DIFFRACTION :

THEORY

M. DIEHL (DESY)

TOPICS AND TALKS

VECTOR MESON PRODUCTION - HIGH t, BFKL L. MOTYKA

- LOW t, NLO L. SZYMANOWSKI

TRANSVERSE DISTRIBUTION OF PARTONS : FROM HERA TO LHC
C. WEISS

DIFFRACTIVE DIJETS - AT HERA G. KRAMER

- AT TEVATRON A. BIALAS

HIGGS PRODUCTION AT LHC C. ROYON
A. D. MARTIN

LEPTON PAIR PRODUCTION IN HEAVY ION COLLISIONS :
MULTIPHOTON EXCHANGES E. KURAEV

SATURATION : THEORY + PHENOMENOLOGY
→ LIST IN A. STASTO'S SUMMARY

+ 2 DISCUSSION SESSIONS

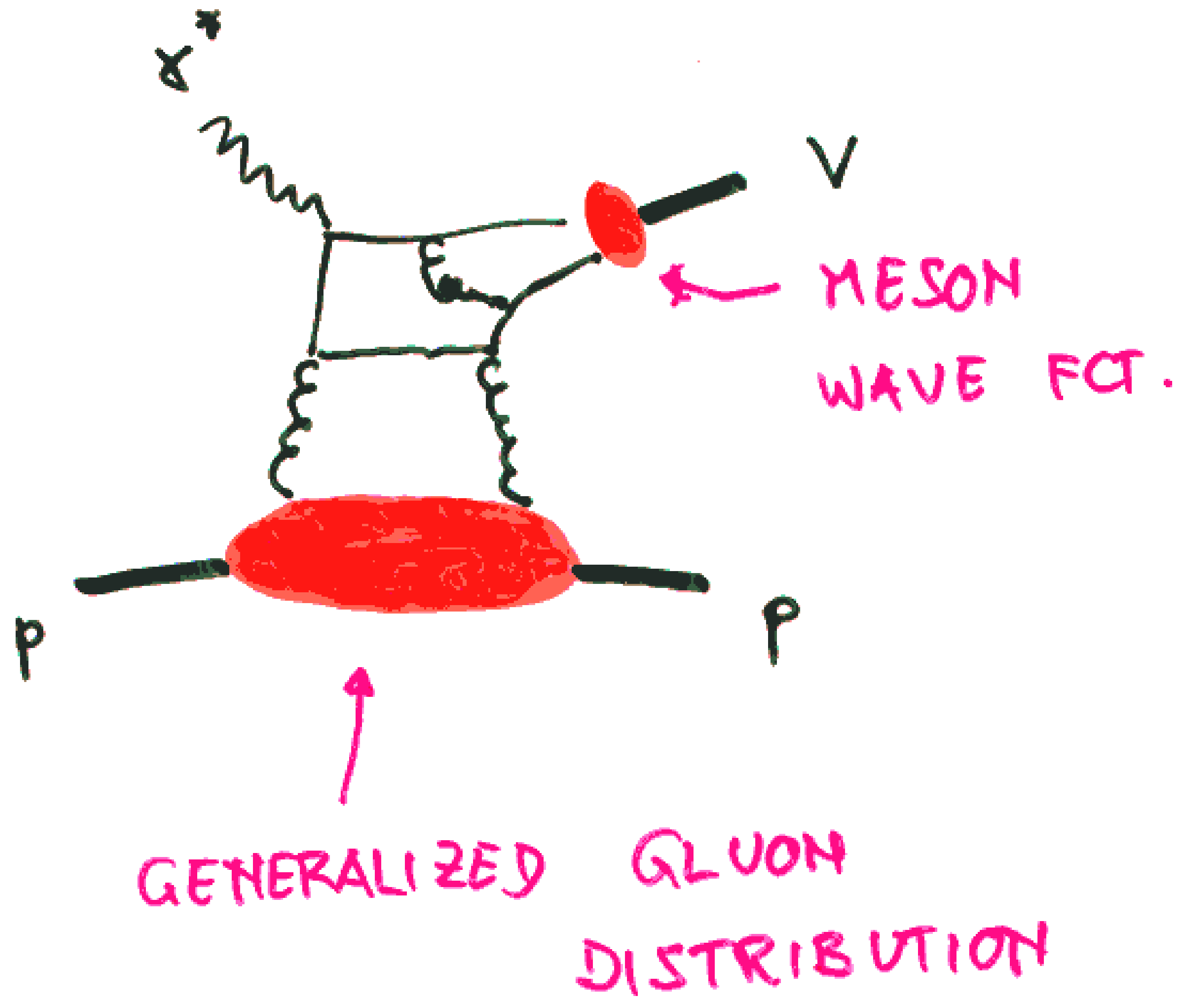
EXCLUSIVE VECTOR MESON PRODUCTION

AT SMALL t

L.SZYMANOWSKI

IN LEADING TWIST ("DGLAP" / "COLLINEAR FACTORIZATION")

APPROXIMATION



- FULL NLO CALCULATION

  FOR BOTH

  $\gamma^* p \to (\rho, \phi, \omega)\ p$

  $\gamma p \to J/\psi\ p$

  $\quad\ \to \Upsilon\ p$

- DEPENDENCE ON μ_F, μ_R REDUCED

- AT SMALL x, NLO CORRECTIONS RATHER LARGE

  TERMS $\sim \ln\frac{1}{x}$ WITH NOT-SO-SMALL PREFACTOR

- FOR J/ψ PHOTOPRODUCTION DOUBT WHETHER PERURBATIVELY STABLE

  Q^2 MIGHT HELP

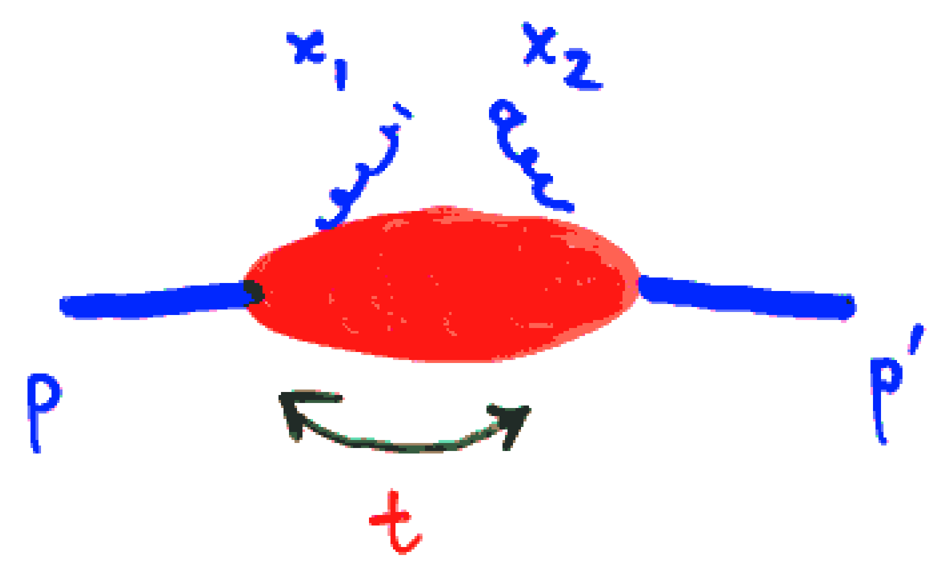
- REQUIRES FURTHER STUDY

A RECURRING THEME:

t - DEPENDENCE OF EXCLUSIVE (OR DIFFRACTIVE) PROCESSES

LEADING TWIST FORMALISM

GENERAL. GLUON DIST'N



↓ FOURIER

b IMPACT PARAMETER

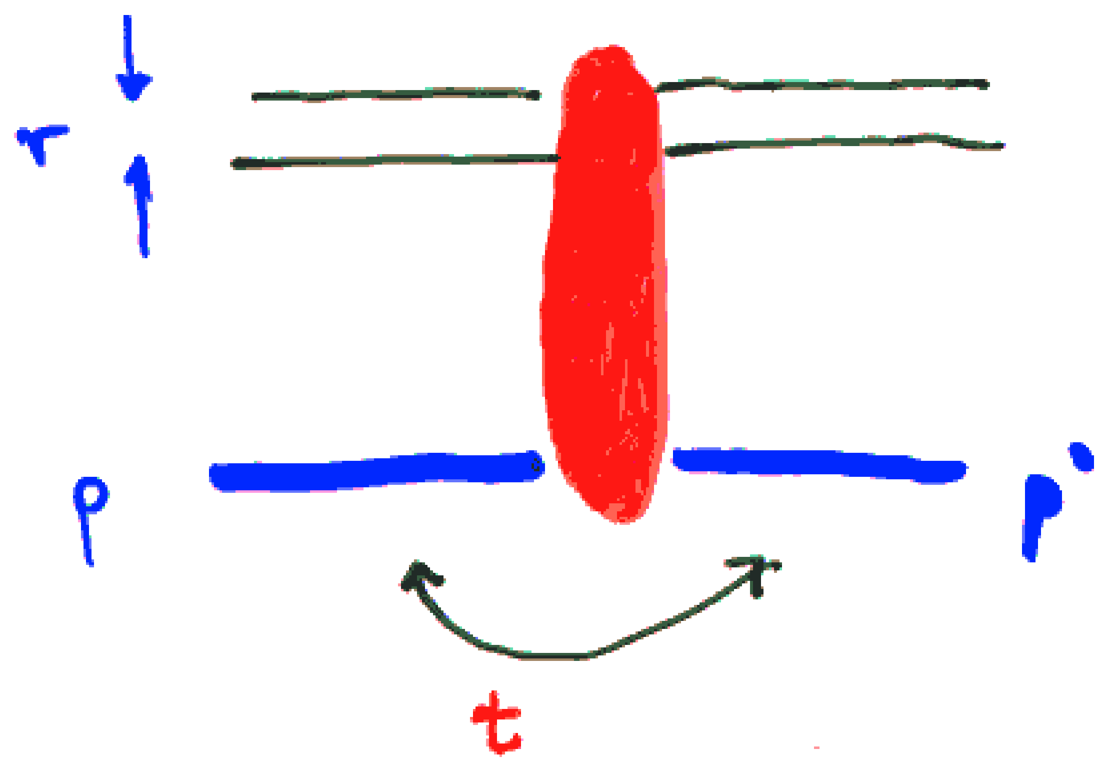
FOR $x_1 = x_2$ ESPECIALLY SIMPLE:

$g(x, b)$

DENSITY OF GLUONS WITH LONGITUD. MOMENTUM xp AT DISTANCE b FROM PROTON CENTER

LEADING ORDER BFKL:

DIPOLE FORMULATION



↓

b

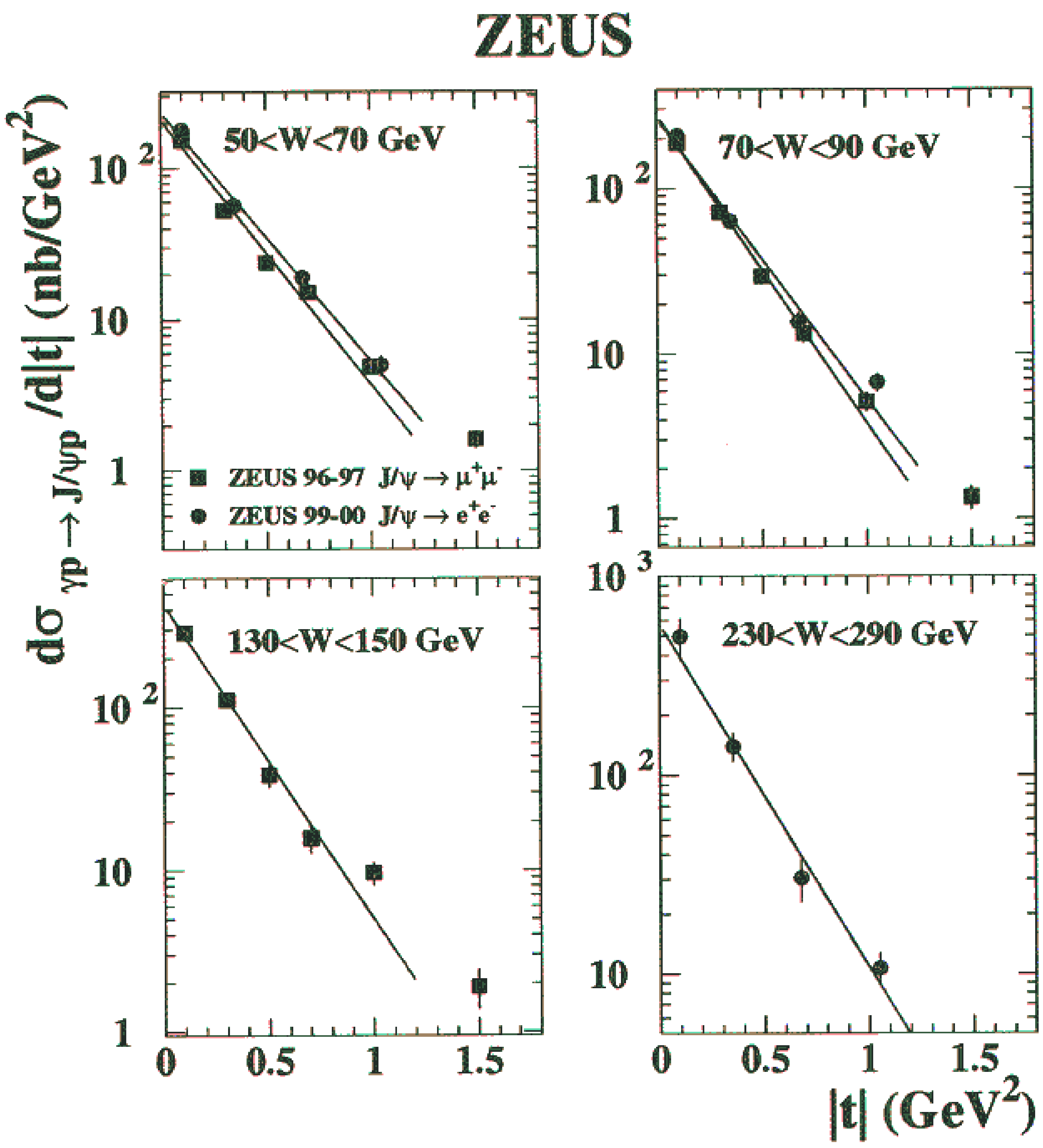
$\Gamma(x, r, b)$

DIPOLE OF SIZE r PROBES GLUONS AT RAPIDITY $\ln\frac{1}{x}$ AT DISTANCE b

- J/ψ photoproduction: t–dependence of cross section

$x \sim \frac{M_{c\bar{c}}^2}{W^2}$

$\sim 10^{-2} \div 10^{-4}$



also: H1

. . . also fixed target data [SLAC, Cornell, Fermilab]

→ Transverse size of gluon distribution

$$\begin{array}{cccc} \langle \rho^2 \rangle_x = & 0.3\,\text{fm}^2 & \text{at} & x \approx 10^{-1} \\ & 0.4 & & 10^{-3} \end{array}$$

↓ Increase

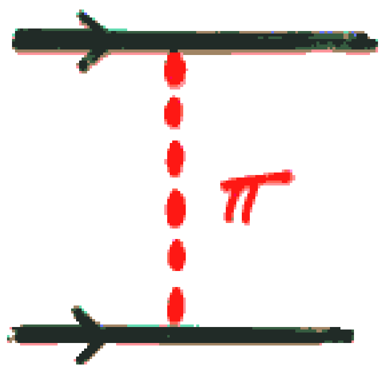
CAN BE UNDERSTOOD AS GLUONS IN "π CLOUD"

[Frankfurt, Strikman 02]

- CAN GO OUT TO $b \sim 1/m_\pi$
- REQUIRES $x \ll m_\pi/m_p$

Large transverse distances: Chiral dynamics

cf. NN-interaction

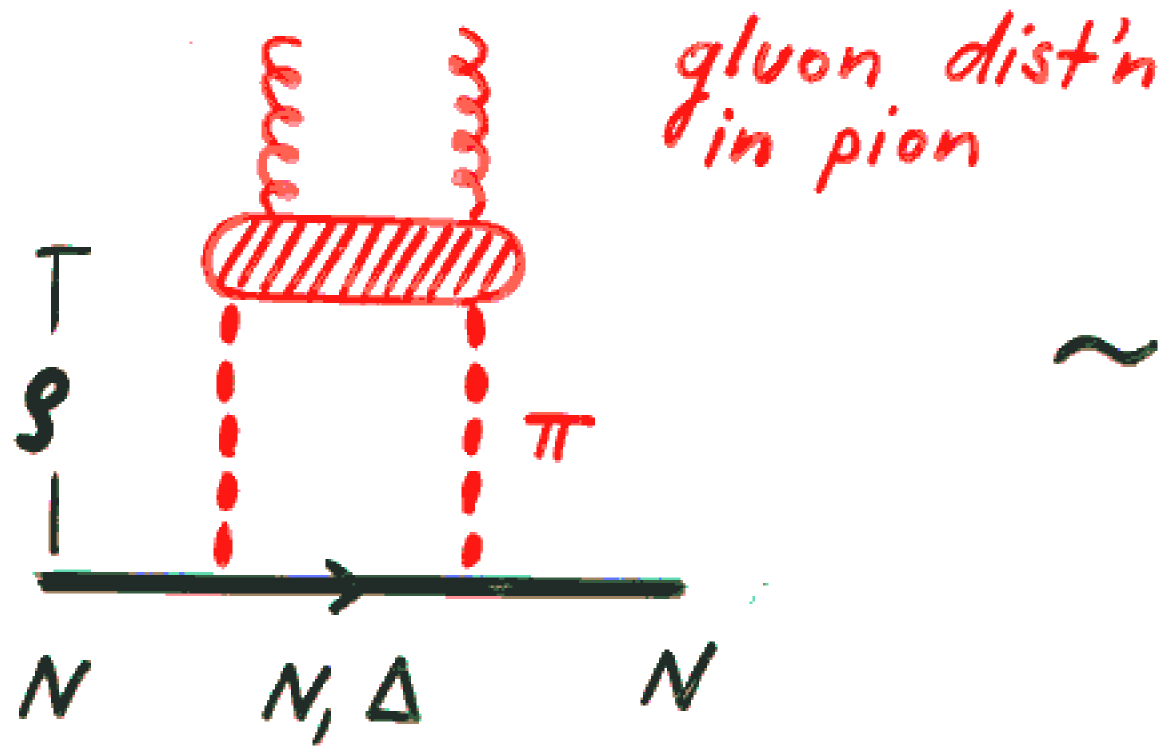


$$\sim \frac{e^{-M_\pi r}}{r}$$

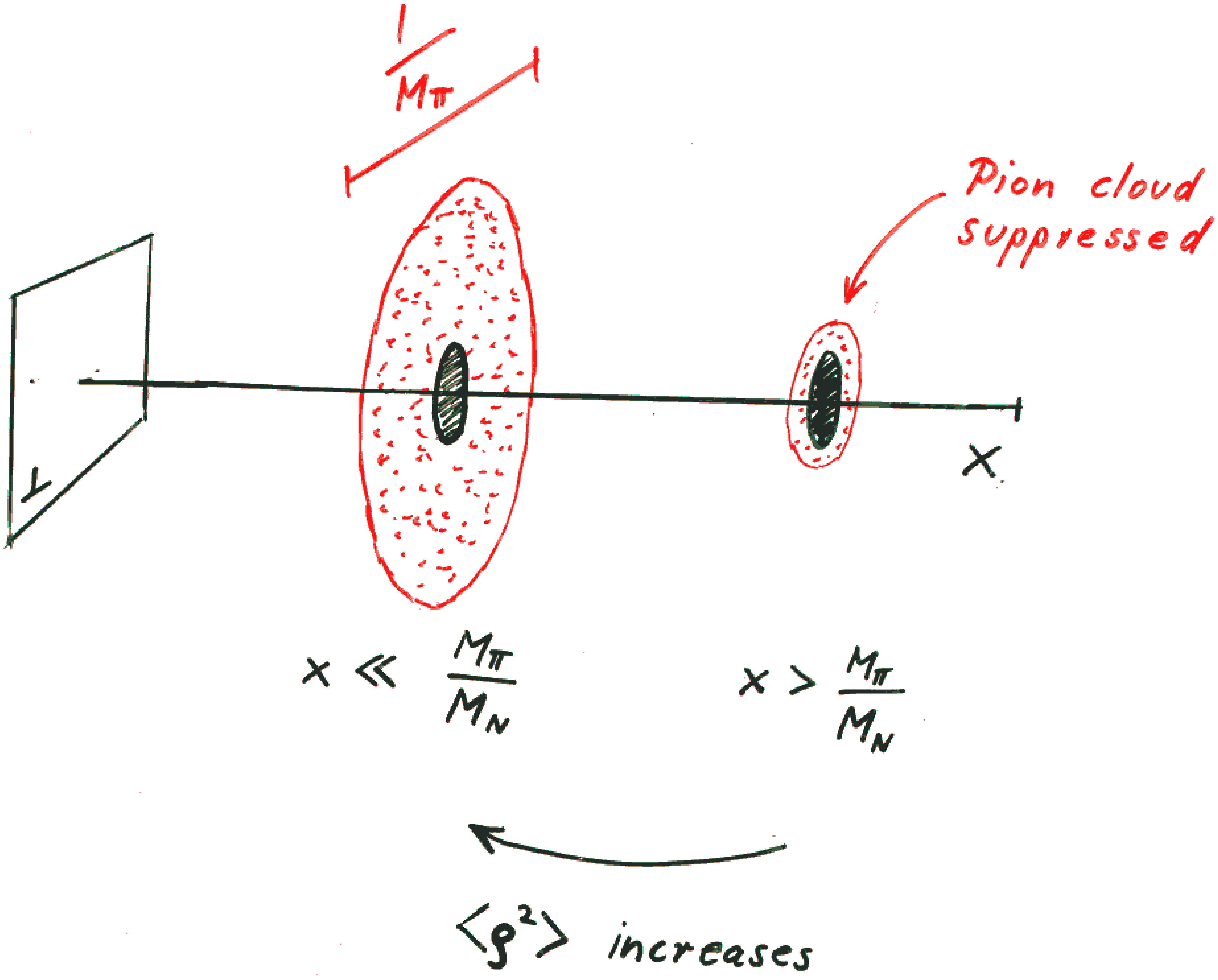
Yukawa potential

- Gluon distribution at $\rho \sim 1/M_\pi$ [Strikman, CW 03]

$g(x,\rho) \sim$



$\sim e^{-2M_\pi \rho} \times \text{function}(x)$



SATURATION

NB: PHENOMENOLOGICAL SUCCESS OF DIPOLE FORMULATION

$\not\Rightarrow$ SATURATION ESTABLISHED AT HERA

MUST DISTINGUISH

- BREAKDOWN OF LEADING TWIST ("DGLAP") DESCRIPTION
- ONSET OF BFKL DYNAMICS
- NONLINEAR EFFECTS
  "UNITARIZATION" → SATURATION
  "STRONG GLUON FIELDS"

TO BE SENSITIVE TO SATURATION,
NEED DIPOLES WITH $r \gtrsim \frac{1}{Q_s}$

SELECT WITH EXTERNAL SCALE $\sim \frac{1}{Q}$

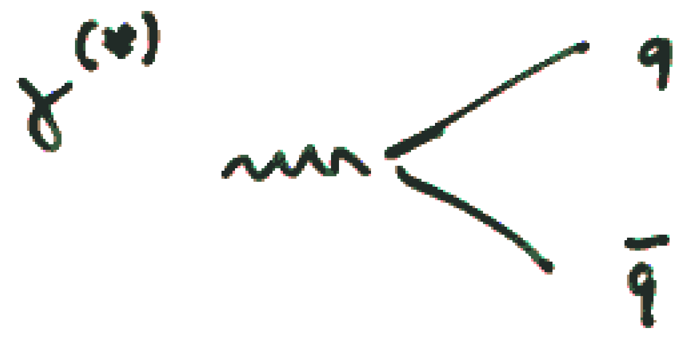
SATURATION SCALE

CHALLENGE :

FIND OBSERVABLES WHERE
Q IS NOT SO LOW THAT
PERTURBATIVE CONTROL IS LOST

"INDICATOR" IS e.g.
SENSITIVITY TO QUARK MASS $m_q \sim$
few 100 MeV

IN PHOTON WAVE FCT.



→ T. ROGERS

- INCLUSIVE OBSERVABLES ?

ESTIMATE → T. ROGERS

$F_2(x_B = 10^{-4}, Q^2 = 2\,\text{GeV}^2)$ HAS ~ 0.2
CONTRIBUTION FROM REGION
WHERE $\Gamma(x, r, b) > \frac{1}{2}$

$\parallel$

DIPOLE CROSS SECT. NORMALIZED
SO THAT $\Gamma = 1$ MEANS
TOTAL ABSORPTION

- SATURATION SCALE $Q_s(x, b)$

  b DEPENDENT

ESTIMATE (MUNIER, STASTO, MUELLER '01)

$Q_s^2 = 1$ to $1.5\ \mathrm{GeV}^2$ AT $b = 0.3$ fm

$\simeq 0.2\ \mathrm{GeV}^2$ AT $b = 1$ fm

- F_2 (AND F_L) AVERAGE OVER b

EXCLUSIVE PROC'S DO NOT

- CANDIDATES $\gamma^* p \to \rho\, p$

  $\gamma^{(*)} p \to J/\psi\ p$

  DVCS

  ⋮

RENEWED TASK :

WHICH PROCESS(ES) MOST

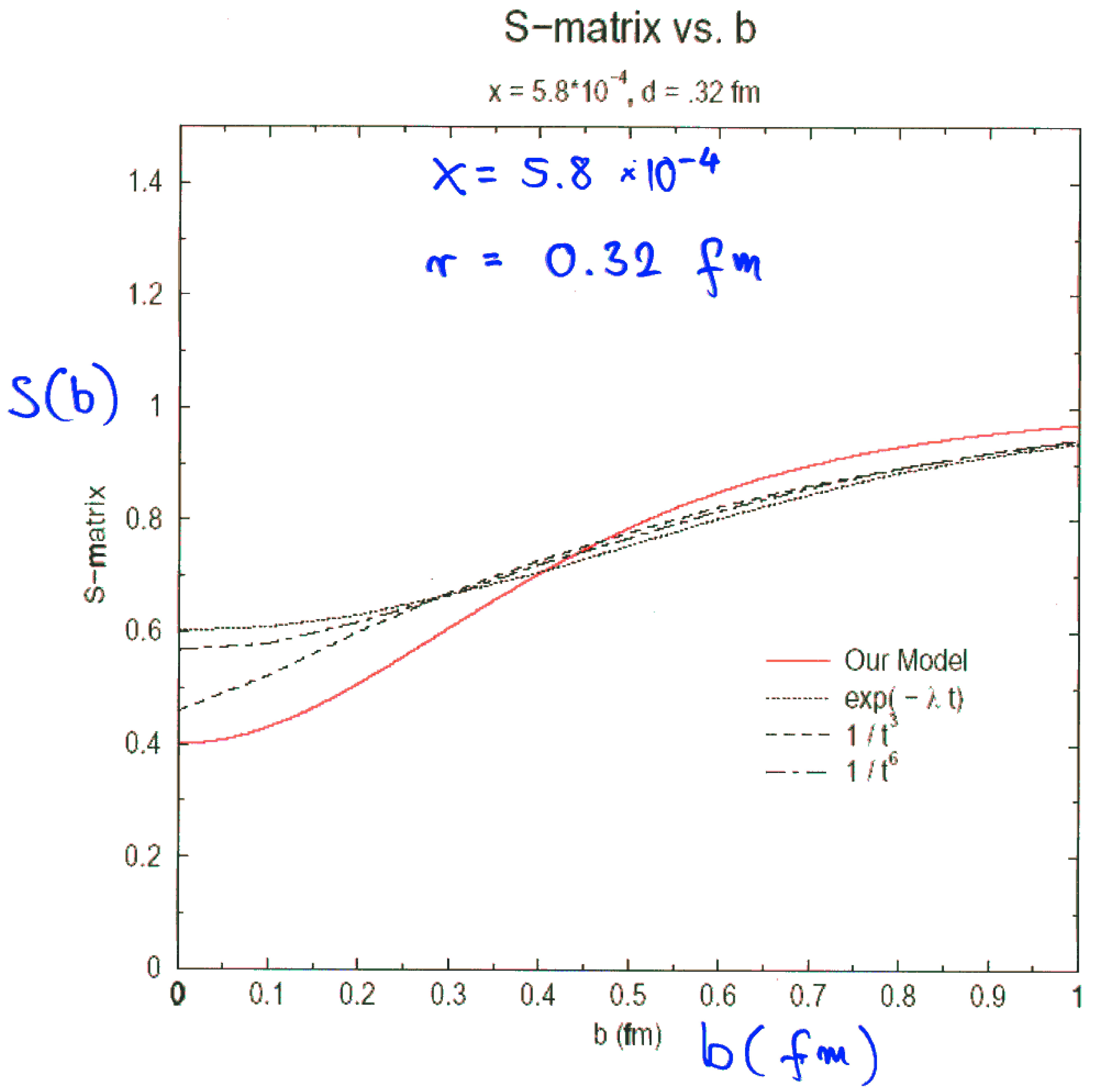
- THEORETICALLY CLEAN ?
- SENSITIVE TO SATURATION ?
- MEASUREMENT - FRIENDLY ?

SENSITIVITY TO SMALL b

NEEDS LARGE $|t|$

$1\ \mathrm{GeV}^2$? $1.5\ \mathrm{GeV}^2$?

TALK
T. ROGERS



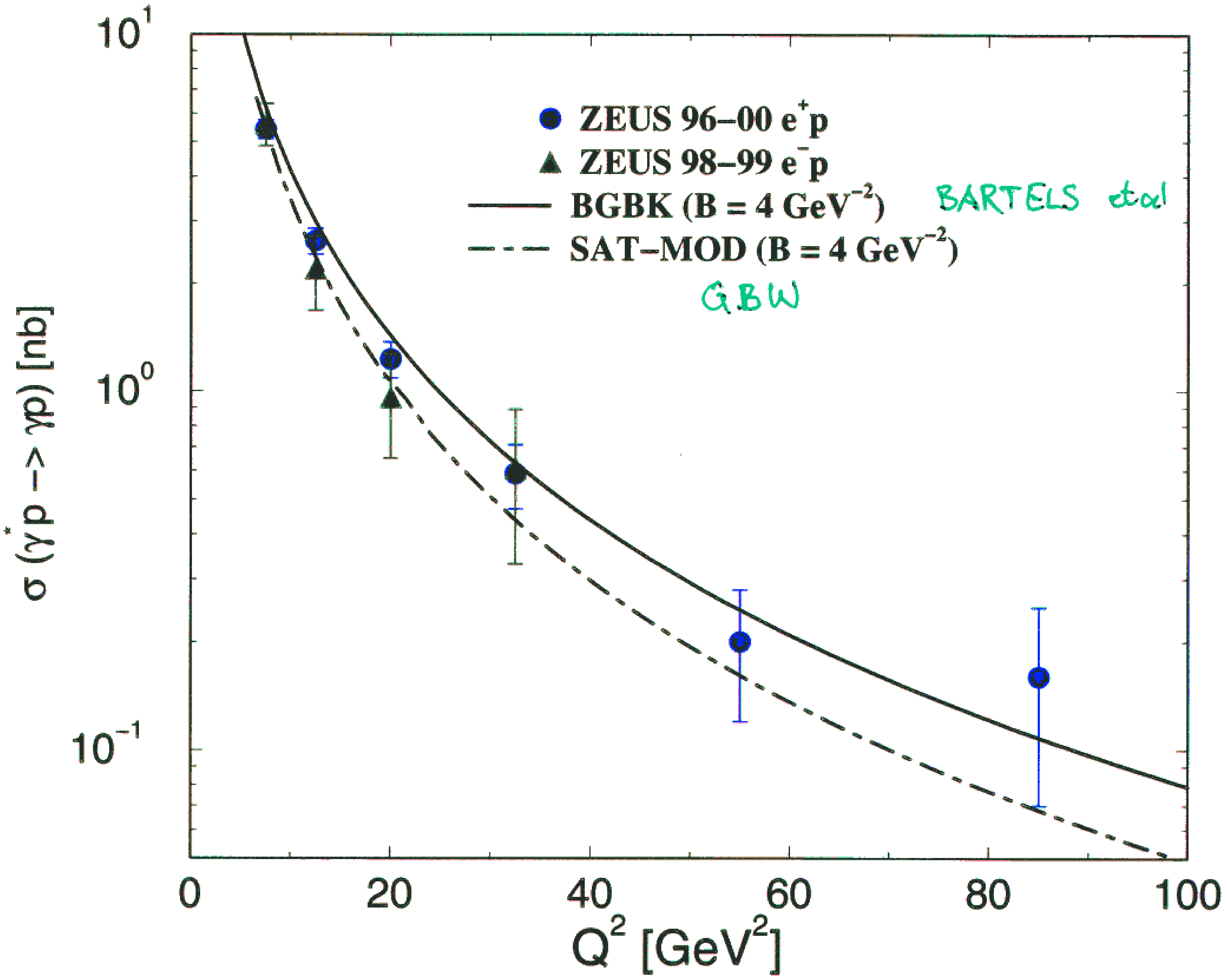
- **Comparison between the MFGS model and one that uses vector meson** ρ **production data alone.** $|t| \leq 0.6\,\mathrm{GeV}^2$ (S. Munier et. al. Nucl. Phys.B603:427,2001.)

Note relation:

$$S(b) \equiv 1 - \Gamma(b)$$

DVCS → L. FAVART

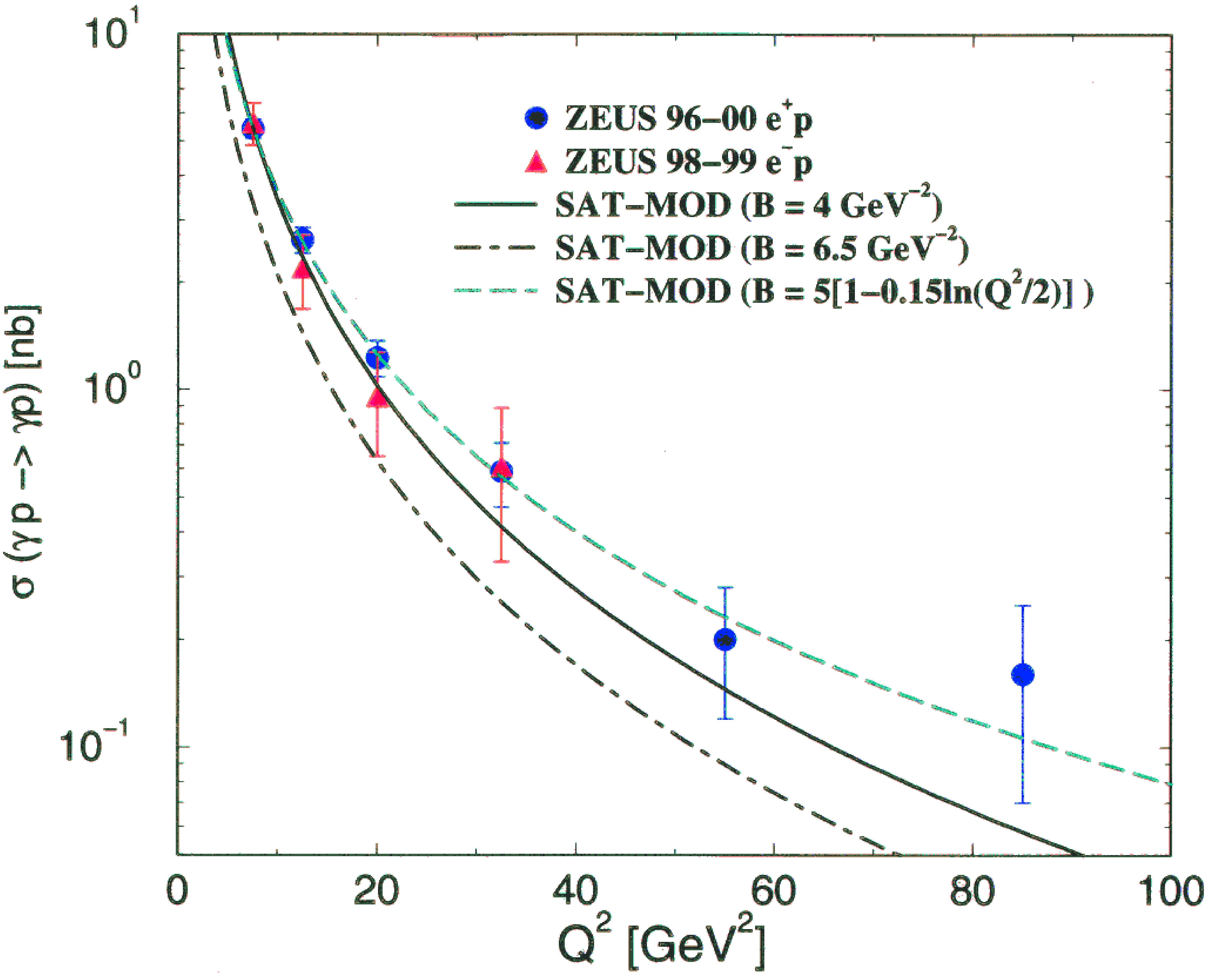
CALCULATION USING DIFFERENT MODELS OF DIPOLE CROSS SECTION



TALK L. FAVART

$$\frac{d\sigma}{dt} \propto e^{tB}$$

t - SLOPE OF DVCS REMAINS
A MAJOR UNKNOWN



INCLUSIVE DIFF'N

AND FINAL STATES

- FACTORIZATION INTO HARD SCATTERING ⊗ DIFFRACTIVE PDFs

PROVEN FOR $\gamma^* p \to X + p$

$\to$ jets + X + p

$\to$ heavy flavor + X + p

PROOFS BREAK·DOWN FOR $\gamma^* \to \gamma$, OR p

SOFT INTERACTIONS BEWEEN

INITIAL + FINAL STATE HADRONS

MAY MODEL THESE SOFT "RESCATTERINGS"

→ "GAP SURVIVAL FACTOR"

DEPENDENCE ON

- IMPACT PARAMETER / t DEPENDENCE OF HARD PROCESS
- ENERGY

EXPECT FACTORIZATION BREAKING

IN $\gamma p \to$ jets + X + p

$\to$ charm + X + p

$\to$ jets + X + n   LEADING n NON-DIFFRACTIVE

- KAIDALOV et al '03

  · ELASTIC + LOW-MASS DISSOCIATIVE RESCATTERINGS ("2-CHANNEL EIKONAL MODEL")

  FOR $\gamma p \to jj + X + p$

  ↑

  AT LO (α_s)

  GET SURVIVAL PROB. $S^2 \approx 0.34$

- H1, ZEUS ANALYSIS LO (α_s) + Lead. Log PARTON SHOWERS

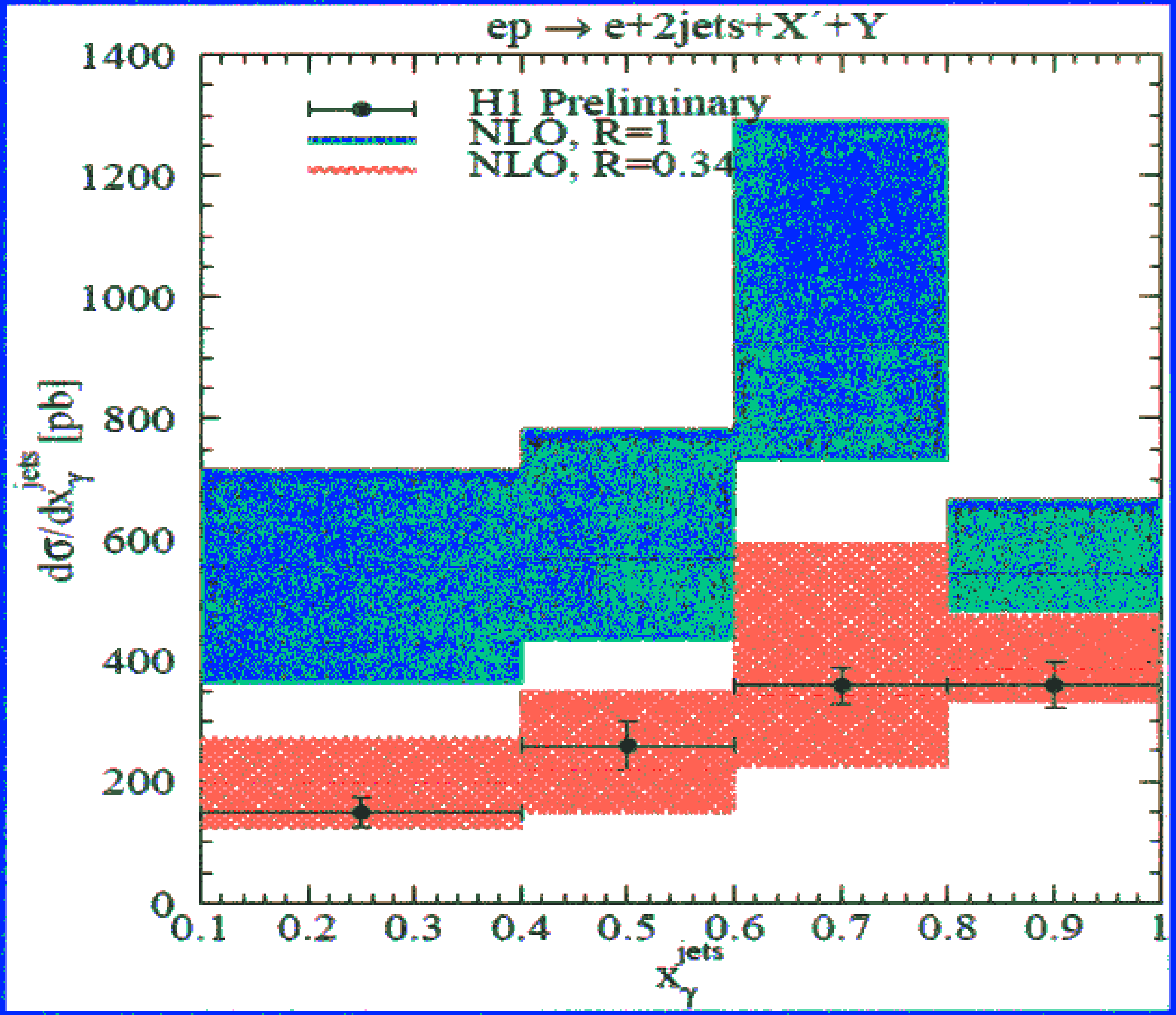
  OK WITH DATA WITH $S^2 = 1$

- KRAMER, KLASEN NLO (α_s)

  REQUIRE $S^2 \simeq 0.34$ FOR RESOLVED PART OF γ

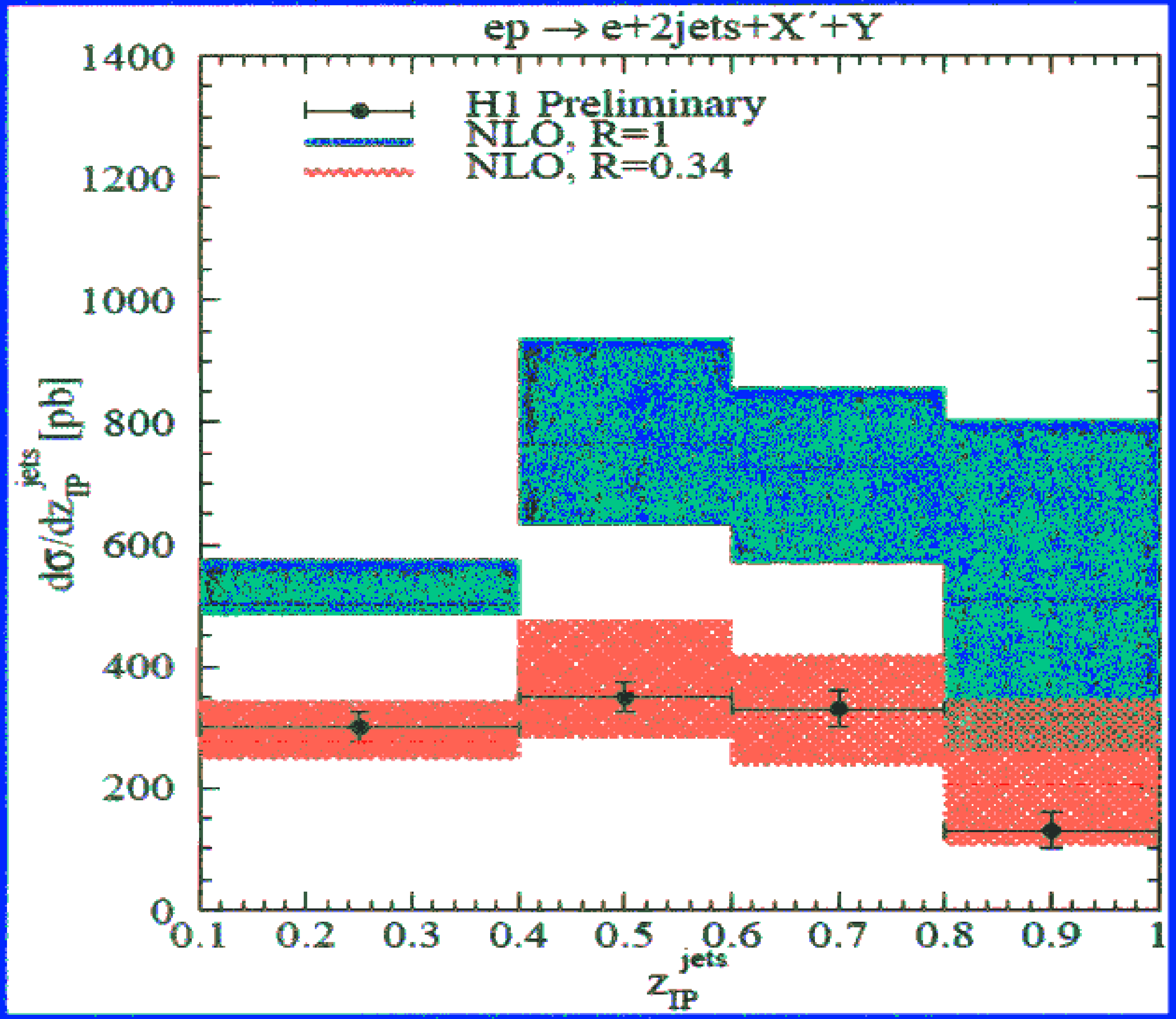
Non-Factorizable
Multi-Pomeron Exchanges

x_γ-dependence: Direct/resolved photons



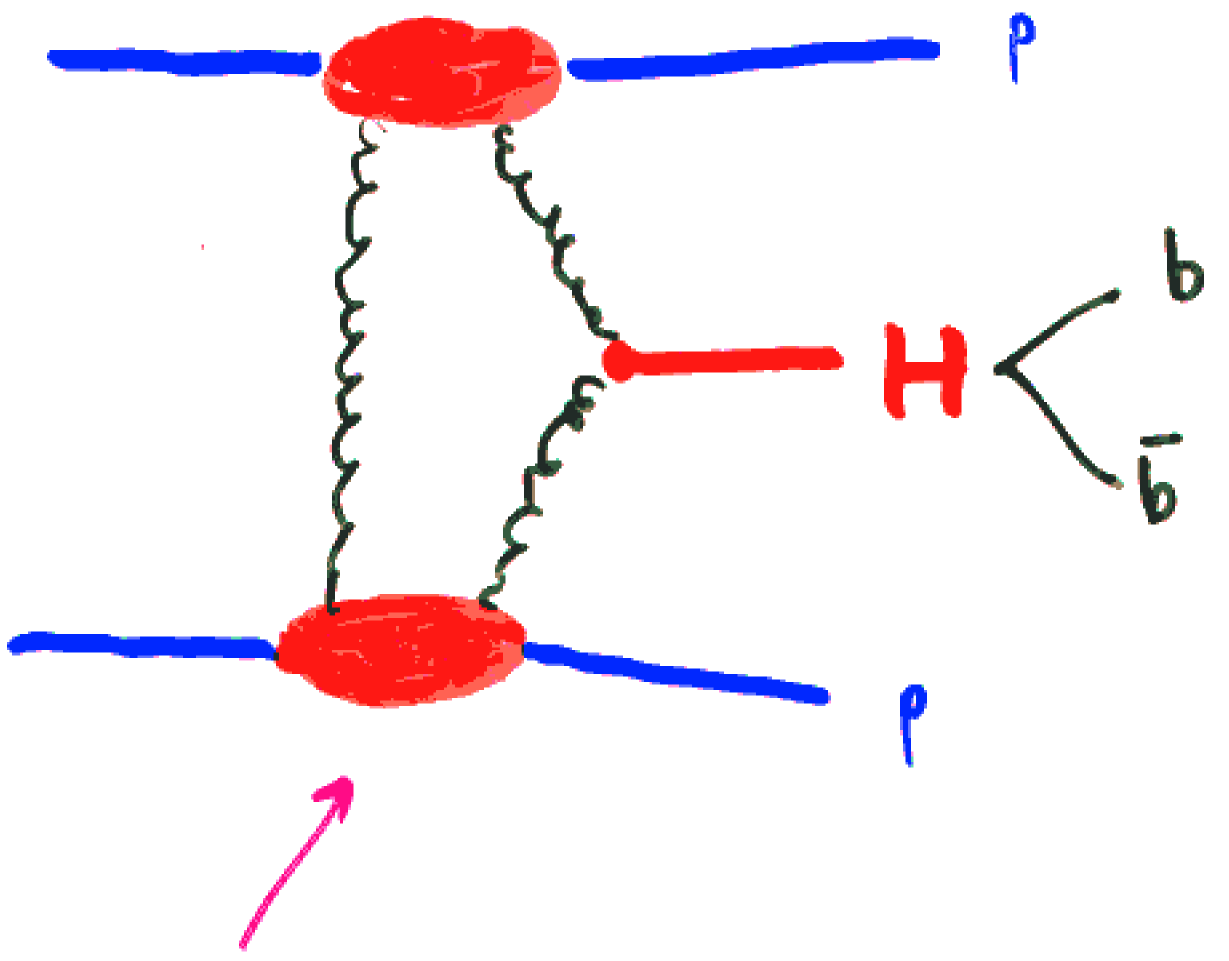
→ In LO, R = 1 agrees better with data!

z_{IP}-dependence:



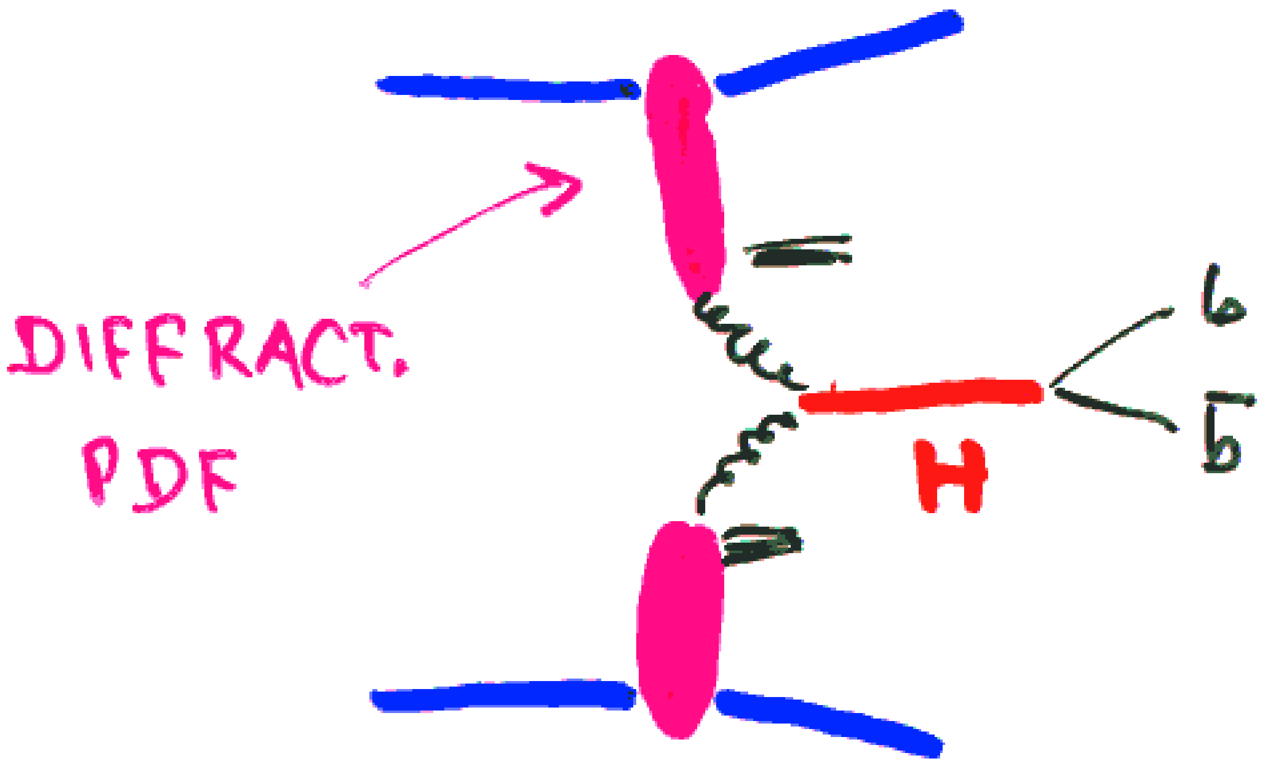
→ Smaller uncertainties in 1/σ dσ/dz

EXCLUSIVE HIGGS PRODUC'N AT LHC



GENERALIZED GLUON DIST'N

"BACKGROUND" FROM



DIFFRACT. PDF

WHEN "ℙ REMANTS" BECOME SOFT

- GAP SURVIVAL PROB. ESTIMATED AS

  ~ 0.028 AT LHC

  (~ 0.05 AT TEVATRON)

  → TALK A. D. MARTIN

- BACKGROUND FROM $gg \to b\bar{b}$

  USE "EXCLUSIVE DIJETS" AT TEVATRON TO CHECK MODELS

  $p\bar{p} \to p + jet\ jet + \bar{p}$

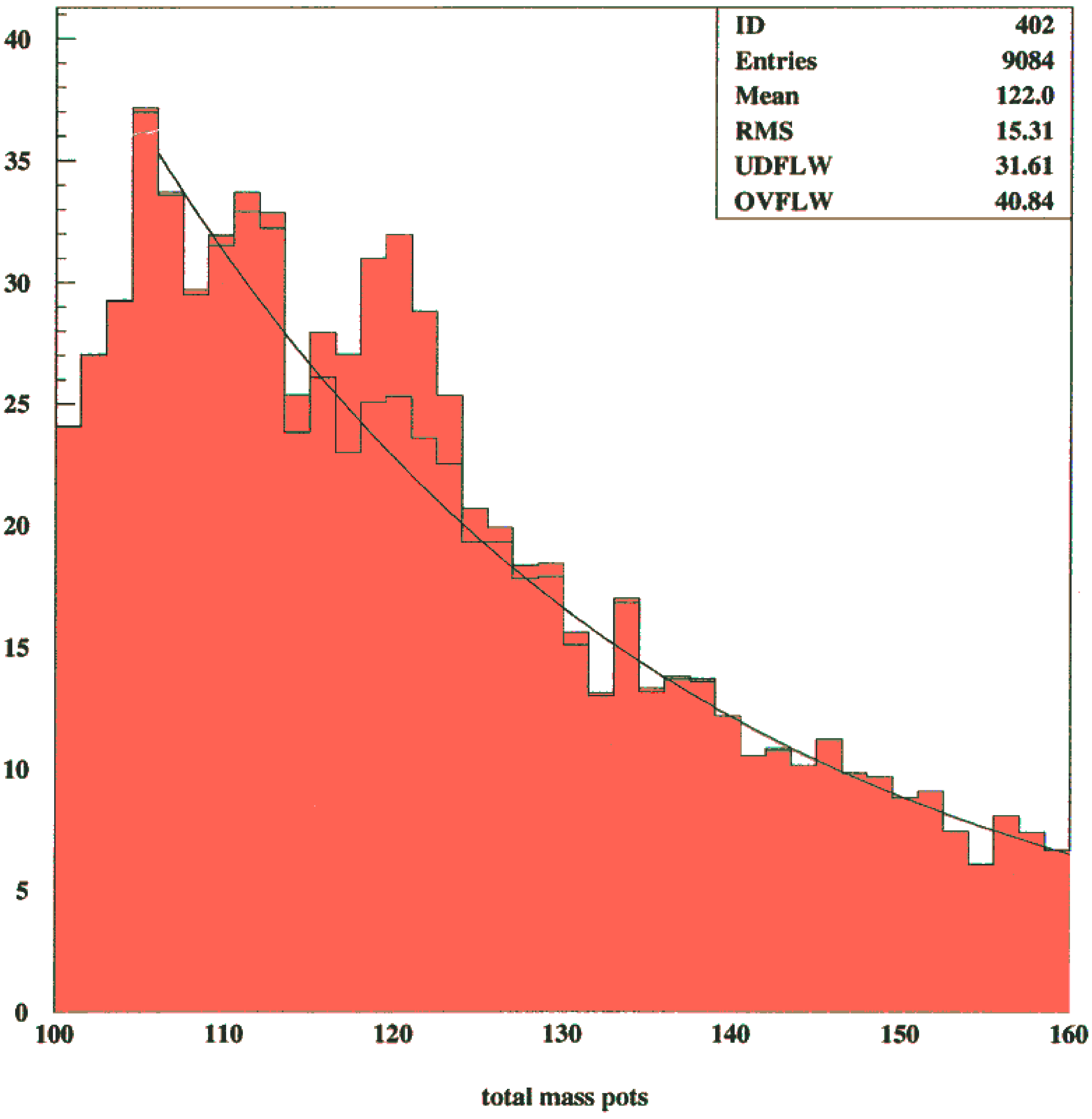
- OVERALL AGREEMENT OF DURHAM AND SACLAY GROUPS CONCERNING SIGNAL X SECTION

TALK C. ROYON

Background and signal

For a Higgs mass of 120 GeV

events for 100 fb^{-1}



M_X / GeV

M_X = missing mass in $pp \to p + X + p$

reconstructed from detected protons

simulation

for CMS

+ TOTEM setup

TALK C. ROYON

MISSING MASS M_X IN $pp \to p+X+p$
AS RECONSTRUCTED BY
ROMAN POTS

Signal and background for 100 fb^{-1}

Use 220 m, and 420 m pots, take into account one bin of 2 GeV width, one of 4 GeV (2 first columns: signal, 2 last ones: background)

M_H	2 GeV	4 GeV	2 GeV	4 GeV
120	8.4	15.6	26.9	55.6
125	7.4	13.3	21.9	45.4
130	6.5	12.6	19.5	38.0
135	5.8	11.0	15.9	32.1
140	4.2	8.2	13.9	27.3

The numbers for Higgs can be multiplied by up to a factor 50 if this is a MSSM Higgs

CRUCIAL EXPERIMENTAL ISSUES

- CUTS TO ENHANCE S/B
- TRIGGERING

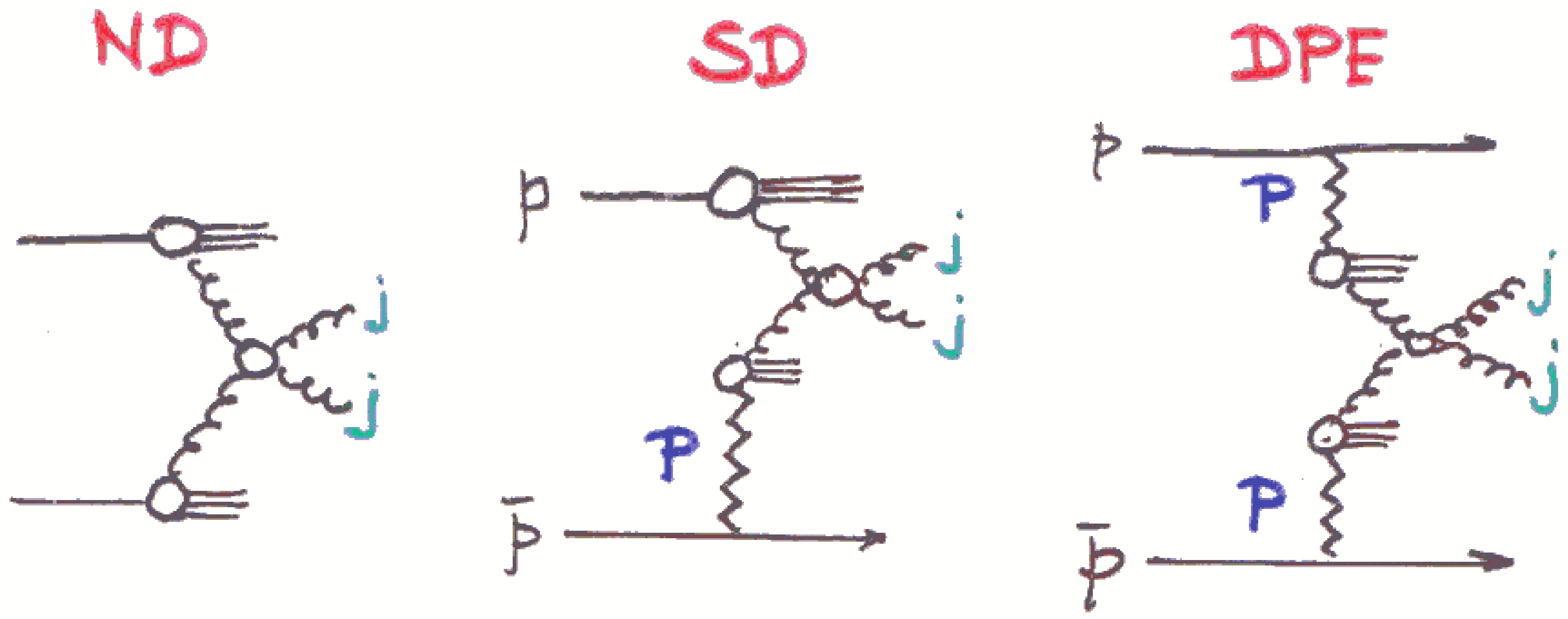
- PERFORMANCE OF ROMAN POTS

THANKS TO

- MY CO-CONVENORS A. BRUNI
  F.-P. SCHILLING
- THE SPEAKERS IN OUR SESSION
- ALL PARTICIPANTS IN THE DISCUSSIONS
- L. McLERRAN FOR IGNITING + LEADING THE SATURATION DISCUSSION

THE ORANIZERS OF THIS WONDERFUL MEETING

Diffractive dijet prod^n at the Tevatron



Multi-$\mathbb{P}$ effects → $S_1 = 0{\cdot}10$ $S_2 = 0{\cdot}05$

KAIDALOV et al.

$$R_1 \equiv \frac{\sigma_{jj}^{SD}}{\sigma_{jj}^{ND}} = \frac{F_P\, f_P}{f_{\bar{p}}} S_1$$

$$\left(f = g + \tfrac{4}{9}\bar{q}\right)$$

$$R_2 \equiv \frac{\sigma_{jj}^{DPE}}{\sigma_{jj}^{SD}} = \frac{F_P\, f_P}{f_p} \frac{S_2}{S_1}$$

$$D = \frac{R_1}{R_2} = \frac{S_1^2}{S_2} \simeq \frac{(0{\cdot}10)^2}{(0{\cdot}05)} \simeq 0{\cdot}2$$

CDF: $D = 0{\cdot}19 \pm 0{\cdot}07$

TALK A. BIALAS : WITH ELASTIC RESCATT. ONLY
GET GENERICALLY $S_2 = S_1$

SLIDE COURTESY OF
A. MARTIN