SuperB fast simulation status and plans

The SuperB fast simulation group
(see slide 30)

7 May 2008

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Goals

Optimization of the detector

- In the medium term the fast simulation will be the most accurate tool to evaluate the impact on the SuperB physics reach of a given detector configuration
- 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 some benchmark measurements
  - what's the impact of the machine background on the event reconstruction

Physics analysis

- Fast simulation will be the main (or maybe the only) tool to do MC physics studies in the medium term.
- Given the typical very high rates of SuperB, it looks likely that the fast MC will have an important role even in the long term.

- NOTE on speed: Consider for example continuum events: ~$3.4*10^{10}$ events in 1yr (10^7s). Even with 50ms/evt with a modern CPU, it would take 24h x 7days for 6.5 months to simulate the events with a fast Monte Carlo using O(10^2) CPUs. CPU time will be a limitation (even) for fast simulation.

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)
$\Upsilon(4S) \to B\bar{B}$	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

Requests from subdetectors

Input from subsystems

- The design of the simulation presented in this document is the result of discussions with the subsystems and take their requests into account as long as it’s possible
- 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: change number of layers, geometry and spatial resolutions. Sometimes optimal design choices are actually trivial and technology, costs or geom. constraints will drive the design (especially true for the L0 design).
- Performance estimation would benefit from having:
  - kalman fit 
  - energy loss and multiple scattering taken into account 
  - pattern recognition 

- Pattern recognition is not implemented to find tracks.
  However, a plan exists to implement the effect of pat. recognition errors on the resolutions of track parameters. The idea is to look for background hits close to the hits from the generated tracks and ‘throw a dice’ to substitute the bkg hit for the generated hit before reconstructing the track.

Drift chamber

- Fast Monte Carlo is needed to study how the measurement of momentum changes as a function of the DCH configuration:
  - number of cells per layer, number of layers, wire orientation
  - spatial resolution of cells
  - mixed configurations (cell size varying as a function of the distance from the beam axis)
- The trajectories must take energy loss and multiple scattering into account and the information of individual hits is required.
  - Note: as opposed to PravdaMC (see also sl. 16)

Particle Id

- The R&D of the barrel uses (or will use) detailed simulation. A fast Monte Carlo is not strictly needed for optimization.
- The response of the PID system, as studied with detailed simulation or Babar data, are incorporated into the fast Monte Carlo in a parametric way.
- Fast simulation can help deciding the impact on physics of endcap PID subsystems. Also in this case the response of the detector would be studied separately and incorporated into the fast MC parametrically.

EMC

- The barrel is taken from Babar and does not require optimization with a fast MC.
- The design optimization of the new forward endcap is being done with Geant4.
- Fast Monte Carlo will help 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.s
- The response of the new IFR will be incorporated into the fast simulation in a parametric way.

Use of existing resources

Exploiting 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). Later the simulation will be independent on the Babar framework.

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 inherit a number of classes developed in Babar, like the *BtaCandidate* (a class representing a reconstructed particle)

PravdaMC (I)

- PravdaMC provides a fast simulation of the Babar detector. It's been used to make some 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
- some 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 (II)

- PravdaMC has been used as a starting point for the development of the SuperB fast MC.
- However, it is necessary to redesign it to implement all the features we want. Eventually it will evolve to something quite different (see next part).

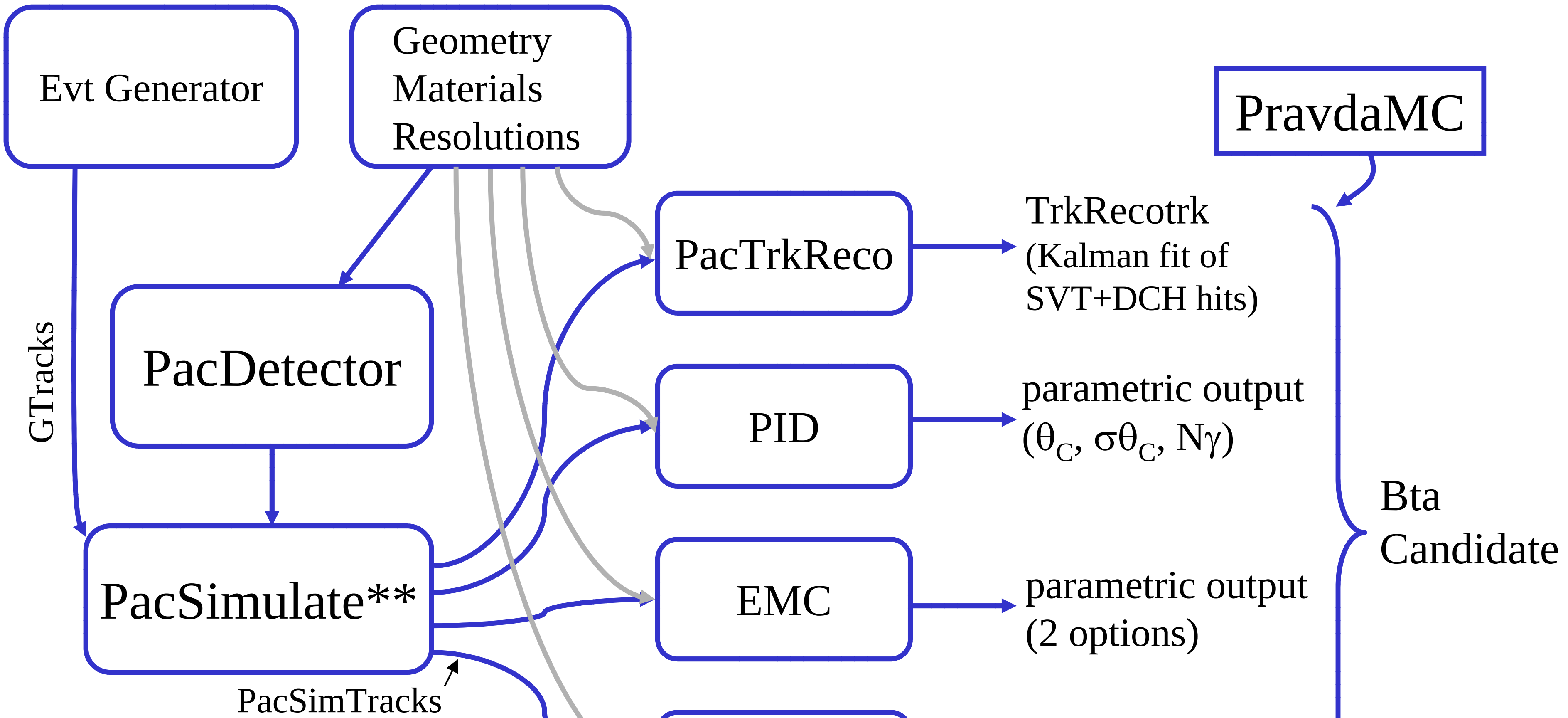
Design of the superB fast simulation

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 (to validate the MC). Possible inclusion of some SuperB models for a few subsystems
- phase 2: from July 2008 till the end of the year
  - Refinement of the code with inclusion of those features that may have not entered in phase 1
  - Inclusion of complete set of SuperB subsystems **
  - Inclusion of machine background effects

** the time scale for the inclusion of the various SuperB subsystem options in the fast MC will depend on how the R&D and detailed simulation of the various detectors proceed

Schematic structure of SuperB fast MC



**describes the passage of a true particle (charged or neutral) through the detector, including the true position, energy loss and scattering.

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 (see sl. 28)
- Extract code needed to perform full Kalman fit (PacTrk)
  - 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 PacTrk to PravdaMC replacing Trackerr.

done

- Describe the material and geometry of the BaBar/SuperB detector and use PacTrk to evaluate **x**,**p** at the entrance of the subsystems (see also slides 22-24).

Particle ID

- In phase 1 the baseline of the PID system will be 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: **p**, δ**p**, **x**, δ**x**, mass and charge. The Babar ring dictionary is used as input.
- In phase 2 the PID system will evolve depending on how the R&D goes. Endcaps may be added. Fast simulation will help with the decision.
- In case endcap PID systems are investigated manpower is needed to parameterize the response into the fast simulation.

EMC

- In phase 1 the EMC system will correspond to the Babar EMC. A description of the new forward endcap may also be implemented.
  - The *true* position of the charged particles at the EMC is given by PacTrk
    - If the charged track intersects a crystal, the EMC response is generated based on: **p**, **x** and mass.
  - The position of the photons at the EMC is extrapolated from its momentum at the production point
    - the response is generated based on **p** and **x**.
- Two different parameterizations are being studied:
  a) A parameterization library is built using the Babar data or detailed simulations and is stored in ROOT files
  b) The EMC showers are simulated with Gflash
- In phase 2 the EMC model will evolve according to the R&D options.
  - First, the new forward endcap is included (if it didn't already in phase 1)
  - Second, the case of a backward endcap is studied

IFR

- In phase 1 the IFR will correspond to the Babar design possibly including some modifications
  - If a track or neutral hadron reaches the IFR, the IFR response (num. inter. lengths, hit multiplicity per layer, etc.) is generated based on $\mathbf{p}$, $\delta\mathbf{p}$, $\mathbf{x}$, $\delta\mathbf{x}$, mass and charge.
- In phase 2 the IFR will reflect more precisely what is being defined by the R&D

Machine background

- The inclusion of the machine background is an important and difficult task.
  - The description “from basic principles” through the generation of bkg particles is not feasible.
- In some cases the impact of bkg can be estimated with the fast MC itself (e.g. the effect on pat. recognition)
- Otherwise we plan to use detailed simulation (or Babar data where useful) and embed the effects into the fast MC.
- The schedule will go in parallel to the activity of the bkg simulation group. Most of the work will be done during phase 2.

Development framework

Babar framework

- PravdaMC, which has been used as starting point, 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 the use of patches (see also slide 29)
- Need to migrate to a SuperB framework
  - see Pacrat in next slide
- The procedure to make part of the Babar code accessible to non-Babar users should 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 produce 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

- While a tarball of PacTrk alone is already available and working. However producing a tarball of PacTrk+PravdaMC is much more difficult because PravdaMC depends on between 50 and 100 Babar packages.

SVN repository

- PravdaMC+PacTrk development has moved to SVN repository hosted at LBL. More details here:
  - http://dnbmac3.lbl.gov/~brownd/SuperB/svn_policy.html
- The tentative plan is to migrate to the Padova SVN repository on the timescale of the Elba meeting.

People

Participating institutions

- **Caltech** (C. Cheng)
- **Cincinnati** (R. Andreassen, B. Meadows, M. Sokoloff)
- **Frascati** (G. Finocchiaro, 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*)

more than 50% is not italian

* retired

Interplay with Physics Groups

Feedback and joint work

- We’re entering a phase where the simulation design is discussed with Physics Groups to receive comments and discuss adjustments.
- Some areas benefit from a joint work with the Physics Groups. In those cases they could be asked to collaborate (and hopefully provide manpower!) 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 on it will contain the User Guide of the new fast Monte Carlo

Mailing lists 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)

Summary

- The development of the fast simulation of the SuperB detector started 4 months ago and is proceeding well
- The activity is on track with respect to the schedule presented in February
- It’s time to interact closely with the Physics groups. Feedback from the SuperB community is very welcome.
- The first version of the code is expected to be released to the users in June

Consider joining the effort.

There is room for contributions in all areas