Title of paper:
Azimuthal correlations in photoproduction and deep inelastic *ep* scattering at HERA and indications of multiparton interactions

Target Journal:

- JHEP or PRD

Outline:

- Overview of the analysis details
- Topic 1: Search for collective behaviour
- Topic 2: Search for MPI in photoproduction
- Figures for publication

Paper presentation 1

March 25th 2021

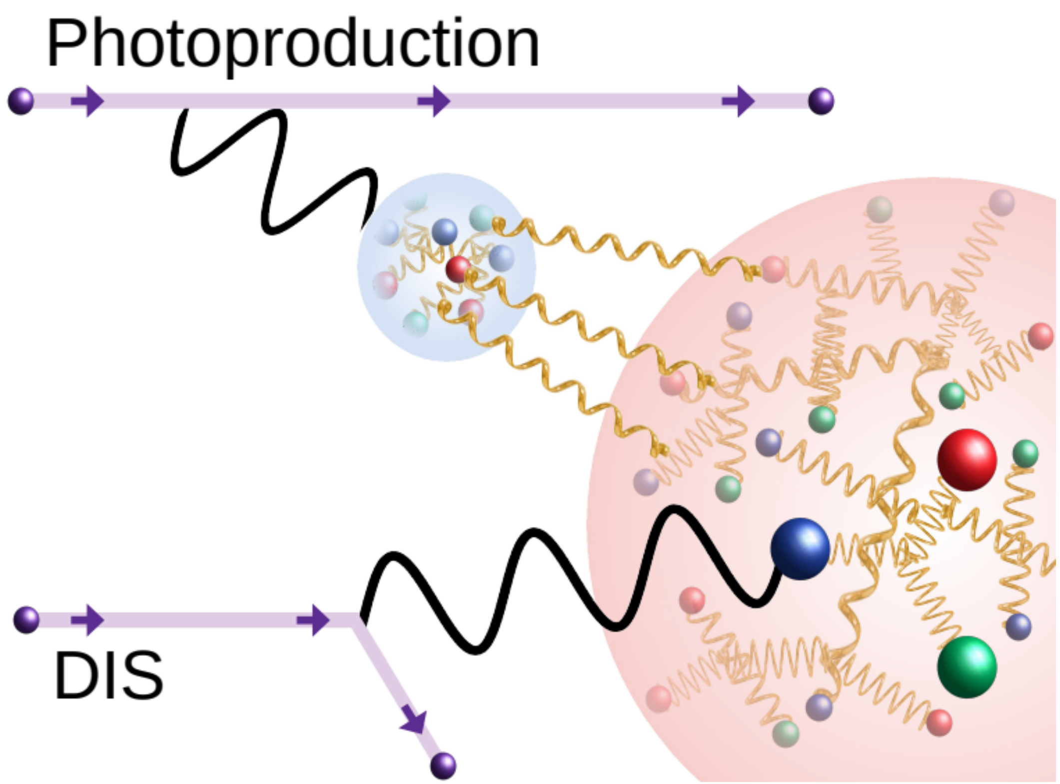
Authors: Dhevan Gangadharan,
Ilya Selyuzhenkov, Silvia Masciocchi, Stefan Floerschinger

Topics of Publication

In 2010, the LHC revealed evidence for “collective behavior” among the produced particles in pp collisions that resembles those found in heavy-ion collisions.This implies that a quark-gluon plasma might also form in “small” systems.

<u>Goal of this analysis:</u>
Search for collective behavior in DIS and PhP as well as multiparton interactions in PhP.

Variants to this figure to be discussed later

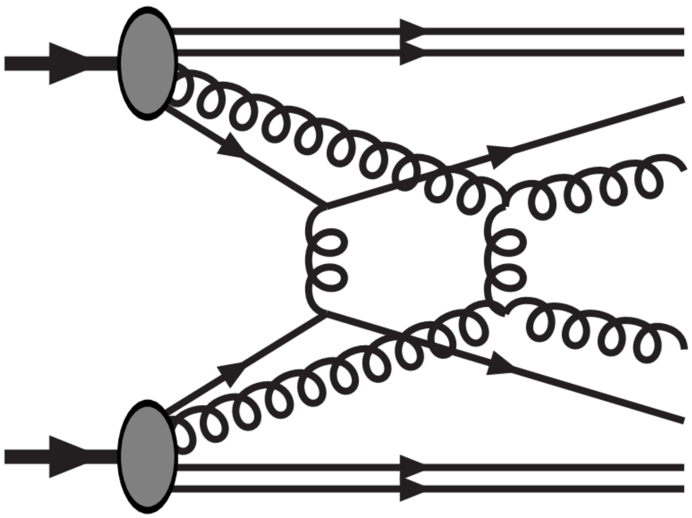


- Figure 1 for the paper.
- Illustrates the initial scattering in two separate scenarios at HERA.
- Hadronic component of photon shown for resolved PhP, as well as MPIs.

MPI and Rescattering definitions

<u>Multiparton interactions (MPI):</u>

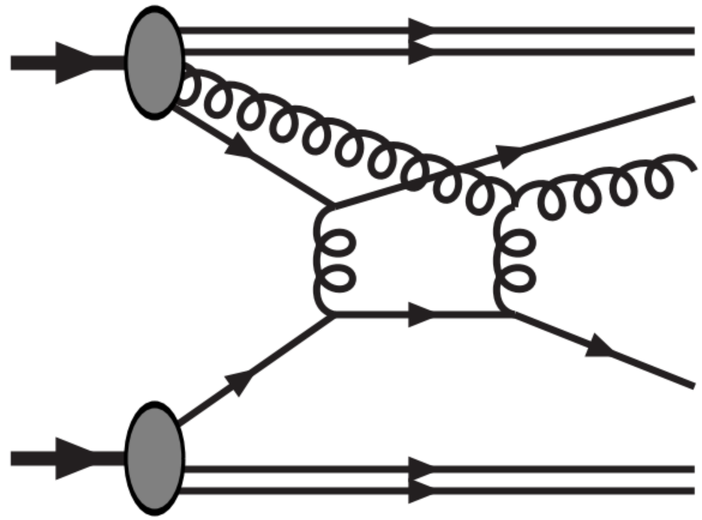
Disjoint pairwise scatterings, i.e. multiple $2 \rightarrow 2$ processes.



Perturbative domain.
Scales in PYTHIA >~ 1 GeV

<u>Rescattering:</u>

The product of a $2 \rightarrow 2$ scattering undergoes successive collisions against several other partons



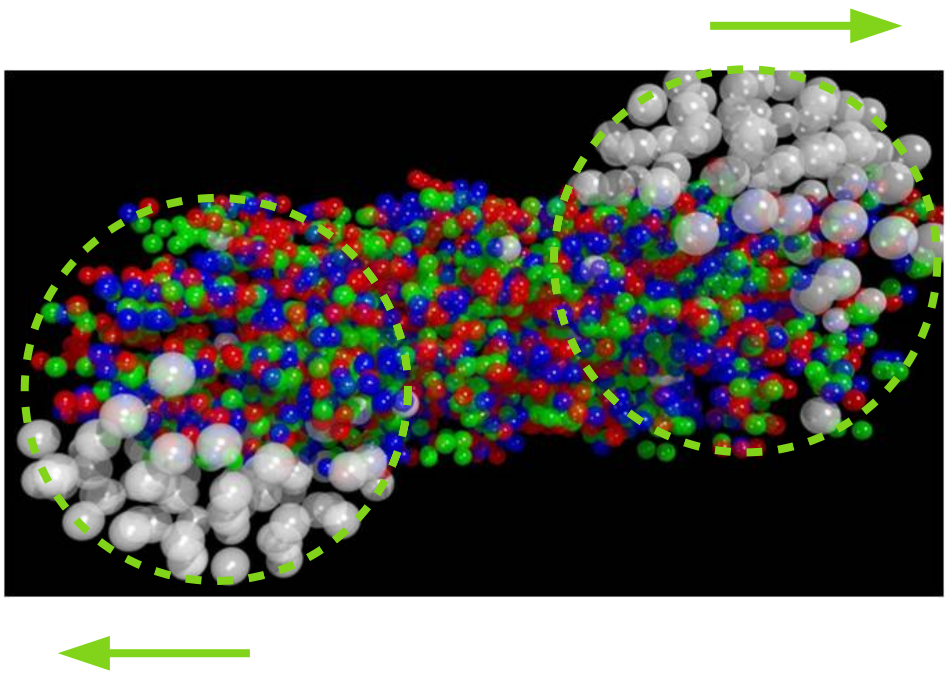
Non-perturbative domain
for low energy densities

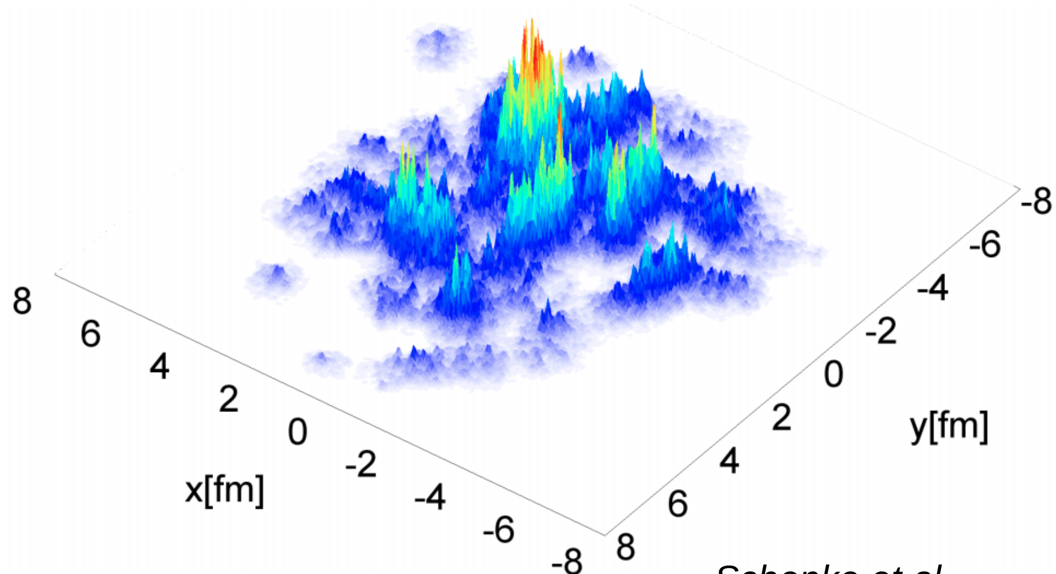
Corke and Sjostrand
JHEP 01 (2010) 035

MPI in heavy-ion collisions

- Heavy-ion collisions present a scenario that is characterized by an extreme degree of MPI.
- A fully overlapping collision between two lead nuclei, with other 200 nucleons each, may lead to as much as 1000 binary nucleon collisions. Each individual binary collision may additionally induce multiple partonic scatterings, allowing for several thousands of MPI in a single event.

Scattering between the incoming nuclear PDFs → Initial state in the transverse plane in a heavy-ion collision





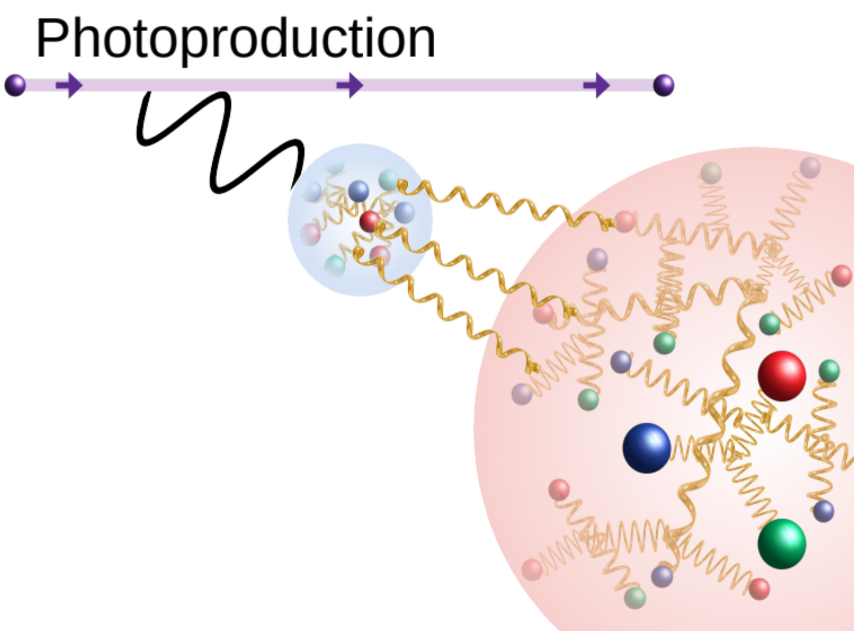
Schenke et al.
PRL 108 252301 (2012)

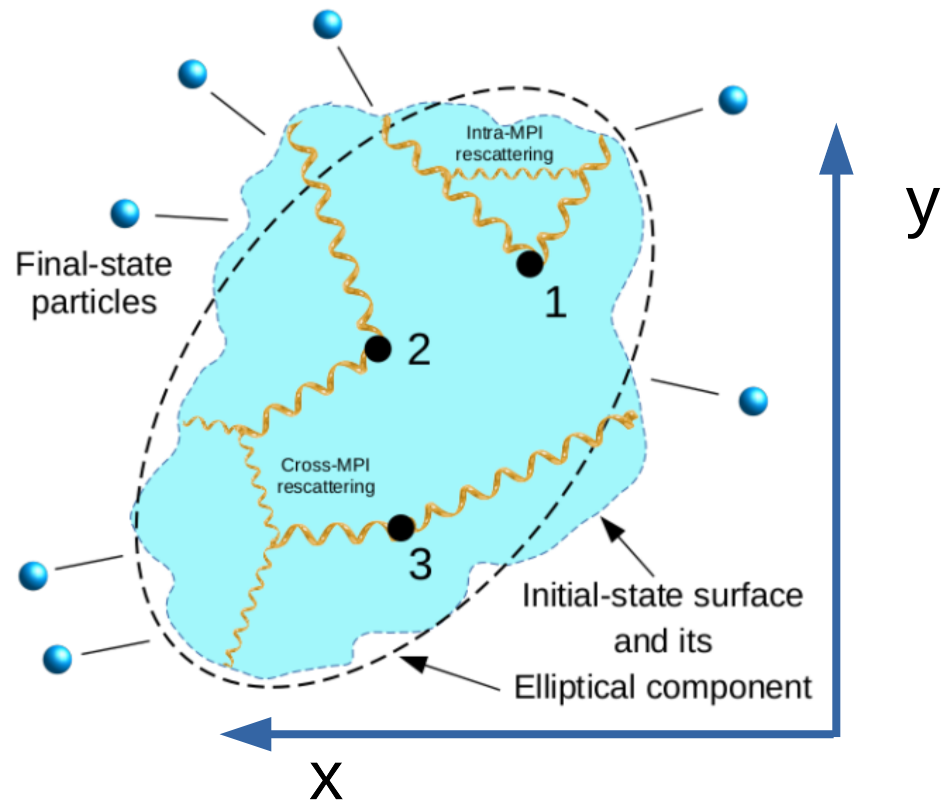
- The matter that is left behind after the initial scattering between the incoming PDFs is called the **initial state**.

Search for MPI in ep photoproduction

- Resolved photoproduction offers an interesting opportunity to search for multiple $2 \rightarrow 2$ parton scatterings between the proton and photon PDFs in ep scattering.
- The initial state is irregular and is the foundation for a possible rescattering stage.

Scattering between the incoming PDFs → Initial state (turquoise)





- Black circles on the right are analogous to the spikes on the previous slide.
- Gluons are drawn to illustrate rescattering.

Azimuthal correlations to probe collective behaviour and MPI

The correlation functions used in this analysis are defined as:

<u>2-particle azimuthal correlations</u>

$$c_n\{2\} = \langle \cos\left(n(\varphi_1 - \varphi_2)\right)\rangle$$

harmonic

Azimuthal angles of particles

Borghini, Dinh, Ollitrault
PRC 64 054901

<u>4-particle azimuthal cumulant</u>

$$c_n\{4\} = \langle \cos\left(n(\varphi_1 + \varphi_2 - \varphi_3 - \varphi_4)\right)\rangle - \underbrace{2\,\langle \cos\left(n(\varphi_1 - \varphi_3)\right)\rangle \langle \cos\left(n(\varphi_2 - \varphi_4)\right)\rangle}_{\text{Explicit removal of 2-body “non-collective” bkg correlations}}$$

- What’s left, after the subtraction, is a measure of “genuine” 4-particle correlations and suppresses few body contributions.
- More robust probe of collectivity.

Data samples

ZEUS data

Dataset	All events	T	T+V+O PhP (DIS)	T+V+O+$N_{\mathrm{ch}} > 20$ PhP (DIS)
03p	3.7 M	0.99 M	0.27 M (0.2)	0.031 M (0.001)
04p	47.5	12.6	3.7 (4.7)	0.455 (0.019)
05e	130.0	43.9	14.8 (16.4)	1.972 (0.082)
06e	44.2	13.4	4.5 (7.0)	0.726 (0.034)
06p	86.6	26.3	9.3 (11.8)	1.402 (0.053)
07p	41.2	11.1	3.7 (5.4)	0.524 (0.022)
Total	353.2 M	108.3 M	36.3 (45.5)	5.110 M (0.211)

Table 1: *Real data samples and event tallies for the PhP (DIS) analysis. The analyzed real data samples and number of events. T = Trigger selections, V = Vertex cuts, O = Offline cuts. v08b orange nTuples used.*

PhP MC: Pythia light-flavor jet

- Used for efficiency and trigger-bias corrections
- Ariadne and Lepto used for the DIS part of the analysis.

Dataset and code names	All events	T	T+V+O	T+V+O+$N_{\mathrm{ch}} > 20$
light-flavor jet 0304p cny324, cnx324, cnw324, cn3z24	128.2 M	14.2 M	8.9 M	1.0 M
light-flavor jet 05e dsmr25	121.4	14.0	8.9	0.9
light-flavor jet 06e etrr26	149.5	17.3	11.1	1.3
light-flavor jet 0607p fiw627	195.5	22.7	14.4	1.5
Total	594.6 M	68.2 M	43.3 M	4.7 M

Table 2: *The analyzed Pythia light-flavor jet PhP MC samples and number of events. MC $Q^2 < 2$. Both direct and resolved components were summed together. T = Trigger selections, V = Vertex cuts, O = Offline cuts. v08b orange nTuples used.*

Event selection

Trigger selection

	TLTs
PhP	HFL 1 || 5 || 21 || 28
DIS	DIS 1, 2, 3, 4, 5, 6, 11 SPP 1, 2, 3, 9 HFL 17, 31

N_{ch} >= 20
for all figures

Primary vertex selection

	V_z	V_{xy}	$N_{vtx\ tracks}$	$N_{vtx\ tracks} / N_{tracks}$	Event vertex $\chi^2 / N_{vtx\ tracks}$
PhP & DIS	-30 < Vz < 30 cm	< 0.5 cm	>= 1	> 0.15	< 50

Offline selection

	Electron probability	Q2	Electron theta	Electron energy	E - Pz	Sinistra CAL entrance locations
PhP	< 0.9	No cut	No cut	< 15 GeV	< 55 GeV	No cut
DIS Q2 scan *Same cuts as past DIS analysis*	> 0.9	> 5 GeV	> 1 rad	> 10 GeV	47 to 69 GeV	Listed in DIS AN and paper

Track selection & multiplicity definitions

Reconstructed track selection criteria:

- ZTT track type
- At least 1 MVD hit
- DCA xy, z < 2 cm
- $0.1 < p_T < 5.0$ GeV
- $-1.5 < \eta < 2$
- $\Delta R > 0.4$ (DIS only)

MC generator particle selection criteria:

- Long-lived primary charged hadrons with mean proper lifetime $\tau > 1$ cm, which were produced directly or from the decay of a particle with $\tau < 1$ cm.
- $0.1 < p_T < 5.0$ GeV
- $-1.5 < \eta < 2$

Multiplicity definitions:

- N_{rec} = # of reconstructed tracks satisfying selection criteria.
- N_{gen} = # of generated particles satisfying selection criteria.
- N_{ch} = # of charged particles in data
  - determined with weights (as done in past DIS analysis)
  - or by an unfolding procedure for the N_{ch} distribution itself.

Correlations are measured as a function of:

- 2-particle correlations: $\Delta\eta = | \eta_1 - \eta_2 |$ & $\langle p_T \rangle = (p_{T,1} + p_{T,2}) / 2$
- 4-particle cumulants: p_T particle of interest (poi), which is the p_T of particle 1.

Challenges to an inclusive PhP analysis

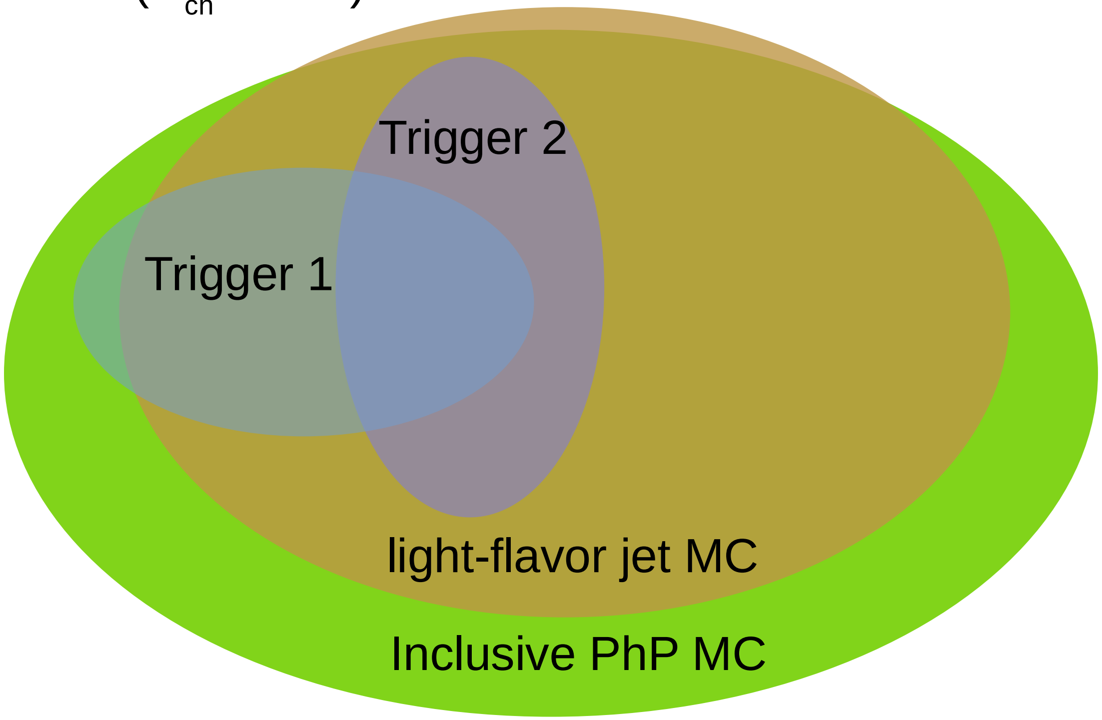
1) **PhP Monte Carlo investigations:** we don't have an inclusive PhP MC dataset.

- Employed MC---"light-flavor jet"---has a jet pre-selection at generator level. An additional correction is applied based on newly generated PYTHIA with and without the known jet bias.
- This implies that the extracted tracking efficiency and trigger-bias corrections are not quite correct.

2) **Trigger investigations:** we don't have an inclusive set of triggers in PhP.

- Use a cocktail of certain triggers and correct for biases with Monte Carlo simulations.

However, these problems can be largely avoided simply by analyzing only high-multiplicity events (N_{ch} >= 20).

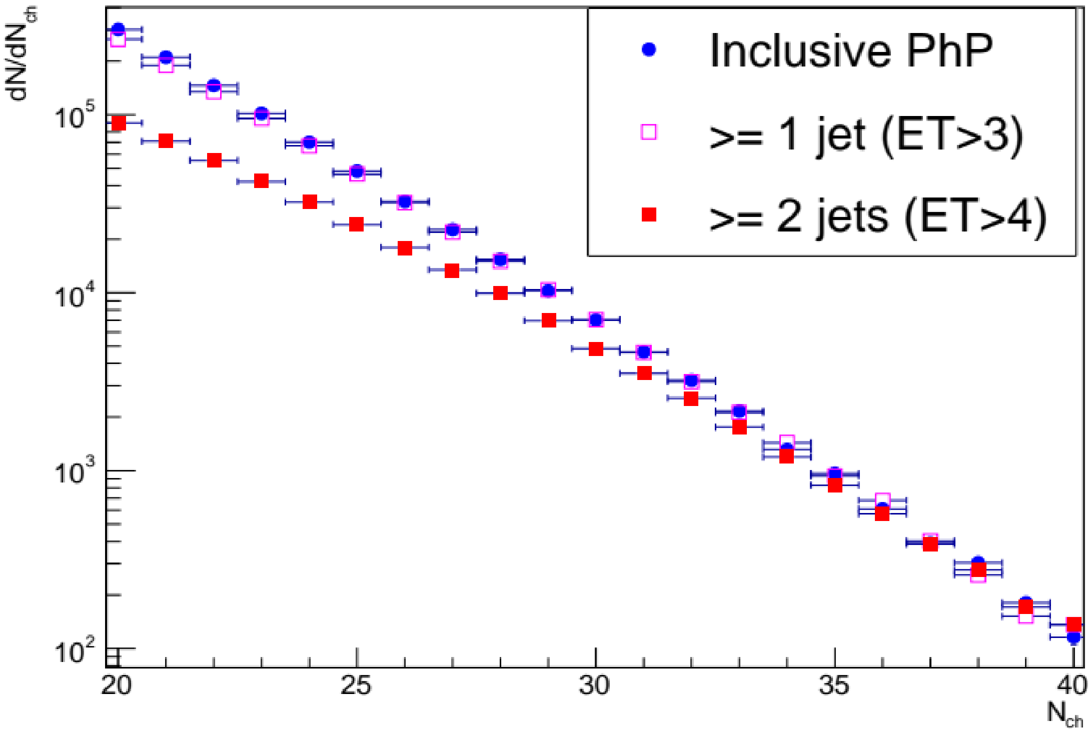


PhP Monte Carlo investigations:
Sequential reduction of MC phase-space with the jet requirements

Pythia 8.303
PHP MC

Light-flavor jet emulation:
At least 1 massless jet with ET > 3 GeV and |y| < 3.0.

Light-flavor dijet emulation:
At least 2 massless jets with ET > 4 GeV and |y| < 3.0.



1 million inclusive PHP pythia events with Nch >= 20 generated.

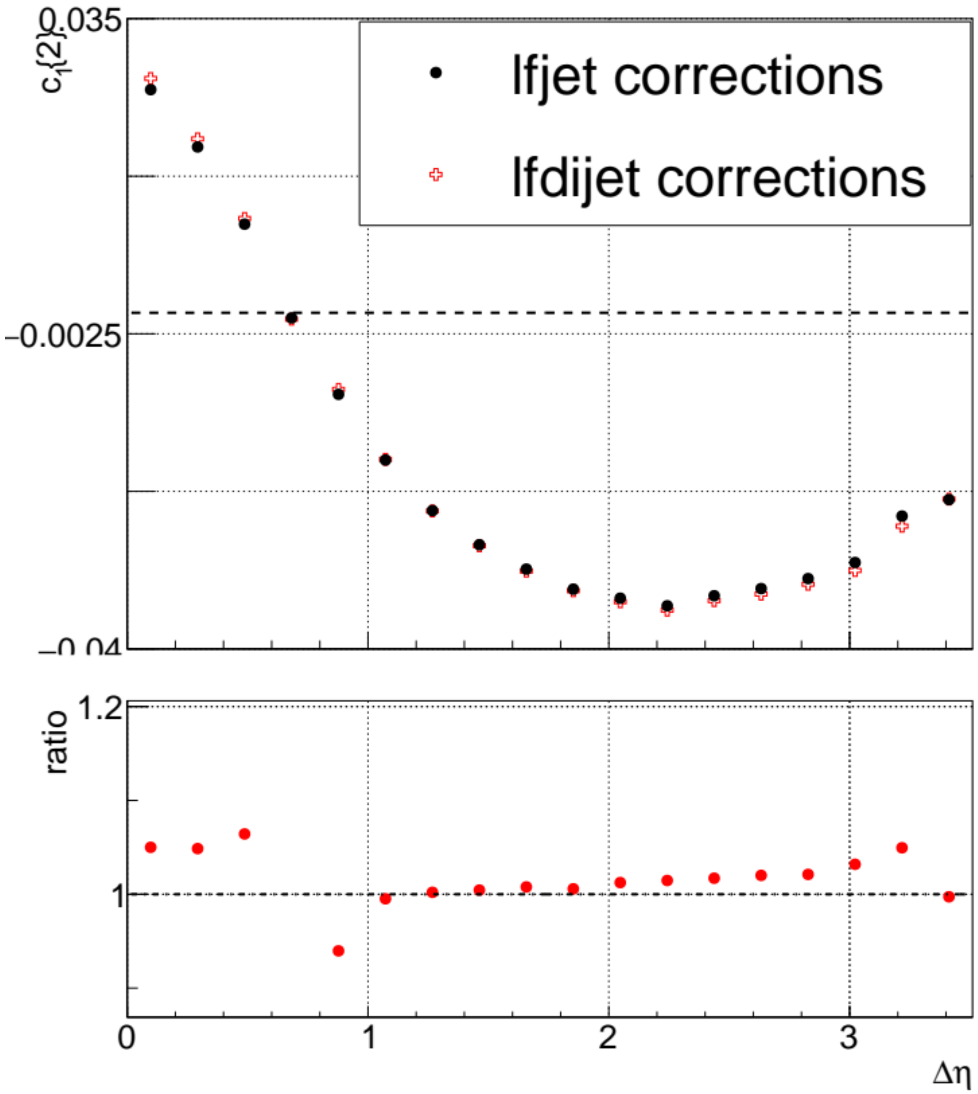
8% of events rejected with 1 jet cut.

61% of events rejected with 2 jet cut.

More studies can be found in a previous presentation.

PhP Monte Carlo investigations:
Systematic uncertainty

ZEUS



Assess the effect of missing phase-space in light-flavor jet MC by comparing the results to those obtained using light-flavor **dijet**

Two-particle correlations vary by <~ 5% and this is assigned as the systematic uncertainty caused by the non-inclusive PhP Monte Carlo sample utilized.

Application of correction factors

For the multiplicity distribution, we unfold using the response Matrix ***R*** (N_{gen} x N_{rec})

$$N_{ch} = \frac{N_{gen,lfjet}}{N^{Trigger}_{gen,lfjet}} \, R \, N_{rec}$$

For the other results, we use weights: $w^{(n)}$ = 1 / efficiency

n = 1 (dN/dpT and dN/dη),
n = 2 ($c_n\{2\}$)
n = 4 ($c_n\{4\}$)

$$D_{corrected} = \frac{D_{lfjet}}{D^{Trigger}_{lfjet}} \, w^{(n)} \, D_{rec}$$

$$D \in \{\frac{dN}{dp_T}, \frac{dN}{d\eta}, c_n\{2\}, c_n\{4\}\}$$

The corrections to the correlation functions can be much larger where they cross zero

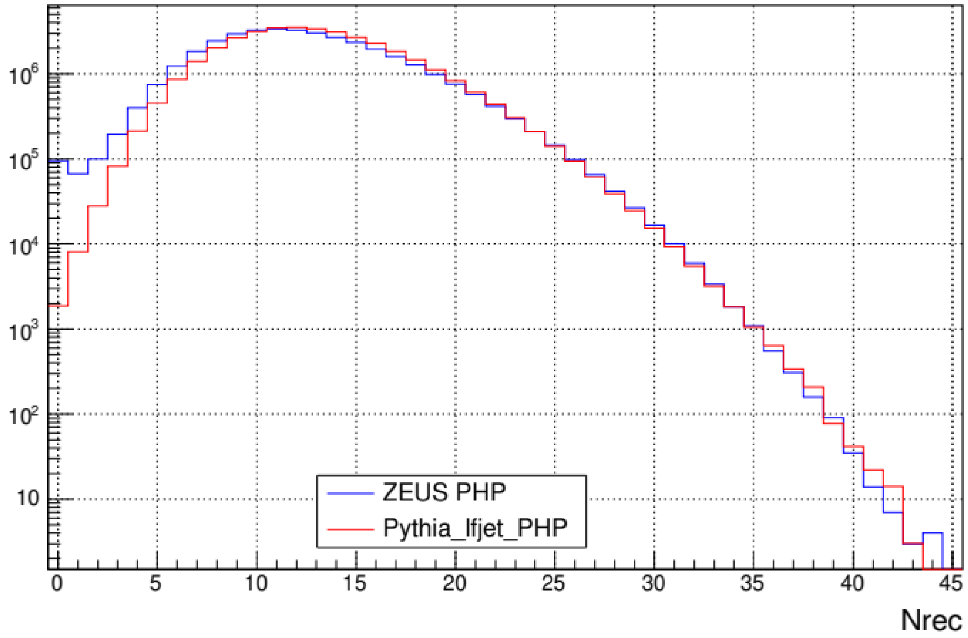
Typically a ~30% correction extracted from the light-flavor jet MC

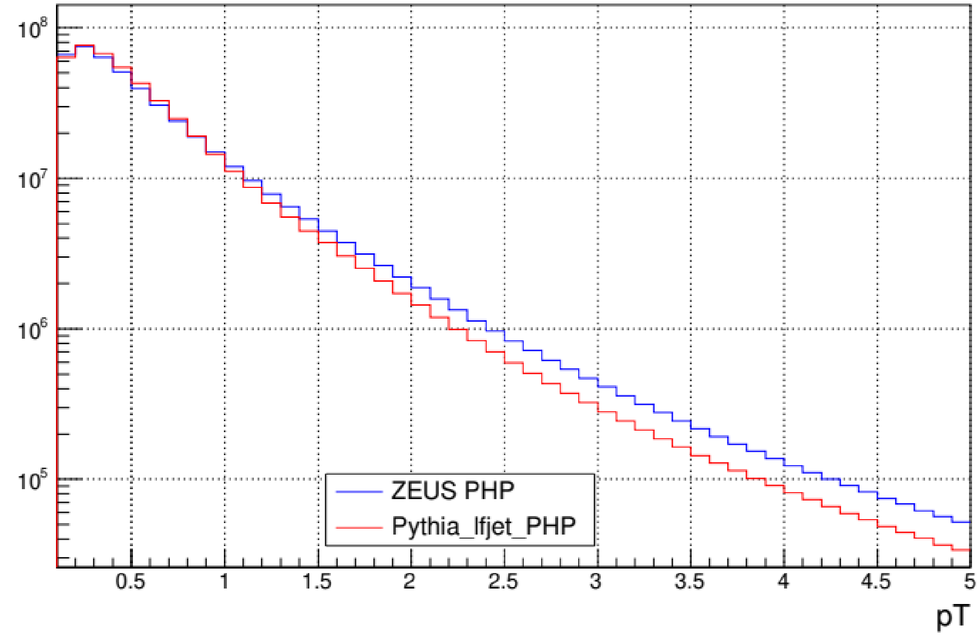
Typically a ~10% correction extracted from the light-flavor jet MC

Example Control Plots

Comparison of reconstruced quantities in ZEUS and MC (no corrections applied).

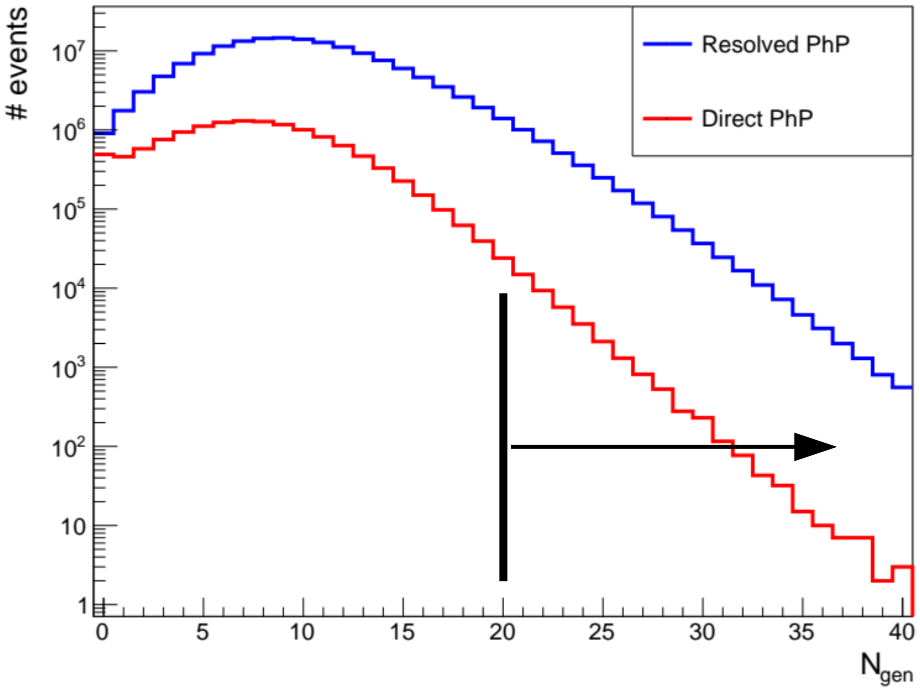
PhP offline cuts and HFL cocktail triggers applied to both.

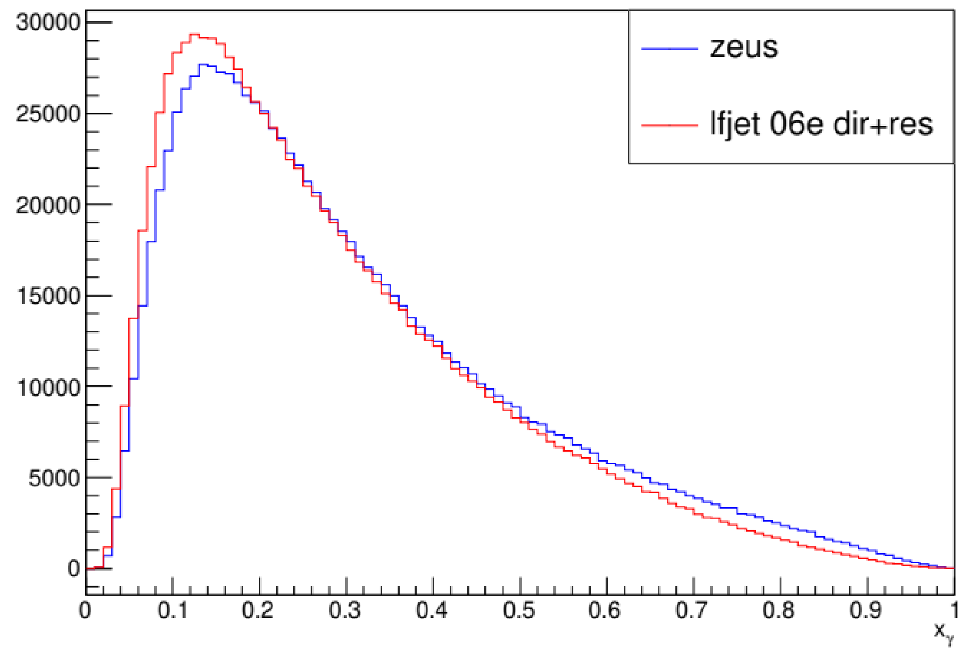




- Agreement between data and MC is reasonable.
- Eta and phi distributions show a similar level of agreement.
- **A supplementary note created to store auxiliary figures can be found here.**

Direct vs resolved:
Multiplicity distributions and x-gamma





- At high multiplicity (Nch >= 20), the fraction of direct PhP is expected to be ~ 1.5%.
- x-gamma in data and MC are in reasonable agreement at high multiplicity.
- **A supplementary note created to store auxiliary figures can be found here.**

Table of systematic variations

Source of systematics	Reference (default)	Variation
MC nonclosure	Generator level distributions and correlations	Efficiency corrected reconstructed distributions and correlations
Track DCA variation *	$DCA_{xy,z} < 2$ cm	$DCA_{xy,z} < 1$ cm
Efficiency correction	PhP: Direct + Resolved DIS: Ariadne	PhP: Resolved only DIS: Lepto
Primary Vertex positions **	$-30 < Vz < 30$ cm	$Vz < 0$, $Vz > 0$
Low-pT tracking efficiency	With corrections from Libov & Bachynska	without
Data-taking conditions * **	All HERA II data: 2003-2007	Individual periods weighted by their relative contribution
PhP MC light-flavor jet bias	Efficiency and trigger-bias corrections extracted from light-flavor jet MC	Extracted instead from light-flavor **dijet** MC
PhP triggers *	Trigger cocktail: HFL 1 || 5 || 21 || 28	HFL 5, 28
PhP offline cuts	$P_e < 0.9$ && $E - Pz < 55$ GeV && $E_e < 15$ GeV	$P_e < 0.98$ && $E - Pz < 65$ GeV && $E_e < 30$ GeV

Total Systematic Uncertainty: ~10-50% for 2-particle correlations

* = symmetrised uncertainty.
** = each variation weighted by their relative contribution.

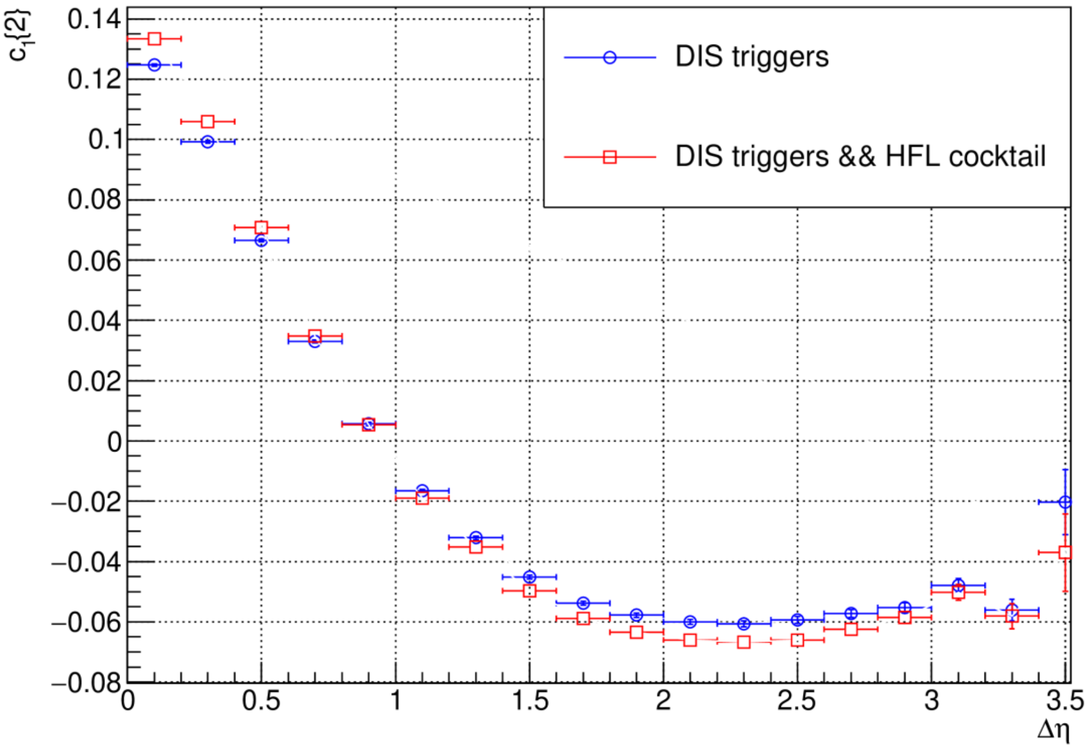
Removed 1 source of systematic uncertainty since the pre-EB meeting

Another way to assess the trigger bias to an inclusive PhP analysis
is to compare the results obtained from:

- the **known inclusive DIS triggers**

to

- the DIS + HFL cocktail triggers.

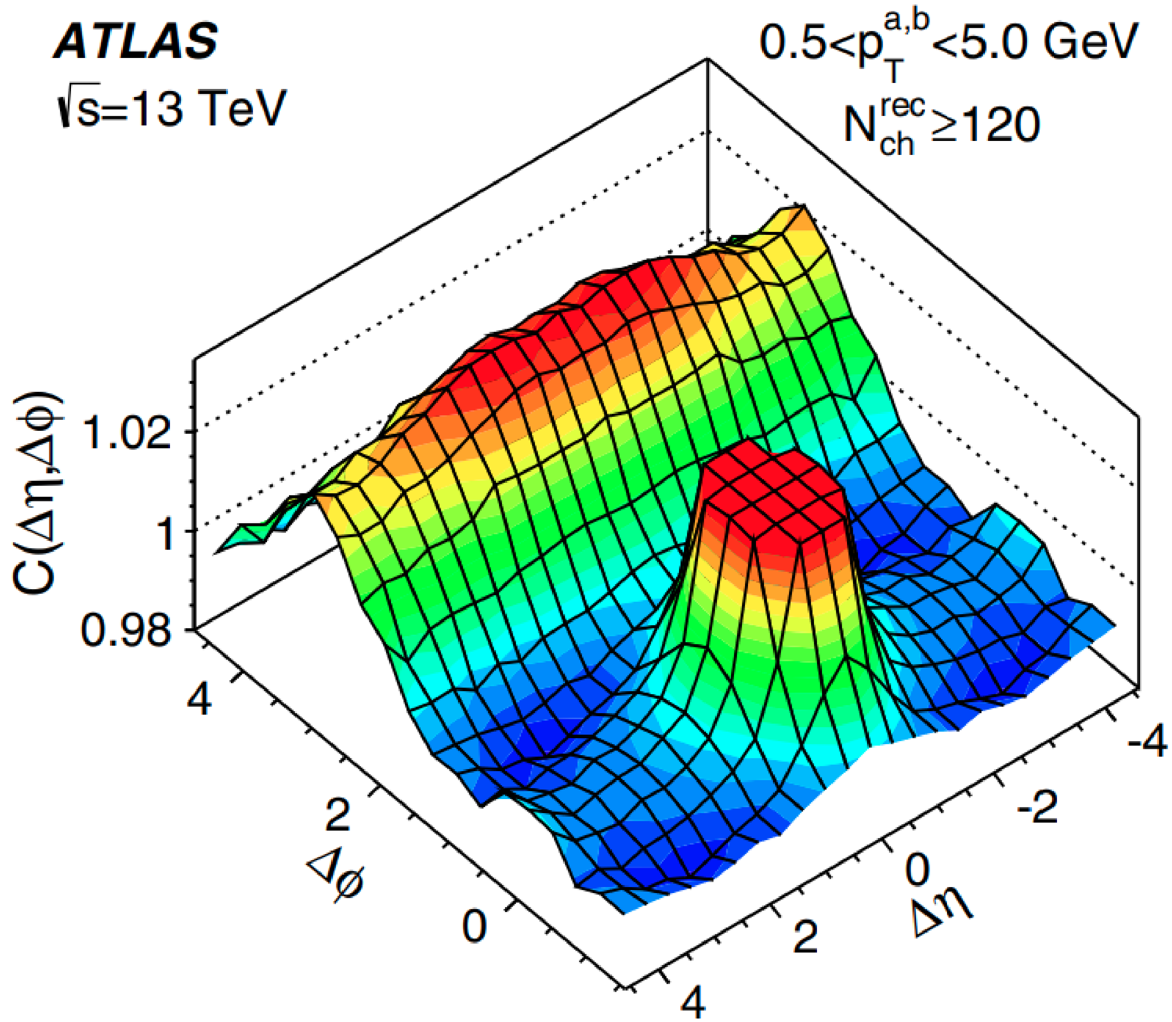


This full bias was previously used as a systematic uncertainty.

However, since we apply a trigger-bias correction, the full bias itself is an excessive systematic uncertainty.

Topic 1:
Search for collective behaviour in PhP and DIS

Collective behaviour observed in high multiplicity pp collisions @ LHC

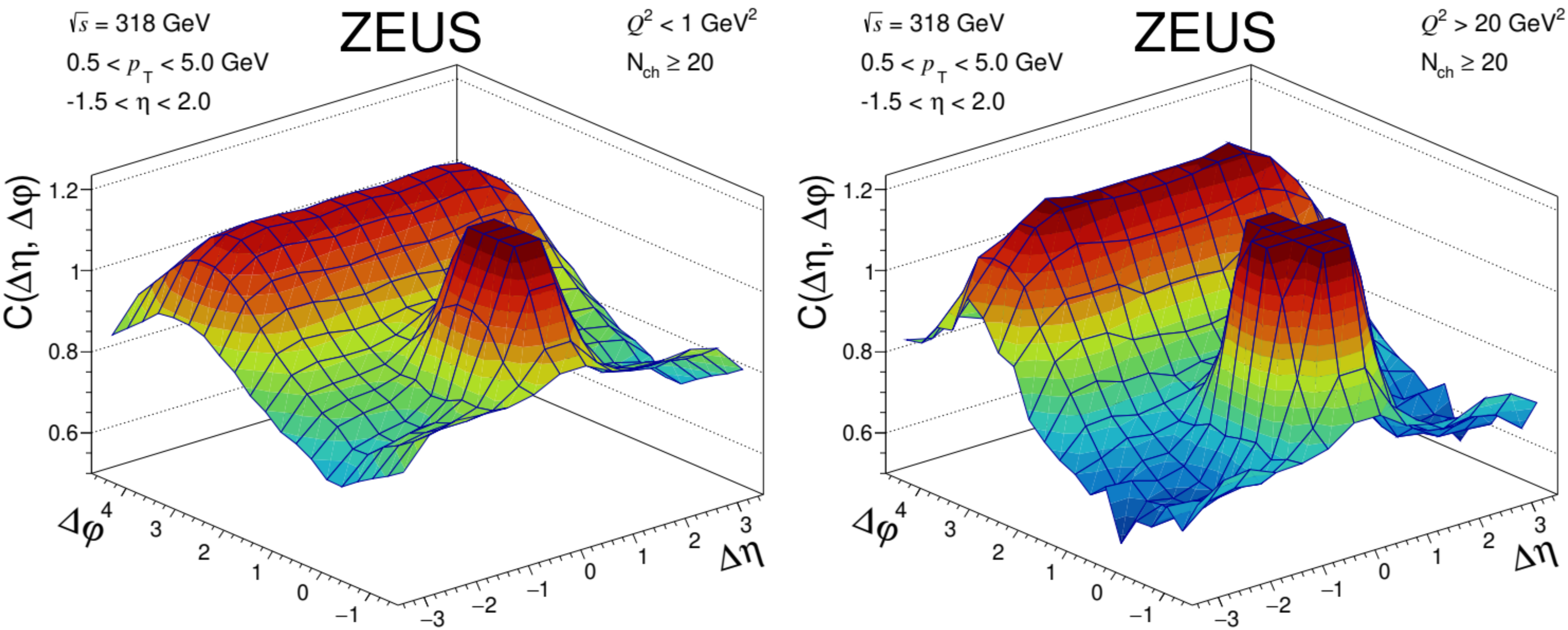


PRL 116 172301 (2016)

- A “double ridge” is visible at Δφ = 0, Δφ = pi.
- This resembles observations made in heavy-ion collisions and came as a surprise when they were observed in pp @ LHC.

Ridge plots from this analysis

There is no clear indication of a double ridge in neither photoproduction nor NC DIS at $Q^2 > 20$ GeV^2.

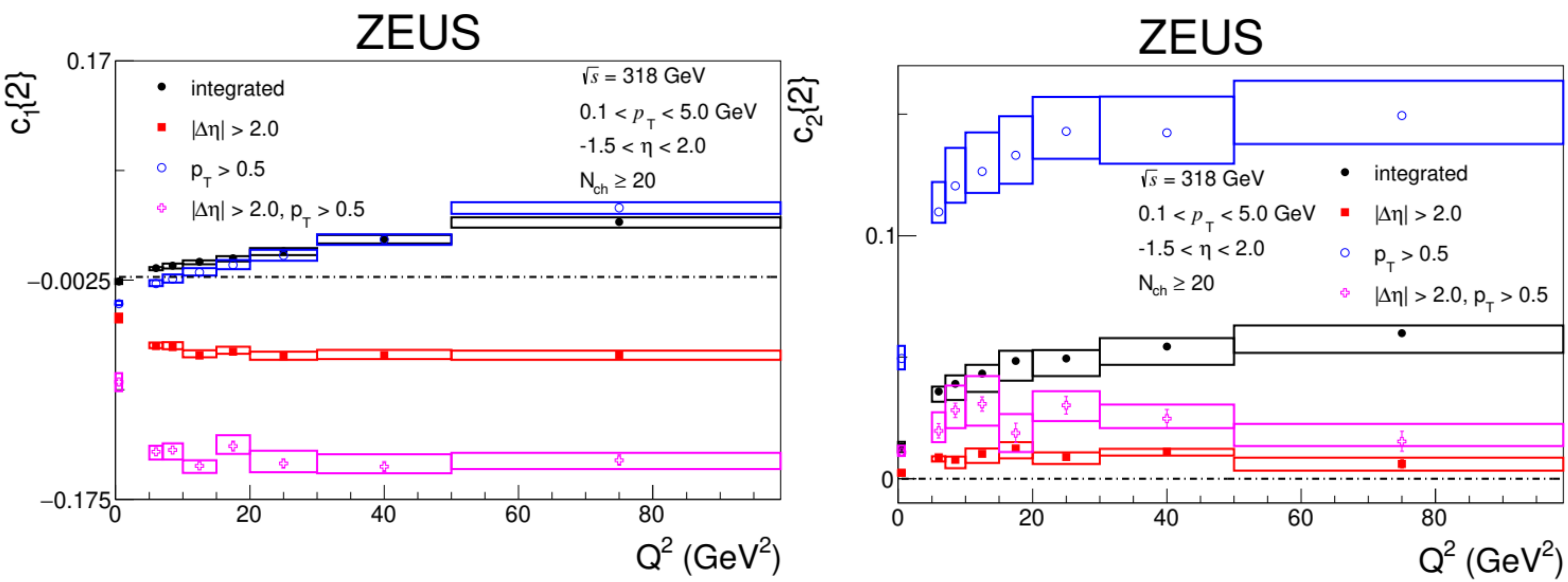


Physics conclusion:
No sign of significant collective behaviour in *ep* scattering at HERA

Q^2 dependence of two-particle azimuthal correlations

The evolution of two-particle correlations with Q^2 clearly demonstrate that their strength in photoproduction is significantly smaller than in DIS.

Long-range ($\Delta\eta > 2$) correlations observed here with **$c_1\{2\}$ are much more negative than $c_2\{2\}$ is positive**, which is not indicative of the kind of the collective behaviour associated with heavy-ion collisions.

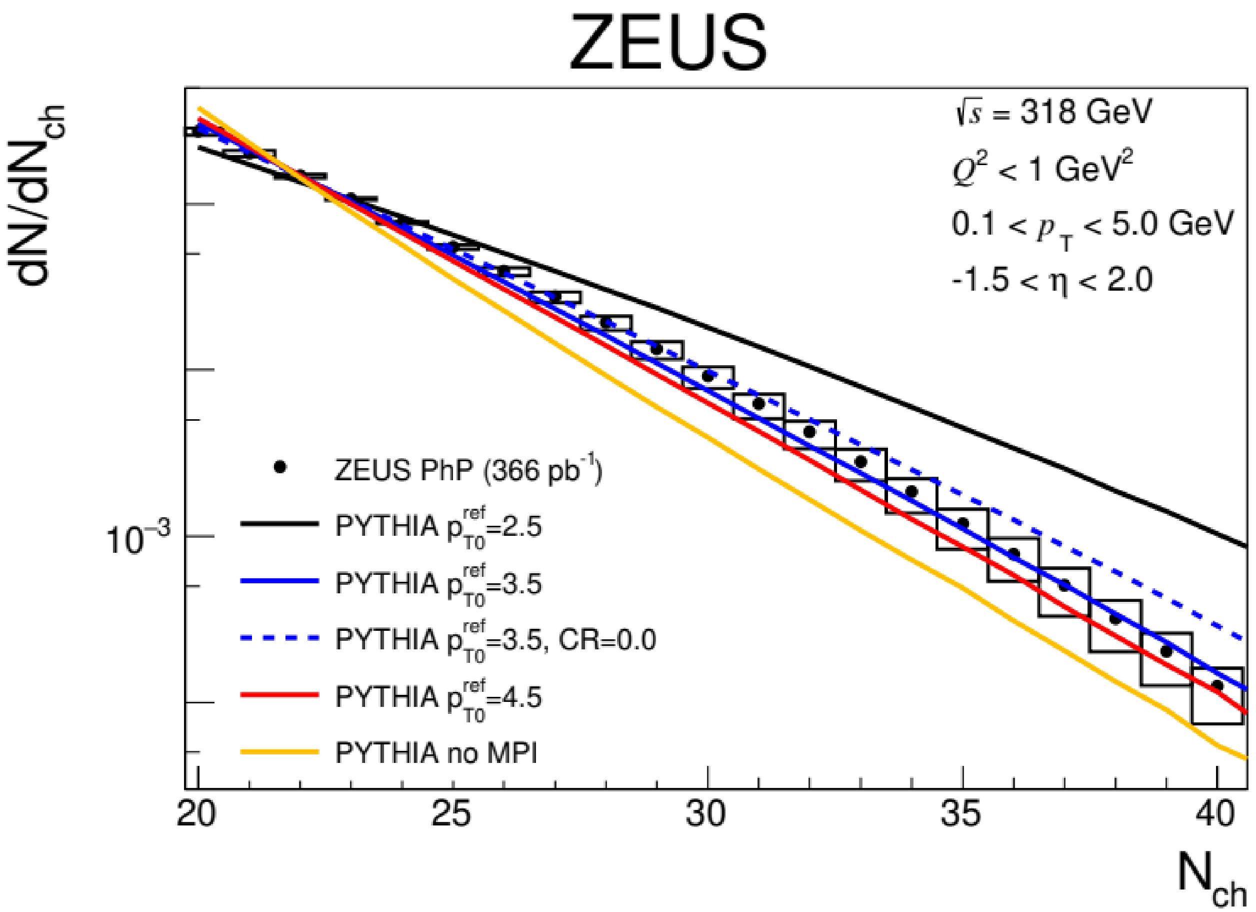


Physics conclusion:
No sign of significant collective behaviour in *ep* scattering at HERA

Topic 2:
Search for MPI in photoproducion

Multiplicity distribution in photoproduction and comparisons to PYTHIA predictions

The main PYTHIA parameter we investigate in PhP is the p_{T0}^{ref} parameter, which regulates the IR divergence in perturbative QCD and adjusts the degree of MPI.



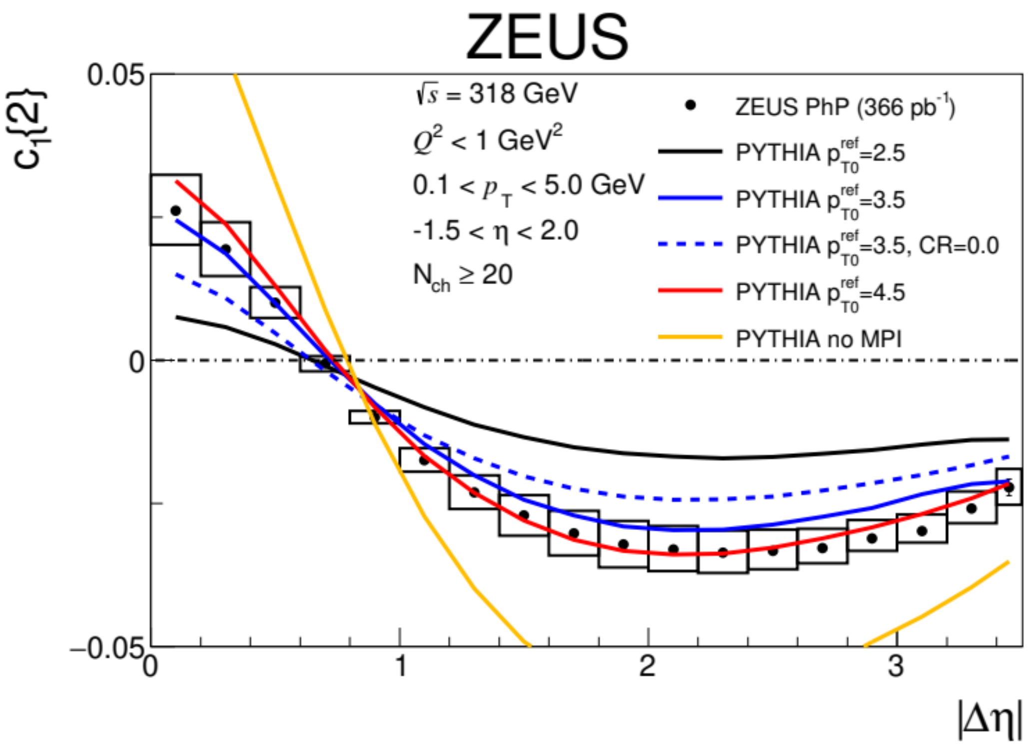
- Each curve has different degrees of MPI.
- Smaller p_{T0}^{ref} → more MPI.
- Colour reconnection, which is analagous to cross-MPI rescattering, is switched off for the dashed blue line.

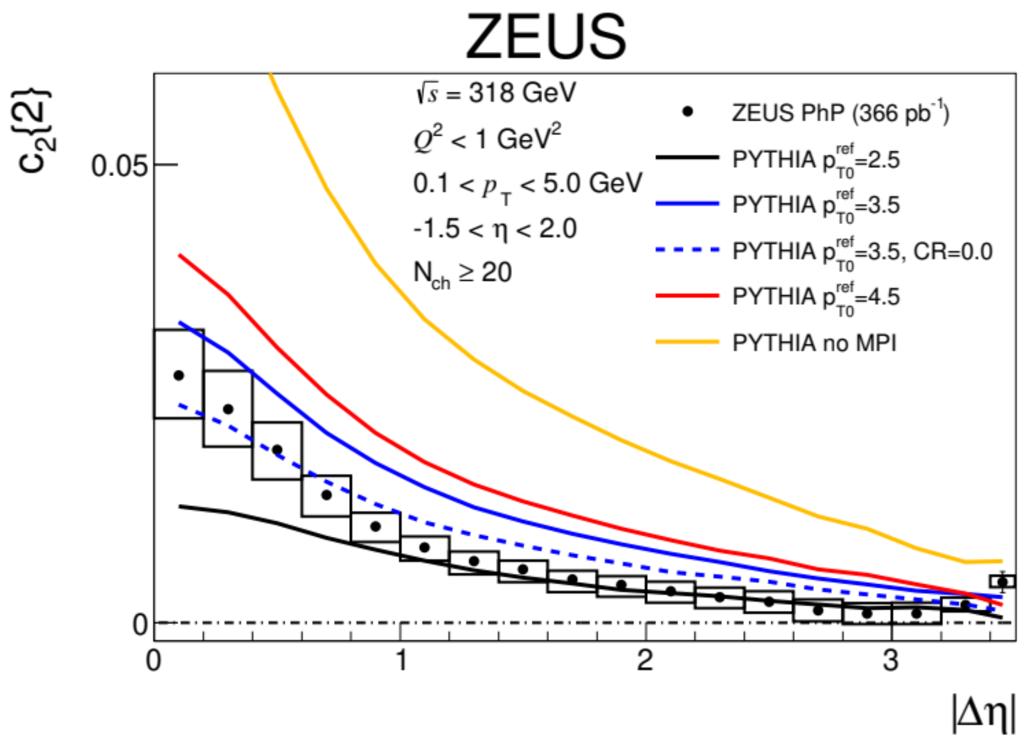
Two-particle correlations in PhP compared to PYTHIA

Comparison of photoproduction measurements to PYTHIA:

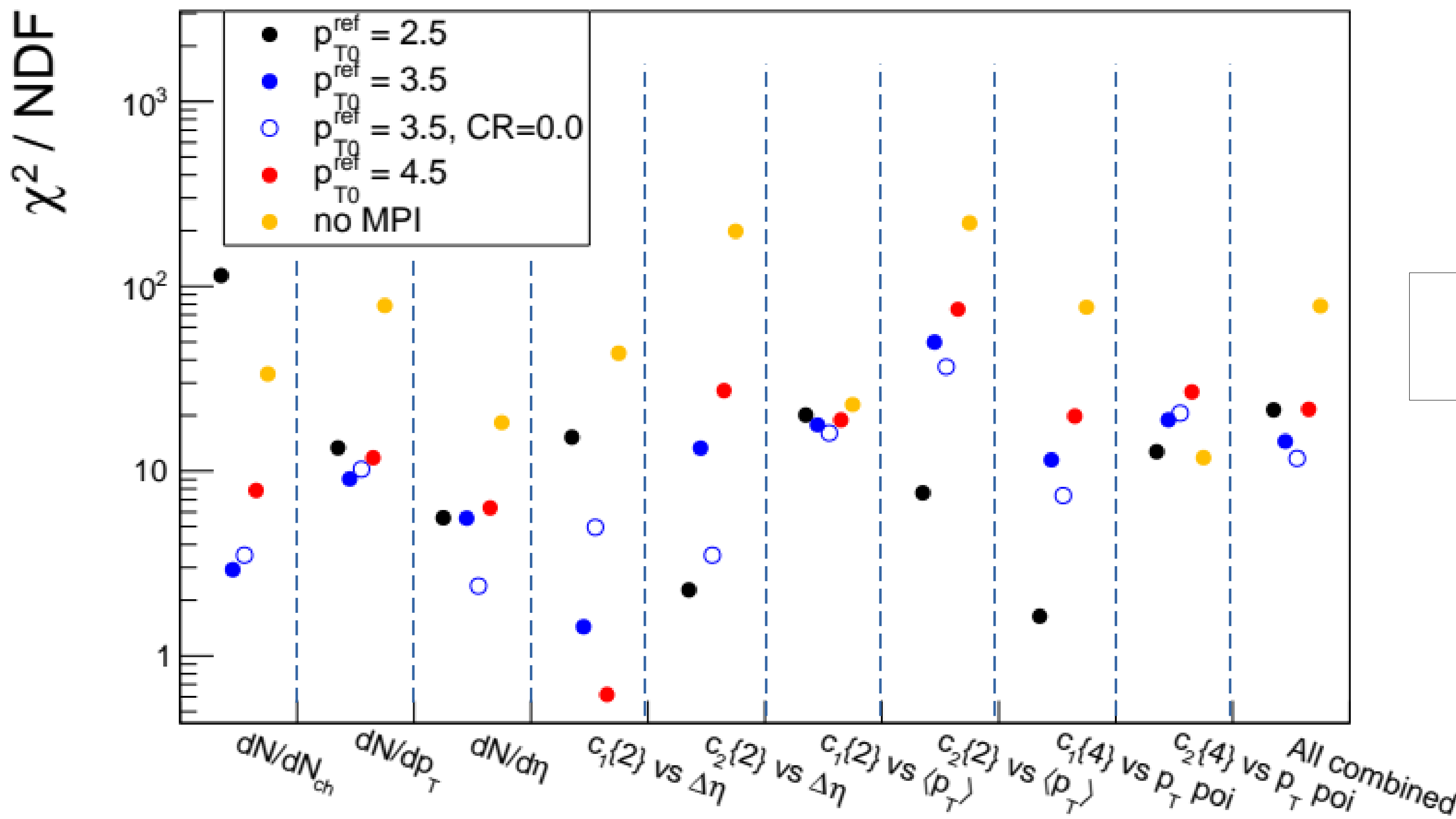
While there is no consistent preference of the p_{T0}^{ref} parameter in PYTHIA from such comparisons, it is clear that the no MPI scenario is never favored.

For the PYTHIA distributions and correlation function projections sensitive to MPI, the comparison to data provides a strong indication of MPI.





Condensed summary plot of comparisons to PYTHIA



New figure
Could be added to paper
or additional material

- The no MPI scenario is clearly the least favored.
- Clearly shows which observables are most sensitive to MPI.

Physics conclusion: strong indication of MultiParton Interactions (MPI) in photoproduction at HERA

Figures for publication

with captions

Figure 1

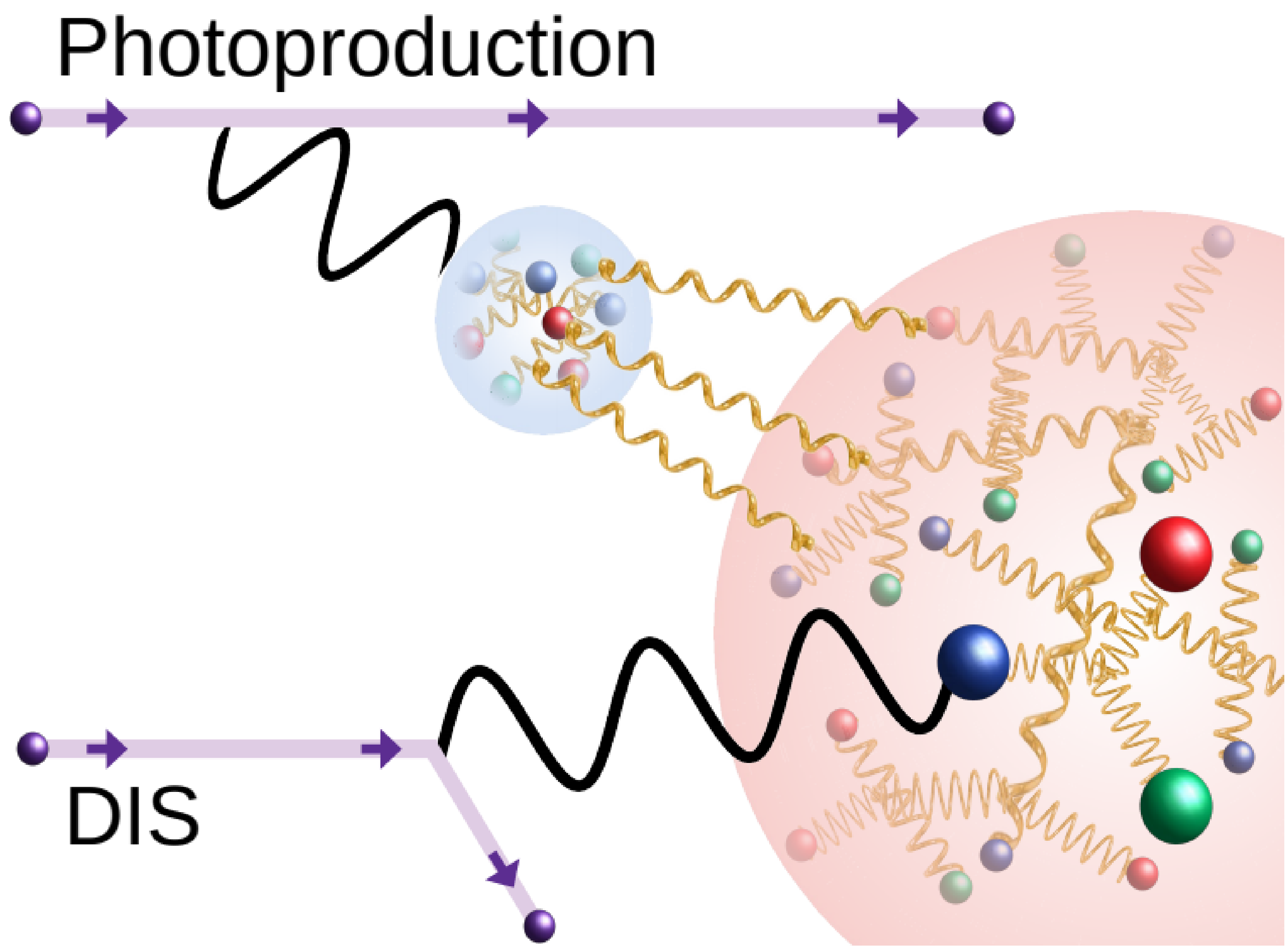


Figure Caption: Illustration of the initial scattering in two separate scenarios: resolved photoproduction and deep inelastic scattering at the top and bottom, respectively. The electron beam is represented by the lines with arrows. The proton and photon PDFs are shown as large and small pale circles, respectively. The exchanged photon is shown as a wavy line. Quarks are shown as spheres while gluons are shown as springs.

Figure 1 variants

Split PhP and DIS
into separate panels

Fig 1a

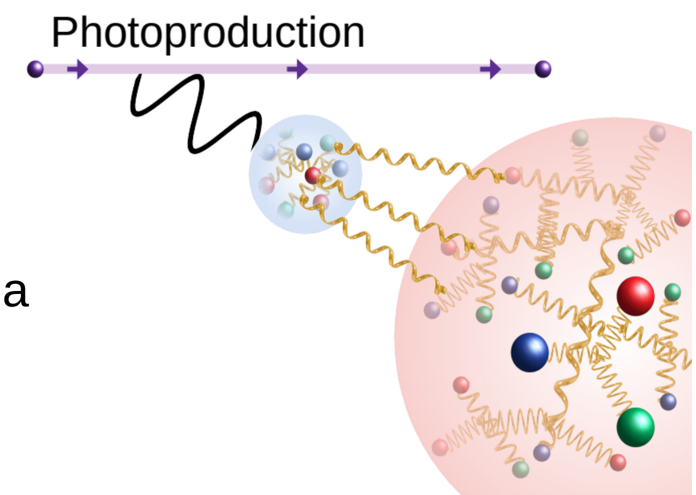
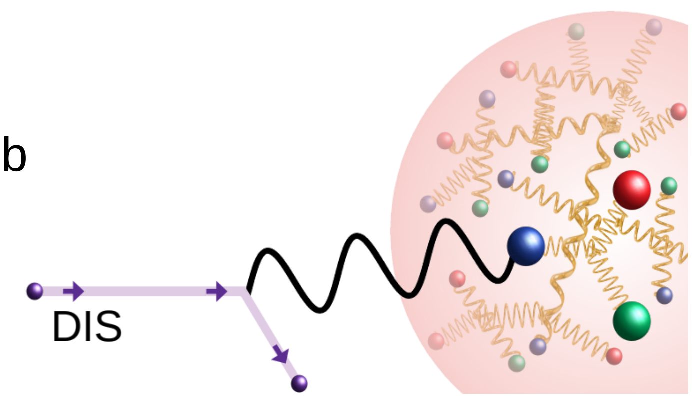
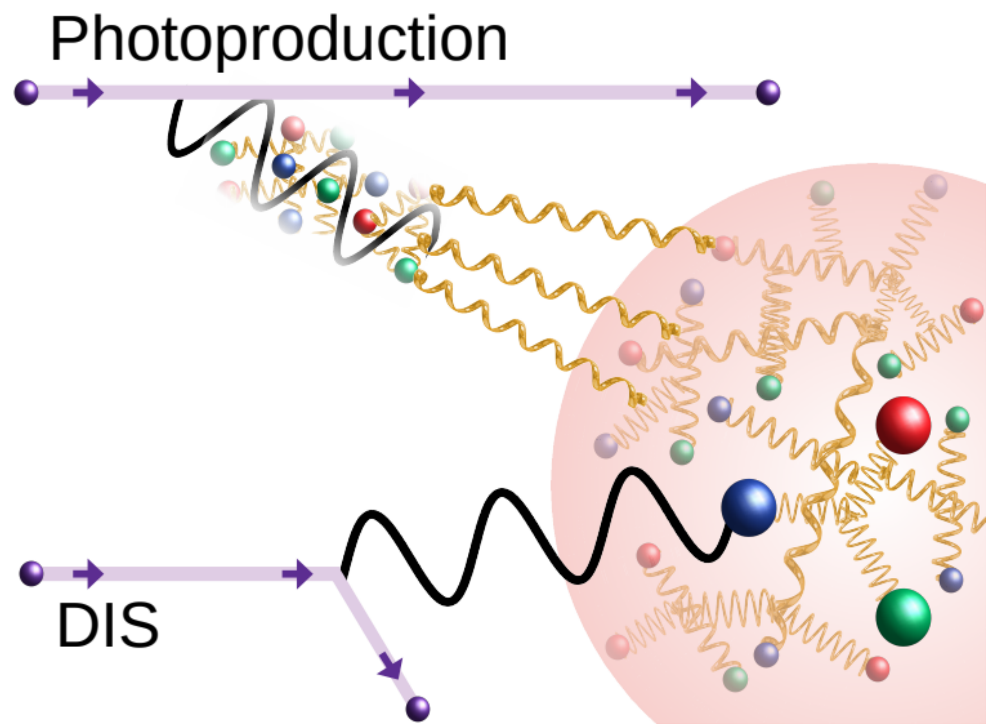


Fig 1b



Photon fluctuates back and forth
into hadronic matter



- Any other suggestions?

Figure 2

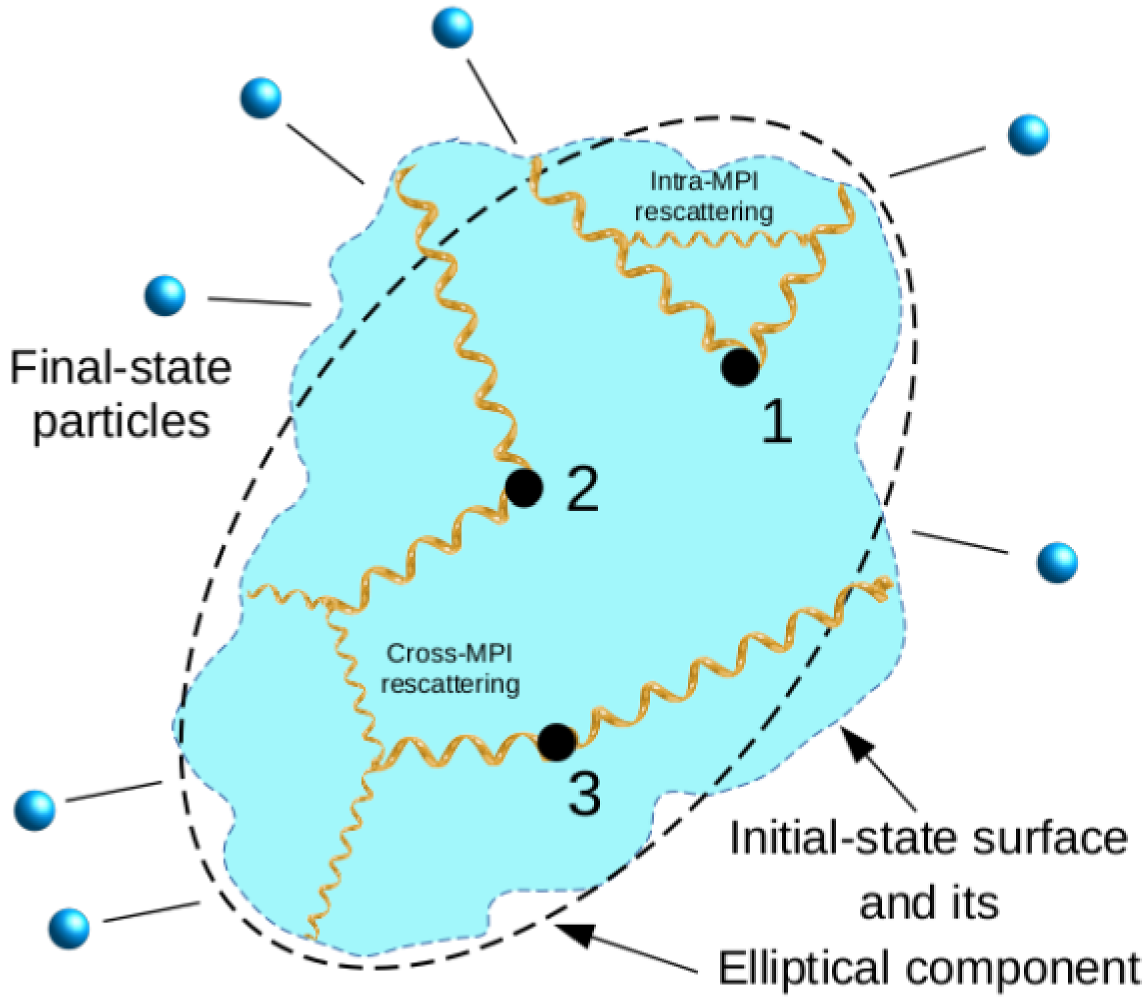
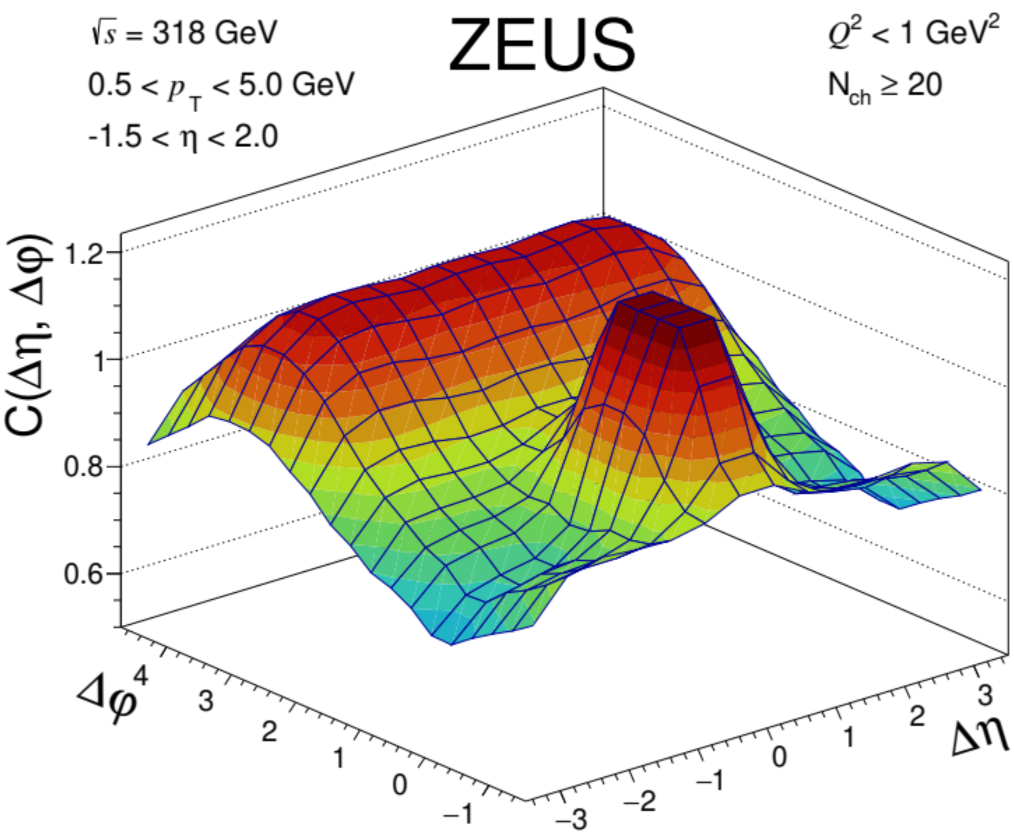


Figure Caption: Transverse view of the evolving collision zone after the initial scattering in resolved photoproduction. Three multiparton interaction (MPI) centers are shown with circles and act as sources of gluons. The possibilities of intra- and cross-MPI rescattering are illustrated near the top and bottom, respectively. Cross-MPI rescattering is akin to colour reconnection in PYTHIA. An initial state with a dominant elliptical eccentricity is shown.

Figures 3 & 4



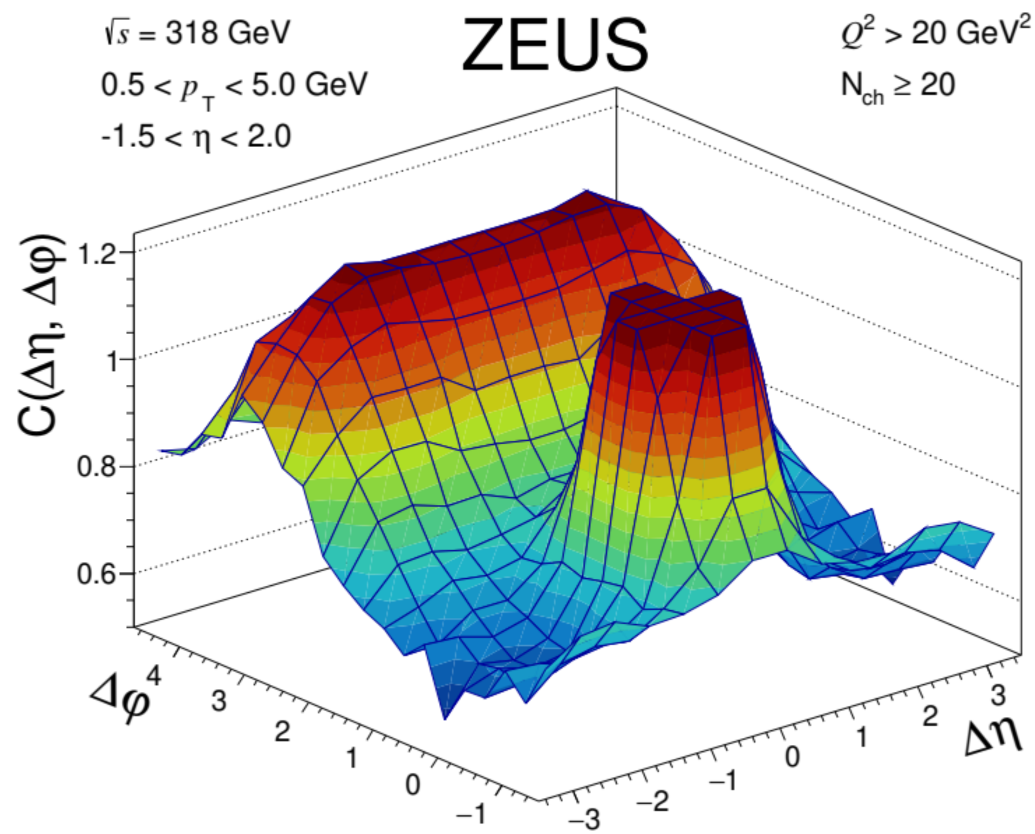


Figure Caption: Two-particle correlation C(Δη, Δφ) in photoproduction and NC DIS for Q^2 > 20 GeV^2. The peaks near the origin have been truncated for better visibility of the finer structures of the correlation. The plots were symmetrised along Δη. No statistical or systematic uncertainties are shown.

Figures 5 & 6

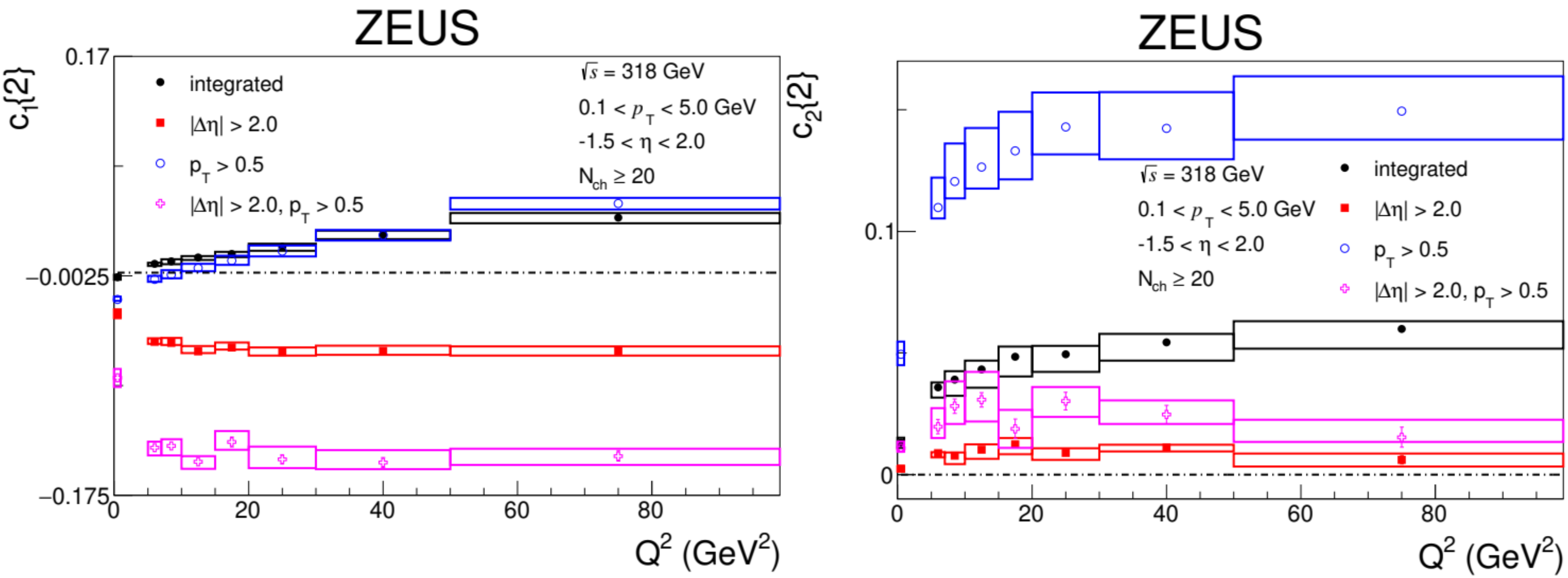


Figure Caption: Two-particle correlations $c_1\{2\}$ and $c_2\{2\}$ versus Q^2 with and without a rapidity separation, and for low- and high-p_T intervals. Photoproduction data is for $Q^2 < 1$ GeV^2, while NC DIS is for $Q^2 > 5$ GeV^2. Zero for $c_1\{1\}$ and $c_2\{2\}$ is indicated with a dot-dashed line. The statistical uncertainties are shown as vertical lines although they are typically smaller than the marker size. Systematic uncertainties are shown as boxes.

Figure 7

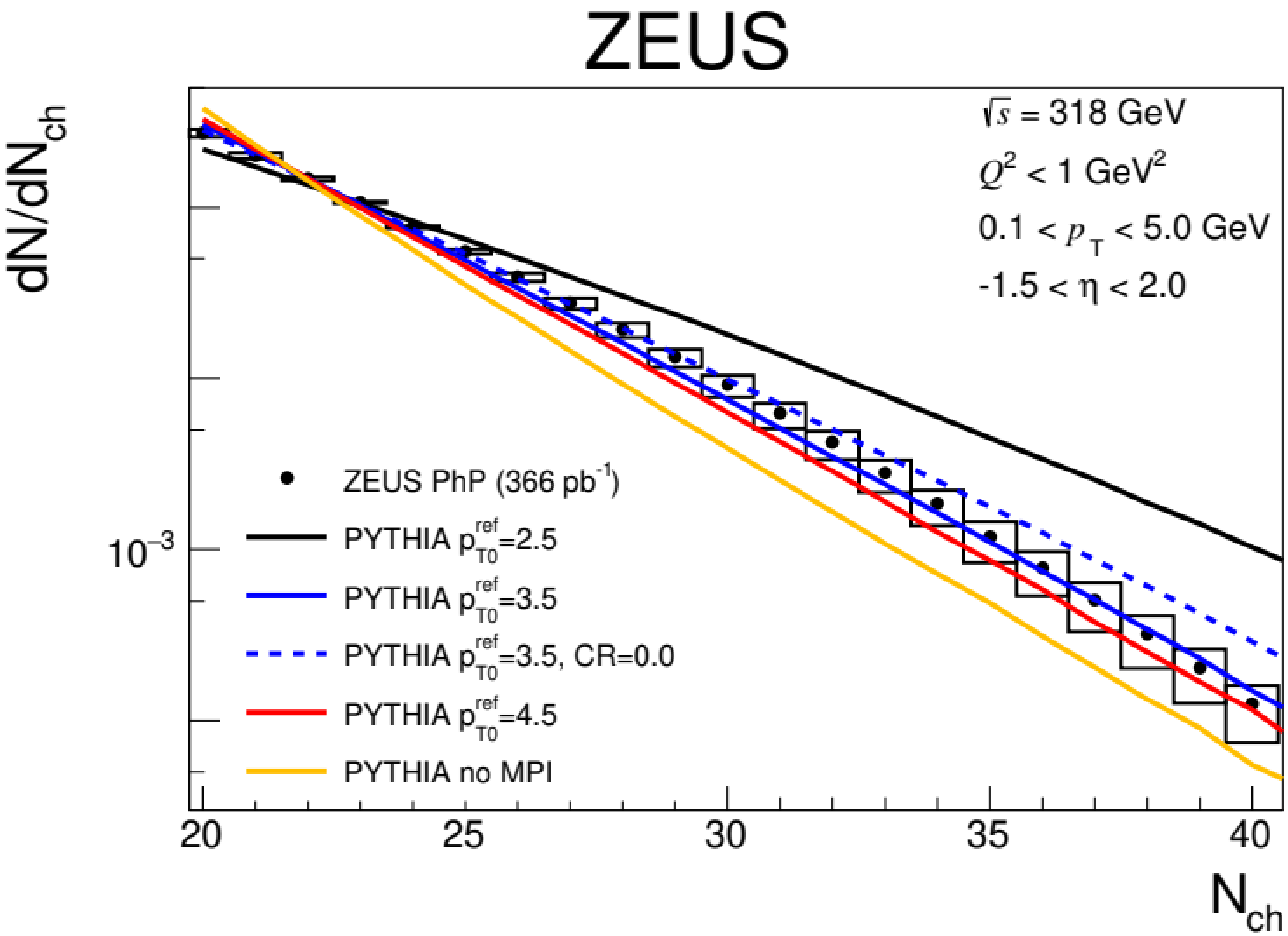


Figure Caption: Charged particle multiplicity distribution dN/dNch compared to PYTHIA expectations for different degrees of multiparton interactions (MPI), which is inversely related to p_{T0}^{ref}. The mean number of MPI for each value of p_{T0}^{ref} is: 5.7 (p_{T0}^{ref}=2.5), 3.8 (p_{T0}^{ref}=3.0), 2.5 (p_{T0}^{ref}=3.5), and 2.1 (p_{T0}^{ref}=4.5). The dashed line corresponds to an expectation with colour reconnection switched off. The integral of the distributions in the range shown are normalised to unity. The statistical uncertainties are shown as vertical lines although they are typically smaller than the marker size. Systematic uncertainties are shown as boxes.

Figure 8 and 9

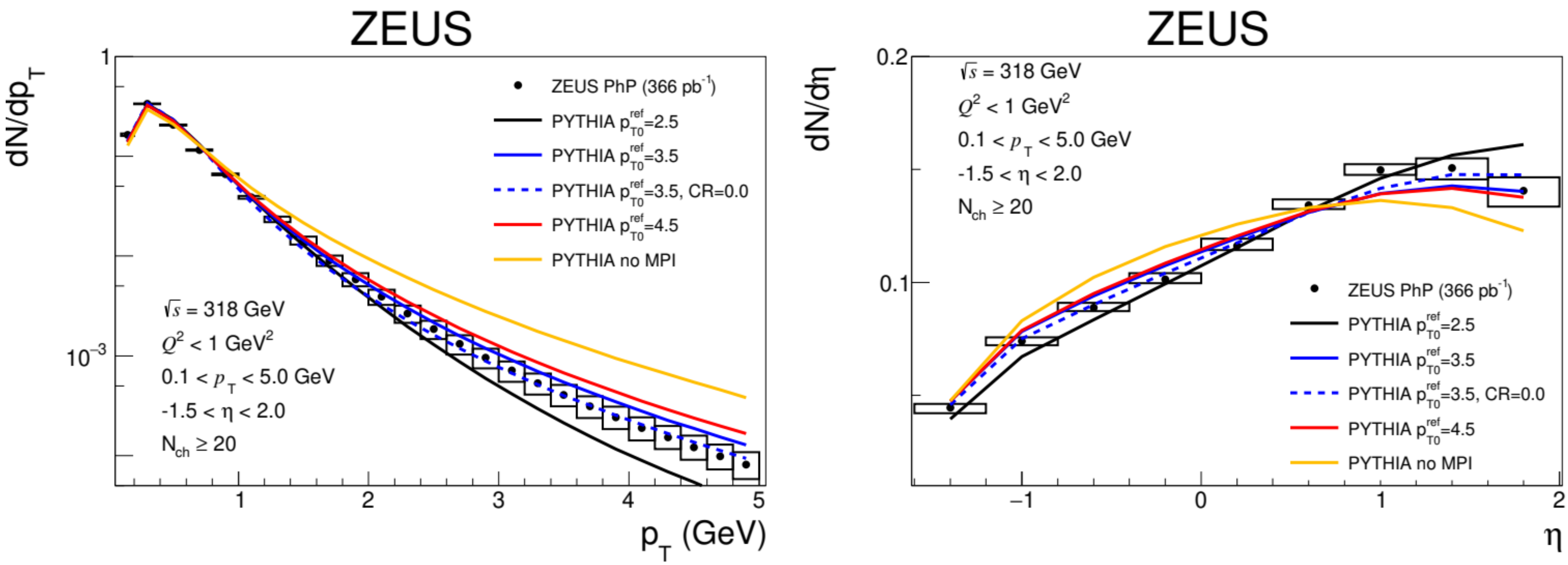


Figure Caption: Charged particle transverse momentum distribution dN/dp$_T$ and dN/dη compared to PYTHIA expectations for different degrees of multiparton interactions (MPI). The other details are as in figure 7.

Figures 10 & 11

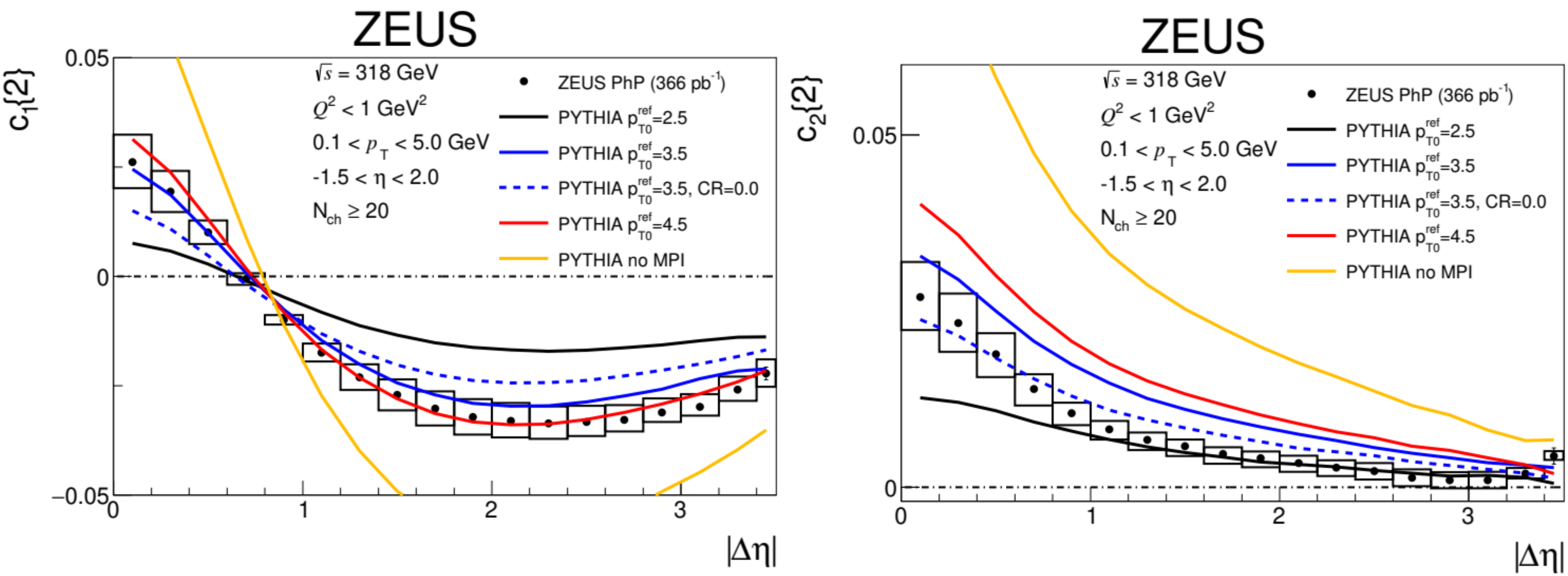


Figure Caption: Two-particle correlations $c_1\{2\}$ and $c_2\{2\}$ versus $|\Delta\eta|$ compared to PYTHIA expectations for different degrees of multiparton interactions (MPI). The other details (except for normalisation) are as in figure 7.

Figures 12 & 13

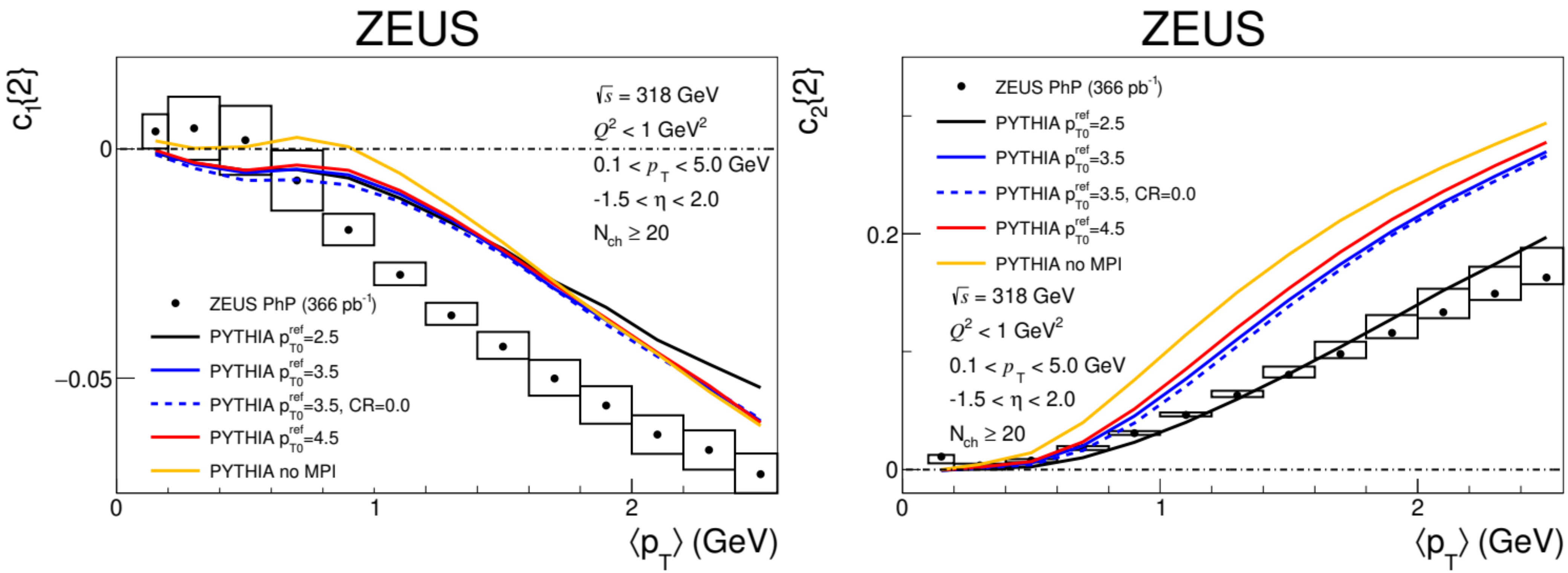
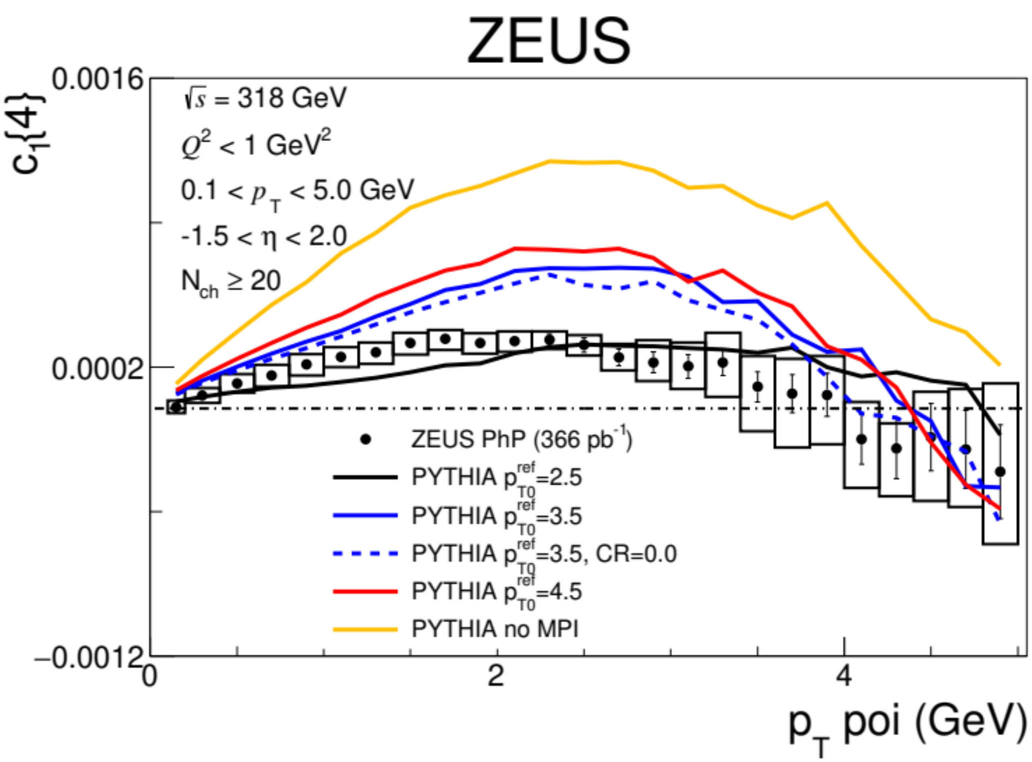


Figure Caption: Two-particle correlations $c_1\{2\}$ and $c_2\{2\}$ versus $<p_T>$ compared to PYTHIA expectations for different degrees of multiparton interactions (MPI). The other details (except for normalisation) are as in figure 7.

Figures 14 & 15



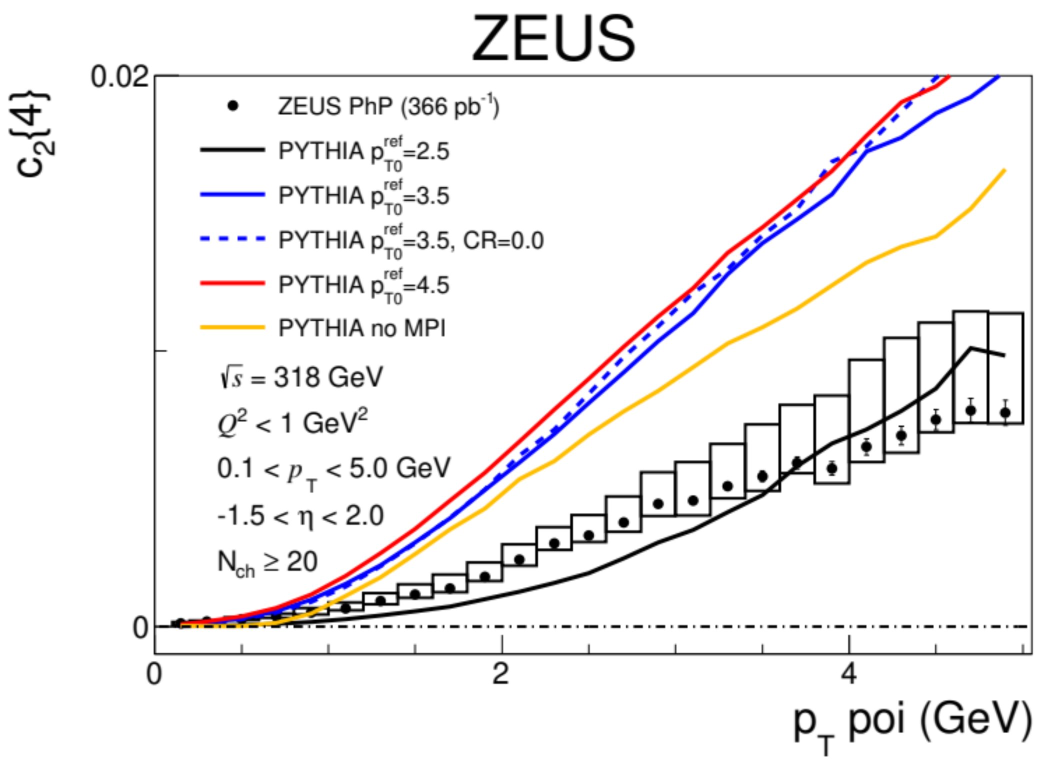


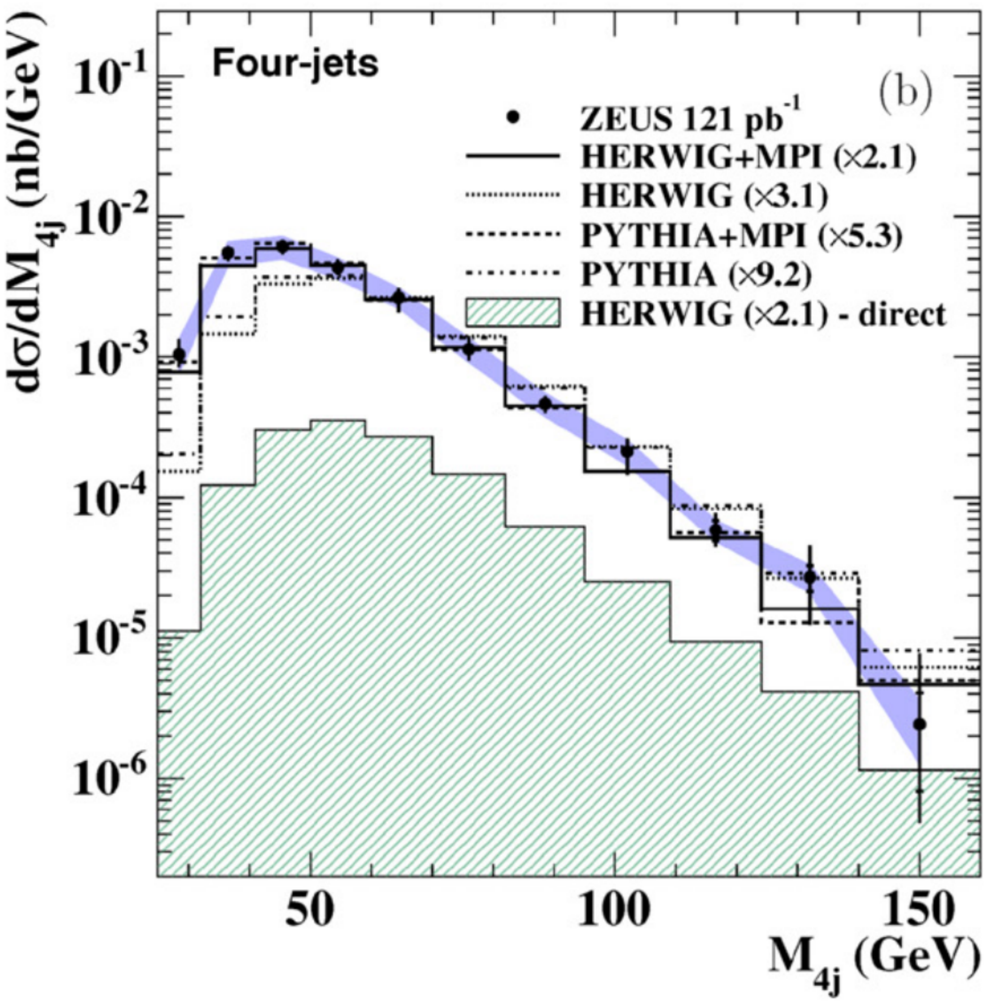
Figure Caption: Four-particle cumulant correlations $c_1\{4\}$ and $c_2\{4\}$ versus p_T poi compared to PYTHIA expectations for different degrees of multiparton interactions (MPI). The other details (except for normalisation) are as in figure 7.

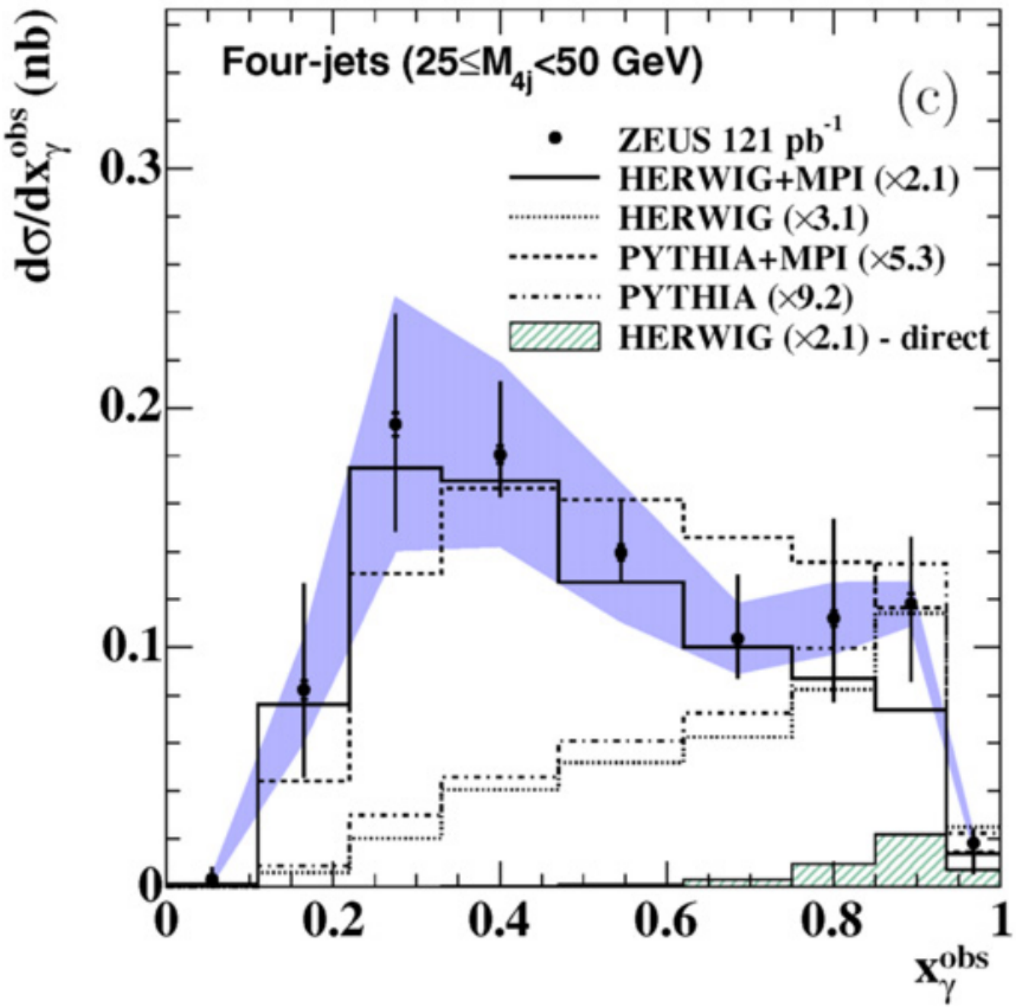
Backup

ZEUS 3- and 4-jet analysis
Another indication of MPI in PhP at HERA

“Three- and four-jet final states in photoproduction at HERA” Nucl. Phys. B 792 (2008) 1-47

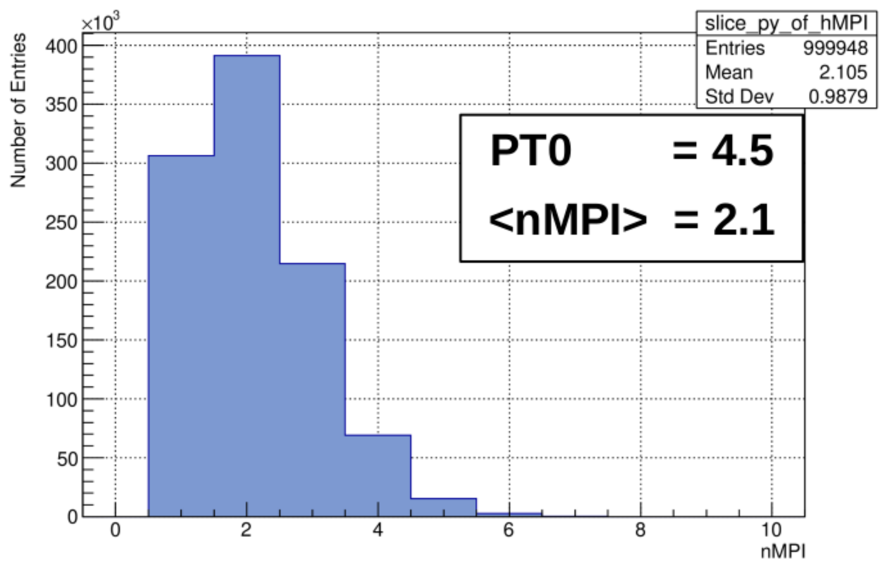
PYTHIA and HERWIG describe the data much better with MPI than without.

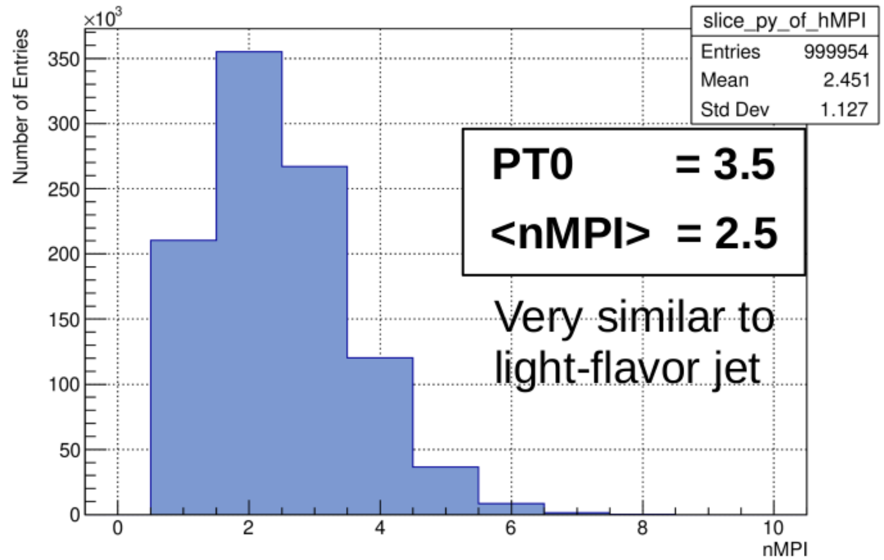


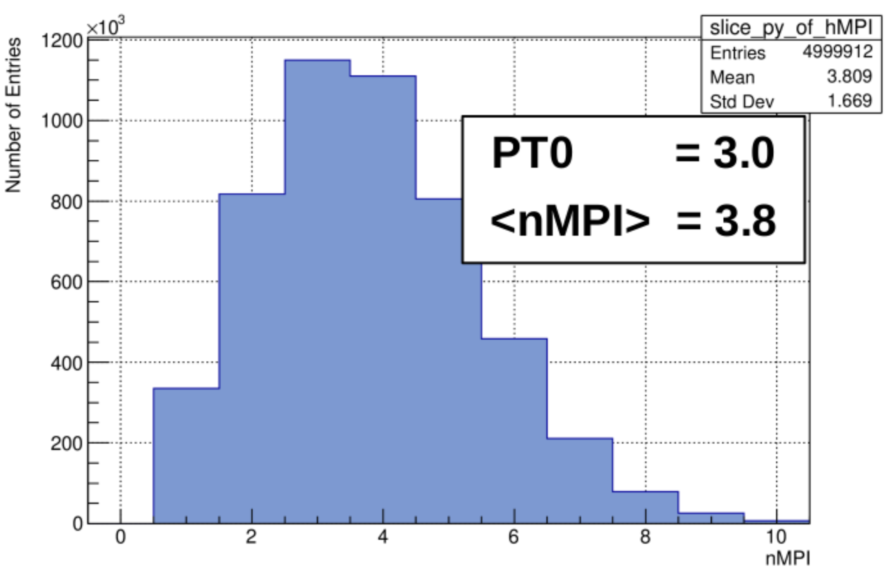


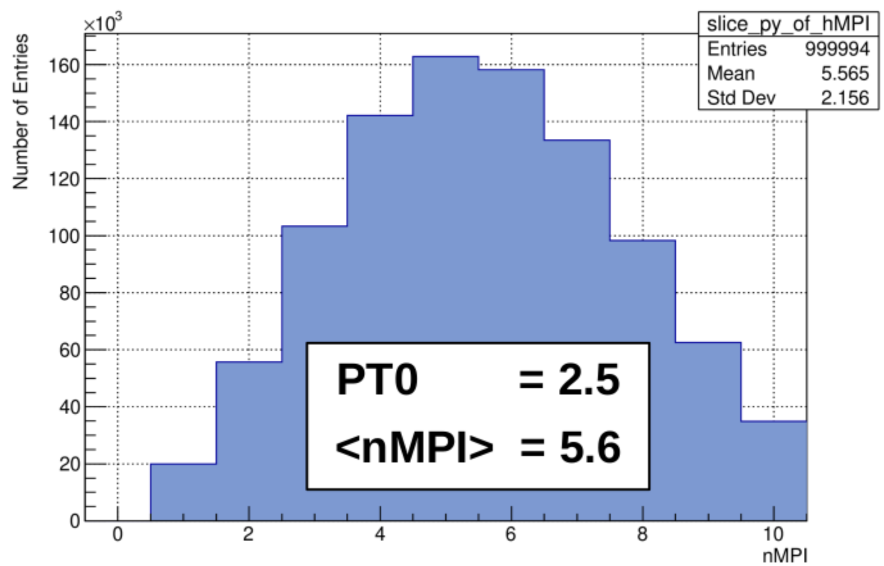
nMPI in PYTHIA PhP

- In DIS as well as direct PHP, the **number of MPI** is one (nMPI = 1) by definition.
- In resolved PHP it can be greater than 1.
- The main parameter in Pythia controlling MPI is PT0: <nMPI> ~ 1 / PT0

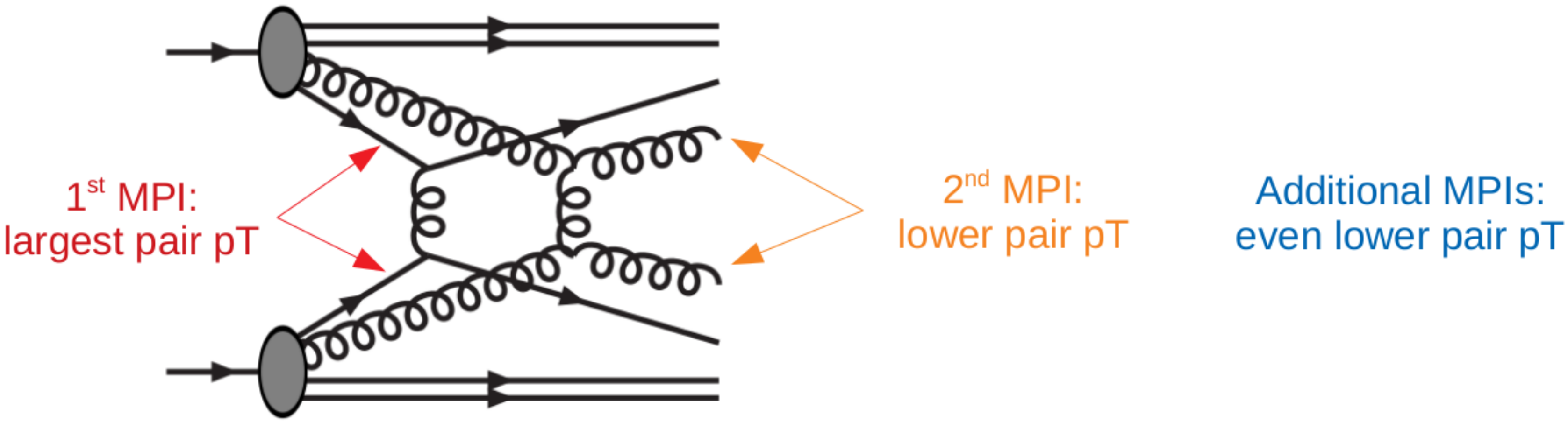


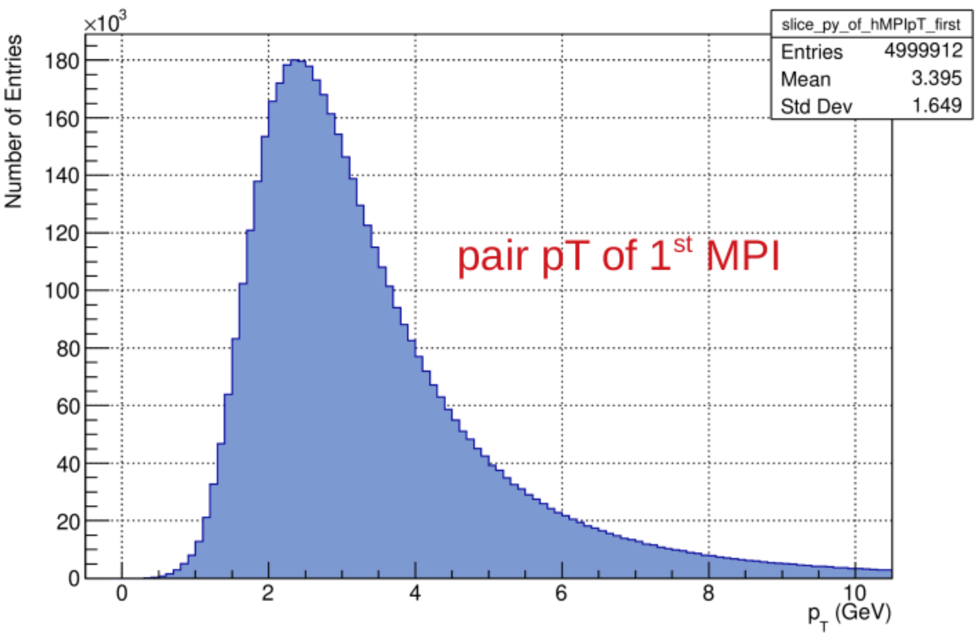


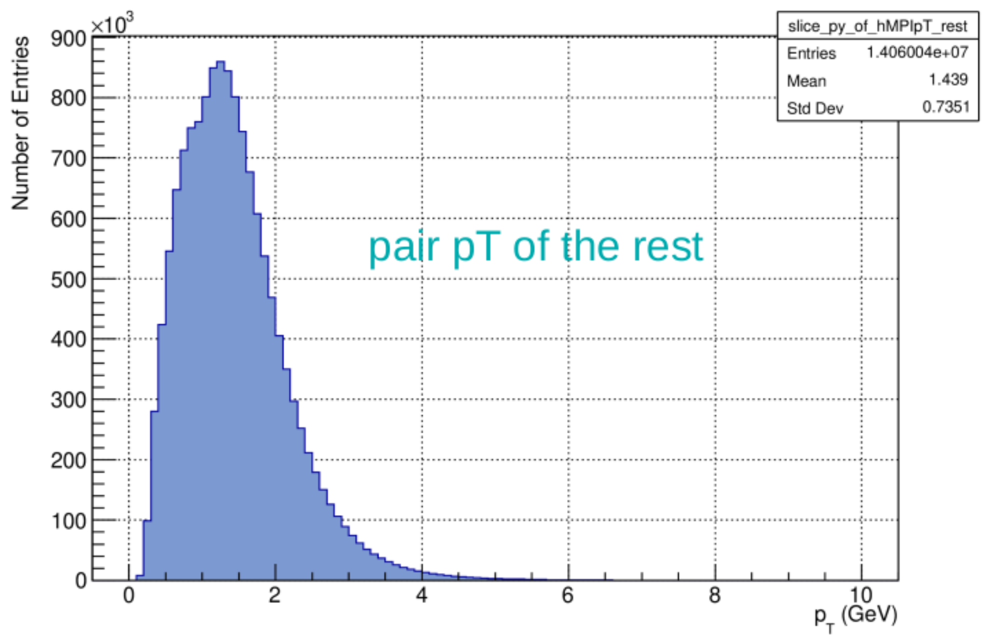




MPI scales in PYTHIA







- Pair pT scale of 2→2 parton interactions decreases with each new MPI.
- Scales of a few subsequent MPIs are in the 1 GeV range and may still be reliably calculated from the **pQCD** elements within PYTHIA.

Previous correction strategy (**Black** factor now removed)

For the multiplicity distribution, we unfold using the response Matrix ***R*** (N_{gen} x N_{rec})

$$N_{ch} = \frac{N_{gen,lfjet}}{N^{Trigger}_{gen,lfjet}} R \, N_{rec}$$

For the other results, we use weights: $w^{(n)}$ = 1 / efficiency

n = 1 (dN/dpT and dN/dη),
n = 2 ($c_n\{2\}$)
n = 4 ($c_n\{4\}$)

$$\underbrace{D_{corrected} = \frac{D_{PhP}}{D^{\geq 1jet}_{PhP}}}\, \frac{D_{lfjet}}{D^{Trigger}_{lfjet}} \, w^{(n)} \, D_{rec}$$

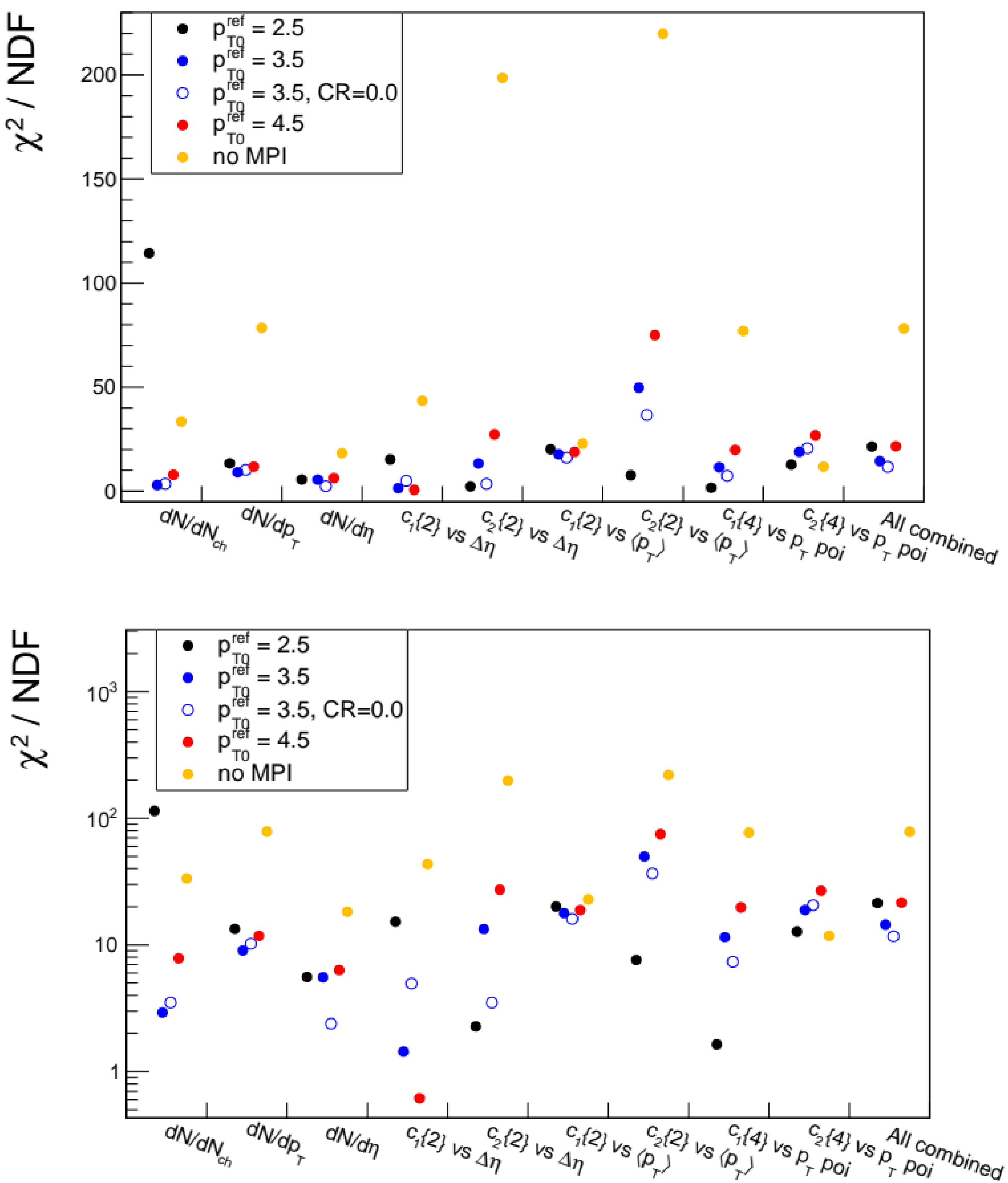
$$D \in \{\frac{dN}{dp_T}, \frac{dN}{d\eta}, c_n\{2\}, c_n\{4\}\}$$

Typically a ~10% Correction.
Was computed from the Pythia that I generated.

Typically a ~30% correction extracted from the light-flavor jet MC

Typically a ~10% correction extracted from the light-flavor jet MC

chi² plot with and without log scale



Sizes in DIS/PhP

Deep inelastic scattering as a probe of entanglement

Dmitri E. Kharzeev[1,2,*] and Eugene M. Levin[3,4,†]

[1] *Department of Physics and Astronomy, Stony Brook University, New York 11794-3800, USA*
[2] *Department of Physics and RIKEN-BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973-5000, USA*
[3] *Department of Particle Physics, School of Physics and Astronomy, Tel Aviv University, Tel Aviv, 69978, Israel*
[4] *Departamento de Física, Universidad Técnica Federico Santa María and Centro Científico-Tecnológico de Valparaíso, Casilla 110-V, Valparaiso, Chile*

(Dated: May 16, 2017)

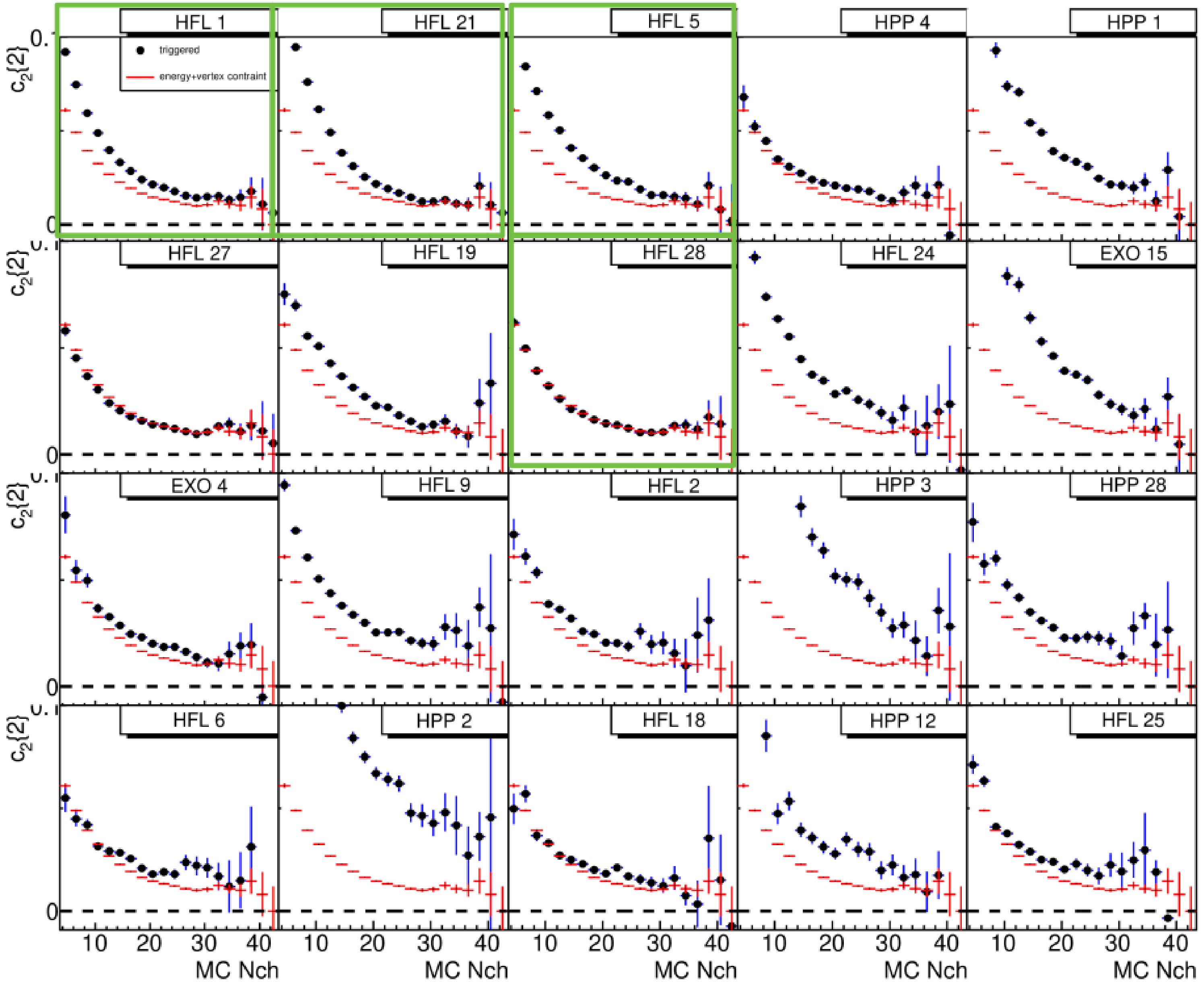
PRD 95, 114008 (2017)

Deep inelastic scattering (DIS) at Bjorken x and momentum transfer $q^2 = -Q^2$ probes only a part of the proton's wave function; let us denote it A. In the proton's rest frame, where it is definitely described by a pure quantum mechanical state, the DIS probes the spatial region A localized within a tube of radius $\sim 1/Q$ and length $\sim 1/(mx)$ [14, 15], where m is the proton's mass. The inclusive DIS measurement thus sums over

- Additional information on the sizes in DIS/PhP obtained via private communication with Richard Lednicky (theorist and vice director of DUBNA).

Top 20 triggers rich in high multiplicity events

1) Early studies of HPP, HFL, & EXO triggers showed that HFL 1, 5, 21, and 28 were among the least-biasing triggers of the generator-level 2-particle correlations.

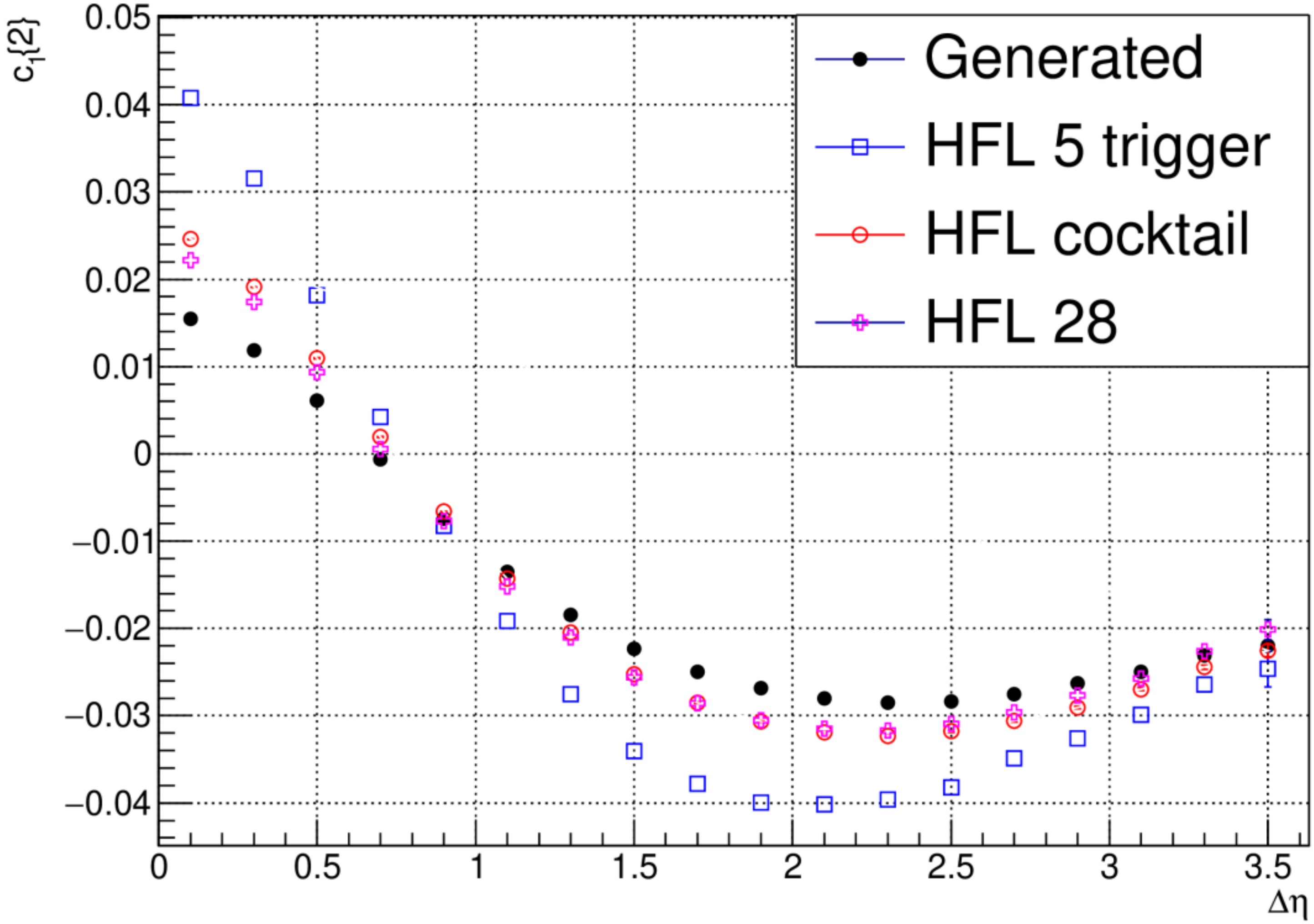


Red lines:
reference correlations

Black points:
specifically triggered correlations

View of the trigger bias

Light-flavor jet
PhP MC



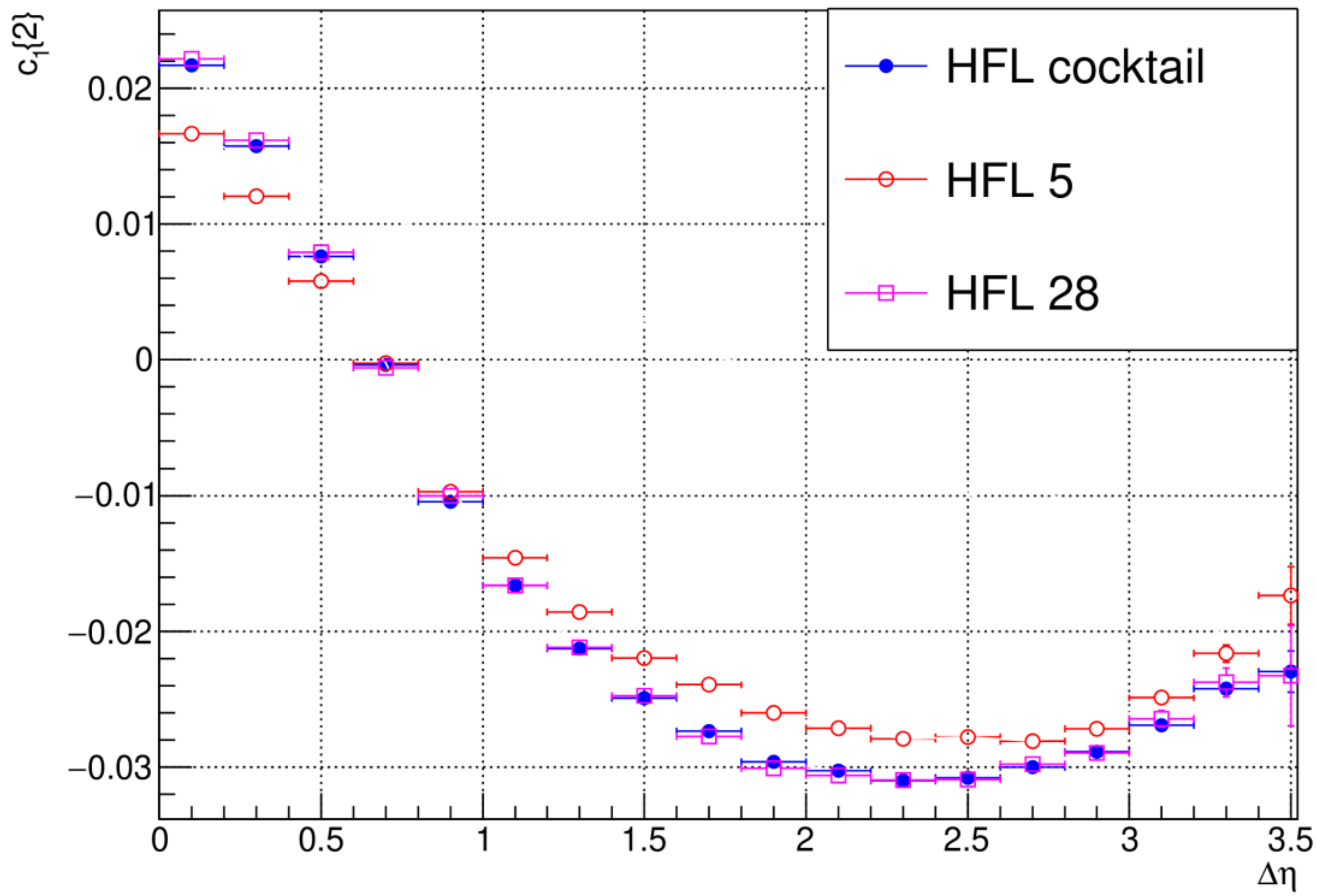
Extracted correction factor

$$\frac{D_{lfjet}}{D_{lfjet}^{\mathrm{Trigger}}}$$

- This correlation projection was among the most biased.
- We use the simulated response of the triggers in Monte Carlo to correct for the trigger bias in data.
- The ratio of gen over triggered forms our correction factor.
- HFL cocktail is our default choice and HFL 5, 28 alone are used for systematics.

Different routes to PhP using different triggers

ZEUS



- After correcting for their biases (obtained from MC), we don't arrive at the same result in zeus data for each trigger.
- Fractional difference between each trigger "route" is used as a systematic uncertainty.

Estimating the bias caused by the missing phase-space in our MC

Although the reduction/alteration of MC phase-space with the jet requirements is significant, its effect on our measurements may not be large.

We rely on MC simulations of the ZEUS detector for the following corrections:

1) Tracking efficiency corrections
2) Trigger-bias corrections

We can get a reasonable estimate of the impact of the MC jet bias by comparing the ZEUS results obtained using:

- light-flavor jet correction factors

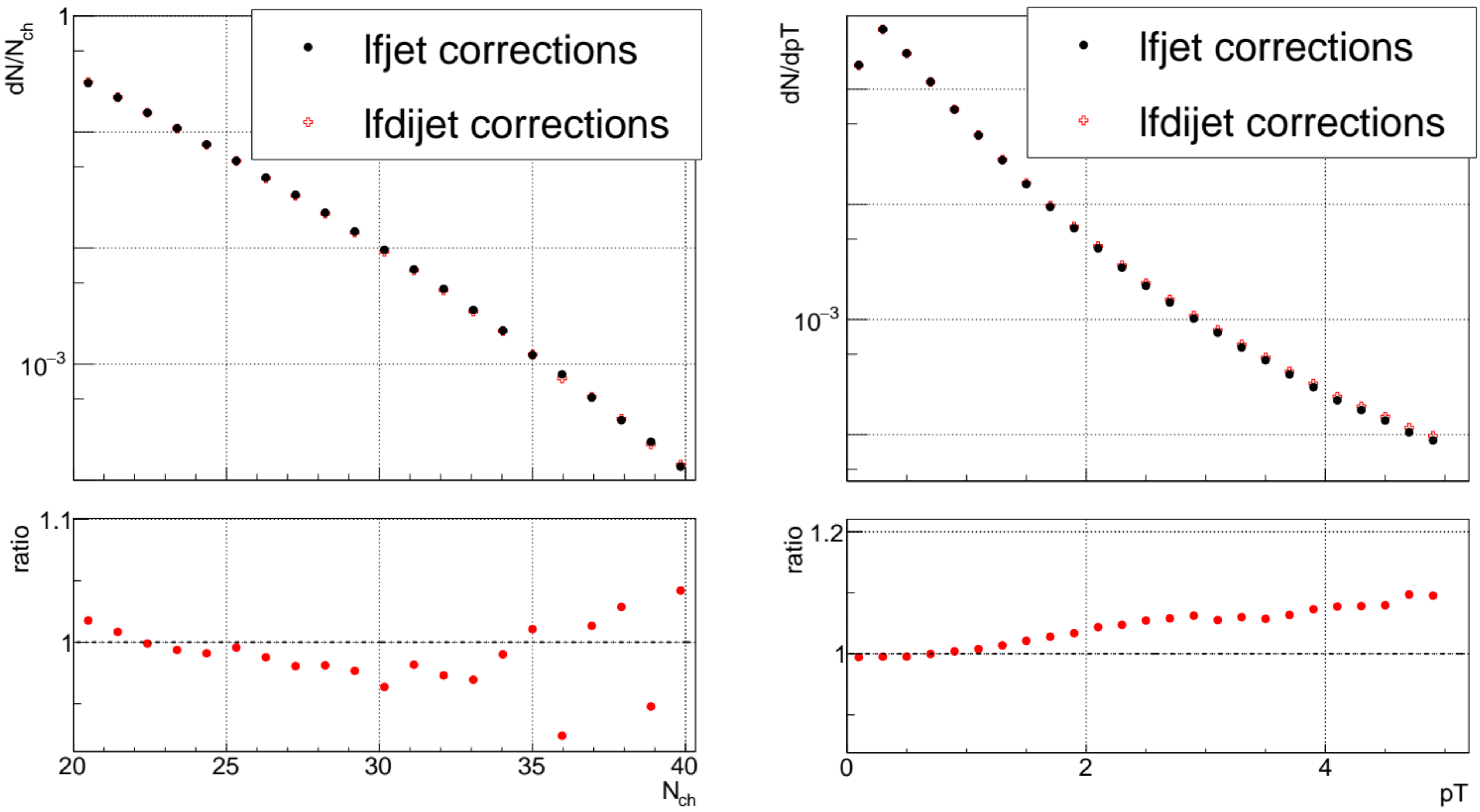
to those using

- light-flavor **dijet** correction factors

ZEUS data with light-flavor jet vs dijet MC corrections

ZEUS

N_{ch} and p_T distributions vary by <~ 10%.



ZEUS light-flavor jet MC sample

- The least biased PHP MC sample generated by ZEUS is the “light-flavor jet” sample. The dominant bias here is the jet requirement.

Resolved PHP for 06e
generated by Sebastian Mergelmeyer <mergelm@desy.de>
with PYTHIA 6.220, AMADEUS v2_03

gamma/e p mode with mi
 Ep = 920
 Ee = 27.52
 mb = 4.75
 mc = 1.35

Resolved PHP Processes:

f + f'   -> f + f' (QCD) (11)
f + fbar -> f' + fbar'   (12)
f + fbar -> g + g   (13)
f + g   -> f + g   (28)
g + g   -> f + fbar   (53)
g + g   -> g + g   (68)

Direct PHP Processes:

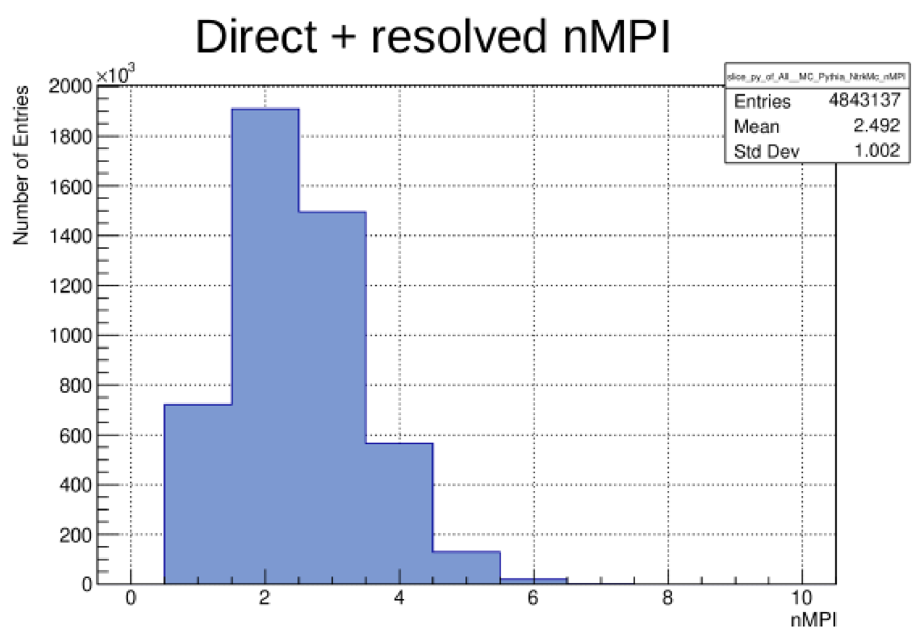
gamma g -> q qbar (54)
gamma q -> q g   (33)

Q^2 < 2
Ptmin = 1.9
Fragmentation: Peterson
 epsilon = 0.0041

cuts:
1 jet requirement, with E_t > 3 and -3 < eta < 3

PDF Proton = CTEQ4L
PDF Photon = GRV G LO

Sigma   = 9156801.88 pb
Red.Factor = 3.1485



About the Inclusive Dijet PhP MC

Important MC not only for HFL, but also for prompt photon in PhP.

Generator-level cuts in the HFL group's inclusive dijet MC:

- *Preselection in AMADEUS*
  2 jets with $|\eta| < 3$, $E_{\mathrm{T}} > 4$ GeV in hadronic final state (massless)
  indicated by `.JJ.ET4.` in the funnel name!

- *Phase space cut in PYTHIA*
  $\hat{P}_{\mathrm{T}} > 2$ GeV

In May I showed their limited efficiencies and how to compute them.

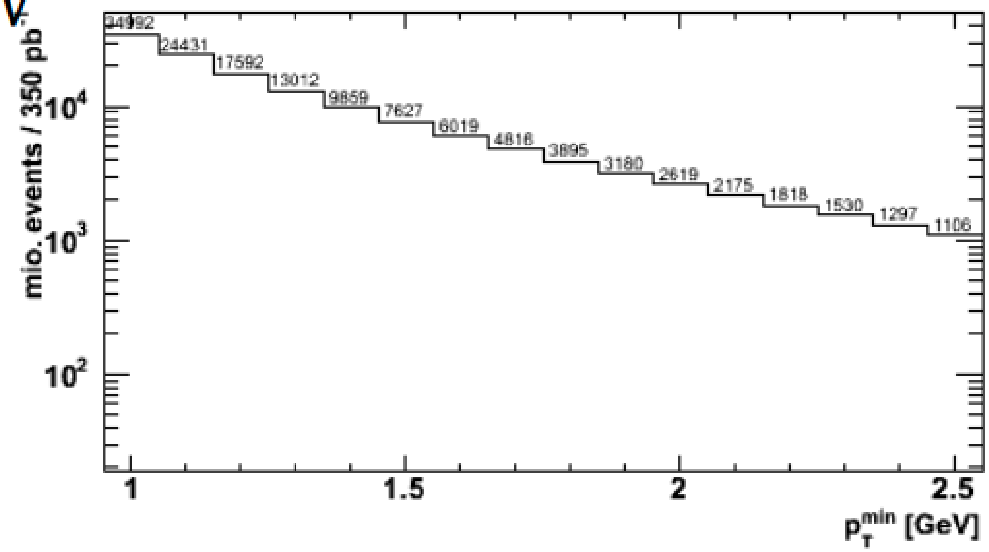
In June prompt photon people reported a large amount of events was "missing" in the MC, especially with their very low 1-jet E_{T}-cut.

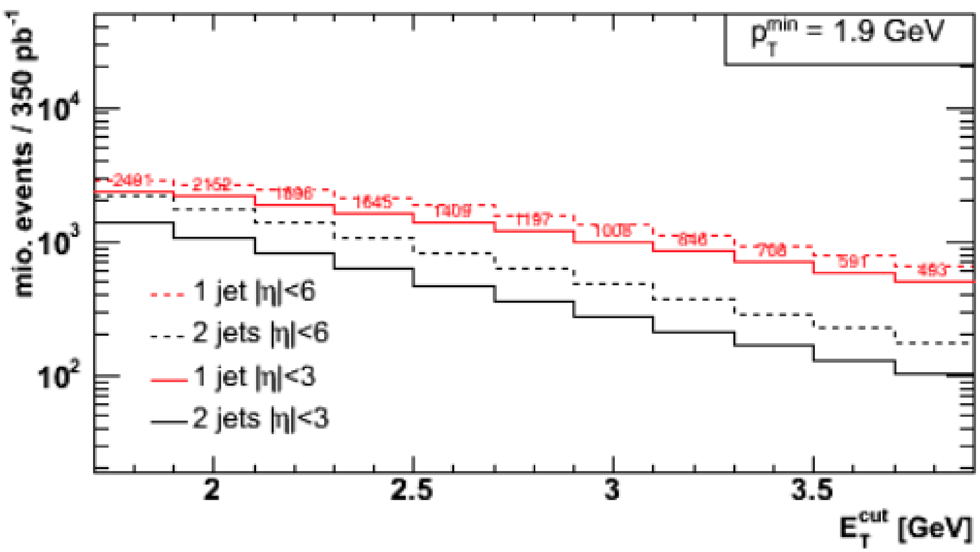
Expected Sizes

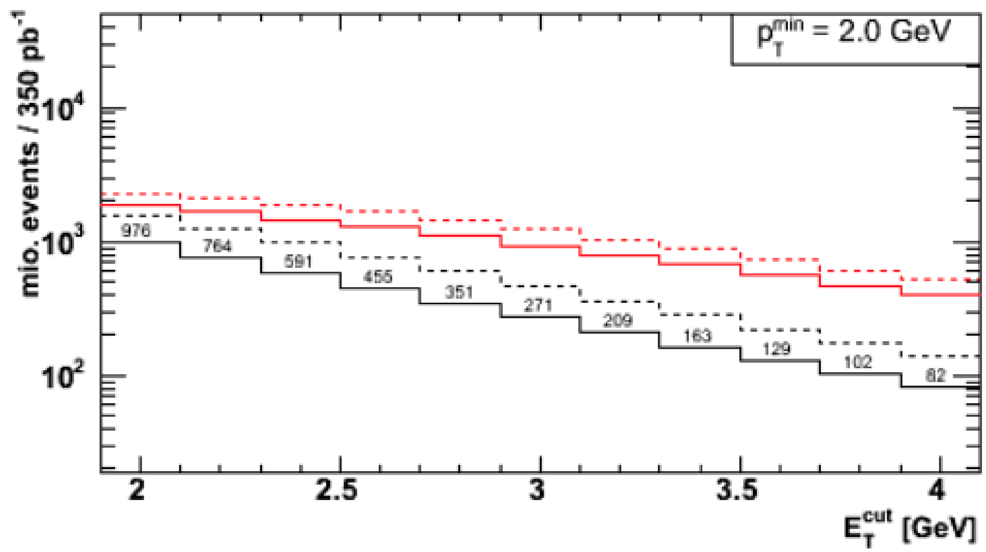
New preselection

- $\hat{P}_T > 1.9$ GeV
- 1 jet with $|\eta| < 3$ and $E_T > 3$ GeV

- 1008 mio. resolved events
- 85 mio. Direct events



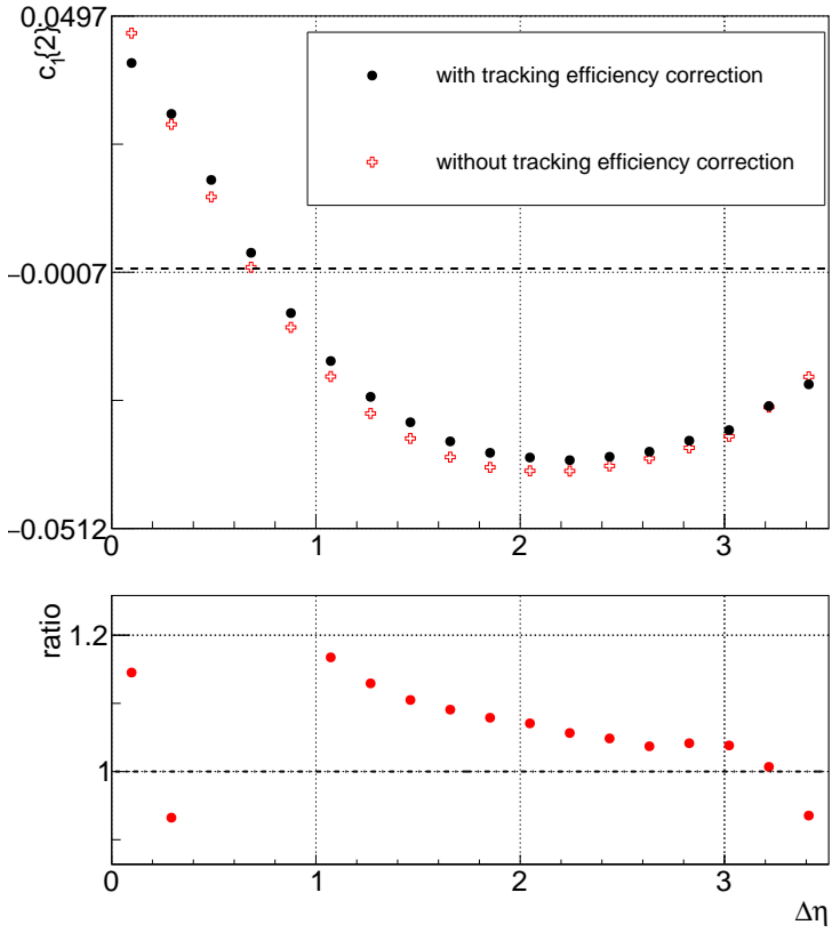




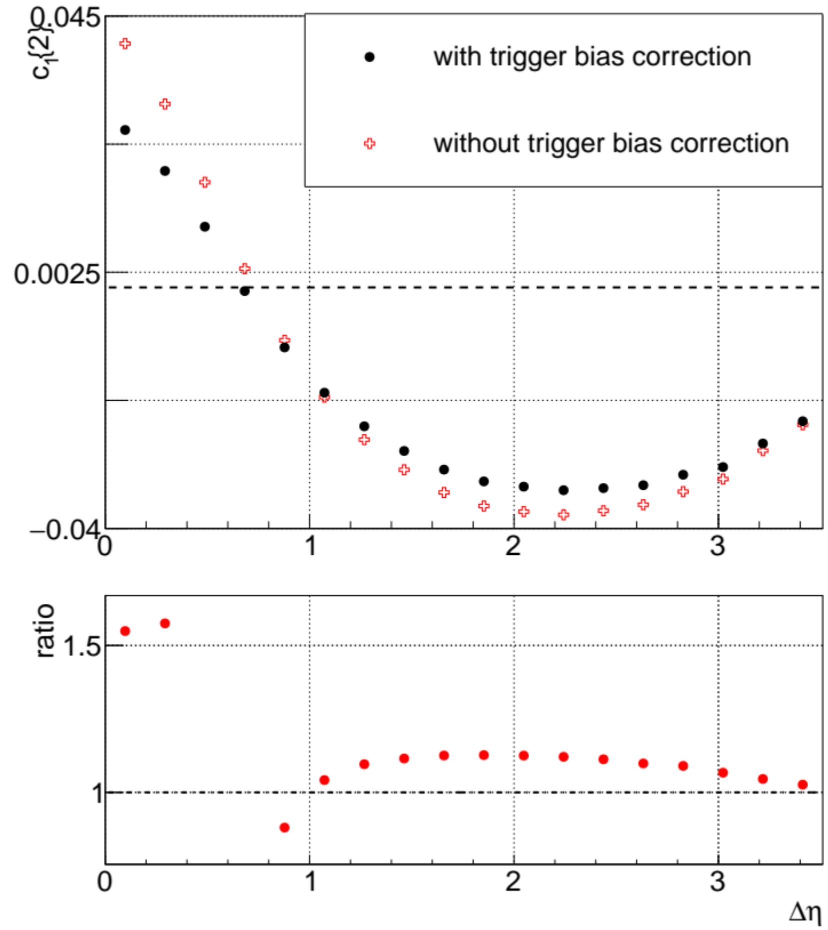
Effect of MC correction factors to the ZEUS data

ZEUS

1) Tracking efficiency corrections



2) Trigger bias corrections



Effect of MC correction factors to the ZEUS data

ZEUS

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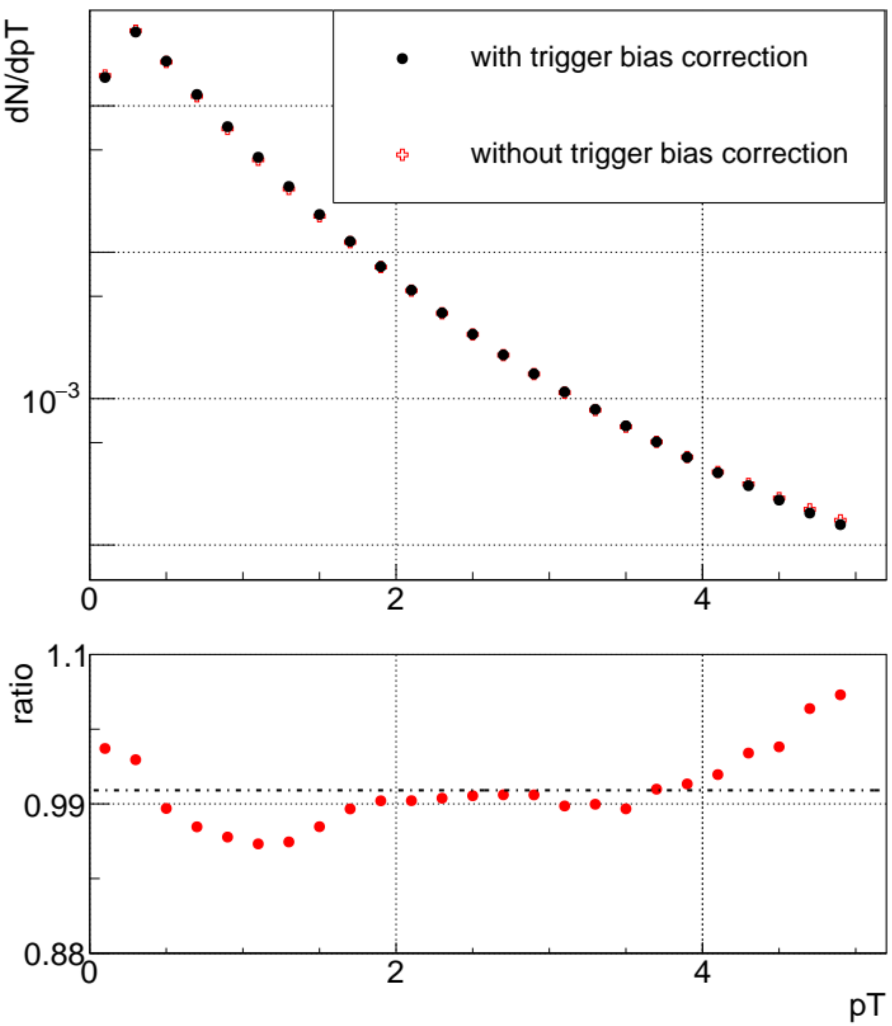

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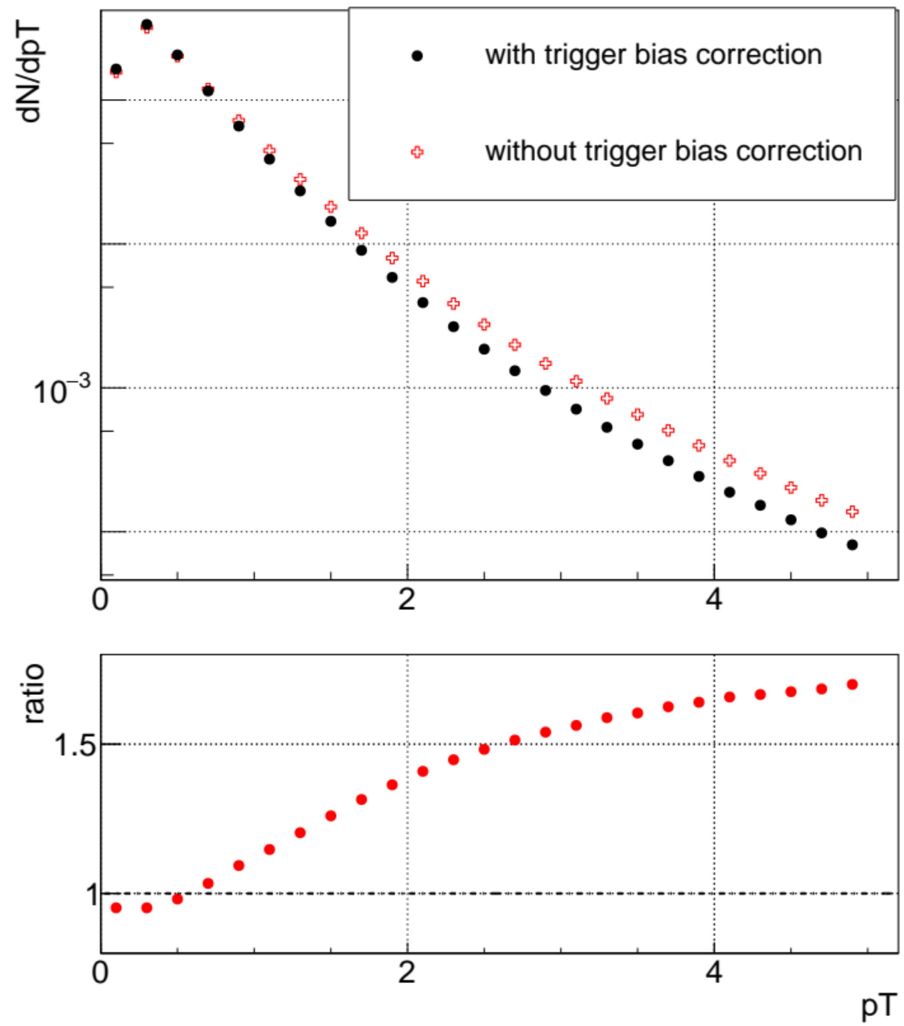

Effect of MC correction factors to the ZEUS data

ZEUS

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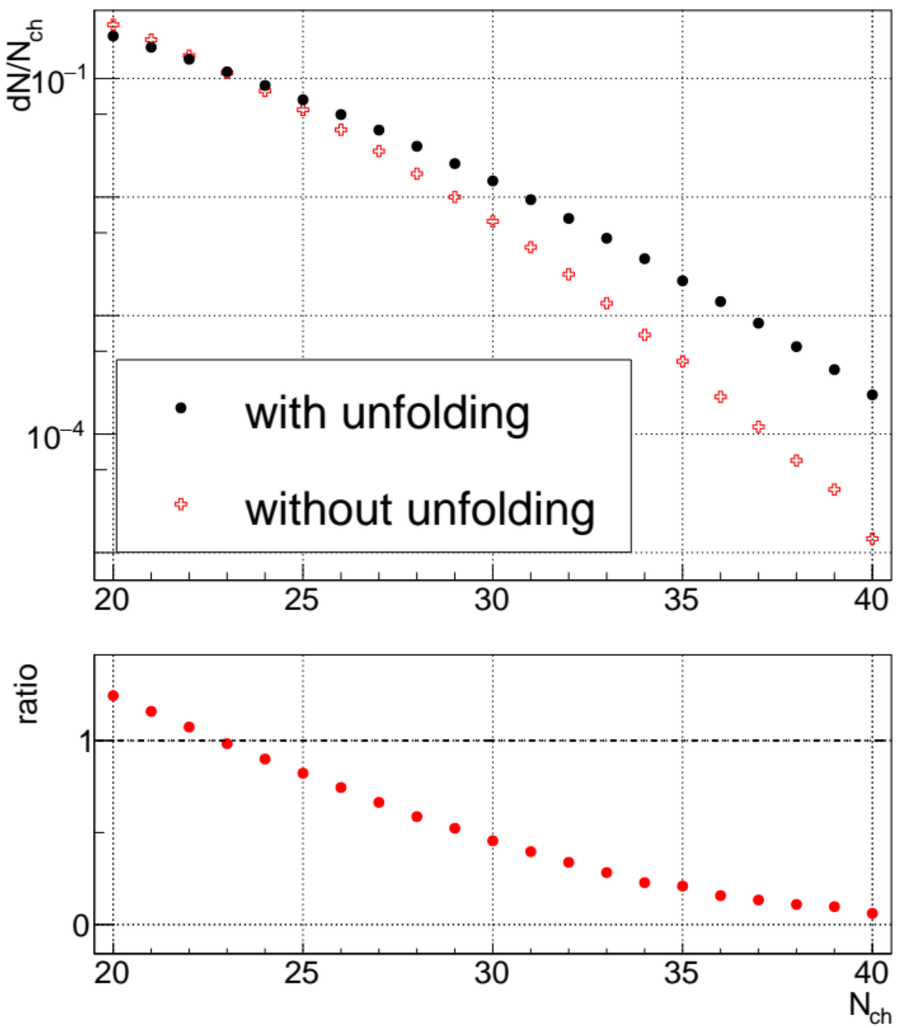

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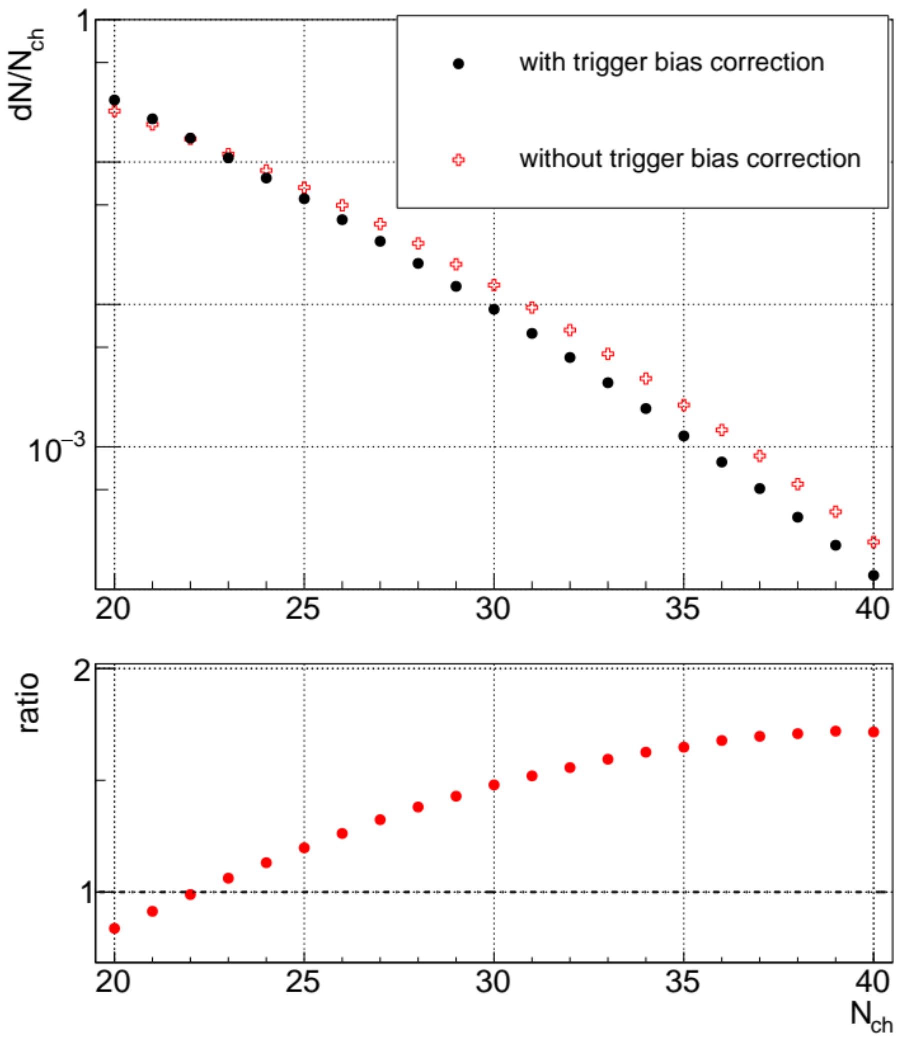
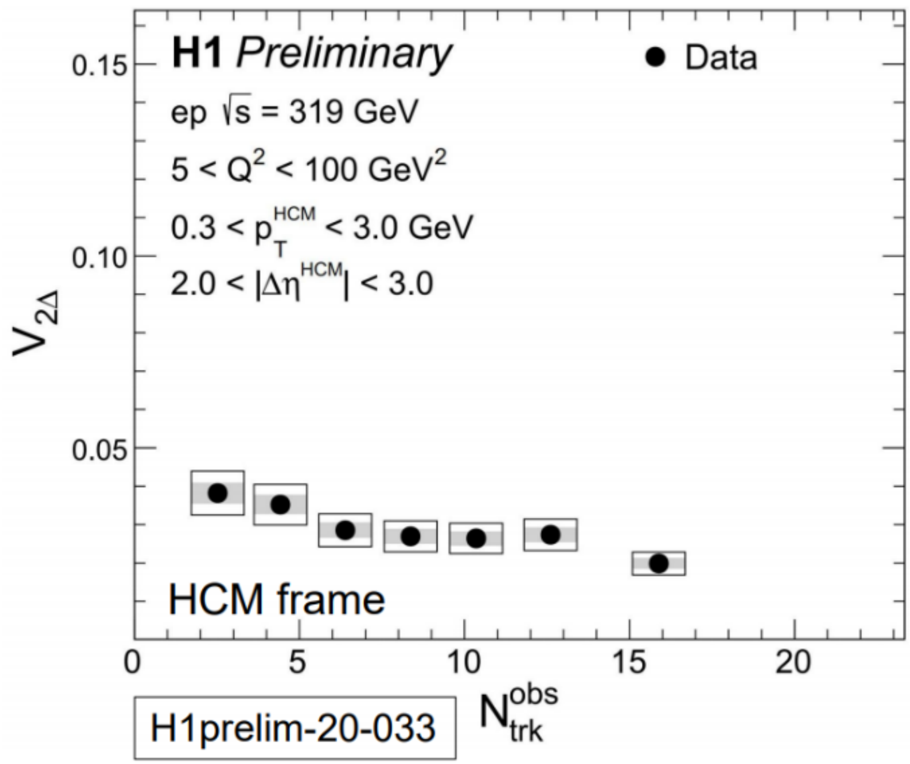
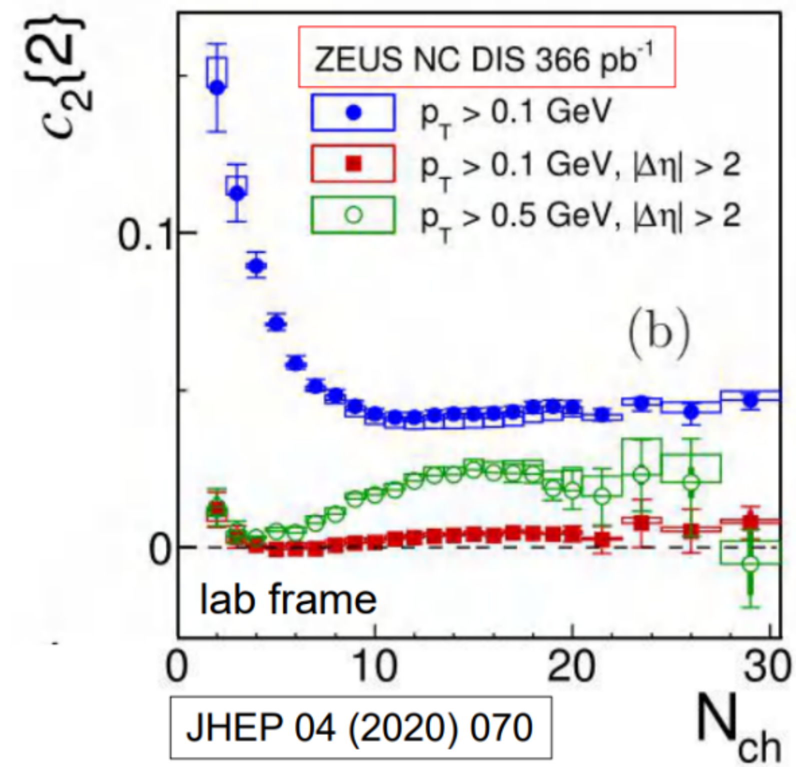


H1 preliminary compared to ZEUS

Fourier coefficient $V_{n\Delta}$ in ep DIS





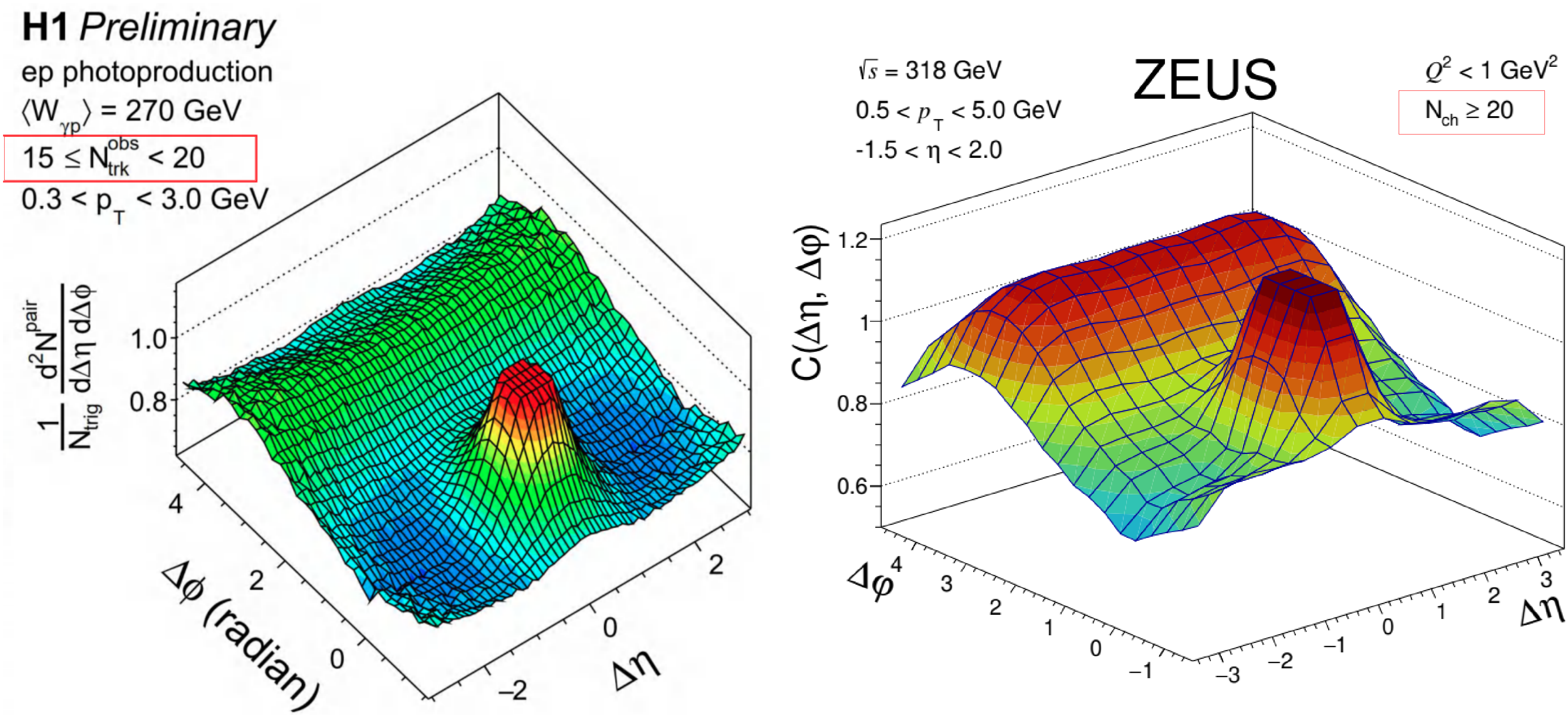
Similar trend as ZEUS result

DIS HCM

$$\frac{1}{N_{trig}}\frac{dN^{pair}}{d\Delta\phi} = \frac{N_{assoc}}{2\pi}\left(1 + \sum_n 2V_{n\Delta}\cos(n\Delta\phi)\right)$$

- Although their analysis is in the Hadronic Center of Mass frame, ZEUS and H1 look compatible.

H1 preliminary compared to ZEUS in photoproduction



- There are differences in analysis details but either way, there is no clear double ridge.