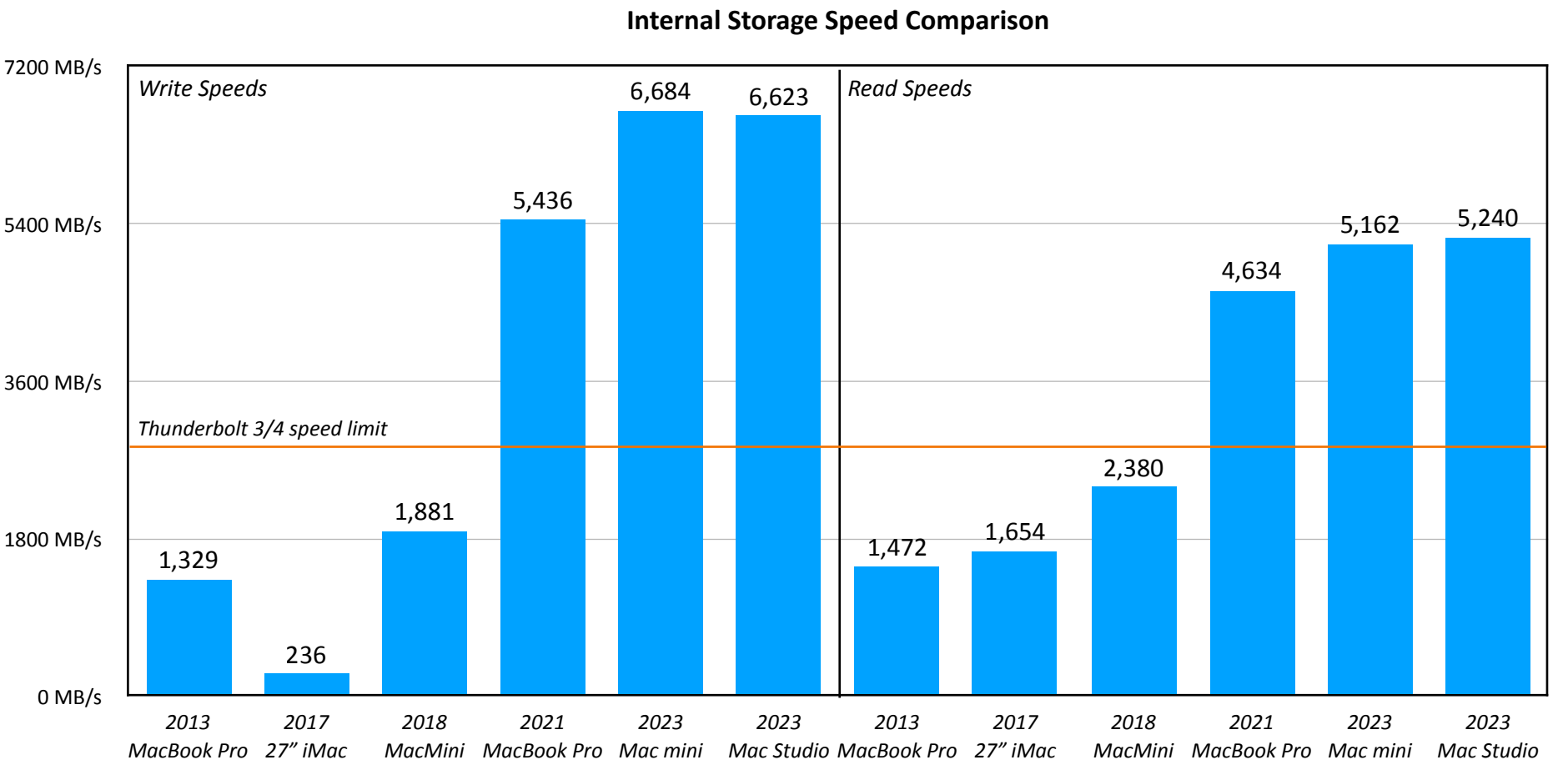
Comparison of Internal Storage Speeds

	2013 MacBook Pro	*2017 27" iMac*	*2018 MacMini*	*2021 MacBook Pro*	*2023 Mac mini*	*2023 Mac Studio*
CPU	*2.6 GHz Core i7*	*3.8 GHz Quad Core i5*	*3.2 GHz 6-Core i7*	*M1 Pro*	*M2 Pro*	*M2 Max*
RAM	*16 GB*	*40 GB*	*8 GB*	*32 GB*	*32 GB*	*64 GB*
Average Write	1,329.3	236.3	1,880.7	5,435.7	6,684.0	6,623.3
Average Read	1,471.7	1,654.0	2,379.7	4,633.7	5,162.0	5,239.7
Max Write	1,333.0	305.0	1,929.0	5,652.0	0.0	6,657.0
Max Read	1,478.0	2,507.0	2,397.0	4,643.0	0.0	5,284.0
Minimum Write	1,323.0	129.0	1,837.0	5,108.0	0.0	6,600.0
Minimum Read	1,461.0	188.0	2,349.0	4,623.0	0.0	5,201.0
St Dev Write	5.5	94.2	46.2	288.6		29.9
St Dev Read	9.3	1,275.3	26.6	10.1	323.5%	41.8
Test 1						
Write	1,323.0	305.0	1,837.0	5,652.0		6,657.0
Read	1,478.0	2,507.0	2,397.0	4,635.0		5,234.0
Test 2						
Write	1,332.0	275.0	1,876.0	5,547.0		6,613.0
Read	1,461.0	2,267.0	2,349.0	4,643.0		5,201.0
Test 3						
Write	1,333.0	129.0	1,929.0	5,108.0		6,600.0
Read	1,476.0	188.0	2,393.0	4,623.0		5,284.0

NOTES

The internal drive of the Mac Studio is:
* Essentially the same speed as the Mac Mini
* 18% faster than the M1 Pro MacBook Pro
* 178% faster than the 2018 Mac mini
* 528% faster than the 2017 iMac
* 324% faster than the 2013 MacBook Pro

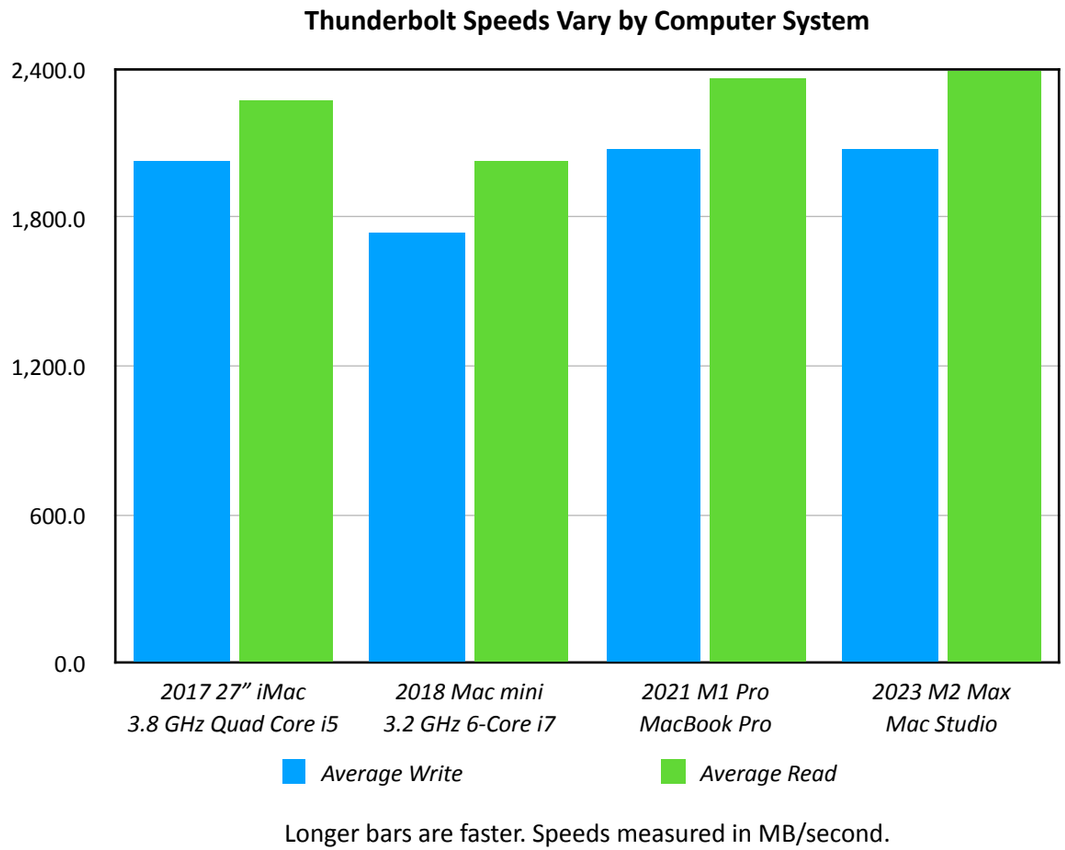
* Test software: AJA System Test (full version)
* Test specs: UHD, 4 GB, 16-bit RGBA files
* All computers used internal SSD drives, except the iMac which had a Fusion drive.
* The Mac mini results are from earlier tests.
* St Dev (standard deviation) measures speed variation. Lower means more consistent.
* 2,850 MB/s is the theoretical speed limit of Thunderbolt 3/4.



Internal storage speeds measured in MB/second.

Thunderbolt Speed Comparison

	2017 27” iMac	*2018 Mac mini*	*2021 MacBook Pro*	*2023 Mac Studio*
CPU	*3.8 GHz Quad Core i5*	*3.2 GHz 6-Core i7*	*M1 Pro*	*M2 Max*
RAM	*40 GB*	*8 GB*	*32 GB*	*64 GB*
Average Write	**2,029.3**	**1,737.0**	**2,076.7**	**2,076.0**
Average Read	**2,272.3**	**2,023.7**	**2,362.0**	**2,391.3**
Max Write	2,031.0	1,753.0	2,078.0	2,106.0
Max Read	2,276.0	2,040.0	2,363.0	2,394.0
Minimum Write	2,026.0	1,721.0	2,075.0	2,017.0
Minimum Read	2,270.0	2,008.0	2,361.0	2,390.0
St Dev Write	2.9	16.0	1.5	51.1
St Dev Read	3.2	16.0	1.0	2.3
Test 1				
Write	2,026.0	1,721.0	2,077.0	2,017.0
Read	2,271.0	2,040.0	2,362.0	2,394.0
Test 2				
Write	2,031.0	1,737.0	2,075.0	2,105.0
Read	2,276.0	2,023.0	2,363.0	2,390.0
Test 3				
Write	2,031.0	1,753.0	2,078.0	2,106.0
Read	2,270.0	2,008.0	2,361.0	2,390.0



Longer bars are faster. Speeds measured in MB/second.

Video Compression Speed Comparison

	Apple Compressor			*Adobe Media Encoder*			*Handbrake*	
Source	*8K ProRes 422*			*8K ProRes 422*			*8K ProRes 422*	
Compressed	*4K ProRes 422*	*4K H.264*	*4K HEVC*	*4K ProRes 422*	*4K H.264*	*4K HEVC*	*4K X.264*	*4K X.265*
2013 MacBook Pro	47:24	44:31	N/A	1:08:51	59:30	N/A	N/A	N/A
2017 27" iMac	27:24	20:12	18:45	28:38	23:17	21:53	1:06:35	2:02:16
2018 MacMini	1:22:05	58:38	N/A	2:14:32	2:14:21	N/A	N/A	N/A
2021 MacBook Pro	02:20	05:57	05:42	09:39	05:42	10:32	30:05	45:57
2023 Mac Studio	01:07	03:12	02:52	04:34	04:37	04:50	21:38	38:04

NOTES

* The same source video was used in all tests: 10 minute 8K ProRes 422 29.97 fps.
* Mac Studio read media using Compressor at 950 MB/s
* Mac Studio read media using Handbrake at 100 MB/s
* H.264 & HEVC were compressed at 8-bit
* H.264 / X.264 - one pass, 20000 bit rate, frame size: 3840 x 2160
* X.264 compression did not seem to utilize hardware acceleration
* HEVC - one-pass, 20000 bit rate, frame size 3840 x 2160
* Handbrake used 100% of all cores, almost no GPUs
* 2013 MacBook Pro: Mojave 10.14.6 — Compressor 4.4.6 — Media Encoder 2020.
* Others: macOS 13.4.1, Compressor: 4.6.4 — Media Encoder: 2023 — Handbrake 1.6.1
* I did not make any determinations of image quality, only speed.
* Ran the ProRes 422 test on the M1 MacBook Pro twice - took the fastest time.

Premiere Pro ProRes Render Speed Comparison

	2013 MacBook Pro	*2017 27" iMac*	*2018 MacMini*	*2021 MacBook Pro*	*2023 Mac Studio*
CPU	*2.6 GHz Core i7*	*3.8 GHz Quad Core i5*	*3.2 GHz 6-Core i7*	*M1 Pro*	*M2 Max*
RAM	*16 GB*	*40 GB*	*8 GB*	*32 GB*	*64 GB*
Average		12:33	63:43	05:43	04:14
Maximum		12:33	63:43	05:49	04:15
Minimum		12:32	63:43	05:37	04:13
St. Dev.		00:01		00:08	00:01
Comparison		3.0	15.1	1.4	1.0
Percent		-66.2%	-93.4%	-25.9%	
Test 1		12:33	1:03:43	05:49	04:13
Test 2		12:32		05:37	04:15

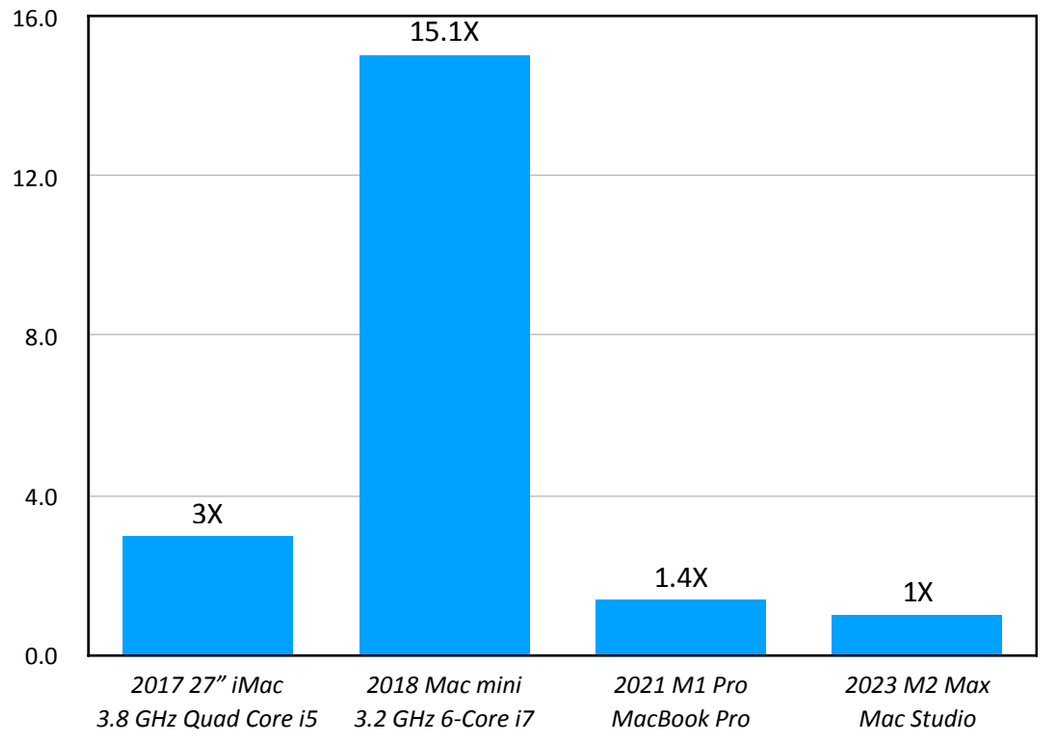
NOTES

* Mac Studio is 26% faster than M1 MacBook Pro
* Mac Studio is 66% faster than 2017 iMac

* Premiere Pro version 23.5
* Test file: 50.2 GB, 29 minute, ProRes 4444 file (1600x900)
* Render test: 3 layers of media rotated, scaled, blurred, desaturated with text and drop shadow added
* Exact same sequence and media used on all systems.
* Rendered into ProRes 4444 as same frame size and rate.
* All render files stored to desktop.
* All computers running macOS 13.4.1 except the 2013 MacBook, running macOS Mojave
* Durations timed by stopwatch
* I only ran the 2013 and 2018 speed tests once because life is too short.
* Mac mini slowness may be due to using an Intel GPU, not AMD.
* No Intel system maxed out CPUs or GPUs
* M1/M2 systems may have processed media using Media Engine, which is not measured in Activity Monitor

* 2018 Mac mini
* 2018 Mac mini rendered 20-30 MB/s
* iMac CPUs 90%, GPUs ~50%
* iMac rendered 65-75 MB/s
* M1 MacBook Pro rendered ~150 MB/s
* M1 MacBook Pro GPUs at 100%, CPUs around 10%
* M2 Mac Studio CPUs around 20%, GPUs around 90%
* M2 Mac Studio rendered 300 - 350 MB/second.

Premiere Pro Render Speed Comparison



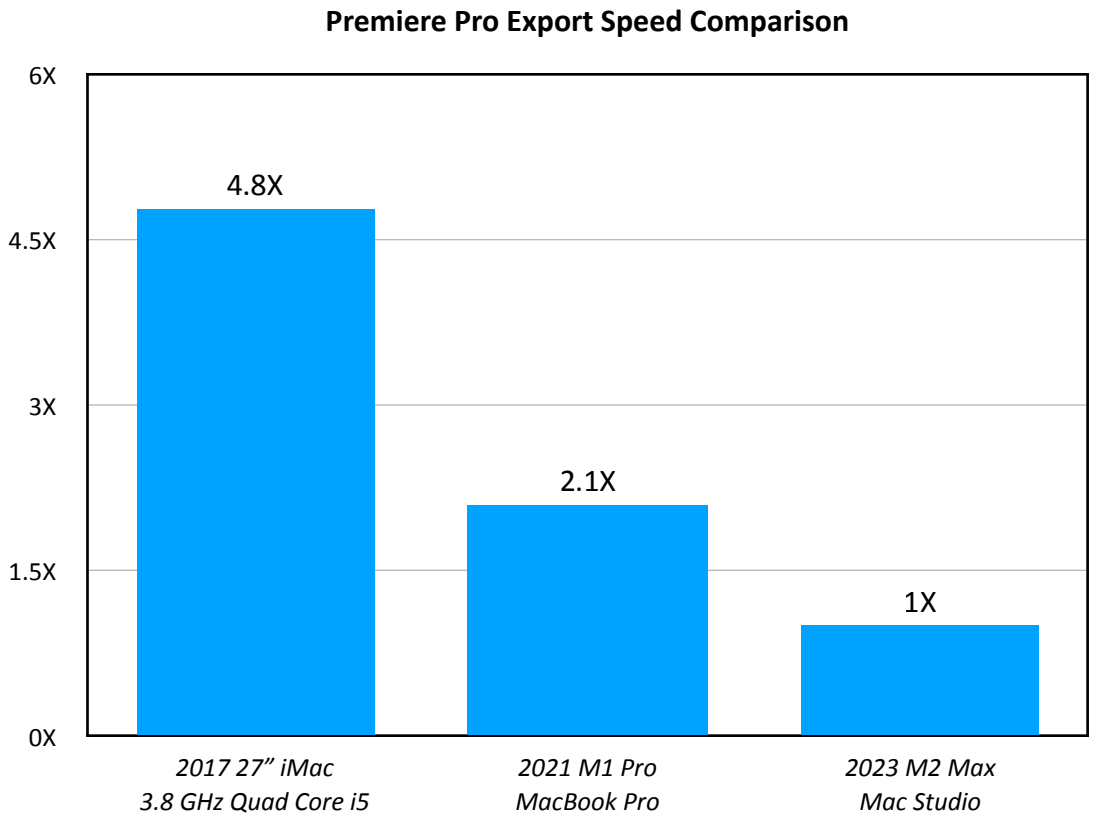
Render 4K ProRes 4444 effects sequence. Shorter bars are faster.

Premiere Pro Export Speed Comparison

	2013 MacBook Pro	*2017 27” iMac*	*2018 MacMini*	*2021 MacBook Pro*	*2023 Mac Studio*
CPU	*2.6 GHz Core i7*	*3.8 GHz Quad Core i5*	*3.2 GHz 6-Core i7*	*M1 Pro*	*M2 Max*
RAM	*16 GB*	*40 GB*	*8 GB*	*32 GB*	*64 GB*
Average		12:30		05:28	02:37
Maximum		13:56		05:29	02:37
Minimum		11:04		05:27	02:37
St. Dev.		02:02		00:01	00:00
Comparison		4.8		2.1	1.0
Percent slower		-79.1%		-52.1%	
Test 1		11:04		05:27	02:37
Test 2		13:56		05:29	02:37

NOTES

* Mac Studio is 52% faster than M1 MacBook Pro
* Mac Studio is 79% faster than 2017 iMac
* Premiere version 23.5
* M-series: GPUs ~95%, CPUs running ~25%.
* M2 Mac Studio reading data 250-300 MB/s
* M1 MacBook Pro reading data 150 - 200 MB/s
* iMac CPUs maxed, GPUs 60%
* iMac reading data 85-100 MB/s
* Mac mini reading data
* The same sequence and media as the render test, but transcoded and output to a ProRes 422 file.
* This had the same specs and speeds as the render test.
* Didn’t test two slowest systems because results closely paralleled rendering.
* I wonder if the slowdown on the iMac was caused by filling the SSD cache on the Fusion drive?



Export 4K ProRes 4444 project into ProRes 422. Shorter bars are faster.

Speed to Create 40 4K Proxy Files (Default Settings)

	Final Cut Pro		*Adobe Premiere Pro*
	ProRes Proxy	*H.264*	*ProRes Proxy*
2017 iMac	22:05	0:17:45	23:48
2018 Mac mini	35:43	31:40	2:51:00
M1 Pro MacBook Pro	02:44	04:19	10:28
M2 Pro Mac mini (Est.)	*02:17*	*03:44*	*06:20*
M2 Mac Studio	01:50	03:08	04:13

NOTES
Timed with a stop watch

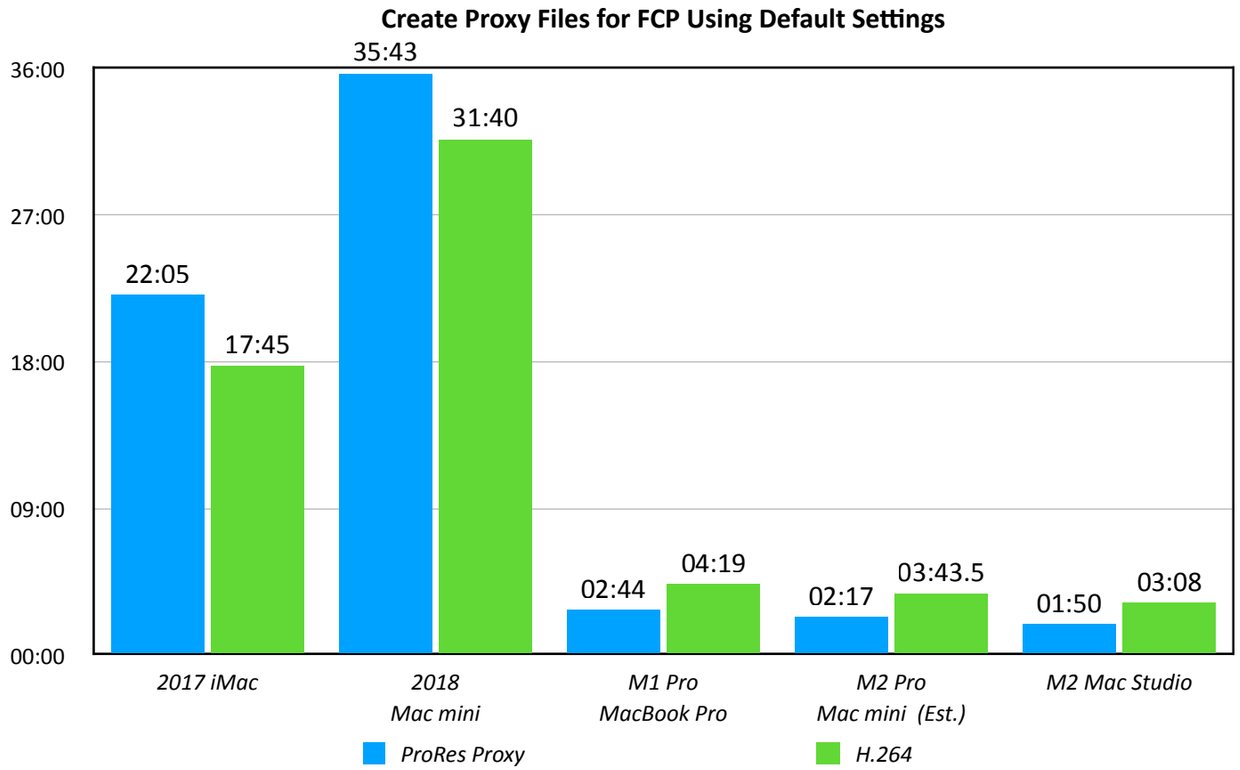
Source: 40 4K ProRes 4444 videos from 11 - 95 seconds each
High-speed storage is essential to achieve these speeds
FCP ProRes read data ~ 2.5 GB/s (Max Thunderbolt) on Mac Studio
FCP H.264 read data ~1 GB/s
FCP uses mostly efficiency CPU cores during encoding
FCP maxes GPUs during ProRes encoding
FCP runs GPUs at 50% during H.264 encoding

All source files stored on SSD RAID for access at Thunderbolt speeds
FCP proxies set to default 50% size
Adobe Media Encoder creates proxies. This was launched prior to beginning time tests.
Premiere proxies set to default of medium resolution ProRes proxy
Premiere reads data ~450 MB/s
GPUs maxed out, CPUs about 10% (using essentially 2 high-performance cores)

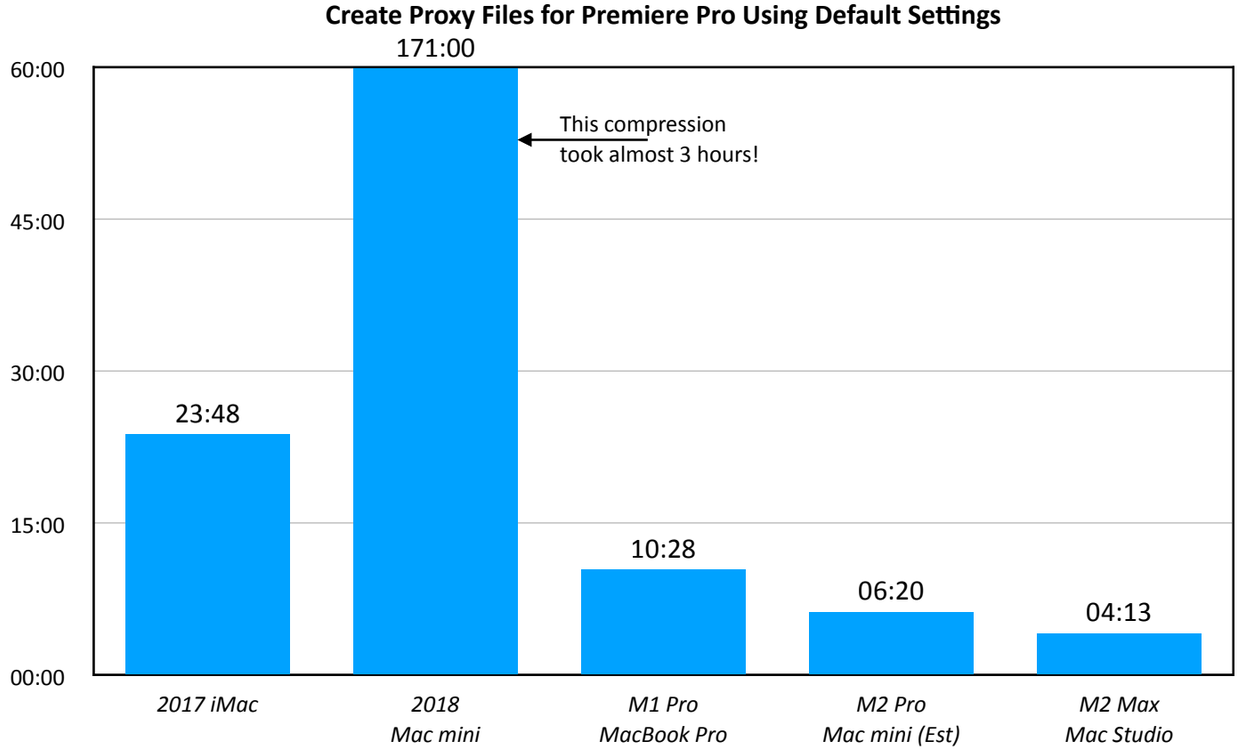
Proxy size between FCP and Premiere is not the same.
FCP = 50%, Premiere = 1280 x 720 ProRes Proxy

iMac 250-300 MB/s reading for FCP ProRes
CPUs maxed. GPU ~25%
iMac Premiere reading 200-250 MB/s
CPUs maxed, GPUs 40%

Mac mini reads data about 150 MB/s
Mac mini 50% CPUs, 50% GPUs
Mac mini speeds show the impact of limited RAM
Mac mini has Intel UHD Graphics 630 GPU - very slow



Time required to create 40 default ProRes proxy files from 4K ProRes 4444 source media.



Time required to create 40 default ProRes proxy files from 4K ProRes 4444 source media.

Premiere Pro Multicam Streaming Comparison

	2017 27" iMac	*2021 MacBook Pro*	*2023 Mac Mini*	*2023 Mac Studio*
CPU	*3.8 GHz Quad Core i5*	*M1 Pro*	*M2 Pro*	*M2 Max*
RAM	*40 GB*	*32 GB*	*32 GB*	*64 GB*
Est. ProRes 2K streams	0	20	35	*22*
H.264 4K streams	0	8	10	*6*
ProRes 422 4K Proxy streams	0	28	35	*22*
ProRes 422 4K streams	0	26	25	*17*
ProRes 422 8K streams	0	0	N/A	*0*

NOTES

* I'm not sure why numbers for the M2 Mac mini are so high.
  The same media was used, but not the same project
* The i5 CPU on the iMac was not strong enough to stream any 4K clips or proxies
* 2023 Mac mini results taken from prior tests using same media
* Mac Studio not maxing out CPUs or GPUs
* M1 MacBook 60% CPU 30% GPU
* Frames would most often drop when cutting between angles
* Did not come close to saturating Thunderbolt
* Did not seem to take advantage of media engine