Diffractive W/Z & Exclusive JJ @ CDF II

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On behalf of the CDF II collaboration

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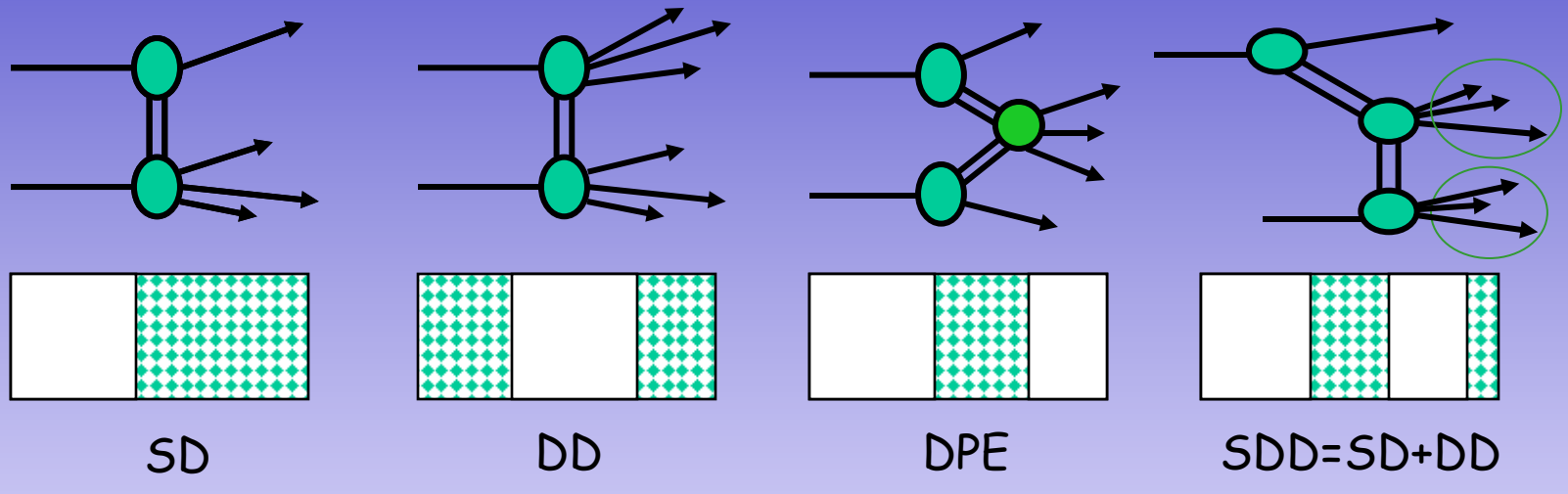
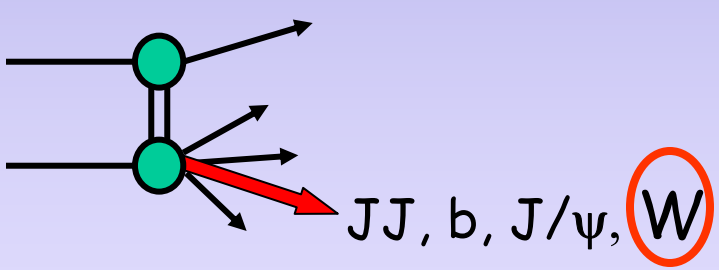
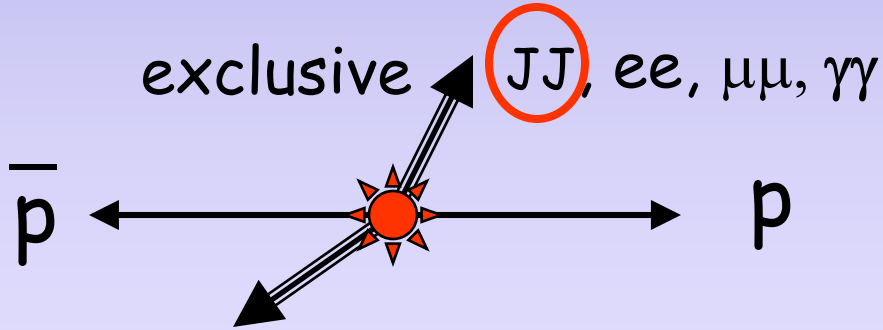
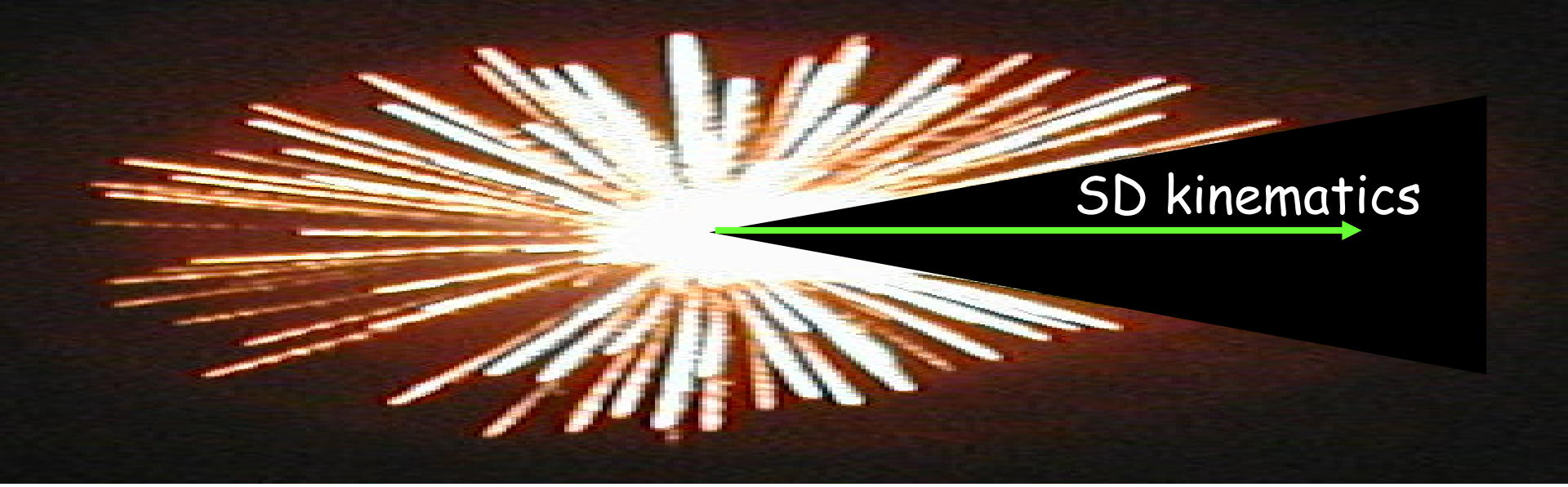
Introduction

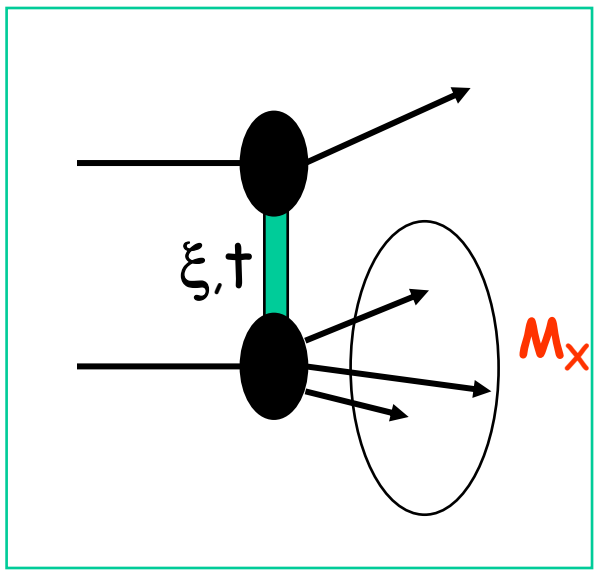
Diffraction @ CDF

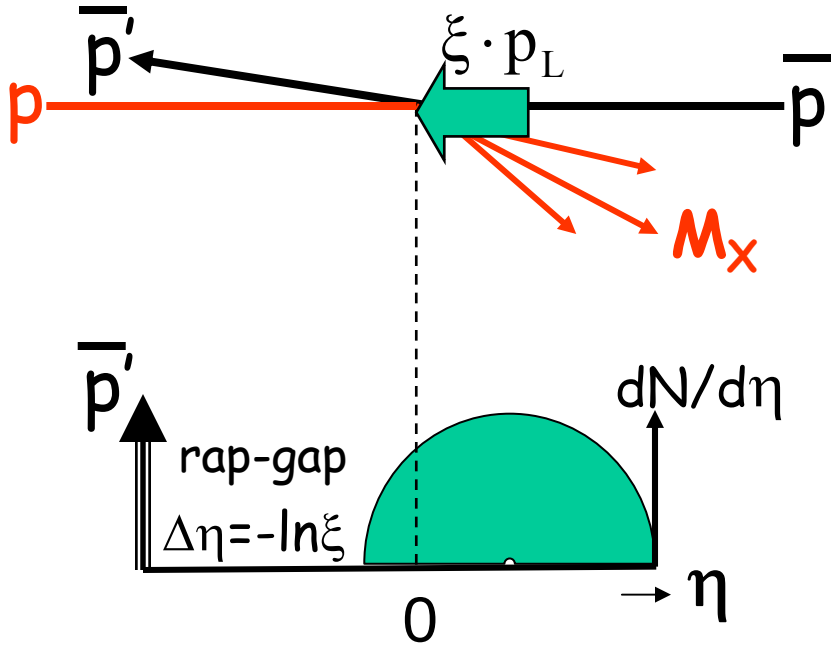




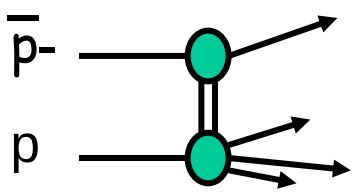



SD kinematics

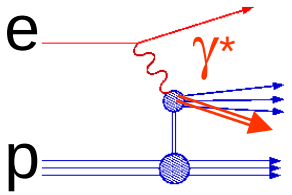

ξ,t
M_X

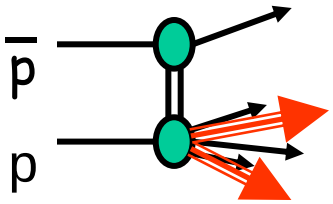

$\bar{p}'$
$\xi \cdot p_L$
p
$\bar{p}$
M_X
$\bar{p}'$
dN/dη
rap-gap
Δη=-lnξ
0
η

Breakdown of factorization – Run I



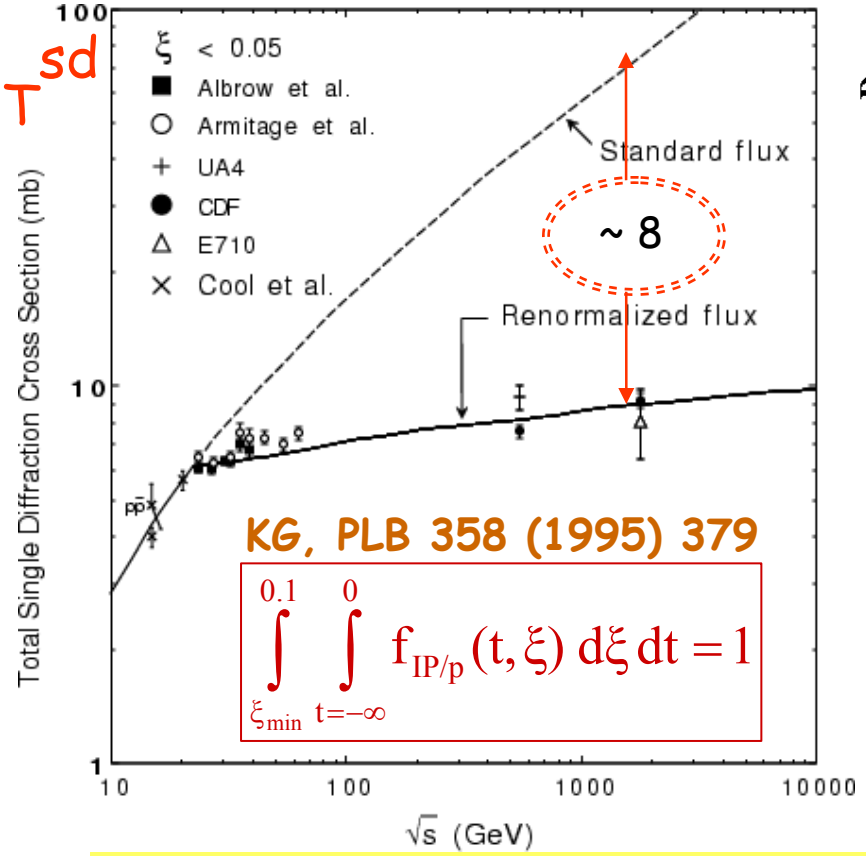
soft





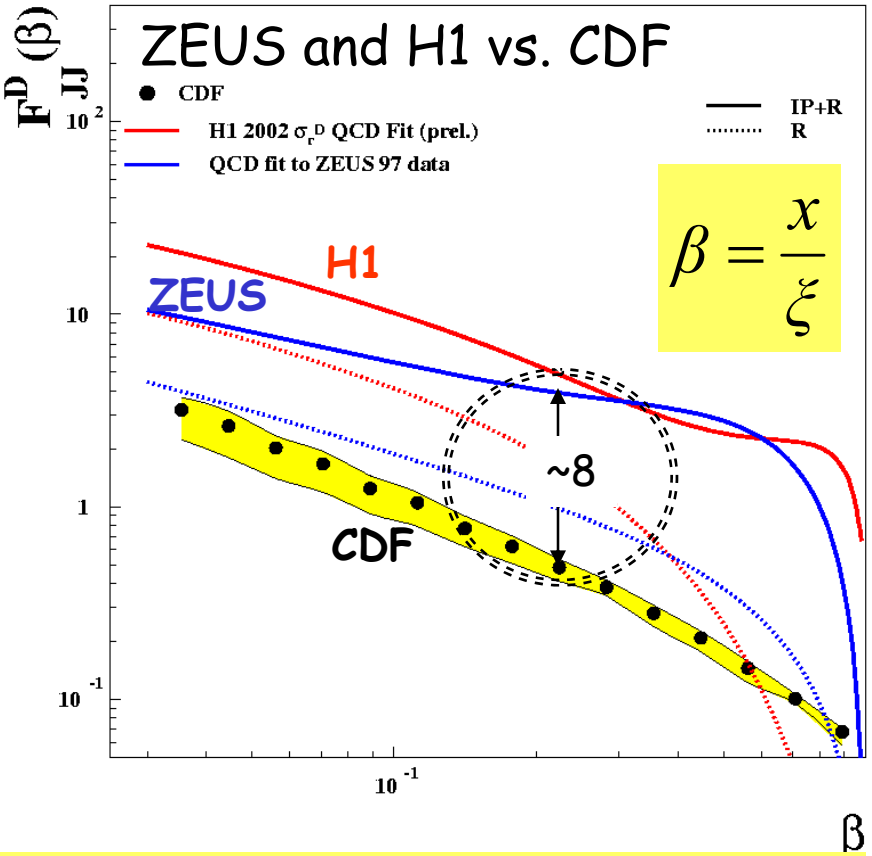
hard

σ_T^{sd}



KG, PLB 358 (1995) 379

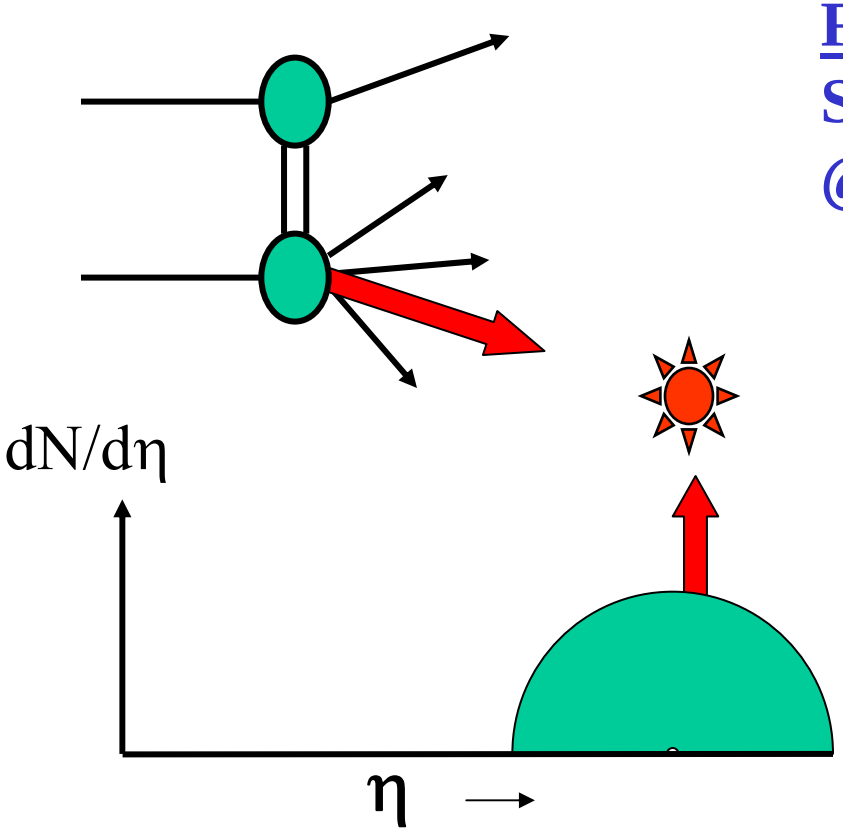
$$\int_{\xi_{min}}^{0.1}\int_{t=-\infty}^{0} f_{IP/p}(t,\xi)\,d\xi\,dt = 1$$



Magnitude: same suppression factor in soft and hard diffraction!
Shape of β distribution: ZEUS, H1, and Tevatron – why different shapes?

Hard diffractive fractions – Run I

$$\bar{p}p \rightarrow (\text{☀} + X) + \text{gap}$$



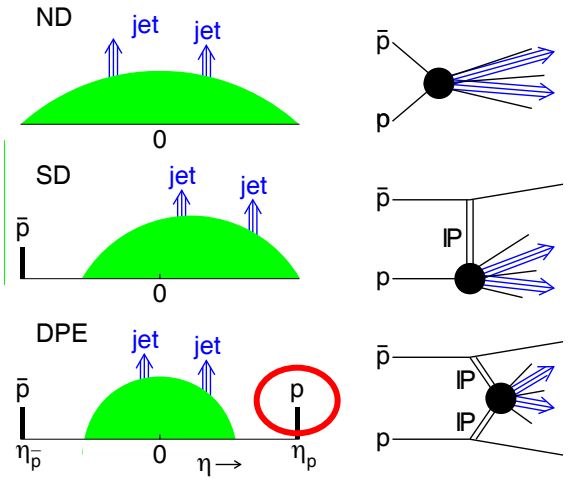
Fraction:
SD/ND ratio
@ 1800 GeV

☀	Fraction %
JJ	0.75 +/- 0.10
W	0.115 +/- 0.55
b	0.62 +/- 0.25
J/ψ	1.45 +/- 0.25

All fractions ~ 1%
(differences due to kinematics)

- ~ uniform suppression
- ~ FACTORIZATION !

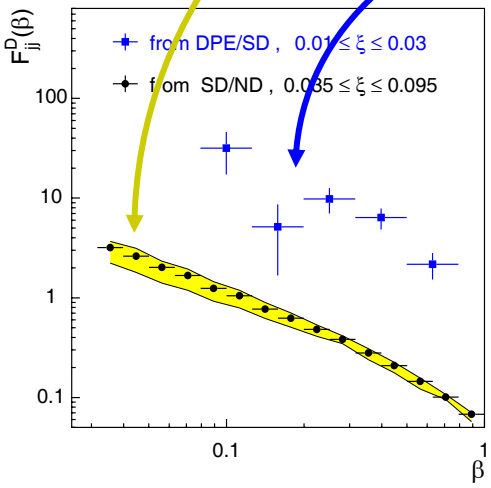
Multi-gap diffraction – Run I
➔ restoring factorization

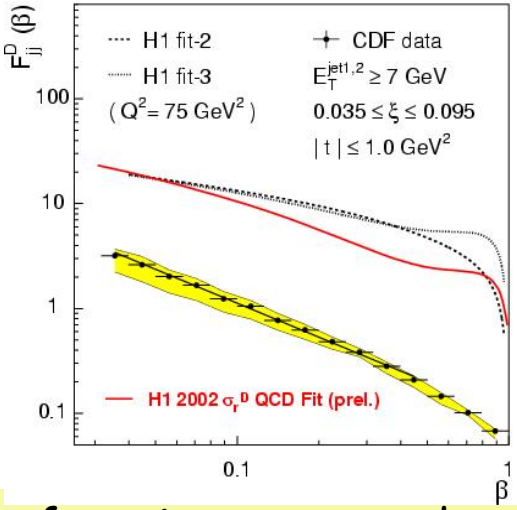


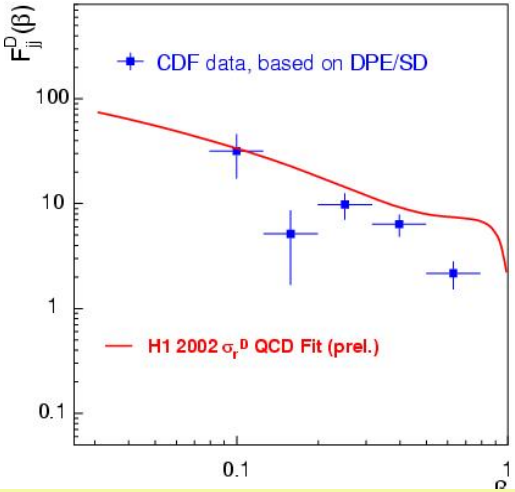
R(SD/ND)

R(DPE/SD)

DSF from two/one gap: factorization restored!

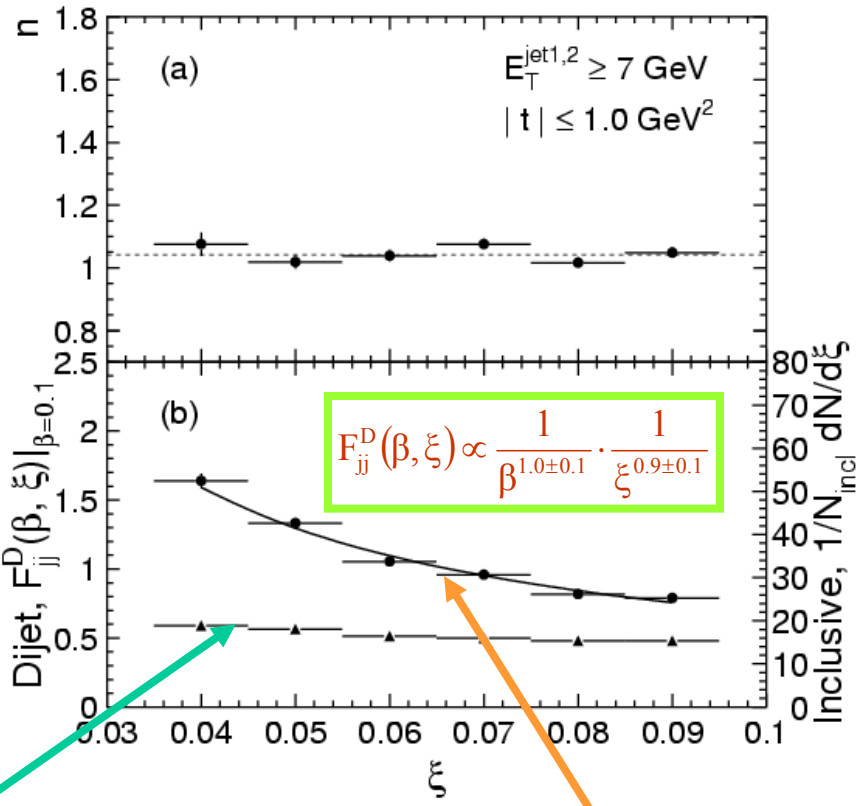






The diffractive structure function measured on the proton side in events with a leading antiproton is NOT suppressed relative to predictions based on DDIS

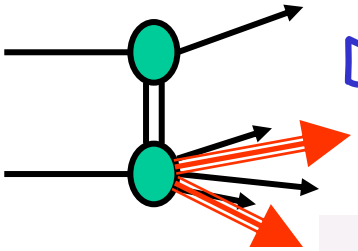
ξ & β dependence of F^D_{jj} - Run I



$$\frac{d\sigma_{incl}}{d\xi} \propto \text{constant}$$

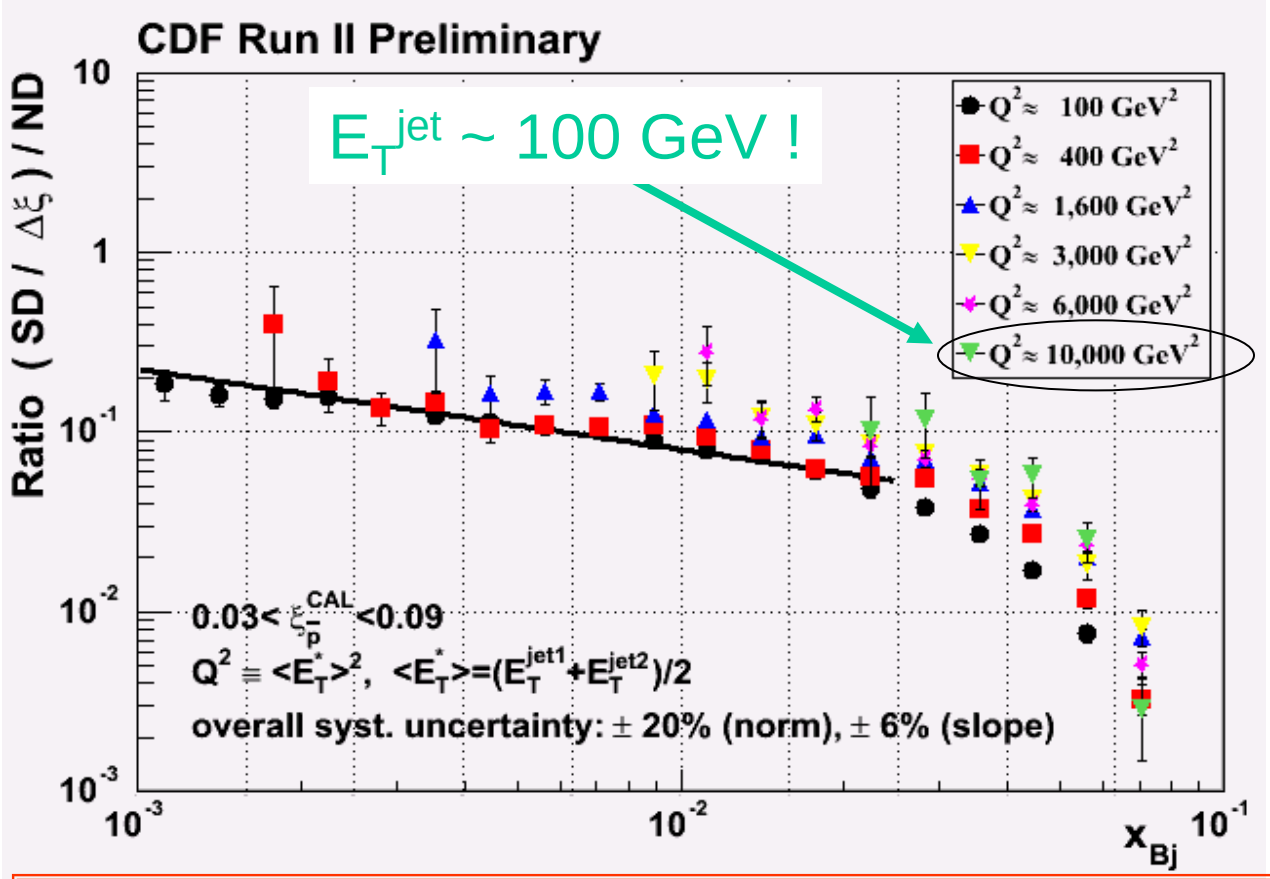
$$F_{jj}^D(\beta,\xi) \propto \frac{1}{\beta^n} \cdot \frac{1}{\xi^m} \quad (n = 1.0 \pm 0.1, \quad m = 0.9 \pm 0.1)$$

Pomeron dominated



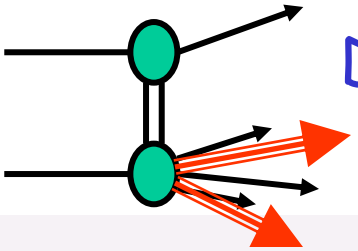
Diffractive structure function – Run II

Q^2 dependence



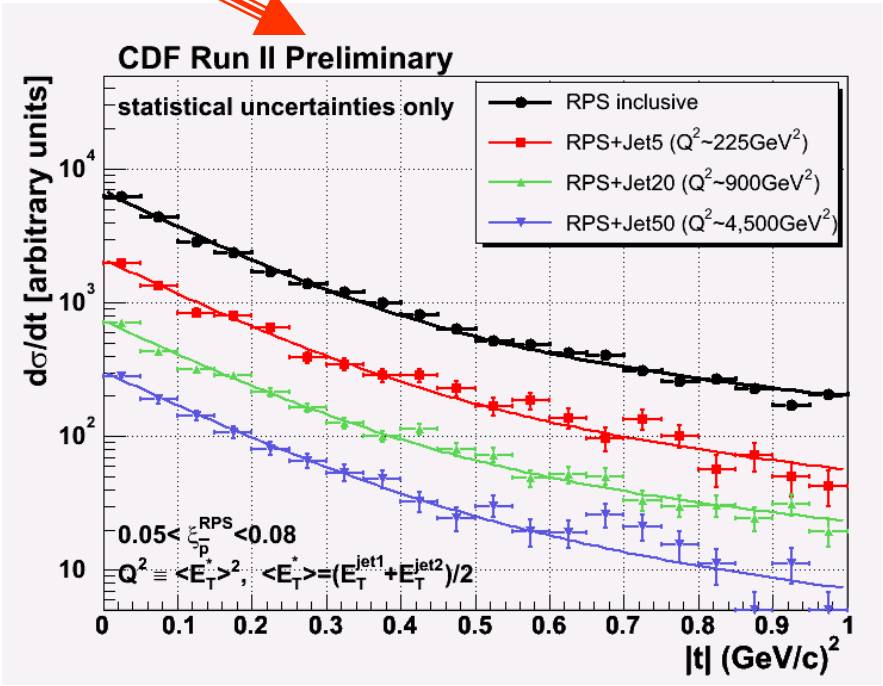
Small Q^2 dependence in region $100 < Q^2 < 10{,}000$ GeV^2

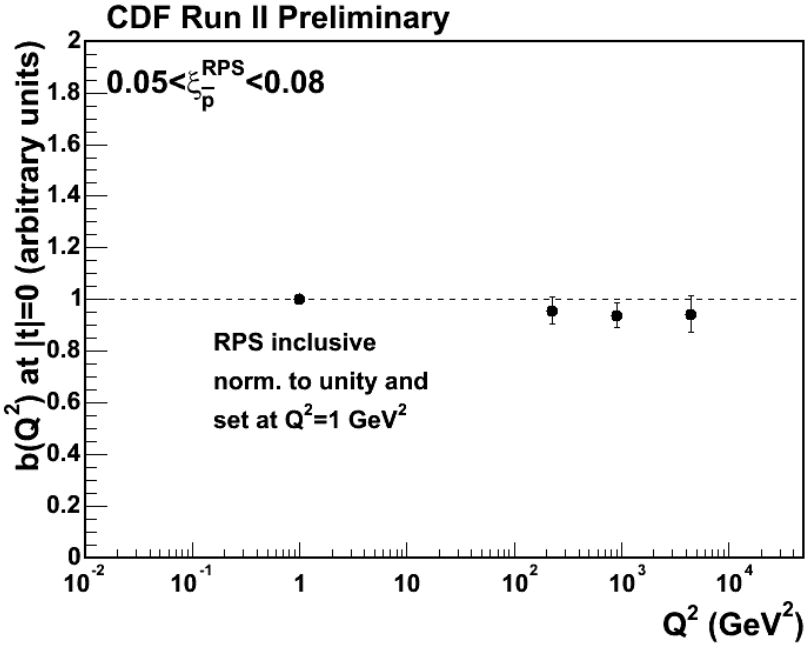
⇨ Pomeron evolves as the proton!



Diffractive structure function – Run II

t- dependence





Fit dσ/dt to a double exponential:

$$F = 0.9 \cdot e^{b_1 \cdot t} + 0.1 \cdot e^{b_2 \cdot t}$$

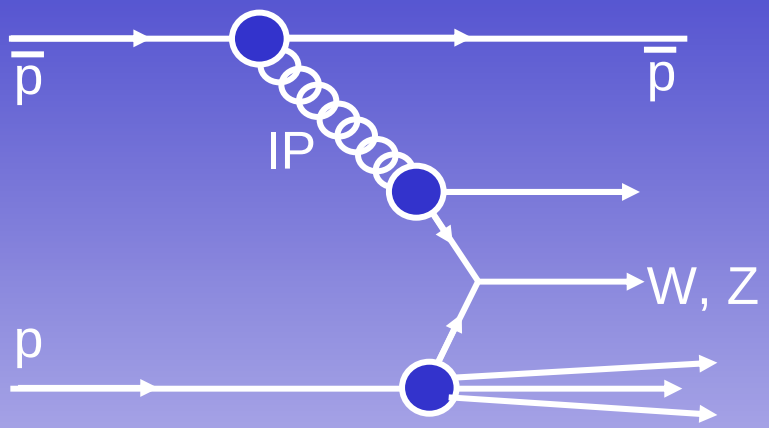
- No diffraction dips
- No Q2 dependence in slope from inclusive to $Q^2 \sim 10^4$ GeV^2

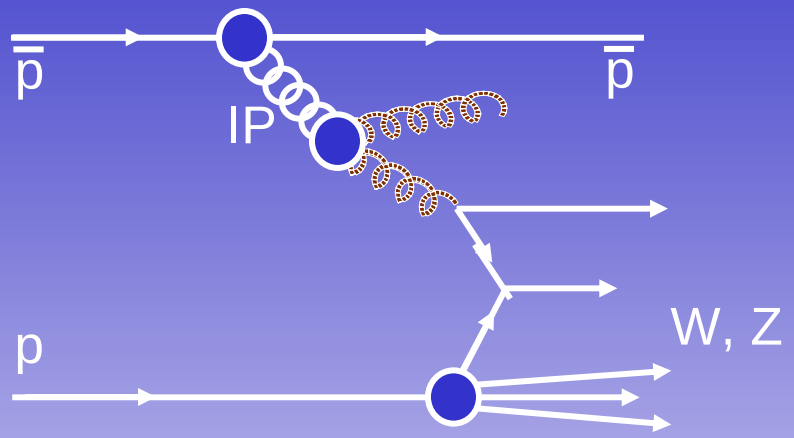
- Same slope over entire region of $0 < Q^2 < 4{,}500$ GeV^2 across soft and hard diffraction!

Looks like…

… the underlying diffractive PDF on a hard scale is similar to the proton PDF except for small differences presumably due to the requirement of combining with the soft PDF to form a spin 1 color singlet with vacuum quantum numbers.

Diffractive W/Z production



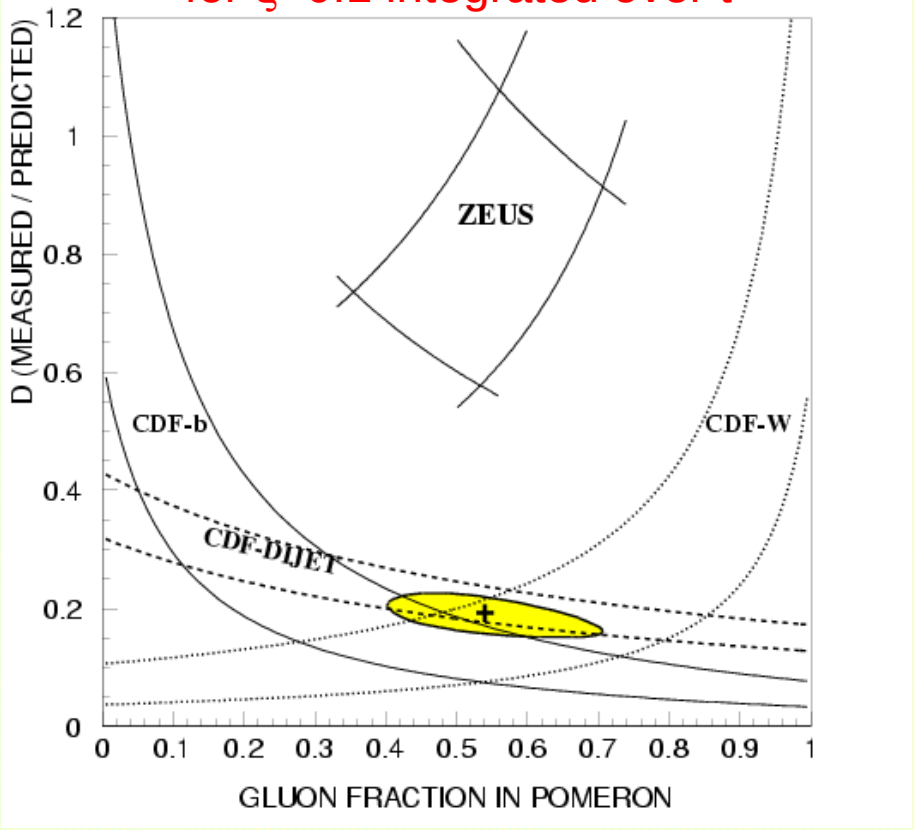


- Diffractive W production probes the quark content of the Pomeron
  - To leading order, the W is produced by a quark in the Pomeron
- Production by gluons is suppressed by a factor of α_S, and can be distinguished from quark production by an associated jet

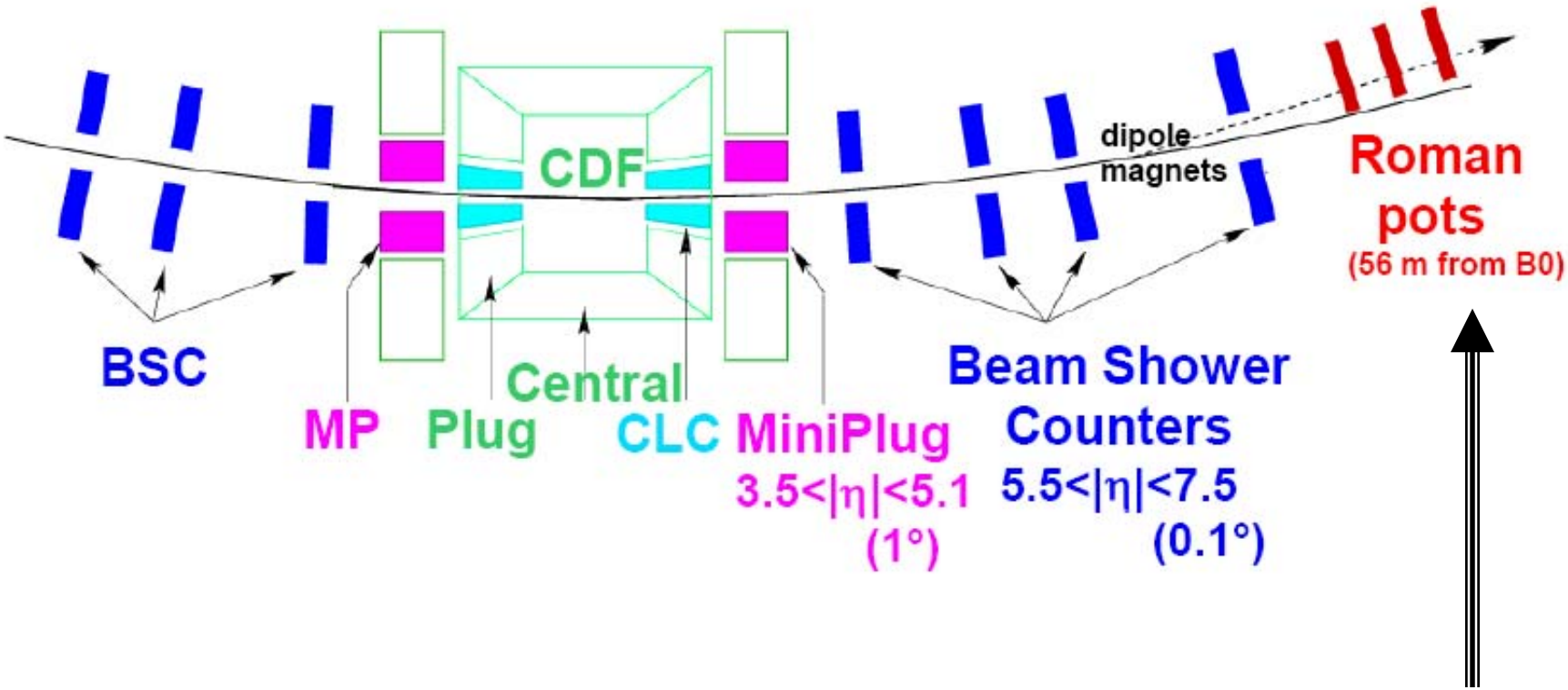
Diffractive W/Z - motivation

- In Run I, combining diffractive dijet production with diffractive W production was used to determine the quark/gluon content of the Pomeron ===➔
- In Run II, we aim at determining the diffractive structure function for a more direct comparison with HERA.
- To accomplish this we use:
  - ➢ New forward detectors
  - ➢ New methodology
  - ➢ More data

Phys Rev Lett **78**, 2698 (1997)
Fraction of W events due to SD
R^w=[1.15±0.51(stat)±0.20(syst)]%
for ξ<0.1 integrated over t

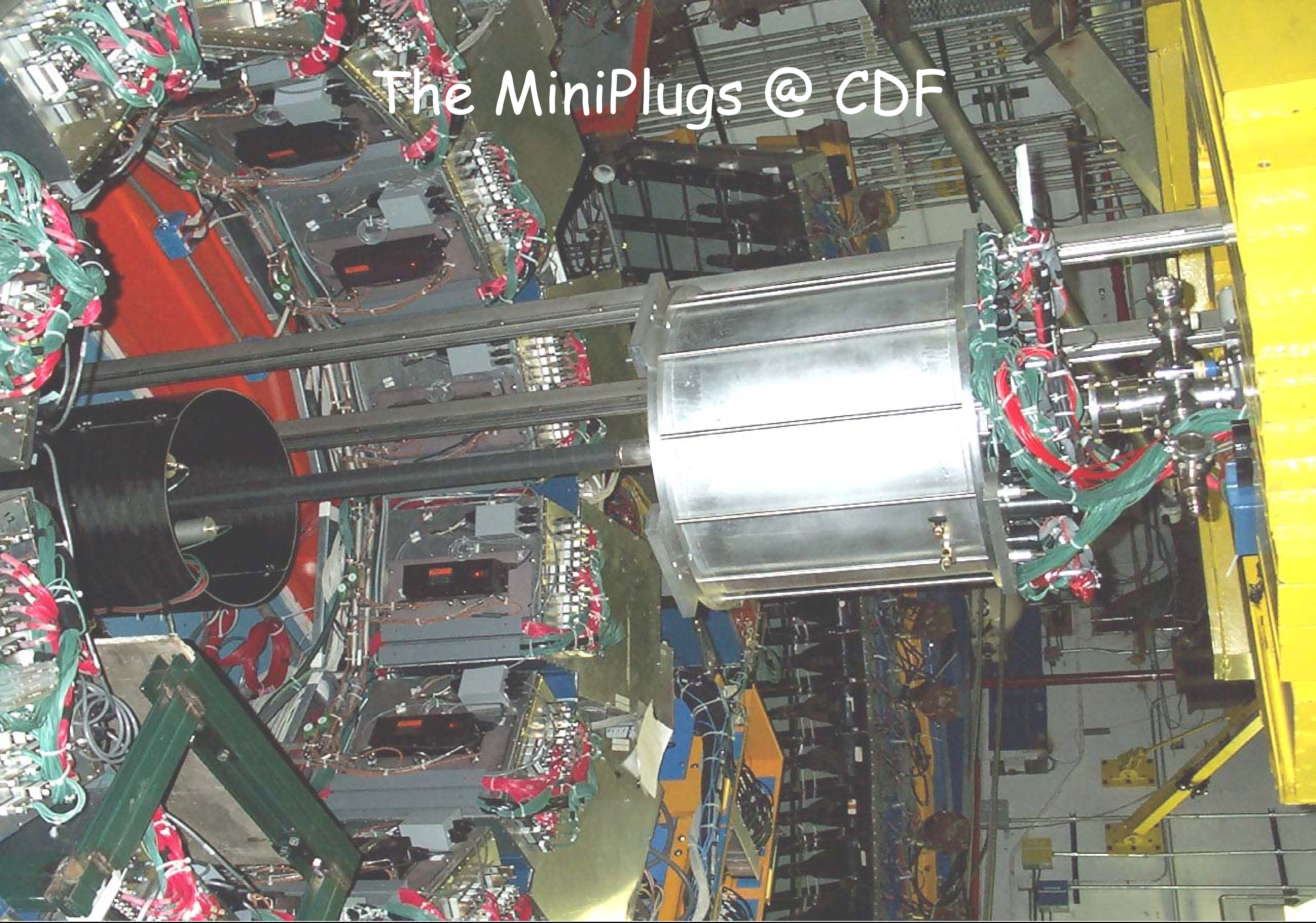


The DF II detectors



RPS acceptance ~80% for $0.03 < x < 0.1$ and $|t| < 0.1$

The MiniPlugs @ CDF



Diffractive W/Z analysis

Using RPS information:

- No background from gaps due to multiplicity fluctuations
- No gap survival probability problem
- The RPS provides accurate event-by-event ξ measurement
- Determine the full kinematics of diffractive W production by obtaining η_ν using the equation:

$$\xi^{RPS} - \xi^{cal} = \frac{\not{E}_T}{\sqrt{s}} e^{-\eta_\nu}$$

where

$$\xi^{cal} = \sum_{towers} \frac{E_T}{\sqrt{s}} e^{-\eta}$$

This allows determination of:

- W mass
- x_{Bj}
- Diffractive structure function

W/Z selection requirements

Standard W/Z selection

$E_T^e (p_T^\mu > 25\ \text{GeV}$

$\not{M}_T > 25\ \text{GeV}$

$40 < M_T^W < 120\ \text{GeV}$

$|Z_{vtx}| < 60\ \text{cm}$

$E_T^{e1} (p_T^{\mu 1} > 25\ \text{GeV}$

$E_T^{e2} (p_T^{\mu 2} > 25\ \text{GeV}$

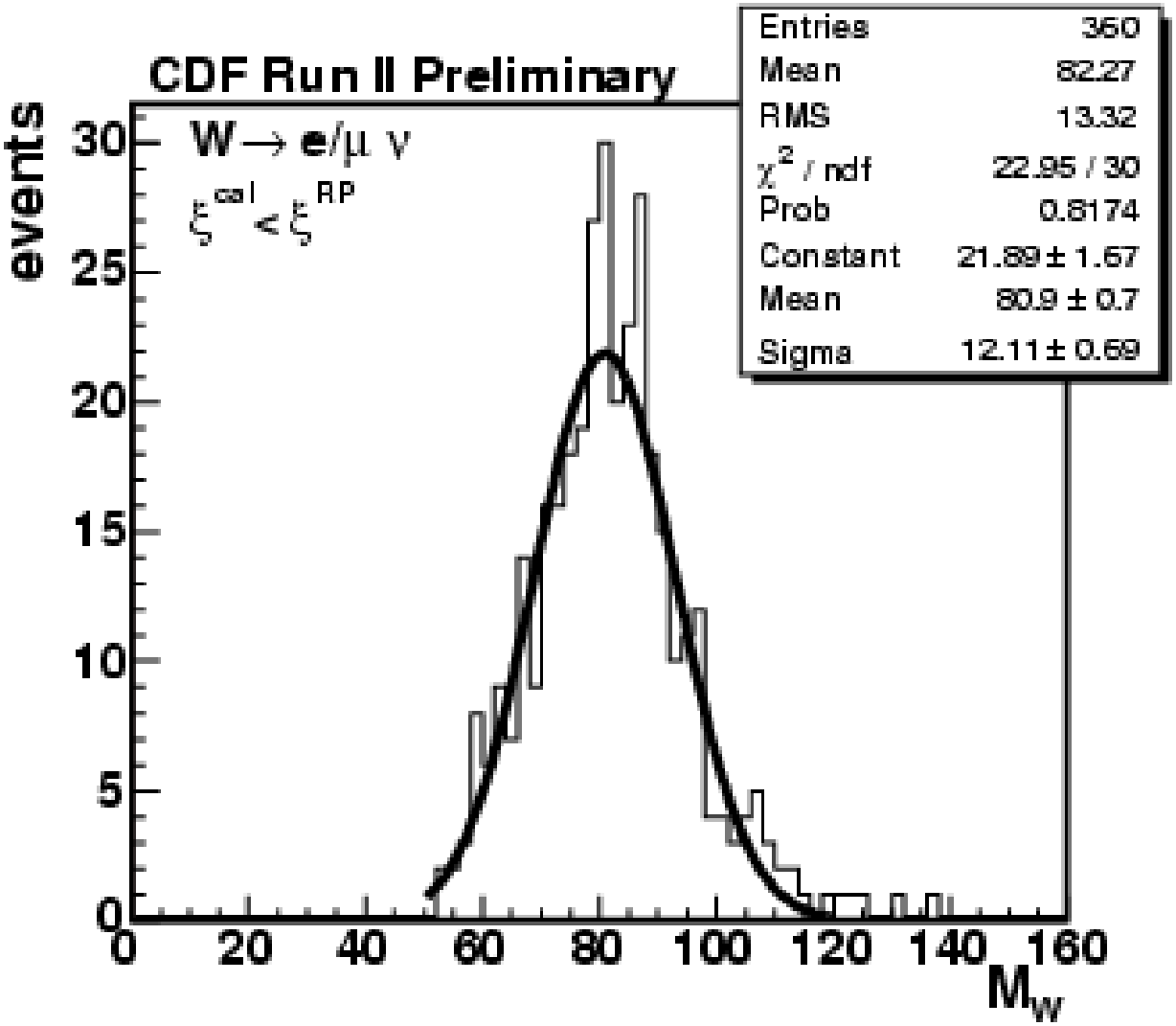
$66 < M^Z < 116\ \text{GeV}$

$|Z_{vtx}| < 60\ \text{cm}$

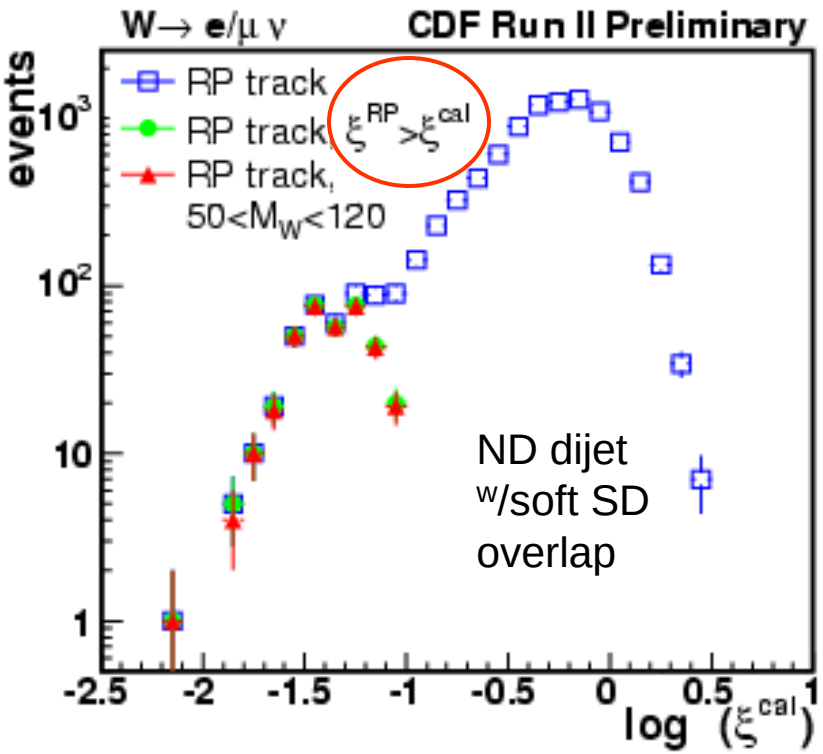
Diffractive W/Z selection

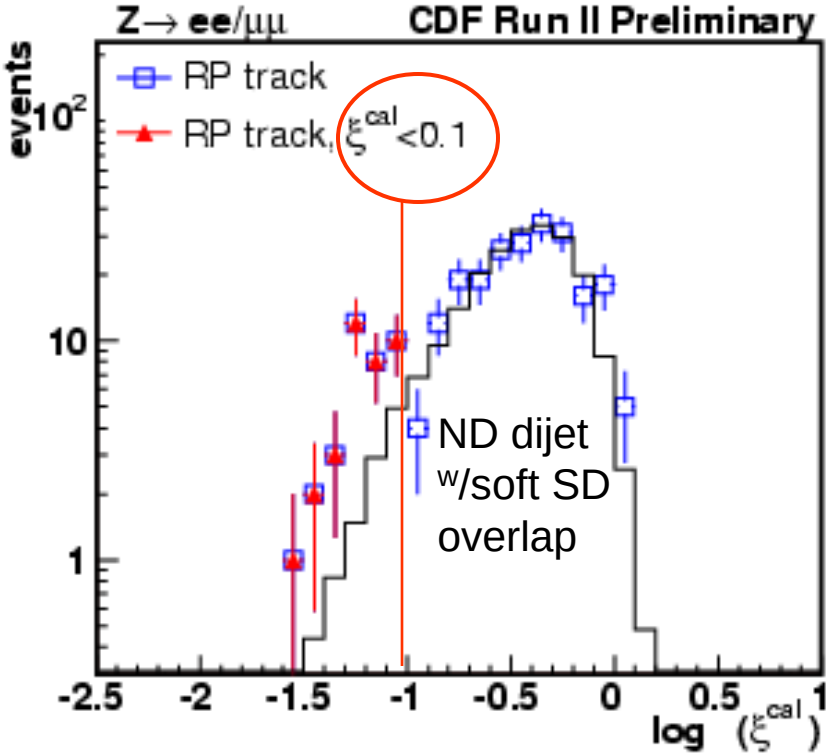
- RPS trigger counters - MIP
- RPS track - $0.03 < \xi < 0.10$, $|t| < 1$
- W➔ $50 < M_W(\xi^{RPS}, \xi^{cal}) < 120$
- Z ➔ $\xi^{cal} < 0.1$

Reconstructed diffractive W mass



Rejection of multiple interaction events





Diffractive W/Z results

R^W $(0.03 < \xi < 0.10, |t|<1) = [0.97 \pm 0.05(stat) \pm 0.11(syst)]\%$

Run I: $R^W = 1.15 \pm 0.55$ % for $\xi < 0.1$ ➔ estimate **0.97 ± 0.47 %** in **$0.03 < \xi < 0.10$ & $|t|<1$)**

R^Z $(0.03 < x < 0.10, |t|<1) = [0.85 \pm 0.20(stat) \pm 0.11(syst)]\%$

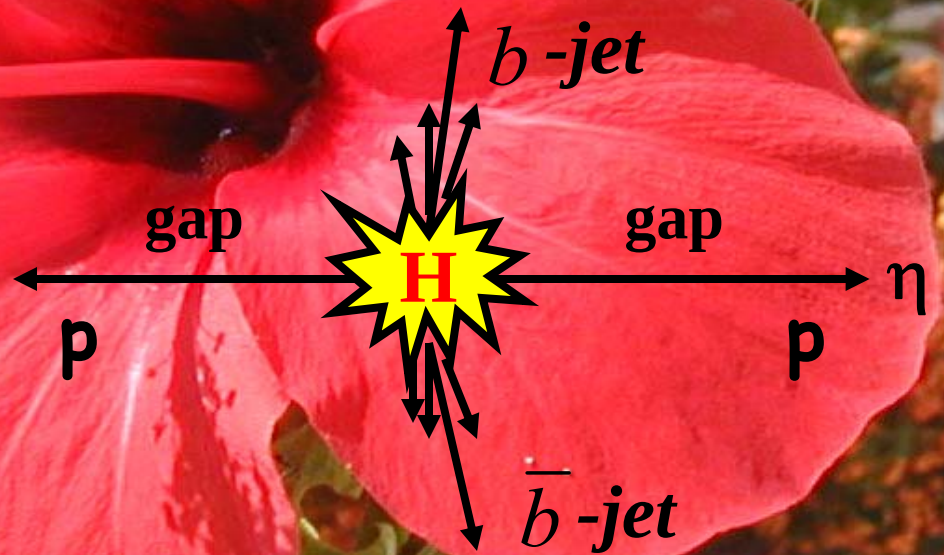
CDF/DØ Comparison – Run I ($\xi < 0.1$)

CDF PRL 78, 2698 (1997)
$R^W = [1.15 \pm 0.51(stat) \pm 0.20(syst)]\%$
gap acceptance $A^{gap} = 0.81$
uncorrected for A^{gap} ➔
$R^W = (0.93 \pm 0.44)\%$
(A^{gap} calculated from MC)

DØ Phys Lett B **574**, 169 (2003)
$R^W = [5.1 \pm 0.51(stat) \pm 0.20(syst)]\%$
gap acceptance $A^{gap} = (0.21 \pm 4)\%$
uncorrected for A^{gap} ➔
$R^W = [0.89 + 0.19 - 0.17]\%$
$R^Z = [1.44 + 0.61 - 0.52]\%$

Stay connected tor $F^D_{W/Z}$

EXCLUSIVE JJ & HIGGS BOSONS



$M_H^2 = (p + \bar{p} - p' - \bar{p}')^2$

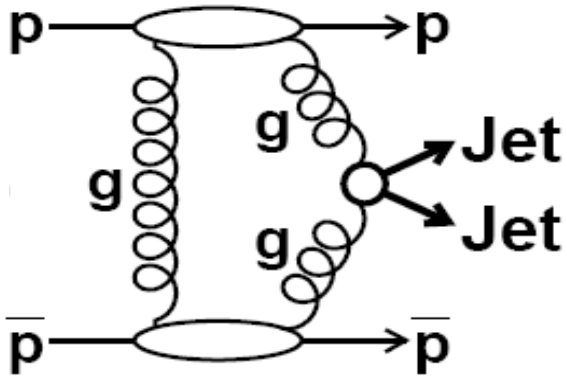
➔ $\Delta M \sim (1\text{-}2)$ GeV

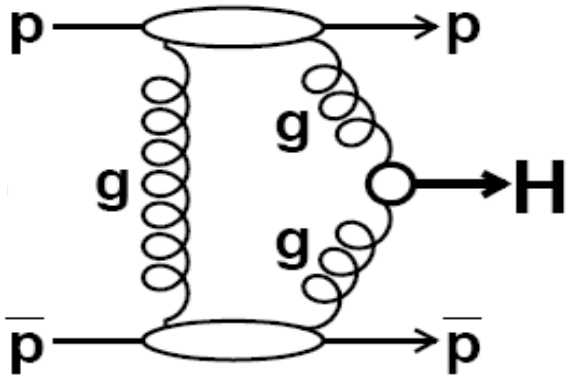
Determine spin of H

Exclusive dijet and Higg production

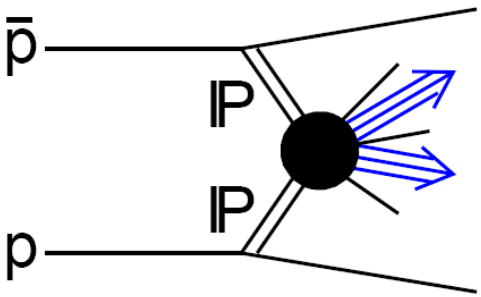
URL: http://link.aps.org/abstract/PRD/v77/e052004 DOI: 10.1103/PhysRevD.77.052004

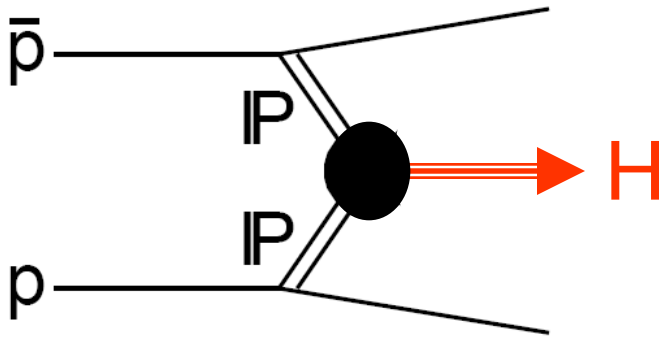
ExHuME





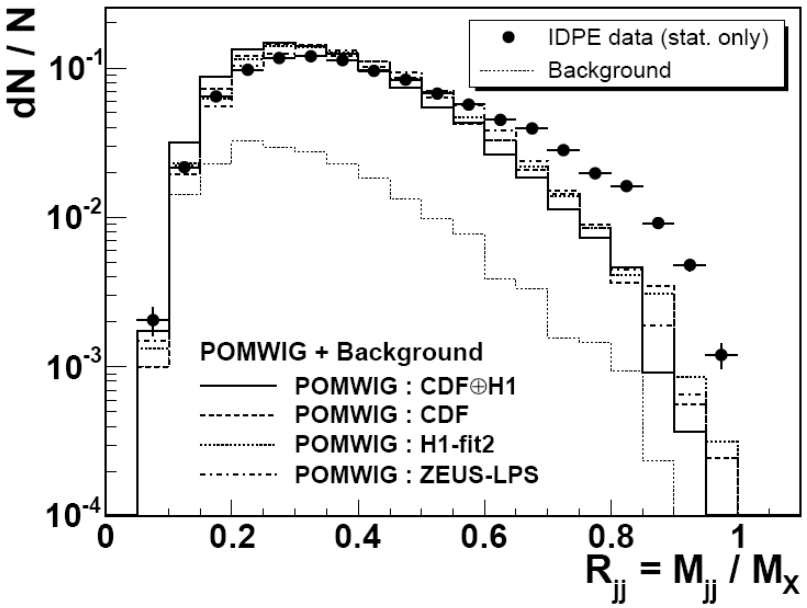
DPEMC





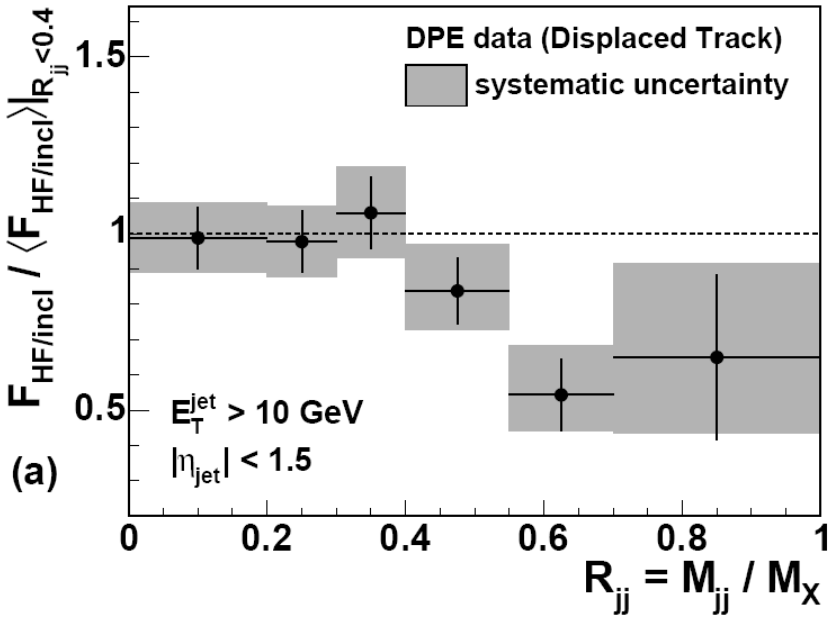
Exclusive dijet signal

dijet mass fraction – all jets



Excess observed over POMWIG MC prediction at large Rjj

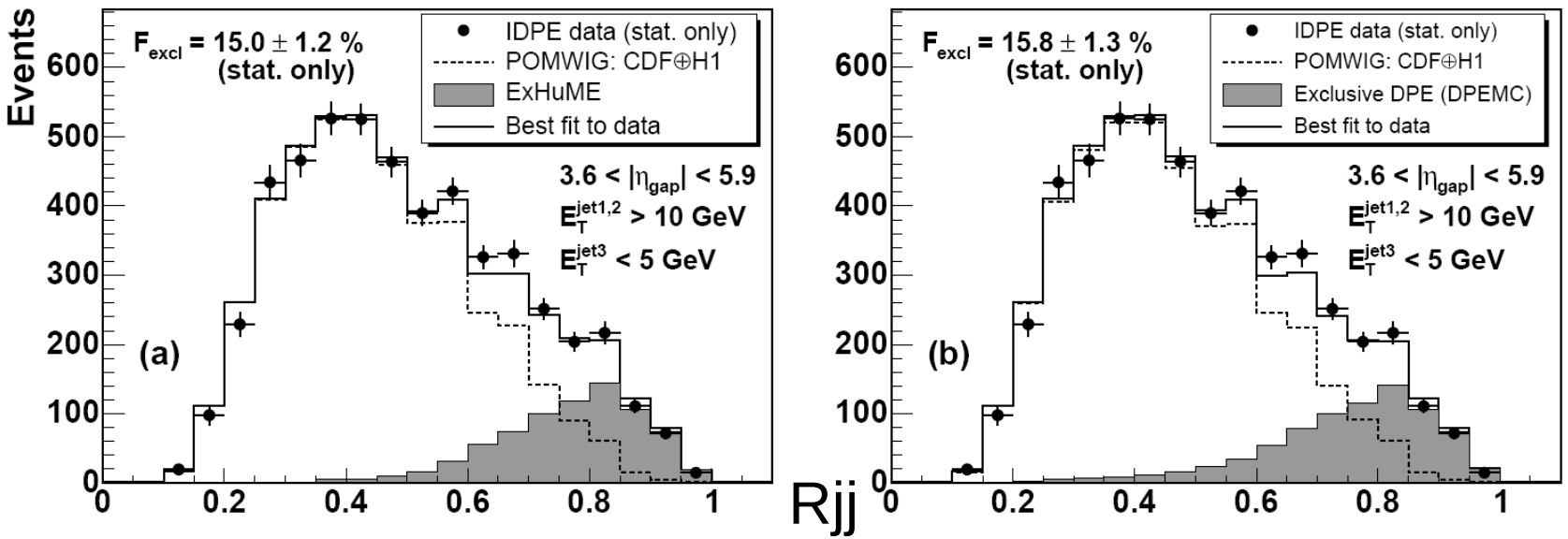
b-jet dijet mass fraction



Exclusive b-jets are suppressed as expected (J_Z= 0 selection rule)

Exclusive dijet content of DPE data

ExHuME ←exclusive MC models→ DPEMC



ExHuME (KMR): $gg \to gg$ process (based on LO pQCD)

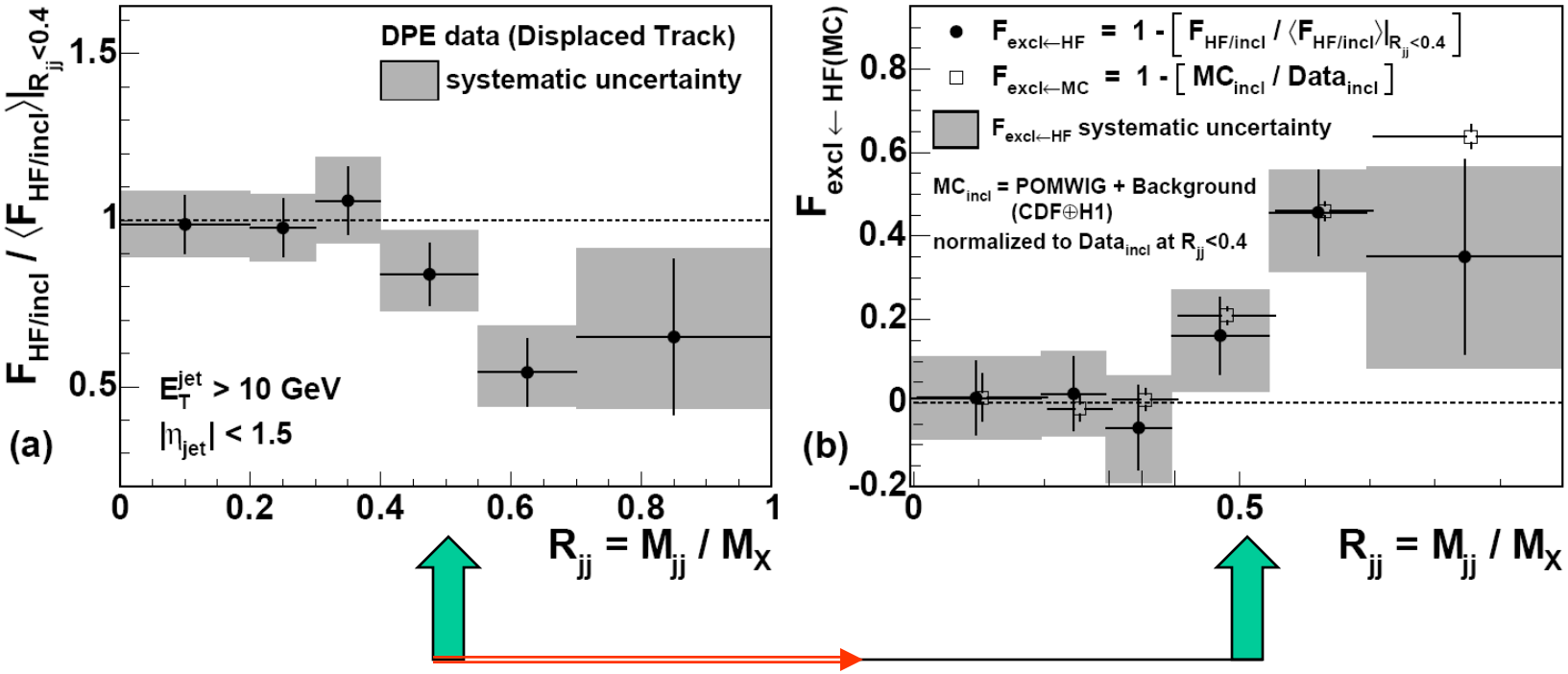
DPEMC: exclusive DPE MC based on Regge theory

Shape of excess of events at high R_{jj} is well described by both ExHuME & DPEMC

HF suppression & incl. MC based signal

HF suppression

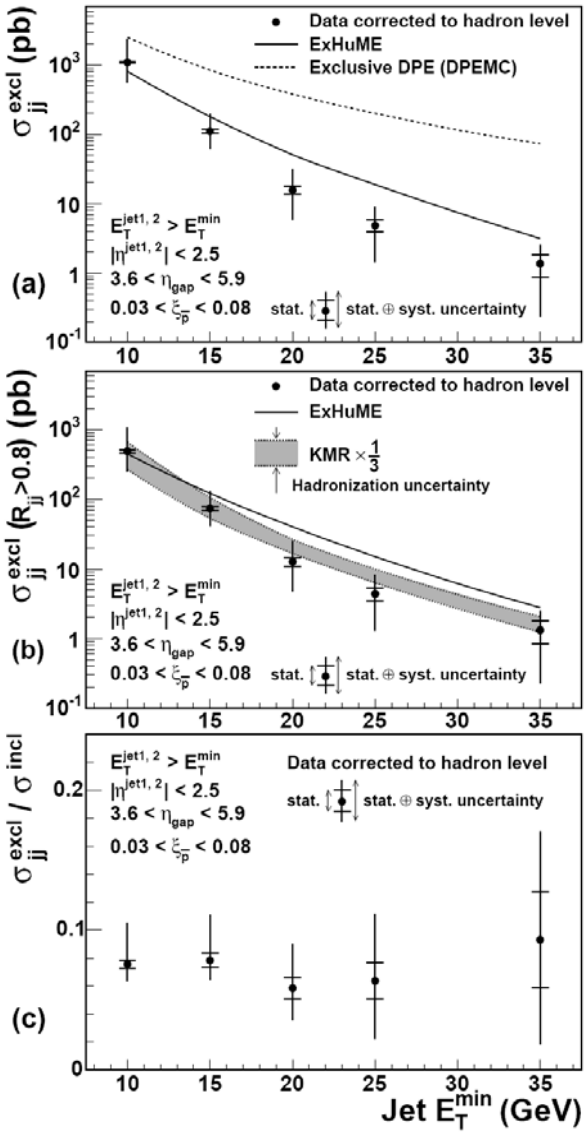
HF vs. incl



Invert HF vertically and compare with 1-MC/DATA

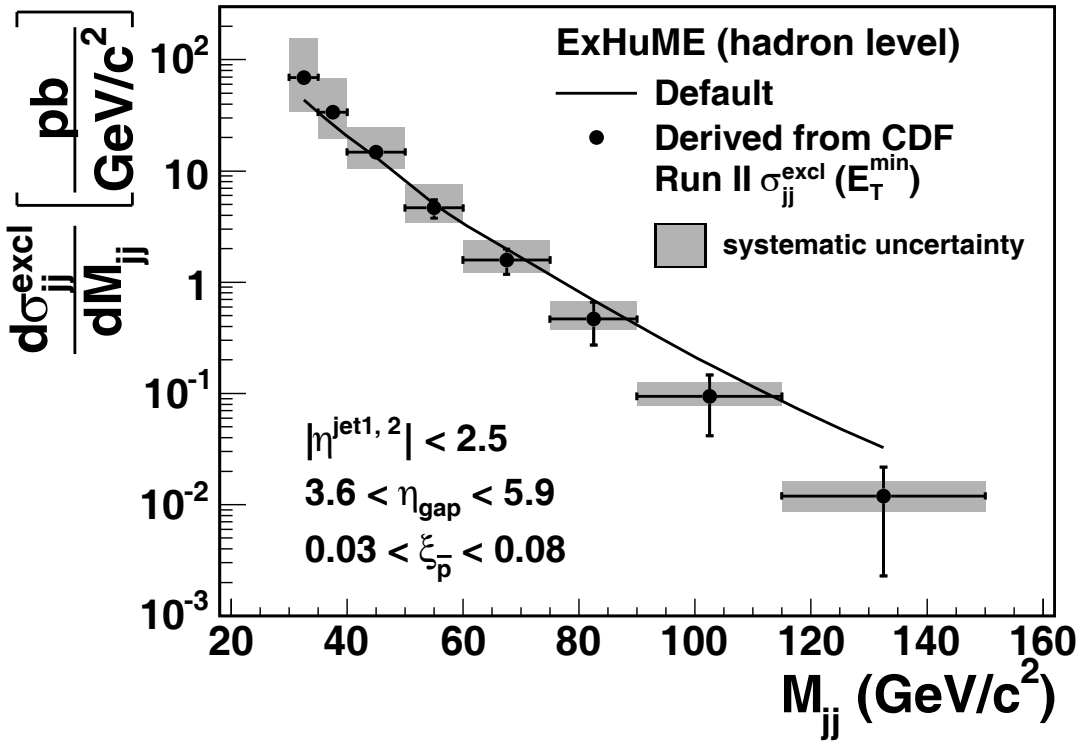
➔ good agreement observed

ExHuME vs. DPEMC and vs. data



- Measured x-sections favor ExHuME
- KMR x 1/3 agrees with data
  - ➔ Within theoretical uncertainty of +/- factor of 3
- $\sigma_{jj}^{excl}/\sigma^{incl}$ approx. independent of E_T^{min}
  - ➔ WHY?

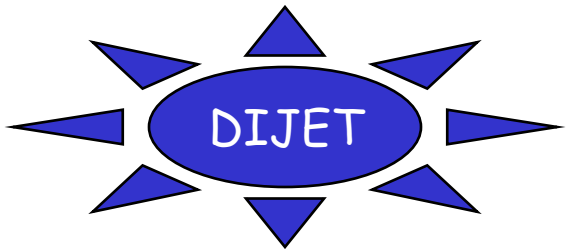
Exclusive dijet x-section vs. M_{jj}



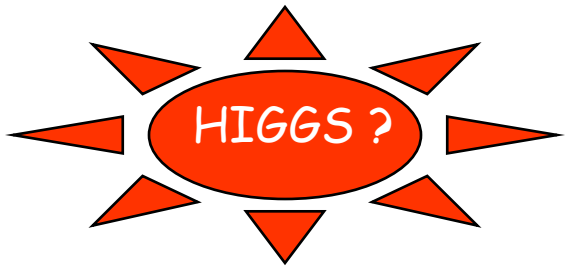
curve: ExHuME hadron-level exclusive dijet cross sections vs. dijet mass

points: derived from CDF excl. dijet x-sections using ExHuME

Stat. and syst. errors are propagated from measured cross section uncertainties using M_{jj} distribution shapes of ExHuME generated data.



SUMMARY



- Introduction
  - diffractive PDF looks like proton PDF
- Diffractive W/Z – RPS data
  - W diffractive fraction in agreement with Run I
  - W/Z diffractive fractions equal within error
  - New techniques developed to enable extracting the diffractive structure function in W production
- Exclusive dijet (Higgs?) production
  - Results favor ExHuME over DPEMC model

Phys. Rev. D **77**, 052004 (2008)