# Discussion on Multiple Parton Interactions 

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We are well-accustomed to multiple interactions in collisions of nuclei (and consequences on final state, i.e. hydrodynamization)

HI and HEP communities are more and more interested in consequences of $>1$ partonic interactions even in pp collisions

How important are (fluctuating) spatial distributions for understanding properties of pp collisions


Figure T. Sjöstrand


"standard" MPI
(is there 2D evolution?)

## DIPSY evolution

 in transverse spaceInitialization of hydro

How do we disentangle the (possibly simultaneous) role of these different scenarios?

## Questions (instead of summary)

 (continuing Andreas' discussion!)- How to move from MC tuning to extraction of physical parameters for the transverse structure of hadrons (including errors)?
- Can one constrain generalised pdf $(\mathrm{g}(\mathrm{x}, \mathrm{b}))$ and multiparton pdf s
- How does re-scattering modify (de-correlate) low- $p_{T}$ jetlike correlations ?
- Can "elementary" string interactions explain collective bahavior in small systems ?


# how to distinguish Hydro and Pythia 

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## Multiplicity and MPI in Pythia

 Limited increase with multiplicity at high multiplicity, while mean pt grows with multiplicity

## color reconnection till high pt

The prediction of pythia spectra for the case of no CR with the predicitons for two CR modes for $\mathrm{z}=\mathrm{Nch} /<\mathrm{Nch}>=$ 0.5 and $>5$ and for the min bias case. The result suggest that with multiplicity the color reconnection increases (ref.3.)

The very low multiplicity events $z<0.5$ could be used as the No CR case in data
 analysis

Color reconnection tuning on the mean pt at 7 TeV


## Comparison with Hydro inspired EPOS3

Z= Nch/ <Nch>



## conclusions

- The differentiation between hydro and Pythia occurs after 2-3 GeV/c. Should be easy to investigate with experimemts
- Interesting behavior at low multiplicity



## hard MPIs = double parton scattering (DPS)

for instance: 4-jet production coming from a double hard scattering of two partons in each incoming hadron
there is a kinematical domain in which this is as important as the leading-twist process of 4 -jet production in one hard scattering


QCD factorization not proven (probably does not apply) yet used in all phenomenological studies parameters (like $\sigma_{\text {eff }}$ ) need to be tuned to unphysical values

## soft MPI = underlying event


the most popular approach in $p+p$ : event generators like PYTHIA

$$
\begin{aligned}
& \text { in } A+A \text { or high-multiplicity } p+p \\
& C G C=\text { first-principle approach if } Q s \text { is large enough }
\end{aligned}
$$

## Hard MPI-Soft MPI interplay ?

when triggering on a hard event, does one bias the distribution of the soft particles by selecting only rare wavefunction configurations of the colliding particles
if so, how to calculate this effect in QCD ?


Important for $\mathrm{p}+\mathrm{A}$ : can we correct for this effect when measuring $\mathrm{R}_{\mathrm{pPb}}$ ?
ALICE: hybrid method measures correction factors in ZDC-selected bins, under assumptions that different regions in eta are proportional to $\mathrm{N}_{\text {part }}$ or $\mathrm{N}_{\text {coll }}$ scaling.

ATLAS: calculates "centrality bias" corrections, restores $\mathrm{N}_{\text {coll }}$ scaling to $\mathrm{Z}, \mathrm{W}$

ATLAS observed centrality-dependent splitting of nuclear modification factor in $\mathrm{p}+\mathrm{Pb}$


Energy conservation in presence of hard process can influence soft processes,
 bias centrality measure


