Review of diffraction at HERA and Tevatron

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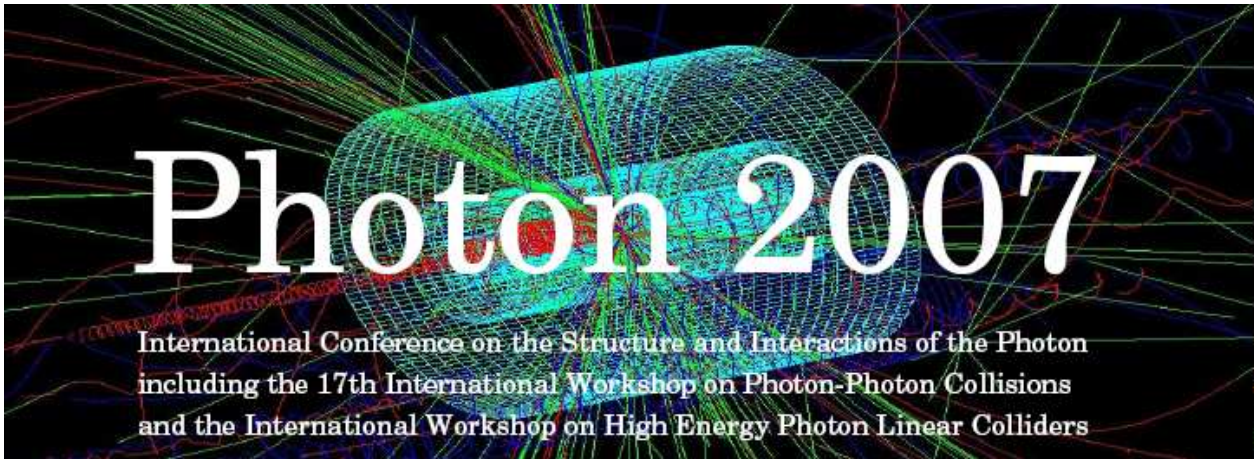
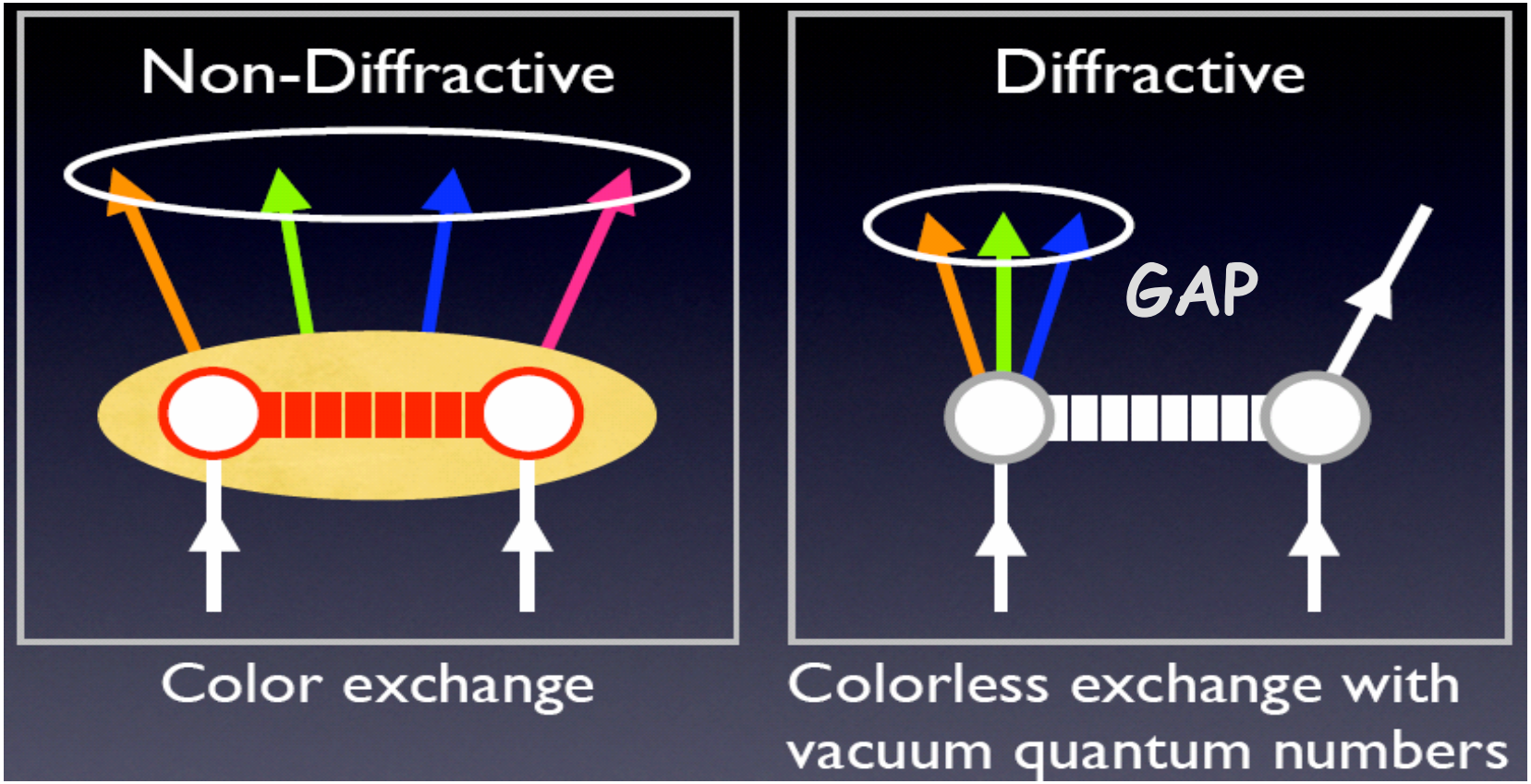


Selected topics on inclusive diffraction at HERA/Tevatron
Perspectives for LHC (including *Higgs*)

Definition of hadronic diffraction

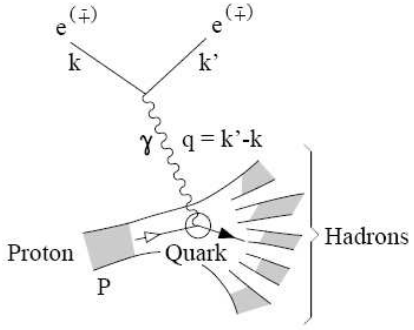


-The proton is left intact or quasi-intact : **Large Rapidity Gap (LRG)**

- Vacuum Quantum Number exchange == Pomeron (IP)

DIS vs DIFF events @ HERA

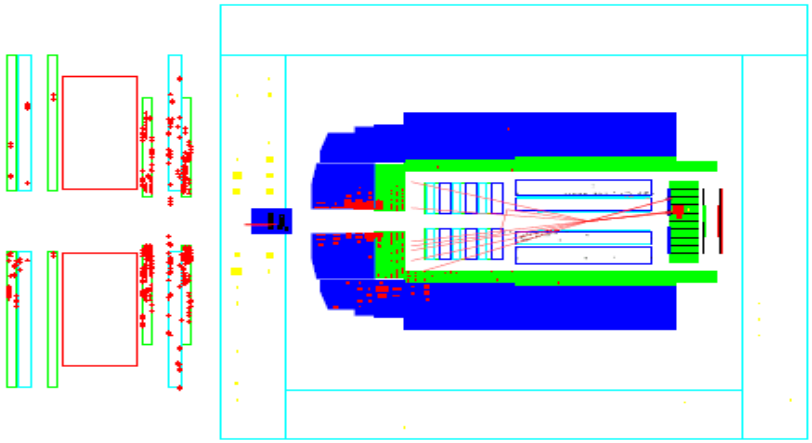
"Ordinary" Deep-Inelastic

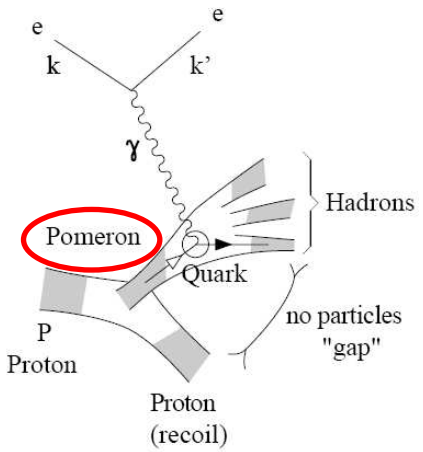


= quark momentum XP

= interaction volume : $Q^{-1} = (-q^2)^{-1/2}$

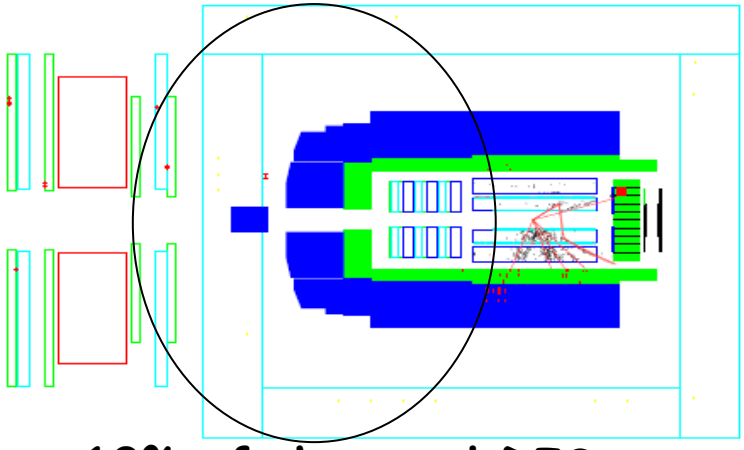
= final quark momentum (x P + q)





"Diffractive" Deep-Inelastic

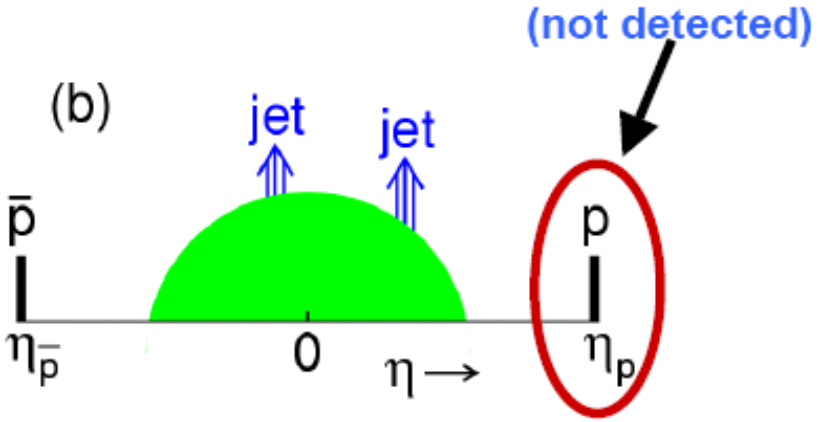
The Pomeron as a composite object

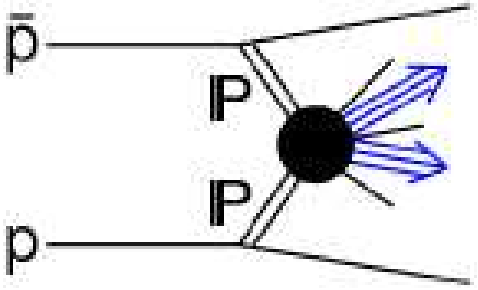


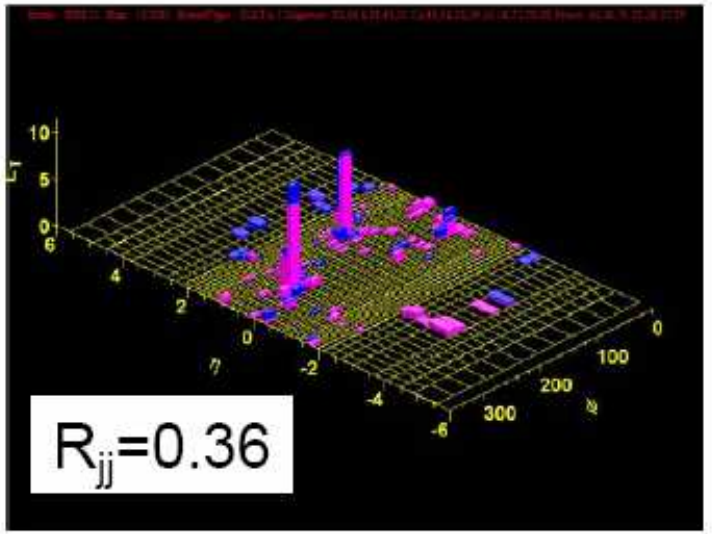
~ 10% of the total DIS events

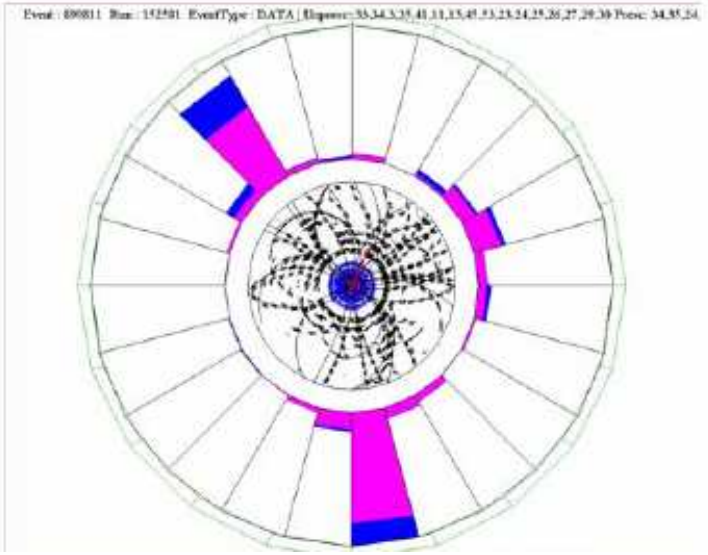
DIFF event @ Tevatron

Hard diffraction with
2 central jets & 2 gaps

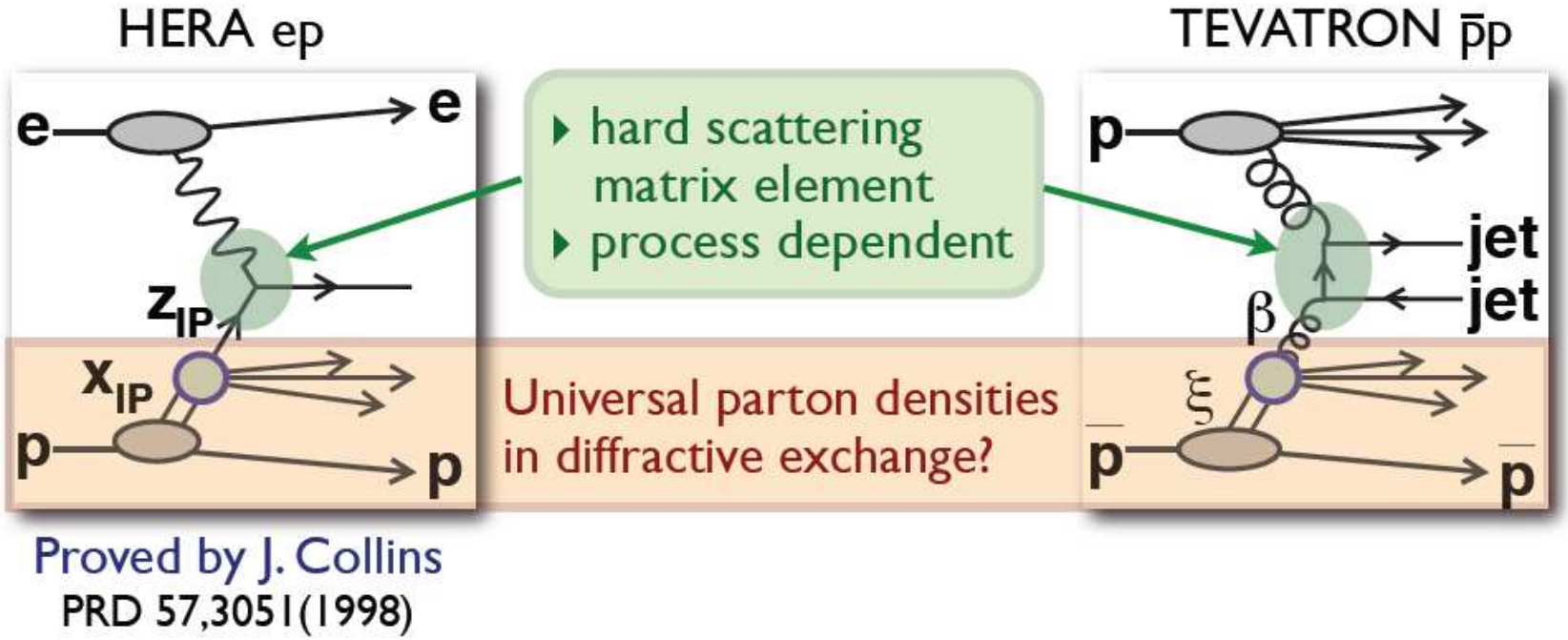








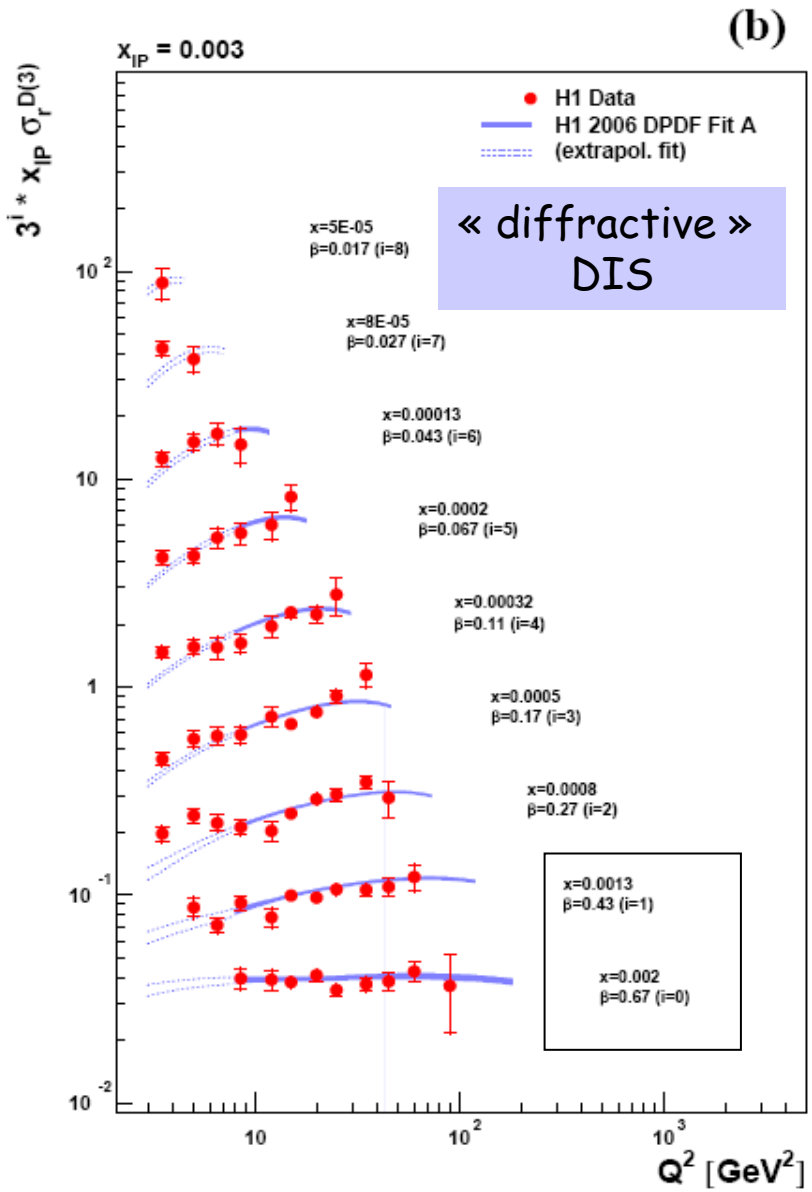
QCD factorisation

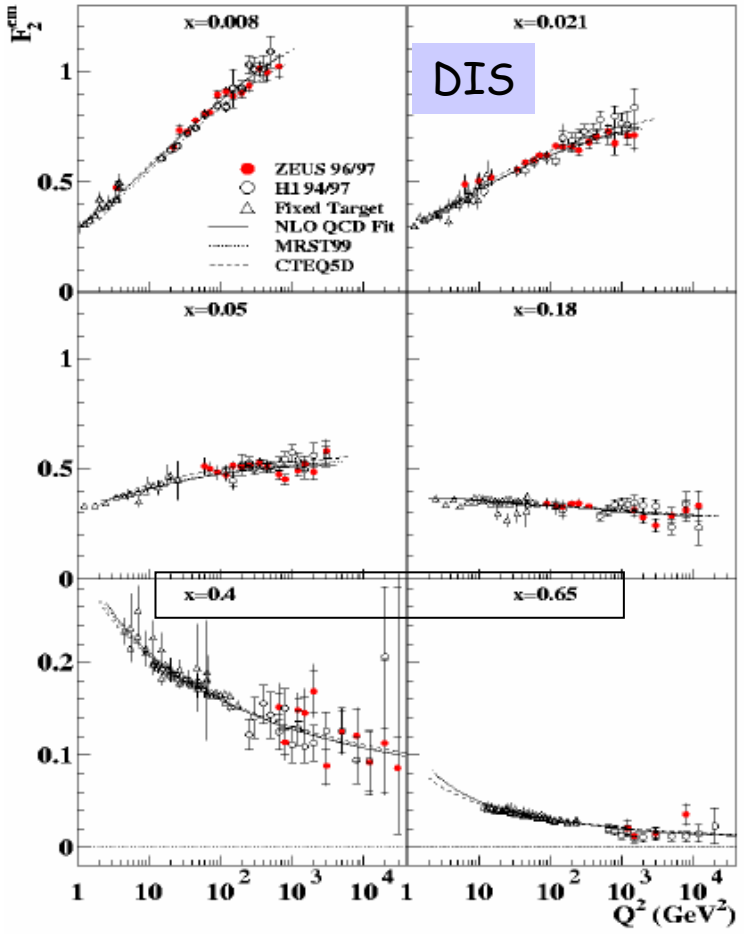


Proved by J. Collins
PRD 57,3051(1998)

$$f_a^D(z,\mu^2,x_{I\!P},t) = \sum_X \int dy_- \, \mathrm{e}^{-izP^+y^-} \langle P\,|\overline{\psi_a}(y_-)\gamma^+|P'X\rangle\langle P'X|\psi_a(0)|\,P\rangle$$

DIFF vs DIS cross sections @ HERA

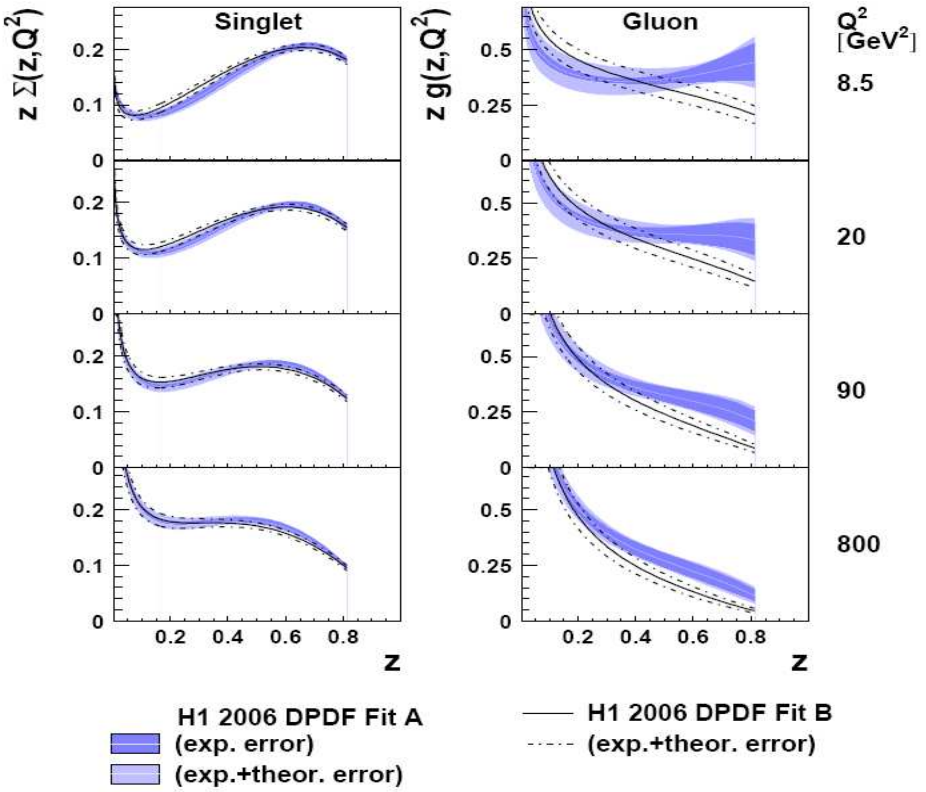


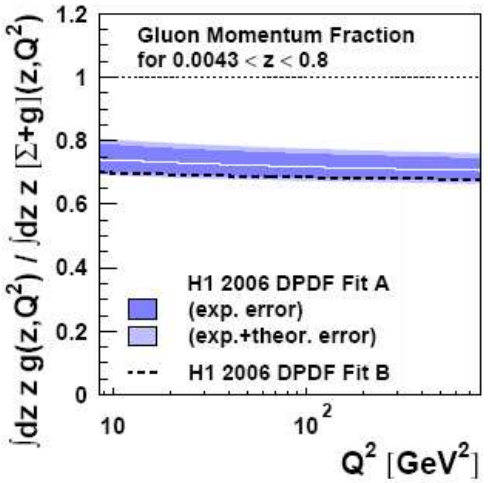


At large β values : scaling violations still >0 for diffraction, *<0 for standard DIS*

=> Large gluon content expected for DIFF

Factorisation & diffractive PDFs



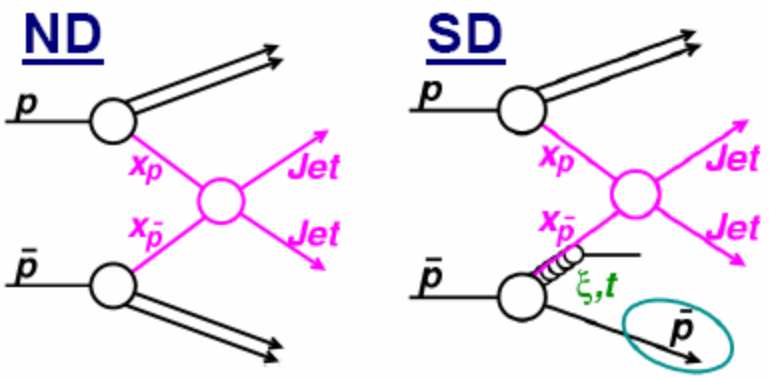


Large gluon content (in the IP)
carrying the main part of the momentum

Large uncertainty @ large β

The factorisation theorem (+resolved IP model+dPDFs)
gives a good description of HERA data

The limit of factorisation @ Tevatron

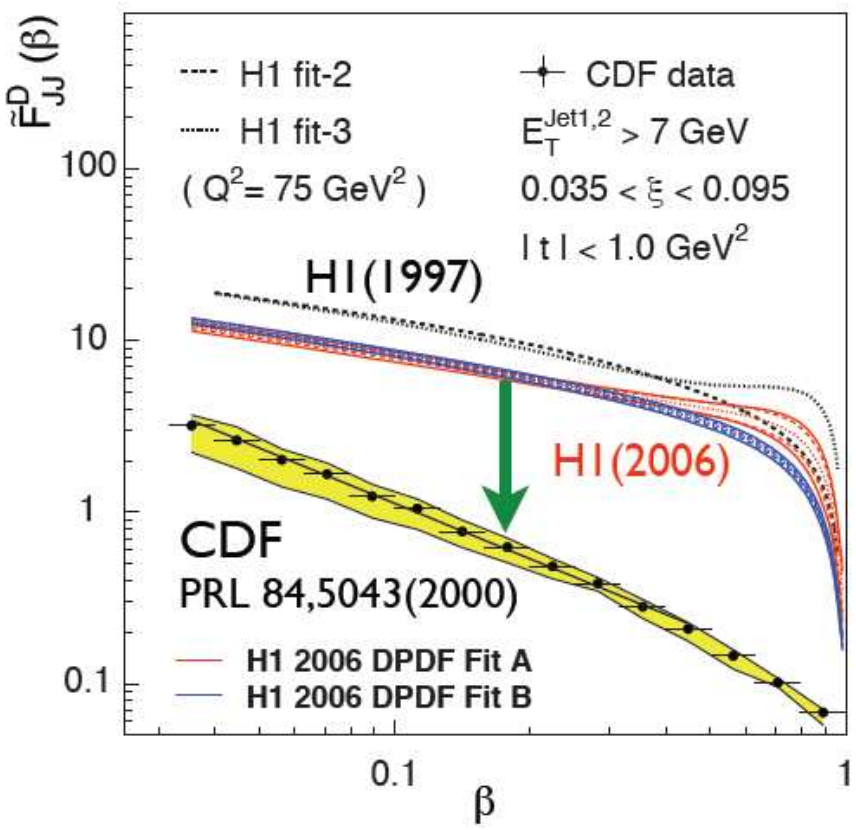


Diff. Structure Function Measurement:

$$R_{\frac{SD}{ND}}(x_{\bar{p}},\xi_p) \approx \frac{F_{jj}^{D}(x_{\bar{p}},\xi_p)}{F_{jj}(x_{\bar{p}})} \quad \text{(LO QCD)}$$

to be measured global fit

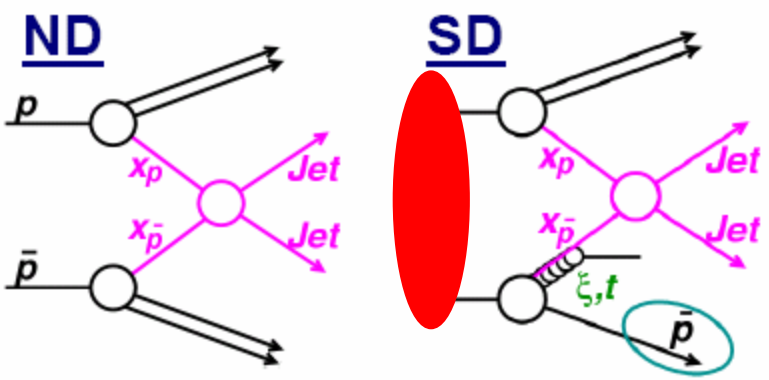
=> F_{jj}^{D} can be derived and compare to expectations from HERA dPDFs



Mismatch of a factor~10 => factorisation does not hold !

=> « survival » gap probability of a few % ?

The limit of factorisation @ Tevatron



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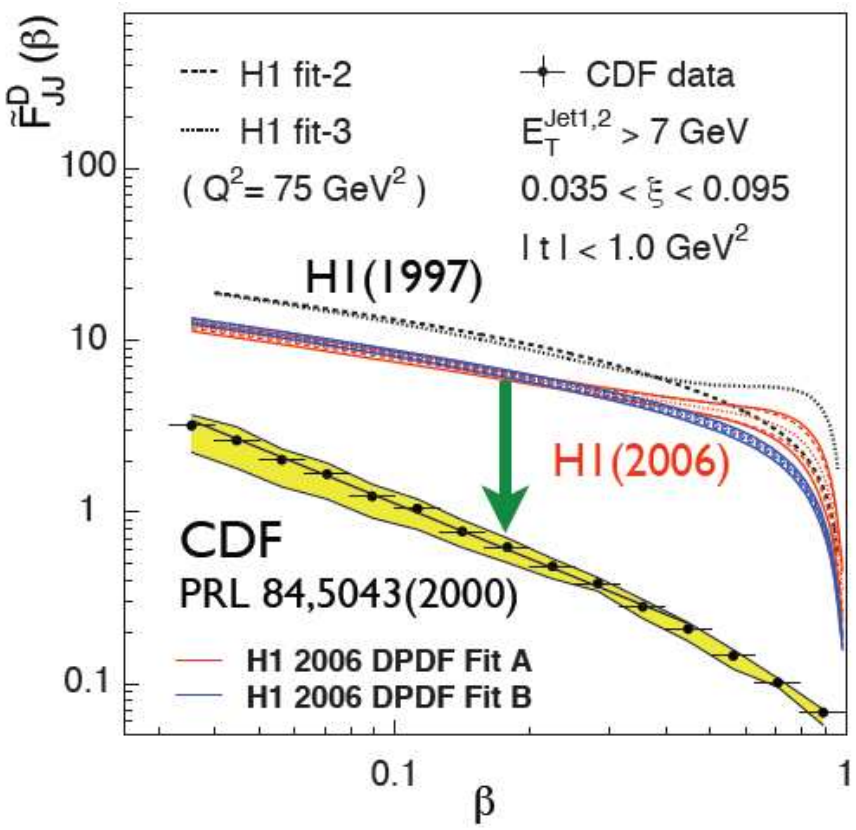

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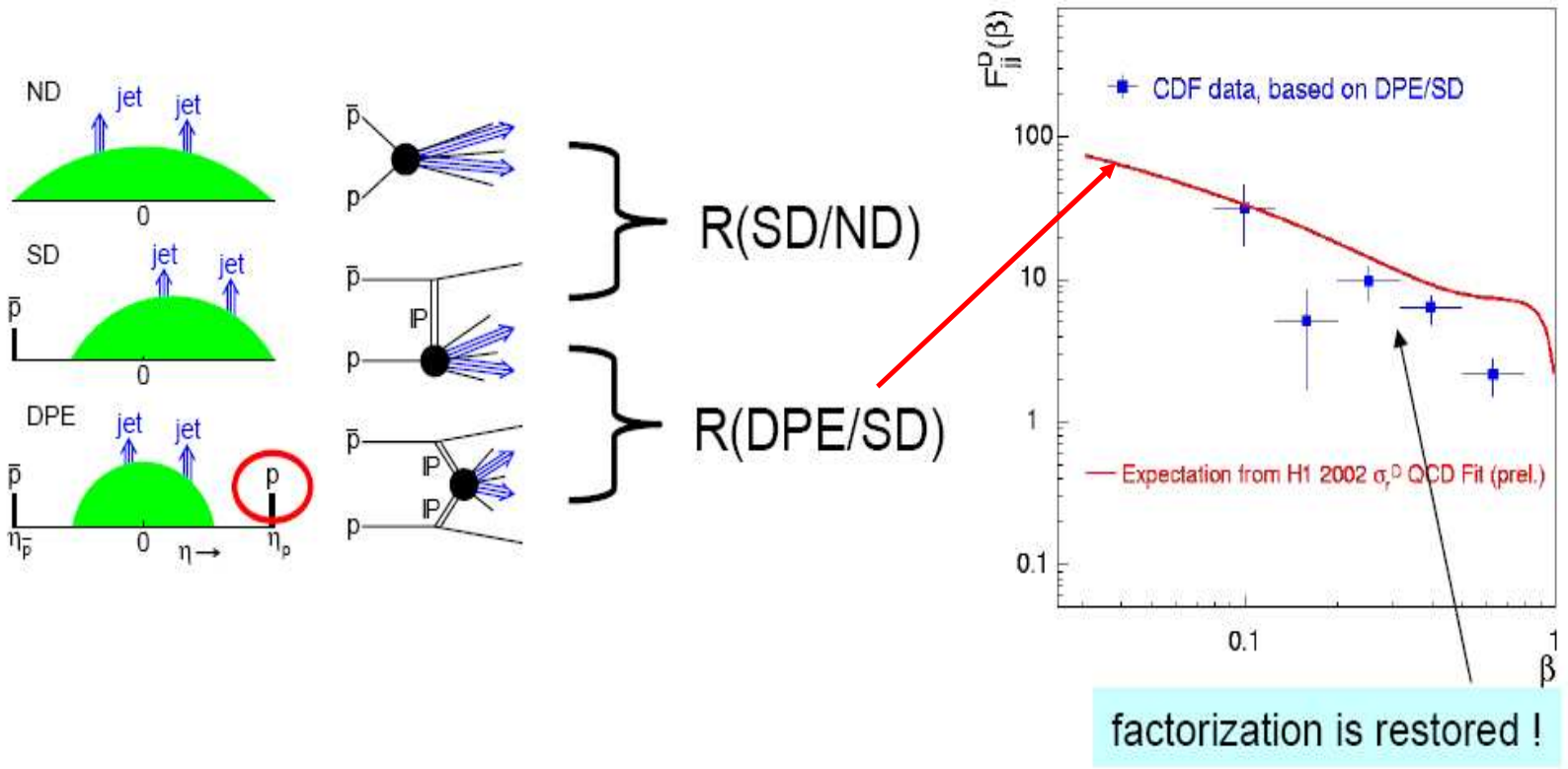
Double Pomeron Exchange @ Tevatron

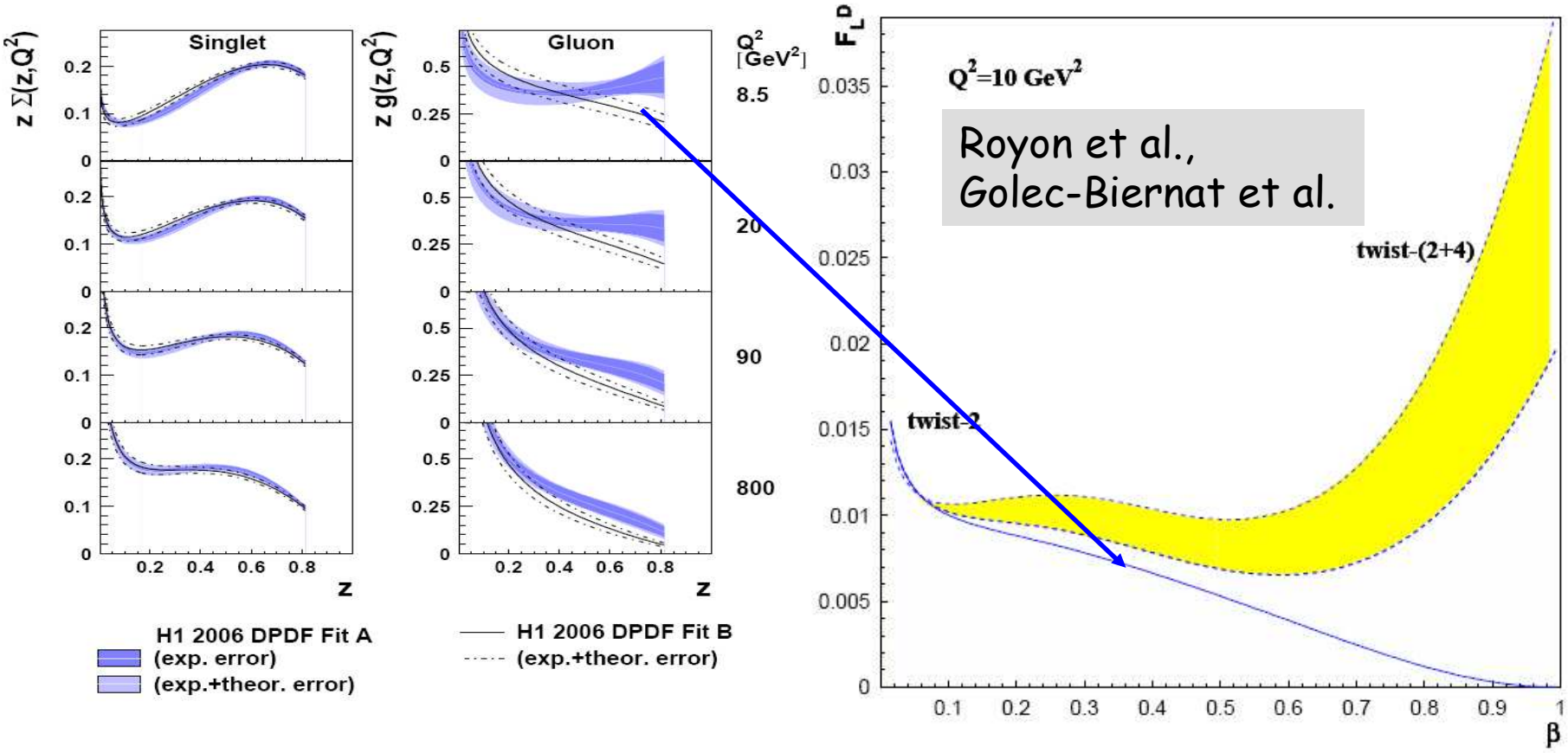


The diffractive S.F. measured on the proton side in events with a leading anti-proton is not suppressed :

The price for producing a gap (survival probability) is paid only once!

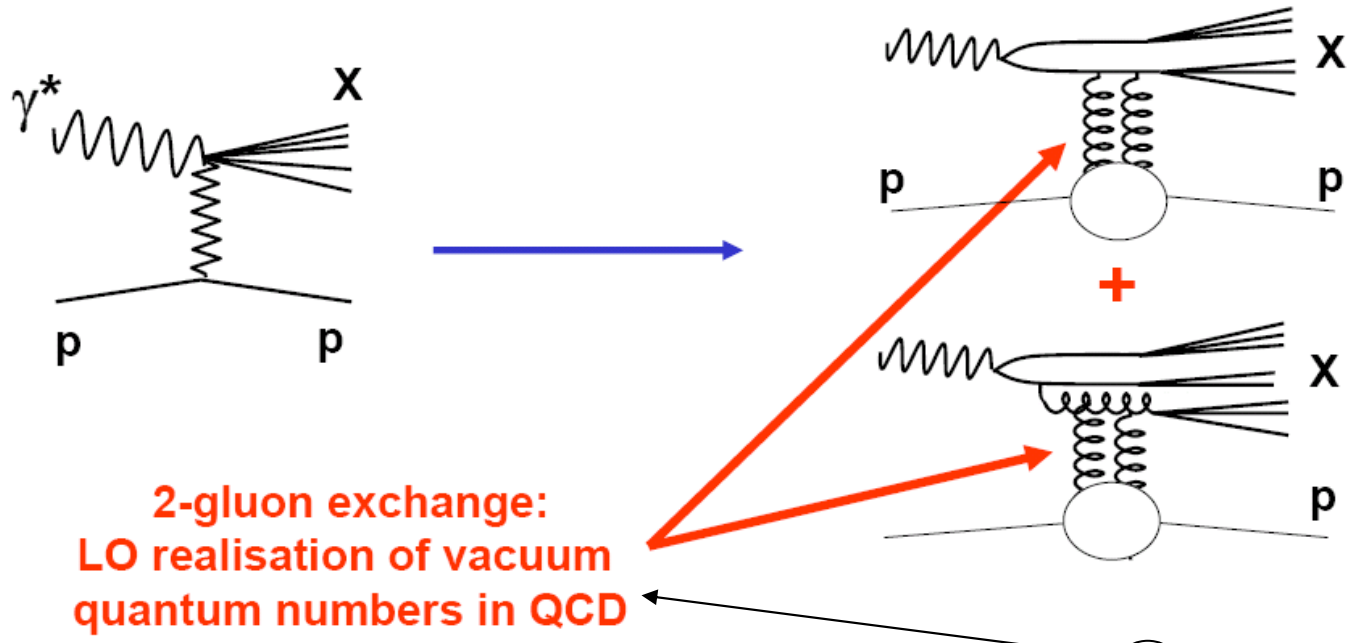
This confirms that the survival Gap probability may be just an underlying interaction between spectator partons in the protons…

A comment on diffractive PDFs



Diffractive PDFs : only « twist-2 » functions (by definition)
=> Essential measurement of FLD needed to conclude on their pertinence for medium/large β (LHC domain)

Can we find a common model for DIFF & DIS ?



2-gluon exchange:
LO realisation of vacuum
quantum numbers in QCD

Universal description DIFF/DIS

Then $\sigma_{diff} \sim Coef \otimes [xG(x,Q^2)]^2$

with $\sigma_{DIS} \sim Coef' \otimes [xG(x,Q^2)]$

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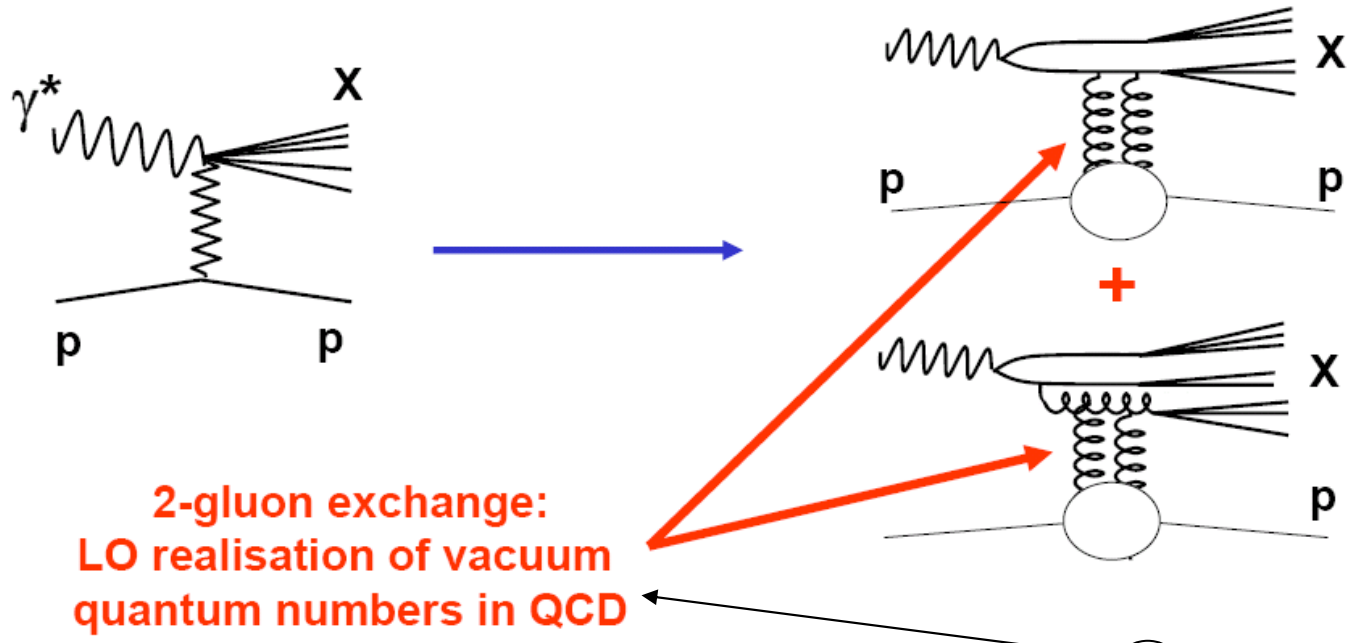


Universal description DIFF/DIS

Then $\sigma_{diff} \sim Coef \otimes [xG(x,Q^2)]^2$

with $\sigma_{DIS} \sim Coef' \otimes [xG(x,Q^2)]$

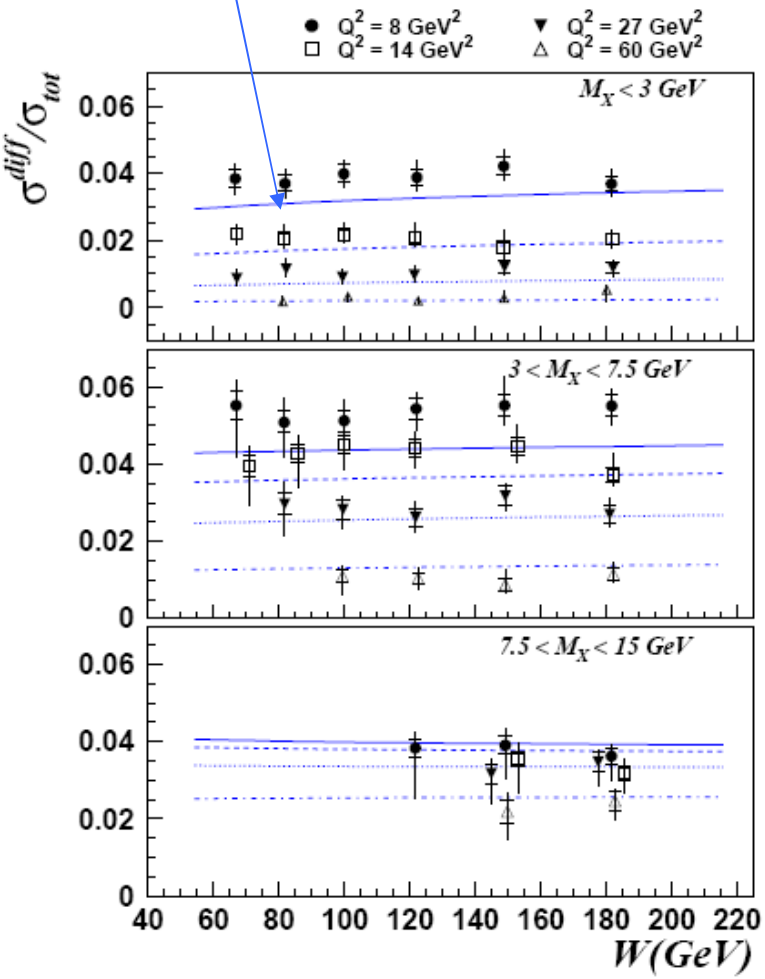
CONSEQUENCE :

@ low x : σ_{DIS} (F2) ~ W^a (a~0.8) => $\sigma_{diff} \sim W^{2a}$ => $\sigma_{diff}/\sigma_{DIS} \sim W^a$

we expect a strong W dependence for the ratio ?!

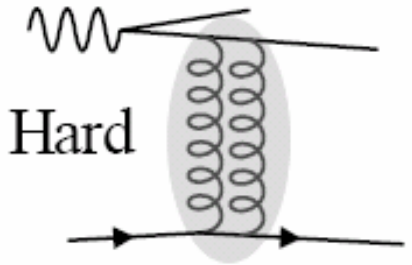
Modeling the diffractive exchange

Prediction of the 2-gluon exchange model + saturation



$\sigma_{diff}/\sigma_{DIS}$ ~ constant [W] !

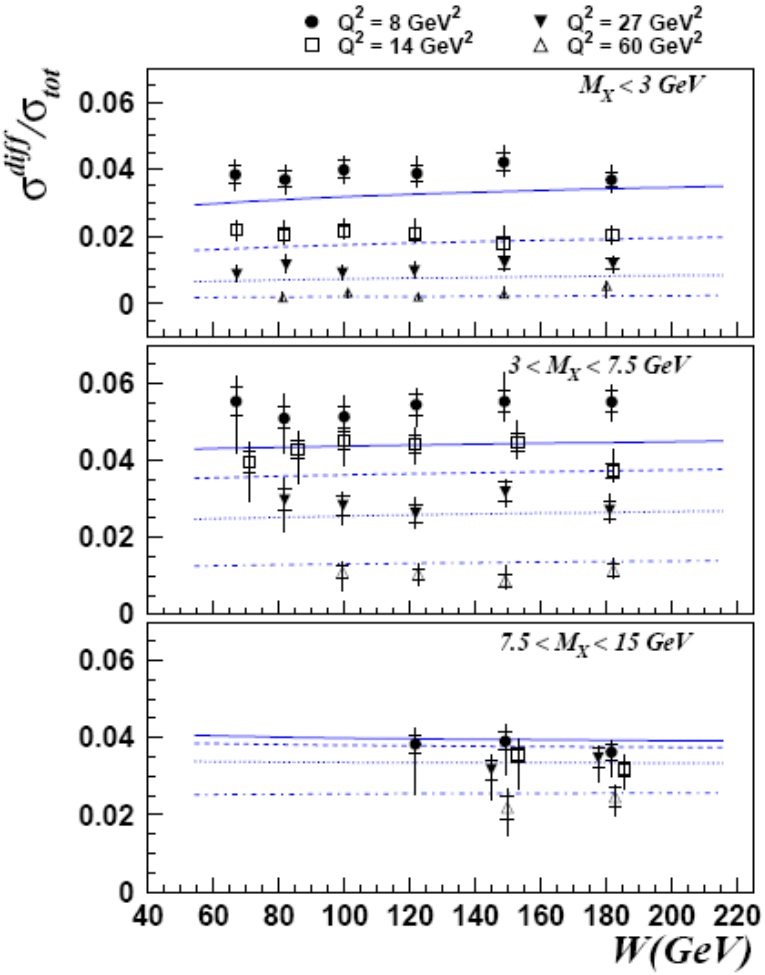
=> Inclusive diffraction : softer than a pure 2-(hard) gluons exchange



Effects of saturation
that screen the increase
of the « dipole » cross section

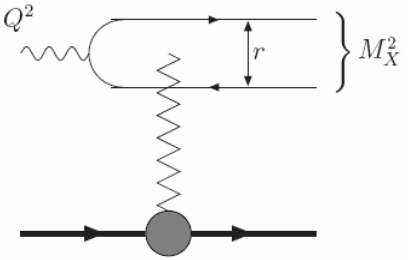
$\sigma_{diff} \sim Coef \otimes [xG(x,Q^2)]^2$
=> DIFF sensitive to saturation (large W)

Modeling the diffractive exchange



$$\hat{\sigma}_{q\bar{q}} = \sigma_0 \left\{ 1 - \exp\left(-\frac{r^2}{4R_0^2(x)} \right) \right\}$$

r : dipole size



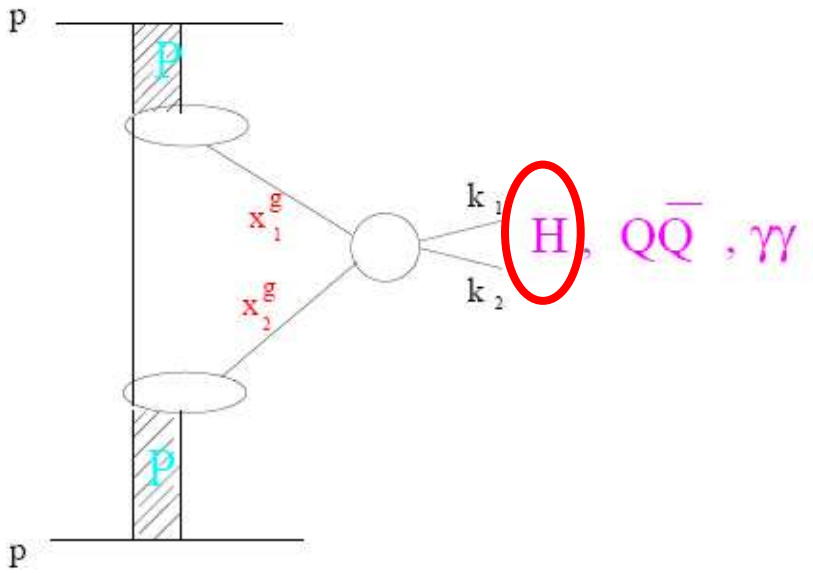
$$\left.\frac{d\sigma_{dif}}{dt}\right|_{t=0} = \frac{1}{16\pi} \int_{r,z} |\Psi(r,z,Q)|^2 \, \hat{\sigma}^2_{q\bar{q}}(x_{I\!P}, r)$$

$$\sim \frac{1}{Q^2} \int_{1/Q^2}^{1/Q_s^2} \frac{dr^2}{r^4} \left(r^2 Q_s^2(x) \right)^2 \sim \frac{Q_s^2(x)}{Q^2} \propto x^{-\lambda}$$

At sufficiently high energy, gluon saturation cuts off the large dipoles already on the 'semi–hard' scale $1/Q_s$!

$\sigma_{diff}/\sigma_{tot}$ ~ constant [W or x] @ fixed Q^2

Some prospects for the LHC



"Exclusive "

Exclusive production of heavy objects in double pomeron exchange (DPE) :

Tag protons on both sides
=> mass of the central system with a high resolution :

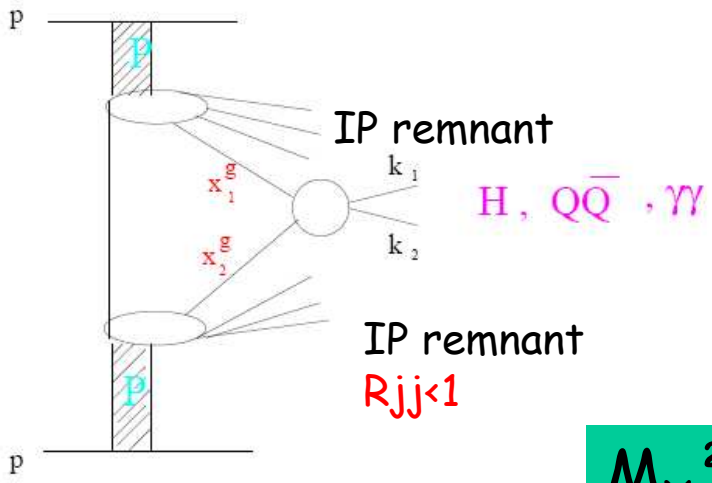
$$M_X^2 = s\,\xi_1\xi_2$$

Exclusive models:

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

First Checks possible @ Tevatron

Double Pomeron Exchange in pp collisions



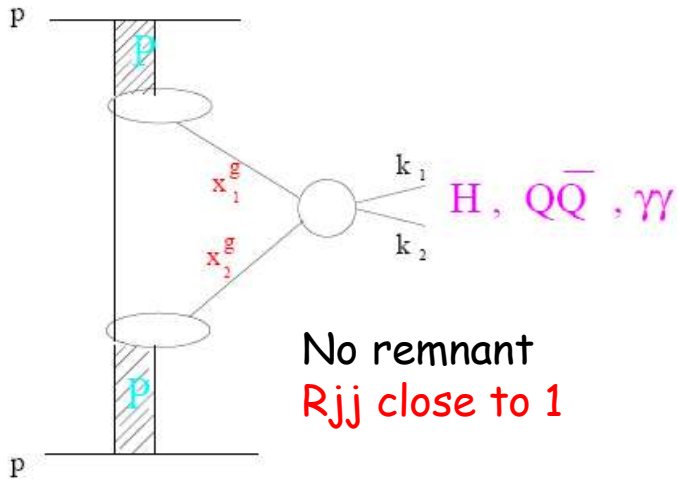
IP remnant

IP remnant

Rjj<1

"Inclusive"

$M_X^2 = s\,\xi_1\xi_2$



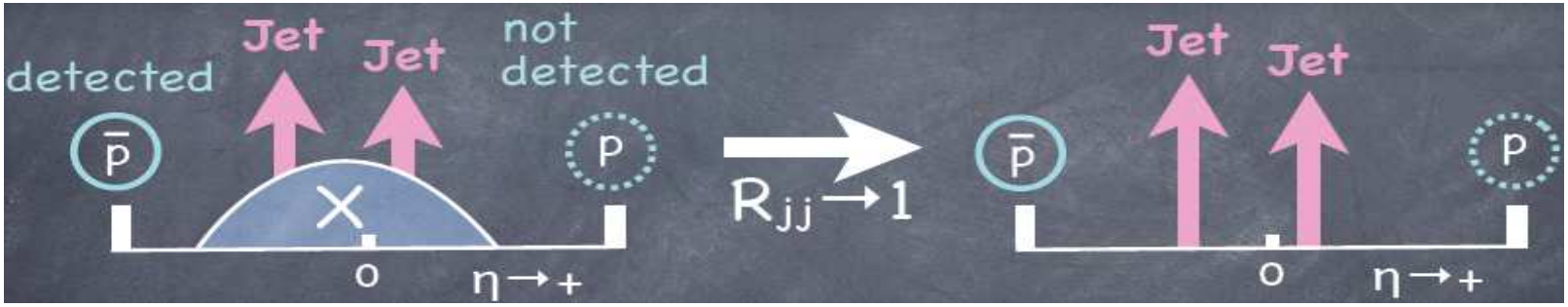
No remnant

Rjj close to 1

"Exclusive "

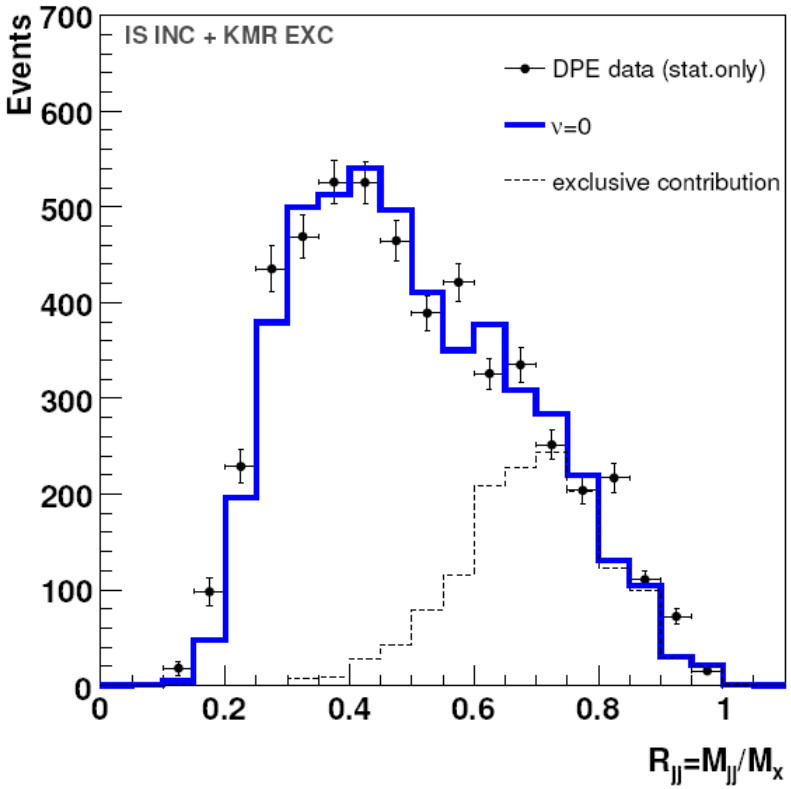
Measurement of the Dijet Mass Fraction @ TeV

$$R_{jj} = \frac{M_{jj}}{M_X}$$

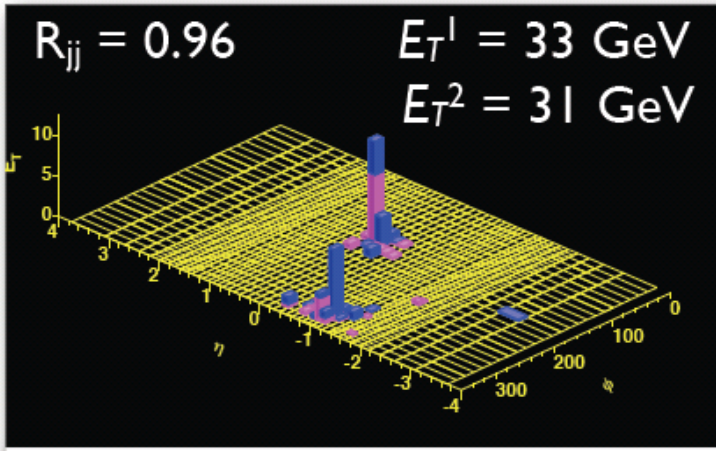


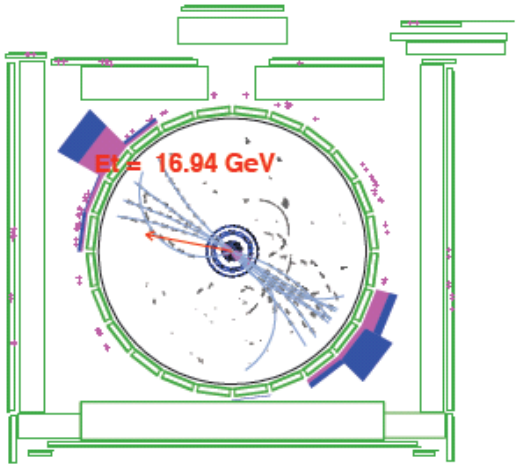
Dijet mass fraction @ TeV : measurement & predictions

Prediction using dPDFs ⊗ survival gap probability
+ exclusive production



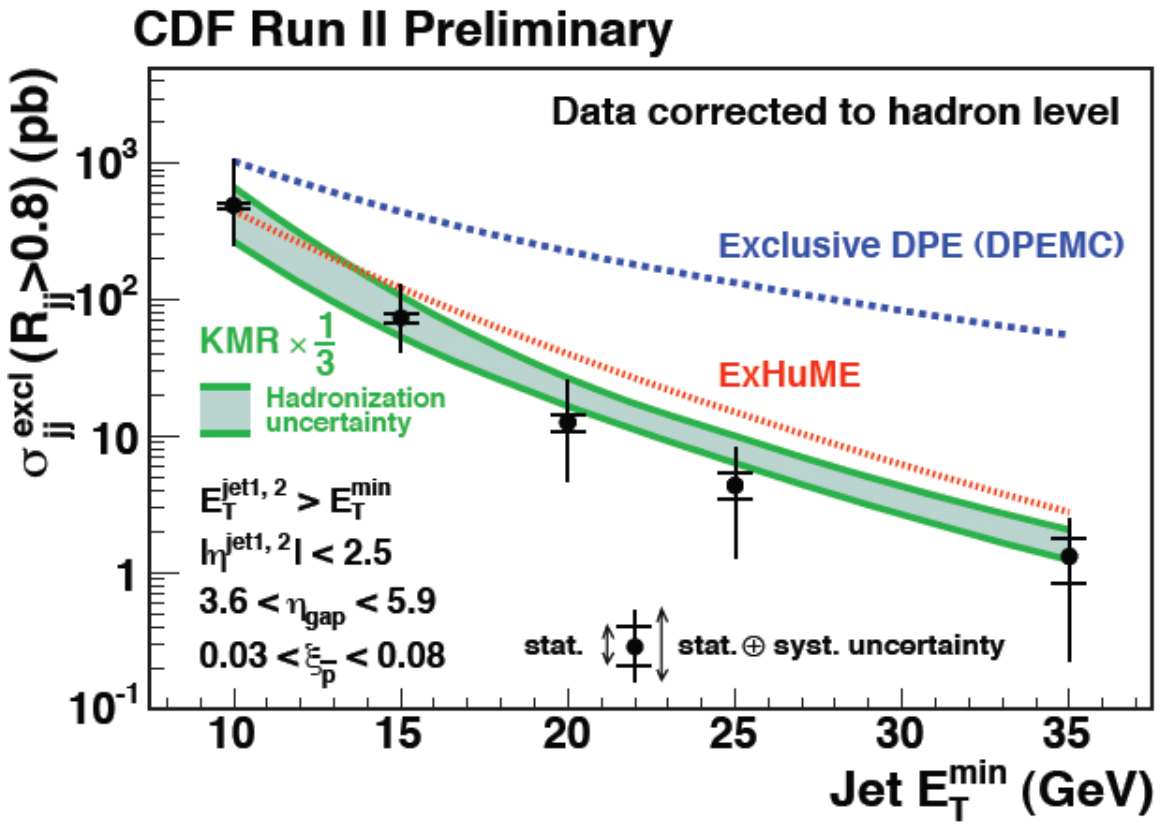
CDF Run II Preliminary

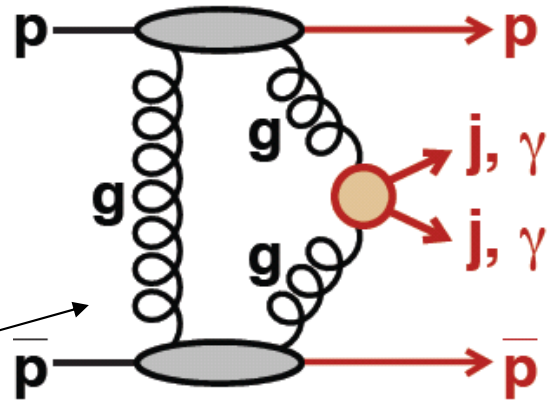




Exclusive events observed ?!

Exclusive dijet cross section





KMR model in agreement with data

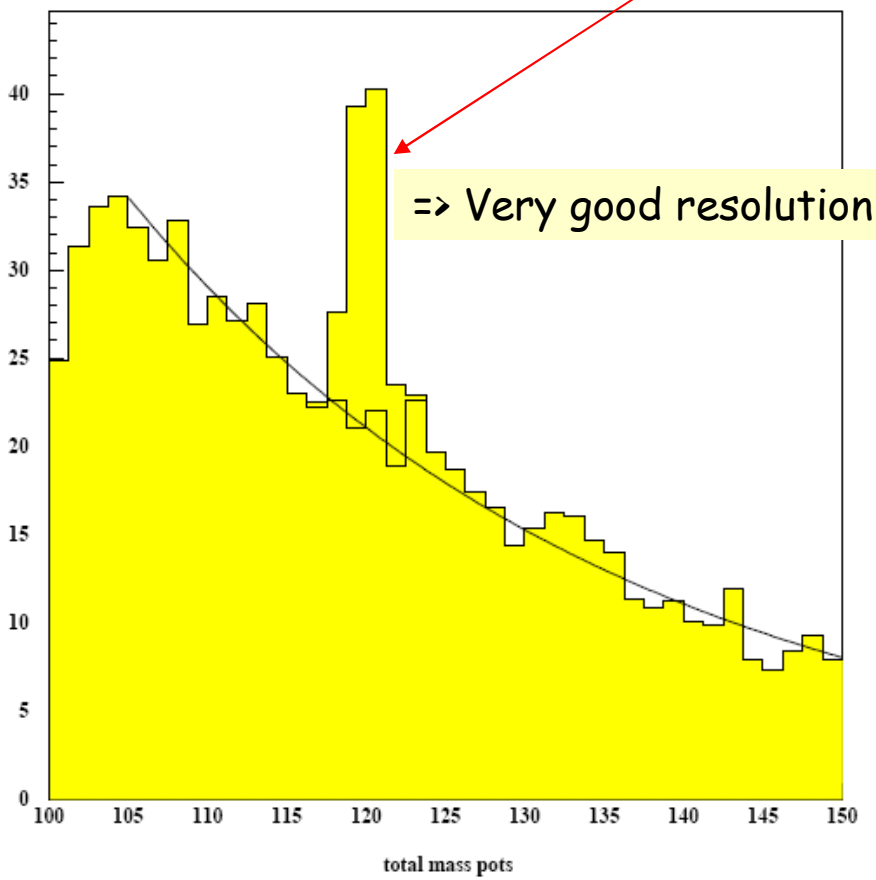
CDF data clearly disfavour Bialas-Landshoff exclusive model

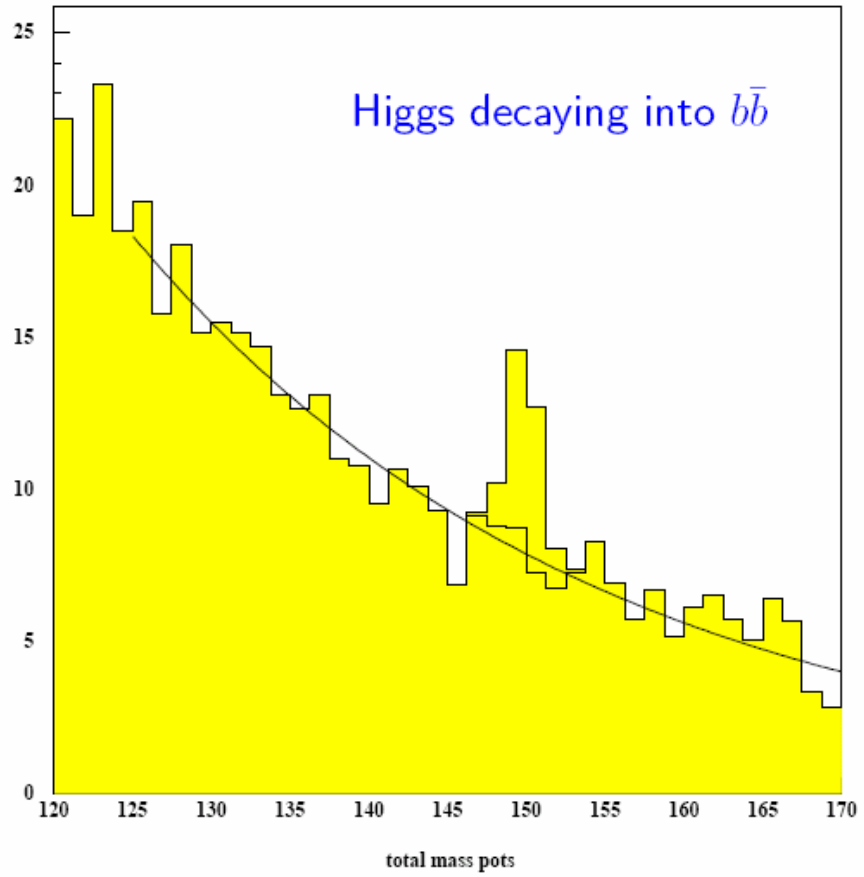
=> We keep the exclusive KMR model for LHC simulations

Exclusive Higgs production @ LHC

After the hints from the TeV, let's come back on the Higgs exclusive production @ LHC : **simul for a 120 & 150 GeV mass Higgs!**

Measurement of the mass from : $M_X^2 = s\,\xi_1\xi_2$

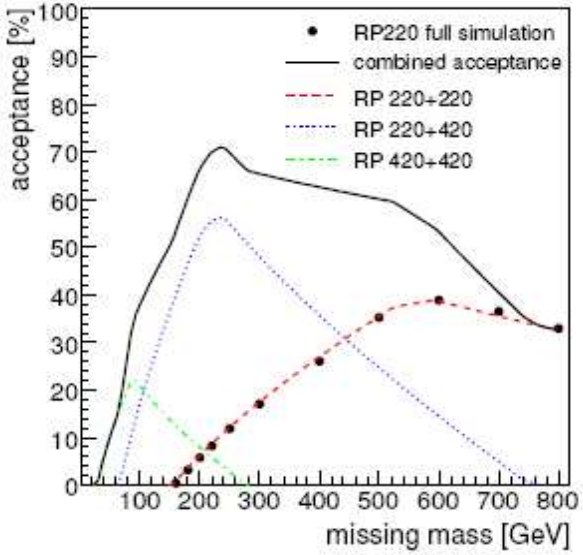


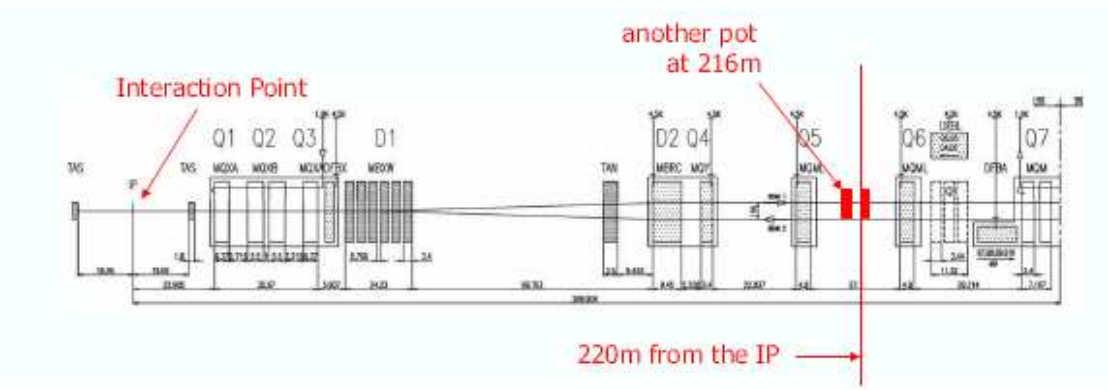


Signal and background for different Higgs masses for 100 fb^{-1}

Experimental aspects @ LHC

- FP420: Project of installing roman pot detectors at 420 m both in ATLAS, CMS; collaboration being built
- Roman pot detectors at 220 m in ATLAS:
  - Natural follow-up of the ATLAS luminosity project at 240 m to measure total cross section
  - Complete nicely the FP420 m project
  - Collaboration between Saclay. Prague, Cracow and Stony Brook (so far) being pursued
  - Collaboration with the FP420 m project concerning detectors, triggers, simulation...





Conclusion

-hadron-hadron cross section @ large energy

- longstanding pb of the IP structure (specific PDFs)

-Modeling DIFF => saturation effects in the nucleon

-Higgs @ LHC

=> New windows opened on the proton structure driving the theory on the low x dynamics etc.