Fast simulation status and plans

This is a draft of a document which will be circulated within the fast simulation group for review and approval

Contents

- Goals
- Requirements from subdetectors
- Use of existing resources
- Design of the SuperB fast simulation
- Development framework
- People
- Input from Physics Groups
- Documentation and discussions

Goals

Optimization of the detector

- In the medium term the fast simulation will be the most accurate tool to evaluate the impact of a given detector configuration on the SuperB physics reach
- Examples:
  - how the design of the vertex detector (radii of layers, geometry, X0, etc.) affects the resolution of the track parameters
  - how the cell size and cell numbers of the drift chamber affect track reconstruction
  - how the angular coverage and the intrinsic resolutions of DIRC and EMC change the physics reach of the benchmark measurements
  - what's the impact of the machine background on the physics output
  - etc.

Physics analysis

- Fast simulation will be the main tool to do MC physics analysis in the medium term.
- Given the rates of SuperB, it's quite likely that the fast MC will have a critical role even in the long term.

- NOTE: ~$3.4*10^{10}$ continuum events in 1yr. Even in an (optimistic?) scenario with 50ms/evt per CPU, it will take $O(10^2)$ CPUs 24h x 7days for 6.5 months to simulate the events with a fast Monte Carlo

TABLE I: Physics rates at 1.0×10^{36} cm$^{-2}s^{-1}$.

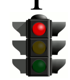
Process	Rate at $\mathcal{L} = 1 \times 10^{36}$ cm$^{-2}s^{-1}$ (kHz)
$\Upsilon(4S) \rightarrow B\bar{B}$	1.1
$udsc$ continuum	3.4
$\tau^+\tau^-$	0.94
$\mu^+\mu^-$	1.16
e^+e^- for $\lvert\cos\theta_{\rm Lab}\rvert < 0.95$	30

Requirements on fast simulation from subsystems

Input from subsystems

- The design of the simulation described later is the result of discussions with the subsystems and try to take their requests into account
- The requirements of the subsystems are summarized in the next 5 slides

Silicon Vertex Tracker

- SVT needs fast MC both for optimization and for performance estimation. The former is less demanding than the latter in terms of simulation features.
- Optimization: sometimes optimal design choices are actually trivial and technology, costs or geom. constraints will drive the design (especially true for the L0 design). In those cases the MC input is not strictly needed.
- Performance estimation would benefit from having:
  - kalman fit 
  - energy loss and multiple scattering taken into account 
  - pattern recognition 
- Pattern recognition can be hardly implemented in the fast simulation. Too much time-consuming. The current plan is not to include it. It may be considered later.
- The effects of background on track reconstruction should be evaluable using the experience with Babar SVT and the input from Geant4 bkg studies. The effects are incorporated in the simulation in terms of efficiency loss, etc..

Drift chamber

- Fast Monte Carlo is needed to study how the measurement of momentum and dE/dx changes as a function of:
  - number of cells per layer
  - number of layers
  - mixed configurations (cell size varying as a function of the distance from the beam axis)
  - spatial resolution of the cell
  - material
- The trajectories must take energy loss and multiple scattering into account and the information of individual hits must be available.

PID

- The R&D of the barrel uses detailed simulation for design optimization. A fast Monte Carlo is not strictly needed.
- Fast simulation can provide useful feedback to decide if endcap PID subsystems are necessary.
- The response of the PID system is studied with detailed simulation (or Babar data) and incorporated into the fast Monte Carlo in a parametric way.

EMC

- The barrel is taken from Babar. Its response is well known from data and detailed MC and will be incorporated parametrically into the fast simulation.
- The design optimization of the new forward endcap is being done with Geant4. The response as simulated with Geant4 will be incorporated into the fast simulation parametrically.
- Fast Monte Carlo will be useful to evaluate the physics case of a rear endcap.

IFR

- Fast Monte Carlo is not needed for the optimization of the IFR, which is done using Babar data and detailed simulation.
- The response of the new IFR will be incorporated into the fast simulation in a parametric way.

Use of existing resources

The BaBar code

- The fast simulation of the superB detector is needed to write the Technical Design Report expected in ~2 years.
- We want to exploit what already exists in Babar as long as it helps in writing the tools faster.
- We've been using the Babar code as a starting point (see next 2 slides). Soon everything will be independent on the Babar framework.

PravdaMC

- PravdaMC is a fast simulation of the Babar detector. It's already been used to make some optimization studies for SuperB.
- pros:
  - fast (14ms/evt on 2GHz Dual Core AMD Opteron to simulate and write $B^0 \rightarrow \pi^+\pi^-$ decays)
  - the output is the Babar *BtaCandidate*, for which many composition and vertexing tools are available
- cons:
  - trajectories not distorted by energy loss and multiple scattering
  - lack of hit-level information
  - tracking code is a monolithic Fortran file difficult to debug/maintain/improve
  - DIRC and IFR are not directly simulated. The PID info is achieved through efficiency/mis-ID ASCII tables.
  - the EMC response is a simple analytic function
  - unstable particles like Ks, $\pi^{\pm}$, $\mu^{\pm}$ do not decay on flight
  - it requires the Babar framework to work
- PravdaMC is being replaced by the new fast simulation program

Vertexing and composition tools

- We want to exploit the tools that were developed to do physics analysis in Babar
  - vertexing
  - flavour tagging
  - composition tools
  - ntuples dumping
- To use these tools for SuperB we need to heritage a number of classes developed in Babar, like the *BtaCandidate* (a class representing the reconstructed particle in Babar)

Design of the superB fast simulation

Phases in 2008

- phase 1: ends in June 2008, ~1 month after the major revision of the work at the Elba workshop
  - goal: first version of the fast MC with the implementation of the Babar detector (a mandatory step to validate the MC)
- phase 2: from July 2008 till the end of the year
  - General refinement
  - Inclusion of a set of SuperB subsystem models
  - Inclusion of machine background

Tracking & Interaction of particles with materials

phase 1

- Use Pacrat, a LBL project to extract Babar code for reuse
  - start with a Babar release + top level application
  - extract dependent code into self-contained tarball
- Extract code needed to perform full Kalman fit
  - start with a simple cylindrical geometry with hits scored with Gaussian smearing and no material effects
  - Implement material condition DB, add energy loss and mult. scattering
  - Develop geometry description interface
- Interface the program (PacTrk) to PravdaMC replacing TRACKERR
- Describe the material of all SuperB detector (at least till the solenoid) in the same way and use PacTrk to evaluate **x**,**p** at the entrance of the subsystems (see also slides 20-22).

PID

- In phase 1 the PID system will correspond to the Babar DIRC.
- The position of the track at the DIRC is given by PacTrk
  - If the charged track intersects a quartz bar, the DIRC response (Θ_C,$\delta\Theta_C$, $N\gamma$) is generated based on: $\mathbf{p}$, $\delta\mathbf{p}$, $\mathbf{x}$, $\delta\mathbf{x}$, mass and charge. The Babar ring dictionary is used.
- In phase 2 the PID system should evolve depending on how the R&D goes. Endcaps may be added. Fast simulation can help with the decision.

EMC

- In phase 1 the EMC system will correspond to the Babar EMC.
- The *true* position of the charged particles at the EMC is given by PacTrk
  - If the charged track intersects a crystal, the EMC response (energy, LAT, …) is generated based on: **p**, **x** and mass. The response is parameterized using the info from Babar data and MC.
- The position of the photons at the EMC is extrapolated
  - the response is generated based on **p** and **x**. The response is parameterized using the info from Babar data and MC.
- The EMC parameterization library can be stored in ROOT files
- In phase 2 the EMC model will evolve according to the R&D options.

IFR

- In phase 1 the IFR will correspond to the Babar IFR possibly including some modifications
  - If a track or neutral hadron reaches the IFR, the IFR response (numb. inter. lengths, hit multiplicity per layer, etc.) is generated based on $\mathbf{p}$, $\delta\mathbf{p}$, $\mathbf{x}$, $\delta\mathbf{x}$, mass and charge.
  - Complication: the IFR is outside the magnet and PacTrk won't determine the charged particle trajectory to it.
- In phase 2 the IFR will reflect more precisely what's being defined by the R&D

Machine background

- The inclusion of the machine background in the fast simulation is not a trivial task.
- The description “from basic principles” through the generation of bkg particles is not considered feasible.
- Plan to study the effects of machine background on the reconstruction (in a number of intensity scenarios) and embed the effects into the fast simulation.
- The schedule depends on how the activity of the bkg simulation group proceeds. Most of the work will start in phase 2.

Development framework

Babar framework

- PravdaMC is a Babar package, therefore:
  - it cannot be used or developed by non Babarians
  - it cannot be modified specifically for SuperB
- So far the development outside Babar has proceeded through patches
- Need to migrate to a SuperB framework
  - see Pacrat in next slide
- Procedure to make part of the Babar code accessible to non-Babar users will be approved by the Council at the Elba meeting

Pacrat

- Project developed at LBL to extract Babar code for reuse
  - It's being used to provide a tarball of PravdaMC+PacTrk to be used standalone (i.e., outside the Babar framework)
- More details here:

https://agenda.infn.it/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=432

SVN

- David will talk about the use of svn later today

People

Participating institutions

temporary list

- **Caltech** (C. Cheng)
- **Cincinnati** (R. Andreassen)
- **Frascati** (M. Rama)
- **LBL** (J. Anderson, D. N. Brown, J. Carlson, I. Gaponenko)
- **Maryland** (G. Simi)
- **Padova** (M. Rotondo)
- **Perugia** (C. Cecchi, S. Germani)
- **Pisa** (J. Walsh)
- **SLAC** (D. Aston, J. Schwiening*)

* retired

Input from Physics Groups

Feedback and joint work

- It’s time to present the simulation design to the Physics Groups, to receive their comments and make possible adjustments.
- A few specific topics benefit from a joint work with the Physics Groups. They could be asked to help on specific tasks.

Documentation and discussions

Wiki

- A wiki page has been setup to collect the documentation for the users
  http://mailman.fe.infn.it/superbwiki/index.php/Fast_SuperB_simulation_main_portal
- Currently it contains the User Guide of PravdaMC. Later it will contain the User Guide of the new fast Monte Carlo

Mailing list and meetings

- Two mailing lists for discussions
  - superb-computing@lists.infn.it
    - general discussion of the SuperB computing
  - superb-fastsimu@lists.infn.it
    - discussions specific to fast simulation
- Regular bi-weekly meetings of fast simulation are held on Thursday at 8:00am PT (the Thursday with no R&D detector meeting)