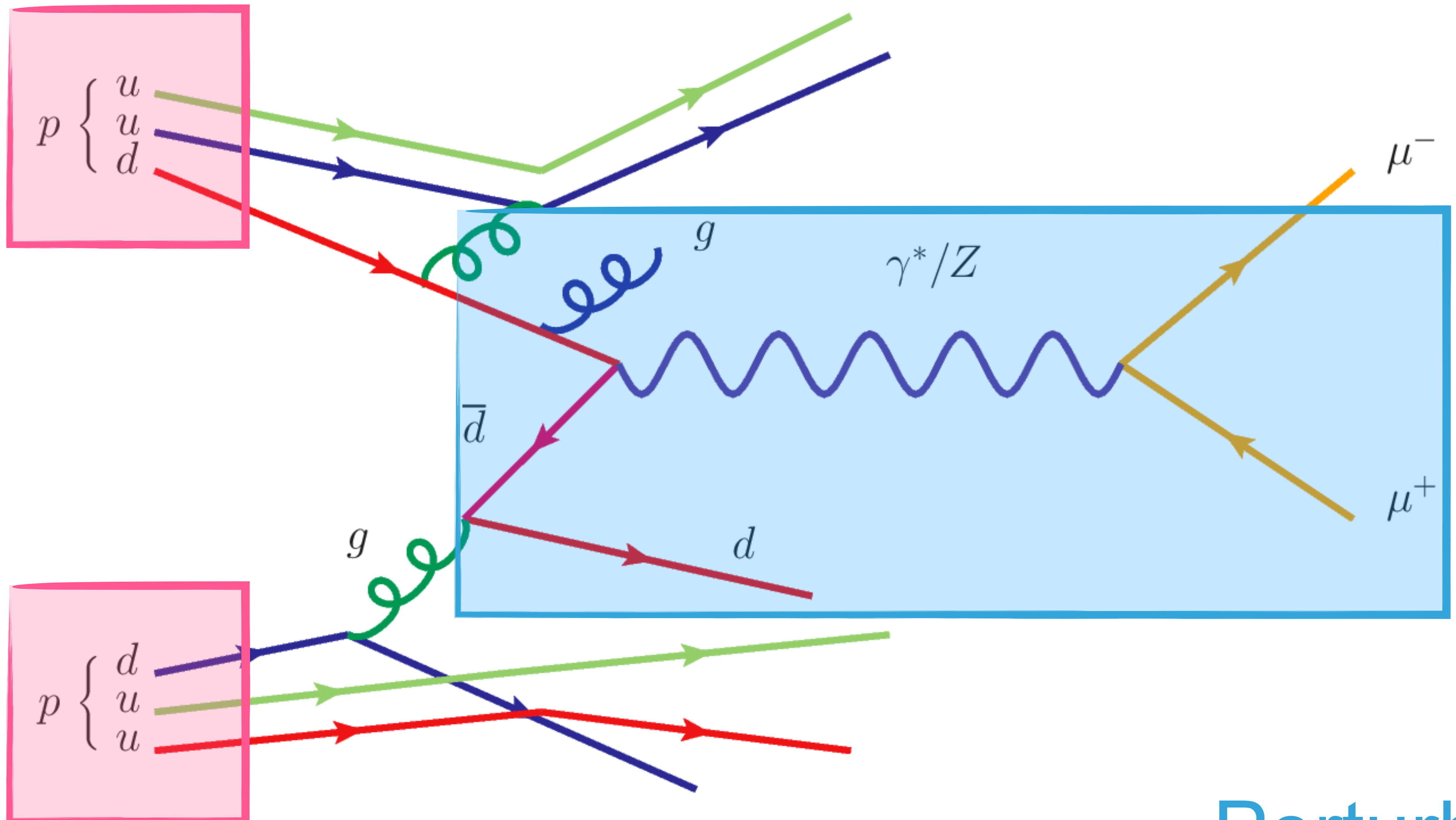
Precise predictions

Parton
Distribution
Functions



Hard
Scattering:
Perturbative
QCD

at N$^{1/2/3}$LO

$$d\sigma^{pp\to ab} = \sum_{i,j} \boxed{f_i \otimes f_j} \otimes \boxed{d\hat{\sigma}^{ij\to ab}} + \ldots$$

Perturbative QCD

$$f_i(x, \mu)$$

data

PDF are process universal

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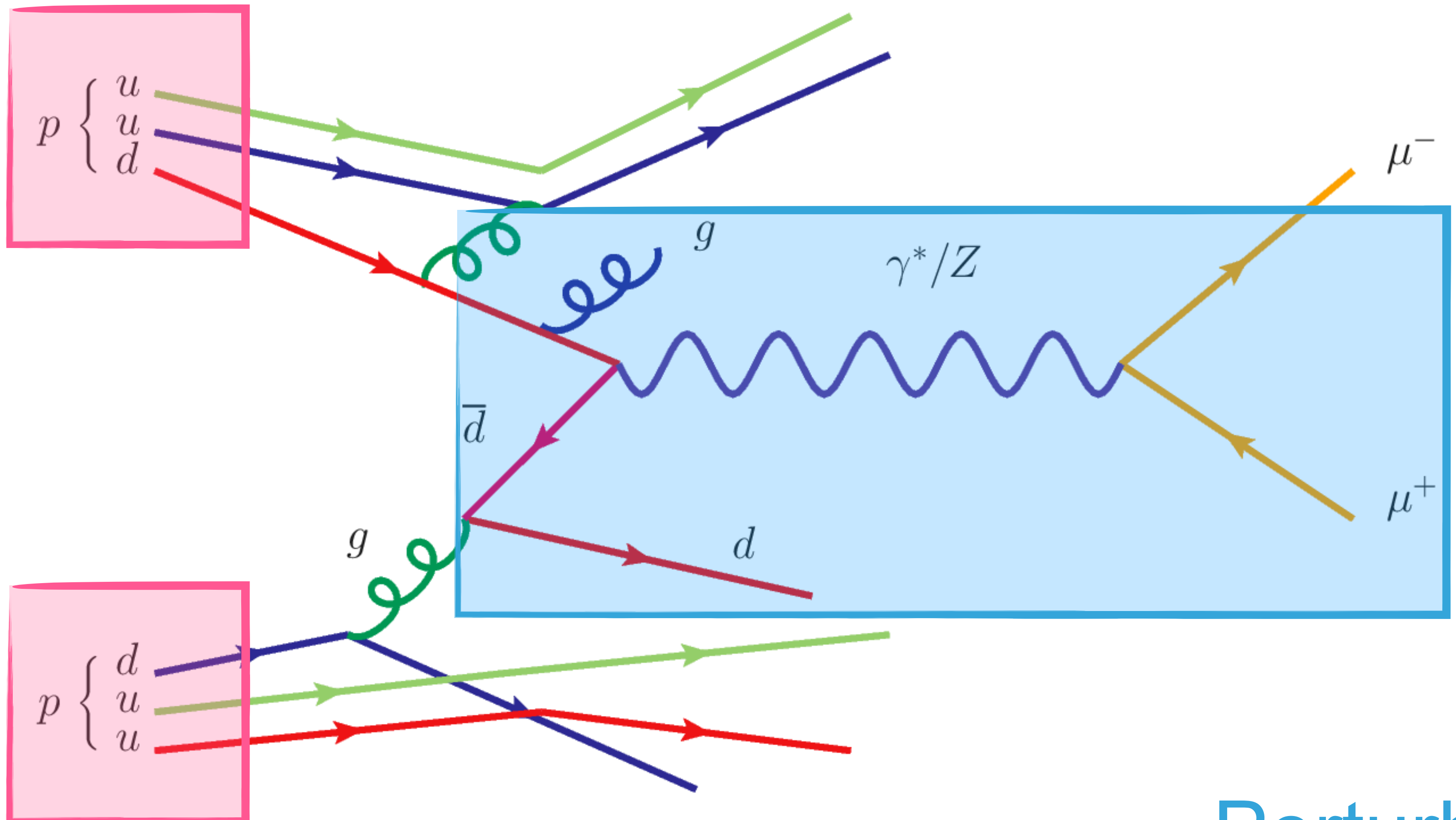
Precise predictions

Parton Distribution Functions



Hard Scattering: Perturbative QCD

at N$^{1/2/3}$LO

Perturbative QCD

$$d\sigma^{pp\to ab} = \sum_{i,j} \boxed{f_i^{\mathrm{SM}} \otimes f_j^{\mathrm{SM}}} \otimes \boxed{d\hat{\sigma}^{ij\to ab}} + \ldots \qquad f_i(x,\mu)$$

∋LHC

SM

data

PDF are process universal

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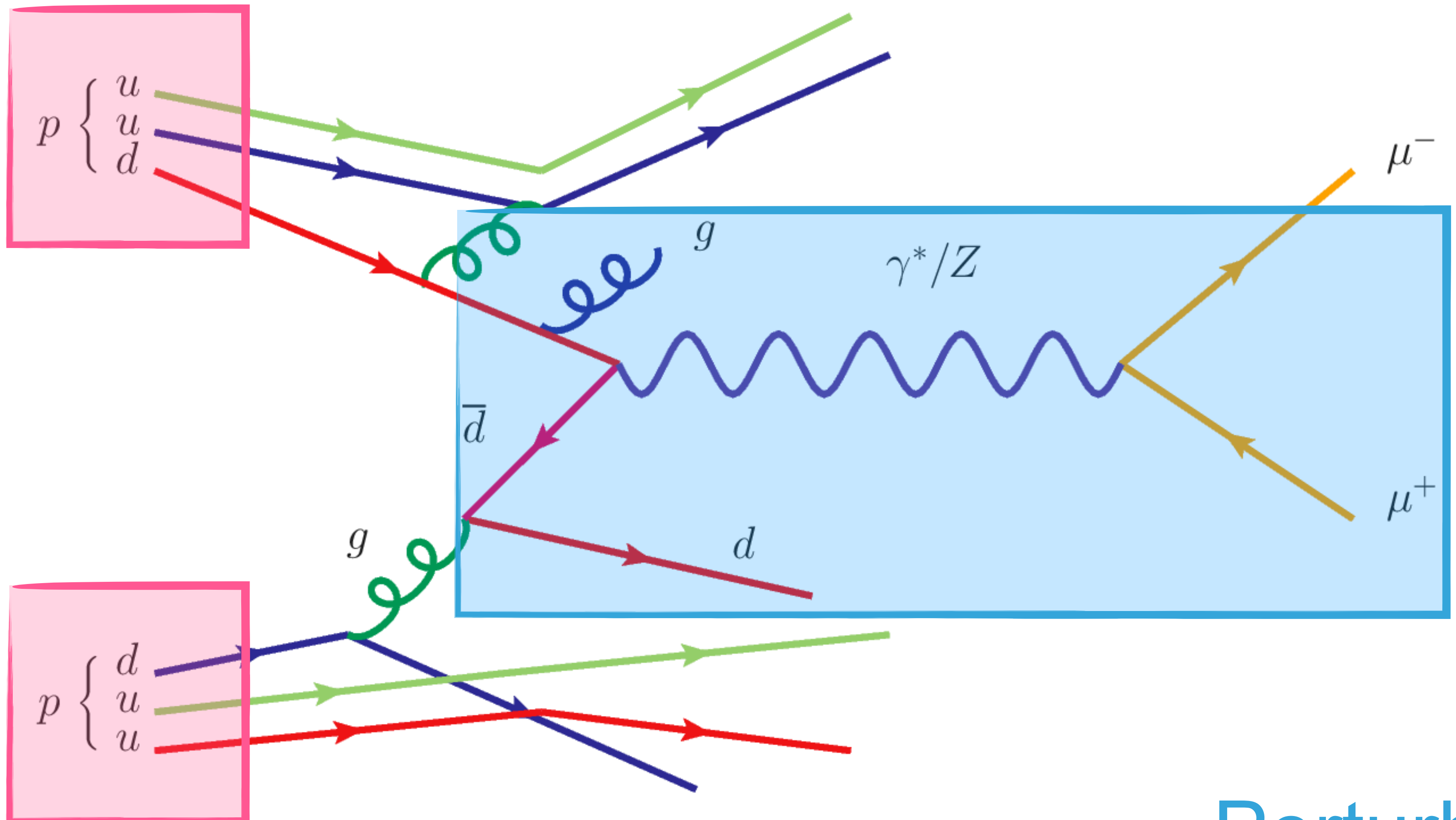
Precise predictions

Parton Distribution Functions



Hard Scattering: Perturbative QCD

at N$^{1/2/3}$LO

Perturbative QCD

$$d\sigma^{pp\to ab} = \sum_{i,j} \boxed{f_i^{\text{SM}} \otimes f_j^{\text{SM}}} \otimes \boxed{d\hat{\sigma}^{ij\to ab}} + \dots \qquad f_i(x,\mu)$$

$\ni$LHC

SM

data

PDF are process universal but model dependent

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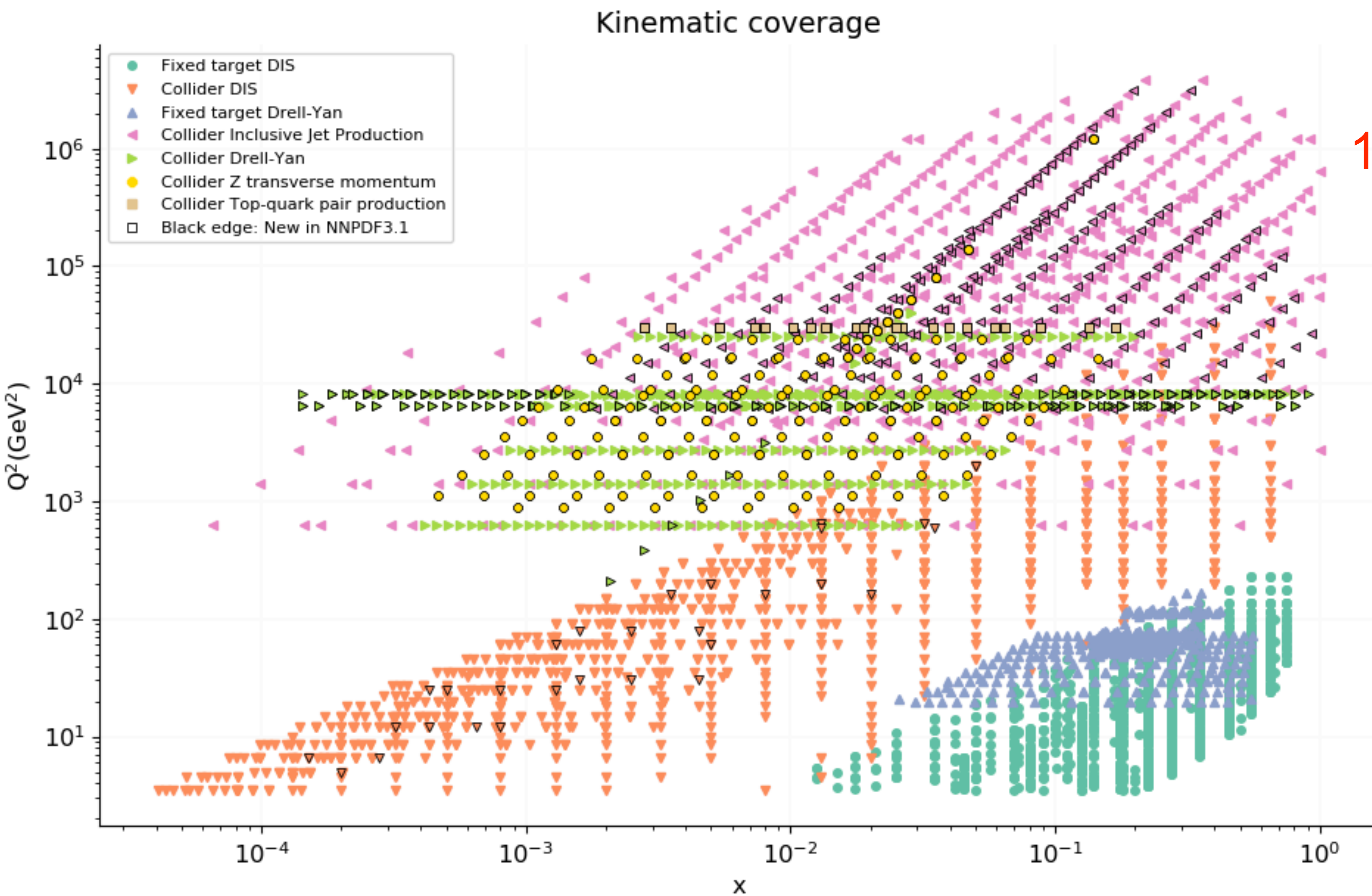
PDF data



1TeV

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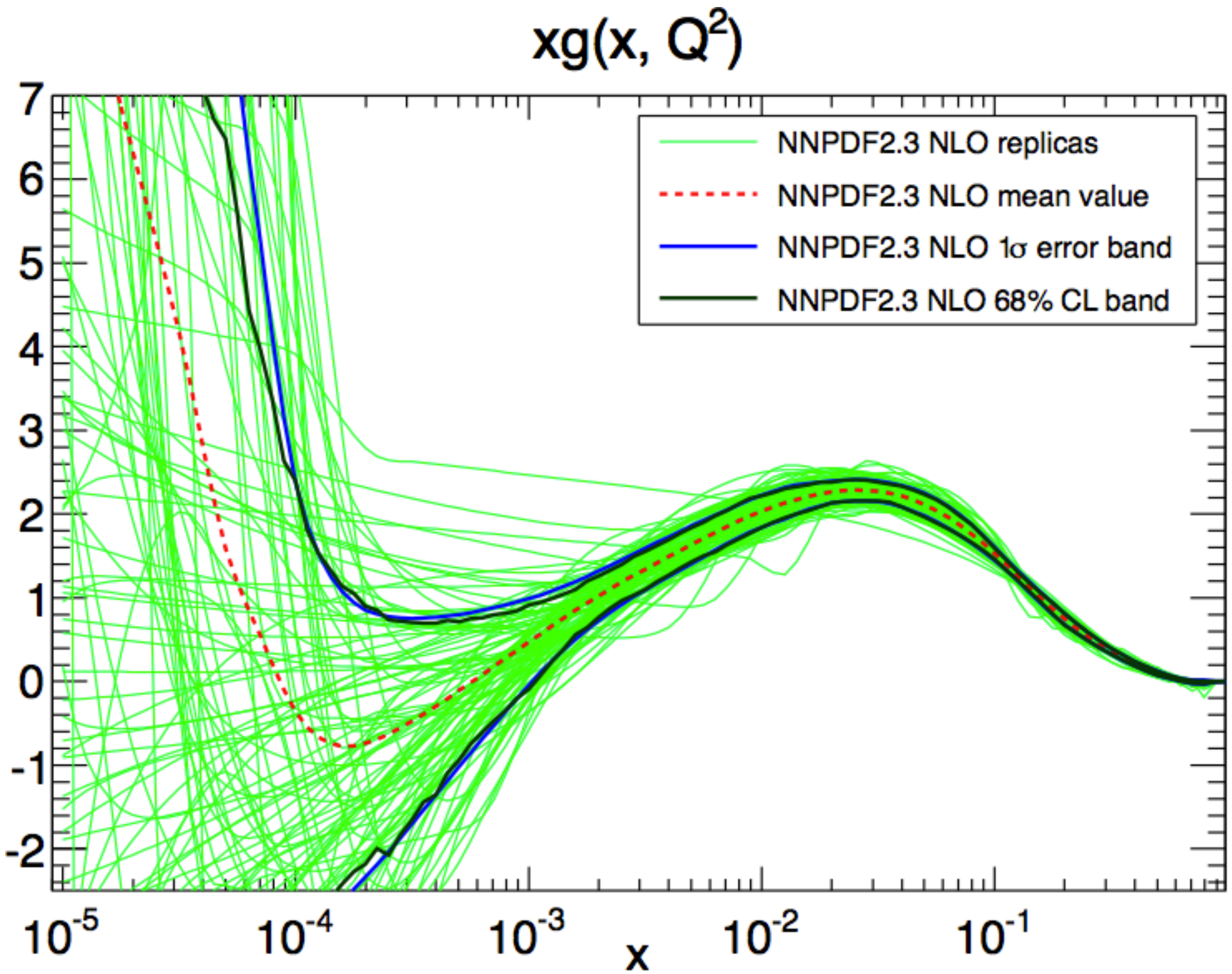
NNPDF

$$F_p^{(\mathrm{art})(k)} = S_{p,N}^{(k)} F_p^{(exp)} \left(1 + \sum_{l=1}^{N_c} r_{p,l}^{(k)} \sigma_{p,l} + r_p^{(k)} \sigma_{p,s} \right)$$



The N(eural)N(etwork)PDFs:

- Monte Carlo techniques: sampling the probability measure in PDF functional space
- Neural Networks: all independent PDFs are associated to an unbiased and flexible parametrization: O(300) parameters versus O(30) in polynomial parametrization
- Genetic algorithm and cross-validation methods

$$\chi^2 = \sum_{i,j=1}^{N_{\mathrm{dat}}} (D_i - T_i)(\mathrm{cov})_{ij}^{-1} (D_j - T_j)$$

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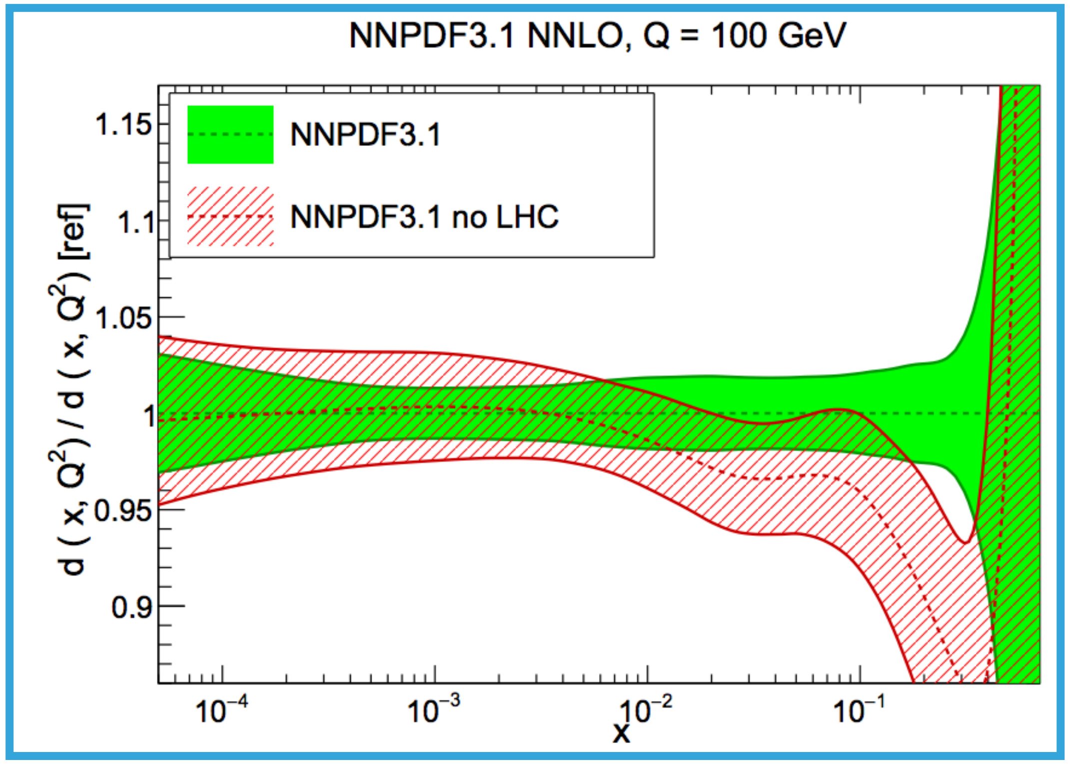
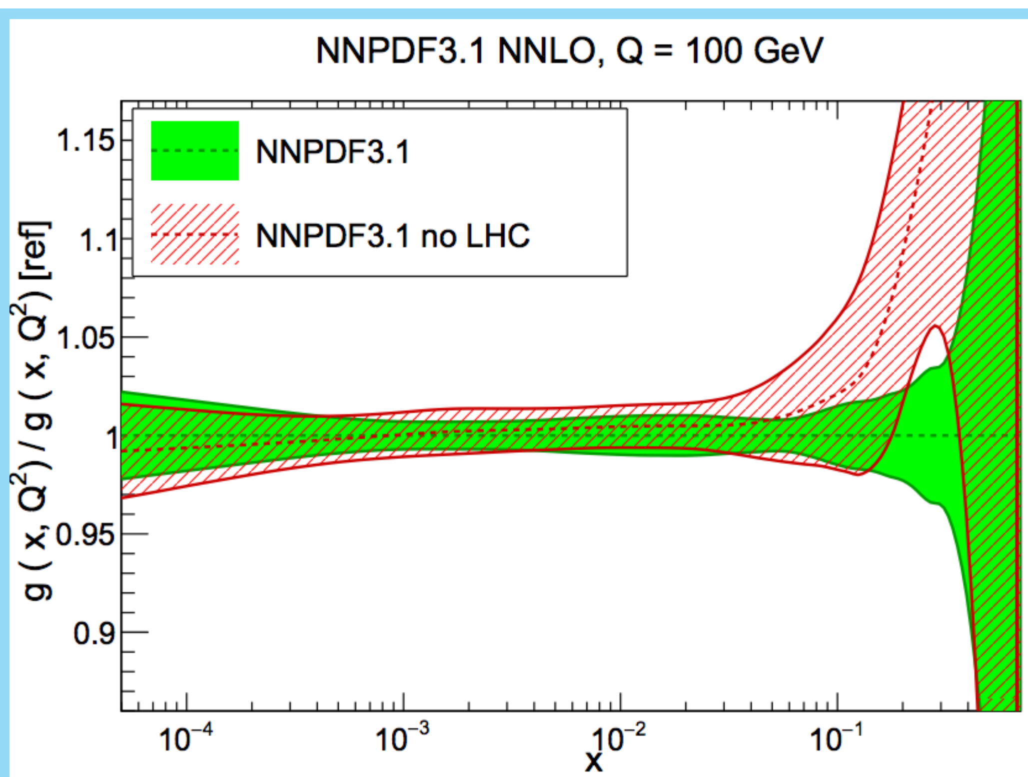
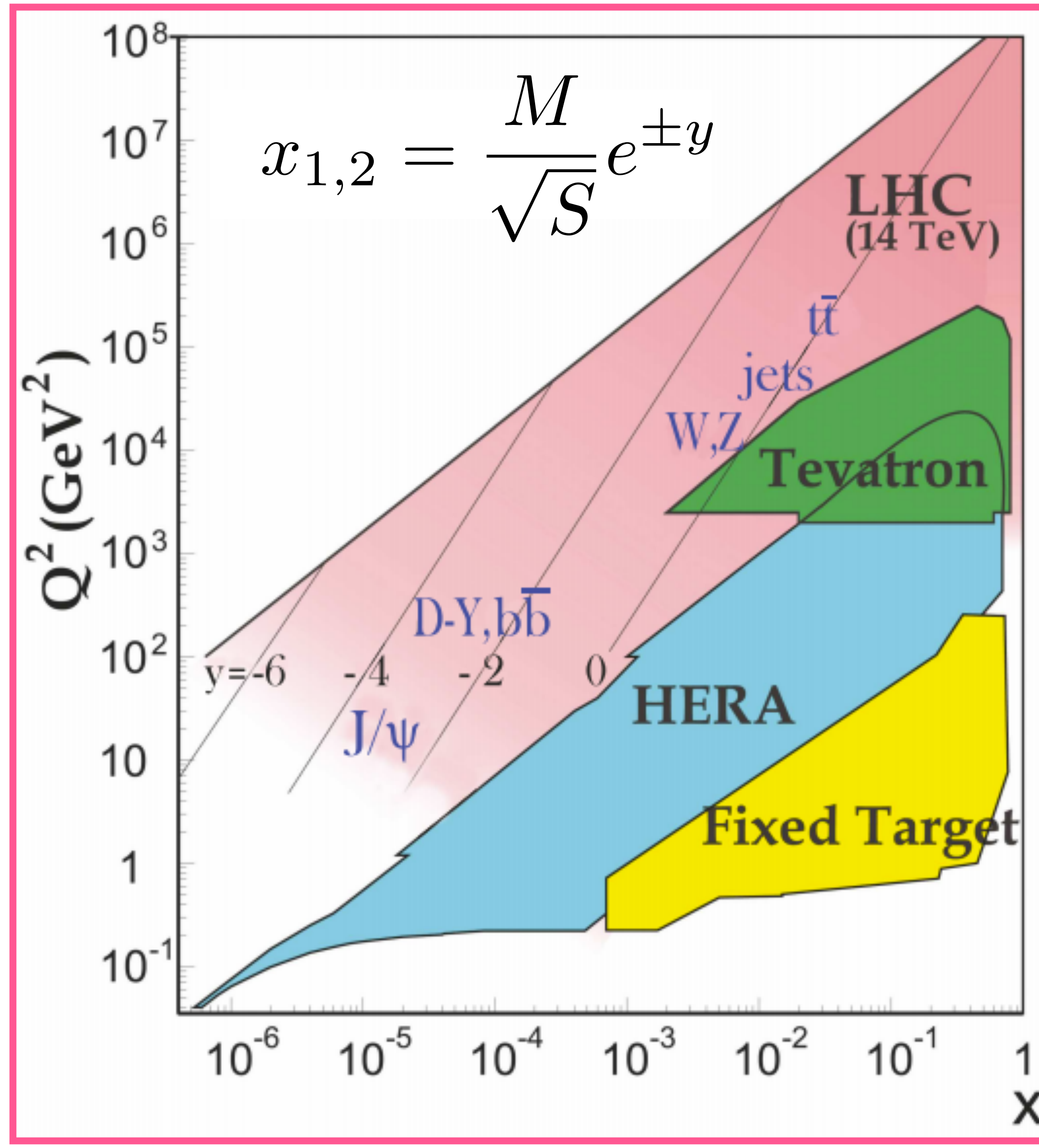
Impact of LHC data





Ball et at, EPJC 77 (2017)

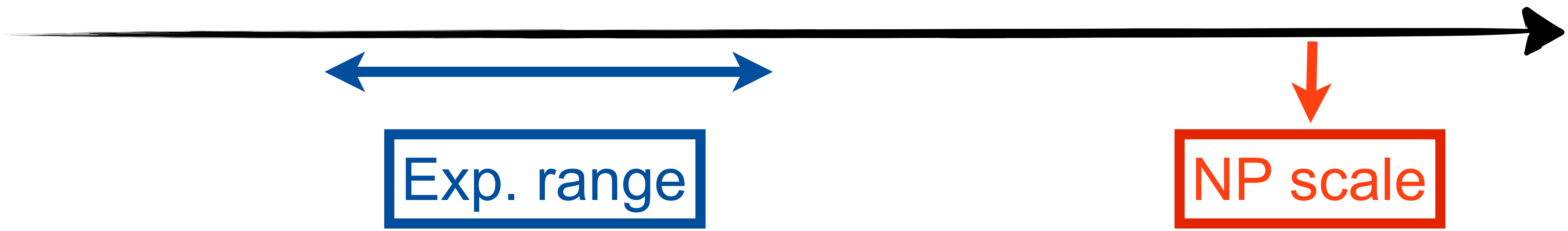


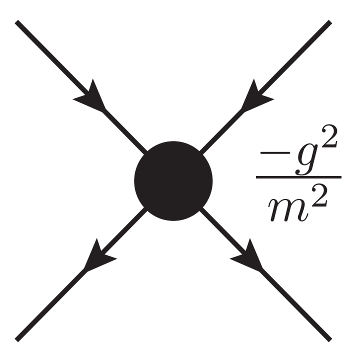
- LHC data provide powerful constrain especially at large x, in the large invariant mass region

EFT

Indirect detection of NP

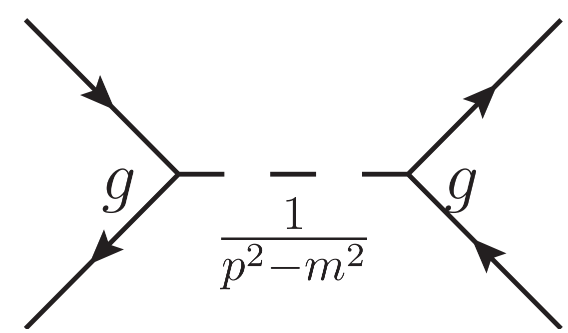
- Assumption : NP scale >> energy probed in experiments





$$p^2 \ll m^2$$

$$\longleftarrow$$



One assumption : $p^2 \ll m^2$

Ex : Fermi theory $-\frac{G_F}{Sqrt[2]} J^\mu J_\mu, \quad J_\mu = J^l_\mu + J^h_\mu, \quad J^l_\mu = \nu_l \gamma_\mu (1 - \gamma_5) l$

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Expansion of the Lagrangian

$$L^{NP} = -\frac{1}{4}V^{\mu\nu}V_{\mu\nu} + M^2 V^\mu V_\mu + \sum_i g_i V_\mu J_i^\mu + h.c.$$

- if V is very heavy $$-\frac{1}{4}V^{\mu\nu}V_{\mu\nu} \sim 0$$

- and the EOM is $$V^\mu = -\frac{1}{M^2}\sum_i g_i J_i^\mu + h.c.$$

$$L_{EFT}^{NP} = -\frac{\left(\sum_i g_i J_i^\mu\right)\left(\sum_i g_i J_{\mu_i}\right)^\dagger}{M^2}$$

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EFT

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_{d>4} \sum_i \frac{C_i}{\Lambda^{d-4}} \mathcal{O}_i^d$$

SM fields & sym.

EFT

Parametrize any NP but an ∞ number of coefficients

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_{d>4} \sum_i \frac{C_i}{\Lambda^{d-4}} \mathcal{O}_i^d$$

SM fields & sym.

- Assumption : $E_{exp} << \Lambda$

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_i \frac{C_i}{\Lambda^2} \mathcal{O}_i^6$$

a finite number of coefficients =>Predictive!

- Model independent (i.e. parametrize a large class of models) : any HEAVY NP

- SM is the leading term : EFT for precision physics

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EFT

Parametrize any NP but an ∞ number of coefficients

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_{d>4} \sum_i \frac{C_i}{\Lambda^{d-4}} \mathcal{O}_i^d$$

SM fields & sym.

- Assumption : $E_{exp} << \Lambda$

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_i \frac{C_i}{\Lambda^2} \mathcal{O}_i^6$$

measure only C_i/Λ^2

a finite number of coefficients =>Predictive!

- Model independent (i.e. parametrize a large class of models) : any HEAVY NP
- SM is the leading term : EFT for precision physics

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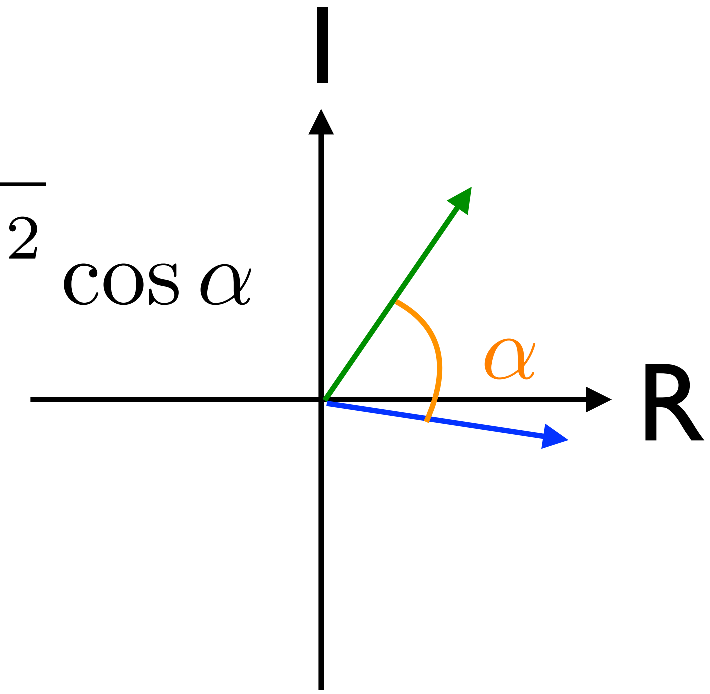
Interference

$$|M(x)|^2 = \underbrace{|M_{SM}(x)|^2}_{\Lambda^0} + \underbrace{2\Re\left(M_{SM}(x)M^*_{d6}(x)\right)}_{\Lambda^{-2}} + \underbrace{|M_{d6}(x)|^2 + \dots}_{\mathcal{O}\left(\Lambda^{-4}\right)}$$

$$\Re\left(M_{SM}(x)M^*_{d6}(x)\right) = \sqrt{|M_{SM}(x)|^2\,|M_{d6}(x)|^2}\cos\alpha$$



Not always positive

Can be suppressed

$$\sigma \propto \sum_x |M(x)|^2 \quad \textbf{if} \quad \begin{aligned} &M_{SM}(x_1) = 1,\; M_{SM}(x_2) = 0 \\ &M_{d6}(x_1) = 0,\; M_{d6}(x_2) = 1 \end{aligned} \qquad \sigma_{int} = 0$$

Observable dependent

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A top example

Top operators

Assume (To be checked) that all the **operators without top** are better **constrained** by other processes (i.e. not involving the top)

$U(2)_q \times U(2)_u \times U(2)_d$ flavour symmetry

=MFV with all F massless but t,b

four heavy quarks	$11 + 2$ CPV
two light and two heavy quarks	14
two heavy quarks and bosons	$9 + 6$ CPV
two heavy quarks and two leptons	$(8 + 3\text{ CPV}) \times 3$ lepton flavours

1802.07237

top pair production

From the Warsaw basis

Two-light-two-heavy (14 d.o.f.)

$$
\begin{aligned}
c^{3,1}_{Qq} &\equiv C^{3(ii33)}_{qq} + \tfrac{1}{6}(C^{1(i33i)}_{qq} - C^{3(i33i)}_{qq}) \\
c^{3,8}_{Qq} &\equiv C^{1(i33i)}_{qq} - C^{3(i33i)}_{qq} \\
c^{1,1}_{Qq} &\equiv C^{1(ii33)}_{qq} + \tfrac{1}{6}C^{1(i33i)}_{qq} + \tfrac{1}{2}C^{3(i33i)}_{qq} \\
c^{1,8}_{Qq} &\equiv C^{1(i33i)}_{qq} + 3C^{3(i33i)}_{qq} \\
c^{1}_{Qu} &\equiv C^{1(33ii)}_{qu} \\
c^{8}_{Qu} &\equiv C^{8(33ii)}_{qu} \\
c^{1}_{Qd} &\equiv C^{1(33ii)}_{qd} \\
c^{8}_{Qd} &\equiv C^{8(33ii)}_{qd} \\
c^{1}_{tq} &\equiv C^{1(ii33)}_{qu} \\
c^{8}_{tq} &\equiv C^{8(ii33)}_{qu} \\
c^{1}_{tu} &\equiv C^{(ii33)}_{uu} + \tfrac{1}{3}C^{(i33i)}_{uu} \\
c^{8}_{tu} &\equiv 2C^{(i33i)}_{uu} \\
c^{1}_{td} &\equiv C^{1(33ii)}_{ud} \\
c^{8}_{td} &\equiv C^{8(33ii)}_{ud}
\end{aligned}
$$

Two-heavy

$$
c^{[I]}_{tG} \equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C^{(33)}_{uG}\}
$$

$$
\begin{aligned}
O^{1(ijkl)}_{qq} &= (\bar{q}_i\gamma^\mu q_j)(\bar{q}_k\gamma_\mu q_l), \\
O^{3(ijkl)}_{qq} &= (\bar{q}_i\gamma^\mu\tau^I q_j)(\bar{q}_k\gamma_\mu\tau^I q_l), \\
O^{1(ijkl)}_{qu} &= (\bar{q}_i\gamma^\mu q_j)(\bar{u}_k\gamma_\mu u_l), \\
O^{8(ijkl)}_{qu} &= (\bar{q}_i\gamma^\mu T^A q_j)(\bar{u}_k\gamma_\mu T^A u_l), \\
O^{1(ijkl)}_{qd} &= (\bar{q}_i\gamma^\mu q_j)(\bar{d}_k\gamma_\mu d_l), \\
O^{8(ijkl)}_{qd} &= (\bar{q}_i\gamma^\mu T^A q_j)(\bar{d}_k\gamma_\mu T^A d_l), \\
O^{(ijkl)}_{uu} &= (\bar{u}_i\gamma^\mu u_j)(\bar{u}_k\gamma_\mu u_l), \\
O^{1(ijkl)}_{ud} &= (\bar{u}_i\gamma^\mu u_j)(\bar{d}_k\gamma_\mu d_l), \\
O^{8(ijkl)}_{ud} &= (\bar{u}_i\gamma^\mu T^A u_j)(\bar{d}_k\gamma_\mu T^A d_l),
\end{aligned}
$$

$$
{}^{\ddagger}O^{(ij)}_{uG} = (\bar{q}_i\sigma^{\mu\nu}T^A u_j)\,\tilde{\varphi}G^A_{\mu\nu},
$$

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Top operators

From the Warsaw basis

Two-heavy $(9+6$ CPV d.o.f.$)$

$$
\begin{aligned}
c_{t\varphi}^{[I]} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{u\varphi}^{(33)}\}\\
c_{\varphi q}^{-} &\equiv C_{\varphi q}^{1(33)} - C_{\varphi q}^{3(33)}\\
c_{\varphi Q}^{3} &\equiv C_{\varphi q}^{3(33)}\\
c_{\varphi t} &\equiv C_{\varphi u}^{(33)}\\
c_{\varphi tb}^{[I]} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{\varphi ud}^{(33)}\}\\
c_{tW}^{[I]} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{uW}^{(33)}\}\\
c_{tZ}^{[I]} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{-s_W C_{uB}^{(33)} + c_W C_{uW}^{(33)}\}\\
c_{bW}^{[I]} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{dW}^{(33)}\}\\
c_{tG}^{[I]} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{uG}^{(33)}\}
\end{aligned}
$$

Two-heavy-two-lepton $(8+3$ CPV$)$

$$
\begin{aligned}
c_{Ql}^{3(\ell)} &\equiv C_{lq}^{3(\ell\ell 33)}\\
c_{Ql}^{-(\ell)} &\equiv C_{lq}^{1(\ell\ell 33)} - C_{lq}^{3(\ell\ell 33)}\\
c_{Qe}^{(\ell)} &\equiv C_{eq}^{(\ell\ell 33)}\\
c_{tl}^{(\ell)} &\equiv C_{lu}^{(\ell\ell 33)}\\
c_{te}^{(\ell)} &\equiv C_{eu}^{(\ell\ell 33)}\\
c_{t}^{S[I](\ell)} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{lequ}^{1(\ell\ell 33)}\}\\
c_{t}^{T[I](\ell)} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{lequ}^{3(\ell\ell 33)}\}\\
c_{b}^{S[I](\ell)} &\equiv {}^{[\mathrm{Im}]}_{\mathrm{Re}}\{C_{ledq}^{(\ell\ell 33)}\}
\end{aligned}
$$

$$
\begin{aligned}
{}^{\ddagger}O_{u\varphi}^{(ij)} &= \bar{q}_i u_j \tilde{\varphi}\,(\varphi^\dagger\varphi),\\
O_{\varphi q}^{1(ij)} &= (\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar{q}_i\gamma^\mu q_j),\\
O_{\varphi q}^{3(ij)} &= (\varphi^\dagger i\overleftrightarrow{D}^I_\mu\varphi)(\bar{q}_i\gamma^\mu\tau^I q_j),\\
O_{\varphi u}^{(ij)} &= (\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar{u}_i\gamma^\mu u_j),\\
{}^{\ddagger}O_{\varphi ud}^{(ij)} &= (\tilde{\varphi}^\dagger iD_\mu\varphi)(\bar{u}_i\gamma^\mu d_j),\\
{}^{\ddagger}O_{uW}^{(ij)} &= (\bar{q}_i\sigma^{\mu\nu}\tau^I u_j)\,\tilde{\varphi}W_{\mu\nu}^I,\\
{}^{\ddagger}O_{dW}^{(ij)} &= (\bar{q}_i\sigma^{\mu\nu}\tau^I d_j)\,\varphi W_{\mu\nu}^I,\\
{}^{\ddagger}O_{uB}^{(ij)} &= (\bar{q}_i\sigma^{\mu\nu}u_j)\quad\tilde{\varphi}B_{\mu\nu},\\
{}^{\ddagger}O_{uG}^{(ij)} &= (\bar{q}_i\sigma^{\mu\nu}T^A u_j)\,\tilde{\varphi}G_{\mu\nu}^A,
\end{aligned}
$$

$$
\begin{aligned}
O_{lq}^{1(ijkl)} &= (\bar{l}_i\gamma^\mu l_j)(\bar{q}_k\gamma^\mu q_l),\\
O_{lq}^{3(ijkl)} &= (\bar{l}_i\gamma^\mu\tau^I l_j)(\bar{q}_k\gamma^\mu\tau^I q_l),\\
O_{lu}^{(ijkl)} &= (\bar{l}_i\gamma^\mu l_j)(\bar{u}_k\gamma^\mu u_l),\\
O_{eq}^{(ijkl)} &= (\bar{e}_i\gamma^\mu e_j)(\bar{q}_k\gamma^\mu q_l),\\
O_{eu}^{(ijkl)} &= (\bar{e}_i\gamma^\mu e_j)(\bar{u}_k\gamma^\mu u_l),\\
{}^{\ddagger}O_{lequ}^{1(ijkl)} &= (\bar{l}_i e_j)\;\varepsilon\;(\bar{q}_k u_l),\\
{}^{\ddagger}O_{lequ}^{3(ijkl)} &= (\bar{l}_i\sigma^{\mu\nu}e_j)\;\varepsilon\;(\bar{q}_k\sigma_{\mu\nu}u_l),\\
{}^{\ddagger}O_{ledq}^{(ijkl)} &= (\bar{l}_i e_j)(\bar{d}_k q_l),
\end{aligned}
$$

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Data

Process	Dataset	$\sqrt{s}$	Info	Observables	$N_{\rm dat}$	Ref
$t\bar{t}$	`ATLAS_tt_8TeV_ljets`	**8 TeV**	lepton+jets	$d\sigma/d\|y_t\|$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/d\|y_{t\bar{t}}\|$	5, 8, 7, 5	[92]
$t\bar{t}$	`CMS_tt_8TeV_ljets`	**8 TeV**	lepton+jets	$d\sigma/dy_t$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/dy_{t\bar{t}}$	10, 8, 7, 10	[93]
$t\bar{t}$	`CMS_tt2D_8TeV_dilep`	**8 TeV**	dileptons	$d^2\sigma/dy_t dp_t^T$, $d^2\sigma/dy_t dm_{t\bar{t}}$, $d^2\sigma/dp_{t\bar{t}}^T dm_{t\bar{t}}$, $d^2\sigma/dy_{t\bar{t}} dm_{t\bar{t}}$	16, 16, 16, 16	[94]
$t\bar{t}$	`CMS_tt_13TeV_ljets`	**13 TeV**	lepton+jets	$d\sigma/d\|y_t\|$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/d\|y_{t\bar{t}}\|$	7, 9, 8, 6	[97]
$t\bar{t}$	`CMS_tt_13TeV_ljets2`	**13 TeV**	lepton+jets	$d\sigma/d\|y_t\|$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/d\|y_{t\bar{t}}\|$	11, 12, 10, 10	[99]
$t\bar{t}$	`CMS_tt_13TeV_dilep`	**13 TeV**	dileptons	$d\sigma/dy_t$, $d\sigma/dp_t^T$, $d\sigma/dm_{t\bar{t}}$, $d\sigma/dy_{t\bar{t}}$	8, 6, 6, 8	[100]
$t\bar{t}$	`ATLAS_WhelF_8TeV`	**8 TeV**	W helicity fract	F_0, F_L, F_R	3	[95]
$t\bar{t}$	`CMS_WhelF_8TeV`	**8 TeV**	W helicity fract	F_0, F_L, F_R	3	[96]

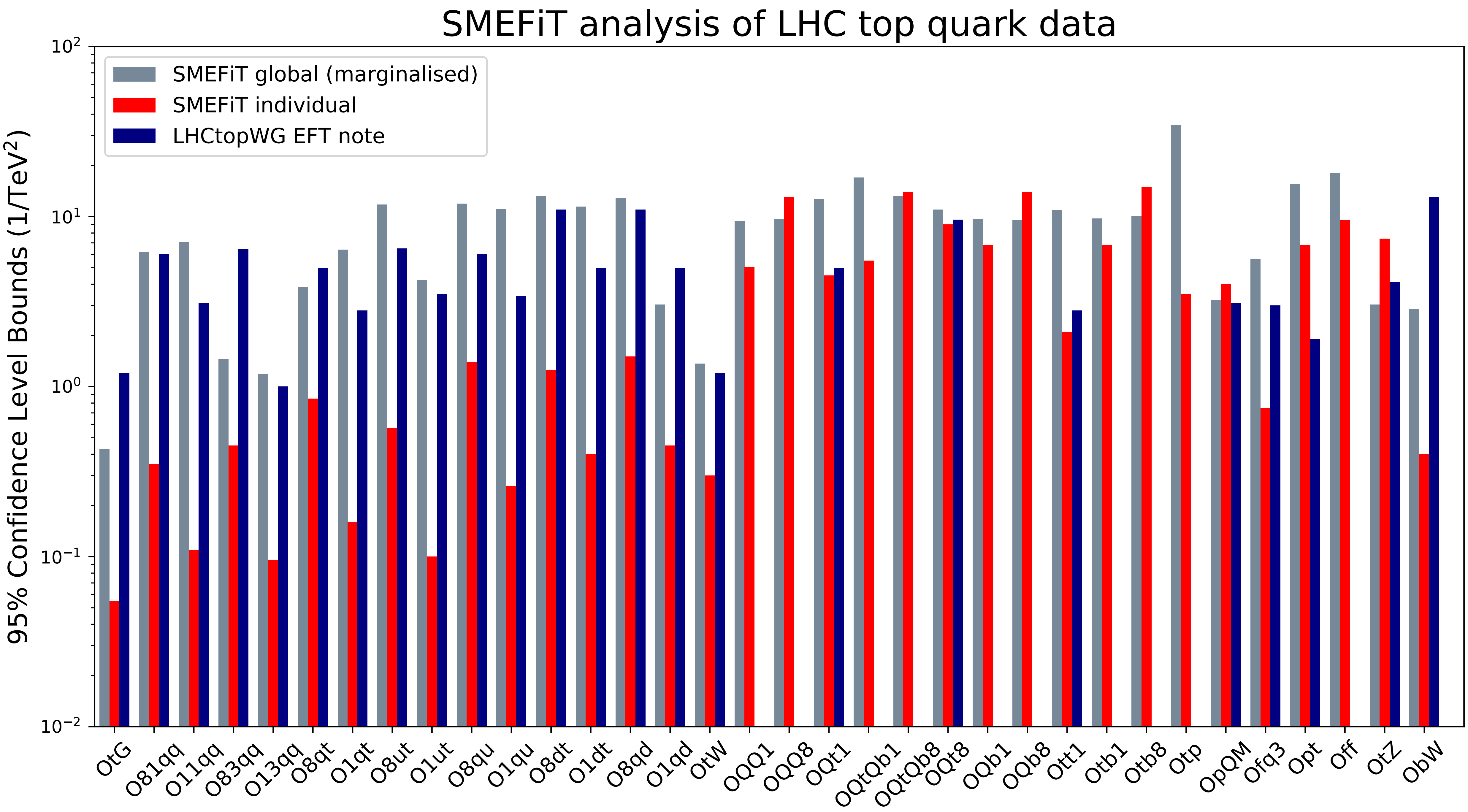
Only one distribution per measurement (correlation)

N.P. Hartland, F.Maltoni, E. R. Nocera, J. Rojo, E. Slade, E. Vryonidou and C.~Zhang,JHEP 1904 (2019) 100

Data

Process	Dataset	$\sqrt{s}$	Info	Observables	N_{dat}	Ref
$t\bar{t}b\bar{b}$	`CMS_ttbb_13TeV`	**13 TeV**	total xsec	$\sigma_{\mathrm{tot}}(t\bar{t}b\bar{b})$	1	[101]
$t\bar{t}t\bar{t}$	`CMS_tttt_13TeV`	**13 TeV**	total xsec	$\sigma_{\mathrm{tot}}(t\bar{t}t\bar{t})$	1	[102]
$t\bar{t}Z$	`CMS_ttZ_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\mathrm{tot}}(t\bar{t}Z)$	2	[103, 104]
$t\bar{t}Z$	`ATLAS_ttZ_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\mathrm{tot}}(t\bar{t}Z)$	2	[105, 106]
$t\bar{t}W$	`CMS_ttW_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\mathrm{tot}}(t\bar{t}W)$	2	[103, 104]
$t\bar{t}W$	`ATLAS_ttW_8_13TeV`	**8+13 TeV**	total xsec	$\sigma_{\mathrm{tot}}(t\bar{t}W)$	2	[105, 106]
$t\bar{t}H$	`CMS_tth_13TeV`	**13 TeV**	signal strength	$\mu_{t\bar{t}H}$	1	[107]
$t\bar{t}H$	`ATLAS_tth_13TeV`	**13 TeV**	total xsec	$\sigma_{\mathrm{tot}}(t\bar{t}H)$	1	[108]

Global top fit



Marg. less constrained than ind.

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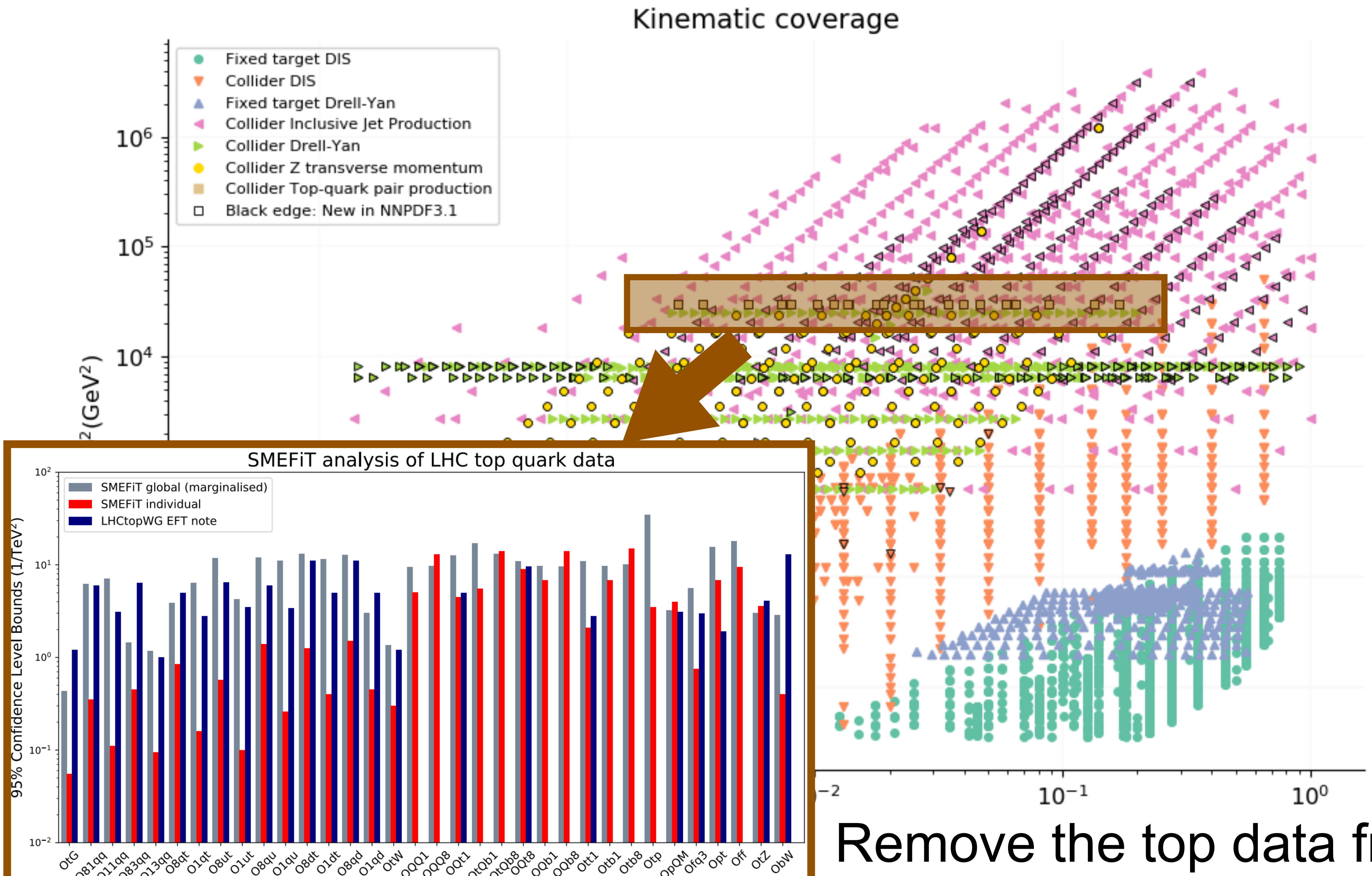
SMEFT constraints data



Remove the top data from pdf fit for the top EFT fit

Hartland et al 1901.05965

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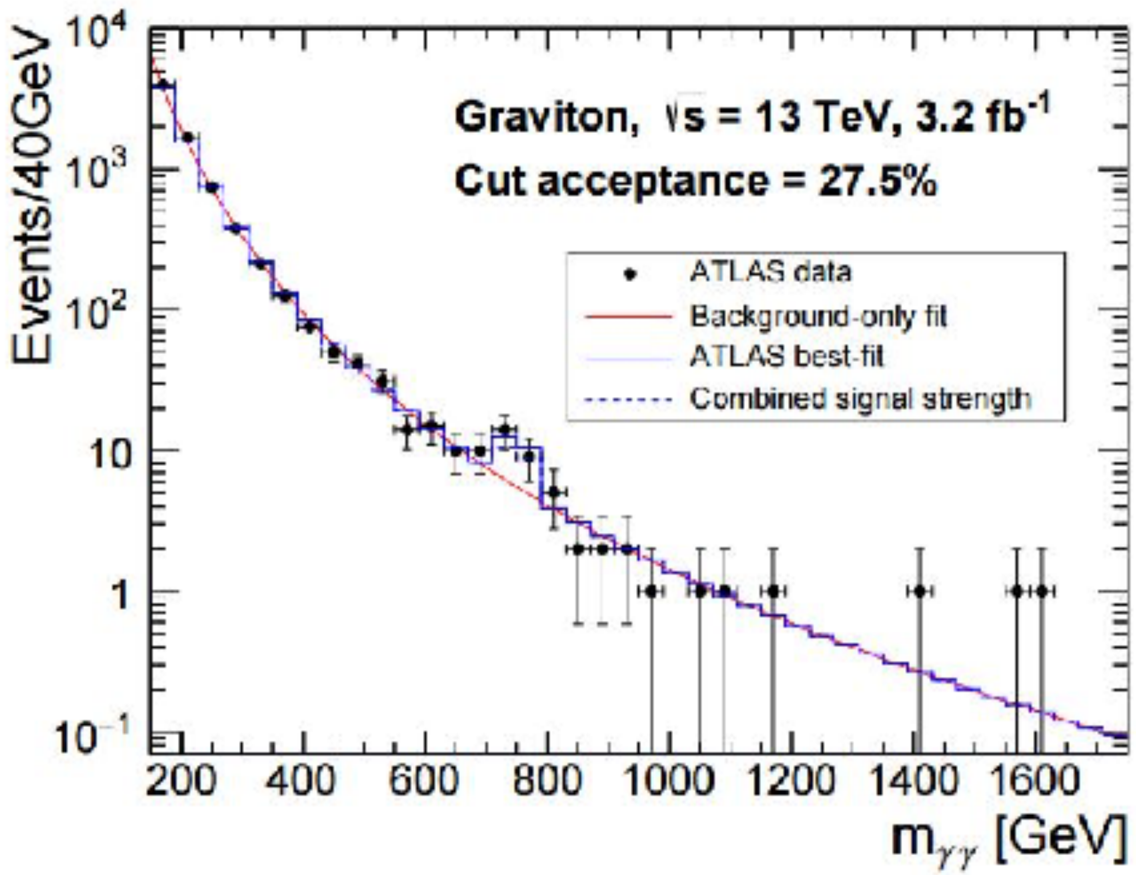
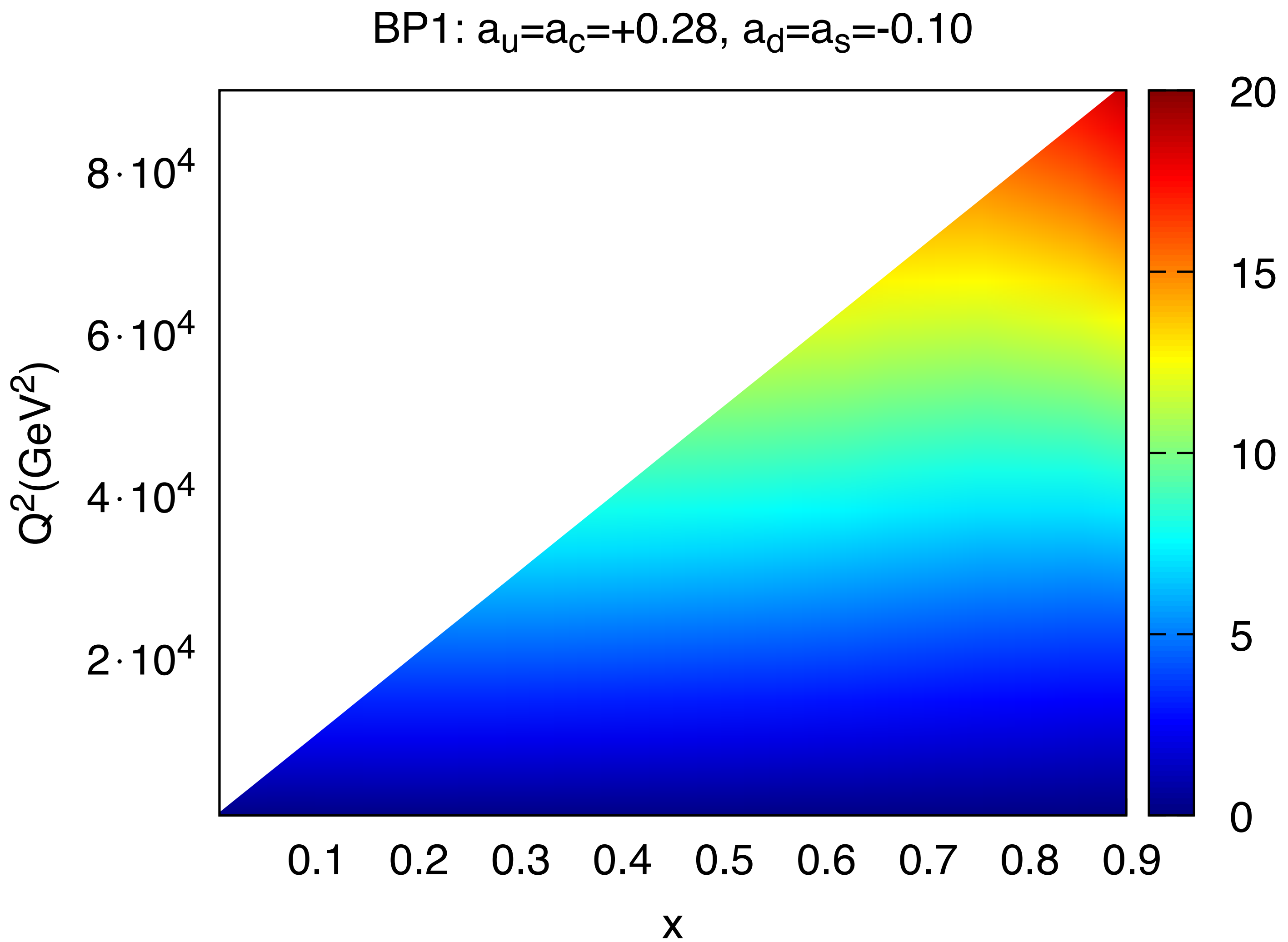
EFT and PDF

$$\mathcal{O}_{lq} = \left(\bar{l}_R \gamma^\mu l_R\right)\left(\bar{q}_R \gamma_\mu q_R\right)\,,\;\; q = u, d, s, c\,,$$





Not single process
Not localised

$$\Delta F_2^{\rm smeft} \supset \frac{x}{12e^4}\left(4a_u e^2 \frac{Q^2}{\Lambda^2}(1+4K_Z s_W^4) + 3a_u^2 \frac{Q^4}{\Lambda^4}\right) \times \left(u(x,Q^2)+\bar{u}(x,Q^2)\right)$$

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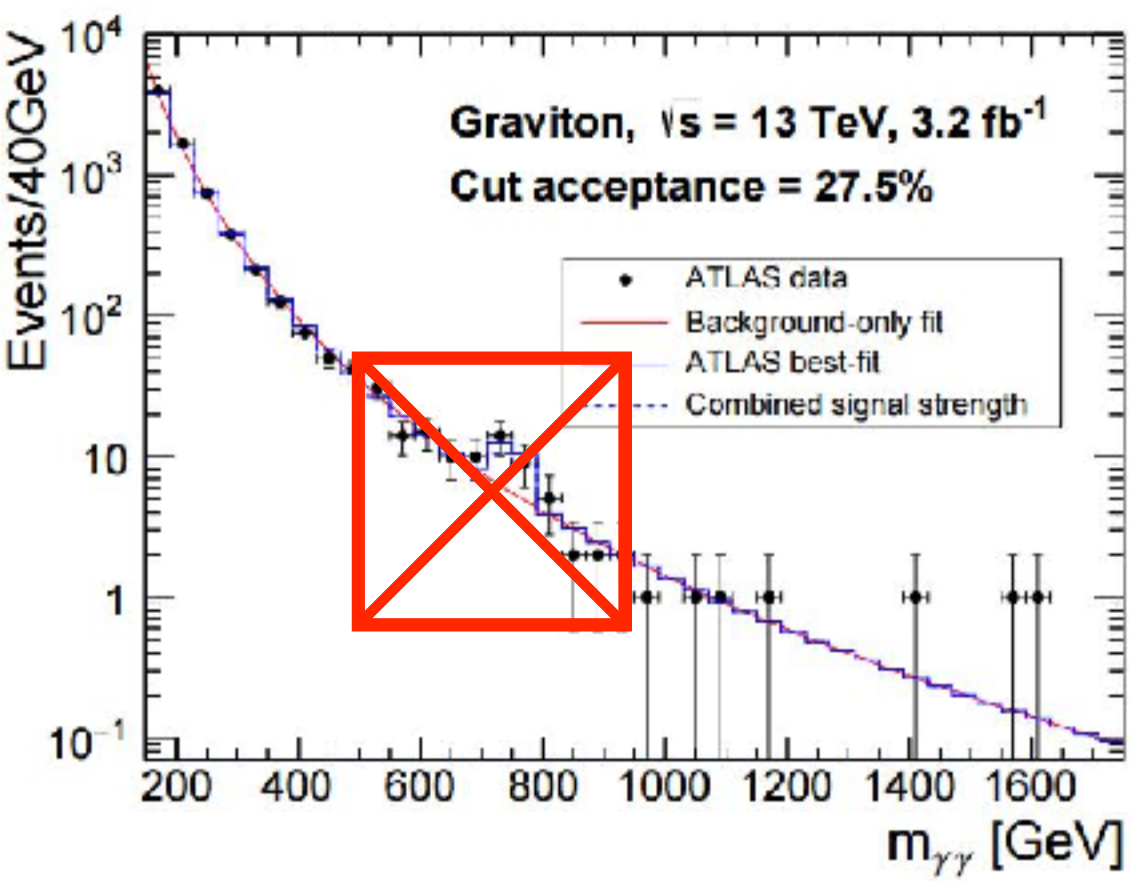
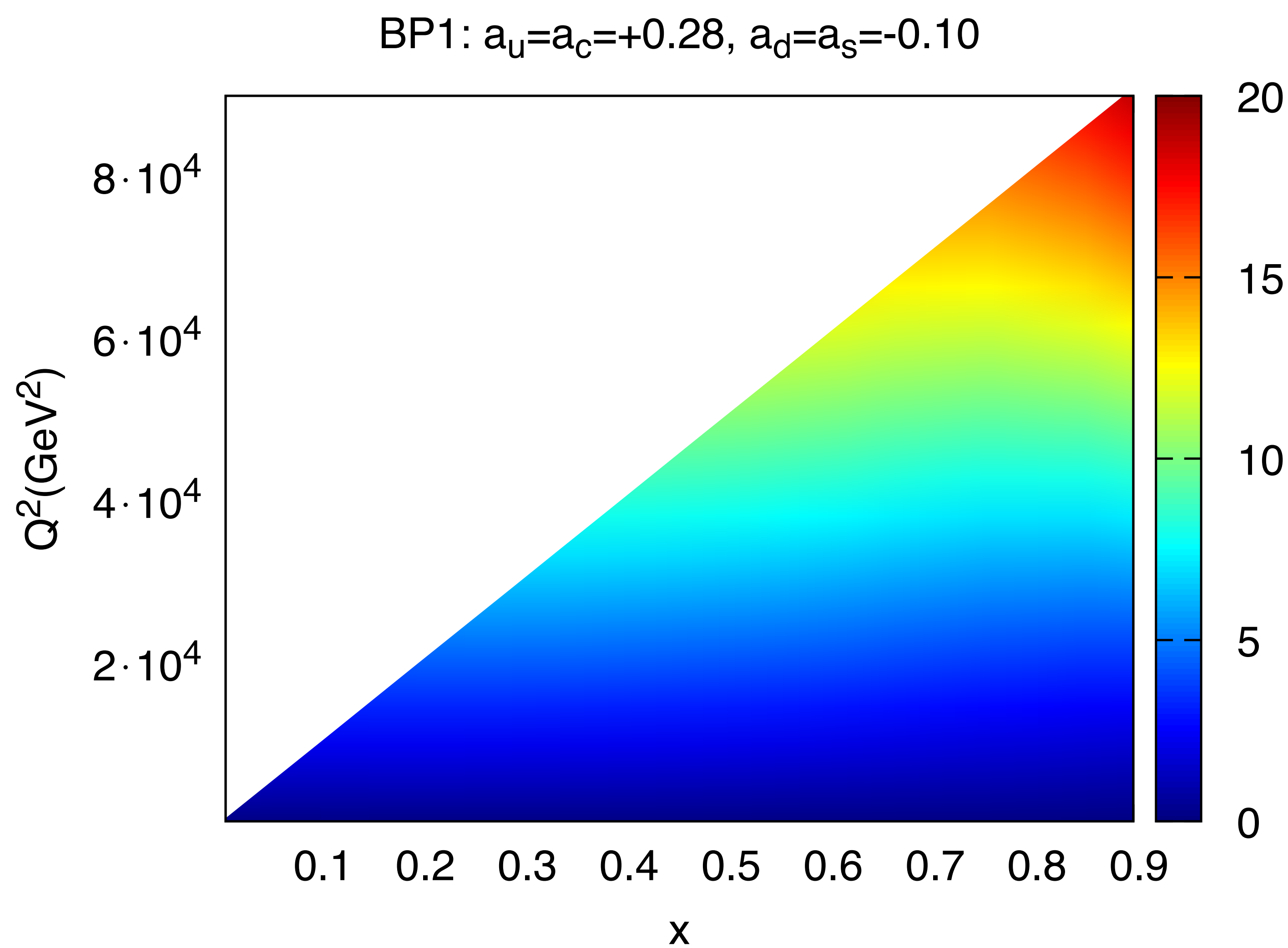
EFT and PDF

$$\mathcal{O}_{lq} = \left(\bar{l}_R \gamma^\mu l_R\right) \left(\bar{q}_R \gamma_\mu q_R\right)\ ,\ \ q = u, d, s, c\,,$$





Not single process
Not localised

$$\Delta F_2^{\rm smeft} \supset \frac{x}{12e^4}\left(4a_u e^2 \frac{Q^2}{\Lambda^2}(1+4K_Z s_W^4) + 3a_u^2 \frac{Q^4}{\Lambda^4}\right) \times \left(u(x,Q^2) + \bar{u}(x,Q^2)\right)$$

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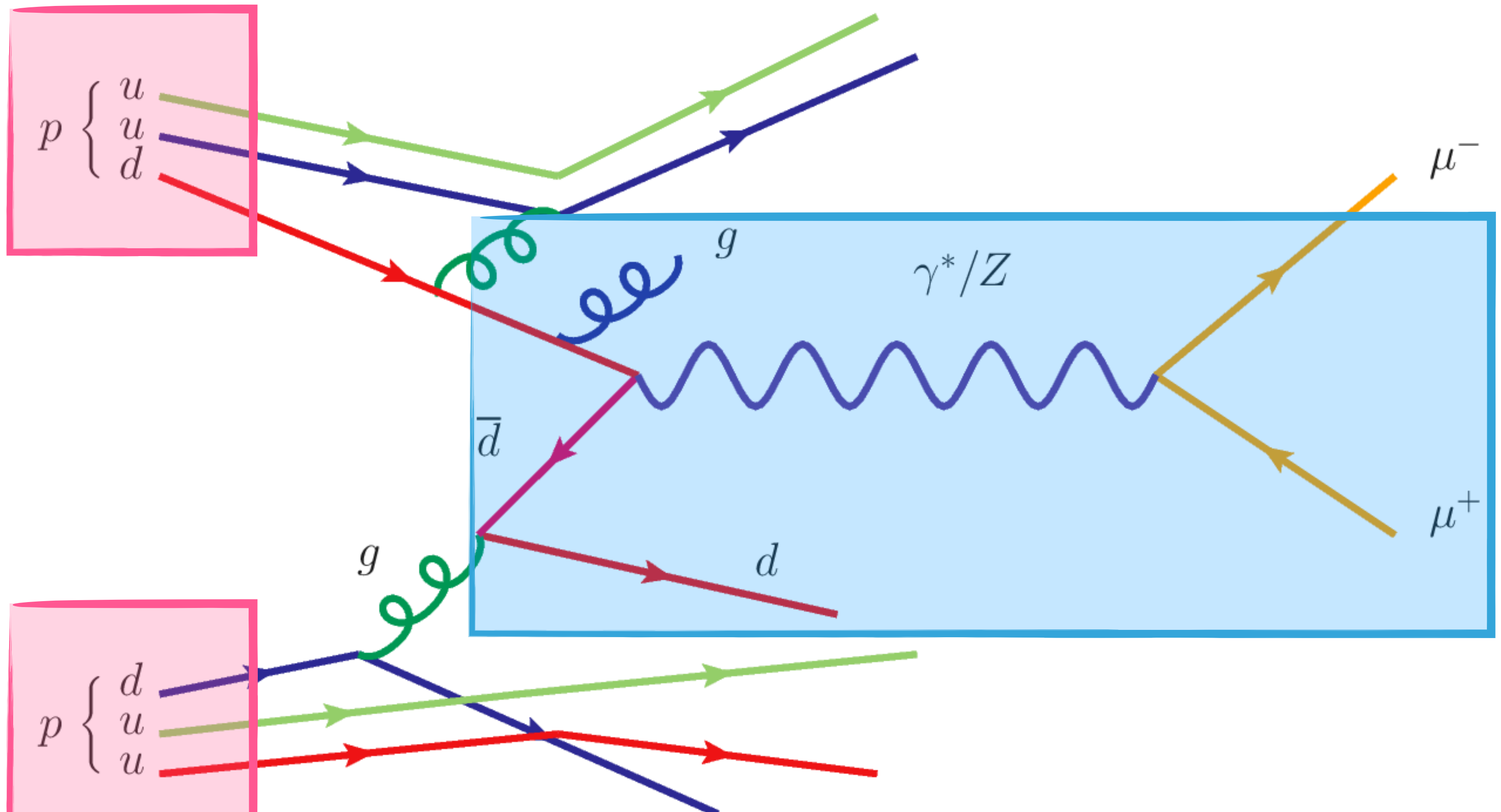
Precise predictions

Parton Distribution Functions



Hard Scattering: Perturbative QCD

at N$^{1/2/3}$LO

Perturbative QCD

$$d\sigma^{pp\to ab} = \sum_{i,j} \boxed{f_i^{\mathrm{SMEFT}} \otimes f_j^{\mathrm{SMEFT}}} \otimes \boxed{d\hat{\sigma}^{ij\to ab}} + \ldots \qquad f_i(x,\mu)$$

$\ni$LHC

SMEFT

data

PDF are process universal but model dependent

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EFT and PDF

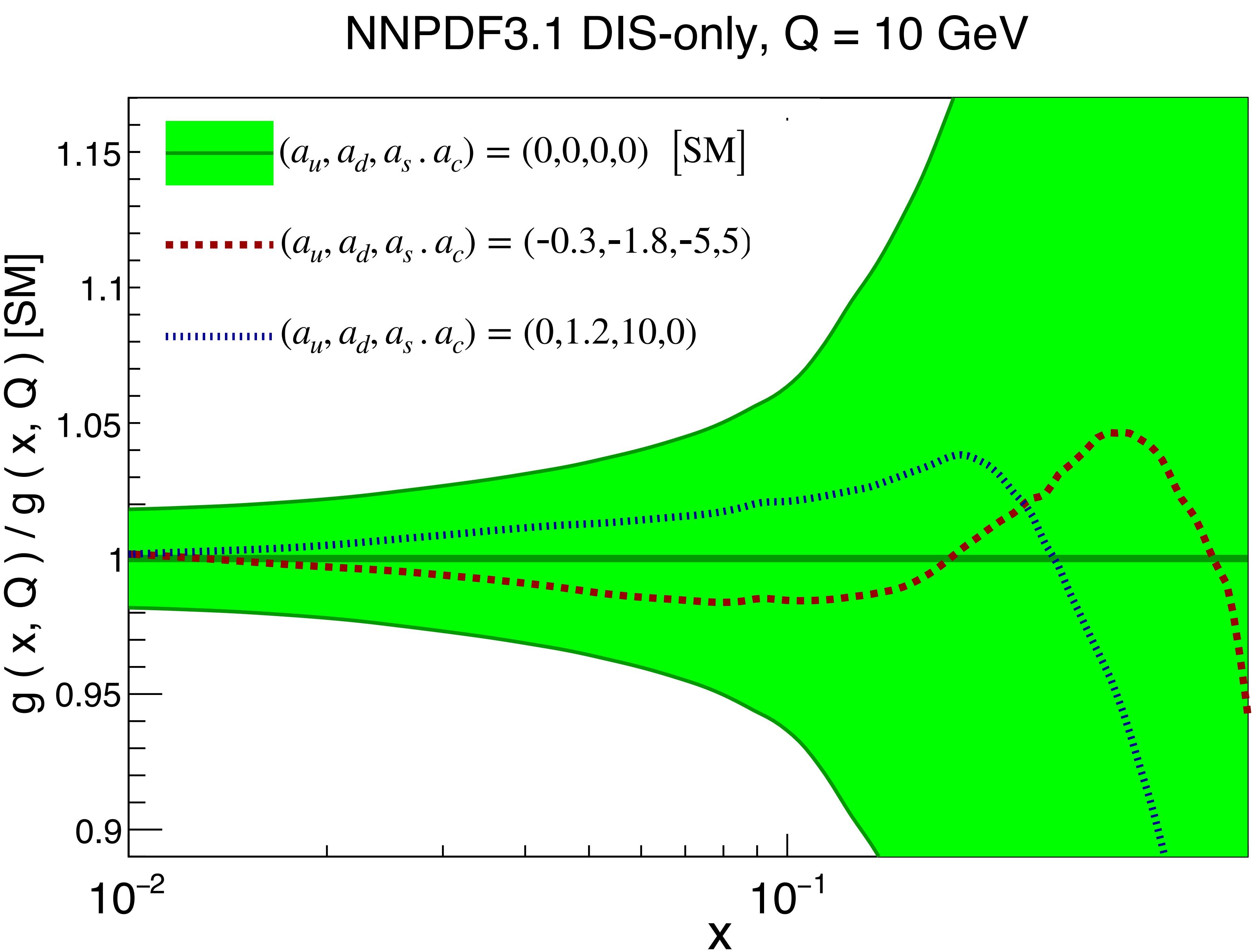
Procedure

- A few operators $\mathcal{O}_{lq} = \left(\bar{l}_R \gamma^\mu l_R\right)\left(\bar{q}_R \gamma_\mu q_R\right)\ , \ q = u, d, s, c\,,$

$$\sigma^{LEP} = \sigma^{SM} + (a_u + a_c)\sigma^u + (a_d + a_s)\sigma^d$$

- DIS data
- PDF for each BP
- χ^2 for each BP
- Combine with 'PDF independent' constraints (LEP diet + Parity)

EFT and PDF



Deviation within uncer. but large uncertainty (DIS only)

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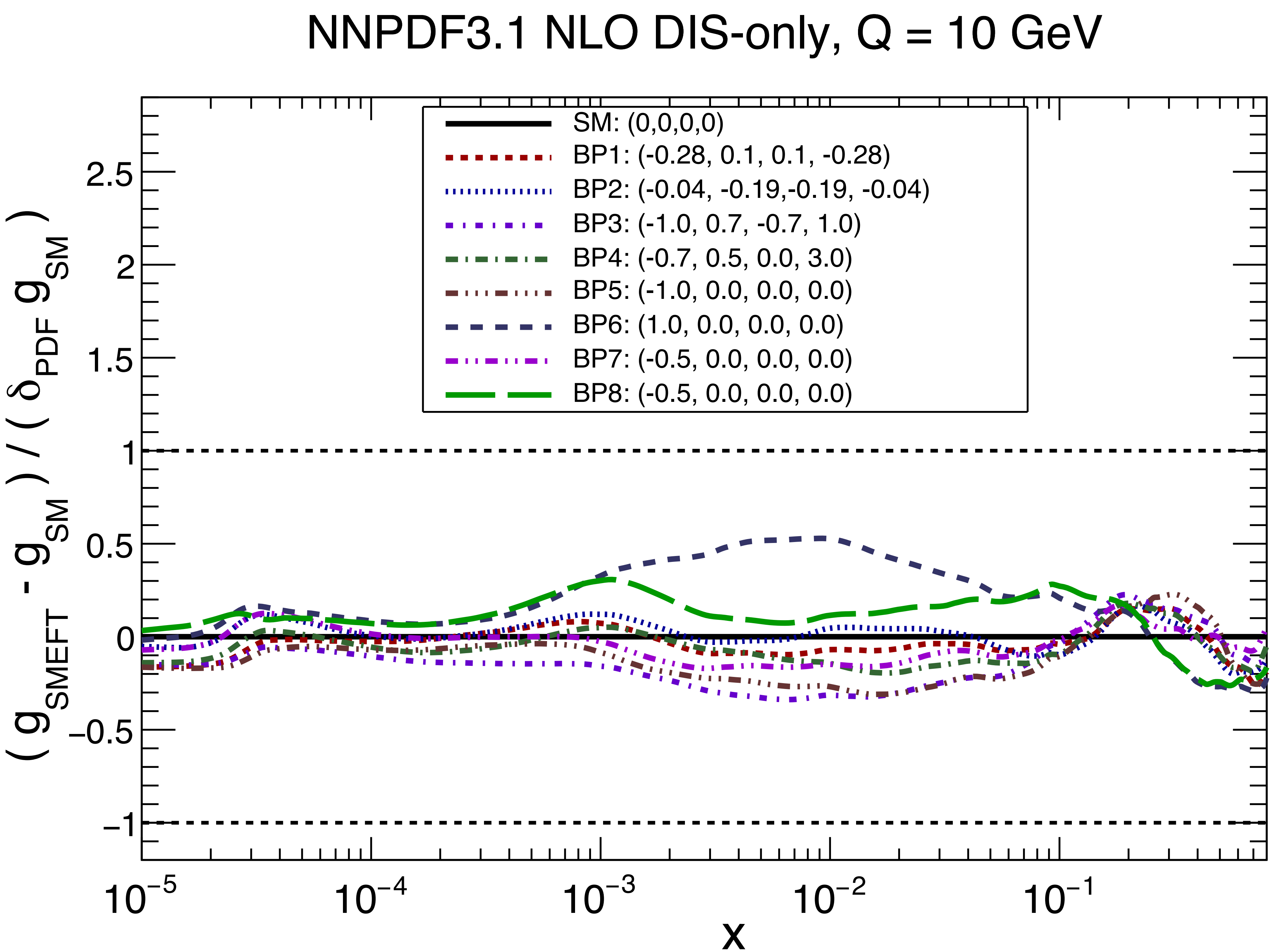
Effect on gluon PDF



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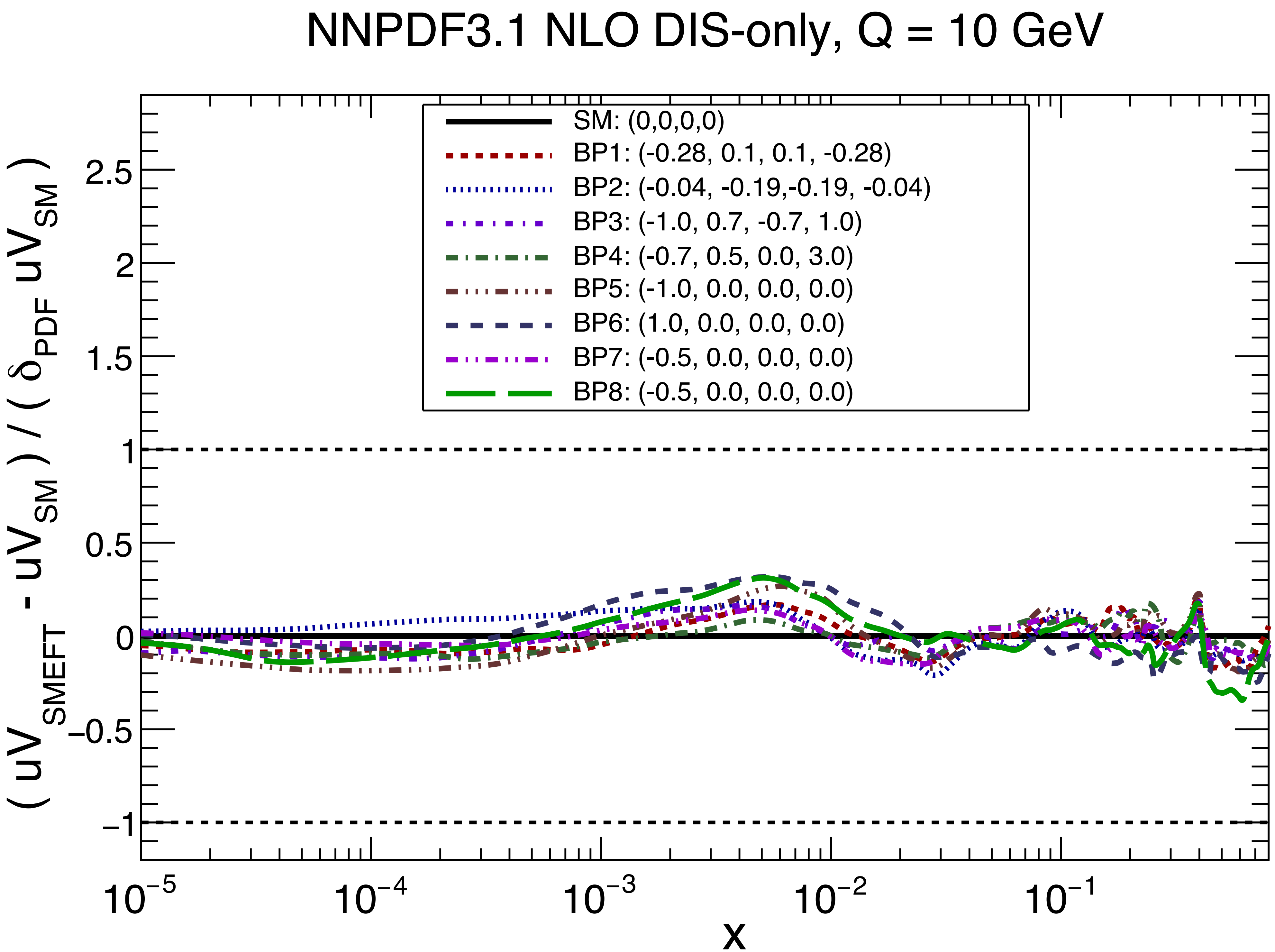
Effect on quarks PDF



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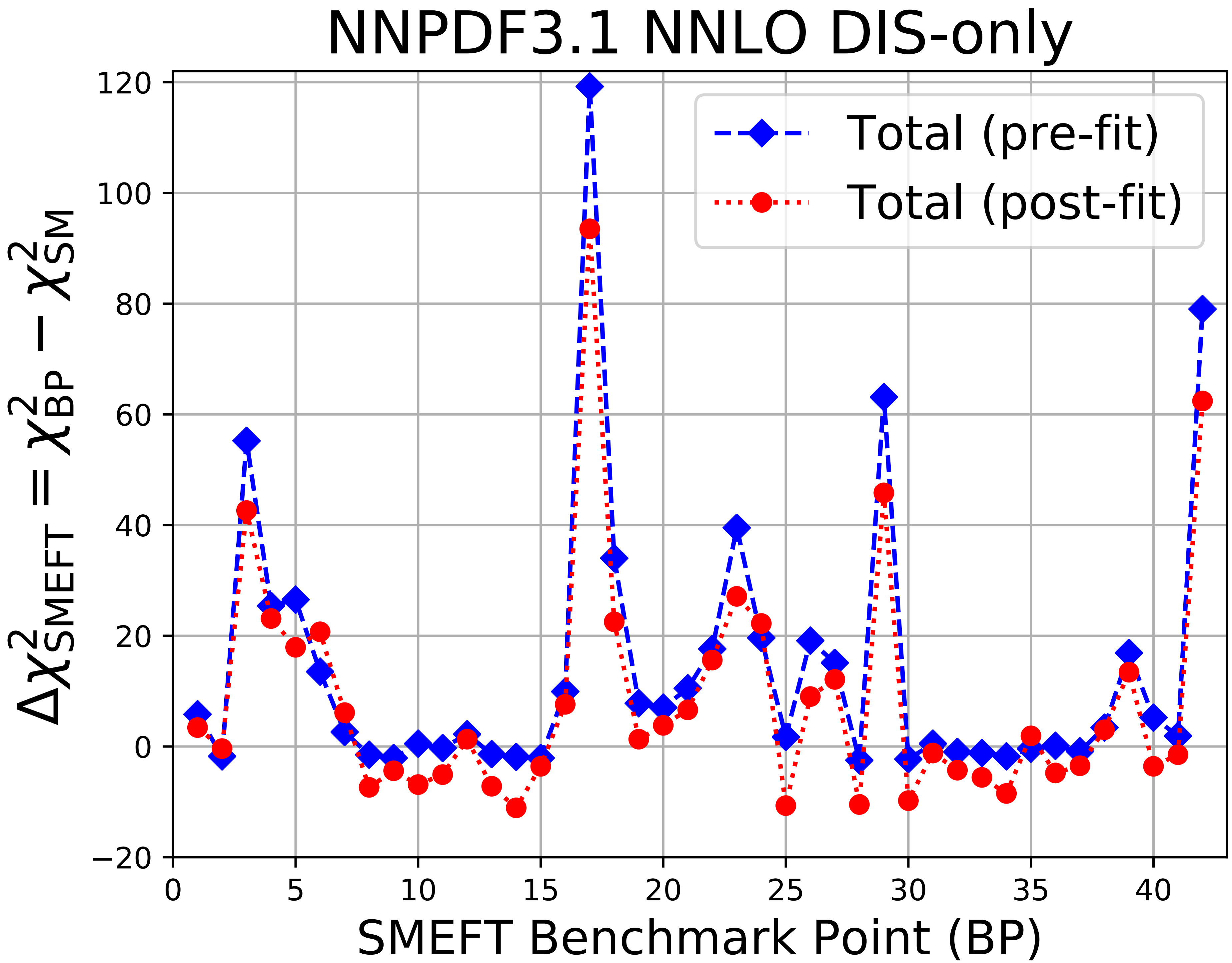
PDF fit for each SMEFT BP



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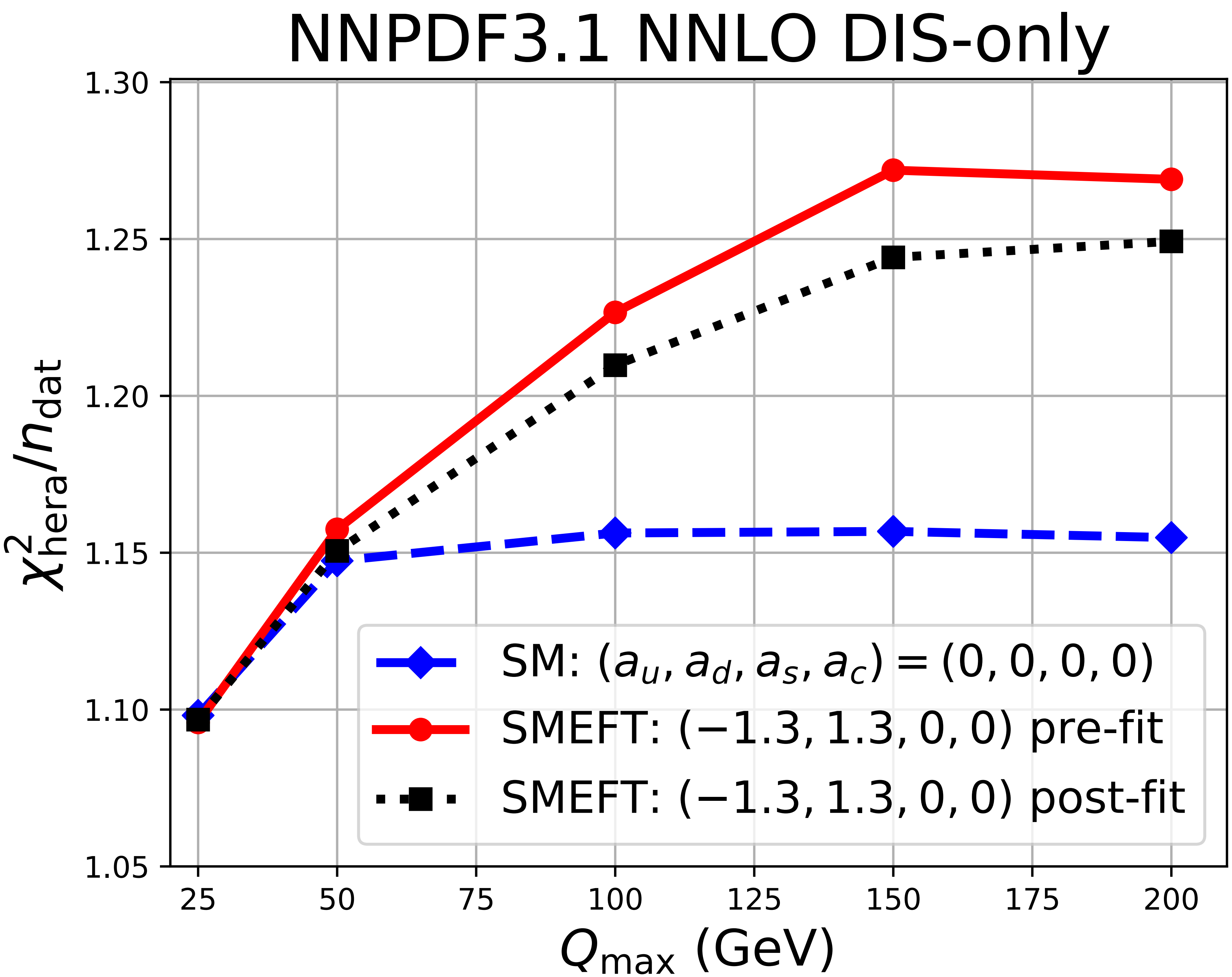
SM vs SMEFT



Operator dependent

$$\sigma_{4F} \sim \sigma_{SM} \times \frac{s}{\Lambda}$$

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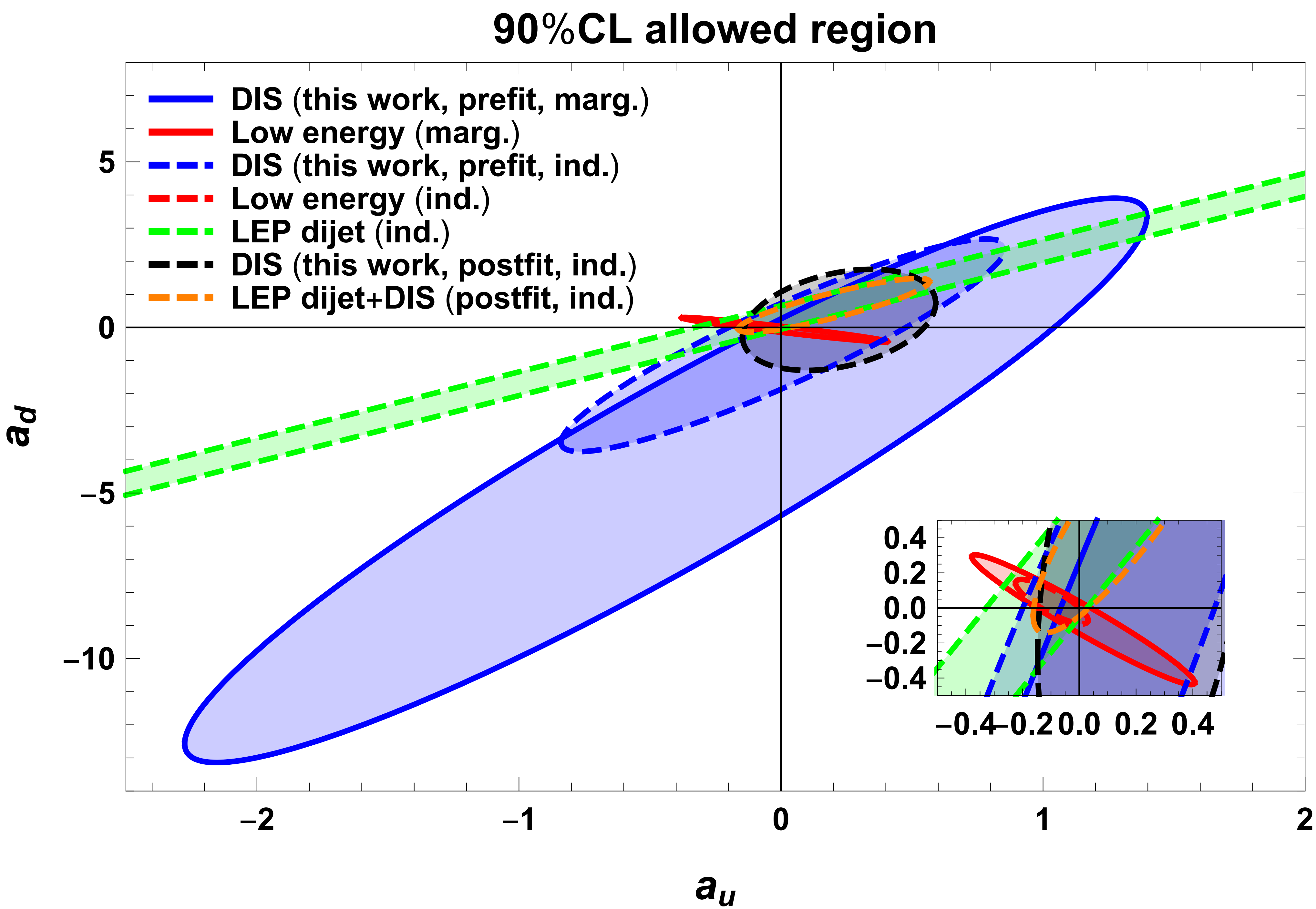
EFT and PDF



Parity
p=2u+d
n=2d+u
or
PDF at
$Q^2 << 1 GeV^2$

LEP correlations only between x-section at different energies

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Outlook

Looking for new physics

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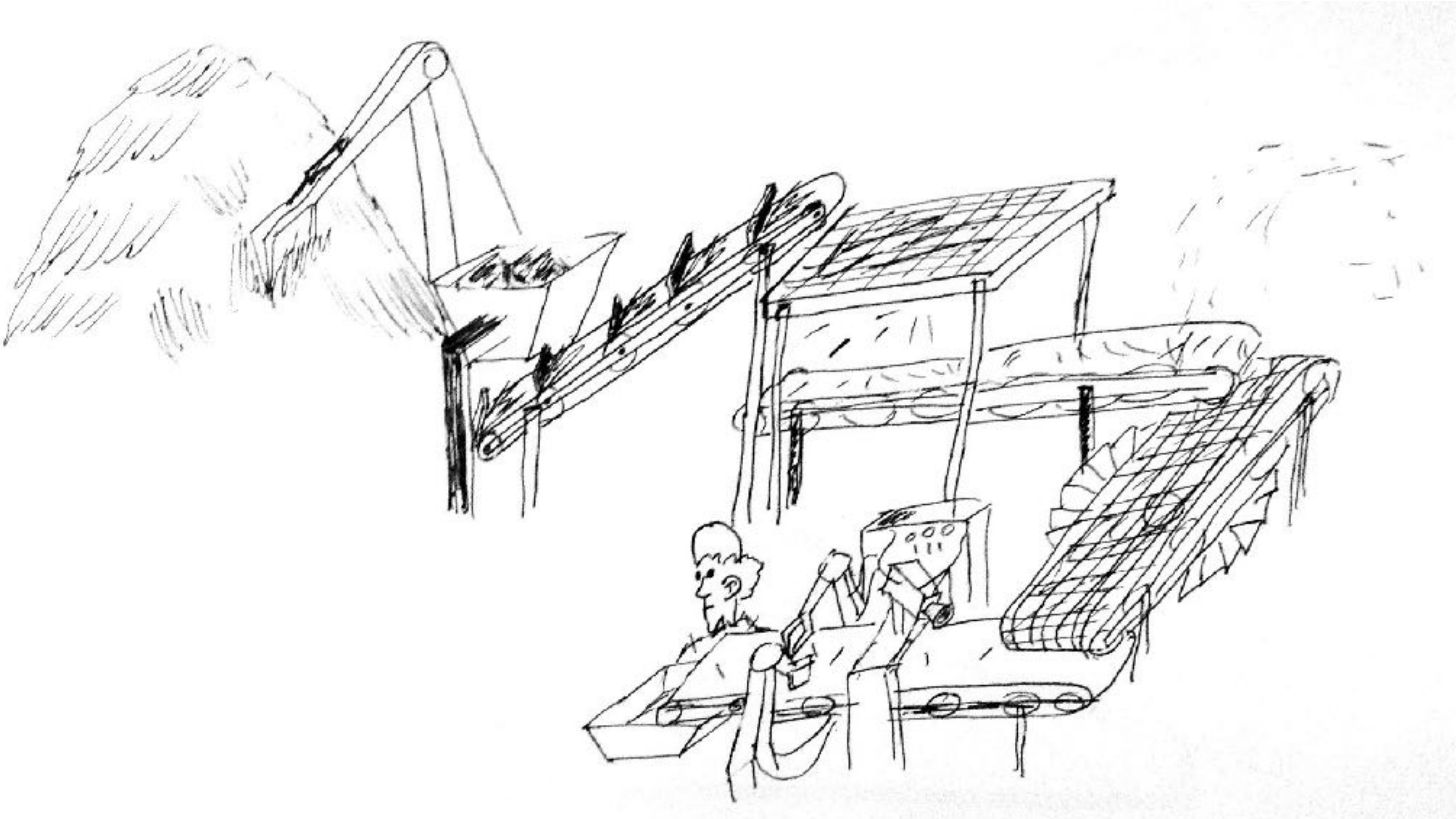
Summary

- EFT provide guidance (which observable)
- EFT is multi-channel/observable
- Global fit with a large number of parameters/multiple data
- Interplay between PDF and EFT
  - add more operators
  - add more data
  - full fit with both PDF and SMEFT

Summary



Thank you

C. Degrande