FlavBit update

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FlavBit: the past

⇛ Theory predictions calculated via SuperIso v2.3.
⇛ Theoretical errors hard-coded and scaled if needed.

⇛ Experimental results are stored in YAML files and read by `Flav_reader`.
⇛ The class also store theoretical errors.
⇛ Errors were symmetrized and other nasty assumptions were made.

Future

Each of the elements of the code is there and we just need to put them together inside Gambit.

FlavBit: present and future

⇛ Theory predictions calculated via SuperIso v3+.
⇛ Program can calculate theoretical errors for each scanning point.

⇛ Experimental results are stored in YAML files and read by external program called `HEPLike`.
⇛ Very nice features included.

HEPLike

⇛ High Energy Physics Likelihood (HEPLike).

- Open source software.
- With separate database of measurements.
- Statistics library.
- Can be interfaced with existing codes.

⇛ It constructs the experimental likelihoods for you!

⇛ Does work with both the χ^2 and (log-)likelihood fits.

⇛ Useful utilities for creating citations and database search.

HEPLike

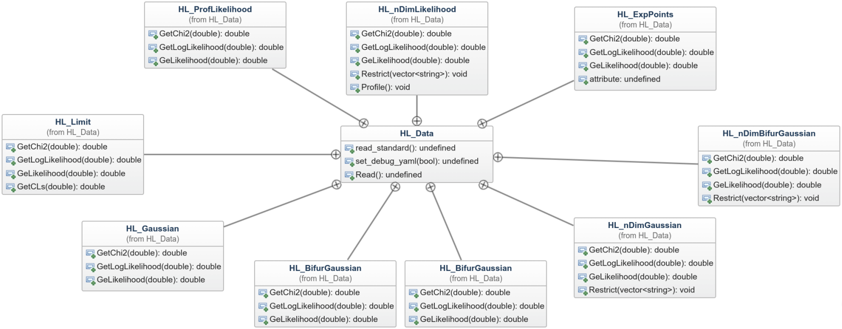
⇛ The are couple of measurement types:

- Upper limits,
- Single measurement with symmetric uncertainty,
- Single measurement with asymmetric uncertainty,
- Multiple measurements with symmetric uncertainty,
- Multiple measurements with asymmetric uncertainty,
- One dimensional likelihood function,
- n-dimensional likelihood function.

Bonus

In addition we provide a way for the future that the experiments can publish the dataset.

HEPLike - code structure



Measurement encoding, `Hl_Data`

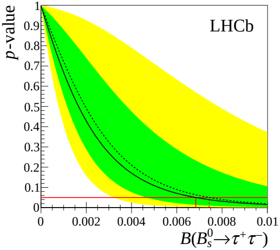
⇒ Measurements are stored in `YAML` file:


```yaml
BibCite: Aaij:2017vbb
BibEntry: '@article{Aaij:2017vbb,
      author         = "Aaij, R. and others",
      title          = "{Test of lepton universality
                         with $B^{0} \rightarrow
                        K^{*0}\ell^{+}\ell^{-}$ decays}",
      collaboration  = "LHCb",

      }
      '
 DOI: 10.1007/JHEP08(2017)055
 Process: R_{Kstar^{*}}
 FileName: RKstar.yaml
 Name: RKstar
 Source: HEPDATA
 SubmissionYear: 2017
 PublicationYear: 2018
 Arxiv: 1705.05802
 Collaborations: LHCb
 Kinematics: q2>1.1 && q2<6.
 HLAuthor: Gal Anonim
 HLEmail: gal.anonim@ifj.edu.pl
 HLType: HL_ProfLikelihood
```

Upper limits, `HL_Limit`

⇛ Example of published p-value scans:



⇛ Information coded as:

```
Cls:
- [0.0, 1.0]
- [1.0e-10, 0.977091694706]
- [2.0e-10, 0.954375824297]
- [3.0e-10, 0.93200355343]
- [4.0e-10, 0.910630700546]
- [5.0e-10, 0.889382721809]
```

Upper limits, HL_Limit

$$pdf(x) = \frac{1}{2^{1/2}\Gamma(1/2)} x^{1/2-1} e^{-x/2}, \quad (1)$$

which had the cumulative distribution function defined as:

$$cdf(x) = \frac{1}{\Gamma(1/2)} \gamma(1/2, x/2). \quad (2)$$

In the above equations the $\Gamma(x)$ and $\gamma(k, x)$ correspond to Gamma and incomplete gamma functions. By revering the $cdf(x)$ one can obtain the χ^2 value:

$$\chi^2 = cdf^{-1}(1-p), \quad (3)$$

and if needed the log-likelihood:

$$-\log(\mathcal{L}) = \frac{1}{2}\chi^2, \quad (4)$$

Single measurement, symmetric error, `HL_Gaussian`

⇛ Well this is as simple as:

```
Observables:
– [ "Br_A2BCZ", 0.1, 0.05, 0.01 ]
```

⇛ The χ^2 is simple:

$$\chi^2 = \frac{(x_{obs} - x)^2}{\sigma^2_{stat} + \sigma^2_{syst}}, \quad (5)$$

⇛ Wilks theorem can be used to translate to (log-)likelihood.

Single measurement, symmetric error, `HL_Gaussian`

⇛ Well this is as simple as:

```
Observables:
- [ "Br_A2BCZ", 0.1, 0.05, 0.01 ]
```

⇛ The χ^2 is simple:

$$\chi^2 = \frac{(x_{obs} - x)^2}{\sigma^2_{stat} + \sigma^2_{syst}}, \tag{6}$$

⇛ Wilks theorem can be used to translate to (log-)likelihood.

Multiple measurement, symmetric error, HL_nDimGaussian

⇛ You need to pass two arguments:

```
Observables:
- [ "BR1", 0.1, 0.02]
- [ "BR2", 0.2, 0.01, 0.01]
- [ "BR3", 0.4, 0.04]
Correlation:
-  [ "BR1", "BR2", "BR3"]
-  [ 1.  ,  0.2 ,  0    ]
-  [ 0.2,   1.,    0.  ]
-  [ 0  ,   0.,   1.   ]
```

⇛ From this one constructs the covariance matrix, and evaluates the χ^2:

$$\chi^2 = V^T \mathrm{Cov}^{-1} V, \tag{7}$$

Measurement, asymmetric error, HL_BifurGaussian, HL_ndimBifurGaussian

⇛ You need to pass two arguments:

```
Observables:
- [ "BR1", 0.1, +0.02, -0.01, 0.02]
- [ "BR2", 0.2, +0.01, -0.05, +0.03, -0.02]
- [ "BR3", 0.3, +0.04, -0.03, 0.05]
Correlation:
-  [ "BR1", "BR2", "BR3"]
-  [ 1. ,   0.1 ,   0.2     ]
-  [ 0.1,     1.,    0.1  ]
-  [ 0.2  ,    0.1,   1.    ]
```

⇛ We choose to interpret this as Bifurcated Gaussian:

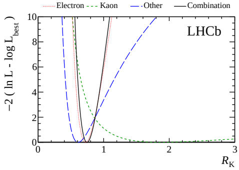
$$\mathrm{Cov}_{i,j} = \begin{cases} \mathrm{Corr}_{i,j}\ \sigma_+^i \sigma_+^j, & \text{if } x^i \geqslant x^i_{obs} \text{ and } x^j \geqslant x^j_{obs} \\ \mathrm{Corr}_{i,j}\ \sigma_+^i \sigma_-^j, & \text{if } x^i \geqslant x^i_{obs} \text{ and } x^j < x^j_{obs} \\ \mathrm{Corr}_{i,j}\ \sigma_-^i \sigma_+^j, & \text{if } x^i < x^i_{obs} \text{ and } x^j \geqslant x^j_{obs} \\ \mathrm{Corr}_{i,j}\ \sigma_-^i \sigma_-^j, & \text{if } x^i < x^i_{obs} \text{ and } x^j < x^j_{obs} \end{cases} \tag{8}$$

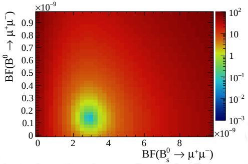
Likelihoods, HL_ProfLikelihood, HL_nDimLikelihood

⇛ Here we add just the location of ROOT object.

```
ROOTData: data/HEPData-ins1599846-v1-Table_1.root
TGraphPath: "Table 1/Graph1D_y1"

ROOTData: data/LHCb/RD/Bs2mumu_5fb/histB2mumu.root
TH2Path: "h_2DScan"
```





⇛ This is the best way to publish results!!!

⇛ The problem is in what way one should publish the higher dim likelihoods?

Publishing data `HL_ExpData`

⇛ The `YAML` entry:

```
ROOTData: data/toy/data.root
TTreePath: t
Observables:
- [ x ]
- [ y ]
- [ z ]
Weight: w
```

⇛ Set the PDF you want to fit:

```
double (*fun)(vector<double> par , vector<double> point)
```

⇛ The program will evaluate the (log-)likelihood on the whole dataset for given parameters.

⇛ You only need a scanning tools and you are done.

Useful functions

⇛ Search for measurement you need:

```
python lookup.py --Arxiv 1705.05802
Found files:
../data/examples/RKstar_lowq2.yaml
```

⇛ Create citation file:

```
Aaij:2017vbb
b2mumu.yaml
```

To prepare the `BiBtex` file user should run the `make_citations.py` script located in the `utils` directory:

```
cd utils
python make_citations.py list.txt
```

Other things in the pipeline, a bit lost but need to reactivated

⇛ Backending `flavio`.

⇛ Backending `EOS`.

Backup