Atlantis Help System
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Chapter 1

About the Atlantis Help System

The Atlantis event display program has two independent systems for online help:

- **Tooltips**
  Tooltip help consists of a set of short text messages associated with practically every graphical component of the user interface. You obtain these short messages by stopping the mouse cursor in the area you want to get help for. If there is some message for this component it will appear on the screen in a few moments.

- **Online documentation**
  The online documentation is a hierarchically organized set of HTML pages, linked to each other by hypertext links. Online pages provide much more detailed descriptions than tooltips, but not every graphical component has an associated page. The online documentation root page (the Table of Contents) is displayed in the Help pop-up window that is opened via the **Help -¿ Help Content** menu option of the Control Window.

  In the Help pop-up window you can start navigating and use the Table of Contents to directly go to the page you are interested in. A hierarchical navigation path is shown at the top of each page and via the Back button you may retrace your steps along the path you followed.

  An alternative (and faster) way to access the online documentation of a graphical component is to right-click on that component. This will show the available help page directly in the Help pop-up window.

  The online documentation is also available as single webpage and as PDF document from the Atlantis website (select item **Documentation** in left margin for a page with options).

Chapter 2

Introduction to Atlantis

Atlantis is an event display program for the ATLAS experiment at the LHC at CERN. The primary goal of the program is the visual investigation and the understanding of the physics of complete events. Secondary goals are to help develop reconstruction and analysis algorithms, to facilitate debugging during commisioning and to create pictures and animations for publications, presentations and exhibitions.

Specific features of the program are:

- The use of **data oriented projections** to reach the goals mentioned above.
- The use of **subviews** within the display area to be able to view various projections simultaneously.
- 2D **animations** beyond panning and zooming.
- 3D **synchronous pointers** across the various projections, so you may pick an object in one projection and see where the object is located in the other projections.

The Atlantis user interface is basically mouse driven and using generally applied facilities of modern user interfaces (e.g. pop-up, tooltip). It consists of a control window ”Atlantis GUI”, a display area window ”Atlantis Canvas” and various pop-up windows.

The orientation of the used coordinate system is described in ATLAS coordinate system.

Atlantis is based on the ALEPH event display DALI and is written entirely in JAVA.

2.1 Data Oriented Projections

Projections and Data

In the program a distinction is made for data in 3D space between space points (e.g. silicon hits) and space lines (e.g. straws from the TRT).

All projections may be used for both types of data. However, space lines are best viewed in the following projections:

YX	TRT, LAr and TILE barrels, RPC, vertex region (intuitive view)
$\phi\rho$	TRT, LAr and TILE barrels, RPC, tracks are straight lines
ρZ	Barrel and endcap calorimeters
X'Z	MDT, RPC and CSC, vertex region (intuitive view)
Y'Z	Orthogonal view to X'Z
ϕZ	TRT endcaps, calorimeter endcaps and TGC
$\phi\eta$	Calorimeters, and their association to tracks and S3D hits
3DBox	Vertex structure of tracks near the primary vertex

These projections were choosen such that space lines are shown as points, so they can be combined easily with and to tracks, clusters, etc.

Projections and Magnetic Field

Depending on the projection and the type of magnetic field, tracks of charged particles will be more or less straight. The following table gives an overview:

	YX
Solenoidal	curved
Toroidal	straight

See also Projections under Parameter Control.

2.2 ATLAS Coordinate System

The ATLAS coordinate system is defined as:

- Z = beam axis = cylinder axis.
- X = horizontal axis.
- Y = vertical axis.

Chapter 3

User Interface

The Atlantis user interface is basically mouse driven and using generally applied facilities of modern user interfaces (e.g. pop-up, tooltip). It consists of a control window ”Atlantis GUI”, a display area window ”Atlantis Canvas” and some pop-up windows.

Via the **control window** the features and parameter settings of Atlantis are controlled. It contains five fundamental components, namely (listed from the top to the bottom of the window):

- **Menu** - Provides functionality for I/O, program customisation and the help system.
- **Canvas Control** - Provides functionality for window management (copy, zoom, pop-up menus, etc.) in the display area or Canvas.
- **Interaction Control** - Provides functionality for user interaction with the program.
- **Parameter Control** - Provides functionality for inspecting and changing various parameters.
- **Output Display** - Displays output of the program (picking output, cuts summary, etc.).

The **display area window** is described under **Atlantis Canvas**.

The **pop-up windows** contain menus which provide different ”one click” operations:

- **Window Menu** - Provides window related operations (restoring of defaults, rotation and flipping, etc.).
- **Projection Menu** - Provides projection specific operations. Each projection has it’s own menu.
- **Interaction Menu** - Provides interaction specific operations. Not all interactions have such a menu.
- **Lists Window** - Allows the interactive definition and manipulation of subsets of data.
- **Mouse Modifiers Window** - Shows information about various mouse modifier keys.
- **Help Window** - To browse the Atlantis Help System pages.

The menus disappear either after the appropriate action has been selected or when another left-click is performed on the corresponding window.

3.1 Control: Menu

The Menu is positioned at the very top of the Atlantis control window. It contains the items **File**, **Pref** (Preferences), **Lists**, **Reset**, **Prev** (Previous), **Next** and **Help**.

File

The File menu item is used to perform operations on event files and to exit Atlantis. Note that event files are expected to be in XML format (which may also be zipped). The item contains the following options:

- **Read Event...** - Displays a dialog window where you can choose which event file to read from your local computer.
- **Read Event From URL** - Displays a dialog window where you can specify a URL to read from.
- **Read Event From Server** - Displays a dialog window where you can specify a server name or IP-address to read events from. This option starts e.g. online event monitoring with Atlantis.
- **Print** - Displays options from which you may choose the output format of the file in which you want to save the picture shown on the Canvas.
  - **EPS** - Encapsulated PostScript. Vector graphics format for posters, publications, etc.
  - **PNG** - Portable Network Graphics. A compressed bitmap format to be used in Powerpoint presentations, etc.
  - **GIF** - Graphics Interchange Format. Another compressed bitmap format.
- **Event Properties** - Displays a window with a summary of various properties of the selected event.
- **Exit** - Exit Atlantis.

Pref

The Preferences menu item is responsible for customizing the application. It contains the following options:

- **Lists** - Creates a Lists pop-up window for the interactive definition and manipulation of subsets of data. This option is the same as the Lists menu item.
- **Layout** - Displays a dialog window that allows the user to choose a layout set to associate with the Canvas.
- **Select Color Map** - Displays a dialog window which allows the user to choose the color set used to draw the pictures. There are four color sets:
  - **Display** - Default color set used for display.
  - **Printer** - The set of colors used when printing.
  - **Gray** - The grayscale set of colors.
  - **B/W** - The black-and-white set of colors.
- **Color Map Editor** - Displays a dialog window that allows the user to edit any of the color sets described above.
- **Read Color Map** - Displays a dialog window that allows the user to replace the current colormap with one previously stored on an XML file.
- **Write Color Map** - Displays a dialog window that allows the user to store the current colormap to an XML file for later use.
- **Write Config** - Displays a dialog window that allows the user to store the current status (configuration) of the program to an XML file for later use.
- **Title** - Adds or removes the title bar from the top of the Canvas.

Lists

Creates a Lists pop-up window for the interactive definition and manipulation of subsets of data.

Reset

Resets Atlantis to the default initial settings.

Prev

Loads and displays the previous event if available.

Next

Loads and displays the next event if available.

Help

The Help menu item provides a way to get access to help information. It has two options:

- **Help Content...** - Starts the Help pop-up window with the table of contents.
- **Mouse Modifiers** - Starts the Mouse Modifiers pop-up window with information about various mouse modifier keys.

3.2 Control: Canvas Control

Pictures are shown in the display area window or **Canvas**, which may have one or more subwindows, the **canvas windows**. So in the case of multiple canvas windows, one may e.g. view event data in different projections on the Canvas. The possible canvas window configurations are specified in **layout sets**.

A layout set is selected via the **Pref-¿Layout** menu option of the Control Window.

The layouts of the current layout set are displayed in the Control Window as a row of rectangles directly under the menu. A rectangle is divided into one or more boxes, representing the canvas windows. A letter or number in a box represents the canvas window name.
For example, in Landscape Layout the canvas windows are UDR, 123456, SR, W, LMR and in Square Layout they are W, SRB, 123456789, LMRB, UCD369.

Canvas Control provides functionality for different kinds of operations on the boxes:

- **Making a canvas window current**
  The current canvas window corresponds to the box with the white background. Clicking with the left mouse button into another named box will select another canvas window to become current. If this is not visible on the Canvas it will be made visible.

  N.B.:
  You can also make a canvas window current by clicking on it in the Canvas (at least, if you can see part of the desired canvas window).

- **Copying the content of one canvas window into another**
  You can copy the content (picture) of one canvas window into another by dragging and dropping it into another one. While you are dragging, the cursor will change to let you know that you are dragging. You can copy canvas windows even if they are not current. After the copy finishes the target canvas window will become current.

N.B.:
Another possibility to copy is to drag from the Canvas Control into the Canvas (if you can see in the Canvas at least a part of the target canvas window).

- **Zooming a region of one canvas window into another**
  Canvas Control contributes to the process of zooming with a rubber band, however you cannot perform a zoom by using Canvas Control only. Further information about using Canvas Control for zooming ia available on the Rubberband page.

- **Accessing the pop-up Window Menu**
  The pop-up Window Menu can be accessed by **right clicking** with the mouse in the corresponding box. The corresponding canvas window will become selected.

3.3 Control: Interaction Control

Interaction Control is one of the main components in the Atlantis user interface. Interactions can be invoked in two different ways:

- In the Control Window they are represented as a set of tabs, each representing a specific interaction. Clicking on a tab makes the corresponding interaction available in the current canvas window.

- An alternative representation can be obtained by holding the **I** keyboard key pressed and right-clicking inside the window (on the Canvas) for which you want to set the interaction (**I + Right Click**). As a result you will get a pop-up menu with exactly the same content as the tabs on the screen. You can select any interaction you want.

It is very important to understand how all the components of the Interaction Control (Interaction Panels) work and to be able to use it in it's full power. There are two sets of interactions:

Global Interactions
These interactions are available in any projection:

- **ZMR** - Zoom/Move/Rotate.
- **RubberBand** - Different kinds of RubberBand selections.
- **Pick** - Used to Pick an object in one projection and find it in another. Also used to display information about hits, tracks or detectors.
- **SC** - Synchronised Cursors, used to see the same point in different projections.

Projection dependent Interactions
These are interactions that perform operations which only make sense in specific projections:

- **Fisheye** - Available in Y/X, ρ/Z, ϕ/ρ, ϕ/Z, X'/Z, Y'/Z and 3D.
- **Skew** - Available in ρ/Z, ϕ/ρ and ϕ/Z.
- **Clock** - Available in Y/X only.
- **Scale** - Available in Y/X, ϕ/η, ρ/Z, ϕ/ρ, ϕ/Z, X'/Z, Y'/Z and 3D.

Interaction Pop-up Menus
Each interaction has an associated pop-up menu. See the page on Pop-up: Interaction Menus

N.B.:
Look at the detailed information about available projections.

3.3.1 Zoom/Move/Rotate (ZMR)

The ZMR interaction allows the user to perform zooming, moving and rotation of the picture content of a canvas window. Make the ZMR interaction current by clicking on the corresponding ZMR tab in the Interaction Control part of the Control Window. After selecting the ZMR tab, the interaction is available in the current canvas window.

Three operations can be performed with the ZMR interaction:

- **Zooming**
  Zooming is done always with respect to a **central point** which the user can specify. The central point is represented by a small red circle superimposed on the picture.
  If you want to perform a zoom operation just drag any point of the picture inside or outside, increasing or decreasing its distance to the central point.
  See the Mouse Modifier table for the different types of zoom that can be applied.

- **Rotation**
  Zooming is also done with respect to a **central point** which the user can specify. To obtain a rotation of the picture you do the same as for zooming while keeping the **R** key of your keyboard pressed. Note that rotation is a projection dependent operation:
  - **YX** - It performs a real rotation around the Central Point.
  - ρ**Z, X'Z, Y'Z**, - It performs a rotation of splitting angle ϕ or the viewing angle ϕ_{VIEW}, respectively.
  - $\phi\rho$**,** ϕ**Z,** $\phi\eta$ - It performs a shift (up or down) of the ϕ scale.

- **Moving**
  You can move (pan) the picture by dragging the picture while keeping the **M** key pressed.

The ZMR Pop-up Menu

The ZMR Pop-up Menu can be accessed by right mouse clicking into a canvas window with ZMR applied. It contains the following utility operations:

- **To Center of Detector** - Sets the **central point** to the geometrical center of the detector.
- **Center the Picture** - Shifts the picture in such a way that the center of the detector coincides with the center of the canvas window.

Mouse Modifier Summary

Modifier Key	Action
None	**Zoom** with respect to the central point (horizontal zoom in the ϕ/ρ projection)
F	**Fast Zoom** with respect to the central point (horizontal zoom in the ϕ/ρ projection); data are not updated during the zoom
H	**Horizontal Zoom** with respect to the central point
V	**Vertical Zoom** with respect to the central point
M	**Move** the picture (panning)
R	**Rotate** (projection dependent)
C	Change position of **central point**

3.3.2 Rubberband

Rubberbands (or selections) provide an alternative way of zooming in Atlantis. Unlike the ZMR Interaction they provide a way to exactly specify the region you are interested in by simply drawing a rubberband around the region and clicking on the **Zoom** Button which pops up. You can set the current window into Rubberband mode by selecting the **Rubberbands** tab on Interaction Control. There are eight different types of rubberbands available:

- **Rectangle**
- **Rotated Rectangle**
- **Square**
- **X Skew**
- **Y Skew**
- **X Slice**
- **Y Slice**
- **Parallelogram**

The **Square** rubberband preserves the aspect ratio of the picture.

You can select the appropriate rubberband from the combo box on the Rubberbands panel (in the Interaction Control).

You can draw a rubberband onto the current window by clicking and then dragging with the left mouse button on the picture. When you release the mouse button a **Zoom** button will automatically pop-up near your mouse. You can re-adjust the rubberband by catching and dragging any of its corners.

You have two options in applying the current rubberband:

- **Zoom in the same window** - To zoom in the same window you just need to click the Zoom button.
- **Zoom in some other window** - To zoom in another window you can:
  - Drag the Zoom button into one of the windows shown in the Window Control.
  - Drag the Zoom button into the target window directly (in the Canvas). This only works if at least some part of the target window is visible on the Canvas.

Rubberbanding in ϕ/η

In the ϕ/η projection only the rectangular rubberband is available. However in this projection the rubberbanding has additional functionality.

3.3.2.1 Rubberbanding in ϕ/η

In the ϕ/η projection only the rectangular rubberband is available. However in this projection the rubberbanding has additional functionality which appears as options in the pop-up menu which appear when a rubberbanding operation is complete. These options are outlined in the following table:

Option	Action
Zoom LAr	Zooms the currently selected region, with the four samplings of the LAr calorimeter being shown in windows 1-4, respectively.
Zoom Calorimeters	As **Zoom LAr**, with additionally the two innermost samplings of the hadronic calorimeters being shown in windows 5 and 6, respectively.
Cut	Switch on the ϕ and η cuts, with the cut region set to that defined by the rubberband. If this **Cut** is dragged into another window the projection in that window is not changed.
Whole Window	Sets the current zoom region to correspond to the whole window
Print Contents	A short summary describing the tracks and the calorimetric energy inside the rubberband region is displayed in the output display.

3.3.3 Pick and Move

There are two modes of picking available, allowing the selection of either hits and tracks or detectors. The appropriate mode may be selected from the combo box on the Pick panel (in the Interaction Control).

Hits and Tracks

If the picking mode is set to hits and tracks:

- Clicking the **left mouse button** will move the cursor to the nearest data item on the screen and information about the picked data item will appear in the output display.
- Clicking the **right mouse button** will move the cursor to the nearest appearance of the previously picked data item in the window where the mouse button is pressed. In the case of
  - a hit, which is drawn once on a window, the cursor is moved to that hit,
  - a hit, which is drawn twice on a window (V-plot) the cursor is moved to the closer of the two,
  - a track, the cursor is moved to that point on the track which is closest to the current cursor position.

Any window on which a mouse button is clicked is automatically popped up.

Lists and Picking

The pick interaction may be used to allow interactive manipulation of Lists. This is controlled by keeping a modifier key pressed on the keyboard while performing the pick. The possible modifier keys are:

Modifier Key	Action
A	**Add** the data item to be picked to the currently selected list node
H	**Highlight**, place the data item to be picked in the Highlight list node, causing it to be drawn in white
C	**Clear** the Highlight list node

Detectors

If the picking mode is set to detectors:

- Clicking the **left mouse button** will print a list of detectors which contain the specified point in the output display.

3.3.4 Synchro Cursors

If different projections are visible simultaneously in separate windows Synchro-Cursors allow the same cursor position to be shown in all projections. Assume as a simple case, that only the Y/X and ϕ/ρ projections are visible. By defining a point in one of the windows it can be displayed in the other window. This concept can be extrapolated to 3D. A point defined by ϕ,η,ρ is shown in all other projections if possible. A subset of the coordinates of this virtual point can be modified in all projections and only the appropriate coordinates can be shown in other projections. This concept is rigorously applied, if the pointer is moved in the ϕ/η projection. Otherwise only those coordinates are shown, which are modified in the projection according to the table below:

Pointer	**Displayed**					
moved in	ρ/Z	Y/X	ϕ/ρ	ϕ/Z	ϕ/η	X'/Z
ρ/Z	ρ,Z,η	ρ	ρ	Z	η	Z
Y/X	ρ	ϕ,ρ	ϕ,ρ	ϕ	ϕ	
ϕ/ρ	ρ	ϕ,ρ	ϕ,ρ	ϕ	ϕ	
ϕ/Z	Z	ϕ	ϕ	ϕ,Z	ϕ	Z
ϕ/η	Z,ρ *	ϕ,ρ*	ϕ,ρ*	ϕ,Z**	ϕ,η	?
X'/Z	Z			Z		Z

* Current ρ is used.

** Current ρ is used to calculate Z.

Setting the angle of splitting in ρ/Z

One special use of the Synchro Cursors interaction is to allow the angle $\phi_{\rho Z}$ of the ρ/Z projection to be set from any other projection which defines ϕ. This transfer of ϕ information is performed while the modifier key **P** is pressed while the cursor is being moved in a ϕ defining projection. This is particularly useful when the ϕ defining projection is taken to be Y/X as in this case all data in one Y/X hemisphere are shown on the upper half of the ρ/Z projection while all data in the other Y/X hemisphere are shown on the lower half of the ρ/Z projection.

3.3.5 Fisheye Transformation

If the calorimeters or the muon detectors are drawn in, e.g., the Y/X projection, the inner 3 tracking chambers may become so small that track recognition suffers. This problem may be partially solved by applying a fisheye transformation, which allows a relative magnification of the inner chambers without increasing the outer radius.

A fisheye transformation is available in most projections:

- **Y/X, ϕ/ρ and ρ/Z projections**
  When ρ ($\sqrt{}(X^2+Y^2)$) is known in a projection (namely Y/X, ϕ/ρ and ρ/Z), it is modified as:
  $$\rho_{new} = \rho \times (1+\mathbf{d}\times\rho_{max})/(1+\mathbf{d}\times\rho)$$

  where ρ_{max} is the outer radius and **d** is the fisheye distortion factor.

  In Y/X the azimuthal angle is unchanged and X_{new}, Y_{new} are calculated from ϕ and ρ_{new}, in ϕ/ρ the azimuthal angle ϕ is unchanged.

  In the case of the ρ/Z projection Z is changed according to the formula:
  $$Z_{new} = Z \times (1+\mathbf{d}\times\mathbf{Z}_{max})/(1+\mathbf{d}\times Z)$$

  where $\mathbf{Z}_{max}$ is the outer Z range. In this projection, radial tracks are slightly curved by the fisheye.

- **Other projections**
  In all other projections where the fisheye is available axes representing distance are transformed with

the formula used to transform Z in the ρ/Z projection.

Applying the Fisheye

To use the **fisheye** transformation, you must first switch it on. The **distortion factor d** is then modified by clicking the left mouse button and dragging the cursor over the picture. If the **F** modifier key is depressed the data will not be updated during the drag allowing for better response.

The Fisheye Pop-up Menu

The Fisheye Pop-up Menu can be accessed by right mouse clicking into the Window. It contains the following set of utility operations:

1. **Set no Fisheye** - switch off the fisheye interaction.

3.3.6 Skew Interaction

The skew interaction is available in the ϕ/ρ, ϕ/Z and ρ/Z projections. In the ϕ/ρ, ϕ/Z it is only available when a small region of the total azimuthal angle has been selected.

The Skew Pop-up Menu

The Skew Pop-up Menu can be accessed by right mouse clicking into the Window. It contains the following set of utility operations:

1. **Set no skew** - Switch off the skew interaction.

3.3.7 Clock Transformation

The clock transformation is an angular fish-eye transformation which allows a selected azimuthal region to be shown in detail while still displaying the full 360°. It is only available in the Y/X projection.

Under a clock transformation about an axis ϕ_0, ϕ transforms to ϕ_{new} with:

$$\phi_{new} = \phi_0 + ((\pi/\mathbf{d})\times\Delta\phi)/((\pi/\mathbf{d})+\pi\text{-}|\Delta\phi|)$$

where **d** is the clock distortion factor and $\Delta\phi$=ϕ-ϕ_0. The clock transformation does not change ρ. The values of X_{new}, Y_{new} are calculated from ρ and ϕ_{new}.

Applying the Clock Transformation

When the clock interaction is selected a white line appears over the picture representing the selected ϕ_0 direction around which to perform the angular fish-eye. This ϕ axis may be rotated by dragging it with the mouse.

To apply a **clock** transformation, you must first switch it on in the interaction control. The **distortion factor d** is then modified by clicking on a point at a selected opening angle with respect to the ϕ_0 direction and dragging it to a larger opening angle.

3.3.8 Scale Interaction

The scale interaction allows the copying of ϕ or Z scales between projections. After selecting the scale interaction, a scale may be copied by dragging it from the source window into the target window. A ϕ-scale copy will only work between two projections which have their vertical axes representing ϕ. A Z-scale copy will only work between two projections which have their horizontal axes representing Z.

3.3.9 Central Point

The central point is useful for zooming (all projections) and rotation (Y/X projection) in a canvas window. It is represented as a small **red circle** superimposed on the picture.

By default the central point is in the center of the detector (0, 0). There are different ways to change it's position:

- By **dragging** it to a new position.
- By pressing the **C** key on the keyboard and the **left** mouse button to specify the new center position.
- By selecting "**To Center of Detector**" in the ZMR Pop-up Menu to set the center back to it's initial position (center of the detector).

3.4 Control: Parameter Control

In order to draw a picture you must define:

- the **window** in the window control field,
- the **projection** in the left column on the parameter control field (pcf) after selecting the proj tab in the top row of the pcf: YX, $\phi\eta$, ρZ, $\phi\rho$, ϕZ, X'Z or Y'Z 3D,
- the **data to be drawn** in the top row of the pcf : data selection,
- **cuts on physical values** of the data in the top row of the pcf : cuts,
- **selected region or picture size** and **position** in the interaction control field,
- **special projection parameters** in the right side of the pcf, after selecting the proj tab in the top row of the pcf,
- **detector colors and attributes** in the top row of the pcf : Detector colors,
- **data colors and symbols** in the left column of the pcf, after selecting the corresponding detector subsystem ID, Calo or Muons from the top row of the pcf.

3.4.1 Event Parameters

The following event parameters may be examined and modified

- **XVTx**: the x coordinate of the primary vertex
- **YVTx**: the y coordinate of the primary vertex
- **ZVTx**: the z coordinate of the primary vertex

3.4.2 Projections

Due to the cylindrical structure of helices and of the ATLAS detector the following data oriented projections are available:

The special linear 3D projections

- The **Y/X projection** looking along the beam axis.

- The **X'/Z projection** looking perpendicular to the beam axis. The angle around the axis may be changed.
- The **Y'/Z projection** looking perpendicular to the beam axis and perpendicular to X'Z. The angle around the axis may be changed.

Non-linear projections

- The **ρ/Z projection**, which is intuitively understandable.

Expert non-linear projections

- The **ϕ/ρ projection**.
- The **ϕ/Z projection**.
- The **ϕ/η projection**, of which the V-plot is a special form.

Choice of projection

All 3D data such as tracks and silicon space points may be viewed in all projections. The other data are best viewed and associated to the 3D tracks and hits in the following projections:

Y/X	TRT, LAr and TILE barrels, RPC ϕ-strips, vertex region (intuitive view)
ϕ/ρ	TRT, LAr and TILE barrels, RPC ϕ-strips, tracks are straight lines
ρ/**Z**	Barrel and endcap calorimeters. Approximate extrapolation to all MDT, RPC z-strips and TGC ρ-strips superimposed
X'/Z	MDT, RPC z-strips and TGC ρ-strips, vertex region (intuitive view)
Y'/Z	Vertex region (intuitive view)- orthogonal to X'Z
ϕ/**Z**	TRT endcaps, calorimeter endcaps and TGC ϕ-strips
ϕ/η	Calorimeters, and their association to tracks and S3D hits

Checking the tracking

In the Y/X, ϕ/ρ and ϕ/Z projections tracks are seen from the side of maximum curvature. In the ρ/Z projection they are seen from the "orthogonal" side, i.e. the side of minimum curvature. Therefore ρ/Z is said to be orthogonal to Y/X, ϕ/ρ and ϕ/Z.

In order to check in space if a track passes through a set of 3D hits or if it points to a set of calorimeter hits the hits and the track must be displayed in at least two 2-dimensional projections which are orthogonal to each other i.e. in ρ/Z and in one of the projections Y/X, ϕ/ρ or ϕ/Z.

Instead of using a pair of projections the 3-dimensional V-plot is sufficient to check pattern recognition and track extrapolation.

3.4.2.1 Y/X Projection

The Y/X projection presents an intuitively understandable picture of data with a precise Y/X measurement. This projection may be used to view 3D tracks and hits and to associate them to data in the TRT, LAr and TILE barrels, and to the RPC ϕ-strips. All other data would appear as lines. In this projection the momentum of tracks may be estimated form the curvature. This projection also provides an intuitively understandable view of the region around the primary vertex.

In the standard view of the Y/X projection, data from the calorimeter and muon endcaps are **not** displayed (in order not to complicate the picture) as they would fall on top of data from the tracking chambers or data from the calorimeter barrel.

Alternatively, the **view** parameter may be used to select a single layer of the muon endcap detectors. In this case, the **TGC Gas Gap** parameter may be used to further select data from only a given sublayer of the detector.

The Y/X projection is special in that it allows both the particle's charge and P_t to be estimated from the track curvature.

Even with **fisheye** the inner layers of the pixel detector fall on rather small circles, which do not take into account the high resolution of the pixel detector. The pixel data are better visualised in the ϕ/ρ projection.

The orthogonal projection to Y/X is the ρ/Z projection.

The Y/X Projection Menu

- **Aspect Ratio 1** - Sets the aspect ratio (width/height) of the picture to 1. The operation ensures that the original picture which was in the window does not go outside the window.

3.4.2.1.1 Muon Endcaps in Y/X Projection In order to display the muon detector endcaps and the respective hits (drawn as points or lines) single stations must be selected:

- **TGC** - Inner 1 and Middle 1, 2, 3. The TGC data may belong to different sublayers selected by the TGC Gas Gap parameter.
- **MDT** - Inner 1, 2, Middle and Outer.

These pictures show best the structure of the layers. Their position can be seen best from ρ/Z. The name of a specific module may be obtained by picking.

In the standard Y/X view the inner detector and the calorimeter and muon barrel are displayed.

3.4.2.2 X'/Z Projection

If one views an event perpendicular to the beam axis, some tracks are curved and some are straight, depending on the azimuthal angle ϕ_{VIEW} of the viewing direction. Such a projection is of use only if a sufficiently narrow jet is selected, which may even consist of a single track. In this case a jet based Cartesian coordinate system is optimal, which depends on the direction of the jet axis:

- Y' = perpendicular to the beam axis and the jet axis,
- X' = perpendicular to the Z and Y' axis, i.e. it lies in the plane containing the beam axis and the jet axis,
- Z = beam-axis.

In the X'/Z projection a single track has minimum curvature and maximum angle to the Z axis. It lies in the display screen. The track is seen from the orthogonal side as compared to the Y/X projection. The jet image is similar to the one in the ρ/Z projection, which is however not limited to single jets. This projection provides a second intuitively understandable view of the region around the primary vertex orthogonal to that of the Y'/Z projection The momentum of tracks may not be estimated form their curvature in this projection.

Due to the maximum angle between jet and Z axis in the X'/Z projection the sub detector sectors lying in the jet direction can be displayed for the barrel and the endcap. This is specially interesting for the MDT tubes. If only one **MDT sector** is displayed and the viewing direction is perpendicular to the sector angle, the MDT tubes can be represented as small circles.

The X'/Z Projection Menu

- **Aspect Ratio 1** - Sets the aspect ratio (width/height) of the picture to 1. The operation ensures that the original picture which was in the window does not go outside the window.

3.4.2.3 Y'/Z Projection

If one views an event perpendicular to the beam axis, some tracks are curved and some are straight, depending on the azimuthal angle ϕ_{VIEW} of the viewing direction. Such a projection is of use only if a sufficiently narrow jet is selected, which may even consist of a single track. In this case a jet based Cartesian coordinate system is optimal, which depends on the direction of the jet axis:

- Y' = perpendicular to the beam axis and the jet axis,
- X' = perpendicular to the Z and Y' axis, i.e. it lies in the plane containing the beam axis and the jet axis,
- Z = beam axis.

In the Y'/Z projection a single track has maximal curvature and minimum angle to the Z axis. Seen with stereo it would leave the plane towards the observer or opposite. The track is seen from the same side as in the Y/X projection only rotated around the Y' axis. This projection provides a second intuitively understandable view of the region around the primary vertex orthogonal to that of the X'/Z projection The momentum of tracks may not be estimated form their curvature in this projection.

The calorimeters muon chamber barrels cannot be displayed as they would overlap the inner tracking detectors. The endcaps can be drawn.

An alternative to Y'/Z is the expert ϕ/Z projection, which is not limited to single jets.

The Y'/Z Projection Menu

- **Aspect Ratio 1** - Sets the aspect ratio (width/height) of the picture to 1. The operation ensures that the original picture which was in the window does not go outside the window.

3.4.2.4 ρ/Z Projection

The ρ/Z projection may be used to view 3D tracks and hits and to associate them to data in the calorimeters. It may also be used to provide a rough association of tracks to the MDT, RPC z-strips and TGC ρ-strips data from all sectors superimposed. To make this possible the muon data are not drawn at ρ but rather at ρ' determined by projecting ρ onto the ϕ-axis of the corresponding sector.

Although not a linear projection, the ρ/Z projection is intuitively understandable. Circles (projections of helices) which pass through the origin are recognised as approximately straight lines:

$$\rho \approx (P_t/P_z)\times(-Z_{vertex})$$

The picture of the detector is the same as if a cut through the beam axis would have been applied. For a point with coordinates ρ and ϕ, this is achieved by defining:

$$\rho=+\surd(X^2+Y^2) \text{ if } \phi_{\rho Z}\text{-}90^\circ < \phi < \phi_{\rho Z}+90^\circ \text{ and } \rho=-\surd(X^2+Y^2) \text{ otherwise}$$

Due to the cylindrical structure of ATLAS, the ρ/Z projection is the only one, where all main detector units may be displayed without overlapping. The different radial sub-elements of the muon detectors do overlap, but may be shown separately in the X'/Z projection.

In the Y/X, ϕ/ρ and ϕ/Z projections tracks are seen from the side of maximum curvature. In the ρ/Z projection they are seen from the "orthogonal" side, i.e. the side of minimum curvature. Therefore ρ/Z is said to be orthogonal to Y/X, ϕ/ρ and ϕ/Z.

In order to check in space if a track passes through a set of 3D hits, or if it points to a set of calorimeter hits, the hits and the track must be displayed in at least two 2-dimensional projections which are orthogonal to each other i.e. in ρ/Z and in one of the projections Y/X, ϕ/ρ or ϕ/Z. Instead of using a pair of projections the 3-dimensional V-plot is sufficient to check pattern recognition and track extrapolation.

Charge and momentum cannot be estimated in ρ/Z.

TRT data cannot be shown, unless very few TRT straws can be selected, which appear as lines, as neither Z in the barrel nor ρ in the endcap are known.

The inner detectors may be enlarged without enlarging the outer ones by using the fisheye interaction.

The angle $\phi_{\rho Z}$ may be modified in any phi defining projection while simultaneously being viewed in the ρ/Z projection as described in the Synchro Cursors interaction.

The ρ/Z Projection Menu

- **Aspect Ratio 1** - Sets the aspect ratio (width/height) of the picture to 1. The operation ensures that the original picture which was in the window does not go outside the window.

3.4.2.5 ϕ/ρ Projection

The ϕ/ρ projection may be regarded as a modified Y/X projection. The same data are displayed in both. This projection may be used to view 3D tracks and hits and to associate them to data in the TRT, LAr and TILE barrels, and to the RPC ϕ-strips.

The ϕ/ρ projection is not intuitively understandable, but allows to get a better angular separation of data from the innermost detectors. It has a singularity at ρ=0, so that the primary vertex cannot be displayed. Circles (projections of helices) which pass through the origin, transform into approximately straight lines, with a gradient inversely proportional to P_t:

$$\rho \ \propto \ P_t \times \sin(\phi - \phi_0) \ \approx \ P_t \times (\phi - \phi_0)$$

where the constant of proportionality depends on the strength of the solenoidal magnetic field. For large path lengths, ϕ will increase (decrease) with increasing path length for negatively (positively) charged tracks. Tracks not pointing exactly to the origin ($d_0 \neq 0$) show a distinct non linearity when approaching ρ=0. Low momentum tracks curve far from the origin, due to the approximation in the above formula.

Checking of pattern recognition is easier in the ϕ/ρ projection, where helices are approximately straight lines, than in the Y/X projection. In particular a Y-Skew rubber-band can be used to optimally select the region around a track for closer inspection. This would correspond to a - non-existent - curved rubber-band pattern in the Y/X projection.

If the standard view is selected, data from the calorimeter endcaps and the muon endcaps are not displayed, in order not to complicate the picture, as they may fall on top of data from the tracking chambers or data from the calorimeter barrel.

Alternatively, the view parameter may be used to select a single layer of the muon endcap detectors. In this case, the TGC Gas Gap parameter may be used to further select data from only a given sublayer of the detector.

The ϕ/ρ projection is special in that it allows both the particle's charge and P_t to be estimated from the track slope.

The projection orthogonal to ϕ/ρ is the ρ/Z projection.

3.4.2.6 ϕ/Z Projection

The ϕ/Z projection may be used to view 3D tracks and hits and to associate them to data in the TRT endcaps, the LAr endcaps, the HEC and to the TGC ϕ-strips. Indeed it is the only projection in which the TRT endcap straws may be viewed.

It is not intuitively understandable, but allows to get a good angular separation of data from the innermost detectors. Circles (projections of helices) which pass through the origin, transform into straight lines, with a gradient inversely proportional to P_z:

$$z\text{-}z_v \;\propto\; P_z\times(\phi\text{-}\phi_0)$$

where the constant of proportionality depends on the strength of the solenoidal magnetic field. For large path lengths, ϕ will increase (decrease) with increasing path length for negatively (positively) charged tracks.

Checking of pattern recognition is easier in the ϕ/Z projection than in the Y/X projection. In particular a Y-Skew rubber-band can be used to optimally select the region around a track for closer inspection. Ideal helices passing through the origin appear as a sequence of parallel lines, one for each turn. Even helices with slowly changing radius can be identified as such. For simulated and reconstructed tracks only the first half turn of the helix is drawn.

If the standard view is selected, data from the calorimeter barrel are not displayed (in order not to complicate the picture) as they fall on top of data either from the tracking chambers or from the calorimeter endcaps.

Alternatively, the view parameter may be used to select a single layer of the muon barrel detectors. In the case of RPC layers, the RPC Gas Gap parameter may be used to further select data from only a given sublayer of the detector.

The projection orthogonal to ϕ/Z is the ρ/Z projection.

3.4.2.7 ϕ/η Projection

Calorimeter data from a single sampling are best shown in a ϕ/η projection, where the energy deposits may be shown through Lego towers or other methods. There are also methods to show several samplings superimposed.

Data from 3D tracking chambers may be shown in this projection with optimal separation of tracks. However one faces the problem, that charge, track momentum and the distance of hits from the beam axis cannot be recognised.

One way out is the V-plot, which preserves all the features of the ϕ/η projection. It may be applied to both tracks and hits. The latter without using any hit to track association.

For a point in space (with coordinates ϕ, η, ρ) a pair of points is displayed on the V-plot picture. In the case of particles moving in a solenoidal field the two displayed points get the same ϕ as vertical position and get two different horizontal positions namely $\eta\pm k\times(\rho_{max}\text{-}\rho)$. The value of the parameter k (Gradient) is set by default but may be changed interactively. The parameter ρ_{max} is set automatically depending on the selected view. As k and ρ_{max} are known, ϕ, η and ρ may be recalculated from the coordinates of a pair of displayed points, which means that the V-plot is a true 3 dimensional image.

The position ZVTx of the primary vertex along the beam axis must be known to calculate η.

The following rules apply to interpret 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 V's are straight.
- For helices not pointing to the origin the arms of the V's are curved:
  - with the same sign of curvature for tracks separated from the origin in z,
  - with opposite sign of curvature for tracks separated in ρ.
- Positive tracks give V's pointing down.
- Negative tracks give V's pointing up.
- The gradient of the V arms is proportional to $1/P_t$:
  - high P_t tracks give V's with large opening angle,
  - low P_t tracks give V's with small opening angle.

View's

In the standard view the energy deposits in the calorimeters are represented by boxes with the area of the box proportional to the energy deposited. All samplings and all calorimeters are drawn superimposed. Furthermore, all energies are given a color according to which of six predefined energy ranges they belong. The cells belonging to each energy range are drawn sequentally with the most energetic range being drawn first. This provides a view of the jet structure of the event where energetic isolated particles may be distinguished from jets. Tracks and S3D hits may be drawn superimposed on the calorimeters with the apex of the V corresponding to the exit of the track from the S3D detectors.

In the S3D and TRT views the apex of the V corresponds to the exit of the track from the S3D and TRT detectors, respectively.

In the other views the calorimeters data corresponding to a single sampling are drawn according to their actual cell structure and the tracks which are superimposed are drawn with the apex of the V corresponding to the intersection of the track with the selected sampling of the calorimeters.

Selecting data from a single jet

Data corresponding to a single jet or isolated particle may be selected using the special rubberband options available in the ϕ/η projection.

Data selection

For convenience the data to be viewed in the V-plot (S3D, STr, RTr and SNP) may be selected directly in the ϕ/η projection.

Options

By default all η values used in this projection are calculated taking into account the z offset of the primary vertex (ZVtx). However, if η vertex is deselected η will be calculated from z=0.

The apex of a V may be drawn to a cylinder smaller than the default associated with a view by setting the ρMax and zMax parameters.

When tracks are being shown without the corresponding S3D hits, it may be useful to draw only the outermost portion of the V as determined by the Short V parameter.

The VPlot Island parameter is used to set the color of the island drawn to allow easier comparison of the relative locations of the hit cells from different samplings which are being displayed in different windows.

The Draw Apex parameter is used to draw an additional symbol at the apex of the V. This is useful for high momentum tracks where it may otherwise be difficult to distinguish the exact location of the apex.

In the V-plot where the S3D hits are normally nearby it is useful to have them represented by a symbol of a smaller size than in the other projections. This difference in symbol size is determined by the S3D Δ Size parameter.

3.4.2.8 3D Projection

The 3D projection is a linear projection of the data such that a given axis is transformed into a stright horizontal line through the center of the window. It allows the user to perform rotations about an arbitrary axis in space. The unit vector of this axis is defined by **(xAxis, yAxis, zAxis)**. The center of rotation is taken to be the reconstructed primary vertex of the event.

Rotations about the selected axis by an angle ϕ are performed by dragging with the **R** modifier key pressed down in the ZMR interaction.

The axis of rotation will by default be set to the line joining the primary vertex to the last secondary vertex to be reconstructed.

3.4.2.9 3DBox Projection

The 3DBox projection allows the user to investigate a small 3D region around a newly formed secondary vertex. Every time a new secondary vertex is formed from a list, the direction of flight of the incoming particle is calculated as the vector joining the primary vertex to the reconstructed vertex. A 3D box of default size 2 mm x 2 mm x 4 cm is formed around this axis. The box has three vertically oriented planes and transparent front and top faces. The left hand plane contains the primary vertex, which is represented by the red point. The axis of the direction of flight of the decaying particle lies horizontally on the screen. The middle and right hand plane are at decay distances of 2 cm and 4 cm, respectively. Tracks fully contained withing the box are represented as straight lines and their intersections with the three planes are shown as ellipses representing the correlated impact parameter errors of the track. The dashed sections of tracks correspond to regions where they pass behind behind a plane.

The user may interact with the region shown in the box via the 3DBox interaction. When the 3D box interaction is selected the size of the box may be adjusted in a manner analogous to the zooming performed in the ZMR interaction.

There are two type of operations which may be performed.

- **Changing the volume contained by the box**
  The volume contained by the box is changed by dragging any point of the picture towards or away from the central point represented by a small **red circle** superimposed on the picture. Dragging towards the central point will increase the volume of the box. Dragging away from the central point will decrease the volume of the box. The length of the box may be changed independently of the width by holding down the **H** key of the keyboard. The width of the box may be changed independently of the length by holding down the **V** key of the keyboard.

- **Rotation**
  In order to obtain a rotation of the tracks around the horizontal axis corresponding to the direction of flight of the decaying particle you drag any point on the picture while keeping the **R** key of your keyboard pressed.

The 3D Box Pop-up Menu

The 3DBox Pop-up Menu can be accessed by right mouse clicking into the Window while keeping the **R** key of your keyboard pressed. It contains the following set of utility operations:

- **Default box Volume** - reset the volume of the box to correspond to the default values.

Mouse Modifier Summary

Modifier Key	**Action**
None	**Change** the volume of the box.
Z	**Change** the volume of the box.
H	**Change** the length of the box.
V	**Change** the width of the box.

3.4.3 Data Selection

Available Data

Select the data to be displayed:

S3D	pixel clusters and silicon strip space points
TRT	TRT straws from the barrel and/or the endcaps
STr	simulated tracks
RTr	reconstructed tracks
SNP	simulated neutral particles
RVx	reconstructed vertices
SVx	simulated vertices
LAr	cells and/or histograms of the liquid argon electromagnetic calorimeter
TILE	cells and/or histograms of the TILE hadronic calorimeter
HEC	cells and/or histograms of the hadronic endcap calorimeter
FCAL	cells and/or histograms of the forward calorimeter
MDT	muon detector tubes
RPC	muon detector 90° angle stereo tubes
TGC	muon detector endcap
CSC	muon detector endcap
R3D	RPC space points
T3D	TGC space points
MTr	muon tracks
SMTr	simulated muon tracks
Det	detectors
Fill	picture background

Order of drawing

The Order in which **STr** (simulated tracks), **RTr** (reconstructed tracks) and **hits** are drawn in the picture may be selected as:

- **STrRTrHits** (default)
- **STrHitsRTr**
- **RtrHitsSTr**

Cuts

Cuts can be applied to the selected data.

Data representation by projection

If and how data are displayed in the different projections:

Data	ρ/**Z**	**Y/X**	ϕ/ρ	ϕ/**Z**	ϕ/η	**X'/Z**
S3D	Point	Point	Point	Point	Points	Point
TRT barrel	Line	Line	Line			
TRT endcap	Line			Line		
STr	S.line	Circle	S.line	S.line	V	Helix
RTr	S.line	Circle	S.line	S.line	V	Helix
SNP	Line	Line	Line	Line	Point	Line
RVx	Point	Ellipse	Point	Point		Ellipse
SVx	Point	Point	Point	Point		Point
LAr	Cell	Cell	Cell	Cell	Square/cell	
FCAL					Square/cell	
HEC	Cell			Cell	Square/cell	
TILE	Cell	Cell	Cell		Square/cell	
MDT	Circle	Line	Line	Line		
RPC	Box	Box	Box	Box		Box
R3D				Box	Box	
TGC		Box	Box	Box		
T3D	Box	Box	Box		Box	Box

Commands

- **All Off** switch off all detectors
- **All On** switch on all detectors

3.4.4 Cuts

Cuts may be applied to select the data to be displayed. Each cut can be switched on or off by clicking on the small check-box on the left hand side. The value of each cut is set in the white field and must be accepted by pressing ”enter”. Cuts which act on real numbers may select values either < or > the cut value. The selection of < or > may be toggled by clicking on them with the mouse. For cuts applied to integer values a mouse click causes a pull down menu to appear where you may select according to the C/JAVA syntax: =, **!=** (not equal), <, <=, > or >=.

Cuts can be made on the following quantities:

Tracks

- |**Pt**| : transverse momentum [GeV/c]
- |**d0**| : distance of closest approach to the beam axis [cm]
- |**z0-ZVtx**| : distance in Z from primary vertex at d0 [cm]
- |**z0**| : distance in Z from nominal origin at d0 [cm]
- |**d0 Loose**| : outer loose d0 cut [cm]
- **NumS3D** : number of associated silicon space points
- **RTr** : identifier of reconstructed track

- **STr** : kine number of simulated track
- **SVx** : originating simulated vertex (0=primary)
- **index**: in the range 0 to numTracks-1

Track association

If the track association of hits or calorimeter cells is known, they may be selected according to the tracks - with their cuts - they are associated to:

- **Hits By STr**:
  - Hits connected to simulated tracks
  - Hits unconnected to simulated tracks
  - All
- **Hits By RTr**:
  - Hits connected to reconstructed tracks
  - Hits unconnected to reconstructed tracks
  - All

Hits

- **Hit type**:
  - Good hits (associated to tracks, or passing the filter)
  - Noise hits (others)
  - All
- **index**: in the range 0 to numHits-1

Silicon hits

- **S3D** region : Barrel/Endcap-/Endcap+/All
- **Group** : group number of hit. 0 = noise. See filter.

Calorimeter cells

- **Energy**: energy deposit [GeV]
- **Cluster**: cluster to which the cell is associated
- **Sampling**: sampling 0 to 3

TRT Straws

- **Threshold**: threshold

Angular region

- **Cut** ϕ: Hits and tracks in the range $\phi \pm \phi_{cut}$

- **Cut** η: Hits and tracks in the range $\eta \pm \eta_{cut}$

List

- **List**: only data in the currently selected list are shown

Summary

- A **summary** of the effects of the currently applied cuts is shown in the output window.

Commands

- **Toggle Standard**: Toggle $|P_t|$, |d0|, |z-ZVtx| and NumS3D cut between **on** and **off**

3.4.5 Detector Colors

The Atlantis projections (except the ϕ/η projection) are chosen in such a way that detector volumes do not overlap. Therefore, one can replace transparent wire frame images by filled areas surrounded by frames, which are easier to perceive intuitively. The fill colors of the various detectors and of the background may be modified.

N.B.:
Small points, lines or cells are better distinguished from background with high intensity contrast. The intensity I of colors can be very roughly estimated, by:

$$I = 4\times I_{green} + 2\times I_{red} + b\times I_{blue} \text{ with b between 0.5 and 1.}$$

N.B.
Blue or magenta backgrounds change colors of very small objects: yellow to white, green to cyan and red to magenta.

When **printing** on normal quality color printers it is advisable to avoid muted colors for areas onto which small objects are drawn. Therefore printed files have their own color set, which takes this into account. Print colors may therefore be different from display colors.

N.B.
The background color of the ϕ/η projection is controlled by the projection and may be modified there.

3.4.6 Inner Detector

Control the attributes of data from the Inner detector, namely

- **S3D** : silicon space points
- **SSC** : silicon strip clusters
- **TRT** : TRT straws
- **STr** : simulated tracks
- **xKalman** : reconstructed tracks
- **iPatRec** : reconstructed tracks
- **IDScan** : reconstructed tracks
- **SVx** : simulated vertices
- **RVx** : reconstructed vertices

The S3D hits may be cleaned with the Silicon hit filter.

3.4.6.1 Silicon 3D Hits (S3D)

Space points from silicon pixel clusters and calculated from the low angle stereo silicon strips are called S3D hits.

Graphical Representation

The color of each hit is defined by the color function which may be either

- **constant**, in which case the constant color is used for all hits,

or it may vary with each hit being given the color of its associated

- **simulated track**, the colors of unconnected and shared hits can be selected,
- **reconstructed track**, the colors of unconnected and shared hits can be selected,
- **subdetector** (Barrel, Endcap+, Endcap-),
- **group**, as determined by the filter, the color of ungrouped hits can be selected,
- **layer**.

See Graphics Attributes for a description of other parameters.

3.4.6.1.1 Silicon Pixels Silicon pixels give directly 3D positions. From each cluster of pixels a space point is calculated. The pixel dimensions are 50μm$\times400\mu$m. The barrel of the pixel detector has 3 layers at 4,11 and 15 cm, respectively, which provide position measurements with a resolution of 12 μm in $\rho\phi$ and 66 μm in z. The endcap has 4 layers at ±35, ±67, ±95 and ±115 cm, respectively, which provide position measurements with a resolution of 12 μm in ρ-ϕ and 77 μm in ρ.

3.4.6.1.2 Silicon Strips To be filled.

3.4.6.1.3 Silicon 3D Hit Filter In the case of normal simulated events and of the real events to be expected, it is difficult if not impossible to recognise tracks, etc., due to ghost hits, delta electrons, hits from the pile up and noise.

A filter is available to clean the events. In the case of fairly clean events, the V-plot may still help out. For the V-plot as for the filter, the z-position of the primary vertex of the "triggering event" is required, so that η can be calculated.

Single filter

The filter is based on the simple requirement, that a 3D hit passes the filter if at least N_H (N_H=**NumHits**) hits on different layers lie in the same direction, as seen from the primary vertex.

In a $\phi\eta$ histogram with cell size $\Delta\phi\times\Delta\eta$, the hits of a given helix with sufficiently high P_t lie in one cell or in its direct neighbours due to rounding or measuring errors.

In a first loop over all hits the histogram is filled, however counting layers and not just hits. This is done using bit patterns. In a second loop over all hits each hit is accepted or rejected depending on the sum of different layers in its histogram bin and its neighbours.

The second loop can be combined with a clustering algorithm, so that hits falling into isolated clusters get a **group** number, which varies with different clusters. The subsets of S3D hits belonging to the different **groups** passing the filter may selected using the **group** parameter.

The strength and P_t acceptance of the filter is defined by $\Delta\eta$ and $\Delta\phi$:

- The value of $\Delta\eta=2\times\eta$ **Range/Num**η reflects measuring η precision and should be as small as possible without loosing hits.
- The value of $\Delta\phi=360°/$**Num**ϕ defines the P_t range in which tracks are accepted and the strength of the filter. A small $\Delta\phi$ (strong filter) rejects much noise but also low P_t tracks.

In the same way one can filter tracks in a given P_t range through a ϕ'η histogram, where ϕ' is defined as ϕ'=ϕ-c×s×ρ, where c depends on the magnetic field. Hits of tracks with P_t=1/s have the same ϕ', and pass the filter. Depending on $\Delta\phi$ also hits of tracks with close P_t do pass. The sign of P_t is equal to the particle charge.

Filter loop

In order to have a strong filter with also low P_t tracks passing, the filter is executed N times in a loop where s is varied between -1/$\mathbf{P}_{t\ MIN}$ and +1/$\mathbf{P}_{t\ MIN}$ with N=1+2×**NumSteps**. Hits, which pass at least one of the single filters, are accepted. An accepted hit may have different group numbers from different filters. Different clusters, which contain the same hit, get the same new group number. Due to measuring errors, some tracks above $\mathbf{P}_{t\ MIN}$ may get lost, so that $\mathbf{P}_{t\ MIN}$ should be sufficiently low.

3.4.6.2 Silicon Strip Clusters (SSC)

Silicon strip clusters are formed from groups of neighbouring silicon strips. In the barrel these silicon strips are either parallel to the beam axis (ϕ-strips) or inclined by either +0.04 radians = 2.3° (u-strips) or by -0.04 radians (v-strips). In the endcaps the ϕ-strips are perpendicular to the cylinder axis. Each layer contains ϕ-strips and either u-strips or v-strips (alternating between neighbouring layers) to allow for low angle stereo. If both such strips fire, when a charged particle traverses the layer, a space point can be calculated. If more than one particle traverse the same layer in close proximity ghost space points are produced.

For barrel layers the ϕ-ρ position of a space point is taken from the position of the ϕ strip. Z is calculated through low angle stereo. For endcap the ϕ-Z position is taken from the ϕ-strip and ρ is calculated through low angle stereo. Each barrel space point is measured with a precision of 16μm in ρ-ϕ and 580 μm in Z, respectively. Two tracks can be distinguished if separated by more than $\approx$200 μm.

The distance between ϕ strips and the u- or v- strips in the same module is 400 μm. The calculated value of Z for the barrel and ρ for the endcap depends of the direction of the track passing through the module. As this is normally unknown, most space point calculations assume particles of infinite momentum coming from X, Y, Z=0.

There are 4 layers in the barrel between 35, and 115 cm, and 9 layers in the endcap between ±82 and ±276 cm.

Graphical Representation

The clusters are represented graphically as a line segment joining their two endpoints.

The color of each hit is defined by the **color function** which may be either

- constant, in which case the **constant** color is used for all hits,

or it may vary with each hit being given the color of its associated

- simulated track. The colors of **unconnected** and **shared** hits can be selected.
- reconstructed track. The colors of **unconnected** and **shared** hits can be selected.
- subdetector. (Barrel,Endcap+,Endcap-)

- layer.
- orientation. (ϕ-strips, u-strips or v-strips)

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.6.3 Transition Radiation Tracker (TRT)

The TRT barrel has straws parallel to the beam axis in the barrel and straws perpendicular to the beam axis in the endcap. The data from each TRT straw is best represented as a circle, however, in practice the radius of each straw (2mm) is so small compared to the length of a track segment (55cm) that when looking at such a track segment the circle can be adequately approximated as a straight line with a length given by twice the drift radius. The barrel straws are represented as lines perpendicular to a radial line in the ϕ/ρ and Y/X projections. The endcap straws are represented as lines perpendicular to the z-axis in the ϕ/Z projection. The drift radius is measured with a precision of around 170μm.

Transition radiation hits

Each straw provides an indication of whether a hit passes a second higher **threshold** associated with transition radiation. This transition radiation is associated with the passage of electrons and such hits may be used in electron identification. These hits can be viewed on their own by selecting the high **threshold** in the Cuts.

Graphical Representation

The color of each hit is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all hits,

or it may vary with each hit being given the color of its associated

- **simulated track**, the colors of **unconnected** and **shared** hits can be selected,
- **reconstructed track**, the colors of **unconnected** and **shared** hits can be selected,
- **subdetector** (Endcap-,Barrel-,Barrel+,Endcap+).

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.6.4 Simulated Tracks (STr)

Simulated particles may be either charged STr or neutral SNP, and may be defined by,

- the 3D position of the vertex, from which the particle originated,
- the 3D momentum vector at the vertex position,
- the particle type.

For charged particles, these parameters may be used to derive helix parameters (perigee parameters), extended by a further value, which gives the vertex position on the helix.

The paths travelled by simulated particles are defined in 3D and can therefore be seen in all projections. These paths do not reflect multiple scattering. Furthermore, for charged particles the helix approximation used is only valid inside the homogeneous solenoidal magnetic field and assuming negligible energy loss.

The color of each simulated particle is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all particles,

or it may vary with each particle being given the color of its

- **index**: in the range 0 to numSTr-1 or 0 to numSNP-1,
- **particle type**:
    - cyan - charged hadrons,
    - yellow - electrons,
    - green - muons,
    - magenta - neutral hadrons,
    - red - photons,
    - orange - neutrinos.

The radius (**radius Tr**) and length (**Z Tr**) of the cylinder to which the particles are drawn can be changed.

Track images are easier recognised if tracks get a black **frame** with a small **frame width**, especially in the V-plot if calorimeters are displayed as well.

In the V-plot simulated neutral particles SNP are drawn as a **symbol** with a given **symbol size**. In the other projections simulated neutral particles are drawn as lines.

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.6.5 Reconstructed Tracks (xKalman)

The reconstructed tracks found by the xKalman algorithm.

3.4.6.6 Reconstructed Tracks (iPatRec)

The reconstructed tracks found by the iPatRec algorithm.

These tracks may be **drawn as** either a helix or a polyline.

3.4.6.7 Reconstructed Tracks (user defined)

The reconstructed tracks found by a third user defined algorithm.

3.4.6.8 Simulated Vertices (SVx)

Simulated vertices from the Monte Carlo truth. Currently only the start vertices of simulated particles are available and there should be at least one simulated particle originating from each simulated vertex.

The **constant** color of the simulated vertices may be changed.

A description of the other parameters describing graphics attributes may be found at Graphics Attibutes.

3.4.6.9 Reconstructed Vertices (RVx)

Reconstructed vertices may be formed interactively inside Atlantis from Lists of reconstructed tracks. These reconstructed vertices are best represented by their error ellipsoids. These representations are currently available only in the Y/X, X'/Z and Y'/Z projections. The error ellipses shown represent **Num Sigma** standard deviations which may be modified.

The **constant** color of these reconstructed vertices may be changed.

A description of the other parameters describing graphics attributes may be found at Graphics Attibutes.

3.4.6.10 Reconstructed Tracks

Reconstructed tracks are described by helix parameters (perigee parameters). The reconstructed tracks are defined in 3D and can therefore be seen in all projections. The helix approximation used is only valid inside the homogeneous solenoidal magnetic field and assuming negligible energy loss and no multiple scattering.

The color of each reconstructed track is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all tracks,

or it may vary with each track being given the color of its

- **index**: in the range 0 to numRTr-1,
- associated **simulated track**
- associated **E/Gamma reconstucted object**

The radius (**radius Tr**) and length (**Z Tr**) of the cylinder to which the tracks are drawn can be changed.

Track images are easier recognised if tracks get a black **frame** with a small **frame width**, especially in the V-plot if calorimeters are displayed as well.

A description of the other parameters describing graphics attributes may be found at Graphics Attibutes.

3.4.7 Calorimeters

Control the attributes of data from the calorimeters, namely

- **LAr** : liquid argon calorimeter
- **TILE** : Tile calorimeter
- **HEC** : hadronic endcap calorimeter
- **FCAL** : Forward calorimeter
- **Jets** measured in the calorimeters
- **E/Gamma** reconstucted objects
- **Clusters** found in the calorimeter
- **Regions Of Interest** used by the trigger

3.4.7.1 Liquid Argon Electromagnetic Calorimeter (LAr)

The Liquid Argon Electromagnetic Calorimeter consists of a barrel and two endcaps. The barrel inner and outer radii are 150 and 198cm, respectively. The end caps start at 315 and end at 450 cm. Each of the barrel and two end caps are made up from four samplings with separate readout. The first sampling (sampling 0) is called the presampler. Each of the four samplings is split in a large number of separate measuring cells in

ϕ and in η. The cell geometry is projective in ϕ and η. The thickness of the different samplings varies with η in order to make the thickness of the two middle samplings to be a roughly constant number of radiation lengths.

A detailed description of the parameters which are common to all calorimeters may be found at Calorimeter Attributes.

The granularity $\Delta\eta\times\Delta\phi$ of the LAr varies over a large range depending on the sampling and pseudorapidity:

	Barrel		**Endcap**	
Sampling	$\Delta\eta\times\Delta\phi$	$\lvert\eta\rvert$ range	$\Delta\eta\times\Delta\phi$	$\lvert\eta\rvert$ range
0 (pre)	0.025×0.1	$\lvert\eta\rvert<1.52$	0.025×0.1	$1.5<\lvert\eta\rvert<1.8$
1	0.003×0.1	$\lvert\eta\rvert<1.475$	0.025×0.1	$1.375<\lvert\eta\rvert<1.5$
			0.003×0.1	$1.5<\lvert\eta\rvert<1.8$
			0.004×0.1	$1.8<\lvert\eta\rvert<2.0$
			0.006×0.1	$2.0<\lvert\eta\rvert<2.5$
			0.1×0.1	$2.5<\lvert\eta\rvert<3.2$
2	0.025×0.025	$\lvert\eta\rvert<1.475$	0.025×0.025	$1.375<\lvert\eta\rvert<2.5$
			0.1×0.1	$2.5<\lvert\eta\rvert<3.2$
3	0.05×0.025	$\lvert\eta\rvert<1.475$	0.05×0.025	$1.5<\lvert\eta\rvert<2.5$

3.4.7.2 Tile Calorimeter (TILE)

The TILE calorimeter is a sampling calorimeter using iron as the absorber and scintillating tiles as the active material. It is used to measure the hadronic energy of particles moving at small pseudorapidities. The total η coverage of the TILE is $|\eta|<1.7$. The TILE is split mechanically into three parts: barrel and left and right extended barrels. The barrel region has a pseudorapidity coverage of $|\eta|<1.0$. The extended barrel region covers the pseudorapidity range $0.8<|\eta|<1.7$. The inner radius of the calorimeter is 2.28m and the outer radius is 4.25m. It is longitudinally segmented into three samplings. The cells are arranged in a pseudo-projective geometry with a granularity of 0.1×0.1 in $\Delta\eta\times\Delta\phi$ for the inner two samplings and 0.2×0.1 in $\Delta\eta\times\Delta\phi$ for the outer sampling.

A detailed description of the parameters which are common to all calorimeters may be found at Calorimeter Attributes.

3.4.7.3 Hadronic Endcap Calorimeter (HEC)

The HEC is a liquid argon based hadronic endcap calorimeter. It is used to measure the hadronic energy of particles in the pseudorapidity range $1.5<|\eta|<3.2$. Each endcap consists of two independent wheels which are longitudinally segmented into four samplings. The cell geometry is fully projective in azimuth and pseudo-projective in pseudorapidity with a granularity of 0.1×0.1 in $\Delta\eta\times\Delta\phi$ in the pseudorapidity range $1.5<|\eta|<2.5$ and 0.2×0.2 in $\Delta\eta\times\Delta\phi$ in the pseudorapidity range $2.5<|\eta|<3.2$.

A detailed description of the parameters which are common to all calorimeters may be found at Calorimeter Attributes.

3.4.7.4 Forward Calorimeter (FCAL)

The FCAL is a liquid argon based calorimeter providing coverage in the pseudorapidity range $3.2<|\eta|<4.9$. It is longitudinally segmented into three samplings. The innermost sampling uses copper as the absorbing material and is primarily used to measure electromagnetic energy. The outer two samplings use tungsten as the absorbing material and are used to measure hadronic energy. The cells have a granularity of 0.2×0.2

in $\Delta\eta\times\Delta\phi$. The FCAL is situated at a distance in z of between 4.7 and 6.1 m from the interaction point and at a radial distance between 7 and 46 cm from the beam axis.

A detailed description of the parameters which are common to all calorimeters may be found at Calorimeter Attributes.

3.4.7.5 Jets

Jets are formed from energy deposits in the cells of the calorimeters. Jets may currently only be viewed in the ϕ/η projection, where they are represented by a circle centred on the jet direction with an area proportional to the jet energy.

The color of each jet is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all jets,

or it may vary with each jet being given the color of its

- **index**: in the range 0 to numJet-1.

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.7.6 E/Gamma Reconstructed objects

E/Gamma reconstructed objects are formed from clusters in the liquid argon calorimeter and tracks reconstructed in the inner detector E/Gamma reconstructed objects may not currently be viewed, however other data may be colored according to their associated E/Gamma object.

The color of each E/Gamma reconstructed object is defined by the **color function** which may be either

- **constant**, in which case the constant color is used for all E/Gamma reconstructed objects,

or it may vary with each E/Gamma reconstructed object being given the color of its

- **index**: in the range 0 to numEGamma-1.

3.4.7.7 Clusters

Clusters are formed from energy deposits in the cells of the liquid argon calorimeter. Clusters may not currently be viewed, however cells in the liquid argon calorimeter may be colored according to their associated cluster

The color of each cluster is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all clusters,

or it may vary with each cluster being given the color of its

- **index**: in the range 0 to numClusters-1,
- associated **E/Gamma reconstucted object**.

3.4.7.8 Regions Of Interest (ROI)

Regions of interest are $\Delta\phi \times \Delta\eta$ regions of solid angle defined by the trigger system. The may currently only be viewed in the ϕ/η projection.

The color of each ROI is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all ROI's,

or it may vary with each ROI being given the color of its

- **index**: in the range 0 to numROI-1.

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.7.9 Calorimeter Attributes

Available Projections

In Atlantis, the calorimeters (LAr, TILE, HEC, FCAL) can be seen in the following projections:

Y/X	LAr barrel, TILE barrel and extended barrel
ρ/**Z**	LAr barrel and endcap, TILE, HEC and FCAL
ϕ/ρ	LAr barrel, TILE barrel and extended barrel
ϕ/**Z**	LAr endcap and HEC
ϕ/η	LAr, TILE, HEC, FCAL

Cells

To display only the calorimeter histograms without the calorimeter cells the cells must be switched off via the **Cells** parameter.

Energy Representation

The energy deposited in a calorimeter cell is represented by a polygon whose area is proportional to the energy in that cell. The process of generating such a polygon is:

1. Calculate the real shape of the cell.
2. Get the centroid of the cell.
3. Scale the cell with respect to the centroid according to the energy density in the cell.

The scaling according to energy density (calibration) can be done in different ways according to the **Energy Calibration** parameter:

- Overall calibration - a single calibration for all the calorimeters. Allows to compare energy deposition in different calorimeters.
- By Energy Type calibration - two independent calibrations for electromagnetic and hadronic energies.
- By calorimeter calibration - a separate calibration for each calorimeter.

Additionally, the user can change the default calibration by switching on the **E/S** parameter and specifying for each calorimeter independently a different value of energy density than that automatically calculated by the program. The value of energy density calculated automatically corresponds to that which would completely fill the geometrical area of the cell with the highest density.

Overlapping Cells

In some projections the cells of the same calorimeter may be overlaid on top of each other. In this case the user has two options in displaying them according to the **Energy Mode** parameter:

- Display the energy **Sum** - the energy displayed is the sum of that in all the overlapping cells.
- Display the energy **Maximum** - the maximum energy cell of all the overlapping cells is calculated and displayed.

Coloring Schemes

The scaled-by-energy-density cells can be colored in different ways according to the **Color Function** parameter:

- **Constant** - a single color is used, which is given by the **Constant** parameter.
- **Sub Detector** - the cells are colored by the sub detector in which they are.
- **Cluster** - coloring by energy cluster which comes with data. If the cell does not belong to any cluster it is colored using the color defined by **Unconnected** parameter.
- **Sampling** - coloring by the sampling(layer) in which the cell is.
- **Jet** - coloring by the jet to which the cell is associated.

Cell Frames and Geometry

Each cell may have a frame which is drawn on the boundary of the cells polygon. The color and the width of this frame can be given by setting the **Frame** and **Frame Width** parameters. Whether the frame is drawn or not is controlled by the state of the **Frame** parameter.

In some cases it may be useful to see not only the scaled cells but also the initial (real) cells. This can be obtained by switching on the **Cell Geometry** parameter. The background color used to draw the cell geometry is given by the value of the same parameter.

Histograms

Another possibility to represent the energy deposition in the calorimeters is by Histograms. Where appropriate the energy deposition is summed over layers and depth. A histogram can be obtained by switching on the **Histogram** parameter. The histogram can get different colors according to the value of the **Histogram** parameter. They can also have a frame with a color given by the **Histo Frame** parameter.

The energy is represented as the length of the histogram tower. The energy to length mapping can be customized by changing the value of **Histo Scale** parameter.

3.4.8 Muon System

Control the attributes of data from the muon system, namely

- **MDT** : MDT muon detector
- **CSC** : CSC muon detector
- **RPC** : RPC muon detector
- **TGC** : TGC muon detector
- **RMTr** : Muon tracks

3.4.8.1 Monitored Drift Tubes (MDT)

The MDT's provide precision tracking of muons, bending in the toroidal magnetic field, over a cylindrical region of 11m in radius and 23m in half-length. Each MDT is a straw with a diameter of 3 cm and a length in the range from 70 to 630 cm. The drift radius within each straw is measured with a precision of $\approx 80\mu$m. The straws are grouped in modules which are rectangular in the barrel region and trapezoidal in the endcap regions. The modules are arranged in three radial stations in the barrel and three axial stations in the endcaps, and 16 sectors in azimuth. Within each module the straws are arranged in two groups of multi-layers, with 4 straws in each multi-layer in the inner station and 3 straws in each multi-layer in the middle and outer stations.

Viewing MDT Data

Within each sector, straws are aligned perpendicular to the radial line joining the nominal origin to the center of that sector. The data from the MDT straws are best viewed in the X'/Z projection by selecting the azimuthal angle of its corresponding sector by switching on the **MDT Sector** mode and selecting the appropriate sector number. Sector number 0 is at 3 o'clock and the sector numbers increase in a counter-clockwise direction. The selected sector is shown on the top half of the picture and the geometrically opposite sector is shown on the bottom half. The MDT hits are normally viewed as circles but they can be drawn as lines by selecting the appropriate **mode**. In the X'/Z projection the MDT hits may be compared directly to the tracks measured in the muon system.

In the ρ/Z projection the MDT data are represented in an approximate way, essentially the X'/Z projection of all 16 MDT sectors are drawn superimposed, with 8 in the top half of the picture and 8 in the bottom. In this way one can easily see the data from all 16 sectors in the same picture. However ρ is only approximated for these MDT hits which can therefore only be approximately compared to tracks measured in the muon system which are still drawn with their true ρ.

Graphical Representation

The color of each hit is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all hits,

or it may vary with each hit being given the color of its associated

- **simulated track**, the colors of **unconnected** and **shared** hits can be selected,
- **reconstructed track**, the colors of **unconnected** and **shared** hits can be selected,
- **subdetector** (Endcap-,Barrel,Endcap+).

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.8.2 Cathode Strip Chambers (CSC)

The CSC's are used to provide precision coordinates in the extreme endcap regions (η>1.9) where MDT's can't be used. They are multiwire proportional chambers with cathode strip readout. The precision coordinaate is obtained by measuring the charge induced on a segmented cathode by the avalanche produced on an anode wire. The cathode strips for the precision measurement are oriented orthogonal to the anode wires. High precision is obtained by charge interpolation between neighbouring strips on the segmented cathode. The anode wire pitch is 2.54 mm and the cathode readout pitch is 5.08 mm. The precision coordinate is measured from a cluster of neighbouring strips with a resolution of around 60 μm. A second orthogonal coordinate is measured with less precision from cathode strips oriented parallel to the anode wires (this coordinaate is not yet available in Atlantis). The resolution of the precision coordinaate measurement is sensitive to the Lorentz angle and the chambers are therefore oriented so that high momentum tracks originating from the interaction enter at normal incidence. CSC's are arranged in two layers of modules each of which provides four coordinate measurements.

Viewing CSC strips and clusters

The precision cathode strips are aligned parallel to the MDT straws and may be best viewed together with them in the X'/Z and ρ/Z projections. The user may select **data** from the strips, the clusters formed from the strips or both. The strips are represented as a histogram of the measured charge. The clusters are respresented by a line corresponding to the one standard deviation uncertainty on the position measurement.

Graphical Representation

The color of each strip is defined by the **strip** color.

The color of each cluster is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all hits,

or it may vary with each hit being given the color of its associated

- **simulated track**, the colors of **unconnected** and **shared** hits can be selected,
- **reconstructed track**, the colors of **unconnected** and **shared** hits can be selected,
- **subdetector** (Endcap-,Endcap+).

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.8.3 Resistive Plate Chambers (RPC)

The RPC's are mainly used to provide a muon trigger but they also provide a second coordinate measurement orthogonal to those from the MDT's. The RPC's are present only in the barrel region, in the endcap regions the same role is performed by the TGC's. Each RPC module consists of two rectangular chambers. Each of these chambers are read out by an orthogonal series of pick-up strips. The η-strips are parallel to the MDT straws and the ϕ-strips are orthogonal to the MDT straws. The strip pitch varies between 3 and 4 cm. Two RPC modules are arranged on the inner and outer faces of each MDT module in the middle station and a third is positioned on either the inner or outer face of each MDT module in the outer station.

Viewing RPC strips

The η-strips are aligned parallel to the MDT straws and may be best viewed together with them in the X'/Z and ρ/Z projections. The ϕ-strips may be best viewed in the Y/X and ϕ/ρ projections.

R3D: RPC space points

From pairs of orthogonal strips belonging to the same RPC chamber a small 3D box may be formed. These R3D hits, which are currently constructed internally in Atlantis from the RPC strips, may be viewed in any projection. The formation of these R3D hits from there corresponding strips is best visualised in the RPC **View**'s of the ϕ/Z projection.

Graphical Representation

The color of each hit is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all hits,

or it may vary with each hit being given the color of its associated

- **simulated track**, the colors of **unconnected** and **shared** hits can be selected,
- **reconstructed track**, the colors of **unconnected** and **shared** hits can be selected,

or each hit may be given a color which indicates whether it is part of an R3D space point

- **is3D**.

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.8.4 Thin Gap Chambers (TGC)

The TGC's are present only in the endcap regions, in the barrel region the same role is performed by the RPC's. The TGC's are mainly used to provide a muon trigger but they also provide a second coordinate measurement orthogonal to those from the MDT's. TGC modules are constructed from either doublets or triplets of chambers. There is a doublet module in the inner station which is used only to provide the second coordinate measurement. There are two doublet modules and one triplet module in the middle station which are used to provide both the trigger and second coordinate measurement. Each chamber consists of orthogonal sets of anode wires and cathode readout strips. The anode wires are parallel to the MDT straws and the cathode strips are orthogonal to both the MDT straws and the beam axis. The anode wires are read out in groups leading to an effective pitch between 0.7 and 3.6 cm. The cathode strip pitch is ?.? cm.

Viewing TGC strips and wires

The anode wires are aligned parallel to the MDT straws and may be best viewed together with them in the X'/Z and ρ/Z projections. The cathode strips may be best viewed in the ϕ/Z projection.

T3D: TGC space points

From pairs of orthogonal strips and wires belonging to the same TGC chamber a small 3D box may be formed. These T3D hits, which are currently constructed internally in Atlantis from the TGC data, may be viewed in any projection. The formation of these T3D hits from their corresponding strips and wires is best visualised in the TGC **View**'s of the Y/X projection.

Graphical Representation

The color of each hit is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all hits,

or it may vary with each hit being given the color of its associated

- **simulated track**, the colors of **unconnected** and **shared** hits can be selected,
- **reconstructed track**, the colors of **unconnected** and **shared** hits can be selected,
- **subdetector** (Endcap-,Endcap+),

or each hit may be given a color which indicates whether it is part of an T3D space point

- **is3D**.

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.8.5 Simulated Muon Tracks (SMTr)

Simulated muon tracks from the Monte Carlo truth information. The paths of these tracks may pass through material and regions of non-uniform magnetic fields. They are stored a three dimensional polyline, with a high density of points in the region of active MDT, RPC and TGC detectors, and a lower density of points elsewhere.

The color of each simulated track is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all tracks,

or it may vary with each track being given the color of its

- **index**: in the range 0 to numSMTr-1,
- **identifier**.

Track images are easier recognised if tracks get a black **frame** with a small **frame width**, especially in the V-plot if calorimeters are displayed as well.

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.8.6 Reconstructed Muon Tracks (RMTr)

Muon tracks reconstructed by the MOORE package. The paths of these tracks may pass through material and regions of non-uniform magnetic fields. They are stored as a three dimensional polyline, with a high density of points in the region of active MDT, RPC and TGC detectors, and a lower density of points elsewhere.

The color of each reconstructed track is defined by the **color function** which may be either

- **constant**, in which case the **constant** color is used for all tracks,

or it may vary with each track being given the color of its

- **index**: in the range 0 to numMTr-1,
- **identifier**.

Track images are easier recognised if tracks get a black **frame** with a small **frame width**, especially in the V-plot if calorimeters are displayed as well.

A description of the other parameters describing graphics attributes may be found at Graphics Attributes.

3.4.9 Graphics Attributes

In general point-like hit data are displayed as **symbols** which may be chosen from

- **filled square**
- **horizontal line**
- **vertical line**
- **plus**

and drawn with a size determined by the **symbol size**.

Tracks and non-point-like hit data are displayed as lines with a selectable **line width**. For non-point-like hit data (e.g. TRT) under certain zooming conditions it is possible for the two ends of the line representing each hit to be separated by very small distances, i.e., less than one pixel on the screen. In such cases hit data may not be visible if drawn as lines. To avoid this situation a **MinSize** may be specified such that if all the lines from a given detector have a length in screen coordinates (pixels) smaller than **MinSize** then the data from this detector are drawn as symbols (squares by default) with a size **MinSize**. Furthermore the user may force non-point-like hit data to be drawn as symbol with size **MinSize** using **Force Symbols**.

For noise hits, where noise hits are those which are not connected to simulated or reconstructed tracks (and in the case of S3D hits are ungrouped by the filter), either a special **noise** symbol with a special **noise size** or a special **noise width** can be selected. By default unconnected or ungrouped hits are white and not easy to distinguish from yellow hits. It is easier to distinguish noise and yellow hits when a different symbol for noise hits is set.

To better distinguish hits from tracks of the same color or from a colored background, they may get a **frame**, where the color can be selected, with a **frame width** which can be modified.

3.5 Control: Output Display

The output display is located at the very bottom of the user interface and represents a replacement for standard terminal output. It provides information in a more readable format by using multiple fonts and colors.

3.6 Display Area: Atlantis Canvas

Pictures are shown in the display area window or Canvas. Shape and layout of the Canvas are variable. The shape can be modified via the **Pref-¿Layout** menu option of the Control Window. Each shape contains a set of layouts, which are displayed in the Control window. Each layout is divided into a number of Canvas windows.

The Canvas is the place where Atlantis draws it's pictures. It is made up of a set of Windows which have different sizes and positions inside the Canvas. The size and position of each window is dictated by the Current Layout which is used to manage the windows. The Current Layout can be changed from the **Preferences Menu**. There are five different layouts:

- **Landscape** - Using a 3×2 grid.
- **Portrait** - Using a 2×3 grid.
- **Square** - Using a 3×3 grid.
- **Square B** - Using a 3×3 grid (alternative substructure).
- **Two Squares** - Using a 2×1 grid.

To view the details of the above setups they may be selected (**Preference->Layout**) and the corresponding layout will appear in the window control area of the user interface.

3.6.1 Windows

Windows are the regions of the screen into which Atlantis draws a single picture. Selection of the current window and copying of pictures between windows is performed via the Window Control.

Each window has associated with it a projection, an interaction and a set of parameters which can all be controlled via the user interface.

Additionally, for convenience some interactions may be performed directly on the windows themselves. In particular, menus may be popped up on a window corresponding to actions which may be performed on that window, or on its associated projection or interaction. These menus are popped up by **right clicking** directly on the window while holding down a **modifier key** on the keyboard as follows:

Modifier Key	Menu	Actions
W	Window	restoring window defaults,rotation and flipping, etc.
P	Projection	projection dependent (e.g. restore aspect ratio)
I or none	Interaction	interaction dependent (e.g. type of rubberband)

3.7 Pop-up: Window Menu

The Window Menu provides window related operations such as restoring the defaults, rotation and flipping, etc.. This menu is the same in all the windows and it is not projection dependent. It can be accessed in two different ways:

- by applying the **W + Right Click** combination in the window from which you want to get the menu.
- by **Right Clicking** in one of the windows in the Window Control.

In both cases the Window Menu will appear on the screen. The content of the menu is:

- **Horizontal Flip** - mirrors the picture w.r.t vertical middle line of the window
- **Vertical Flip** - mirrors the picture w.r.t horizontal middle line of the window
- **Rotate by 90** - rotates the picture by 90° in the clockwise direction
- **Rotate by -90** - rotates the picture by 90° in the counterclockwise direction
- **Toggle Scale** - toggles **on** or **off** the state of the window scales
- **Restore Defaults** - restores the position and the size of the picture in the current window as it was after the startup of the program
- **Freeze** - Freezes the graphics state of the current window
- **Unfreeze** - Unfreezes the graphics state of the current window

Any operation chosen from the Window Menu is applied to the currently selected window.

3.8 Pop-up: Projection Menu

Each Atlantis projection has a pop-up menu associated with it. This menu contains projection dependent operations. To access the projection menu perform the combination **P + Right Click.** As a result the window in which you have clicked will become selected and the menu will appear on the screen. If you select any of the operations of the projection menu, the operation will be applied to the currently selected window.

3.9 Pop-up: Interaction Menus

Each Atlantis interaction has a pop-up menu associated with it. This menu contains interaction dependent operations. To access the interaction menu right click on the corresponding window in the Canvas. As a result the window in which you have clicked will become selected and the menu will appear on the screen. If you select any of the operations of the interaction menu, the operation will be applied to the currently selected window.

The ZMR Pop-up Menu is described on the Zoom/Move/Rotate page.

3.10 Pop-up: List Window

The List Window allows the interactive definition and manipulation of subsets of data. Lists are kept in the form of a singly-rooted tree and may be manipulated in a way similar to Window Explorer.

Predefined lists

By default there are four predefined lists, three of which are used for special purposes:

List	**Purpose**
Highlight	This list should contain at most one item that is to be drawn in a special highlighted color (normally white). This list is controlled via the pick interaction.
Last Drawn	This list contains all data which were actually drawn on the screen by the last drawing operation. This list is by its very nature transient and can only be usefully manipulated after it has been copied.
Others	May be used to control the color of all data which are drawn in a picture but which are not given a color by any user defined list.
List 0	This as a predefined list which may be manipulated by the user

Nodes

The current node is indicated in the Lists Window by a purple background region drawn around its text. If no node is current actions applied to the current list are applied to the root node ”Lists”. Nodes may be either directories (depicted by rectangles) or data items (depicted by squares). Data items may represent a single item (e.g. STr 5 for Simulated track number 5) or a group of similar items (e.g. STr(22) for a group of 22 Simulated Tracks)

Adding data to the current list

Single user selected items may be added to the currently selected directory using the pick interaction. Groups of items are best added by using a rubberband to select and draw them in an unused window temporarily and then by making a copy of the last drawn list.

Manipulation of lists

Data items and directories may be moved by dragging them to the desired destination directory. They may be copied by dragging them to the desired destination directory while holding down the **ctrl-key**. Each node has an associated pop-up menu which may be obtained by right-clicking on its rectangle or square. The contents of the pop-up menu is node specific and may contain standard operations such as:

Option	**Node Type**
Remove	All (except root)
Rename	Directories
New Parent	All (except root)
New Child	Directories
Reset	Root

or it may contain actions appropiate to the type of data contained by the node, e.g. **Vertex** to form a secondary vertex from a group of three reconstructed tracks.

Coloring of lists

A color may be associated to a user-defined node and it will be applied as the default color for all contained child nodes (which are not themselves given a selected color). Colors are applied by selecting a node as current and then clicking on the corresponding color icon in the color palette on the right of the lists window. Two special ”colors” which may be associated are (+) default color or (x) invisible.

3.11 Pop-up: Mouse Modifiers Window

The Mouse Modifiers Window shows information about various mouse modifier keys.

3.12 Pop-up: Help Window

The Help Window is used to browse the online Atlantis Help System pages.

The window is opened showing the Table of Contents via the **Help -¿ Help Content** menu option of the Control Window.

Chapter 4

Glossary

Canvas	Or Display Window, the window used by Atlantis to show pictures. The parts of the Canvas that contain a picture are called Canvas Windows.
Canvas Window	A part of the Canvas or Display Window to show a picture.
Control Window	The window used by Atlantis for control and management.
Display Window	See Canvas.
Window, Canvas	See Canvas Window.
Window, Control	See Control Window.
Window, Display	See Canvas.
ZMR	Zoom/Move/Rotate interaction.