

# An Introduction to FFmpeg

Reto Kromer • AV Preservation by reto.ch

## Open-Source Tools and Resources for Audio-Visual Archives

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## Interacting with the computer

- punched cards and printouts
- **command-line interface (CLI)**
- graphical user interface (GUI)
- touchless interface

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ASCII (1977/1986)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0x	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1x	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2x	SP	!	"	#	\$	%	&	'	(	)	*	+	,	-	.	/
3x	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4x	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5x	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6x	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7x	p	q	r	s	t	u	v	w	x	y	z	{		}	~	DEL

Legend:  
■ Changed or added in 1963 version  
■ Changed in both 1963 version and 1965 draft

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# Software

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# The FFmpeg Family

## Tools

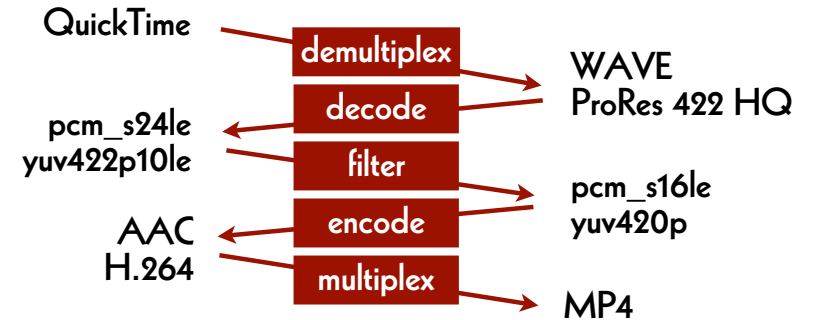
- ffmpeg
- ffprobe
- ffplay

## Libraries

- libavcodec
- libavformat
- libavfilter
- libavutil
- libavdevice
- libswscale
- libswresample
- libpostproc

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# Audio-Visual Exemple



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# Data Transformations



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# File Transformations

## ffmpeg (CLI)

→ [ffmpeg.org](https://ffmpeg.org)

## FFmpeg Cookbook for Archivists

→ [avpres.net/FFmpeg/](https://avpres.net/FFmpeg/)

## ffmprovisr

→ [amiaopensource.github.io/ffmprovisr/](https://amiaopensource.github.io/ffmprovisr/)

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## Metadata Extraction

**MedialInfo** (GUI) and **mediainfo** (CLI)

→ [mediaarea.net/MedialInfo](http://mediaarea.net/MedialInfo)

**ffprobe** (CLI)

→ [ffmpeg.org](http://ffmpeg.org)

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## Media Player

**VLC** (GUI)

→ [www.videolan.org/vlc/](http://www.videolan.org/vlc/)

**mpv** (CLI)

→ [mpv.io](http://mpv.io)

**ffplay** (CLI)

→ [ffmpeg.org](http://ffmpeg.org)

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## A GUI for FFmpeg

**FFCommand Engine** (GUI)

→ [github.com/ColorlabMD/FFCommand\\_Engine](https://github.com/ColorlabMD/FFCommand_Engine)

version 0.6 for macOS via Homebrew:

```
brew tap avpres/formulae
```

```
brew install --HEAD ffcommand-engine
```

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	<b>avantages</b>	<b>disavantages</b>
<b>TIFF DPX OpenEXR</b>	data easier to process	bigger files
<b>JPEG 2000 FFV1</b>	smaller files	data complexer to process

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## Single Images and Streams

### **RAWcooked** (CLI)

→ [mediaarea.net/RAWcooked](http://mediaarea.net/RAWcooked)

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## RAWcooked

- encoding into Matroska (.mkv) using FFV1 video codec and FLAC audio codec
- all metadata preserved
- decoding with bit-by-bit reversibility
- possibility to embed sidecar files, for example MD5, LUT, XML, PDF
- compatibility with media players

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## Basics

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# Set the Working Space

Linux/Mac/Windows Terminal or WSL:

```
cd ~/Desktop
```

Windows locally:

```
cd Desktop
```

Windows on OneDrive Cloud:

```
cd OneDrive
```

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# Command structure

```
$0      $1      ${n}  
command argument_1 ... argument_n
```

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# Command structure

```
$0      $1      ${n}  
command argument_1 ... argument_n
```

common syntaxes of arguments include:

```
--parameter
```

```
--parameter=value
```

```
-p
```

```
-p value
```

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# Generate an Image File

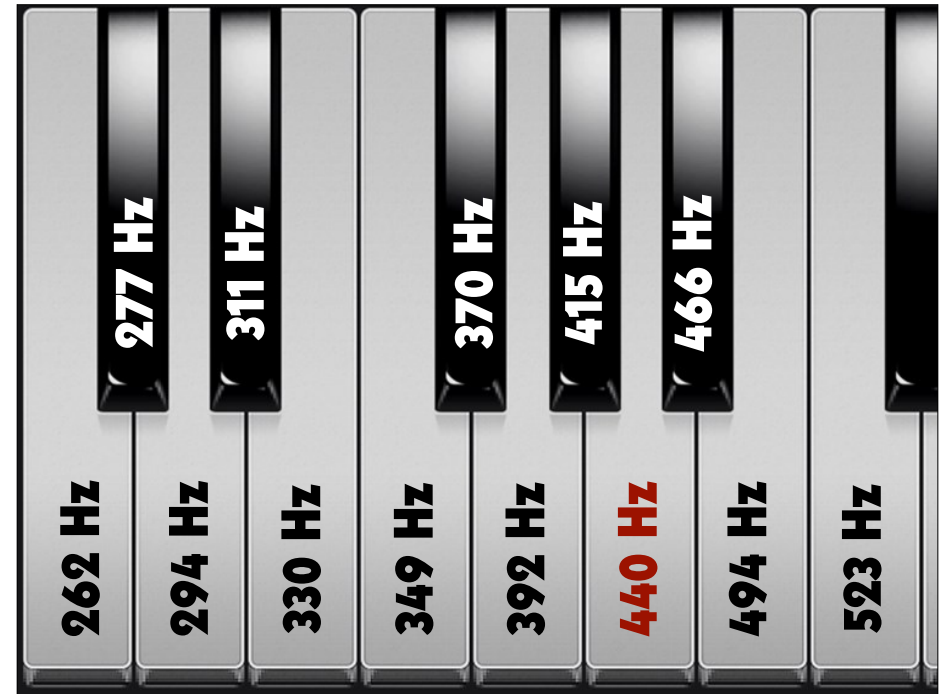
```
ffmpeg  
-lavfi mandelbrot  
-t 10  
-c:v rawvideo  
-pix_fmt uyvy422  
mandelbrot.avi
```

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## Play the Image File

```
ffplay  
mandelbrot.avi
```

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## Generate a Sound File

```
ffmpeg  
-lavfi sine=frequency=440  
-t 10  
la.wav
```

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## Play the Sound File

```
ffplay  
la.wav
```

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## Merge Image and Sound

```
ffmpeg  
-i mandelbrot.avi  
-i la.wav  
-c:v copy  
-c:a copy  
mandela.avi
```

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## Play the AV File

```
ffplay  
mandela.avi
```

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## Extract the Metadata (1)

```
ffprobe  
mandela.avi
```

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## Container

```
ffprobe  
-show_format  
mandela.avi
```

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## Codec

```
ffprobe  
-show_streams  
mandela.avi
```

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## Container and Codec

```
ffprobe  
-show_format  
-show_streams  
mandela.avi
```

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## Format the Output

```
ffprobe  
-show_format  
-show_streams  
-print_format json  
mandela.avi
```

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## Save the Metadata

```
ffprobe  
-show_format  
-show_streams  
-print_format json  
mandela.avi  
> mandela.txt
```

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## Extract the Metadata (2)

```
mediainfo  
  mandela.avi
```

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## Find Help

```
ffmpeg -h  
ffmpeg -codecs  
ffmpeg -decoders  
ffmpeg -h decoder=aac  
ffmpeg -encoders  
ffmpeg -h encoder=libx264  
ffmpeg -filters  
ffmpeg -pix_fmts
```

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## Modify the Container

```
ffmpeg  
  -i mandelbrot.avi  
  -c copy  
  mandelbrot.mov
```

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## Generate Checksums (1)

```
ffmpeg  
  -i mandelbrot.avi  
  -f framemd5  
  mandelbrot.avi_framemd5.txt
```

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## Generate Checksums (2)

**ffmpeg**

**-i** *mandelbrot.mov*

**-f** **framemd5**

*mandelbrot\_mov\_framemd5.txt*

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# Dufaycolor

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## Compare Checksum Files

**Linux/Mac/Windows Terminal or WSL:**

**diff -s**

*mandelbrot\_avi\_framemd5.txt*

*mandelbrot\_mov\_framemd5.txt*

**Windows:**

**fc**

*mandelbrot\_avi\_framemd5.txt*

*mandelbrot\_mov\_framemd5.txt*

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## Play Single Images

**ffplay**

**-loop 0**

*DUFAY\_TIFF/Dufay\_%06d.tif*

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## Different Purposes

archive master format:

→ for preservation and restoration

mezzanine format:

→ for professional use in post-production

dissemination formats:

→ for widely spreading and easy access

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## File Transformations

- from the master file to a mezzanine file and from the mezzanine file to an access file

- from the master file to an access file

→ Compare the quality of the access files.

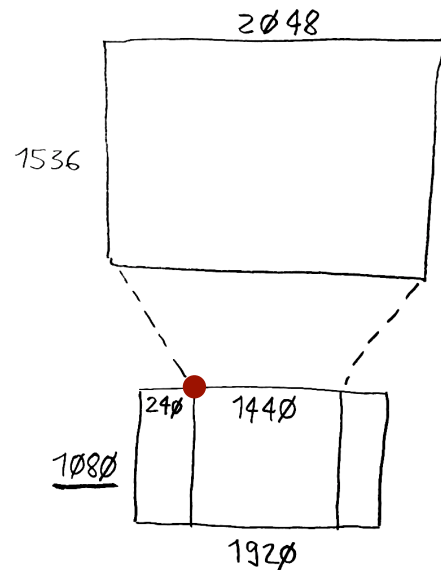
→ Compare the quality of the mezzanine files (Apple ProRes and AVID).

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2K  
4:3



HD  
16:9

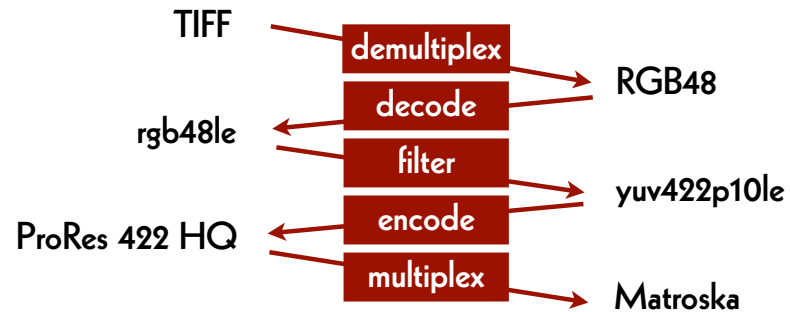


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# ProRes

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## From TIFF to ProRes



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## ProRes 422 and ProRes 4444

- QuickTime (.mov)
- Matroska (.mkv)
- MXF = Material eXchange Format (.mxf)

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## Master → Mezzanine (1)

ffmpeg

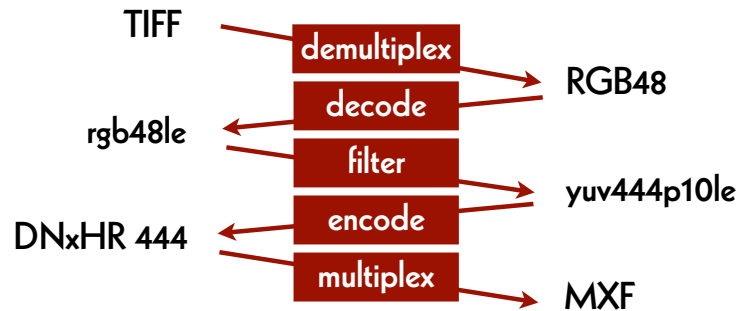
```
-f image2 -framerate 24  
-i DUFAY_TIFF/Dufay_%06d.tif  
-filter:v  
  "scale=1440:1080:flags=lanczos,  
  pad=1920:1080:240:0"  
-c:v prores_ks -profile:v 3  
Dufay_ProRes.mkv
```

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# AVID

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## From TIFF to DNxHR



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## Find Parameters

```
ffmpeg -h encoder=dnxhd
```

```
-profile:v dnxhr_lb -pix_fmt yuv422p  
-profile:v dnxhr_sq -pix_fmt yuv422p  
-profile:v dnxhr_hq -pix_fmt yuv422p  
-profile:v dnxhr_hqx -pix_fmt yuv422p10le  
-profile:v dnxhr_444 -pix_fmt yuv444p10le  
-profile:v dnxhr_444 -pix_fmt gbrp10le
```

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## Master → Mezzanine (2)

```
ffmpeg
```

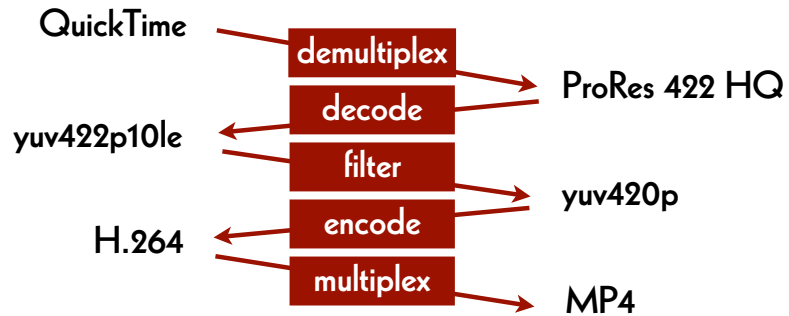
```
-f image2 -framerate 24  
-i DUFAY_TIFF/Dufay_%06d.tif  
-filter:v  
  "scale=1440:1080:flags=lanczos,  
  pad=1920:1080:240:0"  
-c:v dnxhd -profile:v dnxhr_444  
-pix_fmt yuv444p10le  
Dufay_DNxHR.mxf
```

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# H.264

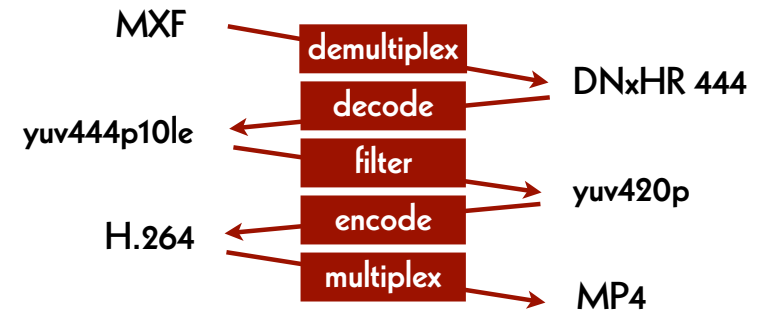
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## From ProRes to H.264



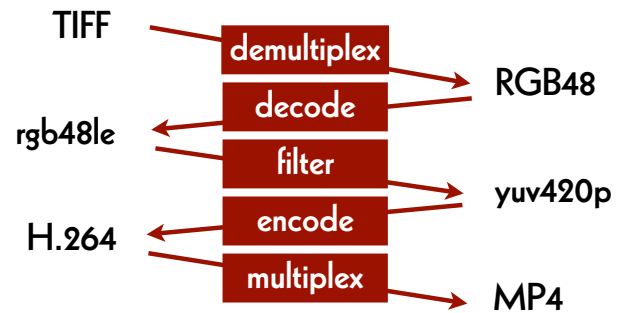
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## From DNxHR to H.264



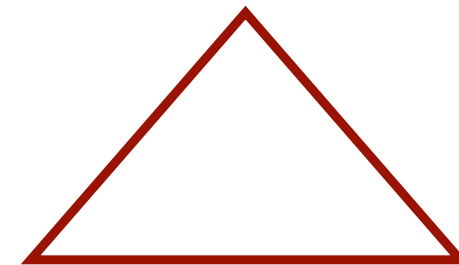
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## From TIFF to H.264



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image quality



encoding time

file size

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## Mezzanine -> Access (1)

```
ffmpeg
-i Dufay_ProRes.mkv
-pix_fmt yuv420p
-c:v libx264 -preset veryslow -crf 30
-movflags +faststart
Dufay_ProRes_H264.mp4
```

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## Mezzanine -> Access (2)

```
ffmpeg
-i Dufay_DNxHR.mxf
-pix_fmt yuv420p
-c:v libx264 -preset veryslow -crf 30
-movflags +faststart
Dufay_DNxHR_H264.mp4
```

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## Master -> Access

```
ffmpeg
-f image2 -framerate 24
-i DUFAY_TIFF/Dufay_%06d.tif
-filter:v
"scale=1440:1080:flags=lanczos,
pad=1920:1080:240:0"
-pix_fmt yuv420p
-c:v libx264 -preset veryslow -crf 30
-movflags +faststart
Dufay_master_H264.mp4
```

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## Quality control

- difference file ("delta" file)
- split screen

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## Split screen (1)

ffmpeg

```
-i Dufay_master_H264.mp4
-i Dufay_ProRes_H264.mp4
-filter_complex
  "[0]crop=iw/2:ih:0:0[left];
  [1]crop=iw/2:ih:iw/2:0[right];
  [left][right]hstack"
Dufay_split_ProRes.mp4
```

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## Split screen (2)

ffmpeg

```
-i Dufay_master_H264.mp4
-i Dufay_DNxHR_H264.mp4
-filter_complex
  "[0]crop=iw/2:ih:0:0[left];
  [1]crop=iw/2:ih:iw/2:0[right];
  [left][right]hstack"
Dufay_split_DNxHR.mp4
```

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## Split screen (3)

ffmpeg

```
-i Dufay_ProRes_H264.mp4
-i Dufay_DNxHR_H264.mp4
-filter_complex
  "[0]crop=iw/2:ih:0:0[left];
  [1]crop=iw/2:ih:iw/2:0[right];
  [left][right]hstack"
Dufay_split_mezzanine.mp4
```

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## Test Filter

ffplay

```
-vf "negate"
Dufay_1_H264.mp4
```

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## Difference file (1)

ffmpeg

```
-i Dufay_master_H264.mp4
-i Dufay_ProRes_H264.mp4
-filter_complex
  "[1]format=yuva444p,
  lut=c3=128,
  negate[1_with_alpha];
  [0][1_with_alpha]overlay"
Dufay_delta_ProRes.mp4
```

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## Difference file (2)

ffmpeg

```
-i Dufay_master_H264.mp4
-i Dufay_DNxHR_H264.mp4
-filter_complex
  "[1]format=yuva444p,
  lut=c3=128,
  negate[1_with_alpha];
  [0][1_with_alpha]overlay"
Dufay_delta_DNxHR.mp4
```

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## Difference file (3)

ffmpeg

```
-i Dufay_ProRes_H264.mp4
-i Dufay_DNxHR_H264.mp4
-filter_complex
  "[1]format=yuva444p,
  lut=c3=128,
  negate[1_with_alpha];
  [0][1_with_alpha]overlay"
Dufay_delta_mezzanine.mp4
```

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