How to use and customize CKMfitter

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WARNING: This is a presentation by non-experts with no previous CKMfitter experience.

For authoritative information, consult the CKM homepage and papers:

http://http://www.slac.stanford.edu/xorg/ckmfitter/

J Charles et al, Eur.Phys.J.C41:1-131,2005

H Höcker, Eur. Phys. J. C21, 225-259 (2001)

CKMfitter

- **Goals**

  global CKM matrix analysis & testing the SM

- **How it works**

  Rfit approach

- **Producing a plot**

  Paw

- **Customizing the scan**

  Inside the datacard

- **Extending the program?**

  Martin’s part of the talk!

Goals

- Perform global fit of CKM matrix.
- Plots for most interesting parameters (e.g. $(\bar{\rho}, \bar{\eta})$ plane)
- Metrology: CKM, other theory parameters, rare decay predictions
- Testing the SM

Consistent treatment of (nongaussian) exp and (nonstatistical) theory errors & constraints requires suitable statistical framework

The R(ange)fit approach

- Model parameterized by N_{th} theory parameters
  $y_i^{th} = \bar{\rho}, \bar{\eta}, m_t^{\overline{MS}}, \alpha_s, \ldots$
- Experiment gives N_{exp} constraints (measurements)
  $x_i^{exp} = a_{J/\psi K_s},\ BR(B \to Dl\nu), \ldots$
- Fixed but uncertain theory quantities affect prediction
  $x_i^{th} = x_i^{th}\left(y_i^{th}, y_j^{QCD}\right)$
  $y_j^{QCD} = f_{B_d}, \hat{B}_{B_d}, \ldots$, residual μ-dependence etc.

y^{QCD} errors generally nonstatistical. Rfit: treat them with frequentist approach (other approach: Bayesian, e.g. UTfit)

Rfit - CKM fit

Experiment gives likelihood for each x_i. Theoretical systematics also described by likelihood.

$$\mathcal{L} = \Pi_{i=1}^{N_{exp}} \mathcal{L}_{exp}(x_i^{exp} - x_i^{th}\left(\vec{y}^{th}, \vec{y}^{QCD}\right)) \, \Pi_{j=1}^{N_{th}} \mathcal{L}_j^{th}(y_j^{QCD})$$

$$\chi^2(\vec{y}) \equiv -2 \log \mathcal{L}(\vec{y})$$

- For *fixed* subset $(\bar{\rho}, \bar{\eta})$ of y_i, scan over all remaining parameters (y^{th} & y^{QCD}) and find $\vec{y}$ with minimal χ^2.
- Constant $\mathcal{L}^{th}$ implies degeneracies.
- To a region $y : \chi^2(y) > \chi_0^2$ assign a C.L. Simple only in Gaussian case. Shift χ^2 to fix total C.L. to one.

Rfit - SM test

Can also assign confidence level to Standard Model (etc)

- Restore absolute (unshifted) value of global χ^2_{min} from original likelihood distribution
- Pick some "true" point $\vec{y}$ with optimal fit (minimal χ^2)
- Monte-Carlo-generate x_i^{exp} using *experimental* likelihood
- No theory parameter variation or convolution with PDF
- Perform a χ^2 fit for $\vec{y}$ and interpret this as χ^2 distribution:

$$\text{C.L.}(\vec{y}_0) \leq \int_{\chi^2 \leq \chi^2(y_0)} \mathcal{F}_{y_0}(\chi^2) \mathrm{d}\chi^2$$

CKM fit

CKMfitter implements theory predictions $\vec{x}(\vec{y})$, the χ^2 fit and confidence level search in Fortran, C++ ($\rightarrow$ Martin's talk)

```
runckm  datacards/ckm_XXX_data ckm_YYY_flags
```

- `ckm_XXX_data` : fit parameters for a fit XXX, experimental constraints and treatment of errors. E.g.

```
$Param
    name        = 'Vub'
    value       = 4.22D-03, 0.11D-03, 0.24D-03
    TakeMeIn    = T          "Gaussian" error
    Free        = F                      "flat" error'
$end
```

- `ckm_flags_YYY` : a number of fit and plot options

Plots

- Scanning is time consuming - $\mathcal{O}(\text{day})$ on a P4 1.7GHz to reproduce the *global* CKM fit (i.e. only the allowed range contour)
- CKMfitter writes hbook files for use with PAW (data analysis tool).
- Complex PAW macros provided to create e.g. contours in (ρ, η) plane
- Can customize, but need to know some PAW
- one- and two-dimensional plots possible