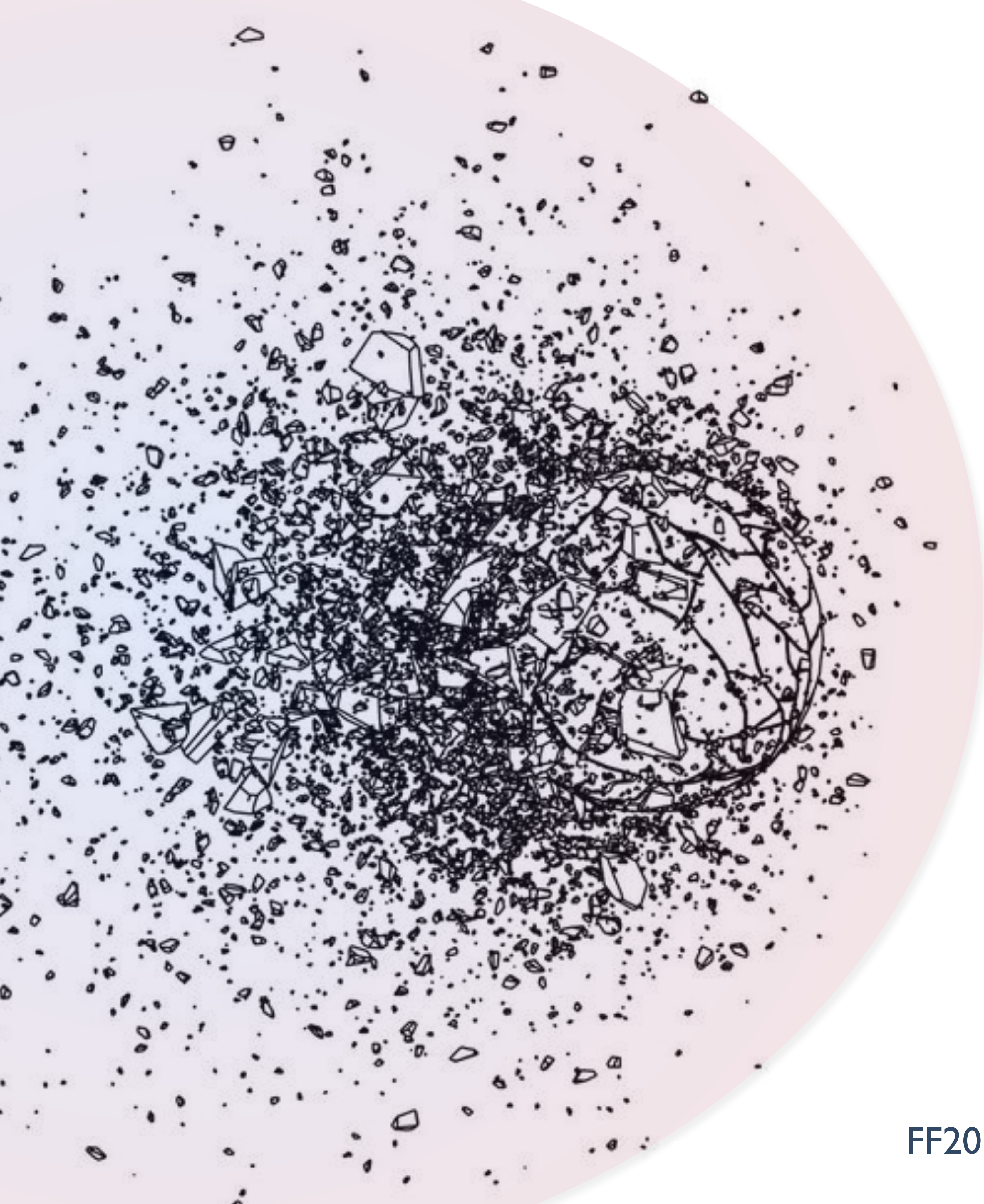

News from DSS

Rodolfo Sassot

Universidad de Buenos Aires

FF2019 - Durham, March 14th, 2019

Outline:

DSS FFs framework

D. de Florian, RS, M. Stratmann arXiv:hep-ph/0703242
arXiv:0707.1506

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to DSS14, DSS17, …

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combined PDFs and FFs from EIC

E. Aschenauer, I. Borsa, RS, C. van Hulse arXiv:1902.10663

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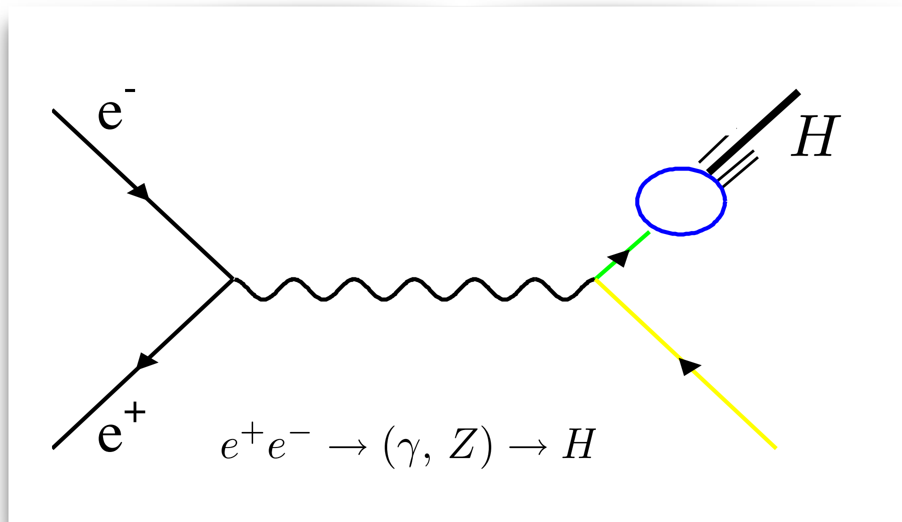

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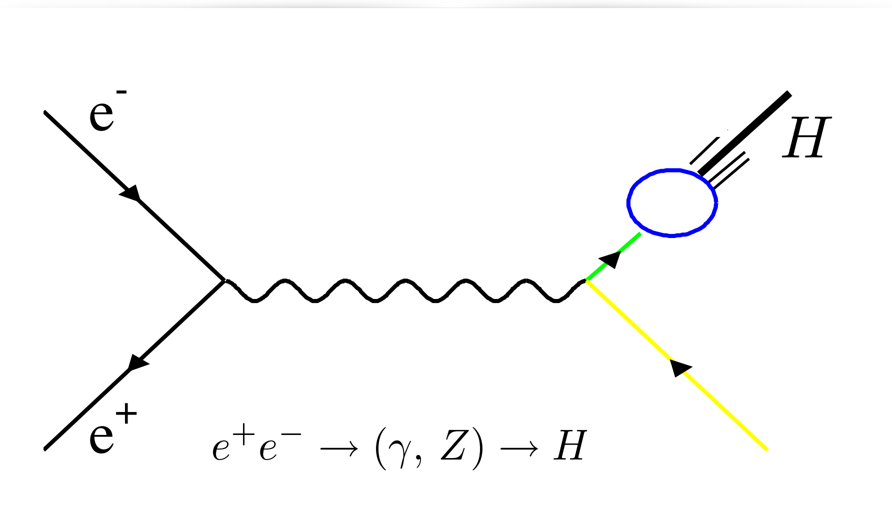

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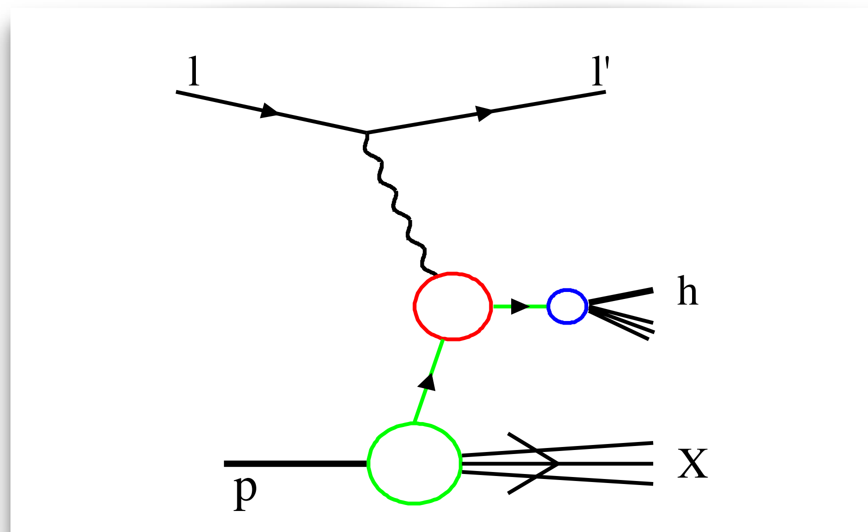

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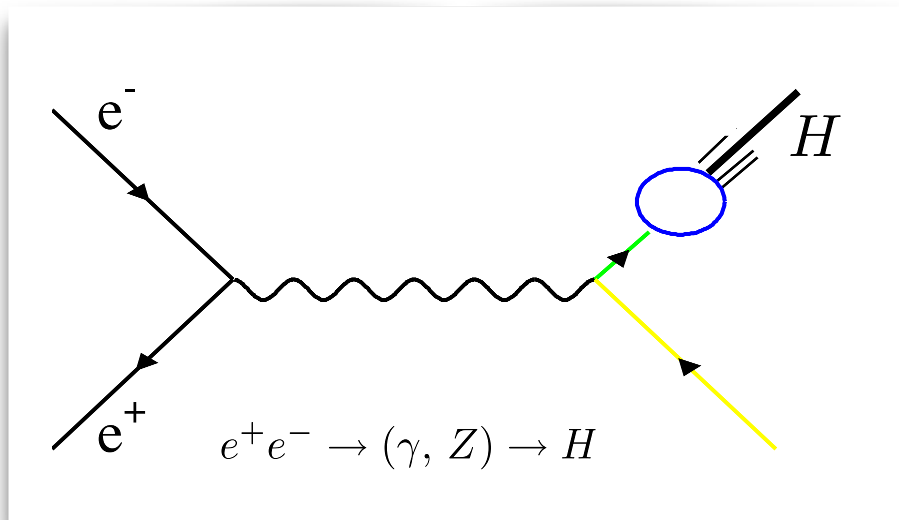

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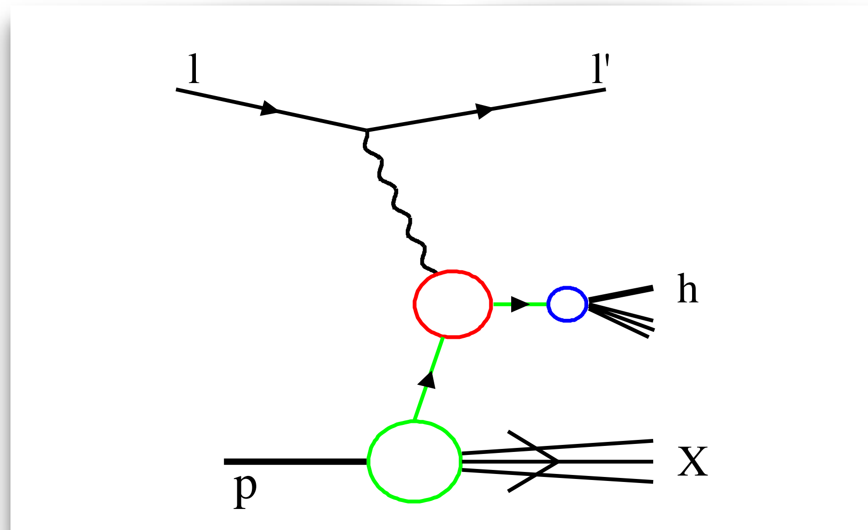

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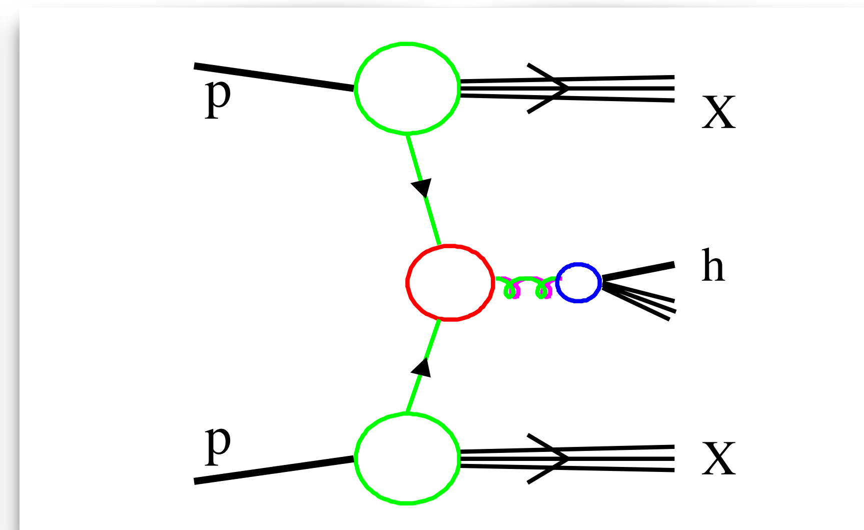

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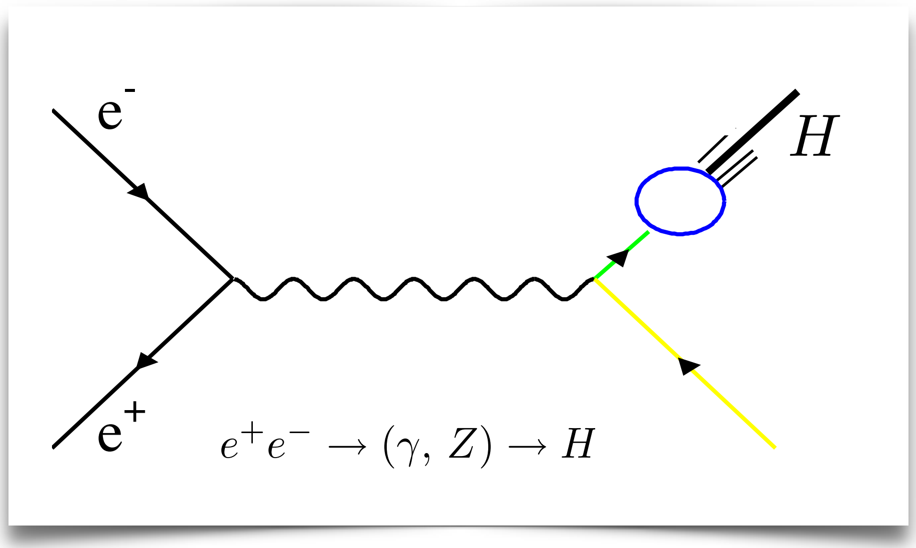

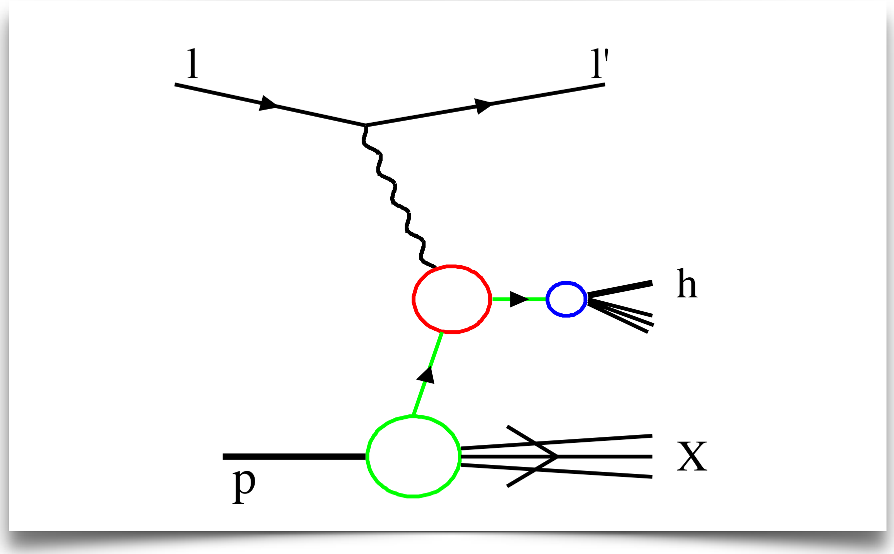

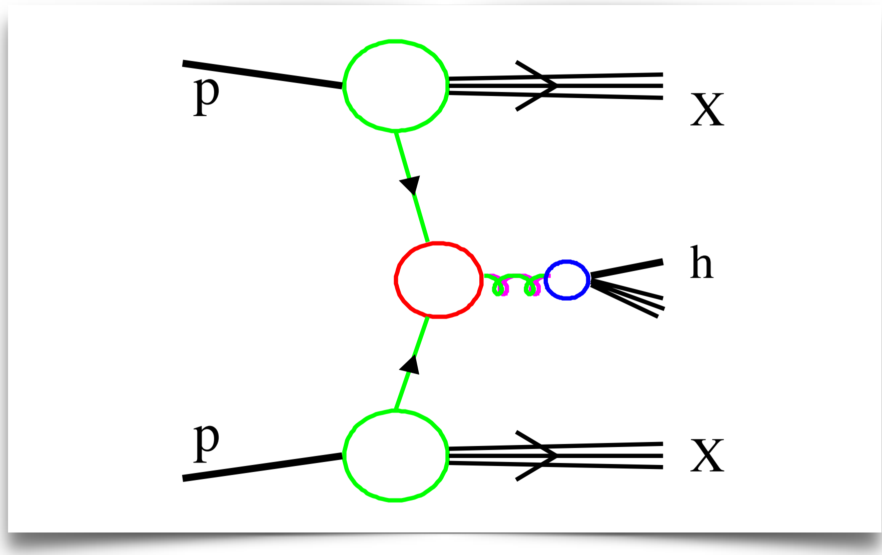

SIA *SIDIS* *pp*

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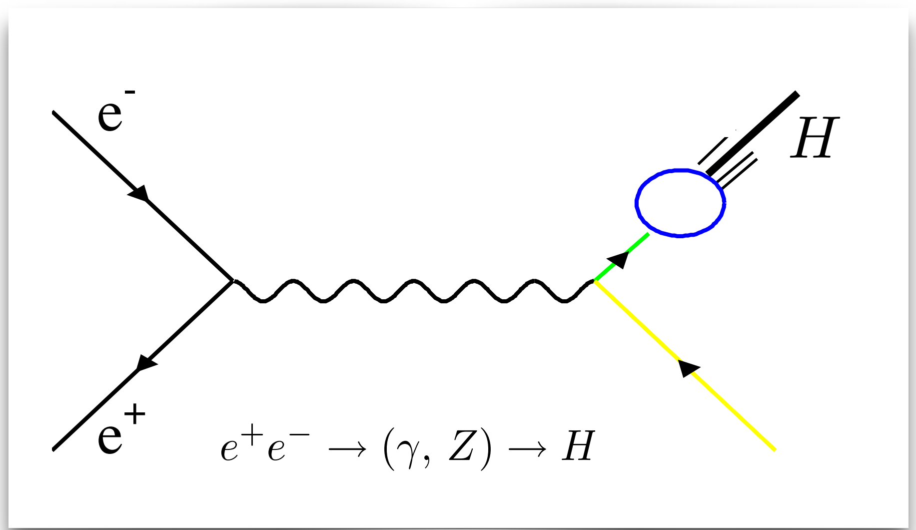

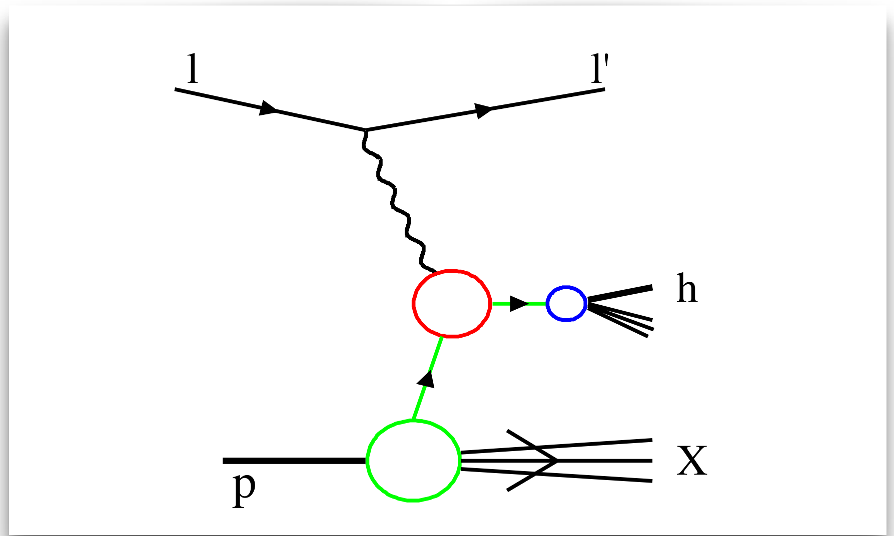

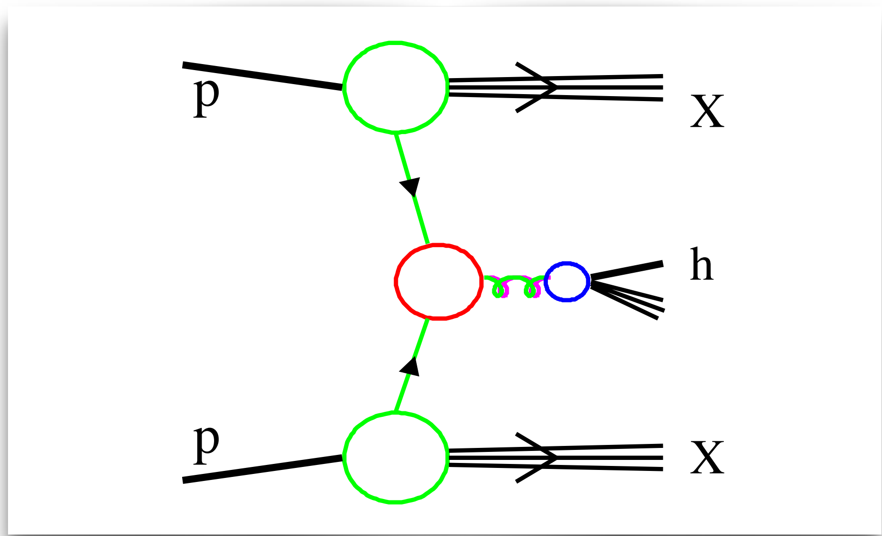

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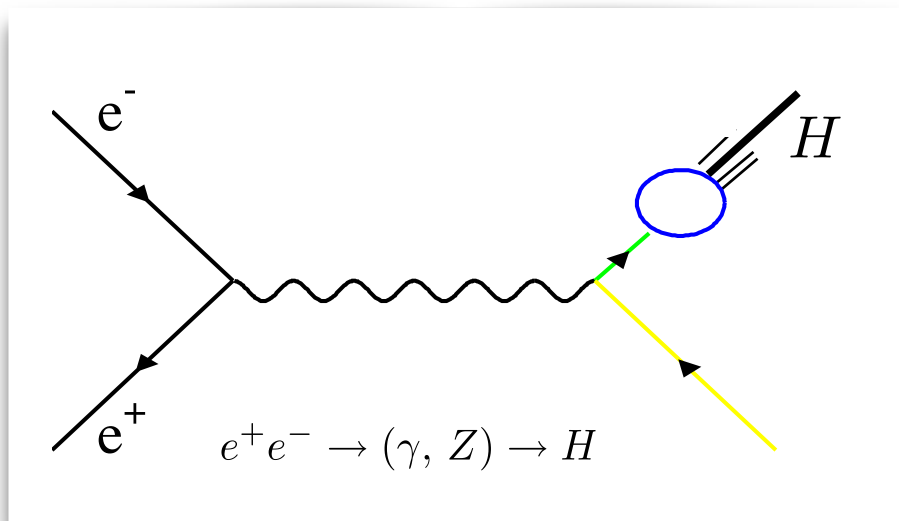

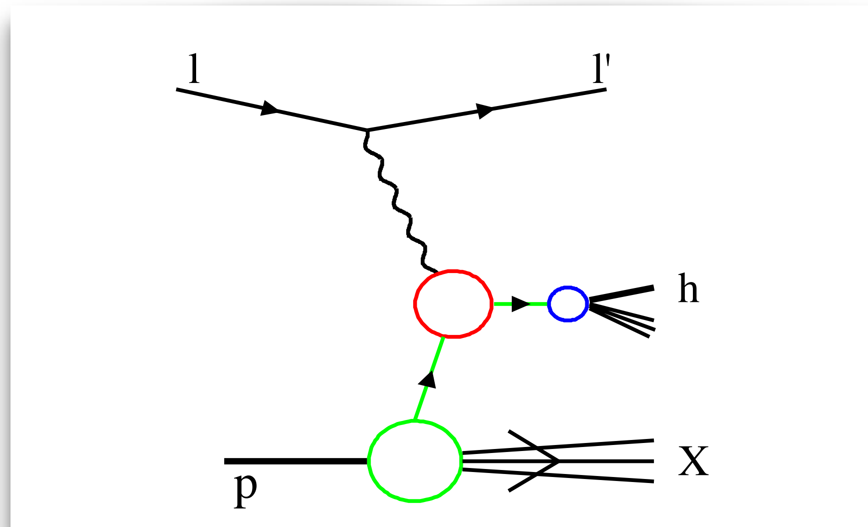

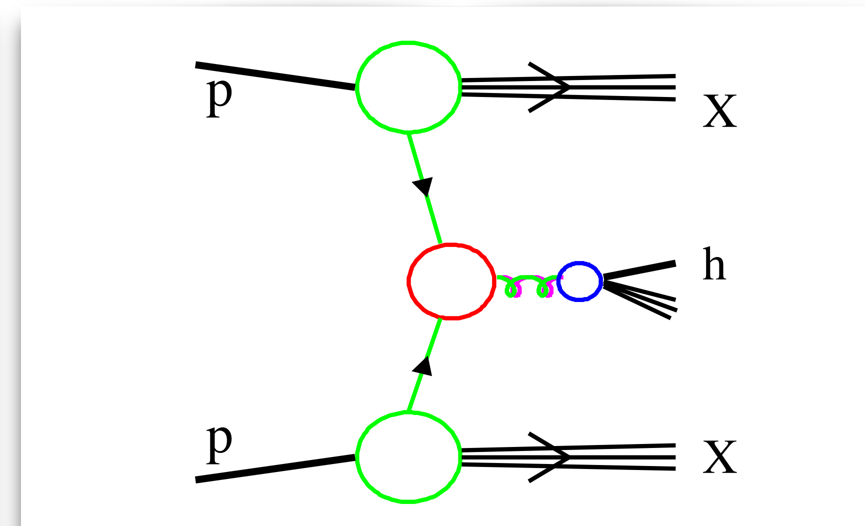

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PDFs as effective charge
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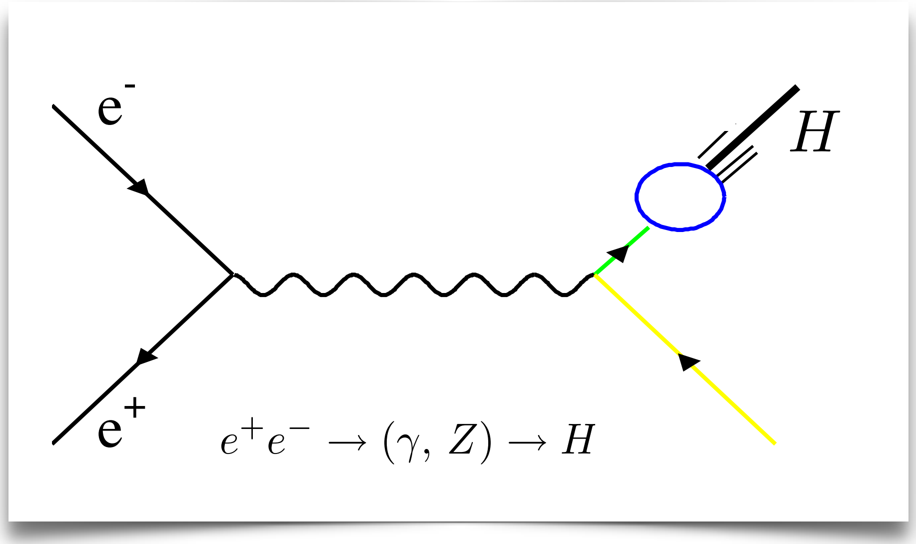

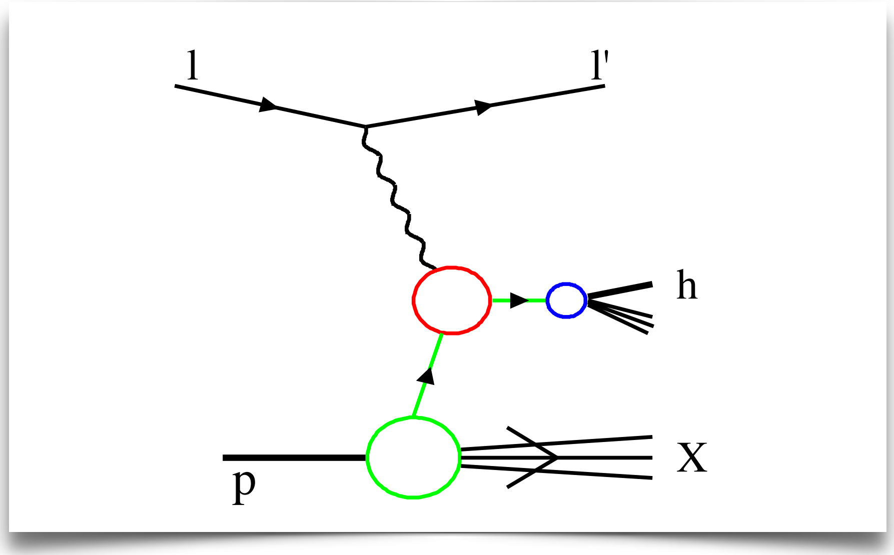

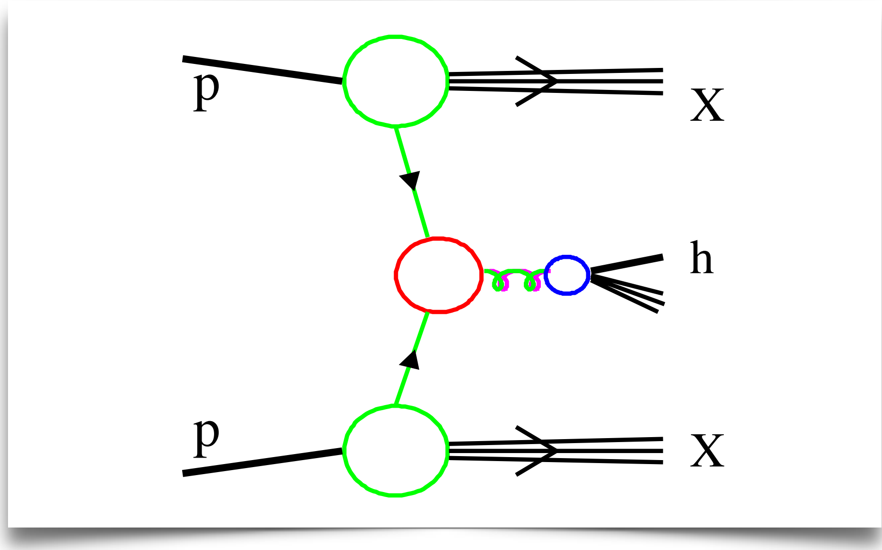

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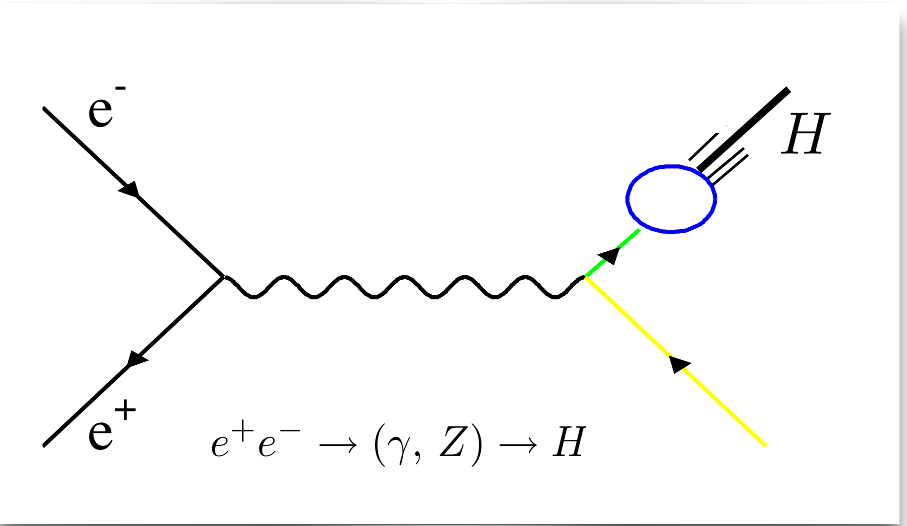

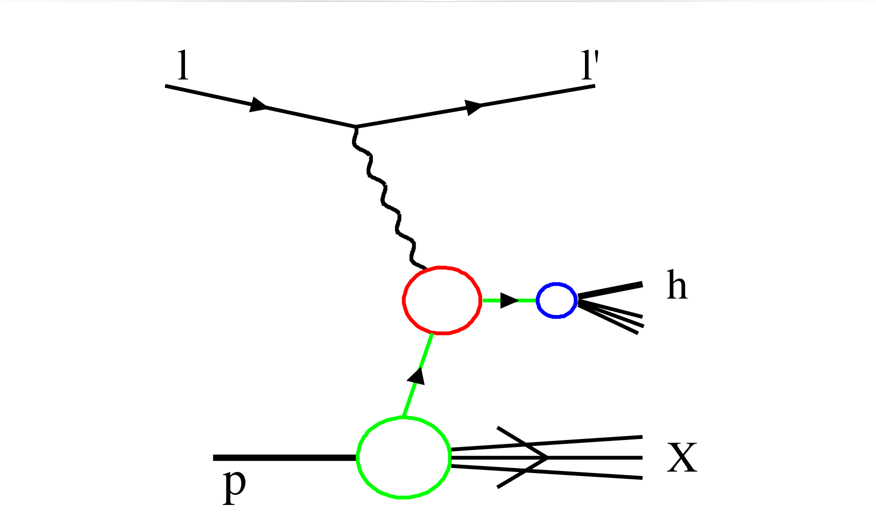

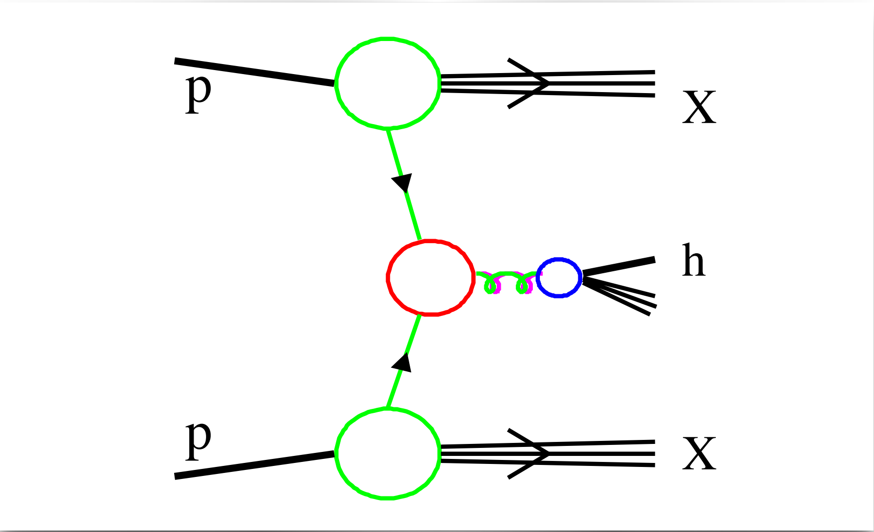

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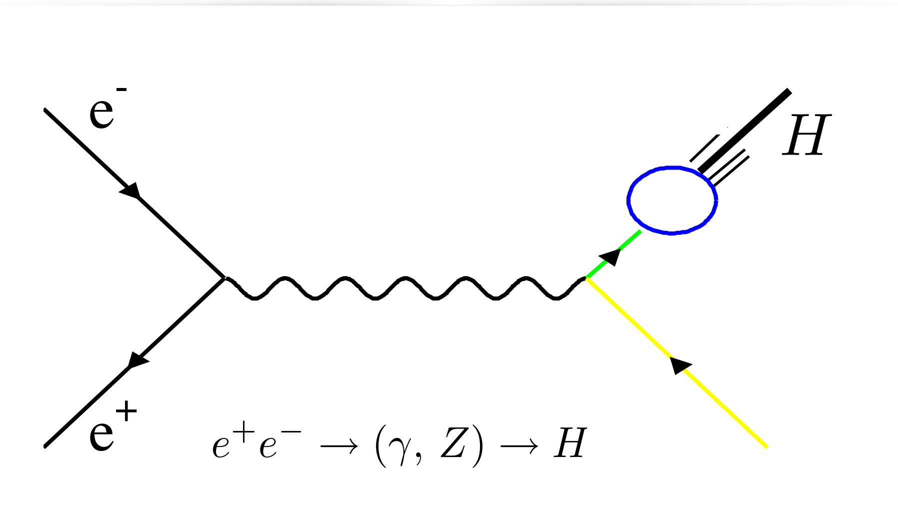

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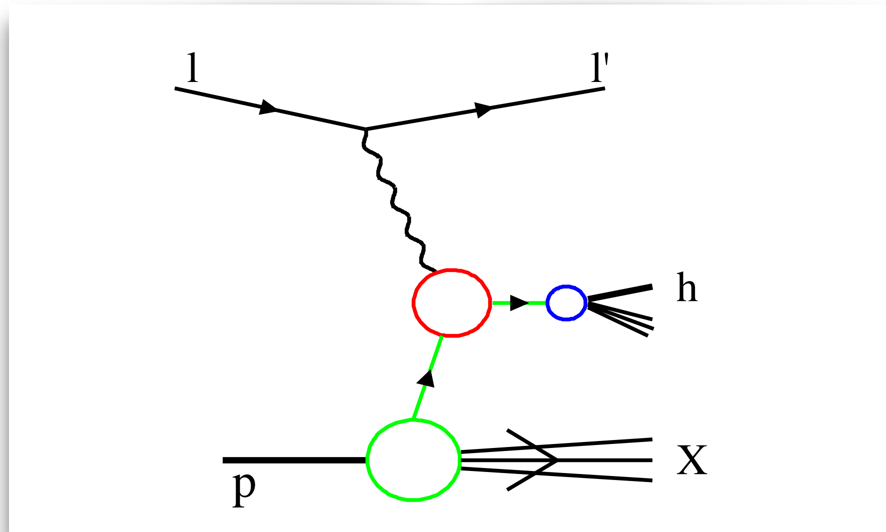

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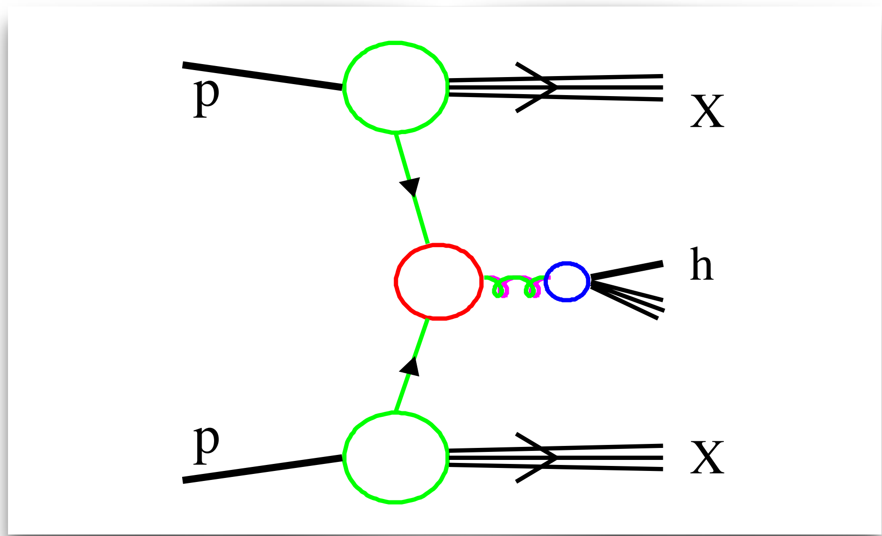

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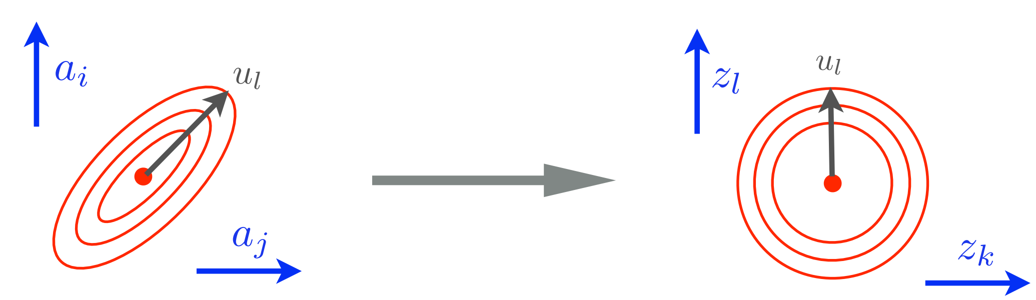

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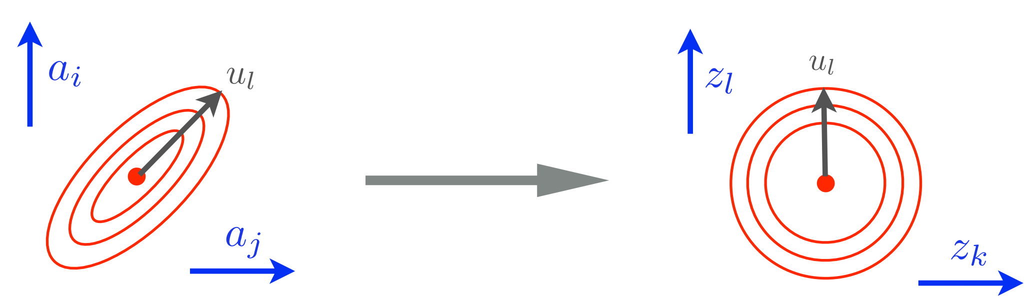

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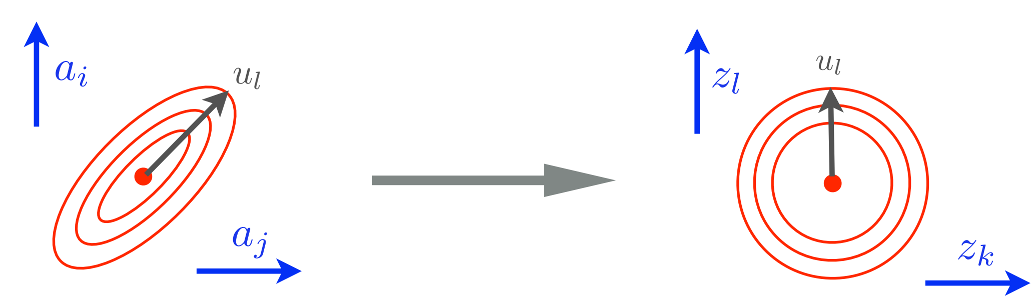

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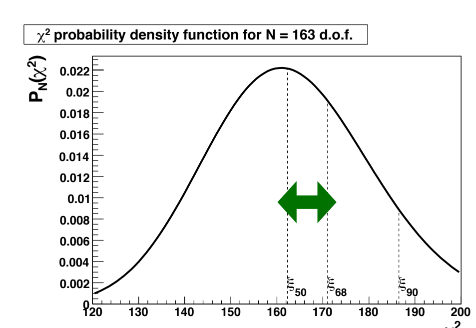
$$\int_0^{\xi_{68}} d\chi^2 \frac{(\chi^2)^{N/2-1} e^{-\chi^2/2}}{2^{N/2}\Gamma(N/2)} = 0.68$$

$$\xi_{50} \longrightarrow \xi_{68}$$



DSS FFs framework:

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theory uncertainties neglected or unknown

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How good are our theory approximations?

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→ illustrative example: NNLO studies

D. Anderle, M. Stratmann, F. Ringer, *Phys. Rev. D 92*, 114010 2015

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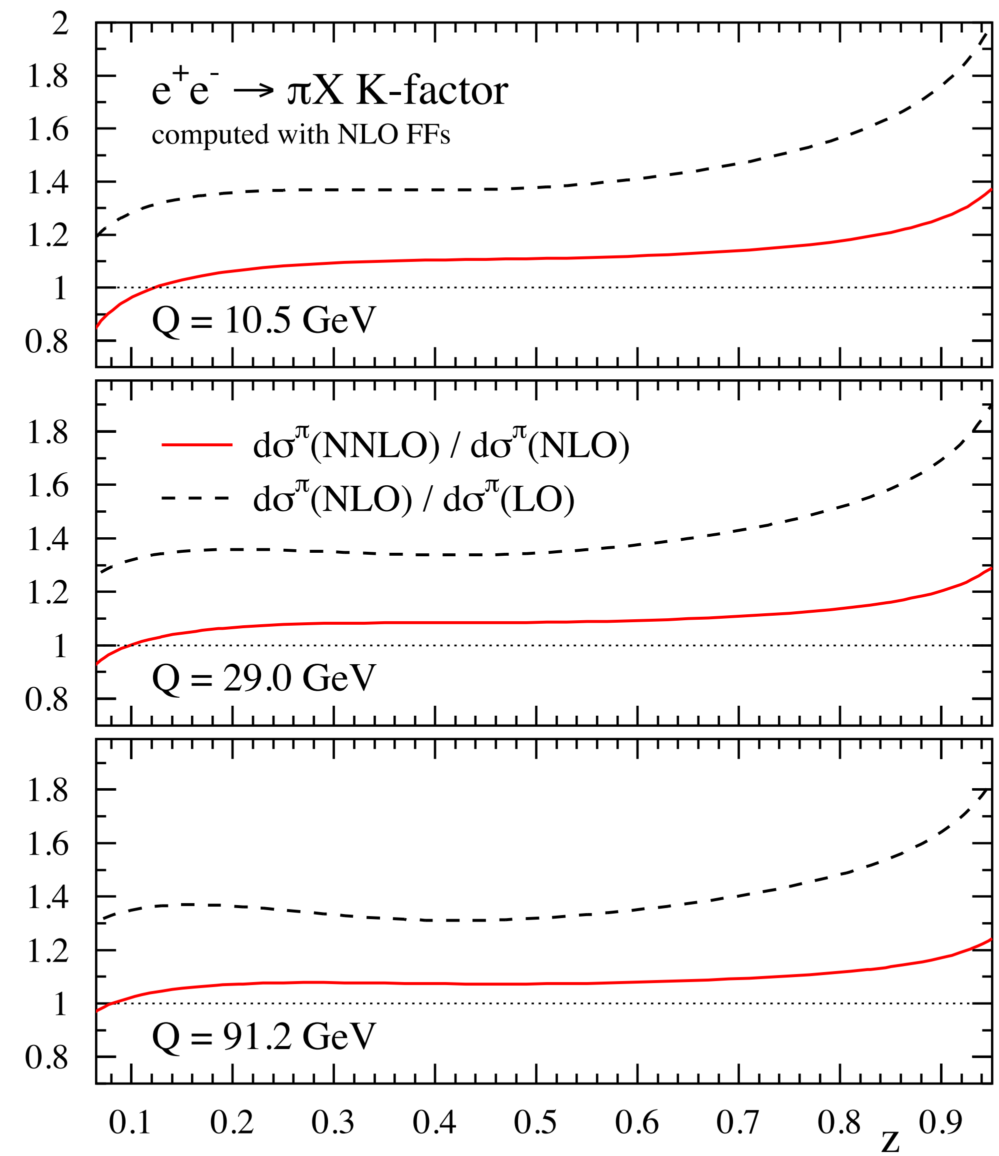

$$K \equiv \frac{d\sigma^\pi(\mathrm{N}^m\mathrm{LO})}{d\sigma^\pi(\mathrm{N}^{m-1}\mathrm{LO})}$$

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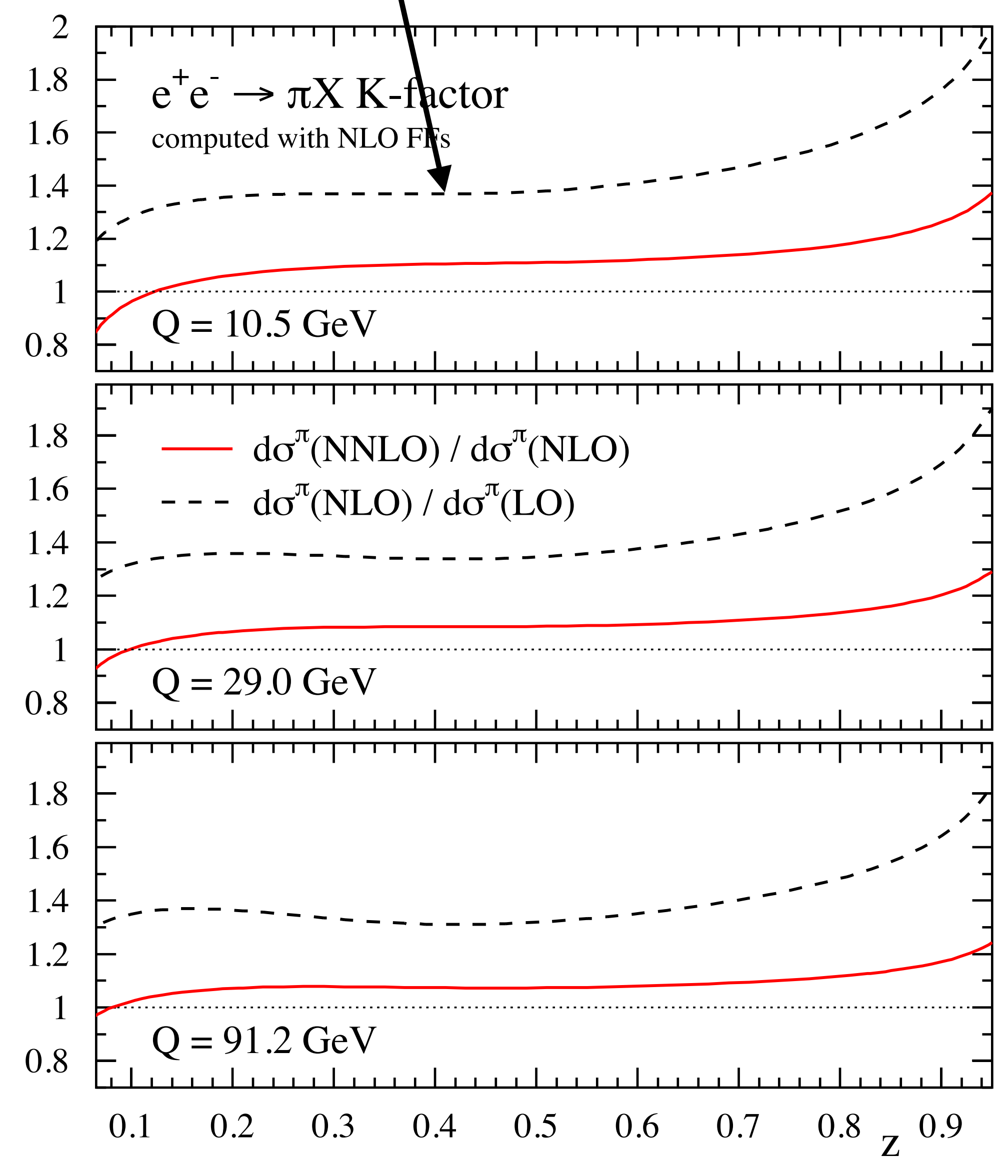
40% correction from LO to NLO



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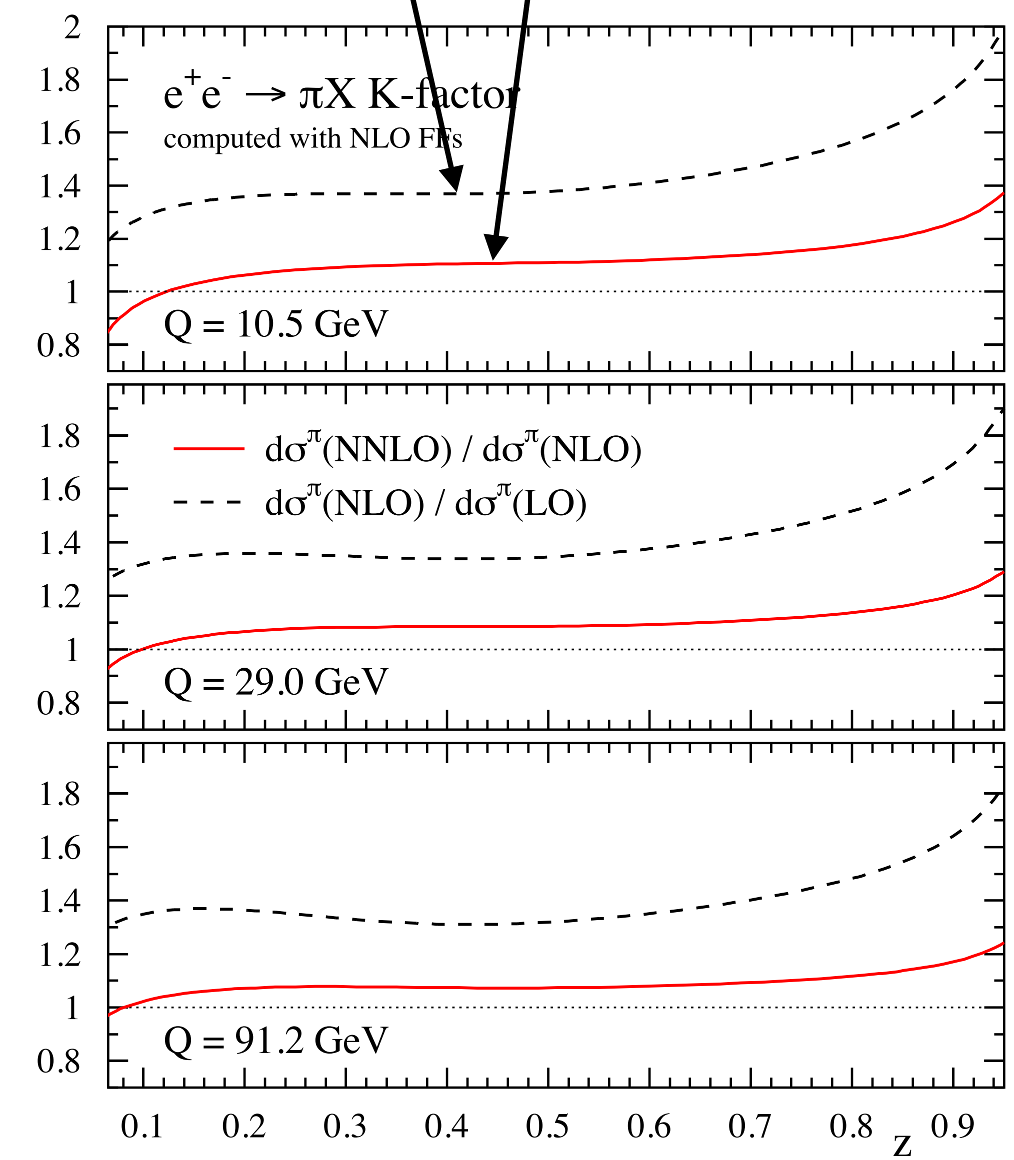
40% correction from LO to NLO

10% correction from NLO to NNLO



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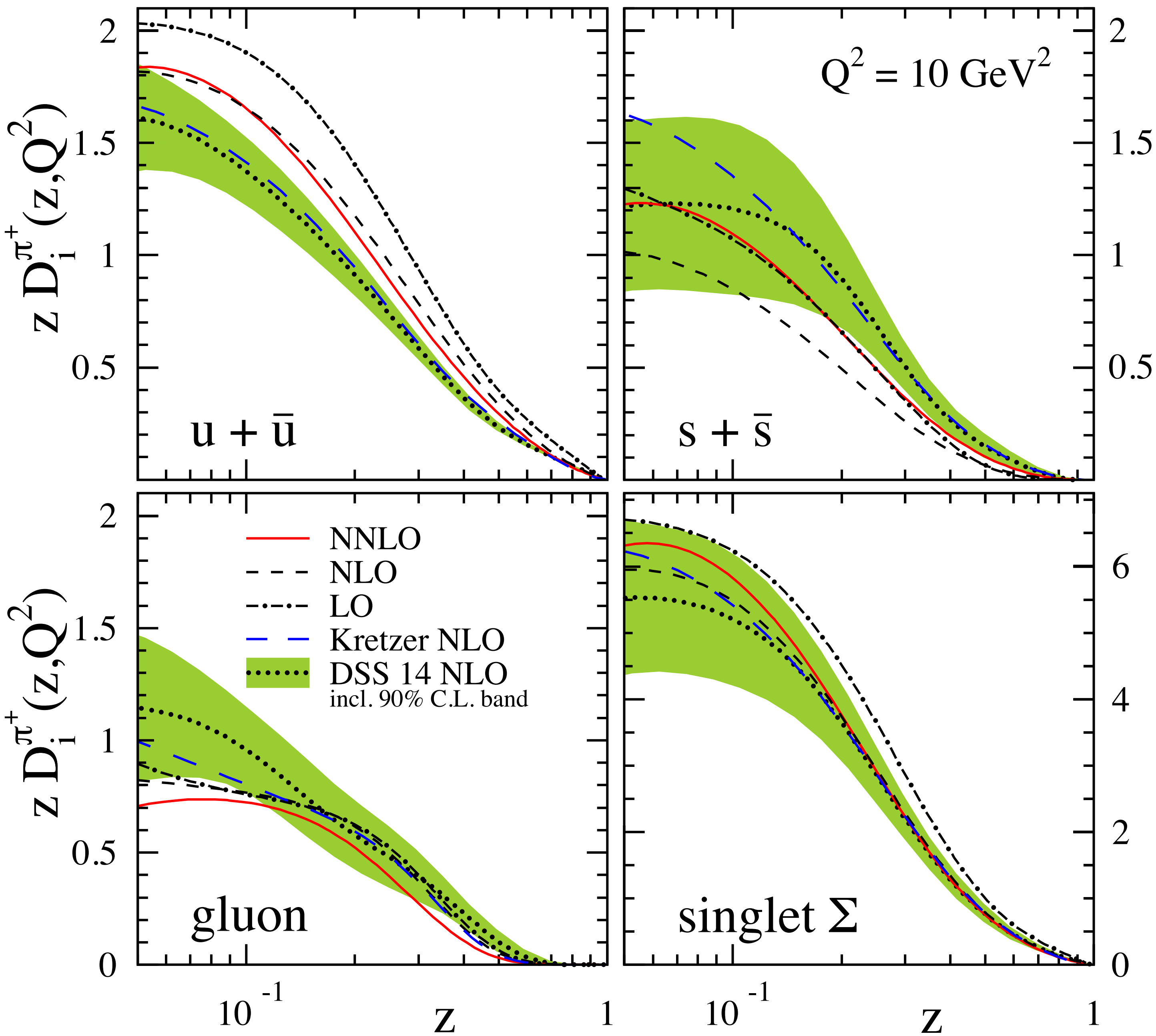

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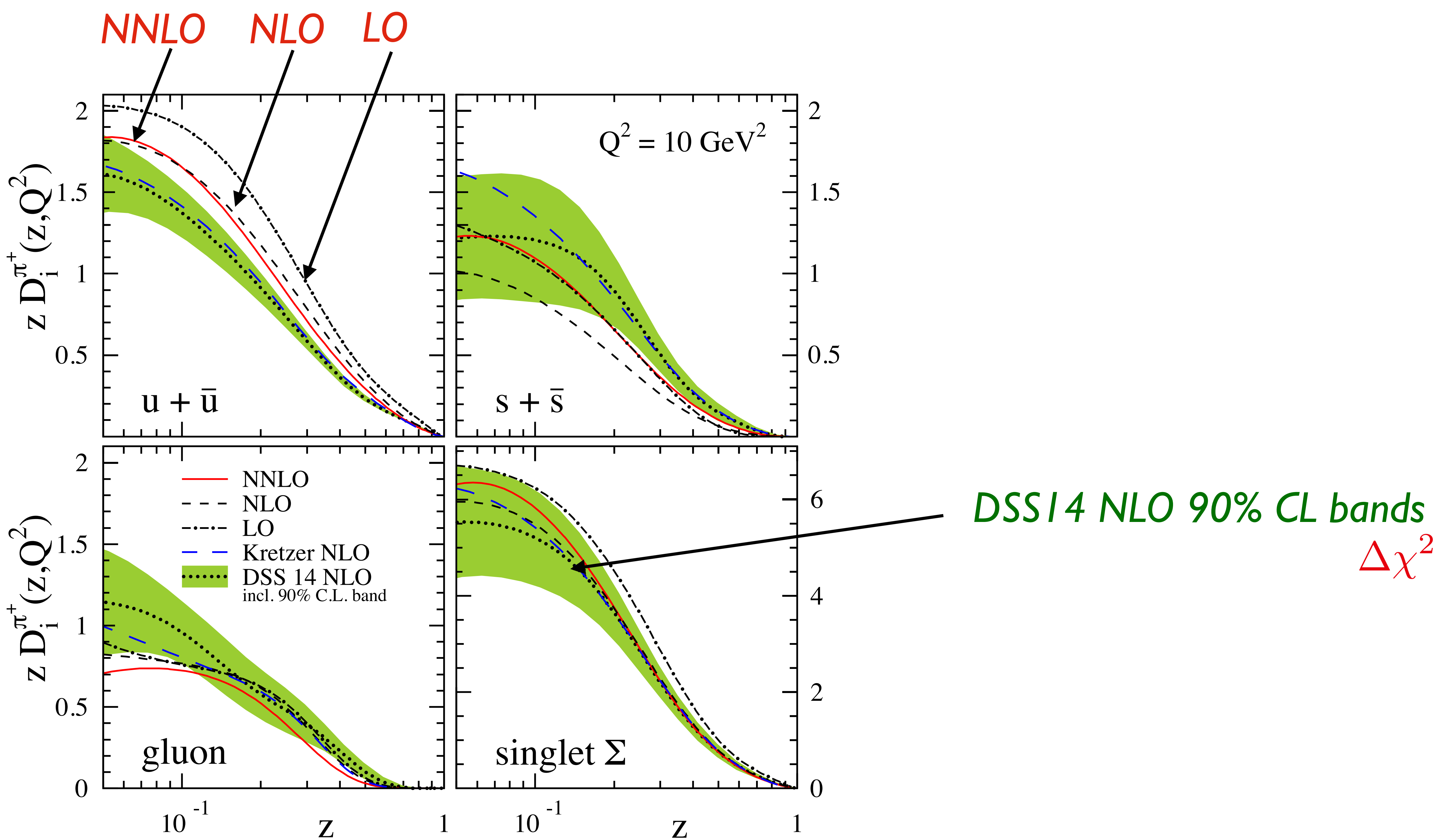

$\Delta\chi^2 = 62$

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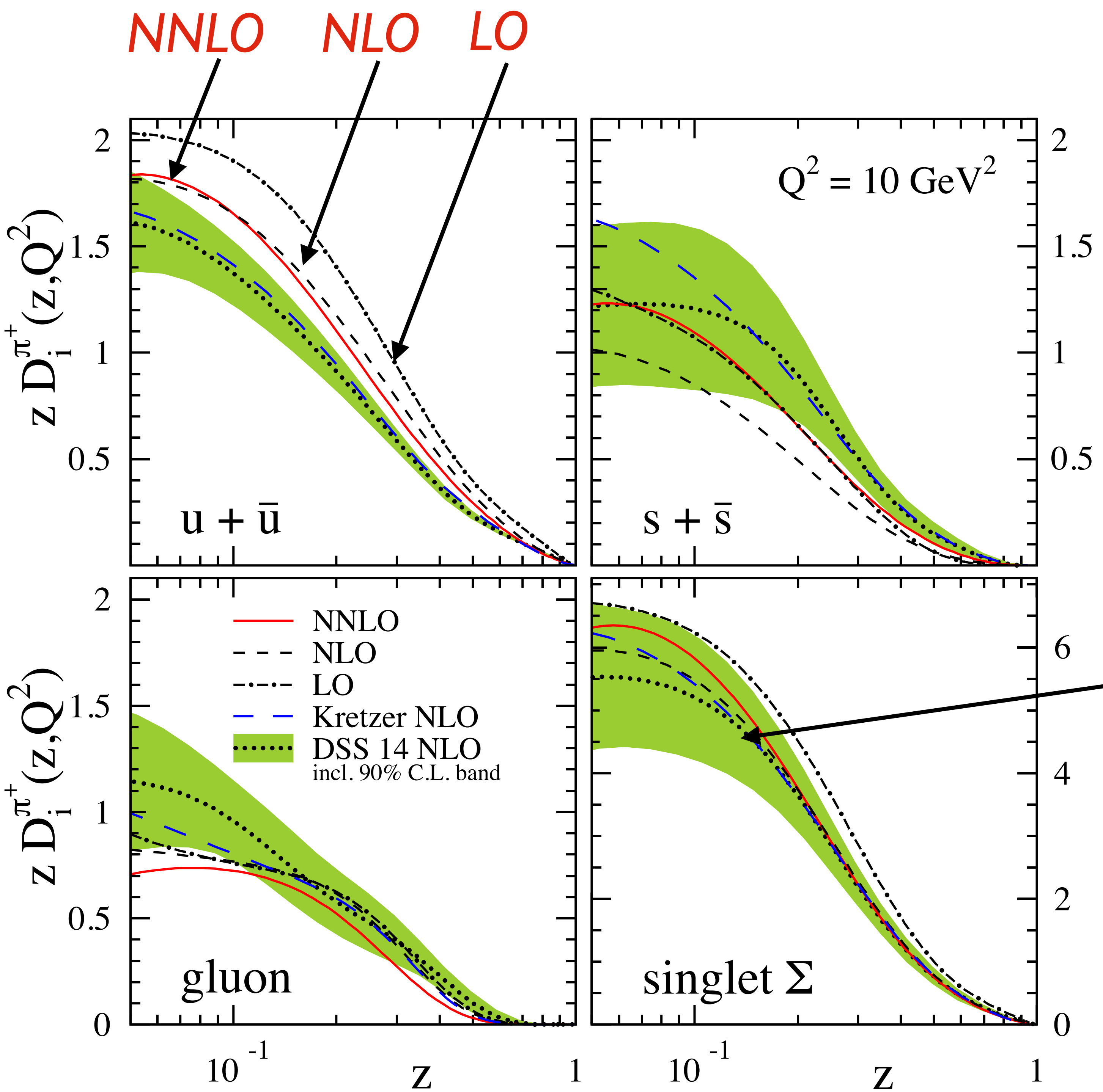
illustrative example: NNLO studies

D. Anderle, M. Stratmann, F. Ringer, *Phys. Rev. D 92*, 114010 2015



DSS14 NLO 90% CL bands

$\Delta\chi^2 = 62$

SIA only fit can constrain the singlet agree with the full fit at NLO

SIA only fit at LO outside 90% CL band

How good are our theory approximations?

➡ illustrative example: pp

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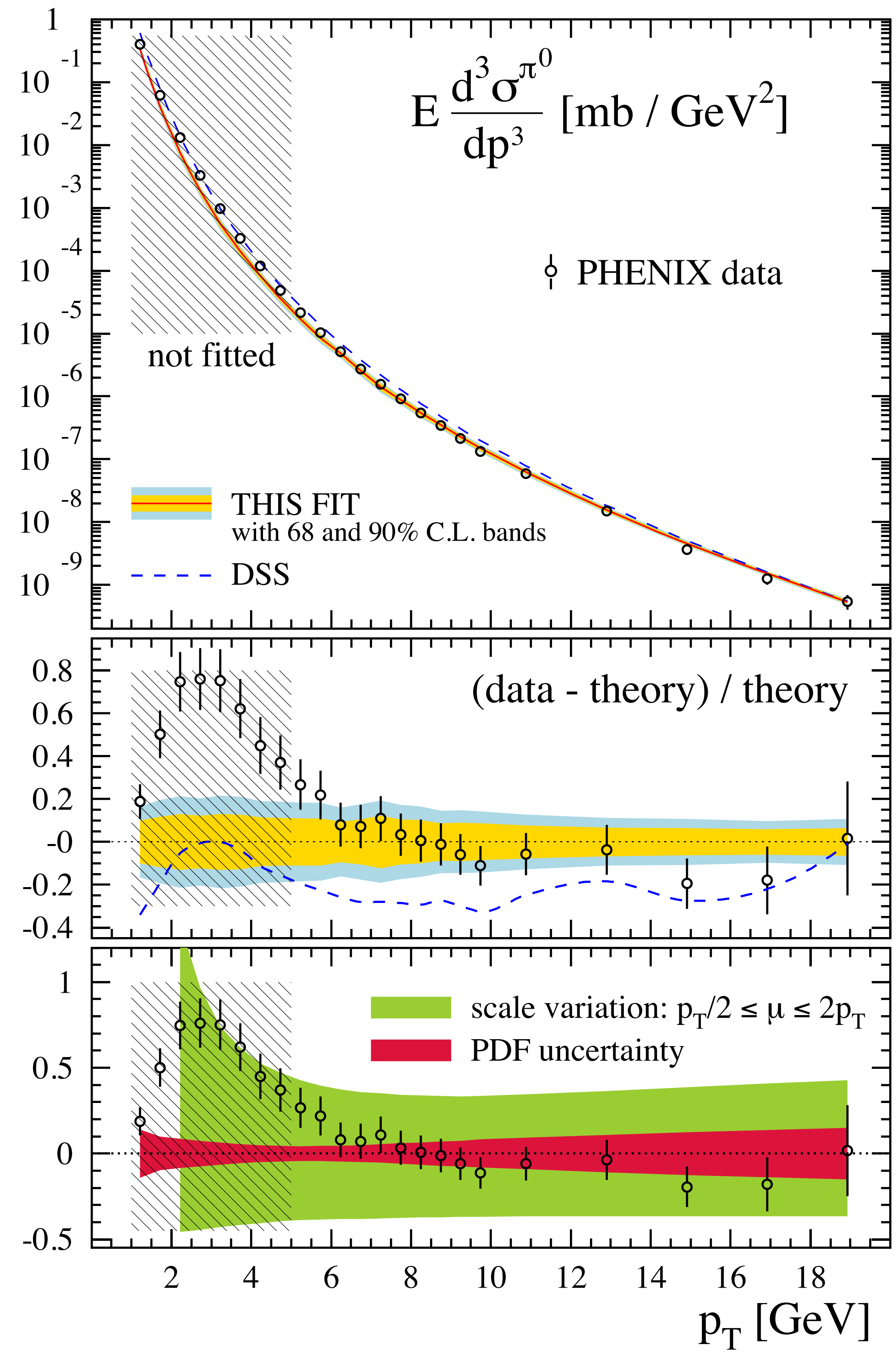
no NNLO calculation yet, no real error estimate

large factorization scale dependence at NLO



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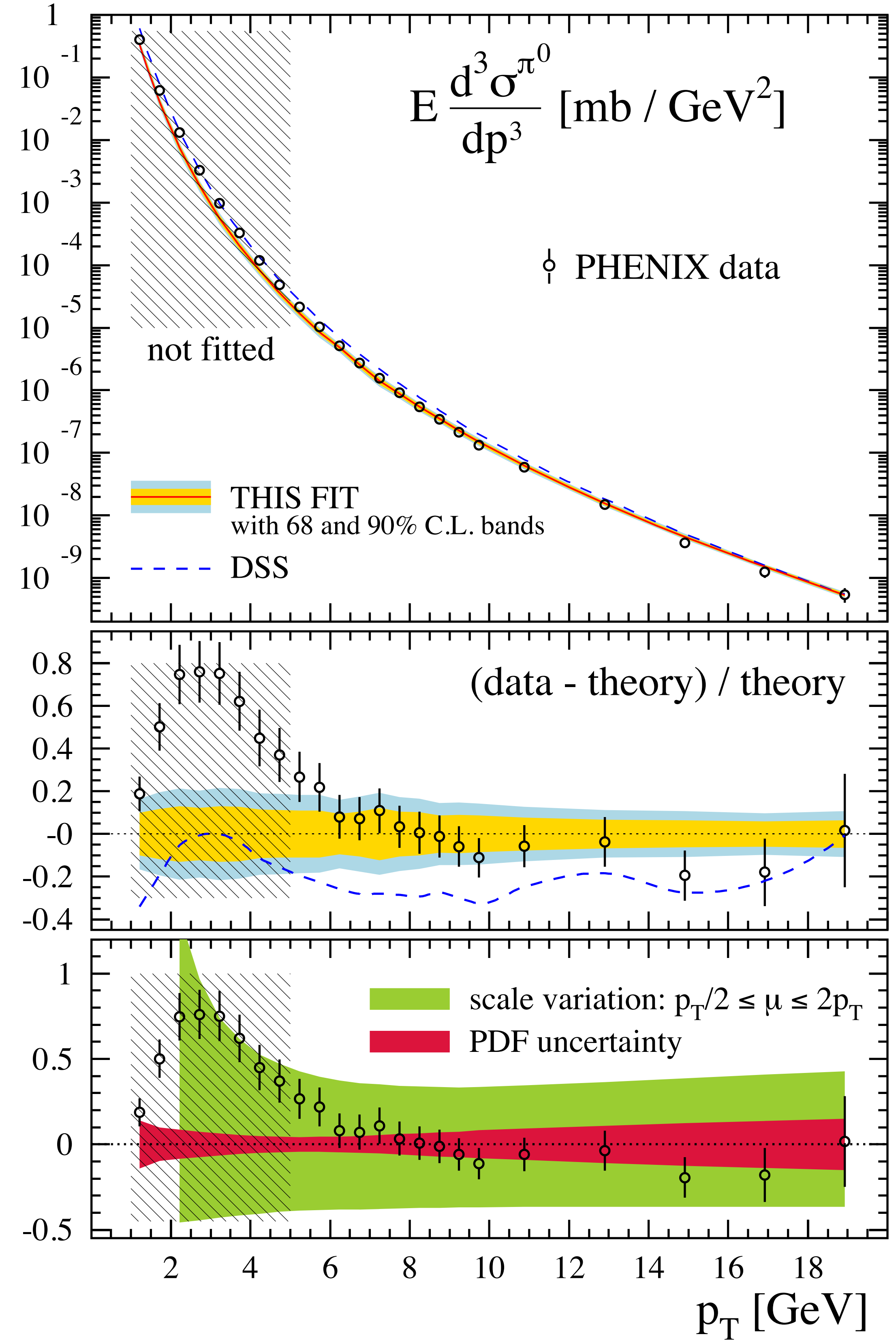

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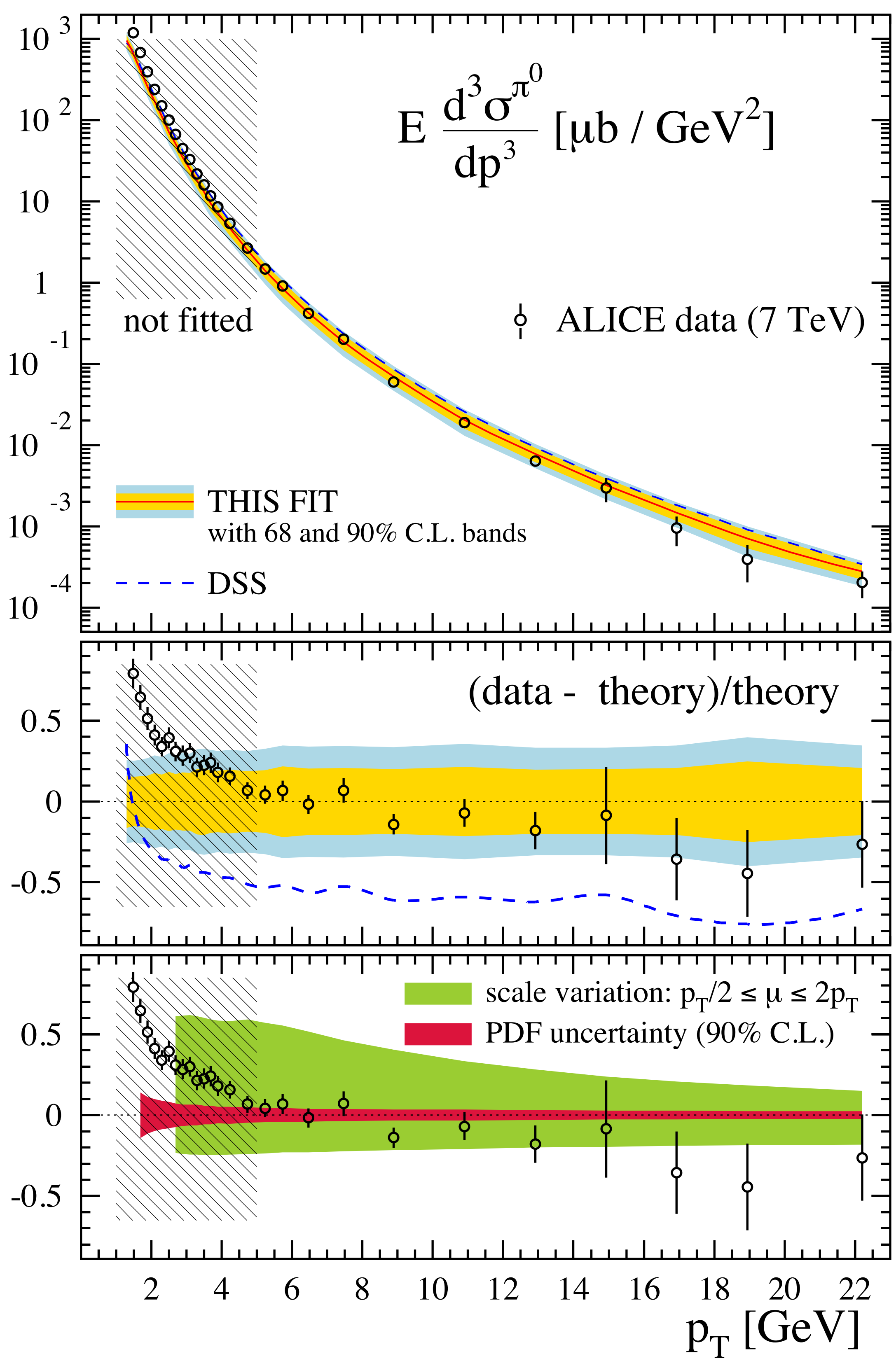

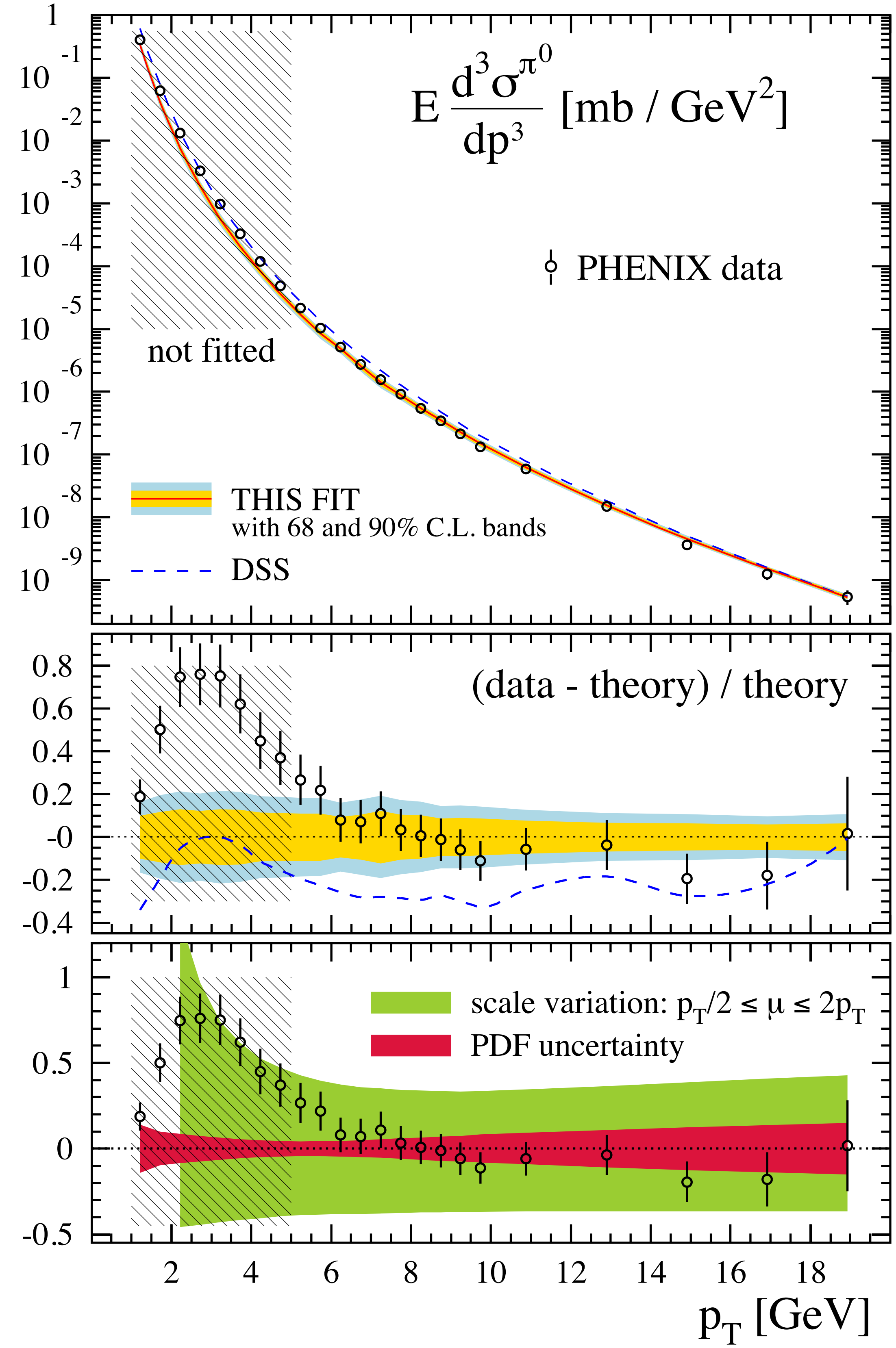

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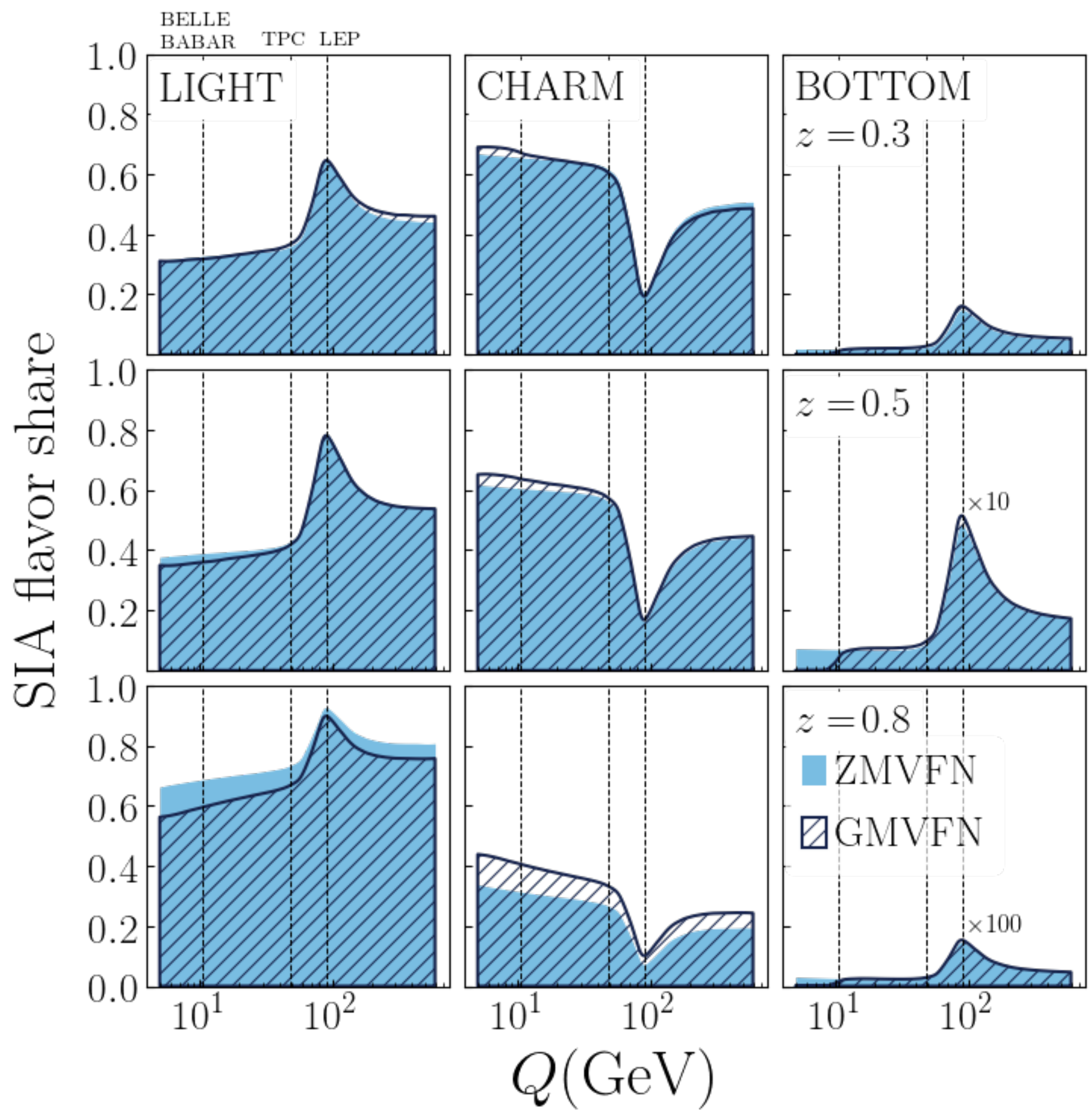

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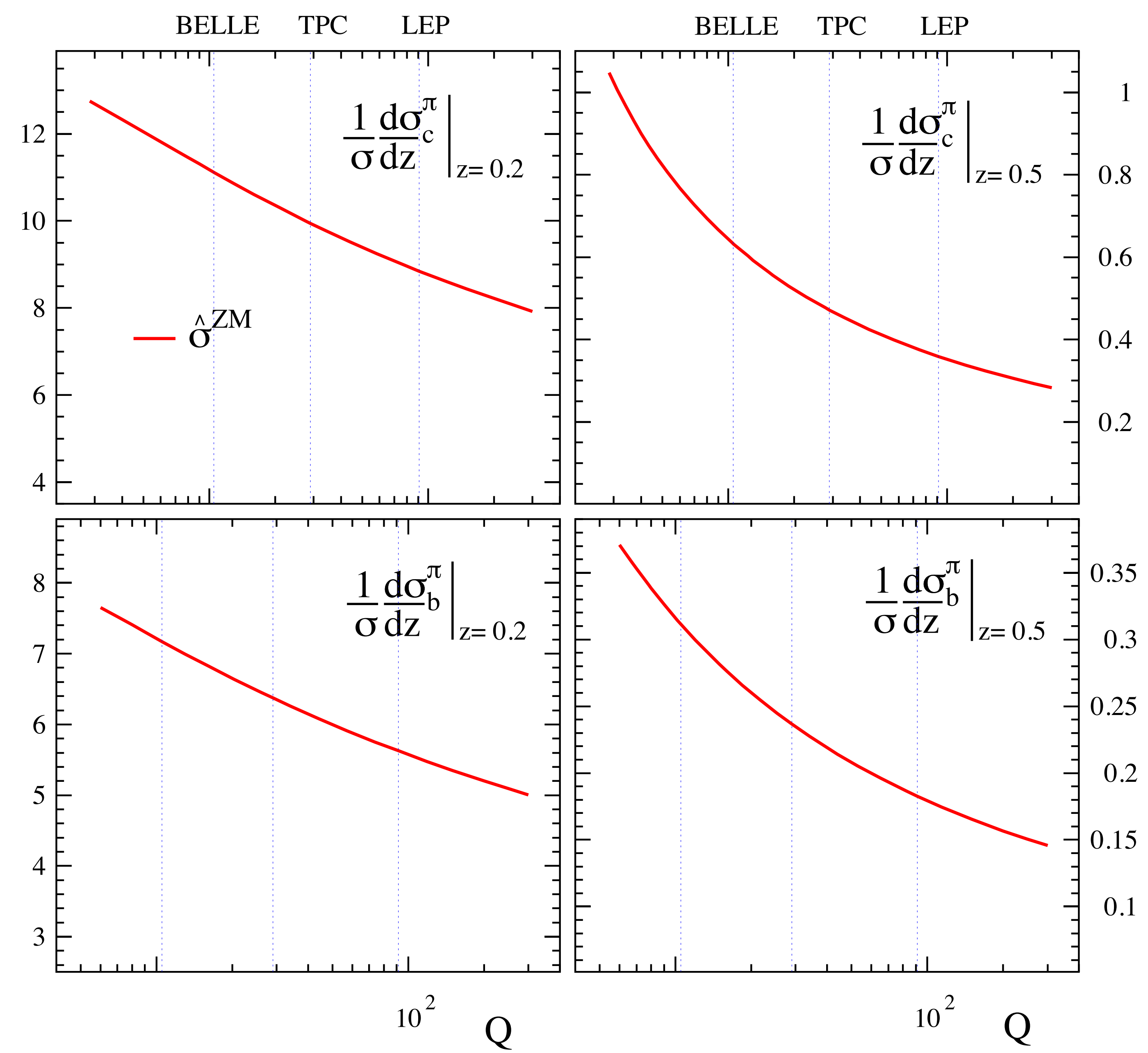

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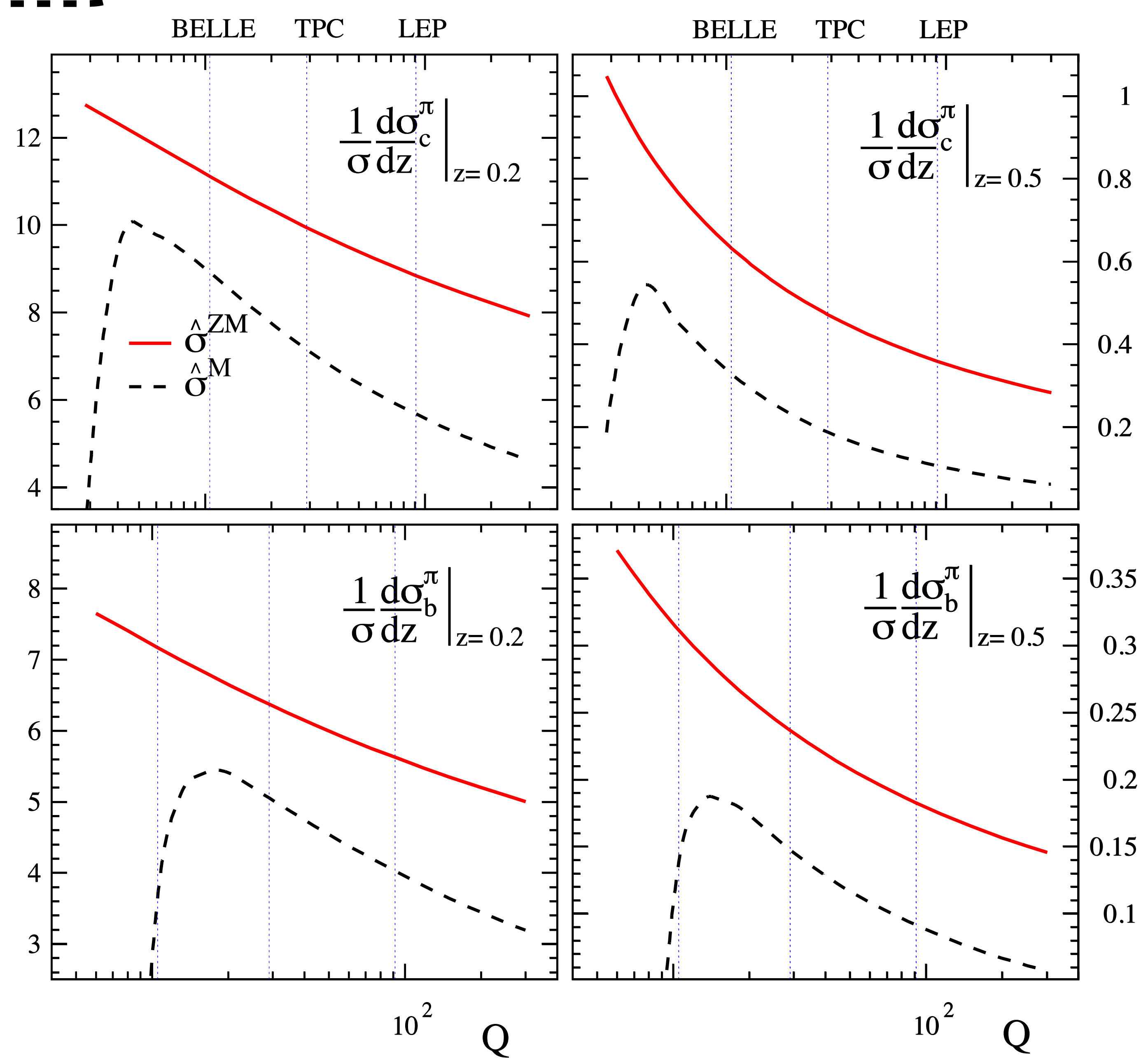

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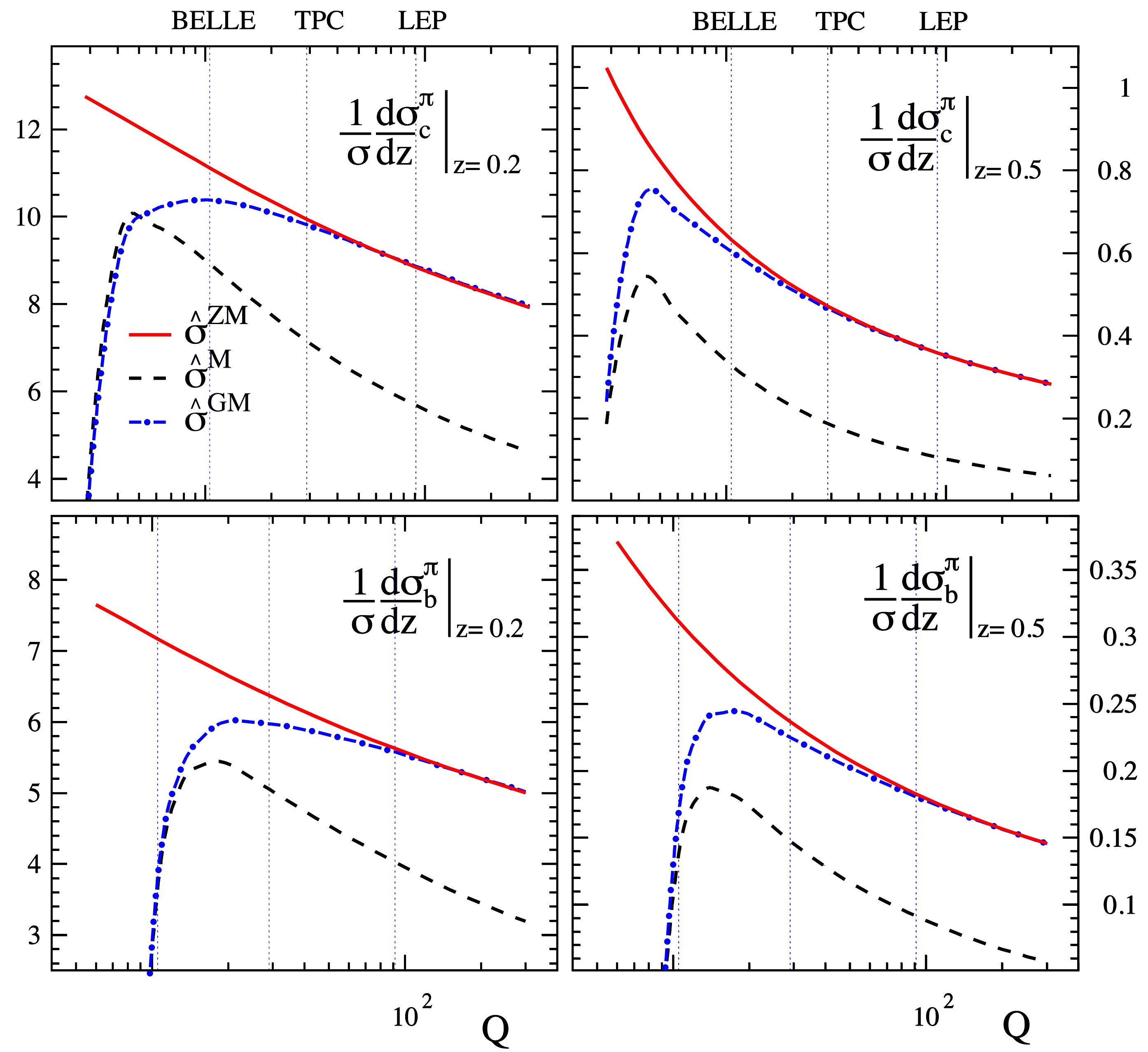

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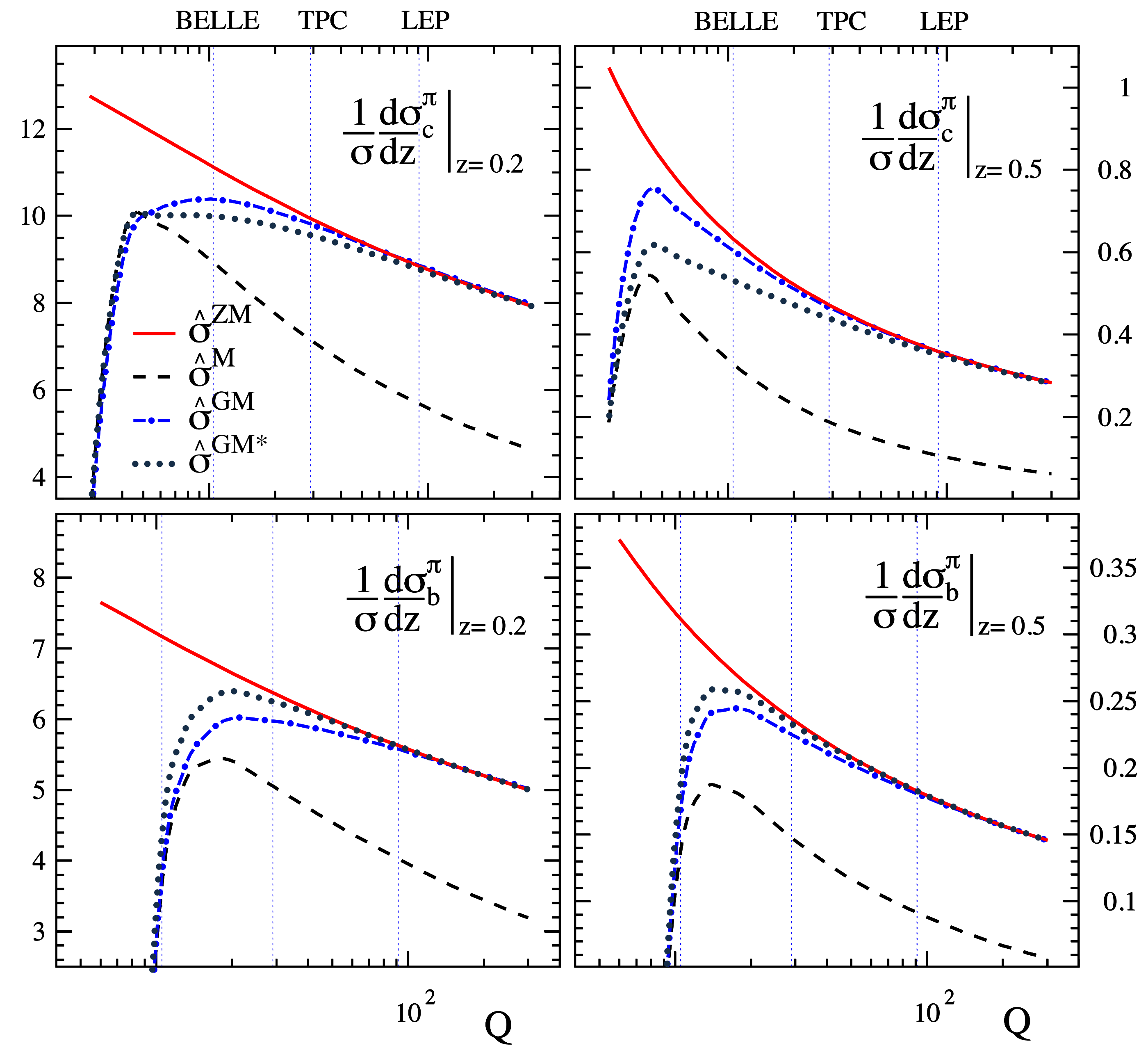

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ALEPH [23]	incl.	22	0.968	21.6	0.994	23.3
BABAR [13]	incl.	39	1.019	76.7	1.002	58.2
BELLE [14]	incl.	78	1.044	19.5	1.019	11.0
DELPHI [24]	incl.	17	0.978	6.7	1.003	9.3
	uds tag	17	0.978	20.8	1.003	9.5
	b tag	17	0.978	10.5	1.003	7.8
OPAL [25]	incl.	21	0.946	27.9	0.970	15.9
SLD [26]	incl.	28	0.938	28.0	0.963	9.5
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TPC [27]	incl.	17	0.997	31.7	1.006	27.9
	uds tag	9	0.997	2.0	1.006	2.0
	c tag	9	0.997	5.9	1.006	4.3
	b tag	9	0.997	9.6	1.006	10.9
COMPASS [28]	$\pi^\pm$ (d)	398	1.003	378.7	1.008	382.9
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PHENIX [30]	π^0	15	1.174	14.3	1.167	14.4
STAR [31]	$\pi^\pm$, π^0	38	1.205	31.2	1.202	33.8
ALICE [32]	π^0	11	0.696	33.3	0.700	31.2
TOTAL:		924		966.4		875.8

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OPAL [25]	incl.	21	0.946	27.9	0.970	15.9
SLD [26]	incl.	28	0.938	28.0	0.963	9.5
	uds tag	17	0.938	21.3	0.963	11.3
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much better χ^2

Heavy quark masses:

$$\boxed{\frac{d\sigma}{dz}^{\mathrm{ZMVFN}} = \sum_{i=q,g,h} \hat{\sigma}_i^{\mathrm{ZM}}(z,Q) \otimes D_i^{\mathrm{ZM}}(z,Q)}$$

$$\frac{d\sigma}{dz}^{\mathrm{M}} = \sum_{i=q,g} \hat{\sigma}_i^{\mathrm{M}}(Q,m_h) \otimes D_i^{\mathrm{M}}(Q) + \hat{\sigma}_h^{\mathrm{M}}(Q,m_h) \otimes D_h^{\mathrm{M}}$$

$$\hat{\sigma}_i^{\mathrm{M}}(Q,m_h) \xrightarrow[m_h \to 0]{} \sum_{j=q,g,h} \hat{\sigma}_j^{\mathrm{ZM}}(Q) \otimes \mathcal{A}_{ji}(Q/m_h)$$

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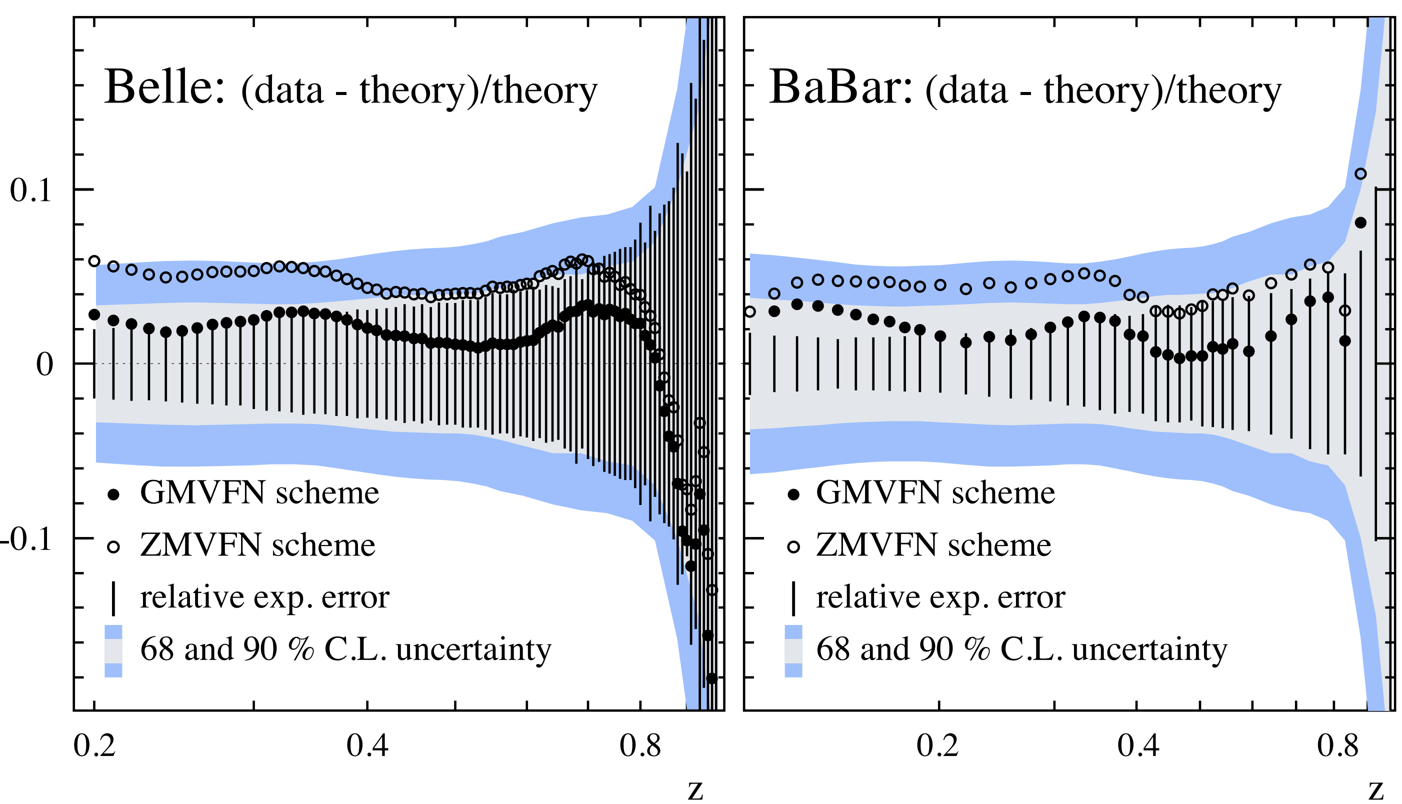
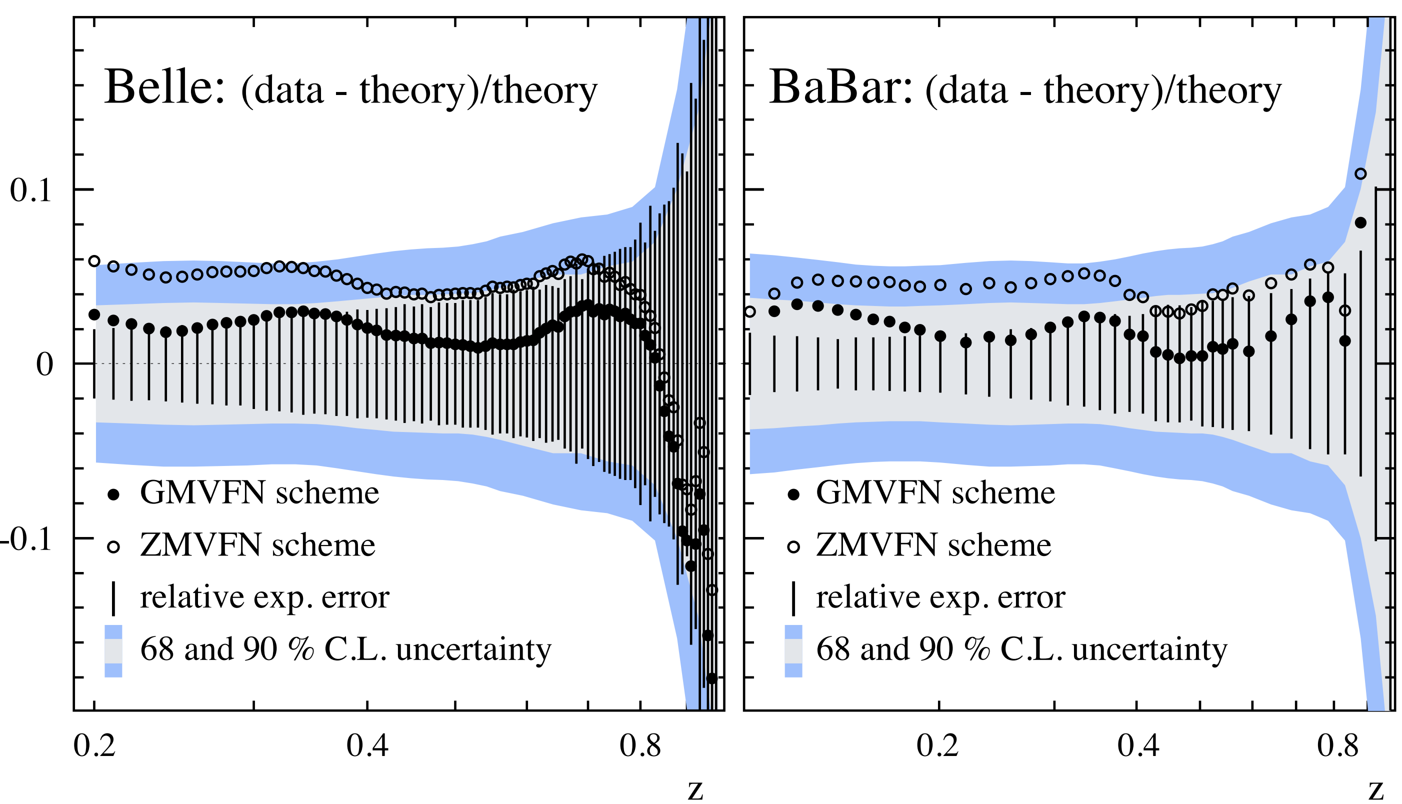


Heavy quark masses:



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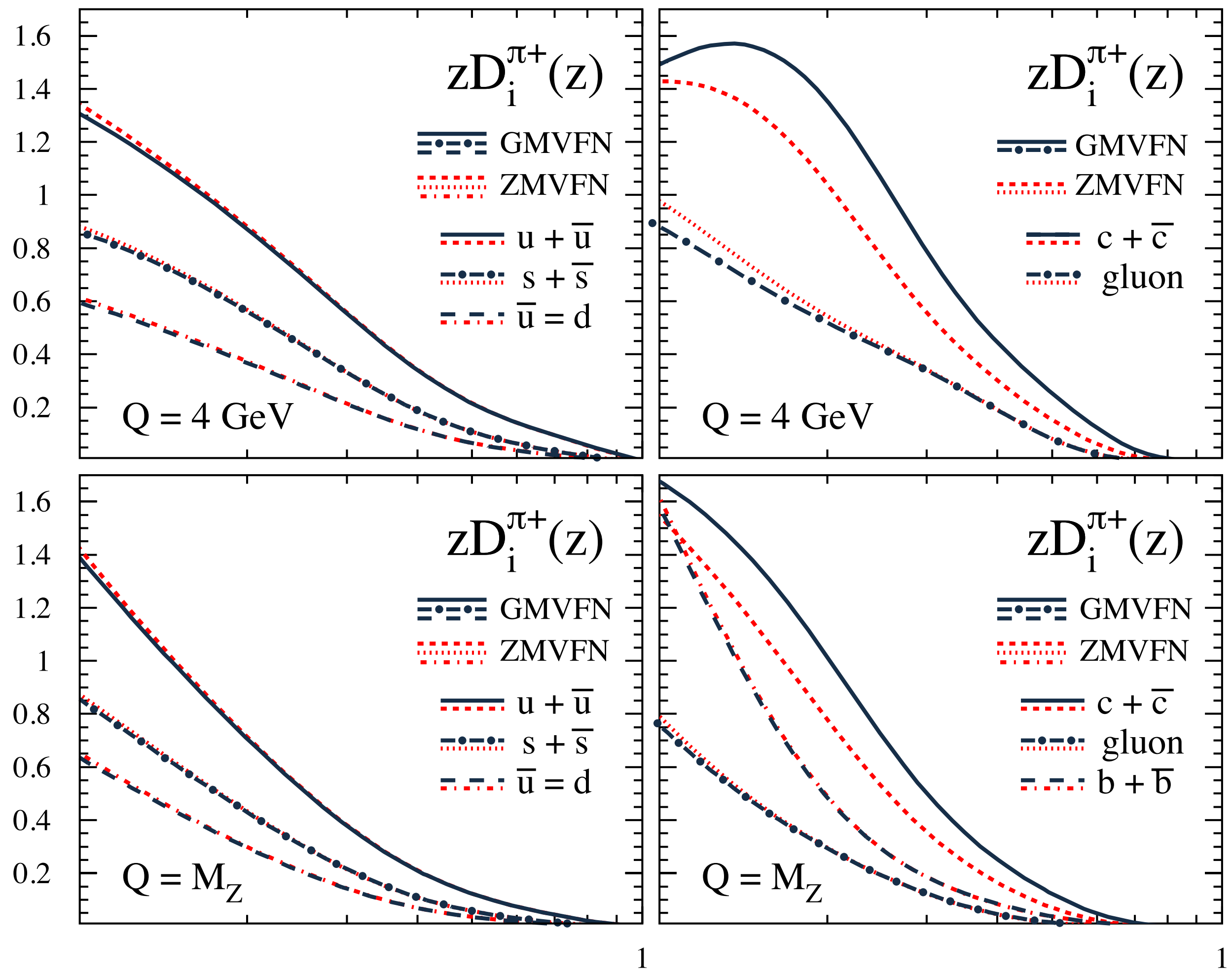

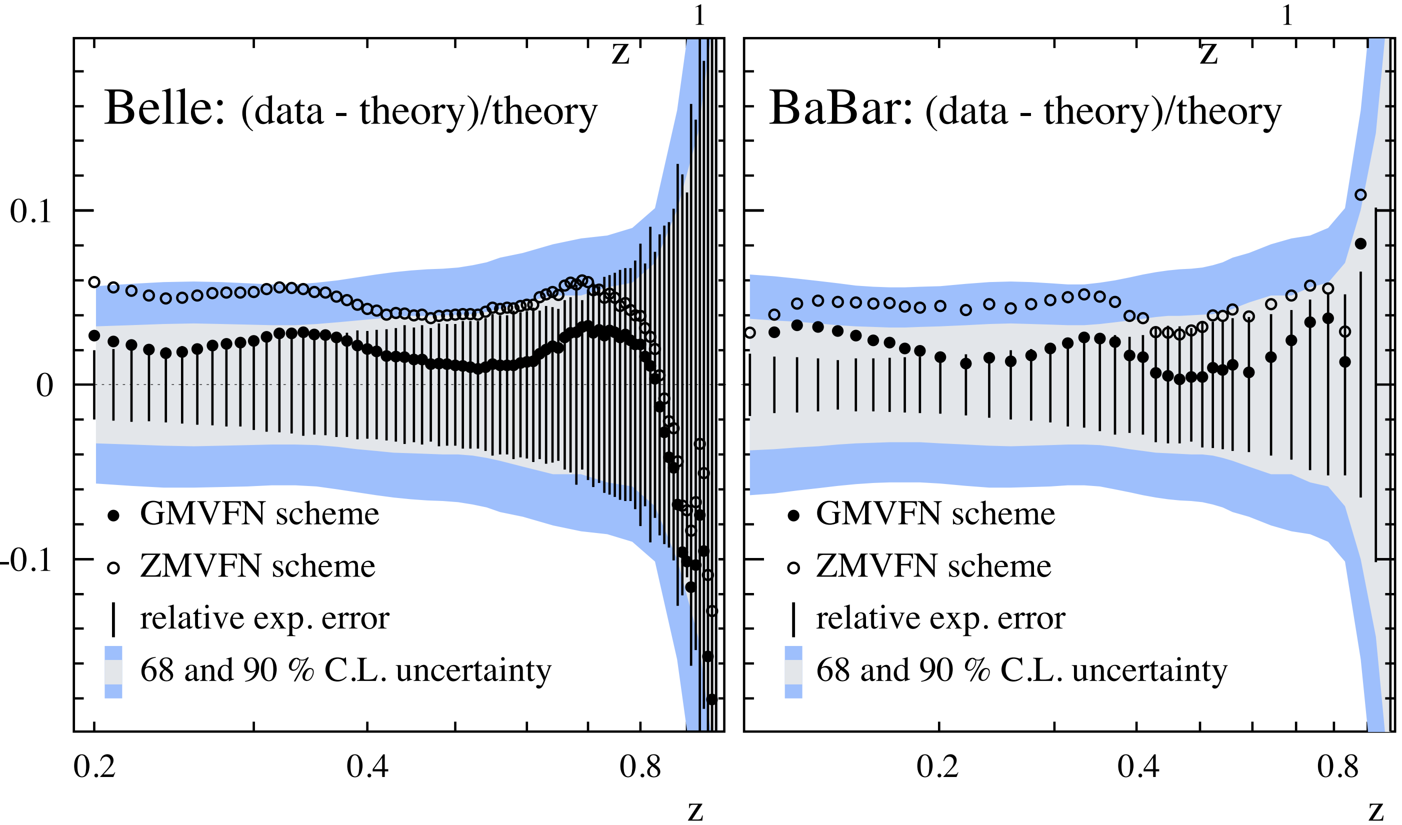

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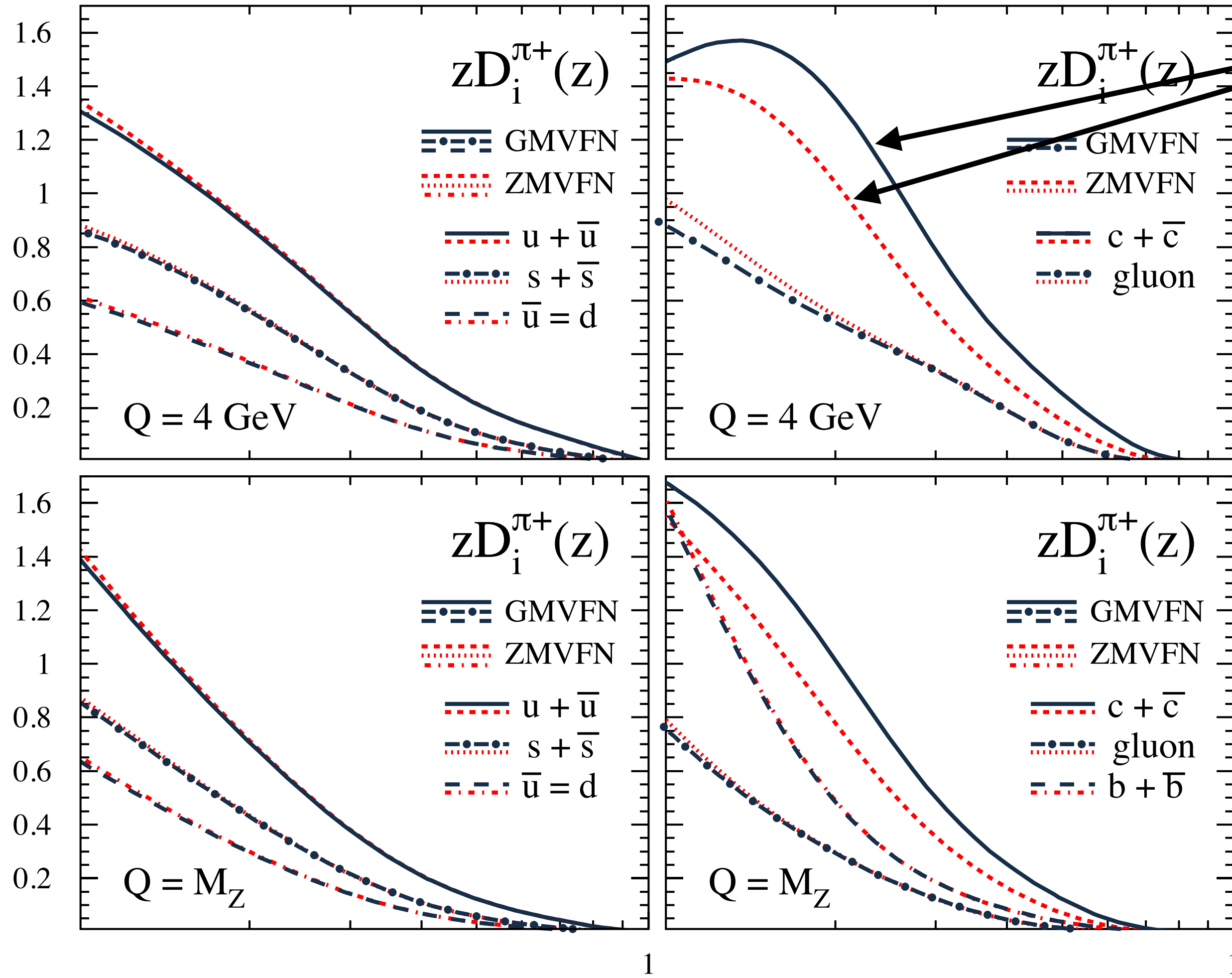
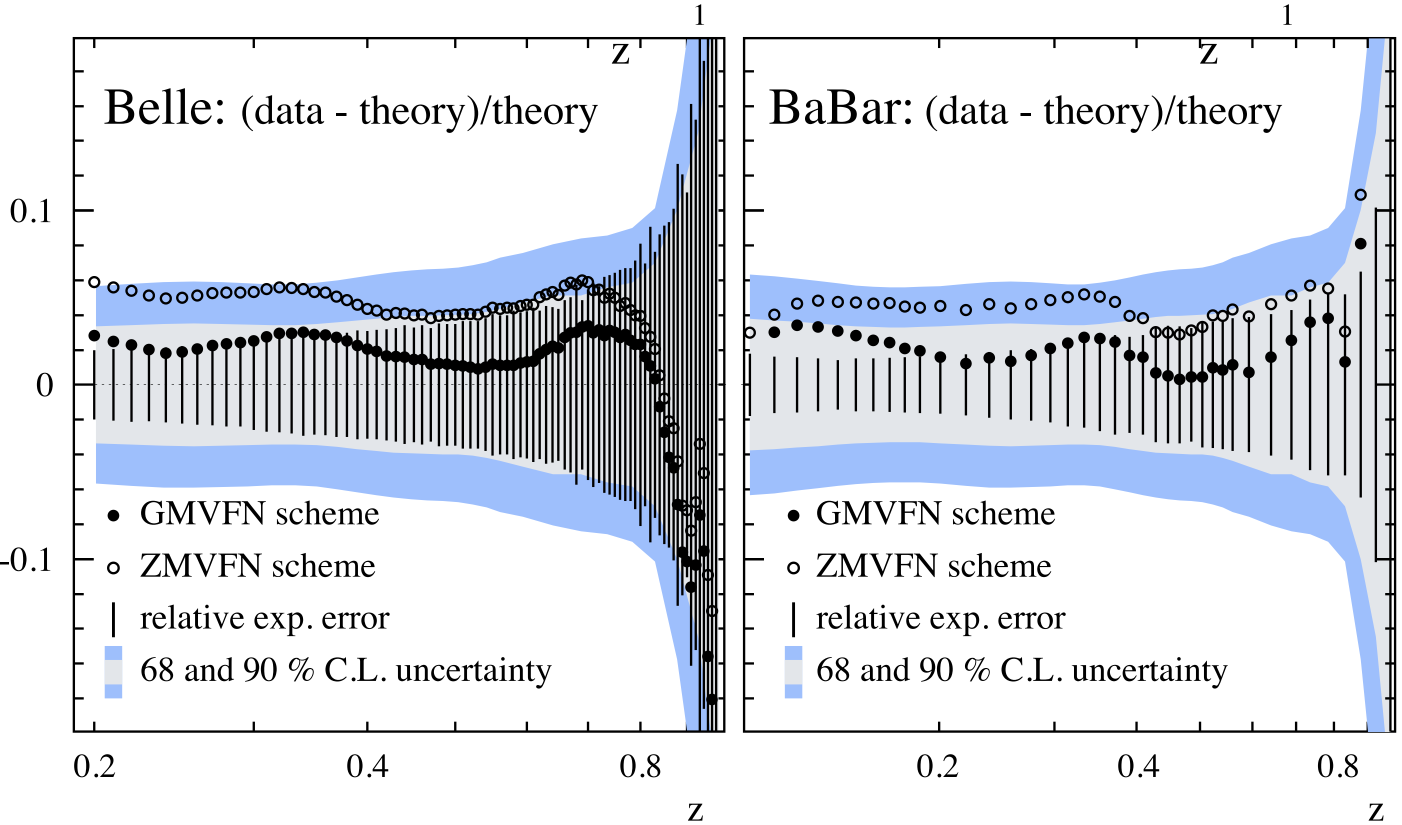
charm changes significantly





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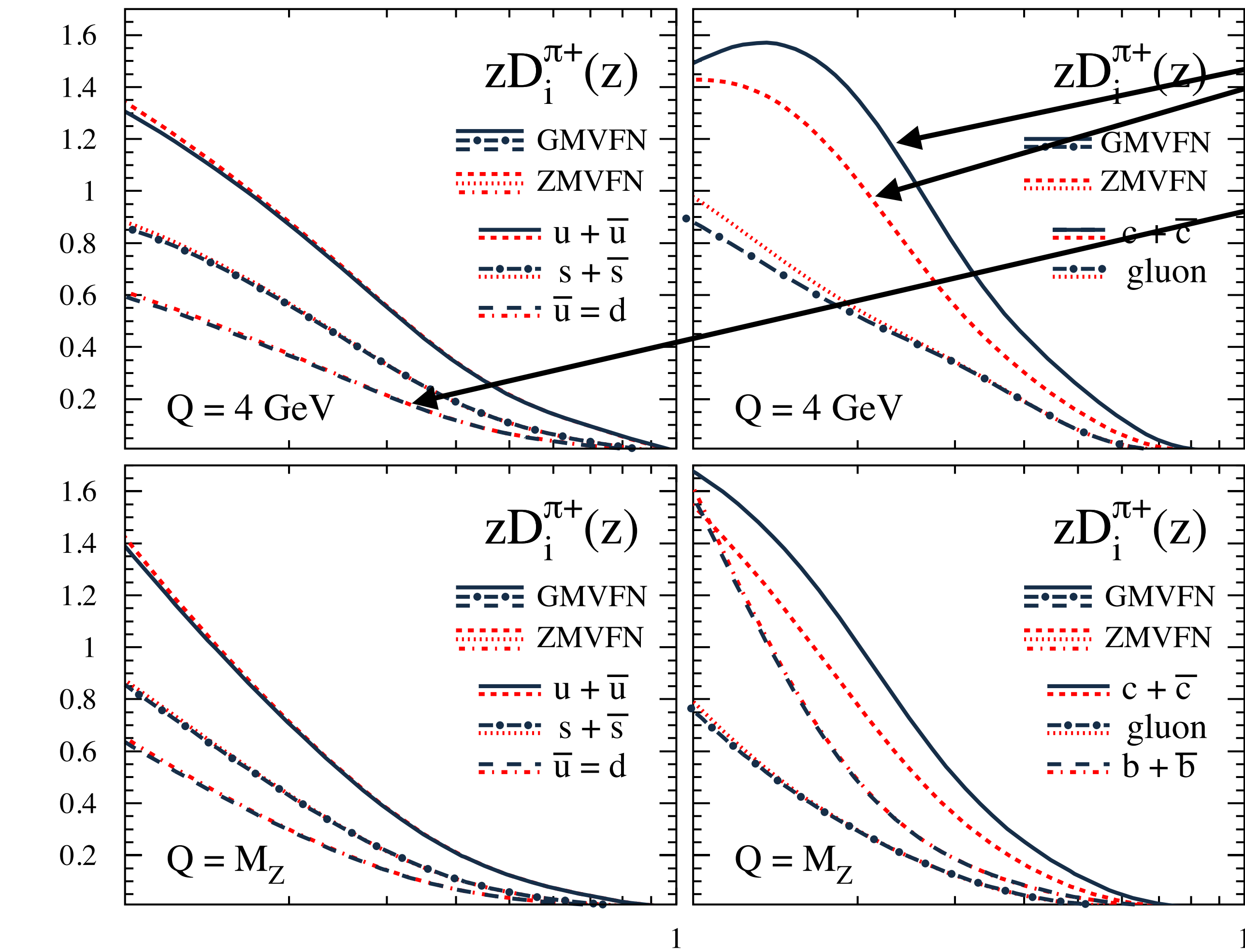

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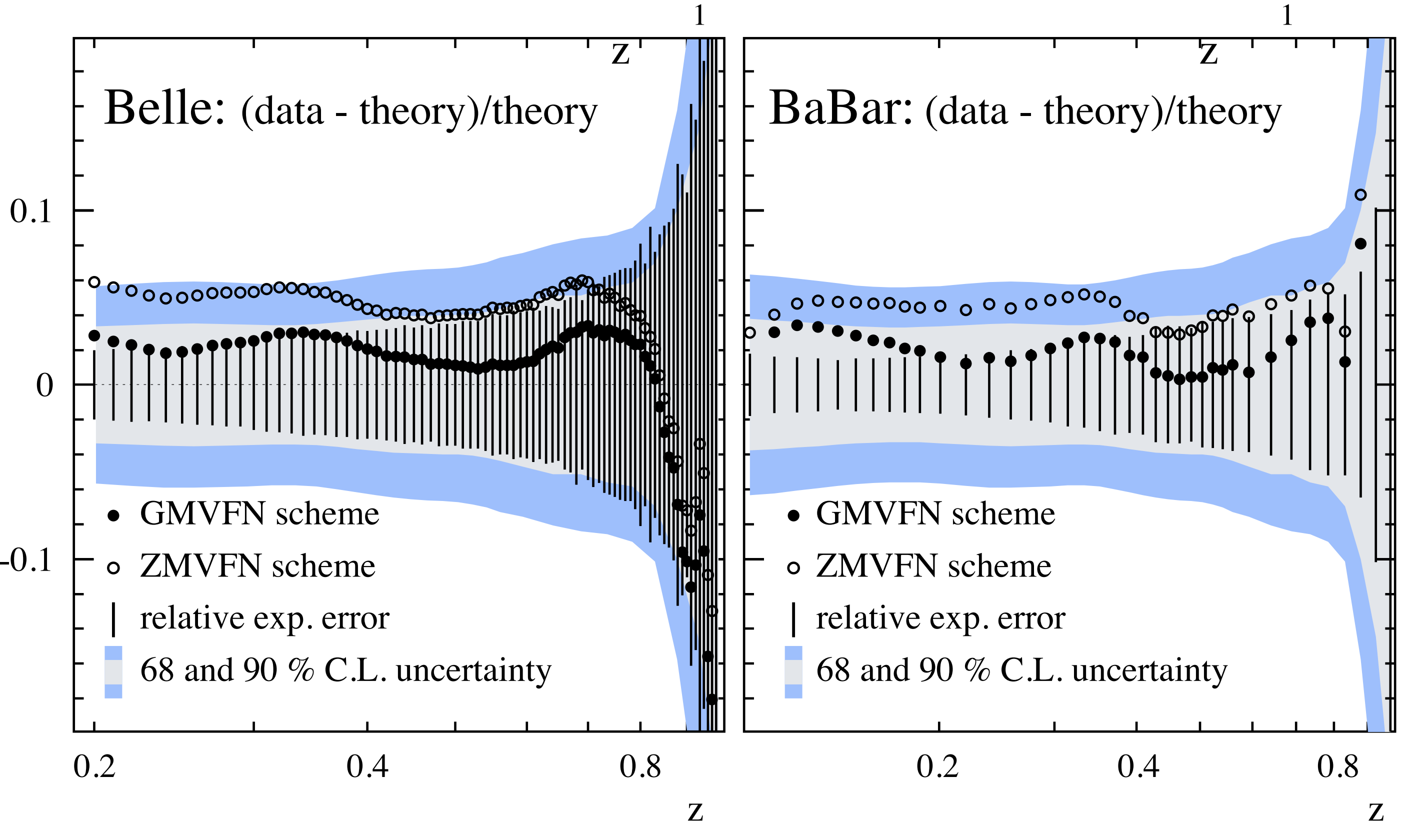
light flavors constrained by sidis



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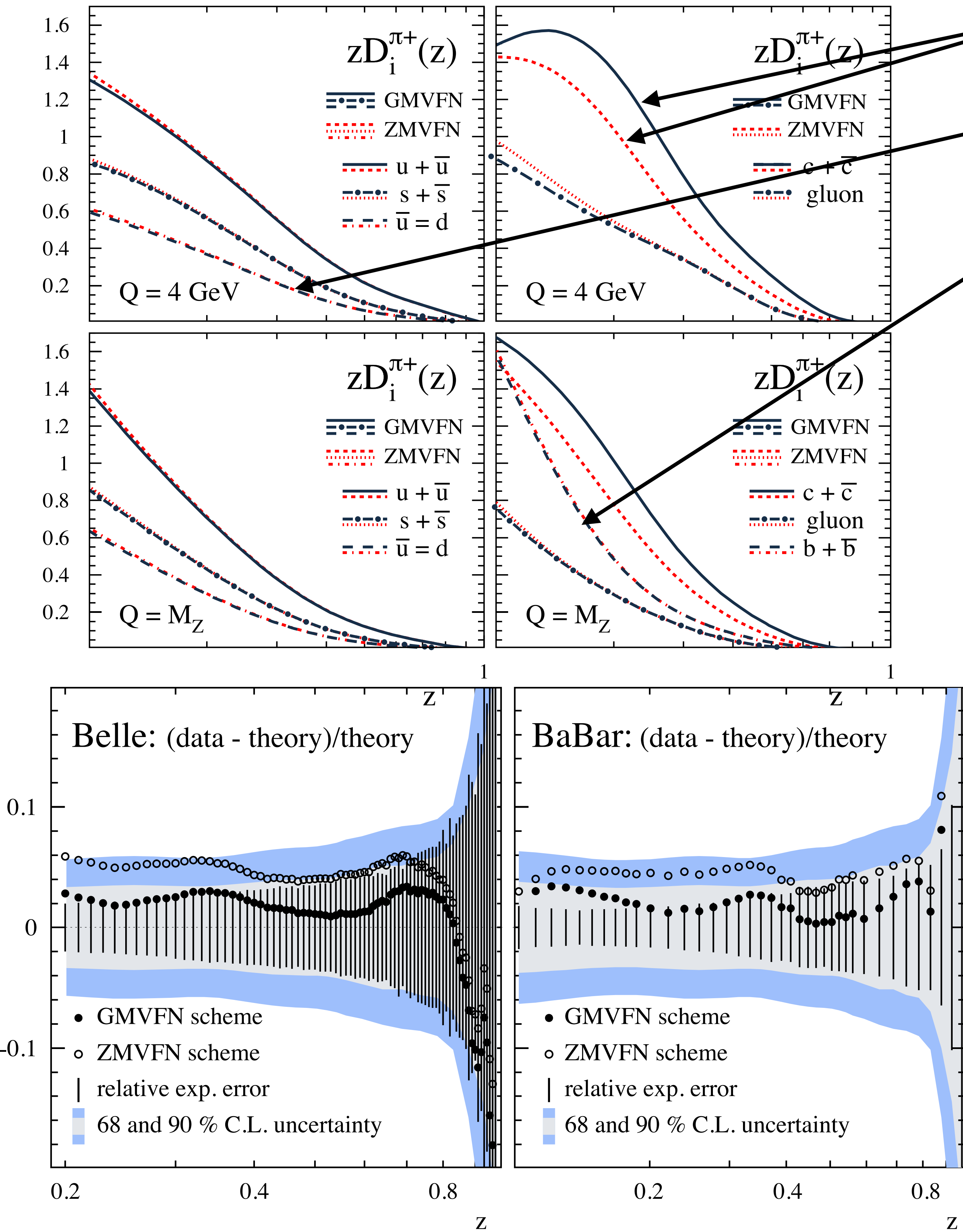

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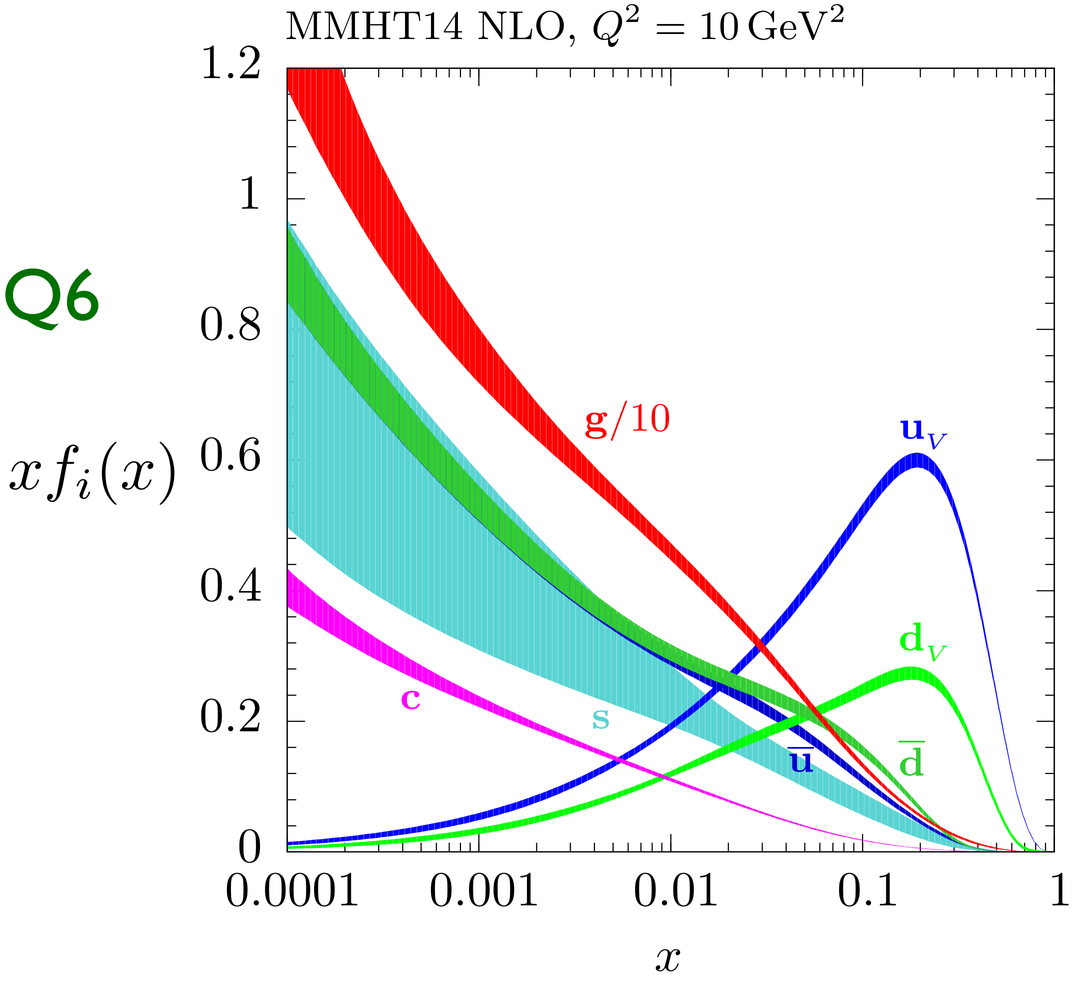

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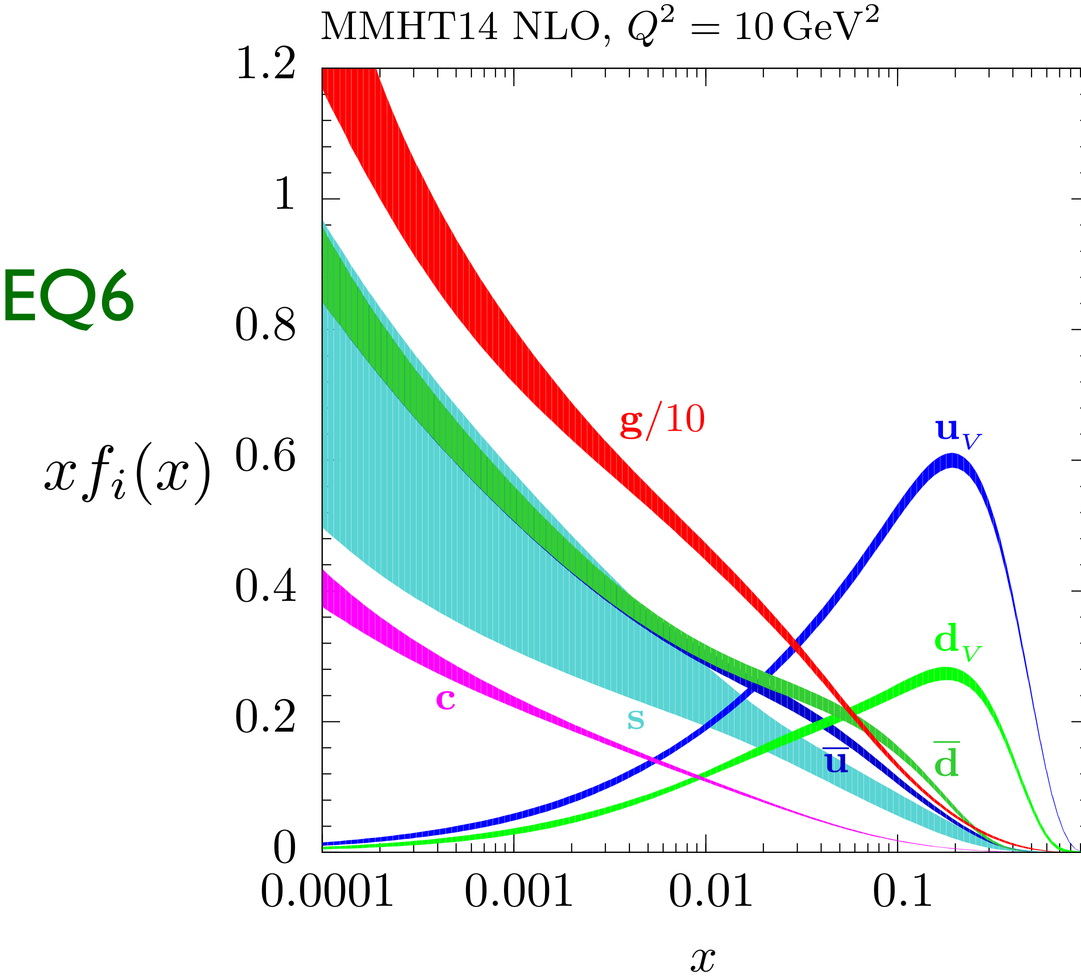

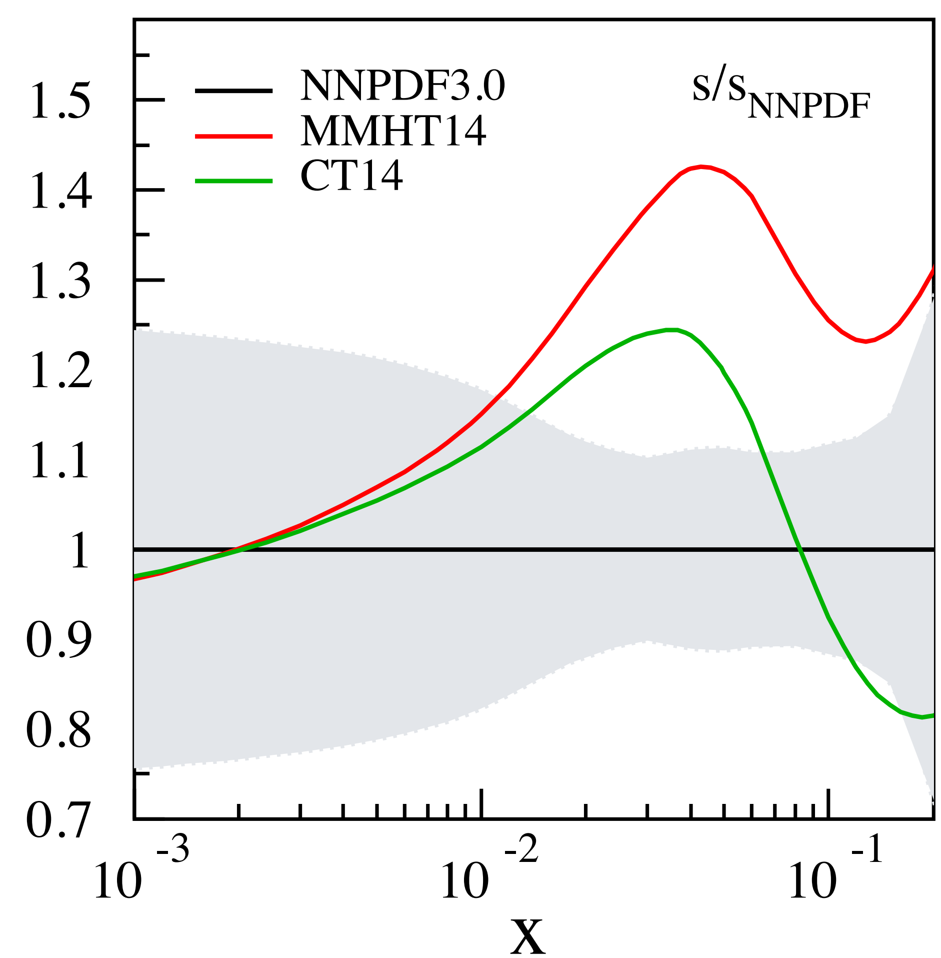

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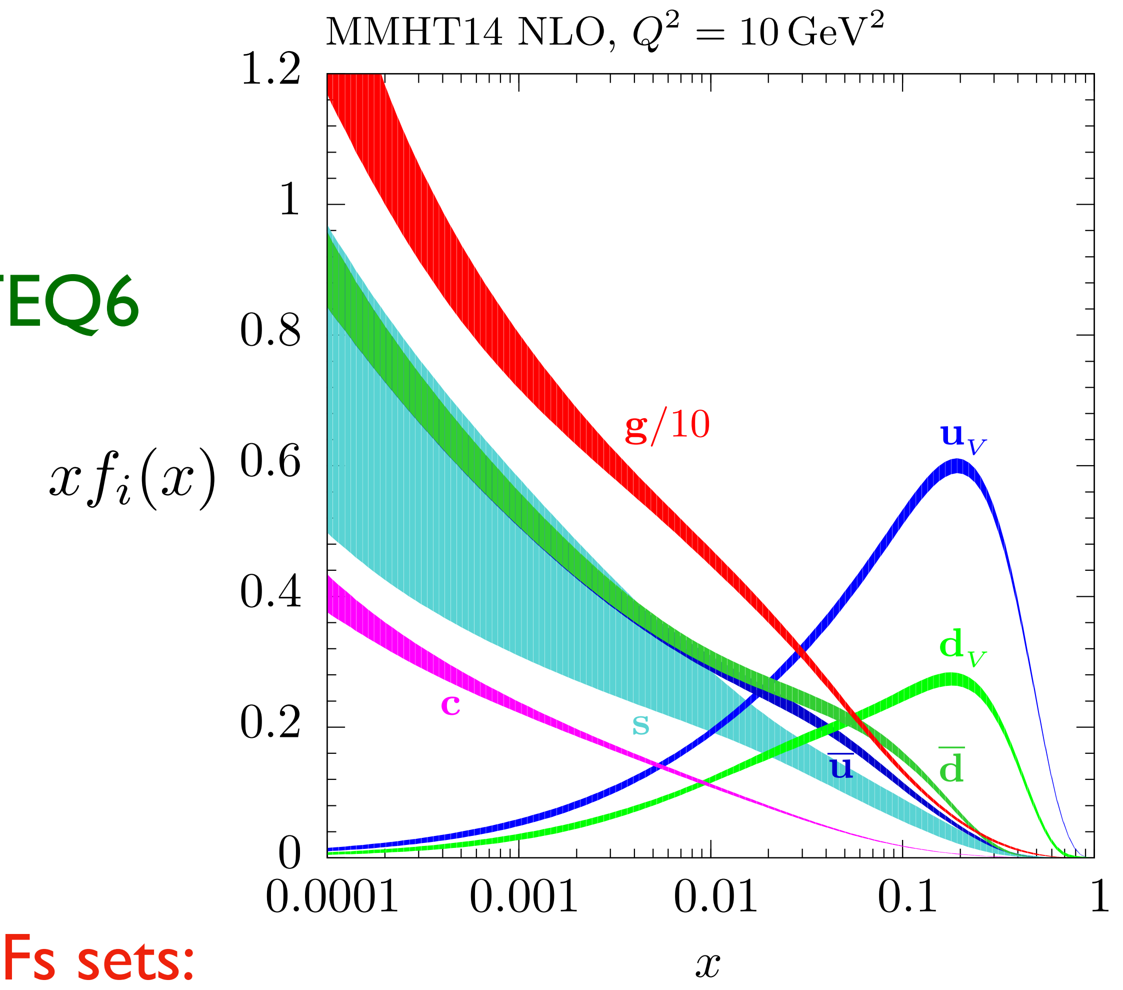
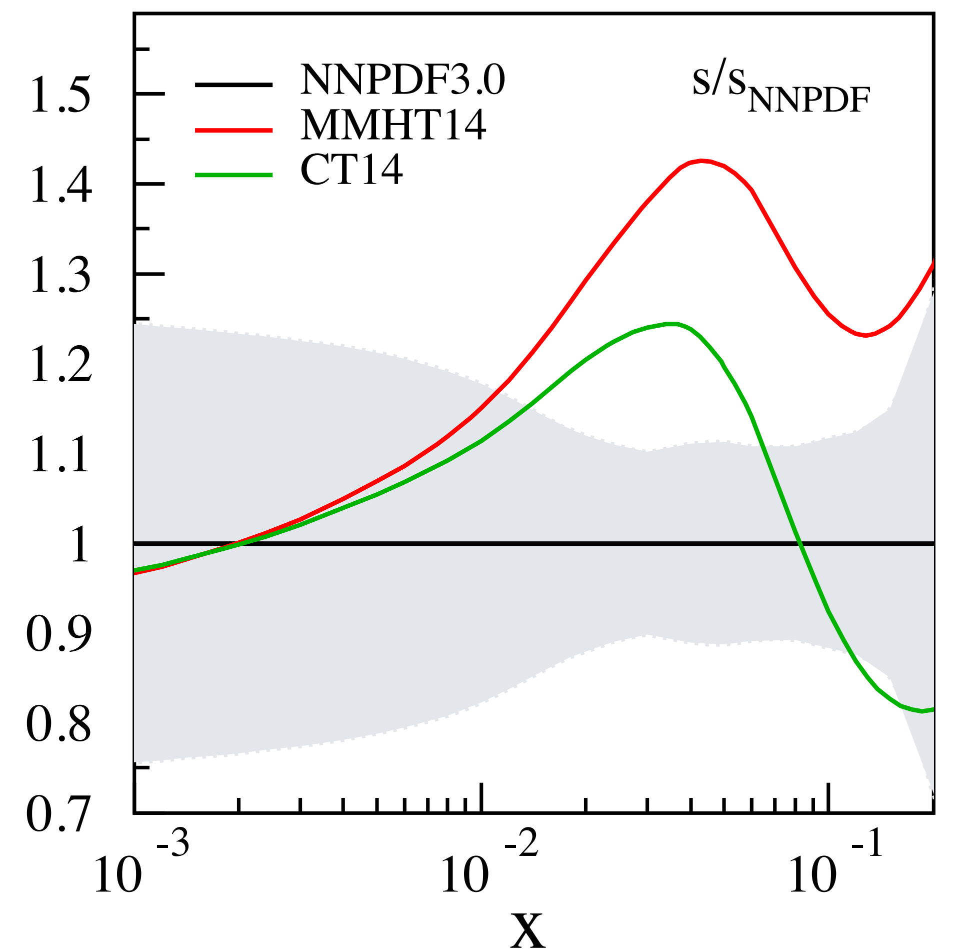
I. Borsa, RS, M. Stratmann arXiv:1708.01630





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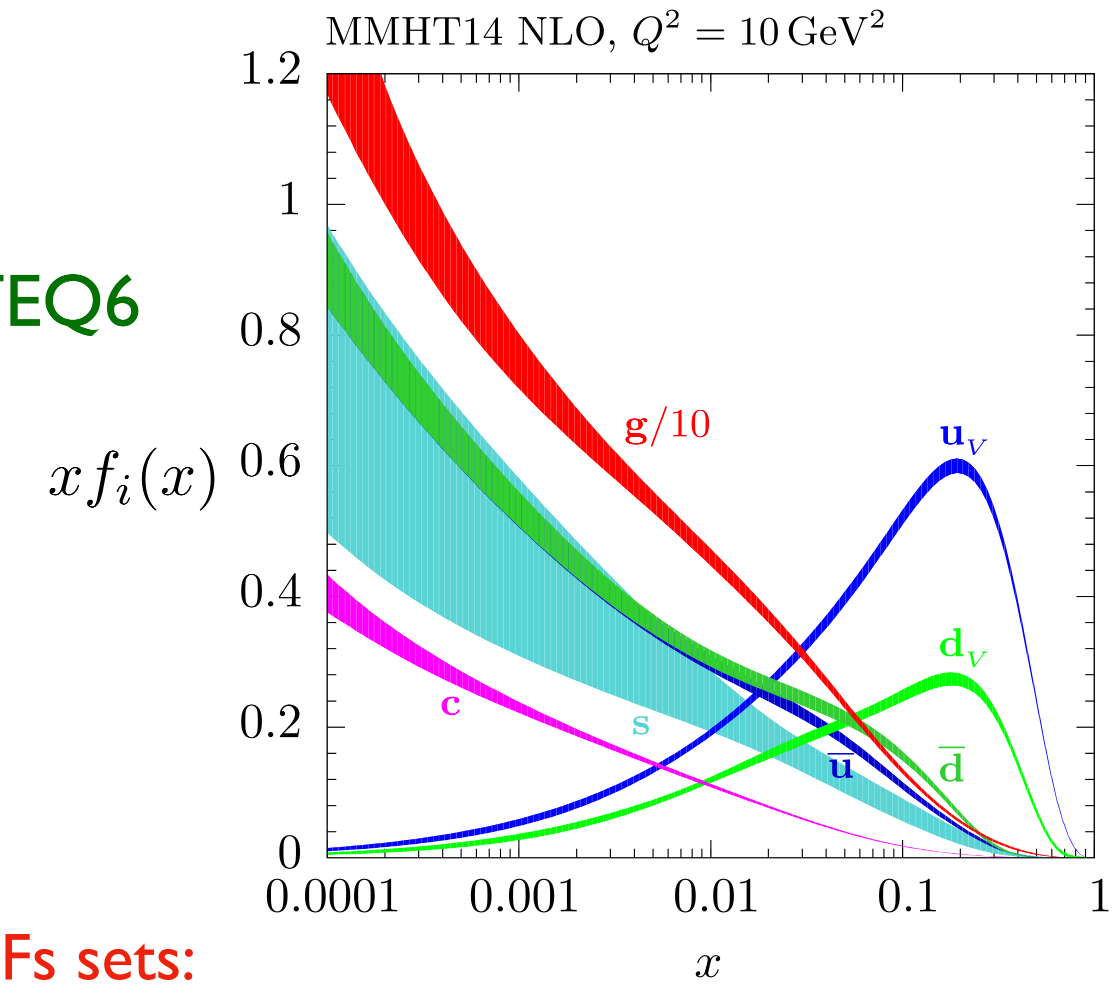

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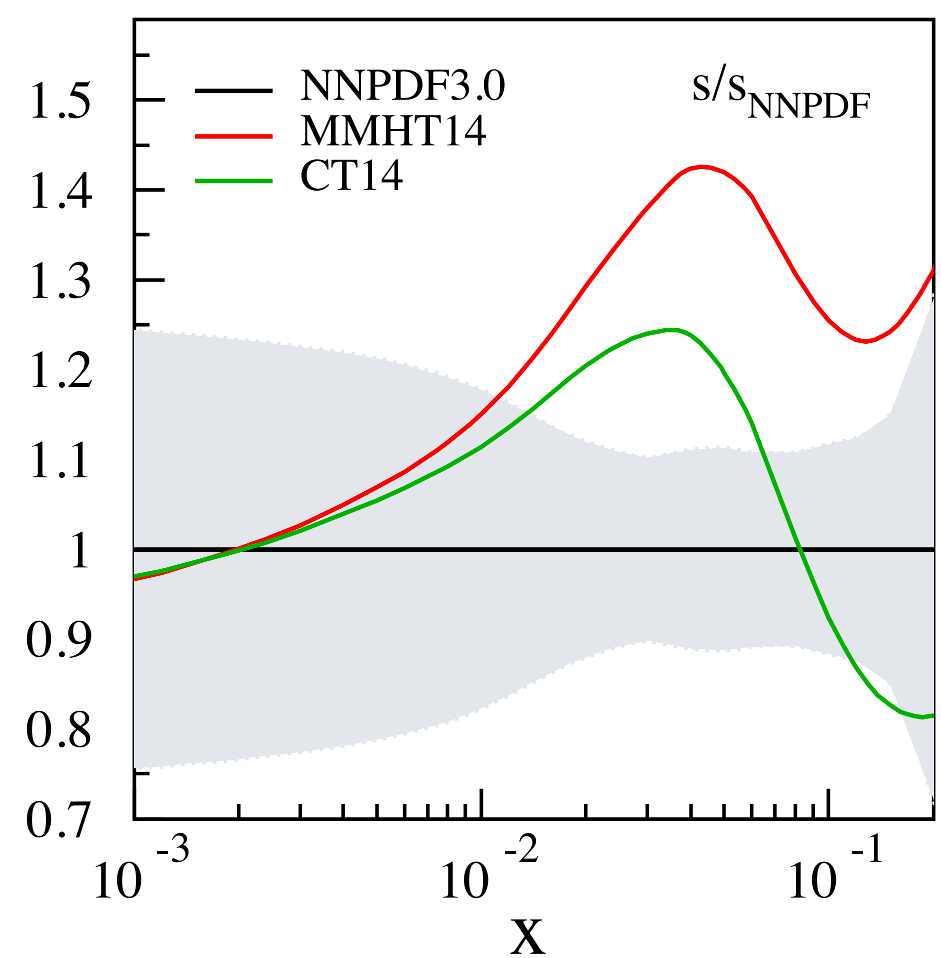

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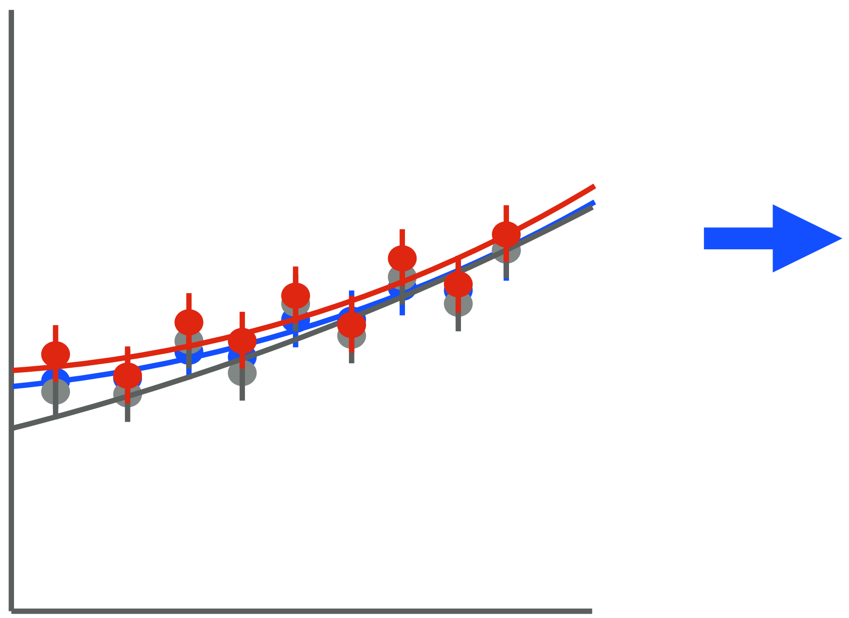

$f_i(x)$ $w(\chi^2)$

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$$f_i^{best}(x) = \frac{1}{N_{rep}} \sum f_i(x)$$

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avoid cumbersome minimization of a large number of parameters

keep track of the effect of less inclusive data

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PDFs **FFs**

PDFs reweigh with SIDIS

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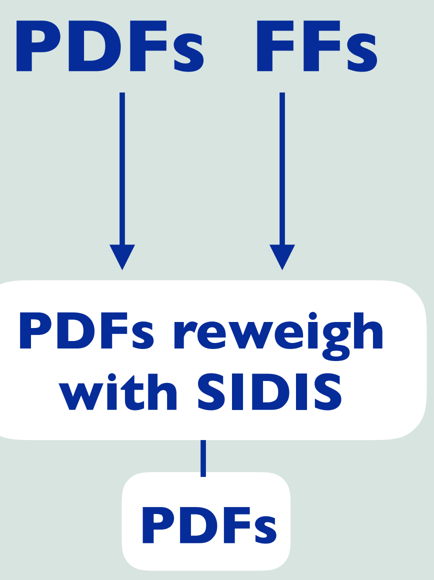

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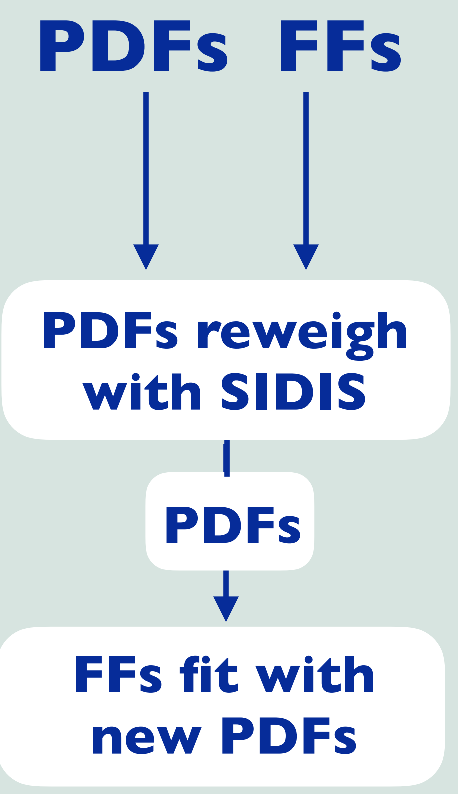

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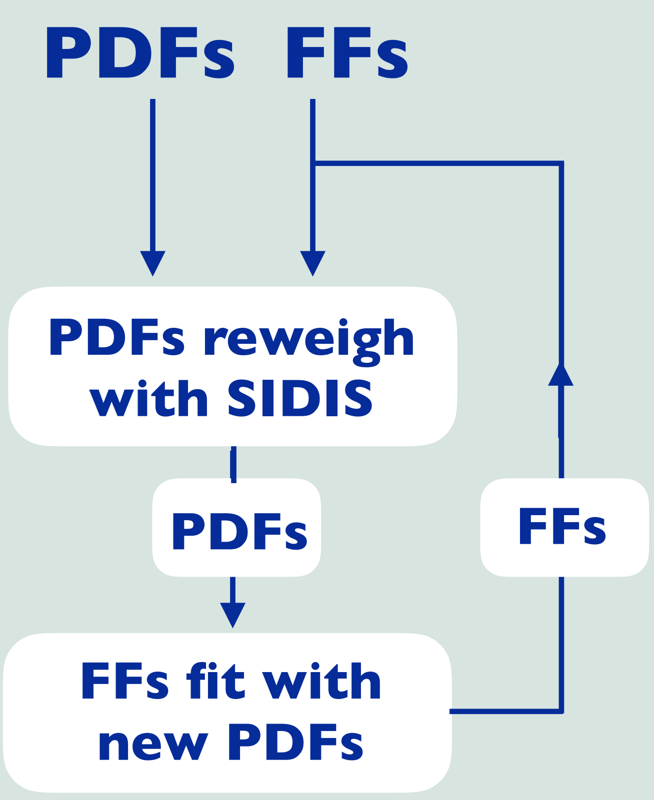

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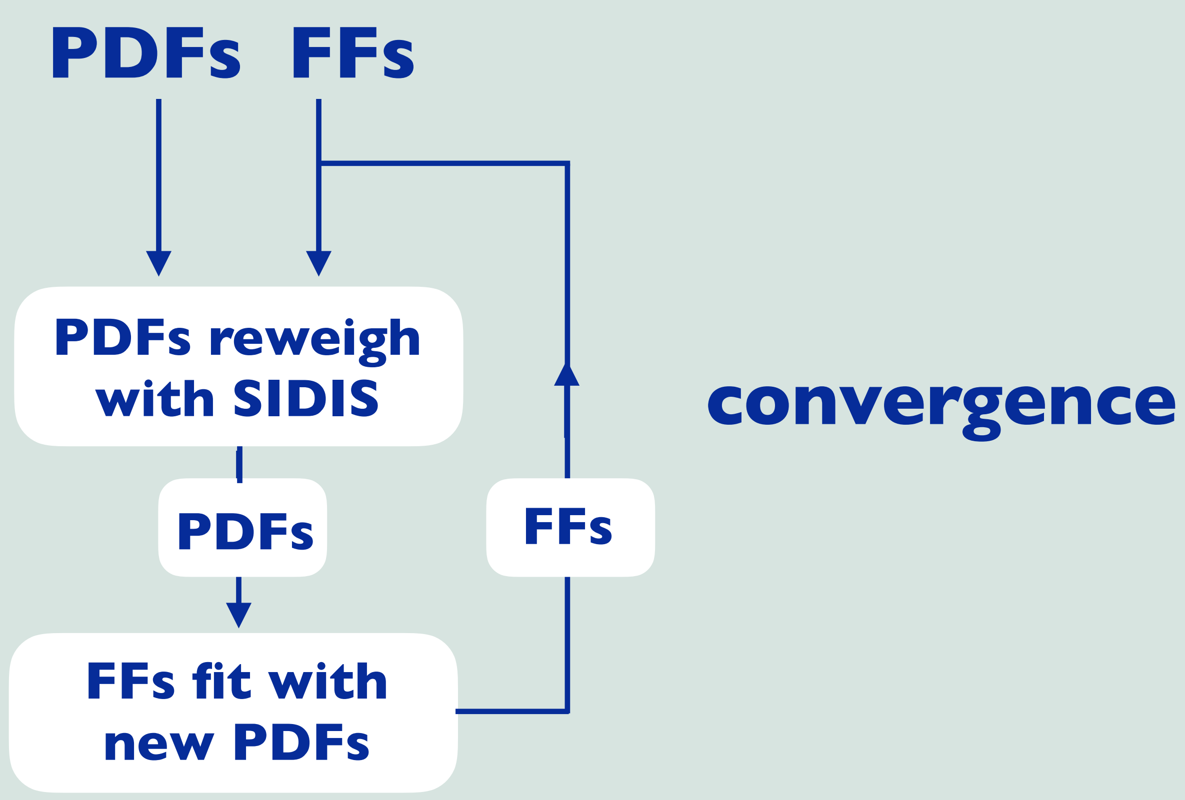

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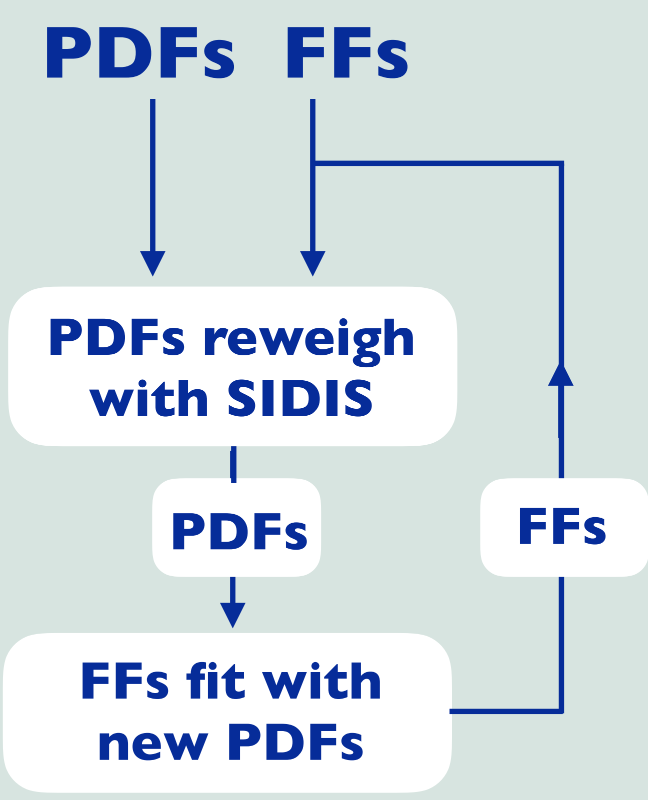

convergence and very fast!

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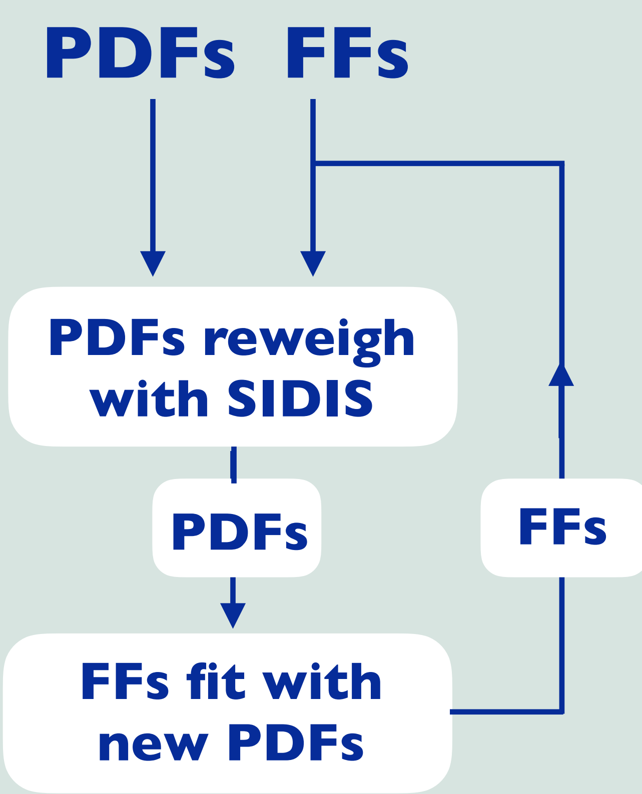
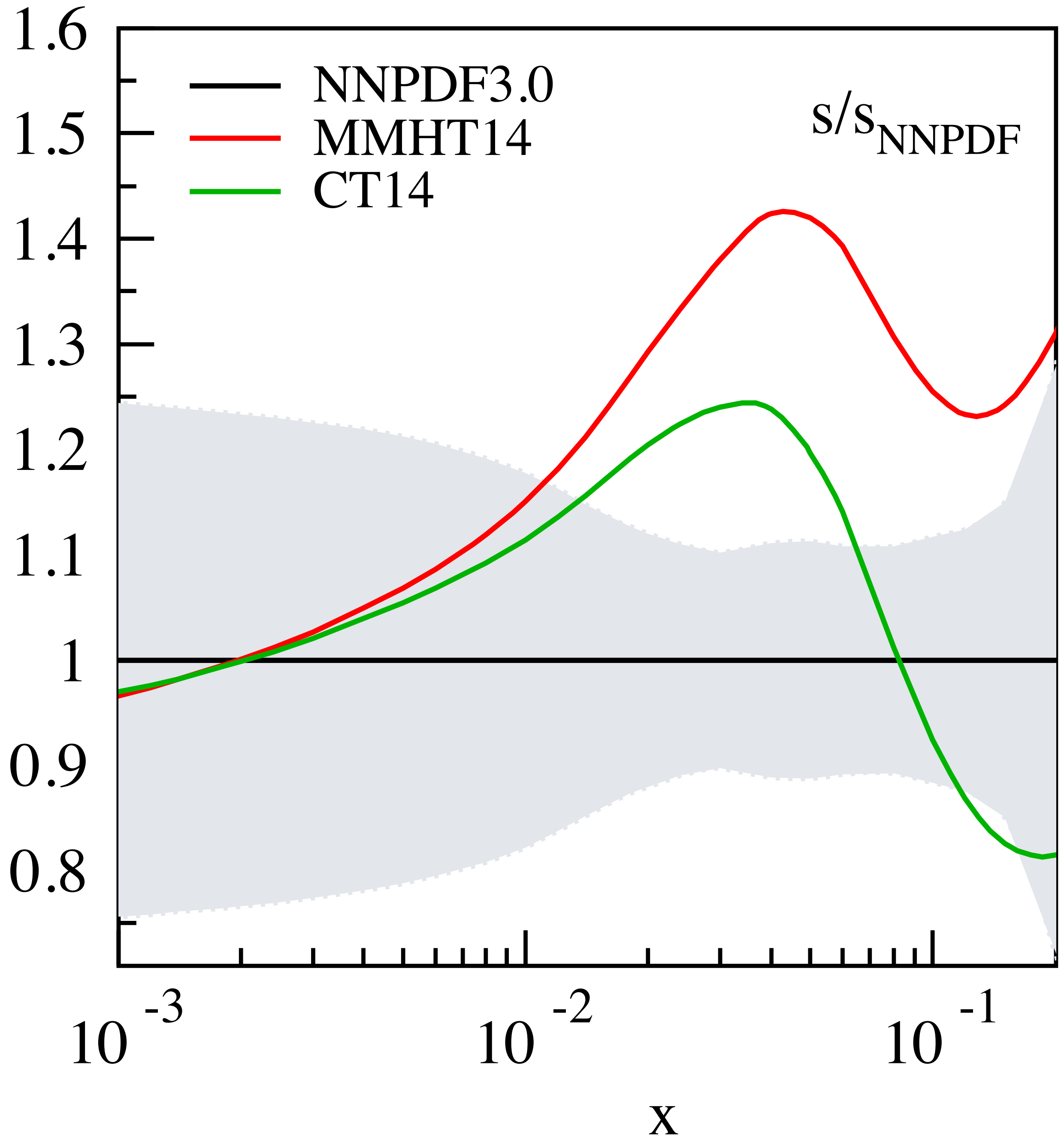


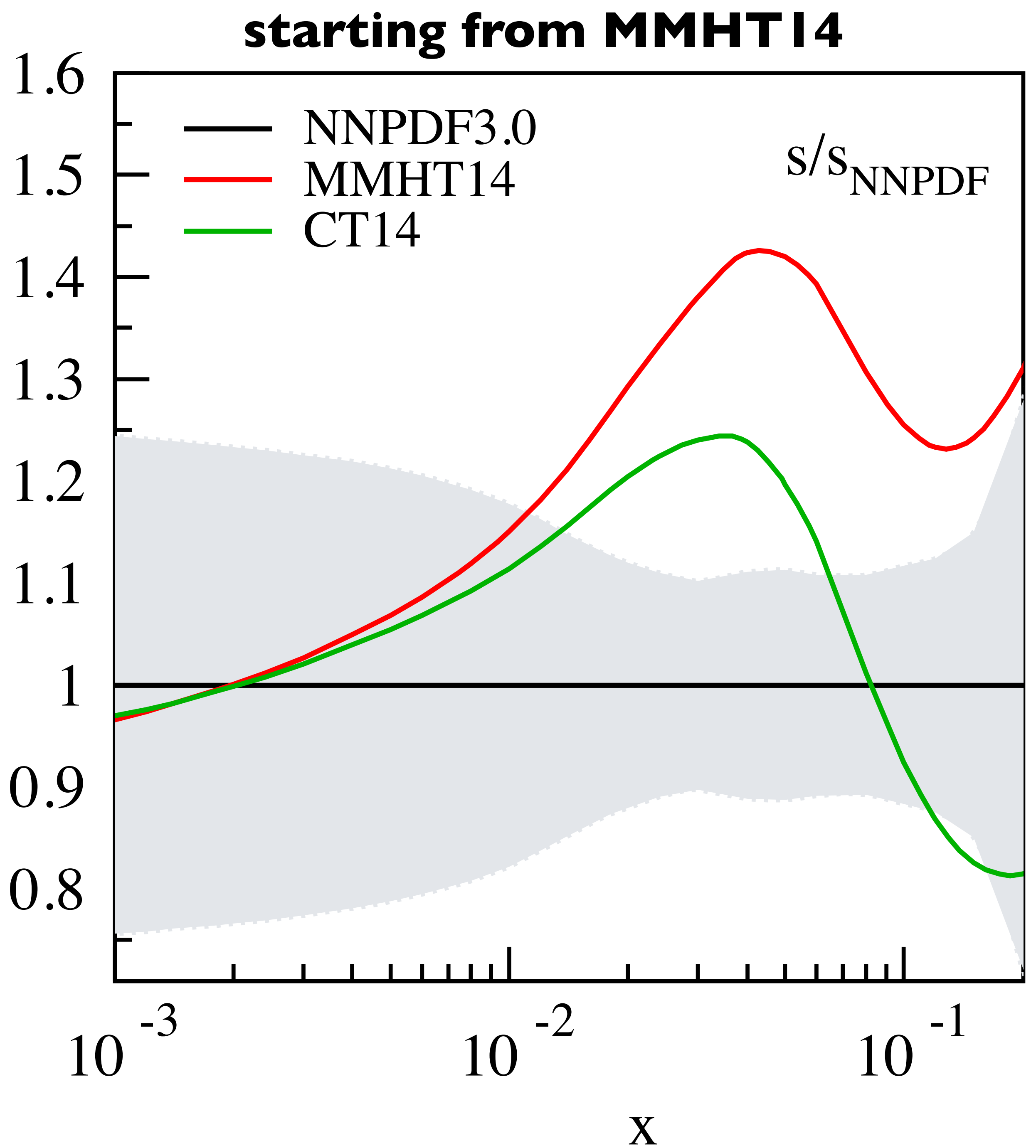
convergence and very fast! robust!

Combined PDFs and FFs extraction



$\chi^2_{FF} = 1271.7$

Combined PDFs and FFs extraction



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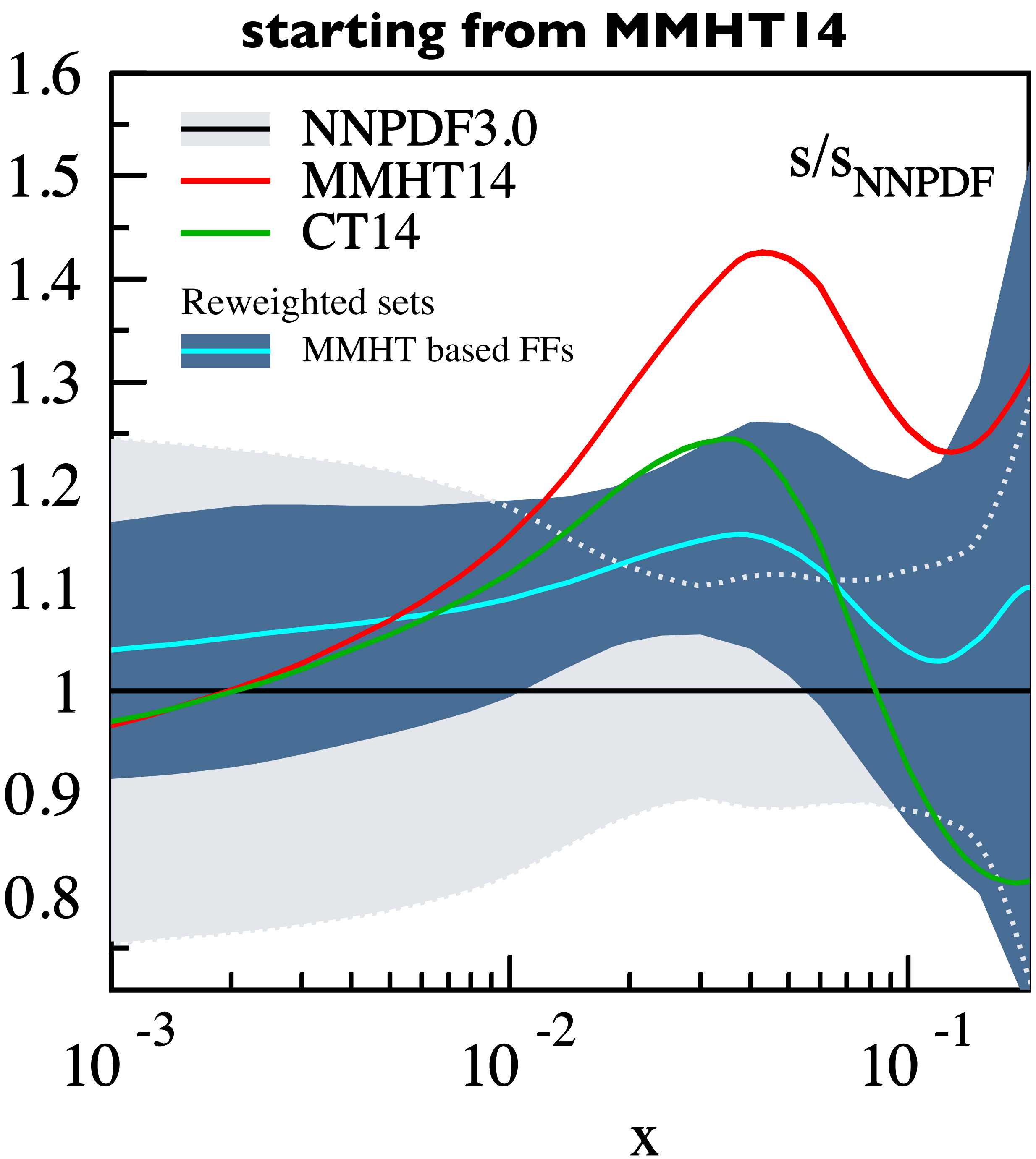

$\chi^2_{FF} = 1271.7$ $\quad$ 1041.3

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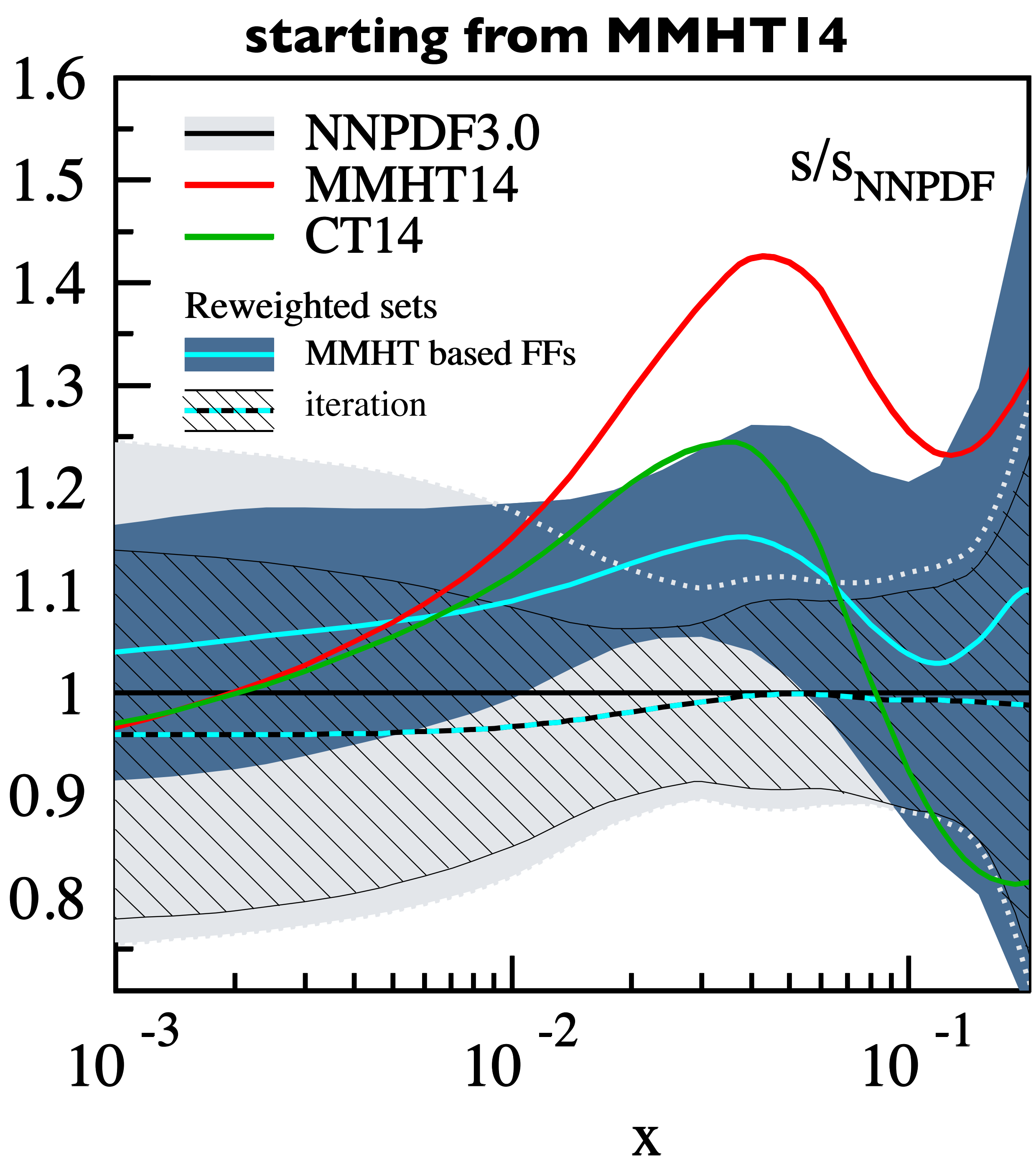

$\chi^2_{FF} = 1271.7$ 1041.3 1002.3

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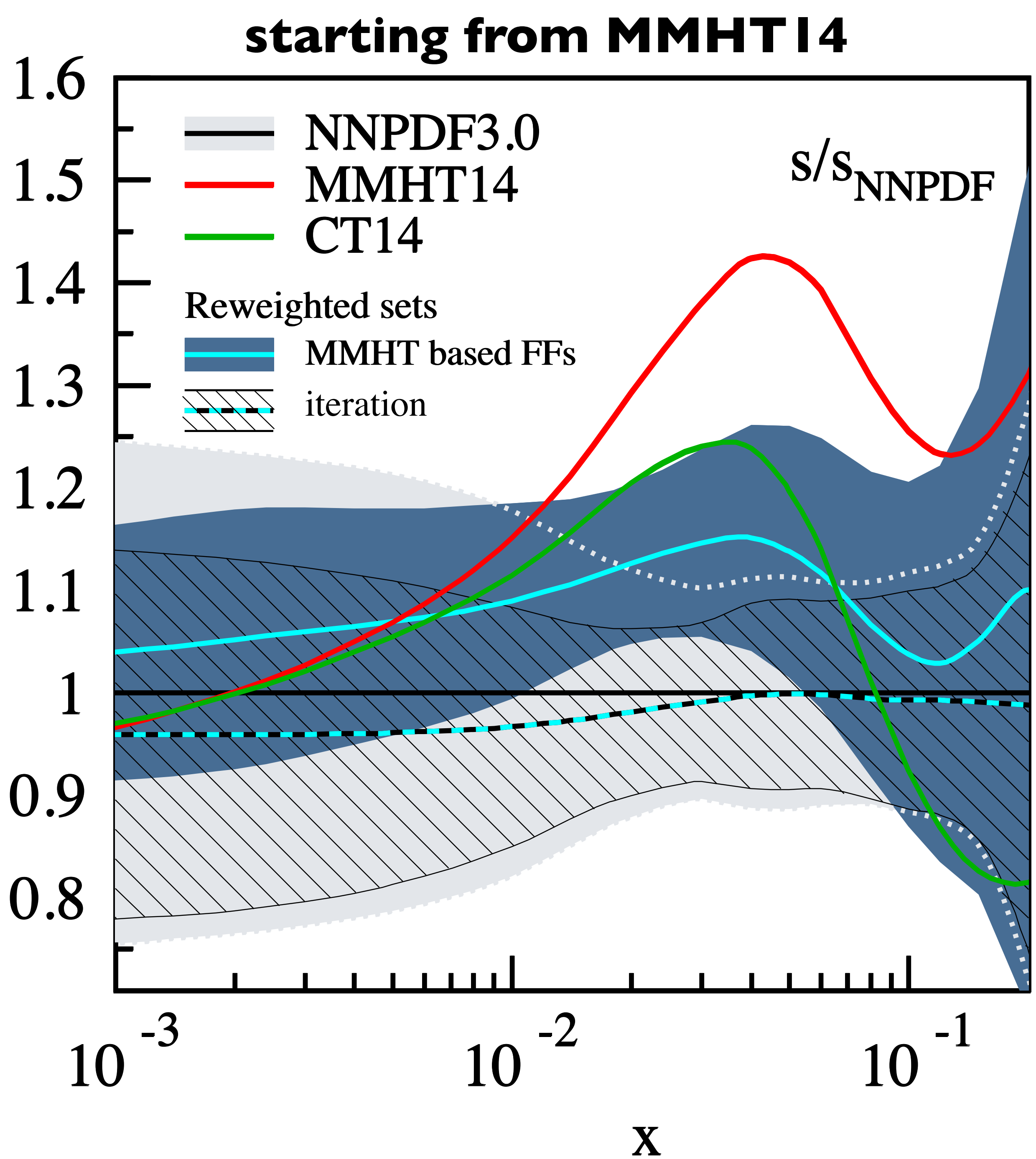

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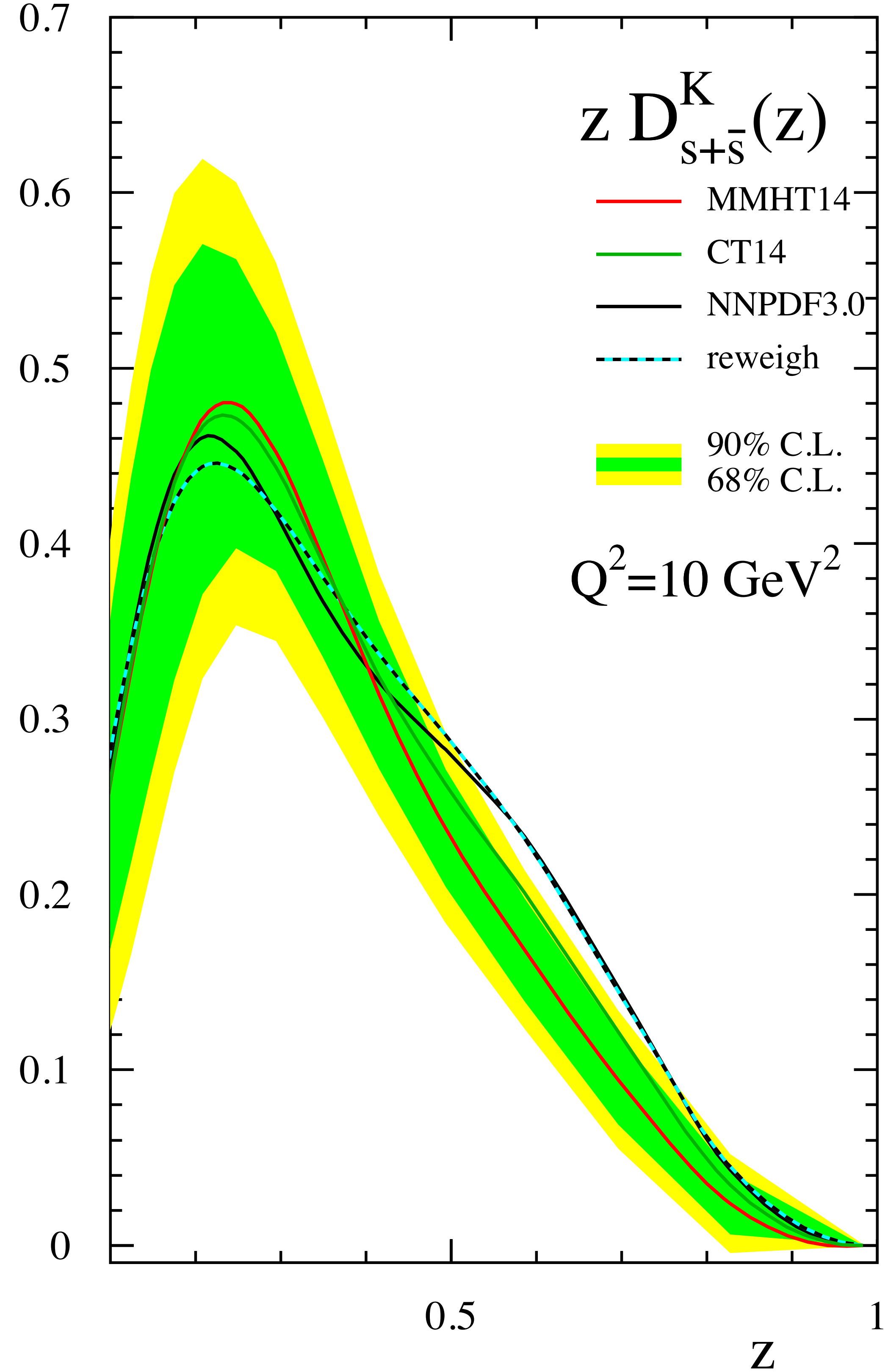

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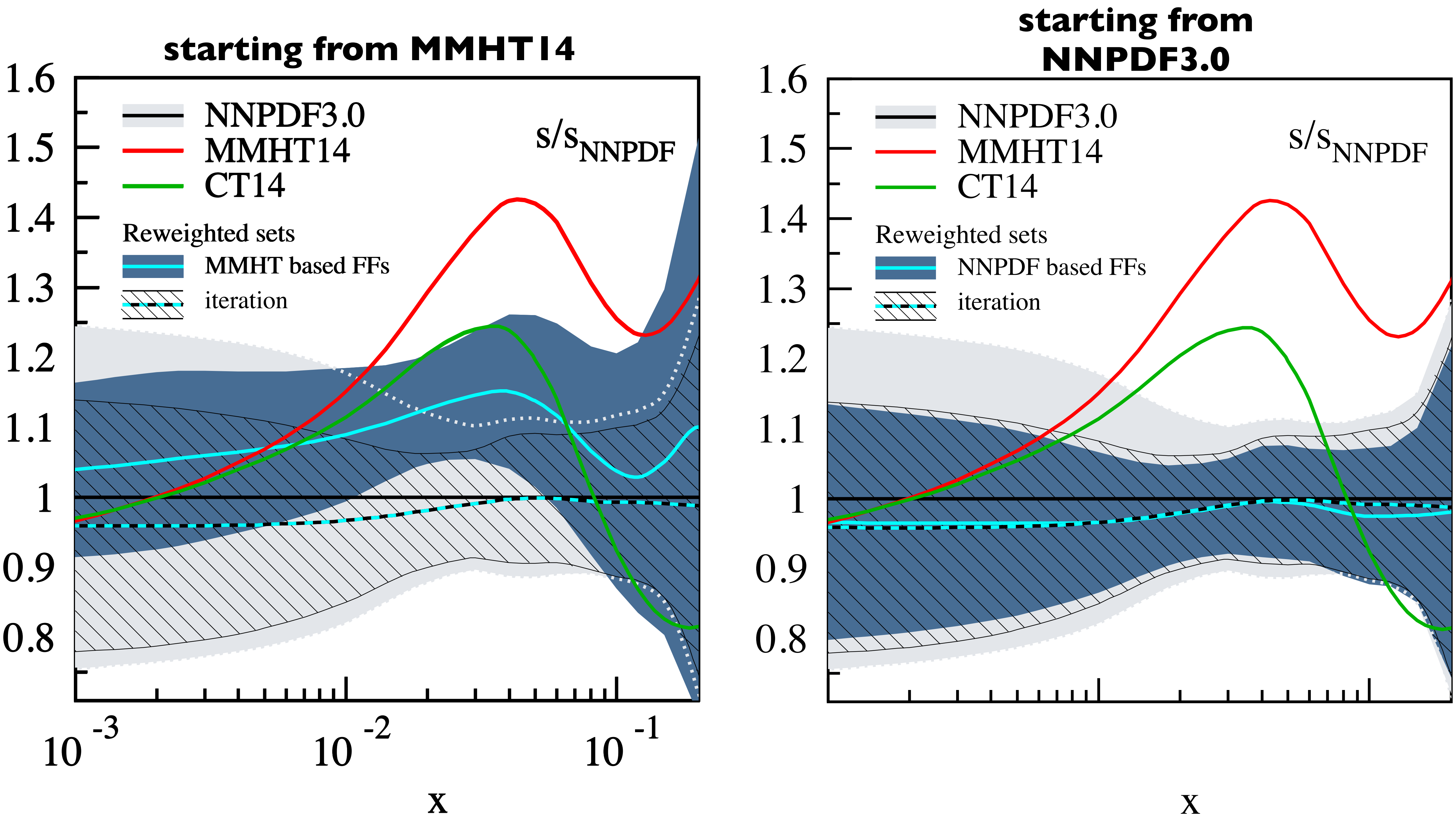
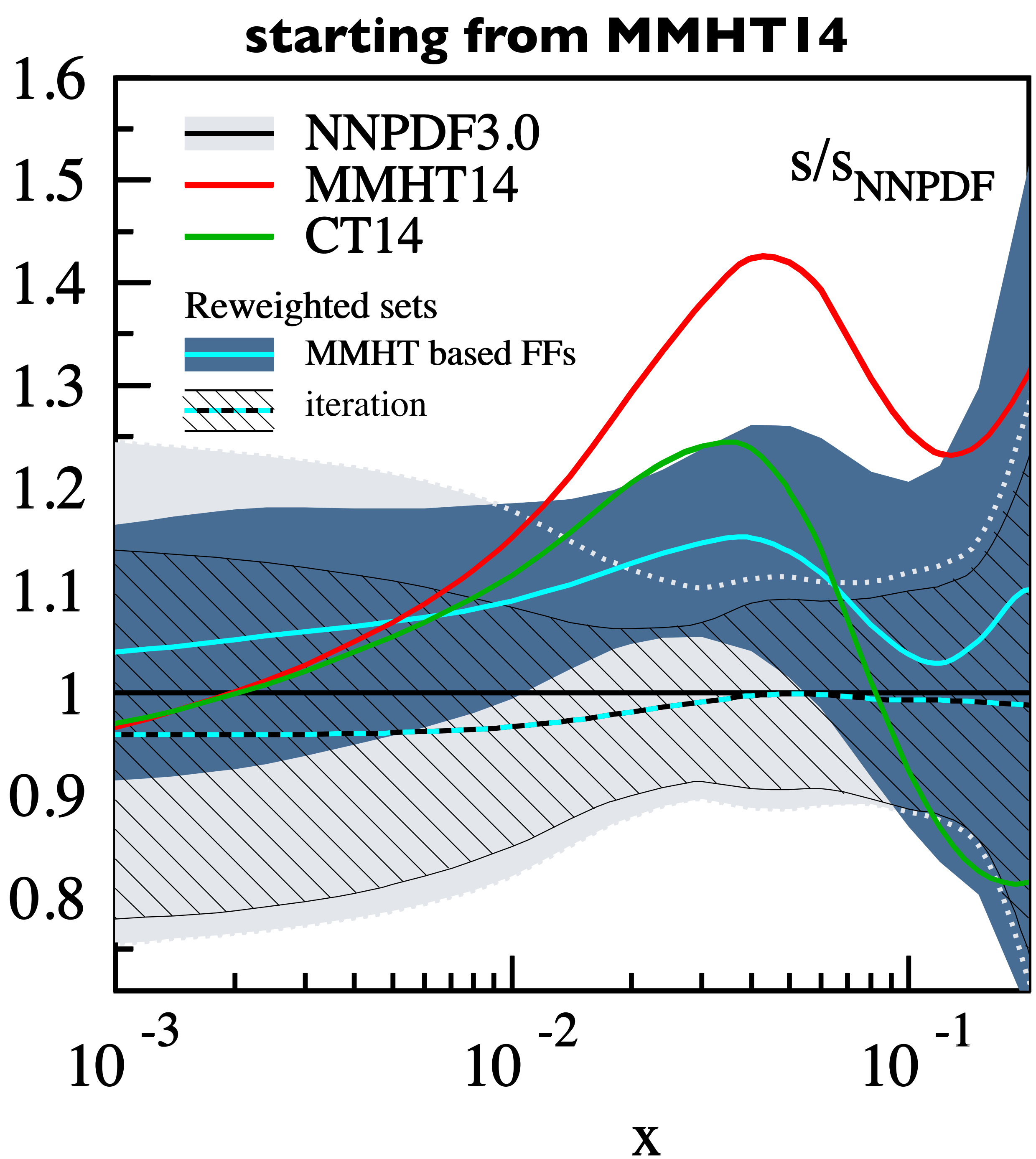
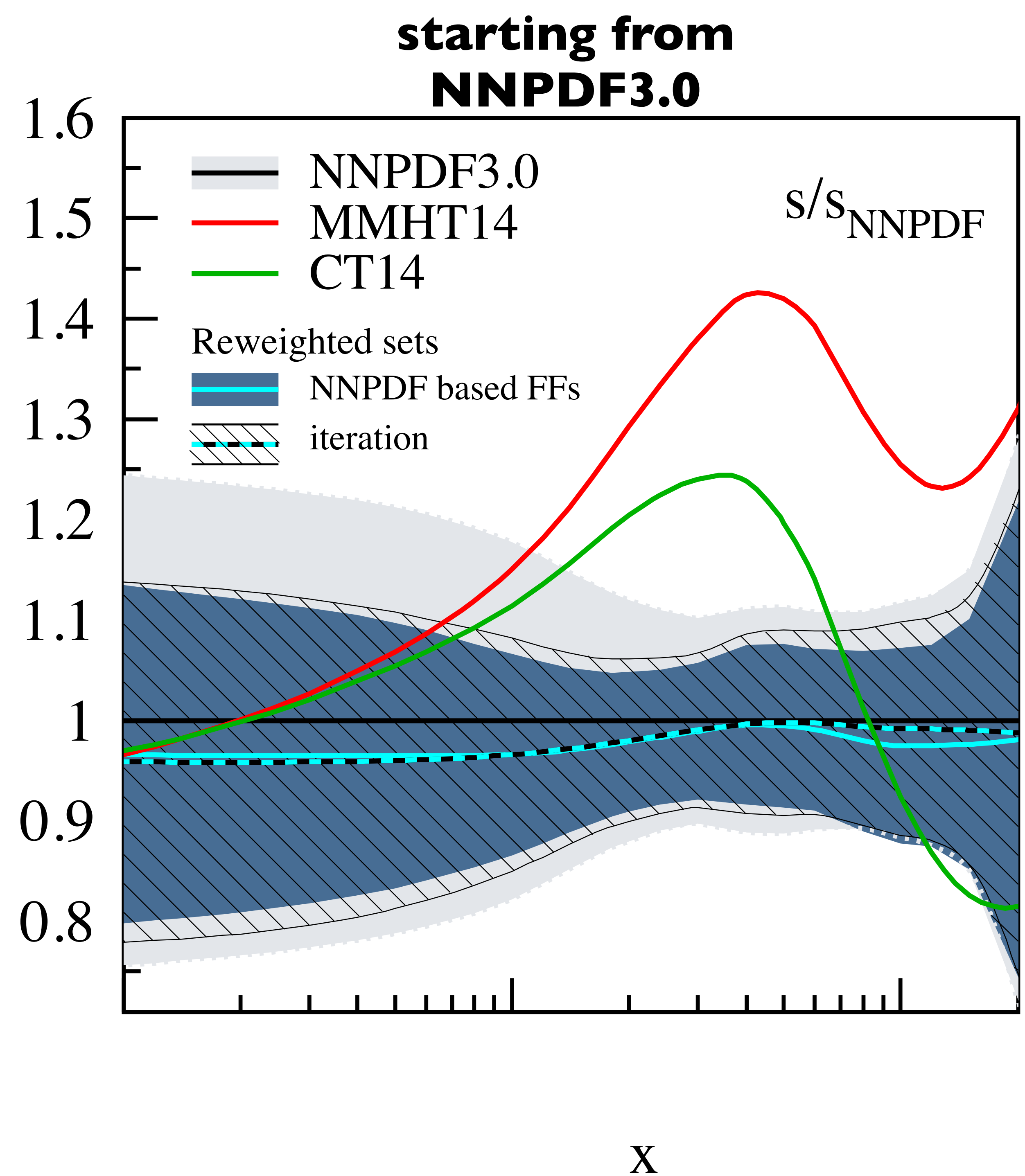


$\chi^2_{FF} =$ 1271.7   1041.3   1002.3   1017.2   1005.3   1000.6

Combined PDFs and FFs extraction





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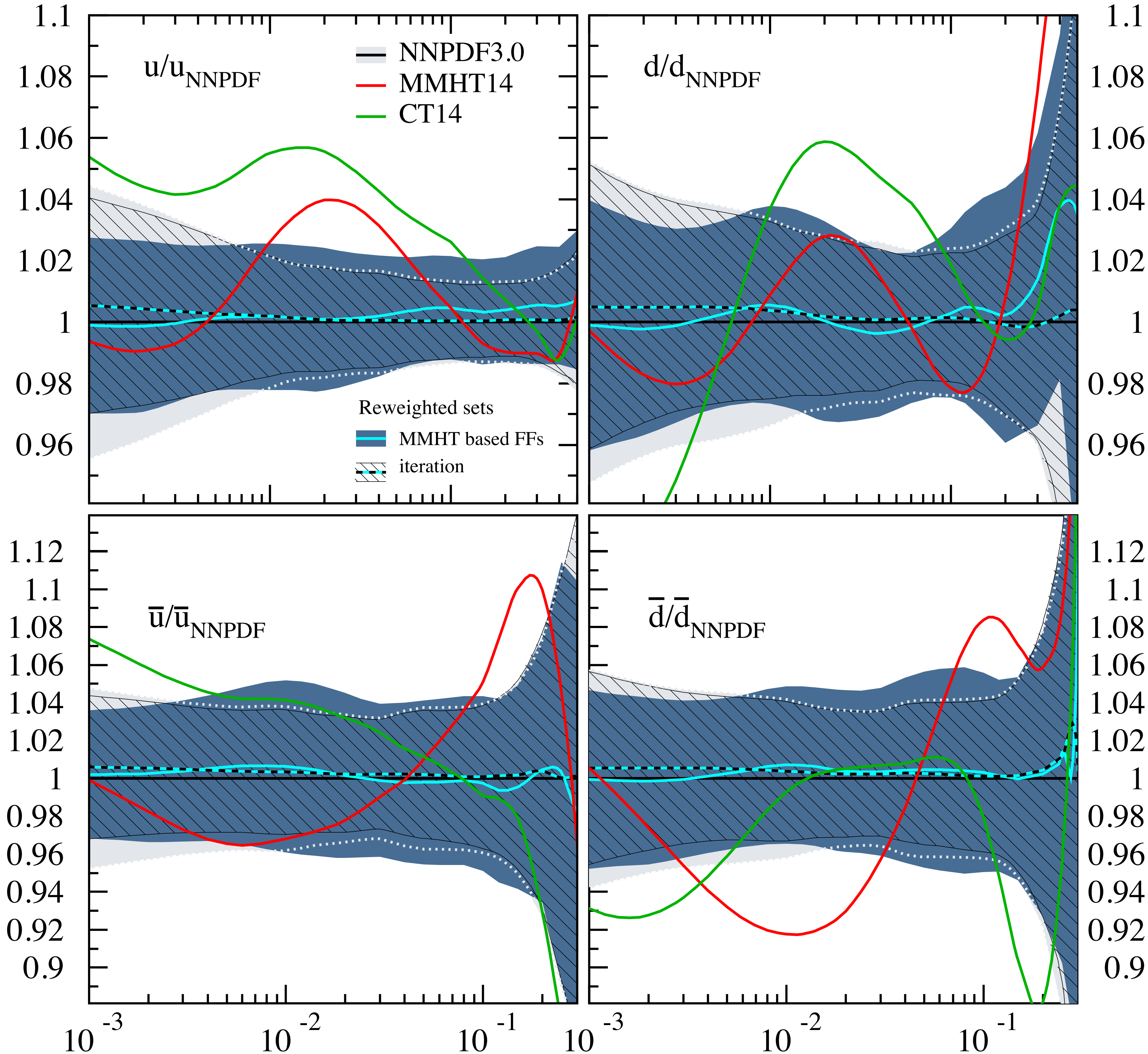
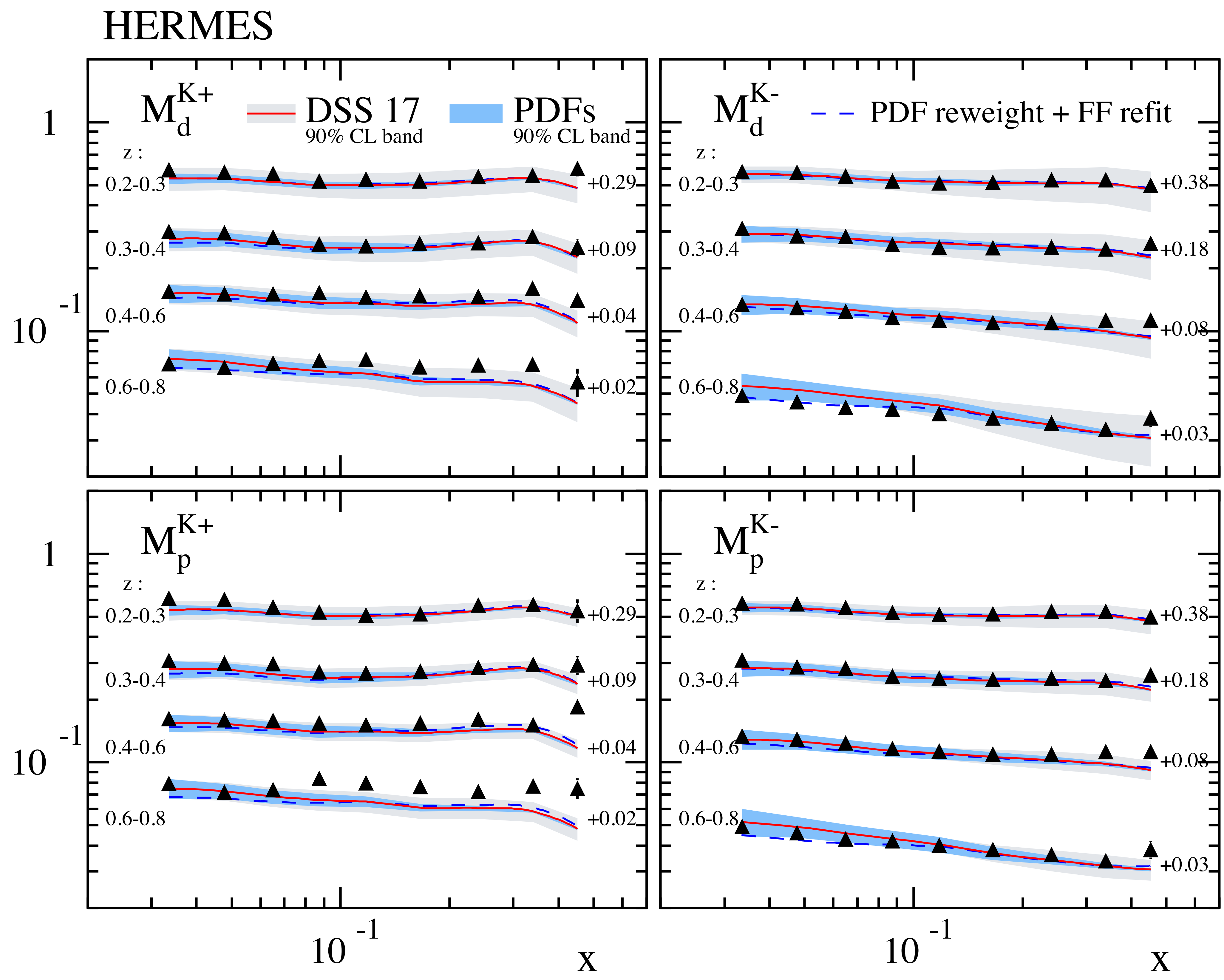
1017.2 1005.3 1000.6

similar results with CT14 replicas

Combined PDFs and FFs extraction



SIDIS revisited:



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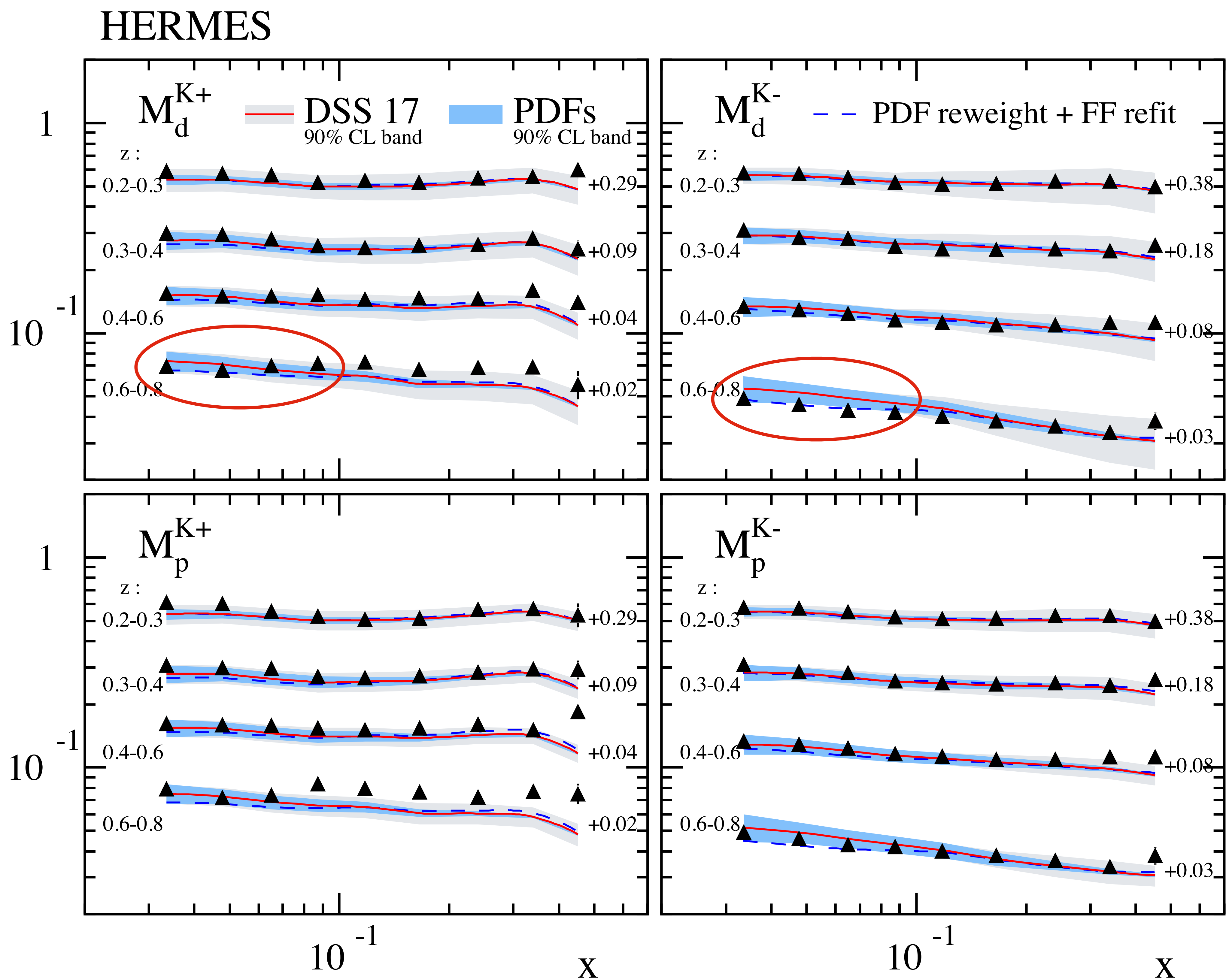
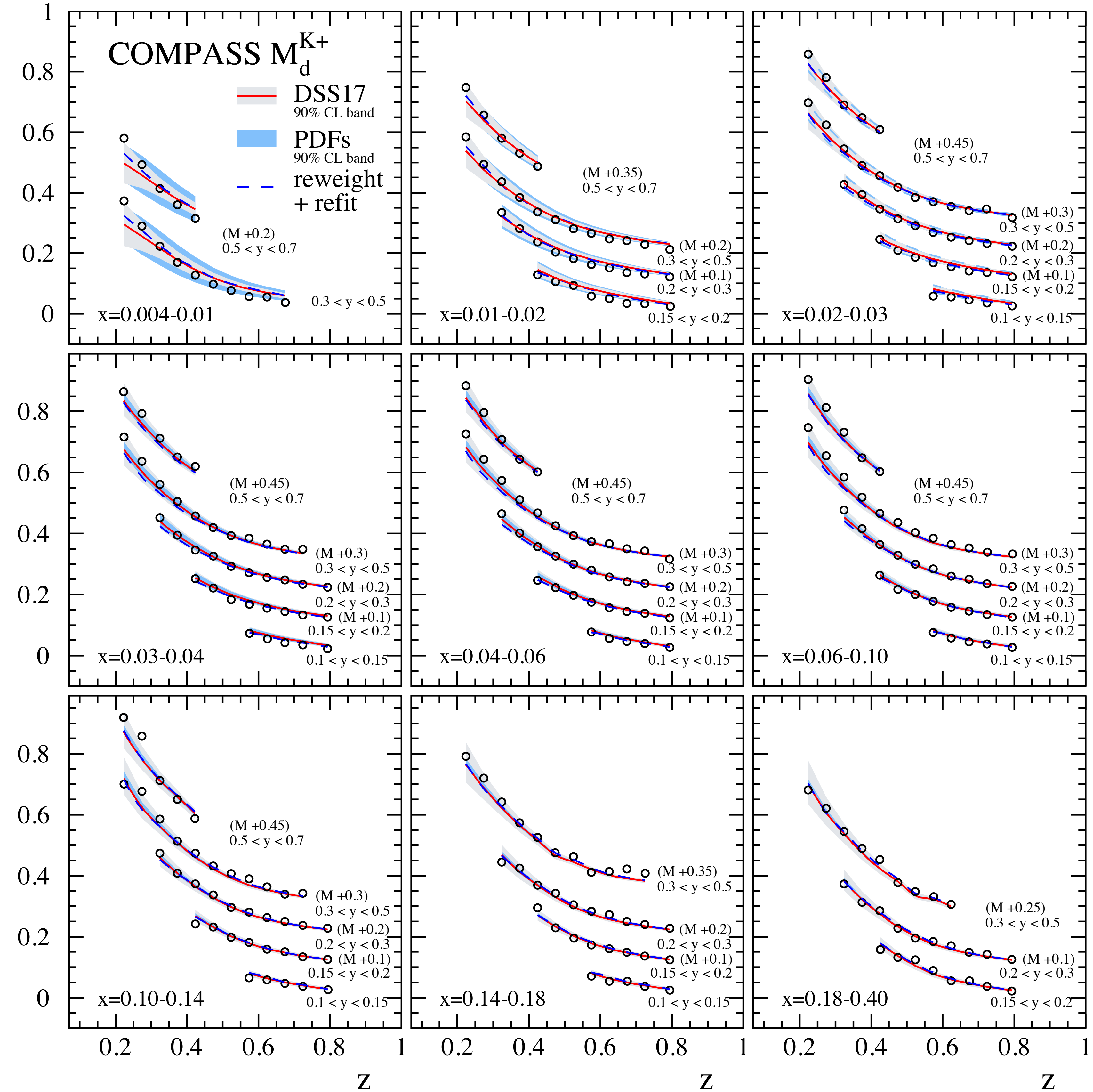
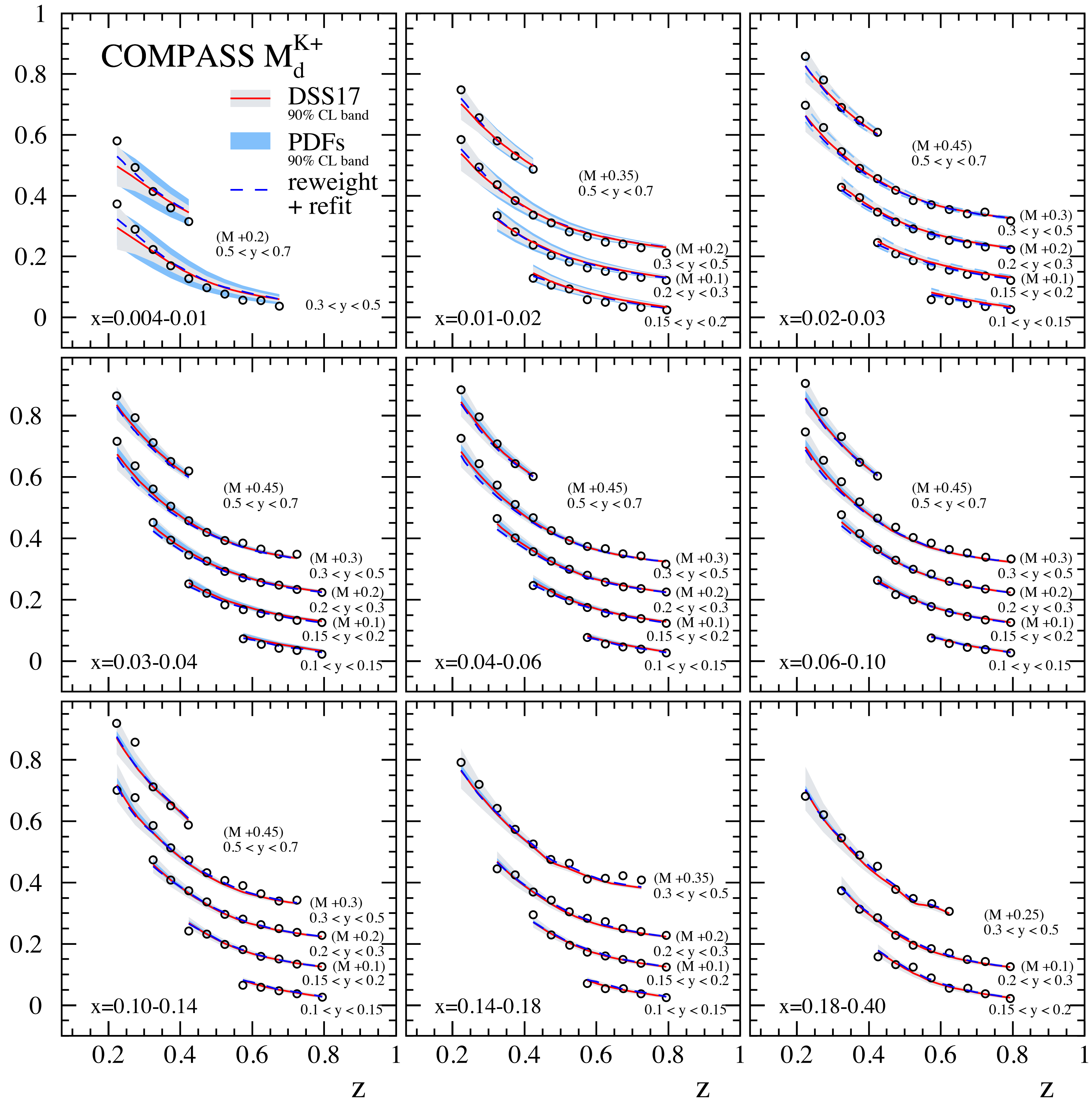




COMPASS M_d^{K+}
DSS17
90% CL band
PDFs
90% CL band
reweight
+ refit
x=0.004-0.01
x=0.01-0.02
x=0.02-0.03
x=0.03-0.04
x=0.04-0.06
x=0.06-0.10
x=0.10-0.14
x=0.14-0.18
x=0.18-0.40
(M +0.2)
0.5 < y < 0.7
0.3 < y < 0.5
(M +0.35)
(M +0.45)
(M +0.3)
(M +0.25)
(M +0.1)
0.2 < y < 0.3
0.15 < y < 0.2
0.1 < y < 0.15
z

SIDIS revisited:



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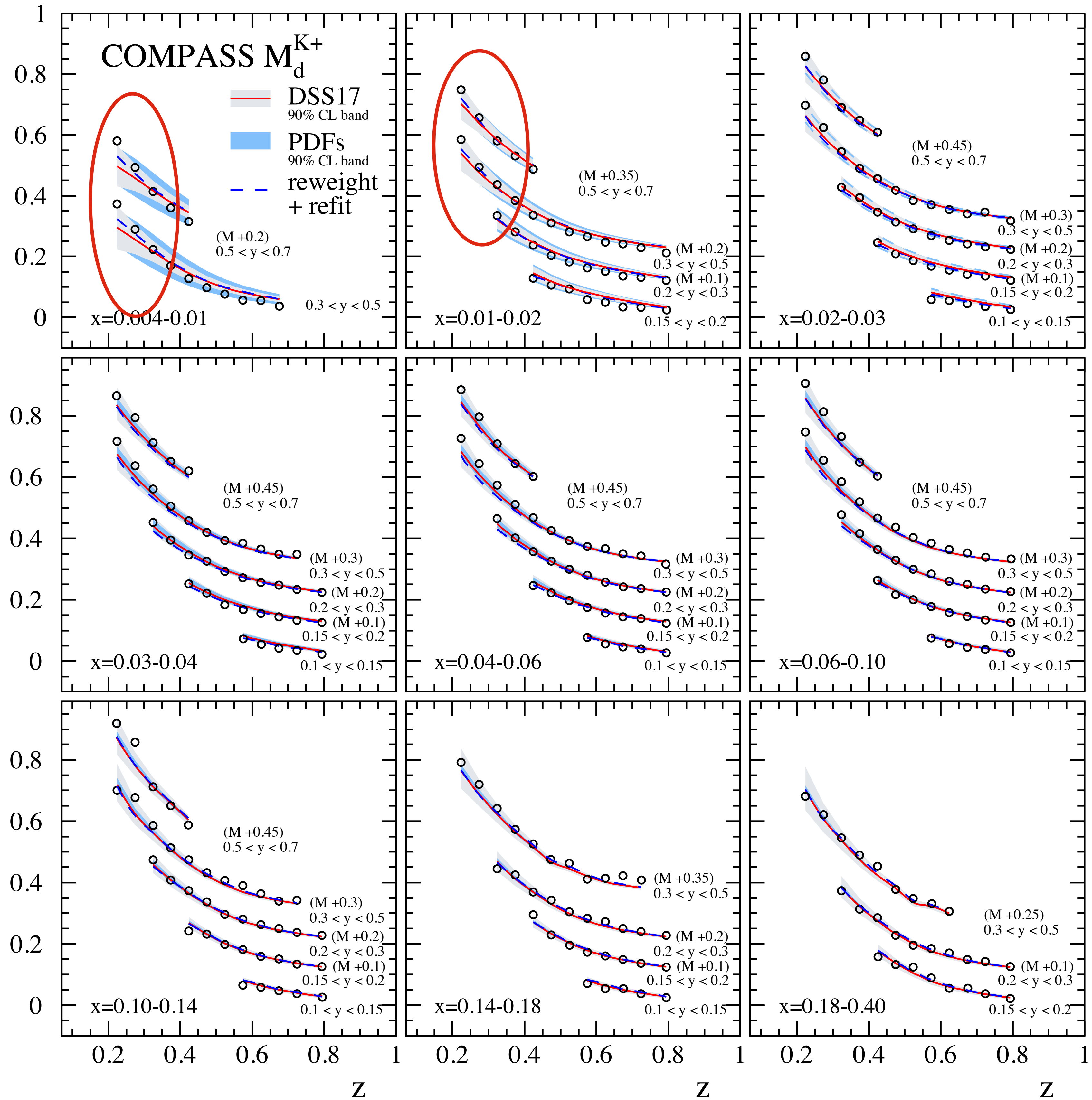
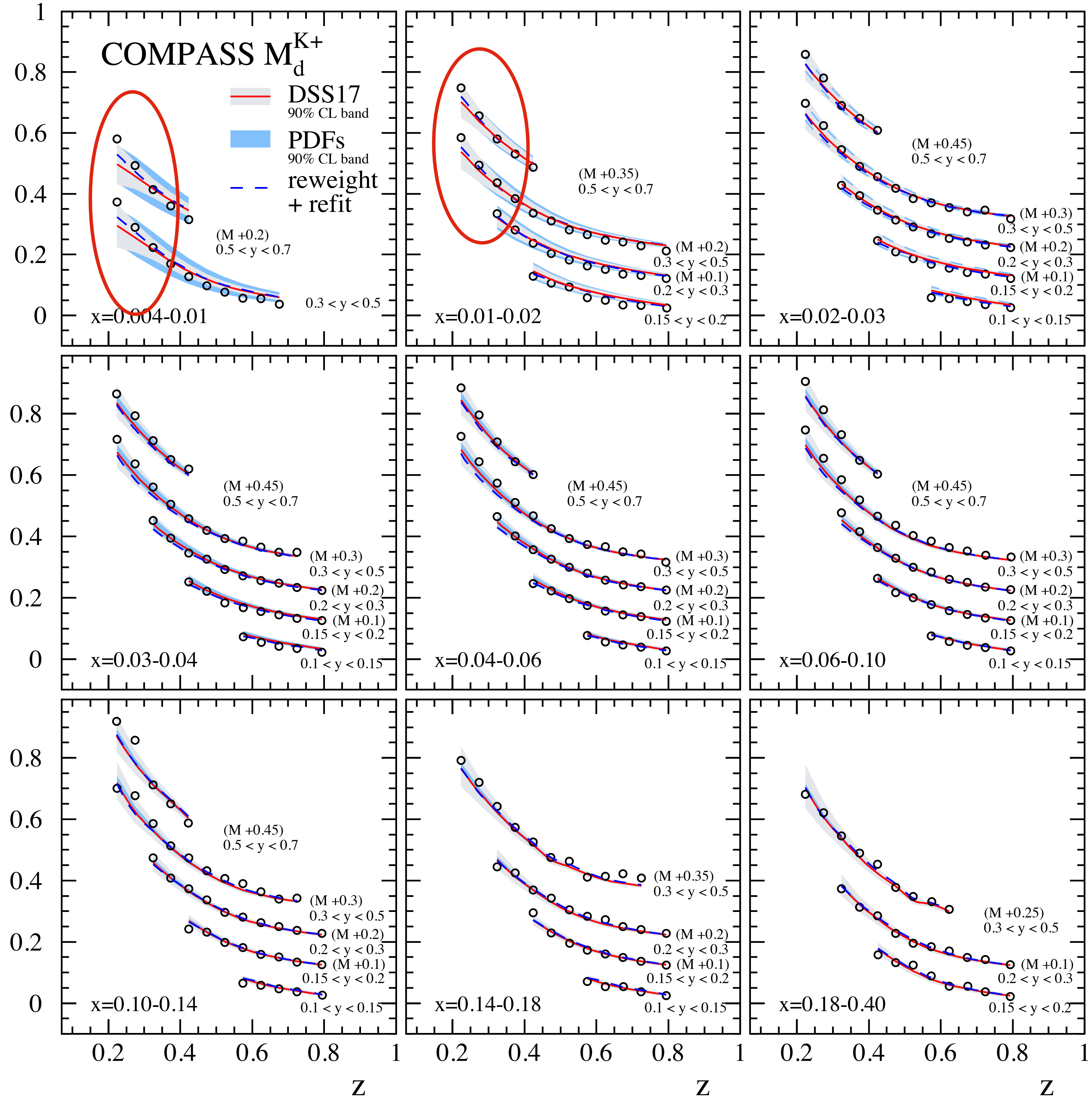


SIDIS revisited:

555.9

467.6

434.5



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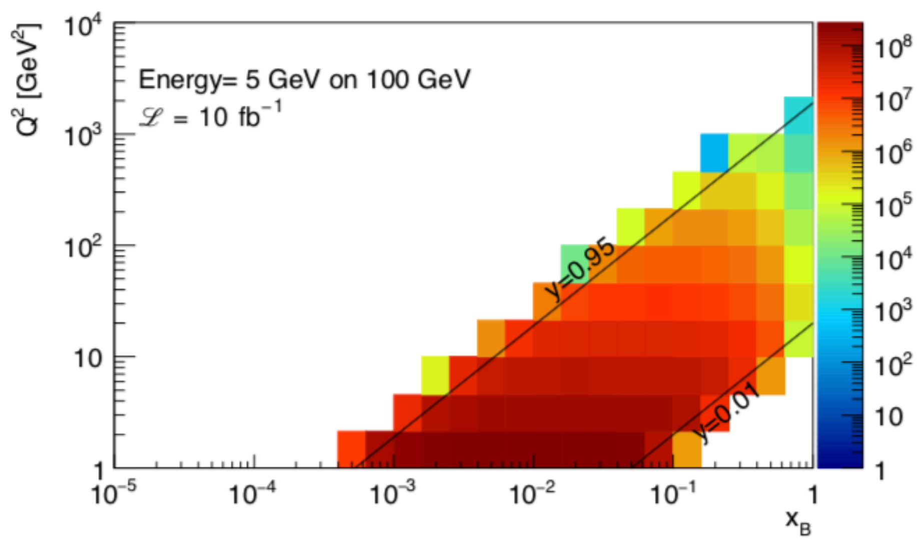

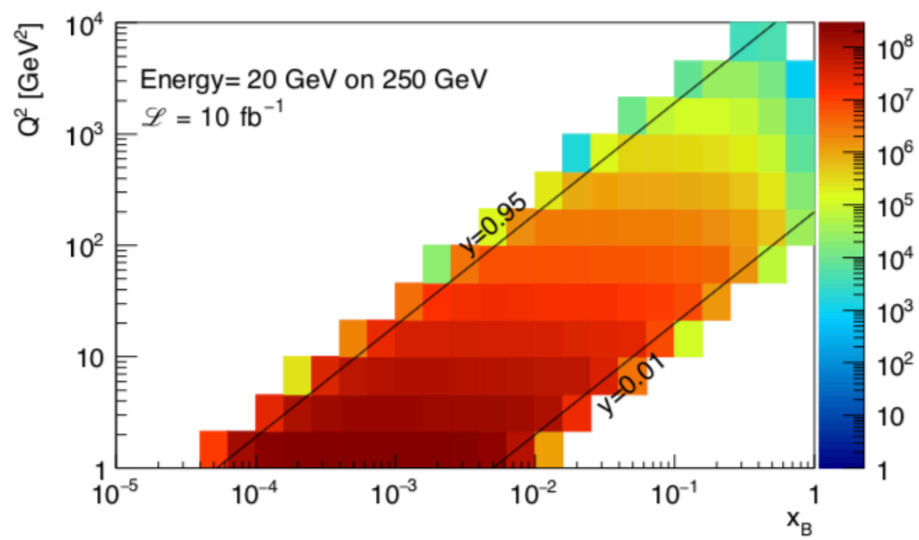

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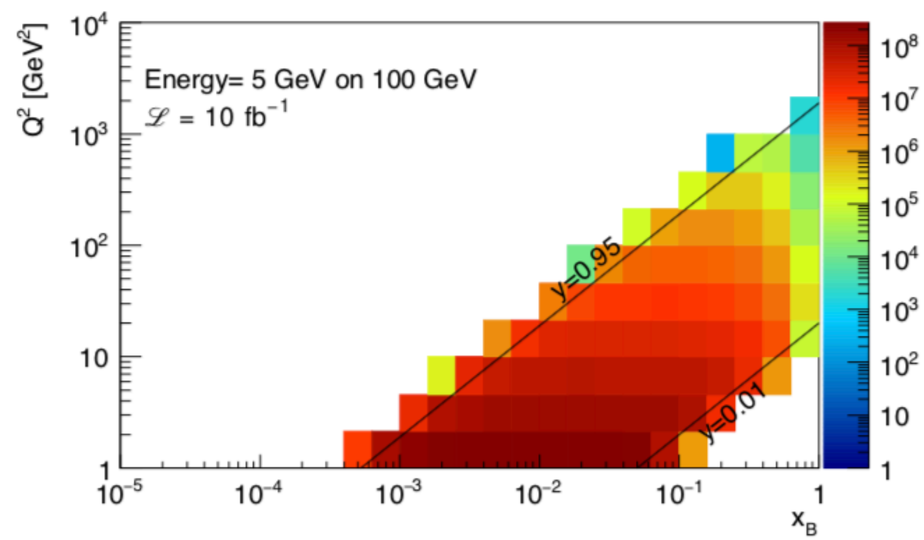

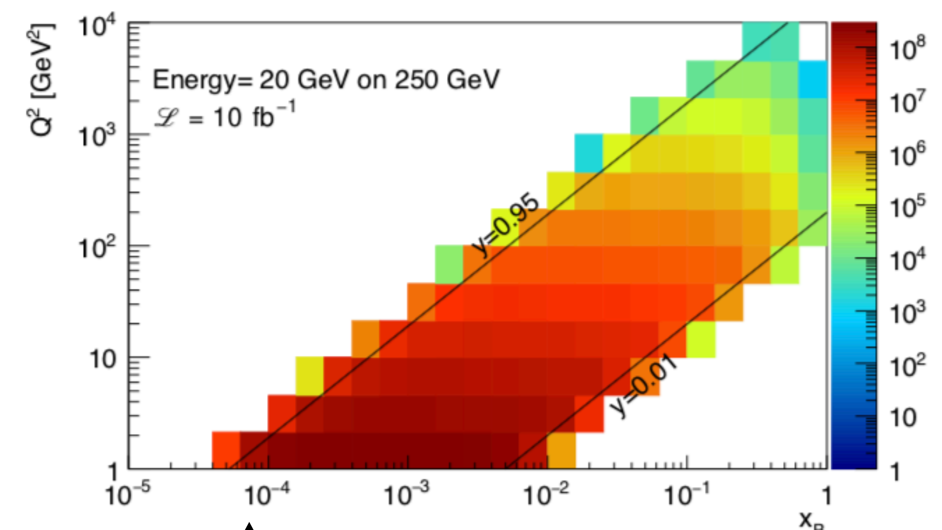

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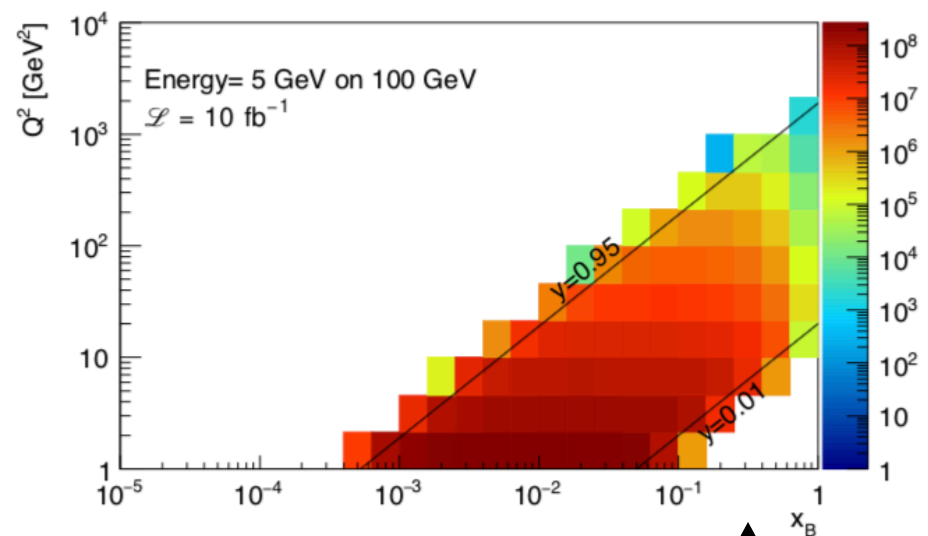

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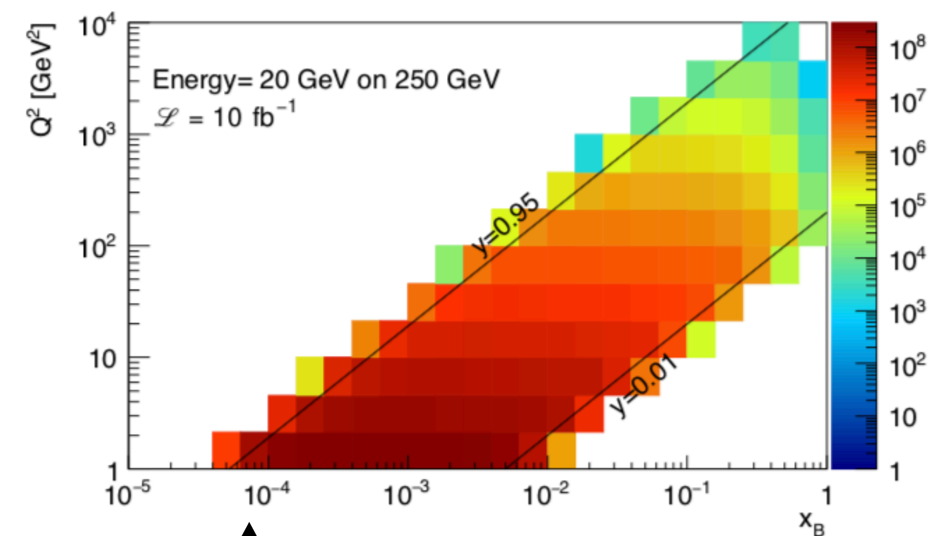

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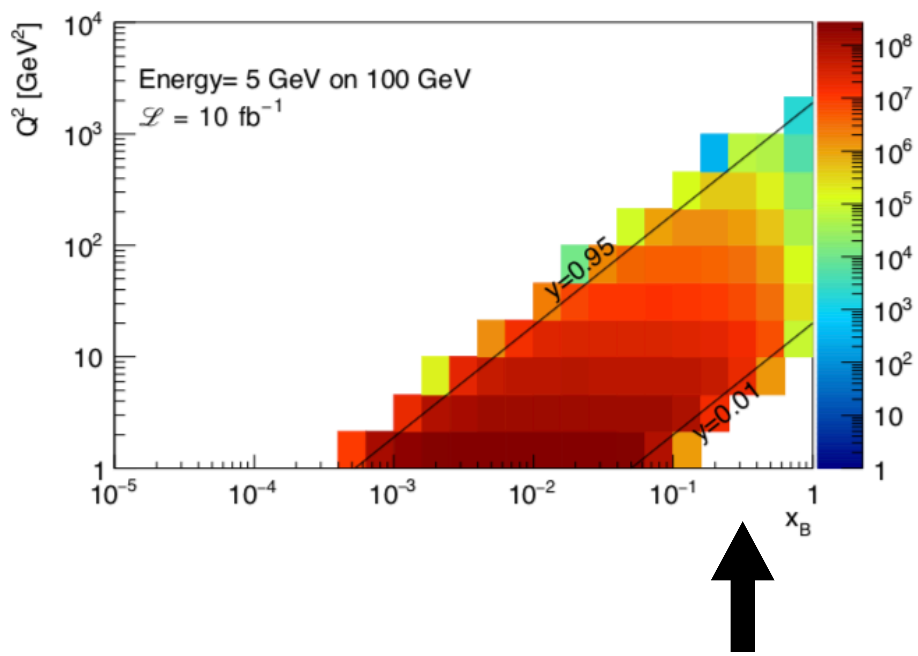

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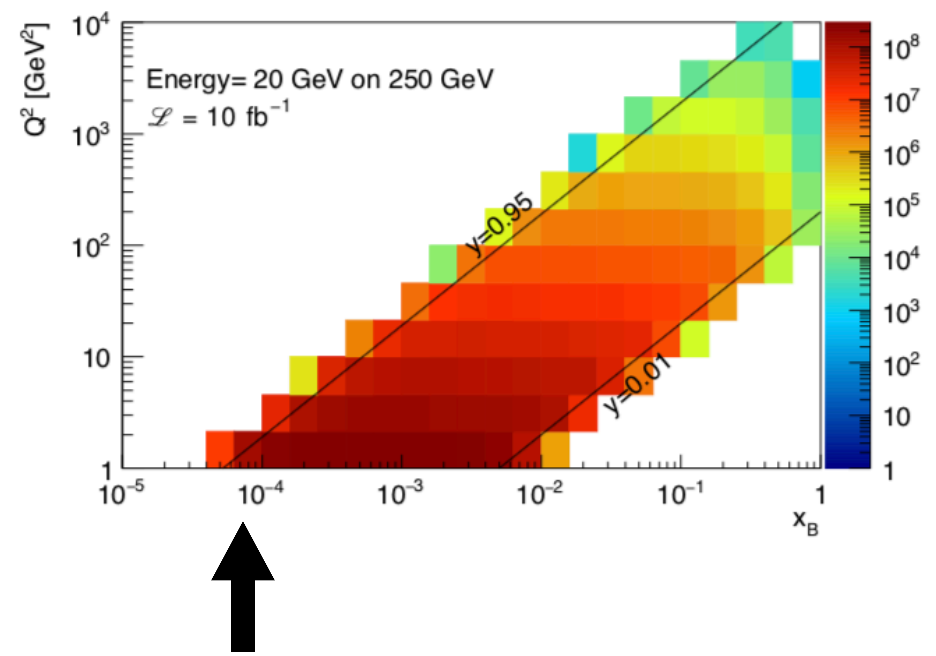

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* variants based on NNPDF3.0

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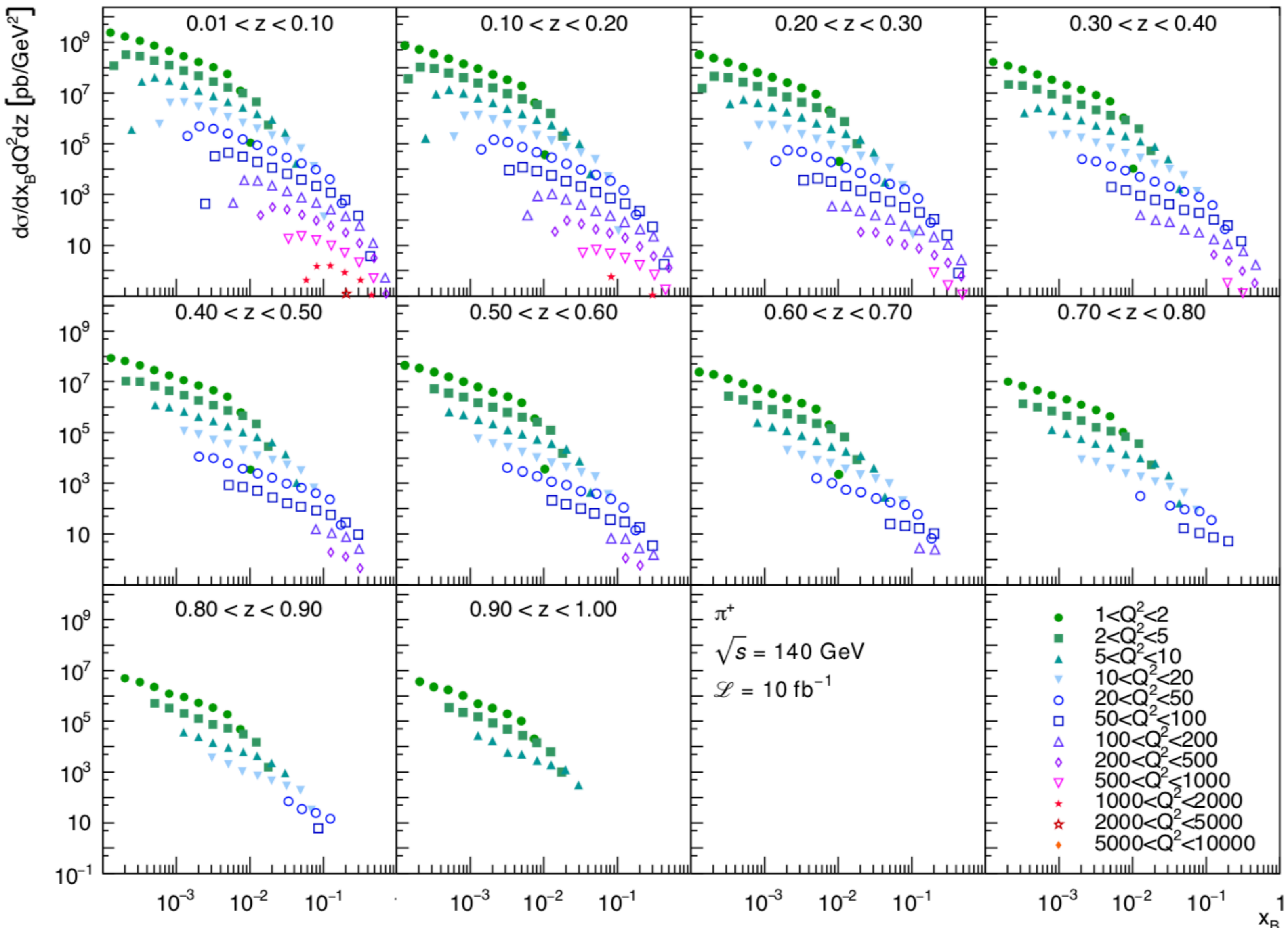

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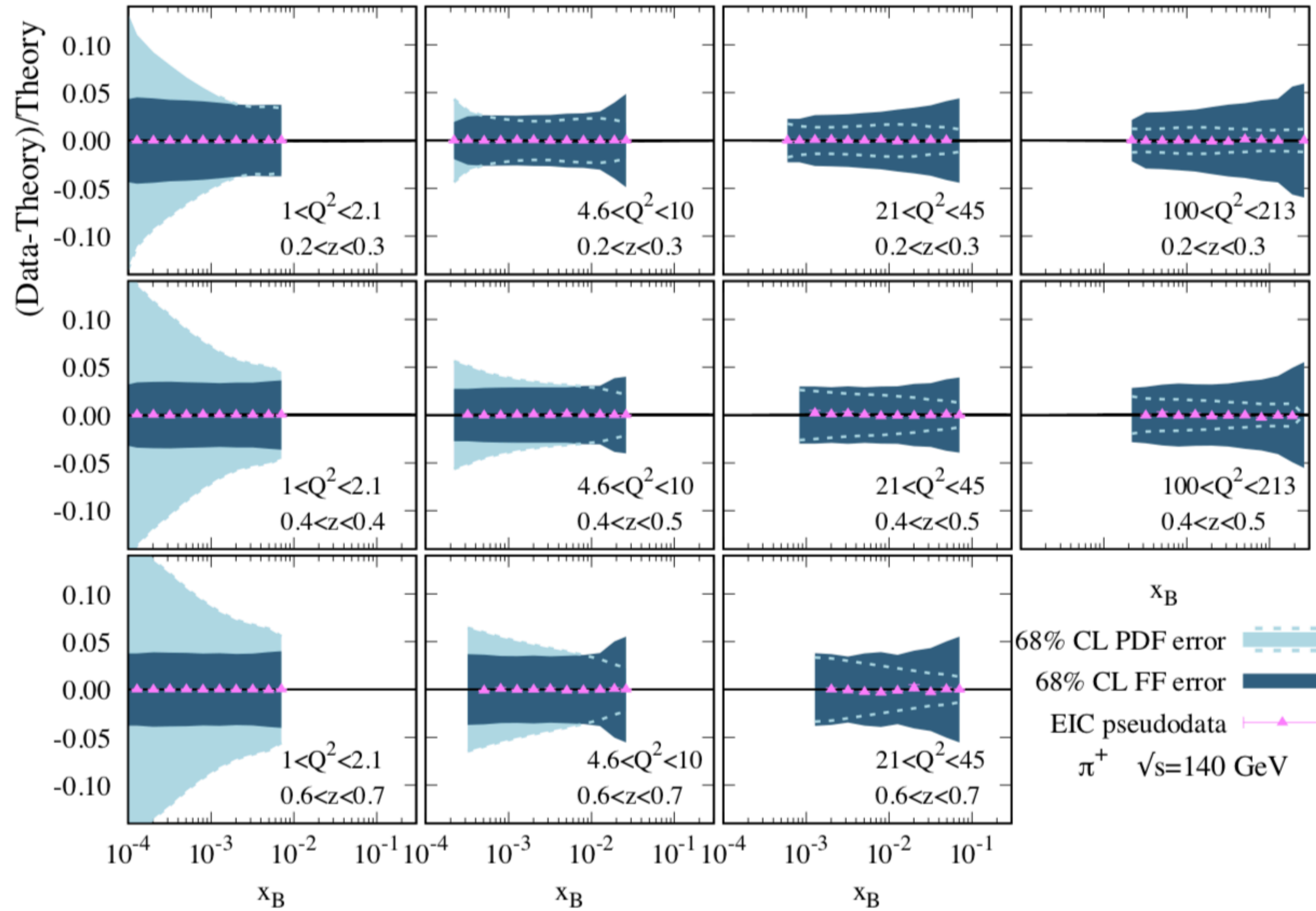

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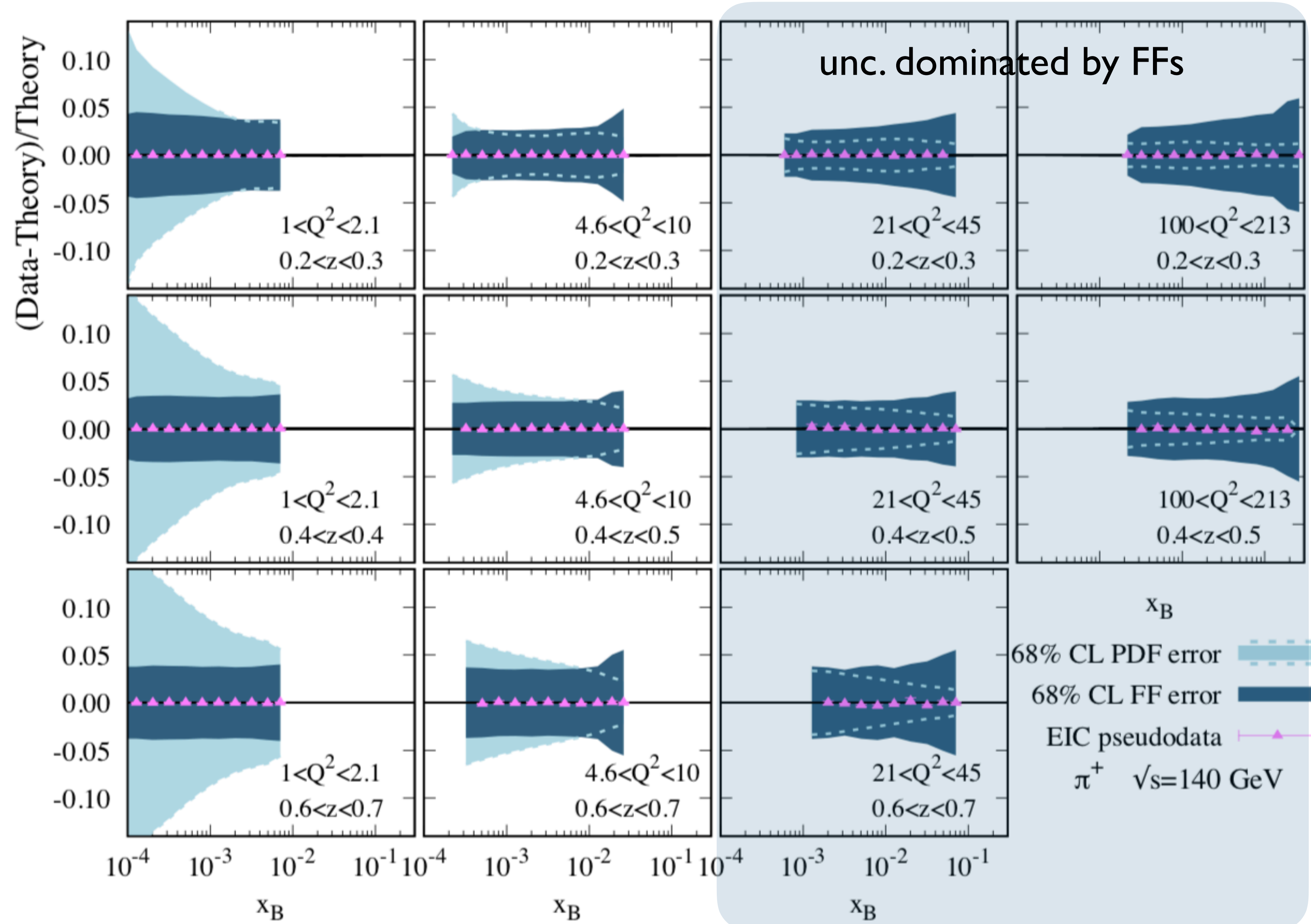

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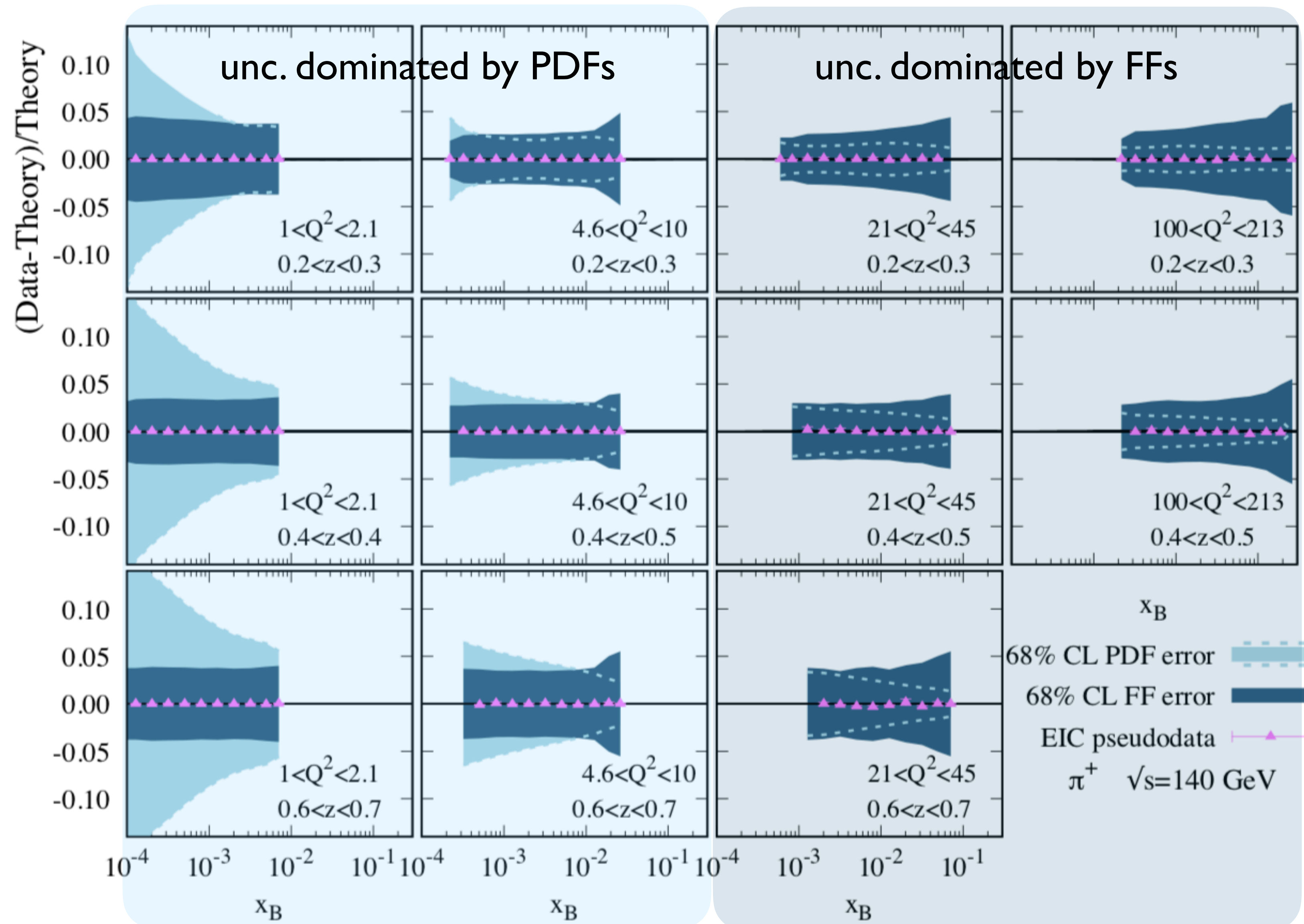

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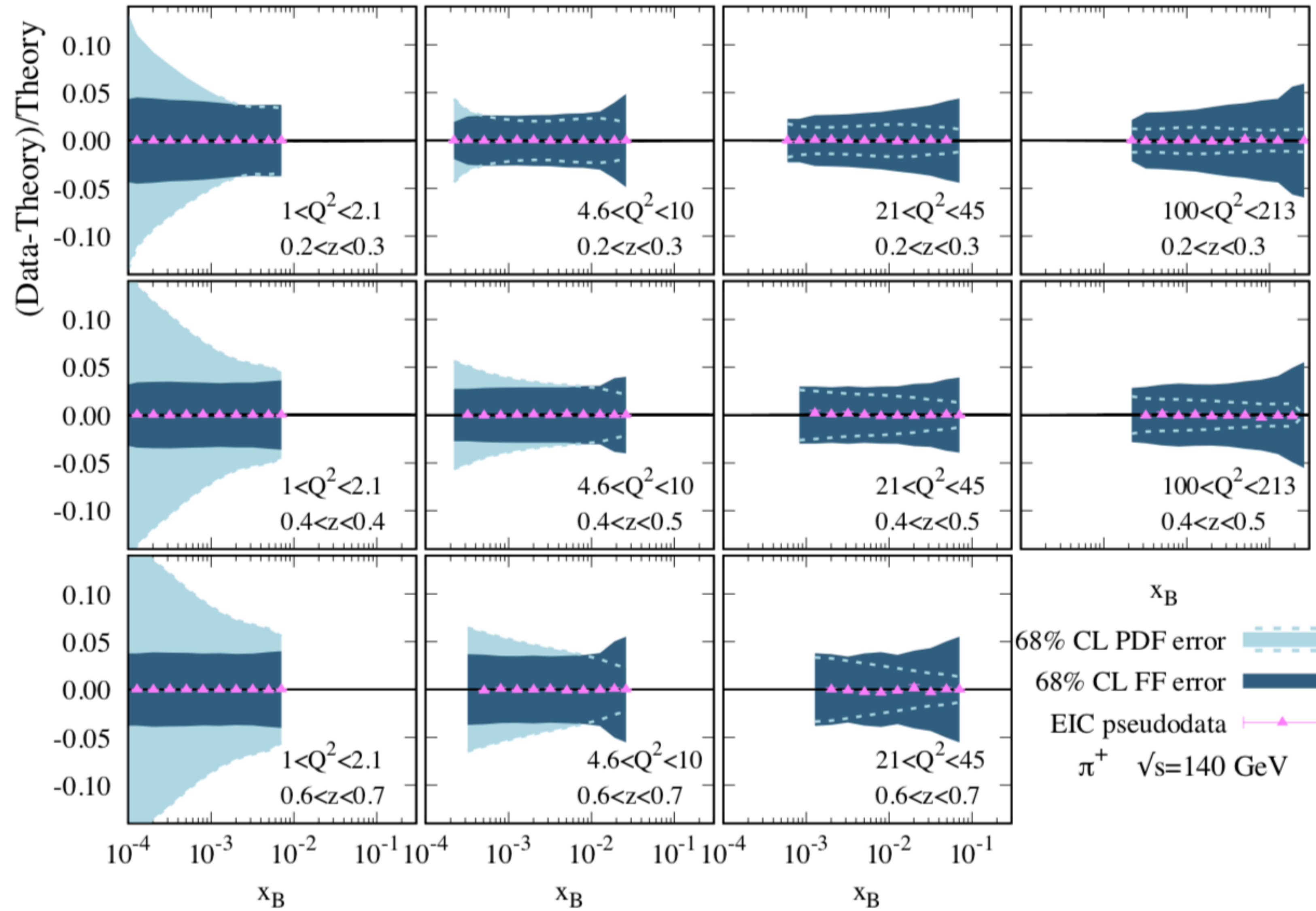

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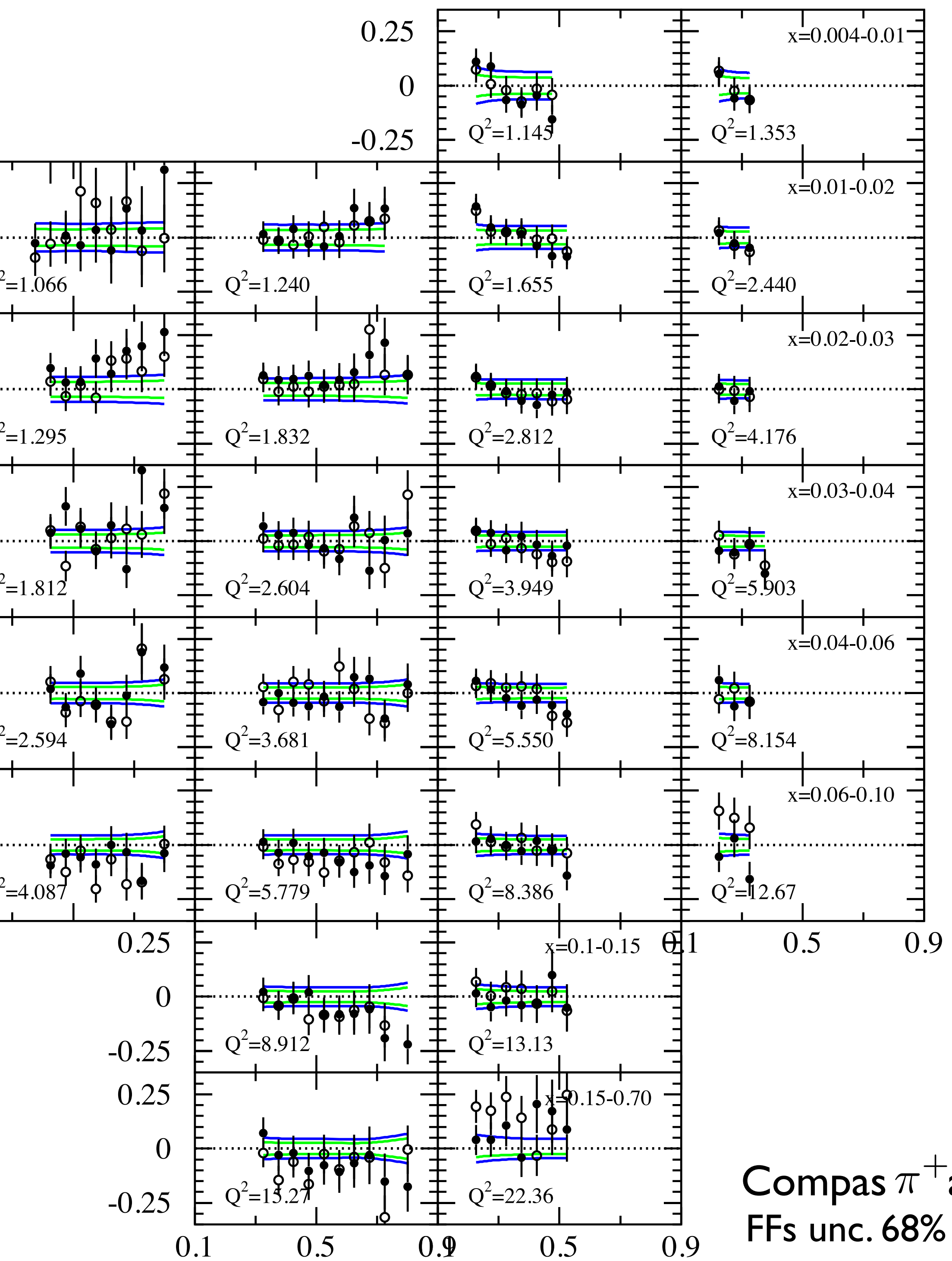
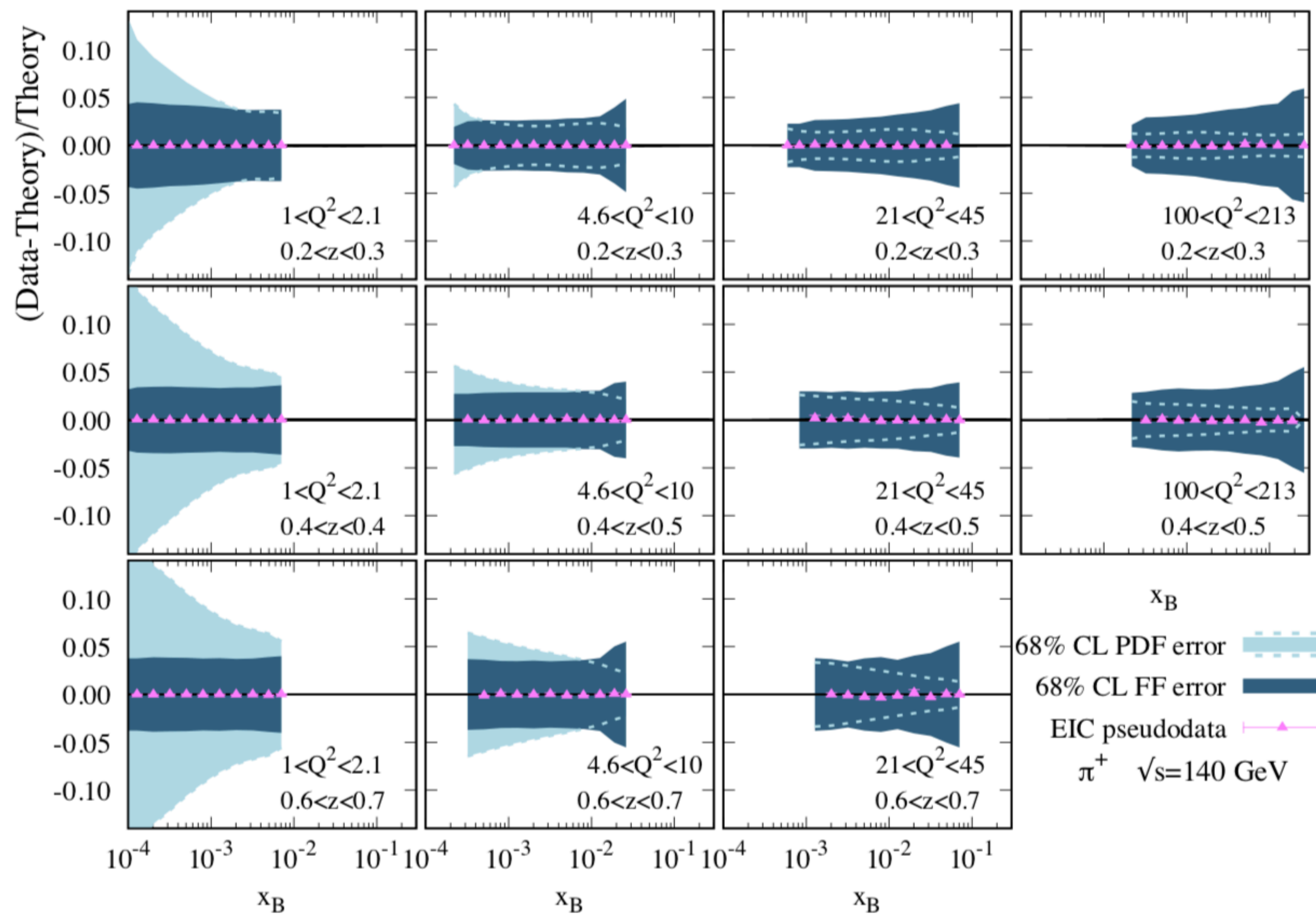


Compas π^+ and π^- SIDIS
FFs unc. 68% and 90% CL



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reweighing of 1000 NNPDF3.0 replicas

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$$S[f_i, \mathcal{O}] = \frac{\langle \mathcal{O} \cdot f_i \rangle - \langle \mathcal{O} \rangle \langle f_i \rangle}{\xi\,\Delta\mathcal{O}\Delta f_i} \qquad \xi \equiv \frac{\delta\mathcal{O}}{\Delta\mathcal{O}}$$

experimental error induced by PDF/FF

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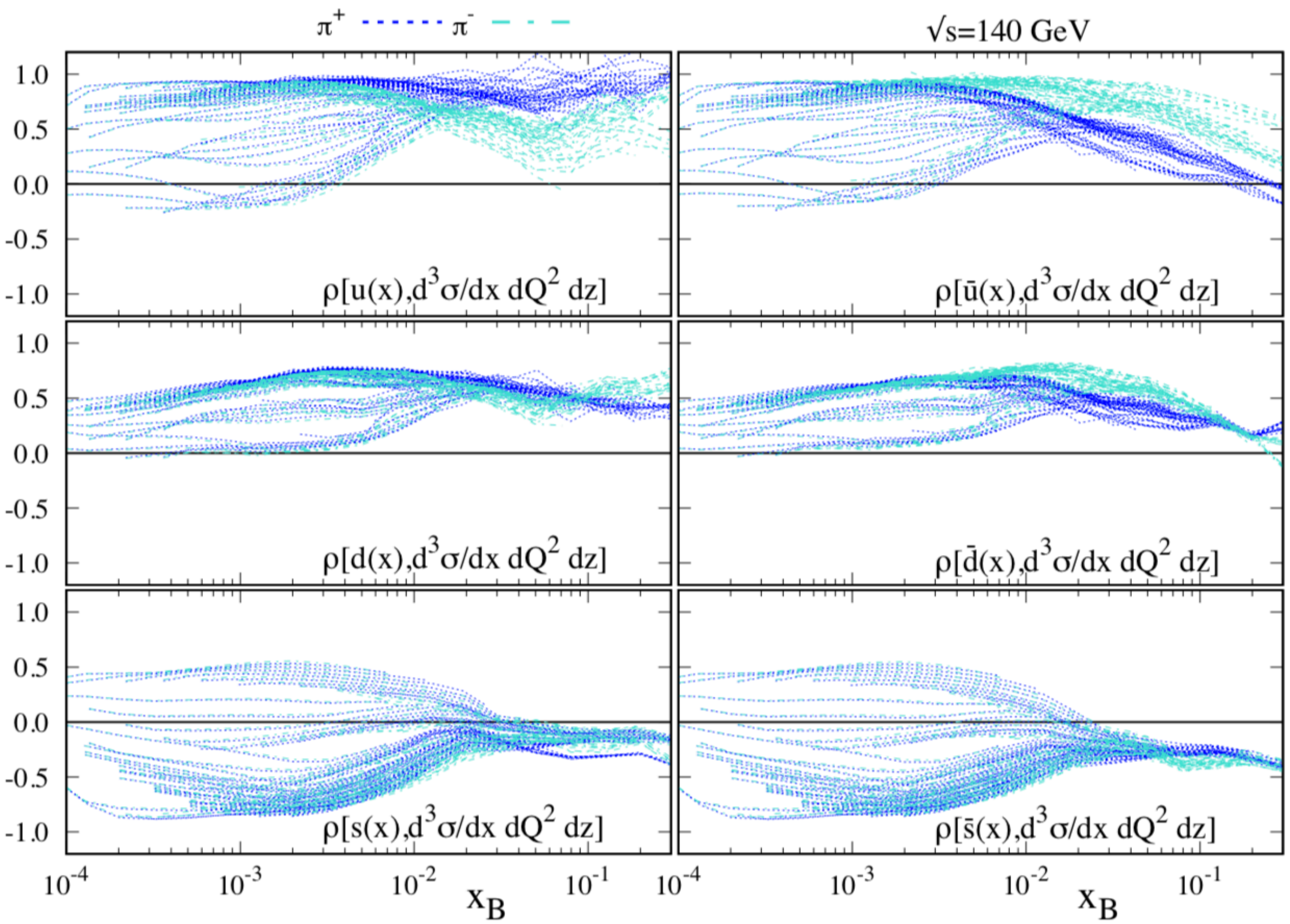

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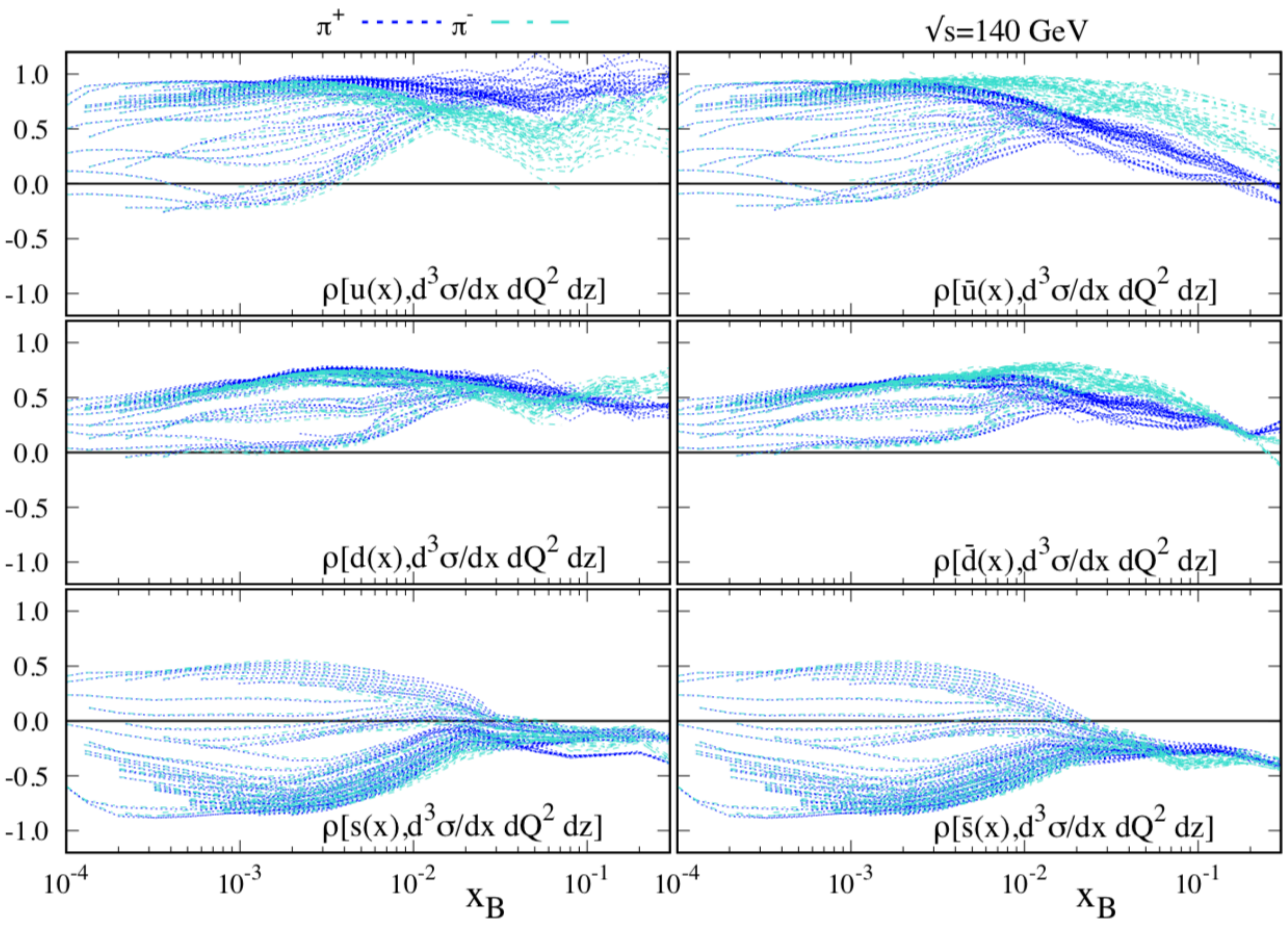

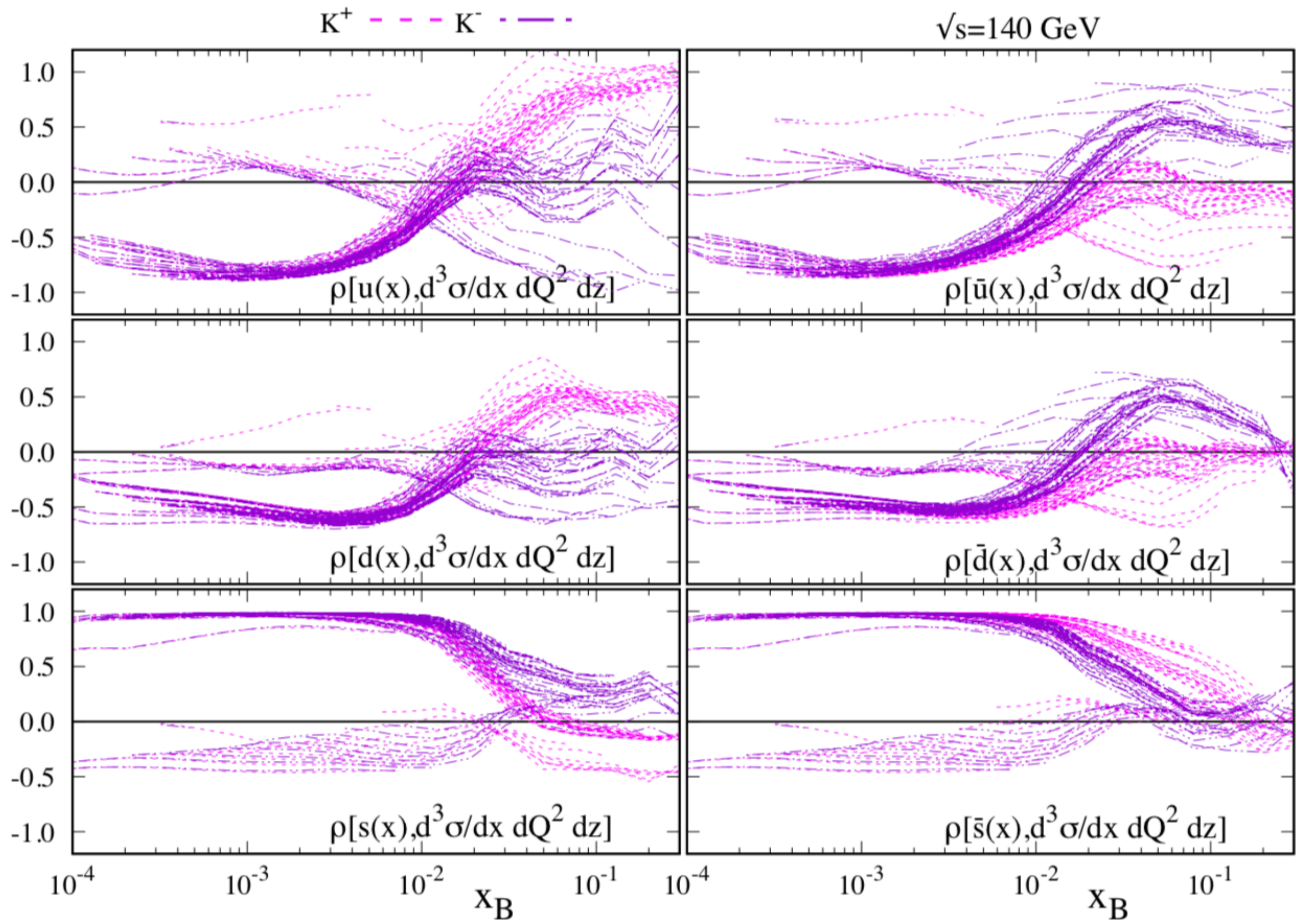

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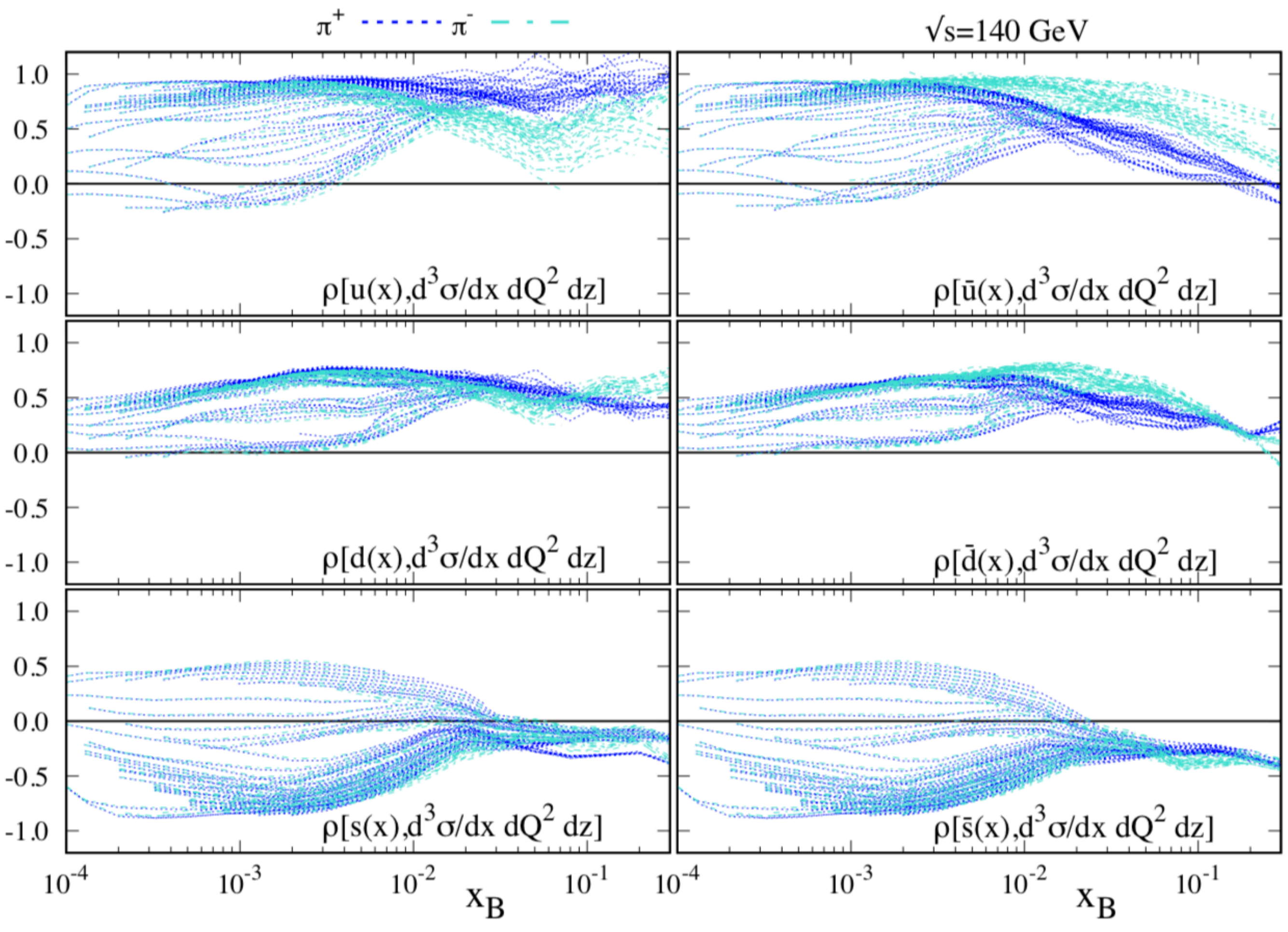

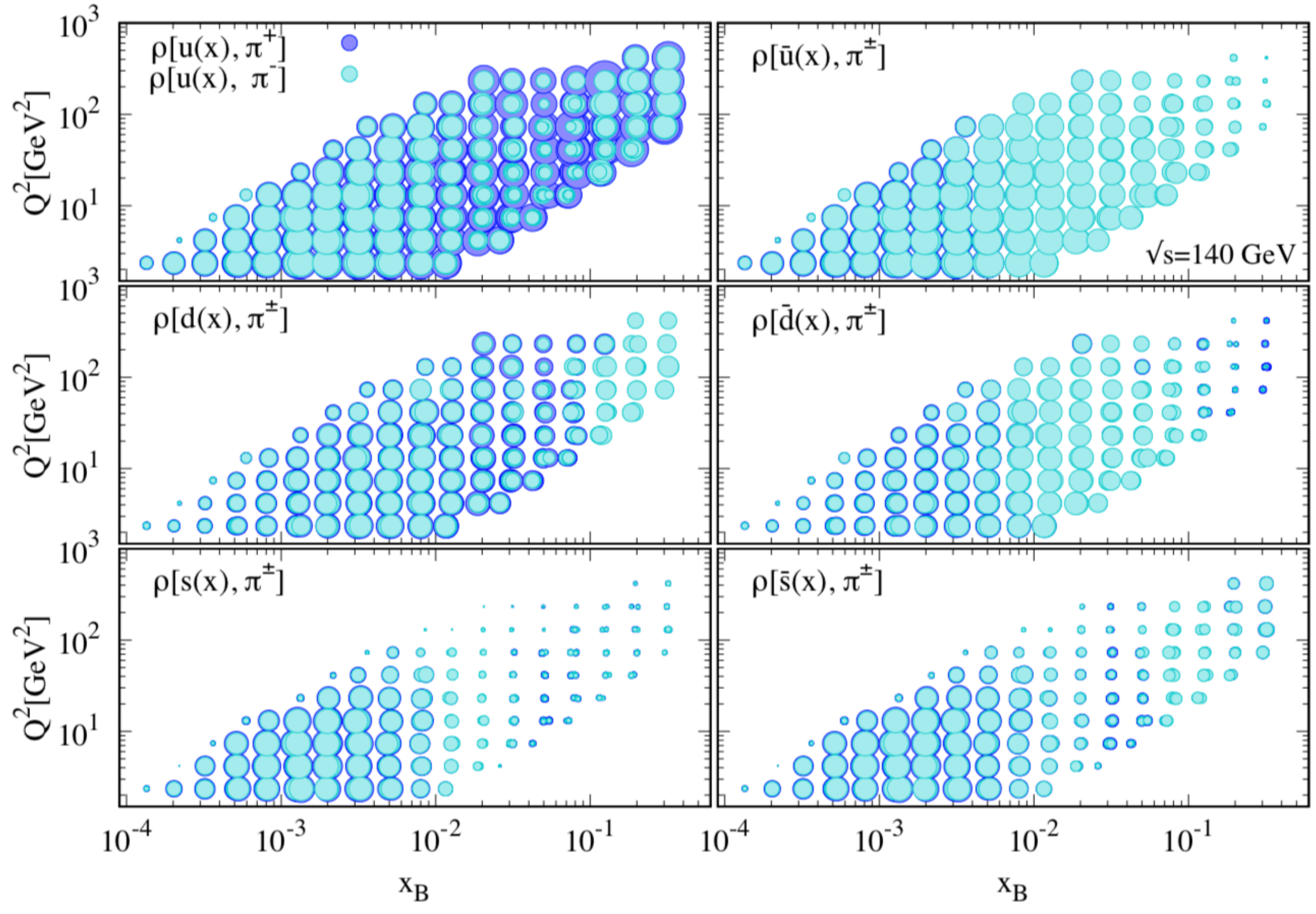

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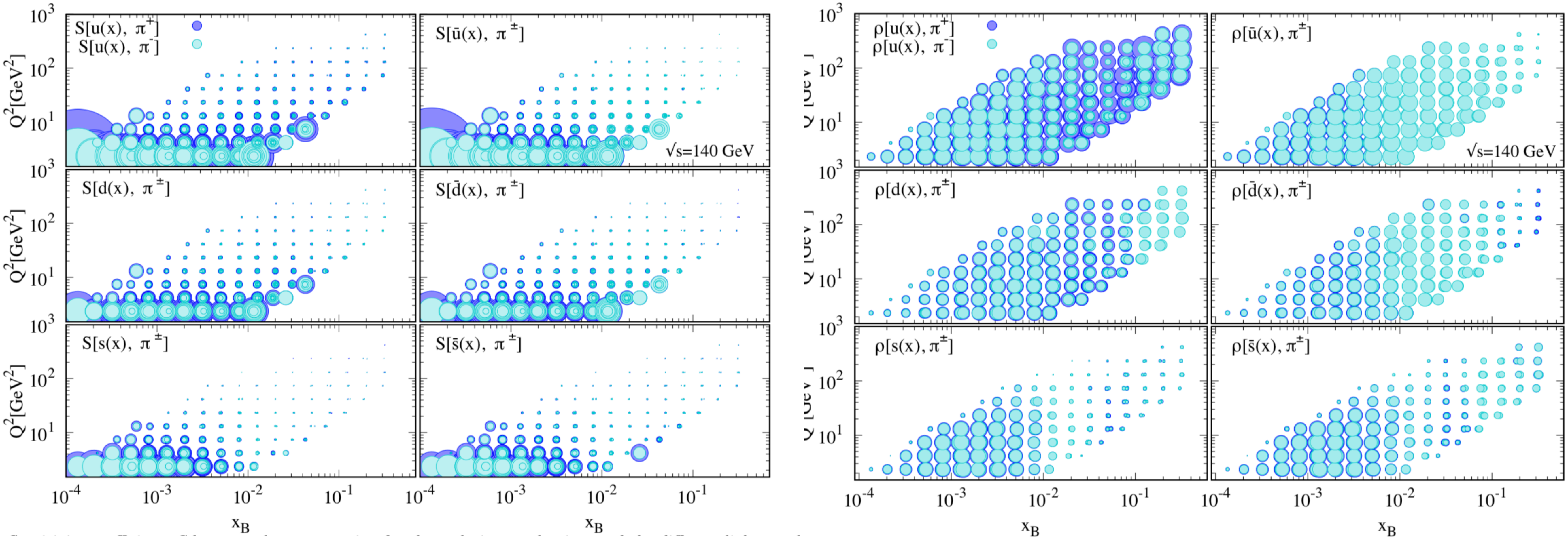

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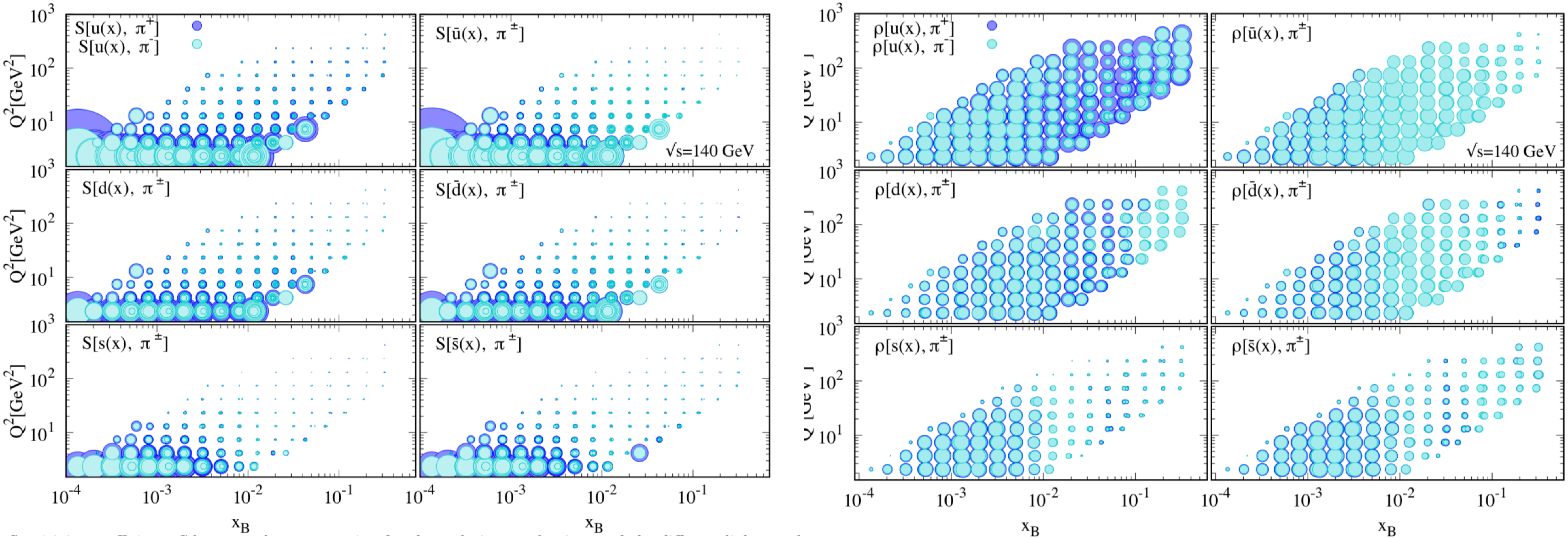

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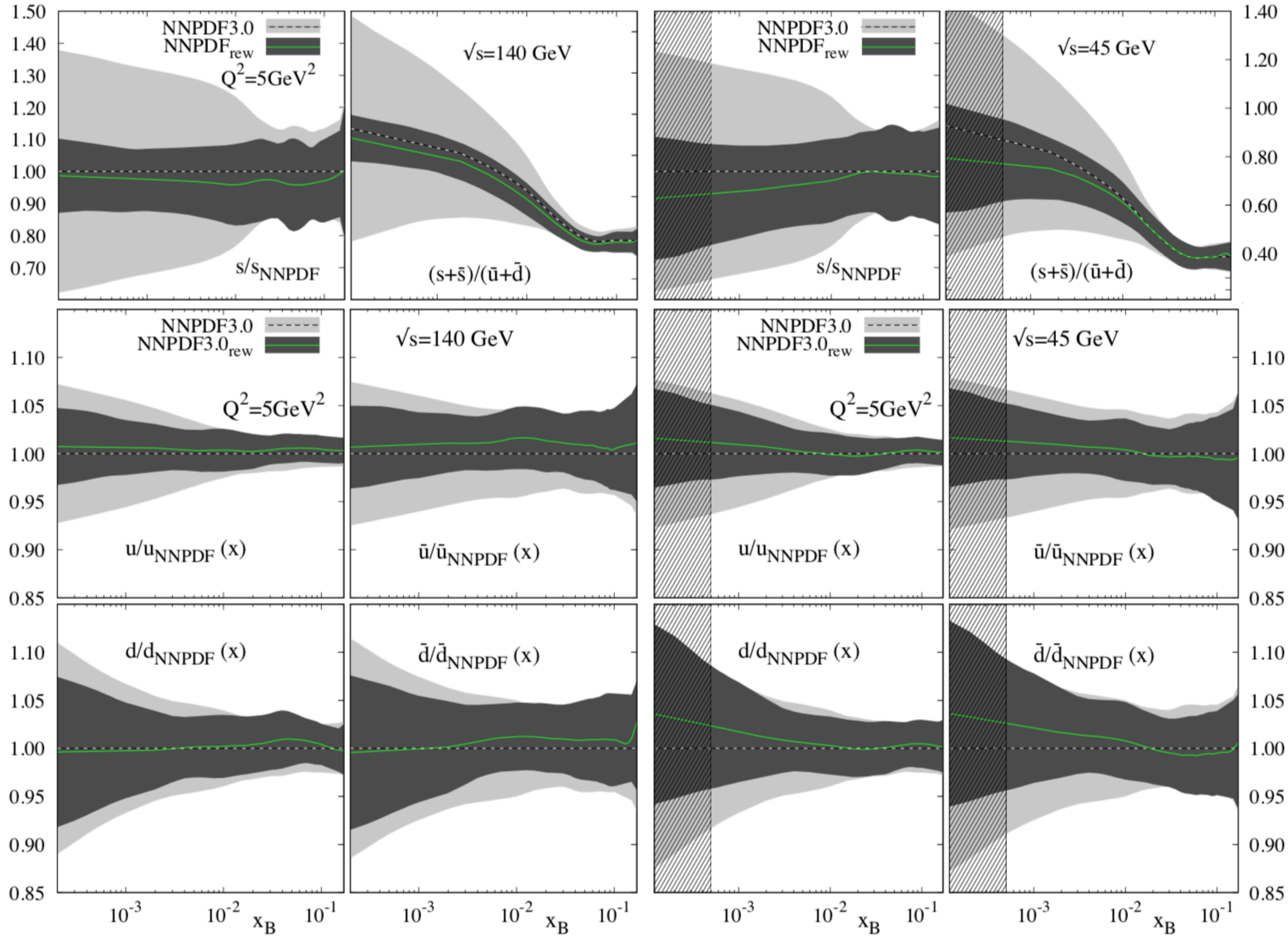

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YPRXDB

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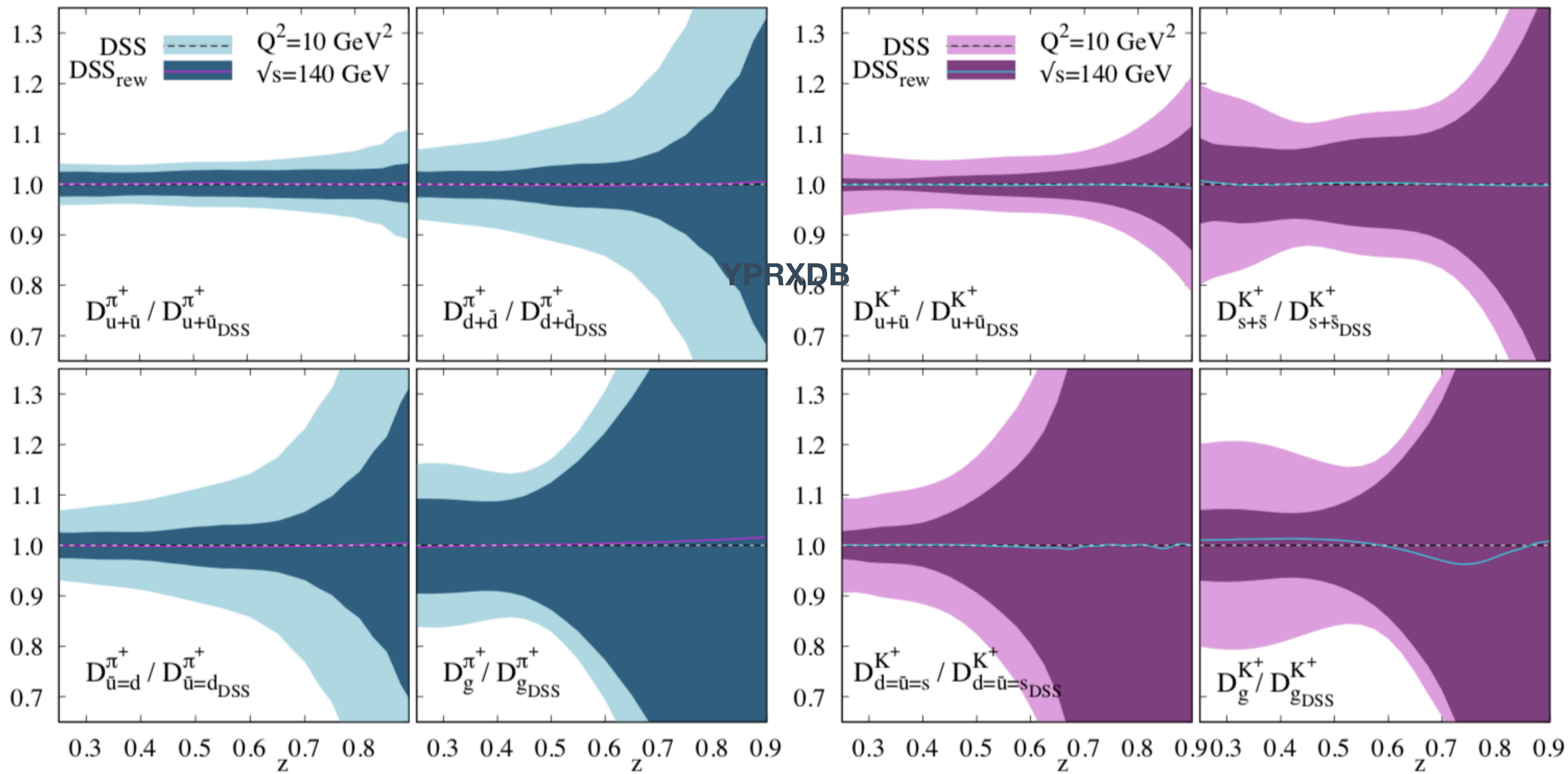

Conclusions:

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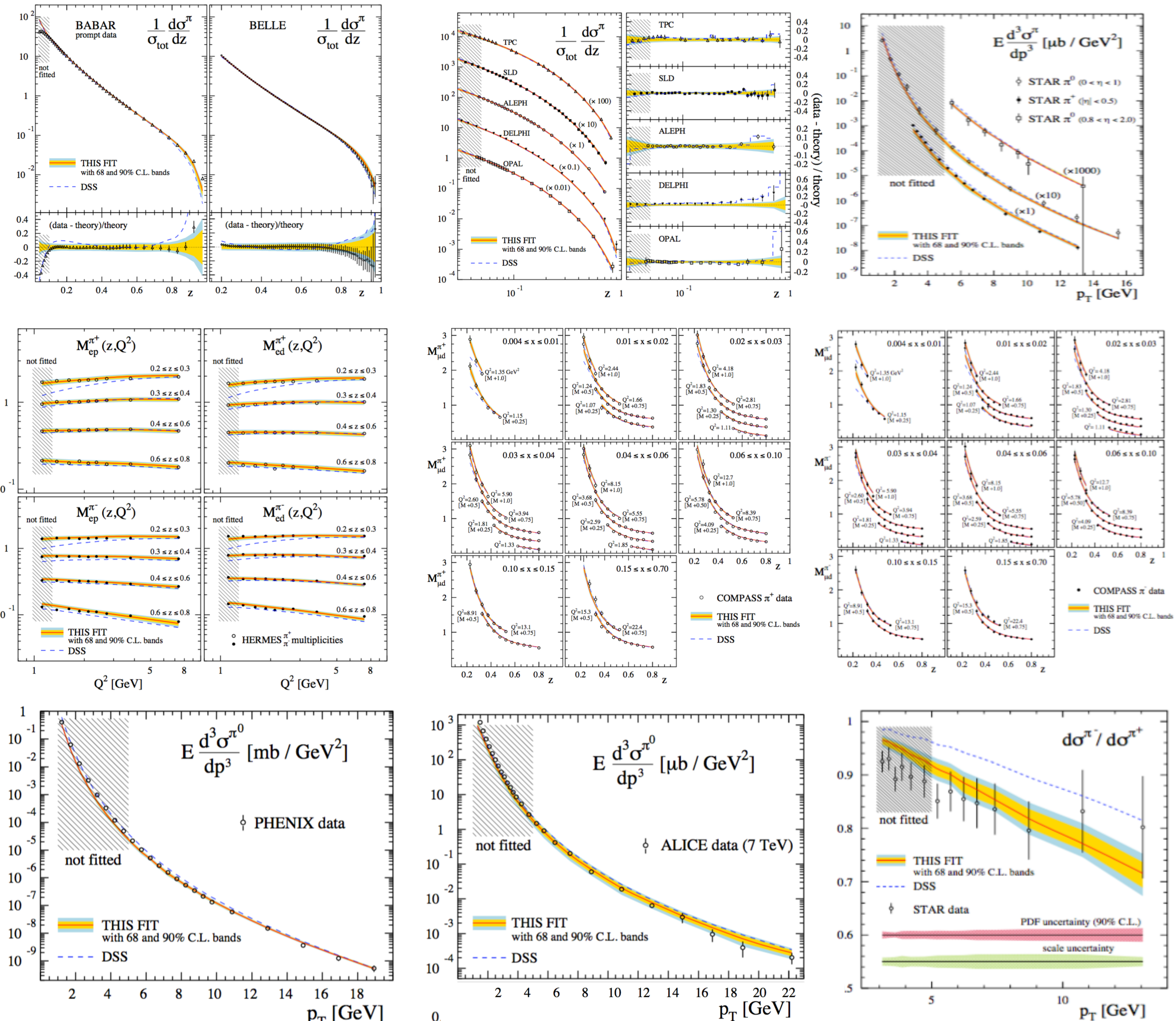
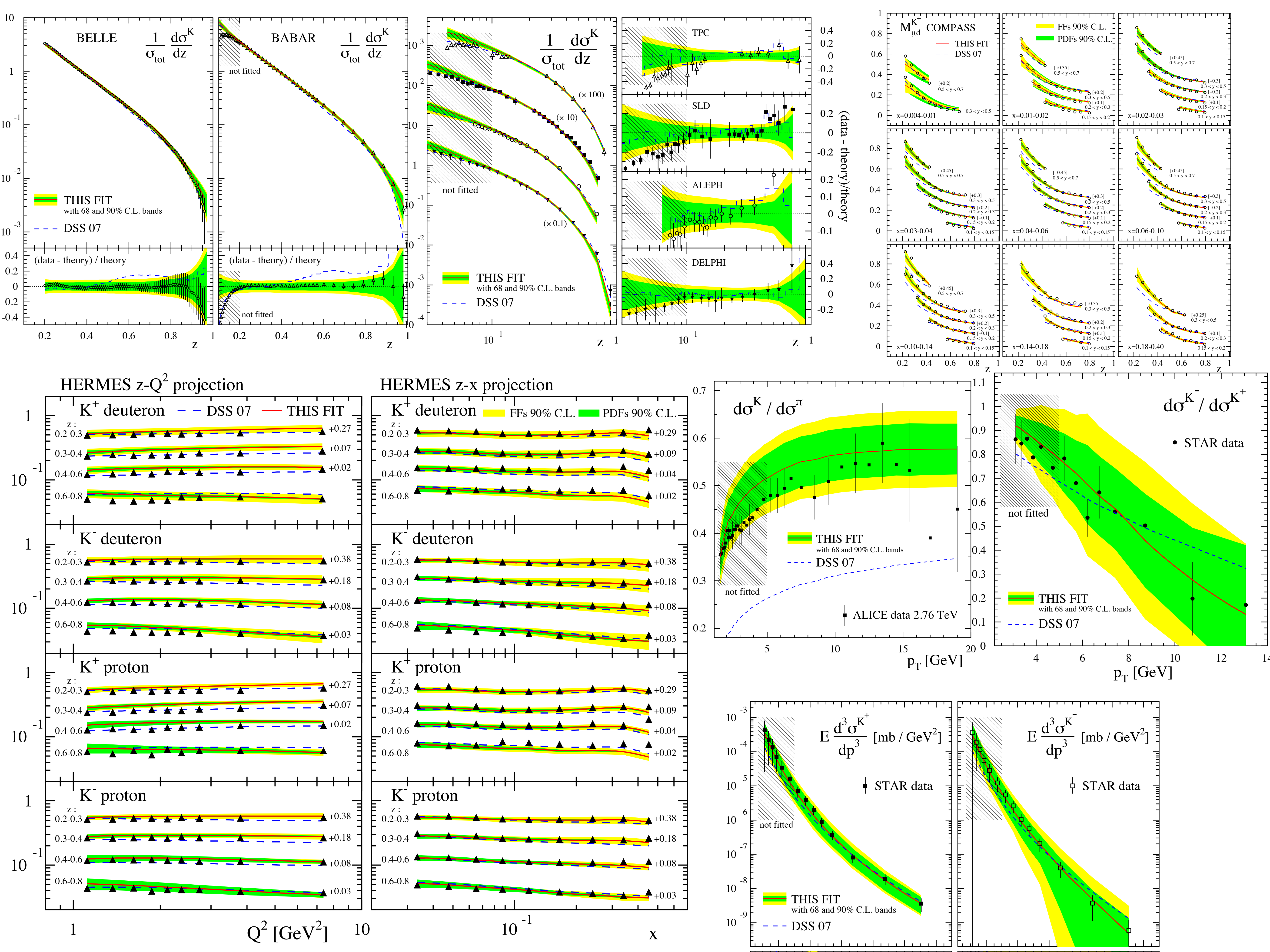
EIC will set a milestone for FFs precision, and their status as precision tools.

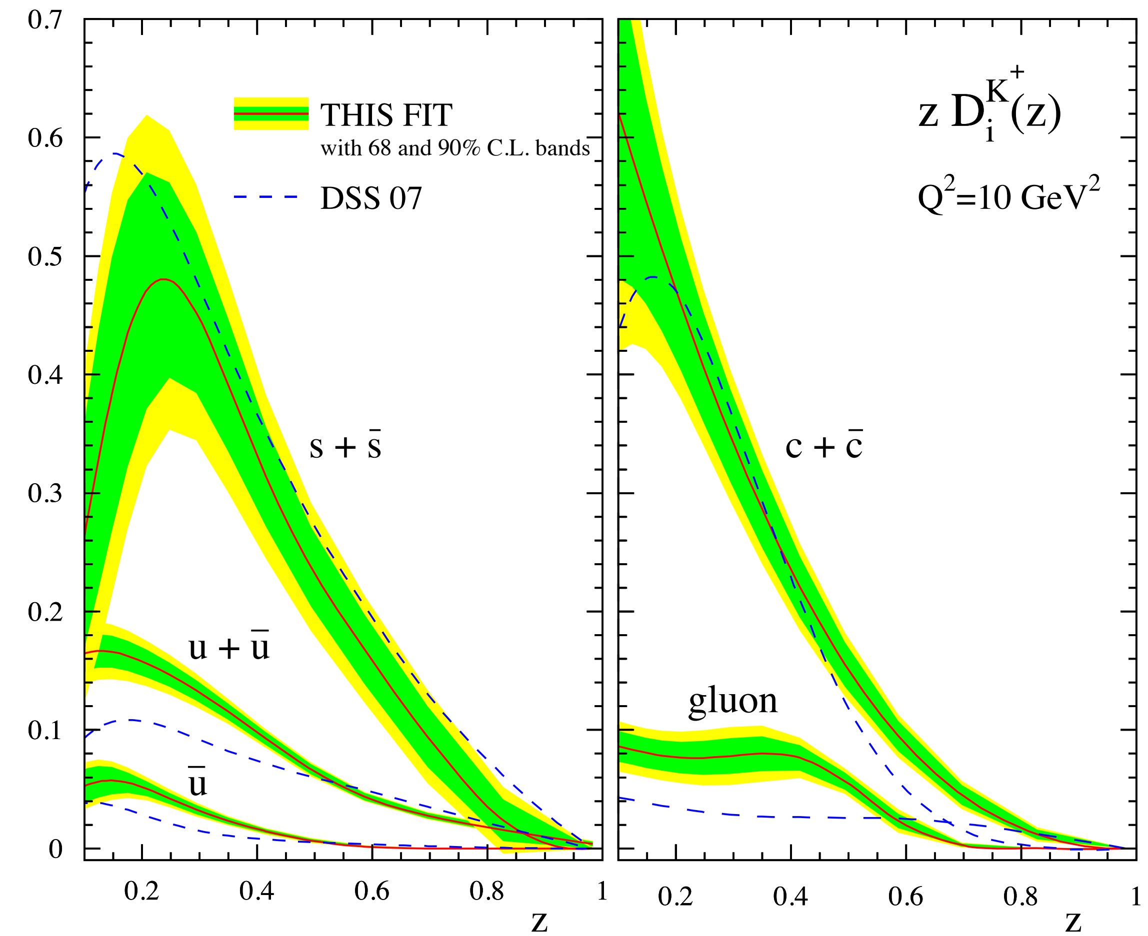
Thanks!

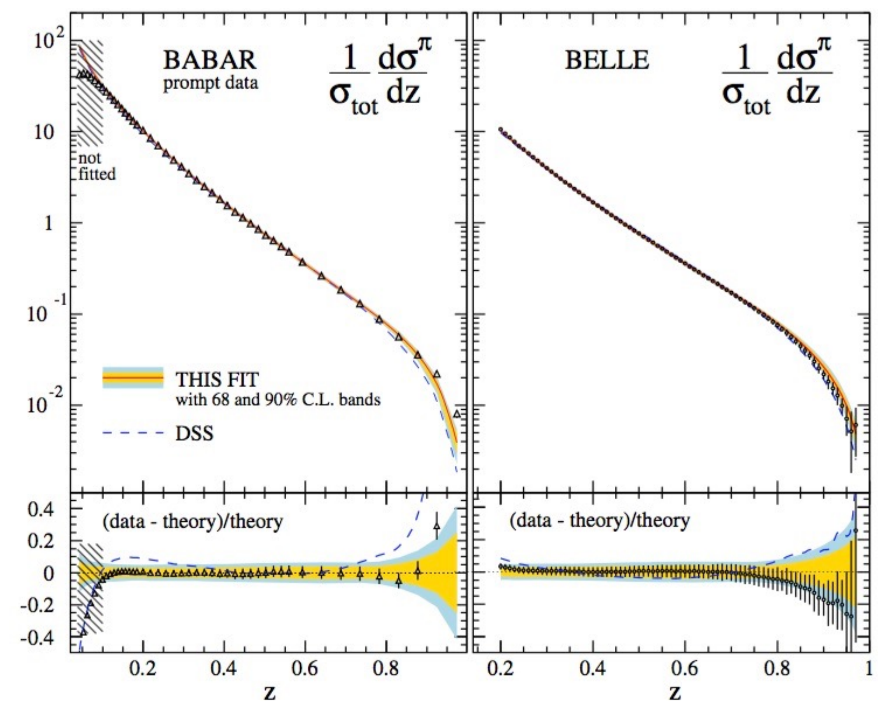


~ 1000 data

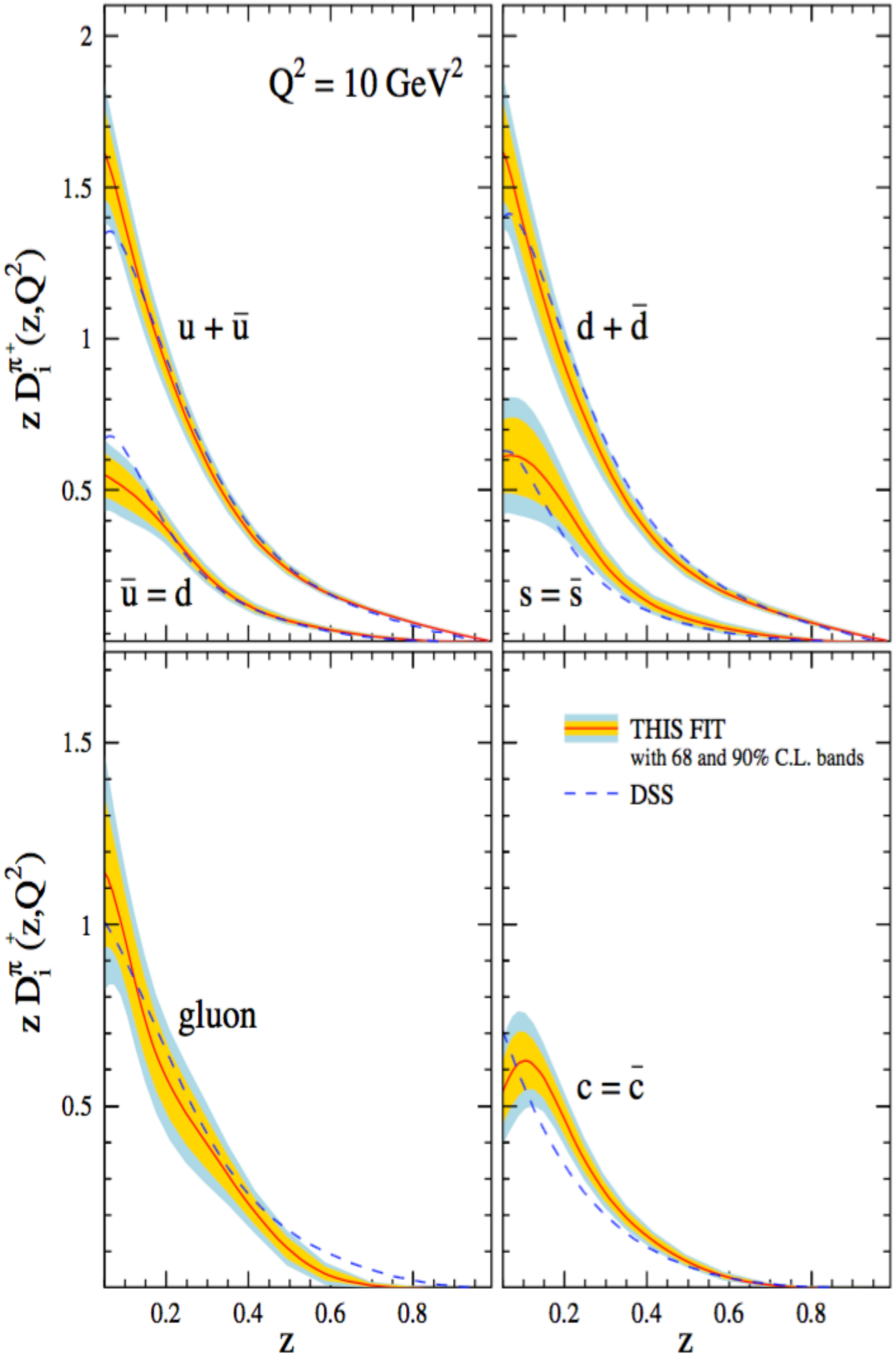
$\chi^2/d.o.f \sim 1.18$


BELLE
BABAR
not fitted
THIS FIT
with 68 and 90% C.L. bands
DSS 07
(data - theory) / theory
z
(× 100)
(× 10)
(× 0.1)
TPC
SLD
ALEPH
DELPHI
(data - theory)/theory
COMPASS
FFs 90% C.L.
PDFs 90% C.L.
HERMES z-Q² projection
HERMES z-x projection
K⁺ deuteron
K⁻ deuteron
K⁺ proton
K⁻ proton
Q² [GeV²]
x
ALICE data 2.76 TeV
STAR data
p_T [GeV]


THIS FIT
with 68 and 90% C.L. bands
DSS 07
$z\,D_i^{K^+}(z)$
Q^2=10 GeV^2
$s+\bar{s}$
$u+\bar{u}$
$\bar{u}$
$c+\bar{c}$
gluon
z
z



BABAR
prompt data
$\frac{1}{\sigma_{tot}}\frac{d\sigma^{\pi}}{dz}$
BELLE
$\frac{1}{\sigma_{tot}}\frac{d\sigma^{\pi}}{dz}$
not fitted
THIS FIT
with 68 and 90% C.L. bands
DSS
(data - theory)/theory
(data - theory)/theory
z
z


$Q^2 = 10\ \mathrm{GeV}^2$
$u + \bar{u}$
$\bar{u} = d$
$d + \bar{d}$
$s = \bar{s}$
gluon
$c = \bar{c}$
THIS FIT
with 68 and 90% C.L. bands
DSS
$z\,D_i^{\pi^+}(z,Q^2)$
z
0.5
1
1.5
2
0.2
0.4
0.6
0.8