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# DØ Diffractive Physics Measurements

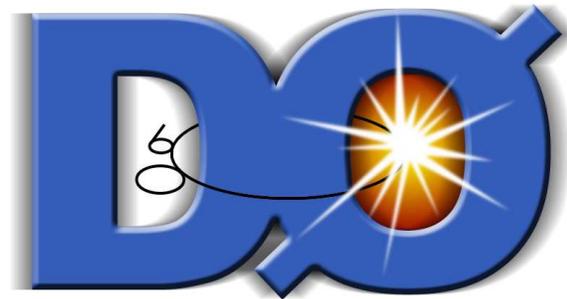
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Duncan Brown

University of Texas

-Arlington-

On Behalf of the DØ Collaboration

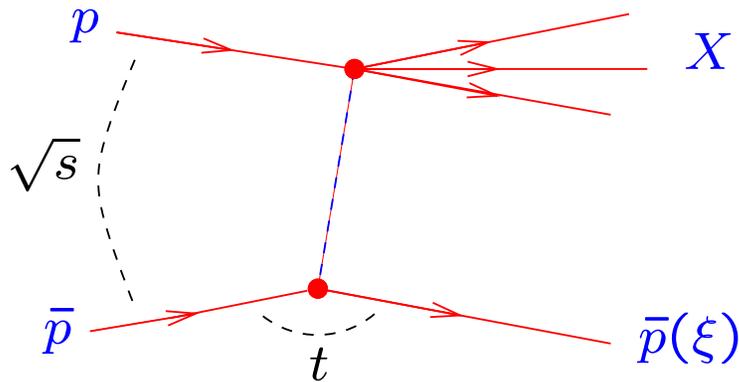


Workshop on Low-x Physics

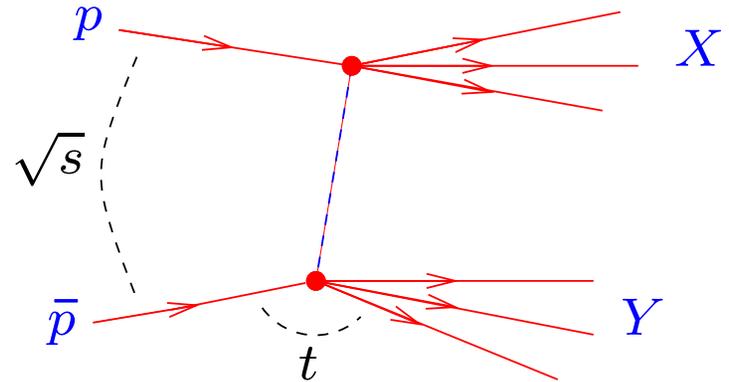
Sinaia, July 1st 2005

# Diffractive Production at the TeVatron

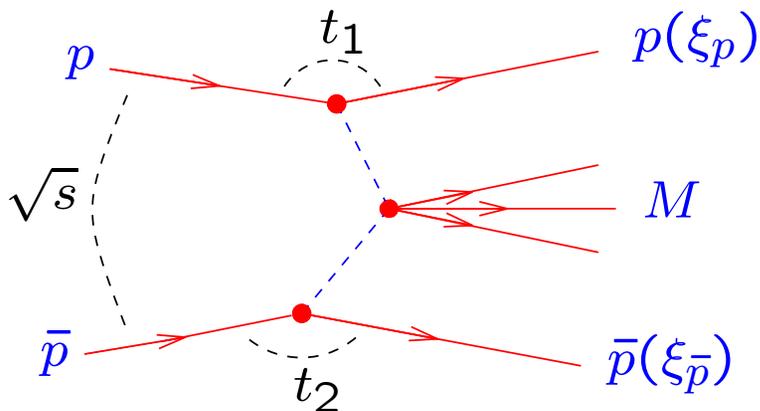
Single Diffraction



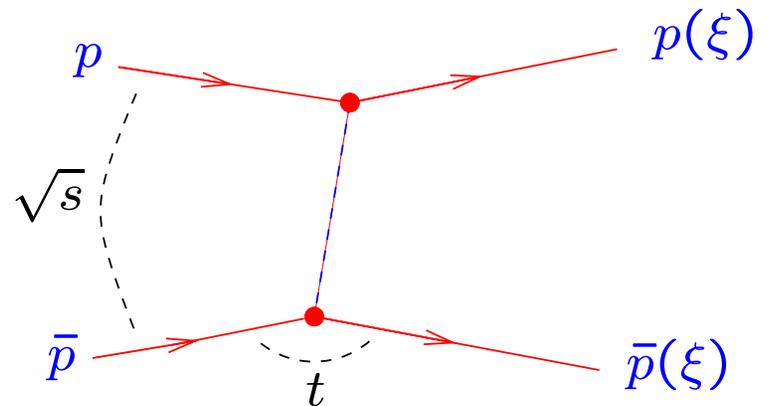
Double Diffraction



Diffractive Central Production



Elastic Diffractive Scattering



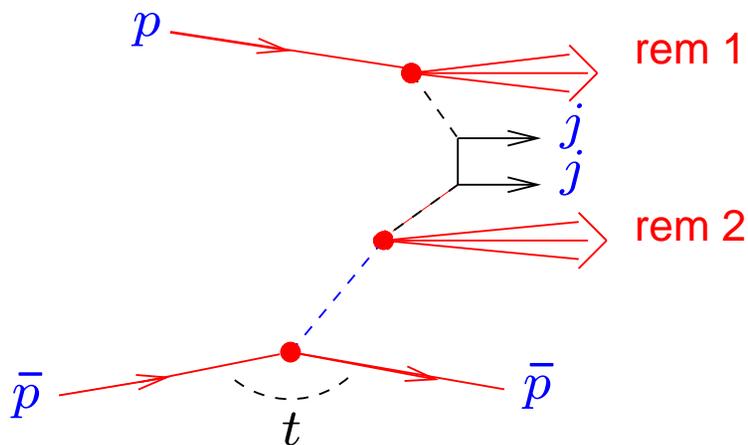
$\Rightarrow$  Simultaneous Probe of Different Diffractive Final States

$\sqrt{s} = 1.96$ TeV (Run II)	$p\bar{p}$ c.o.m energy	$t$ 4-mom. transfer squared	$\xi_p$ fractional proton mom. loss	$\xi_{\bar{p}}$ fractional antiproton mom. loss
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# pQCD and the Pomeron

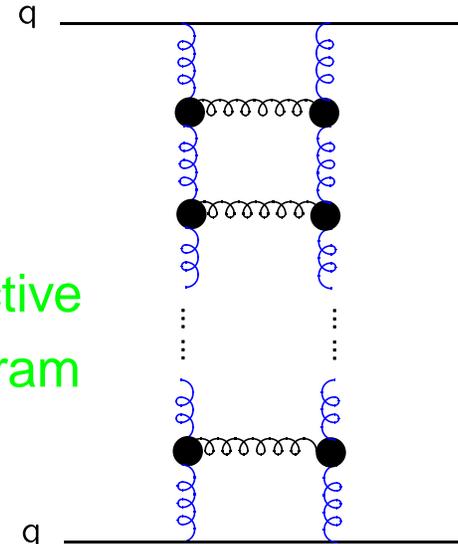
## Lowest Order Exchange: 2 Gluons

- Evolve to Higher Orders in Leading Log (LL) Approximation
- Calculations Require hard-scale: (e.g. Jet Production, Large Mass  $J/\psi, Z$ )



⇒ Probe Non-Trivial Effective Partonic Exchange

## BFKL Ladder



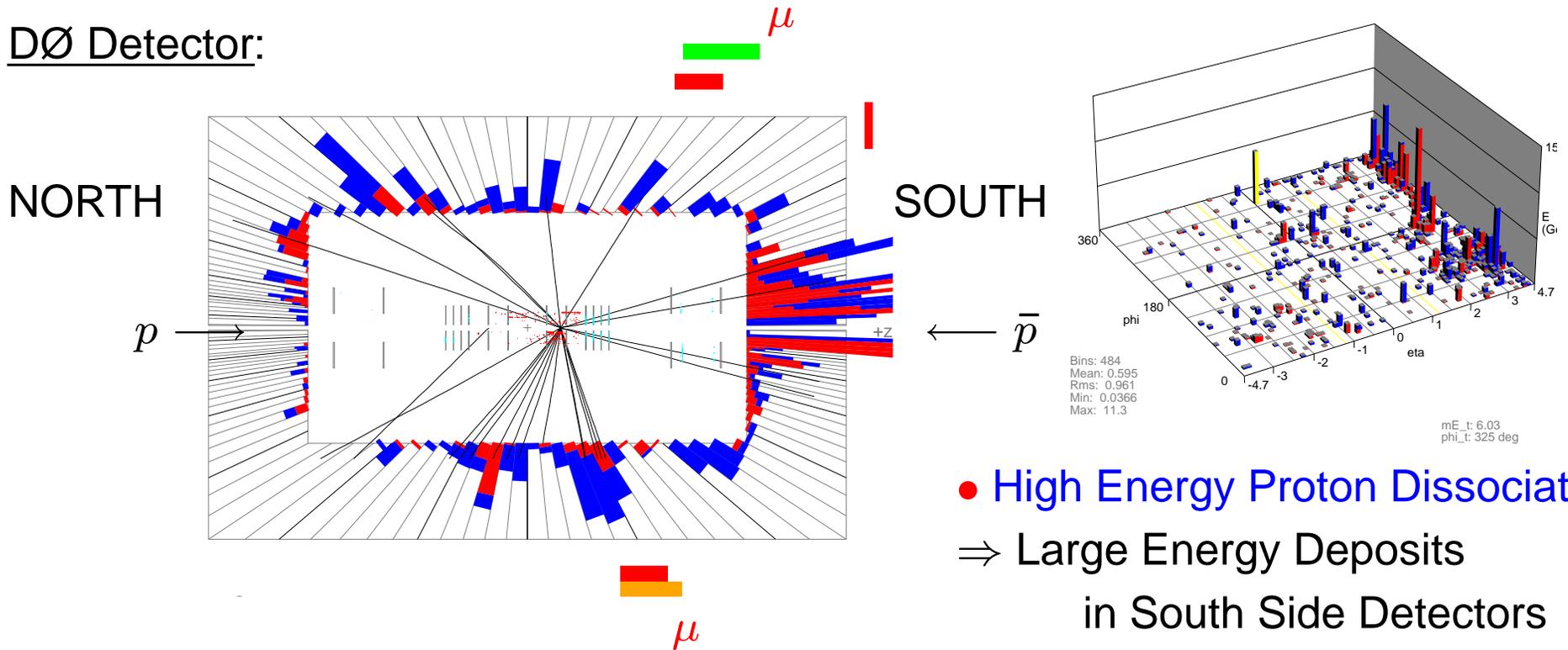
Effective Diagram

(Reggeized Gluon Ladder)

Can Introduce an Effective Pomeron Structure Function  
(G. Ingelman, P. Schlein (1985) Phys. Lett. B152, 256)

# Experimental Signature

DØ Detector:



- High Energy Proton Dissociates  
 $\Rightarrow$  Large Energy Deposits  
 in South Side Detectors

- High Energy Antiproton Scatters through Small Angle  
 $\Rightarrow$  No Scattered Antiproton in Main Detectors  
 $\Rightarrow$  Region of Low Level Energy Deposition (Rapidity Gap): North Side Detectors

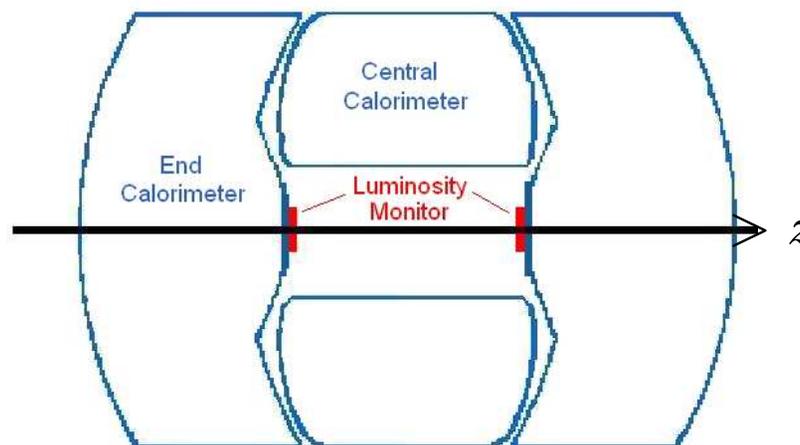
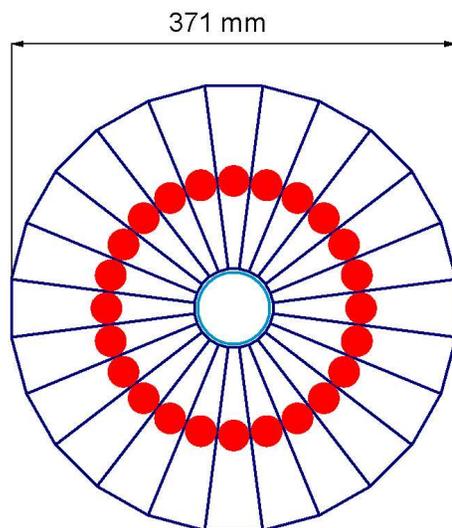
- Two Identified Large  $p_T$  Muon Tracks

- $\Rightarrow$  Candidate Single Diffractive  
 $Z \rightarrow \mu^+ \mu^-$  Event

# Rapidity Gap System

## Luminosity Monitor System

- Two Scintillator Detectors Close to Beam Pipe



Each Detector: Array of 24 Plastic Scintillator Wedges

North and South Detectors  $z \pm 140\text{cm}$

Angular coverage  $2.7 < |\eta| < 4.4$

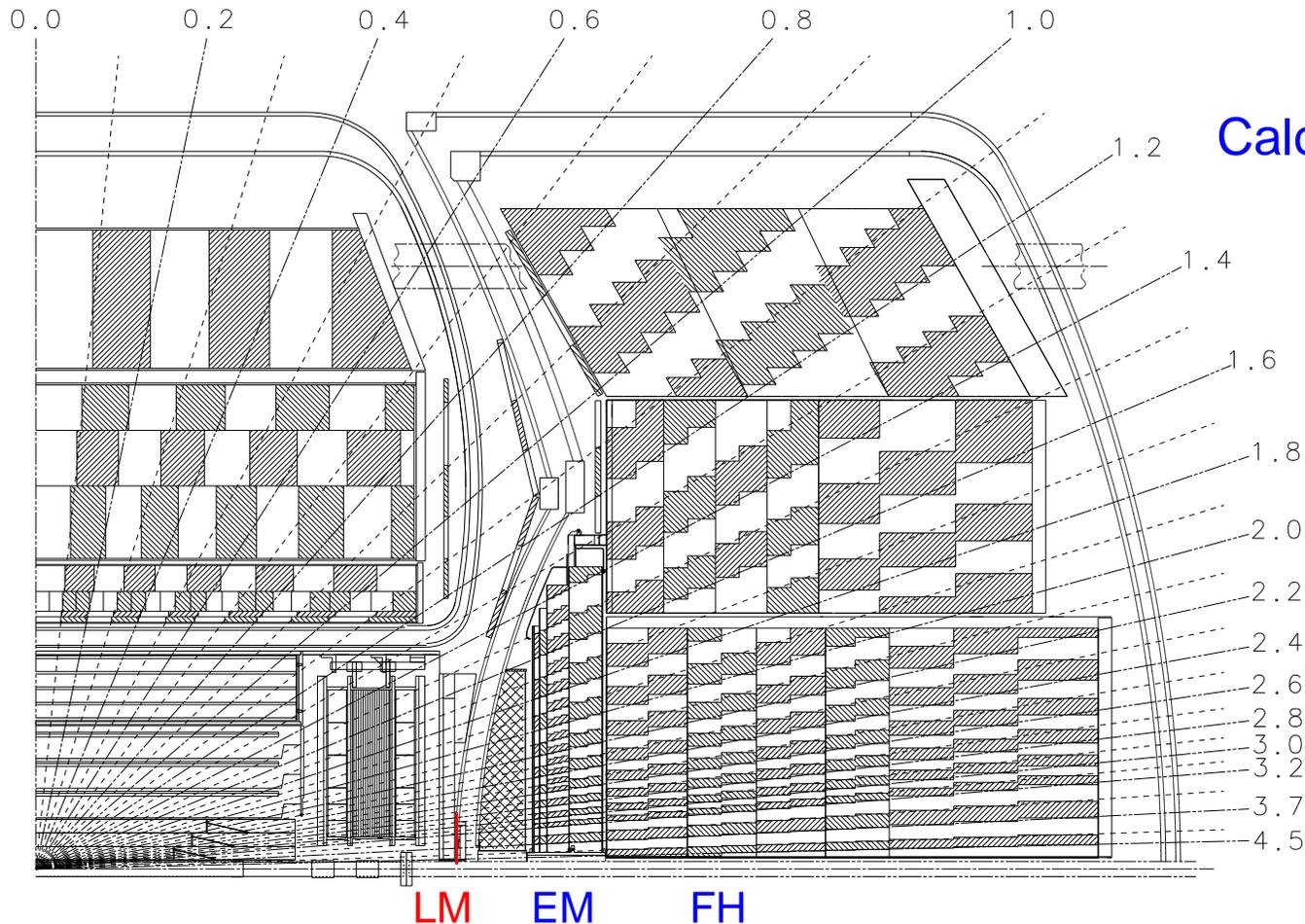
- Summed Detector Charges Provide ON/OFF Signal

⇒ Veto on Activity in Region of Scattered Beam Hadrons

# Rapidity Gap System

## Liquid Argon Calorimeter

(Uranium, Copper, Steel Induce EM/Hadronic showers)



Calorimeter Cells  
Arranged in Layers

- EM  $E_{sum}$  Range:  
 $2.6 < |\eta| < 4.1$
- FH  $E_{sum}$  Range:  
 $2.6 < |\eta| < 5.3$

- Demand Low Cell Energy Sum (Above Threshold) in Calorimeter Layers

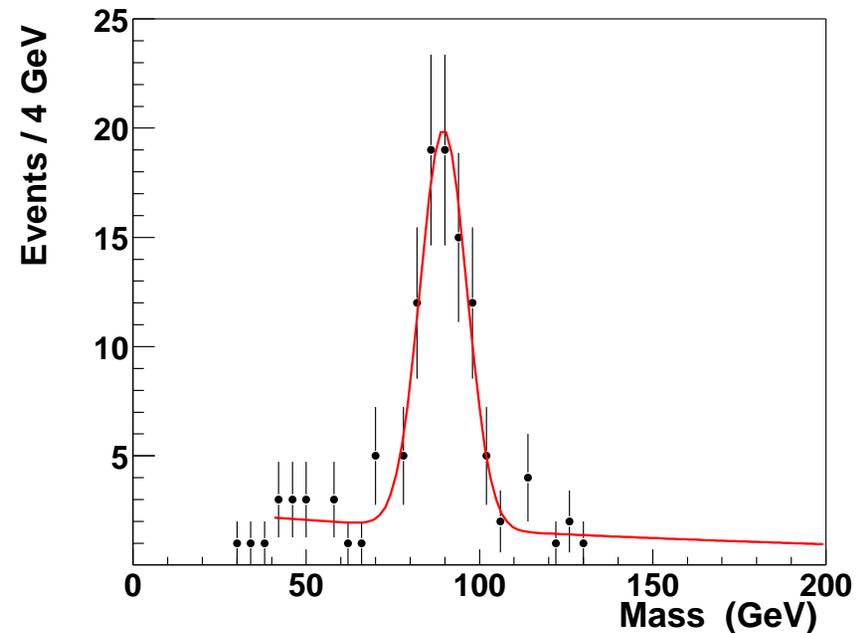
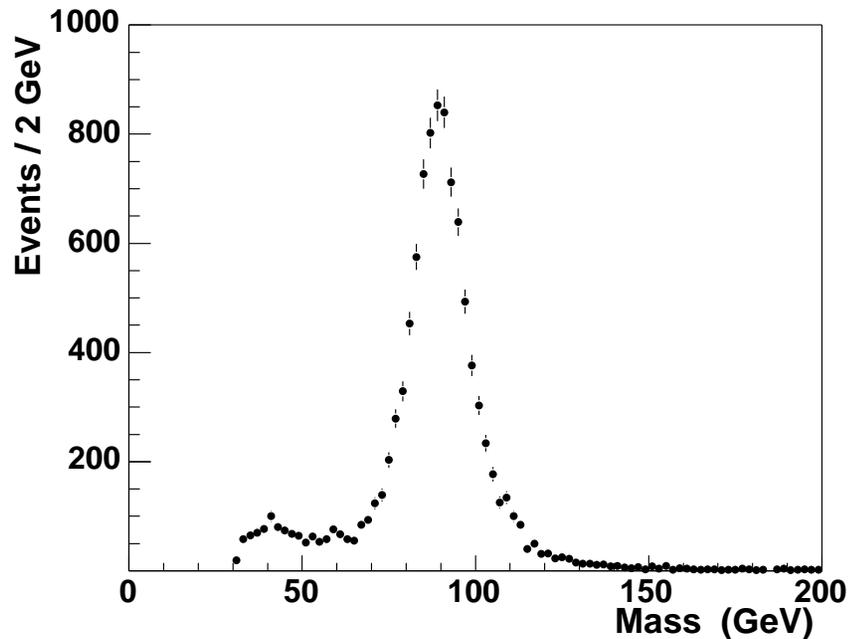
# Diffractive Vector Boson Production

## Run II Diffractive Topics: Diffractive W and Z Production

Run II (2003) Data Sample:  $Z \rightarrow \mu^+ \mu^-$ , Two Good ( $P_T > 15$  GeV) Identified Muon Tracks. At least one isolated, Cosmic Ray Rejection

### Demand Activity North AND South

### Rapidity Gap North OR South



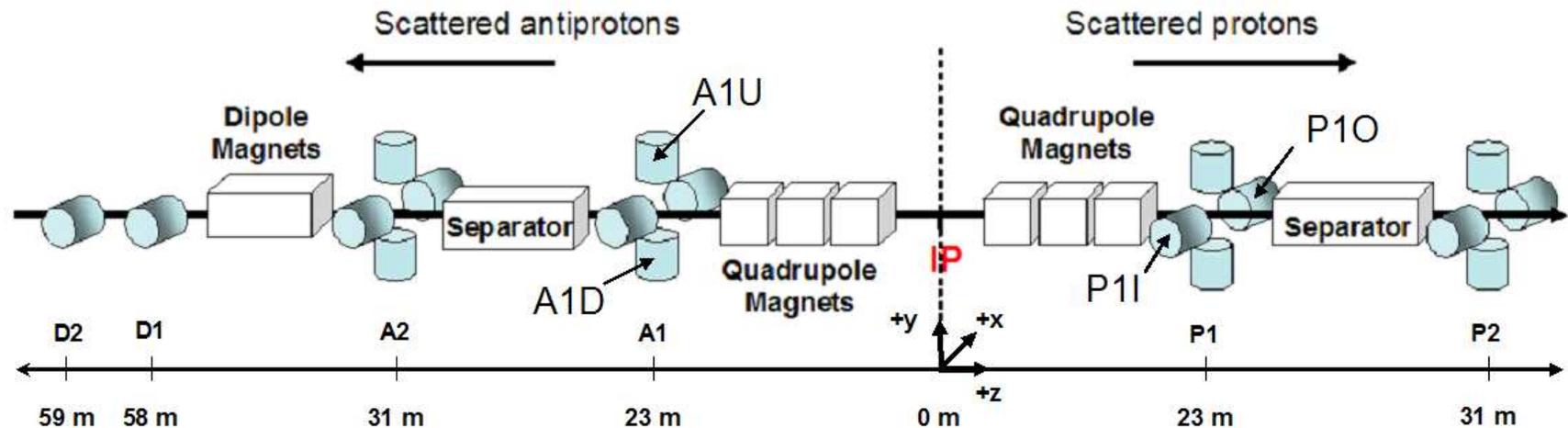
⇒ Single Diffractive Z Production Candidates

Run I Publication: Observation of Diffractively Produced W and Z Bosons in  $\bar{p}p$  Collisions at  $\sqrt{s} = 1800$  GeV.

Phys. Lett. B 574 169 (2003) ← Electron Channel Result

# Run II: DØ Forward Proton Detectors

## Nine Momentum Spectrometers Each Comprised of 2 Scintillating Fiber Detectors



1 Dipole Spectrometer

$|t| = 0 - 3.0 \text{ GeV}^2$  (upper limit  
detector position dependent)  
 $\xi = 0 - 0.08$  (t dependent limits)

8 Quadrupole Spectrometers:

$|t| \approx 0.8 - 3.0 \text{ GeV}^2$  (both limits detector position dependent)  
 $\xi \approx 0 - 1$  (t dependent limits)

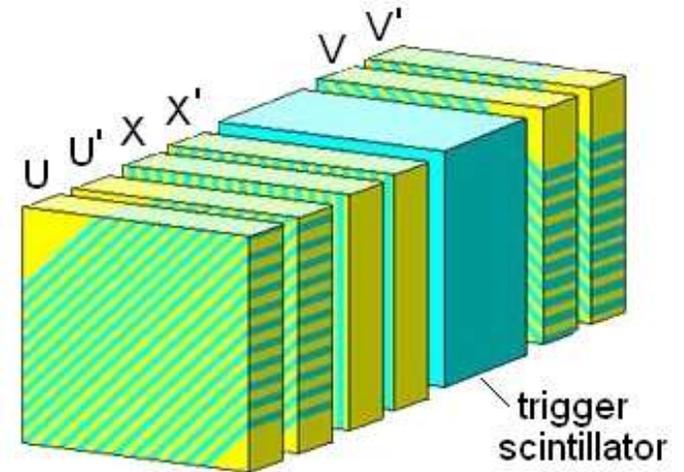
- Located behind Existing Dipole and (low- $\beta$ ) Quadrupole Accelerator Magnets
- Position Detectors Housed Inside Steel Containers (Roman Pots)
  - ⇒ Operate  $\sim$ mm from Beam (Outside Ultra High Vacuum)
- ⇒ Can Reconstruct High Energy Scattered Protons and Antiprotons Directly

# DØ Forward Proton Detector

- 6 Layers of Scintillating Fiber Channels: U,U',X,X',V,V'  
(Each Channel is made up of four fibers)

- 16 Fiber Channels in 'X' layers  
20 Fiber Channels in 'U' and 'V' layers;

- 1 Trigger Scintillator layer  
(Fast Photomultiplier Tube Readout)



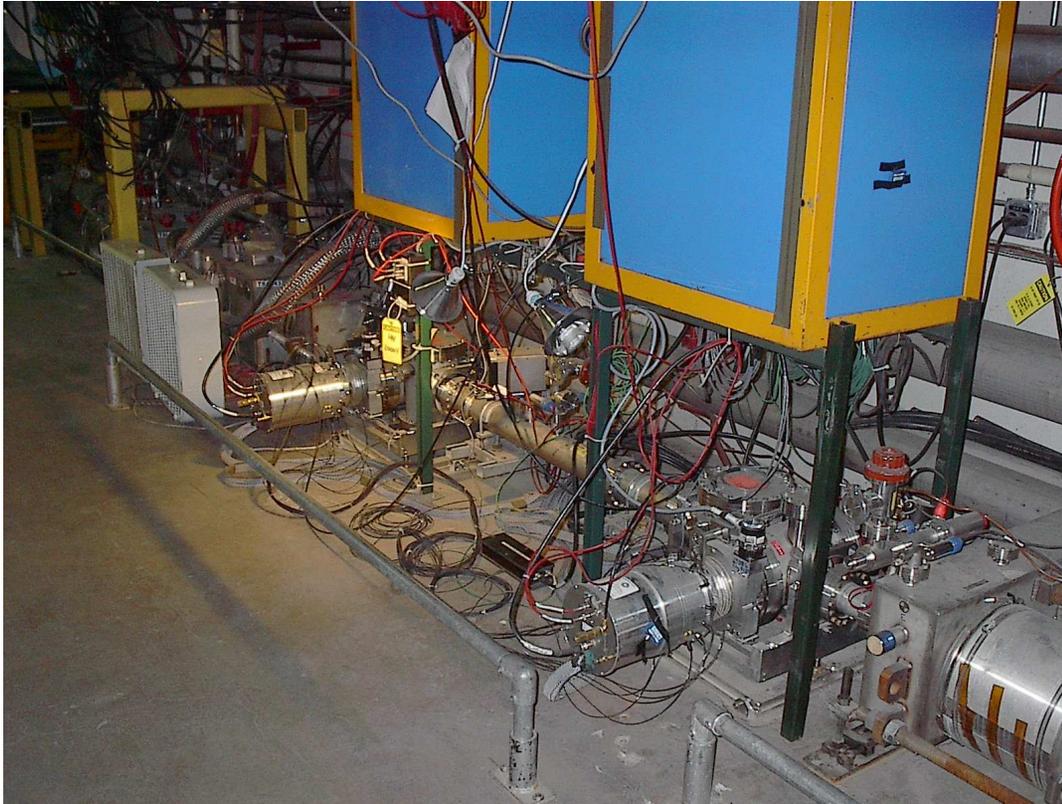
- Channels of 'U' and 'V' layers orientated at  $\pm 45^\circ$  to 'X'  
 $\Rightarrow$  3 Planes for Hit Reconstruction
- Primed and Unprimed Channels Offset w.r.t each other (by 2/3 Fiber)  
 $\Rightarrow$  Finer Hit Resolution

Since Jan. 2004:

All 18 Scintillating Fiber Detectors Regularly Brought Close to the Beam Line  
(Dipole Detectors since Feb 2003)

# Run II: DØ Forward Proton Detectors

6 Castles and 18 Pots constructed in Brazil  
Installed at Tevatron at the end of 2000



FPD Dipole Spectrometer

2005 Recently Added: FPD Elastic, Single and Double Pomeron Triggers  
(Previously Restricted to Special Runs)

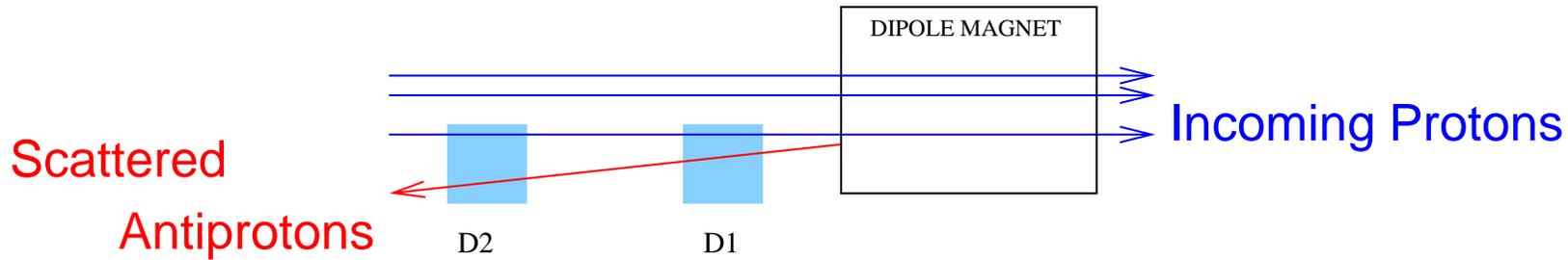
18 Detectors Built Over  
2+ Year Period at UTA

10 Pots Instrumented  
with Detectors (2001-02)

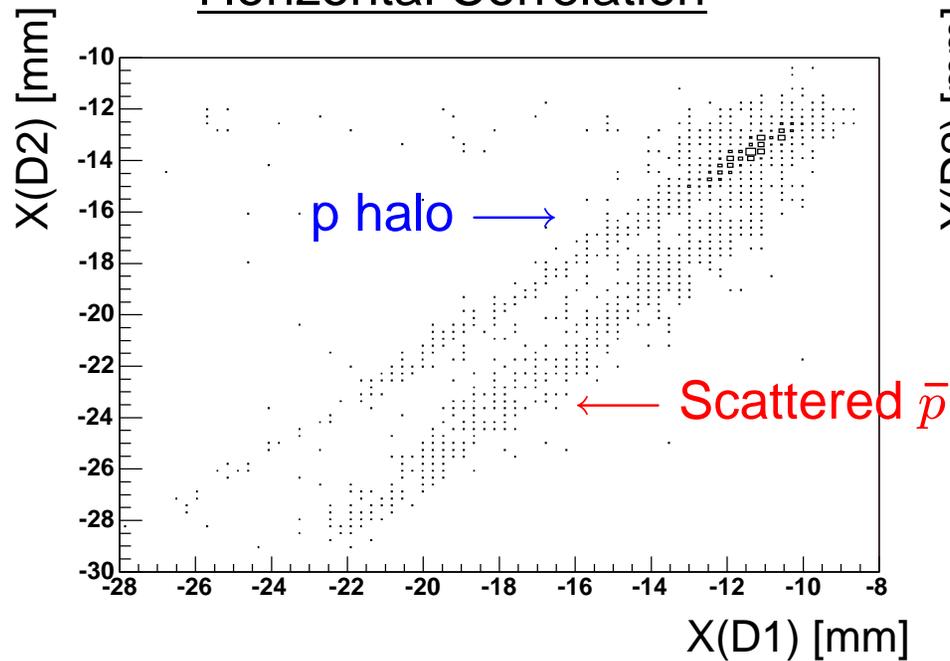
Late 2003: Remaining 8 Detectors  
+ Readout Electronics Installed

# FPD Spectrometer Signals

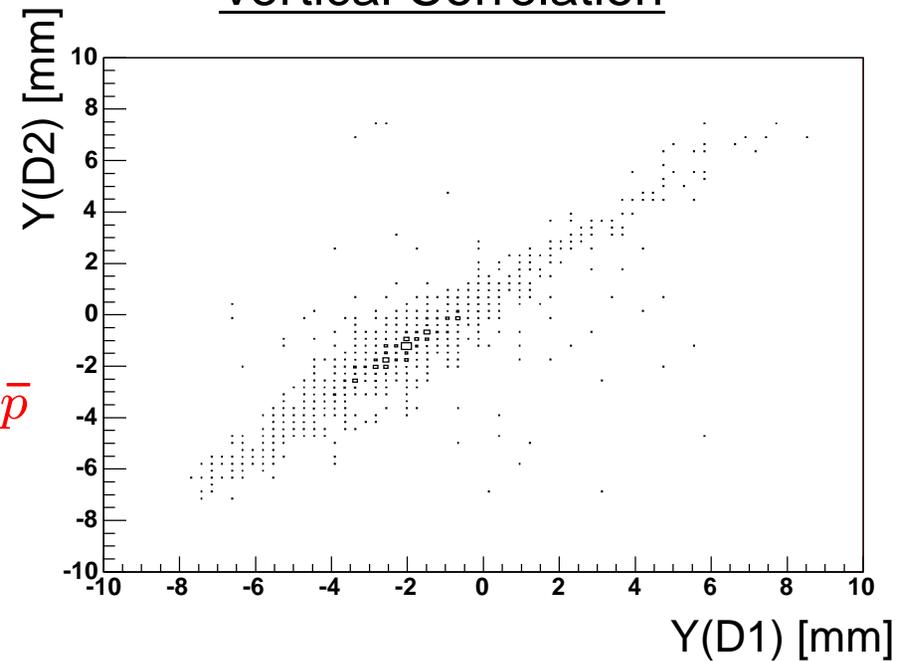
Overhead View of Dipole Spectrometer System:



Horizontal Correlation



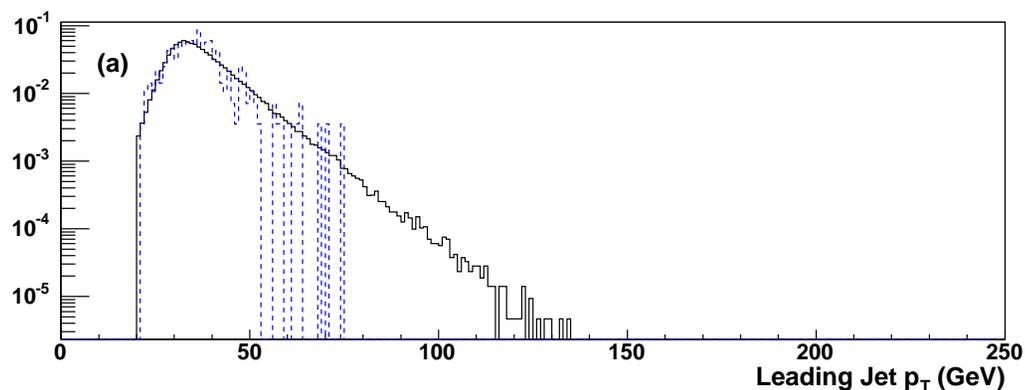
Vertical Correlation



⇒ Good Separation of Signal and Background

# Diffractive Jet Production

## Run II Diffractive Topics: Single Diffractive Dijet Production Diffractive Forward Jet Production



Jet Triggered Events (2003 Sample)

- WITH FPD TAG

- NO TAG REQUIREMENT

### Current Run II Diffractive Triggers Include:

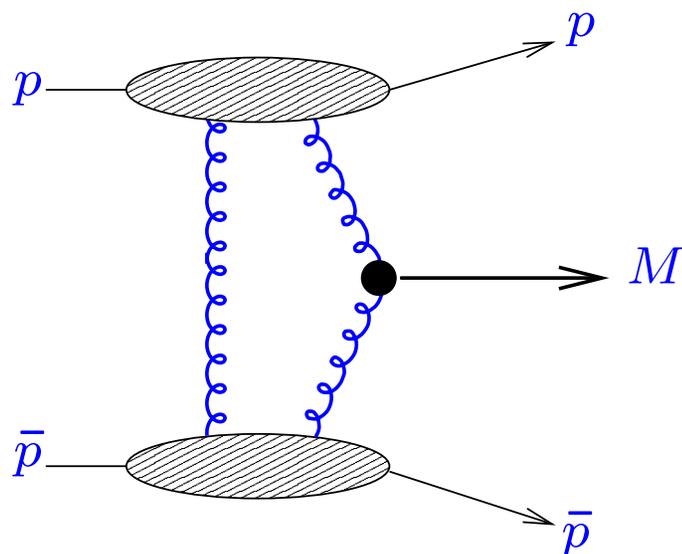
- 15 GeV Jet + (1 or 2) Gaps
  - Double Gap: Low Prescale up to Intermediate Luminosities
- 45 GeV Jet + (1 or 2) Gaps
  - Single Gap: Low Prescale up to Intermediate Luminosities
  - Double Gap: Unprescaled up to Highest Luminosities

⇒ Compare FPD and Gap Selections

Many Run I Jet Measurements: see e.g - B. Abbott *et. al* (*DØ Collaboration*) *Phys. Lett B*531 52 (2002)

# Diffractive Central Production

## Double Pomeron Exchange



## Possible Central Systems Include:

$\chi_c$  and  $\chi_b$  Production  
(Related to Diffractive Higgs Processes)

Diffractive Centrally Produced Di-jets

Glueball States (Central to Lattice QCD)

Run II Diffractive Topics: Double Diffractive Dijet Production  
Inclusive Double Pomeron, Diffractive Heavy Flavour Production

## Current Run II Heavy Flavour Triggers Include:

- $J/\psi$  + Gap: 2 low  $P_t$  muons + (1 or 2) gaps  
Unprescaled up to Highest Luminosities

⇒ Compare FPD 'Missing' Mass with Main Detector Measurement

# Summary and Outlook

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- Many Measurements of Exclusive Diffractive Processes in Progress at DØ
  - Provide New Insight into Structure of the Diffractive Exchange
  - Extend Run I Published Results to Higher  $\sqrt{s} = 1.96$  TeV
- DØ Run II Upgrade Includes Extensive Forward Proton Detector System
  - Directly Measure  $\xi$  and  $t$  of Scattered Protons and Antiprotons

## Run II Increase in Statistics:

- Higher Precision Tests over a Larger Kinematic Region