AFit

A Maximum Likelihood Fitting package based on RooFit and TMVA

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Overview

- Why do we need more than RooFit?
- Available PDFs
- Using AFit PDF builders
- Using AFitMaster to build the model
- Utilities
- Where to find out more information

Why do we need more than RooFit?

- RooFit is a flexible, reliable established fitting package.
- But…
  - Complicated fits take a lot of time to prepare and validate.
  - We lock into a PDF configuration when we write the fit code.
  - Need some impetus to change our analysis…
    - Takes time to modify macros.
    - Can be a real headache!
- The $\mathcal{AFit}$ extension uses an ASCII configuration file to define the fit model.
  - Quick and easy to modify a fit model.
  - A few more 1D PDFs available than RooFit.
  - Minimal coding required (undergraduates can learn how to use aspects of this tool quickly).
  - Utilities to help validate the fit.

Available PDFs

PDF	Pdf Factory Label
Argus	argus
Breit-Wigner	breitwigner
Relativistic Breit-Wigner	relbreitwigner
Bukin	bukin
Chebychev Polynomial	chebyN
Crystal Ball	cbshape
Decay	decay
BCPDecay	cpdecay
BDecay	bdecay
Exponential	exponential
Gaussian	gaussian
Asymmetric Gaussian	agaussian
Generic PDF	generic
Gounaris-Sakurai	gounarissakurai
Helicity	helicity
Histogram	1dhist
KEYS	1dkeys
Landau	landau
Novosibirsk	novosibirsk
Polynomial	polyN
PSF	psf
Resolution‡	resolution
Sigmoid	sigmoid
Step/Veto	step
Voigtian	voigtian
Composite Add PDF	add:x,y,...
Composite Multiply PDF	multiply:x,y,...
Multi-dimensional PDFs	–

- PDF library includes everything you'd expect
  - RooFit PDFs [only 2D missing]
  - Common line-shapes.
  - Sigmoid
  - Veto/step
  - Resolution models
  - Decay models for CP fitting
- Add PDFs together in 1D.
- Multiply PDF by an 'efficiency function' (e.g. helicity distribution).
- Multiply PDFs to make ND.

Using AFit PDF builders

- What is a builder?
  - Each AFit PDF is made using an AFitAbsPdfBuilder derived object.
  - Contains a set of variables: RooAbsReal and RooCategory types that define the shape of the PDF.
    - This is a RooArgSet called `'varSet'`
  - Makes a RooAbsPdf by calling the `getPdf()` function.

```
// the discriminating variable x is the beam constrained B meson mass.
RooRealVar x(''x'', '''', 5.25, 5.29);

// The AUGUS PDF
AFitArgus argus(x, ''arguspdf'');
RooAbsPdf * argusPDF = argus.getPdf();
```

Discriminating variable

AFit pdf builder

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Discriminating variable

AFit pdf Builder

PDF to use for fitting

Unique name of PDF

Using AFit PDF builders

- The builder class has
  - Instances of fit parameters (and the `varSet`).
  - Interface to read parameters from a text file.

e.g. The `AFitArgus` instance has data members

`xi`	=	ξ
`endpoint`	=	m_0

Where the PDF is:

$$\mathcal{P}(m\,;m_0,\xi) = \frac{1}{N}\cdot m\sqrt{1-(m/m_0)^2}\cdot\exp(\xi\,(1-(m/m_0)^2))\cdot\theta(m<m_0)$$
$$\text{where } \theta(m<m_0)=1 \text{ and } \theta(m>m_0)=0.$$

The configuration file to read is set using the

```
AFitAbsPdfBuilder::setDataCard(const char *)
```

Function. When `getPdf()` is called the variables in `varSet` are read from the specified configuration file.

- Can be accessed via a PDF Factory …

Using AFit PDF builders

- … the pdf factory: used to get any type of builder.

AFitAbsPdfBuilder * AFitPdfFactory::makePdf(TString name, TString type, RooAbsReal & var);

- Make a 1D pdf with the specified name, of the specified type (see list on page 4) and the discriminating variable var.

AFitAbsPdfBuilder * AFitPdfFactory::makeConditionalPdf(TString name, TString type,
RooAbsReal & var, RooAbsReal & conditionalvar);

- As above, but for a PDF with a conditional variable: e.g. $\mathcal{R}(\Delta t, \sigma(\Delta t))$.

AFitAbsPdfBuilder * AFitPdfFactory::makePdf(TString name, RooArgList &discVarList);

- Make a multi-dimensional PDF.

Using AFitMaster to build the model

- Build a complicated model with a 2 line ROOT macro:

```
AFitMaster master(‘‘mydatacard.txt’’);
RooAbsPdf * pdf = master.getPdf();
```

- Have to specify fit configuration in text file:

```
[FitConfiguration]
// specify the variables to use in the fit
variables = bMes,bDeltaE
// specify the names of the signal and background components
components = signal,continuum,Bbg0
fitOptions = etrmh

// set the limits and initial values of the variables used
bMes = 5.2700 +/- 0 L(5.25 - 5.29) B(30)
bDeltaE = 0.0000 +/- 0 L(-0.3 - 0.3) B(30)

// set the component types
signal = default
continuum = default
Bbg0 = default

// give initial values for the yields of each component
signalYield = 500.00 +/- 10.000 L(-100 - 10000)
continuumYield = 2000.00 +/- 10.000 L(-100 - 10000)
Bbg0Yield = 50.000 +/- 10.000 L(-100 - 10000)
```

You define the:

variables

fit components

component types

fit yields (assumes you want to do an extended-unbinned ML fit.

Using AFitMaster to build the model

```
// define the shapes used for the signal M_ES and ΔE PDFs
[signal]
signal_bMes_type = gaussian
signal_bDeltaE_type = landau

// define the shapes used for background M_ES and ΔE PDFs
[continuum]
continuum_bMes_type = argus
continuum_bDeltaE_type = poly2

// define the shapes used for background M_ES and ΔE PDFs
[Bbg0]
Bbg0_bMes_type = argus
Bbg0_bDeltaE_type = poly2
```

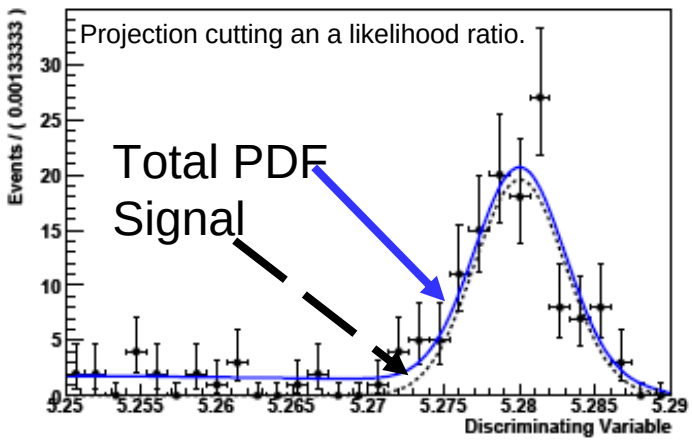
You define the:

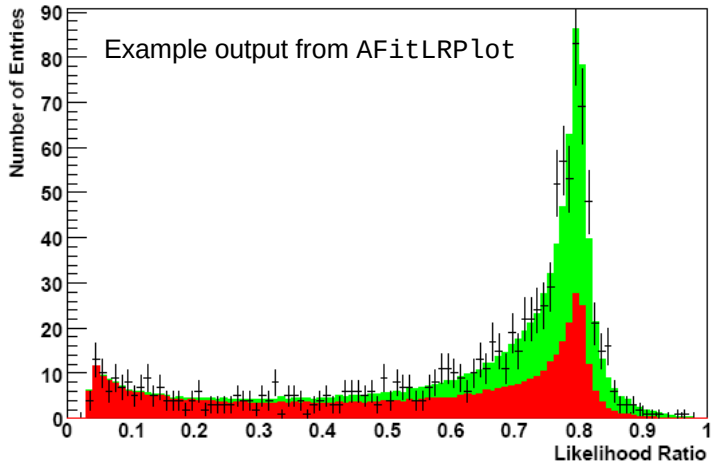
pdf types for each component

- The rest of the configuration file is used to specify the shape parameters.
  - By default all parameters are allowed to float, and have a dummy range.
  - Interface to fit to MC/data control samples (see user guide for details).
  - Can also build a RooSimultaneous using `getSimPdf()`.

Utilities

- When setting up your analysis you will think about
  - Checking for correlations between fit variables: `AFitStatTools`
  - Defining an MVA: `AFitTMVAInterface`
  - Running toys: `AFitToy`
  - Plotting: `AFitProjectionPlot`
    - Projections, (not)cutting on data, on likelihood ratio: S/(S+B)
  - Likelihood ratio plot to test global agreement between fit and MC: `AFitLRPlot`





Where to find out more information

- *AFit* is available from:

  http://pprc.qmul.ac.uk/~bevan/afit/

- Available for down load:
  - User guide
  - Source code
  - Examples available (sub-directory of source code):
    - Exponential decay fit for lifetime
    - M_{ES}-ΔE fit configuration for signal + continuum + B background
    - Simultaneous PDF
    - How to set up a simple TDCPV Δt fit.

- Web page also has quick start compile instructions.

- Requirements: ROOT v5.20 (compiled with RooFit).