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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 (BD-R) or re-writable (BD-RE) disc blanks in a Blu-ray disc (BD) drive attached to your Mac. Depending on your drive’s capabilities, 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.

You can also burn BD content to DVD disc blanks in a standard DVD drive, single- or double-layer, 8 cm or 12 cm discs, although the disc capacity is much less than a BD disc.

- Tracer allows you to customize your file layout, adjust the layer break if necessary, and edit the commands that implement the disc’s menus and other functionality.
- Tracer contains a simplified BD player 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 BD-R/RE 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 elementary 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.

BluStreak Tracer CMF

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, you use an enhanced version of Tracer known as **Tracer CMF**. Tracer CMF contains all of the functionality listed above, plus the ability to export BDCMF folders (containing a disc image plus the additional support files required by a replication facility) to hard disk, and to burn BDCMF folders to BD-R/RE media.

What has changed since BluStreak Premaster?

BluStreak Tracer is based on an earlier application, BluStreak Premaster.

Although Tracer is a new product, for continuity with Premaster it has been introduced as version 2.

If you have used Premaster in the past, you'll find Tracer to be very familiar, but with several major enhancements:

- The user interface has been streamlined. The various windows have been consolidated into a single tabbed window.
- The ability to edit and debug commands in titles and interactive menus has been added.
- There is a new content browser which lists all titles, movie objects, playlists, clips, pages, menus and commands in your projects.
- Tracer can now preview much of your content, using a new playback window that simulates the operation of a Blu-ray player.
- You can now choose and set layer breaks within transport stream files.

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 top-level Mac folder created by an authoring application such as Adobe Encore. This folder corresponds to an entire disc, and contains a **BDMV** subfolder, a **CERTIFICATE** subfolder and may contain other subfolders needed on the final disc. Tracer imports all of the BDMV information except for non-interactive elementary streams, and maintains a reference to the top-level folder so that the streams can be located for playback and export.
- An ISO (UDF) disc volume image file containing **BDMV** and other folders. Tracer imports the same information as it does from Mac folders, and maintains a reference to the image file.
- **(Available in Tracer CMF only)** 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 volume image file containing the disc content but discarding other information that was added during the BDCMF creation process.
- A Blu-ray disc. In this case, Tracer again requires that you extract an image file 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.

Tracer allows you to import content that’s authored specifically for Blu-ray, as well as AVCHD content from video cameras and other similar sources. However, once imported, all content is treated as Blu-ray content — Tracer cannot currently export content in AVCHD format.

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.
- **(Available in Tracer CMF only)** You can create a BDCMF folder on your hard disk.
- **(Available in Tracer CMF only)** You can burn a BDCMF folder directly to blank or rewritable media.

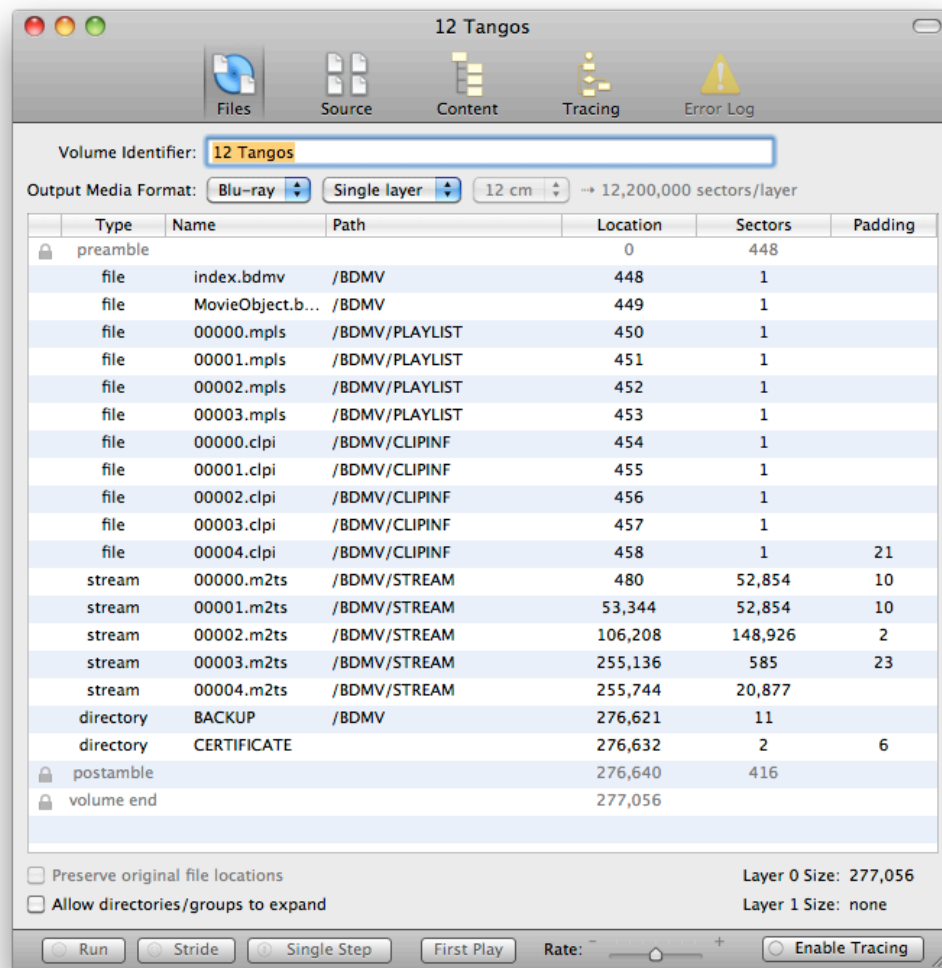
In the last two cases, the job’s content is embedded as a disc image within the BDCMF folder. This BDCMF folder can be sent to a replication facility.

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 five “tabs” (switchable views):



Across the top of the window you can see the five tabs (**Files**, **Source**, **Content**, **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, and Tracer CMF has an additional BDCMF tab.

The buttons across the bottom of the window are used for tracing and debugging the behavior of the disc. See “[Tracing Execution](#)” for more information.

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.

The **Output Media Format** tells Tracer what kind of media you will be using, if you decide to burn a disc or BDCMF image 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. (A disc sector is 2KB, or 2048 bytes.)

Most of the Files tab is taken up by a list all 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 normally applies only to the beginning and end of the disc, but sometimes the content files can be in fixed locations. (See the [Source tab](#) for a discussion of situations where this is desirable.)
- **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 50GB.
 - **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.

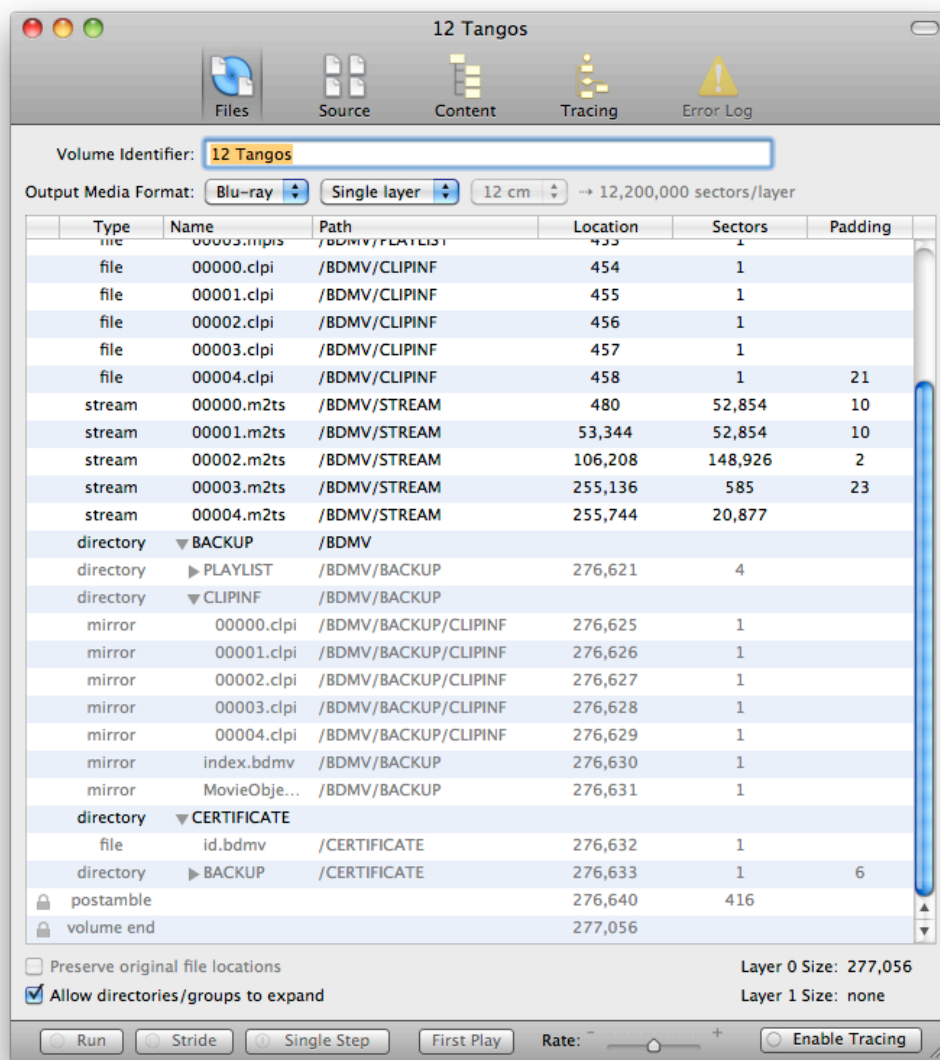
Unless you are using Tracer CME, you normally won't see any groups, because groups are used primarily for AACs files, and AACs files are output only for discs premastered for replication.

 - **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.
- **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-subdirectories. A few files are at the top level of the disc's directory structure, and so have 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.
- **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. Note that stream files are always a multiple of 3 sectors in length.

- **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 **Preserve original file locations** checkbox, used in conjunction with the lock icons. (See the [Source tab](#) for further discussion.) Also shown are the total layer sizes, again in sectors.

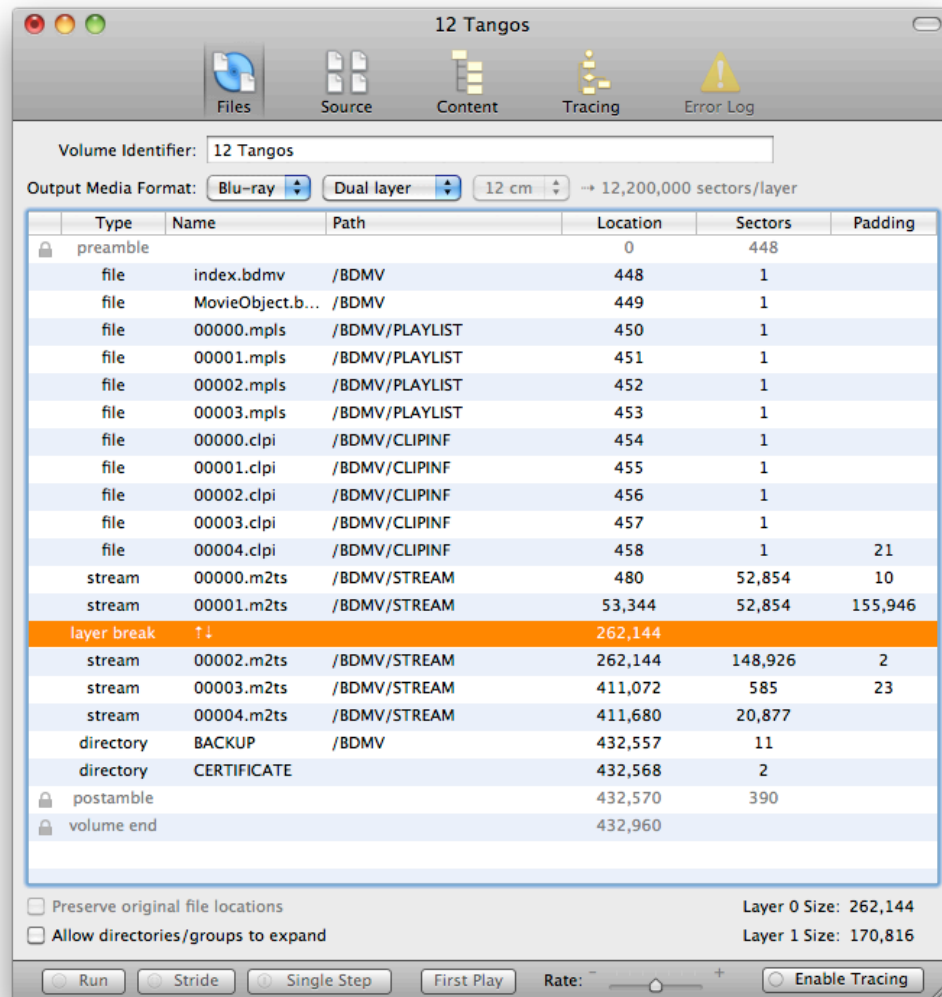
At the bottom of the window is the **Allow directories/groups to expand** checkbox. This checkbox does not affect the layout of the job, but just changes the way the files are displayed in the Files tab. When it is checked, the file list allows you to examine the contents of the various directories and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



This level of detail is rarely useful, though.

Layer Breaks

When you choose a dual-layer output format, the file list shows an additional row representing the position of the layer break:

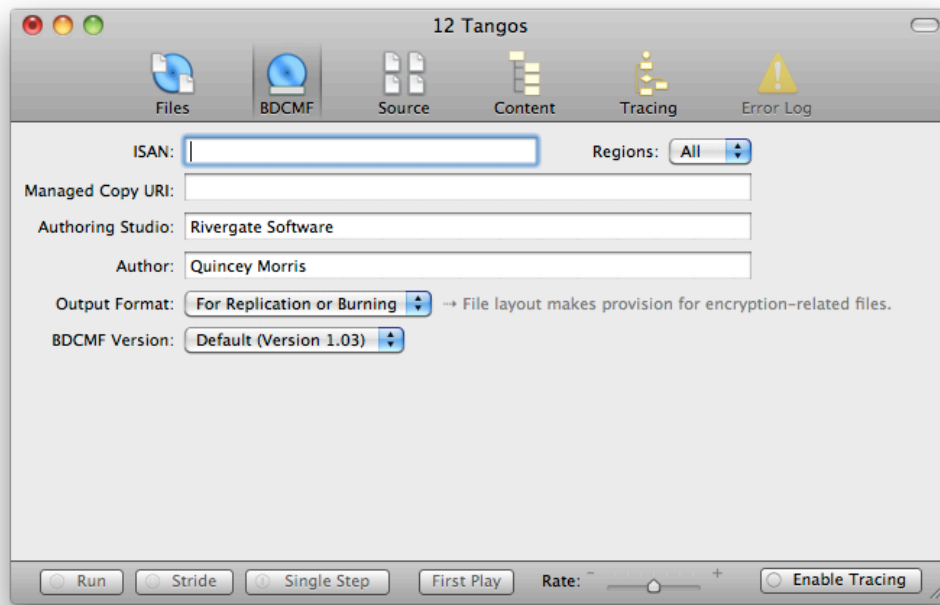


You can drag the layer break up or down in the list to set it wherever you wish.

Note that the last file in layer 0 shows a very large amount of padding in the above example. This looks like an error, but in fact it accurately represents the disc structure. Layer 0 must a minimum physical size requirement (262,144 sectors), and in addition layer 0 must always be larger than layer 1. The large padding number reflects the adjustments that Tracer has made to the disc layout to accommodate such requirements.

BDCMF Tab (Tracer CMF Only)

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



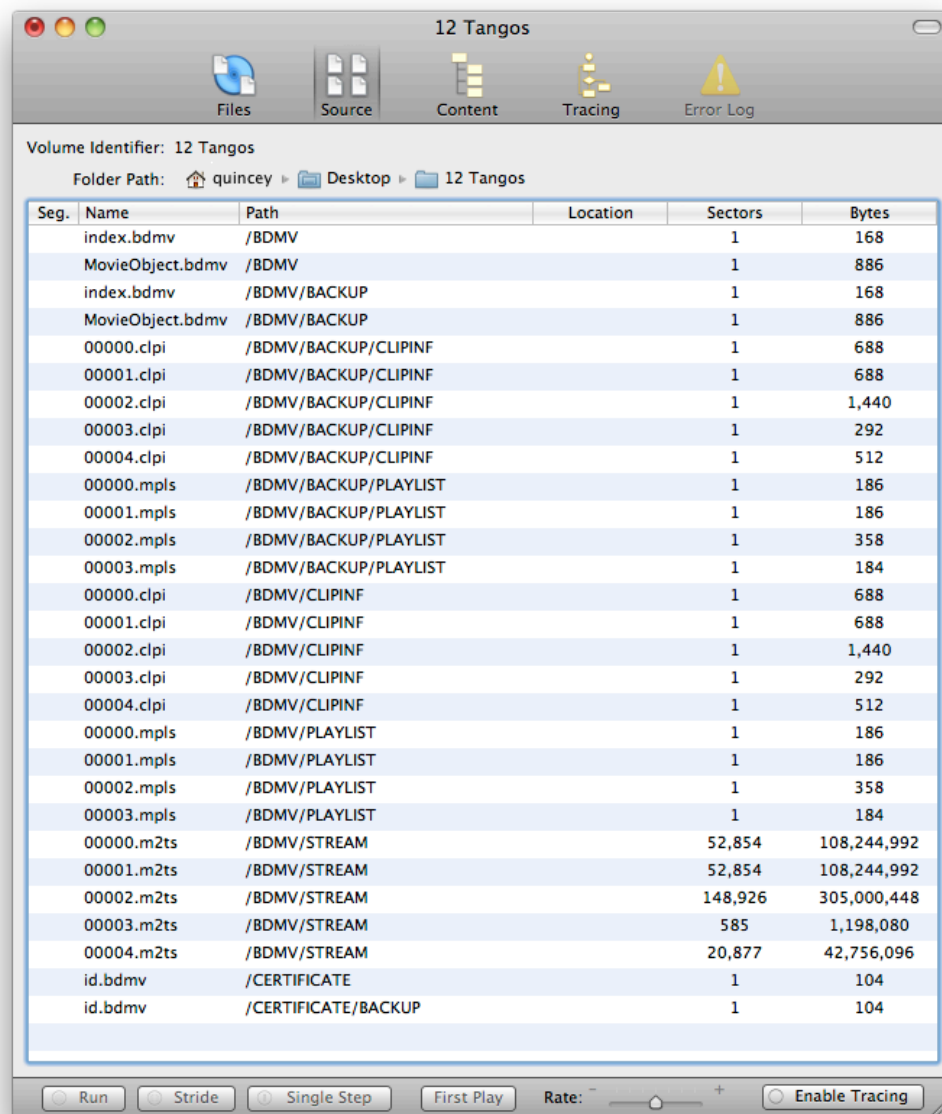
Most of this information is optional or can safely be left at default values.

- **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 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.
- **Output Format** is normally left as **For Replication or Burning**, meaning that disc space is reserved for encryption-related (AACs) files, even if these files will be suppressed because a disc is burned directly from Tracer. With this choice, the disc layout is unaffected by the method of output. If you do not intend to replicate the disc, you can reclaim the relatively small amount of space — usually just a couple of thousand sectors — set aside for AACs files, by choosing **For Burning Only**.
- **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.

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 or disc image, and not when it is a Mac folder.

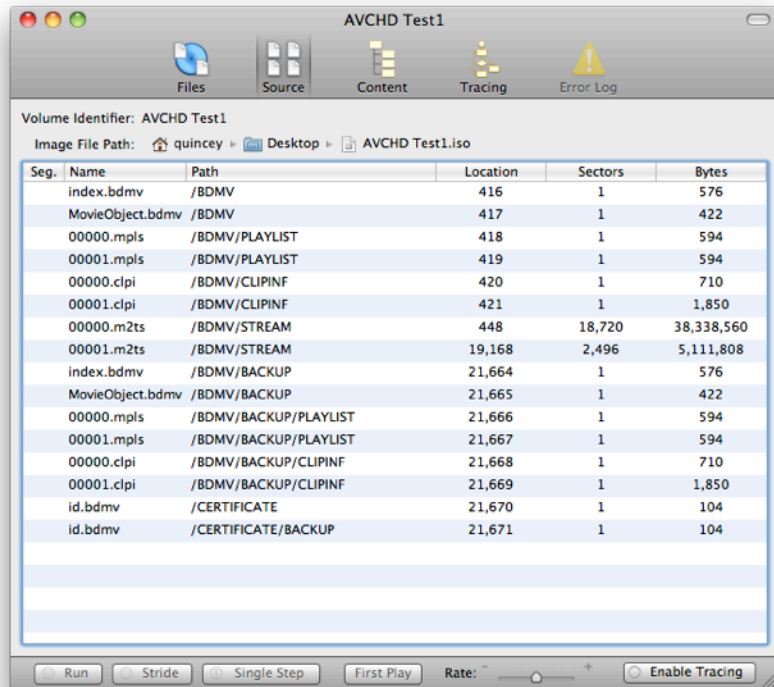
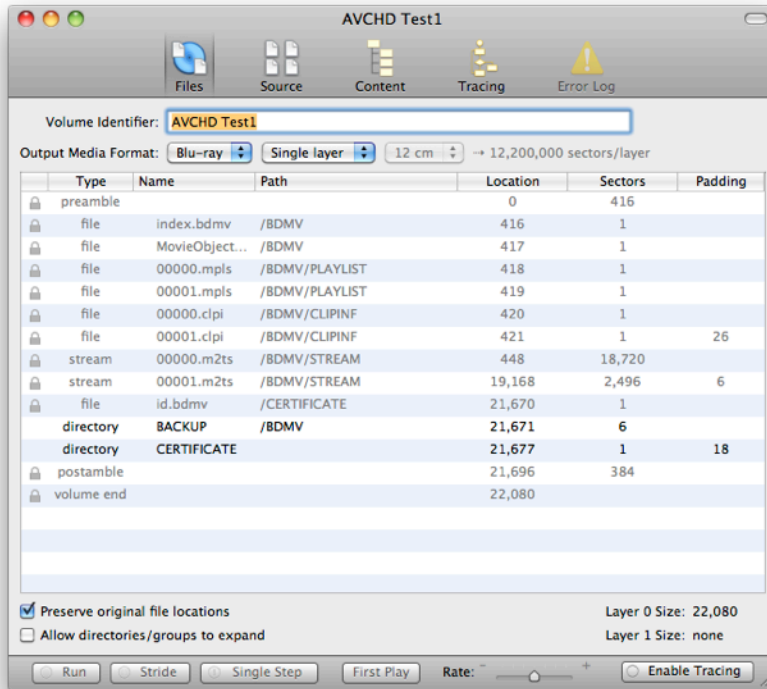


Seg.	Name	Path	Location	Sectors	Bytes
	index.bdmv	/BDMV		1	168
	MovieObject.bdmv	/BDMV		1	886
	index.bdmv	/BDMV/BACKUP		1	168
	MovieObject.bdmv	/BDMV/BACKUP		1	886
	00000.clpi	/BDMV/BACKUP/CLIPINF		1	688
	00001.clpi	/BDMV/BACKUP/CLIPINF		1	688
	00002.clpi	/BDMV/BACKUP/CLIPINF		1	1,440
	00003.clpi	/BDMV/BACKUP/CLIPINF		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 or disc image, the files may have been broken into segments which can appear in any physical order. The “Seg.” column indicates the logical order of such segments.

Preserving Original File Locations

When the source is a disc or disc image only, Tracer is capable of preserving the source layout in the output files list. In this case, the Files tab looks a little different, as in this comparison of the Files and Source tabs of an artificially small example:



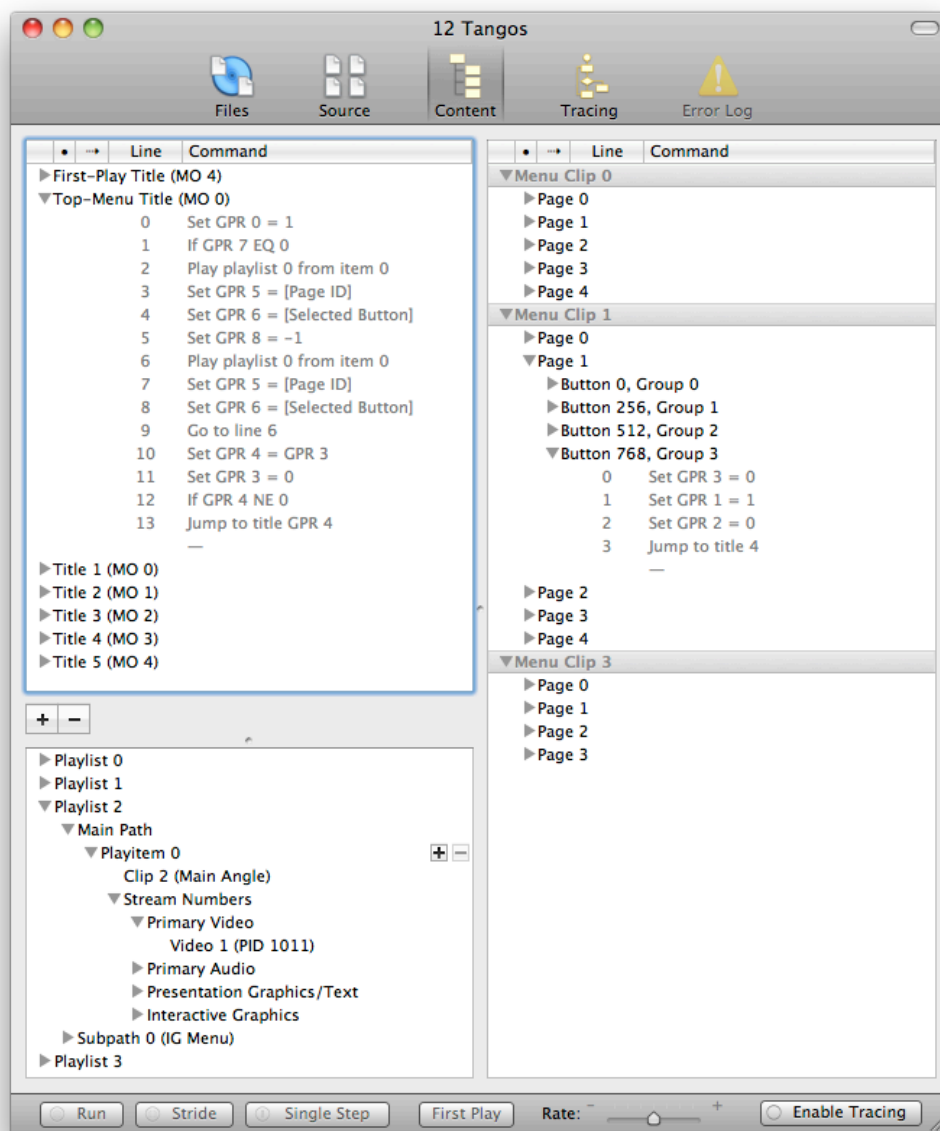
Notice that most of the files are shown gray and are locked in the Files tab list. These files are forced to the same location in the output layout (relative to the start of the files, though, not to the start of the disc) as they are in the source disc and cannot be moved.

Some of the files may be shown as unlocked. These are files that Tracer was unable to place at their original locations for some reason.

If you import a job from a disc or disc image source and do **not** want to preserve the original file locations, simply uncheck **Preserve original file locations** in the Files tab, and files will be organized normally.

Content Tab

The Content tab shows the disc contents, primarily that related to playback and interactive menus, in three lists:



- The first list contains the **titles**, which are the basic video components of the disc from the viewer's point of view.

The list shows 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.

Next, the list shows a series of numbered titles, which are ultimately selected for playback when the viewer navigates the disc's menu system. Some Blu-ray players can also list these titles for direct selection by the viewer.

The title's description shows the number of the associated “movie object” (**MO**), which contains the Blu-ray system commands that implement the title's behavior. The title item may be expanded within the list to show its movie object's commands.

A movie object can be shared by different titles. Also, movie objects unassociated with a title, if any, are shown at the end of the list.

- The + and – buttons below the title list are used to add or remove movie objects from the disc's content.

In some cases, when you need to edit commands to alter or correct the disc's playback behavior, you'll need to add a new movie object beyond the ones provided for you by your authoring software. These buttons allow you to manage such additional movie objects.

- The second list shows the **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.

- The third list shows the **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).

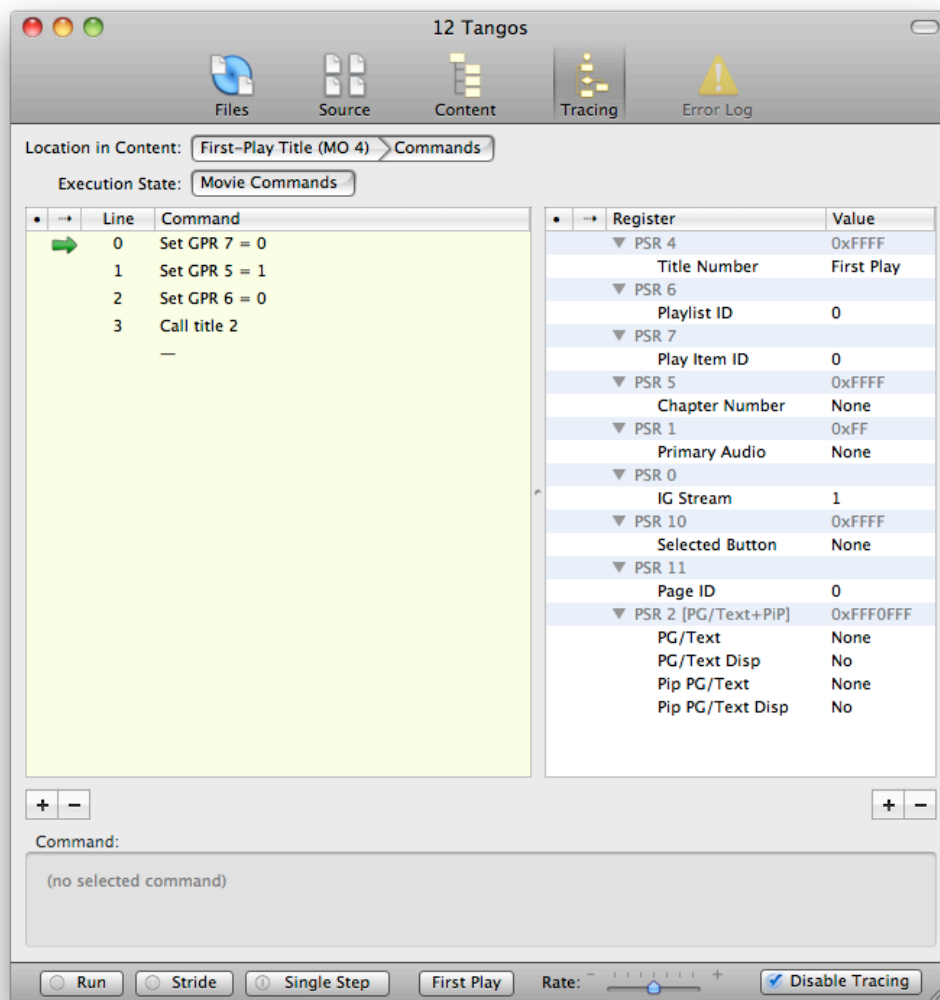
If the structure of the information shown in the Content tab seems complex to you, you are not mistaken — it is complex. Blu-ray has a very flexible and powerful playback architecture, which allows Blu-ray discs to be considerably more sophisticated than standard DVDs. It is usually easier to understand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

Tracing Tab

The Tracing tab shows the player state during the execution of a single set of commands. Each movie object and each button is permitted to have a set of commands, as described for the Content tab.

Use of the Tracing tab is described later on, in “[Tracing Execution](#),” but the main elements of the tab are these:

- **Location in Content** describes the button or movie object to which the listed set of commands belongs.
- **Execution State** shows what is currently in execution in the player. One or more items may be listed here: a current movie object, an in-progress playlist in the current movie object, a suspended movie object, an in-progress playlist in the suspended movie object, and a button. The last-listed item is the one that’s actually executing; the items before it are waiting for it to finish.
- The first list shows a set of commands, usually the set that is currently executing. The + and – buttons below the list are used to add and remove commands.



- The second list shows player “registers” (status values). Two kinds of registers may be shown in the list: Player Status Registers (PSRs) and General Purpose Registers (GPRs).

There are about 30 different PSRs, which indicate the current state of the player. For example, the first one (**Title**) is the title number of 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.

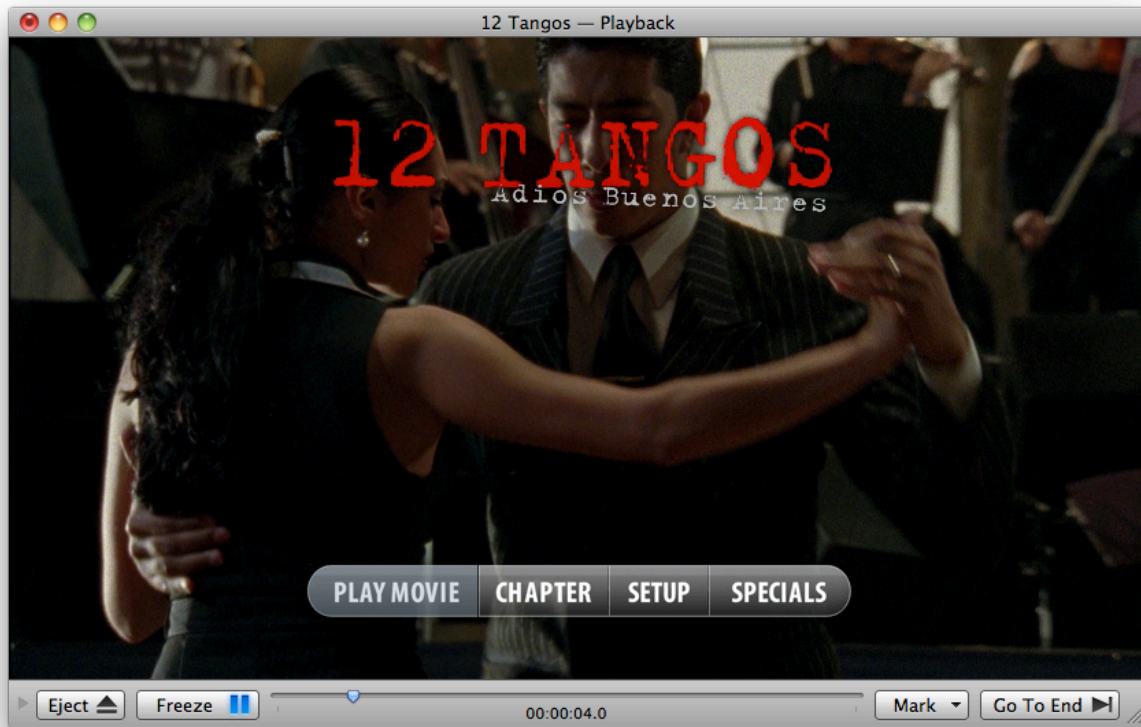
By default, the registers list displays a preset subset of the PSRs, and GPRs are added to the list automatically when their values are changed. You can customize what is shown in the list by using the “+” and “-” buttons below the list.

You can also 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 in the registers list. The list is for your convenience only.

- The inset area at the bottom of the window is used for editing commands. This is described later, in the [“Editing Commands”](#) section.
- The **Enable/Disable Tracing** button permits Tracer’s tracing facilities to be used. Tracing is described later, in the [“Tracing Execution”](#) section.
- The **Run**, **Stride**, **Single Step** and **First Play** buttons and the **Rate** slider control the way commands execute. They are also described in [“Tracing Execution.”](#)

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 **Start/Eject** 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 **Start** to begin playback as if the disc were inserted. Once the disc is playing, the button changes to an **Eject** button. Click **Eject** 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 **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 implement

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

Remote Control Window

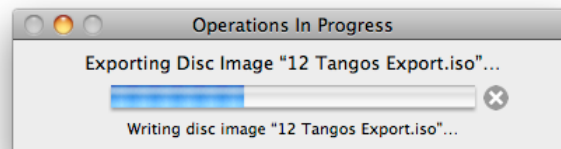
The remote control window simulates a very basic remote control used to navigate a disc's on-screen menus. It contains **Up**, **Down**, **Left** and **Right** buttons which are used to select on-screen buttons in the playback window, and an **OK** button which activates the selected on-screen button:



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

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.

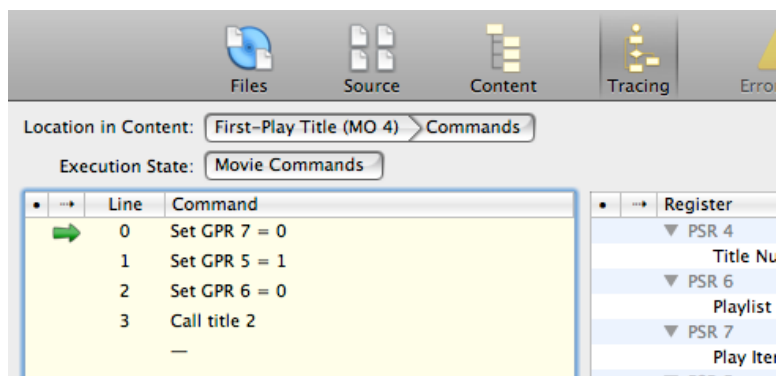
Tracing Execution

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 the currently executing command set in the Tracing tab's command list, but you can change this, and also navigate backwards and forwards between commands in the Tracing tab and items in the Content tab.

Here's an example of a small command set displayed in the Tracing tab:



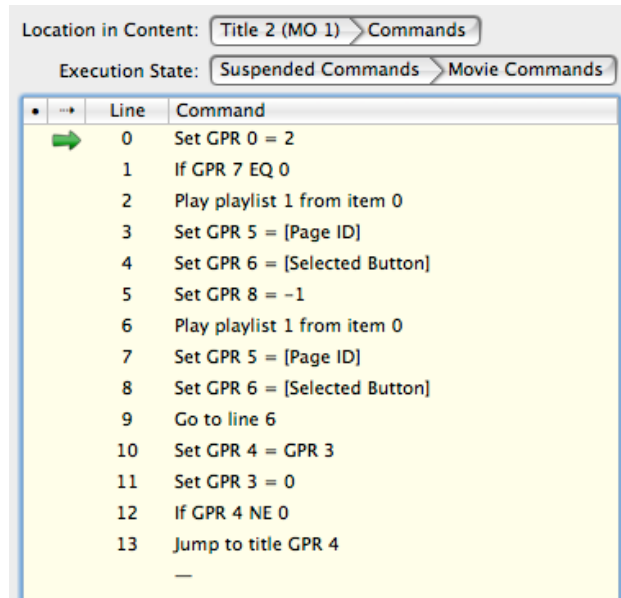
- Every command is shown with a sequential line number, starting from zero.
- The solid green arrow indicates which command is going to be executed next. When a command has started executing, but hasn't finished, the arrow becomes a hollow outline.

*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 waits for other commands to finish.*

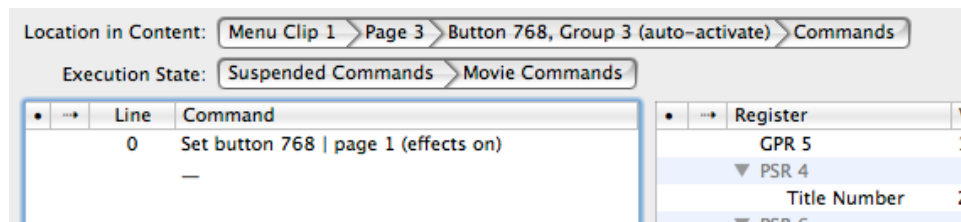
- The yellow background indicates that this command set is currently executing. It's possible for command sets to be "suspended" — temporarily prevented from executing while some other command set gains control. Suspended command sets have an orange background. Here's what this same command set looks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



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



- If you’re not sure which command set you’re seeing, you can orient yourself by looking at the **Location in Content** control above the command list. It shows the title number and movie object number to which the displayed commands belong.
- Button commands look this this:



Note the white background in this example. It means this command set is not currently executing, but is merely being shown in the Tracing tab. Note also that the Content tab location of buttons is more complex to describe than the location of movie objects.

Whether the commands shown are from a button or movie object, you can click on any segment of the **Location in Content** control to switch to the Content tab and select the item you clicked on.

Conversely, when you’re in the Content tab, you can double-click on any item that represents a single command set, and Tracer will switch to the Tracing tab and display those commands.

- The **Execution State** control above the command list shows you which commands are currently executing, or were executing but are now temporarily suspended. In the example we’ve been looking at, the first-play title called title 2. That means that title 2’s commands (**Movie Commands** in the execution state) are now current, and the first-play title’s commands (**Suspended Commands** in the execution state) are waiting for title 2 to finish executing.

You can click on any segment of the execution state control to display the corresponding commands.

- If a button command set is executing, it will be shown in the **Execution State** control.
- If any content is currently playing, or was playing and is suspended, that fact will also be shown in the **Execution State** control. Here's what it looks like when our example has executed a bit further and things have gotten a bit more interesting:

Location in Content: Menu Clip 1 > Page 0 > Button 0, Group 0 (auto-activate) > Commands

Execution State: Suspended Commands > Movie Commands > Movie Playlist > Button Commands

• →	Line	Command
➡	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)
	—	

• →	Register	Value
	GPR 0	2
	GPR 5	1
	▼ PSR 4	
	Title Number	2
	▼ PSR 6	
	Playlist ID	1
	▼ PSR 7	
	Play Item ID	0

Now the execution state is telling you that the original title (**Suspended Commands**) was suspended to execute another title (**Movie Commands**), which were in turn suspended to play content (**Movie Playlist**), 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 playback behavior. You will also, usually, need to know the internal state of the player. This information is contained in the player's "registers," and the contents of the registers are 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	No
	Pip PG/Text	None
	Pip PG/Text Disp	No

As previously discussed, there are 4096 General Purpose Registers (GPRs) and a number of Player Status Registers (PSRs), and many of them are not of interest (or not used at all) in any specific disc. 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	0xFFFF
Title Number	First Play
▼ PSR 6	0
Playlist ID	0
▼ PSR 7	0
Play Item ID	0

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 movie object 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.
- **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.

Most discs do not use text subtitle streams for subtitles, because the text quality is not sufficiently high. Instead, discs uses presentation graphics (PG) streams for subtitles.

- 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:

Location in Content:		Menu Clip 1 > Page 0 > Button 0, Group 0 (auto-activate) > Commands	
Execution State:		Suspended Commands > Movie Commands > Movie Playlist > Button Commands	
Line	Command	Register	Value
0	If GPR 5 EQ 0	GPR 0	2
1	Set GPR 5 = 1	GPR 5	1
2	If GPR 5 GT 4	PSR 4	Title Number 2
3	Set GPR 5 = 1	PSR 6	Playlist ID 1
4	Set button GPR 6 page GPR 5 (effects on)	PSR 7	Play Item ID 0
—	—		

- 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 very straightforward 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 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. A group may consist of just a single button.

Buttons are actually more complicated than that. 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 changes 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 this extraneous level of detail in the Content tab. However, if multiple updates or epochs exist within your disc content, Tracer will show them in the Content 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 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, 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 Content 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 movie object.

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 Tracing tab. You can also choose **Enable Tracing** from the **Tracing** menu.

When tracing is disabled, you are prevented from editing any commands, and commands are executed as fast as possible in the playback window. You also can’t use the buttons at the bottom of the Tracing tab to start and stop execution.

When tracing is enabled, you can edit commands in the Tracing tab, and commands are executed with a short delay in between each, 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, and the buttons at the bottom of the Tracing tab are available for use.

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 **Start** button in the playback window.
- Click the **Run** button in the Tracing tab.

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**. You can click **Pause** to stop execution.*

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

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

- 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 set of commands (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.

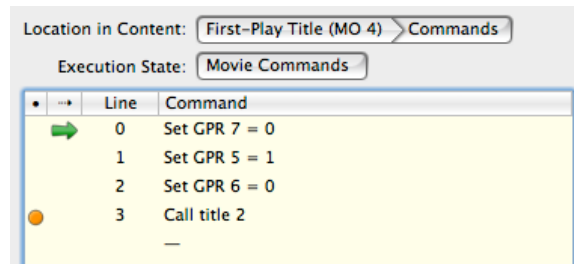
- Clicking **Single Step** executes a single command, then stops at the following command.

*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

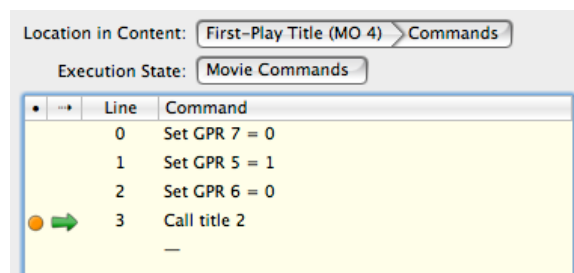
A breakpoint is an option set on individual commands that causes Tracer to stop execution when a command with a breakpoint is reached. Breakpoints exist only within your Tracer job, and have no effect on your disc or its content.

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



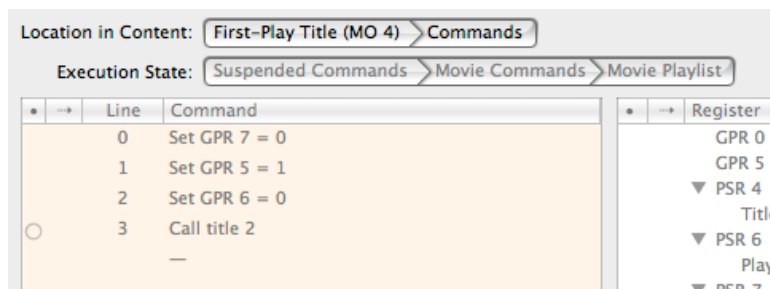
and cleared by clicking in the same place again. Breakpoints can also be set and cleared this way on commands listed in the Content tab.

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:



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 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]	0xFFFF0FFF
PG/Text	None
PG/Text Disp	No
Pip PG/Text	None
Pip PG/Text Disp	No

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
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:

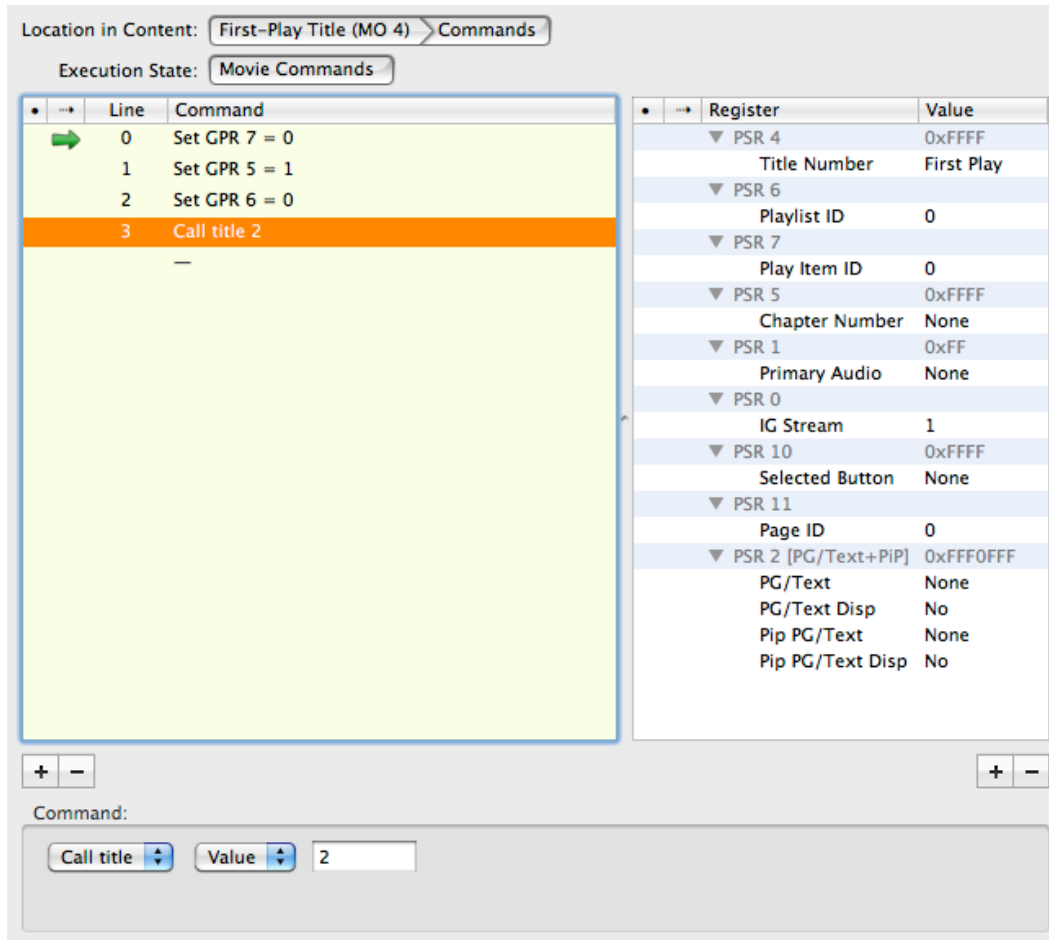
Line	Command
0	Set GPR 7 = 0
1	Set GPR 5 = 1
2	Set GPR 6 = 0
3	Call title 2
—	—

Register	Value
▶ GPR 5	1
▼ PSR 4	0xFFFF
Title Number	First Play
▼ PSR 6	
Playlist ID	0
▼ PSR 7	
Play Item ID	0

You can also set breakpoints on the portions of PSRs that are listed as separate rows, and execution will stop when just those portions change.

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 the inset area below the command list, but in a format that allows you to 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. There are also functions to revert entire command sets, on the **Tracer** menu.

Segmenting Stream Files

Sometimes, when your disc has content that requires two layers, you cannot find a way to lay out your files so that neither layer is too large. This happens when you have very large transport files (**XXXXX.m2ts**). In particular, if you have any single file that's larger than about 12 million sectors, it won't fit onto a single layer.

Under these circumstances, it is possible to split a file across the two layers, but the difficulty comes in finding a good place within the file to use as the split point. Because the layer change takes time in a hardware Blu-ray player, you don't want the split point to occur in the middle of a scene.

With Tracer, you can use the playback window to find a good split point visually, then lay out your files with the layer break between the segments of the split file.

To begin, use the playback window to start playing the clip that you wish to divide. When it is playing, click **Freeze** at the bottom of the playback window — you don't want playback to end while you are busy choosing your split point:



In the bottom left corner, next to the **Eject** button, you'll see a small gray "disclosure" triangle. Click it to expand the window to reveal the hidden controls you'll use to create a split point:



At the bottom center of the window, you'll now see a sector number, which is the **approximate** position of the current frame within its transport stream file.

Remember that the locations and sizes of files in the Files tab are given in terms of sectors. The position is approximate because a frame may fit entirely within a sector, or it may be split across two sectors, or it may require multiple sectors.

Amongst the newly revealed controls, you'll see there are three pairs of frame navigation tools:

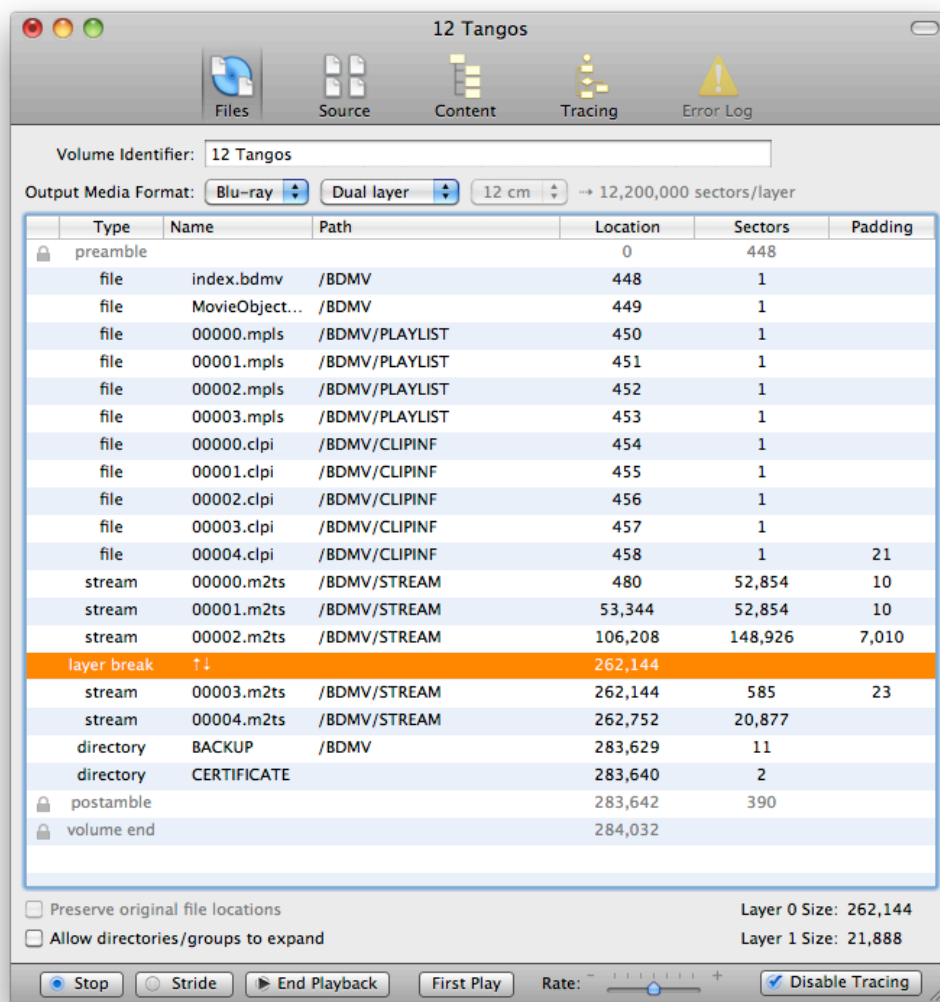
- Single-frame **Forward** and **Backward** buttons. Use these buttons to navigate the clip one frame at a time.
- Splittable-frame **Forward** and **Backward** buttons. Not every frame is allowable as a split point. Use these buttons to navigate between allowable split points.
- Segment **Forward** and **Backward** buttons. Since the clip in our example hasn't been split yet, it consists of a single segment.

You can also drag the time code slider above the sector number display to go directly to different positions within the clip.

There is a second (non-draggable) slider below the sector number, which visually represents the position of the current frame's sector within the transport stream file.

The last pair of buttons are the **Split** and **Join** buttons, which you'll make use of soon. Note the text above these buttons: the clip number of the current clip, its play item number and its playlist number. In our example, there is only one play item, so it's number 0.

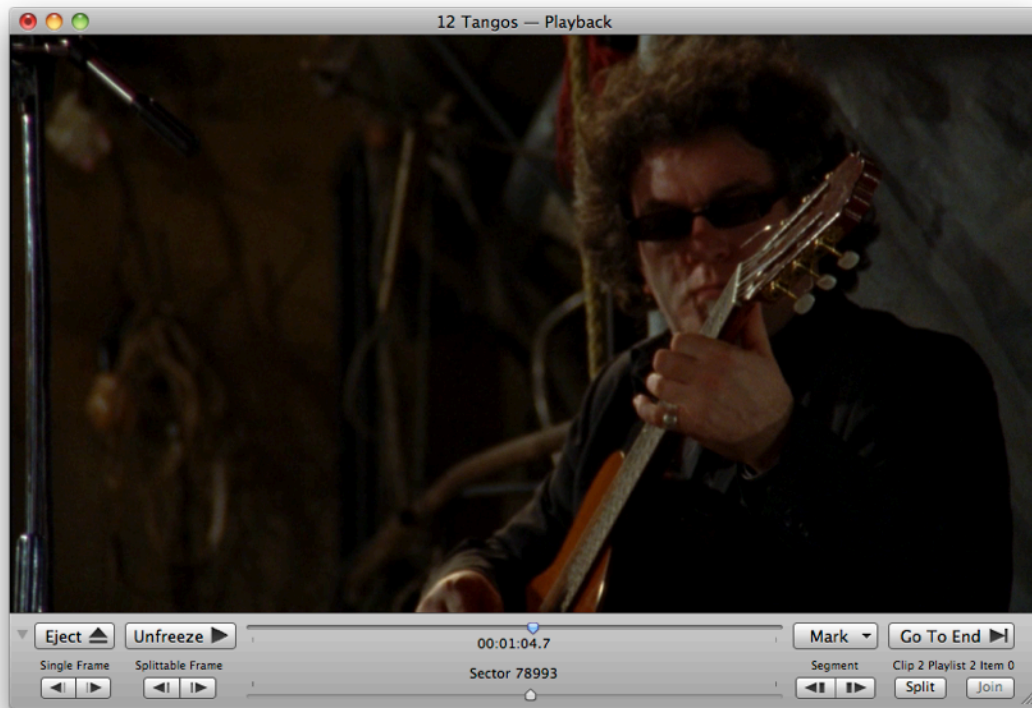
Let's compare this information with what's shown in the Files tab of the job window:



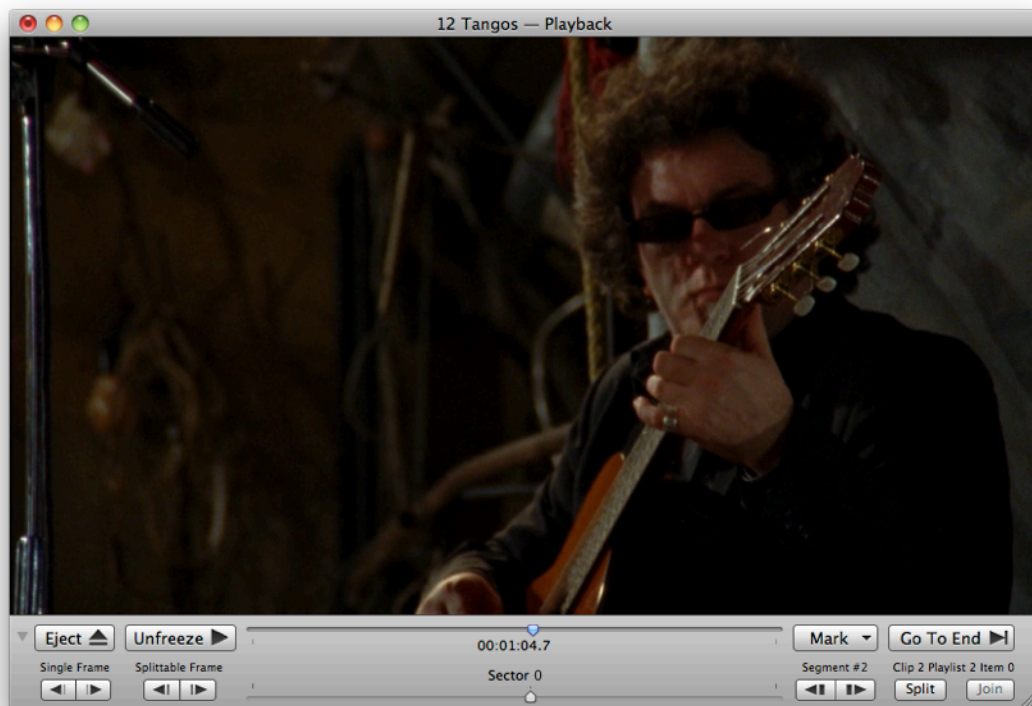
The layer break is highlighted in the list, and above it is the transport stream file for clip 2. It's quite small, only about 150,000 sectors, but we're going to split it anyway, as a demonstration of the technique.

If you look back at the playback window, you'll see that the current frame is at sector 86,085 of the clip file, a little over halfway through. Considering where we paused playback, that looks about right.

In terms of dividing the stream file, this might seem like a potential split point. But you can tell from watching the video that we're in the middle of a steady shot, so this is actually not a good place to put the layer break. By scrubbing around a little using the time code slider, you can find a place nearby where the video cuts from one shot to another:



Let's use that as the split point. All you need to do is click the **Split** button, and notice what changes in the window:



Since you have started a new segment at the current position, playback now at sector number 0 within the new segment, which is segment #2. (The part of the file before the split point is segment #1.)

Let's look at the Files tab again, and see what's changed there:

stream	00000.m2ts	/BDMV/STREAM	480	52,854	10
stream	00001.m2ts	/BDMV/STREAM	53,344	52,854	10
stream[1]	00002.m2ts	/BDMV/STREAM	106,208	79,008	
stream[2]	00002.m2ts	/BDMV/STREAM	185,216	69,918	7,010
layer break	↑↓		262,144		
stream	00003.m2ts	/BDMV/STREAM	262,144	585	23
stream	00004.m2ts	/BDMV/STREAM	262,752	20,877	

The two segments of stream file **00002.m2ts** now appear as separate entries in the list. To place the layer break between them, just drag it into position and you're done:

