

The study of diffractive charged current ep interactions

bachelor thesis

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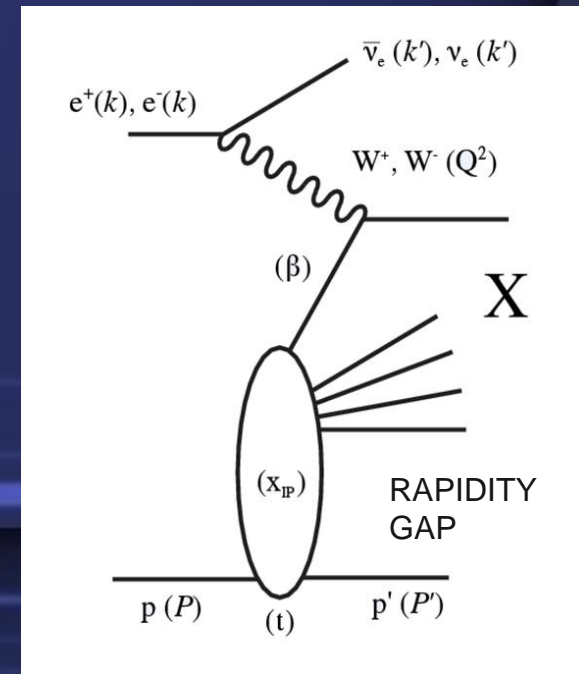
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Motivation and goals of the study

- The study of diffractive charged current $e^\pm p$ DIS is important for understanding the diffraction processes
- Up to now there is only one **published** measurement done by H1 experiment at HERA
- The goal of this study is to examine the possibility to analyze these interactions via future LHeC collider

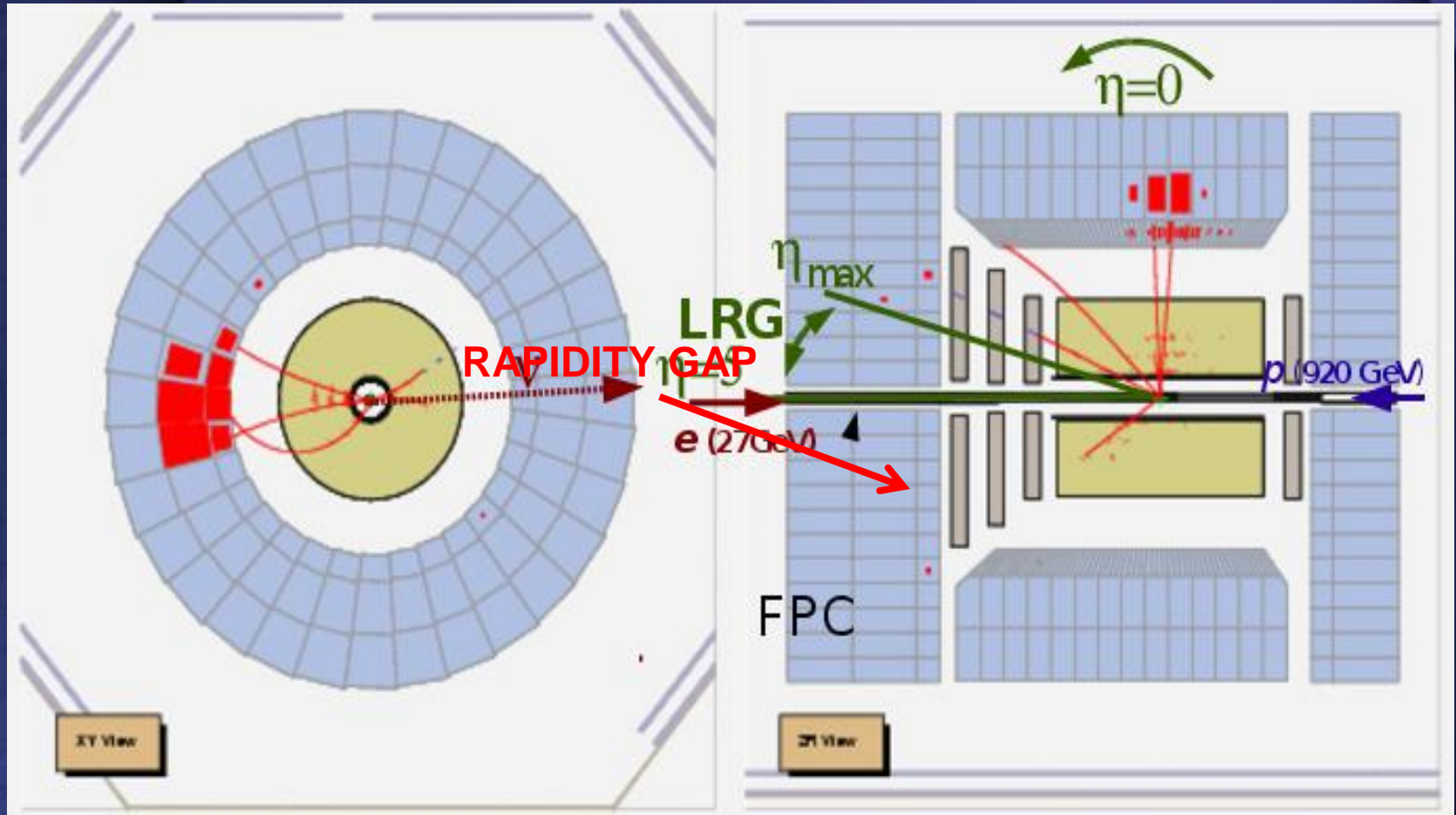
Diffractive charged current (CC) $e^\pm p$ deep inelastic scattering

- In charged current $e^\pm p$ DIS W^\pm bosons are exchanged
- The identity of proton remains unchanged and electron (positron) changes to electron neutrino (antineutrino)
- Experimental signature of diffractive CC events:
 1. Directly measured leading proton or gap in rapidity between the leading proton and the hadronic system
 2. The missing transverse momentum due to the presence of unmeasurable neutrino



- Diffractive CC e

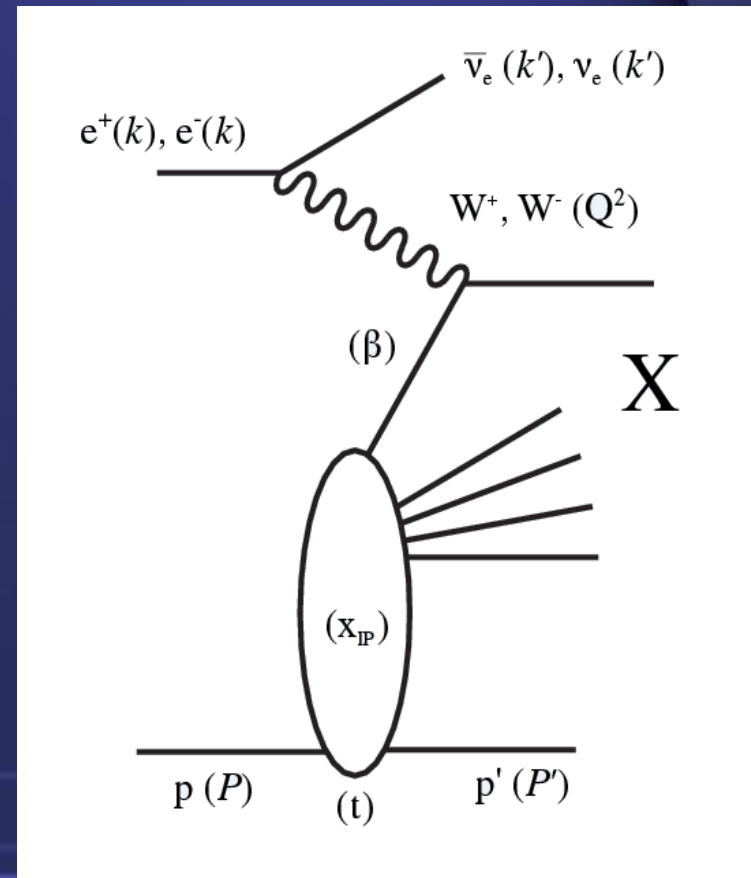
DIS event in the ZEUS detector



Julian Rautenberg, Diffraction 2004, Cala Gonone

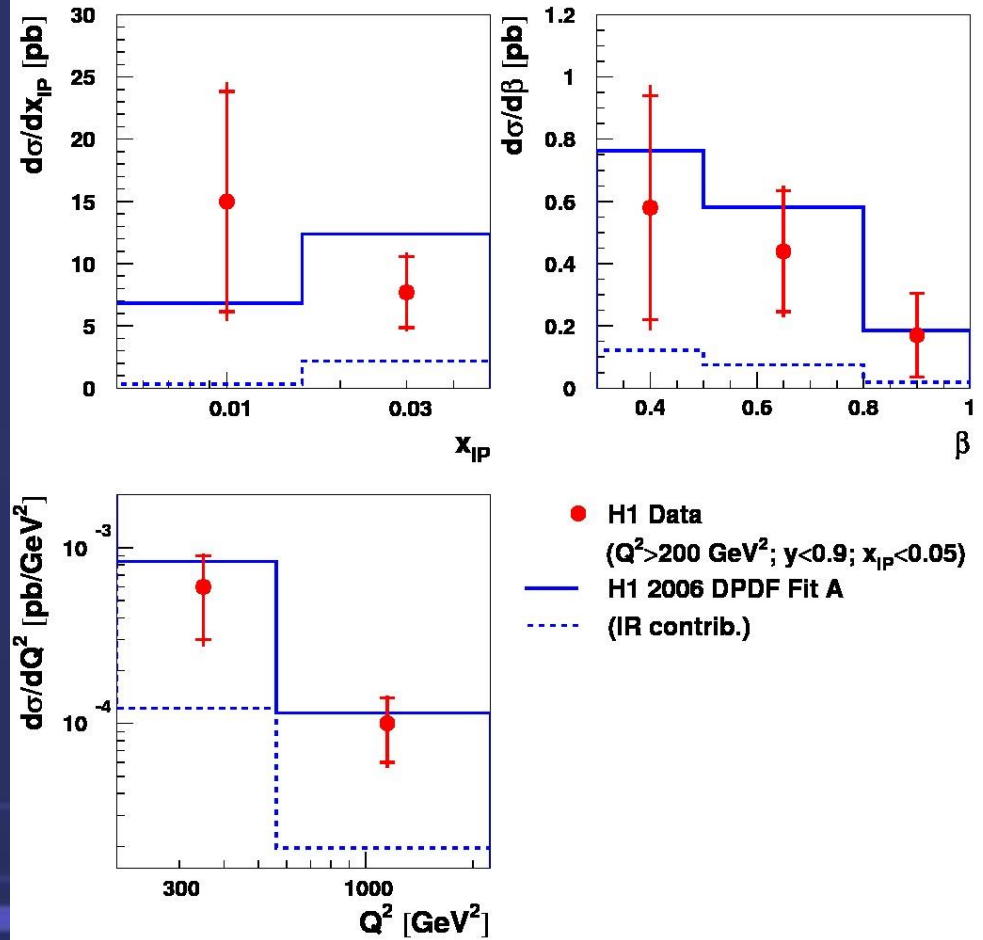
Kinematic variables

- $Q^2 = -q^2$, $q = k - k'$
(negative electron four-momentum transfer squared)
- $x_{\text{IP}} = q(P - P') / qP$
(fraction of proton's momentum carried by the diffractive exchange (pomeron, reggeon))
- $\beta = Q^2 / 2q(P - P')$
(fraction of exchanged object's momentum carried by the struck quark)
- $y = Pq / Pk$
(inelasticity of the scattering process)
- $t = (P - P')^2$
(proton four-momentum transfer squared)



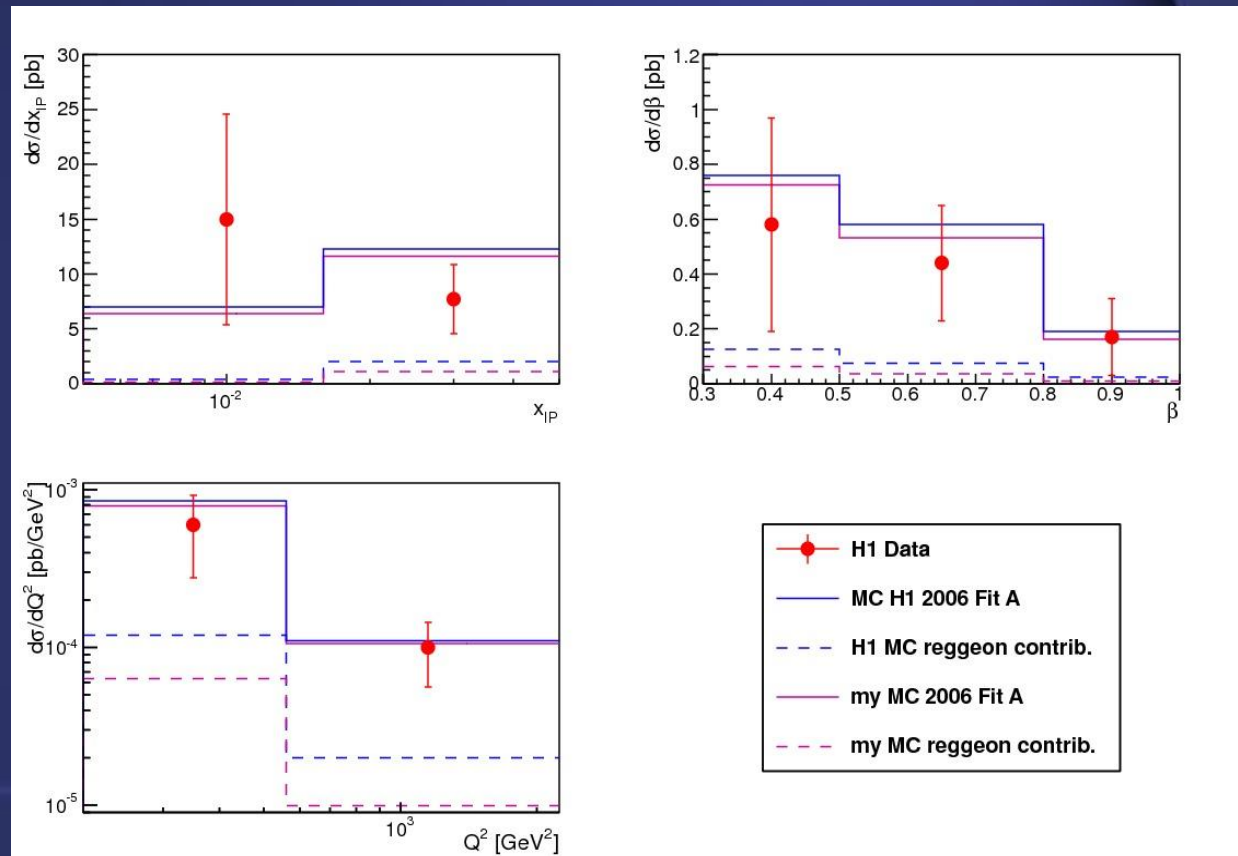
HERA (H1 experiment)

- H1 Collaboration Collaboration, A. Aktas et al., "Measurement and QCD analysis of the diffractive deep-inelastic scattering cross-section at HERA," Eur.Phys.J. C48 (2006) 715–748
- Kinematic region
 $E_e = 27.5 \text{ GeV}$, $E_p = 920 \text{ GeV}$,
 $Q^2 > 200 \text{ GeV}^2$, $y < 0.9$,
 $x_{\text{IP}} < 0.05$, $|t| < 1 \text{ GeV}^2$
- Data are in agreement with the MC RAPGAP predictions, but due to the small statistics any definite conclusions cannot be made



Test of RAPGAP – H1 layout

- MC RAPGAP was tested on reproducing published H1 simulation
- Pomeron contributions were reproduced successfully
- Reggeon contributions are negligible
- In spite of not knowing the exact parameters in RAPGAP steering file, simulations are in a good agreement



Selection of the kinematic region for LHeC

- $E_e = 60 \text{ GeV}$, $E_p = 7 \text{ TeV}$
- $8^\circ < \theta_h < 172^\circ$
- $p_{T\text{miss}} > 20 \text{ GeV}$

(θ_h - angle of hadronic system in respect to incoming proton,

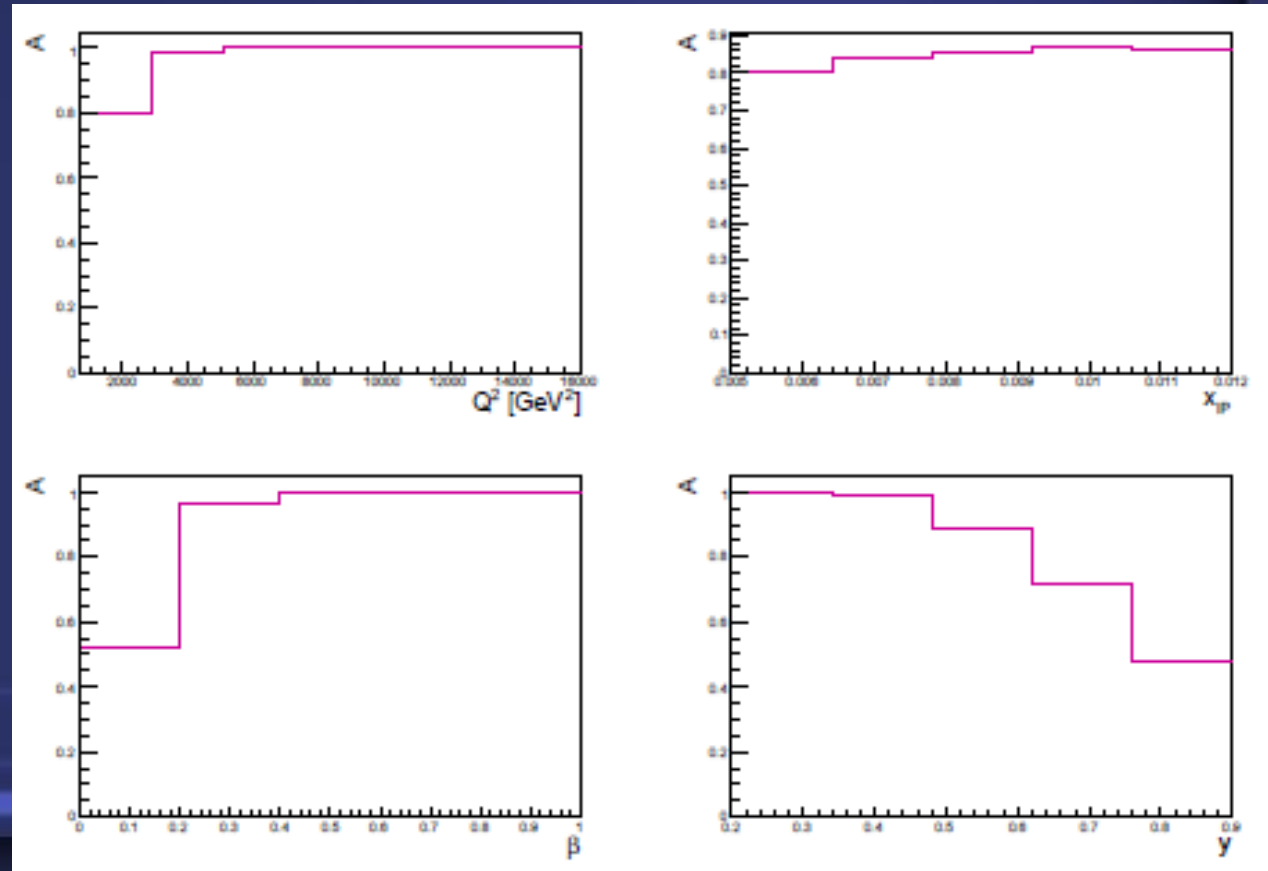
$p_{T\text{miss}}$ - transverse momentum of hadronic system)

→ to achieve reliable event efficiency



- $Q^2 > 700 \text{ GeV}^2$
- $0.2 < y < 0.9$

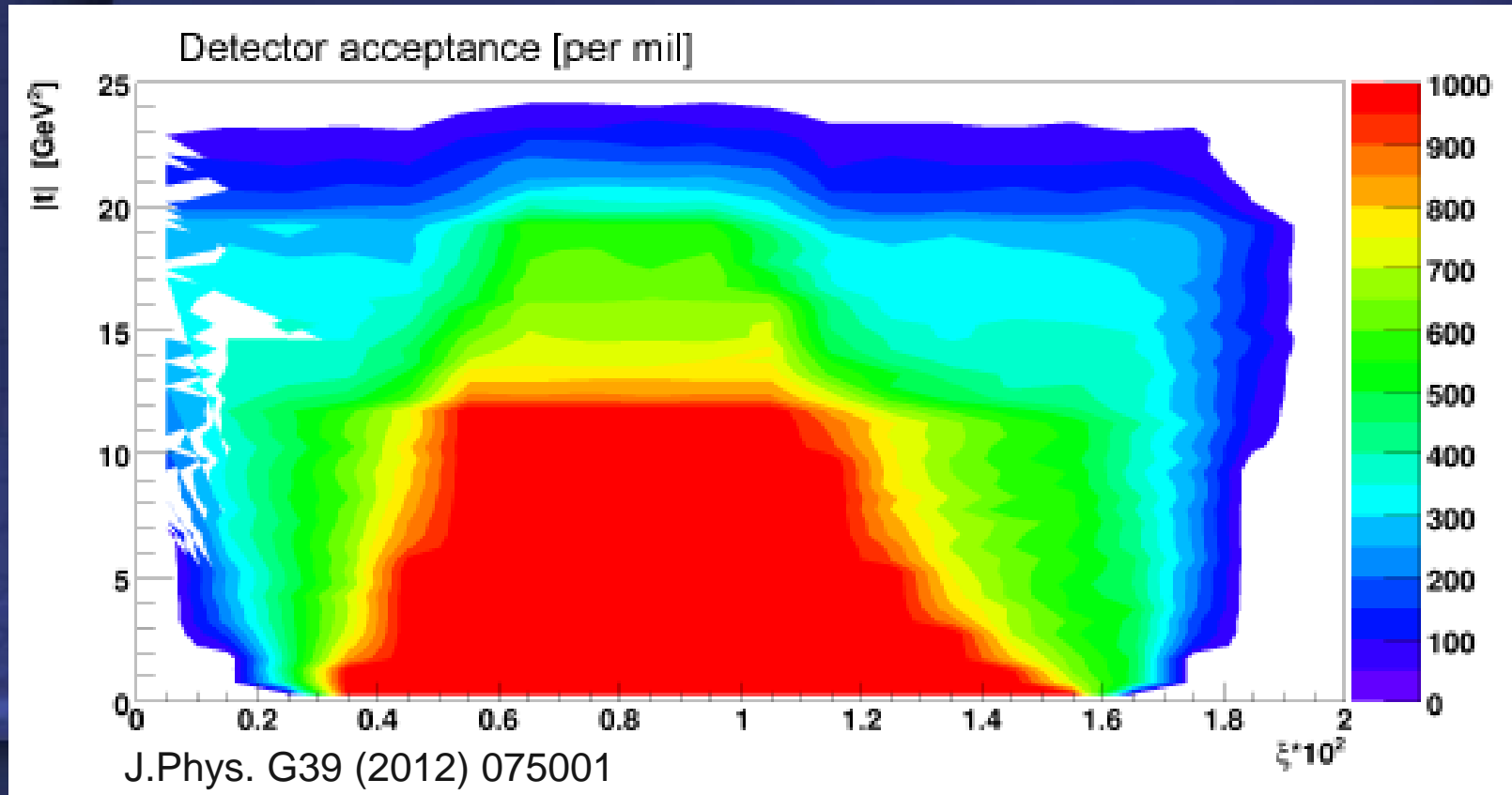
- Events selection efficiency A



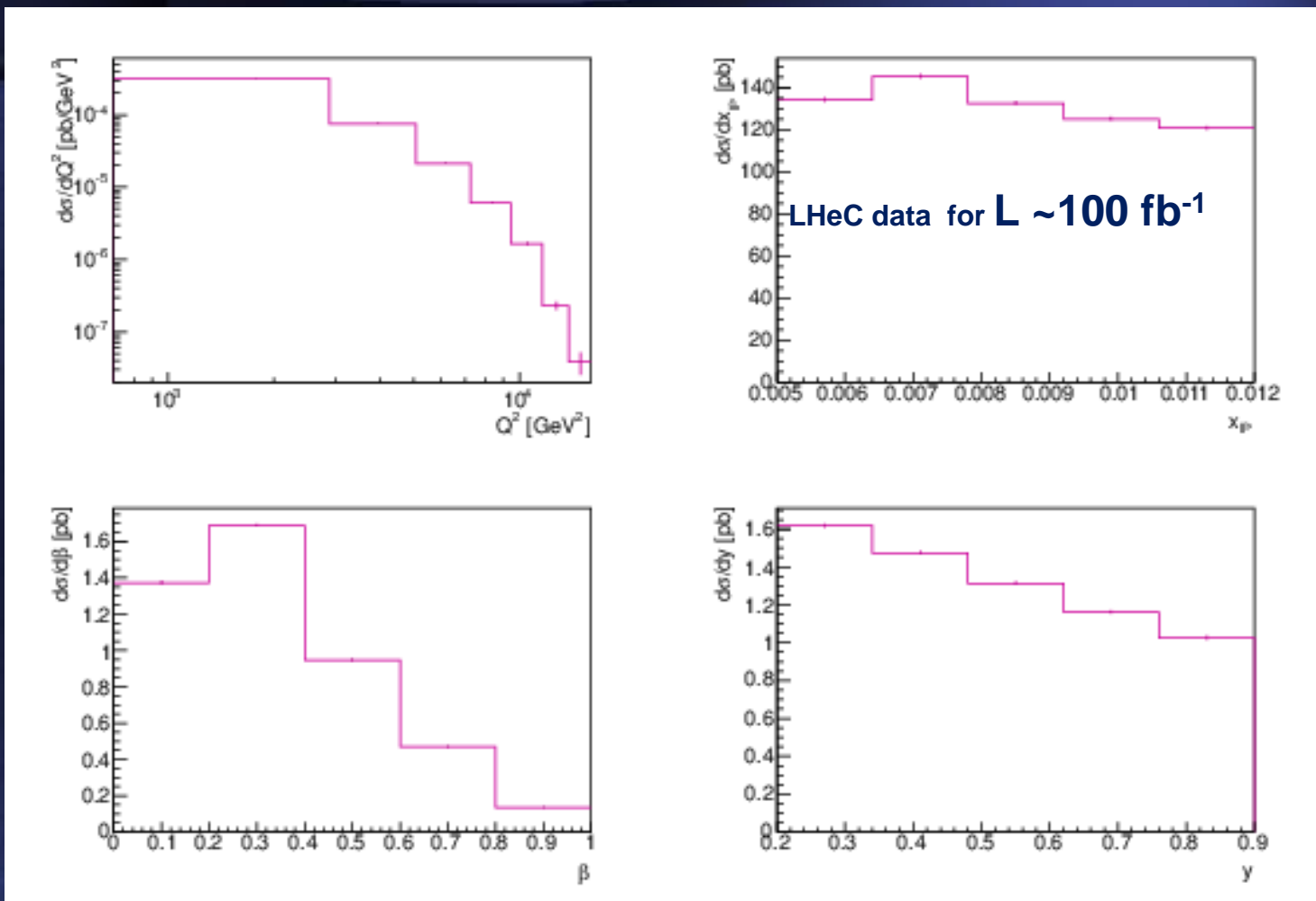
Selection of the kinematic region for LHeC

Additional cuts stemming from the proton detector acceptance

- $0.005 < x_{\text{IP}} < 0.012$, $|t| < 13 \text{ GeV}^2$



LHeC – RAPGAP prediction



- Kinematic region $Q^2 > 700 \text{ GeV}^2$, $0.2 < y < 0.9$, $|t| < 13 \text{ GeV}^2$, $0.005 < x_{\text{IP}} < 0.012$
- Reggeon contribution negligible
- NO CORRECTIONS FOR DETECTOR ACCEPTANCE AND RESOLUTION

HERA – H1

- MC RAPGAP diffractive CC DIS cross section $\sigma \sim 340 \text{ fb}$
- For integrated luminosity 61.6 pb^{-1} ~ 20 diffractive CC DIS events were expected
- Actually **10** diffractive CC DIS events were found and analyzed

LHeC

- MC RAPGAP diffractive CC DIS cross section $\sigma = 923 \pm 1 \text{ fb}$
- For considered integrated luminosity 100 fb^{-1} ~ 78000 diffractive CC DIS events are expected

Conclusions

- Monte Carlo model RAPGAP was tested on the simulation of H1 experiment and used for the simulation of diffractive CC DIS processes in the experimental conditions of LHeC
- For the LHeC configuration in the chosen kinematic region there were predicted ~ 78000 diffractive charged current DIS interactions ($L \sim 100 \text{ fb}^{-1}$)
- This enables to study diffractive CC DIS in a more detailed way than previously