# Status of xFitter project

S. Glazov, XFitter workshop, Minsk, 18 March 2019



### Project front page: <a href="https://www.xfitter.org">https://www.xfitter.org</a>

### xFitter

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#### Welcome to xFitter (former HERAFitter)

Proton parton distribution functions (PDFs) are essential for precision physics at the LHC and other hadron colliders. The determination of the PDFs is a complex endeavor involving several physics process. The main process is the lepton proton deep-inelastic scattering (DIS), with data collected by the HERA ep collider covering a large kinematic phase space needed to extract PDFs. Further processes (fixed target DIS, ppbar collisions etc.) provide additional constraining powers for flavour separation. In particular, the precise measurements obtained or to come from LHC will continue to improve the knowledge of the PDF.

The xFitter project is an open source QCD fit framework ready to extract PDFs and assess the impact of new data. The framework includes modules allowing for a various theoretical and methodological options, capable to fit a large number of relevant data sets from HERA, Tevatron and LHC. This framework is already used in many analyses at the LHC.

#### Downloads of xFitter software package

ℜ xFitter-2.0.0 release is publicly available. All the xFitter releases can be accessed HERE. All the former (HERAFitter) releases can be accessed ● HERE. Description: ● http://arxiv.org/abs/1410.4412

#### **xFitter Meetings**

- 😵 🕫 xFitter Workshop in Krakow 4-7 March 2018
- · User's Meetings: meetings to enhance communication between users and developers (open access)
- Developer's Meeting: technical weekly meetings to ensure communication among developers (restricted access)
- Steering Group's Meeting (restricted access)

#### xFitter representation

· List of results

· List of collected talks

#### **Developers Info (restricted to developers)**

Internal Developments

#### Organisation

Release coordinator/Librarian (revision of the release candidates): Sasha Glazov, Oleksandr Zenaiev

· DESY IT Contact: Yves Kemp

**Getting help** 

Send email to Kitter-help@desy.de





### **Code and data repositories**

### xFitter / DownloadPage

#### Releases of the xFitter QCD analysis package

- Versioning convention: i.j.k with
  - i stable release
  - · j beta release
  - k bug fixes.
- The release notes can be found in this attachment: @xFitter\_release\_notes.pdf .
- Installation script for xFitter together with QCDNUM, APFEL, APPLGRID, LHAPDF listall-xfitter
  - New installation script from master branch linstall-xfitter-master
- Data and theory files are also stored in 🕏 hepforge and can be accessed from there ("List of Data Files"). Alternatively they can be downloaded from cernbox 🔮 cernbox

| Date    |         | Version          | Files              | Remarks  |
|---------|---------|------------------|--------------------|--|
|         | 03/2017 | 2.0.0 FrozenFrog | Aritter-2.0.0.tgz  | stable release with decoupled data and theory file |
| 07/2016 |         | 1.2.2            | @xfitter-1.2.2.tgz | release with decoupled data and theory files       |
| 05/2016 |         | 1.2.1            | Øxfitter-1.2.1.tgz | release with decoupled data and theory files       |
| 02/2016 |         | 1.2.0            | Axfitter-1.2.0.tgz | release with decoupled data and theory files       |

#### Documentation

- Manual (under continuous improvement) can be accessed lehere.
- TUTORIALS adapted for the Frozen Frog release can be downloaded from here.
- The README file (accessible via the package) gives an explanation for a quick start.
- · The INSTALLATION file (accessible via the package) provides information for package installation and usage instructions
- The package is licensed under GNU GPL, please see LICENCE for mode details (accessible via the package).

#### Web access to GIT

The master version can be viewed and downloaded from the https://gitlab.cern.ch/fitters/xfitter.git

- Latest stable release 2.0.0 (FrozenFrog)
- Many recent developments are on master branch of git repository
- Use install-xfitter-master script
- Data files can be accessed using hepforge, or cernbox as alternative.

### Data access: <u>cernbox</u> option

Data and theory files are also stored in 🕏 hepforge and can be accessed from there ("List of Data Files"). Alternatively they can be downloaded from cernbox 🕏 cernbox

|   |                       | ERNBOX |       |          | ↓ Download |
|---|-----------------------|--------|-------|----------|------------|
| 1 |                       |        |       |          |            |
|   | Name 🔺                |        |       | Size     | Modified   |
|   | fixedTarget           |        | 0.0.0 | 110 KB   | 6 days ago |
|   | hera                  |        | ***   | 29.3 MB  | 6 days ago |
|   | lhc                   |        |       | 363.8 MB | 6 days ago |
|   | lhec                  |        |       | 285 KB   | 6 days ago |
|   | test                  |        |       | <1KB     | a day ago  |
|   | tevatron              |        | 0.0.0 | 153 MB   | 6 days ago |
|   | README                |        |       | <1 KB    | 6 days ago |
|   | SVN_UPDATE            |        |       | <1KB     | a day ago  |
|   | 6 folders and 2 files |        |       | 546.4 MB |            |

- A few troubles with hepforge after the server update
- Considering moving to other ways to distribute the data/grid files
- Cernbox option is currently available alternative, may move to /cvmfs distribution.

# Developers meetings, support of the project

- Biweekly meetings, about 1 hour long, to discuss code updates and xFitter analyses
- DESY + remote connections, well attended by active developers
- Will keep at the same pace in future
- Users' meetings are rare, and steering committee is not active. We may want to hold a user meeting for the next xFitter release
- DESY provides support for xFitter server; visits related to xFitter, xFitter meeting:
  - 4 DESY visits for total about 5 person-months last year, plus a "theorist of a month"
  - Limited support for external meetings
- xFitter is supported by DESY PRC.

## User support

- Most of the user help requests are handled via <u>xfitter-help@desy.de</u>
- Usual problems with program installation (yaml libraries in particular), APPLGRID, LHAPDF interaction, QCDNUM version
- Recently increased activity of the help requests, with 3-4 threads per month, usually handled by SG and SZ: volunteer developers are welcome to join. IN and FG are added to the list, which started to help already.
- Some of the questions related to dependencies of 2.0.0 release vs QCDNUM/APPLGRID, new release could help with them

### xFitter talks at conferences

### 2019

| Date          | Conference/Workshop | Presenter  | Link                 | Remarks           |
|---------------|---------------------|------------|----------------------|-------------------|
| 12-18.05.2019 | New trends in HEP   |            | Invited xFitter talk |                   |
| 8-12.04.2019  | 🕈 DIS 2019          | F. Olness  | xFitter talk         | Abstract accepted |
| 23-30.03.2019 | Moriond QCD 209     | I. Novikov | xFitter talk         | Abstract accepted |

### 2018

| Date          | Conference/Workshop                         | Presenter            | Link          |
|---------------|---|----------------------|---------------|
| 17-19.11.2018 | • Workshop on QCD and diffraction ( Krakow) | A. Luszczak          | l Talk        |
| 27-31.08.2018 | • QCD at LHC                                | S. Glazov            | xFitter talk  |
| 16-20.04.2018 | • DIS 2018                                  | S. Glazov, F. Olness | xFitter talks |
| 17-24.03.2018 | Moriond QCD 2018                            | F. Giuli             | xFitter talk  |

- Several presentations of xFitter at the key QCD conferences.
- Coverage could be extended: abstract are typically accepted but it is hard to find speakers.
- Volunteers are welcome.

### Analyses by the xFitter developers team

### List of analyses by xFitter

he link to the list of analyses using former HERAFitter can be accessed 🔮 here

| 7 | 02.2018 | xFitter Developers and Marco Bonvini              | Eur.Phys.J. C78 (2018) no.8, 621, arXiv:1802.00064 | Impact of low-x resummation on QCD analysis of HERA data                       | LHAPDF6 grid files |
|---|---------|---|--|--|--------------------|
| 5 | 07.2017 | xFitter Developers                                | Eur.Phys.J. C77 (2017) no.12 837, arXiv:1707.05343 | Impact of the heavy quark matching scales in PDF fits                          | LHAPDF grids       |
| ; | 01.2017 | F. Giuli, xFitter Developers' team and M. Lisovyi | Eur.Phys.J. C77 (2017) no.6 400, arXiv:1701.08553  | The photon PDF from high-mass Drell Yan data at the LHC                        |                    |
|   | 03.2016 | xFitter and APFEL teams and A. Geiser             | JHEP 1608 (2016) 050, arXiv:1605.01946             | • A determination of mc(mc) from HERA data using a matched heavy flavor scheme |                    |



 ← Sizable change in gluon density at low x<0.001 and low Q2. May have some impact for Higgs production at FCC

- Last year: analysis on impact of low x resummation
- Analyses of pion PDF, charm in charged current DIS, and impact of FBA-DY data on PDFs are in the pipeline (talks right after this)

### Analyses using xFitter

#### List of analyses using xFitter

|        | -       |                                   |                    |  |
|--------|---------|-----------------------------------|--------------------|--|
| Number | Date    | Group                             | Reference          | Title  |
| 2019   |         |                                   |                    |  |
| 77     | 02.2019 | M. Bonvini and F. Giuli           | arXiv:1902.11125   | • A new simple PDF parametrization: improved description of the HERA data  |
| 76     | 02.2019 | A. Verbytskyi et al               | arXiv:1902.08158   | • High precision determination of as as from a global fit of jet rates   |
| 75     | 02.2019 | HL-LHC                            | arXiv:1902.04070   | Standard Model Physics at the HL-LHC and HE-LHC  |
| 74     | 02.2019 | ZEUS                              | arXiv:1902.03048   | Limits on contact interactions and leptoquarks at HERA   |
| 73     | 01.2019 | D. Britzger et al                 | arXiv:1901.08524   | The Tensor Pomeron and Low-xx Deep Inelastic Scattering  |
| 72     | 01.2019 | A. Luszczak, W. Schäfer           | arXiv:1901.07989   | ● Coherent photoproduction of J/ψJ/ψ in nucleus-nucleus collisions in the color dipole approach  |
| 71     | 01.2019 | I. Helenius and C.O.<br>Rasmussen | arXiv:1901.05261   | Hard diffraction in photoproduction  |
| 2018   |         |                                   |                    |  |
| 70     | 12.2018 | FCC                               | CERN-ACC-2018-0056 | Future Circular Collider : Vol. 1 Physics opportunities  |
| 69     | 12.2018 | CMS                               | arXiv:1812.10505   | • Measurement of the tt_tt production cross section, the top quark mass, and the strong coupling constant using dilepton events in pp collisions at sv=s= 13<br>TeV  |
| 68     | 11.2018 | CMS                               | arXiv:1811.10021   | • Measurement of associated production of a W boson and a charm quark in proton-proton collisions at s/=s= 13 TeV  |
| 67     | 10.2018 | CMS                               | CMS-PAS-TOP-18-004 | • Measurements of normalised multi-differential cross sections for top quark pair production in pp collisions at s/=13 TeV and simultaneous determination of the strong coupling strength, top quark pole mass and parton distribution functions |
| 66     | 10.2018 | M.R. Pelicer et al.               | arXiv:1810.05573   | Absorptive effects and power corrections in low .xx DGLAP evolution  |
| 65     | 10.2018 | M. Aziz et al                     | arXiv:1810.12064   | • Impact of the top quark cross-section data on parton distribution functions  |
| 64     | 07.2018 | C. Hadjidakis                     | arXiv:1807.00604   | A Fixed-Target Programme at the LHC: Physics Case and Projected Performances for Heavy-Ion, Hadron, Spin and Astroparticle Studies   |
| 63     | 06.2018 | H1                                | arXiv:1806.01176   | Determination of electroweak parameters in polarised deep-inelastic scattering at HERA   |
| 62     | 04.2018 | A. Bermudez Martinez, et al       | arXiv:1804.11152   | Collinear and TMD parton densities from fits to precision DIS measurements in the parton branching method  |
| 61     | 04.2018 | H1 and ZEUS                       | arXiv:1804.01019   | Combination and QCD analysis of charm and beauty production cross-section measurements in deep inelastic epep scattering at HERA   |
| 60     | 03.2018 | Bo-Ting Wang et al                | arXiv:1803.002777  | Mapping the sensitivity of hadronic experiments to nucleon structure   |
| 59     | 03.2018 | A. Cooper-Sarlar, K. Wichmann     | arXiv:1803.00968   | OCD analysis of the ATLAS and CMS W±W± and ZZ cross-section measurements and implications for the strange sea density  |

- Total number of citations: 149 (42 new since Krakow)
- 77 analyses

   (excluding
   proceedings +
   theses), 19 new
- New analyses:
  - LHC: 5
  - HERA: 3
  - Theory: 11

### Example analysis: Absorptive effects at low x



- Add estimated in the model absorptive corrections to the HERA data. Fit resulting cross sections using xFitter.
- Observe significant change in the gluon distribution at x about 0.001
- A number of last year papers on a similar topic, using xFitter: xFitter arXiv 1802.00064; D.
   Britzger et al arXiv:1901.08524; M. Bonvini and F. Giuli arXiv:1902.11125

### Lessons from xFitter-based analyses

- A few phenomenological analyses using HERA data and (perhaps) not so many LHC:
  - HERA data are more interesting for non-standard evolution at low x
  - xFitter is easier to use for HERA: e.g. it ships with the data
  - statistical fluctuation
- External analyses use xFitter as a "black box", rarely changing program internal structure.
- $\rightarrow$  Try to simplify access to the data files beyond HERA

→ Re-structure xFitter to enable easier introduction of new theory interfaces, evolution modules.

## **Release strategy**

| xFitter   | Rel | eases          |               |                   |              |                   |       |   |                 |     |
|---|-----|----------------|---------------|-------------------|--------------|-------------------|-------|---|-----------------|-----|
| + Create board  |     | Q QUICK FILTER | S: Released U | nreleased Archive | ed           |                   |       |   |                 |     |
| Issues  | Ve  | rsion name     |               | Start dat         | e (optional) |                   | -     | Release date (optional)                     |                 | ſ   |
| Reports   |     | Sign fight     |               |                   | (optionity)  |                   |       | include oute (optionity                     |                 |     |
| 🖴 Releases  |     | Version        | Status        | Progress          | Start date   | Release da        | te    | Description                                 |                 |     |
| Components  | =   | 2.2.0          | UNRELEASED    |                   | -            | 31/Jan/19         |       | new modular program flow for minimiz        | er and evoluti  | on  |
| Add-ons   | =   | 2.0.0          | RELEASED      | ¢                 | 09/Feb/17    | 17/Mar/17         |       | first git release                           |                 |     |
| ROJECT SHORTCUTS  | =   | 2.1.0          | UNRELEASED    |                   | 09/Feb/17    | 31/Jul/18         |       | New theory modules, beta                    |                 |     |
| dd a link to useful information for your<br>hole team to see. |     |                |               |                   | Atlassia     | n Jira Project Ma | anage | ement Software (v7.13.1#713001-sha1:5e0607( | i) · About Jira | 3 . |
| ⊦ Add link  |     |                |               |                   |              |                   |       |   |                 |     |
|   |     |                |               |                   |              |                   |       | A ATLASSIAN                                 |                 |     |

Original release strategy contained staged introduction of new features. However we are getting late with the release 2.1.0 and a few interesting for users and developers features are present in 2.2.0 only

Both 2.1.0 and 2.2.0 need substantial work before being released.

- Frozen Frog: 2.0.0 is two years old
- Release 2.1.0 with new theory interfaces, backward compatible with 2.0.0 for the main features ("master" branch)
- Release 2.2.0, with re-written flow, modular mimization, evolution: not compatible with 2.0.0, ("test\_ceres" branch)

# Highlights of the features in master branch

- Main new feature: modular, developer friendly procedure to add new reactions
- Based on C++ class **ReactionTheory**
- Tools for automatic creation of the template implementation (**AddReaction.py**).
- Some new reactions added
- A few minor updates: new QCDNUM version 17-01-14, new APPLGRID, new HOPPET
- More details in Sasha Z talk tomorrow

# Highlights of features in test\_ceres branch

- Move towards much modular code structure: alternative minimization, evolution, easier parameterisation
- Consistent handling of multiple evolutions for special cases such as pion scattering on tungsten.
- Easier extension of xFitter for nuclear fits, QCD+EW fits ("XyZFitter")
- More details in Ivan N talk tomorrow

→ both 2.0.1 and 2.0.2 release candidates require extensive testing. A few important developments are still not complete

# Workshop goals

- Inform developers and users about recent updates in xFitter code, decide on few open items, split the work, converge on release strategy
- Collect input from the users, to see what can be improved
- Review recent analyses performed using xFitter, see what are possible future analyses and related developments of the code, to achieve them

### Workshop agenda

| Pion PDF   | Ivan NOVIKOV 🛅        |
|--|-----------------------|
|  |                       |
|  |                       |
|  |                       |
| Institute for Nuclear Problems, Belarus State University | 08:10 - 08:50         |
|  |                       |
| Charm CC   | Prof. Fredrick OLNESS |
|  |                       |
| Institute for Nuclear Problems, Belarus State University | 08:50 - 09:10         |
| DV EPA   | Mr. Juri EIASCHI      |
| DIFDA  | WII. JUII FIASCHI     |
| Institute for Nuclear Drablema, Delarus State University | 00:10 00:20           |
| Institute for Nuclear Problems, Belarus State Oniversity | 05.10 - 05.30         |
| HERA improved fits                                       | Francesco GUILI       |
| •  |                       |
|  |                       |
| Institute for Nuclear Problems, Belarus State University | 09:30 - 10:00         |

| ATLAS  | Zhiqing ZHANG           |
|--|-------------------------|
| Institute for Nuclear Problems, Belarus State University | 11:30 - 11:50           |
| CMS  | Mr. Oleksandr ZENAIEV 📄 |
| Institute for Nuclear Problems, Belarus State University | 11:50 - 12:10           |
| Benchmarking of PDFs                                     | Daniel FROIDEVAUX       |
| Institute for Nuclear Problems, Belarus State University | 12:10 - 12:30           |
| QCDNUM   | Michiel BOTJE           |
| Institute for Nuclear Problems, Belarus State University | 13:30 - 13:50           |
| APFEL  | Dr. Valerio BERTONE     |
| Institute for Nuclear Problems, Belarus State University | 13:50 - 14:10           |
| TMDs   | Ms. Aleksandra LELEK    |
| Institute for Nuclear Problems, Belarus State University | 14:10 - 14:30           |

| New developments : master   | Mr. Oleksandr ZENAIEV  |
|---|--|
| Institute for Nuclear Problems, Belarus State University  | 07:30 - 08:00  |
| New developments: test_ceres  | Ivan NOVIKOV   |
| Institute for Nuclear Problems, Belarus State University  | 08:00 - 08:30  |
| NNLO Grids  | Daniel BRITZGER  |
| Institute for Nuclear Problems, Belarus State University  | 08:30 - 09:00  |
| Validation of grids   | Simone AMOROSC   |
| Institute for Nuclear Problems, Belarus State University  | 09:00 - 09:15  |
|   |  |
| Release plans   | Alexander GLAZOV   |
| Release plans<br>Institute for Nuclear Problems, Belarus State University   | Alexander GLAZOV<br>09:30 - 10:00  |
| Release plans<br>Institute for Nuclear Problems, Belarus State University<br>Nuclear xFitter: Towards performing a global analysis of nuclear PDFs using the xFitter  | Alexander GLAZOV<br>09:30 - 10:00<br>Muhammad GOHARIPOUR   |
| Release plans<br>Institute for Nuclear Problems, Belarus State University<br>Nuclear xFitter: Towards performing a global analysis of nuclear PDFs using the xFitter<br>Institute for Nuclear Problems, Belarus State University  | Alexander GLAZOV<br>09:30 - 10:00<br>Muhammad GOHARIPOUR<br>11:30 - 12:00  |
| Release plans<br>Institute for Nuclear Problems, Belarus State University<br>Nuclear xFitter: Towards performing a global analysis of nuclear PDFs using the xFitter<br>Institute for Nuclear Problems, Belarus State University<br>Dipole model/lamda fits   | Alexander GLAZOV<br>09:30 - 10:00<br>Muhammad GOHARIPOUR<br>11:30 - 12:00<br>Henri KOWALSKI                                      |
| Release plans Institute for Nuclear Problems, Belarus State University Nuclear xFitter: Towards performing a global analysis of nuclear PDFs using the xFitter Institute for Nuclear Problems, Belarus State University Dipole model/lamda fits Institute for Nuclear Problems, Belarus State University                    | Alexander GLAZOV<br>09:30 - 10:00<br>Muhammad GOHARIPOUR<br>11:30 - 12:00<br>Henri KOWALSKI<br>12:00 - 12:30                     |
| Release plans Institute for Nuclear Problems, Belarus State University Nuclear xFitter: Towards performing a global analysis of nuclear PDFs using the xFitter Institute for Nuclear Problems, Belarus State University Dipole model/lamda fits Institute for Nuclear Problems, Belarus State University Tensor pomeron fit | Alexander GLAZOV<br>09:30 - 10:00<br>Muhammad GOHARIPOUR<br>11:30 - 12:00<br>Henri KOWALSKI<br>12:00 - 12:30<br>Alexander GLAZOV |

Today: analyses and tools

Tuesday: code development and non-standard analyses Wednesday: code development