New QCD fits to HERA data and looking for exclusive events at the Tevatron

Christophe Royon
DAPNIA-SPP, CEA Saclay

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Contents:

- New DGLAP QCD fits to HERA data and extraction of gluon density in Pomeron

- χ_C production

- Comparison between CDF measurement of dijet mass fraction and pomeron models

- Predictions from Soft Colour Interaction models

- Measurement of exclusive events at the LHC

Work done in collaboration with Oldřich Kepka, Laurent Schoeffel, Robi Peschanski, Murilo Rangel, Maarten Boonekamp

QCD fits to F_2^D data

- Use the most recent F_2^D data published by H1, ZEUS

- DGLAP QCD evolution using MRS-like distributions at the starting scale

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$$
\begin{aligned}
zS(z, Q^2 = Q_0^2) &= \left[A_S z^{B_S} (1-z)^{C_S} (1 + D_S z + E_S \sqrt{z}) \right] \\
&\quad \cdot e^{\frac{0.01}{z-1}} \\
zG(z, Q^2 = Q_0^2) &= \left[A_G (1-z)^{C_G} \right] \cdot e^{\frac{0.01}{z-1}}
\end{aligned}
$$

- In the fits: $\alpha_S(M_Z) = 0.118$, $Q_0^2 = 3$ GeV^2

- Charm quark contribution computed in the fixed flavour scheme using the photon-gluon fusion prescription

- For H1 data: $\alpha_P = 1.12$, $\chi^2/dof \sim 0.9$

- Differences with respect to H1 parton distributions: Q_0^2 fitted, less parameters/flexibility in initial MRS distributions (NB: we find the same result as H1 if we use their approach

- NB: in the same paper (hep-ph/0609291), study also dipole and saturation GBW models which lead also to a good description of HERA data

Parton densities in Pomeron

DGLAP fits to most recent H1 and ZEUS data (see: hep-ph/0609291, hep-ph/0602228)
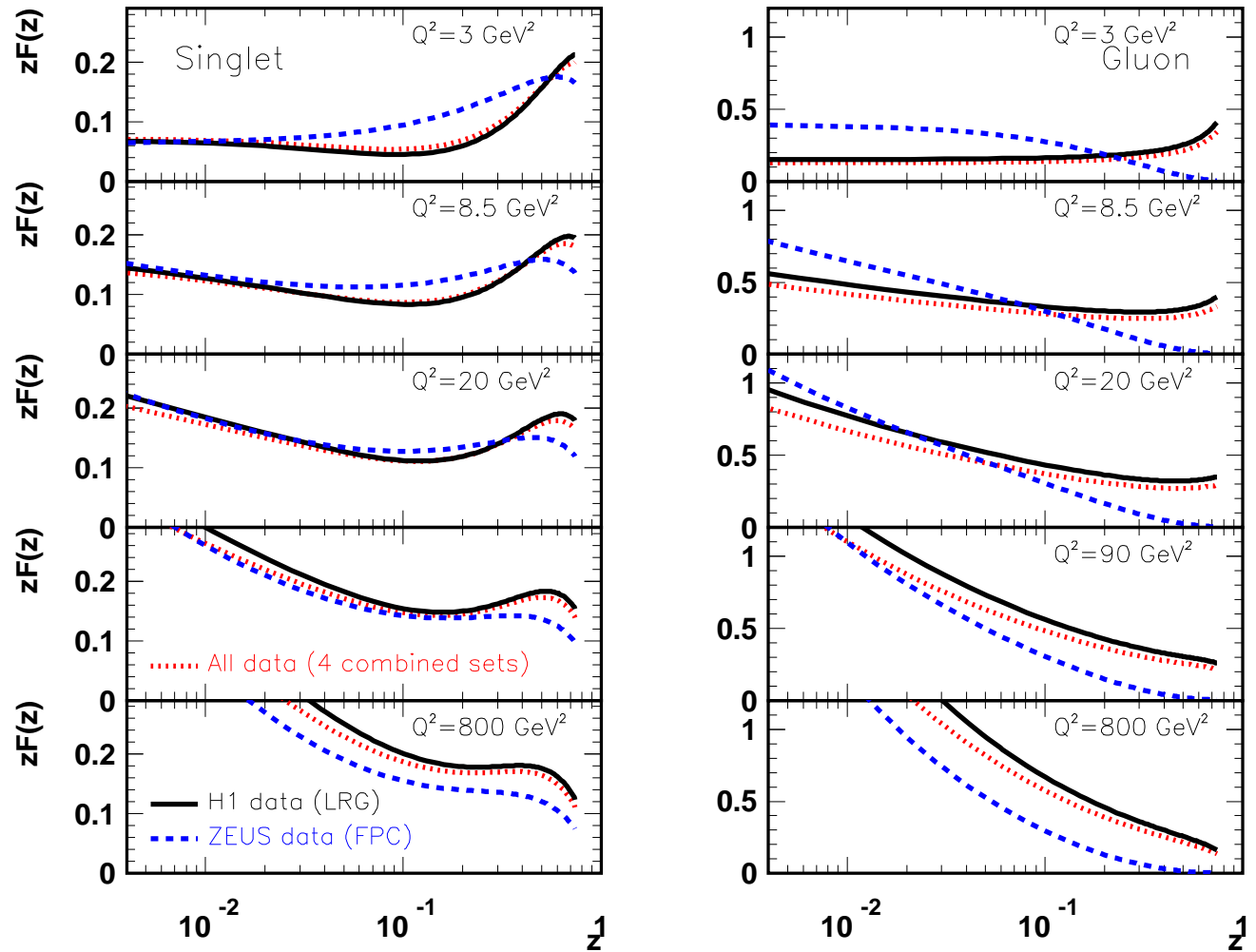
Uncertainty on high β gluon

- Important to know the high β gluon since it is a contamination to exclusive events

- Experimentally, quasi-exclusive events indistinguishable from purely exclusive ones

- Uncertainty on gluon density at high β: multiply the gluon density by $(1-\beta)^\nu$ (fit: $\nu = 0.0 \pm 0.6$)
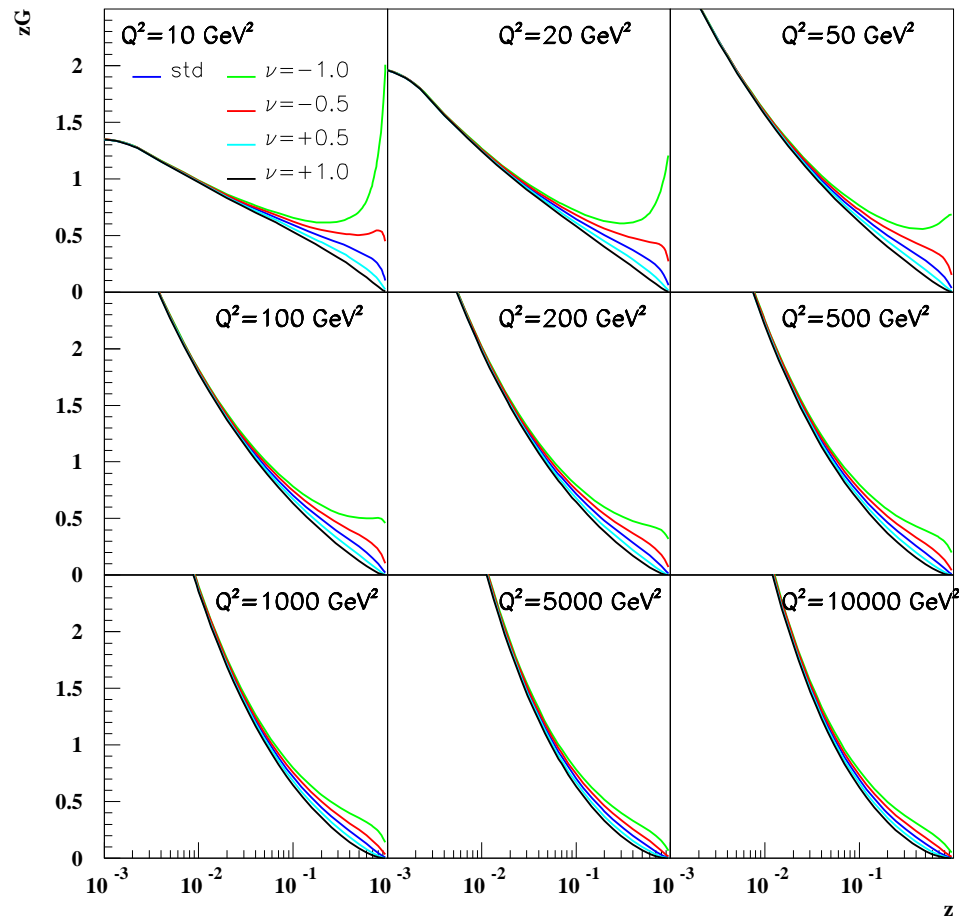
DPEMC Monte Carlo

- **DPEMC (Double Pomeron Exchange Monte Carlo):** New generator to produce events with double pomeron exchange (contains POMWIG, Bialas Landshoff model for inclusive diffraction and both "Durham" and Bialas Landshoff models for exclusive diffraction) http://boonekam.home.cern.ch/boonekam/dpemc.htm, paper to be submitted to Comp. Phys. Com.

- **Interface with Herwig:** for hadronisation

- **Exclusive and inclusive processes included:** Higgs, dijets, diphotons, dileptons, SUSY, QED, Z, W...

- DPEMC generator interfaced with a fast simulation of LHC (as an example CMS, same for ATLAS) and CDF detectors, and a detailed simulation of roman pot acceptance

- Gap survival probability of 0.03 put for the LHC and 0.1 for Tevatron

χ_C exclusive production at the Tevatron?

- hep-ph/0612297, accepted by Nucl. Phys. B

- CDF observation: Upper limit of χ_C exclusive production at the Tevatron in the $J/\Psi\gamma$ channel $\sigma \sim 49$ pb $\pm 18 \pm$ 39 pb for $y < 0.6$ (result not corrected for cosmics, χ_2 contamination)

- Exclusive prediction: 59 pb

- Quasi-exclusive contamination:

| mass fraction	$\nu = 0$	$\nu = -1$	$\nu = -0.5$	$\nu = +0.5$	$\nu = +1.0$
≥ 0.8	5.4	119.1	27.2	0.9	0.2
≥ 0.85	2.0	62.0	11.2	0.2	0.0
≥ 0.9	0.3	19.6	2.9	0.0	0.0
≥ 0.95	0.8	1.7	0.8	0.0	0.0

- Contamination of quasi-exclusive events strongly dependent on assumption on high-β gluon density in pomeron (completely unknown...), and also on precision and smearing of dijet mass distribution

Different models to be studied to compare with DMF

- **Predictions from inclusive models:**
  - **"Factorised models" (FM):** Use the gluon and quark distributions coming from H1 measurements, apply survival probability of 0,1 for Tevatron, predict cross sections
  - **Extension of Bialas Landshoff model:** Diffraction is dominated by the exchange of a non-perturbative Pomeron (soft $\alpha_P = 1.08$, natural for hadron-hadron interaction), no survival probability since model scaled to CDF run I DPE cross section measurement
  - **Soft colour interaction:** Diffraction due to string rearrangement in final state in hadronisation phase
- **Predictions from exclusive models:**
  - **Durham model:** Direct 2-gluon coupling to the proton, pure exclusive event production, presence of Sudakov form factor which leads to a strong mass dependence of the cross section
  - **Bialas-Landshoff model:** Similar to inclusive one, exchange of a non-perturbative soft Pomeron
- **Fast simulation of CDF detector used**

Dijet mass fraction measurement in CDF

- Look for exclusive events (events where there is no pomeron remnants or when the full energy available is used to produce diffractively the high mass object)

- Select events with two jets only, one proton tagged in roman pot detector and a rapidity gap on the other side

- Predictions from the modified Bialas-Landshoff and "factorised" inclusive diffraction models for Jet $p_T > 10$ GeV

- Bialas Landshoff inspired approach lead to similar results as the "factorised" models
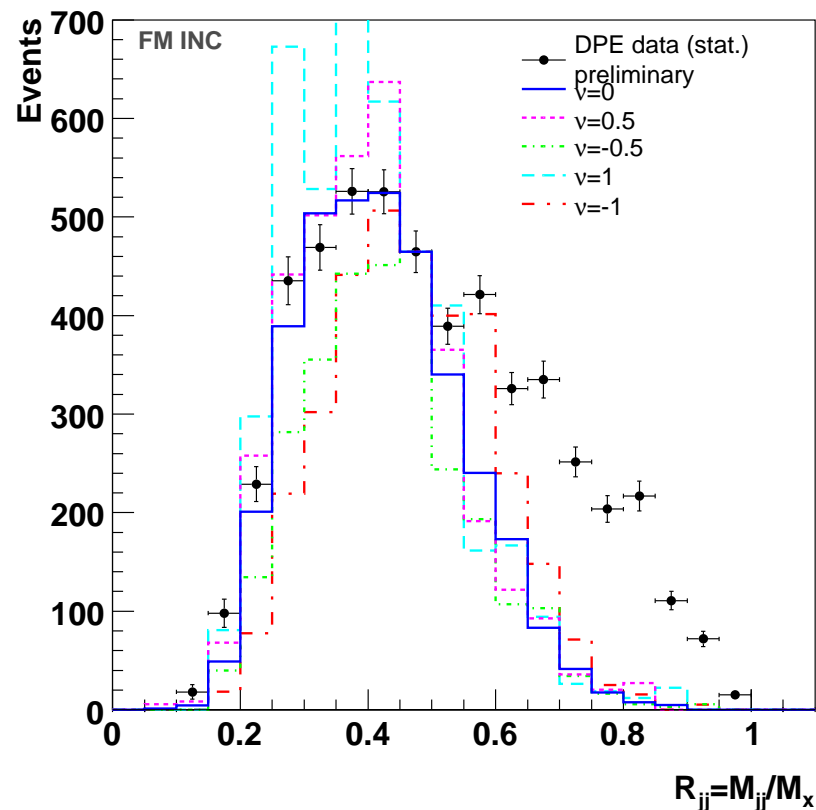
Prediction from inclusive diffraction

- Predictions from the Bialas-Landshoff and "factorised" inclusive diffraction models: Jet $p_T > 25$ GeV

- In the following, we only consider the "factorisable" inclusive models
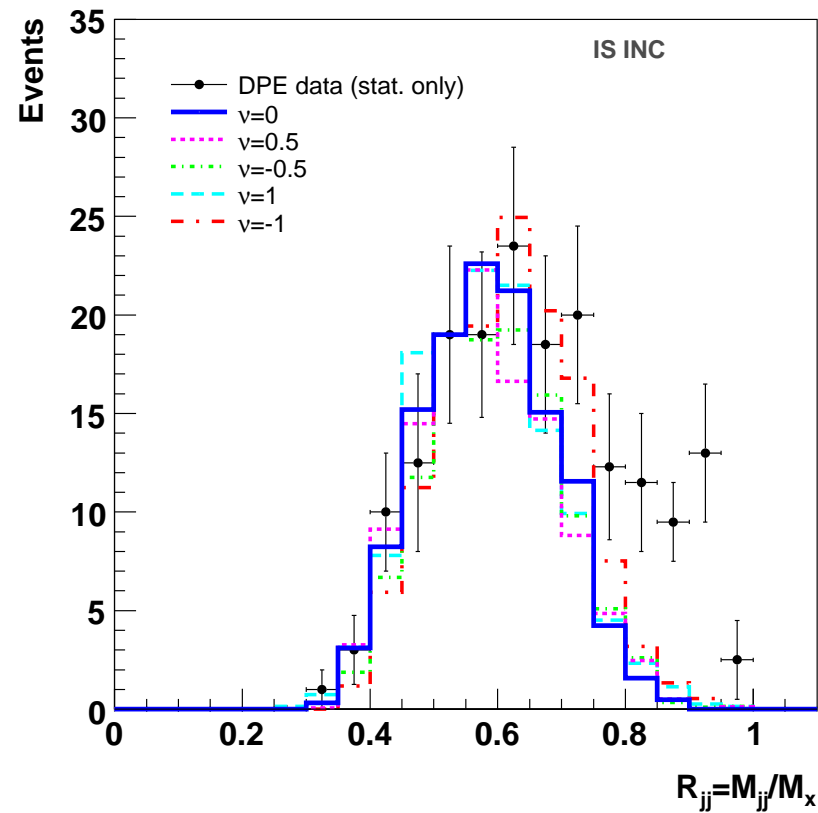
# Prediction from inclusive and exclusive diffraction

- Add the exclusive contribution from Durham or Bialas-Landshoff model (free relative normalisation between inclusive and exclusive contribution)

- Good agreement between measurement and predictions

- As an example: Durham exclusive and either "Factorisable" models for $p_T > 10$ GeV or modified Bialas Landshoff inclusive model for $p_T > 25$ GeV
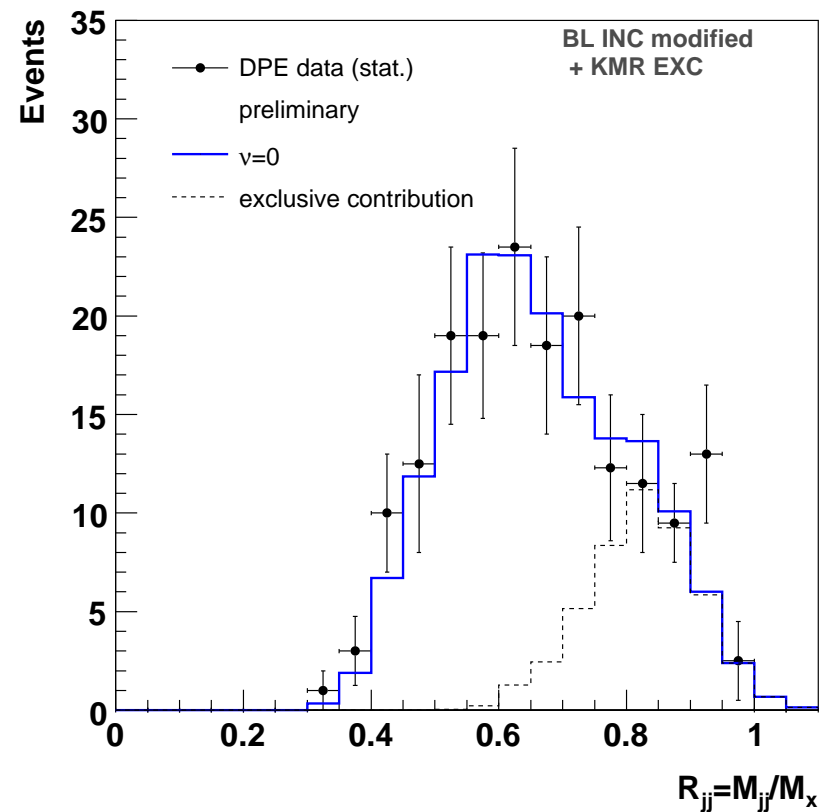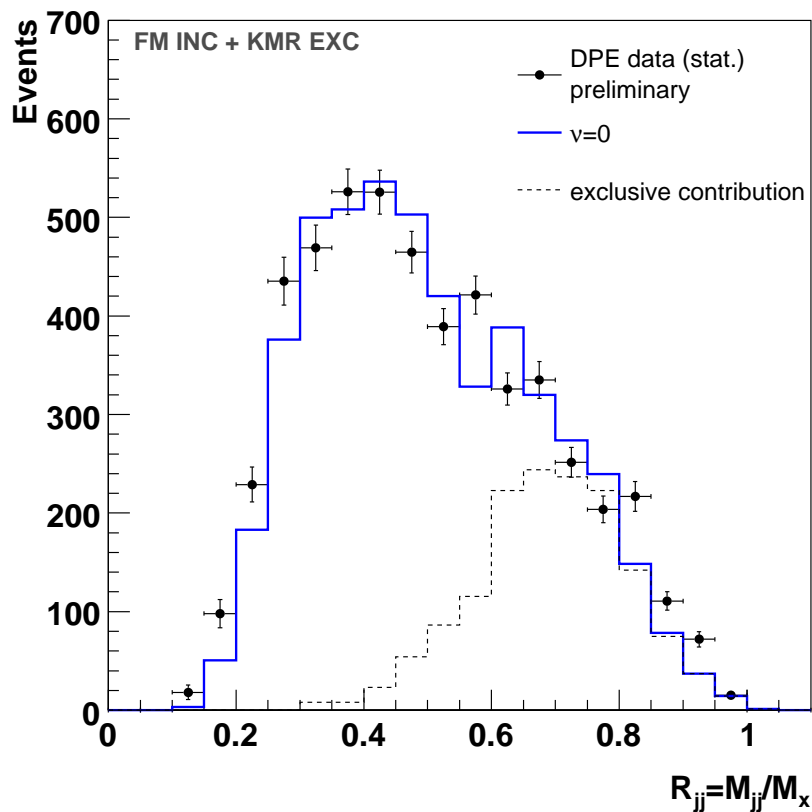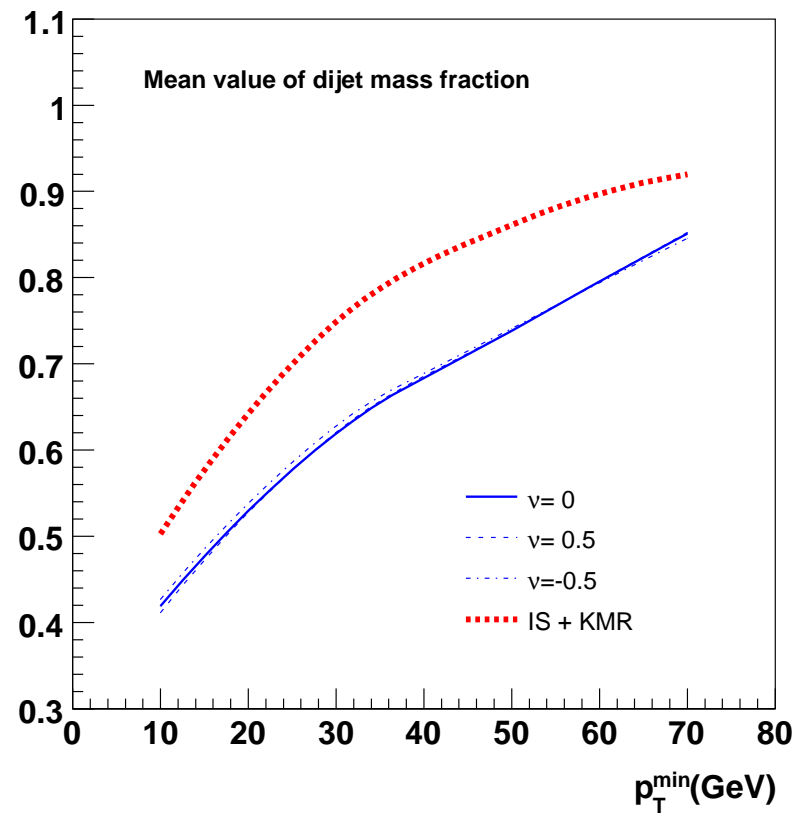
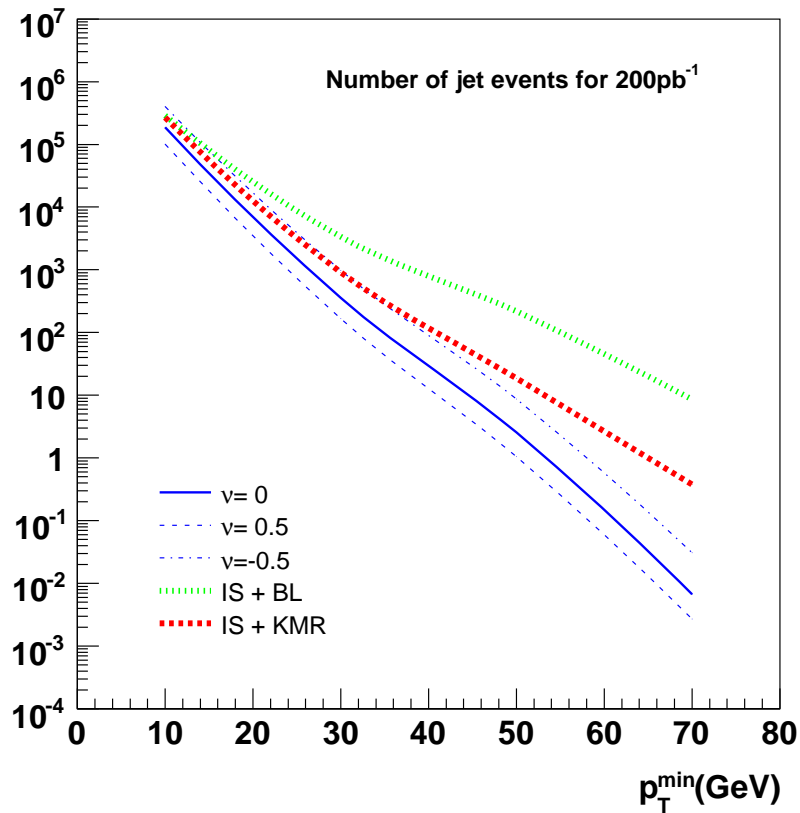# Relative normalisation between inclusive and exclusive

- If model right, expect relative contribution to be stable between at jet $p_T > 10$ GeV and $p_T > 25$ GeV (modulo imperfection of CDF detector fast simulation)

- Bialas Landshoff approach leads to too low dependence on jet p_T whereas Durham model looks better

Contributions	$r^{\mathrm{EXC/INC}}(10 GeV)$	$r^{\mathrm{EXC/INC}}(25 GeV)$
FM + KMR	2.6	1.0
FM + BL exc	0.35	0.038
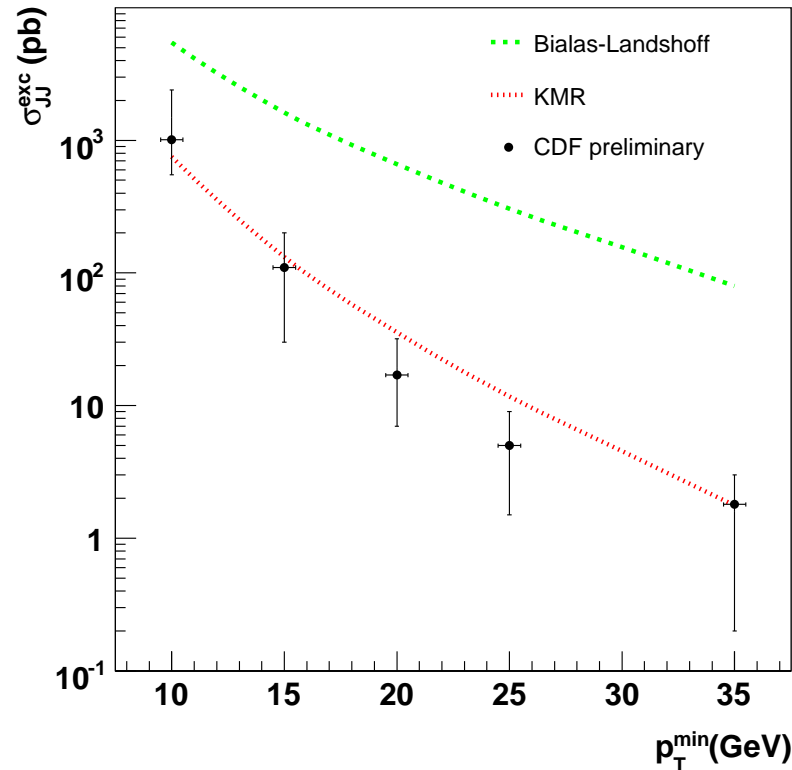
A better way to look for exclusive events?

Exclusive contribution more visible at jet p_T of 30-40 GeV

Number of jet events for 200pb^{-1}

- $\nu = 0$
- $\nu = 0.5$
- $\nu = -0.5$
- IS + BL
- IS + KMR

p_T^{min}(GeV)

Mean value of dijet mass fraction

- $\nu = 0$
- $\nu = 0.5$
- $\nu = -0.5$
- IS + KMR

p_T^{min}(GeV)

Soft Colour Interaction models

- A completely different model to explain diffractive events: Soft Colour Interaction (R.Enberg, G.Ingelman, N.Timneanu, hep-ph/0106246)

- Principle: Variation of colour string topologies, giving a unified description of final states for diffractive and non-diffractive events

- No survival probability for SCI models
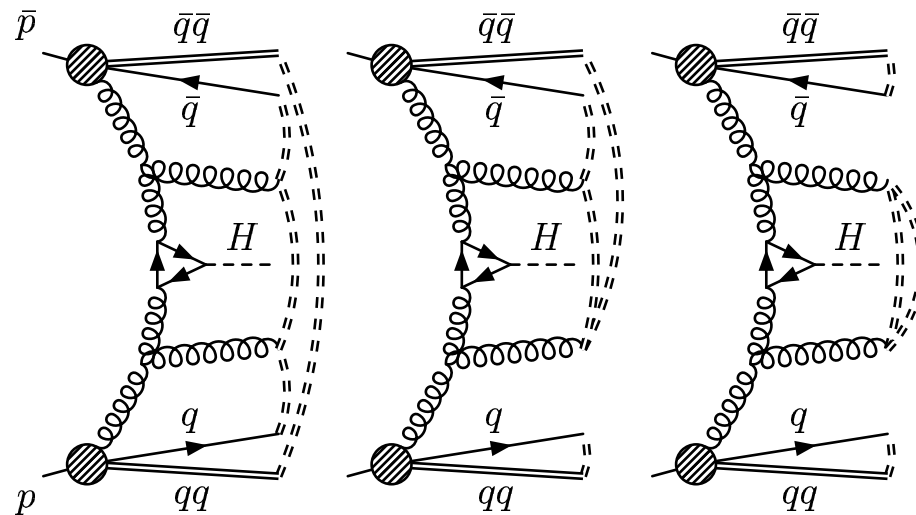
What about SCI?

- SCI models give correct normalisation for single diffraction at Tevatron and diffraction at HERA without any additional parameter

- Exclusive events and SCI: Contribution of exclusive events needed much lower compared to Pomeron-like models, even vanishes for jet $p_T > 25$ GeV...
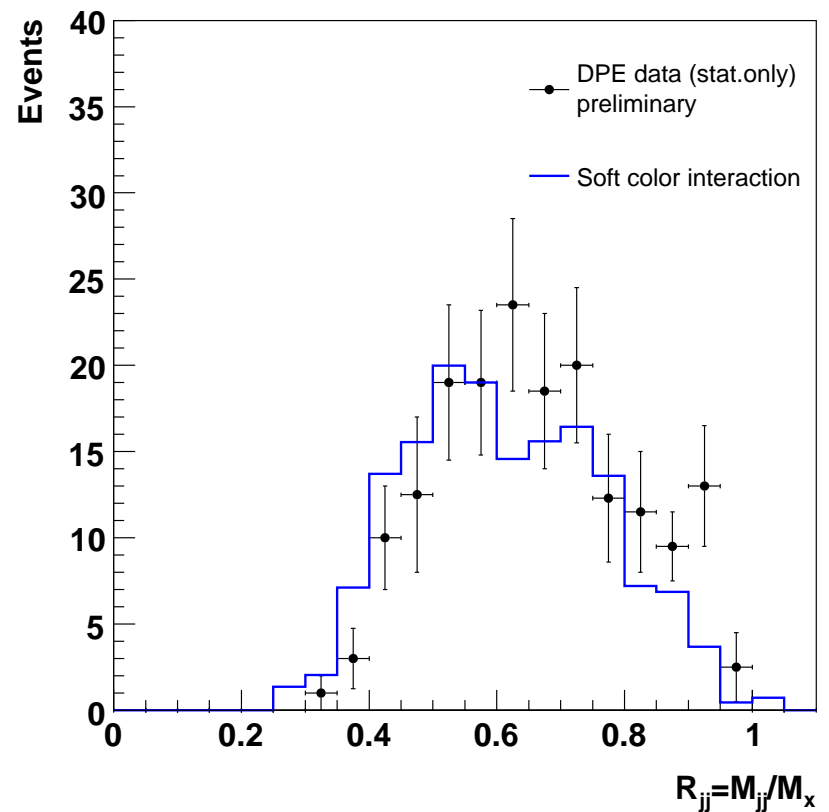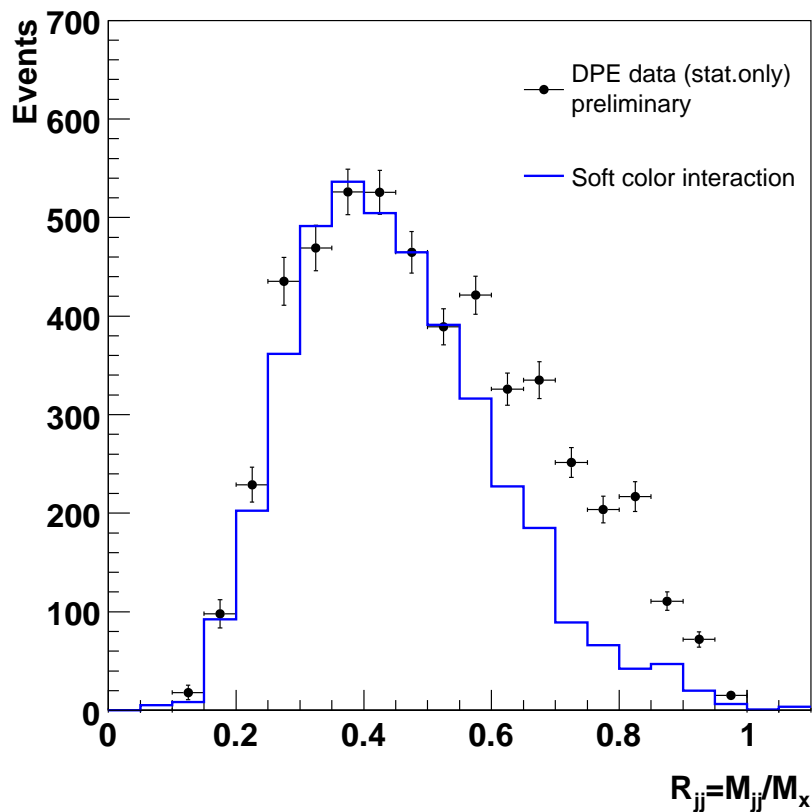
Comments about SCI

- Contribution of exclusive events much smaller for SCI

- "DPE" exchange in SCI models dominated by the following configuration for CDF events: 1 antiproton tagged in the final state, a bunch of particles going through the beam pipe on the other side (dominated by pions), no proton in the final state, due to the fact that only a rapidity gap is requested

- Jet rapidity boosted towards high rapidity: SCI model worth to be studied in more detail, but needs further improvement
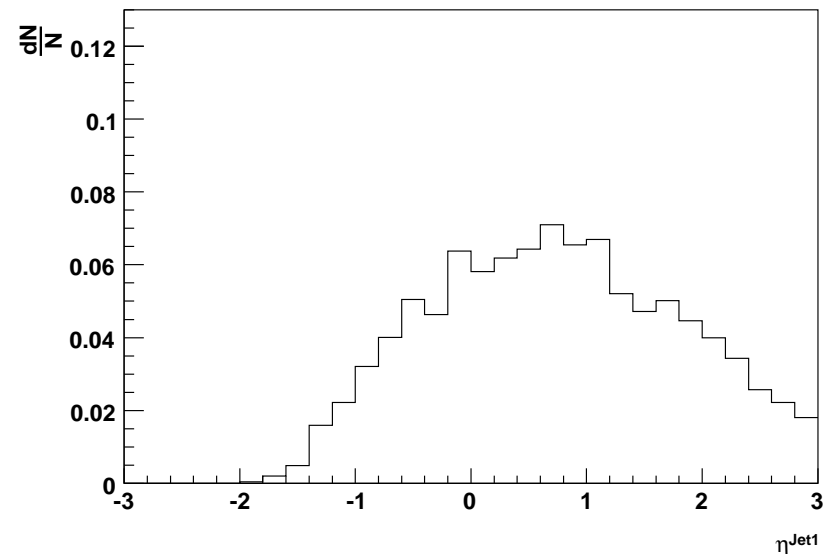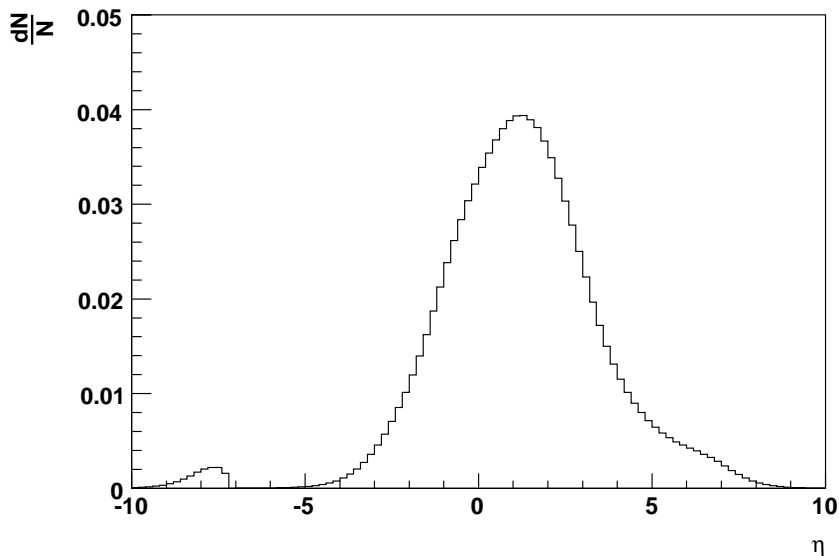
LHC: Exclusive and inclusive events

- Study of exclusive and inclusive production to be made at the LHC: study cross section of both components as a function of jet p_T and perform DGLAP QCD fits

- Important to understand background and signal for exclusive production of rare events: Higgs, SUSY...
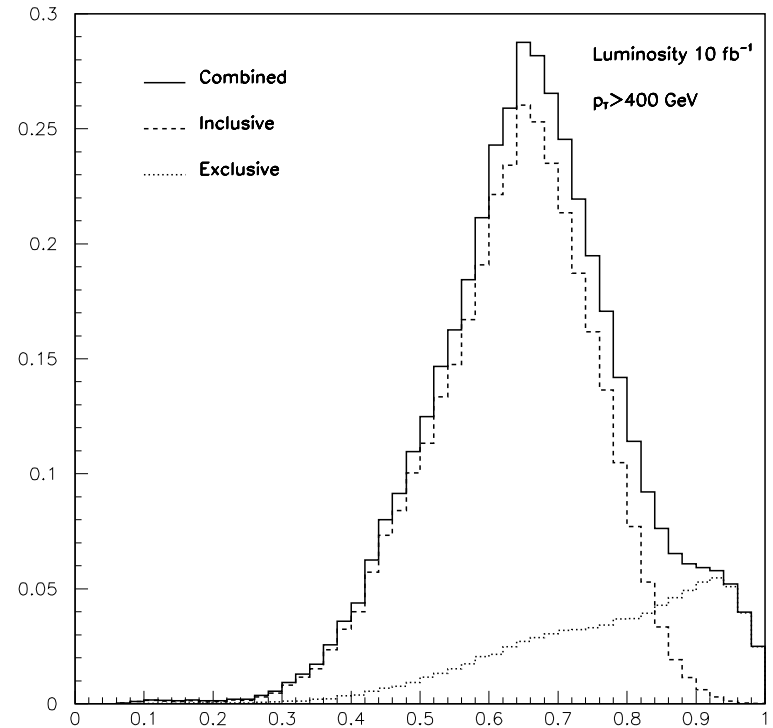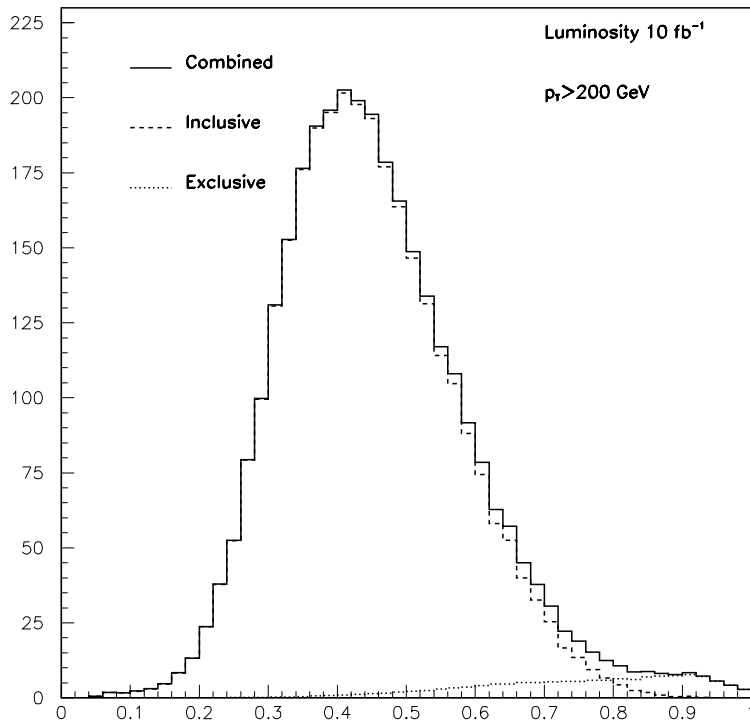
LHC: Exclusive and inclusive events

- Number of dijet events as a function of jet p_T: dominated by uncertainty on gluon density

- Dijet mass fraction (average value as an example): sensitive to exclusive production, quite easy to measure
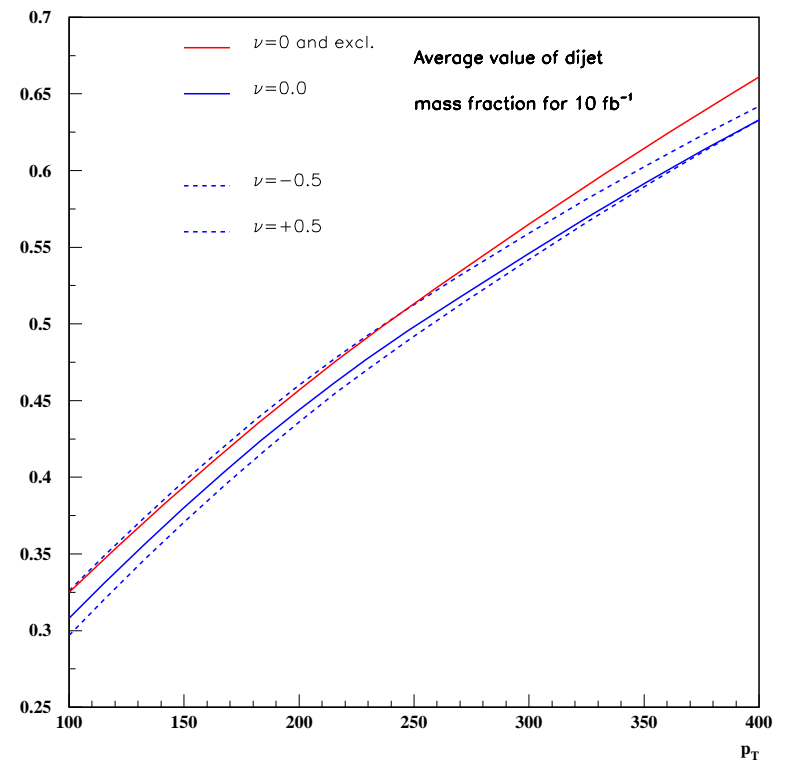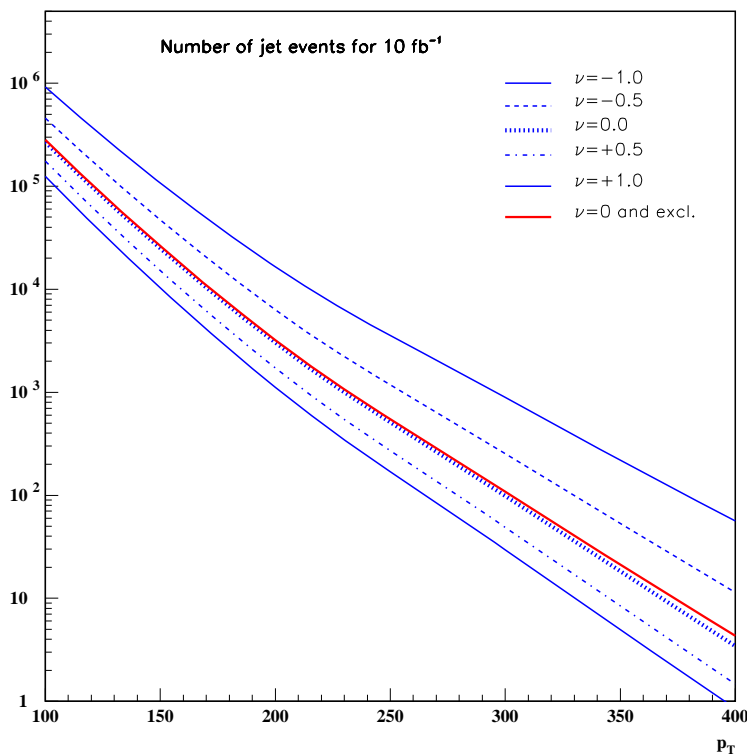
Conclusion

- Inclusive Diffractive model cannot describe properly dijet mass fraction measurement at high values

- Inclusive and Exclusive models together lead to a good description of dijet mass fraction: Durham model together with "factorised" or modified inclusive "Bialas-Landshoff" models are favoured (Bialas-Landshoff exclusive models are disfavoured)

- Ideally look at jets with $p_T > 30 - 40$ GeV at Tevatron to obtain the best separation between inclusive and exclusive events

- At the LHC: Full cross section analysis of exclusive and inclusive production needed to obtain good prediction for Higgs, SUSY...

- SCI models: worth to study in more detail since they show a completely different model of diffraction and lead to a sensibly different dijet mass fraction