Update on section "B meson lifetimes, BBbar mixing and EPR correlations" (section 14.5)
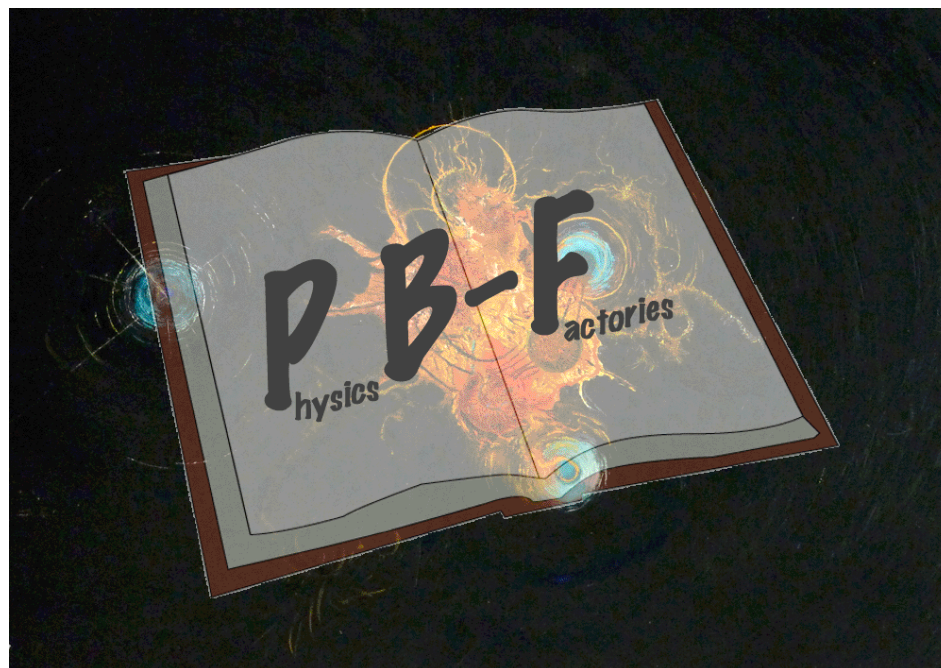

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PBF Book Workshop

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Section outline

- *14.5.1 Introduction*
  - *generic intro to all subsections*
- *14.5.2 B meson lifetimes*
  - *added to this section at Mainz workshop*
- *14.5.3 BBbar mixing*
- *14.5.4 EPR Correlations*
- *14.5.5 CP,T and CPT violation in mixing*
- *14.5.6 Lorentz invariance violation*

- *Still need to decide if CPT and Lorentz invariance violation measurements can be moved here rather then have them in section 14.9 after the discussion of time-dependent measurements of phi1,phi2 and phi3*

B Meson Lifetimes

- *Introduction*
  - *Historical relevance (Discovery of long B lifetime, possibility of mixing and time-dependent CP violation)*
  - *Lifetime measurements before B Factories*
    - *2000 PDG world average*
  - *Motivation at B Factories*
    - *Theoretical predictions*
      - *Spectator model (and deviations thereof)*
      - *QCD corrections for tau+/tau0)*
    - *Importance to demonstrate understanding of systematics relevant for TD CPV and B mixing measurements*
  - *Experimental differences between B Factories and previous B lifetime measurements (LEP/SLC/CDF)*
    - *Samples (size, background, partial vs full reconstruction)*
    - *t vs Δt*

B Meson Lifetimes

- *Measurements*
  - *Tabulate B Factory (not-superseded) results plus averages*
  - *Will refer to earlier super-seeded measurements in text*

Table 15. Measurements of $\tau(B^0)$, $\tau(B^+)$ and $\tau(B^0)/\tau(B^+)$.

		$\tau(B^0)$
Experiment	Method	$\tau(B^0)$ [ps]
BABAR (Aubert, 2001b)	Exclusive hadronic modes	$1.546 \pm 0.032 \pm 0.022$
BABAR (Aubert, 2003g)	Exclusive $D^* l\nu$	$1.523^{+0.024}_{-0.023} \pm 0.022$
BABAR (Aubert, 2006i)	Inclusive $D^* l\nu$	$1.504 \pm 0.013^{+0.018}_{-0.013}$
BABAR (Aubert, 2003b)	Inclusive $D^* \pi, D^* \rho$	$1.533 \pm 0.034 \pm 0.0238$
Belle (Abe, 2005b)	Excl. had. modes $+ D^* l\nu$	$1.534 \pm 0.008 \pm 0.010$
		$\tau(B^+)$
Experiment	Method	$\tau(B^+)$ [ps]
BABAR (Aubert, 2001b)	Exclusive hadronic modes	$1.673 \pm 0.032 \pm 0.023$
Belle (Abe, 2005b)	Exclusive hadronic modes	$1.635 \pm 0.011 \pm 0.011$
		$\tau(B^+)/\tau(B^0)$
Experiment	Method	$\tau(B^+)/\tau(B0)$
BABAR (Aubert, 2001b)	Exclusive hadronic modes	$1.082 \pm 0.026 \pm 0.012$
Belle (Abe, 2005b)	Excl. had. modes $+ D^* l\nu$	$1.066 \pm 0.008 \pm 0.008$

mc

B Meson Lifetimes

- *Describe different measurements*
  - *Full vs. partial reconstruction, hadronic vs. semi-leptonic modes*
  - *A discussion of B's with partially reconstructed D*'s on the "B reconstruction" section would be useful*
- *Compare characteristics of different B Factory lifetime measurements*
  - *List purity, yield and sensitivity (in terms of standard sample size)*
  - *May combine this table with the results table in two-column format*

Table 14.

Measurement	Purity	Yield [B/fb^{-1}]	Δz RMS
BABAR (Aubert, 2001b)	$\approx 90\%$	230	190 μm
BABAR (Aubert, 2003g)			
BABAR (Aubert, 2006i)	64%	605	180 μm
BABAR (Aubert, 2003b)			
Belle (Abe, 2005b)	81%	870	182 μm

B Meson Lifetimes

- *So far one figure added to latex*

  - *Figure is from a superseded result, but looks nicer than figure from final result*

  - *Chosen figure should in general present final result, but ok, if chosen figure demonstrates*

    - *All salient features of measurement and looks superior to final result figure*
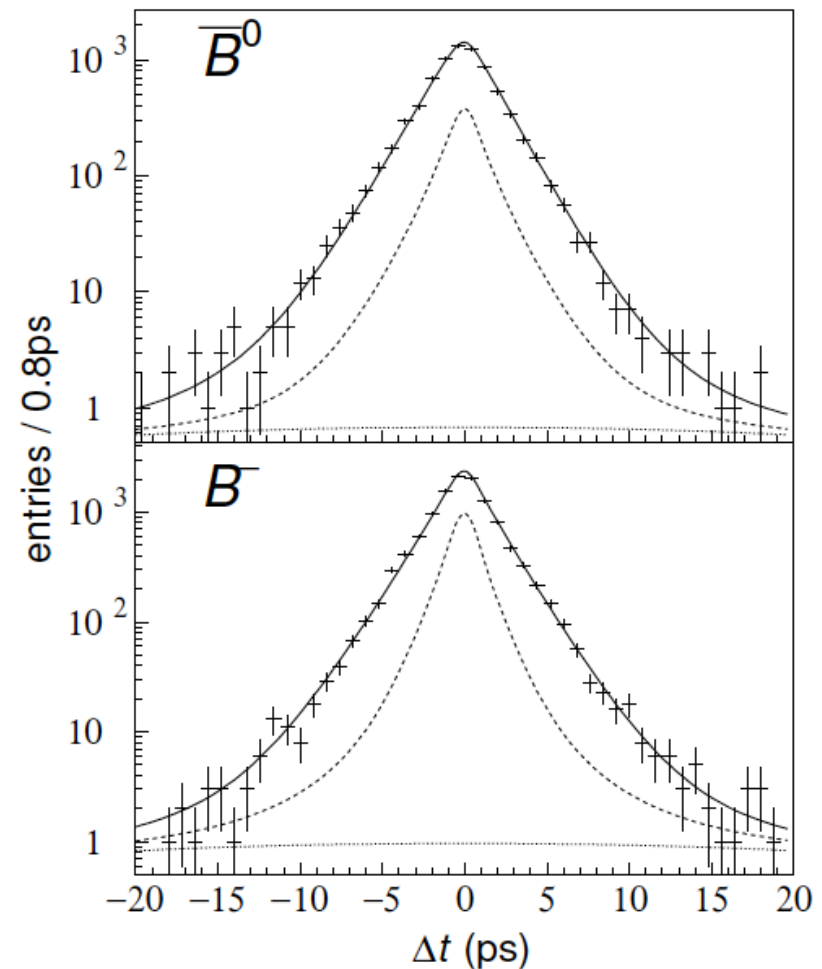

Fig. 26. The Δt distributions of $\overline{B}^0$ (top) and B^- (bottom) candidates. The dashed lines represent the sum of the background and outlier components, and the dotted lines represent the outlier component (Abe, 2002e).

BBbar mixing

- *Plan to have a structure similar to B Lifetimes part, but no actual text written, yet*

- *Samples almost the same as for B Lifetimes measurements*
  - *But in addition have di-lepton measurements*

Table 16. Measurements of Δm_d.

Experiment	Method	Δm_d [ps^{-1}]
BABAR (Aubert, 2002b)	Exclusive hadronic modes	$0.516 \pm 0.016 \pm 0.010$
BABAR (Aubert, 2002c)	Exclusive di-lepton	$0.493 \pm 0.012 \pm 0.009$
BABAR (Aubert, 2006i)	$D^* l\nu$ (partial)	$0.511 \pm 0.007 \pm 0.007$
BABAR (Aubert, 2003g)	Exclusive $D^* l\nu$	$0.492 \pm 0.018 \pm 0.014$
Belle (Zheng, 2003)	$D^* \pi$ (partial)	$0.509 \pm 0.017 \pm 0.020$
Belle (Hastings, 2003)	Di-lepton	$0.503 \pm 0.008 \pm 0.010$
Belle (Abe, 2005b)	Exclusive hadronic modes, $D^* l\nu$	$0.516 \pm 0.016 \pm 0.010$
B factories average		$0.508 \pm 0.003 \pm 0.003$

EPR Correlations

- *Section describes a single analysis*
  - *Go, Bay, et al, PRL 99, 131802 (2007)*
- *Machinery of the mixing analysis is used as a base*
- *Mostly techniques specific to this analysis to adapt the mixing machinery to the different purpose*
  - *Needs its own subsection and should be grouped in the same overall section as lifetimes and mixing*

Comments from review

- *Received first round of comments (Thanks, Bostjan!)*

p. 1, right, par. 1:
you say the motivation and theory is going to be included in each subsection; I have no objection to that, but perhaps there are some common equations/explanations to be nevertheless included in the Introduction subsection?

This is still in flux what part of the introduction goes to the subse and what goes to the section as long as the text is being writter

p. 1, right, par. 2:
I think a pedagogical part regarding the spectator model expectations for the lifetime, and then corrections leading to the differences in lifetimes between various B species should be provided (including equations and probably some illustrative diagrams).

I agree. This will be added.

As I mentioned above it may be a nice pedagogical part to explain the differences between the lifetimes in some more details (as deviations from the spectator model). I would assume the knowledge of the students to be at the level that they know the partial decays widths are proportional to (delta m)^5.

Agreed.

p. 2, left, par. 4:
Here I think it is quite worthwhile to explain that the accuracy of the lifetime determination depends on two terms, one is the intrinsic decay time resolution and the other the RMS of the underlying (exponential) distribution, i.e.
sigma_tau^2 \propto tau^2/N + sigma_t^2
(right?)

This could be done. I need to think about it.

Measurements of delta m and delta Gamma:
I know we've said that we shouldn't go into any details regarding the SuperB factories sensitivities. However, I feel a discussion on the motivation for even more precise determination of both, delta m and of course especially delta Gamma, would be in place here.

Yes, at the end of the section there will be an outlook to the future.

Next Steps

- *Still some discussion on details of the distribution of material between tool section 7 ("Mixing and TD analyses") and this section*

- *Need to decide where CPT and Lorentz invariance violation goes*

- *Address first set of review comments*

- *Plan to have full draft on Lifetimes, B mixing and EPR correlations parts by October*
  - *Will work in parallel on CPT, etc. subsections*