Belle-II Software and Tracking Review

Findings and Recommendations

Report from Reviewers
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Introduction

The aim of the Belle-II software and tracking review was to assess the status of project and its preparation for the start of the Belle-II data taking. In a series of internal meetings and in consultation with the external reviewers a 2 day review meeting was organized at the Max-Planck-Institute for Physics in Munich. The format of those 2 days was defined to be a series of presentations, covering the different aspects of the software project. Plenty of time during those 2 days was reserved for discussions. The presentations at the review workshop[1] were:

- T.Kuhr: “Introduction and overview, including organization”
- T.Hara: “Tracking (and related) issues”
- T.Hara: “Simulation”
- M.Heck: “High Level Design of tracking software and Event Data Model”
- M.Heck: “Track Reconstruction Algorithms“
- M.Heck: “Tracking in the online context”
- S.Yashenko: “Alignment and Calibration”
- T.Hara: “Performance (physics and technical)”

The meeting concluded with a presentation by us, the reviewers, giving our preliminary feedback based on their first impressions. The aim of this document is not to give detailed feedback on each of the individual presentations. Such feedback was covered in the detailed discussions during the review. In this document we summarize our overall findings and our overall recommendations.

Tracking at Belle II

The Belle II detector designed to operate at and near the upsilon resonances. The physics requirements include precise tracking of charged particles, including accurate and precise momentum and impact parameter determination, and extrapolation to outer detectors, in a relatively high-background environment. The upgraded Belle II tracking system consists of two inner layers of pixels based on DepFet detectors, followed by a 4-layer silicon strip detector, and a multi-layer axial plus stereo chamber with square cells ranging from 1 to 2 cm. The upgraded tracking system differs substantially from the Belle tracker, and requires new software to simulate and reconstruct. In addition, higher luminosity at Belle II will generate higher rates for both signals and background that Belle software and computing might not be capable of handling. The purpose of the review was to evaluate

[1] http://kds.kek.jp/conferenceOtherViews.py?view=standard&confId=12382

the readiness of the Belle II tracking and alignment software, and the appropriateness of the technical decisions that have been made in it.

Overall Impressions

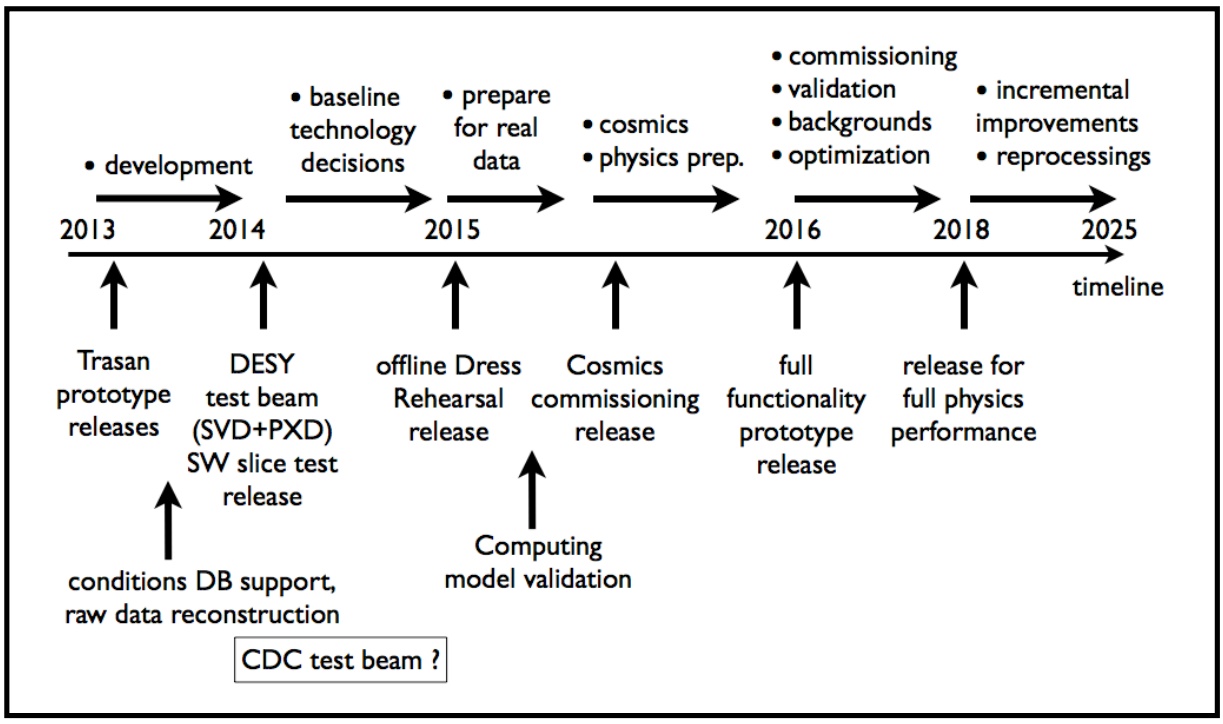
The reviewers were impressed by the quality of the presentations and the huge amount of excellent work that has been reported in the presentations during the 2 days. In general, the technologies under development and the choices of tracking methods seems adequate for the reconstruction problem to solve.

Main Recommendation 1: Define a Roadmap with clear Milestones

Several of the presentations were defining short term goals for the corresponding area of the project. It was hard to judge for the reviewers if individual plans are coherent overall and it was unclear how the progress is monitored. High level milestones for Belle-II were as well discussed during the workshop, but it remained unclear to the reviewers how they are connected to a release schedule. An incomplete list of such high level milestones comprises:

- DEST test beam of SVD and PXD sensors (slice test) in 2014
- commissioning with cosmics in 2015
- commissioning with beam in 2016
- high luminosity running in 2018

Other high level milestones are required to ensure the readiness of the software itself, like some offline Dress Rehearsal. The figure below shows how a possible release plan for the computing project could look like, taking into account the high level milestones, the current status of the software project and its possible evolution.



This release plan implies that software releases with increasing level of functionality are given to the collaboration to carry out the different activities. In order to reach those release deadlines the development needs to be focused on the required new functionality. Releasing the software early is important to obtain user feedback and will help to involve the collaboration at large into the software project.

Main Recommendation 2: Foster Software Integration

During the review an impressive number of tracking software modules were presented that are currently under development. It was demonstrated that all tracking components required for Bell II are covered and that many technical solutions have been developed, though sometimes manpower is limited. At the same time not all of those software components have reached the same level of maturity. It has been noted that some duplication of effort can be identified, as the same functionality sometimes is implemented in more than one software module. While some duplication is desirable, as in using multiple algorithms reconstruct overlapping regions, other parts seemed more historical in nature.

The reviewers recommend to improve on the integration of the tracking components into one overall functional reconstruction. This has several aspects:

- Document (and where lacking define) the common reconstruction Event Data Model (EDM) and software interfaces to common tracking tools and services. Consistently defining the interfaces based on the common EDM ensures modularity of code and eases module replacement without changing client code. Such a software design pattern allows for the required flexibility in configuring the tracking strategy according to the needs. It is as well needed to avoid code duplication, because common tracking tools with public interfaces can be reused in different tracking modules (e.g. track parameter propagation in the field and material effects).
- Prepare an early release with an initial tracking prototype using the proposed EDM and targeted interfaces, with enough functionality to allow users to perform useful physics studies, so that they can provide feedback. Such an early release may even contain truth based reconstruction modules, as they can be replaced with fully functional code modules in subsequent releases.
- Evolving the initial tracking prototype to eventually achieve the best possible physics performance. An important aspect of this is to explore the optimal tracking strategy. Investigate the use of iterative track finding, e.g. starting with CDC based track finding, extending candidates into the silicon detectors, and then reversing the order, starting in the silicon detectors to find additional tracks. An optimal tracking strategy probably will involve the integration of the low-momentum finder. During the discussions at the workshop the concept of a 2nd stage track refinement came up, which seemed attractive to improve the found tracks with the full available detector information. To fully implement the optimal tracking strategy, some missing modules will need to be developed.
- Investigate the full integration of GenFIT into the Belle-II software, not treating it as an external package. GenFIT does provide the track class and requires input in terms of clusters and CDC hits. Hence, it defines core parts of the tracking EDM. Similarly, its material geometry and tool interfaces (e.g. to fitting and extrapolation) provide central tracking functionality to be reused in the overall reconstruction.

- Integrate the alignment software with the reconstruction. Prefer common code for the same functionality to ensure numerical identical results in alignment and reconstruction applications. E.g. base both applications on the same fitter (either GBL or KF), use same field transport, material and geometry, hit creation from raw, etc..

Further Comments and Recommendations

I. Prioritization

- At the review the highest priority for the software project at this point was to provide feedback to the detector design. It was unclear which detector questions need to feedback from the software project to be resolved and how those questions can be addressed in a timely way.
- Lots of projects are going on simultaneously. It was unclear to the reviewers, if the prioritization is consistent and coherent. 'Global' priorities should be defined and clearly communicated within the project. E.g., developments for some features not needed for early tests or early data could be reduced in priority to reduce the immediate burden on developers.
- Tying the priority of projects to the development schedule will help clarify for developers and users what the purpose of changes is, and when features can be expected.

II. Role of User Feedback

It was not clear to the reviewers what are the users impressions of the new tracking and what impact the tracking development work had on the physics studies. Design feedback from the users is vital the software project, e.g. on the analysis Event Data Model or on the analysis interfaces (unchanged from Belle-I ?). User-related development milestones need to be agreed upon for the software project.

During the review it was mentioned that within 6 weeks a first MC production will be carried out based on Trasan. This will be the first exposure of the new software framework (BASF) for users. The reviewers support this strategy, and suggest that the production have as a high priority involving end users and getting feedback from them.

III. Functionality of the Analysis EDM

Clarify the requirements on the mDST based on well defined physics, performance and alignment/calibration use cases. As well, take into account requirements from detector commissioning and cosmics running. Define boundary between full reconstruction EDM (GenFIT based) track and mDST track. Ensure that use case of alignment (e.g. refitting on mDST ?) is fully taken into account.

IV. Reuse of Trasan for Belle-II

The plan to reuse Trasan for Belle-II appears to be an excellent intermediate solution that enables physics users and developers to test an early version of a functional software

chain. Meanwhile, a full functionality tracking prototype can be developed without holding up the rest of the project. It should be investigated which functional modules from Trasan can be ported into the new tracking prototype, especially those that add functionality. Candidates are e.g. the Hough finder or the curl finder.

V. Reconstruction Test on Belle-I (MC) Data

If technically feasible, aim for a Belle-I (MC) reconstruction test with the new software. this will allow for a benchmarking of the physics performance of the new software based on an understood detector.

VI. Technology Details for GenFit

- Investigate use of STEP propagator to deal with continuous material effects.
- At a lower priority, define a simplified “tracking” geometry to speed up track fitting. Export the material model to other tracking modules to avoid code duplication.
- Fully integrate GBL fitter if this becomes the baseline for reconstruction and alignment.

VII. Staffing

Overall staffing level seems reasonable in many areas in the software project. It became evident in the review that some important projects are orphaned (e.g. no senior person in charge of (CDC) track finding). New manpower is joining the project, it is important to integrate them into the group and to help them finding appropriate projects.

VIII. Missing Pieces

During the review a number of missing software modules were identified, either in talks or in the discussions:

- t0 finding algorithms(s)
- CDC calibration prototype
- hit book-keeping data object
- track merging algorithm
- PXD region-of-interested selection algorithm (software version, alongside FPGA version)
- export of Belle data and geometry to new framework gbasf2

It should be investigated if any of these can be repurposed from Belle-I software.