Status of the Analysis on CPV in mixing using P.R. D*lν and K-tag

Martino, 6/30/2008

•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: systematic due to sampling criterion;

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 ~ 24 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;

Bias w.r.t. MC truth vs number of Δt bins

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%.

- |q/p| measured from semilept charge asymmetry with no time dependence

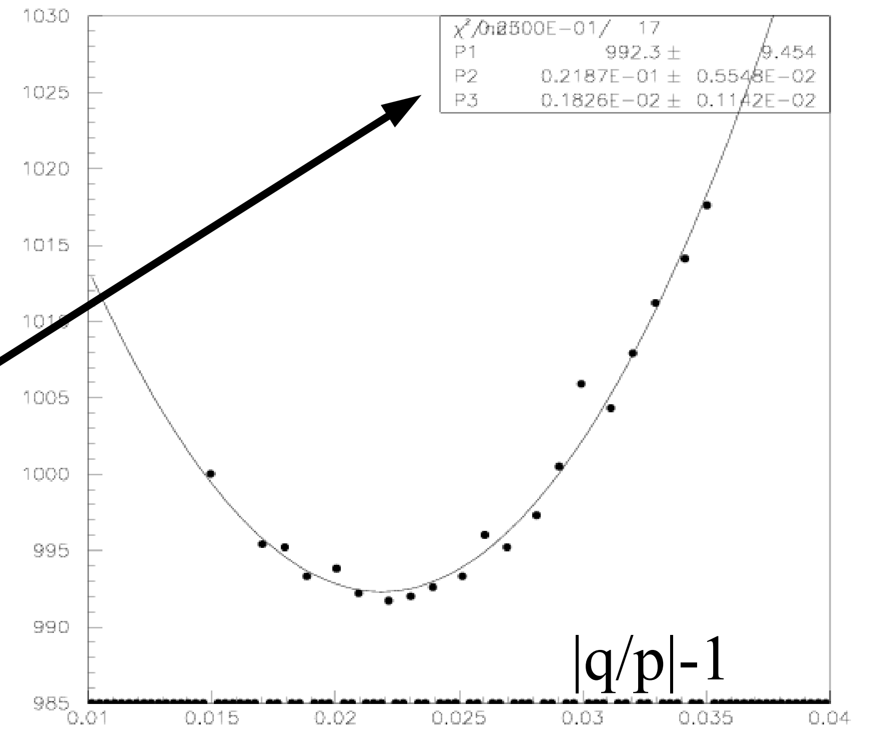
➡ not sensitive to Δt binning

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:

$$\log(L) = \log(L_{min}) + ½((x - x_{min})/\sigma)^2$$



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

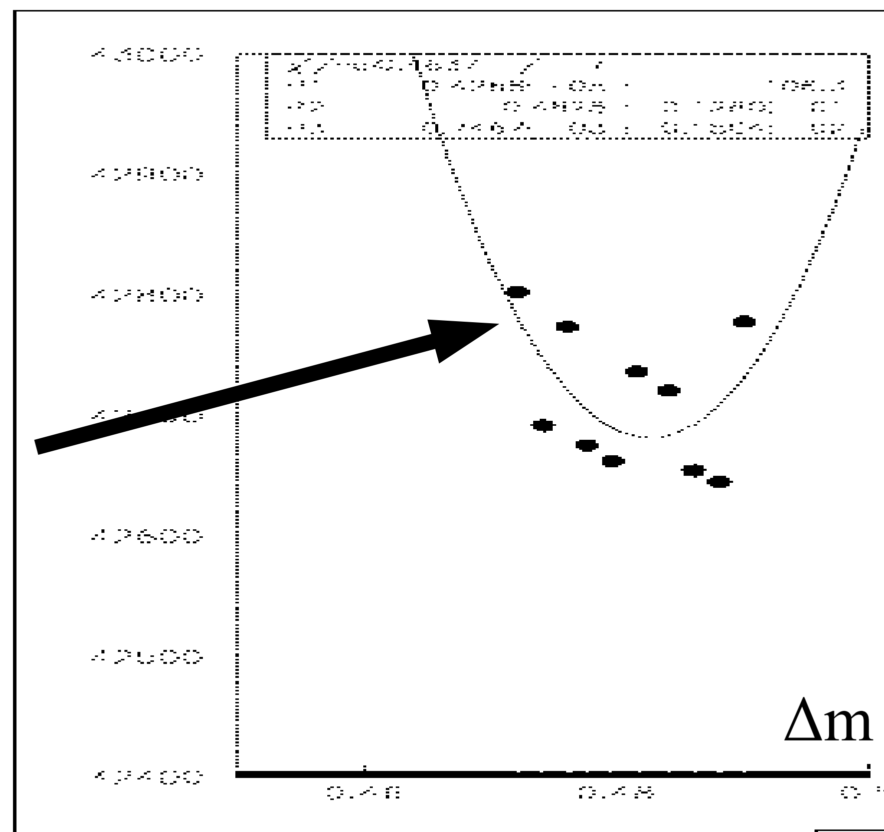
Study of Fit Convergence

•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 (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

•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:

τ_{B0}= 1.540 ps

χ_d=0.1809

Δm=0.489 ps^{-1}

$|q/p|$-1= 0

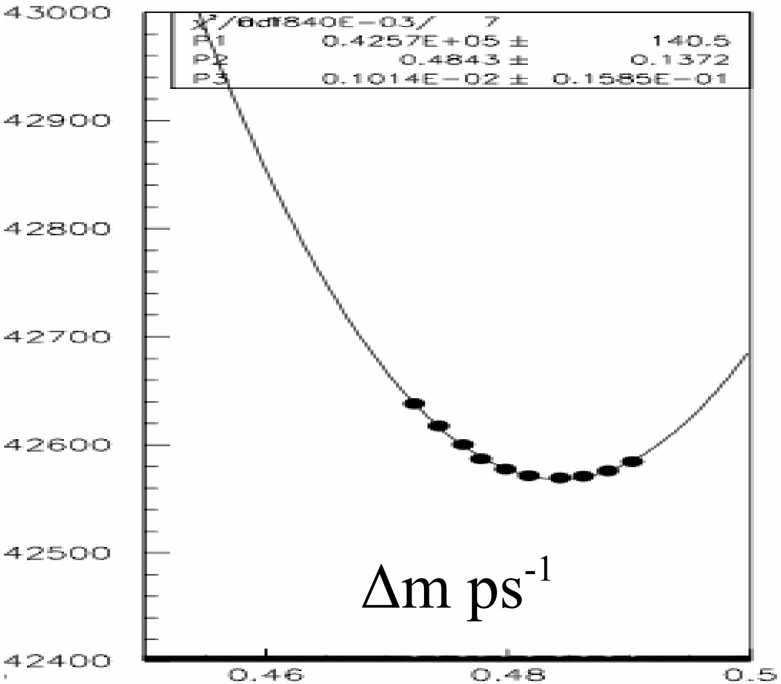
b=0

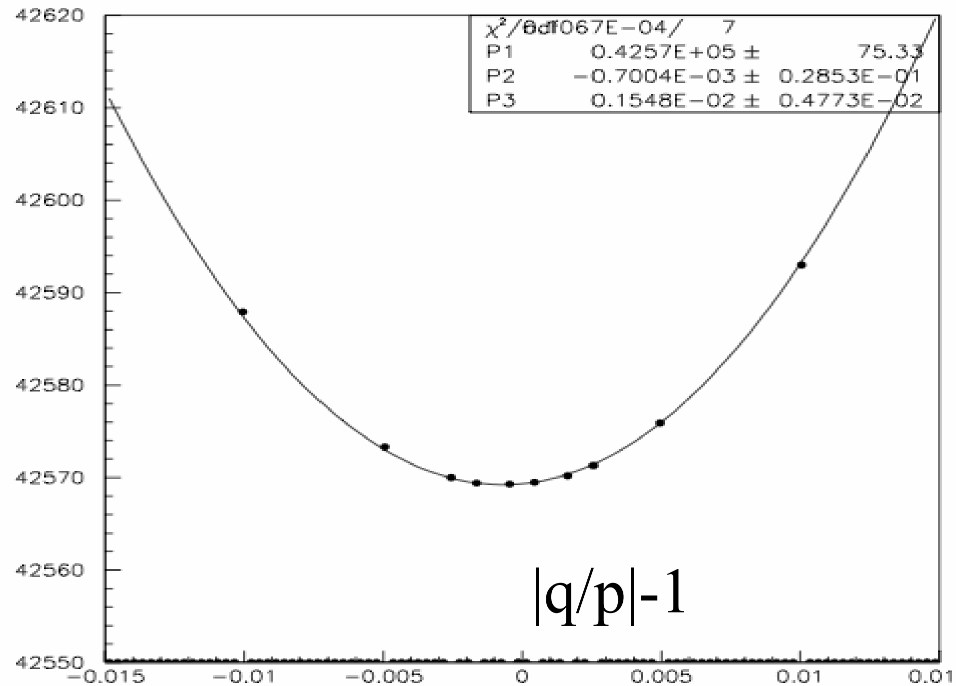
c=0

Doubly Cabibbo Suppressed

Pure B^0 SIGNAL Results

Btag+Dtag Signal Fit with Measured Δt & tagging:





$\tau_{B0} = 1.5232 \pm 0.0018$ $\quad \delta\tau = -0.0168 \pm 0.0018$

$\Delta m = 0.4842 \pm 0.0011$ $\quad \delta\Delta m = -0.0048 \pm 0.0011$

→ 1% bias on both!

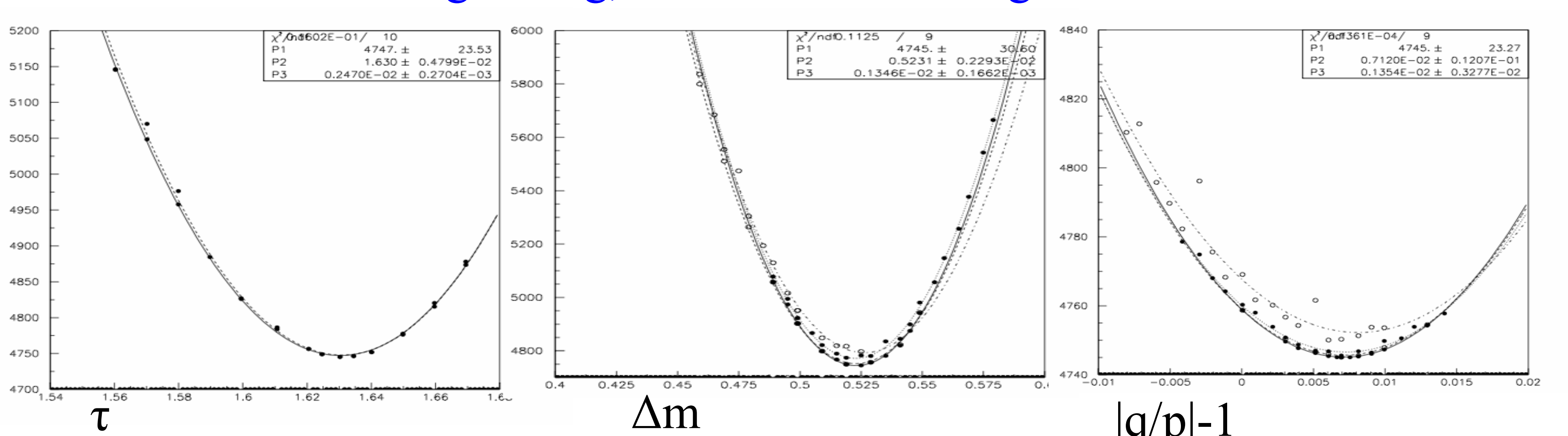
$|q/p|-1 = -0.0006 \pm 0.0015$

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

Atag =0.0134±0.0010
Arec(e)=0.0001±0.0007
Arec(μ)=0.0059±0.0007

B^0 Combinatorial BKG Study

B-tag+D-tag, measured Δt and tag



τ=1.630±0.0025 ps; Δm=0.5231±0.0013 ps^{-1} ; |q/p|-1=0.0071±0.0014

- 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?
- Is the assumption to share the same charge asymmetries between SIG and BKG wrong?

Atag	~0.0125
Arec(e)	~0.0040
Arec(μ)	~0.0130

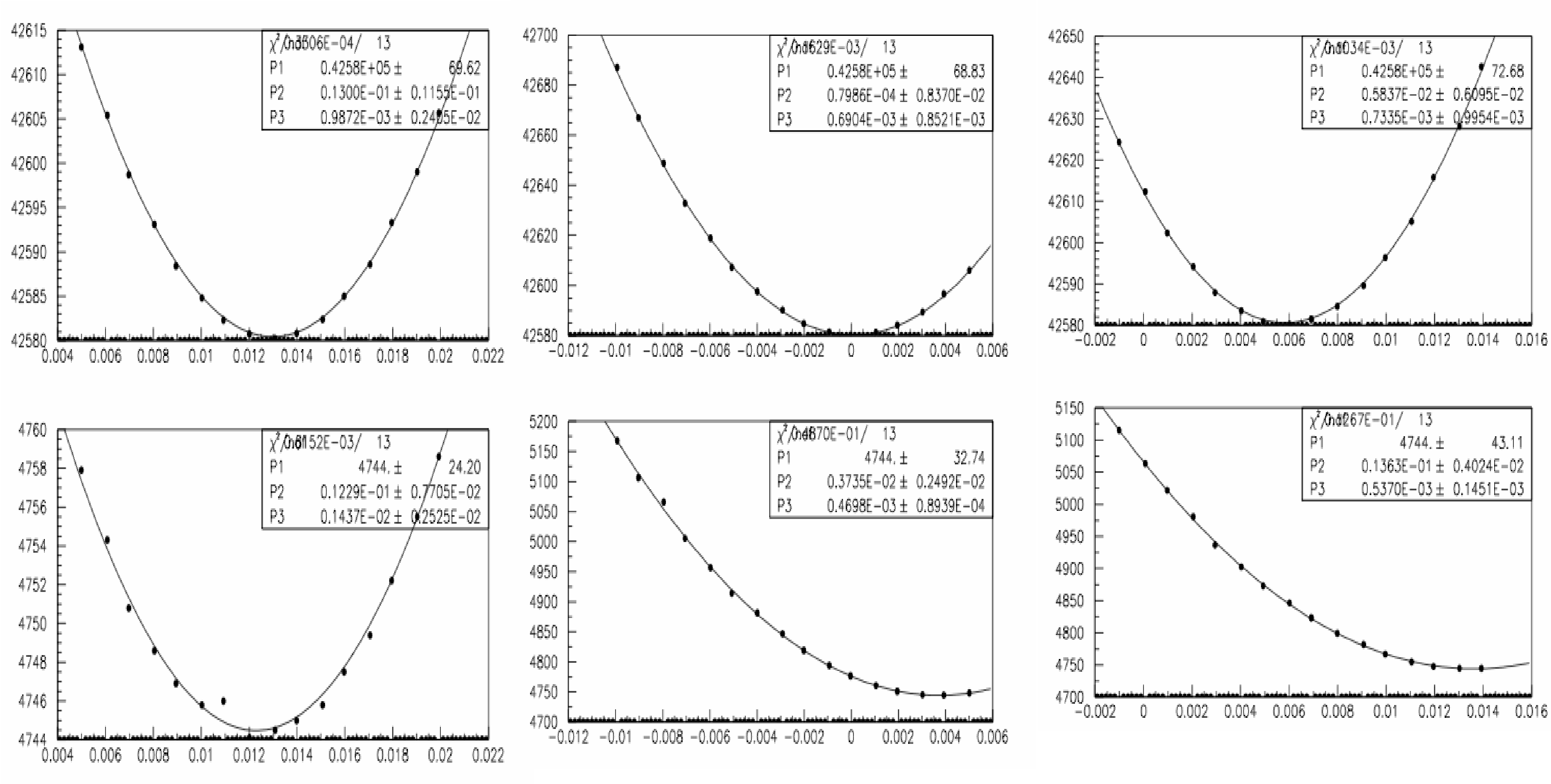
- Look at the detector asymmetries to compare SIGNAL vs BKG...

Detector Asymmetries SIG vs BKG

ATAG | AREC(e) | AREC(μ)

SIGNAL

BKG



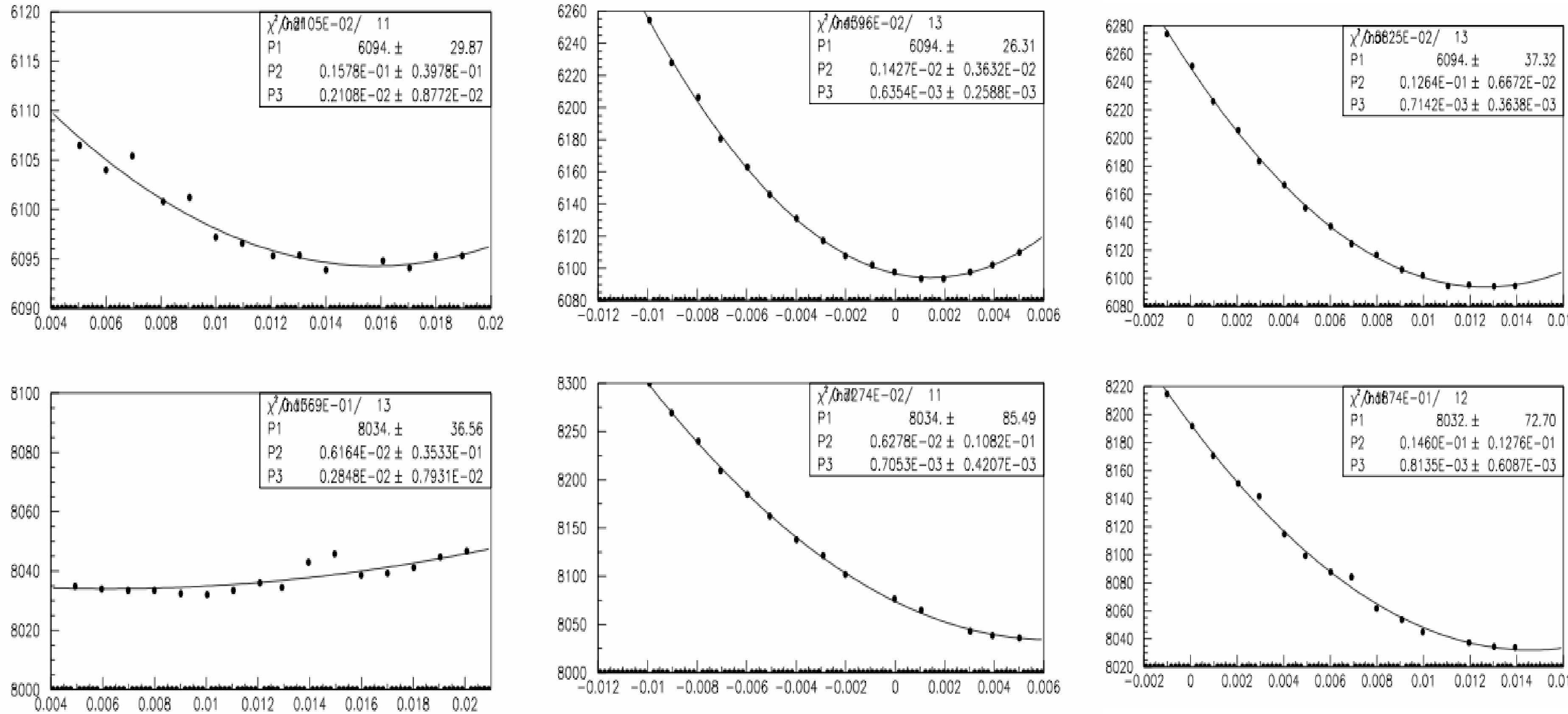
- Atag in good agreement between SIG & BKG;
- Arec(BKG) higher than Arec(SIG)... contradiction w.r.t. our "old fit" results?

BKG Detector Asymmetries: MB vs SB

ATAG AREC(e) AREC(μ)

MASS

SIDE



- Atag(SB) lower than Arec(MB)...
- Arec(SB) higher than Arec(MB)...
- **Is it a true effect or a feature of the fit?**

Arec BKG vs SIGNAL from MC truth

From the comparison of selected # $\overline{B}^0$ vs # B^0

Electron Sample

	SIGNAL	BKG
A Unm	-0.0833229+-0.0384739(%)	-0.113381+-0.0410147(%)
A Mix	0.0453182+-0.0820595(%)	-0.0121102+-0.0743625(%)
A all	-0.0601405+-0.0348352(%)	-0.0897592+-0.0359142(%)
Chi_d (B^0)	0.1804+-0.000189488	0.233433+-0.000214947
Chi_d ($\overline{B}^0$)	0.18002+-0.000189219	0.233071+-0.000214639

Muon Sample

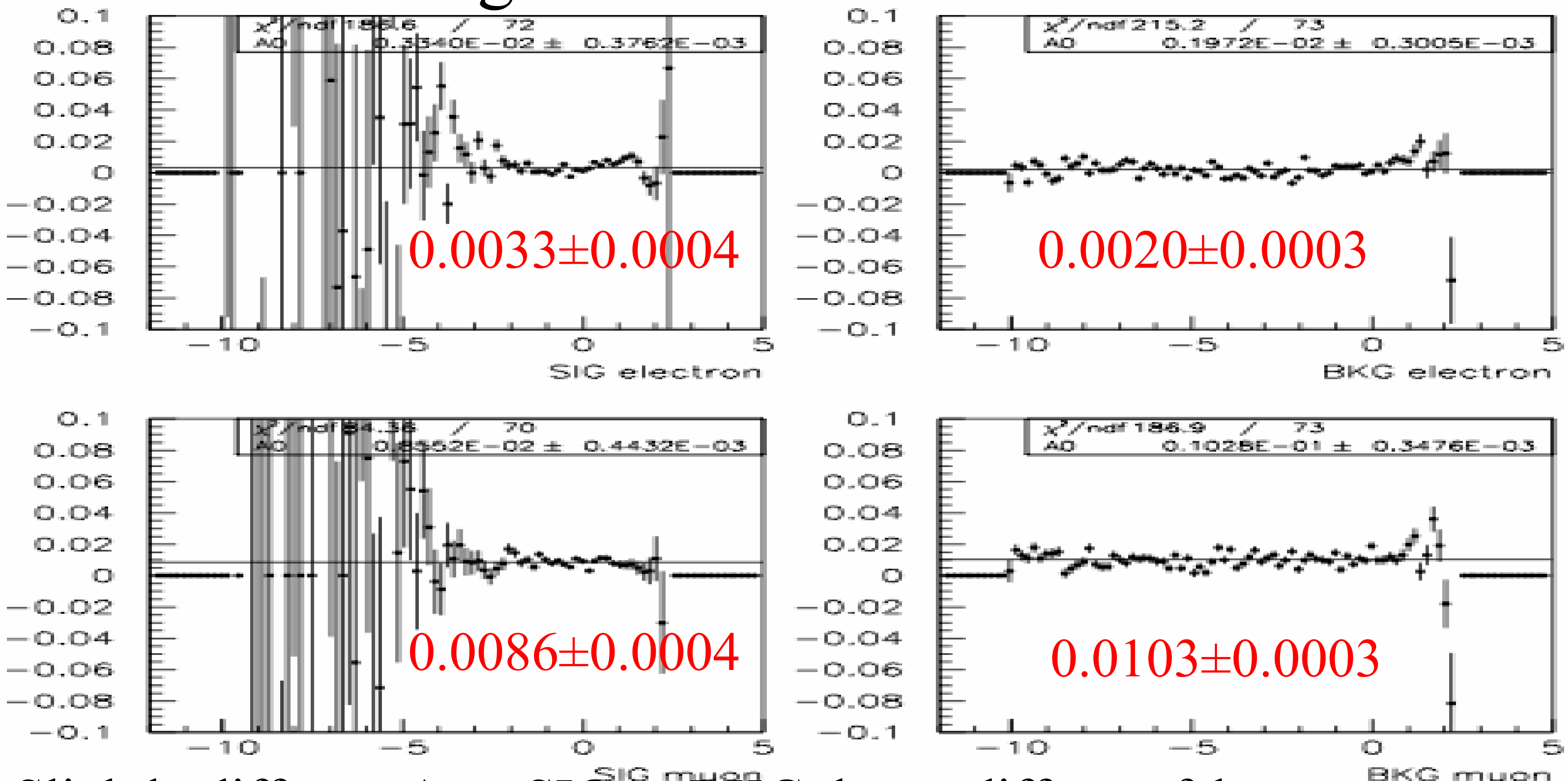
	SIGNAL	BKG
A Unm	0.749731+-0.0463026(%)	0.768166+-0.0481464(%)
A Mix	0.678318+-0.0990136(%)	0.991979+-0.0882264(%)
A all	0.736917+-0.041943(%)	0.819524+-0.0422629(%)
Chi_d (B^0)	0.179339+-0.000226725	0.229861+-0.000250449
Chi_d ($\overline{B}^0$)	0.17955+-0.000228507	0.229069+-0.000252204

- Good agreement found between SIGNAL and BKG!
- Results in agreement with previous page plots for the SIGNAL FIT!
- Selection does not introduce any relevant difference between SIG & BKG.

Arec BKG vs SIGNAL from MC counting

From the comparison of # l^+ vs # l^- (fakes included)

Arec vs $m\nu^2$ Signal BKG



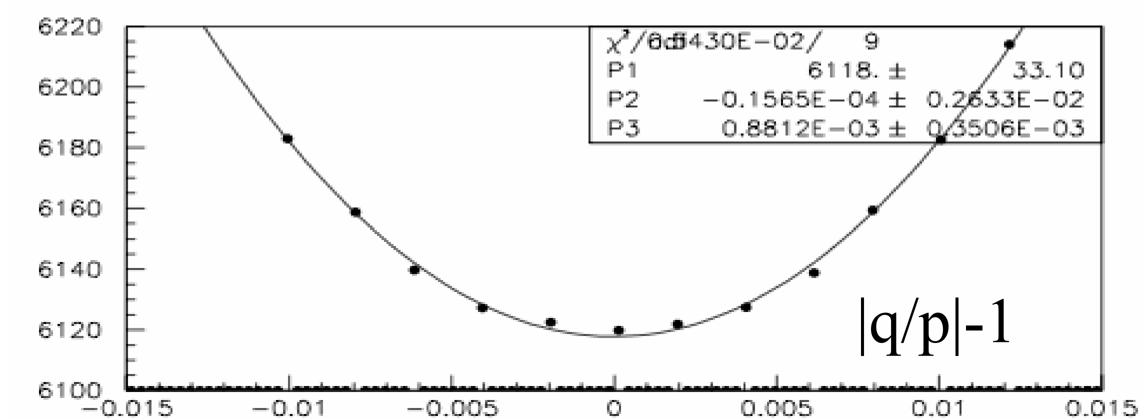
e

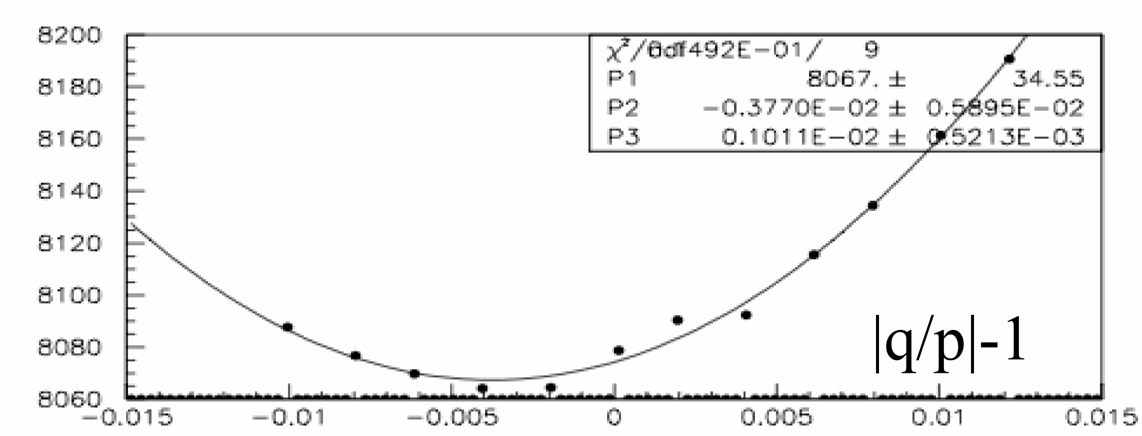
μ

- Slightly different Arec SIG vs BKG due to different fake rate;
- No $m\nu^2$ dependence found in the BKG detector asymmetries...
- **Arec & |q/p| are strongly correlated: maybe the |q/p| bias in the BKG fit would be reabsorbed by using common detector asymmetries for SIG & BKG?**

B^0 Combinatorial BKG: MB vs SB

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





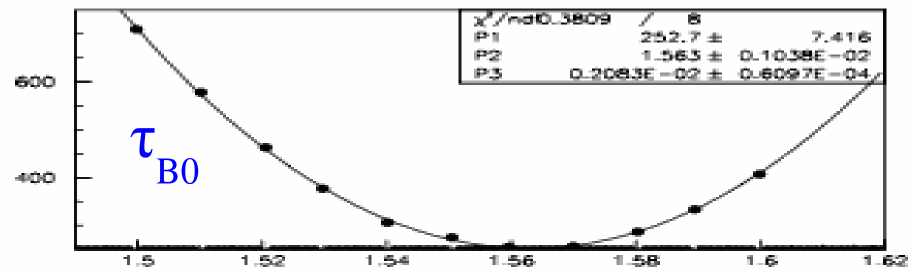
Mass Band:
$|q/p|-1=-0.00002\pm0.00088$
No Bias!

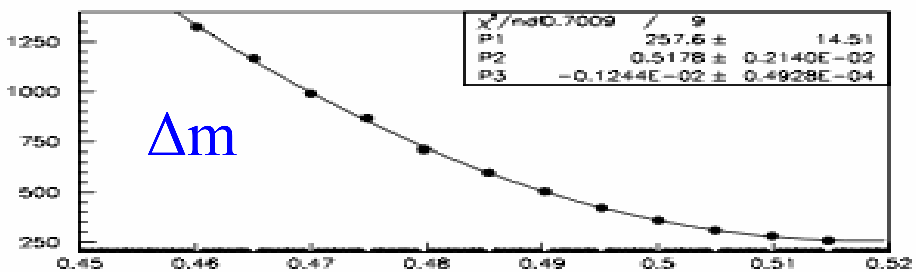
- Compensation between the Arec & |q/p|-1 differences in SIGNAL vs BKG !

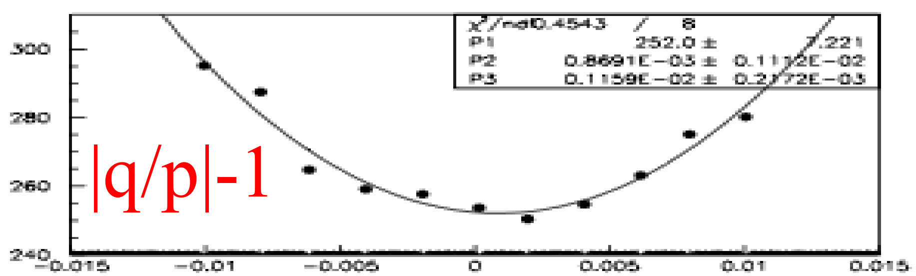
Side Band:
$|q/p|-1=-0.0037\pm0.0010$
Strong Bias!

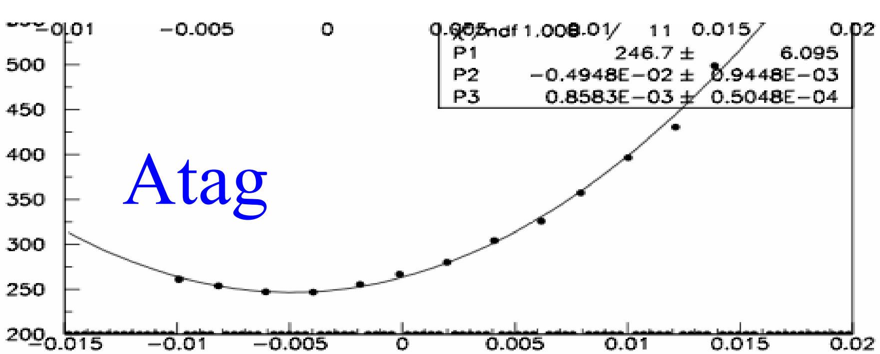
- MB B^0 BKG in good agreement with signal B^0
- ***...try to use just the MB?...***

B^0 SIGNAL+BKG Mass Band Results









$\tau_{B0} = 1.563 \pm 0.0021$ $\delta\tau = 0.023 \pm 0.002$

$\Delta m = 0.517 \pm 0.0012$ $\delta\Delta m = 0.028 \pm 0.001$

$|q/p|-1 = 0.0009 \pm 0.0012$

Atag = -0.0049 ± 0.0009
Arec(e)~ 0.0030
Arec(μ)~ 0.0090

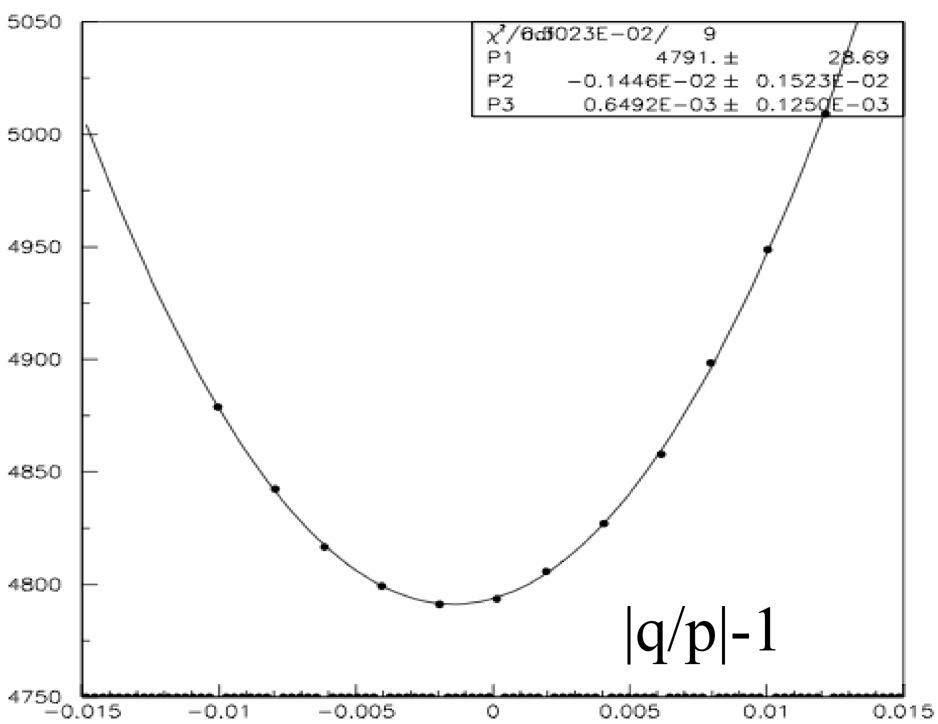
- **No Bias on |q/p|... BUT:**
- Atag changes sign... (it was 0.0134 ± 0.0010 on Pure Signal);
- Arec between SIG & BKG results;
- Strong bias on τ_{B0} & Δm

Due to the strong correlation between SIG & BKG lifetimes, Side Band are needed to fit the BKG effective parameters τ_{B0} & Δm.

➡ **Go back to MB + SB...**

B^0 Combinatorial BKG: MB+SB

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

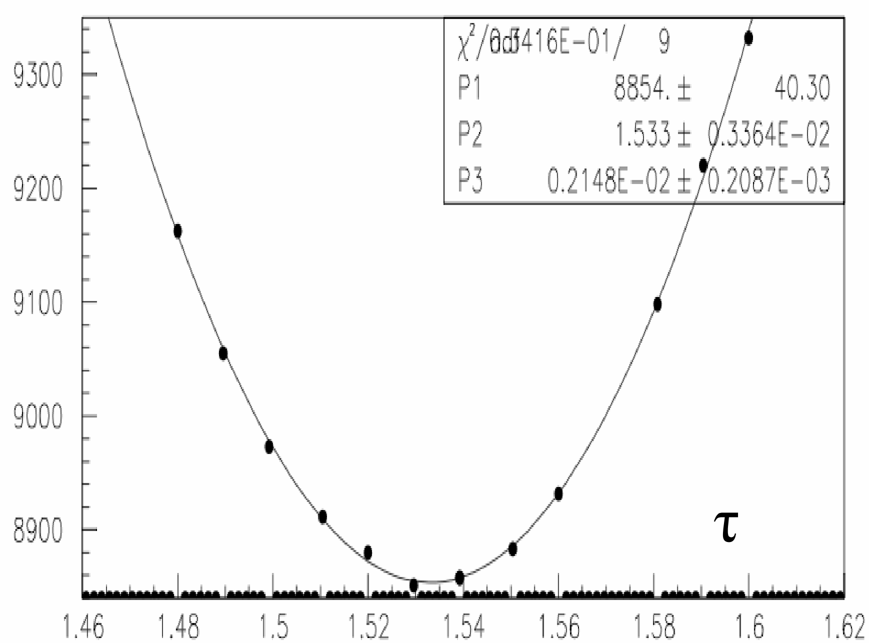


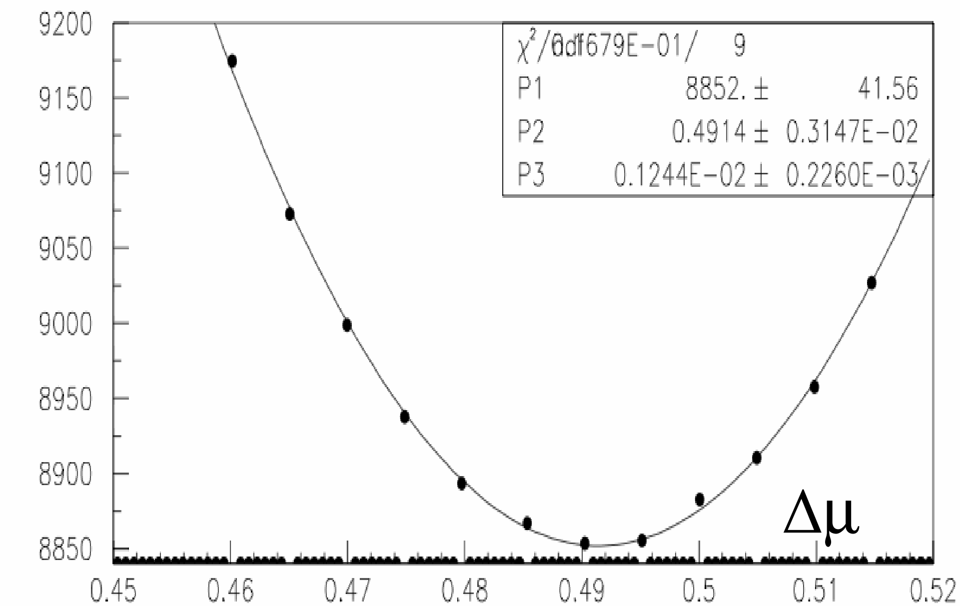
$|q/p|-1=-0.0014\pm0.0006$
in agreement with MB+SB average

- Result compatible with sharing common Atag, Arec between SIGNAL & BKG and **~2σ |q/p| bias... due to the SB component.**

B^0 SIGNAL+BKG: MB+SB Results

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





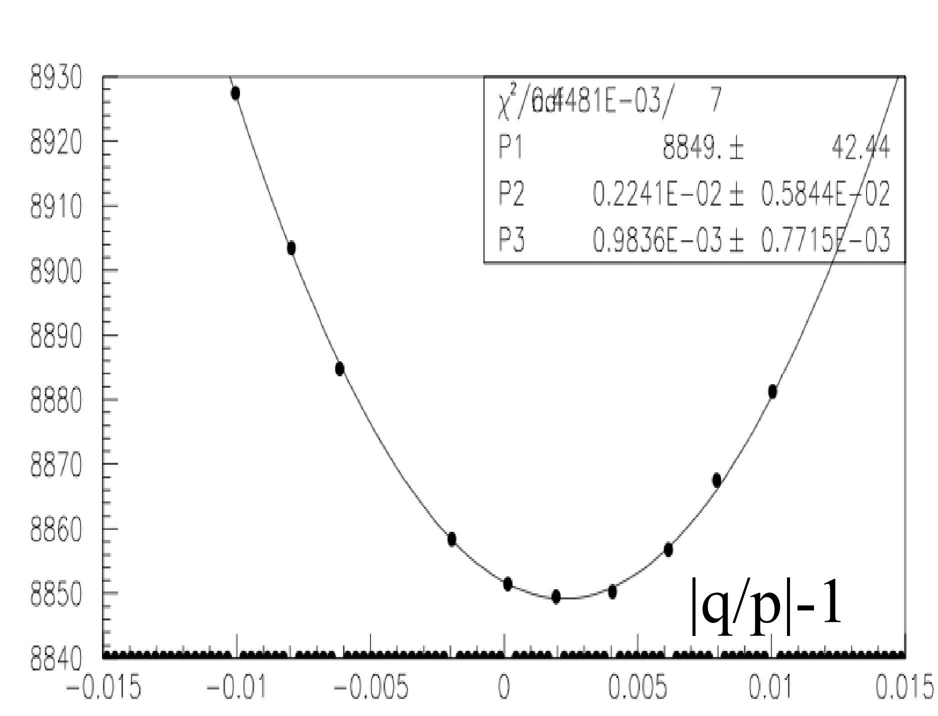
Results on B^0 Monte Carlo:

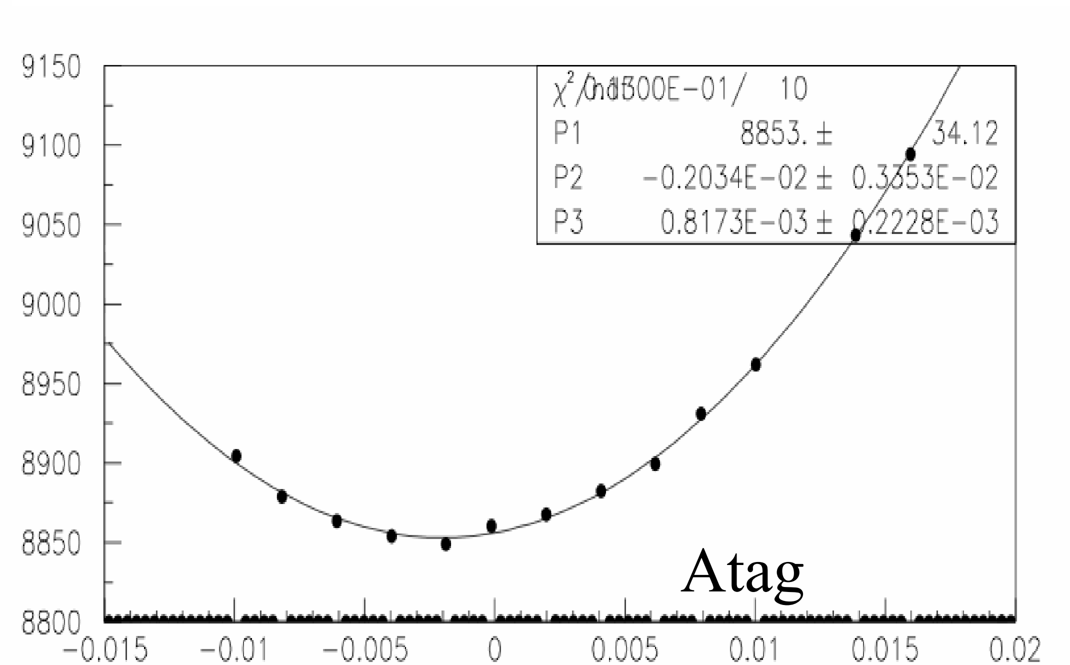
$\tau_{B0} = 1.5330 \pm 0.0021$ $\delta\tau = -0.0070 \pm 0.0021$

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

0.5% bias on both!

B^0 SIGNAL+BKG Results





|q/p|-1=0.0022±0.0010

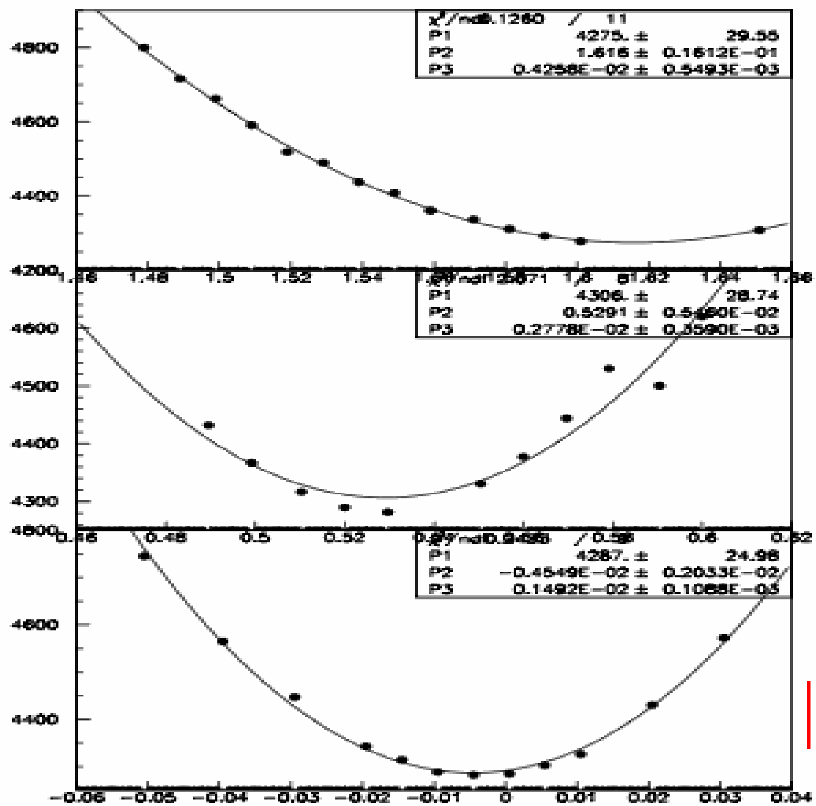
Atag =-0.0020±0.0008
Arec(e) ~ 0.0030
Arec(μ)~ 0.0090

- |q/p| bias still at the level of one statistical sigma of real data RUN1-RUN5 result... but it is however stretched in the $|q/p|_{BKG}$ direction...
- Atag<0 as before; Arec remain stable between SIG & BKG results;
- Feeling that it is not completely right to share the same charge asymmetry between SIG & BKG...

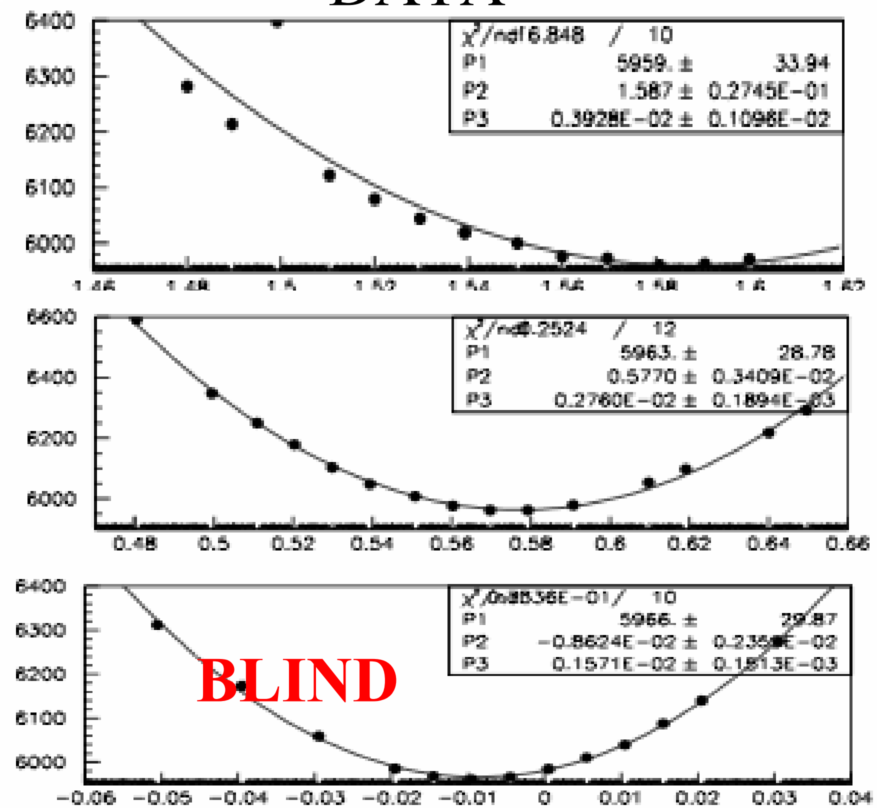
Very Preliminary Full Fit Results

B^+ BKG & continuum added to the MC sample

MC



DATA



τ_{B0}

Δm

$|q/p|$

$\delta\tau = 0.076 \pm 0.004$

$\delta\Delta m = 0.040 \pm 0.003$

$|q/p|-1 = -0.0045 \pm 0.0015$

- τ_{B0} & Δm out of control... what's happening?
- **Data show the same behavior**
- **Again the 0.004 bias on |q/p|...**

- Different Atag, Arec, |q/p| for Signal & BKG?
- Launched scans to check this guess (work in progress)

Toy MC

Enrico Feltresi

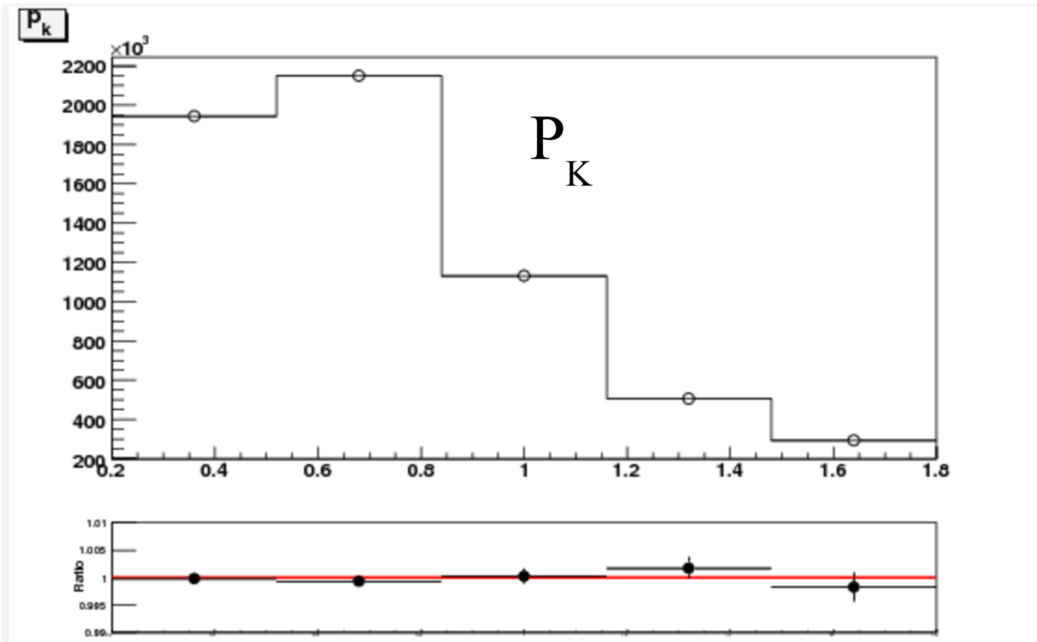
- Generate several experiment starting from the fitted PDF(P_K,Δt,$\sigma\Delta t$) for the various sample categories (B^0/B^+/continuum; peaking/BKG; Btag/Dtag) both for MC and Real Data;

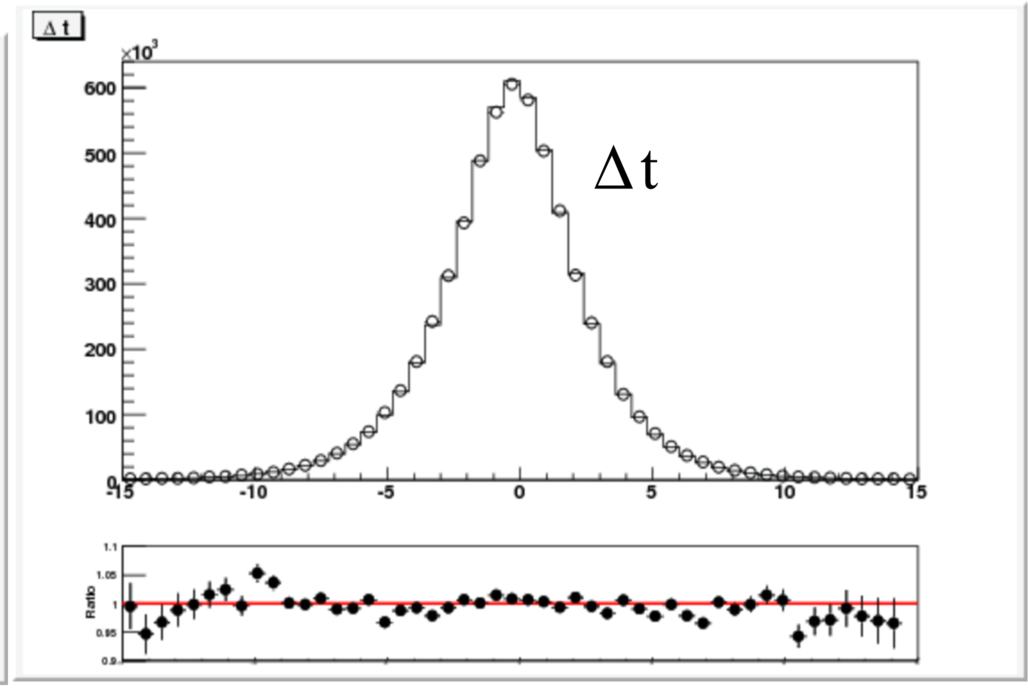
- Fit separately every generated data set;

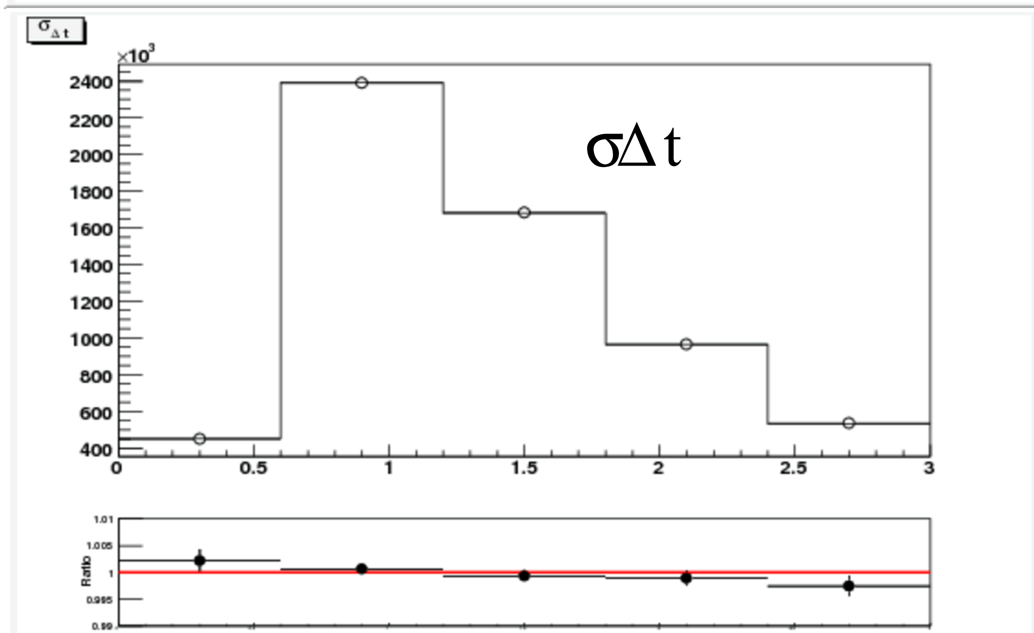
→MC fit validation: study the pull of the various fits result vs MC truth/(vs nominal fit result) to check the nominal statistical error & to look for a possible analysis bias (to be done, waiting for the nominal fit result);

→DATA fit validation: study the pull of the various fits result vs the nominal fit one (to be done, waiting for the nominal fit result);

Comparison between nominal/generated distributions







MC B^0 SIG Btag
(E. Feltresi)

Strategy for full fit validation under debugging.

Conclusion & Next Steps

- Strategy to reach the fit convergence & evaluate the analysis bias finalized;
- No bias found on $|q/p|$, τ_{B0} and Δm on MC Pure Signal;

- Some hints of different detector charge asymmetry between Signal & BKG which could be the cause of :

→ $|q/p|$ bias = 0.0022 ± 0.0010 on MC B^0 (Signal+BKG);
→ $|q/p|$ bias= -0.0045 ± 0.0015 on Full MC;

- No bias on τ_{B0} and Δm on MC B^0 (Signal+BKG);
- Strong bias on τ_{B0} and Δm after the addition of B^+ & continuum BKG

- Toy MC for full fit validation almost finalized;

- Full MC & Data scans using different charge asymmetries between Signal & BKG are going on...

Publication Strategy (to be chosen)

A)Benefit from the binned fit & likelihood scan in order to fully understand the origin of analysis bias before the publication;

B)Send a preliminary result to ICHEP with a bias correction of ~0.004 on $|q/p|$ without measuring τ & Δm;

C)Let's wait for the results of the scans using different charge asymmetries for Signal & BKG...

- Updated Supporting Document & Conference Paper ready in a few days (in the case ICHEP is still the target).