Delineating gluon PDFs and the strong coupling

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Introduction: non-singlet sector

\[ u \text{-valence rather well determined} \]

larger differences for \( d \)-valence, but also quite stable

much smaller but can be determined using Drell-Yan \( \sigma^{pd}/\sigma^{pp} \) ratios

far less relevant except for \( \nu, \bar{\nu} \) differences in dimuon production
Introduction: singlet sector

sea distributions at small $x$ determined by the gluon via RGE evolution

d$/u$ ratio at large $x$ sensitive to nuclear corrections and parametrizations

strange-quark well determined from dimuon (now also LHC) data

largest and most relevant differences in the gluons (and $\alpha_s$ values)
Status of gluon distributions

Large differences at small and large $x$, and in $\alpha_s(M_Z^2)$ values
Propagation to Higgs cross-section

[Anastasiou et al. 2012]
Constraints on the gluon and data selection

Gluon only enters directly (at LO) in:
- $F_L$ (both small and large $x$)
- HQ electroproduction (small $x$)
- jet production (medium to large $x$)

But constrained via scaling violations in the small $x$ region

Momentum sum rule correlates small and large $x$

DIS data often excluded from fits:
\[ Q^2 \gtrsim 4 \text{ GeV}^2, \ W^2 \gtrsim 10 \text{ GeV}^2 \]

Moderate cuts lead to larger $\alpha_s$, thus softer small-$x$ gluons

Jet data also moderately increase $\alpha_s$; should not be used beyond NLO

(NNLO corrections are large)
Data selection: 4475 data points

- Switched to HERA combined neutral-current DIS $\sigma_{n}, \sigma_{c}$
  and included charged-current

- $F_{2}$ replaced for cross-section for SLAC, BCDMS and NMC [ABM 2010]

- From 30 points on $p/n$ ratios to an equal-footing treatment of fixed-target data

- Dimuon data included in nominal fits

- HERMES data included ($p$ and $d$)

- JLab proton and deuteron data included (need lower $W$ cuts)
  
  $$Q^{2} \geq 2\text{GeV}^2, W^{2} \geq 3.5\text{GeV}^2$$

- Inclusion of Rosenbluth separated ($F_{2}, F_{L}$) data from H1, and from
  BCDMS, SLAC, EMC and JLab

[Monaghan et al. 2012]
Calculations

- Experimental correlations properly treated (also multiplicative errors)
- Switched to \( \overline{\text{MS}} \) scheme for heavy quark masses [ABM 2010]
- NNLO_{app} for heavy quark structure functions [ABM 2010]
- Target mass corrections used also for \( F_L \) (in addition to \( F_2 \))
- Nuclear corrections for deuteron data [CJ 2012]
- Determination of higher-twist contributions to structure functions

\[
T_2 F_{2,L}^{p,n}(x, Q^2) + \frac{T_4 F_{2,L}^{p,n}(x)}{Q^2}
\]
The role of the input scale

Any dependence is due to shortcomings of the estimation: *procedural bias*

Extended parametrization: $1 + 27 + 16 = 44$ parameters
Interim results
Interim gluons

Dynamical $\alpha_s(M_Z^2) = 0.1126 \pm 0.0005$

Standard $\alpha_s(M_Z^2) = 0.1147 \pm 0.0007$

JR gluons at large $x$ are rather stable: not very sensitive to the inclusion of Jet data and describe well the Rosenbluth separated $F_L$ data

Comment: ABM result not due to FFNS!!
The strong coupling and the input scale

Central values in good agreement with JR09 (dynamical and standard)

Jets change a bit central values but not dramatically

Uncertainties: $\Delta_{\text{exp}} \simeq 0.0006$, $\Delta_{\text{bias}} \simeq \Delta_{\text{exp}}$, $\Delta_{\text{theo}} \simeq ??$
Origin of our strong coupling values
Origin of our strong coupling values

Fit finds a *compromise*: intermediate central value with reduced uncertainties
(artificially? tolerance parameter $\Delta \chi^2 = 1$?)
Summary and prospects

- Accurate proton PDFs crucial for precise predictions at LHC

- An upgrade of the JR unpolarized distributions with many improvements is currently in preparation: trying to get the most from all pre-LHC data

- Preliminary results mostly consistent with JR09

- Gluon PDFs and $\alpha_s(M_Z^2)$ determination stable

- Errors somewhat small for $\Delta \chi^2 = 1$; due to tensions between data sets?

- Inclusion of LHC data foreseen for next year

Thank you for your attention!!