White Paper

Standards Conversion in a 3D Workflow

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Introduction

Worldwide audiences are becoming accustomed to seeing 3D content. Many new movie releases are now available in 3D, the recent Six Nations rugby championship was shown in 3D in UK cinemas, UK Premier League football was shown in 3D in selected UK pubs, ballet and opera has been available to 3D movie theater audiences in the US and Canada for some time, and many TV channels have now announced forthcoming 3D TV services to the home. The 3D market is being further stimulated by display screen manufacturers who are keen to benefit from the opportunities for home display replacements, as well as 3D games and Blu-ray discs which provide important new content for 3D viewers.

For the broadcaster planning to engage in 3D services, the question of standards conversion is important. Most broadcasters will buy in some external content from international sources e.g. content from major live events such as the Olympic Games or the FIFA World Cup, studio material such as 3D movies originally produced for cinema screenings, and other program material from other 3D TV channels. Standards conversion, from one frame rate to another, is therefore required for 3D services in the same way that it is required for today's HD and SD services.

In this White Paper, we describe some practical examples of 3D standards conversion in which broadcasters and post production users have successfully converted 3D content from one frame rate to another using Snell's Alchemist Ph.C-HD, and we recommend a configuration which offers the best quality results.

3D Standards Conversion

The 3D signal consists of left eye (L) and right eye (R) channels which are captured by two cameras arranged to simulate the different perspectives between a viewer's left and right eyes. The images are captured with exact synchronisation between the two views, and when presented to a viewer on a 3D screen with appropriate viewing conditions e.g. polarised or shuttered glasses, the viewer experiences a sensation of depth.

Well-produced 3D is comfortable and pleasing to viewers as long as precise alignment of the L and R images is respected in any downstream processing, including standards conversion. Viewers will experience discomfort and dissatisfaction if there are differences in vertical alignment, color, or resolution between the two streams. If the horizontal disparity between L and R is changed, the depth perspective will be moved, leading to discomfort and unwanted effects.

Therefore it is essential that any 3D material which needs to be standards converted should be processed through equipment where the user has confidence that identical processing will be applied to the L and the R channels. The standards conversion must not introduce any discrepancies which would affect the end viewing experience.

Some examples of typical 3D material are shown in Figures 1 and 2. These examples show the differences between the two views, which must be precisely replicated in any conversion process. The differences are most visible on the left and right edges of the pictures. For example, in Figure 1(a) the woman on the far right of the scene appears to be exactly on the edge of the picture in the Left view, but is slightly away from the edge in the Right view. Similarly, the player on the left edge of the

scene in the Left view has "29" visible on his shirt, but in the Right view, the "2" is slightly obscured. The effect is more pronounced in Figure 2.

It is these subtle differences that create the impression of depth when the content is viewed on a 3D screen with polarised glasses, since these are the same subtle differences that the human eyes experience when looking at real-world content.

Figure 1(a) : Left channel

Figure 1(b) : Right channel

Figure 1 : Example 3D content used in Snell standards conversion tests

Figure 2(a) : Left channel

Figure 2(b) : Right channel

Figure 2 : Example 3D content used in Snell standards conversion tests

Workflow Options

The choice of 3D standards conversion processing will depend on the overall 3D content workflow, including origination, intermediate storage, post production and transmission or screening.

Two-Channel Standards Conversion : Tape-to-Tape

Users producing 3D material on HD Cam SR tape have the option to record L and R streams onto one tape, using the SR dual stream mode. Such tapes can then be played out using the dual outputs into a 3D display or 3D projector/screen combination which will enable users to enjoy the stereoscopic effect using passive or shuttered polarised glasses.

An example of tape-to-tape workflow for conversion of 3D content produced on HD Cam SR tape is shown in Figure 3. Note that both Alchemist Ph.C-HD converters are set with the same parameters and are externally referenced to a video source which is compatible with the chosen output format. By careful use of the Alchemist Ph.C-HD 'Sync-Auto' timecode mode, the exact same relationship between input frame rate and output frame rate can be maintained for both left eye and right eye conversions (see Appendix A).

The HD Cam SR shown in Figure 3 is just one example device : the two Alchemist Ph.C-HDs can feed any downstream device that supports L and R streams on a dual-link input.

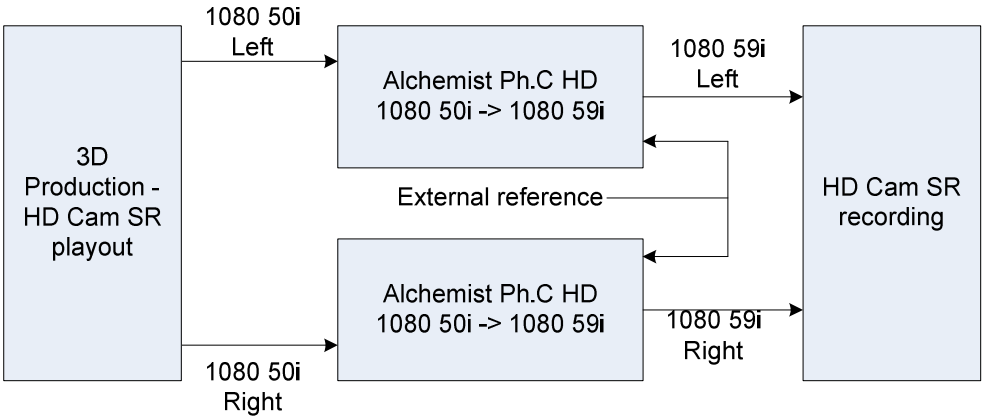

Figure 3 : Two channel 3D content standards conversion

The configuration shown in Figure 3 is most appropriate for non-live productions where it is essential to preserve downstream quality, e.g. for cinema viewing or downstream editing.

Another example of the two channel tape-to-tape workflow is where a user may be originating 3D content in 1080 23.98PsF and requires a 1080 59i output with 2:3 cadence. As shown in Figure 4, this conversion can be supported using two Alchemist Ph.C-HD units with the FilmTools option fitted. Again, the 'Sync-Auto' timecode mode can be utilised to ensure identical 2:3 sequences are applied to both Left eye and Right eye content, with respect to timecode[1] (see Appendix A).

A key benefit of the Alchemist Ph.C-HD Sync-Auto timecode feature is the ability to carry out a two channel 3D conversion using only one Alchemist Ph.C-HD unit. This means that the user can effectively achieve the equivalent of the two unit conversion shown in Figures 3 and 4 using only one Alchemist Ph.C-HD. The conversion requires two passes, but as long as the temporal phase is locked to the same reference point, the user is guaranteed consistent cut position and movement between the two independent conversions of the Left and Right streams. Without Sync-Auto mode, this could not be achieved.

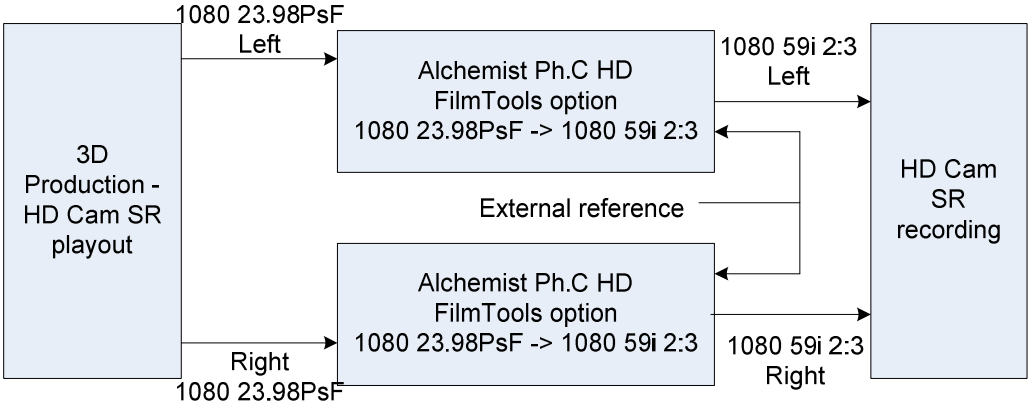

Figure 4 : Two channel 3D conversion requiring 2:3 insertion

One of the benefits which the Alchemist Ph.C-HD FilmTools option bring to the workflow, shown in Figure 4, is that the Alchemist Ph.C-HDs can be set up to automatically detect the input cadence, and can make any necessary corrections if the

[1] The Timecode feature on an Alchemist Ph.C-HD is an option. This option must be present on both Alchemist Ph.C-HDs performing the dual conversion process.

user accidentally supplies content of the wrong cadence or has mixed film and video content after a previous editing stage. Through manual selection of the 2:3 insertion mode and required timecode start points, the user can be sure that exactly the correct cadence will be obtained on both Left and Right streams.

Two-Channel Standards Conversion: Live Workflow

3D standards conversion may also be required for live workflows e.g. where a major sports event is to be broadcast live in 3D. Figure 5 shows a two channel 3D standards conversion integrated into a live transmission workflow. Note that the user may not have control of the 3D production if they are taking a feed from an international supplier.

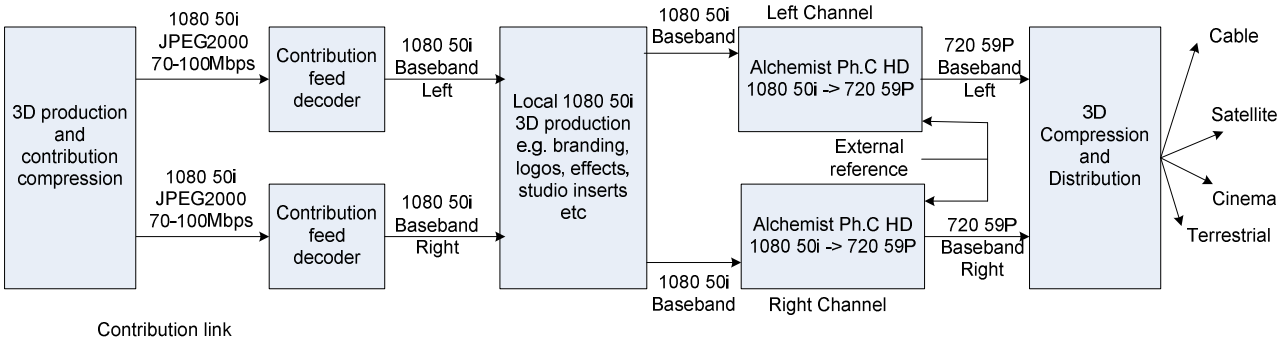

Figure 5 : Two channel 3D standards conversion in a transmission workflow

As can be seen in Figure 5, a similar configuration to that shown in Figure 3 is used, but in the example of Figure 5, the user is converting to 720 59P for transmission. The quality of the pictures viewed at the home display will depend largely on the bandwidth used to compress the pictures at the contribution and transmission stages. Standards conversion using Alchemist Ph.C-HD will be virtually transparent.

Single Channel Standards Conversion

For practical reasons, some broadcasters are favouring a single channel 3D distribution path, where the L and R images are horizontally sub-sampled and placed side by side into a frame before the content is compressed and transmitted. This has the advantage of bandwidth efficiency, as only a single transmission channel is required, rather than two. Other single channel approaches are also possible including vertical sub-sampling leading to a top-over-bottom picture configuration and a time multiplexed approach where odd fields carry the L signal and even fields carry the R signal.

If a broadcaster receives a 3D contribution feed which is already in the side-by-side format, the standards conversion appears towards the end of the processing workflow, as shown in the example of Figure 6.

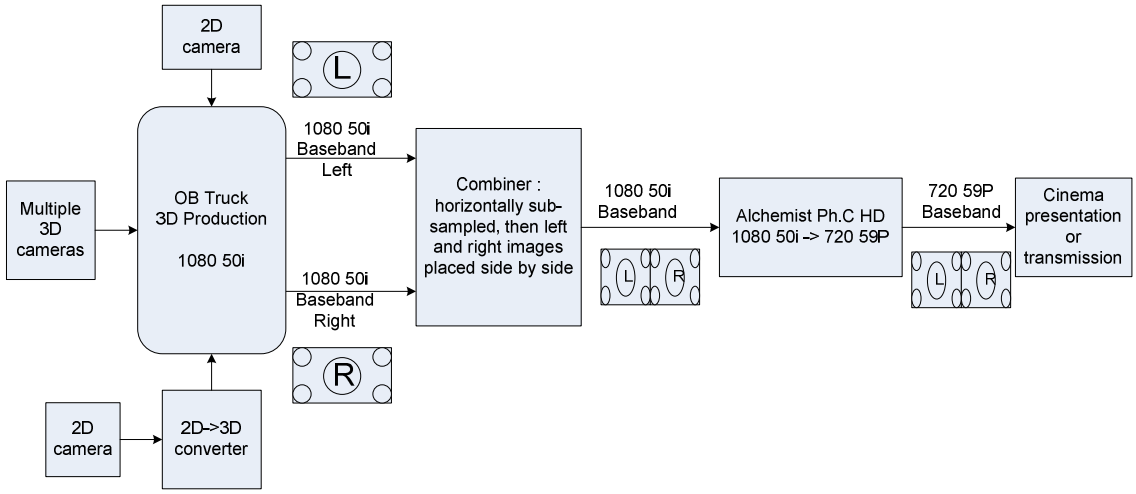

Figure 6 : Example single channel 3D standards conversion

It is important to note that the end quality of the program delivered in Figure 6 will depend critically on the combiner process, which may introduce unnecessary bandwidth limitation when horizontally sub-sampling. The final Alchemist Ph.C-HD standards conversion from 1080 50i to 720 59P will be generally artifact-free.

3D Conversion Testing

To help customers prepare for 3D transmissions and screenings, Snell has carried out testing with the Alchemist Ph.C-HD in both single and dual channel configurations. For successful conversion, identical processing must be applied to the L and the R signals, whether they appear as separate streams via a dual-link connection or multiplexed together into one picture.

The examples shown above in Figures 1 and 2 indicate the type of 3D material that Alchemist Ph.C-HD was used to convert. Such content is quite challenging as it contains highly detailed, high contrast, fast-moving objects. In both the dual and the single channel 3D conversion approaches, Alchemist Ph.C-HD was found to convert the content without any problems, ensuring that the precise differences between L and R were preserved, even with frame rate conversion.

It was clear from the tests that the single channel standards conversion method can lead to a lower final viewing quality due to the horizontal bandwidth limitation at the stage before the standards conversion (see Figure 6), so the dual channel method is recommended if very high quality end presentation is required.

Conclusions

In this White Paper, we have introduced some typical workflows in which 3D content requires frame rate and format conversion, based on real examples we have tested with customers. If the broadcaster has a choice, we recommend the two channel approach as it will lead to the best possible quality end result, since the full available bandwidth of the L and R signals is preserved throughout the workflow.

If the broadcaster is constrained by very limited production or transmission bandwidth, the single channel workflow may be preferred, and in this case, the broadcaster should be aware that the program quality at the viewer's display device can be critically affected by the sub-sampling in the processing chain.

Whichever approach is chosen, Snell's Alchemist Ph.C-HD will provide excellent quality results for the standards conversion step.

Appendix A : Detailed Timecode Set-up Instructions

With regard to dual channel standards conversion, it is important that the same process is applied to both left eye and right eye channels. This is easily achieved by application of the Alchemist Ph.C-HD's 'Sync-Auto' timecode[2] mode.

Assuming that both left-eye and right-eye streams have identical timecode, by identifying a known reference point in both streams (usually this would be the first frame of the program), the Sync-Auto mode ensures that an identical conversion process is applied to each stream. This is very important for seamless processing of 3D content.

For the purposes of demonstration, let us consider an Alchemist Ph.C-HD conversion of 23.98 PsF to 29.97 2:3 where a 2:3 pulldown process is added. In this scenario, the conversion from 23.98 to 29.97 is achieved by repeating certain frames according to the defined 2:3 Pulldown process. It is imperative that the repeated frames in the left eye stream are exactly synchronous with the repeated frames of the right eye stream.

Example of Conversion Without Using Sync-Auto Mode:

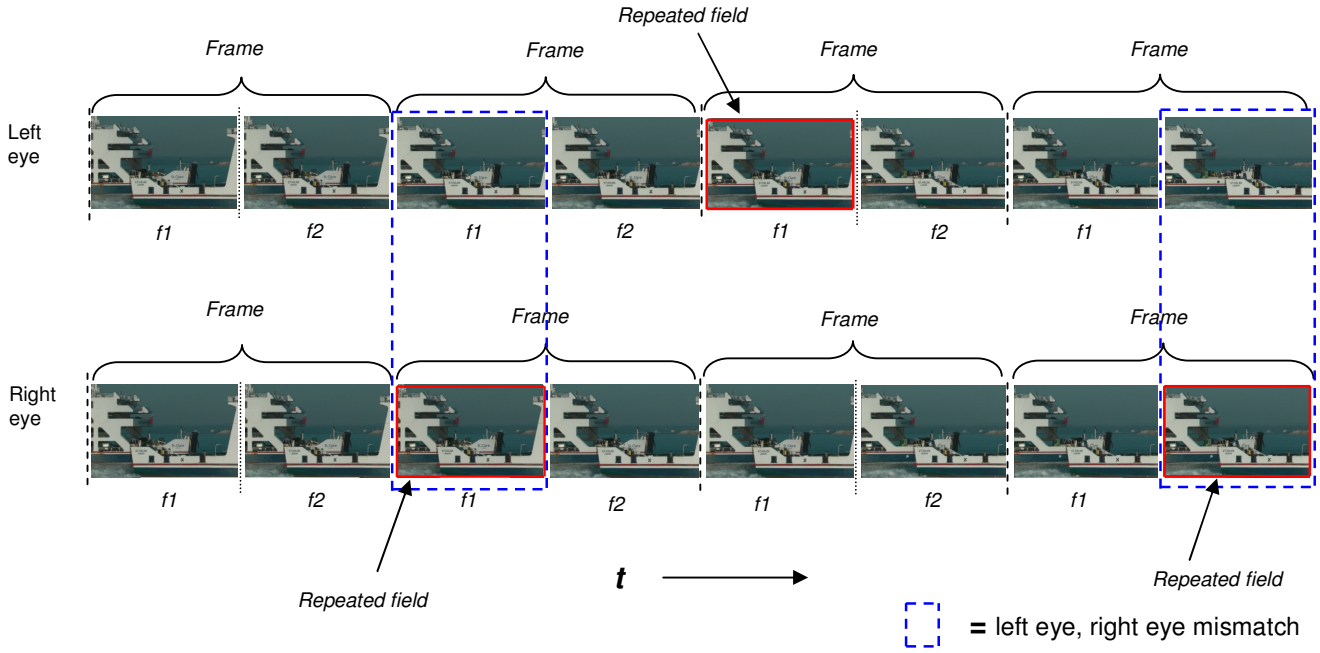

Figure A1: Conversion example of 2:2 to 2:3, dual channel, without cadence control

Figure A1 above depicts a 2:3 insertion to both the left and right eye streams. If each stream is considered individually, the 2:3 insertion is correct. However, the 2:3 insertion has not been controlled with respect to Cadence and Timecode. Although the frames of both left-eye and right-eye streams are exactly synchronous (as a result of Genlocking), the repeated fields in the left-eye stream, are displaced in time compared to the right-eye. This is a highly undesirable scenario for a 3D presentation.

[2] The Timecode feature on an Alchemist Ph.C-HD is an option. This option must be present on both Alchemist Ph.C-HDs performing the dual conversion process.

Example of Conversion Using Sync-Auto Mode:

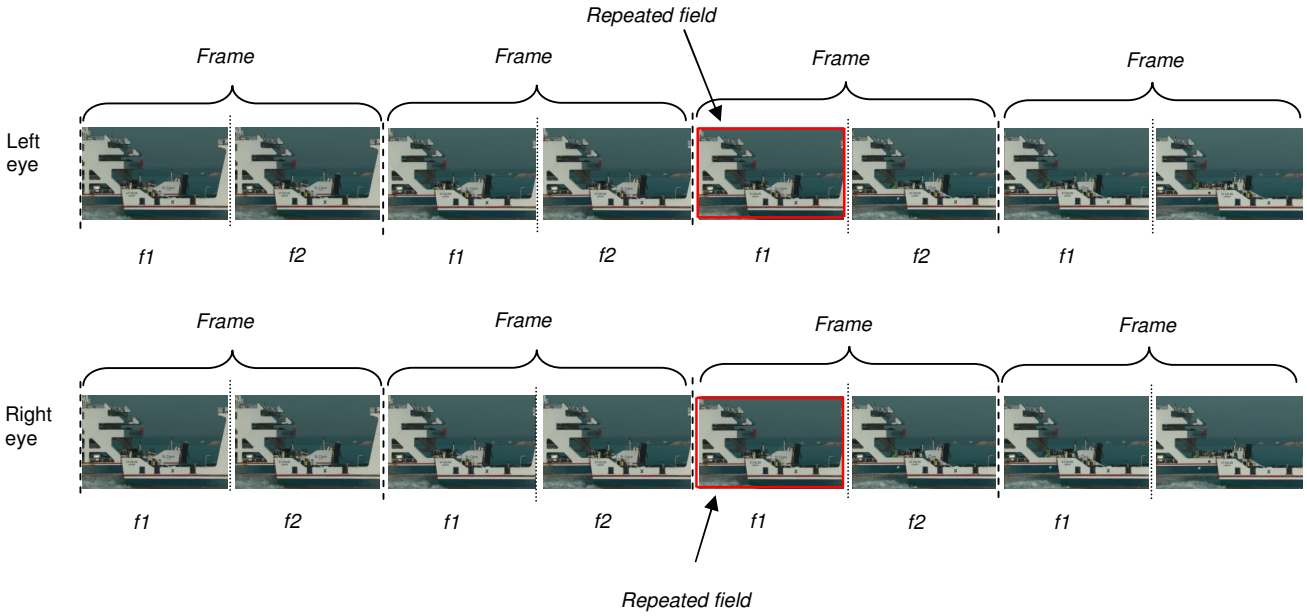

Figure A2: Conversion example of 2:2 to 2:3, dual channel, with cadence control

By the application of the Alchemist Ph.C-HD's 'Sync-Auto' Timecode mode, the 2:3 insertion is identical in both the left-eye stream and the right-eye stream. The repeated fields in each stream are co-incident, as shown in Figure A2.

The example shown is of a simple 2:3 Pulldown process. However, whatever the conversion type employed, it is important that identical processes are applied to both the left and right streams. The implementation of the Sync-Auto timecode mode enables us to achieve this conversion condition.

Alchemist Ph.C-HD Dual 3D Conversion Configuration

The first part of the process would be to analyse the source streams and identify a known reference point in both the left and right eye streams. This would normally be the very first frame of the program. In a 3D presentation, it would be assumed that the first frame of each eye would have the same Timecode[3] value.

Consider a 3D program with left and right eye streams as shown in Figure A3. It is quite a common scenario within the broadcast industry for timecode of the very first frame of the program to be given a TC value of exactly 1 hour. First we would need to analyse the two streams and ensure that the timecode of both left and right eyes are indeed the same (in this example 00:01:00:00).

[3] *The Timecode feature on an Alchemist Ph.C-HD is an option. This option must be present on both Alchemist Ph.C-HDs performing the dual conversion process.*

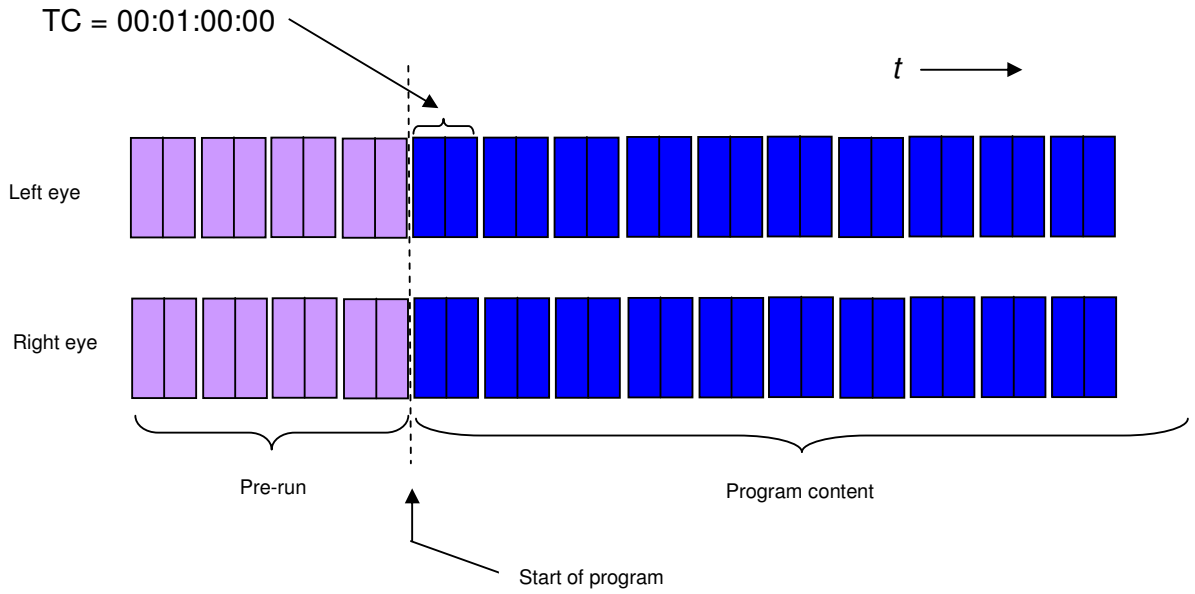

Figure A3: 'Start of Program' 3D analysis

Alchemist Ph.C-HD Setup

A dual 3D Conversion can use two separate Alchemist Ph.C-HD systems at the same time, both set up with an identical configuration, or can use one Alchemist Ph.C-HD in two passes, keeping the settings unchanged, as explained above in the main section of this White Paper.

In the 'Timecode Conversion' menu, the following settings would be made:

1. The Timecode mode is set to: 'Sync-Auto'
2. The 'Input Timecode Trigger' set to: 00:01:00:00

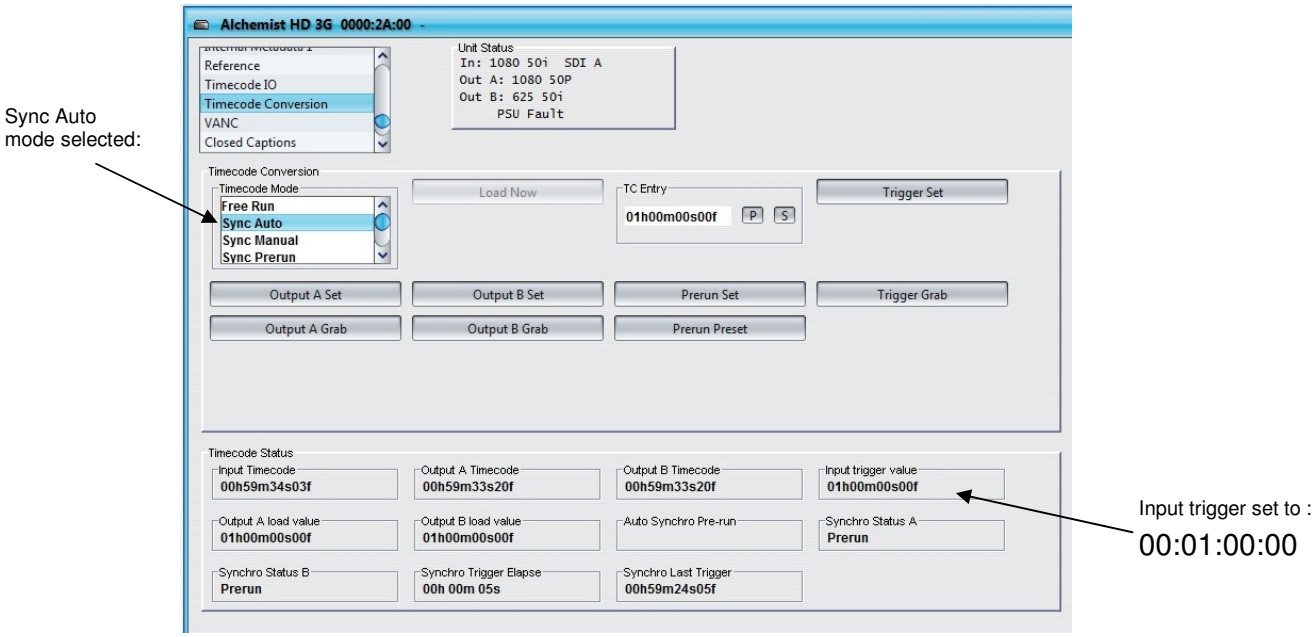

Figure A4 : Set-up for Alchemist Ph.C-HD 'Sync-Auto' Timecode Mode

In the FilmTools Menu, the following settings are applied to the Output sub-menu:

1. Cadence Control set to: 2:3 TC Datum
2. Use Datum Timecode: Enabled
3. Datum TC set to: 00:01:00:00
4. 2:3 Datum Cadence set to: 'AA'
5. 2:3 Cadence reset to: 'at datum point'

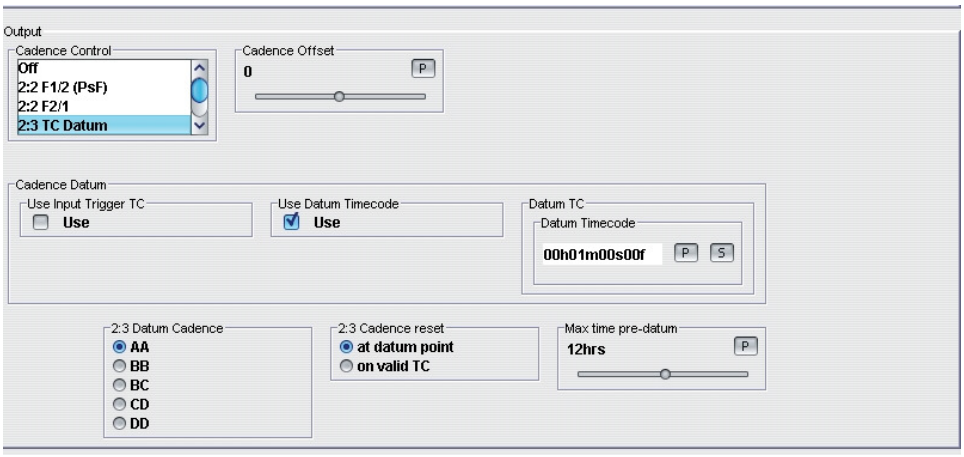

Figure A5 : FilmTools Menu set-up

This settings configuration ensures that the 'AA' frame of our 2:3 insertion occurs exactly at the start of Program. Applying the settings to both Alchemist Ph.C-HDs being used for a dual 3D conversion ensures that the 2:3 insertion is identical in the left and right eye streams.

Dual 3D Conversion Configuration

The above description explains the importance of timecode synchronization in a 23.98 PsF to 29.97 2:3 conversion. However, for any cross-field dual 3D conversion (i.e. involving any frame rate conversion), it is very important to maintain the same relationship between input and output streams, across both left and right eye content. By employing the 'Sync-Auto' Timecode mode on the Alchemist Ph.C-HDs being used for the dual 3D conversion, we can always be assured that exactly the same conversion process is being applied to both left-eye and right-eye streams.