

# Strangeness Production in Deep Inelastic scattering at HERA

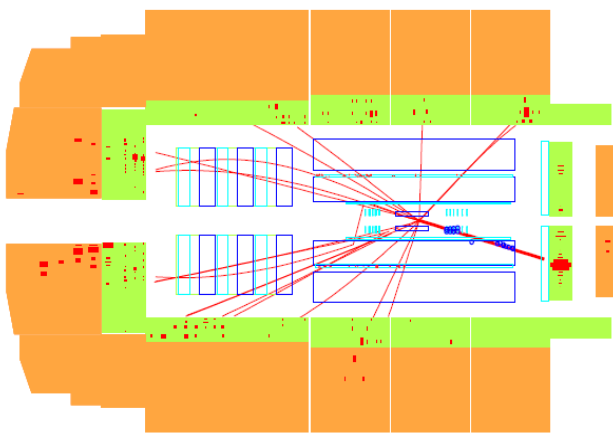
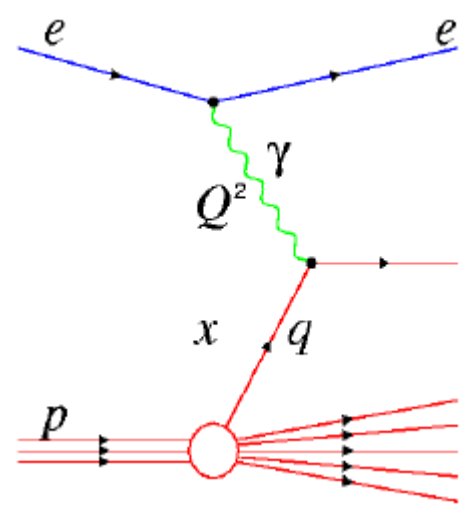
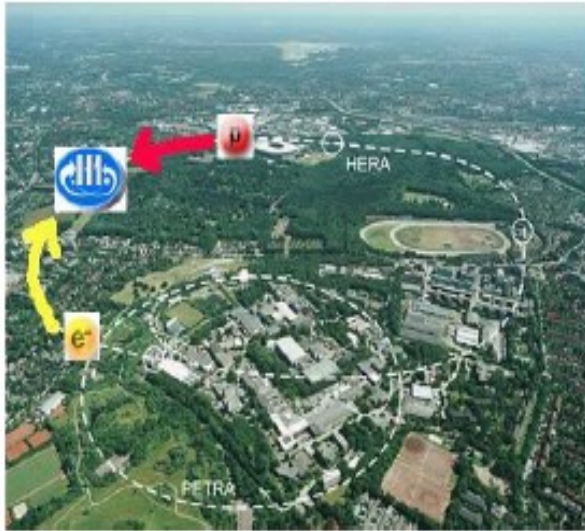
Khurelbaatar Begzsuren, DESY  
(on behalf of the H1 collaboration)



DIS 2013, Marseille, France

# DIS process at HERA

HERA:  $\sqrt{s} = 319 \text{ GeV}$



DIS event at low  $Q^2$

$Q^2$  - photon virtuality

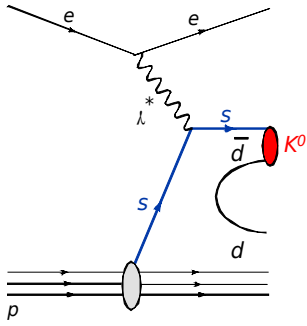
$x$  - Bjorken scaling variable

$y$  - Inelasticity in proton rest frame

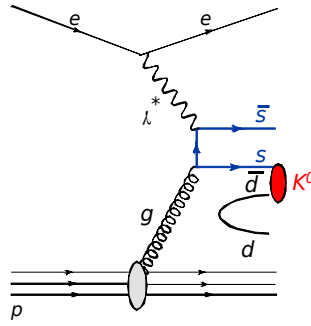
for a fixed center-of-mass energy:

$$Q^2 = xys$$

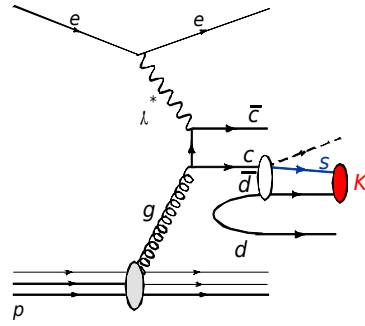
# Strange production mechanism



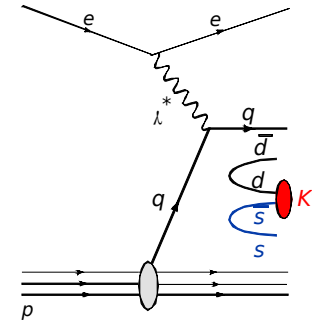
*hard process*



*B meson gluon  
fusion*



*Heavy quark  
decays*



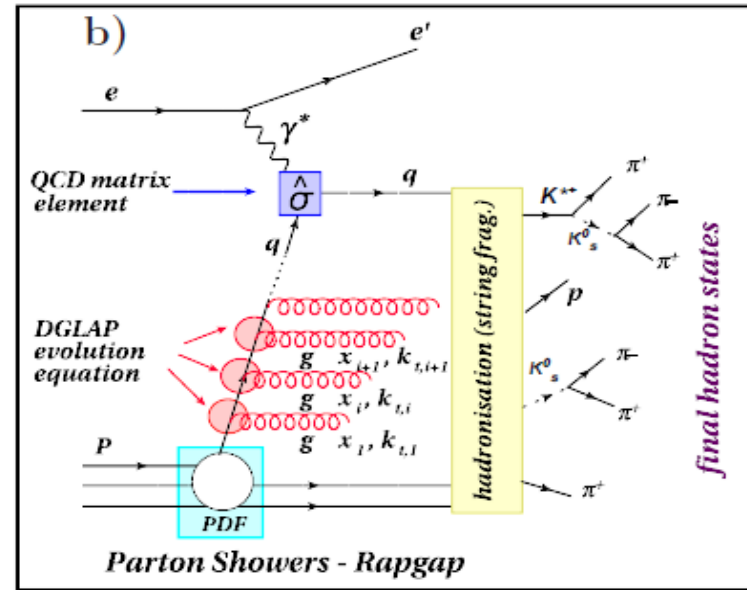
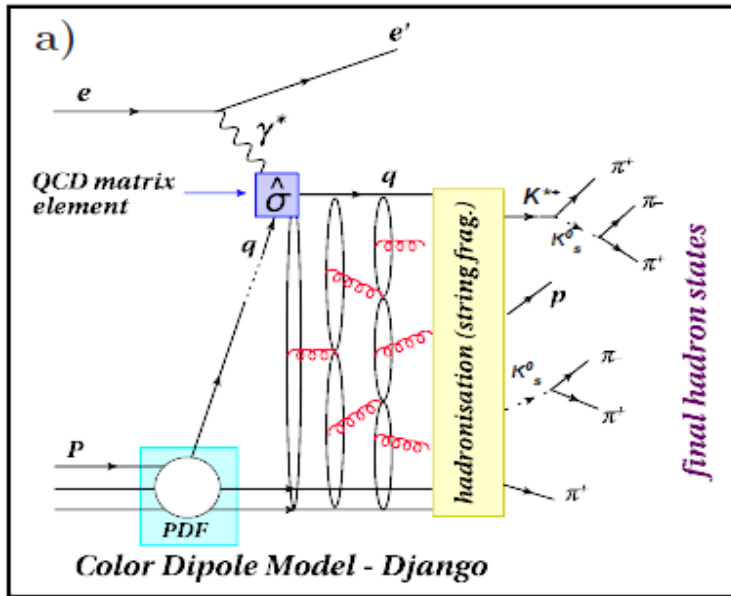
*hadronisation*

All mechanisms contribute significantly

Measurements of strange particle production ( $K_s^0$ ,  $\Lambda$ ):

- understanding QCD
- test of models of fragmentation/hadronisation
- optimisation of the Monte Carlo parameters
- test of  $\lambda_s$  universality

# Monte Carlo simulation



Djangoh, Rapgap- hard partonic processes at the Born level at leading order in  $\alpha_s$

Higher order QCD effects: MEPS in Rapgap

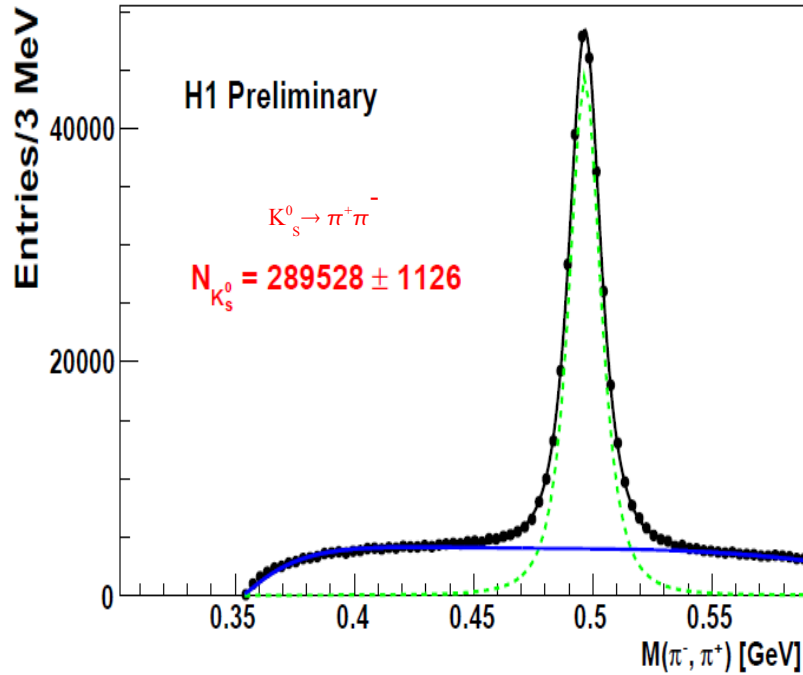
CDM in Djangoh

JETSET - hadronisation process in the Lund string fragmentation model:

$$\lambda_s = 0.286, \lambda_{qq} = 0.108, \lambda_{sq} = 0.690 \text{ tuned to } e^+e^- \text{ data (ALEPH)}$$

# $K_s^0$ and $\Lambda$ visible cross sections

$K_s^0$  at low  $Q^2$

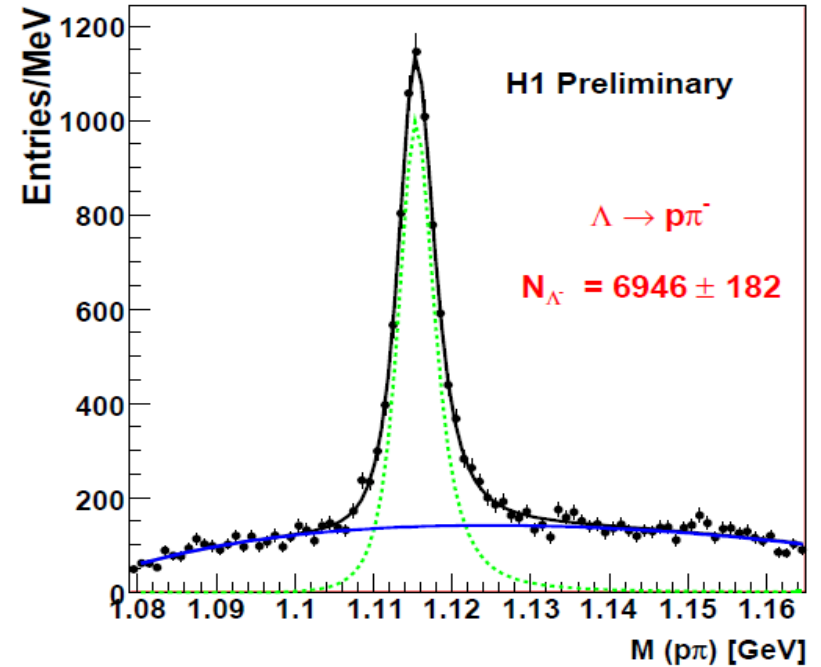


$7 < Q^2 < 100 \text{ GeV}^2$   
 $0.1 < y < 0.6$

$$\sigma_{\text{vis}}(\text{ep} \rightarrow \text{eK}_s^0 X) = 10.66 \pm 0.04(\text{stat.})^{+0.50}_{-0.53}(\text{syst.}) \text{ nb}$$

$\lambda_s$	0.286
$\sigma_{\text{vis}}(\text{ep} \rightarrow \text{eK}_s^0 X) \text{ CDM}$	9.88 nb
$\sigma_{\text{vis}}(\text{ep} \rightarrow \text{eK}_s^0 X) \text{ MEPS}$	10.93 nb

$\Lambda$  at high  $Q^2$

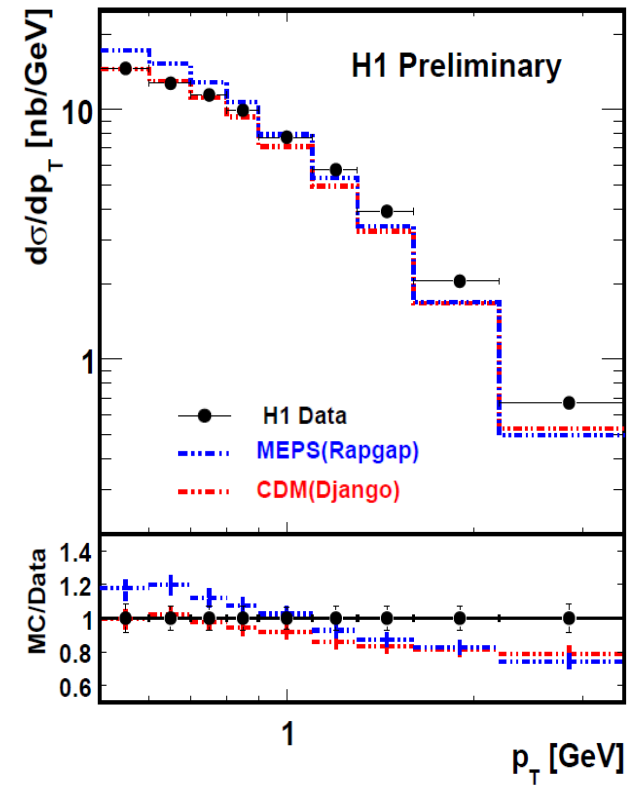
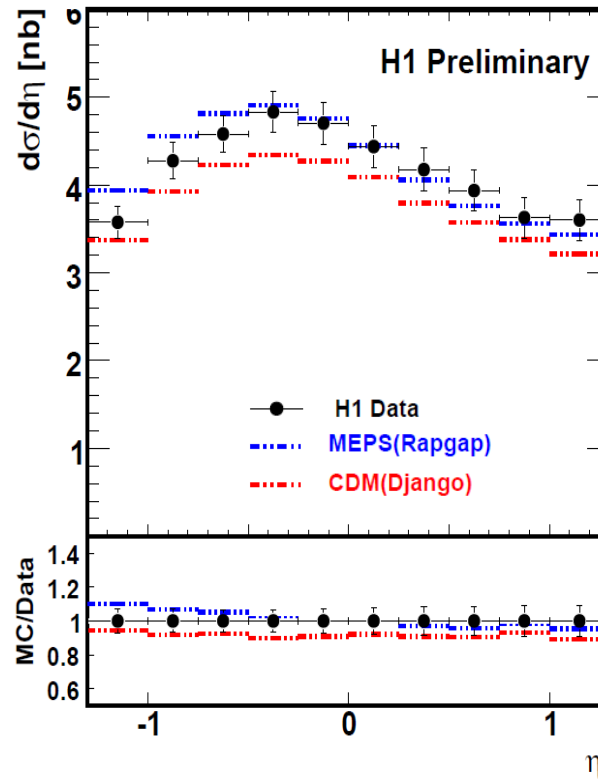
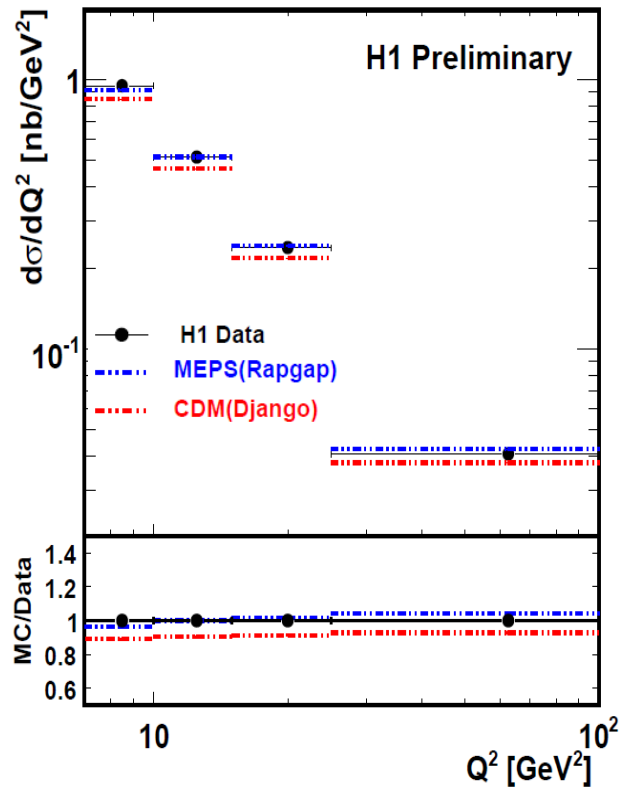


$145 < Q^2 < 20000 \text{ GeV}^2$   
 $0.2 < y < 0.6$

$$\sigma_{\text{vis}}(\text{ep} \rightarrow \text{e}\Lambda X) = 144.7 \pm 4.7(\text{stat.})^{+9.4}_{-8.5}(\text{syst.}) \text{ pb}$$

$\lambda_s$	0.220	0.286
$\sigma_{\text{vis}}(\text{ep} \rightarrow \text{e}\Lambda X) \text{ CDM}$	136 pb	161 pb
$\sigma_{\text{vis}}(\text{ep} \rightarrow \text{e}\Lambda X) \text{ MEPS}$	120 pb	144 pb

# $K_s^0$ differential cross-sections at low $Q^2$



MEPS(Rapgap) describes  $Q^2$  and  $\eta$

CDM(Django) slightly below the data

Both models fail to describe the  $P_T$  dependence

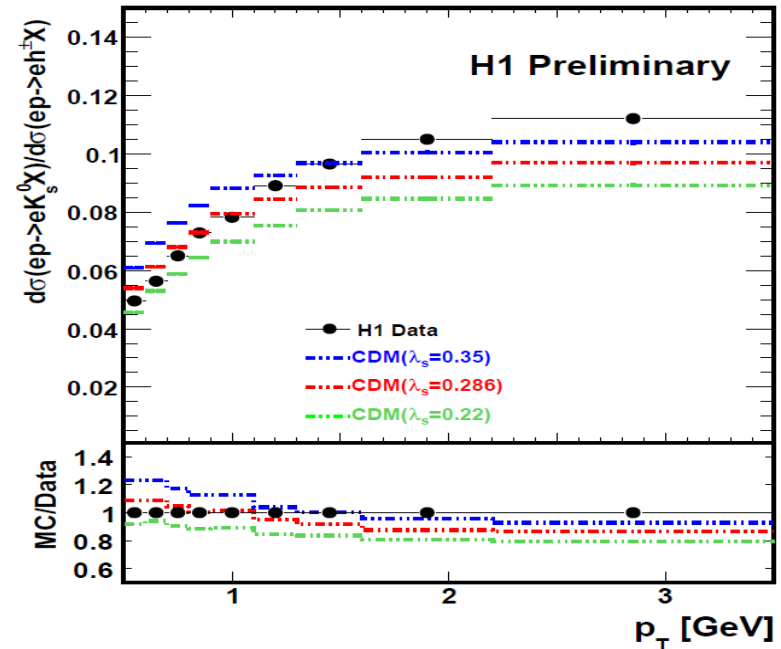
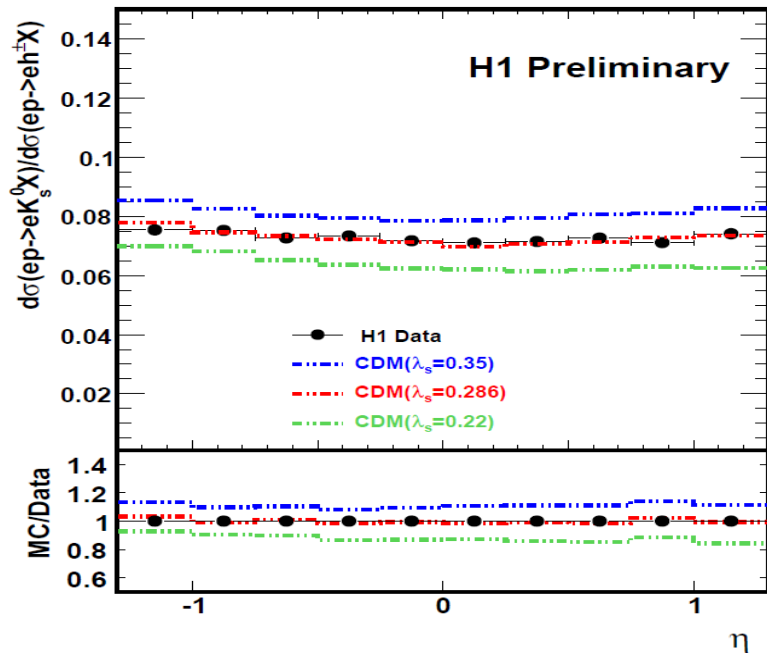
# Ratio of $K_s^0$ to charged particles

$$R = \frac{\sigma_{\text{vis}}(\text{ep} \rightarrow \text{e} K_s^0 \text{X})}{\sigma_{\text{vis}}(\text{ep} \rightarrow \text{e} h^\pm \text{X})} = 0.0721 \pm 0.0003(\text{stat.}) \begin{matrix} +0.0019 \\ -0.0024 \end{matrix} (\text{syst.})$$

$\lambda_s$	0.220	0.286	0.350
CDM	0.064	0.073	0.081

$$7 < Q^2 < 100 \text{ GeV}^2$$

$$0.1 < y < 0.6$$

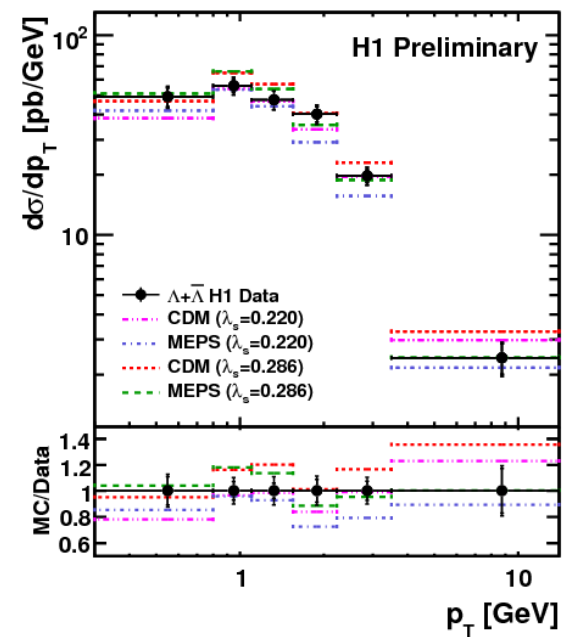
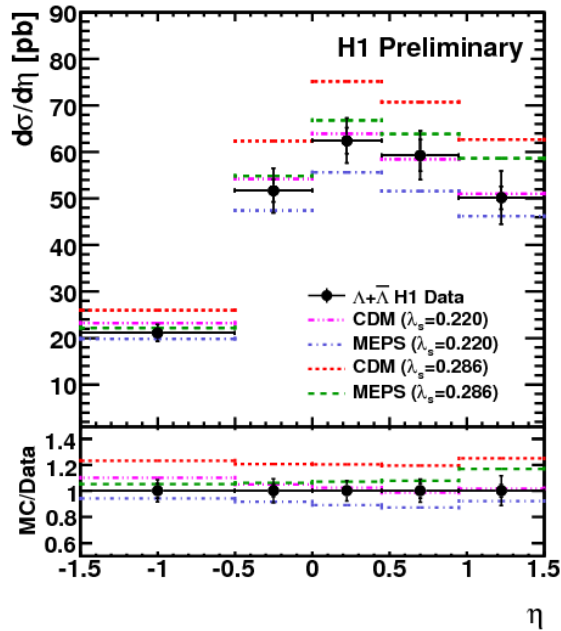
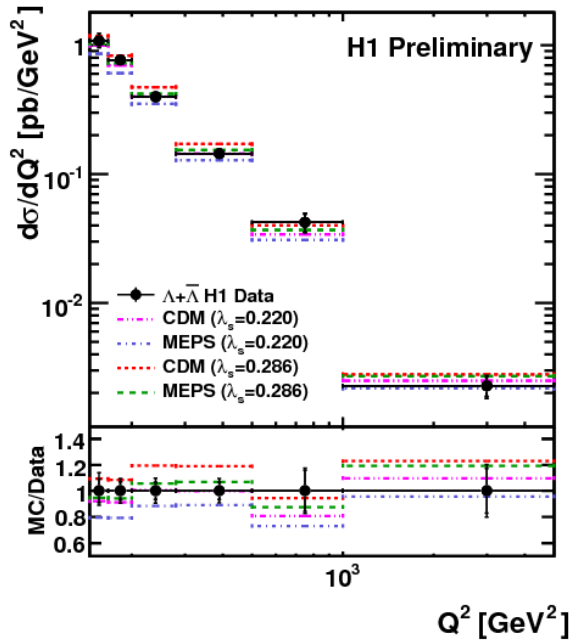


Best description is obtained for  $\lambda_s = 0.286$

$p_T$  shape of the ratio is not described

Large sensitivity on  $\lambda_s$

# $\Lambda$ differential measurement at high $Q^2$



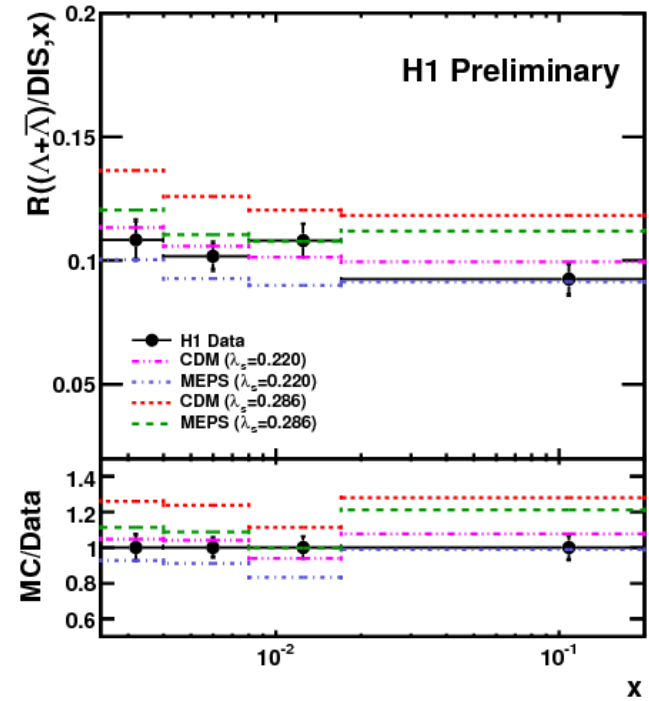
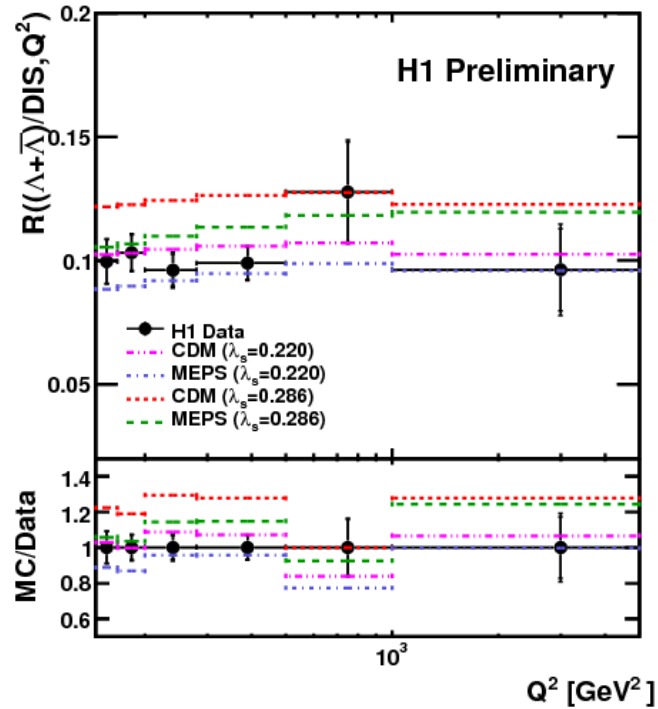
Best description is obtained for MEPS with  $\lambda_s = 0.220$

The cross sections fall rapidly with  $Q^2$  and  $p_T$

The models follow the general behaviour of data, but some differences are seen



# $\Lambda$ production to DIS cross-section ratio



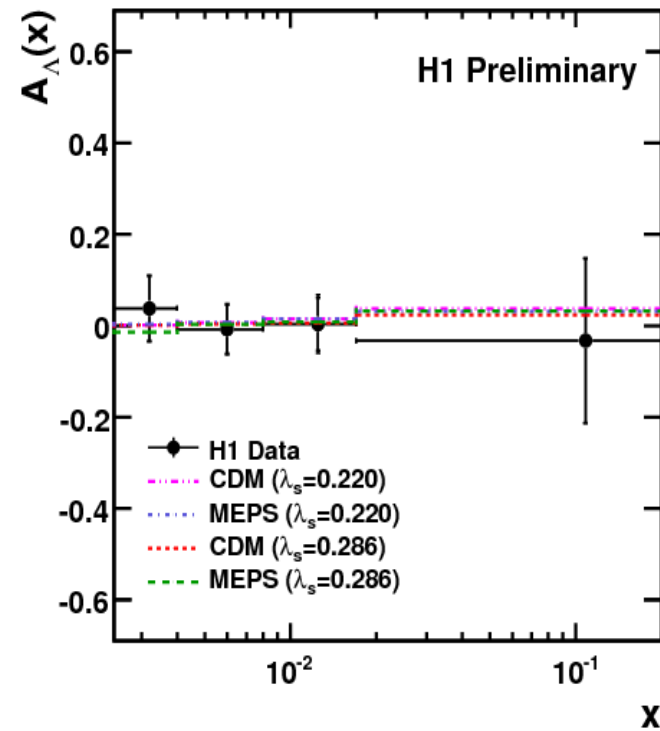
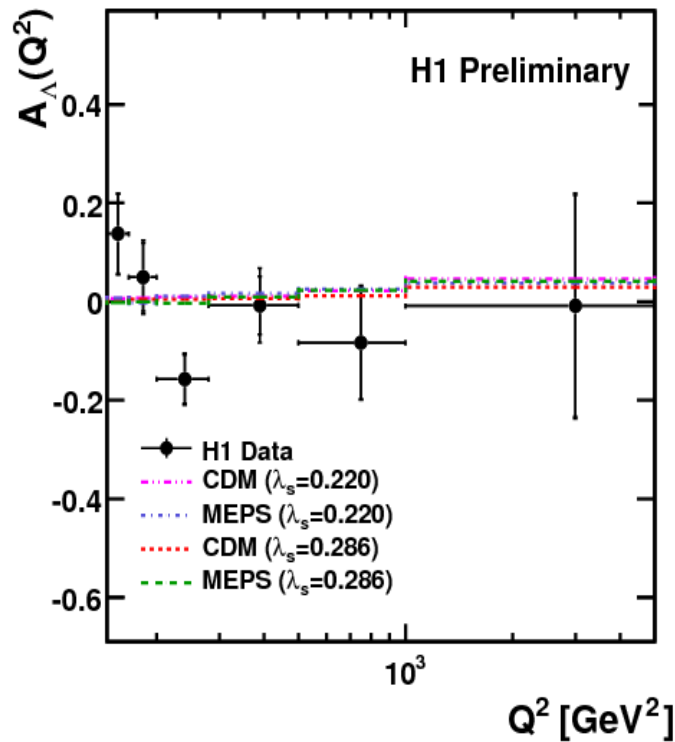
Best description is obtained by CDM(Djangoh) for  $\lambda_s = 0.220$

# $\Lambda$ - $\bar{\Lambda}$ Asymmetry

$145 < Q^2 < 20000 \text{ GeV}^2$   
 $0.2 < y < 0.6$

$$A_{\Lambda} = \frac{\sigma_{\text{vis}}(ep \rightarrow e' \Lambda X) - \sigma_{\text{vis}}(ep \rightarrow e' \bar{\Lambda} X)}{\sigma_{\text{vis}}(ep \rightarrow e' \Lambda X) + \sigma_{\text{vis}}(ep \rightarrow e' \bar{\Lambda} X)}$$

$$A_{\Lambda} = 0.002 \pm 0.022(\text{stat.}) \pm 0.018(\text{syst.})$$



Data do not show any evidence for a non-vanishing asymmetry  
in the  $\Lambda$  phase space region investigated

# Conclusions

$K_s^0$  production at low  $Q^2$ :

-MEPS(Rapgap) gives a reasonable description of the data in  $Q^2, \eta$

but predicts a softer spectrum in Pt

-CDM(Django) reasonable in shape, but below the data

$K_s^0/h^\pm$  ratio:

-MEPS(Rapgap) - a larger  $K_s^0/h^\pm$  yield for  $\lambda_s = 0.286$  than measured

good description for large Pt, but fails at small Pt

-CDM(Django) good description in  $K_s^0/h^\pm$  yield for  $\lambda_s = 0.286$

good description at small Pt, but fails at higher Pt

- $K_s^0/h^\pm$  shows large sensitivity for determining  $\lambda_s$

# Conclusions

## $\Lambda$ Production at high $Q^2$ :

- The measured visible  $\Lambda$  cross section is found to be described best by CDM using  $\lambda_s = 0.220$  and the MEPS model using  $\lambda_s = 0.286$
- When investigating the  $\Lambda$  production to DIS cross section ratio the best agreement is observed for the CDM with  $\lambda_s = 0.220$
- $\Lambda$ - $\bar{\Lambda}$  Asymmetry is found to be consistent with zero