New xFitter developments: master (+ other branches to be merged in master)

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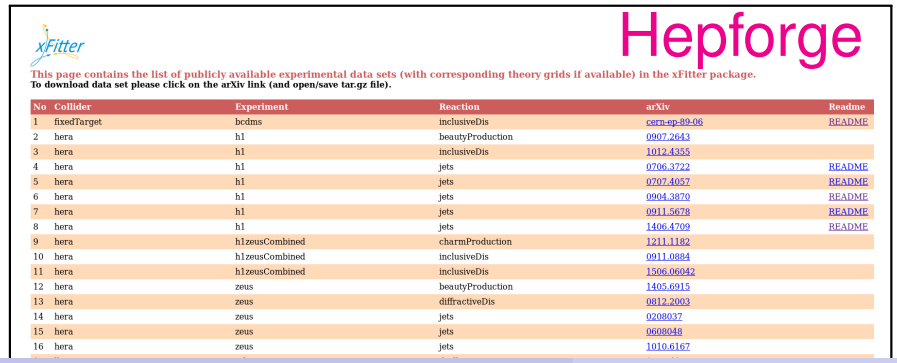
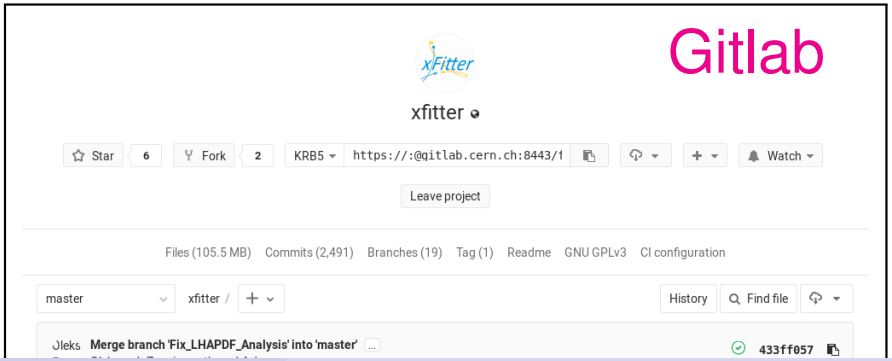
xFitter development workflow

- Regular xFitter meetings (biweekly):
  - discussing development process
  - discussing ongoing physics analyses
    → on demand dedicated meeting between main analysers
- Using CERN services for code development and support:
  - **Gitlab**: `https://gitlab.cern.ch/fitters/xfitter`
    - ★ revision control, code review
    - ★ public access to read the code
  - **JIRA**: `https://its.cern.ch/jira/projects/XFITTER`
    - ★ issue tracking
- Using **Hepforge** to store data:
  - 52 datasets with corresponding theoretical predictions available at: `http://xfitter.hepforge.org/data.html`
  - recently experienced problems due to updates (transfer of new data sets not working): at the moment looking for alternatives



No	Collider	Experiment	Reaction	arXiv	Readme
1	fixedTarget	bcdms	inclusiveDis	cern-ep-89-06	README
2	hera	h1	beautyProduction	0907.2643	
3	hera	h1	inclusiveDis	1012.4355	
4	hera	h1	jets	0706.3722	README
5	hera	h1	jets	0707.4057	README
6	hera	h1	jets	0904.3870	README
7	hera	h1	jets	0911.5678	README
8	hera	h1	jets	1406.4709	README
9	hera	h1zeusCombined	charmProduction	1211.1182	
10	hera	h1zeusCombined	inclusiveDis	0911.0884	
11	hera	h1zeusCombined	inclusiveDis	1506.06042	
12	hera	zeus	beautyProduction	1405.6915	
13	hera	zeus	diffractiveDis	0812.2003	
14	hera	zeus	jets	0208037	
15	hera	zeus	jets	0608048	
16	hera	zeus	jets	1010.6167	



Developments in repository: branches

https://gitlab.cern.ch/fitters/xfitter/branches

heavy-quark differential predictions →

cbdiff
a1a0d549 · fixed bin order · 2 days ago

!!! theory interface !!! →

master default protected
c3e56115 · Merge branch 'fix_removeNotNeedeTypdef' into 'master' · 2 days ago

Ivan's talk →

PionCeres
75664c0b · Resolve "Info" name conflict between latest versions of ROOT and pdf2yaml.h · 2 days ago

Ivan's talk →

test_ceres
8f258a55 · Compile LHAPDF evolution only if it is enabled · 3 days ago

Z3Dfifs
8f369c7d · Patch force additive flag · 5 days ago

new ABMP PDF parametrisation →

abmp
6fbf57f6 · fixed compilation errors (added cmath headers) · 2 weeks ago

LO predictions for DY AFB →

afb
d806db75 · commented out new PDF plots: fixed typo · 2 weeks ago

single top NNLO predictions →

Hathorsingletop
91330cc5 · Update ReactionHathorSingleTop.h · 2 weeks ago

extenison of theory expression →

spline
8cd664a9 · fixed typo · 1 month ago

Recent developments in repository: pull requests

https://gitlab.cern.ch/fitters/xfitter/merge_requests

fix for bug with new ROOT →

remove not needed typedef, which causes naming ambiguity with ROOT TError.h (Info)
!130 · opened 3 days ago by Daniel Britzger

improvement for MC replica method →

Improve toys
!128 · opened 1 month ago by Alexander Glazov

Fix inconsistent treatment of uncertainties when using DataToTheo
!127 · opened 1 month ago by Ivan Novikov

improvement to installation script →

Update install-xfitter to install without /cvmfs
!125 · opened 1 month ago by Oleksandr Zenaiev

new option for uncertainty treatment →

New flag for datasets ForceAdditive to force all systematic uncertainties to be additive
!123 · opened 3 months ago by Alexander Glazov

update to latest ApplGrid version →

Update applgrid
!124 · opened 3 months ago by Oleksandr Zenaiev

update to PDF rotation code →

Hot fix rotate
!122 · opened 3 months ago by Alexander Glazov

Dependent Parameters
!121 · opened 3 months ago by Ivan Novikov `test_ceres`

bug fix →

Fix compilation error for certain lhapdf version
!118 · opened 5 months ago by Alexander Glazov

Fix gsl dependence for ci
!119 · opened 5 months ago by Alexander Glazov

New interface for parameters, parameterisations, decompositions, evolutions + APPLgrid reaction

Theory interface

- A new interface for theoretical predictions:
  - to facilitate developments of new calculations
  - to simplify integration of new tools
  - . . . without modifying the core xFitter code
- Developed since 2016, in December 2017 merged into master
- In 2018 and 2019 actively tested and used in physics analyses (by both xFitter team and external users)
- Current status
  - implemented for vast majority of existing theory & data
  - available in master, correspondingly updated data files available at Hepforge with '-thexp' name suffix
  - **still need extensive testing and your feedback!**

C++ header for NC DIS

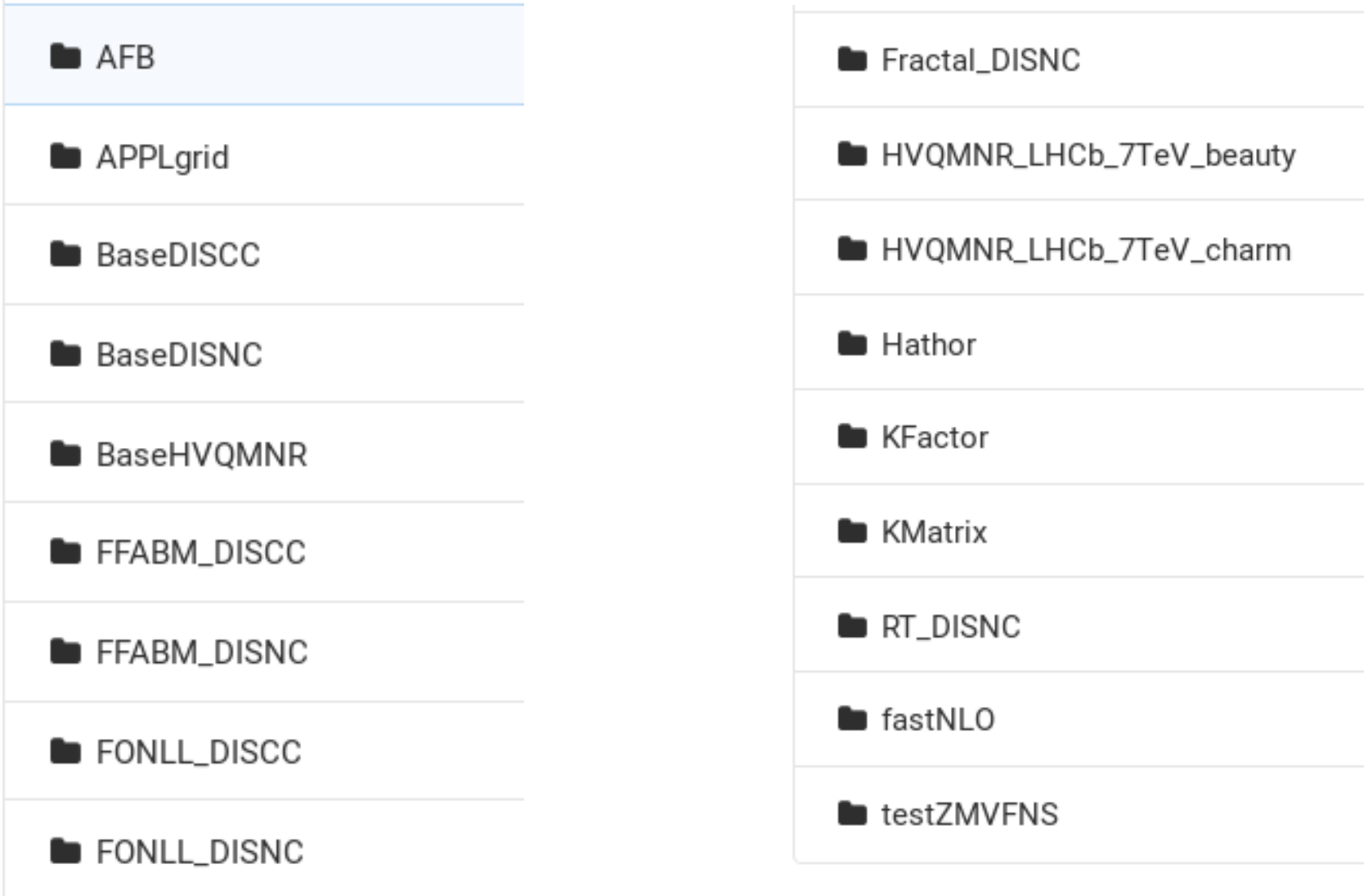
```
class ReactionBaseDISNC : public ReactionTheory
{
 public:
    ReactionBaseDISNC(){};
 public:
    virtual string getReactionName() const { return  "BaseDISNC" ;};
    int initAtStart(const string &);
    virtual void setDatasetParamters( int dataSetID, map<string,string> pars, map<string,double> parsDataset) override ;

    //!< Initialize all EWK couplings here:
    virtual void initAtIteration() override;
    virtual int compute(int dataSetID, valarray<double> &val, map<string, valarray<double> > &err) override ;
 protected:
```

NC DIS data file

```
4  &Data
5    Name = "HERA1+2 NCep 920"
6    IndexDataset = 105
7    Reaction = "NC e+-p"
8
9    TheoryType = 'expression'
10   TermName = 'R'
11   TermType = 'reaction'
12   TermSource = 'use:hf_scheme_DISNC'
13   TermInfo = 'type=sigred:flav=incl:echarge=1:epolarity=0'
14   TheorFxpr = 'R'
```

Theory interface: available processes

https://gitlab.cern.ch/fitters/xfitter/tree/master/reactions



Theory interface: selected new features (1)

- Hathor single top NNLO predictions:
  - interfaced new process which was not available in xFitter
  - calculations at NNLO using pole or $\overline{\text{MS}}$ running top quark mass
  - done by Laia Parets Peris (DESY summer student) and Katernia Lipka, ready to be merged into master
- KMatrix:
  - new linear algebra operation
  - useful for rebinning or effects like detector resolution
  - done by Lukas Materne (DESY summer student) and S.Z., in master
- AFB:
  - LO predictions for DY AFB
  - dedicated physics analysis focused on PDF constraints from AFB measurements by xFitter team
  - done by Juri Fiashi and S.Z., in master

Theory interface: selected new features (2)

- cbdiff:
  - extension of MNR NLO calculations for differ. heavy-quark distributions
  - new options: e.g. use $\overline{\text{MS}}$ mass, easier implementation of new data sets
  - done by S.Z., to be merged in master soon
- charm CC process in ZMVFNS, FF and FONLL:
  - dedicated physics analysis focused on future measurements at LHeC by xFitter team
  - done by S.Z. and Valerio Bertone, in master
- spline:
  - spline interpolation as new functionality in theory expression
  - useful for parameter extractions, e.g. m_t using several sets of ApplGrid tables generated with different values of m_t
  - used in CMS-PAS-TOP-18-004
  - done by S.Z., to be merged in master soon

Theory interface: example of KFactor usage

Data file:

```
TheoryType = 'expression'
TermName = 'Process1','Process2','Mask1','Mask2'
TermType = 'reaction','reaction','reaction','reaction'
TermSource = 'ReactionA','ReactionB','KFactor','KFactor'
TermInfo =
'keyA=valueA','keyA=valueA','keyA=valueA','FileName=maskA.txt','FileName=maskB.txt'
TheorExpr = 'Process1*Mask1+Process2*Mask2'

NData = 2
...
```

maskA.txt:

```
1
0
```

maskB.txt:

```
0
1
```

- 'ProcessA' is used for 1st data point, 'Process B' for 2nd
- one can further e.g. normalise to the sum of 1st + 2nd data points etc.
- such things are done by playing with text files, not touching core code, recompiling etc.

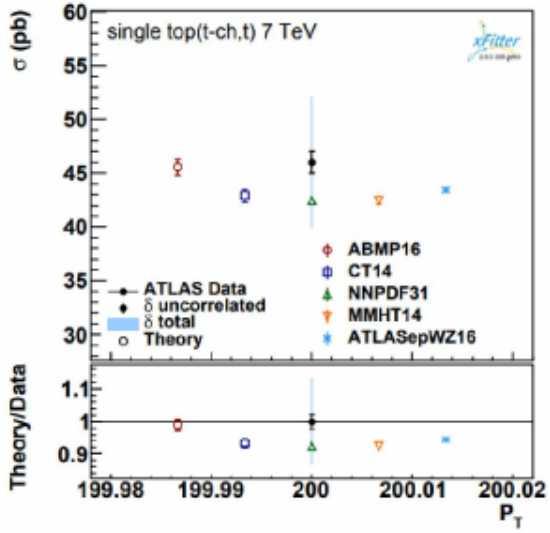
  $\Rightarrow$ this makes xFitter very flexible and handy tool (now can be achieved even more elegant using KMatrix)

Cross section and ratio dependency on PDFs

ATLAS 7 TeV, arXiv: 1406.7844

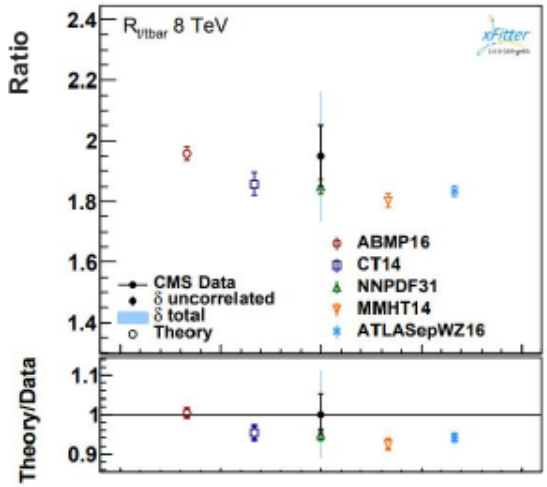
Single top quark production cross section

PDF set	σ_t(pb)	χ^2
NNPDF3.1_nnlo_pdfas	42.4 ± 0.3	0.33
CT14nnlo	42.9 ± 0.5	0.33
MMHT2014nnlo68cl	42.5 ± 0.3	0.56
ABMP16_5_nnlo	45.6 ± 0.7	0.030
ATLAS-epWZ16	43.4 ± 0.3	0.37



Ratio = σ_t / $\sigma_{\bar{t}}$ CMS 8 TeV, arXiv: 1403.7366

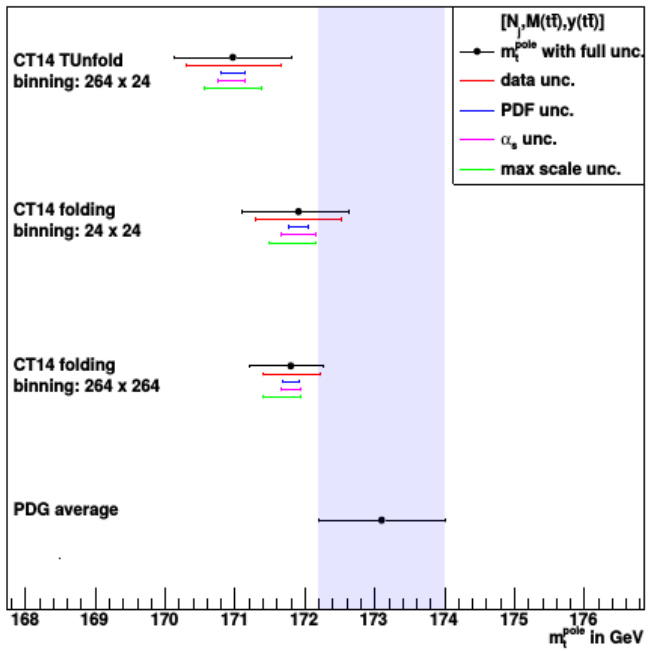
PDF set	Ratio	χ^2
NNPDF3.1_nnlo_pdfas	1.85 ± 0.03	0.060
CT14nnlo	1.86 ± 0.04	0.060
MMHT2014nnlo68cl	1.80 ± 0.03	0.11
ABMP16_5_nnlo	1.96 ± 0.02	0.010
ATLAS-epWZ16	1.84 ± 0.02	0.070



Results(private work)

$$m_{\mathrm{t}}^{\mathrm{pole}} = \left(171.80^{+0.47}_{-0.60}\right)\ \mathrm{GeV}$$

- largest uncertainty from response matrix variation (data)
- variation -0.34% and +0.27%
- improvement in uncertainty through finer binning: ∼30%
- improvement in uncertainty through folding: ∼8% (∼35%)



Summary of theory interface status

- available for majority of processes
- enabled by default now
- comes with new file `parameters.yaml` (replaced `ewparam.txt`)
- requires YAML: providing script to install it `tools/install-yaml`
- requires compiler version compatible with C++11 standard
- **please test and report any problems! [xfitter-help@desy.de]**