ZAF Meeting

Inclusive jet production in DIS using ZEUS data and NNLO QCD analysis in precision determination of $\alpha_s(M_Z)$

PhD project plan

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November 27, 2019

Jet cross sections:

- Test theories by comparison to measurement/ determine theory parameters
- Test perturbative QCD against jet cross sections

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- Coupling constants are fundamental parameters of the Standard Model that cannot be calculated from theory $\rightarrow$ precision measurements crucial for their determination
- α_s by far the least well known fundamental constant[1]

[1] http://pdg.lbl.gov/2019/reviews/rpp2018-rev-phys-constants.pdf

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Parton distribution functions (PDFs):

- Cross sections for QCD processes calculable using perturbation theory and PDFs
- PDFs universal for a given hadron
- Important input for other calculations, e.g. Higgs production at LHC (through top-loop)

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Main part of thesis
Goals

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- Determine cross sections for single inclusive jet production in ZEUS during HERA-II
- Both low and high Q^2 range: $10\,\text{GeV}^2$ to $20\,000\,\text{GeV}^2$
- Highest precision measurement of jet cross sections in this kinematic region yet

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Second goal:

- Fit PDFs and $\alpha_s(M_Z)$ using new jet cross sections
- Also include cross sections from H1 and LHC
- Might profit from theory improvements to further reduce systematic uncertainties

Main part of thesis
Required steps

Reconstruction:

- Accurate calibration of energy scales of electron and jets
- Careful selection of reconstruction algorithm
  - Sinistra for low Q^2 electrons[1]
  - EM for high Q^2 electrons[2]
  - Sinistra and EM for medium Q^2 electrons
  - k_t for jets[3]
- Treat jets as massive

[1] PhD thesis I. Makarenko (2017)
[2] ZEUS internal note 99-077; PhD thesis F. Januschek (2011)
[3] R. Atkin, *Review of jet reconstruction algorithms*

Unfolding:

- Previous ZEUS analyses rely on bin to bin unfolding[1]
- Bin to bin correlations in detector response function are neglected in this approach[2]
- To achieve a more reliable uncertainty estimate, correlations between bins should be taken into account $\rightarrow$ more sophisticated unfolding method required

[1] E.g. PhD theses of J. Behr (2010), H. Perrey (2011), F. Januschek (2011), I. Makarenko (2017)
[2] G. Cowan, *A survey of unfolding methods for particle physics*

Technical task

- PDF fits using xFitter, possibly to determine systematics for ongoing HERAPDF2.0Jets NNLO paper
- Possibly some modifications to xFitter code:
  - Implement heavy flavor masses and compare to massless calculations

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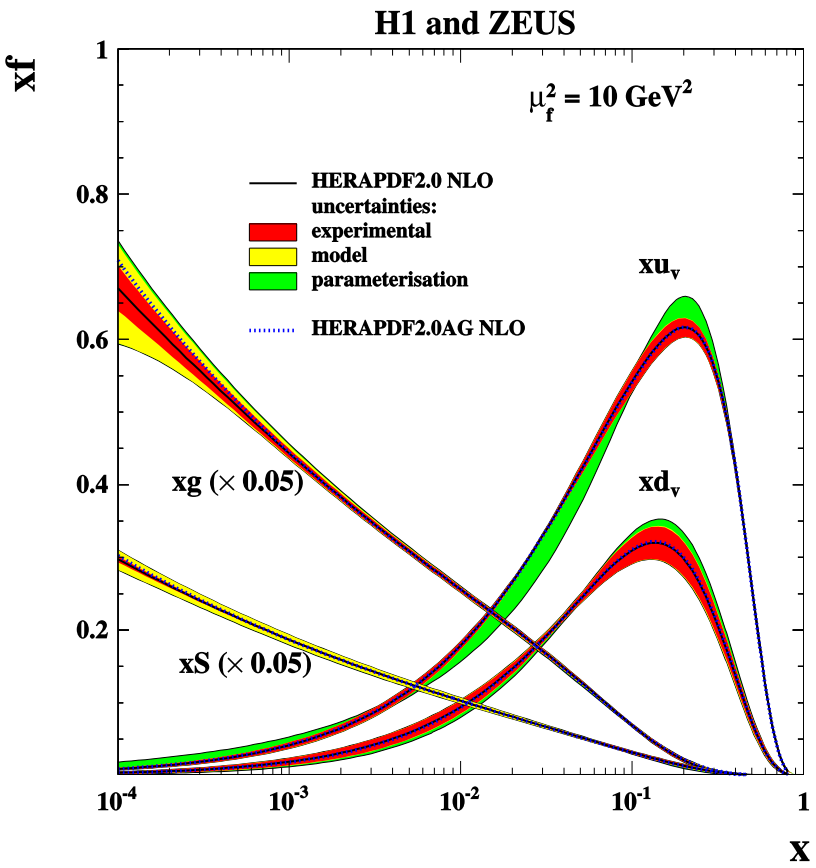
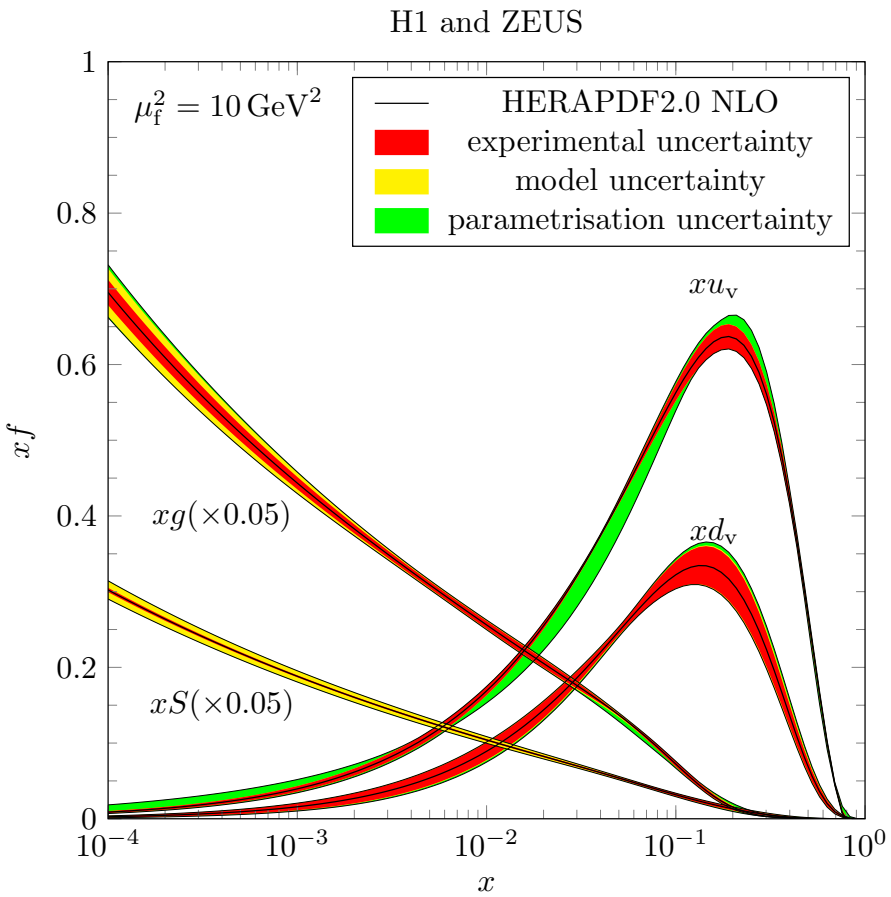
Progress so far:

- Gotten latest version of xFitter from CERN GitLab to compile
- Managed to converge HERAPDF2.0 NLO and NNLO fits using latest version



HERAPDF2.0 NLO[1]

$$\frac{\chi^2}{\text{DOF}} = 1.200$$



Recreation with latest xFitter

$$\frac{\chi^2}{\text{DOF}} = 1.202$$

[1] *H1* & *ZEUS* Collaborations, The European Physical Journal C (2015), **75**

Colliders and detectors at DESY:

Name	Years of operation[1]	Meaning of name
LINAC	1964 – 2007	Linear Accelerator
DESY	1964 – 2007	Deutsches Elektronen Synchrotron
DORIS	1974 – 2013	Double Ring Storage facility
- ARGUS	1987 – 1992	A Russian-German-United States-Swedish Collaboration
- OLYMPUS	2012 – 2013	?
PETRA	1978 – 2007	Positron Electron Tandem Ring Accelerator
HERA	1990 – 2007	Hadron Electron Ring Accelerator
- H1	1992 – 2007	HERA interation point 1 (?)
- ZEUS	1992 – 2007	?
- HERMES	1995 – 2007	?
ALPS	2007 – today	~~Axion-Like~~ Any Light Particle Search

[1] including secondary uses for collider physics (e.g. as pre-accelerator for another collider) but no counting other uses (e.g. as source for synchrotron radiation)