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CERN Theory Group Retreat

Les Houches, 05.11.2014

Main interests:

- LHC phenomenology,
- Parton Distribution Functions (PDFs):
 - extraction and tool development.

$$d\sigma_{\text{had}} = W_{ij} \otimes f_i \otimes f_j d\Phi$$

aMCfast

A fast interface to MG5_aMC@NLO

- Main goal:

- constraining **Parton Distribution Functions** (PDFs) by including as many data as possible from the LHC with the highest accuracy possible.

- Problem:

- presently, hadronic NLO(+PS) calculations are too **time-consuming** to be directly employed in a PDF fit.

- The common solution adopted is:

- **interpolating the PDFs** (and α_s) on the (x, Q^2) -plane with some suitable polynomial basis on a finite number of nodes.
- **Precomputing the hadronic cross section** by using the basis members as input (rather than PDFs themselves).
 - Time-consuming step that must be done only once.
- **Reconstructing the original calculation** by means of the numerical convolution of the precomputed cross sections with an arbitrary PDF set.
 - Very fast \Rightarrow suitable for PDF fits.

aMCfast

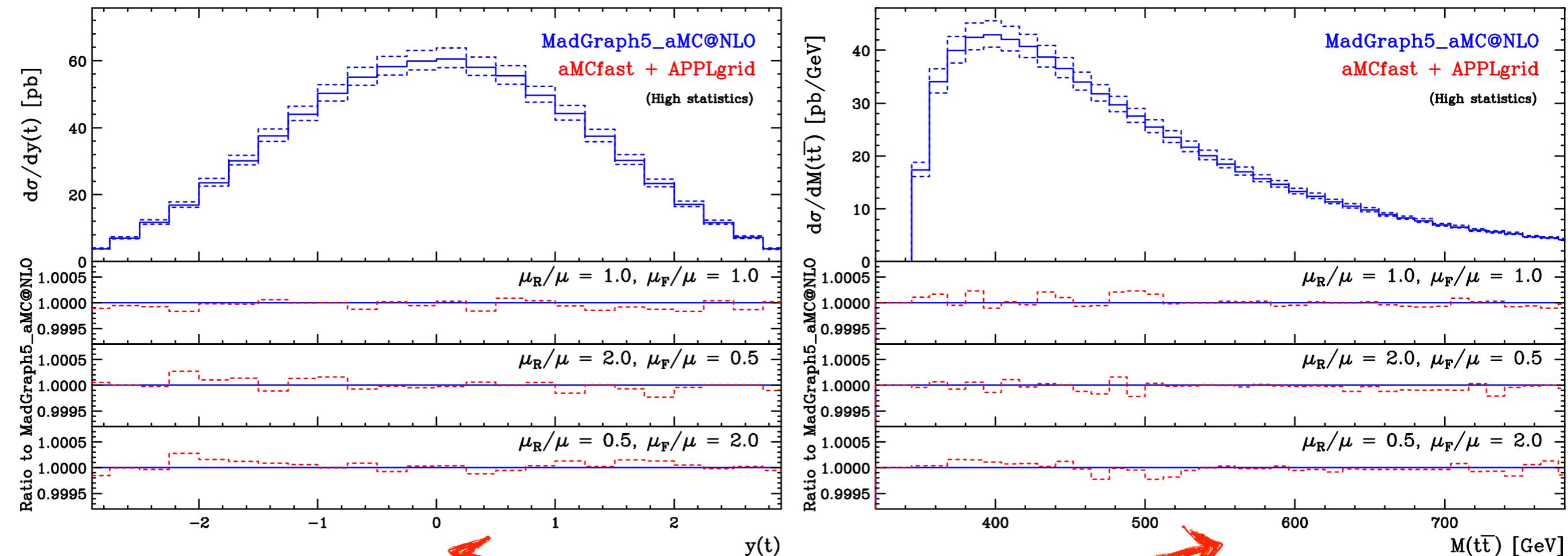
A fast interface to MG5_aMC@NLO

- The objective of aMCfast is:
 - to solve this problem once and for all in a **general manner**.
 - This is actually possible thanks to the fact that NLO(+PS) calculations can now be routinely done by means of **automated codes**.
- The ingredients here are:
 - **MadGraph5_aMC@NLO** [[arXiv:1405.0301](#)]
 - an automated cross section calculator that contains all the ingredients relevant to the computation of LO and NLO cross sections, with or without matching to parton showers.
 - **APPLgrid** [[arXiv:0911.2985](#)]
 - a framework that implements the strategy for the fast computation of cross sections outlined in the previous slide.
- The result is:
 - **aMCfast** [[arXiv:1406.7693](#)]:
 - an automated interface which bridges MadGraph5_aMC@NLO with APPLgrid.

aMCfast

A fast interface to MG5_aMC@NLO: Fixed Order

- The aMCfast interface to the **fixed-order** mode of MG5_aMC@NLO is presently working and validated:
 - already employed in the very recent NNPDF3.0 analysis.
 - As an example, top-pair production:



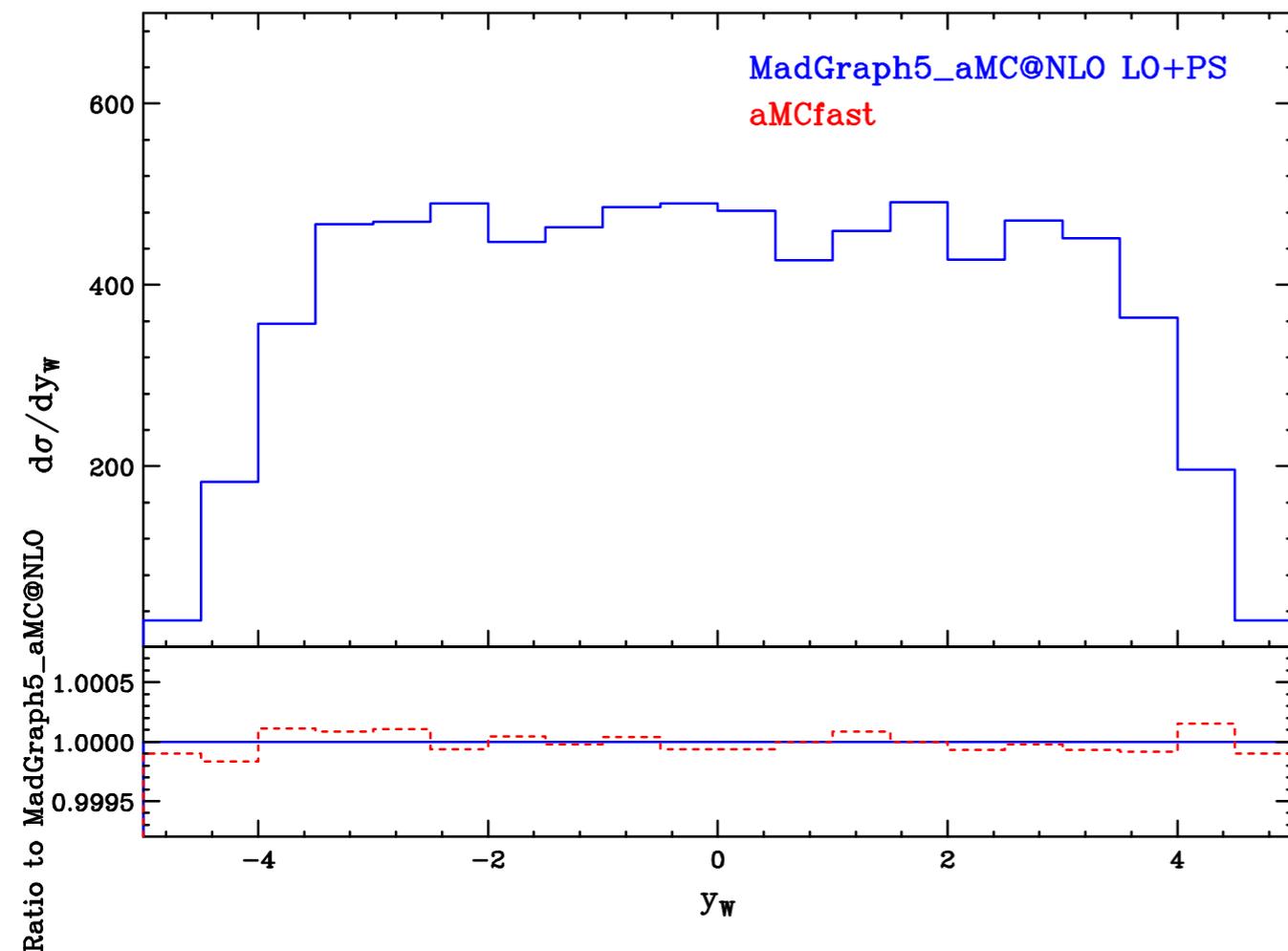
Very high accuracy!

aMCfast

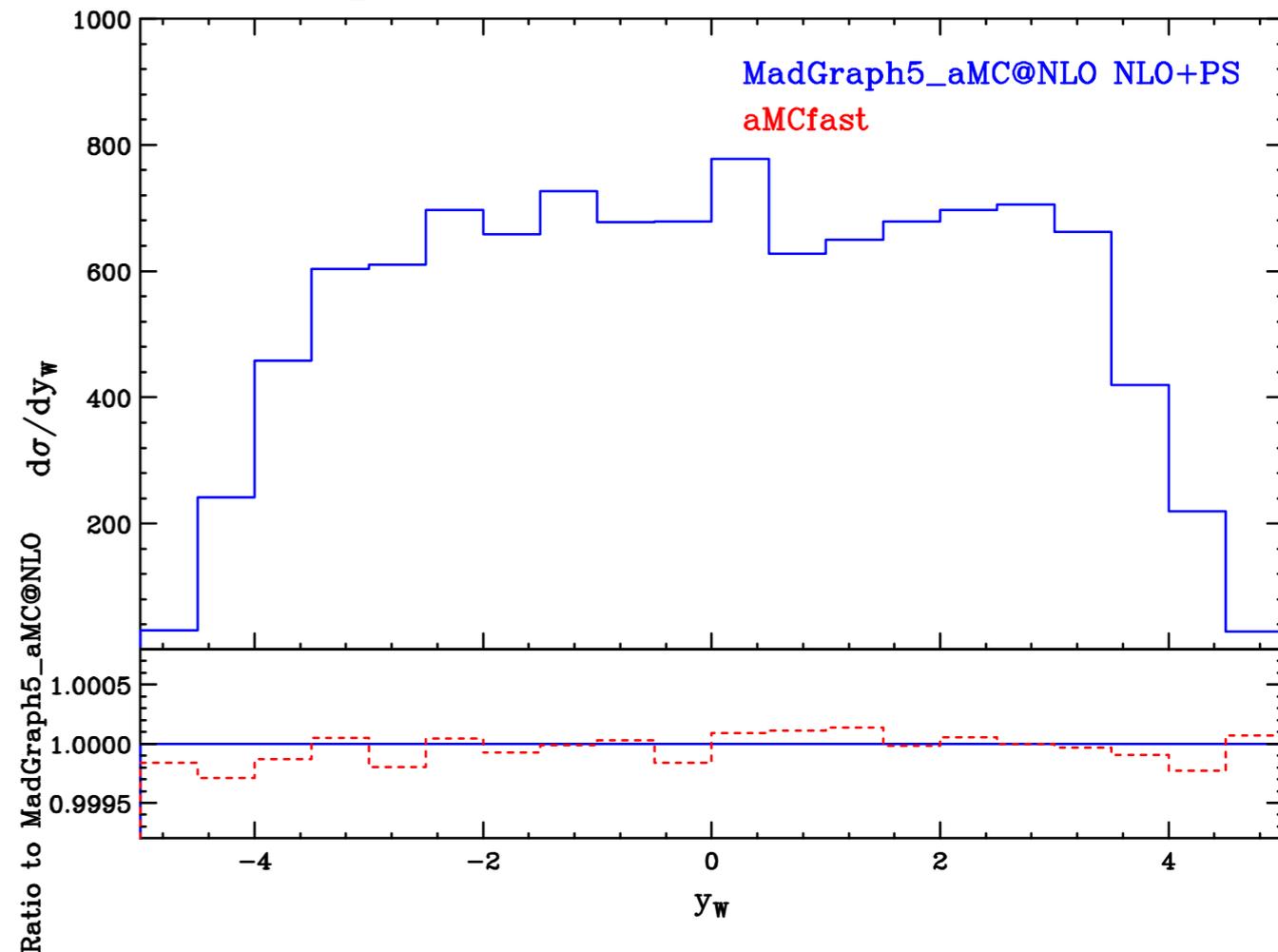
A fast interface to MG5_aMC@NLO: NLO+PS

- The interface to the **(N)LO+PS** mode is work in progress.
- Preliminary results are already available (e^+v + Herwig6):

MadGraph5_aMC@NLO vs. aMCfast (LO+PS)



MadGraph5_aMC@NLO vs. aMCfast (NLO+PS)



- More delicate as compared to the fixed order case because of more conceptual issues due to the presence of the PS.

NNPDF3.0 [arXiv:1410.8849]

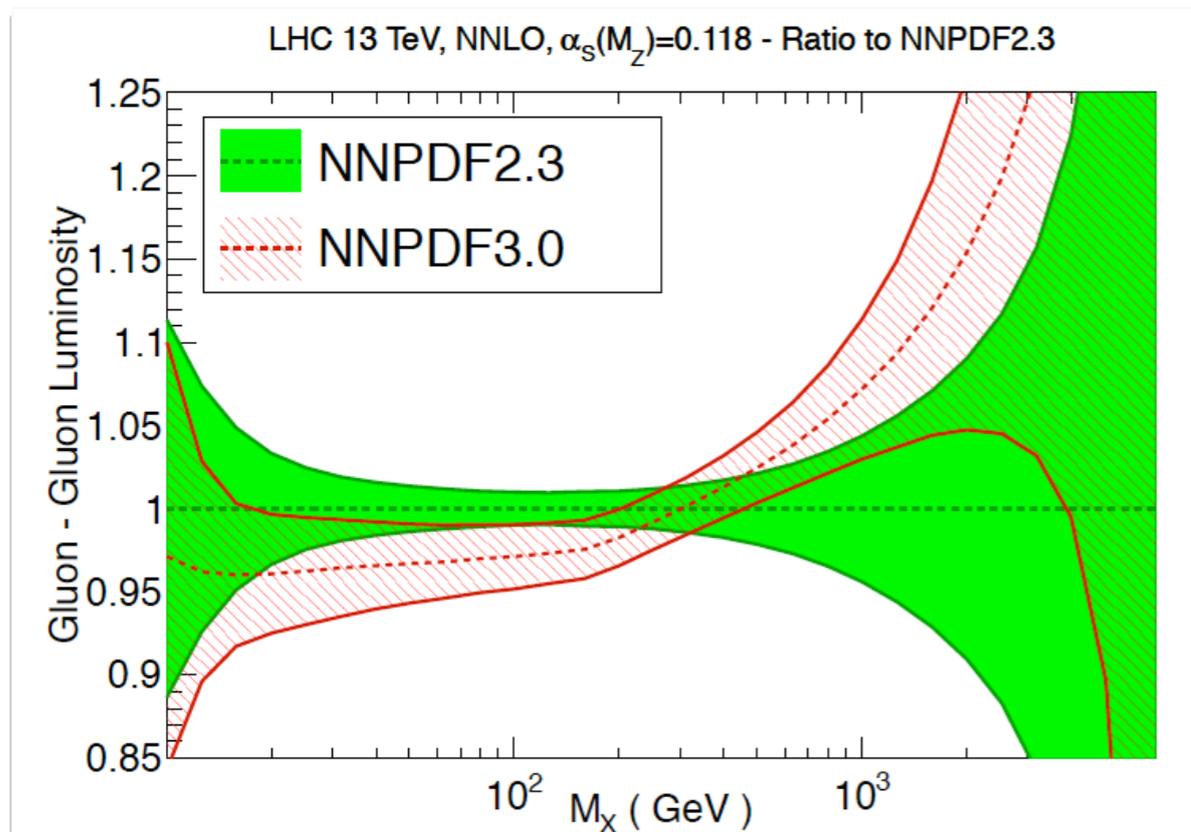
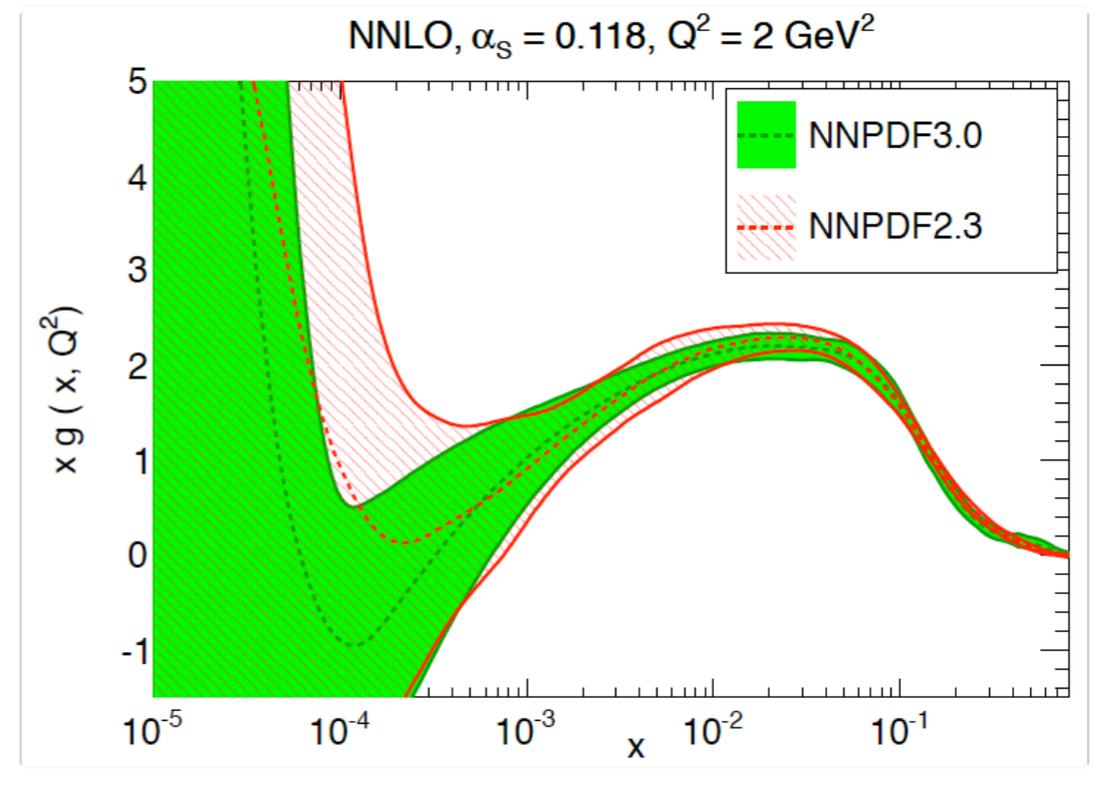
The first PDF set validated on closure tests

- $O(1000)$ **new data** points included:
 - HERA I combined data + HERA II ZEUS and H1 data,
 - LHC jet data, LHC electroweak data, LHC top-pair production data.
- Improved **methodology**:
 - new fitting code completely rewritten in C++,
 - improved PDF parametrization: new fitting basis, optimal determination of the preprocessing exponents and more effective positivity constraints.
 - optimized minimization algorithm: improved genetic algorithm and stopping criterion.
- **Closure testing** \Rightarrow Validation of the methodology:
 - fit on pseudo data generated with known PDFs (MSTW, CT),
 - reproduce the statistical distributions expected.

NNPDF3.0 [arXiv:1410.8849]

The first PDF set validated on closure tests

- **General agreement** between NNPDF2.3 and NNPDF3.0.
- Differences between PDFs at the 1- σ level at most: impact of **new data** and of the **improved methodology**.
- **Uncertainty reduction**, e.g. small- and large- x gluon PDF.



- PDF luminosities, involved in the hadronic process:

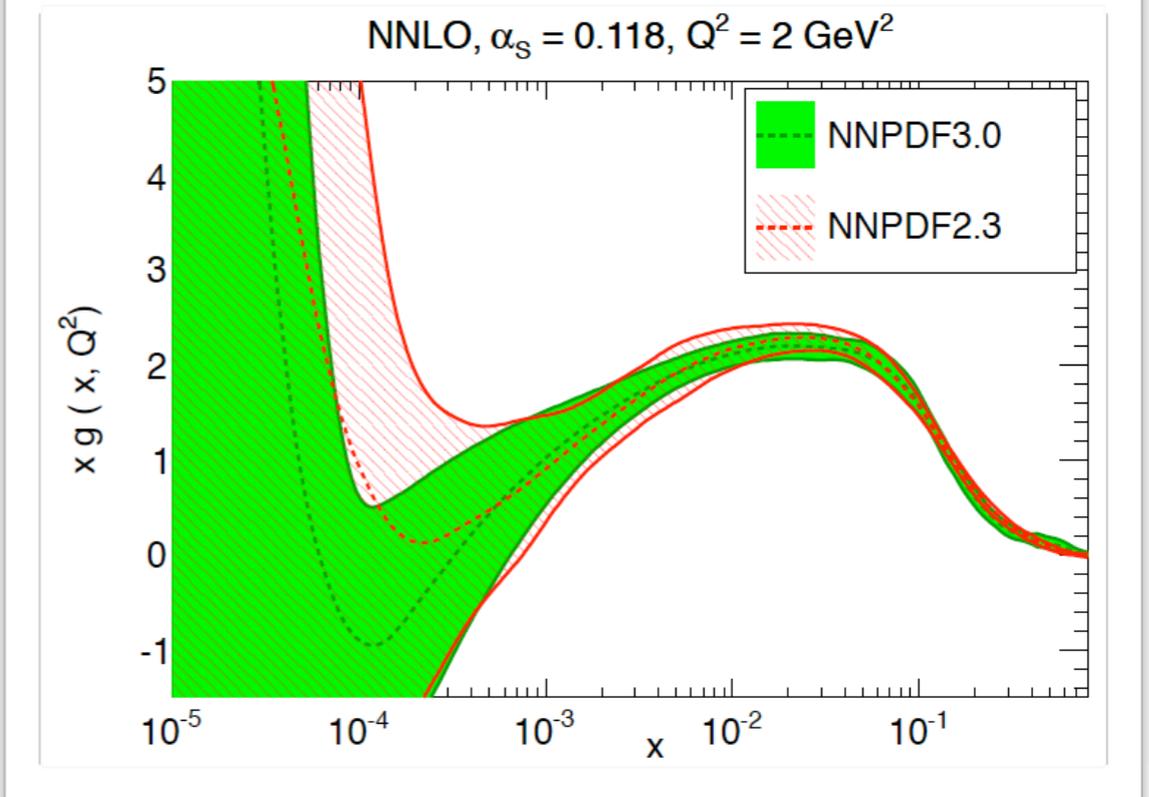
$$\Phi_{ij}(M_X^2) = \frac{1}{s} \int_{\tau}^1 \frac{dx}{x} f_i(x, M_X^2) f_j(\tau/x, M_X^2), \quad \tau = M_X^2/s$$

- Most substantial change in the gluon-gluon luminosity: NNPDF3.0 softer by about one σ than NNPDF2.3 for $M_X < 200$ GeV.
- Relevant for the Higgs in gluon fusion.

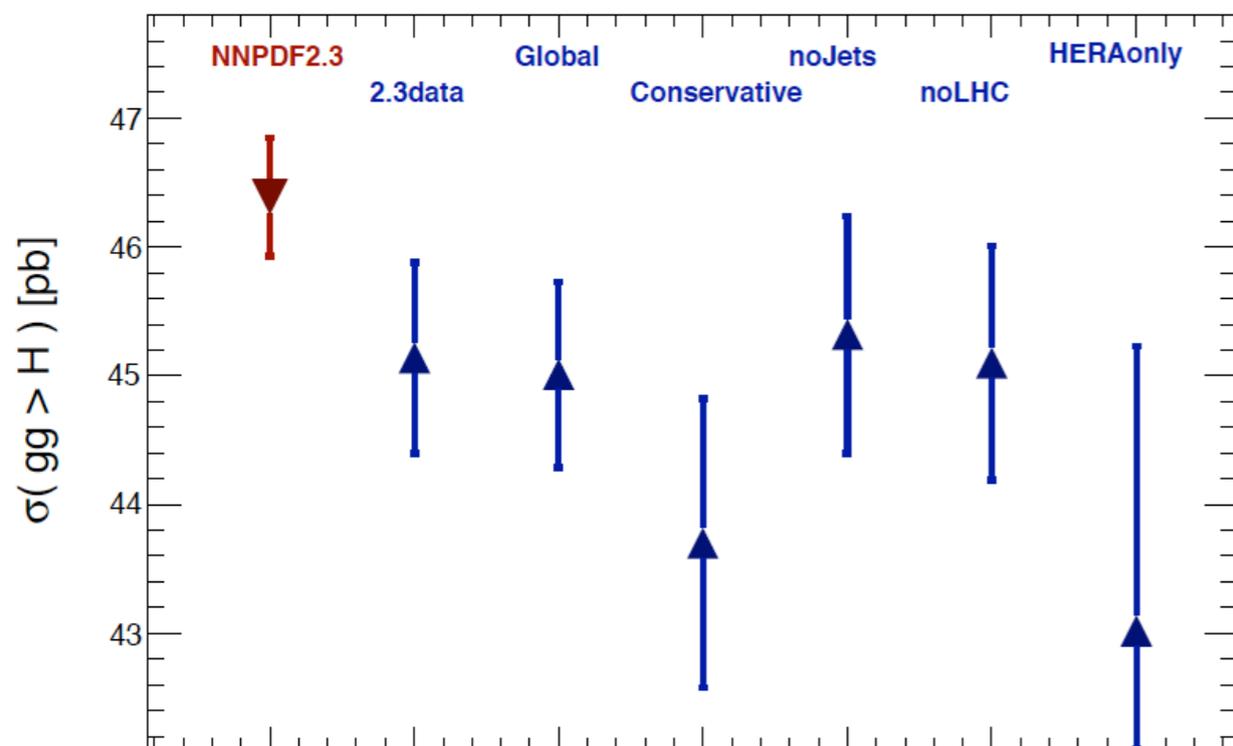
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NNPDF3.0 NNLO, LHC 13 TeV, iHixs1.3.3, $\alpha_s=0.118$



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APFEL [arXiv:1310.1394]

A PDF Evolution Library: Overview

- 🍏 APFEL is a **public** library for QCD+QED combined evolution:
 - 🍏 up to NNLO in QCD and LO in QED.
 - 🍏 FFNS and VFNS.
 - 🍏 Pole and $\overline{\text{MS}}$ heavy quark masses.
 - 🍏 Module for the computation of DIS NC and CC observables up to NNLO in different mass schemes (ZM-VFNS, FFNS and FONLL).
 - 🍏 Interfaces to FORTRAN, C/C++ and Python.
 - 🍏 Interfaced to LHAPDF 5 and 6.
 - 🍏 Graphical User Interface (GUI).
 - 🍏 APFEL is available from <http://apfel.hepforge.org/>.

APFEL [arXiv:1310.1394]

A PDF Evolution Library: Recent Work

- 🍏 A faster evolution.
- 🍏 Improved QCD+QED evolution.
- 🍏 Time-like Evolution (for fragmentation functions).
- 🍏 Tensor gluon evolution.
- 🍏 APFEL will be used in the next NNPDF analyses.
- 🍏 Work in progress to interface APFEL to HERAFitter.
- 🍏 ...

APFEL [arXiv:1310.1394]

A PDF Evolution Library: Recent Work

🍏 The **Web Graphical User Interface:**

<http://apfel.mi.infn.it>

The screenshot displays the APFEL web interface. At the top, there is a navigation bar with the APFEL logo, a 'Contact' link, and a 'Logout' button. Below this is a sidebar on the left with the following sections:

- Workspace**
 - Home
 - My Profile
- PDF MANAGER**
 - My PDF sets
 - Add PDF set
 - Import a LHAPDF grid
- TOOLS**
 - Plotting Tools
- DOWNLOAD RESULTS**
 - View jobs

The main content area is titled 'My APFEL Gallery' and contains the text: 'Below you find a gallery with your recent jobs. If the gallery is empty [start a new job!](#)'

The gallery displays six plots arranged in a 2x3 grid. Each plot shows the evolution of a function $F(x,Q)$ versus $d\ln Q$ for different values of x and Q . The plots are titled with parameters like 'NNPDF23_nlo_as_0118_central'.

On the right side of the gallery, there are three colored buttons for workflow actions:

- Prepare PDF (Red button)
- Select a plotting tool (Green button)
- Collect the result (Blue button)