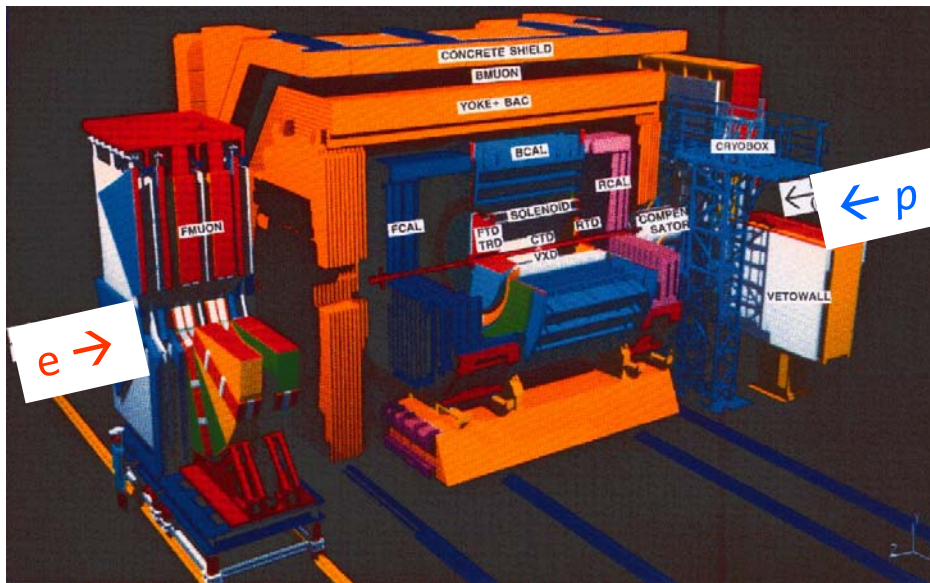


# Strange particle production at HERA

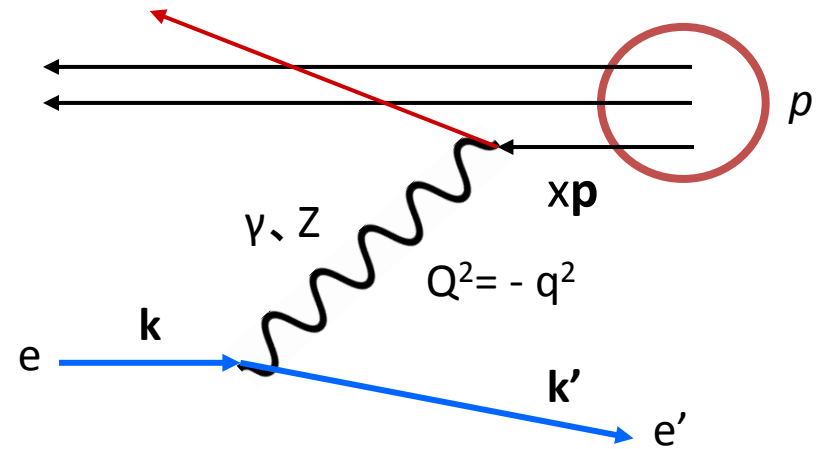


Ryuma Hori (KEK)  
on behalf of ZEUS collaboration

# $ep$ collision at HERA



- HERA at Hamburg
- HERA-II Run (2003-2007)
  - $E_p = 920\text{ GeV}$
  - $E_e = 27.5\text{ GeV}$
  - $\sqrt{s} = 318\text{ GeV}$
  - total luminosity  $\sim 0.4\text{ fb}^{-1}$

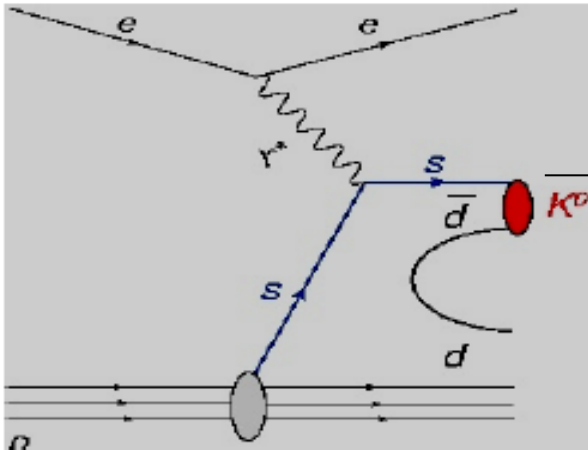


- DIS kinematical variable
  - $Q^2 = -q^2$ : square of 4-momentum transfer
  - $x$ : fraction of  $p$  momentum carried by quark
  - $y$ : inelasticity parameter
- DIS event selection in this analysis
  - $Q^2 > 10\text{ GeV}^2$
  - $E_e > 10\text{ GeV}$
  - $35 < E - P_z < 65\text{ GeV}$
  - $|Z_{\text{vertex}}| < 50\text{ cm}$

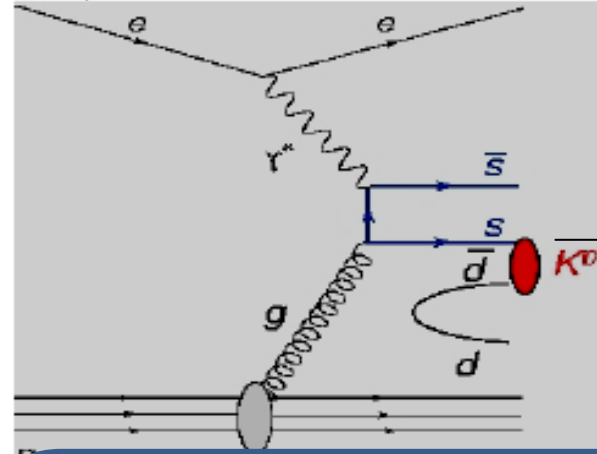
# Strange production mechanisms of HERA

The main processes of strange quark production.

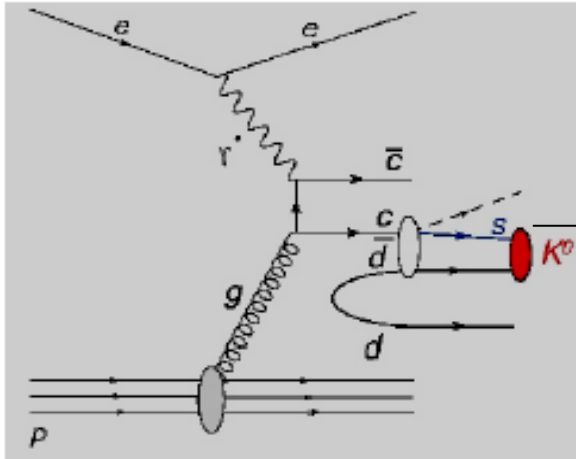
a) QPM, sea quark scattering



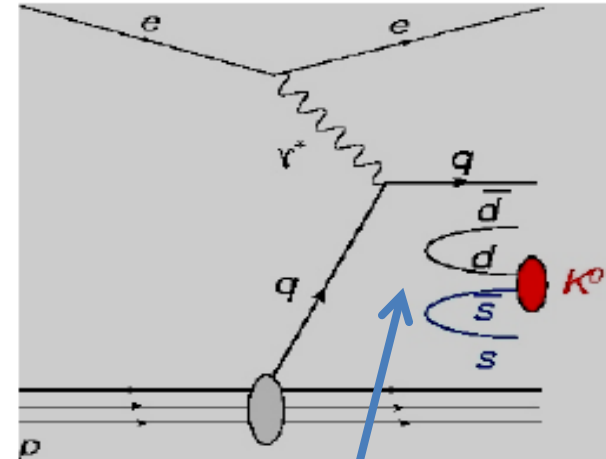
b) Boson-Gluon Fusion



c) Heavy quark decay



d) Hadronization



Fragmentation

# Motivation

Strange hadron productions in  $ep$  collisions are not yet well understood.

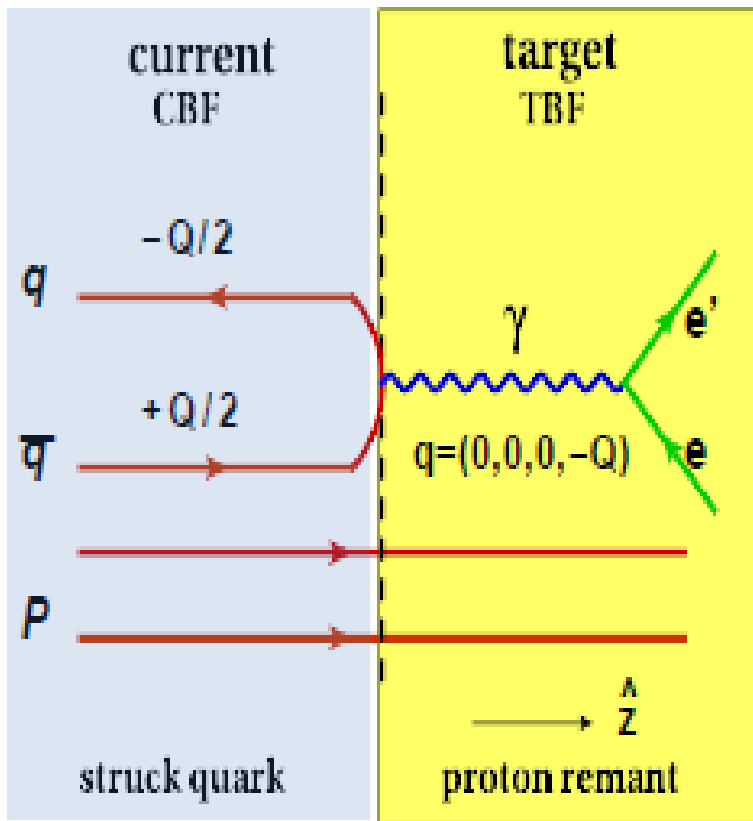
- Is quark fragmentation function (FF) universal?
- Do Next Leading Order (NLO) QCD calculations describe the HERA data?

→ We need HERA-II measurements

Results shown in this talk

- Scaled momentum distribution for  $K^0$ s and  $\Lambda$  (ZEUS)  
 $10 < Q^2 < 40000 \text{ GeV}^2$  HERA II;  
Preliminary results , ZEUS-prel-10-013
- The measurements were performed in the current fragmentation region of the Breit frame.

# Breit frame



- In the Breit frame, struck quark (current region) and proton remnant (target region) are separated.

-Current region is analogous to single hemisphere  $e+e^-$  annihilation.

- Fragmentation studies are based on scaled momentum( $x^p$ ) distribution:

$$x^p = 2p^{\text{Breit}}/Q$$

# Outline

- Comparison of  $K^0$ s and  $\Lambda$  production with NLO QCD calculations + fragmentation functions (FF).

$$\frac{d\sigma}{dx_p} = f(x, Q^2) \otimes \sigma(Q^2) \otimes D(z, Q^2)$$

$f(x, Q^2)$ : parton density function  
 $\sigma(Q^2)$ : cross section of hard-scattering process  
 $D(z, Q^2)$ : FF

Two different FFs are compared with the data.

AKK05+CYCLOPS (for  $K^0$ s and  $\Lambda$ )

S. Albino, B.A. Kniehl, G. Kramer, Nucl. Phys. B 725 (2005) 181

S. Albino, B.A. Kniehl, G. Kramer, Nucl. Phys. B 734 (2006) 50

FFs were obtained from fits to  $e+e^-$  data.

hadrons mass effect was included in small  $x_p$  and  $Q^2$ .

DSS (for  $K^0$ s)

D. de Florian, R. Sassot, M. Stratmann Phys. Rev. D75 (2007) 114010.

FFs were obtained from fits to  $lp$  and  $pp$  data.

no hadrons mass corrections.

# Measurement

## Luminosity

- 290pb<sup>-1</sup> (2005 and 2006-7 data)

## Kinematical Range

- 10 < Q<sup>2</sup> < 40000GeV<sup>2</sup>
- 0.001 < x < 0.75

K<sup>0</sup>s and  $\Lambda$  are selected by tracking.

Scaled momentum distribution is defined as:

$$\frac{1}{N} \left( \frac{n_h}{\Delta x_p} \right) \quad h = K_s^0, \Lambda \quad \Rightarrow D(z, Q^2)$$

N: total number of the hadron

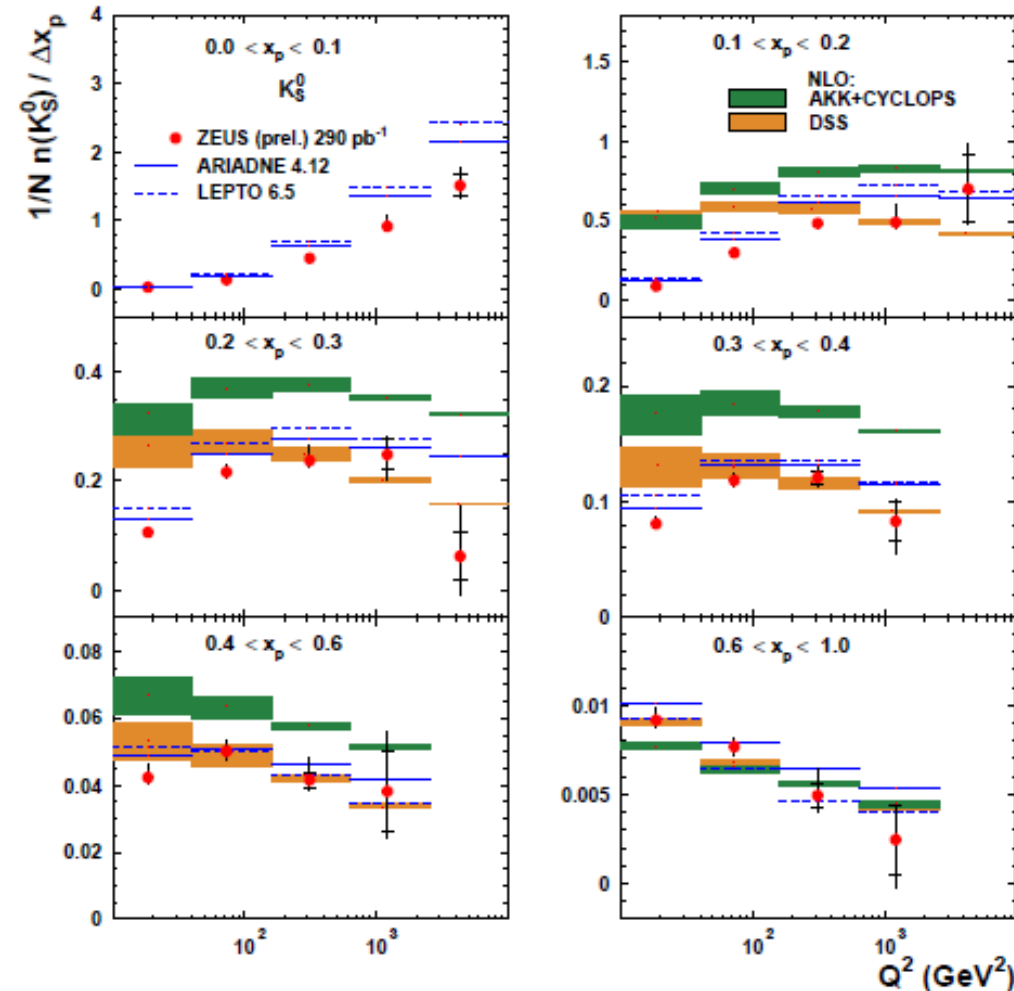
n: number of the hadron in  $\Delta x_p$

$\Delta x_p$ :  $x_p$  bin

# Scaled momentum distributions: $K^0$ s

**ZEUS** ZEUS Preliminary results

Current region of Breit frame



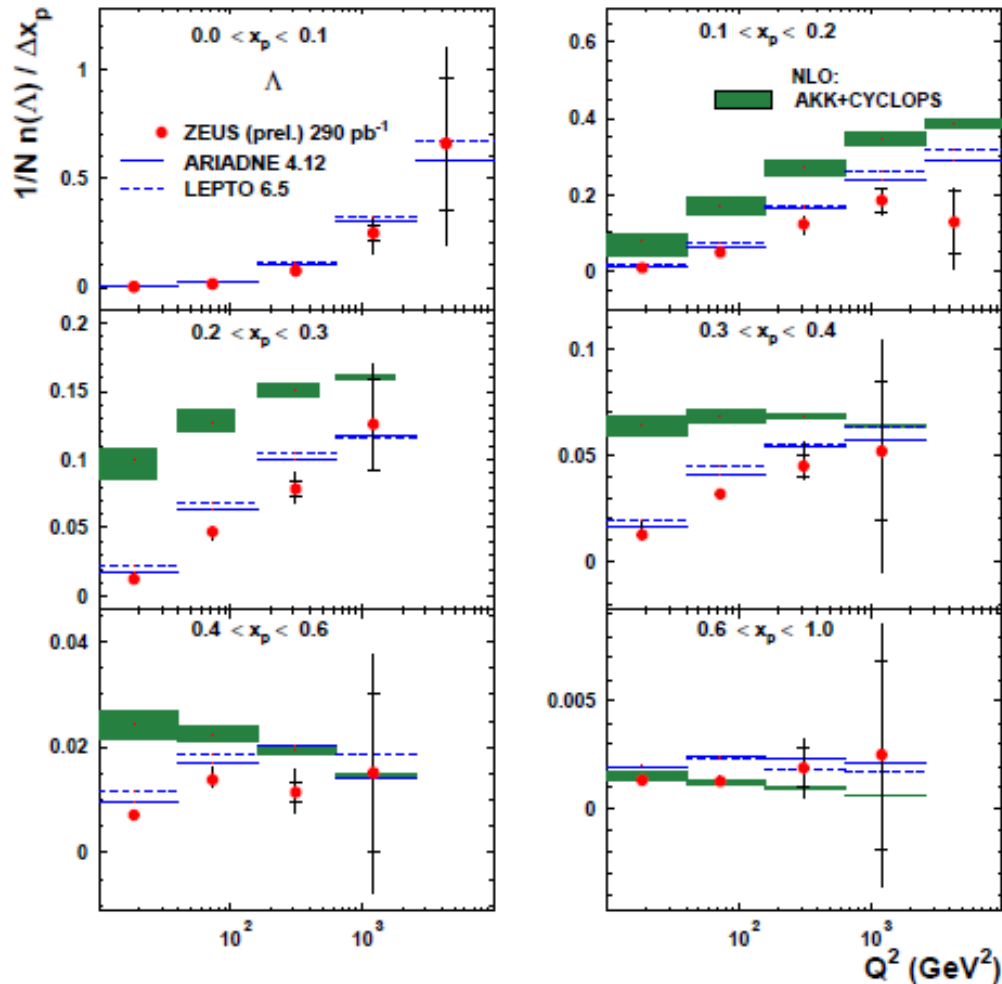
- Scaling violations are observed.
- MC (ARIADNE, LEPTO) can describe the data in full space.
- None of calculations can describe the measured  $x_p$  dependence
  - DSS gives a good description of the data for  $x_p > 0.3$  and  $20 < Q^2 < 40000 \text{ GeV}^2$ .
  - AKK+CYCLOPS is much higher at lower  $x_p$ . But shape is better.  $\leq$ include mass effect.



# Scaled momentum distributions: $\Lambda$

ZEUS Preliminary results

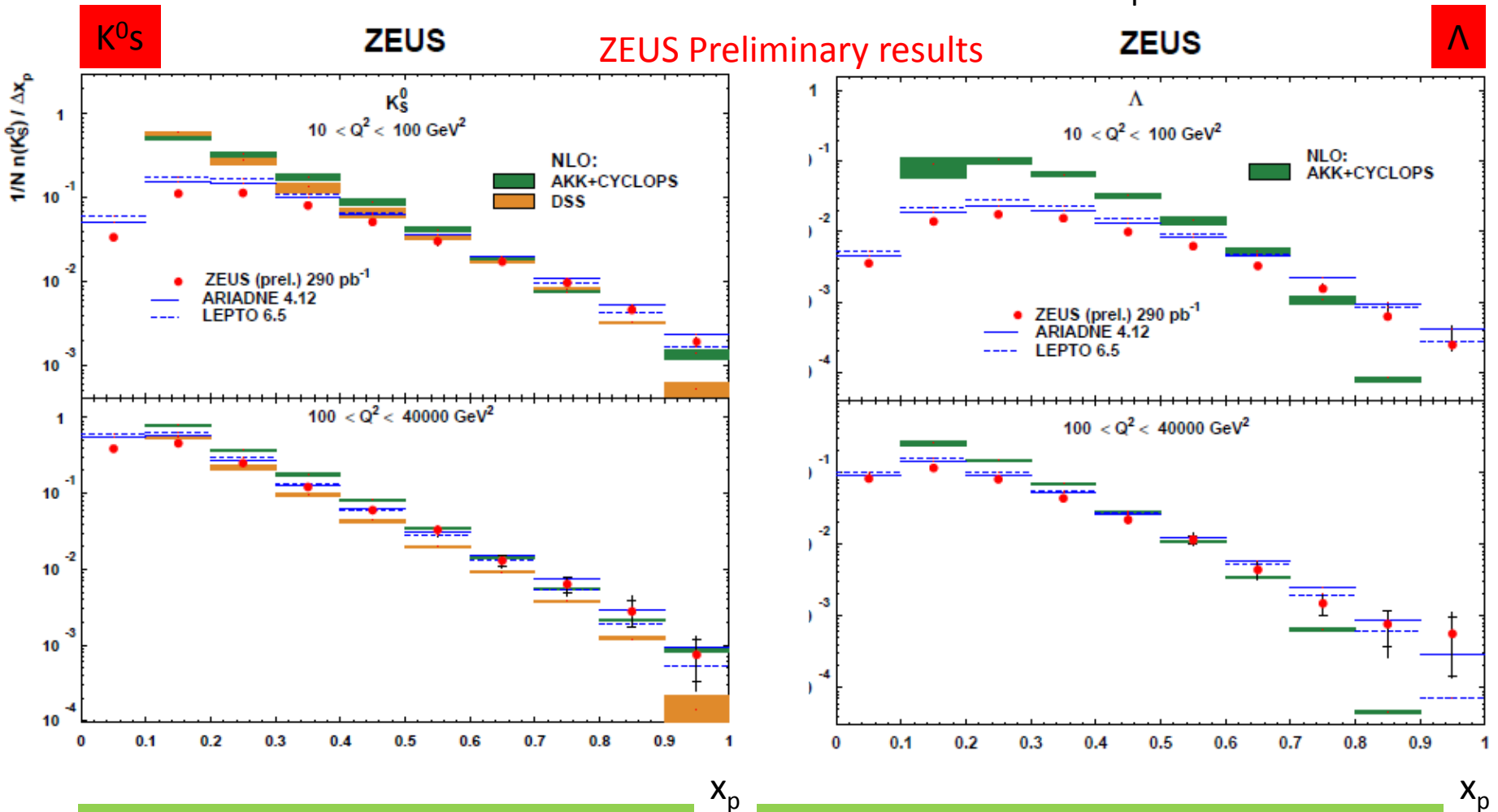
ZEUS



Current region of Breit frame

- Scaling violations are observed.
- MC (ARIADNE, LEPTO) describe the data in most parts of phase space.
- AKK+CYCLOPS does not describe the data  $x_p < 0.6$ .
  - $0.3 < x_p < 0.6$ : different shape

# Scaled momentum distributions( $K^0_s, \Lambda$ ) in low and high $Q^2$ as function of $x_p$



- MCs describe the data in all phase space.
- Description of NLO QCD calculations(AKK+CYCLOPS, DSS) become better at high  $Q^2$  and high  $x_p$ .

# Summary

- Scaled momentum distributions ( $K^0$ s,  $\Lambda$ ) clearly show the scaling violation.
- MC(LO) calculations (LEPTO and ARIADNE) describe well agreement in all phase space.
- NLO QCD calculations with 2 different theoretical approaches (AKK+CYCLOPS and DSS) can describe the data in certain regions of the phase space, but not perfectly.
- We hope that ZEUS results will be useful to constrain the theoretical uncertainties in a description of the strange hadrons.