HATHOR

HAdronic Top and Heavy quarks crOss section calculatoR.

— Release Notes —

See [1] for the original program description.

Hathor Version 1.3

Release date: June 2012

—Enhancements—

High energy behavior

In Ref. [2] the high energy limit of the cross section is investigated in NNLO accuracy. The dominant behavior can be predicted through BFKL dynamics. The subleading terms were estimated from a Padé approximation. In Ref. [2] it is shown that this information can be used to further constrain the $\text{NNLO}_{\text{approx}}$ predictions obtained from soft gluon resummation. In Hathor version 1.3 the high energy approximation is set as default with the (A+B)/2 prescription as described in Ref. [2]. The A-, B- or (A+B)/2-schemes as described in Ref. [2] can be selected using the member function `setHighEnergyScheme(ABSCHEMES scheme)` with `HATHOR::ASCHEME`, `HATHOR::BSCHEME`, or `HATHOR::ABSCHEME` as argument. The high energy approximation can be switched off with the option `NOHIGHENERGY`. A detailed example reproducing the central values from Tabs. 1–3 of Ref. [2] is given in `demo-hathor-1.3.cxx`.

Exact NNLO results for qq channel

In Ref. [3] first results for the NNLO corrections for the $q\bar{q} \to t\bar{t}$ channel are presented. The results are given in terms of a fit function. We have implemented the corresponding formulae (i.e. eqs. (3)–(8) of [3]) in the current Hathor version.

1. Per default Hathor uses the option `NNLO` with the exact results for the $q\bar{q}$ channel while for the remaining contributions $\text{NNLO}_{\text{approx}}$ is used together with the high energy approximation of [2] in the (A+B)/2 scheme.

2. To activate the approximate results (as available in previous version 1.2) use the option `NNLOAPPROX` together with the option `NOHIGHENERGY`.

If the exact NNLO results for $q\bar{q}$ channel is used Ref. [3] must be cited.

—Defects Addressed—

Inconsistent handling of error PDFs in rare circumstances

In previous Hathor versions a minor inconsistency was introduced when error PDF sets were used with different values for α_s for each error PDF (i.e. ABKM or ABM set). The problem

occured only when the option PDF_SCAN was used for the specific PDF sets. We note that most PDF sets use a common α_s value for all error PDFs so that the results are not affected by the inconsistency. In the case of ABKM and ABM the difference of the different α_s values is very small so that the total error introduced is at the per cent level or even smaller.

Hathor Version 1.2

Release date: September 2011

—Enhancements—

Runtime

Minor change in phase space mapping and PDF evaluation to improve speed.

—Defects Addressed—

PDF error evaluation

Fix concerning the evaluation of PDF uncertainties:
Since LHAPDF does not provide a method to figure out whether asymmetric or symmetric errors are used within the error PDFs it was up to now up to the user to select one or the other by adding the option PDF_SYM_ERR (Hathor default is asymmetric error). However even with the option PDF_SYM_ERR set the additional factor $1/\sqrt{N}$ required for NNPDF was not properly taken into account (thanks to U. Husemann for pointing this out).
In version 1.2 we have taken now the following approach:

- New option NNPDF is introduced to select the NNPDF error evaluation. This option also forces PDF_SYM_ERR to be set.
- If the strings "NNPDF" or "abkm" are found in the PDF name the option PDF_SYM_ERR is used and in case of NNPDF the additional factor $1/\sqrt{N}$ is introduced.
- New functions to register an own function provided by the user to evaluate the PDF uncertainty:

  ```
  void clearErrorFun();
  void setErrorFun(void (*fun)(int n, double res[],double & up,
                               double & down))
  ```

  n is the number of PDF sets, double res[] the result of the integration for each set (res[0] is the central value), up and down are the up and down errors as evaluated by the user in fun.

  Example:

```
void symerr(int n,double res[], double & up, double & down){
  for(int i=1; i <= n; i++){
    up += pow(res[i]-res[0],2);
  }
  up = sqrt(up);
  down = up;
}
...
Lhapdf lhapdf(pdfname);
Hathor XS(lhapdf);
XS.setErrorFun(symerr);
```

To remove the function use: `XS.clearErrorFun();`

Hathor Version 1.1

Release date: March 2011

—Enhancements—

—Defects Addressed—

PDFs error evaluation

Using NNPDF created a segmentation fault when using `PDF_SCAN`. Problem fixed, PDF sets with up to 1020 error PDFs are now possible.

References

[1] M. Aliev, H. Lacker, U. Langenfeld, S. Moch, P. Uwer and M. Wiedermann, *"HATHOR: HAdronic Top and Heavy quarks crOss section calculatoR"*, Comput.Phys.Commun. 182, 1034 (2011), `arxiv:1007.1327`.

[2] S. Moch, P. Uwer and A. Vogt, *"On top-pair hadro-production at next-to-next-to-leading order"*, `arxiv:1203.6282`.

[3] P. Bärnreuther, M. Czakon and A. Mitov, *"Percent level precision physics at the Tevatron: first genuine NNLO QCD corrections to $q\bar{q} \to t\bar{t} + X$"*, `arxiv:1204.5201`.