

Atlantis Help System

Table of Contents

1	About the Atlantis Help System	5
2	Introduction	7
2.1	Which coordinate systems are used?	8
2.2	What is necessary to draw a picture?	8
2.3	Download, install and run information	9
3	User Interface	11
3.1	Control Window	11
3.1.1	Menu	11
3.1.1.1	Access to Events	13
3.1.2	Canvas Control	14
3.1.3	Interaction Control	14
3.1.4	Parameter Control	15
3.1.5	Output Display	15
3.2	Canvas	16
3.2.1	Canvas Pads	16
3.3	Pop-up Windows	16
3.3.1	Canvas Pad Menu	17
3.3.2	Projection Menus	17
3.3.3	Interaction Menus	18
3.3.4	Lists Window	18
3.3.5	Modifier Keys Window	19
3.3.6	Help Window	19
3.4	Modifier Keys	19
4	Interactions	21
4.1	Zoom/Move/Rotate (ZMR)	21
4.1.1	Central Point	22
4.2	Rubberband	23
4.2.1	Rubberband in ϕ/η Projection	24
4.3	Pick	24
4.4	Synchro Cursors	25
4.5	Fisheye	25
4.6	Clock	26
4.7	Skew	27
4.8	Scale	27
5	Projections	29
5.1	Y/X Projection	30

5.1.1	Muon Endcaps in Y/X Projection	31
5.2	X'/Z Projection	31
5.3	Y'/Z Projection	32
5.4	ρ /Z Projection	32
5.5	ϕ / ρ Projection	33
5.6	ϕ /Z Projection	34
5.7	ϕ / η Projection	34
5.8	3D Projection	36
5.9	3DBox Projection	36
5.10	Lego Plot	37
6	Data	39
6.1	Data Types	39
6.2	Data Representation in Projections	41
6.3	Data Selection	41
6.4	Cuts	43
7	Detector	47
7.1	Inner Detector (InDet)	47
7.1.1	Silicon 3D Hits (SpacePoint)	47
7.1.1.1	Silicon Pixels	48
7.1.1.2	Silicon Strips	48
7.1.1.3	Silicon 3D Hit Filter	49
7.1.2	Silicon Strip Clusters (SSC)	49
7.1.3	Transition Radiation Tracker (TRT)	50
7.1.4	Simulated Tracks (STr)	51
7.1.5	Reconstructed Tracks	51
7.1.6	Reconstructed Tracks (iPatRec)	52
7.1.7	OBSOLETE: Reconstructed Tracks (IDScan)	52
7.1.8	Simulated Vertices (SVx)	52
7.1.9	Reconstructed Vertices (RVx)	52
7.2	Calorimeters (Calo)	52
7.2.1	Liquid Argon Electromagnetic Calorimeter (LAr)	53
7.2.2	Tile Calorimeter (TILE)	53
7.2.3	Hadronic Endcap Calorimeter (HEC)	53
7.2.4	Forward Calorimeter (FCAL)	54
7.2.5	Jets	54
7.2.6	E/Gamma Reconstructed objects	54
7.2.7	Clusters	54
7.2.8	Regions Of Interest (ROI)	55
7.2.9	Calorimeter Attributes	55
7.3	Muon System (Muons)	56
7.3.1	Monitored Drift Tubes (MDT)	56
7.3.2	Cathode Strip Chambers (CSC)	57
7.3.3	Resistive Plate Chambers (RPC)	58
7.3.4	Thin Gap Chambers (TGC)	58
7.3.5	Simulated Muon Tracks (SMTr)	59
7.3.6	Reconstructed Muon Tracks (RMTr)	60
7.4	Detector (Det)	60
7.5	Miscellaneous	60
7.5.1	Detector Colors	61
7.5.2	Graphics Attributes of Hits	61

8 Interactive Athena	63
8.1 Setting up Atlantis - Interactive Athena communication	63
8.2 Calling the Athena vertex fitter from Atlantis	64
9 Glossary	67

Chapter 1

About the Atlantis Help System

The Atlantis event display program has two independent systems for online help, **tooltips** and **online documentation**. The tooltips are integrated into the program, the online documentation is placed outside the program, but is shown in a pop-up window when referenced from the program.

Tooltips

Tooltip help consists of short text messages associated with practically every graphical component of the user interface. You obtain these messages by stopping the mouse cursor in the area you want to get help for. If a message exists for the component it will appear on the screen after 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->Online Help System** menu option of the menu of the Control Window.

The hierarchy of pages is reflected in the terms chapter, section, subsection.

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 more direct 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 accessible via the Atlantis website <http://atlantis.web.cern.ch/atlantis/>, both as webpages and as PDF document (select **Documentation** in the left margin of a webpage of the Atlantis website).

Chapter 2

Introduction

About Atlantis

Atlantis is an event display program for the ATLAS experiment at CERN's Large Hadron Collider. 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 commissioning and to create pictures and animations for publications, presentations and exhibitions.

Specific features of the program are:

- The use of **data oriented projections**.
- The use of **subviews within the display area window** 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 it is located in the other projections.
- A basically **mouse driven user interface** using generally applied facilities of modern user interfaces (e.g. pop-up, tooltip).

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

About this documentation

Some basics are described in: "Which coordinate systems are used?" and "What is necessary to draw a picture?". Information for new users can be found via "Download, install and run information".

Following this introduction the **user interface** is described first with short descriptions of its full functionality. Then the **interactions** and **projections** that are controlled by the user interface and can be applied to pictures are described. Finally the parameters that control **selection and display of data** and **detector elements** are described.

Leading Principles

Three leading principles form the base of Atlantis development:

1. Atlantis is **fast**.
2. Atlantis is used **intuitively**.
3. Atlantis is used for **complete ATLAS events**.

So we try to realize: **Everything quickly available for everybody!**

2.1 Which coordinate systems are used?

The ATLAS coordinate system (X,Y,Z) is defined as a right-handed system:

- X = horizontal axis, pointing to the centre of the LHC ring,
- Y = vertical axis, pointing upward,
- Z = horizontal axis, following the beam direction.

Additionally, the coordinate system (ϕ,η,ρ) is defined as:

- $\rho = \text{sqrt}(X^2+Y^2)$,
- $\phi = \text{arctan}(Y/X)$, the azimuthal angle, $\phi = 0$ corresponds to the positive X-axis,
- $\eta = \text{arctan}(\rho/Z)$.

2.2 What is necessary to draw a picture?

In order to draw a picture, parameters must be set and selections must be made. All parameters and selections have default values which are used to draw proper pictures when Atlantis is started.

However, you probably want more!

The following list gives an overview of parameters and selections and where they may be changed:

- **Canvas pad**

The place where a picture is drawn. Selection of a canvas pad and manipulation of the picture in a canvas pad (e.g. copying into another canvas pad) are done via the canvas control of the Control Window.

A canvas pad is a subview of the Canvas.

- **Interaction**

The type of interaction (e.g. zooming, picking) to manipulate the picture that will be drawn, is selected and controlled via the interaction control of the Control Window.

- **Projection**

The projection used to create the picture for the canvas pad. A projection is selected via the **Proj** tab of the parameter control of the Control Window.

Specific projection parameters of the selected projection are displayed in the parameter control of the Control Display and can be modified now.

- **Data**

The data to be used can be selected via the **Data** tab of the parameter control of the Control Window. See data selection for a list of data types.

- **Cuts**

Cuts on physical values of the selected data can be set via the **Cuts** tab of the parameter control of the Control Window.

- **Detector colors**

Detector colors can be set via the **Det** tab of the parameter control of the Control Window.

- **Data colors and symbols**

Colors and symbols of the detector subsystem data can be set via the **ID**, **Calo** and **Muons** tabs of the parameter control of the Control Window.

2.3 Download, install and run information

Starting November 17, 2005, Atlantis is distributed with the ATLAS software release. It is available as executables "atlantis" (full version) and "atlantis_beginner" (version with a limited set of GUI options).

N.B.: Note, however, that Atlantis does not depend on any ATLAS software, only JAVA is needed to run it.

See the Download page of the Atlantis website for directions how to get Atlantis.

See the Install/Run page for directions to run Atlantis for Linux, Mac and Windows.

A tag is used in the Atlantis run command to indicate normal events (no tag), Fast Simulation events (tag=Fast), Combined Test Beam events (tag=TB) or a beginner's version with a limited set of GUI options (tag=BEGINNER).

N.B.: Atlantis versions require JAVA version 1.4 or higher to run. However, JAVA version 1.5 is preferred and is used for development.

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 permanent **Control Window** "Atlantis GUI", a permanent display area window "Atlantis Canvas" or **Canvas** and various **pop-up windows**.

Besides, **modifier keys** are available for quick view and control of parameters and selections.

The Control Window is used to view and modify parameters and selections that control the pictures on the Canvas. The pop-up windows are available for quick viewing and modification of relevant parameters and selections.

3.1 Control Window

The Control Window, "Atlantis GUI", is opened when Atlantis is started. It is used to view and modify parameters and selections that control the pictures on the Canvas, the display area of Atlantis. Functionality is grouped into components, namely (listed from top to bottom of the Control Window):

- **Menu** - Provides functionality for I/O, program customisation and the help system.
- **Canvas Control** - Provides functionality to select a canvas pad and to copy pictures between canvas pads.
- **Interaction Control** - Provides functionality for user interaction with the program (pick, zoom, transformations, projections).
- **Parameter Control** - Provides functionality for viewing and changing various parameters (data selection, cuts, detector, subdetector systems, projections).
- **Output Display** - Displays specific output of the program (picking output, cuts summary, etc.).

3.1.1 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**. The options of the menu items are briefly described below.

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 events 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 can be used to start e.g. online event monitoring with Atlantis. See section **Access to events** for details.
- **Interactive Athena** - Displays a dialog window to select and fetch events interactively from Athena. See section **Interactive Athena** for further details.
- **Print** - Displays the graphics output format options from which you may select the one you want to use to save pictures 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 pop-up window with a summary of various properties of the selected event.
- **Overlay Events** - Pile up events (as they are read from whichever source) and display them superimposed. This option is turned off by default, tick the box to enable. This feature was implemented for comparing simple low-size events (e.g. cosmics single track events).
N.B.: Atlantis gets very slow and exhausts available memory quickly if this option is enabled when reading in complex, several magabytes large event files.
- **Clear Event Container** - Clicking this item empties all the events read into Atlantis after Overlay Events was enabled, the last event remains.
- **Read Geometry...** - Displays a dialog window to select and apply a new geometry file in XML format.
- **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 select a shape and layout set that is applied to 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:

- **Online Help System** - Starts the help pop-up window with the table of contents.
- **Modifier Keys** - Starts the modifier keys pop-up window with information about active modifier keys.

3.1.1.1 Access to Events

Events to display in Atlantis can be fetched in many ways:

- **File -j Read Event** - an XML event file or a ZIP archive of XML event files from a local source (i.e. file on the local disk).
- **File -j Read Event From URL** - from a web server over HTTP protocol.
- **File -j Read Event From Server** - from a server started within the JiveXML algtool (Athena - Atlantis event data converter) running in the Athena framework. The name or the IP address of the remote server where Athena runs must be entered into the dialog. The event data is delivered to Atlantis either after the user clicks the **Get Event** button or automatically (with a specified delay) if the **timer** is enabled.

In order to use this feature, the JiveXML server must be started in Athena/JiveXML which is done by **ToolSvc.EventData2XML.OnlineMode = True** (JiveXML job option). Every time Athena reconstructs an event, JiveXML will produce the XML event data for Atlantis. This mechanism can be used for online monitoring and gets rid of the intermediate step of writing the event data into the event files. Nonetheless, if the user spots an interesting event, the data read into Atlantis in this online mode can be stored on the local disk after clicking the **Save Event** button. If not stored, the event data will be lost with reading in the next event.

The JiveXML server listens on the high number non-privileged port on the remote server. Should there be any firewall network security restrictions imposed, it might be necessary to communicate via an SSH tunnel between the local computer running Atlantis and the remote machine running Athena/JiveXML.

- **File -j Interactive Athena** - getting the event on demand (**Get Event** button) while steering the Athena framework from Atlantis through the Athena interactive prompt. Further details in section Interactive Athena.

When starting Atlantis, it tries by default to look for a file **test_events.zip** in the **events** directory. If not found, Atlantis starts without any event read in.

N.B.: When starting Atlantis in the **Fast** or the **TB** mode, the event archives **test_eventsFast.zip**, resp. **test_eventsTB.zip** are looked for.

3.1.2 Canvas Control

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

A layout set is selected via the **Pref->Layout** menu option of the Menu 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 pads. A letter or number in a box represents the canvas pad name.

For example, in Landscape Layout the canvas pads 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 pad current**

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

N.B.:

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

- **Copying the content of one canvas pad into another**

You can copy the content (picture) of one canvas pad 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 pad 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 pad).

- **Zooming a region of one canvas pad 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 is available on the Rubberband page.

- **Accessing the pop-up Canvas Pad Menu**

The pop-up Canvas Pad Menu can be accessed by **right-clicking** with the mouse in the corresponding box. The corresponding canvas pad will become selected.

3.1.3 Interaction Control

The interaction control part of the Control Window is used to activate an interaction in a canvas pad and to modify interaction specific control options of the activated interaction. Control options are described under the specific interactions.

Interactions can be invoked in different ways:

- Via the interaction control of the Control Window:

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 pad and displays

control options (if available for the selected interaction) on the panel just below the set of tabs in the Control Window.

- Via a modifier key in a canvas pad:
An alternative representation is obtained by holding the **I** key down and **right-clicking** inside the canvas pad for which you want to change an interaction. As result you will get a pop-up menu with the same set of tabs as in the Control Window. You can select the interaction you want.

Since not all interactions are available for all projections, only the available interactions are shown for a specific projection.

3.1.4 Parameter Control

Atlantis has many parameters. For convenience these parameters are combined into a number of groups that are accessed via the following tabs:

- **Proj**
To select a projection and to modify specific parameters of the selected projection. See Projections.
- **Data**
To select the data types of which the data will be used and to select the order of display (e.g. when using different track reconstructions). See Data Selection.
See the **InDet**, **Calo** and **Muons** tabs below for the appearance of the data in the various subdetector systems.
- **Cuts**
To apply cuts to the physical values of the selected data. See Cuts.
- **InDet**
To control the display and appearance of data in the inner detector. See Inner detector.
- **Calo**
To control the display and appearance of data in the calorimeters. See Calorimeters.
- **Muons**
To control the display and appearance of data in the muon system. See Muon system.
- **Det**
To control colouring and display of subdetectors. See Detector.

3.1.5 Output Display

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

Information is shown e.g. from:

- Rubberband interaction
- Pick interaction

3.2 Canvas

The display area window or **Canvas** is the place where Atlantis draws pictures. It is opened when Atlantis is started.

Shape, Layout Set and Canvas Pads

The Canvas has a user selectable **shape** with associated **layout set**. A layout set is a set of predefined subwindows within the selected shape. These subwindows are used to draw pictures and are called **canvas pads**.

The different shapes of the Canvas are:

- **Landscape** - Using a 3×2 grid to define the associated layout set.
- **Portrait** - Using a 2×3 grid.
- **Square** - Using a 3×3 grid.
- **Square B** - Using a 3×3 grid (alternative layout set).
- **Two Squares** - Using a 2×1 grid.

The user may select a shape via the **Pref->Layout** menu option of the Menu of the Control Window. The layout set of the selected shape is displayed in and controlled via the Canvas Control of the Control Window.

Each canvas pad has associated with it a **projection** (see Projections), an **interaction** (e.g. zooming, copying, see Interactions) and a **parameter set** (see Parameter Control of the Control Window).

3.2.1 Canvas Pads

Canvas pads are the subwindows of the Canvas into which Atlantis draws pictures (one picture per canvas pad). The selection of the shape and associated layout set of the Canvas determines the available canvas pads (see Canvas).

Selection of the current canvas pad and copying of pictures between canvas pads is performed via the Canvas Control of the Control Window.

Each canvas pad has associated with it a projection, an interaction and a set of parameters, which are controlled via the Interaction Control and the Parameter Control of the Control Window.

Additionally, control is possible via the associated pop-up menus, which are activated by modifier keys in a canvas pad:

Modifier Key	Action
right-click only	Interaction pop-up menu: interaction dependent operations (e.g. type of rubberband)
I + right-click	Interaction pop-up menu: list with available interactions
P + right-click	projection pop-up menu: projection dependent (e.g. restore aspect ratio)
W + right-click	canvas pad pop-up menu: restore canvas pad defaults, rotation, flipping, etc.

3.3 Pop-up Windows

These windows are popped up while running Atlantis, generally by using a modifier key. The pop-up windows contain menus which provide different "one click" operations:

- **Canvas Pad Menu** - Provides canvas pad related operations (restoring of defaults, rotation and flipping, etc.).
- **Projection Menus** - Provide projection specific operations. Each projection has it's own menu.
- **Interaction Menus** - Provide interaction specific operations. Not all interactions have such a menu.
- **Lists Window** - Allows the interactive definition and manipulation of subsets of data.
- **Modifier Keys Window** - Shows information about various modifier keys.
- **Help Window** - To browse the Atlantis Help System pages.
- **ZMR Pop-up Menu** - Zoom/Move/Rotate control.
- **Interactive Athena** - Dialog window for interaction with Athena.

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

See the page on modifier keys.

3.3.1 Canvas Pad Menu

This pop-up menu provides canvas pad related operations such as restoring the defaults, rotation and flipping, etc. This menu is the same for all canvas pads and it is not projection dependent. It can be accessed in two different ways:

- By applying the **W + right-click** combination in the canvas pad from which you want to get the menu.
- By **right-clicking** in one of the canvas mini-windows in the Canvas Control of the Control Window.

In both cases the Window pop-up 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 selected canvas pad
- **Vertical Flip** - mirrors the picture w.r.t horizontal middle line of the selected canvas pad
- **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 canvas pad scales
- **Restore Size and Position** - restores the size and the position of the picture in the selected canvas pad as it was at the startup of the program
- **Freeze** - Freezes the graphics state of the selected canvas pad
- **Unfreeze** - Unfreezes the graphics state of the selected canvas window

Any operation chosen from the Canvas Pad Menu is applied to the currently selected canvas pad.

3.3.2 Projection Menus

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.

3.3.3 Interaction Menus

There are two typical pop-up menus for interaction control:

- **Interaction list pop-up menu**

A menu with a list of all available interactions in a canvas pad. This list is dependent on the selected projection in the canvas pad. The menu is invoked by keeping the **I** key down and **right-clicking**.

- **Interaction pop-up menu**

Many Atlantis interactions have a pop-up menu with interaction dependent operations associated with the selected projection. To invoke the menu, **right-click** in the desired canvas pad. As a result the canvas window 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 canvas pad.

The ZMR Pop-up Menu is described on the [Zoom/Move/Rotate](#) page.

The Fisheye Pop-up Menu is described on the [Fisheye Transformation](#) page.

The Skew Pop-up Menu is described on the [Skew Interaction](#) page.

3.3.4 Lists Window

The Lists pop-up 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 Windows 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 is 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 of the interaction control of the Control Window (the interaction is described under Interactions). 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	Action
Remove	All (except root)	Remove the node from the tree
Rename	Directories	Rename the node
New Parent	All (except root)	Add new parent directory (List) above a node
New Child	Directories	Add new child directory (List) below a node
Reset	Root	Reset the Lists removing any user supplied data

or it may contain actions appropriate 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.

3.3.5 Modifier Keys Window

This pop-up window is activated from the menu of the Control Window and shows information about various active modifier keys.

Modifier Key	Action
I + right-click	Interaction Manager pops up
P + right-click	Projection Menu pops up
W + right-click	Canvas Pad Menu pops up
right-click	Interaction Menu pops up
	Zoom
C	Change position Central Point
F	Fast zoom
H	Horizontal zoom
M	Move (pan)
R	Rotate
V	Vertical zoom
Z	Zoom

3.3.6 Help Window

The help window is a pop-up window that is used to browse the online documentation pages of the Atlantis Help System.

The window may be opened via the **Help->Help Content** menu option of the menu of the Control Window. It starts by showing the Table of Contents.

The window may also be opened by **right-clicking** on a graphical component. If the component has a help page attached, this page is shown.

3.4 Modifier Keys

Modifier keys are combinations of a keyboard key and a mouse key that are used to generate pop-up menus or to perform interactions. Generally a keyboard key is kept pressed and during this pressing, a mouse key is clicked (e.g. to get a pop-up menu) or kept pressed (e.g. zooming).

A list of available modifier keys with conditions and actions:

Modifier Key	Condition	Action
left-press only	in canvas pad	Zoom with respect to the central point (horizontal zoom in the ϕ/ρ projection)
left-press only	in canvas pad 3DBox projection active	Change the volume of the box
right-click only	in canvas pad	Interaction pop-up menu: interaction dependent operations (e.g. type of rubberband)
A + left-click	in canvas pad pick interaction active	Add the data item to be picked to the currently selected list node
C + left-click	in canvas pad pick interaction active	Clear the highlight list node
C + left-click	in canvas pad	Change position of central point
F + left-press	in canvas pad	Fast zoom with respect to the central point (horizontal zoom in the ϕ/ρ projection); data are not shown during the zoom
H + left-click	in canvas pad pick interaction active	Highlight, place the data item to be picked in the highlight list node, causing it to be drawn in white
H + left-press	in canvas pad	Horizontal zoom with respect to the central point
H + left-press	in canvas pad 3DBox projection active	Change the length of the box
I + right-click	in canvas pad	Interaction list pop-up menu: list with available interactions
M + left-press	in canvas pad	Move (panning)
P + right-click	in canvas pad	Projection pop-up menu: projection dependent (e.g. restore aspect ratio)
P + left-press	in canvas pad synchro cursors active	Change splitting angle ϕ and copy it to ρ/Z projection
R + left-press	in canvas pad	Rotate (projection dependent)
R + left-press	in canvas pad 3DBox projection active	Rotate the tracks around the direction of flight of the decaying particle
V + left-press	in canvas pad	Vertical zoom with respect to the central point
V + left-press	in canvas pad 3DBox projection active	Change the width of the box
Z + left-press	in canvas pad	Zoom with respect to the central point (horizontal zoom in the ϕ/ρ projection)
Z + left-press	in canvas pad 3DBox projection active	Change the volume of the box

Chapter 4

Interactions

It is very important to understand how interactions work, so you may use the full power of each. There are two sets of interactions, the interactions that are sensible for all projections (**global interactions**) and the interactions which are only sensible for some specific projections (**projection dependent interactions**). As a consequence, each projection has a specific set of associated interactions represented by the set of tabs in the Control Window.

N.B.: See the detailed information about available projections.

Global Interactions

Interactions that are available in all projections:

- **ZMR** - Zoom, move and/or rotate a picture in a canvas pad.
- **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 cursor position in different projections.

Projection Dependent Interactions

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

Interaction Control

Interactions are selected and interaction parameters are modified via the interaction control of the Control Window.

Interaction Pop-up Menus

Many interactions have an associated pop-up menu that is invoked for a picture by **right-clicking** in the canvas pad. See the page on interaction pop-up menus.

4.1 Zoom/Move/Rotate (ZMR)

The ZMR interaction allows the user to perform zooming, moving and rotation of the picture content in a canvas pad. It is activated for the current canvas pad by clicking on the ZMR tab of the interaction control in the Control Window.

- **Zoom**

Zooming is always done 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 a point of the picture inside or outside, increasing or decreasing its distance to the central point.

See the **Modifier Key Summary** for the different types of zoom that can be applied.

- **Move**

You can move (pan) the picture by dragging a point of the picture while keeping the **M** key pressed.

- **Rotate**

Rotation is also done with respect to a **central point** which the user can specify. To obtain a rotation of the picture you drag a point of the picture around while keeping the **R** key pressed.

Note that rotation is a projection dependent operation:

- **Y/X** - 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.
- ϕ/ρ , ϕ/Z , ϕ/η - It performs a shift (up or down) of the ϕ scale.

The ZMR Pop-up Menu

The ZMR pop-up menu can be accessed by **right-clicking** in 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 pad.

Modifier Key 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 (panning)
R	Rotate (projection dependent)
C	Change position of central point

4.1.1 Central Point

The central point is used by the ZMR interaction for zooming (all projections) and rotation (Y/X projection) in a canvas pad. 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, 0). There are different ways to change it's 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).

4.2 Rubberband

The rubberband interaction provides an alternative way of zooming in Atlantis. Unlike the ZMR interaction you may exactly specify the region you are interested in by simply drawing a rubberband around that region. The interaction is activated for the current canvas pad by clicking on the Rubberband tab of the interaction control in the Control Window.

If rubberbanding is activated, the panel below the rubberband tab shows a box from which you may select a rubberband type:

- **Rectangle**

Rectangle is specified by two opposite corners. Sides run parallel to the projection axes.

- **Rotated Rectangle**

Rectangle is specified by two middle points of opposite sides. These points can be moved to change the orientation of the rectangle and the corners can be moved to increase or decrease the width of the rectangle.

- **Parallelogram**

Parallelogram is specified by two middle points of opposite sides. These points can be moved to change the orientation of the parallelogram (the side with the opposite point remains fixed) and the corners can be moved both to change the orientation and to increase or decrease the width of the parallelogram (the two middle points remain fixed).

- **Square**

Square is specified by the central point and by a corner. Preserves the aspect ratio of the picture.

- **X Skew**

As parallelogram but with base side horizontally fixed.

- **Y Skew**

As parallelogram but with base side vertically fixed.

- **X Slice**

Vertical slice is specified by points on left and right side.

- **Y Slice**

Horizontal slice is specified by points on left and right side.

Draw a rubberband in the current canvas pad by clicking and then dragging with the left mouse button on the picture. When you release the mouse button a pop-up menu will appear near your mouse.

Now you may re-adjust the rubberband by moving any of its corners or (if applicable) middle points.

There are two options to apply the current rubberband:

- **Zoom in the same canvas pad** - Just click the Zoom button of the pop-up menu.

- **Zoom in some other canvas pad** - Two options:

- Drag the Zoom button of the pop-up menu into one of the canvas pads shown in the canvas control of the Control Window.

- Drag the Zoom button of the pop-up menu into the target canvas pad directly (in the Canvas). This only works if at least some part of the target canvas pad is visible on the Canvas.

Rubberband Pop-up Menu

Option	Action
Zoom	Zooms the selected region.
New List	Shows the Lists pop-up window.
Summarize	Information about the selected objects is displayed in the output display of the Control Window.

Unzoom

After a rubberband has been applied, you may right-click in the canvas pad to get a pop-up Unzoom button. Click to undo the zoom. This works recursively.

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 is described in Rubberband in ϕ/η Projection.

4.2.1 Rubberband in ϕ/η Projection

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

Option	Action
Zoom LAr	Zooms the currently selected region, with the four samplings of the LAr calorimeter being shown in canvas pads 1-4, respectively.
Zoom Calorimeters	As Zoom LAr , with additionally the two innermost samplings of the hadronic calorimeters being shown in canvas pads 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 canvas pad the projection in that canvas pad is not changed.
Whole Window	Sets the current zoom region to correspond to the whole canvas window
Print Contents	A short summary describing the tracks and the calorimetric energy inside the rubberband region is displayed in the output display of the Control Window.

4.3 Pick

The pick interaction has two modes, allowing the selection of either hits and tracks or detectors. The desired mode is selected from the box on the panel of the Pick tab in the interaction control of the Control Window.

Hits and Tracks

If the picking mode is set to hits and tracks:

- Clicking the **left mouse button** in a canvas pad will move the cursor to the nearest data item in the window and will show information about the picked data item on the output display of the Control Window.
- Clicking the **right mouse button** will move the cursor to the nearest appearance of the previously picked data item in the canvas pad where the mouse button is pressed. In the case of
 - a hit, which is drawn once on a canvas pad, the cursor is moved to that hit,
 - a hit, which is drawn twice on a canvas pad (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 canvas pad in which a mouse button is clicked, is automatically popped up.

Detectors

If the picking mode is set to detectors:

- Clicking the **left mouse button** in a canvas pad on a detector element will print the name of the element on the output display of the Control Window.

Lists and Picking

The pick interaction may be used for the interactive manipulation of lists by using a modifier key while performing the pick. The available modifier keys are:

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

4.4 Synchro Cursors

If different projections are visible simultaneously in separate canvas windows, then synchro cursors show the same cursor position in all projections. Synchro cursors are activated by clicking on the SC tab of the interaction control in the Control Window.

Now simply click in a canvas pad with the left mouse key and, while keeping the key pressed, move around in the canvas pad to see the synchro cursor follow the cursor position. The synchro cursors in the other canvas pads follow the leading synchro cursor. The synchro cursor in any canvas pad may be used as leading cursor.

The concept is simple: a 3D point defined by (ϕ, η, ρ) in one projection is shown in all other projections by conversion to the appropriate coordinates. This 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 splitting angle in ρ/Z

A special feature of the synchro cursors interaction is to set the angle $\phi_{\rho Z}$ of the ρ/Z projection from any other projection which defines ϕ . This transfer of ϕ information is performed by keeping modifier key **P** 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.

4.5 Fisheye

If the calorimeters and the muon detectors are drawn in, e.g. the Y/X projection, the inner tracking chambers are so small that track recognition may suffer. 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. Besides, since the outer parts of the detector are in sight, tracks are still completely visible.

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 \mathbf{d} 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 the value of Z is changed according to the formula:

$$Z_{new} = Z \times (1+\mathbf{d}\times Z_{max})/(1+\mathbf{d}\times Z)$$

where 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, the axes representing distance are transformed with the formula used to transform Z in the ρ/Z projection.

Applying the Fisheye Transformation

The fisheye interaction is selected for the current canvas pad by clicking on the Fisheye tab of the interaction control in the Control Window. The label of the tab contains a toggle to activate and deactivate the fisheye and a box with the value of the distortion factor \mathbf{d} . This value is modified by clicking the left mouse button and dragging the cursor over the picture. If the **F** modifier key is pressed while dragging, the data will not be updated, thus allowing for better response.

The Fisheye Pop-up Menu

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

- **Set no Fisheye** - Switch off the fisheye interaction.
- **To Window Radius** - Not implemented yet.

4.6 Clock

The clock transformation is an angular fisheye 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:

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

where \mathbf{d} is the clock distortion factor and $\Delta\phi=\phi-\phi_0$. 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

The clock interaction is selected for the current canvas pad by clicking on the Clock tab of the interaction control in the Control Window. The label of the tab contains a toggle to activate and deactivate the interaction. Upon activation the distortion factor \mathbf{d} is modified by clicking on a point at a selected opening angle with respect to the ϕ_0 direction and dragging it to a larger or smaller opening angle.

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 fisheye. This ϕ axis may be rotated by dragging it with the mouse.

4.7 Skew

The skew interaction is activated for the current canvas pad by clicking on the Skew tab of the interaction control in the Control Window. It is available in the ρ/Z , ϕ/ρ and ϕ/Z projections. However, 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-clicking into the desired canvas pad. It contains the following set of utility operations:

- **Set no skew** - Switch off the skew interaction. (doesn't work for ρ/Z : BUG!)

4.8 Scale

The skew interaction is activated for the current canvas pad by clicking on the Scale tab of the interaction control in the Control Window.

The scale interaction allows the copying of ϕ or Z scales between projections. After activating 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 .

The scale interaction does not have a pop-up menu.

Chapter 5

Projections

Available Projections

The projections that are available in Atlantis are data oriented, that is, they are adapted to the cylindrical structure of helices and of the ATLAS detector. The following projections are available:

Linear 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.

Special projections

- The **3D projection**.
- The **3DBox projection**.
- The **Lego Plot**.

Selection of Projections

A projection is selected via the Parameter Control of the Control Window or via the projection pop-up menu.

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:

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, orthogonal view with respect to X'/Z projection
ϕ/Z	TRT endcaps, calorimeter endcaps and TGC ϕ -strips
ϕ/η	Calorimeters, and their association to tracks and S3D hits
3DBox	Shows tracks near the primary vertex to investigate secondary vertices

These projections were chosen 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:

	Y/X	ϕ/ρ	ϕ/Z	ρ/Z
Solenoidal	curved	curved	curved	\sim straight
Toroidal	\sim straight	\sim straight	\sim straight	curved

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.

5.1 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 from 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.

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

5.2 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 from 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.

5.3 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 from their curvature in this projection.

The calorimeters and the 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.

5.4 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:

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

and

$$\rho = -\sqrt{(X^2+Y^2)} \quad \text{otherwise}$$

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 ϕ 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.

5.5 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 $\rho=0$, 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 $\rho=0$. 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.

5.6 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 :

$$z-z_v \propto P_z \times (\phi-\phi_0)$$

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.

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.

5.7 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

$$\eta \pm k \times (\rho_{max}-\rho)$$

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 sequentially 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 ρ Max and z Max 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.

5.8 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.

5.9 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 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-clicking into the desired canvas pad 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.

Modifier Key Summary

Modifier Key	Action
left-press only	Change the volume of the box
Z + left-press	Change the volume of the box
H + left-press	Change the length of the box
V + left-press	Change the width of the box
R + left-press	Rotate the tracks around the direction of flight of the decaying particle

5.10 Lego Plot

The lego plot shows stacks of energy seen in the calorimeter towers. The stacks are positioned on the surface spanned by η (in radians) and ϕ (in degrees).

Currently no pop-up window is attached to the lego plot.

Chapter 6

Data

The **data types** that are available in Atlantis are listed in section Data Types. The graphical representation of data types in the different projections on the Canvas is listed in section Data Representation in Projections.

Control of data to be displayed on the Atlantis Canvas is done by making a selection of available data and by applying cuts to the selected data:

- The **selection of data** is found via the **Data** tab of the parameter control of the Control Window. See Data Selection for a description of the various selections. Order of drawing, data representation by projection and commands are listed here.
- The **cuts that can be applied** are found via the **Cuts** tab of the parameter control of the Control Window. See Cuts for a description of the various cuts that can be applied.

Control of attributes of data types is described in chapter Detector.

6.1 Data Types

The table below contains a list of names and short descriptions of the data types available in Atlantis. The names are in alphabetical order.

CaloETMis	(Calo) missing Et in calorimeters
CSC	(Muons) muon detector endcap
EmTauROI	(Calo) ...
ETMis	(ATLAS) total of missing Et
FCAL	(Calo) cells and/or histograms of the forward calorimeter
HEC	(Calo) cells and/or histograms of the hadronic endcap calorimeter
iPatTrack	(InDet) reconstructed tracks by iPatTrack
Jet	(ATLAS) ...
JetROI	(Calo) ...
LAr	(Calo) cells and/or histograms of the liquid argon electromagnetic calorimeter
MDT	(Muons) muon detector tubes
MSeg	(Muons) segments of muon tracks
MuonETMis	(Muons) missing Et in muon system
RecVertex	(InDet) reconstructed vertices
RMTr	(Muons) reconstructed muon tracks
RPC	(Muons) muon detector 90° angle stereo tubes
SiCluster	(InDet) ...
SiHit	(InDet) ...
SimVertex	(InDet) simulated vertices
SMTr	(Muons) simulated muon tracks
SpacePoint	(InDet) pixel clusters and silicon strip space points
SNP	(Calo) simulated neutral particles
STr	(InDet) simulated tracks
TGC	(Muons) muon detector endcap
TILE	(Calo) cells and/or histograms of the TILE hadronic calorimeter
Track	(InDet) reconstructed tracks
TrigInDetTrack	(InDet) ...
TrigSiSpacePoint	(InDet) ...
TRT_DriftCircle	(InDet) ...

The table below contains the list of old names and short descriptions of the data types available in Atlantis.

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

6.2 Data Representation in Projections

The following table shows 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

6.3 Data Selection

Selection of data is made available via the **Data** tab of the parameter control section in the Control Window. The various selection options are described below.

The data types that are available in Atlantis are listed under Data Types. The graphical representation of data types in the available projections is listed under Data Representation in Projections.

Order

The order of drawing of simulated tracks (**STr**), reconstructed tracks (**RTr**) and hits (**Hits**) is set by selecting one of the following options:

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

For the default option the simulated tracks are drawn first, then the reconstructed tracks (so with perfect reconstruction you will only see the reconstructed tracks) and finally the hits.

Ass Hits To

The track type to which hits are assigned to:

- **Track**
- **iPatTrack** (default)
- **TrigInDetTrack**

RTr Order

The order of drawing of track types:

- **Track iPatTrack TrigInDetTrack** (default)
- **TrigInDetTrack iPatTrack Track**

SpacePoint Order

The order of drawing of spacepoints:

- **SpacePoint TrigSiSpacePoint** (default)
- **TrigSiSpacePoint SpacePoint**

ETMis Choice

- **ETMis (final) only** (default)
- **CaloETMis only**
- **MuonETMis only**

Status

Hierarchical lists to make data types active/inactive for drawing. See Data Types for a short description of the data types.

- **InDet**
 - **Spacepoint**
 - **TrigSiSpacePoint**
 - **SiHit**
 - **SiCluster**
 - **TRT_DriftCircle**
 - **STr**

- **Track**
- **iPatTrack**
- **TrigInDetTrack**
- **SimVertex**
- **RecVertex**
- **Calo**
 - **LAr**
 - **TILE**
 - **HEC**
 - **FCAL**
 - **SNP**
 - **EmTauROI**
 - **JetROI**
 - **CaloETMis**
- **Muons**
 - **MDT**
 - **CSC**
 - **RPC**
 - **TGC**
 - **MSeg**
 - **RMTr**
 - **SMTr**
 - **MuonETMis**
- **ATLAS**
 - **Jet**
 - **ETMis**

Cuts

Finally, different cuts can be applied to the selected data. See section Cuts.

6.4 Cuts

Cuts may be applied to select the data to be displayed. Cuts are grouped per subdetector system and are accessible via the **Cuts** tab of the parameter control section in the Control Window.

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 displayed in the white field and is modified by changing the value in the field, followed by pressing the **Enter** key on the keyboard.

Cuts which act on real numbers may select values either $<$ or $>$ the cut value. The selection of $<$ or $>$ is toggled by clicking on them with the left mouse button.

For cuts applied to integer values a left-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 tracks, track associations, hits, calorimeter cells, TRT straws, angular regions. See below.

InDet: Inner Detector

Most cuts are applied to tracks.

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. See **Hits By STr** and **Hits By RTr**.

- **|Pt|** : (tracks) transverse momentum [GeV/c]
- **|d0|** : (tracks) distance of closest approach to the beam axis [cm]
- **|z0|** : (tracks) distance in Z from nominal origin at d0 [cm]
- **|d0 Loose|** : (tracks) outer loose d0 cut [cm]
- **|z0-ZVtx|** : (tracks) distance in Z from primary vertex at d0 [cm]
- **Num SpacePoint** : (tracks) number of associated silicon space points
- **STr (barcode)** : (tracks) kine number of simulated track
- **STr type** : (tracks) type of simulated track
 - **charged hadron** (default)
 - **electron**
 - **muon**
 - **neutral hadron**
 - **photon**
 - **neutrino**
- **SimVertex** : (tracks) originating simulated vertex (0=primary)
- **SCT/Pixel** : ...
 - **All** (default)
 - **Endcap-**: ...
 - **Barrel**: ...
 - **Endcap+**: ...
- **TRT_DriftCircle** : ...
 - **All** (default)
 - **Barrel-**: ...
 - **Barrel+**: ...
- **RTr** : (tracks) identifier of reconstructed track
- **Hits By STr** :
 - **All** (default)
 - **Connected**: hits connected to simulated tracks
 - **Unconnected**: hits unconnected to simulated tracks
- **Hits By RTr** :

- **All** (default)
- **Connected**: hits connected to reconstructed tracks
- **Unconnected**: hits unconnected to reconstructed tracks
- **Hit type**:
 - **noise**: noise hits (other hits)
 - **good**: good hits (associated to tracks, or passing the filter)
 - **all** (default)
- **Group** : group number of silicon hit: 0 = noise. See filter.
- **Threshold**: threshold for TRT Straws
 - **high** (default)
 - **low**

Calo: Calorimeters

- **Jet Et**: ...
- **Energy**: energy deposit [MeV]
- **FCAL**: ...
 - **all** (default)
 - **Endcap-**
 - **Endcap+**
- **Cluster**: cluster to which the cell is associated

Muons: Muon System

No cuts available yet.

ATLAS

- **Index**: (tracks) in the range 0 to numTracks-1
- **Module**: ...
- **Layer**: ...
- **Cut ϕ** : (angular region) hits and tracks in the range $\phi \pm \phi_{cut}$
- ϕ : (angular region) ...
- **Cut η** : (angular region) hits and tracks in the range $\eta \pm \eta_{cut}$
- η : (angular region) ...
- **ByList**: (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.

Chapter 7

Detector

This chapter describes specific elements and element attributes of the detector subsystems (Inner Detector, Calorimeters and Muon System) and general elements and element attributes of the full detector.

7.1 Inner Detector (InDet)

Elements, attributes and control are grouped:

- **SpacePoint** : silicon space points
SpacePoint hits may be cleaned with the Silicon hit filter.
- **TrigSiSpacePoint** :
- **SiHit** :
- **SiCluster** : silicon strip clusters
- **TRT_DriftCircle** : TRT straws
- **STr** : simulated tracks
- **Track** : reconstructed tracks
- **iPatTrack** : reconstructed tracks
- **TrigInDetTrack** :
- **Fil** :
- **SimVertex** : simulated vertices
- **RecVertex** : reconstructed vertices

7.1.1 Silicon 3D Hits (SpacePoint)

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

The following element and attribute items are available and can be controlled:

- **Color Function**
The color of each hit is defined by the color function selected from the following options:
 - **Constant** (default)
in which case the color defined by item **Constant** is used for all hits,

- **Simulated Track**
the colors of unconnected and shared hits can be selected by items **Unconnected** and **Shared**,
 - **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**.
- **Constant**
The color of all hits, used for the **Constant** color function.
 - **Unconnected**
The color used for unconnected hits.
 - **Shared**
The color used for shared hits.
 - **Ungrouped**
 - **Symbol Size**
The size in pixels of the symbol used to represent hits.
 - **Symbol**
The type of symbol used to represent hits.
 - **Frame**
 - **Frame Width**
 - **Noise Size**
 - **Noise**

See Graphics Attributes of Hits for a description of graphics parameters related to hits.

7.1.1.1 Silicon Pixels

Silicon pixels give directly 3D positions. From each cluster of pixels a space point is calculated. The pixel dimensions are $50\mu\text{m}\times 400\mu\text{m}$. The barrel of the pixel detector has three layers at 4, 11 and 15 cm, respectively, which provide position measurements with a resolution of $12\mu\text{m}$ in ρ - ϕ and $66\mu\text{m}$ in Z . The endcap has four layers at ± 35 , ± 67 , ± 95 and ± 115 cm, respectively, which provide position measurements with a resolution of $12\mu\text{m}$ in ρ - ϕ and $77\mu\text{m}$ in ρ .

7.1.1.2 Silicon Strips

To be filled.

7.1.1.3 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 ($N_H = \mathbf{NumHits}$) 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 $\Delta\eta = 2 \times \eta \mathbf{Range/Num}\eta$ reflects measuring η precision and should be as small as possible without losing hits.
- The value of $\Delta\phi = 360^\circ / \mathbf{Num}\phi$ 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 $\phi'\eta$ histogram, where ϕ' is defined as $\phi' = \phi - c \times s \times \rho$, 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 $-1/P_{t \text{ MIN}}$ and $+1/P_{t \text{ MIN}}$ with $N = 1 + 2 \times \mathbf{NumSteps}$. 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 $P_{t \text{ MIN}}$ may get lost, so that $P_{t \text{ MIN}}$ should be sufficiently low.

7.1.2 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 $= 2.3^\circ$ (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 $16\mu\text{m}$ in ρ - ϕ and $580\mu\text{m}$ in Z , respectively. Two tracks can be distinguished if separated by more than $\approx 200\mu\text{m}$.

The distance between ϕ strips and the u- or v- strips in the same module is $400 \mu\text{m}$. 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 four layers in the barrel between 35, and 115 cm, and nine 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.

7.1.3 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 $170 \mu\text{m}$.

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.

7.1.4 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.

7.1.5 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 reconstructed 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 Attributes.

7.1.6 Reconstructed Tracks (iPatRec)

The reconstructed tracks found by the iPatRec algorithm.

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

7.1.7 OBSOLETE: Reconstructed Tracks (IDScan)

Obsolete.

7.1.8 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 Attributes.

7.1.9 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 Attributes.

7.2 Calorimeters (Calo)

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** reconstructed objects
- **Clusters** found in the calorimeter
- **Regions Of Interest** used by the trigger

7.2.1 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 198 cm, 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	$\Delta\eta \times \Delta\phi$	$ \eta $ range	$\Delta\eta \times \Delta\phi$	$ \eta $ range
0 (pre)	0.025×0.1	$ \eta < 1.52$	0.025×0.1	$1.5 < \eta < 1.8$
1	0.003×0.1	$ \eta < 1.475$	0.025×0.1	$1.375 < \eta < 1.5$
			0.003×0.1	$1.5 < \eta < 1.8$
			0.004×0.1	$1.8 < \eta < 2.0$
			0.006×0.1	$2.0 < \eta < 2.5$
			0.1×0.1	$2.5 < \eta < 3.2$
2	0.025×0.025	$ \eta < 1.475$	0.025×0.025	$1.375 < \eta < 2.5$
			0.1×0.1	$2.5 < \eta < 3.2$
3	0.05×0.025	$ \eta < 1.475$	0.05×0.025	$1.5 < \eta < 2.5$

7.2.2 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 2.28 m and the outer radius is 4.25 m. 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.

7.2.3 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.

7.2.4 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 $\sim 0.2 \times 0.2$ 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.

7.2.5 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.

7.2.6 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.

7.2.7 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 reconstructed object**.

7.2.8 Regions Of Interest (ROI)

Regions of interest are $\Delta\phi \times \Delta\eta$ regions of solid angle defined by the trigger system. They 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.

7.2.9 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.

7.3 Muon System (Muons)

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

7.3.1 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 23 m 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

$\approx 80\mu\text{m}$. 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 four straws in each multi-layer in the inner station and three 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.

7.3.2 Cathode Strip Chambers (CSC)

The CSC's are used to provide precision coordinates in the extreme endcap regions ($\eta > 1.9$) where MDT's can't be used. They are multiwire proportional chambers with cathode strip readout. The precision coordinate 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 $60\mu\text{m}$. A second orthogonal coordinate is measured with less precision from cathode strips oriented parallel to the anode wires (this coordinate is not yet available in Atlantis). The resolution of the precision coordinate 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 represented 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.

7.3.3 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.

7.3.4 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.

7.3.5 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 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 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.

7.3.6 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.

7.4 Detector (Det)

This section describes elements and element attributes that apply to the full detector.

Colors of the detector are described under Detector Colors and graphical attributes under Graphics Attributes.

7.5 Miscellaneous

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.

7.5.1 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:

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

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.

7.5.2 Graphics Attributes of Hits

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.

Chapter 8

Interactive Athena

Athena can be accessed interactively from Atlantis via the Interactive Athena dialog window. This window is popped up by selecting the **File->Interactive Athena** menu option of the Control Window. *i/p*

By means of this dialog the user is able to steer the Athena framework directly from the Atlantis display. The other necessary component is the Python script **InteractiveServer.py**, that is started on the Athena interactive prompt.

It is possible to perform various actions from the Atlantis dialog window as if the commands were typed on the Athena interactive prompt directly, e.g. changing/querying the values of the job options, executing the methods of Athena algtools/algorithms, directing Athena to process the next event by calling **theApp.nextEvent()** and eventually getting the XML event data.

InteractiveServer.py is a Python script that is used to interface the Atlantis Interactive Athena dialog and the Athena interactive Python prompt (when Athena is started by **athena -i [job_option_file]**). Once the script is started, the created server receives requests from the Atlantis user, processes these requests and sends the results back to Atlantis.

The CVS location of the script is **offline/graphics/AtlantisJava/share/InteractiveServer.py**. In the Athena environment it can be obtained by **get_files InteractiveServer.py** as well.

Establishing the communication between Atlantis and Athena is described in section Setting up Atlantis - Interactive Athena communication.

Using the Athena vertex fitter from Atlantis is described in section Calling the Athena vertex fitter from Atlantis

N.B.: If the user opts for some reason not to use the Athena algtools and still be able to start **InteractiveServer.py**, it's possible to create the server without initialising the algtools. Before starting the script on the Python prompt by **execfile ("InteractiveServer.py")** it is necessary to make the following assignment: **argumentInteractiveServer = "NO_ALGTOOLS"** It is not then possible to obtain the XML event data (JiveXML algtool) or run the vertexing in Athena.

N.B.: If due to network security restrictions the connection between Atlantis and the **InteractiveServer.py** on the Athena prompt can't be established directly, an SSH tunnel can be created through which both parties should be able to connect.

8.1 Setting up Atlantis - Interactive Athena communication

- Atlantis has been started (most likely on the local machine)
- Athena environment is set up (most likely run remotely)

- Getting **InteractiveServer.py** to the run directory: **get_files InteractiveServer.py** (or copy from CVS)
- Starting Athena in the interactive mode: **athena -i myTopOptions.py**
- Type command: **theApp.initialize()** (it could also go at the bottom of the top options file)
- Start server by **execfile ("InteractiveServer.py")** after which the interactive prompt is taken over by the script.
- Provided that everything went well (no error messages were printed), algtools were initialised and the server was bound to the port, copy and paste this information into the Atlantis dialog:

- **server name**
- **server port**
- **key**

Key is a randomly generated string and is a protection against user's Athena session being driven by another user who happens to put into his Atlantis dialog window the name of the remote machine and the port that someone else is using.

- Provided that there are no network security issues disabling direct communication, the user can now type the Athena commands in Atlantis, steer Athena and demand the actual XML event data or run the Athena vertex fitter from Atlantis.
- **theApp.nextEvent()** should be the first command to execute in order to be able to obtain some XML event data.
- Pressing Ctrl-c shuts down **InteractiveServer.py** and the interactive prompt is given back to the user.
- **myTopOptions.py** (bottom of the file)

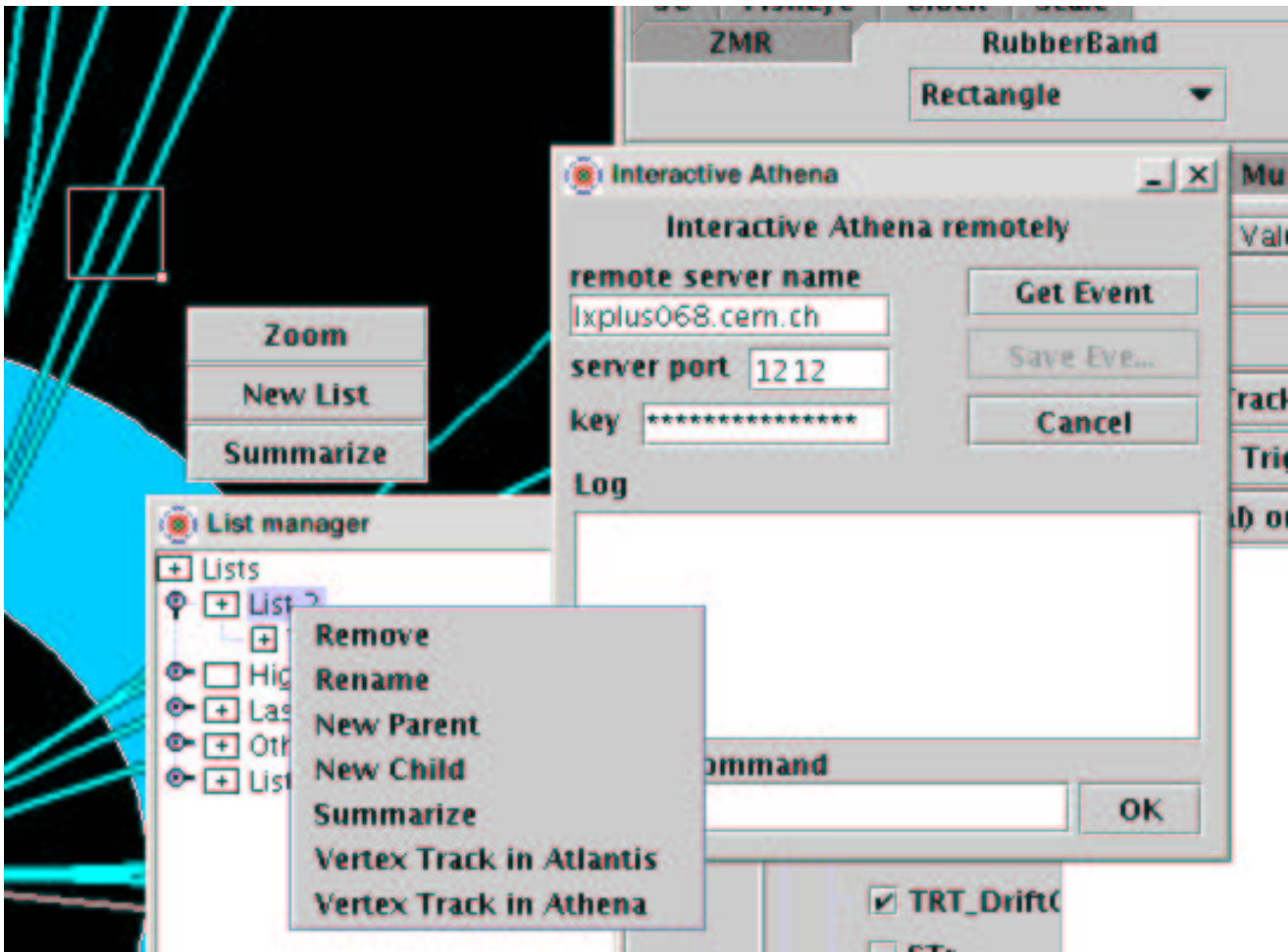
```
doJiveXML = True
include ("RecExCommon/RecExCommon_topOptions.py")
include ("PyAnalysisCore/InitPyAnalysisCore.py")
include ("InteractiveTools/jobOptionsBase.py")
ToolSvc.EventData2XML.DataTypes += ["Vertex"]
ToolSvc.EventData2XML.xKalmanTracks = "Tracks"

# vertexing algorithms
# ToolSvc.VxWrapperTool.VxToolName = "Trk::FastVertexFitter"
ToolSvc.VxWrapperTool.VxToolName = "Trk::FullVertexFitter"
```

8.2 Calling the Athena vertex fitter from Atlantis

- It is necessary to carry out the procedure described in section Setting up Atlantis - Interactive Athena communication. The actual vertexing algorithm type is chosen in **myTopOptions.py**. The picture below shows the vertexing process.
- Tracks whose IDs are to be sent to the Athena vertex fitter have to be selected with the "rubberband" Atlantis interaction. After doing so, a pop-up menu appears on the canvas where the user selects **New List**, into which these tracks are put.

- The most recent list is now highlighted in the Atlantis List manager dialog window. If only **Track** tracks were put into the list (and no other objects such as hits or tracks of other types), an item **Vertex in Athena** appears in the context menu after right-clicking on the list item in the List manager.
Only with **Track** tracks one can call the Athena vertex fitter. The Atlantis internal vertex fitter can be called upon **Track** tracks and **iPatTrack** tracks.
- Given that proper information was filled in the Atlantis Interactive Athena dialog and the connection to **InteractiveServer.py** could be established, the **Track** tracks IDs were sent to Athena and the fitter called. This can be observed in the window where Athena is started from.
In order to find out whether or not the listed tracks come from a common vertex, the user has to hit the **Get Event** button and search for a new item of the **RecVertex** datatype (see event summary in the output window in the bottom part of the GUI or **File -> Event Properties**) once updated event data arrive. If the vertex was found and the **RecVertex** datatype is switched on (Data tabpane, InDet) a newly calculated vertex will be displayed for instance in the XY projection as an ellipse. The tracks which form this vertex will be shortened to the centre of that ellipse (in XY).
- The picture below demonstrates the aforementioned procedure.



Chapter 9

Glossary

This page is under construction (November 16, 2005).

Atlantis Canvas	The name of the Display Window or Canvas. See Canvas .
Atlantis GUI	The name of the Control Window. See Control Window .
Canvas	Or Display Window. The permanent window used by Atlantis to show pictures. The Canvas contains one or more canvas pads in which the pictures are shown.
Canvas Control (Control Window)	For selection and control of canvas pads .
Canvas Pad	A part of the Canvas that shows a picture of a specific event with specific cuts, transformations and interactions applied.
Central Point	Used by the ZMR interaction for zooming and rotation in a canvas window.
Control Window	Permanent window named "Atlantis GUI". The window used by Atlantis for control and management. It contains Menu , Canvas Control , Interaction Control , Parameter Control and Output Display parts.
Display Window	Or Canvas . See Canvas .
Interaction Control (Control Window)	To select and control interactions .
Interactions	The real work! Zoom, move, rotate, select, special transformations, etc.
Menu (Control Window)	To select and print events, to set personal preferences, to get help and to reset Atlantis.
Modifier Key	Combinations of a keyboard key and a mouse key, that are used to generate pop-up menus or to perform interactions.
Output Display (Control Window)	Output area to display information about various topics, e.g. track information, pick information, cuts summary.
Pad, Canvas	See Canvas Pad .
Parameter Control (Control Window)	To view and modify Atlantis parameters.
Window, Control	See Control Window .
Window, Display	Or Canvas . See Canvas .
ZMR	Interaction to zoom, move and/or rotate a picture in a canvas pad .
New item	Description.