Confronting lattice parton densities with global analysis

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Overview

1. Motivation
2. Connecting quasi-PDFs to light cone PDFs
3. Fitting results

Motivation

Big picture: What is the structure of the nucleon? → PDFs

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$$q(x,\mu^2) = \int \frac{d\xi^-}{4\pi} e^{-ix\xi^- P^+} \langle P|\bar{\psi}(\xi^-)\gamma^+ \exp\left[-ig\int_0^{\xi^-} d\eta^- A^+(\eta^-)\right]\psi(0)|P\rangle$$

Can't analytically calculate these matrix elements from first principles of QCD

Motivation

Big picture: What is the structure of the nucleon? ➞ PDFs

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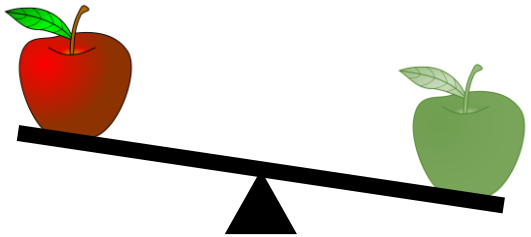
Approach: Infer PDFs from experiment or lattice observables

Motivation

Global analysis: direct “apples to apples” comparison of lattice and experimental results for PDFs



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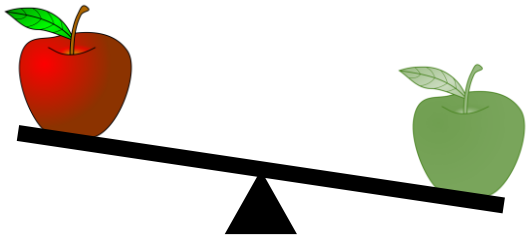

Goals:

1) Understand discrepancy in $\bar{u}, \bar{d}$ asymmetry

   Experiment: $\bar{u} < \bar{d}$ (NMC, NA51, E866)

   Lattice: $\bar{d} < \bar{u}$ (ETMC)

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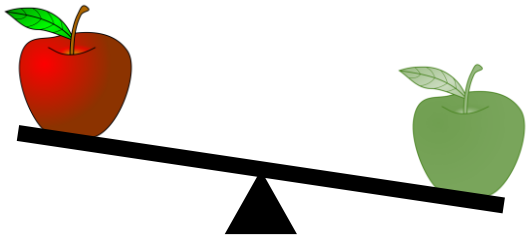

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2) How much does lattice data further constrain fits?

PDFs from the lattice

Can access PDFs from lattice observables using:

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2) Pseudo-PDFs Radyushkin 2017
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We focus on this approach

Quasi-PDFs to light cone PDFs

Quasi-PDF: $\tilde{f}(y,\mu,P_3) = \int_{-\infty}^{\infty} \frac{dz}{4\pi} e^{-iyP_3 z} \langle \mathcal{O} \rangle (z)$

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Perturbative matching to light cone PDF:

$$\langle \mathcal{O} \rangle (z) = -\int_{-\infty}^{\infty} dy\, e^{-iyP_3 z} \int_{-1}^{1} \frac{dx}{|x|} C\left(\frac{y}{x}, \frac{\mu}{xP_3}\right) f(x,\mu)$$

Matching kernel

Light cone PDF

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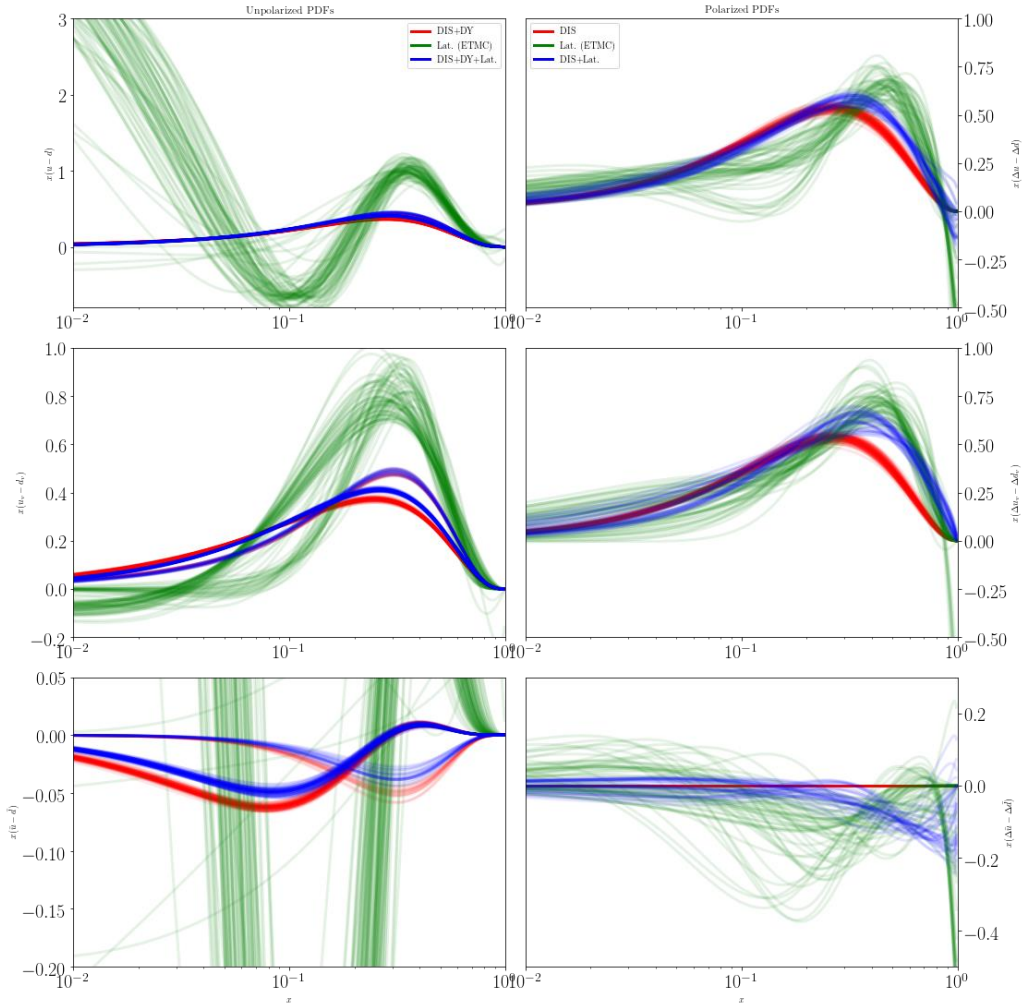
Matching kernel

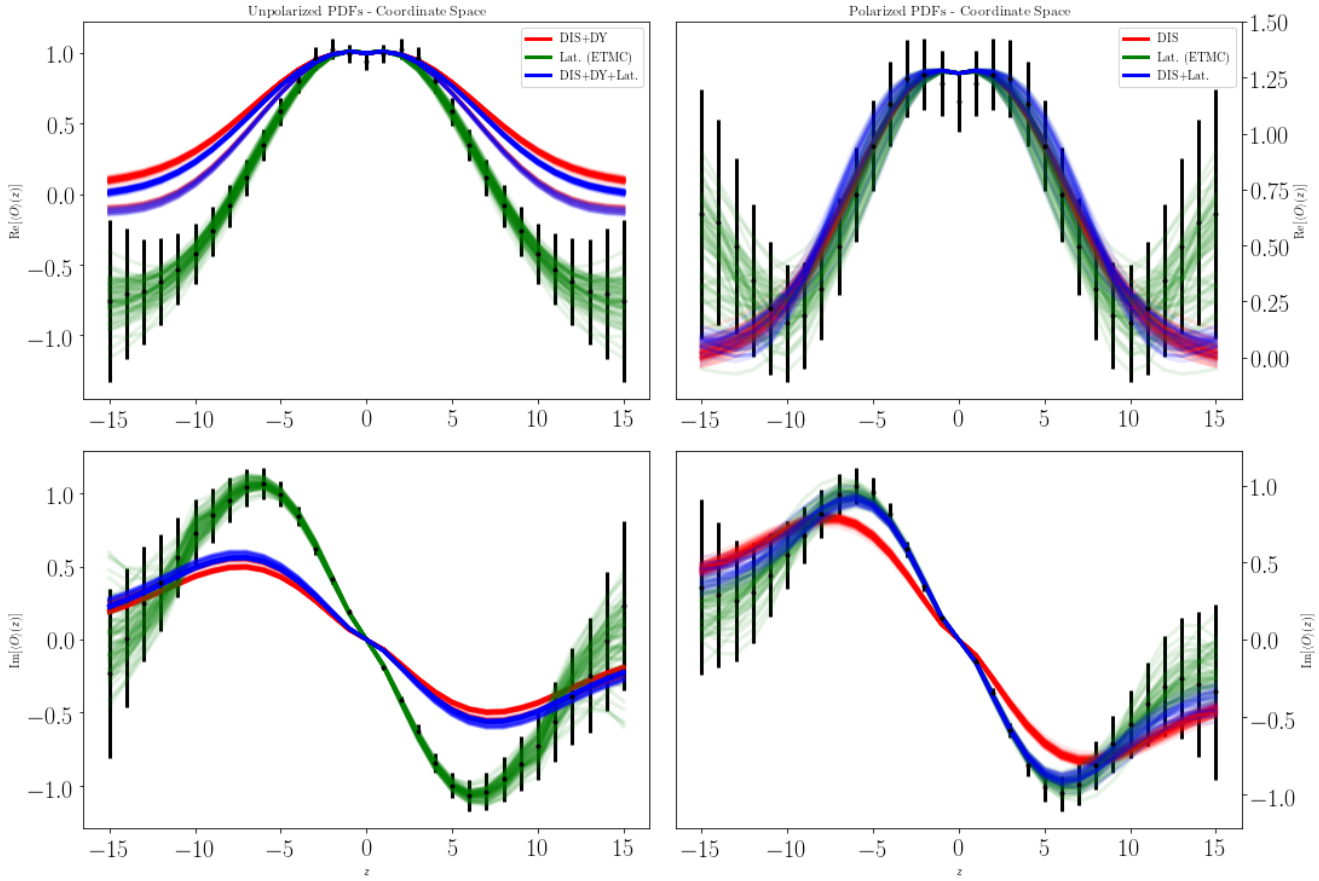
Light cone PDF

$f(x) = q(x)\Theta(0 \le x \le 1) - \bar{q}(-x)\Theta(-1 \le x \le 0)$

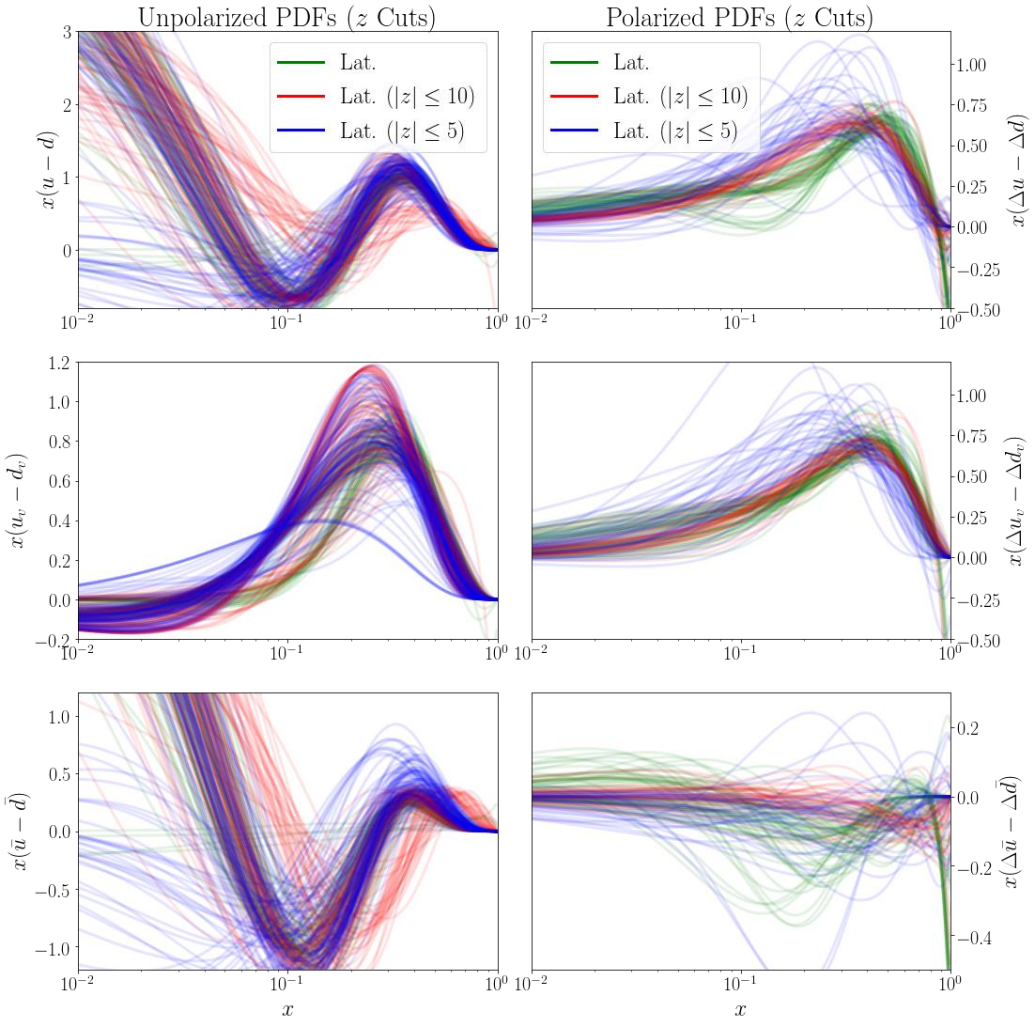
+ if polarized PDF

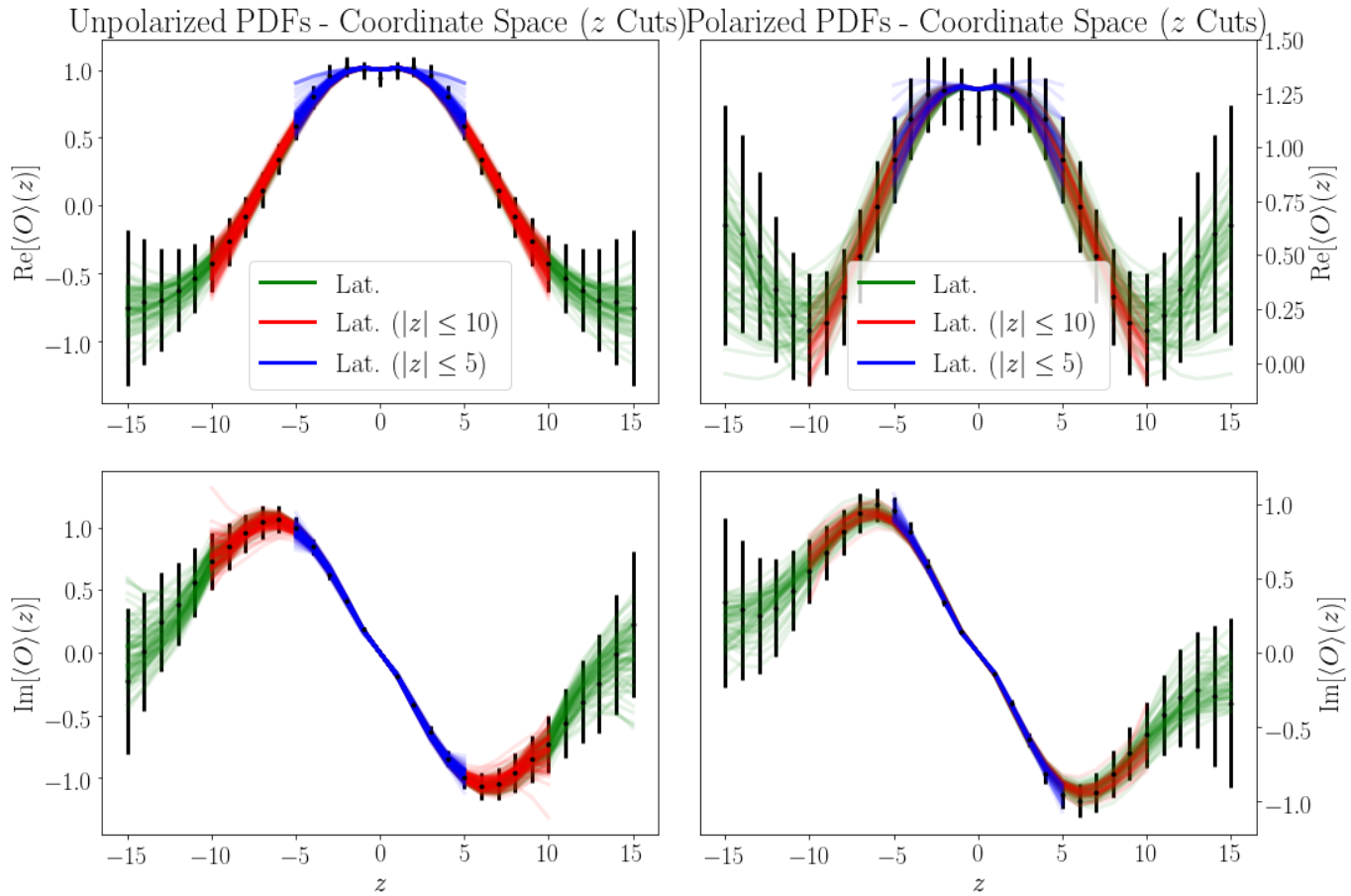
Global fits


Unpolarized PDFs
Polarized PDFs
DIS+DY
Lat. (ETMC)
DIS+DY+Lat.
DIS
Lat. (ETMC)
DIS+Lat.

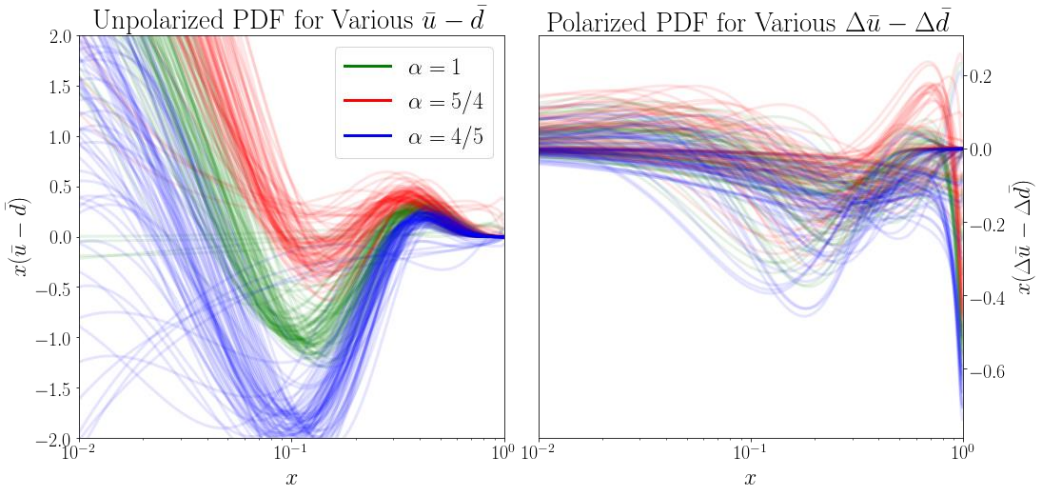

Unpolarized PDFs - Coordinate Space
Polarized PDFs - Coordinate Space
DIS+DY
Lat. (ETMC)
DIS+DY+Lat.
DIS
Lat. (ETMC)
DIS+Lat.
z

Understanding lattice data: z cuts

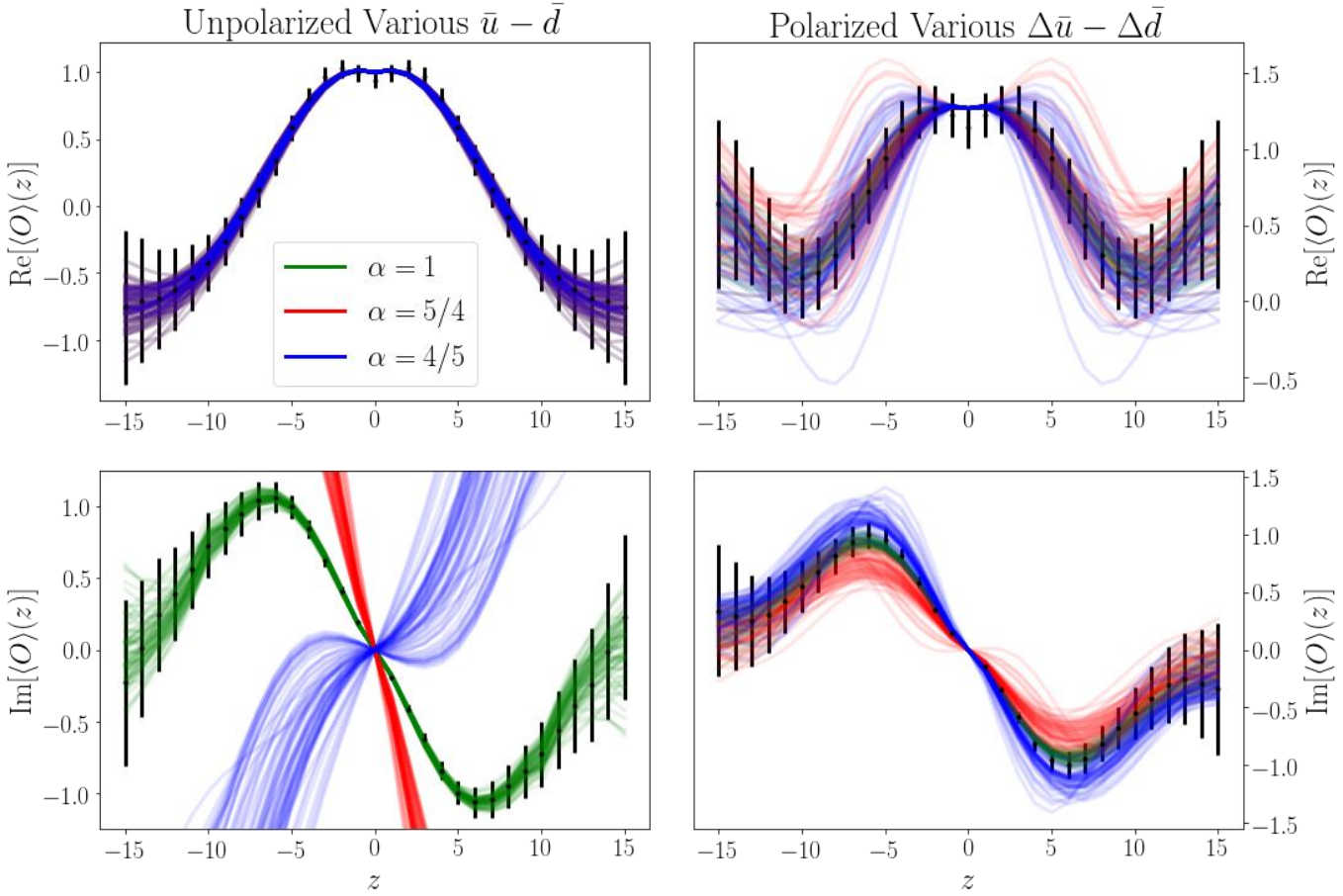




Understanding lattice data: varying $\bar{u}, \bar{d}$



$$\bar{u} \to \alpha\bar{u}$$
$$\bar{d} \to \bar{d}/\alpha$$



Summary

1) We compare PDF fits using ETMC lattice data and experimental data within the same global analysis framework
2) Polarized PDFs have greater agreement between lattice and experiment than unpolarized PDFs
3) Polarized lattice data has a greater impact on combined fits than unpolarized latticed data
4) Lattice data needs tighter error bars particularly at large z

Questions?