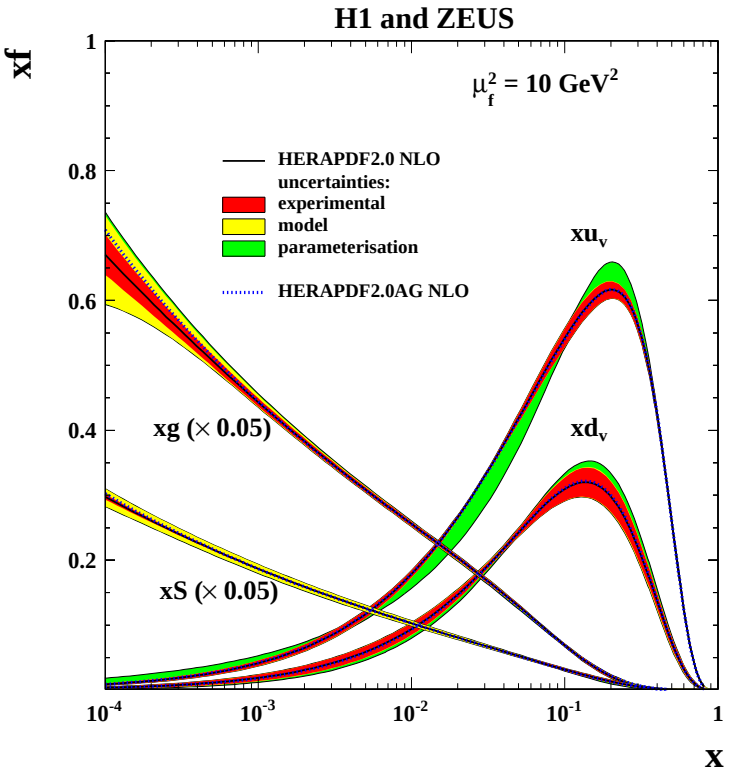
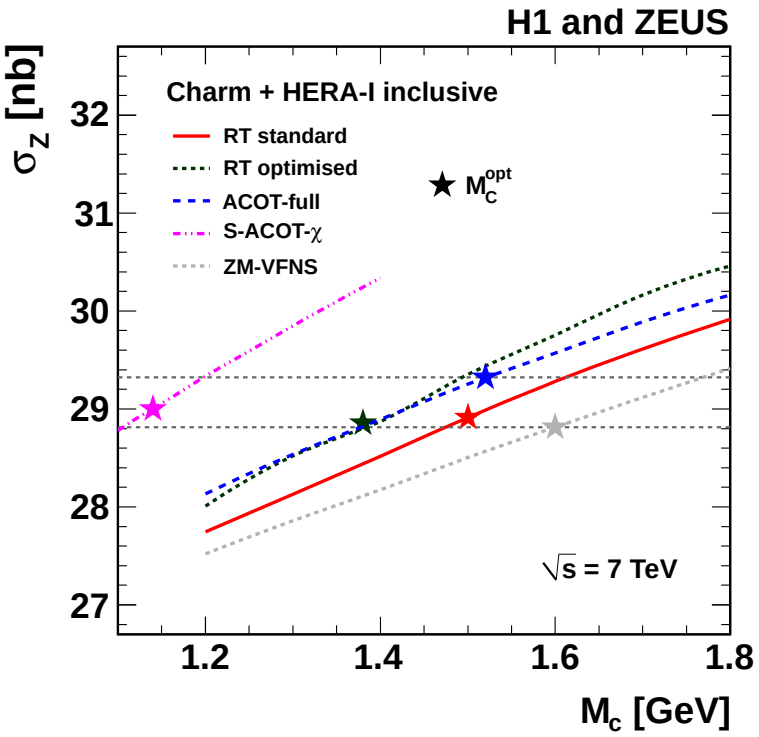
Overview of experimental challenges: more precision and new observables

S. Glazov, xFitter workshop, Dubna 18/02/2015

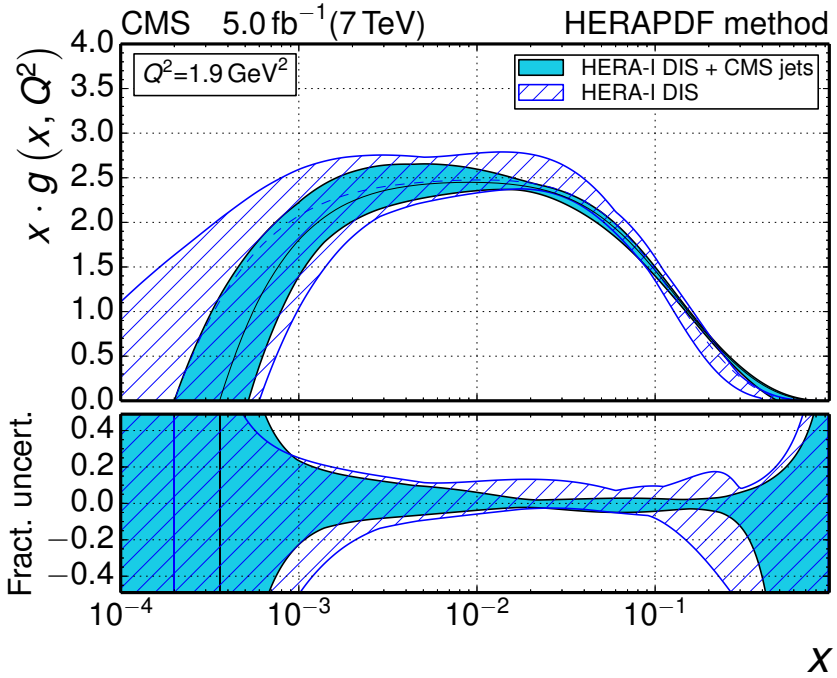
xFitter results: DIS

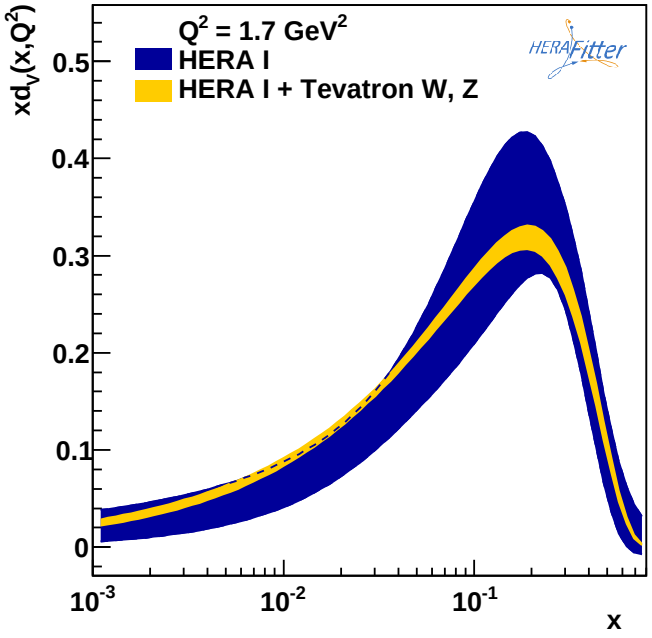


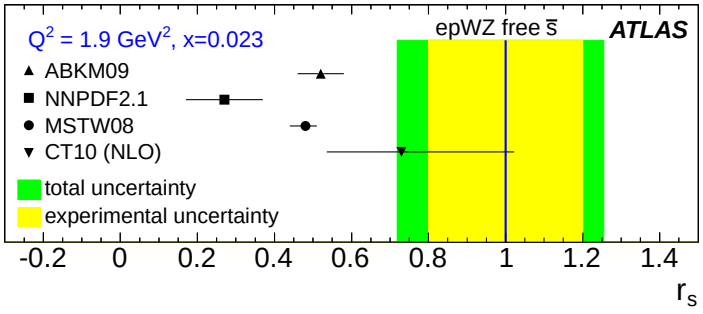


- xFitter started as a project to fit DIS data. HERAPDF2.0 PDF set is produced using xFitter.
- Extensive set of different heavy-flavour calculation approaches (now also all FONLL treatments, thanks to APFEL interface) allowed unique study of HERA F_2^{cc} to M_C, important for LHC phenomenology.

xFitter results: $p\bar{p}$, pp-inclusive

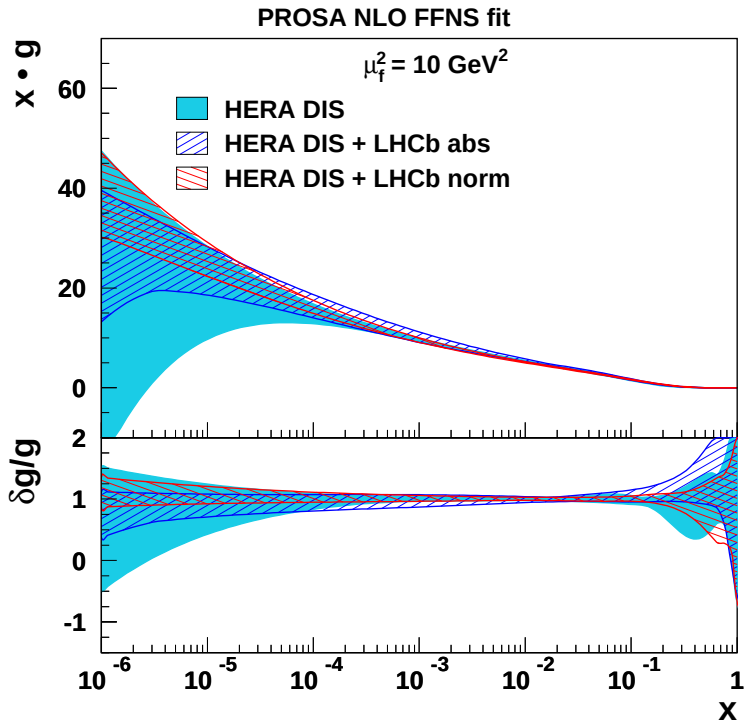


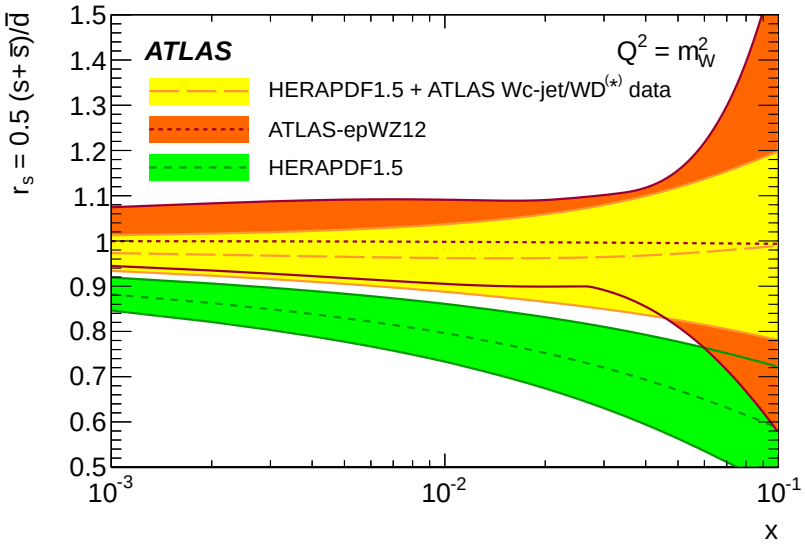




LHC and Tevatron pp and $p\bar{p}$ data were included in fits using APPLGRID and FastNLO interfaces to MCFM and NLOJET++. Flexible parameterisation and different error estimation methods included in xFitter allow to study the impact of the data on PDFs in least biased way.

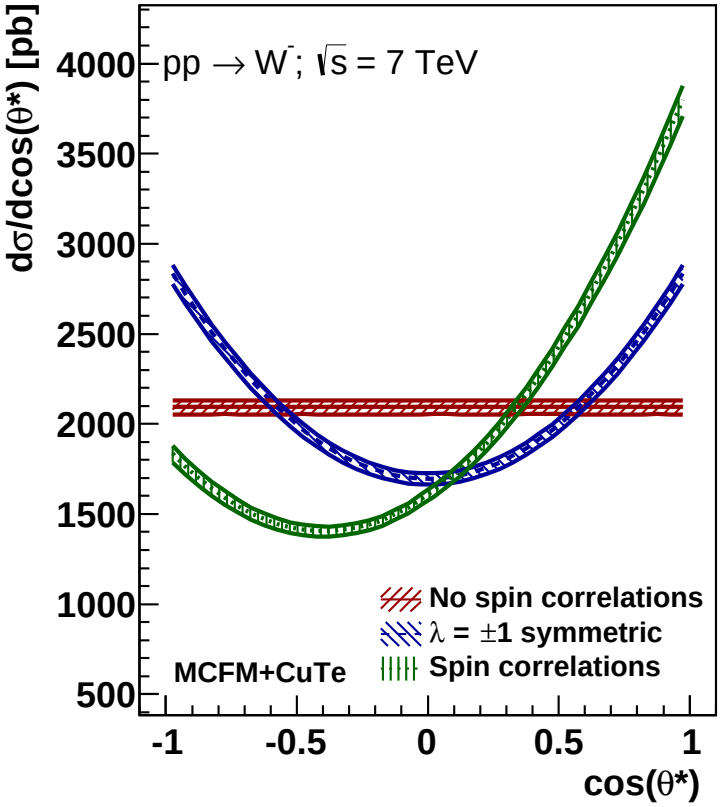
xFitter results: LHC semi-inclusive

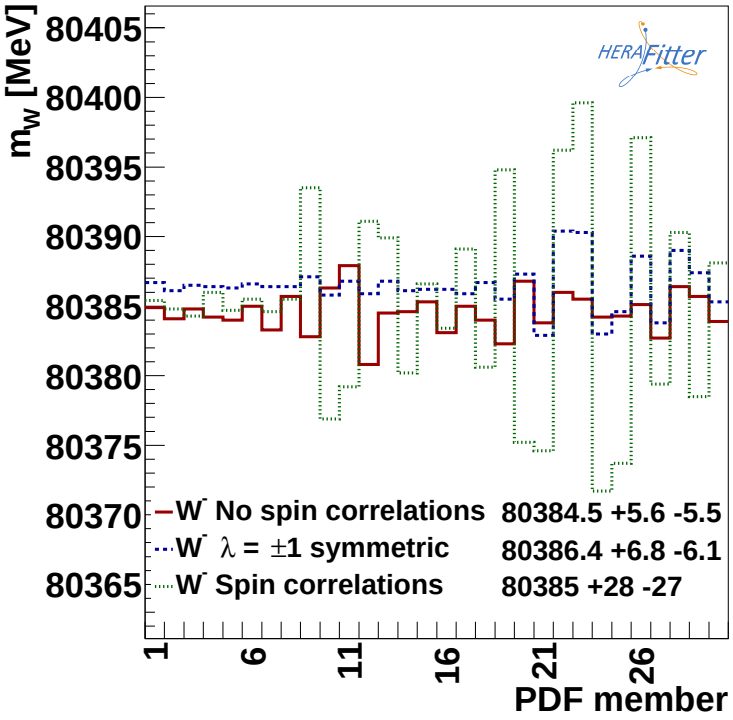




LHC observables with heavy-quarks in the final state can be very powerful to measure various PDFs. However fragmentation corrections are more tricky and the way to fit the data is more complex. Dedicated calculation, implemented after optimizing the numerical integration and profiling were used to overcome that.

Precision challenge: *W*-mass





- At the LHC, the *W* boson mass can be measured using lepton p_T.
- *W* boson is produced polarised; polarisation affects lepton kinematics.
- Effect of the polarisation can be studied by turning it off, completely or transverse polarisation only. Uncertainty in transverse polarisation, arising from valence quarks, has significant impact on the *W* mass.

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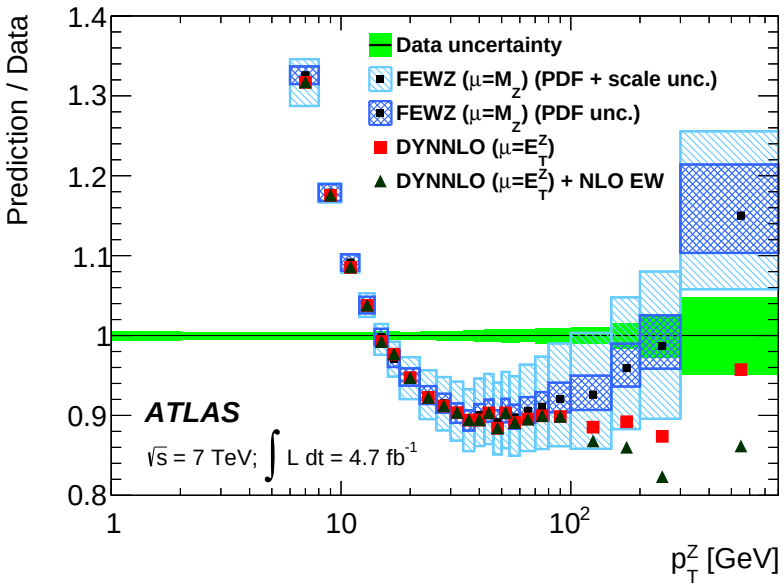
New data challenges

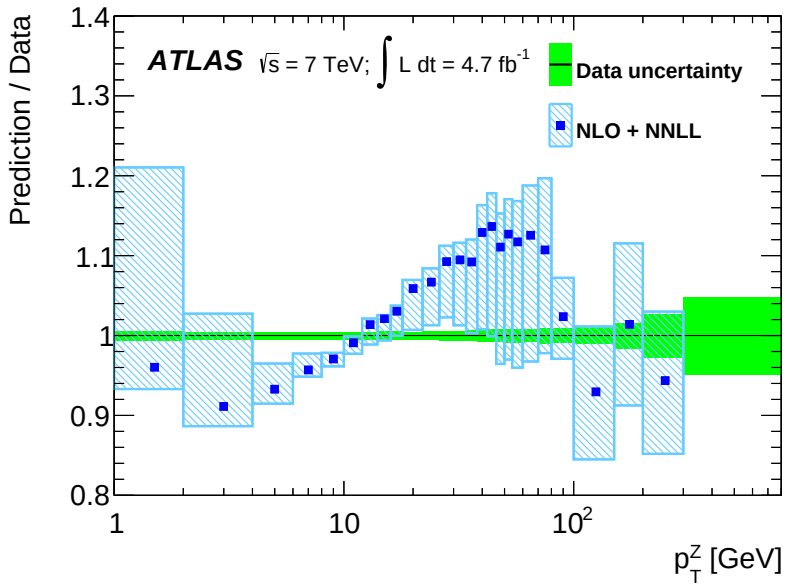
- Precision inclusive W, Z observables will reach $\sim 0.5\%$ accuracy. Intrinsic theory uncertainties for NNLO calculations is $\sim 0.2 - 0.3\%$. Not a limiting factor at the moment, but perhaps we can start thinking about N^{3}LO and k-factor free calculations ?
- Jet cross sections and ratios at different CME energy reach high accuracy. For NLO, scale variations dominate the uncertainties. NNLO jet fits ?
- Plenty of accurate data on Z/γ^*-boson p_T, especially for low p_T. True PDF plus soft gluon emission resummation fits ?
- New experimental data on Z-boson polarisation, which can differentiate $q\bar{q}$ vs qg processes, can we include these data ?

New data challenges

- New calculations of W+jet and Z+jet at NNLO, can we learn more from these processes on α_S and g-density ?
- Several processes are sensitive to $\gamma\gamma$ scattering, how to separate the photon PDF the best way ?
- Still no fully coherent way to include $W + c$ in fits. Can we include fragmentation corrections in xFitter ?
- 13 TeV data samples will bring sizable diboson samples. How to use these data, e.g. $W^{\pm}Z$ asymmetry in the best way ?
- Accurate differential $t\bar{t}$ measurements are on the way. What about fast and open-source NNLO differential calculations ?

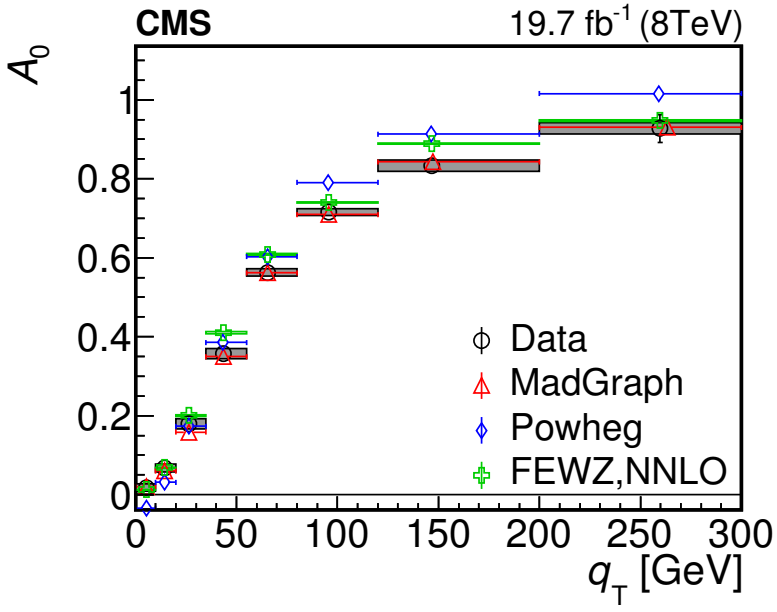
Z/γ^* transverse momentum data





- Data accuracy reaches is at few permile level for p_T up to 100 GeV. NNLO calculations fail to describe high p_T data.
- Ultimate precision is reached for low $p_T < 20$ GeV. Here calculations including soft gluon emission or using TMDs may work. How to include them to xFitter in an optimal way?

Z polarisation: CMS



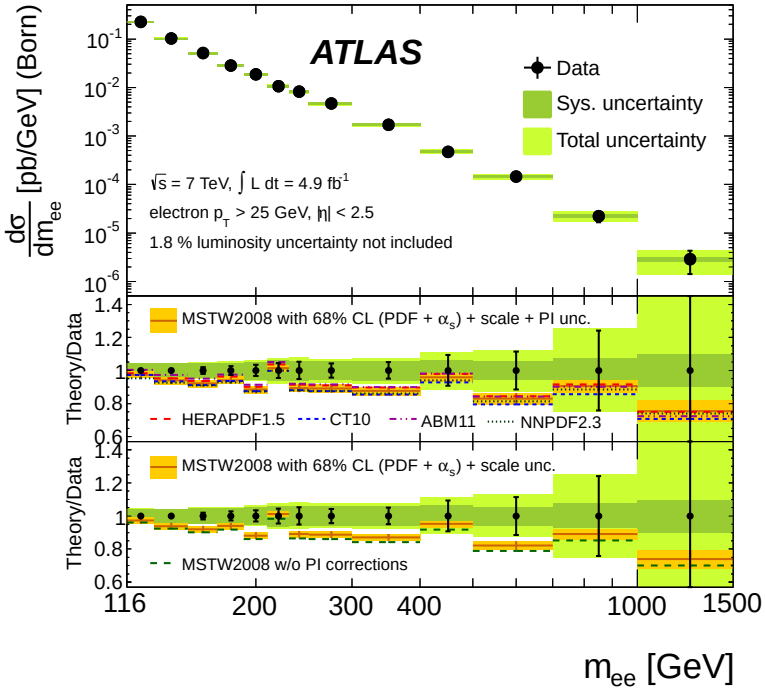
Z bosons are produced polarized, with CS $\cos\theta^*$ dependence given by:

$$\frac{d\sigma}{d\cos\theta^*} \sim (1+\cos^2\theta^*) + A_0\frac{1}{2}(1-3\cos^2\theta^*) + A_4\cos\theta^* \,.$$

For $q\bar{q}$ annihilation $A_0 = p_T^2/(M_Z^2+p_T^2)$ while for the Compton qg process $A_0 \approx 5p_T^2/(M_Z^2+5p_T^2)$. Can we use this to constrain the gluon density ?

CMS, Phys. Lett. B 750 (2015) 154, arXiv:1504.03512

Off-peak DY production



- For the off-peak lepton pair production other processes such as $\gamma\gamma \to \ell\ell$ start to become sizable, comparable to PDF uncertainties.
  Measurements better optimized to $\gamma\gamma$ kinematics are expected soon.
- We have photon evolution in xFitter, however need to get corresponding calculations of the coefficient functions (e.g. via APPLGRID).

x-Fitter as a theory-merger platform

- xFitter merges together theoretical calculations using various approaches. We have access to different x-space (APFEL, QCDNUM) and N-space (MELA) evolution codes, a number of heavy flavour computations in DIS, APPLGRID and FastNLO.
- Various theory calculations use well-established programs such as MCFM as a starting point, however this could be an older version of the code.
- Basically all MCFM processes are interfaced to APPLGRID: could one automatically optimize corresponding calculations, via clever xFitter interface ?
- Can xFiter serve as a reference interface and baseline repository for ep and pp calculations ?

Summary

- Many interesting developments and important results using xFitter are obtained in the past.
- Further improvements are still required, e.g. for high precision processes such are W-mass measurement.
- A lot of LHC data which can be used to constrain our knowledge on PDFs: already present and expected in future.
- Many theory developments for pp-data: NNLO, NNLL, TMDs ...

$\rightarrow$ xFitter is a perfect platform to bring the data and theory developments together.