Combined analysis of polarized and unpolarized PDFs and fragmentation functions

Nobuo Sato
University of Connecticut
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Motivations

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- **SIDIS data from JLab 12 brings new challenges**

  + **Quantitative** limits of $x, Q^2, z, ...$ where factorization theorems are applicable

  + Universality of non perturbative objects
    $\rightarrow$ **predictive power**

  + QCD analysis framework that extracts **simultaneously** all non-perturbative objects (including TMDs)

  + Framework with the same theory assumptions

Motivations

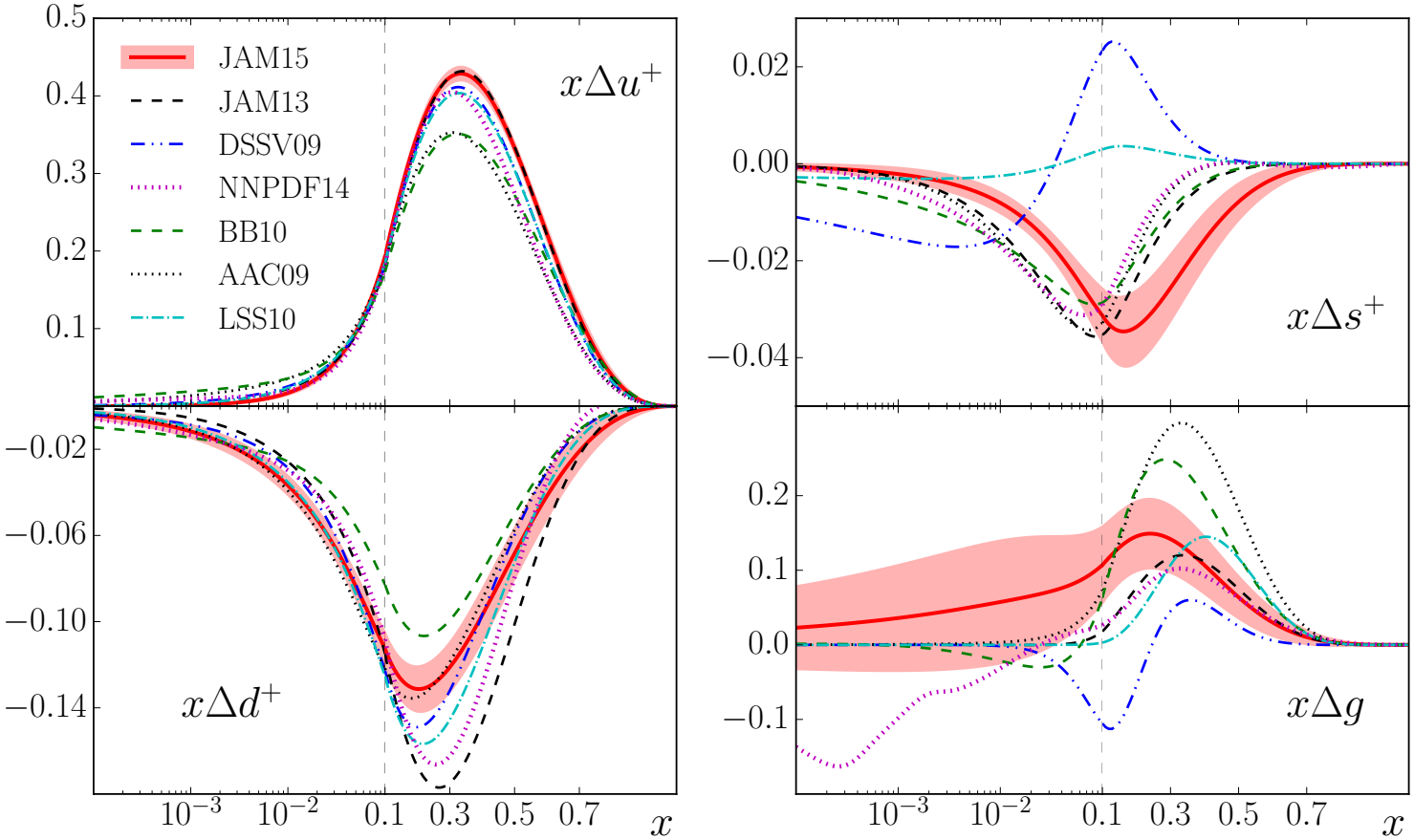
- **Inclusion of modern data analysis techniques**
  - + Bayesian likelihood analysis

$$\mathcal{P}(f|\text{data}) = \mathcal{L}(\text{data}, f)\pi(f)$$

  - + Estimation of expectation values and variances:
    - maximum likelihood + Hessian (+tolerance)
    - maximum likelihood + Lagrange multipliers
    - nested sampling
    - data resampling
    - partition and cross validation
    - iterative Monte Carlo (IMC)

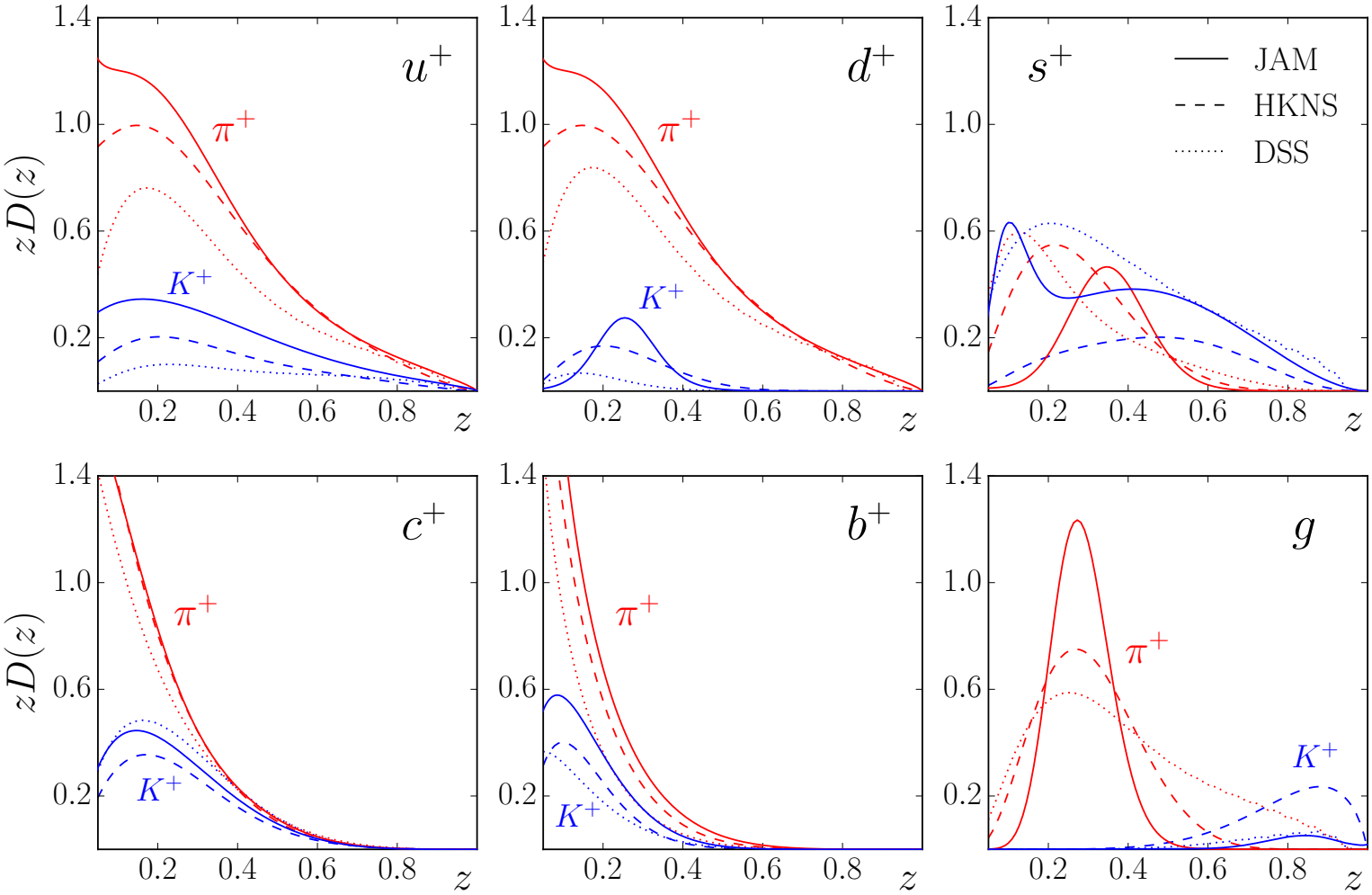
History

JAM15: ΔPDFs (NS, Melnitchouk, Kuhn, Ethier, Accardi)



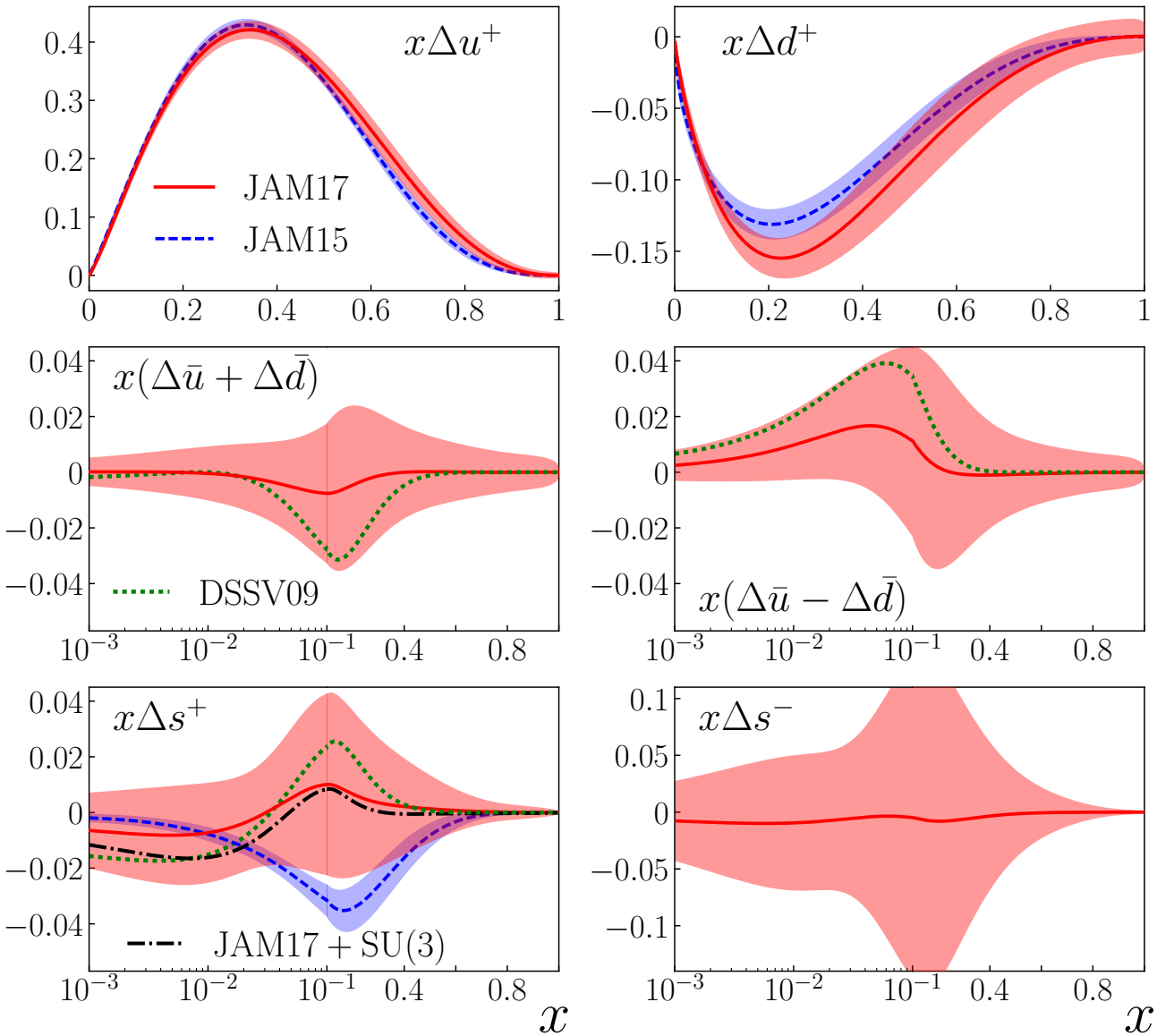
+ Inclusion of all the JLab 6GeV data
+ Determination of twist 3 g_2
+ SU2, SU3 constraints imposed:
+ **DSSV and JAM Δs^+ is inconsistent**

JAM16: FFs (NS, Ethier, Melnitchouk, Hirai, Kumano, Accardi)



+ π and K Belle, BaBar up to LEP energies
+ **JAM and DSS $D_{s^+}^K$ consistent**

JAM17: ΔPDF +FF (Ethier, NS, Melnitchouk)



- \+ No SU(3) constraints
- \+ Sea polarization consistent with zero
- \+ Precision of ΔSIDIS is not sufficient to determine sea polarization

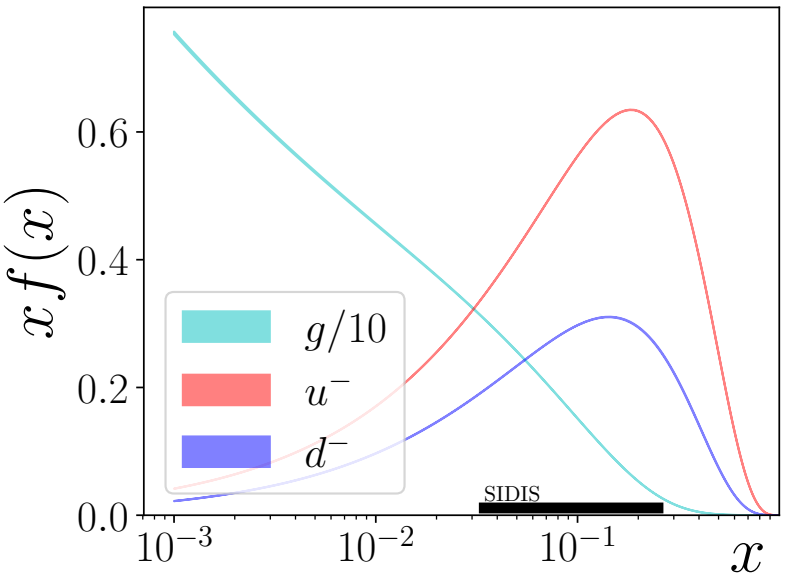
Present

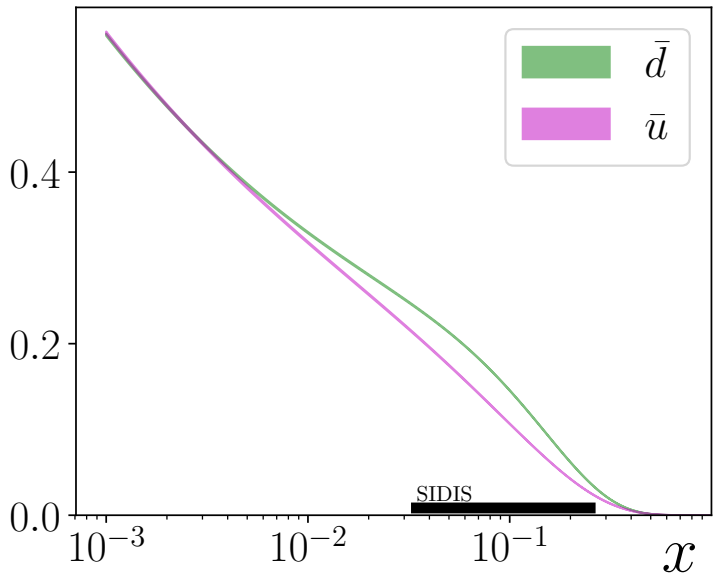
JAM18: Universal analysis (preliminary)

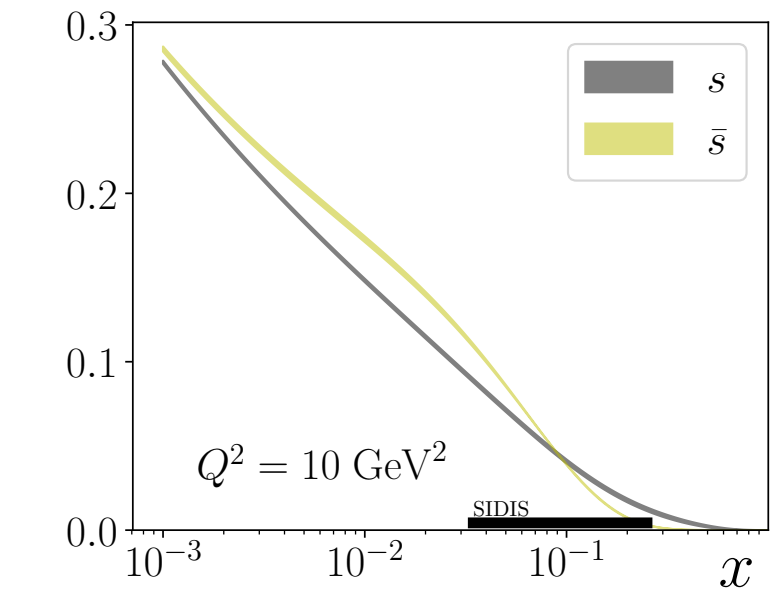
Andres, Ethier, Melnitchouk, NS, Rogers

- **Data sets**
  - + DIS, SIDIS(π, K), DY
  - + ΔDIS, ΔSIDIS(π, K)
  - + $e^+e^-(\pi, K)$
- **Theory setup**
  - + Observables computed at **NLO in pQCD**
  - + DIS structure functions only at **leading twist** ($W^2 > 10$ GeV^2)
- **Likelihood analysis (first steps)**
  - + Use maximum likelihood to find a candidate solution
  - + Use resampling to **check for stability** and estimate uncertainties
  - + 80 shape parameters and 91 data normalization parameters: **171 dimensional space**
  - + Sampling to be extended with IMC/Nested Sampling

JAM18: PDFs (preliminary)

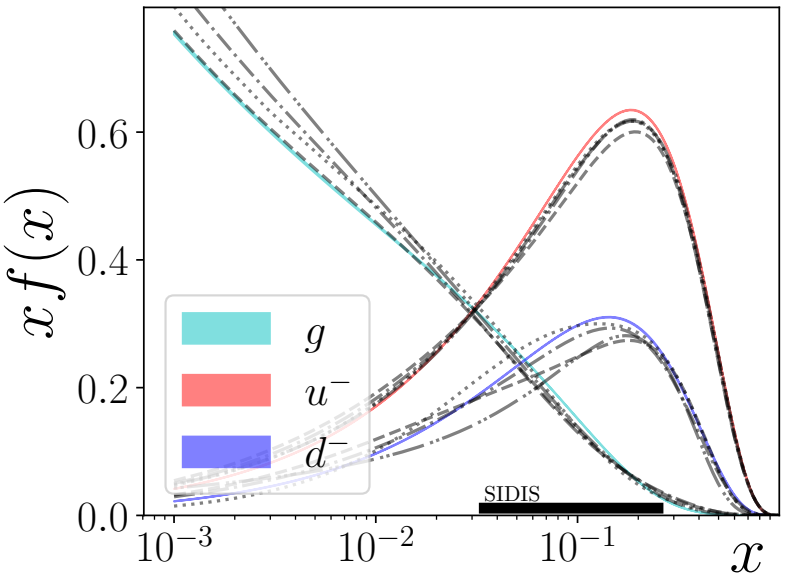


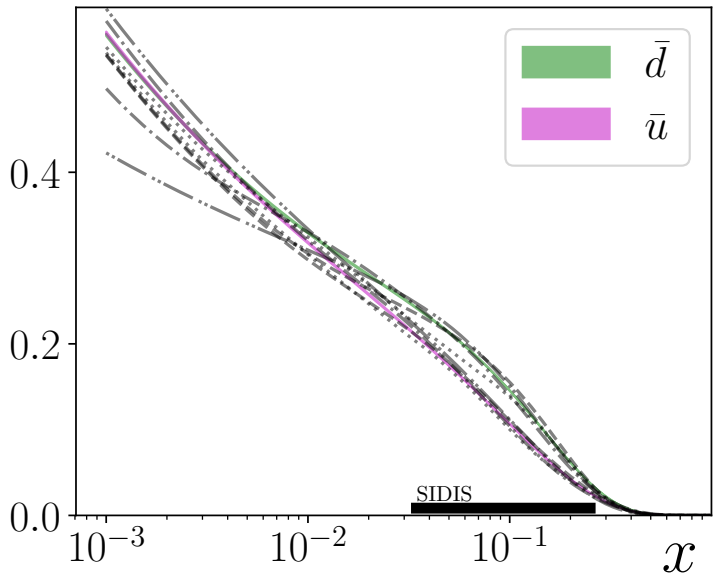


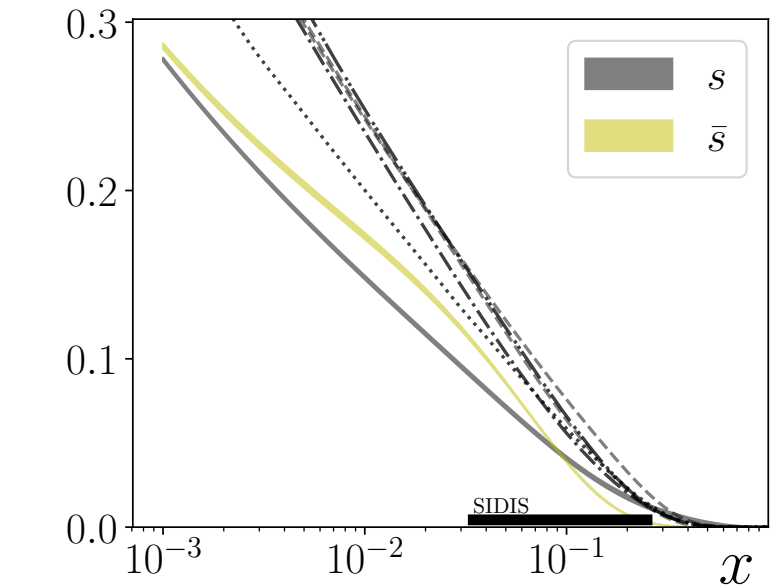


- $\bar{d} - \bar{u}$ constrained mainly by DY
- SIDIS is in agreement with DY's $\bar{d} - \bar{u}$
- $s - \bar{s} \neq 0$

JAM18: PDFs (preliminary)

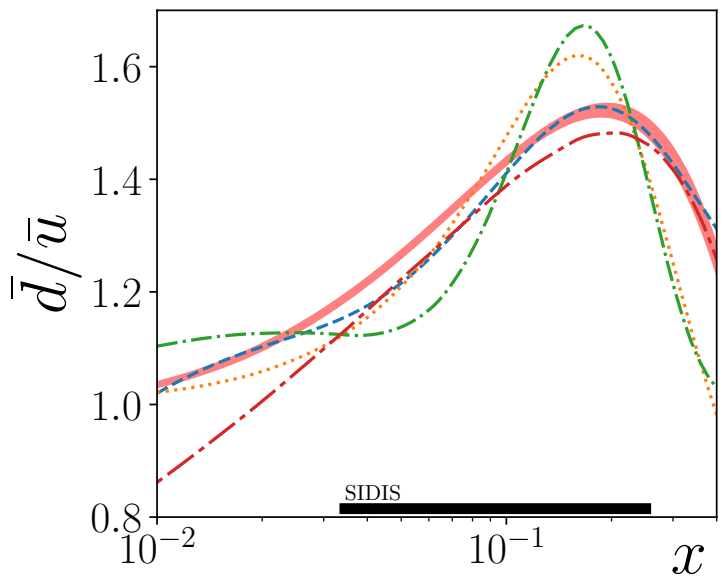


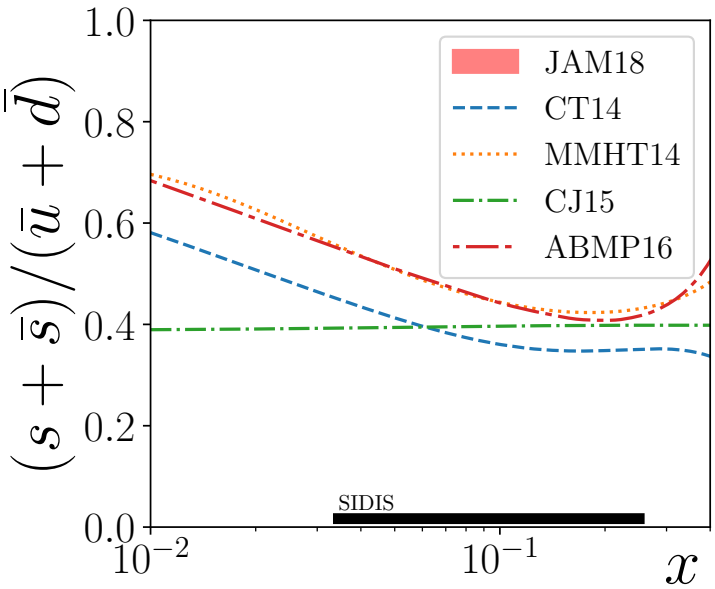


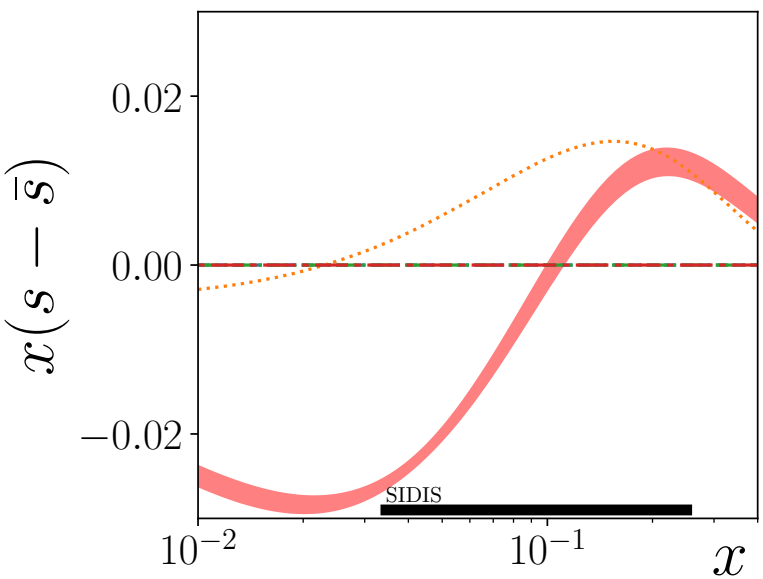


- Comparison with other groups
  - dashed: MMHT14
  - dashed-dotted: CT14
  - dotted: CJ15
  - dot-dot-dash: ABMP16
- Big differences for $s, \bar{s}$ distributions

JAM18: upolarized sea (preliminary)

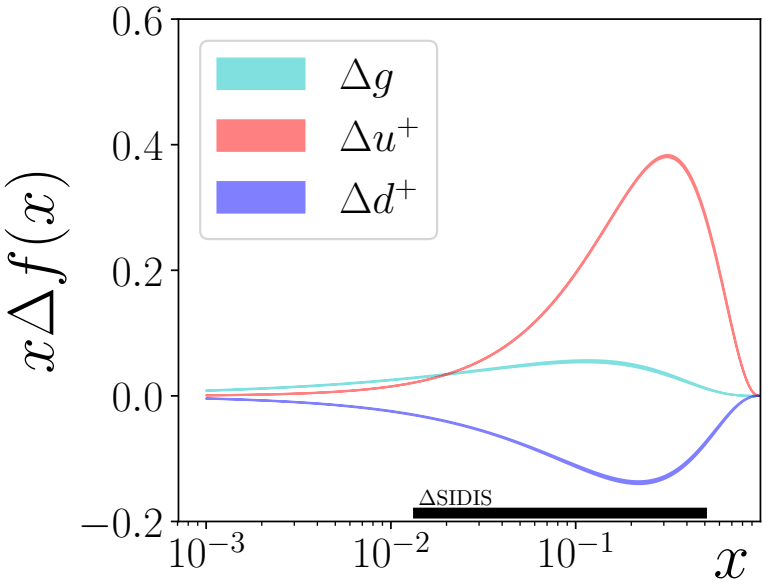


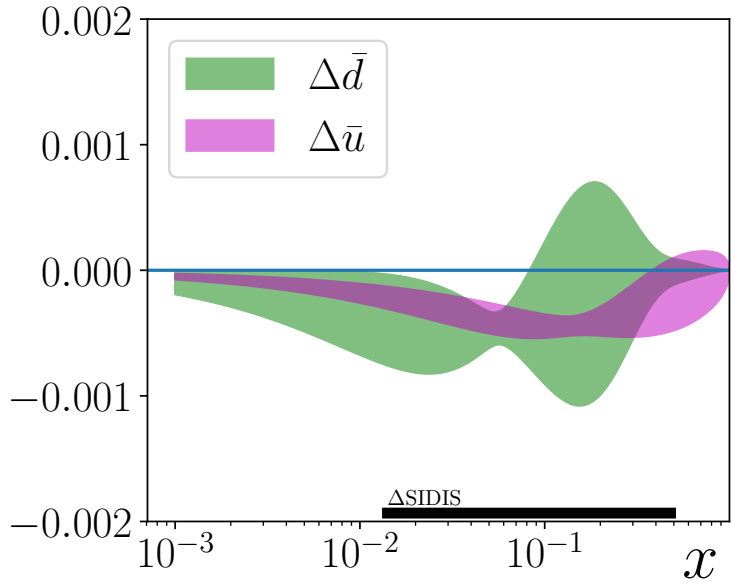


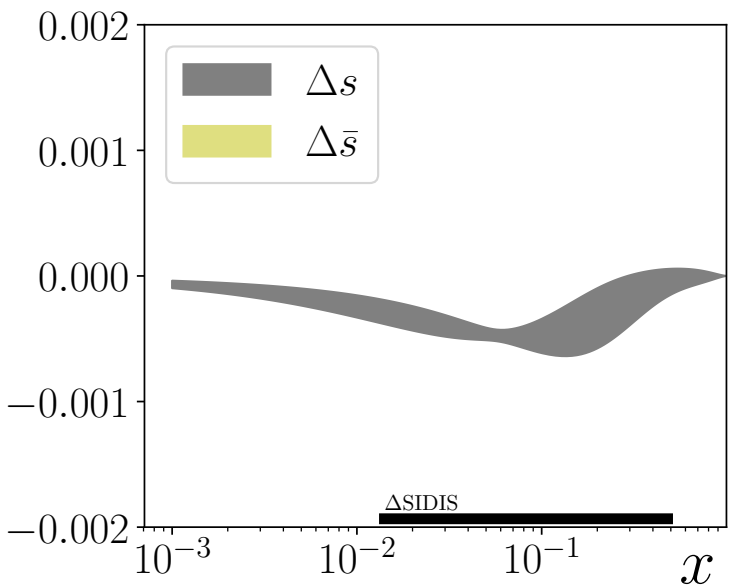


- For CJ and CT, $s = \bar{s}$
- MMHT uses neutrino DIS
- SIDIS favors a strange suppression
- and a larger s, $\bar{s}$ asymmetry

JAM18: ΔPDFs (preliminary)

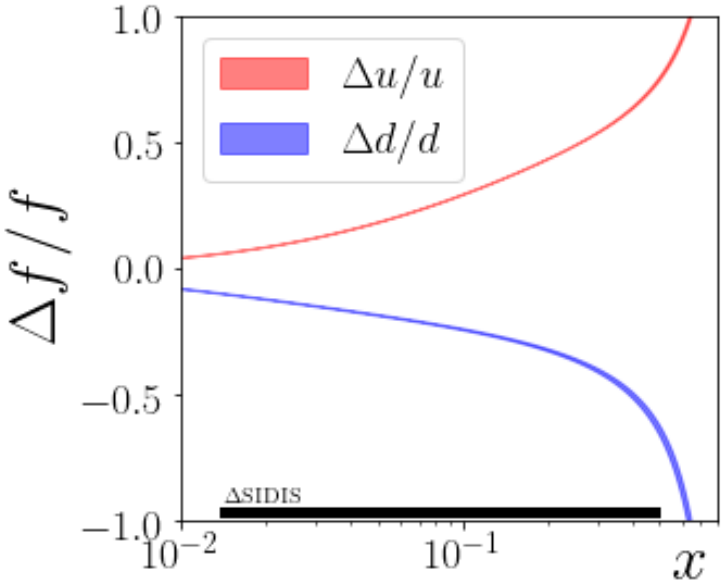


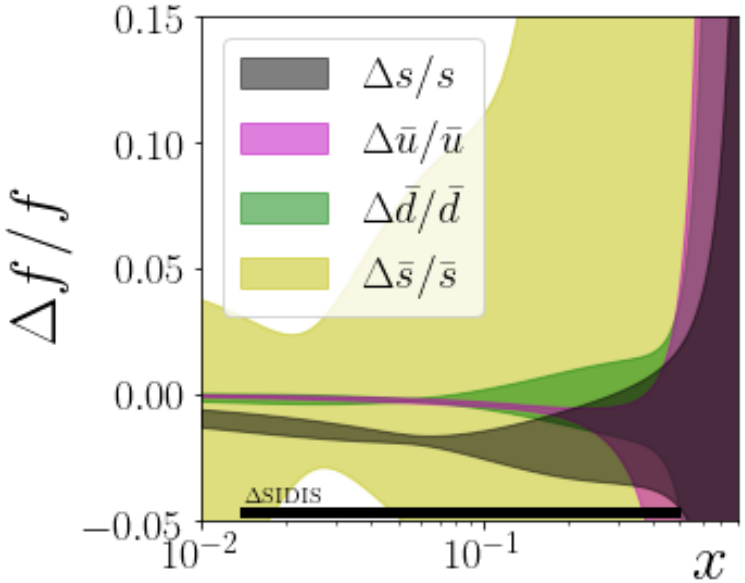


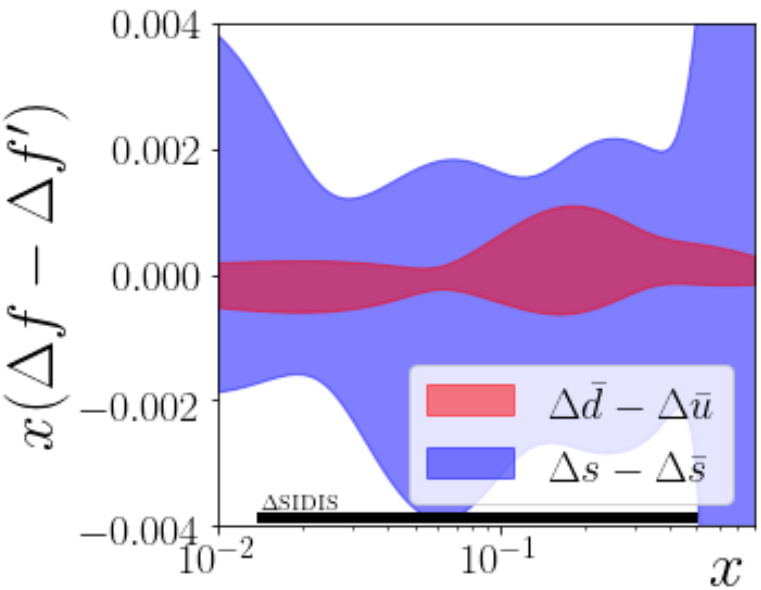


- Recall no SU2,SU3 imposed
- $\Delta s, \Delta\bar{u}, \Delta\bar{d}$ are much better known than $\Delta\bar{s}$
- It means, most of the uncertainty on Δs^+ is from $\Delta\bar{s}$

JAM18: polarized sea (preliminary)

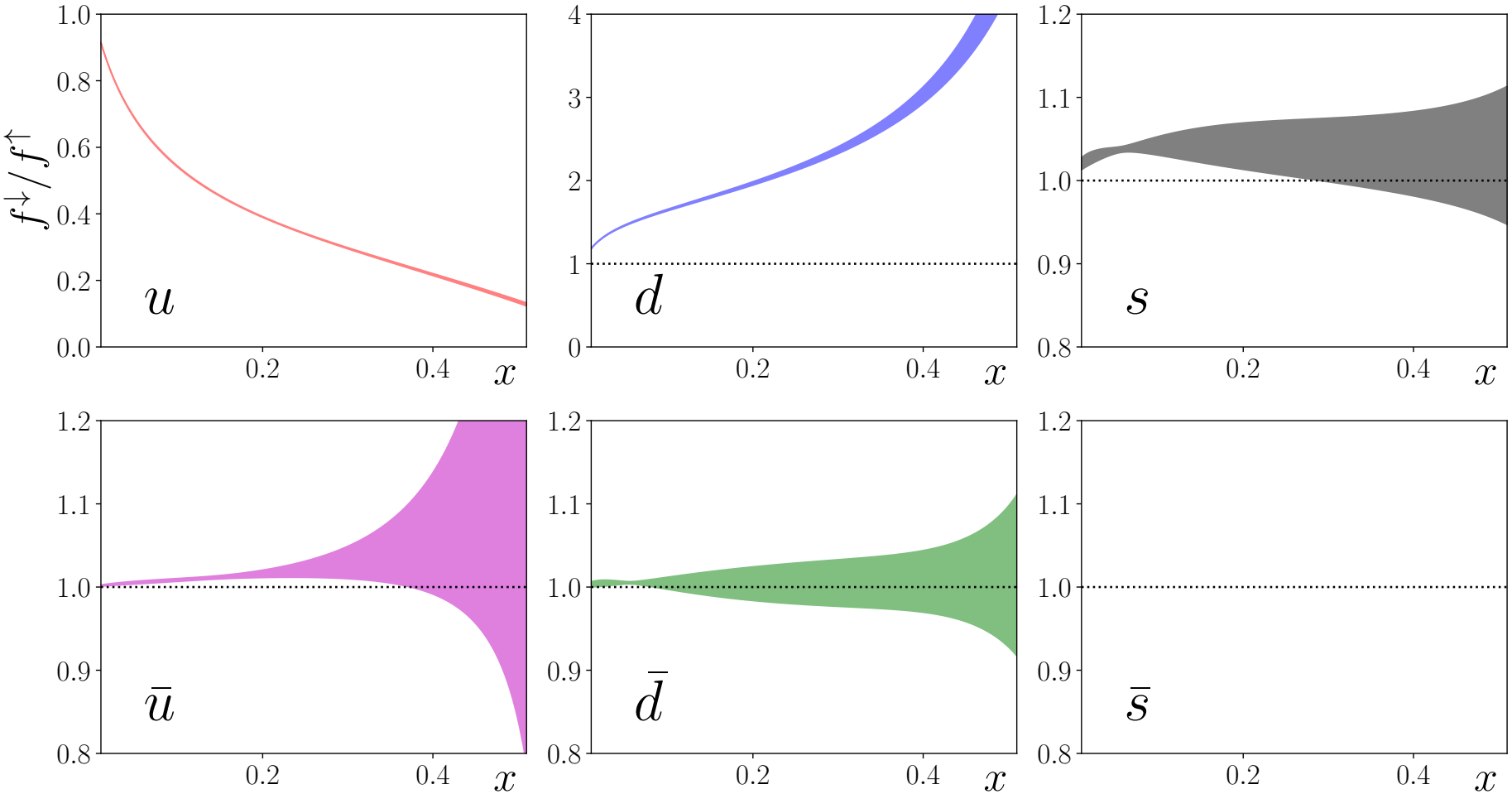






- $\Delta f/f \to 1$ only realized for u
- Polarized sea asymmetry is consistent with zero

JAM18: helicity PDFs (preliminary)



- Helicity distributions seems to be the same for the sea

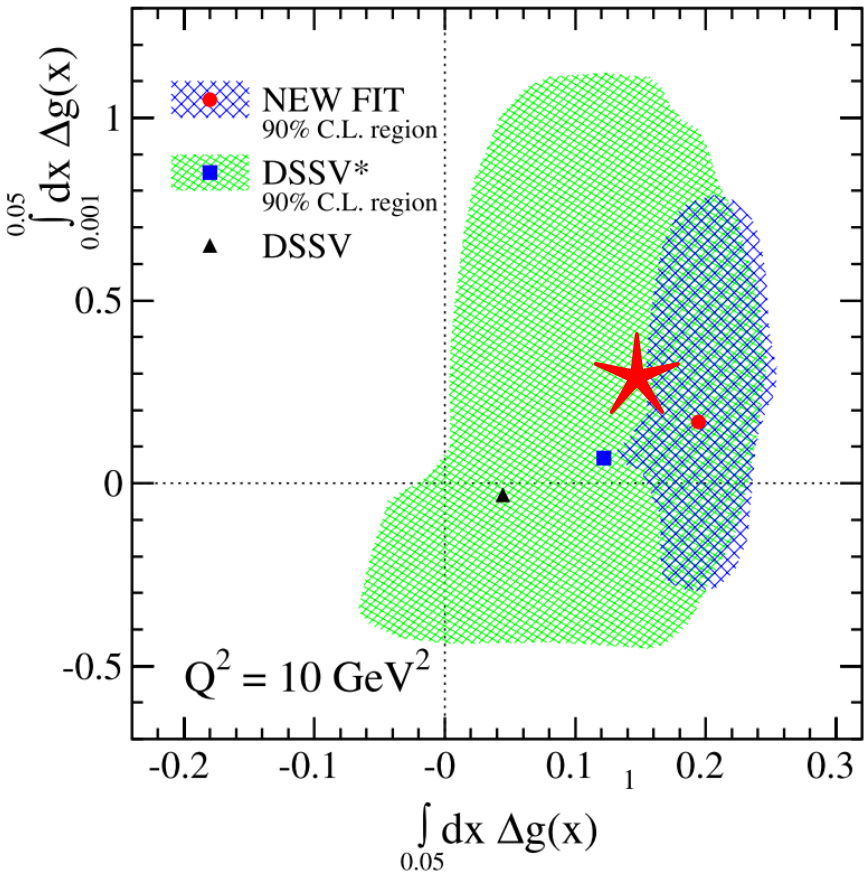
JAM18: moments (preliminary)

obs.	JAM15	JAM17	JAM18	JAM18 [truncated]
g_A	$1.269(3)$	$1.24(4)$	$1.163(5)$	$1.107(5)$
g_8	$0.59(3)$	$0.4(2)$	$0.5(4)$	$0.39(2)$
$\Delta\Sigma$	$0.28(4)$	$0.36(9)$	$0.3(2)$	$0.386(7)$
$\Delta\bar{u} - \Delta\bar{d}$	0	$0.05(8)$	$0.0002(6)$	$-0.0001(5)$
Δg	$1(15)$	–	$0.22(1)$	$0.172(9)$

- Large uncertainties on the full $\Delta\Sigma$ stem from
- JAM18 [truncated] means integration over ΔDIS and ΔSIDIS kinematics $\Delta\bar{s}$

JAM18: Δg (preliminary)

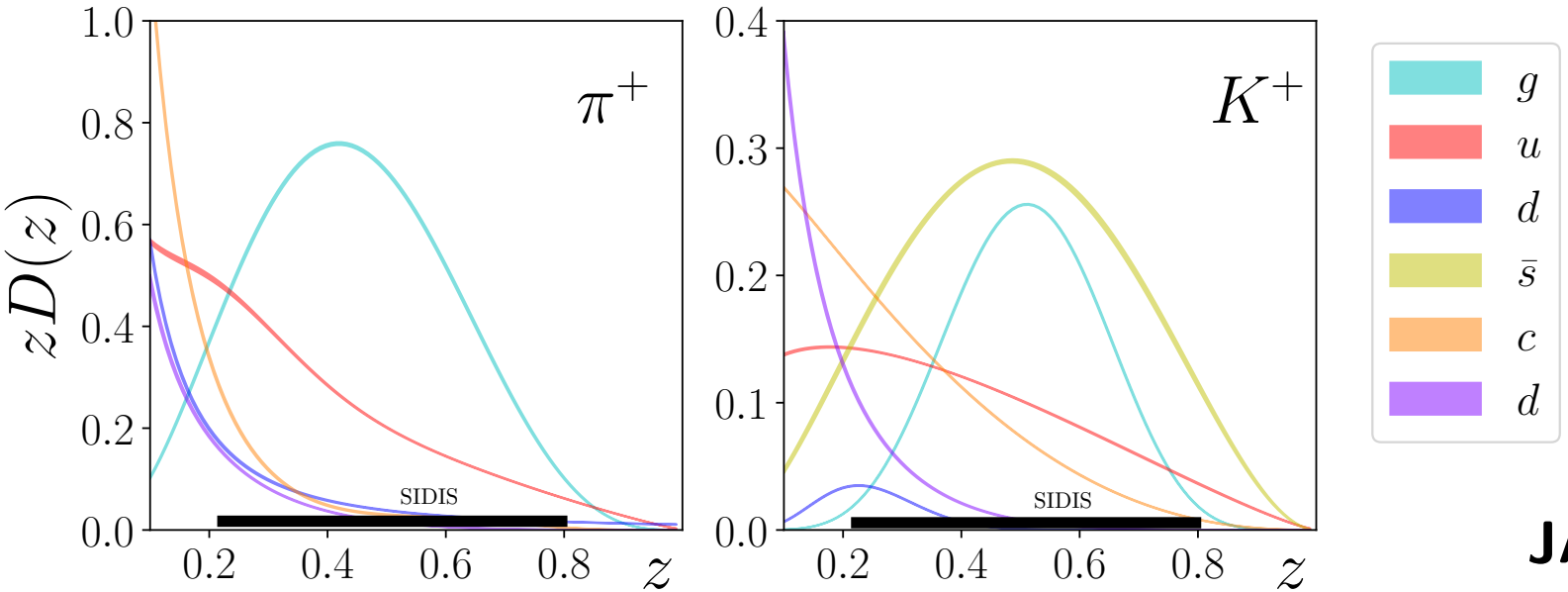
DSSV14



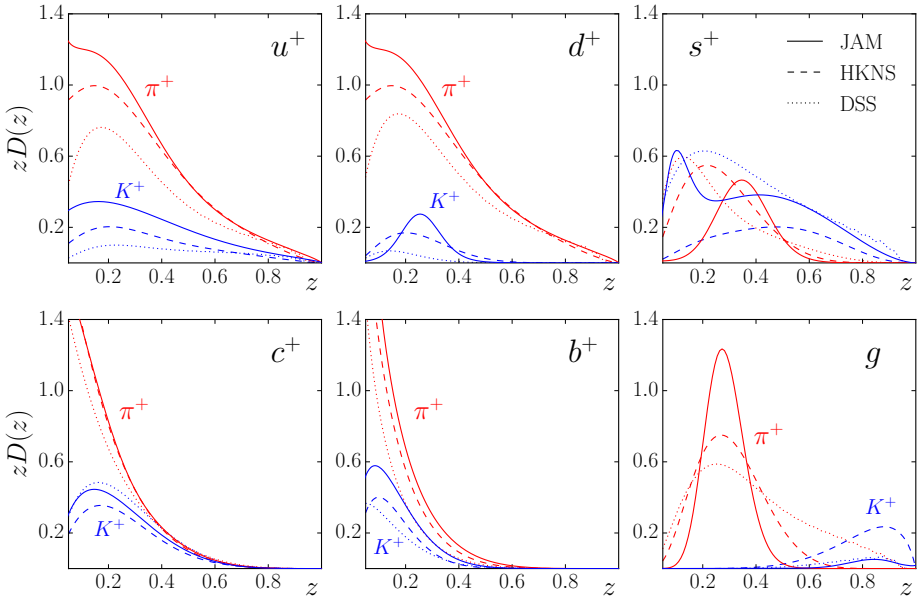
JAM18

- $\int_{0.05}^{1} dx \Delta g(x) = 0.145(5)$
- $\int_{0.001}^{0.05} dx \Delta g(x) = 0.229(9)$
- Not so bad for a prediction

JAM18: FFs (preliminary)



JAM16



- gluon FFs are significantly affected by SIDIS
- This feature is key for p_{T} differential SIDIS $\rightarrow$ see my talk "3D Structure of the Nucleon: TMDs"

Summary and outlook

- First **universal** analysis of PDFs, ΔPDF and FFs
  - + New insights on nucleon sea distributions ($s, \bar{s}$ asymmetry)
  - + π and K gluon FFs are required by SIDIS to peak at larger z $\rightarrow$ relevant for TMD physics
  - + The universal analysis will to be extend to TMD analysis
- Next steps
  - + Perform additional checks using IMC and Nested Sampling
  - + Make predictions to high energy observables and check the genuine predictive power of the universal analysis