News on CPV in mixing using P.R. D*lν and K-tag

Martino, 4/22/2008

- Alessandro Gaz PHD thesis results:

$|q/p|-1 = xxx \pm 0.0025(stat)\pm 0.0018(syst)\pm 0.0023(bias)$

(2^{nd} best meas. @ B factories)

A good result but:

- |q/p| bias ~ 0.004 from MC, bigger than statistical error;
- Bias reflects in the largest systematic error...

Large bias on τ_{B0}, Δm_d: PDG:

- τ_{B0} = 1.490±0.004 ps — PDG: 1.530±0.009 ps
- Δm_d = 0.5699±0.0022 ps^{-1} — PDG: 0.507±0.005 ps^{-1}

➡ **Bias to be understood before publication!**

Problems of the Unbinned Fit

A) Slowness:

- Fit of the full Run1-Run5 data statistics too long (~100 free paramaters);
- Split of data set (takes ~ 24 h to fit 5% of the real data statistics);
- Result from the average of the different subsample;

B) Convergence difficulty:

- log(Likelihood) shows a structure with secondary minima;
- Measured Bias is actually a true effect or is it a feature of the fit instability?
- Same question about the evaluation of systematic uncertainties;

➡ A) and B) effects interfere:
Slowness precludes studies on convergence & stability of the fit.

Solution: Binned Fit

- Binning extended to all the relevant variables:

Δt, $\sigma(\Delta t)$, P_K, $m^2\nu$, $\theta(l\text{-}K)$ = 50K bins

8 event categories: (e/μ) X (Mixed/Unmixed) X (K^+/K^-)

➔Convergence takes ~ 8 h on the full R1-R5 data statistics!

➔Result on data compatible with the "Old-Unbinned" fit!

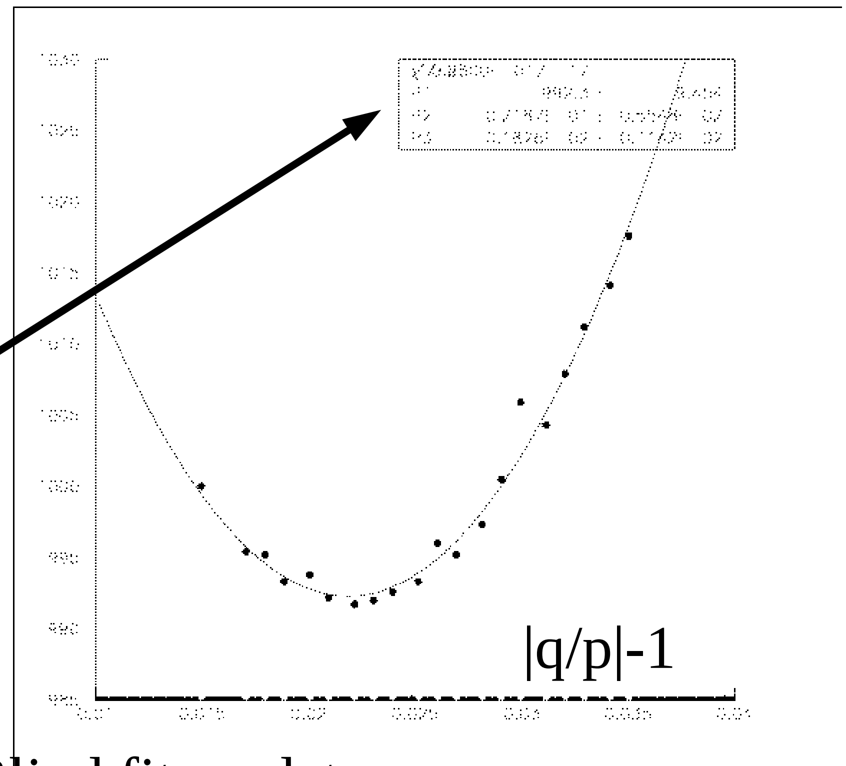
➡

- Go back to the MC in order to:
  - ➔ Define a strategy to reach the fit convergence;
  - ➔ Understand at which level of fit complexity the bias does appear (perfect/measured resolution and tagging; only signal/full sample composition);
- Re-blind the fit on real data;

Study of Fit Convergence

- Study the Δlog(L) profile around the minimum by performing a set of several fits with a fixed value of a relevant variable x (i.e. |q/p|-1, Δm_d, ...) and floating all the other parameters;
- Determination of the parameter & statistical error directly from the plot by means of a parabolic fit:

$$\log(L) = \log(L_{min}) + \tfrac{1}{2}((x - x_{min})/\sigma)^2$$



x_{min} = Best Value

σ = Statistical Error

To be compared with the nominal fit results

Blind fit on data:

|q/p|-1 = 0.022±0.002

in agreement with Alessandro thesis result

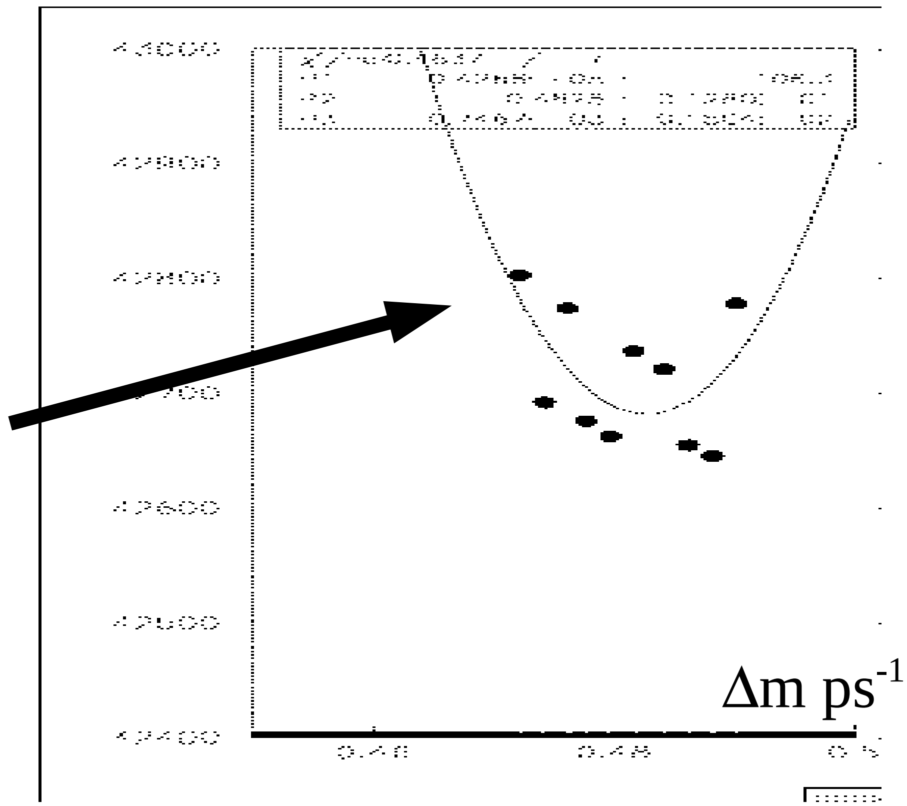
Study of Fit Convergence

•log(L) shows multiple minima: often the fit does not converge to the absolute minimum (minuit status= FAILED, usually Covariance Matrix not positive defined);

•log(L) scan is the solution!

Scan vs Δm of B^0 MC Signal with measured Δt & tag

In case of problem in the fit convergence, the parabolic fit to the log(L) profile is BAD.



Definition of Fit Strategy

Recipe to reach the convergence:

1) Perform the nominal fit;

in case of convergence problems:

2) Launch a scan on Gridka (~10 fits need a few hours);

3) Check if the parabolic fit is good & it gives x_{min} and σ in good agreement with the nominal fit;

4) Otherwise: Launch another fit starting from the parameters corresponding to the lowest minimum of the log(L) in the previous set of fits;

5) Iteratively reach a good log(L) profile;

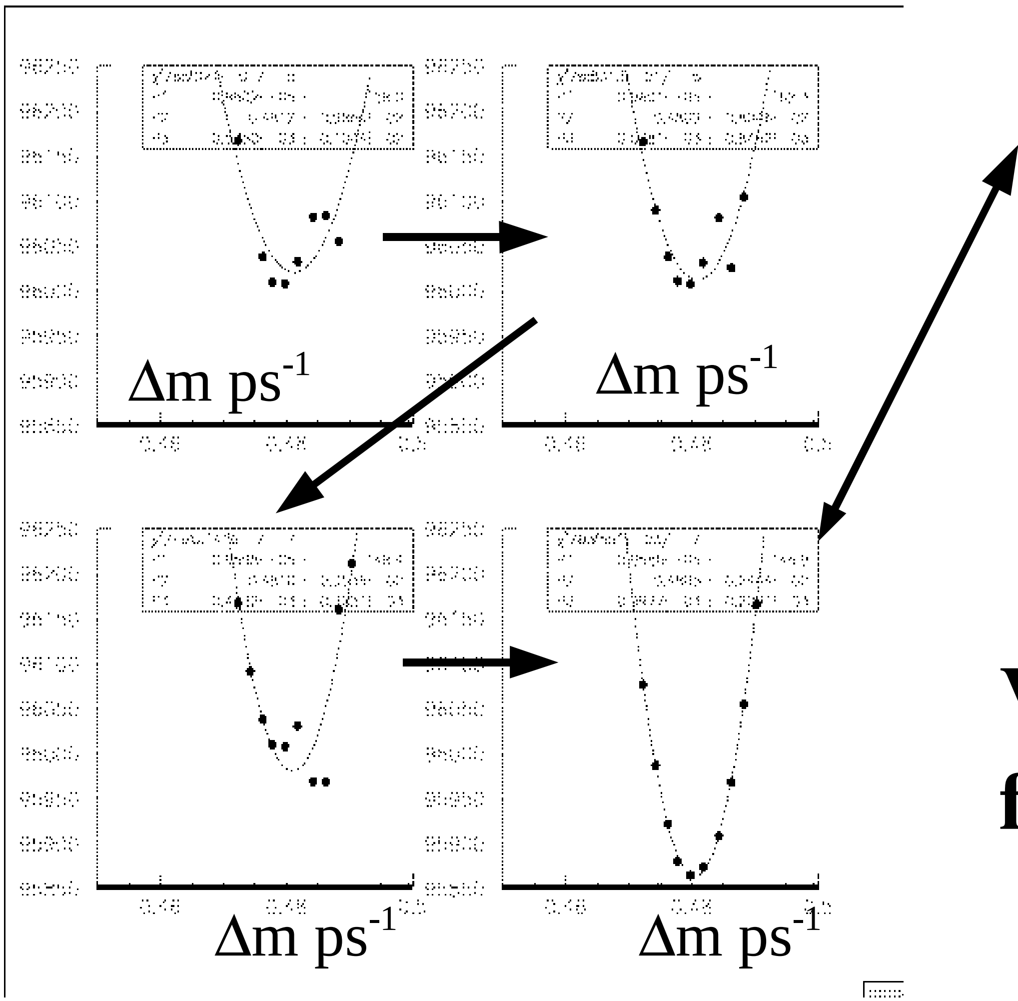
6) Perform the nominal fit starting from the parameters of the best fit of the set;

➡ The nominal fit converges!

Fit Strategy

- Example on MC: $\Delta\log(L)$ vs Δm_d:

Signal B^0 B-tag, Exper. Δt + perfect tag:



$\Delta m = 0.4805 \pm 0.0004\ ps^{-1}$

To be compared with the nominal fit result, obtained according to the recipe:

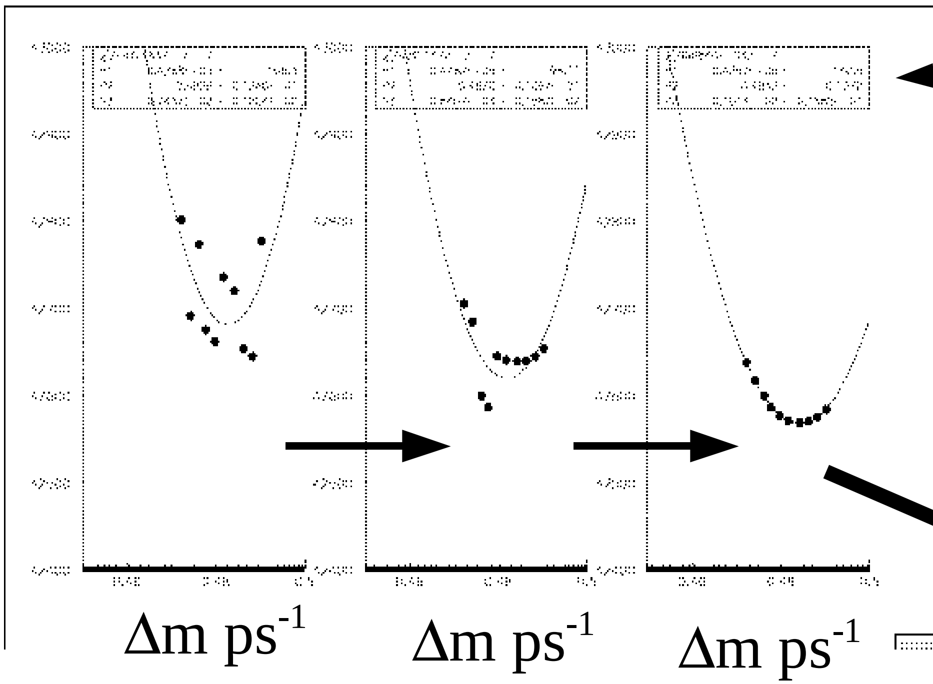
$\Delta m = 0.4803 \pm 0.0003\ ps^{-1}$

Very Good agreement found!

Fit Strategy

- Example on MC: Δlog(L) vs Δm_d

Signal B^0 B-tag+D-tag, Exper. Δt and tag:



$\Delta m = 0.4843 \pm 0.0010\ ps^{-1}$

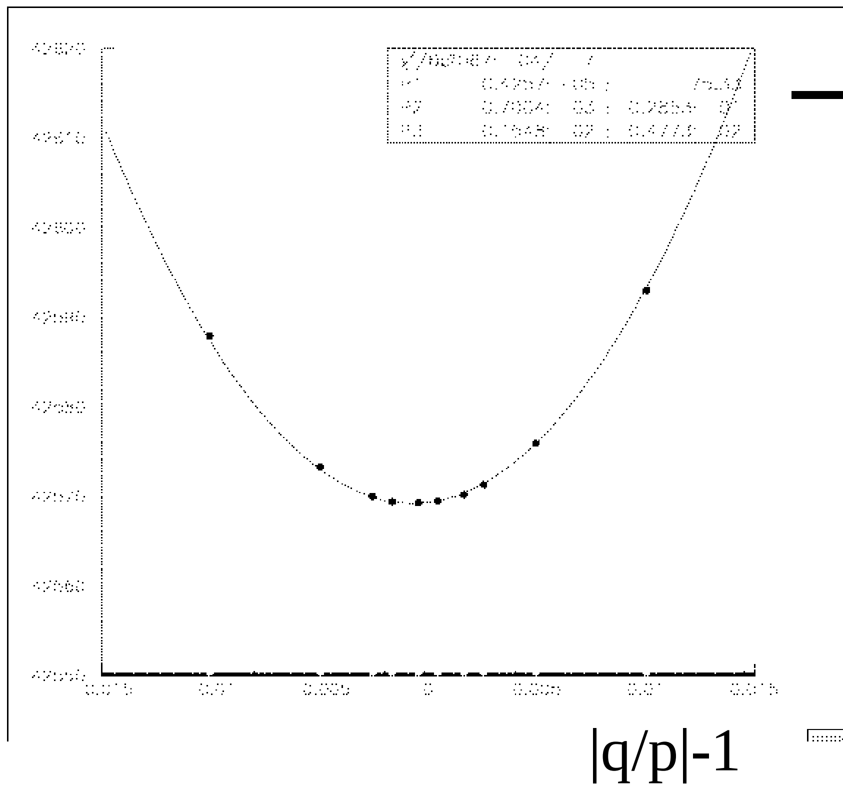
To be compared with the nominal fit result, obtained according to the recipe:

$\Delta m = 0.4842 \pm 0.0011\ ps^{-1}$

Starting from the minimum of this last scan vs Δm......

Fit Strategy

.... We got this very good profile vs |q/p|-1:



(Signal B^0 B-tag+D-tag, meas. Δt and tag)

|q/p|-1=-0.0007±0.0015

To be compared with the nominal fit result, obtained according to the recipe:

|q/p|-1=-0.0006±0.0015

The Log(L) scan strategy allow us to:

1) Reach the convergence at the “true” Log(L) minimum;
2) Check the statistical error of the nominal fit.

MC Validation: Fit Bias

- Study the bias on τ, Δm, $|q/p|$ step by step, from MC truth to experimental Δt and tagging. Add one component at a time from pure B^0 signal to full sample composition to see at which level of fit complexity the bias becomes dangerous (if it is the case...).
- Use only CONVERGED fits, obtained by means of the “log(L) Scan” recipe to avoid fit instability effects;

MC-Reference parameters:

τ_{B0}= 1.540 ps

χ_d=0.1809

Δm=0.489 ps^{-1}

$|q/p|-1$= 0

b=0

c=0

Doubly Cabibbo Suppressed

Bias w.r.t. MC truth

B^0 Btag Signal Fit with Perfect Resolution & tagging:

Δt Bins:	20	50	100
τ_{B0}	0.0183±0.0007	-0.0062±0.0006	-0.0095±0.0006
Δm	-0.0159±0.0002	-0.0049±0.0002	-0.0033±0.0002
b	0.0019±0.0004	0.0021±0.0005	0.0021±0.0005
c	0.0000±0.0005	-0.0003±0.0004	-0.0002±0.0004

➡ Use at least 50 Δt bins; 100 Δt bins in the following

Fitted χ_d = 0.1761±0.0001 0.1778± 0.0001 0.1780± 0.0001

(in good agreement with F(mixed) = 0.1786±0.0002)

➡ -0.2% selection bias on F(mixed) (MC truth: χ_d=0.1809)
Bias of several Statistical Sigmas on τ & Δm, but <1%.

Bias w.r.t. MC truth

B^0 Btag Signal Fit with Perfect Resolution & exp. tagging:

τ_{B0}	-0.0099±0.0006
Δm	-0.0065±0.0005
b	0.0033±0.0007
c	0.0007±0.0013
χd	-0.0045±0.0002

→ Bias ~ 1.3%

Mistag effect (comparison with previous page result):

τ_{B0}	-0.0004
Δm	-0.0032
b	0.0012
c	0.0009
χd	-0.0016

→ Experimental (mis)tag is not a problem, biggest effect on Δm

Bias w.r.t. MC truth

B^0 Btag Signal Fit with Measured Δt & perfect tagging:

τ_{B0}	-0.0019±0.0011	
Δm	-0.0087±0.0003	→ Bias ~ 1.8%
b	-0.0002±0.0008	
c	0.0044±0.0009	
χd	-0.0044±0.0001	

Resolution effect (comparison w.r.t. Perfect Δt & tagging fit):

τ_{B0}	0.0080
Δm	-0.0022
b	-0.0035
c	0.0037
χd	0.0001

→ Experimental Δt resolution is not a problem, biggest effect on τ.

Bias w.r.t. MC truth

B^0 Btag+Dtag Signal Fit with Measured Δt & tagging:

τ_{B0}	-0.0169±0.0018	→ Bias ~ 1.1%
Δm	-0.0048±0.0011	
b	-0.0004±0.0013	
c	-0.0844±0.0019	
χd	-0.0049±0.0005	
|q/p|-1	-0.0006±0.0015	

- As already known, due to the Dtag resolution model, we will not be able to measure DCS parameters b, c.

- τ, Δm show a 1% bias... (nice for just "effective" parameters)... however we have to go on by adding all the missing components to determine the global analysis bias and decide if measure also τ & Δm;

- Very good result on |q/p|.

Next Steps

- Add all the backgrounds (combinatorial, charged B decays, continuum) to the fit and complete the MC validation;
- Finalize the procedure on a BLIND fit to the real data;
- Perform a Toy MC validation;
- Re-determine the Systematic Uncertainties;
- Summer Conference/Publication?
- Alessandro Gaz left the group after two years of fruitful work...
- ... but Enrico Feltresi from Dresda is ready to go on!