Delineating gluon PDFs and the strong coupling

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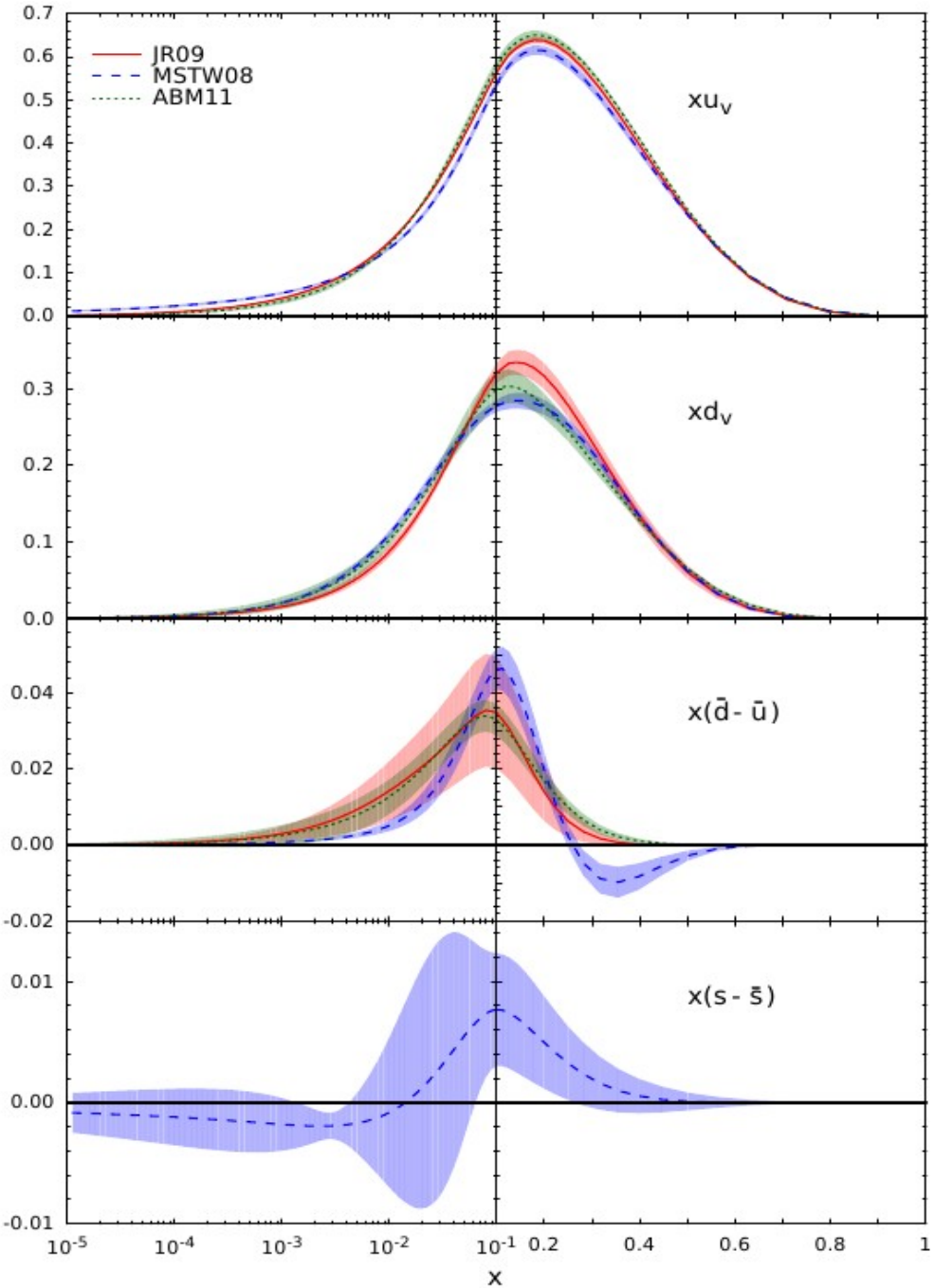
Introduction: non-singlet sector



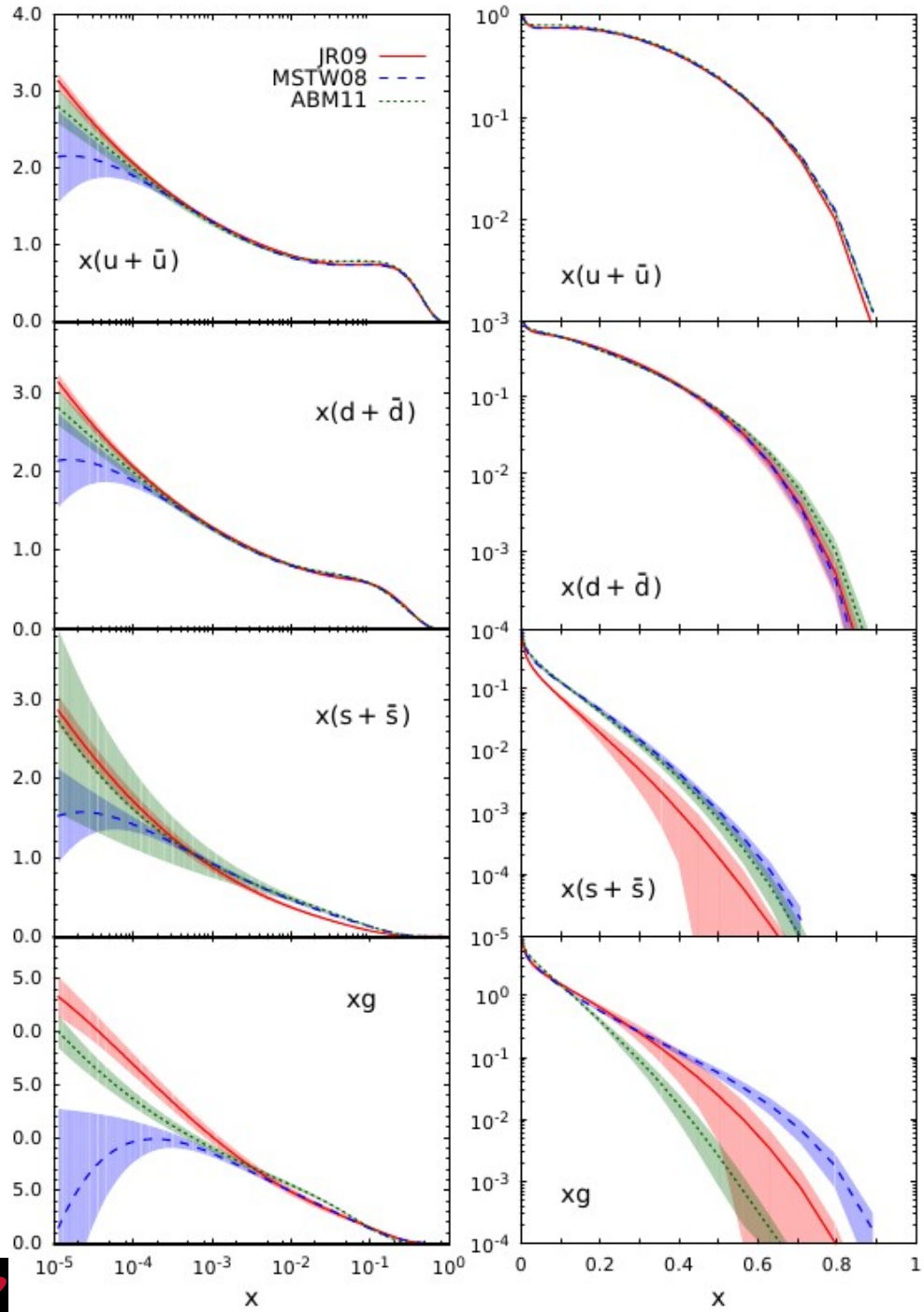
u-valence rather well determined

larger differences for *d*-valence, but also quite stable

much smaller but can be determined using Drell-Yan σ^{pd}/σ^{pp} ratios

far less relevant except for $\nu, \bar{\nu}$ differences in dimuon production

Introduction: singlet sector



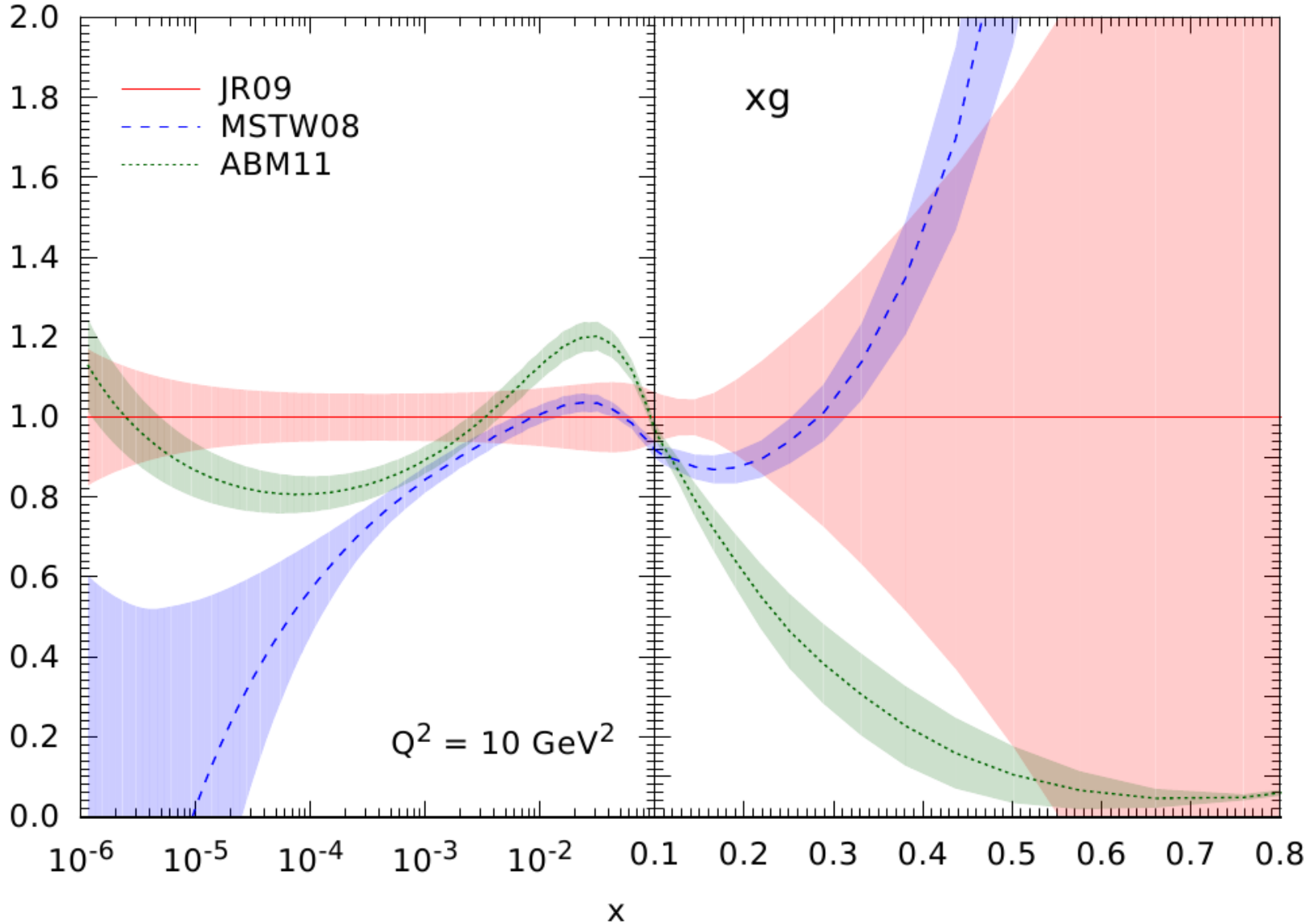
sea distributions at small x determined by the gluon via RGE evolution

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 α_s values)

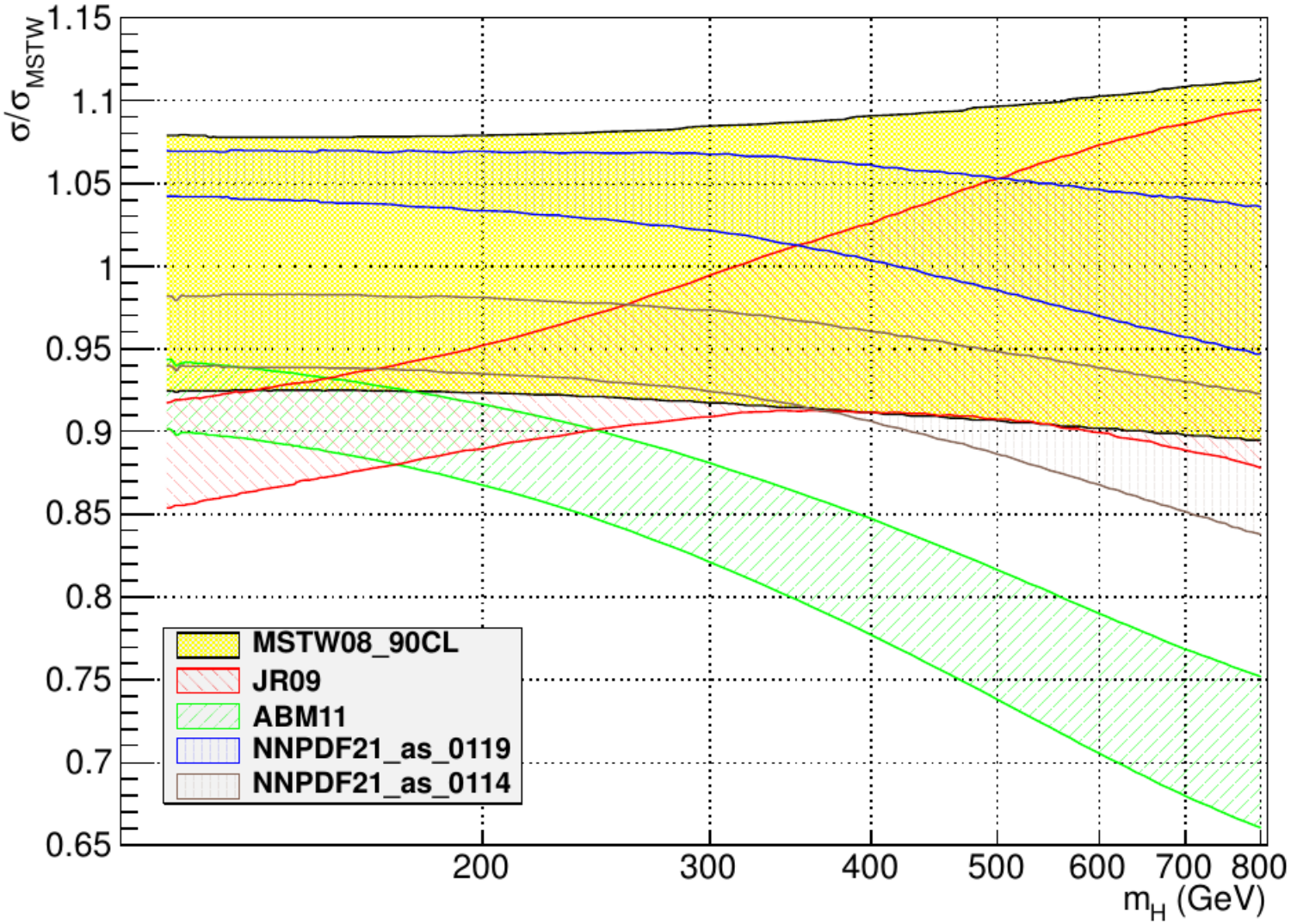
Status of gluon distributions



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:

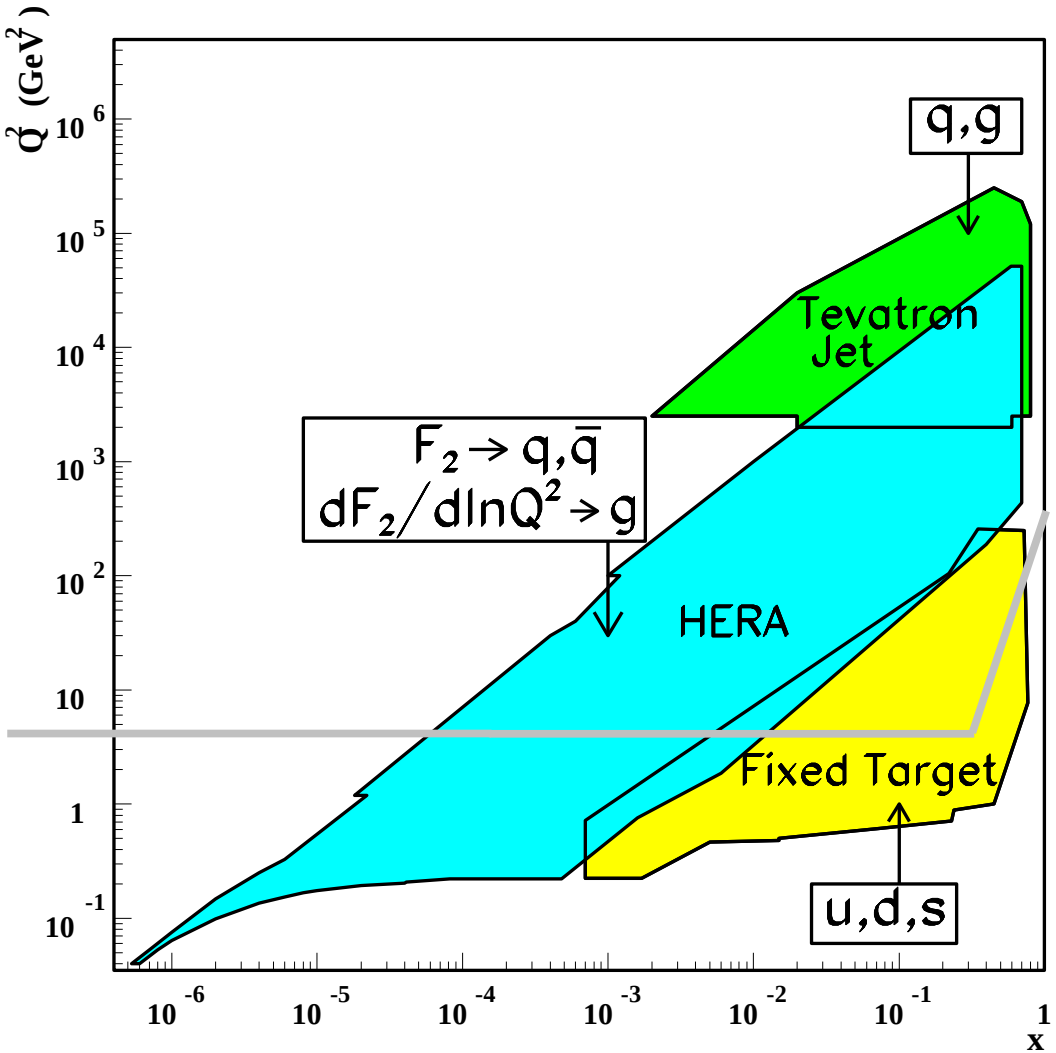
- F_L (both small and large x)
- HQ electroproduction (small x)
- jet production (medium to large x)

But constrained via scaling violations in the small x region

Momentum sum rule correlates small and large x

DIS data often excluded from fits:

$$Q^2 \gtrsim 4\ \mathrm{GeV}^2,\ W^2 \gtrsim 10\ \mathrm{GeV}^2$$



[Particle Data Group]

Moderate cuts lead to larger α_s, thus softer small-x gluons

Jet data also moderately increase α_s; should *not* be used beyond NLO

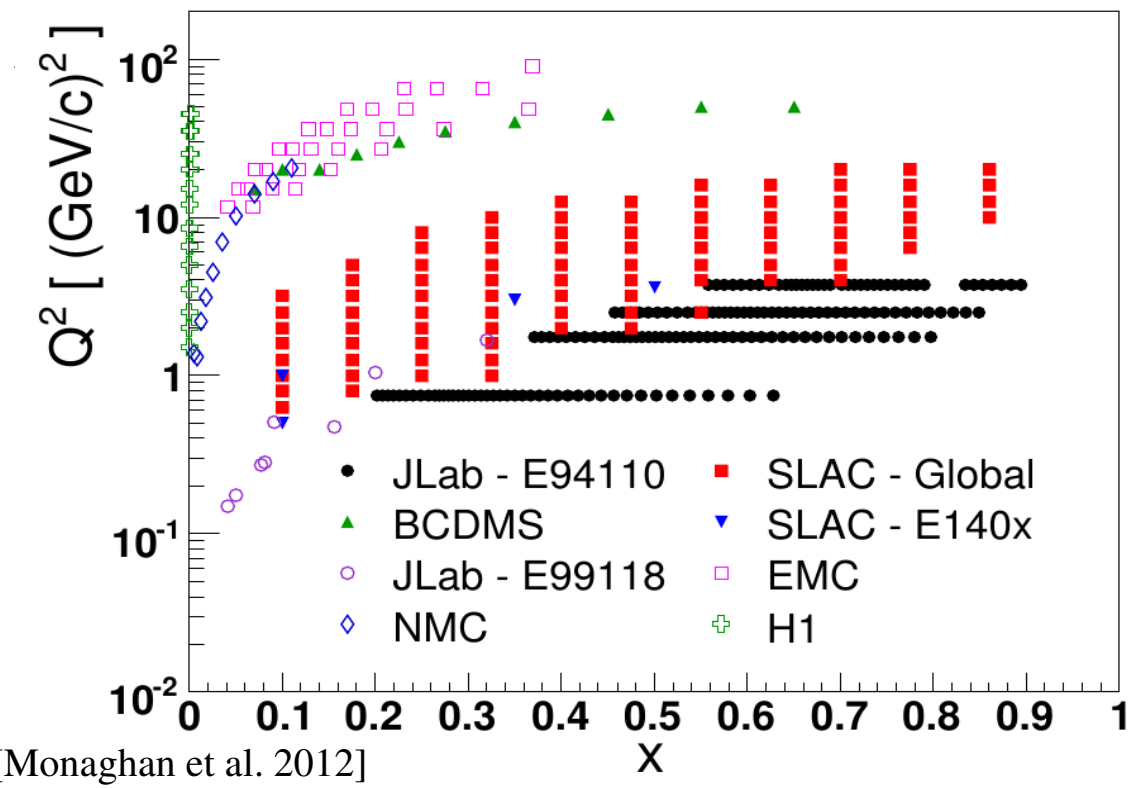
(NNLO corrections are large)

Data selection: 4475 data points

- Switched to HERA combined neutral-current DIS σ_r, σ_r^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)

$$Q^2 \geq 2\mathrm{GeV}^2, W^2 \geq 3.5\mathrm{GeV}^2$$

- Inclusion of Rosenbluth separated (F_2, F_L) data from H1, and from BCDMS, SLAC, EMC and JLab

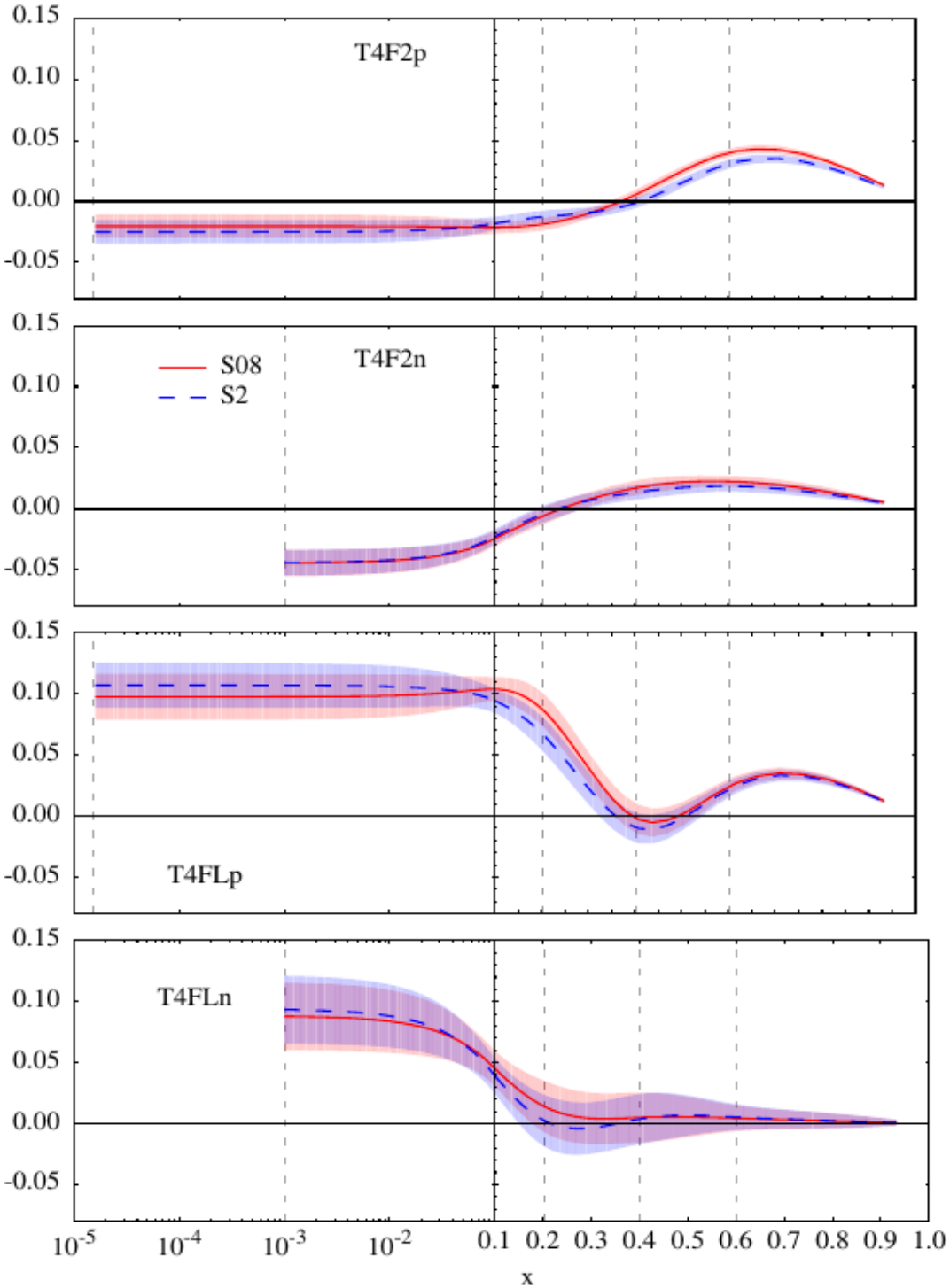


[Monaghan et al. 2012]

Calculations

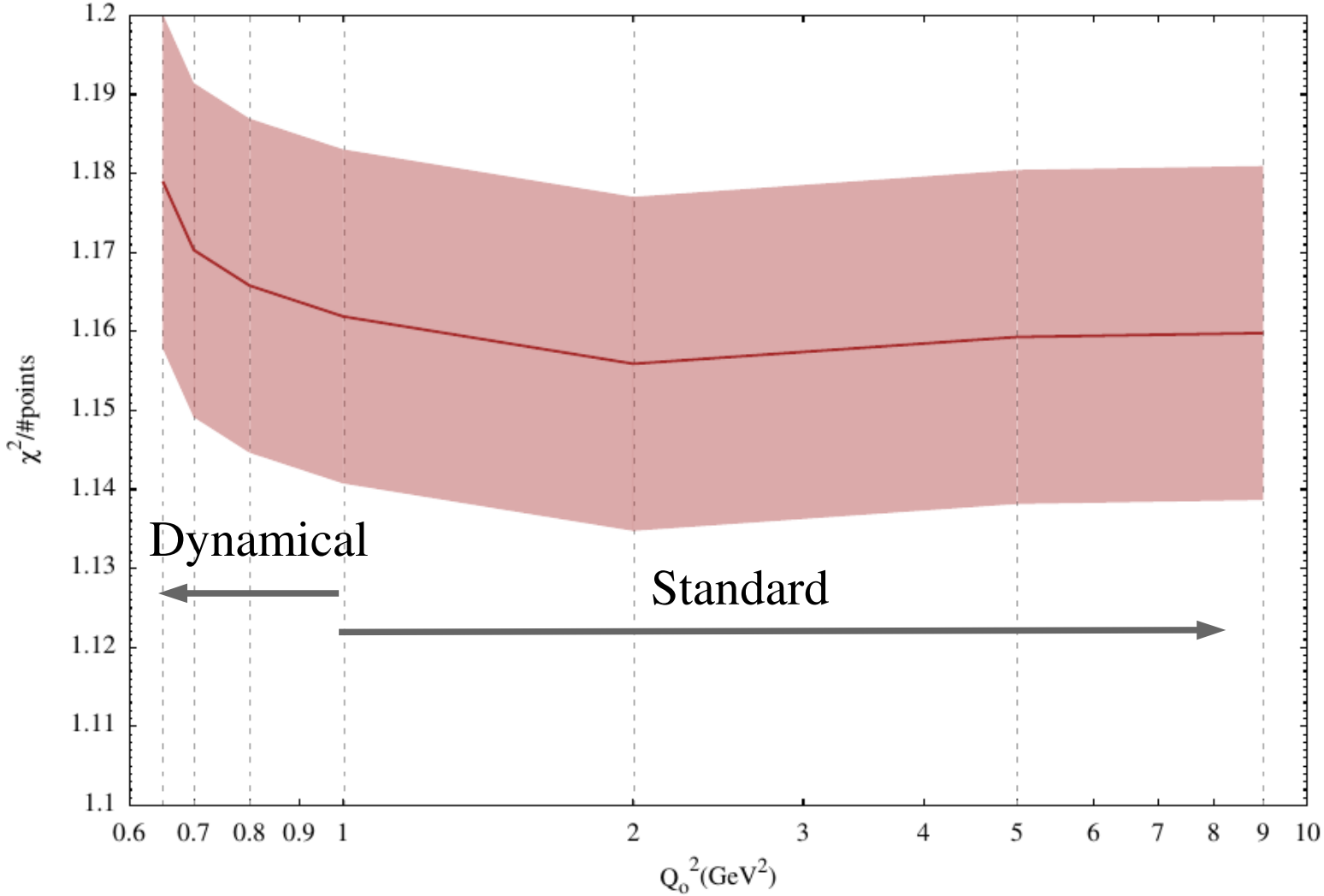
- Experimental correlations properly treated (also multiplicative errors)
- Switched to $\overline{\mathrm{MS}}$ scheme for heavy quark masses [ABM 2010]
- NNLOapp for heavy quark structure functions [ABM 2010]
- Target mass corrections used also for F_L (in addition to F_2)
- Nuclear corrections for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

$$T2F_{2,L}^{p,n}(x,Q^2) + \frac{T4F_{2,L}^{p,n}(x)}{Q^2}$$



The role of the input scale [PJD, PLB714 (2012) 301]

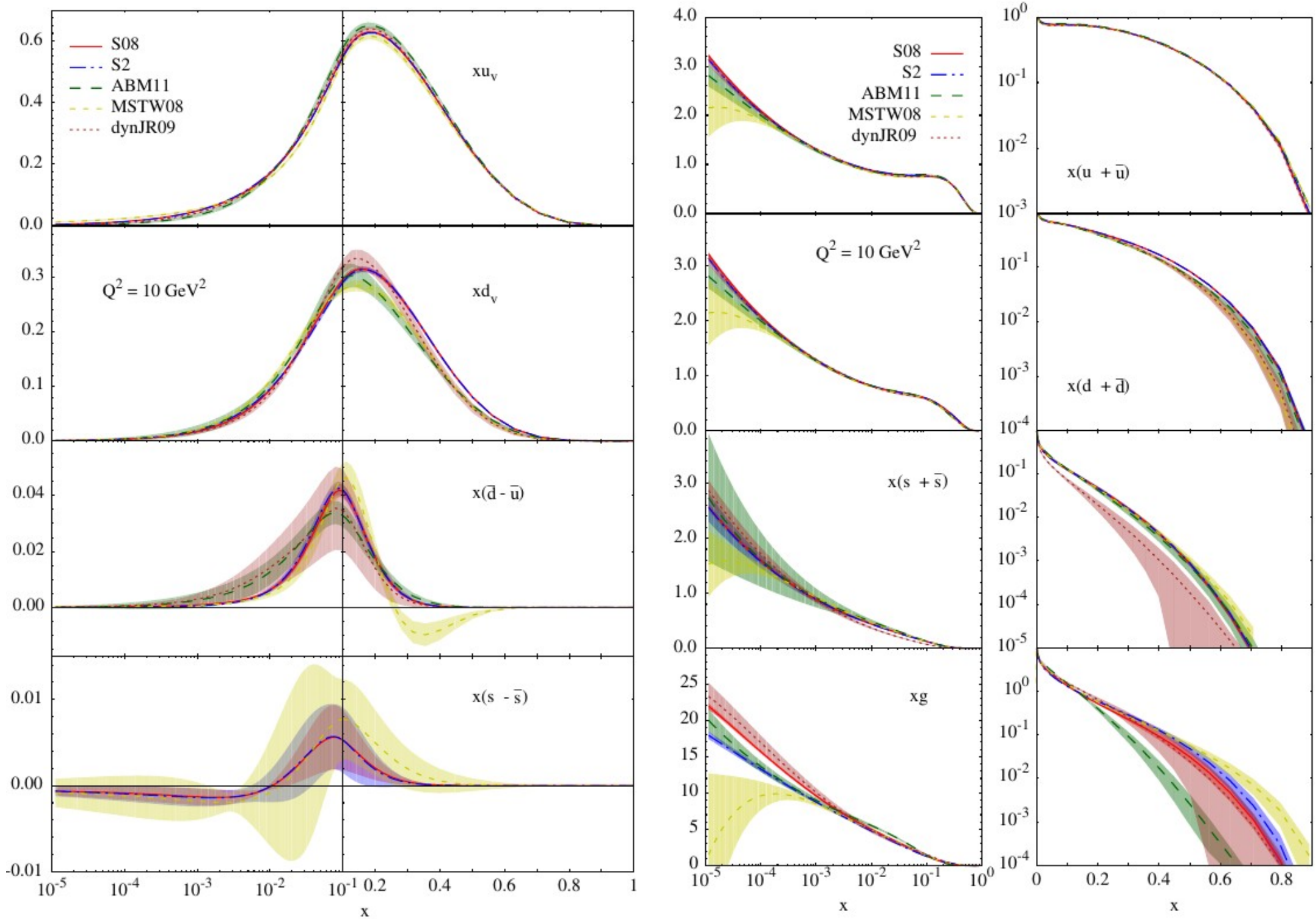
Any dependence is due to shortcomings of the estimation: *procedural bias*



Comment:
g > 0!

Extended parametrization: 1 + 27 + 16 = 44 parameters

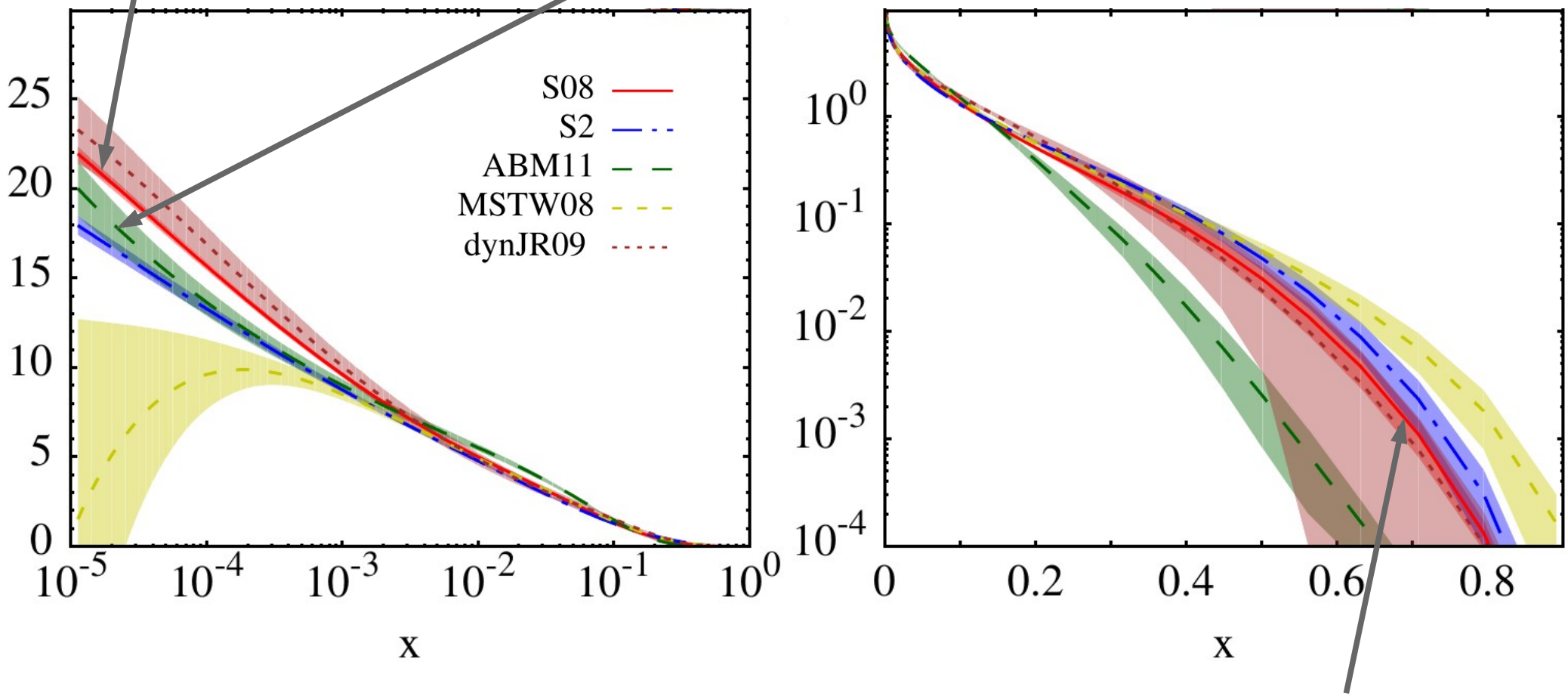
Interim results



Interim gluons

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

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

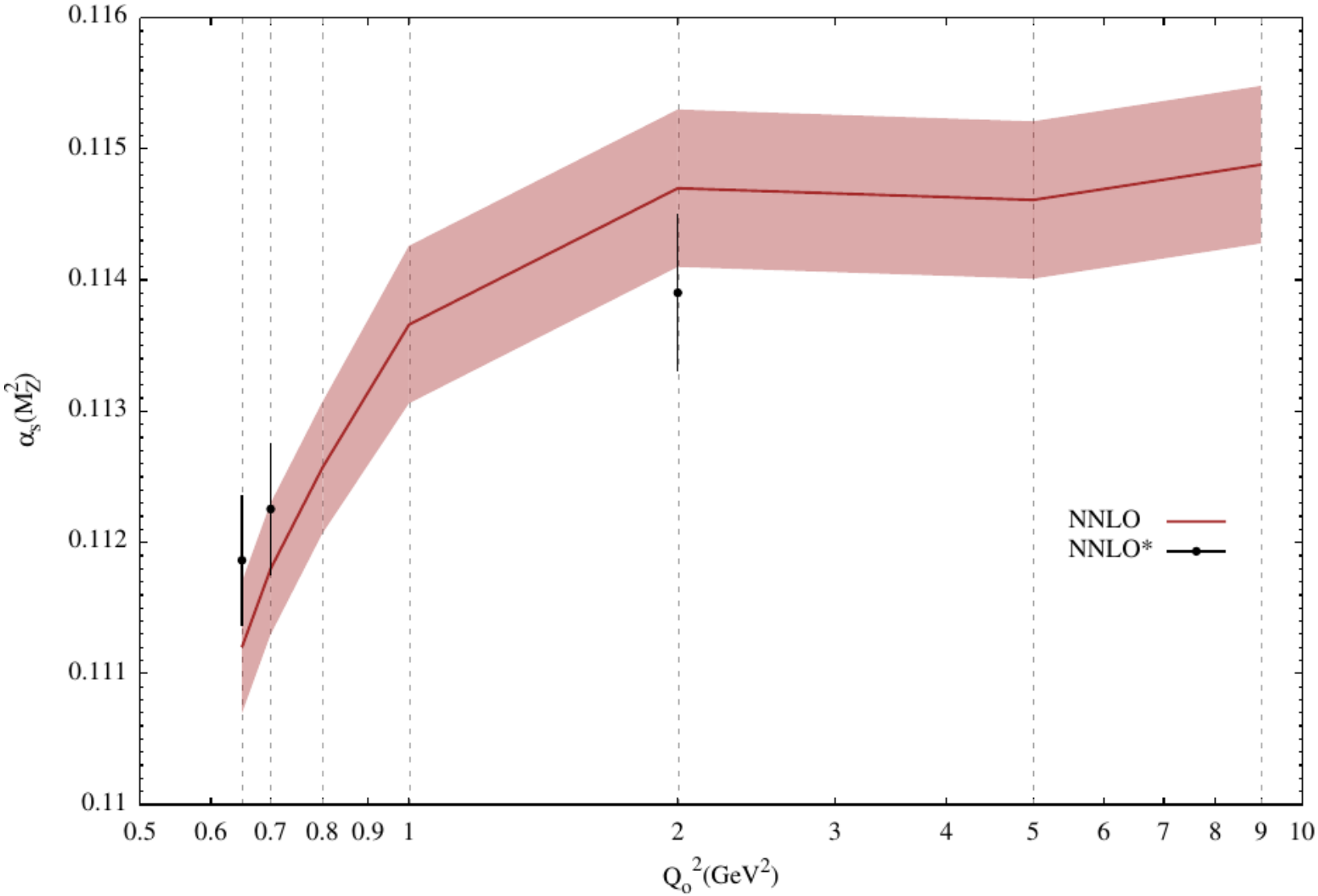


JR gluons at large x are rather *stable*: not very sensitive to the inclusion of Jet data and describe well the Rosenbluth separated F_L data

Comment: ABM result not due to FFNS!!

The strong coupling and the input scale

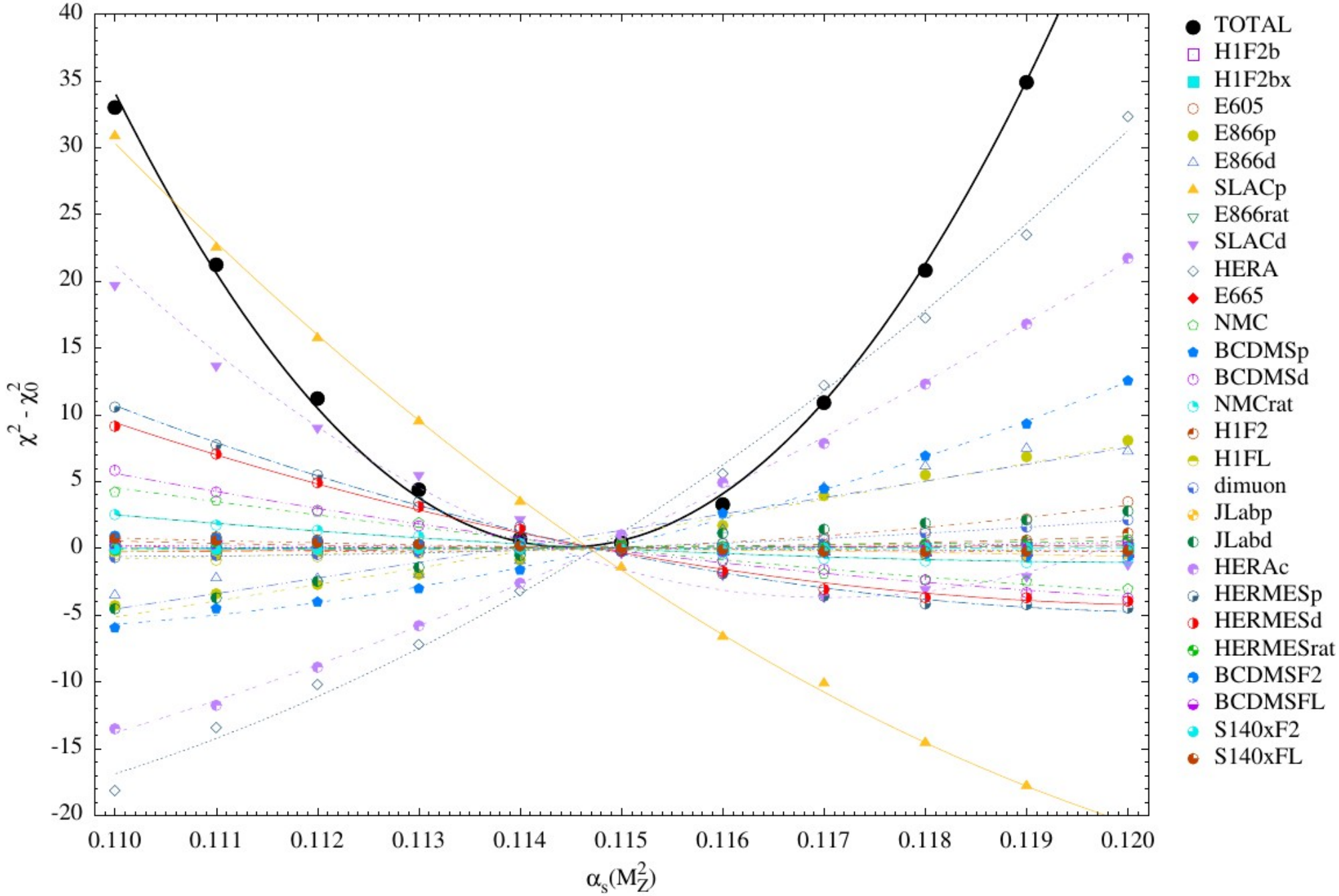
Central values in good agreement with JR09 (dynamical and standard)



Jets change *a bit* central values but *not* dramatically

Uncertainties: $\Delta_{\rm exp} \simeq 0.0006$, $\Delta_{\rm bias} \simeq \Delta_{\rm exp}$, $\Delta_{\rm theo} \simeq ??$

Origin of our strong coupling values



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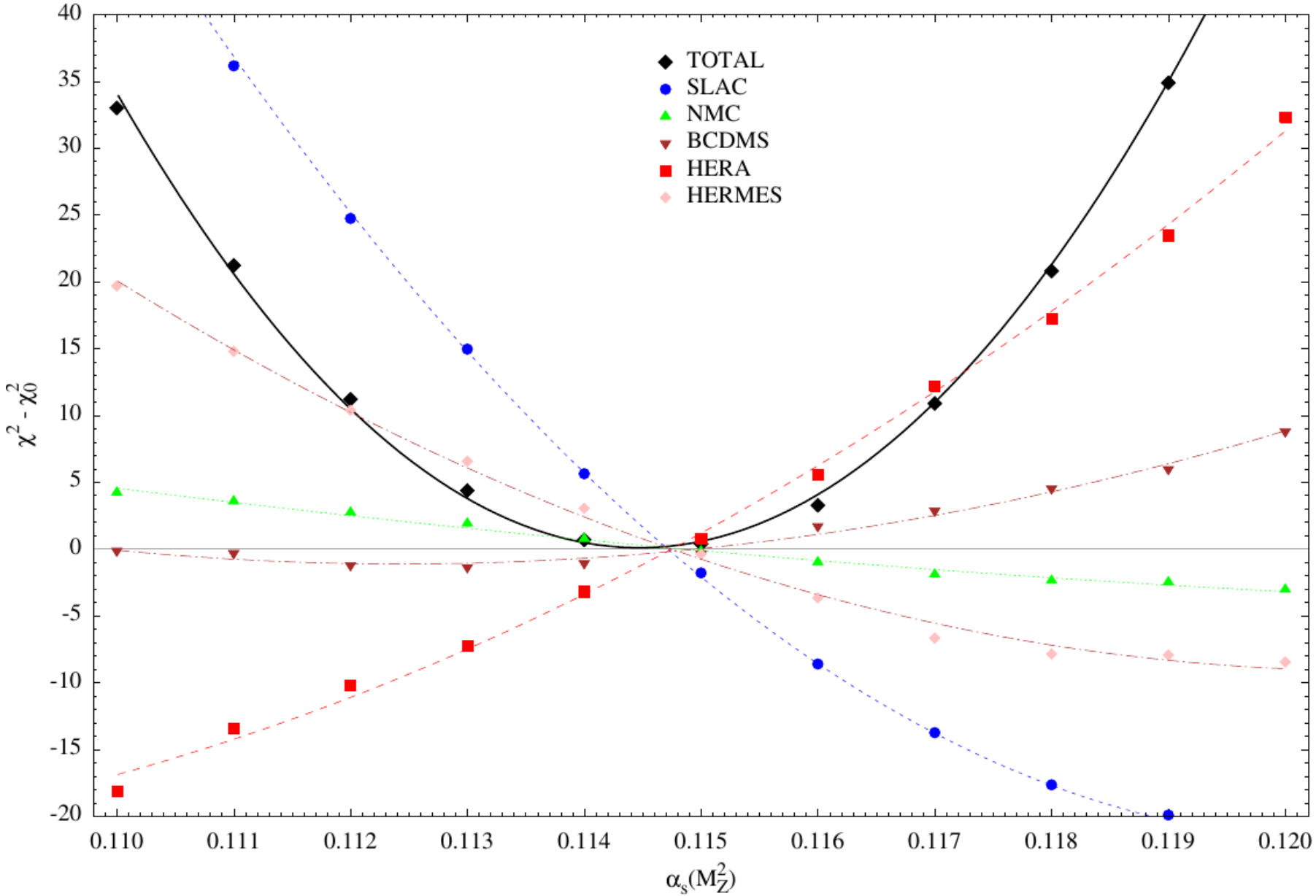

Fit finds a *compromise*: intermediate central value with reduced uncertainties

(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!!