UNIVERSITY OF CAMBRIDGE

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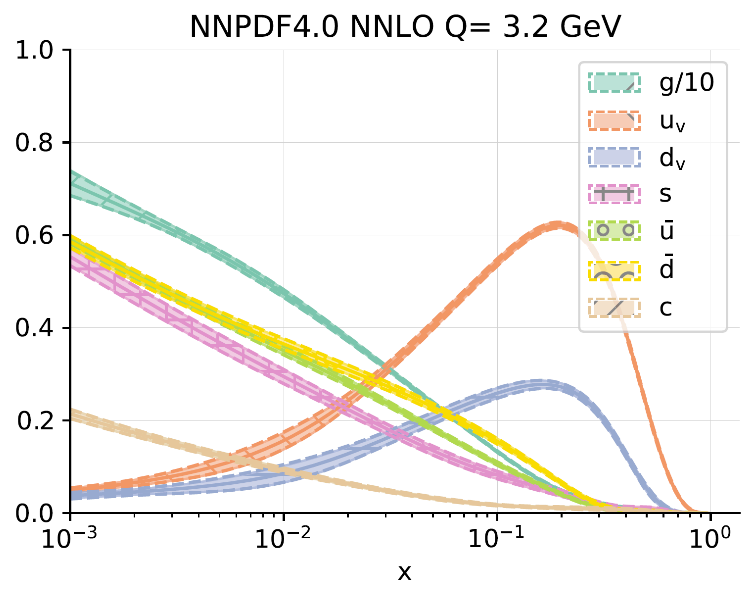
MANUEL MORALES ALVARADO

THE INTERPLAY BETWEEN PDF FITS AND BSM SIGNATURES

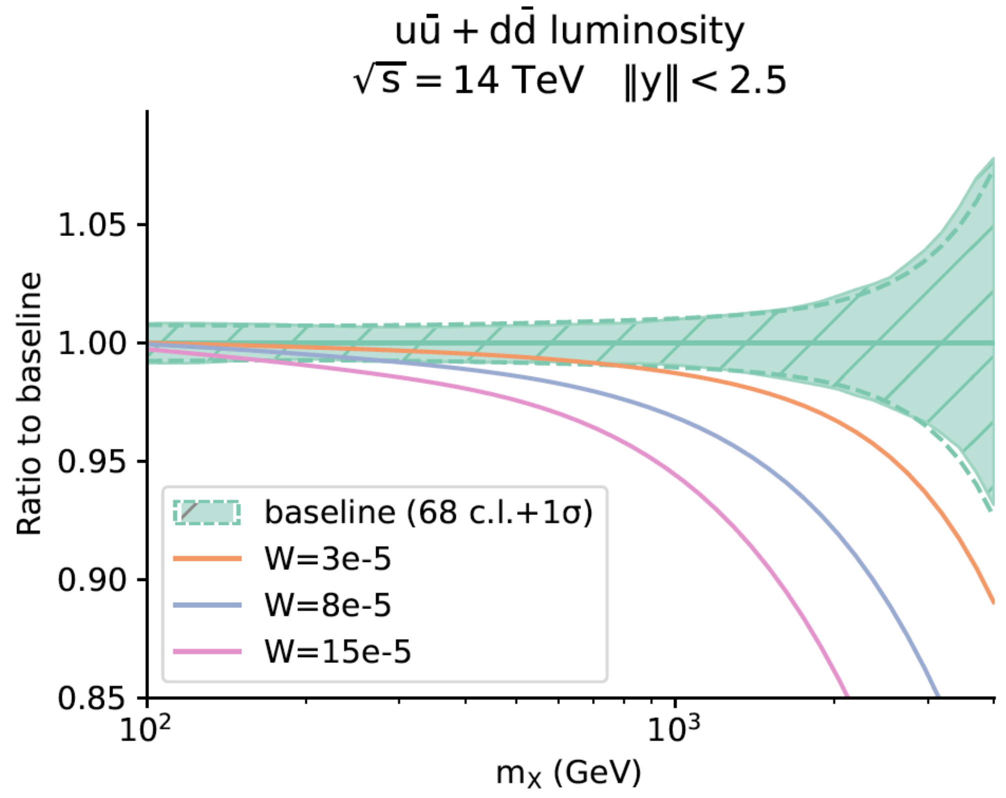
PBSP

OUTLINE



$$+ \quad \frac{c_i}{\Lambda^2}$$

Simultaneous PDF-EFT determination



Can PDFs absorb new physics?

Conclusions and outlook

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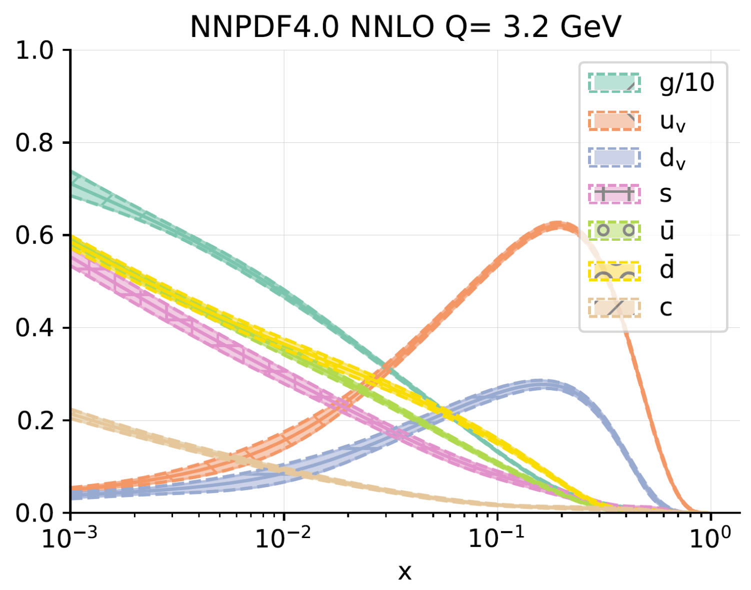

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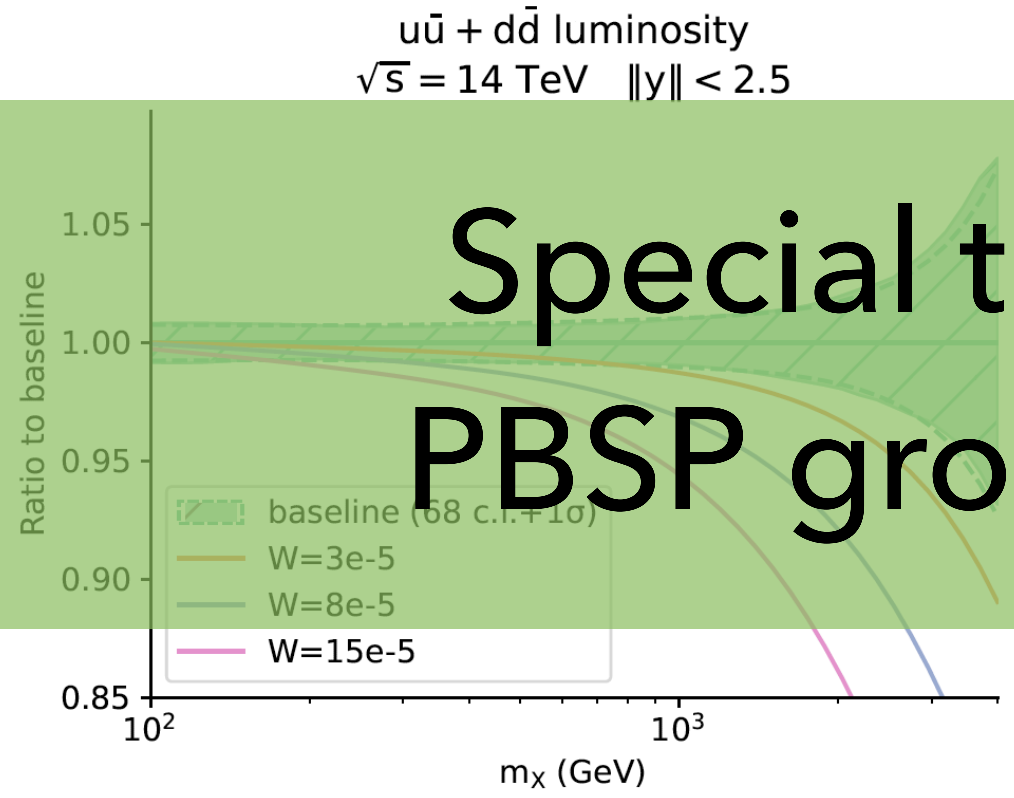

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Special thanks to members of the PBSP group for some of the slides!

Conclusions and outlook

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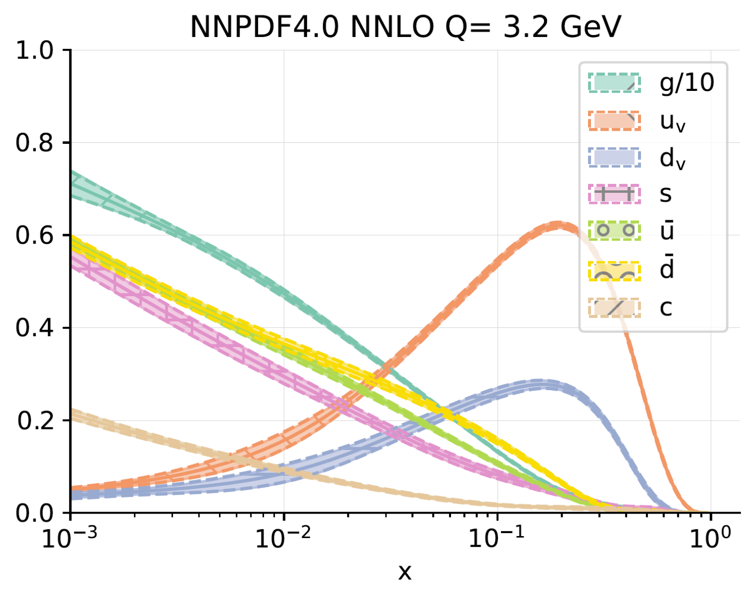

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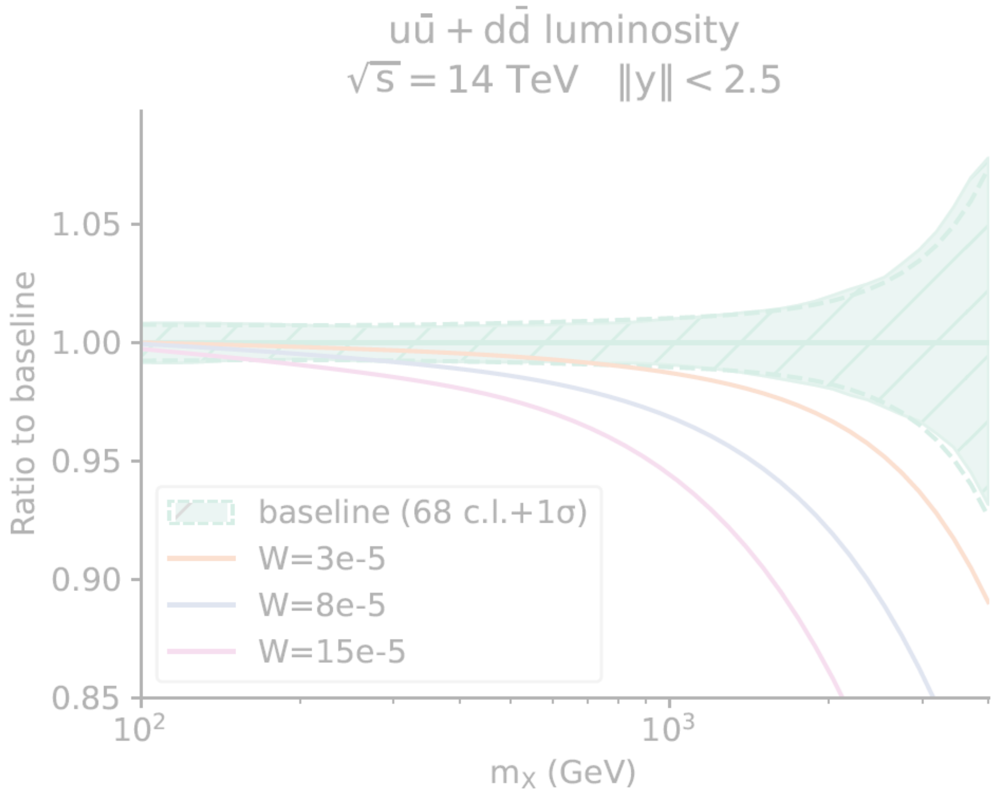

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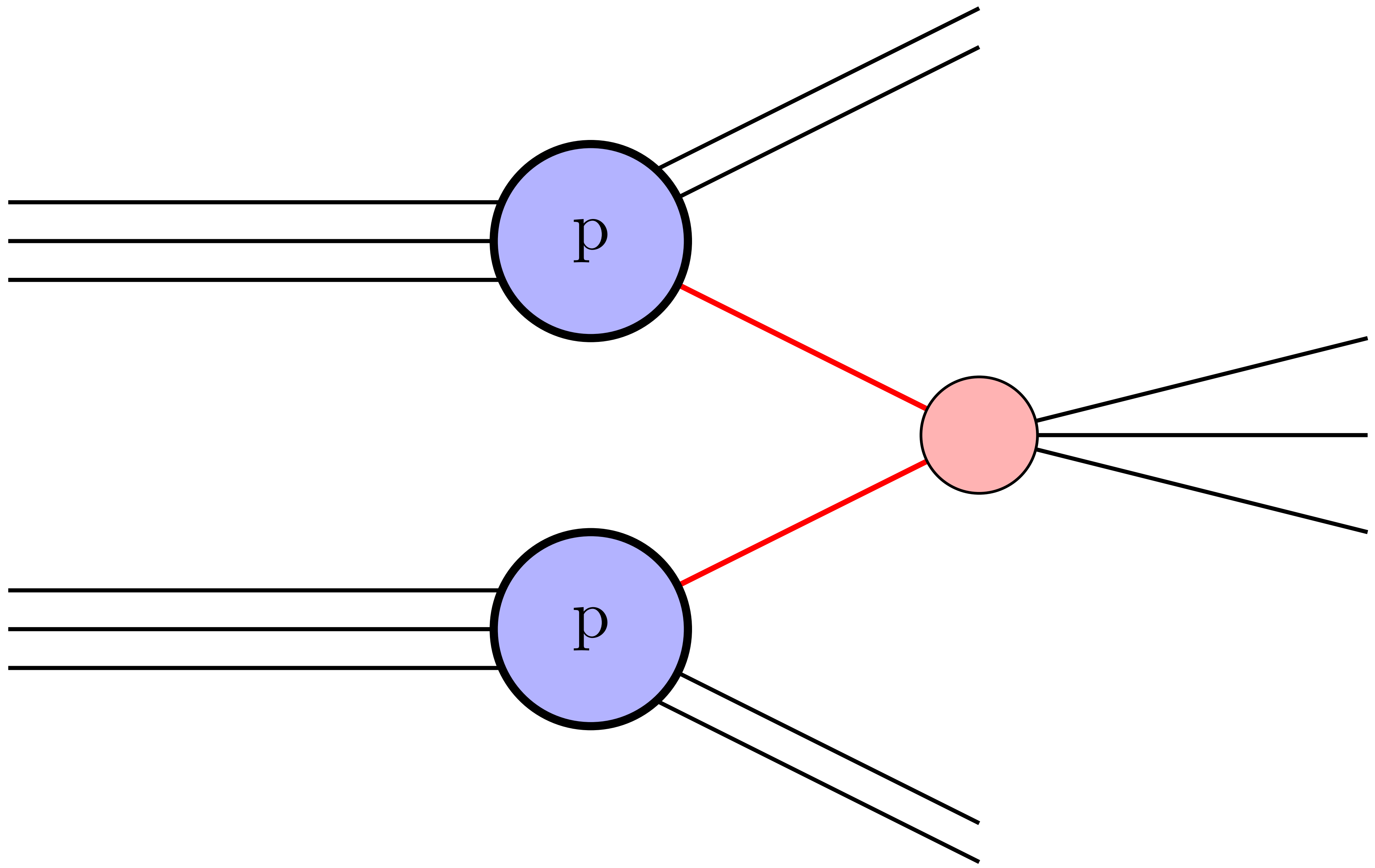
Conclusions and outlook

PARTON DISTRIBUTION FUNCTIONS

Consider a proton-proton collision



PARTON DISTRIBUTION FUNCTIONS (PDFS)

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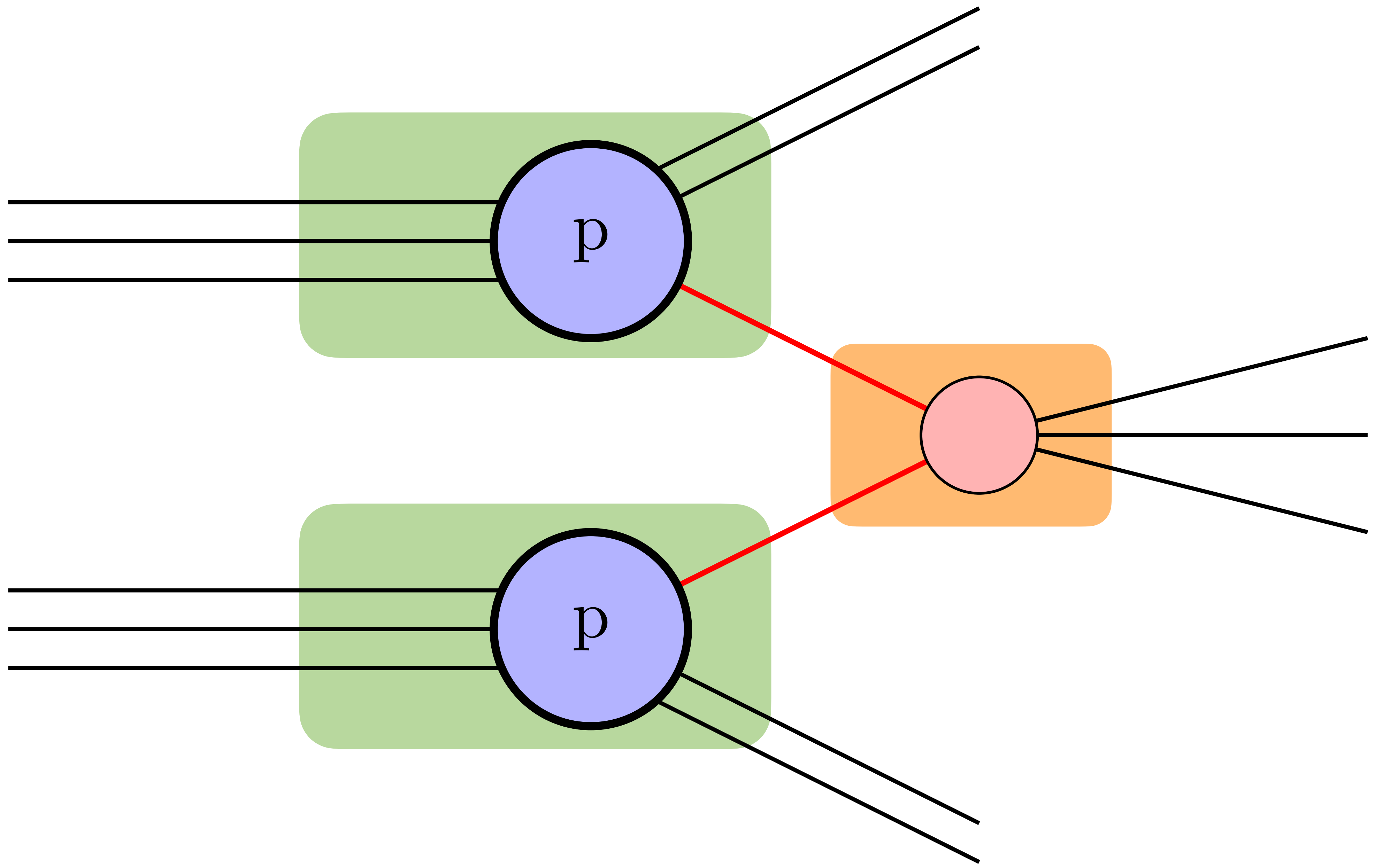


$$\sigma = \sum_{i,j} \int_0^1 dx_1 \int_0^1 dx_2 f_i(x_1) f_j(x_2) \hat{\sigma}_{ij}(x_1, x_2)$$

$x_{1,2}$: fraction of the hadron's momentum that is carried by the interacting partons

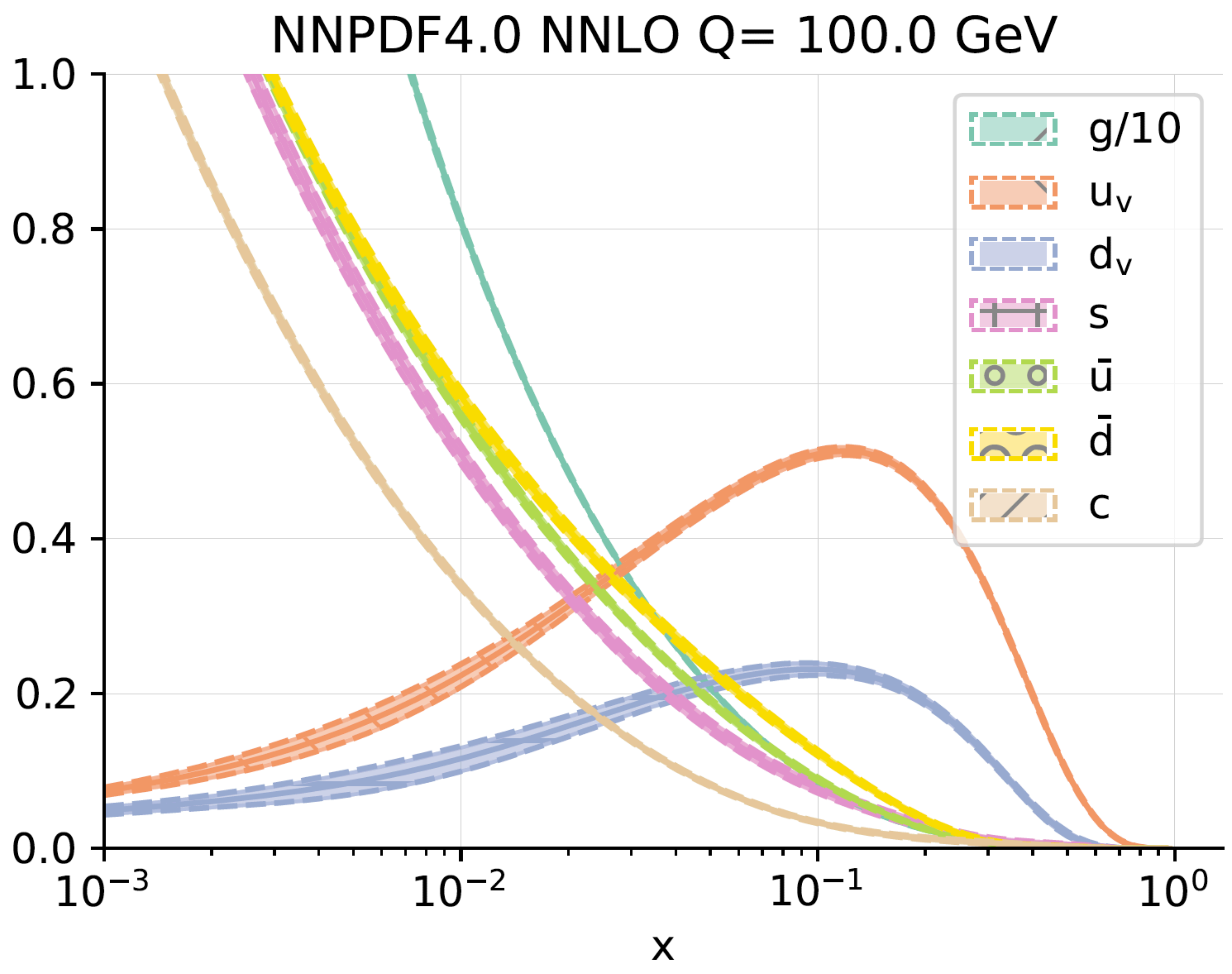
$\hat{\sigma}_{ij}$: partonic cross section

$f_i(x)$: PDF of a parton of type i. It represent the probability of finding a parton of type i carrying a fraction x of the total momentum.

PDF DETERMINATION

PDFs cannot be calculated from first principles → they have to be extracted from data

$$f(x, Q^2)$$



Ball et al. arXiv: 2109.02653

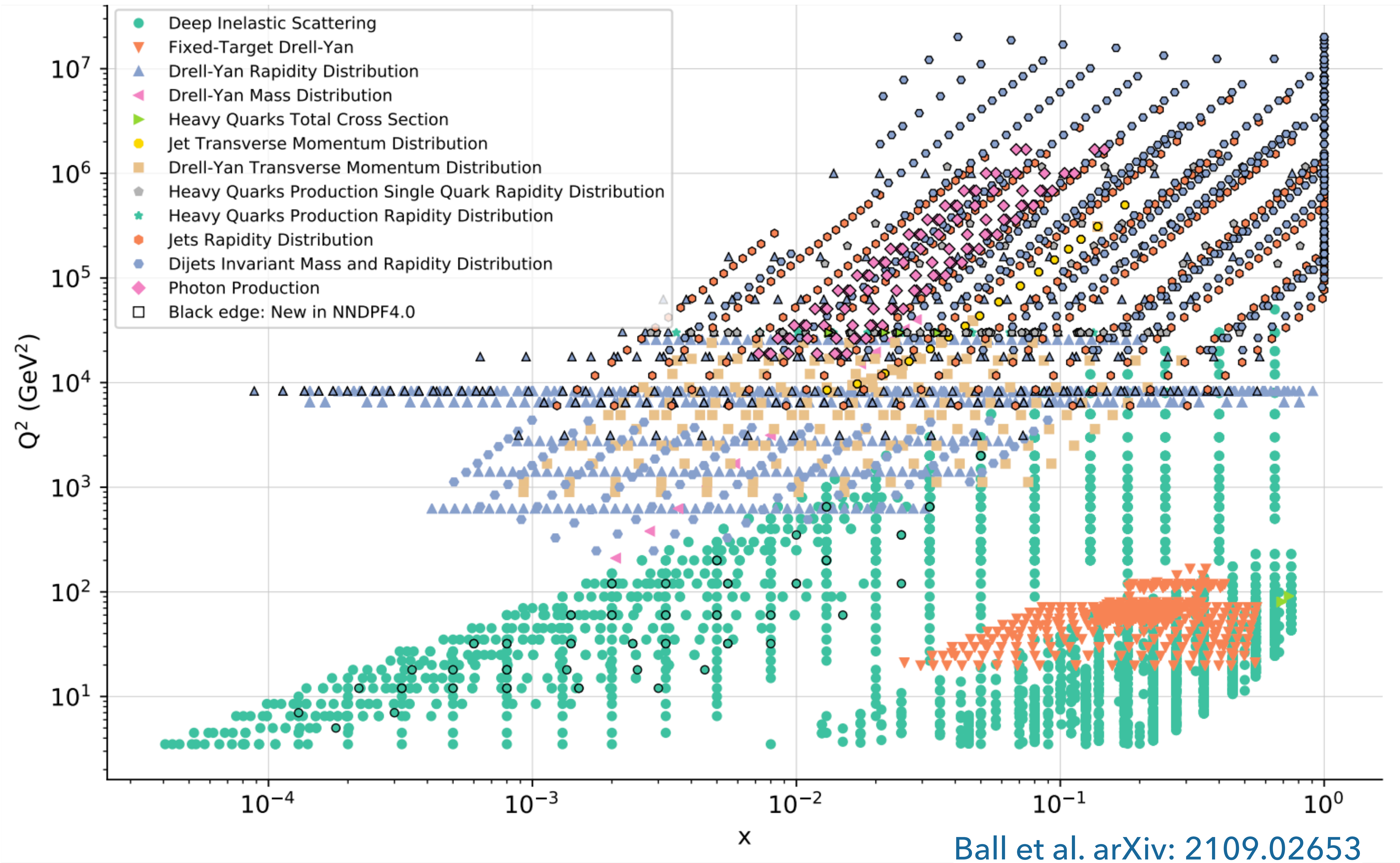
Recent global PDF fits include:

- NNPDF 4.0: Ball et al., 2109.02653
- CT18: Hou et al., 1912.10053
- MSHT20aN3LO: McGowan et al., 2207.04739

PDF DETERMINATION

A huge number of measurements go into PDF fits.

In NNPDF ~4500 datapoints



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PDF DETERMINATION

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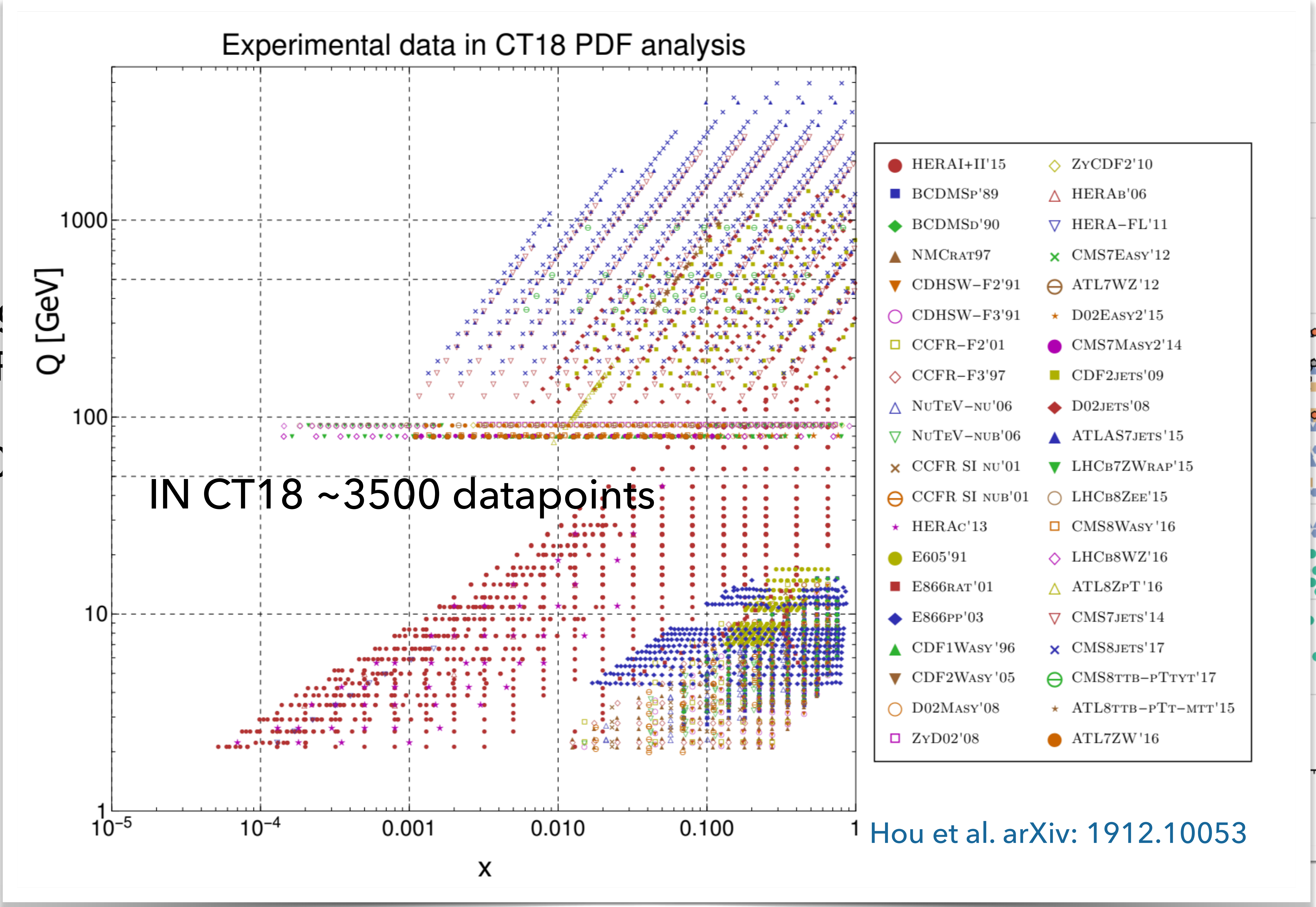
into P

~450



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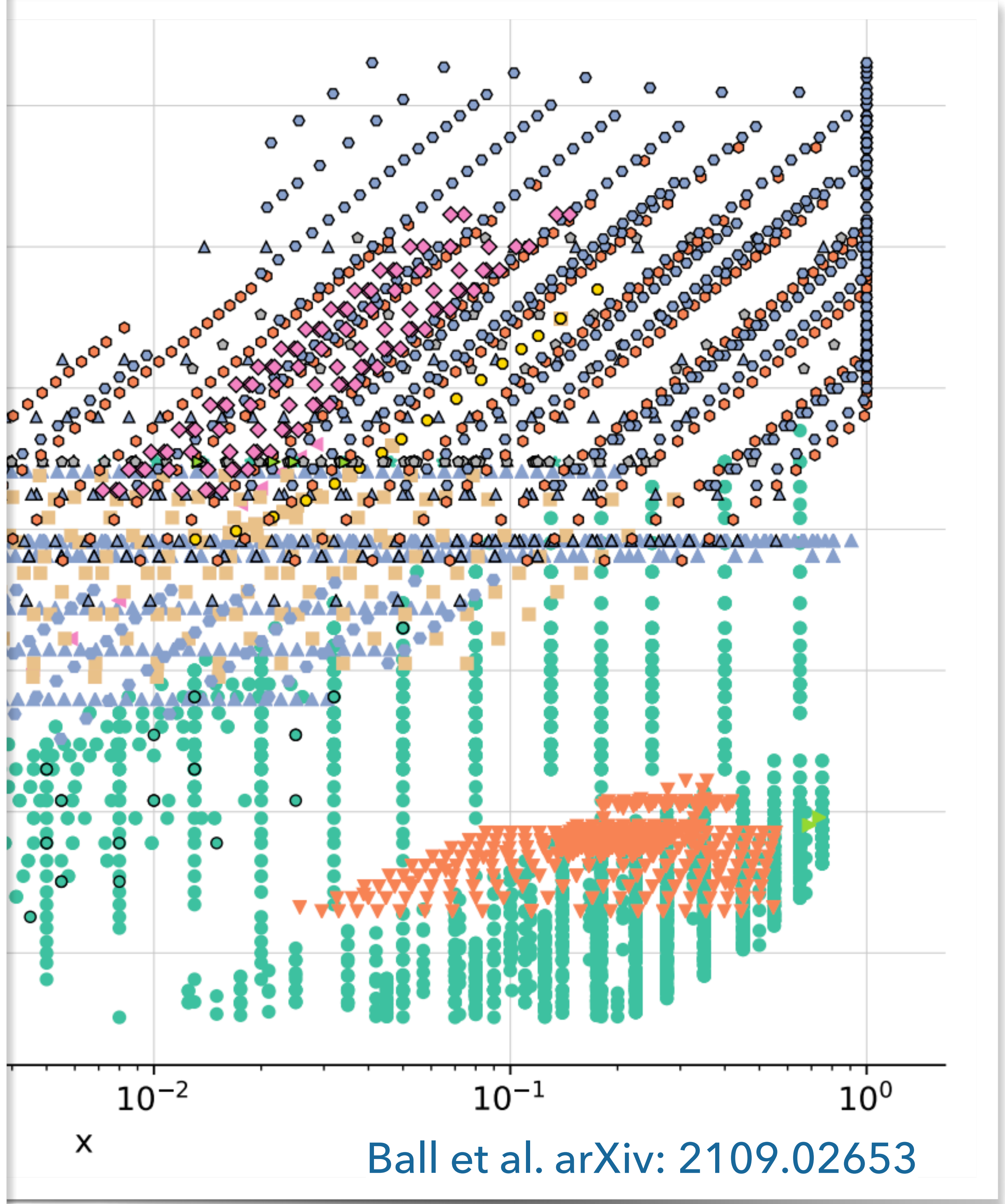

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PDF DETERMINATION

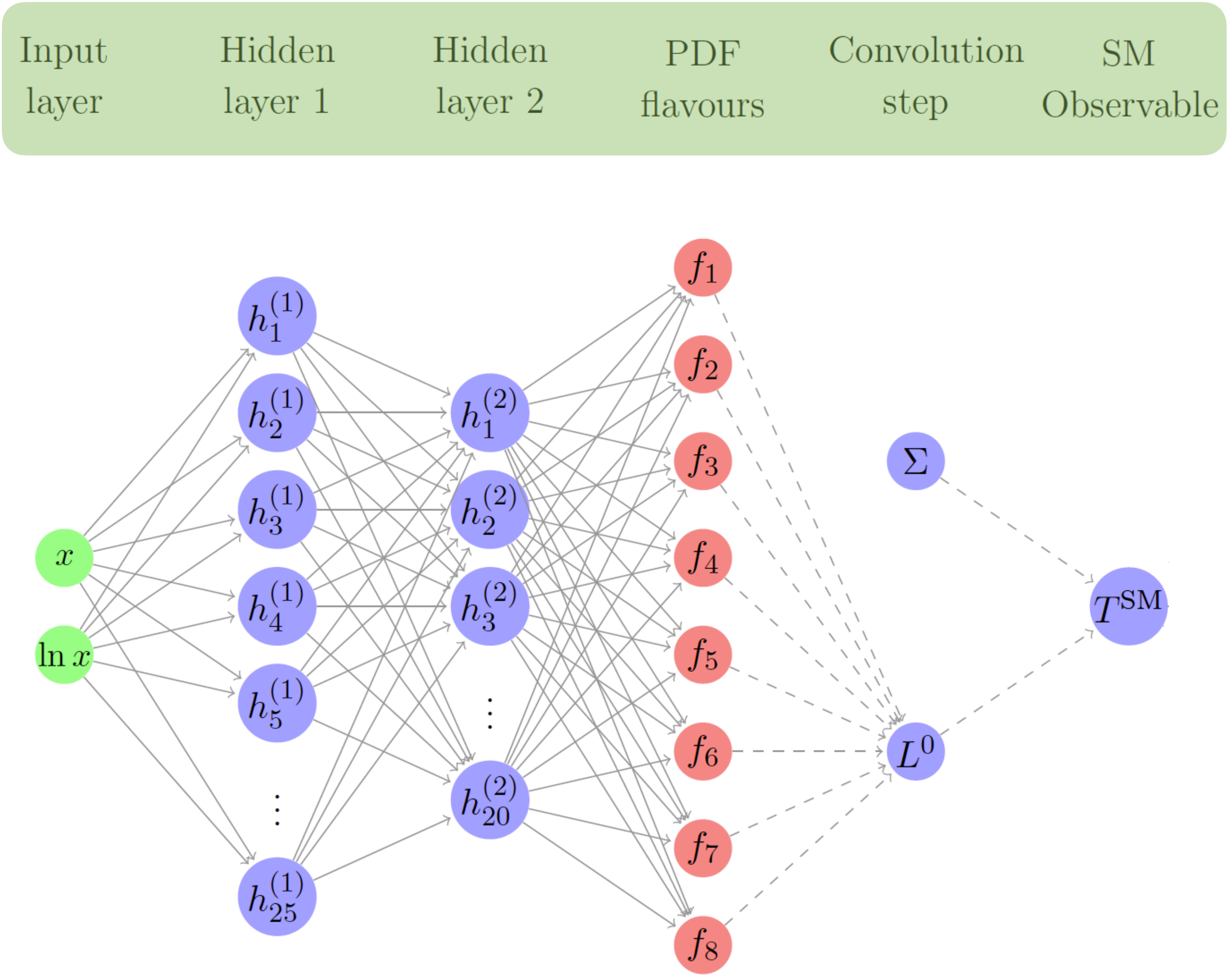
In the case of NNPDF4.0, neural networks (NNs) are used to fit the PDFs

The optimal parameters of the NN are found by minimising

$$\chi^2(\theta) = \frac{1}{N_{\rm dat}}(\mathbf{D} - \mathbf{T}(\theta))^T(\mathbf{cov})^{-1}(\mathbf{D} - \mathbf{T}(\theta))$$

$$\theta = \theta_{opt}$$

NNPDF4.0



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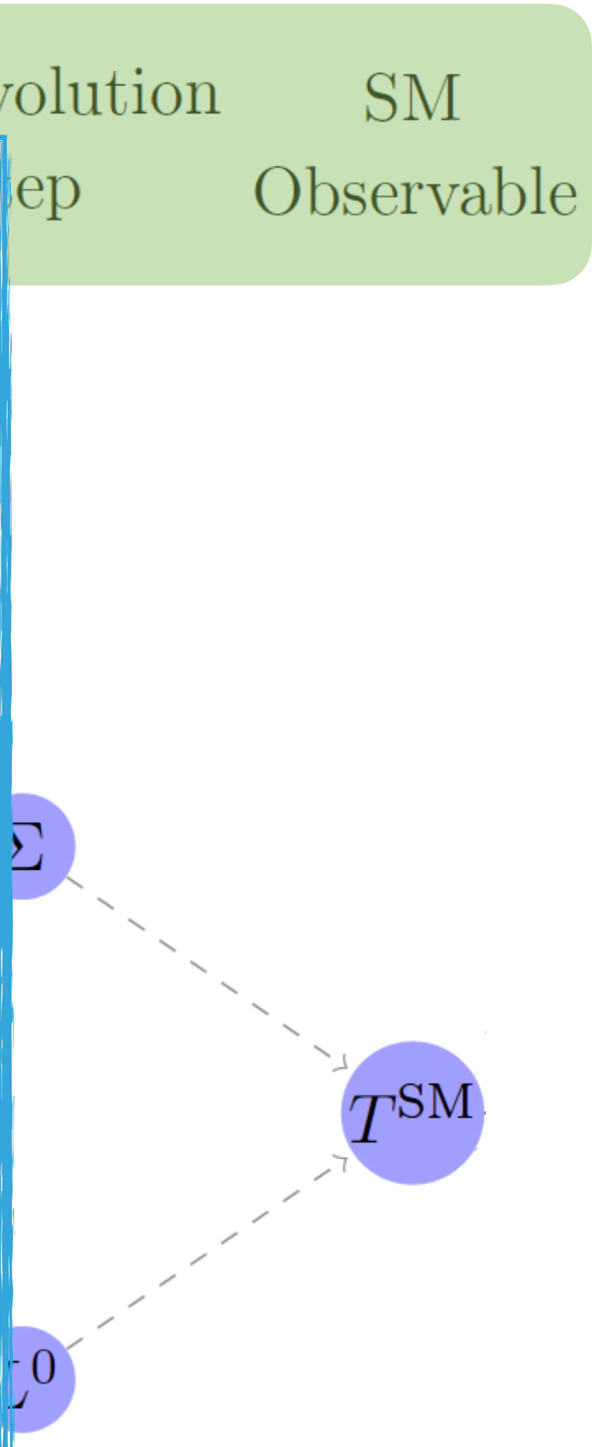

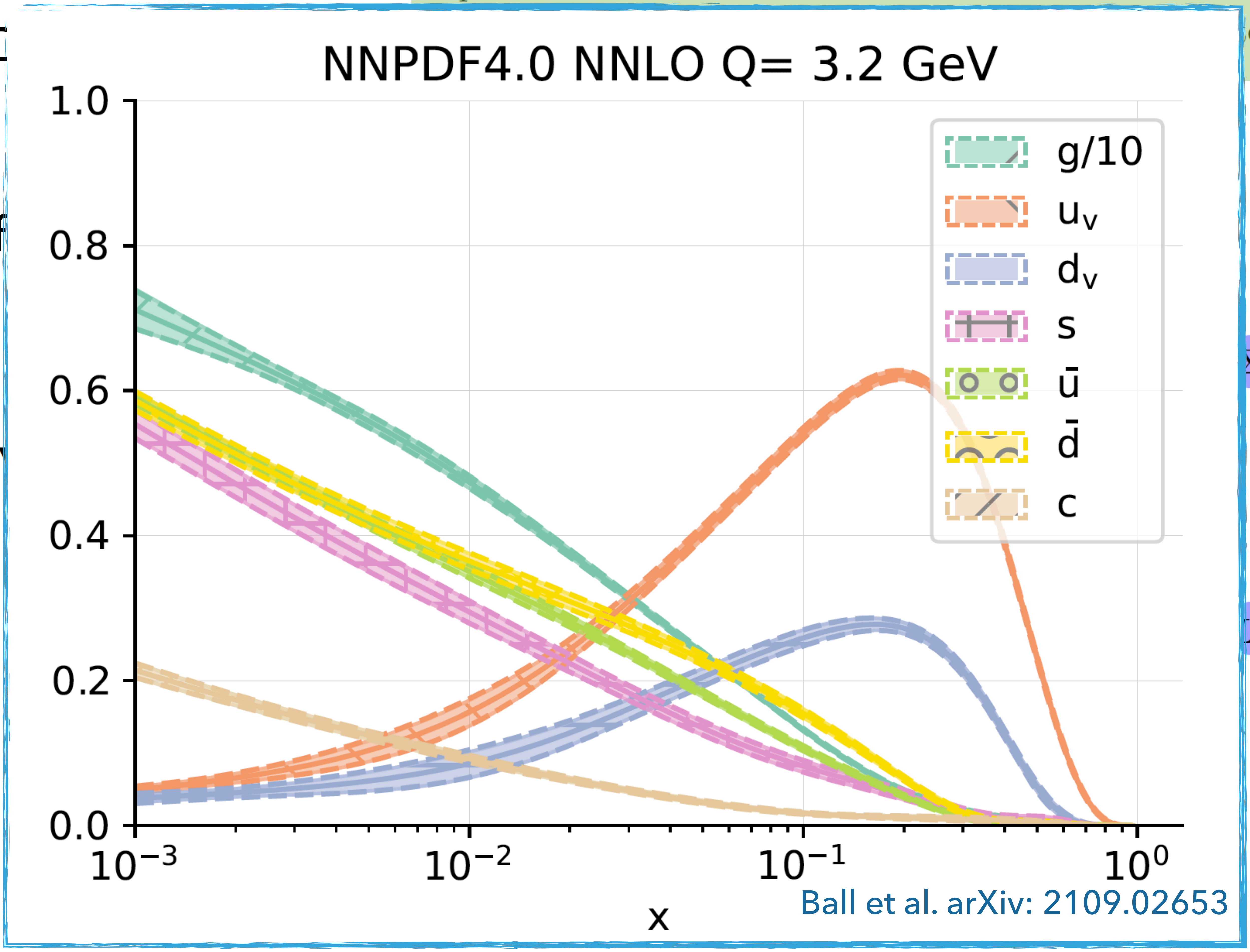

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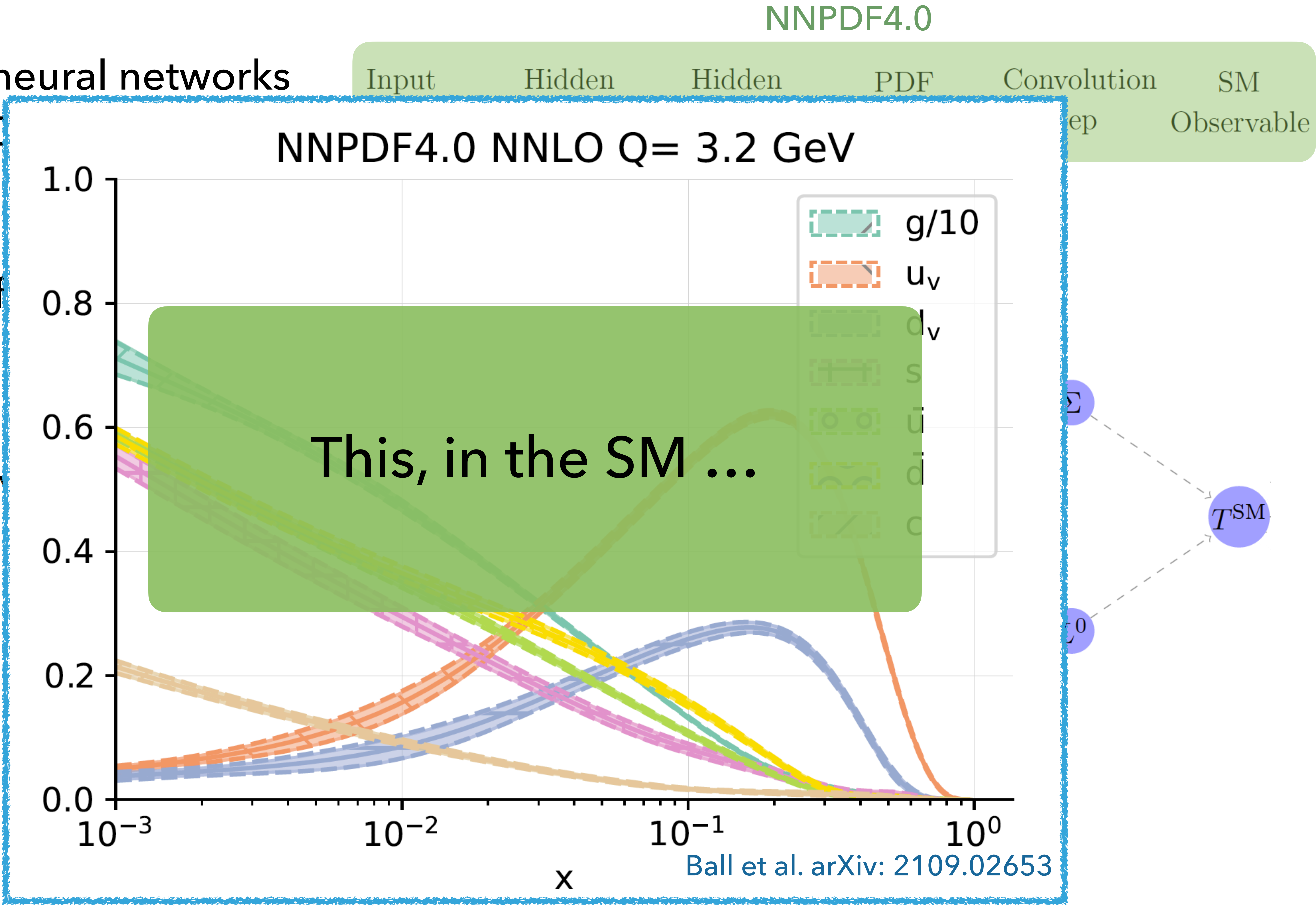

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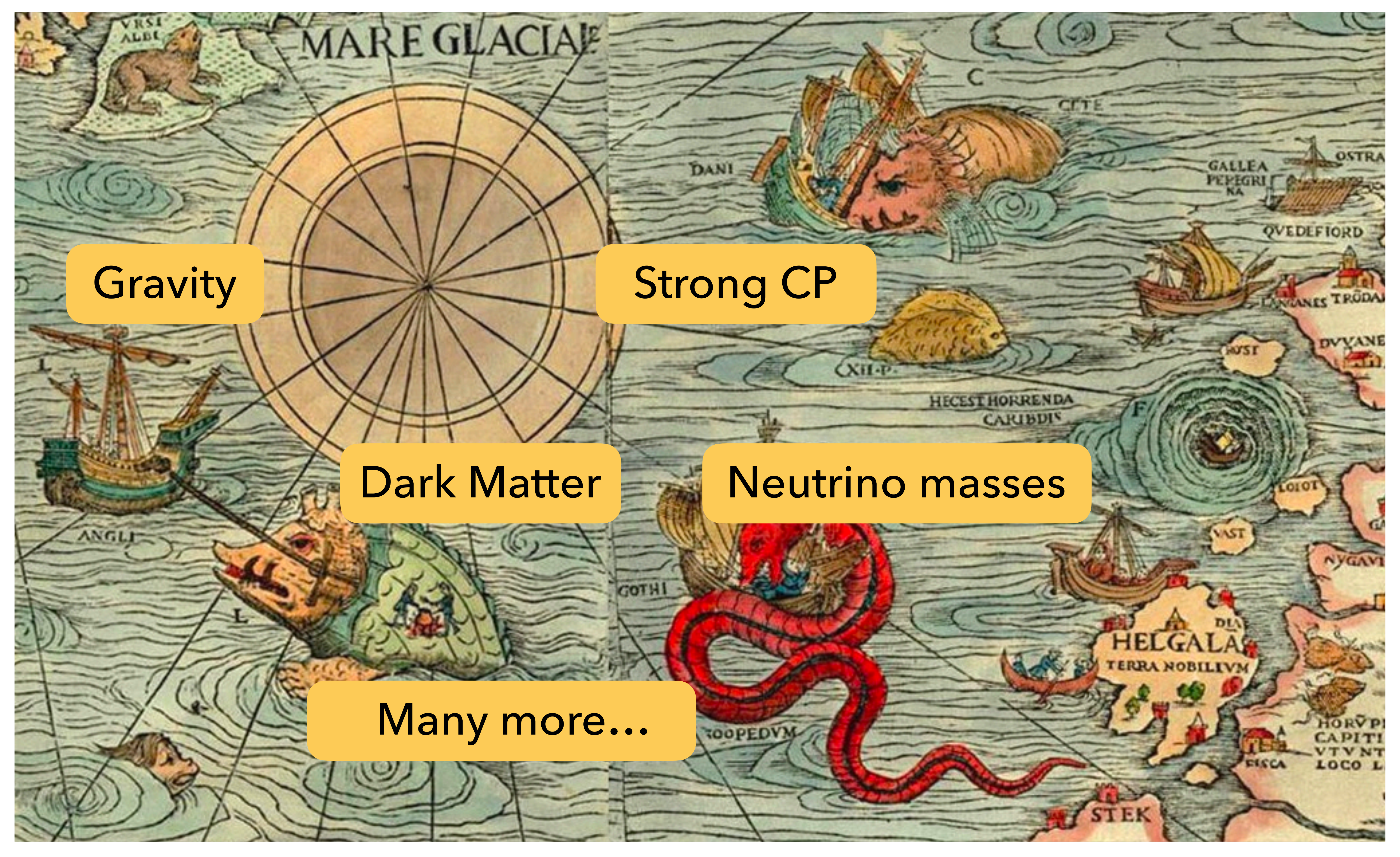
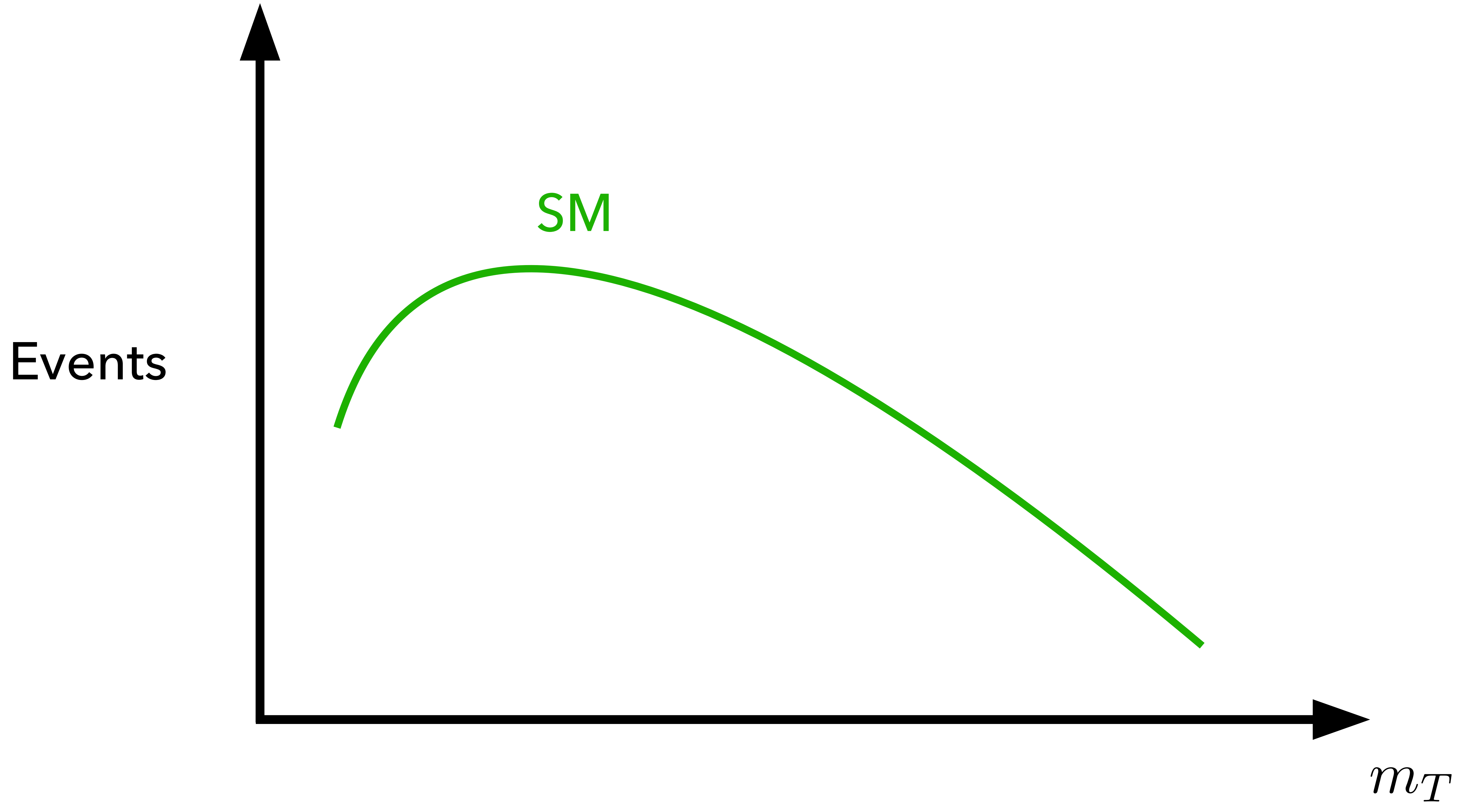
THE STANDARD MODEL AND BEYOND

Although the SM is very successful, it leaves many things unexplained



INDIRECT SEARCHES BEYOND THE STANDARD MODEL (BSM)

Consider the following distribution



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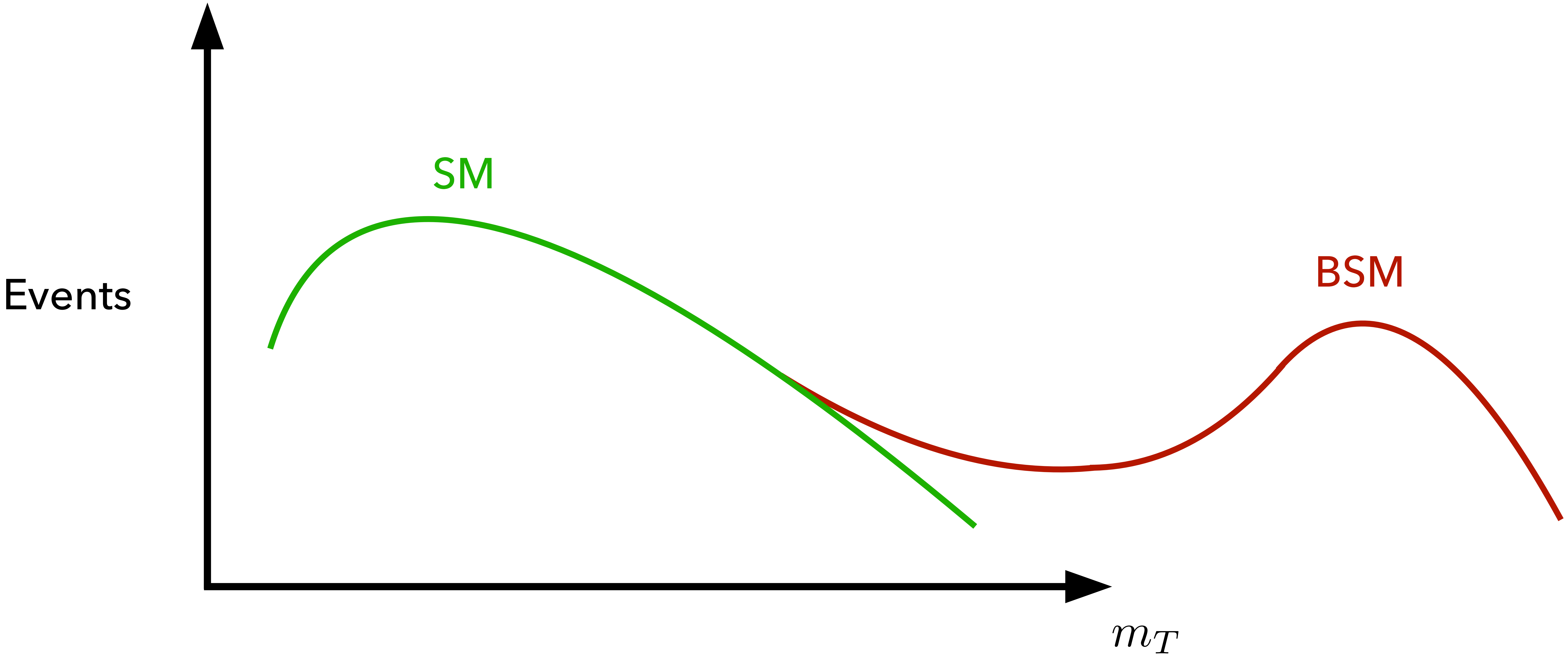

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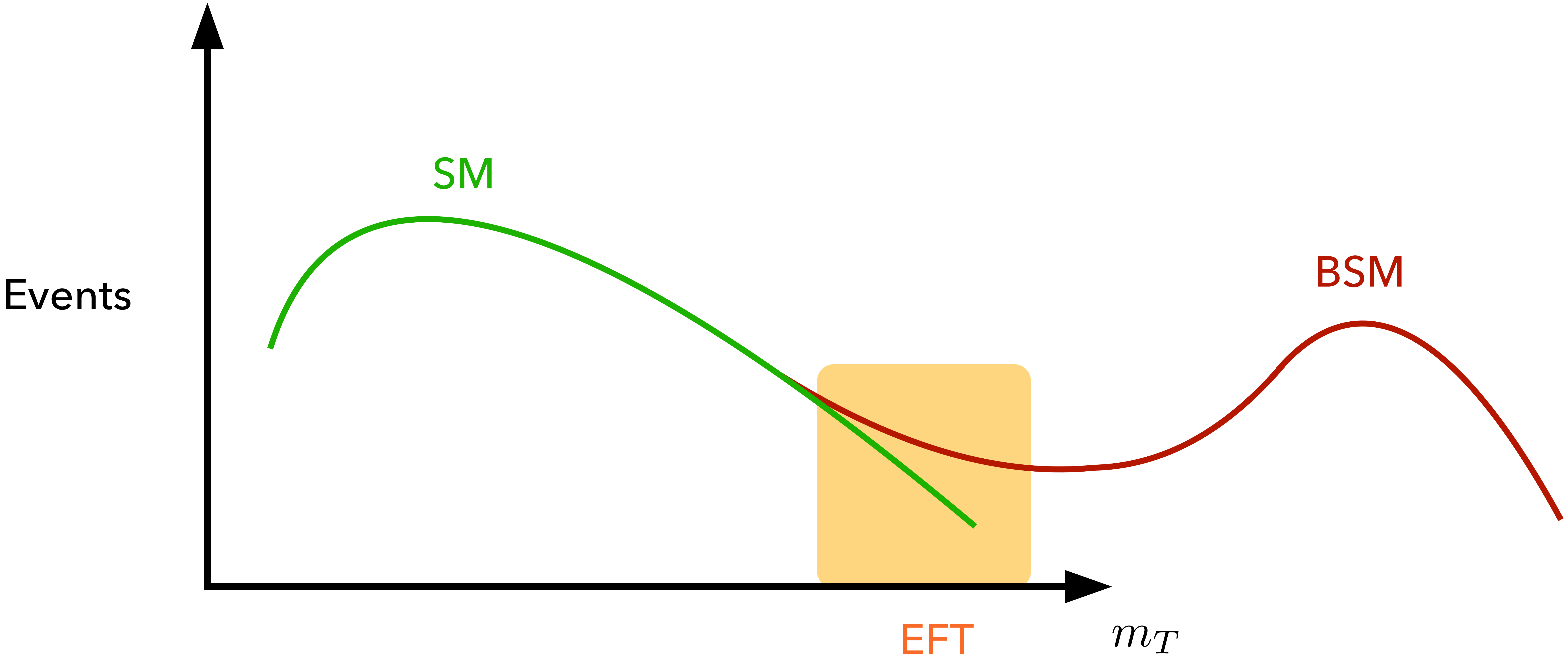

THE STANDARD MODEL AND BEYOND

Indirect evidence for new physics requires precision

- Measurement of observables in a global context
- More precise and accurate measurements
- Better understanding of uncertainties
- Better theoretical predictions
- Etc …

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Indirect evidence for new physics requires precision

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- Etc …

This calls for a framework to interpret small deviations…

STANDARD MODEL EFFECTIVE FIELD THEORY (SMEFT)

In the SMEFT we supplement the SM Lagrangian with towers of higher dimensional operators

$$\mathcal{L}_{\mathrm{SMEFT}} = \mathcal{L}_{\mathrm{SM}} + \sum_{d>4,i} \frac{c_i}{\Lambda^{d-4}} Q_i^{(d)}$$

Usually, we retain only the leading contributions

$$\mathcal{L}_{\mathrm{SMEFT}} = \mathcal{L}_{\mathrm{SM}} + \sum_{i} \frac{c_i}{\Lambda^{2}} Q_i^{(6)} + \cdots$$

$\{c_i\}$	Wilson coefficients
$\{Q_i^{(6)}\}$	Dimension 6 operators
Λ	High energy scale

STANDARD MODEL EFFECTIVE FIELD THEORY (SMEFT)

In the SMEFT we supplement the SM Lagrangian with towers of higher dimensional operators

Usually, we retain

An EFT for the SM must fulfil certain conditions

1. Its gauge group must contain $SU(3)_c \times SU(2)_L \times U(1)_Y$
2. The SM fields must be incorporated
3. At low energies, it must reduce to the SM (in absence of weekly coupled light physics)

Λ High energy scale

STANDARD MODEL EFFECTIVE FIELD THEORY (SMEFT)

In the SMEFT we supplement the SM Lagrangian with towers of higher dimensional operators

$$\mathcal{L}_{\rm SMEFT} = \mathcal{L}_{\rm SM} + \sum_i \frac{c_i}{\Lambda^2} Q_i^{(6)} + \cdots$$

Up to dimension 6, these operators can be parametrised in the Warsaw basis:

B. Grzadkowski et al.
arXiv:1008.4884

X^3		φ^6 and $\varphi^4 D^2$		$\psi^2\varphi^3$	
Q_G	$f^{ABC}G_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$	Q_φ	$(\varphi^\dagger\varphi)^3$	$Q_{e\varphi}$	$(\varphi^\dagger\varphi)(\bar l_p e_r \varphi)$
$Q_{\widetilde G}$	$f^{ABC}\widetilde G_\mu^{A\nu}G_\nu^{B\rho}G_\rho^{C\mu}$	$Q_{\varphi\Box}$	$(\varphi^\dagger\varphi)\Box(\varphi^\dagger\varphi)$	$Q_{u\varphi}$	$(\varphi^\dagger\varphi)(\bar q_p u_r \widetilde\varphi)$
Q_W	$\varepsilon^{IJK}W_\mu^{I\nu}W_\nu^{J\rho}W_\rho^{K\mu}$	$Q_{\varphi D}$	$(\varphi^\dagger D^\mu\varphi)^\star(\varphi^\dagger D_\mu\varphi)$	$Q_{d\varphi}$	$(\varphi^\dagger\varphi)(\bar q_p d_r \varphi)$
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$X^2\varphi^2$		**$\psi^2 X\varphi$**		**$\psi^2\varphi^2 D$**	
$Q_{\varphi G}$	$\varphi^\dagger\varphi\, G^A_{\mu\nu}G^{A\mu\nu}$	Q_{eW}	$(\bar l_p\sigma^{\mu\nu}e_r)\tau^I\varphi W^I_{\mu\nu}$	$Q_{\varphi l}^{(1)}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar l_p\gamma^\mu l_r)$
$Q_{\varphi\widetilde G}$	$\varphi^\dagger\varphi\, \widetilde G^A_{\mu\nu}G^{A\mu\nu}$	Q_{eB}	$(\bar l_p\sigma^{\mu\nu}e_r)\varphi B_{\mu\nu}$	$Q_{\varphi l}^{(3)}$	$(\varphi^\dagger i\overleftrightarrow{D}^I_\mu\varphi)(\bar l_p\tau^I\gamma^\mu l_r)$
$Q_{\varphi W}$	$\varphi^\dagger\varphi\, W^I_{\mu\nu}W^{I\mu\nu}$	Q_{uG}	$(\bar q_p\sigma^{\mu\nu}T^A u_r)\widetilde\varphi\, G^A_{\mu\nu}$	$Q_{\varphi e}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar e_p\gamma^\mu e_r)$
$Q_{\varphi\widetilde W}$	$\varphi^\dagger\varphi\, \widetilde W^I_{\mu\nu}W^{I\mu\nu}$	Q_{uW}	$(\bar q_p\sigma^{\mu\nu}u_r)\tau^I\widetilde\varphi\, W^I_{\mu\nu}$	$Q_{\varphi q}^{(1)}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar q_p\gamma^\mu q_r)$
$Q_{\varphi B}$	$\varphi^\dagger\varphi\, B_{\mu\nu}B^{\mu\nu}$	Q_{uB}	$(\bar q_p\sigma^{\mu\nu}u_r)\widetilde\varphi\, B_{\mu\nu}$	$Q_{\varphi q}^{(3)}$	$(\varphi^\dagger i\overleftrightarrow{D}^I_\mu\varphi)(\bar q_p\tau^I\gamma^\mu q_r)$
$Q_{\varphi\widetilde B}$	$\varphi^\dagger\varphi\, \widetilde B_{\mu\nu}B^{\mu\nu}$	Q_{dG}	$(\bar q_p\sigma^{\mu\nu}T^A d_r)\varphi\, G^A_{\mu\nu}$	$Q_{\varphi u}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar u_p\gamma^\mu u_r)$
$Q_{\varphi WB}$	$\varphi^\dagger\tau^I\varphi\, W^I_{\mu\nu}B^{\mu\nu}$	Q_{dW}	$(\bar q_p\sigma^{\mu\nu}d_r)\tau^I\varphi\, W^I_{\mu\nu}$	$Q_{\varphi d}$	$(\varphi^\dagger i\overleftrightarrow{D}_\mu\varphi)(\bar d_p\gamma^\mu d_r)$
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$Q_{lq}^{(1)}$	$(\bar l_p\gamma_\mu l_r)(\bar q_s\gamma^\mu q_t)$	Q_{eu}	$(\bar e_p\gamma_\mu e_r)(\bar u_s\gamma^\mu u_t)$	Q_{qe}	$(\bar q_p\gamma_\mu q_r)(\bar e_s\gamma^\mu e_t)$
$Q_{lq}^{(3)}$	$(\bar l_p\gamma_\mu\tau^I l_r)(\bar q_s\gamma^\mu\tau^I q_t)$	Q_{ed}	$(\bar e_p\gamma_\mu e_r)(\bar d_s\gamma^\mu d_t)$	$Q_{qu}^{(1)}$	$(\bar q_p\gamma_\mu q_r)(\bar u_s\gamma^\mu u_t)$
		$Q_{ud}^{(1)}$	$(\bar u_p\gamma_\mu u_r)(\bar d_s\gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar q_p\gamma_\mu T^A q_r)(\bar u_s\gamma^\mu T^A u_t)$
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				$Q_{qd}^{(8)}$	$(\bar q_p\gamma_\mu T^A q_r)(\bar d_s\gamma^\mu T^A d_t)$
$(\bar LR)(\bar RL)$ and $(\bar LR)(\bar LR)$		**B-violating**			
Q_{ledq}	$(\bar l_p^j e_r)(\bar d_s q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(q_s^{\gamma j})^T C l_t^k\right]$		
$Q_{quqd}^{(1)}$	$(\bar q_p^j u_r)\varepsilon_{jk}(\bar q_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(u_s^\gamma)^T C e_t\right]$		
$Q_{quqd}^{(8)}$	$(\bar q_p^j T^A u_r)\varepsilon_{jk}(\bar q_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jn}\varepsilon_{km}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(q_s^{\gamma m})^T C l_t^n\right]$		
$Q_{lequ}^{(1)}$	$(\bar l_p^j e_r)\varepsilon_{jk}(\bar q_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(u_s^\gamma)^T C e_t\right]$		
$Q_{lequ}^{(3)}$	$(\bar l_p^j\sigma_{\mu\nu}e_r)\varepsilon_{jk}(\bar q_s^k\sigma^{\mu\nu}u_t)$				

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		$Q_{ud}^{(1)}$	$(\bar u_p \gamma_\mu u_r)(\bar d_s \gamma^\mu d_t)$	$Q_{qu}^{(8)}$	$(\bar q_p \gamma_\mu T^A q_r)(\bar u_s \gamma^\mu T^A u_t)$
		$Q_{ud}^{(8)}$	$(\bar u_p \gamma_\mu T^A u_r)(\bar d_s \gamma^\mu T^A d_t)$	$Q_{qd}^{(1)}$	$(\bar q_p \gamma_\mu q_r)(\bar d_s \gamma^\mu d_t)$
				$Q_{qd}^{(8)}$	$(\bar q_p \gamma_\mu T^A q_r)(\bar d_s \gamma^\mu T^A d_t)$

$(\bar LR)(\bar RL)$ and $(\bar LR)(\bar LR)$		B-violating	
Q_{ledq}	$(\bar l_p^j e_r)(\bar d_s q_t^j)$	Q_{duq}	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(q_s^{\gamma j})^T C l_t^k\right]$
$Q_{quqd}^{(1)}$	$(\bar q_p^j u_r)\varepsilon_{jk}(\bar q_s^k d_t)$	Q_{qqu}	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jk}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(u_s^\gamma)^T C e_t\right]$
$Q_{quqd}^{(8)}$	$(\bar q_p^j T^A u_r)\varepsilon_{jk}(\bar q_s^k T^A d_t)$	Q_{qqq}	$\varepsilon^{\alpha\beta\gamma}\varepsilon_{jn}\varepsilon_{km}\left[(q_p^{\alpha j})^T C q_r^{\beta k}\right]\left[(q_s^{\gamma m})^T C l_t^n\right]$
$Q_{lequ}^{(1)}$	$(\bar l_p^j e_r)\varepsilon_{jk}(\bar q_s^k u_t)$	Q_{duu}	$\varepsilon^{\alpha\beta\gamma}\left[(d_p^\alpha)^T C u_r^\beta\right]\left[(u_s^\gamma)^T C e_t\right]$
$Q_{lequ}^{(3)}$	$(\bar l_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar q_s^k \sigma^{\mu\nu} u_t)$		

How can we account for SMEFT effects in PDF fits?

THE PDF–EFT INTERPLAY

The PDF and EFT worlds do not normally talk to each other.

THE PDF-EFT INTERPLAY

The PDF and EFT worlds do not normally talk to each other. Schematically,

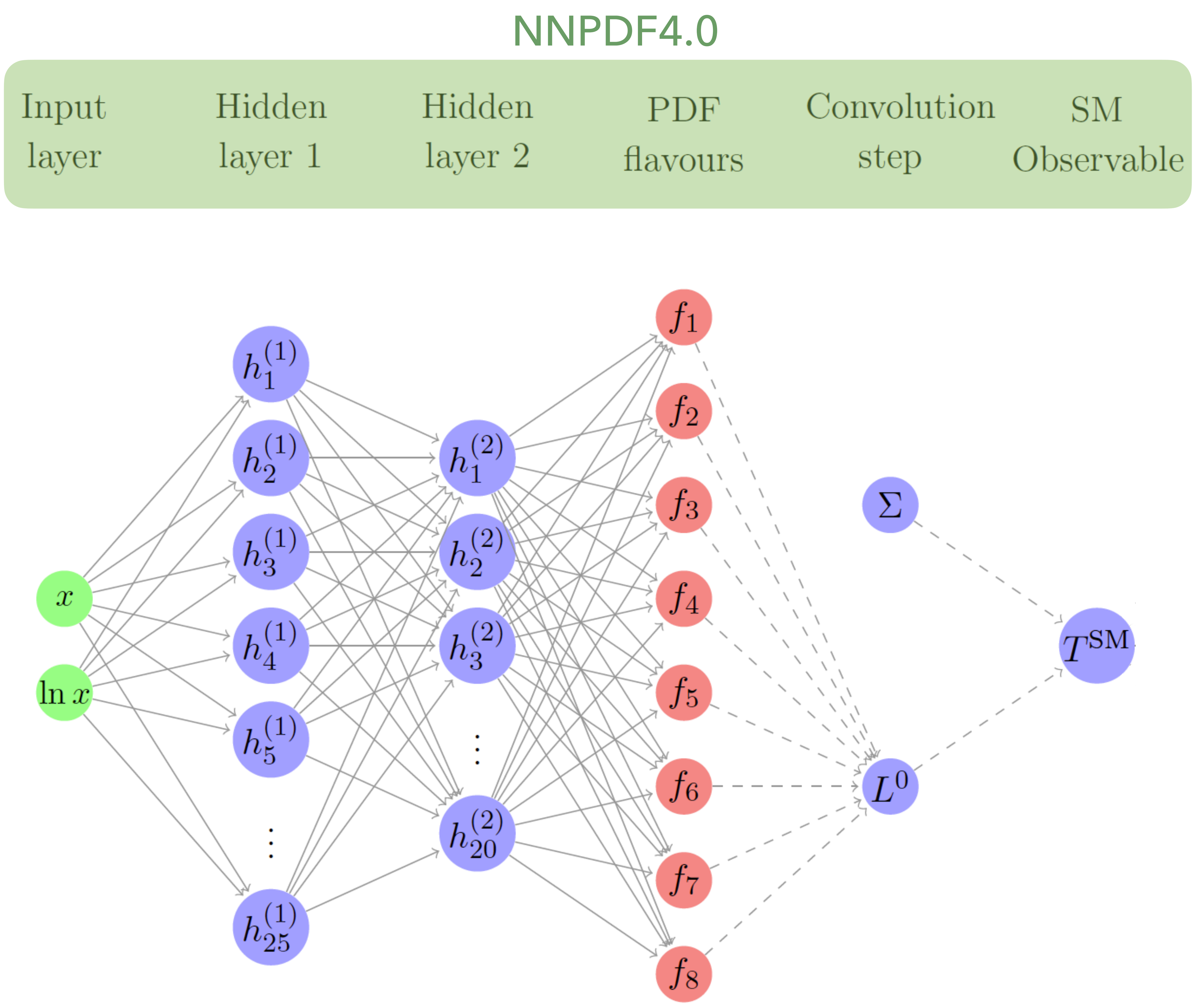
θ : PDF parameters

c : BSM parameters

PDF fits	EFT fits
BSM coefficient are kept fixed	PDF coefficients are kept fixed
$c = \bar{c}$	$\theta = \bar{\theta}$
$\sigma(\theta, \bar{c}) = \mathrm{PDF}(\theta) \otimes \hat{\sigma}(\bar{c})$	$\sigma(\bar{\theta}, c) = \mathrm{PDF}(\bar{\theta}) \otimes \hat{\sigma}(c)$

METHODOLOGY – SIMUNET

It is based on NNPDF4.0...



METHODOLOGY - SIMUNET

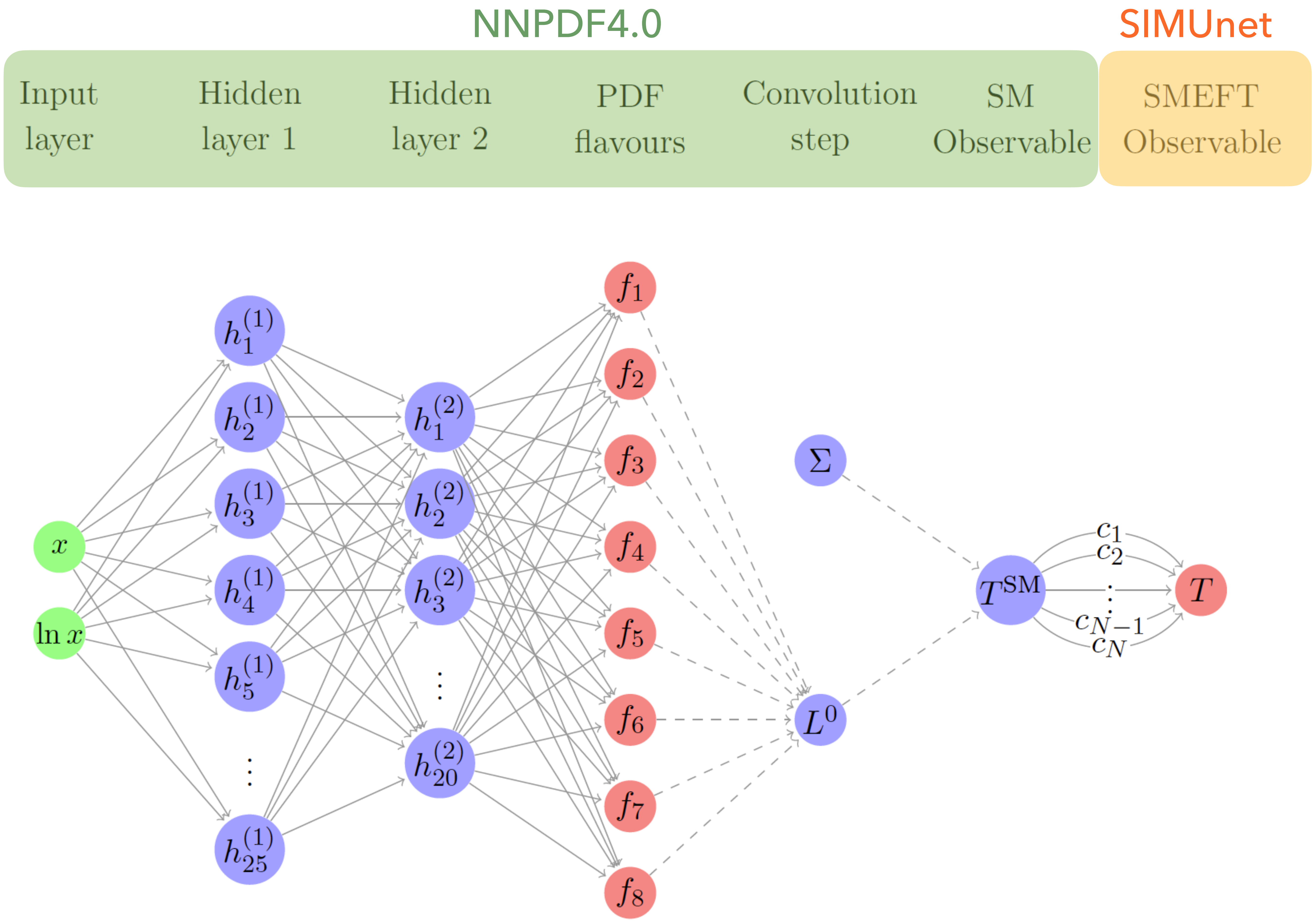
It is based on NNPDF4.0, but we add an extra layer of trainable parameters

The $\{c_i\}$ parameters map the SM prediction to a potentially SMEFT affected prediction

The $\{c_i\}$ parameters and the θ PDF parameters can optimised **simultaneously**

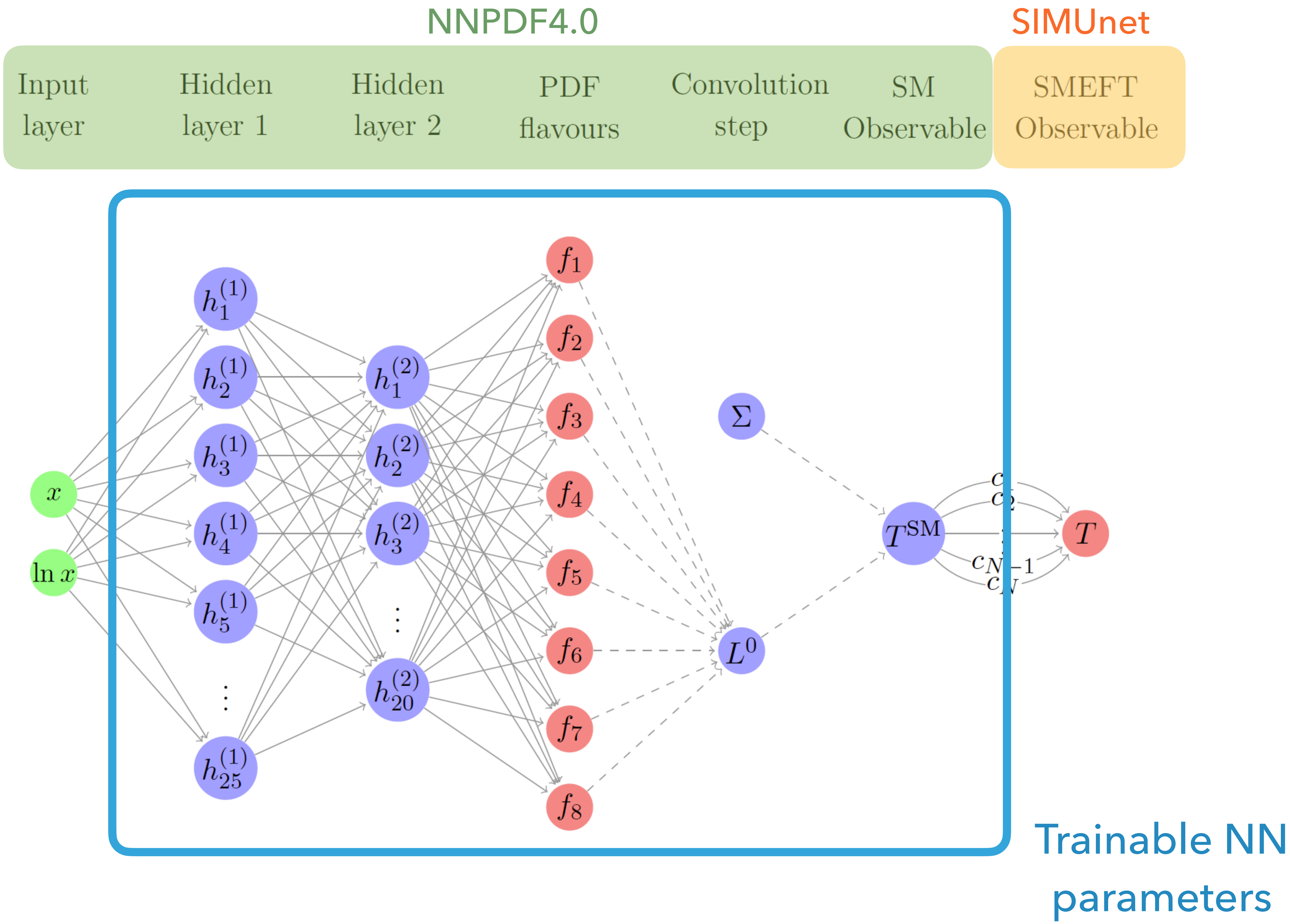
$$\chi^2(\hat{\theta}) = \frac{1}{N_{\rm dat}}(\mathbf{D} - \mathbf{T}(\hat{\theta}))^T(\mathbf{cov})^{-1}(\mathbf{D} - \mathbf{T}(\hat{\theta}))$$

$$\hat{\theta} = \theta \cup \{c_i\}$$



Iranipour, Ubiali, arXiv: 2201.07240

METHODOLOGY – SIMUNET



In a simultaneous PDF-SMEFT fit, we obtain

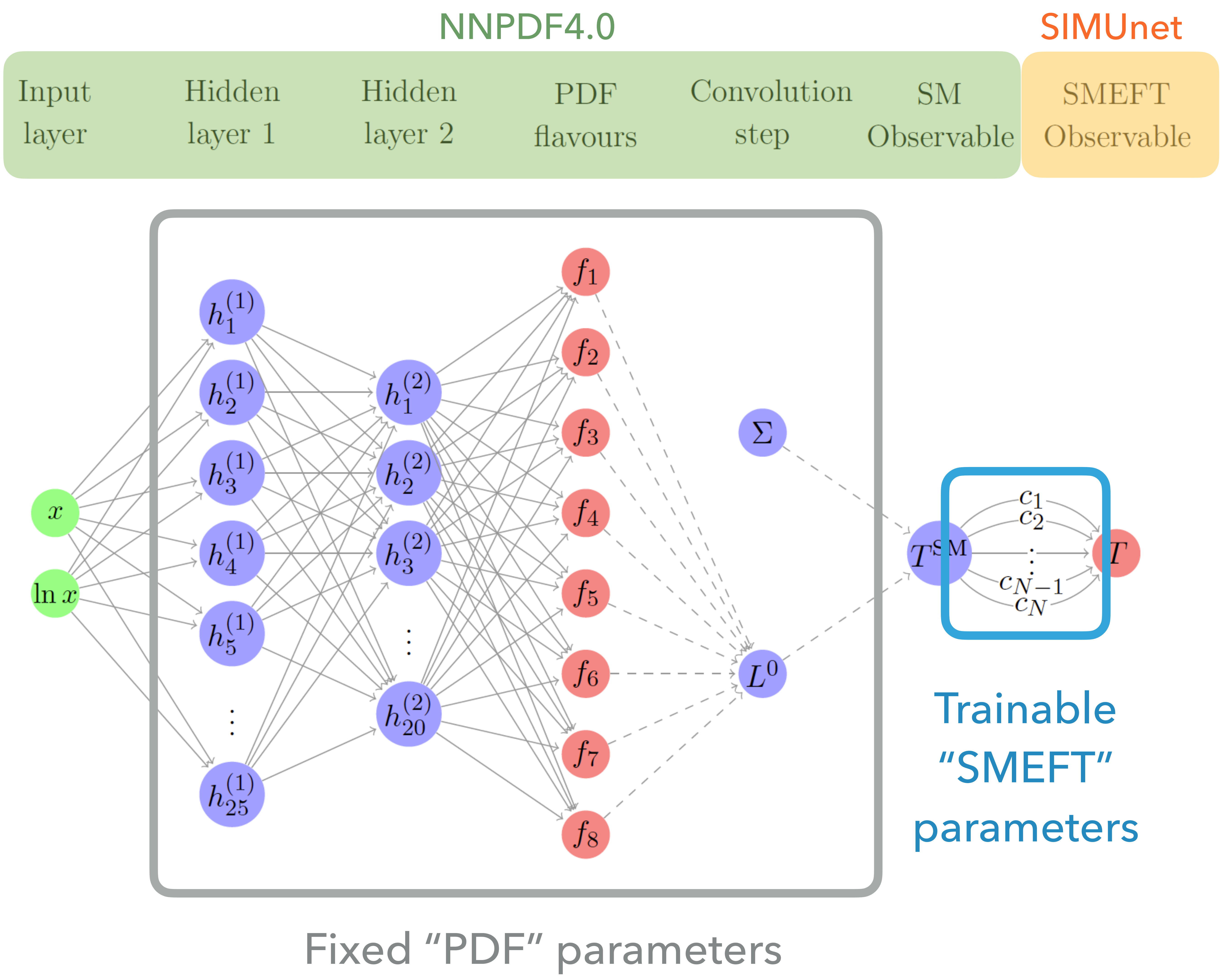
- Wilson coefficients
- PDFs

All the parameters of the NN are trainable

METHODOLOGY - SIMUNET

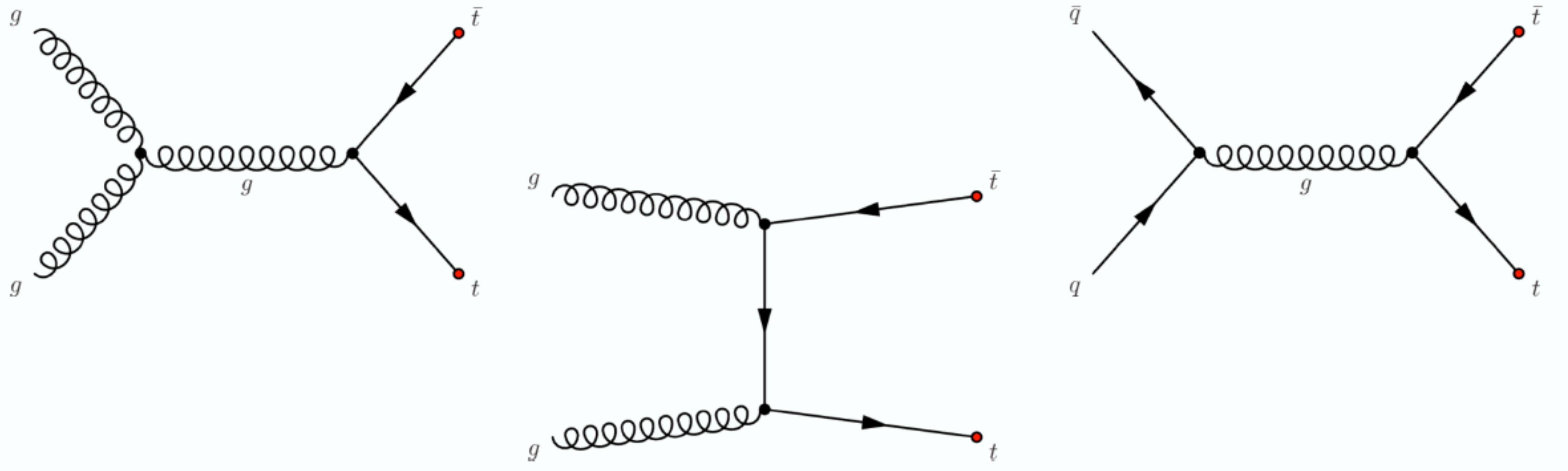
SIMUnet can also perform fixed-PDF fits, therefore only fitting the Wilson coefficients

Now, let us study what happens with the PDF-EFT interplay in the top sector…

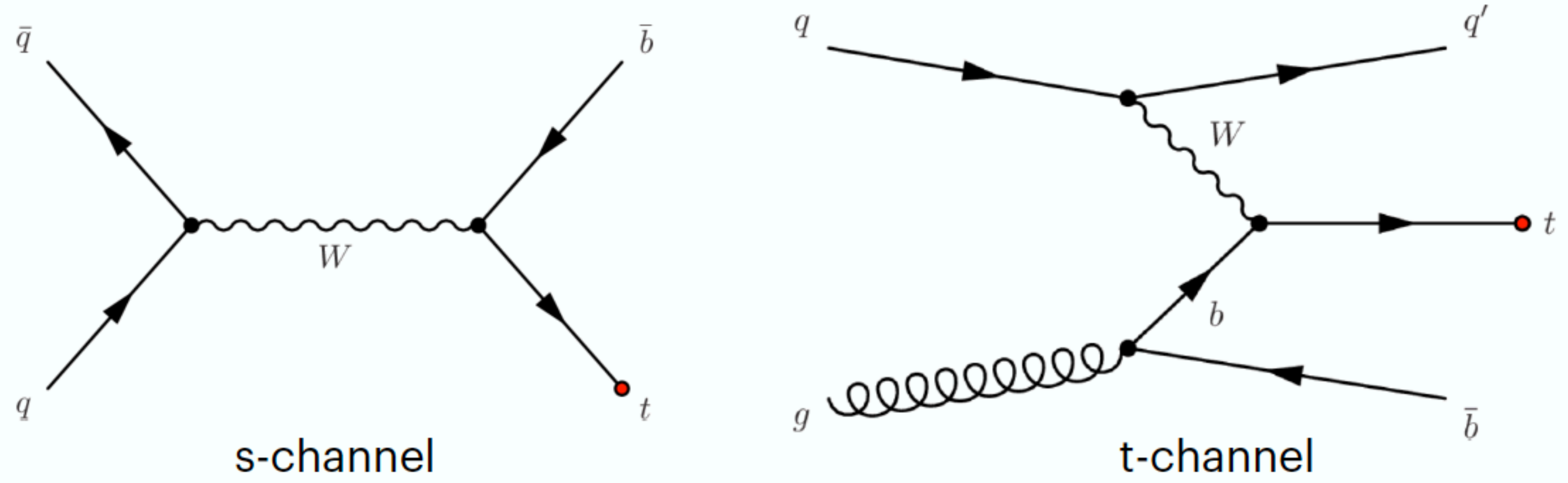


PDF–SMEFT INTERPLAY IN THE TOP SECTOR [2303.06159]

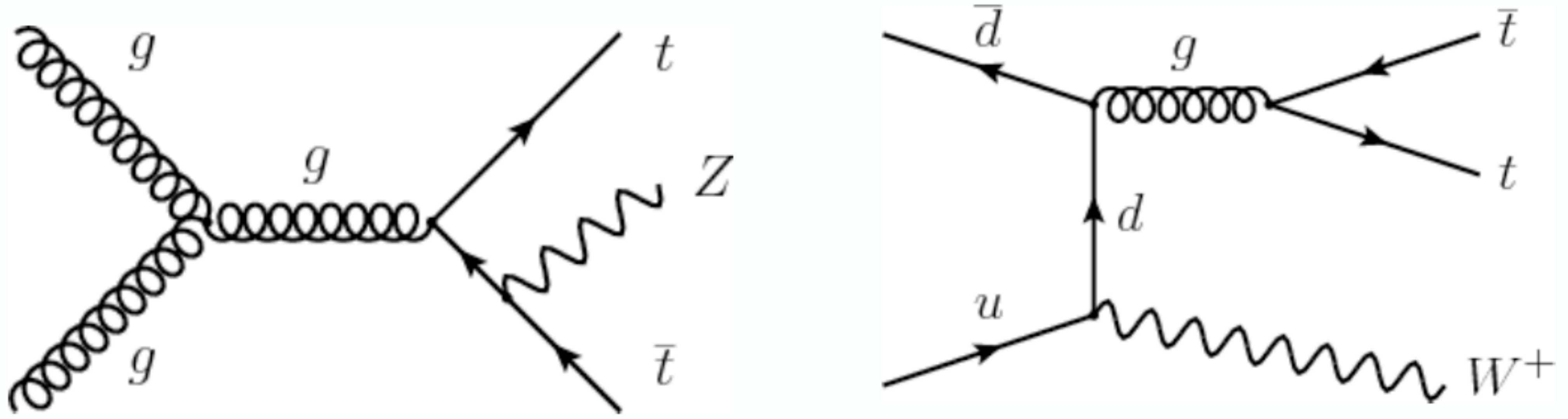
Some top processes that we consider are



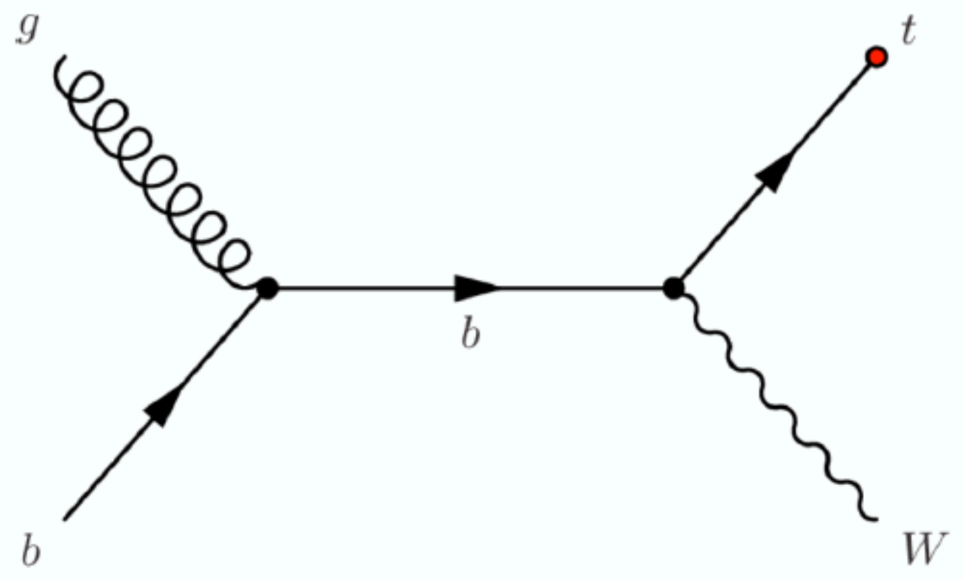
inclusive $t\bar{t}$



single top



associated $t\bar{t}$



associated single top

PDF–SMEFT INTERPLAY IN THE TOP SECTOR [2303.06159]

Predictions for those processes are affected by SMEFT operators

c_{tZ} c_{tW} c_{tG}	$c_{\phi t}$ $c_{\phi Q}^{(3)}$ $c_{\phi Q}^{(1)}$
dipoles	currents
c_{qd}^{1} $c_{qq}^{1,3}$ c_{dt}^{1} c_{qt}^{1} $c_{qq}^{1,1}$ c_{qu}^{1} c_{ut}^{1}	c_{qd}^{8} $c_{qq}^{8,3}$ c_{dt}^{8} c_{qt}^{8} $c_{qq}^{8,1}$ c_{qu}^{8} c_{ut}^{8}
four-fermion singlets	four-fermion octets

PDF–SMEFT INTERPLAY IN THE TOP SECTOR

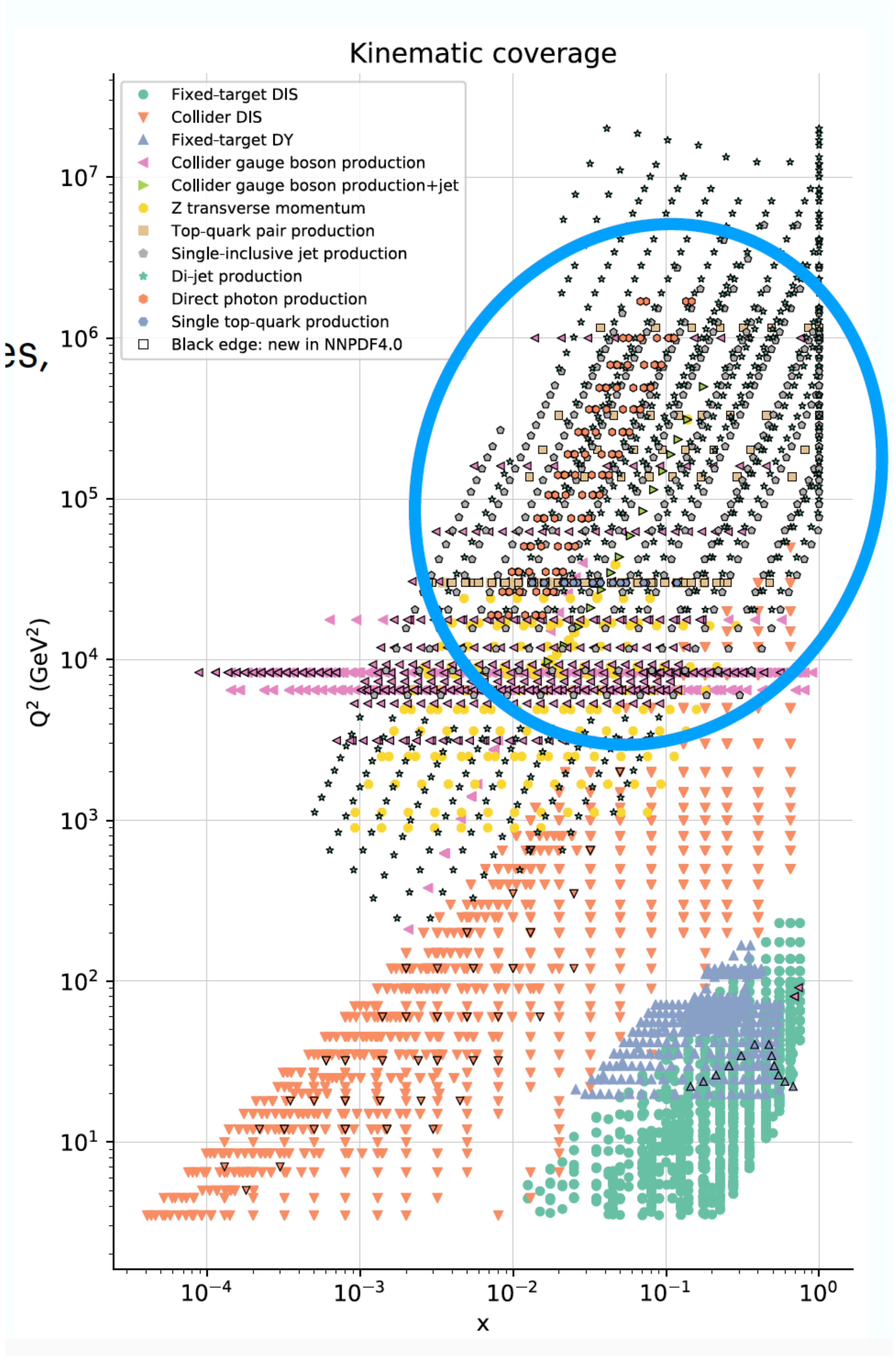
The top sector has been studied in many EFT analyses

Hartland et al., 1901.05965
Brivio et al, 1910.03606
Ellis et al., 2012.02779
Ethier at al., 2105, 00006

+ more

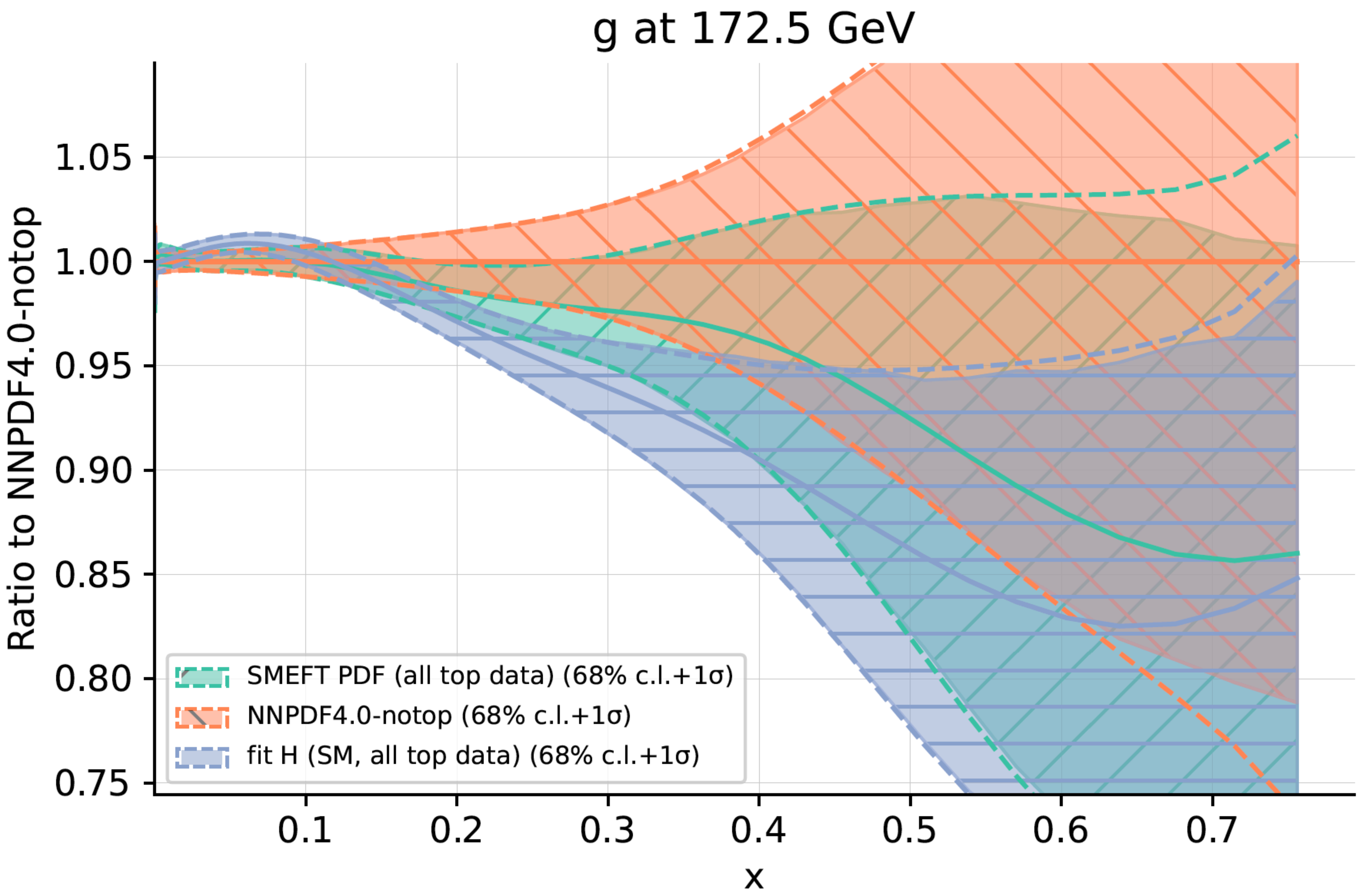
For our study we use the most comprehensive and up-to-date LCH top datasets available: 185 points

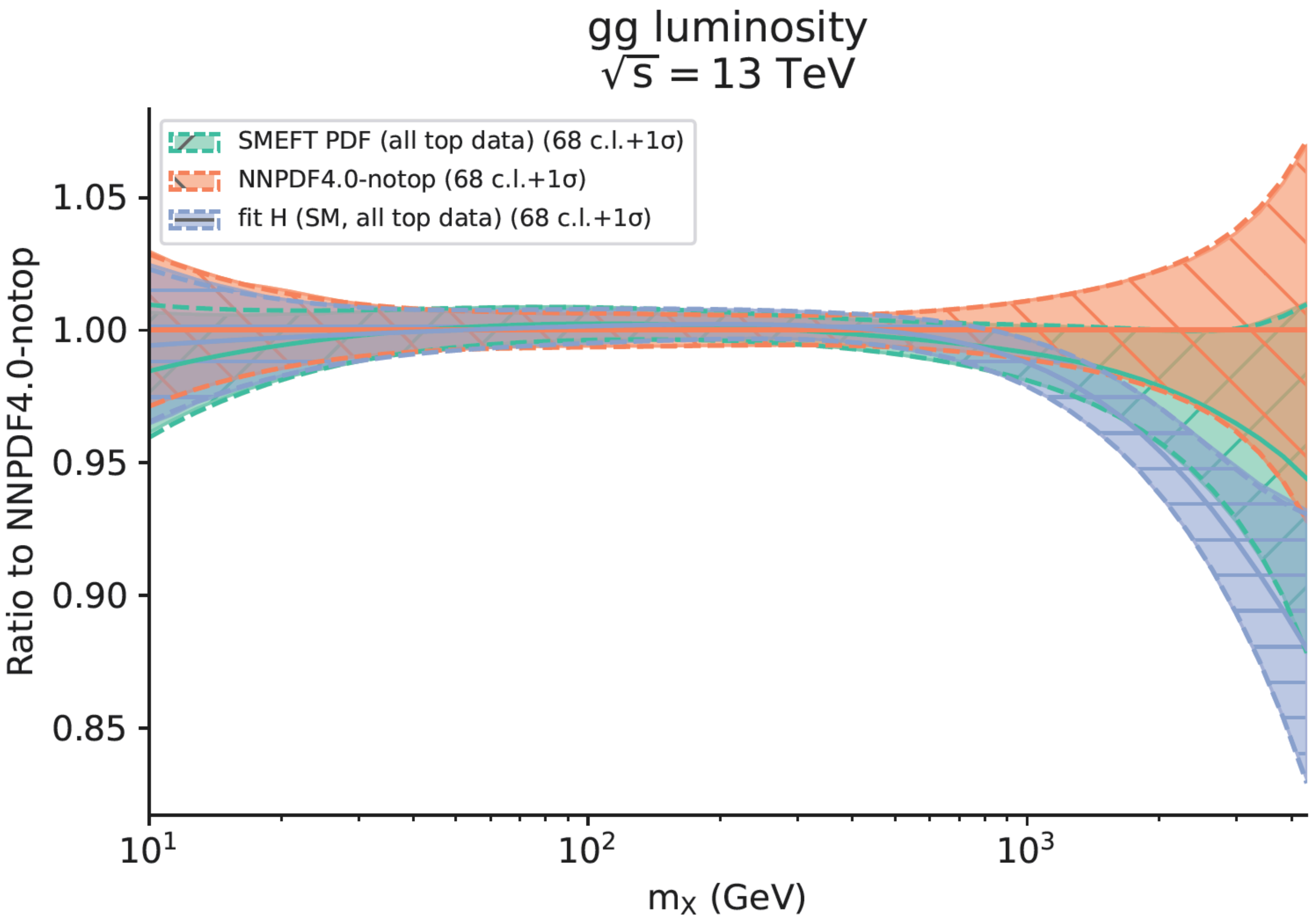
We study the effects of ~20 operators in the SMEFT



IMPACT OF TOP DATA ON PDFS

The inclusion of the new datasets has a noticeable impact on the gluon PDF





* No top data: DIS, DY, V, V+j

The Wilson coefficients partially 'absorb' the impact of the new top data on the PDFs

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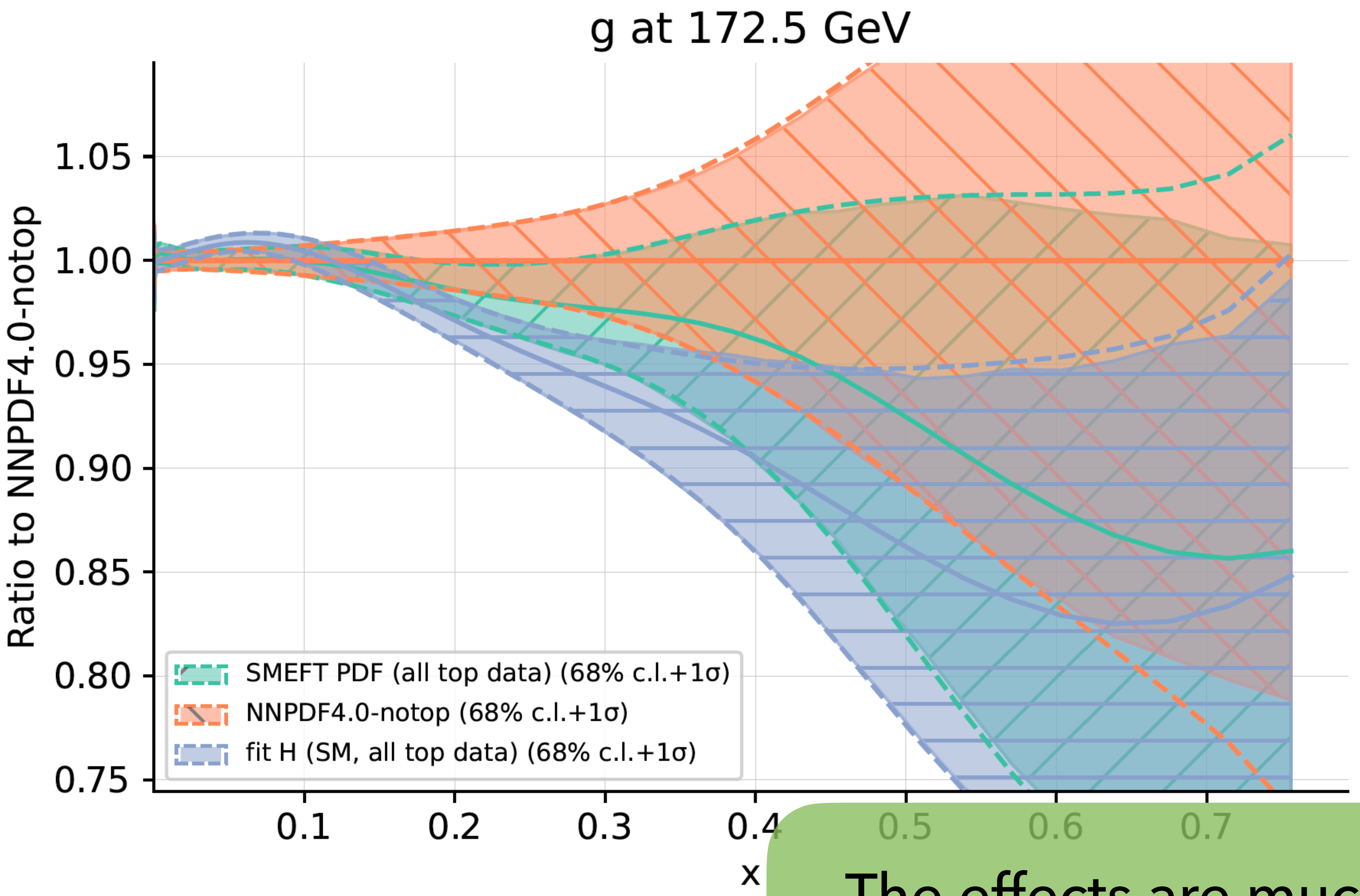
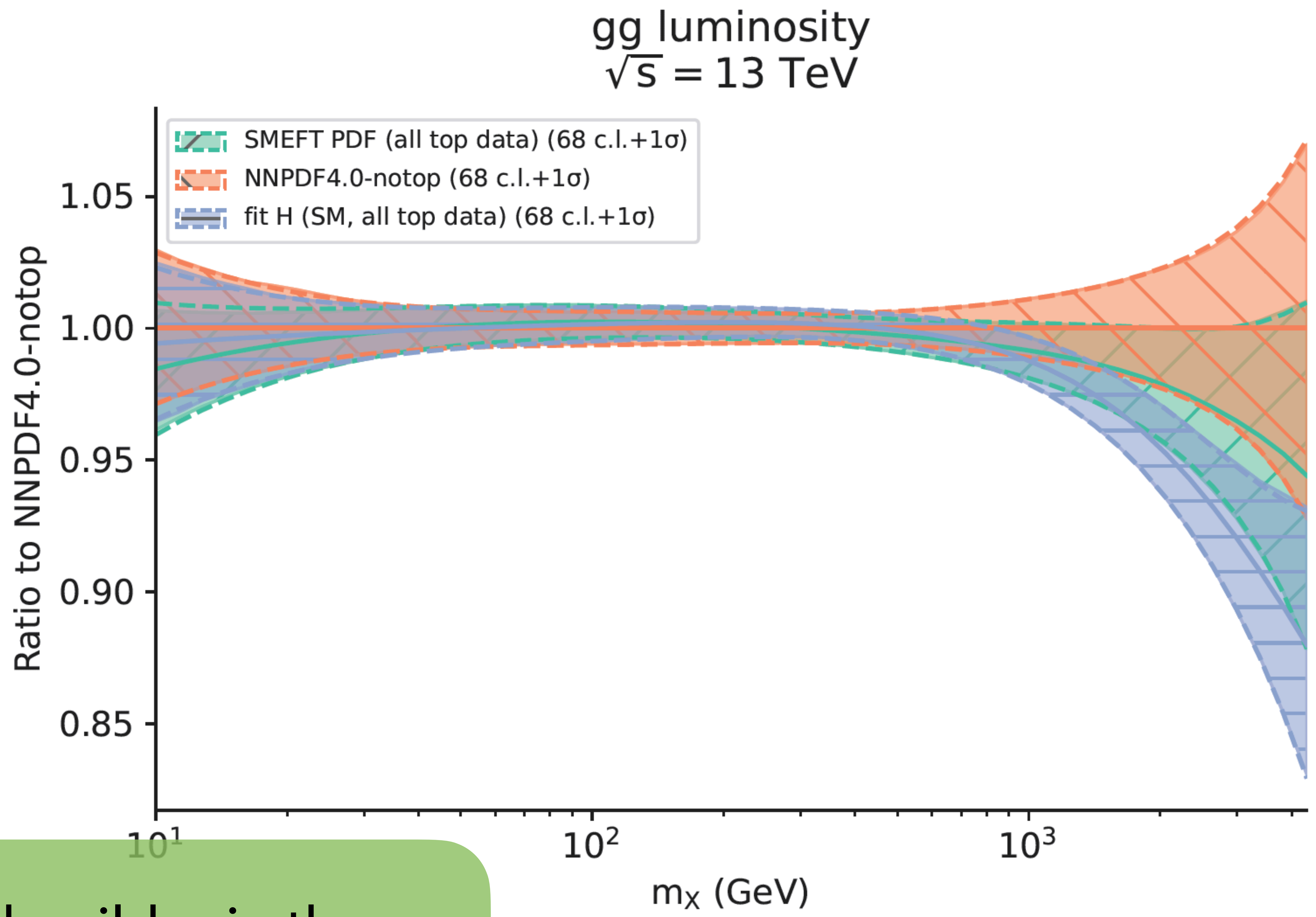


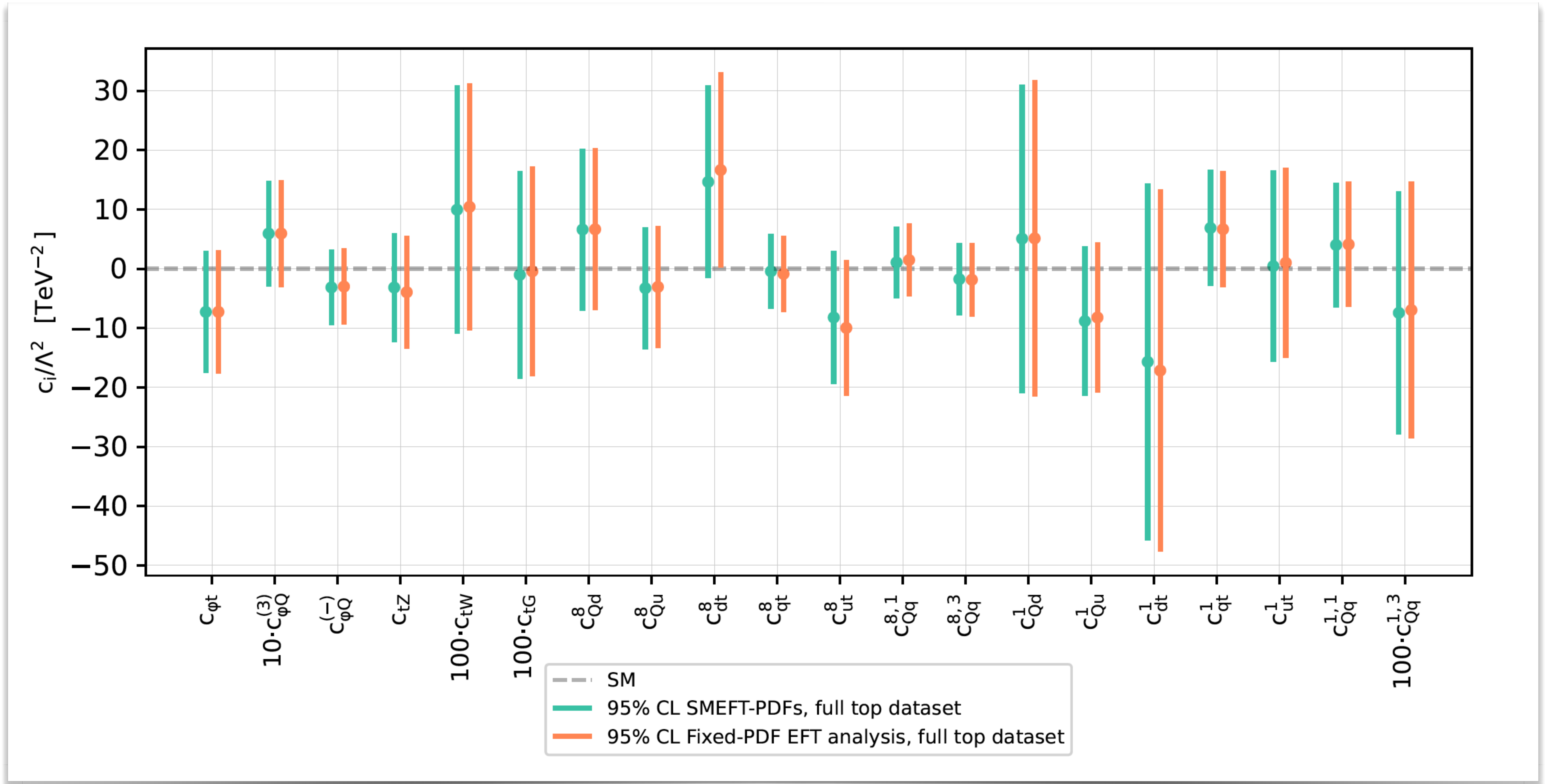


* No top data: DIS, DY, V, V+j

The effects are much milder in the SMEFT

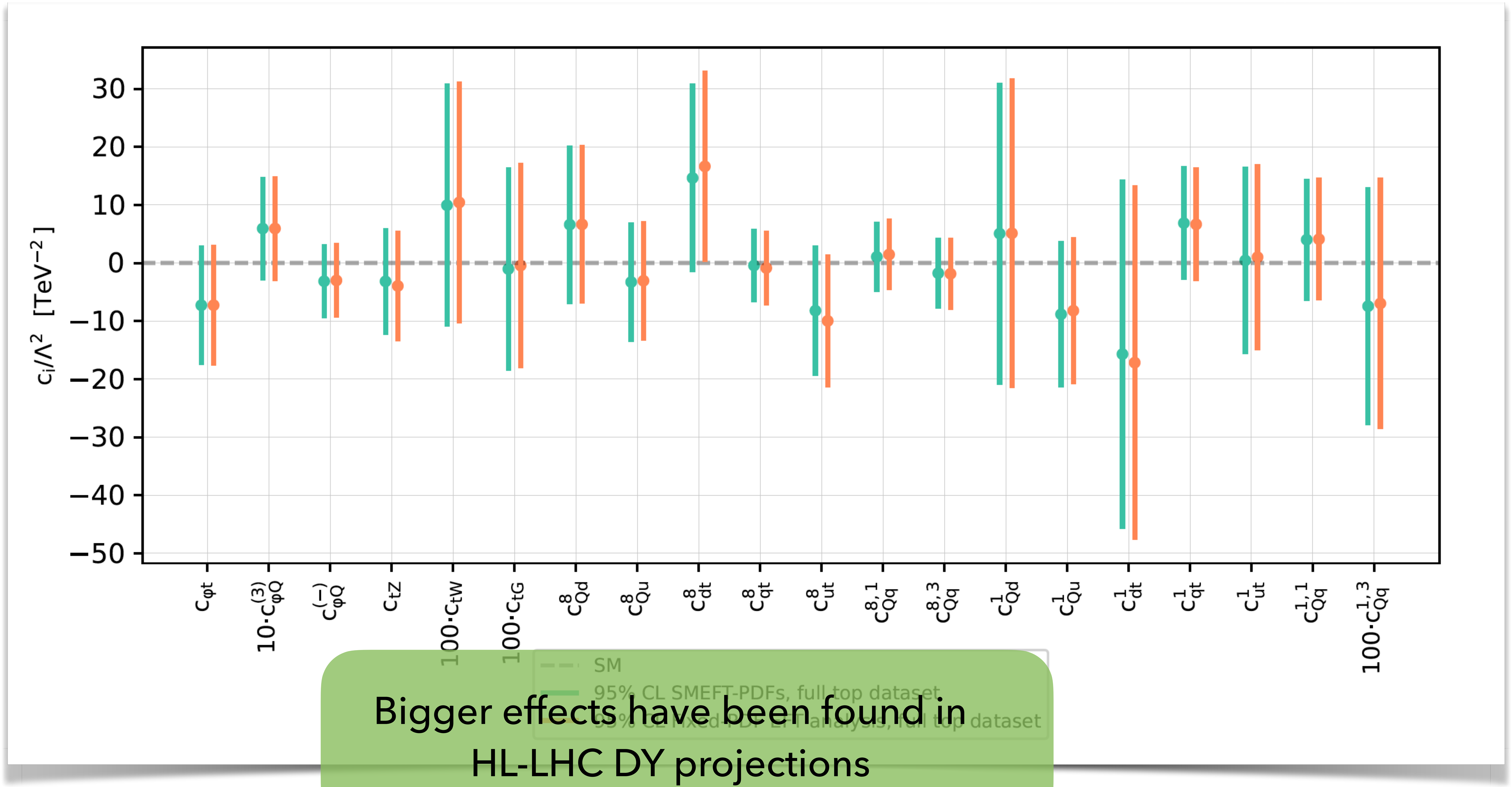
The Wilson coefficients partially 'absorb' the impact of the new top data on the PDFs!

SMEFT FIXED-PDF AND SIMULTANEOUS FITS



We see small effects on the Wilson coefficients, ~5-10%

SMEFT FIXED-PDF AND SIMULTANEOUS FITS



Bigger effects have been found in HL-LHC DY projections

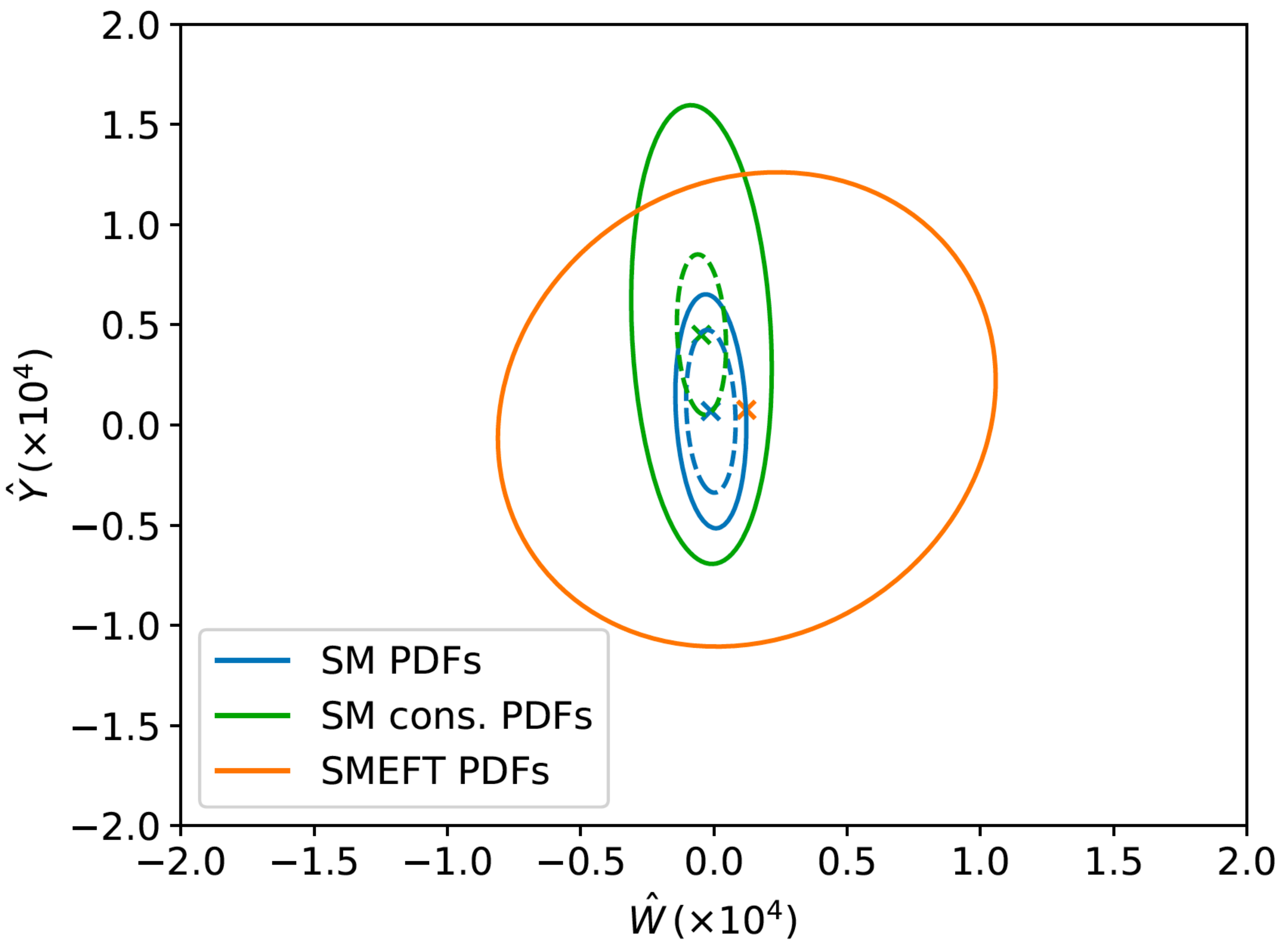
We see small effects on the Wilson coefficients, ~5-10%

PDF–SMEFT INTERPLAY IN DY TAILS

In [2104.02723] the authors performed a PDF-SMEFT analysis using HL-LHC DY projections in the presence of 2 Wilson coefficients

$$\mathcal{L}_{\rm SMEFT} \supset -\frac{\hat{W}}{4m_W^2}(D_\rho W^a_{\mu\nu})^2 - \frac{\hat{Y}}{4m_W^2}(\partial_\rho B_{\mu\nu})^2$$

Greljo et al, 2104.02723



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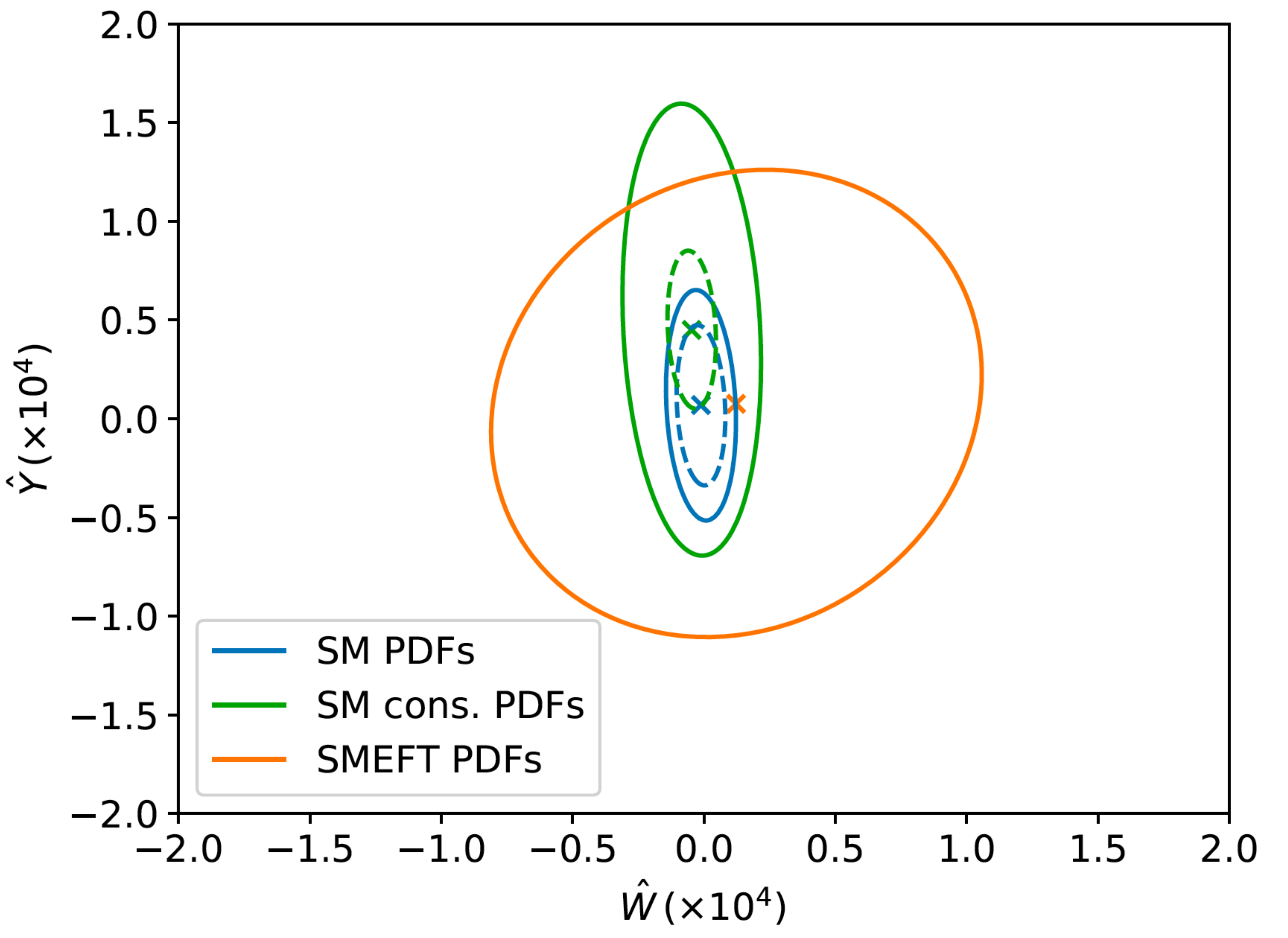


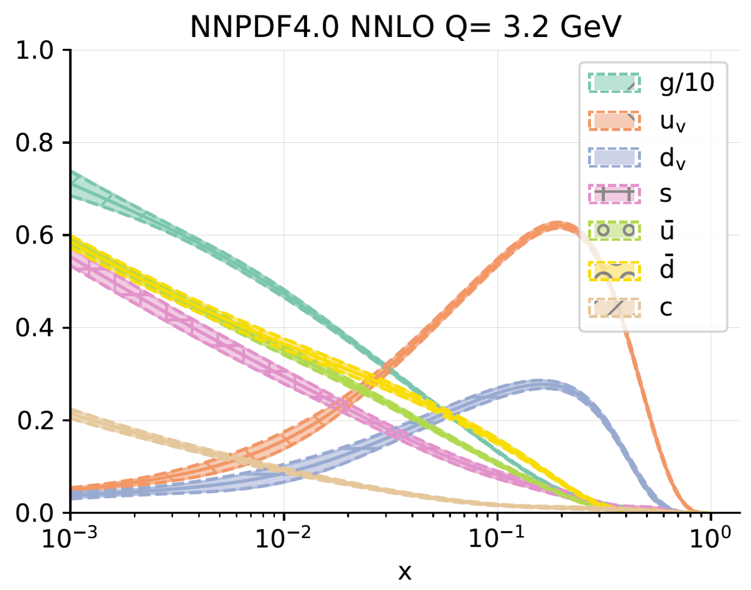
Neglecting the PDF-SMEFT interplay can lead to an overestimate of the constraints on Wilson coefficients

PDF-SMEFT INTERPLAY

Part of the landscape includes

- Deep inelastic scattering [S. Carrazza et al., 1905.05215]
- DY tails [Greljo et al., 2104.02723]
- DIS/DY [Liu et al., 2201.06586]
- Jet/top [Gao et al., 2211.01094]
- Jets [CMS, 2211.10431]
- …

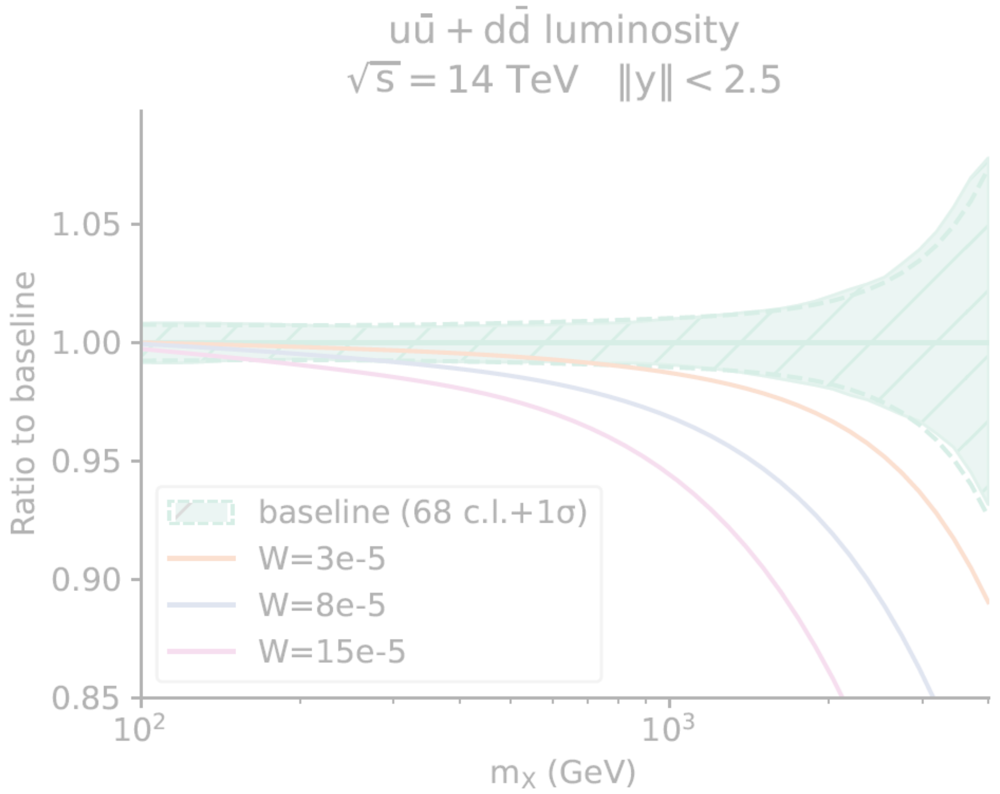
OUTLINE



$$+ \quad \frac{c_i}{\Lambda^2}$$

Simultaneous PDF-EFT determination

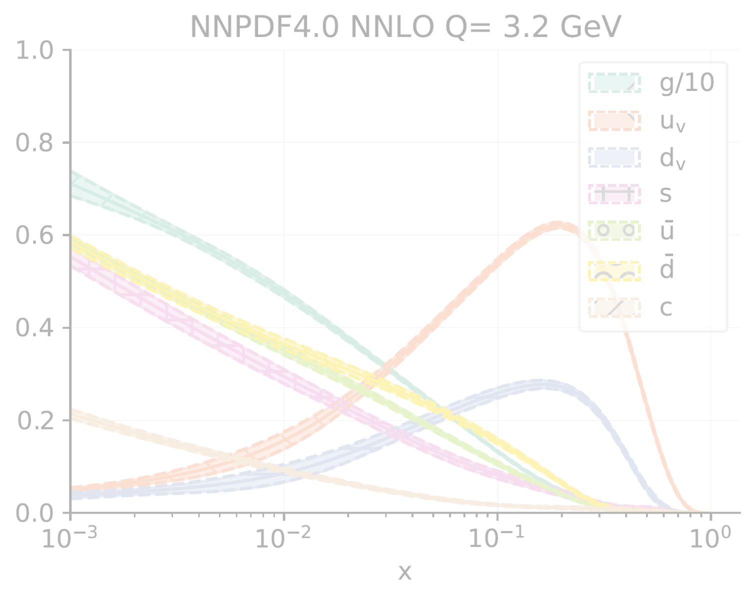
Neglecting the PDF-EFT interplay can lead to biased results both in the SM and beyond



Can PDFs absorb new physics?

Conclusions and outlook

OUTLINE



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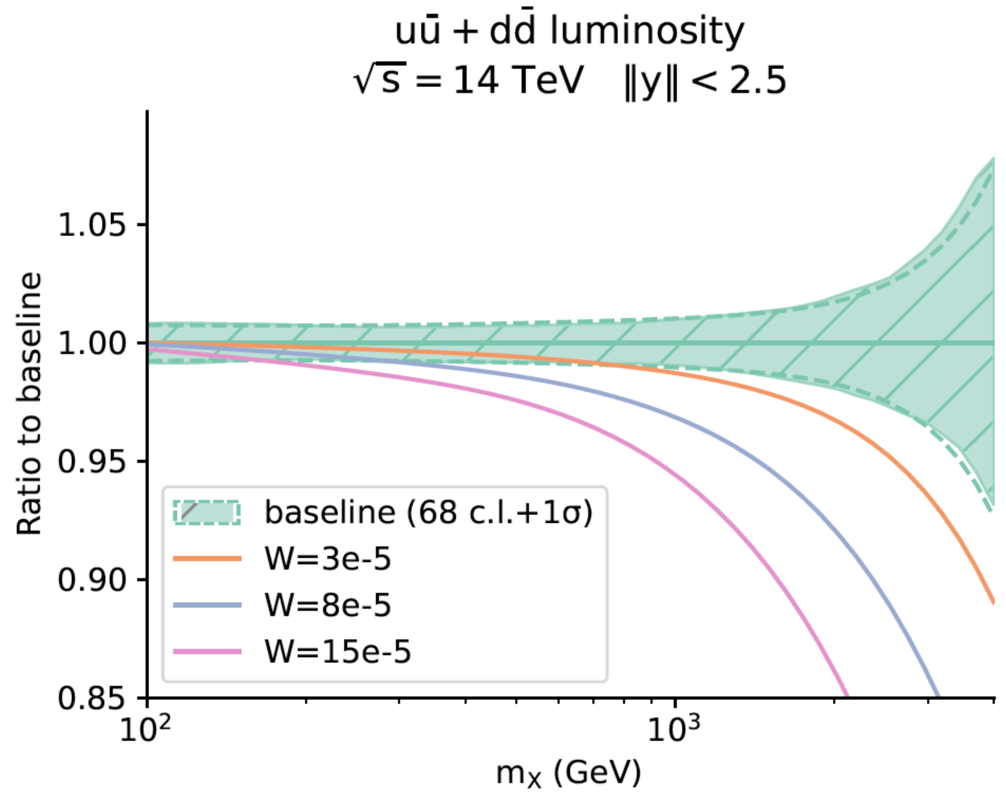


Can PDFs absorb new physics?

Conclusions and outlook

CAN PDFS ABSORB NEW PHYSICS? [2307.10370]

To systematically assess in PDFs can absorb new physics, we will work in a setting in which we pretend that we know the law of Nature

Our methodology will be based on NNPDF's closure testing framework [NNPDF 1410.8849, Del Debbio et al., 2211.05787]

FITTING METHODOLOGY

Let us suppose that the law of Nature is given by the SM plus some new physics (NP) contributions

$$T \equiv T(\theta_{\rm SM}, \theta_{\rm NP})$$

The *true* value of the observable is given by

$$T^* \equiv T(\theta^*_{\rm SM}, \theta^*_{\rm NP})$$

The observed data is

$$D_0 = T^* + \eta \qquad \eta \sim \mathcal{N}(0, \Sigma)$$

CONTAMINATED PDFS

We perform two kinds of fits

Fit name	Nature	Fitted parameters
Baseline	Standard Model: $\theta^*_{\mathrm{NP}} \equiv 0$	Standard Model only: θ_{SM}
Contaminated	SM + new physics: $\theta^*_{\mathrm{NP}} \neq 0$	Standard Model only: θ_{SM}

NP is injected into the pseudodata via K-factors

$$T \equiv \left(1 + cK_{\mathrm{lin}} + c^2 K_{\mathrm{quad}}\right) \hat{\sigma}^{\mathrm{SM}} \otimes \mathcal{L}$$

Now we are **not** focusing on PDF-EFT simultaneous fits. Our main goal is to assess the contamination of SM fits

CONTAMINATED PDFS

How can we assess if PDFs have been contaminated by NP?

If there are many datasets that enter the fit that *are not* affected NP, and some that datasets that *are* affected by NP, they could appear inconsistent and poorly described by the resulting fit

We use the NNPDF dataset selection criteria [NNPDF 2109.02653], where a dataset is flagged if

$$\chi^2/n_{\rm dat} > 1.5 \qquad\qquad n_\sigma = \frac{\chi^2 - 1}{\sigma_{\chi^2}}$$

Alternatively, we say that the PDFs would be "contaminated"

BSM SCENARIO (Z')

We first consider a universal Z′ scenario, which generates an effective Y parameter

Salvioni et al., 0909.1320
Langacker, 0801.1345
Panico et al., 2103.10532

$$\mathcal{L}_{\text{SMEFT}}^{Z'} = \mathcal{L}_{\text{SM}} - \frac{g'^2 \hat{Y}}{2m_W^2} J_Y^\mu J_{Y,\mu}$$

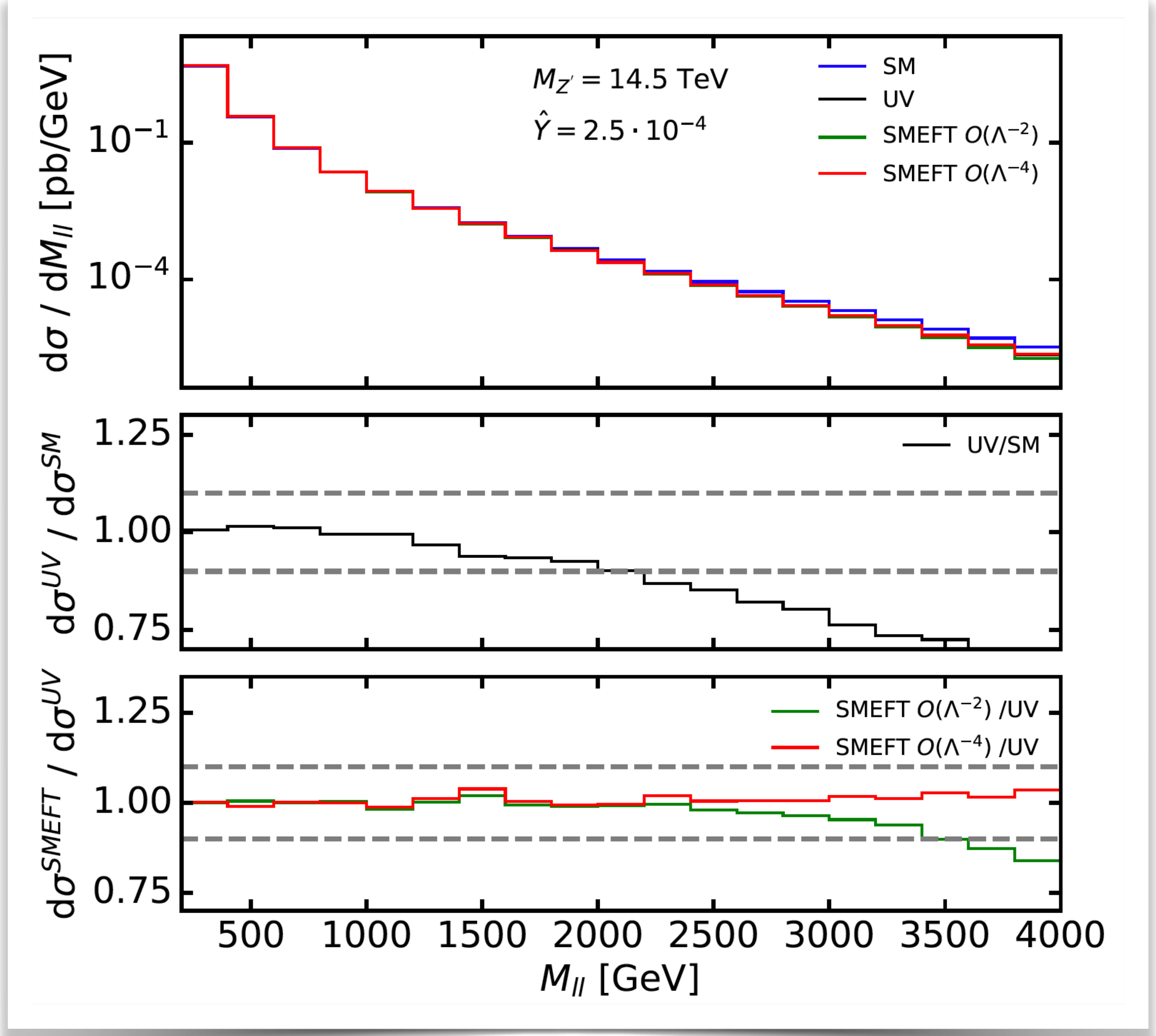
$$J_Y^\mu = \sum_f Y_f \bar{f} \gamma^\mu f$$

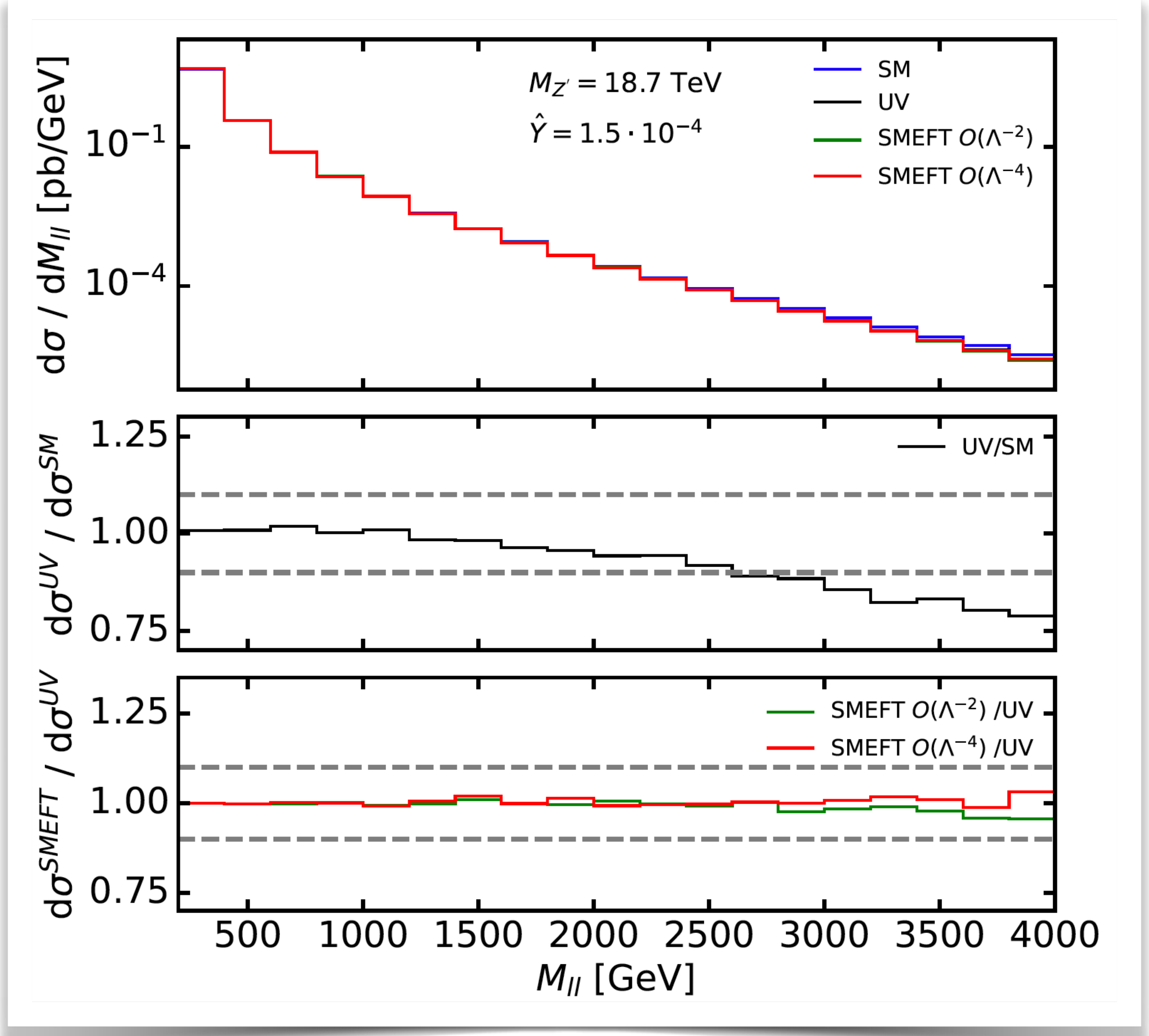
$$\hat{Y} = \frac{g_{Z'}^2}{M_{Z'}^2} \frac{m_W^2}{g'^2}$$

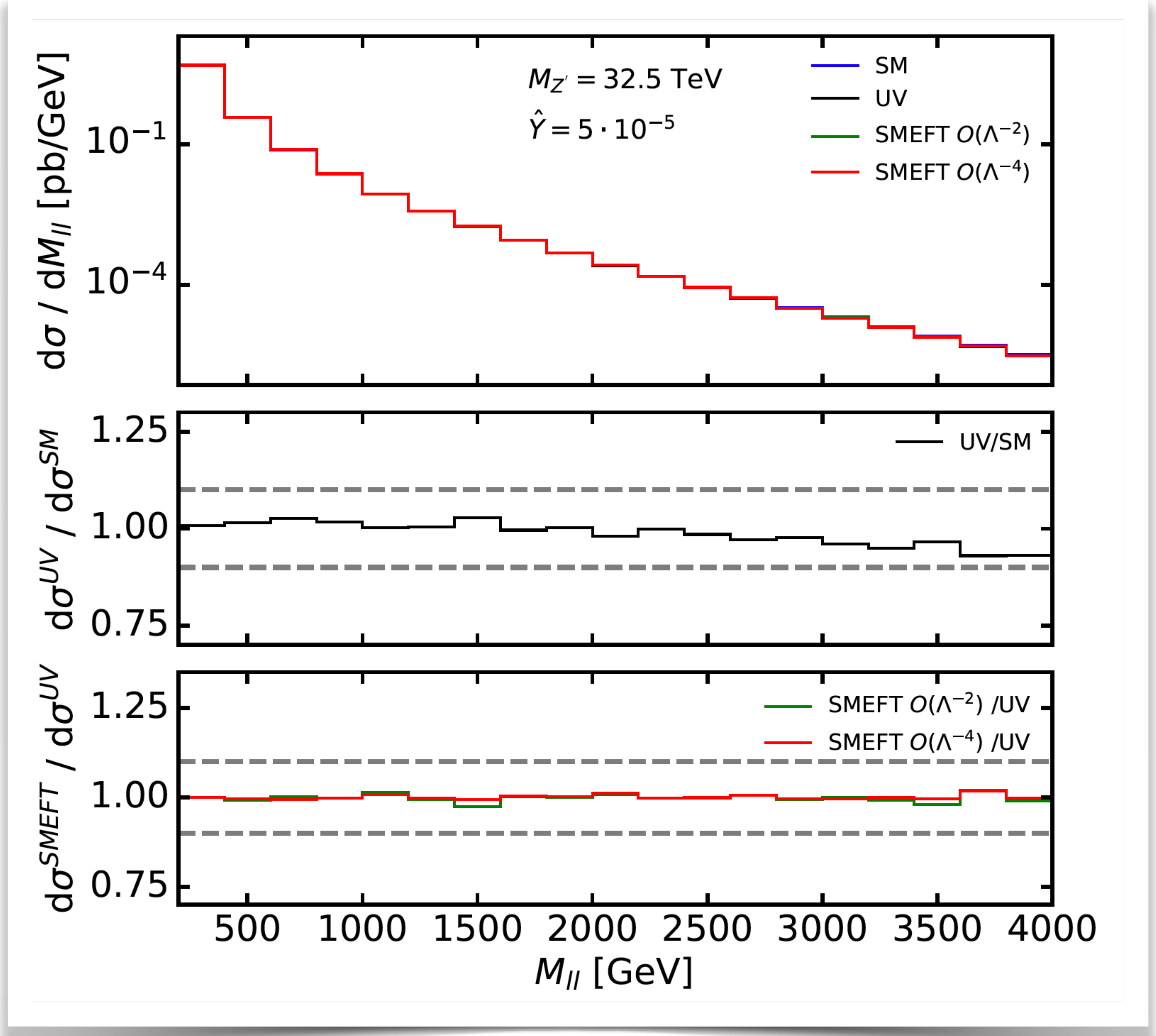
Other SMEFT operators are generated by a Z′, but their effect is small

BSM SCENARIO (Z’)

We use different benchmarks to see how the EFT approximation works







For heavier masses of the Z′ a linear EFT describes the UV faithfully

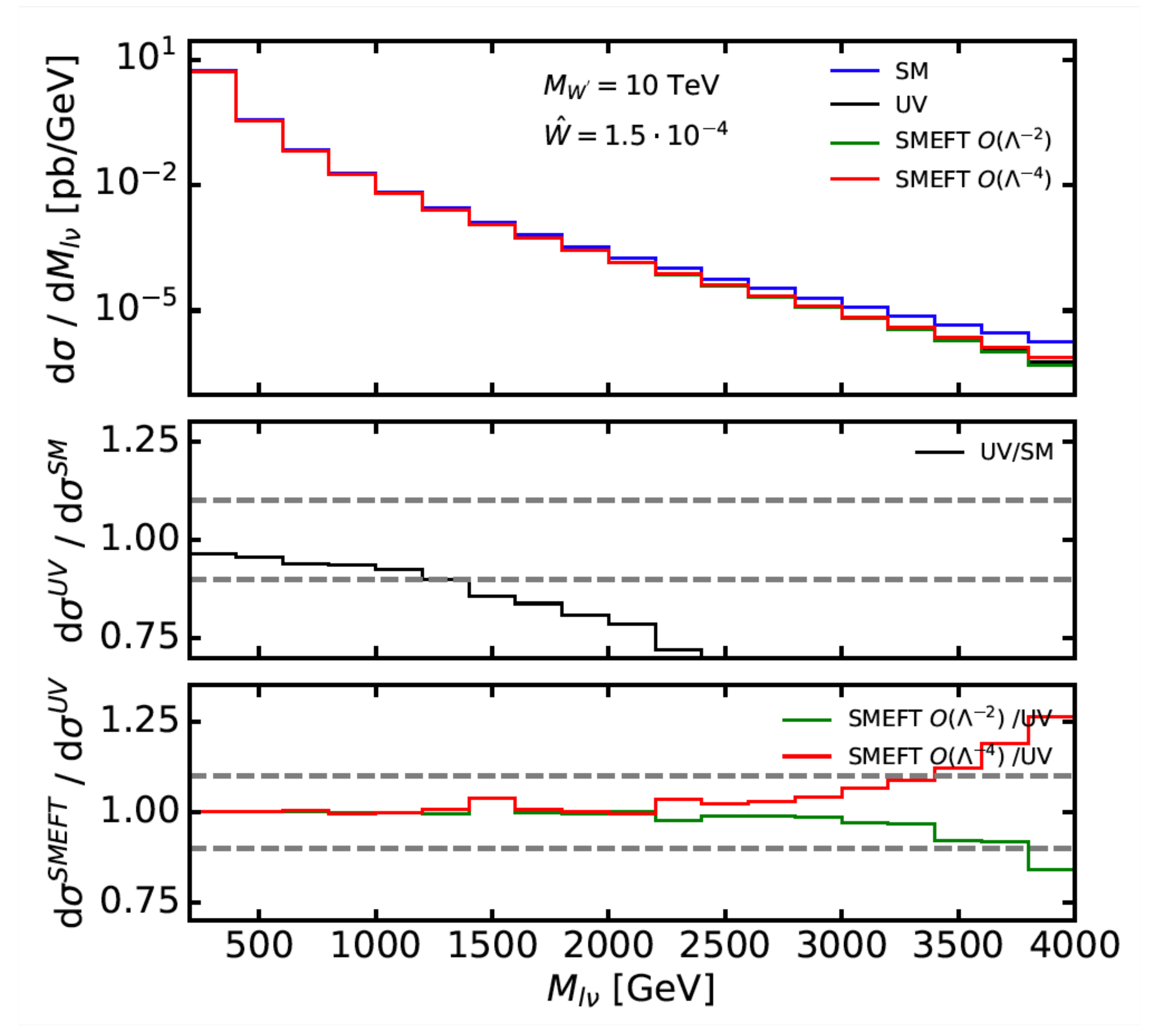
BSM SCENARIO (W')

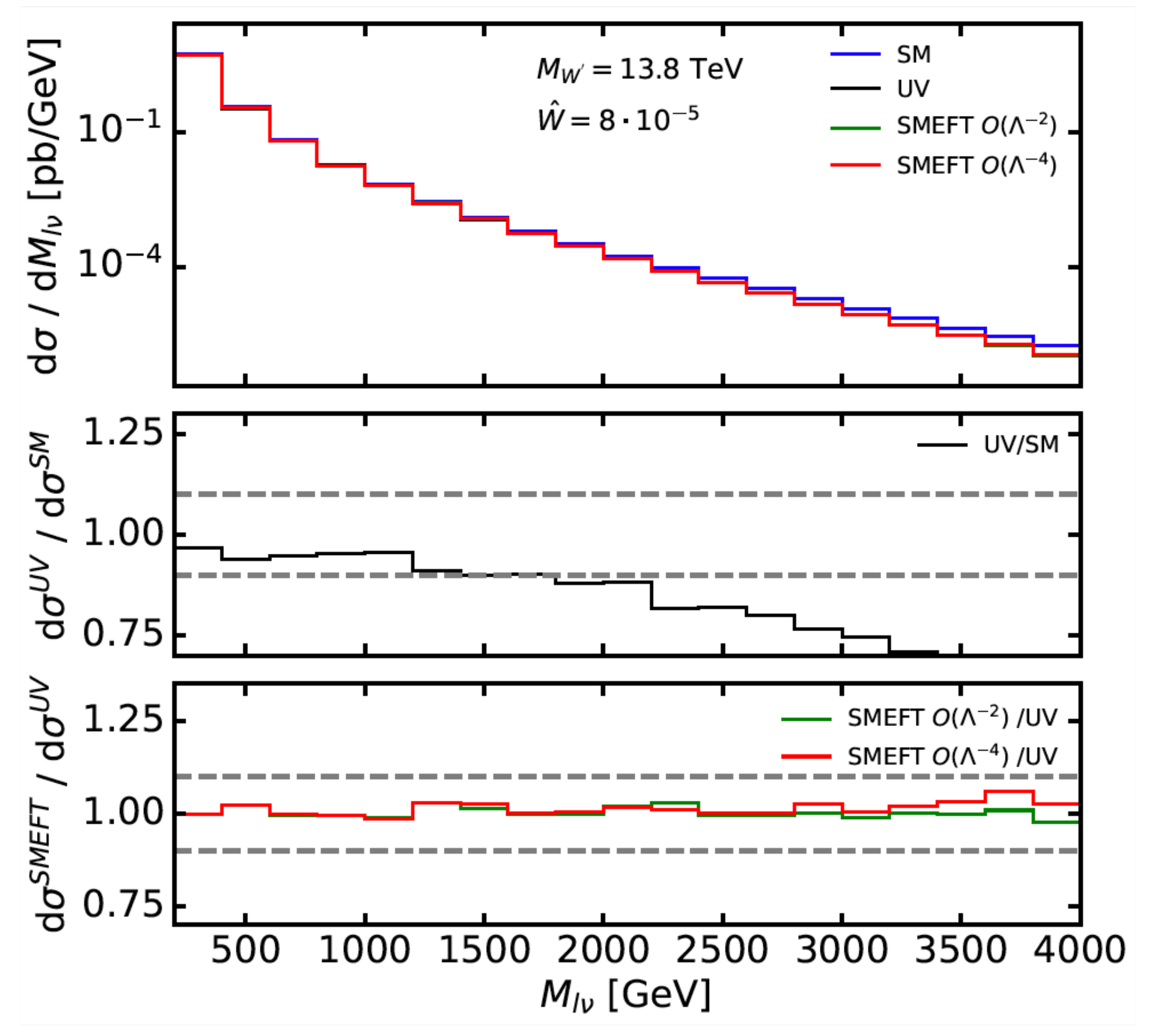
We also consider a W' prime scenario, and proceed analogously

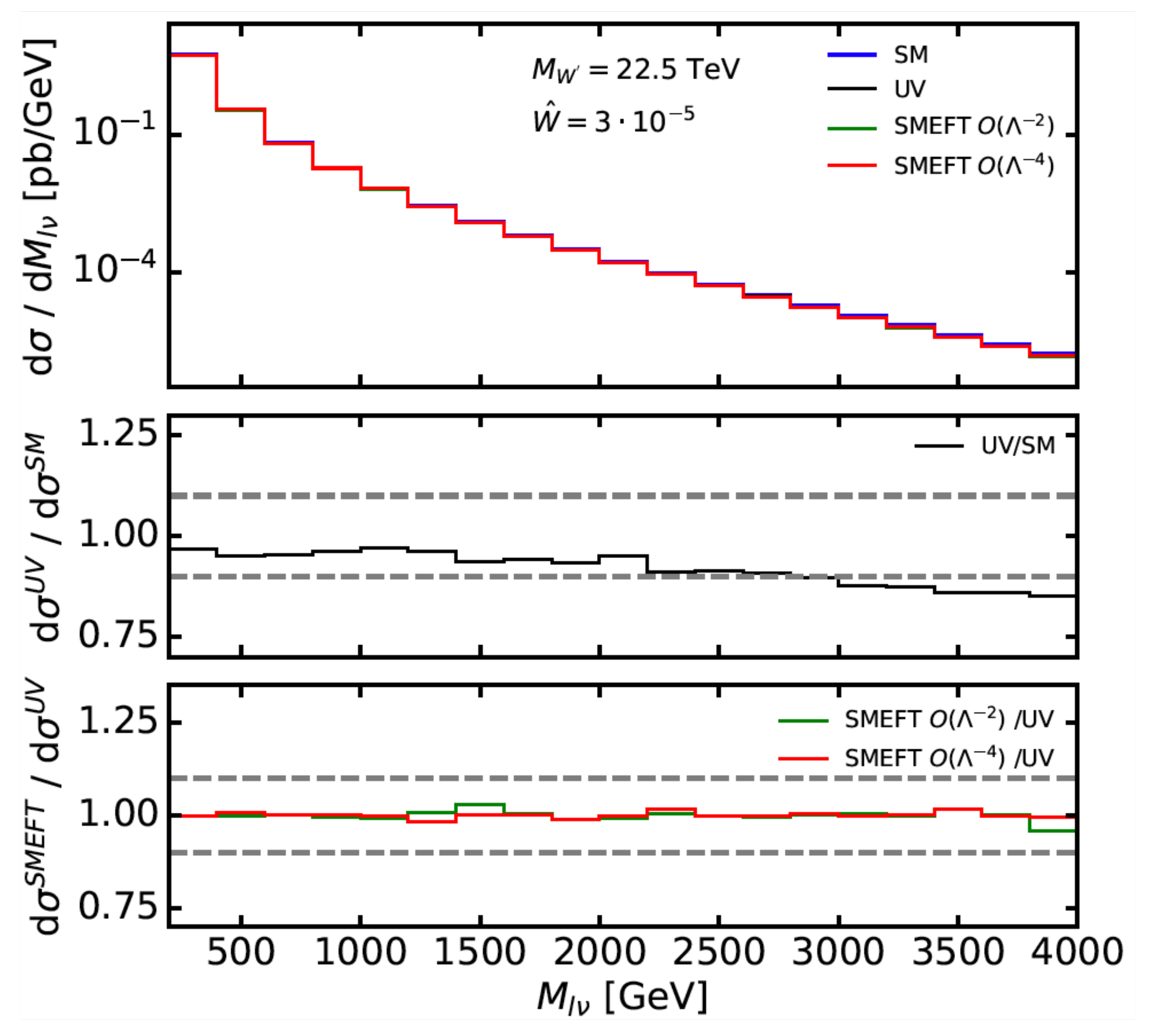
$$\mathcal{L}_{\text{SMEFT}}^{W'} = \mathcal{L}_{\text{SM}} - \frac{g^2 \hat{W}}{2m_W^2} J_L^{a,\mu} J_{L,\mu}^a$$

$$J_L^{a,\mu} = \sum_{f_L} \bar{f}_L T^a \gamma^\mu f_L$$

$$\hat{W} = \frac{g_{W'}^2}{g^2} \frac{m_W^2}{M_{W'}^2}$$



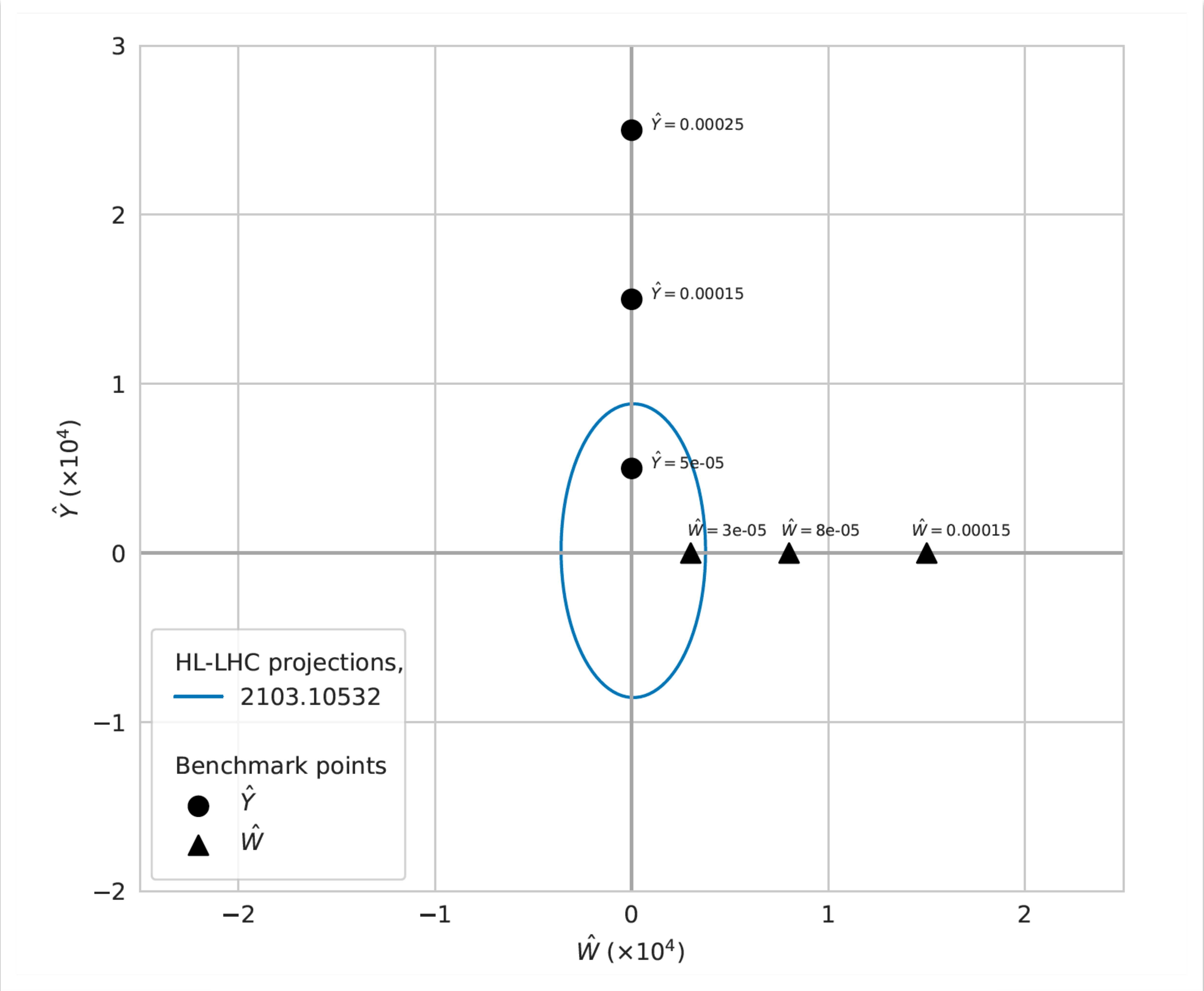




BSM SCENARIOS

The benchmarks points are the following

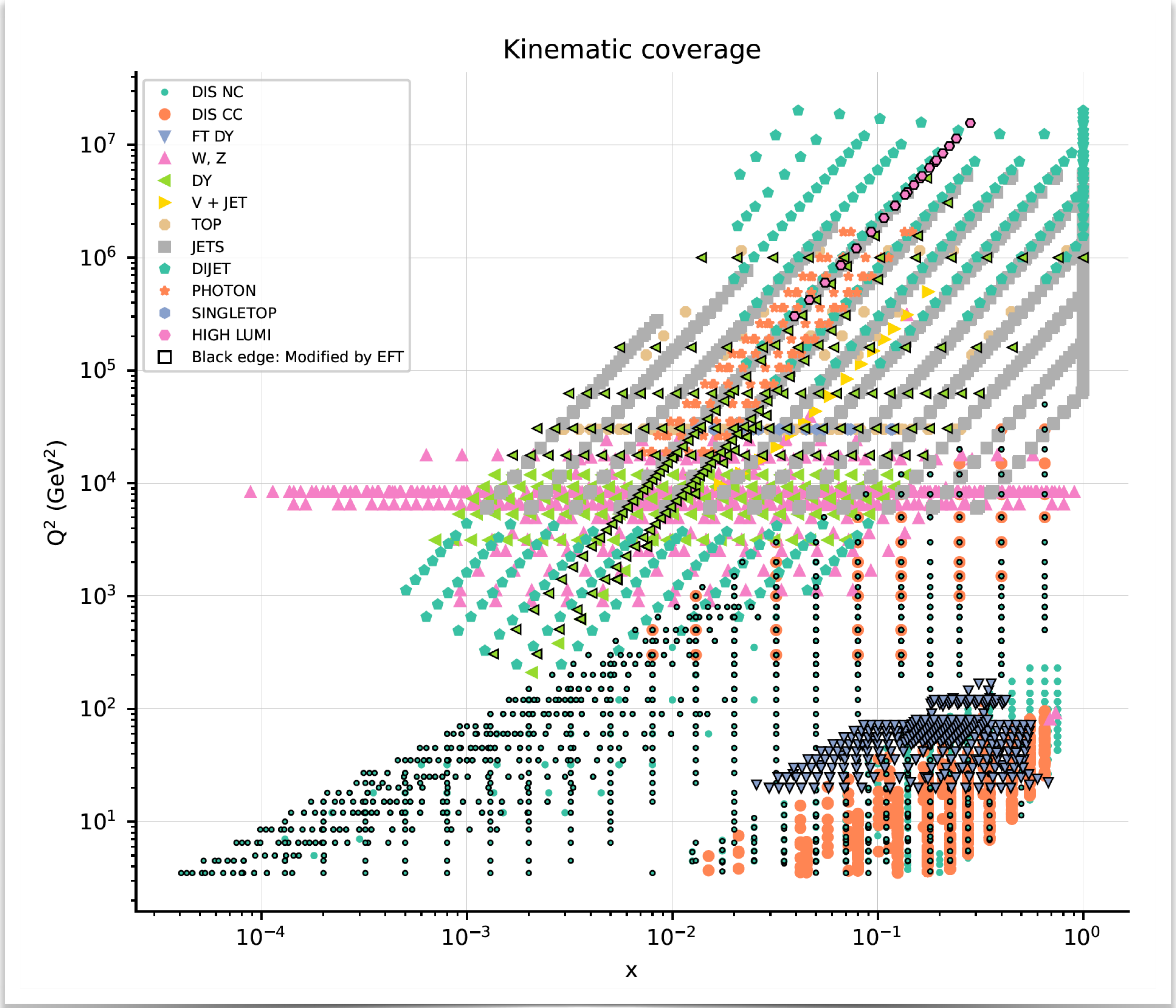
They are compared to the constraints at 95% CL given by fully differential DY projections [Torre et al., 2008.12978]



DATASETS

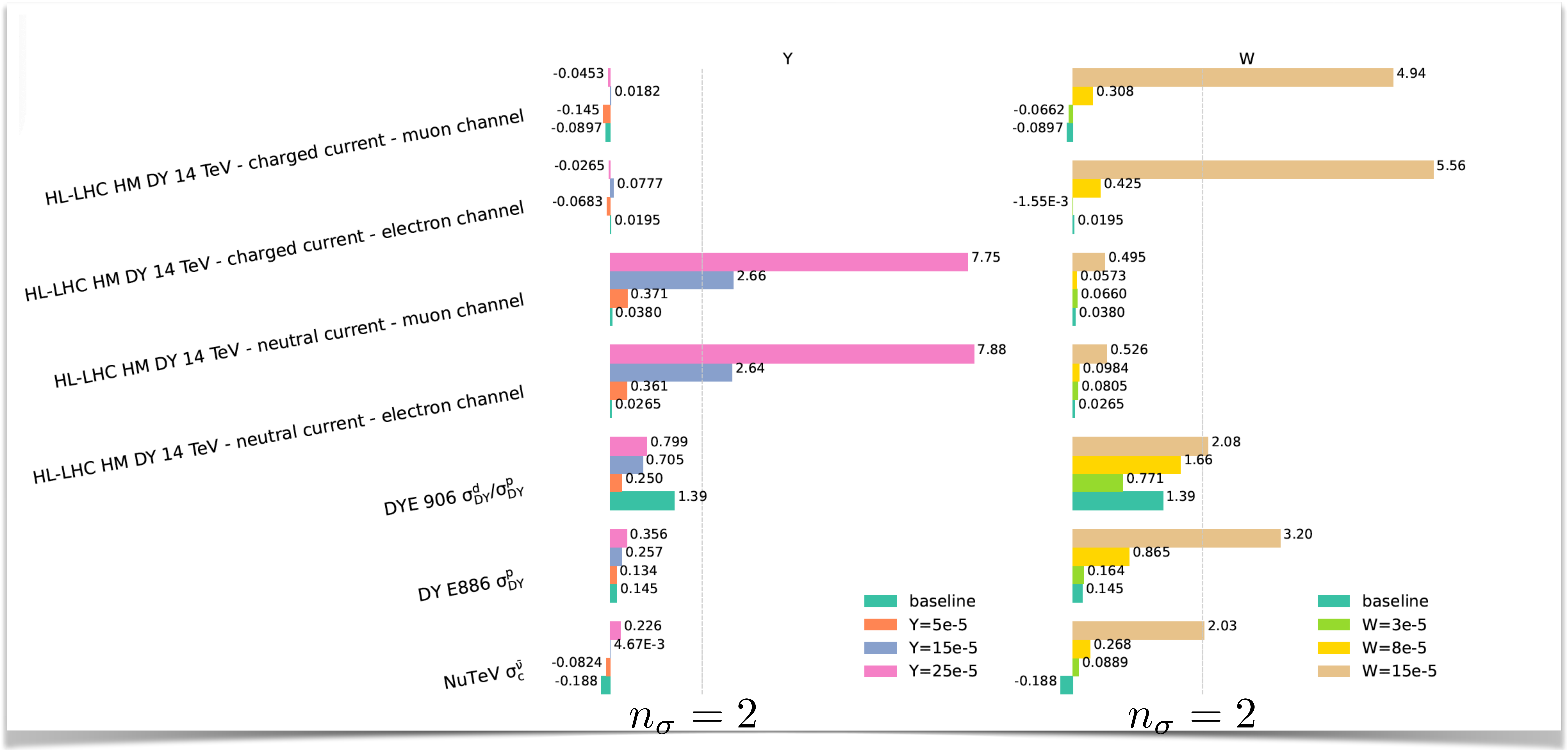
We generate MC data for all datasets included in NNPDF4.0, and include NC and CC HL-LHC projections

DIS and DY datasets are affected by the EFT



PDF CONTAMINATION SUMMARY

n_σ



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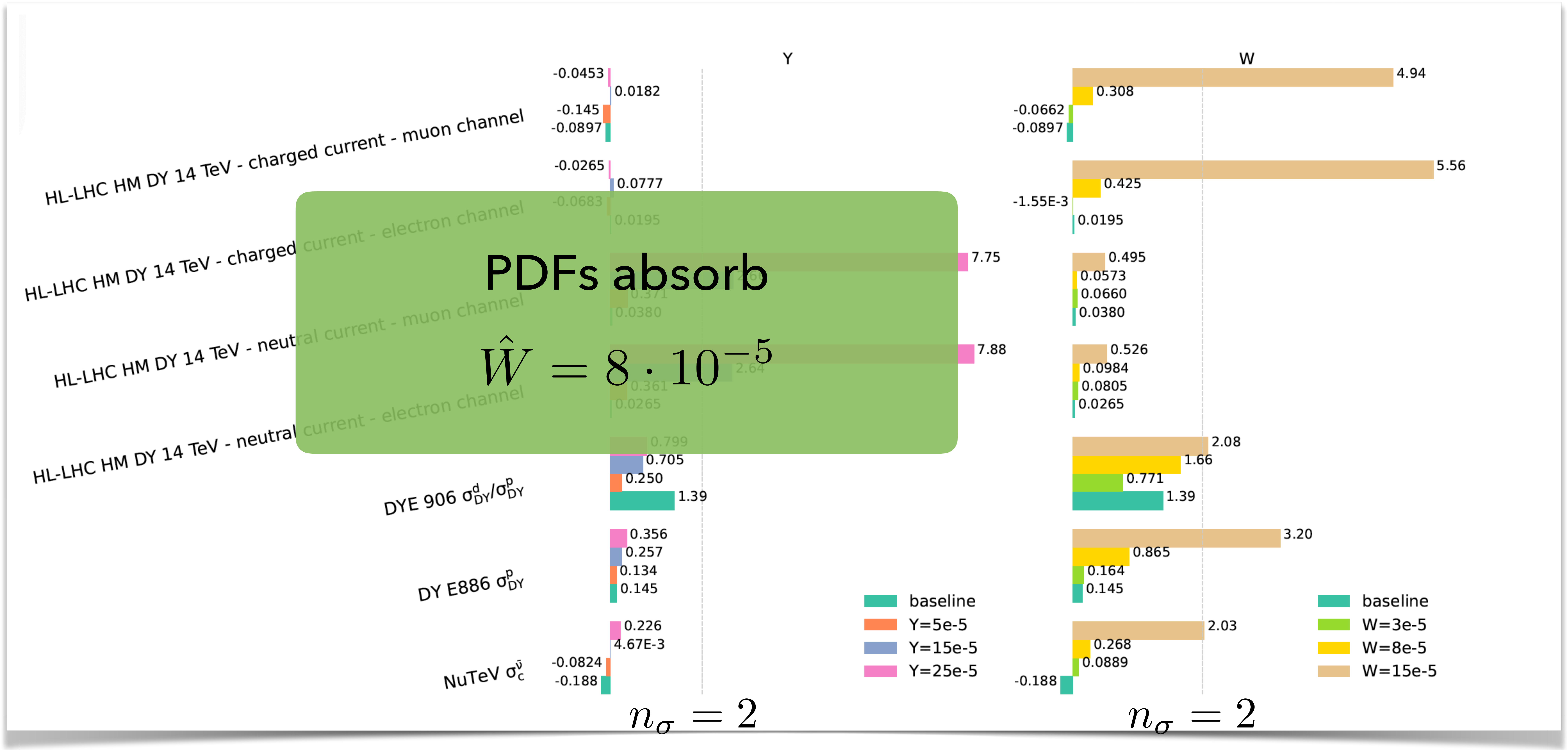
n_σ



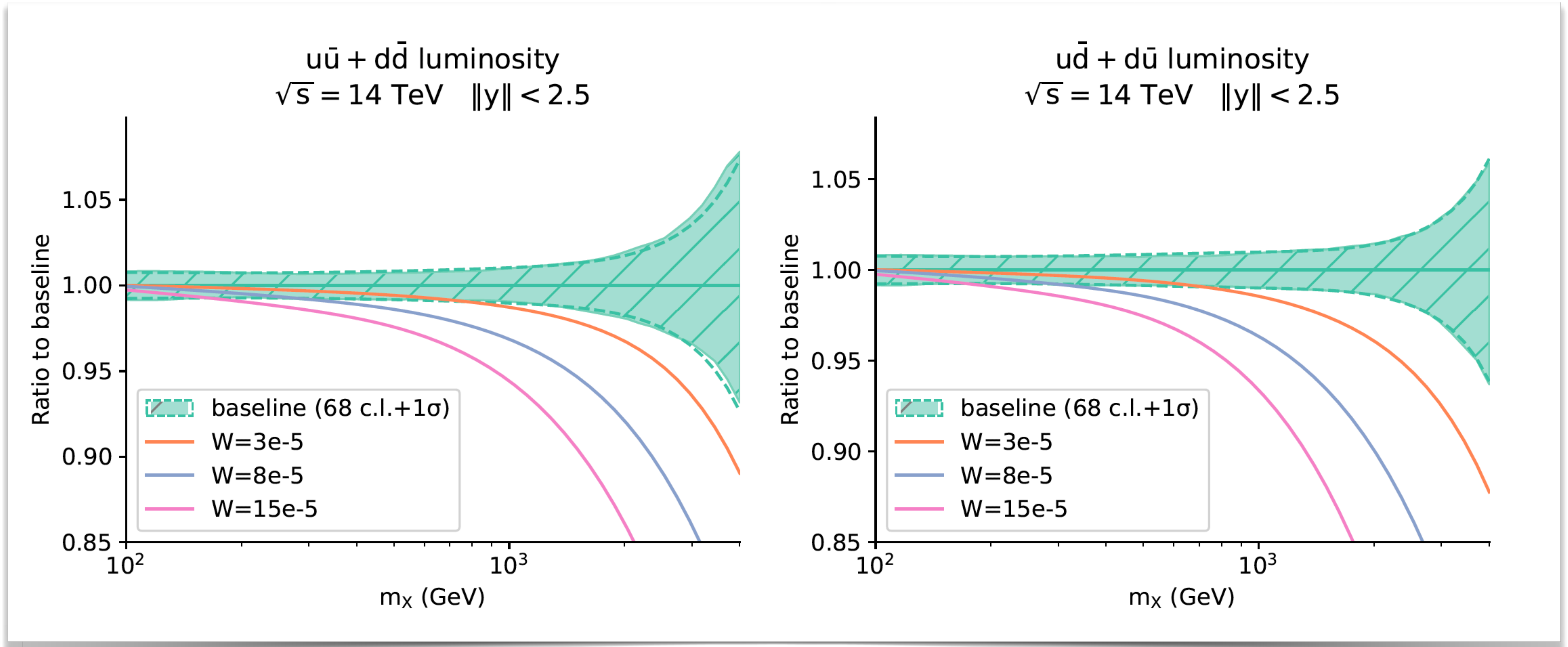
PDFs absorb

$\hat{W} = 8 \cdot 10^{-5}$

$n_\sigma = 2$ $n_\sigma = 2$

LUMINOSITIES IN PRESENCE OF W

NC and CC luminosities shift from the baseline and manage to compensate each other



The shift in PDFs compensates the NP effects, which are missed in the fit

CONSEQUENCES OF NP CONTAMINATION IN PDF FITS

What happens is we unknowingly use contaminated PDFs?

They can have big effects on processes that did not enter the fit (and are not affected by W)

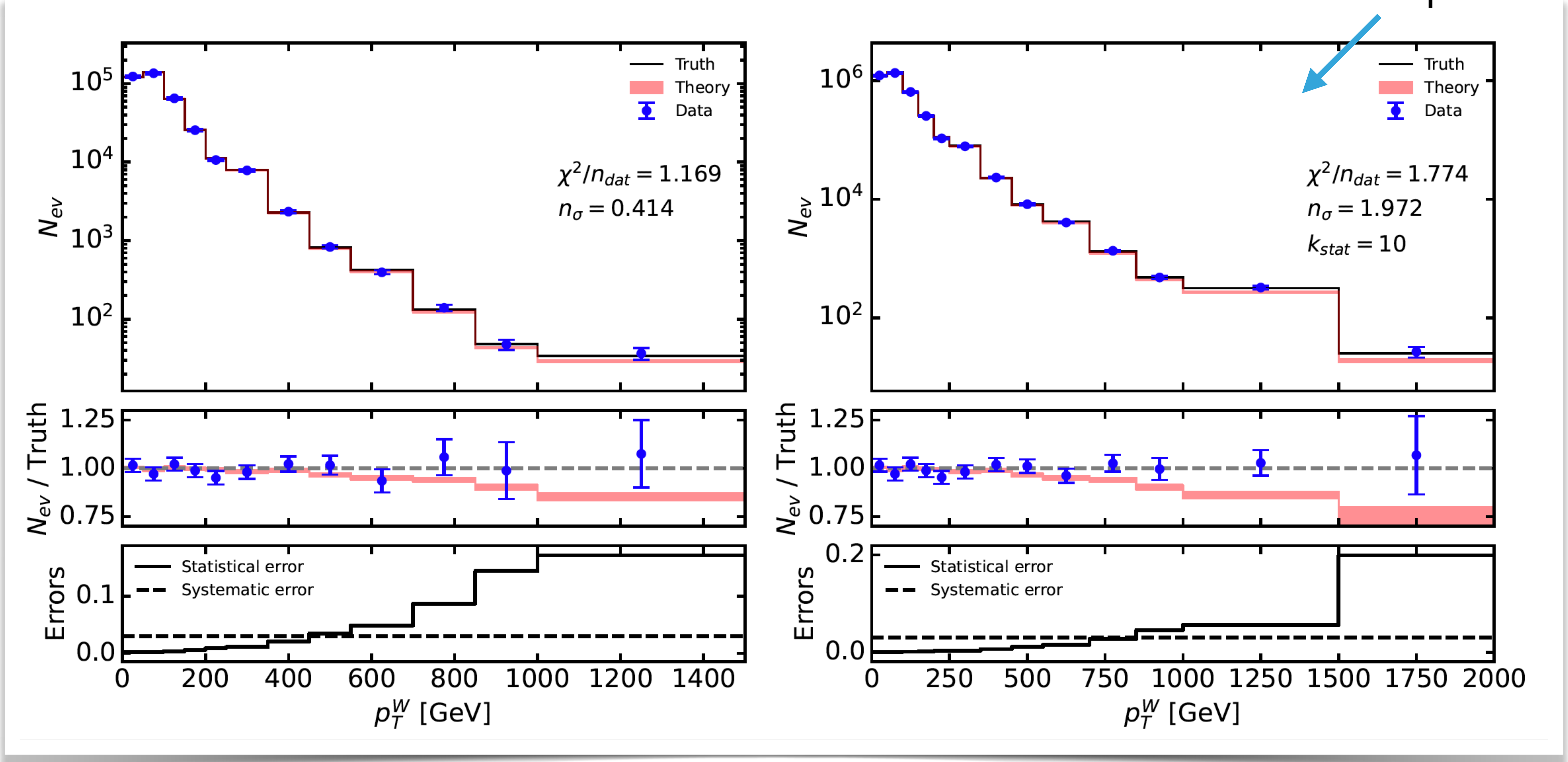
W^+H

@ HL-LHC

Data: "True" PDF x SM

Theory: "Cont" PDF x SM

"x10 lumi improvement"



CAN WE DISENTANGLE NP EFFECTS?

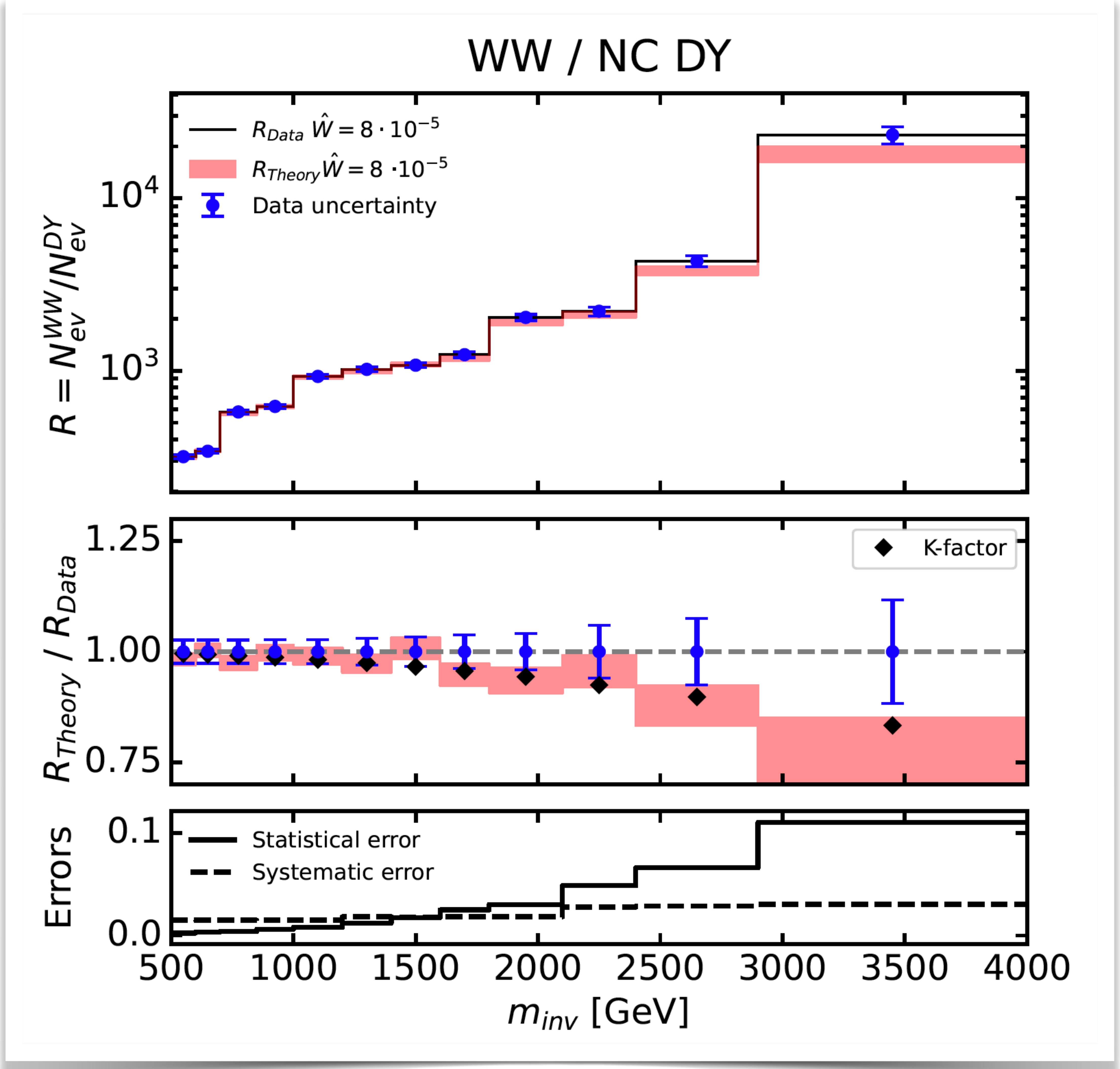
Large-x antiquark PDFs were mostly responsible for accommodating NP. More low energy measurements could help to flag inconsistencies

CAN WE DISENTANGLE NP EFFECTS?

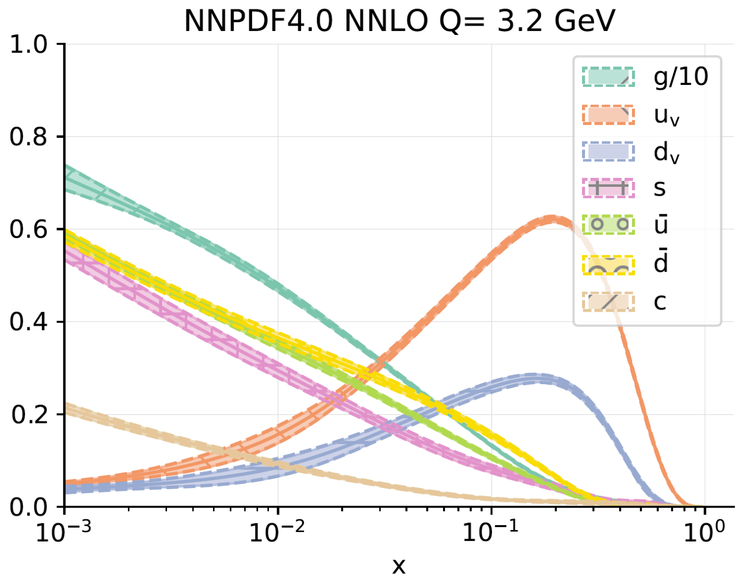
Large-x antiquark PDFs were mostly responsible for accommodating NP. More low energy measurements could help to flag inconsistencies.

We can disentangle NP effects with ratio observables that probe the same lumi channels

However, one cannot determine if NP is present in DY or diboson datasets



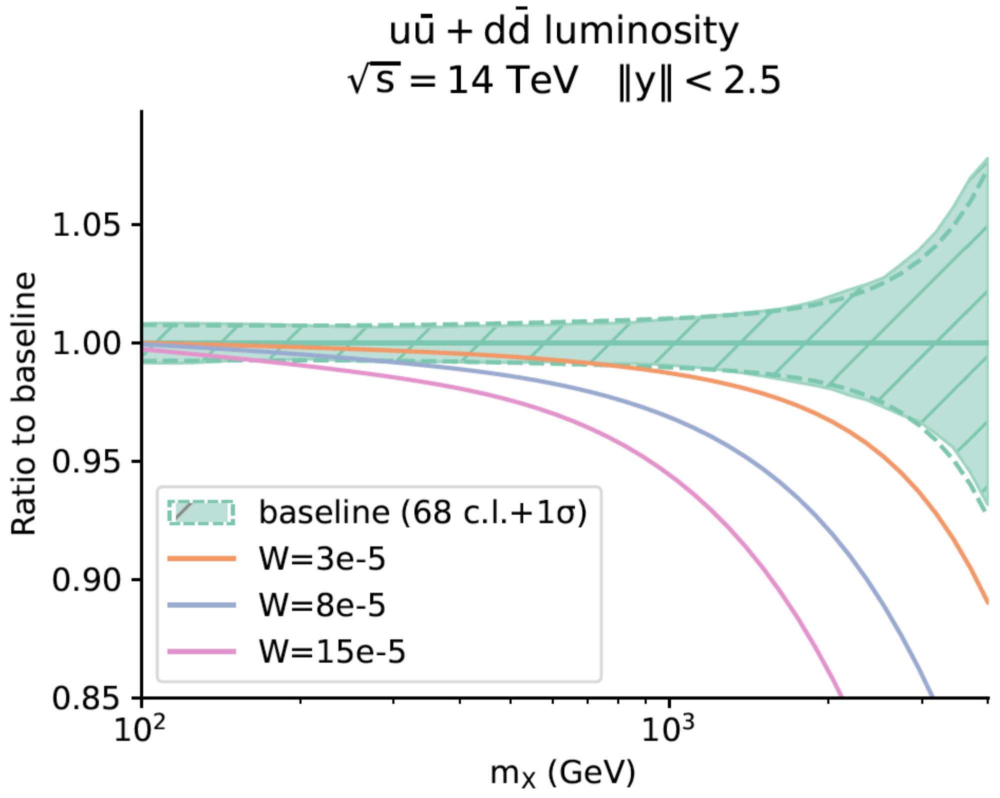
OUTLINE



$+ \frac{c_i}{\Lambda^2}$

Simultaneous PDF-EFT determination

Neglecting the PDF-EFT interplay can lead to biased results both in the SM and beyond

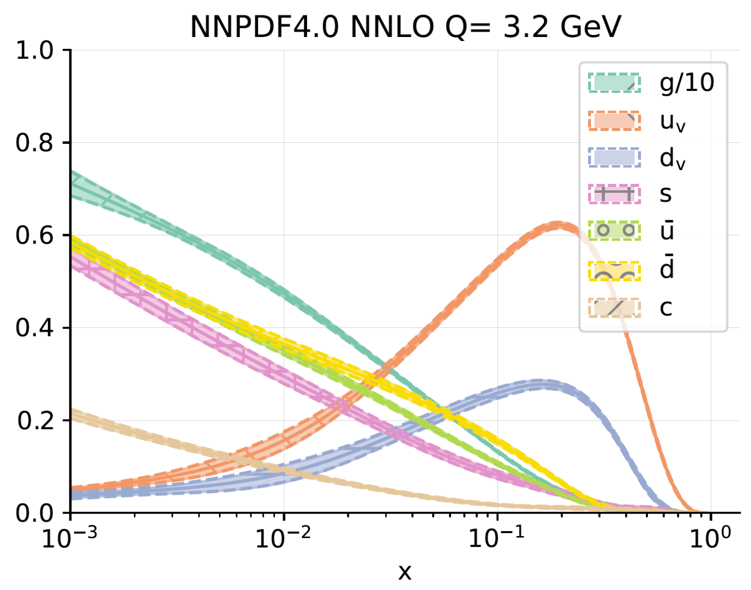


Can PDFs absorb new physics?

Yes, but the disentanglement can be difficult

Conclusions and outlook

OUTLINE



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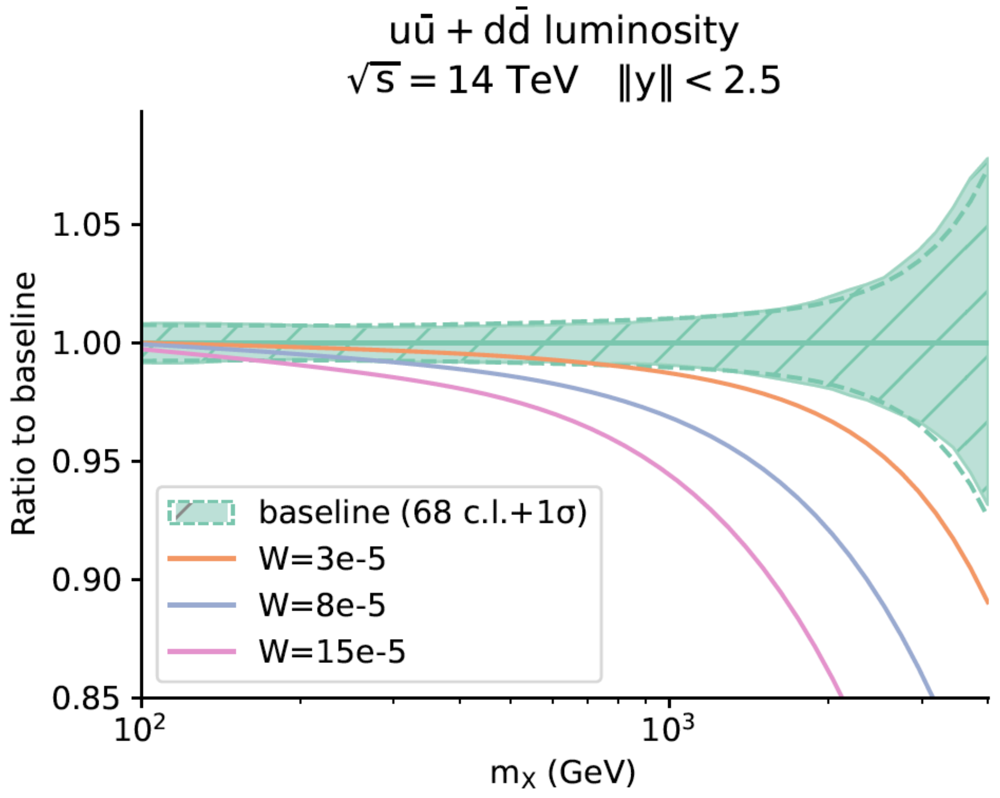

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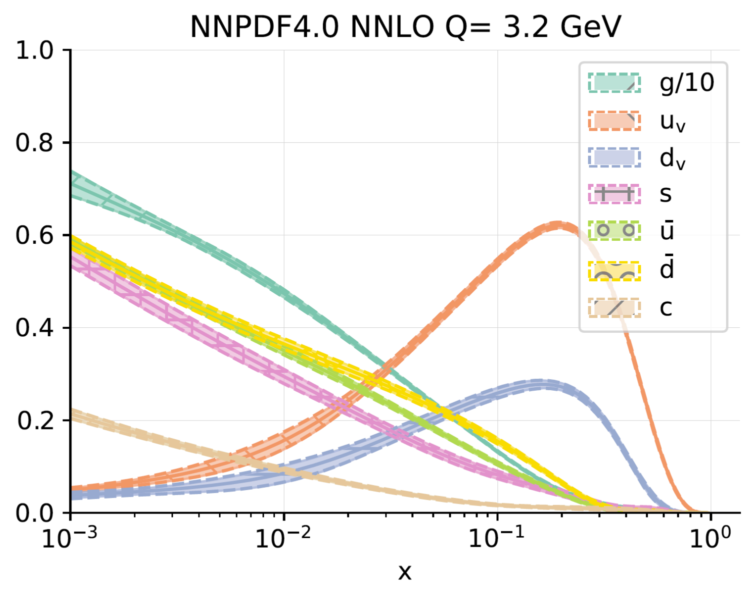

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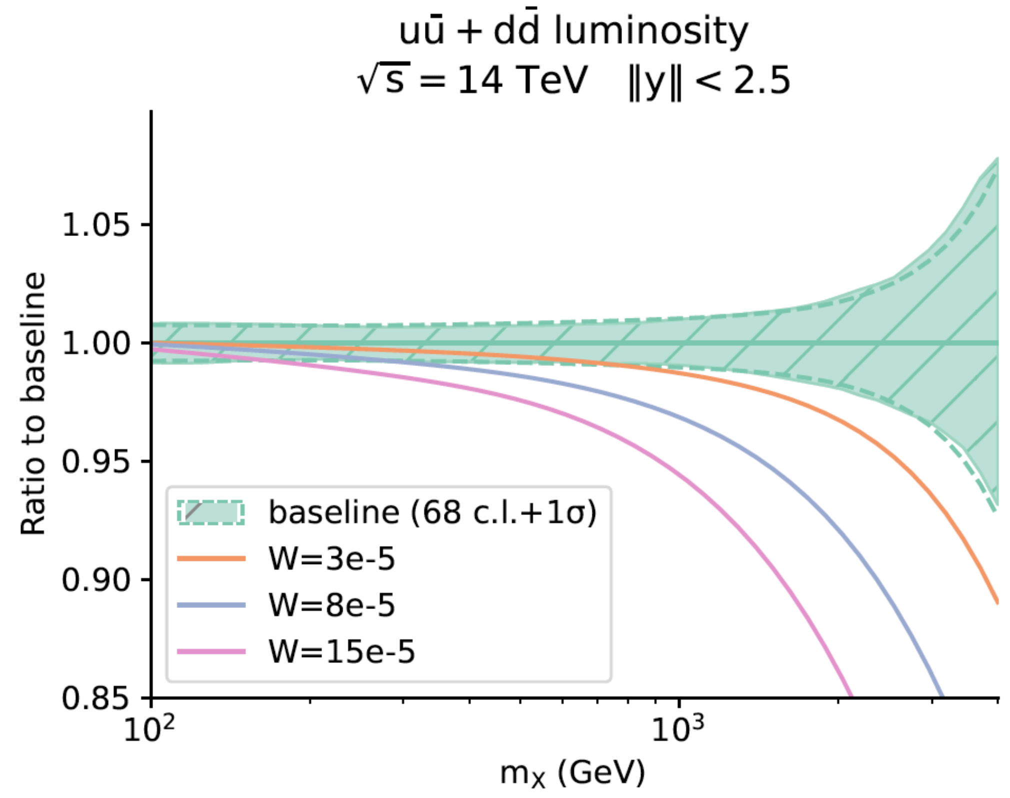

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Conclusions and outlook

CONCLUSIONS

- We have discussed the PDF-EFT interplay
- Neglecting the PDF-EFT interplay can lead to biased results both in the SM and beyond
- Potential effects of new physics could be 'absorbed' by the PDFs
- Ratio observables can help to minimise the PDF contamination. However, more constraints are needed to disentangle potential NP effects in PDFs

Thank you for your attention!