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

Martino, 5/28/2008

•Alessandro Gaz PHD thesis results:

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

(2nd 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	1.530 ±0.009 ps
•Δm_d= 0.5699± 0.0022 ps^{-1}	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, $m^2\upsilon$, Θ(l-K) = 50K bins

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

➔Convergence takes ~ 15 h on the full R1-R5 data statistics by floating all the parameters!

➔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;

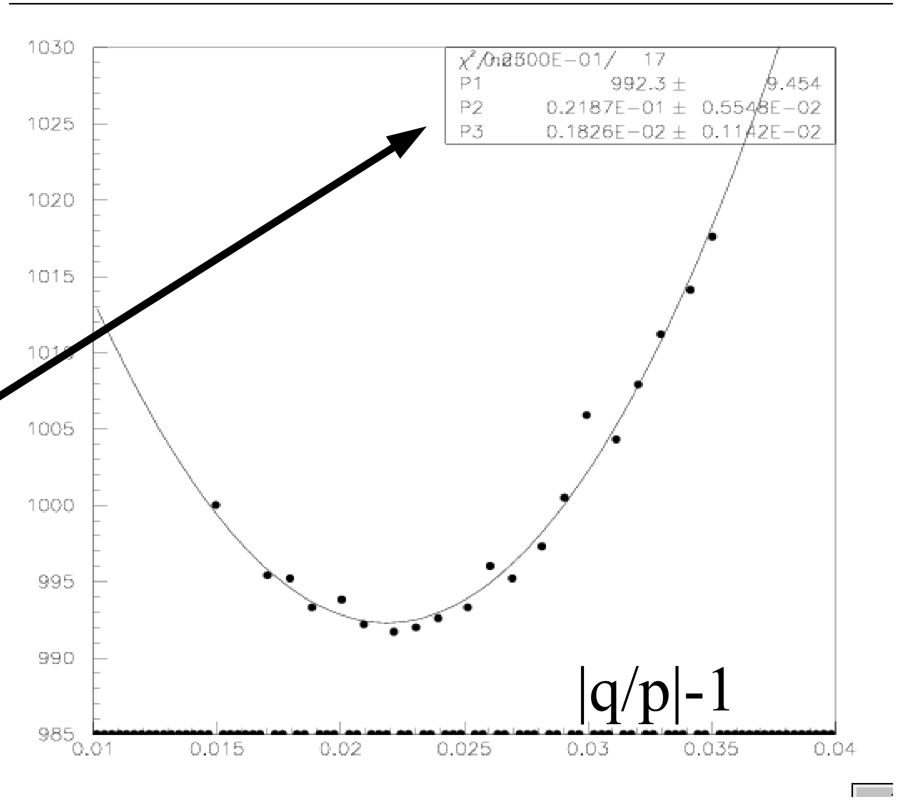
- Determination of the parameter & statistical error directly from the plot by means of a parabolic fit:

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

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

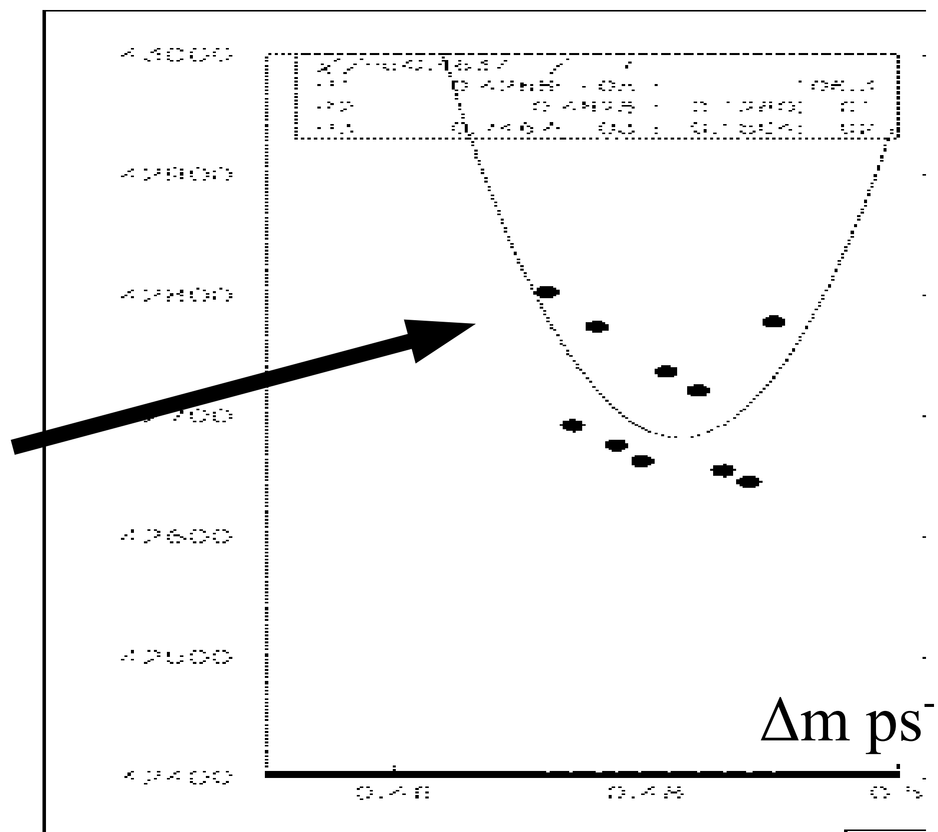
Study of Fit Convergence

•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 (often using experimental resolution or Signal+BKG sample):

2) Launch a scan on Gridka (~10 fits need a few hours → a couple of days depending on sample statistics & fit complexity)

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 scan starting from the parameters corresponding to the lowest minimum of the log(L) in the previous one;

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

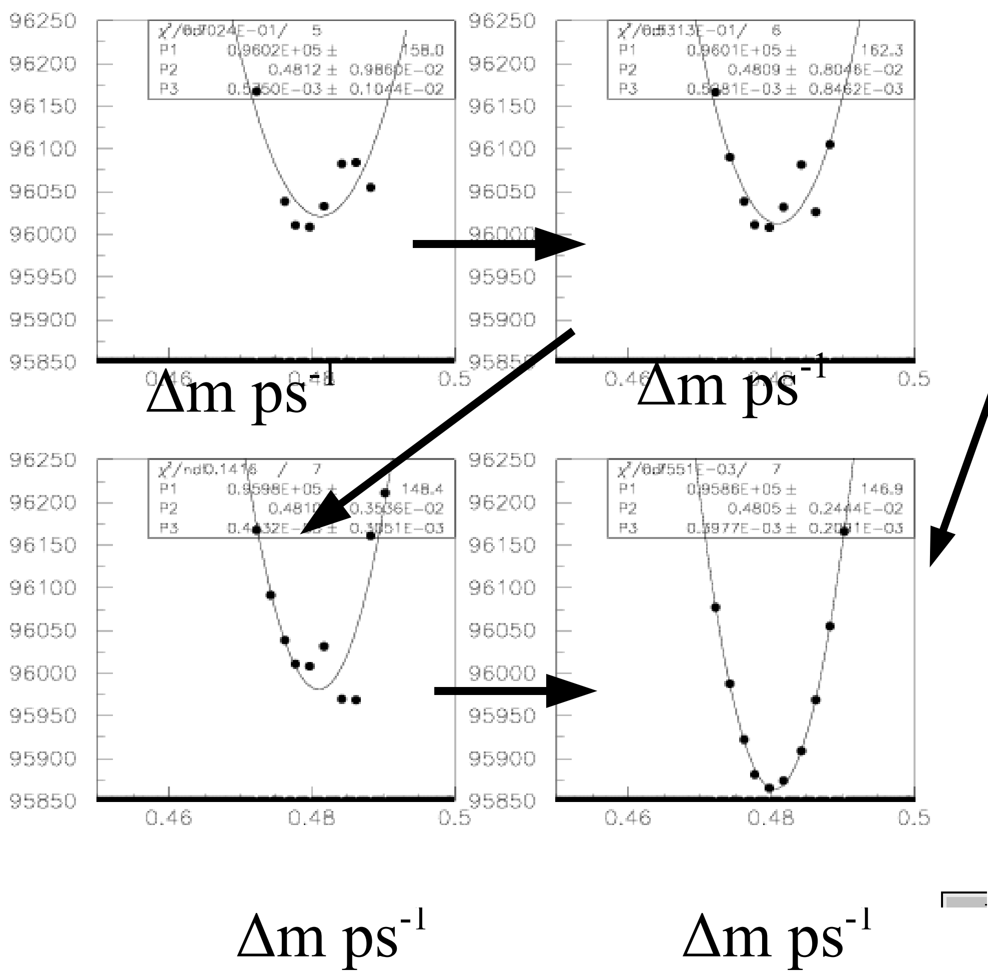
6) Perform the nominal fit starting from the parameters of the best fit of the set;

→ 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:

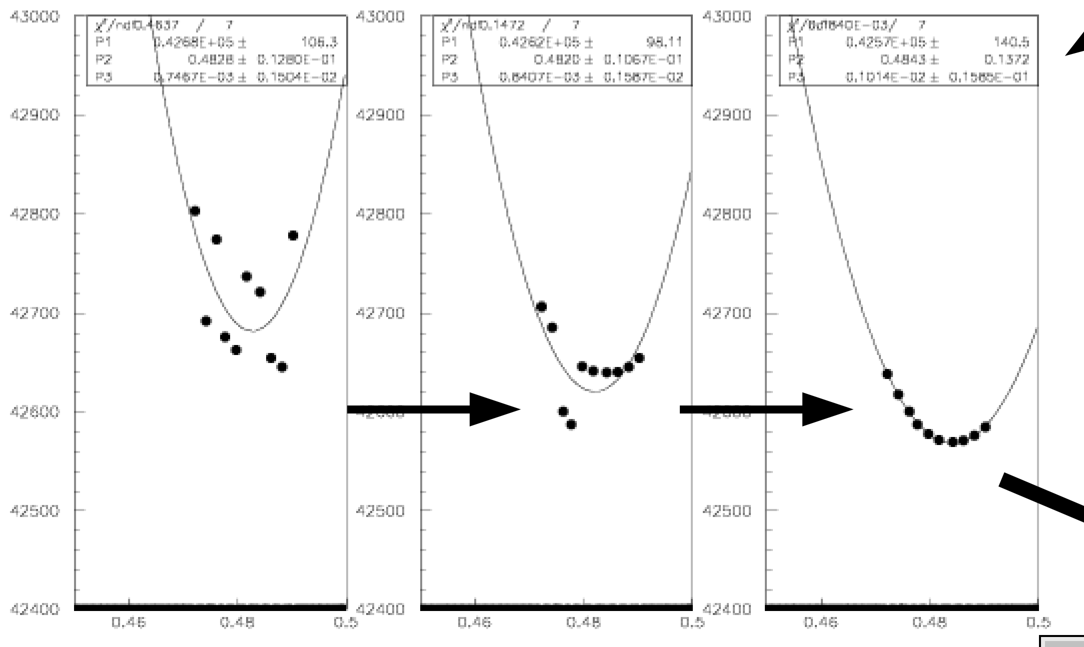
$\Delta m = 0.4803 \pm 0.0003\ ps^{-1}$

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:



Δm ps^{-1} Δm ps^{-1} Δm ps^{-1}

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

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

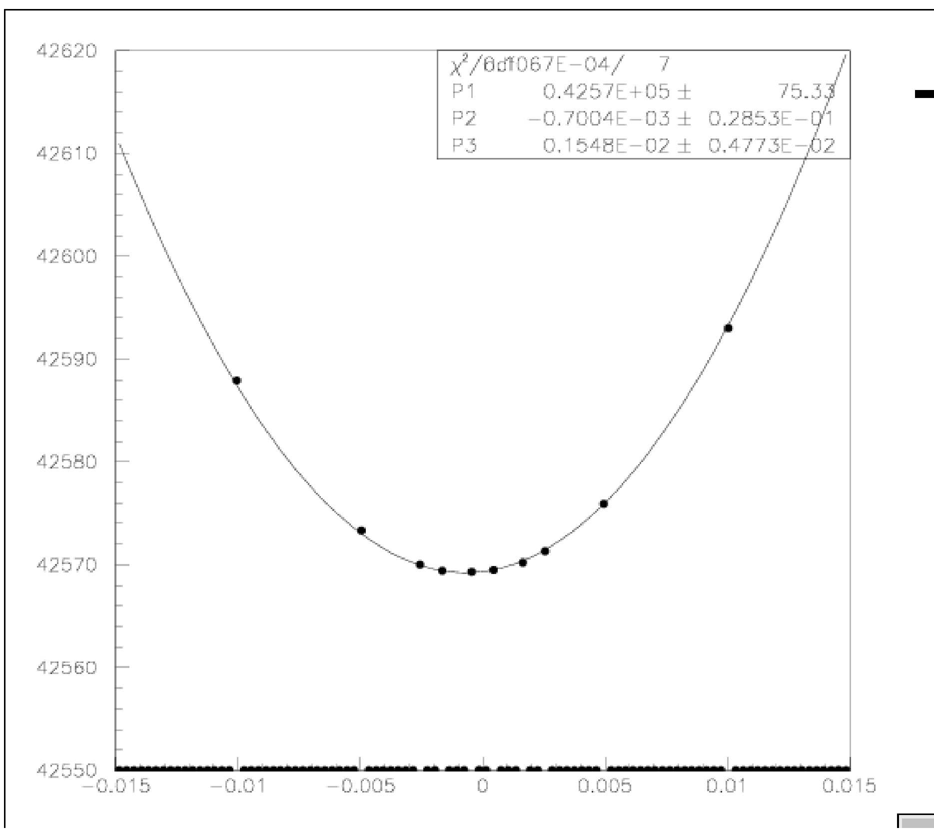
$\Delta m = 0.4842 \pm 0.0011$ ps^{-1}

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

Fit Strategy

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

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



|q/p|-1

→ |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

Fit Strategy

•To reach the absolute minimum usually is very useful to perform likelihood scans over different relevant variables (Δm, q/p, τ, Detector Asymmetries, dilutions)

➡ 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:

$\tau_{B0} = 1.540$ ps

$\chi_d = 0.1809$

$\Delta m = 0.489\ ps^{-1}$

$|q/p| - 1 = 0$

$b = 0$

$c = 0$

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 = 0.176±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_δ=0.1809)
Bias of several Statistical Sigmas on τ_{B0} & Δm, but <1%.

Bias w.r.t. MC truth

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

τ_{B0}	-0.0098±0.0006
Δm	-0.0065±0.0005
b	0.0033±0.0007
c	0.0007±0.0013
χ_d	-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
χ_d	-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
χ_δ	-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
χ_δ	0.0001

→ Experimental Δt resolution is not a problem, biggest effect on τ_{B0}

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	
χ_d	-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.

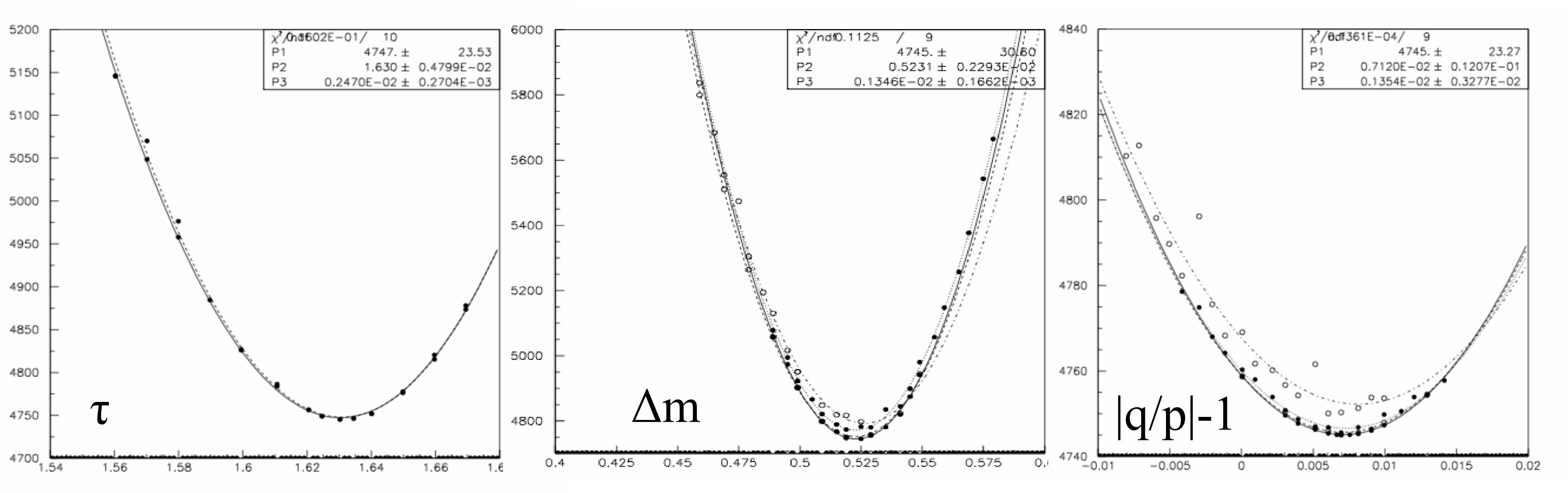
Results on Pure-Signal Monte Carlo:

- τ_{B0} , Δm show a 1% bias ;

•NO BIAS on |q/p| (with the "old unbinned" procedure we had already a 0.004 bias on q/p at this level)

B^0 Combinatorial BKG Study

B-tag+D-tag, measured Δt and tag



$\tau=1.630\pm0.0025$ ps; $\Delta m=0.5231\pm0.0013$ ps^{-1} ; $|q/p|-1=0.0071\pm0.0014$

- χ_d(BKG)>χ_d(SIG) (if two $B^0 \to D^* l \upsilon$ decays in the event, it's possible to pick up lepton & π^* from the two different sides with the right charge correlation):

  ➞ τ_{BKG}, Δm_{BKG} just effective parameters;

- $|q/p|-1$ shows a strong bias... PROBLEM?

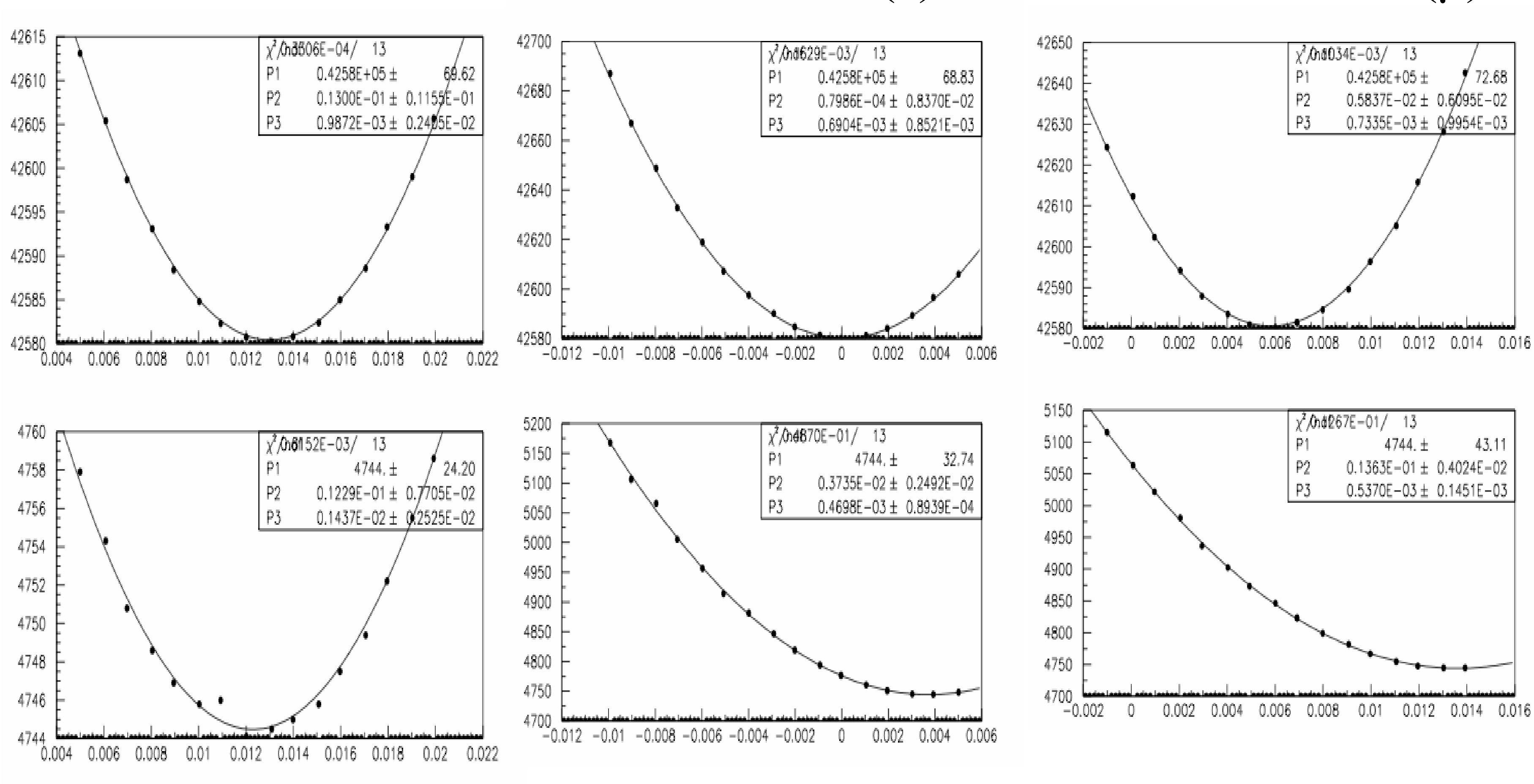
- Look at the detector asymmetries to compare SIGNAL vs BKG...

Detector Asymmetries SIG vs BKG

ATAG | AREC(e) | AREC(μ)

SIGNAL

BKG



- Atag in good agreement between SIG & BKG;
- Arec(BKG) higher than Arec(SIG)... contradiction w.r.t. our "old fit" results?
- Arec & |q/p| are strongly correlated: maybe the |q/p| bias would be reabsorbed by using common detector asymmetries?

Arec BKG vs SIGNAL from MC counting

Electron Sample

SIGNAL

A Unm -0.0833229+-0.0384739(%)

A Mix 0.0453182+-0.0820595(%)

A all -0.0601405+-0.0348352(%)

Chi_d 0.1804+-0.000189488 0.18002+-0.000189219

B^0 $\bar{B}^0$

BKG

A Unm -0.113381+-0.0410147(%)

A Mix -0.0121102+-0.0743625(%)

A all -0.0897592+-0.0359142(%)

Chi_d 0.233433+-0.000214947 0.233071+-0.000214639

B^0 $\bar{B}^0$

Muon Sample

SIGNAL

A Unm 0.749731+-0.0463026(%)

A Mix 0.678318+-0.0990136(%)

A all 0.736917+-0.041943(%)

Chi_d 0.179339+-0.000226725 0.17955+-0.000228507

B^0 $\bar{B}^0$

BKG

A Unm 0.768166+-0.0481464(%)

A Mix 0.991979+-0.0882264(%)

A all 0.819524+-0.0422629(%)

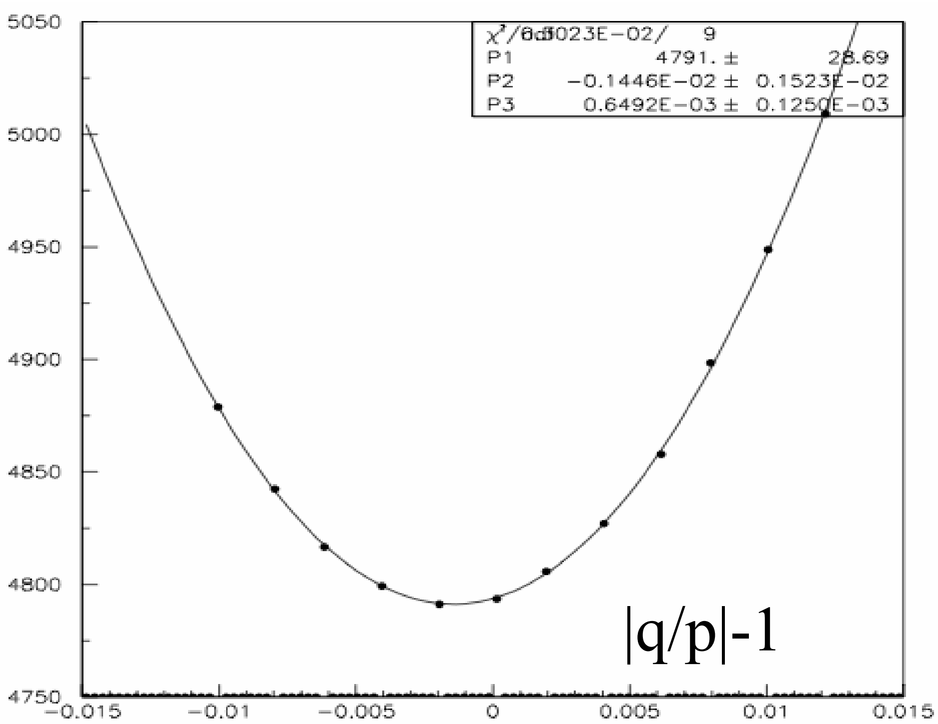
Chi_d 0.229861+-0.000250449 0.229069+-0.000252204

B^0 $\bar{B}^0$

- Good agreement found between SIGNAL and BKG!
- Results in agreement with previous page plots for the SIGNAL FIT!

B^0 Combinatorial BKG Study

CHECK:
Perform a scan on q/p(BKG) by fixing Atag, Arec to the SIGNAL ones:

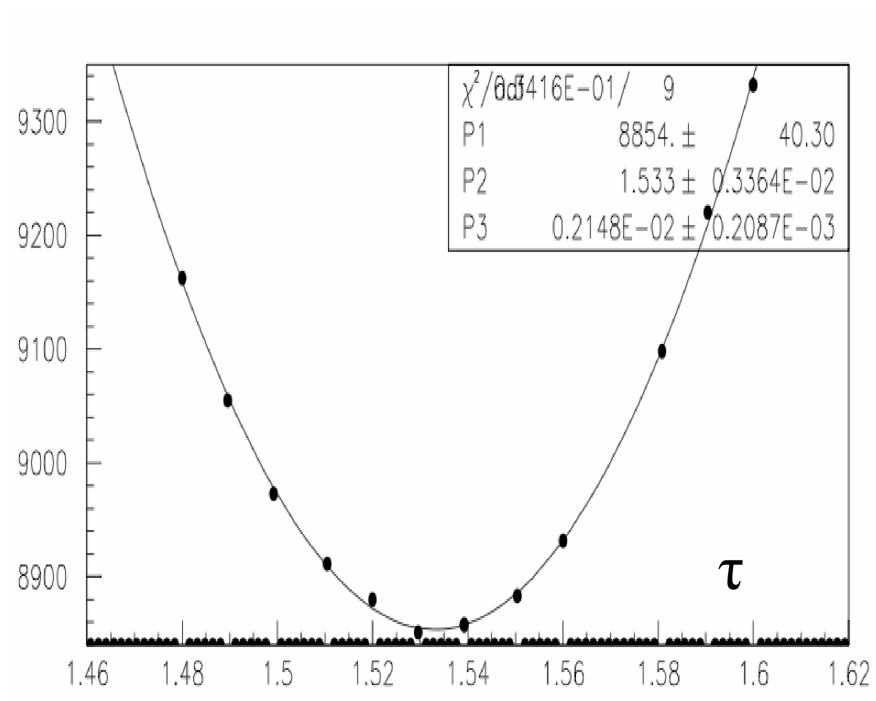


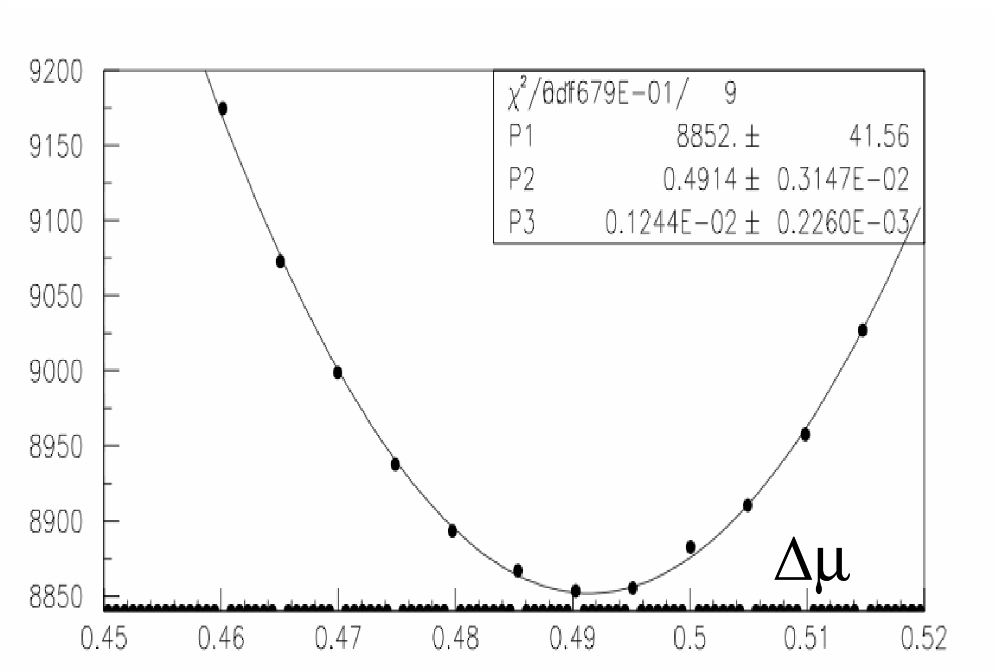
$|q/p|-1=-0.0014\pm0.0006$
bias strongly reduced!

- Compensation between the Arec & |q/p|-1 differences in SIGNAL vs BKG !
- Result compatible with sharing common Atag, Arec between SIGNAL & BKG and negligible |q/p| bias...

B^0 SIGNAL+BKG Results

- Scan performed by using common Atag & Arec for SIGNAL & BKG





Results on B^0 Monte Carlo:

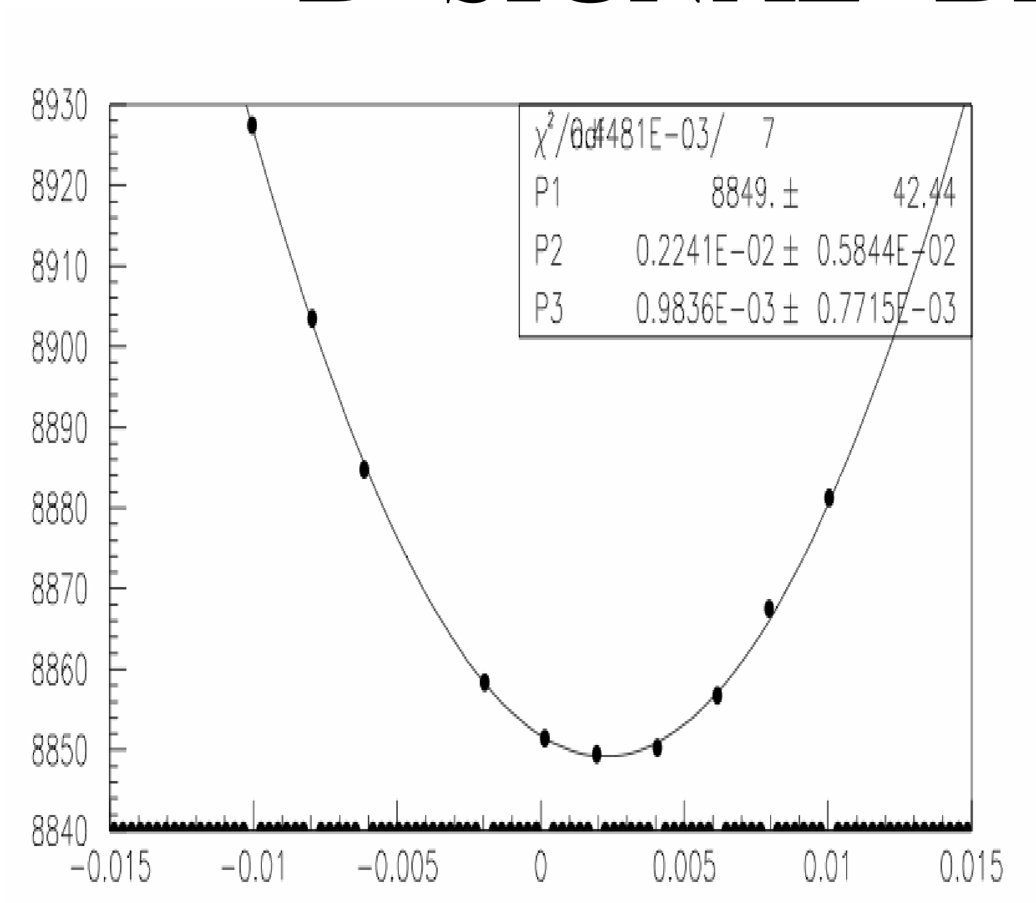
$\tau_{B0} = 1.5330 \pm 0.0021$ $\qquad \delta\tau = -0.0070 \pm 0.0021$

$\Delta m = 0.4914 \pm 0.0012$ $\qquad \delta\Delta m = 0.0024 \pm 0.0012$

0.5% bias on both!

Let's wait for the Full MC sample result to decide if we want to measure them

B^0 SIGNAL+BKG Results



|q/p|-1

→ $|q/p|-1=0.0022\pm0.0010$

|q/p| bias still at the level of one statistical sigma of real data RUN1-RUN5 result.

Conclusion & Next Steps

•Strategy to reach the fit convergence & evaluate the analysis bias finalized;

•Scan on the Full MC statistics with all the BKG included already started;

•BLIND Scan on the RUN1-RUN5 real data statistics under way;

•Enrico Feltresi is working on the development of a Toy MC for the result validation;

•We still hope to be in time for Summer Conferences: Franco is going to begin to write the Conference Paper;