The ATLAS Detector Digitization Project for 2009 data taking

What do we mean by Digitization in ATLAS?

In ATLAS, digitization refers to the process of converting 4 simulated hits in active volumes of the detector to Raw Data Objects (RDOs), which act as an input to the reconstruction. This includes propagating charge to readout electrodes, front end electronics simulation and conversion of these responses into RDOs. Level 1 trigger simulation can also be performed during the digitization step. As part of the digitization process it is also possible to simulate the electronics response to a number of 4 simulated sub-events as a single digitized event. This process is called “pile-up”. The real ATLAS detector writes out data in various byte stream formats. When byte stream is read into a reconstruction job it is converted into the appropriate transient RDO representation. The transient RDO representations can be persistified (saved to file) in POOL format. An advantage of this is that the “digitization output of the Monte Carlo”, the “Truth Digitization”, which is not available in the byte stream format, can also be persistified. Some digitization algorithms simulate this step, others produce RDOs directly. In all cases algorithms exist to convert RDOs into byte stream format and vice-versa. The formats are similar, the main difference is that the separate transient and persistent representations of the RDOs allow more efficient storage.

Core Digitization Framework

- Entirely PYTHON based.
- Highly configurable.
- Ensures sensible default values and resolves any conflicting settings.
- Inputs: Hit Objects (produced by the ATLAS GEANT 4 simulation)
- Outputs: Raw Data Objects (can be written out to a POOL file if required)
- Can be run stand-alone or as part of simulation or reconstruction jobs.

Sub-detector Digitization Packages

Digitization algorithms exist for all ATLAS sub-detectors shown in the plot above and also for the Beam Conditions Monitor (situated next to the beampoint) and LUCID (situated ±17m from the interaction point).

Algorithms for other Forward Detectors will be added as required. Work is ongoing to further optimize all algorithms, particularly in the case of digitizing high luminosity pileup events.

Event Pile-up

Problem

- Dead and noisy channels can be added by non-default detector conditions database tags.
- Some sub-detectors simulate dead and noisy channels during the reconstruction step instead.
- Random noise and cross-talk may be switched on and off in the Inner Detector, Calorimeters and Muon Spectrometer separately.
- Detector misalignments are fixed in the GEANT 4 simulation step by the Geometry tags used.
- Distortions of modules are also simulated in some sub-detectors.

Solution 1: Pile-up

One solution is to simulate the hard-scattering interactions, minimum bias interactions, beam halo events, beam gas events and cavern background events separately.

More about Pile-up

- Minimum bias events are generated using Pythia. The mean number of minimum-bias interactions per bunch crossing is 23 at the design luminosity of 10^34 cm^−2 s^−1, with 25 ns bunch spacing. In the simulation, 4 depends linearly on luminosity and bunch spacing. The number of minimum-bias interactions per bunch crossing is Poisson-distributed. Thus, some bunch crossings may have zero interactions.
- Cavern background events are generated using a Geant 3/GCALOR based program which generates particle fluxes in an envelope around the muon spectrometer.
- Beam gas includes the residual Hydrogen, Oxygen, and Carbon gases in the ATLAS beam pipe. Events are generated using Rfjg.

Solution 2: Data Overlay

The zero bias trigger data needed for this type of event overlay can be selected at random from the filled bunch crossing. The sub-detectors should be read out with an 8-bit zero-suppression as is possible and with the Higher Level Trigger in “pass-through” mode.

More about Data Overlay

- In principle one can attempt to overlay RDOs from a zero-bias trigger with RDOs from a minimum bias trigger for each sub-detector.
- In practice the zero-bias trigger is more likely to be a zero-suppressed trigger too. This trigger bit would be pushed into a pipeline of exactly 1 bit, such that the zero-bias trigger hypothesis is exactly the same bunch crossing, but 1 orbit later. Appropriately pre-filtered to the output rate needed for simulations (1/25 Hz) this would mean that the bit follows the luminosity and that the bunch structure is guaranteed to be tight.

The ATLAS Detector Digitization Project

K Assamagan (BNL), P Calafiura (LBL), J D Chapman (Cambridge), D Costanzo (Sheffield), A Dell’Acqua (CERN), A Di Simone (Rome & INFN), G Lima (Northern Illinois), Z Marshall (Columbia), A Rimoldi (Pavia & INFN), I Ueda (Tokyo), S Vahsen (LBL), D Wright (Stanford), Y Zhou (Academia Sinica)