Exclusive production at the Tevatron/LHC

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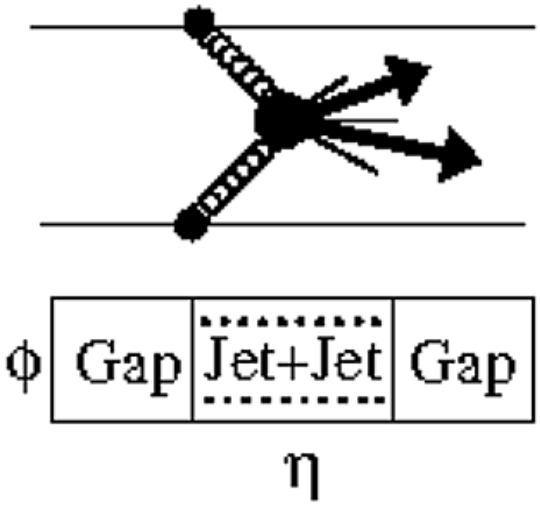
- Inclusive vs. exclusive diffraction models
- Dijet mass fraction as measured by CDF
- Soft color interaction
- Dijet mass fraction at the LHC
- Conclusion

arXiv:0704.1956 [hep-ph]
In collaboration with M. Boonekamp, R. Peschanski, C. Royon, L. Schoeffel

Hard diffraction at the Tevatron/LHC



Exclusive channel interesting:

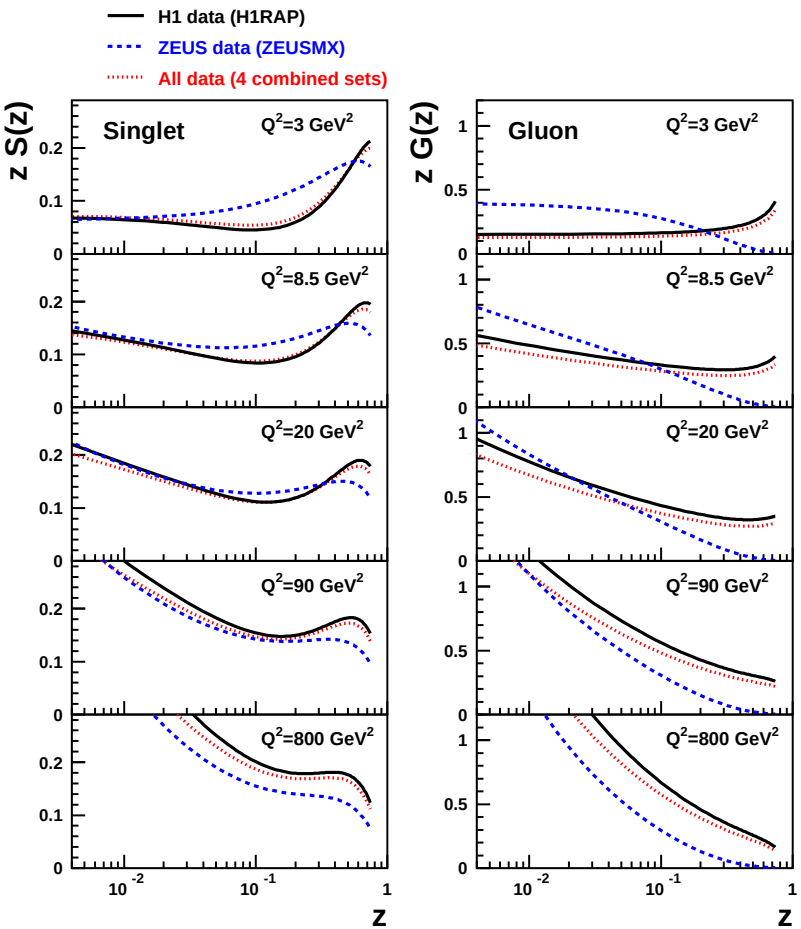
- Tagging outgoing protons: good mass resolution (as good as $2 \sim 3$ GeV for a M_H =140 GeV)
- Absolute determination of quantum numbers of any resonance

double pomeron exchange

- Gaps between produced jets and outgoing protons, no color interaction
- Pomeron model:
  - exchange of colorless objects - pomerons
  - central production is described as a hard scattering of pomeron constituents $\Rightarrow$ pomeron parton densities

Diffractive structure functions from HERA

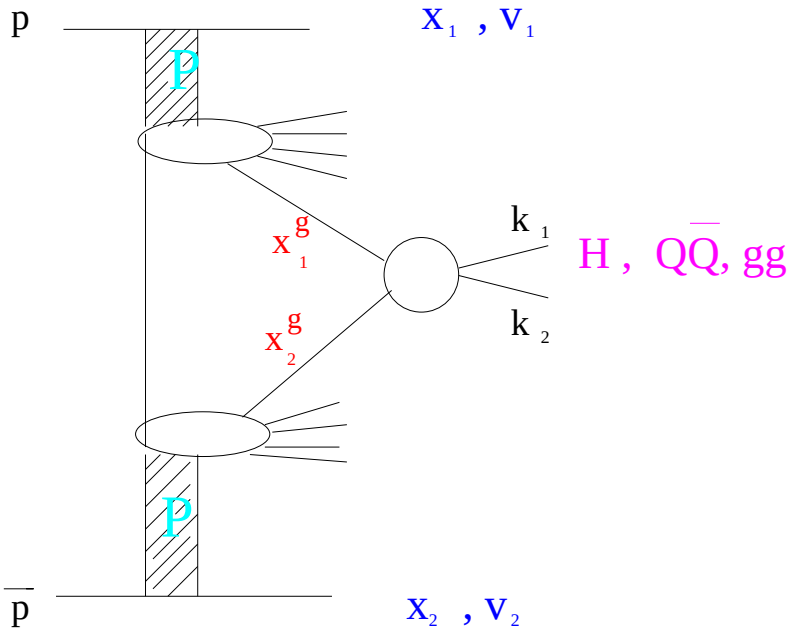
- Global fits of HERA F_2^D (see previous presentation of L. Schoeffel)
- Pomeron is gluon dominated, gluon poorly constrained at high β
  (β - momentum fraction of the pomeron carried by gluon)



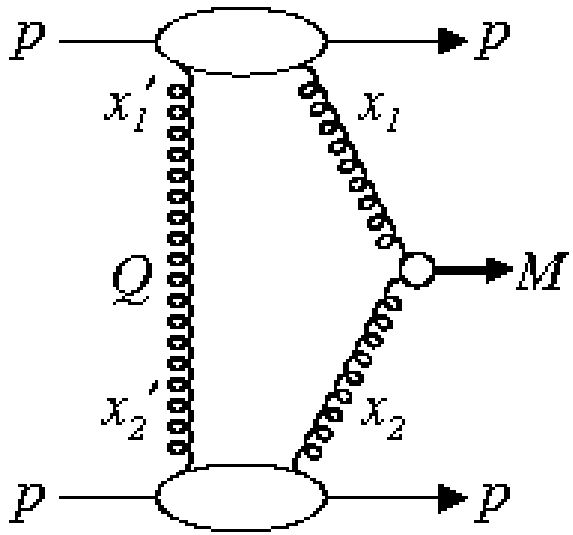
- Gluon density function smaller than in older H1 fits
- Nucl.Phys.B764:15-28, 2006

Production of heavy objects diffractively

Inclusive:



Exclusive:



- Inclusive diff: pomeron from HERA used for prediction at the Tevatron
- Exclusive diff: heavy object produced alone, no pomeron remnants
- Dijet mass fraction - suitable observable to see exclusive signal

$$R_{JJ} = M_{JJ}/M_X$$

- Increase of signal in $R_{JJ} \to 1$ for exclusive production
- Another observable suggested (`hep-ph/0605113`)

$$R_J = 2E_T(\cosh\eta^*)/M_X \quad \eta^* = \eta - Y_M$$

DPE models

Inclusive models:

- Factorized model (FM)
  - exchange of perturbative pomerons (reggeons)
  - factorization break-up only up to the survival probability factor
- BPR model (BL inclusive)
  - non-perturbative, soft pomeron, utilizes shape of the pomeron PDFs, normalization must be adopted from data
  - (inclusive extension of the Bialas-Landshoff exclusive model)

Exclusive models:

- KMR model
  - perturbative calc., direct coupling of two gluons to the protons
- Bialas-Landshoff exclusive model
  - non-perturbative, soft pomeron

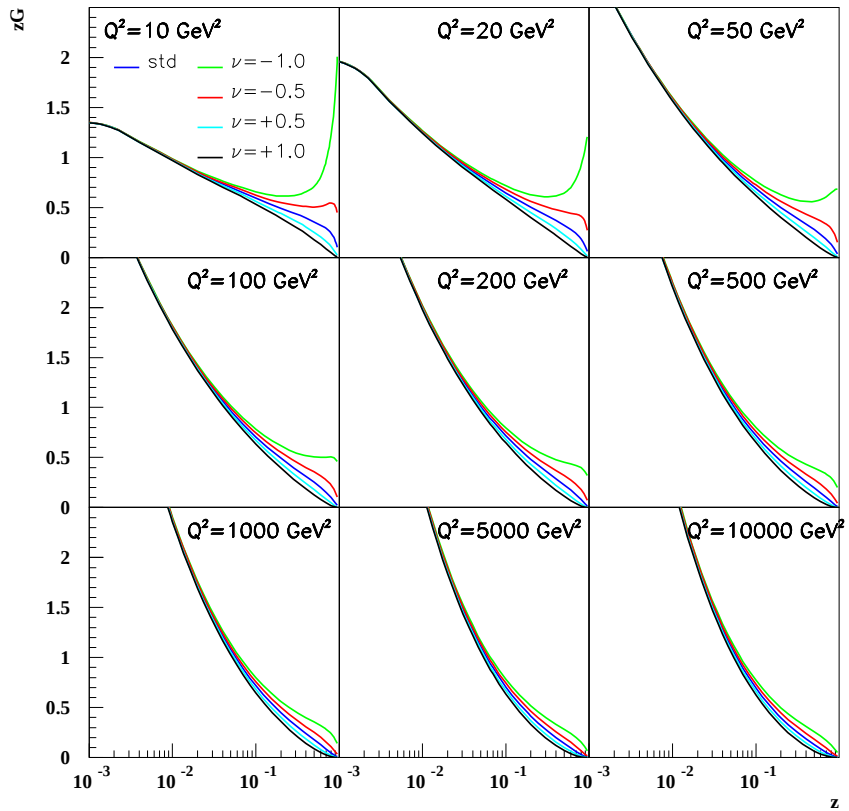
DPEMC monte carlo

- All DPE models implemented in DPEMC
  (Double pomeron exchange monte carlo)

  It is a flexible inteface to study also:
- Single diffraction, exclusive χ_c, χ_b production
- QED procceses: $\gamma\gamma$ interaction between protons (or heavy nuclei)
- Production of dijets, dileptons, diphotons, WW, H, Z, SUSY particles ...
- Embeded in HERWIG
- Various parton densities in the pomeron included
- Interfaced with ATLAS full simulation ATHENA
- $http://boonekam.home.cern.ch/boonekam/dpemc.htm$

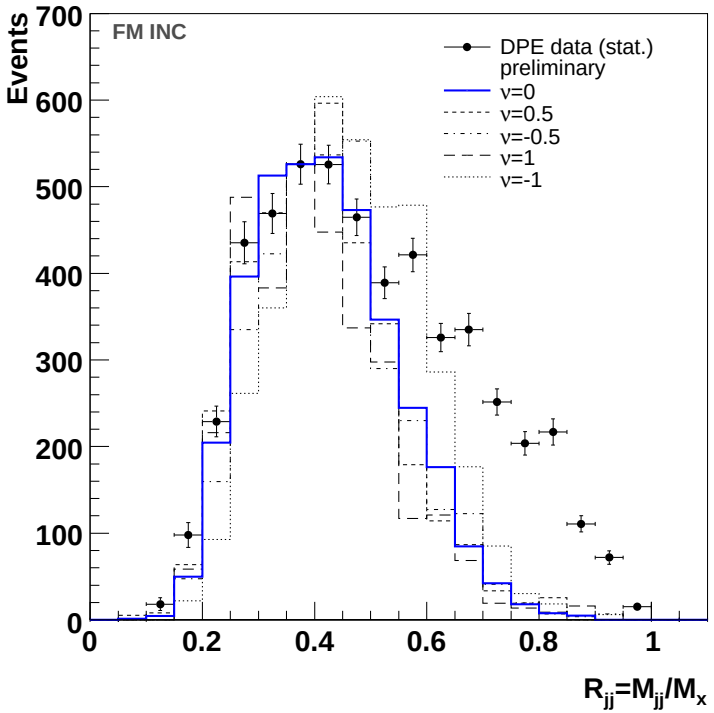
Gluon uncertainty at high β

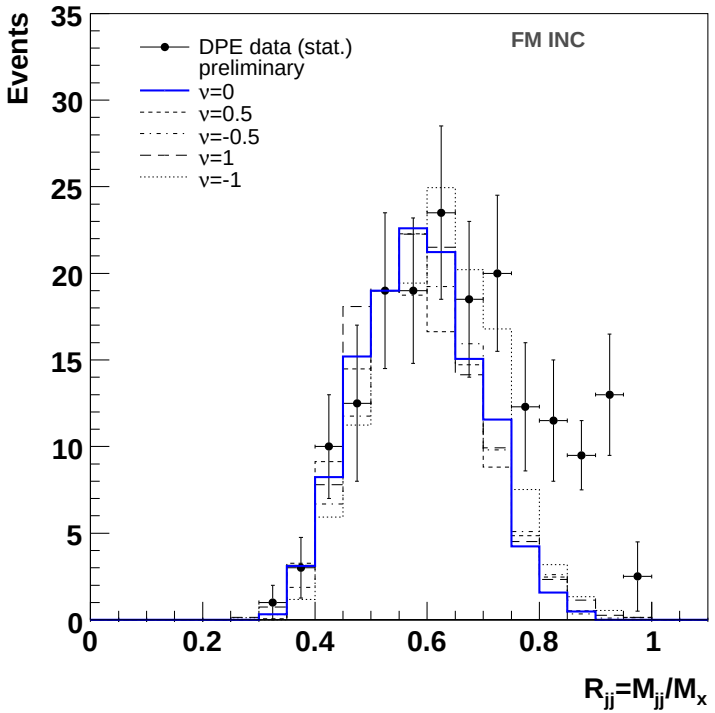
- Caution: high β gluon not well constrained
- Study of the gluon uncertainty: multiply the gluon by factor $(1-\beta)^{\nu}$
- Reminder: QCD fits yield $\nu = 0 \pm 0.6$



DMF at the Tevatron - inclusive models

Factorized model: $p_T^{jet1,2} > 10\,\text{GeV}$ $p_T^{jet1,2} > 25\,\text{GeV}$

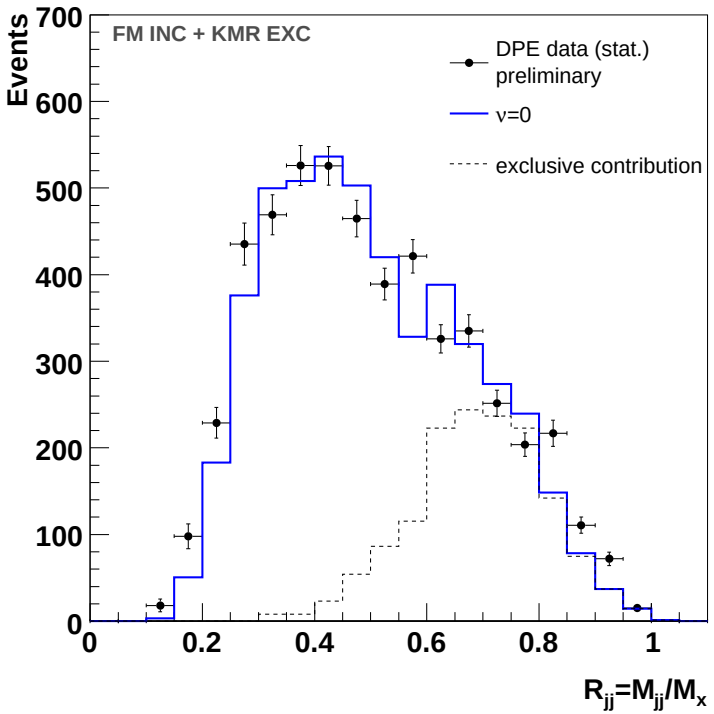




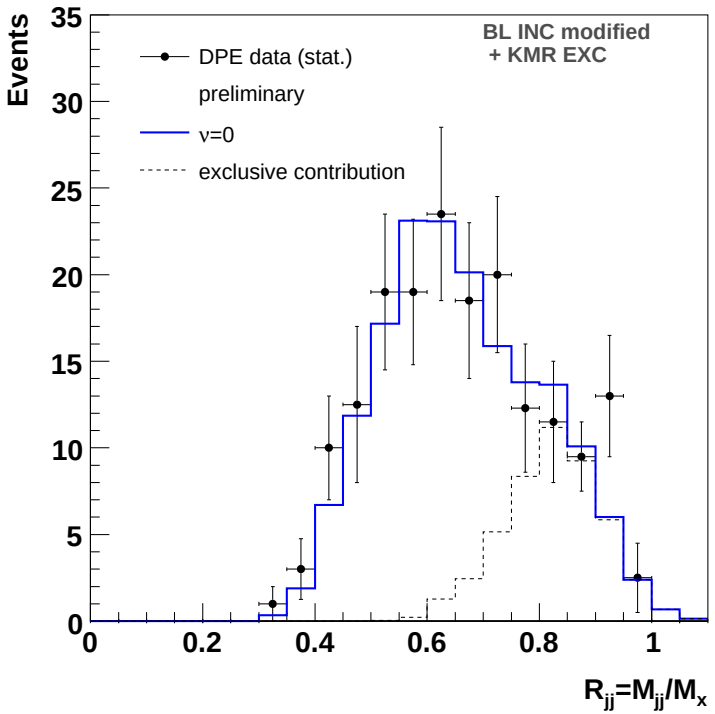
- Preliminary results, CDF note 8493, (2006)
- Can we explain the tail of DMF by enhancing gluon dens. at high β?
- No. Other contribution needed $\Rightarrow$ exclusive production
- Same conclusion for BPR model

DMF - inclusive + exclusive models

Factorized + KMR model:
$p_T^{jet1,2} > 10\,\text{GeV}$



BPR + KMR model:
$p_T^{jet1,2} > 25\,\text{GeV}$

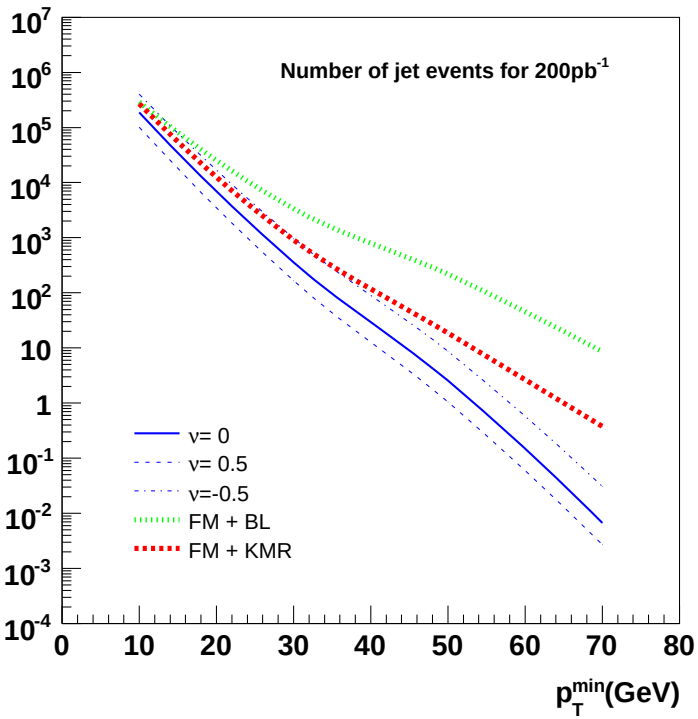


- Binned likelihood fit of inclusive and exclusive contribution
- Good description of the data

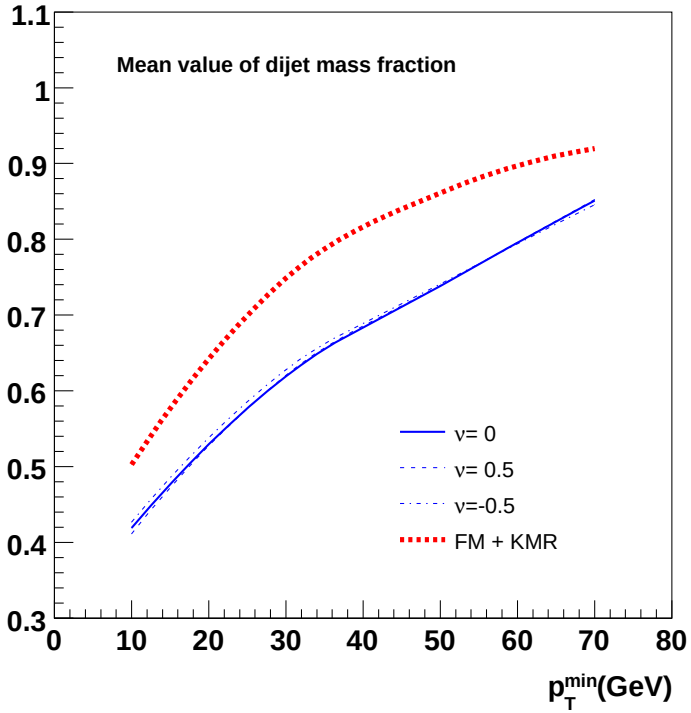
Other observables

- Other variables to identify the exclusive contribution
- Relative norm. between inc. and exc. fixed by fit to DMF $p_T^{min} = 25$ GeV
- Optimal signal for jets p_T^{min}=30GeV

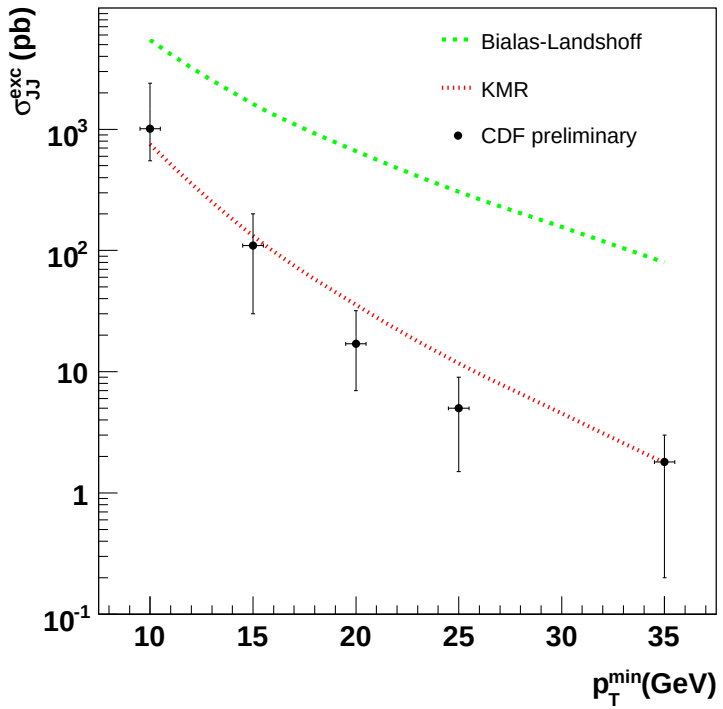
Number of jet events



Mean value of DMF dist.

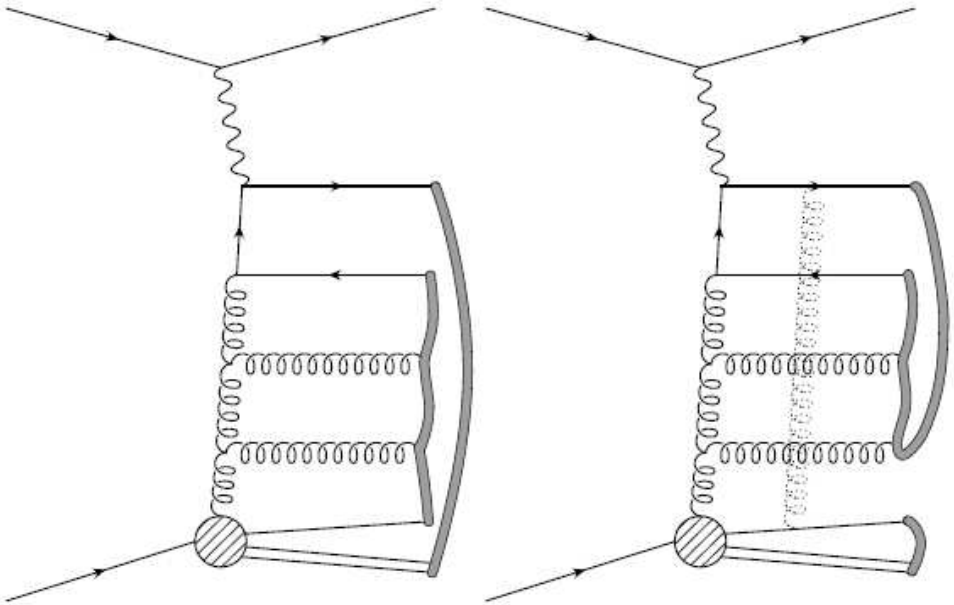


p_T dependance of exclusive cross section



- KMR model in agreement with data
- CDF data clearly disfavour Bialas-Landshoff exclusive model

Soft color interaction model

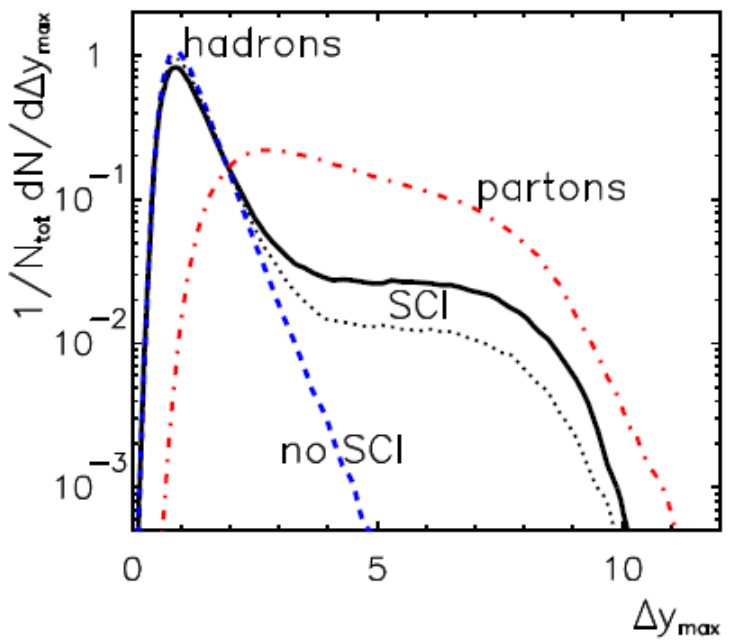


- After developement of partonic shower, additional soft color interaction can occur between partons with probability P
- From F_2^D

$$P \sim 0.5$$

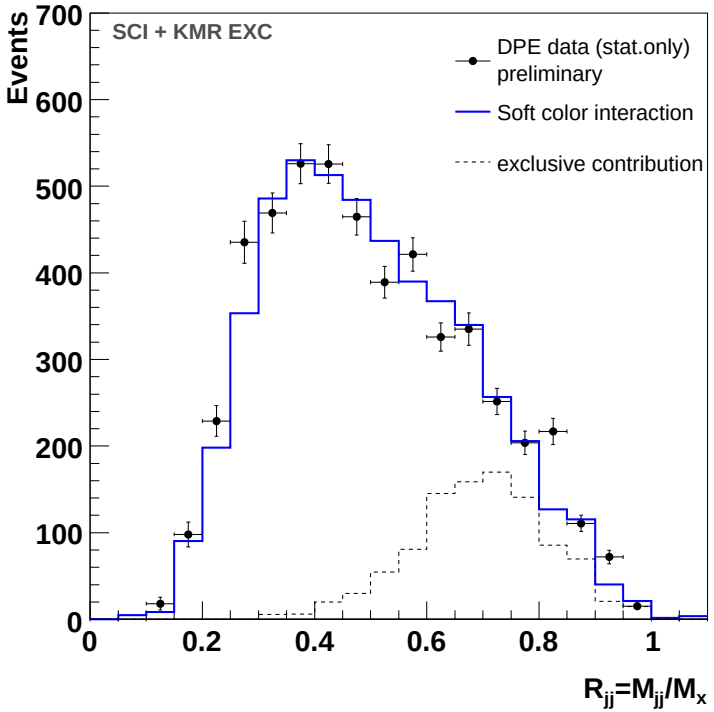
Enberg, Ingelman, Timneanu
Phys. Rev. D64(2001)114015

- Based on Lund string model

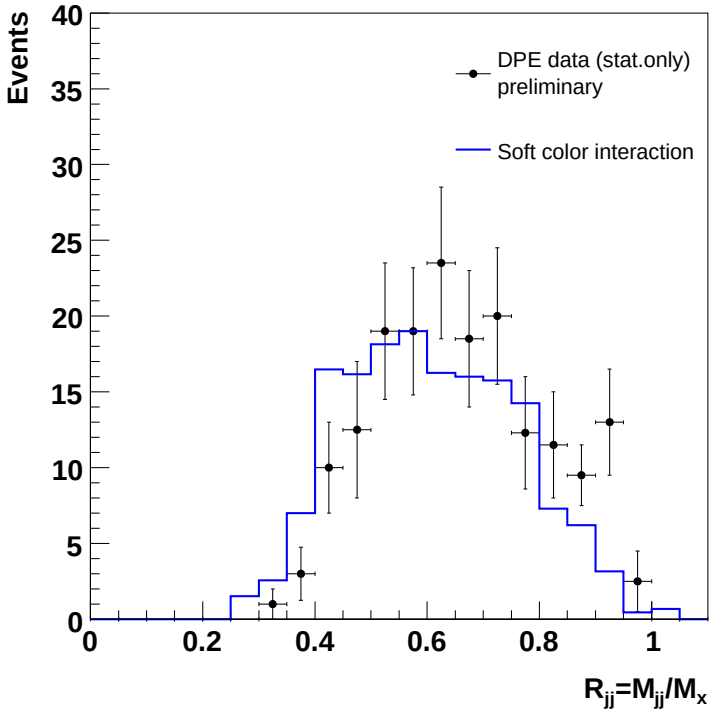


Dijet mass fraction with SCI

SCI+KMR: $p_T^{jet1,2} > 10$ GeV



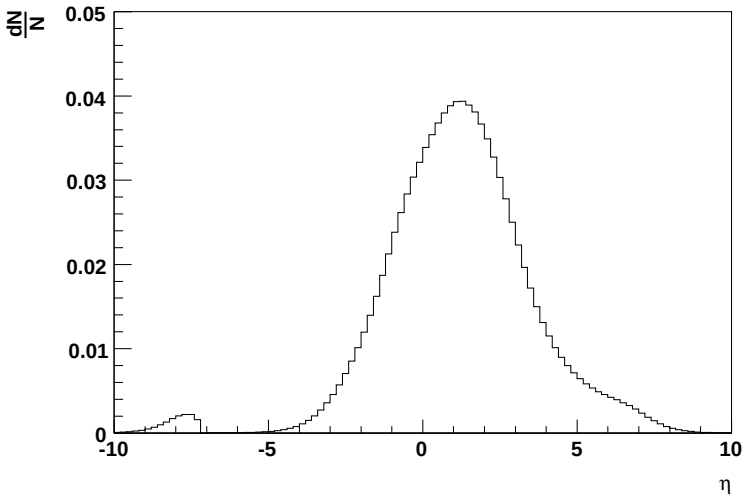
$p_T^{jet1,2} > 25$ GeV



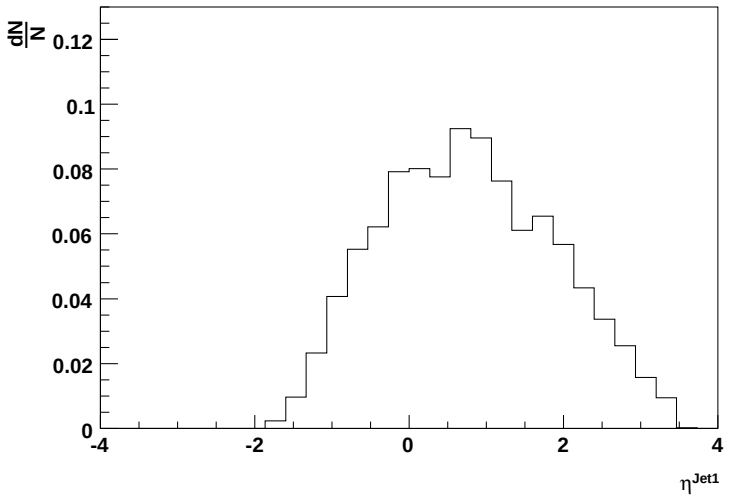
- Less exclusive contribution needed for $p_T^{jet1,2} > 10$ GeV, no for 25 GeV
- But the model has a cavity:
  Probability to get two protons in final state is very small!

Rapidity distribution in SCI

Particle flow ($\eta_{\bar{p}} \sim 8$)



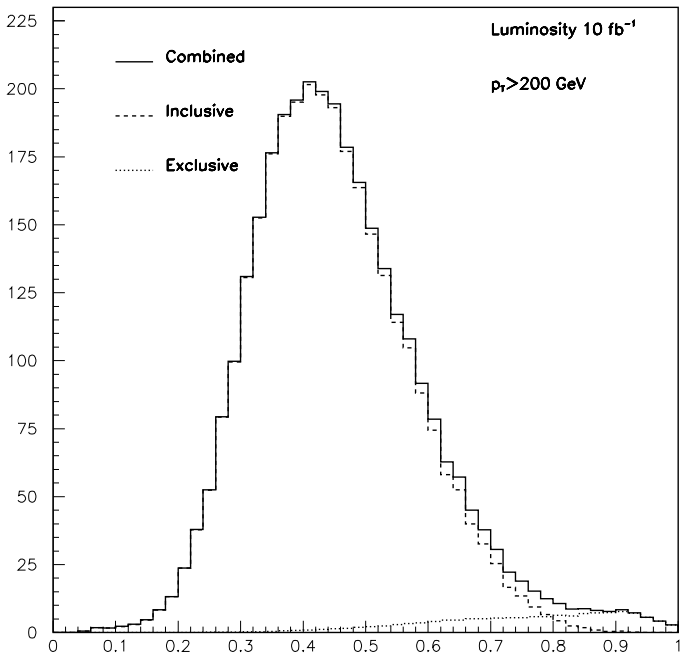
Jet1 rapidity distribution



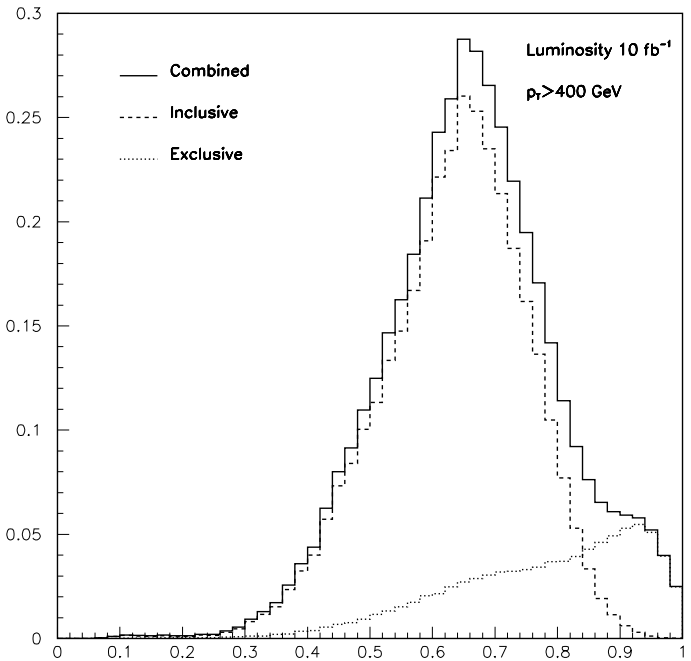
- Strictly speaking only SD signal: tagging $\bar{p}$ + rapidity gap as CDF
- $\bar{p}$ accompanied by other particles (mainly pions)
- Jet η distribution not symetric, unlike pomeron models and CDF data

Dijet mass fraction at the LHC

FM+KMR: $p_T^{jet1,2} > 200$ GeV



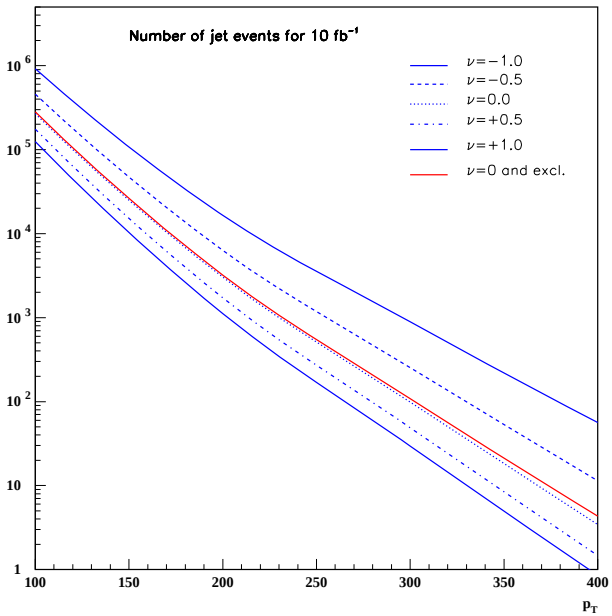
FM+KMR: $p_T^{jet1,2} > 400$ GeV



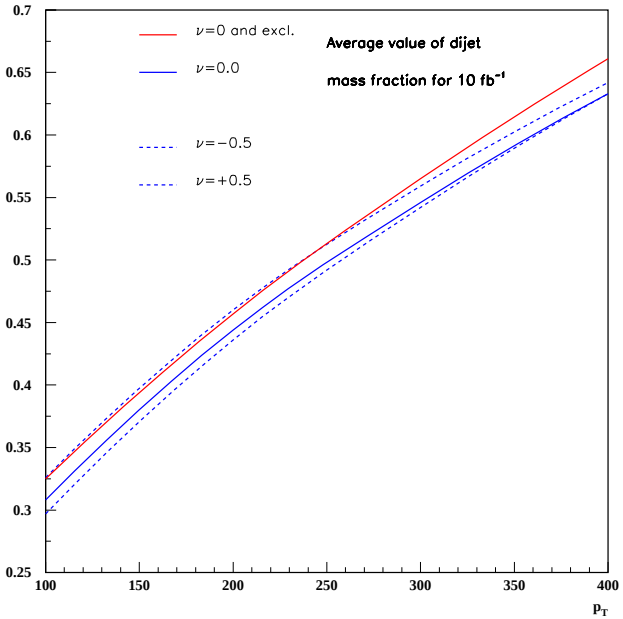
- Exclusive production dominates for e.g $R_{JJ} > 0.8$

Other observables at the LHC

FM+KMR: Number of jet events



FM+KMR: Mean of dijet mass fraction



- Exclusive contribution and uncertainty on the gluon density entangled
- Full QCD fit will have to be performed at the LHC: fitting the parton densities using DGLAP and the exclusive contribution at the same time

Conclusion

- Neither of models (Factorized and BPR model) can explain the CDF dijet mass fraction preliminary data even if taking the gluon uncertainty in the pomeron into account $\Rightarrow$ suggests that other contribution needed
- If soft color interaction model is to be considered, probability of producing two protons must be fixed (increased)
- Exclusive signal and gluon uncertainty are entangled at the LHC
  Full QCD analysis will have to be performed fitting parton densities and exclusive production