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DETECTOR SIMULATION FOR THE SSC

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Abstract

Detector simulation activities for SSC detector designs are described. Topics include the extensive work to date using existing programs. In addition, the several efforts to extend the capabilities of today's programs are described, as are practical and experimental use of new computing platforms for simulation. Finally, progress in the field is compared with the recommendations of the first workshop in this series in 1987.

Use of Standard Programs

Although work is underway to develop improved simulation programs for use in the SSC program, most of the practical calculations that have been done so far have made use of existing programs. Simulations have been needed not only for collaborations to make optimizations of their initial designs, but also for demonstrating the performance of the detectors in the initial documents that have been submitted to the SSC Laboratory.

With some variations, the mainstays of detector simulation for all detectors have been GEANT3 and EGS4, along with event generation using ISAJET, Pythia, HERWIG and PAPAGENO. The Bottom Collider Detector (BCD) for their Expression of Interest (EoI) did a very detailed tracking simulation within GEANT. Other detectors paid most attention to calorimeter simulations, adding parameterized showers (SDC), parametrizations of EM showers blow a cutoff (EMPACT/TEXAS) or

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using fitted parametrizations of resolutions (L*). CALOR89 was used extensively by SDC for design of the calorimeter details. Figure 1 shows a study of the effect on compensation of varying the ratio of thicknesses of scintillator and absorber for a number of absorber materials.

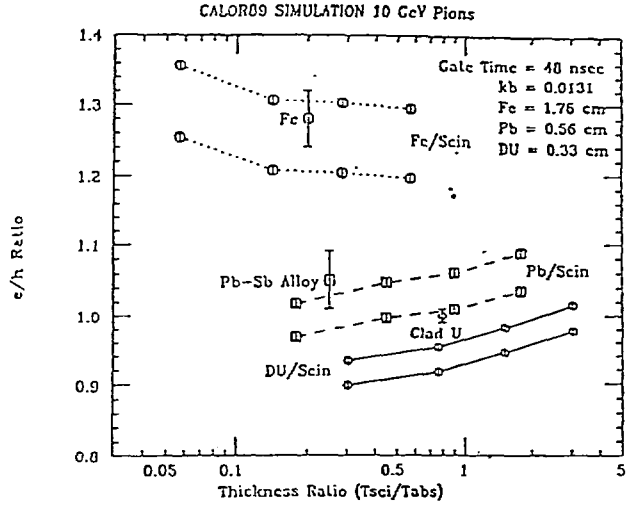

Fig. 1: Use of CALOR89 in designing the scintillator version of calorimetry for SDC. The compensation ratio is shown as a function of scintillator thickness divided by a fixed thickness of absorber.

Program Development

Much work has begun to upgrade and in some cases replace existing simulation programs in order to meet the needs of the SSC. Much recent development has been done by the D0 collaboration, not specifically for the SSC, but to prepare for their turnon in a few months. A significant addition to GEANT from D0 has been a list-driven geometry specification that allows changes to detector geometry without recompiling and relinking the program. In additions, D0 has developed useful frozen shower and parameterization approaches to approximate calorimeter simulation.

Work specifically for the SSC includes the following:

- Oak Ridge National Laboratory, The University of Tennessee, and Logicon, Inc., have made a proposal to the SSC Laboratory to make substantial enhancements to CALOR. These include reengineering the code to rationalize the years of development that have gone into it, adding a modern user interface, providing interfaces to CAD programs, and importantly providing full documentation.

- The University of Mississippi has ported CALOR to UNIX, initially on Silicon Graphics 4D machines. This is the first step in their plan to add CALOR as an option for shower simulation in GEANT3.

- Florida State University and Martin Marietta Corporation have developed a system to translate CAD data in DXF format to GEANT structures (with some restrictions so far on the CAD structures allowed). They are designing a set of rules that CAD-based designers can use to ensure translatability to GEANT structures.

- The SDC collaboration is about to release SDCSIM, which provides a common framework for simulation, allowing use of several event generators and of GEANT or faster detector simulation options.

- FNAL has developed a fast non-GEANT SSC-oriented simulation program, known as SSCSIM.

- Argonne has provided a new parameterized shower program for use with GEANT, based on a "Gauss's Law" integration over a shower parameterization.

Simulation on New Platforms

In addition to new capabilities in software, the SSC Laboratory has recently inaugurated a major UNIX computing facility for performing simulation and other detector design calculations. Known

as the Physics Detector Simulation Facility (PDSF), its organization is shown in Fig. 2. Its major components include 30 SUN workstations (SPARC II's, but without screens) that provide interactive access to the facility for program development. Then for batch execution of debugged programs, three Silicon graphics 4D/380 computers are provided with eight processors each. Finally efficient access to files is provided by a Silicon graphics 4D/320 working as a file server and two Summus tape robots, providing access to 100 8 mm tape cartridges.

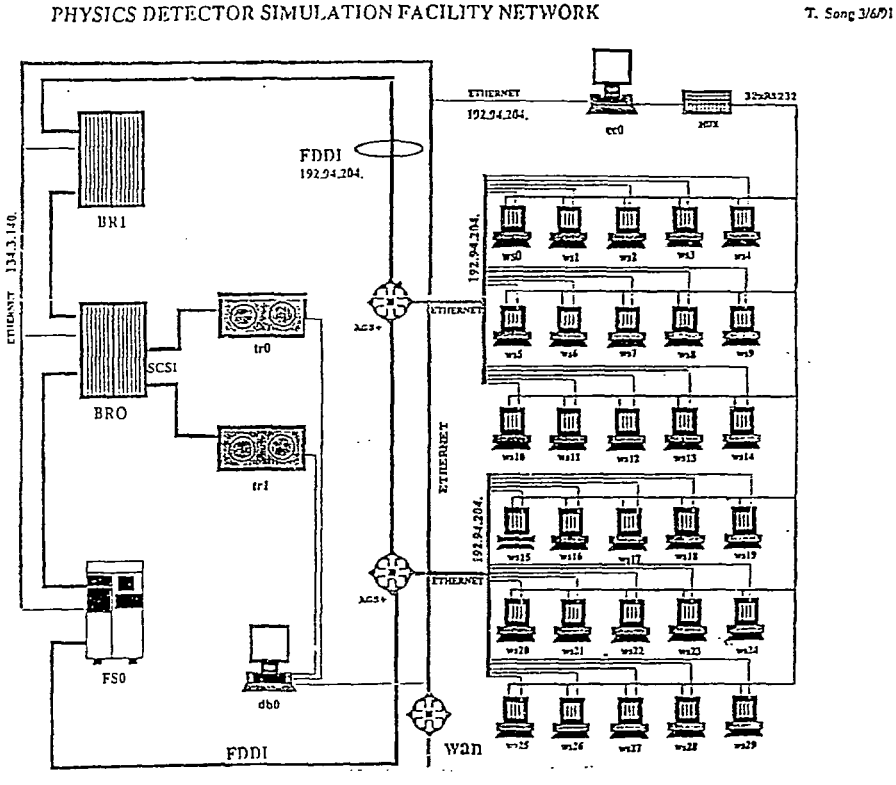

Fig. 2: Schematic view of the initial Physics Detector Simulation Facility at the SSC Laboratory.

Software system elements in the PDSF include NFS file mounting, the Network Information System (Yellow Pages), Network Queuing System (NQS) for batch submission and control, and the Fermilab Cooperative Processes Software (CPS), allowing effective use of several processors for a single simulation job. Figure 3 shows SDCSIM

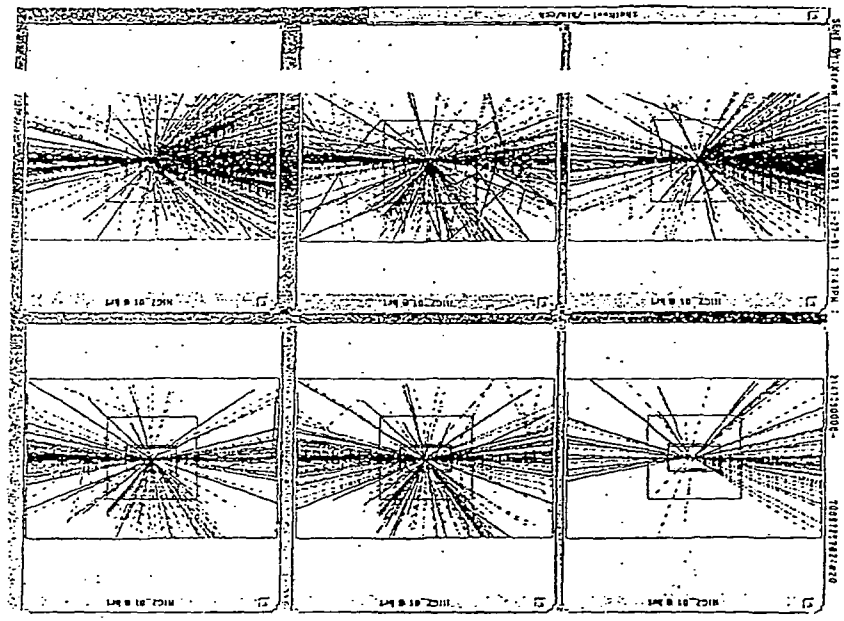

Fig. 3: Multiple events on a single X-window display. The events argenerated by the SDCSIM program developed for the SDC detector running on six processors in the PDSF simultaneously.

running on six separate SPARC II processors and providing event displays on a single X-window workstation.

The University of Florida has developed a new software system to allow coordination of multiple computers for a single simulation job. Known as UFMULTI, the system runs multiple copies of a simulation program under the control of a single Task Supervisor. the initial implementation has been on VAXes, using DECnet for communication. The system has now been moved to UNIX DECstations, still with DECnet communications. The next step of the development is to move the communications to TCP/IP, so that the system can be used on all UNIX platforms.

Experimental Programs

Several exploratory projects are underway, aimed not at immediate practical use, but at approaches that might yield new ways of doing simulation in a few years. These projects are exploring both hardware and software innovations.

- Boston University is exploring the use of the Single Instruction Multiple Data paradigm for parallel computing by porting the EGS4 code to the Connection Machine. They start with multiple input particles and collect calls to particular subroutines until enough have accumulated to occupy all virtual processors.

- The University of Pennsylvania is benchmarking ISAJET, ZEBRA, and GEANT3 on i860 processors, with a view to using one of the parallel systems of i860's.

- Argonne has implemented parallel execution of EGS and ISAJET on several present-generation parallel machines in the Advanced Computing Research Facility at Argonne. This will also be done on the Intel Touchstone.

- Louisiana State University and Southern University have proposed to adapt several current simulation codes to SIMD and MIMD parallel computers.

- Groups from SLAC and Lund are exploring the object-oriented approach to event generation in an experiment called McOOP. Figure 4 shows the use of Object-Oriented concepts in McOOP.

- Groups from SLAC, CERN, and University of Washington are exploring the object-oriented approach to detector simulation in a program called Gismo, which will be described elsewhere in this meeting.

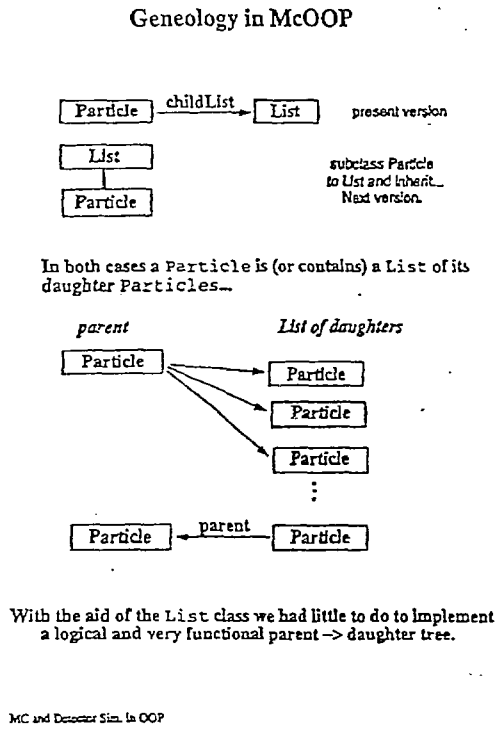

Fig. 4: Use of Object Oriented programming for event generation in McOOP.

Scorecard on 1987 Recommendations

With the developments outlined above, and others coming from Europe and the rest of the world, we can now ask to what degree the simulation fraternity has succeeded in implementing the recommendations that were developed at the first of these workshops, the one at Argonne in 1987. In the space below, I briefly state the relevant recommendations from 1987 and then comment on the progress. Finally in parentheses, I give a score: "OK", if the recommendation is satisfied, "+" is substantial progress has been made, "-" if progress is disappointing.

- Continue development of GEANT, rather than developing a new program for LHC and SSC. This has certainly succeeded, but most

of the development that has been incorporated into GEANT has still come from the CERN group and their close collaborators in Europe. It would still be desirable to broaden this base. (OK)

- Replace Patchy. This has been done, with the advent of CMZ. But there is also substantial use of CMS, even though its use mandates restricting code management to VAXes. (OK)

- Allow geometry input with a graphical interface and provide interfaces to CAD programs. As described above, progress has been made in this area. (+)

- Develop further shower libraries and parametrizations and integrate them into the standard GEANT package. (+)

- Provide a library of cuts and parametrizations appropriate to tested calorimeter designs. (-)

- Provide a library of digitization routines for standard detector components. (-)

- Provide fast simulation programs for initial exploration of detector design issues. These have been developed as in the case of SSCSIM described above and of QFL. (OK)

- Interface CALOR to GEANT as an additional hadronic cascade option. (+)

- Adopt a common set of particle identification codes to be used in both event generators and detector simulation programs. The Particle Data Group at LBKL has developed such a set of id codes, which are being incorporated into simulation programs. (OK)

- Organize continuing working groups to make progress on the issues identified at this workshop. (-)

- Hold similar workshop in the future at reasonable intervals. (OK)

Looking over the evaluation, I find five "OK", 3 "+", and 3 (-). So, the great majority of the concerns identified at Argonne have at least been substantially addressed. I trust the MC91 will be a major step in continued progress.

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