THE ATLANTIS VISUALISATION PROGRAM FOR THE ATLAS EXPERIMENT

J. Drohan, J. Couchman, N. Konstantinidis, Z. Maxa, University College London
Hans Drevermann, CERN
F. Crijns, E. Jansen, P. Klok, C. Timmermans, University of Nijmegen
D. Petrusca, G. Taylor, UC Santa Cruz

Abstract

We describe the philosophy and design of Atlantis, an event visualization program for the ATLAS experiment at CERN. Written in Java, it employs the Swing API to provide an easily configurable Graphical User Interface.

Atlantis implements a collection of 2D/3D data-orientated projections which enable the user to quickly understand and visually investigate complete ATLAS events. Event data is read from XML files, produced by a dedicated algorithm running in the ATLAS software framework ATHENA, and translated into internal data objects. Multiple views of the data can be displayed within the main canvas area, with varying size and position. Interactions such as zoom, selection and query can occur between these views using Drag and Drop.

Associations between data objects, as well as the values of their member variables, provide criteria upon which the Atlantis user may filter a full Atlas event. By choosing whether or not to show certain data, and if so in what colour, a more personalised and useful display may be obtained. The user can dynamically create and manage their own associations and perform context dependent operations upon them.

INTRODUCTION

Atlantis is an event display for the ATLAS experiment at CERN. When the LHC starts running in 2007, it will collide protons with a center of mass energy of 14TeV at a bunch crossing rate of 40MHz. At the design luminosity of $10^{34}\text{cm}^{-2}\text{s}^{-1}$ there will be approximately 23 interactions per bunch crossing. Atlantis aims to provide easy, fast, error free visual investigation and physical understanding of these complicated events. This involves enabling the user to understand and check aspects of the reconstruction such as clustering, tracking and associations between data objects, e.g. tracks to clusters.

PROGRAM OVERVIEW

Atlantis is a Java application employing the Java2D package for graphics and Swing for the Graphical User Interface (GUI). The main Atlantis canvas is a layered panel, allowing multiple projections to be displayed on the screen at once, with varying size and position. These displays can be adjusted within the GUI by the graphical window controls and they can be moved between positions using Drag and Drop.

Access to Event Data

Atlantis reads events from XML files. At present, these files are created by a dedicated algorithm, JiveXML, running in the ATLAS software framework ATHENA. This algorithm runs after full reconstruction or fast simulation and produces one file per event. These files can either be read locally by Atlantis or accessed over a network, either as XML or within a zip file. JiveXML can also act as an XMLRPC server to send files directly to Atlantis. A design luminosity event is approximately 20MB in size, or 4MB compressed within a zip.

Detector Geometry

Atlantis displays an idealised detector geometry to rapidly convey the context in which hits are to be viewed. This information is read at startup from an XML configuration, enabling Atlantis to be easily extended for use with different geometry setups such as test beams.

Interactions

Atlantis provides the user with the following mouse based interactions, made available by selecting the corresponding tab on the GUI (Figure 1).

Zoom/Move/Rotate (ZMR) Zooming is carried out with respect to a central position specified by the user. Mouse modifier keys M and R enable use of the Move and Rotate functions.

Rubberband Rubberbands provide an alternative method for zooming by drawing a band around the region of interest. A summary of data contained within the area is available as an option.

Pick This interaction allows selection of hits and tracks or detectors. It also provides the ability to navigate to selected data in different projections.

Fisheye Transformation This is a radially dependant zoom allowing relative magnification of the inner detectors without increasing the outer radius (Figure 2).

Clock Transformation This is an angular fisheye transformation that allows a selected azimuthal region to be shown in detail whilst still displaying the full 360^o.

Synchro-Cursors Cursors are simultaneously visible in all projections.

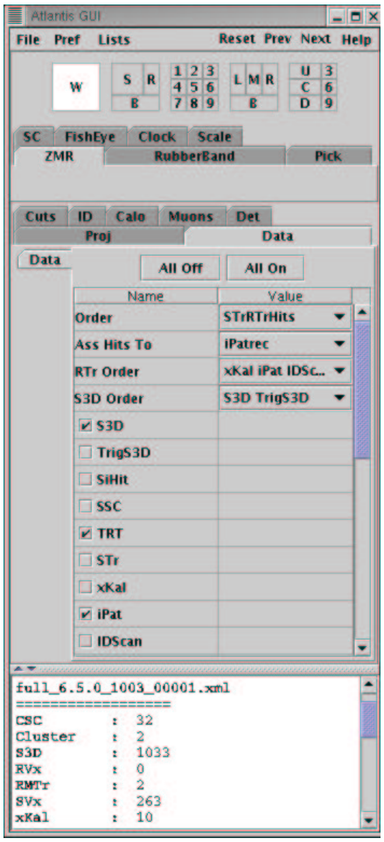

Figure 1: The Atlantis Graphical User Interface.

Menus

The user interface contains a tabbed panel of menus for display manipulation (Figure 1). The Data menu allows selection of the data types to be drawn on screen. It also allows for reordering of different track and hit types, e.g. reconstructed and simulated tracks. The Projection menu changes the projection in the current window and the Cuts menu allows data to be cut by parameter or association to other data types. There are a series of sub-detector specific menus which provide the ability to alter the colour, shape and size of data objects from that sub-detector and also to colour the objects by association.

The user can create a more useful display by using this ability to cut and colour objects in combination. For example, by selecting only hits belonging to truth tracks, and then colouring these by their association to reconstructed tracks, it is easy to see possible problems with track reconstruction and investigate the cause of unused truth hits.

Configuration and Image Output

Atlantis is easily configurable, offering the possibility to modify and save colour maps, projection/window setup and the GUI content. These saved settings are automatically loaded on startup. EPS, PNG and GIF image output is available.

DATA ORIENTATED PROJECTIONS

3D Cartesian coordinates are not always optimal for colliding beam experiments. Atlantis utilises a collection of 2D projections[1], including the intuitive Y/X, Y'/Z, X'/Z, ρ/Z projections as well as the more powerful but non-intuitive ϕ/ρ, ϕ/Z projections and the V-Plot (3D).

Y/X

The Y/X projection is an easily understandable projection looking along the beam line. This projection is useful to view tracks and hits in the inner silicon detectors, providing estimation of charge and P_T, and associating them to the TRT, LAr and TILE barrels. This projection is also useful to look at the Muon RPC ϕ-strips. Endcap information is not displayed for the calorimeters and muon system as these would fall ontop of the tracking and calorimeter barrel data, complicating the picture. Separate views in this projection are available for the muon endcaps and forward calorimeters (FCAL). Figure 2 is the Y/X projection with a fisheye transformation applied.

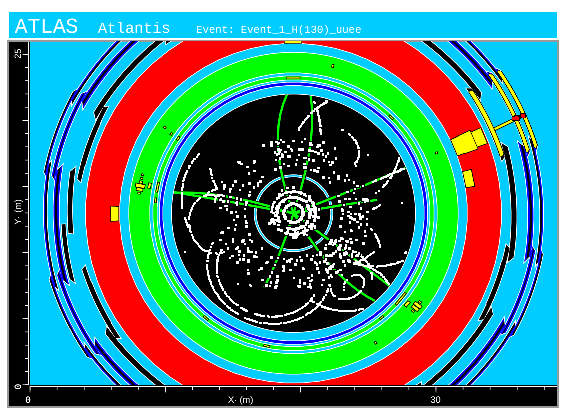

Figure 2: The Y/X Projection with fisheye applied.

X'/Z

The X'/Z projection is a useful view for the muon system and vertex region. The eight muon sectors, both barrel and endcap, can be viewed individually. This enables comparisons between the reconstructed muon tracks and hits in the Monitored Drift Tubes (MDTs), seen as circles in this view (Figure 3).

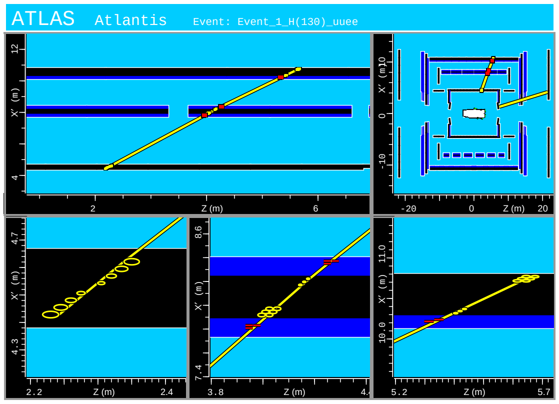

Figure 3: The X'/Z Projection showing a single muon sector (top right), a zoomed view into the upper most muon track (top left) and a zoomed view for each muon MDT layer (bottom).

ρ/Z

The ρ/Z projection is the only projection where all the main detector units can be displayed without overlapping (Figure 3). It enables the user to associate between inner detector hits and tracks and the full calorimeter system. It provides a rough association to muon data from all sectors superimposed. This is a non-linear projection but is intuitively understandable, with tracks from the origin taking the form of approximately straight lines.

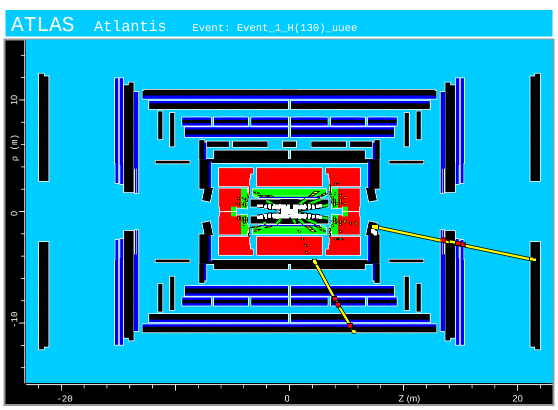

Figure 4: The ρ/Z Projection.

ϕ/ρ

The ϕ/ρ can be regarded as a modified Y/X projection, with the same data being displayed in both. This is not an intuitive projection but allows a better angular separation of data from the innermost detectors. Pattern recognition is easier in this projection (Figure 5) as helices are approximately straight lines. Tracks not pointing to the origin are distinctly non-linear when approaching ρ=0 and both the particle's charge and P_T can be estimated from the track slope.

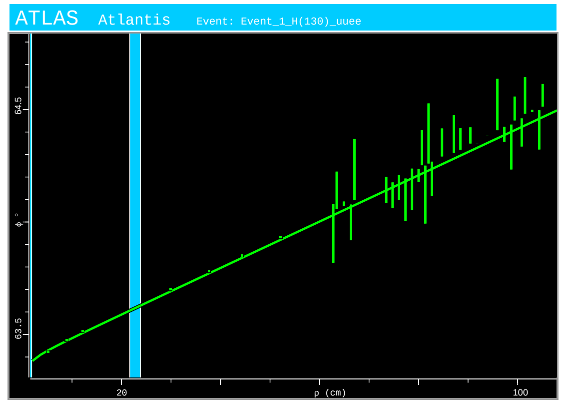

Figure 5: The ϕ/ρ Projection showing a track in the inner detector.

V-Plot

The V-Plot is a modified form of the ϕ/η projection. ϕ/η provides optimal separation of tracks but doesn't provide charge, P_T estimation or ρ information for hits. The V-Plot provides a solution to this, drawing two points for each single point on the ϕ/η plot using the equation $\eta \pm kx(\rho_{max} - \rho)$, where ρ_{max} is normally the outer SCT radius. ϕ, η, ρ may be recalculated from each pair of points, making this a 3D projection. The following rules apply to interpret the V-Plot (Figure 6).

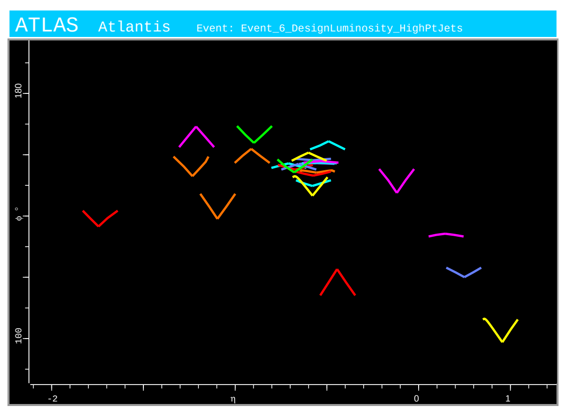

Figure 6: The V-Plot.

- Helices transform into a V-like pattern.
- For helices pointing to the origin with not too low P_T the arms of the Vs are straight.
- For helices not pointing to the origin the arms of the Vs are curved, with the same sign of curvature for tracks separated from the origin in z and the opposite sign for tracks separated in ρ.
- Positive tracks give Vs pointing upwards.
- Negative tracks give Vs pointing downwards.
- The gradient of a V is proportional to $1/P_T$. High P_T tracks give Vs with an obtuse angle.

ADVANCED FEATURES

Filtering Algorithm

Within Atlantis it is possible to filter inner detector space points to remove those not consistent with tracks originating from a given primary vertex position (Figure 7). The filtering algorithm is based on the fact that all hits of a track with sufficiently high P_T are contained in a small solid angle in (ϕ,η) that starts from the track's initial z position, in contrast to hits from tracks originating from different z positions. If enough hits are contained in a (ϕ,η) bin then they are accepted by the filter. This algorithm is extremely efficient and is now the basis of a fast tracking algorithm for the ATLAS Level 2 Trigger[2].

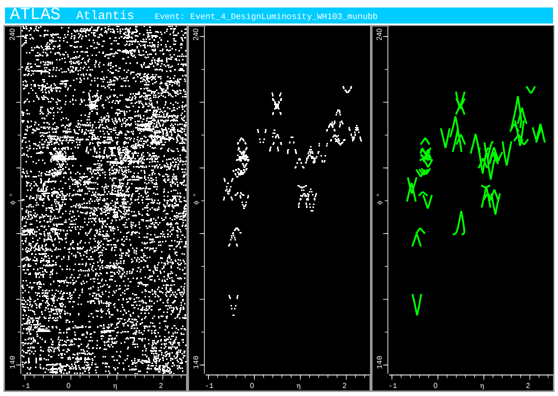

Figure 7: V-Plot projection of a high luminosity event before (left) and after (middle) filtering. Reconstructed tracks for comparison (right).

Lists

Lists provide the user with the ability to dynamically create and manage their own associations. One of the main uses of lists is to construct secondary vertices from a group of reconstructed tracks.

3DBox Projection

The 3DBox projection allows the user to investigate a small 3D region around a newly formed secondary vertex (Figure 8). The box is formed with default size (2mm x 2mm x 4mm) around the direction of flight of the incoming particle. The box contains three vertically orientated planes. The intersection of the planes and the tracks within the box are shown as ellipses representing the correlated impact parameter errors of the track. The user can zoom and rotate the area contained by the box to check the validity of the vertex.

CONCLUSIONS

Atlantis is an event display tailored for the visual investigation of complete ATLAS events. It provides the user with a set of data orientated projections, including a modified form of the ϕ/η projection known as the V-Plot. Atlantis has an intuitive menu system, is fast and easy to use. The program is available to download from `www.cern.ch/atlantis`, along with documentation and a picture database.

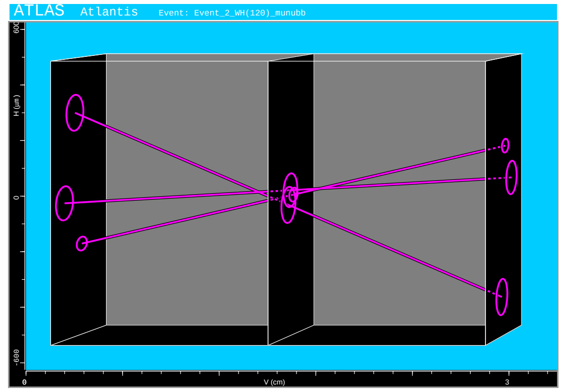

Figure 8: The 3D Box Projection.

REFERENCES

[1] H.Drevermann D.Kuhn B.S.Nilsson, 'Is there a Future for Event Display?', Proc. of 1992 CERN School of Computing, L'Aquila, Italy, CERN Yellow Report 93-03.

[2] N. Konstantinidis H. Drevermann, "Fast Tracking in Hadron Collider Experiments", ACAT, October 2000