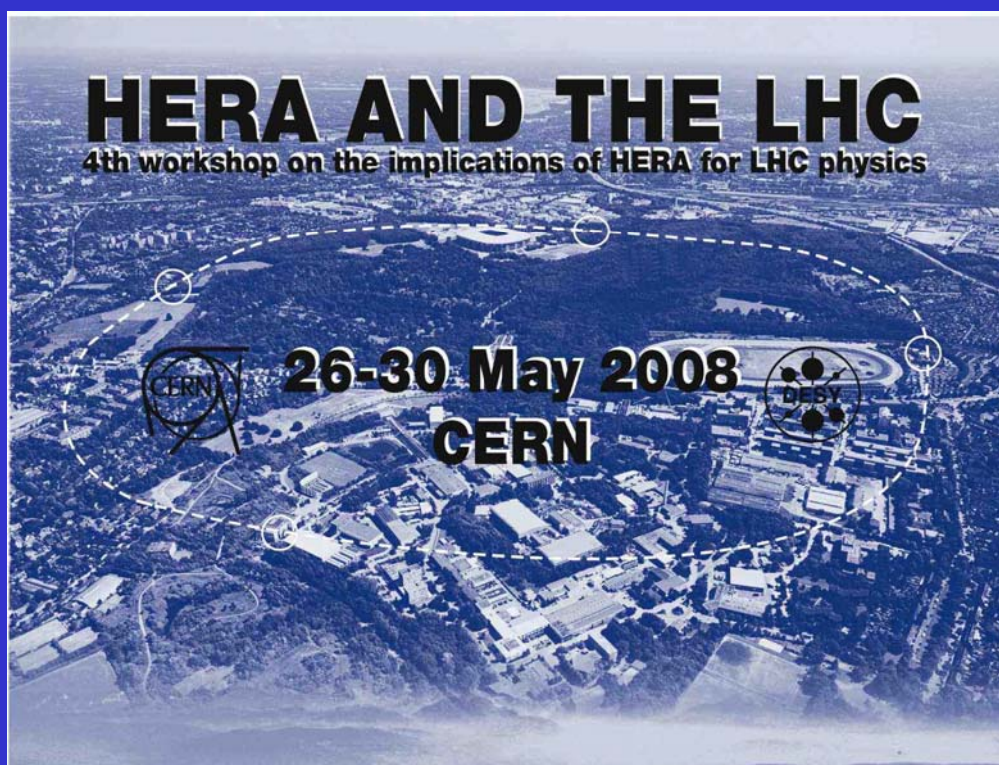


Diffractive and Exclusive Dijets and W/Z at CDF



K. Goulios
The Rockefeller University

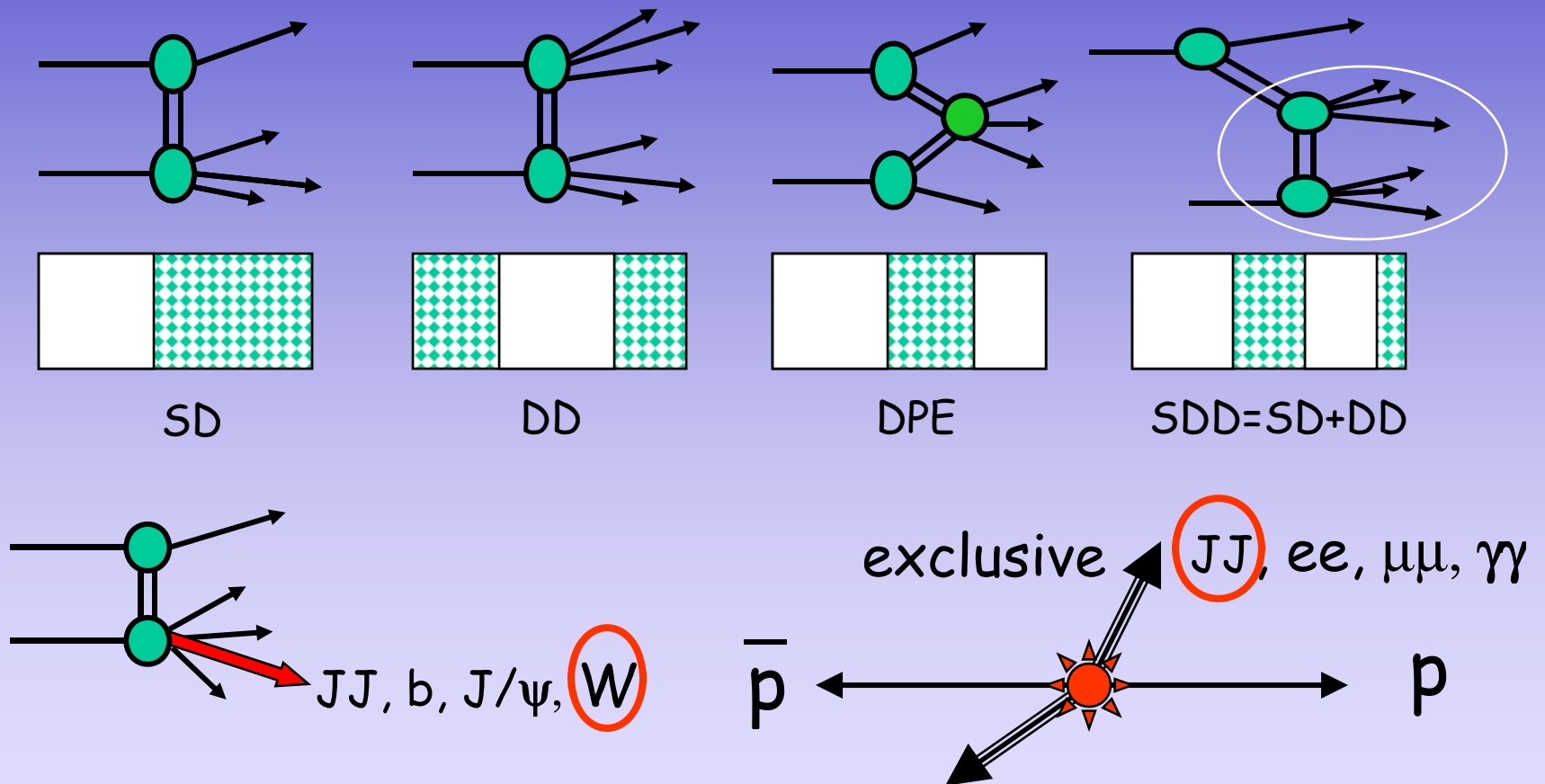


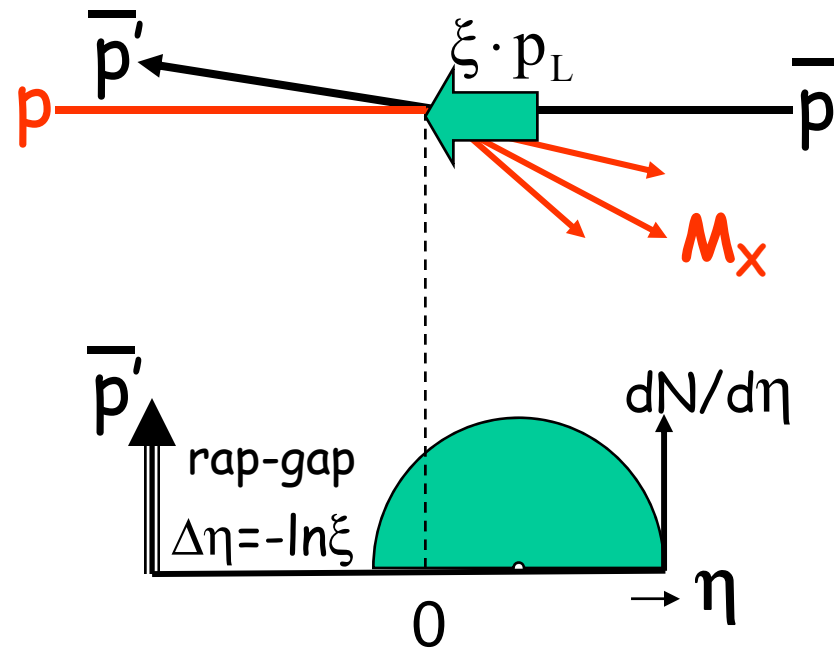
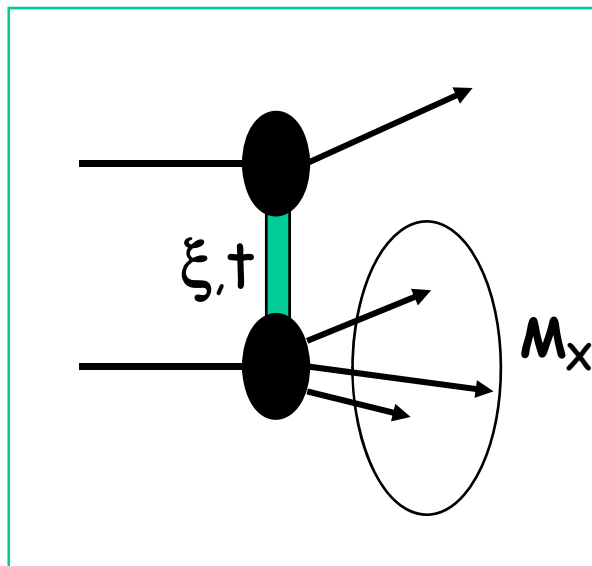
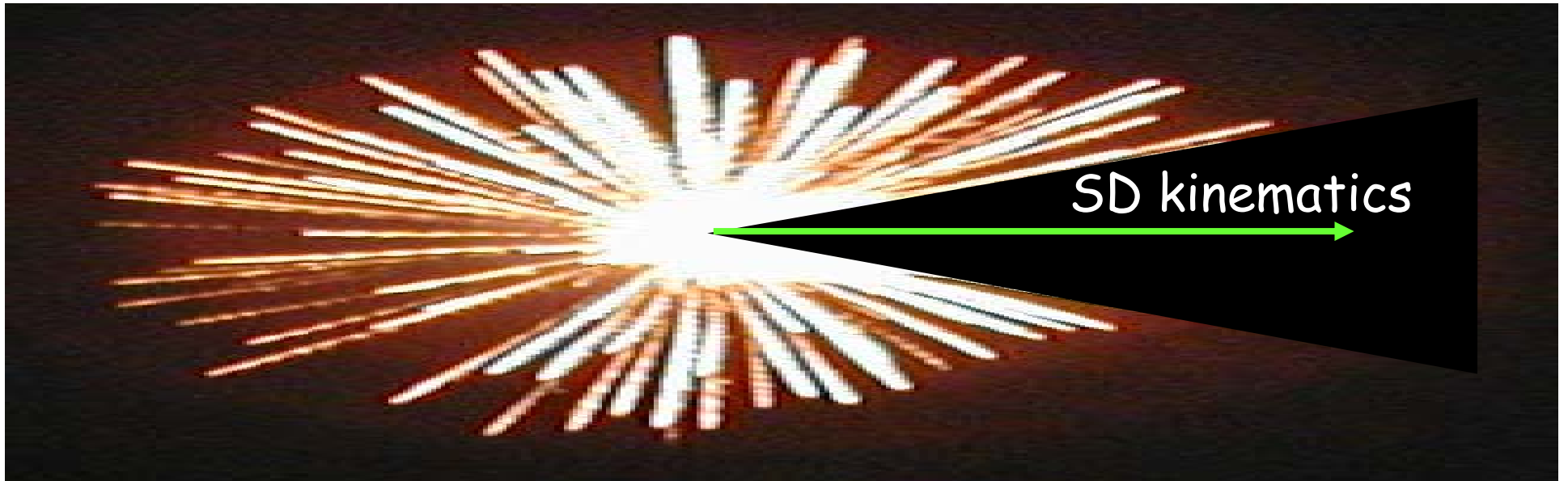
Contents

- Introduction
- Diffractive W/Z
- Exclusive JJ

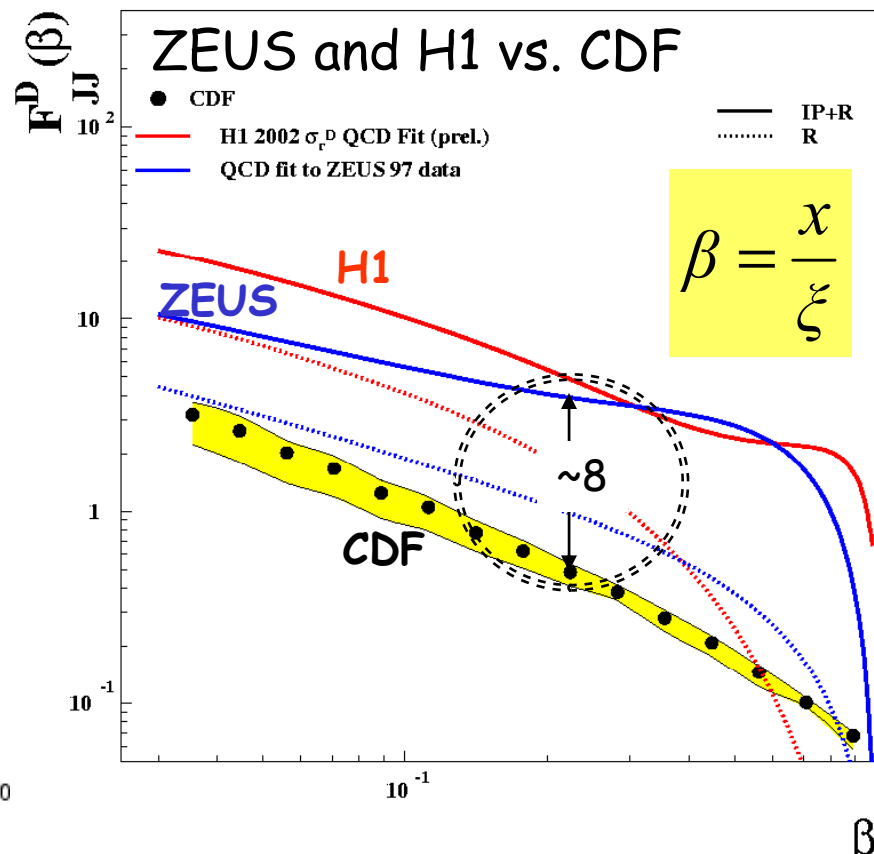
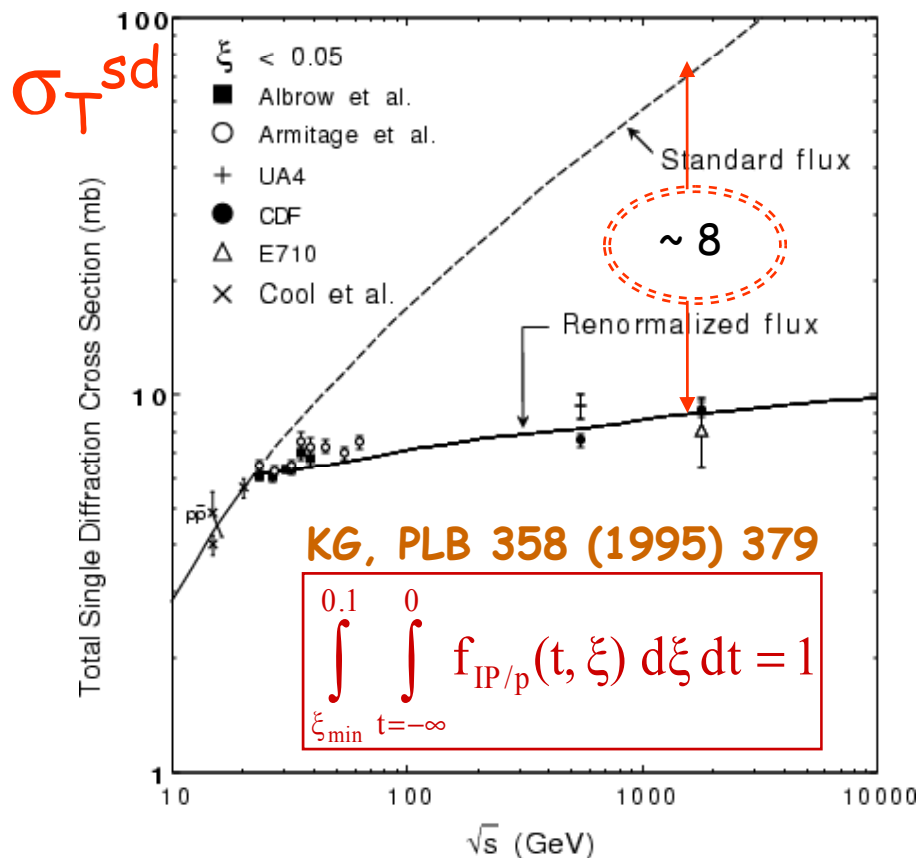
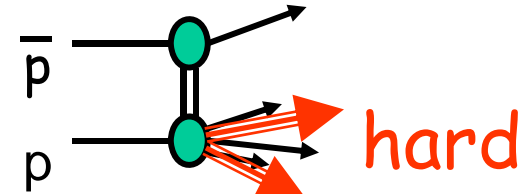
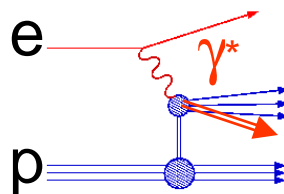
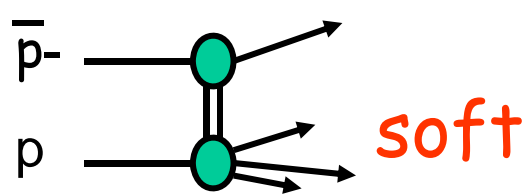
Introduction

Soft and hard diffraction @ CDF





Breakdown of factorization - Run I




Magnitude: same suppression factor in soft and hard diffraction!

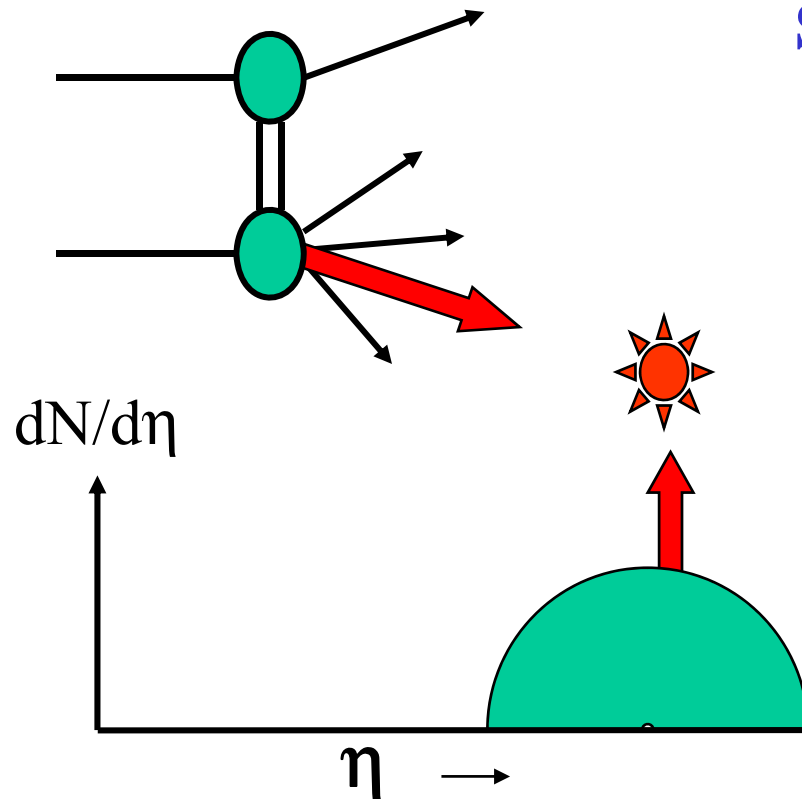
Shape of β distribution: ZEUS, H1, and Tevatron - why different shapes?

Hard diffractive fractions - Run I

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

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

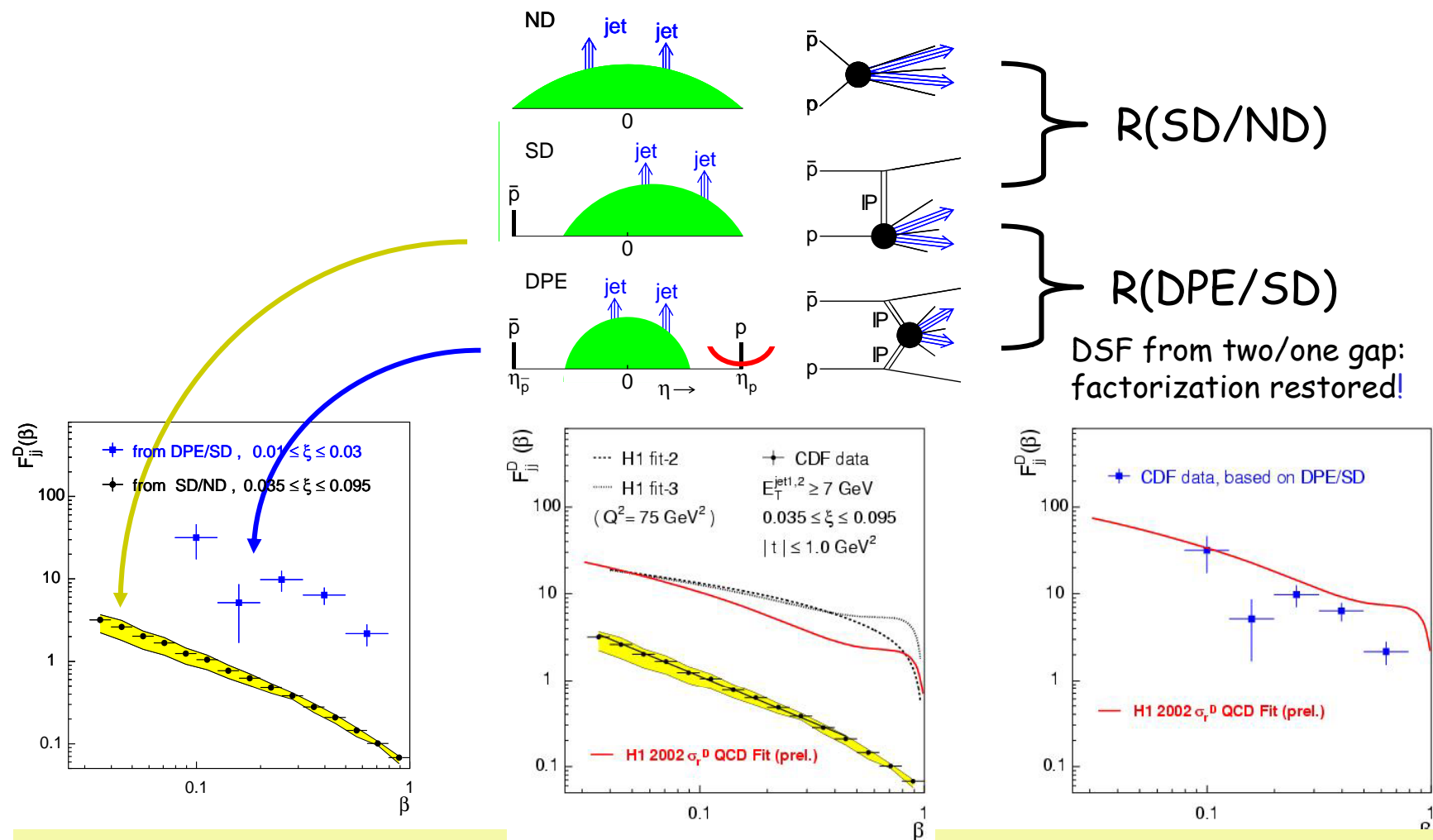


All fractions ~ 1%
(differences due to kinematics)

- ~ uniform suppression
- ~ **FACTORIZATION !**

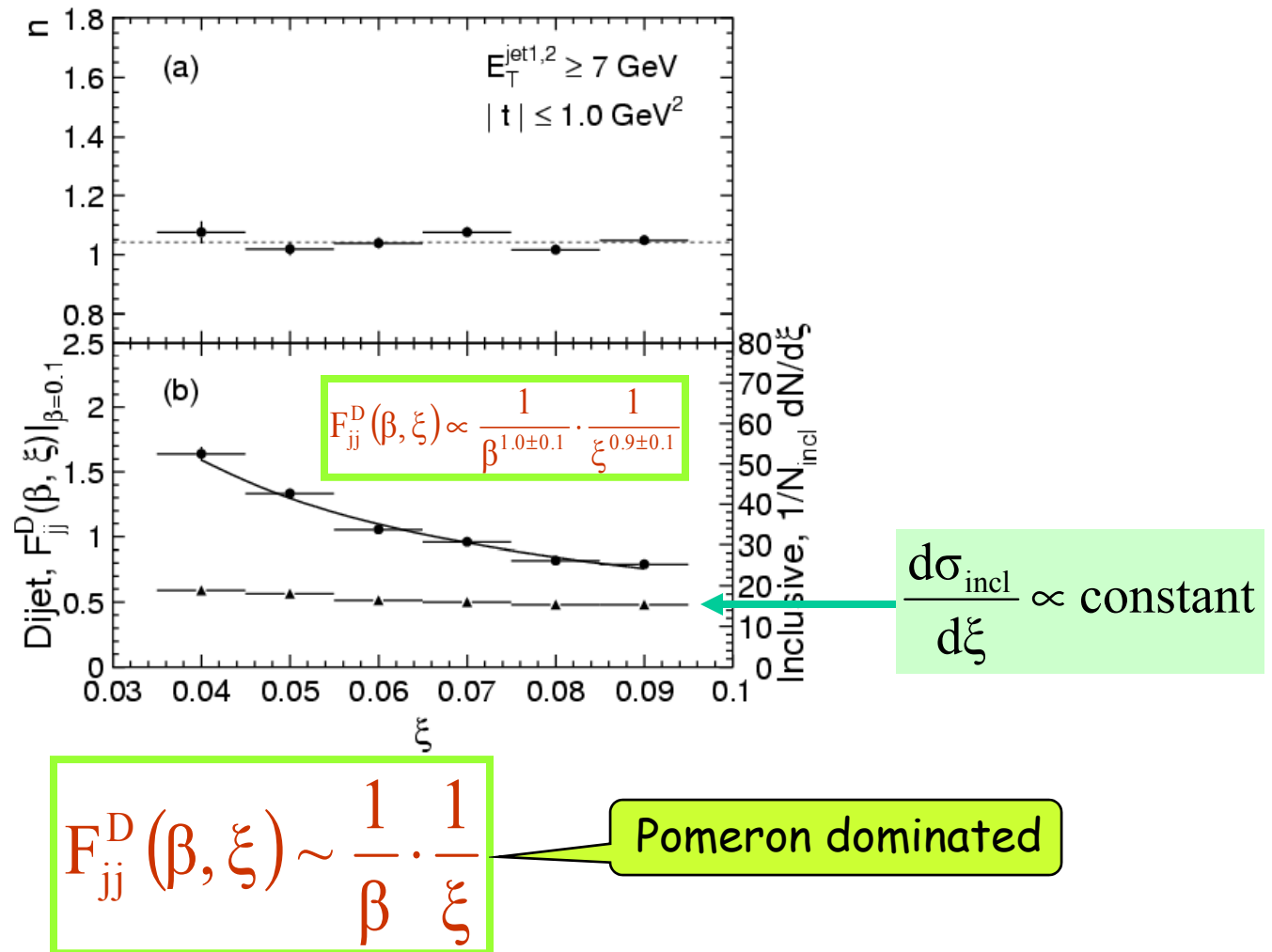
Multi-gap diffraction - Run I

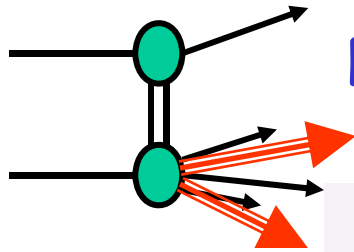
→ restoring factorization



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

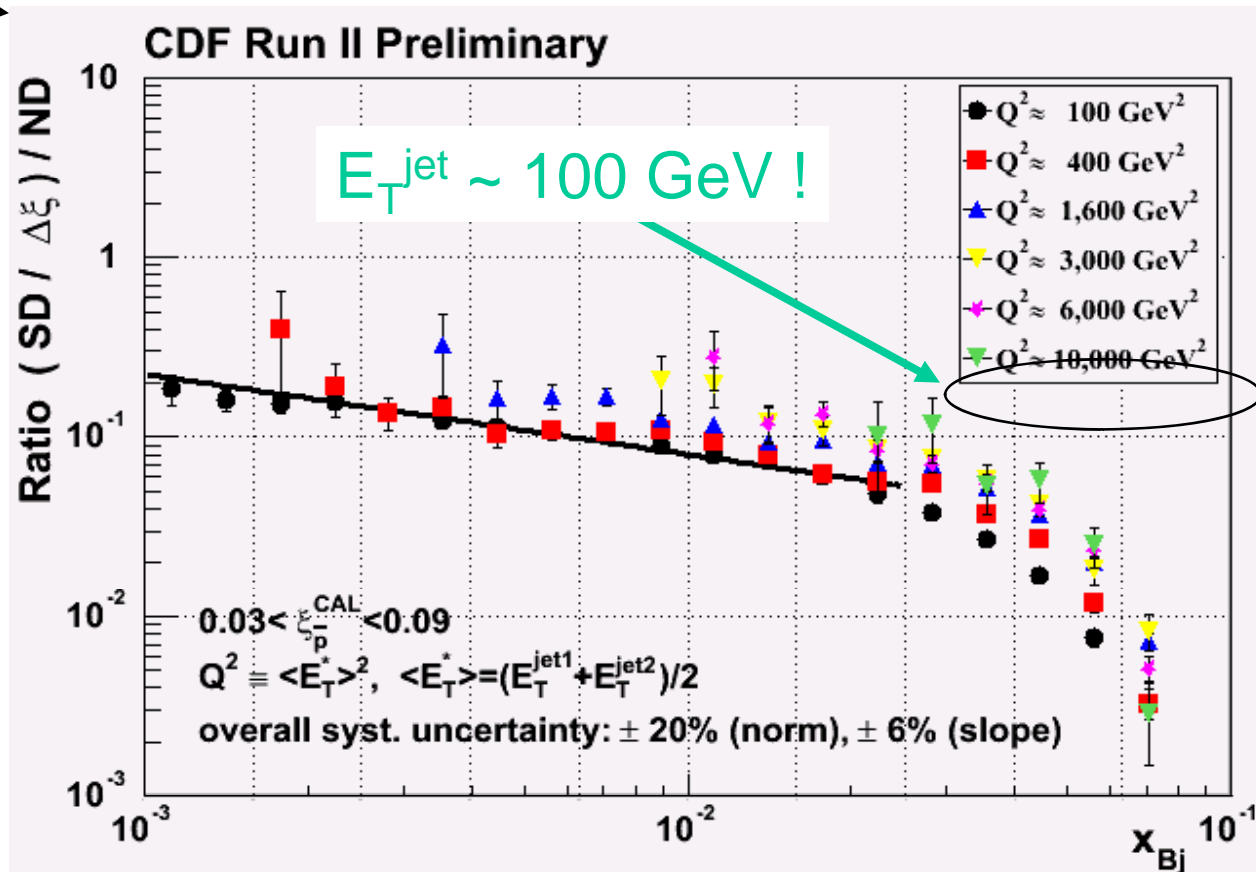
ξ & β dependence of F_{jj}^D - Run I



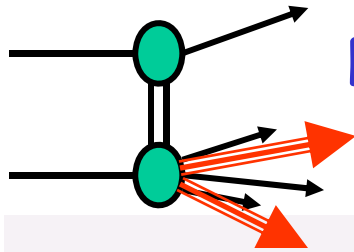


Diffractive structure function - Run II

Q^2 - dependence

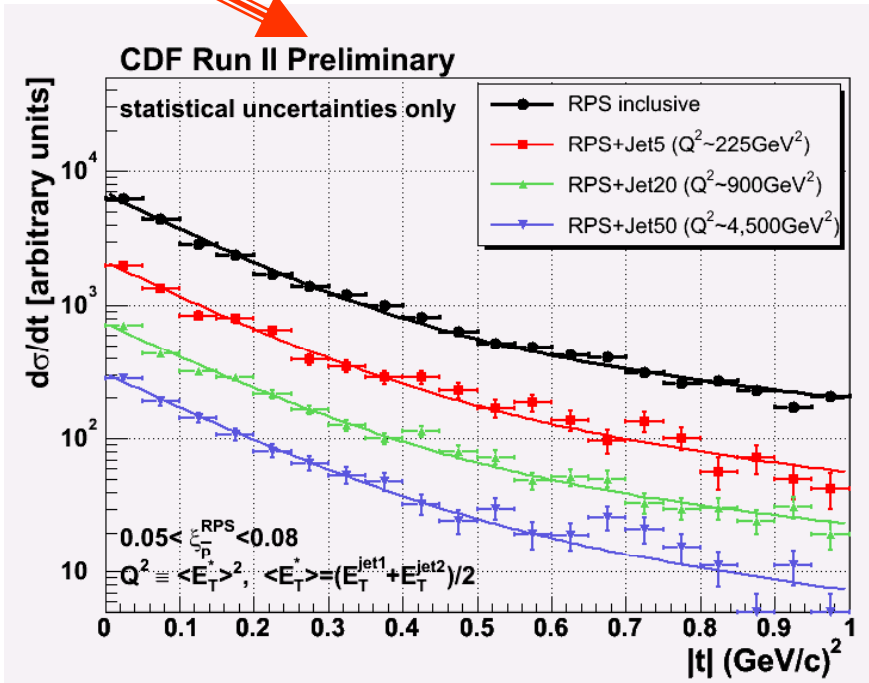


- Small Q^2 dependence in region $100 < Q^2 < 10,000 \text{ GeV}^2$ where each $d\sigma^{\text{ND}}/dE_T$ vary by a factor of $\sim 10^4$
- ➔ The Pomeron evolves as the proton !



Diffractive structure function - Run II

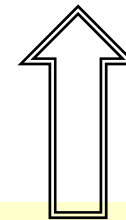
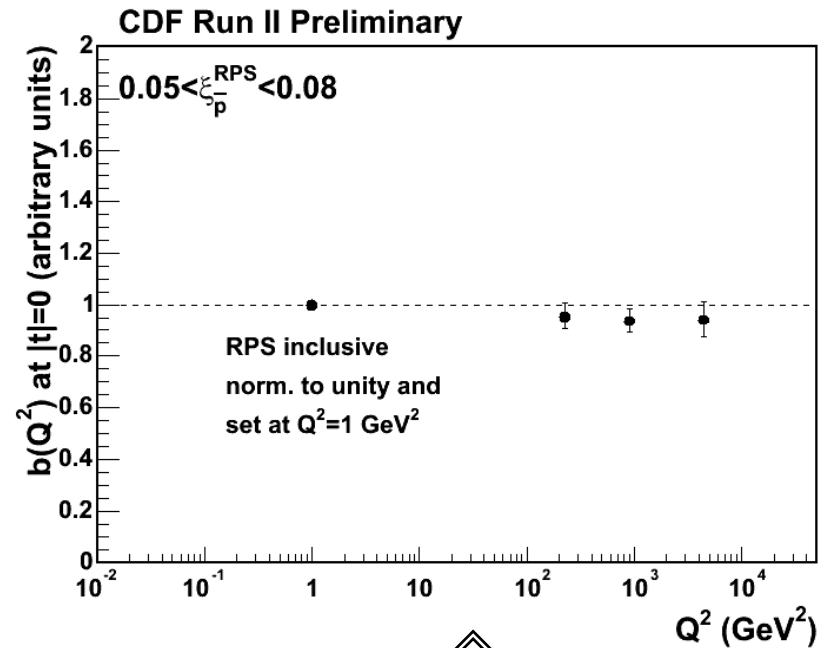
t - dependence



Fit $d\sigma/dt$ 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 Q^2 dependence in slope from inclusive to $Q^2 \sim 10^4 \text{ GeV}^2$

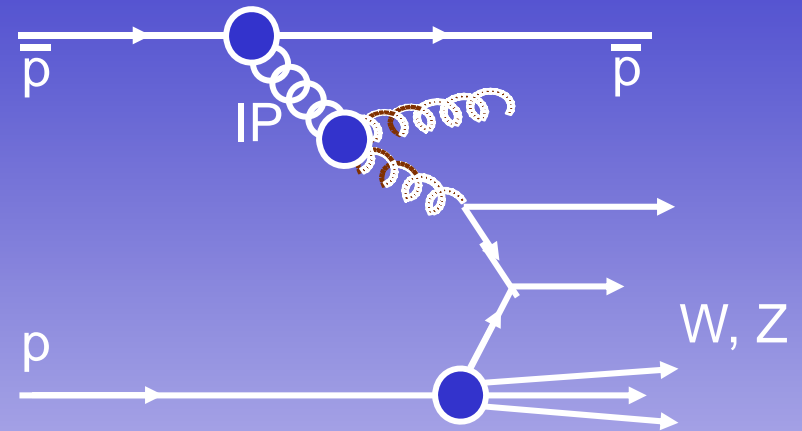
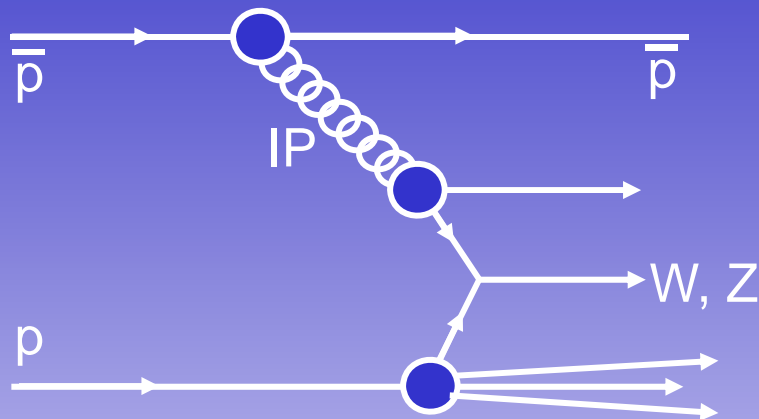


- Same slope over entire region of $0 < Q^2 < \sim 10\,000 \text{ GeV}^2$ across soft and hard diffraction!

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

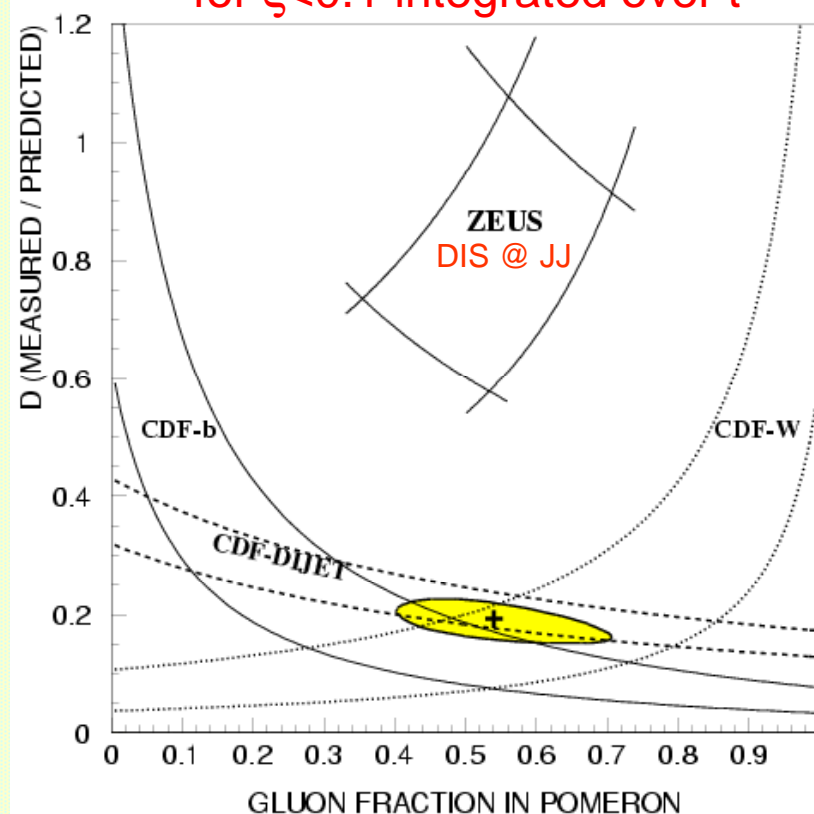
Diffractive W/Z - motivation

- **In Run I**, by combining diffractive dijet production with diffractive W production we determined 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

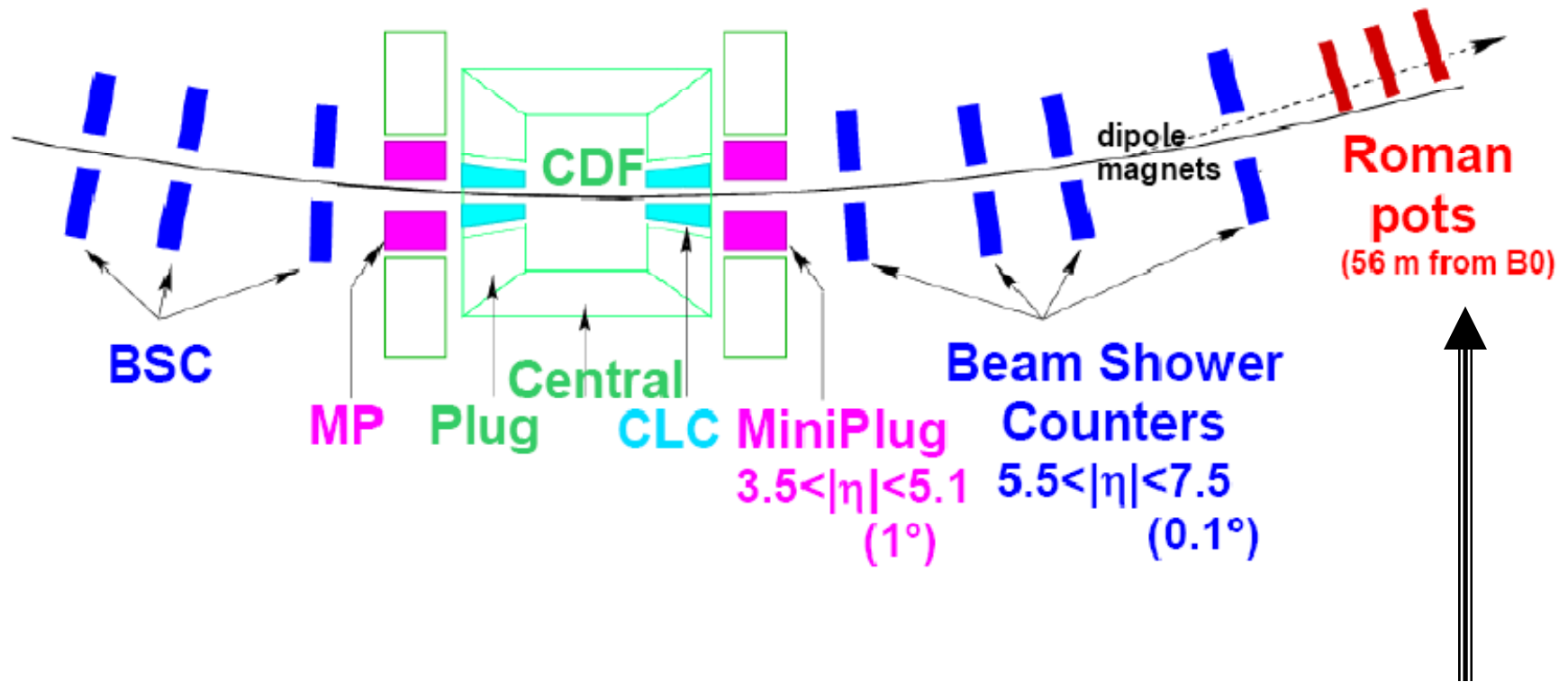
Phys Rev Lett **78**, 2698 (1997)

Fraction of W events due to SD

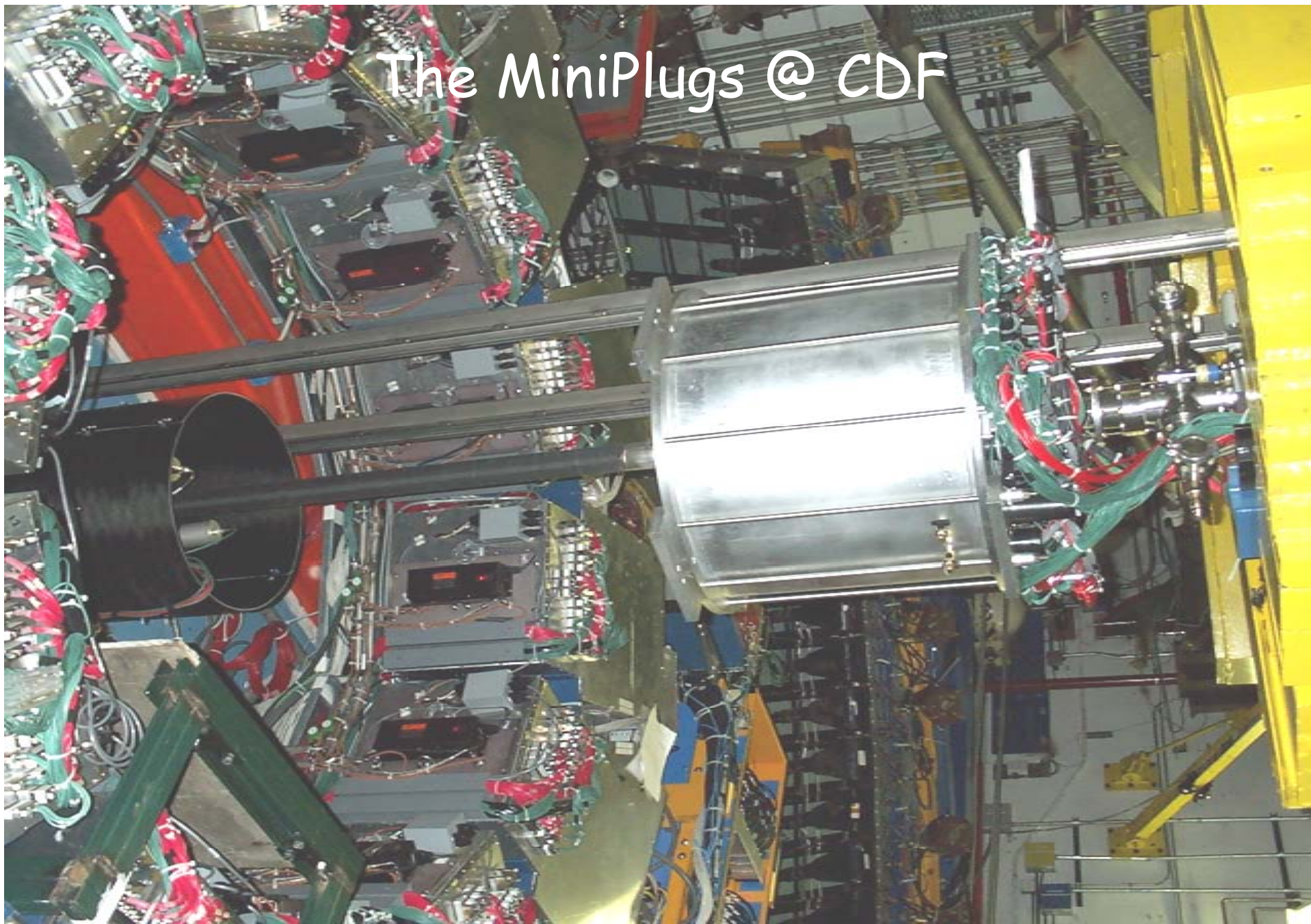
$R^W = [1.15 \pm 0.51(\text{stat}) \pm 0.20(\text{syst})] \%$
for $\xi < 0.1$ integrated over t



The DF II detectors



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



Diffractive W/Z analysis

Using RPS information:

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

$$\xi^{\text{RPS}} - \xi^{\text{cal}} = \frac{E_T}{\sqrt{s}} e^{-\eta_v}$$

where

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

This allows the determination of:

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

W/Z selection requirements

Standard W/Z selection

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

$$M_T > 25 \text{ GeV}$$

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

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

$$E_T^{e1}(p_T^{\mu1} > 25 \text{ GeV})$$

$$E_T^{e2}(p_T^{\mu2} > 25 \text{ GeV})$$

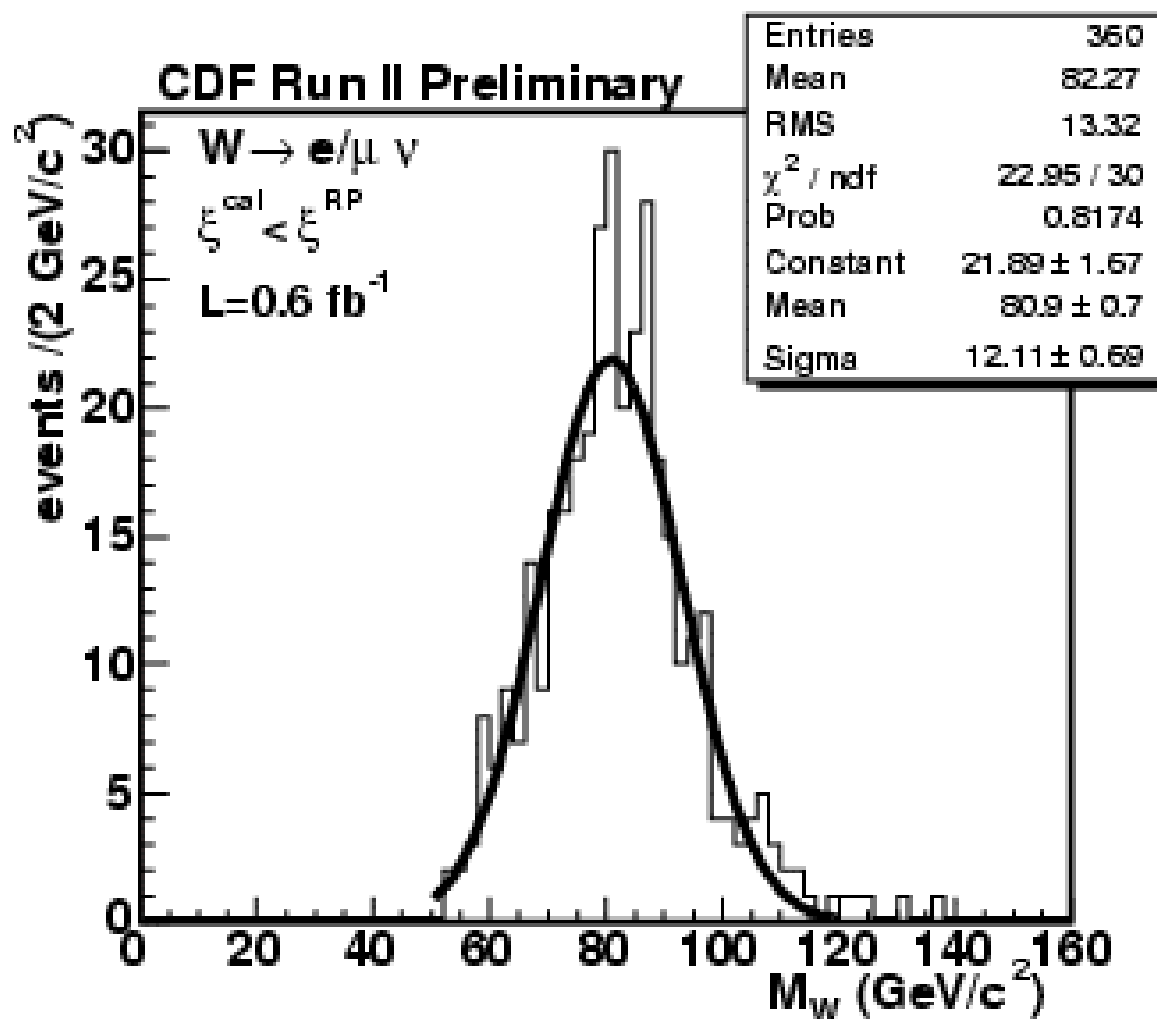
$$66 < M^Z < 116 \text{ GeV}$$

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

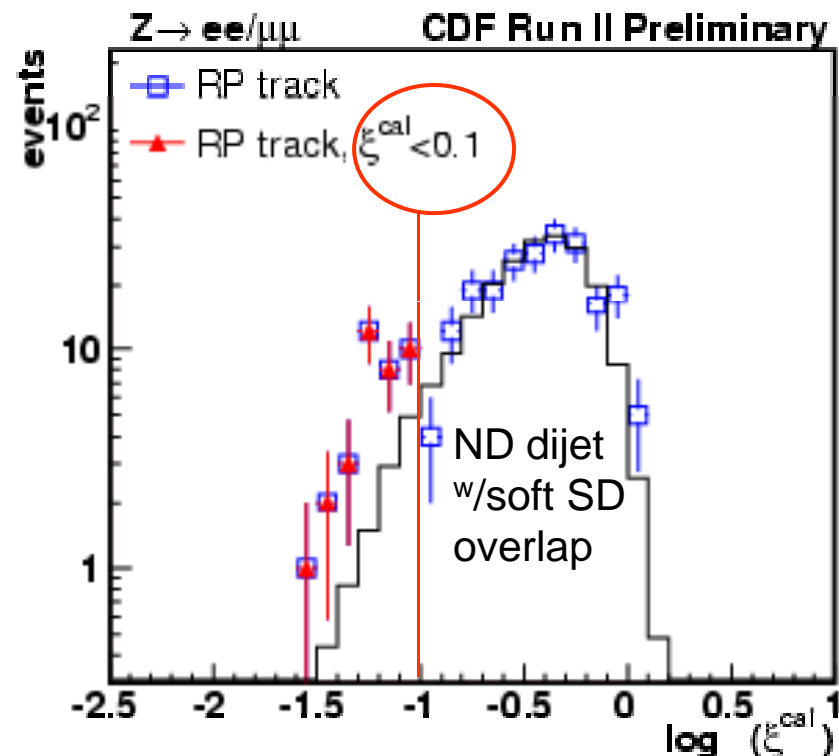
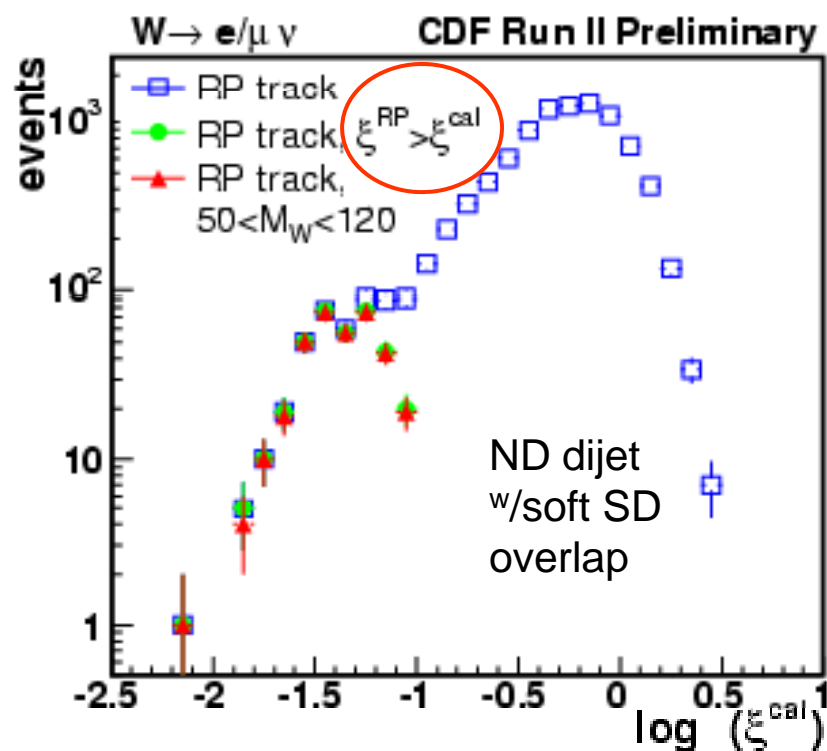
Diffractive W/Z selection

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

Reconstructed diffractive W mass



Rejection of multiple interaction events



Diffractional W/Z results

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

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

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

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

CDF PRL 78, 2698 (1997)

$$R^W = [1.15 \pm 0.51(\text{stat}) \pm 0.20(\text{syst})]\%$$

ap acceptance $A^{\text{gap}} = 0.81$

uncorrected for $A^{\text{gap}} \rightarrow$

$$R^W = (0.93 \pm 0.44)\%$$

(A^{gap} calculated from MC)

DØ Phys Lett B **574**, 169 (2003)

$$R^W = [5.1 \pm 0.51(\text{stat}) \pm 0.20(\text{syst})]\%$$

gap acceptance $A^{\text{gap}} = (0.21 \pm 4)\%$

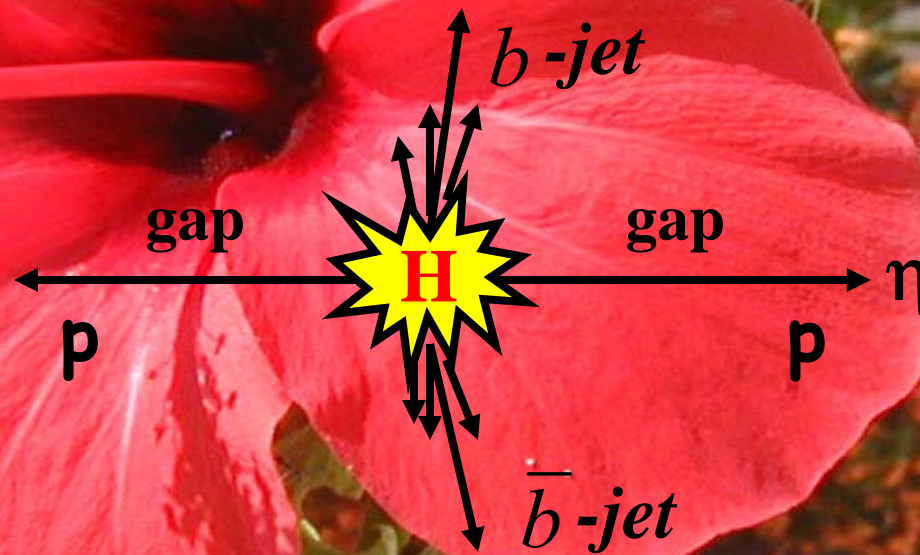
uncorrected for $A^{\text{gap}} \rightarrow$

$$R^W = [0.89 + 0.19 - 0.17]\%$$

$$R^Z = [1.44 + 0.61 - 0.52]\%$$

Stay connected for results on $F^D_{W/Z}$

EXCLUSIVE JJ & HIGGS BOSONS



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

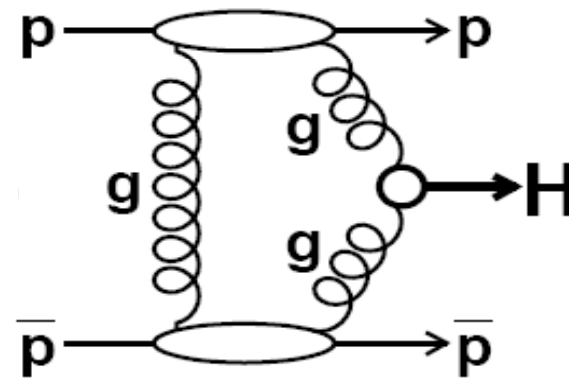
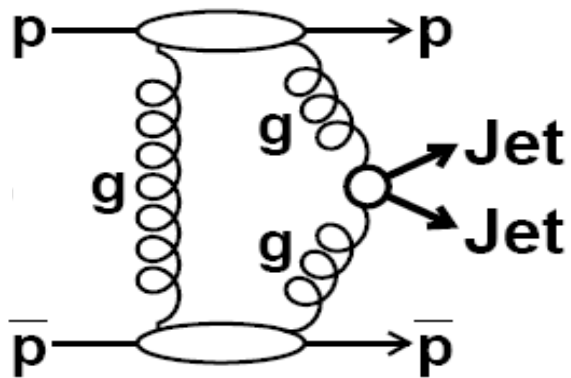
$$\Rightarrow \Delta M \sim (1-2) \text{ GeV}$$

Determine spin of H

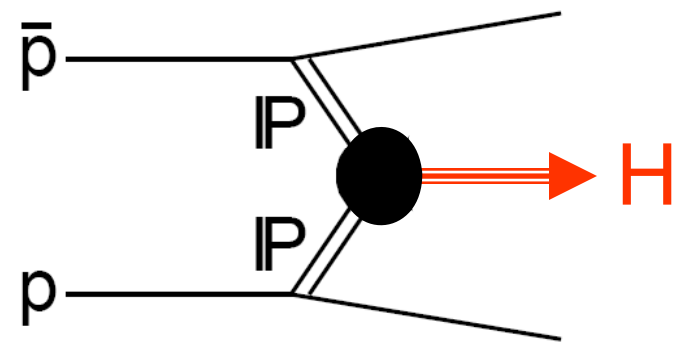
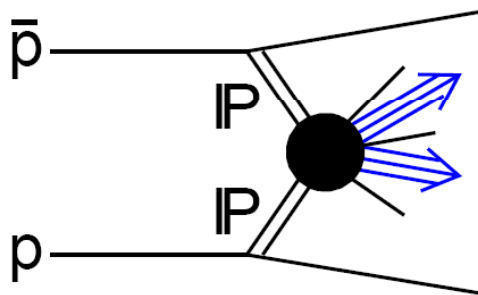
Exclusive dijet and Higg production

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

ExHuME

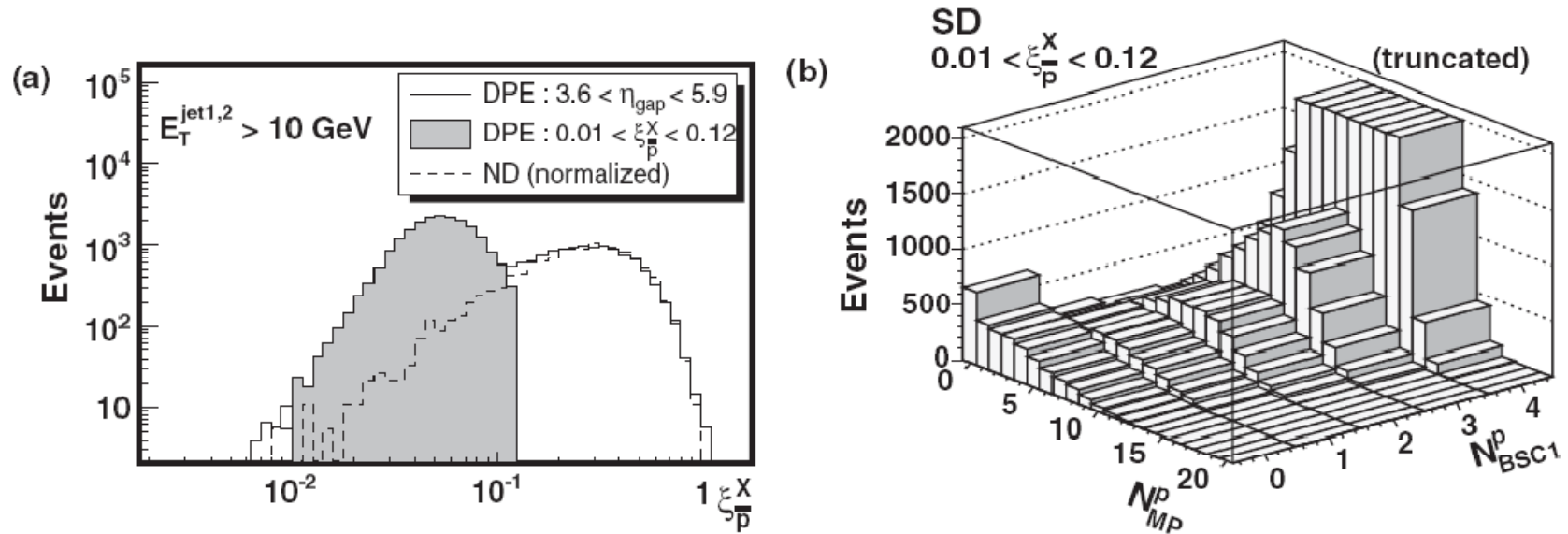


DPEMC

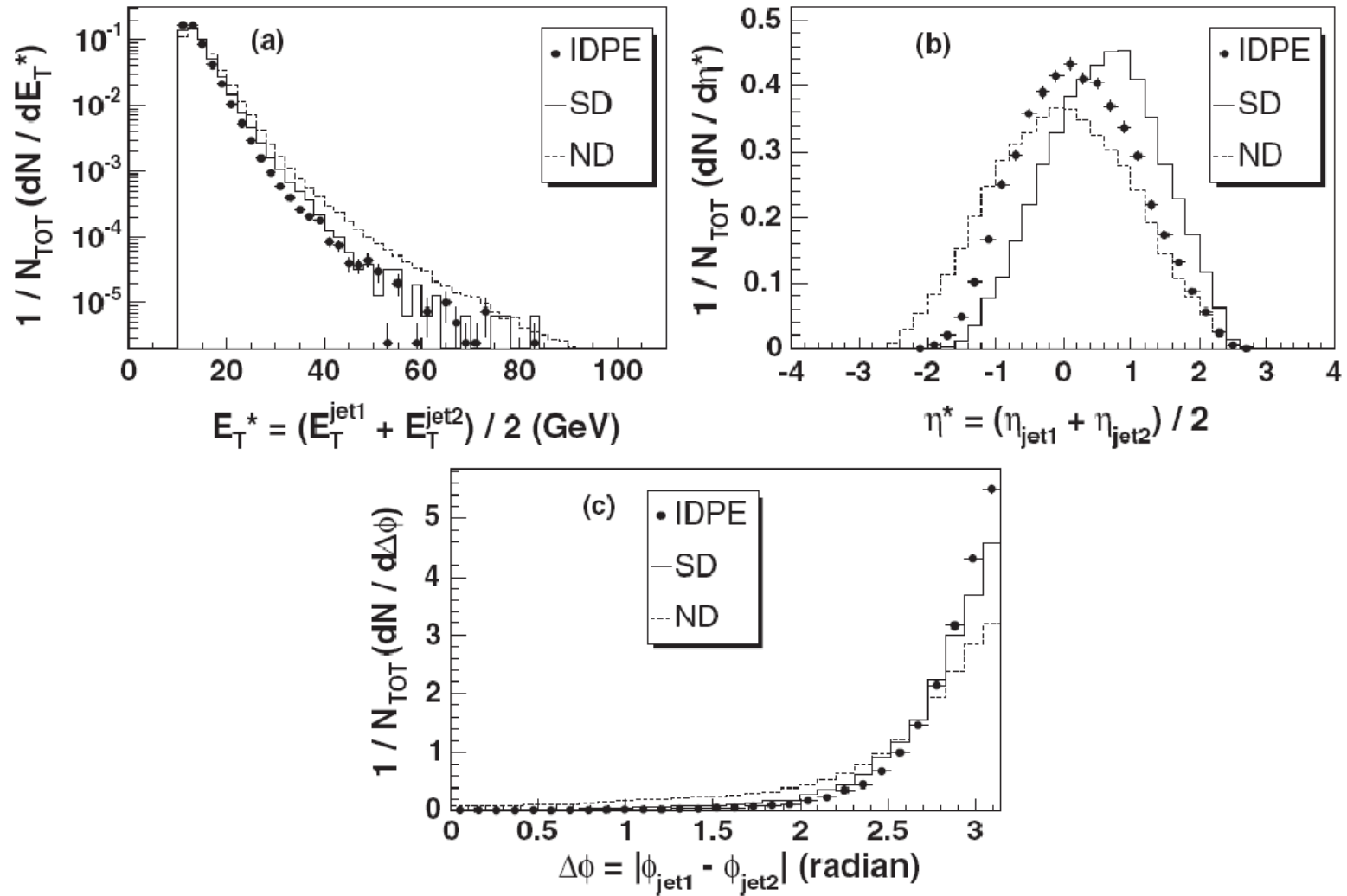


The DPE data sample

$$\xi_{\text{pbar}}^{\text{CAL}} = \sum_{\text{towers}} \frac{E_T}{\sqrt{s}} e^{-\eta}$$

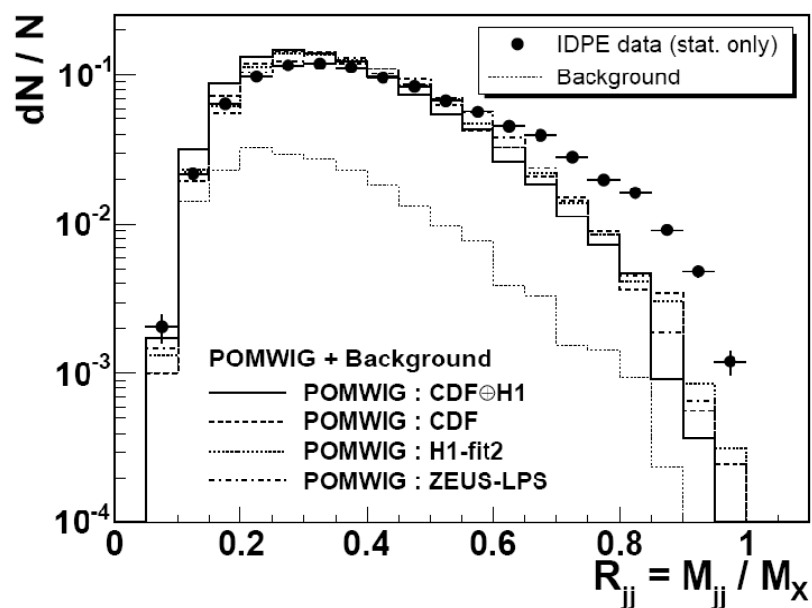


Kinematic distributions



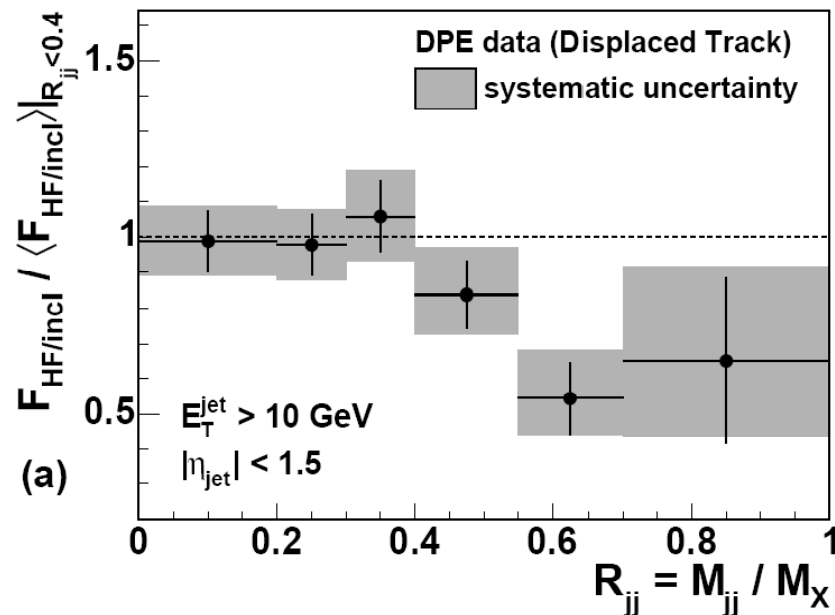
Exclusive dijet signal

dijet mass fraction - all jets



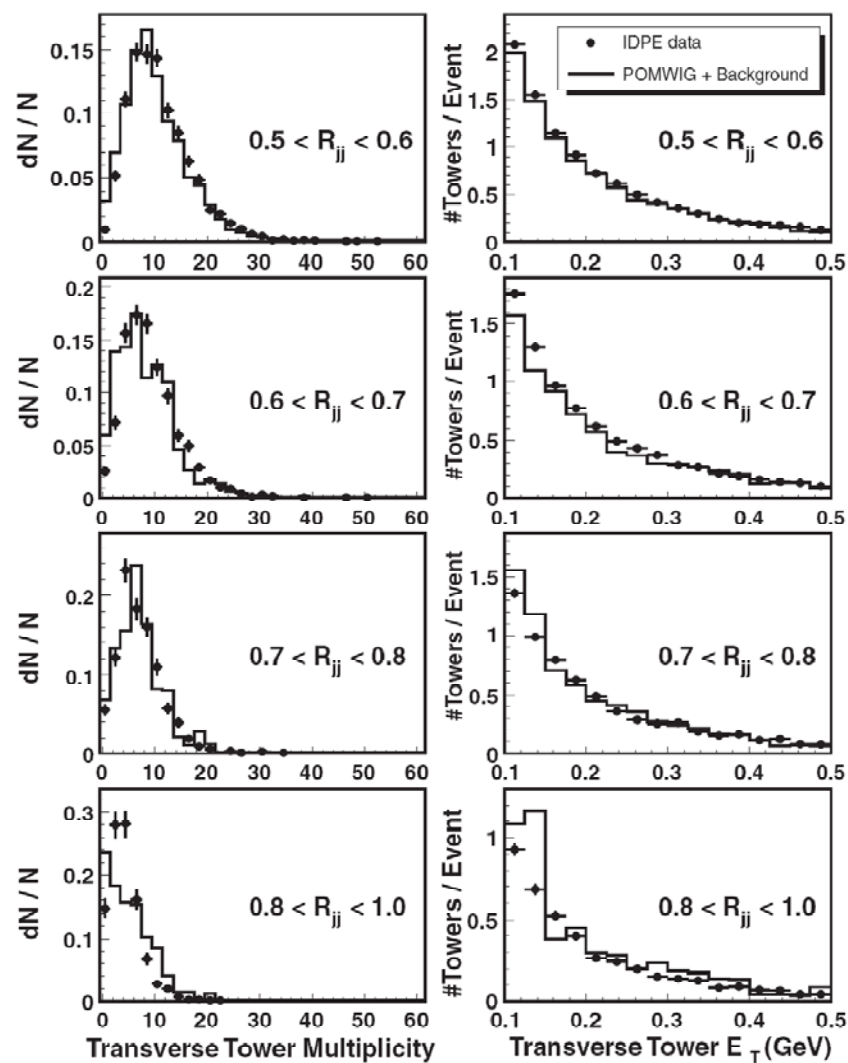
Excess observed over POMWIG
MC prediction at large R_{jj}

b-jet dijet mass fraction

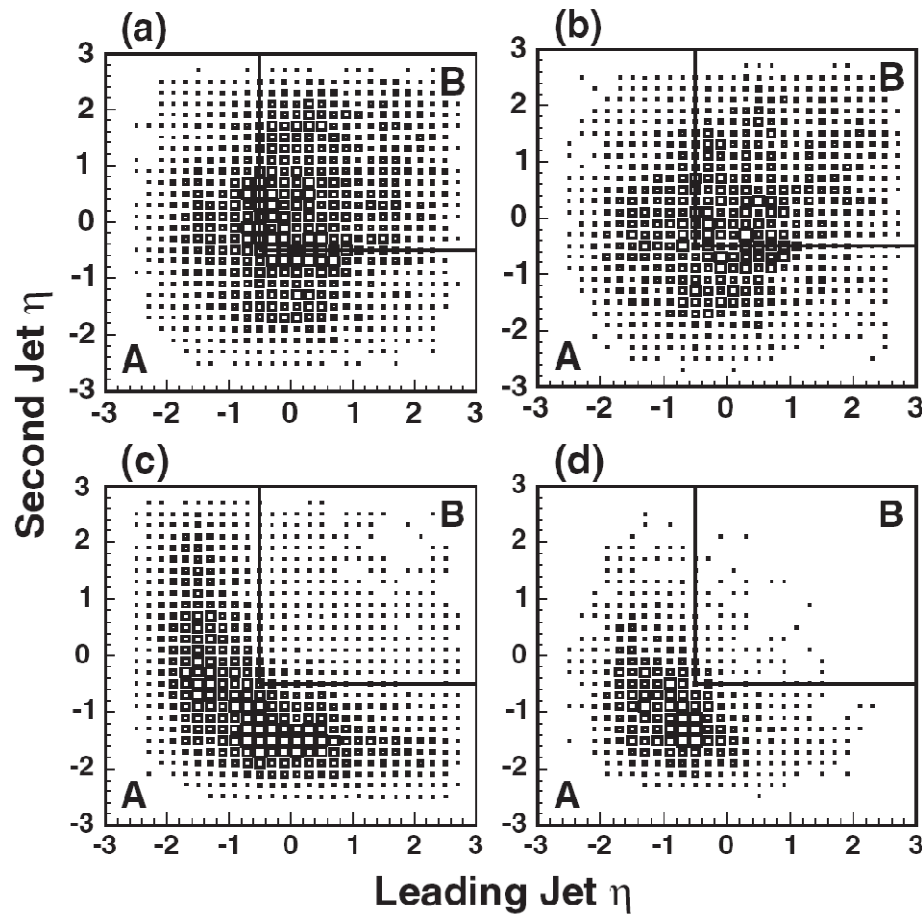


Exclusive b-jets are suppressed
as expected ($J_Z = 0$ selection rule)

Underlying event



Jet1 vs. Jet2: signal and background regions

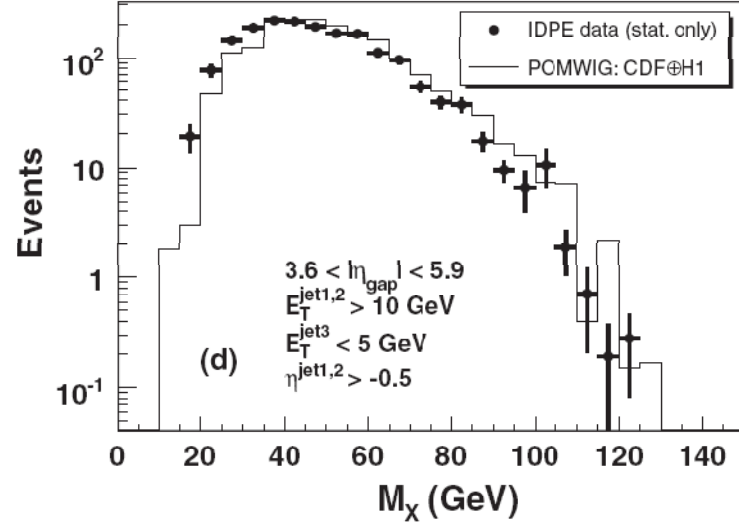
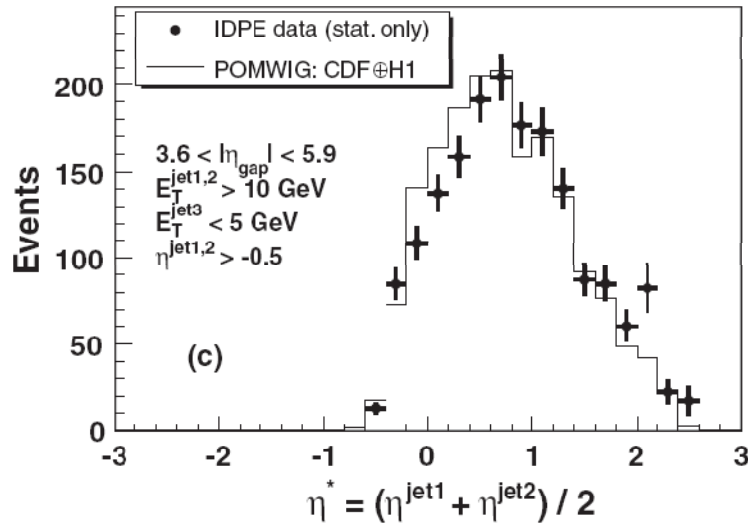
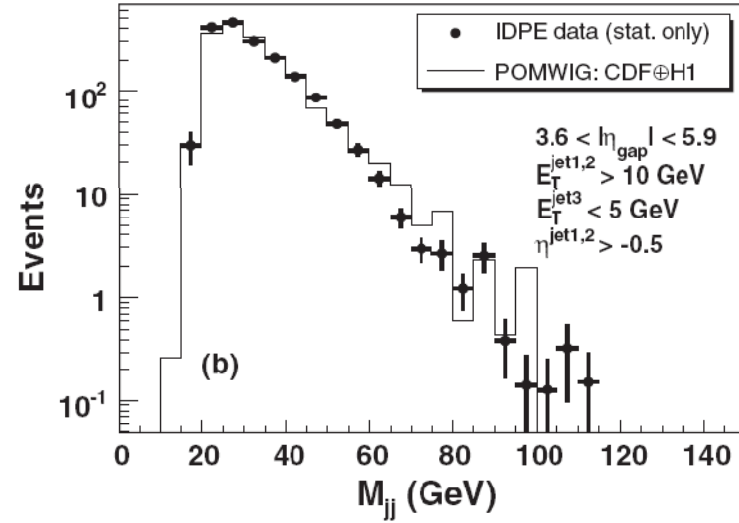
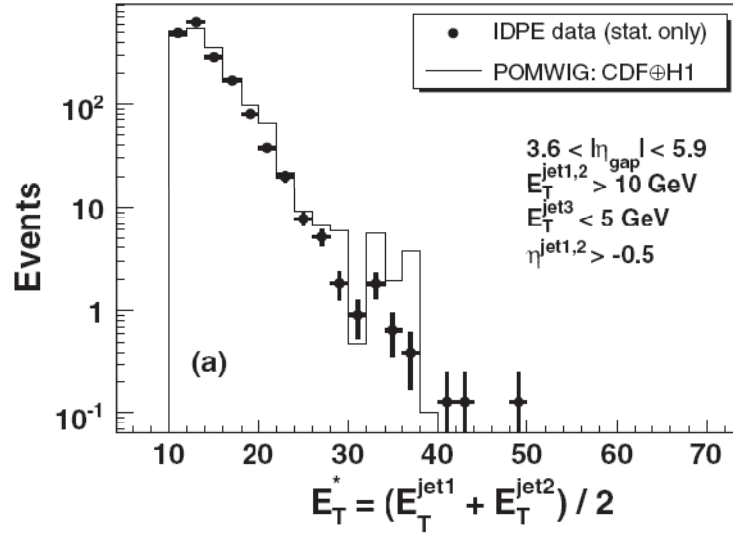


DATA

A: signal region
B: background region

POMWIG

Background region

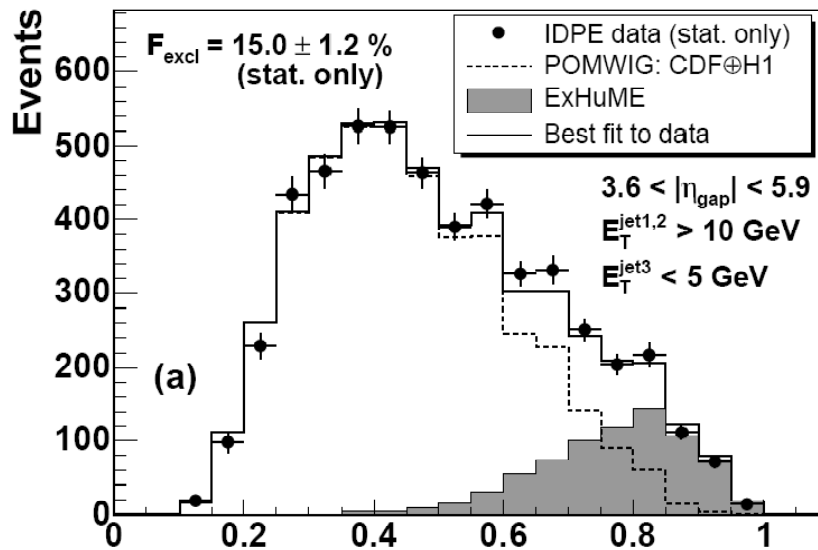


Inclusive DPE ^W/LRG-p data vs. MC

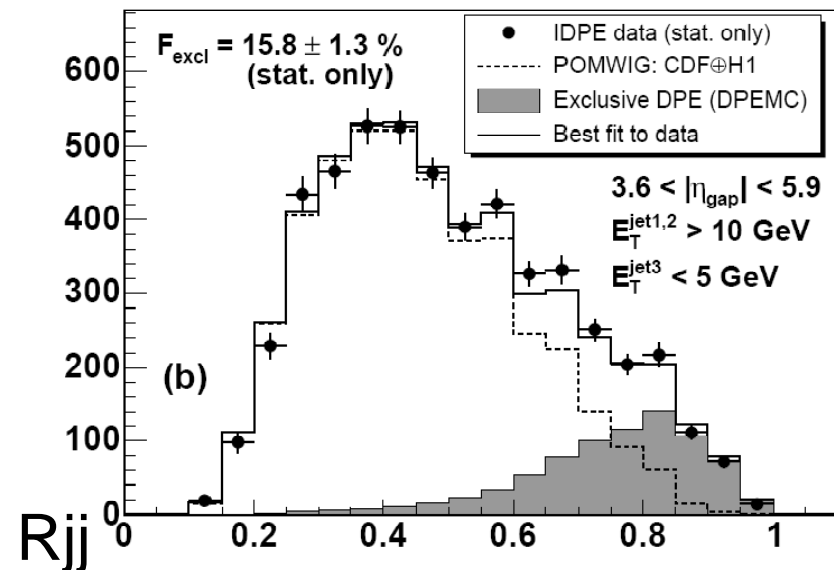
ExHuME

←exclusive MC models→

DPEMC



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

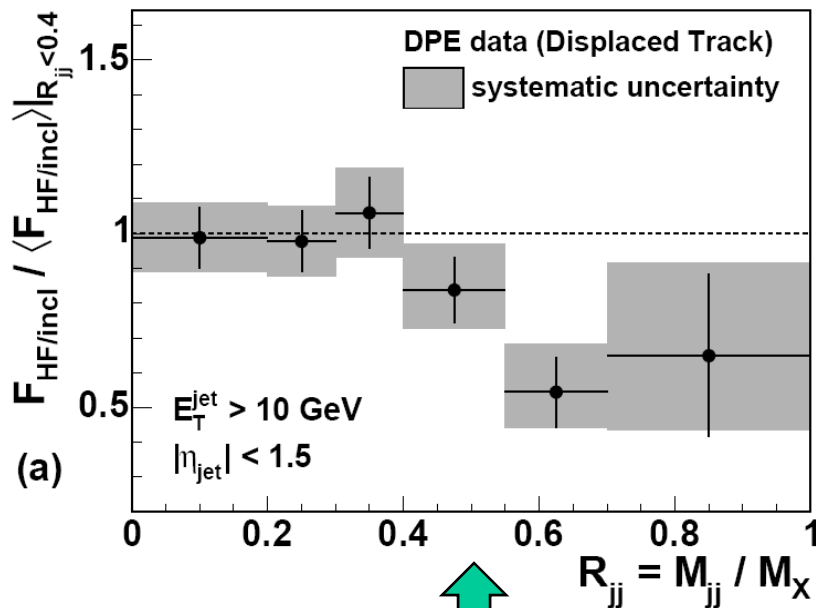


DPEMC: exclusive DPE MC
 based on Regge theory

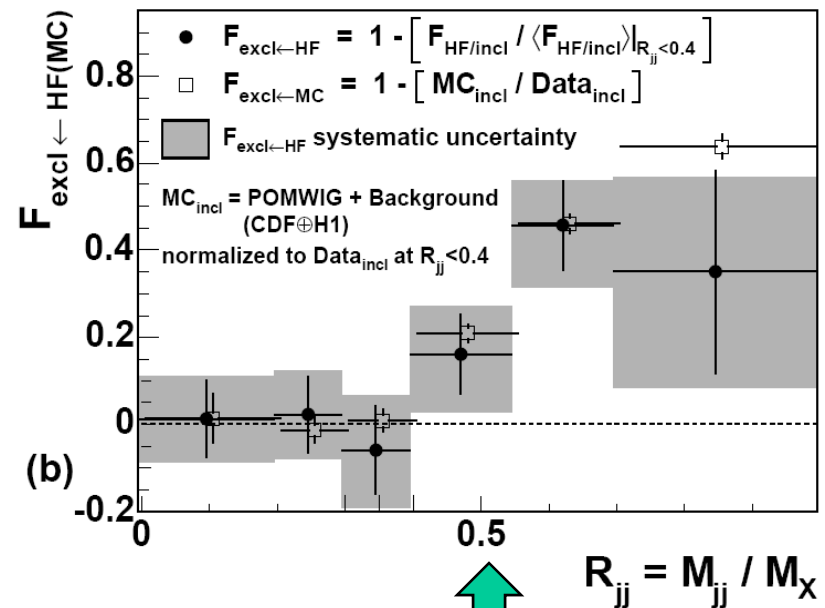
Shape of excess of events at high R_{jj}
 is well described by both ExHuME & DPEMC

HF suppression vs. inclusive signal

HF suppression

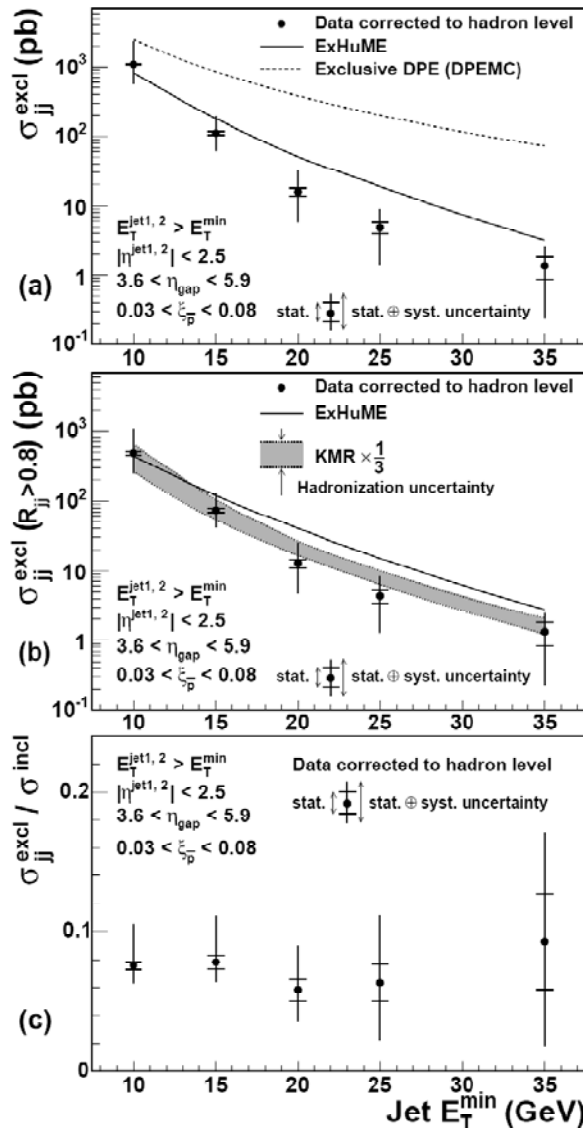


HF vs. incl



Invert HF vertically and compare with 1-MC/DATA
 → good agreement observed

ExHuME vs. DPEMC and vs. data

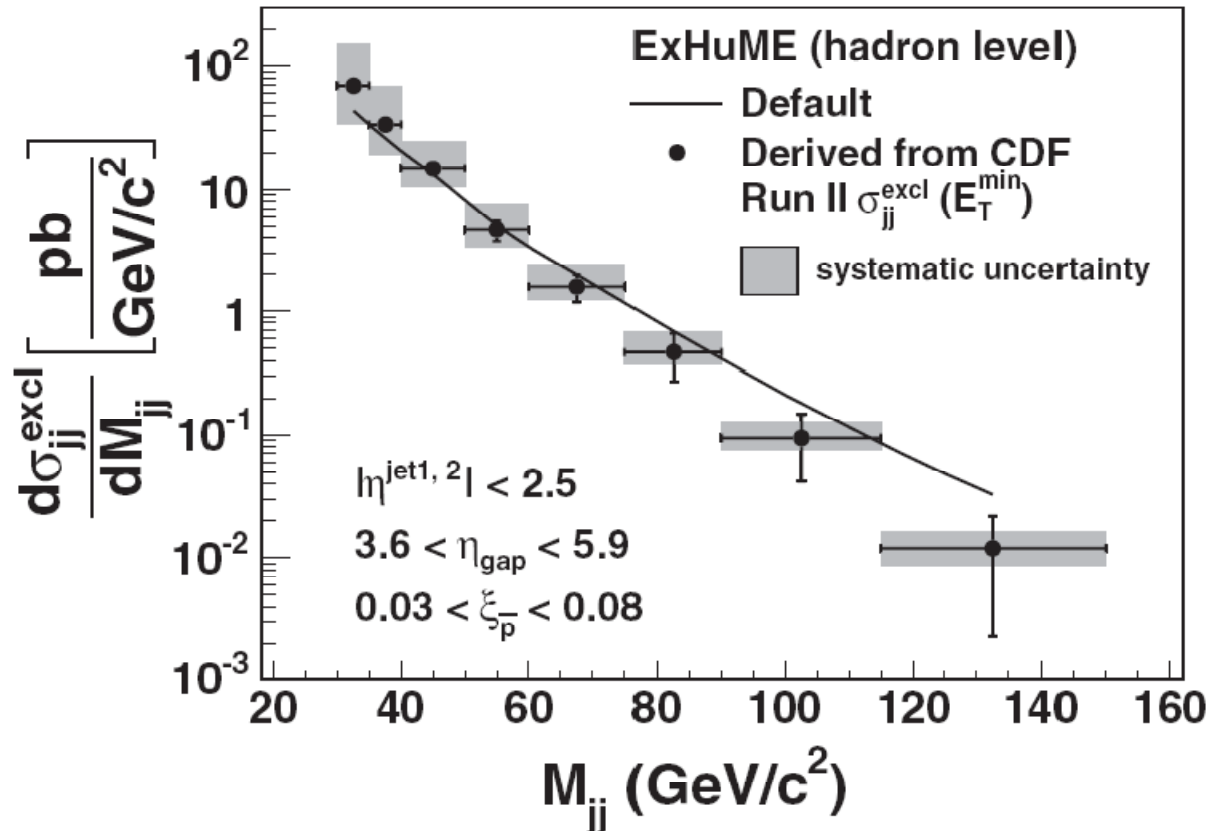


Measured x-sections favor ExHuME

KMR $\times 1/3$ agrees with data
 → Within theoretical uncertainty of +/- factor of 3

$\sigma_{jj}^{excl} / \sigma_{jj}^{incl}$ approx. independent of E_T^{min}
 → WHY?

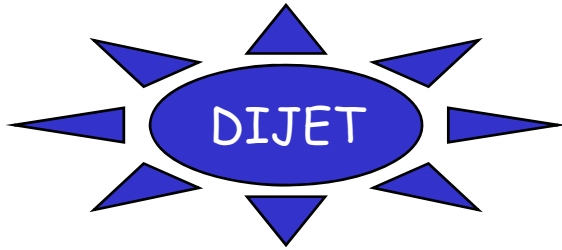
Exclusive dijet x-section vs. M_{jj}



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

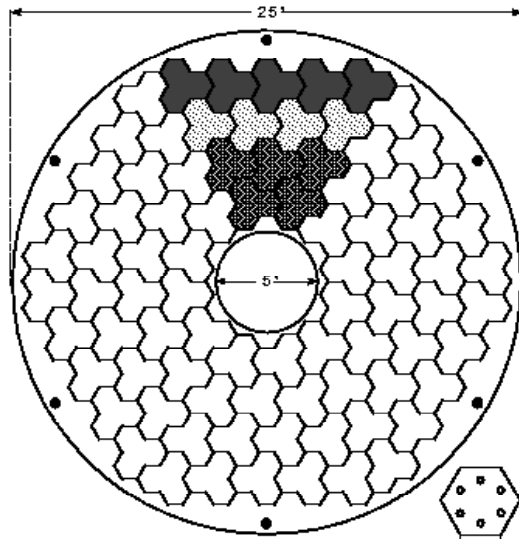
- Results favor ExHuME over DPEMC
Phys. Rev. D **77**, 052004 (2008)

BACKUP

Measurements w/the MiniPlugs
Dynamic Alignment of RPS Detectors
 E_{jet}^T Calibration



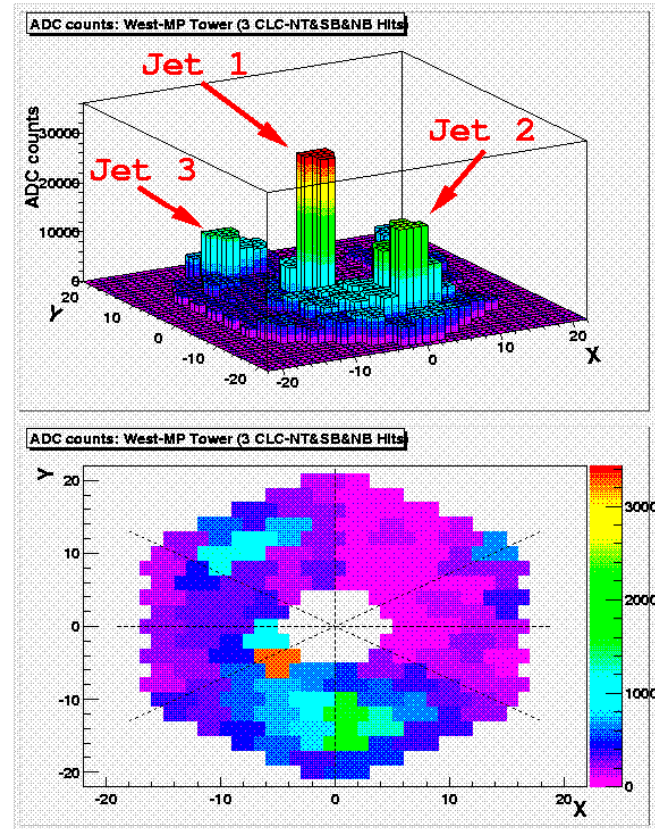
Measurements ^{w/} the MiniPlugs



← MP TOWER
STRUCTURE

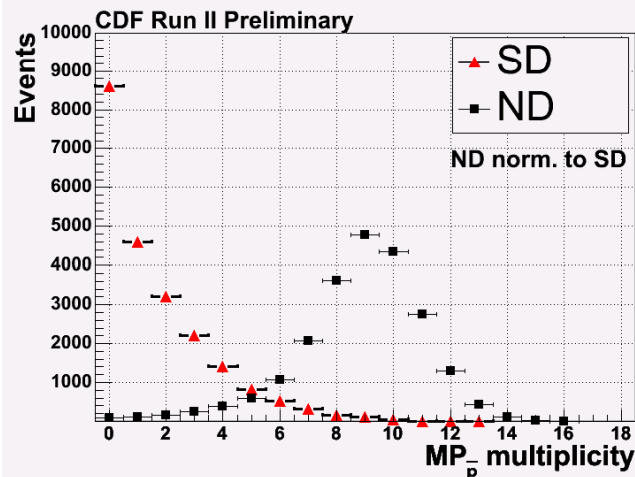
→ MULTIPLICITY
@ POSITION

→ ENERGY



ADC counts in MiniPlug towers
in a $p\bar{p}$ event at 1960 GeV.

- “jet” indicates an energy cluster and may be just a hadron.
- 1000 counts ~ 1 GeV



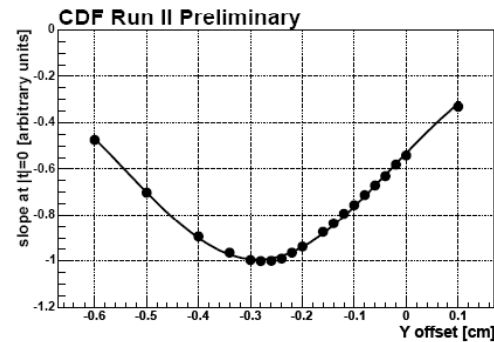
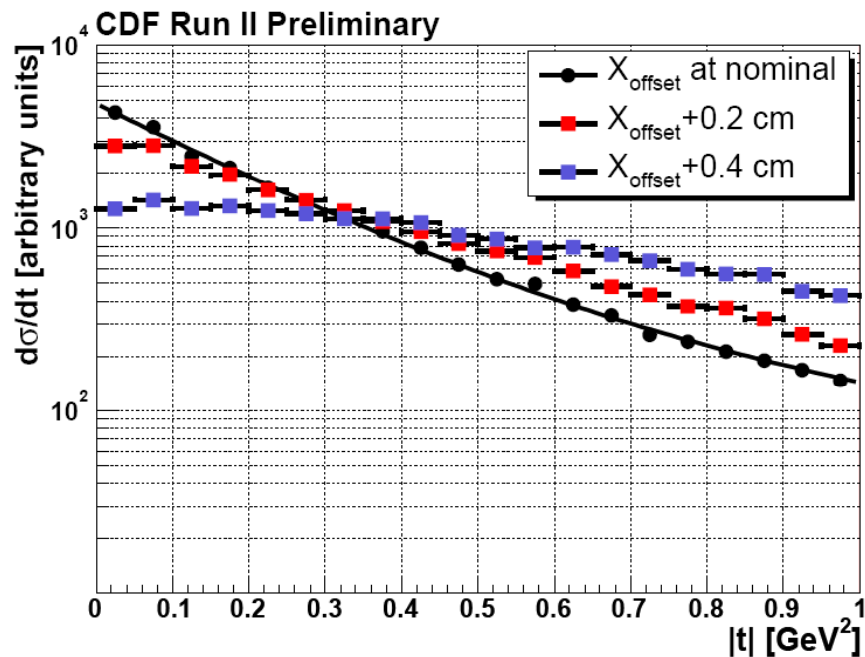
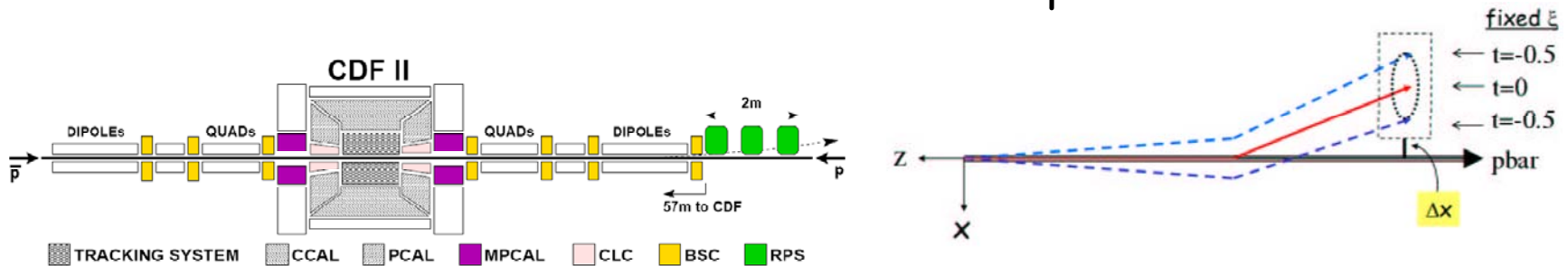
Multiplicity of SD and ND events

$$\xi^{\text{CAL}} = \frac{\sum_i E_T^i e^{-\eta_i}}{\sqrt{s}}$$

NIM A 430 (1999)
NIM A 496 (2003)
NIM A 518 (2004)

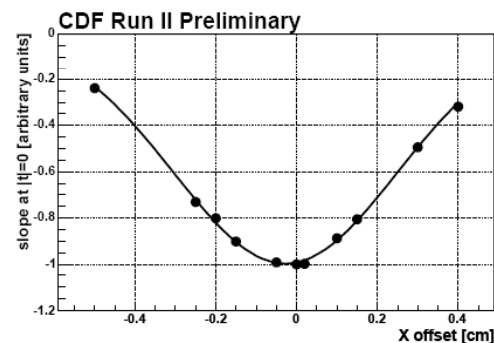
Dynamic Alignment of RPS Detectors

Method: iteratively adjust the RPS X and Y offsets from the nominal beam axis until a maximum in the b-slope is obtained @ $t=0$.



Limiting factors

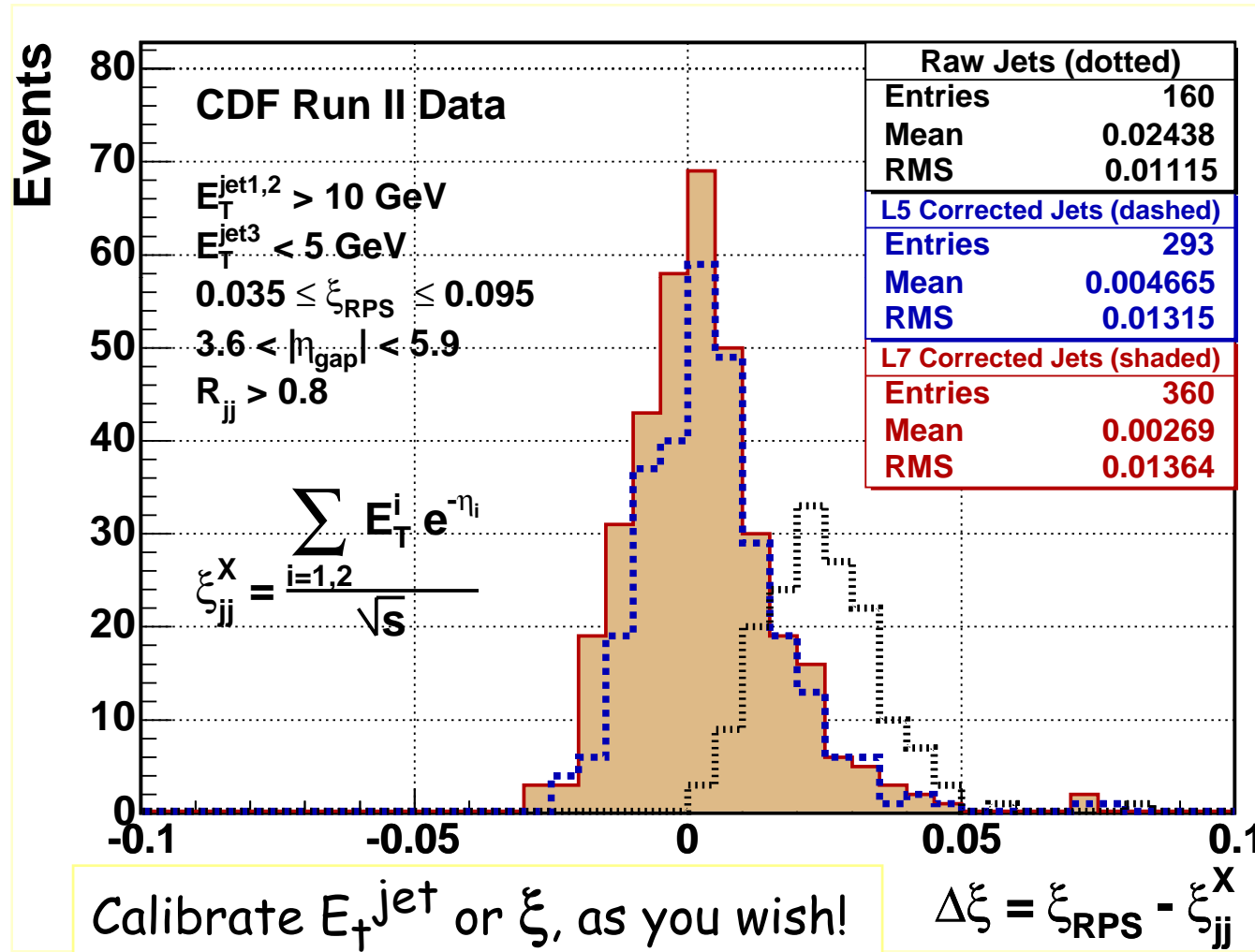
- 1-statistics
- 2-beam size
- 3-beam jitter



@ CDF
w/lowlum data
 $\pm 30 \mu\text{m}$

E_T^{jet} Calibration

→ use RPS information to check jet energy corrections ←





thank you