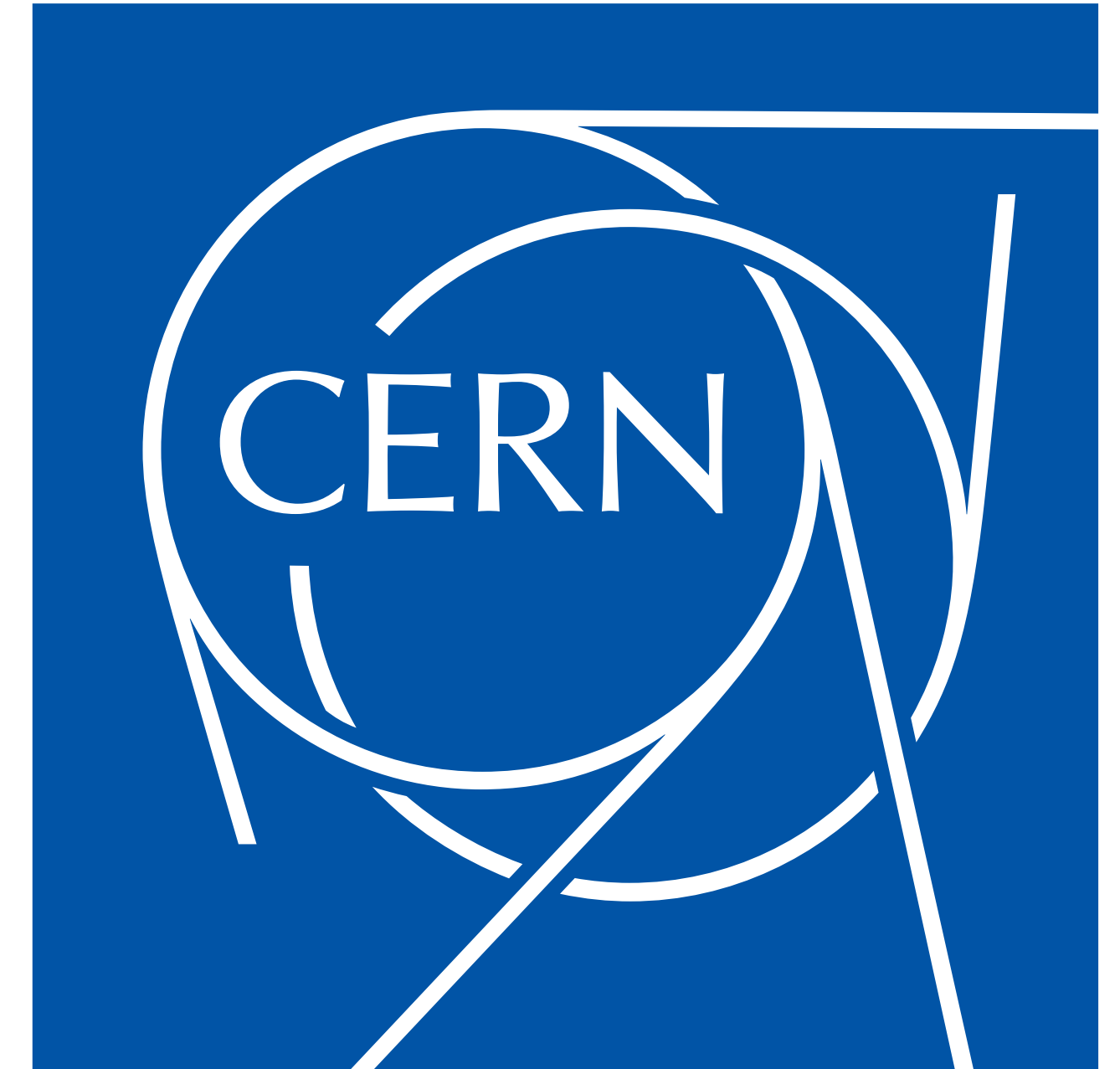


Prospects of TeV muons for PDF physics and QCD



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Introduction

I'm going to focus on the effect that fixed-target muon DIS data could have on PDF determination, but in what regards Standard Model studies, a TeV DIS machine would generally be a really good idea anyway.

I'm taking at a starting point the data collected by the New Muon Collaboration (NMC) in the late 80s, and expecting (hoping?) that the flux of muons can be used as a muon beam of $E \sim \text{TeV}$ hitting against some arbitrary target.

Some caveats are necessary:

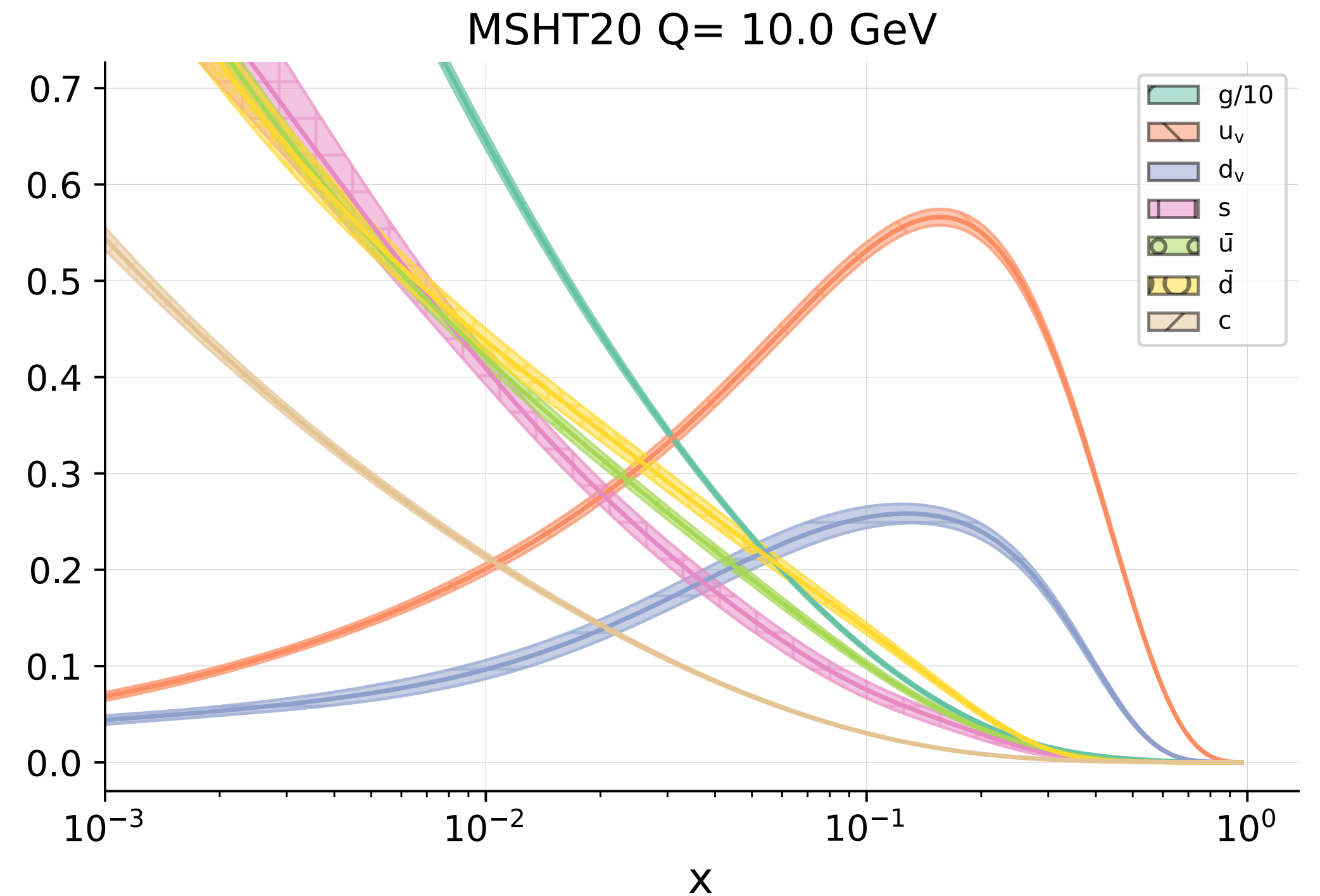
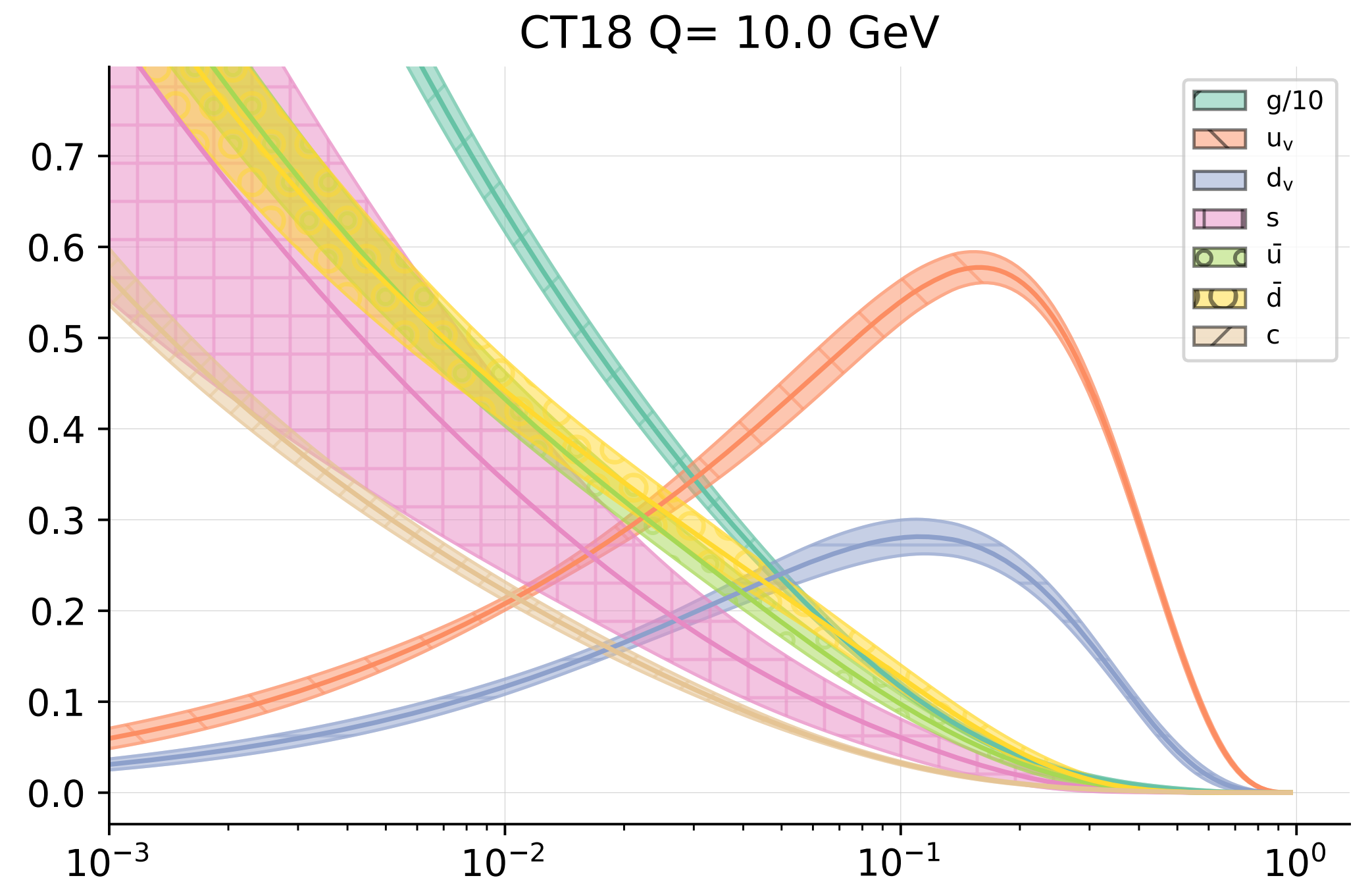
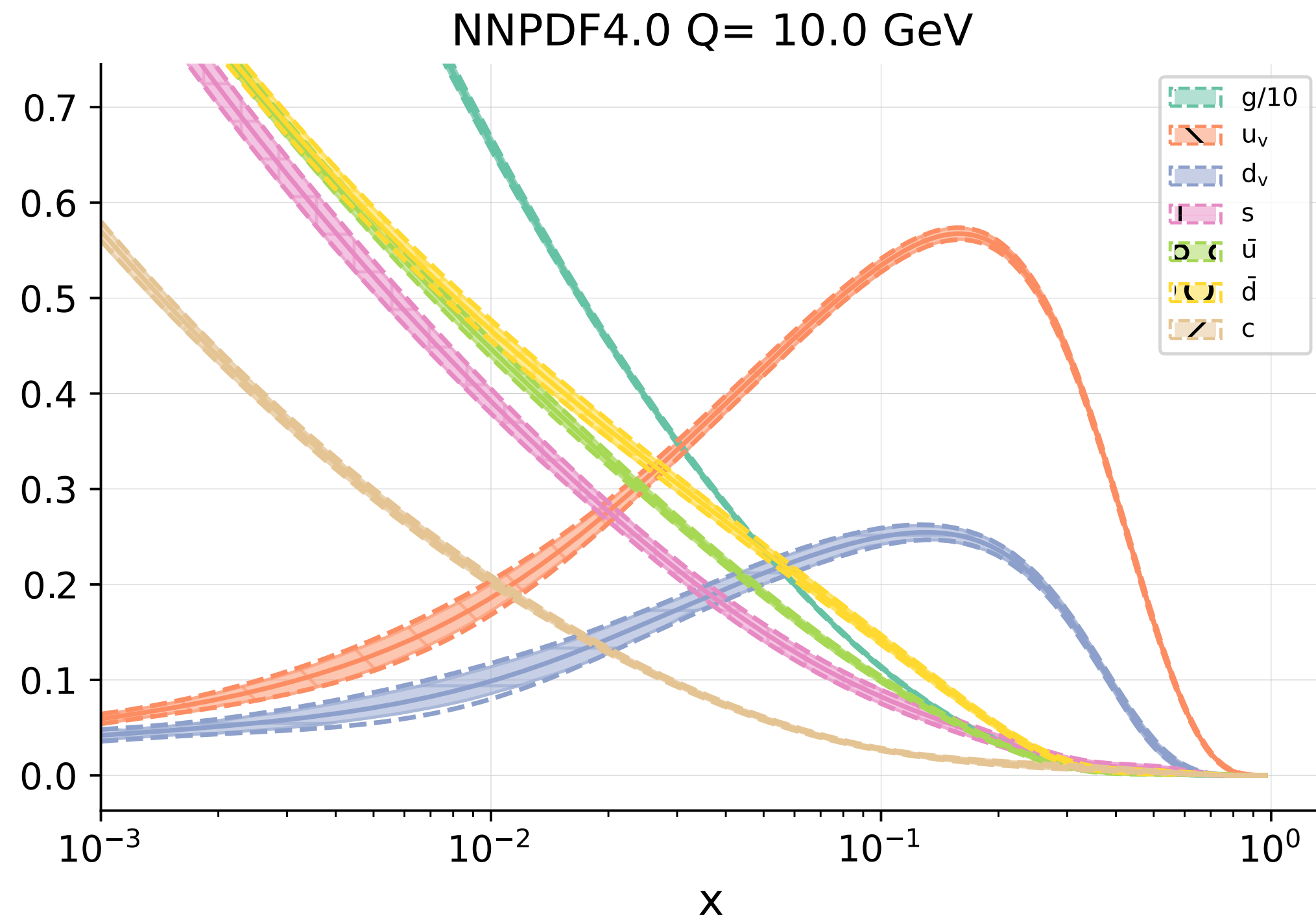
- I work on PDF fitting, so I spend most of my time thinking about what's wrong with PDFs
- I'm not an experimentalist, so I tend to be very optimistic about what can and cannot be done I've marked some of the plots as "preliminary", can also be understood as "quick tests"

Current global PDFs

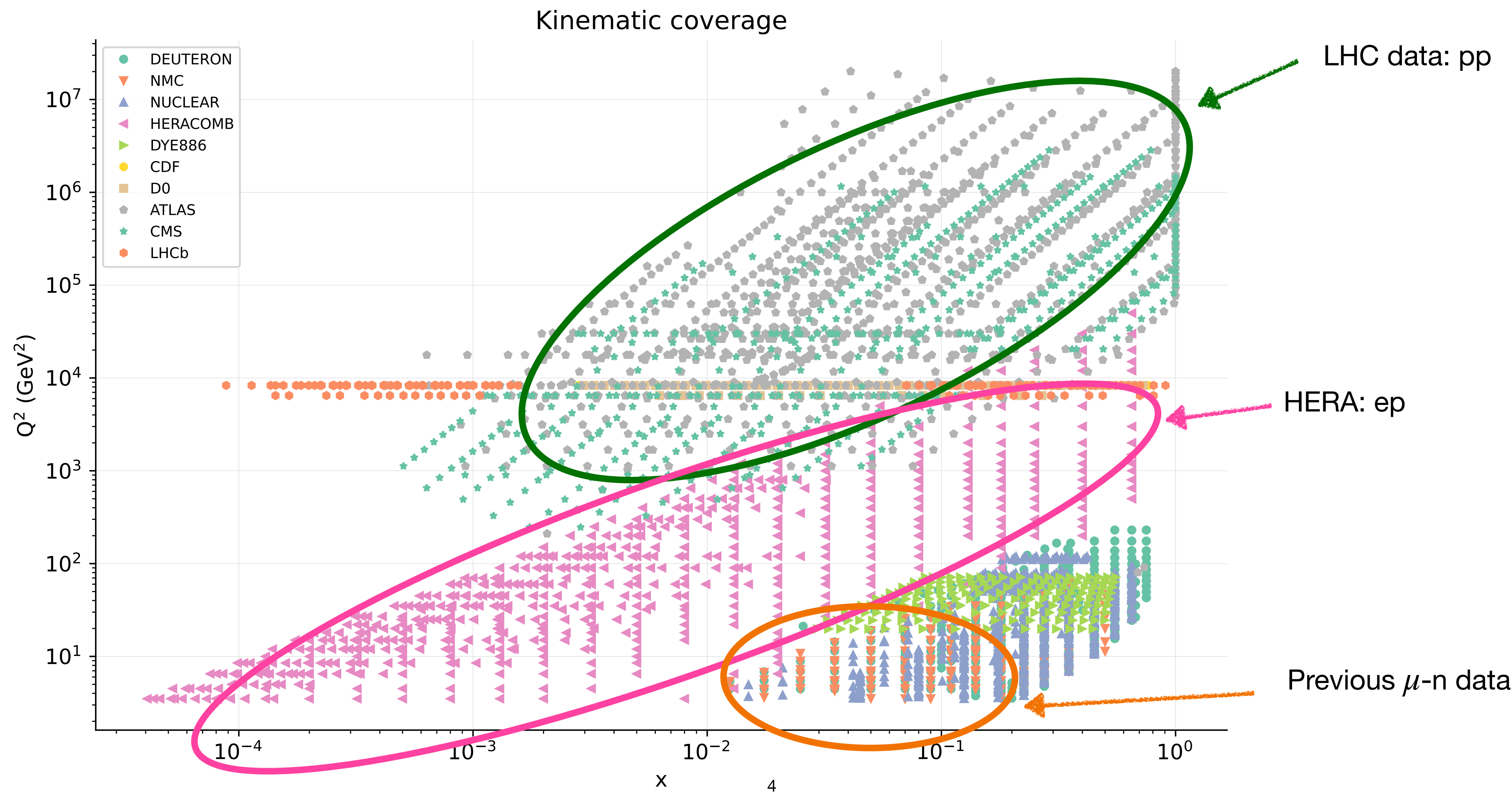
The last releases the three biggest collaborations:

- **CT18** [hep-ph] 1912.10053
- **MSHT20** [hep-ph] 2012.04684
- **NNPDF4.0** [hep-ph] 2109.02653

A lot of room at low- x for a better understanding of the PDF!

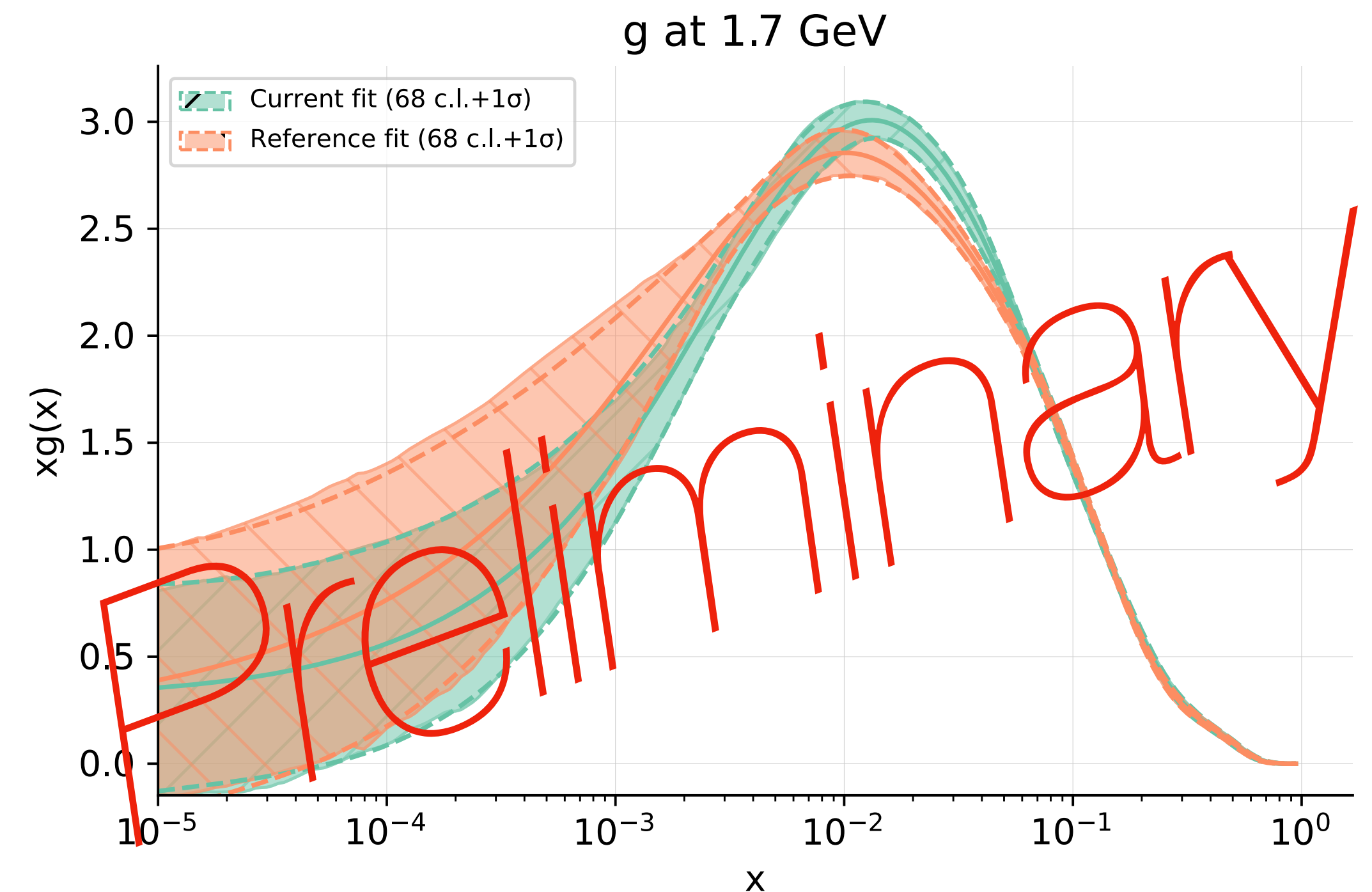
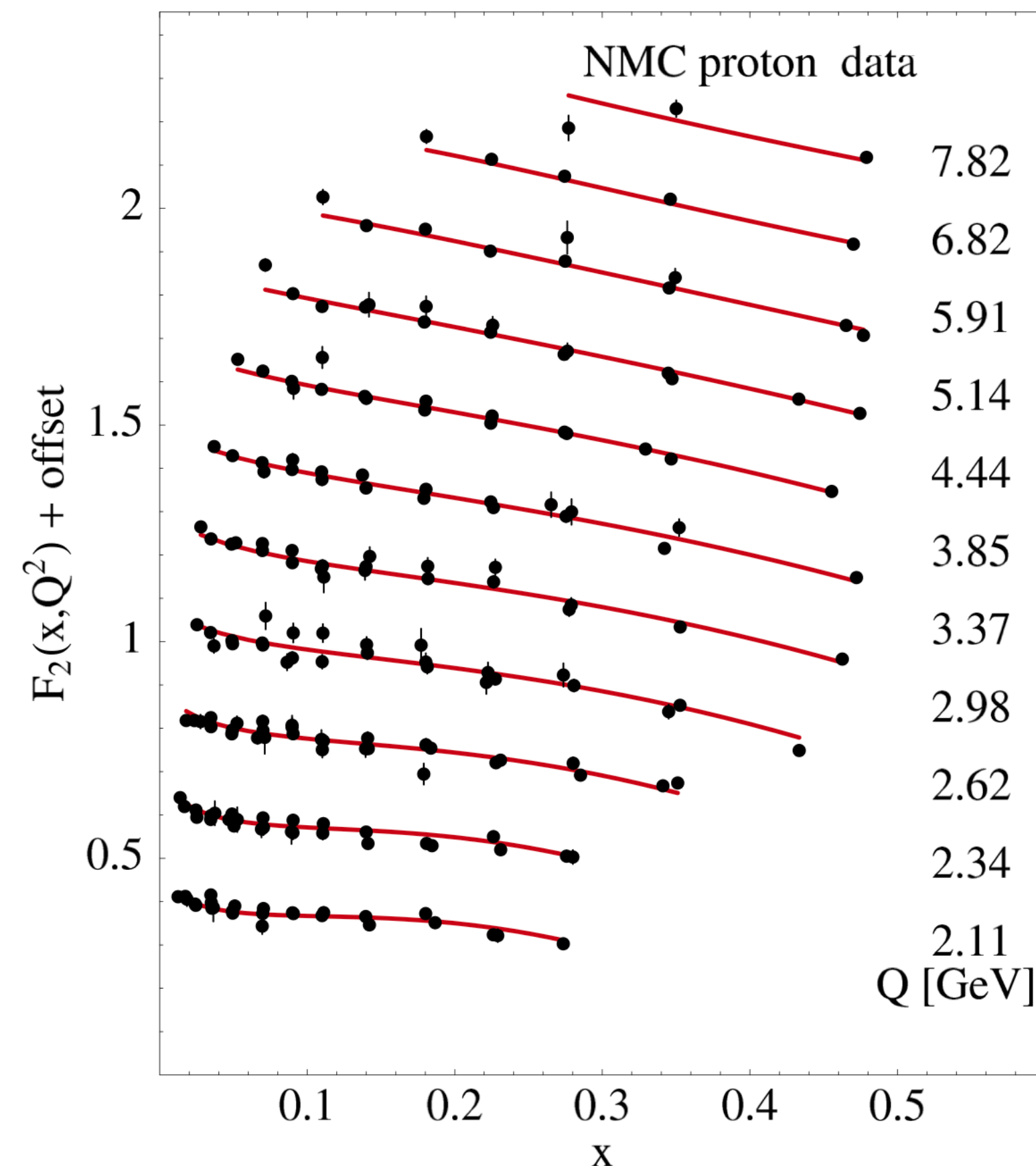


The full PDF dataset



The importance of the FT DIS data

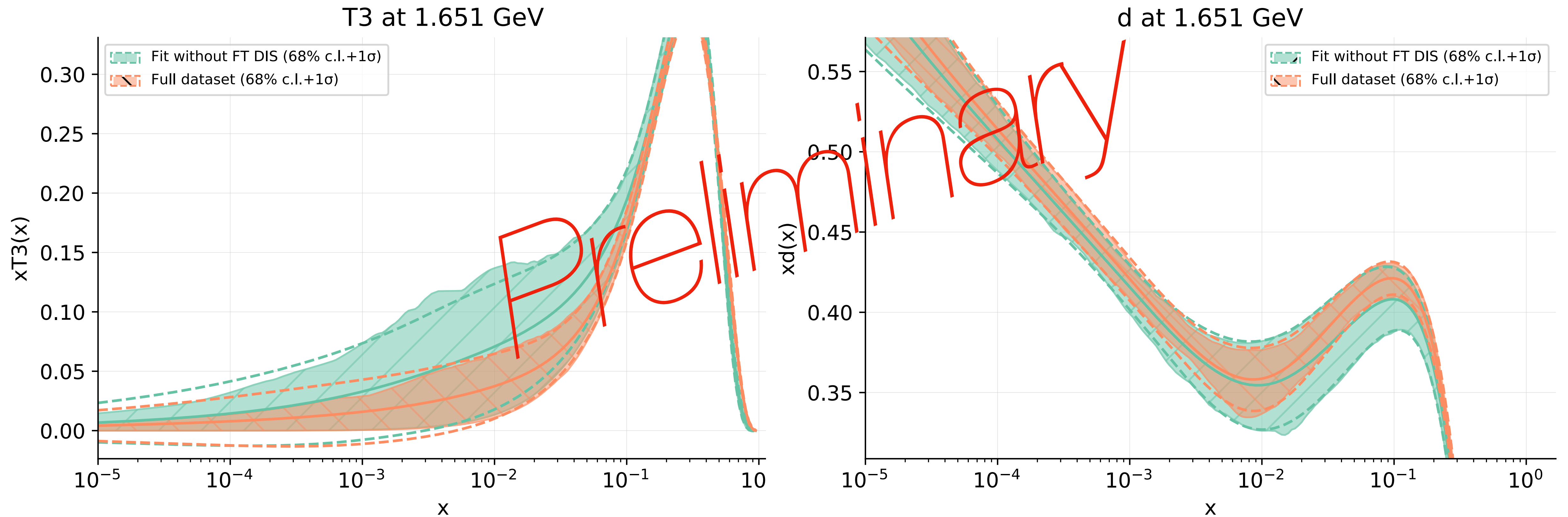
Let's take one specific example, the F2 structure function data from the NMC collaboration from [hep-ph/9610231], which has some problems of internal inconsistencies* (but is included in all global PDF fits).



*See for instance hep-ph/ 0201195 or 0204232, plot above from 0201195

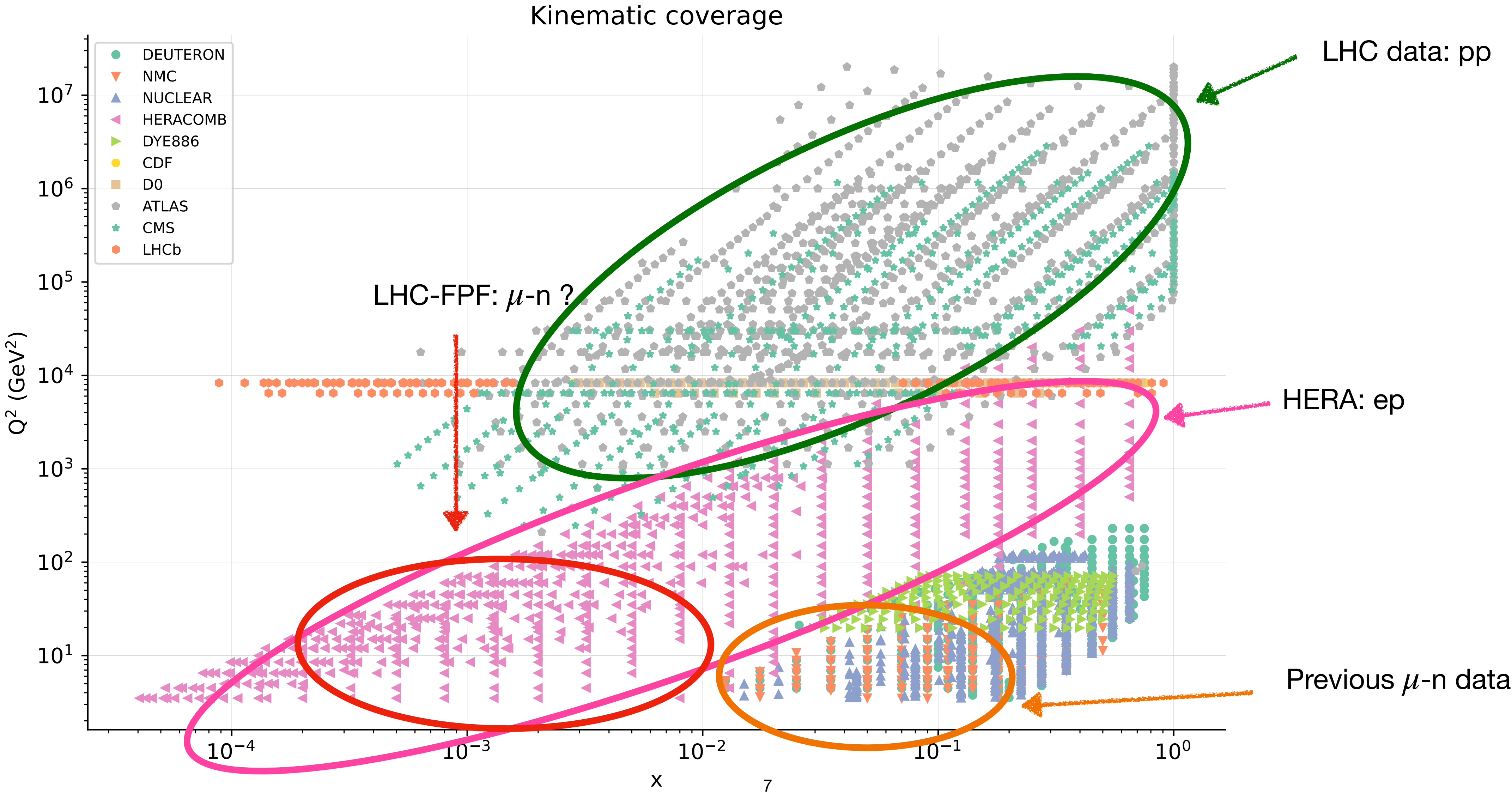
Why don't we remove it?

we kind of need it...



Note: not all FT-DIS suffer from the same problems but some of the do, so it is in our best interest to make sure we have the best possible realisation of this important physics probe!

The full PDF dataset: with extra data

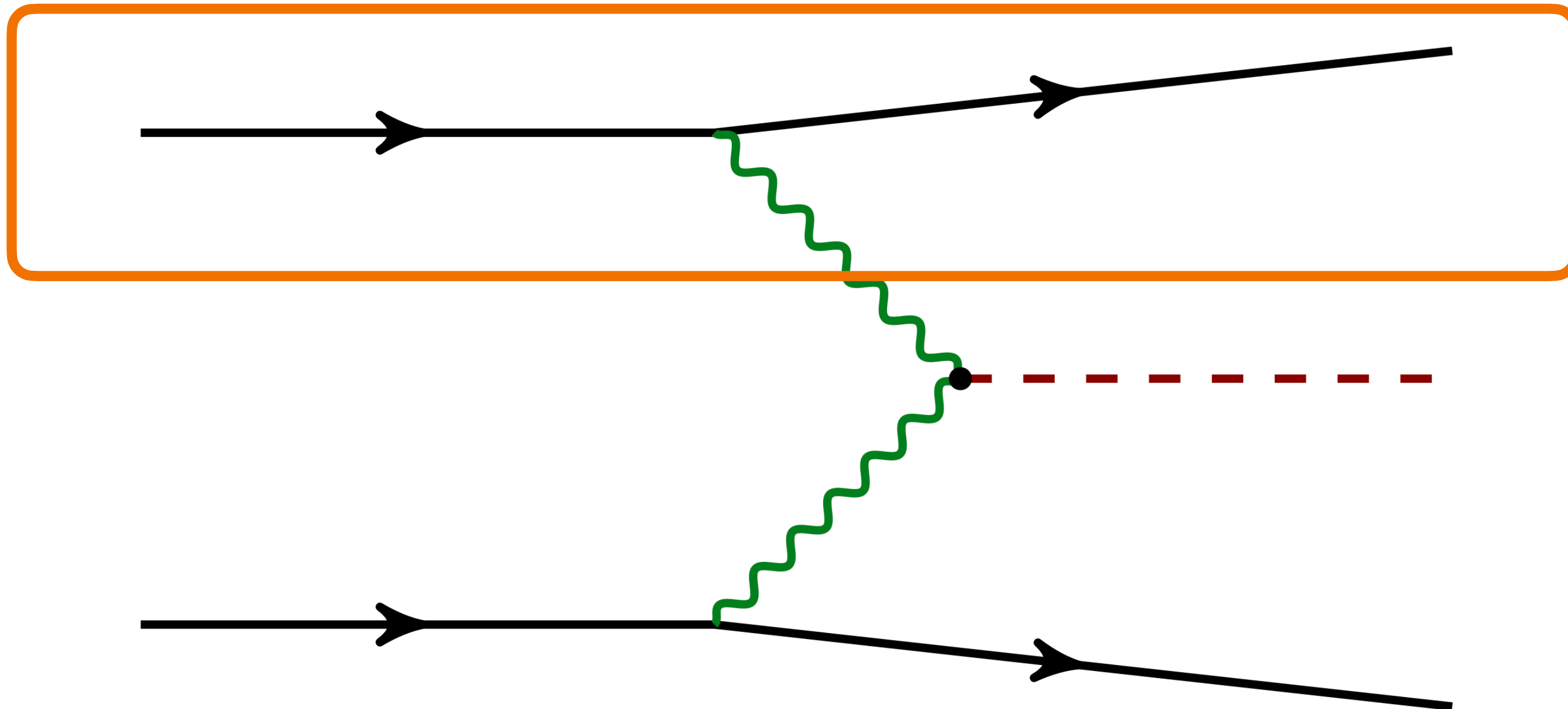


There's life beyond PDFs (citation needed)

A highly energetic muon beam could be utilized for other interesting physics, e.g. **Higgs production in the VBF channel.**

usually modelled in the DIS-approximation, with both legs separated to avoid finding complicated structures difficult to compute...

not an approximation if one of the legs is a lepton!



source: <https://phdcomics.com/pdf/HiggsBoson.pdf>

Very restrictive cuts needed to remove contributions that cannot be computed & to remove gluon-gluon background: not a problem here!

Theoretical predictions available up to N3LO

Summary

- muon data has played a crucial role in the determination of parton distribution functions and some of the data is due an update/confirmation: this could be a great chance to just so!
- Beyond enhancing the determination in regions where data is already available, the highly energetic muons could also broaden the kinematic coverage
- Opportunity to revisit old (but important) data
- If we have a beam of muons, and the target is arbitrary, nothing stopping us from going beyond $A=1$:)
- New windows to important processes