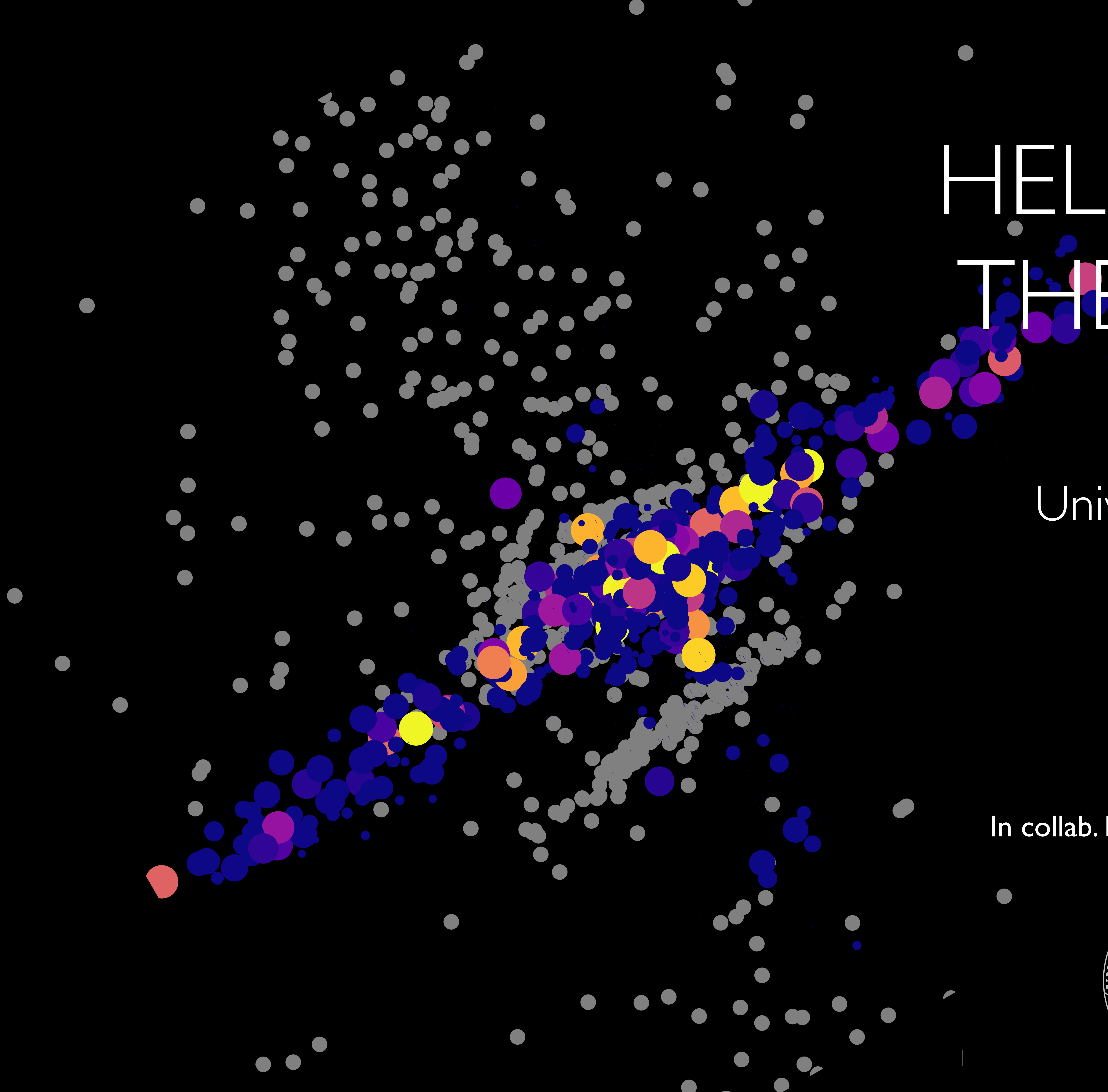


HELICITY PDFs AT THE FUTURE EIC

Ignacio Borsa
Universidad de Buenos Aires

IR4YR- Group
June 23th 2020

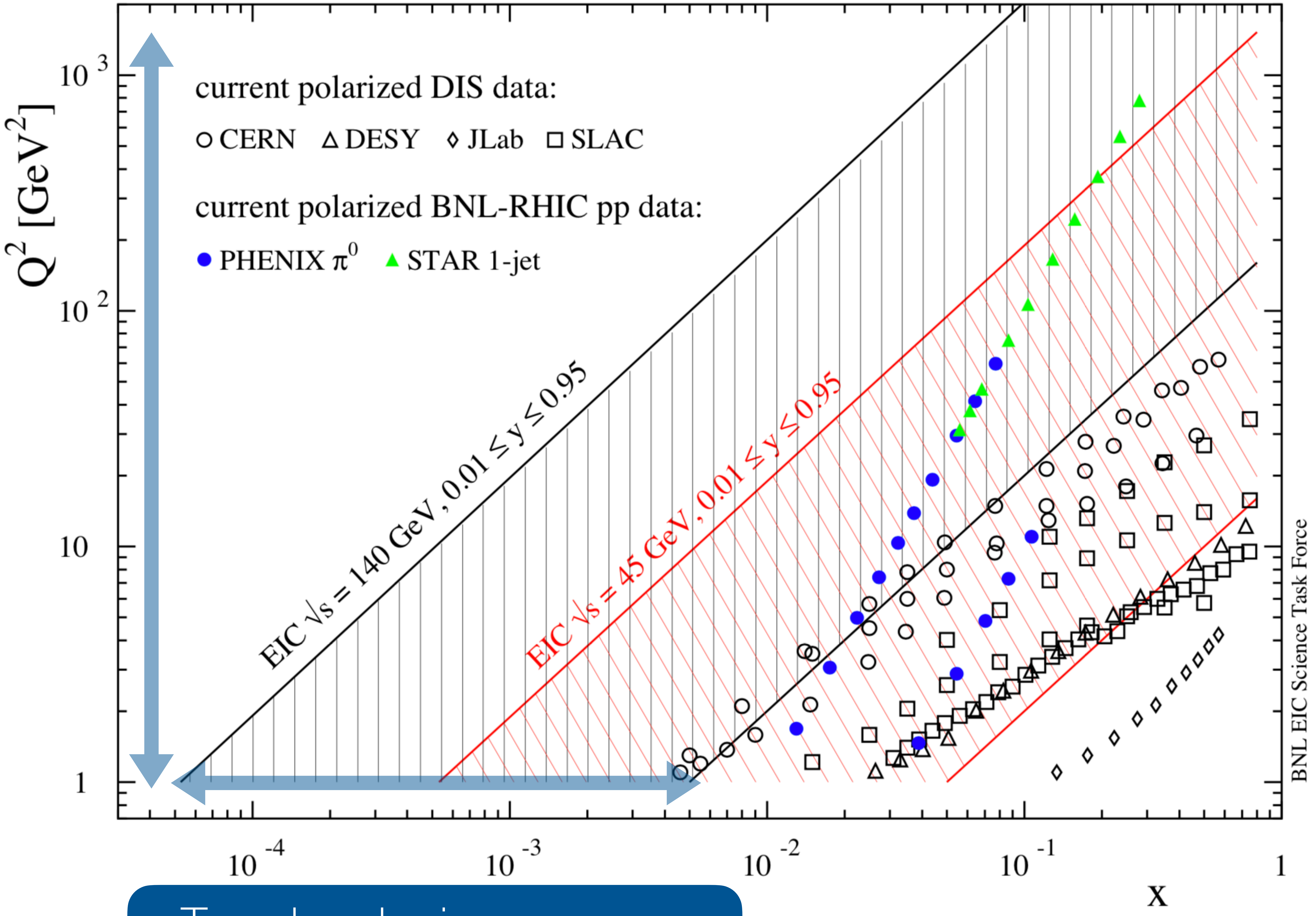
In collab. E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

universidad de buenos aires - exactas
departamento de física

SPIN PHYSICS @ EIC

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

Pseudodata for Polarized DIS & SIDIS



Lever-arm in Q^2

Two decades in x coverage

$$\frac{1}{2} = \frac{1}{2}[\Delta q + \Delta\bar{q}] + \Delta g + \mathscr{L}$$

$$\Delta f(\mu) \equiv \int_0^1 f(\mu, x)\, dx$$

+

$$\mu^2 \frac{d}{d\mu^2} \begin{pmatrix} \Delta q(x,\mu^2) \\ \Delta g(x,\mu^2) \end{pmatrix} = \int_x^1 \frac{dz}{z} \begin{pmatrix} \Delta\mathcal{P}_{qq} & \Delta\mathcal{P}_{qg} \\ \Delta\mathcal{P}_{gq} & \Delta\mathcal{P}_{gg} \end{pmatrix} \begin{pmatrix} \Delta q \\ \Delta g \end{pmatrix} \left(\frac{x}{z}, \mu^2\right)$$

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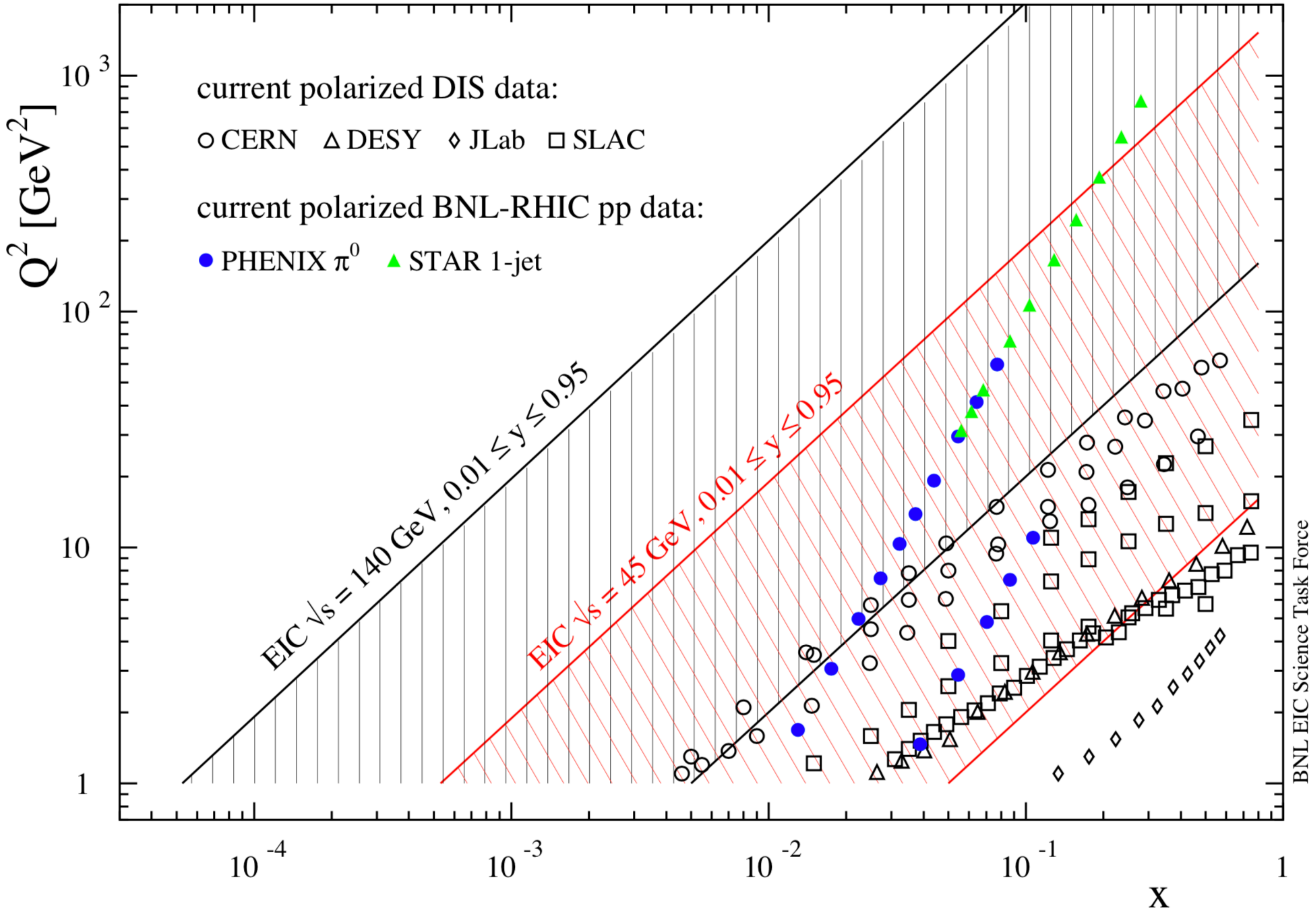


DIS and SIDIS ($\pi^{\pm}, K^{\pm}$) double spin asymmetries for:

5 GeV x100 GeV $\sqrt{s} = 45$ GeV

20 GeV x250GeV $\sqrt{s} = 140$ GeV

DIS (He-3) double spin asymmetries for:

20 GeV x166GeV $\sqrt{s} = 115$ GeV

Asymmetries & uncertainty estimations generated with PEPSI

10 fb^{-1}, GRSV

$Q^2 > 1$ GeV^2

$0.01 < y < 0.95$

$W^2 > 10$ GeV^2

$-4 < \eta < 4$

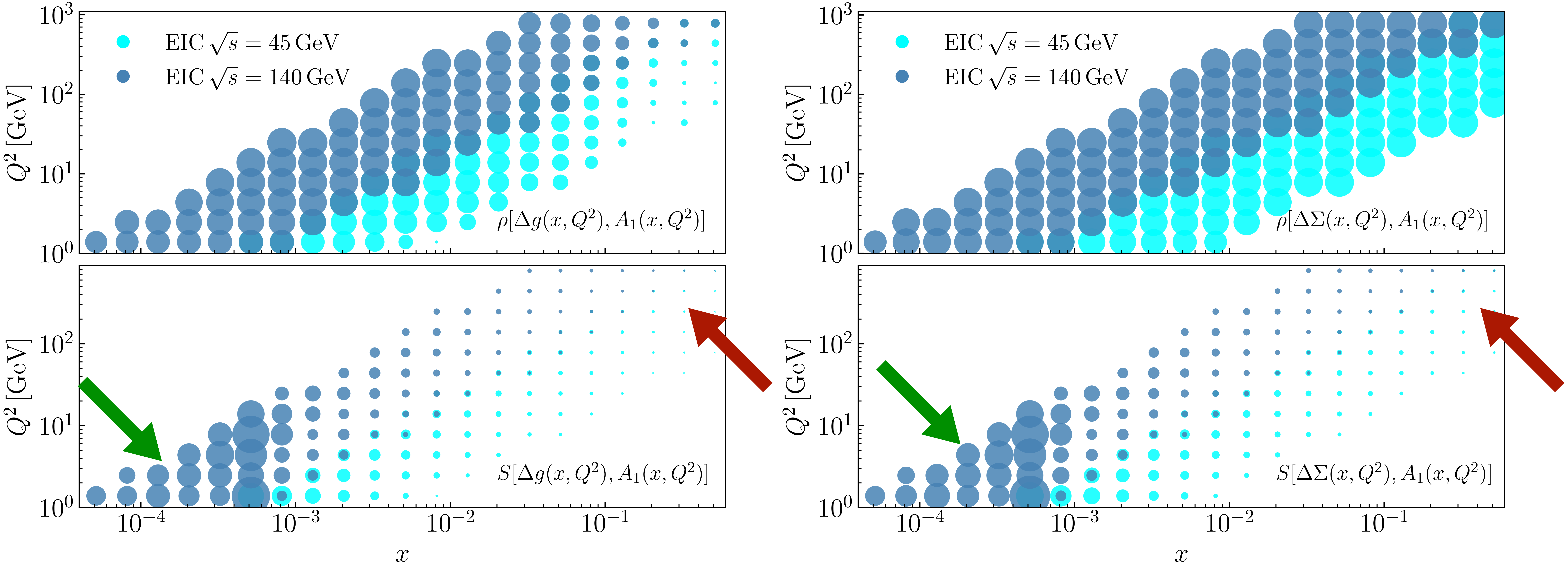
Asymmetries and Uncertainties corrected with the full NLO calculation (DSSV14 ; NNPDF3.0; DSS14/17)

DIS CORRELATION AND SENSITIVITY COEFFICIENTS

Monte Carlo sampling of DSSV14 Réplicas

De Florian, Lucero, Sassot, Stratmann, Vogelsang *Phys.Rev.D* 100 (2019) 11, 114027

$$\rho_w[A,B] = \frac{\langle A - \langle A \rangle \rangle \langle B - \langle B \rangle \rangle}{\sigma_A^{th}\,\sigma_B^{th}} \qquad S[A,B] = \frac{\langle A - \langle A \rangle \rangle \langle B - \langle B \rangle \rangle}{\xi\,\sigma_A^{th}\,\sigma_B^{th}} \qquad \xi = \frac{\sigma_B^{exp}}{\sigma_B^{th}}$$



- Stronger correlation with Δg for lower values of x, while the correlation with $\Delta\Sigma$ is ~1 for whole range
- Higher sensitivity for the less constrained low-x region

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

ASSESSING THE IMPACT OF EIC PSEUDO DATA

1) New Global Fit supplementing DSSV14 dataset with DIS pseudo data @ 45 GeV, with Monte Carlo Sampling

De Florian, Lucero, Sassot, Stratmann, Vogelsang
Phys.Rev.D 100 (2019) 11, 114027

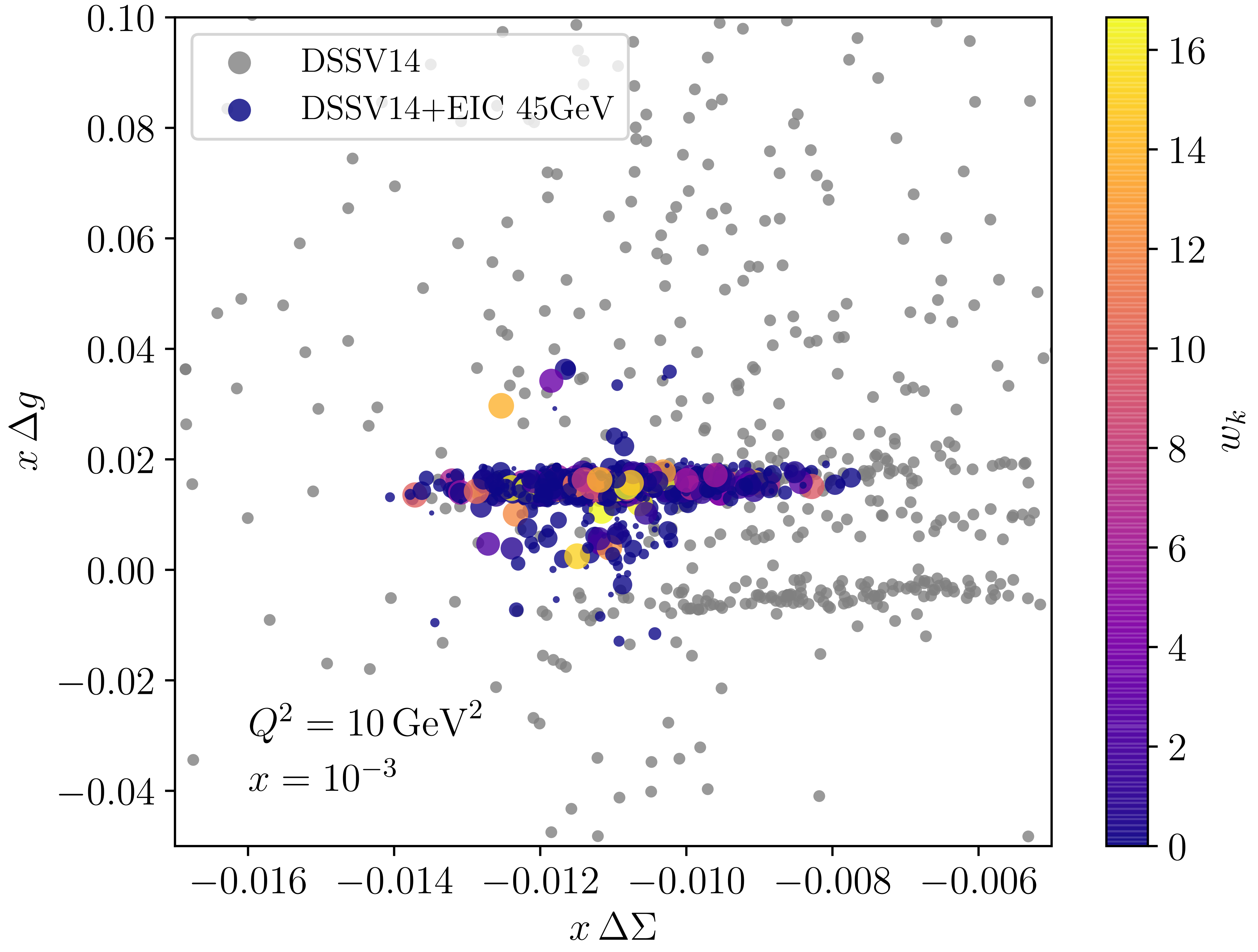
MC ensemble of 950 replicas generated from DSSV14 dataset+ EIC pseudodata

Helicity Distributions obtained from each replica within the DSSV14-like framework

Modified parametrization with increased flexibility in the low-x region

$$x\Delta f_i(x,\mu_0) = \sum_{j=1}^{3} N_{ij}\, x^{\alpha_{ij}}(1-x)^{\beta_{ij}} + \sum_{j'=1}^{3} N_{ij'}\, x^{\alpha_{ij'}}(1-x)^{\beta_{ij'}}$$

Same flexibility for low and high x



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Same flexibility for low and high x

2)Reweighting of the DSSV14+EIC@45 with DIS pseudo data at $\sqrt{s} = 140$ GeV

De Florian, Lucero, Sassot, Stratmann, Vogelsang
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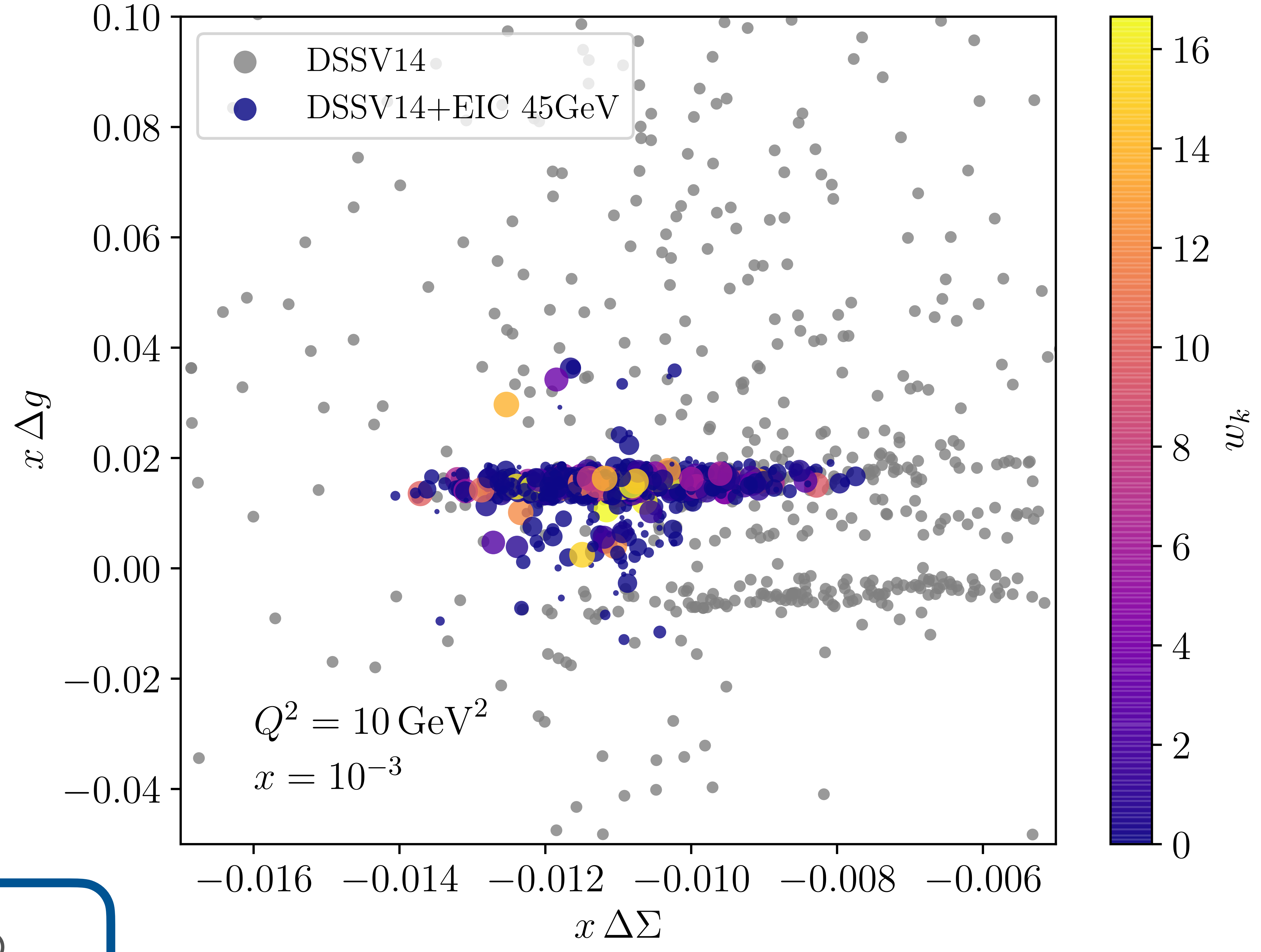

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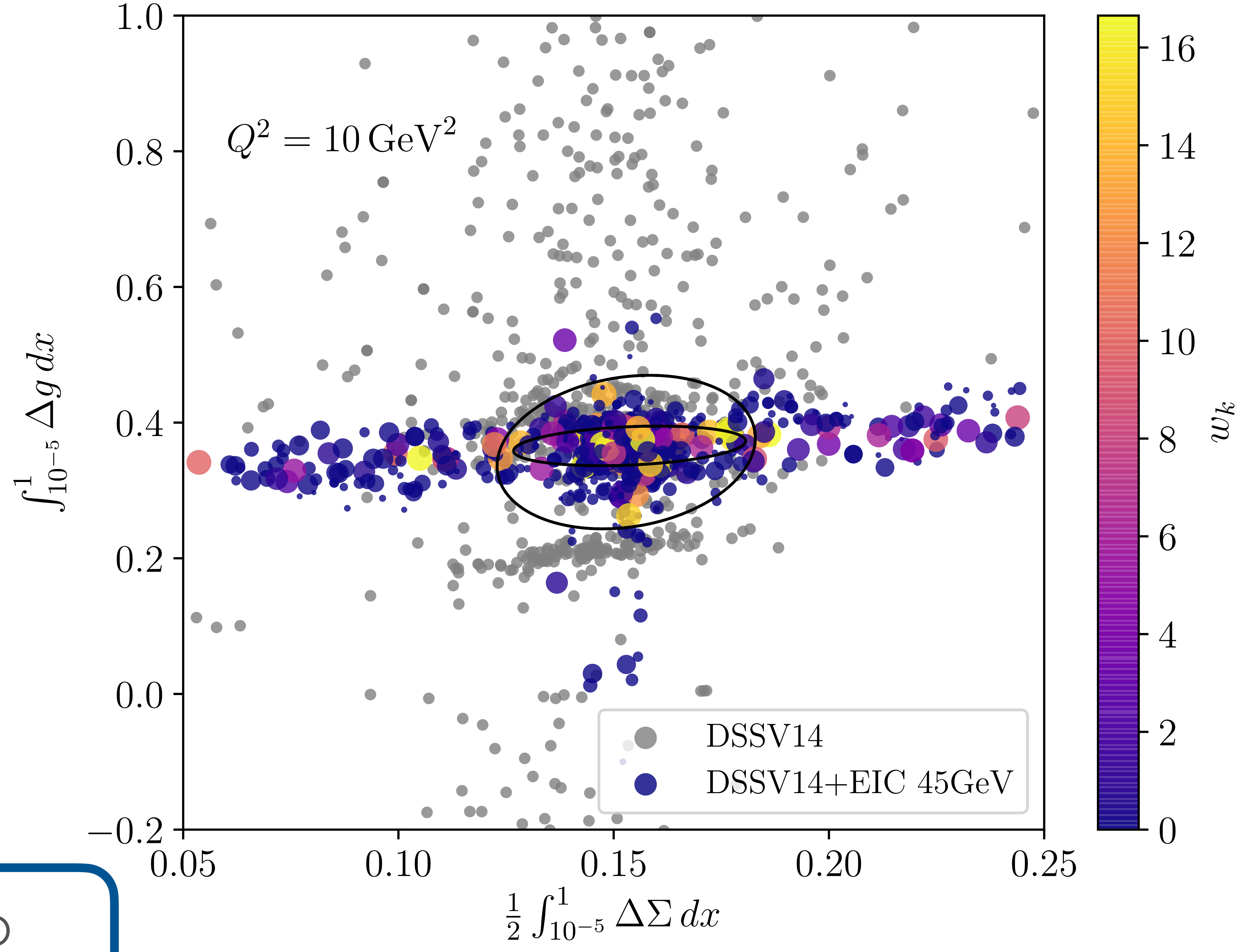
Same flexibility for low and high x



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In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

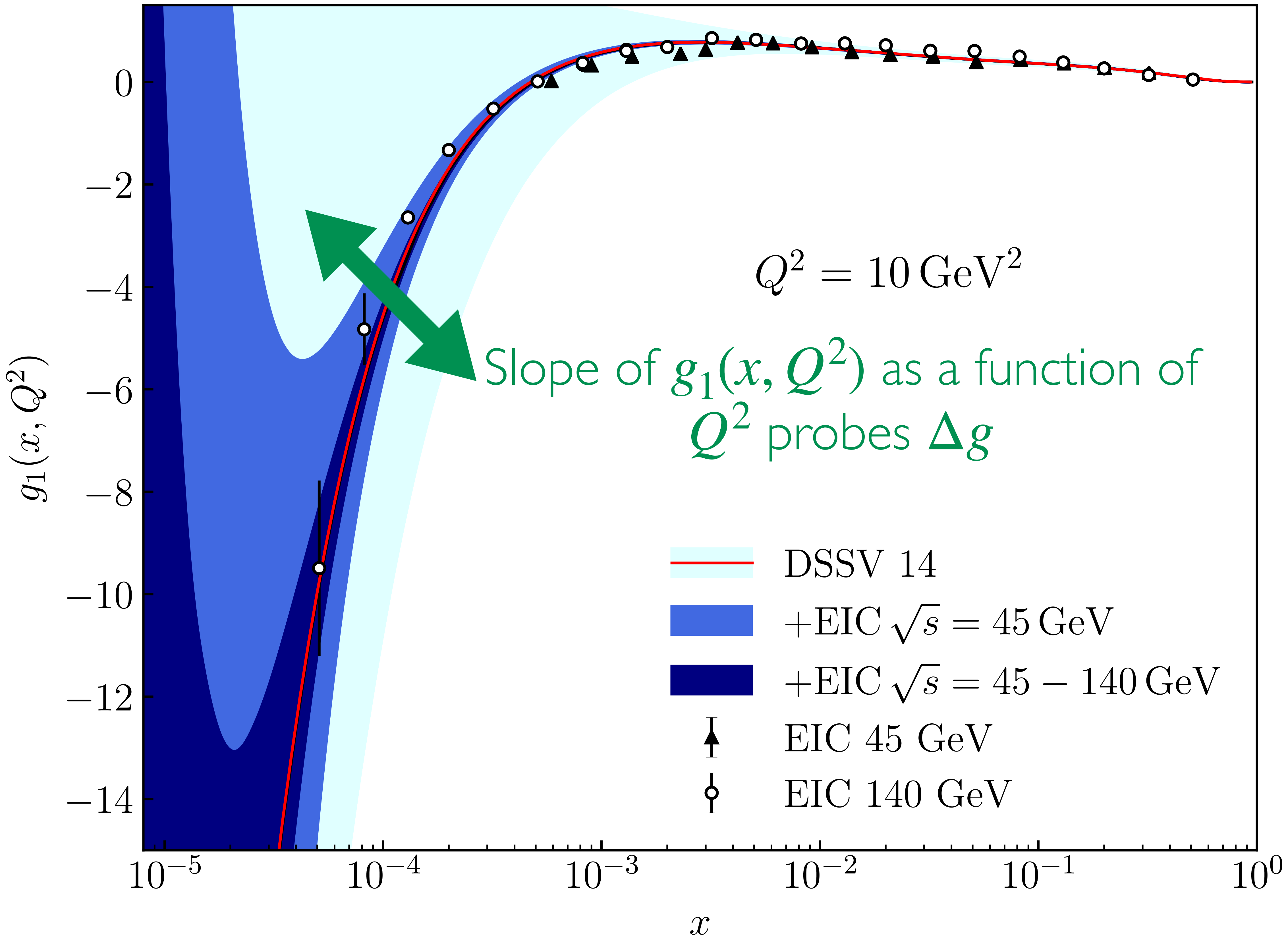
IMPACT OF DIS DATA

$$g_1(x,Q^2) = \left(\pm\frac{1}{12}\Delta q_3^{NS} + \frac{1}{36}\Delta q_8^{NS} + \frac{1}{9}\Delta\Sigma\right) \otimes \left(1 + \frac{\alpha_s}{2\pi}\Delta C_q\right) + \frac{\alpha_s}{2\pi}\sum_q e_q^2\,\Delta C_g \otimes \Delta g$$

$$\Delta q_3^{NS} \equiv (\Delta u + \Delta\bar{u}) - (\Delta d + \Delta\bar{d})$$
$$\Delta q_8^{NS} \equiv (\Delta u + \Delta\bar{u}) + (\Delta d + \Delta\bar{d}) - 2(\Delta s + \Delta\bar{s})$$
$$\Delta\Sigma \equiv (\Delta u + \Delta\bar{u}) + (\Delta d + \Delta\bar{d}) + (\Delta s + \Delta\bar{s})$$

$$\frac{d}{d\ln Q^2}\begin{pmatrix}\Delta\Sigma^1\\ \Delta g^1\end{pmatrix} = \frac{\alpha_s}{2\pi}\begin{pmatrix}\Delta P_{qq}^1 & 2\,n_f\,P_{qg}^1\\ \Delta P_{gq}^1 & P_{qg}^1\end{pmatrix}\begin{pmatrix}\Delta\Sigma^1\\ \Delta g^1\end{pmatrix}$$

$$\frac{d}{d\ln Q^2}\Delta q_{NS} = \frac{\alpha_s}{2\pi}\Delta P_{qq}^1\,\Delta q_{NS}$$



Mainly probes the quark contributions (gluon contribution is suppressed in α_s)

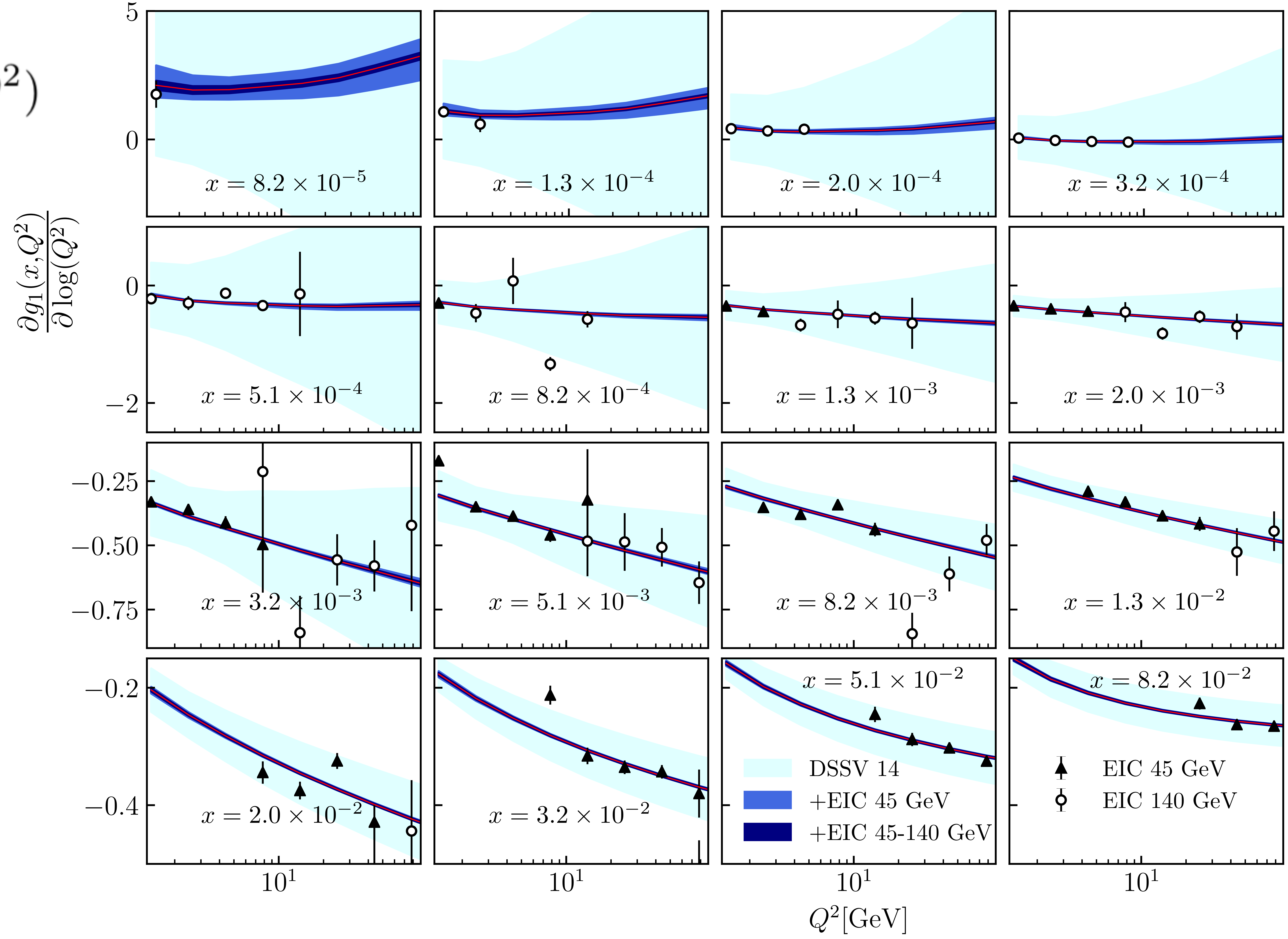
Gluon and Flavor contribution come (ideally) from the evolution equations

No separation between Δq and $\Delta\bar{q}$

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

IMPACT OF DIS DATA

$$\frac{\partial g_1(x,Q^2)}{\partial \ln Q^2} \approx -\Delta g(x,Q^2)$$

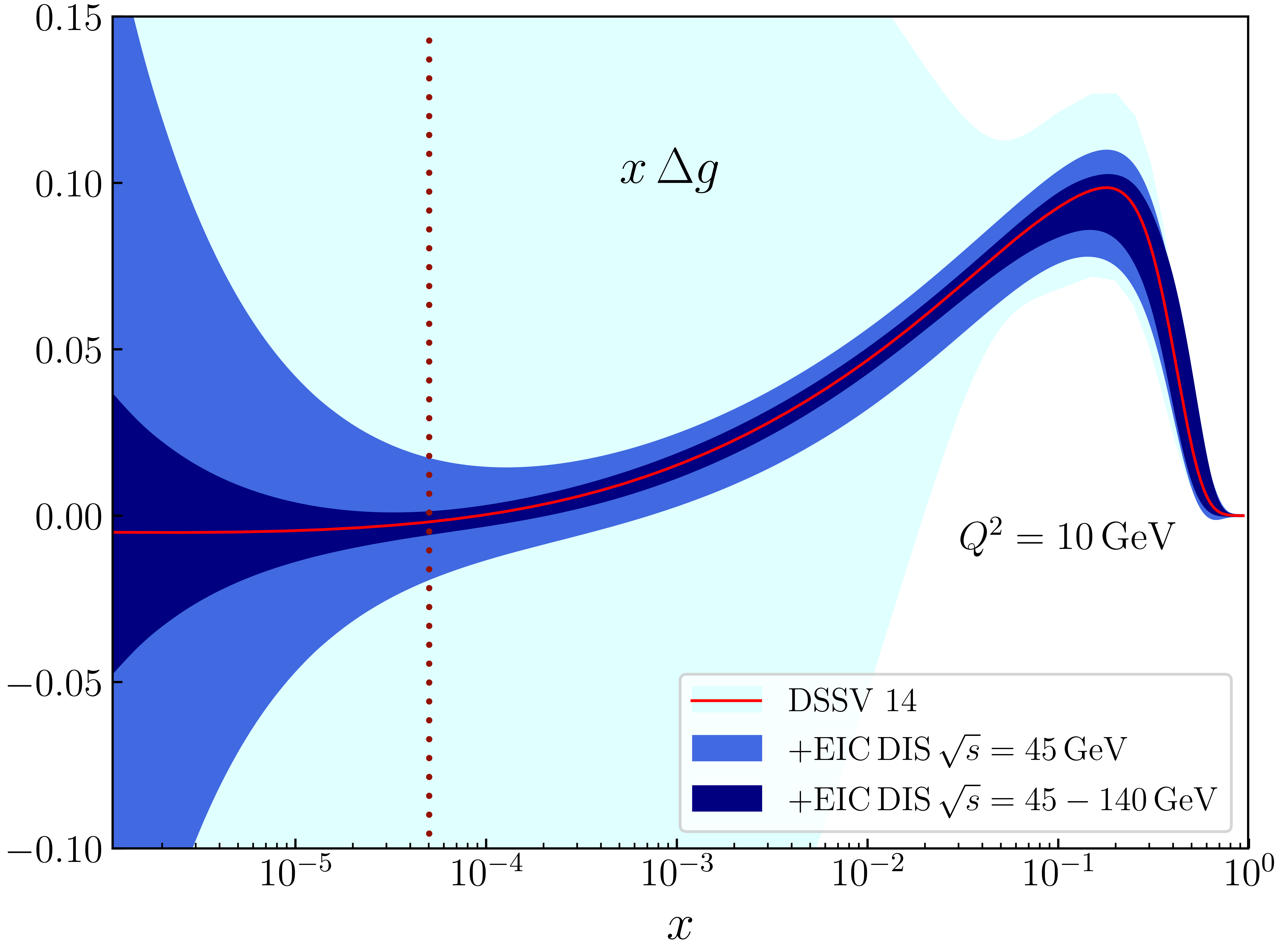


In collaboration with E. Aschenauer, G. Lucero, A.

IMPACT OF DIS DATA

1) Generation of the DSSV14+EIC@45 set

2) Reweighting of the DSSV14+EIC@45 with DIS pseudo data at $\sqrt{s} = 140$ GeV



Impressive reduction of the uncertainty for the unexplored region x<0.01 (factor ~2 reduction for x~0.1)

DIS@45 constrains Δg down to x~5x10^{-4}

DIS@ 140 reduce the uncertainty band in a factor ~3

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

IMPACT OF DIS DATA

1) Generation of the DSSV14+EIC@45 set

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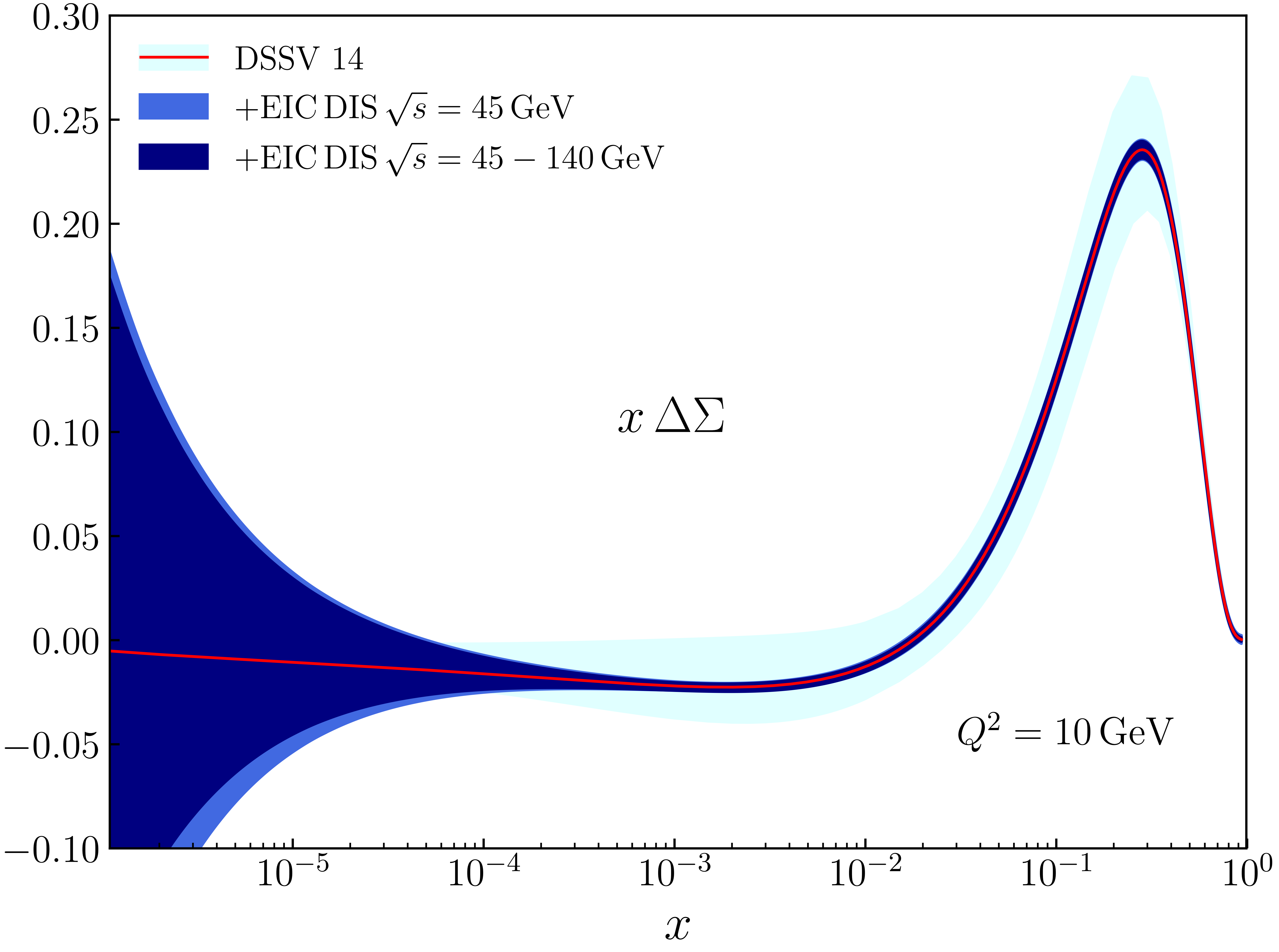


Impressive reduction of the uncertainty for the unexplored region x<0.01 (factor ~2 reduction for x~0.1)

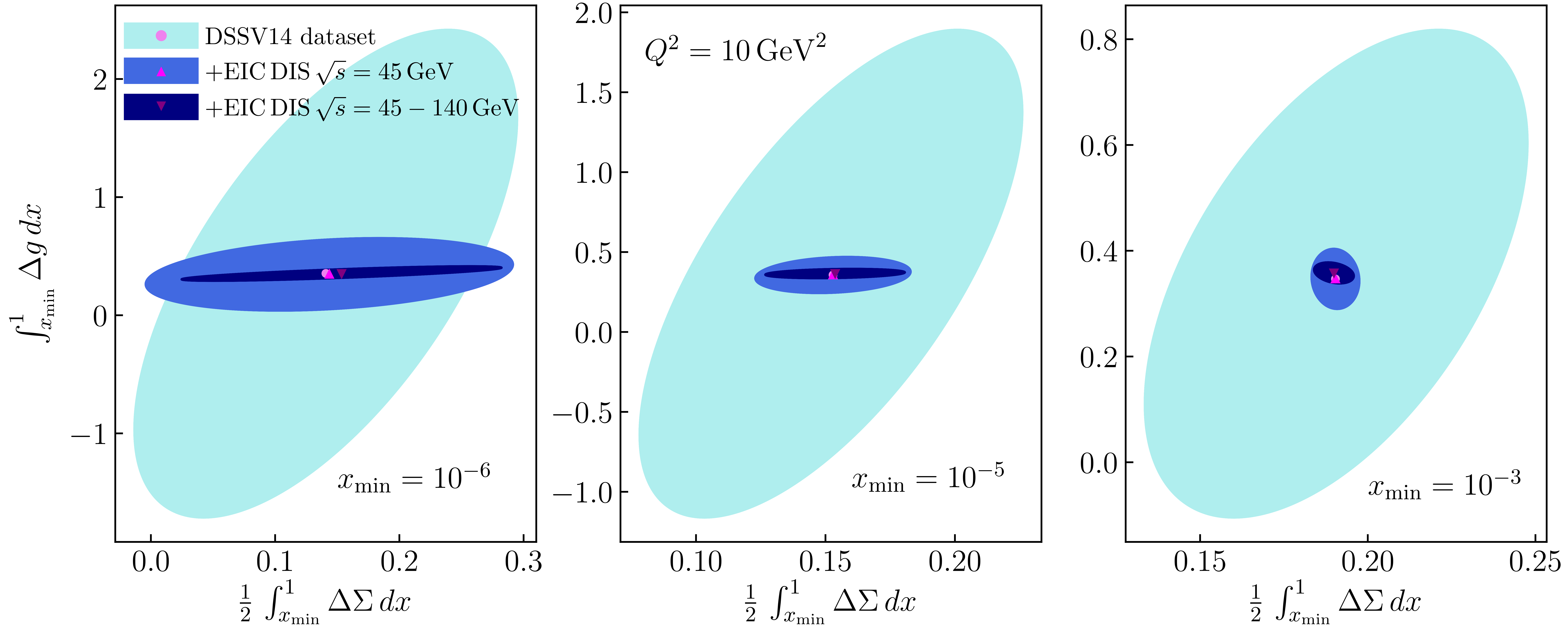
DIS@45 constrains Δg down to x~5x10^{-4}

The addition of DIS@140 does not have a significant impact

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

IMPACT OF DIS DATA

Disentangling the quarks and gluons spin budget



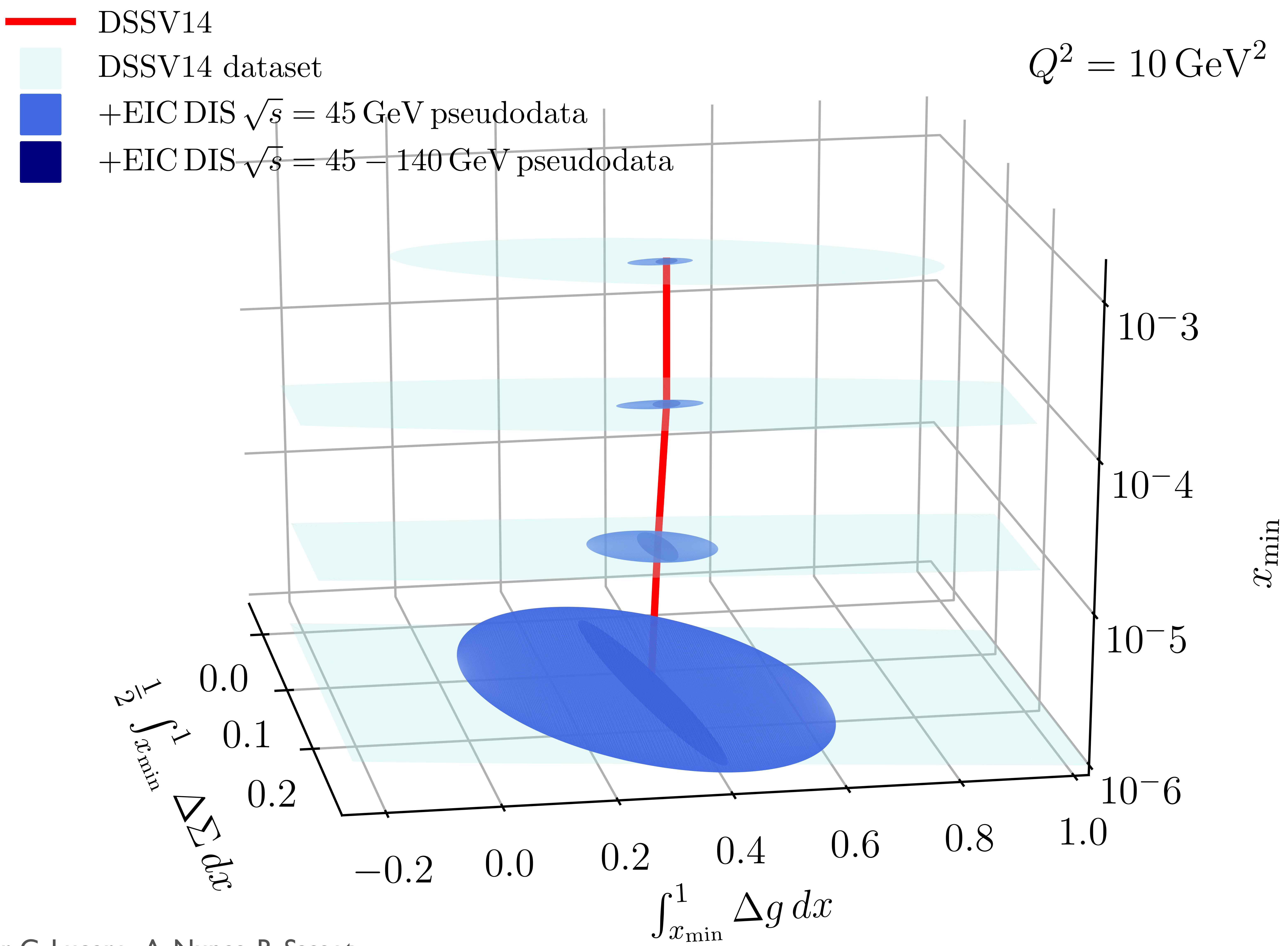
(Almost) no constraints in the unprobed region

Remarkable reduction in the gluon contribution to the proton spin

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

IMPACT OF DIS DATA

Disentangling the quarks and gluons spin budget

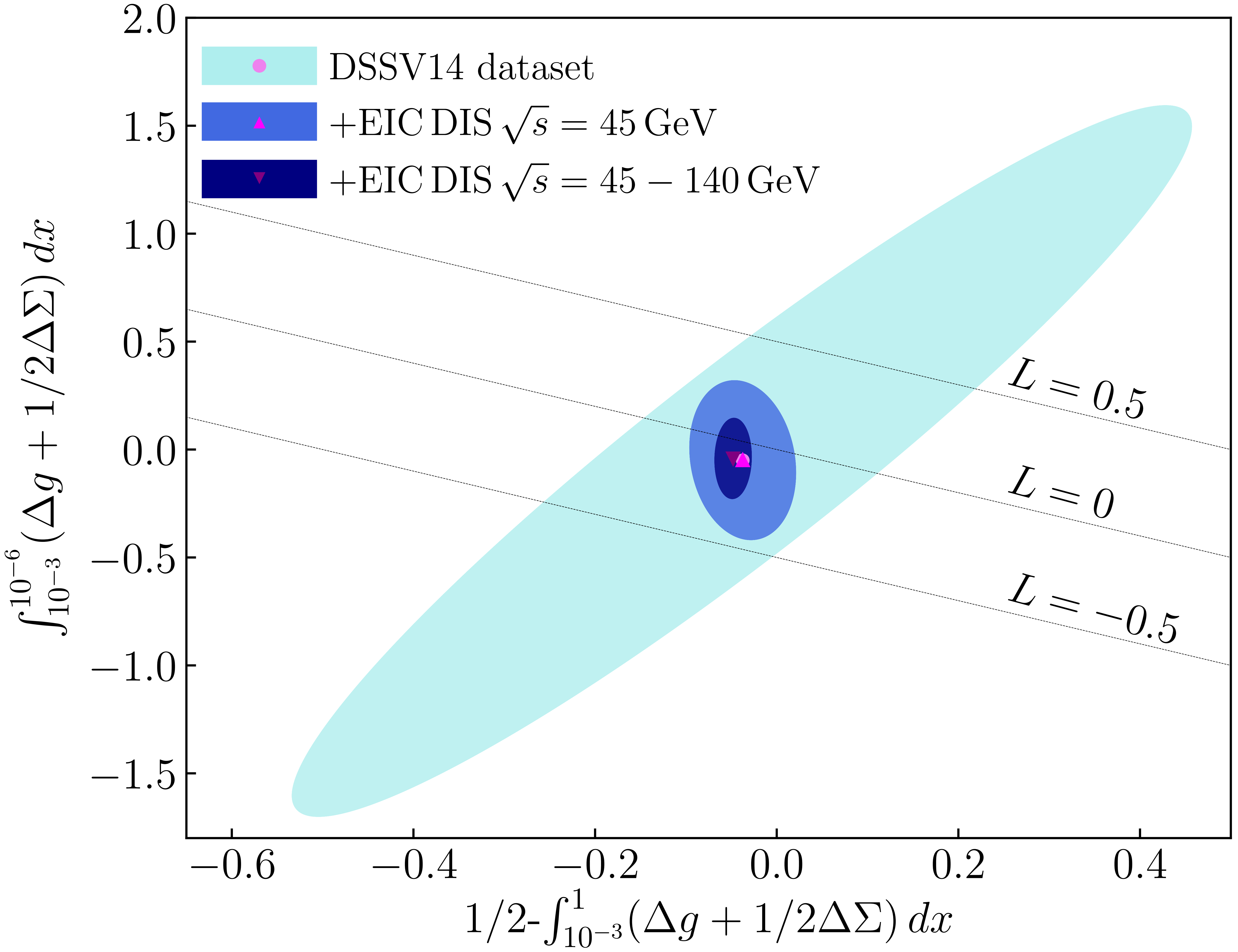


In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

IMPACT OF DIS DATA

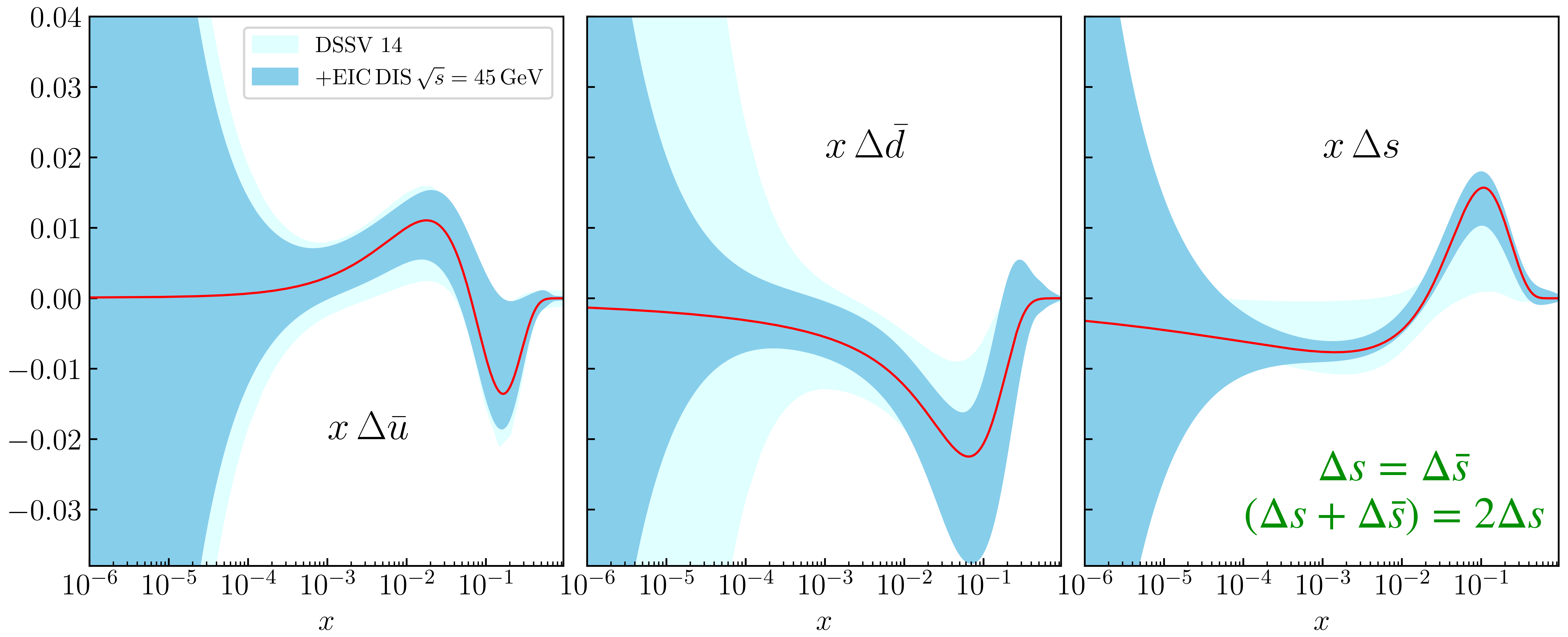
How important is the contributions from low-momentum partons?

Net spin contribution from partons with lower x



OAM contribution from parton with x down to 10^{-3}

(NOT) PROBING THE SEA QUARKS WITH NC DIS



Milder constraint on the sea quarks distributions due to the lack of flavor separation

Symmetry assumptions on the strange distribution $(\Delta s + \Delta\bar{s}) = 2\Delta s$ make it sensible to inclusive measurements

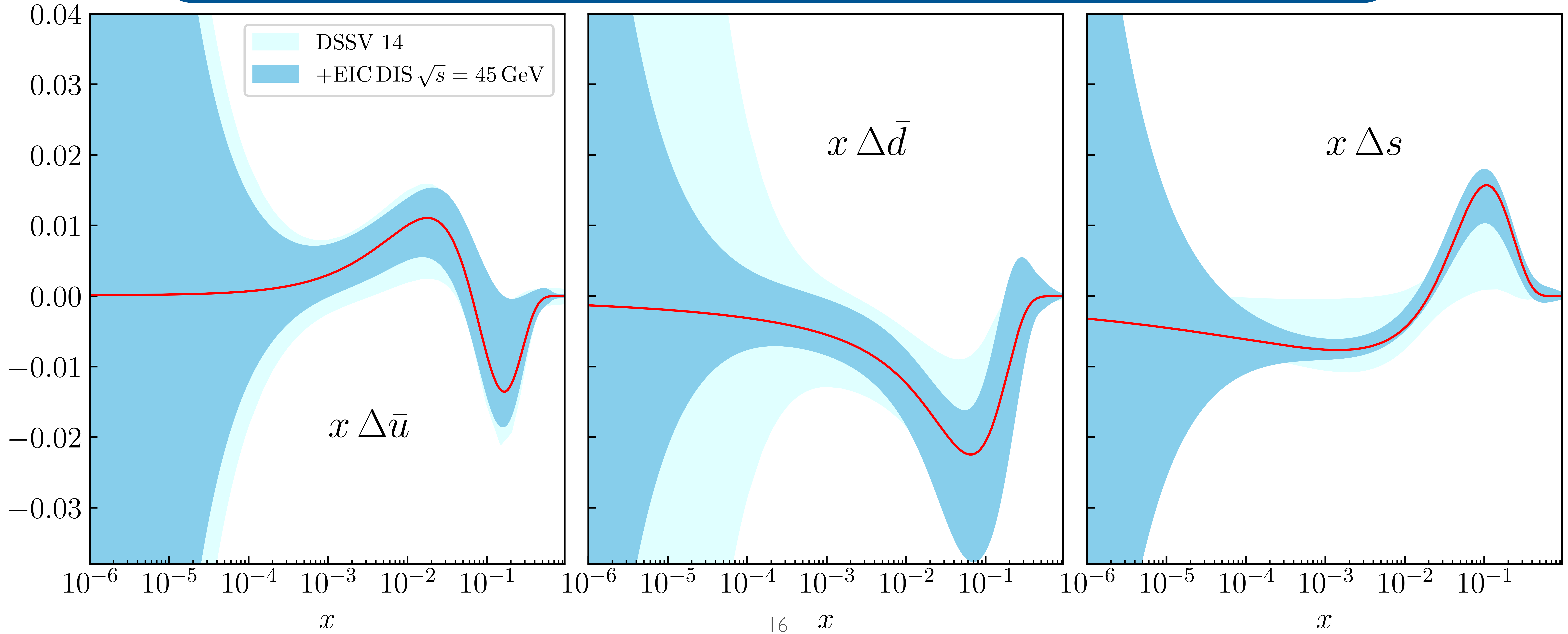
Include Flavour sensitive observables: CC DIS/SIDIS

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

IMPACT OF SIDIS DATA

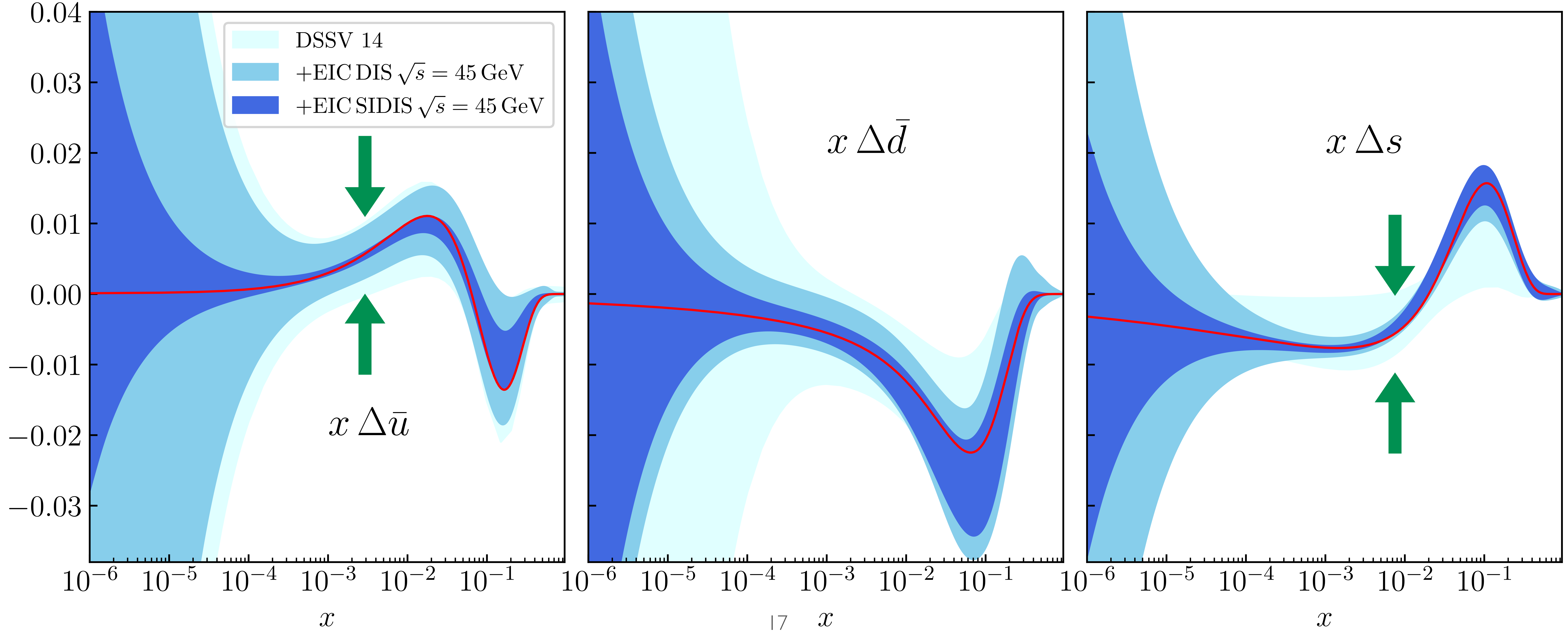
$$A_1 = \frac{\sigma^H \uparrow\Downarrow - \sigma^H \uparrow\Uparrow}{\sigma^H \uparrow\Downarrow + \sigma^H \uparrow\Uparrow} \longrightarrow \frac{g_1^H}{F_1^H}$$

1. DSSV14+ DIS@45
2. + Semi Inclusive DIS ($\pi^\pm, K^\pm$) at $\sqrt{s} = 45$ GeV
3. Alternatively, + Semi Inclusive DIS ($\pi^\pm, K^\pm$) at $\sqrt{s} = 140$ GeV



IMPACT OF SIDIS DATA

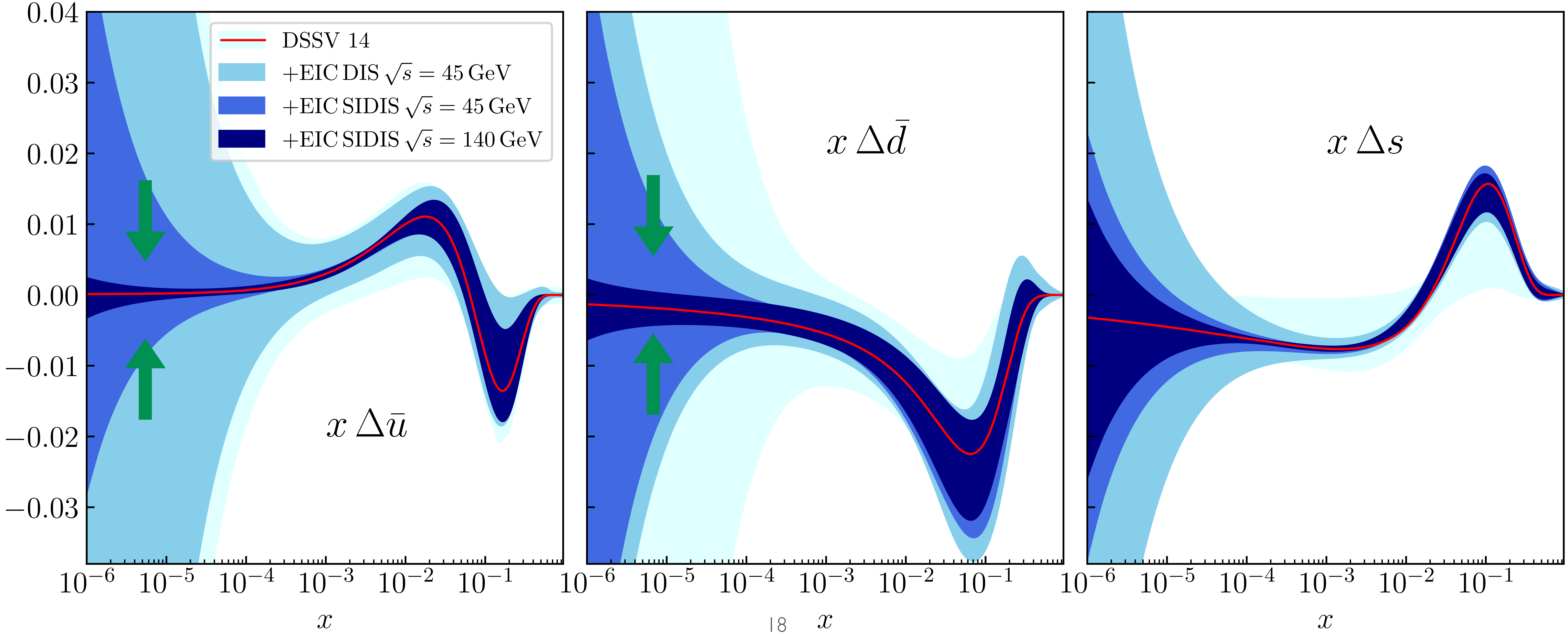
Stronger constraints on $\Delta\bar{u}$ (charge factor) and $\Delta\bar{s}$ (symmetry assumptions in DSSV framework) compared to $\Delta\bar{d}$



IMPACT OF SIDIS DATA

Stronger constraints on $\boldsymbol{\Delta\bar{u}}$ (charge factor) and $\boldsymbol{\Delta\bar{s}}$ (symmetry assumptions in DSSV framework) compared to $\boldsymbol{\Delta\bar{d}}$

SIDIS @140 GeV pushes the growth ni the uncertainty at least a decade in x for $\boldsymbol{\Delta\bar{u}}$ and $\boldsymbol{\Delta\bar{d}}$ due to the wider kinematical coverage



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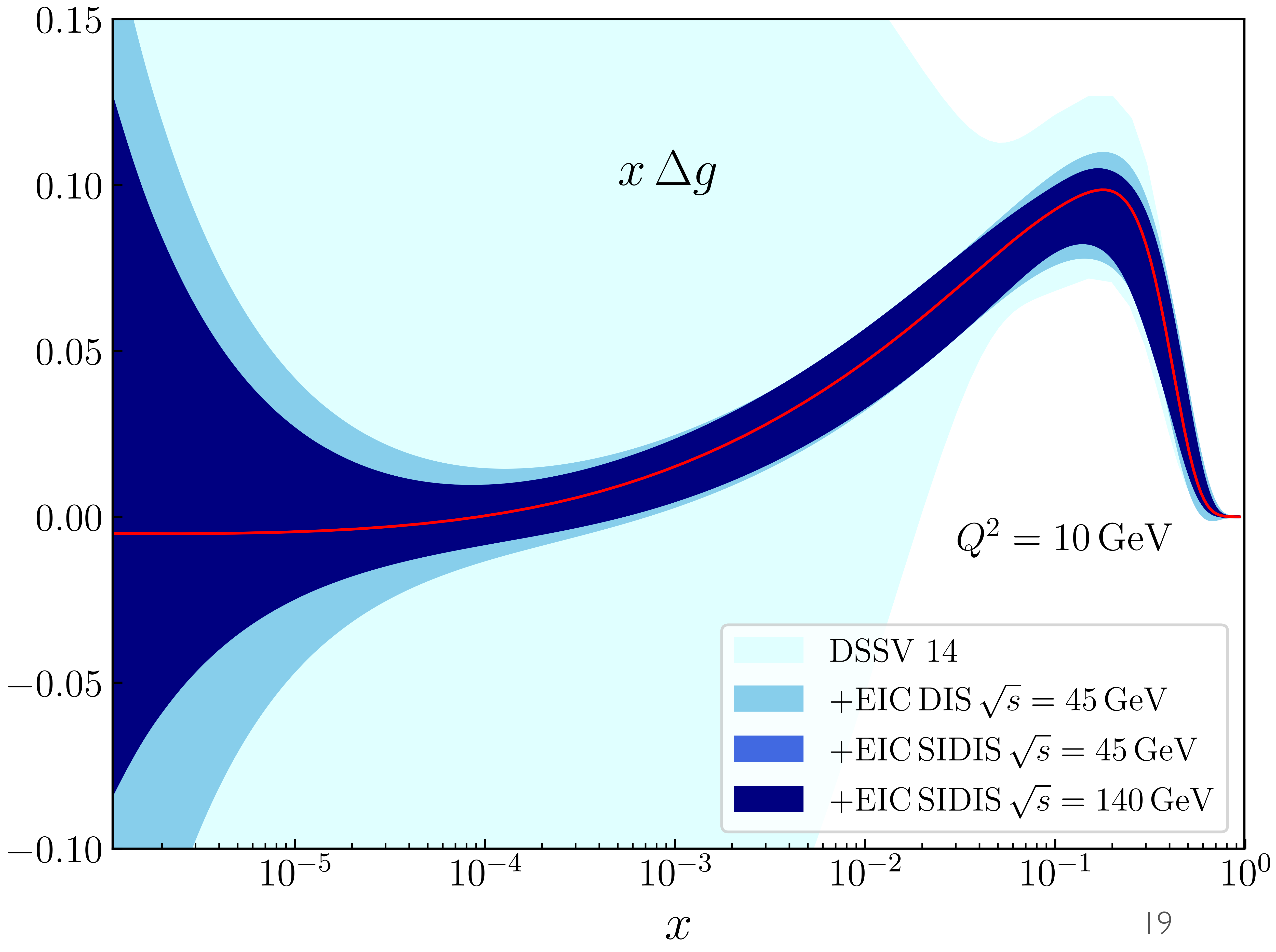

Milder impact on Δg. Complementary to Inclusive DIS measurements

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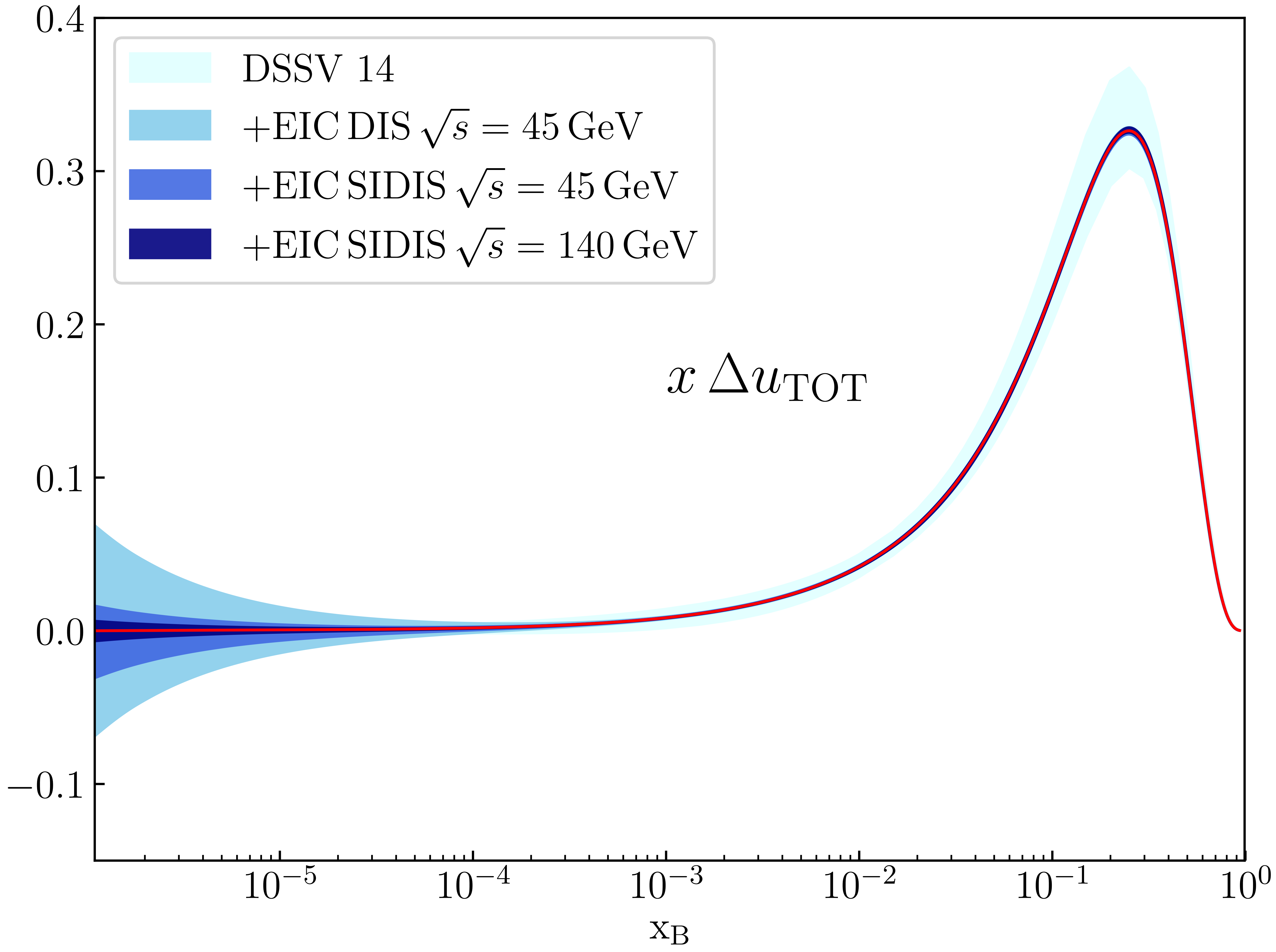

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Good grip on the total total distributions Δu_{TOT} and Δd_{TOT}.

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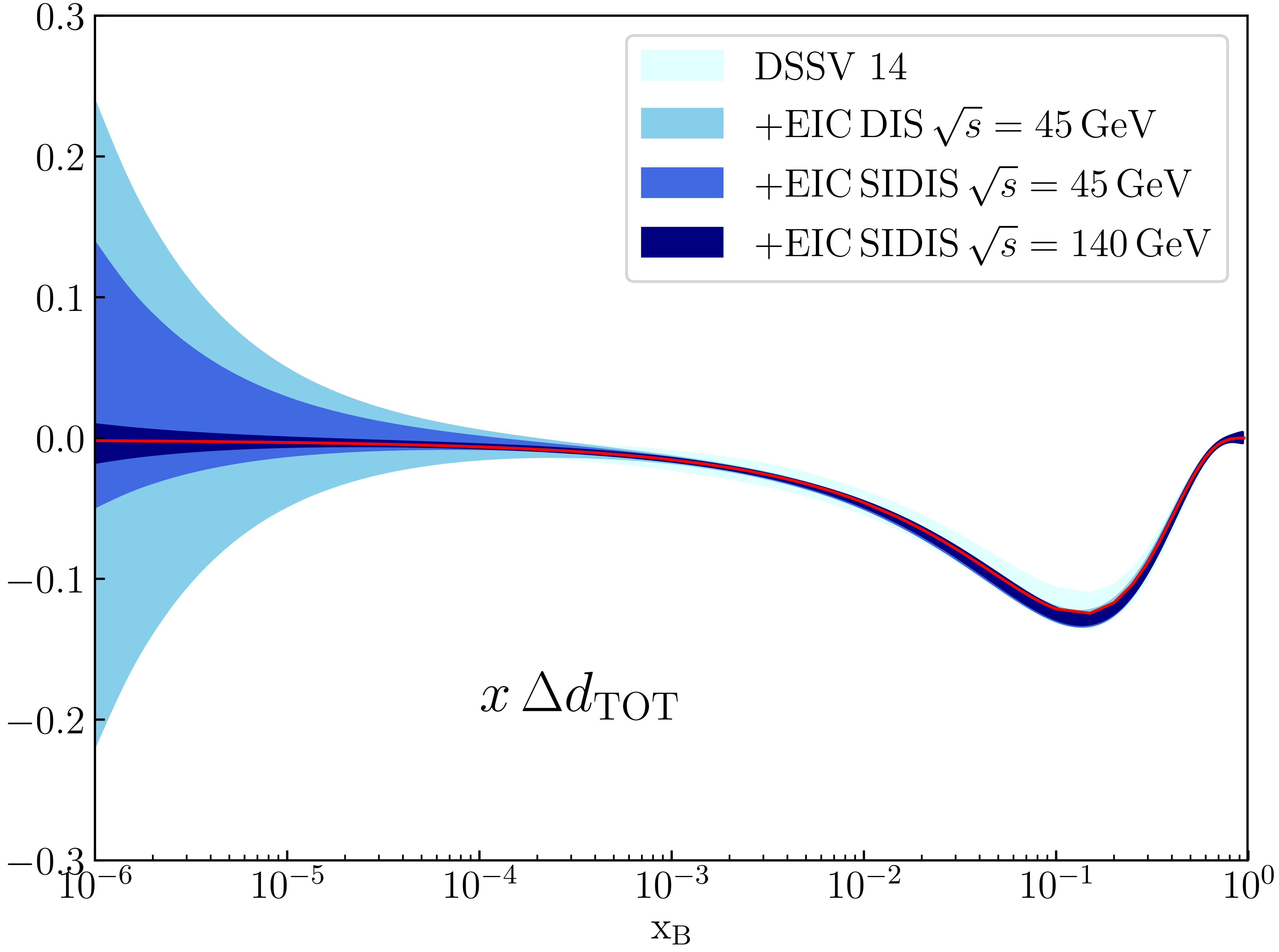

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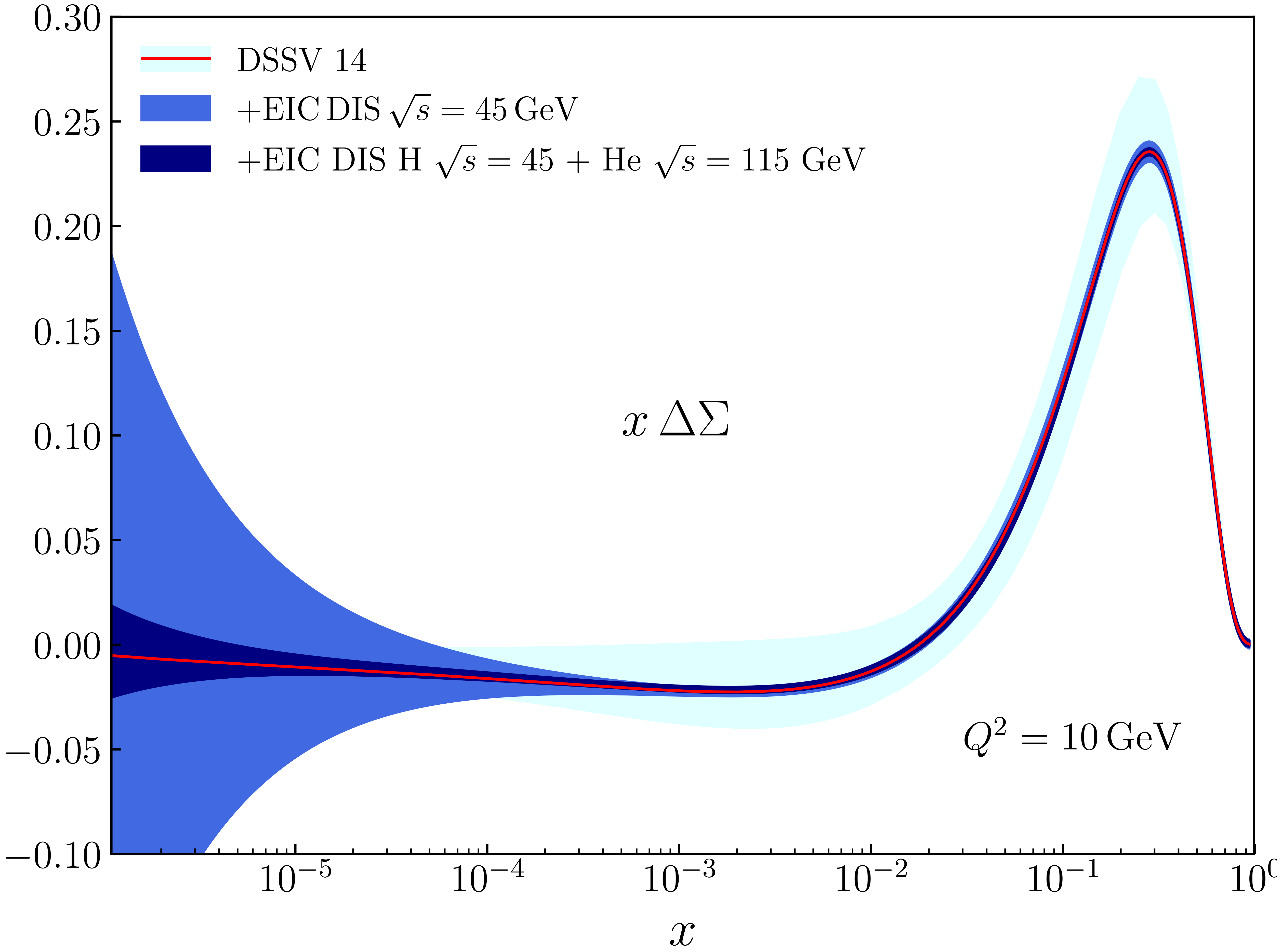
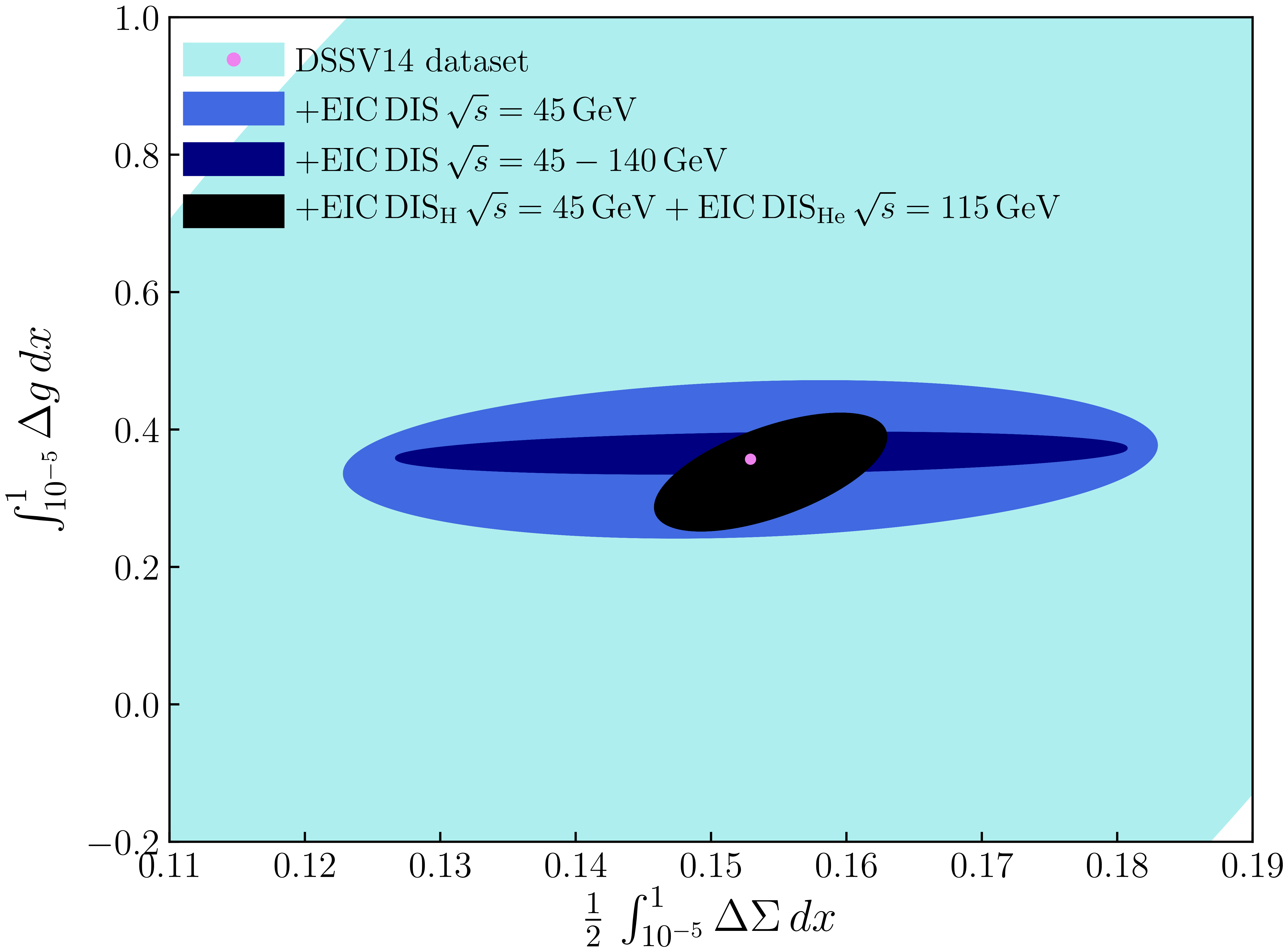
IMPACT OF DIS WITH He DATA

Disentangling the quarks and gluons contribution to the spin budget

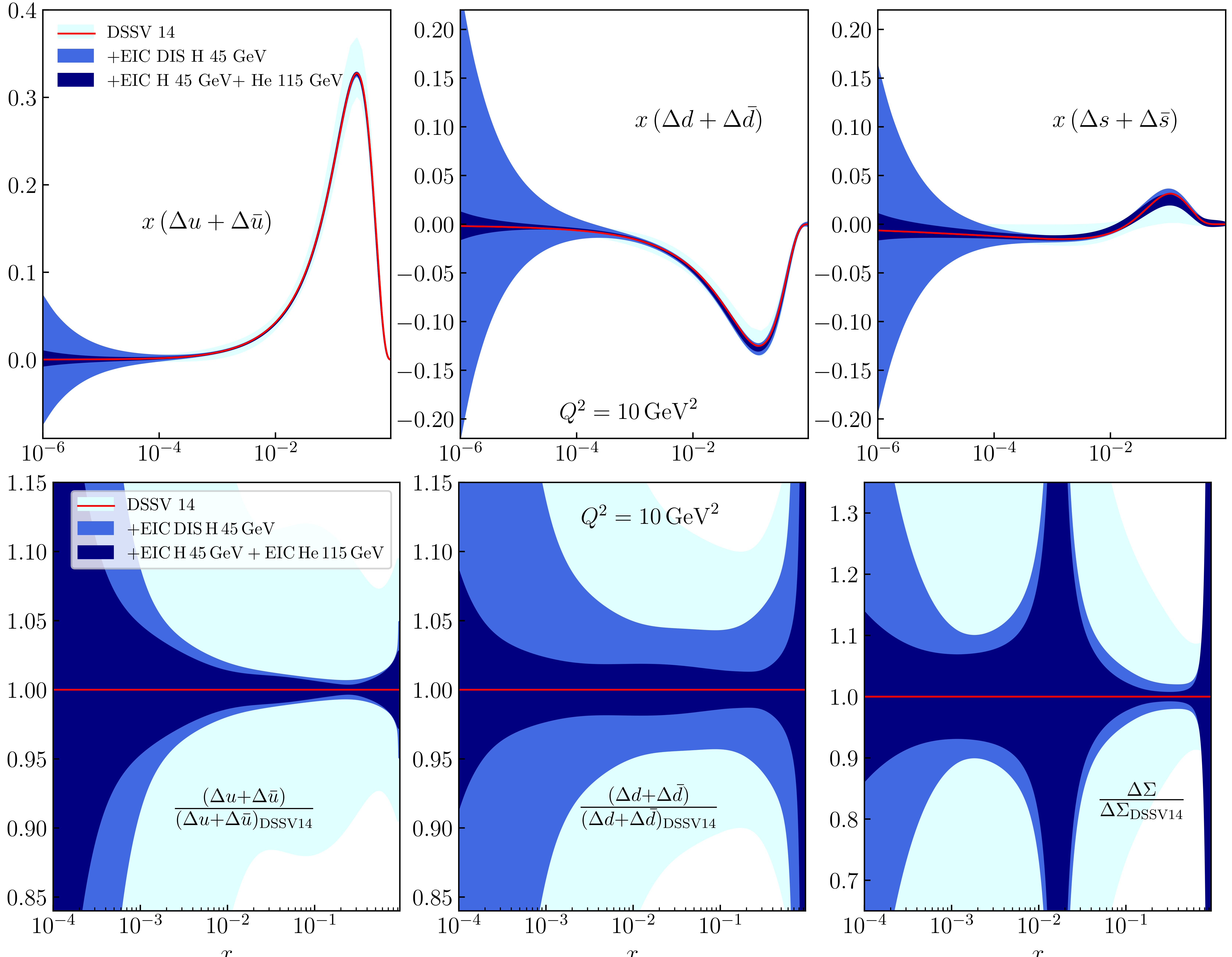




Complementarity with the DSSV14+DIS@45 set of replicas. New fit will be needed

Significant improvement in $\mathbf{\Delta\Sigma^1}$ expected!

IMPACT OF DIS WITH HE DATA



Improved flavour separation also expected

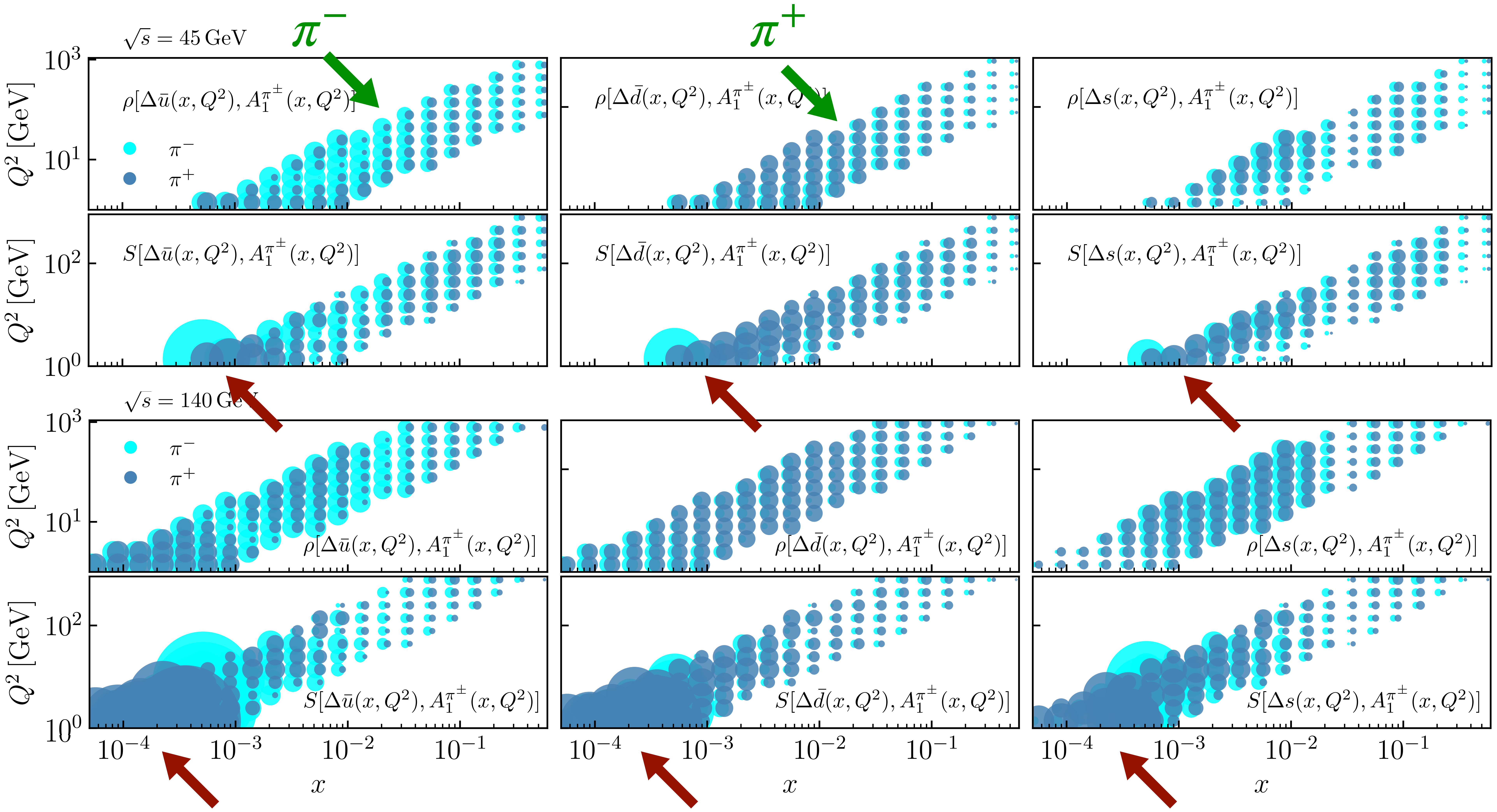
Reduction in the uncertainty to the percent level for $10^{-3}<x<10^{-1}$

SUMMARY

- **EIC DIS data at 45 GeV** expected to provide important constraints on $\Delta\Sigma$ and specially on the less constrained Δg down to $x \sim 10^{-3}$.
- **EIC DIS data at 140 GeV** expected to further reduce the uncertainty in a factor 3, while pushing the uncertainty growth one decade in x.
- **Semi-inclusive DIS** offers a remarkable tool to probe the sea quark of the parton, and determine their separate contributions to the protons spin.
- **DIS with He3 targets** expected to further improve flavor separation and the quark contribution to the proton spin

THANK YOU

SIDIS CORRELATION AND SENSITIVITY COEFFICIENTS



- High x probes mainly the proton's valence composition, as well as the hadron structure
- Stronger correlation for lower x values as Gluon emissions become relevant
- Again, higher sensitivities for the unproved low-x region

Access to low x is instrumental to determine the contribution of each quark flavor to the proton spin

In collaboration with E. Aschenauer, G. Lucero, A. Nunes, R. Sassot

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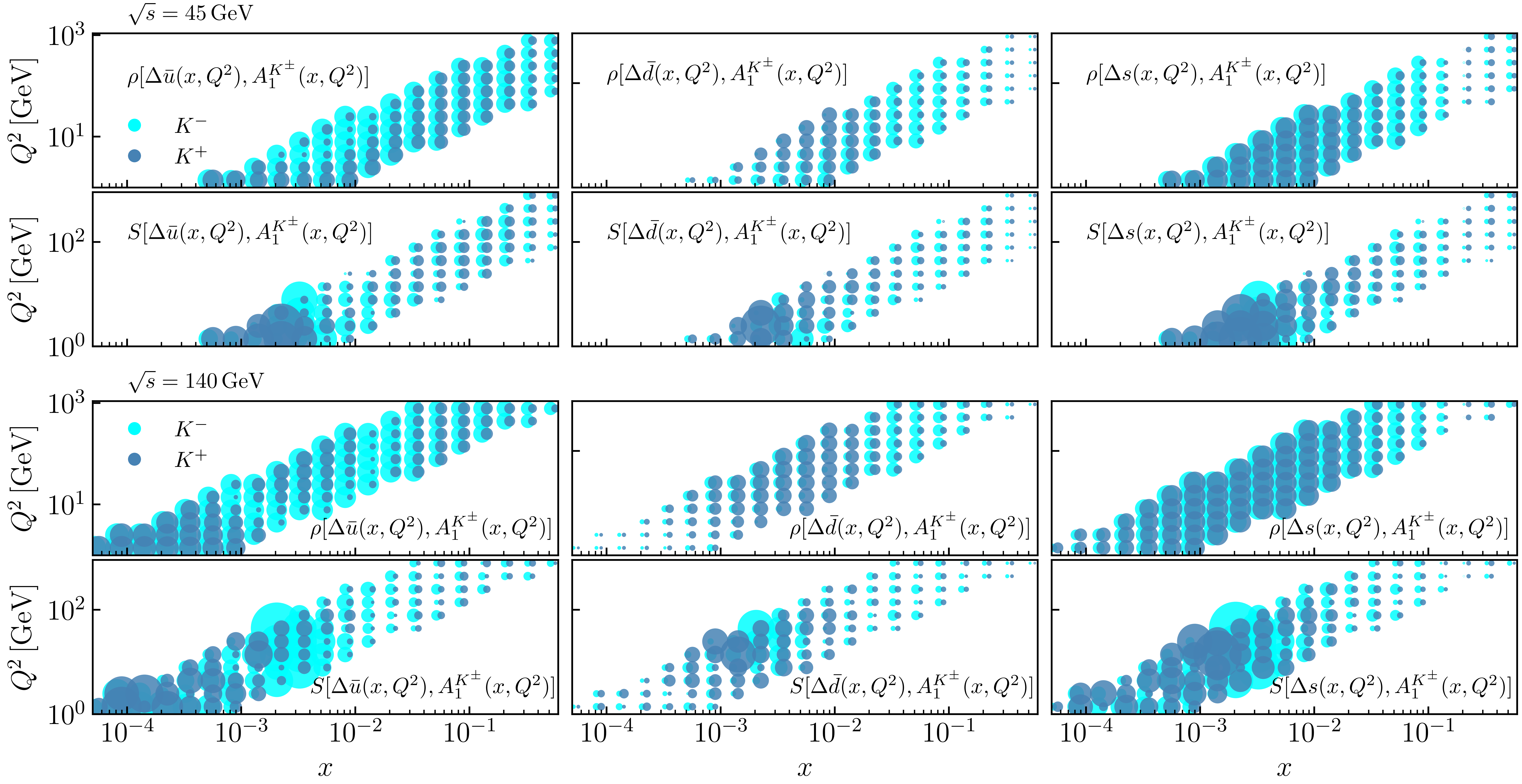

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