

## BaBar-Belle Legacy Book White Paper

The BaBar and Belle collaborations have together published about six hundred journal articles over the last eight years and at least another one hundred will come out of ongoing analyses. As usual in high-energy physics these articles typically describe the measurement of a single physics parameter or a small set of parameters. There are currently no publications by either BaBar or Belle which review all of their measurements in a certain area of physics, putting the individual results into perspective.

BaBar and Belle have published their physics results in a manner typical for high-energy physics experiments. Important measurements are often described in a series of papers with increasing integrated luminosity. Often a first paper with early data is based on a limit, while later papers then follow with first evidence or first observation or eventually a precision measurement. Sometimes, but not always, at least one of the papers is a full length Physical Review (or equivalent) article, which describes the measurement in adequate detail. However, this is often not the paper that contains the final result. Rather the update papers typically describe only the changes with respect to the previous publication and the new result. Since the analyses techniques are almost always improved between publications, it can become quite cumbersome to find out exactly how the final result of a specific measurement was obtained.

BaBar and Belle have over the last few years continuously developed more and more sophisticated techniques to extract information from the data with maximum sensitivity. Often these techniques are used by multiple analyses. However, most BaBar and Belle results have been published in Physical Review Letters, Physical Review D Rapid Communications and Physics Letters where the page limits usually do not allow a detailed description of the analysis techniques. The BaBar-Belle Legacy Book will solve this problem by providing descriptions of all of the analysis techniques that were developed by the two experiments.

Another disadvantage of only publishing individual results is that sometimes the combination of many distinct measurements is necessary to evaluate the impact on the underlying physics. For example, the consistency between the measurements of the sides and angles of the Unitarity Triangle is a question neither BaBar nor Belle have coherently addressed in a paper. Instead the information is distributed in numerous BaBar and Belle papers on  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $V_{ub}$ ,  $V_{cb}$ , etc. A publication describing all of these results would make it easier to evaluate how consistent these measurements are within the CKM framework of the Standard Model.

As of today, BaBar and Belle have never co-authored a paper. However, BaBar and Belle results have been combined in the past by the Particle Data Group (PDG) and the Heavy Flavor Averaging Group (HFAG). In fact, the HFAG was formed by BaBar and Belle to combine measurements from the two experiments. In particular when information beyond the typically quoted central values and plus-minus one standard deviation uncertainties were required to calculate an average. However, the HFAG and PDG averages are not

peer-reviewed and the HFAG results are only published as electronic preprints. There are no published peer-reviewed combined results from the B factories.

All these issues can be addressed with a BaBar-Belle Legacy Book. The book will contain full reviews on all of the major physics areas that the B factories have studied over the last decade. In addition, it will contain detailed descriptions of the tools and techniques developed and used in BaBar and Belle analyses and short summaries of the BaBar and Belle detectors.

A draft outline for the BaBar-Belle Legacy Book is shown at the end of this paper. The BaBar-Belle Legacy Book will roughly be divided into three distinct parts: a brief description of the BaBar and Belle detectors, the analysis tools used in the measurements and the physics results and their interpretation.

In many aspects the BaBar Belle Legacy Book will be similar to the BaBar Physics Book [1]. The big difference however is that the physics information is now based on  $1.5 \text{ ab}^{-1}$  of data and the book will reflect the progress in the field made by BaBar and Belle in the last decade.

The detector part will describe the salient features of the BaBar and Belle detectors at a level similar to chapter 3 in the BaBar Physics Book. The part on tools and techniques will be similar to chapter 4 of the BaBar Physics Book and cover topics such as flavor tagging, recoil B reconstruction, multivariate discriminants, etc. The largest part of the book will be devoted to the physics results of the BaBar and Belle experiments, the combination of those results (both between the same measurements from both experiments and from different measurements), and the interpretation of the results.

The physics part will be structured by physics topics. A starting point could be similar to the structure of the physics working groups of the experiments (e.g. the BaBar AWGs). The relevant measurements by the experiments in each area will be described and where appropriate B factory averages given. The results will be interpreted and put in context with other measurements.

We envision the following rough time line for the BaBar Belle Legacy Book. During 2009 the BaBar and Belle management teams will identify the main editors of the book (one or two persons from BaBar, Belle and theory each) and agree on the rough structure of the book. Once the structure of the book is defined the coordinators and writers of the individual sections will be identified. Each major topic will have at least one main writer from BaBar and one main writer from Belle. The physics chapters are expected to be co-written with theorist participation. The writing of the book will start before the end of 2009 and continue until the end of 2011. A number final results have already been published, and it is reasonable to expect that sections associated with these analyses will be written by mid-2010 as an initial goal. The remaining results will continue to be added until the end of 2011. The book will then be submitted for peer-review and publication in 2012. This schedule starts within the Intense Analysis Period of BaBar and goes into the

Steady Analysis Period. At this point we have an informal note from Belle that they are in general enthusiastic about participating in a BaBar-Belle Book.

This time line allows the BaBar Belle Legacy Book to be published before the next generation B factories start taking data. SuperBelle anticipates first collisions in 2012 and SuperB somewhat later. A new generation of students and postdocs will be analyzing the data of these super B factories. Many of them will not have had the chance to look at real data from Belle and BaBar. To them the BaBar-Belle Legacy Book will be an invaluable source of information. It will provide them with an overview of all possible analyses at the B factories in sufficient detail to allow them to design their analysis at the Super B factories and/or to perform analysis of the BaBar and Belle data in the foreseen Archival period.

Beyond the immediate value for people who will work on future flavor factories, the BaBar-Belle Legacy Book will be the ultimate publication for all the topics that have been studied by BaBar and Belle. It will contain full reviews of the areas in a uniform format. As such it will provide a coherent picture of the physics exploited by the B factories. It will be an ideal starting point for high-energy physicists who have not worked on, but are interested to learn about the physics of the B factories.

A general concern is the availability of sufficient personnel within the BaBar and Belle collaborations to complete the BaBar-Belle Legacy Book project within the given schedule: the collaborations have to gather the needed manpower without compromising the finalization of the ongoing and planned analyses. We expect that the project requires about 15 section coordinators/writers from each experiment and the participation of about 10 theorists. This is a large number considering that a large fraction of the BaBar and Belle collaborators are involved in other experiments. On the other hand many BaBar and Belle collaborators are interested and/or involved in a Super B factory and probably more likely to contribute to the writing of the BaBar Belle Legacy Book. Furthermore, it is expected that the ambition of the project, backed by two large Collaborations, will attract the attention of physicists otherwise planning to withdraw their participation and will provide an incentive for finalizing most analyses, including possible joint analyses, in due time to be incorporated in the Book

## References

[1] The BaBar Physics Book, Eds. P.F. Harrison and H.R. Quinn, SLAC-R-504 (1998).

Status quo

1. ~600 papers by BaBar and Belle (BaBar: 167 PRL, 71 PRD, 122 PRD-RC, 1 PRD brief; Belle: 107 PRL, 82 PRD (incl. RC, brief), 41 PLB) – but not many “long papers” (with more than 10 pages)
  - a. Many measurements are covered in more than one paper (e.g.  $\sin 2\beta$  with  $J/\psi K_S$ )

- b. Many interesting aspects of the measurements are not covered at all (combination of measurements)
  - c. Many papers use similar techniques, but due to space constraints in PRL and PRD-RC are not sufficiently described in many papers
2. No peer-reviewed combined BaBar-Belle results

#### Scientific value and Physics Interest

1. Full review of BaBar and Belle physics results in uniform format
2. Legacy of BaBar and Belle methods, results and impact in the field

#### The Book

0. B-Factories
  1. Detectors and Collaborations
  2. Tools and Methods
    - a. Flavor Tagging
    - b. Vertexing
    - c. Recoil B reconstruction
    - d. Multivariate discriminants
    - e. Maximum Likelihood fitting
    - f. Analysis optimization
    - g. Blind analysis
  3. Results and Interpretation
    - a. B physics
      - i. CKM elements
        1. Sides ( $V_{ub}$ ,  $V_{cb}$ ,  $V_{td}$ ,  $V_{ts}$ )
        2. Angles ( $\alpha$ ,  $\beta$ ,  $\gamma$ )
      - ii. Rare B decays
        1. Radiative and EW penguins
        2. Leptonic Decays
        3. Etc.
      - iii. Hadronic B decays
      - iv. Mixing
      - v. CPT violation / EPR correlations
      - vi. Etc.
    - b. Heavy Quarkonia
      - i. Charmonium
      - ii. Bottomonium
    - c. Charm physics
      - i. D Mixing and CPV
      - ii. Charm decays (incl. baryons)
    - d. Tau physics
    - e. QED and ISR

#### BaBar-Belle management issues

0. Assess the viability of the project
1. Identify main editors
  - a. BaBar (2), Belle (2), Theory (1)
2. Identify three (BaBar, Belle, theory) main editors per chapter
3. Identify authors per sub-chapter
4. Define the project
  - a. Time line
  - b. Meetings organization
  - c. Publication policy
  - d. Authorship
  - e. Funding