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SIMULATION OF THE $\overline{\text{P}}$ANDA EXPERIMENT WITH PANDAROOT

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Abstract

$\overline{\text{P}}$ANDA is a future experiment designed to study fundamental questions of hadron and nuclear physics. This requires capability to measure rare processes, *i.e.* excellent understanding and optimization of the detector system. Thus, extensive simulations are a must.

In autumn 2006 the $\overline{\text{P}}$ANDA collaboration decided to migrate to a new simulation framework, called PandaRoot. The code is based upon the FairRoot project, which is strongly supported at GSI. Here, basic features of PandaRoot are discussed, *i.e.* its structure, supported platforms, event generators, transport codes, reconstruction and analysis. Examples of results from the complete simulation chain for a selected detector are presented.

1 The $\overline{\text{P}}$ANDA experiment

Within the next few years, a new international facility FAIR (Facility for Antiproton and Ion Research) will be built in GSI–Darmstadt. One of its components is the High Energy Storage Ring (HESR) providing high-quality beams of antiprotons with momenta up to 15 GeV/c. $\overline{\text{P}}$ANDA is a future large-scale detector system, located on the internal target station, which will exploit this beam.

The physics program of the $\overline{\text{P}}$ANDA project is focused on studying the non-perturbative regime of QCD and is discussed in Ref. [1].

Planned measurements impose stringent requirements on the detector system. For example, it provides an almost full coverage of the solid angle,

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good particle identification in a large momentum range, good vertex and momentum resolution along with high count-rate capability. Current status of the detector design is presented in Ref. [2].

2 The PandaRoot Framework

PandaRoot is a next–generation computing framework being developed by the $\overline{\text{P}}$ANDA collaboration in synergy with other FAIR–related software activities within the joint FairRoot project. The framework serves both simulation and analysis, and will be described in the following subsections.

2.1 Objectives

The simulation studies of $\overline{\text{P}}$ANDA are detector- and physics-related.

To the first group belong simulations aiming to improve the detector setup by optimizing the acceptances and resolutions. The discrimination power of the particle identification detectors is also of vital importance. In view of the very high interaction rate of the order of 10^7 s^{-1}, simulations are helpful in choosing the appropriate granularity and provide hints that for certain regions a different detector type should be considered. Moreover, for $\overline{\text{P}}$ANDA the triggerless data acquisition system is foreseen [3]. Its proper design requires a good knowledge of total data rates of the overall detection system as well as of the individual components. Also, strategies to reduce the online data stream from about 100 GB/s to 100 MB/s are being developed and verified by simulations.

The other group of activities focuses on tests of physics-related detector performances. For this purpose, the strategies of the analysis of simulated and experimental data are being developed and tested via feasibility studies for several benchmark channels. A list of benchmark channels is given in Ref. [4].

2.2 Main Features

The main features characterizing the PandaRoot computing framework are the following:

- it serves simulations as well as data analysis;
- it is fully ROOT-based [5], which ensures good support, easy maintenance and – of crucial importance for the environment with a continuous human-power flow – a low threshold for newcomers;
- it is prepared to run on the Grid network;

- it is portable: it compiles on several different Linux flavors with many compiler versions. This feature is continuously monitored via the Quality Assurance Dashboard system, which collects compilation statistics from all sites hosting PandaRoot.

2.3 Structure of the Framework

The structure of the framework is presented schematically in Fig. 1 and described in more detail in Ref. [6]. The heart of the design is the Run Manager,

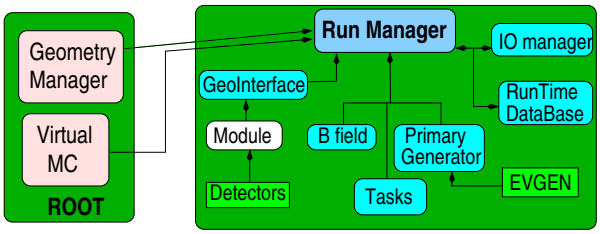

Figure 1: Schematic representation of the design of PandaRoot.

which manages the overall program flow and the communication between the different modules, namely Geometry Interface, Event Generator, IO Manager and Virtual Monte Carlo. The latter is based on a particularly interesting concept offering a possibility to switch between different transport codes (currently available are Geant3, Geant4 and Fluka) without recompilation of the code. Different analyses or operations performed on a certain set of data are plugged in to the Run Manager as Tasks, thus ensuring modularity. Moreover, tasks can be organized in a hierarchy, thereby, allowing complicated and user-defined analysis schemes.

Several event generators have been integrated into PandaRoot: Dual Parton Model [7], EvtGen [9], Pluto++ [8] and UrQMD [10]. These generators provide a model for the total $\overline{p}p$ cross-section, resonance decay trees, hadronic processes and nuclear reactions $\overline{p}A$, respectively.

Currently the $\overline{\text{P}}$ANDA computing group is finishing the implementation of the individual detectors in the framework. For most of the detectors, the digitization part has been implemented as well. Various reconstruction algorithms and advanced analysis tools, such as a Kalman filter and channel composition tools, are being developed in parallel.

2.4 Example of Use

Already within the present simulation framework it is possible to perform advanced physics simulations for some detectors. As an illustration, the

reconstruction of J/ψ mass from the following process: $\overline{p}p \rightarrow Y(4260) \rightarrow J/\psi\,\pi^+\pi^- \rightarrow e^+e^-\pi^+\pi^-$ is shown in Fig. 2. The simulation chain comprises

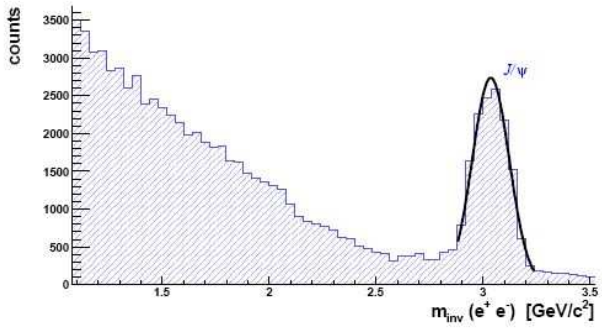

Figure 2: The reconstructed e^+e^- invariant mass for the decay of J/ψ.

event generation, simulation, track reconstruction and combinatorial analysis, for which the electron mass was assigned to all tracks.

3 Summary

PandaRoot is a versatile and a portable framework for simulation and analysis of the $\overline{\text{P}}$ANDA experiment. The implementation of the individual detector components is nearly finished. Furthermore, the development of advanced tools for reconstruction and analysis is in progress. The framework has already been used to optimize detector components. The first physics analyses have been performed as well.

Acknowledgments

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