Customizing CKM Fitter

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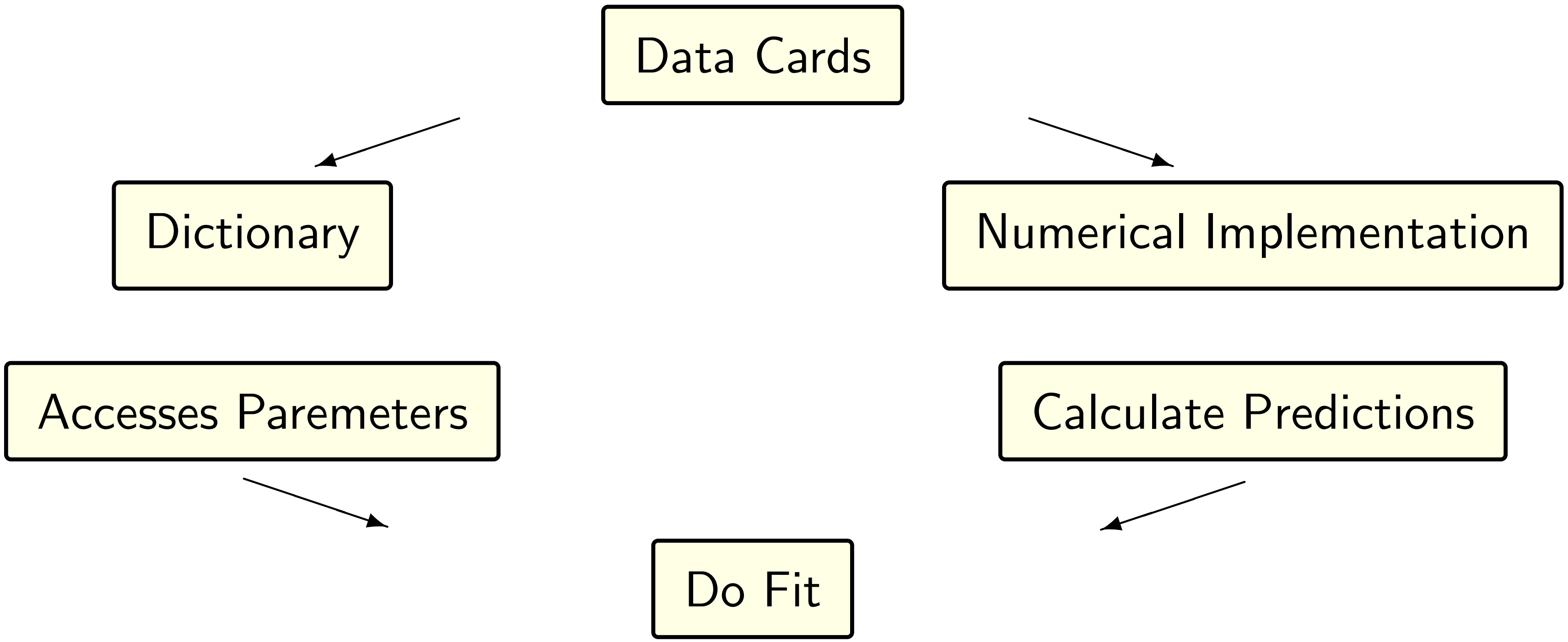
- Stucture of CKM Fitter
- Data Cards and FORTRAN
- Theoretical Expressions
- A new Calculation
- An Example: $K^+ \to \pi^+ \bar{\nu}\nu$
- Adding P_c to CKM Fitter
- "Flat" and "Gaussian"
- Summery

SFB Meeting

Structure of CKM Fitter



Dictionary

`CkmDico.F`

- Dictionary for the parameters defined in the Data Cards: Fitting and Prediction
- Dictionary for global variables
- Theory parameters are accessed with

```
Function getParFromName
         ( name, whatDoYouWant )
```

- Theory predictions (e.g. ϵ_K)

```
Function getTheoryFromName( name,
                            whatDoYouWant )

Double Precision sm_EpsK

calc  = (whatDoYouWant.ne.
                            IWantNothing)
error = 0.D0

If (name.eq.'EpsK') Then
  If (calc) getTheoryFromName =
    sm_EpsK( error )
```

Implementation of Theoretical Expressions

- Implemented in:
  - `CkmKRare.F`, `CkmKRMix.F`, ...
- ϵ_K is a typical implementation
  - Get theory parameters
  - Wolfenstein or PDG ?
  - Calculate Theoretical Expression
  - Flag $\rightarrow$ Calculate Errors

```
Double Precision Function
      sm_EpsK( dsm_EpsK )


mt = getParFromName( 'mt',
             IWantFitValue )
BK = getParFromName( 'BK',
             IWantFitValue )


If (CkmType.eq.Wolfenstein) Then
             ...    End If
```

What to do with a new calculation?

Many Constraints

Complex Statistics

Demanding Numerics

CKM Fitter has

the Constraints

Statistical Methods

Let us study this in a simple example

Our Little Project: $K^+ \to \pi^+ \nu \bar{\nu}$ at NNLO

So Far Under Control:

- $X(x_t)$: The top contribution
  - No large logs
  - Scale uncertainty at two loop of $\pm 1\%$
- Contributions of higher dimensional Ops
  - Calculated using CHPT [Isidori et al. '05]
  - $P_c(X) \to P_c(X) + 0.04 \pm 0.02$

μ_c Dependence

- $P_c(X)$: The charm contribution at NLO
  - Contains a large log $\ln \frac{m_c}{M_W}$
  - Large Logs are resummed up to NLO
    $P_c(X) = .37 \pm .04_{\text{th}} \pm .03_{m_c} \pm .01_{\alpha_s}$
- New Calculation at NNLO [Buras, MG, Haisch, Nierste '05]
  - Reduces scale dependence drastically
    $P_c(X) = .37 \pm .01_{\text{th}} \pm .03_{m_c} \pm .01_{\alpha_s}$
- Include it into CKMFitter

Our little project

Include the New NNLO calculation into the $K^+ \to \pi^+ \bar{\nu}\nu$ function of CKM Fitter

- Add a numerical Approximation of P_c to the $K^+ \to \pi^+ \bar{\nu}\nu$ function
- Now we can do a 1D Frequentist Fit
- The dominant error is due to the uncertainty in m_c, which has a flat error
- We can also use "Gaussian" errors with CKM Fitter

Make P_c accessible

- Data Cards:
  - constrNVar $= 55 + 1$,
  - constrName = 'PcKPi',
  - ...
- CkmDico.F

```
If (name.eq.'PcKpi') Then
   If (calc) getTheoryFromName =
      bghn_PcKpi( error )
```

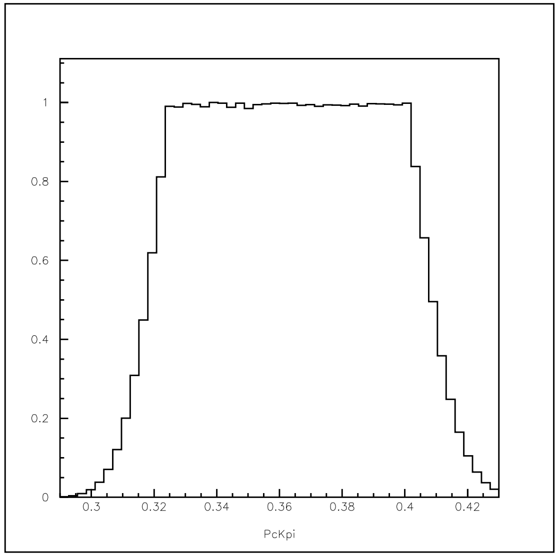
Formula for P_c

- Implement P_c in a numerical approximation
- New "Model" Parameters, e.g. μ_c, do appear
- μ_c has to be implemented into the datacards, and can be accessed via the `getParFromName` function in `CKMDico.F`
- μ_c should have a "flat" error but we can also study a "Gaussian" one

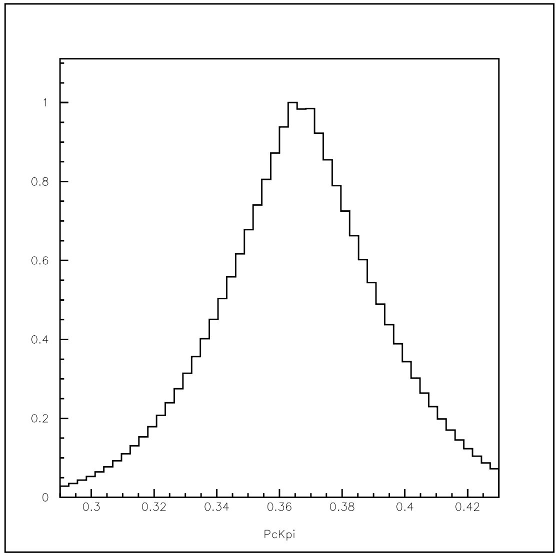
```
Double Precision Function
    bghn_PcKpi( dsm )
...
mucScale  = getParFromName
    ( 'mucScale ', IWantFitValue )
...
bghn_PcKpi =
   (0.378 + 0.622*(mc - 1.3) - ...)*
   0.2248**4/lambda**4

Return
End
```

P_c with "flat" and "Gaussian" errors

- The dominant error is due to the error in m_c
- the flat error in m_c is dominating the error in P_c: $P_c = 0.339\,^{+0.074}_{-0.025}$ (only illustrative)



- Taking the error in m_c and the other theoretical errors Gaussian we arrive at a more narrow curve: $P_c = 0.364\,^{+0.038}_{-0.033}$ (only illustrative)



Summary

- CKM Fitter provides
  - Statistical treatment of experimental errors
  - consistent "scan" over theoretical parameters
  - A huge implementation of physical observables
- Can be customized by
  - simply changing the function of a theoretical prediction
  - Adding a new observable to the Data Cards and the dictionary
  - Can we easily change the definition of an theoretical model error to a statistical one?