GOING FAST
SPATIAL STREMS, WIDE CHANNELS, AND 1024-QAM

Just a little deuce coupe with a flat head mill
But she'll walk a Thunderbird like she's standin still
She's ported and relieved and she's stroked and bored
She'll do a hundred and forty with the top end floored

7SIGNAL®

WI-FI DATA RATES – HOW FAST IS FAST

How fast is fast? Pretty darn fast – the table goes up to 9.6 Gbps data rate, or somewhere around 5 Gbps real TCP throughput! But, for our purposes let's say 2 Gbps data rate.

MCS Index	Spatial Stream	Modulation	Coding	OFDM (802.11ax)											
				20MHz			40MHz			80MHz			160MHz		
				0.8µs GI	1.6µs GI	3.2µs GI	0.8µs GI	1.6µs GI	3.2µs GI	0.8µs GI	1.6µs GI	3.2µs GI	0.8µs GI	1.6µs GI	3.2µs GI
0	8	BPSK	1/2	68.8	65	58.5	137.6	130	117	288.2	272.2	245	576.5	544.4	490
1	8	QPSK	1/2	137.6	130	117	275.3	260	234	576.5	544.4	490	1152.9	1088.9	980
2	8	QPSK	3/4	206.5	195	175.5	412.9	390	351	864.7	816.7	735	1729.4	1633.3	1470
3	8	16-QAM	1/2	275.3	260	234	550.6	520	468	1152.9	1088.9	980	2305.9	2177.8	1960
4	8	16-QAM	3/4	412.9	390	351	825.9	780	702	1729.4	1633.3	1470	3458.8	3266.7	2940
5	8	64-QAM	2/3	550.6	520	468	1101.2	1040	936	2305.9	2177.8	1960	4611.8	4355.6	3920
6	8	64-QAM	3/4	619.4	585	526.5	1238.8	1170	1053	2594.1	2450	2205	5188.2	4900	4410
7	8	64-QAM	5/6	688.2	650	585	1376.5	1300	1170	2882.4	2722.2	2450	5764.7	5444.4	4900
8	8	256-QAM	3/4	825.9	780	702	1651.8	1560	1404	3458.8	3266.7	2940	6917.6	6533.3	5880
9	8	256-QAM	5/6	917.6	866.7	780	1835.3	1733.3	1560	3843.1	3629.6	3266.7	7686.3	7259.3	6533.3
10	8	1024-QAM	3/4	1032.4	975	877.5	2064.7	1950	1755	4323.5	4083.3	3675	8647.1	8166.7	7350
11	8	1024-QAM	5/6	1147.1	1083.3	975	2294.1	2166.7	1950	4803.9	4537	4083.3	9607.8	9074.1	8166.7

from mscindex.com

WI-FI DATA RATES – GOING FAST

3 Things for higher data rates:

1) Add more Spatial Streams
   2SS is 2x as fast a 1SS, 3SS is 3x as fast, and so forth…

2) Wider Channels
   40 MHz is 2x as fast as 20 MHz, 80 MHz is 4x as fast as 20 MHz, 160 MHz is 8x as fast as 20 Mhz.

3) More complex Modulation and Coding
   64-QAM is 1.5x as fast as 16-QAM, 256-QAM is 2x as fast as 16-QAM, 1024-QAM is 2.5x as fast as 16-QAM

WI-FI DATA RATES – SPATIAL STREAMS

Since 802.11n, Wi-Fi has supported multiplexing data streams.

802.11n allows up to 4 streams, 802.11ac and ax up to 8 streams.

802.11n and 802.11ac APs typically support up to 4 spatial streams, and it looks like 802.11ax premium enterprise APs will support 8 streams.

A quick check of Newegg showed that all 802.11ax client adapters **support 2 spatial streams** (2.4 Gbps).
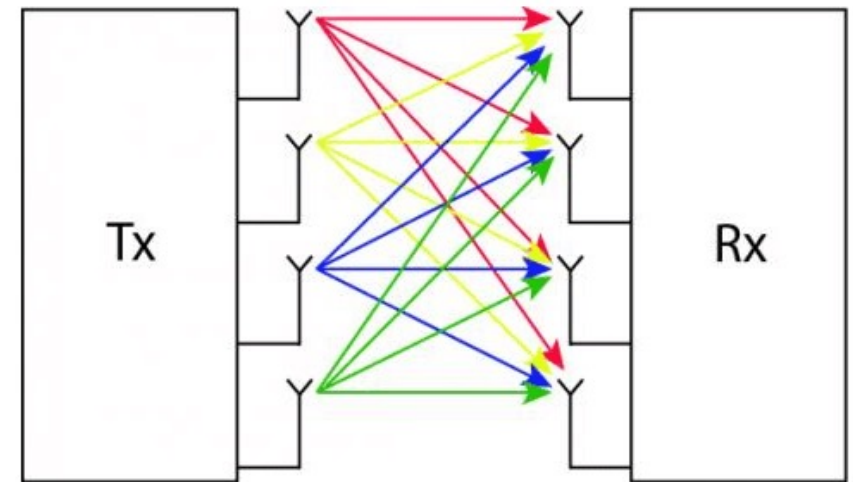
WI-FI DATA RATES–WIDER CHANNELS-AVAILABLE SPECTRUM

The use of wider channels in the 5 GHz band has been limited by the amount of spectrum available, but with the introduction of Wi-Fi 6E, operating in the 6 GHz band, the use of 80 & 160 MHz channels become practical.
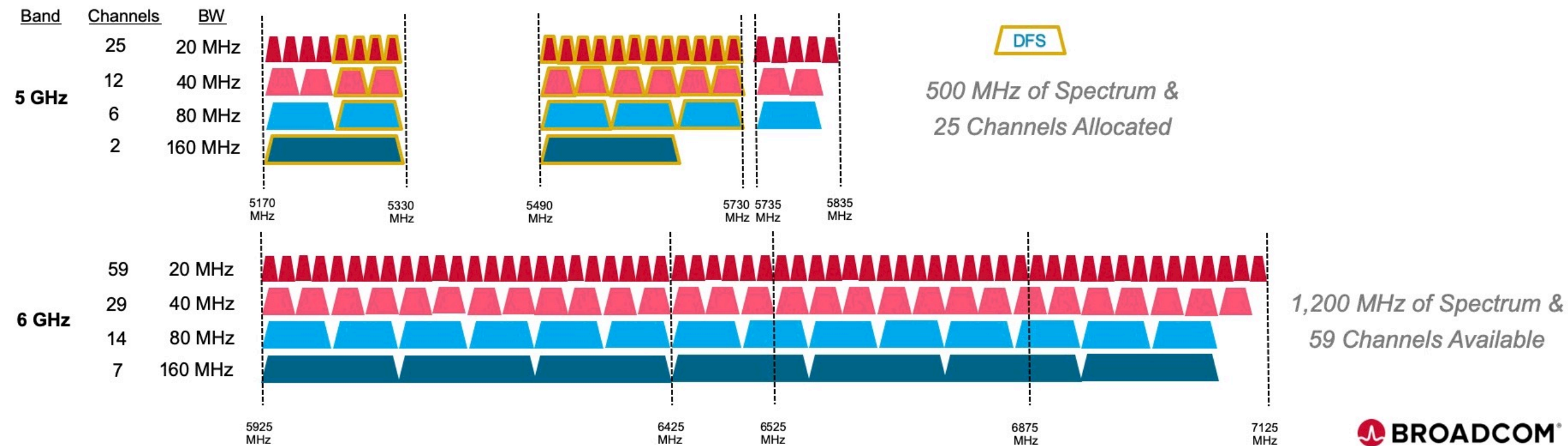
WI-FI DATA RATES – WIDER CHANNELS - NOISE

The universe hates fast Wi-Fi – The radio receiver creates it's own, internal noise, called 'thermal noise', the sound of electrons bumping around. -174 dBm / Hz at room temperature.   There is no escaping it.

All the other, external, noise? Twice (3 dB) as much of it every time you double the channel width too.

Thermal Noise

Bandwidth	Thermal Noise (80 F / 27 C)
20 MHz	-101 dBm
40 MHz	-98 dBm
80 MHz	-95 dBm
160 MHz	-92 dBm
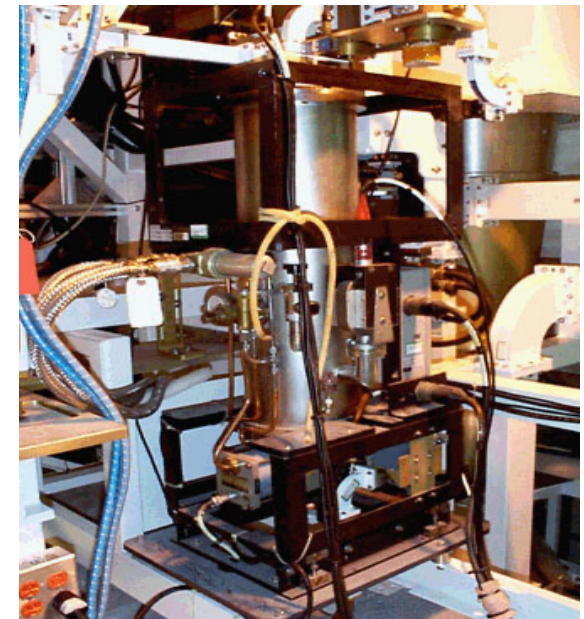
WI-FI DATA RATES – MORE COMPLEX MODULATION

Required SNR

MCS Index (ax)	Modulation	Code Rate	SNR dB
0	BPSK	1 / 2	3
1	QPSK	1 / 2	6
2	QPSK	3 / 4	8
3	16-QAM	1 / 2	11
4	16-QAM	3 / 4	15
5	64-QAM	2 / 3	21
6	64-QAM	3 / 4	20
7	64-QAM	5 / 6	21
8	256-QAM	3 / 4	26
9	256-QAM	5 / 6	28
10	1024-QAM	3 / 4	31
11	1024-QAM	5 / 6	33

As higher modulation schemes and denser code rates are used, higher SNR is required.
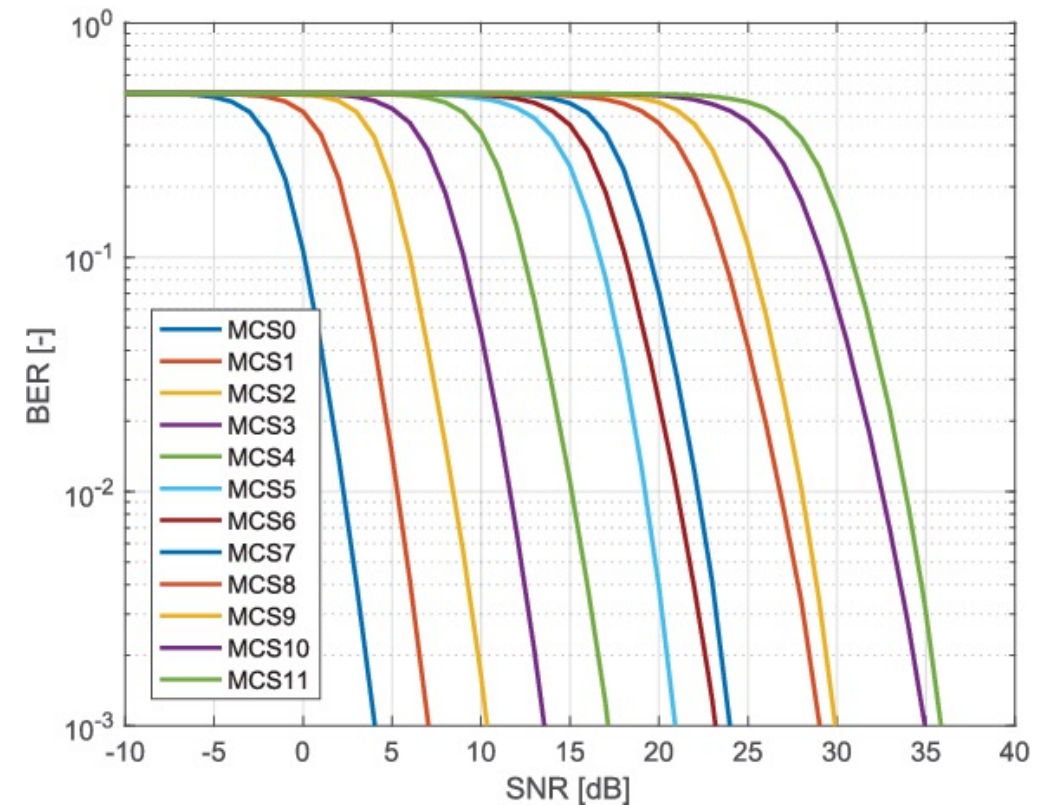
WI-FI DATA RATES – BRINGING IT TOGETHER

Required RSSI   "Perfect Radio"

MCS Index (ax)	Modulation	Code Rate	SNR dB	20 MHz RSSI dBm	40 MHz RSSI dBm	80 MHz RSSI dBm	160 MHz RSSI dBm
0	BPSK	1 / 2	3	-98	-95	-92	-89
1	QPSK	1 / 2	6	-95	-92	-89	-86
2	QPSK	3 / 4	8	-93	-90	-87	-84
3	16-QAM	1 / 2	11	-90	-87	-84	-81
4	16-QAM	3 / 4	15	-86	-83	-80	-77
5	64-QAM	2 / 3	21	-80	-77	-74	-71
6	64-QAM	3 / 4	20	-81	-78	-75	-72
7	64-QAM	5 / 6	21	-80	-77	-74	-71
8	256-QAM	3 / 4	26	-75	-72	-69	-66
9	256-QAM	5 / 6	28	-73	-70	-67	-64
10	1024-QAM	3 / 4	31	-70	-67	-64	-61
11	1024-QAM	5 / 6	33	-68	-65	-62	-59

WI-FI DATA RATES – BRINGING IT TOGETHER

Required RSSI   "Realistic Radio"

MCS Index (ax)	Modulation	Code Rate	SNR dB	20 MHz RSSI dBm	40 MHz RSSI dBm	80 MHz RSSI dBm	160 MHz RSSI dBm
0	BPSK	1 / 2	3	-95	-92	-89	-86
1	QPSK	1 / 2	6	-92	-89	-86	-83
2	QPSK	3 / 4	8	-90	-87	-84	-81
3	16-QAM	1 / 2	11	-87	-84	-81	-78
4	16-QAM	3 / 4	15	-83	-80	-77	-74
5	64-QAM	2 / 3	21	-77	-74	-71	-68
6	64-QAM	3 / 4	20	-78	-75	-72	-69
7	64-QAM	5 / 6	21	-77	-74	-71	-68
8	256-QAM	3 / 4	26	-72	-69	-66	-63
9	256-QAM	5 / 6	28	-70	-67	-64	-61
10	1024-QAM	3 / 4	31	-67	-64	-61	-58
11	1024-QAM	5 / 6	33	-65	-62	-59	-56

Matches Cisco 9130ax AP. Whew!

All AP's data rate distribution summary; Direction: download
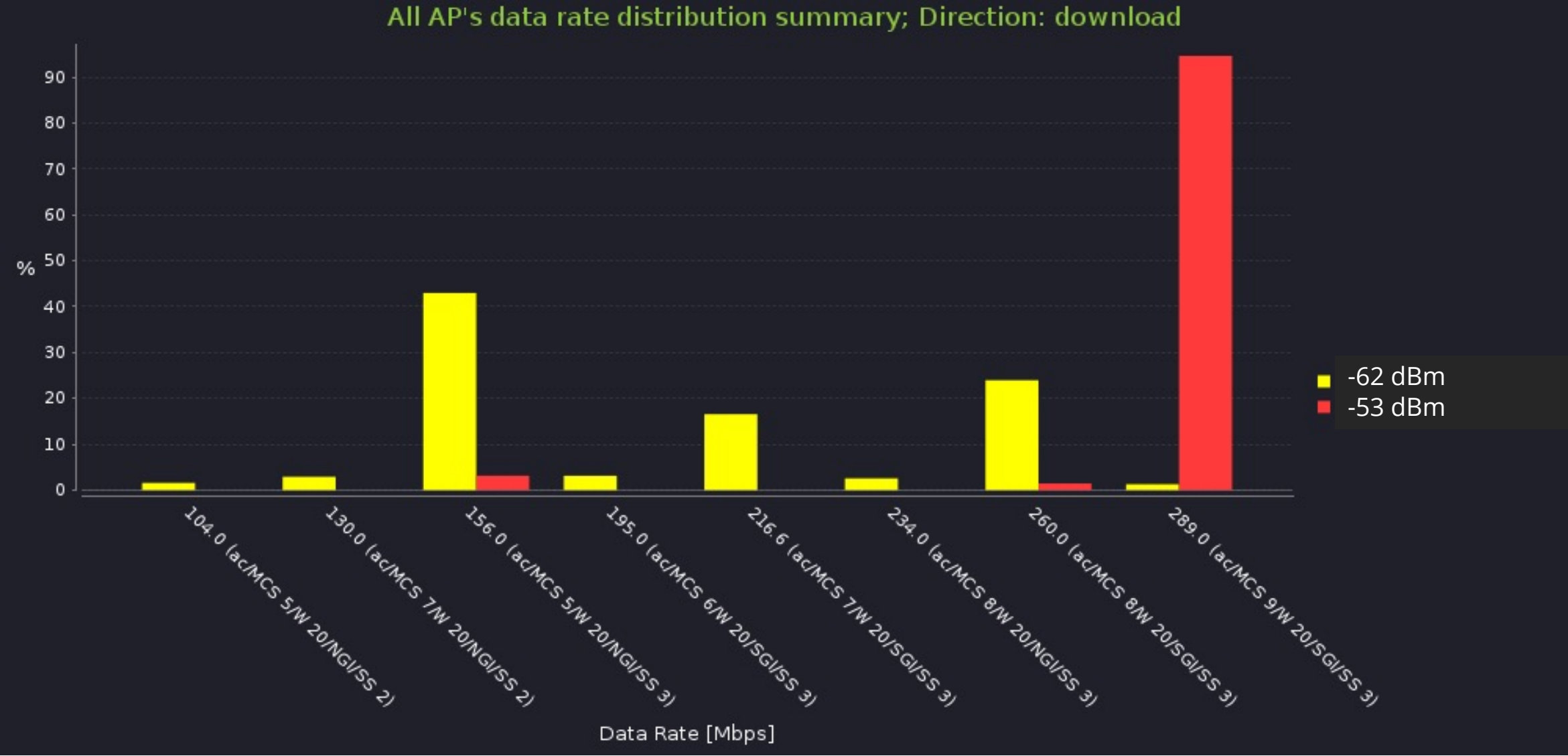
WI-FI DATA RATES – BACK TO GOING FAST

So, back to that first slide – where we said 'fast' was 2 Gbps.

What combination of spatial streams, channel width, and modulation get us there?

Spatial Streams: **2**, because that is the best we can do with current client adapters.

Channel Width: 80 MHz tops out at 1.2 Gbps for 2 streams, so it has to be **160 MHz.**

Modulation: Even with 160 MHz channels, we still need MCS 10 or 11, **1024-QAM.**

Put it all together, and with no external interference, a clear channel, and the wind at your back – around **-58 dBm**.

Q&A