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# Full LCD Detector Simulation with GISMO

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**Abstract.** We present a status update of a full simulation package using GISMO[1]. This package is a functioning tool producing simulation data for the two standard LCD detector designs, in a framework allowing easy changes to the detector designs. The simulation engine, GISMO, is separated from the application code, GISMOAPPS, to allow for a future upgrade to GEANT4 within the same framework.

## WHY DO FULL SIMULATION?

The vast majority of analyses presented at this workshop use "fast simulations" with parameters describing particle interactions, detector response and event reconstruction. However, for detailed detector comparisons, reconstruction algorithm development, and beam background studies a full simulation package is needed. The full simulation includes physics effects (dE/dx, production of secondaries, decays in flight, etc.) and detector effects (cracks and edges) not reproduced in fast simulations. These effects may also severely impact clustering and track finding algorithms in complex events. Even in analyses using the fast simulation, to realistically determine the parameters the full simulation is required.

## THE LCD GISMO PACKAGE

GISMO is a reasonably full-featured simulation package written in C++. AIX, Linux, OSF1, SunOS, and NT platforms are supported. A full Prod/Dev/Test environment exists with Development Environment Controller[2], with all files stored in CVS for easy access.

All materials and active elements are input via XML, using an ascii definition file. This allows for detailed descriptions of detector elements in a readable and easily changeable format. An example piece of an ascii definition file is shown in Table 1. Current implementation describes all elements in terms of cylinders and cones, although there is no inherent limitation in either XML or GISMO requiring this. There is currently no checking preventing overlapping volumes, so for any detector change the output is carefully checked.

Event data are input from /HEPEVT/ using the FNAL STDHEP I/O package. Each particle is followed until it decays, interacts, is absorbed, or exits a predefined world volume. Electromagnetic interactions are performed by EGS, and hadronic

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interactions by Gheisha, both with 1 MEV cutoff energies. Each decay or interaction product is then tracked, with a complete record of parentage and offspring. For interactions within the calorimeters, all offspring are deleted before output with all detector responses attributed to the shower-initiating particle.

The philosophy the LCD group has adopted is that the full simulation should account for all known physics processes recording precise information at active detector elements, while responses of the active elements (resolutions, overlap losses, etc.) should be done at a later stage. This allows flexibility in response modeling without the need to rerun the full simulation. Therefore tracking digitizations contain the actual position at active layers, while calorimeter digitizations contain the total energy per channel as well as each particle's contribution. Sufficient information is recorded to allow a coarser segmentation modeling from the same data run with finer segmentation of the calorimeters.

Simulation data are output in binary format using SIO[3], readable from both C++ and Java.

**TABLE 1. Ascii file for defining EM Endcap Calorimeter in S2 detector**

```
<volume id = "EM_ENDCAP" >
   <disk reflected = "yes">
    <disk_dimensions inner_r = "24.0" inner_z = "152.5" outer_r = "70.0" />
    <layering n="50" >
      <slice material = "W" width = "0.2" />
      <slice material = "Si" width = "0.03" sensitive = "yes" />
      <slice material = "G10" width = "0.1" />
      <slice material = "Air" width = "0.17" />
    </layering>
    <segmentation theta = "300" phi = "300" />
   </disk>
   <calorimeter type = "em" />
  </volume>

  <volume id="EM_ENDCAP_ELECTRONICS">
   <disk>
    <disk_dimensions inner_r = "24.0" inner_z = "177.5"
                outer_r = "70.0" />
    <layering>
      <slice material = "G10" width = "7.0" />
    </layering>
   </disk>
   <support type = "electronics" />
  </volume>
```

# THE DETECTORS

Full simulation runs are proceeding with the two current LCD designs, L2 and S2. S2 is a smaller design with silicon tracking, a stronger magnetic field than the L2 design, and the coil inside the hadronic calorimeter. L2 contains a 144 layer TPC with the coil outside the hadronic calorimeter. The position and composition of the major components of each detector are summarized in Table 2.

**TABLE 2. Current Detector Designs**

| | **S2** | **L2** |
|---|---|---|
| Beam Pipe | .075 cm Be + .01 cm Ti shield<br>1 cm inner radius | .075 cm Be + .01 cm Ti shield<br>1 cm inner radius |
| Vertex | 5 layers .01 cm Si<br>R = 1.2 – 6.0 cm | 5 layers .01 cm Si<br>R = 1.2 – 6.0 cm |
| Tracker | 3 doublets Si, R = 14,42,70 cm<br>5 Si discs Z = 31-149 cm | 144 layer TPC, R = 52-190 cm<br>5 Si discs Z = 30-270 cm<br>1 layer Si R = 48 cm |
| EM Calorimeter | 50 layers W/Si R = 78-103 cm<br>50 layers W/Si Z = 152-178 cm<br>Segment: Θ = 10mr Φ = 20mr | 40 layers Pb/Scint R = 196-220<br>40 layers Pb/Scint Z = 297-322<br>Segment: Θ = 10mr Φ = 20mr |
| Hadronic Calorimeter | 38 layer Cu/Scint R = 188-287<br>38 layer Cu/Scint Z = 189-388<br>Segment: Θ = 10mr Φ = 20mr | 120 layer Pb/Scint R = 233-365<br>120 layer Pb/Scint Z = 334-446<br>Segment: Θ = 30mr Φ = 60mr |
| Muon Calorimeter | 10 layer Fe R = 300-420 cm<br>10 layer Fe Z = 298-318 cm<br>Segment: Θ = 30mr Φ = 60mr | 24 layer Fe R = 453-645 cm<br>24 layer Fe Z = 447-669 cm<br>Segment: Θ = 30mr Φ = 60mr |
| Luminosity Monitor | 50 layer W/Si Z = 151-176 cm<br>Segment: Θ = 10mr Φ = 20mr | 50 layer W/Si Z = 300-325 cm<br>Segment: Θ = 10mr Φ = 20mr |
| Coil | 29 cm Al<br>R = 113-182 cm<br>B = 6T | 29 cm Al<br>R = 378-448 cm<br>B = 3T |

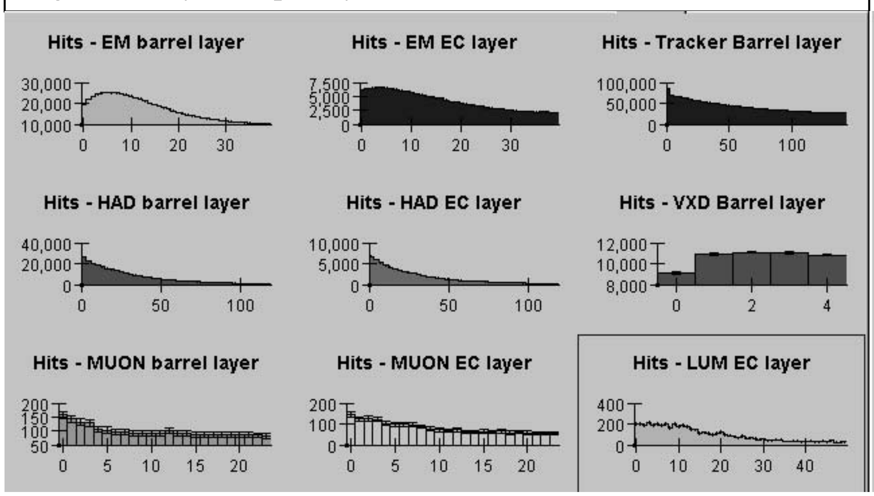
# Data sets

Data sets of 10,000 events each exist for udscb, tt, ZZ, WW, and ZH. They are archived at SLAC (lcddata01.slac.stanford.edu) and accesssible through FTP or Java Analysis Studio, with plans to make them available at PENN (sp05.hep.upenn.edu). A variety of diagnostic generator samples are also available.

A quality control package is routinely run on each data set after it is generated. The package is roughly divided into three parts: tracks, hits, and reconstruction. The tracks section plots event generation, particle types and distributions, and starting and end points to check that decays and interactions are reasonable and that material is where it is defined. The hits section plots position and layer frequencies for each active detector, checking the active volume definitions as well as the defined positions. Total visible energy and energy response with respect to different particle types are also checked in this section. The reconstruction section is under development, checking that the current algorithms find charged tracks and clusters. As an example, the layer hit frequencies of each of the detectors defined for L2 is shown in figure 1.

The simulation data is currently being used to develop tracking and clustering algorithms, and was used in some analyses reported in this workshop [4]. Comparisons of detector designs in global parameters (resolutions, visible energy, etc.) as well as performance for specific analyses are underway.

Figure 1. Layer frequency distributions for the L2 detector




## FUTURE PLANS

Work is currently underway to replace the GISMO engine with GEANT4 while maintaining the current framework for defining and creating the geometry.

## ACKNOWLEDGMENTS

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[1] T.H.Burnett "Gismo: An Object-Oriented Approach to Particle Transport and Detector Modeling" in Proceedings of the International Conference of Monte Carlo Simulations in High Energy and Nuclear Physics, 1993.
[2] A. Waite http://www-sldnt.slac.stanford.edu/nld/new/Docs/DEC/dec.pdf
[3] A. Waite http://www-sldnt.slac.stanford.edu/nld/new/Docs/FileFormats/sio.pdf
[4] G. Bower "Calorimeter Optimization for Jet Identification" in these proceedings