Software for the CALICE Project(s)

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This article describes the software framework employed by the CALICE collaboration to handle the data to be obtained during test beam measurements. The software framework is based on ILC software tools like LCIO, Mokka, Marlin and LCCD. Thus, the CALICE test beam effort will provide an important testing ground for the concepts under consideration for the ILC software framework.

1. INTRODUCTION

The CALICE collaboration is building calorimeter prototypes for detectors planned to measure the final state of e^+e^- collsions at the ILC. Large scale test beam measurements will be performed during the years 2005 and 2006 at various sites using high energy electron and hadron beams [1]. The test beam setup will comprise prototypes of the electromagnetic calorimeter (Ecal), hadronic calorimeters (Hcal, digital and analogue) as well as a tail catcher prototype. The measurements are supported by a drift chamber system to determine the impact point of the primary particles on the calorimeter surface. The considerable size of the test beam setups requires a careful design of the software framework to be used in the detector simulation and the handling of the measured data. Fig. 1 shows a general overview on the software chain which is about to be realized by the CALICE collaboration. The propagation of the data within the chain is based on LCIO [2] which is already widely used within ILC related simulation studies. For the first time it will be also employed on a large scale for the processing of measured data. In the following the main parts of the software chain will be briefly introduced.

2. DETECTOR SIMULATION

The test beam setup is implemented into GEANT4 [3] using the Mokka [4] package for a flexible geometry interface. The implementation shown in Fig. 2 comprises the drift chambers, the electromagnetic calorimeter protoype, the so-called analogue hadronic calorimeter prototype as well as the tail catcher. According to the envisaged test beam program, the implementation allows for different impact angles of the primary particles. Five different setups are available for the simulations studies featuring impact angles of 0, 10, 20, 30 and 40 degree. The possibility of defining different setup parameters within Mokka was mainly driven forward by the needs of the test beam simulation. The simulation will allow for an extensive comparison of the test beam data obtained with hadron beams with the various hadronic models as available within GEANT4. The understanding of the shower development in the hadronic calorimeter and the corresponding refining of the shower models is one of the primary goals of the CALICE test beam effort.

The implemented cell dimensions in the analogue hadronic calorimeter are 10x10x5 mm^3 The cell sizes in the calorimeter as built for the test beam measurements are somewhat larger. The transition from the fine granularity to the coarser granularity is realized by a ganging algorithm which is implemented as a Marlin processor [9] and is foreseen to be applied within the digitization step which runs after the simulation. The chosen cell sizes in the simulation provides the option to study the effects of different cell sizes on particle flow algorithms without the need to repeat many times the time consuming simulation step.

As a final remark it has to be noted that the CALICE collaboration also maintains a simulation of the test beam

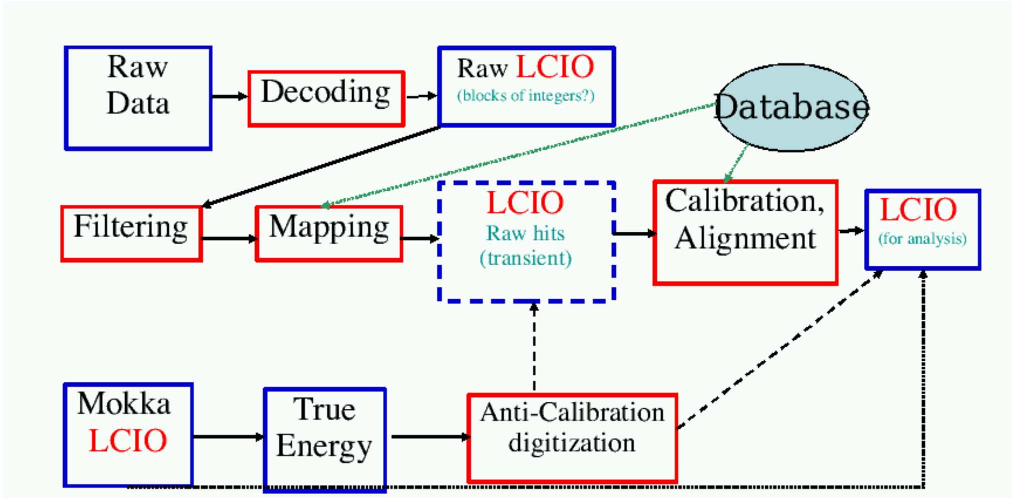

Figure 1: Schematic overview on the flow for measured and simulated data within the CALICE test beam measurements.

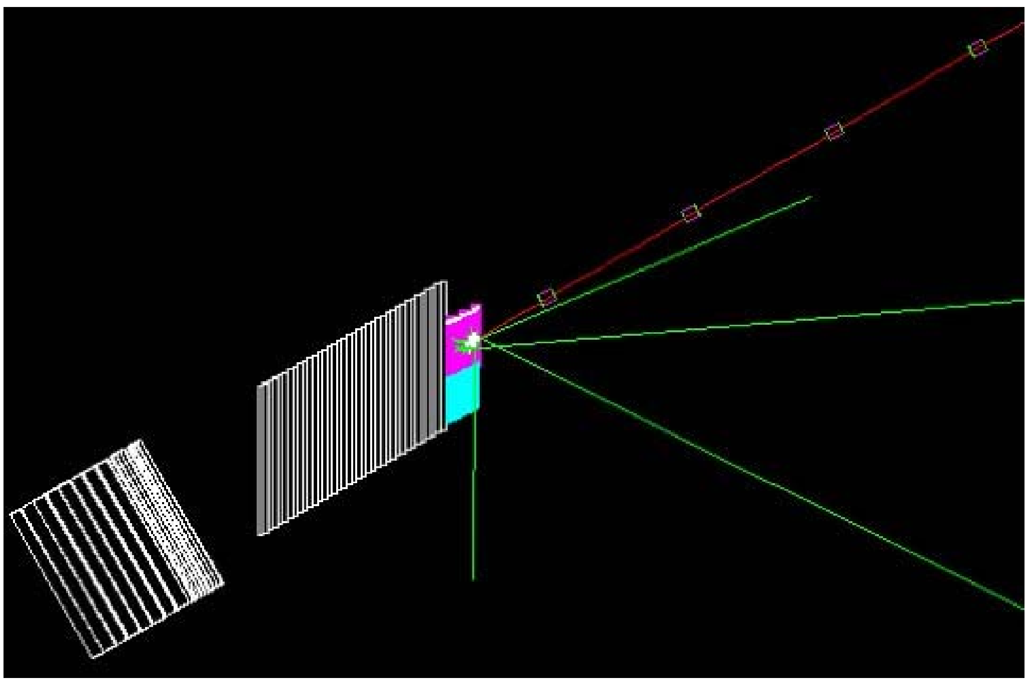

Figure 2: Mokka based GEANT4 implementation of the CALICE test beam setup. Shown are (from right to left): The drift chambers, the Ecal prototype, the analogue Hcal prototype, the Ecal prototype and the tail catcher.

setup based on GEANT3 [5, 6] to be able to compare with hadronic shower models not available within GEANT4.

3. HANDLING OF RAW DATA, DATA STORAGE AND ACCESS

It has been agreed to base the processing the of the CALICE test beam data on the LCIO software package. The data acquisition system, however, delivers the raw data in a special binary format and splits the data into various data types. Examples for these datatypes are the ADC data of the energy depositions in the calorimeter cells, TDC data which contain drift chamber information or configuration data which define the trigger setup for a given range during the data taking.

The data are made available in LCIO format by a converter program written in C++ [10]. Each data type is handled by a dedicated driver class. By this, the data conversion is structured in a modular way allowing for the easy adding of new data types if necessary. The access to the data types is provided by user friendly interface classes created around the LCGenericObject data type available in LCIO [11]. The introduction of these interface classes leads to a complete decoupling of the analysis software from the details of the data acquisition software which is still subject to frequent modifications. Note, that during the conversion step no data selection is applied. It is however foreseen to assign a primary quality flag to the data to allow for a quick data selection at a later stage of the data processing.

The conversion of 200000 events on an Intel Pentium 4 CPU with 2.4 GHz takes roughly 15 Minutes and the file size of the resulting LCIO files is roughly 30% smaller than that of the original binary files. All data analyses will start on these LCIO raw data files. The original raw data files are however kept for reference. The data currently taken with single modules of the analogue Hcal are converted on a regular basis into LCIO.

Roughly 250 GByte of raw data have been collected during a four week period at the DESY test beam with a first version of the protoype of the electromagnetic calorimeter. The complete test beam program will produce a data amount of the order of 3-5 TByte. The data are centrally stored in the DESY dCache pool [12]. The data are automatically copied into the dCache pool when a data run has been finished. It is planned to provide access to the data using grid tools. For that purpose a virtual organisation *calice* has been established which is hosted by DESY.

4. HANDLING OF CONDITIONS DATA

Conditions Data are all kind of data which are needed to analyze the data beside the actual event data. Examples for this kind of data are calibration constants or the interconnection between the hardware identifier which might be subject to changes and a unique identifier like a cell ID. The conditions data needed for the CALICE test beam effort will be kept in a MySQL database which is centrally hosted by DESY and made available to the CALICE collaboration via network access. The software package CondDBMySQL [8] provides an convenient interface to a MySQL database and allows for the definition of validity ranges of the conditions data in terms of time stamps. Similar to the code management system cvs, it permits additionally to create and administer different versions of a given set of conditions data. The CondDBMySQL package was originally developed by the Lisbon Atlas Group for the ATLAS experiment at the LHC. The need for the maintenance of conditions data within the CALICE test beam measurements motivated the development of the LCCD [7] software package (Linear Collider Conditions Data). It allows the storage of conditions data in various formats such as simple files, information attached within LCIO to an LCEvent or a MySQL database. The LCCD package establishes an interface to CondDBMySQL which is compatible with the interface to other sources of conditions data.

5. RECONSTRUCTION

The processing and analysis of the test beam data will be performed within the Marlin analysis framework. Processors to calibrate the data have already been developed. LCIO Files containing LCIOCalorimeterHits from the data and simulation branch are made persistent and available for further analysis. The data are input to e.g. Marlin processors which have been developed for cluster reconstruction [13–15].

6. CONCLUSION

The CALICE test beam measurements constitute a considerably large data taking effort within the ILC R&D programs. The data processing is entirely based on software tools developed for ILC related studies and thus provides an important testing ground for these tools. It has already led to important extensions of the software such as the introduction of LCCD, a general package for the handling of Conditions Data. The experience which will be gathered during the CALICE data taking will have a sizable impact on future developments of software for the ILC.

References

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[2] F. Gaede *et al.*, “LCIO - A persistency framework for linear collider simulation studies” LC-TOOL-2003-053, see *http://www-flc.desy.de/lcnotes*
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[3] S. Agostinelli *et al.*, ”GEANT4 - A simulation toolkit”, NIM **A 506** (2003) 250

[4] For a reference see *http://polywww.in2p3.fr/geant4/tesla/www/mokka/mokka.html*.

[5] R. Brun *et al.*, GEANT3.21 program.

[6] For a reference see *http://www.desy.de/ rasp/caloppt/caloppt.html*.

[7] F. Gaede, “Overview of Simulation and Reconstruction Tools in Europe”, These proceedings.
See also *http://ilcsoft.desy.de/lccd*.

[8] For a reference see *http://savannah.cern.ch/projects/conddb-mysql*

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See also *http://ilcsoft.desy.de/marlin*.

[10] Version v00-05 is documented under
http://www-flc.desy.de/store/hcal/simsoft/calice_soft/lcioconverter/v00-05/raw2lcio.

[11] Version v00-05 is documented under
http://www-flc.desy.de/store/hcal/simsoft/calice_soft/reco/v00-05/userlib.

[12] For a reference see *http://www.dcache.org*.

[13] C. Ainsley ”Cluster finding in CALICE calorimeters”
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[14] G. Mavromanolakis ”Calorimeter Clustering with minimal spanning trees”
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