Report on SIMBES:
The New Simulation Program for BES-I/II

Jiangchuan Chen, Baosen Cheng, Canguo Li, Huaimin Liu, Lin Zhang
Monte Carlo Group, Division 1, IHEP
http://hpws3.ihep.ac.cn/~ licg/mc.html

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This talk is organized as following: the first section is a short review of the progress of SIMBES project; the second section presents selected results from the programmers' test; the third section is a long answer to a short question; and finally we summerize what need to be done to release and improve SIMBES.

1 A Brief History of SIMBES

1.1 BES96: proposed and approved

The old simulation program SOBER was unsatisfactory for two types of reasons: first, the users wanted a GEANT3-based simulation program, so that hadronic processes could be simulated; second, the programmers needed a maintainable software that is improvable and upgradable. Since good physics follows good engineering, the second type of reason is more important, although not so obvious to nonexperts. Another motivation for the SIMBES project was to prepare us for developing the Tau-Charm Factory's simulation program, as SIMBES will be the first genuine BES-made CERNLIB-GEANT-based simulation software.

The investigation was started in the end of 1995, and the design was reported on the BES96 meeting. We decided the best way, also the most efficient way, was to write a new program from scratch in the framework of GEANT3, instead of upgrading the old program SOBER.

The estimated labor cost was 3 ManYears. This was already a very daring and optimistic number. Now the deadline set by the BES-II data taking was the end of 96. The only way to meet the dealine was to perform a parallel teamwork. Even without the deadline problem, teamwork is the proper strategy. However, the reality was, even with a dealine so near, the supporting manpower did not come in time.

1.2 BES97: succeeded yet not finished

A year had passed. The data taking did not happen, and the program was not finished due to a shortage of the requested manpower.

For a software like SIMBES, the quality of the interface or boundary, to large extent, determines the quality and fate of the program. By this time, the SIMBES-GEANT3 interface was completed and proved to be ok; the SIMBES-DRUNK interface was completed and proved to be ok; the data cards and constants files reading facilities were completed and proved to be ok. Engineeringwise, SIMBES was now on a safe ground.

The quality of physics relies on the GEANT3 and digitization code. From users point of view, the most visible differences between the new SIMBES and the old SOBER manifest in the shower counters' simulation. Fortunately, we had 2 shower counter experts(BS Cheng and JC Chen) within our code developing team, and the BSC and ESC digitization code were finished in time, and the test results as I showed you at the last year's annual meeting were truly beautiful.

The CPU time per event was about twice that of SOBER, mostly spent on the shower simulation. SIMBES is currently interfaced to GEANT3.21, the most advanced version of GEANT3. GEANT4, written in C++, may become available soon. By design, it will be straightforward to re-interface SIMBES to GEANT4. We expect a GEANT4-based SIMBES to be as fast as SOBER.

Memory usage was less than that of SOBER.

Shower counter simulation is also the most time-consuming and involves most of GEANT3 library code. Therefore the success of the shower counter simulation foretold the success of the SIMBES project.

However, SIMBES could not be delivered without the digitization code of MDC, TOF and MUO which were waiting for experts to finish.

The interactive graphical version XSIMBES, which does not need digitiation code, was releasable by this time, but was not released, because users who had never used this type of simulation program failed to appreciate the power of this new great learning tool.

The BES-II data-taking was postponed. And our request for manpower was unheard.

1.3 BES98: all engineering work finished

We had to finish the rest of the digitization code by ourselves. CG Li wrote the MDC digitization code; L Zhang wrote the TOF digitization code; HM Liu wrote the MUO digitization code.

An intensive test on the program was conducted. Some results will be presented in the next section.

The user interfaces were redesigned to make the program simpler to use. The user's manual was written and put on the Monte Carlo group's home page.

The deadline was already passed. We still need manpower to conduct users' test of the new software.

2 The Programmers' Test of The Program

The programmers' test is like a manufacturer's test. It is different from and cannot substitute the users' test. The purpose of this test is limited to exposing and fixing technical problems. We are not examining physics performance such as the shower simulation quality and the particle identification capability, although the test results may convince you much of those desired qualities.

SIMBES was checked against the BES-II data and SOBER. We programmers had examined lower level items such as the charge spectrum and pulse height. However, the users are usually interested in the higher level end product items. In this report, we present only a few most often used and most sensitive items in the TRACK LIST(filled by the reconstruction program DRUNK).

It should be noted that the comparisons between Monte Carlo and BES-II data were not exact: (1) for dimuon data at $3.1GeV$, the real data deviates severely from the expected $(1 + \cos\theta)$ angular distribution(a known but unsolved problem); (2) for Bhabha data at $3.1GeV$, the Monte Carlo data correspond to Bhabha process only, while the real data contains $J/\psi \to e^+e^-$ process.

2.1 MDC (by CG Li)

For the MDC, we checked the reconstructed track momentum(Fig. 1), reconstructed z(Fig. 2) coordinate of vertex. The values and errors of these two quatilties test the correctness of the cell geometry, wire positions, distance to time conversion code, and magnetic field distribution. Since GEANT3 fails to provide a straightforward way to define the stereo wire layers, SIMBES code had to be rather complex to deal with stereo layers. Fortunately, the test results convinced us that we had done everything correctly.

We have also checked $dEdx$-based particle identifications (Fig. 3). SIMBES provides two ways to calculate $dEdx$ spectrum: (1) let GEANT3.21 handle it and (2) calculate $dEdx$ by SOBER's algorithm which samples the BES data's charge spectrum. However, (1) Monte Carlo raw charge data cannot be compared with the BES-II real data directly, due to the current way of calibration; and (2) reconstruction program DRUNK cannot process the GEANT3 calculated $dEdx$ data properly. Therefore, GEANT3.21's algorithm and SOBER's algorithm of $dEdx$ cannot be compared before DRUNK is modified. When compared with BES-II data, both SOBER and SIMBES showed problems in $dEdx$-based particle IDs. The problem seems to be due to ADC constants used by the simulation programs. However, this issue worths a special study. We should leave it to experts.

From the programmers' point of view, SIMBES's simulation of the MDC is successful and satisfactory.

2.2 TOF (by L Zhang)

For the Barrel TOF, we examined reconstructed time-of-flight, and the difference between t.o.f and track path derived t.o.f(Fig. 4). Results showed SIMBES is even better than SOBER. Since the energy loss and handling of multiple hits in SIMBES are different from those in SOBER, while the digitization algorithm and many parameters are the same, the fairly good agreement with the BES-II data was perhaps partly due to good luck.

From the programmers' point of view, SIMBES's simulation of the BTOF is successful and satisfactory.

2.3 BSC (by BS Cheng) and ESC (by JC Chen)

For the shower counters, we checked the SQS charge in each readout layer (Fig. 5, Fig. 8), the cluster width(Fig. 7, Fig. 10) and energy in each layer(Fig. 6, Fig. 9), and the total event energy(Fig. 11). Thanks to GEANT3's tracking, the results are very nice, a great improvement over SOBER. Here we see that SOBER is not so good even in simulating electromagetic showering process.

From the programmers' point of view, SIMBES's simulation of the BSC and ESC is very successful and satisfactory.

2.4 **MUO** (by HM Liu)

For the muon detector, we checked the most challenging items: matching precision between MUO hits and MDC tracks(Fig. 12, Fig. 13). MDC track need to be extended through BSC and COIL region to reach MUO. However, the B field in the coil (thickness 37cm) is very complex, and in the Monte Carlo is treated as zero field. The material of coil is approximated as 50% Al +50% air. The test results showed that SIMBES-Data agreement were not bad, better than SOBER-Data agreement.

From the programmers' point of view, SIMBES's simulation of the MUO is successful and satisfactory.

3 Can We Release SIMBES?

During the code development, SIMBES has been used by the programmers for over 1.5 years. The test results convinced us that the simulation is basically correct.

3.1 Users' Test Needed

When released to the general public, there may be minor problems in user interface which may cause the program fail to compile, link or run. As frustrating and annoying as these problems are to the users, they are actually harmless. We can release SIMBES now, and let users encounter and report these trivial problems. We can fix these problems easily and quickly.

The most dangerous are hidden bugs which degrade the quality of the simulation. Even if all bugs were removed, the program may still need improvement. For example, to change algorithms and parameters to improve the data-MC agreement. What is good enough is an ambiguous question, the answer depends on the analysis' need. Users' test is needed in addition to the programmers' test.

It is safe and most efficient to make an intensive users' test on the new program in the beginning, and publish the test results in the form of an internal report. Another option is the SOBER-DRUNK way: to let each physics analyzer to discover and re-discover the problems over a span of many years.

3.2 Joint Forces Needed

Users' test is a part of the detector study. Its purpose is not limited to uncovering technical problems. The test cannot be a single person or a single group's task. Each subdetector group and physics topical group should take its share. Solution of the problems may also require help from reconstruction and calibration experts. There are several reasons: (1) subdetector and physics analyzers know better what to look at, and can discover problems quickly; (2) problems may not locate only in SIMBES, but also in DRUNK anbd calibration; (3) Further improvement of data-MC agreement in general requires changes in DRUNK and calibration.

We would like to comment that software need to be maintained like the hardware. In data-taking shift, we can call experts to handle special problems. Do we have a call list of software experts? For SIMBES, the answer is yes. But for event generators, DRUNK and calibration, do we have experts available for each special field?

4 Recommendations

We recommend: (1) release SIMBES on HPUX platforms now; (2) start to adapt SIMBES to other Unix platforms; (3) organize and start comprehensive users tests of SIMBES, SOBER(and DRUNK); (4) start work on DRUNK code modifications as required by SIMBES.

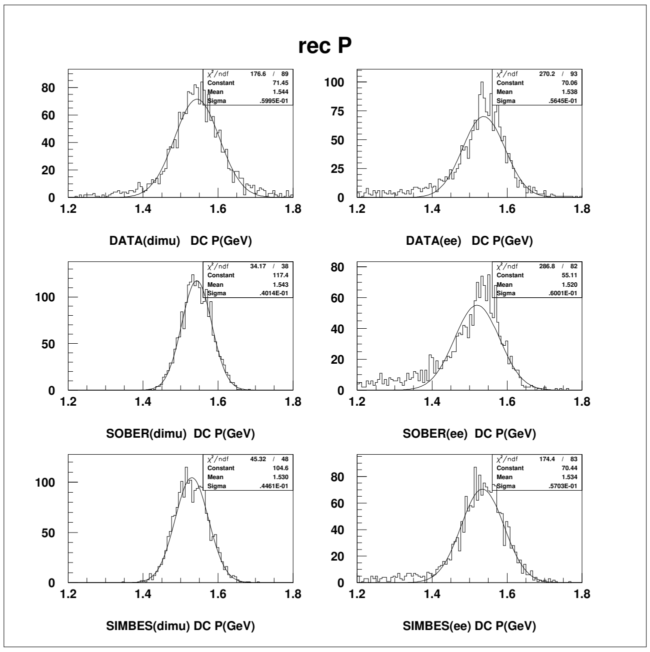

Figure 1: comparison of the MDC reconstructed momentum for BES-II data, SOBERv100 data and SIMBES data. The events are 3.1 GeV dimuon(left) and Bhabha(right)(the BES-II data contains $J/\psi \to ee$). Gaussian fit curves are shown.

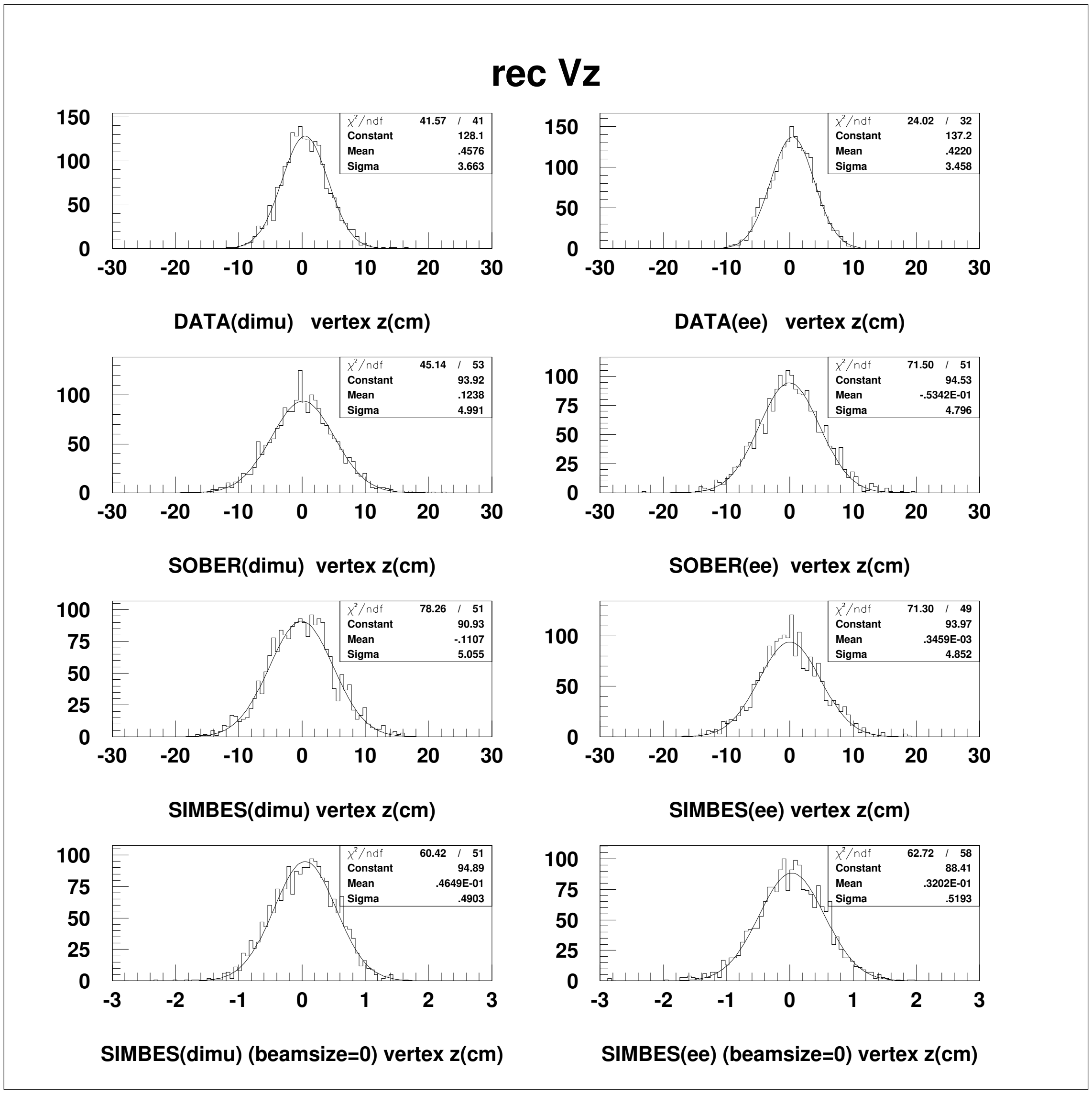

Figure 2: comparison of the MDC reconstructed vertex for BES-II data, SOBERv100 data and SIMBES data. The events are 3.1 GeV dimuon(left) and Bhabha(right)(the BES-II data contains $J/\psi \to ee$). The bottom row shows the reconstrion error by setting the beam bunch length to zero in SIMBES.

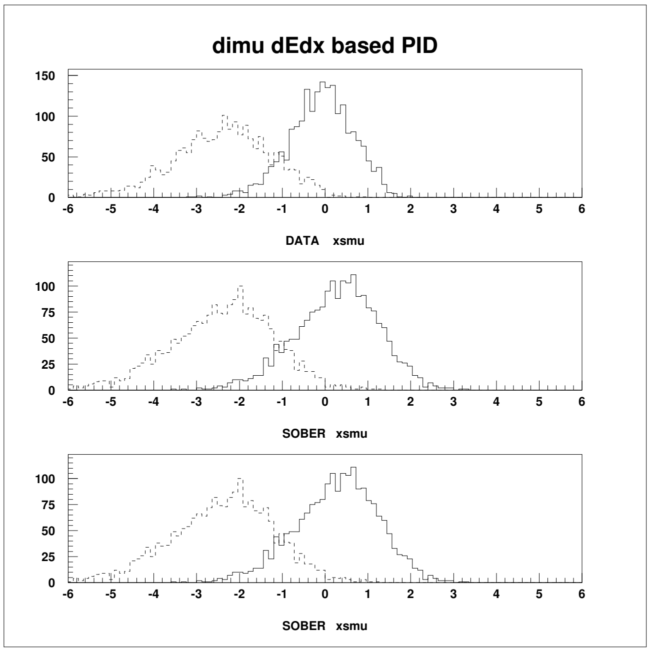

Figure 3: comparison of the MDC dEdx based particle ID for BES-II data, SOBERv100 data and SIMBES data. The events are 3.1 GeV dimuon. Solid(dot) lines are e-like (μ-like) probabilities.

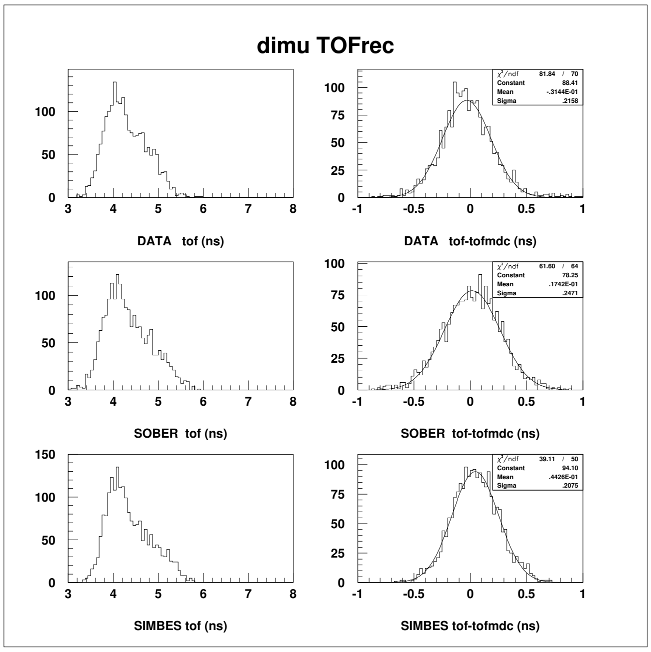

Figure 4: comparison of the reconstructed TOF(left) and resolution(right) for BES-II data, SOBERv100 data and SIMBES data. The events are 3.1 GeV dimuon.

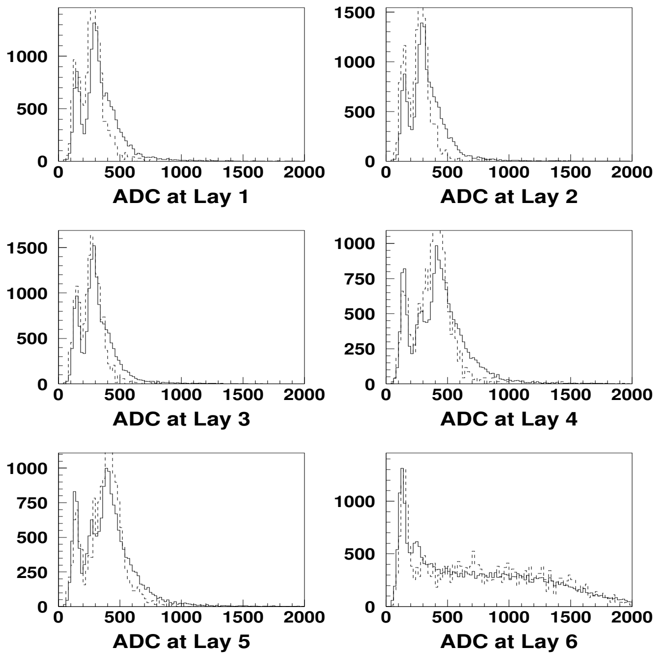

Figure 5: comparison of the single channel(both ends added) charge spectra of the dimuon(3.1GeV) data(solid line) and SIMBES(dashed line) in each readout layer of BSC.

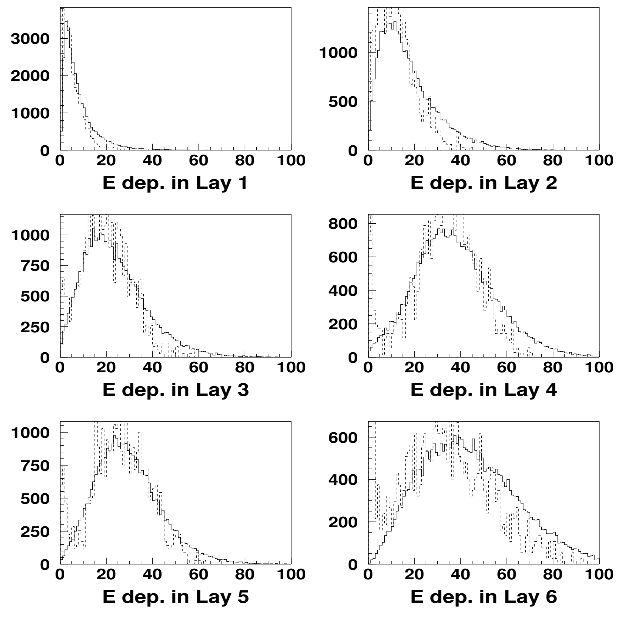

Figure 6: comparison of the cluster energy of the Bhabha(3.1GeV) data(solid line) and SIMBES(dashed line) in each readout layer of BSC(cuttoff energy=0.01MeV).

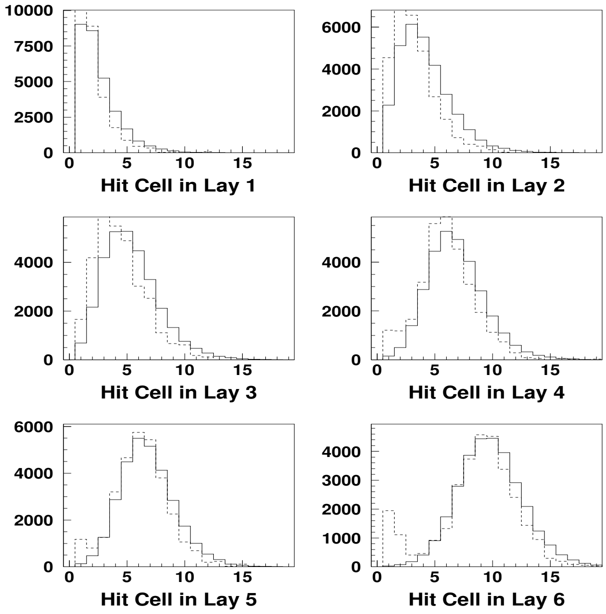

Figure 7: comparison of the cluster width(number of hit channels) of the Bhabha(3.1GeV) data(solid line) and SIMBES(dashed line) in each readout layer of BSC(cutoff energy=0.01MeV.

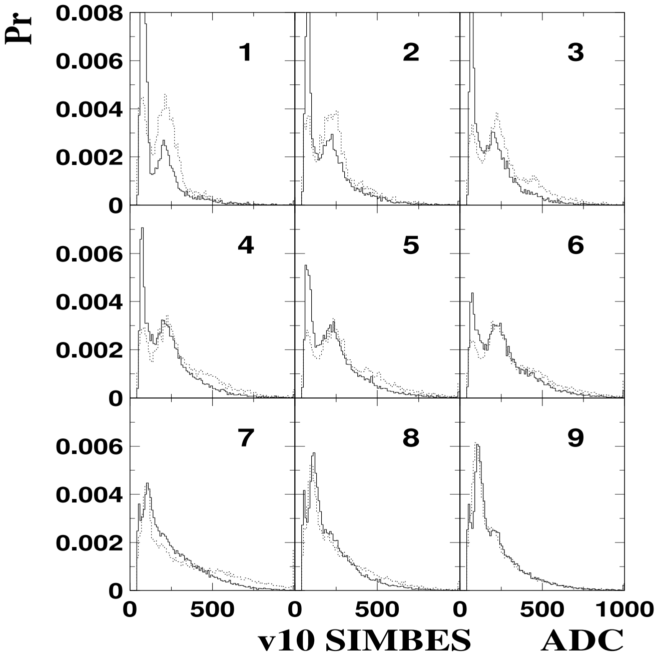

Figure 8: comparison of the single channel(both ends added) charge spectra of the Bhabha(3.1GeV) data(solid line) and SIMBES(dashed line) in each readout layer of ESC.

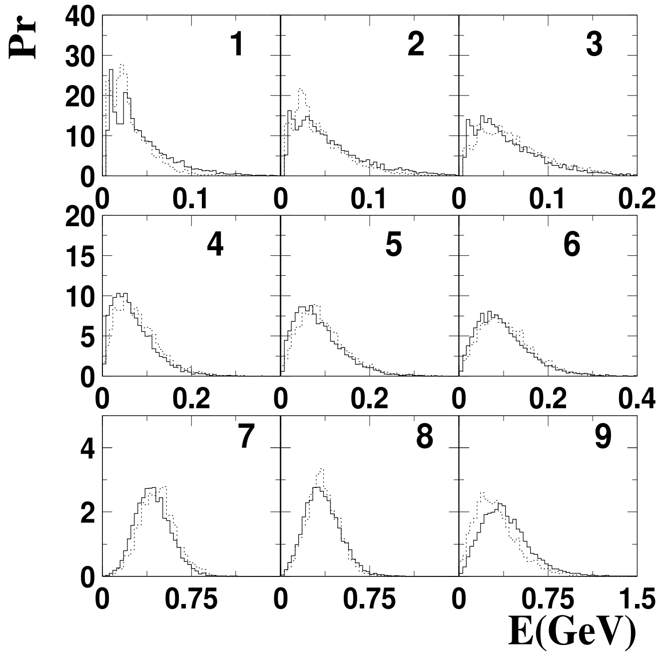

Figure 9: comparison of the cluster energy of the Bhabha(3.1GeV) data(solid line) and SIMBES(dashed line) in each readout layer of ESC.

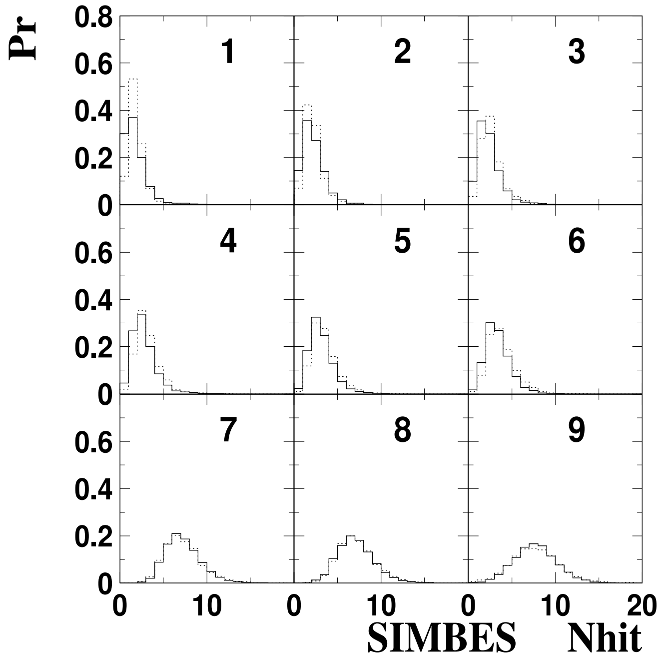

Figure 10: comparison of the cluster width(number of hit channels) of the Bhabha(3.1GeV) data(solid line) and SIMBES(dashed line) in each readout layer of ESC.

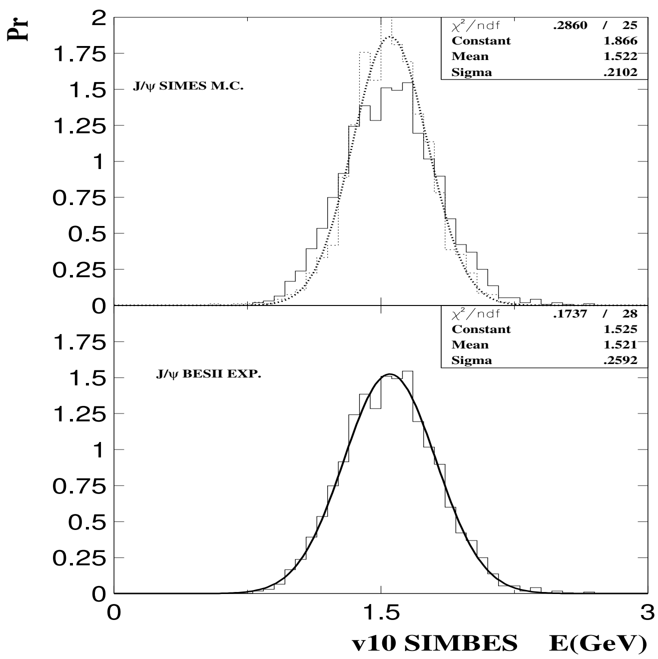

Figure 11: comparison of the total cluster energy of the Bhabha(3.1GeV) data(solid line) and SIMBES(dashed line) in ESC.

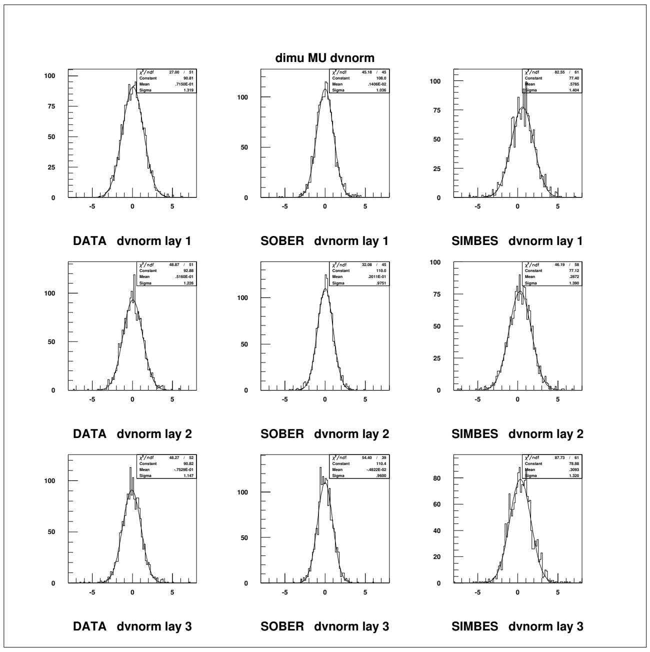

Figure 12: comparison of the MUO hit-track match in XY plane for BES-II data, SOBERv100 data and SIMBES data. The events are 3.1 GeV dimuon.

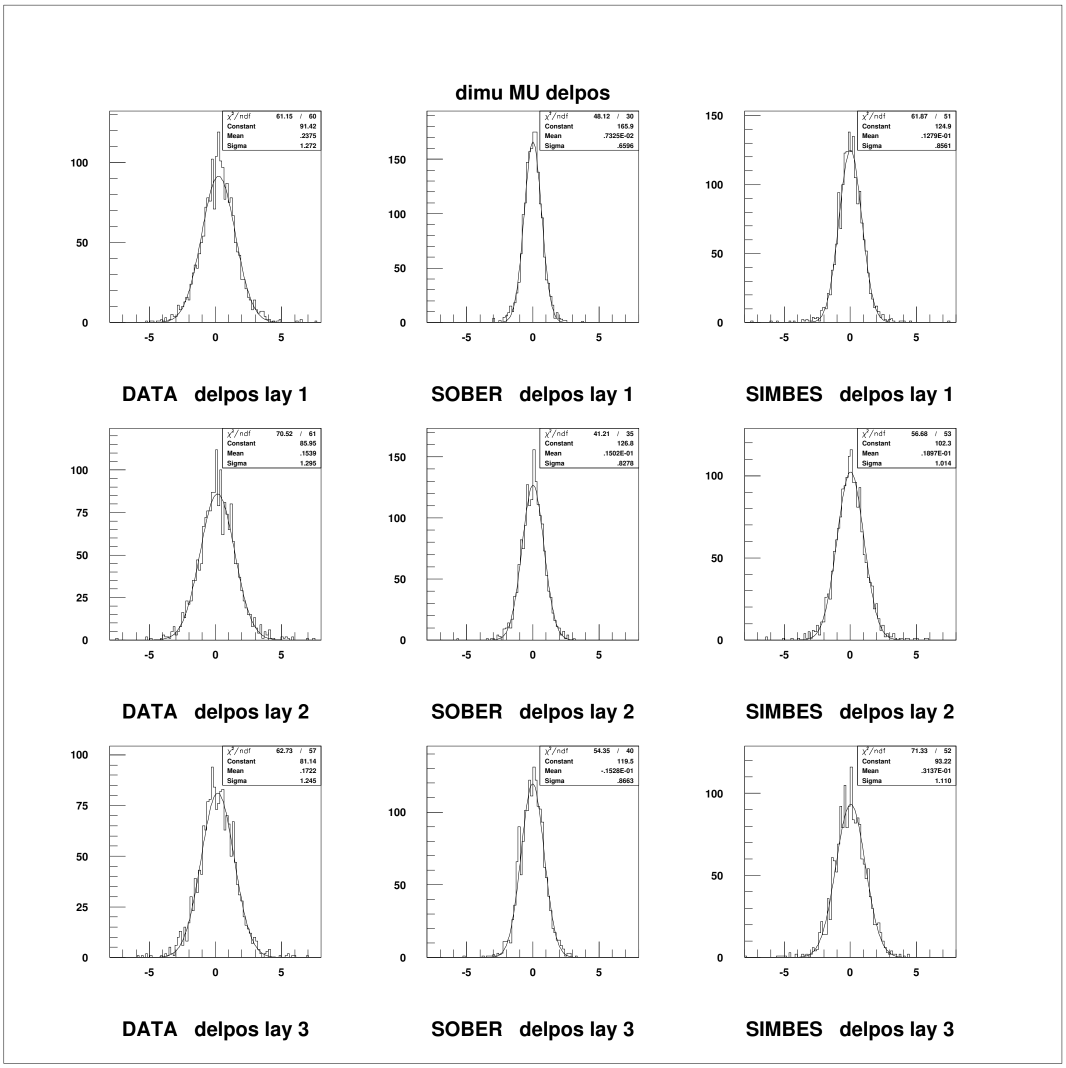

Figure 13: comparison of the MUO hit-track match in Z for BES-II data, SOBERv100 data and SIMBES data. The events are 3.1 GeV dimuon.