Study of the impact of the EIC on unpolarized TMDs

SIDIS Working Group meeting

Lorenzo Rossi

July 9th

Istituto Nazionale di Fisica Nucleare

UNIVERSITÀ DI PAVIA

TMD Factorization - structure of TMDs

$$\hat{f}_1^q(x_B, \mathbf{b}_T; \mu_F, \zeta_F) = [C \otimes f_1](x_B, b_\star; \mu_{b_\star}, \mu_{b_\star}^2) \exp\left\{ \int_{\mu_{b_\star}}^{\mu_F} \frac{d\mu'}{\mu'} \gamma(\mu', \zeta_F) \right\}$$

$$\times \left(\frac{\zeta}{\mu_{b_\star}^2} \right)^{K(b_\star, \mu_{b_\star})/2} \left[\frac{\zeta}{Q_0} \right]^{-g_K(\mathbf{b}_T)/2} f_1^{NP}(x, \mathbf{b}_T; \zeta, Q_0)$$

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(perturbative calculable)

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Fit extraction

Collins, "Foundations of Perturbative QCD"

MAPTMD24 extraction - starting points

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- Global analysis of Drell-Yan and Semi-Inclusive DIS data sets: ***2031*** data points (DY + SIDIS)

MAP Collaboration, arXiv 2405.13833

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- Extremely good description: $\chi^2/\mathrm{N_{data}} = 1.08$

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The sea is the least constrained ⟷ ***The up quark is the most one***

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generated by Gregory Matousek

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predictions using the MAP24 global fit

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Uncorrelated one (statistics)

Correlated one (systematics)

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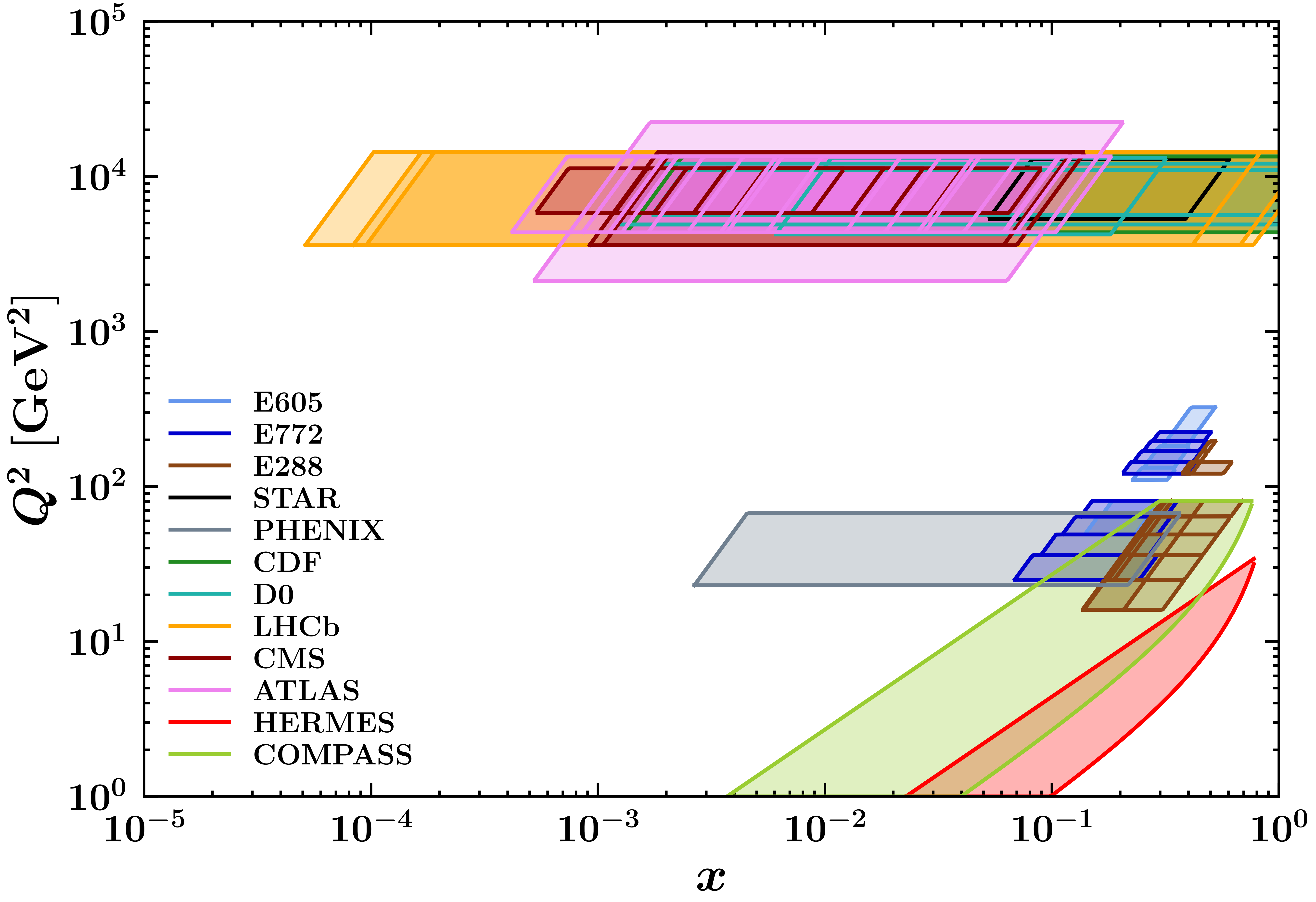
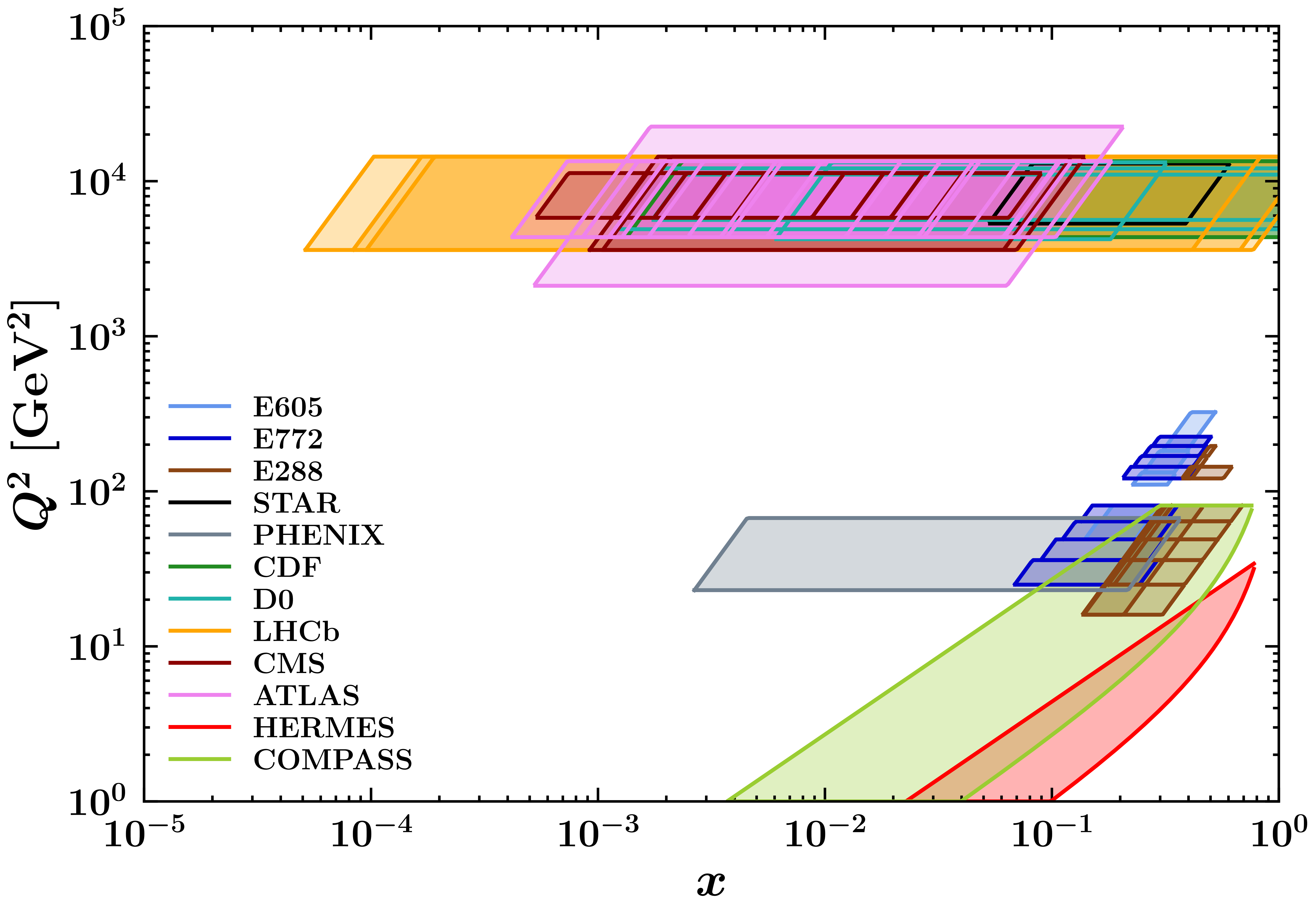


MAPTMD24 extraction - EIC Pseudodata

5x41 in π^+



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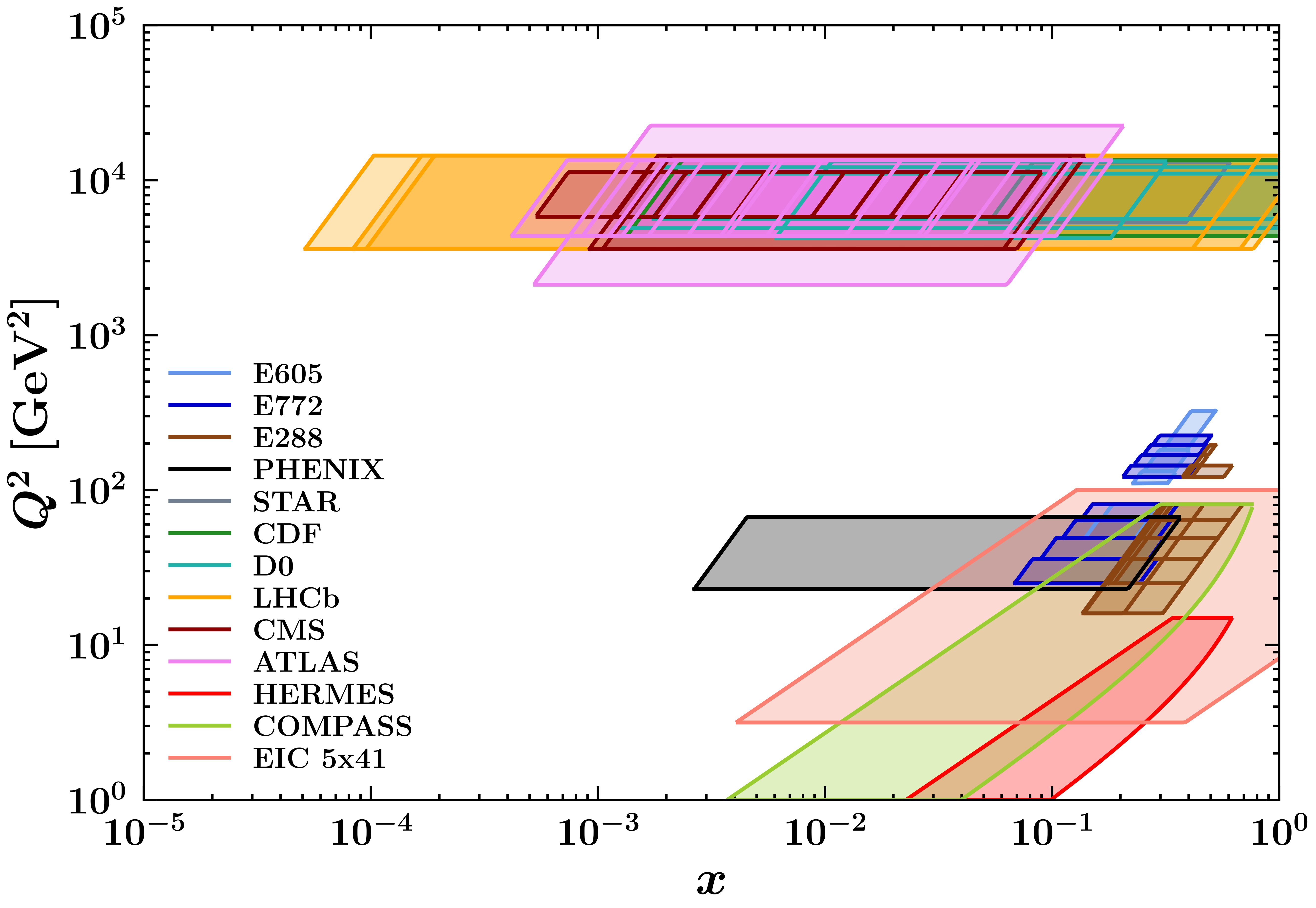

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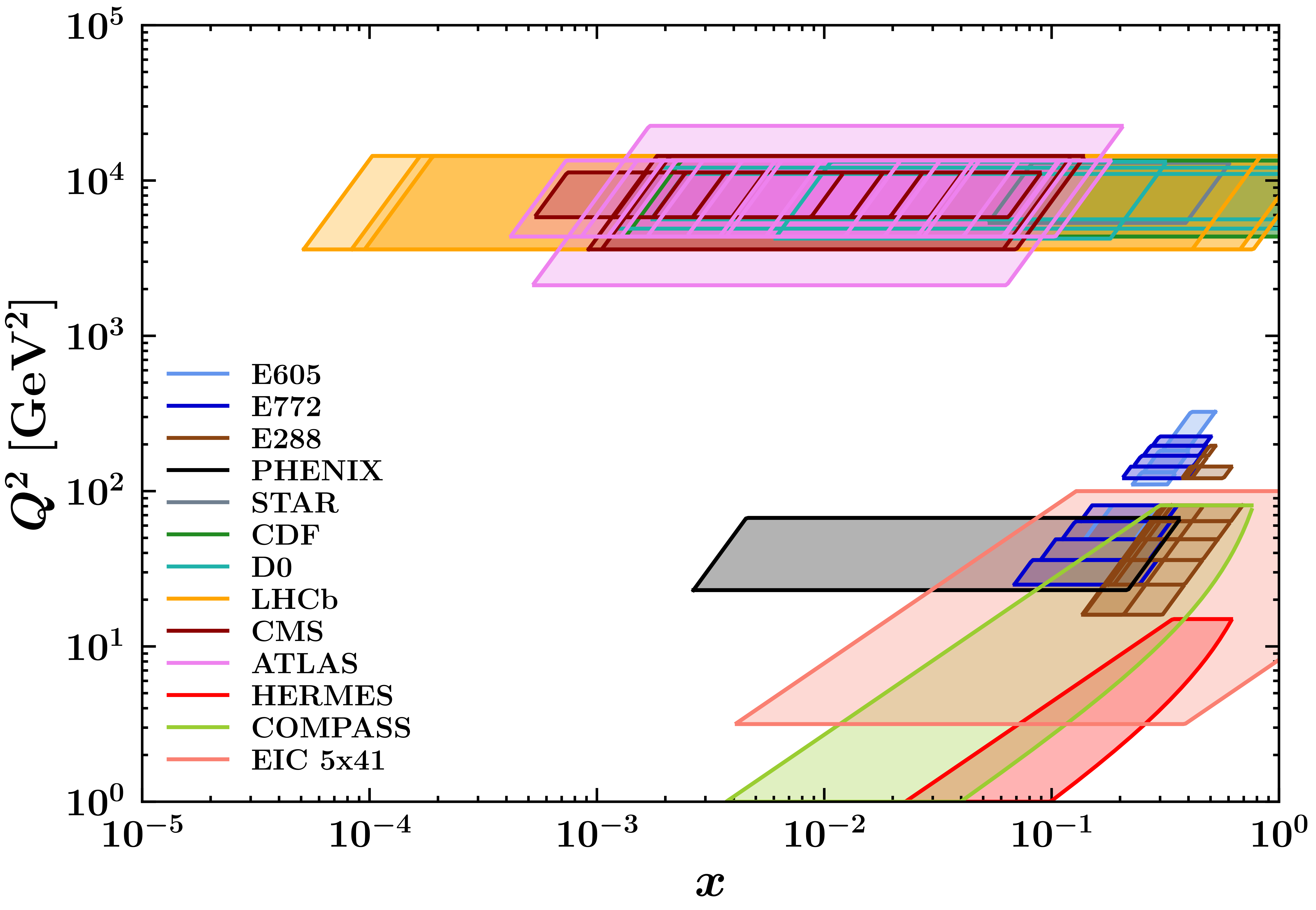
10x100 in π^+



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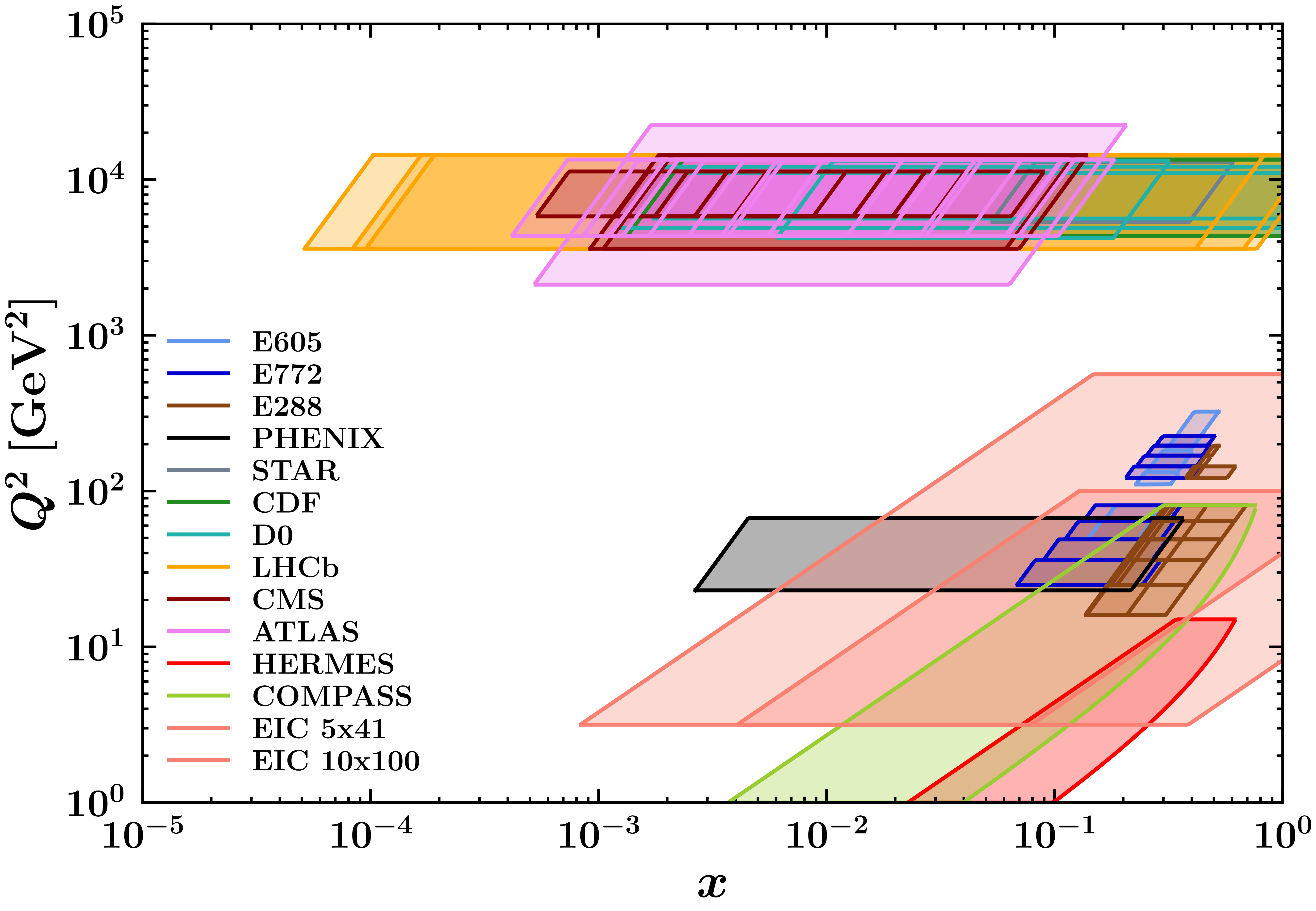

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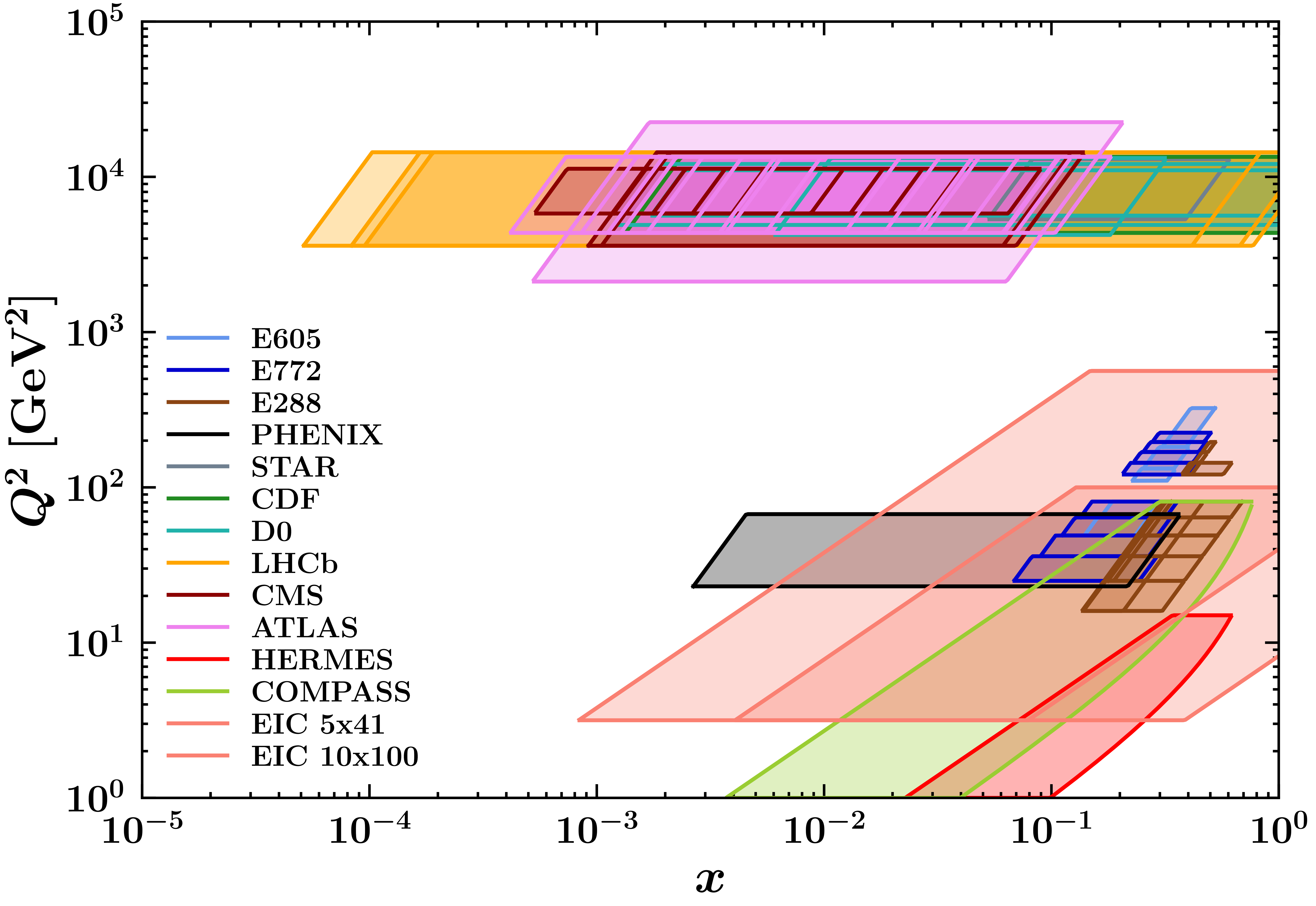
5x41 in π^+

10x100 in π^+

18x275 in π^+



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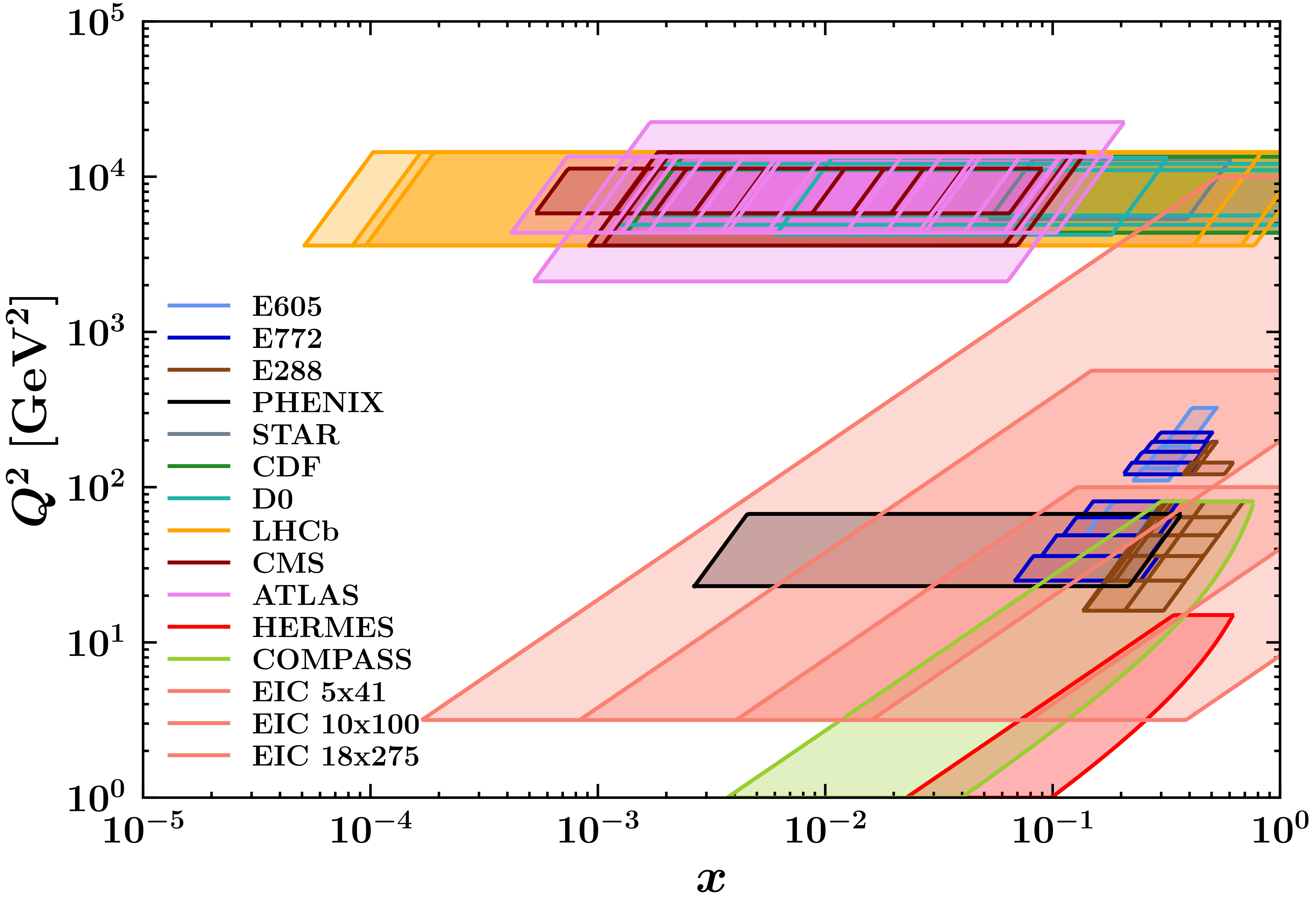

MAPTMD24 extraction - EIC Pseudodata

Number of datapoints

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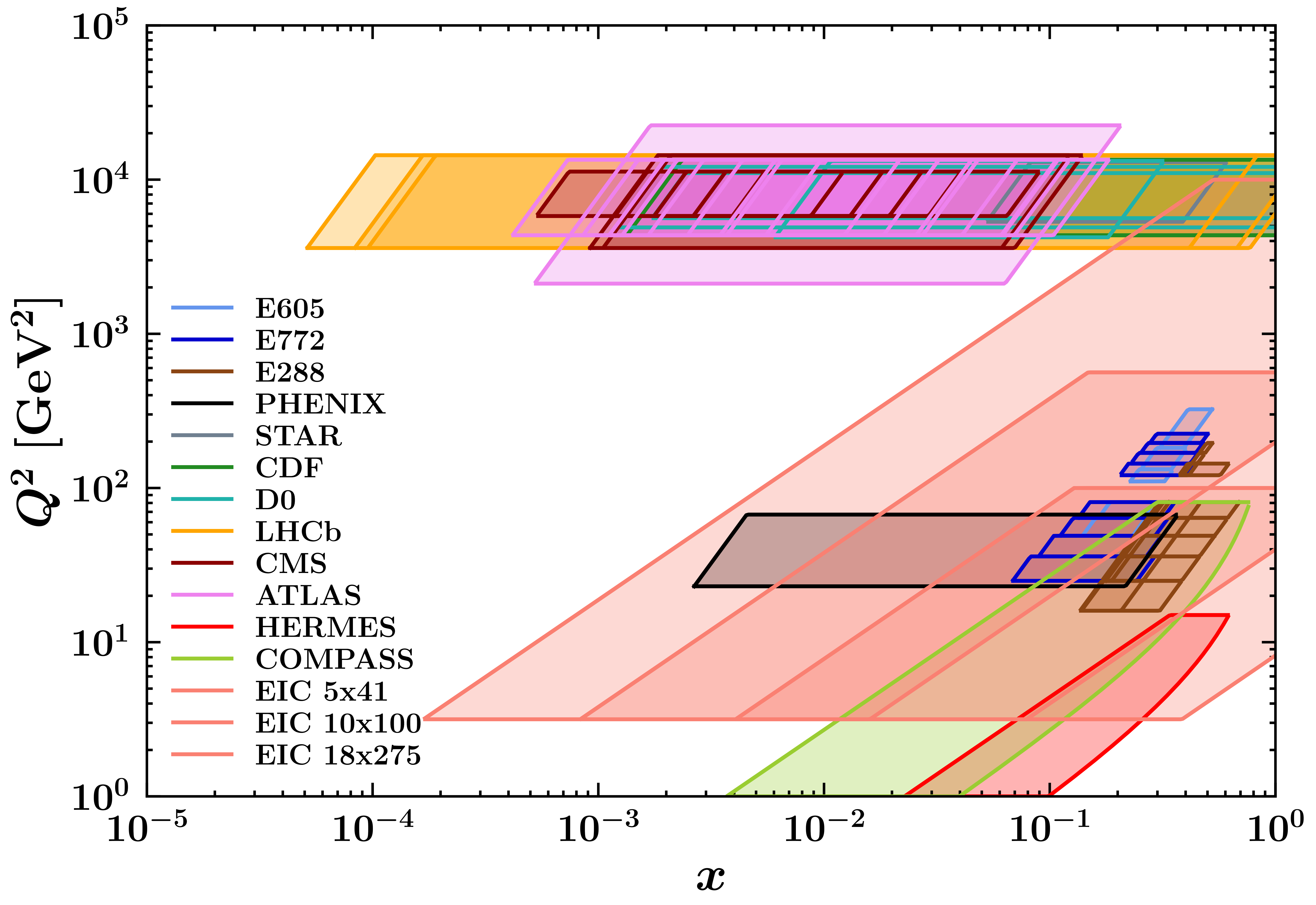

MAPTMD24 extraction - EIC Pseudodata

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5x41 in π^+	**1273**
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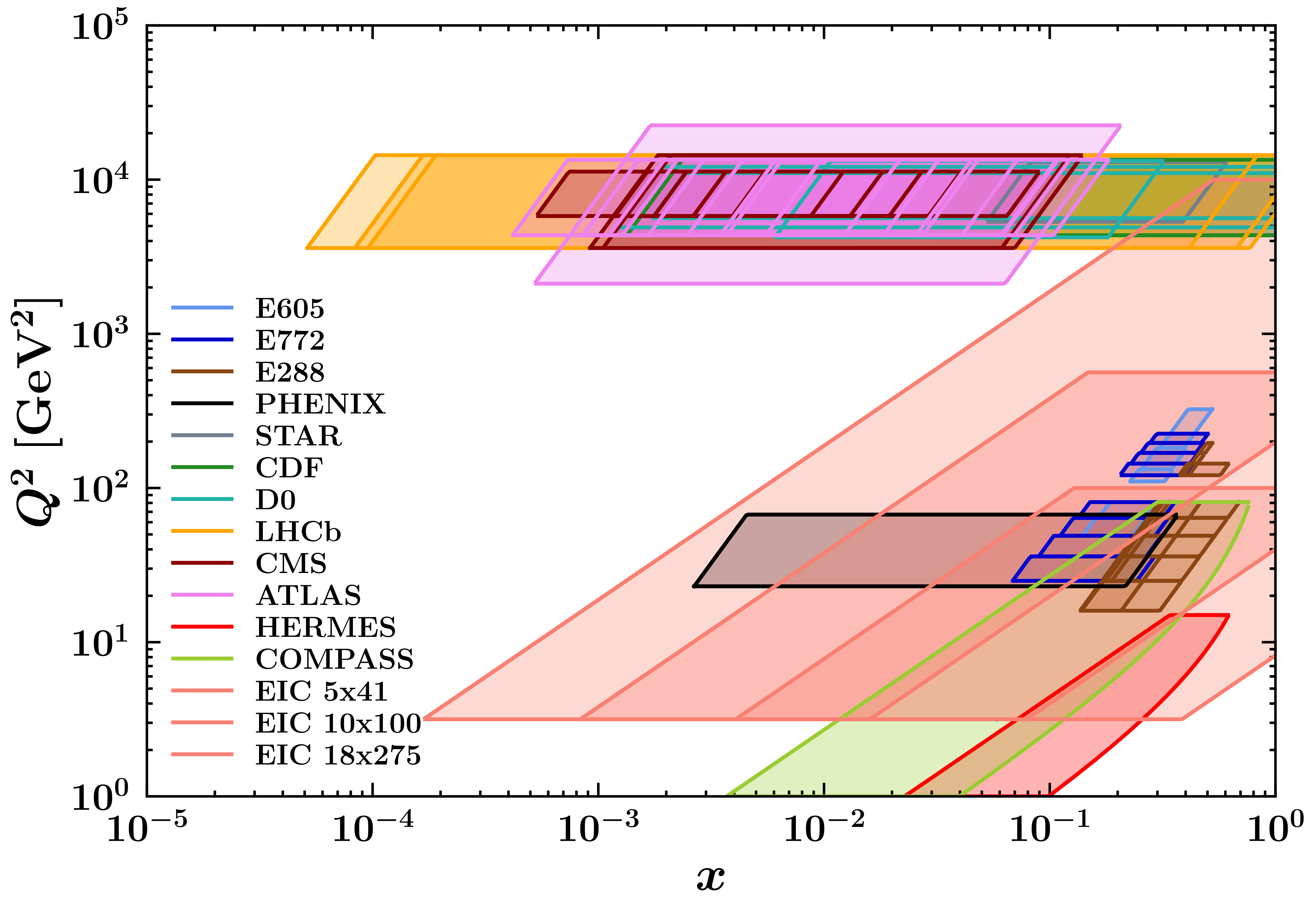

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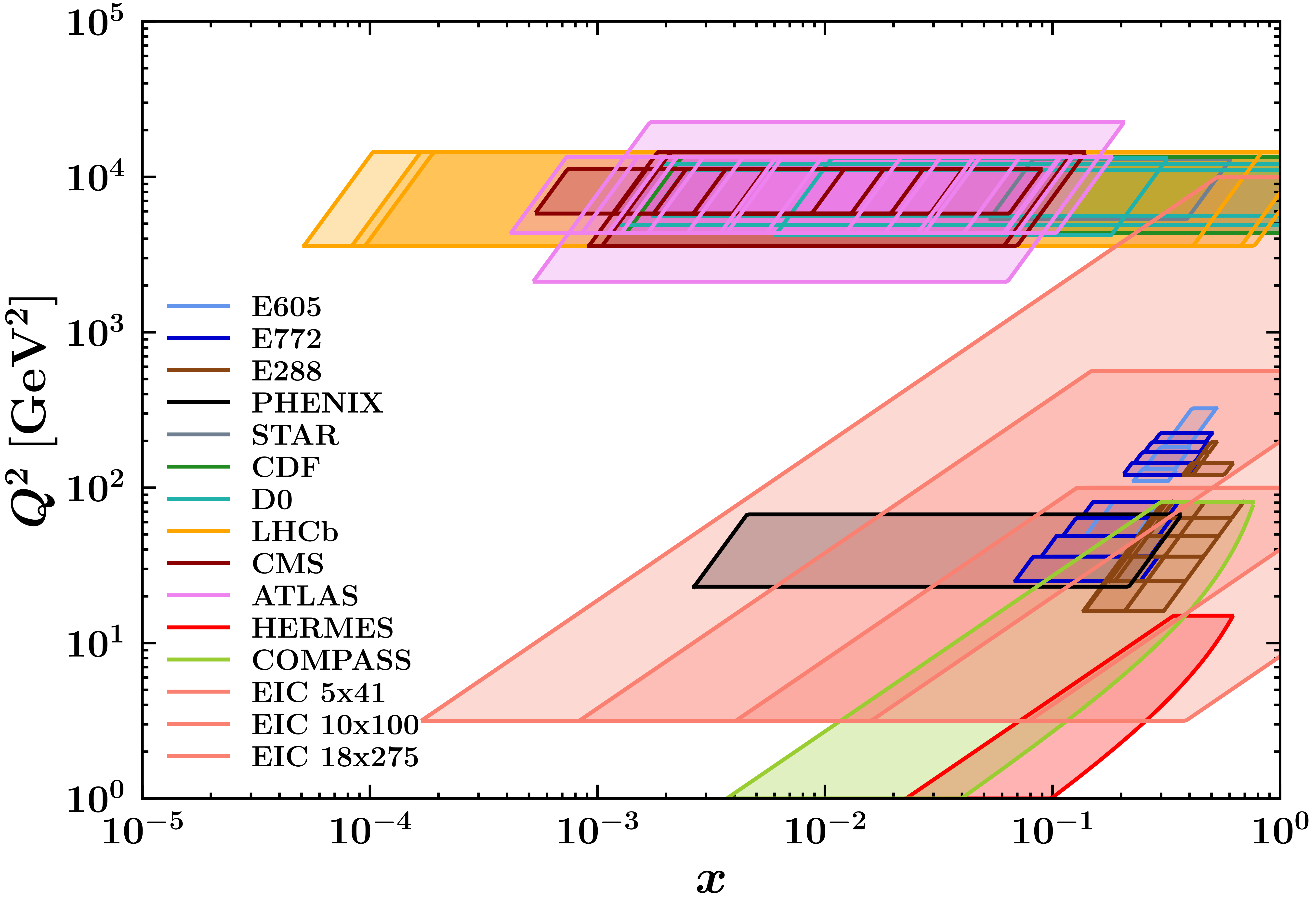

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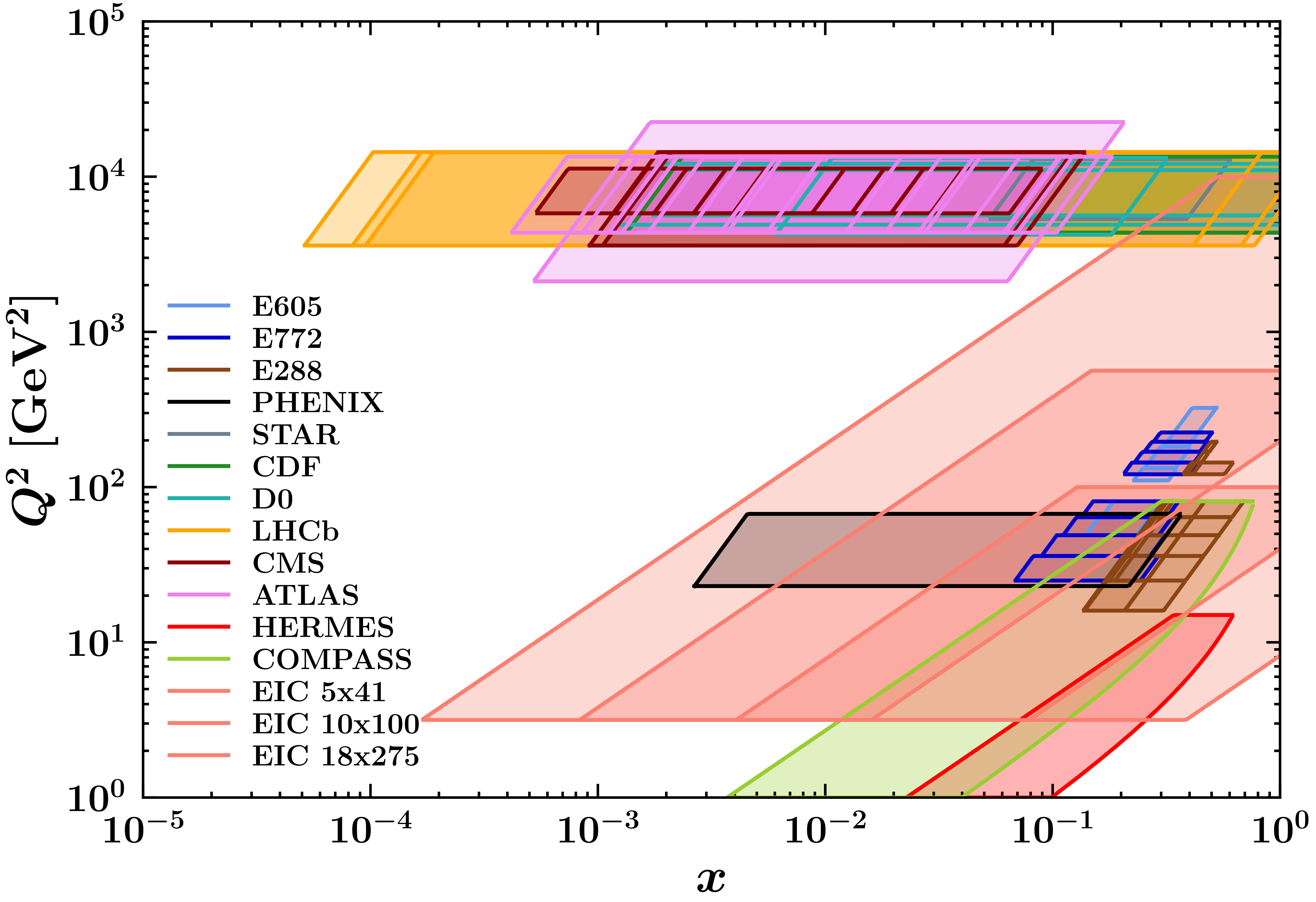

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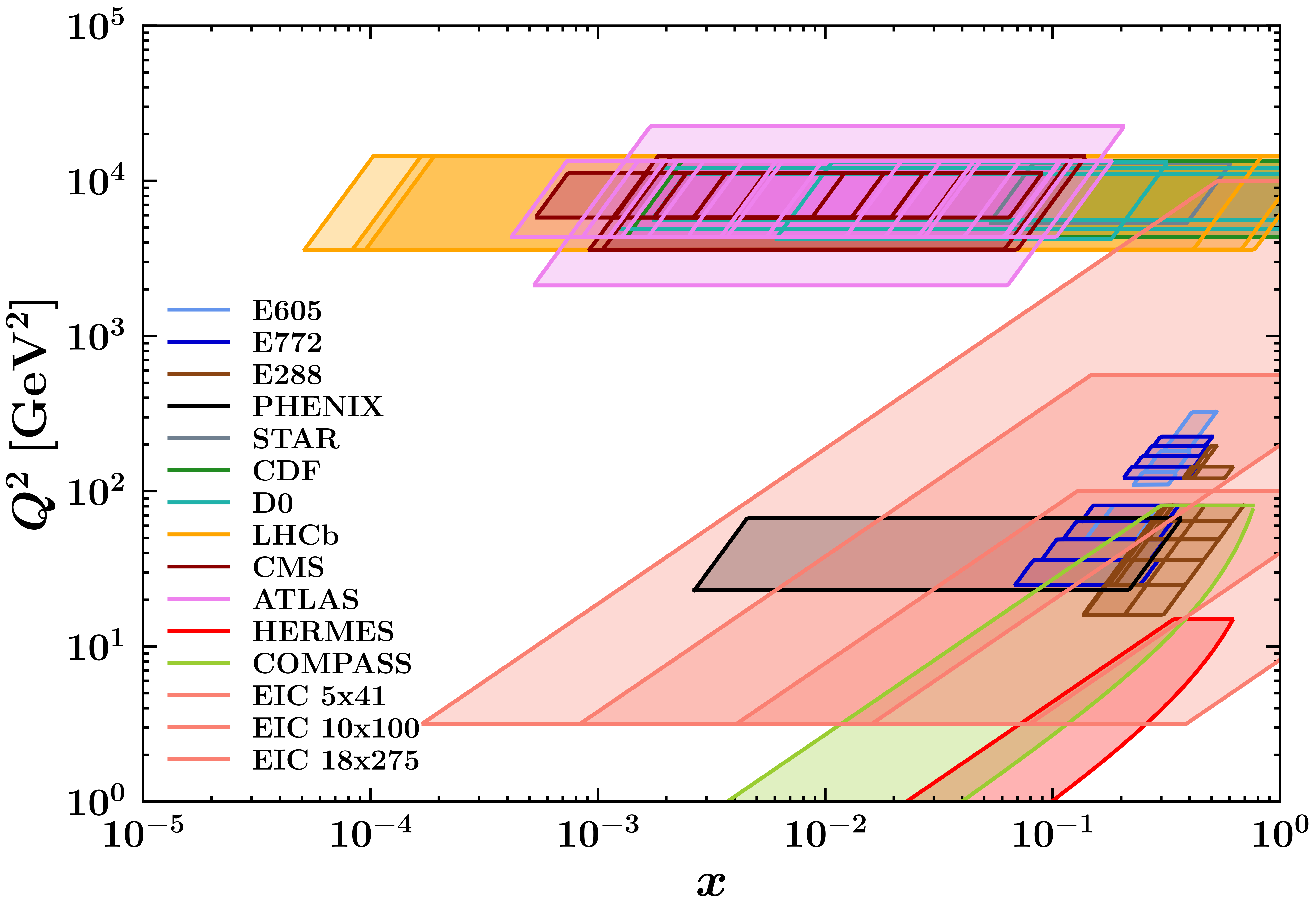
MAPTMD24



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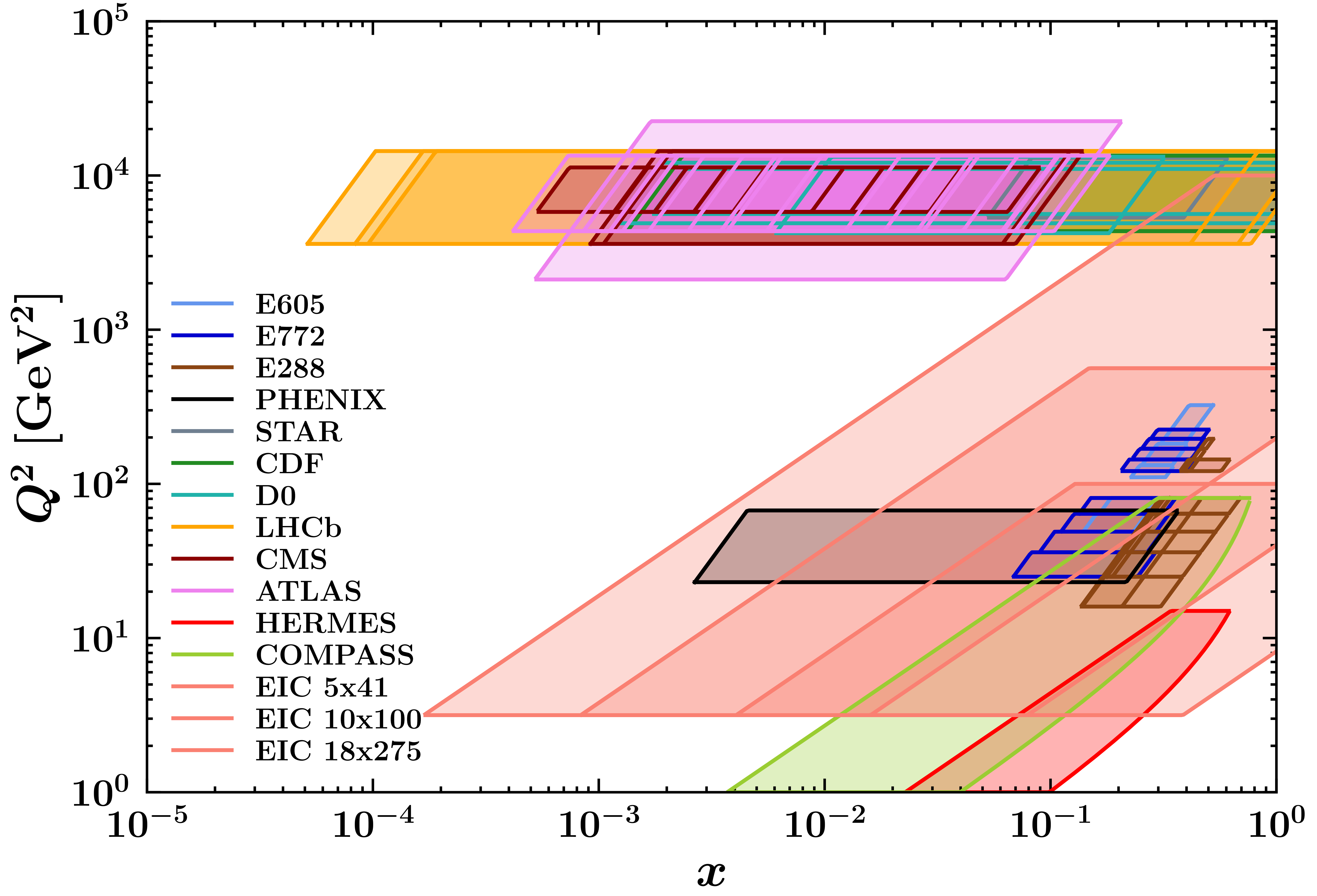

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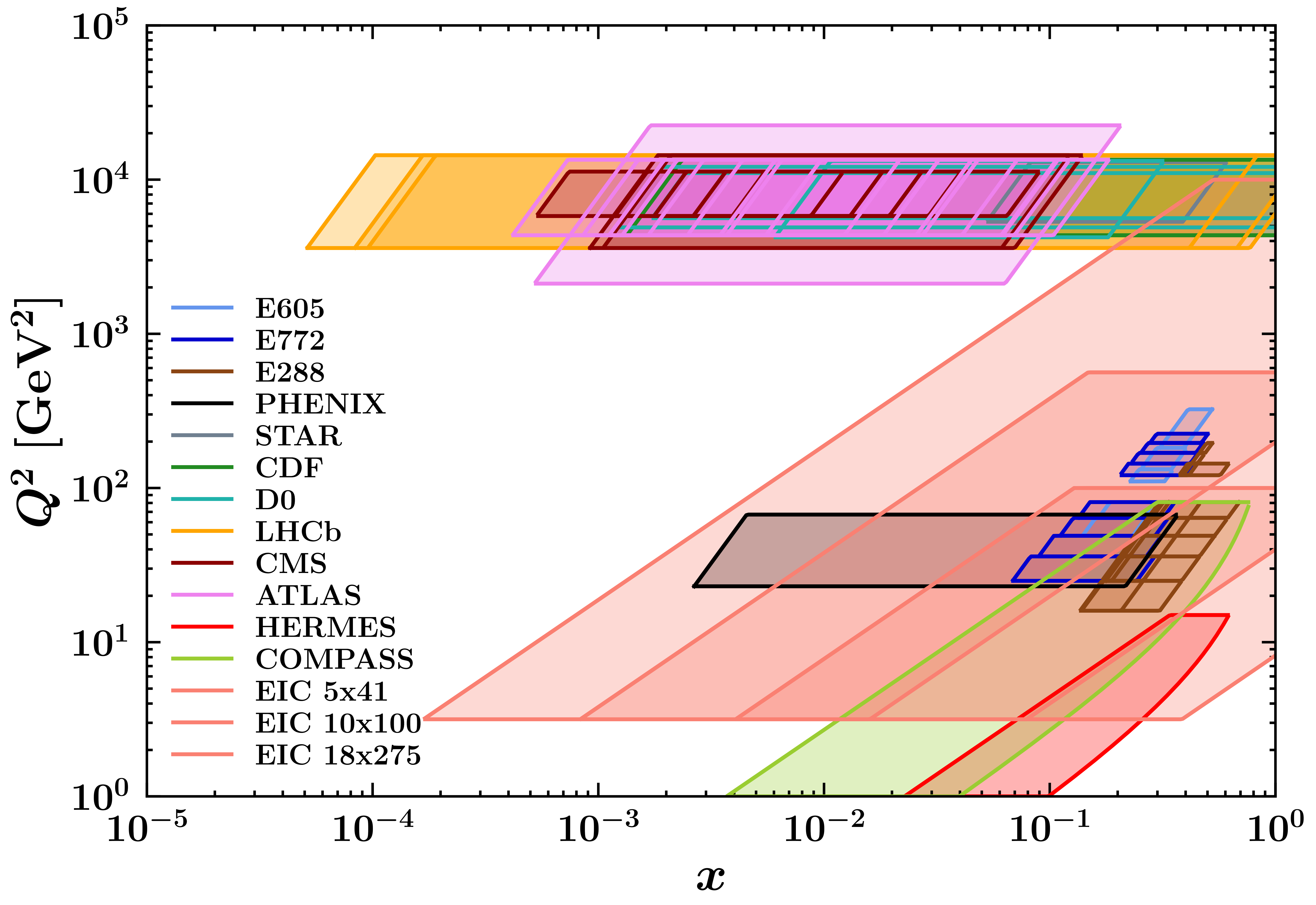

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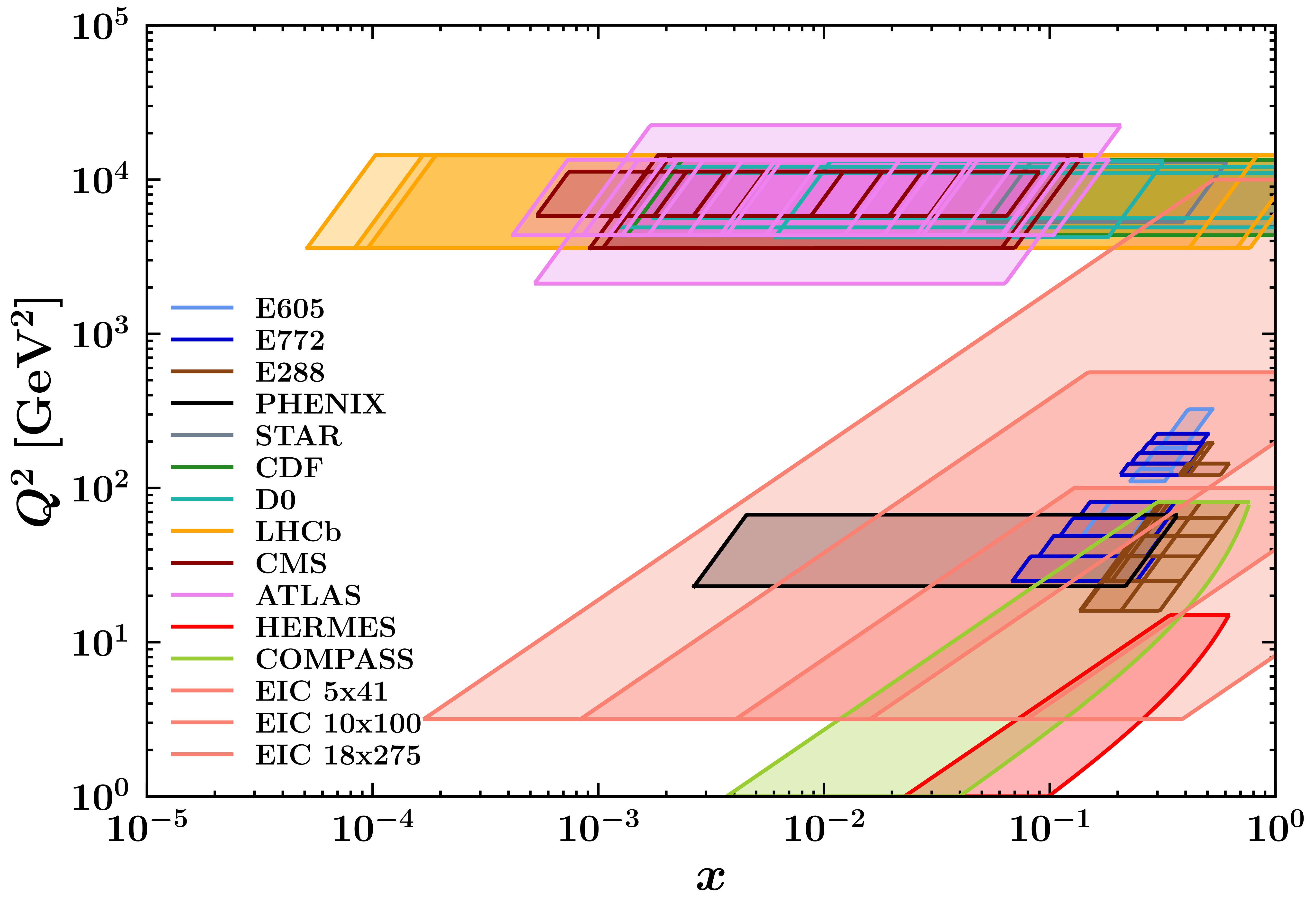

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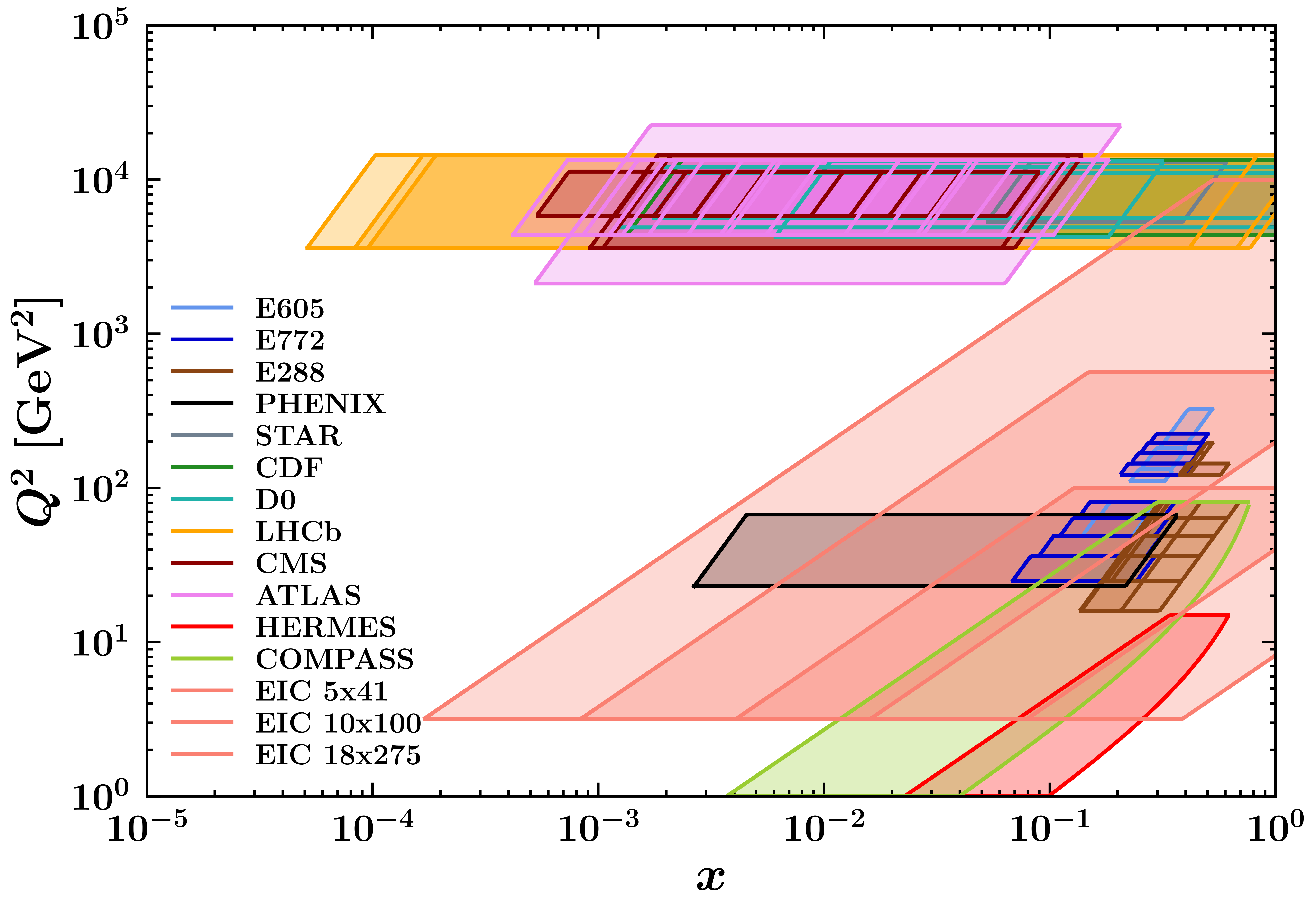

6563 → We (re)fit this data

MAPTMD24 extraction - EIC Pseudodata

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TMDs at Q = 2 GeV and x = 0.001

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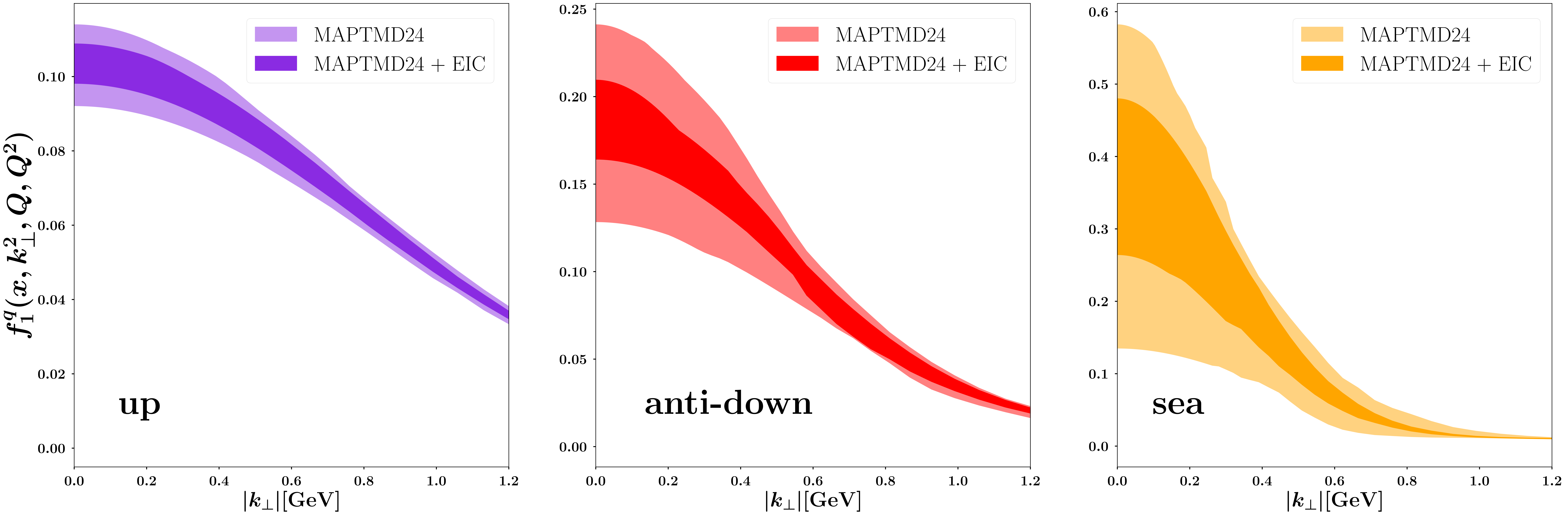

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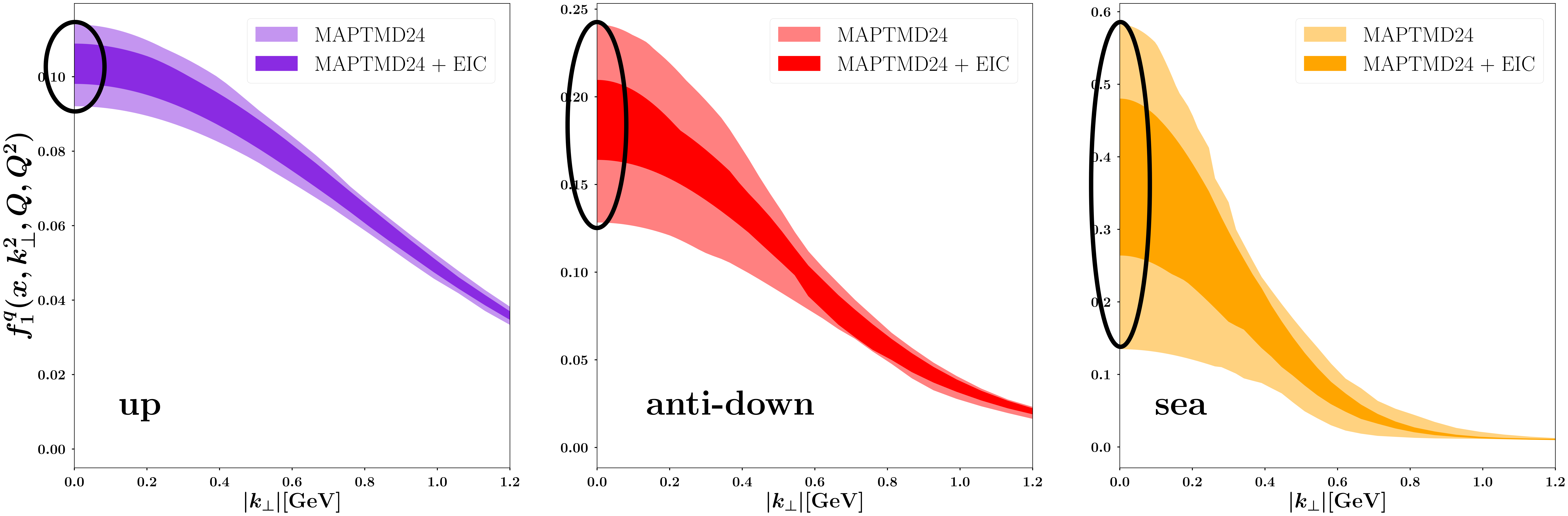

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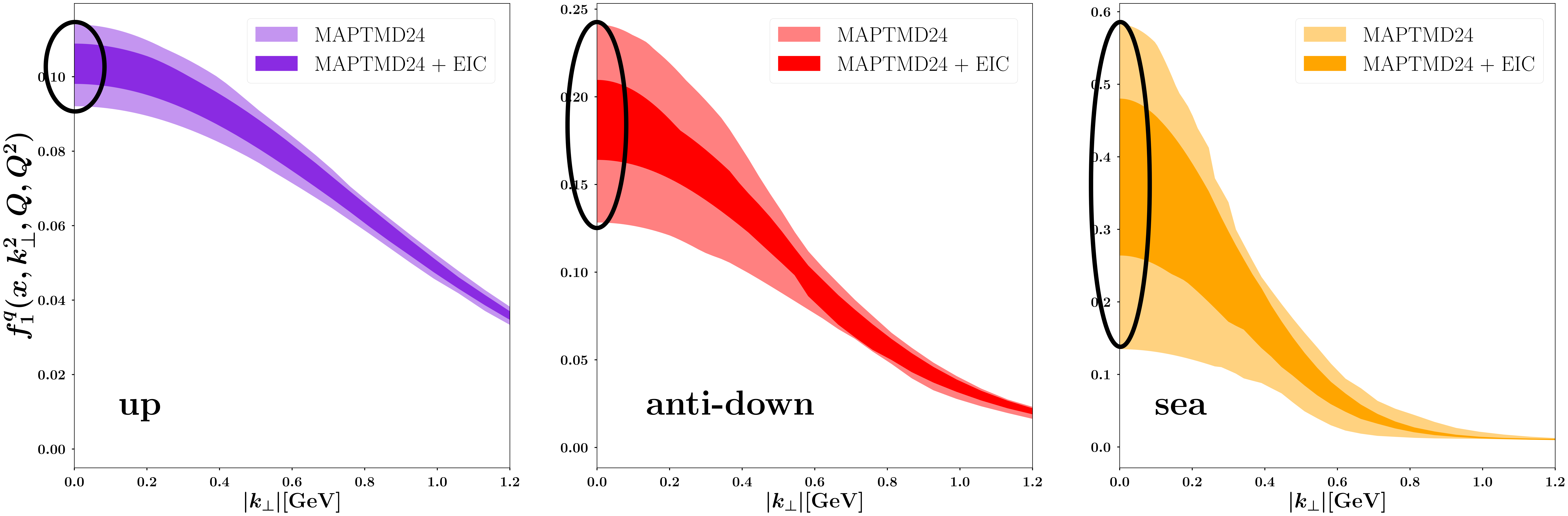

Decreasing of the uncertainty bands

MAPTMD24 extraction - EIC Pseudodata

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To better visualize the reduction in uncertainty bands, instead of plotting the ***TMDs***, we can plot ***their relative uncertainties***:

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$$\frac{f_1^q(x, |\mathbf{k}_T^2|; Q, Q^2) - \langle f_1^q(x, |\mathbf{k}_T^2|; Q, Q^2)\rangle}{\langle f_1^q(x, |\mathbf{k}_T^2|; Q, Q^2)\rangle}$$

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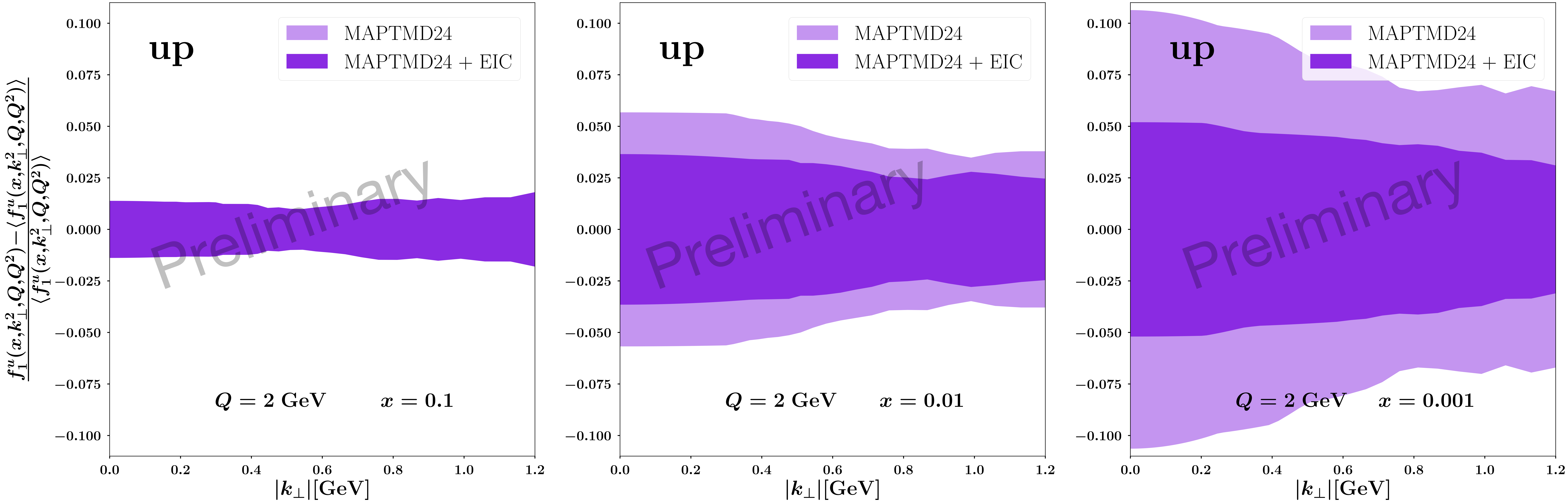

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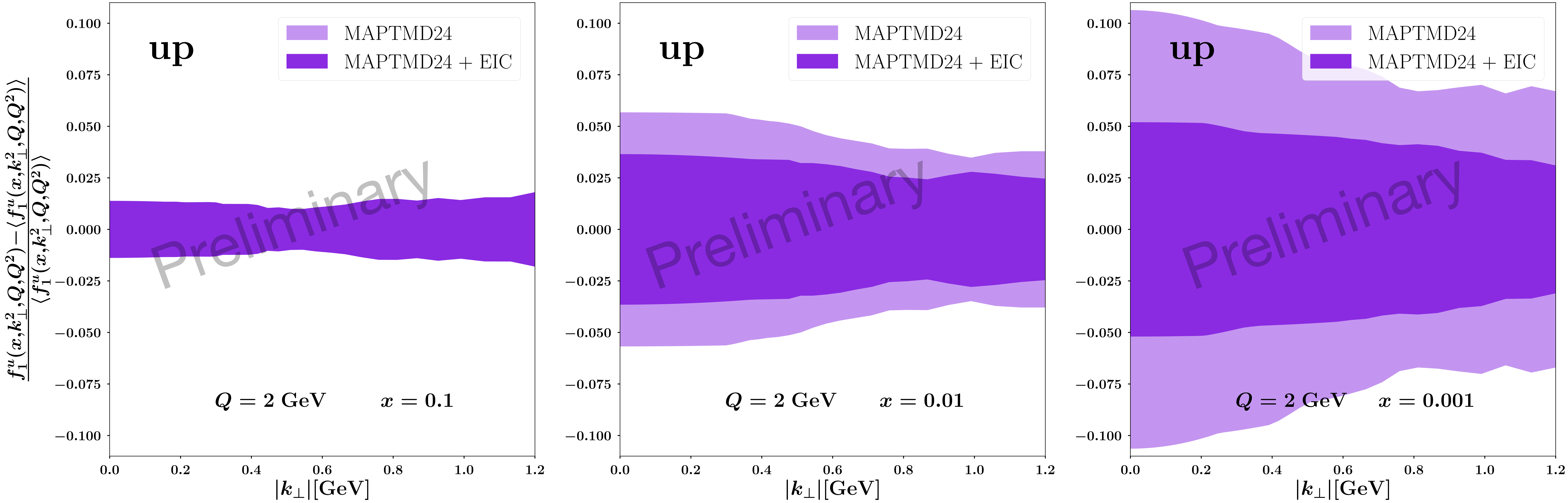

Strong impact at different values of x

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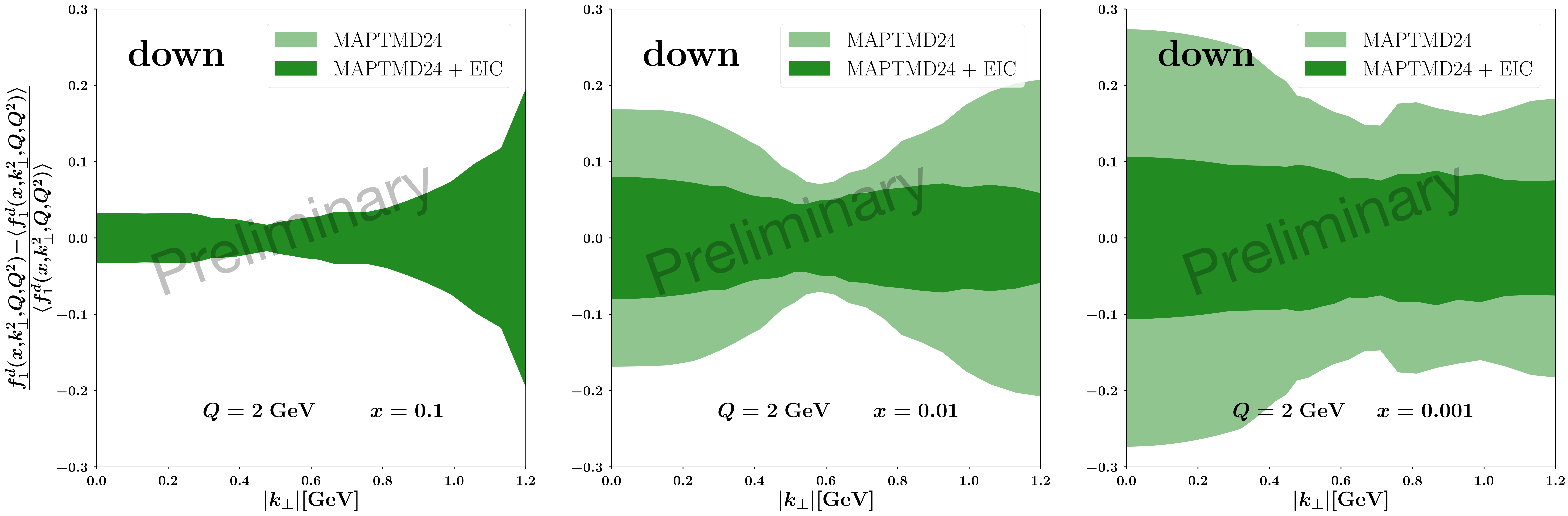

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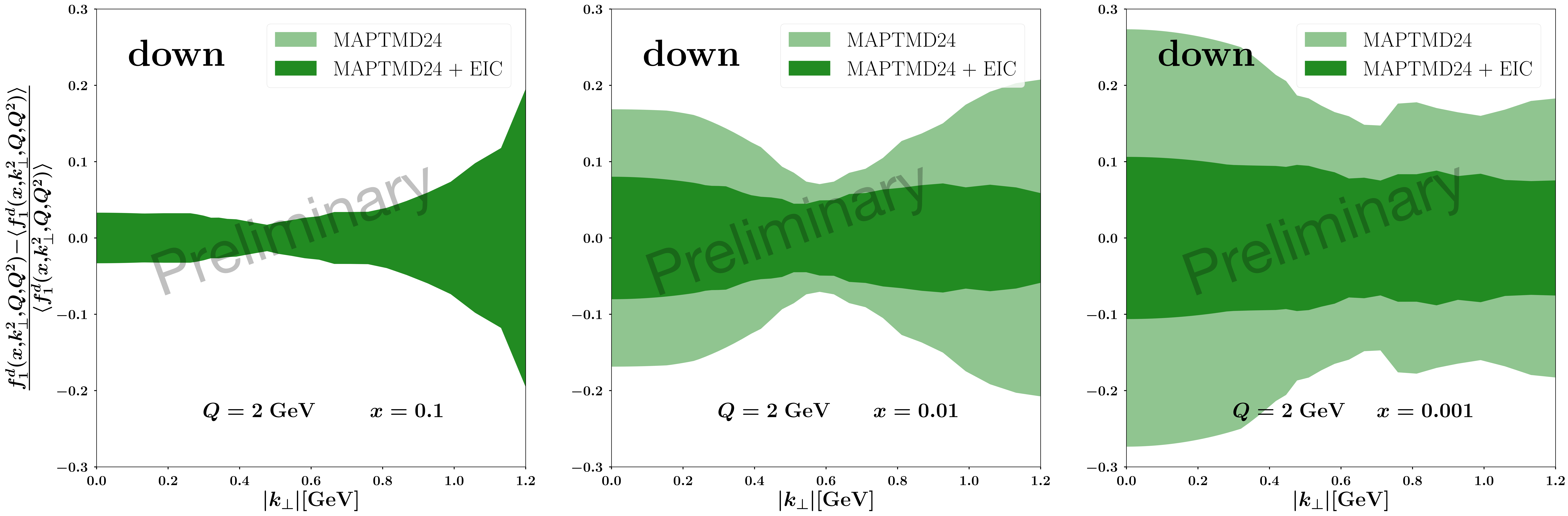

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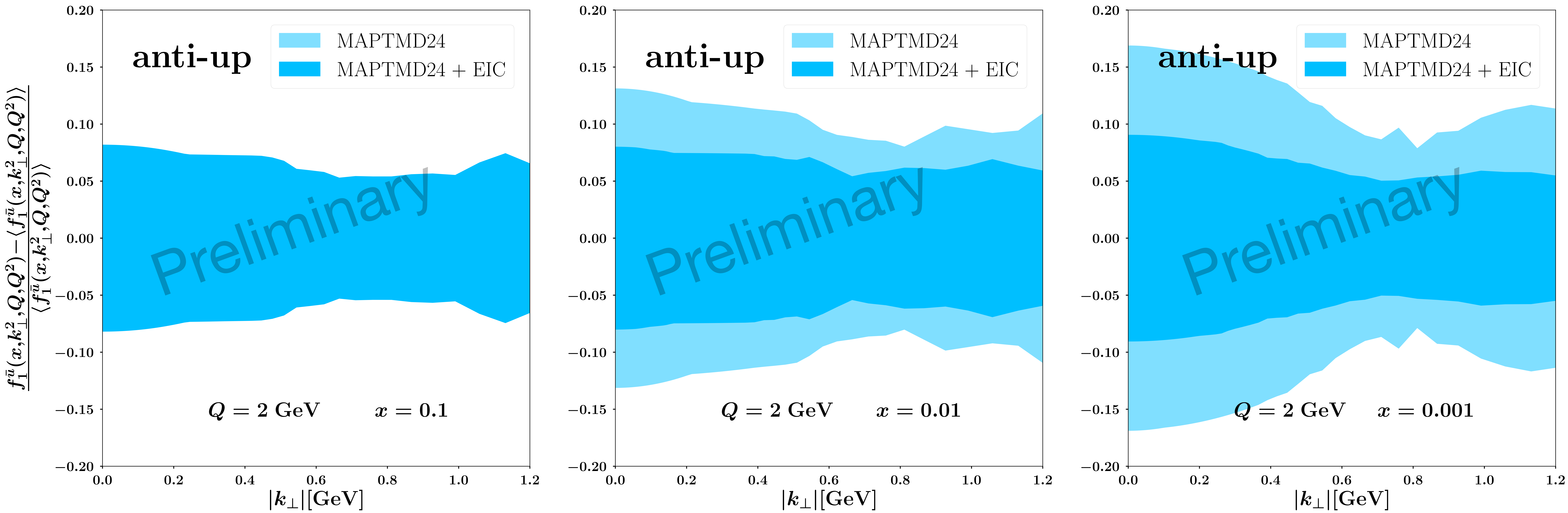

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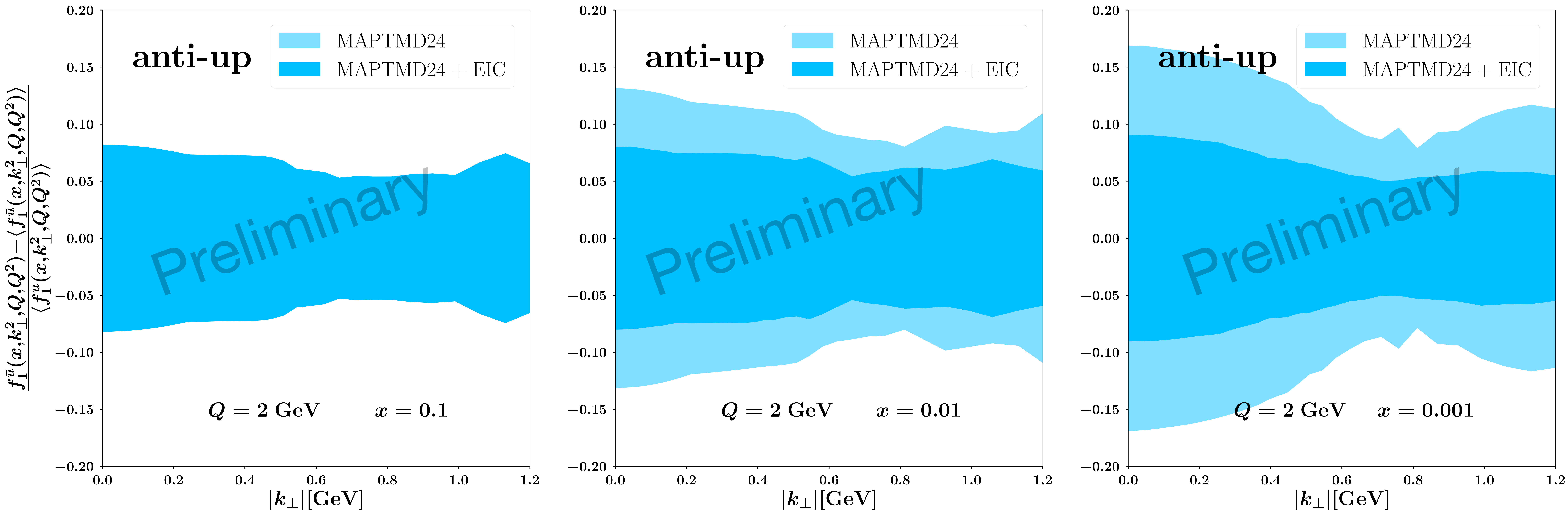

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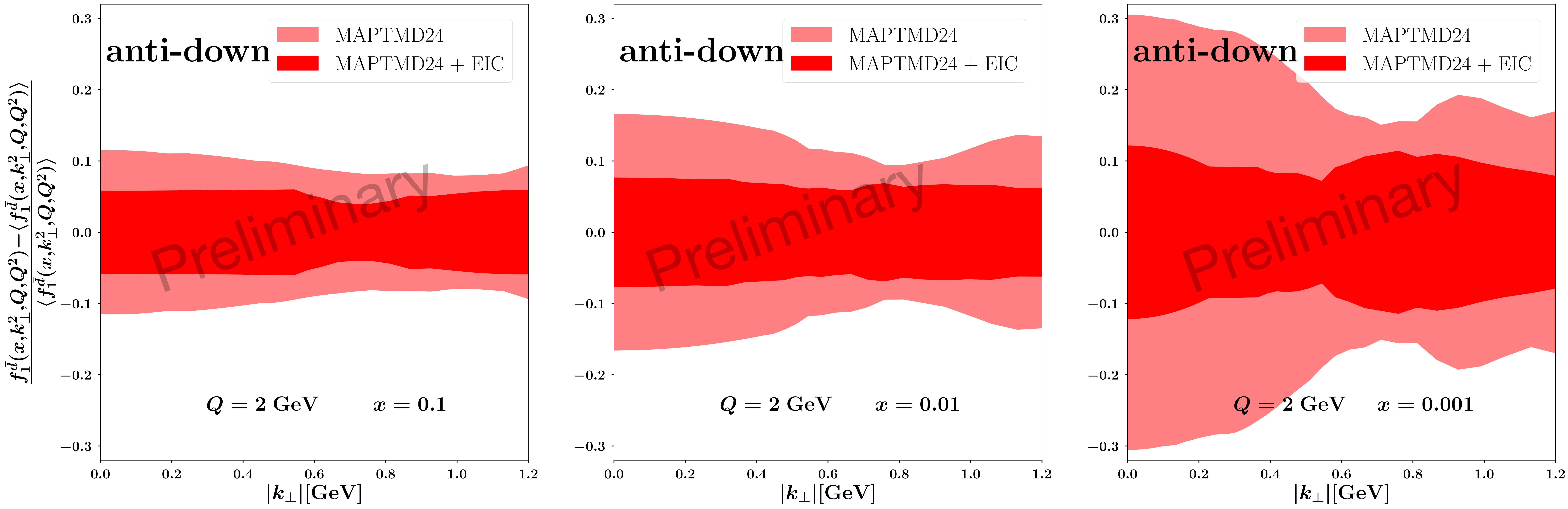

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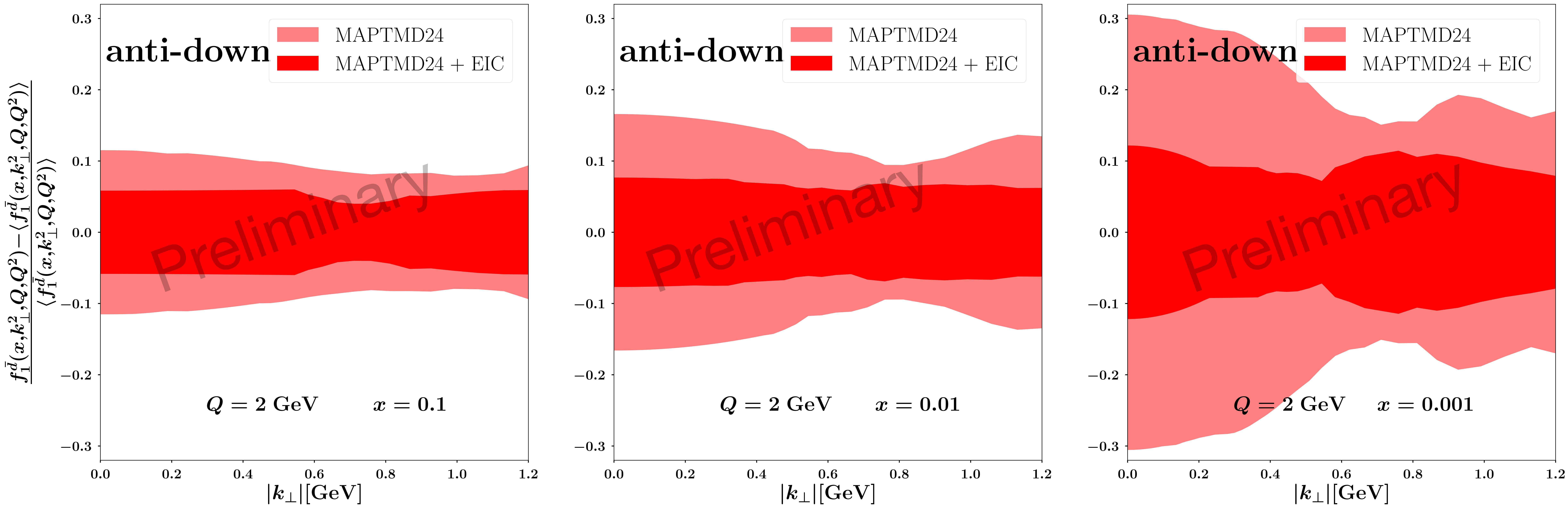

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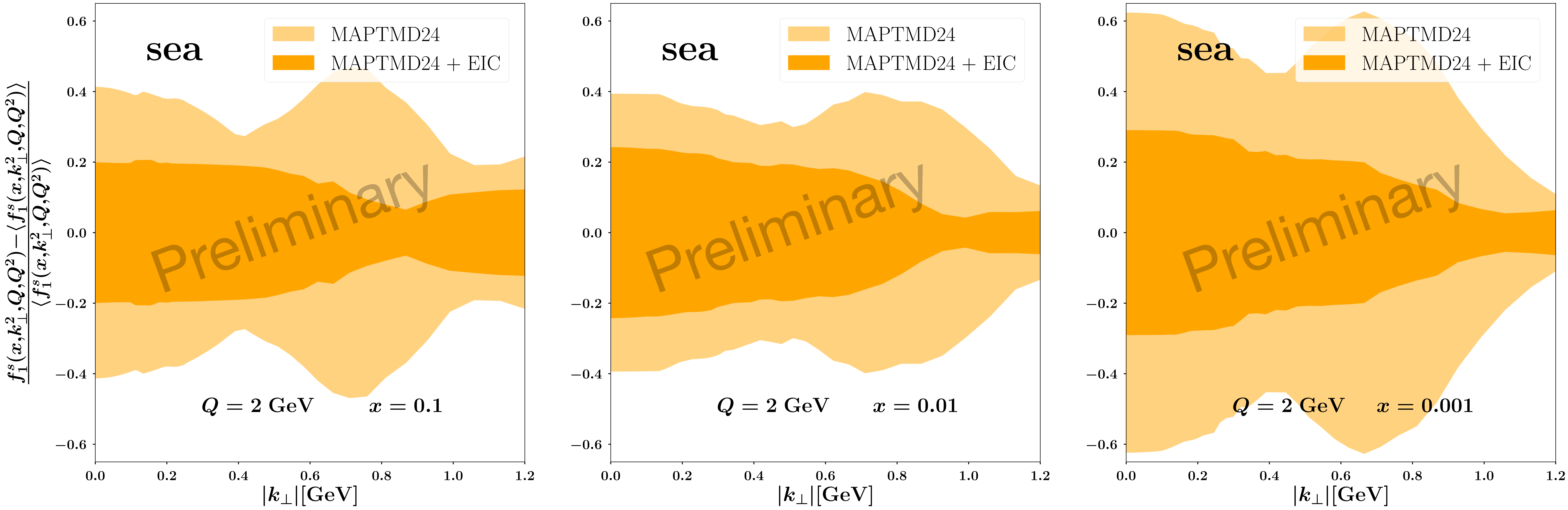

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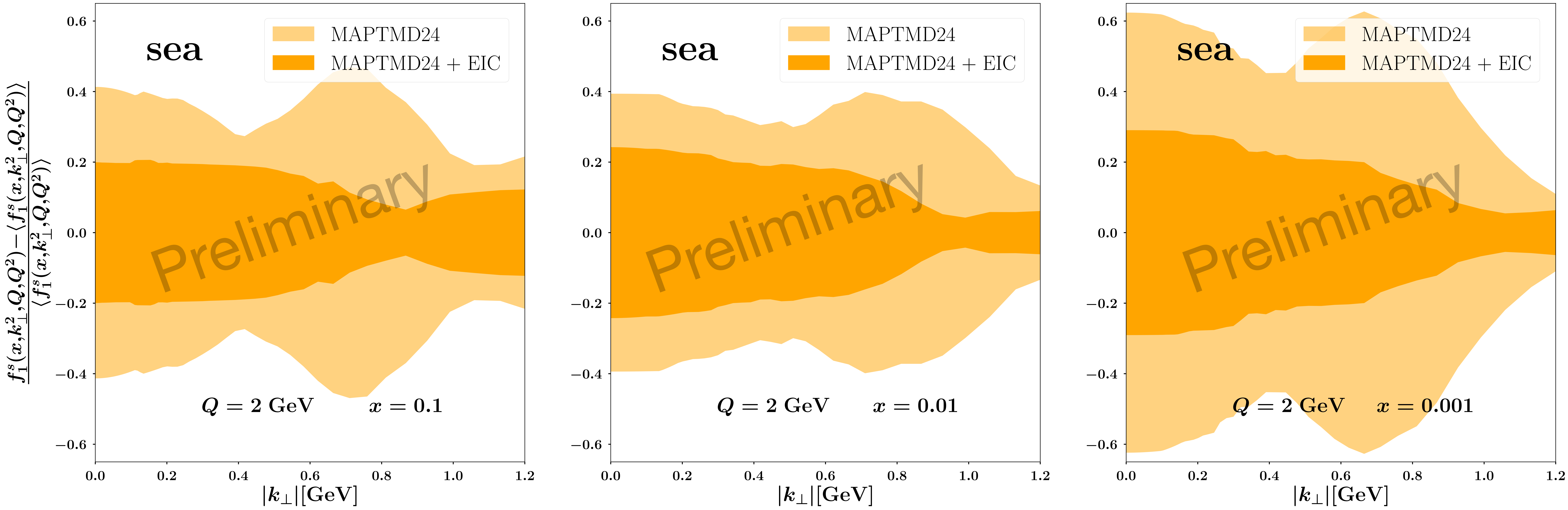

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Uncertainties in $k_\perp = 0$

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MAP24	$x = 10^{-1}$	$x = 10^{-2}$	$x = 10^{-3}$
u	3.3 %	5.7 %	10.6 %
d	12.7 %	16.8 %	27.3 %
$\bar{u}$	10.6 %	13.1 %	16.9 %
$\bar{d}$	12.4 %	16.6 %	30.5 %
sea	41.2 %	39.4 %	62.2 %

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$\bar{u}$	$10.6\,\%$	$13.1\,\%$	$16.9\,\%$
$\bar{d}$	$12.4\,\%$	$16.6\,\%$	$30.5\,\%$
sea	$41.2\,\%$	$39.4\,\%$	$62.2\,\%$

MAP+EIC	$x = 10^{-1}$	$x = 10^{-2}$	$x = 10^{-3}$
u	$1.4\,\%$	$3.6\,\%$	$5.2\,\%$
d	$3.3\,\%$	$8.0\,\%$	$10.6\,\%$
$\bar{u}$	$8.1\,\%$	$8.0\,\%$	$9.0\,\%$
$\bar{d}$	$5.8\,\%$	$7.7\,\%$	$12.5\,\%$
sea	$19.9\,\%$	$24.2\,\%$	$29.0\,\%$

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sea	$19.9\,\%$	$24.2\,\%$	$29.0\,\%$

With the addition of ***EIC pseudodata***, the uncertainties for almost all scenarios decrease by approximately ***50% or more***

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  - From EIC Pseudodata Fits we have encouraging results on uncertainties reduction for all the flavors.
- Start to study the impact on the TMD FFs, even if it’s more complicated
- Include also other EIC energy configurations.