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

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➔Motivations, Method, Analysis Strategy & MC Results:
See Alessandro talks this week (TDBC AWG, Plenary)

Some more technical details & news:

➔Code Improvement: Higher velocity;

➔Detector Asymmetry: Compatibility over different event sample categories;

➔True–Δt puzzle: MC bug in flavor determination?

➔D-tagged event fraction: fit to θ(K-l) angle;

➔Sample composition: fit to $m\nu^2$;

➔Next Step for MC Validation: Toy for Continuum event sample;
Toy MC with CPV.

Code Improvement

•Fit Strategy: Binned (100 Δt $\times$ 25 $\sigma\Delta t$) Maximum-Likelihood fit performed on the (Mixed/Unmixed)$\times$(K_{tag}^{+}/K_{tag}^{-}) four subsamples...

•...For nine different categories of events:
(B^0/B$^+$)$\times$(Resonant/BKG)$\times$(Btag/Dtag) + continuum...

•...To determine simultaneously:

➔Physics: $|q/p|$, b, c, τ, Δm;

➔Detector Asymmetry: Arec(electrons), Arec(muons), Atag(K);

➔Mistag: ω, $\Delta\omega$ (depending on sample);

➔Resolution parameters: pulls, offsets, τ(GEXP) (depending on sample);

➔**Total of 154 parameters which can be floated in the fit.**

➔**New Strategy: Compute at each Minuit iteration just the PDFs containing a parameter which is currently varying:**

➔**Gain a factor 5/10 in time, mainly for the BKG subsamples.**

Detector Asymmetry

- Crucial Issue: discriminate between physical and detector charge asymmetry without relying on control samples;

- Assumption: all the event categories share the same detector asymmetry;

- Idea: determine the experimental asymmetry directly from the real data using all the "BKG" samples with no "CPV in mixing" information:

➔B^0 resonant D-tagged;
➔B^0 combinatorial D-tagged (Signal Band + Side Band)
➔B^+ resonant+combinatorial (Signal Band + Side Band);

➡ **Compatibility of the detector asymmetry between the Btag & Dtag samples checked on MC ...**

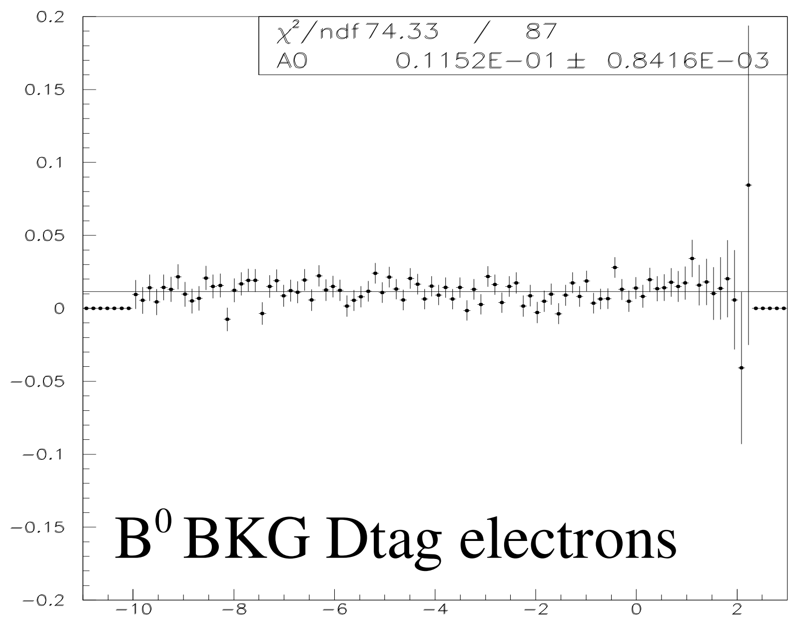
•$A_{lK}=(N(l^+K^+)-N(l^-K^-))/(N(l^+K^+)+N(l^-K^-))$, Run1-5 MC Results

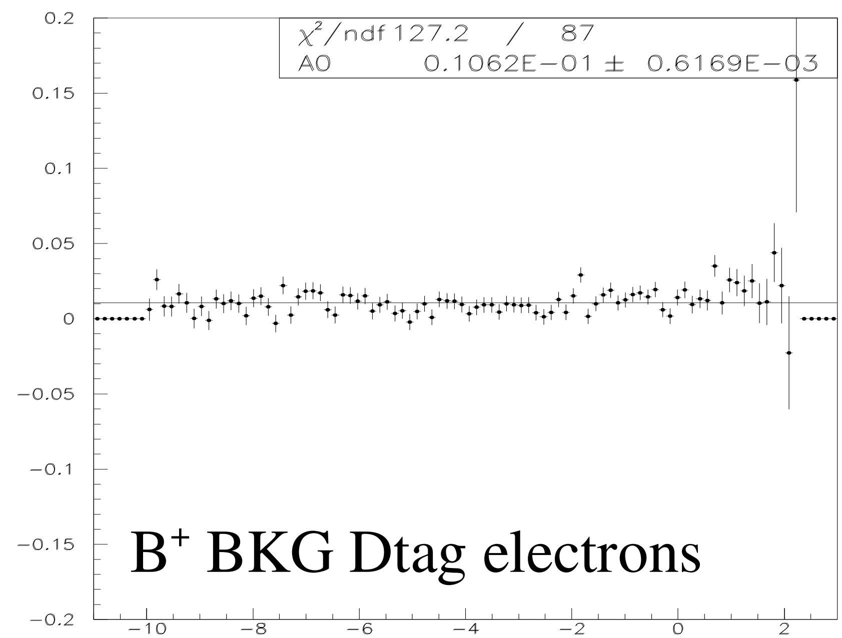
•Nice agreement found between Btag and Dtag event samples:

B^0 resonant:	Btag	Dtag
Electrons	0.0144+-0.0011	0.0137+-0.0007
Muons	0.0201+-0.0013	0.0189+-0.0008

•Nice Stability found for all the samples over the $m\nu^2$ range:

Use SB & MB together!





•$m\nu^2$

•$m\nu^2$

•**The "raw" detector charge asymmetry A_{lK} can be expressed in terms of three sources:**

➔Reconstruction Asymmetry: $Ar = (\varepsilon(l^+\pi^-) - \varepsilon(l^-\pi^+))/(\varepsilon(l^+\pi^-) + \varepsilon(l^-\pi^+))$

➔Tag Asymmetry: $At = (\varepsilon(K_{tag}^+) - \varepsilon(K_{tag}^-))/(\varepsilon(K_{tag}^+) + \varepsilon(K_{tag}^-))$

•Mistag difference: $\Delta\omega = \omega^+(B^0_{tag} \longrightarrow \overline{B^0}) - \omega^-(\overline{B^0}_{tag} \longrightarrow B^0)$

•Ar, At shared by all the event samples

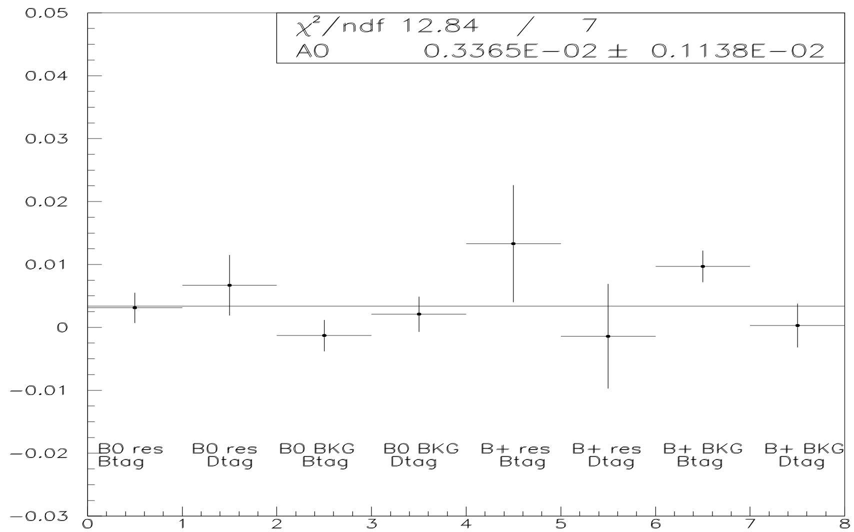
•ω,$\Delta\omega$ depend on sample, due to the different decay modes involved.

•Not Correct to compare directly the raw A_{lK}...

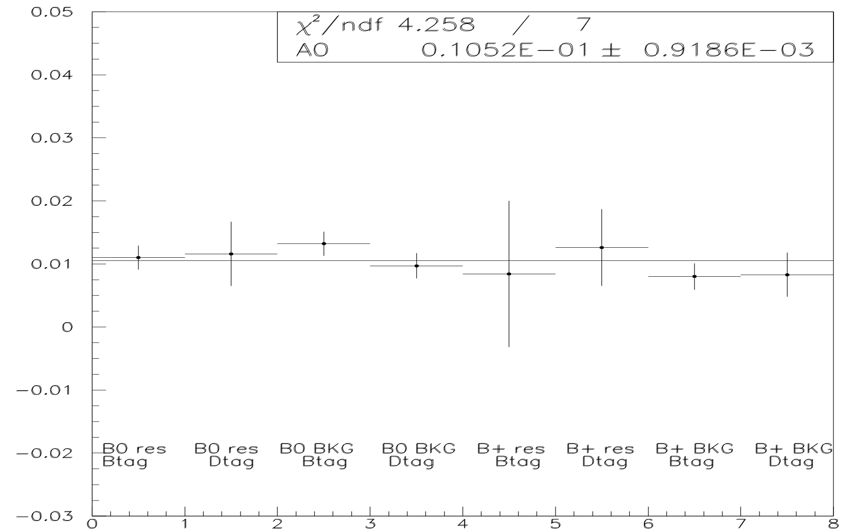
➡ **Compatibility of Ar & At between the various categories checked on MC**

➔**RUN1 MC results** (Run1-5 under way...)

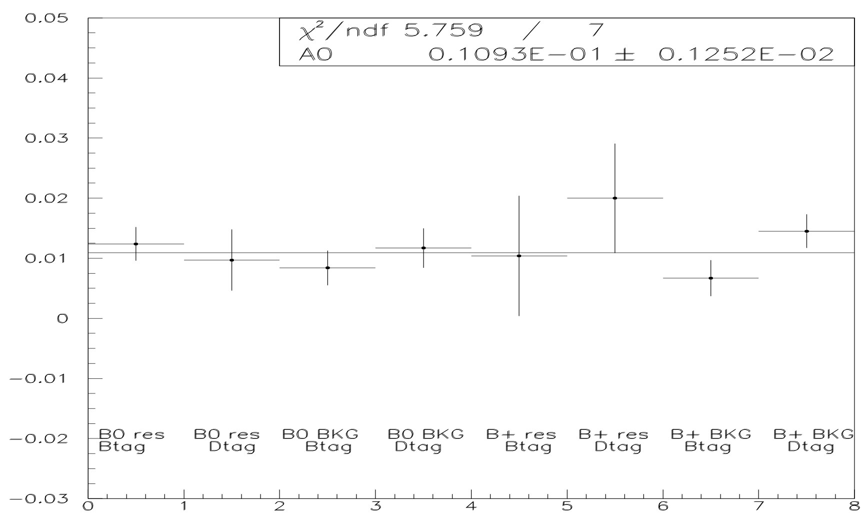
Arec (electrons)



Atag



Arec (muons)



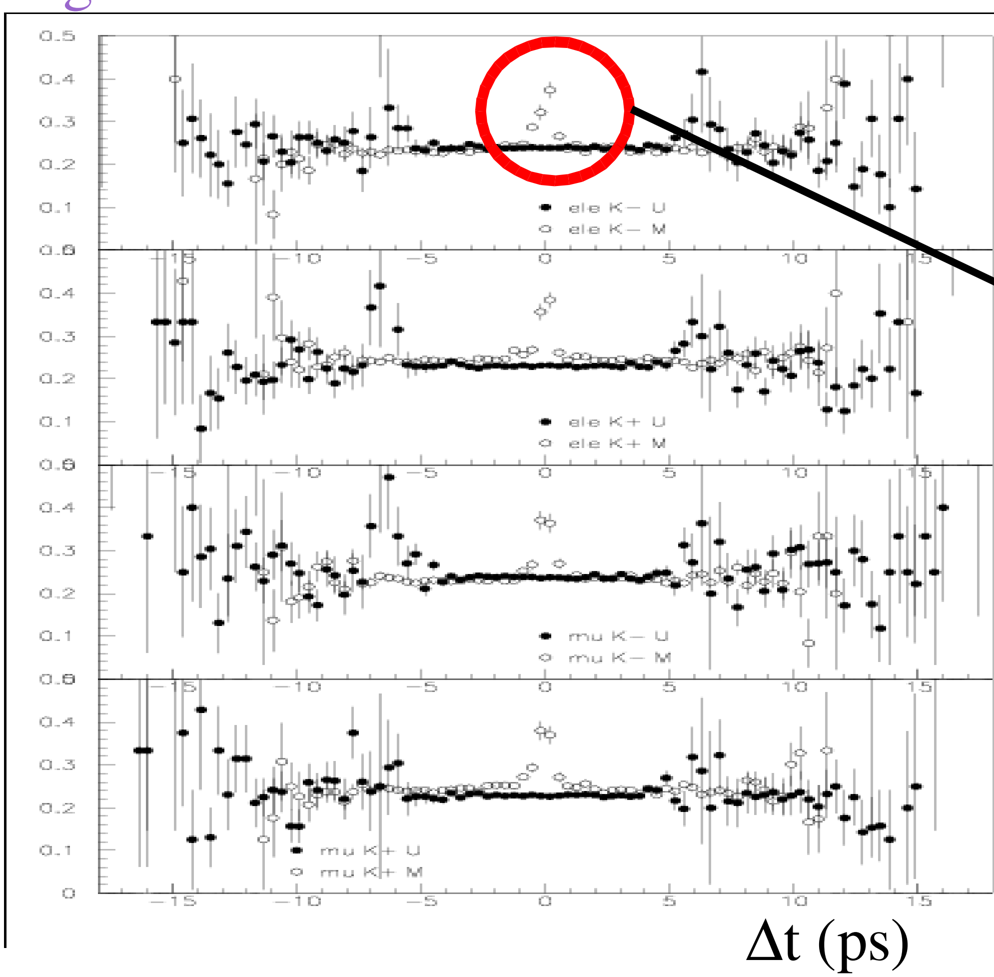
➔Nice agreement found

➔**Ar & At common to all the 8 different samples!**

True–Δt Puzzle

➔All what follows was discovered on **Run1-5 generic MC R18 from InclSemilep Skim (analysis 31);**

➔Mistag rates ω(mixed) vs ω(unmixed) for B^0 resonant B-tagged events are not in agreement!



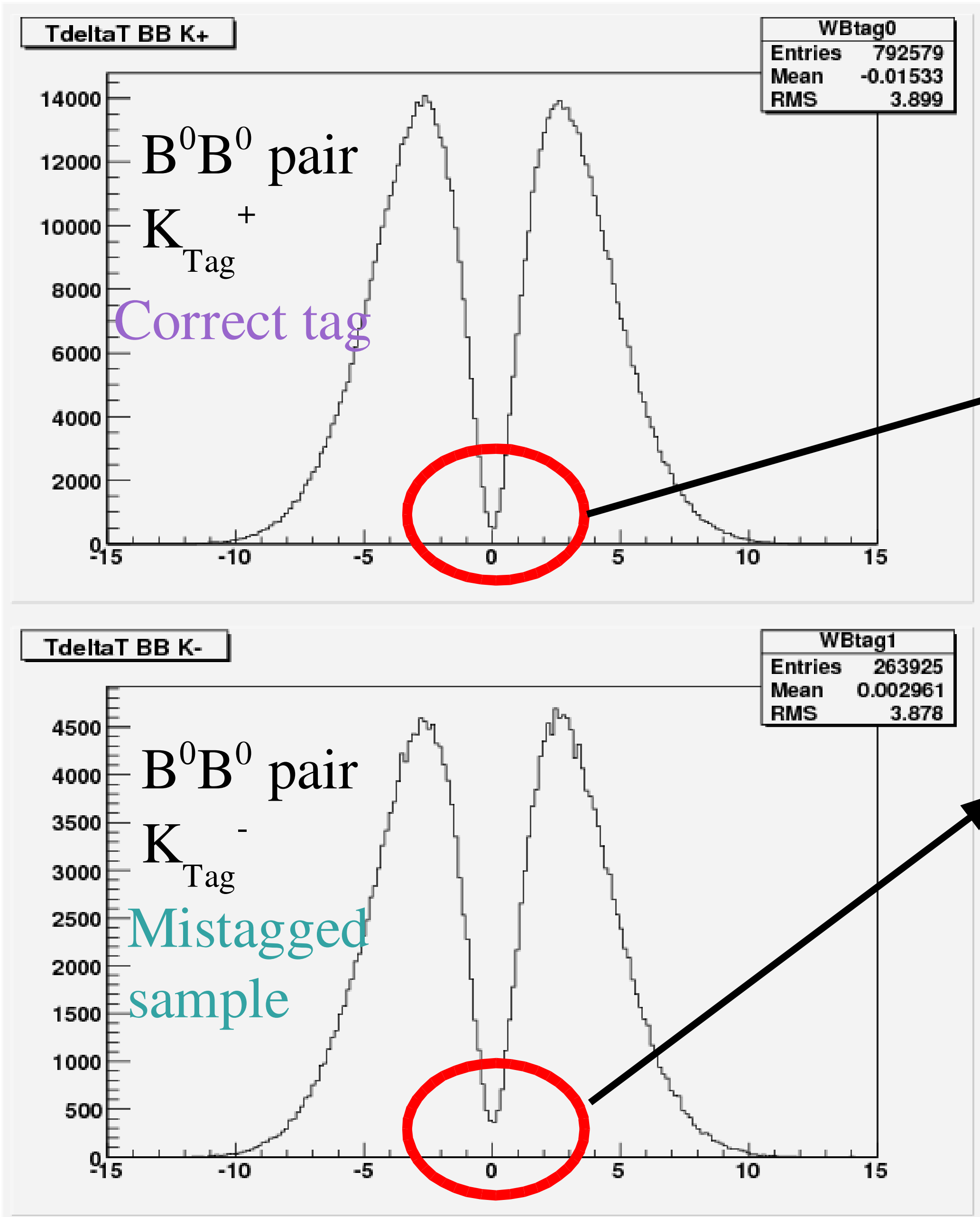
ω vs True-Δt

➔ω(mixed)>>ω(unmixed) in the |Δt|<1 ps region;

➔Both Electron & Muon samples affected;

➔Both K^+ & K^- samples affected;

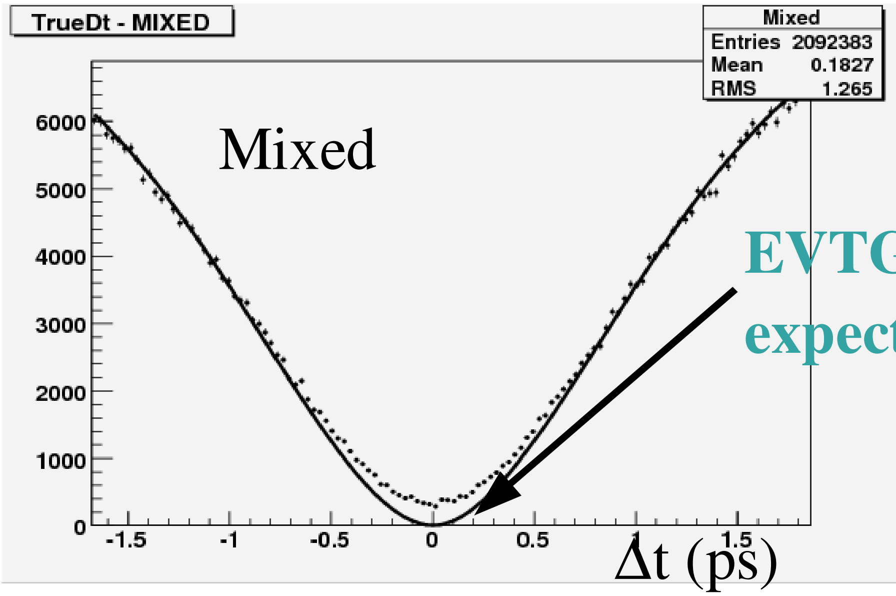
➔ **True-Δt** distribution for the Mixed event sample **(B flavor from Lund Code)**



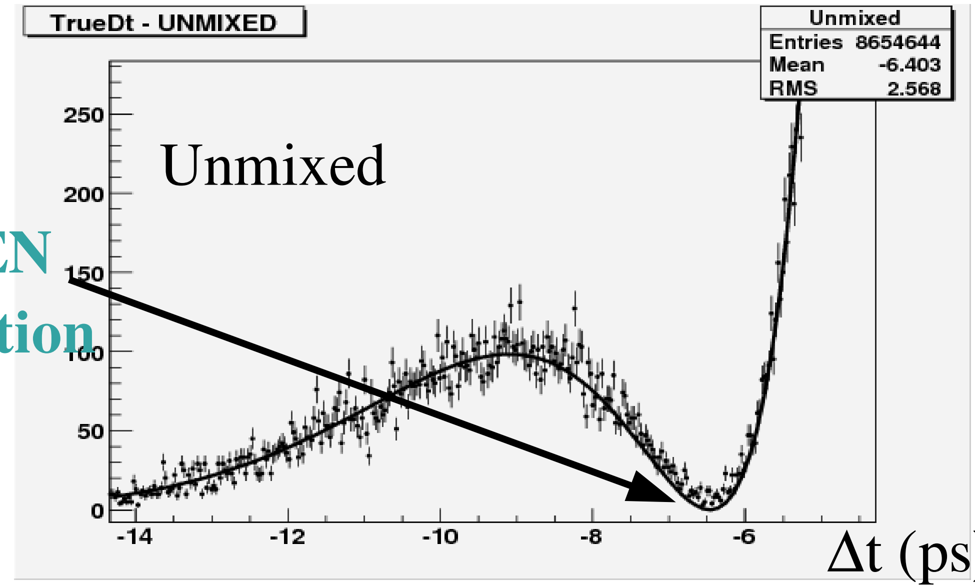
➔**Mixed events at Δt=0 !**

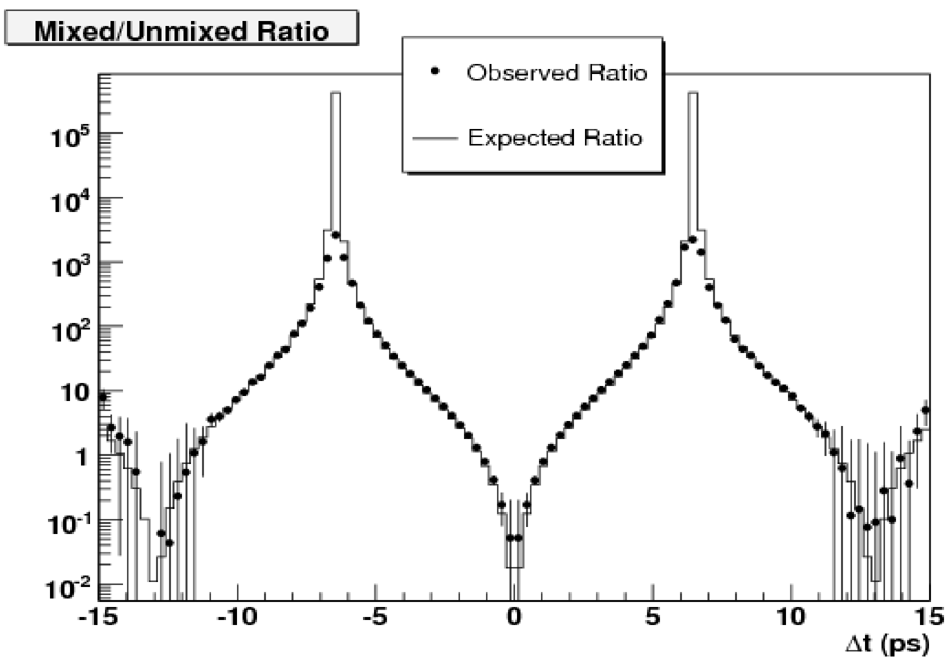
➔Effect more evident for the mistagged sample $B^0 \rightarrow K^-_{tag}$ (lower plot) wrt the correctly tagged sample $B^0 \rightarrow K^+_{tag}$ (upper plot)

➔Observed event yeld wrt expectations:

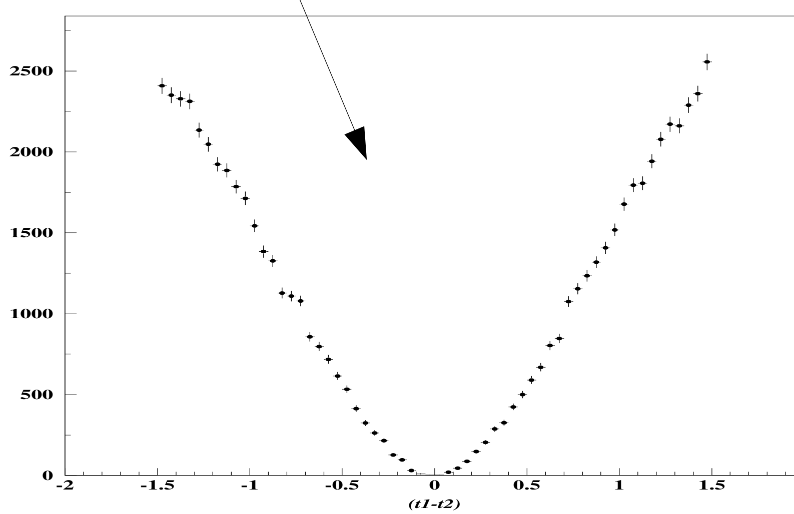


EVTGEN expectation

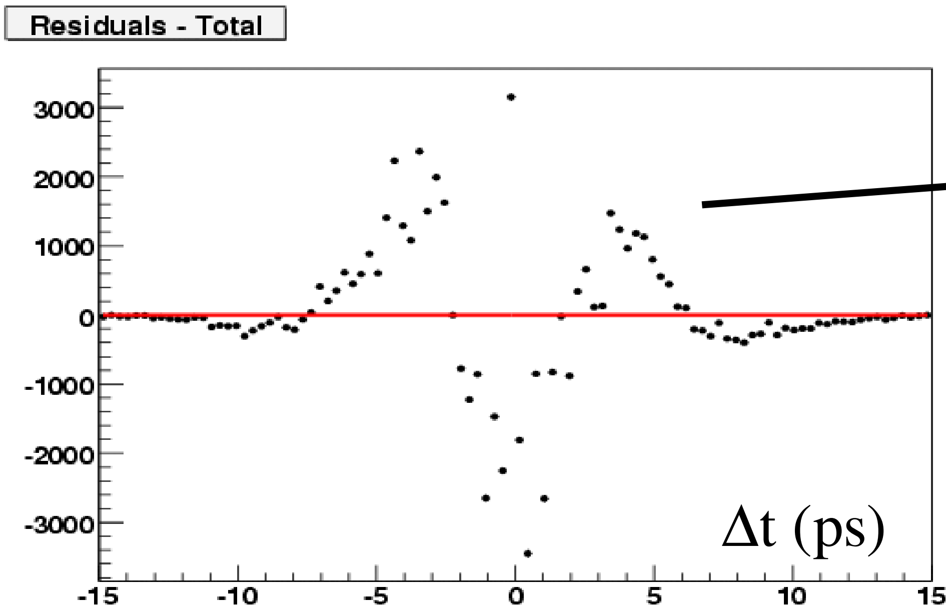




➔By running EVTGEN by ourselves we found no problems (M.Rotondo):



Further Checks



➔Residuals of the Mixed+Unmixed True-Δt distribution fitted by an exponential: Another problem?

➔"Visual scanning" the printout of some event confirms the result;

➔Different $\tau(B^0)$ obtained by fitting Mixed vs Unmixed event samples (MC generation: τ=1.540 ps, Δmd=0.489 ps^{-1}):

	$\tau(B^0)$	Δmd
Unmixed	1.5340±0.0008	0.4865±0.0002
Mixed	1.5059±0.0018	0.4854±0.0007

Strong disagreement in τ

Possible Explanations(?)

➔Skimming cannot “create” mixed event at true-$\Delta t=0$;

➔**Bug in our true-Δt computation?**

B^0 flavor comes directly from Lund Code, true-Δt computed from the two mesons decay time: why this effect should depend on the K charge?

➔**Bug in MC flavor assignment?**

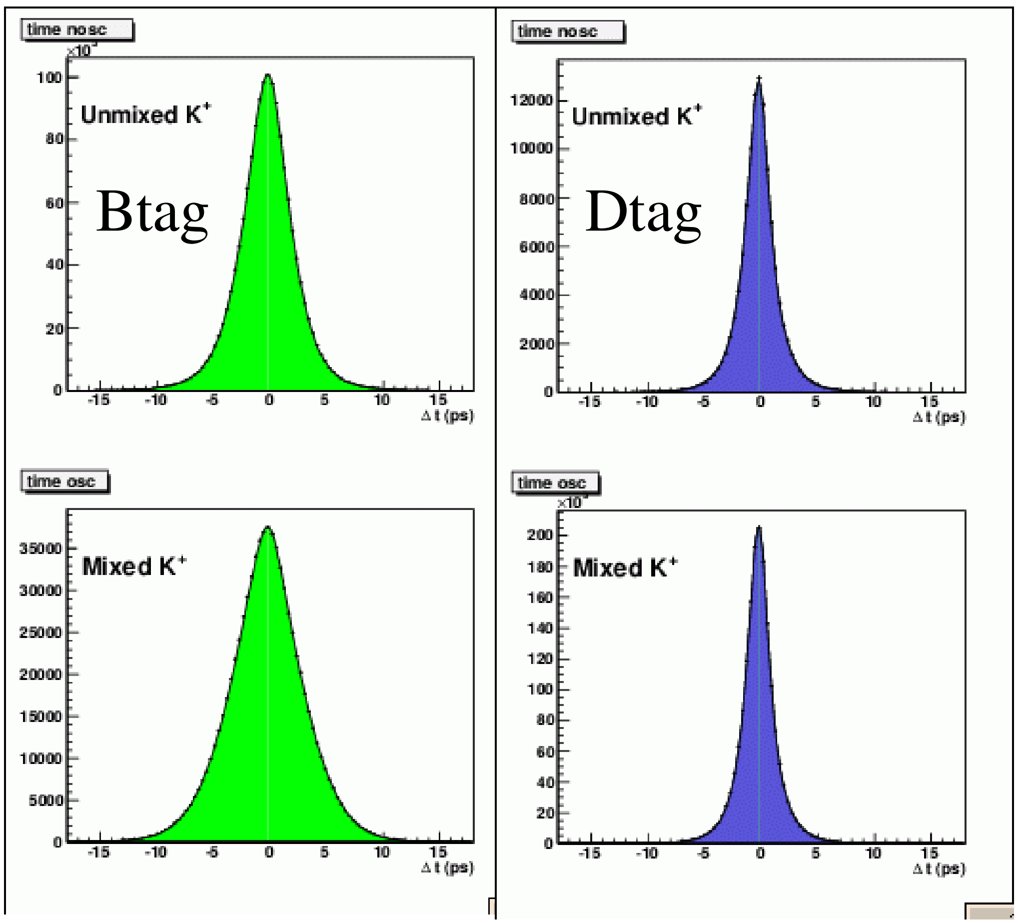
A random flavor misassignment would reflect both in higher mistag rate at $\Delta t=0$ (due to the peaked Unmixed Δt distribution) and in a higher yield of events with the “wrong” K charge wrt the “right” K charge at $\Delta t=0$;

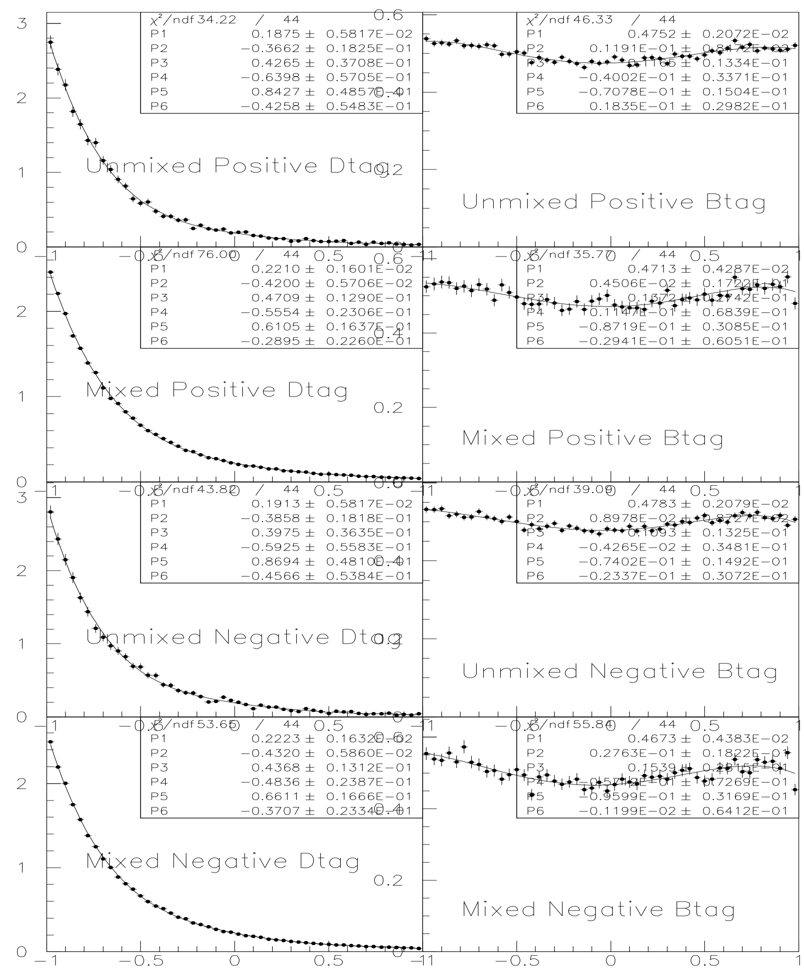
- Is it a general problem?
- Did any other guy find a similar effect?

Btag+Dtag combined fit

➔Btag vs Dtag separation exploiting simultaneously (Δt, θ) informations

➔Normalized PDFs($\theta_{Ktag\text{-}lepton}$): ($B^0/B^+$)×(RES/BKG)×(mix/unmix)×(B_{tag}/D_{tag})×(K^+/K^-)×(e/μ)= 64 different samples;

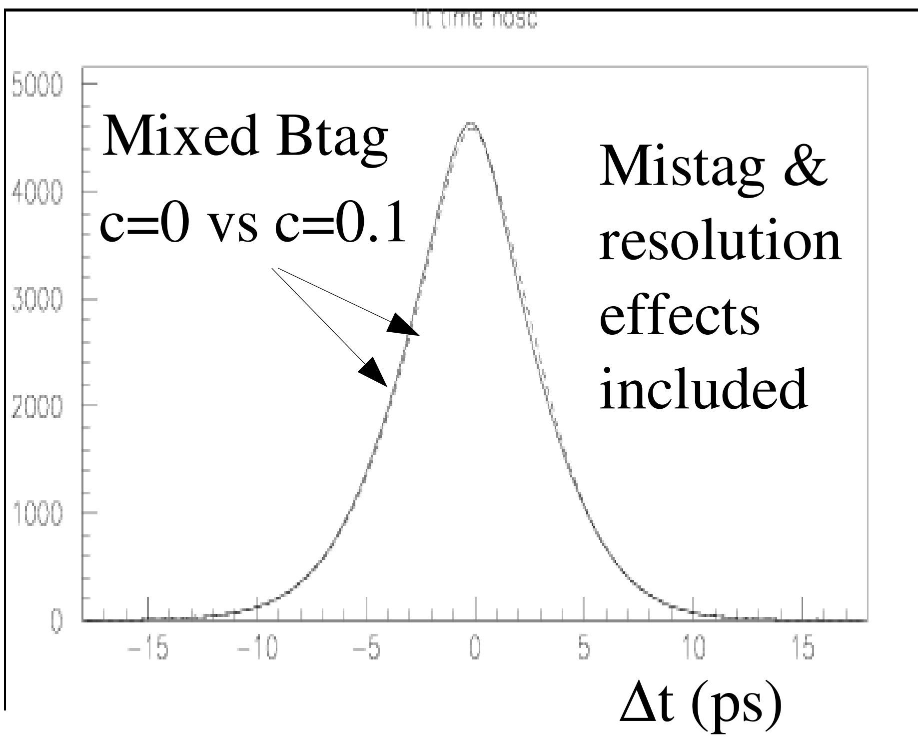


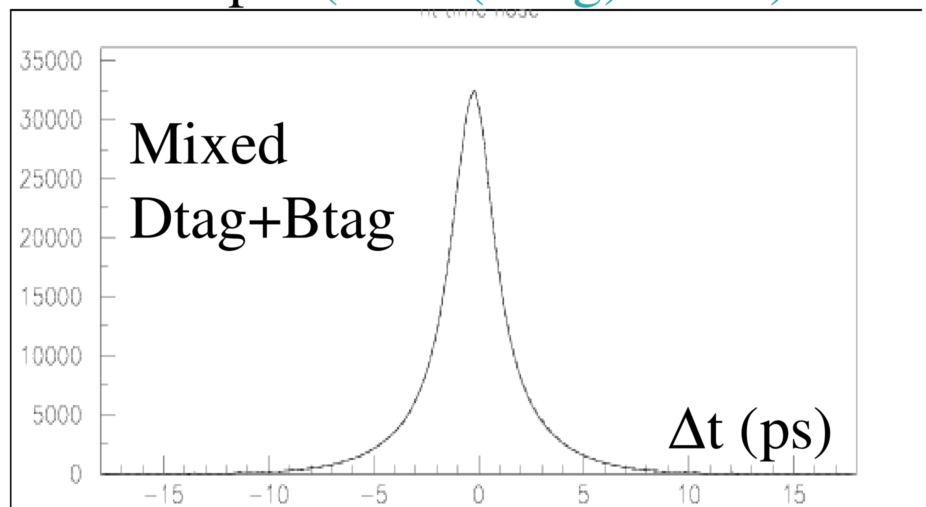


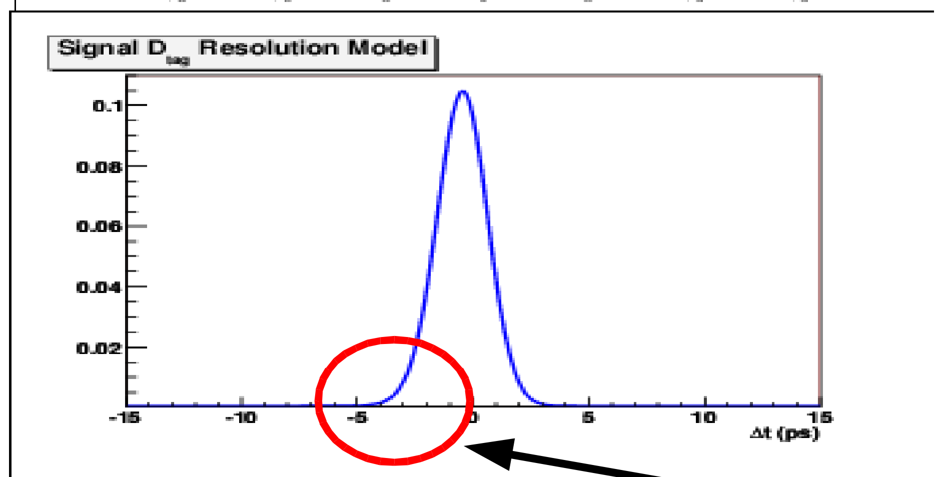
$\cos(\theta_{Ktag\text{-}lepton})$

➔Modeling of D-tagged events is a crucial issue

➔Dtag events mostly populate the mixed event sample (Fr^{MIX}(Dtag)~70%) which is the most sensitive to b, c :



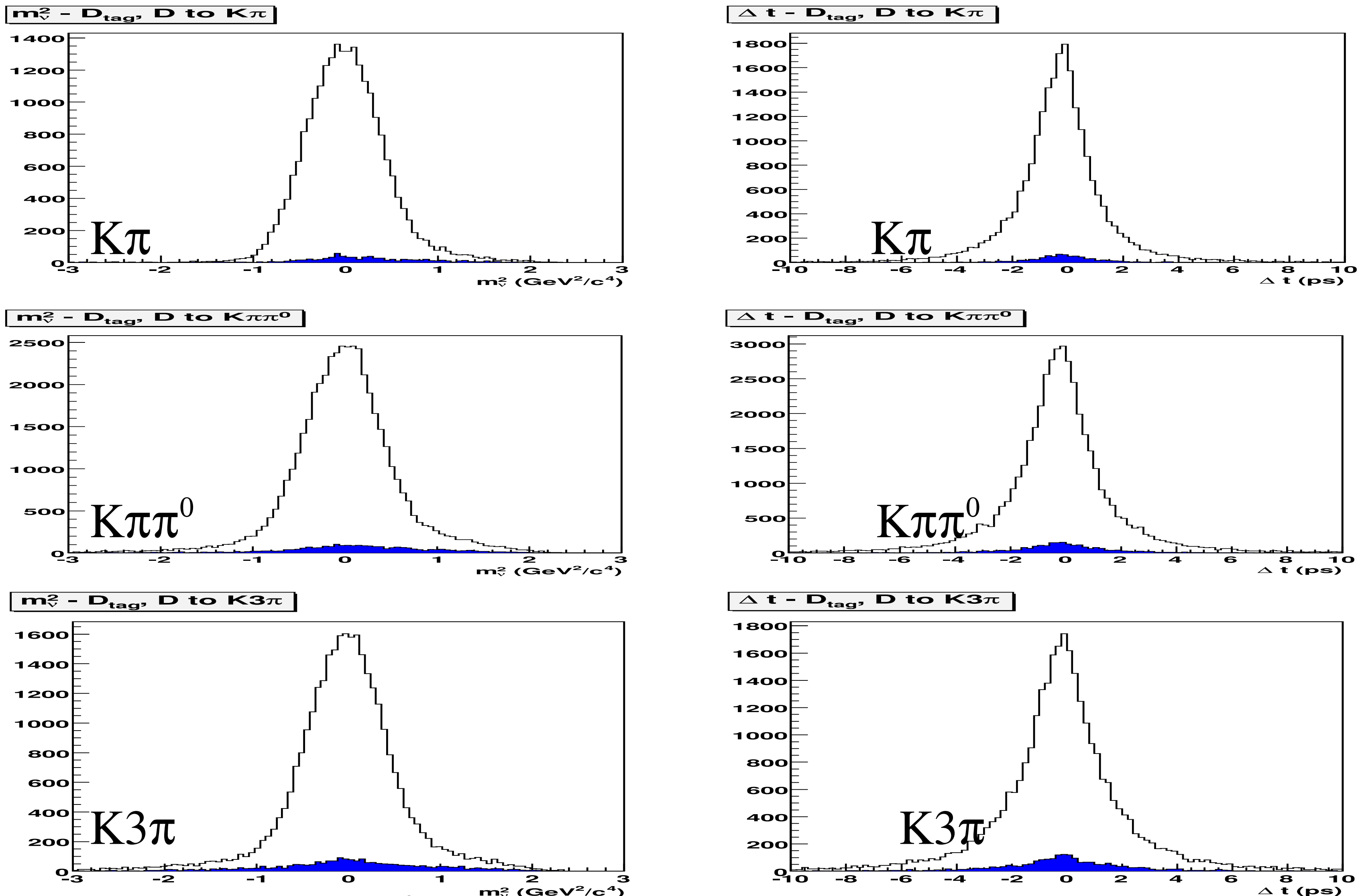




➔**Inaccurate determination of Dtag resolution parameters (namely τ(GEXP) & offsets) could mimic c ≠0! (this effect brought us to discover the Pk dependence of resolution parameters...)**

➔Modeling of D-tagged events can be checked using control samples of exclusively reconstructed $B^0 \rightarrow D^*l\nu$ ($D^0 \rightarrow K\pi$, $K\pi\pi^0$, $K3\pi$)

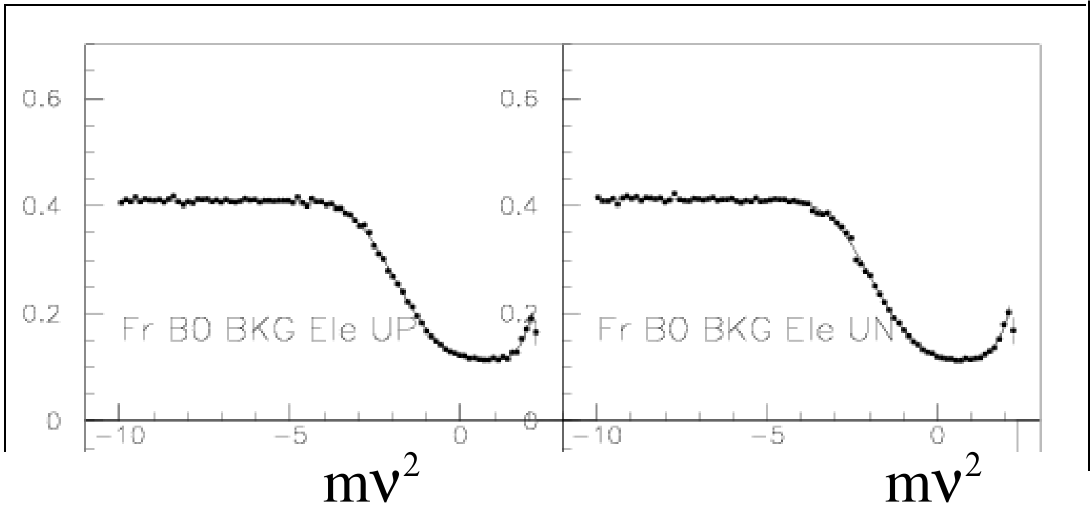
➔K used as K_{tag} in the usual sample

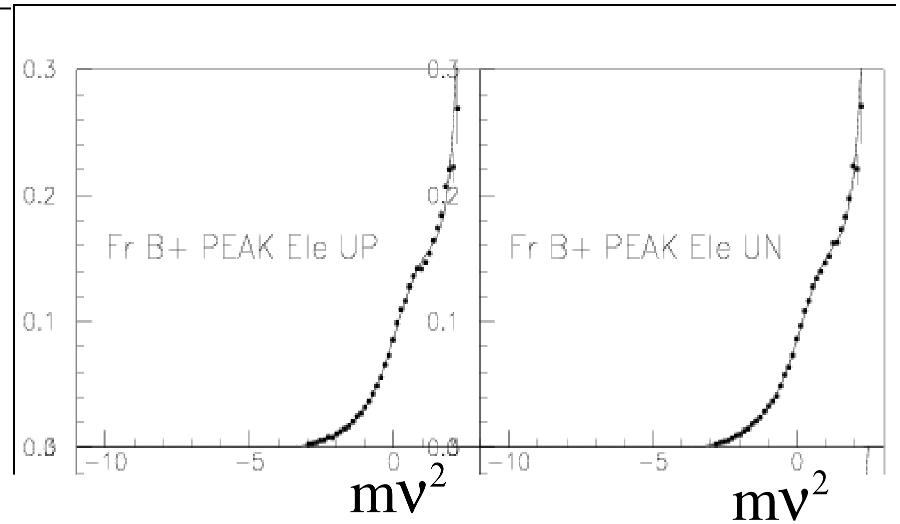


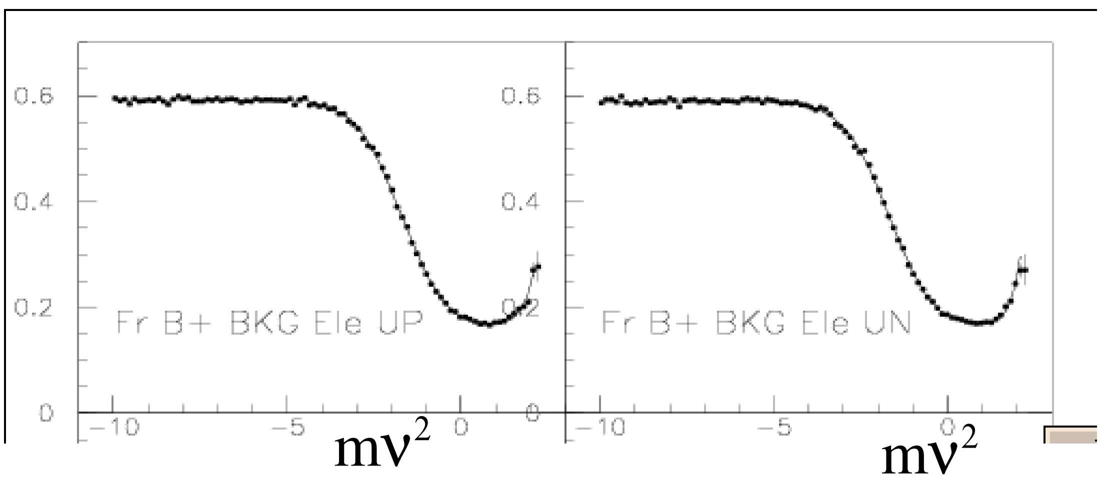
$m\nu^2$ Δt

MC Global Fit

➔Fraction of the various event categories:
$(B^0/B^+)\times(RES/BKG)\times(mix/unmix)\times(K^+/K^-)\times(e/\mu)$ determined from external fits on $m\nu^2$







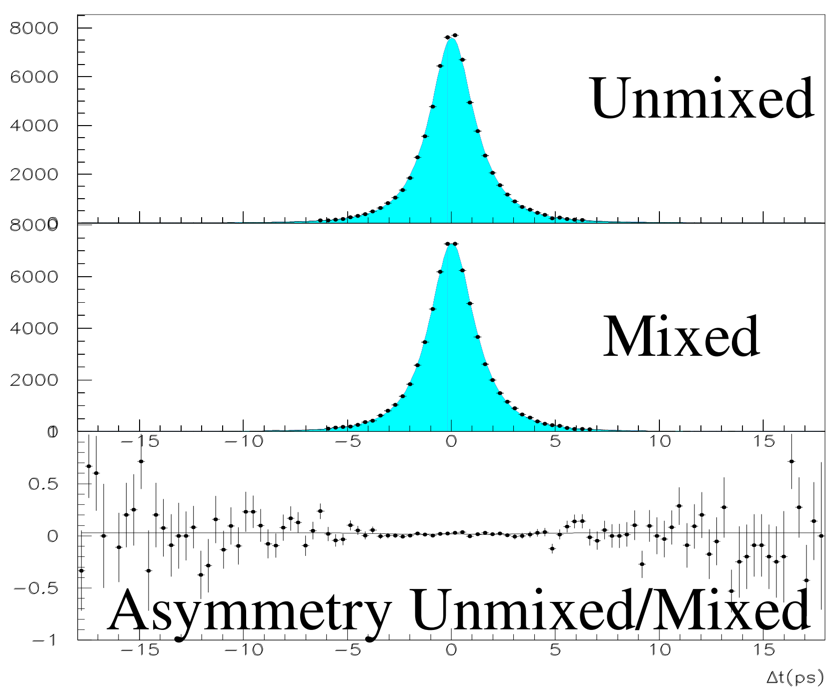
➔32 different parameterizations

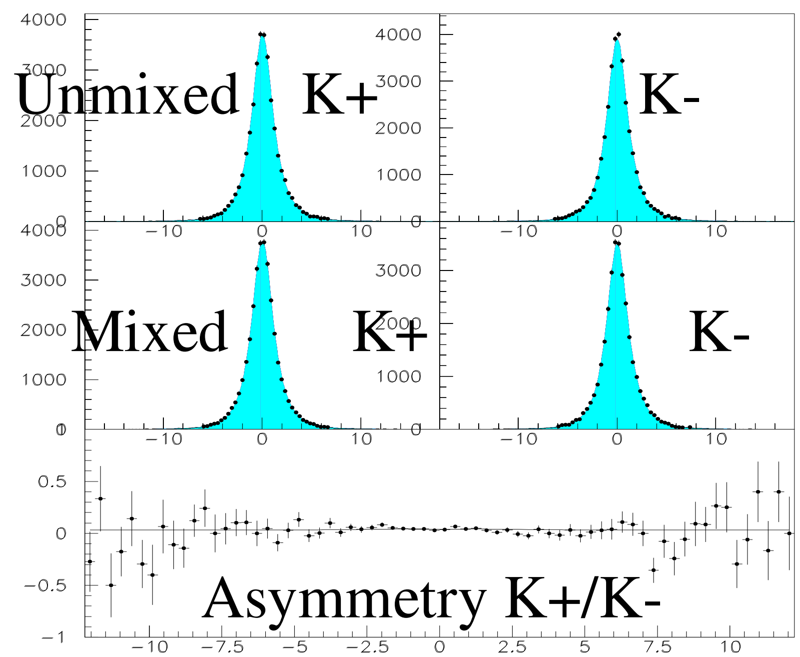
➔$Fr(B^0\ RES) = 1 - \sum Fr(BKG)_k$

Treatment of the Continuum event sample in the global fit

➔Strategy: Simultaneous fit to onpeak & offpeak events to constrain the continuum PDF parameters;

➔MC Global fit: a Toy sample of continuum events, generated from the offpeak data sample, is going to be added to the MC to check the method.





Δt (ps) Δt (ps)

CPV Toy MC

➔MC samples with CPV are needed to look for possible analysis bias on the |q/p|, b, c parameters;

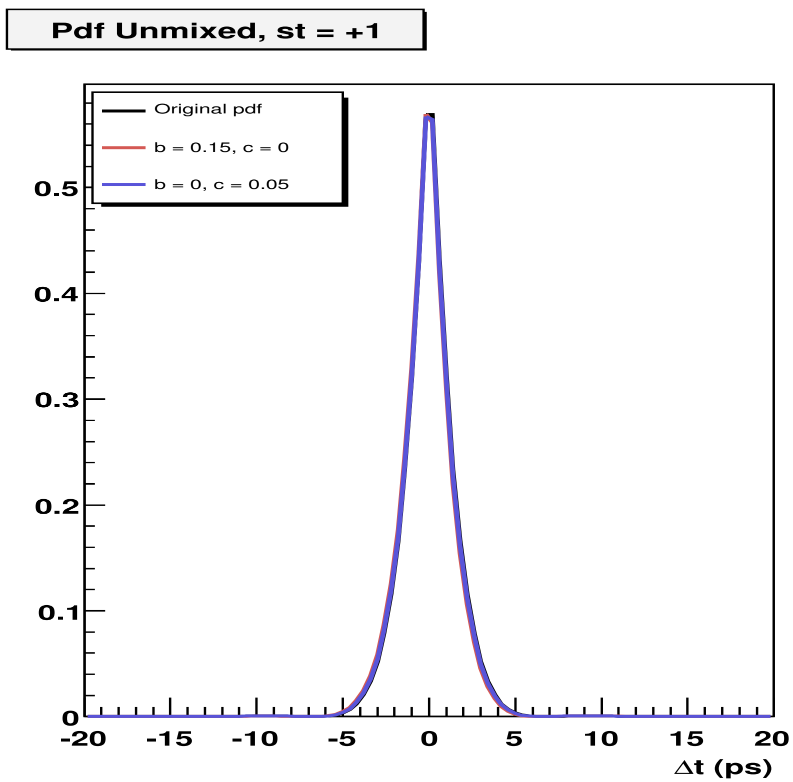
➔Present assumption of sharing the same CPV parameters between B^0 resonant and B^0 combinatorial samples to be verified;

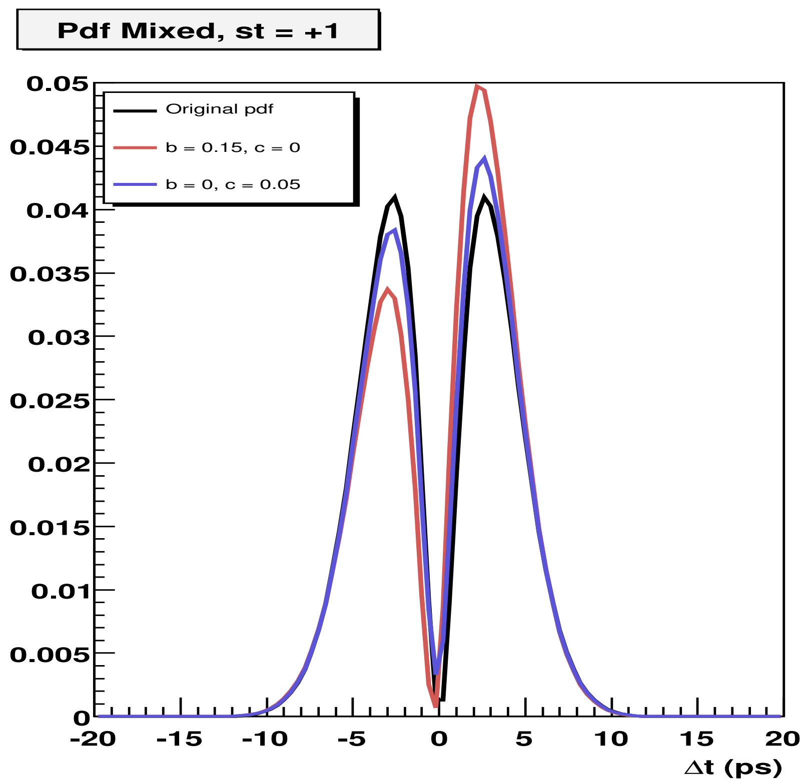
➔Several Toy event samples with different CPV parameter values generated from the generic MC by discarding events;

➔Probability of keeping the event: $\mathrm{Prob}(\Delta t) \sim \mathrm{PDF}^{CPV}(\Delta t) \,/\, \mathrm{PDF}^{original}(\Delta t)$

➔Di

bins





Conclusions & Next Steps

- Analysis Strategy succesfully checked;
- Global MC Fit almost finalized (waiting for the Toy MC continuum sample);
- Toy MC samples including CPV ready in a while;
- Problem with the true-Δt distribution for mixed event still to be understood;

NEXT STEPS:

- Real Data sample analysis;