An Introduction to FFmpeg

Reto Kromer • AV Preservation by reto.ch

FFmpeg Workshop
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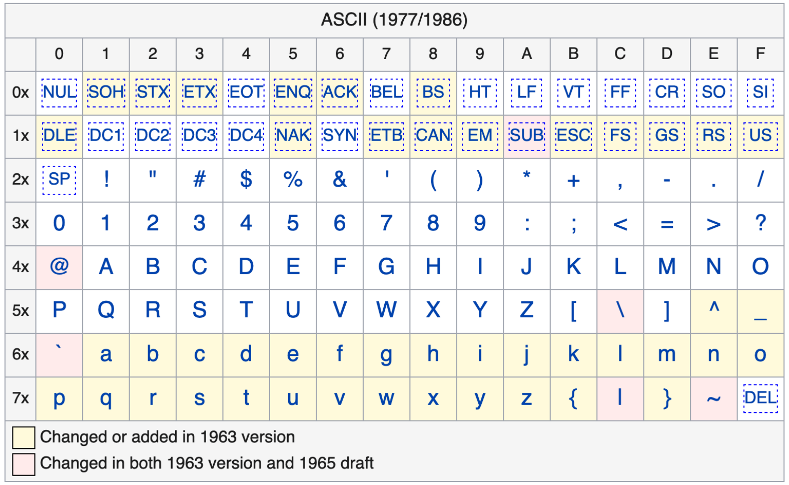


ASCII (1977/1986)																
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0x	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR	SO	SI
1x	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS	RS	US
2x	SP	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3x	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4x	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5x	P	Q	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

🟨 Changed or added in 1963 version
🟥 Changed in both 1963 version and 1965 draft

Interacting with the computer

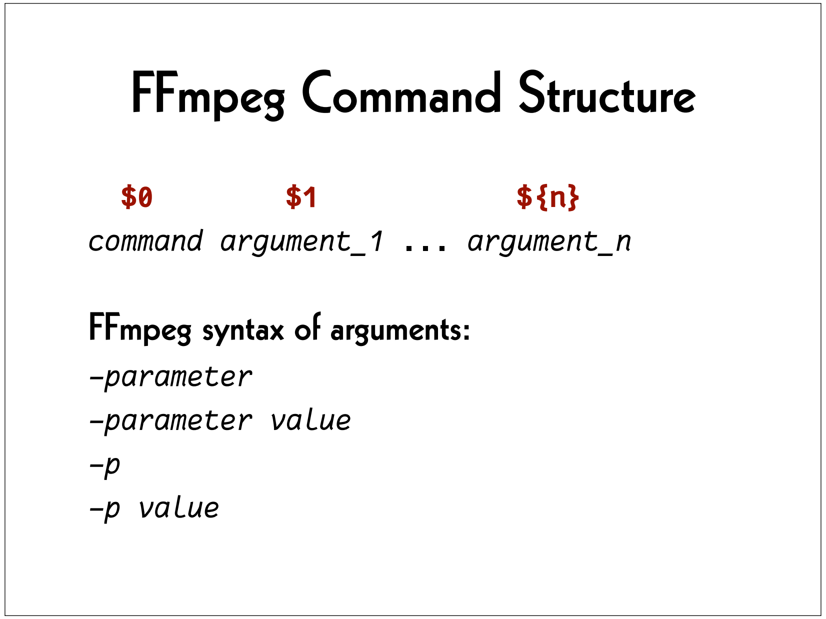
- punched cards and printouts
- **command-line interface (CLI)**
- graphical user interface (GUI)
- touchless interface

Unix/Linux Command Structure

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

common syntaxes of arguments include:

```
--parameter
--parameter=value
-p
-p value
```

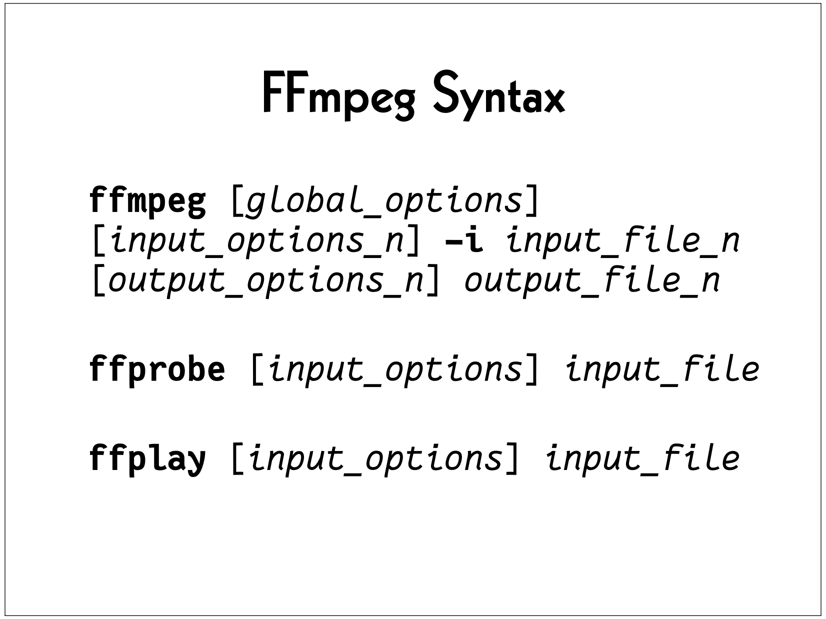


FFmpeg Command Structure

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

FFmpeg syntax of arguments:

```
-parameter
-parameter value
-p
-p value
```

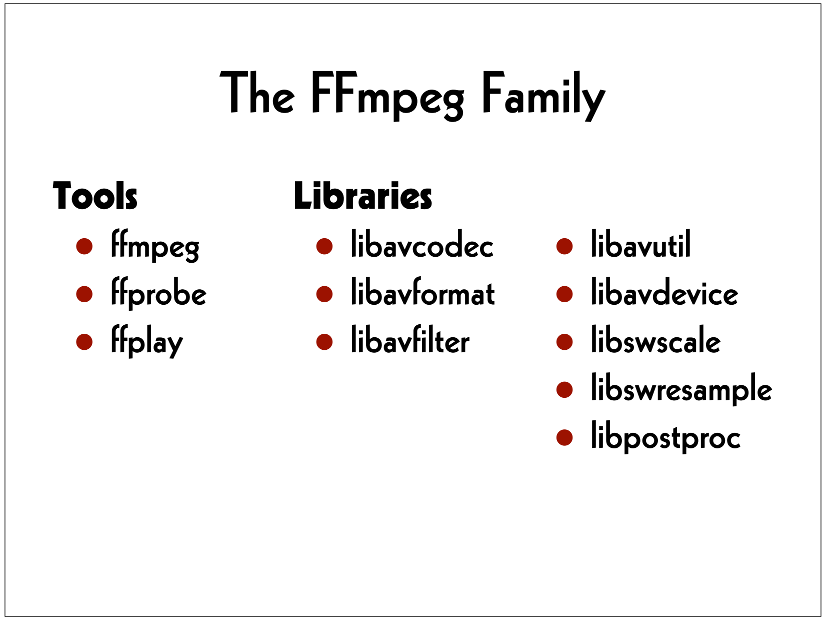


FFmpeg Syntax

```
ffmpeg [global_options]
[input_options_n] -i input_file_n
[output_options_n] output_file_n

ffprobe [input_options] input_file

ffplay [input_options] input_file
```



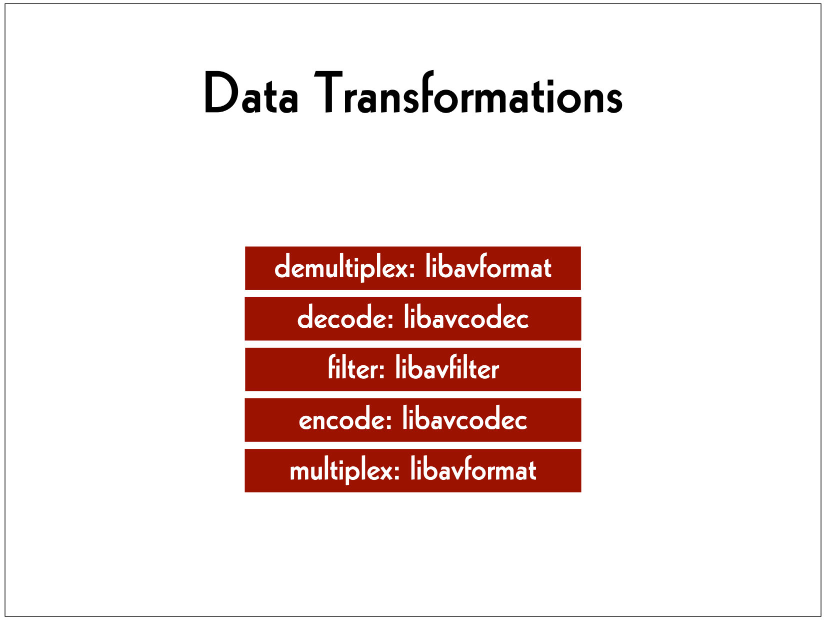
The FFmpeg Family

Tools

- ffmpeg
- ffprobe
- ffplay

Libraries

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



Data Transformations

demultiplex: libavformat

decode: libavcodec

filter: libavfilter

encode: libavcodec

multiplex: libavformat

FFmpeg is used in

- VLC and mpv
- Audacity, Shutter Encoder and Handbrake
- QCTools and AEO-Light
- vrecord
- Google Chrome and YouTube
- "et cetera et cetera et cetera"

File Transformations

ffmpeg (CLI)
➔ ffmpeg.org

FFmpeg Cookbook for Archivists
➔ avpres.net/FFmpeg/

ffmprovisr
➔ amiaopensource.github.io/ffmprovisr/

Metadata Extraction

MediaInfo (GUI) and **mediainfo** (CLI)
➔ mediaarea.net/MediaInfo

ffprobe (CLI)
➔ ffmpeg.org

MediaInfo Parameter Definitions
➔ http://bits.ashleyblewer.com/mediainfo-definitions/

Media Player

VLC (GUI)
➔ www.videolan.org/vlc/

mpv (CLI/GUI)
➔ mpv.io

ffplay (CLI)
➔ ffmpeg.org

A GUI for FFmpeg

FFCommand Engine (GUI)
➔ 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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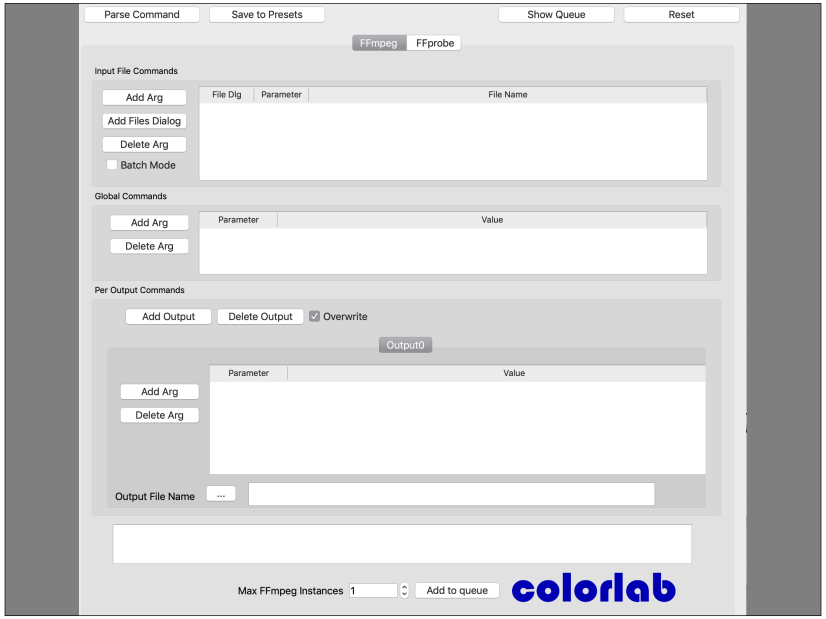

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1st Part

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Set the Working Space

```
# Linux
# Mac
# Windows Terminal or WSL
# Windows locally:
cd Desktop

# Windows on OneDrive Cloud:
cd OneDrive
```

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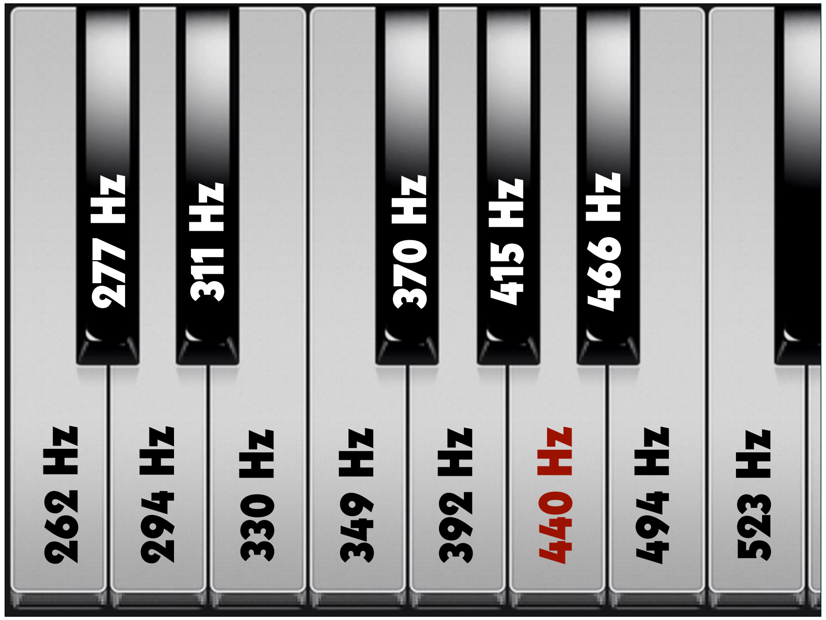
Generate an Image File

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

Play the Image File

```
ffplay
  mandelbrot.avi
```



Generate a Sound File

```
ffmpeg
  -f lavfi -i "sine=frequency=440"
  -c:a pcm_s16le
  -ar 48k
  -ac 2
  -t 10
  la.wav
```

Play the Sound File

```
ffplay
  la.wav
```

Merge Image and Sound

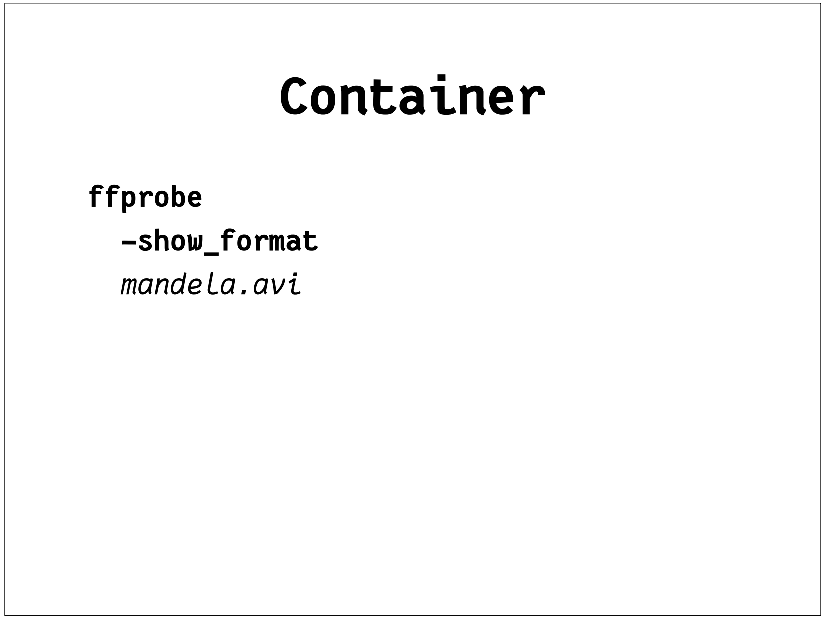
```
ffmpeg
  -i mandelbrot.avi
  -i la.wav
  -c:v copy
  -c:a copy
  mandela.avi
```

Play the AV File

```
ffplay
  mandela.avi
```

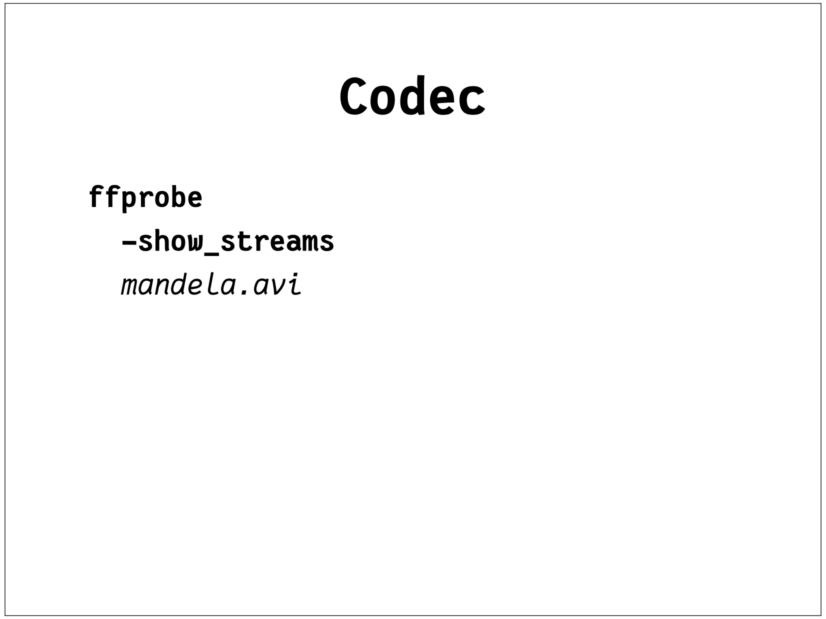
Extract the Metadata (1)

```
ffprobe
  mandela.avi
```



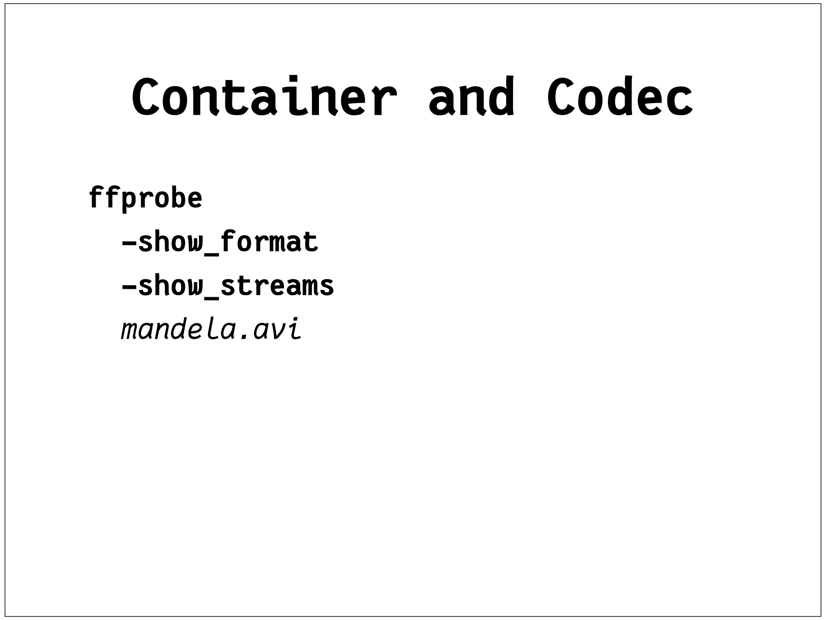
Container

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



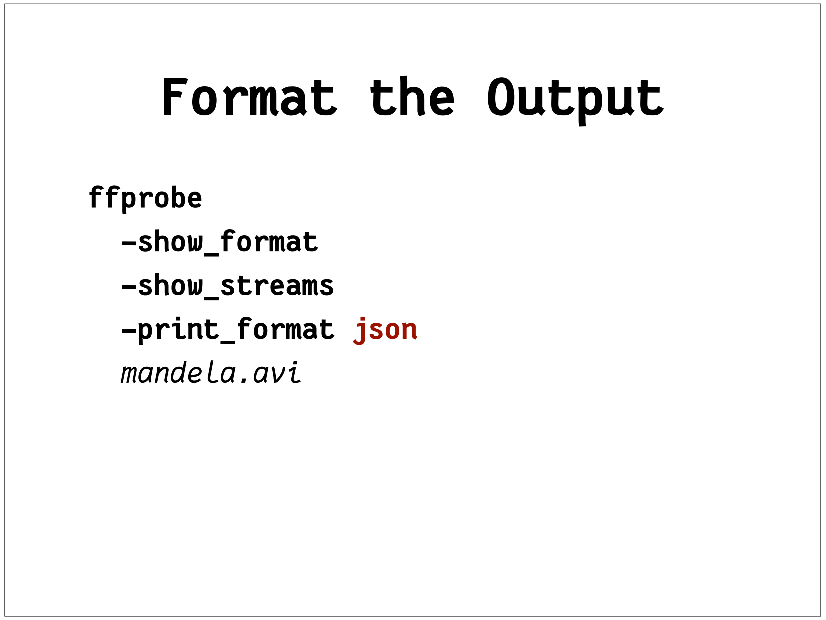
Codec

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



Container and Codec

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



Format the Output

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

Save the Metadata

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

Extract the Metadata (2)

```
mediainfo
  mandela.avi
```

Find Help (1)

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

Modify the Container

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

Generate Checksums (1)

```
ffmpeg
  -i mandelbrot.avi
  -f framemd5
  mandelbrot_avi_framemd5.txt
```

Generate Checksums (2)

```
ffmpeg
  -i mandelbrot.mov
  -f framemd5
  mandelbrot_mov_framemd5.txt
```

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
```

2nd Part

Play Single Images

```
ffplay
  -loop 0
  DUFAY_TIFF/Dufay_%06d.tif
```

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

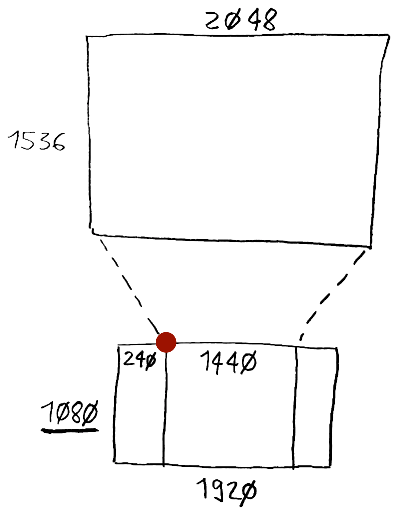
→ Compare the quality of the access files.

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

2K
4:3

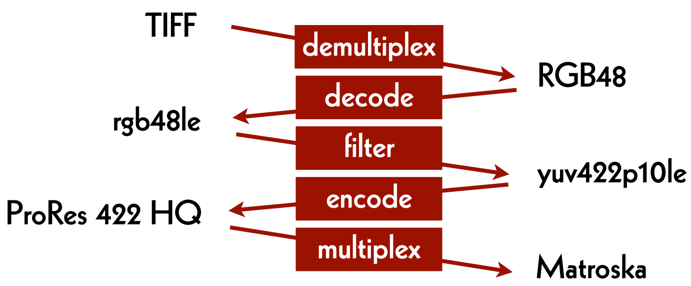
↓

HD
16:9



ProRes

From TIFF to ProRes



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ProRes 422 and ProRes 4444

possible containers

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

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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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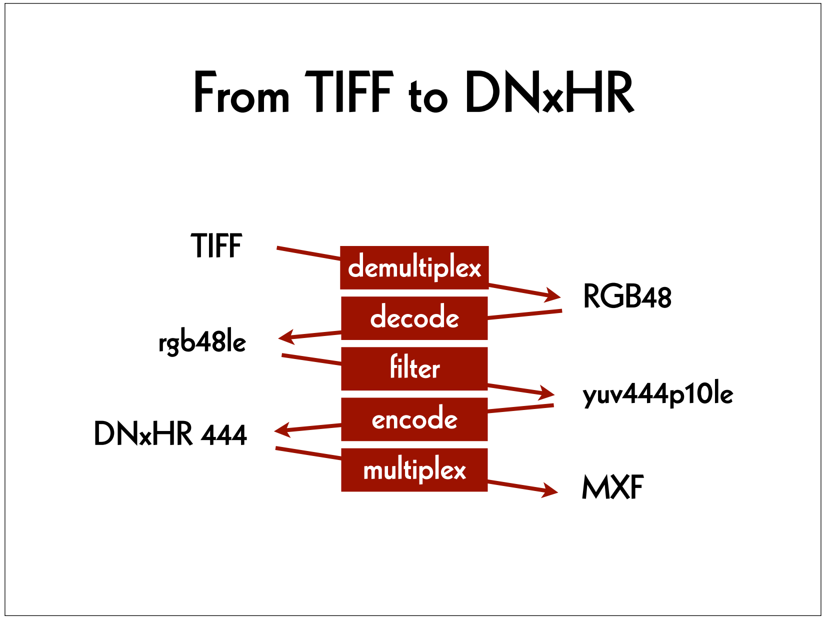

From TIFF to DNxHR

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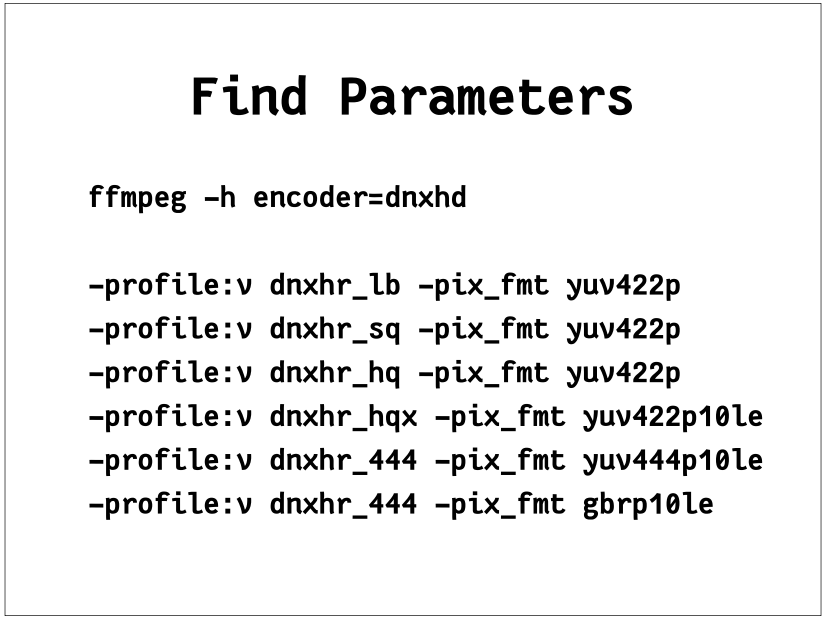

Find Parameters

```
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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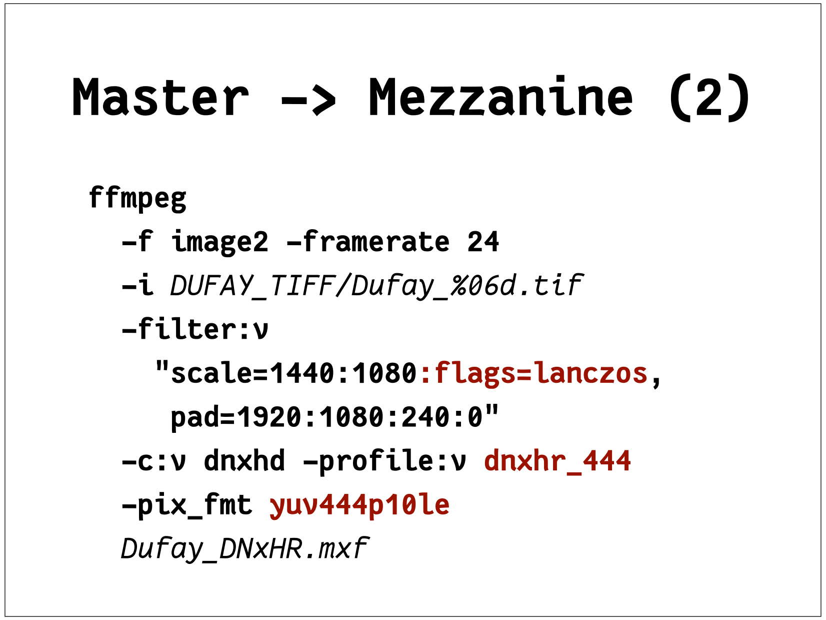

Master -> Mezzanine (2)

```
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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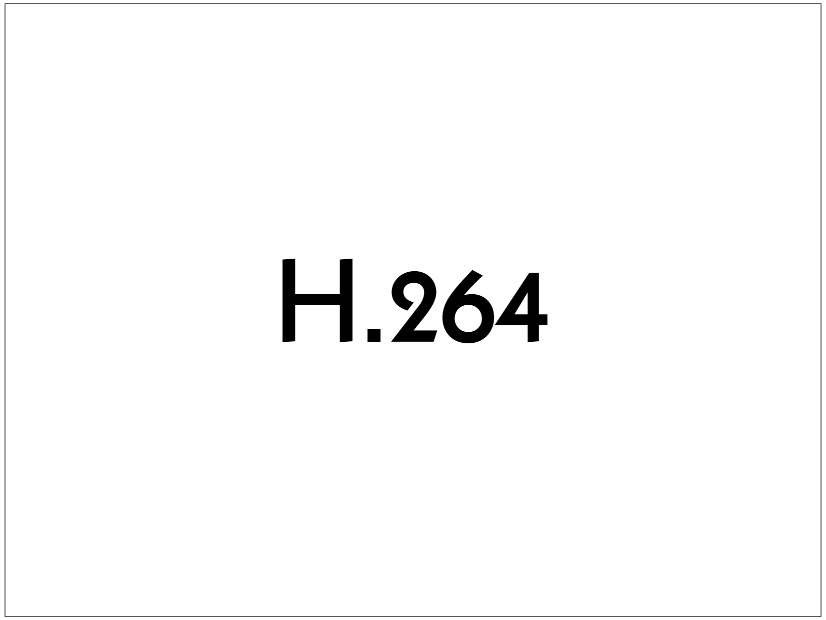

H.264

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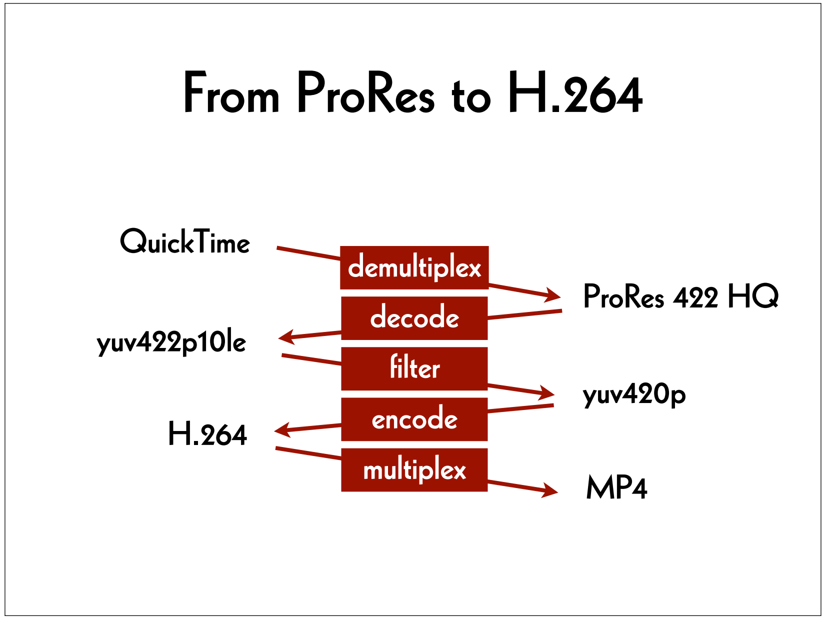

From ProRes to H.264

QuickTime
demultiplex
ProRes 422 HQ
decode
yuv422p10le
filter
yuv420p
encode
H.264
multiplex
MP4

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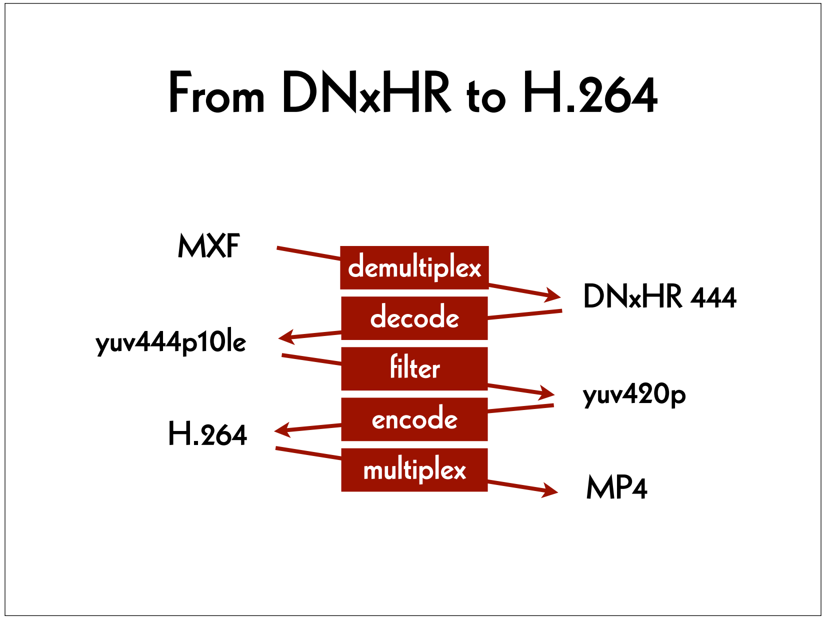

From DNxHR to H.264

MXF
demultiplex
DNxHR 444
decode
yuv444p10le
filter
yuv420p
encode
H.264
multiplex
MP4

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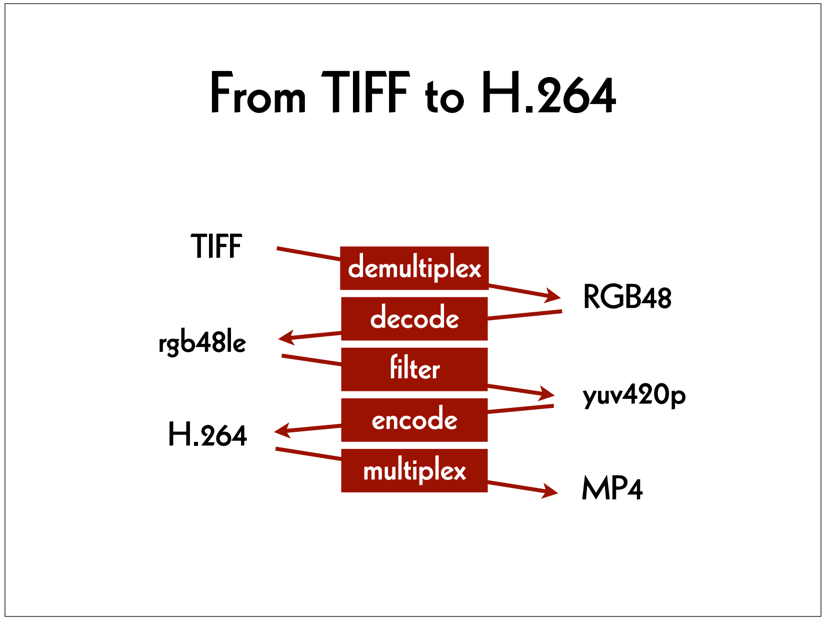

From TIFF to H.264

TIFF
demultiplex
RGB48
decode
rgb48le
filter
yuv420p
encode
H.264
multiplex
MP4

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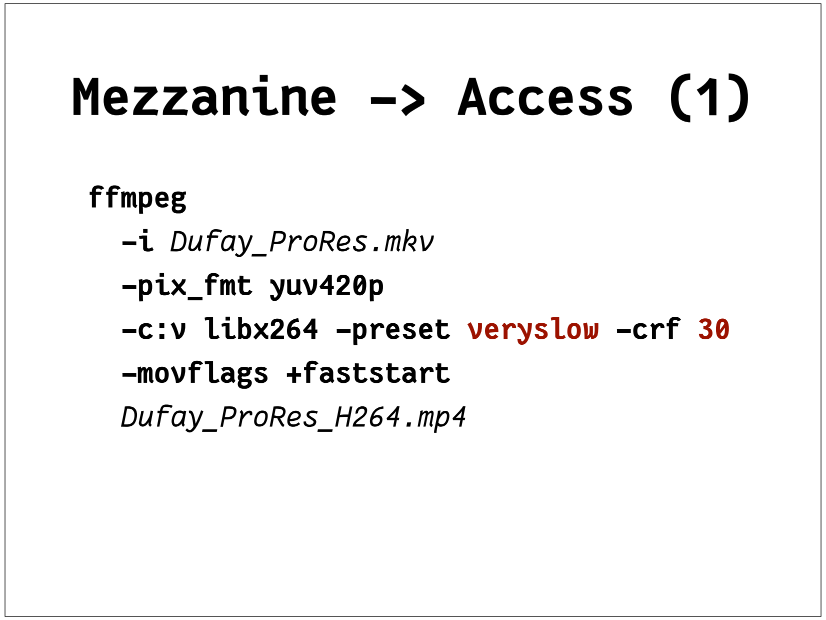

Mezzanine -> Access (1)

```
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
```

Master -> Access

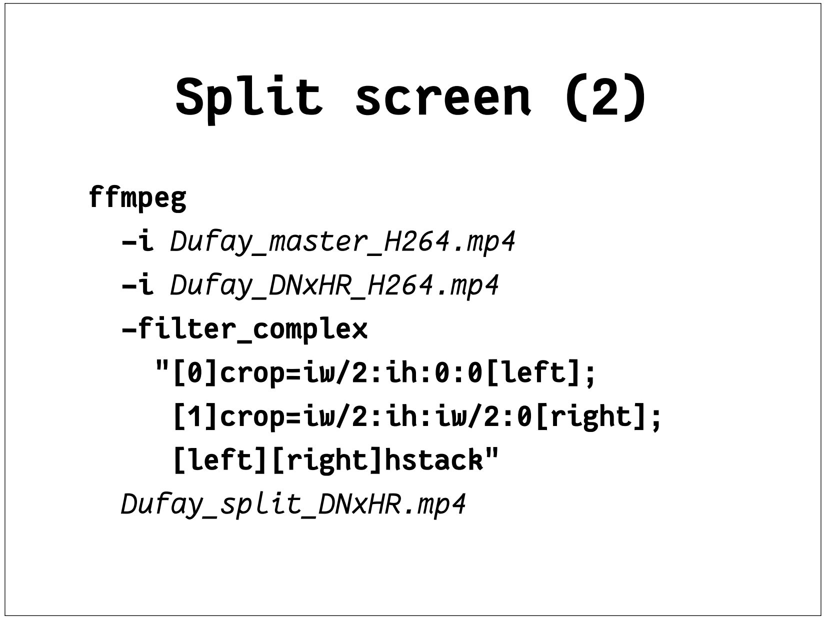
```
ffmpeg
  -f image2 -framerate 24
  -i DUFAY_TIFF/Dufay_%06d.tif
  -filter:v
    "scale=1440:1080:flags=lanczos,
     pad=1920:1080:240:0"
  -pix_fmt yuv420p
  -c:v libx264 -preset veryslow -crf 30
  -movflags +faststart
  Dufay_master_H264.mp4
```

File Comparison

- split screen
- difference file (“delta” file)

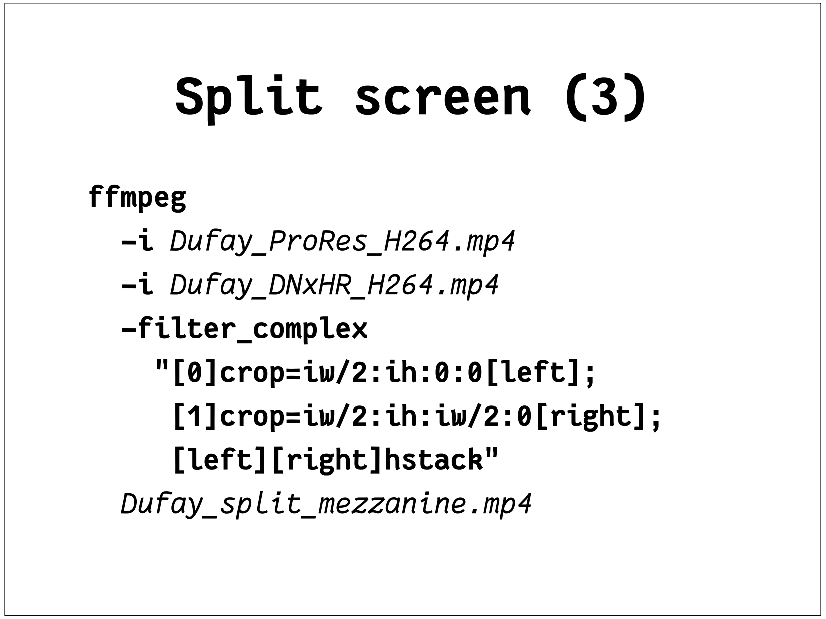
Split screen (1)

```
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
```



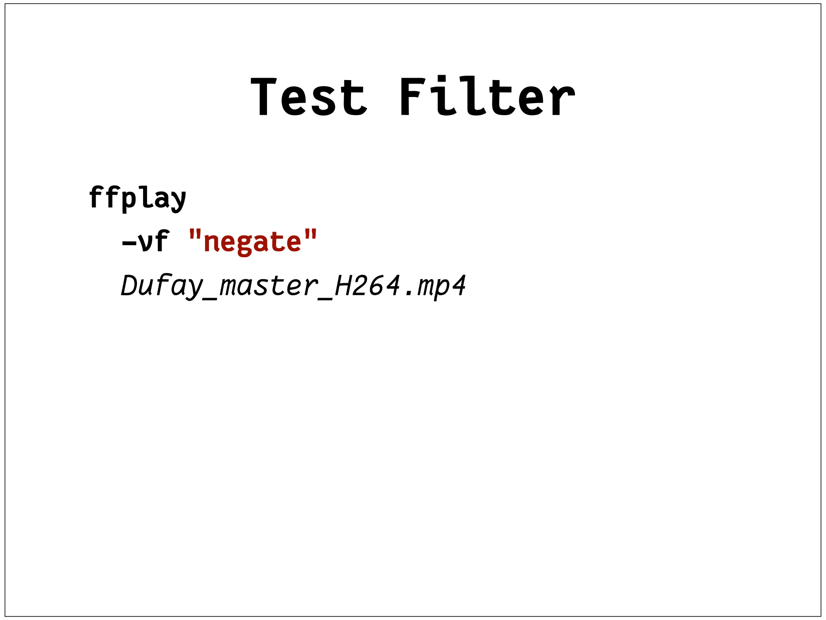
Split screen (2)

```
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
```



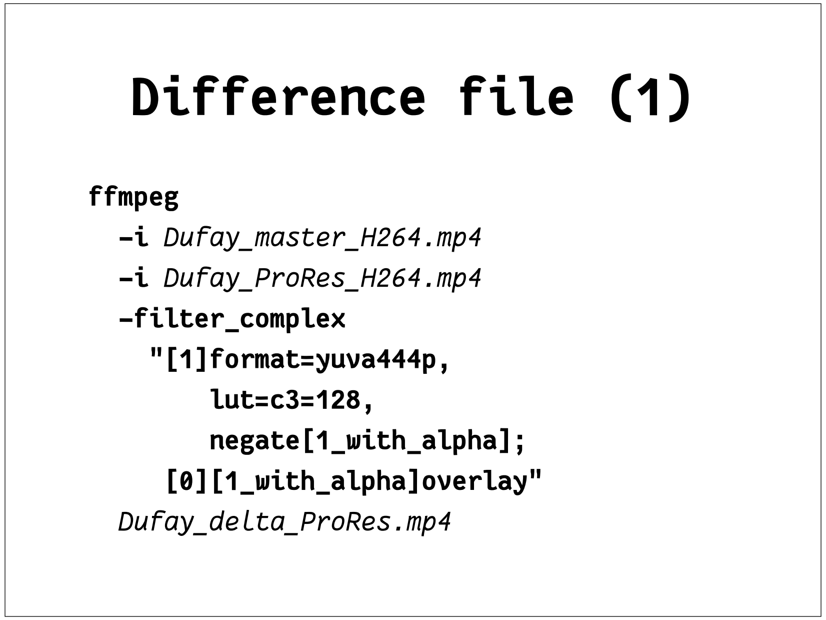
Split screen (3)

```
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
```



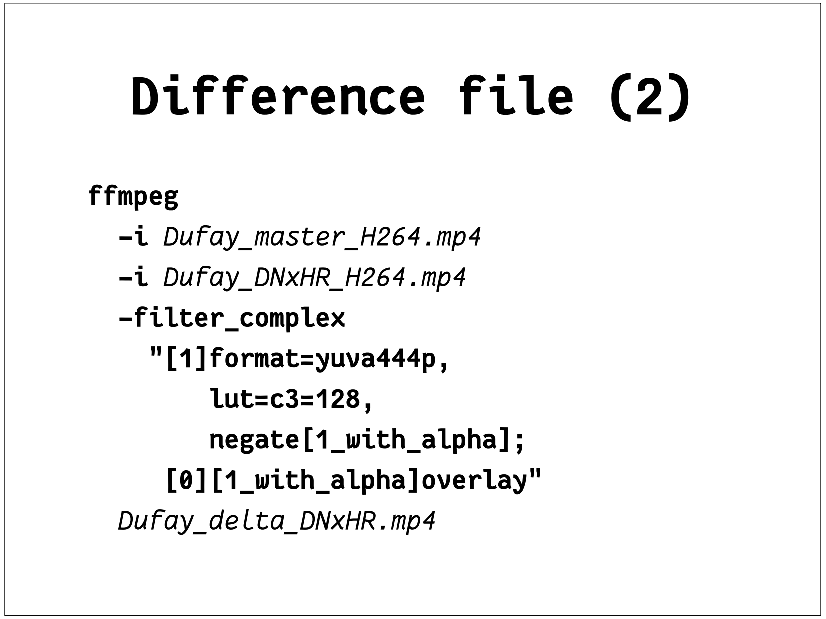
Test Filter

```
ffplay
  -vf "negate"
  Dufay_master_H264.mp4
```



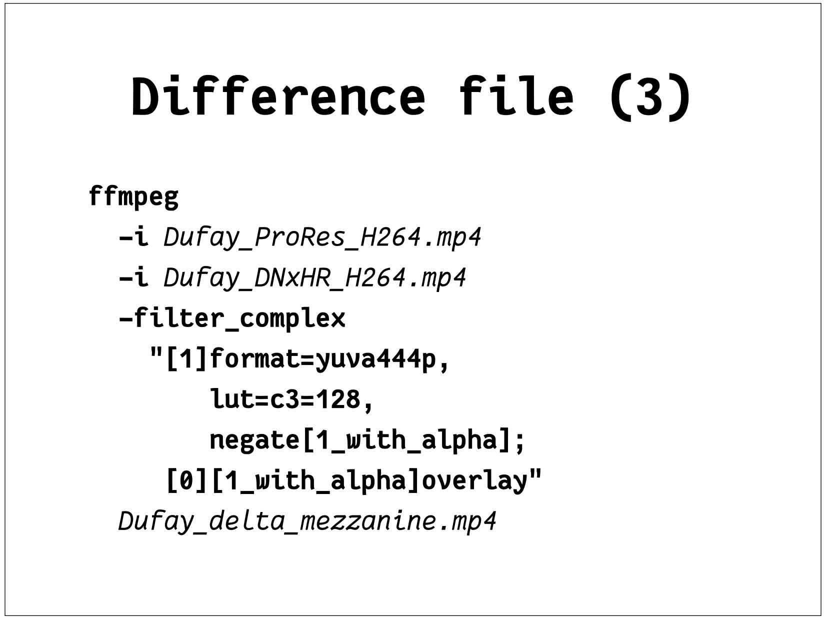
Difference file (1)

```
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
```



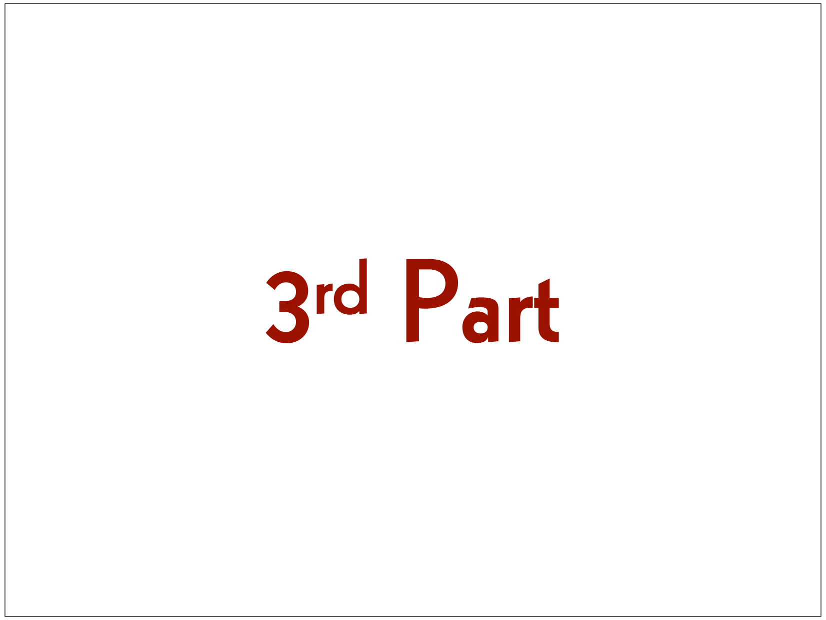
Difference file (2)

```
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
```

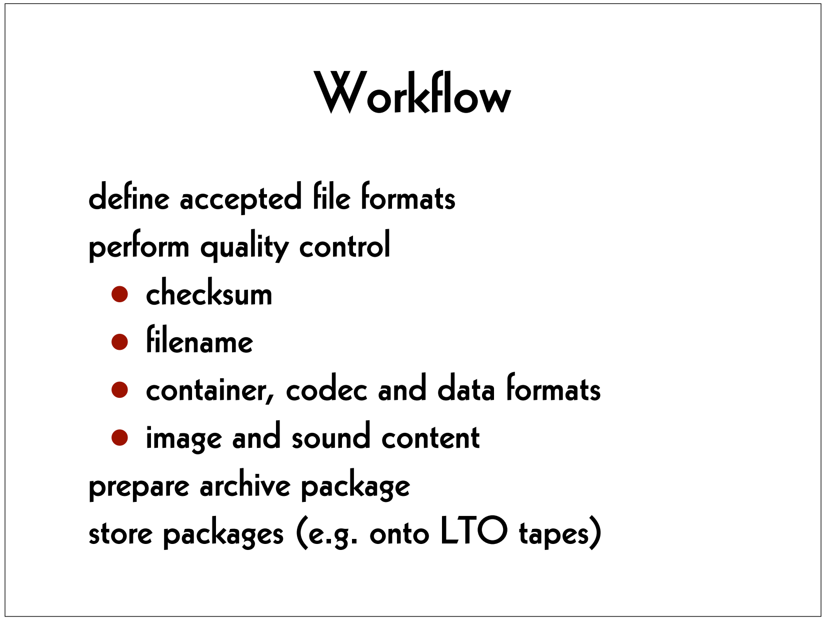


Difference file (3)

```
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
```



3rd Part



Workflow

define accepted file formats

perform quality control

- checksum
- filename
- container, codec and data formats
- image and sound content

prepare archive package

store packages (e.g. onto LTO tapes)

Quality control

- check technical metadata
- analyse signal
- watch image and listen sound

- difference file
- split screen

Quality Control Tools

container and codec

- MediaInfo, ffprobe, MediaConch
- hexdump, fq

image and sound content

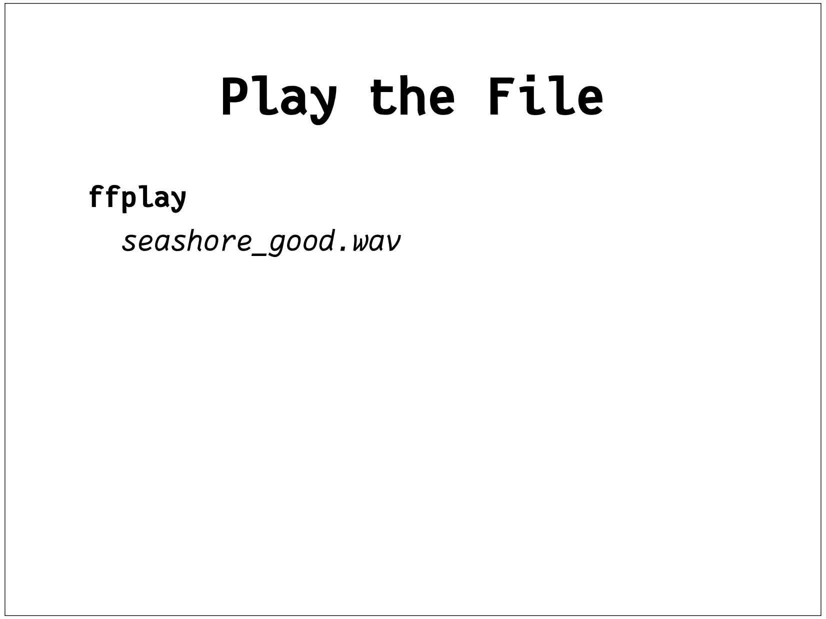
- QCTools, qcli, SignalServer
- VLC, mpv, ffplay

Archival Tools

- RAWcooked
- BagIt

Generate a Sound File

```
ffmpeg
  -f lavfi -i "anoisesrc=color=brown"
  -filter:a "tremolo=f=0.1:d=0.9"
  -c:a pcm_s24le
  -ar 96k
  -ac 2
  -t 60
  seashore_good.wav
```



Play the File

```
ffplay
  seashore_good.wav
```

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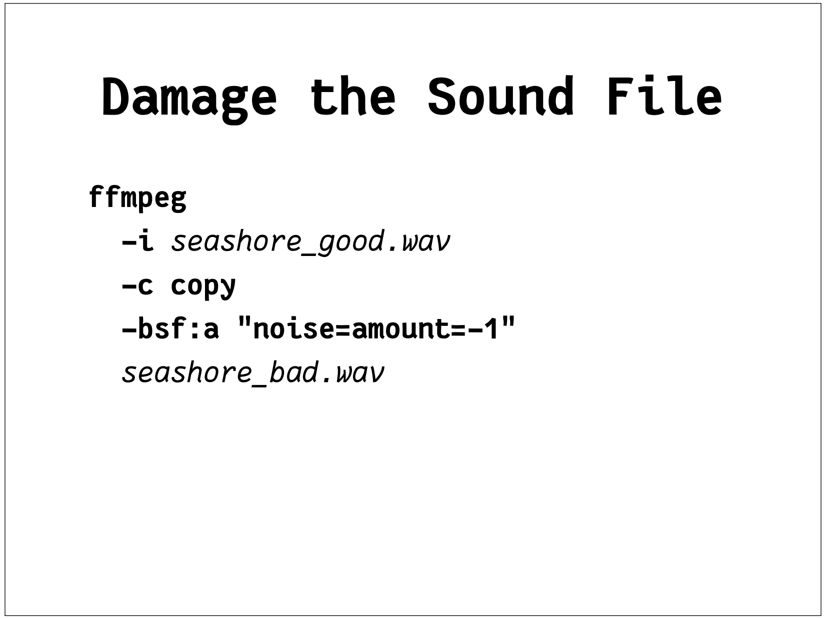

Damage the Sound File

```
ffmpeg
  -i seashore_good.wav
  -c copy
  -bsf:a "noise=amount=-1"
  seashore_bad.wav
```

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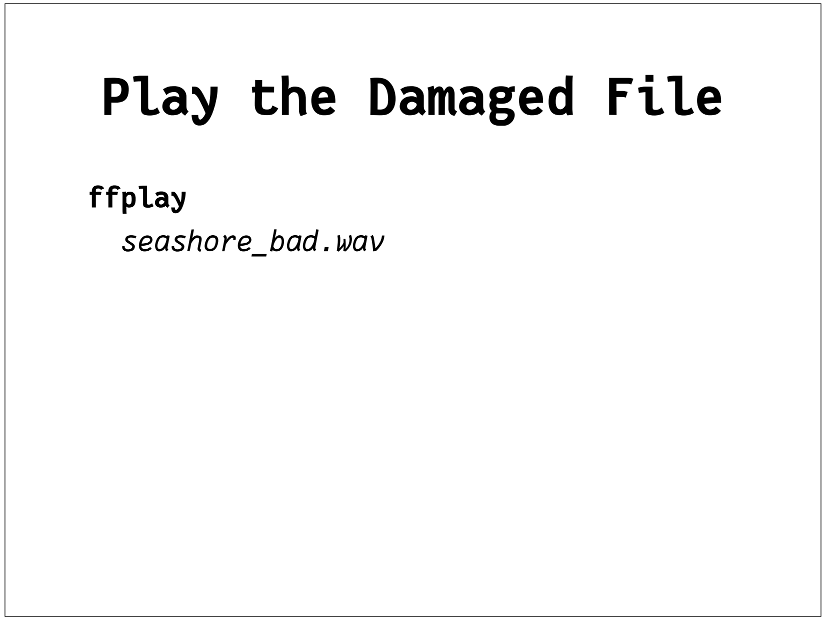

Play the Damaged File

```
ffplay
  seashore_bad.wav
```

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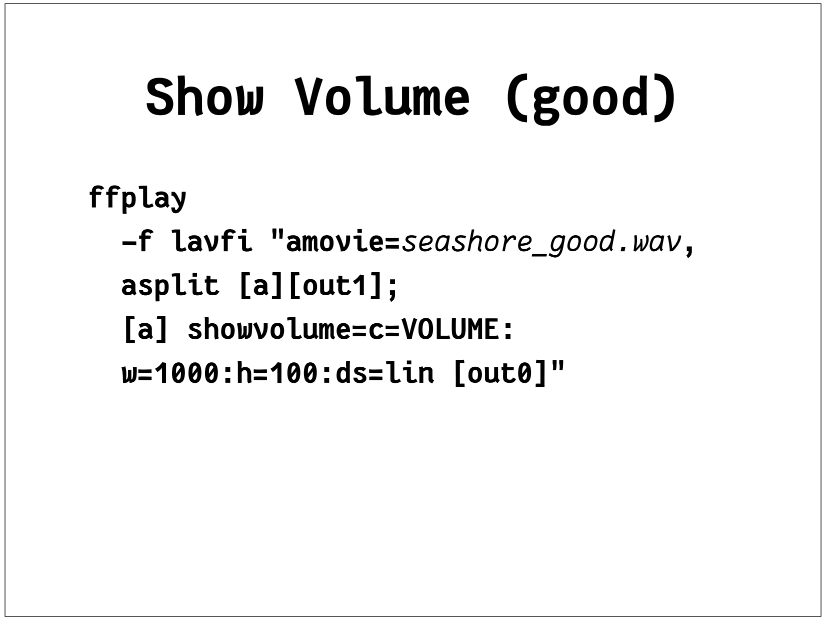

Show Volume (good)

```
ffplay
  -f lavfi "amovie=seashore_good.wav,
  asplit [a][out1];
  [a] showvolume=c=VOLUME:
  w=1000:h=100:ds=lin [out0]"
```

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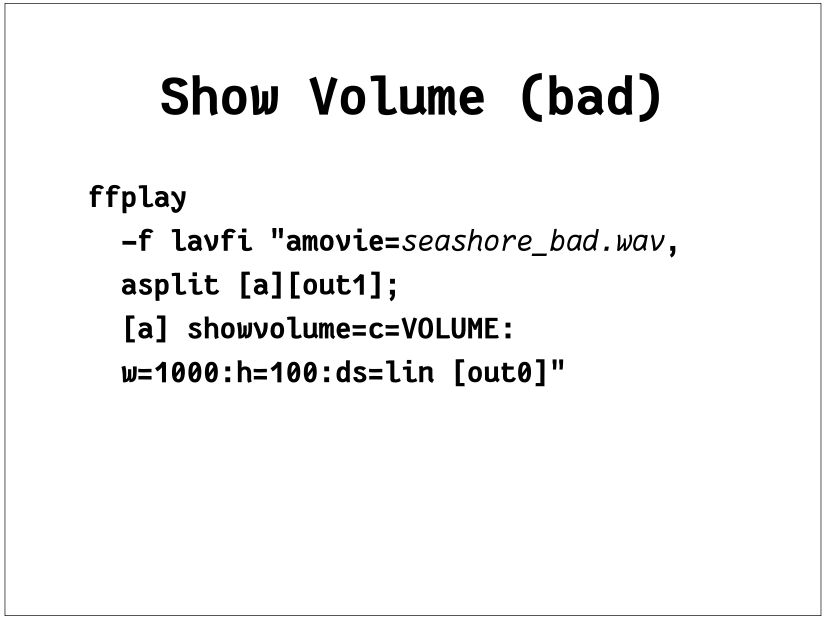
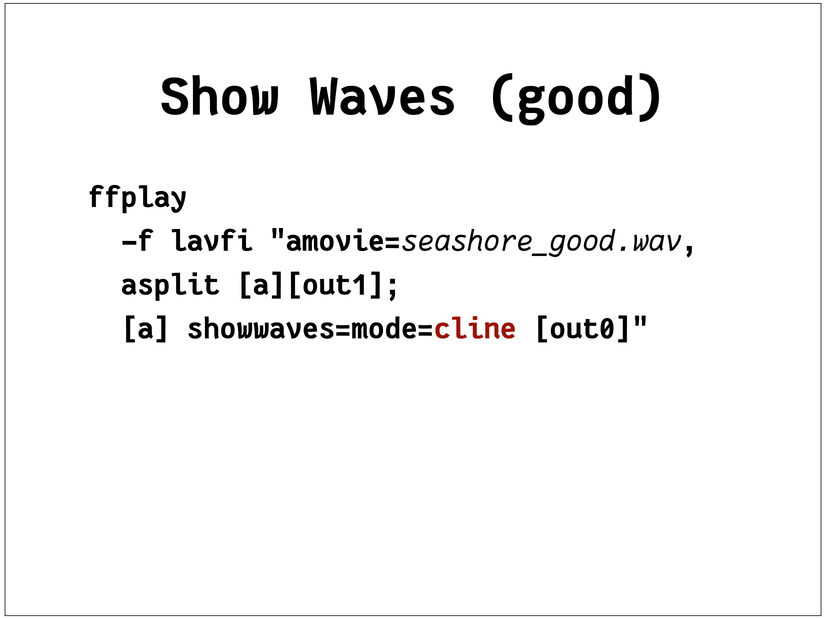


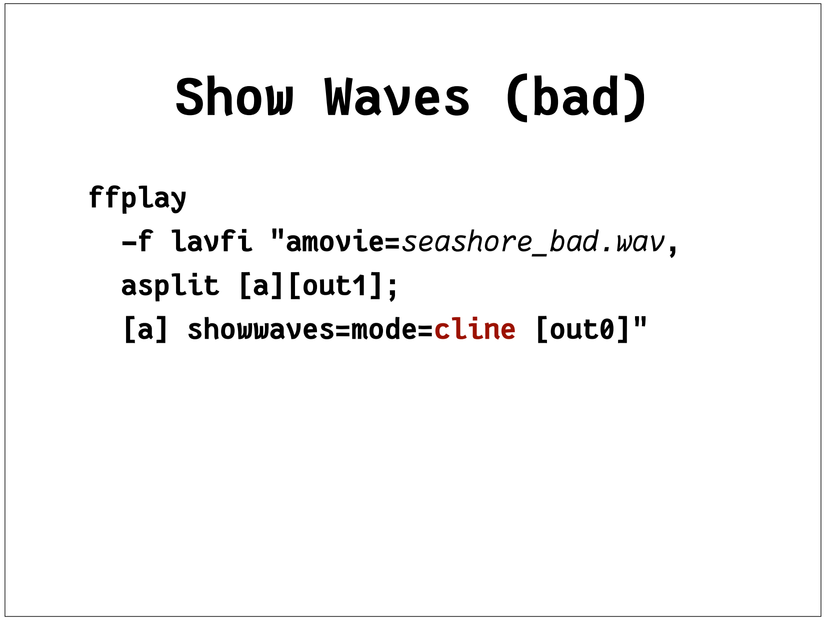
Show Volume (bad)

```
ffplay
  -f lavfi "amovie=seashore_bad.wav,
  asplit [a][out1];
  [a] showvolume=c=VOLUME:
  w=1000:h=100:ds=lin [out0]"
```



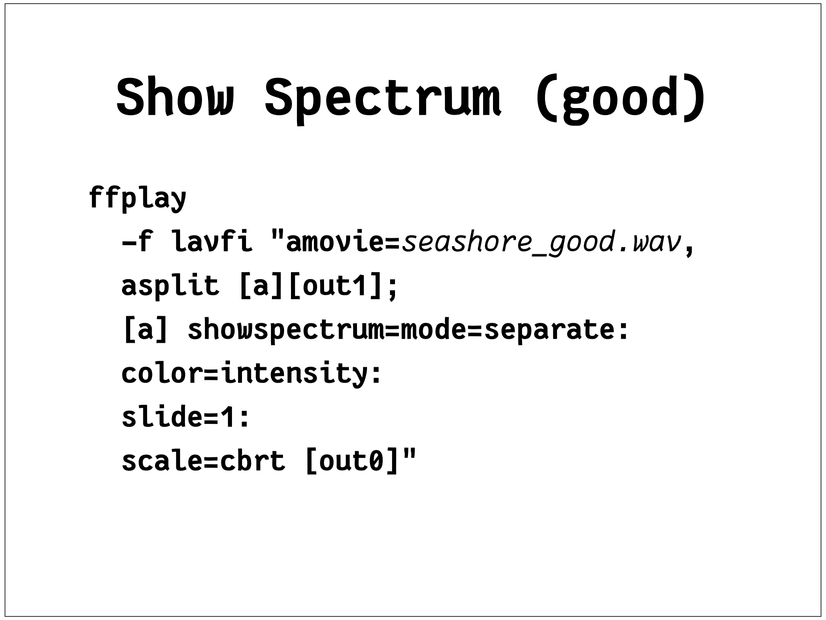
Show Waves (good)

```
ffplay
  -f lavfi "amovie=seashore_good.wav,
  asplit [a][out1];
  [a] showwaves=mode=cline [out0]"
```



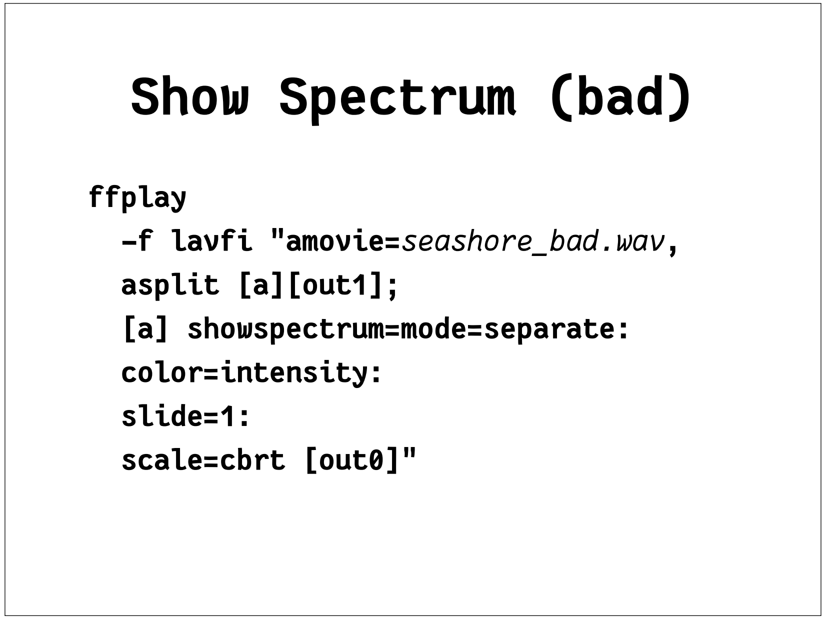
Show Waves (bad)

```
ffplay
  -f lavfi "amovie=seashore_bad.wav,
  asplit [a][out1];
  [a] showwaves=mode=cline [out0]"
```



Show Spectrum (good)

```
ffplay
  -f lavfi "amovie=seashore_good.wav,
  asplit [a][out1];
  [a] showspectrum=mode=separate:
  color=intensity:
  slide=1:
  scale=cbrt [out0]"
```



Show Spectrum (bad)

```
ffplay
  -f lavfi "amovie=seashore_bad.wav,
  asplit [a][out1];
  [a] showspectrum=mode=separate:
  color=intensity:
  slide=1:
  scale=cbrt [out0]"
```

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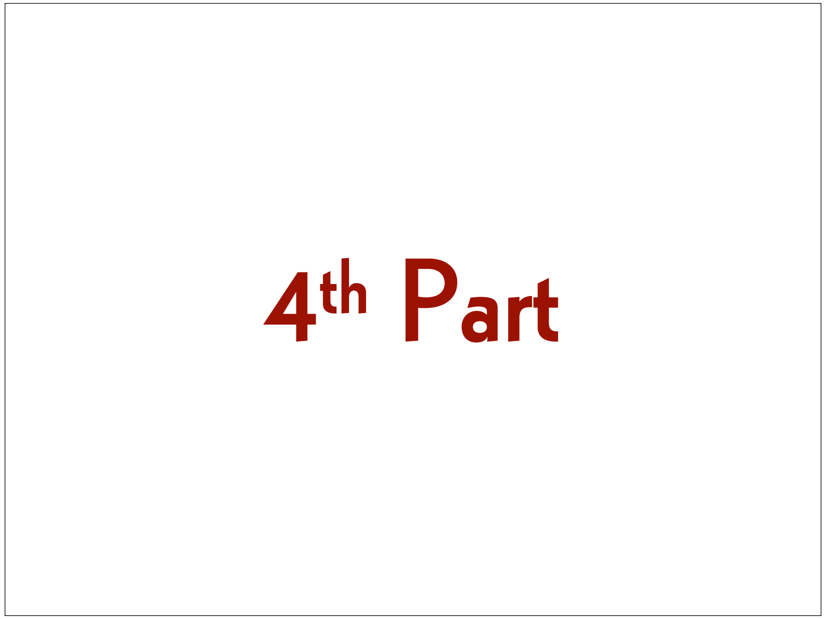

4th Part

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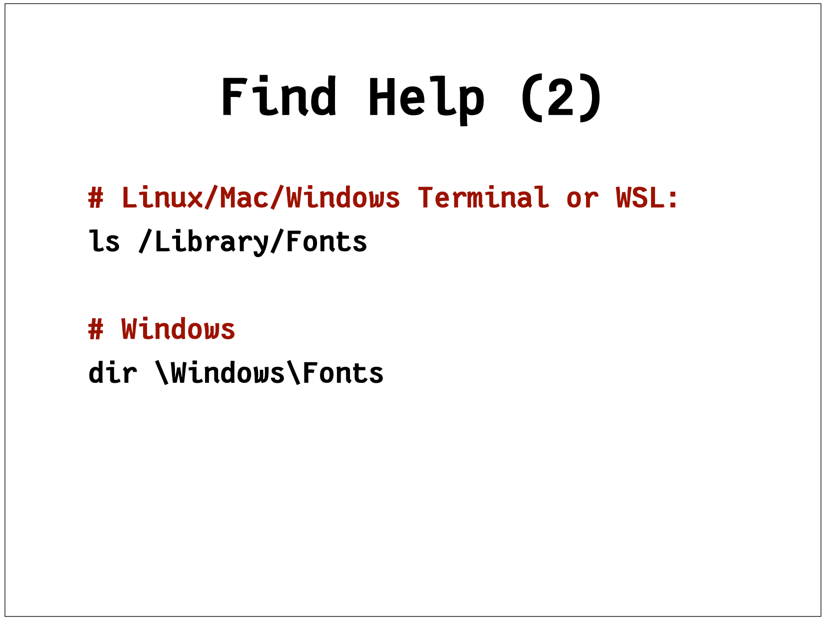

Find Help (2)

```
# Linux/Mac/Windows Terminal or WSL:
ls /Library/Fonts

# Windows
dir \Windows\Fonts
```

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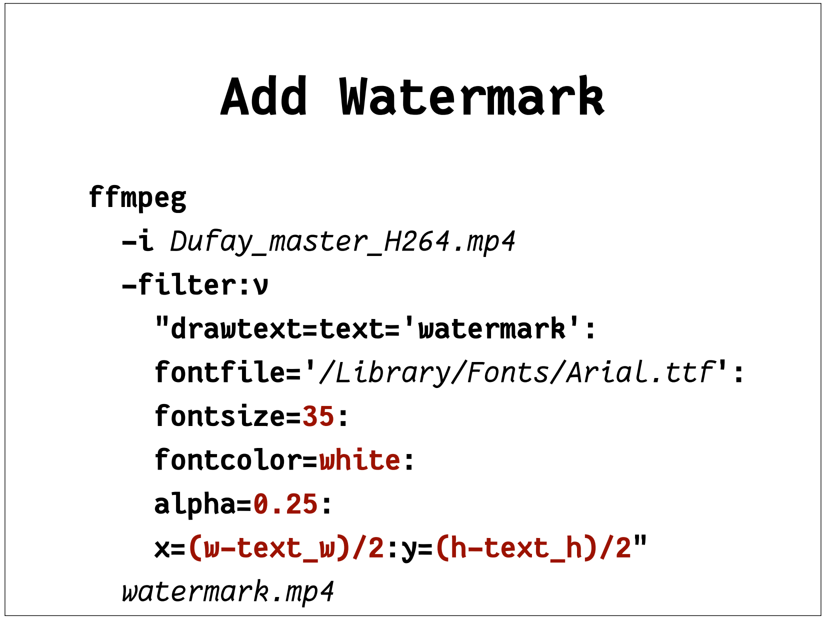
Add Watermark

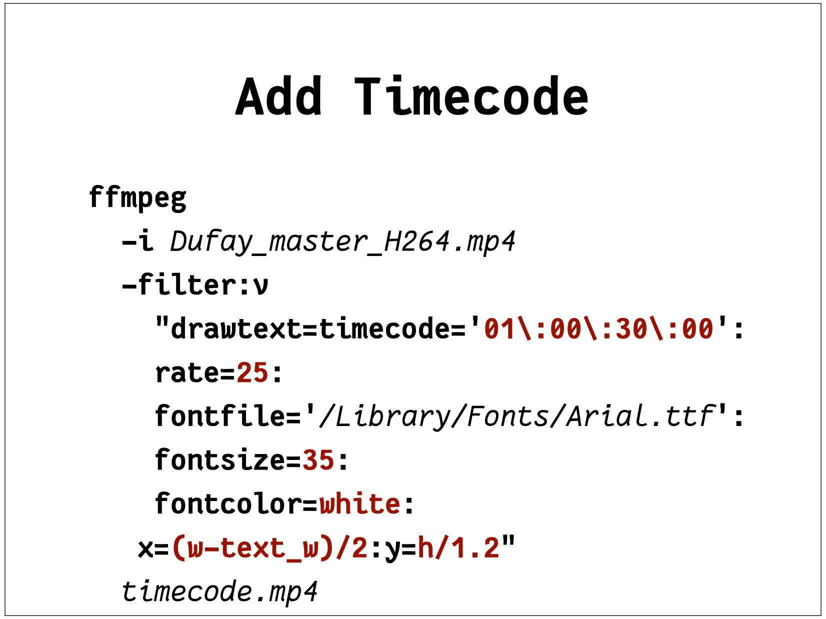
```
ffmpeg
  -i Dufay_master_H264.mp4
  -filter:v
    "drawtext=text='watermark':
    fontfile='/Library/Fonts/Arial.ttf':
    fontsize=35:
    fontcolor=white:
    alpha=0.25:
    x=(w-text_w)/2:y=(h-text_h)/2"
  watermark.mp4
```

80



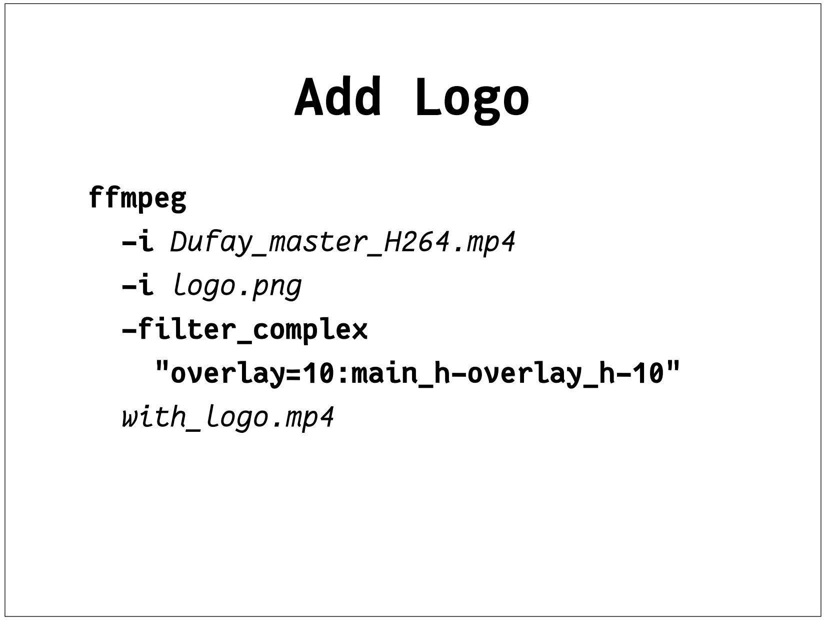
Add Watermark

```
ffmpeg
  -i Dufay_master_H264.mp4
  -filter:v
    "drawtext=text='watermark':
    fontfile='/Library/Fonts/Arial.ttf':
    fontsize=35:
    fontcolor=white:
    alpha=0.25:
    x=(w-text_w)/2:y=(h-text_h)/2"
  watermark.mp4
```



Add Timecode

```
ffmpeg
  -i Dufay_master_H264.mp4
  -filter:v
    "drawtext=timecode='01\:00\:30\:00':
    rate=25:
    fontfile='/Library/Fonts/Arial.ttf':
    fontsize=35:
    fontcolor=white:
   x=(w-text_w)/2:y=h/1.2"
  timecode.mp4
```



Add Logo

```
ffmpeg
  -i Dufay_master_H264.mp4
  -i logo.png
  -filter_complex
    "overlay=10:main_h-overlay_h-10"
  with_logo.mp4
```

AV Preservation by

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