MarlinTPC: A common software framework for TPC development

The goal of MarlinTPC is to provide a versatile software package for simulation, digitisation, reconstruction and analysis for TPC prototype measurements and simulation studies. It uses *Marlin* as the base reconstruction framework, the *Geometry API for Reconstruction* package GEAR and the *Linear Collider Input Output* (LCIO) event data model. Using a common reconstruction framework and data format allows the exchange of data between the different groups and improves the comparability of the results.

MarlinTPC was designed to be as flexible as possible. It is suited for TPCs equipped with GEMs, Micromegas or anode wires as gas amplification systems, using several kinds of readout electronics. All pad geometries which can be described by GEAR can be simulated and reconstructed. The TimePix chip, which is investigated as a very fine granular readout for Micro Pattern Gas Detectors, is also supported.

Currently MarlinTPC consists of more than 50 different so called processors, which represent the particular computing tasks. This high modularity allows a good code reusability. Detectors specific processors can easily be exchanged or different algorithms can be compared, while the rest of the simulation or reconstruction chain may remain untouched.

1 Simulation and Digitisation

For the simulation and digitisation both a detailed and a fast branch are available. The detailed branch starts by simulating the primary ionisation in the gas. Afterwards each single electron is tracked through the chamber, including distortions of the electric and the magnetic field. After simulating gas amplification and shaping of the electronics the charges are filled into 3D bins (voxels), which resemble the quantisation of the readout due to the pad layout and the sampling frequency of the electronics.

The fast digitisation branch reads in charge depositions simulated by Mokka (the GEANT4 model of the Large Detector Concept) and fills the voxels by applying a Gaussian smearing. Using a voxel map resembling the readout electronics, both branches provide realistic TPC raw data including pile-up of several events in a large TPC at the ILC. In a last step the voxel information is converted into the specific raw data formats for ADCs or TimePix.

Additional modules allow the calculation of primary ionisation and ion backdrift. The distortions of the electric field caused by these charges can be calculated and their effect is included in the drift process.

2 Reconstruction

For reconstruction on a pad plane, a pulse search on each channel is performed. Afterwards pulses on neighbouring pads are grouped together and a hit with 3D space coordinates is reconstructed, using the pad geometry provided by GEAR. With the high resolution readout using the TimePix ASIC, which has a pixel size of $55 \times 55\ \mu\text{m}^2$, the ionisation clusters in the gas can be resolved. In this case a specific clustering algorithm is needed to reconstruct the 3D hits.

To search for straight tracks, a hit based finder operating on pad rows and a geometry independent finder using Hough transformations is implemented. A different approach is to look for contiguous areas on the pad plane to identify tracks. Here no track hypothesis is needed and also curved tracks and even curling trajectories can be found.

For track fitting there are also several processors available: A global likelihood fitter determines the track parameters by maximising the likelihood of the measured signals on a pad plane. It does not use the intermediate step of reconstructing hits and automatically includes the pad response. For hit based track fitting a χ^2-fitter is available, as well as a linear regression processor for straight tracks.

3 Analysis

The LC-TPC collaboration has agreed on default analyses which should be provided for comparability of measurements. MarlinTPC provides processors to produce these default plots and values, like residual distributions, number of hits per pad or comparison between reconstructed and predicted track. In addition there are processors to produce histograms useful for commissioning a detector, like occupancy and distributions of reconstructed hit coordinates. Also some tools for debugging the code are available.

4 Conditions Data

Additional information which is needed during the reconstruction (run parameters like the gas mixture used or calibration data like the drift velocity in the gas) has to be accessible through a well defined interface. For this purpose MarlinTPC provides a set of LCIO data classes which can be stored as Linear Collider Conditions Data (LCCD). The LCCD toolkit automatically provides the correct calibration data or run parameters for the reconstruction processors.

5 Conclusions

Although developed in the context of the LC-TPC collaboration, MarlinTPC is a generic TPC R&D package which is not restricted to or specific for the linear collider. Its high modularity makes it flexible and allows easy adaptation to all different kinds of TPC geometries and readout technologies. Currently the Software is being tested in different R&D groups and will be used as the common reconstruction and analysis framework for the joint beam tests with the EUDET large TPC prototype, which will be performed at DESY in autumn 2008.

The status of the software as of October 2007 is described in the EUDET-Report-2007-04, which also contains a list of references to the underlying software packages (see `http://www.eudet.org/e26/e27/e380/eudet-report-2007-04.pdf`).
MarlinTPC Homepage: `http://ilcsoft.desy.de/portal/software_packages/marlintpc`