APFEL package and interface

arXiv:1310.1394

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PDF4LHC - CERN
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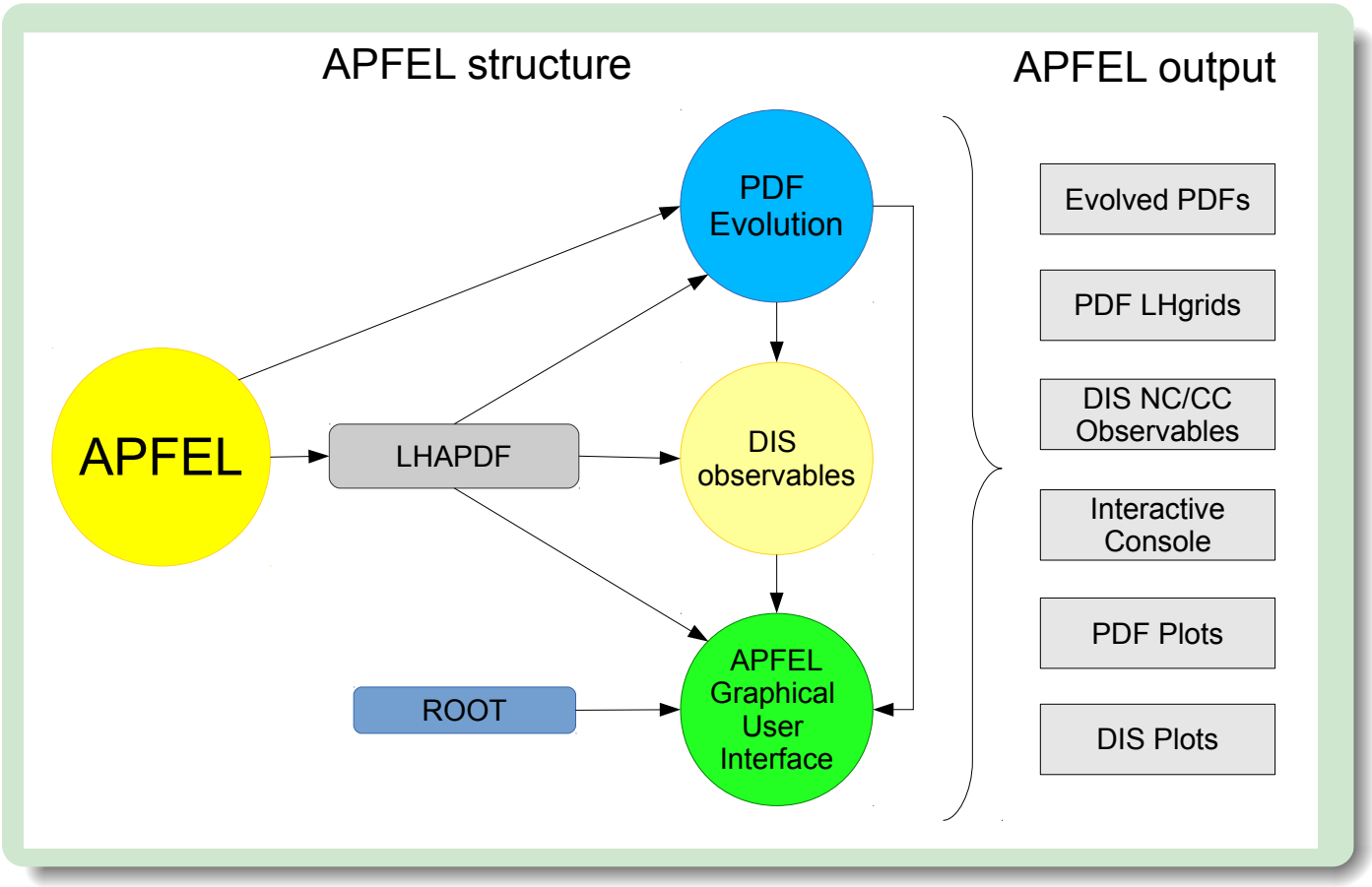
http://apfel.hepforge.org/

in collaboration with Valerio Bertone and Juan Rojo

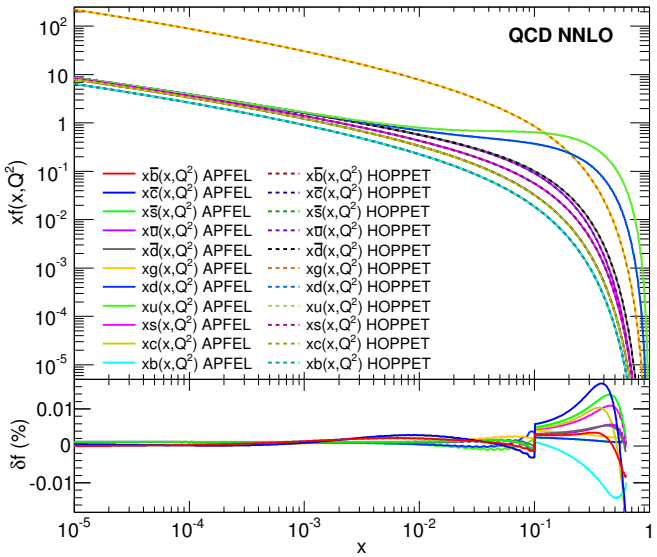
Introduction to APFEL

- APFEL is a **public** PDF evolution library with **QED corrections**
- Simple tool for **PDF manipulation**
- APFEL is composed by **three modules**: DGLAP, DIS, GUI

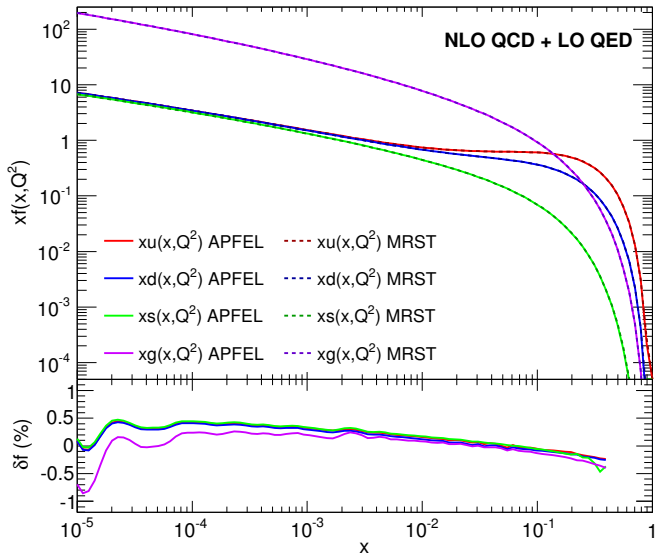


APFEL evolution features

- APFEL **evolution features**:
  - up to **NNLO** in **QCD** and **LO** in **QED**,
  - **FFNS** and **VFNS** solution in x-space,
  - Pole and $\overline{\text{MS}}$ heavy quark masses
- Technical features:
  - interface to **LHAPDF 5 & 6** (input/output)
  - interfaces in **Fortran**, **C/C++** and **Python**
- Benchmark against HOPPET, partonevolution, MSTW04QED [arXiv:1310.1394]



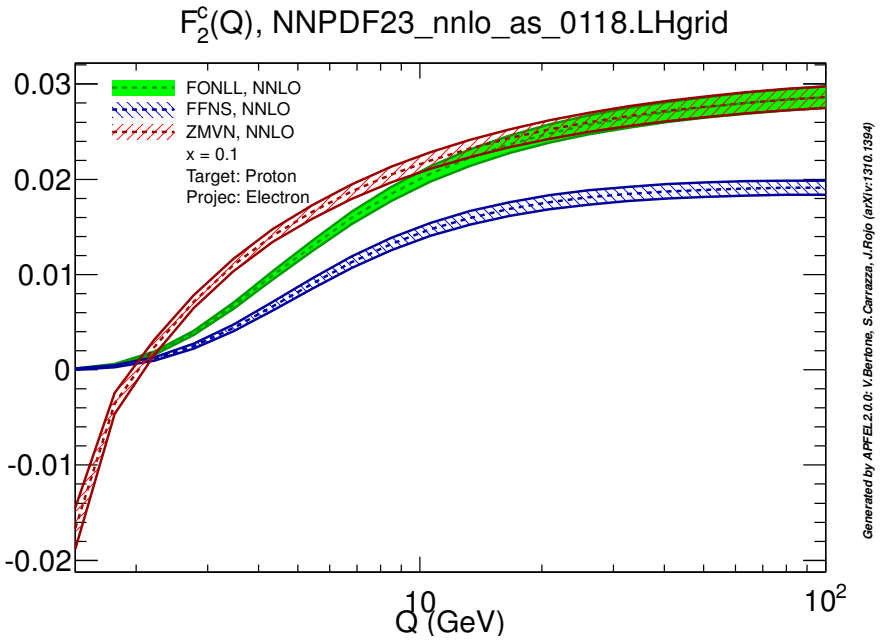
(a) HOPPET vs APFEL (QCD)



(b) MSTW04 vs APFEL (QCD+QED)

APFEL DIS module

- The **DIS module**:
  - Computation of **DIS observables**:
    - ★ all the **NC** and **CC** observables: F_2,F_l, F_3 and reduced cross sections
  - Up to order α_s^2 (when possible)
  - Schemes: **FONLL**, **FFNS** and **ZM-VFNS**,
  - Interface to **APFEL evolution** and/or **LHAPDF**



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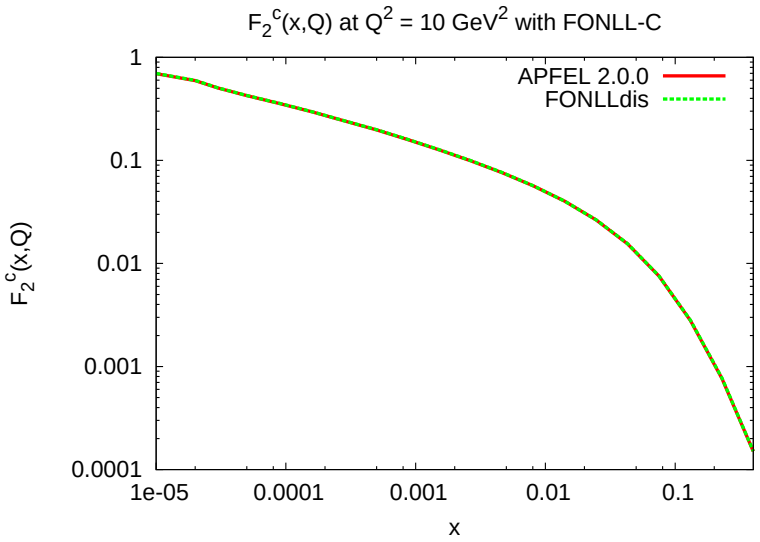
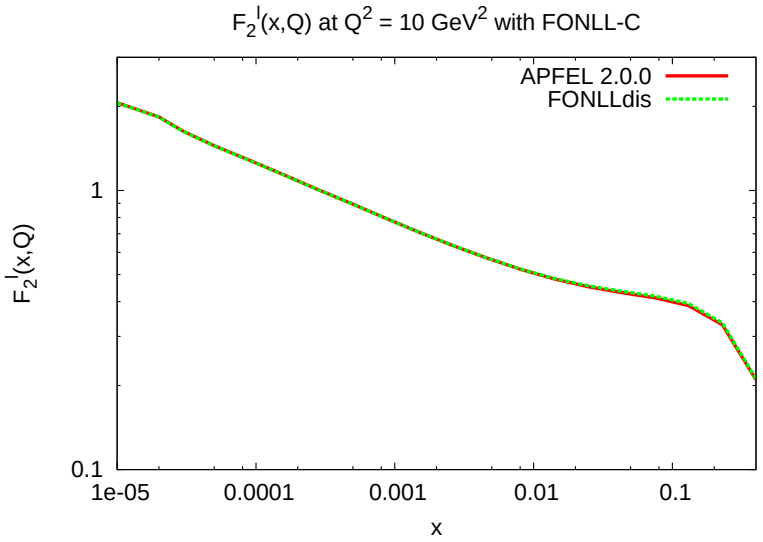
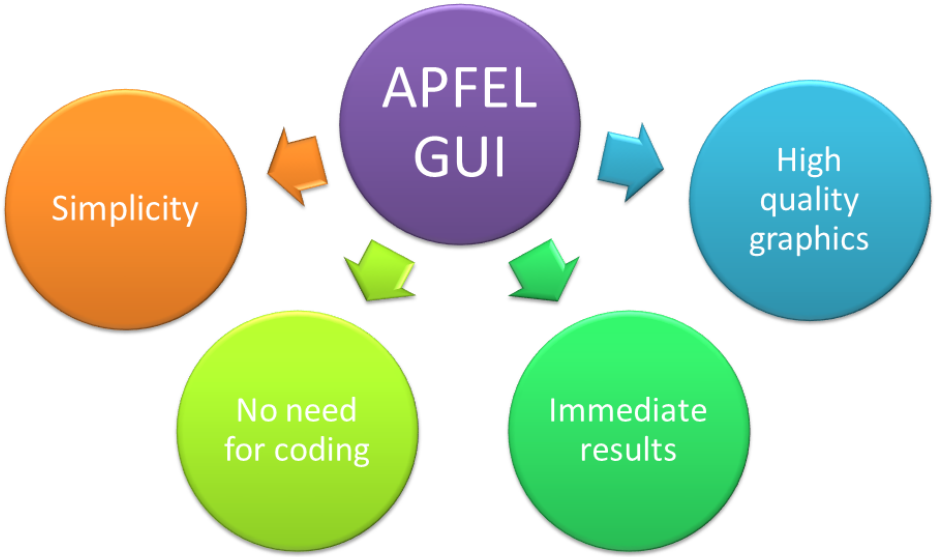
  - Schemes: **FONLL**, **FFNS** and **ZM-VFNS**,
  - Interface to **APFEL evolution** and/or **LHAPDF**
- Benchmark of NC F_2 against FONLLdis [arXiv:1001.2312]





APFEL Graphical User Interface

- Why a **Graphical User Interface** (GUI)?



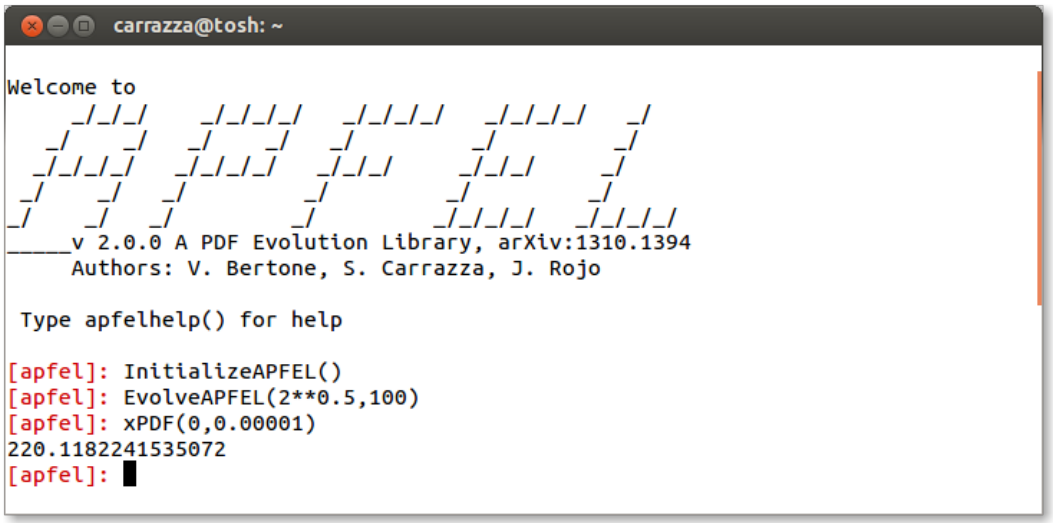
APFEL GUI

- PDF plots: **all LHAPDF grids**
  - ★ PDF error treatment
- Evolution performed by
  - ★ APFEL and/or LHAPDF
- Computation of Luminosities
- Computation of DIS observables

- APFEL GUI 2.0.0:
  - System requirements: ROOT, LHAPDF, Qt4
  - `http://apfel.hepforge.org/download.html`
- Plots cross-checked against "PDF benchmarking 2012" [arXiv:1211.5142]

APFEL Interactive Console

- APFEL provides the shell command `apfel`
  - **interactive access** to all the APFEL functionalities
- ***Example:***
  - evolving the gluon PDF at $x = 10^{-5}$ between $\sqrt{2}$ and 100 GeV.

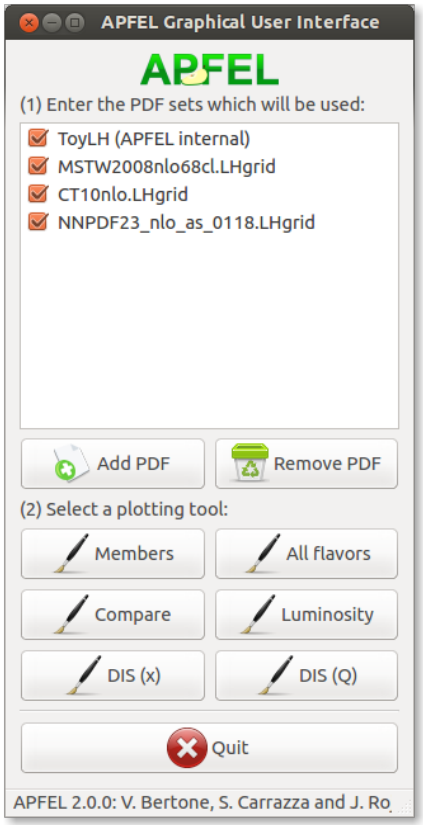


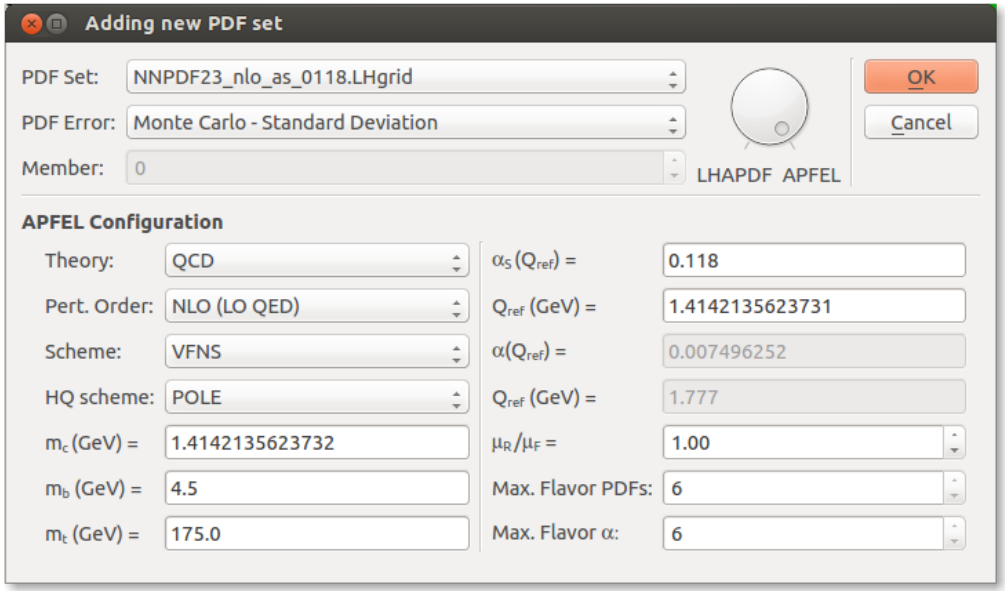
- *Other examples:*
  - instantaneous PDF values, LHgrid generation
  - luminosity computation, DIS observables computation, etc.

APFEL GUI 2.0.0

- Possibility to select and tune the evolution of every single PDF set.
  - takes as input **PDFs from LHAPDF** and the **internal APFEL toy**.
  - simple and intuitive replacement/setup of evolution.

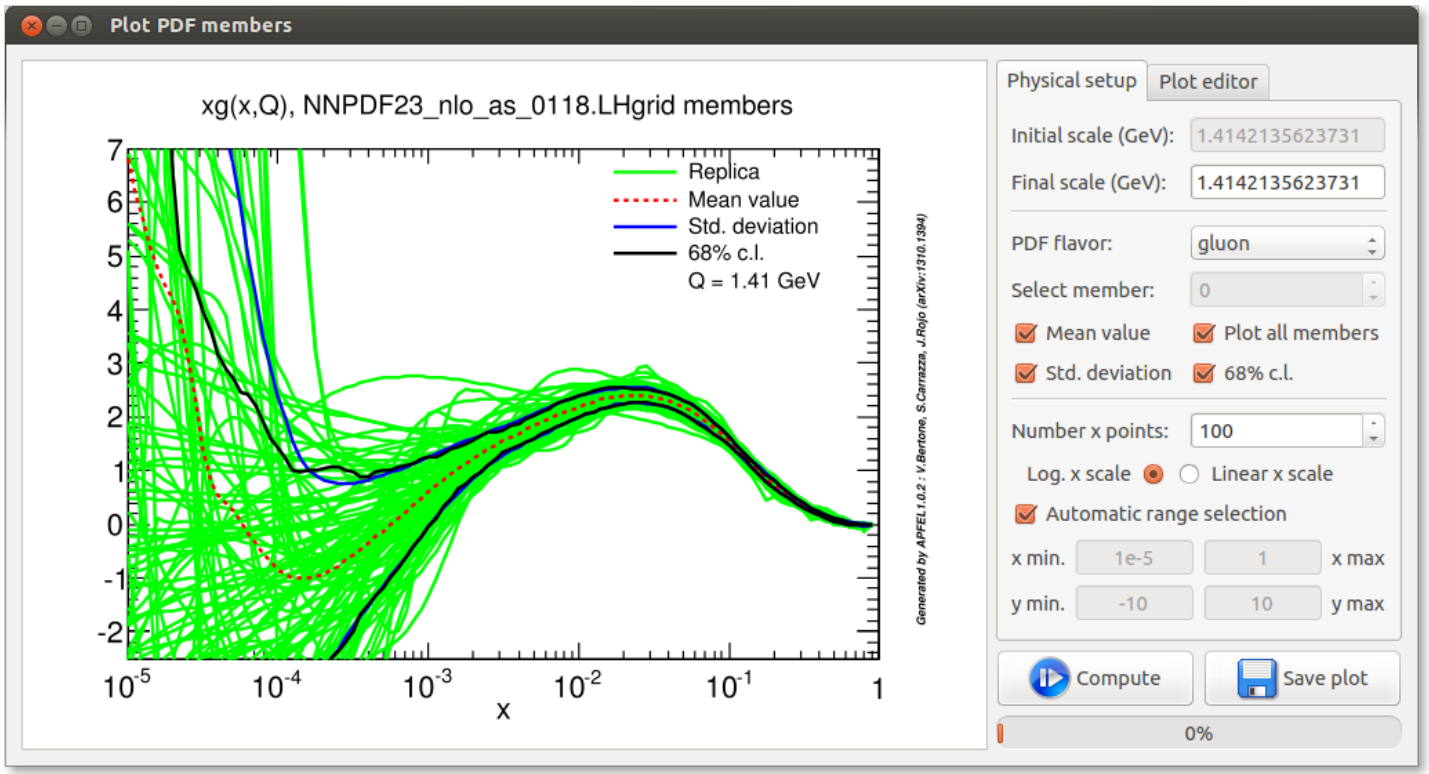
Example Main window and PDF setup:





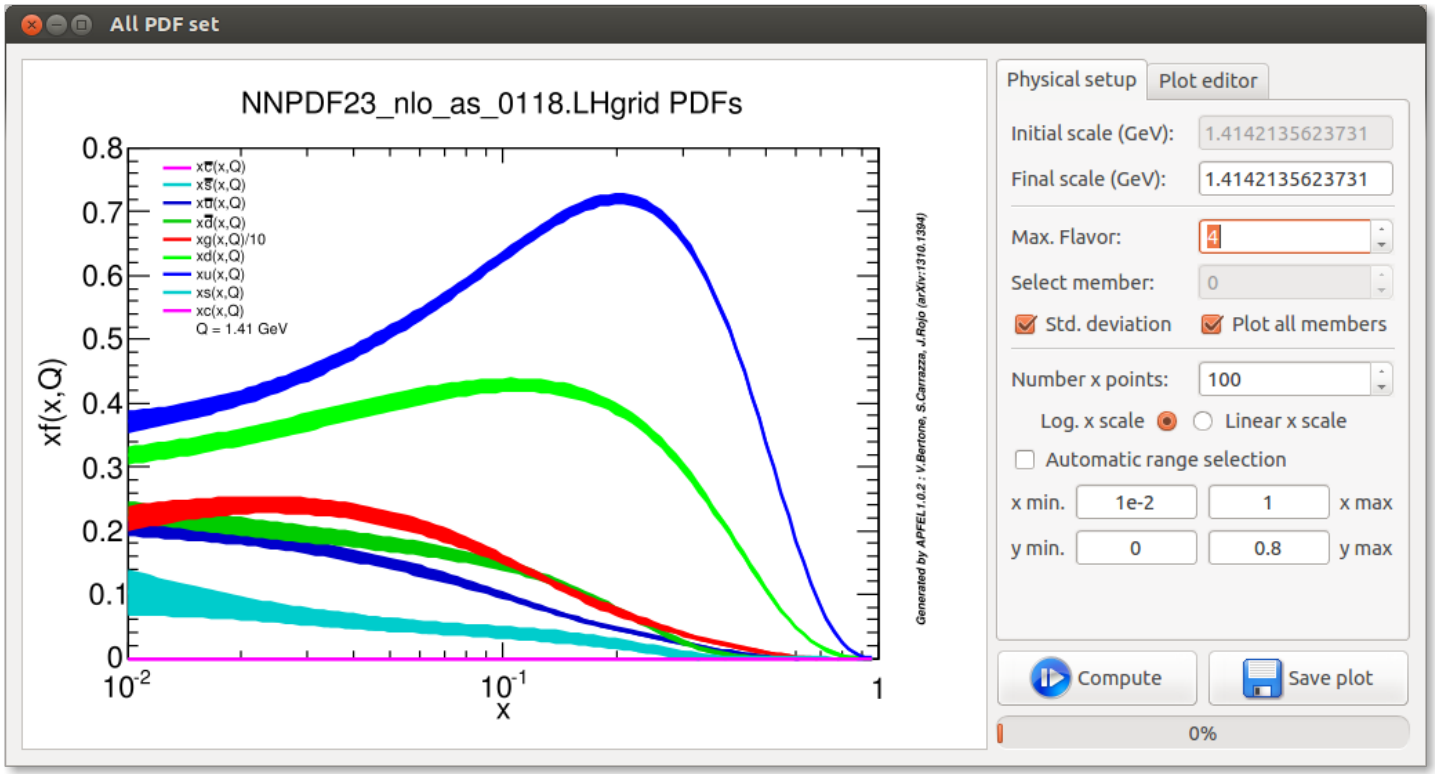
APFEL GUI 2.0.0

- **Functionalities:** Member plot:
  - PDF Flavor: physical basis.
  - Uncertainties: Monte Carlo, Eigenstates, etc.
  - Plot customization: axis range, colors, titles, etc.



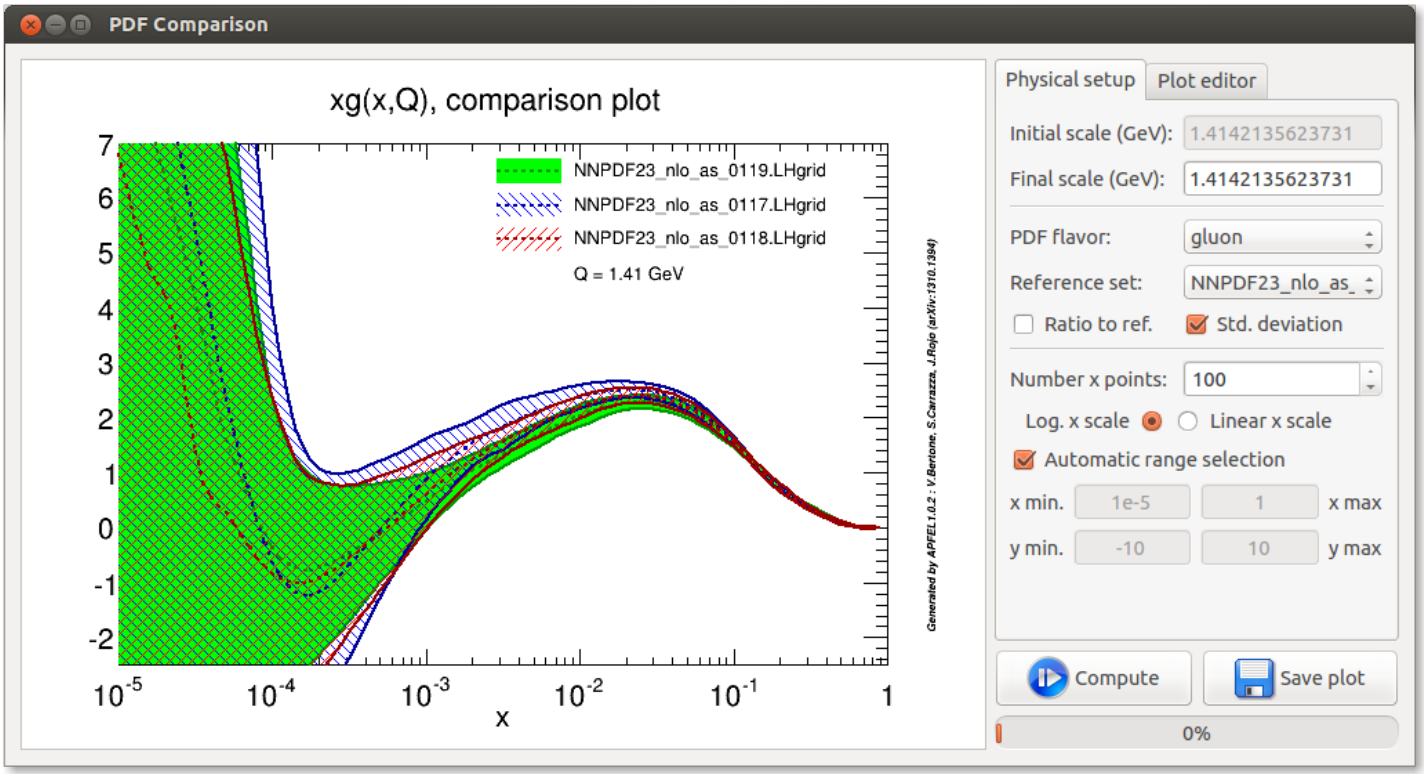
APFEL GUI 2.0.0

- **Functionalities:** All-in-on plot:
  - PDG like plot with custom options.
  - Possibility to save plots in: ps, eps, pdf, root, png.



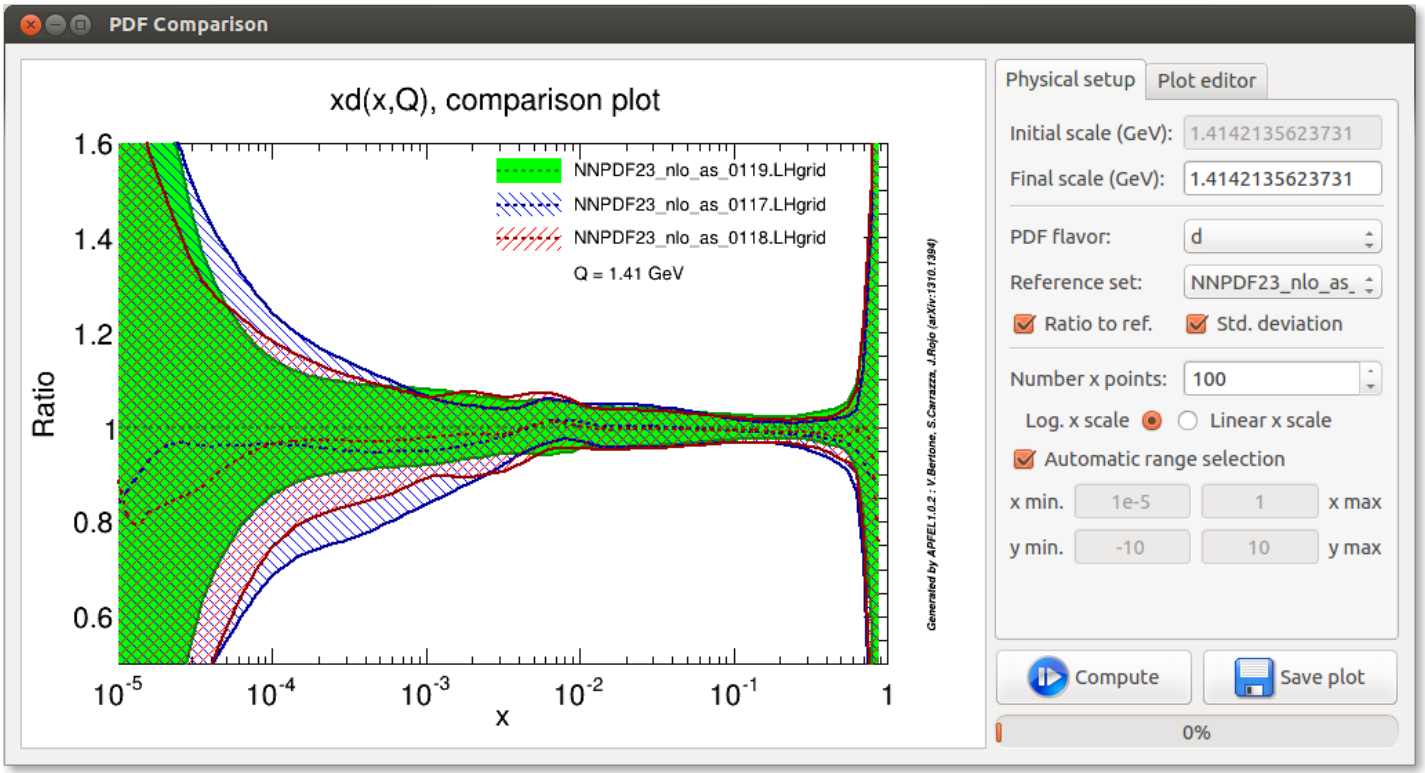
APFEL GUI 2.0.0

- **Functionalities:** PDF comparison:
  - compares multiple PDF sets



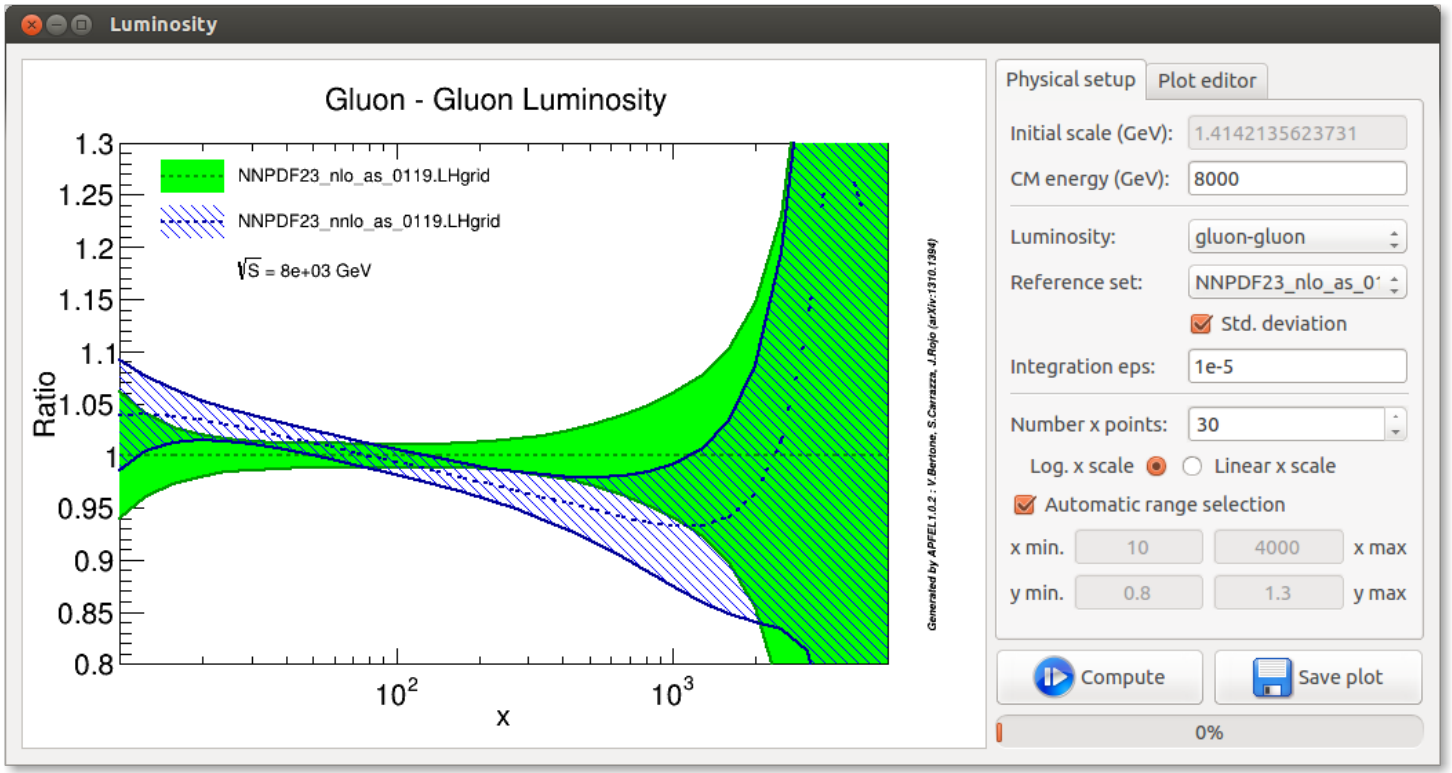
APFEL GUI 2.0.0

- **Functionalities:** PDF comparison ratio:
  - compares multiple PDF sets by performing the ratio



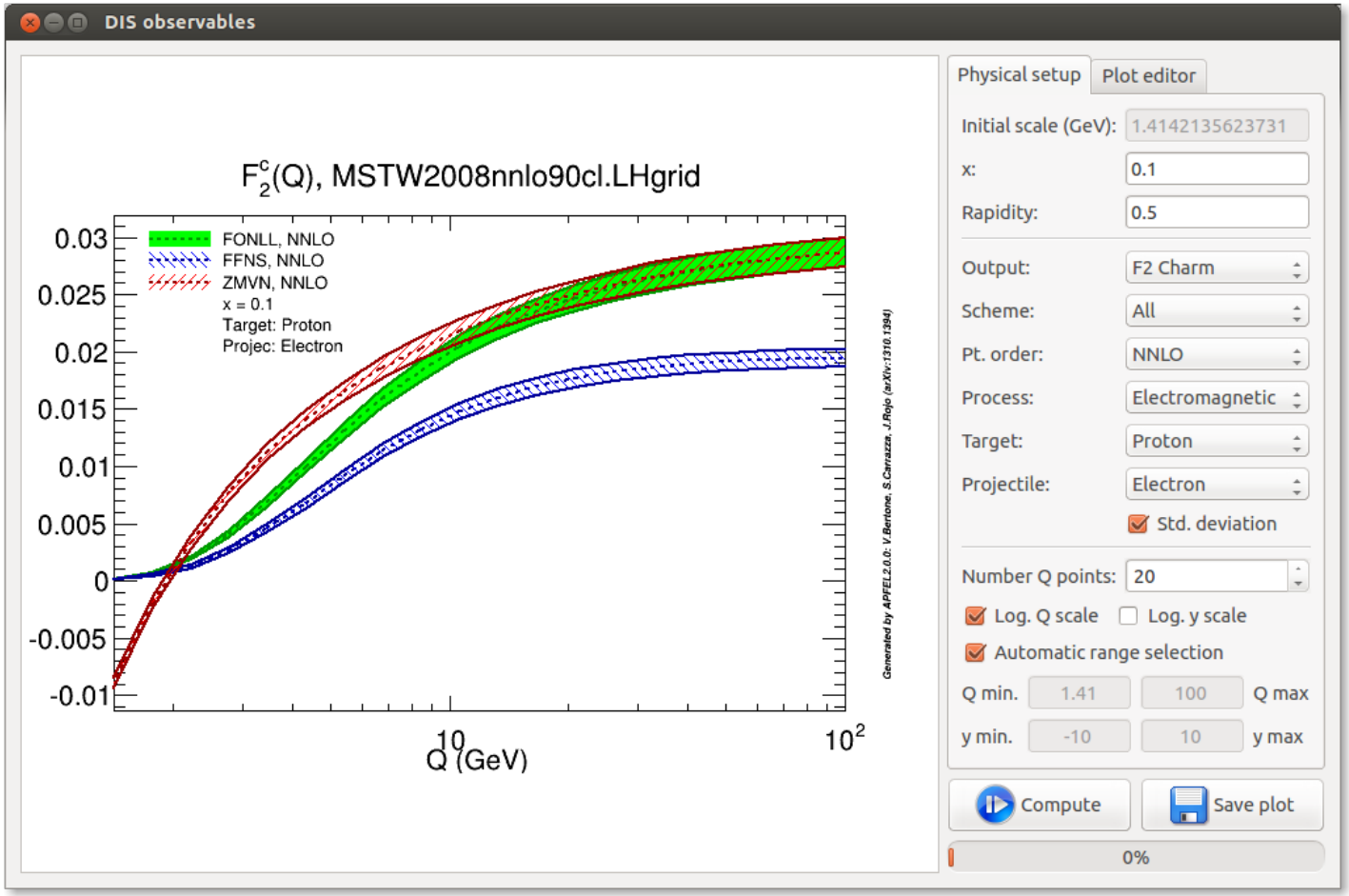
APFEL GUI 2.0.0

- **Functionalities:** PDF luminosity:
  - compares PDF luminosities: gg, $q\bar{q}$, qg, $c\bar{c}$, $b\bar{b}$, cg, bg, qq, $\gamma\gamma$, γg.



APFEL GUI 2.0.0

- **Functionalities:** DIS observables
  - compares DIS observables with different schemes.
  - possibility to perform plots in function of x and Q



Outlook

- **Summary**
  - *APFEL features*
    - ⋆ **PDF evolution library** with QCD+QED combination
    - ⋆ **DIS observables code** based on FONLL
    - ⋆ GUI: a complete **PDF analysis tool**
  - *Coming soon:*
    - ⋆ Interface to **APPLgrid**: DIS observables and evolution.
    - ⋆ Future **web-application** based on APFEL GUI 2.0.0.
- ***Code/manual and instructions:***

`http://apfel.hepforge.org/`