

GLOBAL QCD ANALYSIS AND PARTON DENSITIES

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PHENOEXP2018
ICAS UNSAM

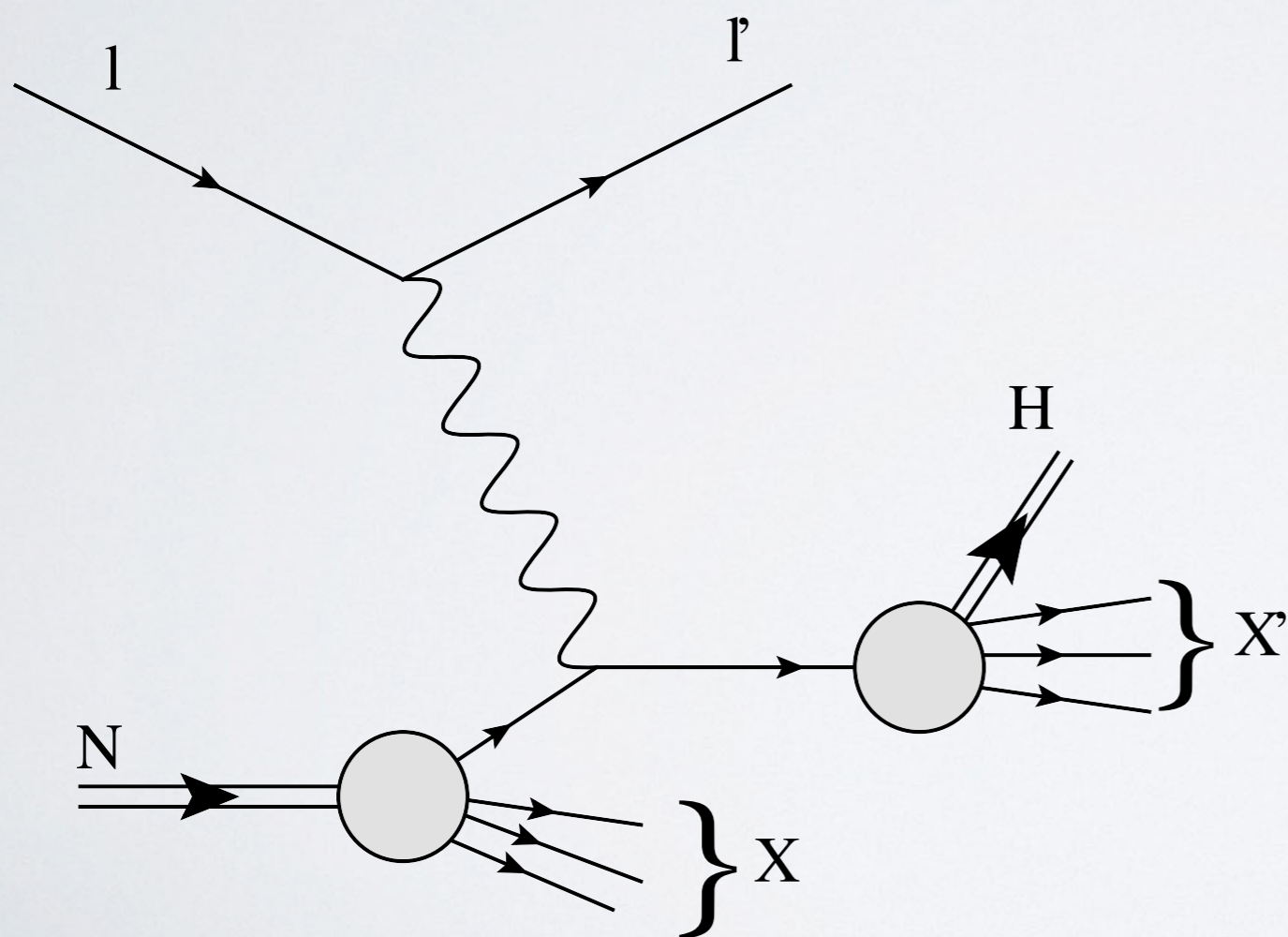
In collaboration with R. Sassot & M. Stratmann



universidad de buenos aires - exactas
departamento de física

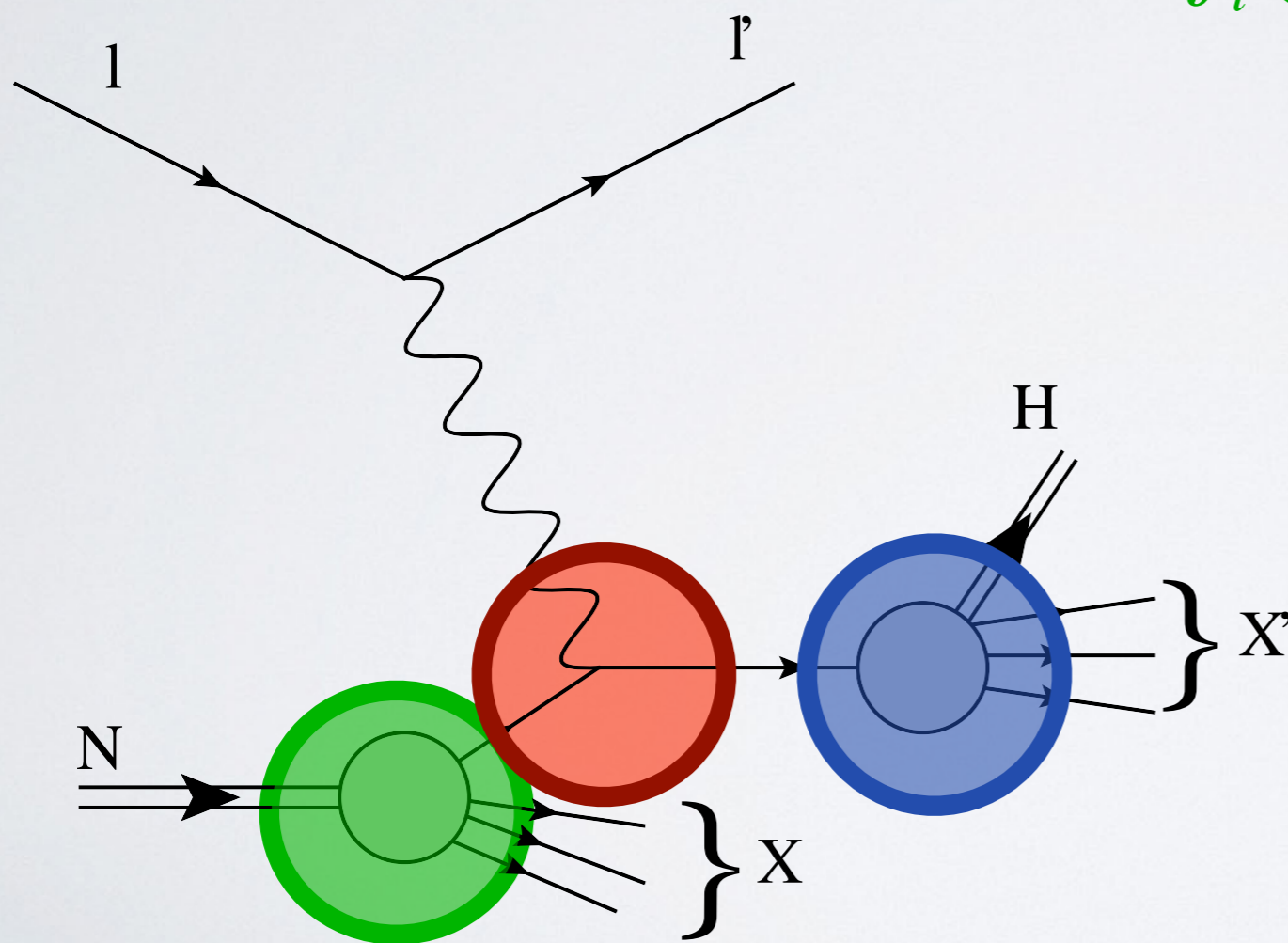
HADRONIC QCD IN A NUTSHELL

FACTORIZATION



HADRONIC QCD IN A NUTSHELL

FACTORIZATION



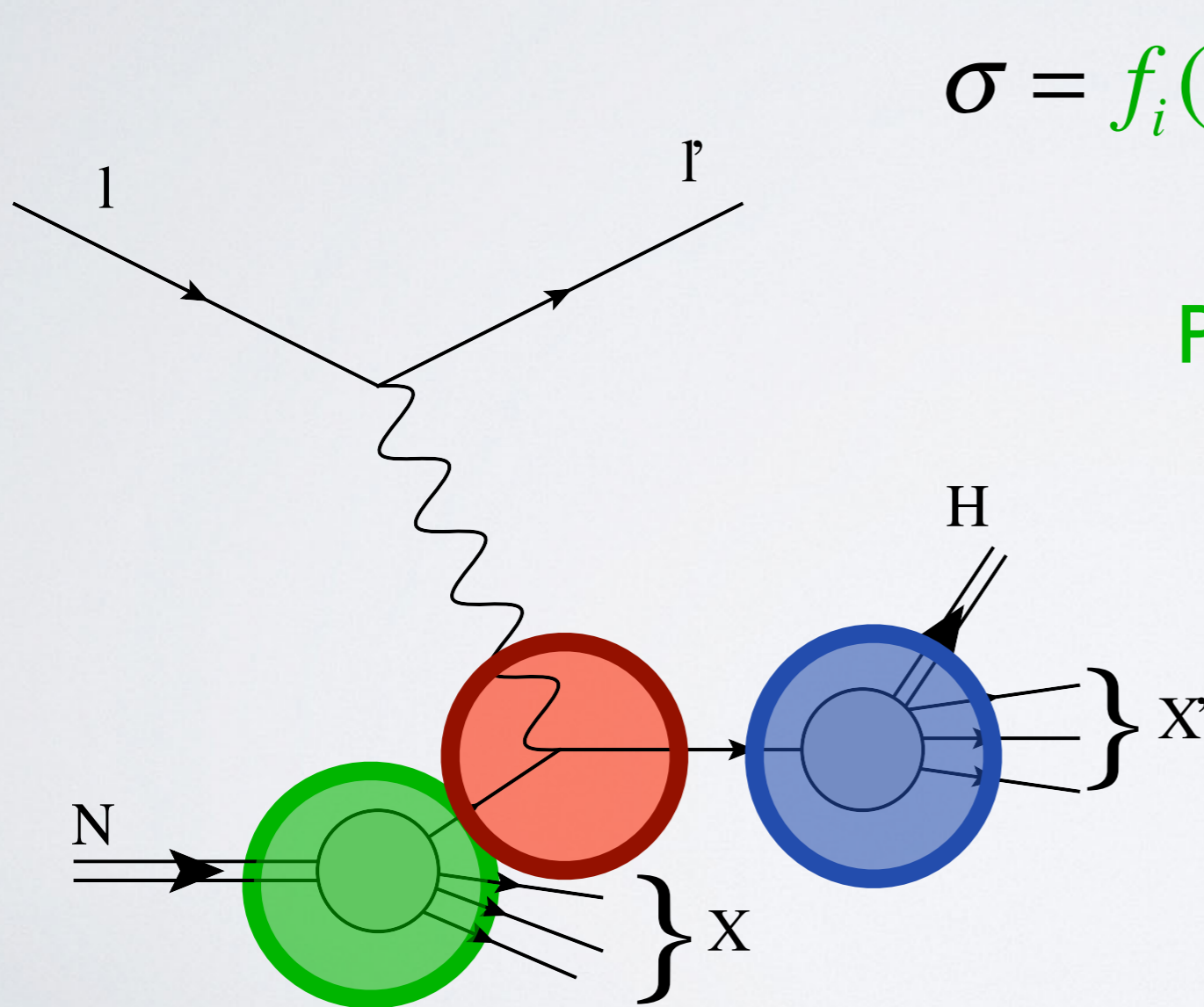
$$\sigma = f_i(x, Q^2) \otimes \hat{\sigma}_{ik}(Q^2) \otimes D_k^H(z, Q^2)$$

$$\hat{\sigma}_{jk} = \hat{\sigma}_{jk}^{(0)} + \alpha_s \hat{\sigma}_{jk}^{(1)} + \dots$$

Hard Scattering Cross Section
(Can be calculated with pQCD)

HADRONIC QCD IN A NUTSHELL

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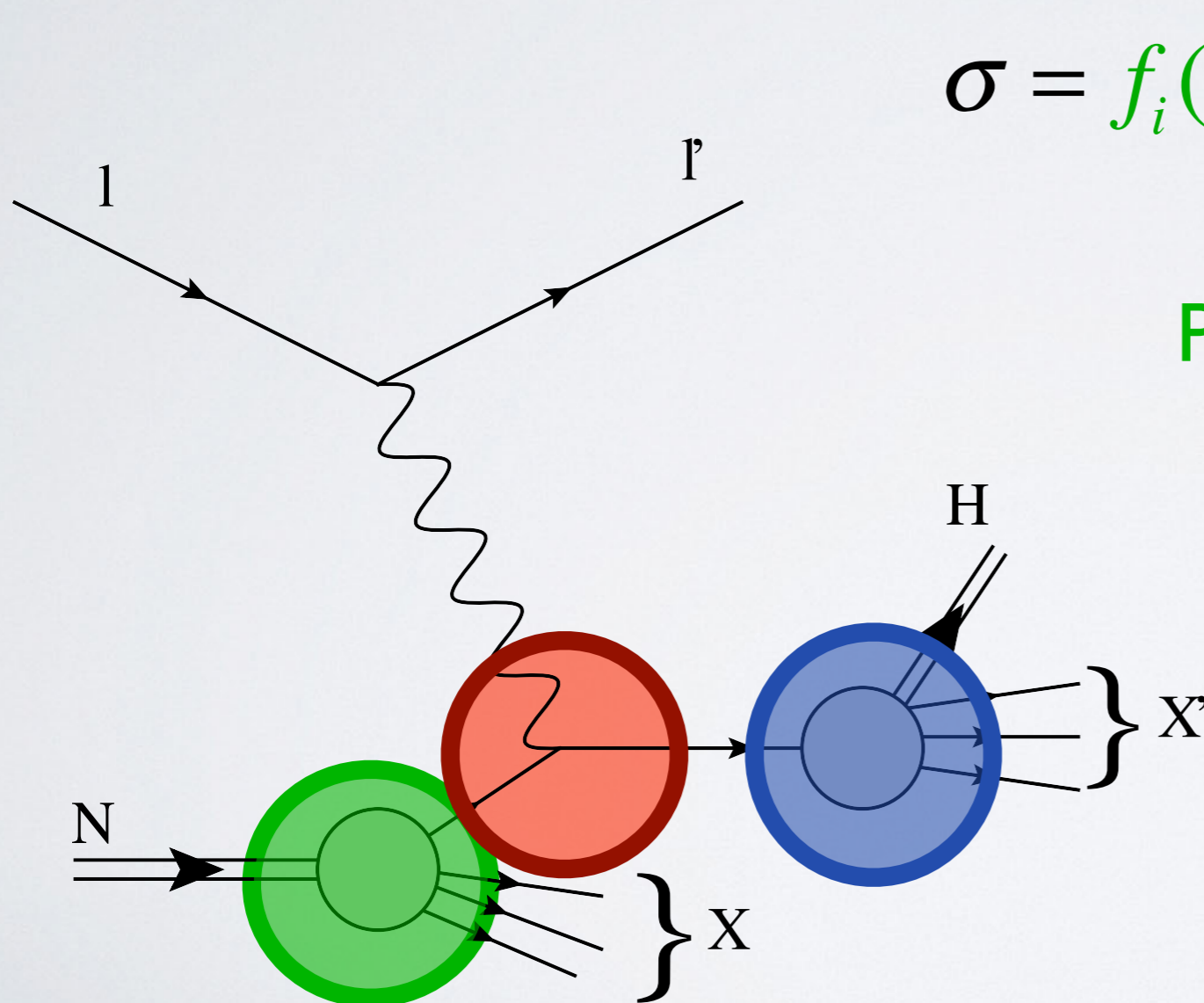
PDFs

FFs

Translate hadronic degrees of freedom into those of quarks and gluons

HADRONIC QCD IN A NUTSHELL

FACTORIZATION



$$\sigma = f_i(x, Q^2) \otimes \hat{\sigma}_{ik}(Q^2) \otimes D_k^H(z, Q^2)$$

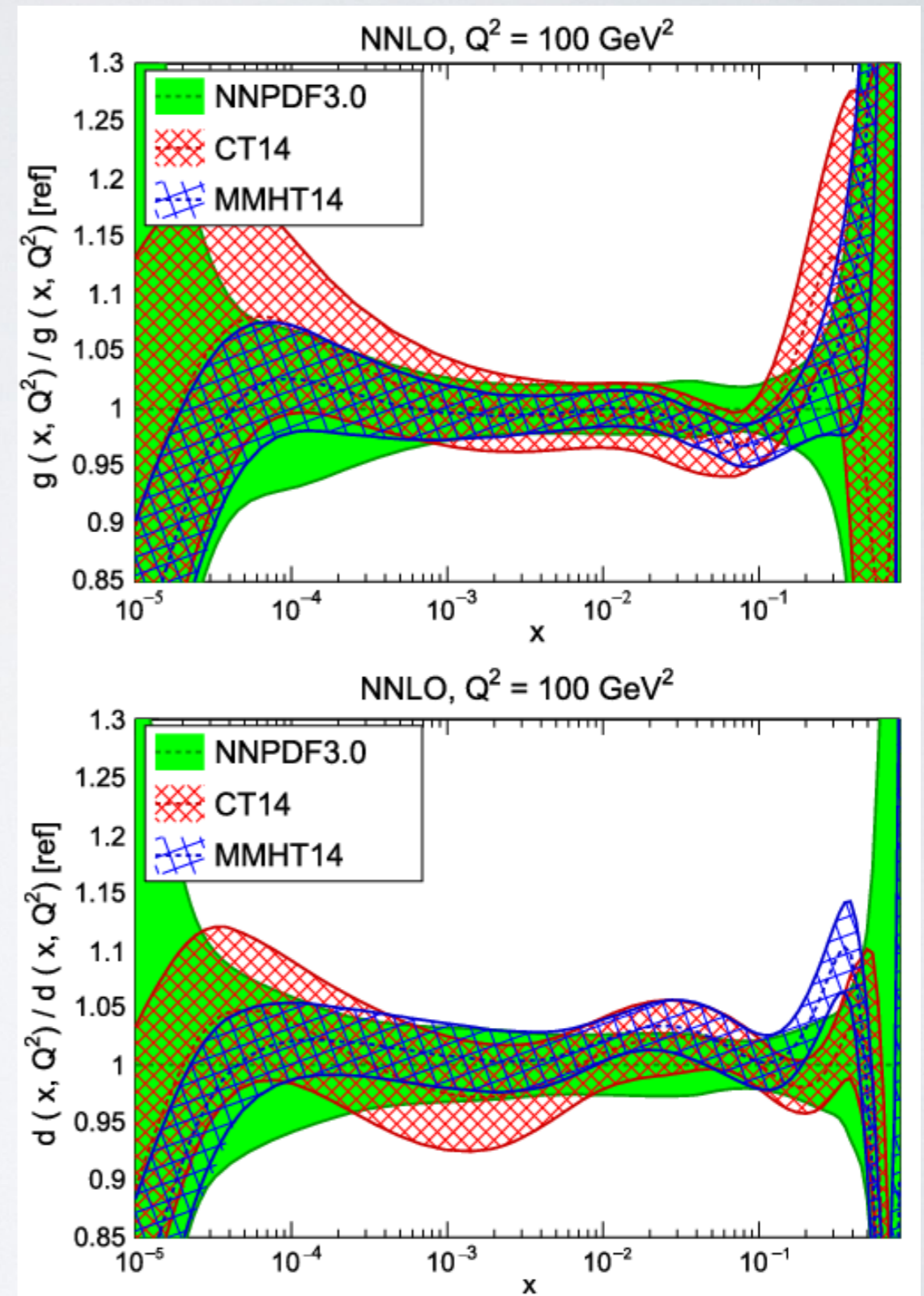
\downarrow PDFs \downarrow FFs

- Non-Perturbative Functions
- We have to extract them from experimental data

GLOBAL ANALYSIS

PDF'S CURRENT STATUS

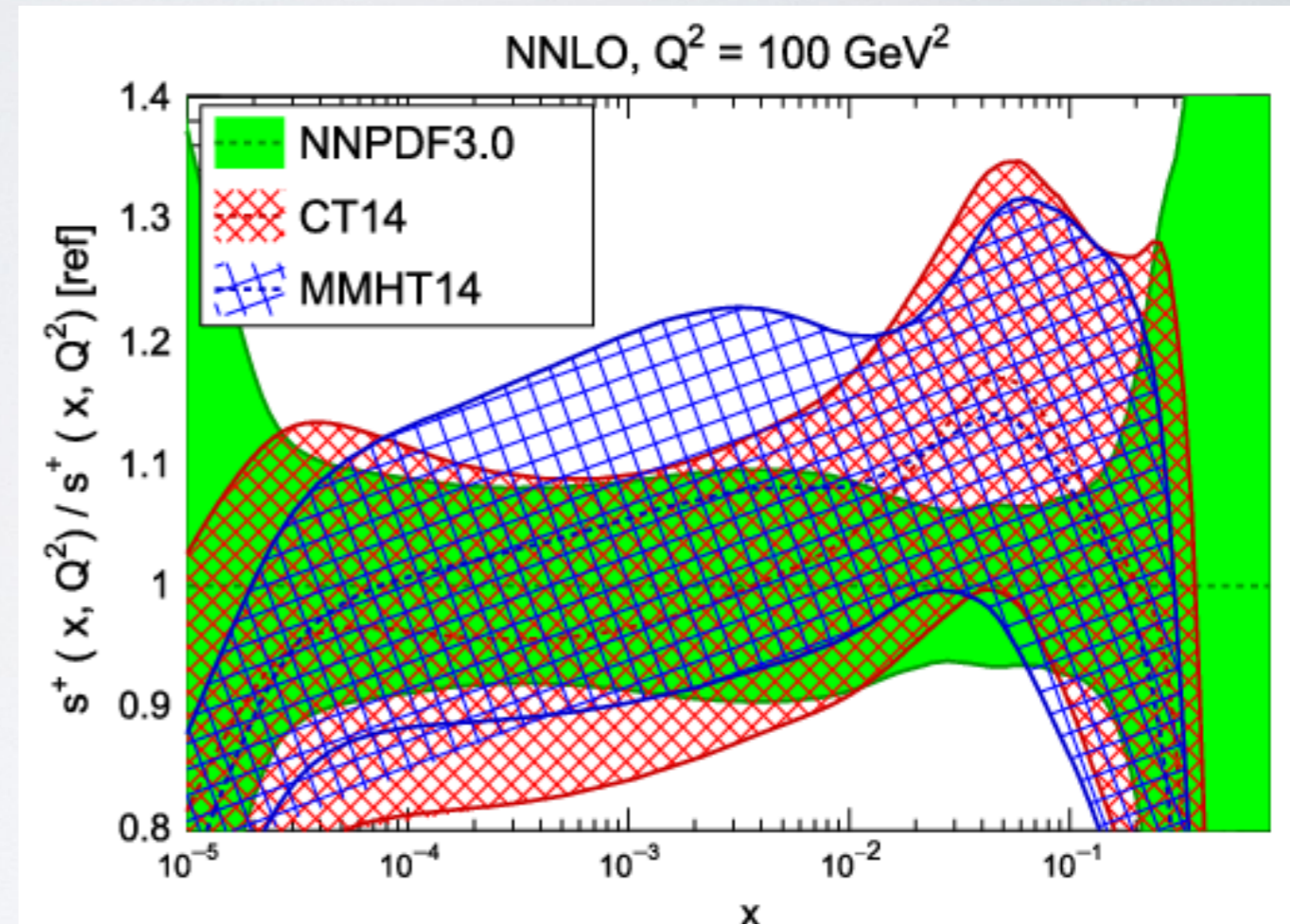
- Remarkable increase in the sophistication and precision of the extraction over the last years.
- Uncertainties reduction to a few percent points.



PDF'S CURRENT STATUS

BUT...

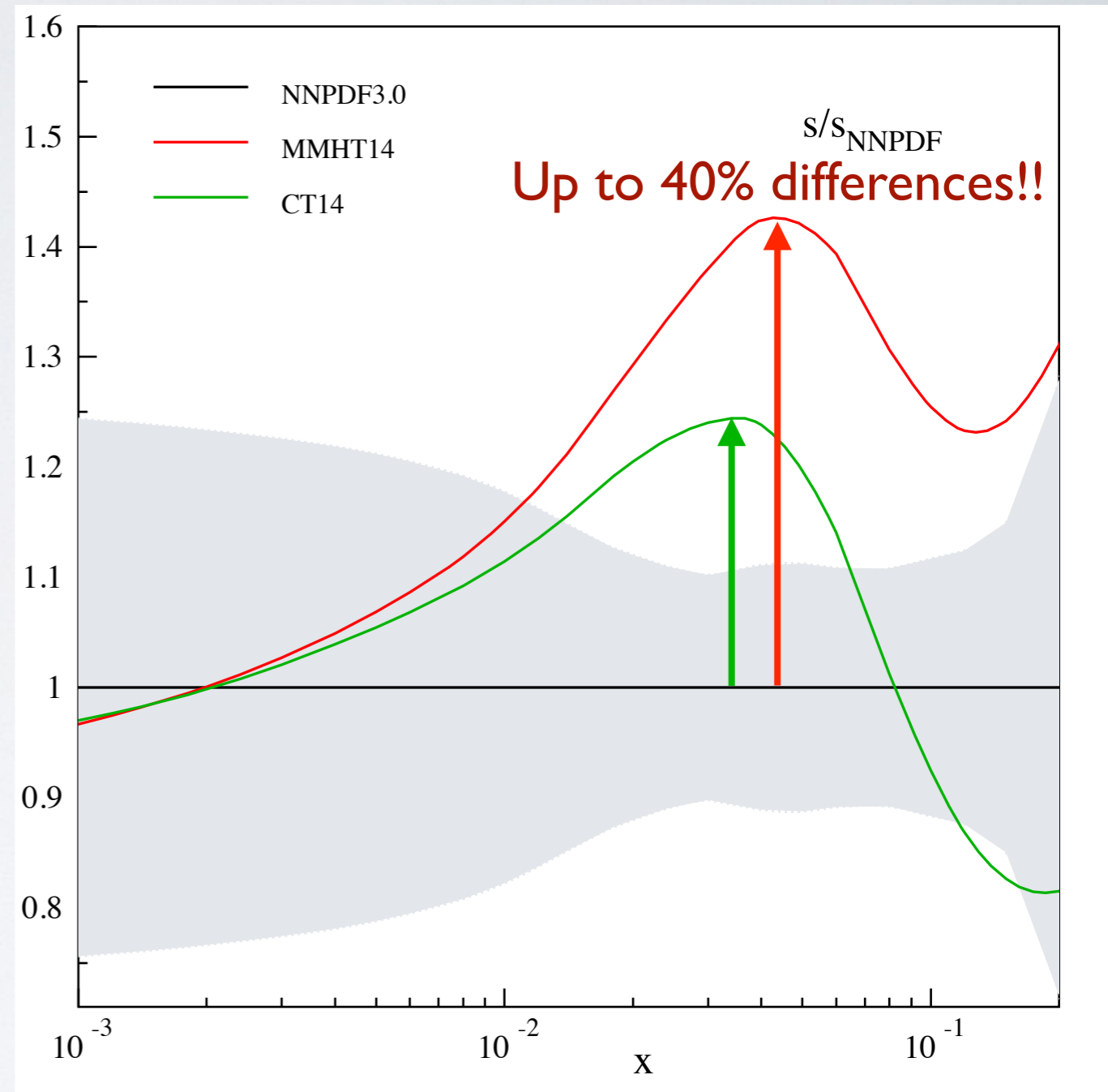
- Precision measurements at the LHC will eventually require a systematic knowledge of PDFs at the percent level.
- Need for improvement in the precision and reliability of PDF determination



PDF'S CURRENT STATUS

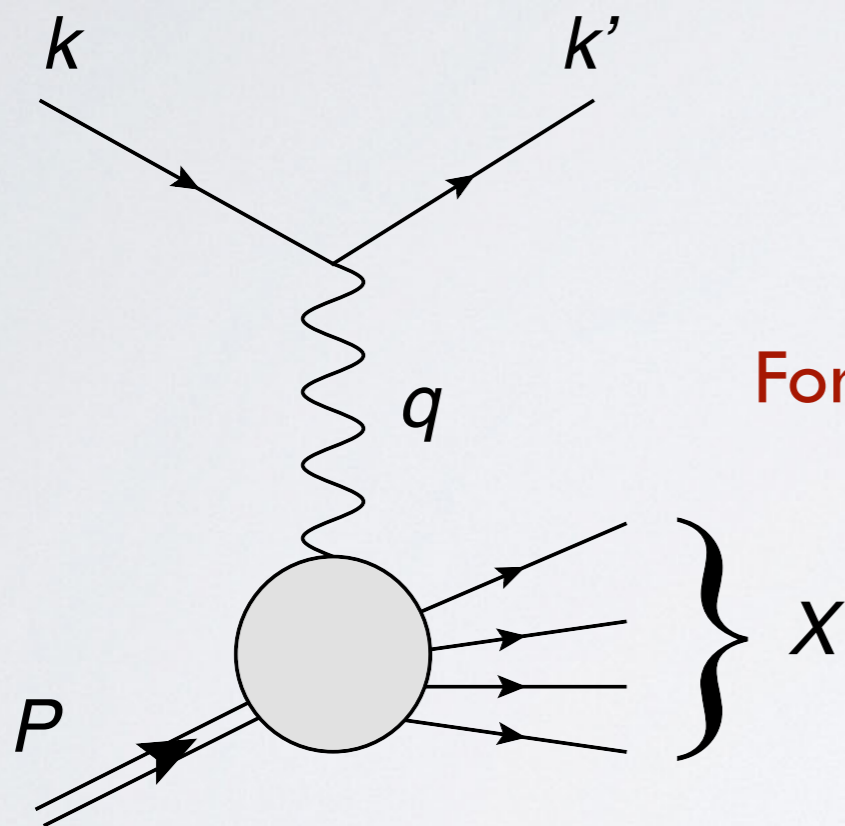
BUT...

- Precision measurements at the LHC will eventually require a systematic knowledge of PDFs at the percent level.
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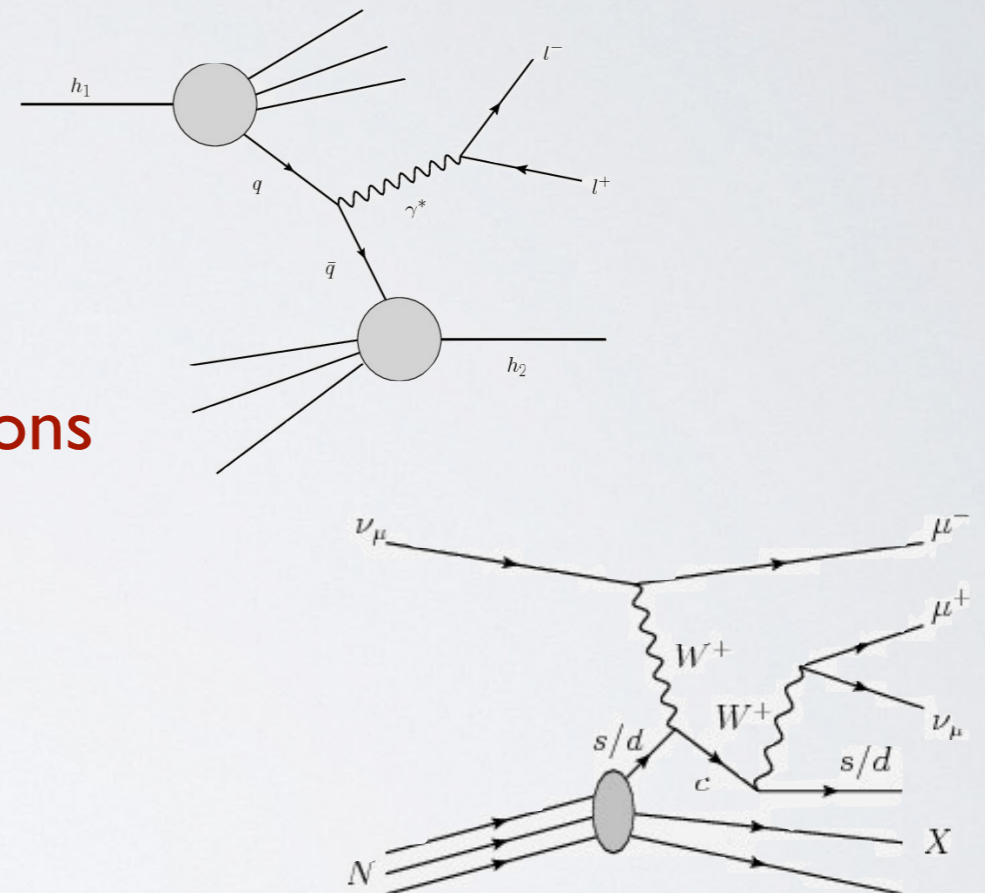


HOW WELL DETERMINED ARE THESE PARTON DISTRIBUTIONS?

The extraction has a strong dependence with the experiments that are used



For strange distributions



Inclusive Processes (DIS)

$$[f_q^P(x) + f_{\bar{q}}^P(x)]$$

+ Flavor symmetries

- DIS with electroweak currents
- Leptonic decays of W bosons

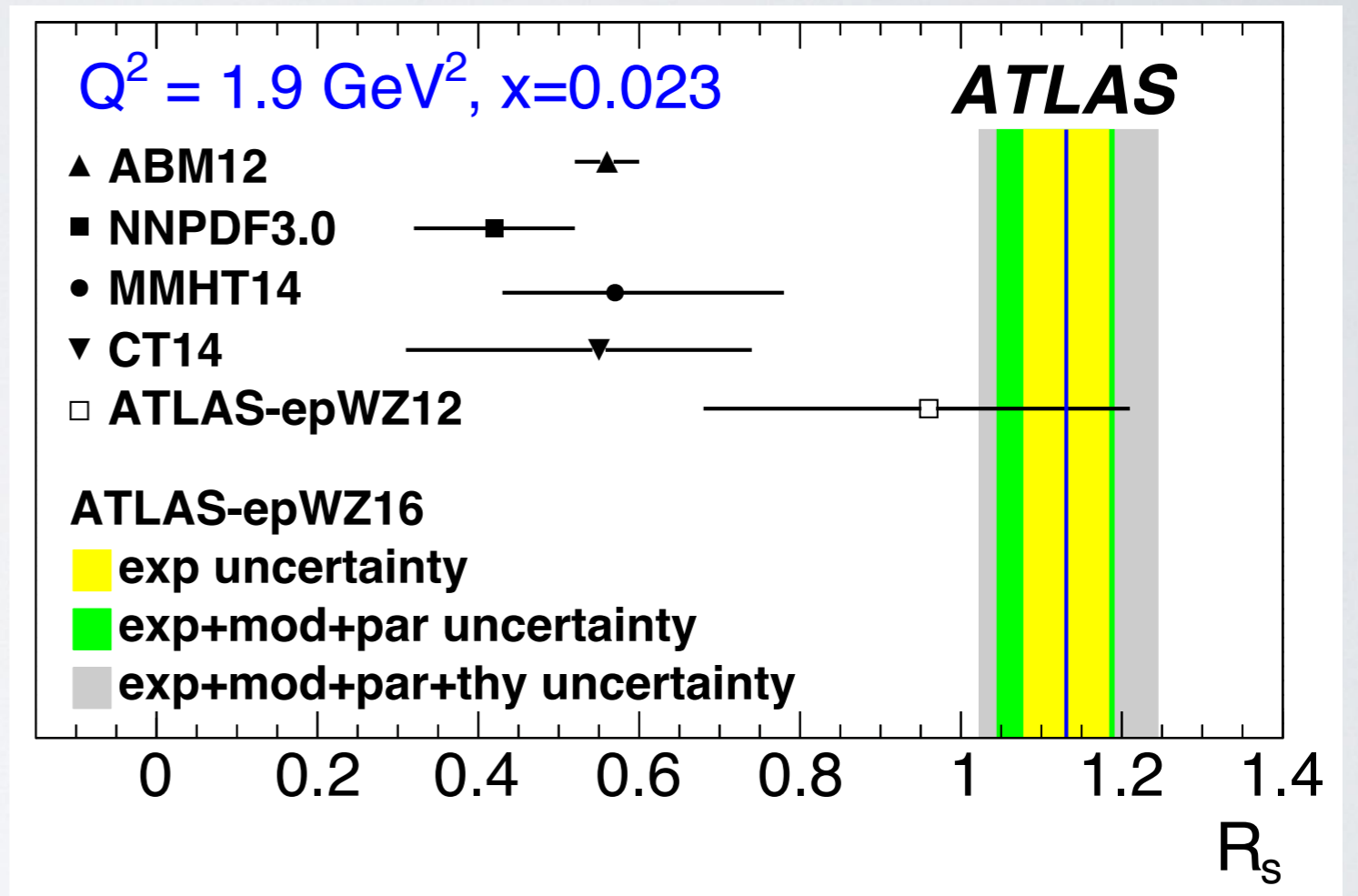
Indirect sensitivity to the sea content of the proton

HOW WELL DETERMINED ARE THESE PARTON DISTRIBUTIONS?

The strangeness puzzle

$$R_s(x, Q^2) = [s(x, Q^2) + \bar{s}(x, Q^2)] / [\bar{u}(x, Q^2) + \bar{d}(x, Q^2)]$$

Tension in strangeness driven by disagreement between collider data and neutrino DIS



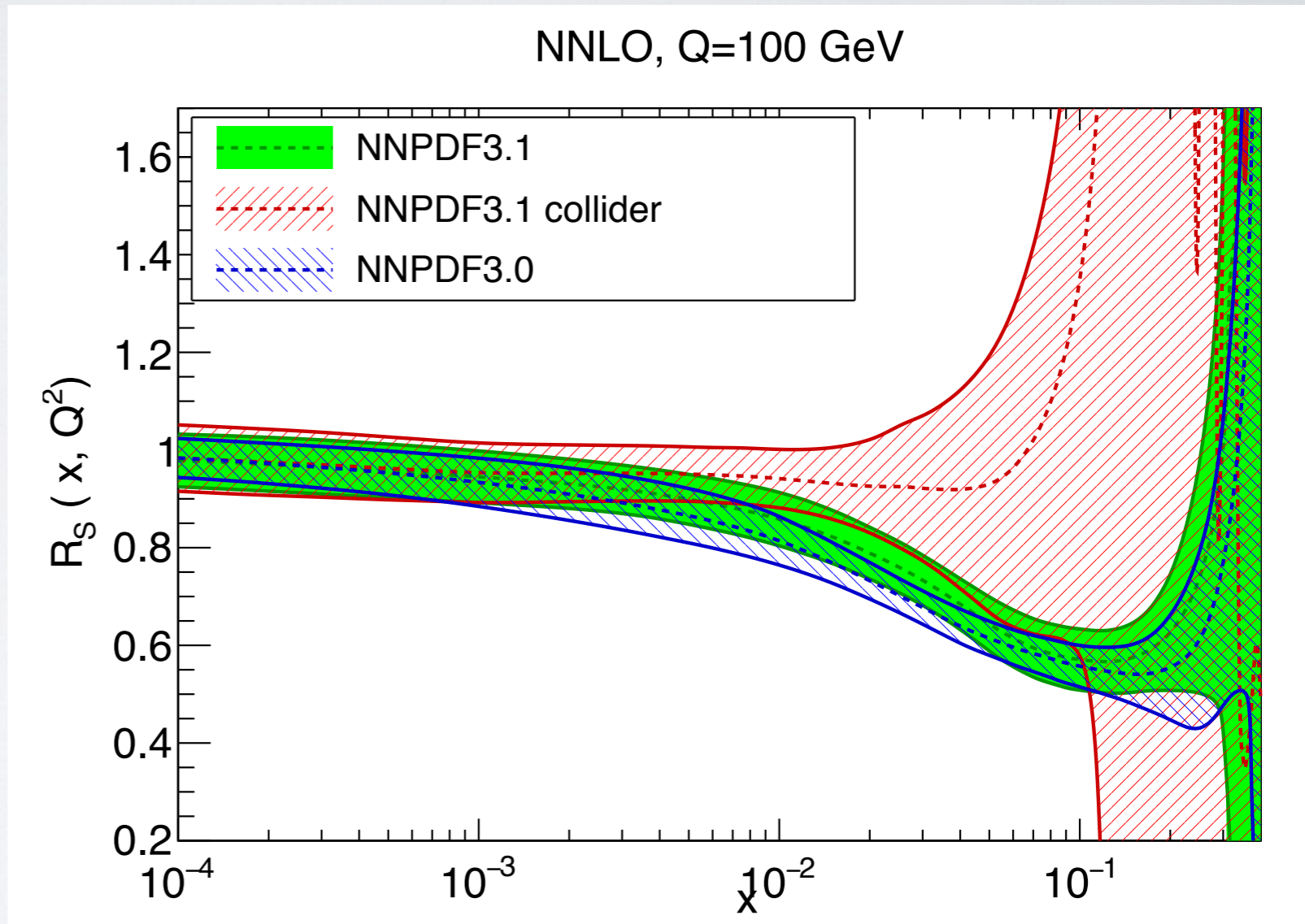
	NNPDF3.1 Global	NNPDF3.1 Collider
ATLAS 2011 W/Z	2.14	1.55
ATLAS 2010 W/Z	0.96	0.92
NuTeV dimuon	0.82	26.5

HOW WELL DETERMINED ARE THESE PARTON DISTRIBUTIONS?

The strangeness puzzle

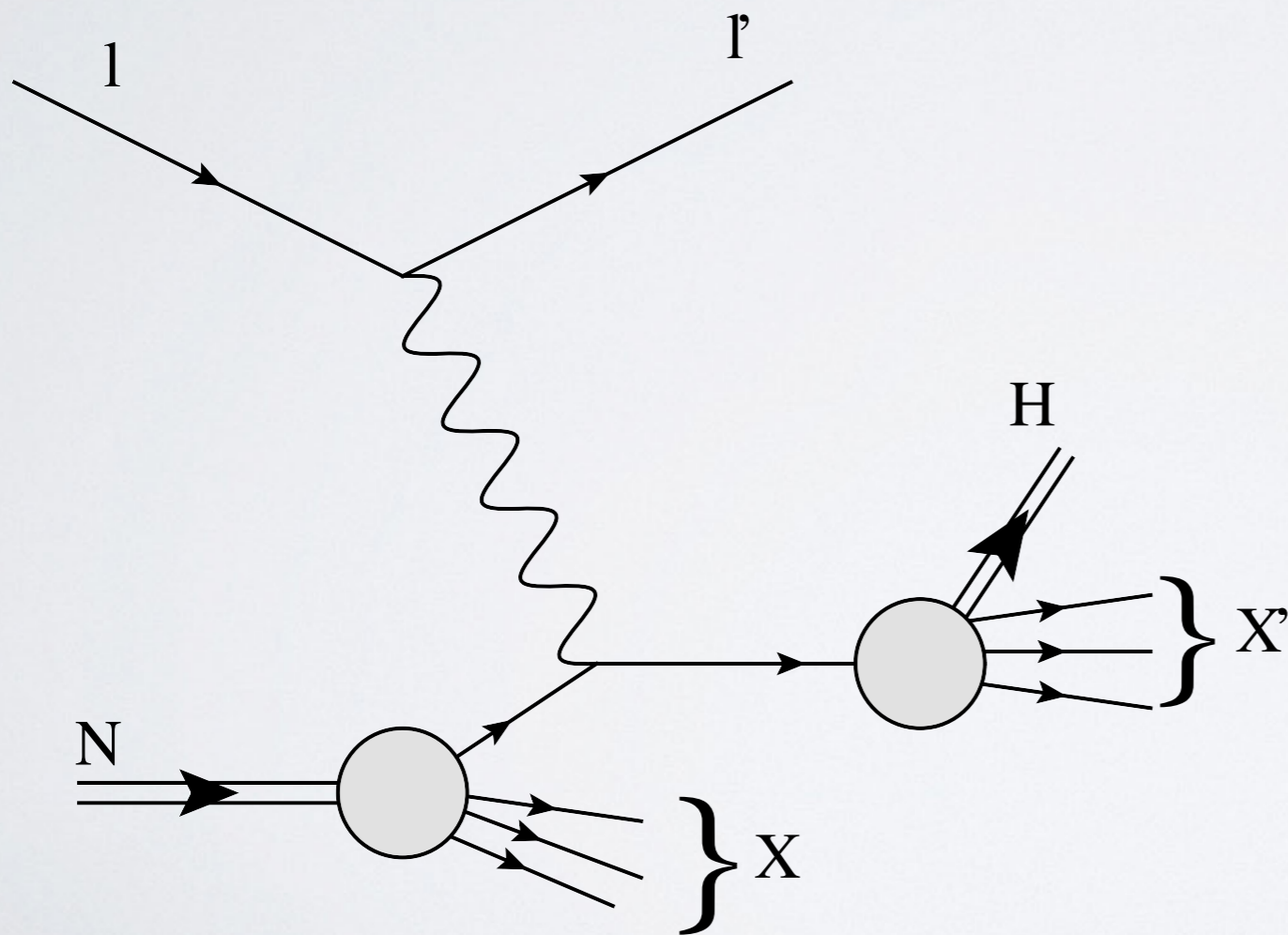
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Tension in strangeness
driven by disagreement
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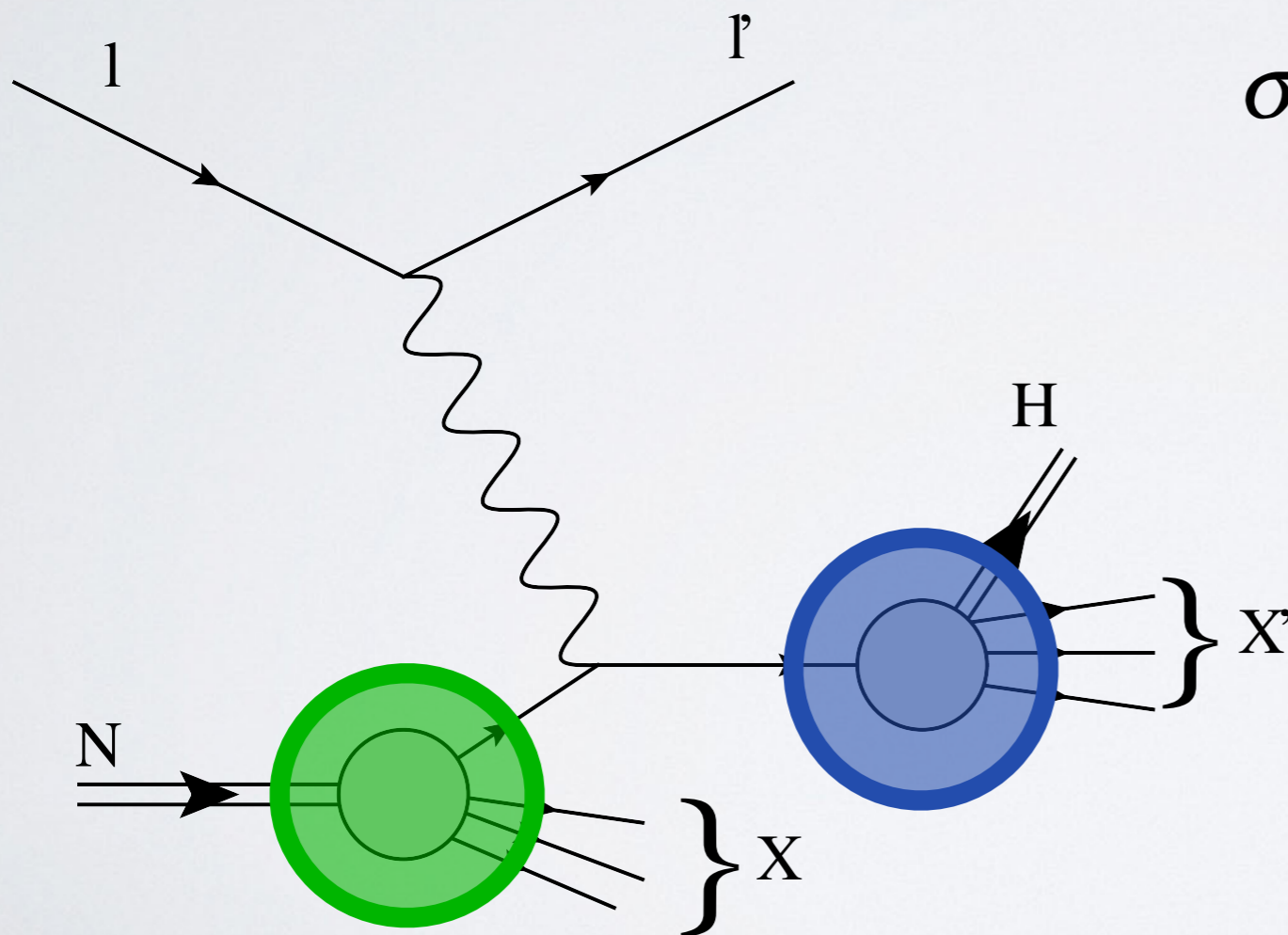
SEMI-INCLUSIVE OBSERVABLES

Improve parton distribution functions using data from flavor-sensitive experiments like SIDIS



COMBINED EXTRACTION OF PDFS & FFS

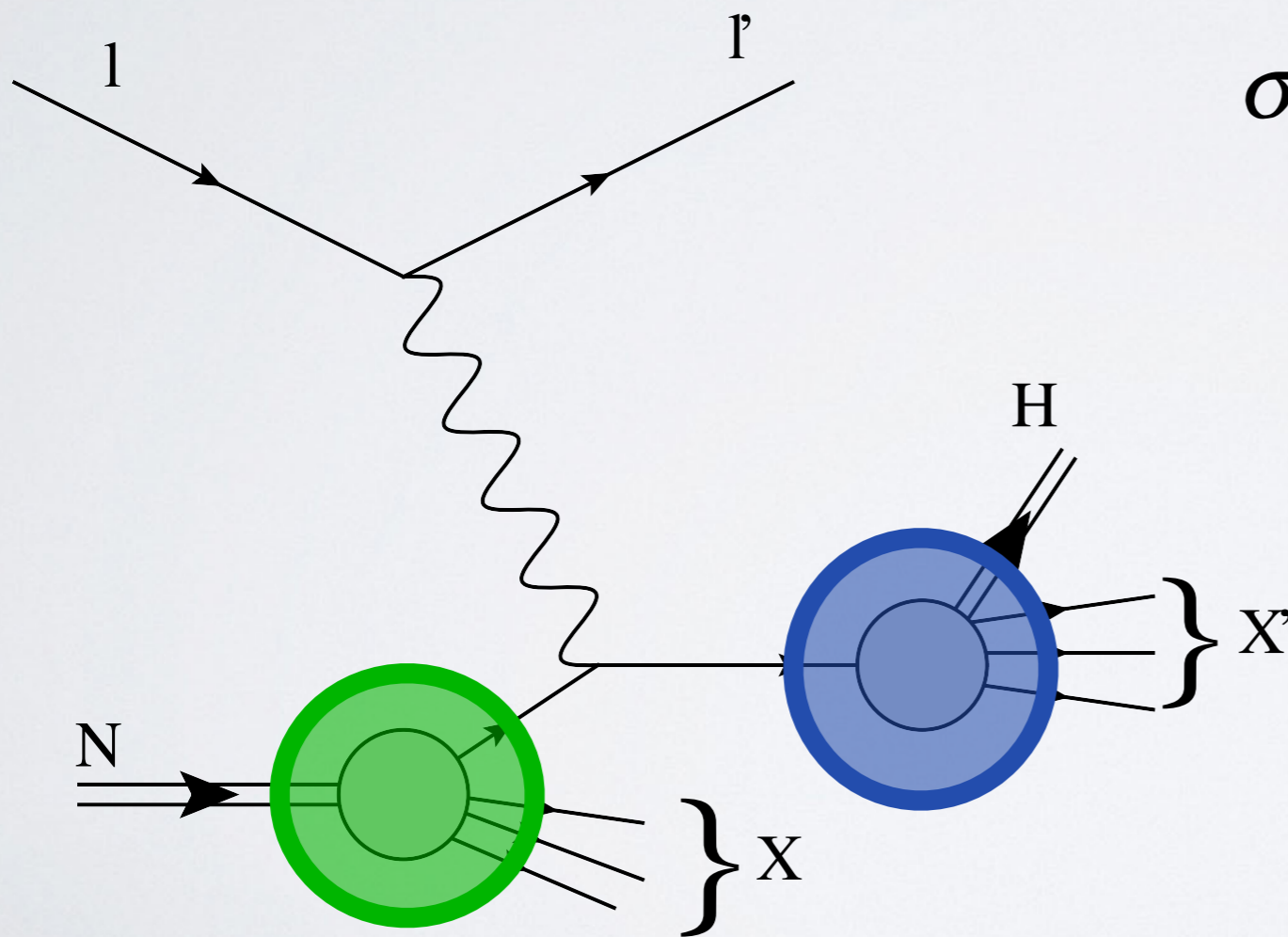
Improve parton distributions using data from flavor-sensitive experiments like SIDIS



$$\sigma = \frac{1}{2} \sum_{q, \bar{q}} e_q^2 f_q^P(x, Q^2) \otimes D_q^H(z, Q^2)$$

COMBINED EXTRACTION OF PDFS & FFS

Improve parton distributions using data from flavor-sensitive experiments like SIDIS



$$\sigma = \frac{1}{2} \sum_{q, \bar{q}} e_q^2 f_q^P(x, Q^2) \otimes D_q^H(z, Q^2)$$

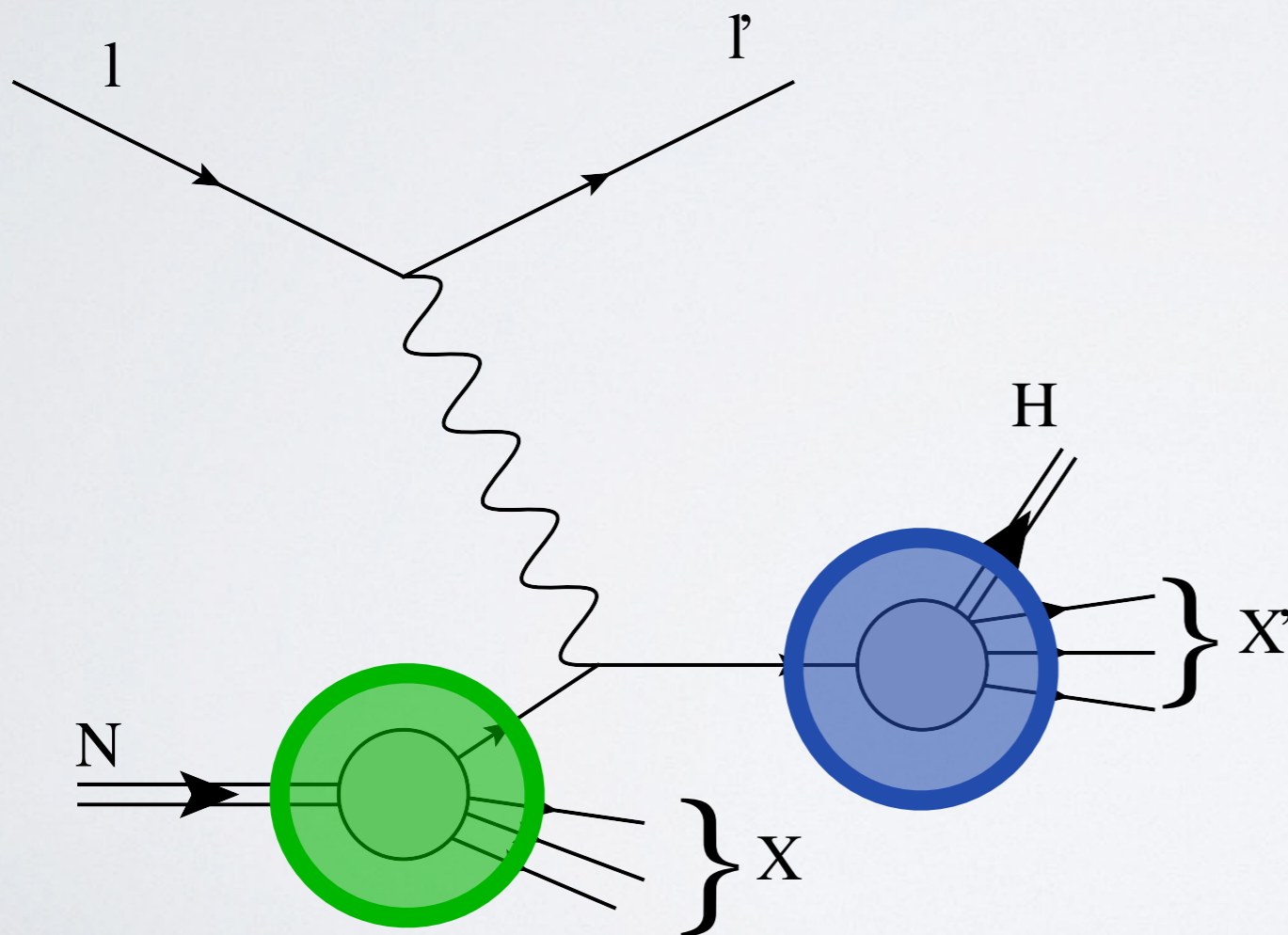
For example

$$|K^+\rangle = |u\bar{s}\rangle \quad |K^-\rangle = |\bar{u}s\rangle$$

Charged kaon SIDIS can improve the sea distributions

COMBINED EXTRACTION OF PDFS & FFS

Improved parton distributions using data from flavor-sensitive experiments like SIDIS



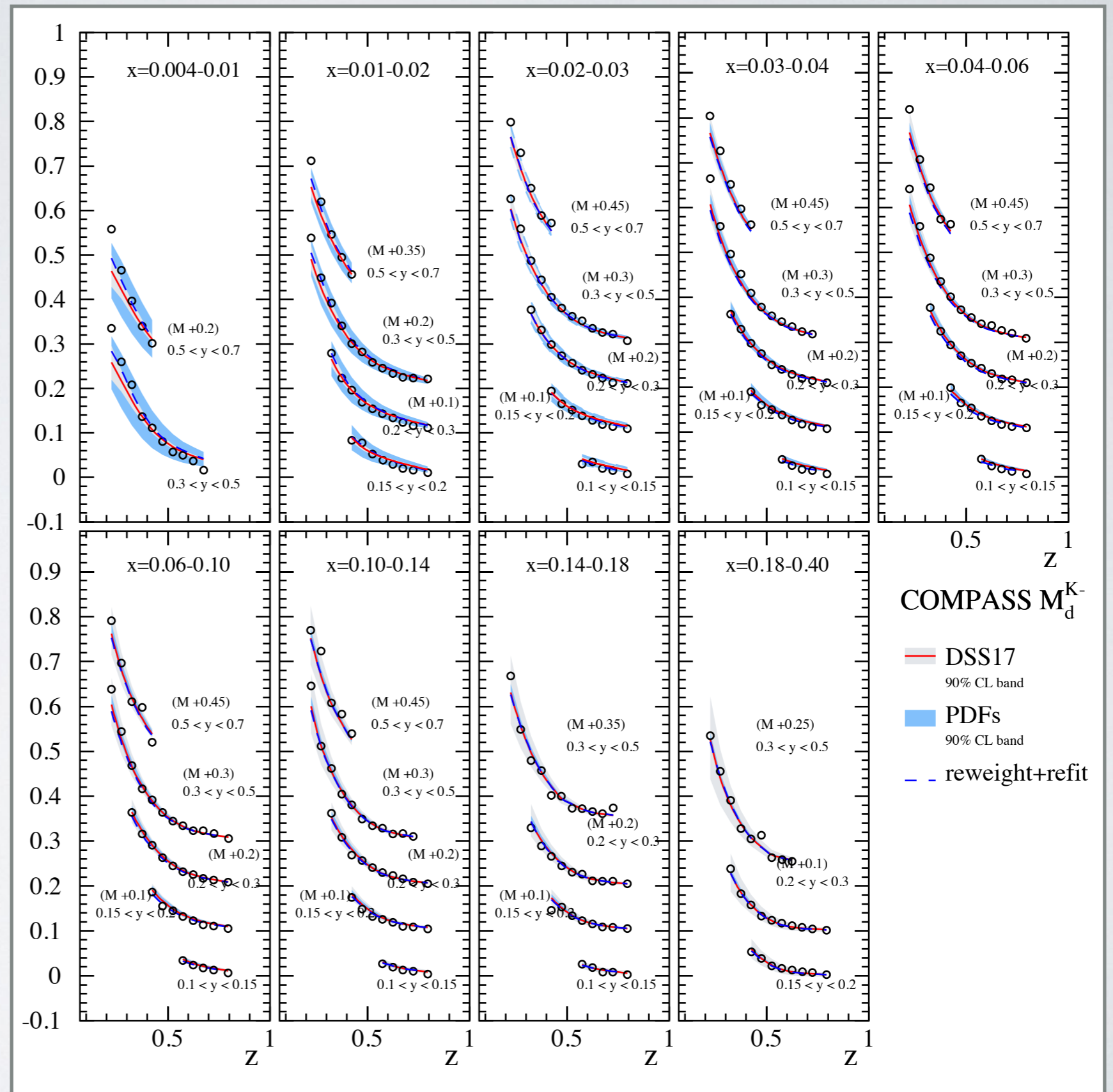
Slightly Cumbersome

- Big number of parameters to fit
- Factorial-like growth of the number of iterations needed
- Different Phase Space/Topography

NEW COMPASS SIDIS DATA

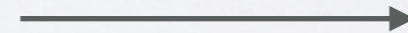
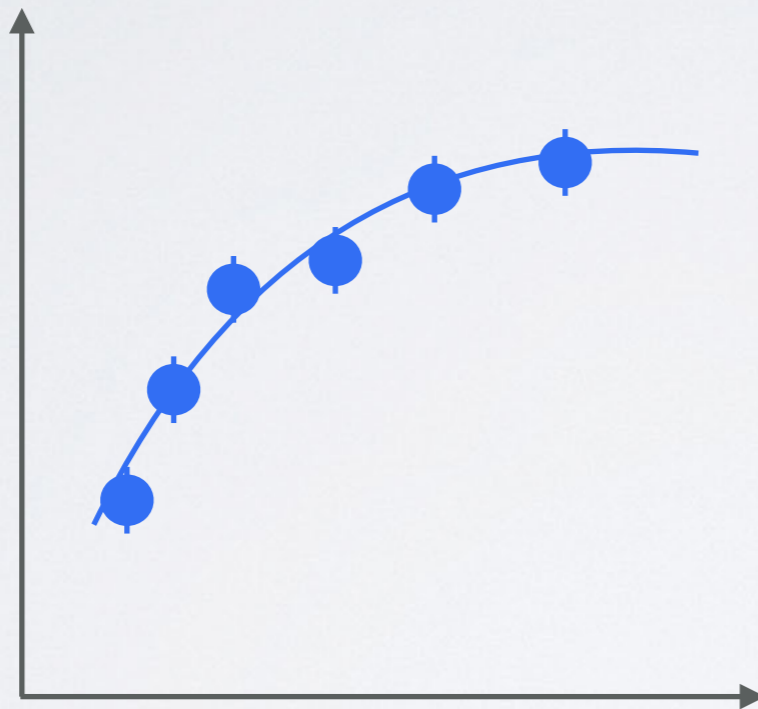
$$M_{p(d)}^{K^\pm} = \frac{d\sigma_{p(d)}^{K^\pm} / dx dy dz}{d\sigma_{p(d)} / dx dy}$$

Compass
Multiplicity data in
bins of x , z and y



REWEIGHTING

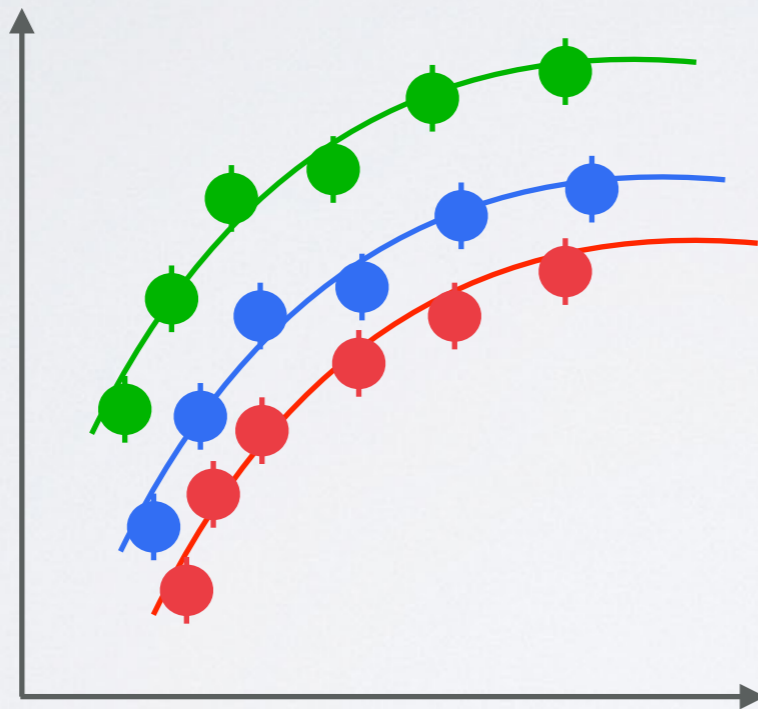
Inclusion data of semi-inclusive observables through Bayesian inference



$$f_i(x)$$

REWEIGHTING

Inclusion data of semi-inclusive observables through Bayesian inference



$$f_i(\mathbf{x}) \quad w(k)$$

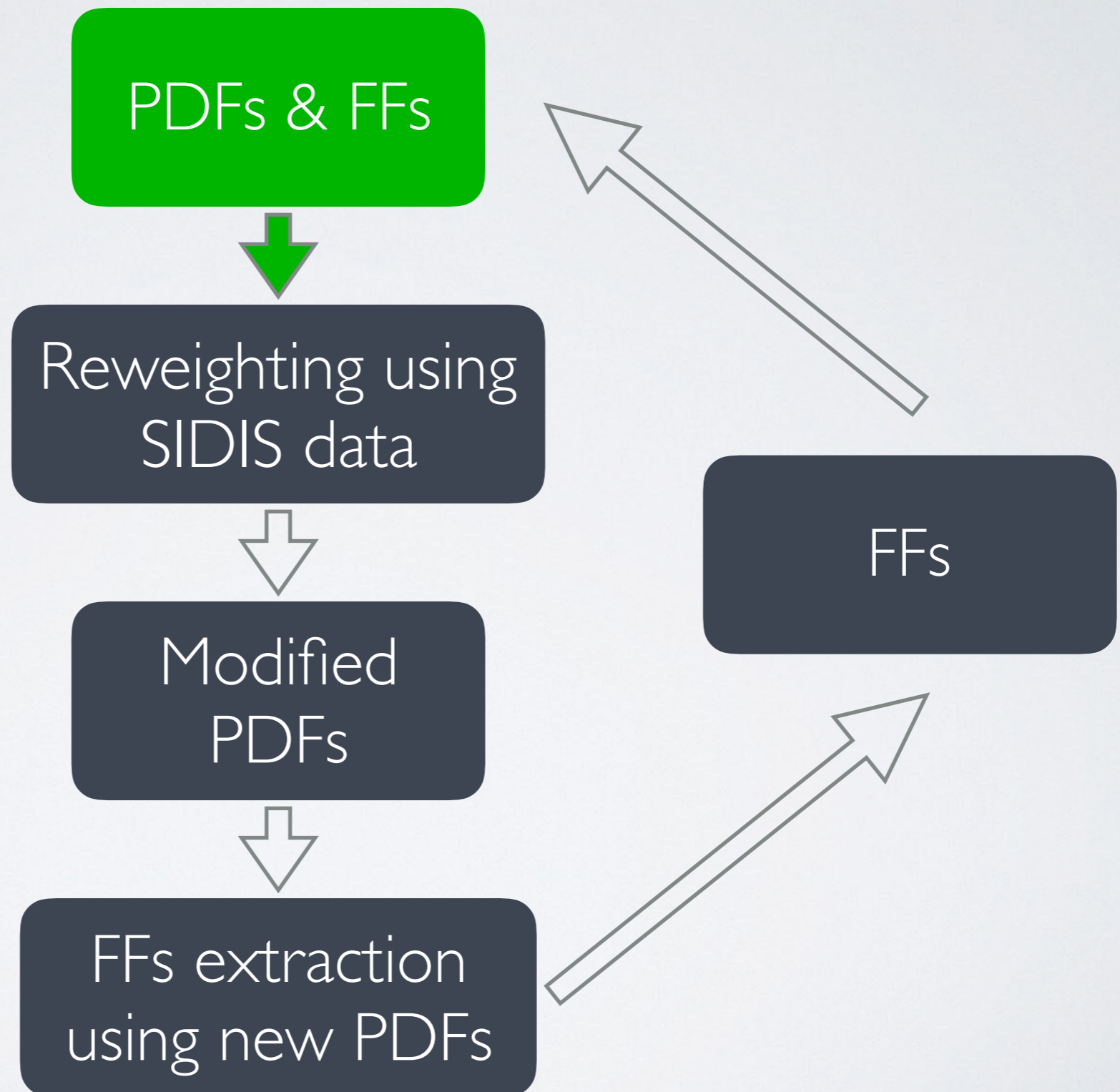
$$f_i(\mathbf{x}) \quad w(k)$$

$$f_i(\mathbf{x}) \quad w(k)$$

$$\langle O \rangle = \frac{1}{N_{rep}} \sum_{k=1}^N O[f(k)]$$

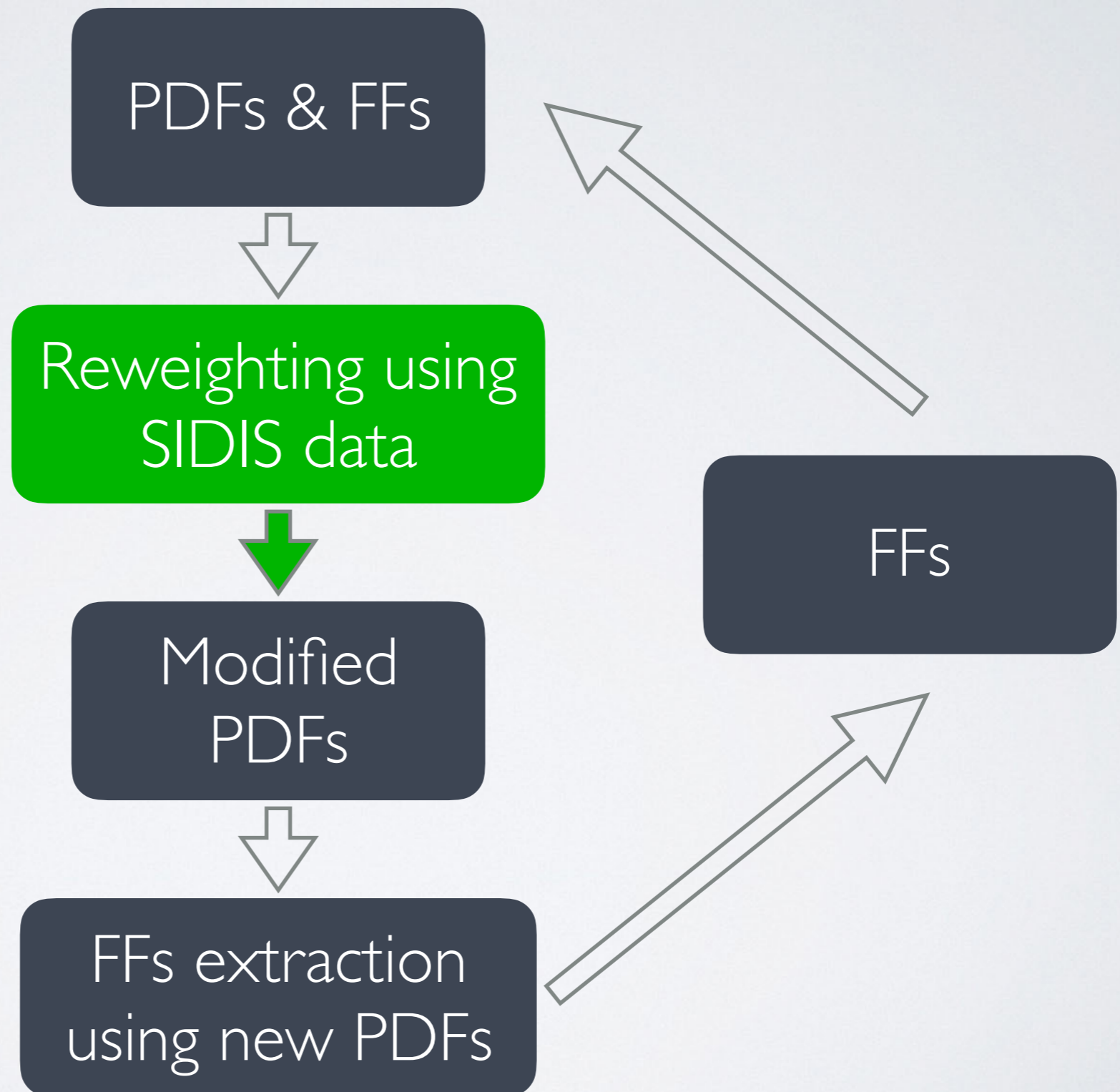
ITERATIVE PDF & FF EXTRACTION

Is the result independent from the original sets?



ITERATIVE PDF & FF EXTRACTION

Is the result independent from the original sets?
How to account for the FFs error in the reweighing?

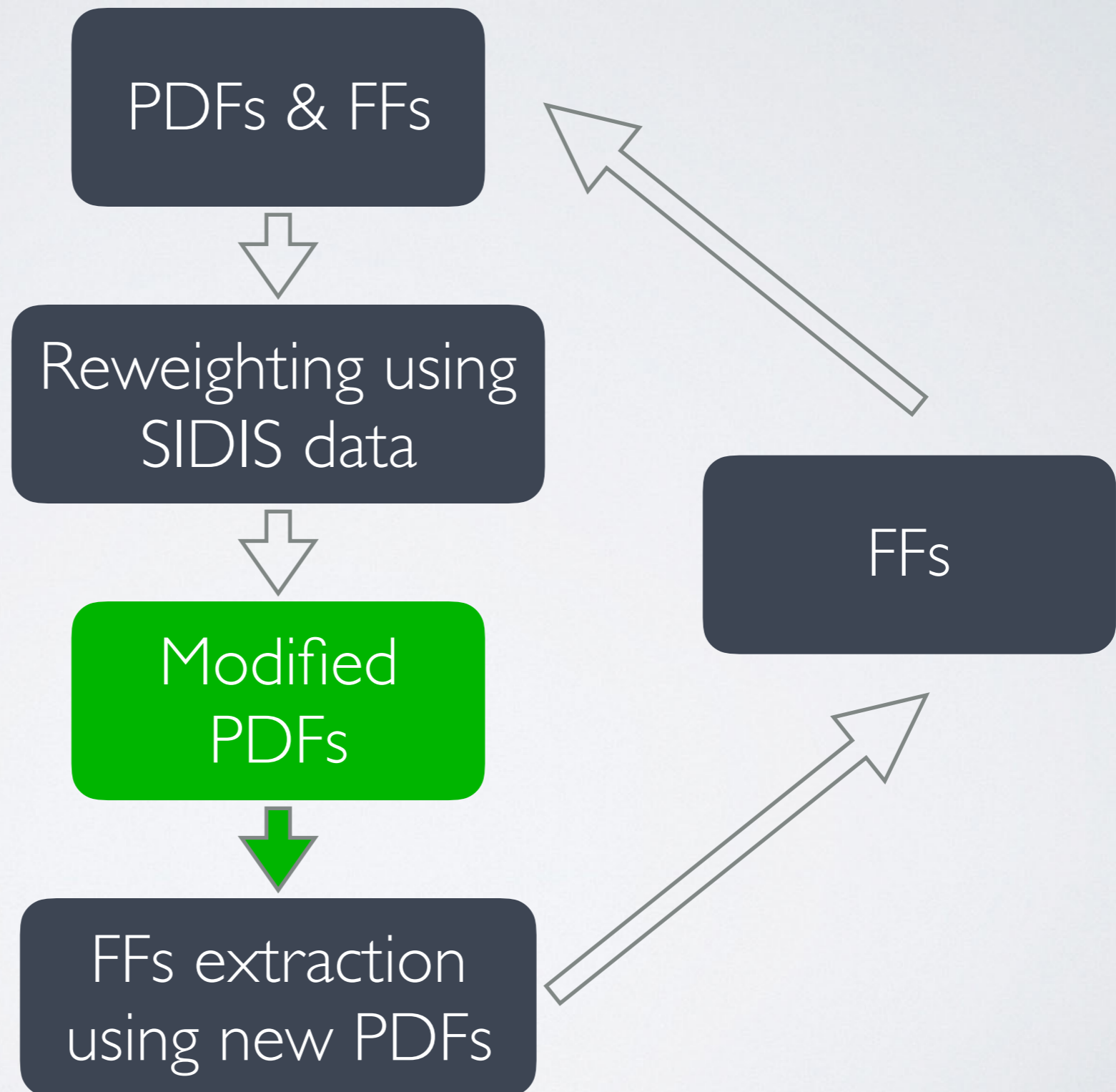


ITERATIVE PDF & FF EXTRACTION

Is the result independent from the original sets?

How to account for the FFs error in the reweighing?

Is the modified set of PDFs an improvement?



ITERATIVE PDF & FF EXTRACTION

PDFs & FFs



Reweighting using
SIDIS data

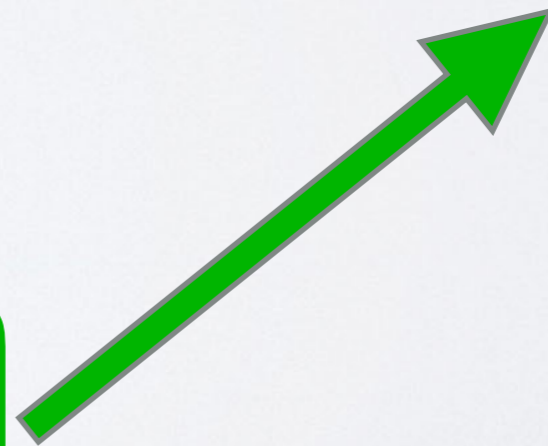


Modified
PDFs



FFs extraction
using new PDFs

FFs



Is the result independent from the original sets?

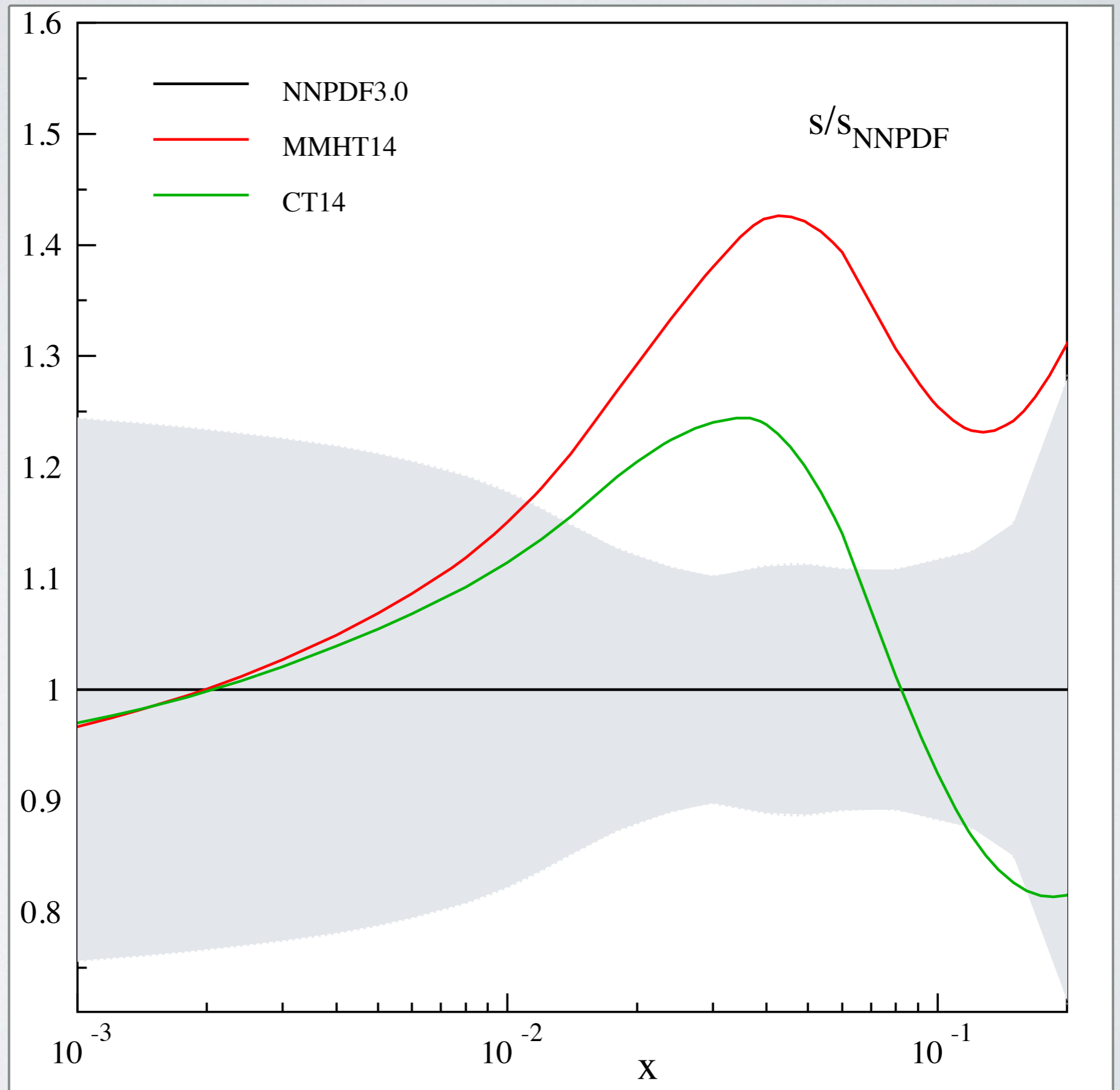
How to account for the FFs error in the reweighing?

Is the modified set of PDFs an improvement?

Convergence?

REWEIGHTING IN ACTION: STRANGE QUARK DISTRIBUTION

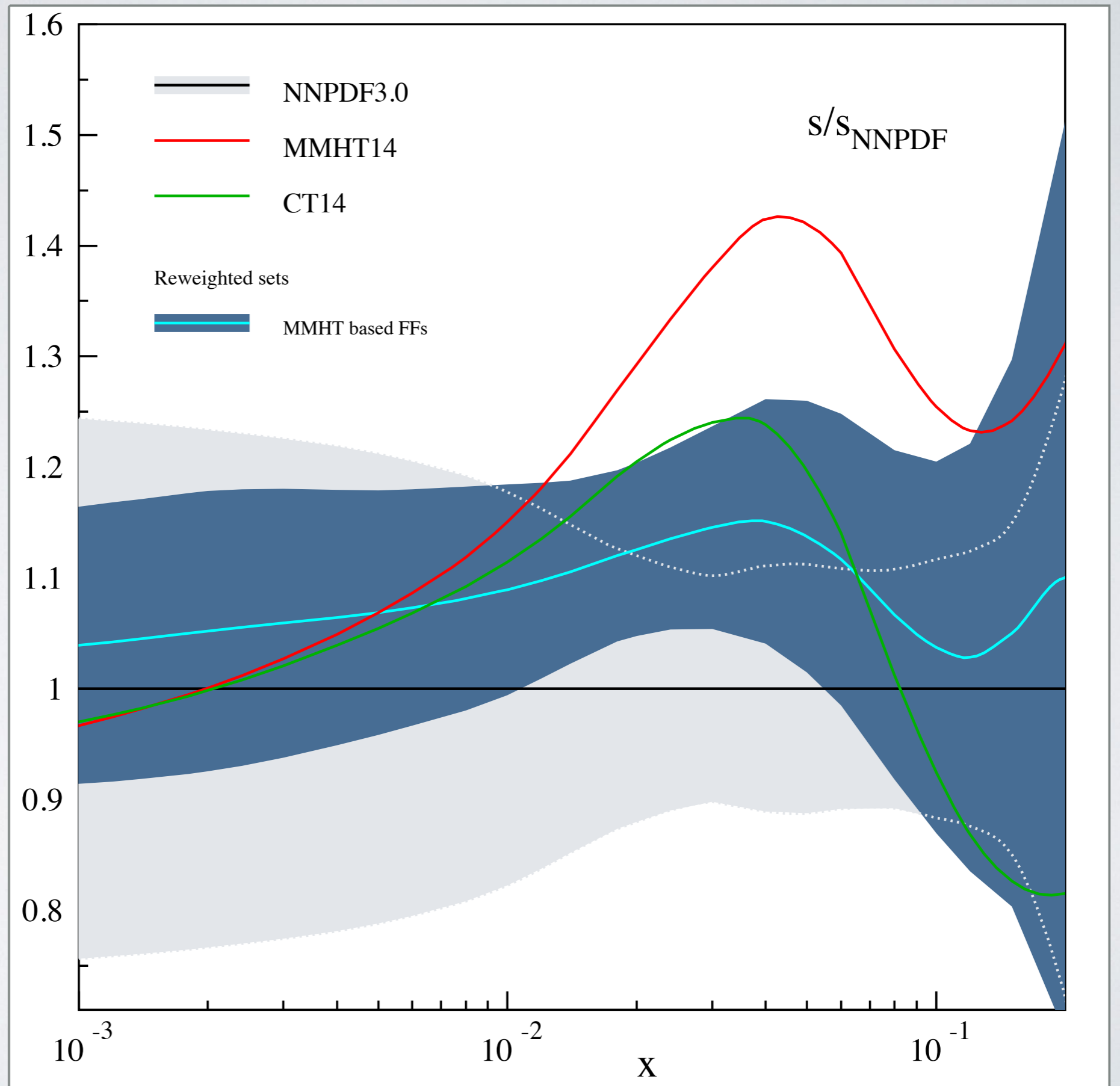
$$\chi^2_{FFs} = 1271$$



REWEIGHTING IN ACTION: STRANGE QUARK DISTRIBUTION

$$\chi^2_{FFs} = 1271$$

$$\chi^2_{FFs} = 1041$$

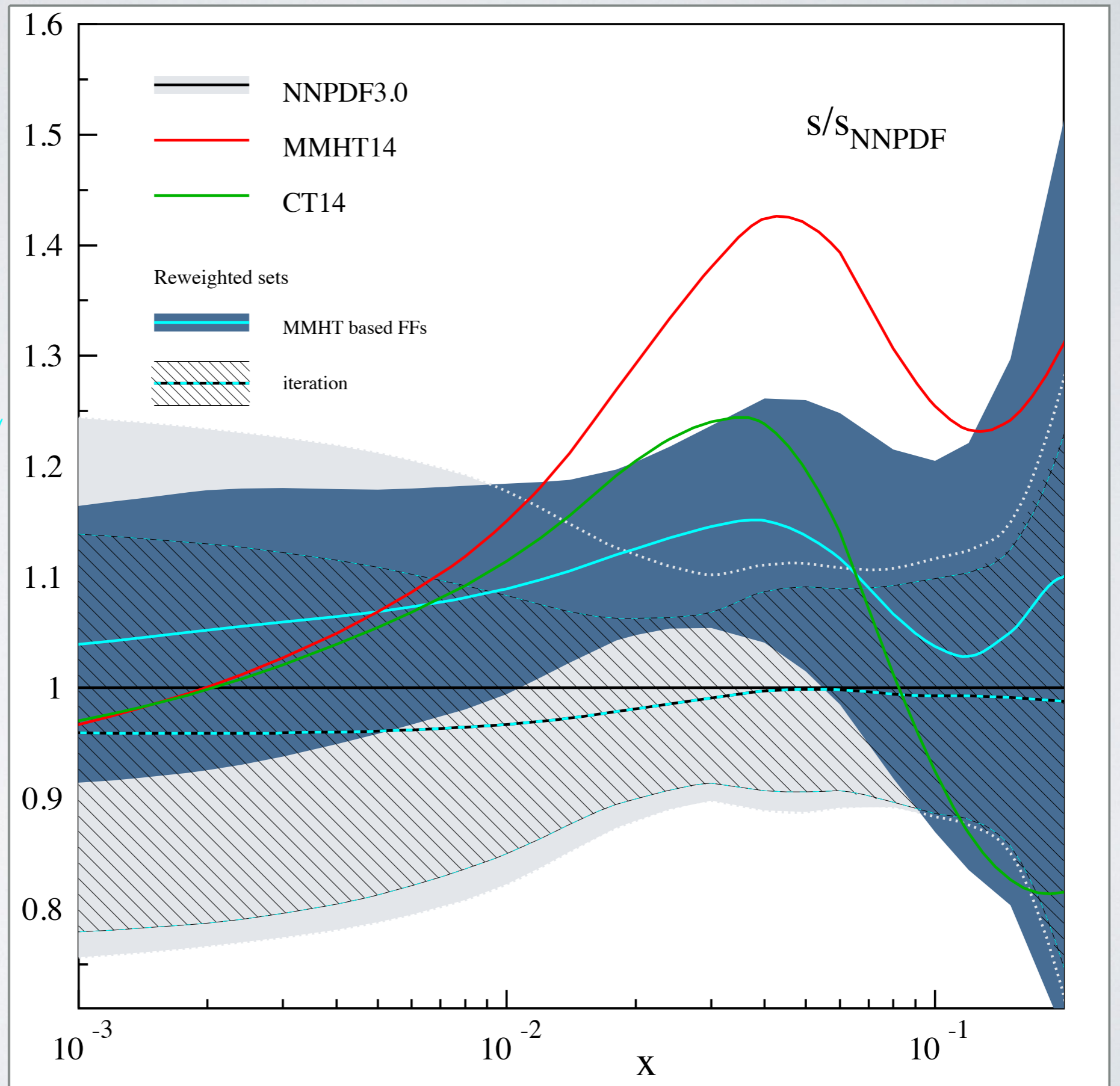


REWEIGHTING IN ACTION: STRANGE QUARK DISTRIBUTION

$$\chi^2_{FFs} = 1271$$

$$\chi^2_{FFs} = 1041$$

$$\chi^2_{FFs} = 1002$$



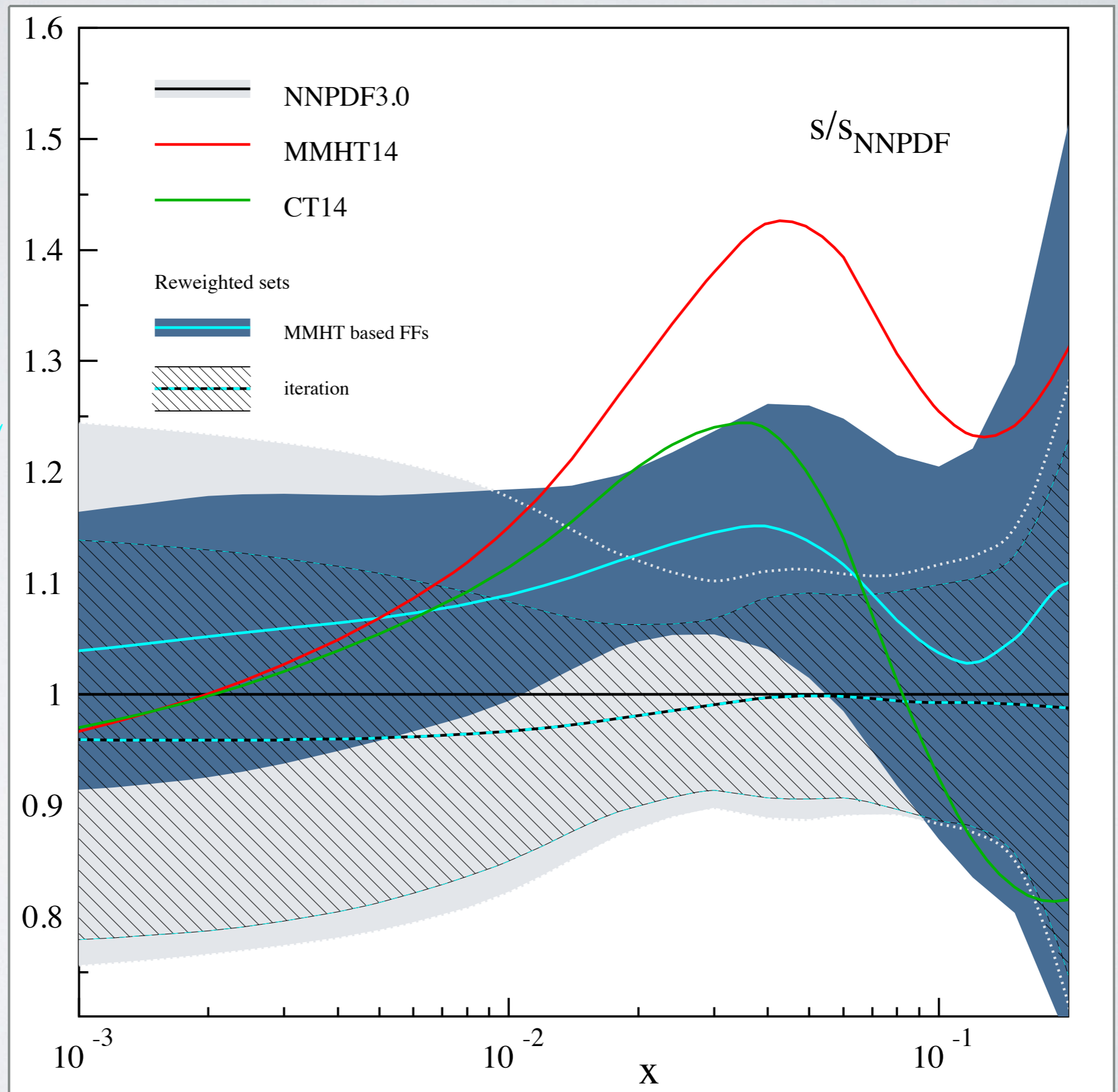
REWEIGHTING IN ACTION: STRANGE QUARK DISTRIBUTION

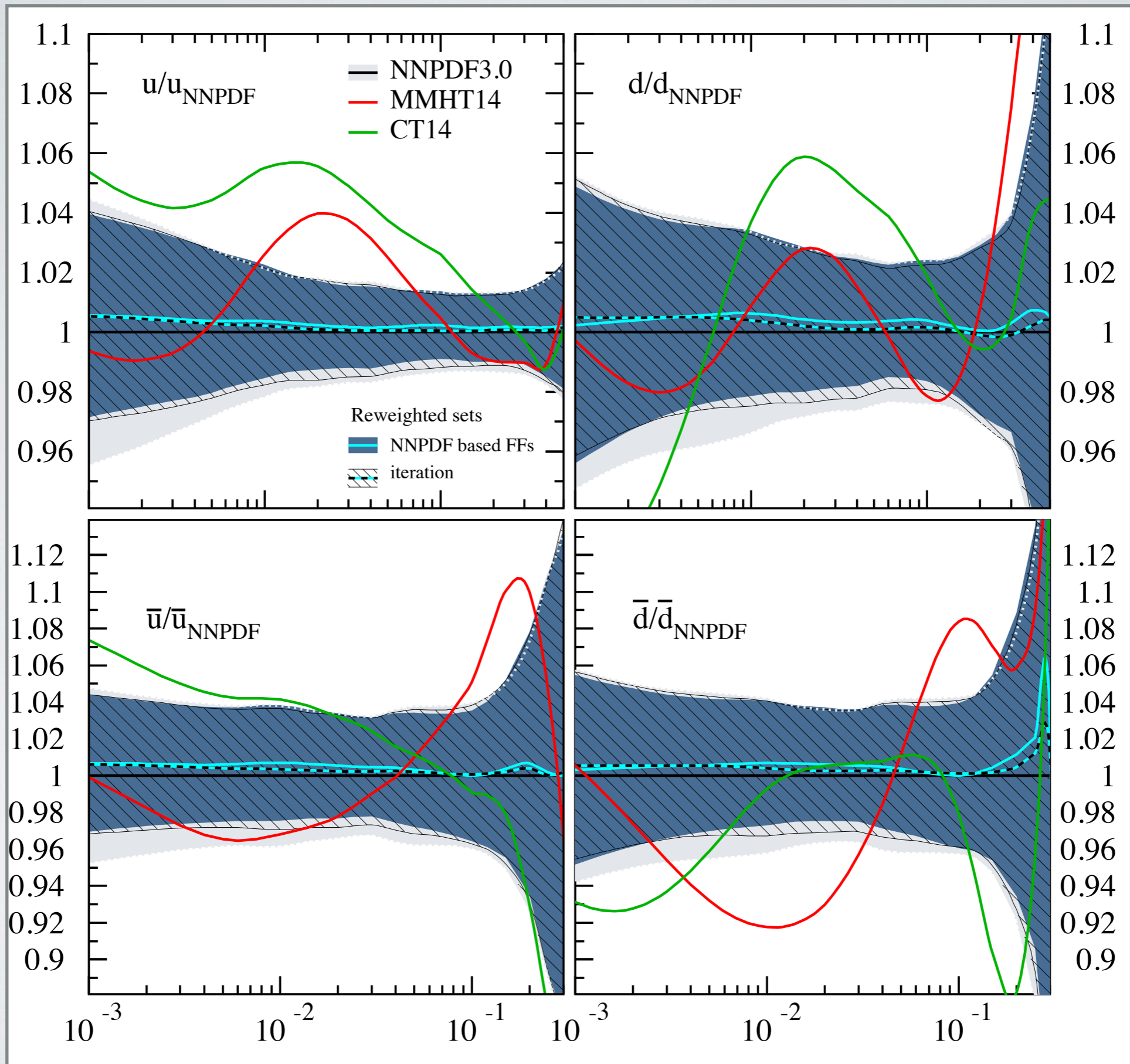
$$\chi^2_{FFs} = 1271$$

$$\chi^2_{FFs} = 1041$$

$$\chi^2_{FFs} = 1002$$

- Fast convergence
- Uncertainties reduction of order 10%

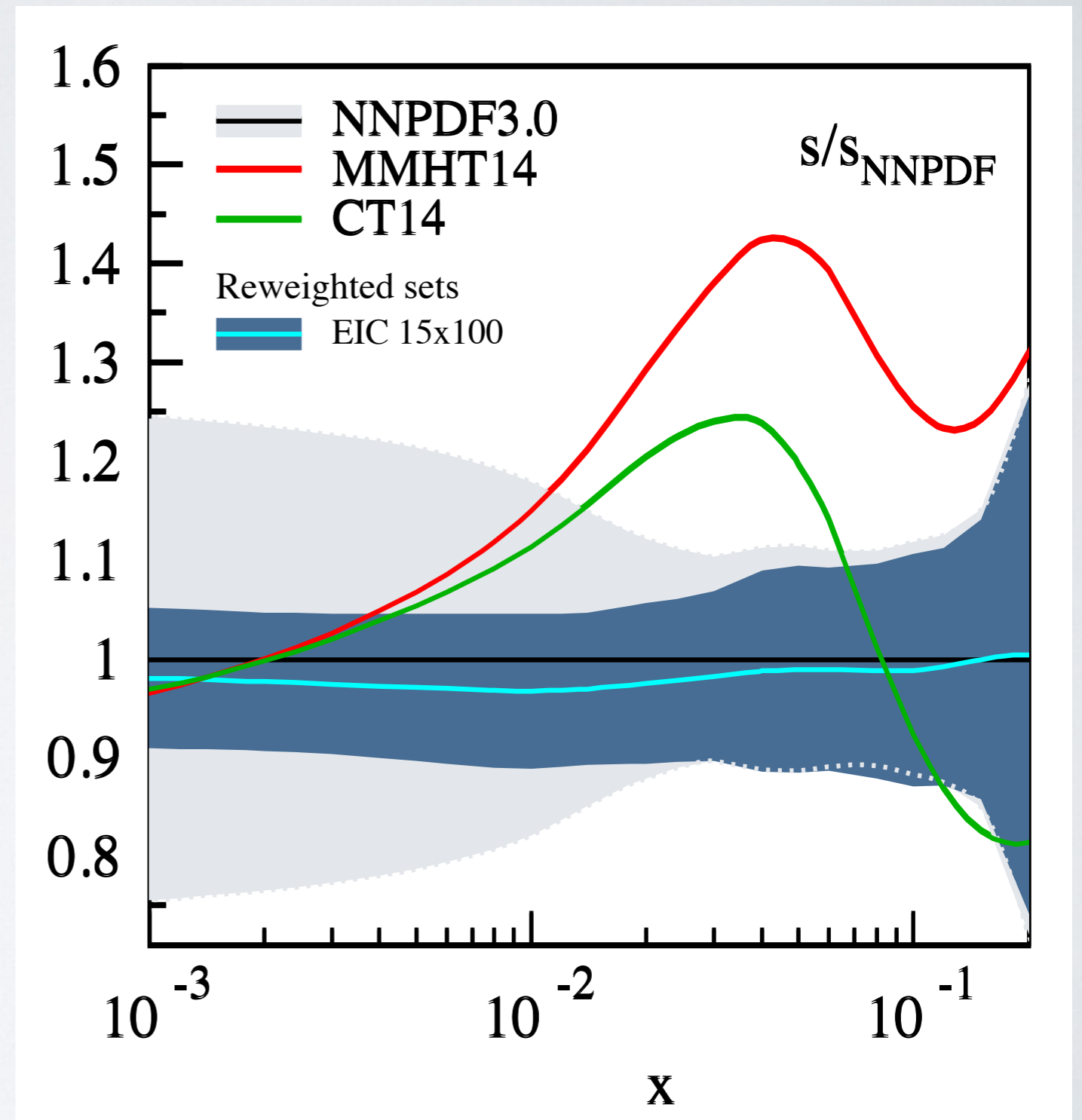




REWEIGHTING IN ACTION: IMPACT FROM FUTURE EIC DATA

Reduction in the uncertainties of order 15%

- Great tool to constrain the strangeness in the proton, as well as isospin symmetry breaking and charge symmetry breaking



SUMMARY

- The combined extraction of PDFs & FFs works, providing strong constraints on the strange sea of the proton
- The method proved to be robust
- EIC data expected to provide an important constraint on PDFs & FFs:

New insights on the:

- Proton's strange content
- Charge (& isospin) symmetry breaking

REWEIGHTING IN ACTION: REWEIGHTED FFS

