Production of neutral strange particles in Deep Inelastic Scattering at HERA

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DESY,
small x Workshop, May 8, 2004

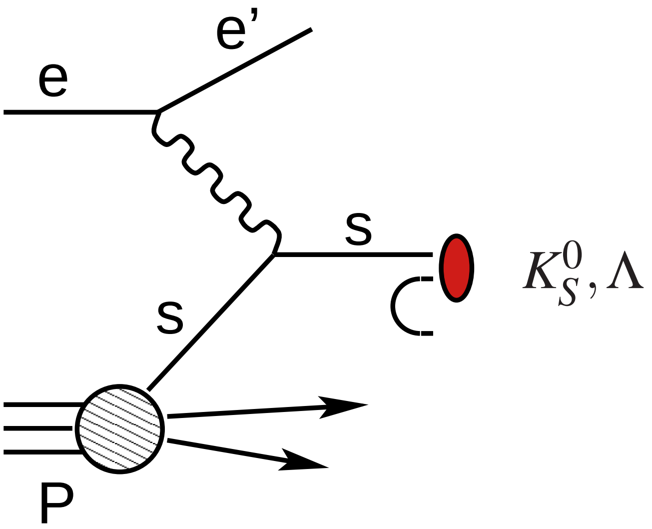
- Strangeness in DIS and Motivation
- Reconstuction of K^0_S Mesons and Λ Baryons
- Total and Differential Cross Sections and Comparison with Models
- Summary

Results presented not yet published by H1 - only in PhD thesis

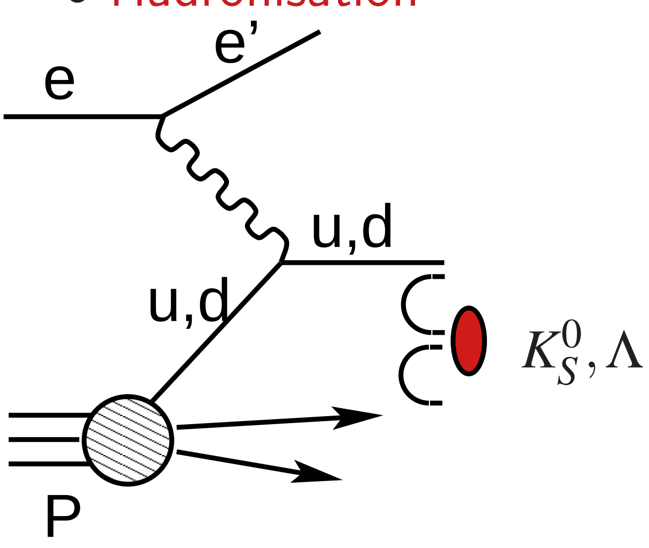
Strange Particle Production in DIS

Sources of Strangeness in DIS

- s-Quark in hard subprocess



- Hadronisation



- Decays (b,c)
- Instantons, Glueballs, Pentaquarks, ...

DIS Kinematics:

Photonvirtuality $Q^2 = (k - k')^2 = xys$

Skalingvariables $x_{bj} = \frac{Q^2}{P \cdot q}$ $y = \frac{P \cdot q}{P \cdot k}$

Motivation

Strangeness Production not yet well understood

BaryonProduction

Hadronisation Universality?

main source for strangeness

Lund String Model

Parameter: λ_S: suppression of strange $s\bar{s}$

e^+e^--Daten(LEP): $\lambda_S = 0.3$

HERA (H1,ZEUS) : $\lambda_S \approx 0.2 - 0.3$

Model independent determination of

Suppression of strange $q\bar{q}$:

ratio of $D^\pm$-, D^0- and D_s Rates : $\lambda_S = 0.266$

in good agreement at H1, ZEUS, LEP

Cluster Model in HERWIG

Event Selection and K_S^0, Λ Reconstruction

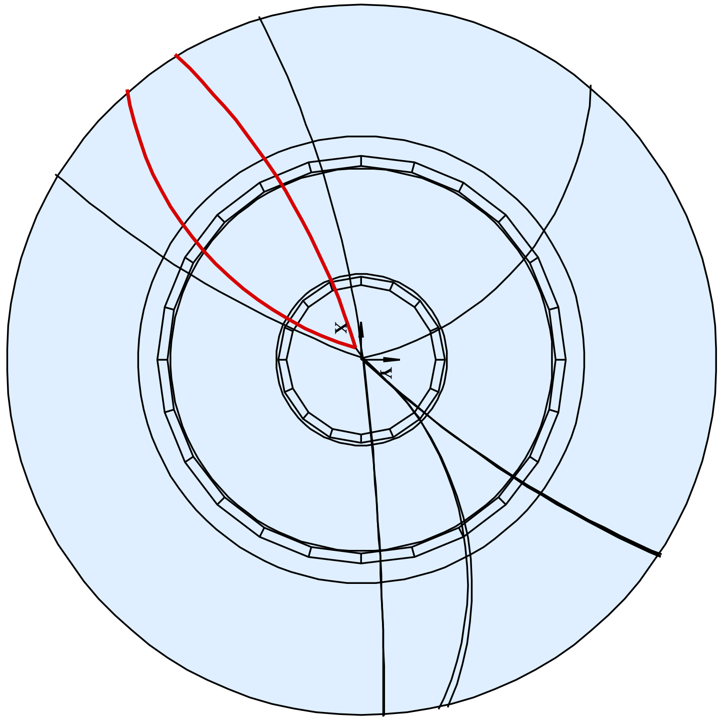
Event Selection:

H1 Data 1996,1997 : $L = 17.8\text{pb}^{-1}$

$E(e^+) = 27.5$GeV and $E(p) = 820$GeV

Kinematic Range:

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



Reconstruction of K_S^0 and Λ:

$K_S^0 \rightarrow \pi^+\pi^-$ $\quad$ $\Lambda \rightarrow p\pi^-$ und c.c.

$c\tau = 2.68$ cm and 7.89cm

$\rightarrow$ Secondary Vertices

Visible K_S^0, Λ Range

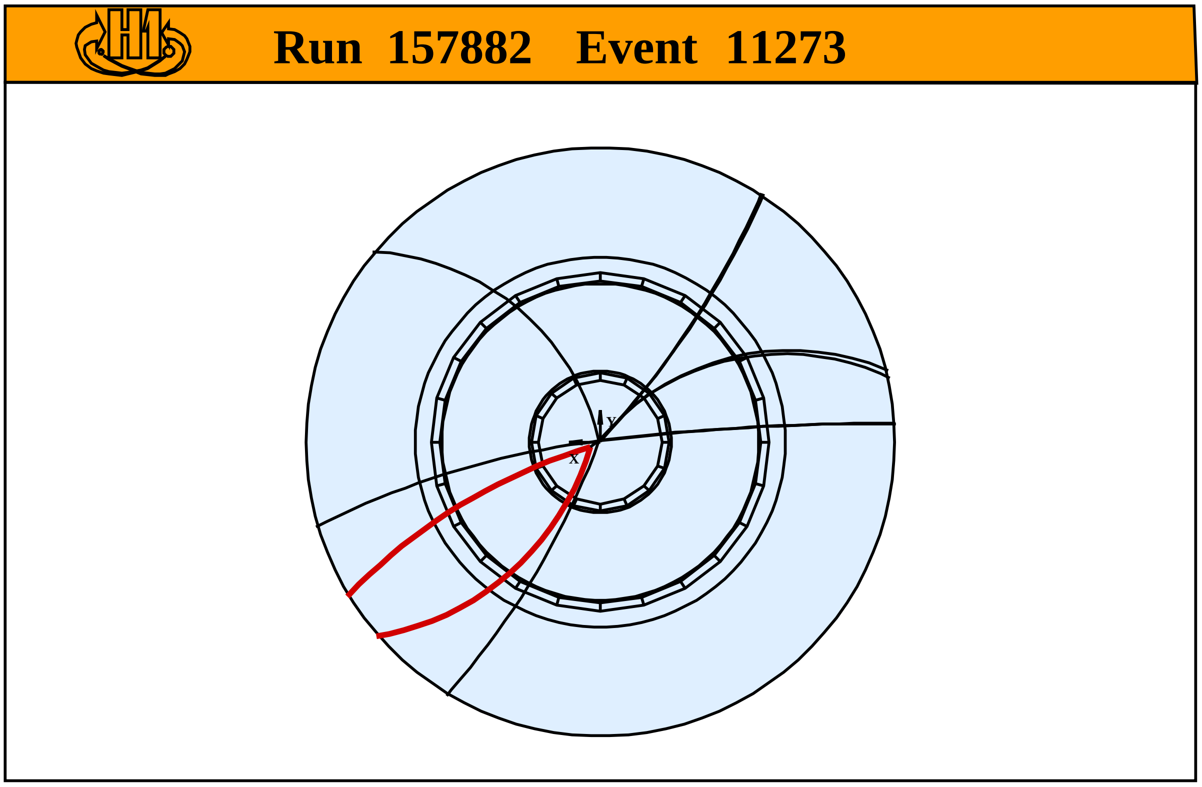
Central Region

$0.5 < p_T(K_S^0, \Lambda)$

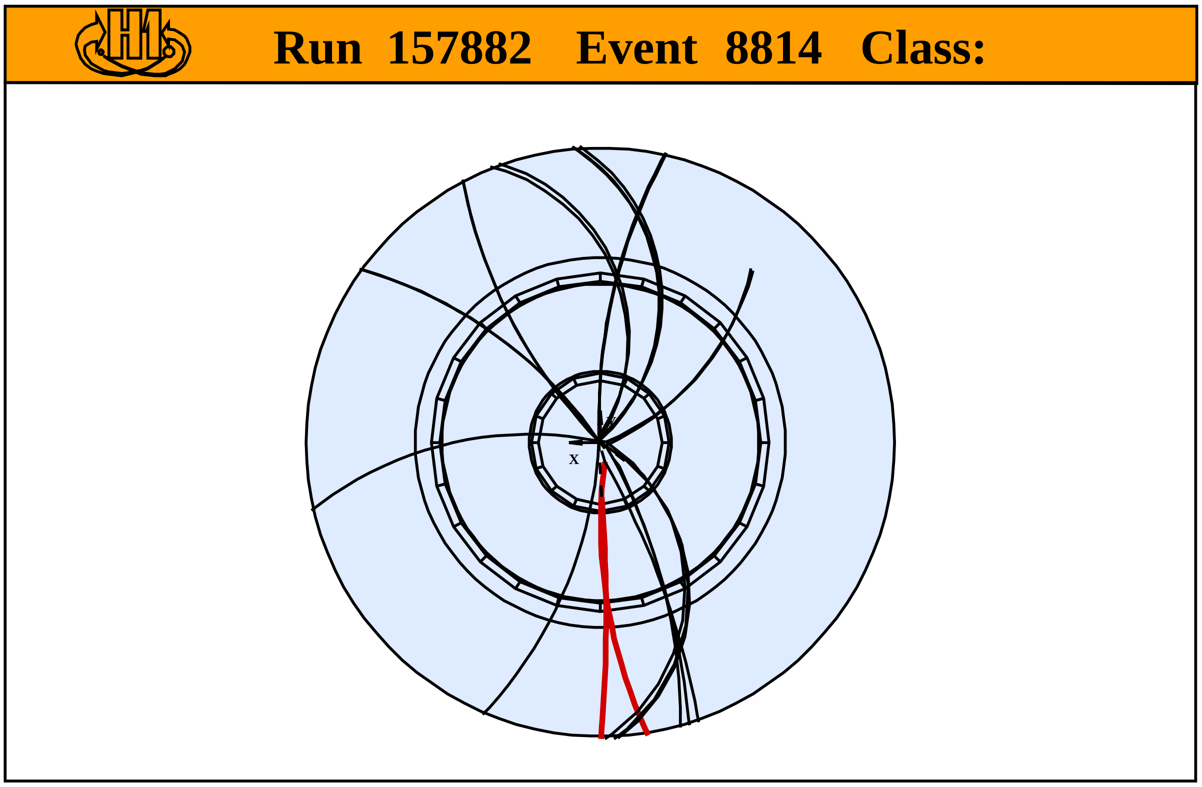
$-1.3 < \eta < 1.3$ $\quad$ $\eta = -\ln\tan\theta/2$

H1 Event Displays

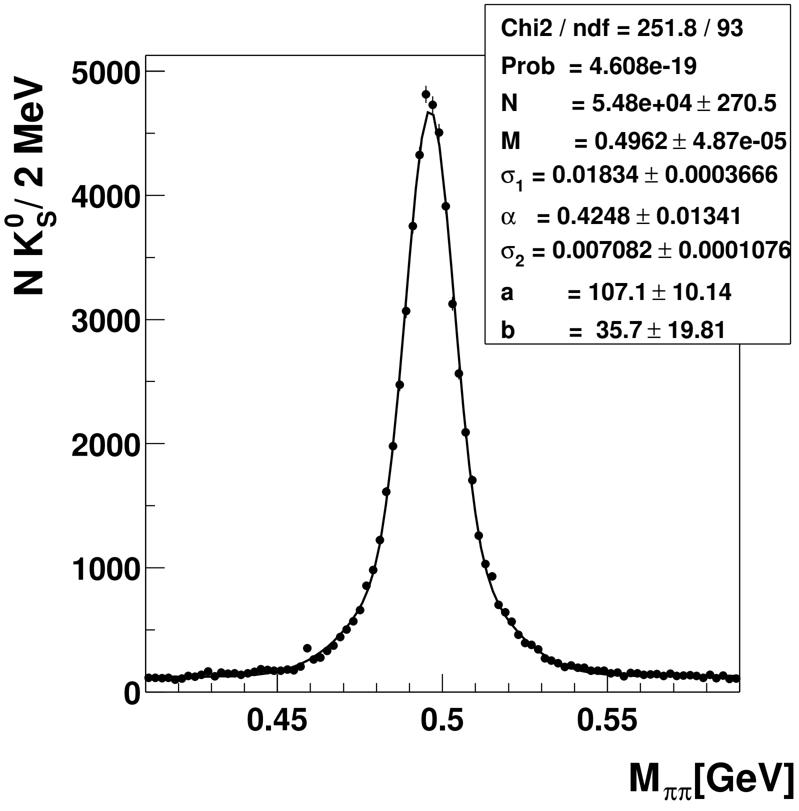
$K_S^0 \to \pi\pi$

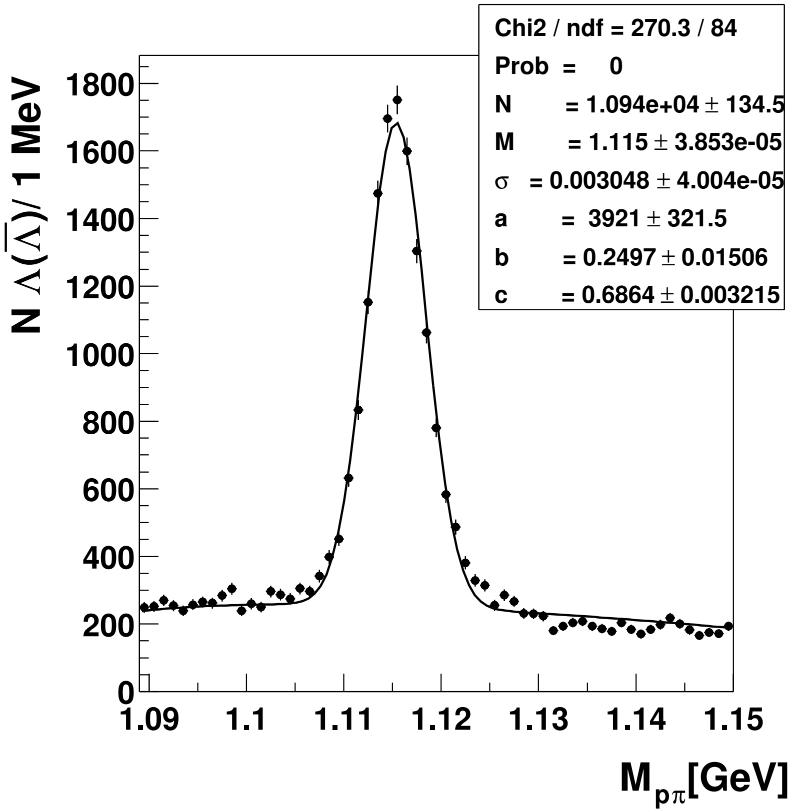


$\Lambda \to p\pi$



K_S^0 and Λ Signal





$N = 54801 \pm 271$ K_S^0 decays

$N(\Lambda(\bar{\Lambda})) = 10938 \pm 135$ Λ decays

Total K_S^0 and Λ Cross Sections

H1 DATA 96,97 $L = 17.8\mathrm{pb}^{-1}$

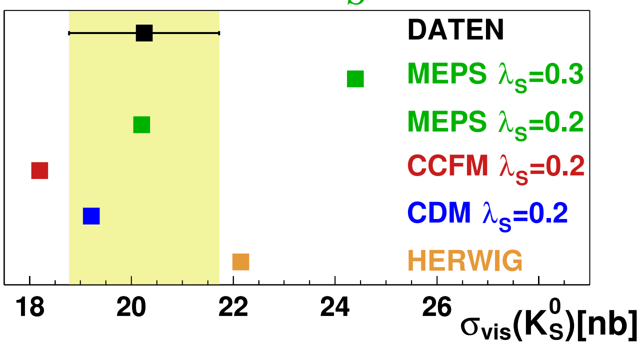
$2 < Q^2 < 100\,\mathrm{GeV}^2, \quad 0.1 < y < 0.6$

visible range

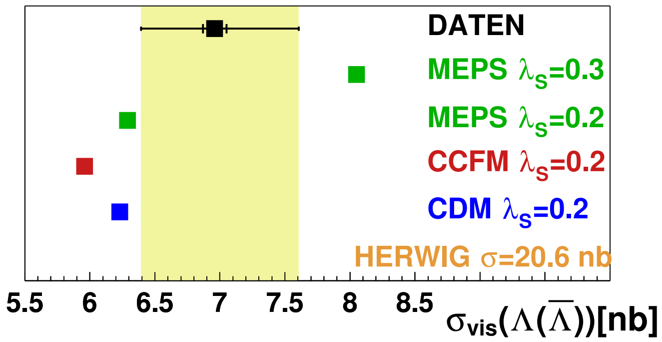
$p_T(K_S^0, \Lambda) > 0.5$ GeV and $|\eta(K_S^0 \Lambda)| < 1.3$

$\eta = -\ln\tan\theta/2$

K_S^0



Λ



Comparison with QCD Models:

MEPS (RAPGAP) MatrixElements + PartonShower

CCFM (CASCADE) CCFM Evolution
(J2003 - set2)

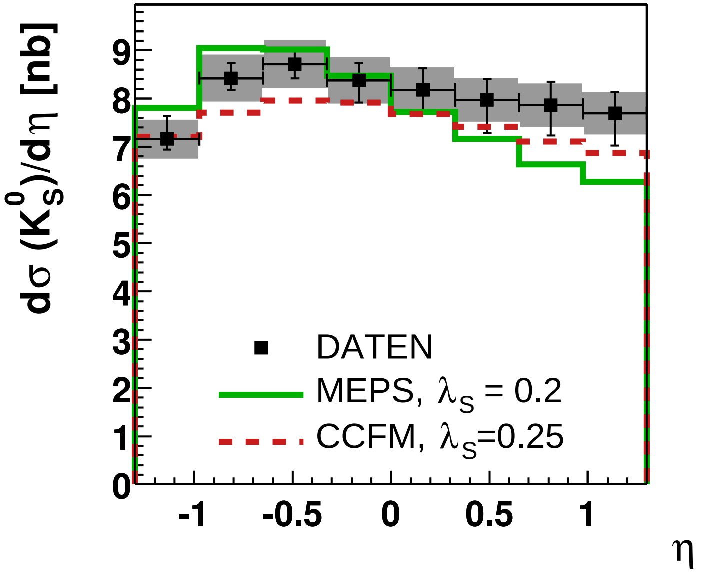
CDM (DJANGOH) Gluon Rad.: Color Dipole Model

Lund-String Model: $\lambda_S = 0.2 - 0.25$
(LEP: $\lambda_S = 0.3$)

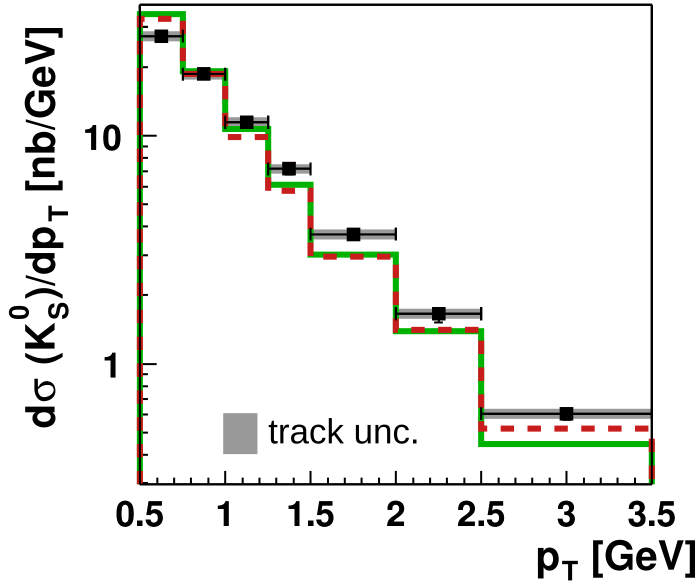
HERWIG Cluster Fragmentation

Differential Cross Sections in Lab Frame

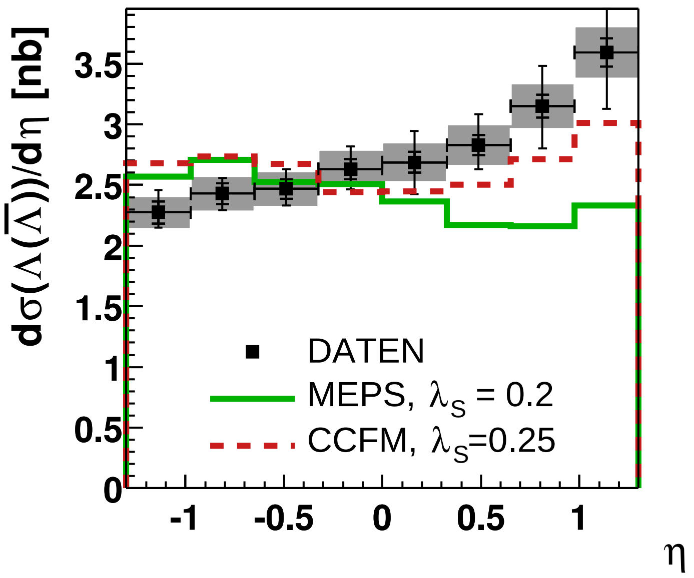
K_S^0



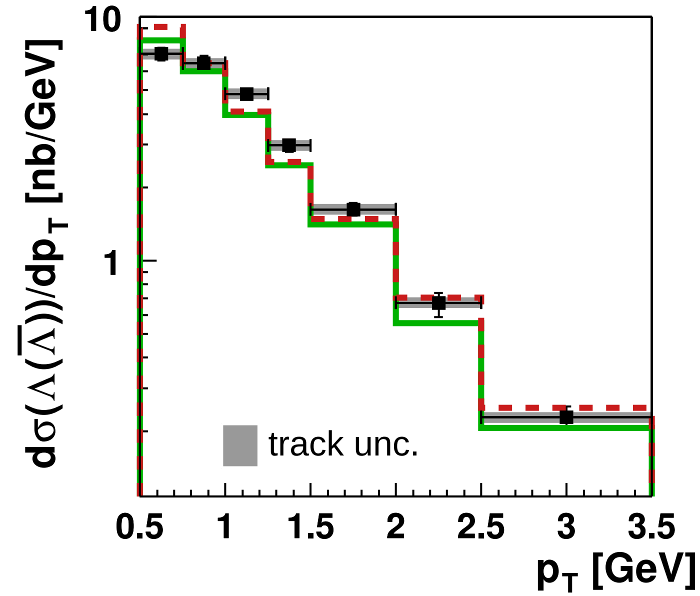
K_S^0



Λ



Λ



$\lambda_S \approx 0.2 - 0.25$

η Spectrum of K_S^0
MEPS: not perfect
CCFM: better

p_T Spectrum of K_S^0
too soft

η Spectrum of Λ
rise at $\eta > 0$
not described

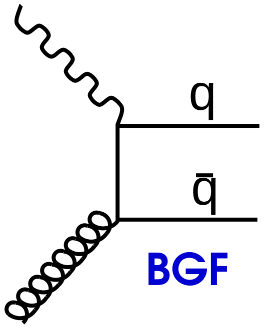
p_T Spectrum of Λ
too soft

MEPS with only BGF Processes

CCFM better description than MEPS

difference: CCFM vs. DGLAP Evolution

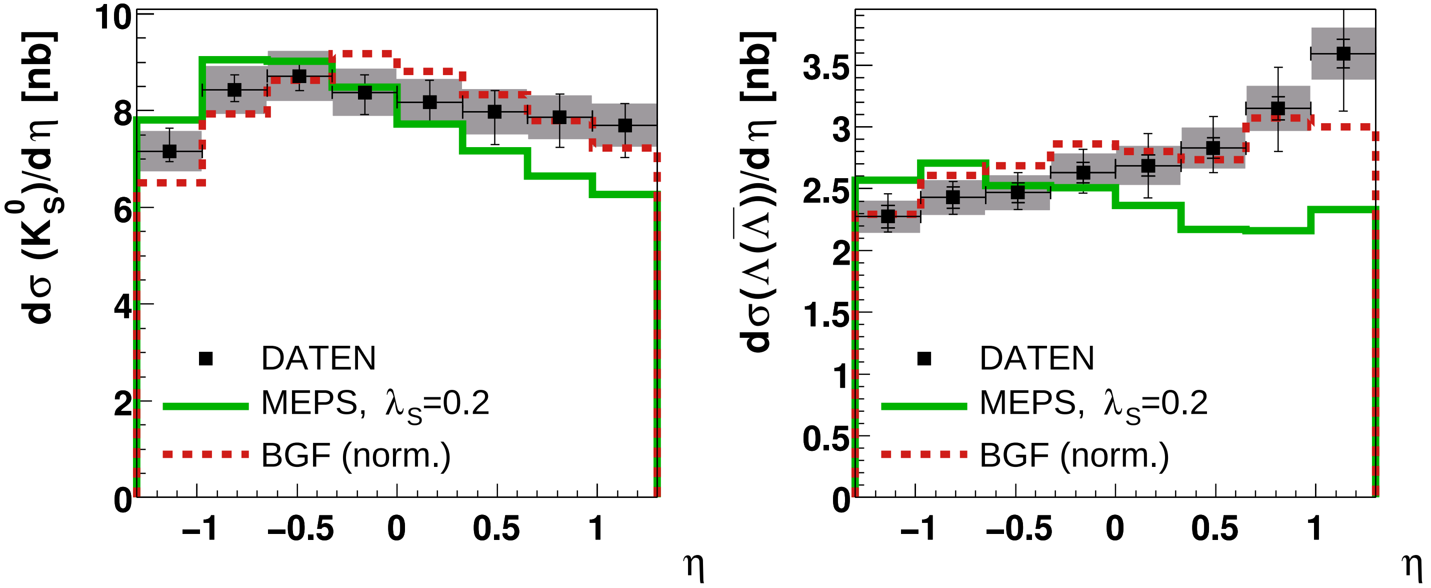
hard subprocess: BGF QPM + BGF + QCDC



Comparison of MEPS with MEPS "BGF only"

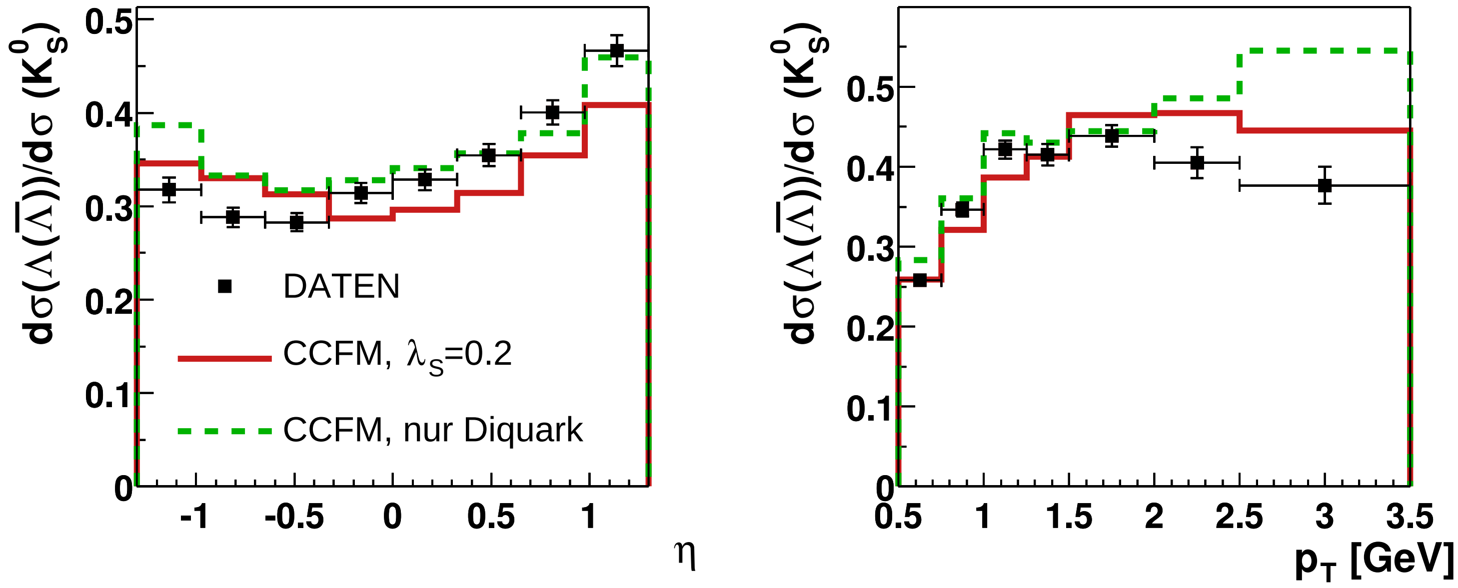
K_S^0- and Λ Cross Sections in η

K_S^0 Λ



gluon induced processes - better description of data?

Relative Production of $\Lambda(\bar{\Lambda})$ and K_S^0



Baryon Production Mechanis in Lund String Model

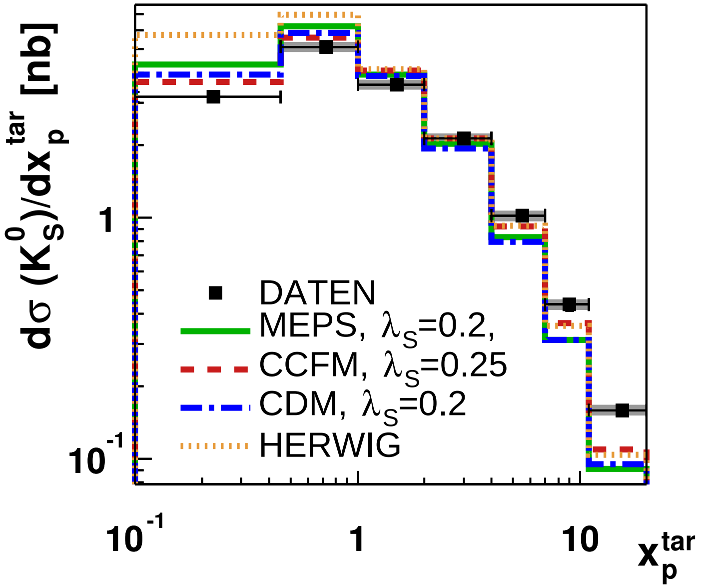
standard Diquark and Popcorn Baryon Production

modified Only Diquark Production

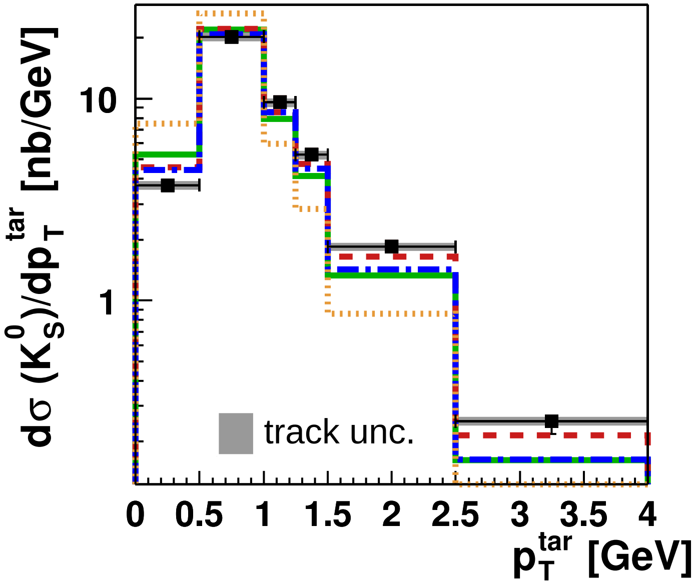
only Diquark Prod.: B/M larger, no better description

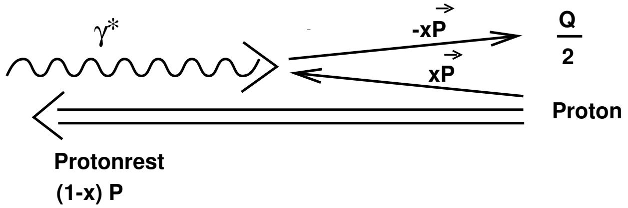
Target Hemisphere of the Breitframe

K_S^0



K_S^0

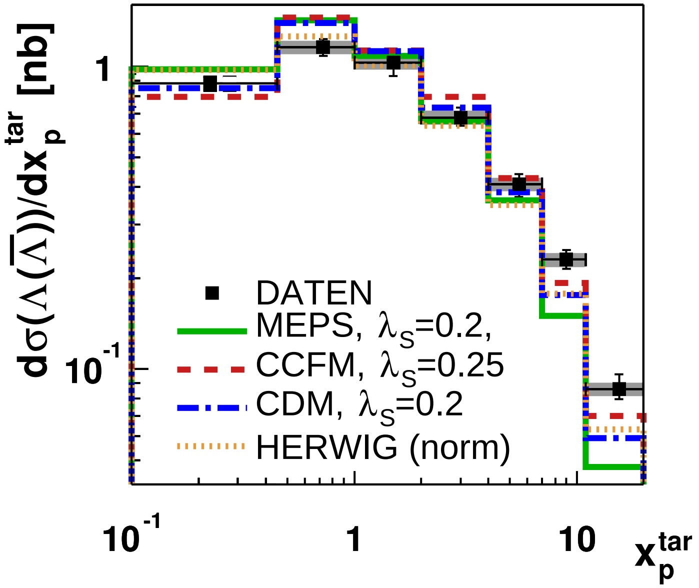




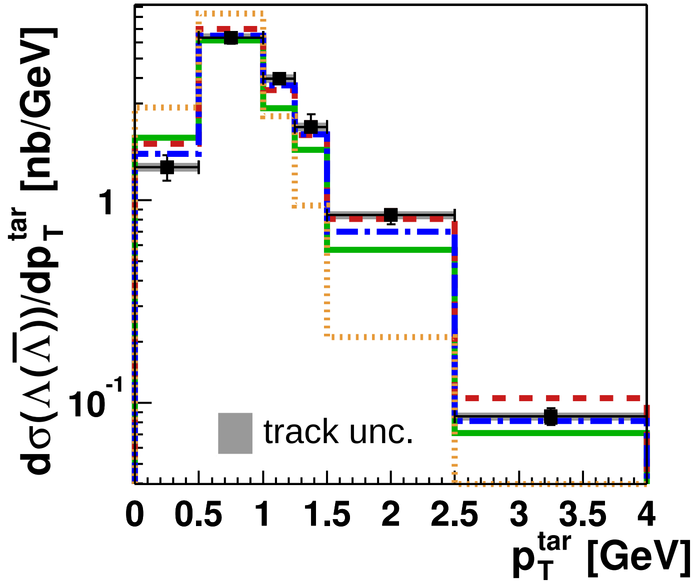
Target H. Current H.

$$x_p = 2|\vec{p}^{Breit}|/Q$$

Λ



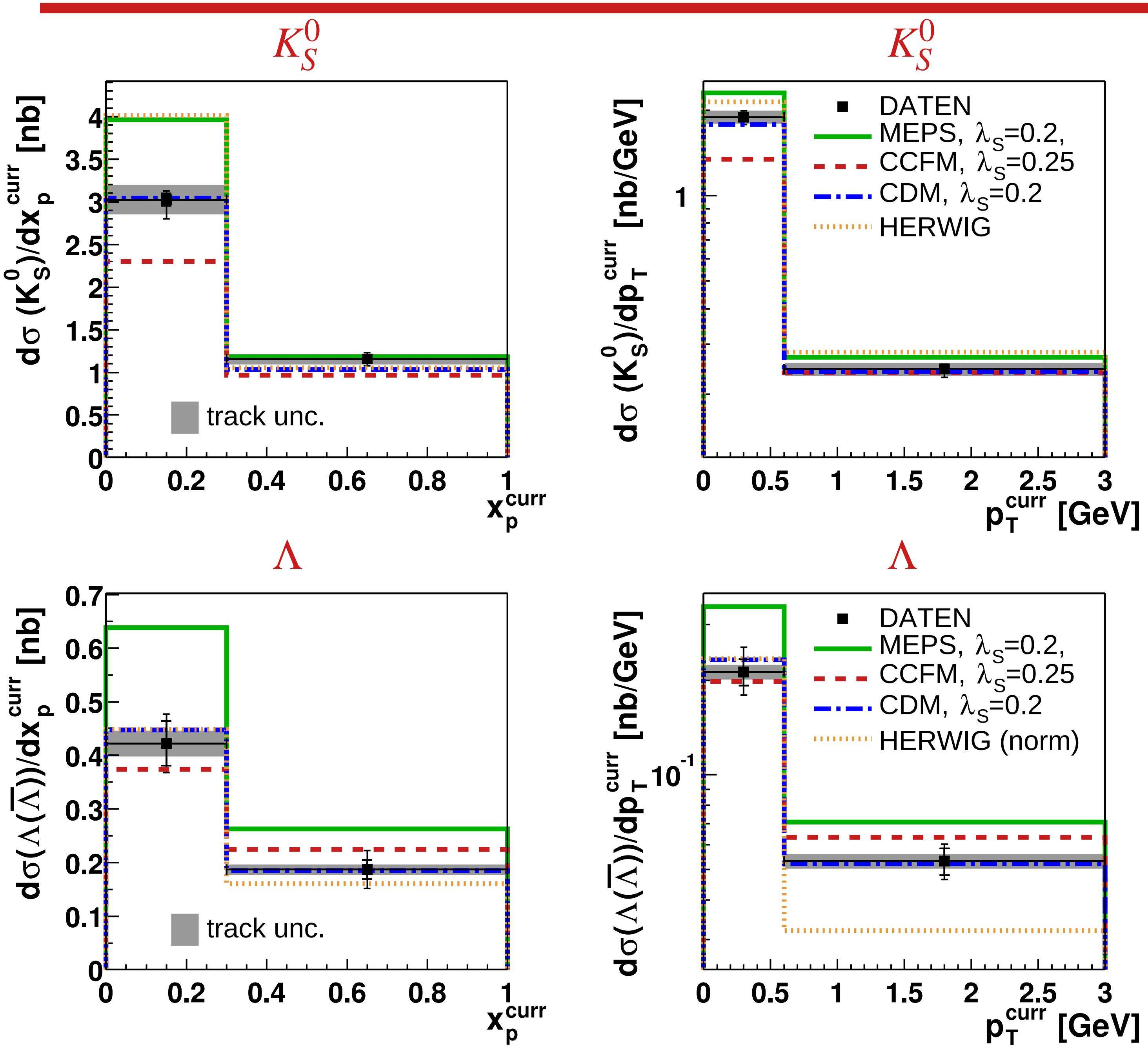
Λ

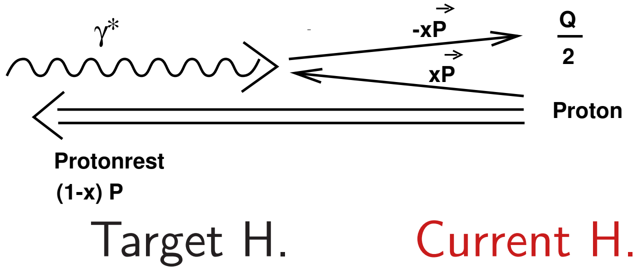


Models underestimate Data at large x_p

p_T^{breit} most Models too soft

Current Hemisphere of the Breitframe





$x_p = 2|\vec{p}^{Breit}|/Q$

few Events in Current-Hemisphäre

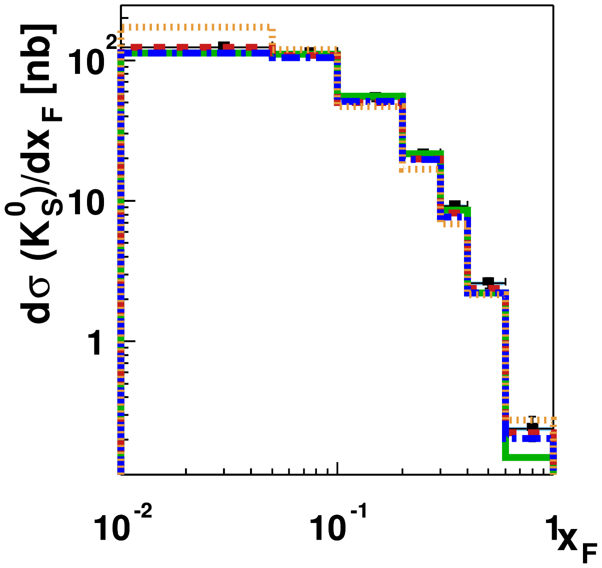
large stat. errors

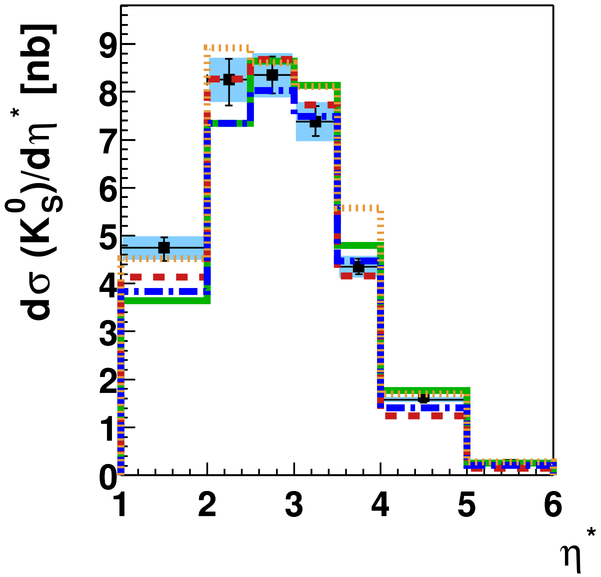
best Description of Data: CDM

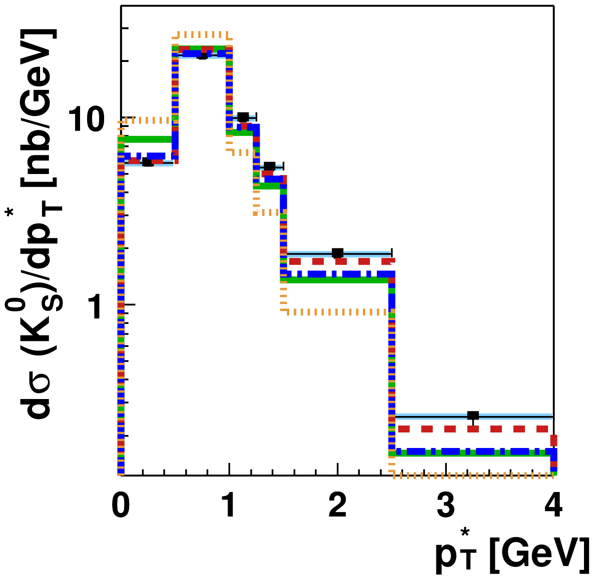
Summary

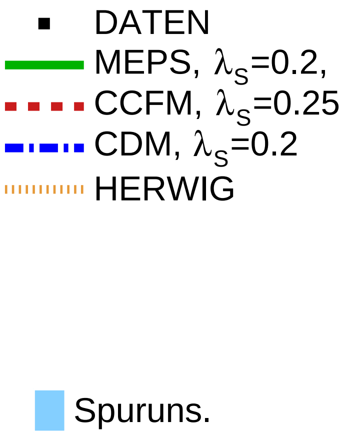
- visible K_S^0 and Λ Cross Sections $2 < Q^2 < 100\,\mathrm{GeV}^2$, $0.1 < y < 0.6$
- small strangeness suppression ($\lambda_S \approx 0.2 - 0.25$) favored (compared to e^+e^- $\lambda_S = 0.3$)
- Comparison of diff. Cross Sections with Models
  no model gives perfect description of Data
  - p_T Spektra modelled too softly
  - Rise of Λ Production with η
    * CCFM closer to DATA
    * MEPS BGF only better shape description
  - Breitframe:
    Current Hemisphere: lower statistics, better description?

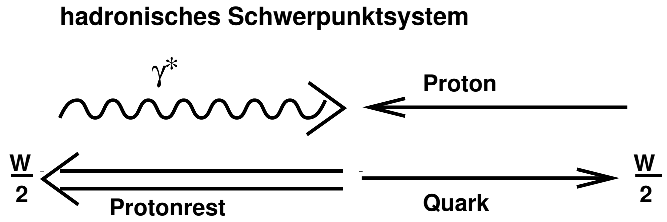
Differential Cross Sections - K_S^0 in HCMS











positive z-Axis - Photon Direction

scaled long. momentum $x_F = 2p_z^*/W$

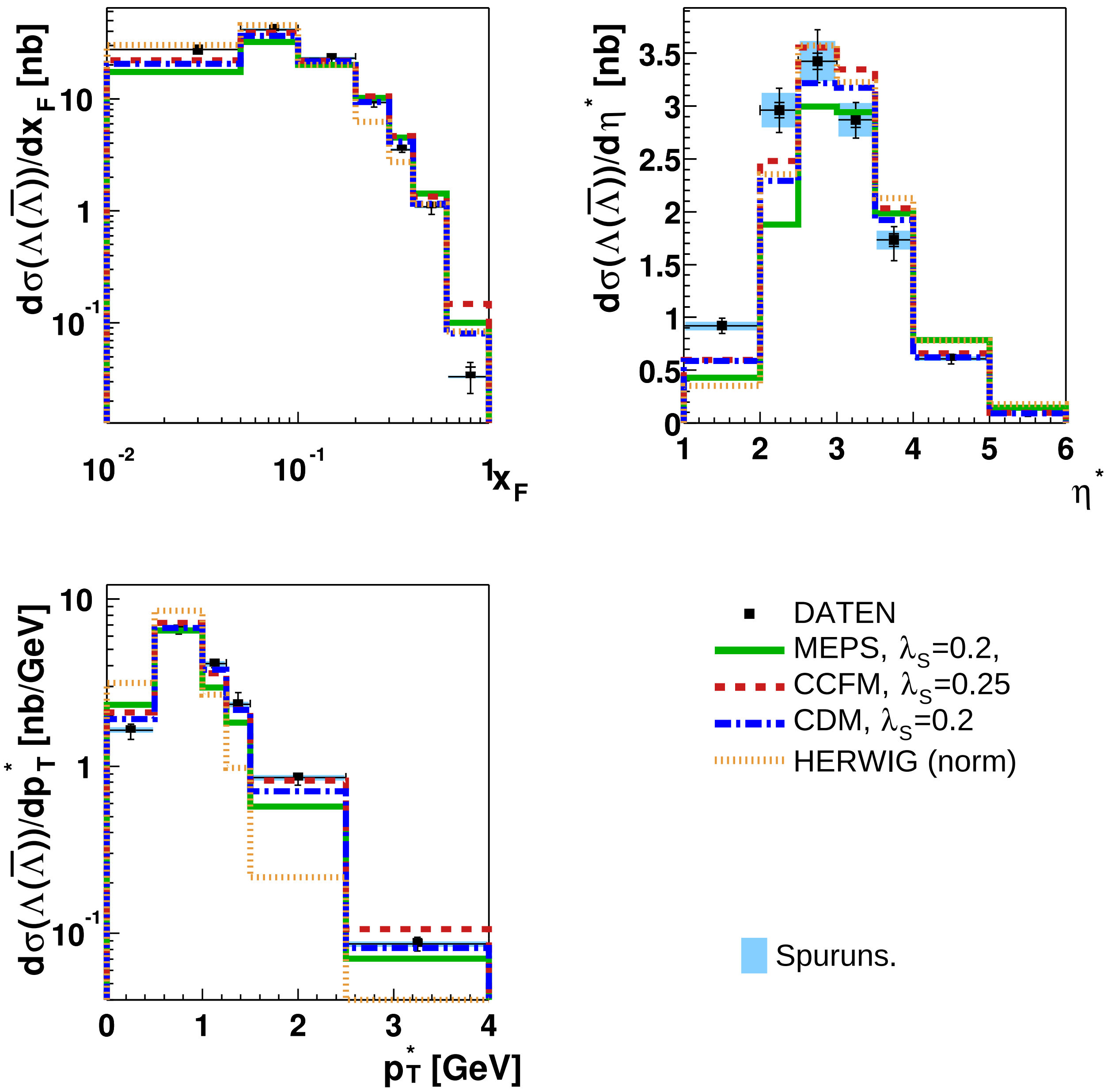
x_F-Spectra shape dep. on λ_S

low $\lambda_S \approx 0.2 - 0.25$ favoured

at η^* models undershoot Data

p_T^*-Spectra too soft

Differential Cross Sections - Λ in HCMS



x_F-spectrum not described: models undershoot Data at small
overestimate at high x_F

at low η^*: predictions too low

p_T-Spectra slightly too soft
best described by CCFM and CDM

Decay Angle Distribution of Λ

Angle between Proton in Λ restframe and Λ direction of flight $\cos\theta^*$

Polarization of Λ Baryons : $I(\theta*) \propto -\alpha P \cos\theta^*$

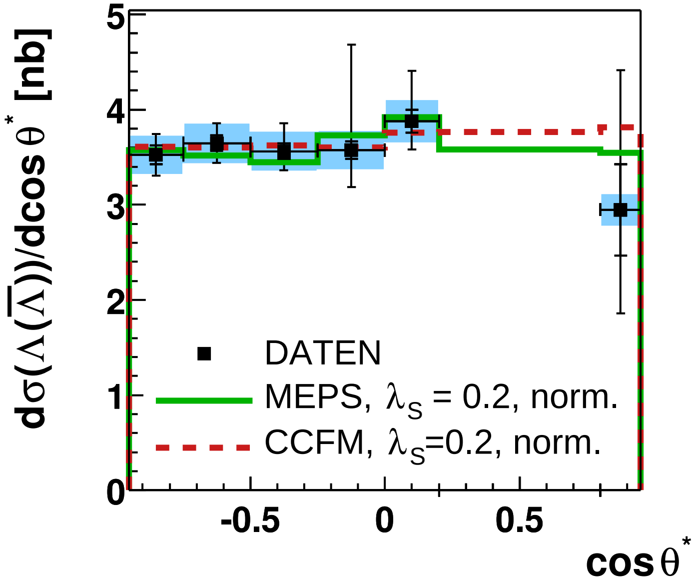
Problems:

- Bgr from K_S^0 concentrated at $0.2 < \cos\theta^* < 0.8$
- Efficiency lower at $\cos\theta^* > 0$ due to Kinematic of Decay

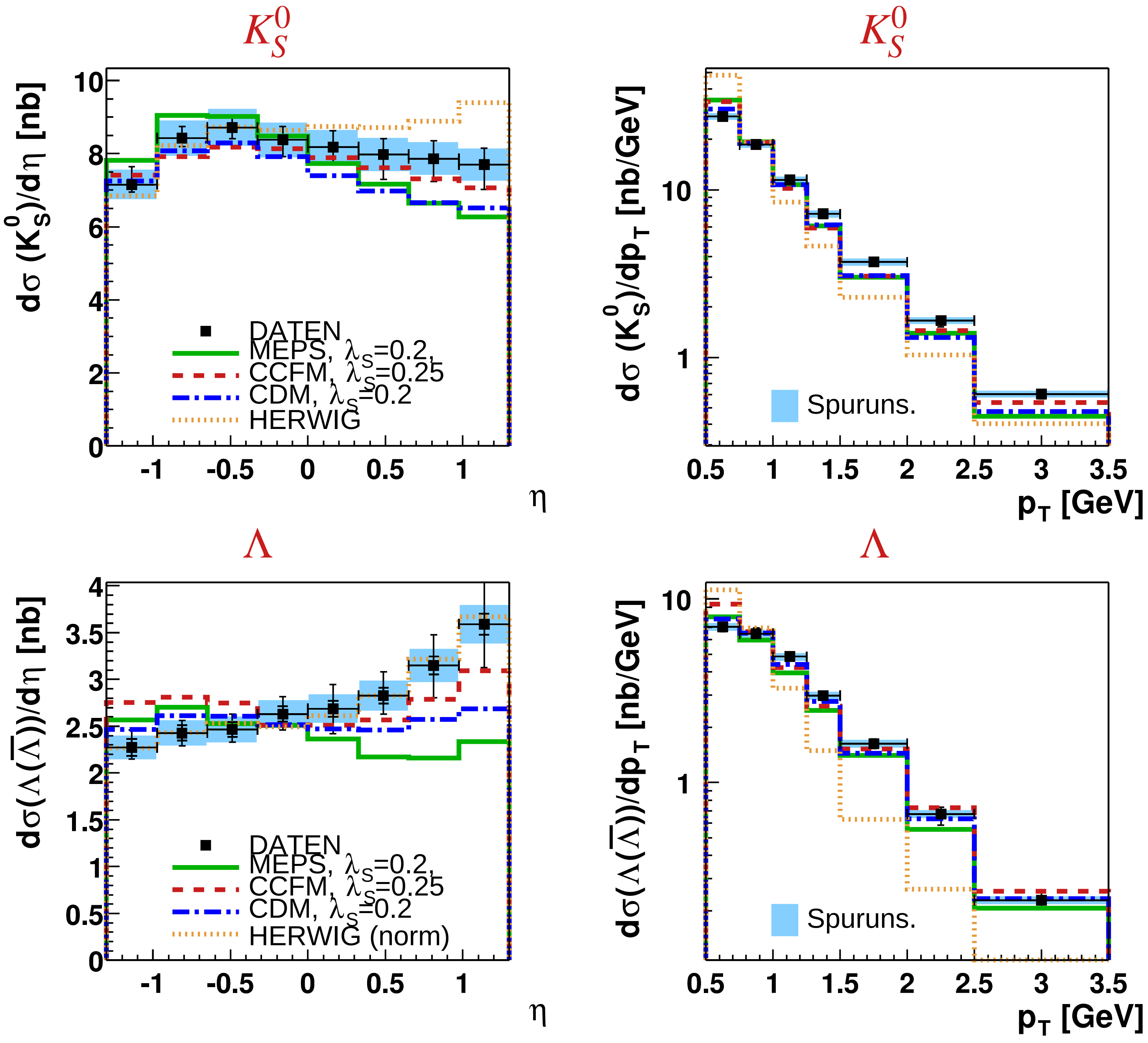
No Measurement possible in Region 0.2 - 0.8

Large Systematic Error at highest $\cos\theta^*$

Polarization compatible with 0

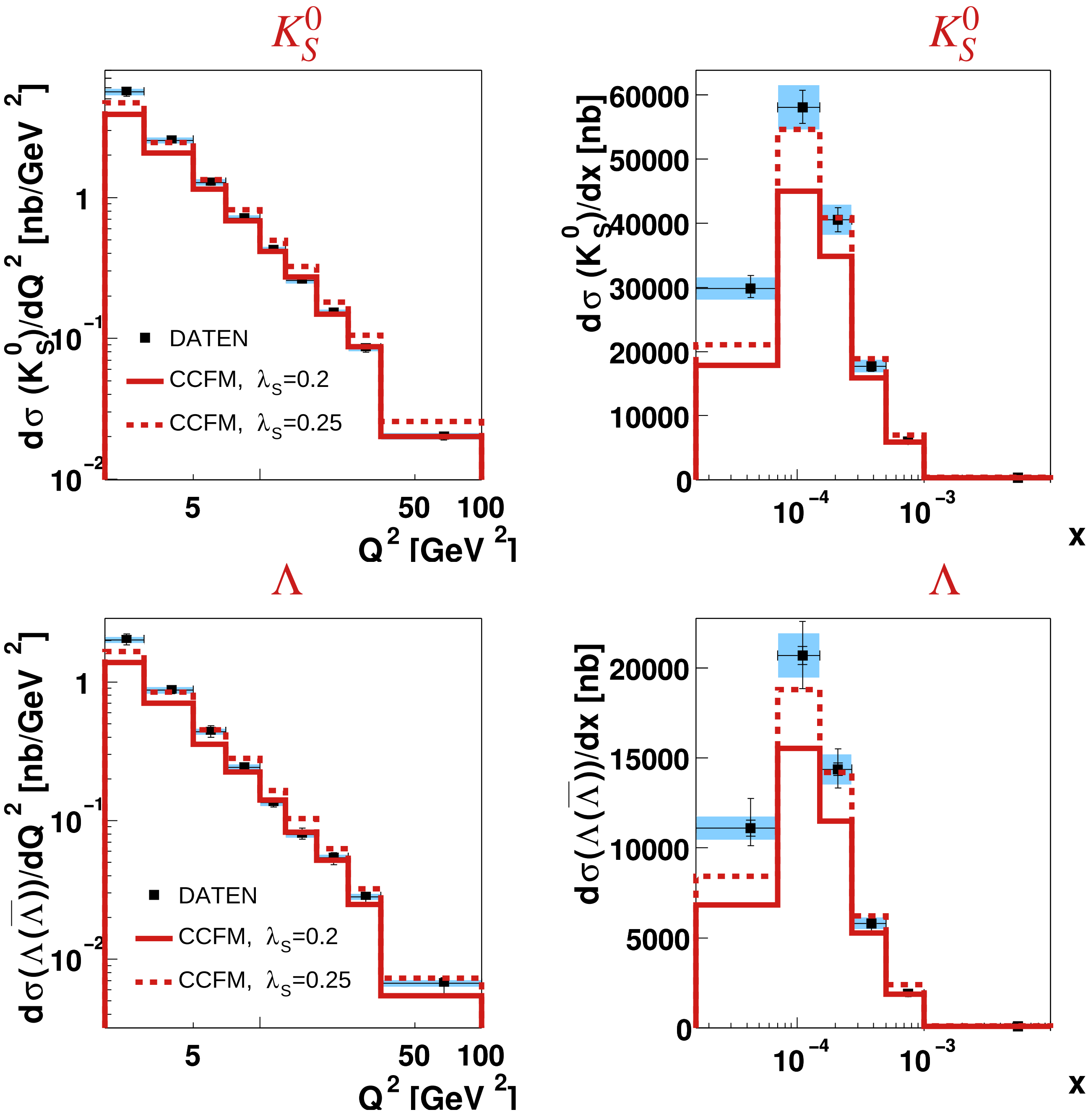


Diff. K_S^0 and Λ Cross Section in Lab Frame



best description by CCFM and CDM

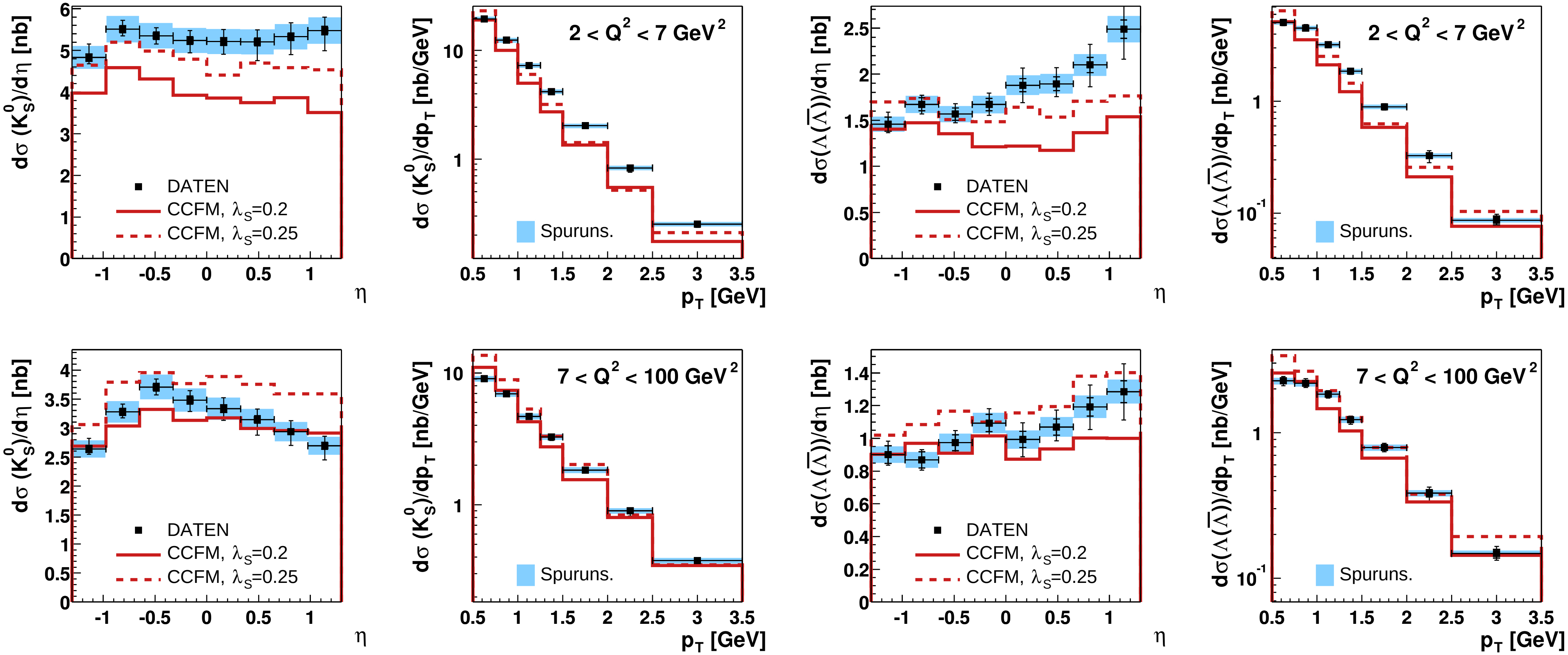
Q^2 Dependence of K_S^0 and Λ production



Cross Sections at low x and low Q^2 compared to CCFM

Double Differential Cross Sections

K_S^0-Wirkungsquerschnitte Λ-Wirkungsquerschnitte



low Q^2: larger deviations, $\lambda_S \approx 0.25 - 0.3$

larger Q^2: better shape description, lower $\lambda_S \approx 0.2$

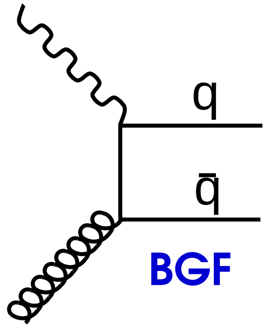
Q^2 Dependence not modelled correctly

MEPS with only BGF Processes

K_S^0 and Λ cross section seems to be better described by gluon induced processes only.

What can we learn from this?

Ideas, how to confirm this hypothesis?



Comparison of MEPS with MEPS "BGF only"

K_S^0- and Λ Cross Sections in η