

# Polarized scattering at NLO+PS in the POWHEG BOX

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In collaboration with Barbara Jäger

Based on

[JHEP 07 \(2024\) 177](#)

[Eur.Phys.J.C 86 \(2026\) 7](#)

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High Precision for Hard Processes (HP2 2026)

Karlsruhe - October 7th 2026



# Introduction

Why polarized processes?

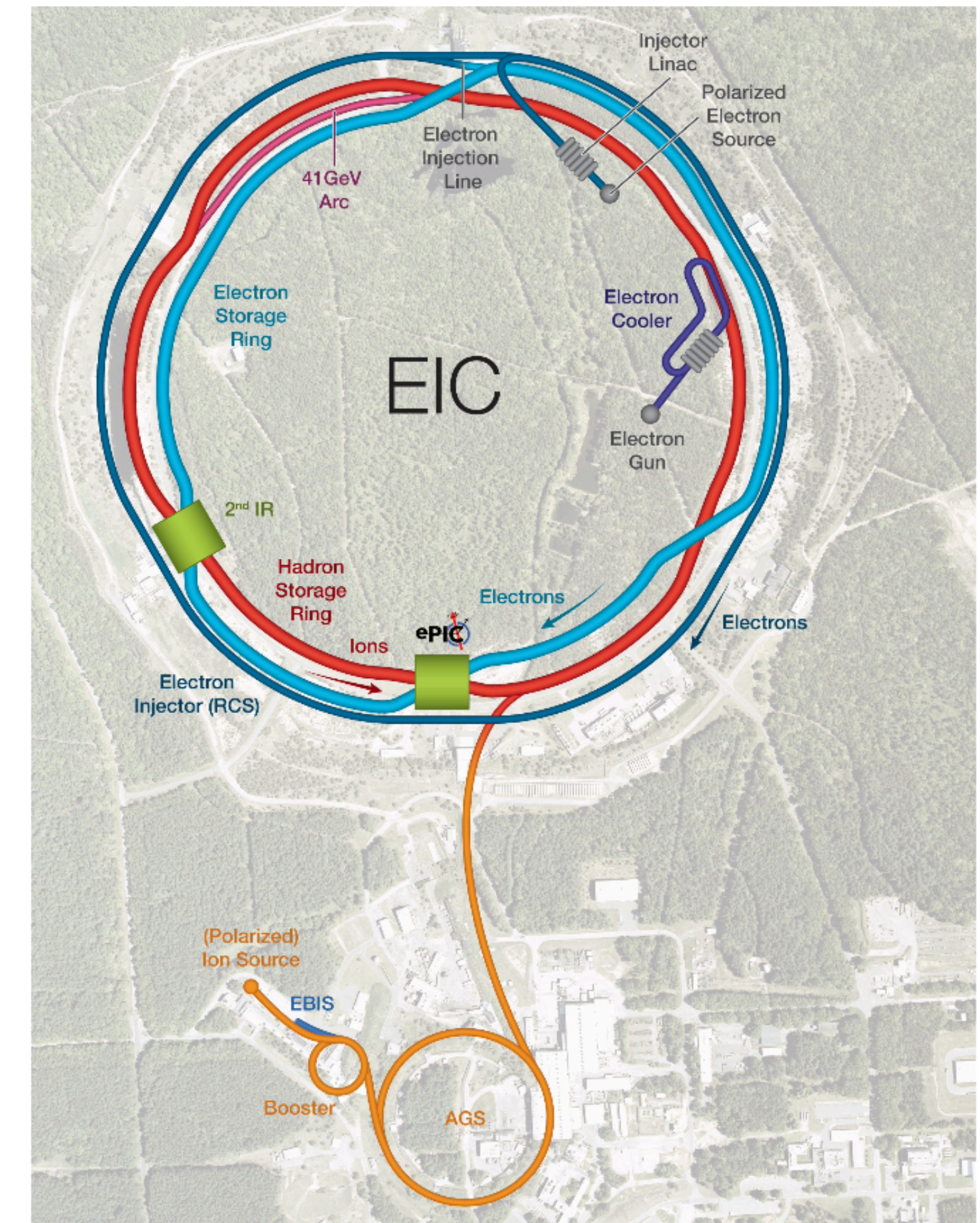
# Introduction - Why polarized processes?

## Decomposing the spin of the proton

- ▶ Proton spin defined in terms of Proton Sum Rules [Jaffe, Manohar (1990); Ji (1996)]

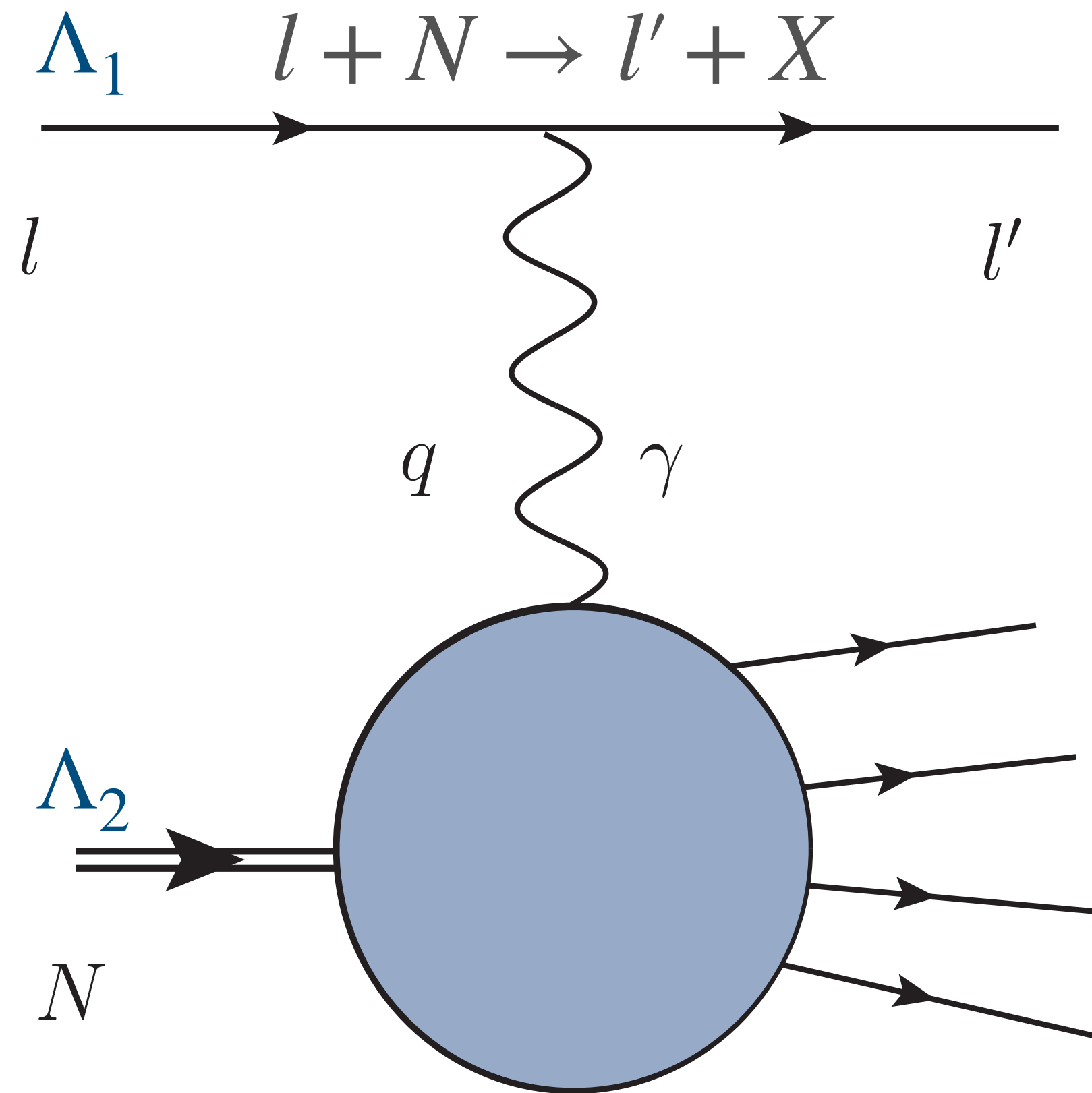
$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta g + L_q + L_g$$

- ▶ **EMC, SLAC, SMC (CERN), HERMES (DESY)**: Low amount of spin carried by quarks,  $\Delta\Sigma \sim 0.25 \ll 1$ .
- ▶ **COMPASS (CERN), HERMES (DESY), RHIC-Spin, JLab**: First evidence of positive polarization of gluons from polarized proton-proton collisions at RHIC [de Florian, Sassot, Stratmann, Vogelsang (2008-); Nocera, Ball Forte, Ridolfi, Rojo (2013-); Cocuzza, Ethier, Melnitchouk, Sato (2013-)]
- ▶ **EIC**: Spin physics at the core of EIC program. Unique access to the proton's spin structure [EIC Yellow Report (2022)].



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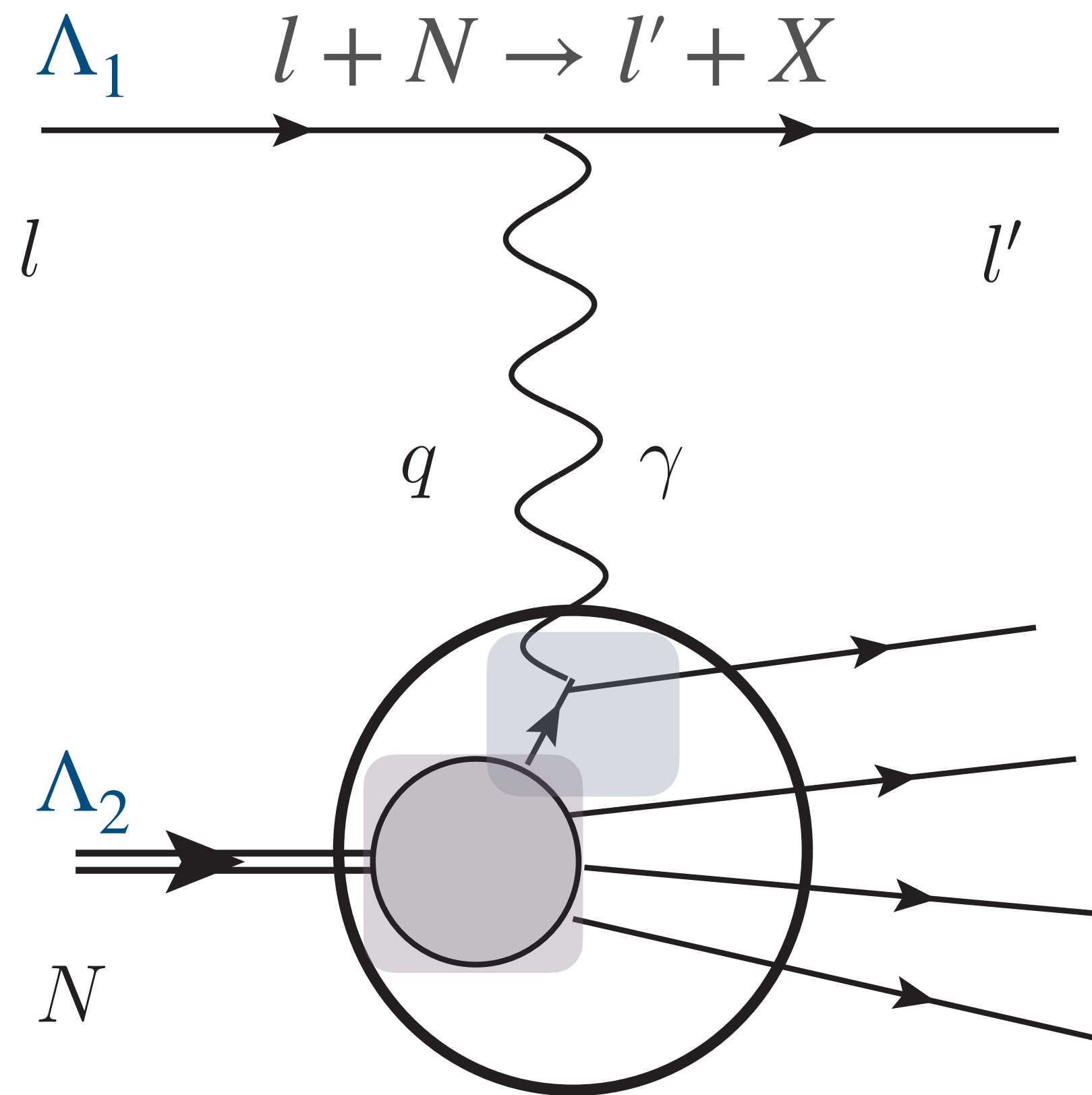


$$\Delta\sigma \equiv \frac{1}{4} [\sigma^{++} + \sigma^{--} - \sigma^{+-} - \sigma^{-+}]$$

Longitudinally polarized cross section

# Introduction - Why polarized processes?

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$$\Delta\sigma \equiv \frac{1}{4} [\sigma^{++} + \sigma^{--} - \sigma^{+-} - \sigma^{-+}]$$

Longitudinally polarized cross section

$$\Delta\sigma = \sum_a \int dz \Delta f_a(z, \mu_F^2) \Delta\hat{\sigma}_i(\alpha_S(\mu_R), \mu_F^2, \mu_R^2)$$

Polarized PDFs  $\Delta f_a \equiv f_a^+ - f_a^-$

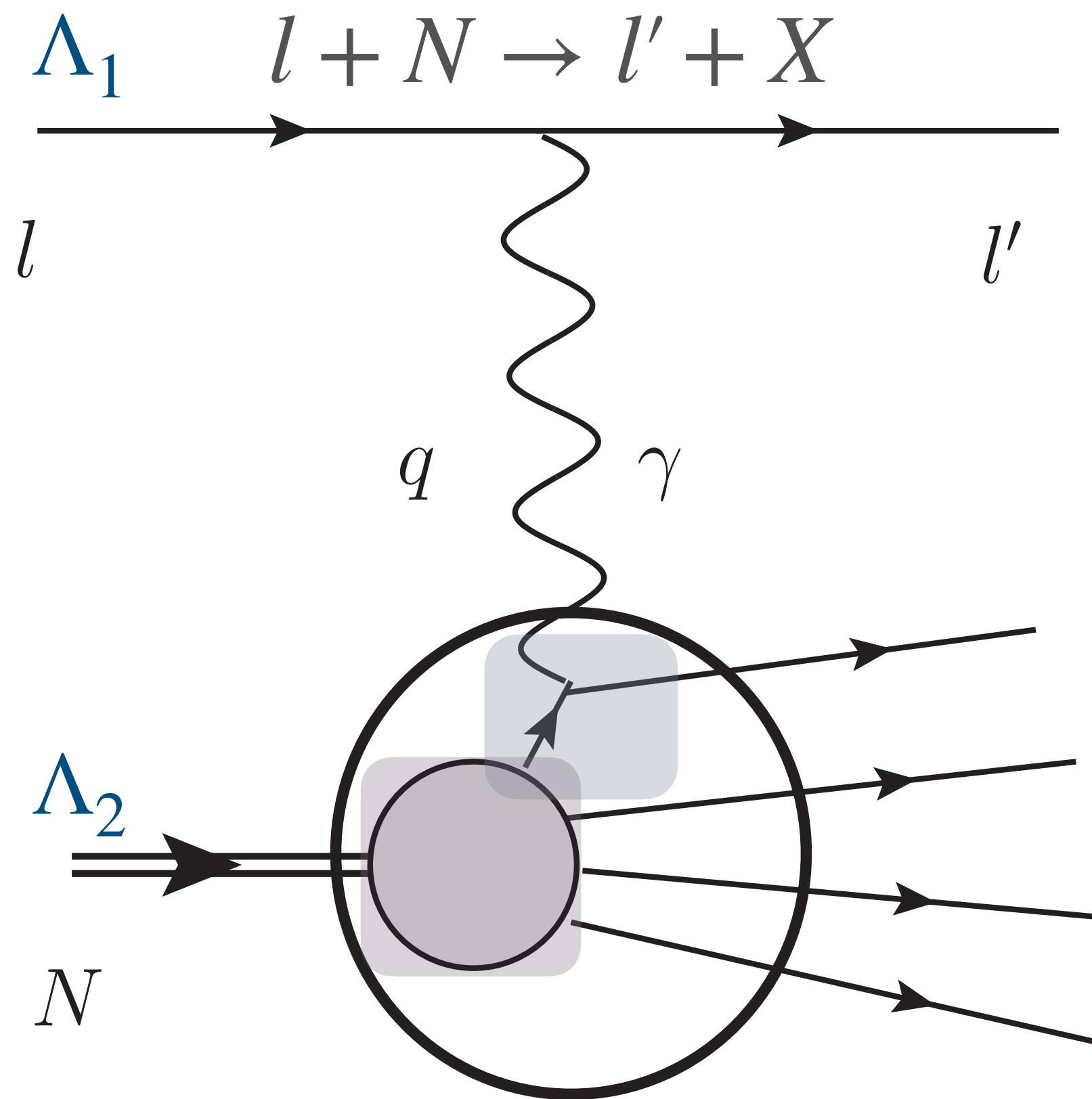
Polarized Partonic cross-section  $\Delta\hat{\sigma} \equiv \frac{1}{4} [\sigma^{++} + \sigma^{--} - \sigma^{+-} - \sigma^{-+}]$

$\Delta f_a(\mu_F^2) = \int_0^1 \Delta f_a(x, \mu_F^2) dx$

Contribution of parton  $a$  to the proton's spin

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PDFs' scale dependence can be calculated perturbatively in QCD

$$\frac{\partial}{\partial \ln \mu^2} \Delta f_i(z, \mu^2) = \sum_j \int_z^1 \frac{dy}{y} \Delta P_{ji}(y, \alpha_S(\mu^2)) \Delta f_j\left(\frac{z}{y}, \mu^2\right)$$

They can be determined at some input scale from a set of experimental measurements  $\rightarrow$  QCD global analyses

# Introduction - Spin physics at the EIC

The EIC spin program will require precise predictions for electron-ion collisions

- ▶ Increased theoretical accuracy
- ▶ Precise MC event generators

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## Calculations for polarized DIS observables beyond NLO:

- NNLO structure functions  $g_1$  (photon exchange)  
van Neerven, Zijlstra (1994)
- NNLO NC & CC structure functions  $g_1, g_4, g_5$   
IB, de Florian, Pedron (2022)
- Approx. NNLO and N3LO Semi-Inclusive DIS  
Abele, de Florian, Vogelsang (2022)
- NNLO Single-Jet production  
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## Fragmentation functions

- NNLO extraction of parton-to-hadron FFs based on SIA  
Anderle, Ringer, Stratmann (2015)  
Bertone, Carrazza, Hartland, Nocera, Rojo (2017)  
Soleymaninia, Goharipour, Khanpour (2018)
- NNLO extractions of parton-to-hadron FFs based on SIA and (a)SIDIS  
IB, de Florian, Sassot, Stratmann, Vogelsang (2022)  
Abdul Khalek, Bertone, Khoudli, Nocera (2022)  
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## MC event generators for DIS w/ higher order corrections:

- HERWIG  
D'Errico, Richardson (2012)  
**Polarized** - Masouminia, Papaefstathiou, Richardson (2026)
- SHERPA  
Carli, Gehrmann, Höhe (2009)  
Höhe, Krauss, Schönherr, Siegert (2010)  
Höhe, Kuttimalai, Li (2018)  
Meinzinger, Silvetti, Reichelt (2025)
- PYTHIA  
Helenius, Laulainen, Preuss (2024, 2026)
- POWHEG  
Banfi, Ferrario Ravasio, Jäger, Karlberg, Reichenbach, Zanderighi (2024)  
Buonocore, Limatola, Nason, Tramontano, (2024)  
**Polarized** - IB, Jäger (2024)

~~Solevmanova, Gouliou, Kharin (2018)~~

Update older LO polarized eN event generators

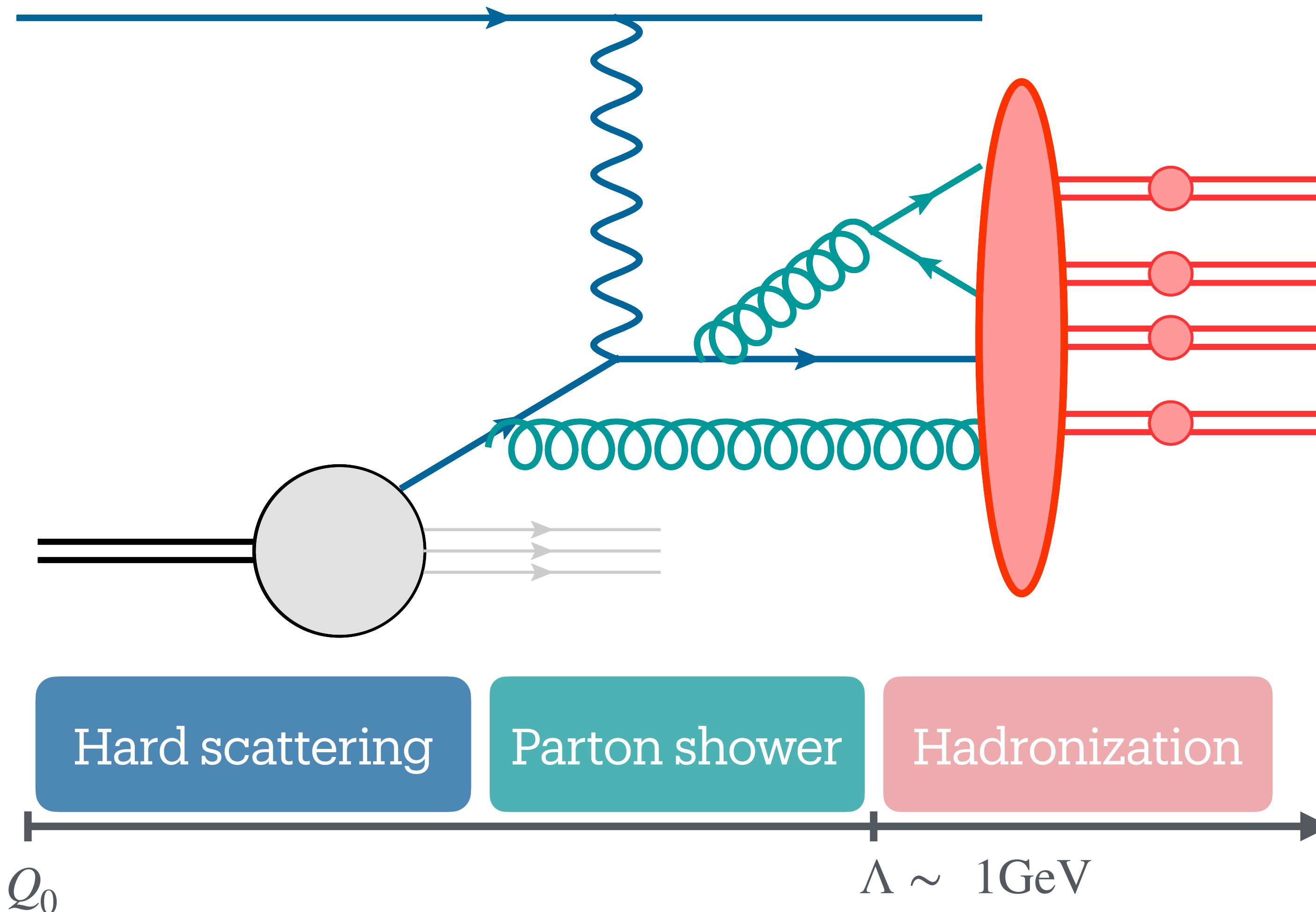
- PEPSI  
Mankiewicz, Schäfer, Veltri (1992)
- DJANGO  
Charchula, Schuler, Spiesberger (1994)  
Aschenauer, Burton, Martini, Spiesberger, Stratmann (2013)

# Matching higher order corrections to Parton Showers

POWHEG basics

# Shower Monte Carlo event generators

SMC in a nutshell - See talk by D. Reichelt



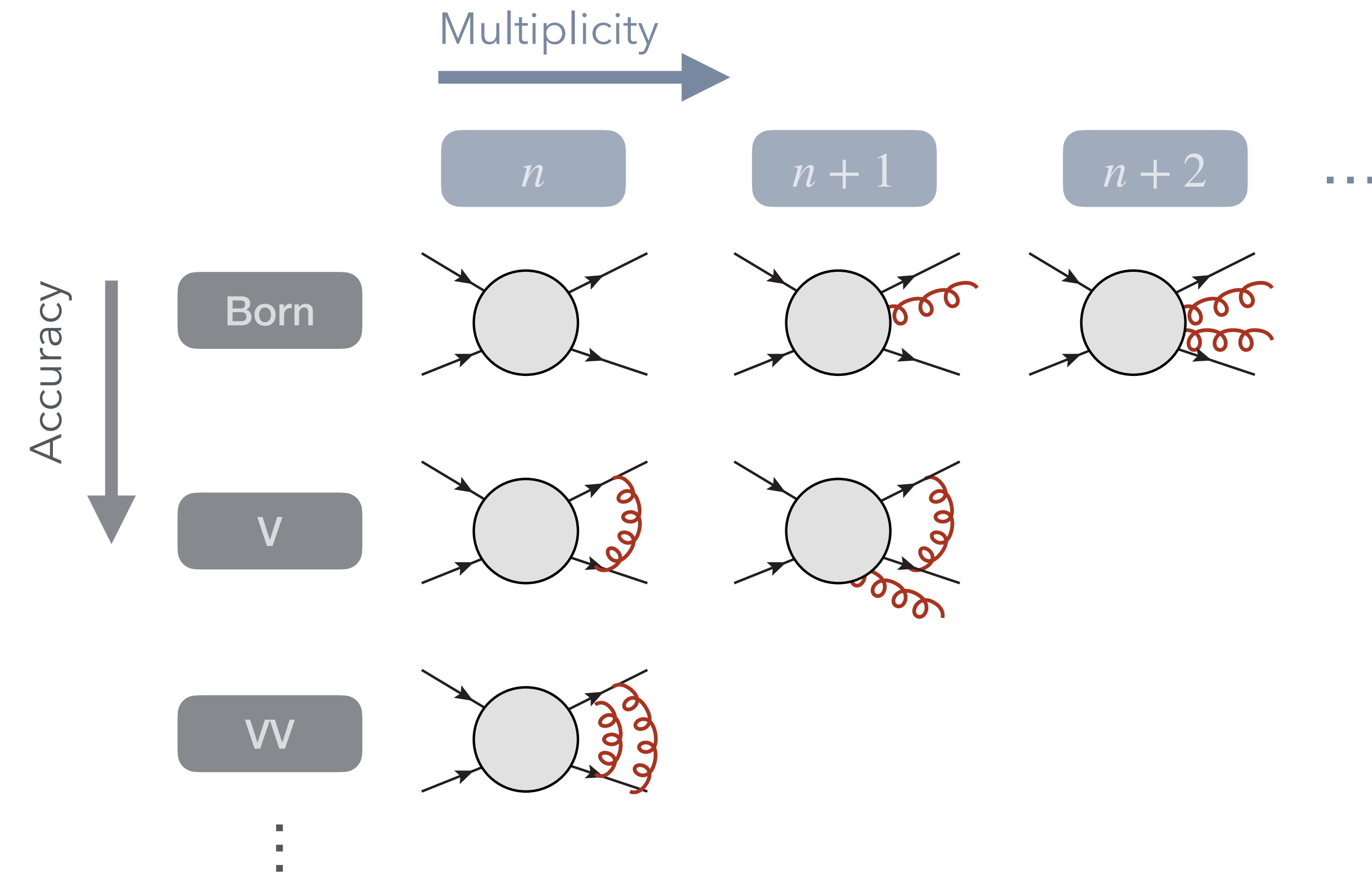
Resummation of enhanced contributions in the collinear limit

$$d\sigma_{\text{SMC}} = B(\Phi_n) d\Phi_n \left\{ \Delta_{t_0} + \frac{\alpha_S}{2\pi} P(z) \frac{1}{t} \Delta_t d\Phi_r \right\}$$

- ▶ Iterated simulation of softer and softer emissions from hard scale down to hadronization scale
- ▶ Leading logarithmic accuracy (correct behavior in the collinear limit)
- ▶ Simulate hadronization and hadronic decays

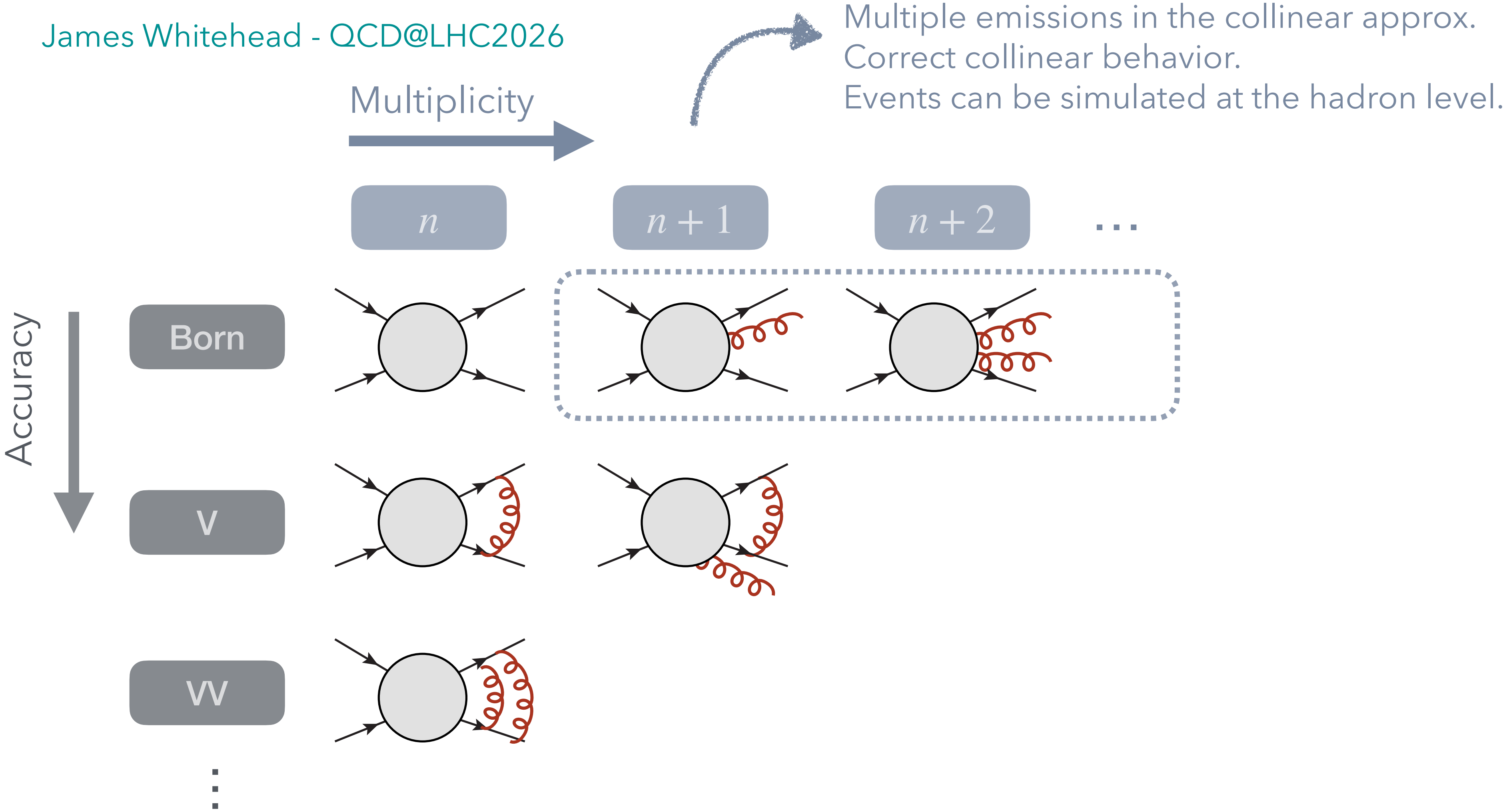
# Matching higher order corrections to PS

James Whitehead - QCD@LHC2026



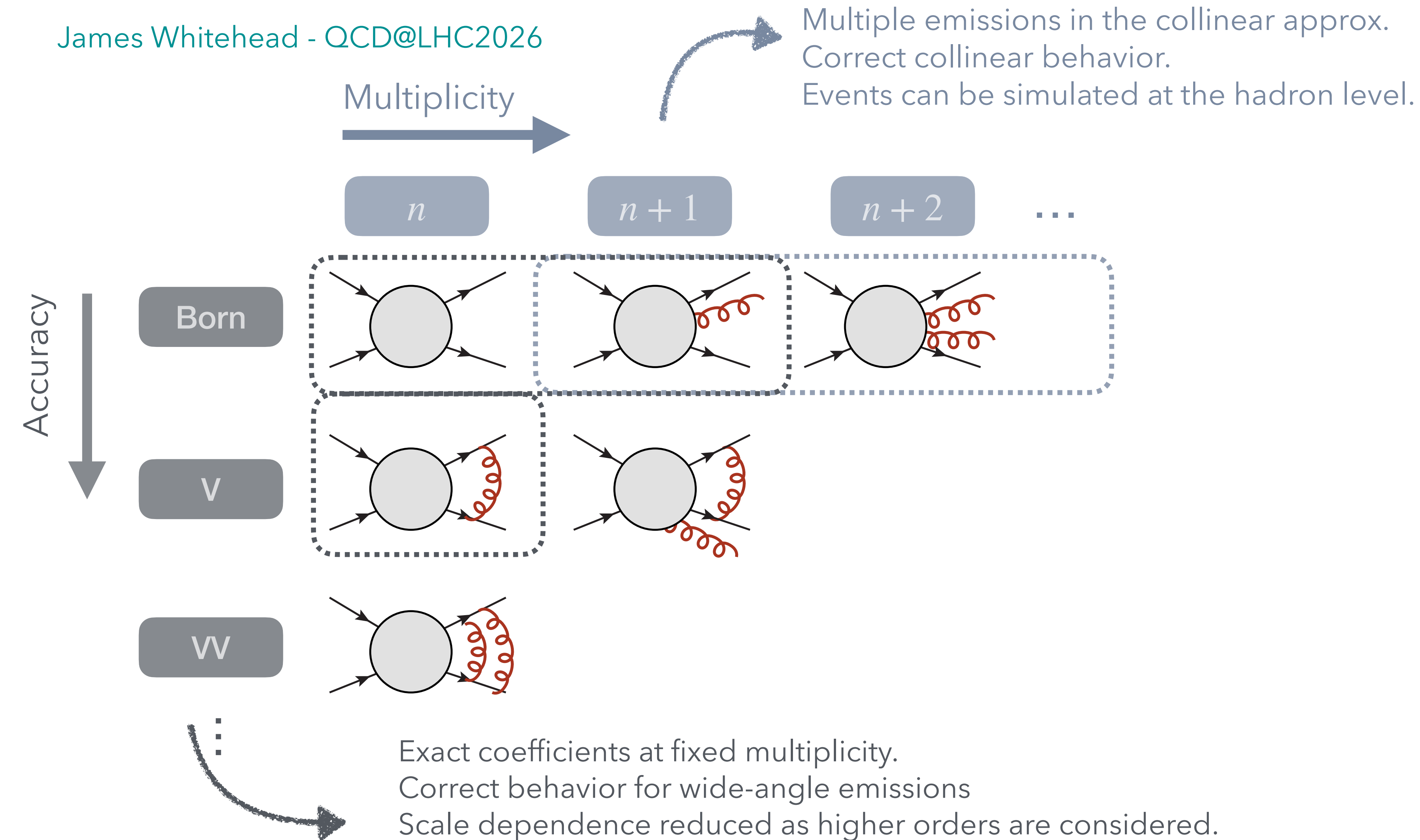
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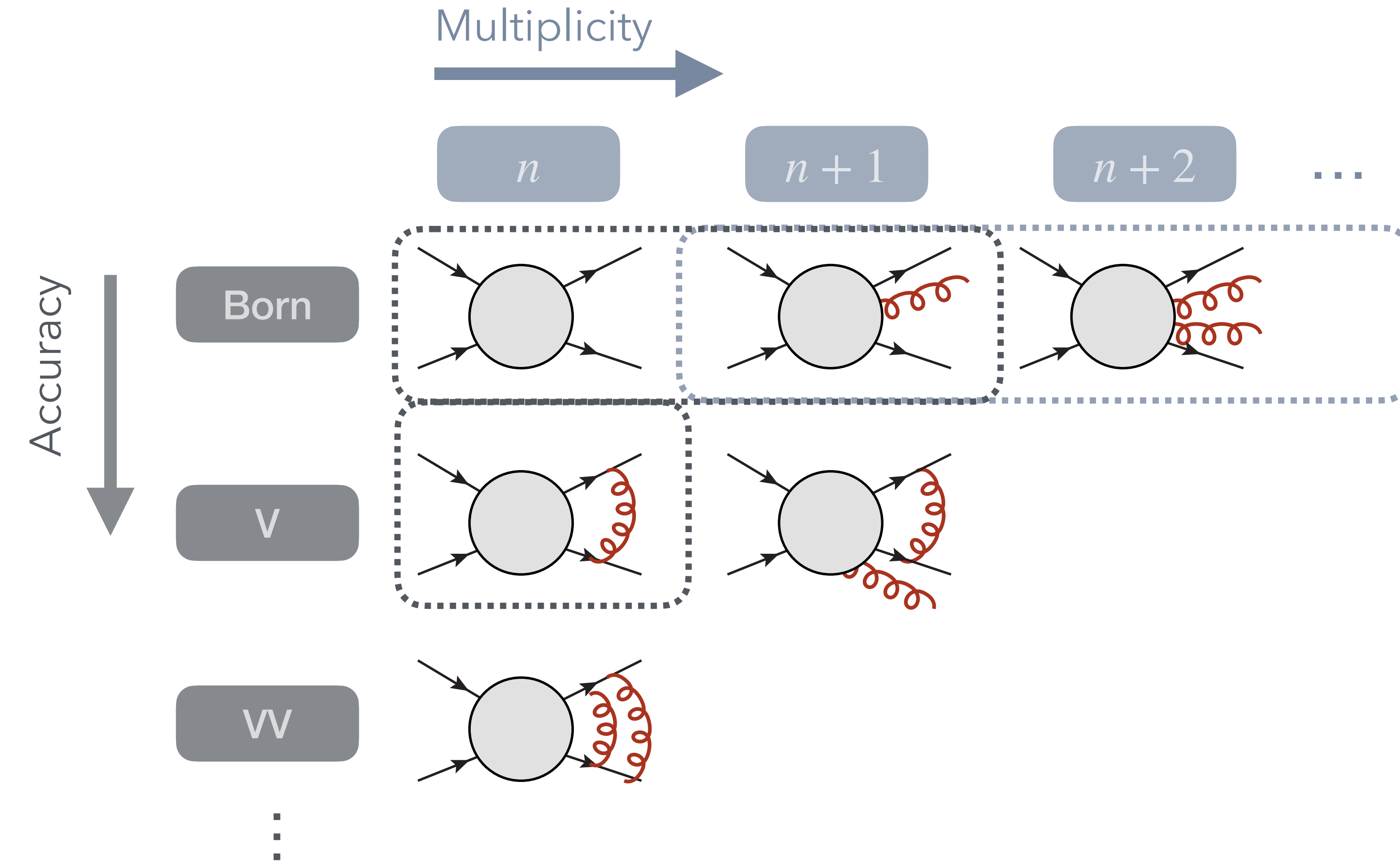
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# Matching higher order corrections to PS

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**Try to merge the two approaches, trying to keep the desirable features of both.**  
**Potential problems with double counting of real emission**

Consistent matching of NLO+PS  
 MC@NLO - Frixione, Webber (2001)  
 POWHEG - Nason(2004) ; Frixione, Nason, Oleari (2007)

Matching of NNLO+PS  
 UNNLOPS - Höhe, Pressten (2014, 2015)  
 GENEVA - Alioli, Bauer, Berggren, Hornig, Tackmann, Vermilion, Walsh, Zuberi (2013)  
 MiNNLOPS - Monni, Nason, Re, Wiesemann, Zanderighi (2020)

# Matching higher order corrections to PS

POsitive-Weight Hardest Emission Generator (POWHEG)

$$d\sigma_{\text{SMC}} = B(\Phi_n) d\Phi_n \left\{ \Delta_{t_0} + \frac{\alpha_S}{2\pi} P(z) \frac{1}{t} \Delta_t d\Phi_r \right\}$$
$$d\sigma_{\text{NLO}} = d\Phi_n \left\{ B(\Phi_n) + \left[ V(\Phi_n) + \int d\Phi_r C(\Phi_n, \Phi_r) \right] + \left[ R(\Phi_n, \Phi_r) - C(\Phi_n, \Phi_r) \right] d\Phi_r \right\}$$

POWHEG - Nason (2004);  
Frixione, Nason, Oleari (2007)

# Matching higher order corrections to PS

Positive-Weight Hardest Emission Generator (POWHEG)

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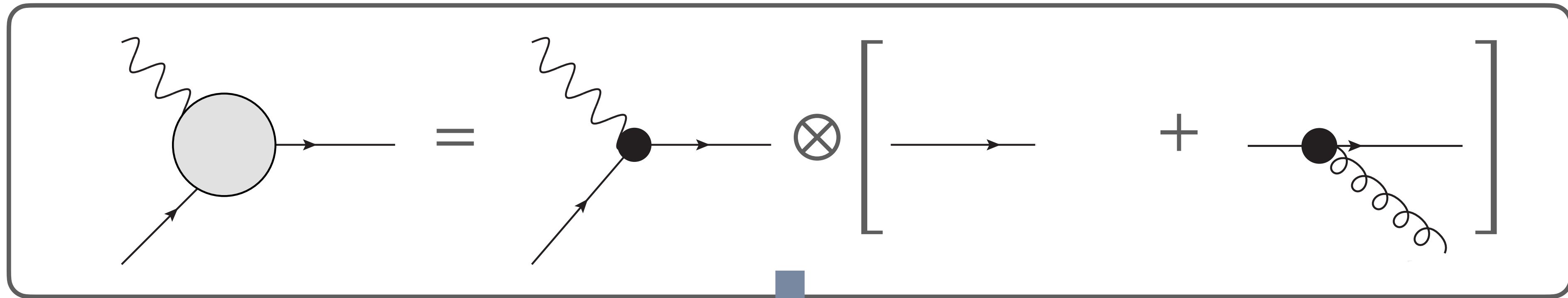


$$d\sigma_{\text{POWHEG}} = \bar{B}(\Phi_n) d\Phi_n \left\{ \Delta(\Phi_n, p_{Tmin}) + \frac{R(\Phi_n, \Phi_r)}{B(\Phi_n)} \Delta(\Phi_n, p_T) d\Phi_r \right\}$$

POWHEG - Nason (2004);  
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POWHEG  
SUDAKOV

$$\bar{B}(\Phi_n) = B(\Phi_n) + \left[ V(\Phi_n) + \int d\Phi_r C(\Phi_n, \Phi_r) \right] + \int d\Phi_r [R(\Phi_n, \Phi_r) - C(\Phi_n, \Phi_r)]$$

$$\Delta(\Phi_n, p_T) \sim \exp \left[ - \int d\Phi'_r \frac{R(\Phi_n, \Phi'_r)}{B(\Phi_n)} \theta(p'_T - p_T) \right]$$

POWHEG - Nason (2004);  
Frixione, Nason, Oleari (2007)

# Matching higher order corrections to PS

## POsitive-Weight Hardest Emission Generator (POWHEG)



Hardest emission generated according to the POWHEG Sudakov and  $\bar{B}(\Phi_n)$



Subsequent radiation generated using parton-shower programs +  $p_T$ -veto



NLO accuracy on integrated quantities



(At least) Leading log accurate



$$d\sigma_{\text{POWHEG}} = \bar{B}(\Phi_n) d\Phi_n \left\{ \Delta(\Phi_n, p_{Tmin}) + \frac{R(\Phi_n, \Phi_r)}{B(\Phi_n)} \Delta(\Phi_n, p_T) d\Phi_r \right\}$$

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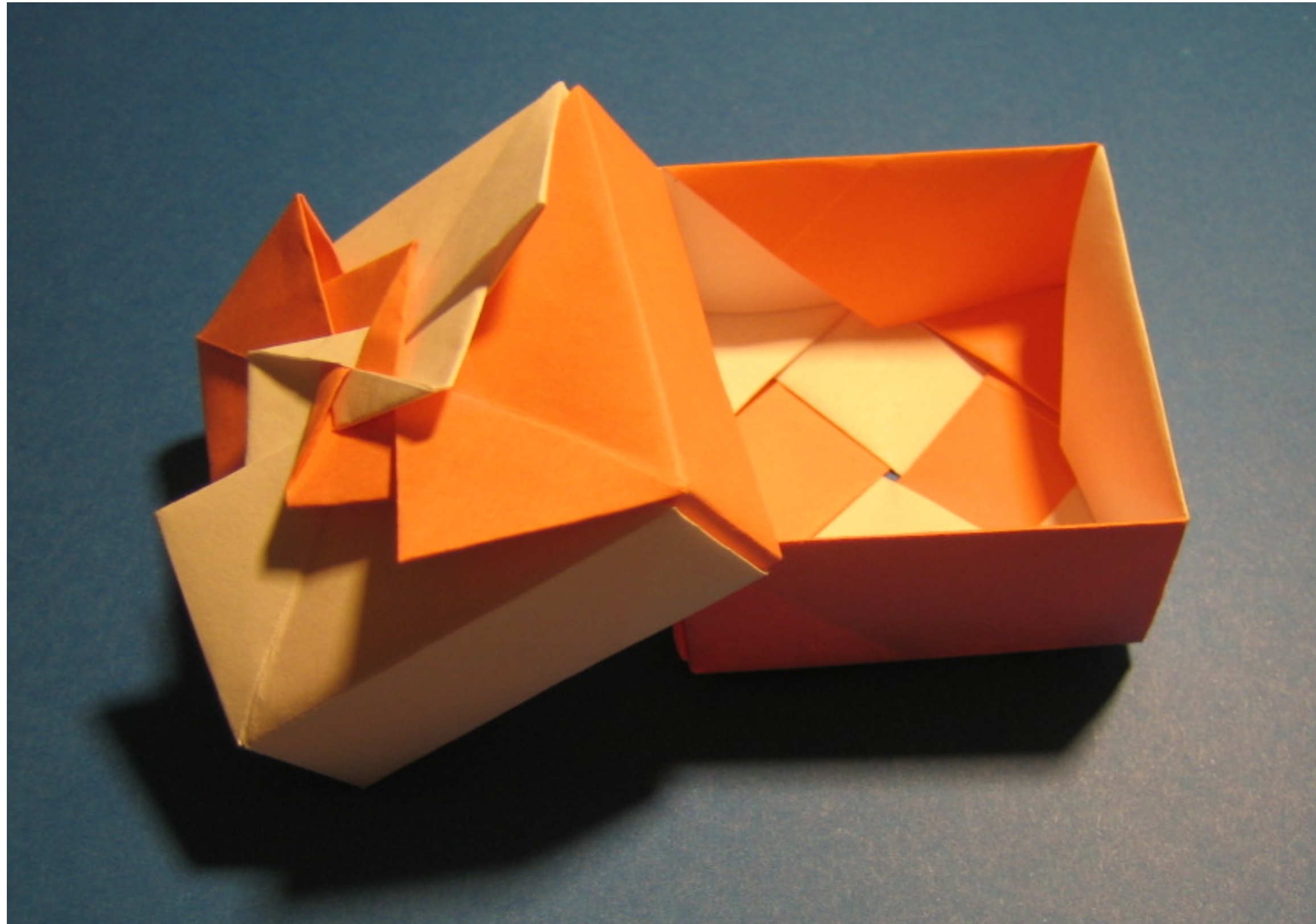
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# Matching higher order corrections to PS

## POWHEG-BOX



<https://powhegbox.mib.infn.it/>

POWHEG - Frixione, Nason, Oleari (2007)

POWHEG-BOX - Alioli, Nason, Oleari, Re (2010)

Public computer framework that implements the POWHEG formalism for generic NLO processes.

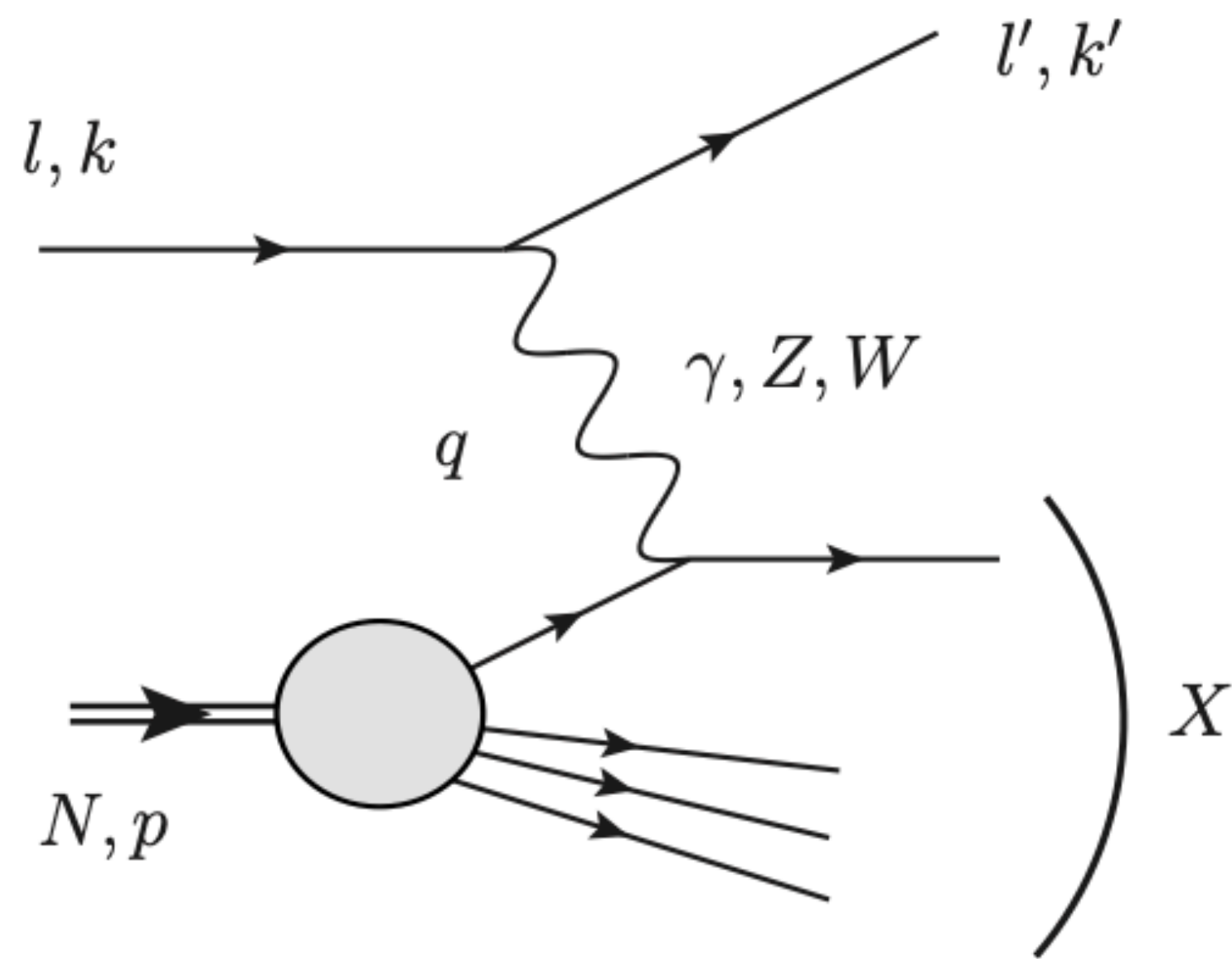
- ▶ Only necessary to provide a few standard elements:
  - List of Born and Real partonic processes
  - Born phase space
  - Born squared amplitudes, spin- and color-correlated amplitudes
  - Real squared amplitude
  - Finite part of virtual corrections
- ▶ The code handles the NLO calculation (FKS subtraction scheme [Frixione, Kunszt, Signer(1996)]), and the generation of the hardest radiation.
- ▶ Events written into the Les Houches interface, to be treated by the LO PS.

# Matching higher order corrections to PS

## DIS in the POWHEG-BOX

DIS kinematics

$$l(k) + N(P) \rightarrow l'(k') + X$$



Kinematical invariants

$$Q^2 = -q^2 \quad x = \frac{Q^2}{2P \cdot q} \quad y = \frac{q \cdot P}{k \cdot p}$$

- Default POWHEG-BOX tailored for observables in hadronic collisions
- Real radiation mappings fix partonic centre-of-mass energy  $\Rightarrow$  Leptonic kinematic would not be preserved
- Modified mappings for radiation phase-space  $d\Phi_{n+1}^\alpha = d\bar{\Phi}_n d\Phi_{\text{rad}}^\alpha$ , so that lepton momenta depend exclusively DIS variables  $x_B, Q^2, y$

NLO + PS implementation of DIS in POWHEG-BOX

[Banfi, Ferraro Ravasio, Jäger, Karlberg, Reichenbach, Zanderighi (2024);

Buonocore, Limatola, Nason, Tramontano (2024)]

# Matching higher order corrections to PS

## POLARIZED processes in the POWHEG-BOX

IB, Jäger *JHEP* 07 (2024) 177 [See also Masouminia, Papaefstathiou, Richardson (2026)]

$$d\Delta\sigma_{\text{POWHEG}} = \Delta\bar{B}(\Phi_n) d\Phi_n \left\{ \Delta^{\text{pol}}(\Phi_n, p_{Tmin}) + \frac{\Delta R(\Phi_n, \Phi_r)}{\Delta B(\Phi_n)} \Delta^{\text{pol}}(\Phi_n, p_T) d\Phi_r \right\}$$

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$$\Delta^{\text{pol}}(\Phi_n, p_T) \sim \exp \left[ - \int d\Phi'_r \frac{\Delta R(\Phi_n, \Phi'_r)}{\Delta B(\Phi_n)} \right]$$

### Modifications to handle processes with polarized initial-state hadrons



Polarized Matrix elements & PDFs



NLO Subtraction scheme → implementation of polarized FKS subtraction  
de Florian, Frixione, Signer, Vogelsang (1999)

$$P_{ab}^<(z, \epsilon) \rightarrow \Delta P_{ab}^<(z, \epsilon) \text{ for ISR}$$

$$dM \rightarrow \Delta M$$

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### Modifications to handle processes with polarized initial-state hadrons



Polarized Matrix elements & PDFs



NLO Subtraction scheme → implementation of polarized FKS subtraction



Handle negative-valued Born cross sections. Positive-weight events not guaranteed. Positive- and negative-weight events generated according to

$$n_+ = \frac{\sigma(+)}{\sigma(+) + |\sigma(-)|} \quad n_- = \frac{\sigma(-)}{\sigma(+) + |\sigma(-)|}, \text{ with } w_+ = (\sigma(+) + |\sigma(-)|), \quad w_- = -(\sigma(+) + |\sigma(-)|)$$

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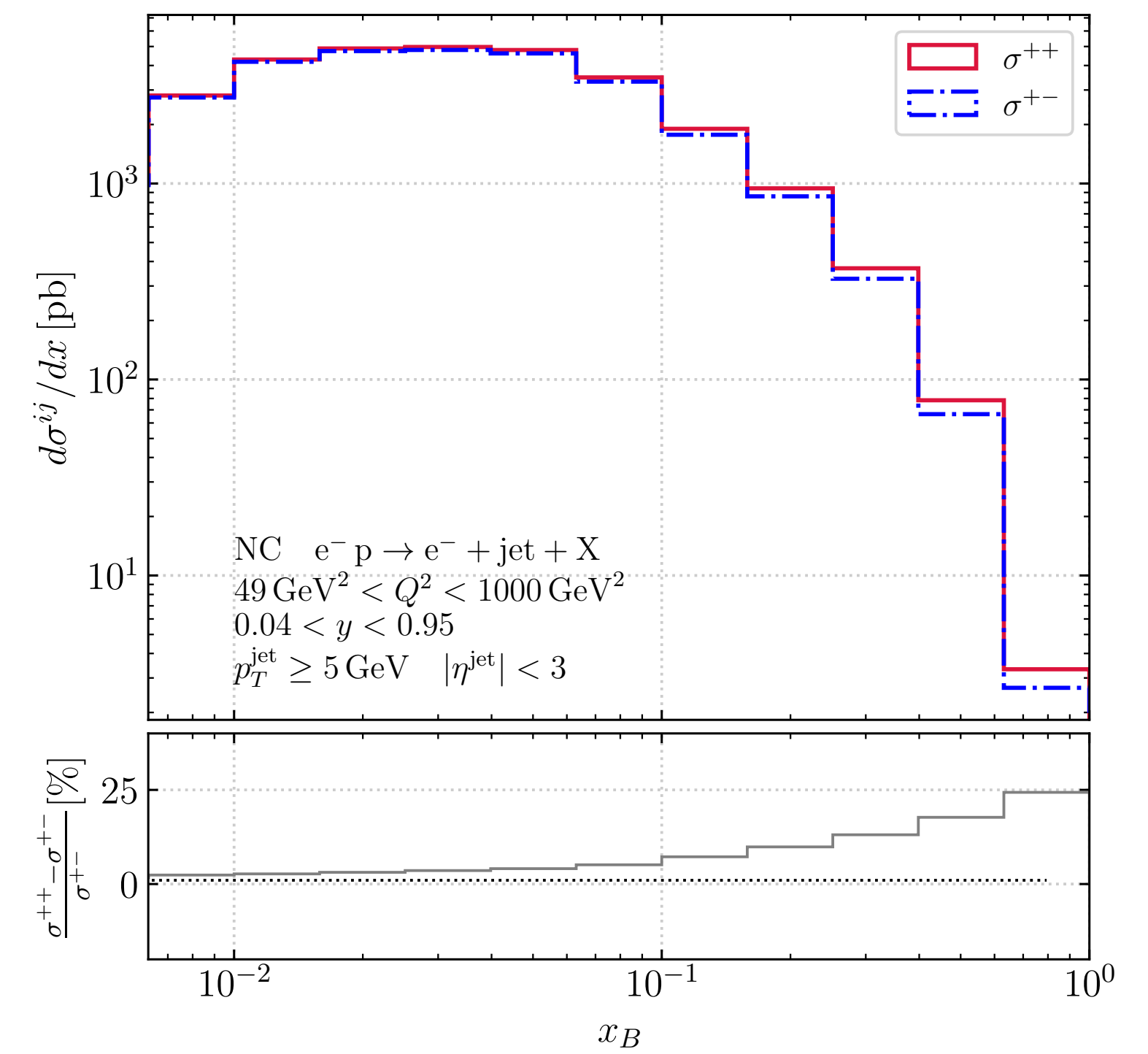
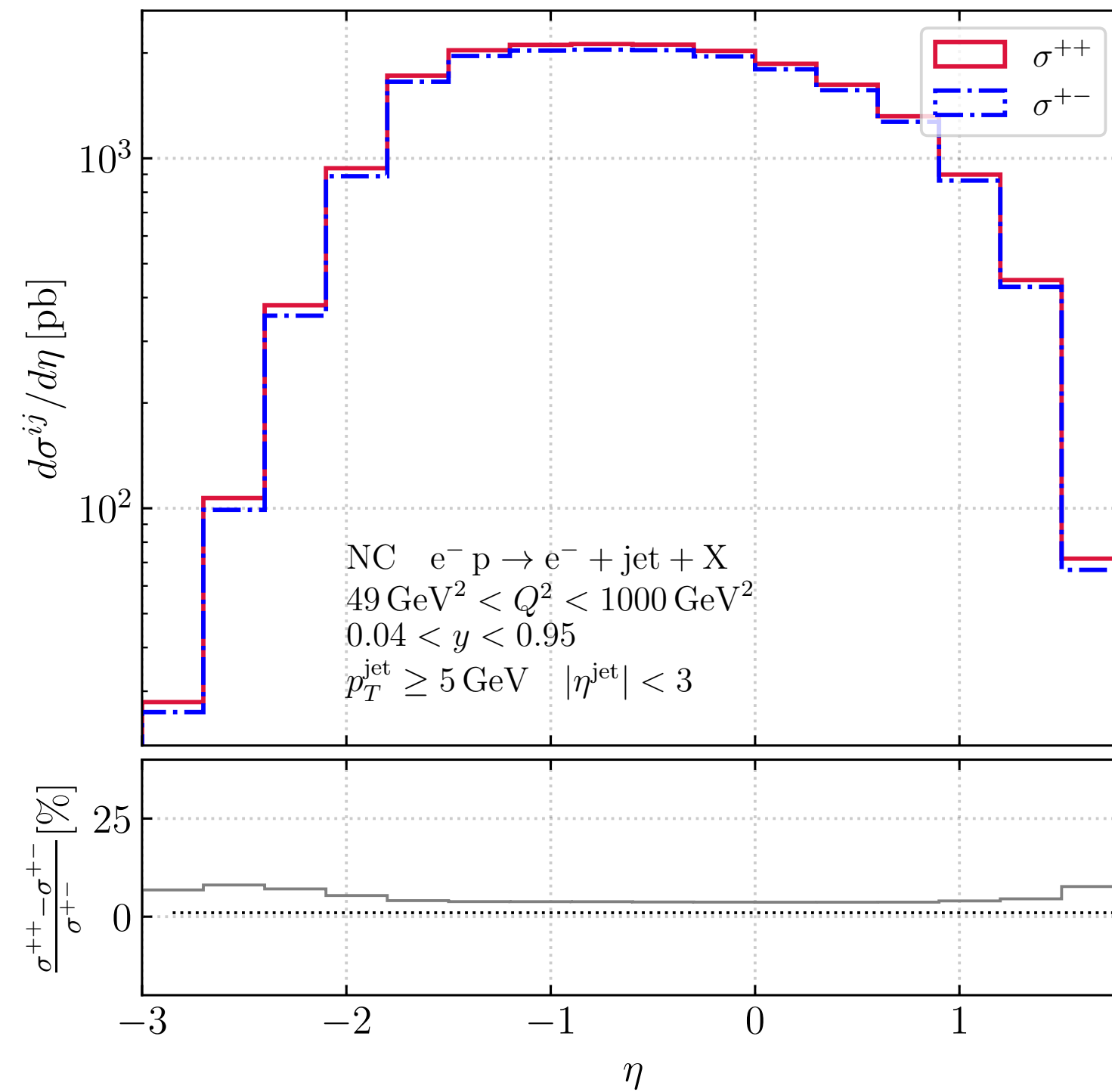
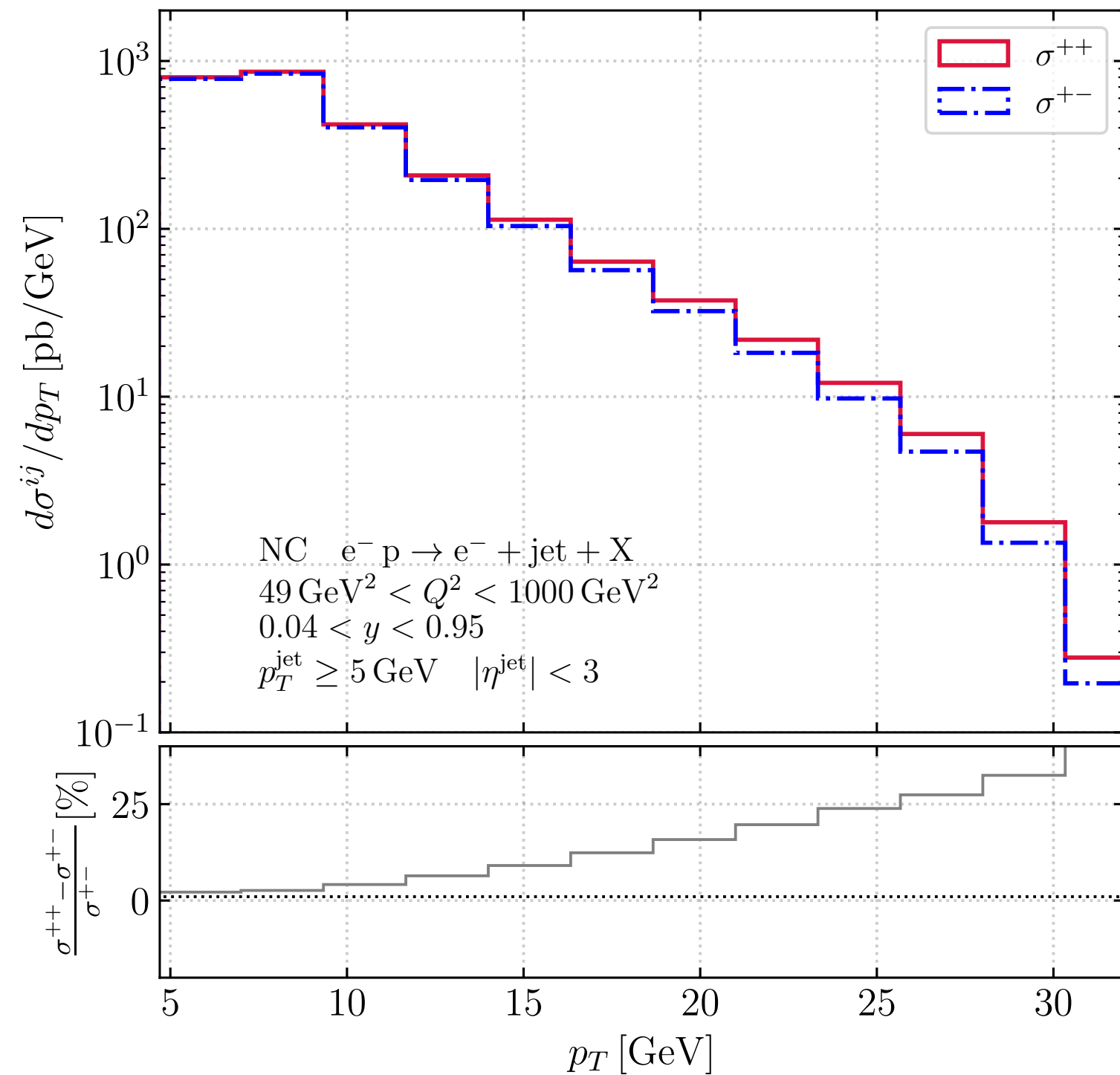
Unpolarized Parton shower, but dominant logarithmic contributions correctly reproduced:

- Since  $\Delta P_{qq} = P_{qq'}$ , emission of gluons from an initial-state quark line described correctly.
- Since  $\Delta P_{ij}(z \rightarrow 1) = P_{ij}(z \rightarrow 1)$ , Initial-state soft-collinear behavior correctly captured.
- No polarization effects for final state-radiation.

# Matching higher order corrections to PS

## POLARIZED processes in the POWHEG-BOX

$$d\Delta\sigma_{\text{POWHEG}} = \Delta\bar{B}(\Phi_n) d\Phi_n \left\{ \Delta^{\text{pol}}(\Phi_n, p_{T\min}) + \frac{\Delta R(\Phi_n, \Phi_r)}{\Delta B(\Phi_n)} \Delta^{\text{pol}}(\Phi_n, p_T) d\Phi_r \right\}$$



# Jet production in polarized DIS

Phenomenological studies for the EIC

IB, Jäger *JHEP* 07 (2024) 177

# Phenomenology

## Single jet production in the EIC (NC & CC)



$$e^- + p \rightarrow \ell + \text{jet} + X$$



$$E_e = 18 \text{ GeV} \quad \text{and} \quad E_p = 275 \text{ GeV}$$



$$(\sqrt{s} = 140 \text{ GeV})$$



$$49 \text{ GeV}^2 \leq Q^2 \leq 1000 \text{ GeV}^2 \quad \text{and} \quad 0.04 \leq y \leq 0.95$$



$$5 \text{ GeV} \leq p_T^{\text{jet}} \quad \text{and} \quad |\eta^{\text{jet}}| < 3$$



anti- $k_T$  algorithm with  $R = 0.8$  and E-recombination



Polarized PDFs: DSSV14 [[de Florian, Sassot, Stratmann, Vogelsang \(2014\)](#)]



PS: Antenna shower from VINCIA, as implemented in PYTHIA8

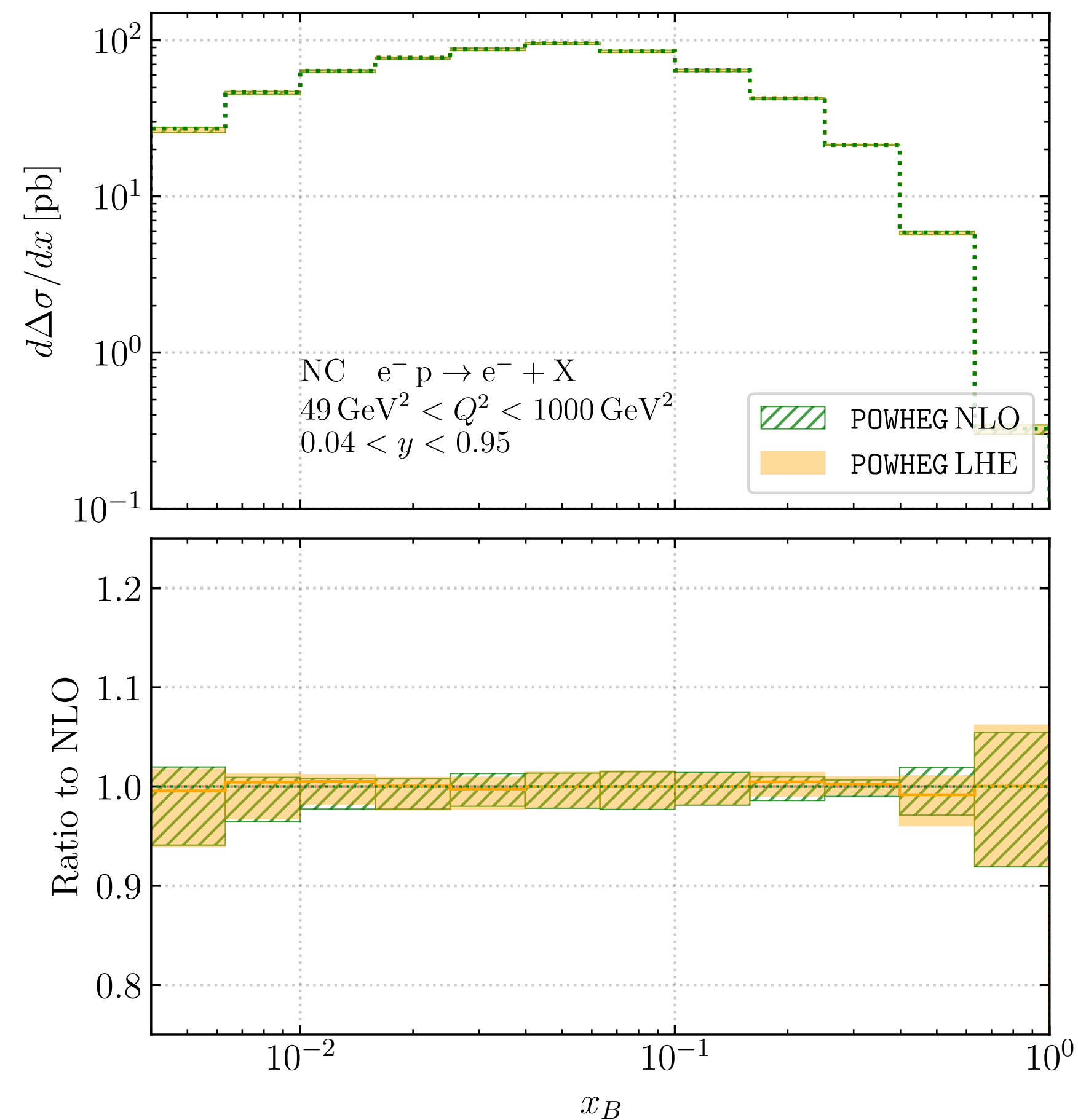
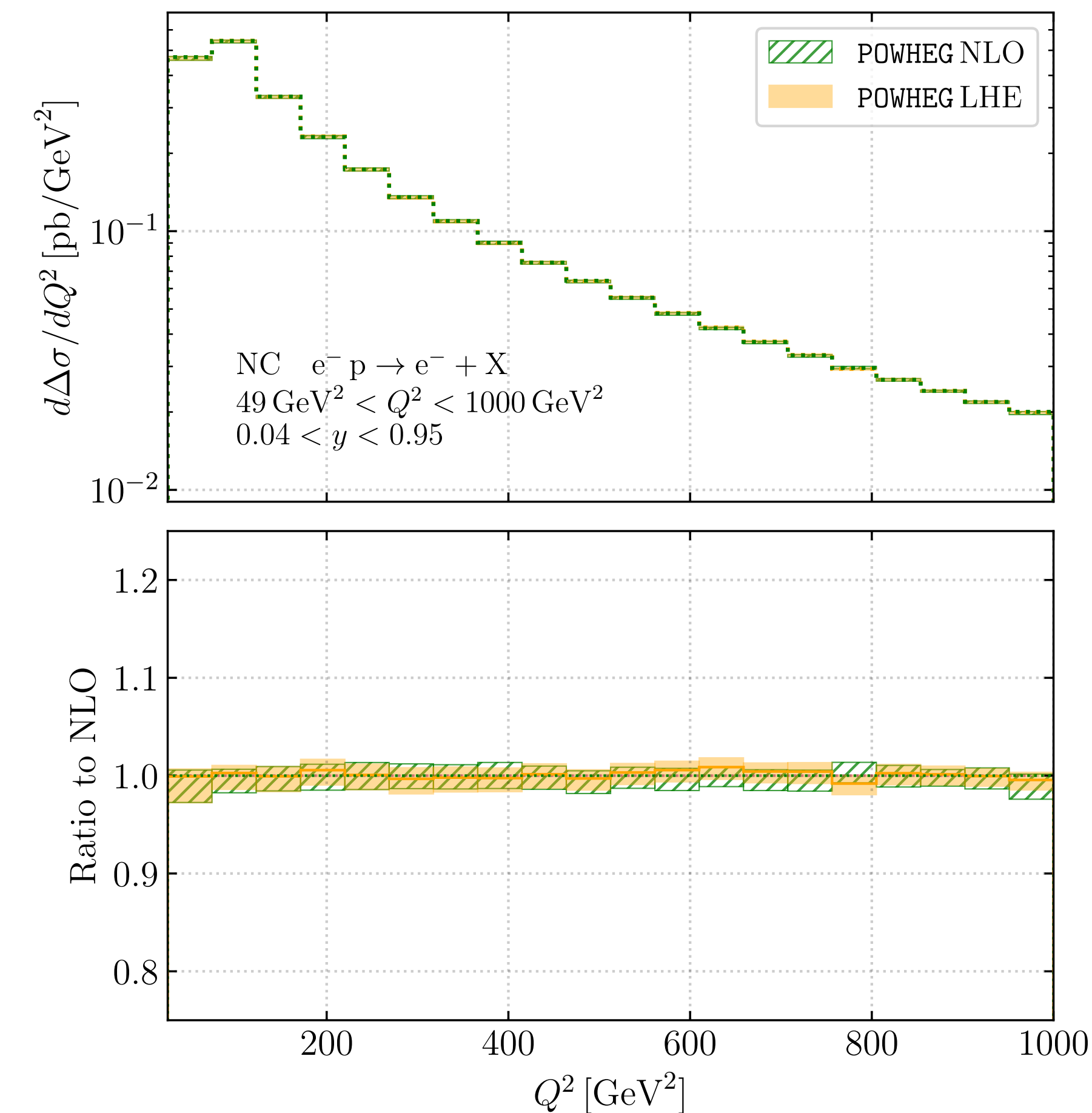


Theoretical uncertainty from 7-point scale variation

# Validation

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



Some checks:

Cross section differential in  
 $Q^2, x_B$   
(No cuts on the outgoing  
partons)

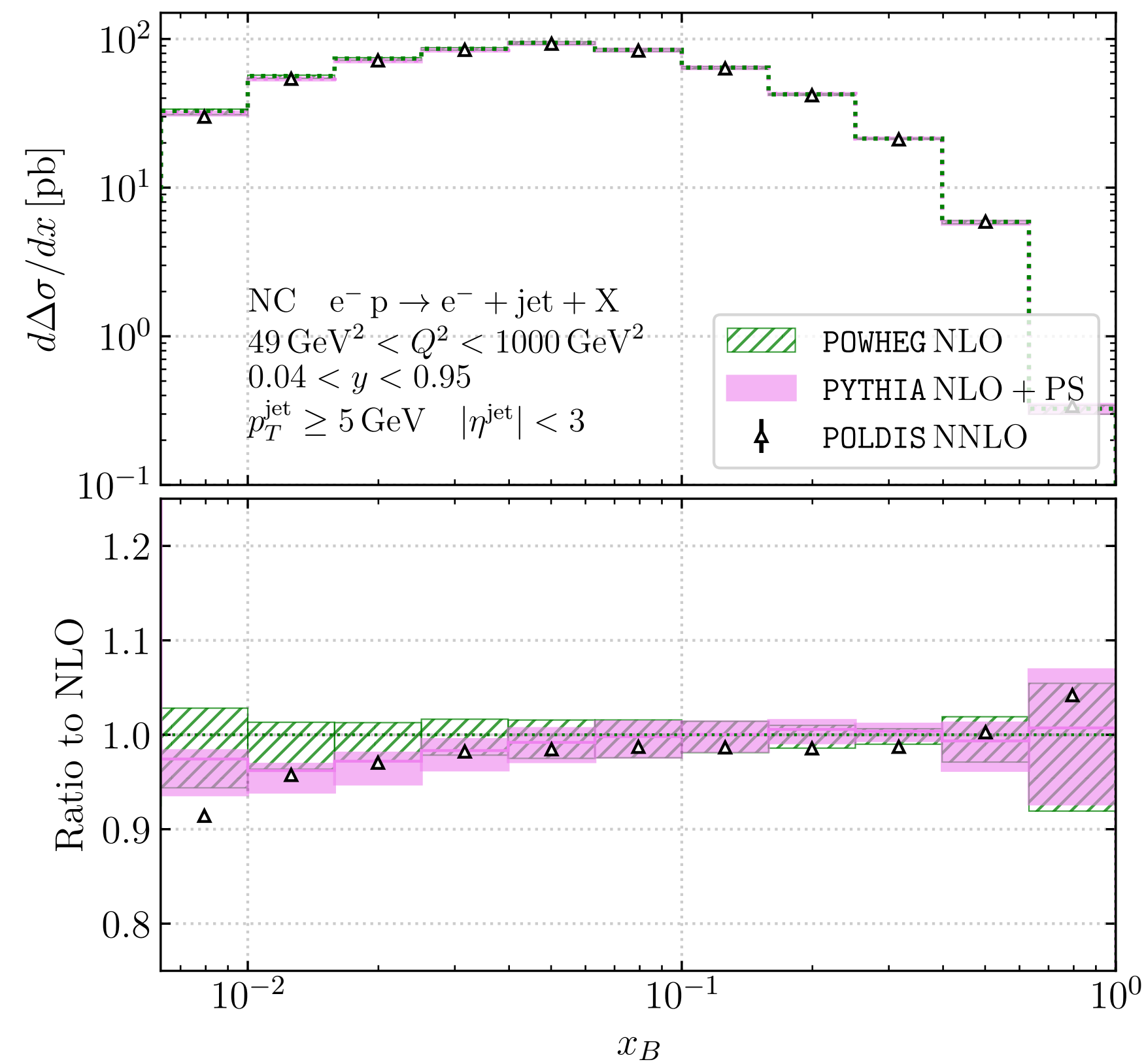
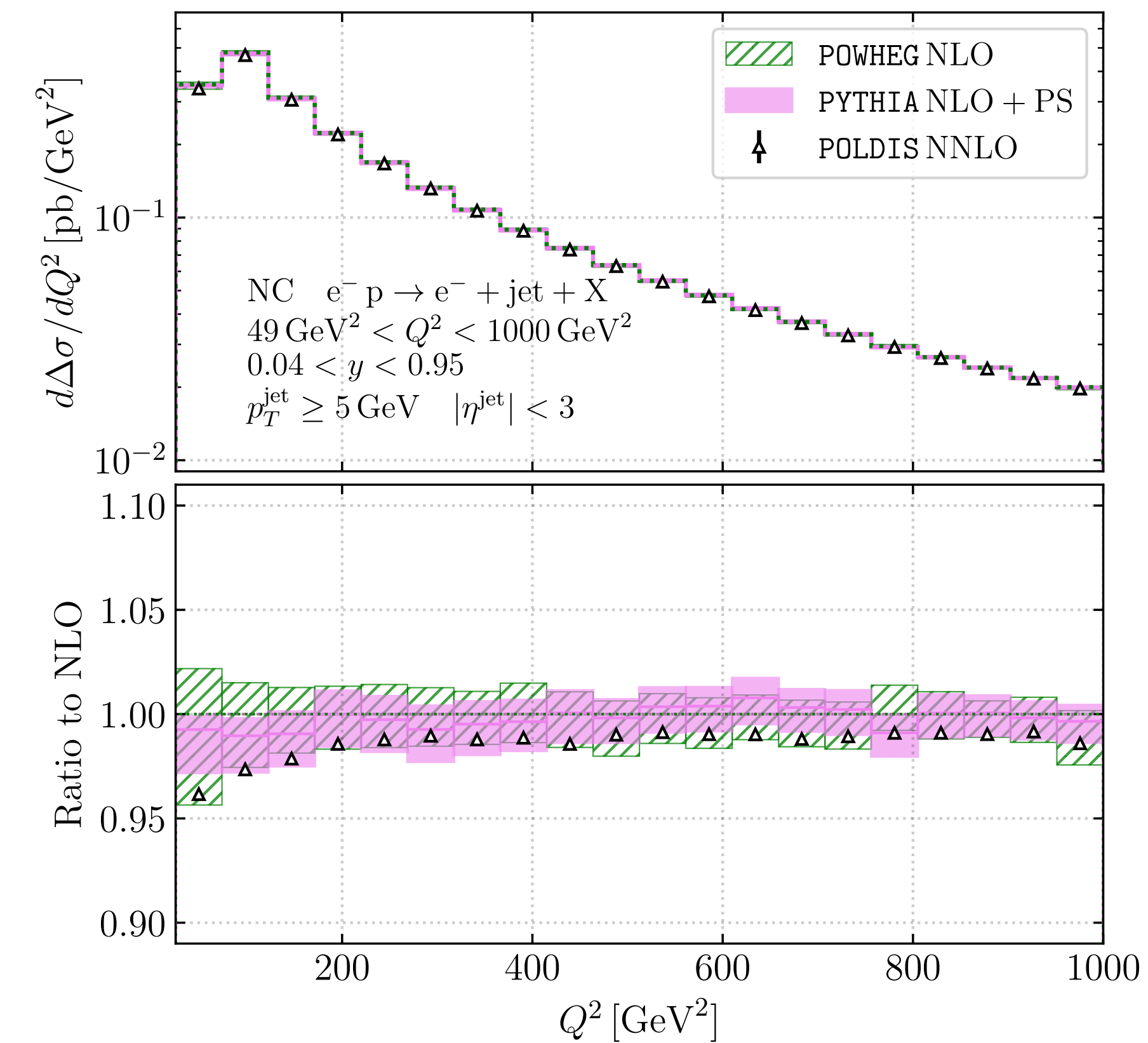


NLO accuracy for  
observables inclusive in the  
additional radiation

# Phenomenology

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



Some checks:

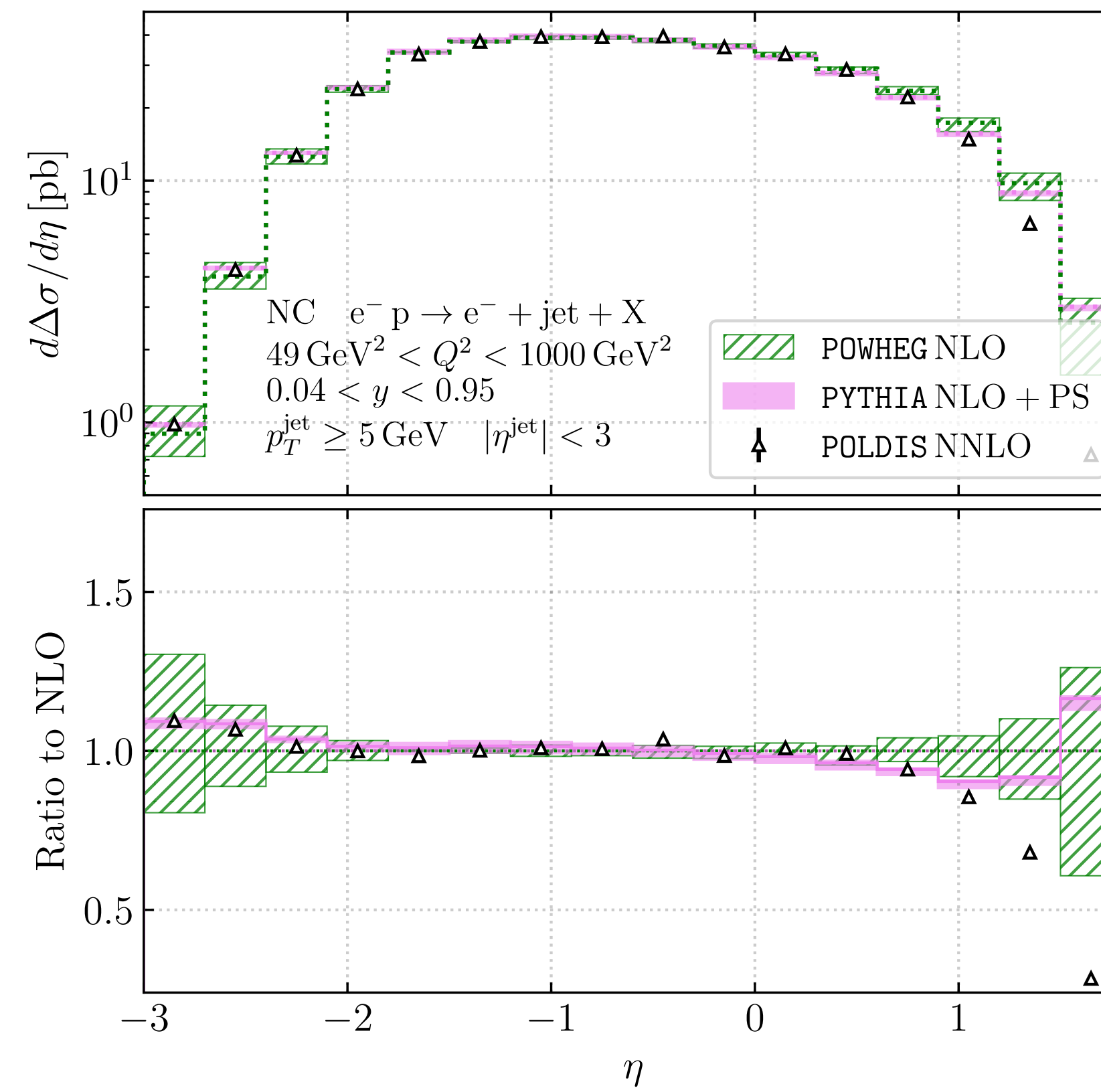
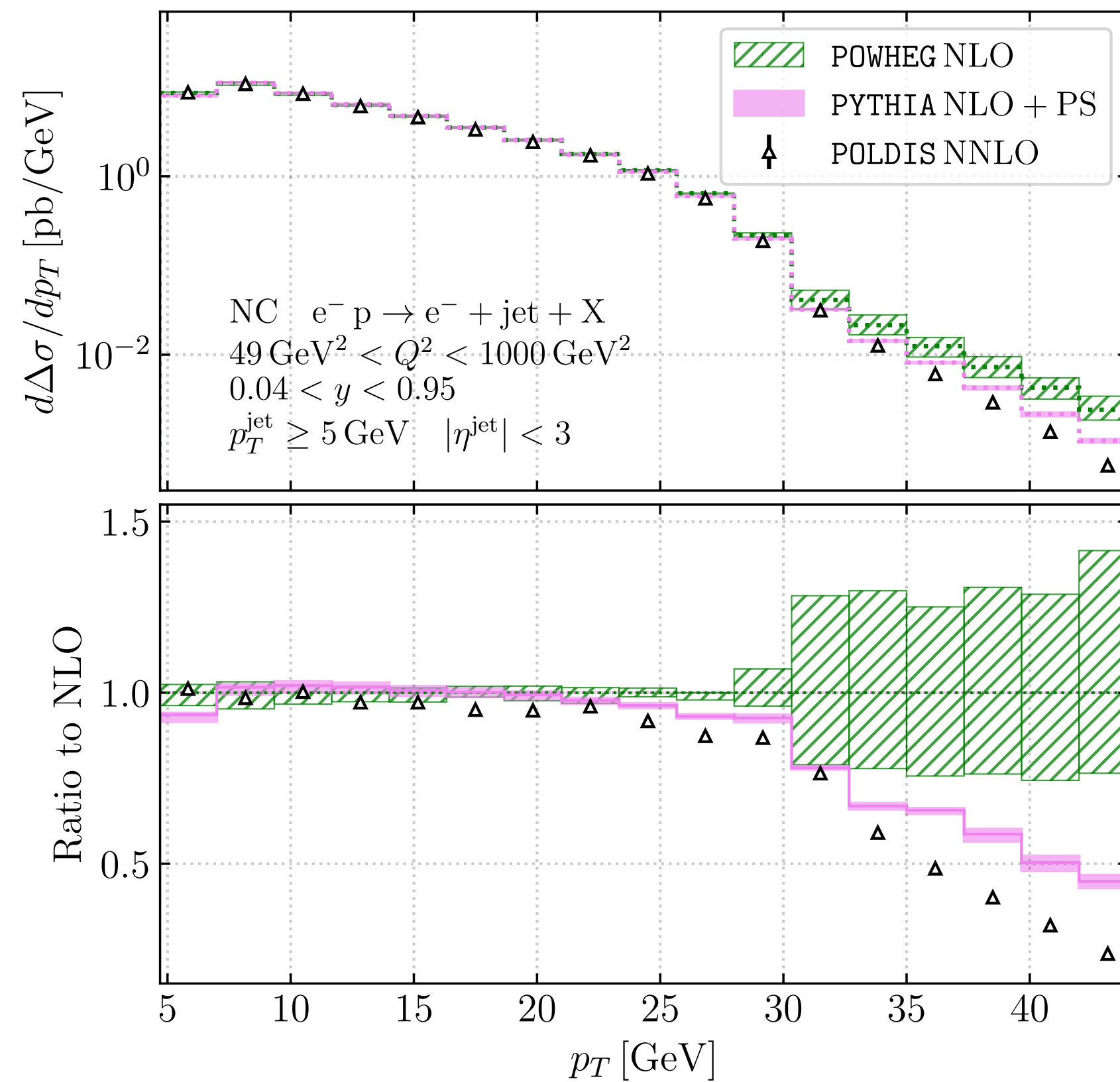


Improvement in the agreement with NNLO results (small corrections from the PS to more inclusive observables)

# Phenomenology

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



Some checks:

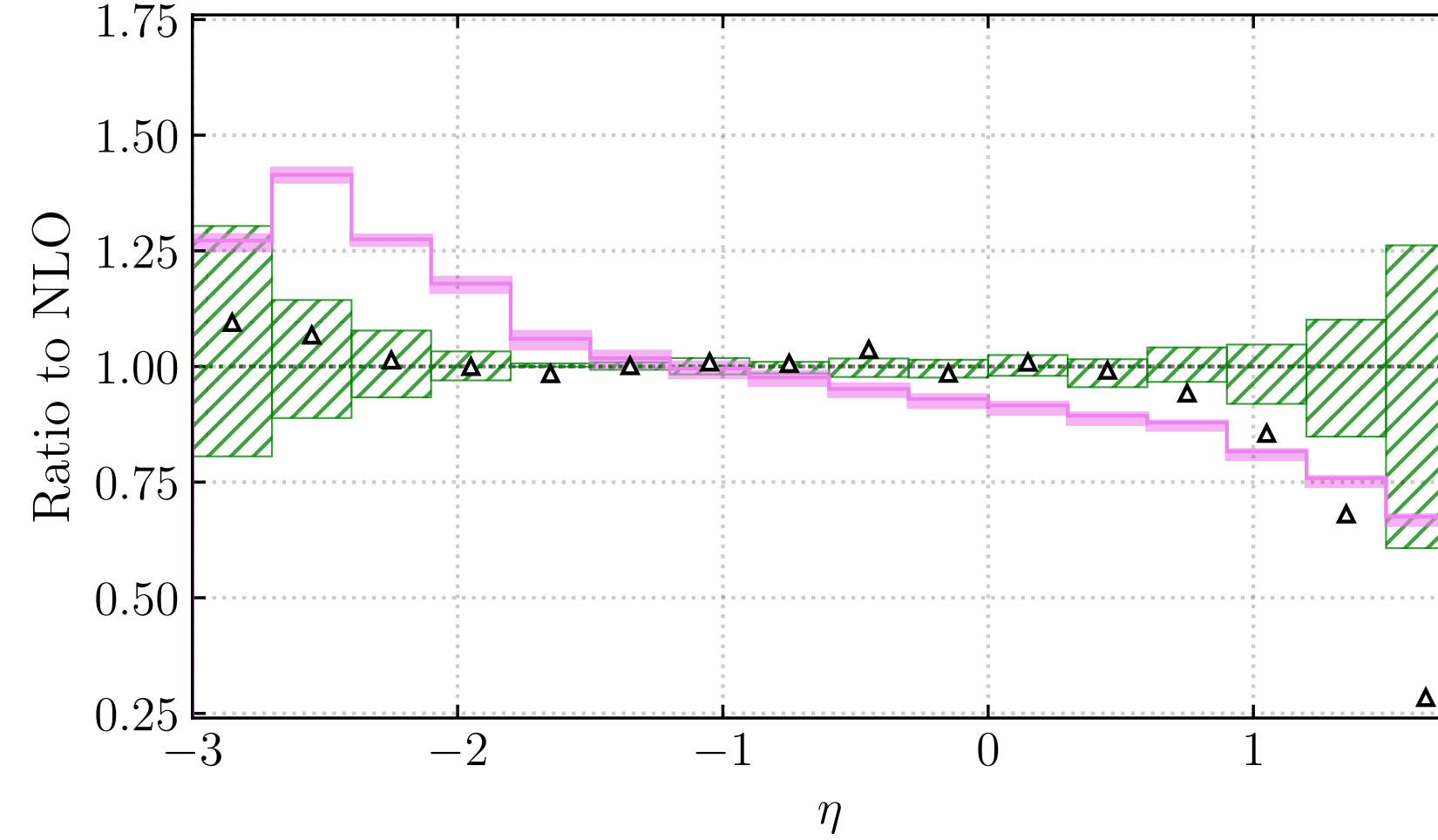
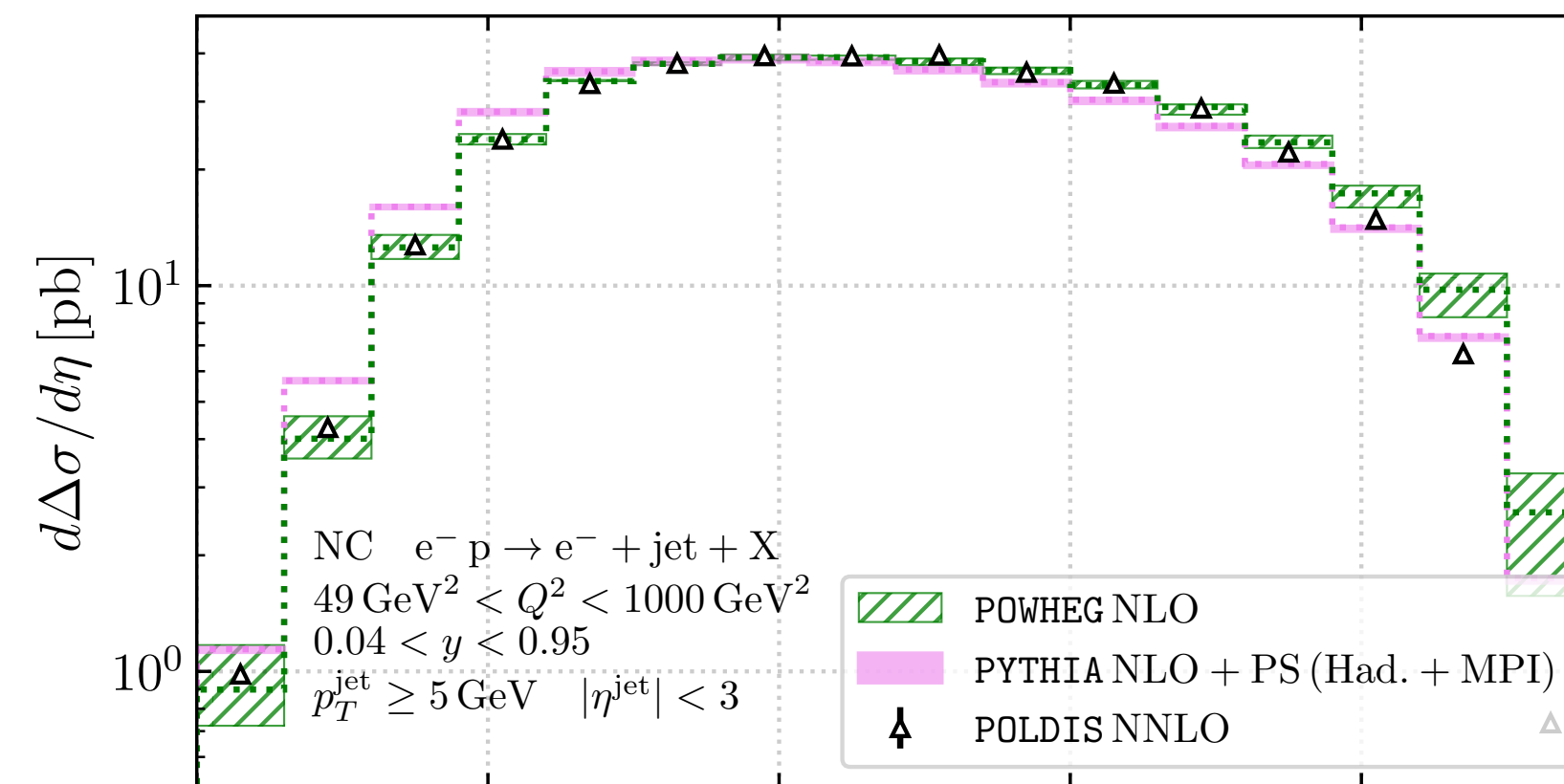
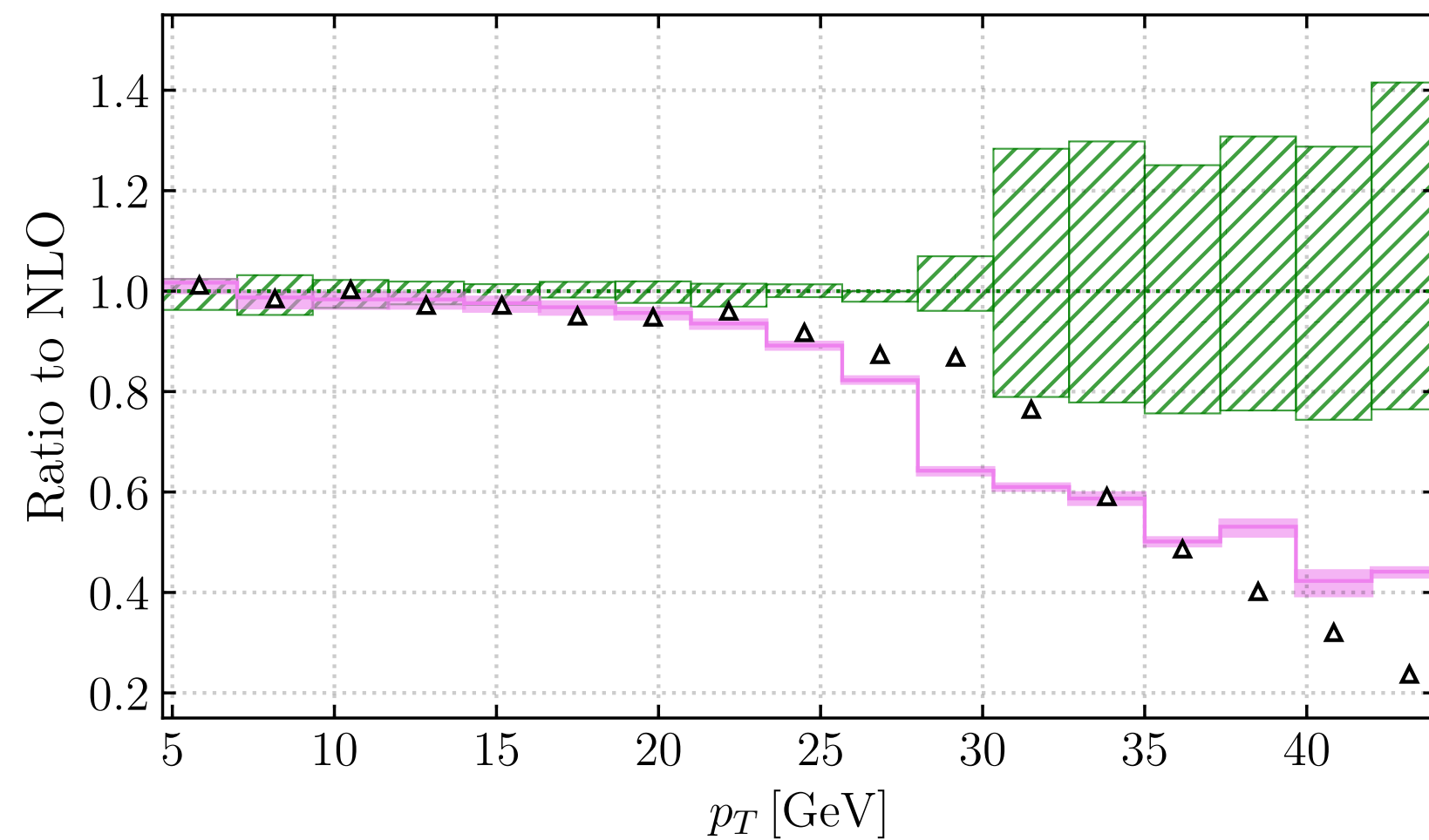
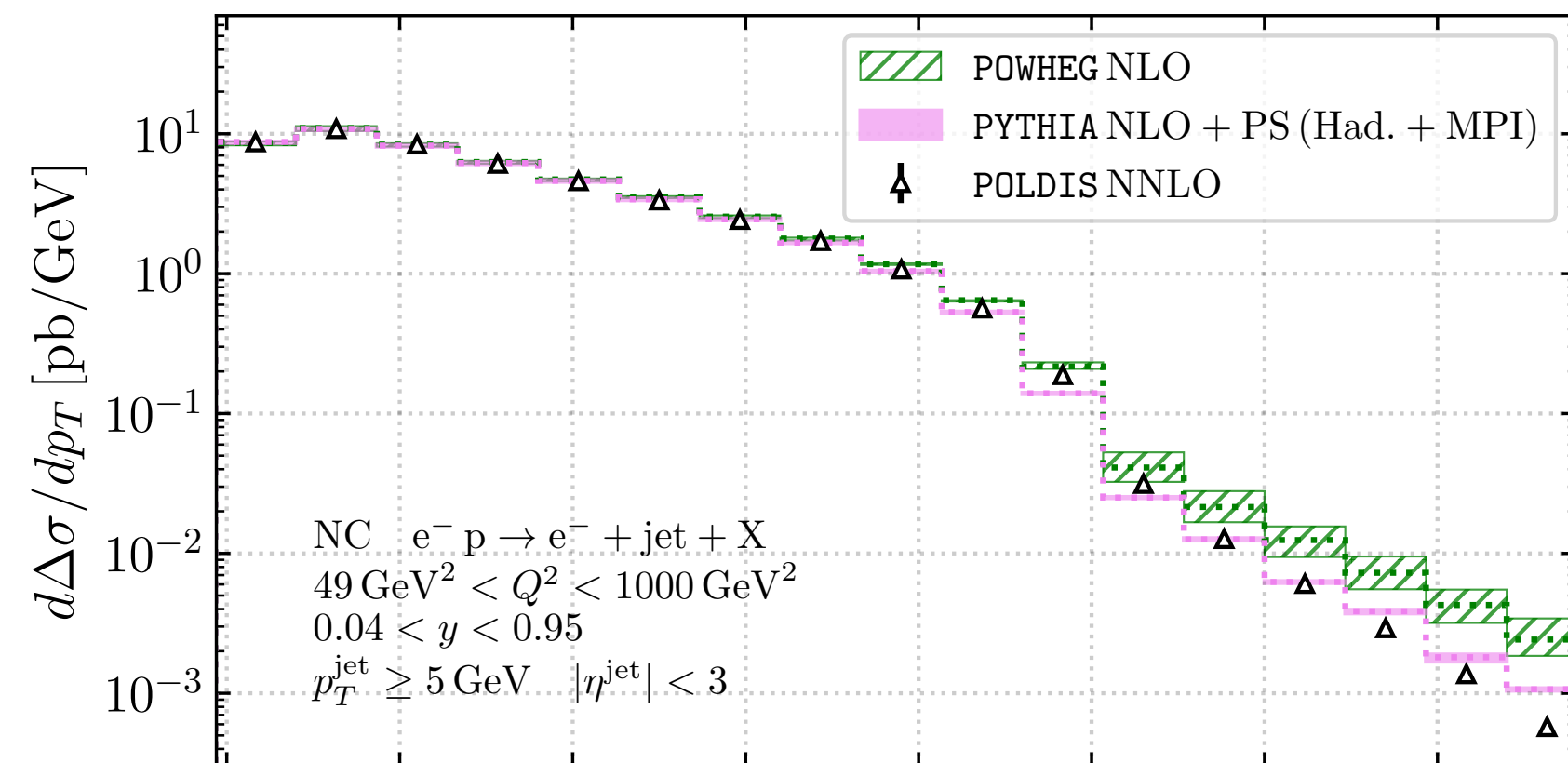


Improvement in the agreement with NNLO results (sizable corrections in the kinematically-suppressed regions)

# Phenomenology

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177

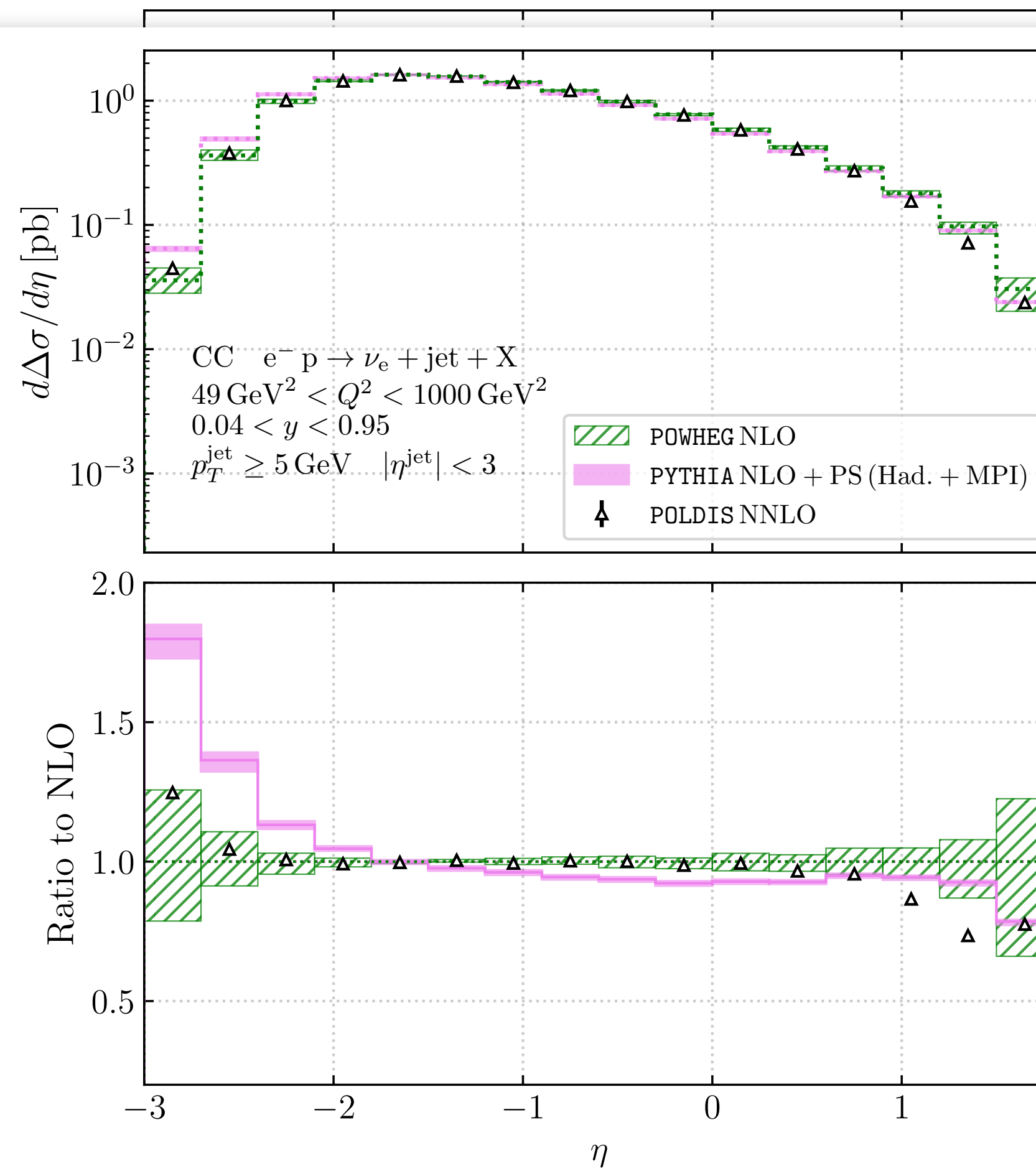
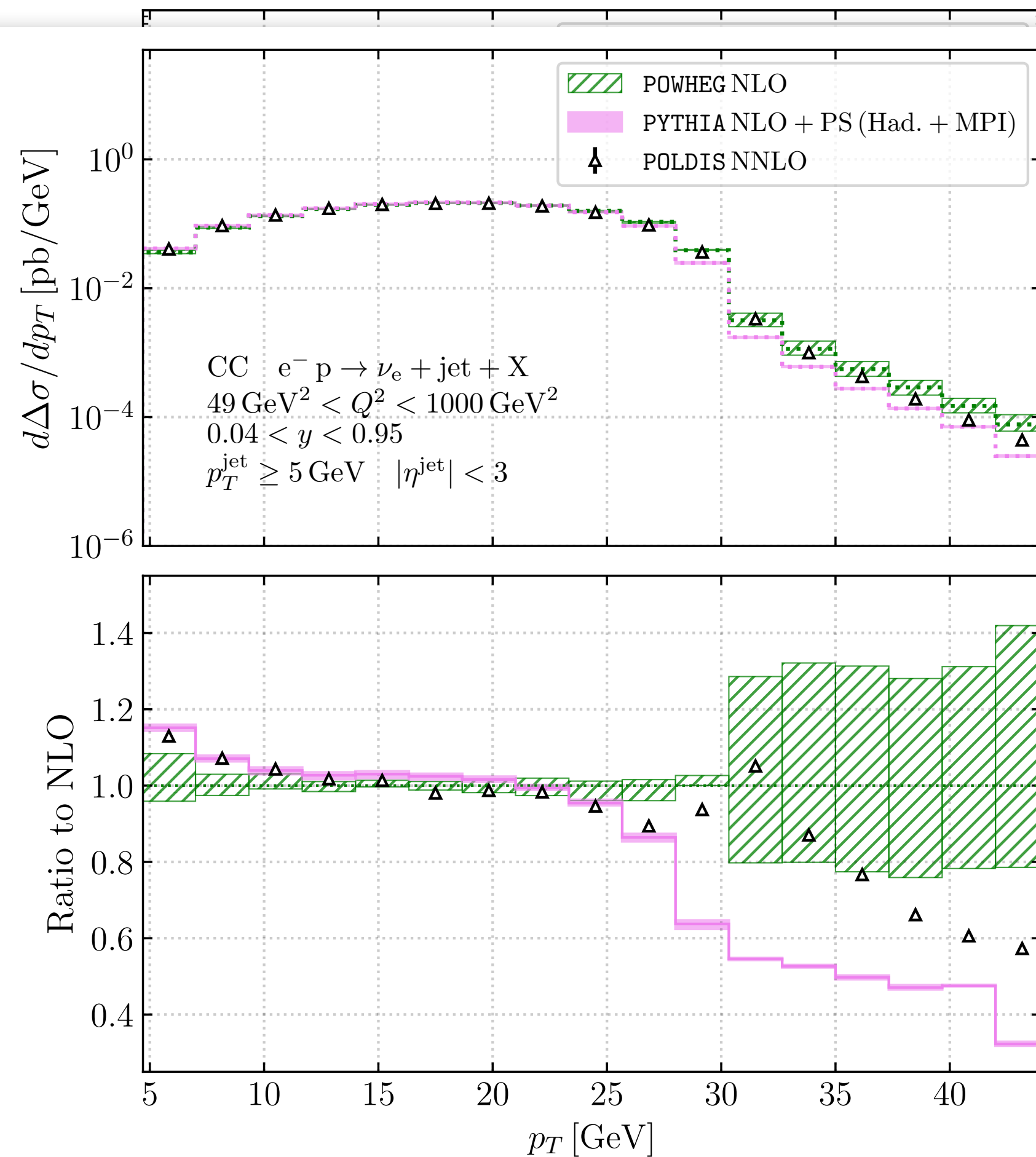


- Sizable PS effects in kinematically-suppressed regions
- Hadronization effects further suppress the high- $p_T$  region, while low- $\eta$  is enhanced

# Phenomenology

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



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# Di-jet production polarized proton-proton collisions

Phenomenological studies for RHIC

Betz, IB, Jäger Eur.Phys.J.C 86 (2026)

# Di-jet production in polarized pp

## Status of theoretical predictions

### Inclusive jet

- ▶ Single-inclusive jet production at NLO ("small cone" approximation) [Jäger, Stratmann, Vogelsang (2004)]
- ▶ Single-inclusive jet at NLO+NLL (threshold resummation) [de Florian, Wagner (2010)]
- ▶ Single-inclusive production + dependence on the jet algorithm [Mukherjee, Vogelsang (2012)]

### Di-jet production

- ▶ Di-jet production at NLO (polarized extension of FKS subtraction) [de Florian, Frixione, Signer, Vogelsang (1999)]

### Extension to NNLO limited to the unpolarized case

- ▶ Single-jet and di-jet production at NNLO [J. Currie, A. Gehrmann-De Ridder, T. Gehrmann, E. W. N. Glover, A. Huss and J. Pires (2017)]  
[X. Chen, T. Gehrmann, E. W. N. Glover and J. Mo (2022)]

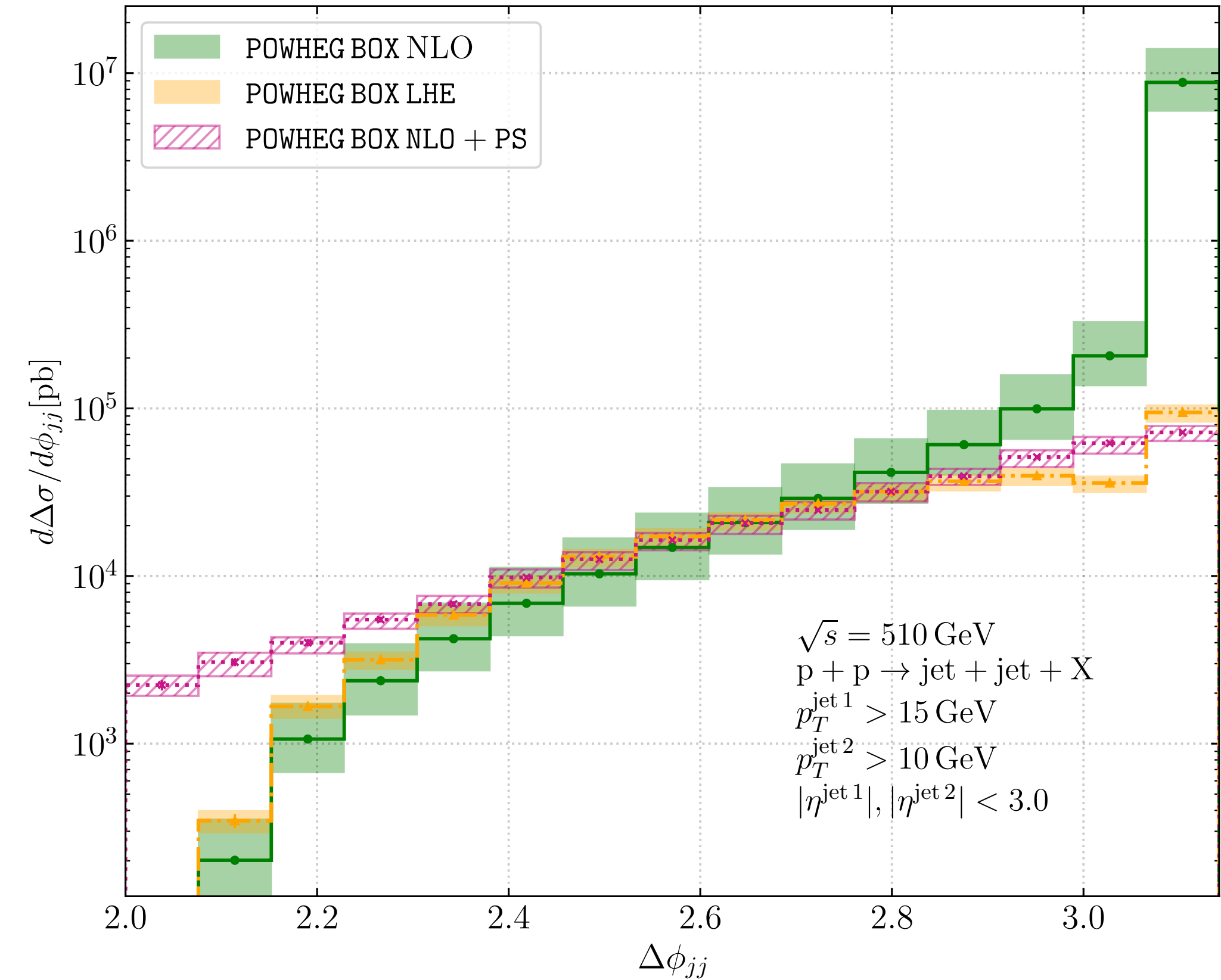
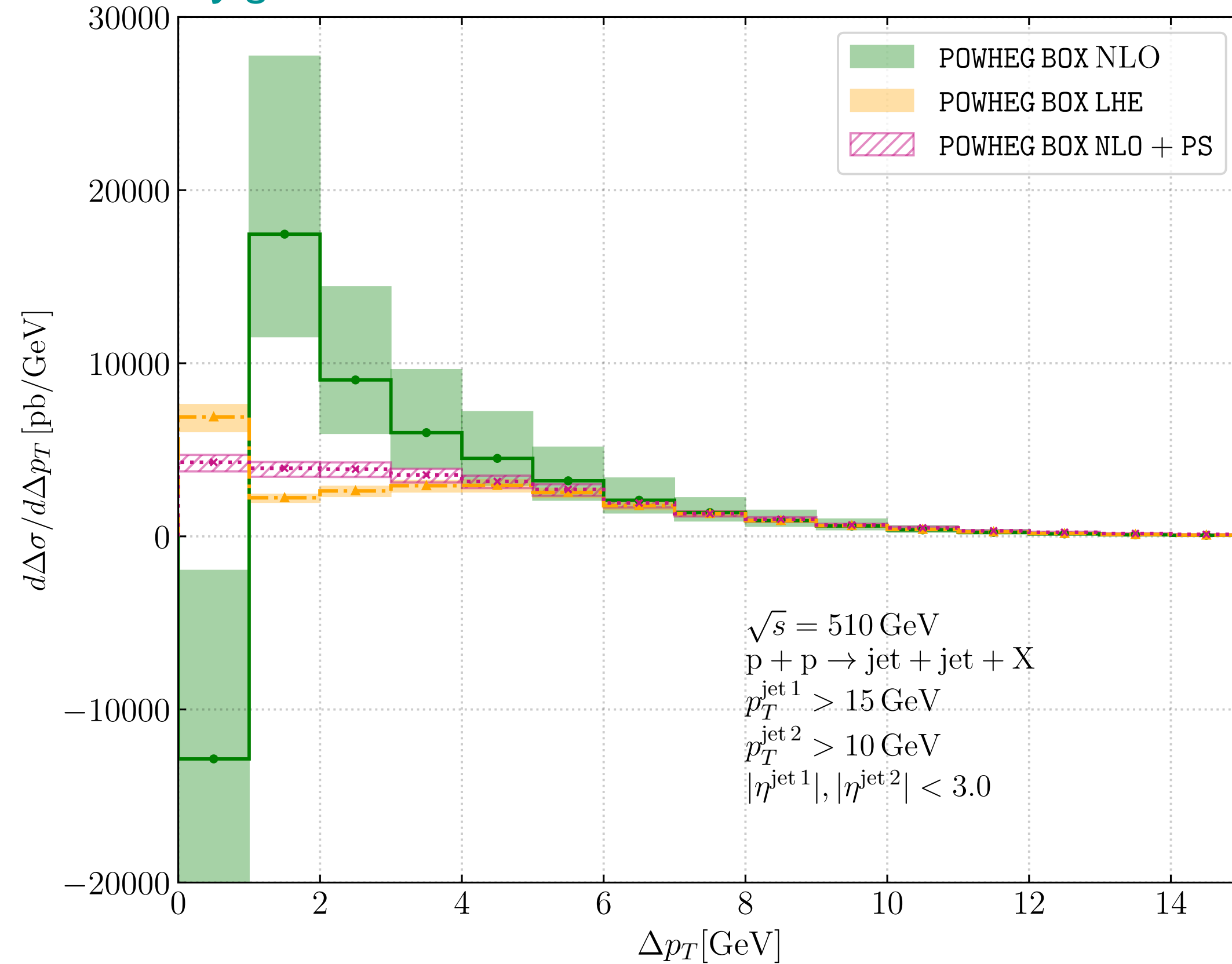
### NLO+PS available only for unpolarized case

- ▶ Di-jet production in POWHEG [Alioli, Hamilton, Nason, Oleari, Re (2010)]
- ▶ MadGraph5\_aMC@NLO [Alwall, Frederic, Frixione, Hirschi, Maltoni, Mattelaer, Shao, Stelzer, Torrielli, Zaro (2014)]

# Phenomenology

## Di-jet production in RHIC kinematics

Betz, IB, Jäger 2602.05949



Sizable differences between NLO and NLO+PS in regions where large logs are expected

# Phenomenology

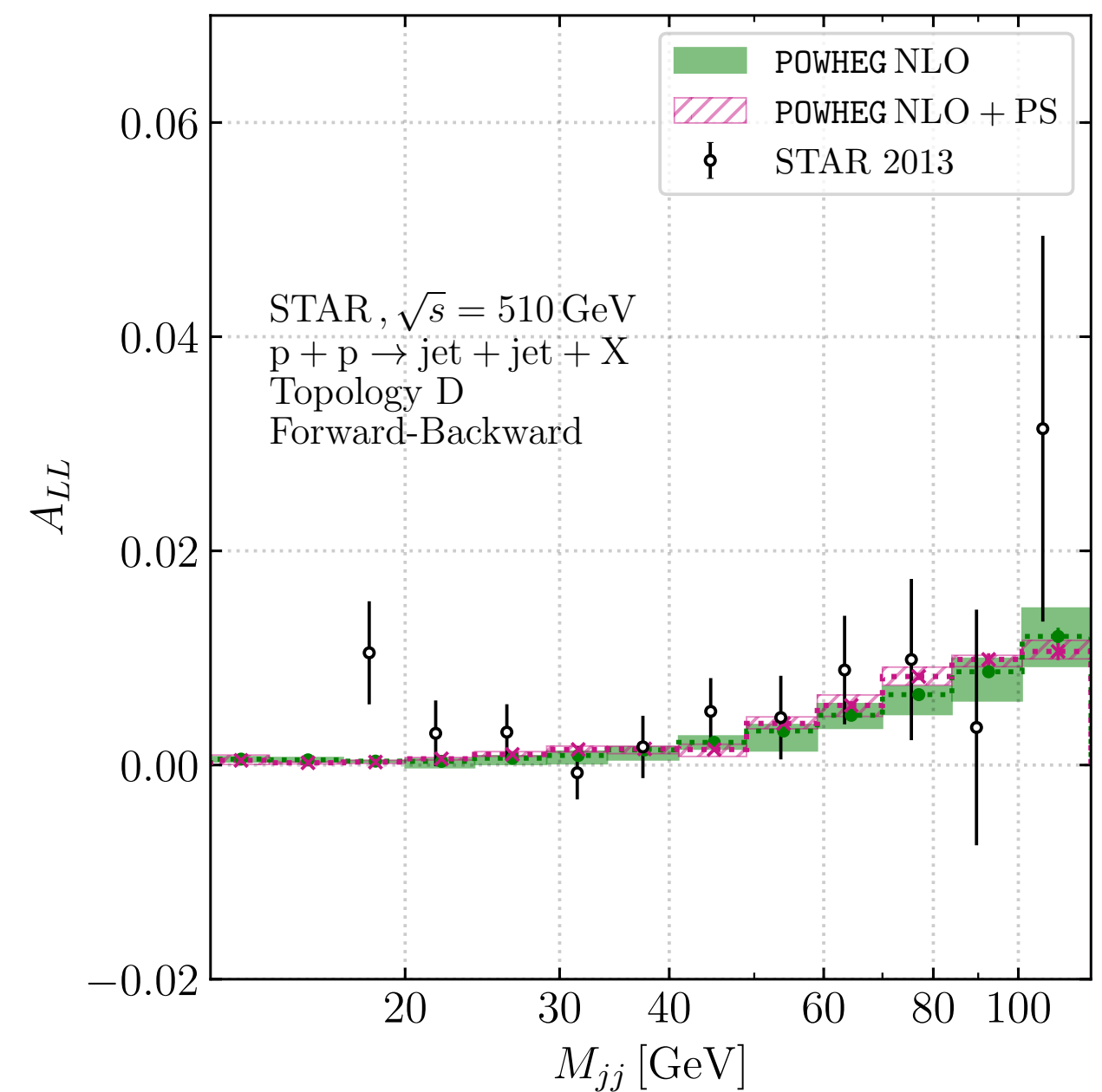
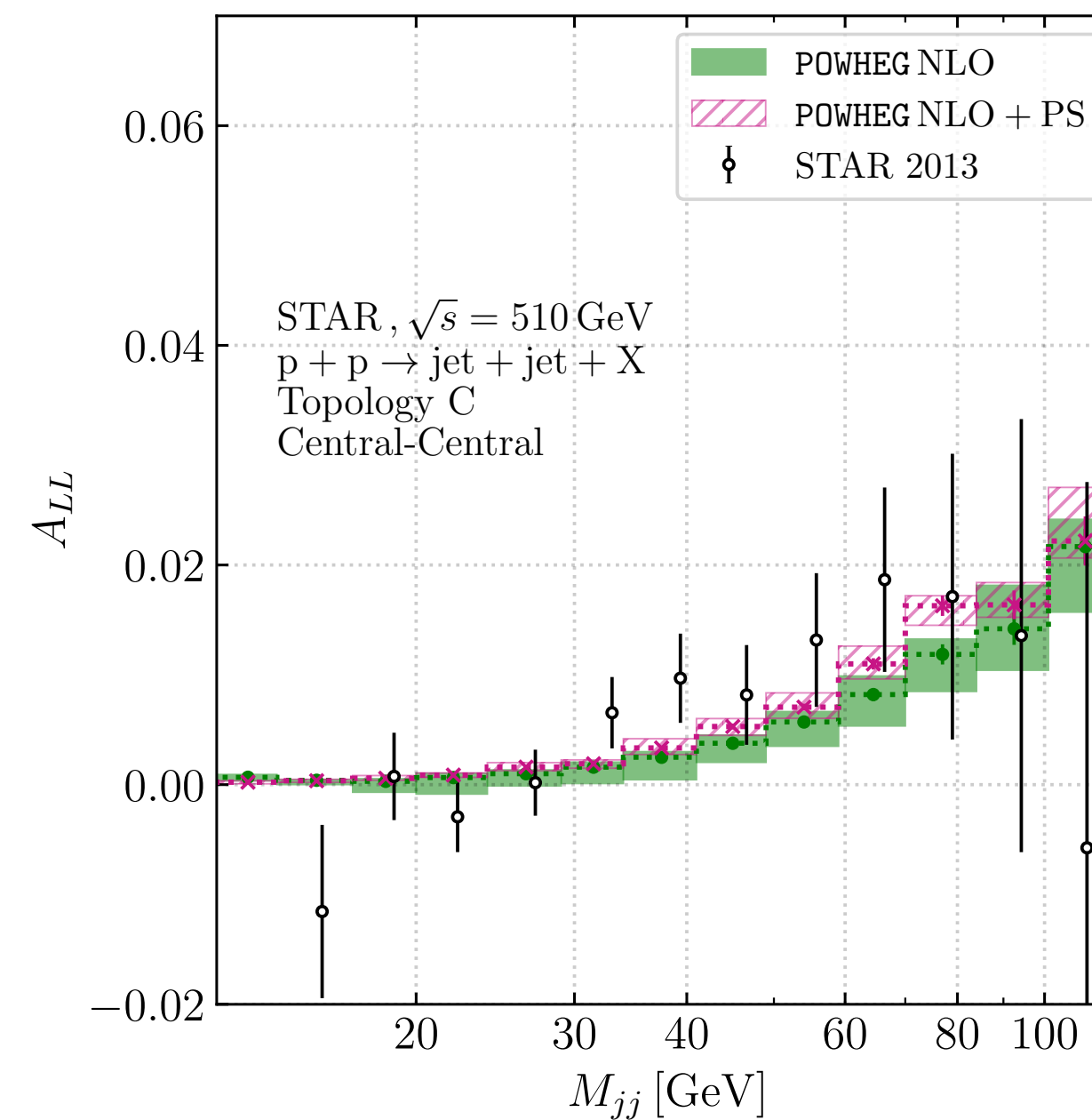
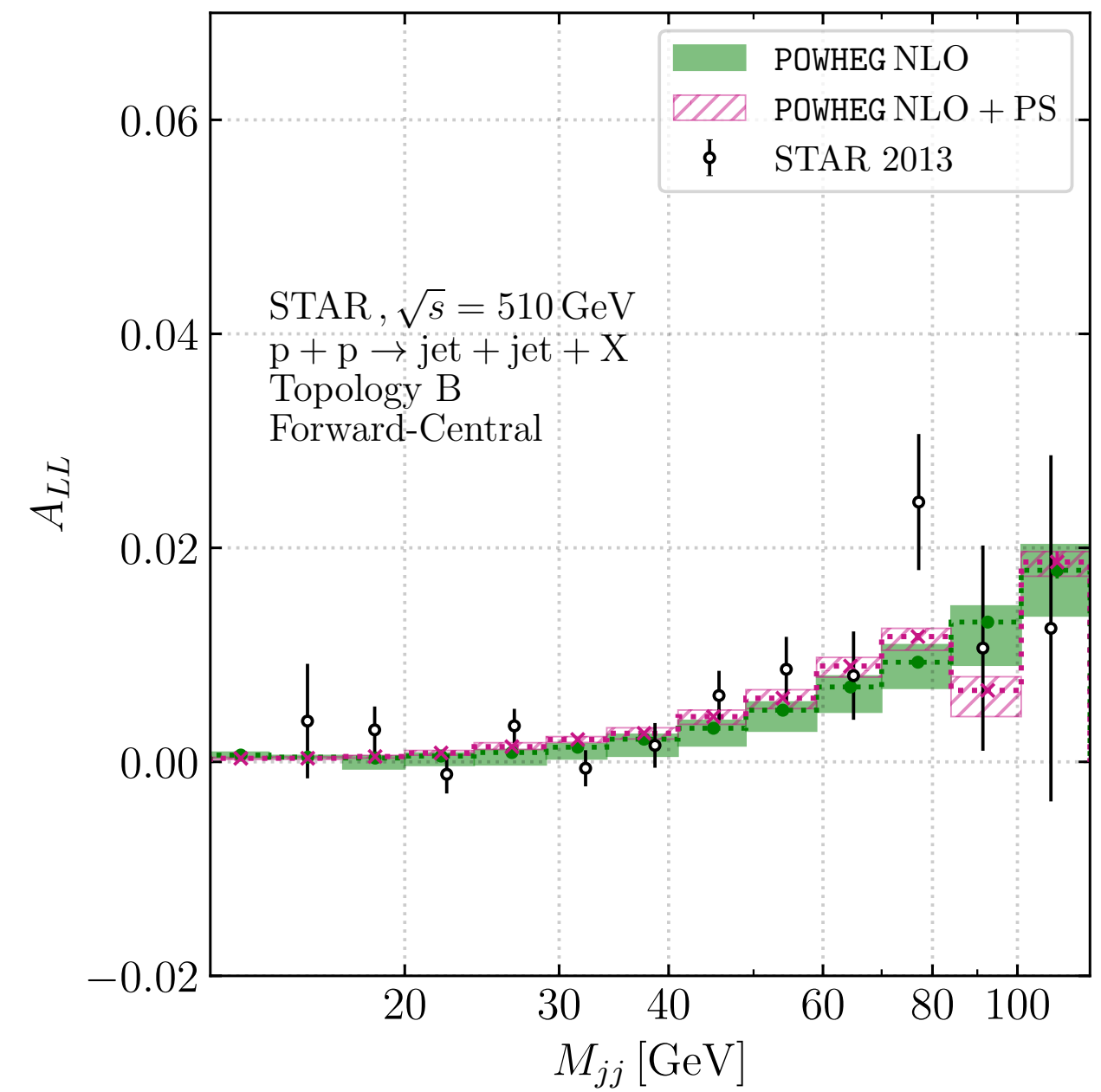
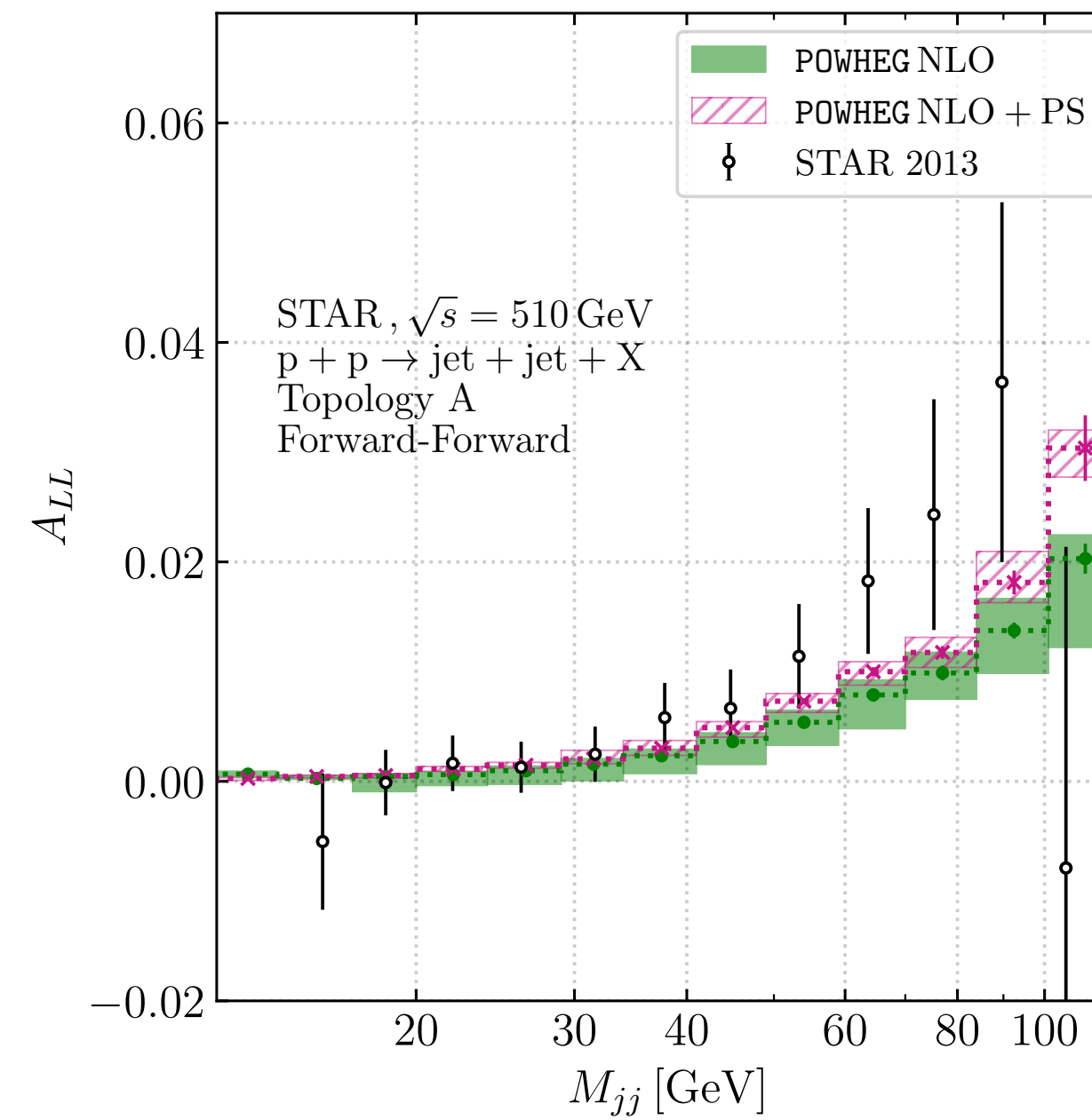
$A_{LL} = \frac{d\Delta\sigma}{d\sigma}$  at  $\sqrt{s} = 510$  GeV as a function of dijet invariant-mass [STAR 2110.11020]

$$p_T^{\text{jet } 1} > 7 \text{ GeV} \quad p_T^{\text{jet } 2} > 5 \text{ GeV}$$

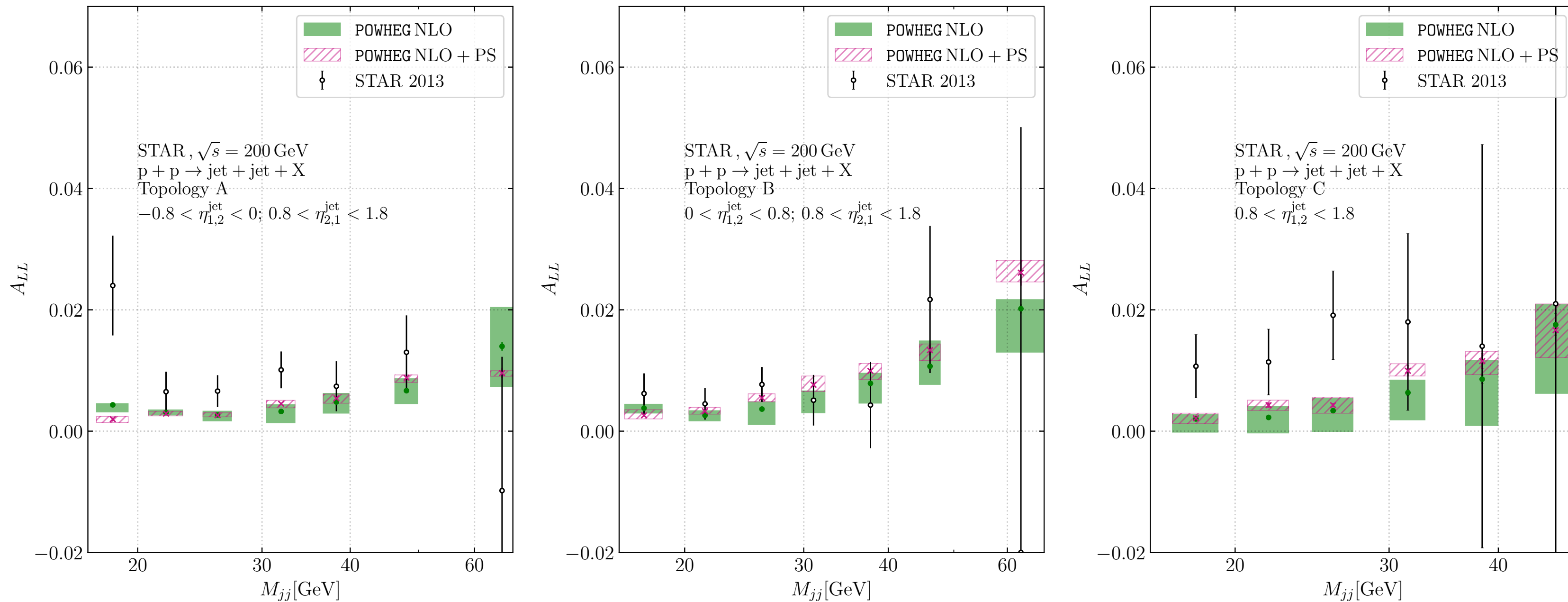
$$\text{anti-}k_T \quad R = 0.5$$

| Bin | $\eta_3$ and $\eta_4$ regions                       | Physics description |
|-----|-----------------------------------------------------|---------------------|
| A   | $0.3 <  \eta_{3,4}  < 0.9; \eta_3 \cdot \eta_4 > 0$ | Forward-forward     |
| B   | $ \eta_{3,4}  < 0.3; 0.3 <  \eta_{4,3}  < 0.9$      | Forward-central     |
| C   | $ \eta_{3,4}  < 0.3$                                | Central-central     |
| D   | $0.3 <  \eta_{3,4}  < 0.9; \eta_3 \cdot \eta_4 < 0$ | Forward-backward    |

- Mild impact of the parton shower in the double-spin asymmetries
- Increase in  $A_{LL}$  for larger values of  $M_{\text{inv.}}$  slightly improves description of data



# Phenomenology



$$A_{LL} = \frac{d\Delta\sigma}{d\sigma} \text{ at } \sqrt{s} = 200 \text{ GeV}$$

[STAR 2411.18976]

$$p_T^{\text{jet } 1} > 8 \text{ GeV} \quad p_T^{\text{jet } 2} > 6 \text{ GeV}$$

$$\text{anti-}k_T \quad R = 0.6$$

|                                                   |                    |
|---------------------------------------------------|--------------------|
| $-0.8 < \eta_{1,2} < 0.0; 0.8 < \eta_{2,1} < 1.8$ | East Barrel-Endcap |
| $0.0 < \eta_{1,2} < 0.8; 0.8 < \eta_{2,1} < 1.8$  | East Barrel-Endcap |
| $0.8 < \eta_{1,2} < 1.8$                          | Endcap-Endcap.     |



Impact of the parton shower largely cancels in the spin asymmetries at lower c.m.s energies  
 Similar description of data compared to NLO

# Summary

- ▶ Monte Carlo Generators for eN scattering crucial to fully realize the EIC physics program.
- ▶ The EIC spin program, in particular, will require matching of higher order corrections with parton showers that consistently account for polarized beams.
- ▶ NLO+PS implementation of polarized DIS in the POWHEG-BOX  
(publicly available in <https://powhegbox.mib.infn.it/>)
  - Extended POWHEG scheme to account for the helicities of the initial-state particles.
  - Events generated according to the NLO cross section, with PS effects bringing the distributions closer to the NNLO results.
  - Important step towards the development of polarized parton-shower generators for EIC, with polarization included in all stages of simulation.

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  - Important step towards the development of polarized parton-shower generators for EIC, with polarization included in all stages of simulation.
- ▶ NLO+PS implementation of di-jet production in polarized proton-proton collisions  
(publicly available in <https://powhegbox.mib.infn.it/>)
  - Slight improvement in the description of experimental data, although within large experimental uncertainties.

**Thank you**

**Some extra slides**

# Present EIC Concept (2026)

## Ultimate EIC Performance Parameters:

- High Luminosity:  $L = 10^{33} - 10^{34} \text{cm}^{-2}\text{sec}^{-1}$
- Highly Polarized Beams: 70% (electrons & light ions)
- Large Center of Mass Energy Range:  $E_{\text{cm}} = \sim 20 - 100$ , upgradeable to 140 GeV
- Large Ion Species Range: protons – Uranium
- Large Detector Forward Acceptance and Low-Background Conditions
- Possibility to Implement a Second Interaction Region (IR)

## Accelerator Status at a glance:

- ✓ Polarized light ion/proton source
- ✓ Ion injection and initial acceleration systems – Linac (200 MeV), Booster (1.5 GeV), AGS (25 GeV)
- UPGRADE** Hadron Storage Ring (40, 100-275 GeV) – **HSR**
- NEW** Electron Pre-Injector (750 MeV linac)
- NEW** Beam Accumulation Ring (750 MeV) – **BAR**
- NEW** Electron Rapid Cycling Synchrotron (0.75 GeV – top energy) – **RCS**
- NEW** Electron Storage Ring (5 GeV – 9 GeV, upgrade to 18 GeV) – **ESR**
- NEW** Interaction Region(s) – **IR**
- NEW** Hadron Cooling System

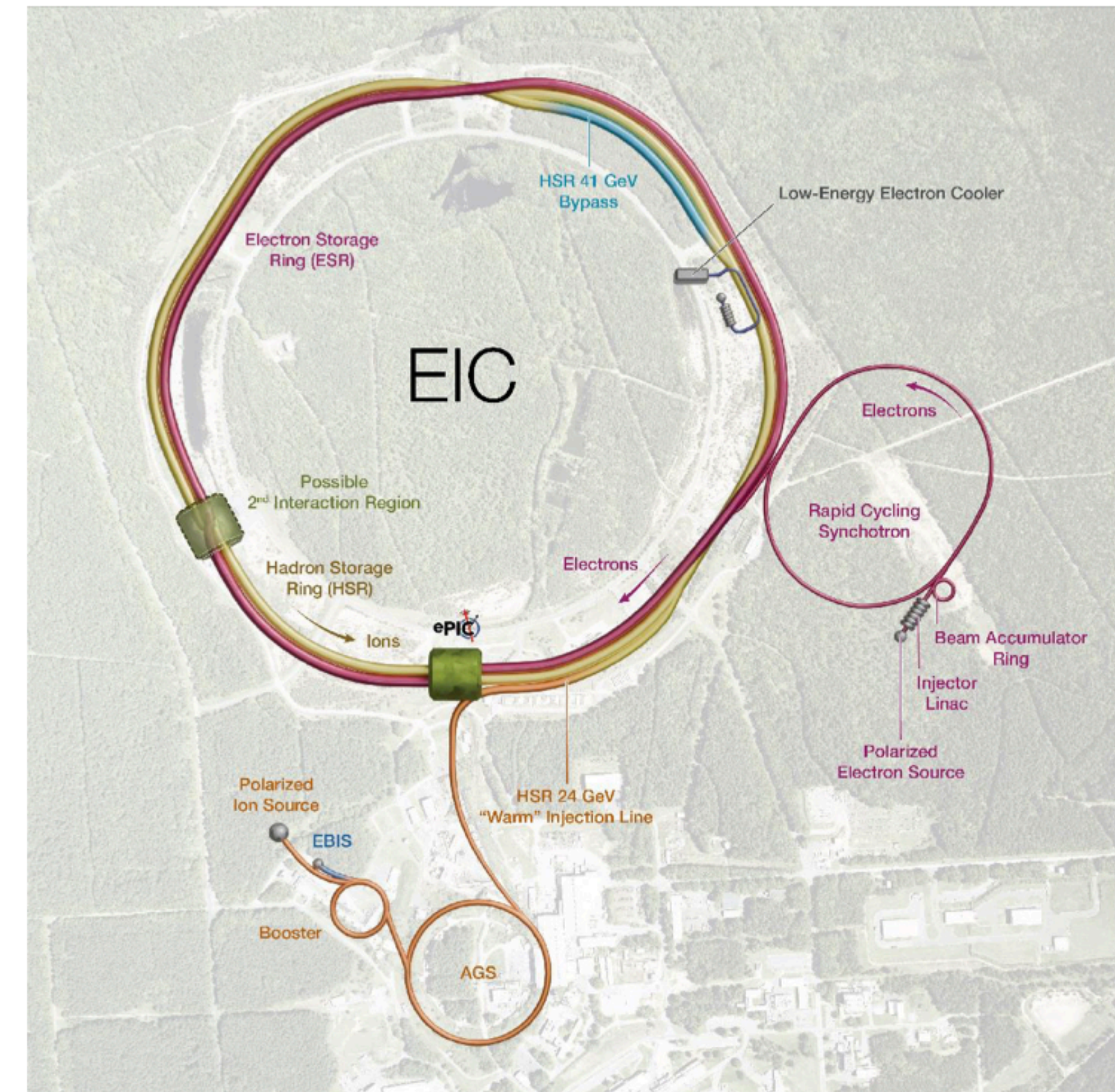
## Electron-Ion Collider

MC4EIC workshop on Monte Carlo event generation for the EIC

E.C. Aschenauer

4

E.Aschenauer MC4EIC 2026 workshop

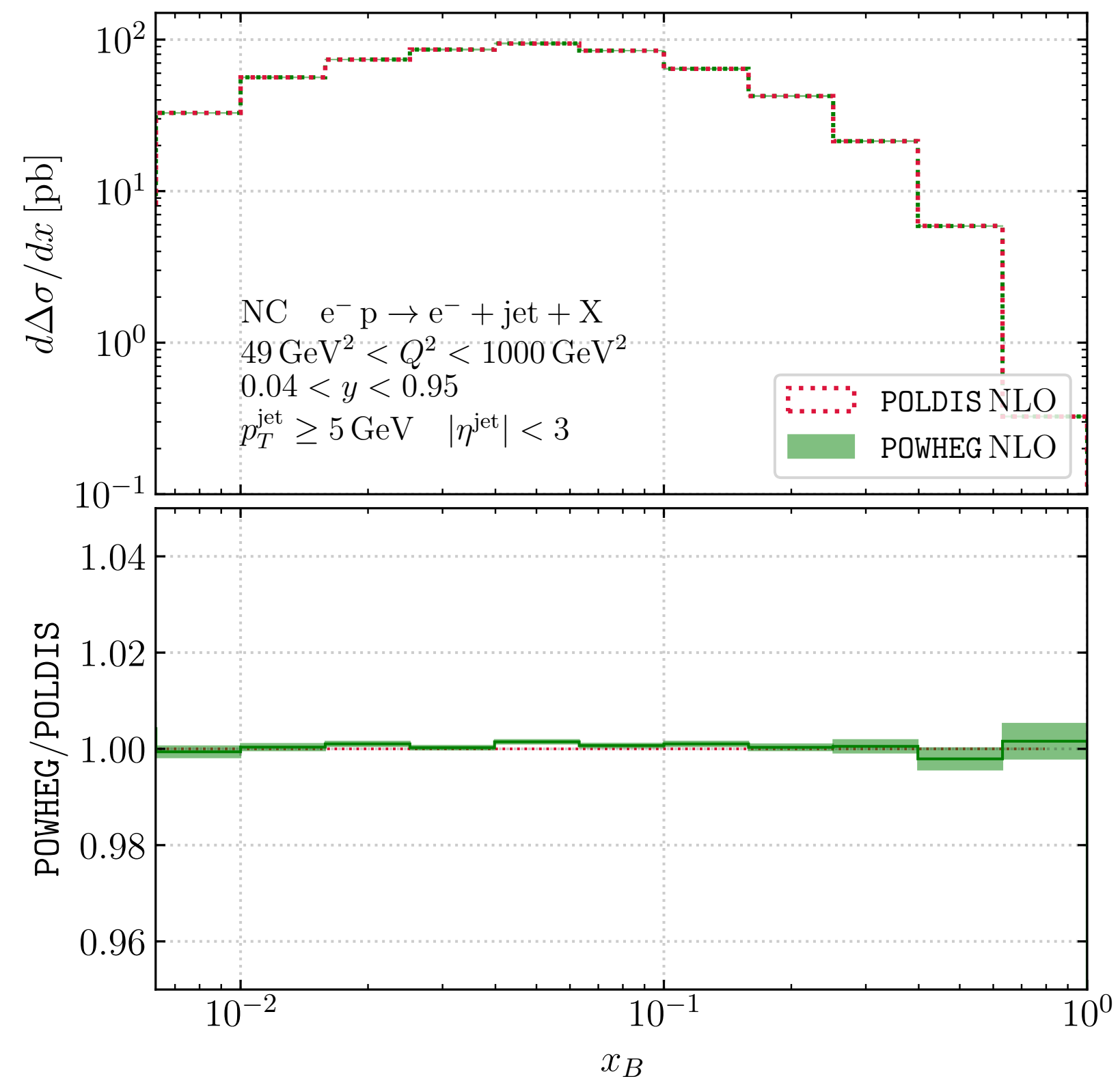
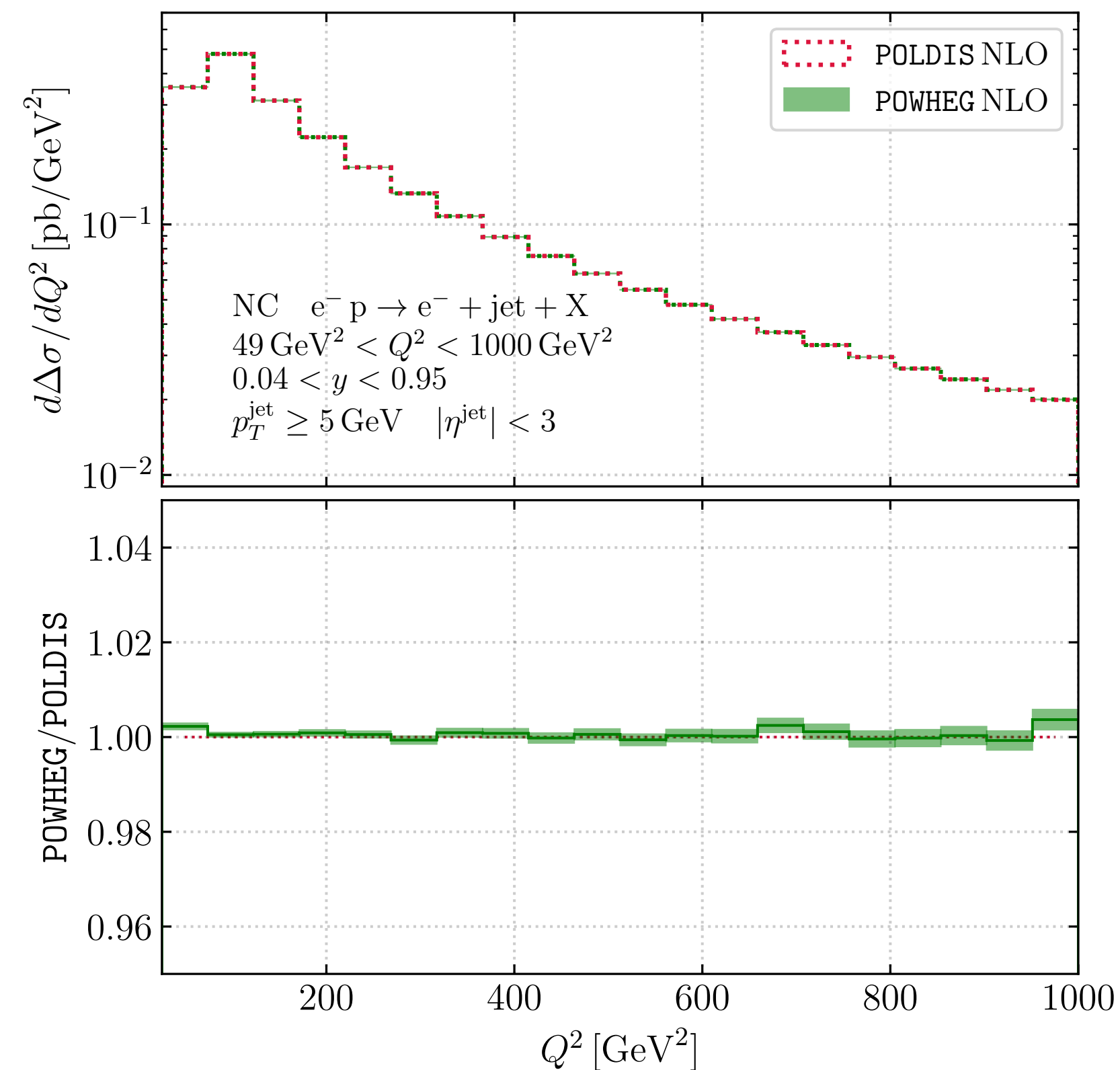


**Protons: ~40, 100 – 275 GeV**  
**Electrons: 5 – 9 GeV, upgradeable to 18 GeV**

# Validation

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



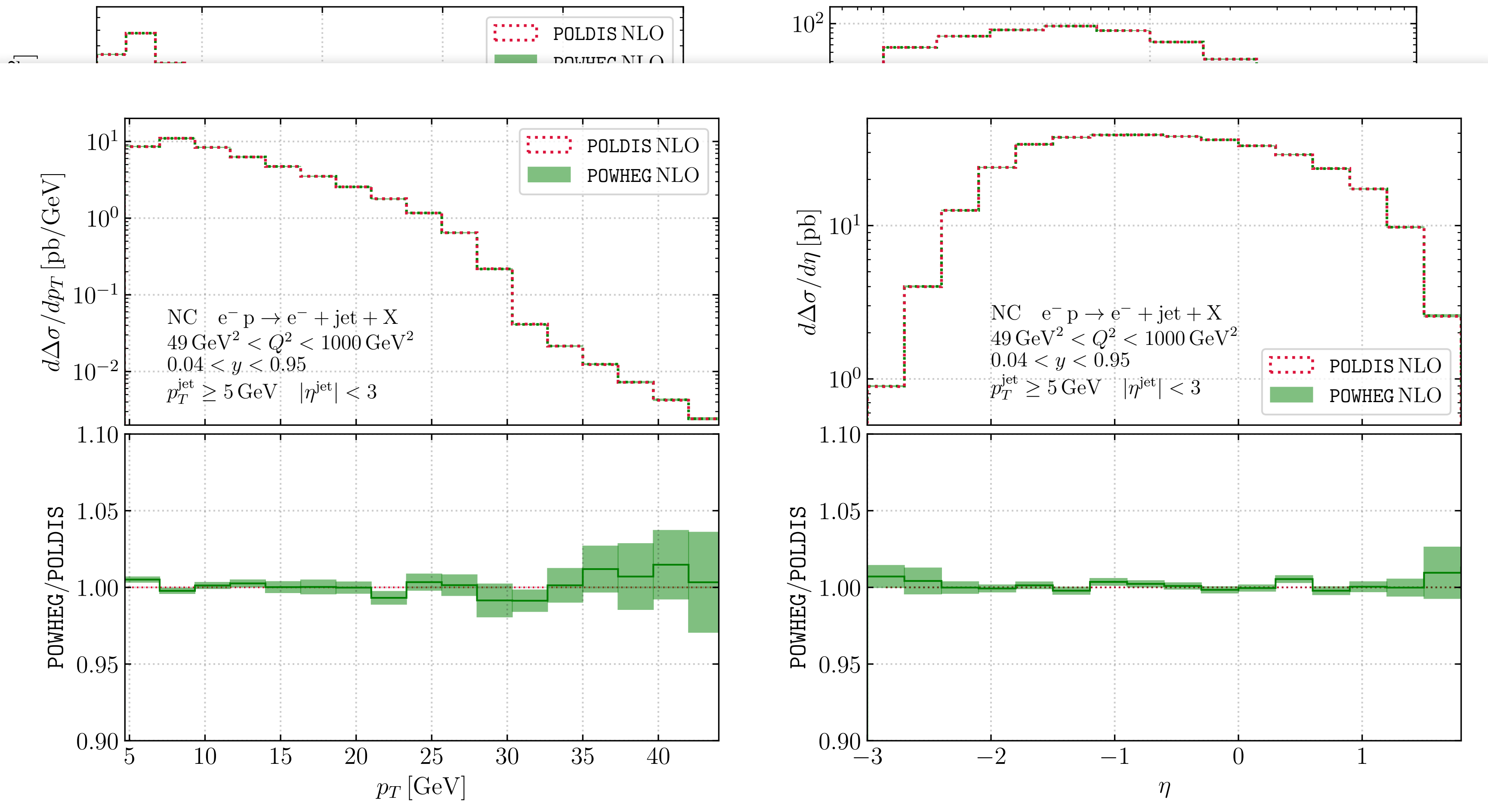
Some checks:

Fixed-order benchmark  
against code POLDIS  
[IB, de Florian, Pedron (2020,  
2022)]

# Validation

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



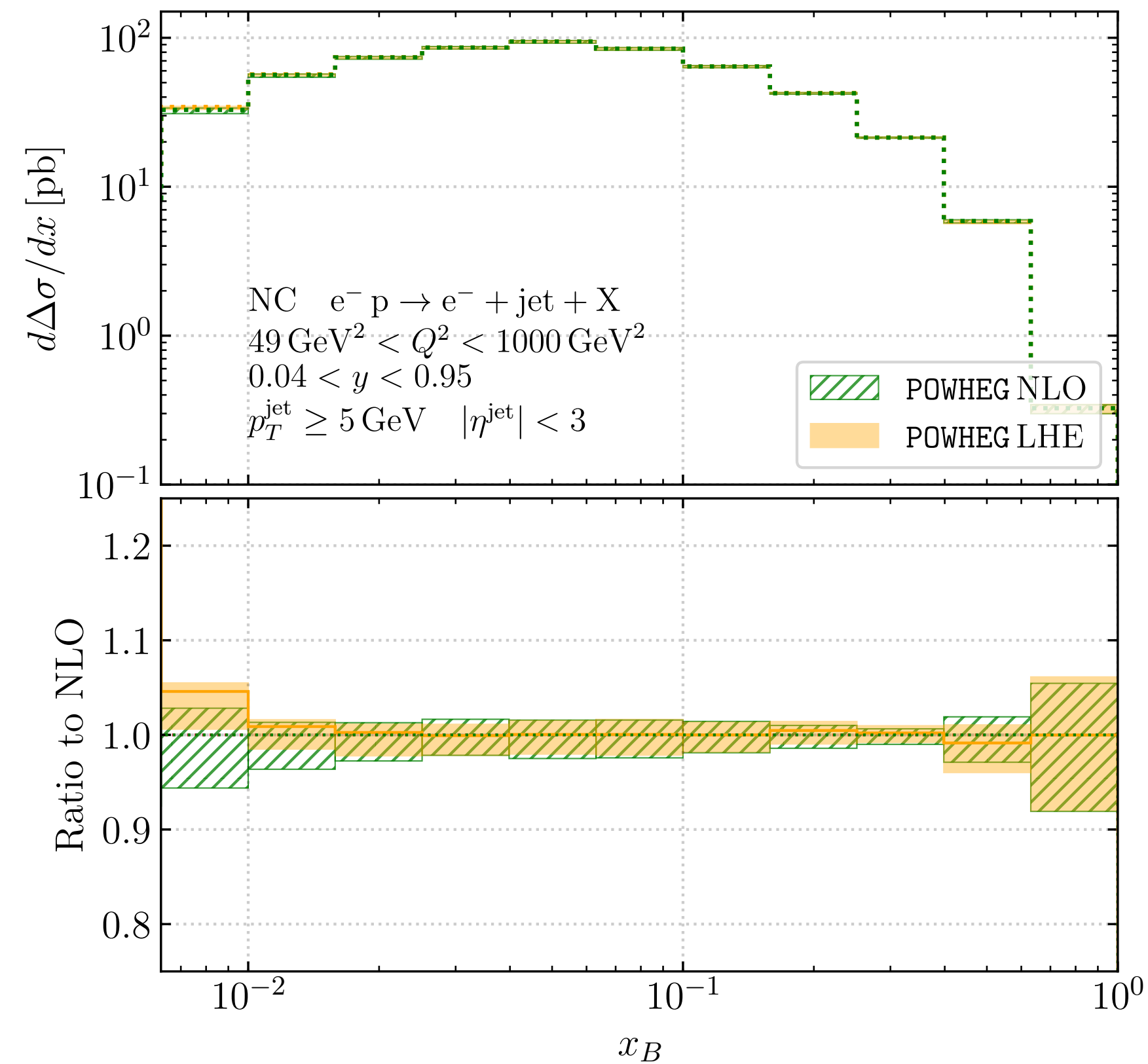
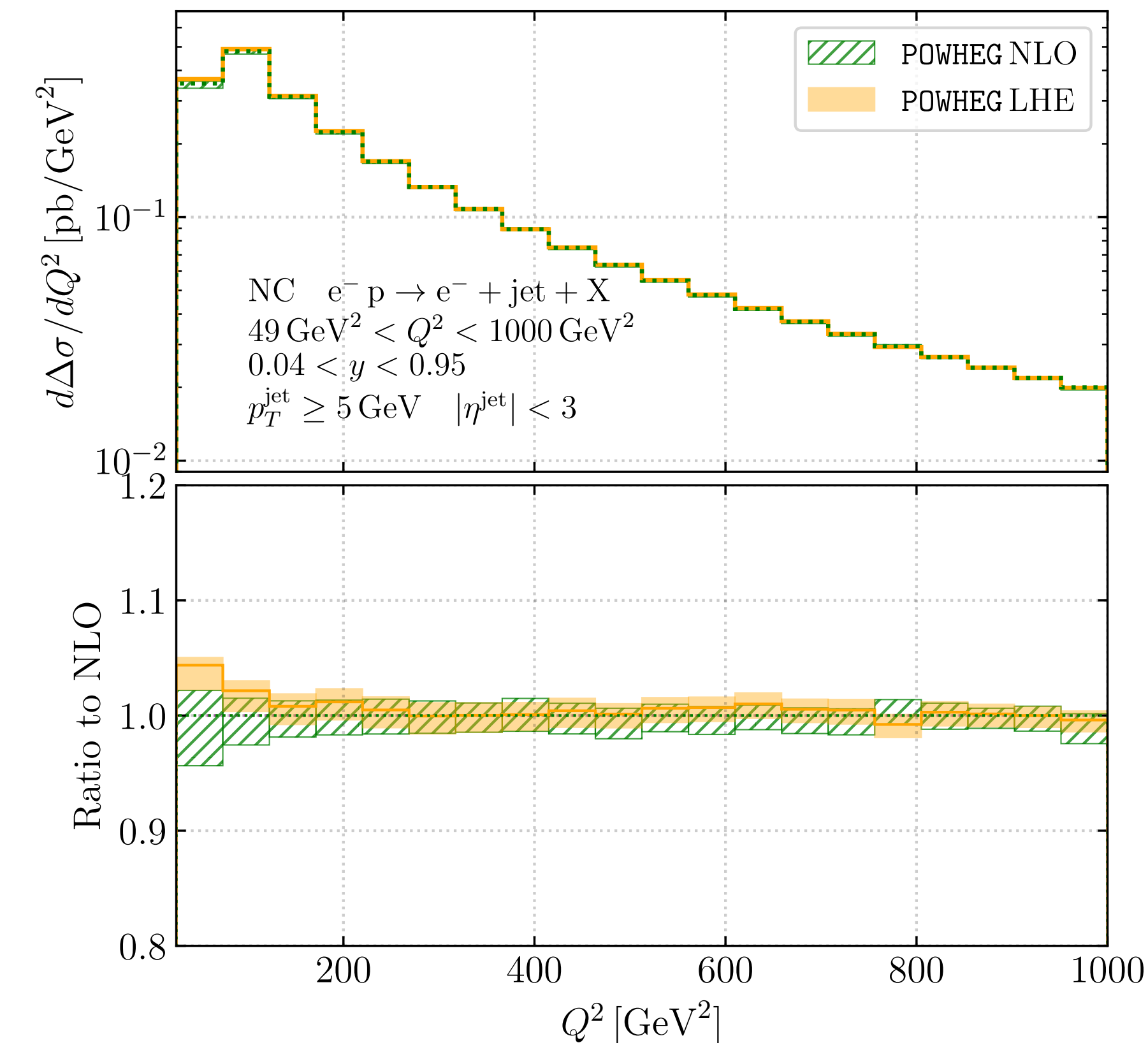
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# Phenomenology

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



Some checks:

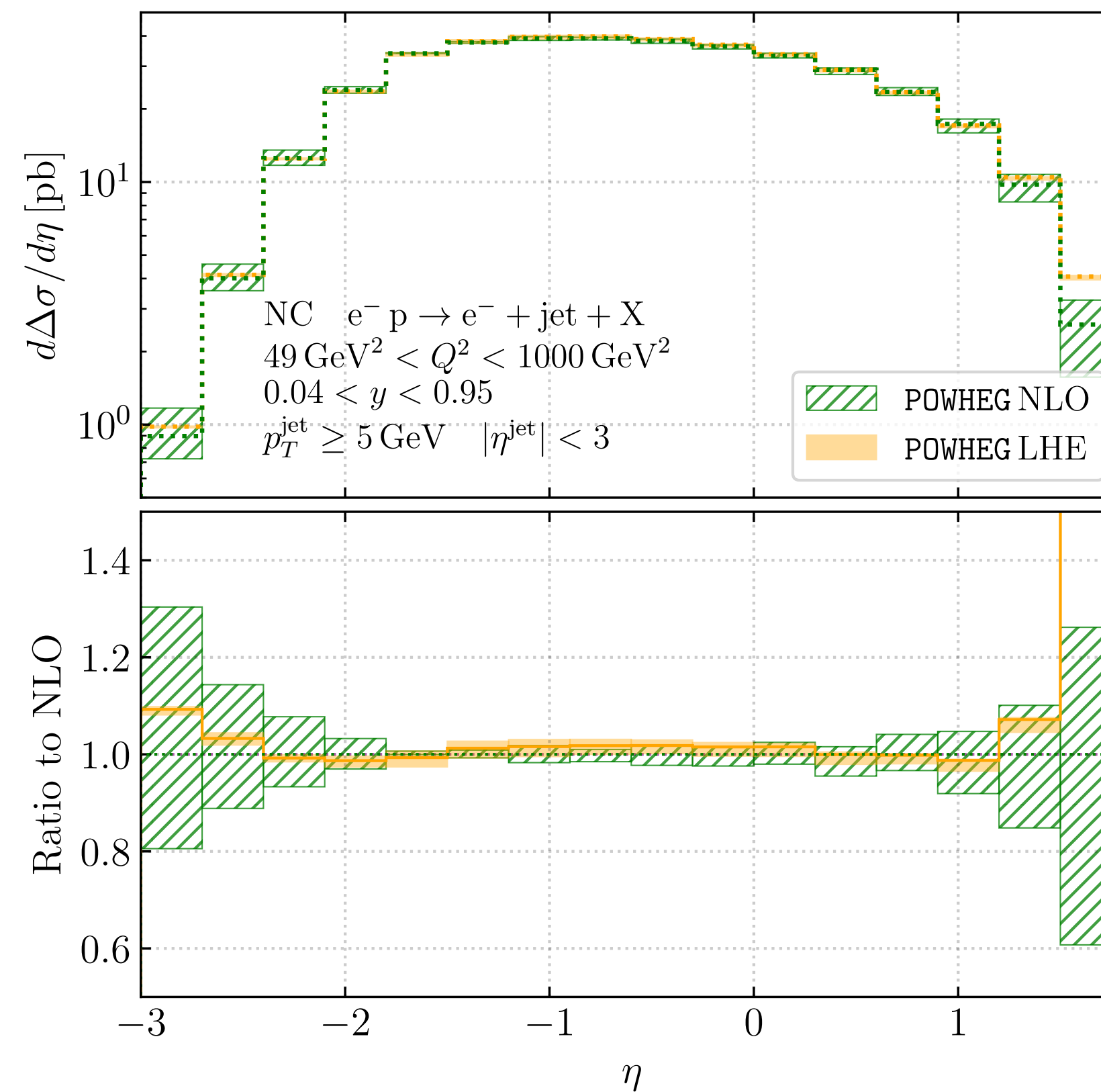
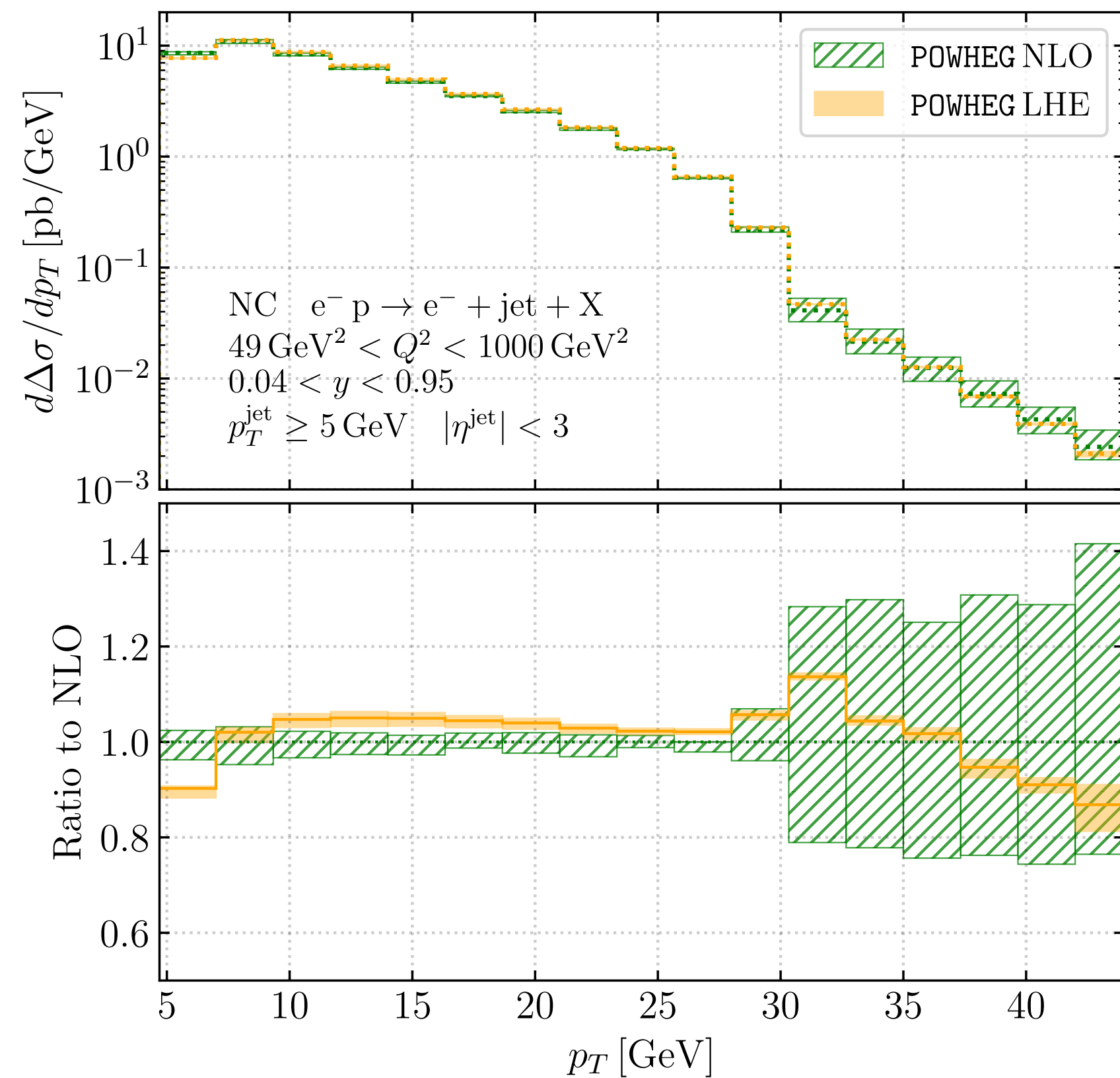
Cross section differential in  $p_T^{\text{jet}}, \eta^{\text{jet}}$  for jet production

- ☑ POWHEG events (LHE) distributed according to the NLO cross section in regions where enhanced-logs not expected

# Phenomenology

## Single-Jet production in NC DIS

IB, Jäger *JHEP* 07 (2024) 177



Some checks:

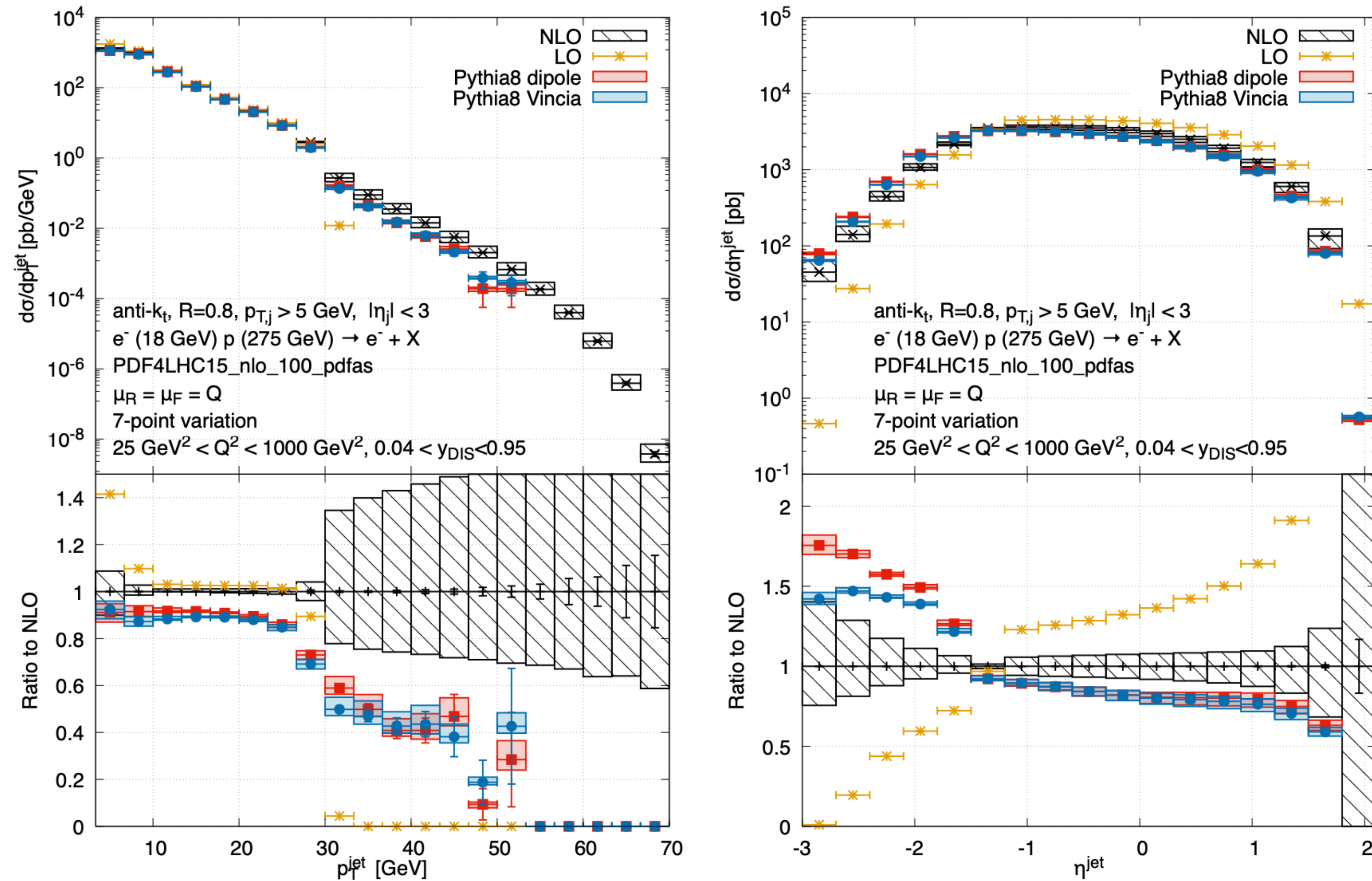
Cross section differential in  
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POWHEG events (LHE)  
distributed according to the  
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# Phenomenology

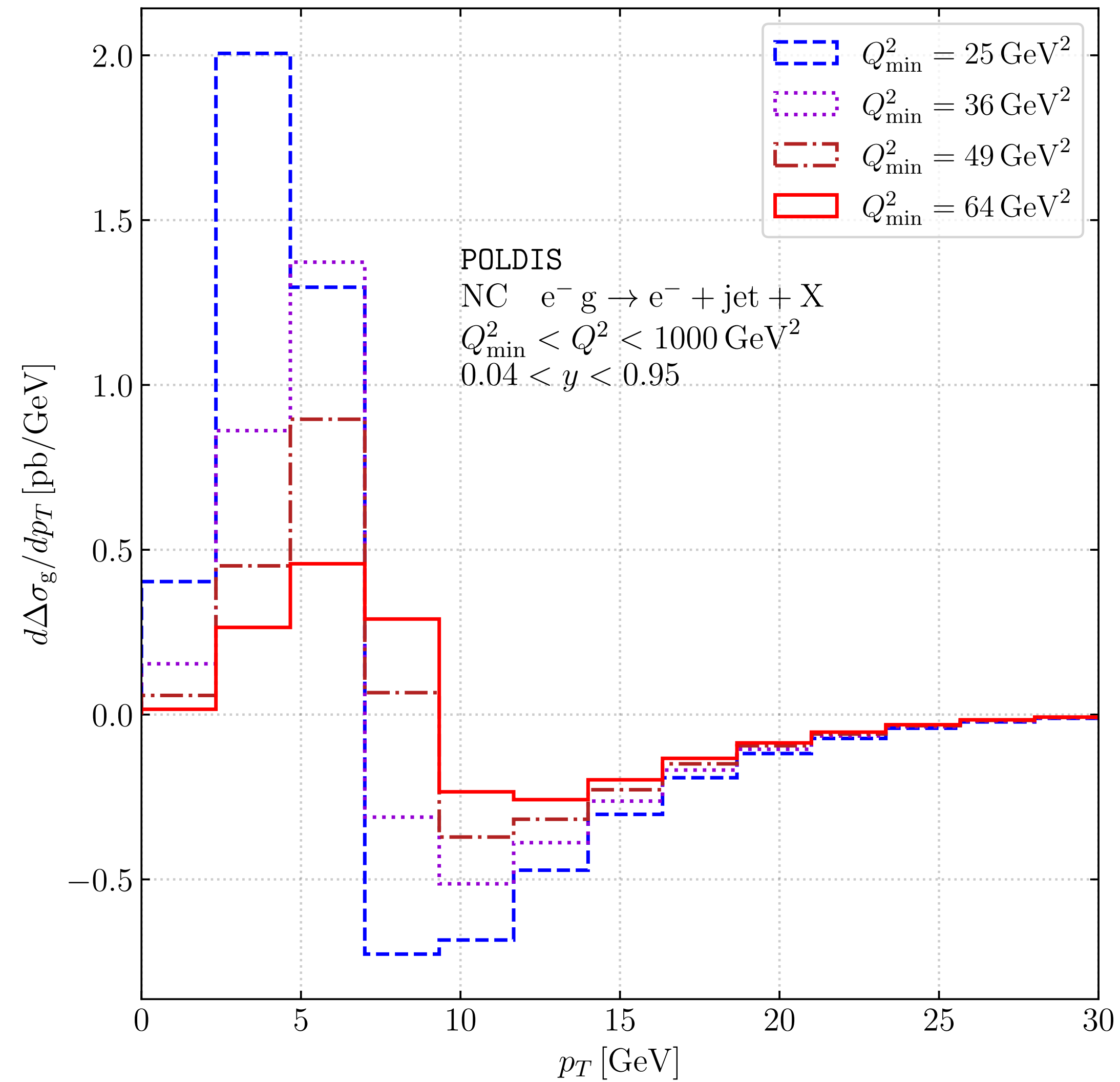
## Single-Jet production in unpolarized NC DIS



Banfi, Ferraro Ravasio, Jäger, Karlberg, Reichenbach, Zanderighi (2024)

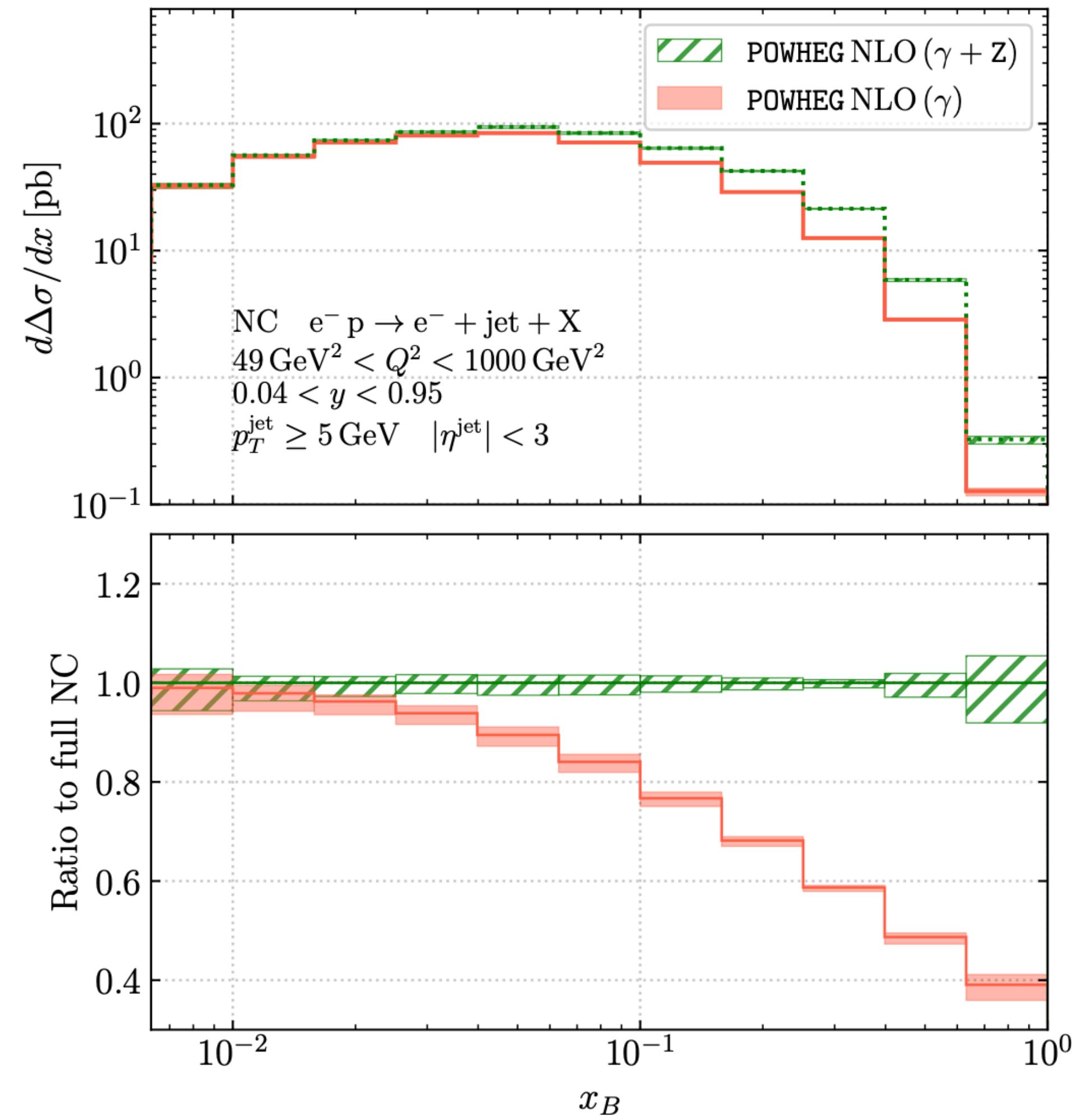
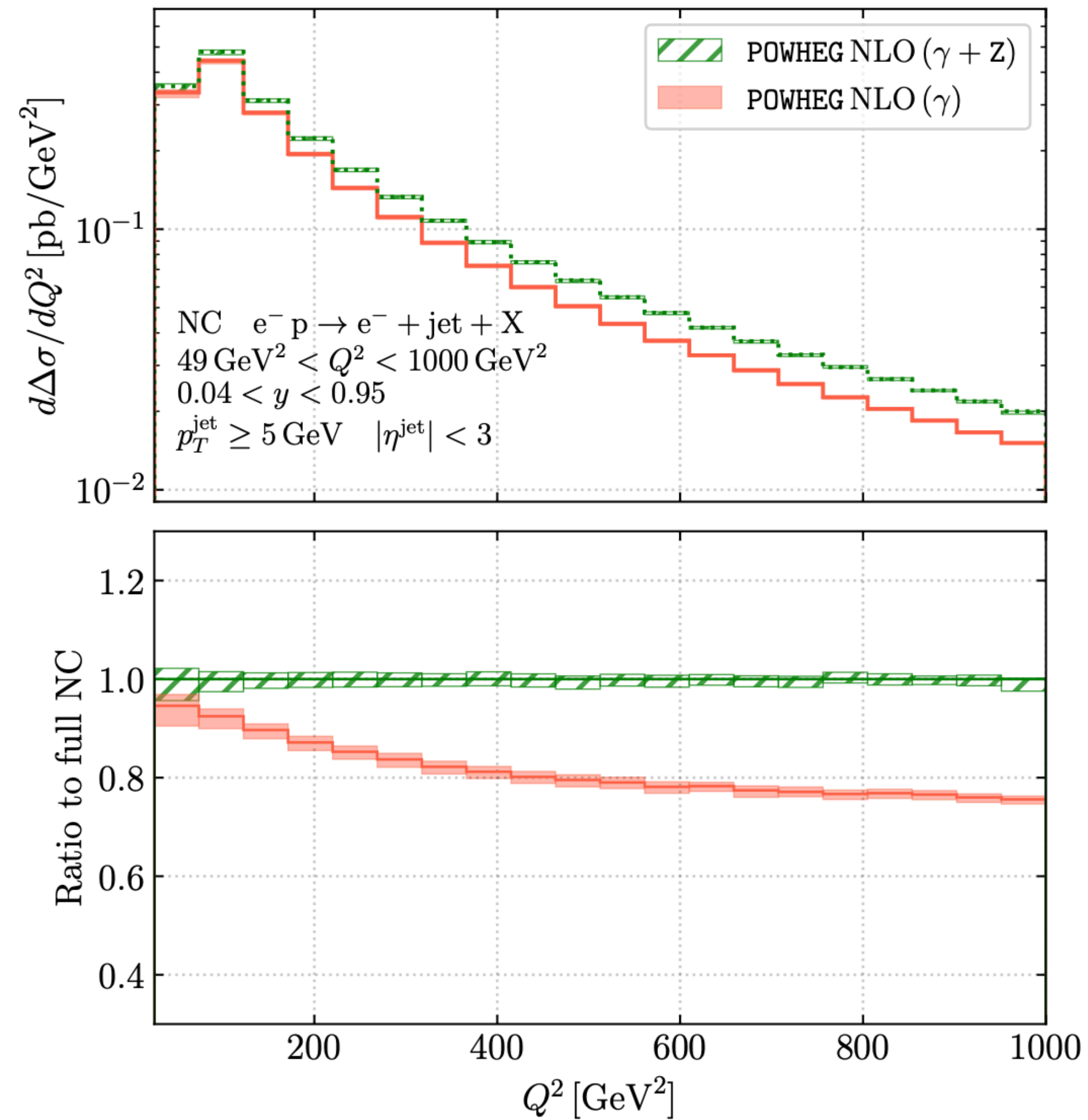
# Phenomenology

## Extra plots



# Phenomenology

## Extra plots



# Phenomenology

Di-jet production @NLO+PS - Betz, IB, Jäger 2602.05949

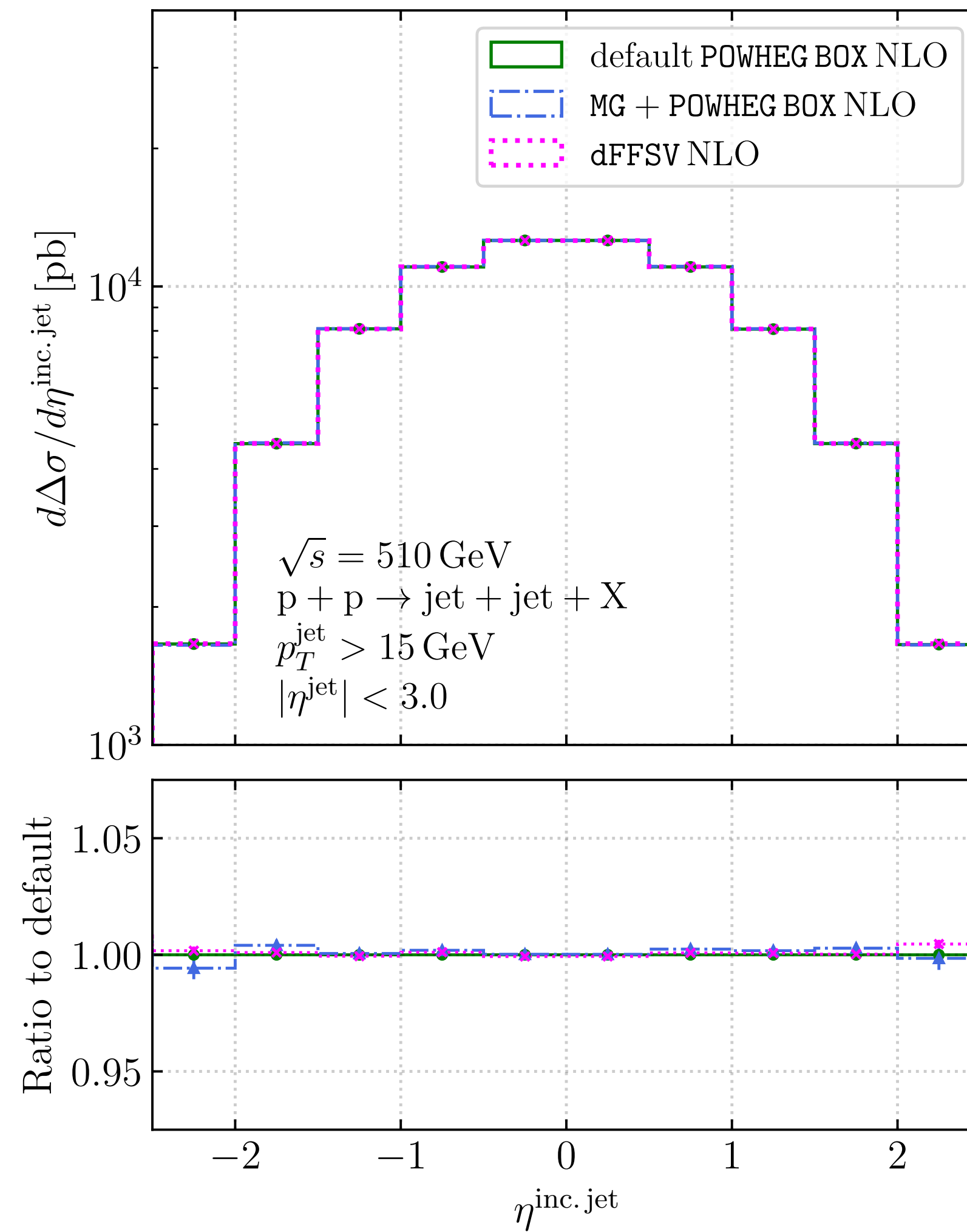
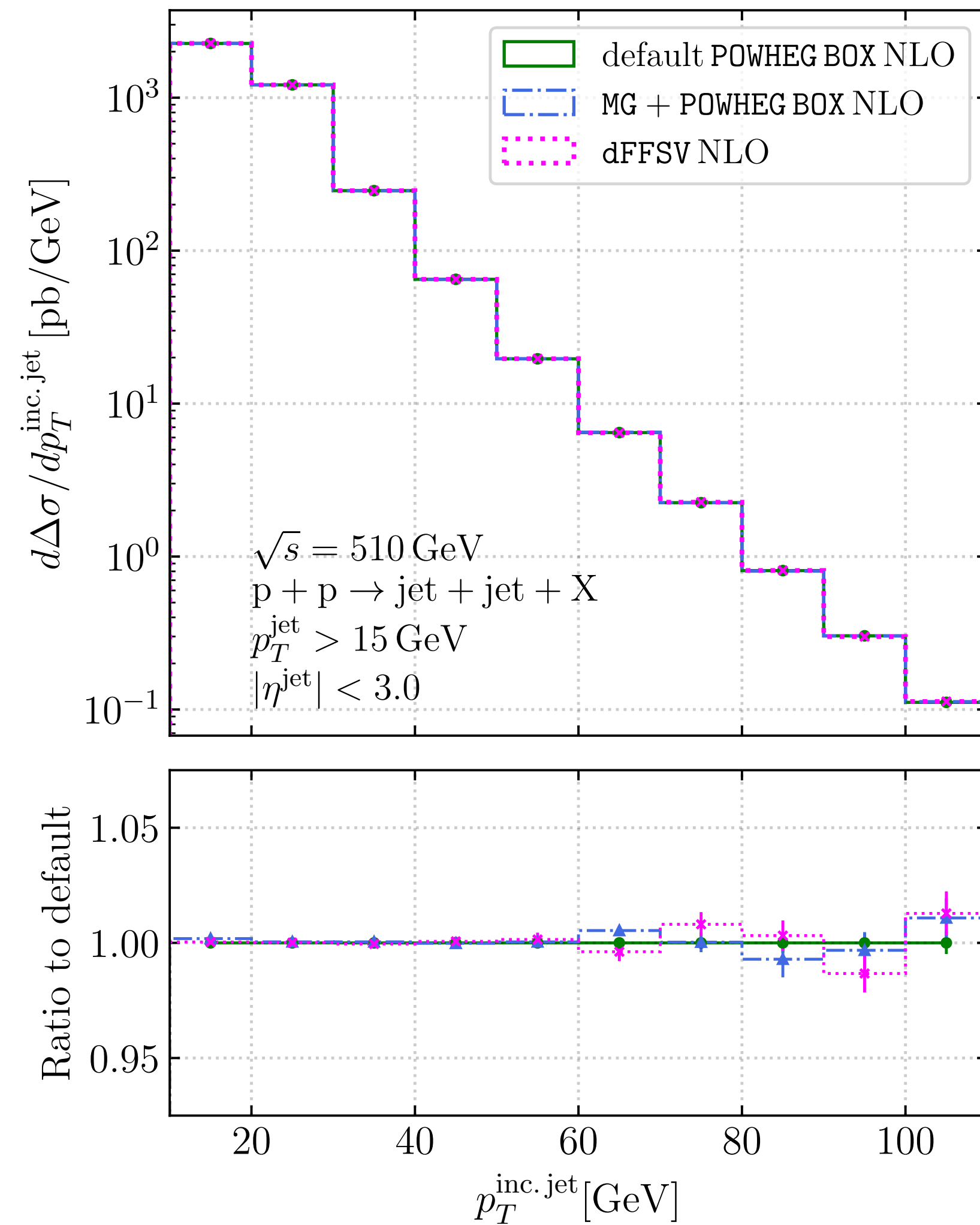
$$p + p \rightarrow \text{jet} + \text{jet} + X$$

$$\sqrt{s} = 510 \text{ GeV}$$

- 
- anti- $k_T$  algorithm with  $R = 1$  and E-recombination
- Polarized PDFs: BDSSV24 [IB, de Florian, Sassot, Stratmann, Vogelsang (2024)]
- Unpolarized PDFs: MSHT20 [Bailey, Cridge, Harland-Lang, Martin, Thorne (2020)]
- Parton Shower: PYTHIA6
- Theoretical uncertainty from 7-point scale variation

# Validation

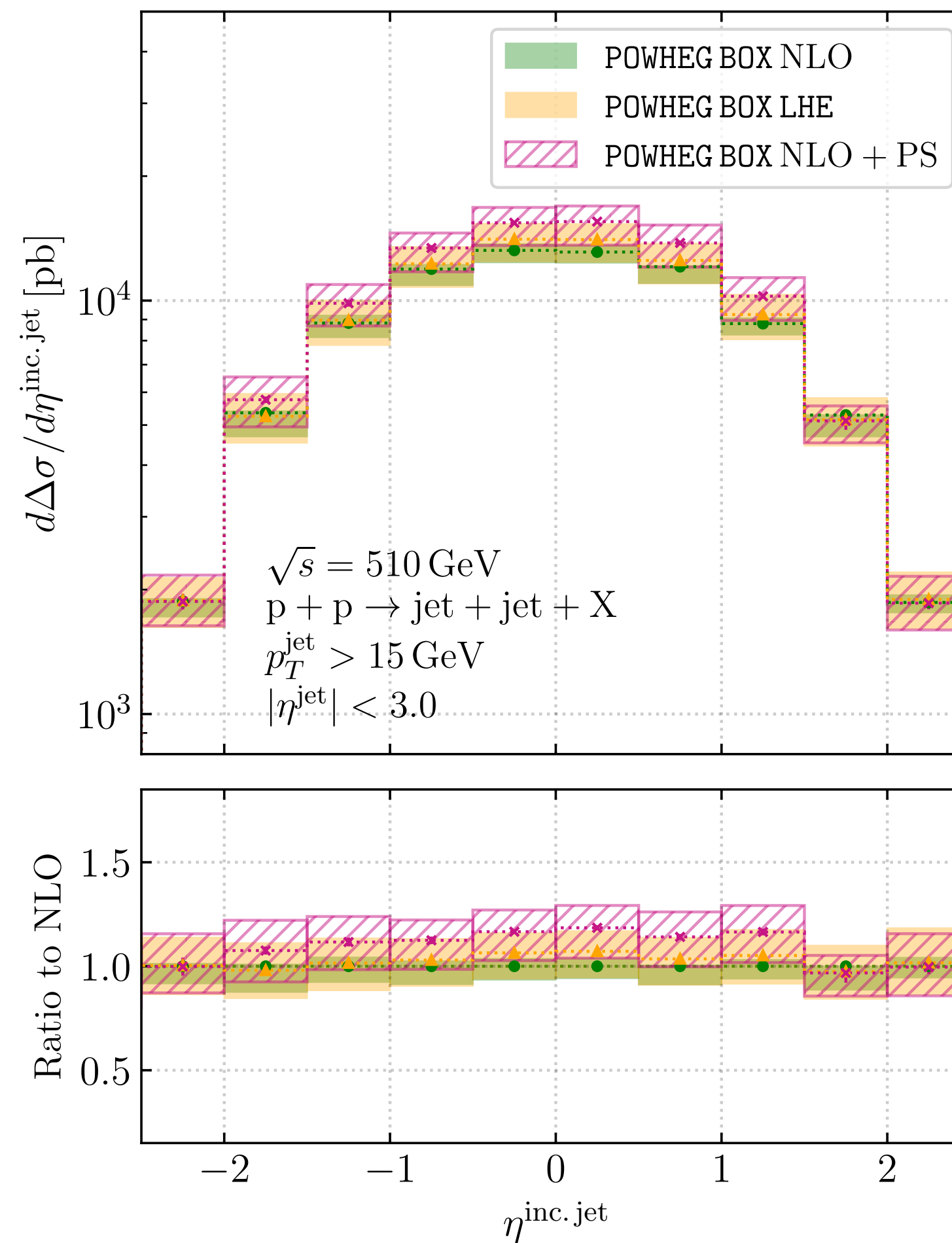
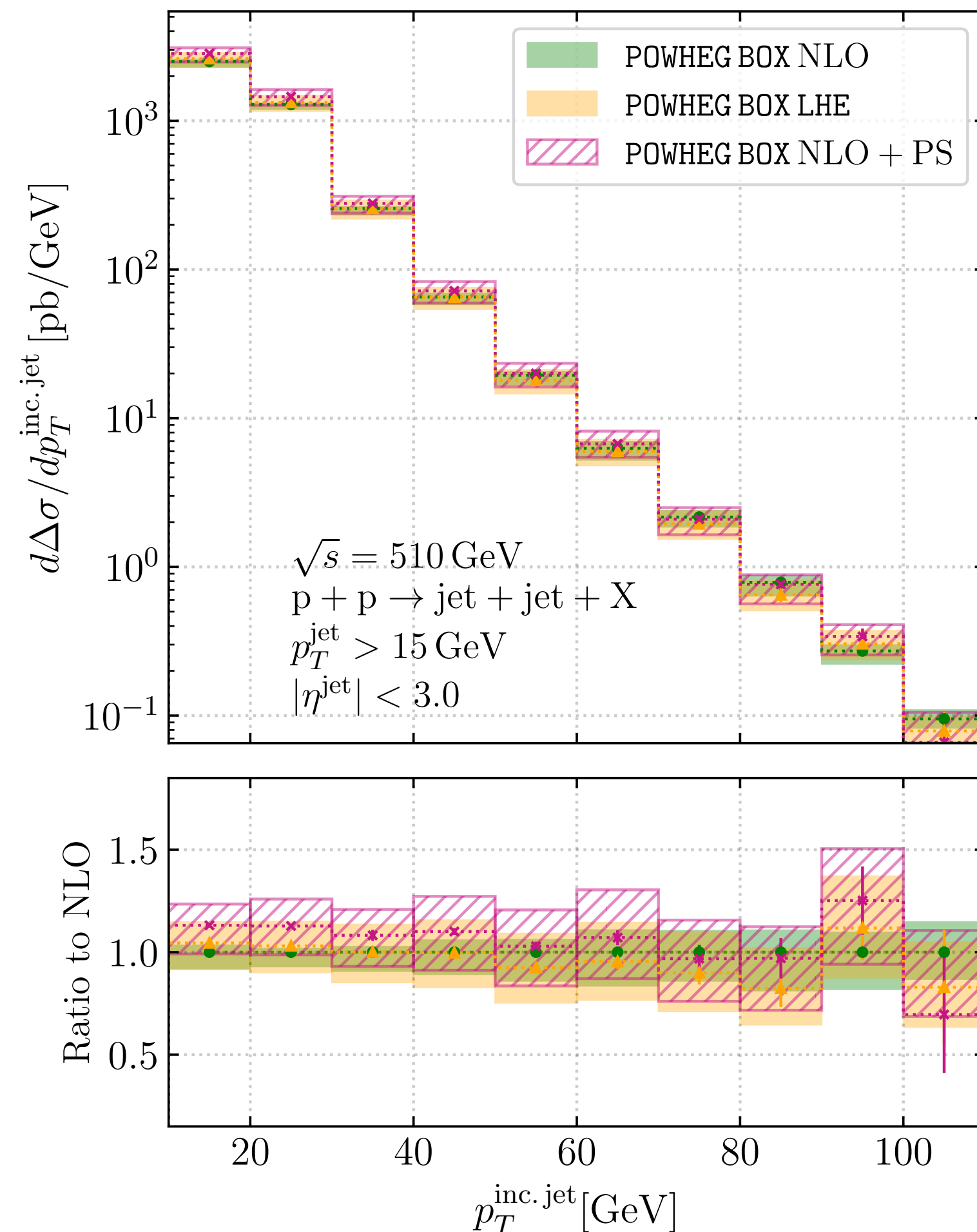
## Di-jet production in polarized pp



# Phenomenology

## Di-jet production in RHIC kinematics

Betz, IB, Jäger 2602.05949



### Some checks:

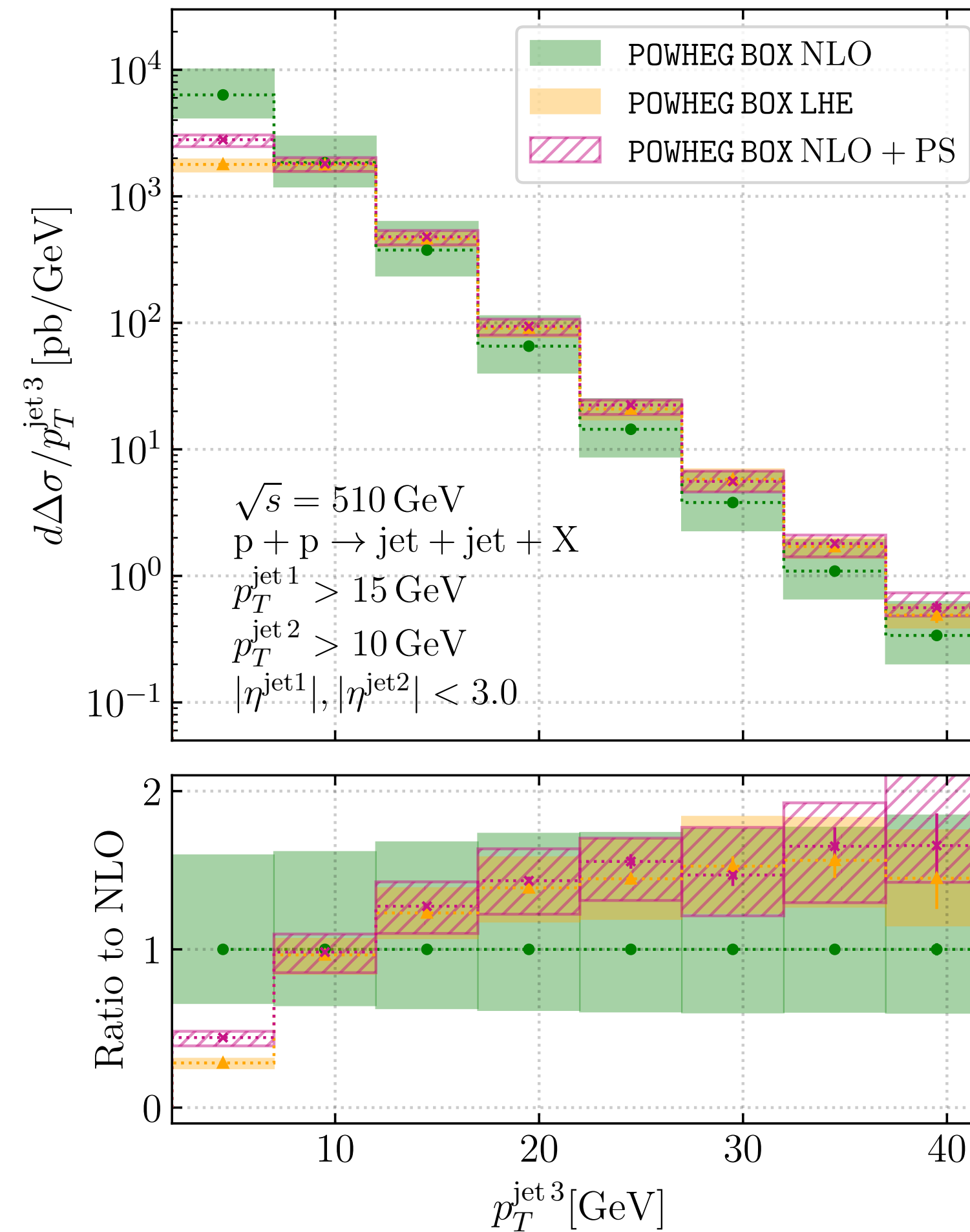
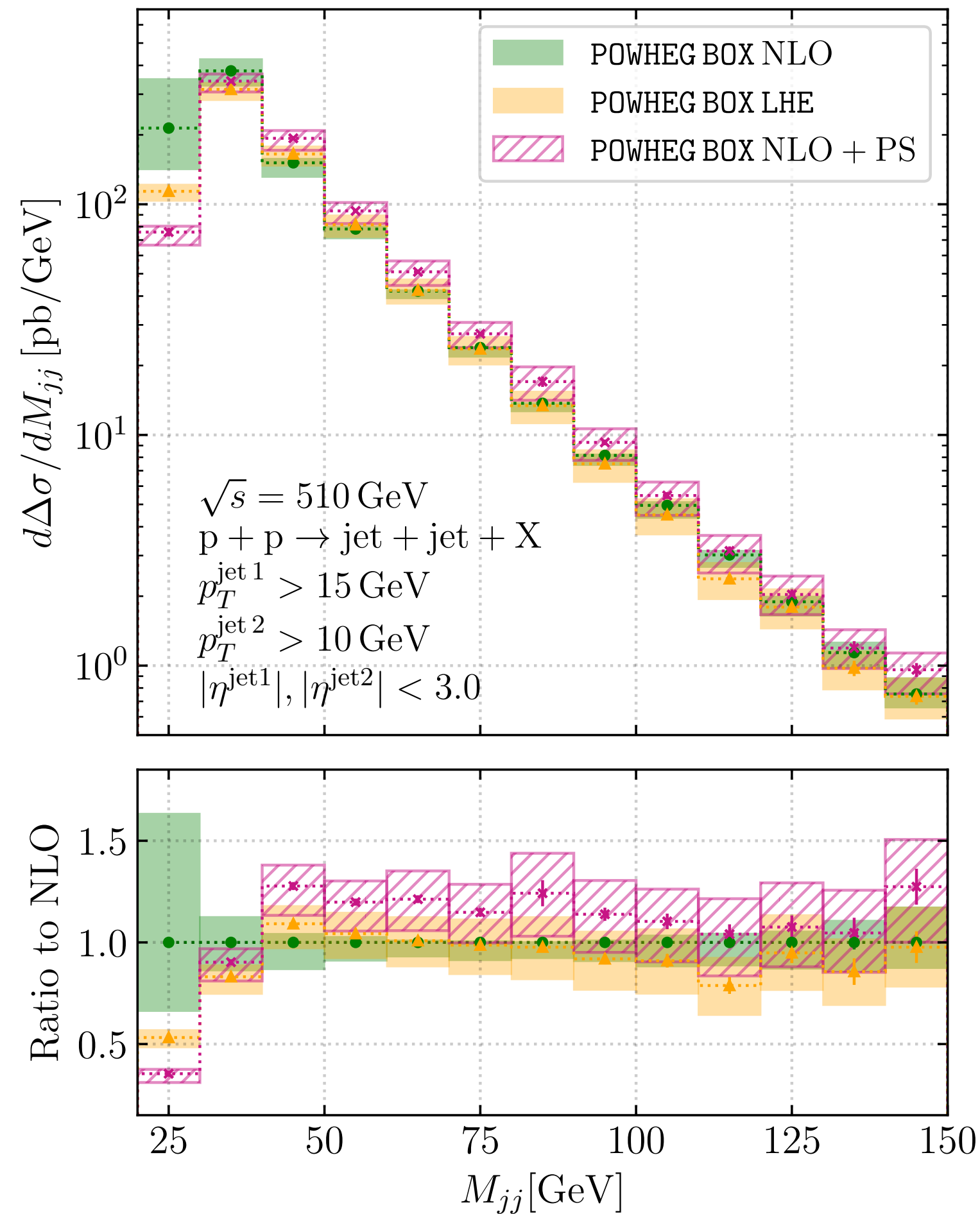
Comparison between NLO and hardest-emission (LHE) cross sections for inclusive-jet production

- ☑ NLO accuracy for observables inclusive in the additional radiation
- ☑ Agreement in regions where Sudakov effects expected to be small

# Phenomenology

## Di-jet production in RHIC kinematics

Betz, IB, Jäger 2602.05949



### Some checks:

Comparison between NLO and hardest-emission (LHE) cross sections for more exclusive distributions

☑ Sudakov suppression for low- $p_T^{\text{jet } 3}$