

LHC Working Group on Forward Physics and Diffraction  
Diffractive W Analysis Plans





## Who am I???

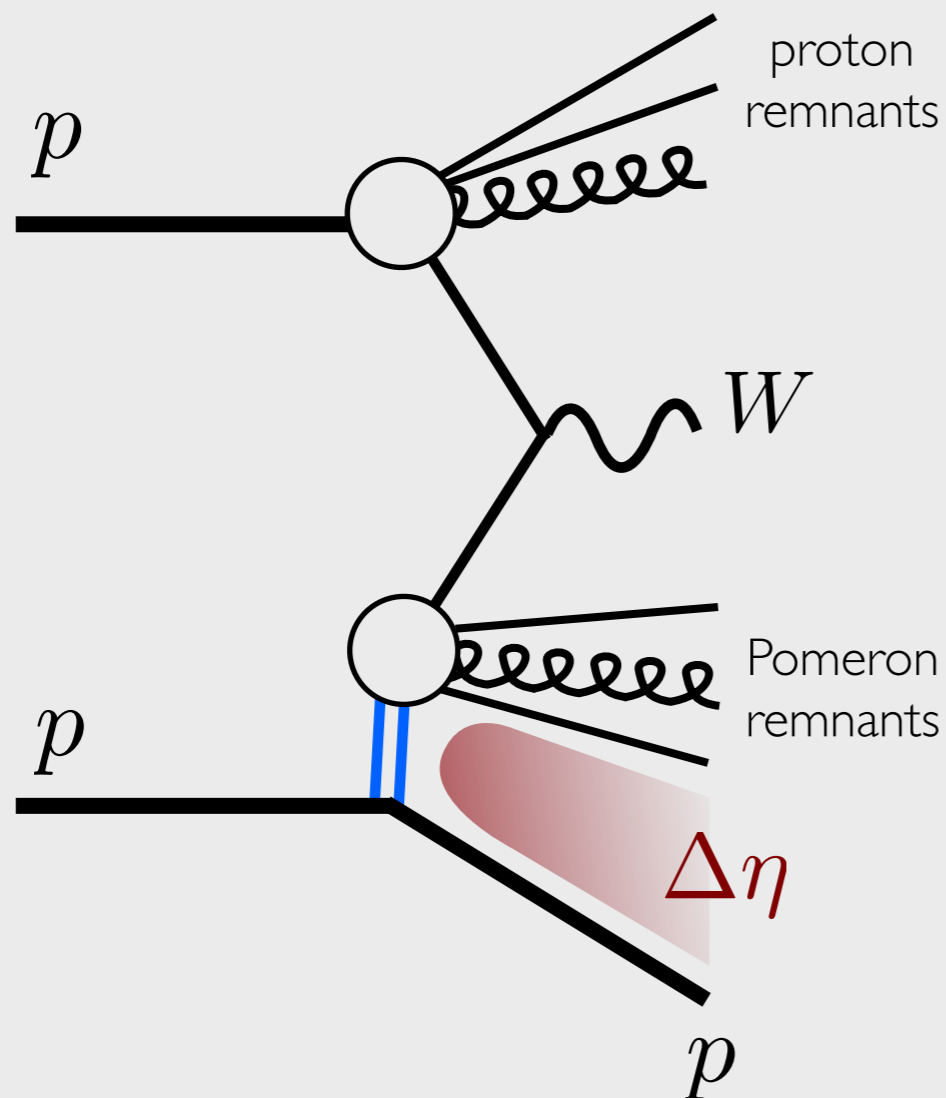
- An(n)abel(le) Chuinard, PhD from McGill University, Montréal
- Previously working in LHCb for my Masters in CH  
CP violation and Charge Asymmetry in  $B^\pm \rightarrow \eta' K^\pm$   
Selection optimization for  $X(3872) \rightarrow J/\psi \pi \pi$
- As joined ATLAS 1 year ago. Now wants to contribute in the Forward Physics group for my thesis!



# SINGLE DIFFRACTIVE W PRODUCTION

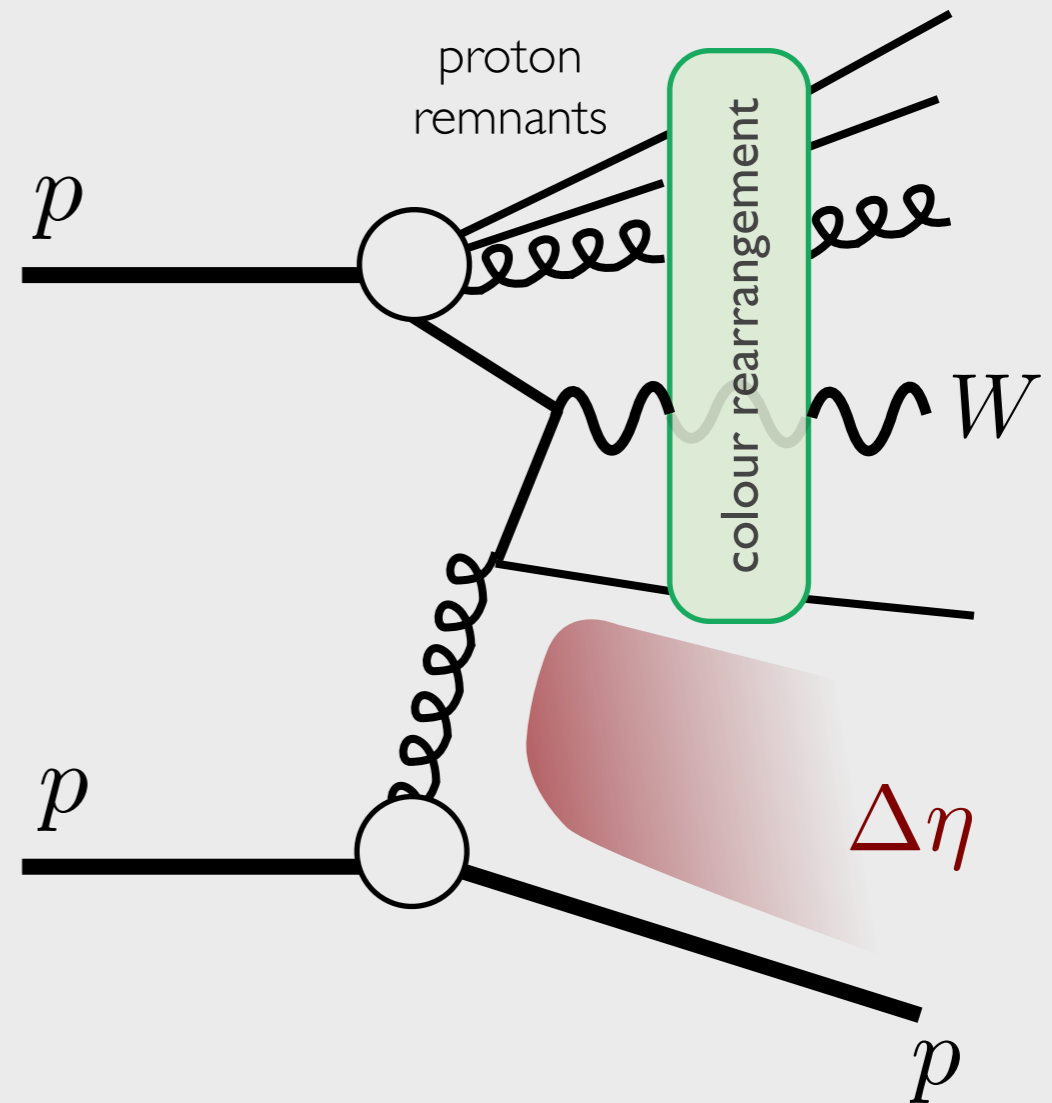


## Single Pomeron Exchange



Interacting quarks coming from **Pomeron**

## Soft Colour Interaction?



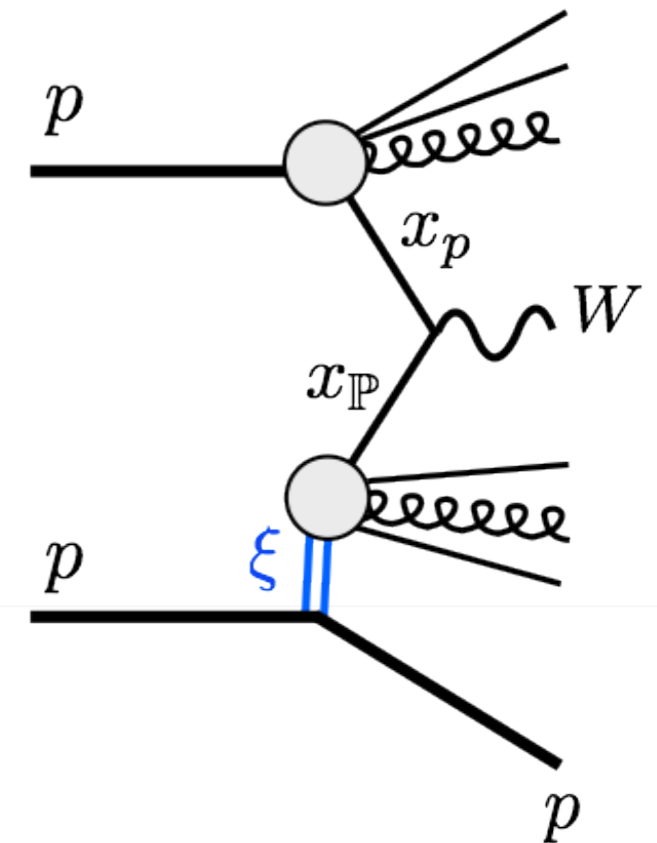
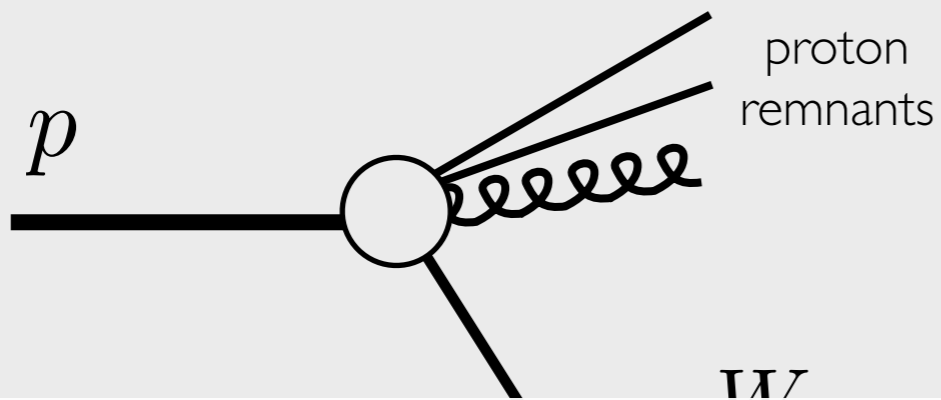
Interacting quarks coming from **proton**



# SINGLE DIFFRACTIVE W PRODUCTION



## Single Pomeron Exchange



Rapidity Gap Survival Probability

Diffractive Pomeron PDF

Non Diffractive Proton PDF

$$d\sigma = S^2 \cdot \Phi_{\mathbb{P}}(\xi, t) \cdot f_{\mathbb{P}}(x_{\mathbb{P}}/\xi, \mu^2) \cdot f_{\text{PDF}}(x_p, \mu^2) \cdot d\sigma_{\text{hard}}(x_{\mathbb{P}}, x_p, \mu^2)$$

Pomeron flux

Pomeron PDF

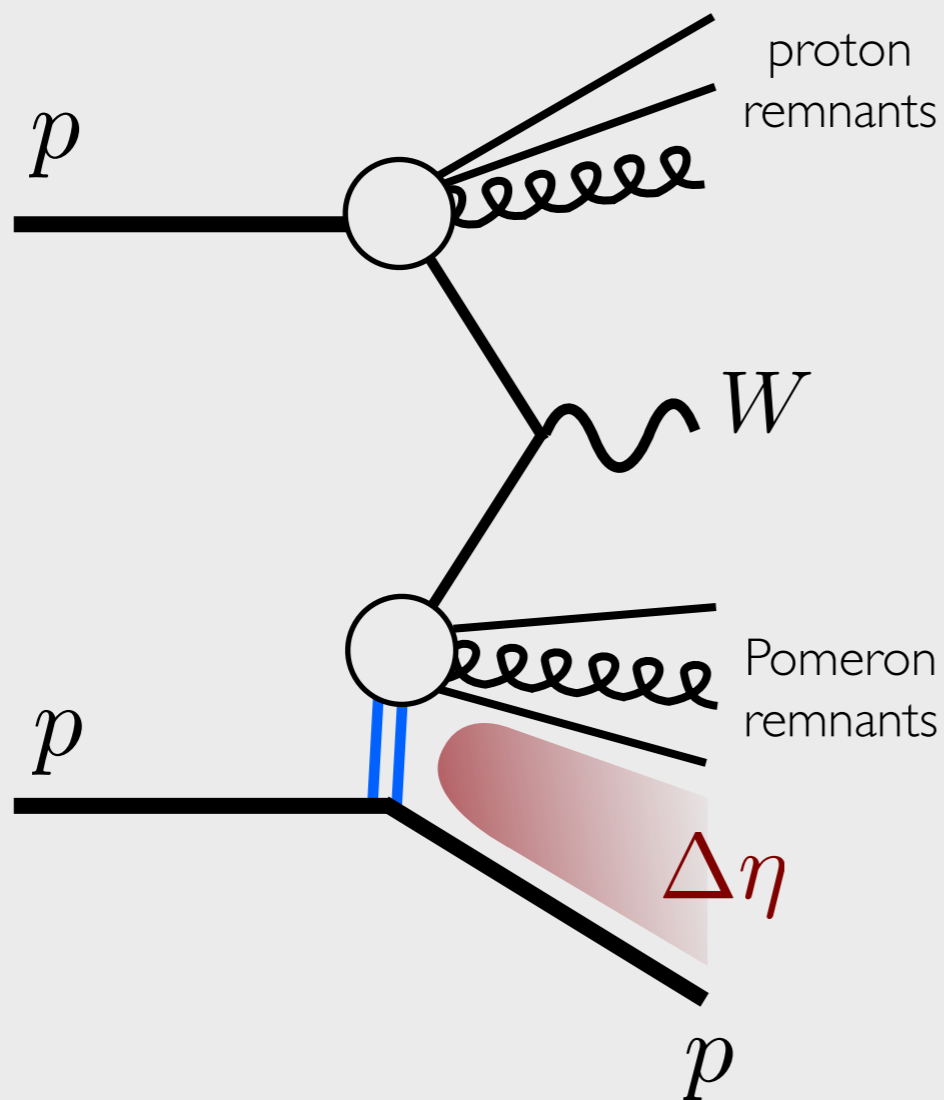
Cross-section for parton-parton hard interaction



# SINGLE DIFFRACTIVE W PRODUCTION

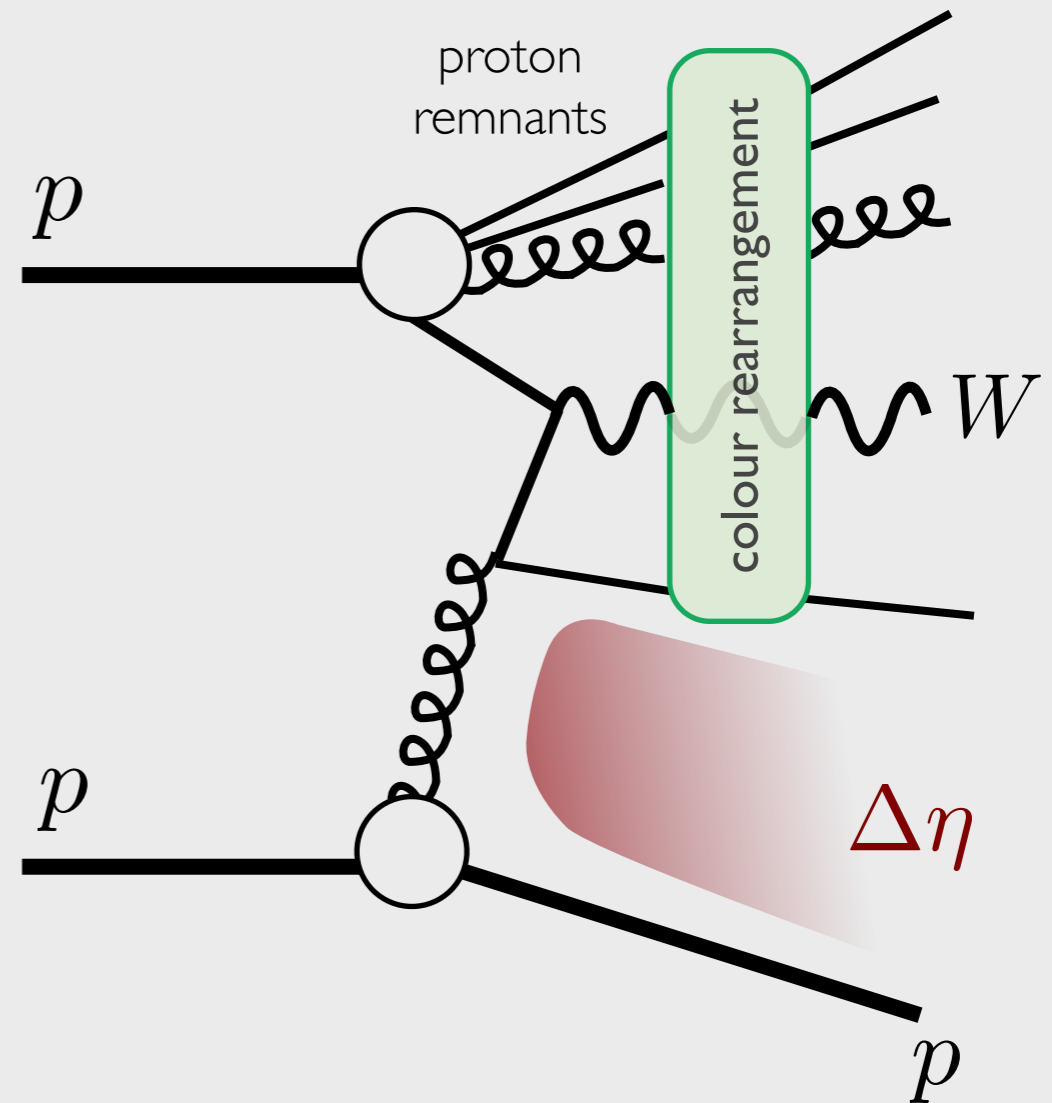


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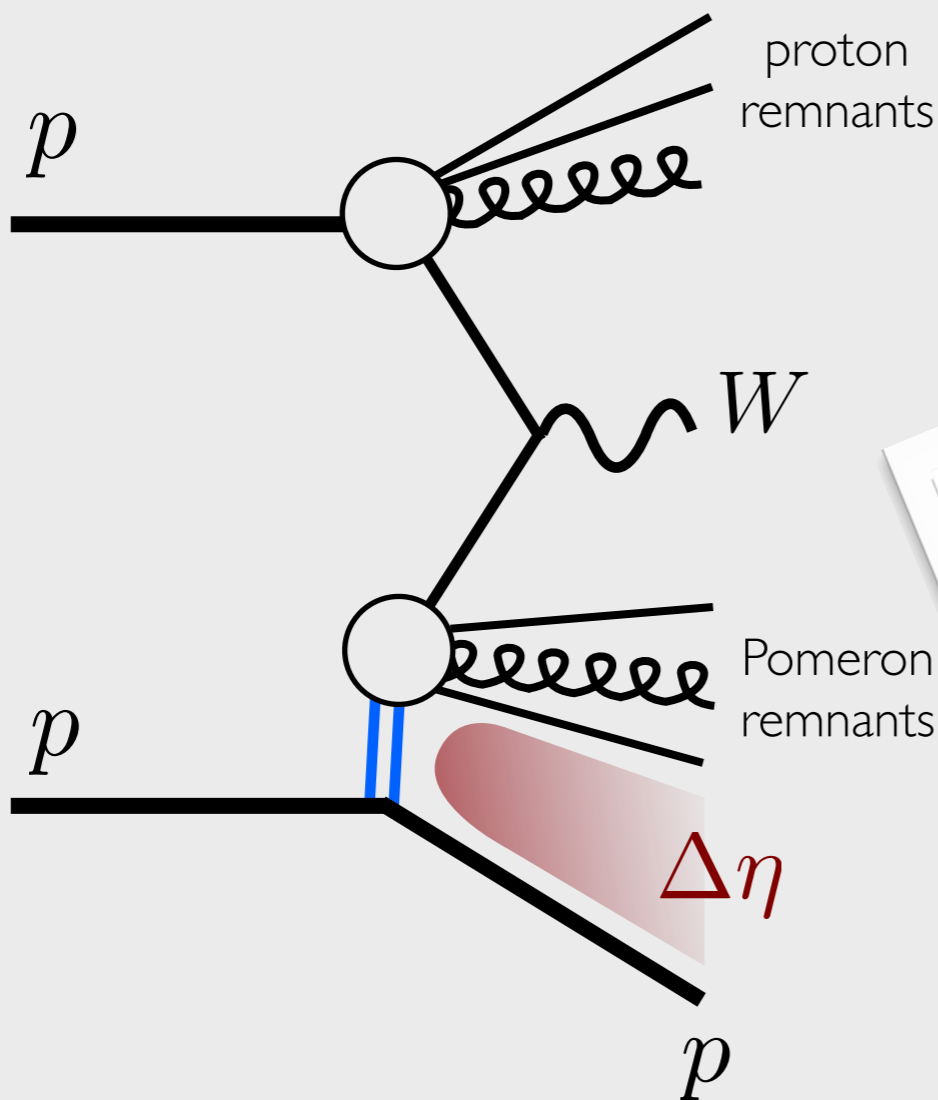
Interacting quarks coming from **proton**



# SINGLE DIFFRACTIVE W PRODUCTION



## Single Pomeron Exchange



Interacting quarks coming from **Pomeron**

## Soft Colour Interaction?



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UNIVERSITET

DOI:10.1103/PhysRevD.87.094017

PHYSICAL REVIEW D 87, 094017 (2013)  
**Diffractive  $W^\pm$  production at hadron colliders as a test of color singlet exchange mechanisms**  
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We revisit diffractive and exclusive  $W^\pm X$  production at hadron colliders in different models for soft color exchanges. The process  $pp \rightarrow p[W^\pm X]p$ , and in particular a  $W^\pm$  charge asymmetry, has been suggested as a way to discriminate diffractive processes as being due to pomeron exchange in Regge phenomenology or QCD-based color reconnection models. Our detailed analysis for leading protons and central  $W^\pm X$  production, including a vanishing  $W^\pm$  charge asymmetry. We demonstrate that soft color exchange models provide a continuous transition from diffractive to inelastic processes and thereby include the intrinsic asymmetry of pomeron models. Such sensitivity also concerns the differential distributions in proton momentum and  $W^\pm$  transverse momentum, which opens possibilities to discriminate between different color reconnection models.

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### I. INTRODUCTION

Diffractive and exclusive processes in quantum chromodynamics (QCD) still remain a theoretically unsolved and intriguing chapter of the Standard Model of particle physics. Considerable progress has been made in recent years by focusing on diffractive hard-scattering processes [1], where a hard scale defines a partonic subprocess which can be calculated perturbatively and used as a well-defined backbone for the poorly understood soft processes that give rise to a leading proton or a large gap in rapidity with no particle production. In such processes the dominating effect is thus caused by soft fluctuations of the gluonic field at large distances, making diffractive observables very sensitive to nonperturbative QCD dynamics and, therefore, providing a tool to explore this unsolved sector of QCD. Considering scales as low as  $\mu_{\text{soft}} \sim \Lambda_{\text{QCD}}$ , individual gluons are not resolved and one should rather consider collective gluon fields, such as those modeled through Pomeron exchange in the Lund hadronization model [2], or even string-like objects, such as those modeled through pomeron exchange using Regge phenomenology initially developed in the pre-QCD era and, on the other hand, models based on soft gluon exchange between hard-scattered partons and beam hadron remnants, which can modify the color topology between the emerging partons resulting in a different final state of hadrons, e.g., with

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rapidity gaps. The latter type of dynamics was first introduced in the soft color interaction (SCI) model [5] and was later developed in various ways such as the generalized area law (GAL) model [6], making the probability for color exchanges dynamical. Many different diffractive hard-scattering processes have been observed experimentally and studied theoretically [7]. Much attention has been given to central Higgs boson production [8], in particular the spectacular Higgs boson production process  $pp \rightarrow pHp$  at the LHC, where the Higgs boson mass might be reconstructed from a measurement of the leading proton momenta [9,10]. However, the estimated cross section is small and has a substantial uncertainty due to its dependence on soft QCD dynamics [11].

On the experimental side, both the CDF and D0 collaborations at the Fermilab Tevatron have reported the measurement of several different diffractive processes [12–15]. There are also some first results from the CMS experiment at the LHC [16,17]. Of special interest here is the diffractive gauge boson production for which the CDF experiment recently reported results based on the forward spectrometer to detect leading antiprotons [18]. Compared to measurements based on rapidity gaps, this has the advantage of a much smaller dependence on the gap survival and gap acceptance factors, resulting in more stringent tests of diffractive models.

On the theoretical side, the diffractive production of gauge bosons has also received attention [19,20] due to a rather high sensitivity to the production mechanism and at the same time a large enough cross section to be experimentally observed and studied in detail. The intricate mechanism of QCD factorization breaking in diffractive Drell-Yan and  $W, Z$  production [21] enhances the interest for these kinds of processes.

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Color Interactions and Diffractive Hard Scattering at the Fermilab Tevatron

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### Abstract

nonperturbative QCD can be obtained by the interaction models. Their essence is the variety, giving a unified description of final states diffractive and nondiffractive events in  $ep$  (law model) applied to  $p\bar{p}$ , considering event including beam particle remnants, we find a good description also and jets in diffractive events or two rapidity gaps in the conditions for diffractive  $J/\psi$  production reduces both a gap and a color interaction approach action, and some possible different approaches are

EVTeX



# W Charge Asymmetry to test the Pomeron Model

$$\mathcal{A} = \frac{N^+ - N^-}{N^+ + N^-}$$

Systematic errors cancel out

$N^+$ : number of  $W^+$  (related to the differential cross-section of prod. of  $W^+$ )

$N^-$ : ....

$$\frac{d\sigma_{W^+}}{dyd\xi} \propto (u(x_p) + \bar{d}(x_p)) \cdot f_{\mathbb{P}}(x_{\mathbb{P}}/\xi)$$

$$\frac{d\sigma_{W^-}}{dyd\xi} \propto (d(x_p) + \bar{u}(x_p)) \cdot f_{\mathbb{P}}(x_{\mathbb{P}}/\xi)$$

## if Single Pomeron Exchange...

Probe the flavour content of the Pomeron.

$$\text{If } \left. \begin{array}{l} u^D = \bar{u}^D \\ d^D = \bar{d}^D \\ s^D = \bar{s}^D \end{array} \right\} \mathcal{A} = 0$$

Other scenarios (compatible with HERA):

$$\left. \begin{array}{l} u^D/d^D = 2 \\ u^D/d^D = 0.5 \end{array} \right\} \mathcal{A} \neq 0$$

## if Soft Colour Interaction...

Diffraction structure happens after hard W production.

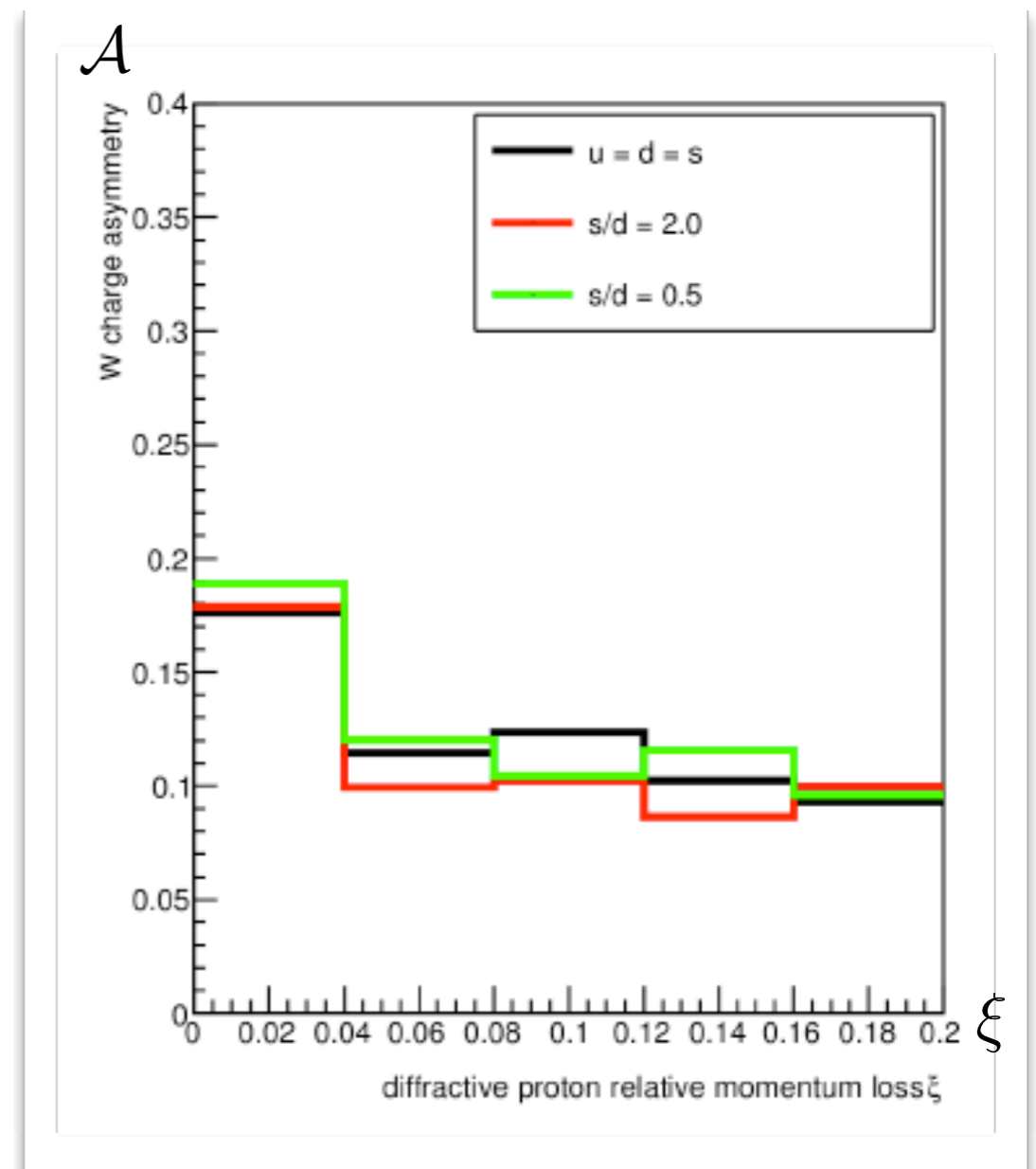
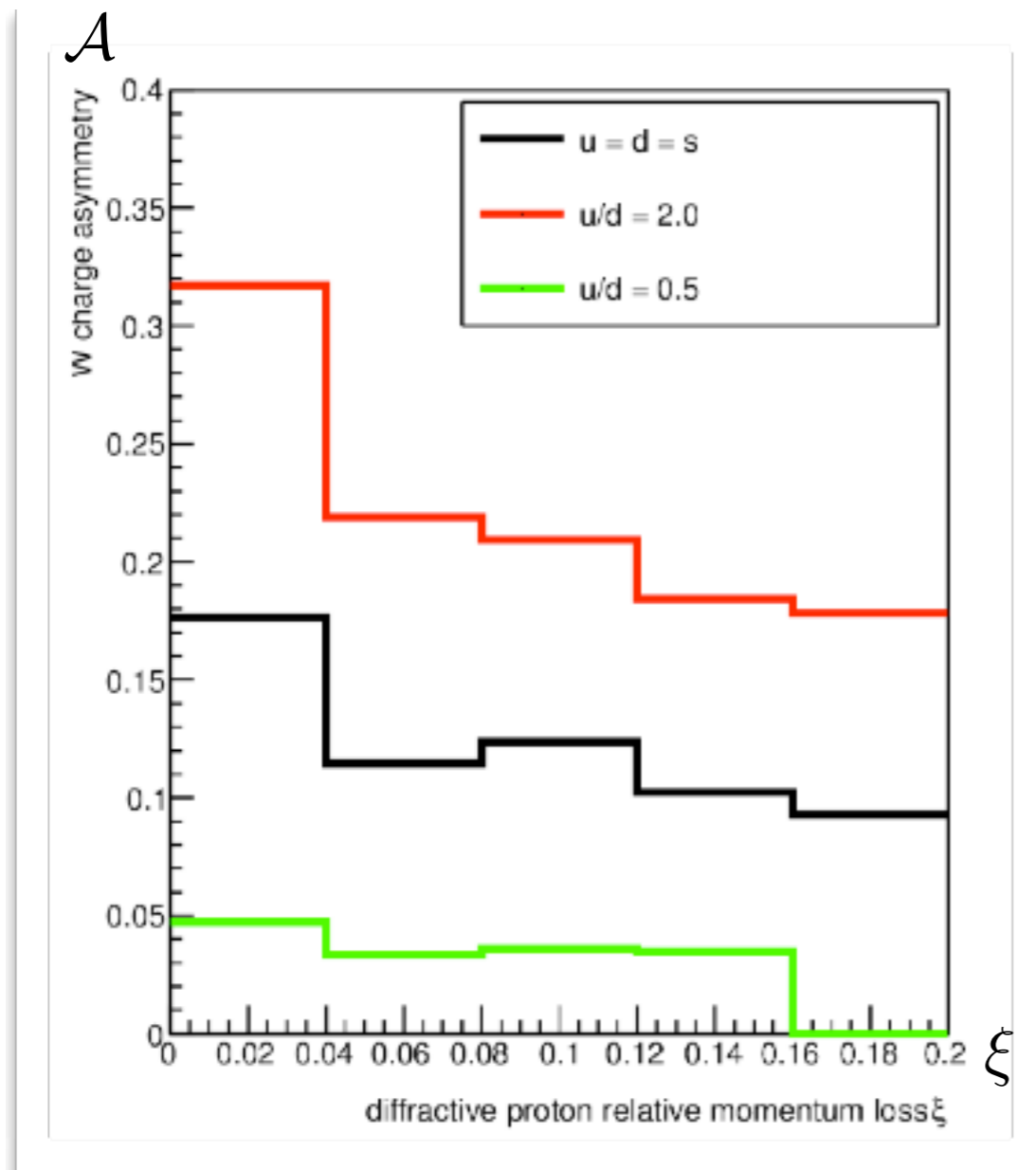
➔ Should get the same value as for non-diffractive processes

$$\mathcal{A} \neq 0 \qquad \mathcal{A} \approx A_{ND}$$



# W Charge Asymmetry to test the Pomeron Model

Sensitivity to Pomeron DPDFS to be tested with FPMC:







## Challenges and perspectives

### Experimentally...

- Rapidity Gap measurement (statistical fluctuations in ND events)
- Pile-up: need to be handled
- QCD background from ND (polluting minimum bias observed in calorimeters)
  - ➔ Need good vertex reconstruction
  - ➔ Careful selection
  - ➔ Need proton tagging and tof (AFP)

### On the theory side...

- No universal model for Pomeron
  - ➔ Need to understand Pomeron parton densities