Strangeness Production in DIS at HERA

- HERA kinematics
- Strange Particles (K^0_s, Λ) Production in *ep* Collisions

  Differential cross-sections
  Λ - $\bar{\Lambda}$ asymmetry
  Ratios of differential cross sections (Λ /K^0_s,K^0_s/$h^{\pm}$)

- Summary

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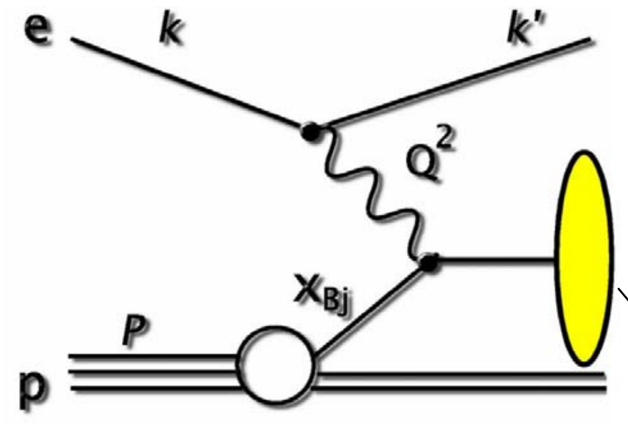
$e^{\pm}p$ kinematics at HERA



ep center of mass energy $s = (P+k)^2$

hadronic final state mass $W^2 = (P+q)^2$

exchanged momentum (squared) $Q^2 = -q^2 = -(k-k')^2$

inelasticity variable $y = \frac{qP}{kP} \cong \frac{W^2 + Q^2}{s}$

Bjorken scaling variable $x_{Bj} = \frac{Q^2}{2qP} \cong \frac{Q^2}{sy}$

Hadrons:
light (u,d)
strange (s)
heavy (c,b)

non-perturbative hadronisation process
leading to hadronic final state

Measurement:

Neutral Current (NC)

Deep Inelastic Scattering (DIS)

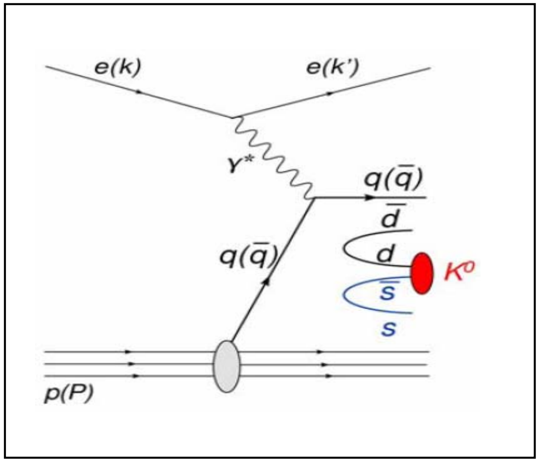
$2 < Q^2 < 100\ \mathrm{GeV}^2$

$0.1 < y < 0.6$

kinematics from scattered electron

HERA I data int. luminosity of $\approx 50\ \mathrm{pb}^{-1}$

Processes for Strangeness Production in *ep* Scattering



Dominant: **hadronisation (**non-perturbative process)

LUND string fragmentation model
strangeness suppression factor $\lambda_s = P(s)/P(q)$

more parameters for baryon production:

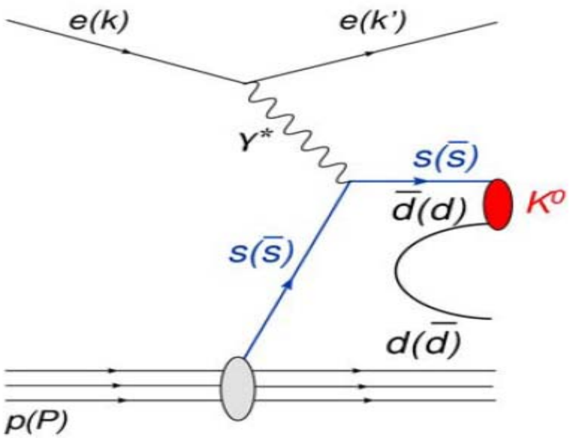
diquark suppression factor $\lambda_{qq} = (P(qq)/P(q)$

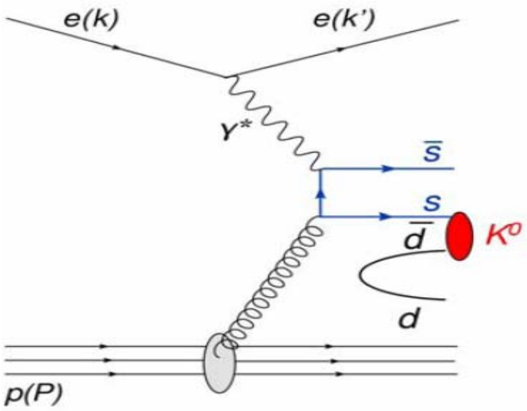
strange diquark suppression factor $\lambda_{sq} = (P(sq)/P(qq))/(P(s)/P(q))$

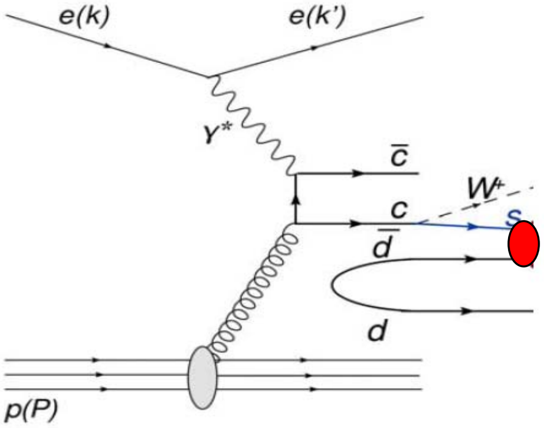
hard processes: QPM

boson-gluon fusion

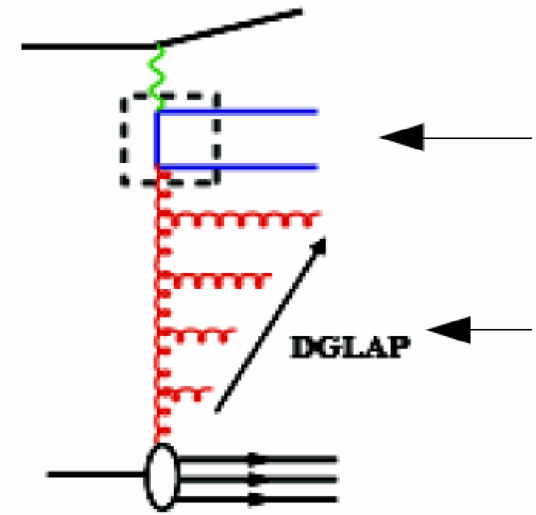
decays of heavy quarks



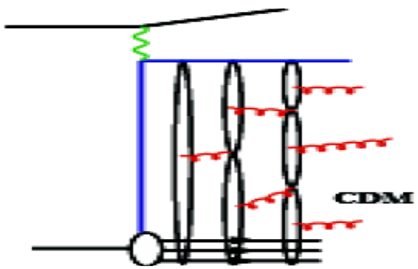




QCD Models for DIS *ep* Interactions



LEPTO



ARIADNE

MEPS Matrix Element+ Parton Shower

DGLAP – strong ordering in k_T of emitted partons

CDM Color Dipole Model

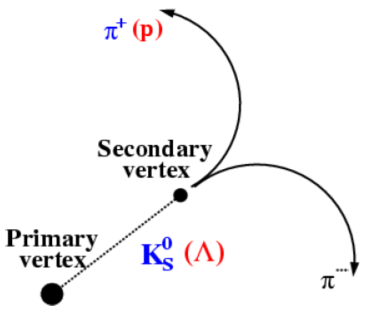
dipoles radiate independently $\rightarrow$ no ordering in k_T of emitted partons

Both are interfaced to JETSET for hadronisation (Lund string model) with λ_s=0.286, λ_{qq}=0.108, λ_{sq}=0.690 (e^+e^- ALEPH tuned parameters)

only λ_s varied for comparison of the predictions

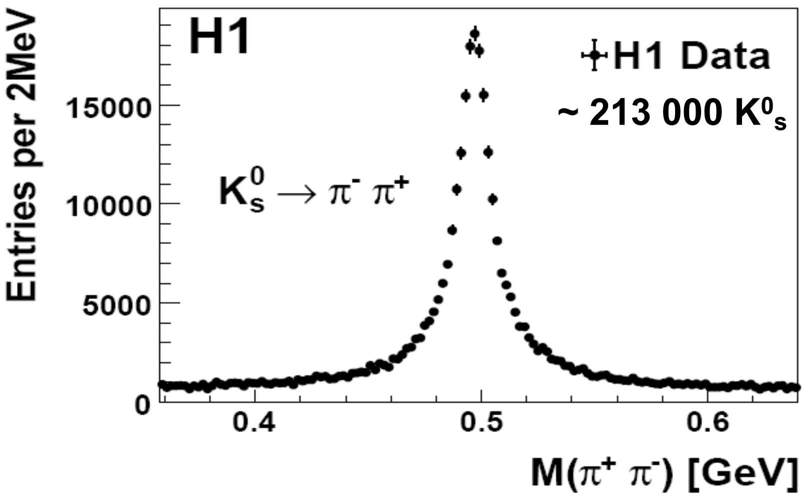
Observation of K^0_s , Λ

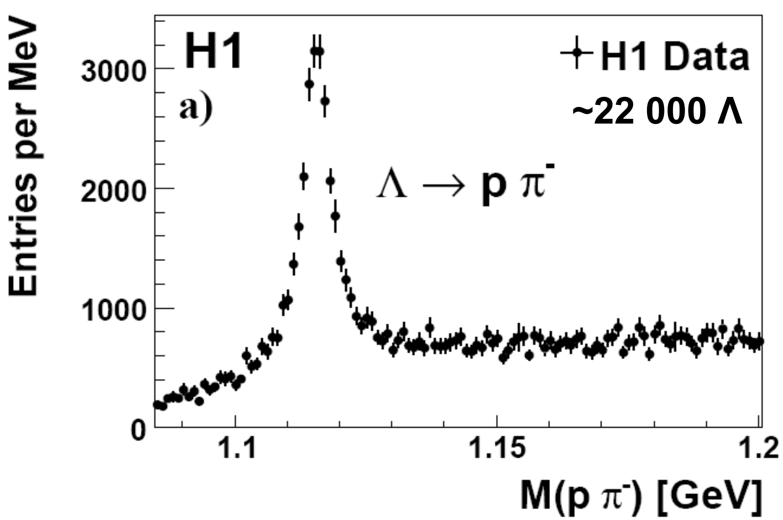
K^0_s , Λ signals

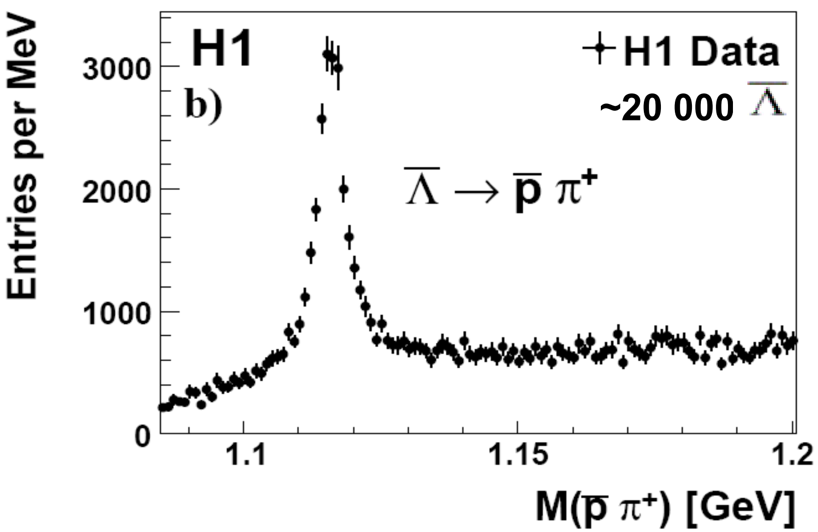


$0.5 < p_t < 3.5$ GeV

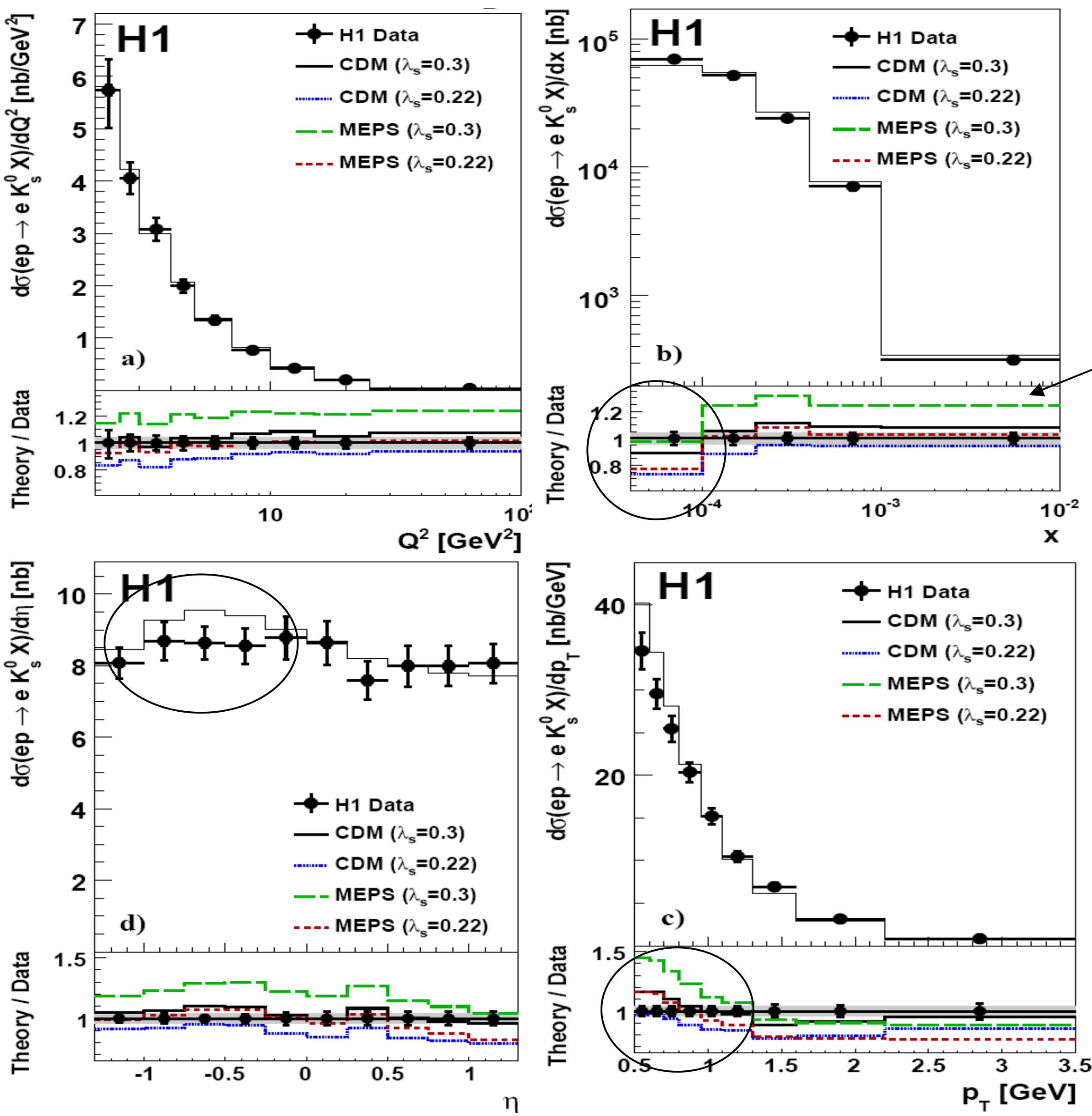
$-1.3 < \eta < 1.3$







K^0_S differential production cross-sections in LAB frame in Q^2, x, η, p_T



Overall agreement with LO Monte Carlo predictions

CDM with $\lambda_s = 0.3$

MEPS with $\lambda_s = 0.22$

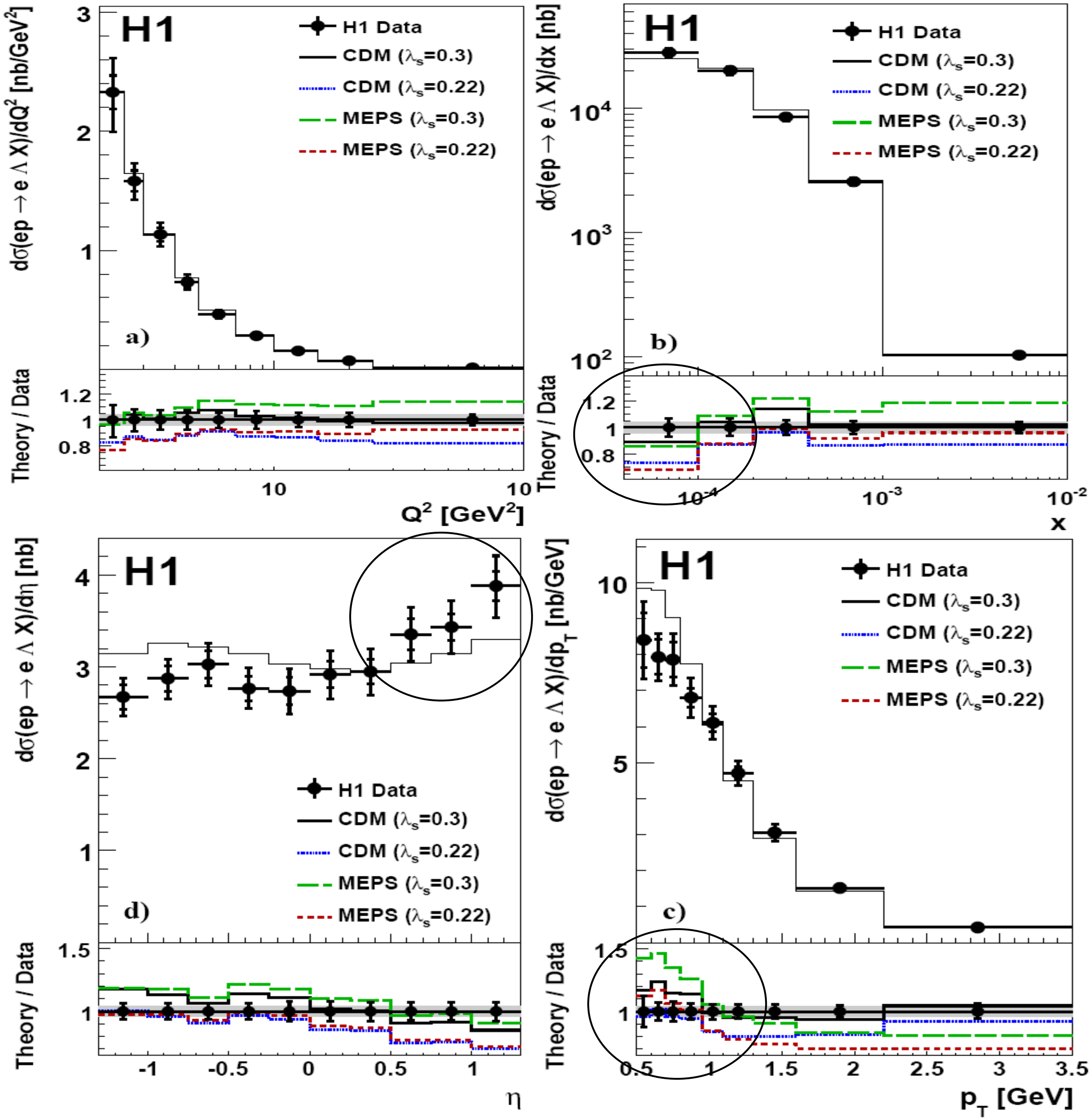
Theory(MC pred.)/Data

- Data points

Difficulties:

at low x ,
at low p_T ,
shape of η

Λ differential production cross-sections in LAB frame in Q^2, x, p_T, η



Overall agreement with
LO Monte Carlo predictions

CDM and **MEPS**
with λ_s = 0.3

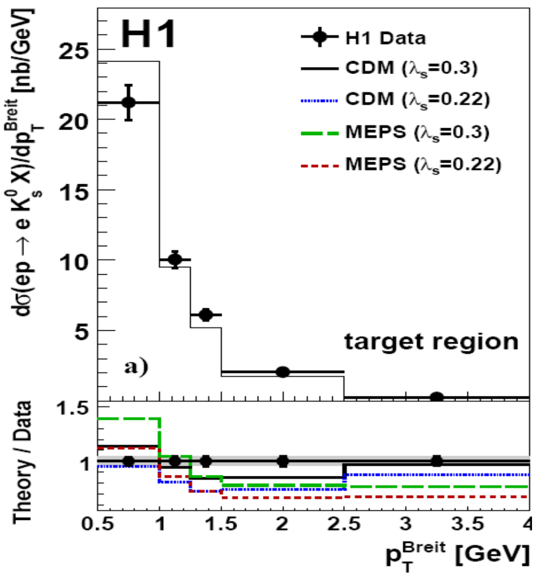
(strange baryon production
depends not only on λ_s ,
but also on λ_{qq}, λ_{sq})

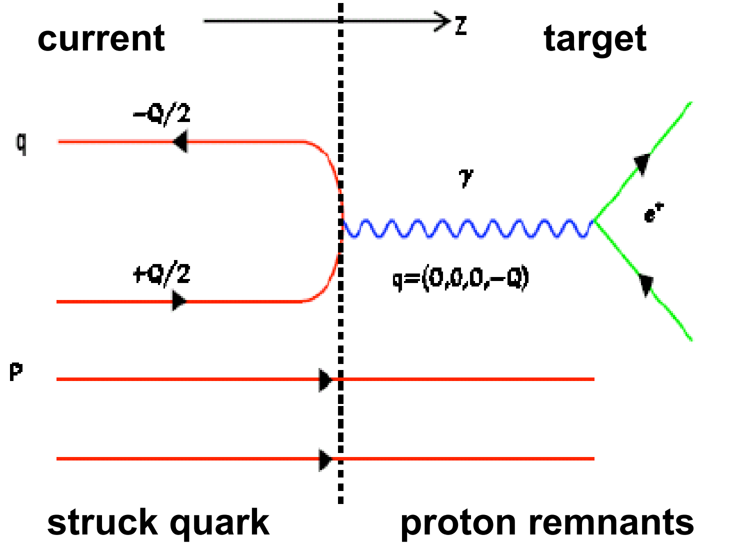
Difficulties:

at low x ,
at low p_T ,
shape of η

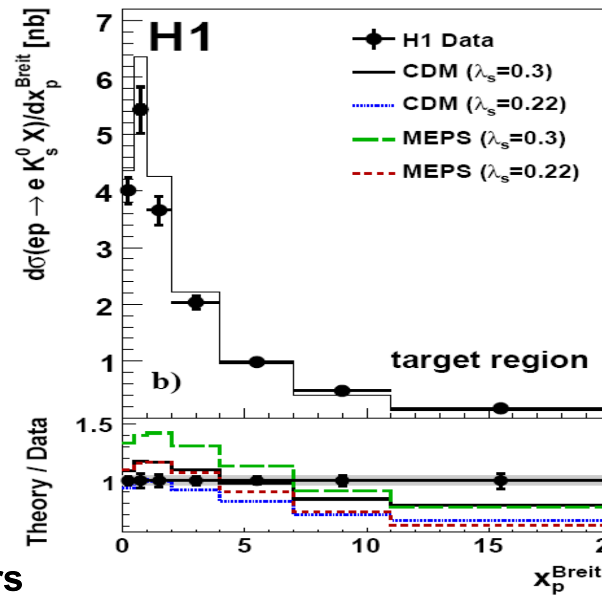
K^0_S differential x-sections in Breit frame in p_T^{Breit}, x_p^{Breit}

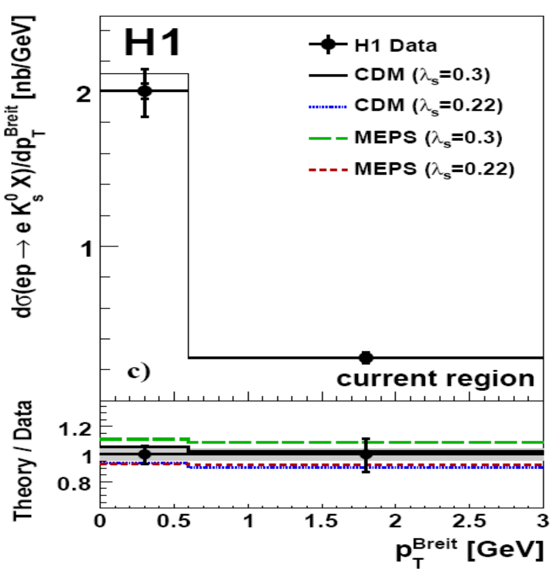
$$x_p^{Breit} = \frac{(2p_h^{Breit})}{Q}$$





QPM picture is modified by higher orders

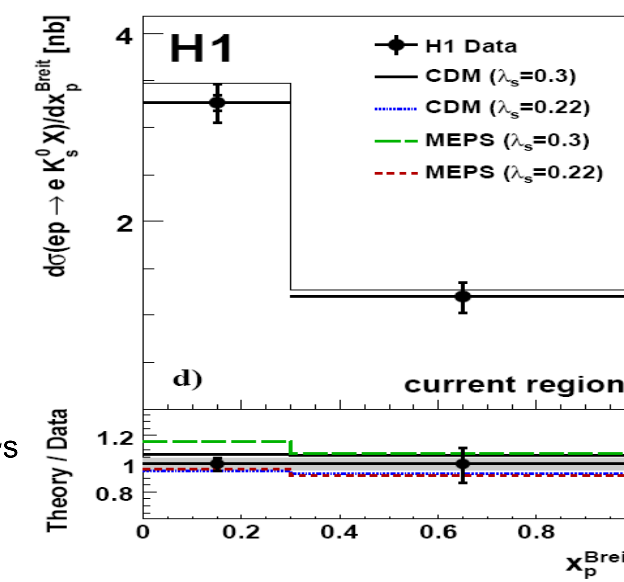




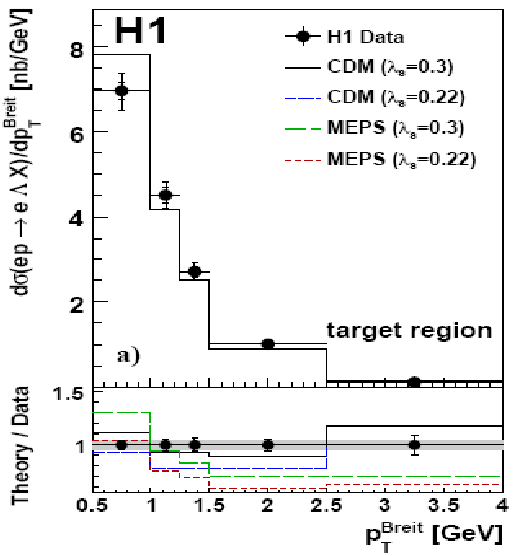
CDM and **MEPS** with $\lambda_s = 0.3$

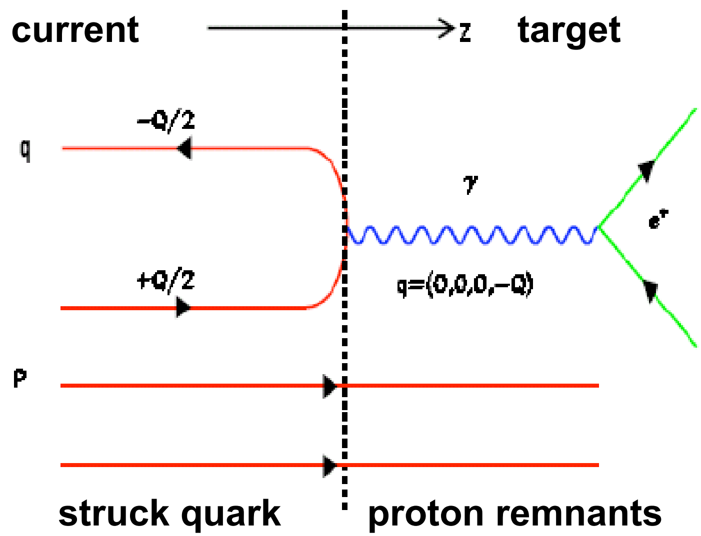
describe the differential x-sections

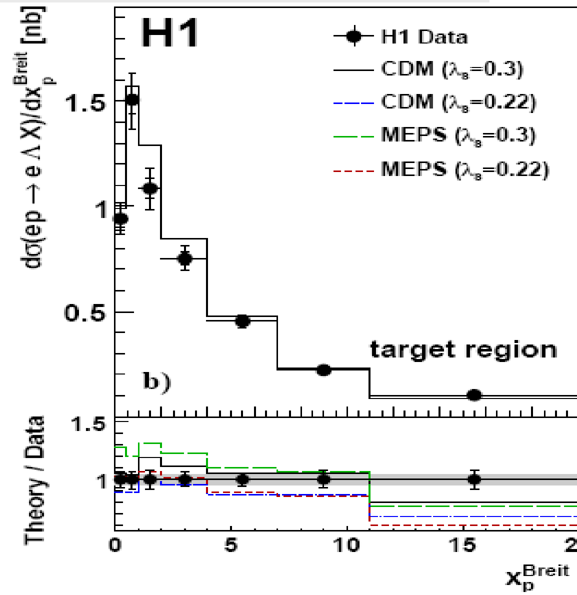
current region less sensitive to λ_s with respect to the laboratory frame or target hemisphere



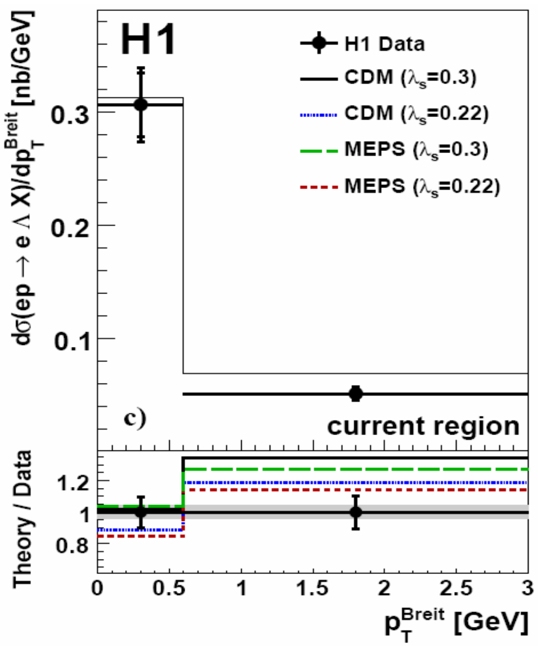
Λ differential production cross-sections in Breit frame in x_p^{Breit}, p_T^{Breit}







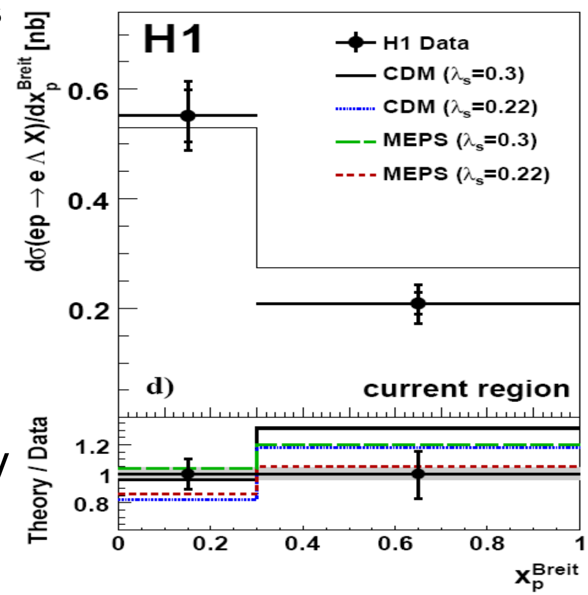
QPM picture is modified by higher orders



CDM and **MEPS** with λ_s = 0.3

describe the differential cross-sections

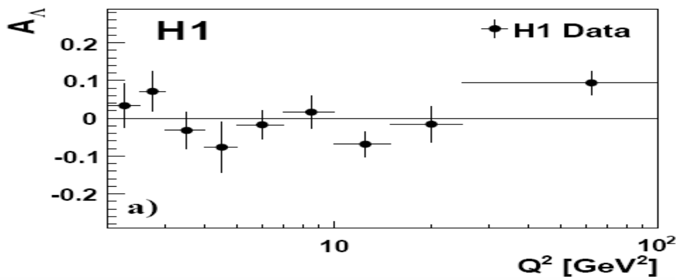
current region less sensitive to λ_s with respect to the laboratory frame or target hemisphere

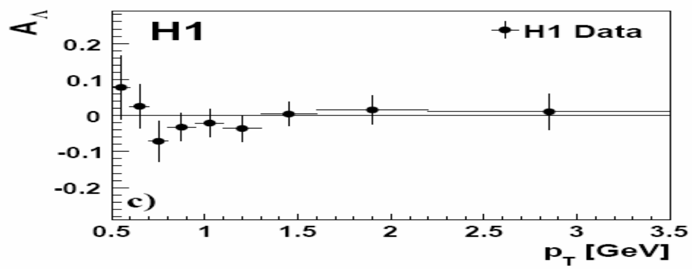


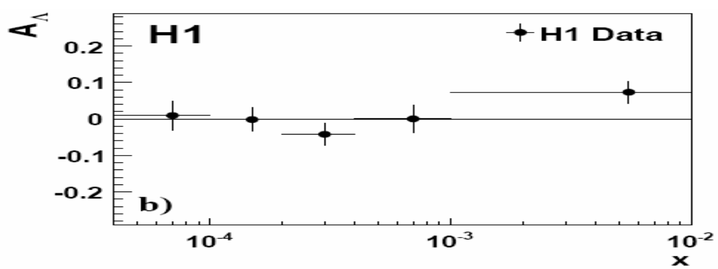
$\Lambda - \overline{\Lambda}$ Asymmetry

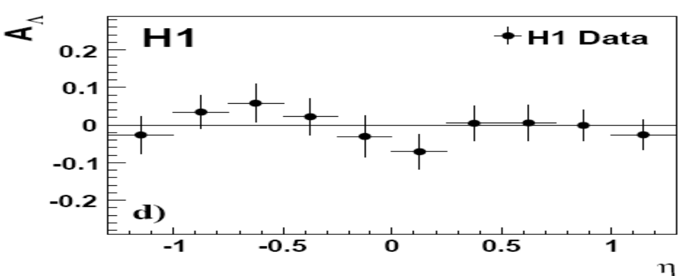
$$A_\Lambda = \frac{[\sigma_{vis}(ep \to e\Lambda X) - \sigma_{vis}(ep \to e\bar{\Lambda}X)]}{[\sigma_{vis}(ep \to e\Lambda X) + \sigma_{vis}(ep \to e\bar{\Lambda}X)]}$$

Laboratory frame







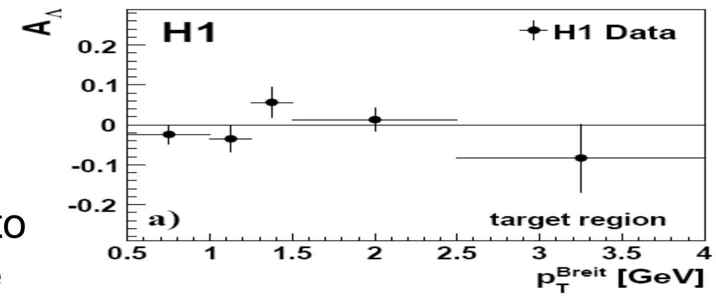


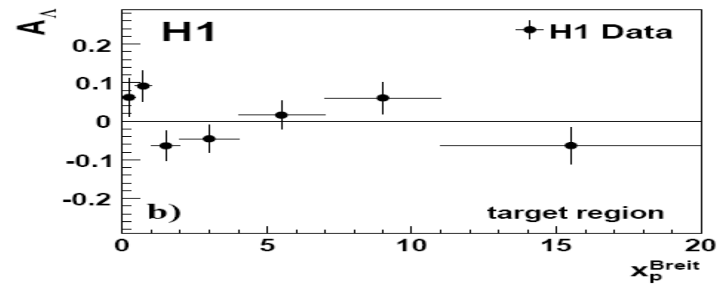
Test of transfer of the baryon number from the proton beam to the final state strange particles

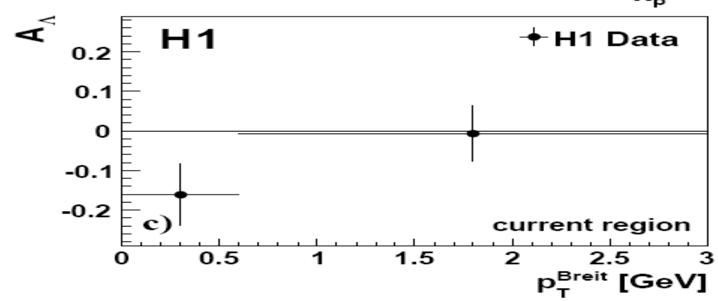
$A_\Lambda \approx 0$

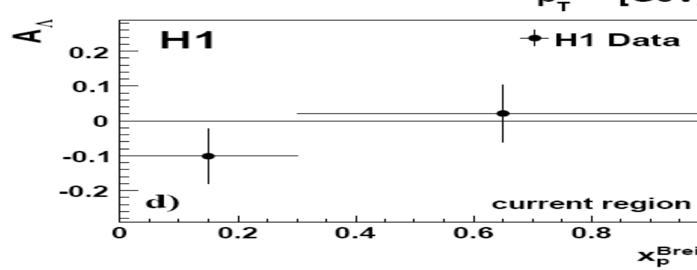
No evidence of baryon number transfer is visible in the measured data

Breit frame

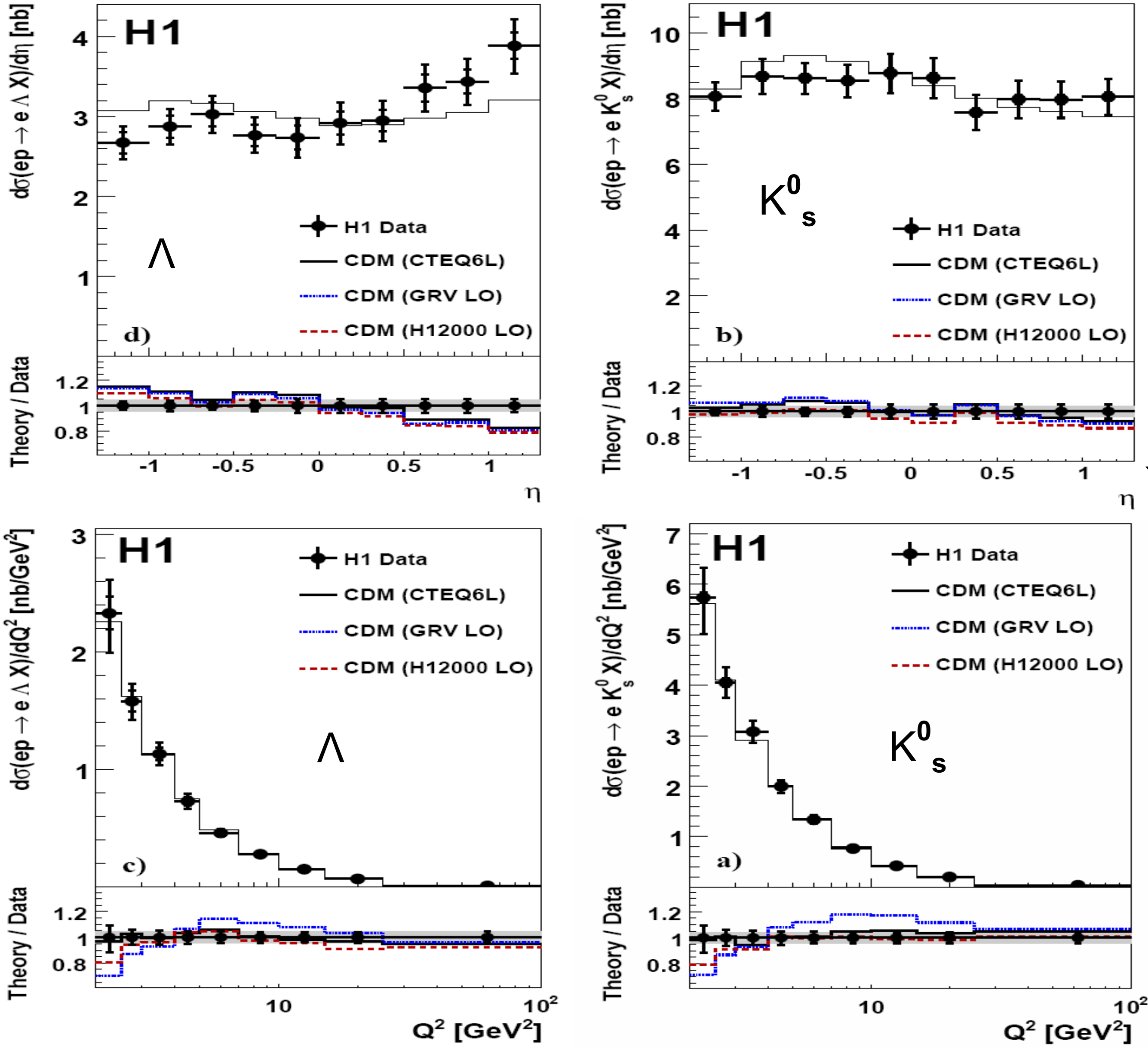








Sensitivity of K^0_s, Λ Production to Proton Parton Density Functions



CDM predictions with $\lambda_s = 0.286$

PDF parametrisations:
CTEQ6L,
H12000 L0
GRV-94 LO

K^0_s , Λ

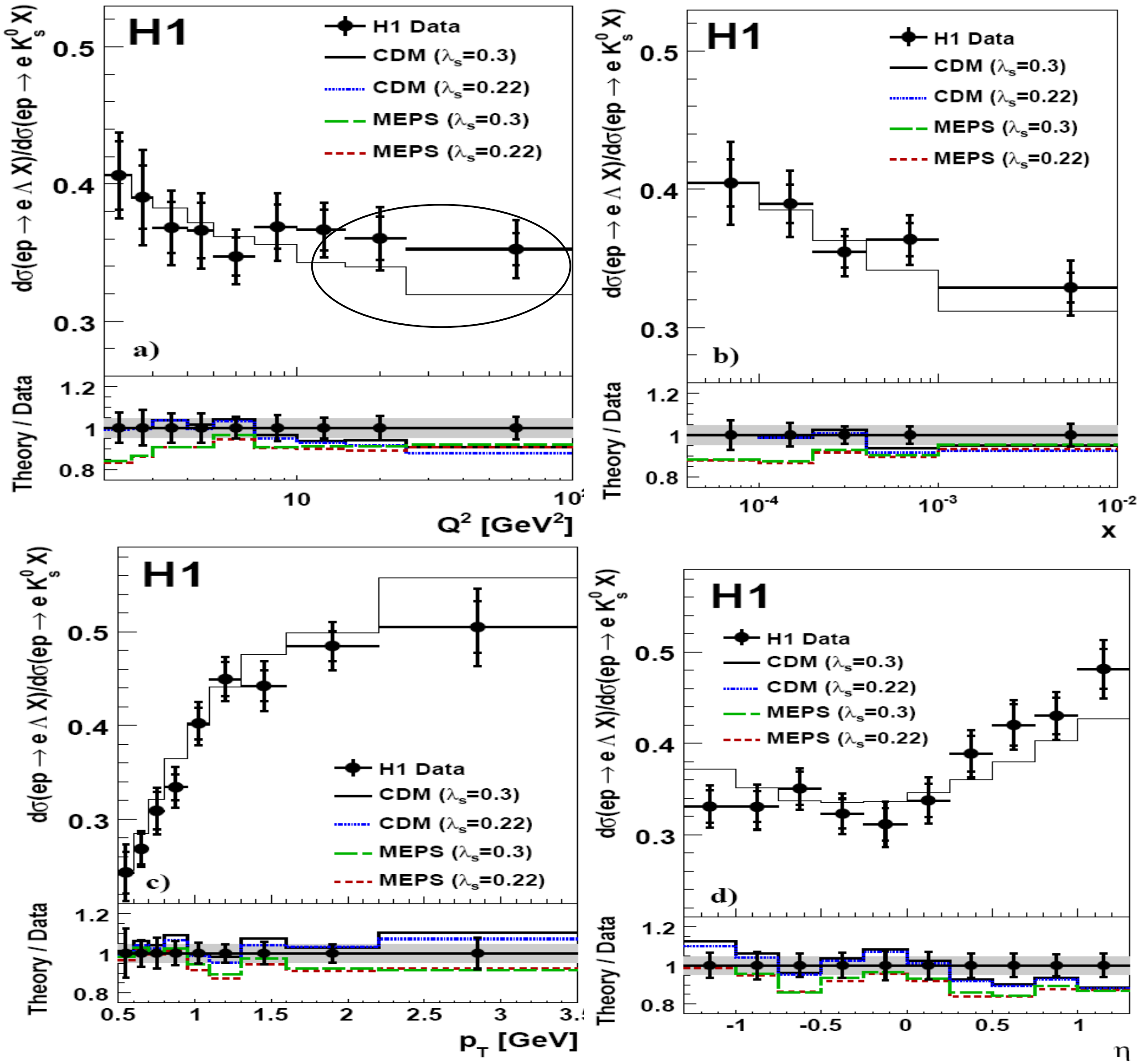
η distributions:
no sensitivity to PDF

Q^2 distributions:
different predictions for different PDFs

Ratio of production cross sections: strange baryons/strange mesons

$$ep \rightarrow e\Lambda X \,/\, ep \rightarrow eK_s^0 X$$

LAB frame



CDM describes the data

MEPS below the data

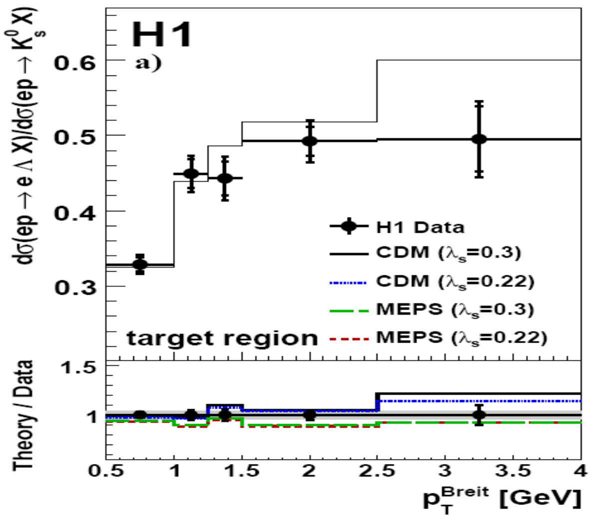
difficulties:
at high Q^2
η shape

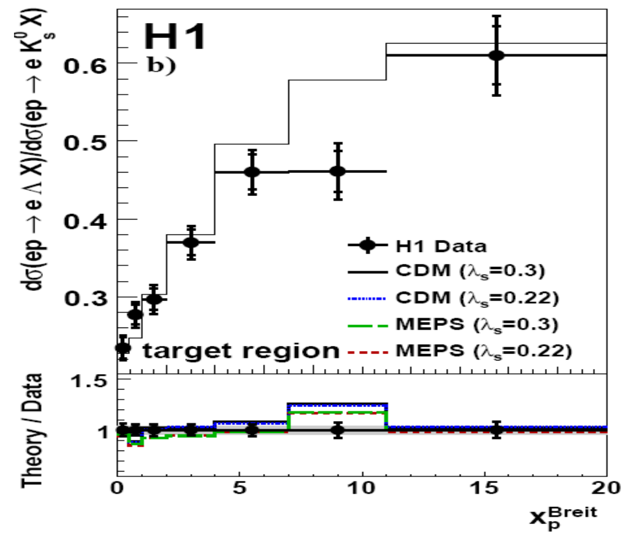
no sensitivity to λ_s, as expected

Ratio of production cross sections: strange baryons/strange mesons

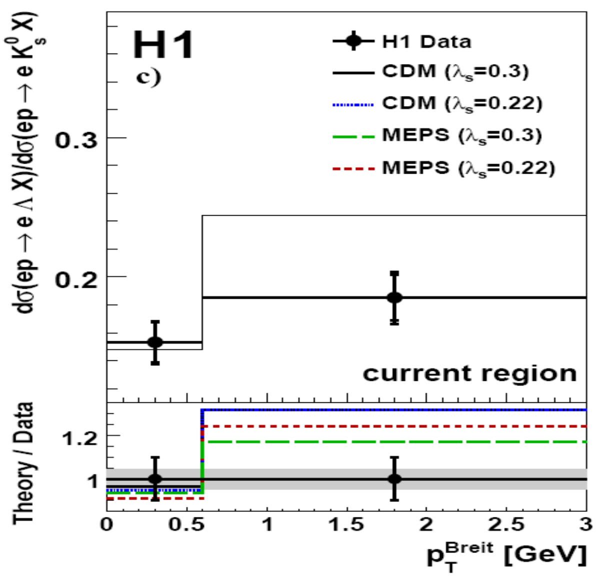
$$e\,p \rightarrow e\,\Lambda\,X \,/\, e\,p \rightarrow e\,K_s^0\,X$$

Breit frame

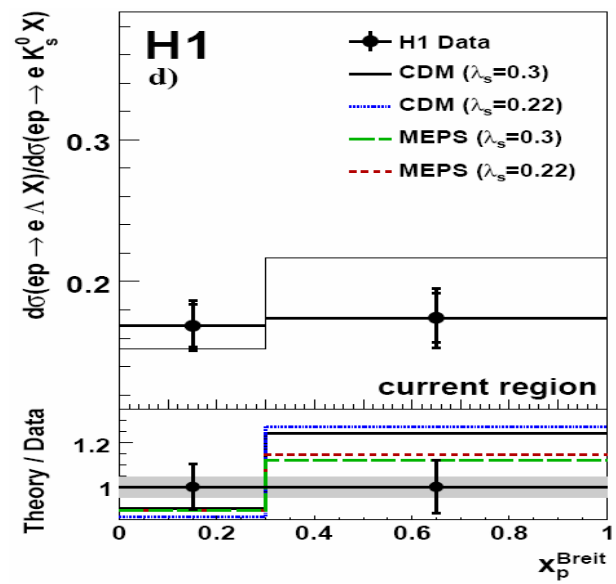




distributions in the target and current hemispheres reasonably well described by CDM and MEPS models

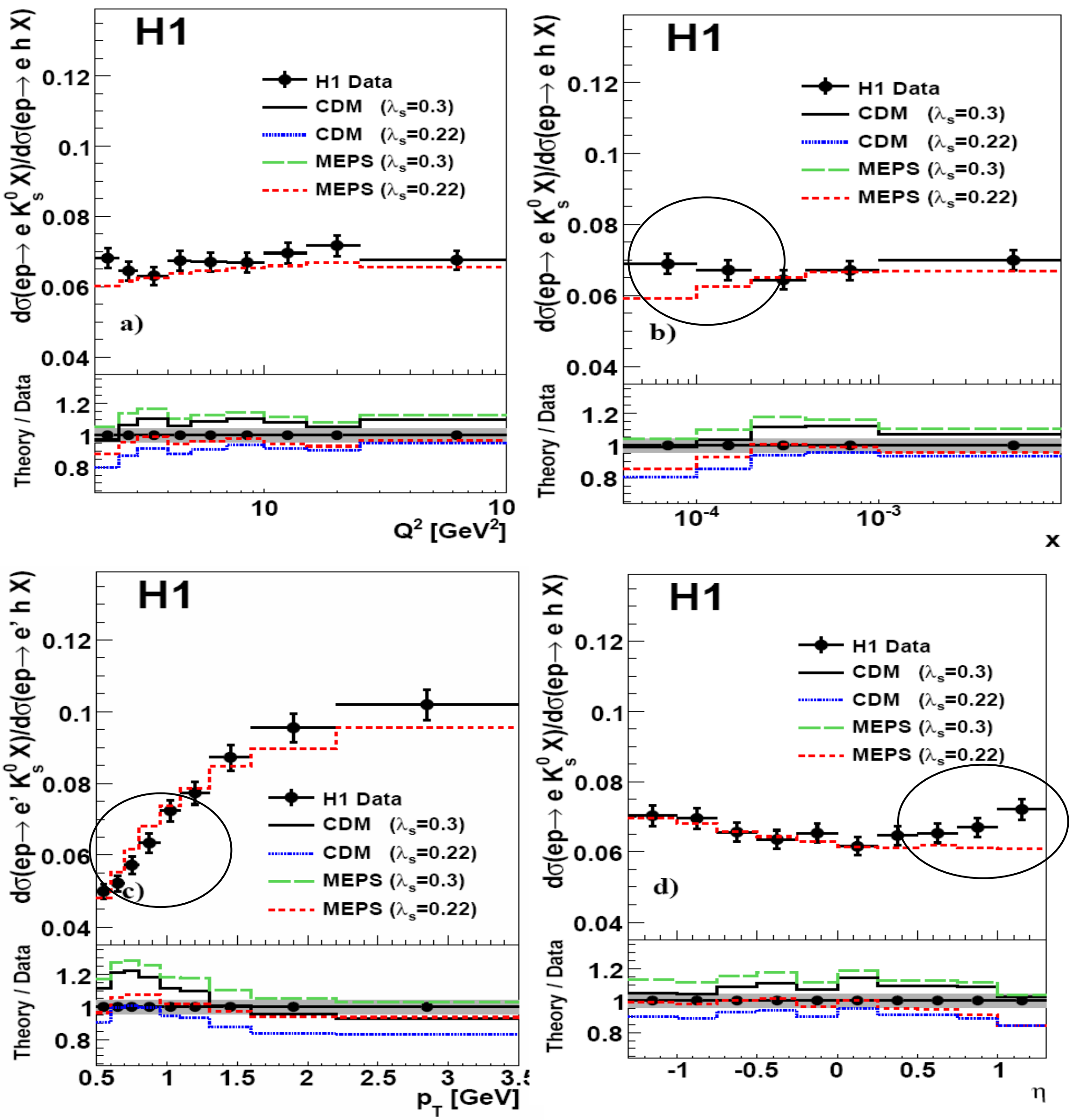


very weak dependence on λ_s



Ratio of production cross sections: strange mesons/charged hadrons

$$e\,p \rightarrow e\,K^0_s\,X \,/\, e\,p \rightarrow e\,h^{\pm}\,X$$ **LAB**



$h^{\pm}$ in the same kinematic region as K^0_s

ratio rises strongly with p_T,
~constant as a function of x, Q^2, η

MEPS favours a lower value of $\lambda_s = 0.22$ over the full phase space

CDM at low Q^2 better with $\lambda_s=0.3$, at high Q^2 prefered lower $\lambda_s=0.22$

difficulties :
- at low x,
- at low p_t,
- large positive η

Summary

- K^0_s and Λ production in laboratory frame:
  reasonable good description by LO Monte Carlos (CDM, MEPS)
  CDM with $\lambda_s = 0.3$ best , but
- both models have difficulties at small x, low p_T , η shape
- $\mathbf{K^0_s}$ and Λ production in Breit frame:
  well described by both the MEPS and CDM predictions with $\lambda_s = 0.3$
- ratios of production cross-sections:
  Λ/K^0_s better described by CDM with $\lambda_s = 0.3$
  K^0_s/charged hadrons better described by MEPS with $\lambda_s = 0.22$

No single combination of model and λ_s describes all data in the measured region

- no indication of baryon number transfer is observed