

NNPDF & single top

5th CMS Single Top Workshop Oviedo, Spain 29/11/28 Emma Slade Rudolf Peierls Centre for Theoretical Physics, University of Oxford





Current status in NNPDF

NNPDF methodology

Figure courtesy of Juan Rojo Uses ML Experimental data fit validation, statistical estimators, diagnosis tools Fixed-target & collider DIS Tevatron and LHC measurements Jets, DY, top, Z pT, APFEL WEB Uses ML_ Uses ML_ http://apfel.mi.infn.it/ Statistical framework The global QCD fit on-line plotting toolbox PDF parametrisation, Minimise figure of merit (*) and PDF uncertainties and propagation determine PDF parameters LHAPDF Model and theory uncertainties Ihapdf.hepforge.org standard interface for public PDF delivery Theory calculations (*) $\chi^{2}(\{a_{i}\}) = \sum_{m=1}^{N_{\text{dat}}} \left(\sigma_{m}^{(\text{exp})} - \sigma_{m}^{(\text{th})}(\{a_{i}\})\right) (\text{cov}_{\text{exp}} + \text{cov}_{\text{th}})_{mn}^{-1} \left(\sigma_{n}^{(\text{exp})} - \sigma_{n}^{(\text{th})}(\{a_{i}\})\right)$ APPLgrid, FastNLO, aMCfast.... External (N)NLO codes NNLO DGLAP evolution Fast NLO grids DIS structure functions **NNLO QCD &** MCFM, NLOjet++, FEWZ, NLO EW K-factors DYNNLO, private codes... APFEL, HOPPET, QCDNUM, ...

NNPDF methodology



* O(5000) data points

- * O(40) experiments
- * Highly non-trivial validation of QCD factorisation $\chi^2/N_{dat} \approx 1$

Top data in NNPDF

Existing top data in NNPDF

- * The most recent NNPDF set, NNPDF3.1 [1706.00428] contains top quark data in the form of $t\bar{t}$ pair production
- * We include:
 - * normalised y_t distribution from ATLAS at 8 TeV (lepton+jets)
 - * normalised $y_{t\bar{t}}$ distribution from CMS at 8 TeV (lepton+jets)
 - total cross-sections from ATLAS and CMS at 7,8,13 TeV
- * Good reduction of gluon uncertainty at $x \gtrsim 0.1$
- * See [1611.08609] for more details



NNPDF3.1 NNLO, Q = 100 GeV

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 - total cross-sections from ATLAS and CMS at 7,8,13 TeV
- Large reduction of gg luminosity clear implications for BSM physics searches
- * gg luminosity PDF error decreases from 11% to 5% at 2 TeV



Existing top data in NNPDF

- Constraints on the large-x gluon provided by top-quark differential data are comparable to those derived from inclusive jet production
- The top data is based on a much smaller number of data points than jet data
- * Heavy resonance searches are typically performed in the tails of the $m_{t\bar{t}}$ and p_T^t distributions
- * Therefore, the gluon fitted from data on y_t and $y_{t\bar{t}}$ is safer for use in in BSM searches employing $m_{t\bar{t}}$ and P_T^t distributions.



Adding single top data to NNPDF

Applicability of single top

- Single top production occurs via the scattering of a bottom quark with a light quark
- Provides constraints on bottom PDF
- Single top and single anti-top production is generated by different initial state partons — flavour separation



Fig. from 1702.02859



[1609.03920]

[1702.02859]



Applicability of single top

- * Measurement of the ratio $R_t \equiv \sigma_t / \sigma_{\bar{t}}$ provides vital information on flavour separation, in particular in the ratio u/d
- * 2 experimental measurements of R_t at 8 and 13 TeV from ATLAS show sensitivity of differing PDF fits to the ratio
- The experimental uncertainties are still large at 13 TeV, due to the limited statistics but the CMS prelim plot at 13 TeV shown earlier shows an improvement in all PDF sets



[1609.03920]



Fig. from 1702.02859

[1702.02859]



Applicability of single top

- The experimental uncertainties are still large at 13 TeV for ATLAS, due to the limited statistics but the CMS prelim plot at 13 TeV shown earlier shows an agreement with nearly all PDF sets
- Addition of single-top data may help alleviate the remaining discrepancy between groups



Fig. from 1702.02859



[1609.03920]

[1702.02859]



Plan for NNPDF4.0

Datasets to be implemented

- For NNPDF4.0, single-top data from both ATLAS and CMS is available at all centre of mass energies
- NNLO QCD calculations

 [1708.09405] are available at
 inclusive and differential level
- Fits with NLO & NNLO single top data will be possible
- * Datasets on next slide with * have incomplete correlation information and are currently on hold until full breakdown of systematics are available



Datasets to be implemented

- * CMS \sqrt{s} = 7 TeV total cross-section [1209.4533]
- * CMS $\sqrt{s} = 8$ TeV total cross-section & t/\bar{t} ratio [1403.7366]
- * CMS \sqrt{s} = 13 TeV total cross-section & t/\bar{t} ratio [1610.00678] *
- * ATLAS $\sqrt{s} = 7$ TeV total cross-section, ratio and differential [1406.7844]
- * ATLAS $\sqrt{s} = 8$ TeV total cross-section, ratio and differential [1702.02859] *
- * ATLAS $\sqrt{s} = 13$ TeV total cross-section and ratio [1609.03920]

Datasets to be implemented

- s-channel production will not be implemented due to lower statistics & therefore larger uncertainties
- Associated production (tW, tZ) also not included for similar reasons
- In total, we expect to add ~3 new datapoints from CMS and ~20 from ATLAS (including differential distributions)

Conclusions and outlook

- * Within NNPDF we are *actively* adding single-top data both in the form of total cross-sections & differential distributions
- The theory (inclusive and differential) calculations will be computed at NNLO QCD
- * Current plan is for the next global release, NNPDF4.0, to include single-top data from CMS & ATLAS
- * We hope to better constrain the bottom PDF and improve *u*, *d* flavour separation

Conclusions and outlook

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