Neutrino dimuon production and the dynamical determination of strange parton distributions

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Dimuon production

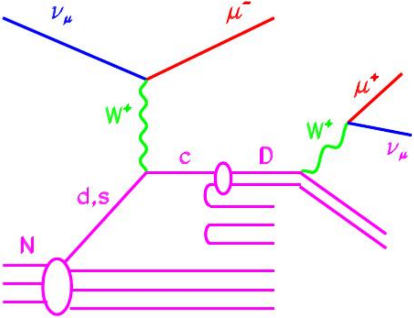
The dynamical approach

Fitting the data

The strangeness asymmetry

Relevance for the NuTeV anomaly

Dimuon production



[NuTeV Coll. PRD64 (2001) 112006]

Signature: Two muons of different sign

Directly related to **charged current charm production** $\propto s(x,Q^2)$ (FFNS)

Sensitive to differences between s and $\bar{s}$

Overall normalization proportional to B_c

$$\frac{d\sigma^+}{dxdy}\left(x,y,E_{\nu(\bar{\nu})}\right) = \frac{G_F^2 M E_{\nu(\bar{\nu})}}{\pi} B_c\, \mathscr{A}\left(x,y,E_{\nu(\bar{\nu})}\right) \frac{d\sigma^{\nu(\bar{\nu})}}{dxdy}\left(x,y,E_{\nu(\bar{\nu})}\right)$$

Acceptance corrections [Kretzer et al.] at NLO!

Nuclear corrections (iron) using FFNS NLO GRV98 [de Florian et al.]

The dynamical approach

Idea: at low-enough Q^2 only "valence" partons would be "resolved"

$\longrightarrow$ *structure at higher Q^2 appears* ***radiatively*** *(i.e. due to QCD* ***dynamics****)*

DYNAMICAL:

$Q_0^2 < 1\,\mathrm{GeV}^2$ optimally **determined**

$\mathbf{a} > 0$ *"valence-like"*

"STANDARD":

$Q_0^2 = 2\,\mathrm{GeV}^2$ arbitrarily **fixed**

Unrestricted parameters

$$xf(x, Q_0^2) = N x^{\mathbf{a}} (1-x)^b (1 + A\sqrt{x} + Bx)$$

DYNAMICAL	"STANDARD"
Positive definite input distributions	Arbitrary fine tunning ($g < 0$!)
QCD **predictions** for $x \lesssim 10^{-2}$	**Extrapolations** to unmeasured region
More restrictive, **less uncertainties**	Less restrictive, *marginally* smaller χ^2

Physical aid for determining **CC for DGLAP** $\neq$ **NP structure** of the nucleon

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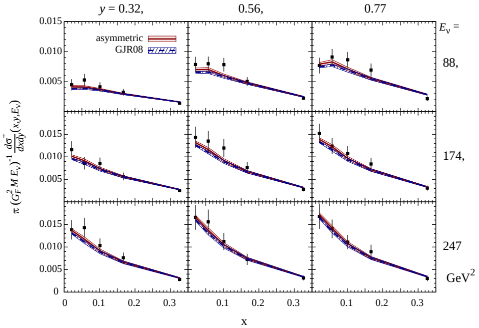

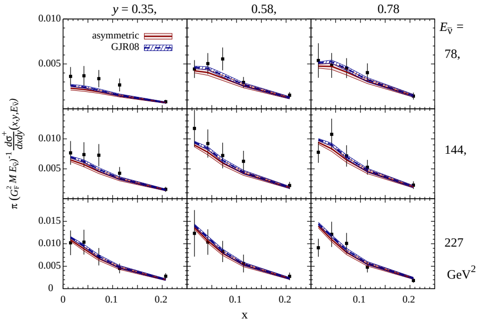

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$\Rightarrow$ **radiatively generated strangeness plausible!**: $s(x,Q_0^2)+\bar{s}(x,Q_0^2)=0$

Introducing an asymmetry χ^2 goes down to 60: $s(x,Q_0^2)-\bar{s}(x,Q_0^2)\neq 0$

Neutrino increases, antineutrino decreases $\Rightarrow$ **"positive" asymmetry**

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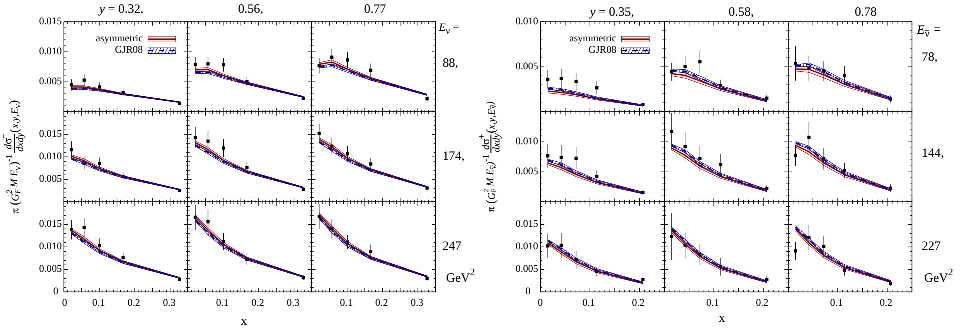

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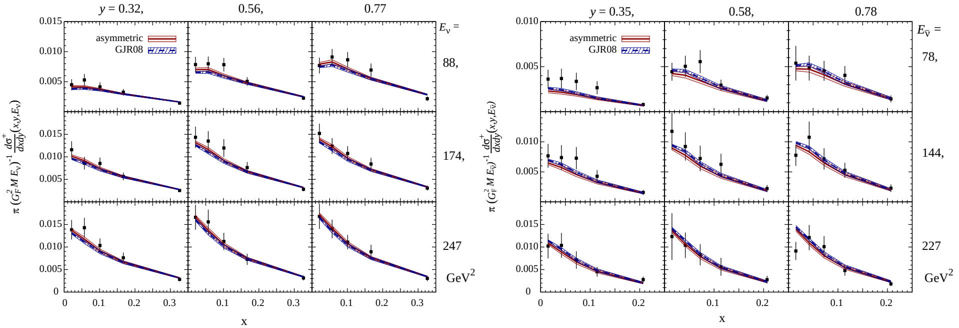

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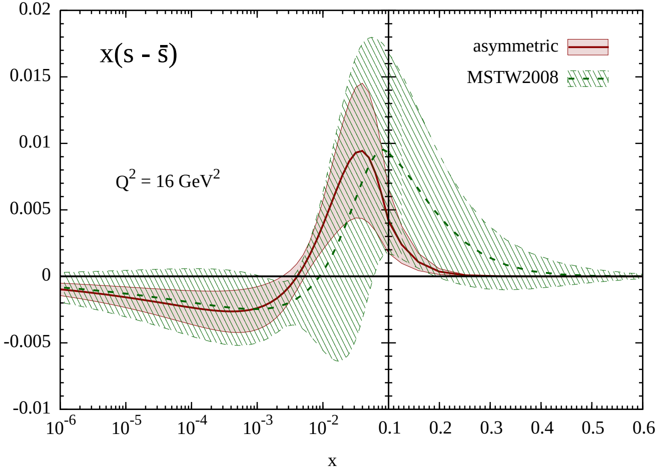


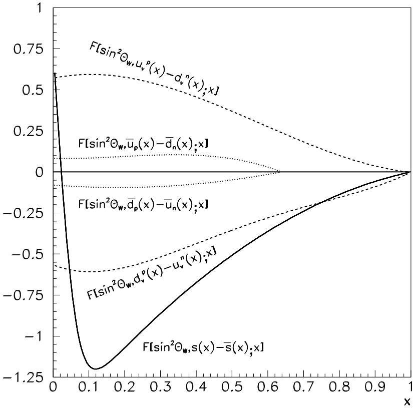
Compatible with previous determinations but smaller uncertainties

Very **small effect** (for most applications): $S^{-} \equiv \int_0^1 dx\, x(s-\bar{s}) = 0.0008 \pm 0.0005$

Important for dedicated experiments (e.g. NuTeV anomaly)

Relation to the NuTeV anomaly

Experimental methods(functionals): $\Delta s_W^2 = \int_0^1 F[s_W^2, \delta \overset{(-)}{q}; x] x \delta \overset{(-)}{q}(x, Q^2)\, dx$



Total shift: $\Delta s_W^2|_{\text{total}} =$

$= \Delta s_W^2|_{\text{QED}} + \Delta s_W^2|_{\text{NP}} + \Delta s_W^2|_{\text{strange}}$

Isospin–symmetry violating PDFs:

NP mass effects: $\Delta s_W^2|_{\text{NP}}$ [Londergan et al.]

radiative QED effects: $\Delta s_W^2|_{\text{QED}}$

Strange asymmetric PDFs: $\Delta s_W^2|_{\text{strange}}$

All effects combined remove the "anomaly" (within SM)!

Using $R^- \equiv \frac{\sigma_{\text{NC}}^{\nu N} - \sigma_{\text{NC}}^{\bar{\nu} N}}{\sigma_{\text{CC}}^{\nu N} - \sigma_{\text{CC}}^{\bar{\nu} N}} = R_{\text{PW}}^- + \delta R_I^- + \delta R_s^-$ overestimates the corrections ($\approx 20\%$–40%)

Conclusions

Strangeness in the nucleon well determined by dimuon–production data

Dynamical approach: more **predictive** and **smaller uncertainties**

Within the dynamical approach $s(x,Q_0^2) + \bar{s}(x,Q_0^2) = 0$ **works well!**

Data well described by strange–symmetric (NLO) distributions

However a **small positive asymmetry** preferred

NuTeV “anomaly” **removed** (within SM) **by several effects**

Corrections to the PW relation overestimates the effects