Observation of Diffractively Produced W- and Z-Bosons

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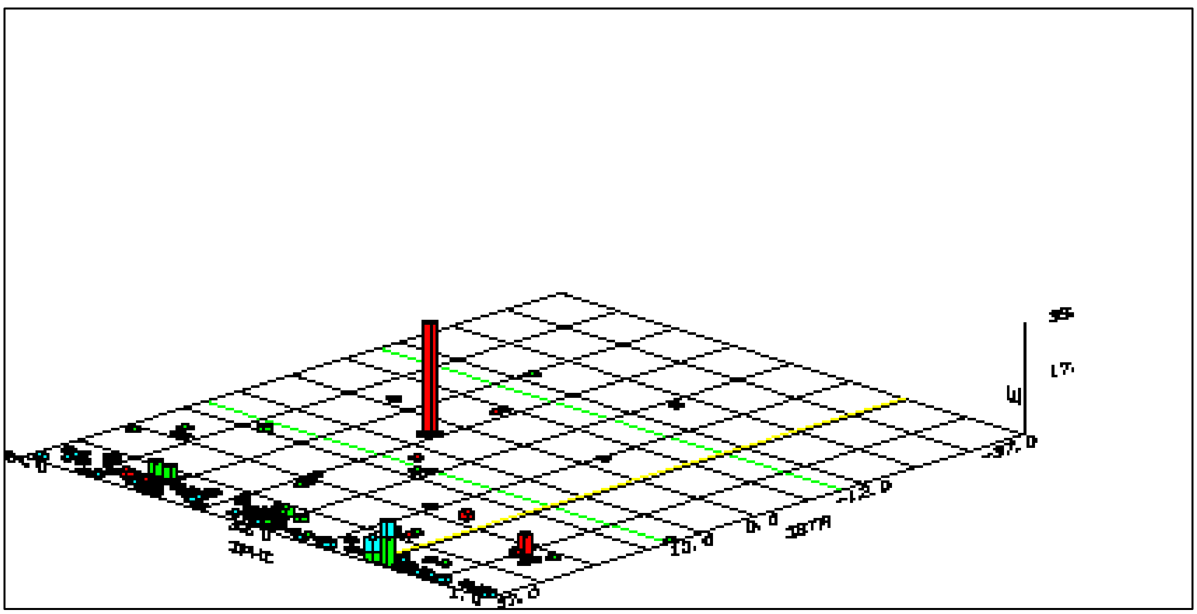
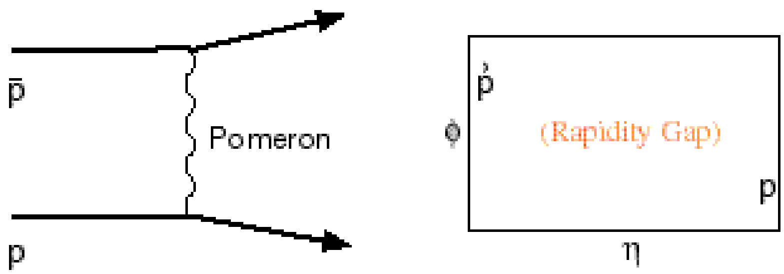


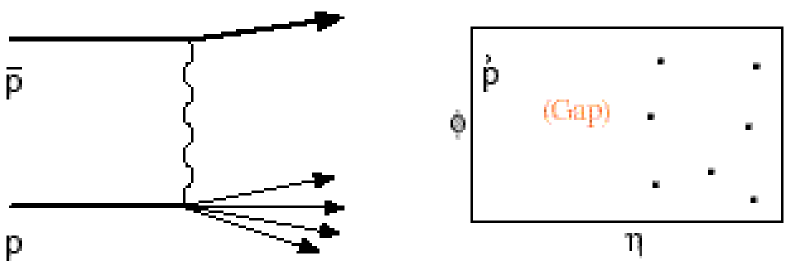
DOE Review
November 14, 2001
UT-Arlington

Diffraction

Soft Processes:

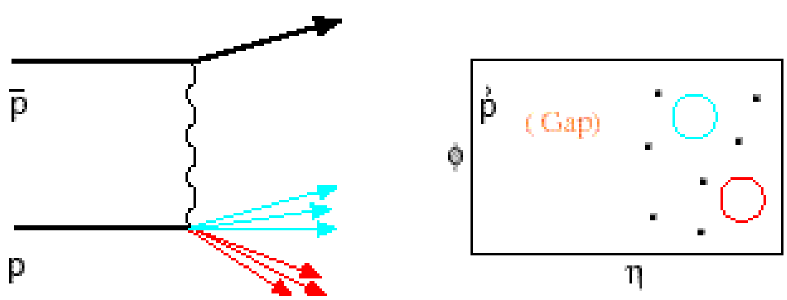


Elastic Scattering

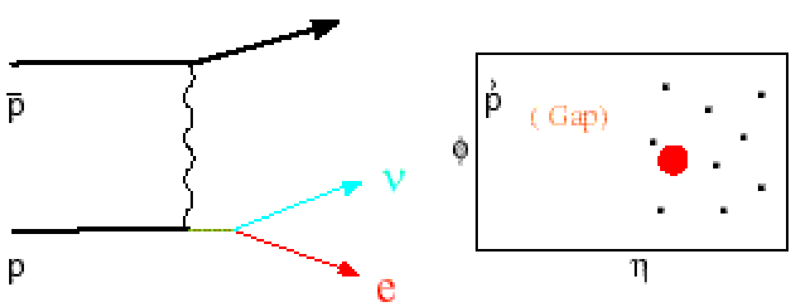


Single Diffraction

Hard Processes:



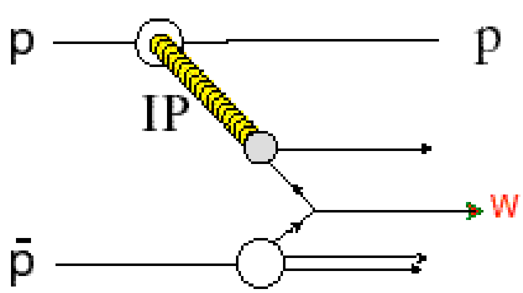
Hard Single Diffraction



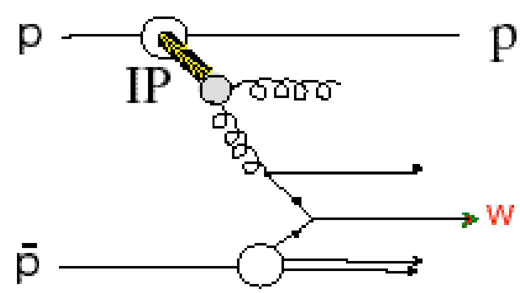
Diffractive W

Why study the Diffractive W?

The pomeron (IP) structure is not yet understood which motivates a study that will better clarify the quark/gluon composition involved. This is found in the diffractive W, which to leading order can only happen based on a quark component in the pomeron.[1]



a) LO: $q\bar{q} \rightarrow W$



b) NLO: $qg \rightarrow q + W$

Diffractive process (a) probes the quark content of the pomeron.

[1] *(Bruni & Ingelman, Phys. Lett. B311(1993)318)*

CDF Diffractive W

CDF {PRL 78 2698 (1997)} measured $R_W = 1.15 \pm 0.55\%$
where R_W = Ratio of diffractive/non-diffractive W
a significance of 3.8σ

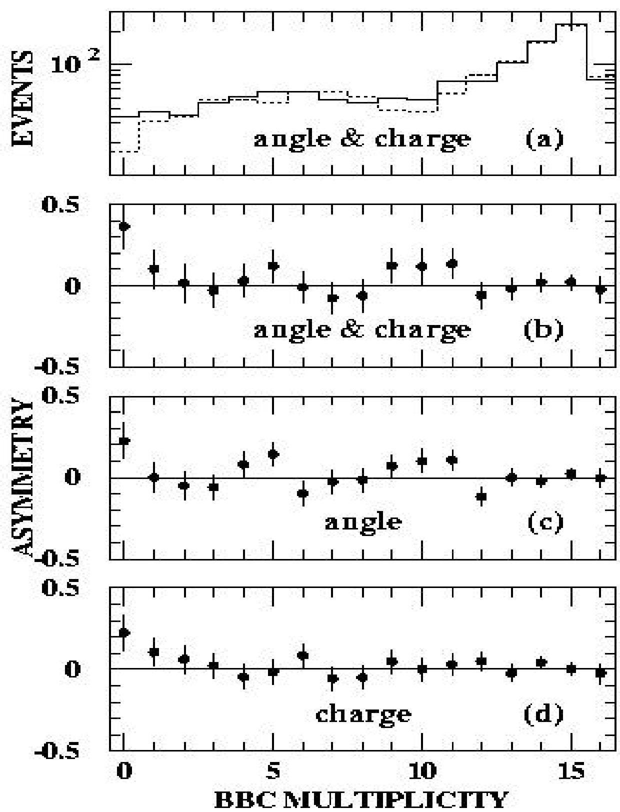


Figure 2: (*a*) Electron angle and charge doubly-correlated (solid) and anticorrelated (dashed) distributions (see text) versus BBC multiplicity, and (*b*) the corresponding asymmetry, defined as the bin-by-bin difference over sum of the two distributions in (*a*). The diffractive signal is seen in the first bin as an excess of events in the correlated distribution in (*a*), and as a positive asymmetry in (*b*). An asymmetry is also seen in the first bin of the individual angle (*c*) and charge (*d*) distributions.

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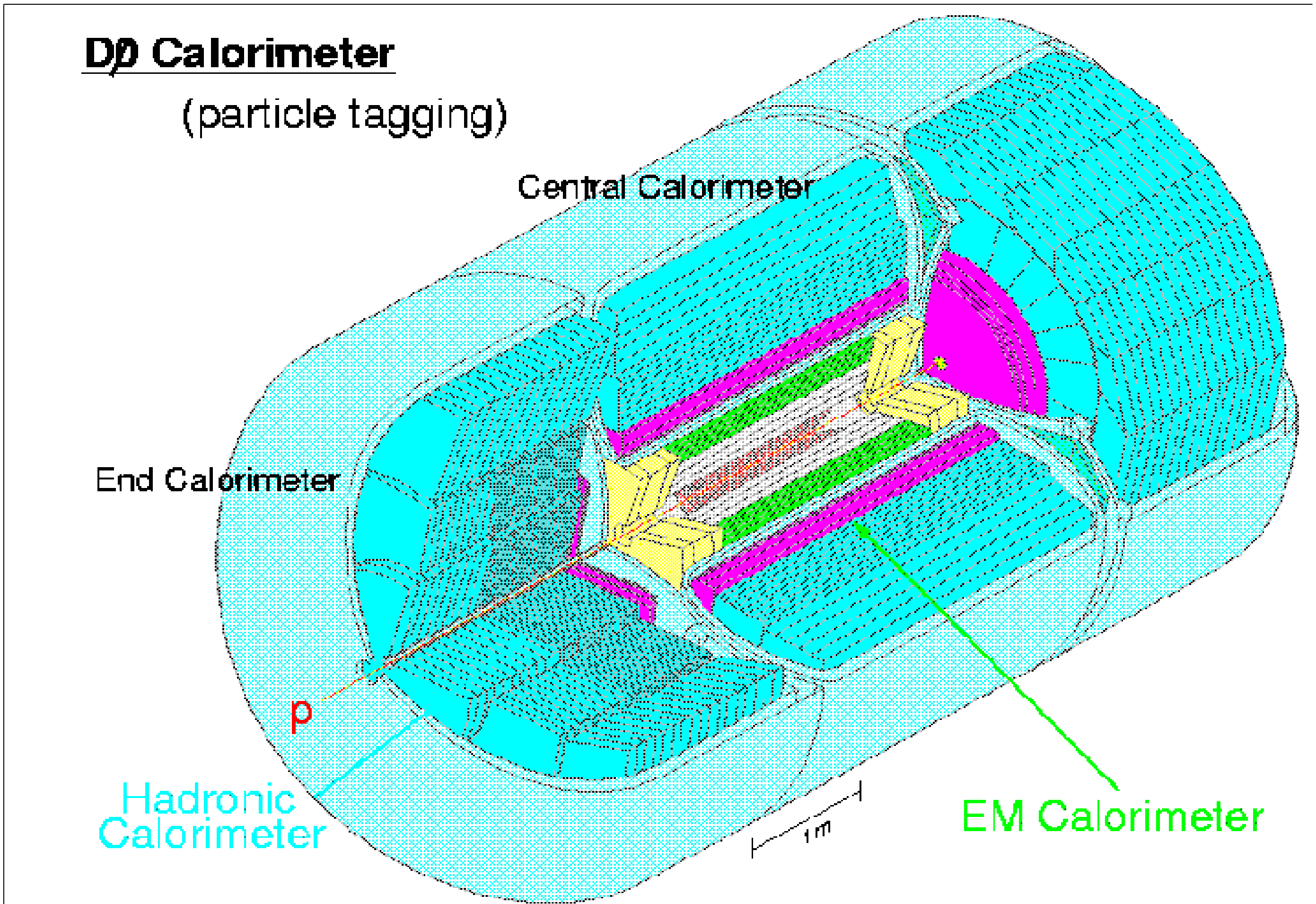
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

DØ Detector



Tagging Particles: (Forward Gaps)

n_{CAL} == number of total calorimeter towers ($\Delta\eta x \Delta\varphi$=0.1x0.1) with Energy > threshold

n_{L0} – # of Level 0 scintillator tiles hit

	Energy Threshold	h **coverage**
EM Calorimeter	150 MeV	2.0<|η|<4.1
Had Calorimeter	500 MeV	3.2<|η|<5.2

Data Samples

Central and Forward electron W Event Selection:

Start with Run1b W→eν candidate sample

Variable		N Events
filter	electron + $\not{E}_T$	119,890
No Level 0 Requirement in trigger	Run number > 85277	84,310
Main Ring Cuts		63,978
Single Interaction		17,870
Central Calorimeter or Endcap Calorimeter	$\lvert\eta_{det}\rvert < 1.1$ $1.5 < \lvert\eta_{det}\rvert < 2.5$	17,626
Electron Quality	isolation, shape, EM fraction	17,201
E_T and $\not{E}_T$	> 25 GeV	12,622
Total e W sample		12,622
Final Central e sample	$\lvert\eta_{det}\rvert < 1.1$	8,724
Final Forward e sample	$1.5 < \lvert\eta_{det}\rvert < 2.5$	3,898

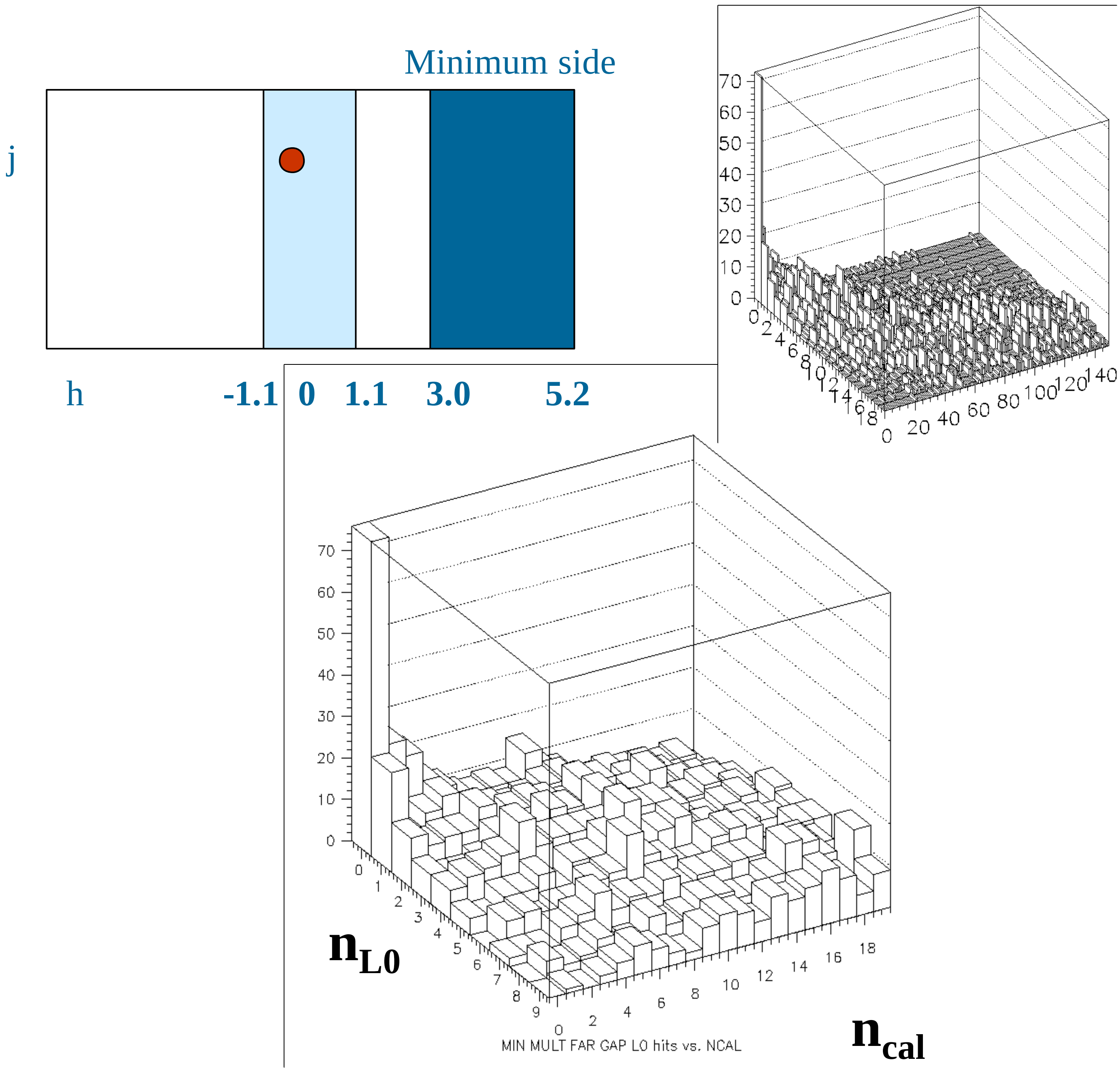
Table 1: Central and Forward W electron event selection criteria.

Z Event Selection: Start with Run1b Z→ee candidate sample

Variable		N Events
filter	two electrons	13,912
No Level 0 Requirement in trigger	Run number > 85277	10,023
Main Ring Cuts		8,751
Single Interaction		2,381
Central Calorimeter or Endcap Calorimeter	$\lvert\eta_{det}\rvert < 1.1$ $1.5 < \lvert\eta_{det}\rvert < 2.5$	1,781
E_T of electrons	> 25 GeV	1,149
Electron Quality 1 tight 1 loose	isolation, shape, EM fraction	893
Invariant Mass window		811
Total e Z sample		811

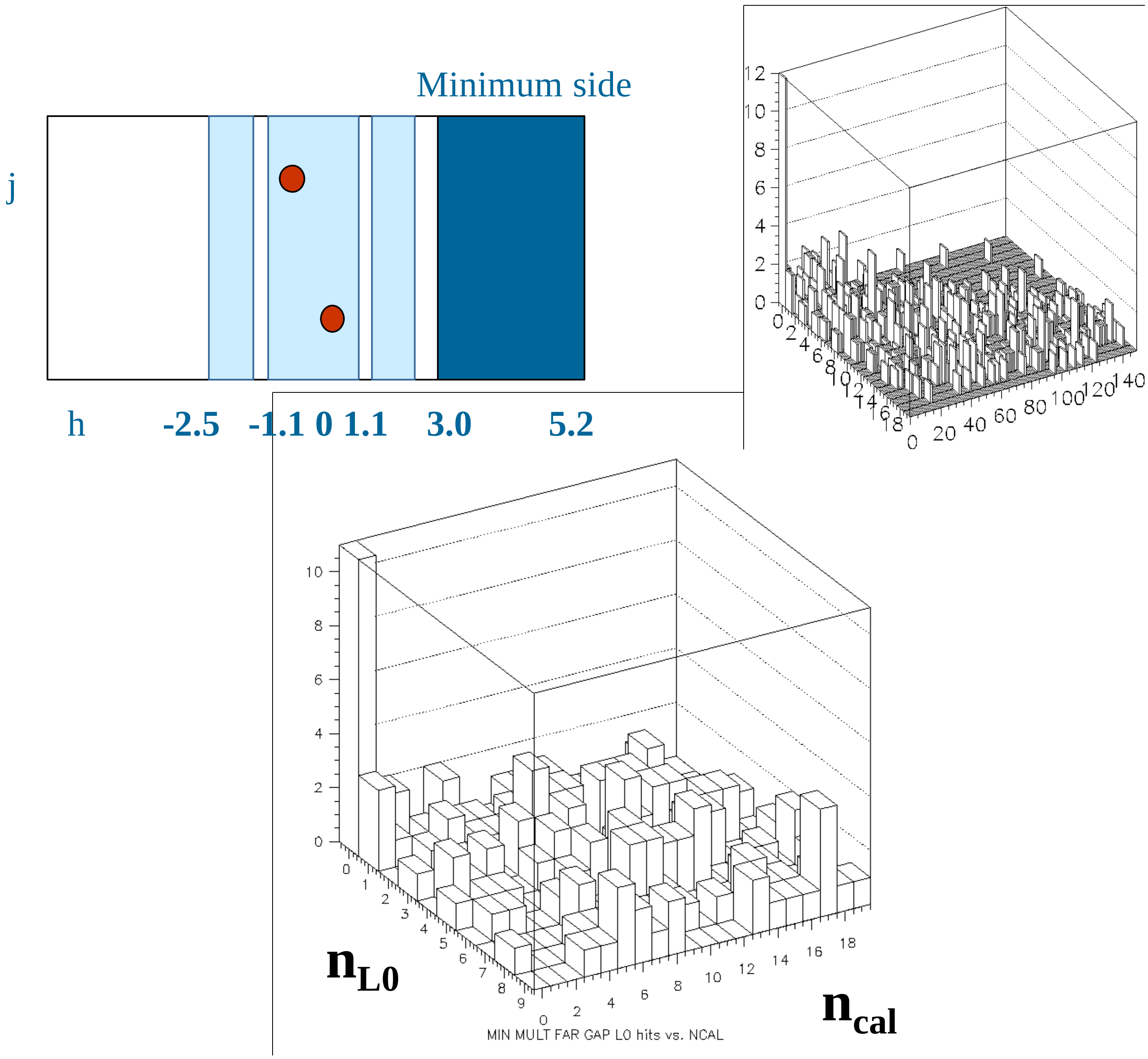
Table 2: Z electron event selection criteria.

Central W Multiplicity



Peak at (0,0) indicates diffractive W-boson

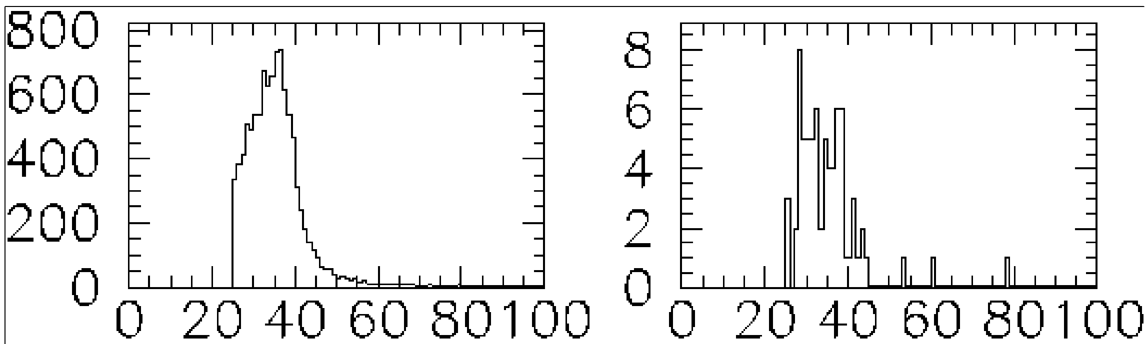
Z Multiplicity



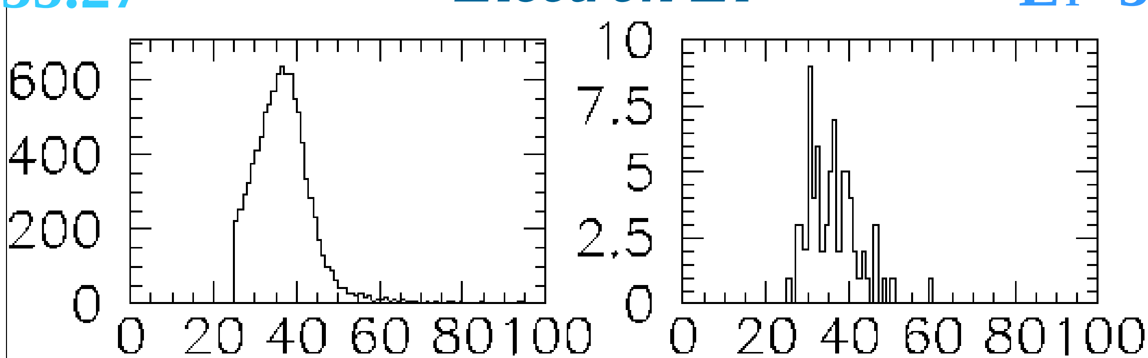
Peak at (0,0) indicates diffractive Z-boson

Central W Event Characteristics

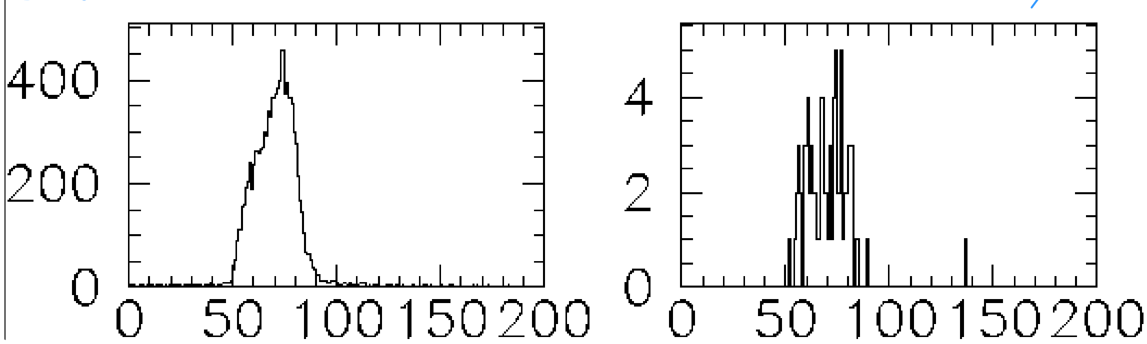
Standard W Events | **Diffractive W Candidates**



$\overline{E_T}=35.27$ *Electron E_T* $\overline{E_T}=35.16$

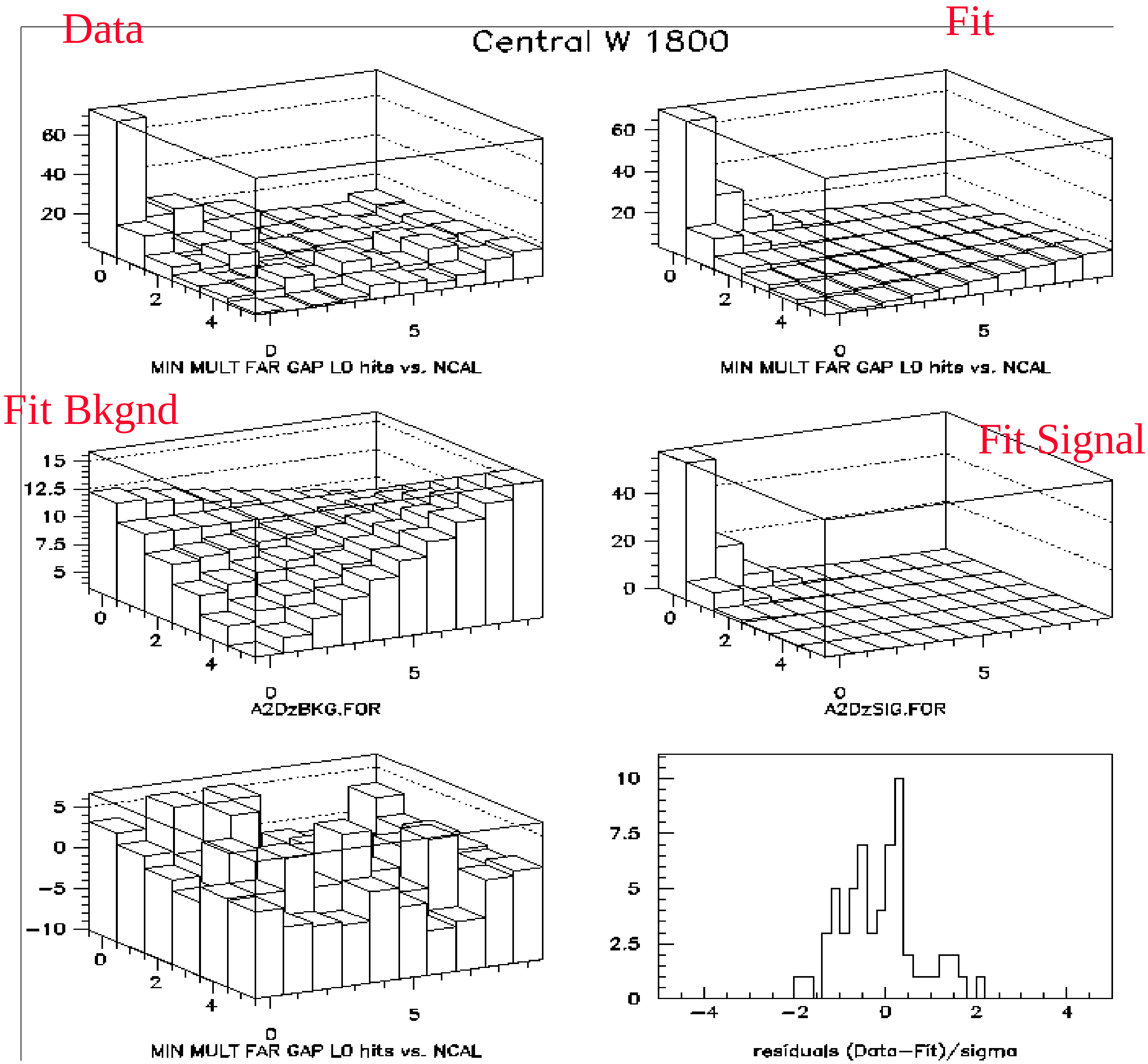


$\overline{\not{E}_T}=37.12$ *Neutrino E_T* $\overline{\not{E}_T}=36.08$



$\overline{M_T}=70.64$ *Transverse Mass* $\overline{M_T}=70.71$

W Multiplicity Fit



Final Results

$W \to e\nu$	Measured Gap Fraction	Probability that Background Fluctuates to Data
central, $\lvert\eta\rvert < 1.1$	$1.08 \pm^{0.21}_{0.19}$ %	0.1×10^{-13}
forward, $1.5 < \lvert\eta\rvert < 2.5$	$0.64 \pm^{0.19}_{0.16}$ %	0.6×10^{-7}
total $W \to e\nu$ **sample**	$0.89 \pm^{0.20}_{0.19}$ %	
$Z \to e^+e^-$	**Measured Gap Fraction**	
$Z \to e^+e^-$ **sample**	$1.44 \pm^{0.62}_{0.54}$ %	0.5×10^{-5}

Table 1: Measured gap fractions and probabilities for W- and Z-bosons.

R (W/Z) {Cross Section Ratio of Diffractive W/Z} =0.62±0.27

Summary

- **New definitive observation of Diffractive W-boson signal: R_W = (0.89 + 0.20 – 0.19)%**

- **First observation of Diffractive Z-bosons**

- **Cross section ratio of Diffractive W/Z 0.62±0.27**

- Diffractive W/Z show similar characteristics to non-diffractive ones.

- Pomeron based MC does not predict **magnitude or** h **dependence of results**