

# Table of Contents

What can BluStreak Tracer do?	1
Blu-Ray Disc Concepts	2
Blu-Ray Media	2
Disc Images and Build Folders	3
Transport and Elementary Streams	3
Blu-Ray Commands and Java	4
Presentation Layers	4
Tracer Workflow	5
A Tour of Tracer Windows	6
Job Window	6
Files Tab	7
BDCMF Tab	10
Source Tab	12
Playlists Tab	13
Tracing Tab	14
Playback Window	19
Remote Control Window	21
Progress Window	21
Tracing Execution	22
Choosing Which Commands are Displayed	22
Interpreting the Registers List	24
Commands Overview	25
How Execution Works	26
Buttons, Pages, Clips, Playlists, Play Items, Titles, Movie Objects	28
How Tracing Works	29
Using Command Breakpoints	30
Using Register Breakpoints	31

Editing Commands	32
Advanced Content Editing	33
Title Options	33
Movie Object Options	33
Menu Clip Options	34
Repeatable Play Items	34
Direct Clip Playback	35

## What can BluStreak Tracer do?

**BluStreak Tracer** is a Mac application that helps you prepare Blu-ray content for “mastering”, or transfer to a master disc. This preparation process is known as “premastering”.

There are two approaches to disc mastering, depending on the number of disc copies you will need, and on the production processes and costs you are prepared to incur.

For small or non-commercial projects, you will likely choose to burn read-only or re-writable disc media in a Blu-ray disc drive attached to your Mac. You can burn single- or double-layer discs, and you can repeat the burn operation to create multiple discs.

*Discs duplicated this way do **not** contain any content encryption.*

- Tracer allows you to customize your file layout and edit the commands that implement the disc’s menus and other functionality.
- Tracer contains a simplified Blu-ray player simulation which can show you the operation of your video, audio and interactive menu content.
- You can trace the player operation step by step, to diagnose and correct errors in the commands created by other applications earlier in the authoring process.
- Tracer burns discs to writable media directly, and exports disc images (which can be mounted in the Finder) to hard disk.
- Tracer can burn and export discs and disc images containing both command-based menus and Java-based (BDJ) menus, but it cannot interpret the contents of BDJ files.
- Tracer also cannot encode content: video, audio and other content streams must have been prepared before the premastering process is begun.
- Tracer can recover content from existing discs and disc images, provided they are not encrypted.

For large or commercial projects, you will likely send an image of your disc to a commercial replication facility, which will make a master disc for you, and then manufacture the number of copies you need. Because replication is expensive and sometimes difficult, extra premastering steps are required to ensure that the manufacturing process goes smoothly, especially for content encryption.

For such projects, Tracer can export **BDCMF** folders (containing a disc image plus the additional support files required by a replication facility) to hard disk, or burn **BDCMF** folders to writable media.

- Tracer can create **BDCMF** folders for data-only discs (“Type P”), as well as for discs with movie content (“Type A”). For data-only discs, the **BDCMF** folder is a packaging format only, as there is no content encryption in the manufacturing process.

# Blu-Ray Disc Concepts

## Blu-Ray Media

Blu-ray content can be written to four different kinds of physical media (discs): BD-ROM, BD-R, BD-RE and DVD.

### BD-ROM Media

This is the kind of disc on which commercial Blu-ray titles are manufactured. Production of BD-ROM discs requires a large replication facility, and is therefore practicable only for runs of 1,000 or more discs.

BD-ROM media is also the **only** type of media that supports encryption of the disc's contents. The encryption process is tightly controlled, and works as follows:

- During premastering, Tracer creates a set of incomplete files which are modified during mastering at the replication facility. These files are called **AACS files** because "AACS" is the Blu-ray content encryption system.
- When you are ready to deliver your disc to a replication facility for mastering, you send them a Tracer-created **BD-CMF** folder which contains all your disc's content, plus the incomplete AACS files and other support files.
- You **also** deliver to the replication facility an AACS encryption key that you have purchased from the licensing authority, AACS Licensing Administrator (<http://aacsla.com>).
- The replicator verifies all of the information you send them, then applies the encryption key to the content to produce the final master disc.

### BD-R Media

This is a kind of disc which you can write on a Blu-ray drive attached to your Mac. No AACS files are written, because there is no way to encrypt content on this media type.

BD-R is a good choice if you plan to distribute only tens or perhaps hundreds of copies of your disc. It is a write-once media type, so BD-R discs cannot be reused after burning.

### BD-RE Media

This type of disc is similar to BD-R except that it is re-writable — it may be erased and reused after burning.

BD-RE is a good choice of media type for testing your disc content. You can lay out your disc in Tracer, burn a BD-RE sample, and try it in a hardware Blu-ray player. If the disc plays to your satisfaction, you can then proceed to duplication onto BD-R media, or replication onto BD-ROM media.

### DVD Media

Many Blu-Ray players can play Blu-ray content from DVD media, so Tracer can burn your content to DVD media, either in a Blu-ray burner, or a regular DVD burner such as the one built into your Mac.

The drawback with DVD media is that discs hold much less content than BD media — 9 GB maximum for DVD, compared with 25 GB per layer for BD. However, if your content is small, DVD media is a cheaper alternative.

*For DVD disc media, Tracer can burn single- or dual-layers, on 8 cm or 12 cm discs.*

## Disc Images and Build Folders

While physical discs are the required medium of Blu-ray distribution, they are inconvenient as a means of data exchange during the authoring and premastering process.

It is usually much easier to avoid the extra step of burning a disc by using **disc images** instead. Disc images are regular files on your hard disk that contain a byte-for-byte representation of the data on a physical disc. You can move disc images between hard disks, or send them over a network between computers.

If a disc image file's name ends in a **“.ISO”** extension, it is possible to **mount** the disc image by double-clicking it in the Finder. This causes the disc image to appear in the Finder's “Devices” list, as if it were a disc you'd inserted into one of your drives.

Mounted Blu-ray disc images contain two top-level folders (**BDMV** and **CERTIFICATE**), and possibly other files and folders — conventionally called “ROM data” — placed there by your content authoring system.

Most content authoring systems, such as Adobe Encore, for example, can export disc images, which can be imported into Tracer. Usually, they can also export an ordinary folder, containing the **BDMV** and **CERTIFICATE** subfolders along with any ROM data.

Tracer can also import such **build folders**, without the need to create a disc image, but it's generally preferable to use a disc image whenever possible.

*In most respects, there is no difference between importing a disc image or a build folder into Tracer, except for discs containing video content with seamless multi-angle changes, for which a build folder lacks crucial layout information.*

## Transport and Elementary Streams

During content authoring, you assemble a collection of video and audio clips, along with subtitles, graphics and navigation menus, and a large part of the authoring process involves placing these elements in sequence on timelines.

Each sequence of similar elements is known as an **elementary stream**:

- **Primary video streams** are playable video content.
- **Secondary video streams** are additional video content for the picture-in-picture (PiP) function of Blu-ray players.
- **Primary audio streams** are the main audio track for primary video streams.
- **Secondary audio streams** are additional audio tracks for alternate languages, commentary or PiP content.
- **Text subtitle streams** are a basic means of providing subtitles for the primary and PiP video streams.
- **Presentation graphics (PG) streams** are non-interactive graphical elements that can be displayed over the primary video. In many movies, PG streams are used for subtitles instead of text subtitle streams.
- **Interactive graphics (IG) streams** are graphical elements, also displayed over the primary video, which can be designed to permit interaction with the viewer. IG streams are used for navigation menus, and (on some discs) for interactive games.

When your authoring system builds a disc, disc image or build folder, it generates all elementary streams needed for a given playback timeline, then multiplexes them into a single **transport stream** file.

*Multiplexing ensures that each piece of the content is available to the player at just the right time, so that it never needs to backtrack to find the information it needs — which would cause a “hitch” during playback.*

These transport stream files are named with a 5-digit number and a “**.M2TS**” extension. In addition, certain summary information about the transport stream files is provided in separate **clip information** files. Each clip information file has the same 5-digit number — the “clip number” — as the corresponding transport stream file, but with a “**.CLPI**” extension instead.

## Blu-Ray Commands and Java

Blu-ray content is presented to viewers using either of two models of control: Blu-ray commands, or a Blu-ray Java environment (“BDJ”).

Blu-ray commands are a relatively simple control “language” in which instructions to the playback mechanisms may be issued. Tracer understands this command language, allowing it to follow, or “trace”, the sequence of commands that plays back a title. [“Tracing Execution”](#) describes the command and tracing process in detail.

BDJ is like a complete computer system within the Blu-ray player. BDJ is also capable of sending requests for additional information and content to web sites, if the player has a network connection.

*Tracer does not contain a BDJ environment, and therefore cannot play back BDJ titles. It can, however, premaster such titles.*

## Presentation Layers

When your Blu-ray disc is playing back, the on-screen image seen by the viewer is composed of up to four layers:

1. Main video. This is the feature being played back, or the video background of a non-popup menu.
2. PiP video. This may be visible only when requested by the viewer.
3. Presentation graphics or text subtitles. Only one of the two types of stream may be displayed at once.
4. Interactive graphics. These represent the on-screen navigation system, or interactive content such as games.

Generally, all of these layers are coordinated in appearance to provide a unified video experience for the viewer.

*If the disc uses BDJ for playback, then the actual layer structure is up to the controlling BDJ program.*

## Tracer Workflow

Tracer treats the content for each disc as a separate “job.” You create a new job by importing the content into Tracer, starting from one of the following sources:

- A **disc image file** created by an authoring application such as Adobe Encore. This file corresponds to an entire Blu-ray disc, within which is a **BDMV** folder, a **CERTIFICATE** folder and possibly other files and folders needed on the final disc. Tracer imports all of the **BDMV** information except for non-interactive elementary streams, and maintains a reference to the image file so that streams can be located for playback and export
- A **build folder** containing **BDMV** and other subfolders. Tracer imports the same information as it does from a disc image file, and maintains a reference to the build folder.
- A **BDCMF** folder. **BDCMF** folders are created by Tracer’s export functions, or by the export functions of other applications you might have used in the past. Tracer requires that you **extract** a disc image file containing the disc content, discarding other information that was added during the **BDCMF** creation process.
- A Blu-ray disc. In this case, Tracer requires that you first extract an image file onto hard disk, so that it can find the disc content without requiring you to keep the disc in the disc drive.

*Note that you cannot extract a disc image from a replicated (encrypted) disc.*

Once the import is complete, Tracer shows you the disc layout and content in a **job window**. Later sections describe in detail how to work with job windows. When you have prepared the job to your satisfaction, you can immediately export the job, in one of the following ways:

- You can burn the job directly to blank or rewritable media. This disc can be played in a hardware Blu-ray player as soon as burning is complete.
- You can create a disc image as a file on your hard disk. Image files are sometimes used as an interchange format between various software applications.
- You can create a **BDCMF** folder on your hard disk.
- You can burn a **BDCMF** folder directly to blank or rewritable media.

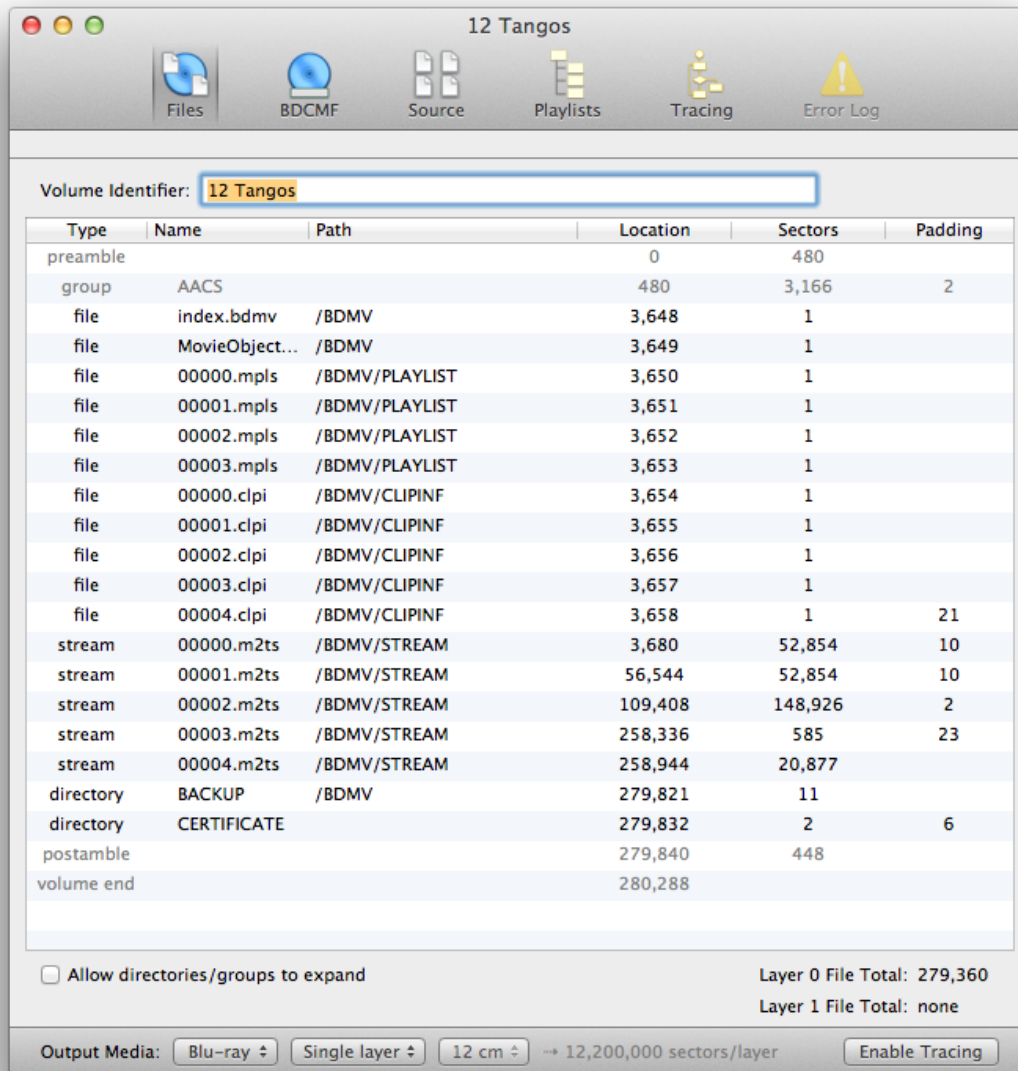
In the last two cases, the job’s content is embedded as a disc image within the **BDCMF** folder. This **BDCMF** folder can be sent to a replication facility.

As an alternative to exporting your job immediately, you can choose to **save** the job on your hard disk. Saving the job is often desirable, because it means you will not lose your file layout and other job parameters when you quit Tracer, in case you need to repeat the export later on.

# A Tour of Tracer Windows

## Job Window

The job window is where you examine and lay out the files of your Tracer job. It normally contains six “tabs” (switchable views):



Across the top of the window you can see the six tabs (**Files**, **BDCMF**, **Source**, **Playlists**, **Tracing** and **Error Log**). You can switch between the tabs by clicking on the tab titles or icons.

*The Error Log tab is disabled unless there are errors to report.*



## Files Tab

At the top of the **Files** tab is the **Volume Identifier**, or name of the disc being produced. It is obtained from the imported disc image, if available, or from the name of the imported folder, but you can change it if you wish.

Most of the **Files** tab is taken up by a list of the files in your disc. Note that some rows are have black text and some are gray. Black rows may be freely reordered, though the initial order is the recommended one. Gray rows are fixed in the file order by the Blu-ray specification, and cannot be reordered manually. The columns in the list have the following meanings:

- The lock icon indicates a file whose physical location on the disc is fixed. This applies only to the beginning and end of the disc.
- **Type** indicates what kind of item the row represents:
  - **file** indicates a content file other than a transport stream file. Non-stream files are typically quite small.
  - **stream** indicates a transport stream file. These files can be very large, up to the disc capacity of about 50 GB (25 GB per layer).
  - **stereo** indicates a composite transport stream containing “stereo” (left- and right-eye) video streams for 3D presentation.
  - **mirror** indicates a file that is a backup copy of another file on the disc.
  - **directory** indicates a directory, other than the **BDMV** directory, that will contain files in the output disc.
  - **group** indicates a collection of files that are listed as a single item, to prevent clutter in the file list.
  - **preamble** and **postamble** indicate required sectors at the beginning and end of the disc, which describe the structure of the disc itself. Tracer maintains these sectors automatically.
  - **volume end** marks the end of the information that will be recorded on the disc.
  - **layer break** marks the position of the layer break, for a dual-layer disc layout.
- **Name** is the name of the file, directory, group, or other item that the row represents.
- **Path** is the disc-relative path of the file or directory. Most files are in the **BDMV** subdirectory, or one of its sub-sub-directories. There may be a few files at the top level of the disc’s directory structure, which has no path.
- **Location** is the sector number of the start of the file or — in the case of a directory or group — the first file in the directory or group.

*Sector numbers represent physical locations on a Blu-ray disc at which data is recorded.*

- **Sectors** is the number of sectors occupied by the file or — in the case of a directory or group — all of the files in the directory or group.

*A sector is 2 KB, or 2048 bytes.*

- **Padding** is the number of wasted sectors between the end of the file (or files) represented by the row and the location of the next row. Padding is required by the Blu-ray specification for some files.

Below the list is the **Allow directories/groups to expand** checkbox. Also shown are the total layer sizes, again in sectors.

**Allow directories/groups to expand** does not affect the layout of the job, but just changes the way the files are displayed in the **Files** tab. When it is checked, the file list allows you to examine the contents of the various directories and groups:

12 Tangos

Files BDCMF Source Playlists Tracing Error Log

Volume Identifier: 12 Tangos

Type	Name	Path	Location	Sectors	Padding
file	00001.clpi	/BDMV/CLIPINF	3,655	1	
file	00002.clpi	/BDMV/CLIPINF	3,656	1	
file	00003.clpi	/BDMV/CLIPINF	3,657	1	
file	00004.clpi	/BDMV/CLIPINF	3,658	1	21
stream	00000.m2ts	/BDMV/STREAM	3,680	52,854	10
stream	00001.m2ts	/BDMV/STREAM	56,544	52,854	10
stream	00002.m2ts	/BDMV/STREAM	109,408	148,926	2
stream	00003.m2ts	/BDMV/STREAM	258,336	585	23
stream	00004.m2ts	/BDMV/STREAM	258,944	20,877	
directory	▼ BACKUP	/BDMV			
directory	► PLAYLIST	/BDMV/BACKUP	279,821	4	
directory	▼ CLIPINF	/BDMV/BACKUP			
mirror	00000.clpi	/BDMV/BACKUP/CLIPINF	279,825	1	
mirror	00001.clpi	/BDMV/BACKUP/CLIPINF	279,826	1	
mirror	00002.clpi	/BDMV/BACKUP/CLIPINF	279,827	1	
mirror	00003.clpi	/BDMV/BACKUP/CLIPINF	279,828	1	
mirror	00004.clpi	/BDMV/BACKUP/CLIPINF	279,829	1	
mirror	index.bdmv	/BDMV/BACKUP	279,830	1	
mirror	MovieObje...	/BDMV/BACKUP	279,831	1	
directory	▼ CERTIFICATE				
file	id.bdmv	/CERTIFICATE	279,832	1	
directory	► BACKUP	/CERTIFICATE	279,833	1	6
postamble			279,840	448	
volume end			280,288		

☒ Allow directories/groups to expand

Layer 0 File Total: 279,360  
Layer 1 File Total: none

Output Media: Blu-ray ◂ Single layer ◂ 12 cm ◂ → 12,200,000 sectors/layer Enable Tracing

This level of detail is rarely useful, though.

The layer sizes show you the total size in sectors of the files placed on each layer of the disc.

*Layers are typically larger than the total size of the files they contain, due to layout overheads imposed by the Blu-ray specification.*

In the toolbar area along the bottom of the window, the **Output Media** menus tell Tracer what kind of media you will be using, if you decide to burn a disc image or **BDCMF** folder to blank media. You can choose between **Blu-ray** or **DVD** and **Single Layer** or **Dual Layer** media. If you choose **DVD** media, you can also choose the media size (**8 cm** or **12 cm**). To the right of these choices, informational text tells you how many sectors you will be able to store on each layer of the chosen media.

The last button in the toolbar is the **Enable Tracing** button, which appears in this position of all tabs. It is used for tracing and debugging the behavior of the disc. See “[Tracing Execution](#)” for more information.

### Layer Breaks

When you import a job, Tracer tries to distinguish between a single- or dual-layer disc based on the sizes of the files on the disc.

*It is a quirk of the Blu-ray format that a disc image or build folder does not contain any information about where the layer break should be, or even if the disc is intended to be dual-layer.*

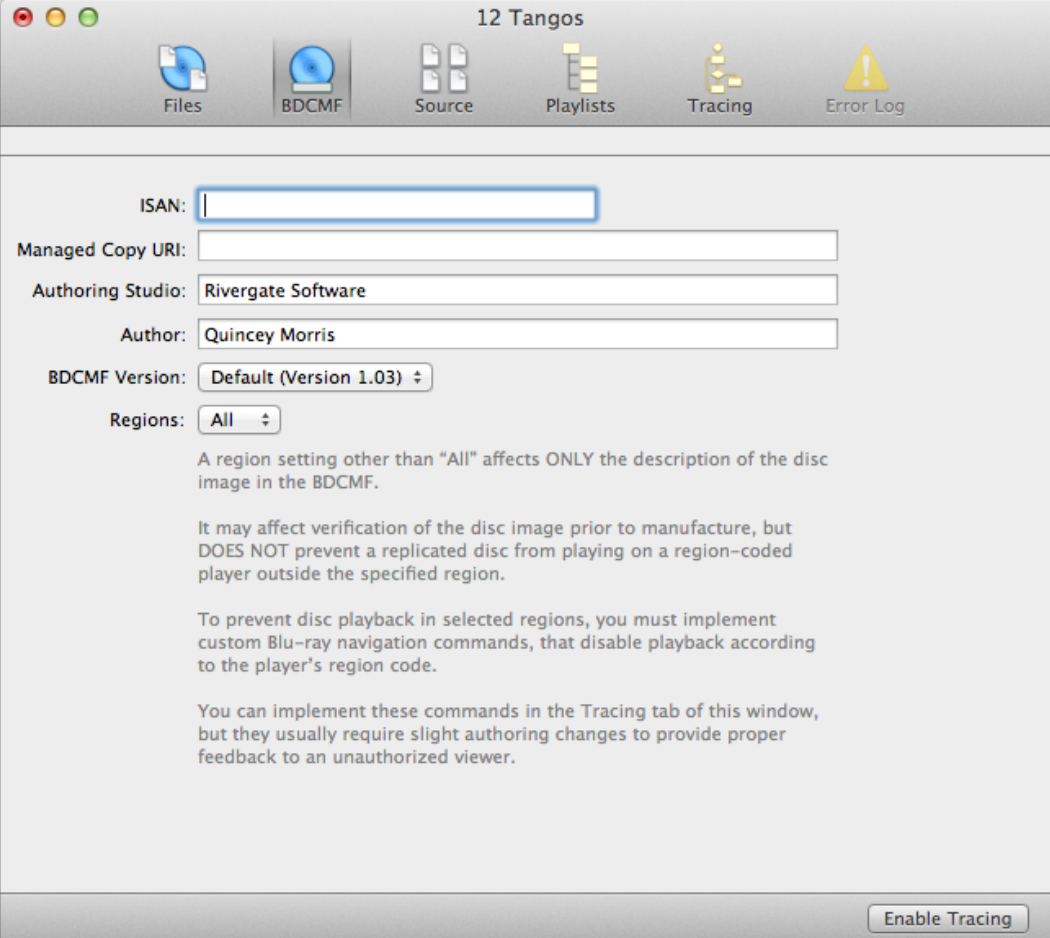
If the files will not fit on a single layer, Tracer chooses a dual-layer layout, and places a layer break between two files so that both layers are within the capacity of the disc media. If necessary — if the disc contains a file that is too large to fit on a single layer — Tracer will automatically split the large file into two parts, and put each part on a separate layer.

*Unlike DVD players, Blu-ray players can play seamlessly across the layer break in all but the most exceptional circumstances. There is no need for careful manual placement of the layer break, as there is with DVDs, so placement is automatic in Tracer.*

## BDCMF Tab

The **BDCMF** tab contains information that will be used for mastering your disc at a replication facility.

*The ability to export and burn **BDCMF** folders using this information is an add-on capability of Tracer.*



The screenshot shows the '12 Tangos' application window with the 'BDCMF' tab selected. The interface includes a toolbar with icons for Files, BDCMF, Source, Playlists, Tracing, and Error Log. The main content area contains several input fields and a dropdown menu for BDCMF settings. The 'ISAN' field is empty. The 'Managed Copy URI' field is empty. The 'Authoring Studio' field contains 'Rivergate Software'. The 'Author' field contains 'Quincey Morris'. The 'BDCMF Version' dropdown is set to 'Default (Version 1.03)'. The 'Regions' dropdown is set to 'All'. Below these fields, there is explanatory text about region settings and playback. At the bottom right, there is an 'Enable Tracing' button.

12 Tangos

Files BDCMF Source Playlists Tracing Error Log

ISAN:

Managed Copy URI:

Authoring Studio:

Author:

BDCMF Version:

Regions:

A region setting other than "All" affects ONLY the description of the disc image in the BDCMF.

It may affect verification of the disc image prior to manufacture, but DOES NOT prevent a replicated disc from playing on a region-coded player outside the specified region.

To prevent disc playback in selected regions, you must implement custom Blu-ray navigation commands, that disable playback according to the player's region code.

You can implement these commands in the Tracing tab of this window, but they usually require slight authoring changes to provide proper feedback to an unauthorized viewer.

Most of this information is optional or can safely be left at default values.

- **ISAN** (International Standard Audiovisual Number) is a global identification number similar to the ISBN that identifies books. You do not need to specify an ISAN unless your replicator, or your own business requirements, demand one. Visit [www.isan.org](http://www.isan.org) for more information.
- **Managed Copy URI** is a web link that allows BDJ-enabled Blu-ray players to contact your web site, if your disc contains any BDJ interactive content. This is optional unless your disc design requires it.

- **Authoring Studio** and **Author** are informational, and are included in **BDCMF** output for the benefit of the replication facility. You can set a default authoring studio for new jobs in the Tracer preferences (choose **Preferences...** from the **BluStreak Tracer** menu). The author defaults to your login user name.
- **BDCMF Version** is normally left as **Default**, which currently means **BDCMF** file format version 1.03. In rare cases, your replication facility may require your **BDCMF** output to specify a different version. In that case, you can choose a specific version from this popup menu.

*There is essentially no difference between the output produced by Tracer for the different versions, aside from the version number itself.*

- **Regions** may be set to **All**, or any combination of **A** (Americas), **B** (Europe/Africa) or **C** (Asia/Australia). **All** is strongly recommended.

### Using the Regions Setting

The **BDCMF** tab allows you to specify region limitations for your disc, but Blu-ray's handling of regions is counter-intuitive — especially if you are familiar with region restrictions in DVDs.

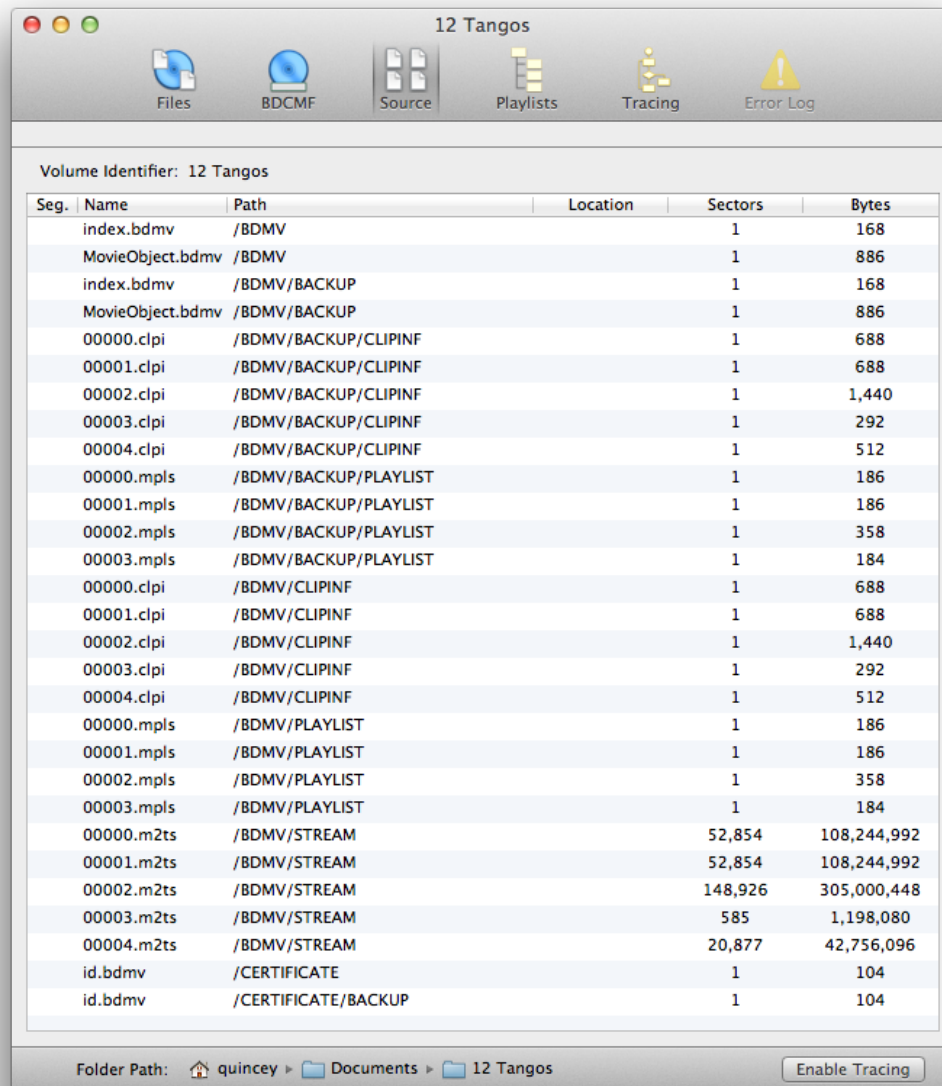
Any region restrictions you specify here are simply documentation of your intention, primarily for the benefit of your replicator, who may use the information in verifying your disc. For example, if you specify region A (USA) only, but your content has only German-language audio, the replicator may query the correctness of your content, since German is a region B (Europe and Africa) language.

It's strongly recommended that you don't use region restrictions at all, but if you must do so, you should consider the following issues:

- Many Blu-ray players have no region restriction for playback. This is especially true for players sold to consumers in the countries covered by region B and region C (Asia and Australia). Such players will play back all discs, regardless of your intentions.
- Blu-ray players with a region restriction do **not** prevent playback automatically. Instead, you are responsible for providing Blu-ray navigation commands that implement the restriction behavior you want. In most cases, you will need to provide content (video stills, at least) to display an error screen when the restriction is violated — Blu-ray players have no built-in mechanism for this. That is, adding region restrictions usually requires some slight re-authoring of the disc.
- It is not difficult to add Blu-ray navigation commands to prevent playback on restricted players — though it does require some basic programming skills — but it will add a step to the mastering process. You should allow additional time to design and test the commands.

## Source Tab

The **Source** tab lists the files that Tracer imported to produce the output file layout shown in the **Files** tab. Its columns are similar to those in the **Files** tab, although somewhat simpler. Note that a sector location is shown only when the source is a disc image, and not when it is a build folder.

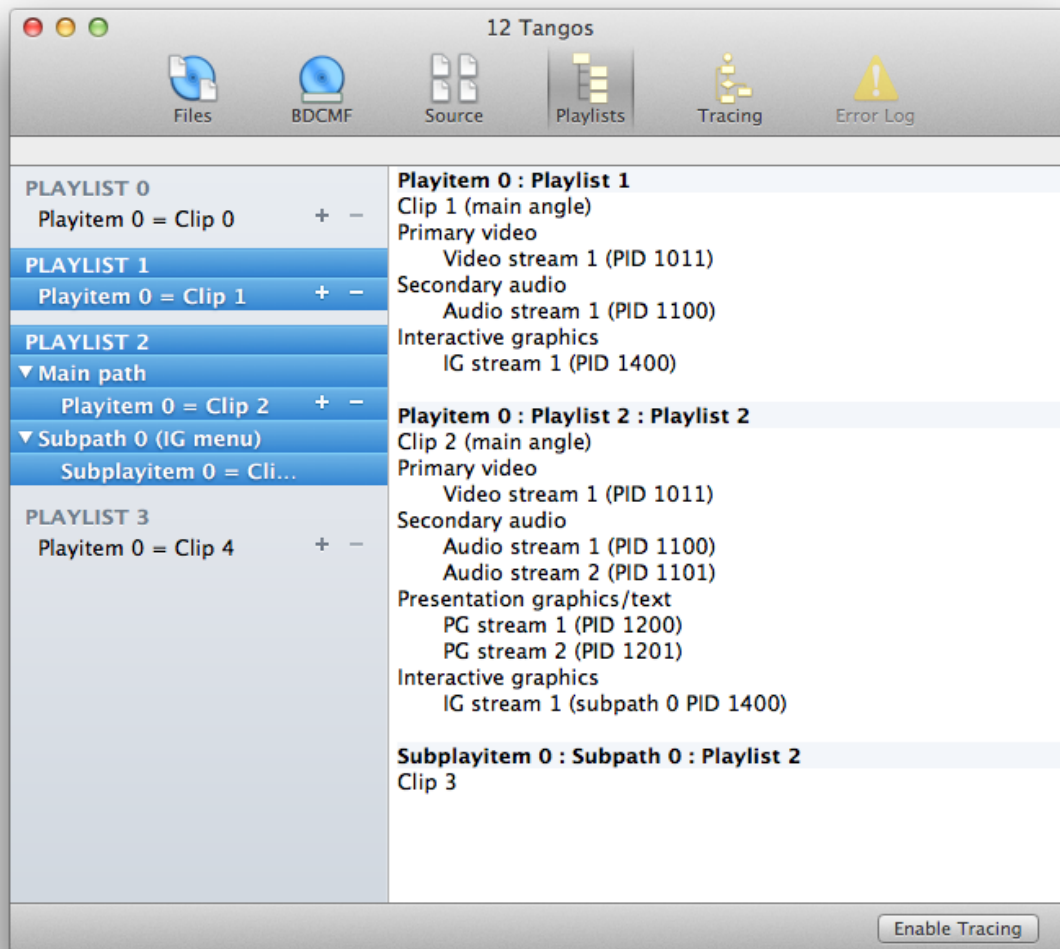


Seg.	Name	Path	Location	Sectors	Bytes
	index.bdmv	/BDMV		1	168
	MovieObject.bdmv	/BDMV		1	886
	index.bdmv	/BDMV/BACKUP		1	168
	MovieObject.bdmv	/BDMV/BACKUP		1	886
	00000.clpi	/BDMV/BACKUP/CLIPINF		1	688
	00001.clpi	/BDMV/BACKUP/CLIPINF		1	688
	00002.clpi	/BDMV/BACKUP/CLIPINF		1	1,440
	00003.clpi	/BDMV/BACKUP/CLIPINF		1	292
	00004.clpi	/BDMV/BACKUP/CLIPINF		1	512
	00000.mpls	/BDMV/BACKUP/PLAYLIST		1	186
	00001.mpls	/BDMV/BACKUP/PLAYLIST		1	186
	00002.mpls	/BDMV/BACKUP/PLAYLIST		1	358
	00003.mpls	/BDMV/BACKUP/PLAYLIST		1	184
	00000.clpi	/BDMV/CLIPINF		1	688
	00001.clpi	/BDMV/CLIPINF		1	688
	00002.clpi	/BDMV/CLIPINF		1	1,440
	00003.clpi	/BDMV/CLIPINF		1	292
	00004.clpi	/BDMV/CLIPINF		1	512
	00000.mpls	/BDMV/PLAYLIST		1	186
	00001.mpls	/BDMV/PLAYLIST		1	186
	00002.mpls	/BDMV/PLAYLIST		1	358
	00003.mpls	/BDMV/PLAYLIST		1	184
	00000.m2ts	/BDMV/STREAM		52,854	108,244,992
	00001.m2ts	/BDMV/STREAM		52,854	108,244,992
	00002.m2ts	/BDMV/STREAM		148,926	305,000,448
	00003.m2ts	/BDMV/STREAM		585	1,198,080
	00004.m2ts	/BDMV/STREAM		20,877	42,756,096
	id.bdmv	/CERTIFICATE		1	104
	id.bdmv	/CERTIFICATE/BACKUP		1	104

Also, when the source is a disc image, the files may have been broken into segments which might appear in any physical order. The **Seg.** column indicates the logical order of such segments.

## Playlists Tab

The **Playlists** tab shows the disc's **playlists**, which are groupings of video, audio and other content that are played as a unit:



A disc whose content is a movie will often have one playlist that represent the whole movie, plus other playlists that represent special features and the video loops that play behind the on-screen navigation menus.

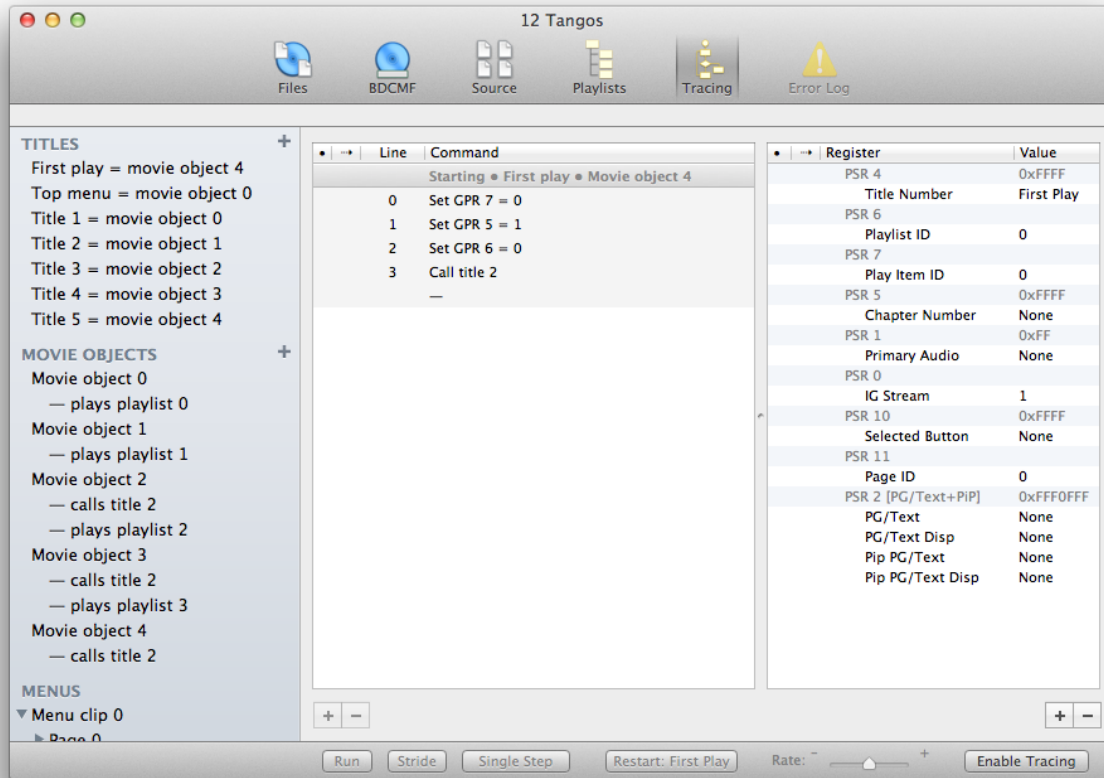
Playlist numbers correspond to the names of the **XXXXX.mpls** files in the **Files** tab.

You can view details of the playlists by selecting one or more items in the list on the left of the tab. Detailed information for the selection appears on the right.

*The + and – buttons next to some items in the list allow those items to be repeated automatically. See [“Advanced Content Editing”](#) for details.*

## Tracing Tab

The **Tracing** tab describes the behavior of your disc, and allows you to follow the player state during the execution of the Blu-ray **commands** that control the way content is presented to a person viewing the disc.



This is the most complex of the job window tabs, and consists of three main areas: the **content list**, the **command list**, and **player registers**.

### Content List

The leftmost area shows the imported content of your disc that relates to playback behavior. It consists, in turn, of three sections:

- The first section shows **titles**, which are the basic video components of the disc from the viewer's point of view. The viewer, using on-screen navigation menus and a remote control, ultimately selects a title for playback. Some Blu-ray players have a control-panel display that allows direct selection of titles.

Listed first are two special titles: the **first play** title that always plays when the disc is inserted and contains copyright warnings and other similar information that should never be skipped by the viewer, and the **top menu** title that contains the disc's main on-screen navigation menu that is displayed when the viewer presses the **Top Menu** (or similarly named) button on the remote control.



For all practical purposes, titles are merely cross-references to “movie objects” that contain Blu-ray commands. You can click the arrow to the right of any title to select the corresponding movie object.

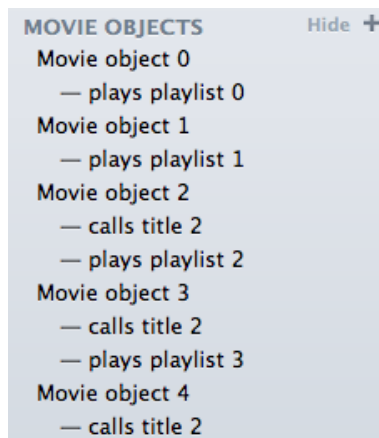


You may occasionally wish to create or delete titles. To add a title, click the + button to the right of the section heading. To delete a title, click the – button to the right of its name.

*You can only delete a title when it has been disassociated from its movie object.*

Titles have several behavioral options that you might rarely need to edit. These are discussed in [“Advanced Content Editing”](#).

- The second section shows **movie objects**:



The main purpose of movie objects is to hold sets of Blu-ray commands, as you’ll see below.

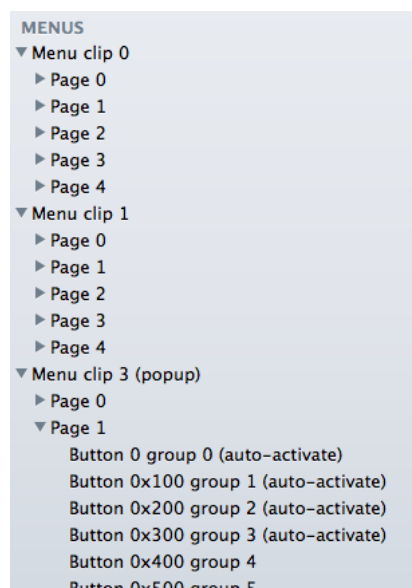
*A movie object can be shared by different titles.*

Sometimes, when you need to edit commands to alter or correct the disc’s playback behavior, you’ll need to add a new movie object. To create a new movie object, click the + button to the right of the section heading. To delete a movie object, click the – button to the right of its name.

*You can only delete movie objects when they’re no longer associated with a title.*

Each movie object also has several behavioral options. These are discussed in [“Advanced Content Editing”](#).

- The third section shows **menu clips**, or interactive menu definitions:



Clip numbers correspond to the names of the **XXXXX.clpi** (clip information) and **XXXXX.m2ts** (transport stream) files in the **Files** tab, but only files that actually contain menus are shown in this list.

Each menu clip consists of **pages**, which represent different menu displays (from the viewer’s point of view) or different states of the same menu display.

Each page consists of **buttons** and **button groups**. In Blu-ray terminology, “button groups” are actually what the viewer thinks of as buttons, while “buttons” in a group are the different options that the group provides.

Each button has an associated set of commands which are executed whenever the button is activated, either automatically when selected, or manually when the viewer presses the **OK** button on the player’s remote control.

Each button’s description in the list shows the group that the button belongs to, and whether the button auto-activates (executes its commands when selected).

Menu clips, like movie objects, have options which you see if you select a single menu clip. These are discussed in [“Advanced Content Editing”](#).

If the information shown in the content list seems complex to you, you are not mistaken — it is complex. Blu-ray has a very flexible and powerful playback architecture, which allows Blu-ray discs to be considerably more sophisticated than standard DVDs. It is usually easier to understand the disc behavior by following the actual flow of command execution, and that is where Tracer’s command tracing abilities will come to your assistance.

## Command List

The central area of the **Tracing** tab shows one or more command sets, each preceded by a heading that describes the source of the commands (title and/or movie object, or button):

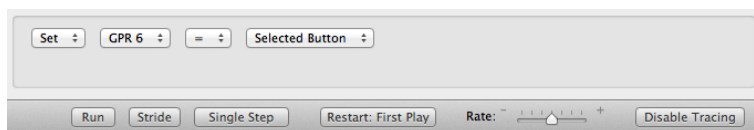
Executing • Button 0 group 0 (auto-activate) • Page 0 • Menu clip 1	
➡	0 If GPR 5 EQ 0 1 Set GPR 5 = 1 2 If GPR 5 GT 4 3 Set GPR 5 = 1 4 Set button GPR 6   page GPR 5 effects on —
Interrupted • Title 2 • Movie object 1	
⇒	0 Set GPR 0 = 2 1 If GPR 7 EQ 0 2 Play playlist 1 from item 0 3 Set GPR 5 = [Page ID] 4 Set GPR 6 = [Selected Button] 5 Set GPR 8 = 0xFFFFFFFF 6 Play playlist 1 from item 0 7 Set GPR 5 = [Page ID] 8 Set GPR 6 = [Selected Button] 9 Go to line 6 10 Set GPR 4 = GPR 3 11 Set GPR 3 = 0 12 If GPR 4 NE 0 13 Jump to title GPR 4 —
Suspended • First play • Movie object 4	
⇒	0 Set GPR 7 = 0 1 Set GPR 5 = 1 2 Set GPR 6 = 0 3 Call title 2 —
Movie object 0	
	0 Set GPR 0 = 1 1 If GPR 7 EQ 0 2 Play playlist 0 from item 0 3 Set GPR 5 = [Page ID] 4 Set GPR 6 = [Selected Button] 5 Set GPR 8 = 0xFFFFFFFF 6 Play playlist 0 from item 0 7 Set GPR 5 = [Page ID] 8 Set GPR 6 = [Selected Button]

- The first one, two or three command sets represent commands that are being executed: (1) an optional button command set, (2) an in-progress movie object command set, and (3) an optional suspended movie object command set. All of these command sets have a colored background: yellow for the current execution, and orange for interrupted or suspended executions.

*For performance reasons, executing command sets are shown only when tracing is enabled using the **Enable Tracing** button in the bottom right corner of the window.*

- Next in the list after the executing command sets are command sets for any titles, movie objects or buttons you have selected in the content list to the left. This allows to view and compare multiple command sets at one time. Command sets for selected content items are shown with a white background.
- The + and – buttons below the list are used to add and remove commands.

- There is an inset command editing area at the bottom of the window used for editing commands. Select a single command to see this editing area. Command editing is described later, in [“Editing Commands”](#).



- The **Run**, **Stride**, **Single Step**, **Restart** and **Enable Tracing** buttons and the **Rate** slider control the way commands execute. They are described in [“Tracing Execution”](#).

## Player Registers

Third main area of the **Tracing** tab shows player **registers** (status values). Two kinds of registers may be shown in the list: Player Status Registers (PSRs) and General Purpose Registers (GPRs).

Register	Value
GPR 0	2
GPR 5	1
PSR 4	
Title Number	2
PSR 6	
▶ Playlist ID	1
PSR 7	
Play Item ID	0
PSR 5	0xFFFF
Chapter Number	None
PSR 1	0xFF
Primary Audio	None
PSR 0	
IG Stream	1
PSR 10	
▶ Selected Button	0
PSR 11	
Page ID	0
PSR 2 [PG/Text+PIP]	0xFFFFFFF
PG/Text	None
PG/Text Disp	None
Pip PG/Text	None
Pip PG/Text Disp	None

There are about 30 different PSRs, which indicate the current state of the player. For example, the first one (**Title Number**) is the currently executing title. Some PSRs are set automatically by the player, while others are affected by commands.

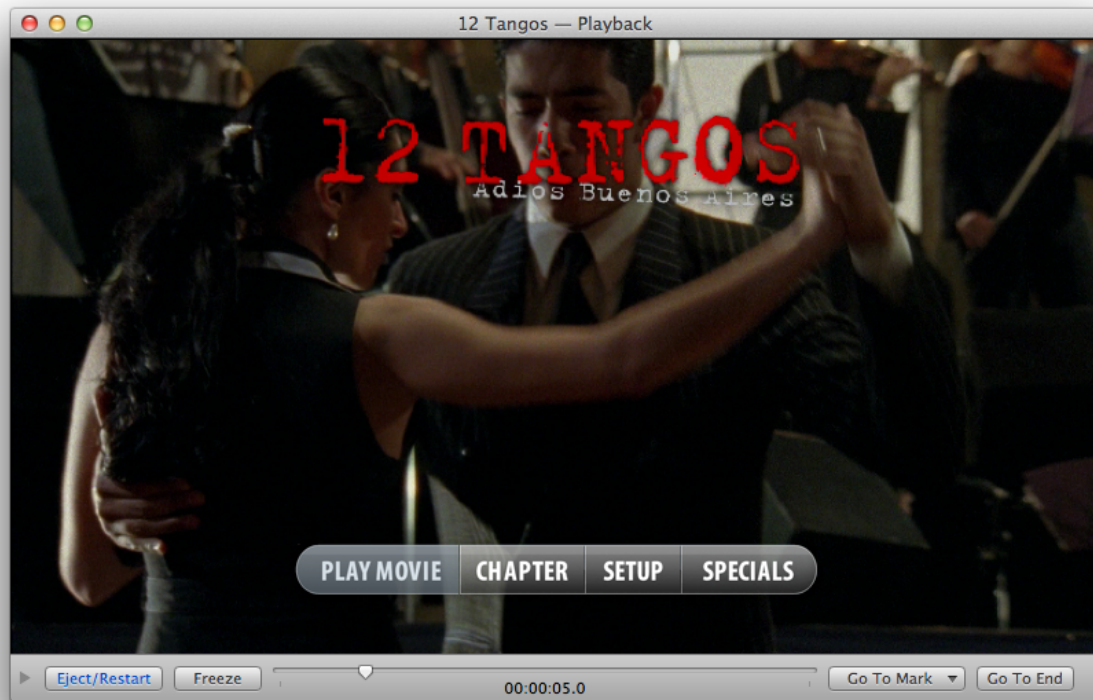
There are 4096 different GPRs, though the list only shows the ones that have been explicitly requested for display, directly by you or indirectly by commands executed or edited. The values contained in the GPRs are normally set by commands, but you can change them manually if you wish, by double-clicking a number in the **Value** column to make it editable.

*A blue arrow is shown next to a register value that was changed by the last-executed navigation command.*

By default, the registers list displays a preselected subset of the PSRs, and GPRs are added to the list automatically when their values are changed. You can customize what is shown in the list by using the + and – buttons below the list, and re-order the items in the list by dragging them up or down within the list.

*The behavior of the disc is not affected by what is displayed or not displayed in the registers list. The list is for your convenience only.*

## Playback Window



The playback window is a simplified Blu-ray player that shows what your job will look like and how it will behave when your manufactured disc is inserted into a viewer's Blu-ray player. The buttons at the bottom of the window do not represent controls available to the viewer, but are aids to the process of debugging the disc's commands:

- The **Insert/Start** or **Eject/Restart** button simulates the process of inserting and removing a disc from a Blu-ray player. Initially, after you import or open a job, the Tracer player is inactive: click **Insert/Start** to begin playback as if the disc were inserted. Once the disc is playing, the button changes to an **Eject/Restart** button: click **Eject/Restart** to return the player to its inactive state.
- The **Freeze/Unfreeze** button controls whether the player displays the video and audio of the current playlist normally, in real time, or freezes playback at the current frame. This does not represent a viewer's ability to play or pause the movie using the remote control, but is merely a convenient way of freezing the player state so that you can examine content and commands in the job window without having the current playlist end before you are ready.
- The **Go to End** button serves the opposite purpose. It forces the current playlist to end immediately, even if there is still some un-played content. Again, it is not a viewer function, but a convenience for you, if want to follow the disc's behavior without waiting for an entire movie to play to completion.
- The **Go To Mark** button is a pull-down menu that gives you access to the playback "marks" for the current playlist. Typically marks represent the chapters or scenes of a movie feature, and are used by the disc's commands to im-

plement a scene selection menu. You can choose any of the marks from the button's menu to skip to the corresponding time code.

### Showing Button Borders

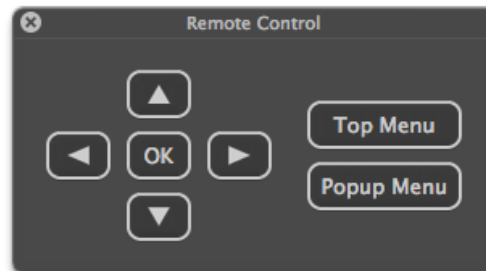
During playback of on-screen navigation menus, it can be difficult relate the screen's appearance to the various buttons in the the **Tracing** tab's content list. If you're not sure which button represents which on-screen menu choice, you can use **Show Menu Button Borders** on the **Playback** menu.

When enabled, this option shows a colored border around each button that's currently displayed, along with the button number, page number and menu clip number:



## Remote Control Window

The remote control window simulates a very basic remote control used to navigate a disc's on-screen menus. It contains **Up**, **Down**, **Left** and **Right** buttons which are used to select on-screen buttons in the playback window, and an **OK** button which activates the selected on-screen button:

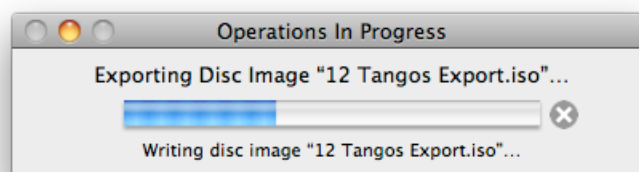


The **Top Menu** button forces the player to jump to the commands in the top-menu title shown in the content list of the **Tracing** tab of the job window. The **Popup Menu** alternately hides or shows the current popup menu, if there is one.

*You can also select and activate a button directly by clicking on it in the playback window.*

## Progress Window

When performing certain lengthy operations, such as importing or exporting discs, Tracer shows the progress of the operation in a separate progress window:



When this window appears, Tracer is performing the requested operation in the background, and you can continue working on the same or another disc simultaneously.

*It is safe to make changes to a job while it is being exported — the export operation outputs the job in its state at the time the export was started, and subsequent changes do not affect the in-progress export operation.*



# Tracing Execution

The job window's **Tracing** tab is your control center for monitoring, debugging and editing your disc's behavior. Everything in this tab relates to the various sets of commands that define this behavior. Remember that every movie object and every button may have a set of commands attached.

## Choosing Which Commands are Displayed

By default, Tracer displays only the currently executing command sets in the **Tracing** tab's command list, but you can display additional command sets by selecting titles, movie objects or menus in the content list at the left of the tab.

Here's an example of a small command set displayed in the **Tracing** tab, as it would appear immediately after importing:

Line	Command
Starting • First play • Movie object 4	
0	Set GPR 7 = 0
1	Set GPR 5 = 1
2	Set GPR 6 = 0
3	Call title 2
—	

This is the disc's first-play command set. Notice that the commands are shown with a gray background, indicating that tracing is not yet enabled. If you click the **Enable Tracing** button at the bottom right of the window, you will see more information about the execution state:

Line	Command
Executing • First play • Movie object 4	
➡ 0	Set GPR 7 = 0
1	Set GPR 5 = 1
2	Set GPR 6 = 0
3	Call title 2
—	

- Every command is shown with a sequential line number, starting from zero.
- The solid green arrow indicates which command is going to be executed next. When a command has started executing, but hasn't finished, the arrow becomes a hollow outline.

*Most commands finish executing instantly, so you'll only see the hollow arrow in special cases, most often with a **Play** command, which waits for video playback to end before completing execution, or a **Call** command, which is suspended while commands in a different command set to finish.*

- The yellow background indicates that this command set is currently executing. It's possible for command sets to be "interrupted" or "suspended" — temporarily prevented from executing while some other command set gains control. Interrupted and suspended command sets have an orange background. Here's what this same command set looks like when it's executing line 3, which is a **Call** command that might take a while to complete execution:

Suspended • First play • Movie object 4	
0	Set GPR 7 = 0
1	Set GPR 5 = 1
2	Set GPR 6 = 0
⇨ 3	Call title 2
—	



Line 3 has “called” the command set in title 2’s movie object, which is now the current command set:

Line	Command
Executing • Title 2 • Movie object 1	
0	Set GPR 0 = 2
1	If GPR 7 EQ 0
2	Play playlist 1 from item 0
3	Set GPR 5 = [Page ID]
4	Set GPR 6 = [Selected Button]
5	Set GPR 8 = 0xFFFFFFFF
6	Play playlist 1 from item 0
7	Set GPR 5 = [Page ID]
8	Set GPR 6 = [Selected Button]
9	Go to line 6
10	Set GPR 4 = GPR 3
11	Set GPR 3 = 0
12	If GPR 4 NE 0
13	Jump to title GPR 4
—	—

*If you’re not sure which command set you’re seeing, you can orient yourself by looking at the heading of the command set. It shows the title number and movie object number to which the displayed commands belong.*

- Button commands look this this:

Button 0x300 group 3 (auto-activate) • Page 3 • Menu clip 0	
0	Set button 768   page 1 effects on
—	—

*Note the white background in this example. It means this command set is not currently executing, but has merely been selected in the content list.*

- If a button command set is executing, it will be shown at the top of the command list. Here’s what our earlier example looks like it has executed a bit further and things have gotten a bit more interesting:

Line	Command
Executing • Button 0 group 0 (auto-activate) • Page 0 • Me...	
0	If GPR 5 EQ 0
1	Set GPR 5 = 1
2	If GPR 5 GT 4
3	Set GPR 5 = 1
4	Set button GPR 6   page GPR 5 effects on
—	—
Interrupted • Title 2 • Movie object 1	
0	Set GPR 0 = 2
1	If GPR 7 EQ 0
2	Play playlist 1 from item 0
3	Set GPR 5 = [Page ID]
4	Set GPR 6 = [Selected Button]
5	Set GPR 8 = 0xFFFFFFFF
6	Play playlist 1 from item 0
7	Set GPR 5 = [Page ID]
8	Set GPR 6 = [Selected Button]
9	Go to line 6
10	Set GPR 4 = GPR 3
11	Set GPR 3 = 0
12	If GPR 4 NE 0
13	Jump to title GPR 4
—	—
Suspended • First play • Movie object 4	
0	Set GPR 7 = 0
1	Set GPR 5 = 1
2	Set GPR 6 = 0
3	Call title 2
—	—

The command list tells you that the first-play title was suspended to execute title 2, which became busy playing content, which in its turn was interrupted to execute the commands for button 0 of page 0 of menu clip 1.

## Interpreting the Registers List

Knowing what commands a disc will execute is only part of the story, when it comes to understanding the disc's play-back behavior. You will also, usually, need to know the internal state of the player. This information is contained in the player's registers, shown in the registers list:

Register	Value
PSR 4	0xFFFF
Title Number	First Play
PSR 6	
Playlist ID	0
PSR 7	
Play Item ID	0
PSR 5	0xFFFF
Chapter Number	None
PSR 1	0xFF
Primary Audio	None
PSR 0	
IG Stream	1
PSR 10	0xFFFF
Selected Button	None
PSR 11	
Page ID	0
PSR 2 [PG/Text+PIP]	0xFFFF0FFF
PG/Text	None
PG/Text Disp	None
Pip PG/Text	None
Pip PG/Text Disp	None

As previously discussed, there are 4096 General Purpose Registers (GPRs) and a number of Player Status Registers (PSRs). Many of them are not of interest (or not used at all) in most discs. Therefore, it's not useful for the list to show **all** of the registers. Instead, Tracer starts each newly imported job with a small set of PSRs, and GPRs are added automatically as their values changed by commands:

Register	Value
GPR 0	2
GPR 5	1
PSR 4	
Title Number	2
PSR 6	
Playlist ID	0
PSR 7	

Note that GPRs are added to the top of the list by default (you can re-arrange the list simply by dragging the registers into the order you want), and that GPRs are displayed slightly differently from PSRs.

- A GPR occupies a single row, showing the register number and its current numeric value. Small values are shown as decimal numbers. Larger values are shown as hexadecimal numbers (preceded by "0x").

- A PSR occupies at least two rows. The first row, similar to a GPR, shows the register number and the value of the entire register.

The second and subsequent rows show the values of pre-defined portions of the PSR. For example, PSR 2 controls the behavior of subtitles (as graphics in a PG stream or as text in a text subtitle stream) for both the primary video — the main feature — and the secondary video — the PiP display. The full 32-bit PSR 2 is interpreted as having two independent 16-bit halves, one each for primary and secondary video.

Within each half, 12 bits are dedicated to the stream number, and one bit indicates whether the stream is to be displayed or not. The remaining three bits of each half are unused and meaningless.

Therefore, Tracer displays four additional rows for PSR 2:

▼ PSR 2 [PG/Text+PiP]	0xFFFFFFF
PG/Text	None
PG/Text Disp	No
Pip PG/Text	None
Pip PG/Text Disp	No

The overall (32-bit) value of the PSR is **0xFFFFFFF**, which is broken down into its constituent parts in the detail rows.

*In this example, both stream numbers are 0xFFF (hexadecimal), which is 4095 (decimal), the value that Blu-ray specification uses to indicate that the stream number has not been determined yet.*

If you wish to see less detail of the PSR value, you can click the disclosure triangle beside the PSR number, and the detail rows will be temporarily hidden.

## Commands Overview

Let's look next at what commands the Blu-ray playback system provides. Chances are, your authoring software created the commands for you, but in order to understand the behavior of your disc, you will need to understand what the various commands can do.

- **Set** commands allow you to change the contents of the General Purpose Registers (GPRs), which may hold any values your commands need. Recall that there are 4096 different GPRs, numbered from 0 to 4095. **Set** commands can set a GPR to a specific number (e.g. **Set GPR 5 = 1**), or to the value of another GPR or PSR (e.g. **Set GPR 6 = GPR 21**), or can perform calculations (e.g. **Set GPR 1002 + 1**), or any of several other more specialized functions.
- **If** commands compare registers (GPRs or PSRs) and/or numbers to determine whether they are equal, unequal, one less than the other, and so on. If the tested condition is true, the next sequential command will be executed; otherwise the next command is skipped over, and the following command is executed.
- **Go to** commands divert the sequential flow of control, and specify which command in the current command set should be executed next.
- **Jump to** commands transfer control to a specified title or movie object. **Call** commands are similar, but they first suspend the current title before transferring control. Later, if a **Resume** command is executed, control comes back to the the original command set at the point where it was suspended, and it continues execution.

*The difference between **Go to** and **Jump to** is that **Go to** always stays within the current command set, while **Jump to** always transfers control to a different command set.*

- **Play** commands (which can occur only in movie object command sets, not buttons) cause a specified playlist to start playing. Command execution is temporarily suspended until playback is complete, at which point command execution continues with the following command. **Play** commands can choose to play back from the beginning of a playlist, from a numbered play item within the playlist, or from a specific “mark” (scene or chapter marker) within the playlist.

*If you don’t want to wait for playback to complete, you can click the **End Playback** button (or the **Go To End** button in the playback window) to force the currently playing video to end immediately.*

- **Branch** commands (which can occur only in button command sets, not movie objects) cause a currently playing playlist to jump to a different play item or mark. The **Terminate** command (also allowable only in button command sets) causes playback to stop immediately, and the regular flow of command execution to continue.
- The **Set button/page** command designates a current menu page and/or a selected button. It is used for switching between different on-screen menus, and for choosing options within a menu.
- The **Set stream** command is a specialized command used for switching between various audio, subtitle (PG or text) and interactive graphics (menu) streams, and for choosing between different video angles.

*Many discs do not use text subtitle streams for subtitles, but use presentation graphics (PG) streams instead.*

- The **Set secondary stream** command is another specialized command, used for switching between various streams and other options that control picture-in-picture (PiP) playback, when such content is available as part of your disc.

There are a few other specialized commands that we won’t examine here, except to note that **Nop** (no operation) is a command that does nothing.

*Some Blu-ray authoring software likes to sprinkle **Nop** commands throughout command sets, typically as targets of **Go to** commands. Such constructions aren’t really necessary, but do no harm.*

## How Execution Works

The general flow of execution of a Blu-ray disc follows a fairly simple pattern.

- When a disc is inserted into a hardware player, the commands belonging to first-play title start executing automatically. These commands may preset some of GPR values to be used later on, or check language or region codes, but at some point they invoke a playlist that’s non-interruptible by the viewer, which contains FBI warnings, copyright notices, disclaimers, animated logos and other similar content.
- Any time a **Play** command invokes a playlist, command execution is temporarily suspended until playback of that playlist is complete.

If the playlist contains an interactive graphic stream, **Page 0** of the IG stream is overlaid on top of the video playback (unless the IG stream has been designated as a popup menu — in that case, the IG stream is not displayed until the viewer presses the **Popup Menu** button on the remote control).

Any time a new page is chosen, implicitly or by a **Set button/page** command, the page's default button is selected, and if that button has been designed to auto-activate, its commands are executed immediately. That's why, in the example we looked at earlier, a set of button commands had interrupted playback:

Line	Command
Executing • Button 0 group 0 (auto-activate) • Page 0 • Me...	
0	If GPR 5 EQ 0
1	Set GPR 5 = 1
2	If GPR 5 GT 4
3	Set GPR 5 = 1
4	Set button GPR 6   page GPR 5 effects on
—	—
Interrupted • Title 2 • Movie object 1	
0	Set GPR 0 = 2
1	If GPR 7 EQ 0
2	Play playlist 1 from item 0
3	Set GPR 5 = [Page ID]
4	Set GPR 6 = [Selected Button]
5	Set GPR 8 = 0xFFFFFFFF
6	Play playlist 1 from item 0
7	Set GPR 5 = [Page ID]
8	Set GPR 6 = [Selected Button]
9	Go to line 6
10	Set GPR 4 = GPR 3
11	Set GPR 3 = 0
12	If GPR 4 NE 0
13	Jump to title GPR 4
—	—
Suspended • First play • Movie object 4	
0	Set GPR 7 = 0
1	Set GPR 5 = 1
2	Set GPR 6 = 0
3	Call title 2
—	—

- Usually, the first-play title will cause one of two things to happen after playback of the various legal notices is complete. Either it will transfer control directly to the main menu title, or it will first play some other title(s) such as trailers, and then transfer control to the main menu title.

The main menu title **may** be the top-menu title, but usually isn't. Often, the main menu and the top menu are almost identical in appearance, except that the top menu has a “Resume” choice for the viewer where the main menu has a “Play” choice.

Other variations are possible. On simple discs, the first-play title might transfer control directly to the main feature playlist instead of a main menu. However, the first play/main menu/top menu organization is typical.

- This overall pattern — sequential command execution, with transfer of control provided by **Go to**, **Jump to** and **Call** commands, with temporary suspension caused by **Play** commands, which are in turn interrupted by various events that trigger button commands — is repeated many times to provide the disc's complete set of behaviors. The design of the various command sets affects the way these behaviors work as much as, or perhaps more than, the content that's actually played back.
- Remote control button presses can affect the flow of command execution. The **OK** button on the remote control, for example, activates the current on-screen button, which in turn causes the button's command set to start executing. The **Top Menu** button on the remote control causes the current playlist to be suspended or terminated and the commands of the top-menu title to be executed instead. The **Popup Menu** button on the remote control causes the current popup menu to be displayed, allowing the viewer to interact with its on-screen buttons as if it were a regular menu.

## Buttons, Pages, Clips, Playlists, Play Items, Titles, Movie Objects

The term “button” has several different meanings when Blu-ray discs are being discussed. We’ve used at least four different meanings so far:

- “**Buttons**” are items in interactive graphics (IG) streams that have commands attached to them and have an associated graphical image. Buttons are organized into button groups, which are collections of buttons whose graphical image share the same on-screen location. Only one button in a group can be visible at any one time, though a group may consist of just a single button.

*Buttons are actually a bit more complicated. They have separate graphical images for their unselected, selected and activated states. In addition, their images can be animations instead of still images, and buttons can have sounds associated with them.*

- “**Buttons**” are also regions of the player screen that the viewer **thinks of** as buttons. These are often an optical illusion created by overlaying IG stream button images onto graphics in the underlying video content. Typically, the IG stream button images represent only the parts of the on-screen button appearance that change when the button changes state.
- “**Buttons**” are also physical elements of a physical remote control. They are physically pressed by a viewer.
- “**Buttons**” are also graphical elements of Mac software applications, which trigger actions within the software.

So, for example, in Tracer you might use your mouse to click a button (meaning #4) in the remote control window, which simulates the viewer pressing a button (meaning #3) on an actual remote control, which triggers a graphical change in an on-screen button (meaning #2) representing the user’s choice of an option or an action, which causes a change of appearance in the IG stream button (meaning #1). This can be a little confusing.

- **Pages** are merely convenient collections of button groups designed to be seen together. Pages are, more or less, what you would naturally think of as the various on-screen menus of your disc. Pages may also have “in” and “out” effects, which are graphical animations that appear when the page is shown on-screen or removed from the screen. Page effects allow the button images to appear to swoop onto the screen, for example, or to implode or explode, and so on. Pages are stored inside IG streams.

*IG streams have a deeper organizational hierarchy than just pages, button groups and buttons. Pages are organized into “updates”, and updates are organized into “epochs”. Updates and epochs provide additional control of IG streams over time. It is very rare for an IG stream to contain more than one epoch or update, so Tracer normally hides these extraneous levels of detail in the **Tracing** tab. However, if multiple updates or epochs exist within your disc content, Tracer will show them in the **Tracing** tab.*

- **Clips** are units of playback. The most important — and largest — are clips containing a primary video stream. Such clips may also contain one or more primary audio streams (for different languages or audio formats or numbers of channels), plus an IG stream, one or more presentation graphics (PG) streams, and one or more text subtitle streams. Other clips may contain a secondary (PiP) video stream and various other secondary streams that belong to it. Yet other clips may contain just a single IG stream, or just a single PG stream, and so on.

Each clip is represented by a pair of numbered files: the clip info (**XXXXX.clpi**) file, and the transport stream (**XXXXX.m2ts**) file, which you can see in the **Files** tab.

- **Playlists** are collections of clips or parts of clips, organized into a sequential playback order. As you may have already noticed, the structure of Blu-ray content can be quite complicated, and playlists are no exception to this.

A playlist is actually a sequence of **play items**, and each play item can aggregate video, audio and other streams from multiple clips and/or choose only portions of clips. If you are interested in seeing how playlists are constructed, you can examine them in the **Playlists** tab.

Playlists are also stored in numbered files (**XXXXX.mpls**), but these numbers are unrelated to the clip numbers described above.

- **Titles** are viewer-oriented groupings of content, most often chosen by the viewer via on-screen menus. We've already encountered the special "first play" and "top menu" titles. The rest of the titles are identified by title numbers starting from 1. Titles are all stored in the **index.bdmv** file on your disc.

In some player hardware, the viewer can also choose titles via the remote control, or via front-panel buttons and display. Such choices, called "title search" in Blu-ray lingo, are by title number and duration only — there are no title descriptions available to the viewer except via on-screen menus.

- **Movie objects** are really just command sets used by titles, along with a very few options that control their behavior. They are separate from titles so that different titles can share the same commands.

Buttons have their own command sets, but can also **Call** or **Jump to** movie object command sets. Movie objects are all stored in the **MovieObjects.bdmv** file on your disc.

## How Tracing Works

You enable tracing by clicking the **Enable Tracing** button in the toolbar at the bottom of the main job window. You can also choose **Enable Tracing** from the **Tracing** menu.

When tracing is enabled, each command is executed with a short delay, so that you have a chance to follow what is being executed. The **Rate** slider at the bottom of the **Tracing** tab allows you to adjust the length of the delay.

When tracing is disabled, commands are executed as fast as possible. You also can't use the buttons at the bottom of the **Tracing** tab to start and stop execution, but must use playback window buttons instead.

Aside from these minor differences, playback works exactly the same whether tracing is enabled or disabled.

When you import a new job or open an existing job, Tracer prepares to execute the first command of the first-play title's command set, but does not start execution. You can start execution in one of these ways:

- Click the **Insert/Start** button in the playback window.
- Click the **Run** button in the **Tracing** tab, if tracing is enabled.

Execution continues until it is specifically ended:

- If an error occurs.
- If a **Break** command is executed. (That's the only purpose of the **Break** command: to stop execution. Therefore it's not often used, since it would not be obvious to the viewer why the disc "stopped working".)

- If you click a **Pause** button at the bottom of the **Tracing** tab.

*When you click **Run** to start execution, the button changes to **Pause**.*

- If a breakpoint is reached. Breakpoints are discussed later, under “[Using Command Breakpoints](#)” and “[Using Register Breakpoints](#)”.

Instead of clicking **Run**, you can execute commands by clicking the **Stride** or **Single Step** buttons:

- Clicking **Stride** starts playback just like **Run**, but adds another condition under which execution will stop. If the flow of execution switches for any reason to a different command set (whether button commands or movie object commands), execution stops at the first command in the new command set.

*When you click **Stride** to start execution, the button changes to **Pause**. You can click **Pause** to stop execution.*

This is a good way, for example, to find out easily what commands are going to be executed when an on-screen button is activated in the player, even if you don’t know in advance which buttons are involved.

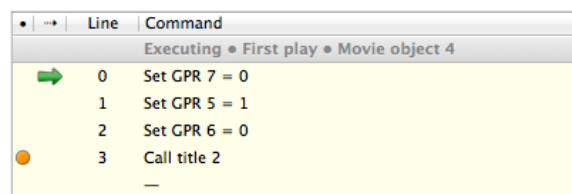
- Clicking **Single Step** executes a single command, then stops at the following command.

*If the command being executed is a **Play** command, it may take quite a while to finish executing. When playback is in progress, the **Single Step** button changes to **End Playback**. You can end playback immediately by clicking **End Playback**, or by clicking the **Go to End** button in the playback window.*

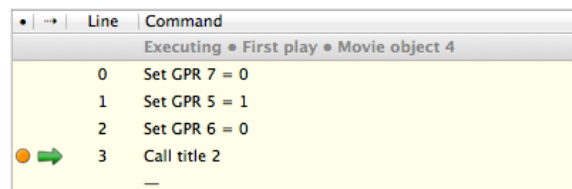
## Using Command Breakpoints

A breakpoint is an option set on individual commands that causes Tracer to stop execution when any command with a breakpoint is reached. Breakpoints exist only within your Tracer job, and have no effect on your disc or its content.

Breakpoints can be set or cleared in the **Tracing** tab by clicking in the left margin of the command list:



When a breakpoint is reached, execution stops just **before** the command with the breakpoint:



You continue with execution in any of the ways already discussed, using the **Run**, **Stride** or **Single Step** buttons.



When tracing is disabled, Tracer does not stop at breakpoints, although they are not discarded. Under these circumstances, breakpoints are displayed as hollow outlines to indicate that they are being ignored:

•	→	Line	Command
Starting • First play • Movie object 4			
		0	Set GPR 7 = 0
		1	Set GPR 5 = 1
		2	Set GPR 6 = 0
○		3	Call title 2
		—	—

## Using Register Breakpoints

Tracer monitors changes made to GPRs and PSRs by each command, and indicates with a blue arrow which registers have been changed by the most recent command:

•	→	Register	Value
		GPR 5	1
		PSR 4	
	➡	Title Number	2
		PSR 6	
		Playlist ID	0
		PSR 7	
		Play Item ID	0
		PSR 5	0xFFFF
		Chapter Number	None
		PSR 1	0xFF
		Primary Audio	None
		PSR 0	
		IG Stream	1
		PSR 10	0xFFFF
		Selected Button	None

In some cases, when you are trying to follow the behavior of a disc's commands, you will find that a register (typically a GPR) has been changed by a long sequence of commands, but it's not easy to determine which command caused the change. Instead of perhaps single-stepping through hundreds of individual commands, you can tell Tracer that you want execution to stop when a specific register is altered, by setting a breakpoint on the GPR or PSR:

•	→	Line	Command
Executing • First play • Movie object 4			
➡		0	Set GPR 7 = 0
		1	Set GPR 5 = 1
		2	Set GPR 6 = 0
		3	Call title 2
		—	—

•	→	Register	Value
●		GPR 5	0
		PSR 4	0xFFFF
		Title Number	First Play
		PSR 6	
		Playlist ID	0
		PSR 7	
		Play Item ID	0

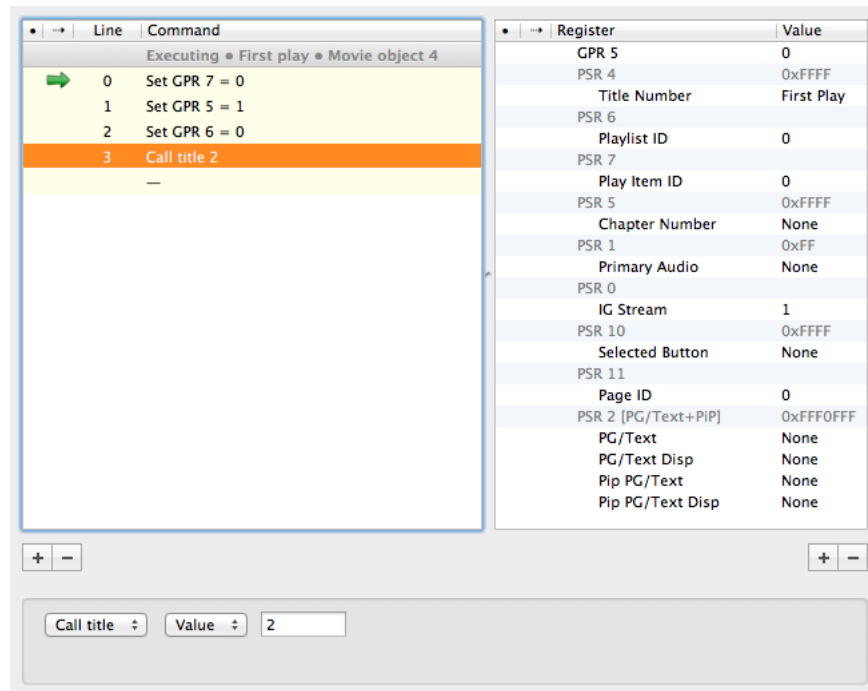
When the value of the register changes, execution stops **after** the command that made the change:

•	→	Line	Command
Executing • First play • Movie object 4			
		0	Set GPR 7 = 0
		1	Set GPR 5 = 1
➡		2	Set GPR 6 = 0
		3	Call title 2
		—	—

•	→	Register	Value
●	➡	GPR 5	1
		PSR 4	0xFFFF
		Title Number	First Play
		PSR 6	
		Playlist ID	0
		PSR 7	
		Play Item ID	0

## Editing Commands

You edit commands when you need to change the playback behavior of your disc, or if you need to correct an error in the commands supplied by your authoring software. To edit an existing command, simply select it in the **Tracing** tab of the job window. The selected command is displayed within an inset area below the command list:



*The command editing area is hidden until you select a command for editing.*

You can then change the various components of the command.

- When editing commands, work from left to right, since many of your choices depend on choices you made further to the left.
- To insert a command, select the command **before** which you'd like your new command to appear, and click the + button below the command list. A **Nop** (do-nothing) command is inserted at that line. Simply edit it to get the command you want.
- To delete commands, select the commands and click the – button below the command list.
- Remember that you have **Undo** available on the **Edit** menu, if you make unintentional command changes.

# Advanced Content Editing

Tracer has a few advanced content editing functions, which are useful in specific premastering scenarios.

## Title Options

Titles serve two different purposes on Blu-ray discs. **Movie titles** are the unit of playback from the viewer's perspective, representing the main feature and any special features on the disc. Movie titles typically have a specific duration, and — if the Blu-ray player has a “title search” function — are selectable via that function. **Interactive titles** represent all other playable content, typically navigation menus, though the category also encompasses interactive games and miscellaneous content.

Your authoring system will normally choose the title type, and you'll have little reason to change it. However, when you make extensive disc navigation changes in Tracer, you may need to create new titles, and you should set the title type appropriately.

*To create a new title, click the + button to the right of the “Titles” section heading.*

To set the title type, or to edit other title options, select a **single** title in the content list. Also:

- The movie object popup menu allows you to associate any movie object (or no movie object) with the title. For example, your authoring software may have created two titles that share a single movie object, but you may decide that the titles need slightly different behavior. You can create a new movie object that implements the difference, then use the popup menu to associate this movie object with one of the titles.

*If you want to delete a title, you must first disassociate it from its movie object. Then you will see a – button to the right of the title that deletes the title.*

*Similarly, to delete a movie object, you must first disassociate it from any titles that refer to it.*

- **Title search prohibited** indicates whether the title participates in a Blu-ray player's “title search” function. Normally, movie titles should have this option checked, and menu titles should not.
- **Title display prohibited** indicates whether a Blu-ray player may display an elapsed time readout during title playback. Normally, this option is checked for a movie title that has a specific duration (and does not, for example, loop continuously).

*This option is available only for titles that participate in the title search function.*

## Movie Object Options

Although movie objects, listed in the **Tracing** tab's content list, are primarily intended as “containers” of Blu-ray commands, they also have a few associated options which you may wish to change on occasion. To edit the options, select a **single** movie object in the content list.

- **Will resume from top menu** indicates whether the movie object — if its playback is interrupted by the viewer pressing the **Top Menu** button on the remote control — should allow the interrupted playback to resume later.

- **Top menu call prohibited** indicates whether the viewer is allowed to interrupt playback with the **Top Menu** remote control button when the movie object is in control.
- **Title menu search prohibited** indicates whether titles using the movie object are excluded from a hardware player's title search functions.

*In most cases, the correct behaviors are set by your authoring system, and you have no reason to change these options.*

## Menu Clip Options

Menu clips, also listed in the **Tracing** tab's content list, can be of two types, which you can see and edit when you select a **single** menu clip in the content list.

- **Always on** menu clips are displayed continuously when their associated playlists are being played. A disc's main or top menu is a good example of an always-on menu — it remains displayed until the viewer chooses the main feature or some other disc content.
- **Popup** menu clips are displayed over an in-progress video feature, but do not interrupt the feature. A viewer calls up a popup menu using the **Popup On** button on the remote control, and dismisses it with the **Popup Off** button (or, in some cases, with an on-screen button with an equivalent effect).

Switching these menu clip options is useful in some advanced workflows based on inflexible authoring systems. Visit our web site at <http://rivergatesoftware.com> for tutorials and other information about advanced work flows.

*Some menus are authored in such a way that they cannot be switched from **Always on** to **Popup**. Only “out-of-mux” (separately multiplexed) menu streams can be switched in Tracer.*

## Repeatable Play Items

“Always-on” menu clips, as described in the previous section, normally consist of various on-screen buttons that are displayed over a short looping video clip, perhaps about 30 seconds long.

In many content authoring systems, it is difficult to achieve “seamless” looping, where there is no visible break between the end of the clip and the start of the subsequent repeat.

If the clip meets certain technical requirements — most importantly that it's neither too short or too long — Tracer can arrange for the clip to be repeated seamlessly as many times as you choose. To repeat clips:

- Determine the clip number, the playlist number and the play item number of the clip you wish to repeat.

*The easiest way to get this information is to play the disc in Tracer's playback window. When the looping menu background is playing, show the segmentation controls at the bottom of the window (by clicking the disclosure triangle at the bottom left), then look for the information you need, just above the **Split/Join** buttons.*

- Go to the **Playlists** tab, and find the corresponding playlist number and play item number.

If the play item is eligible for seamless looping, you will see + and – buttons beside the play item.

- Use these buttons to adjust the number of repetitions. Usually, a total running time of between 5 and 20 minutes is a good choice.

## Direct Clip Playback

In a few circumstances, you may know from the **Files** tab which large stream file you want to split across the layer break of a dual-layer disc, but you might have no means of playing back this file in order to use Tracer's segmentation controls, which are located at the bottom of the playback window.

This situation typically arises when you have a BDJ title, which Tracer recognizes but cannot play back.

You can play such clips directly in the playback window, bypassing the Blu-ray commands that are normally required:

- If playback is in progress, click the playback window's **Eject/Restart** button to end playback.
- Go to the **Playback** menu, and choose the **Source** item. This item has a submenu listing all of the clip numbers (that is, transport stream file numbers) of files that contain primary video.
- Choose the desired clip number.
- Click the **Insert/Start** button in the playback window.

You should now be able to use the segmentation controls to split the clip at a suitable point. See "[Segmenting Stream Files](#)" for further details of this procedure.

*When you are finished playing back the individual clip, restore the normal playback behavior by choosing **First Play** from the **Source** submenu.*