Confidential

3DV7 512Gb iTLC S5E Full Qual. Result

with FW 17.0 for 1/2/4/8DP

SK hynix Inc.

31st May, 2022

Main Report

Full-Qual Main Part Result

✓ Full-Qual Report Main Part – 1/2/4/8DP

Mode	QUAL	Check Point number	Check Point name	Sample Size By Density	PE Cycle	Read Disturb	Data Retention	Read Temp	UECC	PO	ESF /PSF	Cross 70'C PO	Pass/Fail Result	Correctness Fail Bit Level		FW	Remark
														Max	Median		
TLC	8	CP2	SOL HTDR	1DP : 49PKG	300	-	2.5year	25℃	-	-	-	-	PASS	328	108	17.0	
				2DP : 24PKG	300									336	108		
				4DP : 15PKG	300									316	100		
				8DP : 23PKG	300									296	104		
		CP3	EOL HTDR	1DP : 50PKG	3K	-	1year	25℃	-	-	-	-	PASS	236	84		
				2DP : 24PKG	3K									232	80		
				4DP : 15PKG	3K									216	76		
				8DP : 23PKG	3K									212	80		
		CP11	EOL Latency	1DP : 50PKG	3K	-	1month	55℃	-	-	-	-	PASS	112	40		
				2DP : 25PKG	3K									124	36		
				4DP : 15PKG	3K									100	36		
				8DP : 23PKG	3K									128	36		
		CP4A	SOL X-Temp	1DP : 50PKG	300	-	1year	85℃	- -	- -	- -	- -	PASS	196	72		
				2DP : 24PKG	300									220	68		
				4DP : 15PKG	300									196	64		
				8DP : 23PKG	300									228	64		
		CP4B	EOL X-Temp	1DP : 50PKG	3K	-	-	85℃	-	-	-	-	PASS	104	32		
				2DP : 25PKG	3K									108	32		
				4DP : 15PKG	3K									96	32		
				8DP : 24PKG	3K									128	32		
		CP4C	EOL X-Temp	1DP : 50PKG	3K	-	-	-15℃	-	-	-	-	PASS	104	36		
				2DP : 25PKG	3K									108	36		
				4DP : 15PKG	3K									116	36		
				8DP : 24PKG	3K									140	40		

Full-Qual Main Part Result

✓ Full-Qual Report Main Part – 1/2/4/8DP

Mode	QUAL	Check Point number	Check Point name	Sample Size By Density	PE Cycle	Read Disturb	Data Retention	Read Temp	UECC	PO	ESF /PSF	Cross 70'C PO	Pass/Fail Result	Correctness Fail Bit Level		FW	Remark
														Max	Median		
TLC	10	CP8	LATENCY	1DP : 49PKG	300	100K	3month	CT 30℃	-	-	-	-	Pass	156	52	17.0	
			LATENCY	2DP : 24PKG	300	100K	3month	CT 30℃	-	-	-	-	Pass	184	52		
			LATENCY	4DP : 15PKG	300	100K	3month	CT 30℃	-	-	-	-	Pass	152	48		
			LATENCY	8DP : 25PKG	300	100K	3month	CT 30℃	-	-	-	-	Pass	164	52		
		CP9A	LATENCY	1DP : 49PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	152	48		
			LATENCY	2DP : 24PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	204	48		
			LATENCY	4DP : 13PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	140	48		
			LATENCY	8DP : 25PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	164	48		
		CP9C	LATENCY	1DP : 49PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	136	44		
			LATENCY	2DP : 24PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	180	44		
			LATENCY	4DP : 13PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	132	40		
			LATENCY	8DP : 25PKG	3K	100K	1month	CT 30℃	-	-	-	-	Pass	152	40		
		CP10	Erase Tolerance	1DP : 49PKG	3K	-	11months	CT 30℃	-	-	-	-	Pass	240	92		
			Erase Tolerance	2DP : 24PKG	3K	-	11months	CT 30℃	-	-	-	-	Pass	244	88		
			Erase Tolerance	4DP : 12PKG	3K	-	11months	CT 30℃	-	-	-	-	Pass	244	88		
			Erase Tolerance	8DP : 25PKG	3K	-	11months	CT 30℃	-	-	-	-	Pass	300	92		

Full-Qual Main Part Result

✓ Full-Qual Report Main Part – 1/2/4/8DP

Mode	PQC	Check Point number	Check Point name	Sample Size By Density	PE Cycle	Read Disturb	Data Retention	Read Temp	UECC	PO	ESF /PSF	Cross 70'C PO	Pass/Fail Result	Correctness Fail Bit Level		FW	Remark
														Max	Median		
SLC	12	CP3	EOL HTDR	1DP : 48PKG	100K	-	1year	25℃	-	-	-	-	PASS	12	4	17.0	
				2DP : 25PKG	100K									12	4		
				4DP : 15PKG	100K									16	4		
				8DP : 24PKG	100K									16	4		
		CP11	EOL Latency	1DP : 49PKG	100K	-	1month	55℃	-	-	-	-	PASS	16	4		
				2DP : 25PKG	100K									16	4		
				4DP : 15PKG	100K									16	4		
				8DP : 24PKG	100K									16	4		
		CP4A	SOL X-Temp	1DP : 48PKG	10K	-	1year	85℃	-	-	-	-	PASS	12	4		
				2DP : 25PKG	10K				-	-	-	-		12	4		
				4DP : 15PKG	10K									12	4		
				8DP : 24PKG	10K									12	4		
		CP4B	EOL X-Temp	1DP : 49PKG	100K	-	-	85℃	-	-	-	-	PASS	20	4		
				2DP : 25PKG	100K									16	4		
				4DP : 15PKG	100K									16	4		
				8DP : 24PKG	100K									16	4		
		CP4C	EOL X-Temp	1DP : 49PKG	100K	-	-	-15℃	-	-	-	-	PASS	20	4		
				2DP : 25PKG	100K									20	4		
				4DP : 15PKG	100K									16	4		
				8DP : 24PKG	100K									24	4		

Full-Qual Main Part Result

✓ Full-Qual Report Main Part – 1/2/4/8DP

Mode	PQC	Check Point number	Check Point name	Sample Size By Density	PE Cycle	Read Disturb	Data Retention	Read Temp	UECC	PO	ESF /PSF	Cross 70'C PO	Pass/Fail Result	Correctness Fail Bit Level		FW	Remark
														Max	Median		
SLC	13	CP8	LATENCY	1DP : 50PKG	10K	100K	3month	CT 30℃	-	-	-	-	Pass	12	4	17.0	
			LATENCY	2DP : 31PKG	10K	100K	3month	CT 30℃	-	-	-	-	Pass	12	4		
			LATENCY	4DP : 20PKG	10K	100K	3month	CT 30℃	-	-	-	-	Pass	12	4		
			LATENCY	8DP : 15PKG	10K	100K	3month	CT 30℃	-	-	-	-	Pass	16	4		
		CP9A	LATENCY	1DP : 50PKG	100K	100K	1month	CT 30℃	-	-	-	-	Pass	16	4		
			LATENCY	2DP : 31PKG	100K	100K	1month	CT 30℃	-	-	-	-	Pass	12	4		
			LATENCY	4DP : 20PKG	100K	100K	1month	CT 30℃	-	-		-	Pass	16	4		
			LATENCY	8DP : 15PKG	100K	100K	1month	CT 30℃	-	-		-	Pass	16	4		
		CP9C	LATENCY	1DP :50 PKG	100K	100K	1month	CT 30℃	-	-		-	Pass	12	4		
			LATENCY	2DP : 31PKG	100K	100K	1month	CT 30℃	-	-		-	Pass	16	4		
			LATENCY	4DP : 20PKG	100K	100K	1month	CT 30℃	-	-		-	Pass	16	4		
			LATENCY	8DP : 15PKG	100K	100K	1month	CT 30℃	-	-		-	Pass	16	4		
		CP10	Erase Tolerance	1DP : 48PKG	100K	-	11months	CT 30℃	-	-	-	-	Pass	20	4		
			Erase Tolerance	2DP : 30PKG	100K	-	11months	CT 30℃	-	-	-	-	Pass	20	4		
			Erase Tolerance	4DP : 20PKG	100K	-	11months	CT 30℃	-	-	-	-	Pass	20	4		
			Erase Tolerance	8DP : 15PKG	100K	-	11months	CT 30℃	-	-	-	-	Pass	24	4		

Full-Qual Main Part Result

✓ Full-Qual Report Main Part – 1/2/4/8DP

Mode	Flow	Type	Check Point Name	Sample Size By Density	PE Cycle	Read Disturb	Data Retention	Read Temp	UECC	PO	ESF/PSF	Cross 70℃ PO	Pass/Fail Result	Correctness Fail Bit Level		FW	Remark
														Max	Median		
TLC	X-ray	Type 1	X-ray Tolerance	1DP : 56PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	128	36	FW 17.0	
		Type 2		1DP : 56PKG	300	100K	3months	CT 30℃	-	-	-	-	Pass	116	36		
		Type 3		1DP : 58PKG	3K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	108	32		
		Type 1		2DP : 53PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	144	36		
		Type 2		2DP : 53PKG	300	100K	3months	CT 30℃	-	-	-	-	Pass	128	36		
		Type 3		2DP : 55PKG	3K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	112	32		
		Type 1		4DP : 46PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	112	36		
		Type 2		4DP : 46PKG	300	100K	3months	CT 30℃	-	-	-	-	Pass	128	36		
		Type 3		4DP : 51PKG	3K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	108	32		
		Type 1		8DP : 49PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	120	32		
		Type 2		8DP : 49PKG	300	100K	3months	CT 30℃	-	-	-	-	Pass	116	36		
		Type 3		8DP : 57PKG	3K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	104	28		
SLC		Type 1		1DP : 56PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	48	4		
		Type 2		1DP : 56PKG	10K	100K	3months	CT 30℃	-	-	-	-	Pass	12	4		
		Type 3		1DP : 58PKG	100K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	12	4		
		Type 1		2DP : 53PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	20	4		
		Type 2		2DP : 53PKG	10K	100K	3months	CT 30℃	-	-	-	-	Pass	16	4		
		Type 3		2DP : 55PKG	100K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	20	4		
		Type 1		4DP : 46PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	40	4		
		Type 2		4DP : 46PKG	10K	100K	3months	CT 30℃	-	-	-	-	Pass	12	4		
		Type 3		4DP : 51PKG	100K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	32	4		
		Type 1		8DP : 49PKG	1	100K	3months	CT 30℃	-	-	-	-	Pass	40	4		
		Type 2		8DP : 49PKG	10K	100K	3months	CT 30℃	-	-	-	-	Pass	28	4		
		Type 3		8DP : 57PKG	100K	100K	1month/ 3months	CT 30℃	-	-	-	-	Pass	32	4		

Full-Qual Main Part Result

✓ Full-Qual Report Main Part – 1/2/4/8DP

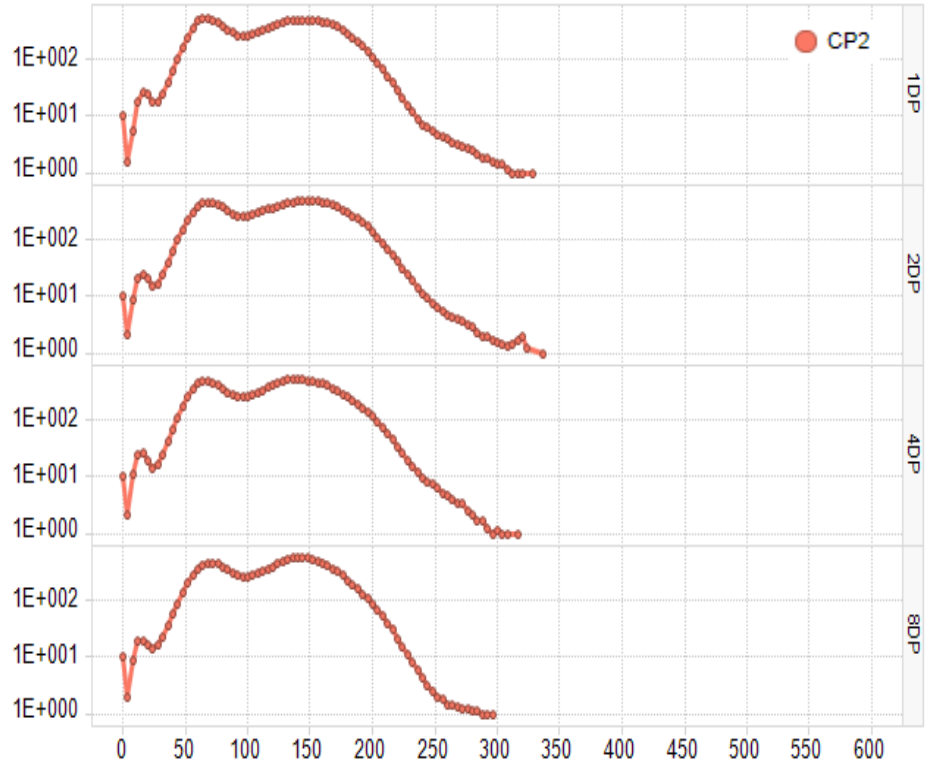
Mode	Check Point Number	Check Point Name	Sample Size By Density	PE Cycle	Read Disturb	Data Retention	Read Temp	Pass/Fail Result	Bitflip Fail Bit Level		FW	Remark
									Max	Median		
Boot Block	CP1	Boot Qual	1DP : 60PKG	-	-	5years	25℃	Pass	2	0	FW 17.0	
	CP2		1DP : 60PKG	-	-	5years	25℃	Pass	2	0		
	CP1	Boot Qual	2DP : 60PKG	-	-	5years	25℃	Pass	2	0		
	CP2		2DP : 60PKG	-	-	5years	25℃	Pass	2	0		
	CP1	Boot Qual	4DP : 60PKG	-	-	5years	25℃	Pass	2	0		
	CP2		4DP : 60PKG	-	-	5years	25℃	Pass	2	0		
	CP1	Boot Qual	8DP : 60PKG	-	-	5years	25℃	Pass	2	0		
	CP2		8DP : 60PKG	-	-	5years	25℃	Pass	2	0		

TLC (SOL HTDR) – CP2

☑ Reliability Check points satisfied with checkpoint 2

TLC Checkpoint 2 (Data Retention)			
Test Result			PASS
Correctness Fail Bit Level (Indepth DEF)			HTDR 2.5Y
			100%
1DP	EW 300	Max	328
		Median	108
2DP	EW 300	Max	336
		Median	108
4DP	EW 300	Max	316
		Median	100
8DP	EW 300	Max	296
		Median	104

● Indepth Histogram (EW+HTDR 2.5Yr)

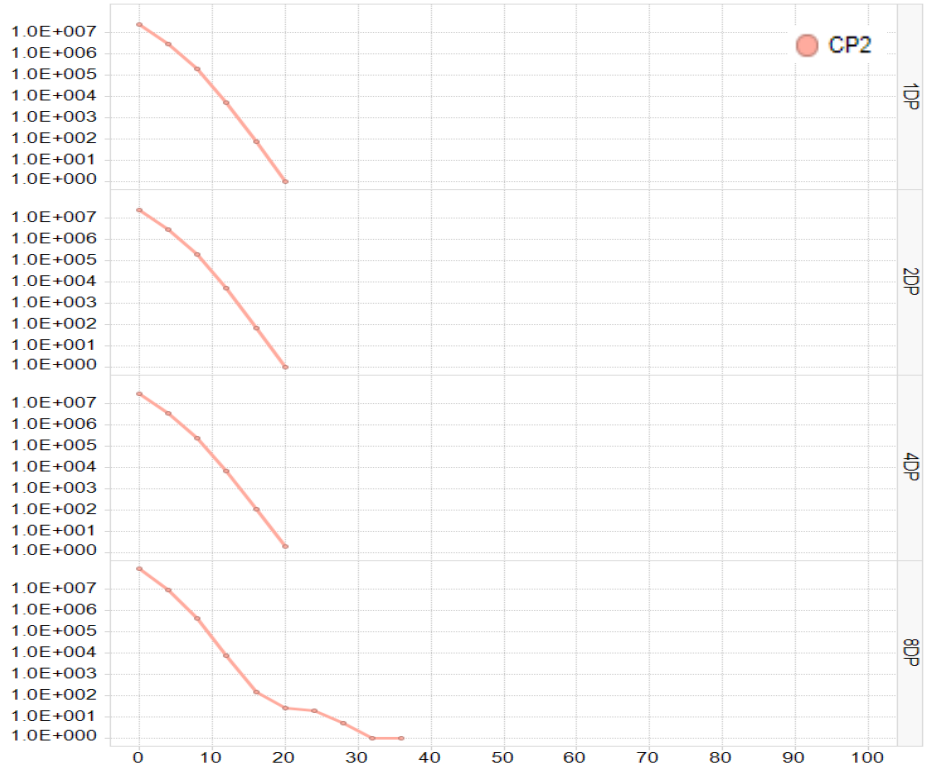


TLC (SOL HTDR) – CP2

☑ Reliability Check points satisfied with checkpoint 2

TLC Checkpoint 2 (Data Retention)			
Test Result			PASS
Correctness Fail Bit Level (Hard Error)			HTDR 2.5Y
			100%
1DP	EW 300	Max	20
		Median	4
2DP	EW 300	Max	20
		Median	4
4DP	EW 300	Max	20
		Median	4
8DP	EW 300	Max	36
		Median	4

● Hard Error Histogram (EW+HTDR 2.5Yr)

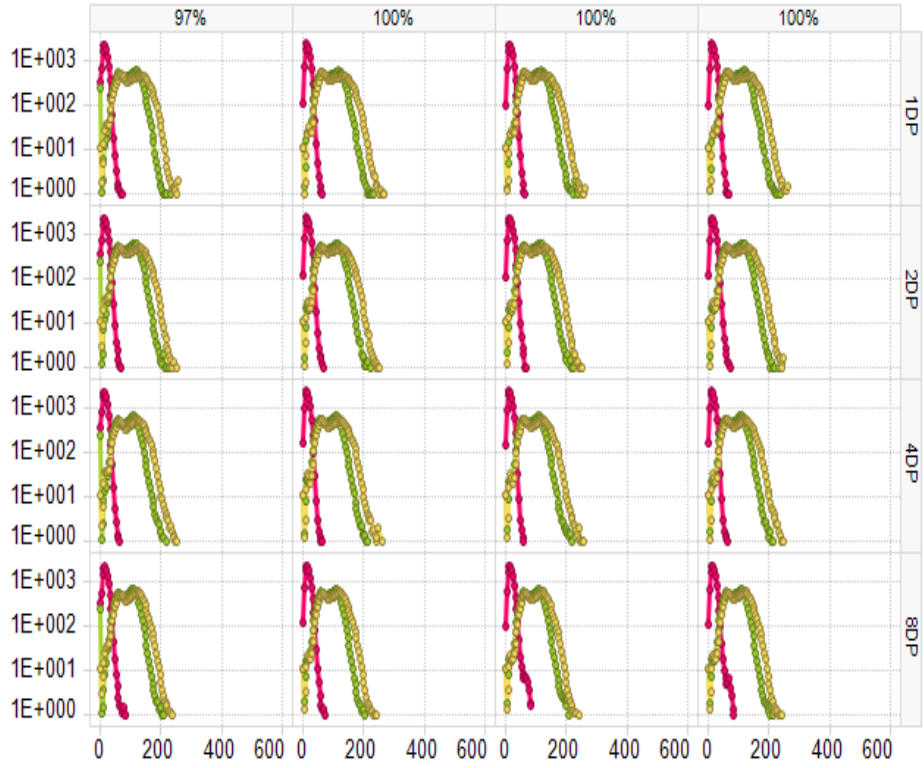


TLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3

TLC Checkpoint 3 (Data Retention)														
Test Result			PASS											
Correctness Fail Bit Level (Indepth DEF)			EW				HTDR 1Y				HTDR 1Y+2week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	72	64	64	68	232	232	236	236	256	268	260	260
		Med	20	20	20	20	84	84	84	84	92	96	96	100
2DP	EW 3K	Max	68	68	68	72	228	224	224	232	252	252	252	248
		Med	20	20	20	20	80	80	80	80	88	92	92	92
4DP	EW 3K	Max	64	64	60	64	216	212	216	212	252	260	256	248
		Med	20	20	20	20	80	76	76	76	84	88	88	88
8DP	EW 3K	Max	84	72	84	84	208	204	212	212	236	240	244	240
		Med	24	20	24	24	80	76	80	76	84	88	88	88

● Indepth Histogram (EW+HTDR 1Yr+2week)

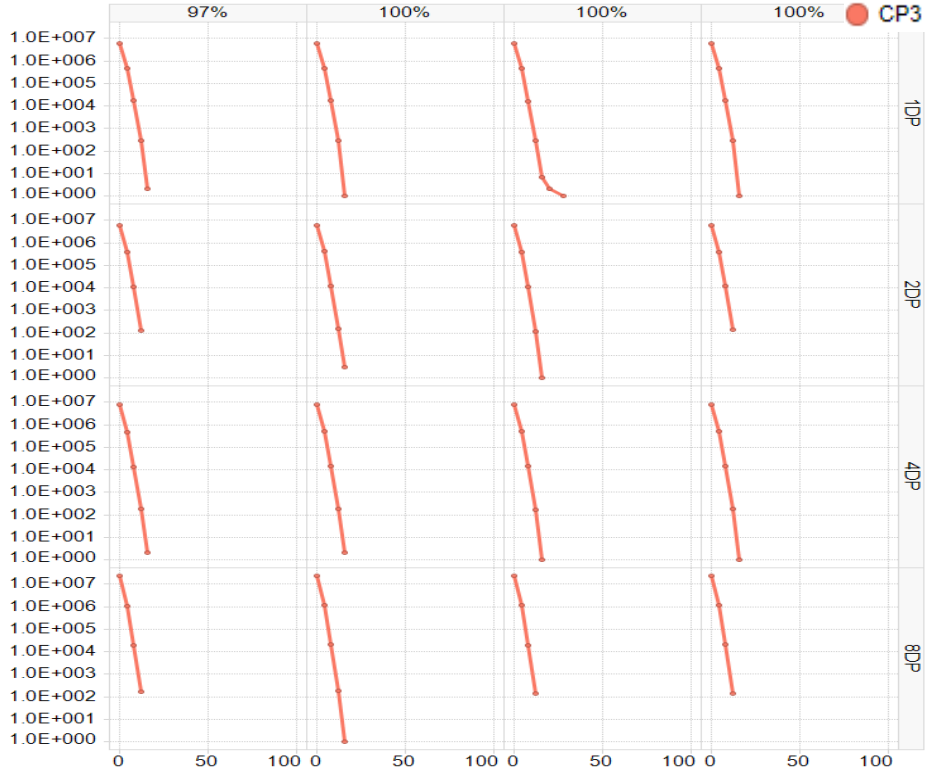


TLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3

TLC Checkpoint 3 (Data Retention)					
Test Result		PASS			
Correctness Fail Bit Level (Hard Error)		HTDR 1Y			
		97%	100%	100%	100%
1DP	Max	16	16	28	16
	Median	4	4	4	4
2DP	Max	12	16	16	12
	Median	4	4	4	4
4DP	Max	16	16	16	16
	Median	4	4	4	4
8DP	Max	12	16	12	12
	Median	4	4	4	4

● Hard Error Histogram (EW+HTDR1Yr)

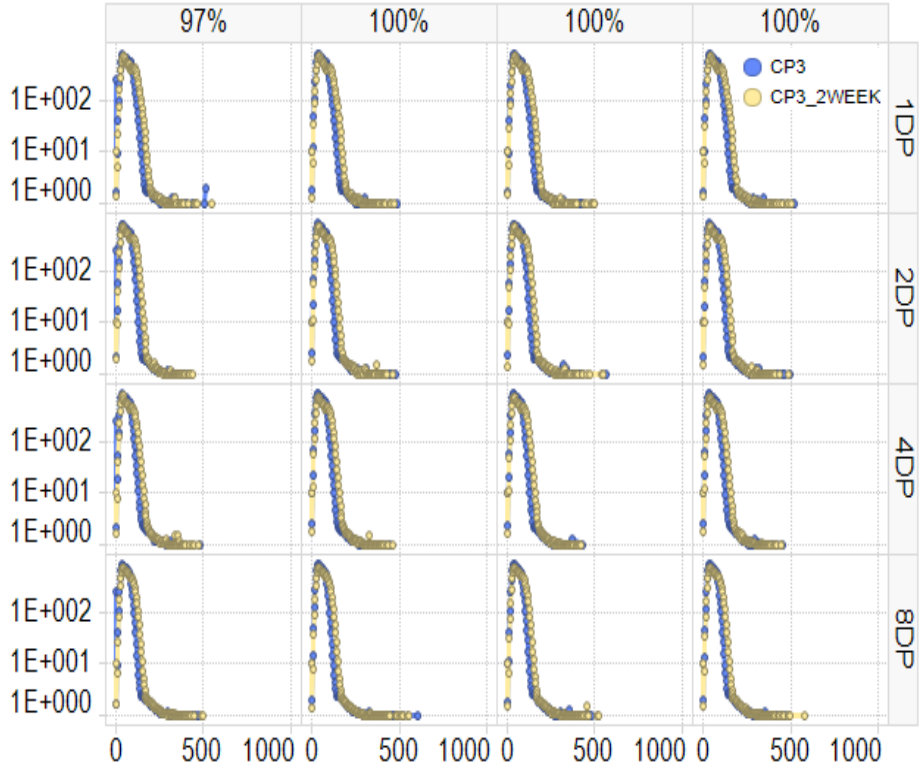


TLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3

TLC Checkpoint 3 (Data Retention)									
Test Result			PASS						
Correctness Fail Bit Level (Indepth ADSP)			HTDR 1Y				HTDR 1Y+2week			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	512	488	476	524	544	468	500	500
		Med	80	80	80	80	88	92	92	92
2DP	EW 3K	Max	416	480	560	496	436	464	544	484
		Med	76	76	76	76	84	84	84	84
4DP	EW 3K	Max	476	444	432	452	468	464	416	448
		Med	76	76	76	76	84	84	84	84
8DP	EW 3K	Max	468	608	480	468	492	552	520	576
		Med	76	76	76	76	80	84	84	84

● Indepth Histogram_ADSP (EW+HTDR 1Yr)



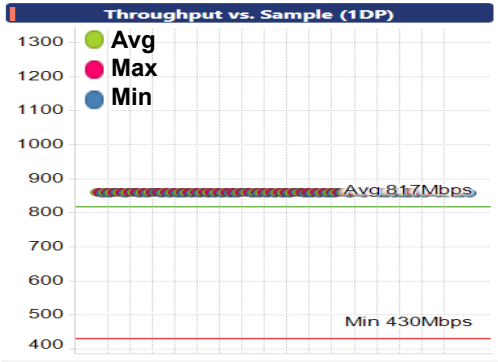
TLC (Sequential Throughput) – CP11

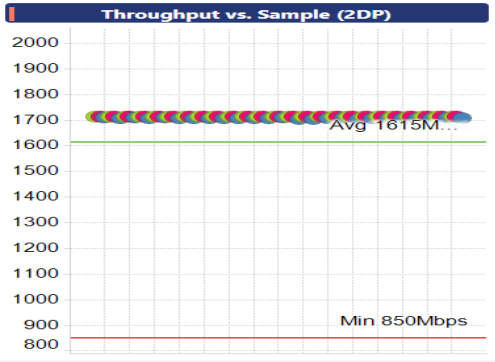
☑ Throughput Test satisfied with checkpoint 11

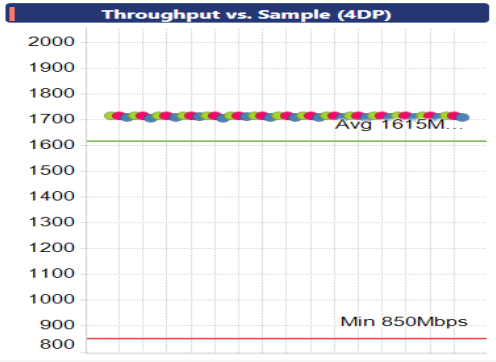
- Throughput Measurement Table

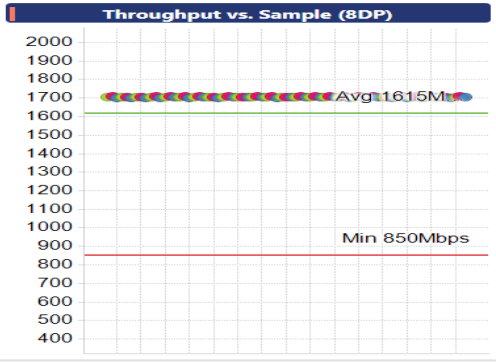
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	860.88	860.69	858	1714.66	1714.38	1705	1714.55	1713.56	1705	1706.38	1705.25	1699
	EW+RD100K+1month (CT 30C)	859	857.42	844	1711.22	1707	1681	1711.93	1710.08	1694	1706.36	1704.83	1697

- Throughput vs. Sample(PKG) (Initial)

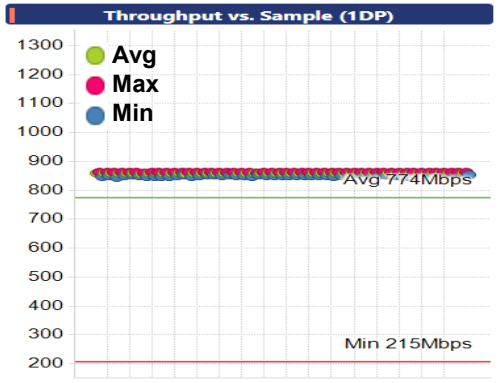


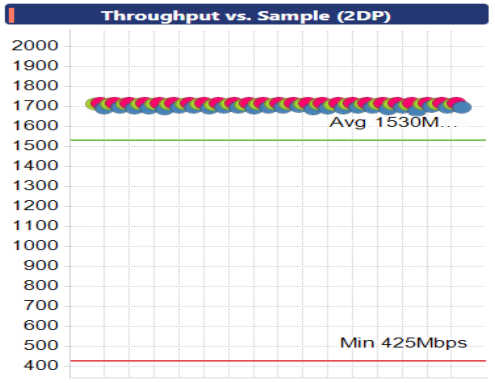


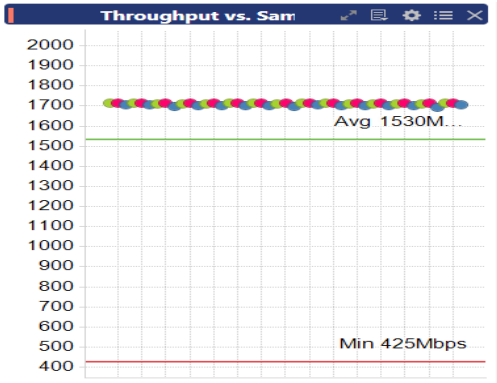


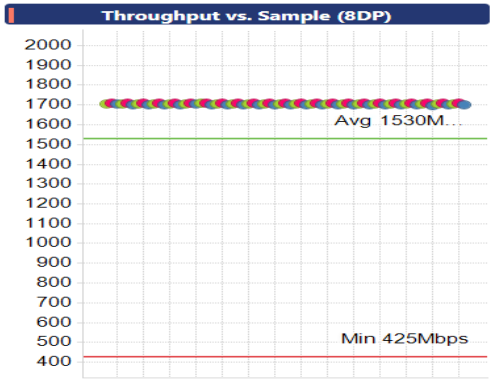


- Throughput vs. Sample(PKG) (EW+RD100K+1month)









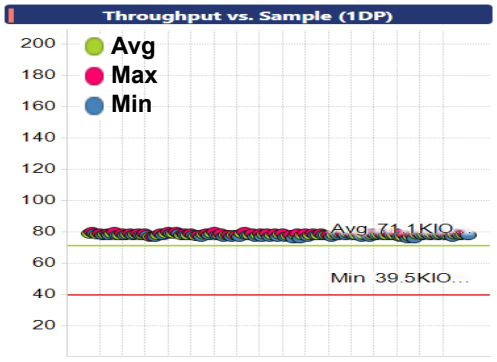
TLC (RR Throughput) – CP11

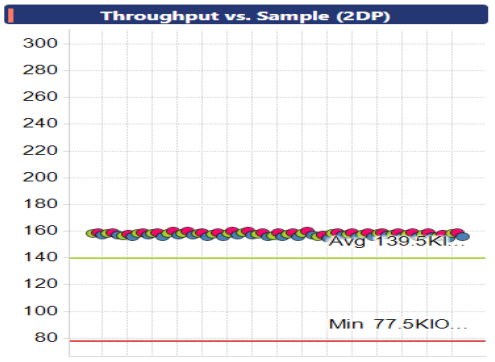
☑ Throughput Test satisfied with checkpoint 11

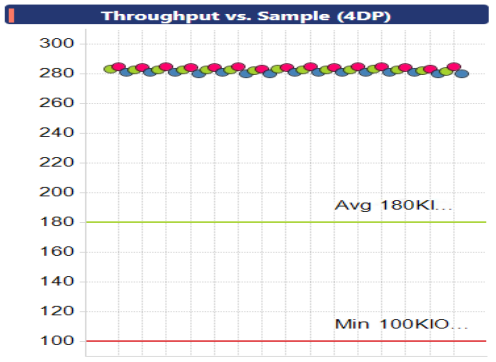
- Throughput Measurement Table

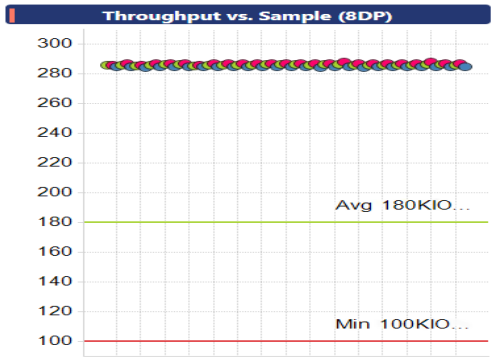
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	78.25	77	76	157.85	155.81	155	282.58	281.69	280	285.92	285.19	284
	EW+RD100K+1month (CT 30C)	78.25	77	77	157.85	156.33	154	282.68	281.75	280	286.04	285.5	283

- Throughput vs. Sample(PKG) (Initial)

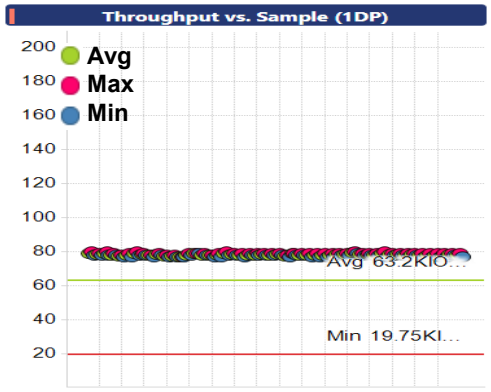


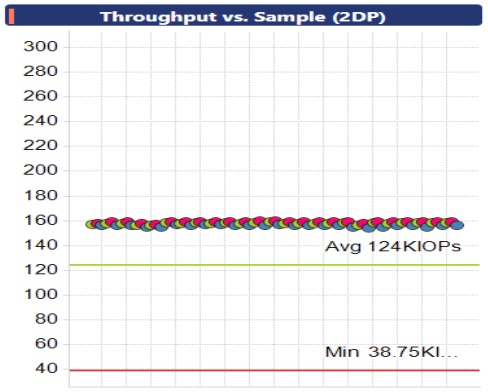


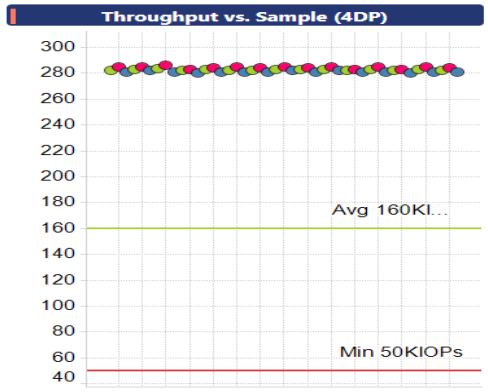


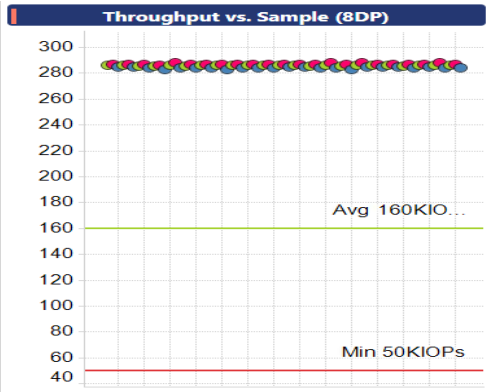


- Throughput vs. Sample(PKG) (EW+RD100K+1month)







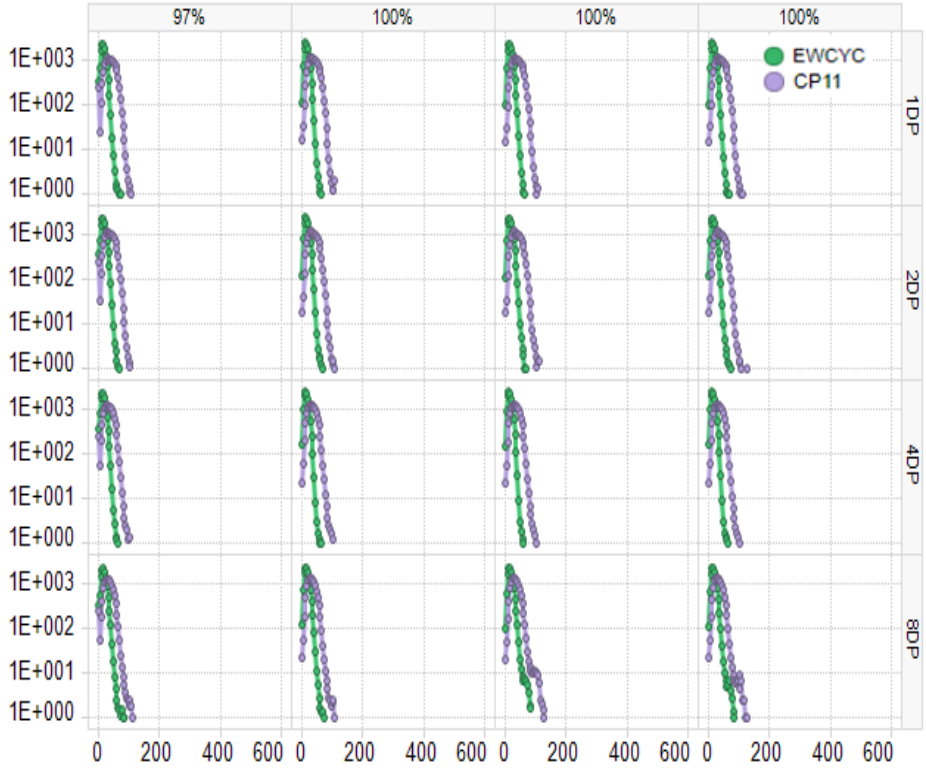


TLC (EOL Latency) – CP11

☑ Read latency satisfied with checkpoint 11

ITEM	Stack	EW	Bin	Apple Spec	EW + Read 100K + 1Month		
					Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP11 (CT 60'C)	1DP	3K	tR≤160us	TBD	0.999993	0.999979	49.88
			tR≤200us	TBD	-	-	
			tR≤1300us	TBD	0.000008	0.000021	
	2DP	3K	tR≤160us	TBD	0.999994	0.999984	49.86
			tR≤200us	TBD	-	-	
			tR≤1300us	TBD	0.000006	0.000016	
	4DP	3K	tR≤160us	TBD	0.999994	0.99998	50.49
			tR≤200us	TBD	0.000001	0.000001	
			tR≤1300us	TBD	0.000006	0.00002	
	8DP	3K	tR≤160us	TBD	0.999994	0.999982	50.36
			tR≤200us	TBD	0.000002	0.000004	
			tR≤1300us	TBD	0.000006	0.000017	

● Indepth Histogram (EW+1Month)

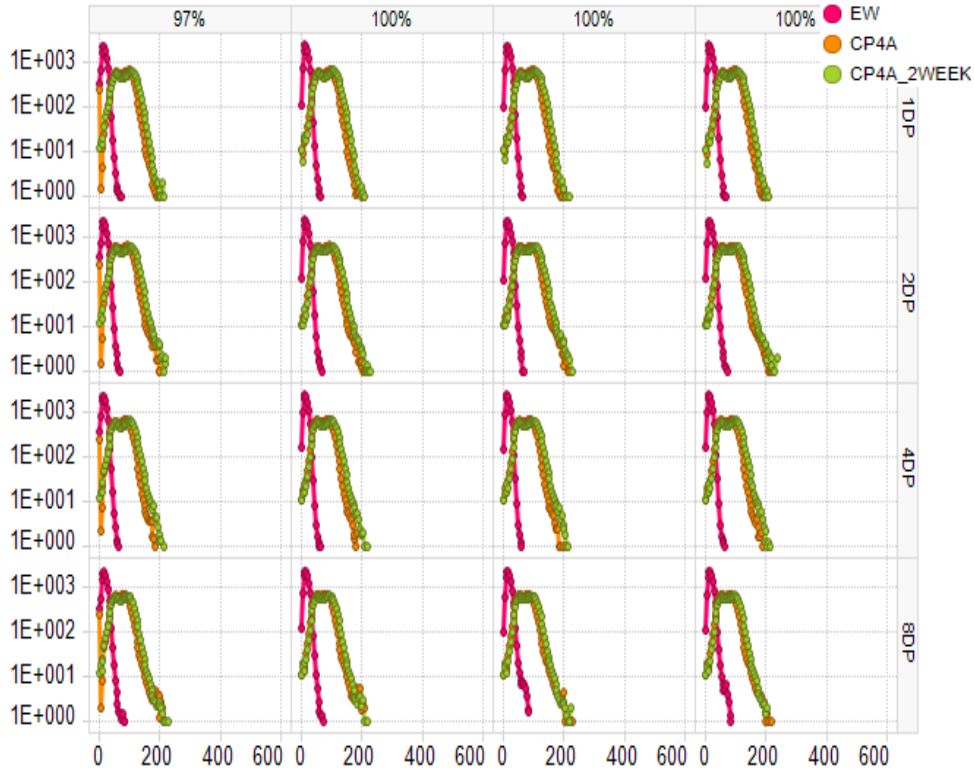


TLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A

TLC Checkpoint 4A (X-Temp)														
Test Result			PASS											
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp				100℃ Cross Temp +2Week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 300	Max	72	64	64	68	196	196	192	192	212	208	216	208
		Med	20	20	20	20	72	72	72	72	76	76	76	76
2DP	EW 300	Max	68	68	68	72	204	212	220	216	220	228	228	236
		Med	20	20	20	20	68	68	68	68	72	76	76	76
4DP	EW 300	Max	64	64	60	64	184	184	196	188	212	216	212	212
		Med	20	20	20	20	64	64	64	64	68	72	72	72
8DP	EW 300	Max	84	72	84	84	212	208	228	220	228	216	224	204
		Med	24	20	24	24	64	64	68	64	68	68	72	72

● Indepth Histogram (EW+100℃ Cross Temp)

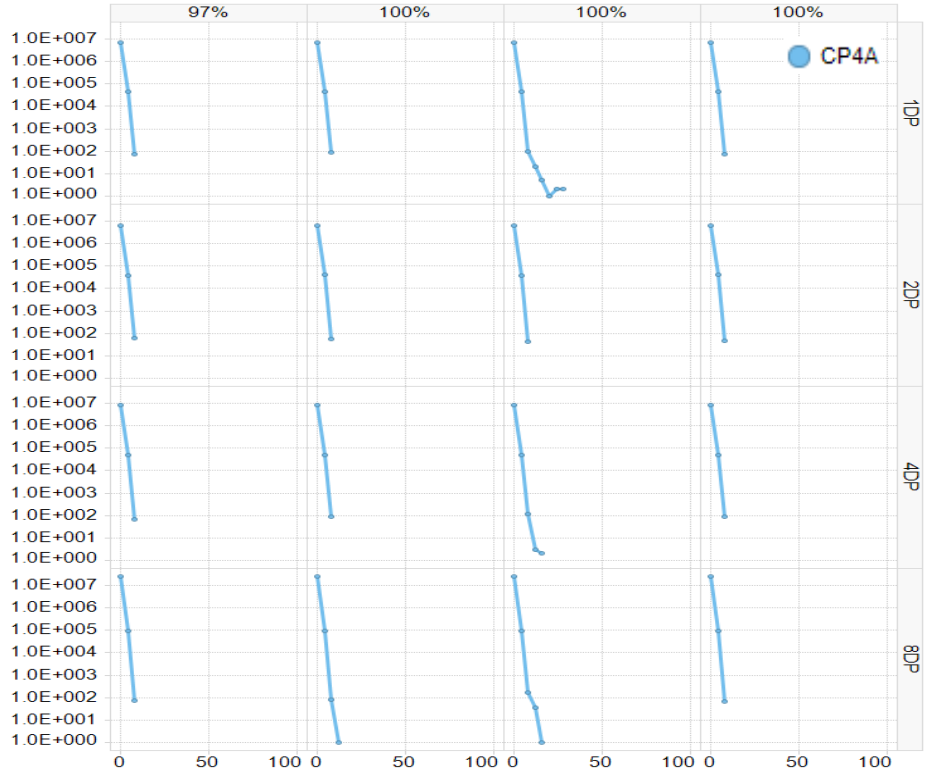


TLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A

TLC Checkpoint 4A (X-Temp)						
Test Result			PASS			
Correctness Fail Bit Level (Hard Error)			100℃ Cross Temp			
			97%	100%	100%	100%
1DP	EW 300	Max	8	8	28	8
		Median	0	0	0	0
2DP	EW 300	Max	8	8	8	8
		Median	0	0	0	0
4DP	EW 300	Max	8	8	16	8
		Median	0	0	0	0
8DP	EW 300	Max	8	12	16	8
		Median	0	0	0	0

● Hard Error Histogram (EW+100℃ Cross Temp)

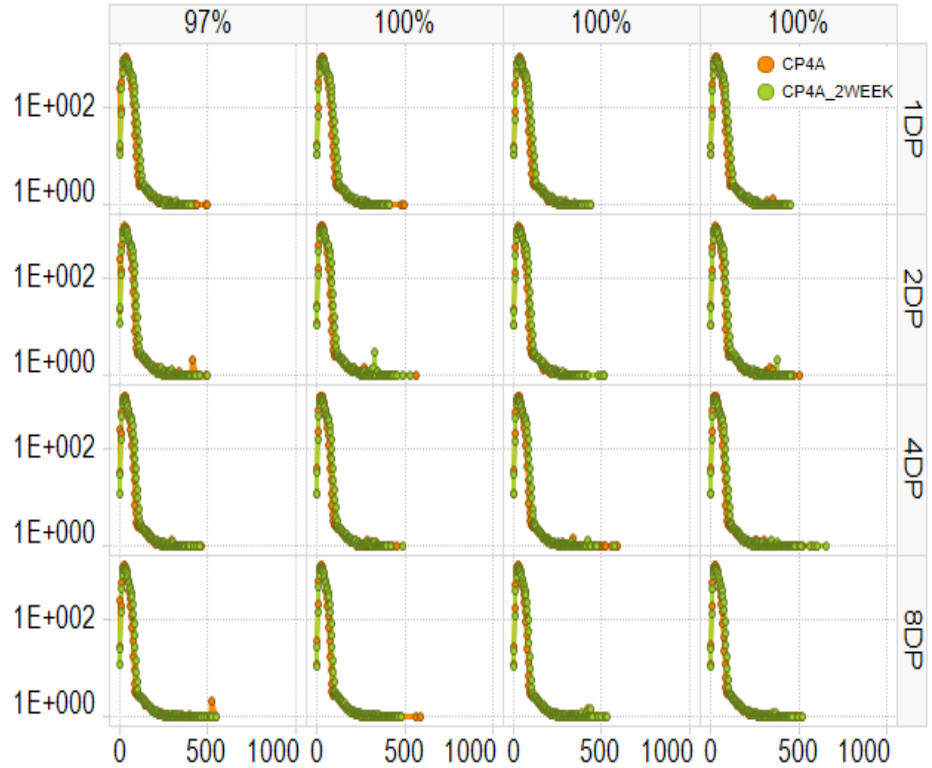


TLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A

TLC Checkpoint 4A (X-Temp)									
Test Result			PASS						
Correctness Fail Bit Level (Indepth ADSP)			100℃ Cross Temp				100℃ Cross Temp +2Week			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 300	Max	492	496	436	432	404	408	436	452
		Median	60	60	60	60	68	68	68	68
2DP	EW 300	Max	484	564	512	500	496	528	516	456
		Median	56	56	56	60	64	64	64	64
4DP	EW 300	Max	460	452	588	572	456	488	572	656
		Median	56	56	56	56	64	60	64	60
8DP	EW 300	Max	544	588	512	516	544	480	532	524
		Median	56	56	56	56	60	60	60	60

● Indepth Histogram_ADSP (EW+100℃ Cross Temp)



TLC (EOL X-Temp) – CP4B

☑ Reliability Check points satisfied with checkpoint 4B

TLC Checkpoint 4B (X-Temp)									
Test Result			PASS						
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	72	64	64	68	100	104	100	100
		Median	20	20	20	20	36	32	36	36
2DP	EW 3K	Max	68	68	68	72	96	100	108	104
		Median	20	20	20	20	32	32	32	32
4DP	EW 3K	Max	64	64	60	64	96	88	92	92
		Median	20	20	20	20	32	32	32	32
8DP	EW 3K	Max	84	72	84	84	116	112	128	124
		Median	24	20	24	24	32	32	32	32

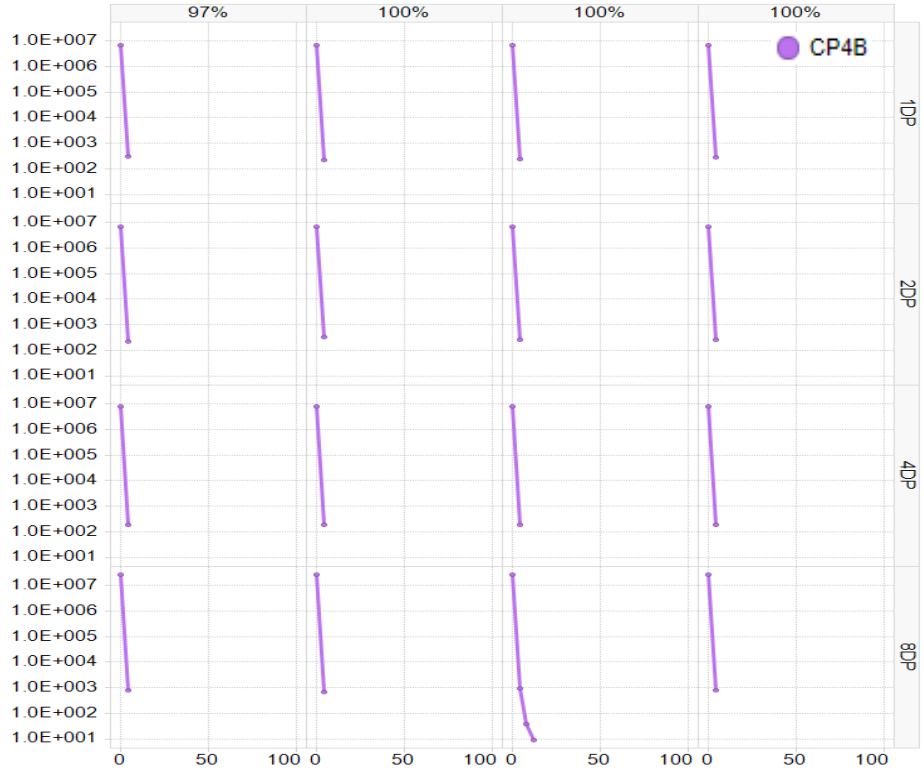
● Indepth Histogram (EW + 100℃ Cross Temp)

TLC (EOL X-Temp) – CP4B

☑ Reliability Check points satisfied with checkpoint 4B

TLC Checkpoint 4B (X-Temp)						
Test Result			PASS			
Correctness Fail Bit Level (Hard Error)			100℃ Cross Temp			
			97%	100%	100%	100%
1DP	EW 3K	Max	4	4	4	4
		Median	0	0	0	0
2DP	EW 3K	Max	4	4	4	4
		Median	0	0	0	0
4DP	EW 3K	Max	4	4	4	4
		Median	0	0	0	0
8DP	EW 3K	Max	4	4	12	4
		Median	0	0	0	0

● Hard Error Histogram (EW + 100℃ Cross Temp)

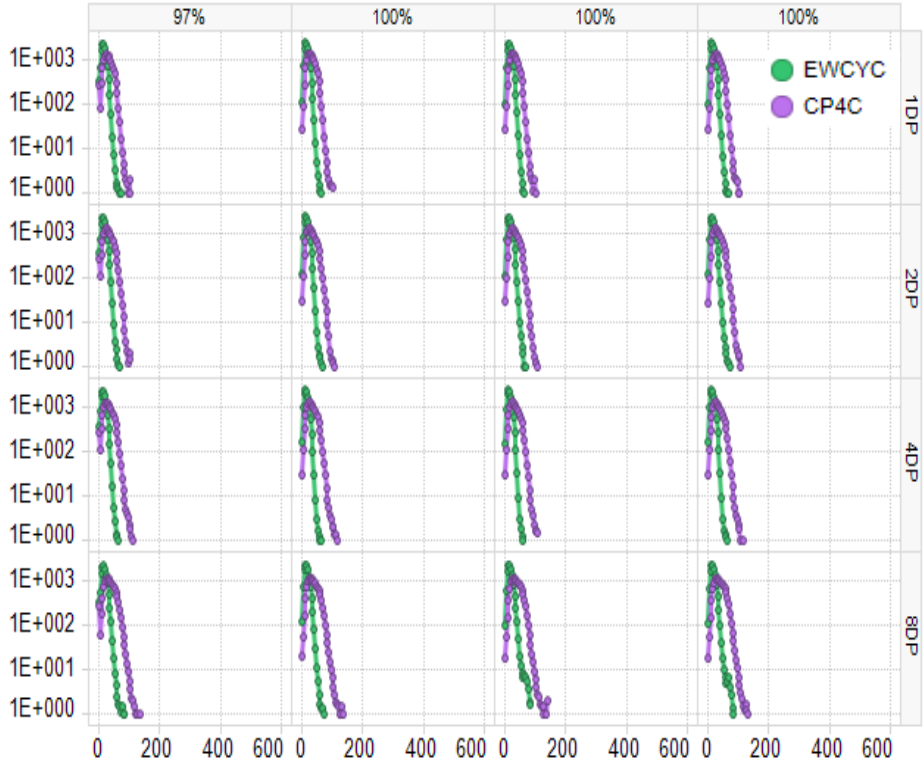


TLC (EOL X-Temp) – CP4C

☑ Reliability Check points satisfied with checkpoint 4C

TLC Checkpoint 4C (X-Temp)									
Test Result			PASS						
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	72	64	64	68	104	100	100	104
		Median	20	20	20	20	36	36	36	36
2DP	EW 3K	Max	68	68	68	72	104	108	108	108
		Median	20	20	20	20	36	36	36	36
4DP	EW 3K	Max	64	64	60	64	112	116	108	116
		Median	20	20	20	20	36	36	36	36
8DP	EW 3K	Max	84	72	84	84	136	136	140	132
		Median	24	20	24	24	40	40	40	40

● Indepth Histogram (EW+100℃ Cross Temp)

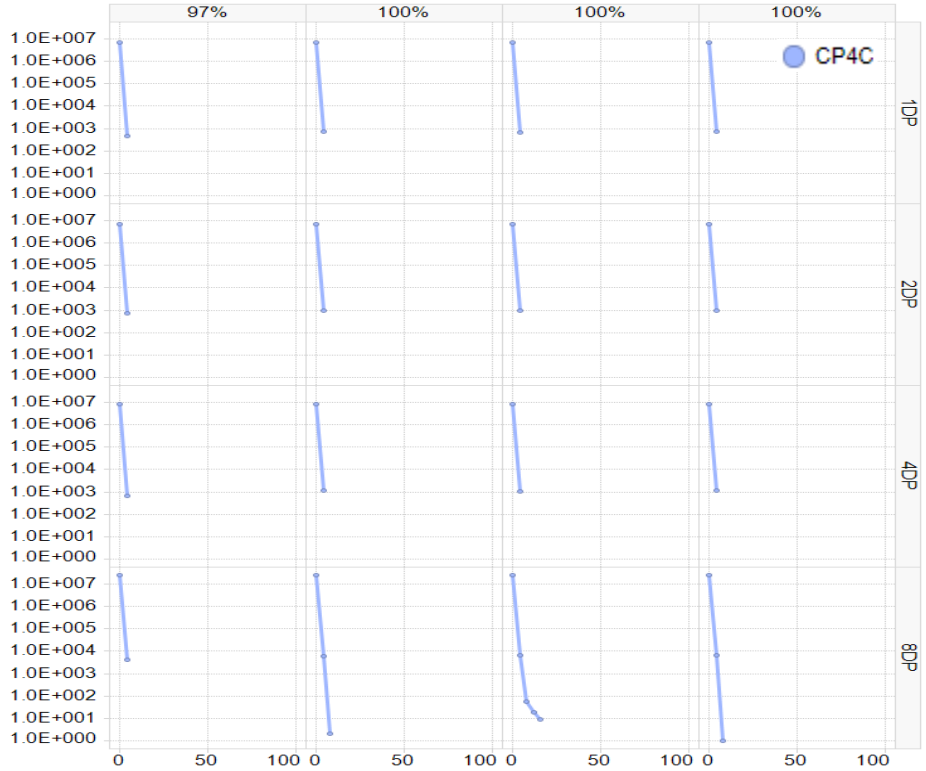


TLC (EOL X-Temp) – CP4C

☑ Reliability Check points satisfied with checkpoint 4C

TLC Checkpoint 4C (X-Temp)						
Test Result			PASS			
Correctness Fail Bit Level (Hard Error)			100℃ Cross Temp			
			97%	100%	100%	100%
1DP	EW 3K	Max	4	4	4	4
		Median	0	0	0	0
2DP	EW 3K	Max	4	4	4	4
		Median	0	0	0	0
4DP	EW 3K	Max	4	4	4	4
		Median	0	0	0	0
8DP	EW 3K	Max	4	8	16	8
		Median	0	0	0	0

● Hard Error Histogram (EW + 100℃ Cross Temp)



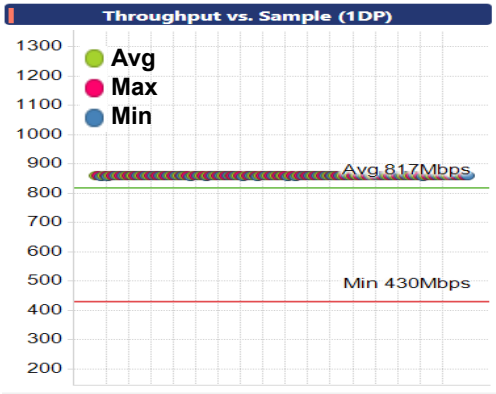
TLC (Sequential Throughput) – CP8

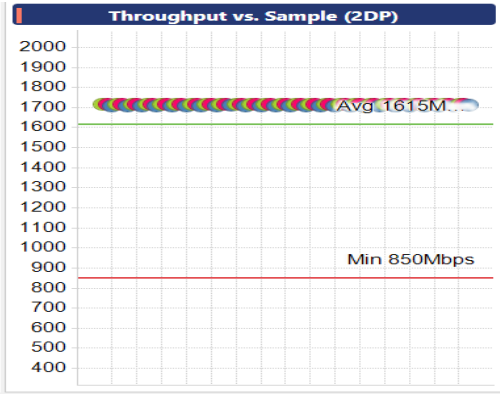
☑ Throughput Test satisfied with checkpoint 8

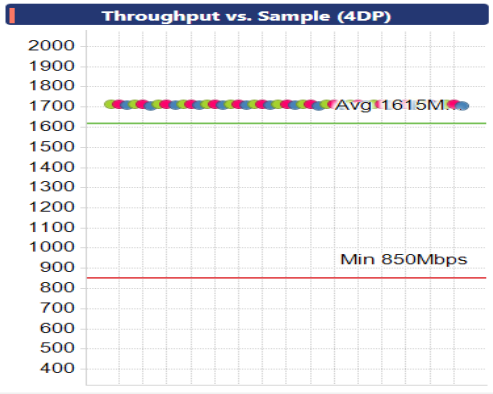
- Throughput Measurement Table

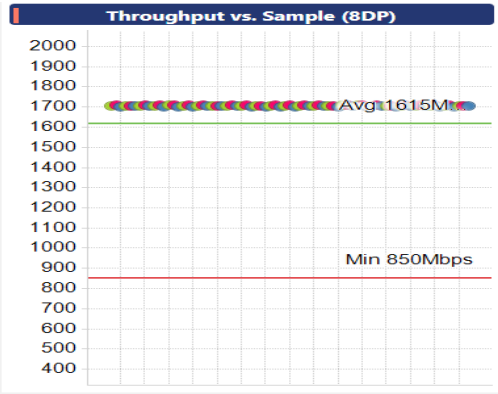
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 300	Initial	860.89	860.56	858	1714.59	1714.38	1705	1714.54	1713.56	1705	1706.44	1705.5	1700
	EW+RD100K+3month (CT 30C)	856.66	853.31	836	1704.28	1694.31	1638	1707.8	1703.19	1668	1705.18	1702.56	1675

- Throughput vs. Sample(PKG) (Initial)

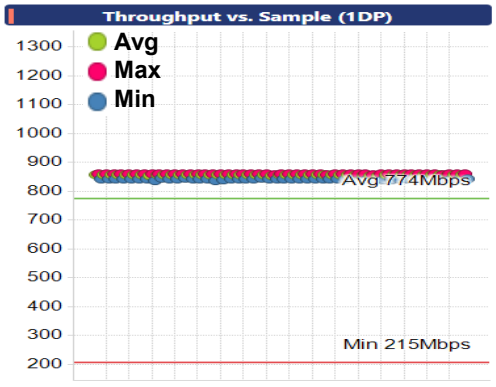


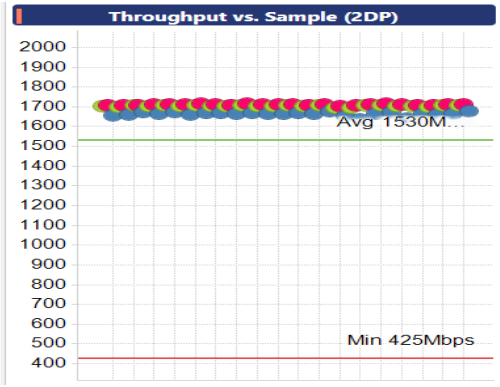


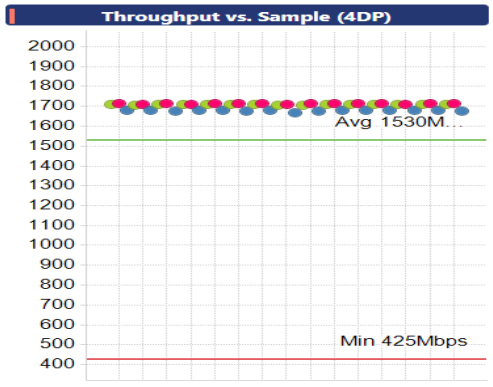


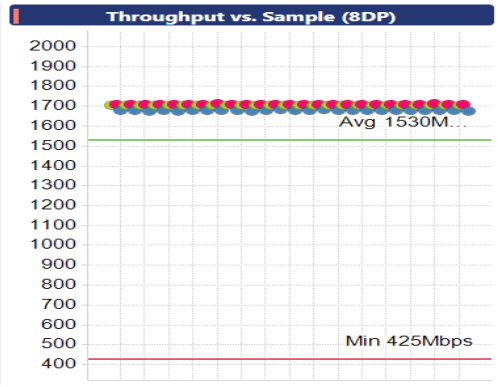


- Throughput vs. Sample(PKG) (EW+RD100K+3Months)









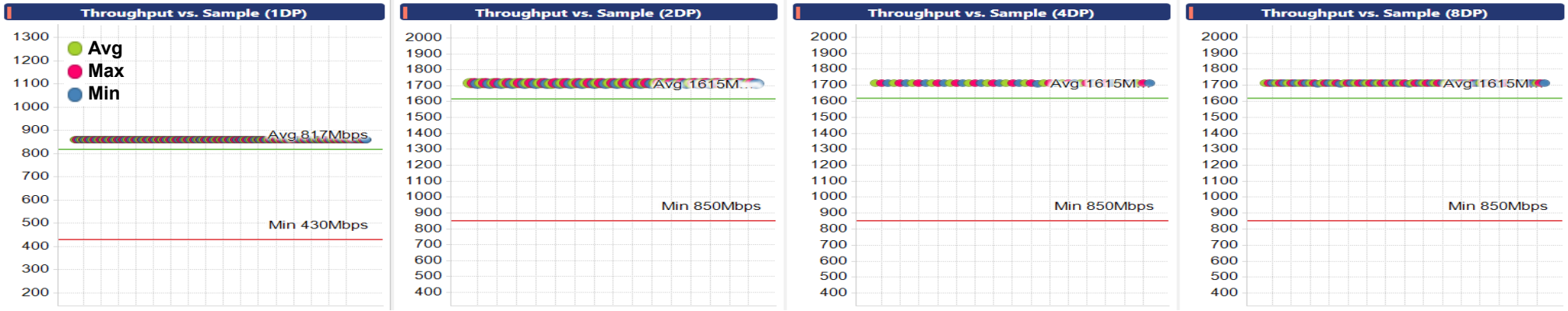
TLC (RC Throughput) – CP8

☑ Throughput Test satisfied with checkpoint 8

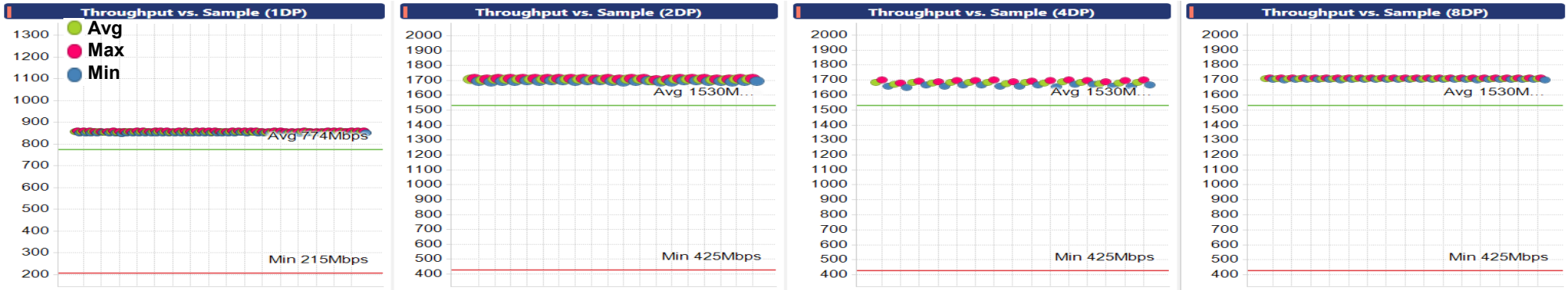
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 300	Initial	860.74	860.5	860	1714.53	1714	1713	1714.38	1713.25	1708	1712.64	1711.75	1711
	EW+RD100K+3month (CT 30C)	856.1	853	848	1706.01	1697.25	1689	1681.5	1670.25	1652	1710.51	1709	1701

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (EW+RD100K+3Months)



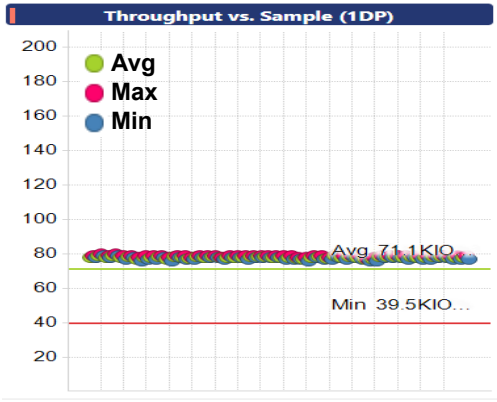
TLC (RR Throughput) – CP8

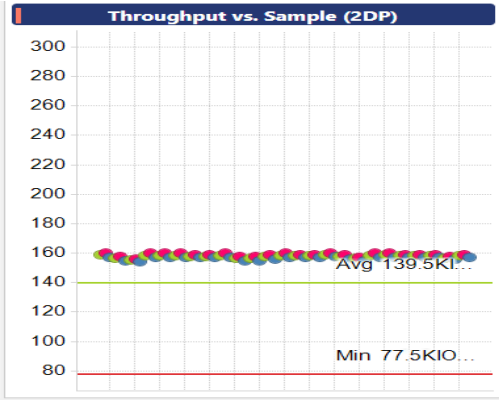
☑ Throughput Test satisfied with checkpoint 8

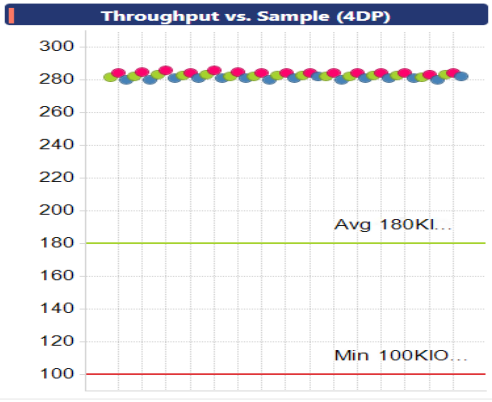
- Throughput Measurement Table

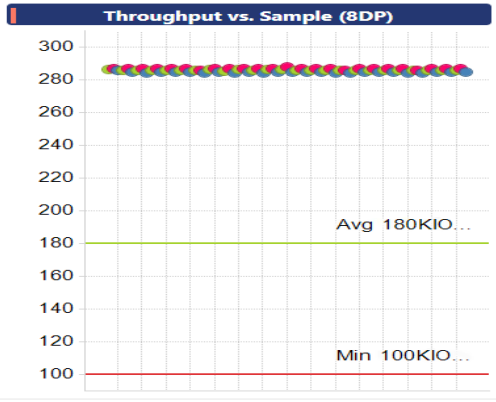
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 300	Initial	78.15	76.75	76	157.79	155.31	154	282.48	281.5	280	285.89	285.25	284
	EW+RD100K+3month (CT 30C)	78.07	76.75	67	157.35	154.44	131	282.31	280.31	258	285.86	285.19	276

- Throughput vs. Sample(PKG) (Initial)

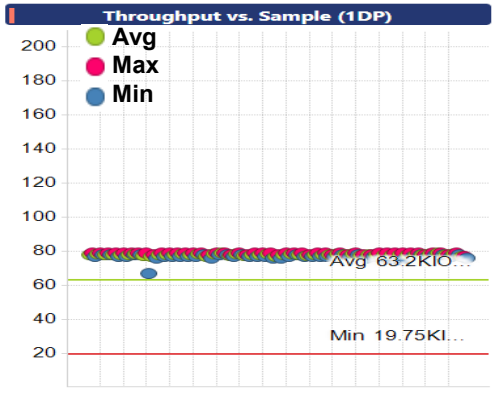


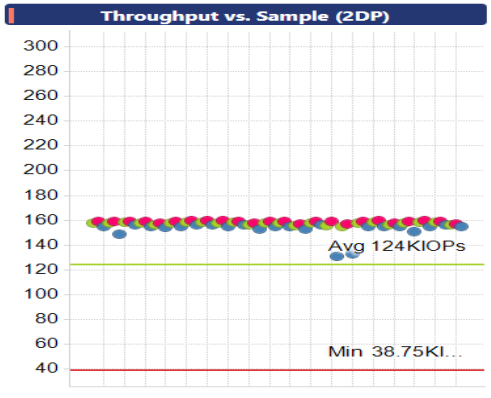


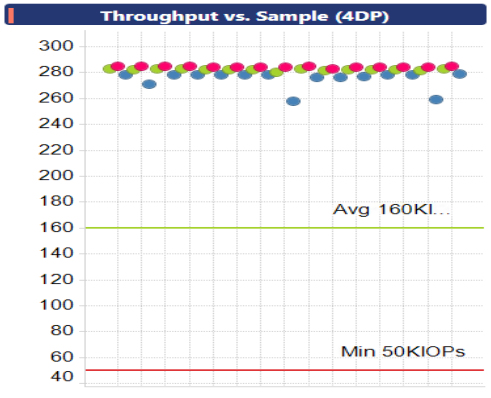


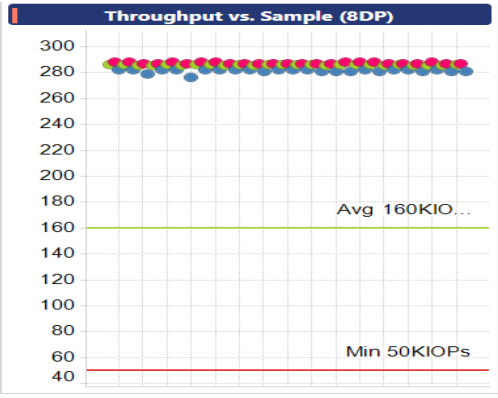


- Throughput vs. Sample(PKG) (EW+RD100K+3Months)









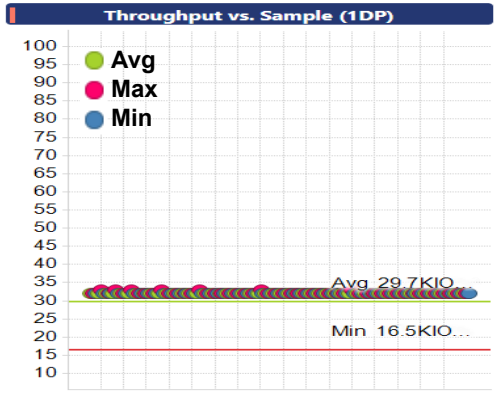
TLC (16K RR Throughput) – CP8

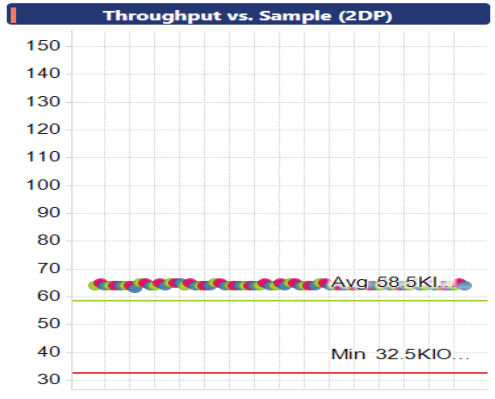
☑ Throughput Test satisfied with checkpoint 8

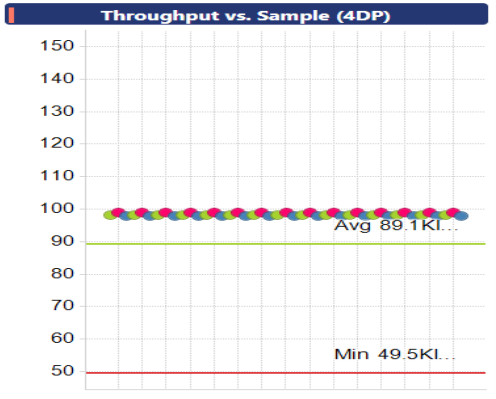
- Throughput Measurement Table

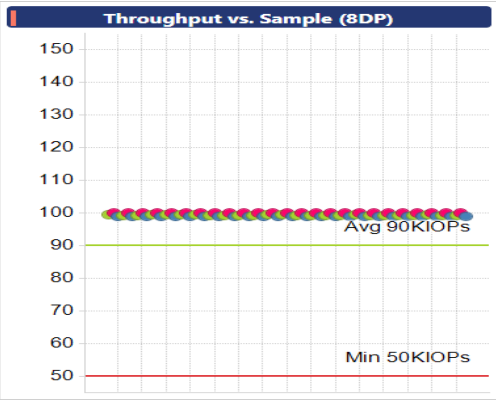
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 300	Initial	32.01	32	32	64.22	63.94	63	98.06	98	98	99.31	99.06	99
	EW+RD100K+3month (CT 30C)	31.99	31.88	30	64.13	63.69	62	97.99	97.81	95	99.17	98.94	98

- Throughput vs. Sample(PKG) (Initial)

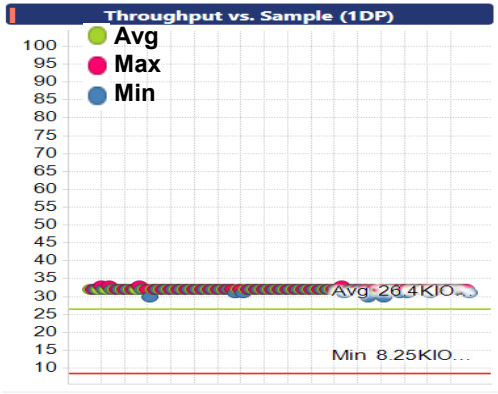


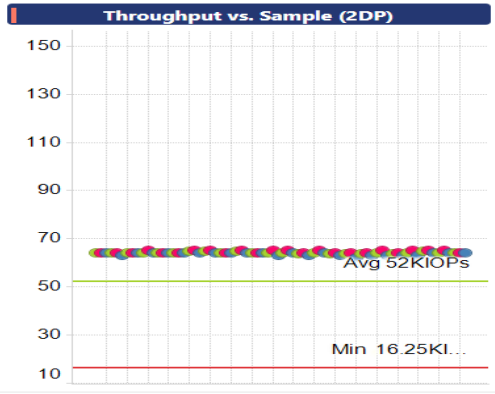


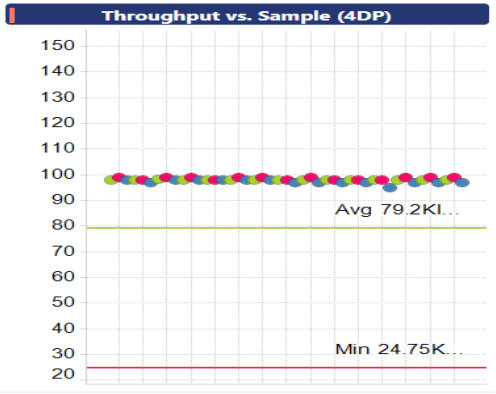


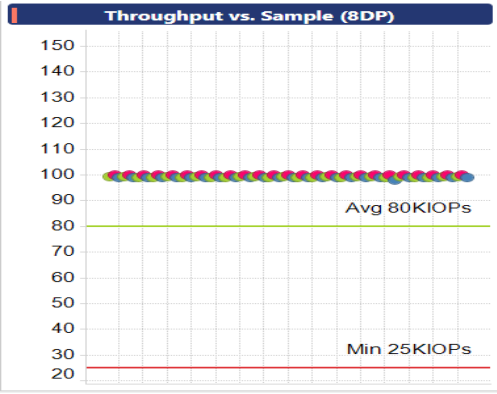


- Throughput vs. Sample(PKG) (EW+RD100K+3Months)





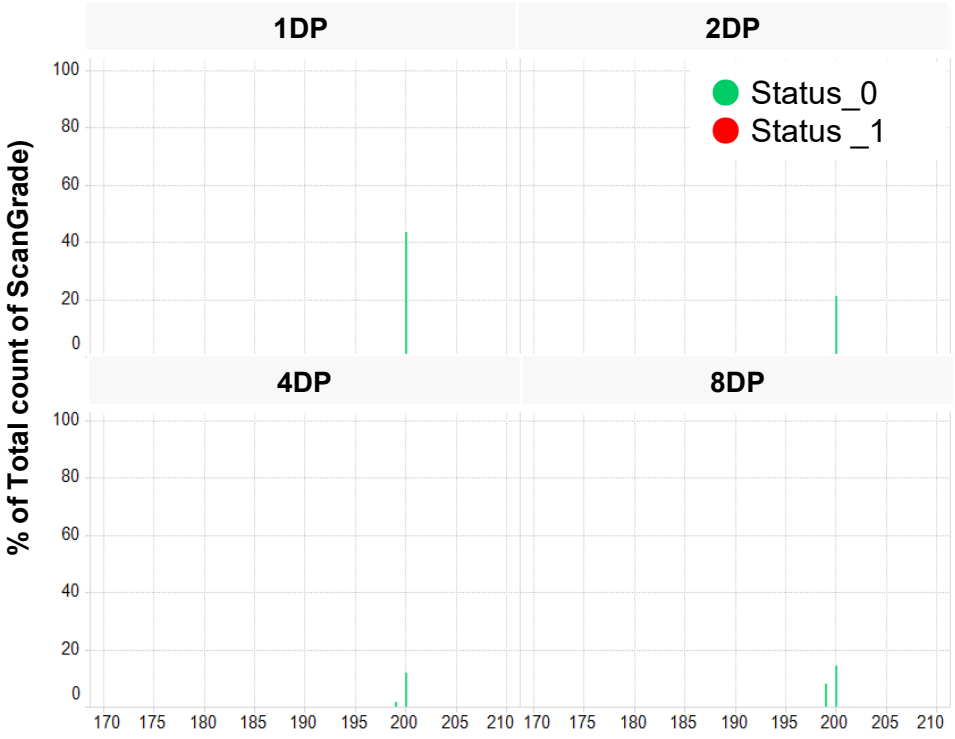




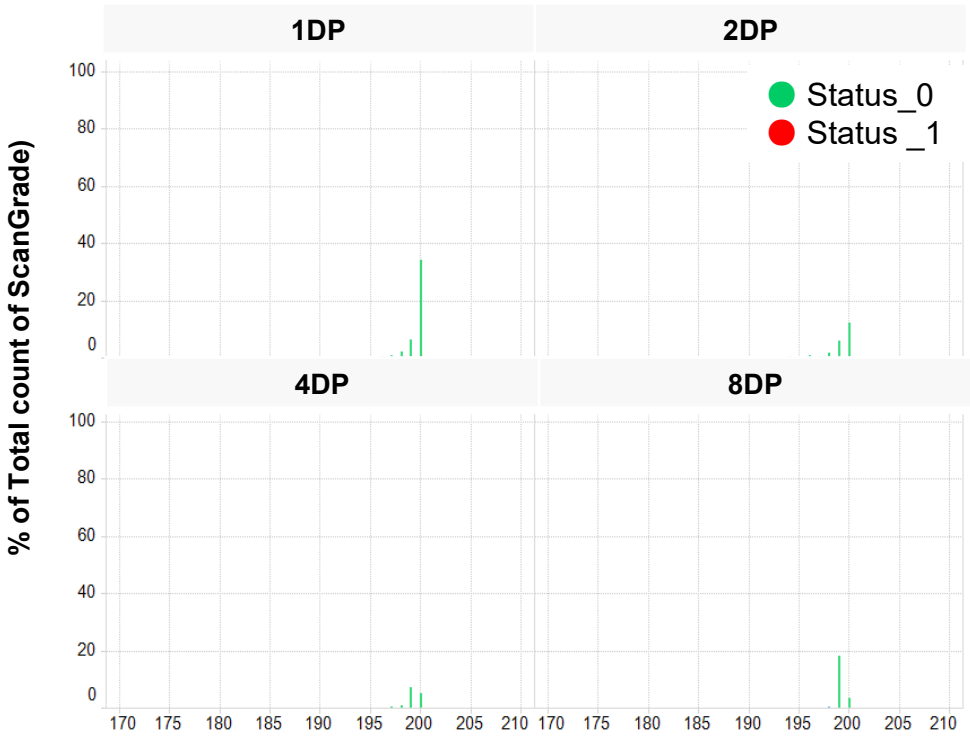
TLC (Read Scan) – CP8

☑ Read Scan satisfied with checkpoint 8

- Read Scan Histogram (EW)



- Read Scan Histogram (EW + RD 100K + 3Months)

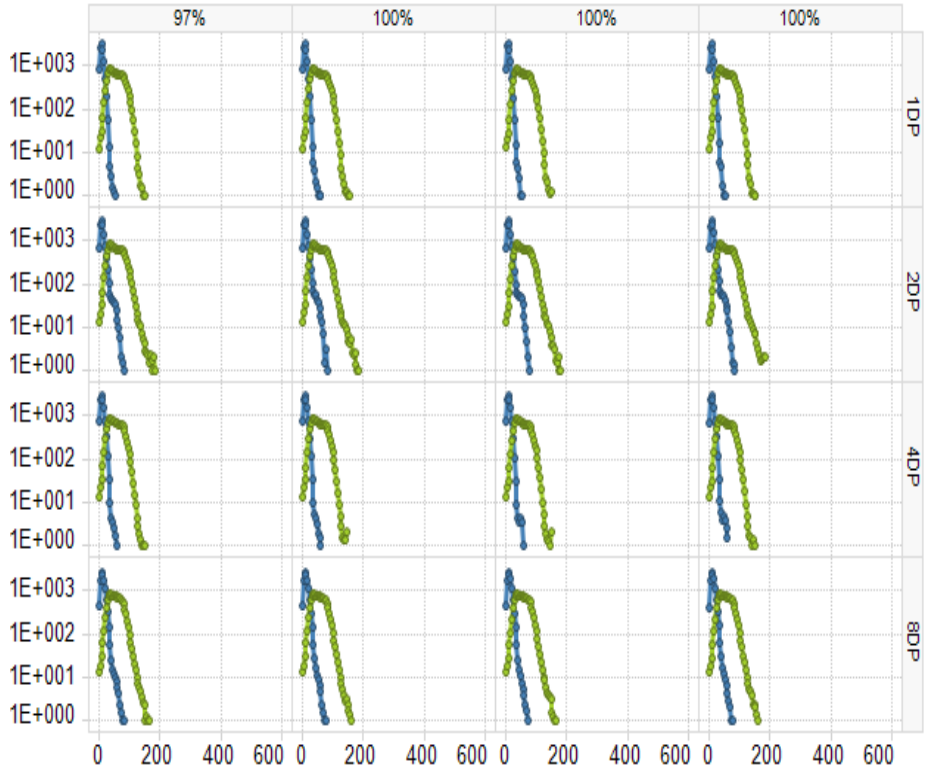


TLC (SOL Latency) – CP8

☑ Read latency satisfied with checkpoint 8

ITEM	Stack	Bin	Apple Spec	EW + Read 100K + 3Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP8 (CT 30'C)	1DP	tR≤160us	TBD	0.999973	0.999939	50.54
		tR≤200us	TBD	0.000002	0.000008	
		tR≤1300us	TBD	0.000027	0.000059	
		tR≤10.5ms	TBD	0.000001	0.000001	
	2DP	tR≤160us	TBD	0.999964	0.999879	50.68
		tR≤200us	TBD	0.000005	0.000078	
		tR≤1300us	TBD	0.000034	0.0001	
		tR≤10.5ms	TBD	0.000001	0.000001	
	4DP	tR≤160us	TBD	0.999955	0.999797	51.53
		tR≤200us	TBD	0.000003	0.000024	
		tR≤1300us	TBD	0.000046	0.000178	
		tR≤10.5ms	TBD	0.000001	0.000001	
	8DP	tR≤160us	TBD	0.999953	0.999792	51.05
		tR≤200us	TBD	0.000004	0.000029	
		tR≤1300us	TBD	0.000051	0.000192	
		tR≤10.5ms	TBD	0.000001	0.000001	

- Indepth Histogram (EW + RD 100K + 3months)



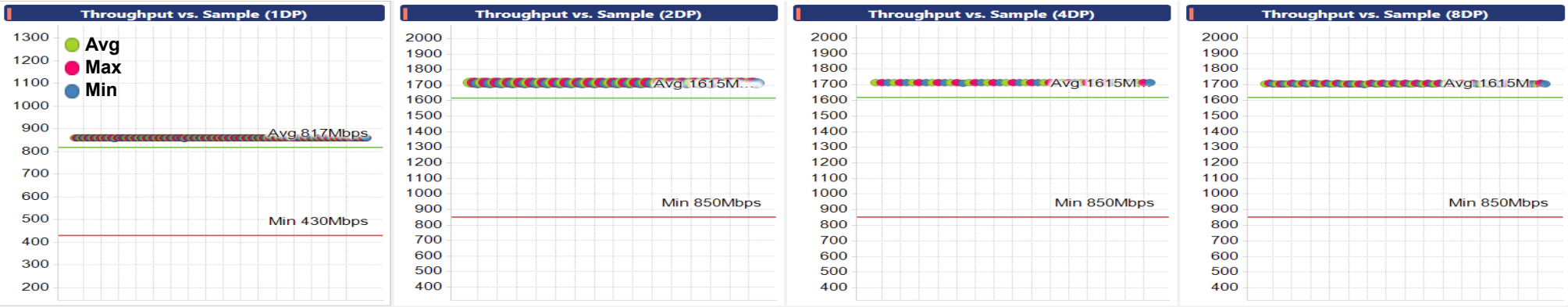
TLC (Sequential Throughput) – CP9A

☑ Throughput Test satisfied with checkpoint 9A

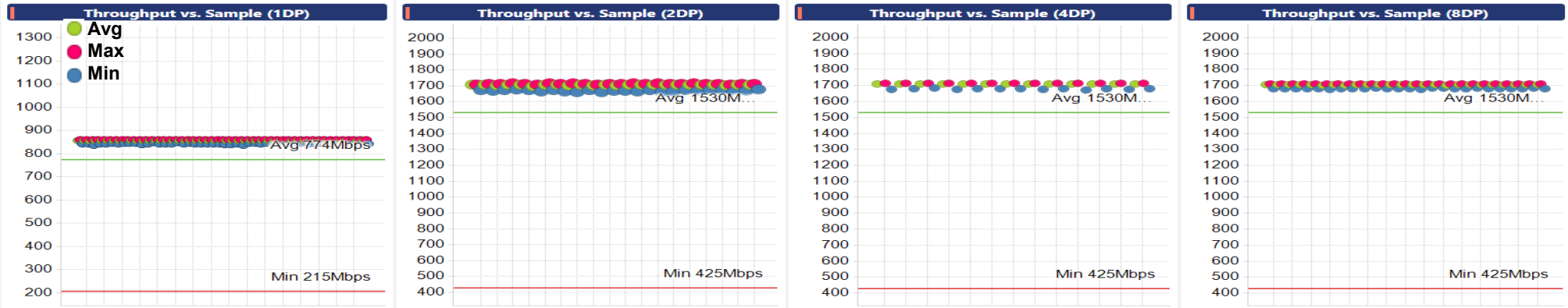
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	860.88	860.44	858	1714.91	1714.25	1711	1714.89	1714.19	1710	1706.56	1705.44	1703
	EW+RD100K+1month (CT 30C)	857.2	855.13	836	1706.36	1700.38	1661	1708.56	1707.56	1671	1704.94	1703	1676

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



TLC (RC Throughput) – CP9A

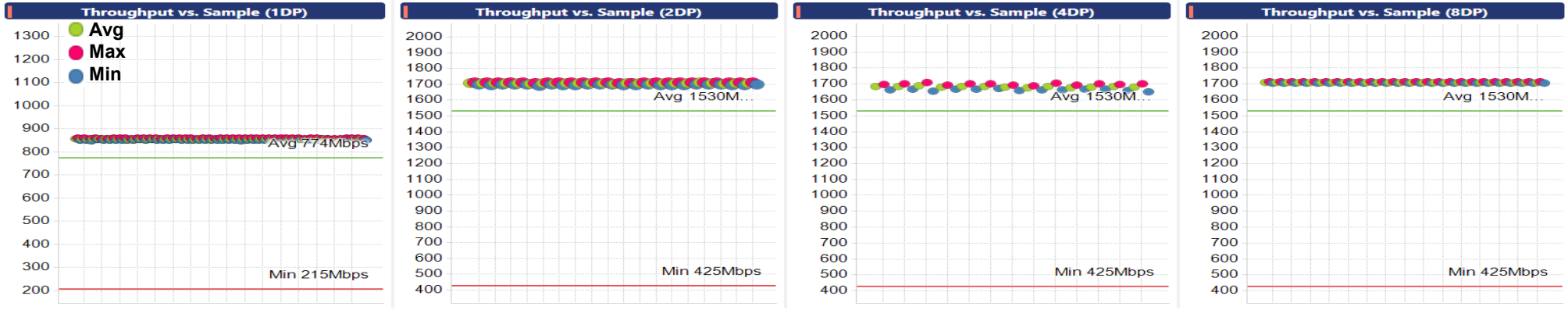
☑ Throughput Test satisfied with checkpoint 9A

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	860.96	860.5	860	1714.96	1714.25	1714	1714.84	1714	1714	1712.77	1712	1712
	EW+RD100K+1month (CT 30C)	856.48	854	848	1707.54	1701.75	1693	1682.71	1675	1651	1710.61	1709.25	1704

- Throughput vs. Sample(PKG) (Initial)

- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



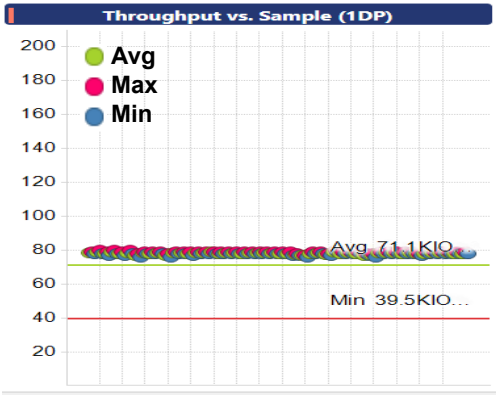
TLC (RR Throughput) – CP9A

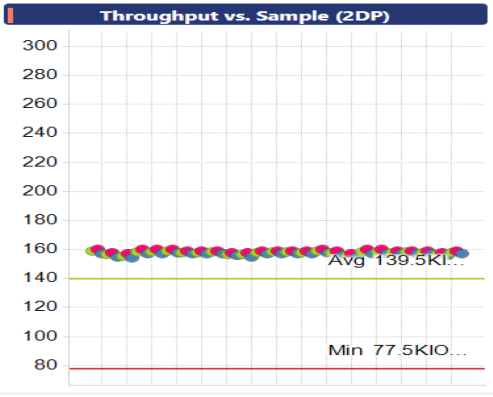
☑ Throughput Test satisfied with checkpoint 9A

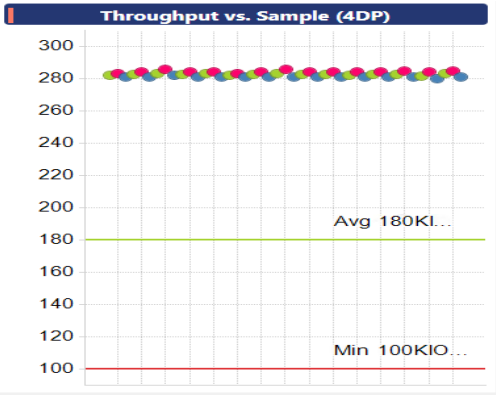
- Throughput Measurement Table

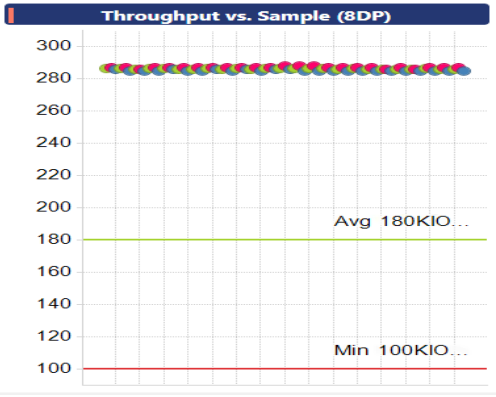
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	78.19	76.88	76	157.72	155.5	154	282.59	281.63	280	286.01	285.44	285
	EW+RD100K+1month (CT 30C)	78.06	76.75	66	157.67	155.94	150	282.55	281.75	277	285.92	284.88	272

- Throughput vs. Sample(PKG) (Initial)

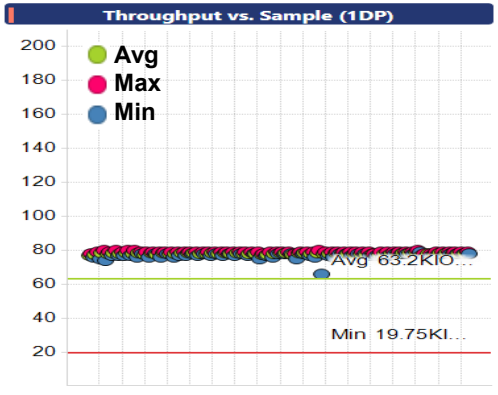


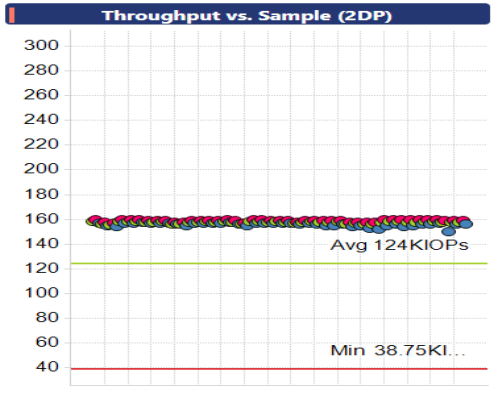


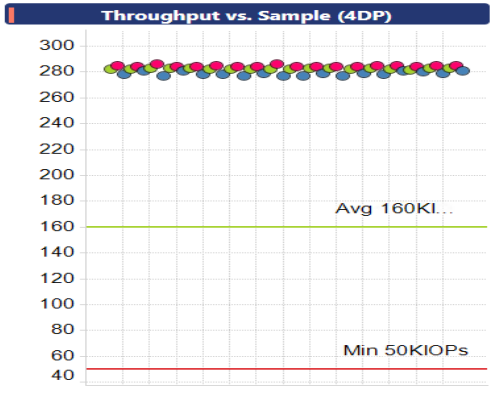


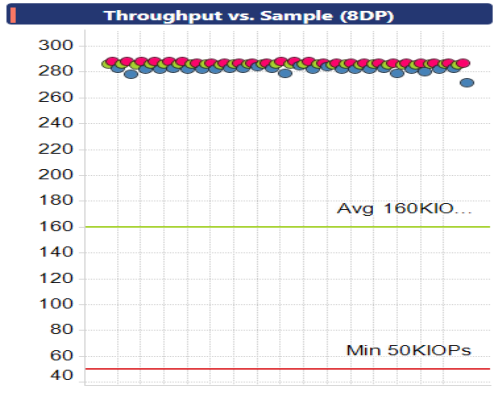


- Throughput vs. Sample(PKG) (EW+RD100K+1Month)









TLC (16K RR Throughput) – CP9A

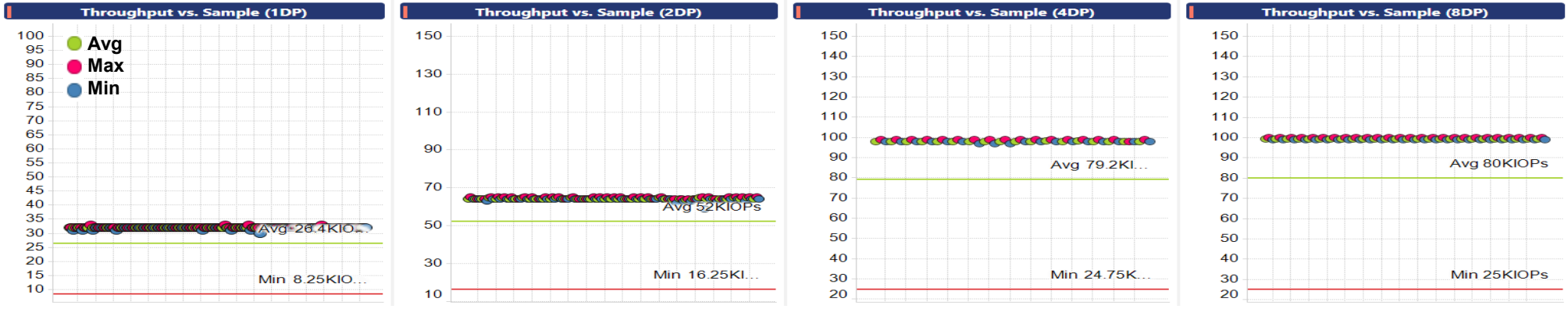
☑ Throughput Test satisfied with checkpoint 9A

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	32	32	32	64.25	63.94	63	98.05	98	98	99.34	99.13	99
	EW+RD100K+1month (CT 30C)	31.99	31.88	30	64.18	63.81	59	98.06	97.94	97	99.37	99.19	99

- Throughput vs. Sample(PKG) (Initial)

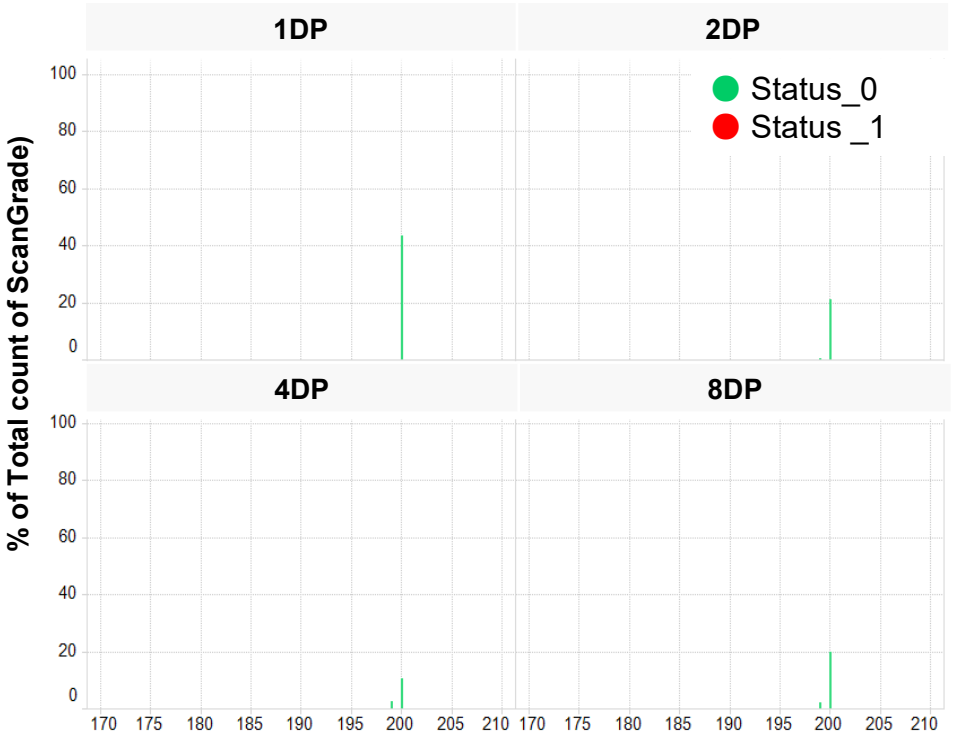
- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



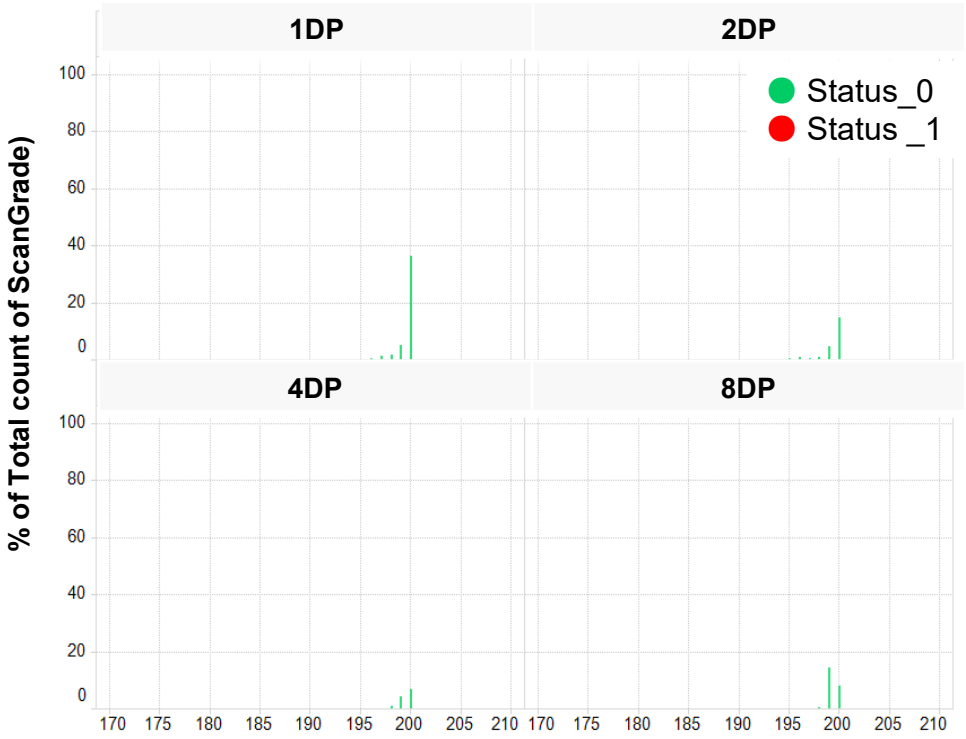
TLC (Read Scan) – CP9A

☑ Read Scan satisfied with checkpoint 9A

● Read Scan Histogram (EW)



● Read Scan Histogram (EW + RD 100K + 1Month)

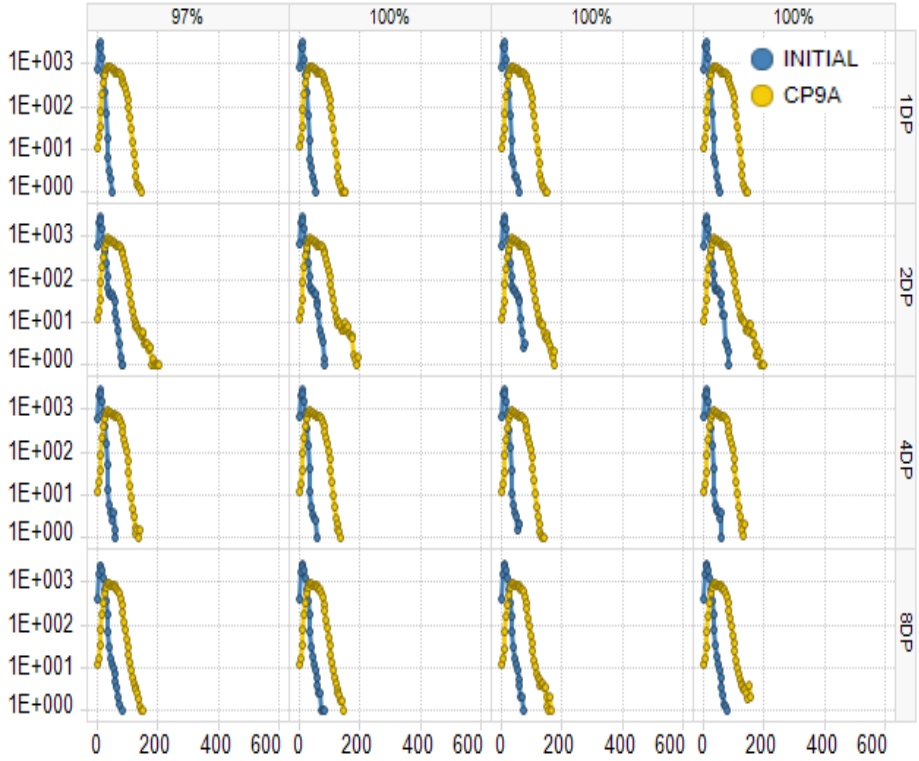


TLC (EOL Latency) – CP9A

☑ Read latency satisfied with checkpoint 9A

ITEM	Stack	Bin	Apple Spec	EW + Read 100K + 1Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP9A (CT 30'C)	1DP	tR≤160us	TBD	0.999978	0.999951	50.54
		tR≤200us	TBD	0.000003	0.000008	
		tR≤1300us	TBD	0.000021	0.000048	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	0.999973	0.999906	50.58
		tR≤200us	TBD	0.000006	0.000042	
		tR≤1300us	TBD	0.000026	0.00009	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	0.999975	0.999939	51.29
		tR≤200us	TBD	0.000005	0.000025	
		tR≤1300us	TBD	0.000024	0.000059	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	0.99998	0.999887	50.93
		tR≤200us	TBD	0.000002	0.000005	
		tR≤1300us	TBD	0.00002	0.00011	
		tR≤10.5ms	TBD	0.000001	0.000001	

● Indepth Histogram (EW + RD 100K + 1month)



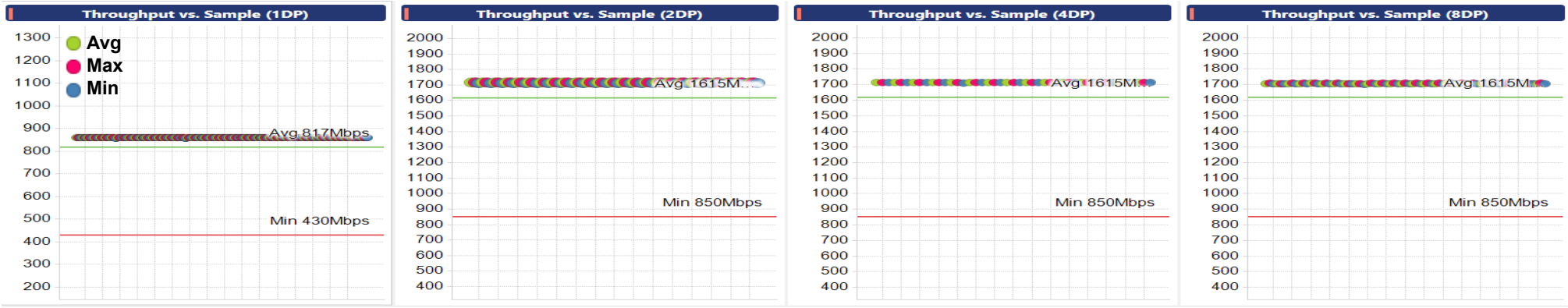
TLC (Sequential Throughput) – CP9C

☑ Throughput Test satisfied with checkpoint 9C

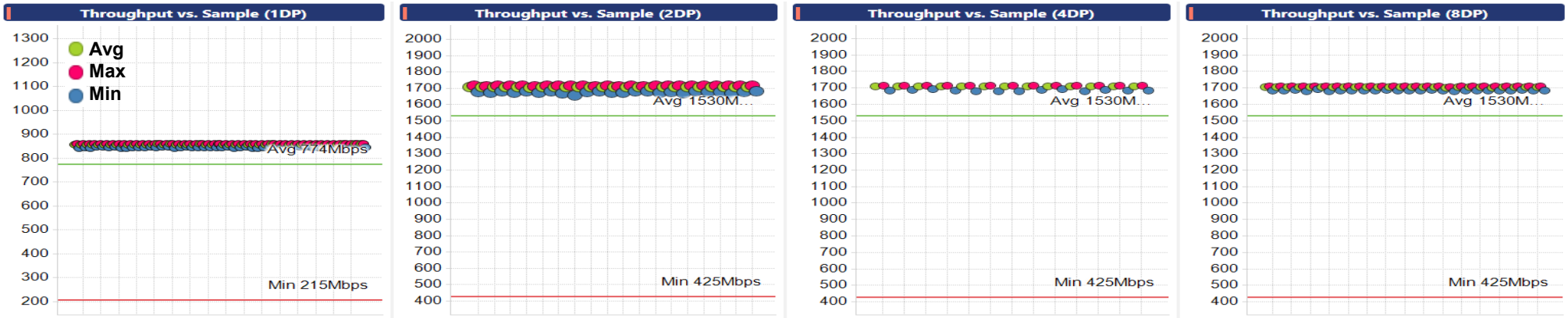
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	860.88	860.44	858	1714.91	1714.25	1711	1714.89	1714.19	1710	1706.56	1705.44	1703
	EW+RD100K+1month (CT 30C)	858.1	856.31	838	1708.36	1704	1656	1709.52	1708.13	1678	1704.84	1702.25	1680

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



TLC (RC Throughput) – CP9C

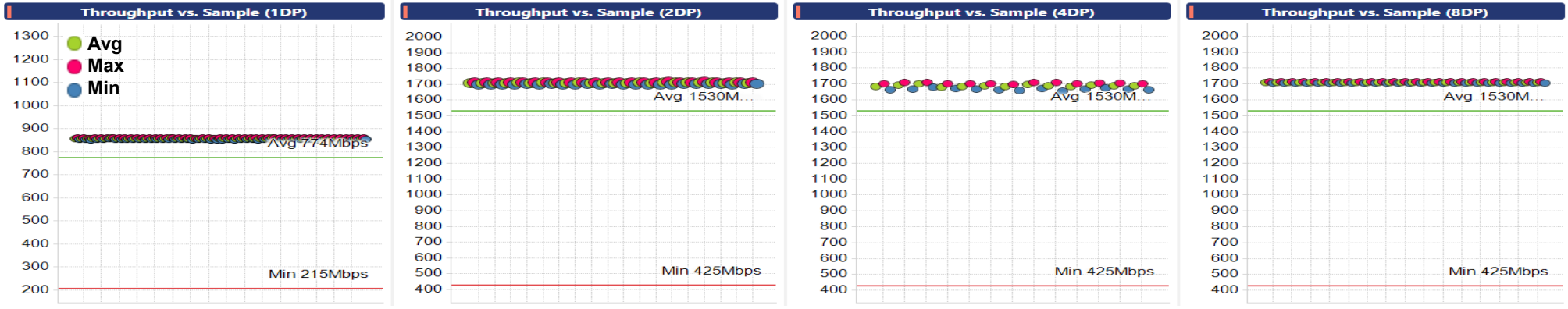
☑ Throughput Test satisfied with checkpoint 9C

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	860.96	860.5	860	1714.96	1714.25	1714	1714.84	1714	1714	1712.77	1712	1712
	EW+RD100K+1month (CT 30C)	857.62	855.75	850	1709.55	1706.75	1698	1688.76	1677	1654	1710.71	1709.5	1704

- Throughput vs. Sample(PKG) (Initial)

- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



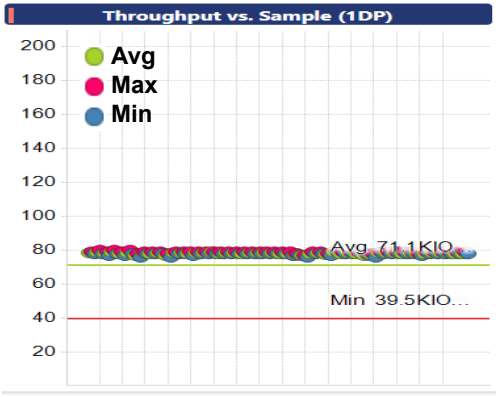
TLC (RR Throughput) – CP9C

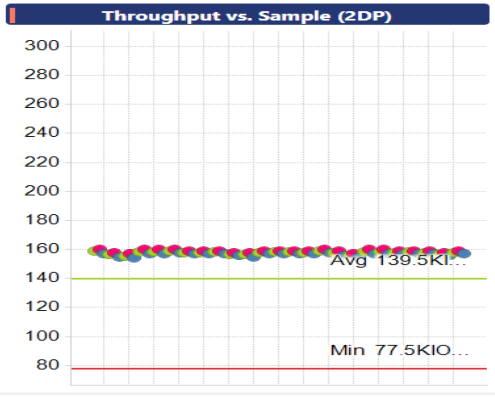
☑ Throughput Test satisfied with checkpoint 9C

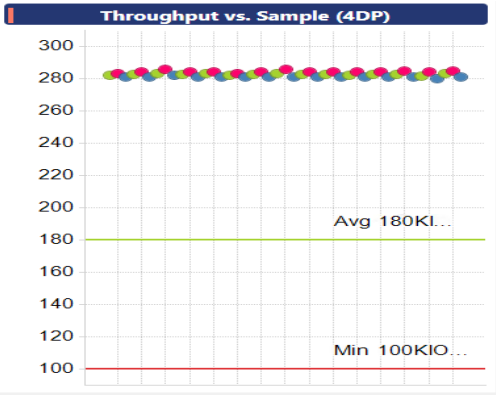
- Throughput Measurement Table

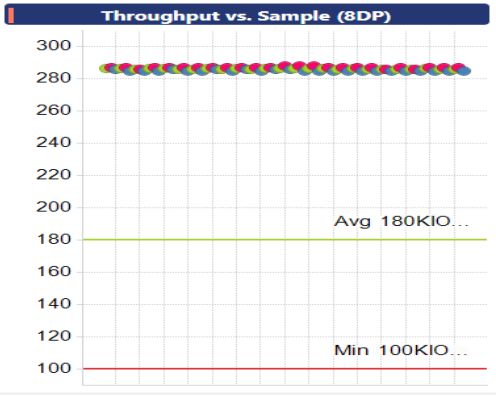
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	78.19	76.88	76	157.72	155.5	154	282.59	281.63	280	286.01	285.44	285
	EW+RD100K+1month (CT 30C)	78.15	76.88	71	157.78	156	153	282.75	282.06	277	286	285.25	280

- Throughput vs. Sample(PKG) (Initial)

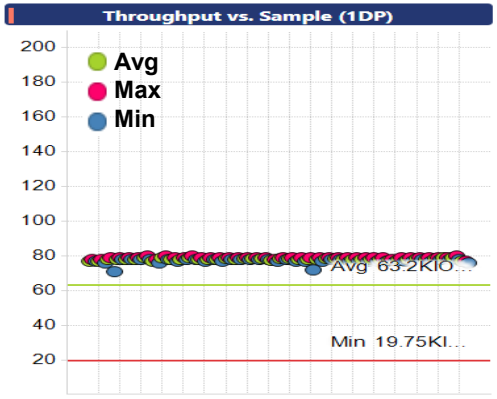


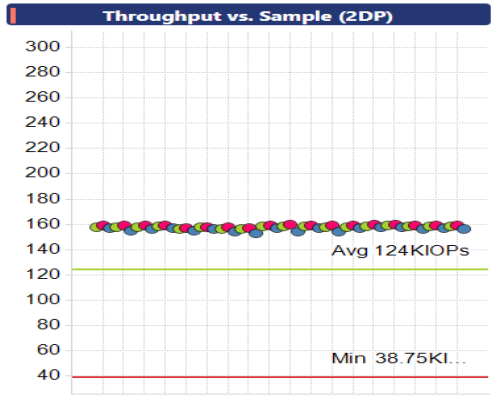


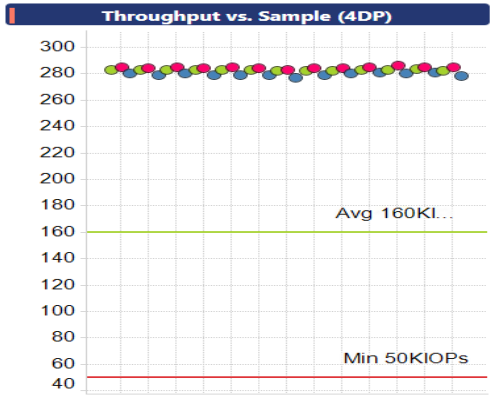


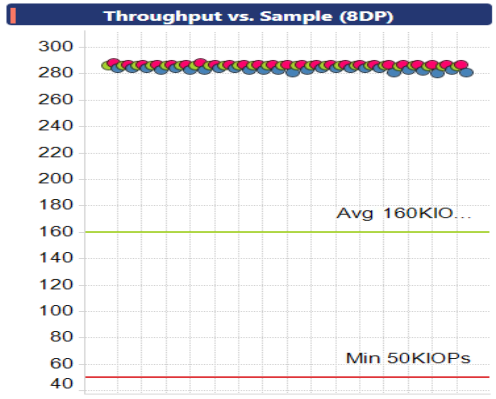


- Throughput vs. Sample(PKG) (EW+RD100K+1Month)









TLC (16K RR Throughput) – CP9C

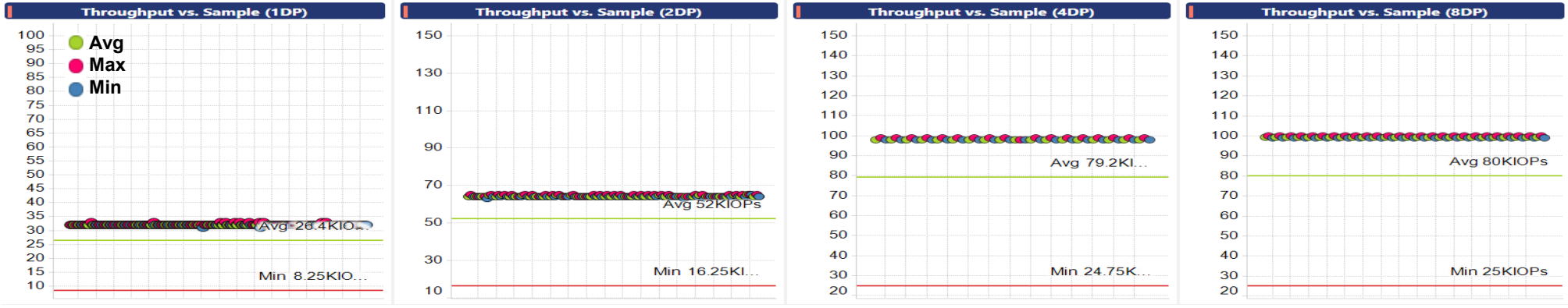
☑ Throughput Test satisfied with checkpoint 9C

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	32	32	32	64.25	63.94	63	98.05	98	98	99.34	99.13	99
	EW+RD100K+1month (CT 30C)	32.01	31.94	31	64.24	63.94	63	98.05	98	98	99.34	99.13	99

- Throughput vs. Sample(PKG) (Initial)

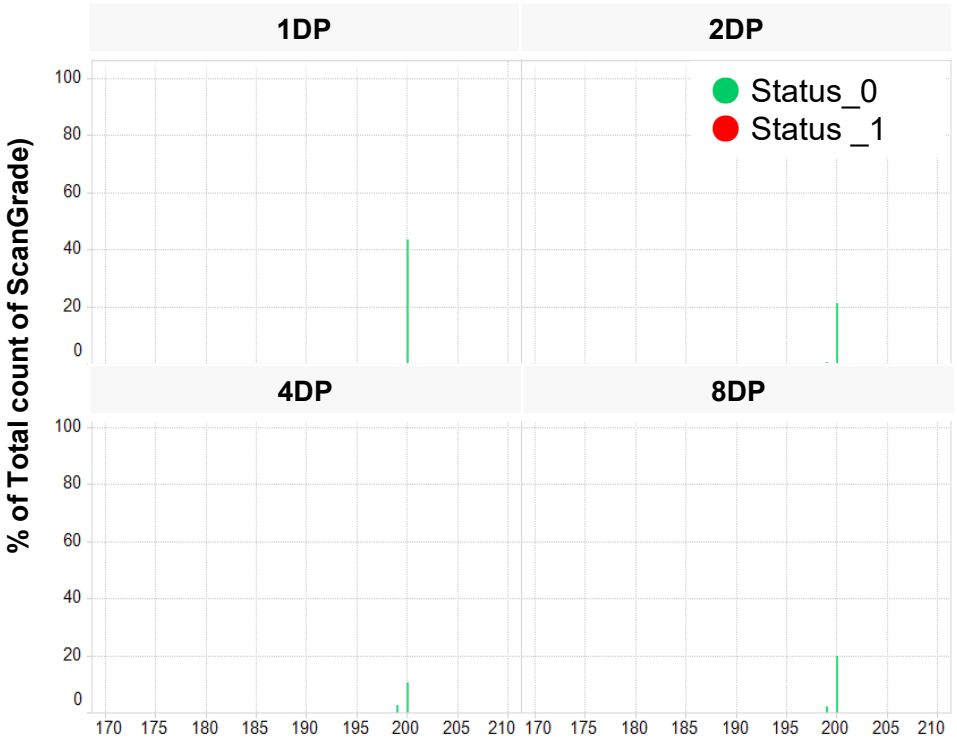
- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



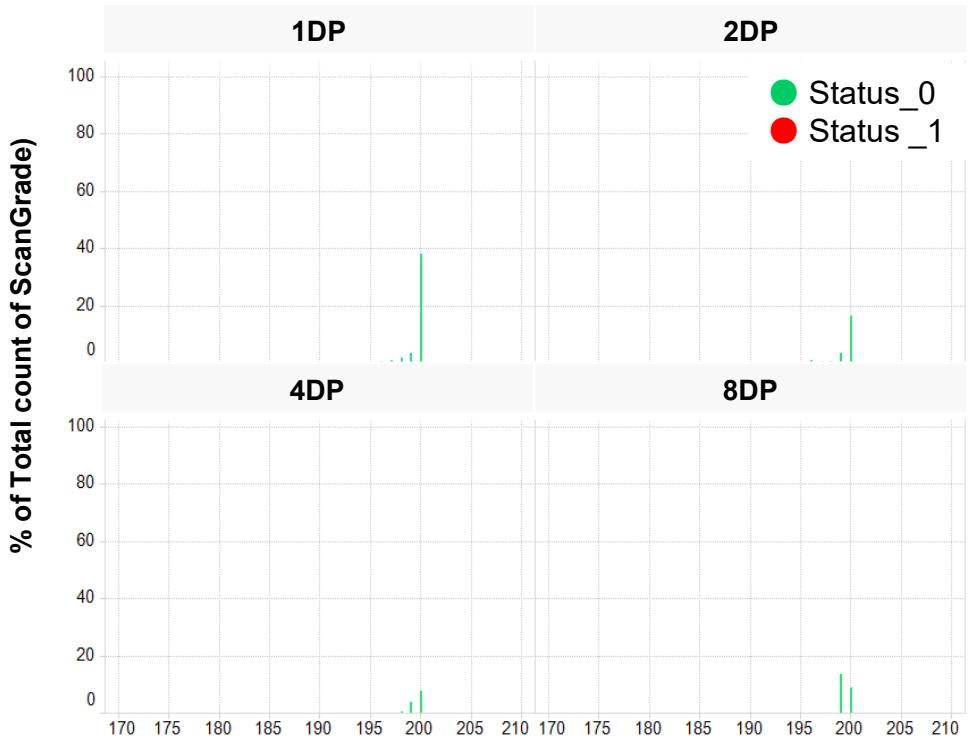
TLC (Read Scan) – CP9C

☑ Read Scan satisfied with checkpoint 9C

● Read Scan Histogram (EW)



● Read Scan Histogram (EW + RD 100K + 1Month)

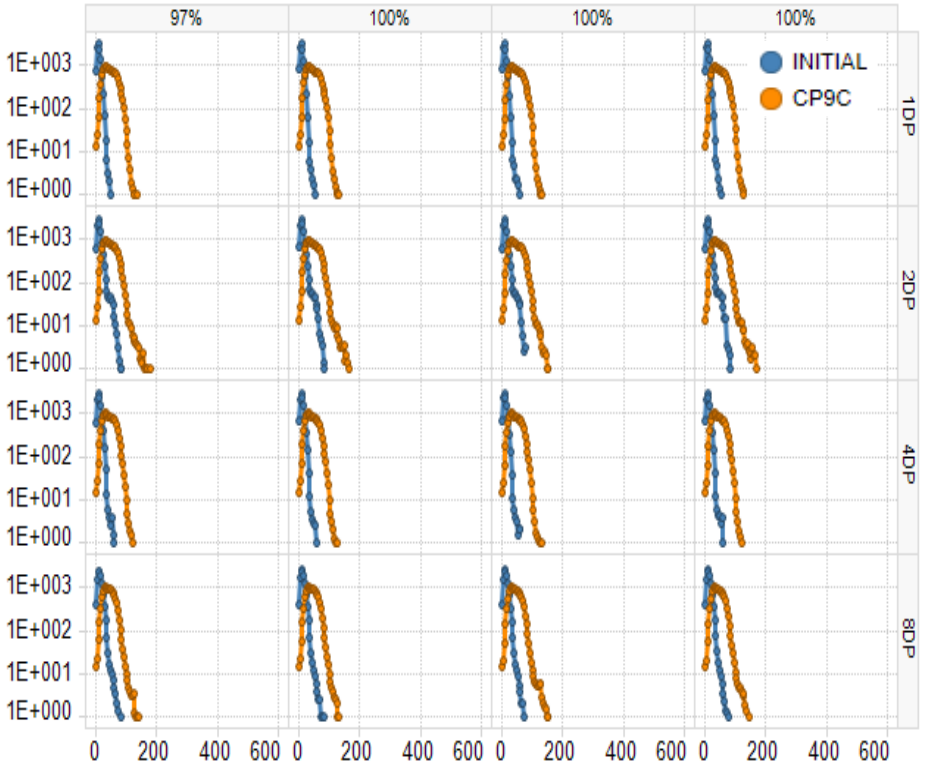


TLC (EOL Latency) – CP9C

☑ Read latency satisfied with checkpoint 9C

ITEM	Stack	Bin	Apple Spec	EW + Read 100K + 1Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP9C (CT 30'C)	1DP	tR≤160us	TBD	0.999989	0.999966	50.22
		tR≤200us	TBD	0.000002	0.000003	
		tR≤1300us	TBD	0.000011	0.000031	
		tR≤10.5ms	TBD	0.000001	0.000001	
	2DP	tR≤160us	TBD	0.999985	0.999936	50.40
		tR≤200us	TBD	0.000002	0.000012	
		tR≤1300us	TBD	0.000015	0.000063	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	0.999987	0.999971	51.12
		tR≤200us	TBD	0.000001	0.000001	
		tR≤1300us	TBD	0.000013	0.000028	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	0.999988	0.99995	50.76
		tR≤200us	TBD	0.000001	0.000002	
		tR≤1300us	TBD	0.000012	0.000049	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram (EW + RD 100K + 1month)

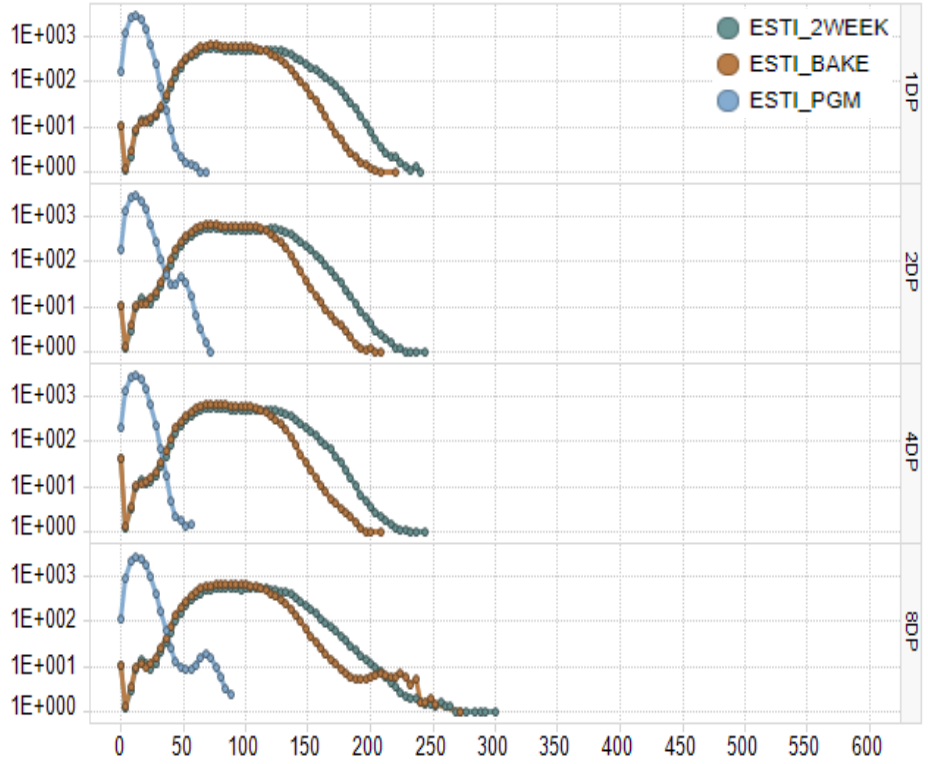


TLC (Erase Tolerance) – CP10

☑ Reliability Check points satisfied with checkpoint 10

Erase Tolerance					
Test Result			PASS		
Correctness Fail Bit Level			PGM	HTDR 12Months	HTDR 12Months +2Week
1DP	PGM	Max	68	220	240
		Median	20	84	92
2DP	PGM	Max	72	208	244
		Median	20	80	88
4DP	PGM	Max	56	208	244
		Median	20	80	88
8DP	PGM	Max	88	272	300
		Median	20	84	92

● Indepth Histogram (PGM + 12Months+2week)

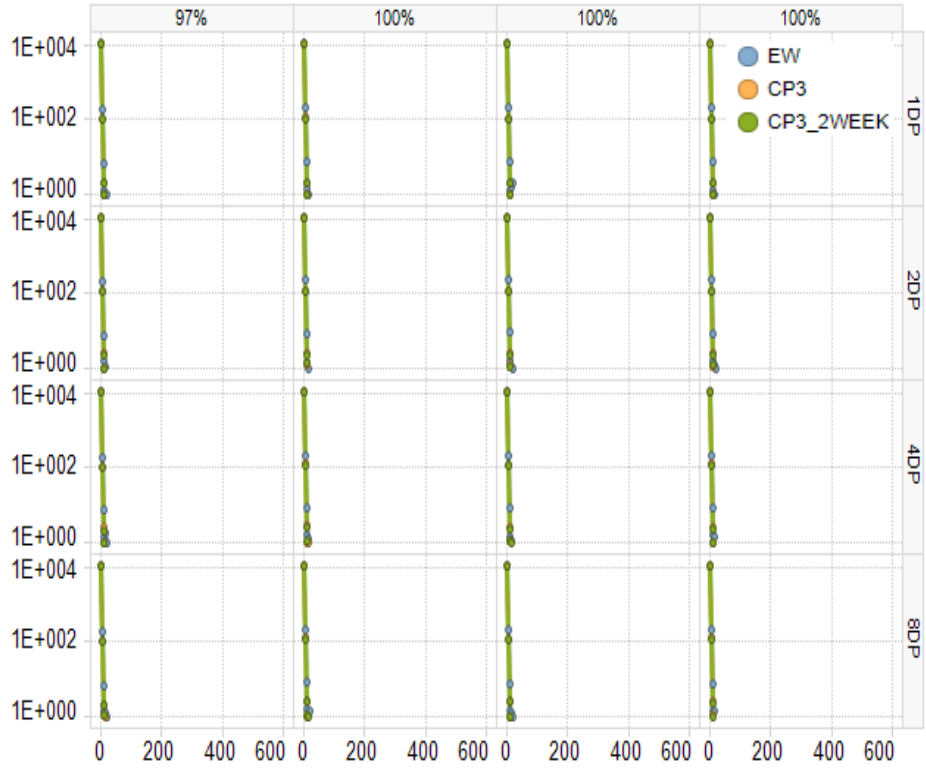


SLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3

SLC Checkpoint 3 (Data Retention)														
Test Result			PASS											
Correctness Fail Bit Level (Indepth DEF)			EW				HTDR 1Y				HTDR 1Y+2week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 100K	Max	20	16	20	16	12	12	12	12	12	12	12	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
2DP	EW 100K	Max	16	16	20	20	12	12	12	12	12	12	12	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
4DP	EW 100K	Max	20	16	16	16	12	16	12	12	12	12	16	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
8DP	EW 100K	Max	20	20	20	16	16	12	12	12	12	16	12	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4

● Indepth Histogram (EW + HTDR 1Yr + 2Week)

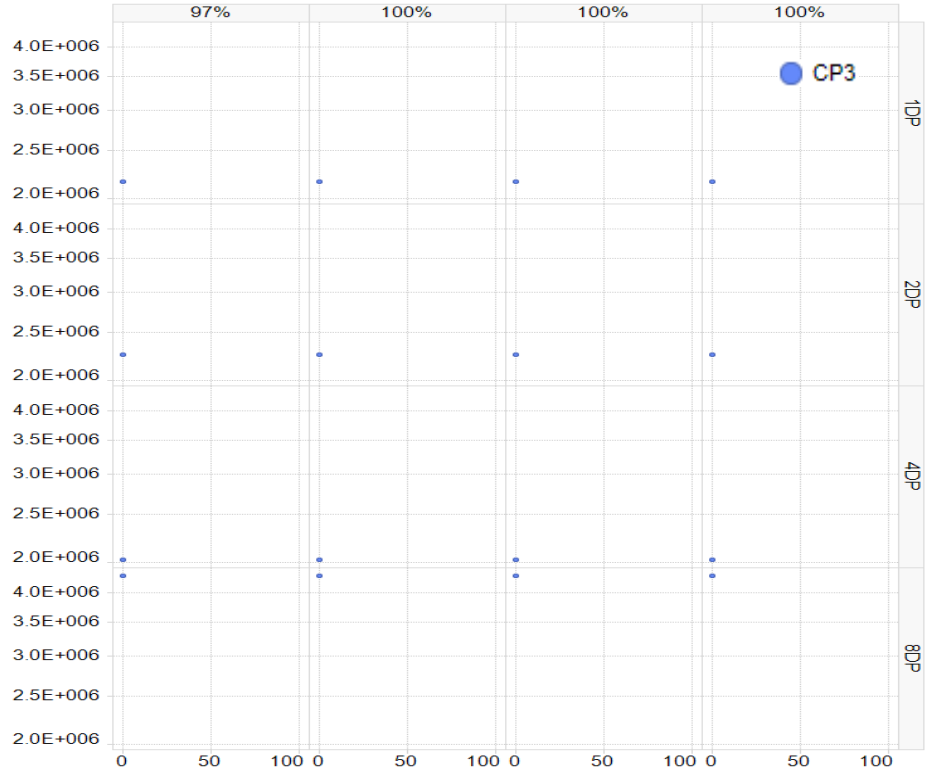


SLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3

SLC Checkpoint 3 (Data Retention)						
Test Result			PASS			
Correctness Fail Bit Level (Hard Error)			HTDR 1Yr			
			97%	100%	100%	100%
1DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
2DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
4DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
8DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0

● Hard Error Histogram (EW + HTDR 1Yr)

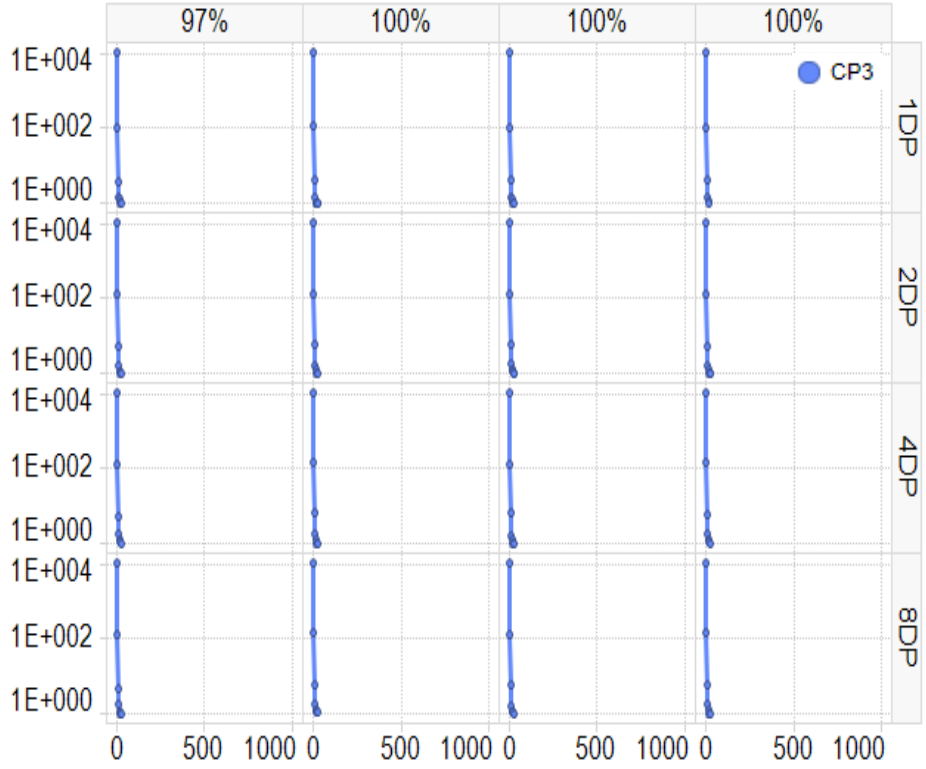


SLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3

SLC Checkpoint 3 (Data Retention)						
Test Result			PASS			
Correctness Fail Bit Level (Indepth ADSP)			HTDR 1Yr			
			97%	100%	100%	100%
1DP	EW 100K	Max	24	28	24	20
		Median	4	4	4	4
2DP	EW 100K	Max	28	24	28	28
		Median	4	4	4	4
4DP	EW 100K	Max	24	24	24	24
		Median	4	4	4	4
8DP	EW 100K	Max	24	24	24	24
		Median	4	4	4	4

● Indepth Histogram_ADSP (EW + HTDR 1Yr)



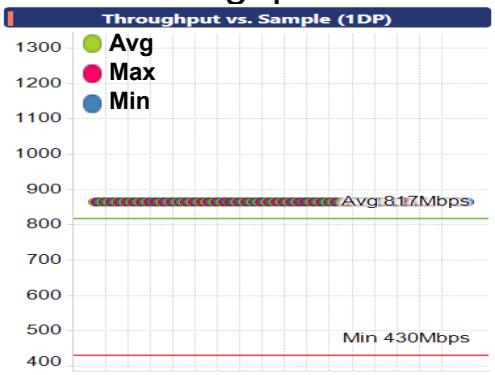
SLC (Sequential Throughput) – CP11

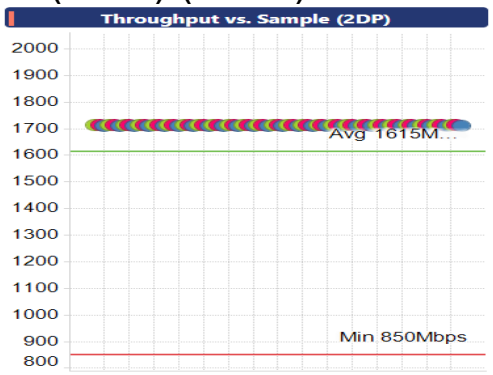
☑ Throughput Test satisfied with checkpoint 11

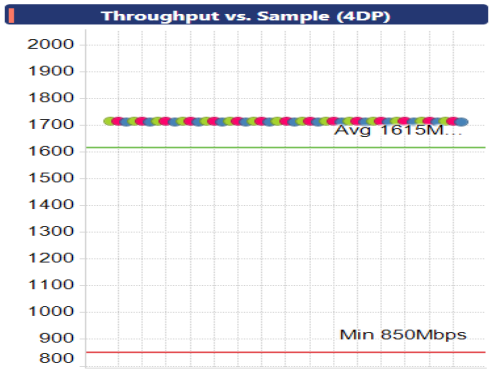
- Throughput Measurement Table

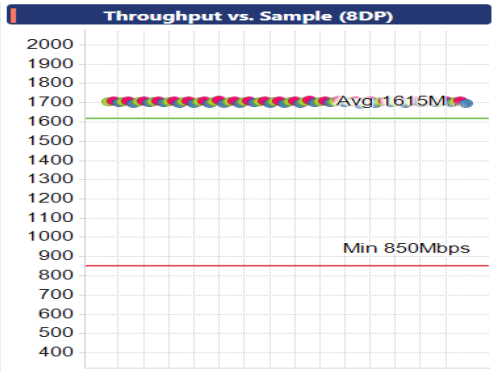
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	864.94	864.94	864	1713.88	1713.88	1712	1714.6	1714.17	1713	1704.53	1702.63	1695
	EW+RD100K+1month (CT 30C)	864.81	864	864	1714	1714	1714	1714.59	1714.33	1714	1704.69	1702.67	1698

- Throughput vs. Sample(PKG) (Initial)

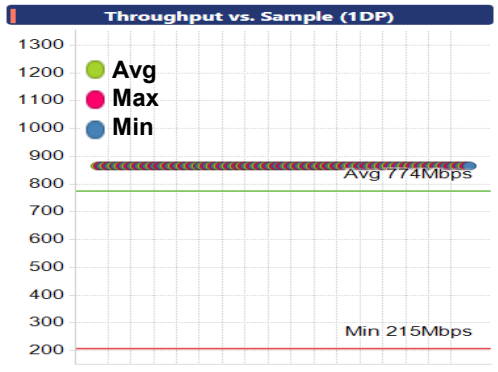


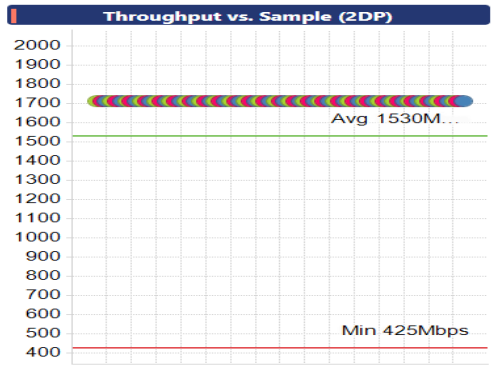


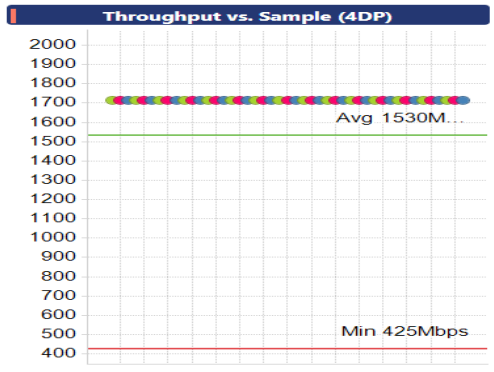


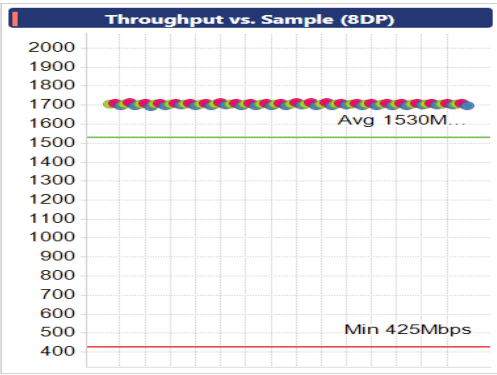


- Throughput vs. Sample(PKG) (EW+RD100K+1month)









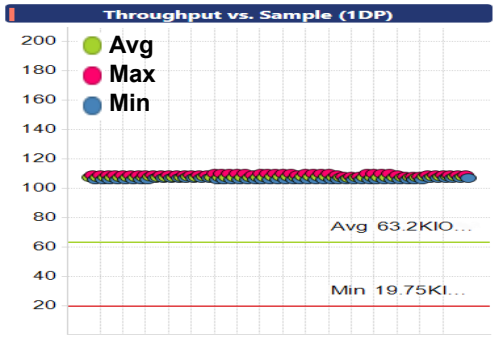
SLC (RR Throughput) – CP11

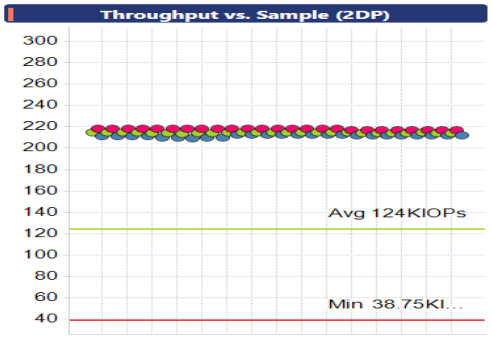
☑ Throughput Test satisfied with checkpoint 11

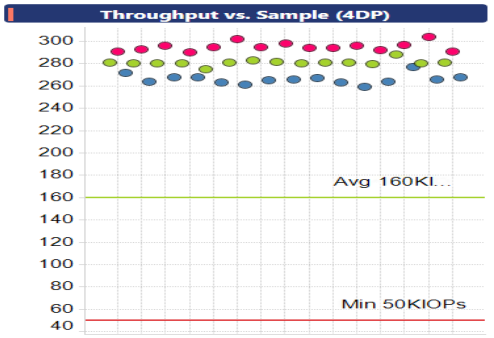
- Throughput Measurement Table

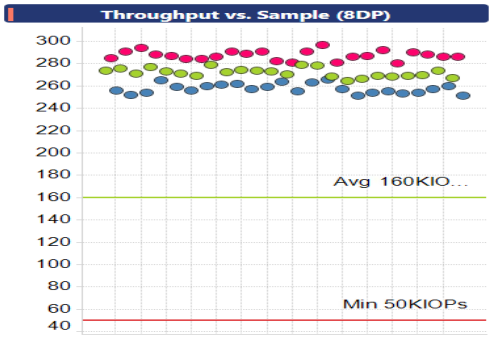
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	107.69	106.81	106	214.48	213.13	209	280.82	272.42	259	272	262.88	251
	EW+RD100K+1month (CT 30C)	107.86	107	106	214.32	213	210	280.59	274.89	257	273.78	264.83	257

- Throughput vs. Sample(PKG) (Initial)

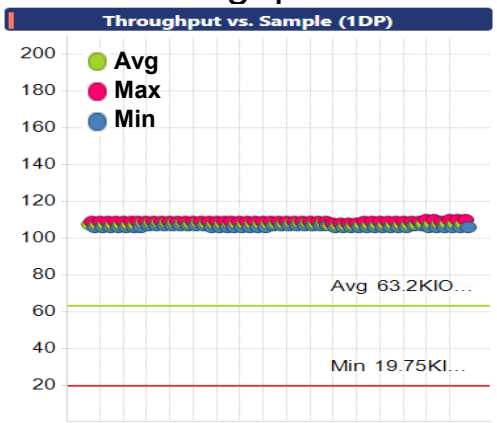


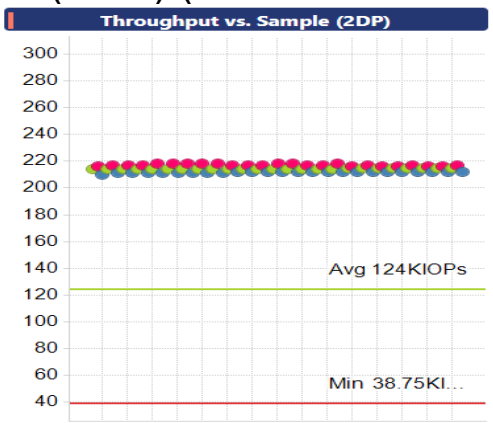


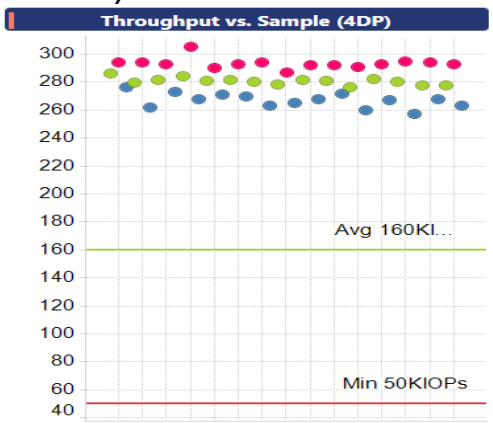


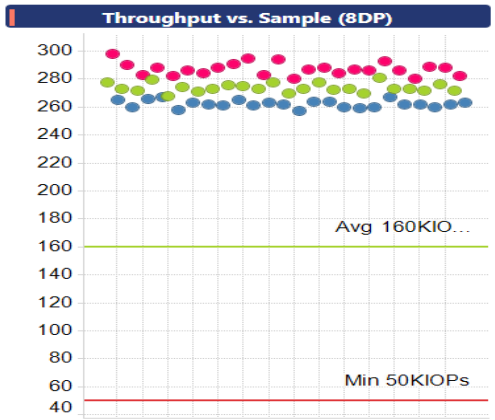


- Throughput vs. Sample(PKG) (EW+RD100K+1month)







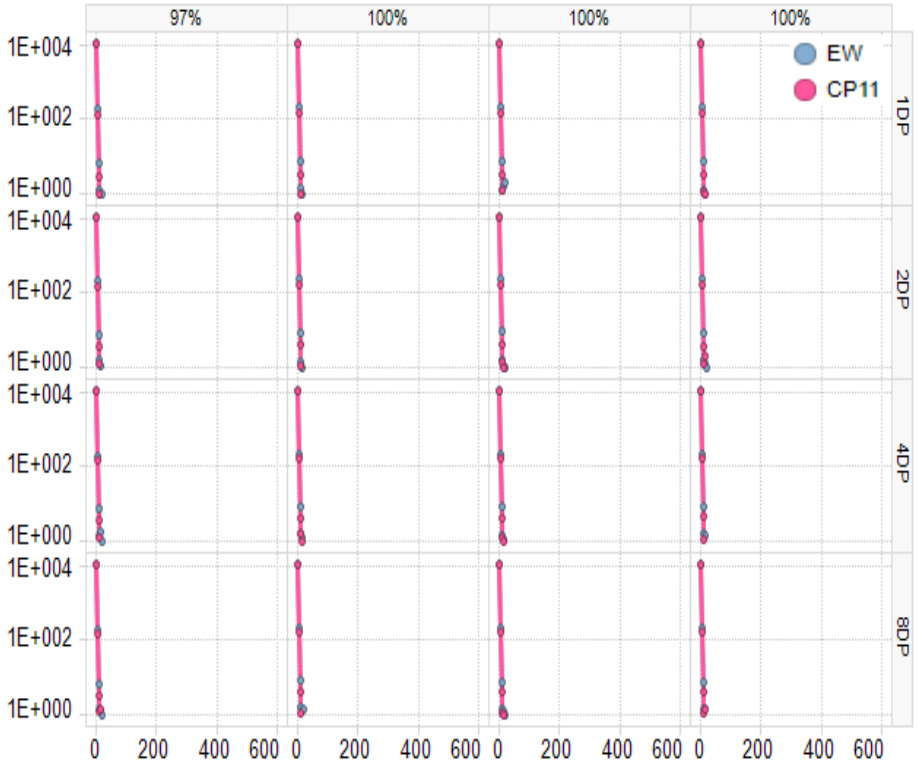


SLC (EOL Latency) – CP11

☑ Read latency satisfied with checkpoint 11

ITEM	Stack	EW	Bin	Apple Spec	EW + Read 100K + 1Month		
					Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP11 (CT 60'C)	1DP	100K	tR≤160us	TBD	1	1	30.08
	2DP	100K	tR≤160us	TBD	1	1	30.08
	4DP	100K	tR≤160us	TBD	1	1	31.02
	8DP	100K	tR≤160us	TBD	1	1	30.81

● Indepth Histogram (EW + 1Month)

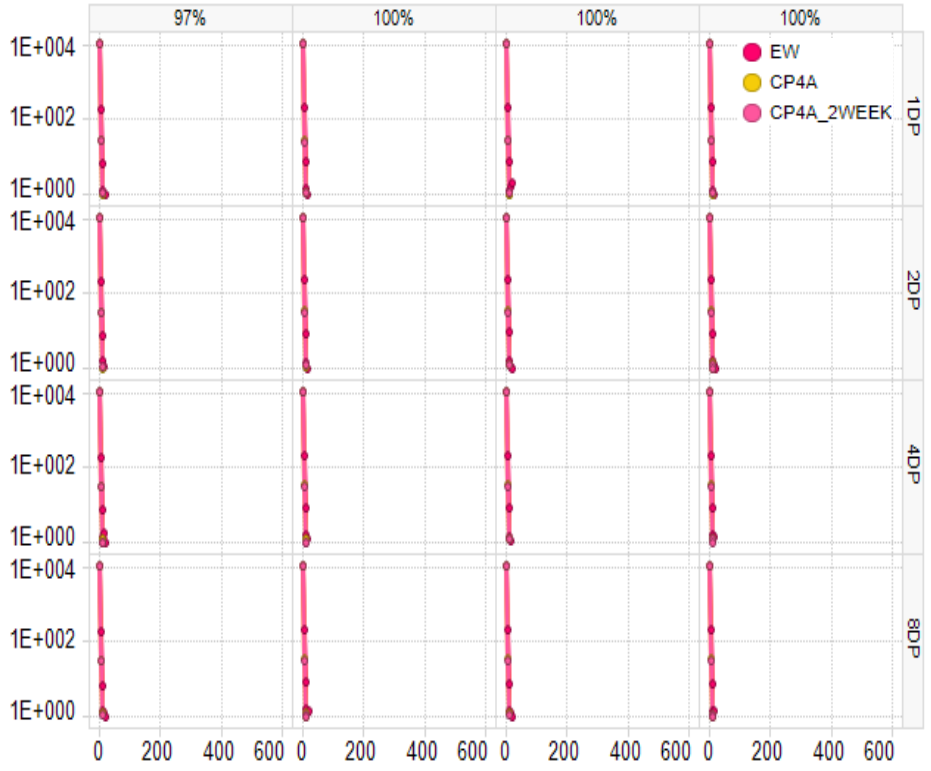


SLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A.

SLC Checkpoint 4A (X-Temp)														
Test Result			PASS											
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp				100℃ Cross Temp +2week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 10K	Max	20	16	20	16	8	8	12	8	8	8	8	8
		Med	4	4	4	4	4	4	4	4	4	4	4	4
2DP	EW 10K	Max	16	16	20	20	8	8	8	12	8	8	8	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
4DP	EW 10K	Max	20	16	16	16	12	8	8	8	12	12	8	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
8DP	EW 10K	Max	20	20	20	16	8	12	8	12	8	12	8	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4

● Indepth Histogram (EW+100℃ Cross Temp)

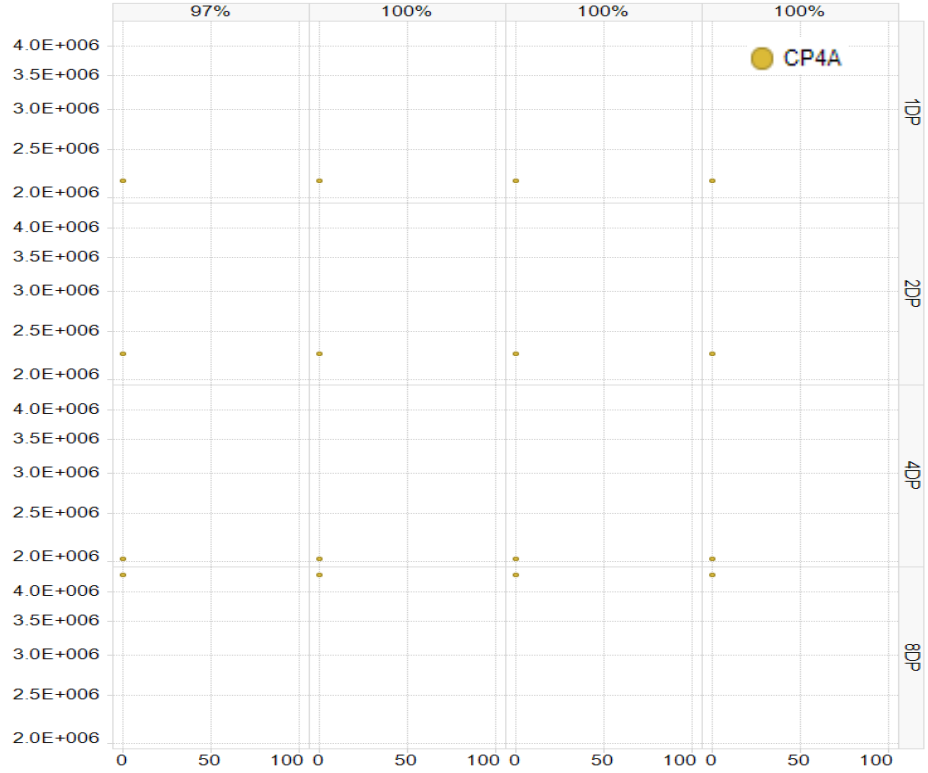


SLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A

SLC Checkpoint 4A (X-Temp)						
Test Result			PASS			
Correctness Fail Bit Level (Hard Error)			100℃ Cross Temp			
			97%	100%	100%	100%
1DP	EW 10K	Max	0	0	0	0
		Median	0	0	0	0
2DP	EW 10K	Max	0	0	0	0
		Median	0	0	0	0
4DP	EW 10K	Max	0	0	0	0
		Median	0	0	0	0
8DP	EW 10K	Max	0	0	0	0
		Median	0	0	0	0

● Hard Error Histogram (EW + 100℃ Cross Temp)

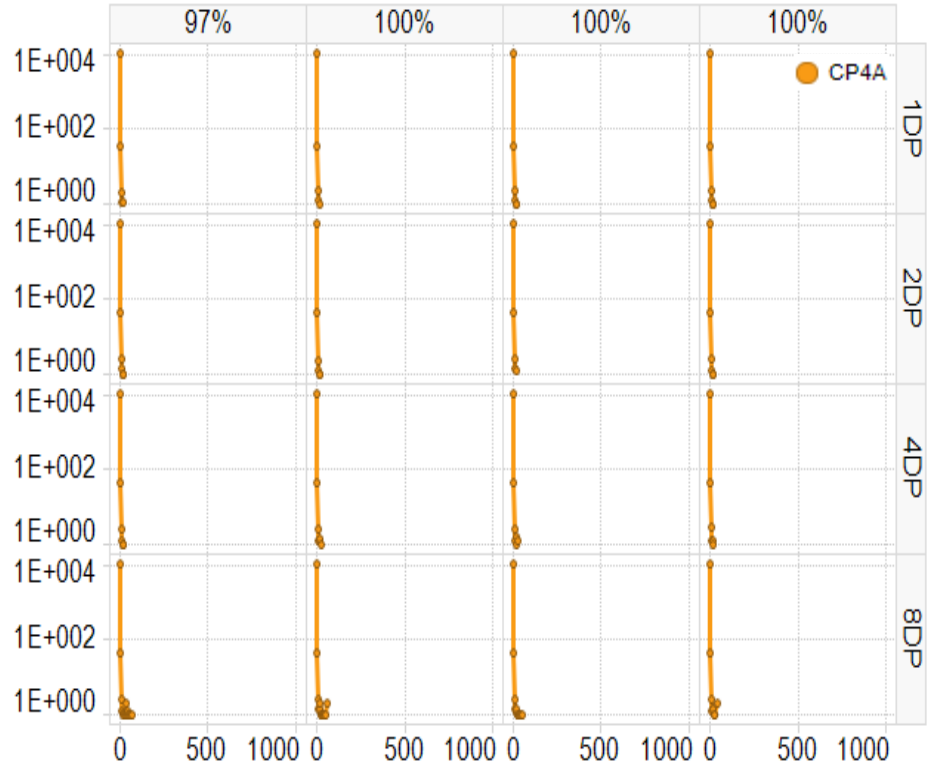


SLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A

SLC Checkpoint 4A (X-Temp)						
Test Result			PASS			
Correctness Fail Bit Level (Indepth ADSP)			100℃ Cross Temp			
			97%	100%	100%	100%
1DP	EW 10K	Max	16	16	20	20
		Median	4	4	4	4
2DP	EW 10K	Max	20	20	16	20
		Median	4	4	4	4
4DP	EW 10K	Max	20	24	24	20
		Median	4	4	4	4
8DP	EW 10K	Max	68	56	52	40
		Median	4	4	4	4

● Indepth Histogram_ADSP (EW + 100℃ Cross Temp)

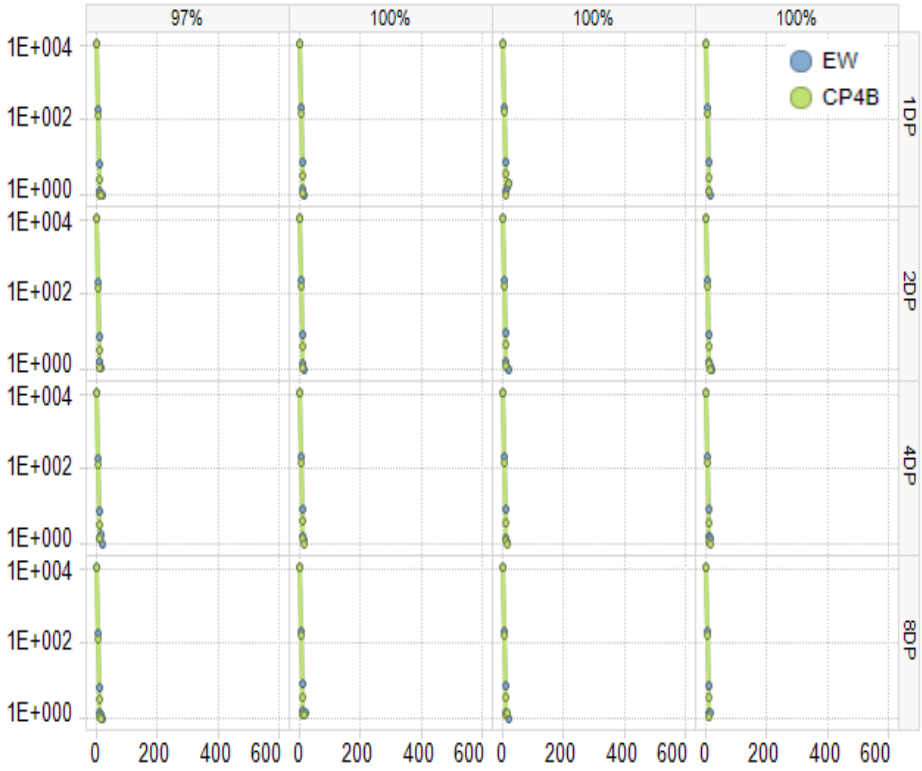


SLC (EOL X-Temp) – CP4B

☑ Reliability Check points satisfied with checkpoint 4B.

SLC Checkpoint 4B (X-Temp)										
Test Result				PASS						
Correctness Fail Bit Level				EW				100℃ Cross Temp			
				97%	100%	100%	100%	97%	100%	100%	100%
SLC	1DP	EW 100K	Max	20	16	20	16	16	12	20	12
			Median	4	4	4	4	4	4	4	4
	2DP	EW 100K	Max	16	16	20	20	12	12	12	16
			Median	4	4	4	4	4	4	4	4
	4DP	EW 100K	Max	20	16	16	16	12	16	16	16
			Median	4	4	4	4	4	4	4	4
	8DP	EW 100K	Max	20	20	20	16	16	16	16	12
			Median	4	4	4	4	4	4	4	4

● Indepth Histogram (100℃ Cross Temp)

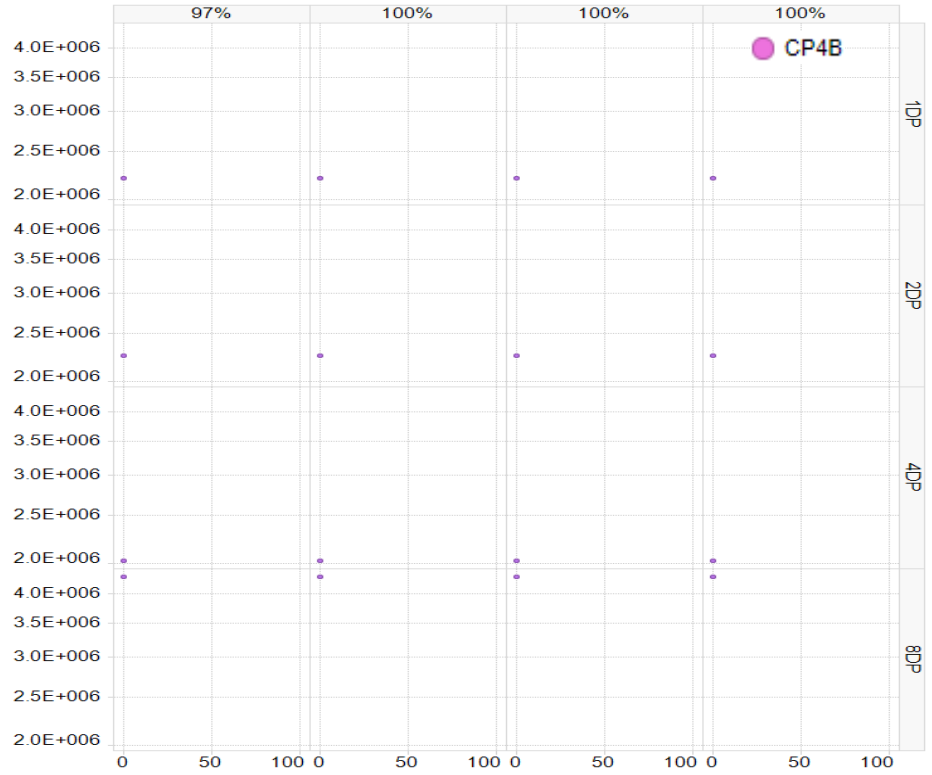


SLC (EOL X-Temp) – CP4B

☑ Reliability Check points satisfied with checkpoint 4B

SLC Checkpoint 4B (X-Temp)						
Test Result			PASS			
Correctness Fail Bit Level (Hard Error)			100℃ Cross Temp			
			97%	100%	100%	100%
1DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
2DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
4DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
8DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0

● Hard Error Histogram (EW + 100℃ Cross Temp)

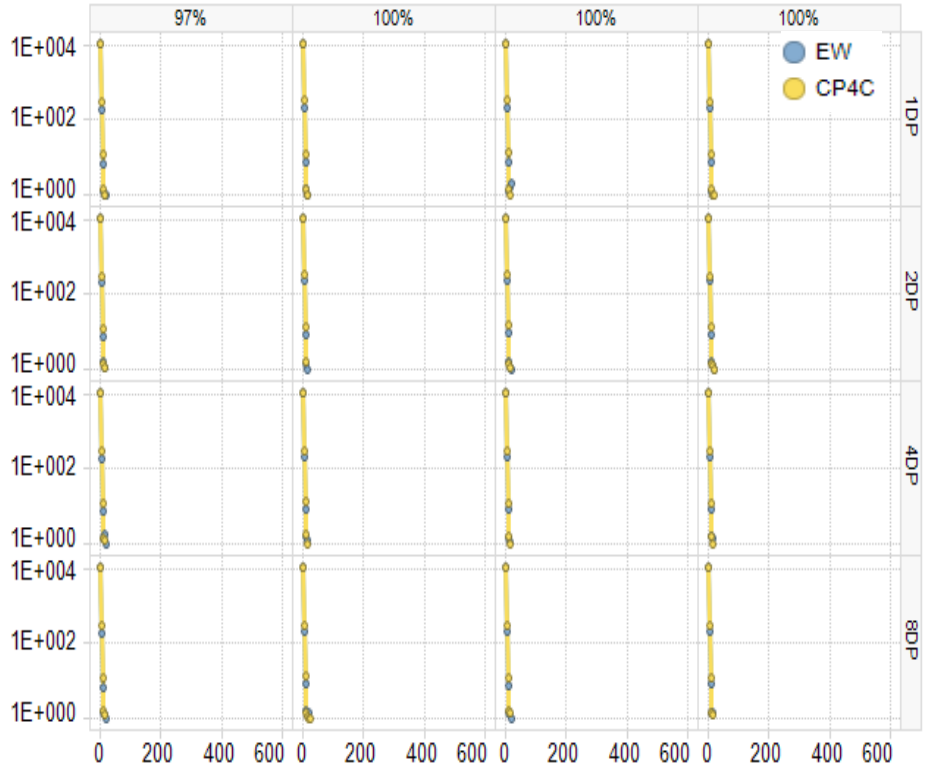


SLC (EOL X-Temp) – CP4C

☑ Reliability Check points satisfied with checkpoint 4C

SLC Checkpoint 4C (X-Temp)											
Test Result				PASS							
Correctness Fail Bit Level				EW				100℃ Cross Temp			
				97%	100%	100%	100%	97%	100%	100%	100%
SLC	1DP	EW 100K	Max	20	16	20	16	16	16	16	20
			Median	4	4	4	4	4	4	4	4
	2DP	EW 100K	Max	16	16	20	20	16	12	16	20
			Median	4	4	4	4	4	4	4	4
	4DP	EW 100K	Max	20	16	16	16	16	16	16	16
			Median	4	4	4	4	4	4	4	4
	8DP	EW 100K	Max	20	20	20	16	16	24	16	16
			Median	4	4	4	4	4	4	4	4

● Indepth Histogram (100℃ Cross Temp)

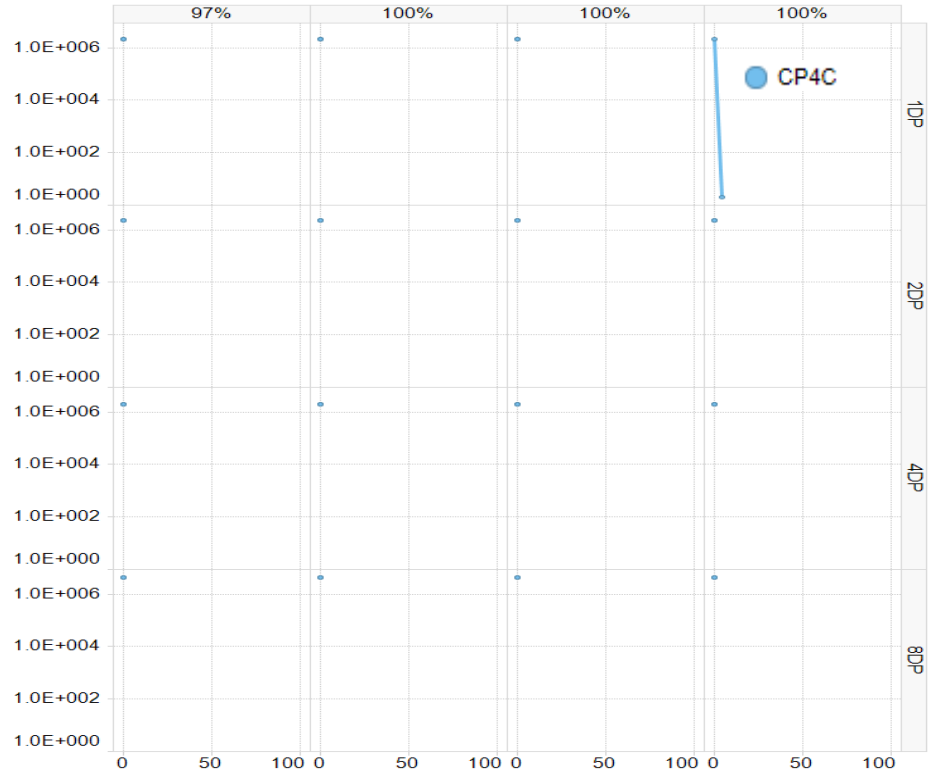


SLC (EOL X-Temp) – CP4C

☑ Reliability Check points satisfied with checkpoint 4C

SLC Checkpoint 4C (X-Temp)						
Test Result			PASS			
Correctness Fail Bit Level (Hard Error)			100℃ Cross Temp			
			97%	100%	100%	100%
1DP	EW 100K	Max	0	0	0	4
		Median	0	0	0	0
2DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
4DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0
8DP	EW 100K	Max	0	0	0	0
		Median	0	0	0	0

● Hard Error Histogram (EW + 100℃ Cross Temp)



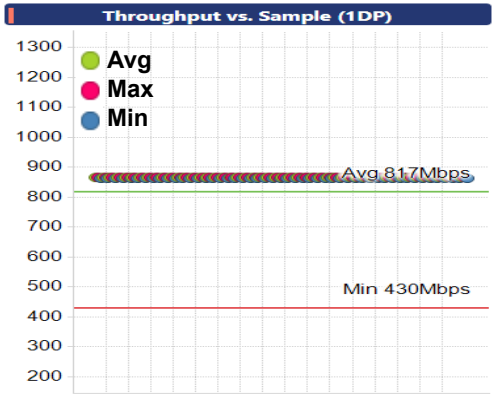
SLC (Sequential Throughput) – CP8

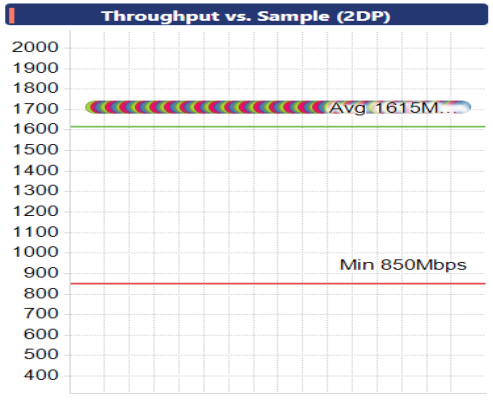
☑ Throughput Test satisfied with checkpoint 8

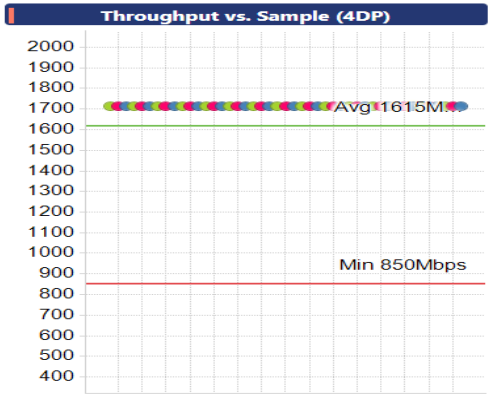
- Throughput Measurement Table

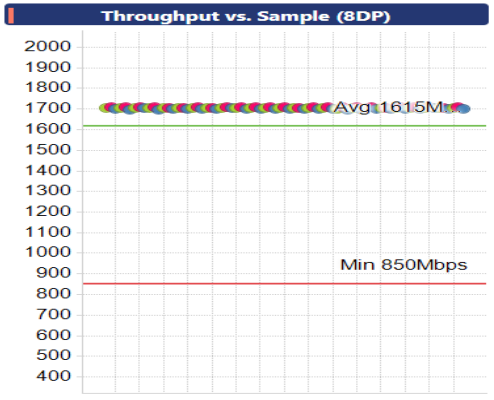
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 10K	Initial	864.94	864.94	864	1713.88	1713.88	1712	1714.53	1714.17	1713	1704.51	1702.13	1696
	EW+RD100K+3month (CT 30C)	864.87	864	864	1713.88	1713.88	1712	1714.5	1714.17	1713	1704.6	1702.5	1694

- Throughput vs. Sample(PKG) (Initial)

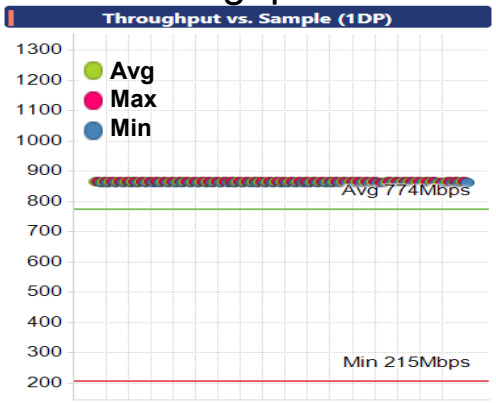


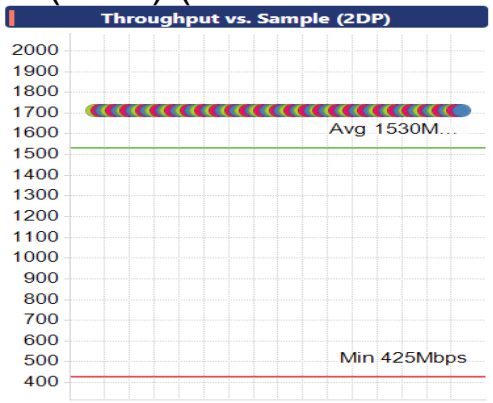


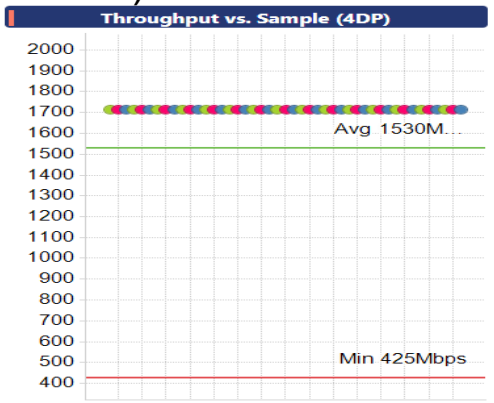


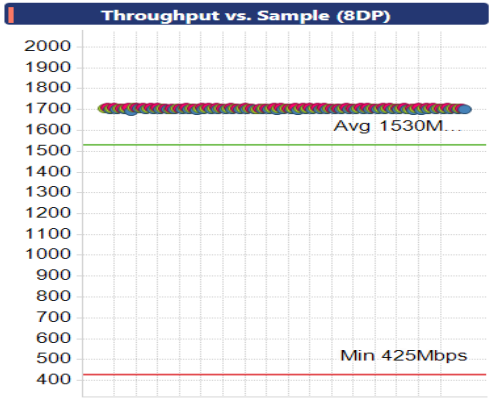


- Throughput vs. Sample(PKG) (EW+RD100K+3Months)









SLC (RC Throughput) – CP8

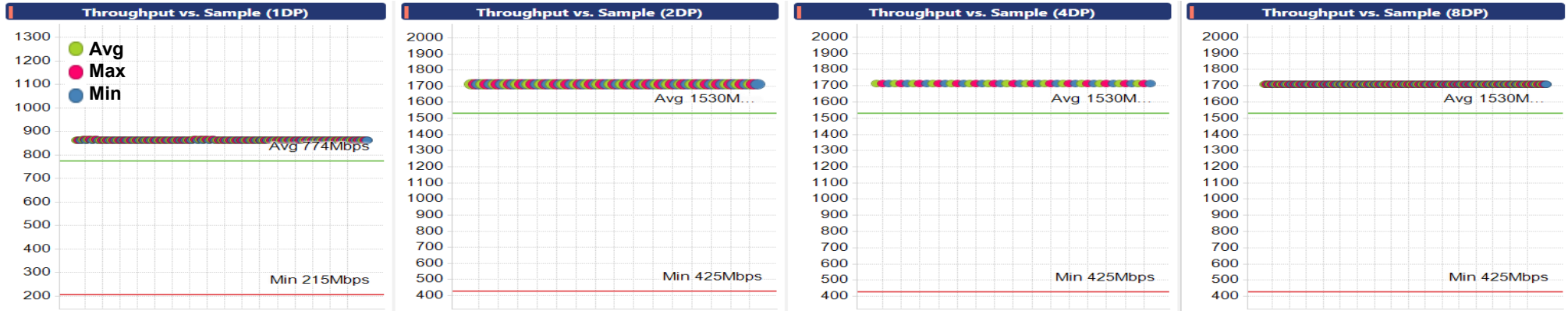
☑ Throughput Test satisfied with checkpoint 8

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 10K	Initial	864.03	864	864	1714	1714	1714	1714	1714	1714	1710.72	1709	1709
	EW+RD100K+3month (CT 30C)	864.07	864	864	1714	1714	1714	1714	1714	1714	1710.88	1710	1710

- Throughput vs. Sample(PKG) (Initial)

- Throughput vs. Sample(PKG) (EW+RD100K+3Months)



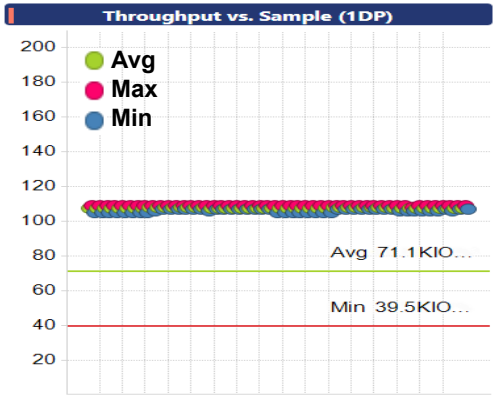
SLC (RR Throughput) – CP8

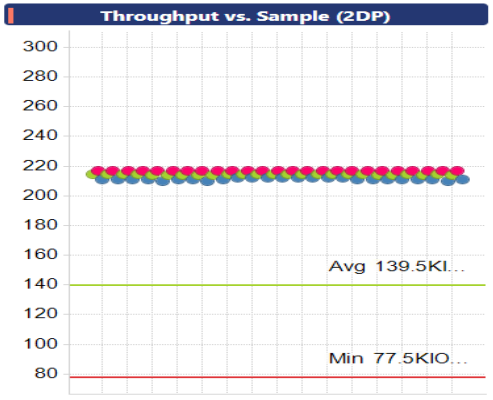
☑ Throughput Test satisfied with checkpoint 8

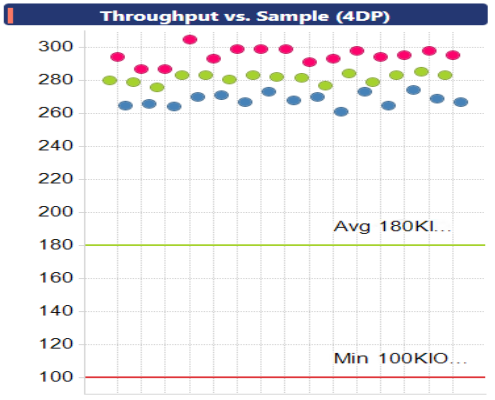
- Throughput Measurement Table

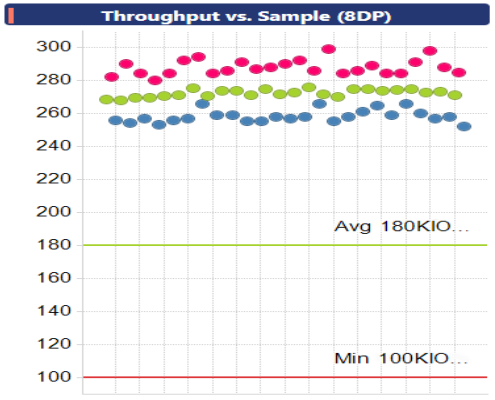
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 10K	Initial	107.69	107	105	214.35	213.75	210	281.36	274.67	261	272.28	267	252
	EW+RD100K+3month (CT 30C)	107.73	107.44	106	214.32	213.25	210	281.16	276.79	254	272.02	263.38	250

- Throughput vs. Sample(PKG) (Initial)

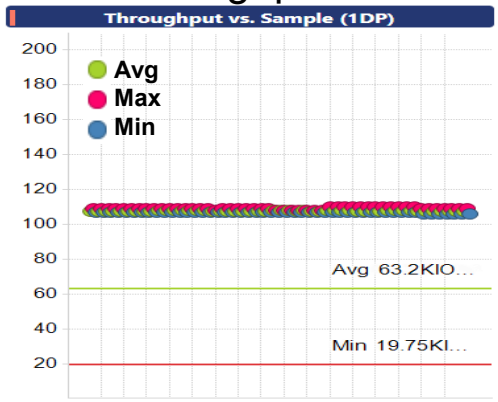


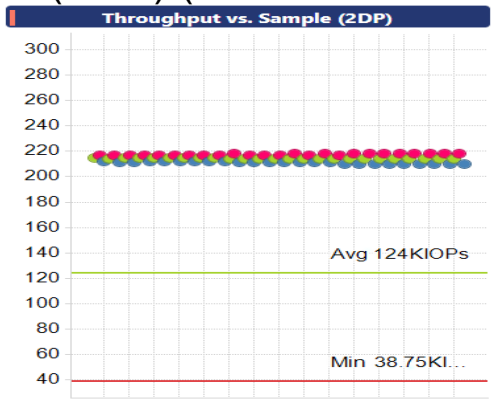


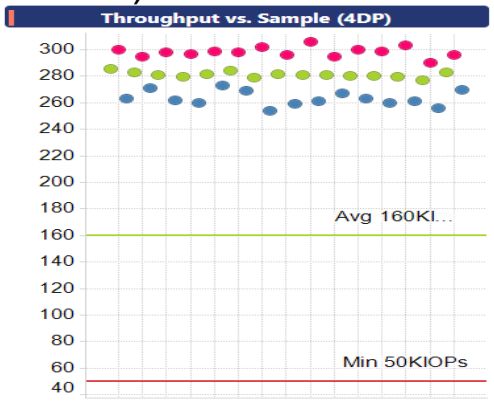


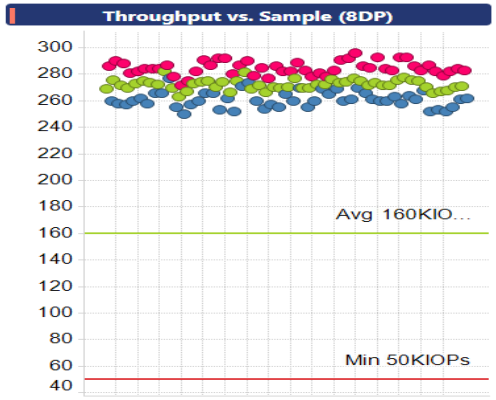


- Throughput vs. Sample(PKG) (EW+RD100K+3Months)









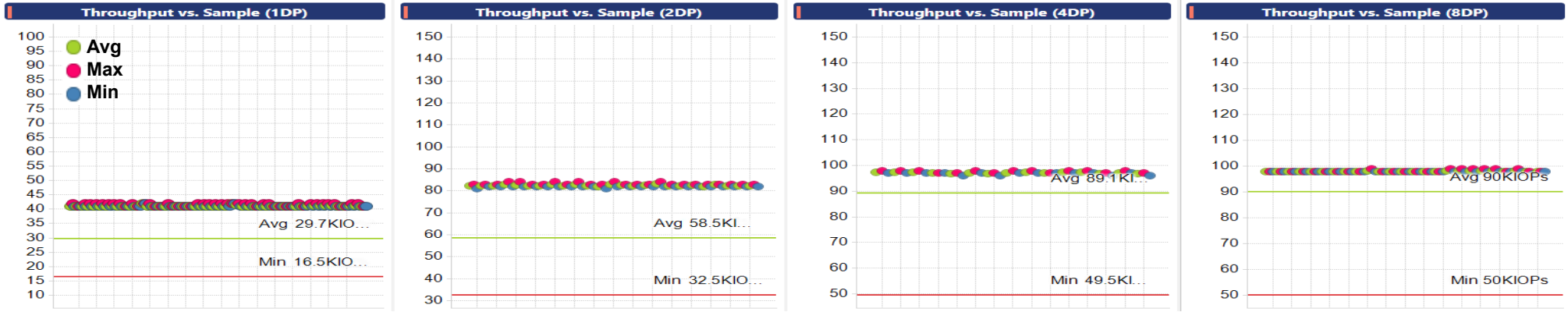
SLC (16K RR Throughput) – CP8

☑ Throughput Test satisfied with checkpoint 8

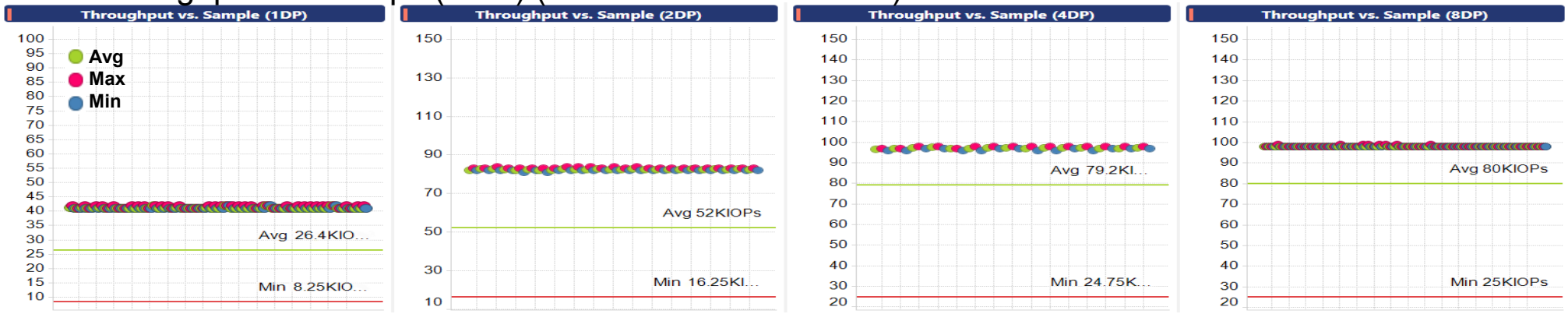
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 10K	Initial	41.11	41	41	82.49	82	81	97.14	96.75	96	98.02	97.88	97
	EW+RD100K+3month (CT 30C)	41.14	41	41	82.51	82	81	97.13	96.75	96	98.04	98	98

- Throughput vs. Sample(PKG) (Initial)



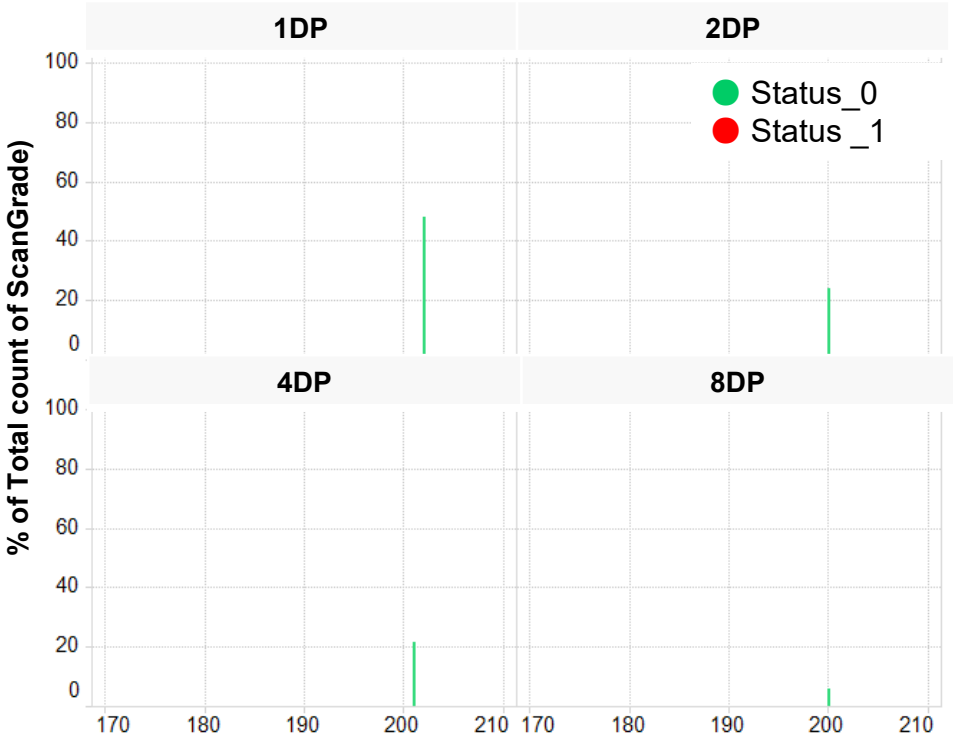
- Throughput vs. Sample(PKG) (EW+RD100K+3Months)



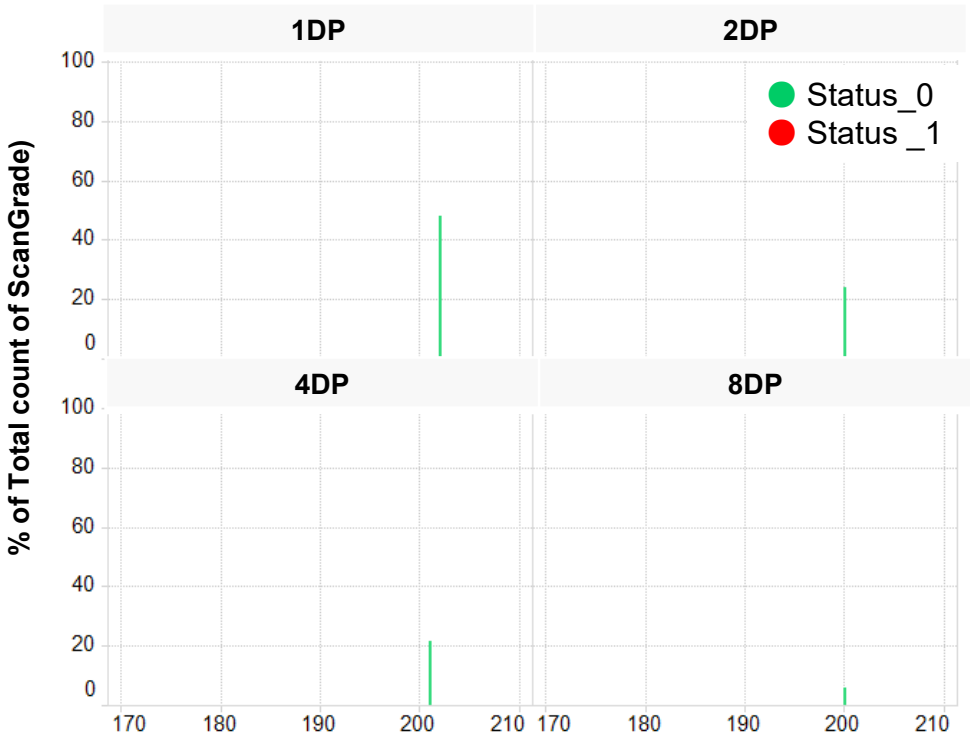
SLC (Read Scan) – CP8

☑ Read Scan satisfied with checkpoint 8

- Read Scan Histogram (EW)



- Read Scan Histogram (EW + RD 100K + 3Months)

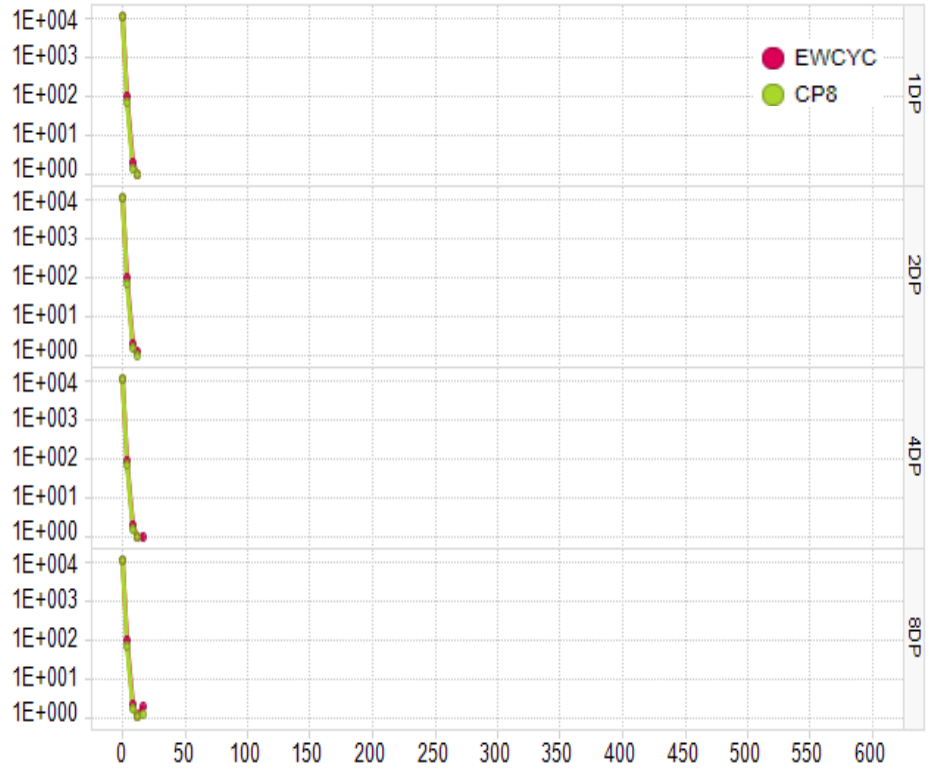


SLC (SOL Latency) – CP8

☑ Read latency satisfied with checkpoint 8

ITEM	Stack	Bin	Apple Spec	EW + Read 100K + 3Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP8 (CT 30'C)	1DP	tR≤160us	TBD	1	1	30.09
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	1	1	30.09
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	1	1	30.95
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	1	1	30.90
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram (EW + RD 100K + 3months)



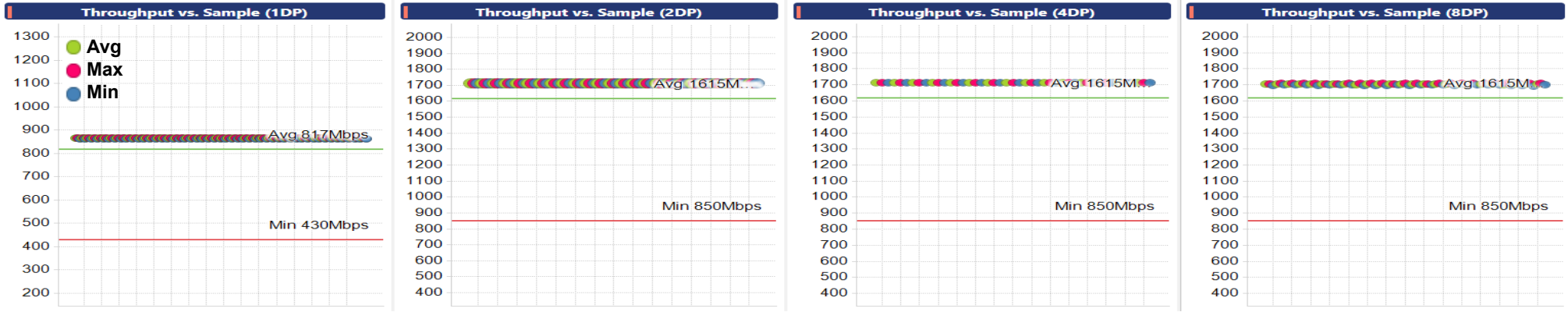
SLC (Sequential Throughput) – CP9A

☑ Throughput Test satisfied with checkpoint 9A

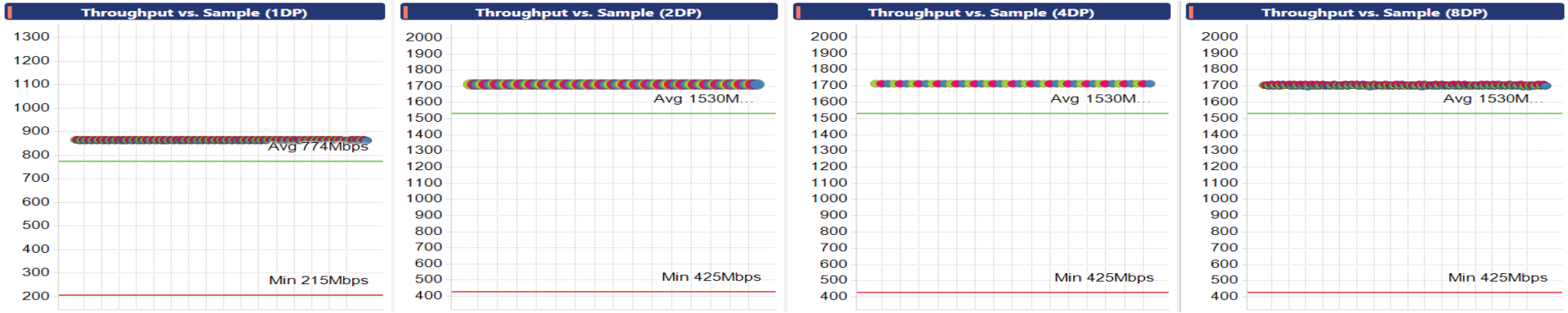
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	864.94	864.94	864	1713.92	1713.88	1712	1714.5	1714.08	1714	1704.38	1701.13	1694
	EW+RD100K+1month (CT 30C)	864.87	864	864	1713.88	1713.88	1712	1714.52	1714.12	1713	1704.87	1703	1696

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



SLC (RC Throughput) – CP9A

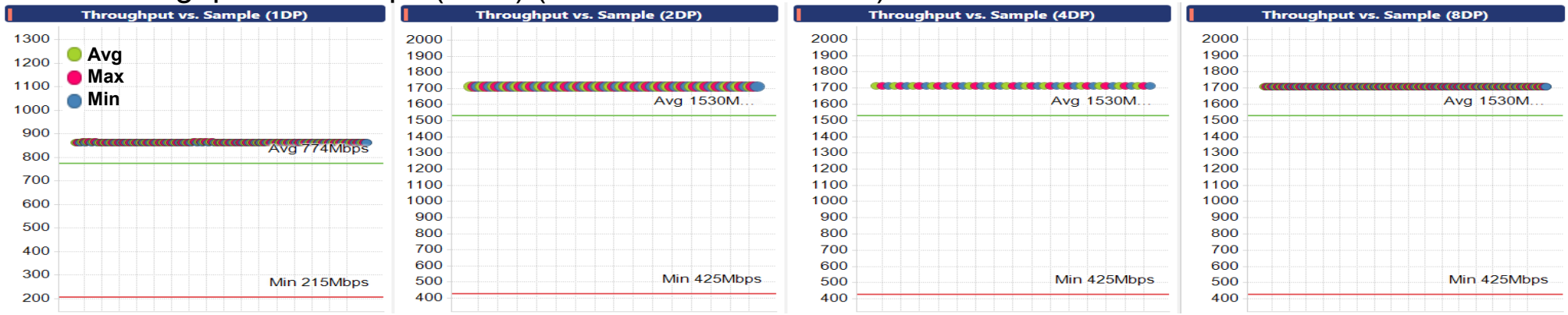
☑ Throughput Test satisfied with checkpoint 9A

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	864.04	864	864	1714	1714	1714	1714	1714	1714	1710.92	1710	1710
	EW+RD100K+1month (CT 30C)	864.07	864	864	1714	1714	1714	1714	1714	1714	1710.84	1710	1710

- Throughput vs. Sample(PKG) (Initial)

- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



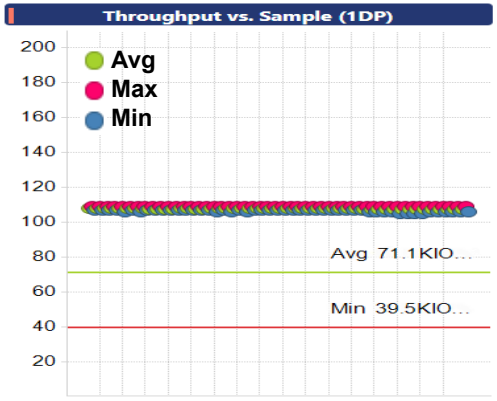
SLC (RR Throughput) – CP9A

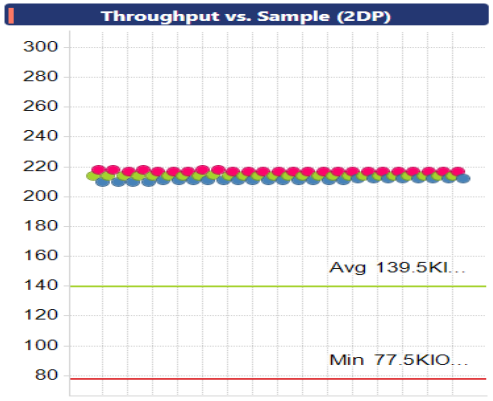
☑ Throughput Test satisfied with checkpoint 9A

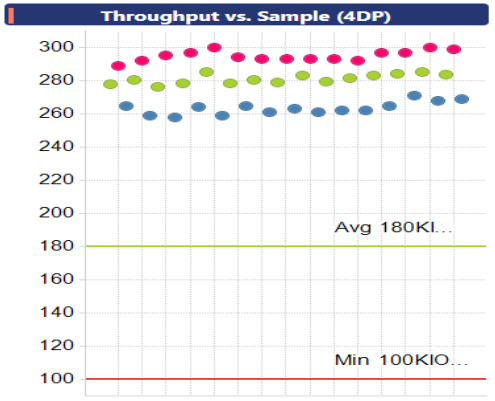
- Throughput Measurement Table

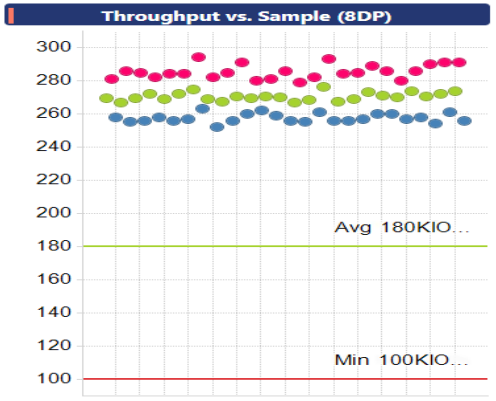
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	107.76	107.25	105	214.09	213.56	210	281.18	274.58	258	270.59	264.75	252
	EW+RD100K+1month (CT 30C)	107.56	106.5	106	213.76	212.94	210	281.27	277.12	255	272.33	267.13	250

- Throughput vs. Sample(PKG) (Initial)

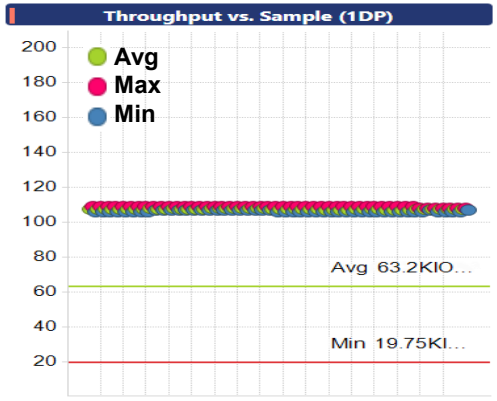


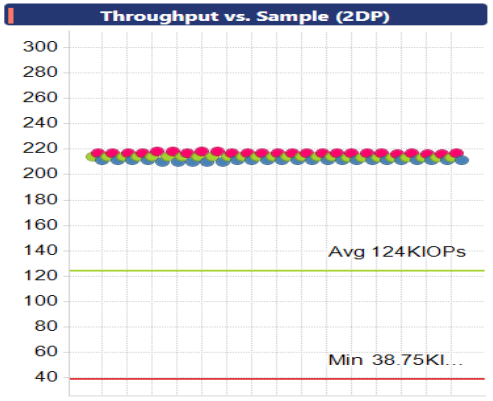


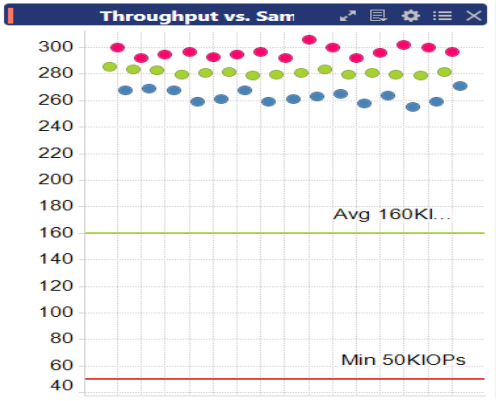


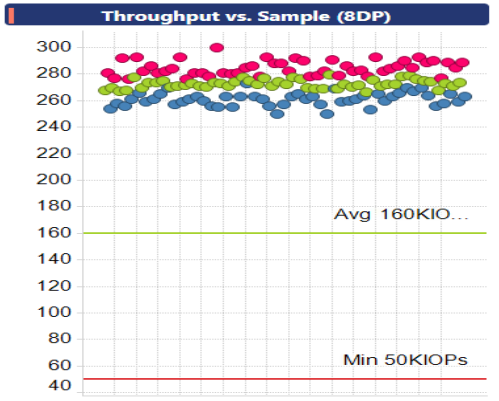


- Throughput vs. Sample(PKG) (EW+RD100K+1Month)









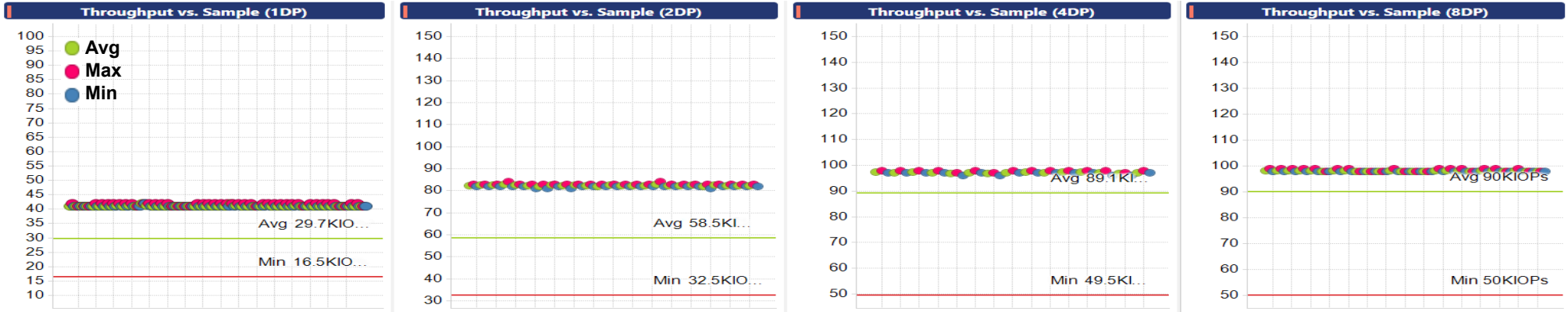
SLC (16K RR Throughput) – CP9A

☑ Throughput Test satisfied with checkpoint 9A

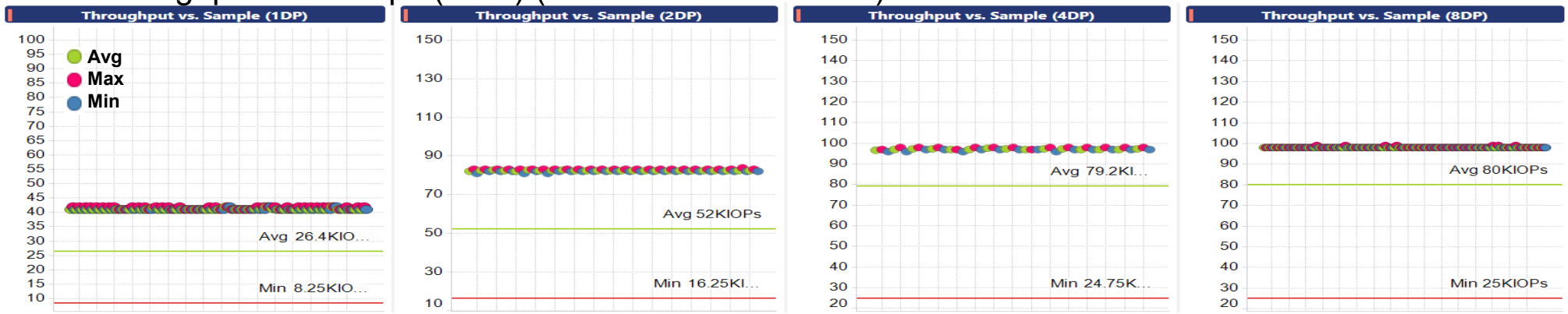
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	41.1	41	41	82.42	82	81	97.15	96.75	96	98.05	98	98
	EW+RD100K+1month (CT 30C)	41.13	41	41	82.43	82	81	97.12	96.67	96	98.02	98	98

- Throughput vs. Sample(PKG) (Initial)



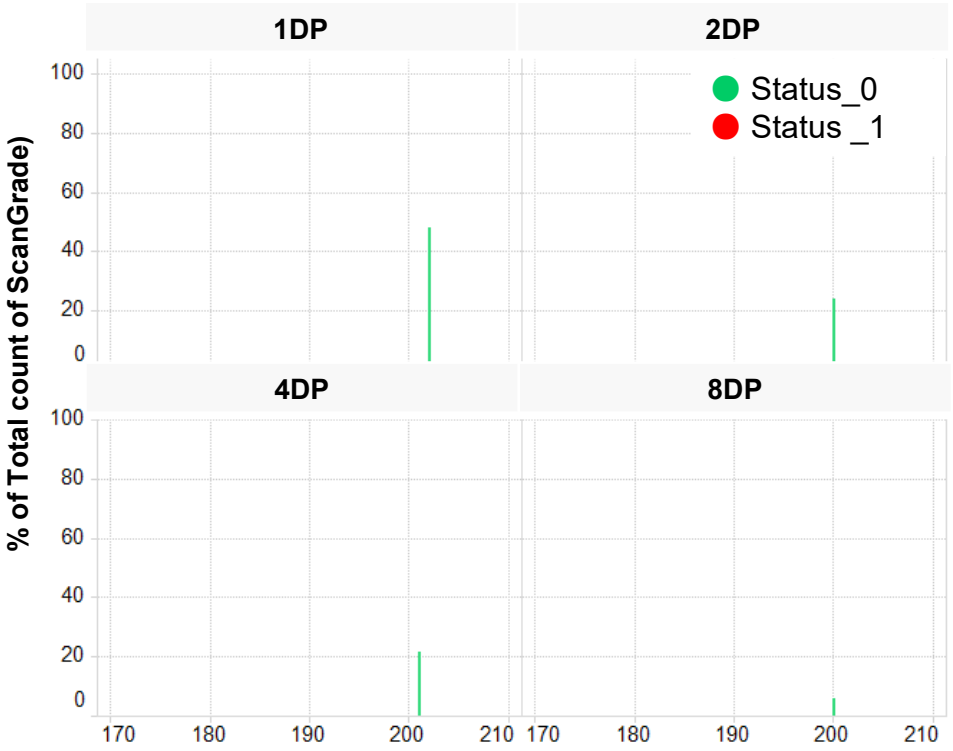
- Throughput vs. Sample(PKG) (EW+RD100K+1Month)



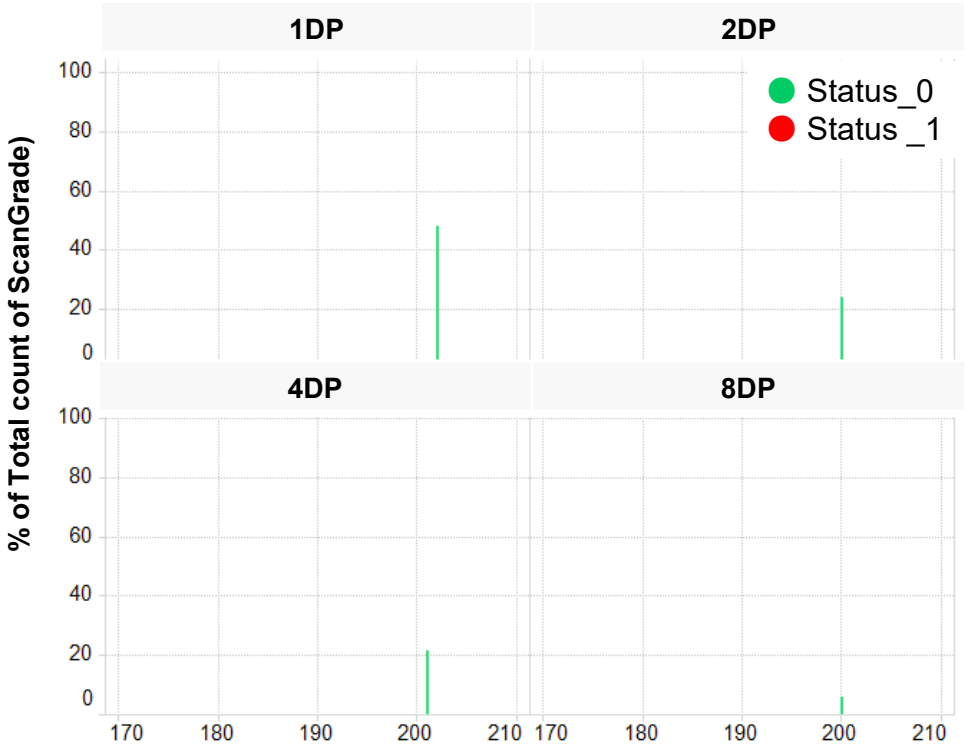
SLC (Read Scan) – CP9A

☑ Read Scan satisfied with checkpoint 9A

- Read Scan Histogram (EW)



- Read Scan Histogram (EW + RD 100K + 1Month)

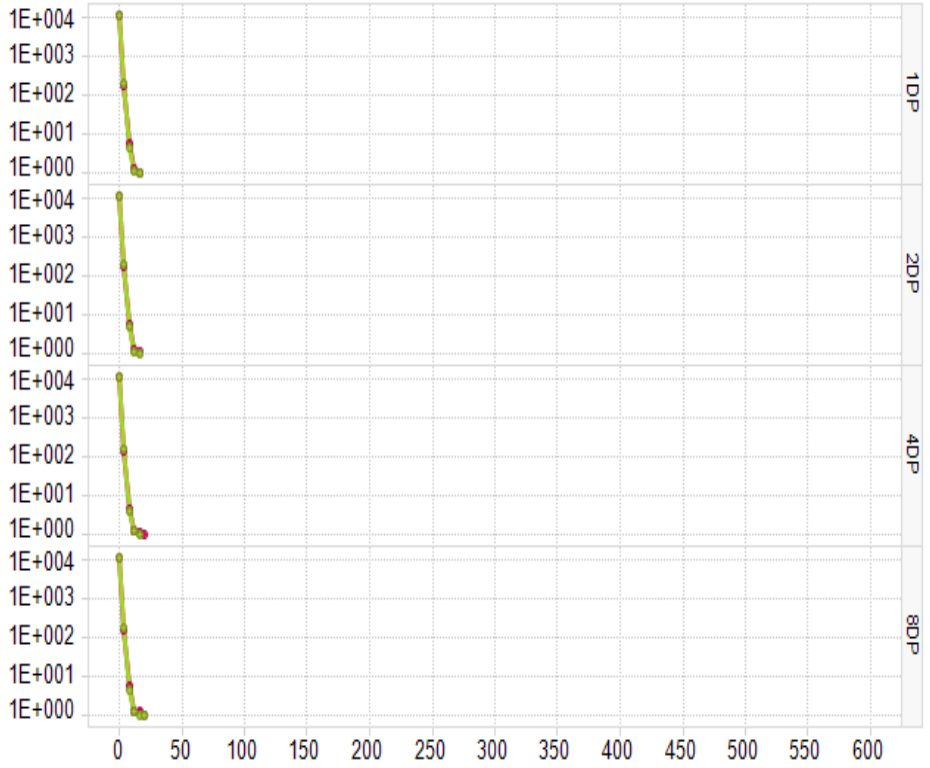


SLC (EOL Latency) – CP9A

☑ Read latency satisfied with checkpoint 9A

ITEM	Stack	Bin	Apple Spec	EW + Read 100K + 1Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP9A (CT 30'C)	1DP	tR≤160us	TBD	1	1	30.09
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	1	1	30.08
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	1	1	31.05
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	1	1	30.92
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram (EW + RD 100K + 1month)



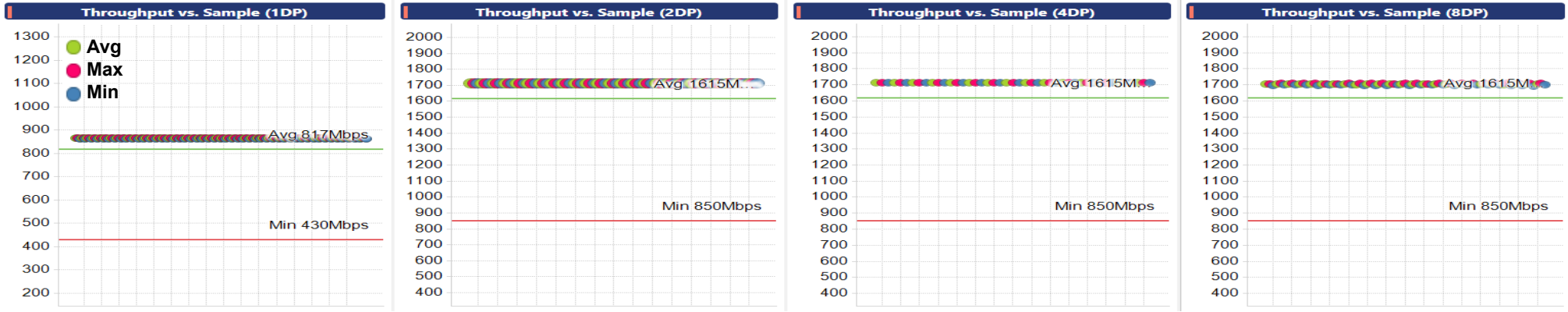
SLC (Sequential Throughput) – CP9C

☑ Throughput Test satisfied with checkpoint 9C

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	864.94	864.94	864	1713.92	1713.88	1712	1714.5	1714.08	1714	1704.38	1701.13	1694
	EW+RD100K+1month (CT 30C)	864.88	864	864	1713.88	1713.88	1712	1714.5	1714.12	1713	1704.68	1703.13	1696

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (EW+RD100K+1Month)

SLC (RC Throughput) – CP9C

☑ Throughput Test satisfied with checkpoint 9C

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	864.04	864	864	1714	1714	1714	1714	1714	1714	1710.92	1710	1710
	EW+RD100K+1month (CT 30C)	864.07	864	864	1714	1714	1714	1714	1714	1714	1710.44	1709	1709

- Throughput vs. Sample(PKG) (Initial)

- Throughput vs. Sample(PKG) (EW+RD100K+1Month)

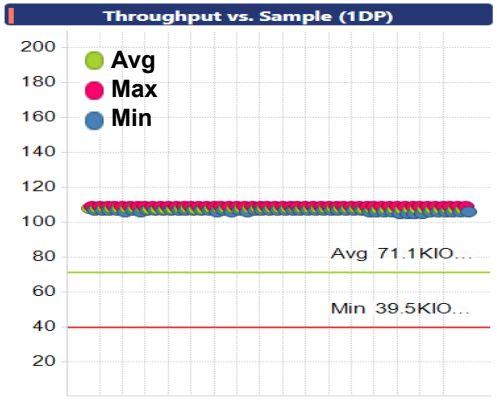
SLC (RR Throughput) – CP9C

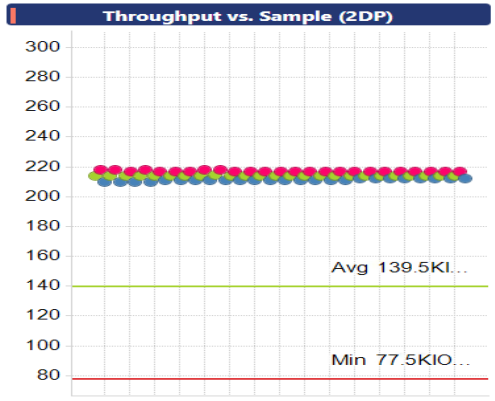
☑ Throughput Test satisfied with checkpoint 9C

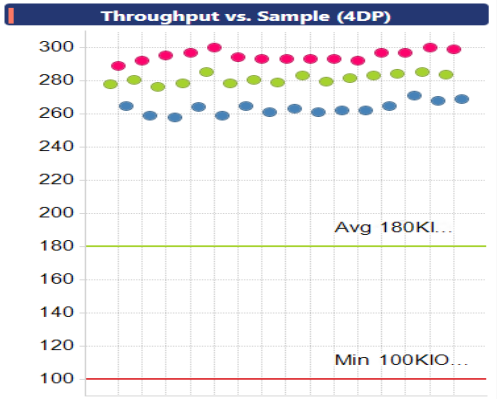
- Throughput Measurement Table

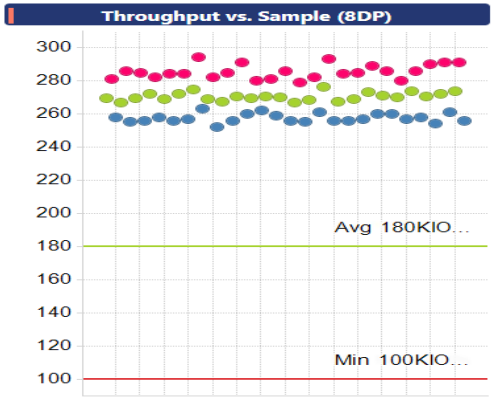
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	107.76	107.25	105	214.09	213.56	210	281.18	274.58	258	270.59	264.75	252
	EW+RD100K+1month (CT 30C)	107.79	107.19	106	214.29	213.56	211	281.42	278.04	260	272.4	264.63	245

- Throughput vs. Sample(PKG) (Initial)

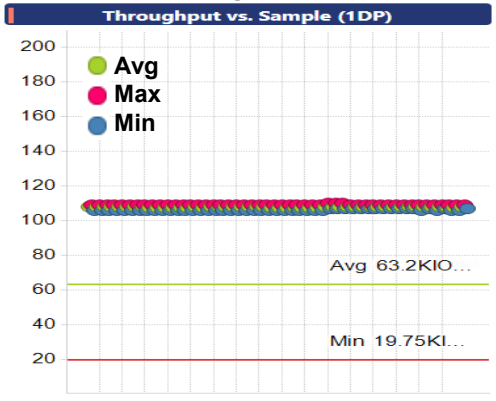


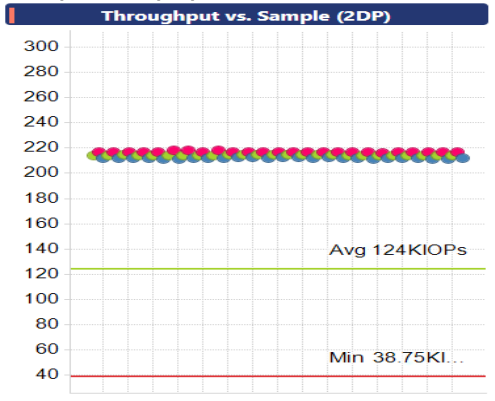


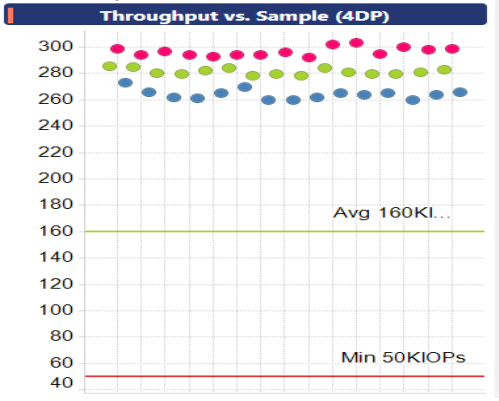


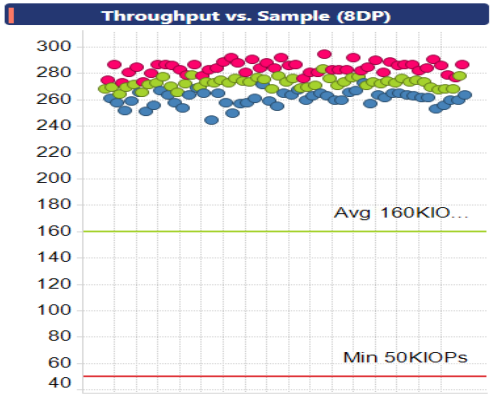


- Throughput vs. Sample(PKG) (EW+RD100K+1Month)









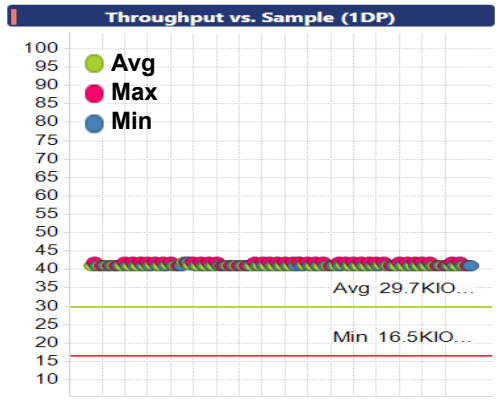
SLC (16K RR Throughput) – CP9C

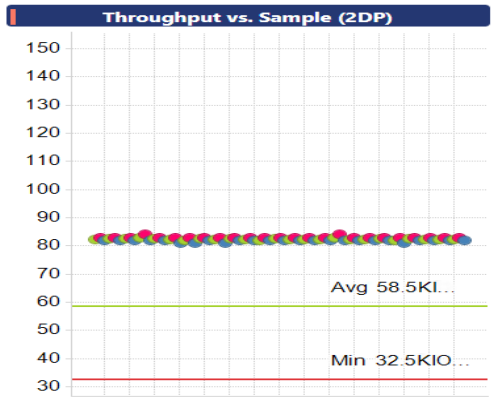
☑ Throughput Test satisfied with checkpoint 9C

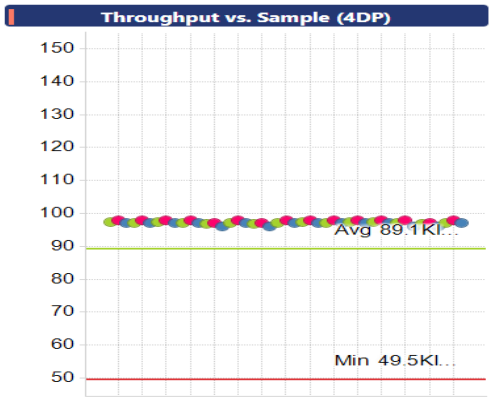
- Throughput Measurement Table

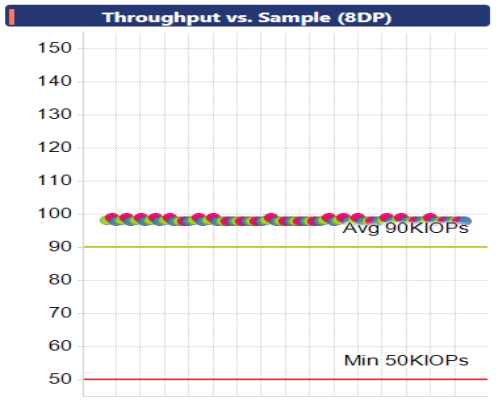
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	41.1	41	41	82.42	82	81	97.15	96.75	96	98.05	98	98
	EW+RD100K+1month (CT 30C)	41.15	41	41	82.4	82	81	97.09	96.67	96	98.03	98	98

- Throughput vs. Sample(PKG) (Initial)

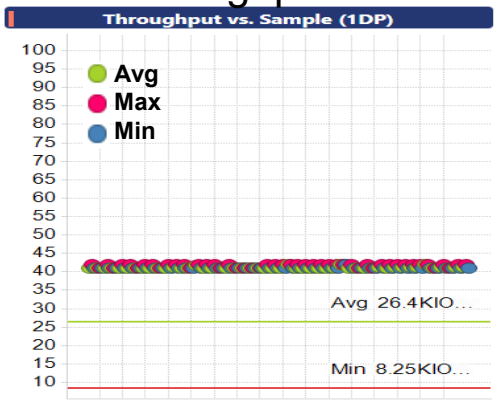


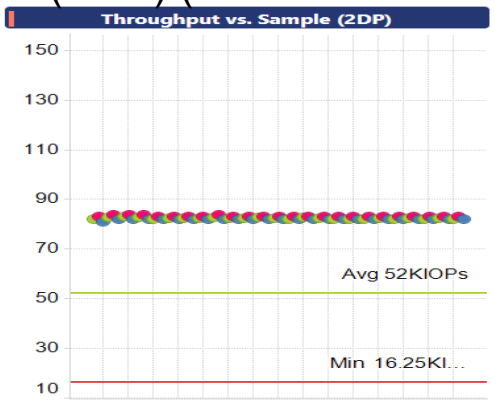


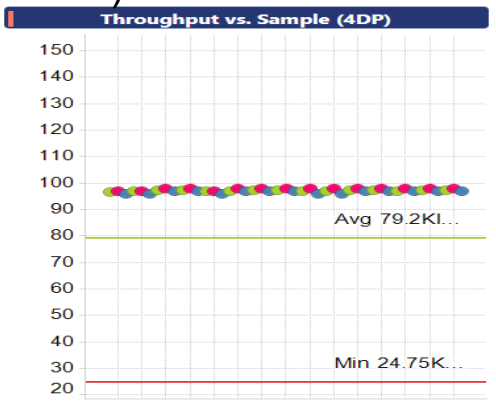


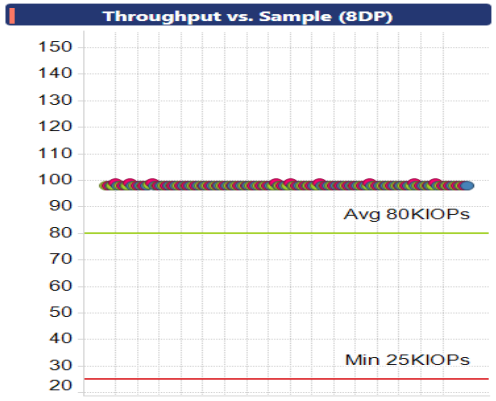


- Throughput vs. Sample(PKG) (EW+RD100K+1Month)





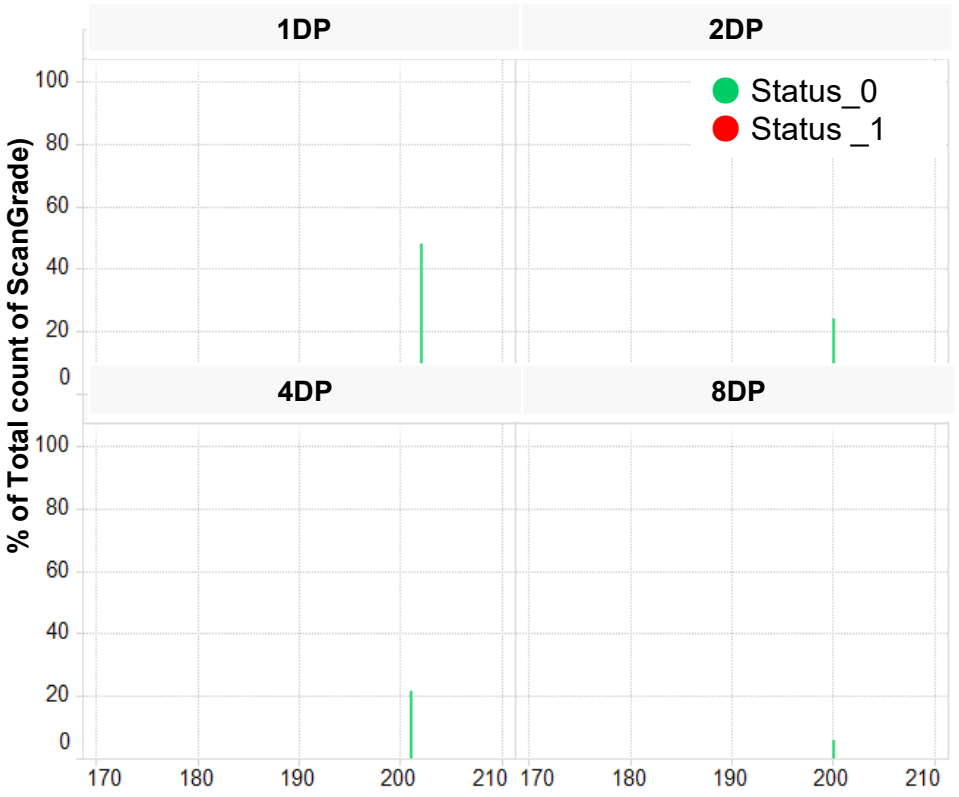




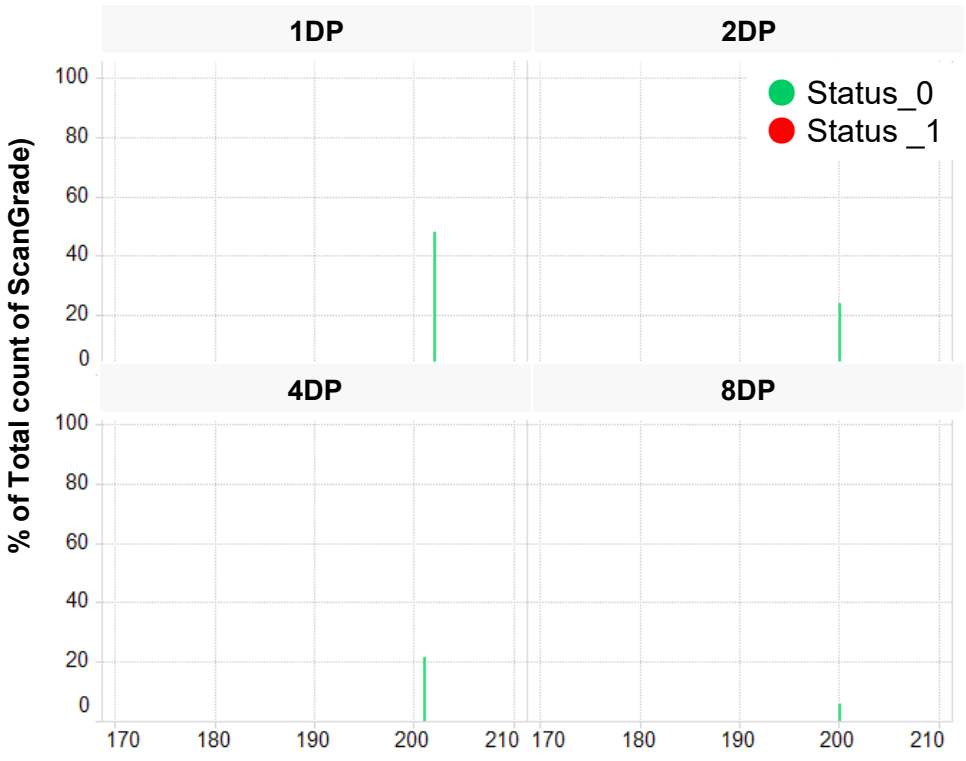
SLC (Read Scan) – CP9C

☑ Read Scan satisfied with checkpoint 9C

● Read Scan Histogram (EW)



● Read Scan Histogram (EW + RD 100K + 1Month)

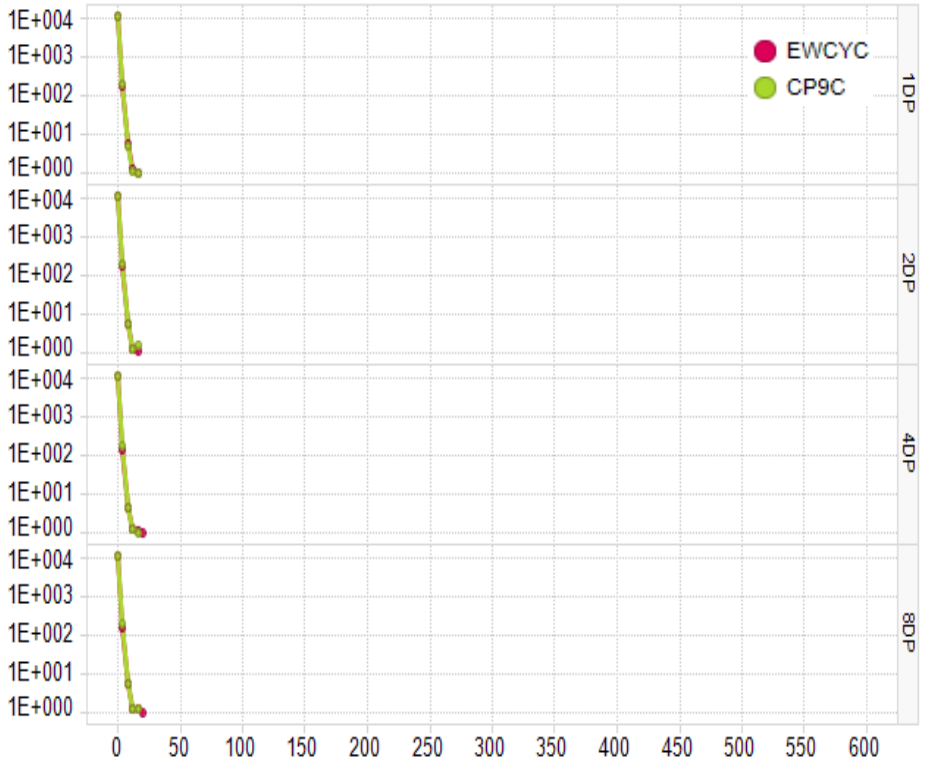


SLC (EOL Latency) – CP9C

☑ Read latency satisfied with checkpoint 9C

ITEM	Stack	Bin	Apple Spec	EW + Read 100K + 1Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
CP9C (CT 30'C)	1DP	tR≤160us	TBD	1	1	30.08
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	1	1	30.08
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	1	1	30.98
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	1	1	31.06
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	-	-	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram (EW + RD 100K + 1month)

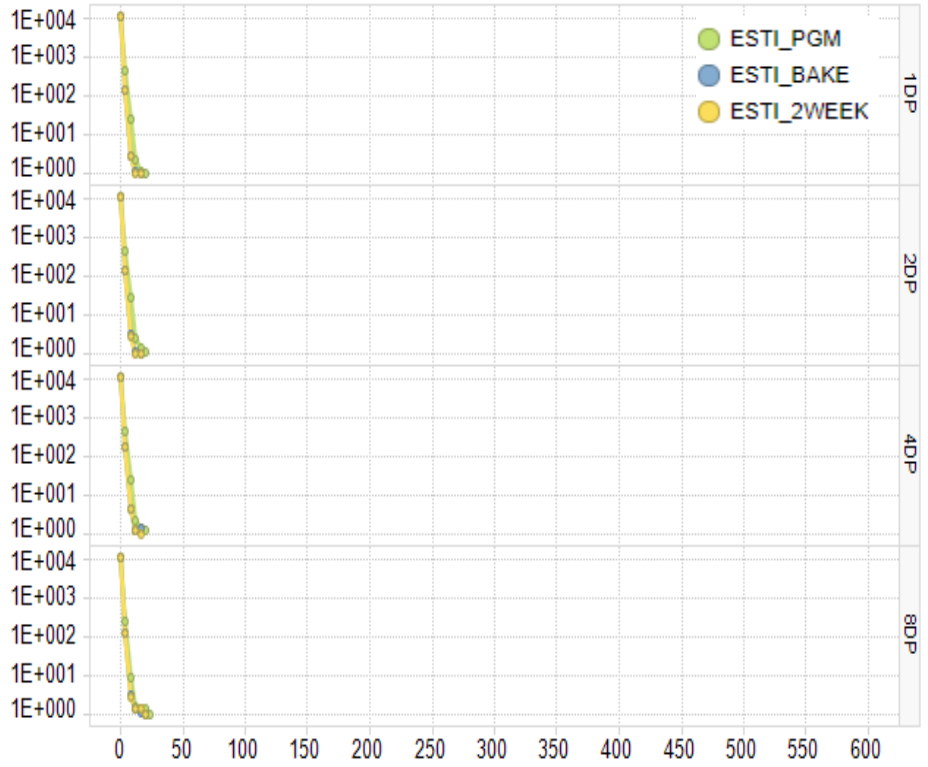


SLC (Erase Tolerance) – CP10

☑ Reliability Check points satisfied with checkpoint 10

Erase Tolerance					
Test Result			PASS		
Correctness Fail Bit Level			PGM	HTDR 12Months	HTDR 12Months +2Week
1DP	PGM	Max	20	16	16
		Median	4	4	4
2DP	PGM	Max	20	16	16
		Median	4	4	4
4DP	PGM	Max	20	16	16
		Median	4	4	4
8DP	PGM	Max	24	20	20
		Median	4	4	4

● Indepth Histogram (PGM + 12Months+2week)



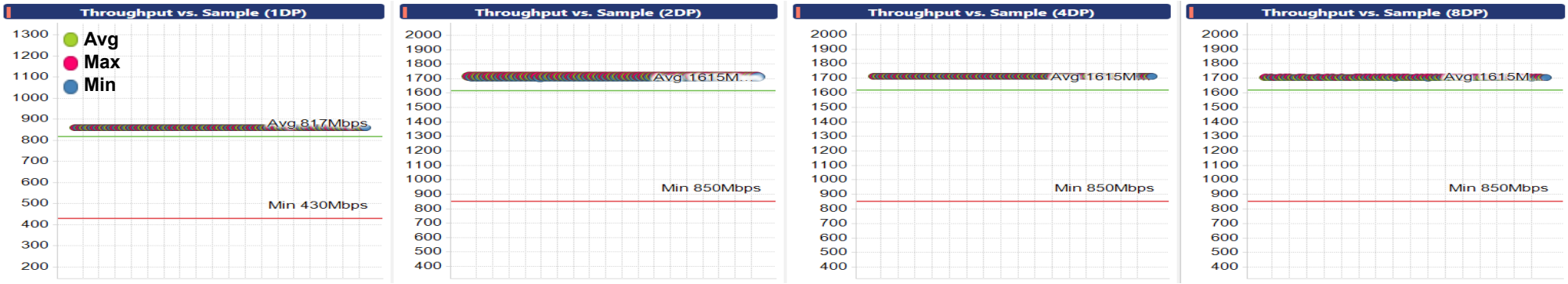
TLC (Sequential Throughput) – X-Ray TLC Type1

☑ Throughput Test satisfied with checkpoint X-Ray TLC Type1

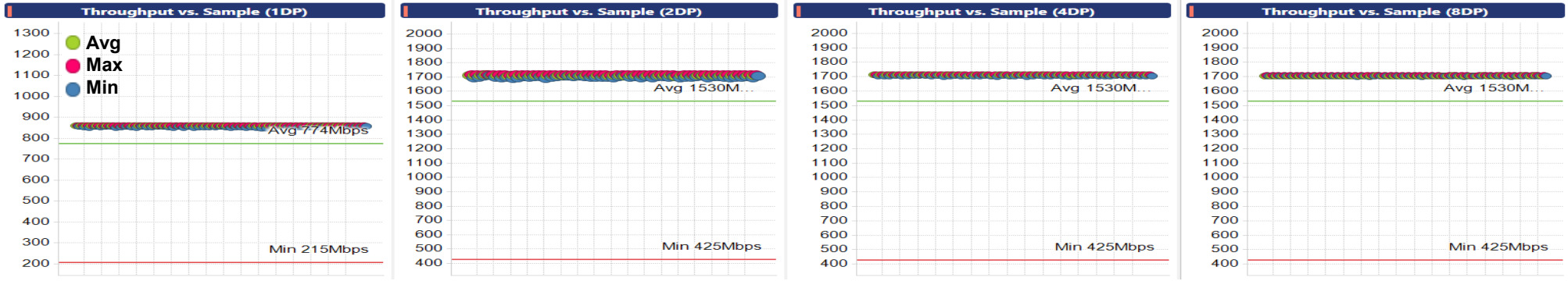
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 1	Initial	860.94	860.75	860	1714.93	1714.63	1709	1714.94	1714.06	1713	1706.24	1704.69	1703
	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months	859.9	857.75	847	1712.31	1703.25	1693	1712.64	1710.75	1700	1706.72	1705.5	1703

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)



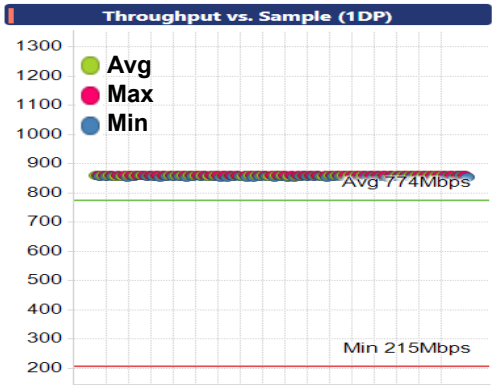
TLC (RC Throughput) – X-Ray TLC Type1

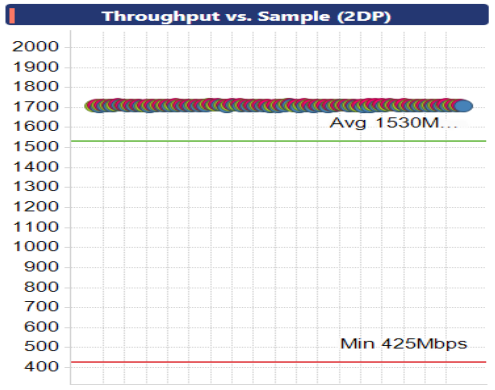
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type1

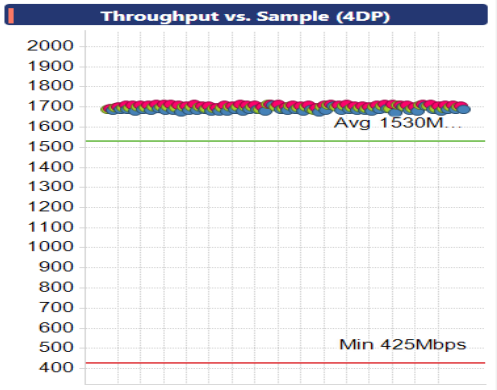
- Throughput Measurement Table

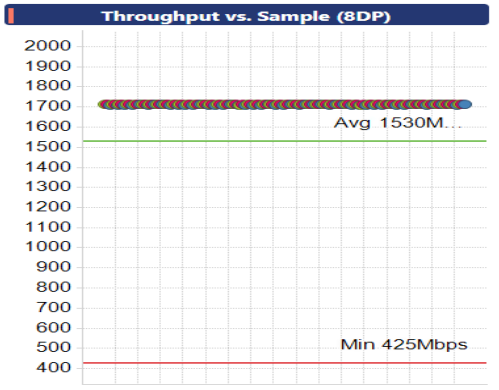
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 1	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months	859.15	858	855	1712.07	1709	1703	1699.03	1686	1673	1712.33	1711.25	1709

- Throughput vs. Sample(PKG) (EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)









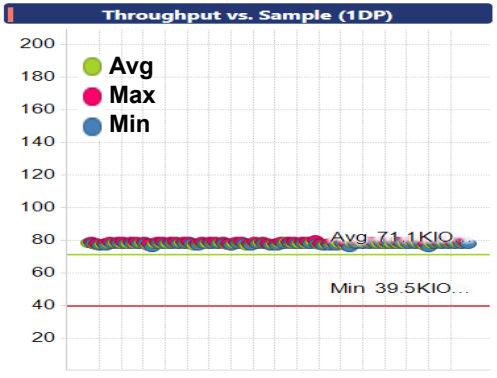
TLC (RR Throughput) – X-Ray TLC Type1

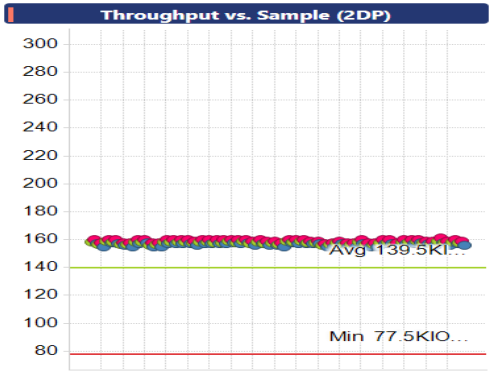
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type1

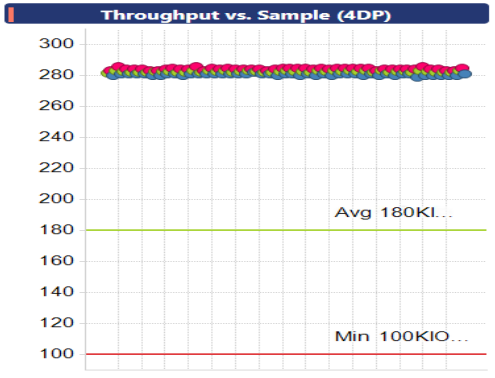
- Throughput Measurement Table

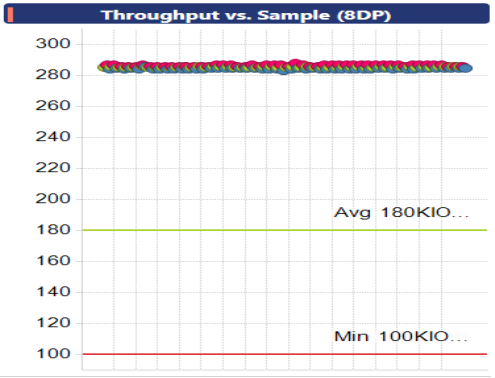
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 1	Initial	78.15	76.94	76	157.72	155.94	155	282.55	281.25	279	285.47	284.69	283
	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months	78.12	76.69	74	157.54	155.81	140	282.61	281.44	275	285.9	285.19	278

- Throughput vs. Sample(PKG) (Initial)

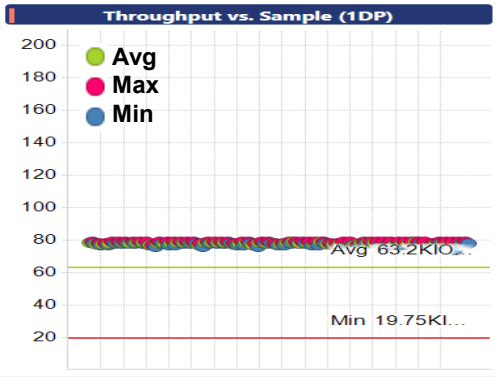


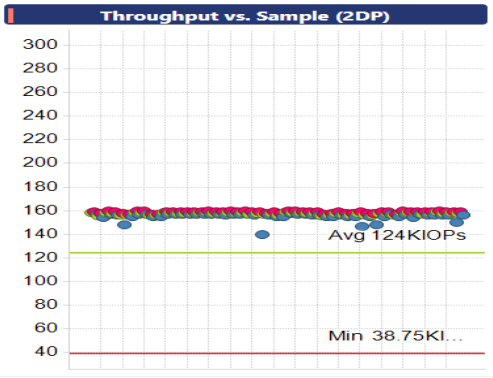


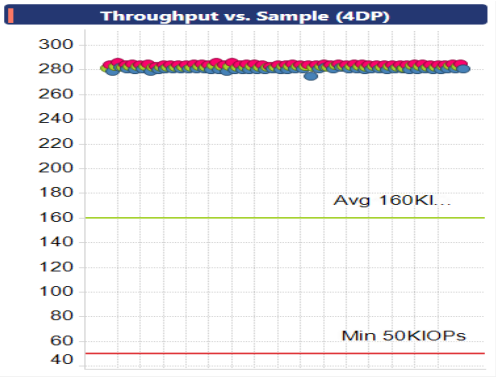


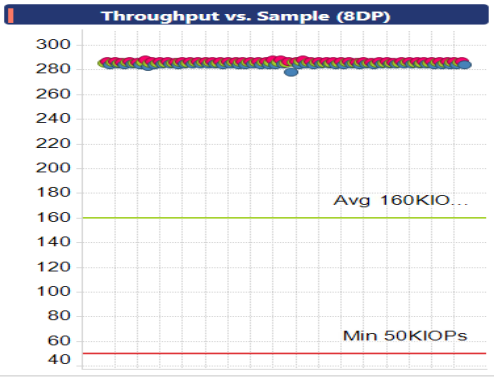


- Throughput vs. Sample(PKG) (EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)





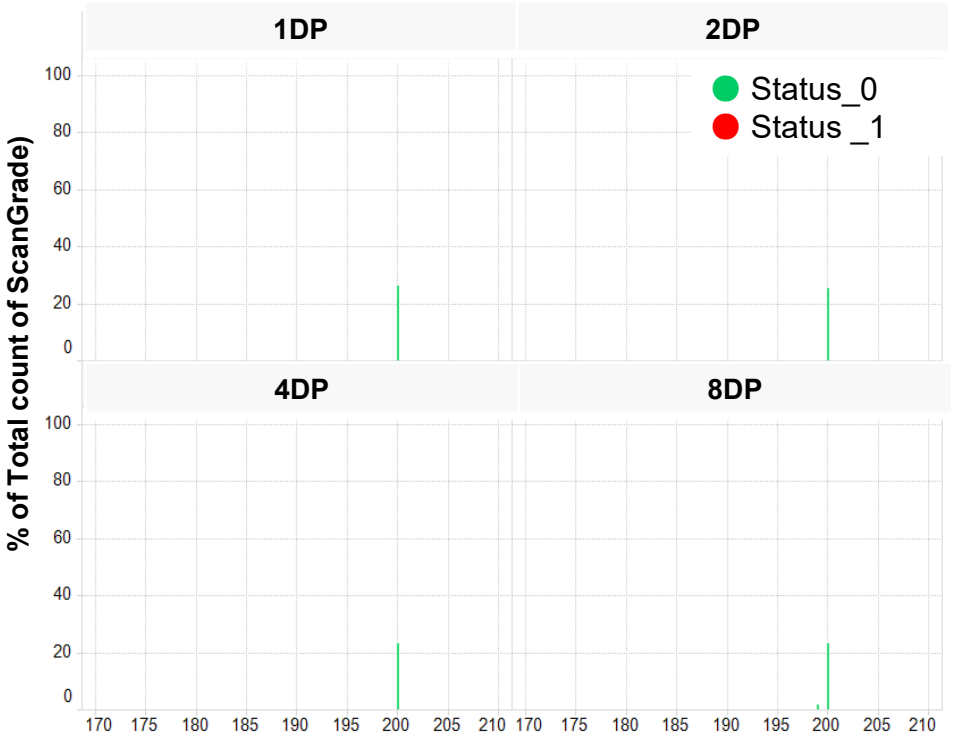




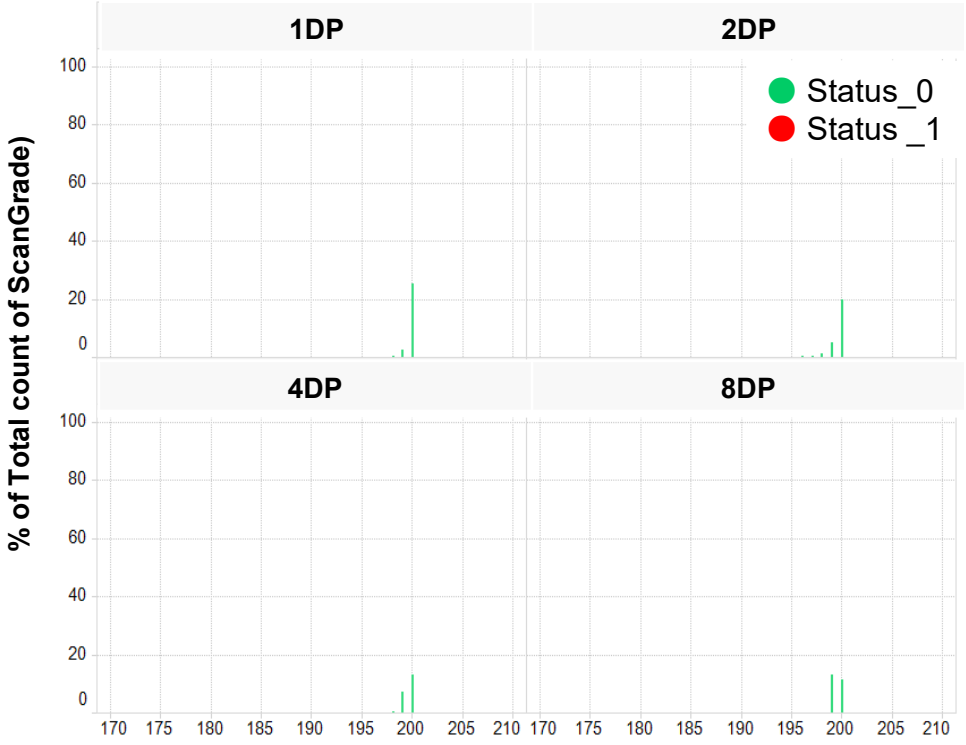
TLC (Read Scan) – X-Ray TLC Type1

☑ Read Scan satisfied with checkpoint X-Ray TLC Type1

● Read Scan Histogram (EW)



● Read Scan Histogram
(EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)

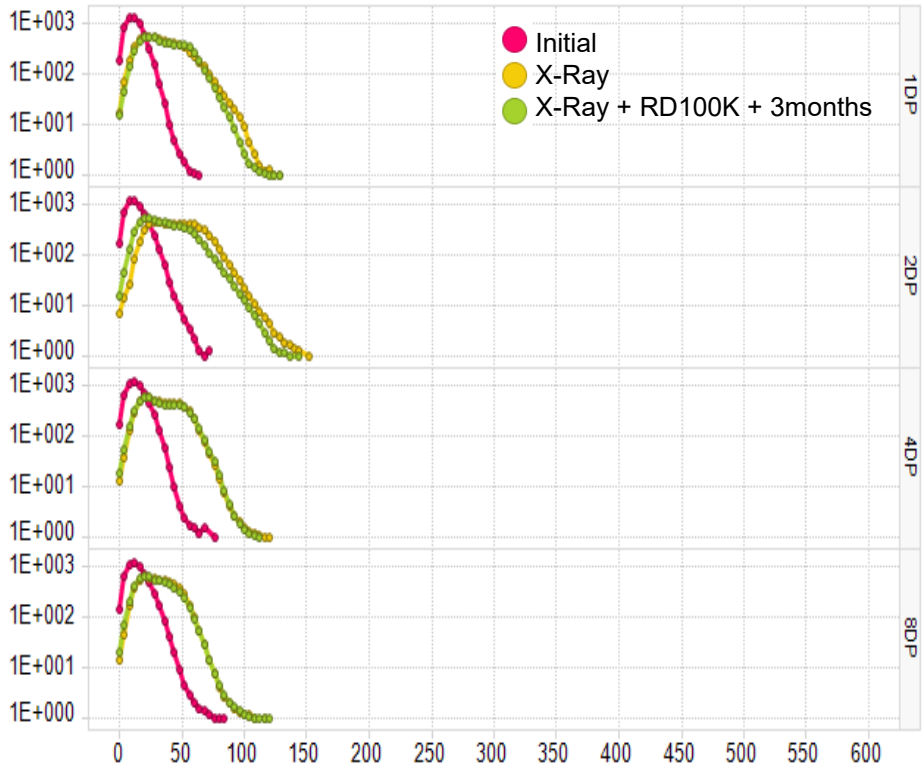


TLC (EOL Latency) – X-Ray TLC Type1

☑ Read latency satisfied with checkpoint X-Ray TLC Type1

ITEM	Stack	Bin	Apple Spec	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray TLC Type1	1DP	tR≤160us	TBD	0.999994	0.999986	50.00
		tR≤200us	TBD	0.000001	0.000001	
		tR≤1300us	TBD	0.000006	0.000013	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	0.999992	0.999972	50.18
		tR≤200us	TBD	0.000001	0.000003	
		tR≤1300us	TBD	0.000009	0.000028	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	0.999993	0.999976	50.77
		tR≤200us	TBD	0.000002	0.00001	
		tR≤1300us	TBD	0.000008	0.00002	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	0.999995	0.999983	50.43
		tR≤200us	TBD	0.000001	0.000006	
		tR≤1300us	TBD	0.000005	0.000017	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram
(EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)



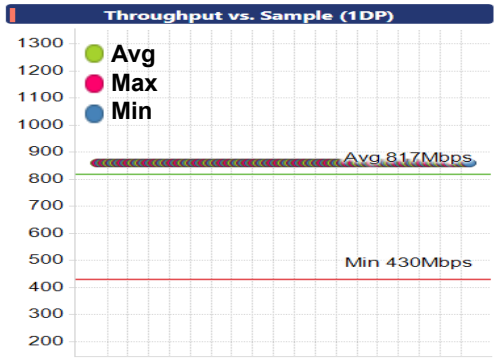
TLC (Sequential Throughput) – X-Ray TLC Type2

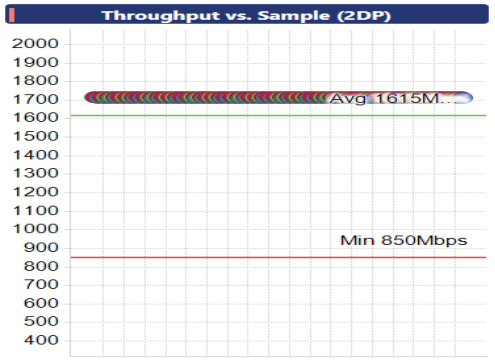
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type2

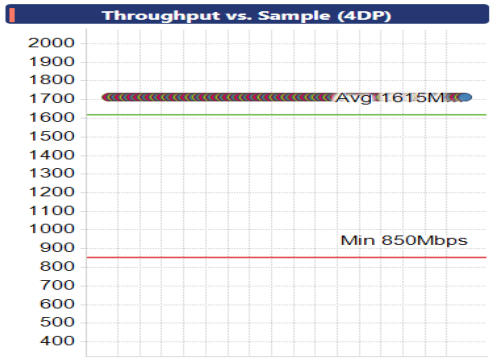
- Throughput Measurement Table

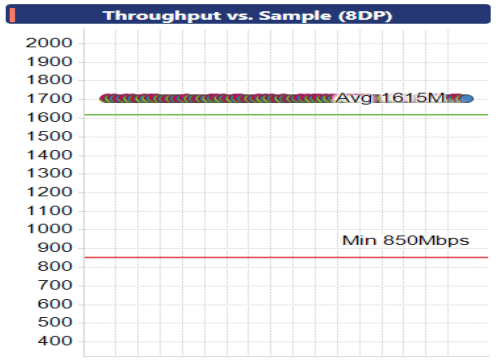
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 300	Initial	860.94	860.69	860	1714.94	1714.88	1714	1714.96	1714.06	1714	1706.23	1705.19	1704
	X-Ray 1Gr + EW + RD100K + 3Months	860.53	859.31	856	1713.84	1710.13	1701	1713.51	1711.94	1704	1706.43	1704.69	1700

- Throughput vs. Sample(PKG) (Initial)

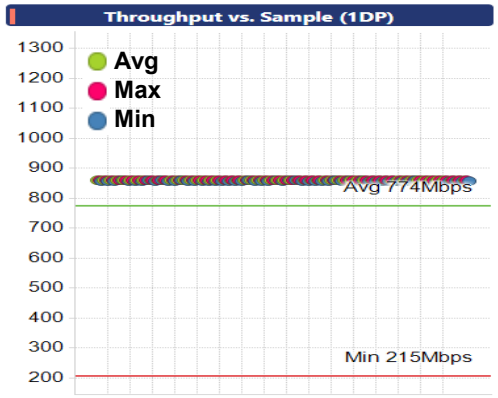


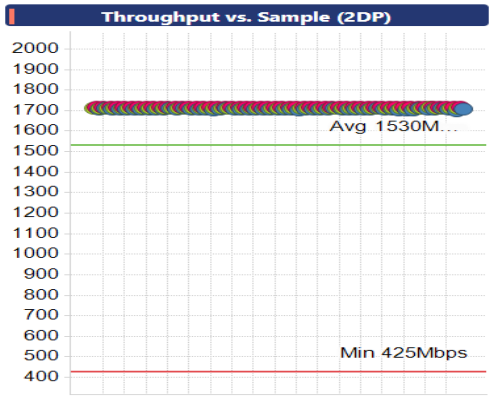


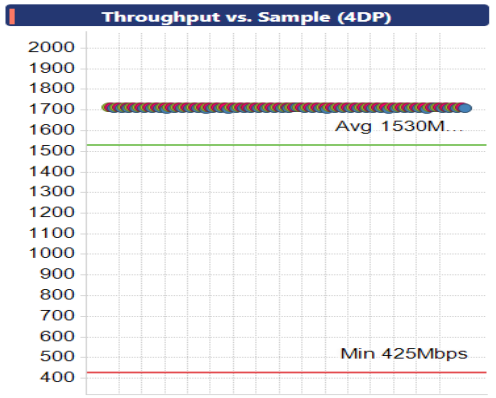


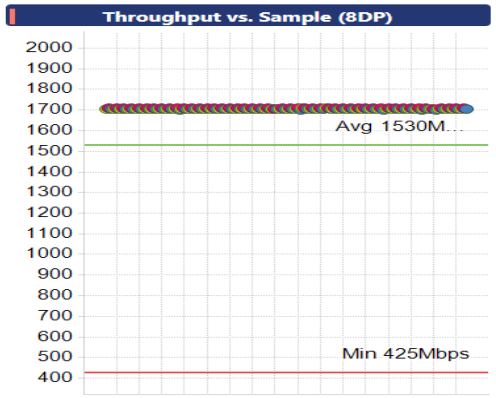


- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Months)









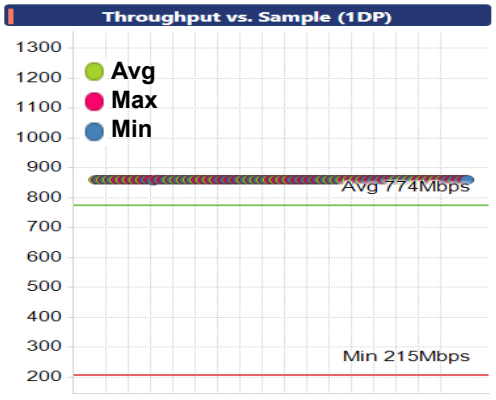
TLC (RC Throughput) – X-Ray TLC Type2

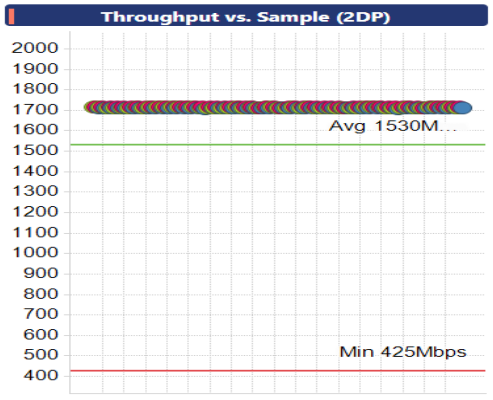
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type2

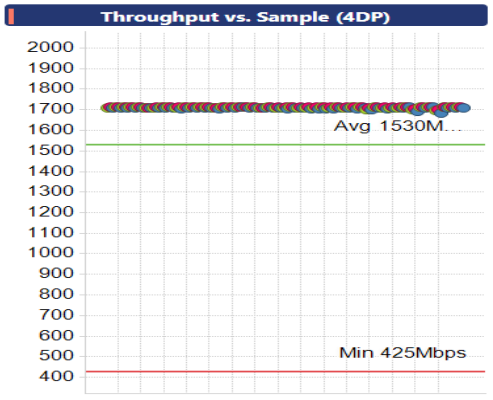
- Throughput Measurement Table

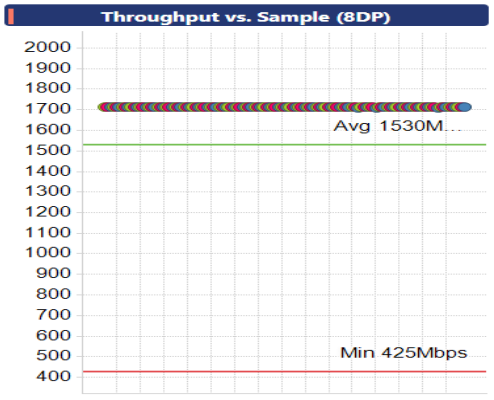
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 300	X-Ray 1Gr + EW + RD100K + 3Months	860.49	859.75	857	1714.23	1711	1706	1711.13	1696.25	1685	1712.62	1711.75	1711

- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Months)









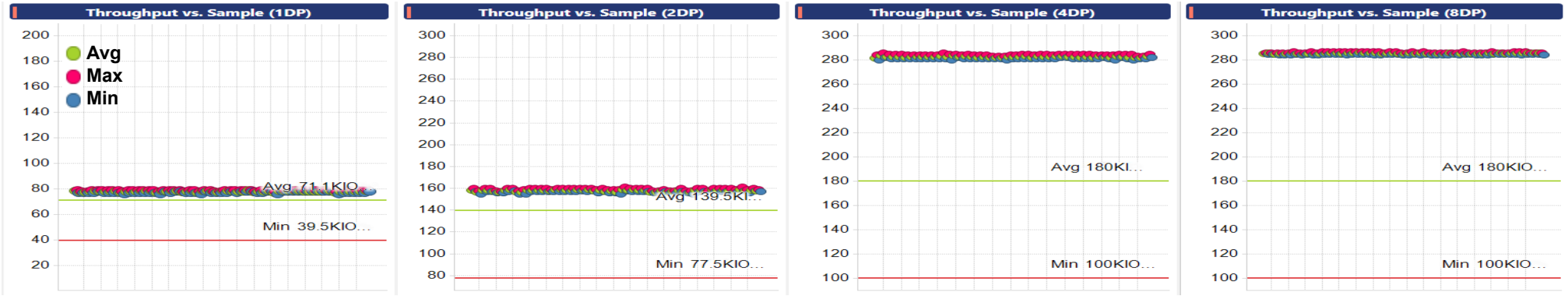
TLC (RR Throughput) – X-Ray TLC Type2

☑ Throughput Test satisfied with checkpoint X-Ray TLC Type2

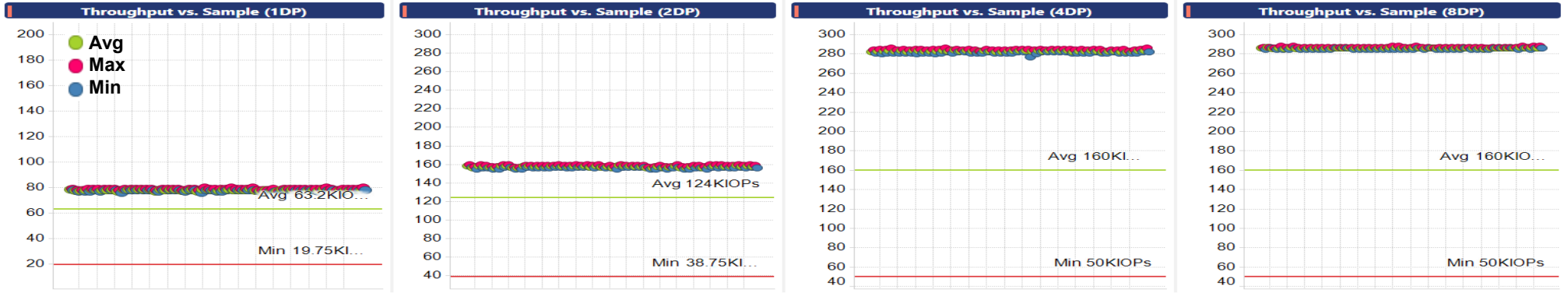
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 300	Initial	78.12	76.81	76	157.91	156.19	155	282.63	281.5	280	285.49	284.88	284
	X-Ray 1Gr + EW + RD100K + 3Months	78.11	76.69	76	157.64	155.94	155	283.01	282	277	286.21	285.44	285

- Throughput vs. Sample(PKG) (Initial)



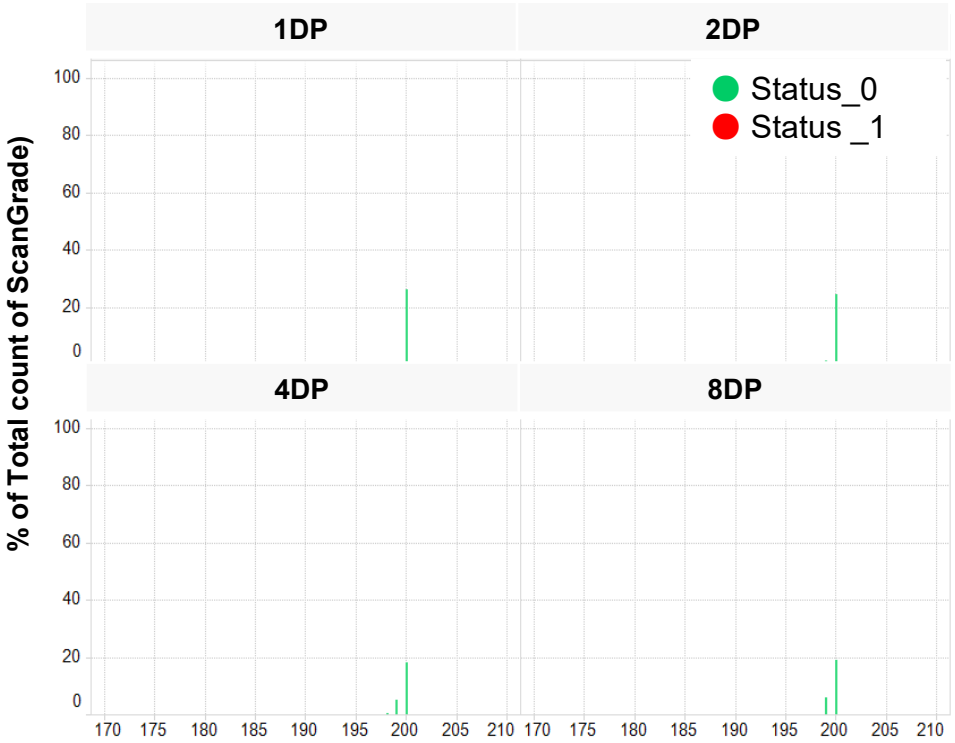
- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Months)



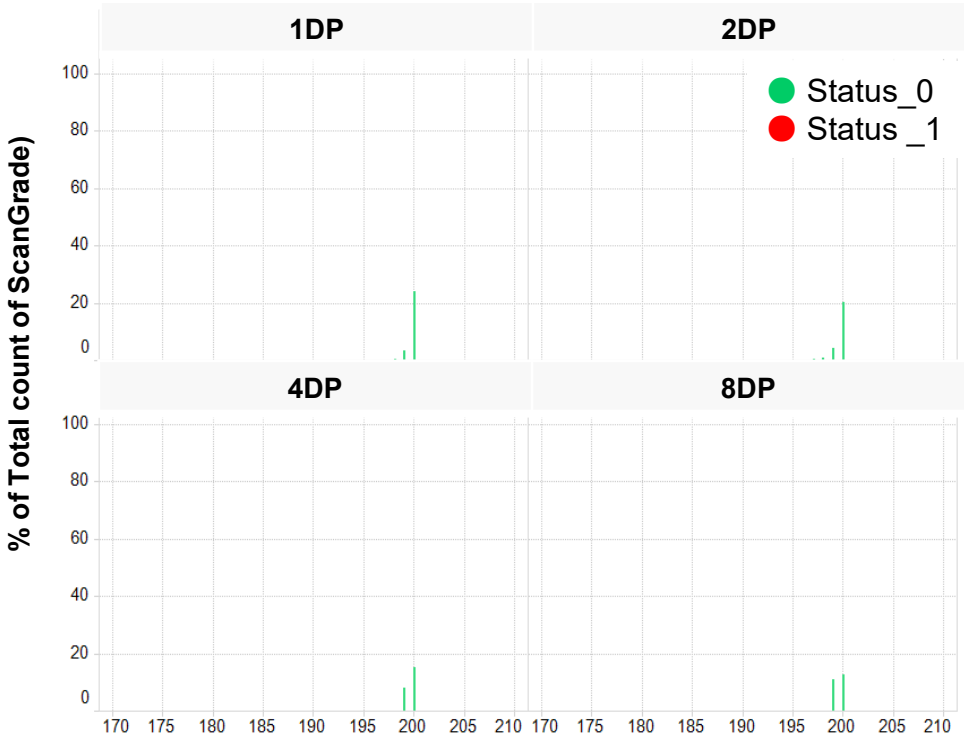
TLC (Read Scan) – X-Ray TLC Type2

☑ Read Scan satisfied with checkpoint X-Ray TLC Type2

● Read Scan Histogram (EW)



● Read Scan Histogram
(X-Ray 1Gr + EW + RD100K + 3Months)

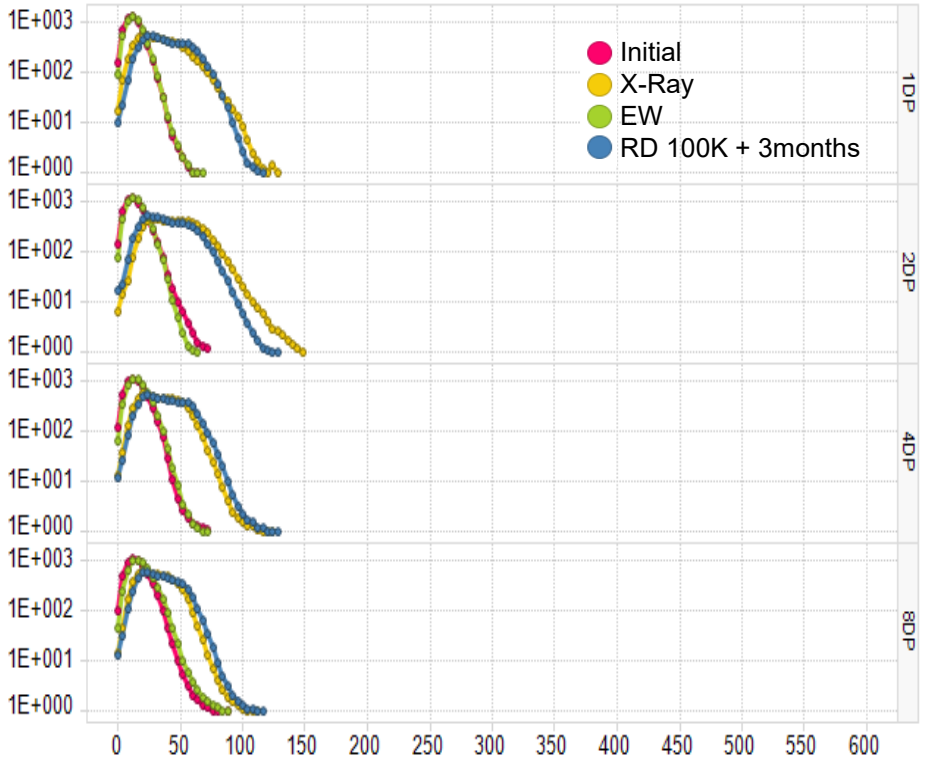


TLC (EOL Latency) – X-Ray TLC Type2

☑ Read latency satisfied with checkpoint X-Ray TLC Type2

ITEM	Stack	Bin	Apple Spec	X-Ray 1Gr + EW + RD100K + 3Months		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray TLC Type2	1DP	tR≤160us	TBD	0.999991	0.999975	50.17
		tR≤200us	TBD	0.000001	0.000003	
		tR≤1300us	TBD	0.000009	0.000024	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	0.999988	0.999968	50.24
		tR≤200us	TBD	0.000001	0.000003	
		tR≤1300us	TBD	0.000012	0.00003	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	0.99999	0.999973	50.65
		tR≤200us	TBD	0.000001	0.000006	
		tR≤1300us	TBD	0.00001	0.000027	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	0.999991	0.999974	50.56
		tR≤200us	TBD	0.000001	0.000005	
		tR≤1300us	TBD	0.000009	0.000022	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram
(X-Ray 1Gr + EW + RD100K + 3Months)



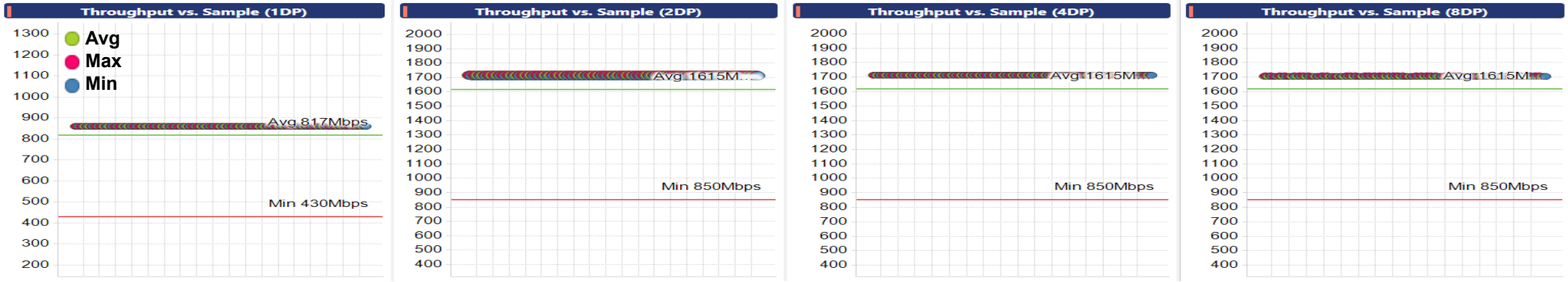
TLC (Sequential Throughput) – X-Ray TLC Type3 (1M)

☑ Throughput Test satisfied with checkpoint X-Ray TLC Type3 (1M)

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	860.93	860.63	859	1714.94	1714.94	1714	1714.87	1713.75	1713	1706.27	1704.94	1704
	X-Ray 1Gr + EW + RD100K + 1Month	860.48	859.56	854	1714.01	1712.5	1701	1713.49	1711.56	1707	1706.38	1705	1700

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 1Month)

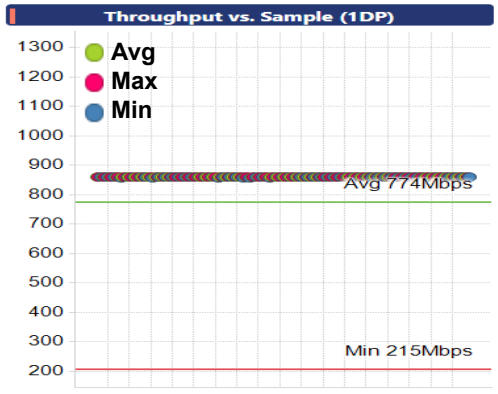
TLC (RC Throughput) – X-Ray TLC Type3 (1M)

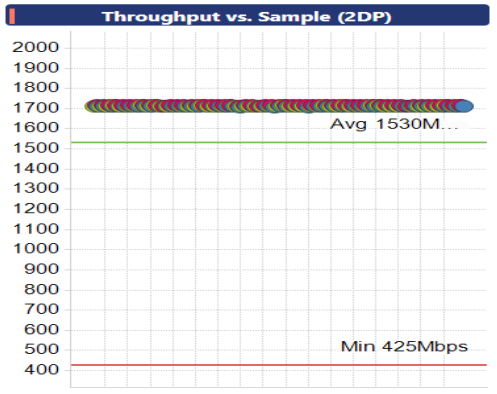
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type3 (1M)

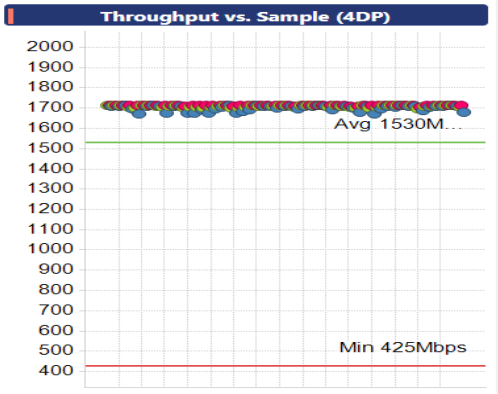
- Throughput Measurement Table

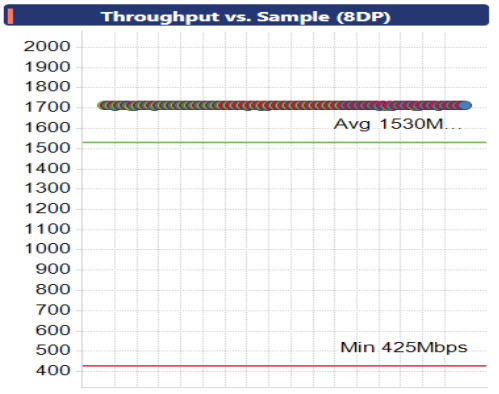
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	X-Ray 1Gr + EW + RD100K + 1Month	860.36	859.25	857	1714.1	1713	1710	1709.15	1695	1671	1712.55	1711.25	1711

- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 1Month)









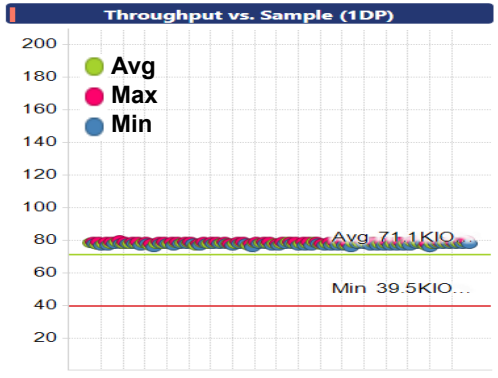
TLC (RR Throughput) – X-Ray TLC Type3 (1M)

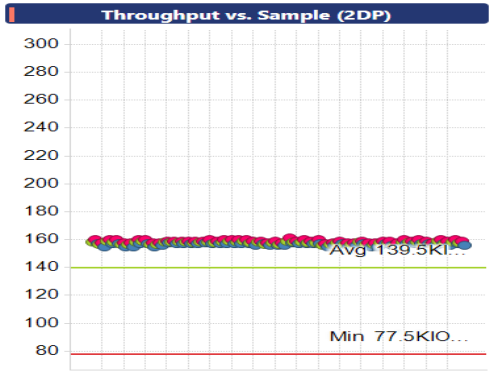
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type3 (1M)

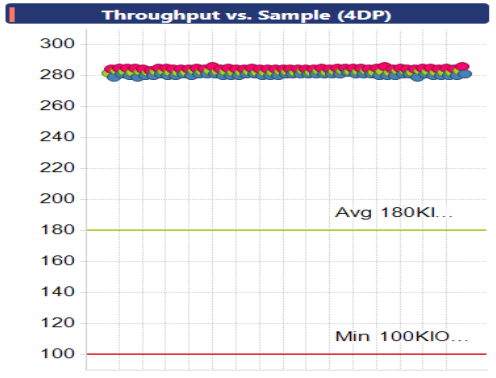
- Throughput Measurement Table

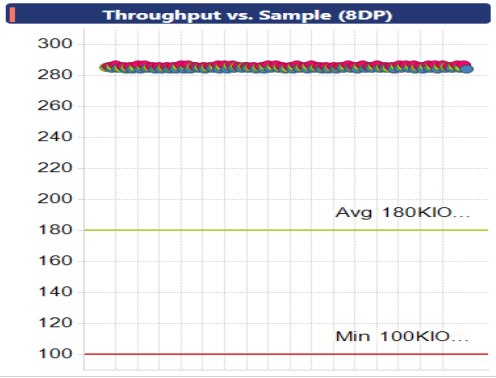
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	78.16	76.94	76	157.71	156	155	282.49	281.38	279	285.49	284.69	284
	X-Ray 1Gr + EW + RD100K + 1Month	78.14	76.81	76	157.63	155.94	155	282.5	281.56	279	285.68	284.81	284

- Throughput vs. Sample(PKG) (Initial)

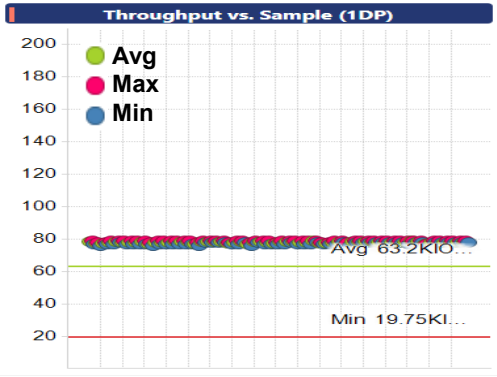


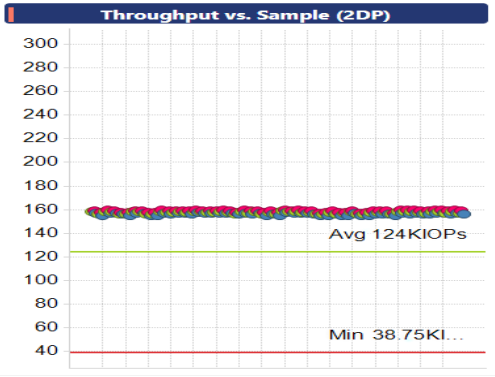


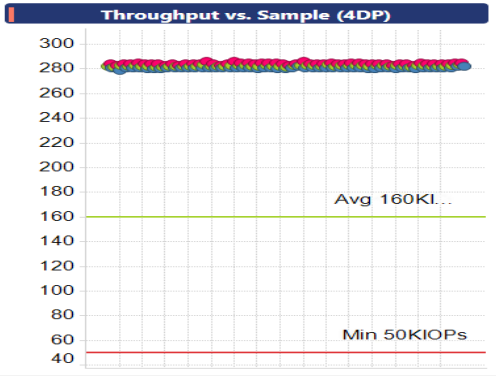


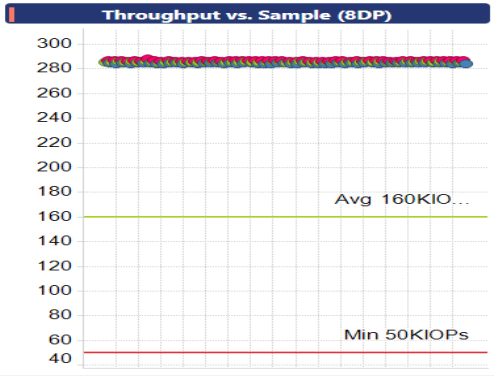


- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 1Month)





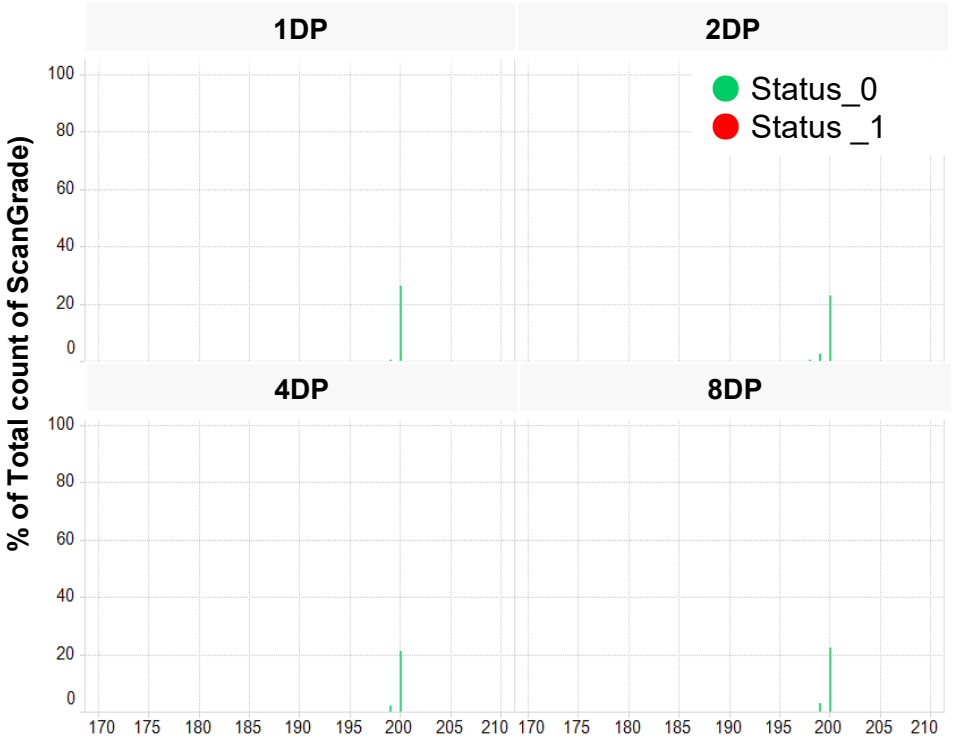




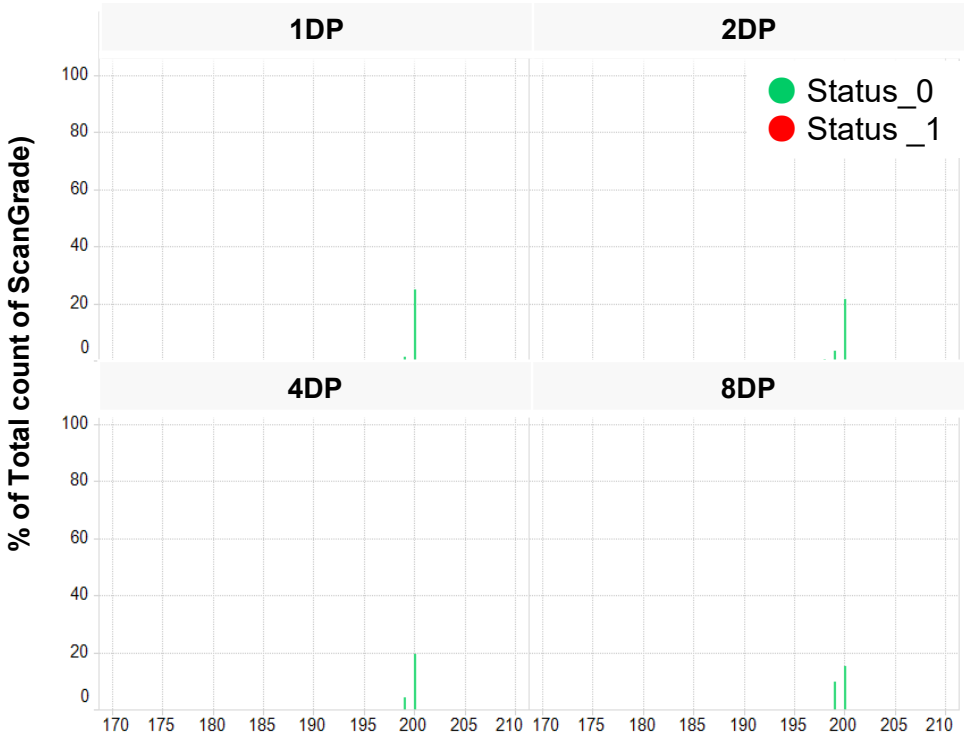
TLC (Read Scan) – X-Ray TLC Type3 (1M)

☑ Read Scan satisfied with checkpoint X-Ray TLC Type3 (1M)

● Read Scan Histogram (EW)



● Read Scan Histogram
(X-Ray 1Gr + EW + RD100K + 1Month)

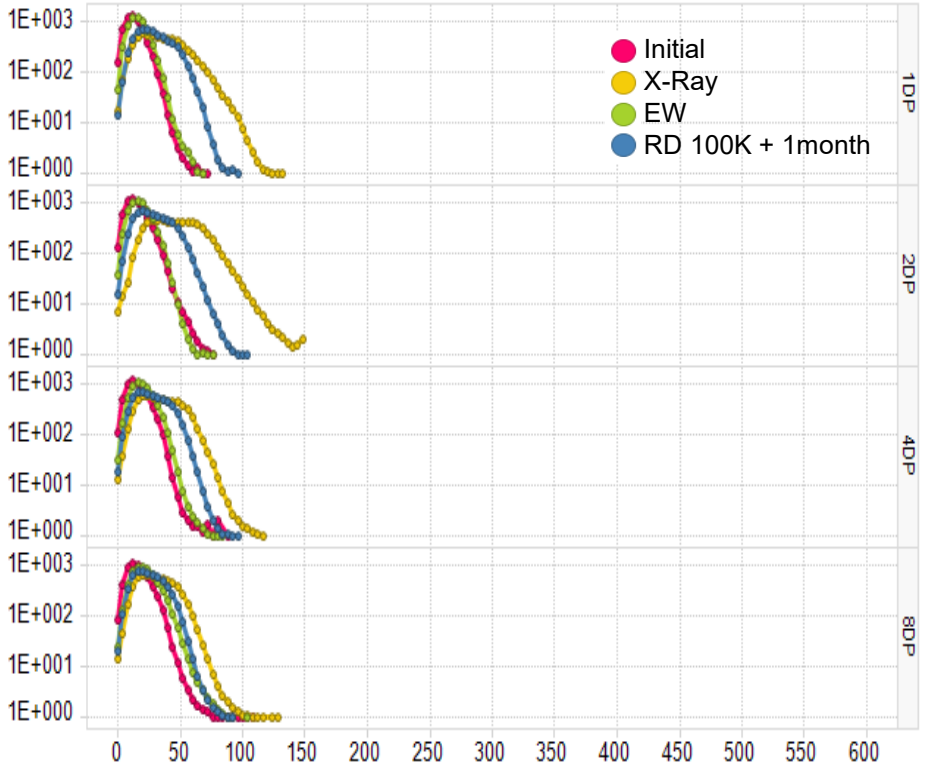


TLC (EOL Latency) – X-Ray TLC Type3 (1M)

☑ Read latency satisfied with checkpoint X-Ray TLC Type3 (1M)

ITEM	Stack	Bin	Apple Spec	X-Ray 1Gr + EW + RD100K + 1Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray TLC Type3 (1M)	1DP	tR≤160us	TBD	0.999997	0.999994	50.10
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	0.000003	0.000006	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	0.999997	0.999989	50.09
		tR≤200us	TBD	-	-	
		tR≤1300us	TBD	0.000004	0.000001	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	0.999998	0.999991	50.56
		tR≤200us	TBD	0.000001	0.000001	
		tR≤1300us	TBD	0.000003	0.000009	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	0.999997	0.999987	50.43
		tR≤200us	TBD	0.000001	0.000005	
		tR≤1300us	TBD	0.000003	0.00001	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram
(X-Ray 1Gr + EW + RD100K + 1Month)



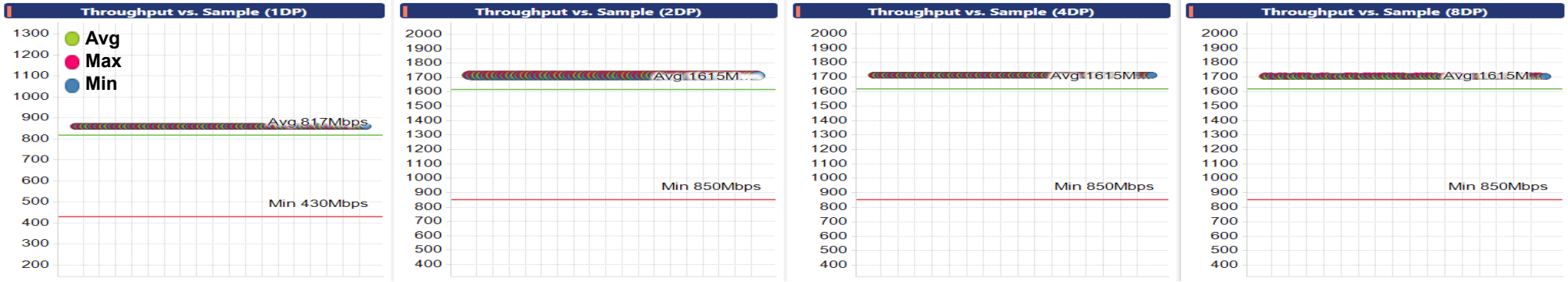
TLC (Sequential Throughput) – X-Ray TLC Type3 (3M)

☑ Throughput Test satisfied with checkpoint X-Ray TLC Type3 (3M)

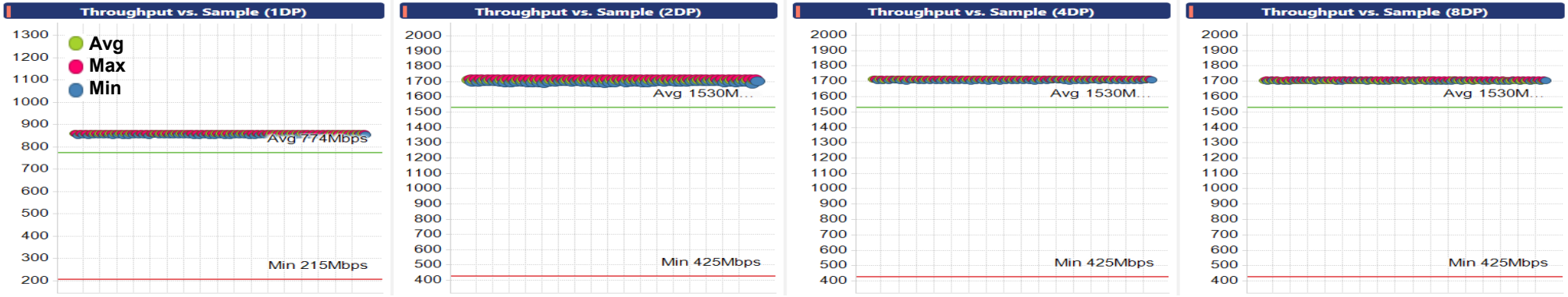
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	860.93	860.63	859	1714.94	1714.94	1714	1714.87	1713.75	1713	1706.27	1704.94	1704
	X-Ray 1Gr + EW + RD100K + 3Month	860.02	858.81	850	1713.16	1710.5	1685	1712.86	1711.5	1700	1706.3	1704.94	1699

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Month)



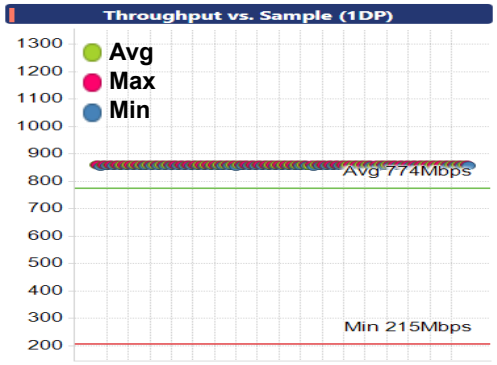
TLC (RC Throughput) – X-Ray TLC Type3 (3M)

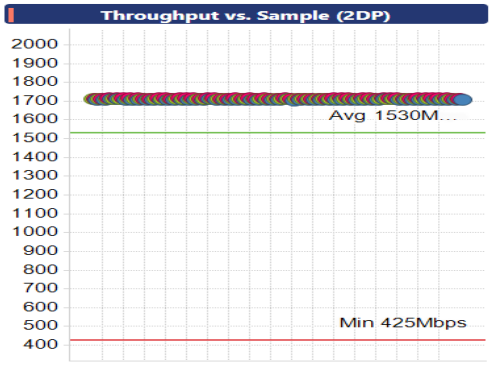
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type3 (3M)

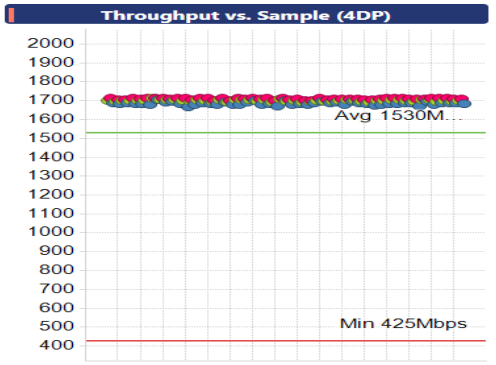
- Throughput Measurement Table

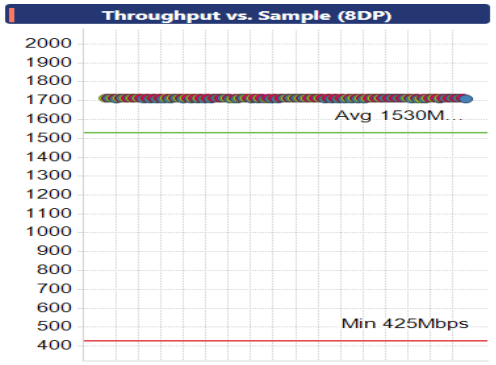
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	X-Ray 1Gr + EW + RD100K + 3Month	859.39	858	854	1712.67	1711.25	1705	1700.91	1692.25	1666	1712.31	1711.5	1710

- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Month)









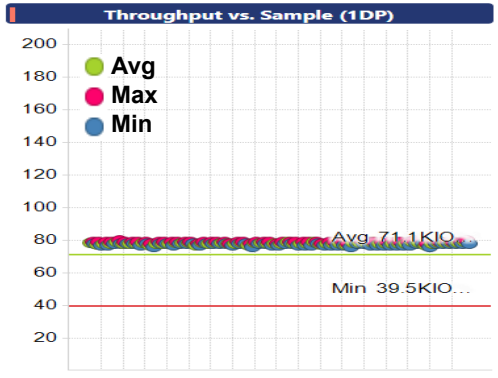
TLC (RR Throughput) – X-Ray TLC Type3 (3M)

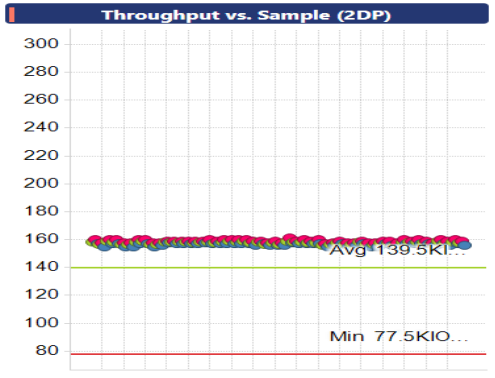
☑ Throughput Test satisfied with checkpoint X-Ray TLC Type3 (3M)

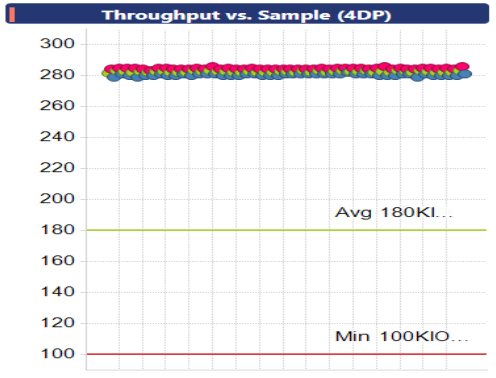
- Throughput Measurement Table

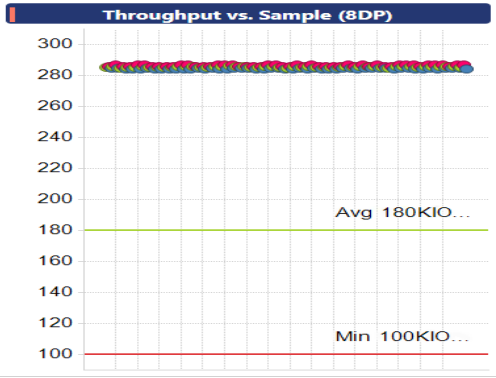
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 3K	Initial	78.16	76.94	76	157.71	156	155	282.49	281.38	279	285.49	284.69	284
	X-Ray 1Gr + EW + RD100K + 3Month	78.15	76.88	76	157.53	155.75	154	282.62	281.63	279	285.93	285.38	283

- Throughput vs. Sample(PKG) (Initial)

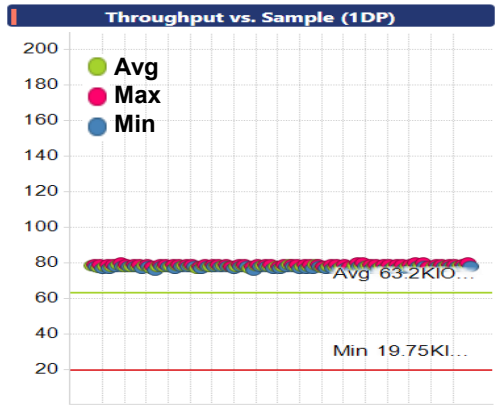


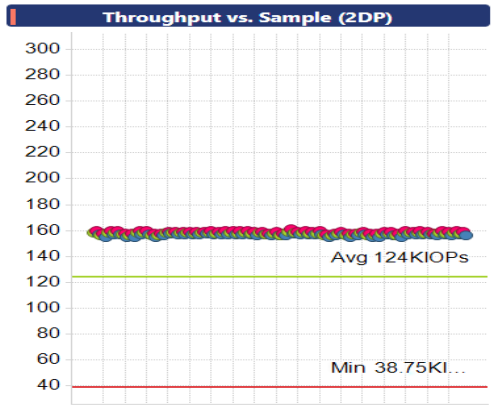


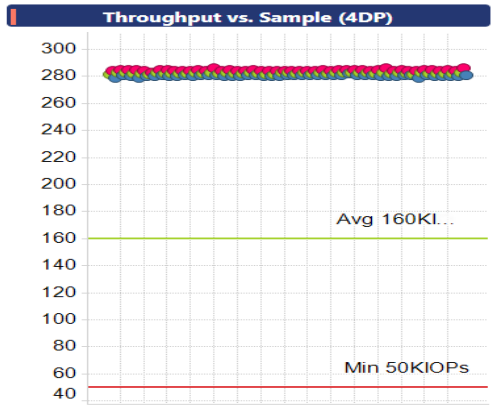


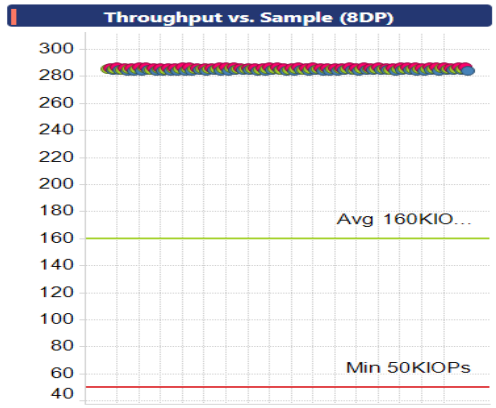


- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Month)





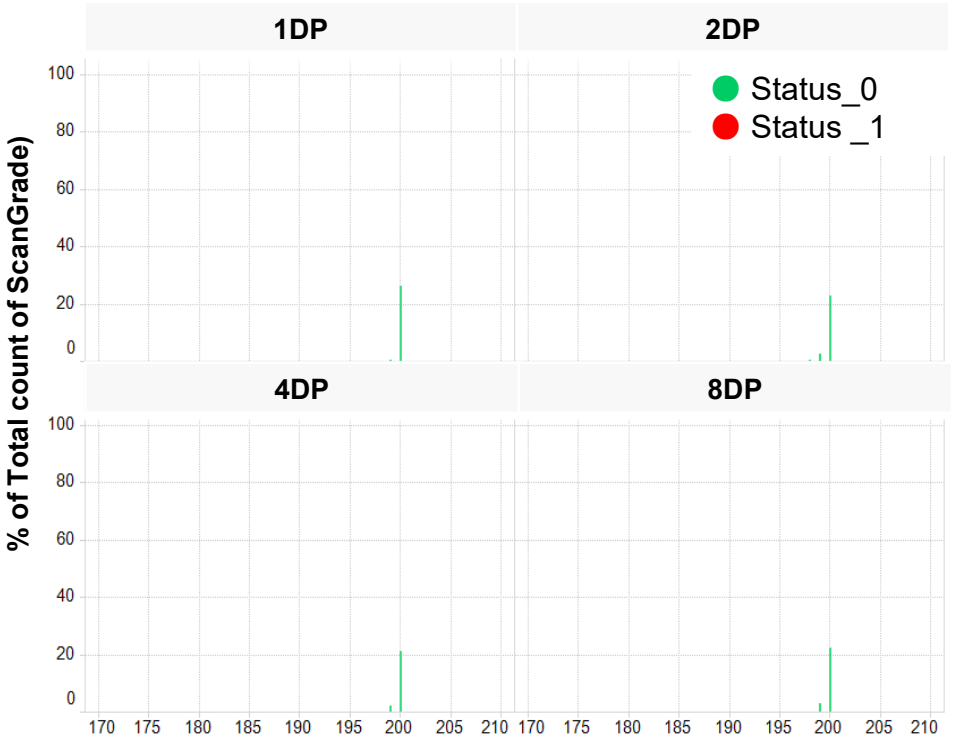




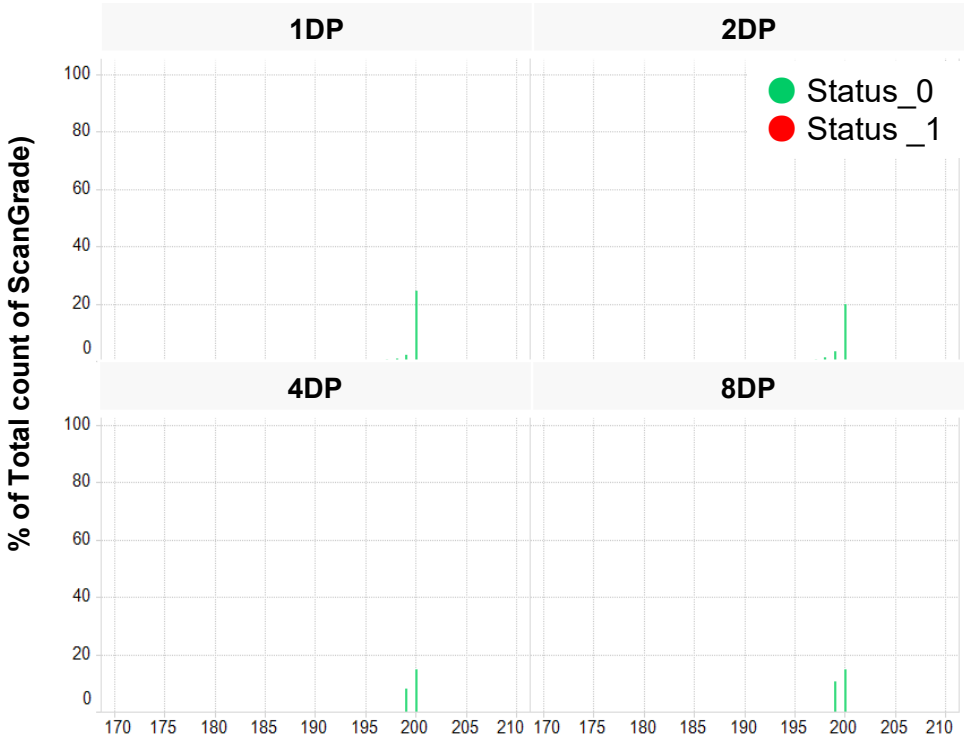
TLC (Read Scan) – X-Ray TLC Type3 (3M)

☑ Read Scan satisfied with checkpoint X-Ray TLC Type3 (3M)

● Read Scan Histogram (EW)



● Read Scan Histogram
(X-Ray 1Gr + EW + RD100K + 3Month)

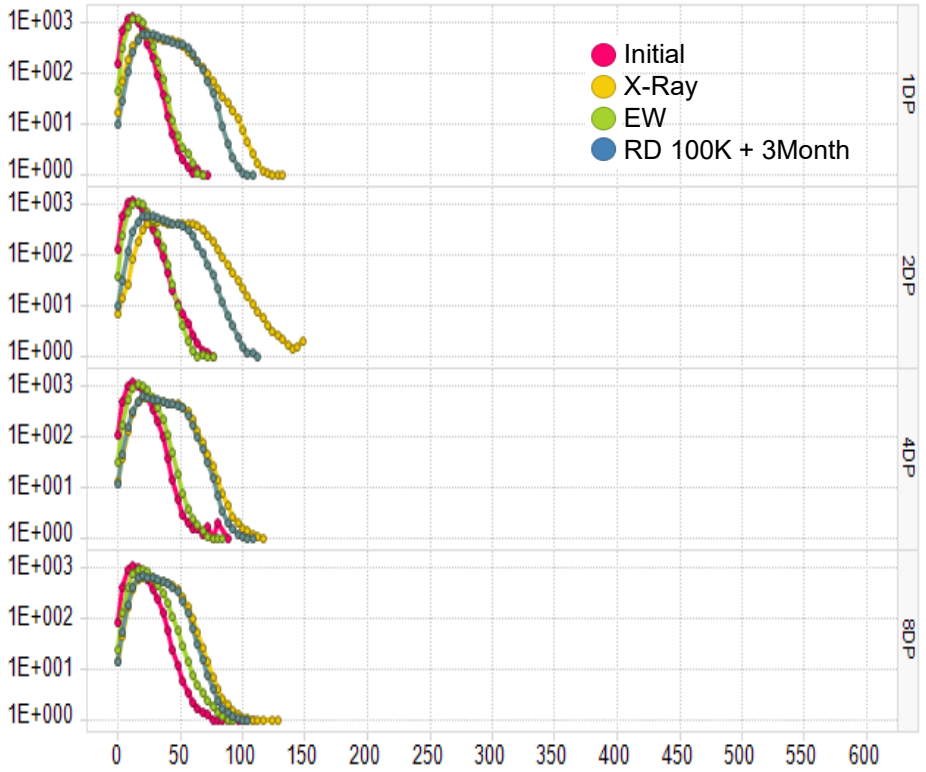


TLC (EOL Latency) – X-Ray TLC Type3 (3M)

☑ Read latency satisfied with checkpoint X-Ray TLC Type3 (3M)

ITEM	Stack	Bin	Apple Spec	X-Ray 1Gr + EW + RD100K + 3Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray TLC Type3 (3M)	1DP	tR≤160us	TBD	0.999994	0.999983	49.91
		tR≤200us	TBD	0.000001	0.000001	
		tR≤1300us	TBD	0.000006	0.000017	
		tR≤10.5ms	TBD	-	-	
	2DP	tR≤160us	TBD	0.999993	0.999982	50.05
		tR≤200us	TBD	0.000001	0.000003	
		tR≤1300us	TBD	0.000007	0.000016	
		tR≤10.5ms	TBD	-	-	
	4DP	tR≤160us	TBD	0.999994	0.999984	50.73
		tR≤200us	TBD	0.000001	0.000001	
		tR≤1300us	TBD	0.000006	0.000015	
		tR≤10.5ms	TBD	-	-	
	8DP	tR≤160us	TBD	0.999996	0.999988	50.39
		tR≤200us	TBD	0.000001	0.000002	
		tR≤1300us	TBD	0.000004	0.000011	
		tR≤10.5ms	TBD	-	-	

● Indepth Histogram
(X-Ray 1Gr + EW + RD100K + 3Month)



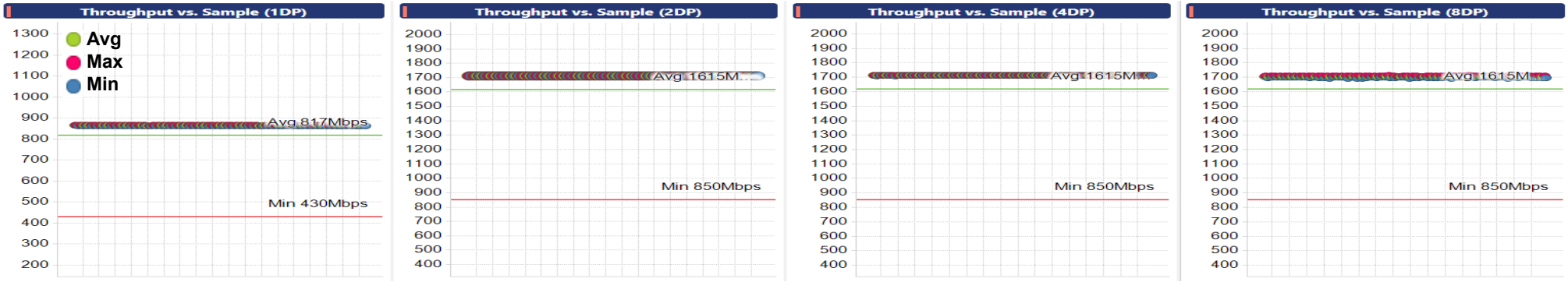
SLC (Sequential Throughput) – X-Ray SLC Type1

☑ Throughput Test satisfied with checkpoint X-Ray SLC Type1

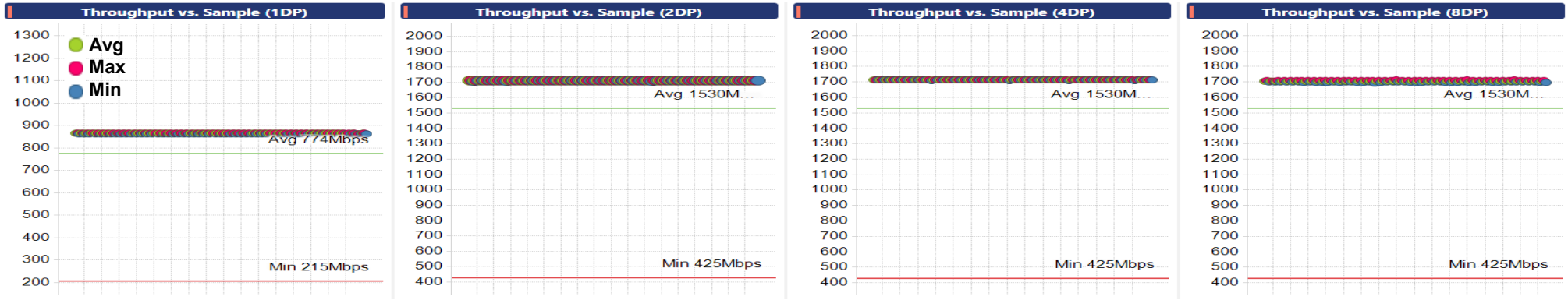
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 1	Initial	864.9	864	864	1713.94	1713.88	1712	1714.58	1714	1711	1704.73	1703.31	1693
	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months	864.91	864	864	1713.92	1713.56	1707	1714.53	1714	1711	1704.67	1703.25	1692

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)



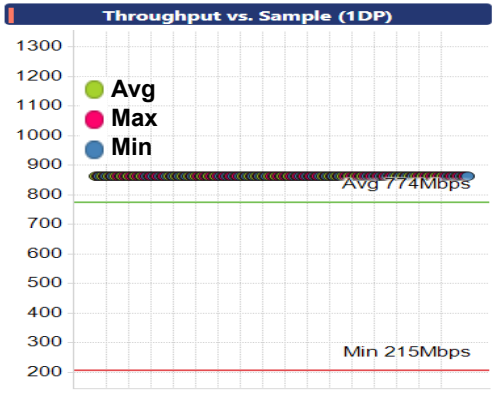
SLC (RC Throughput) – X-Ray SLC Type1

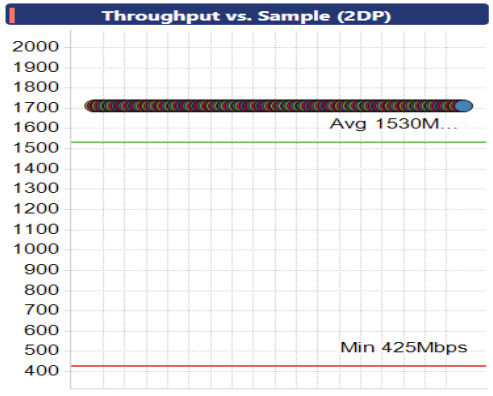
☑ Throughput Test satisfied with checkpoint X-Ray SLC Type1

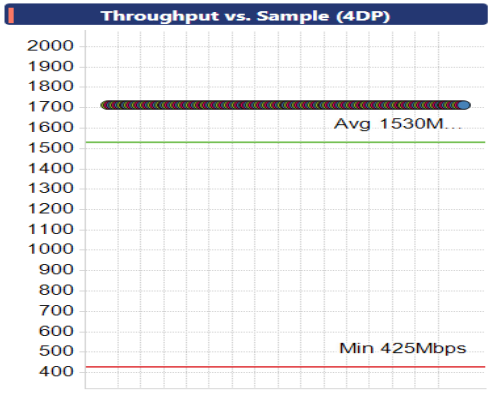
- Throughput Measurement Table

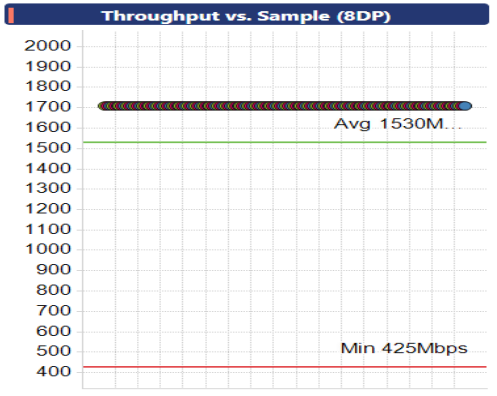
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 1	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months	864	864	864	1713.99	1713.5	1713	1714	1714	1714	1710.8	1710	1710

- Throughput vs. Sample(PKG) (EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)









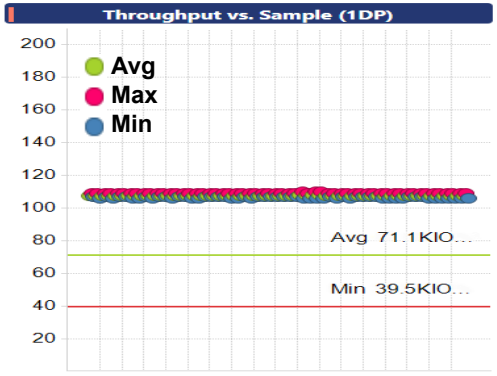
SLC (RR Throughput) – X-Ray SLC Type1

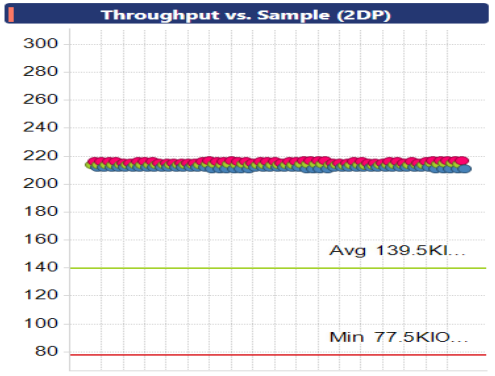
☑ Throughput Test satisfied with checkpoint X-Ray SLC Type1

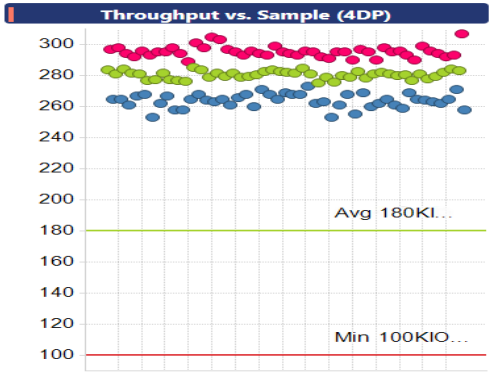
- Throughput Measurement Table

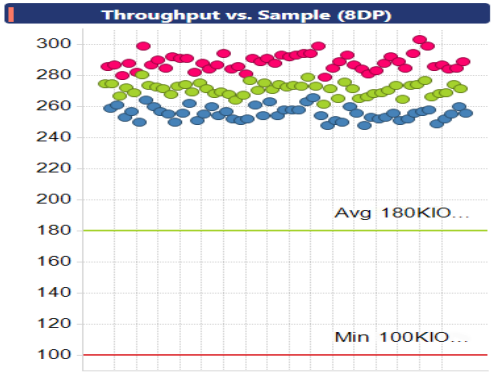
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 1	Initial	107.56	107.19	106	214.04	213.44	211	280.51	273.69	253	271.25	261.31	248
	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months	107.64	107	106	214.28	213.13	210	279.46	273.75	256	268.78	260	246

- Throughput vs. Sample(PKG) (Initial)

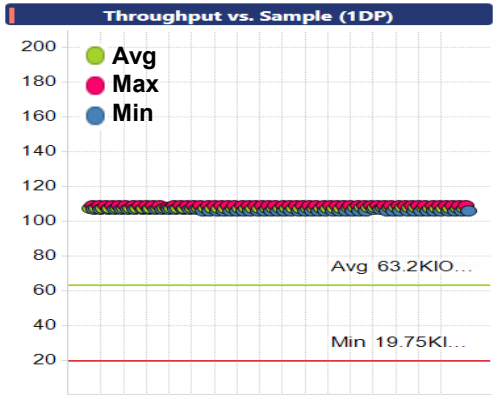


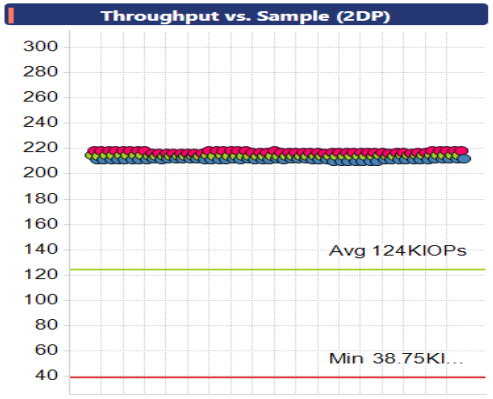


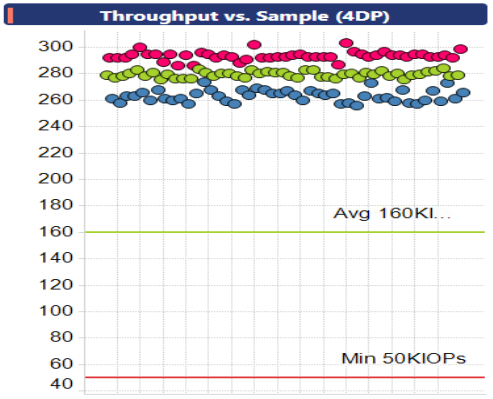


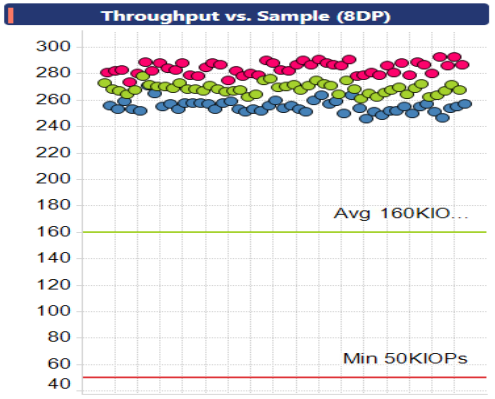


- Throughput vs. Sample(PKG) (EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)





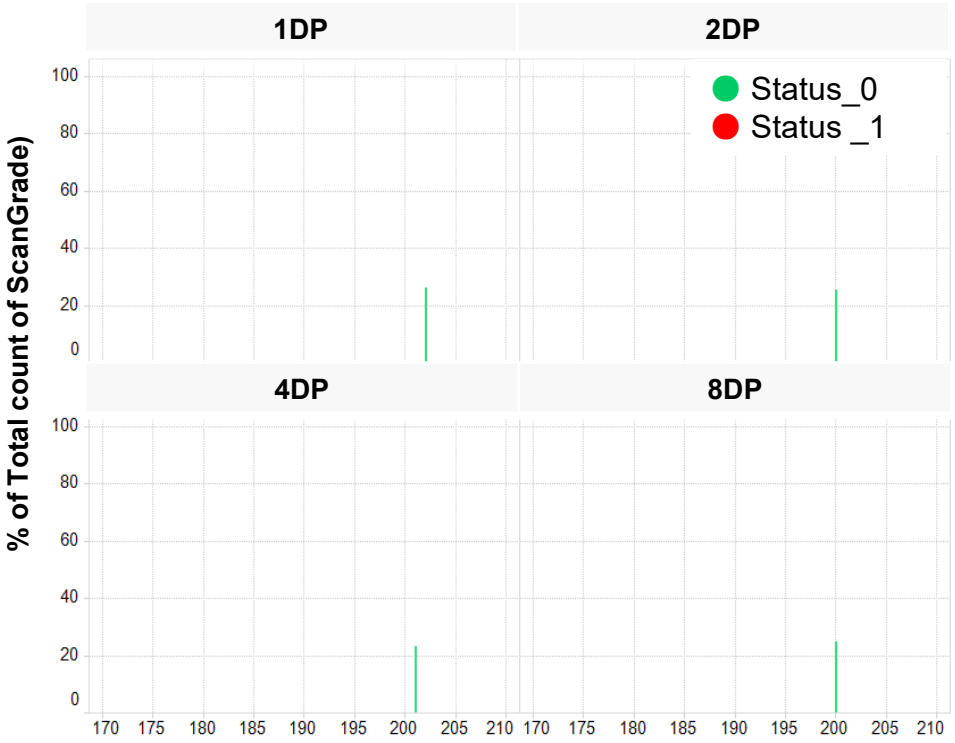




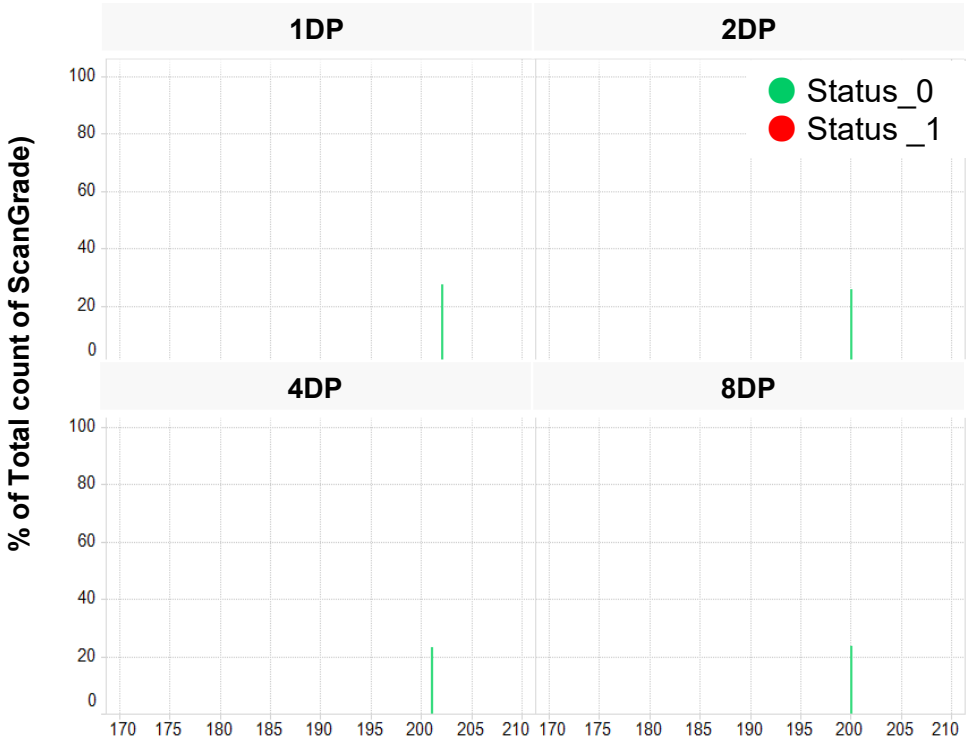
SLC (Read Scan) – X-Ray SLC Type1

☑ Read Scan satisfied with checkpoint X-Ray SLC Type1

● Read Scan Histogram (EW)



● Read Scan Histogram
(EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)

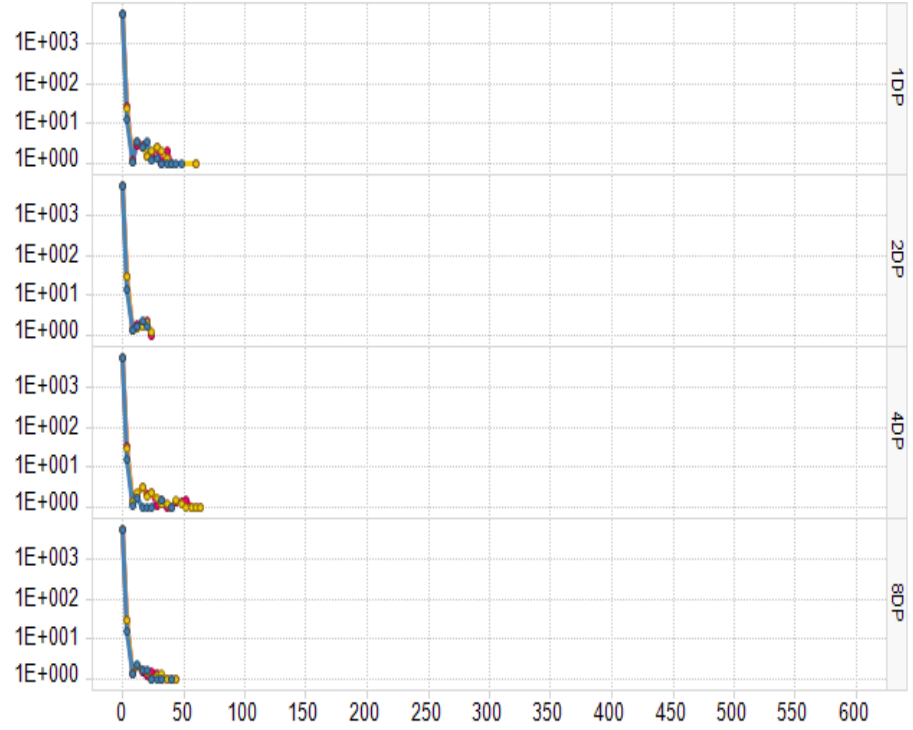


SLC (EOL Latency) – X-Ray SLC Type1

☑ Read latency satisfied with checkpoint X-Ray SLC Type1

ITEM	Stack	Bin	Apple Spec	EW 1Cycle + X-Ray 1Gr + RD100K + 3Months		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray SLC Type1	1DP	tR≤160us	TBD	1	1	30.05
	2DP	tR≤160us	TBD	1	1	30.05
	4DP	tR≤160us	TBD	1	1	30.95
	8DP	tR≤160us	TBD	1	1	30.95

● Indepth Histogram
(EW 1Cycle + X-Ray 1Gr + RD100K + 3Months)



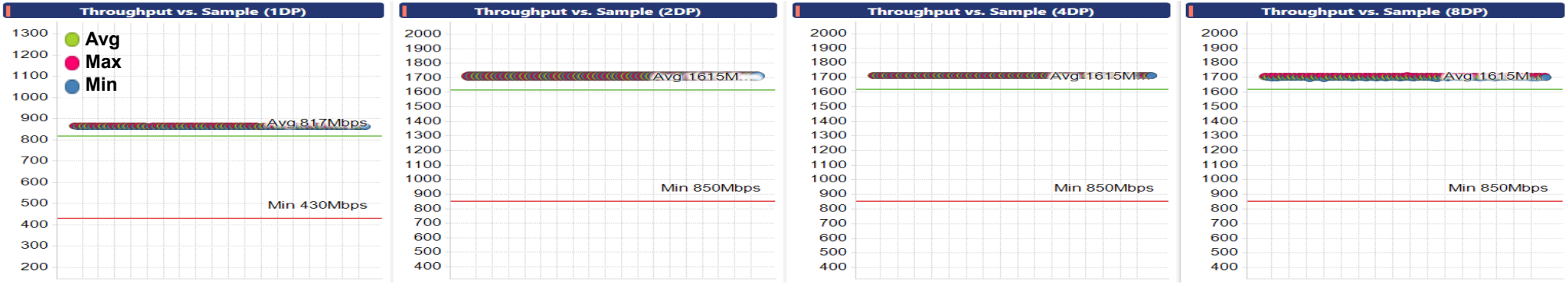
SLC (Sequential Throughput) – X-Ray SLC Type2

☑ Throughput Test satisfied with checkpoint X-Ray SLC Type2

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 10K	Initial	864.9	864	864	1713.93	1713.88	1712	1714.59	1714	1714	1704.78	1702.94	1692
	X-Ray 1Gr + EW + RD100K + 3Months	864.9	864	864	1713.93	1713.88	1712	1714.54	1714	1714	1704.7	1703.06	1695

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Months)

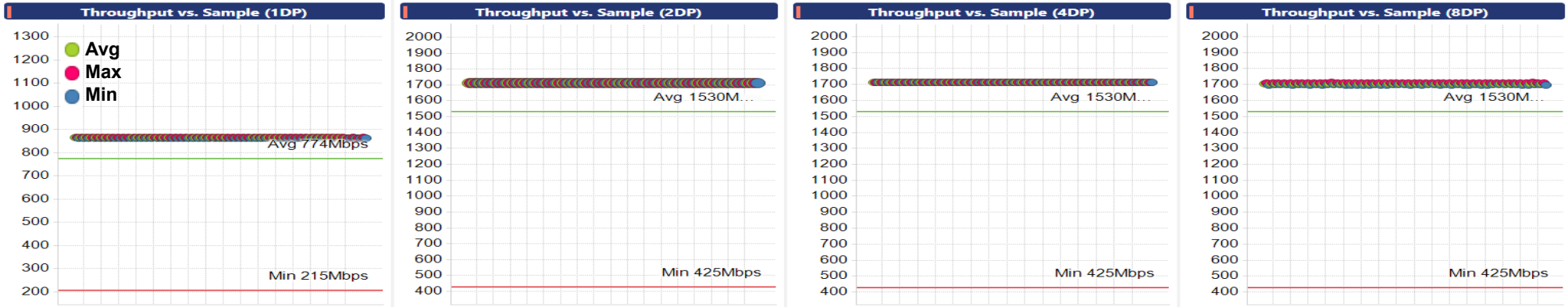
SLC (RC Throughput) – X-Ray SLC Type2

☑ Throughput Test satisfied with checkpoint X-Ray SLC Type2

- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 10K	X-Ray 1Gr + EW + RD100K + 3Months	864	864	864	1714	1714	1714	1714	1714	1714	1710.82	1710	1709

- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Months)



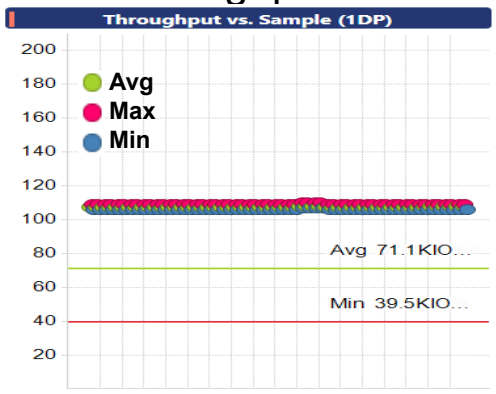
SLC (RR Throughput) – X-Ray SLC Type2

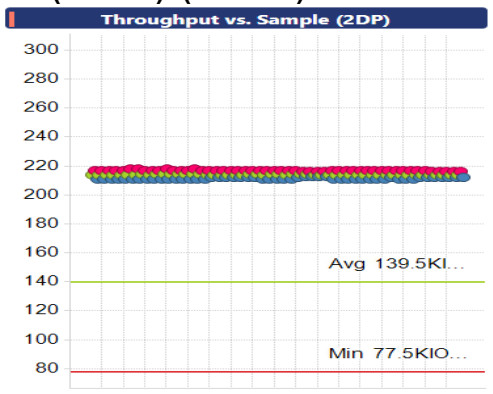
☑ Throughput Test satisfied with checkpoint X-Ray SLC Type2

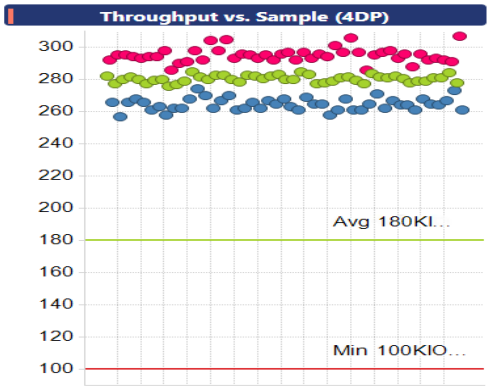
- Throughput Measurement Table

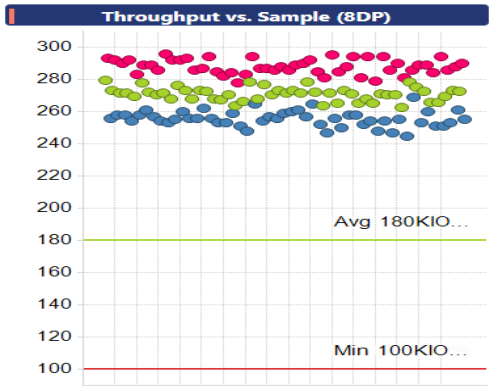
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 10K	Initial	107.57	107.06	106	214.13	213.56	211	280.38	272.63	257	270.98	261.63	245
	X-Ray 1Gr + EW + RD100K + 3Months	107.84	107.38	106	214.33	213.19	210	280.25	272.13	256	269.01	260	248

- Throughput vs. Sample(PKG) (Initial)

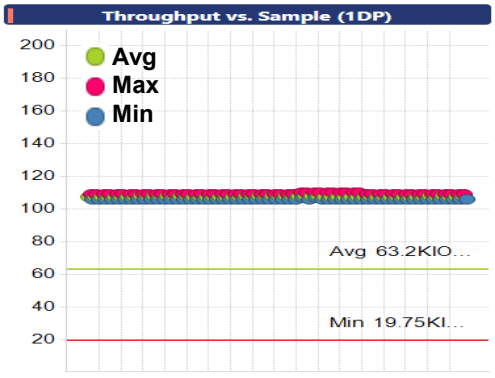


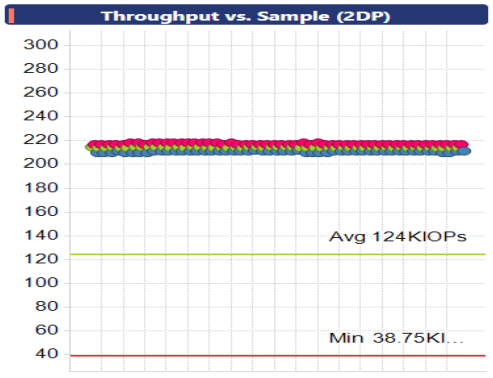


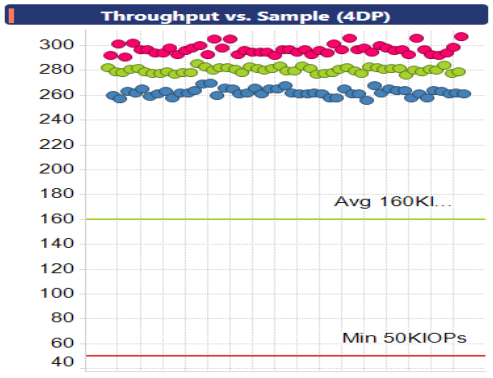


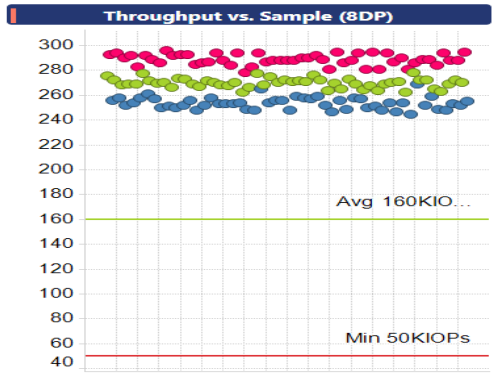


- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Months)





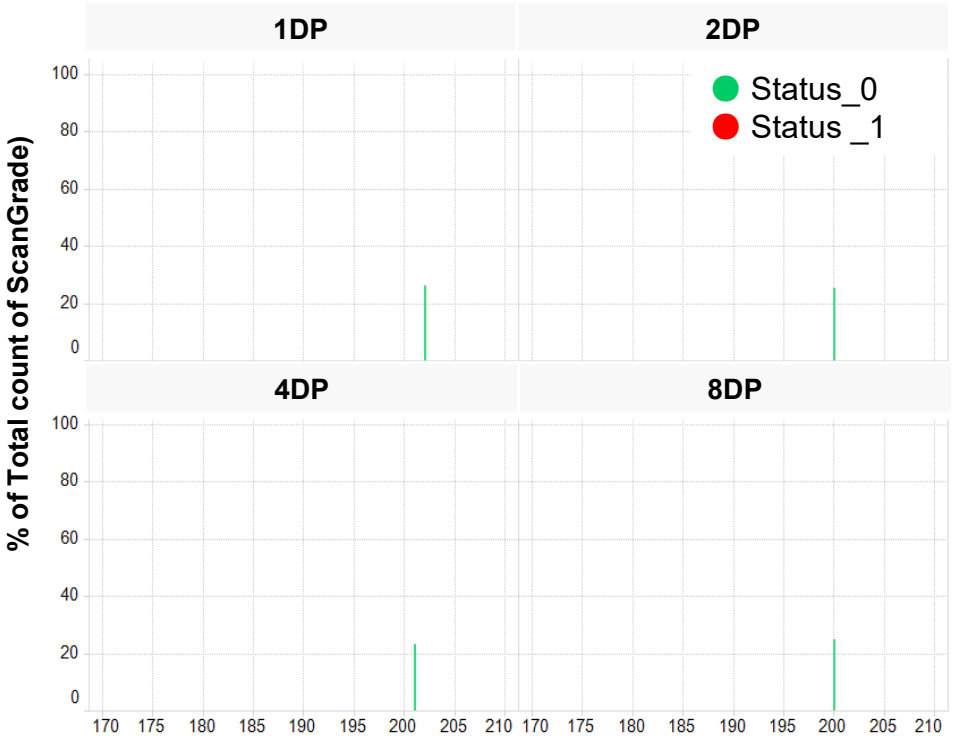




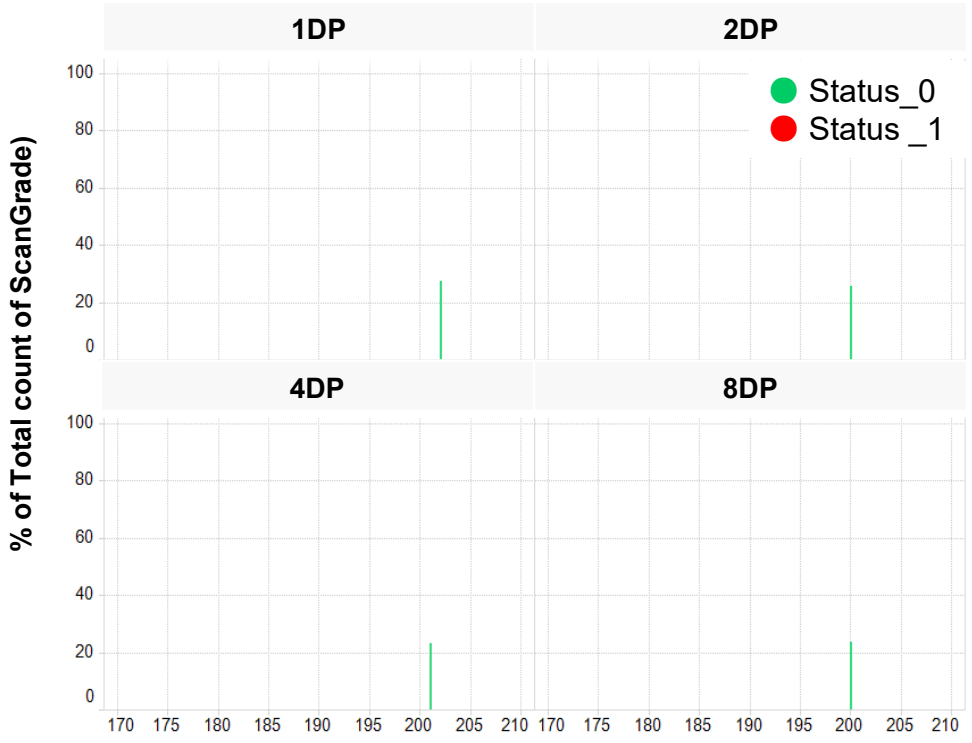
SLC (Read Scan) – X-Ray SLC Type2

☑ Read Scan satisfied with checkpoint X-Ray SLC Type2

● Read Scan Histogram (EW)



● Read Scan Histogram
(X-Ray 1Gr + EW + RD100K + 3Months)

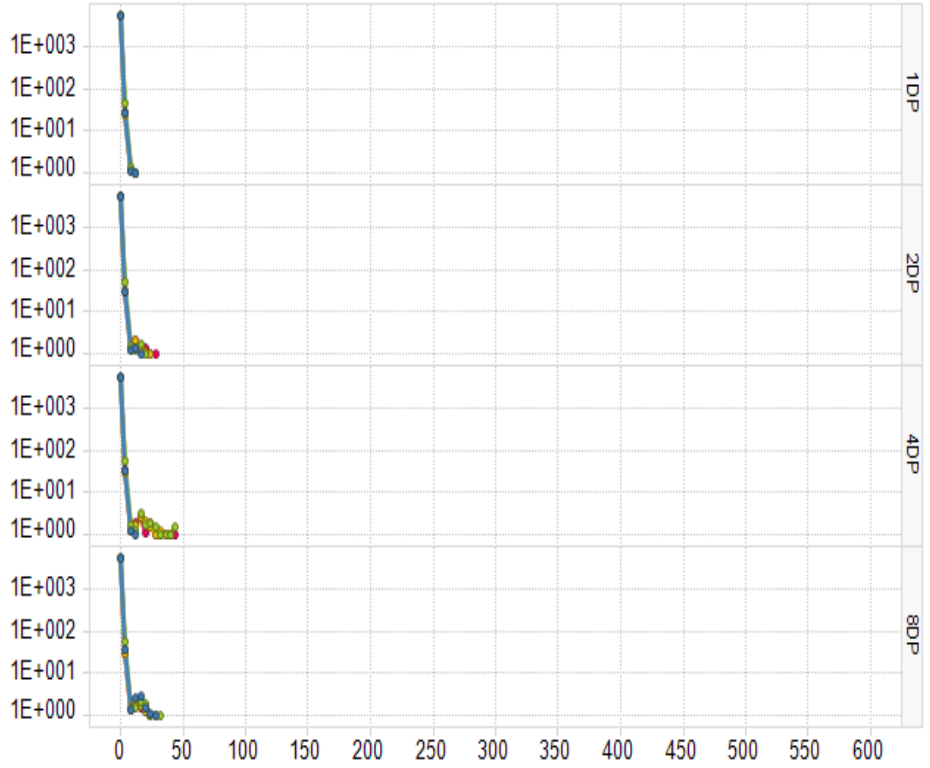


SLC (EOL Latency) – X-Ray SLC Type2

☑ Read latency satisfied with checkpoint X-Ray SLC Type2

ITEM	Stack	Bin	Apple Spec	X-Ray 1Gr + EW + RD100K + 3Months		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray SLC Type2	1DP	tR≤160us	TBD	1	1	30.07
	2DP	tR≤160us	TBD	1	1	30.07
	4DP	tR≤160us	TBD	1	1	31.03
	8DP	tR≤160us	TBD	1	1	31.00

● Indepth Histogram
(X-Ray 1Gr + EW + RD100K + 3Months)



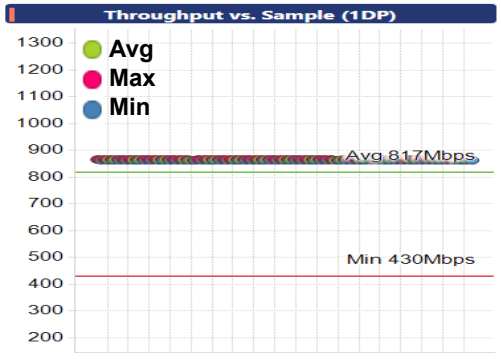
SLC (Sequential Throughput) – X-Ray SLC Type3 (1M)

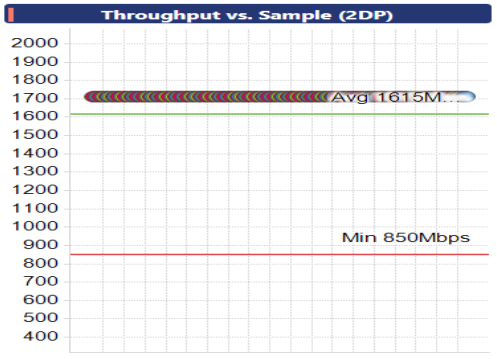
☑ Throughput Test satisfied with checkpoint X-Ray SLC Type3 (1M)

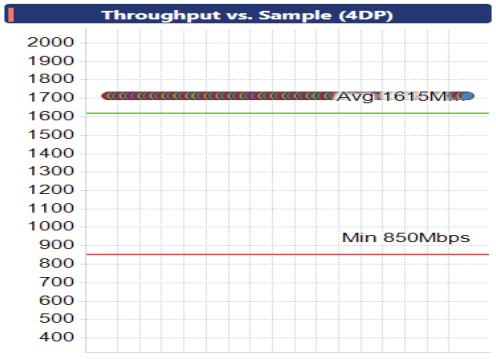
- Throughput Measurement Table

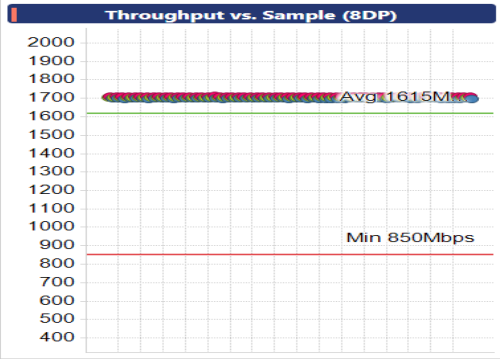
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	864.91	864	864	1713.93	1713.88	1712	1714.55	1714	1714	1704.86	1702.94	1696
	X-Ray 1Gr + EW + RD100K + 1Month	864.9	864	864	1713.93	1713.56	1707	1714.56	1714.13	1713	1704.83	1702.69	1695

- Throughput vs. Sample(PKG) (Initial)

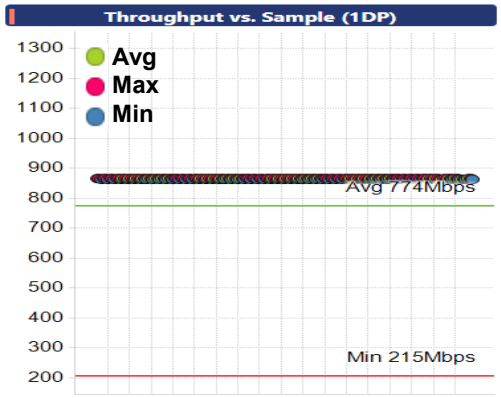


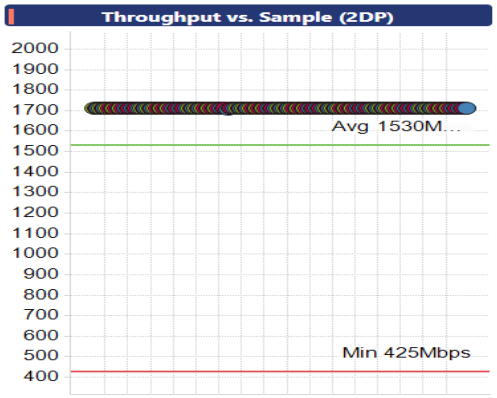


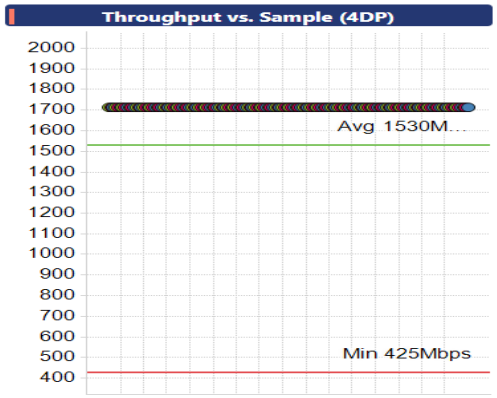


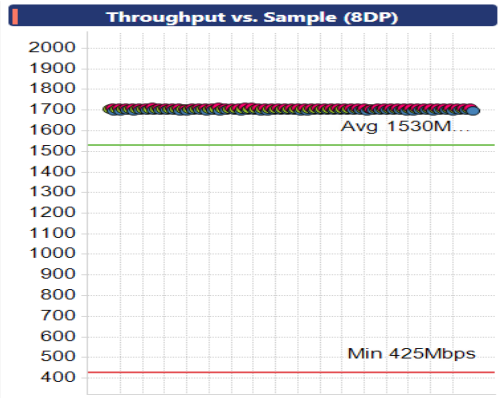


- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 1Month)









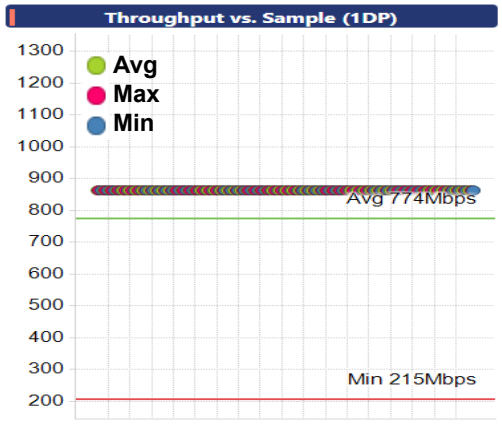
SLC (RC Throughput) – X-Ray SLC Type3 (1M)

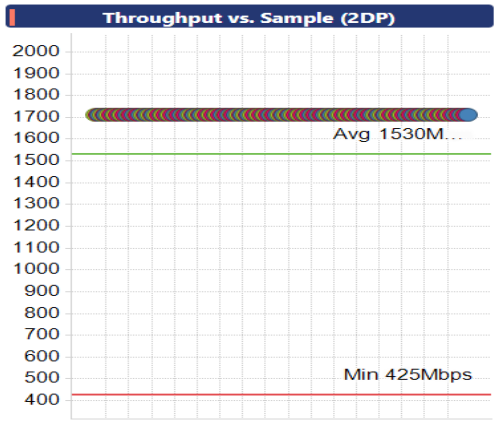
☑ Throughput Test satisfied with checkpoint X-Ray SLC Type3 (1M)

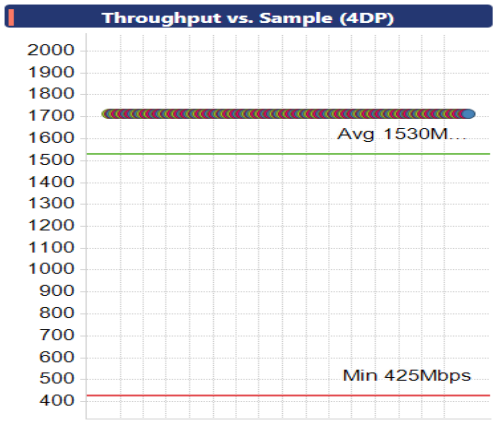
- Throughput Measurement Table

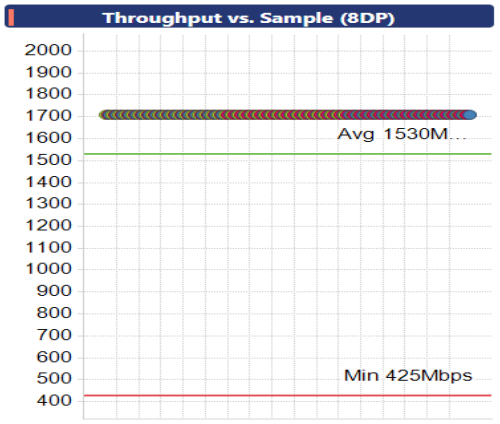
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	X-Ray 1Gr + EW + RD100K + 1Month	864	864	864	1714	1714	1714	1714	1714	1714	1710.85	1710.5	1710

- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 1Month)









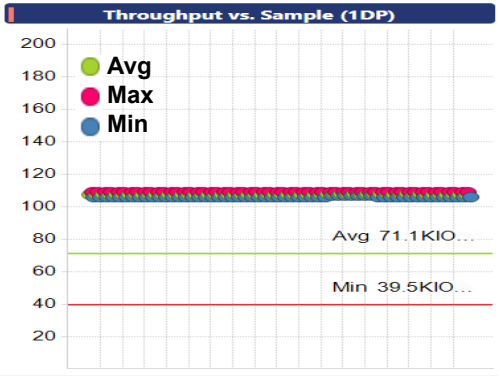
SLC (RR Throughput) – X-Ray SLC Type3 (1M)

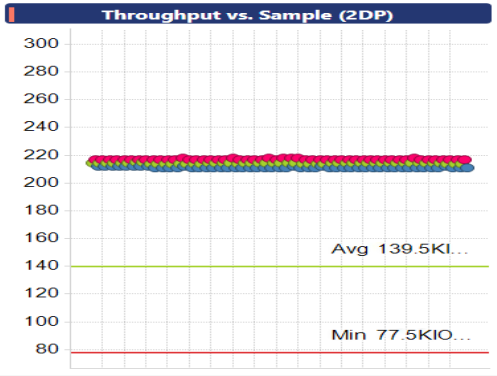
☑ Throughput Test satisfied with checkpoint X-Ray SLC Type3 (1M)

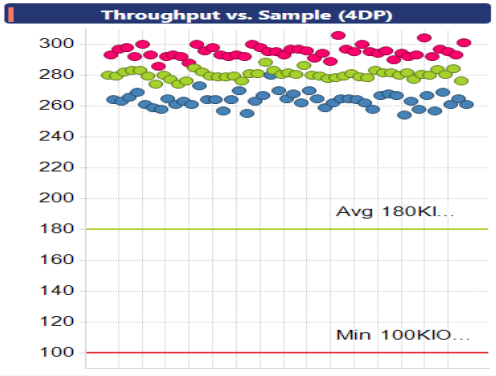
- Throughput Measurement Table

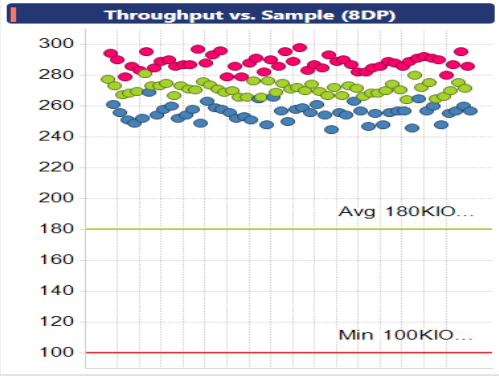
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	107.66	107	106	214.41	213.56	211	280.16	273.06	254	271.16	261.31	245
	X-Ray 1Gr + EW + RD100K + 1Month	107.68	106.81	105	214.06	213.19	208	280.27	273.63	255	270.31	260.13	246

- Throughput vs. Sample(PKG) (Initial)

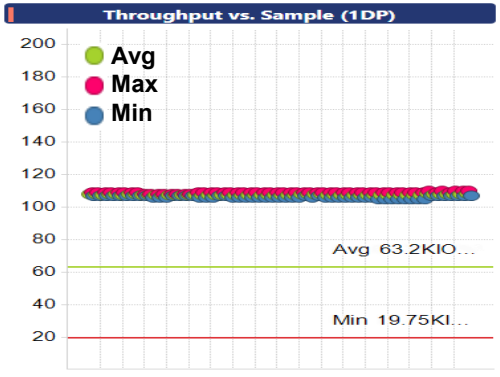


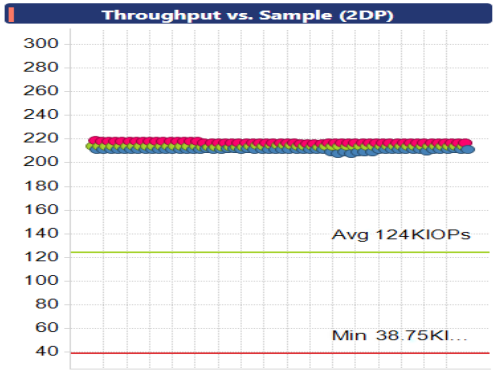


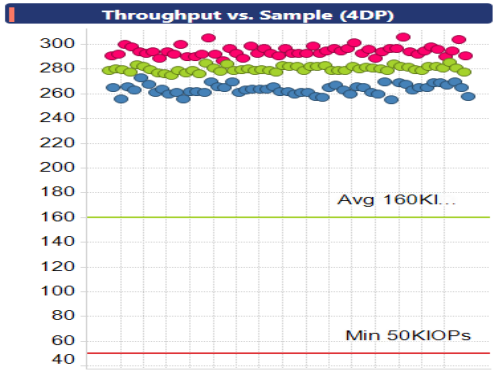


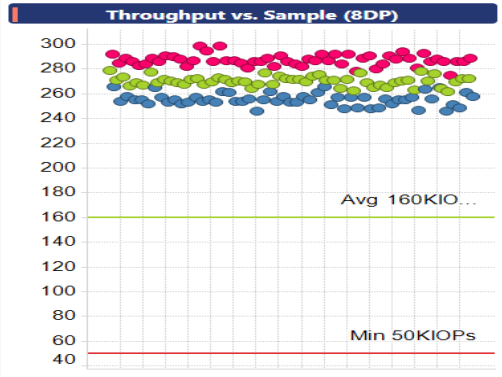


- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 1Month)





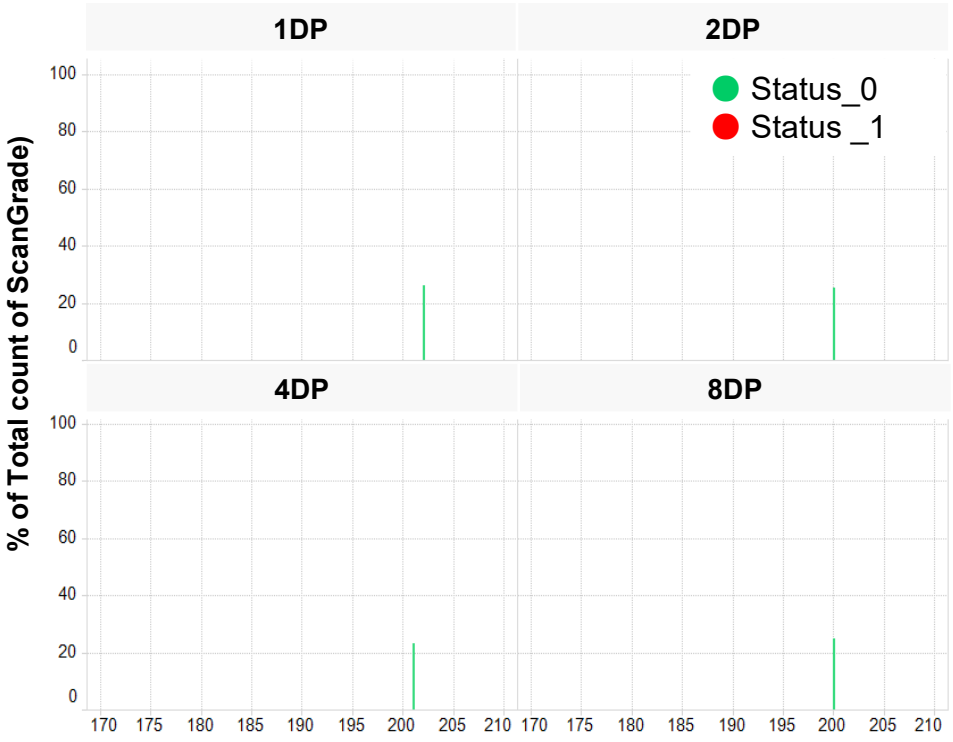




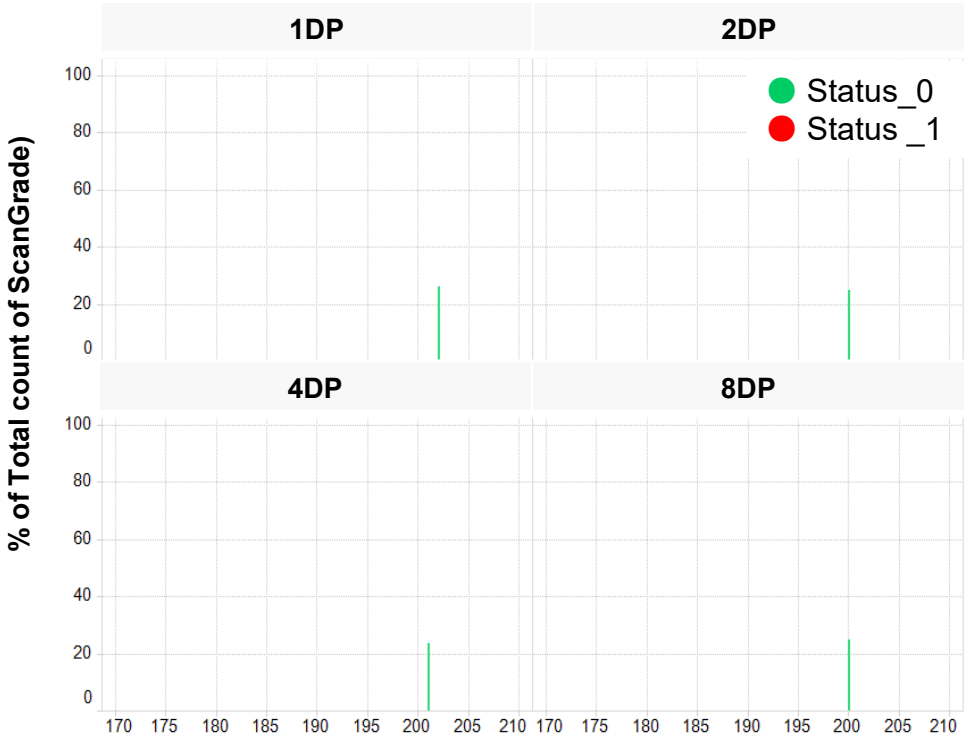
SLC (Read Scan) – X-Ray SLC Type3 (1M)

☑ Read Scan satisfied with checkpoint X-Ray SLC Type3 (1M)

● Read Scan Histogram (EW)



● Read Scan Histogram
(X-Ray 1Gr + EW + RD100K + 1Month)

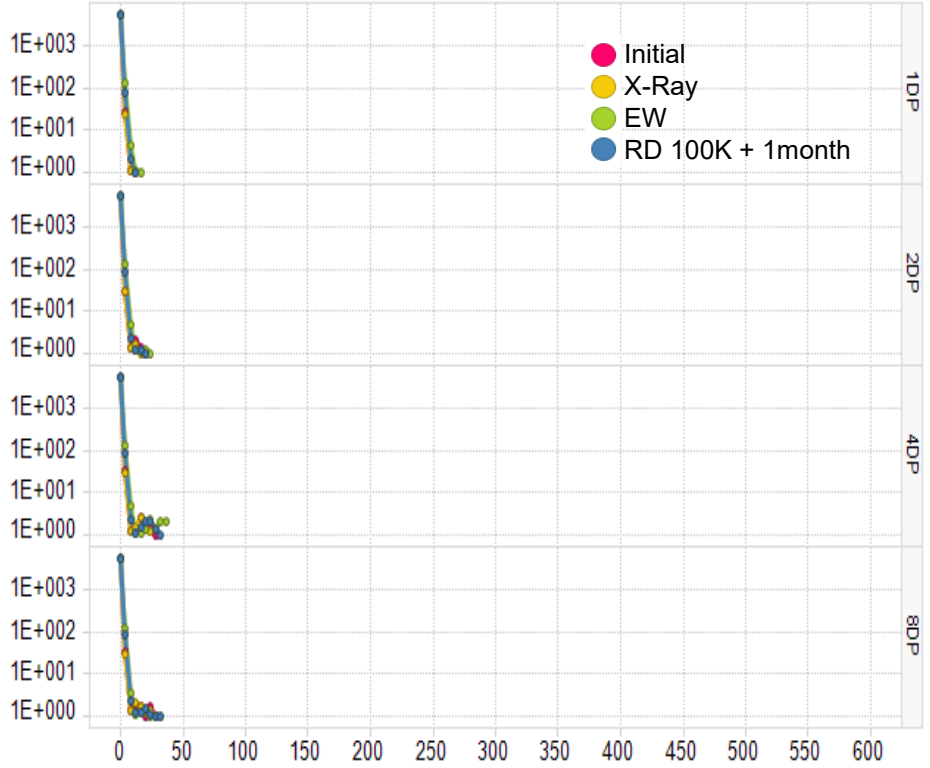


SLC (EOL Latency) – X-Ray SLC Type3 (1M)

☑ Read latency satisfied with checkpoint X-Ray SLC Type3 (1M)

ITEM	Stack	Bin	Apple Spec	X-Ray 1Gr + EW + RD100K + 1Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray SLC Type3 (1M)	1DP	tR≤160us	TBD	1	1	30.05
	2DP	tR≤160us	TBD	1	1	30.06
	4DP	tR≤160us	TBD	1	1	31.14
	8DP	tR≤160us	TBD	1	1	30.93

● Indepth Histogram
(X-Ray 1Gr + EW + RD100K + 1Month)



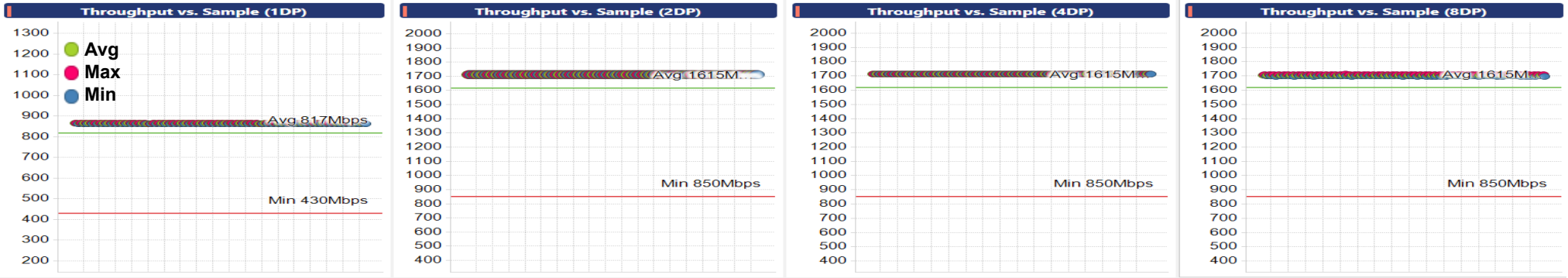
SLC (Sequential Throughput) – X-Ray SLC Type3 (3M)

☑ Throughput Test satisfied with checkpoint X-Ray SLC Type3 (3M)

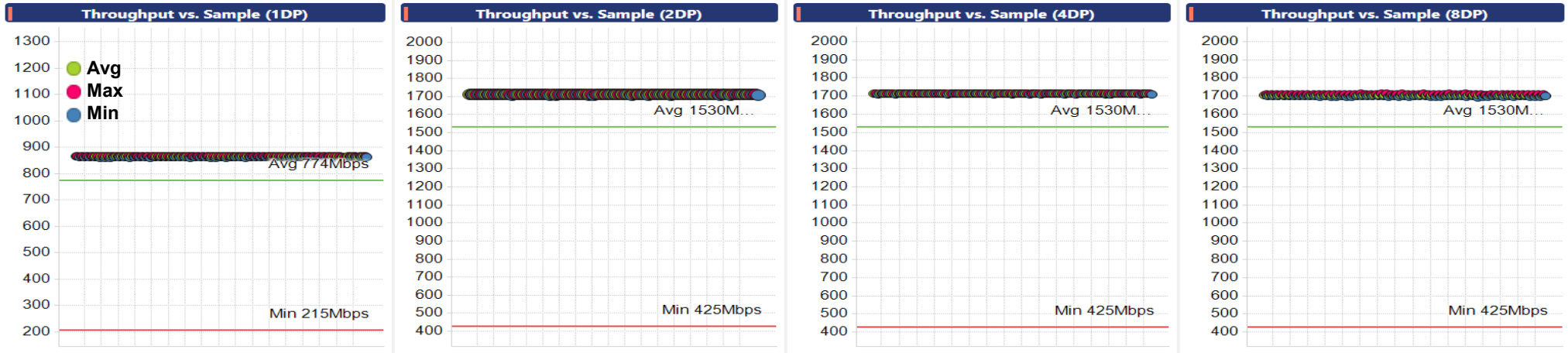
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	X-Ray 1Gr + EW + RD100K + 3Month	864.88	864	861	1713.89	1713.5	1706	1714.54	1714	1711	1704.7	1703.38	1693

- Throughput vs. Sample(PKG) (Initial)



- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Month)



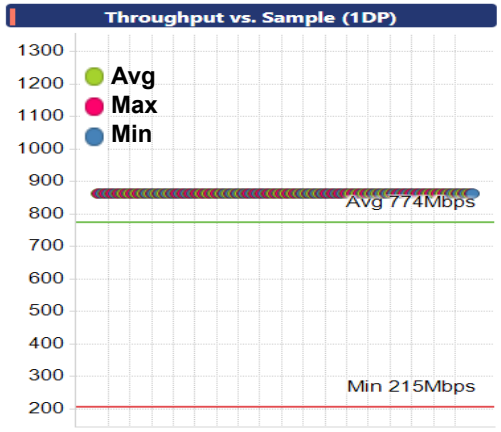
SLC (RC Throughput) – X-Ray SLC Type3 (3M)

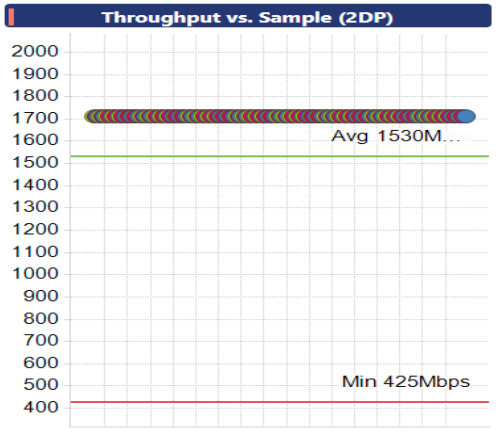
☑ Throughput Test satisfied with checkpoint X-Ray SLC Type3 (3M)

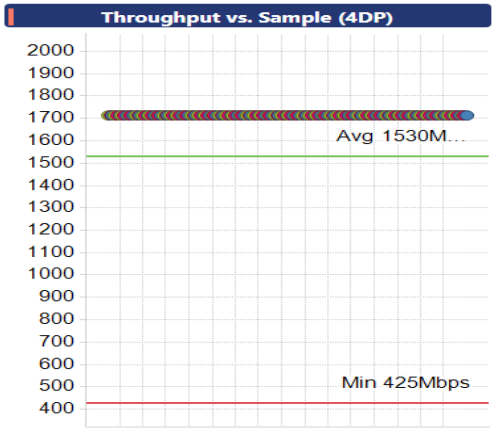
- Throughput Measurement Table

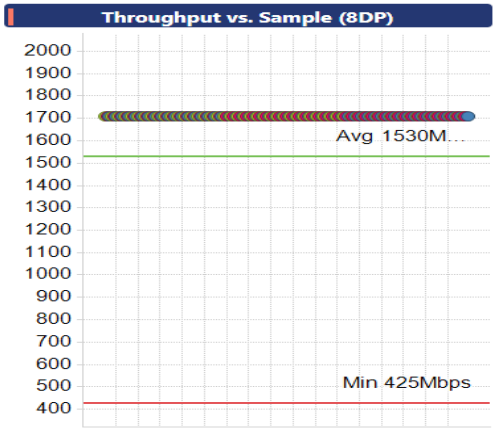
Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	X-Ray 1Gr + EW + RD100K + 3Month	864	864	864	1714	1714	1714	1714	1714	1714	1710.85	1710.5	1710

- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Month)









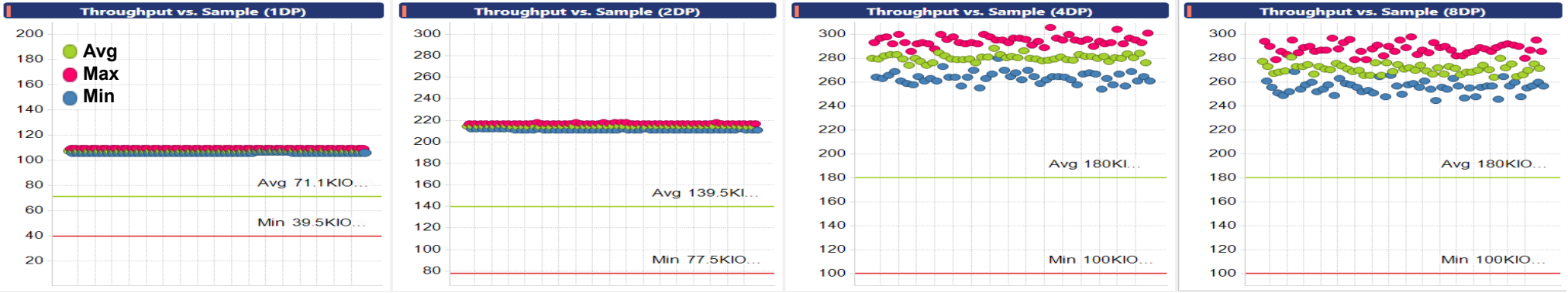
SLC (RR Throughput) – X-Ray SLC Type3 (3M)

☑ Throughput Test satisfied with checkpoint X-Ray SLC Type3 (3M)

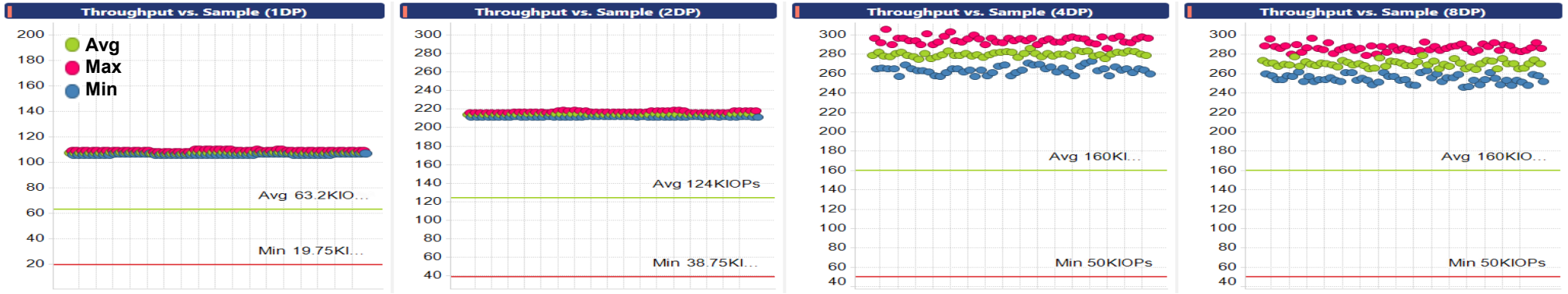
- Throughput Measurement Table

Stack		1DP			2DP			4DP			8DP		
	Throughput	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band	Avg. Package	Worst Avg. Package	Worst Band
EW 100K	Initial	107.66	107	106	214.41	213.56	211	280.16	273.06	254	271.16	261.31	245
	X-Ray 1Gr + EW + RD100K + 3Month	107.65	106.94	106	214.31	213.25	211	280.1	274.19	257	270.19	260.88	246

- Throughput vs. Sample(PKG) (Initial)



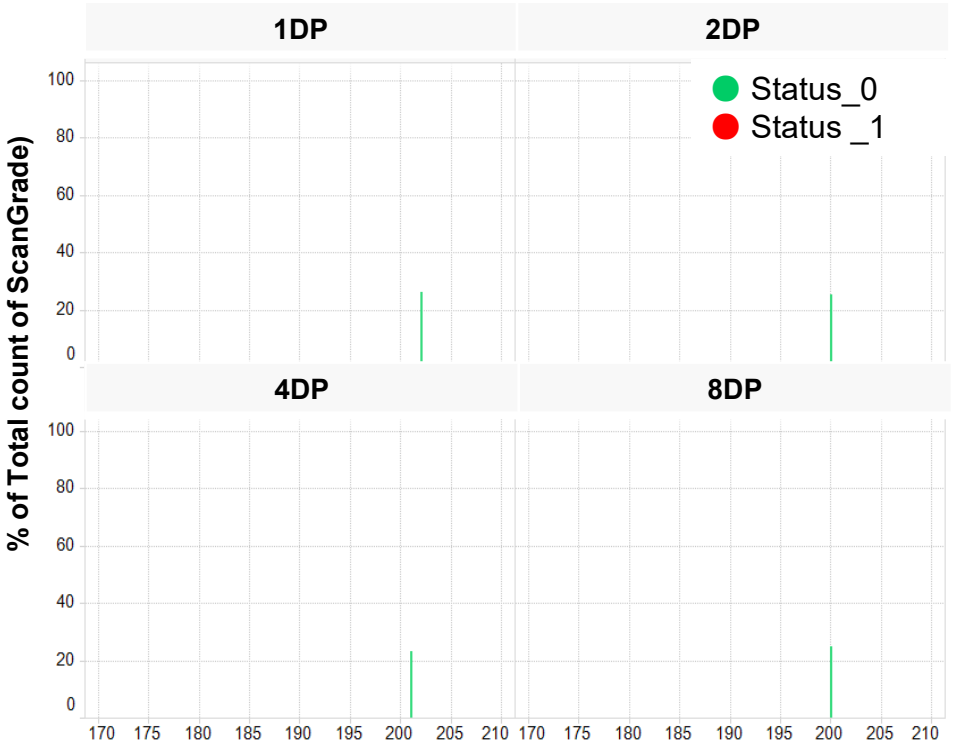
- Throughput vs. Sample(PKG) (X-Ray 1Gr + EW + RD100K + 3Month)



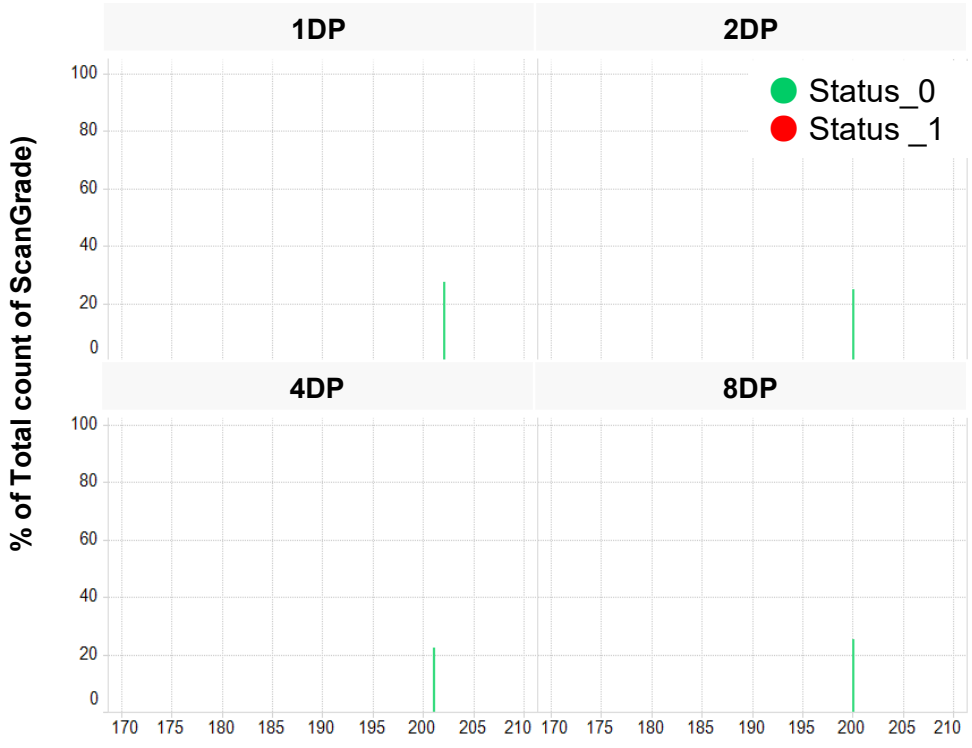
SLC (Read Scan) – X-Ray SLC Type3 (3M)

☑ Read Scan satisfied with checkpoint X-Ray SLC Type3 (3M)

● Read Scan Histogram (EW)



● Read Scan Histogram
(X-Ray 1Gr + EW + RD100K + 3Month)

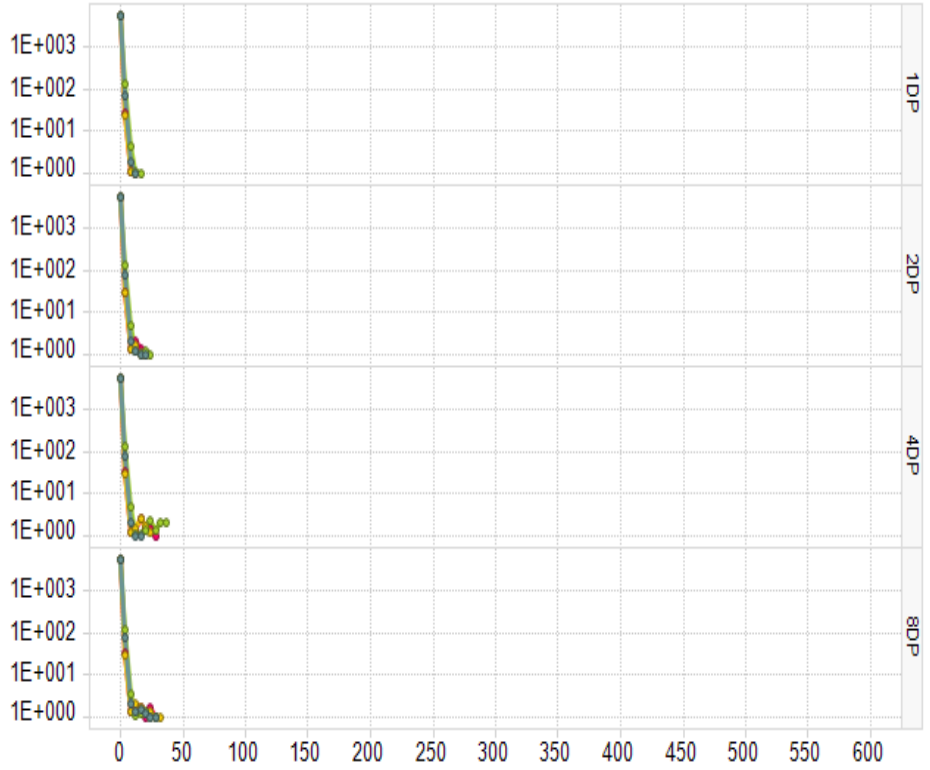


SLC (EOL Latency) – X-Ray SLC Type3 (3M)

☑ Read latency satisfied with checkpoint X-Ray SLC Type3 (3M)

ITEM	Stack	Bin	Apple Spec	X-Ray 1Gr + EW + RD100K + 3Month		
				Average All S5E Dies	Worst Case S5E Die	Average Latency Worst S5E Dies
X-Ray SLC Type3 (3M)	1DP	tR≤160us	TBD	1	1	30.05
	2DP	tR≤160us	TBD	1	1	30.06
	4DP	tR≤160us	TBD	1	1	30.97
	8DP	tR≤160us	TBD	1	1	30.92

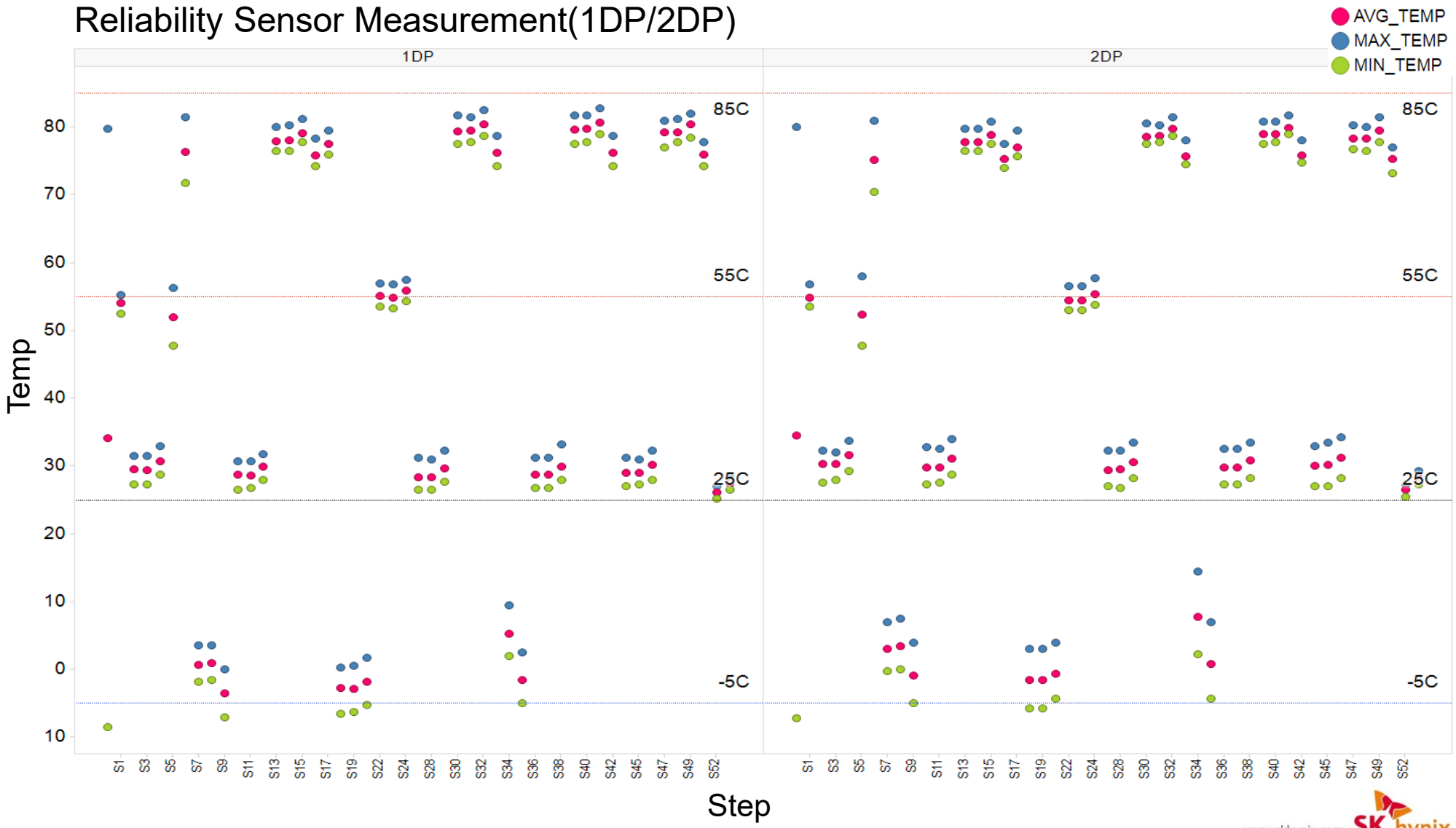
● Indepth Histogram
(X-Ray 1Gr + EW + RD100K + 3Month)



Appendix

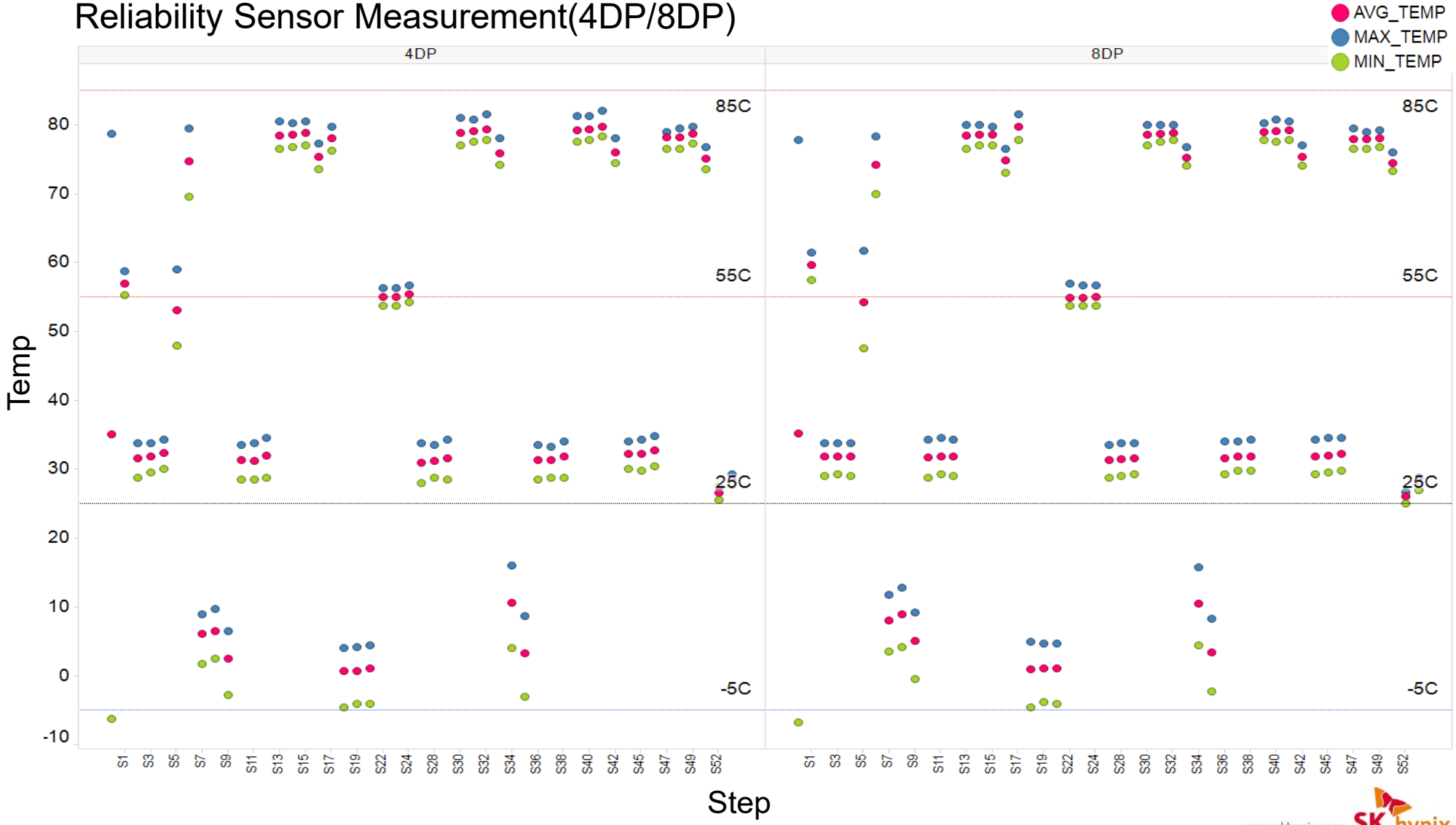
[QUAL8] TLC Reliability

QUAL8 Reliability Temp Measurement



QUAL8 Reliability Temp Measurement

Reliability Sensor Measurement(4DP/8DP)

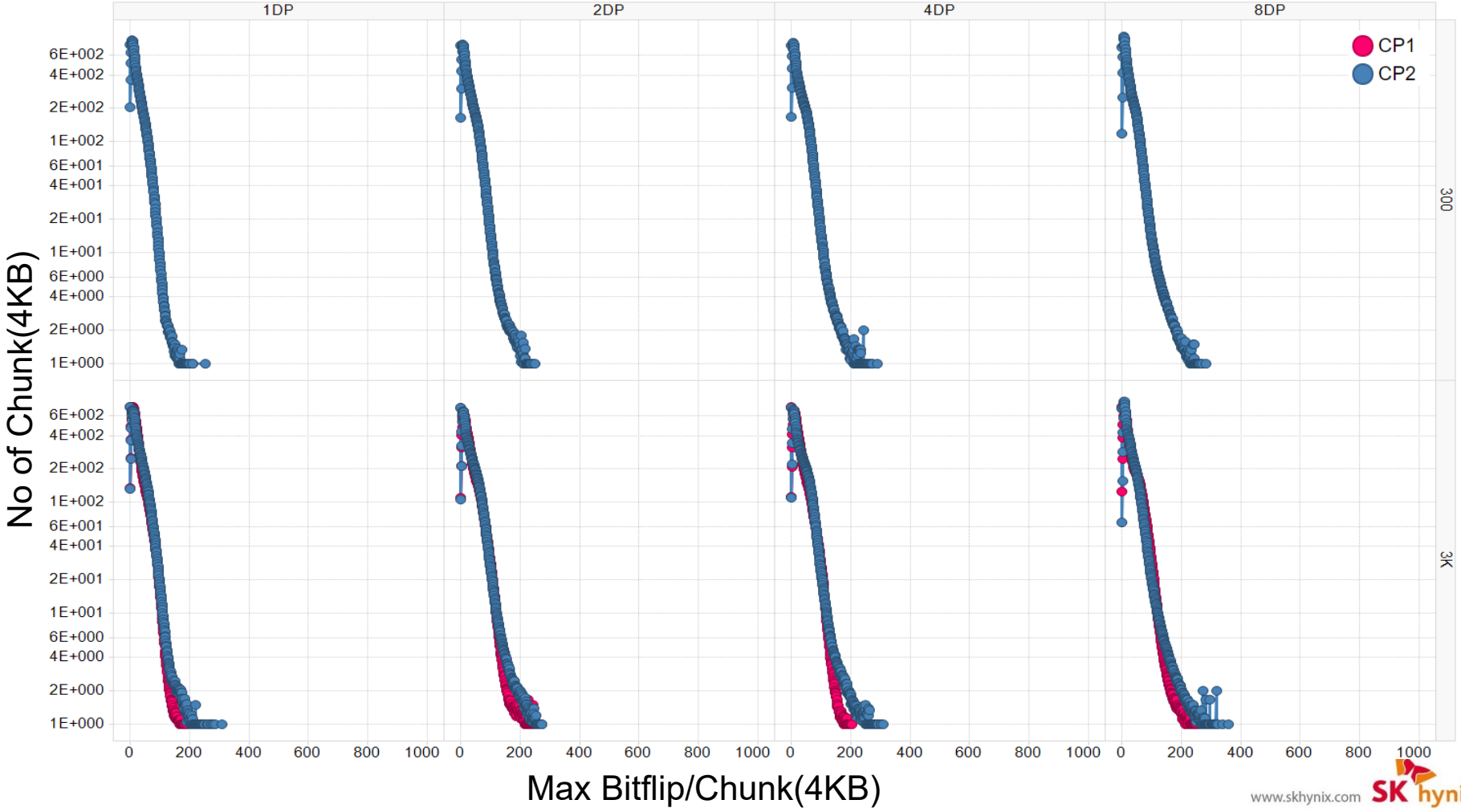


QUAL8 Reliability Cycling Bitflips Measurement

☑ EW No. of Chunk vs. Bit Flips

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Bitflip Monitor 1Checkpoint @90%, 2Checkpoint @10%



QUAL8 Reliability tPROG/tBERS

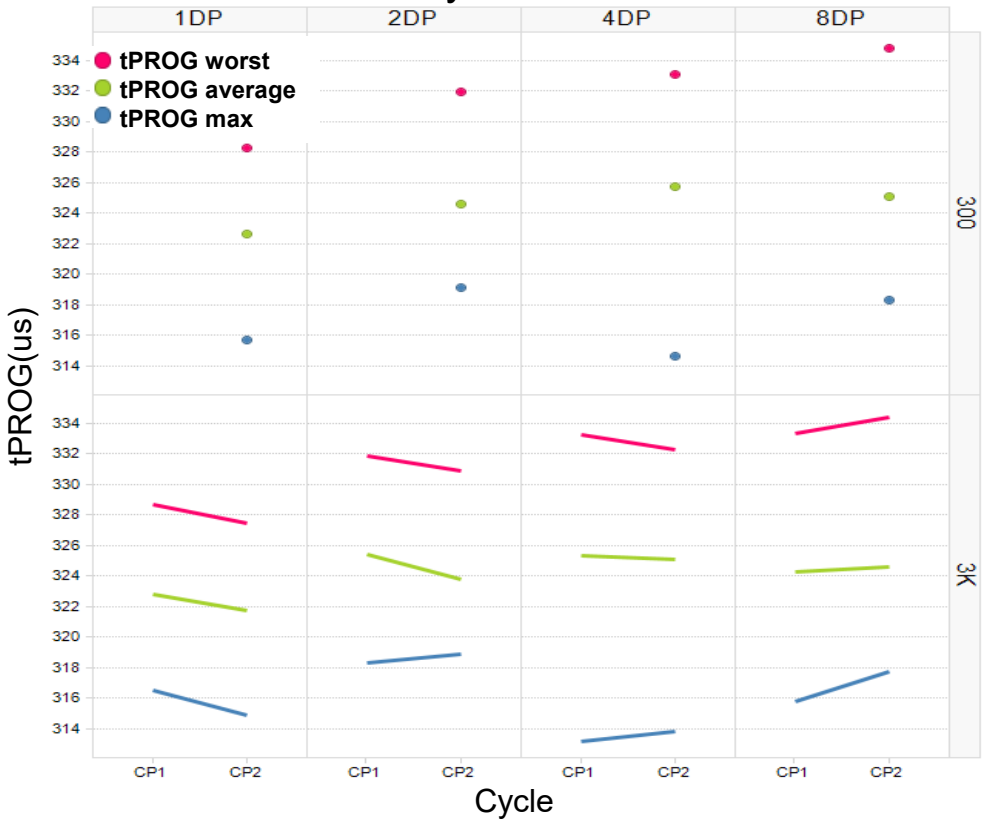
☑ EW tPROG/tBERS

$$tPROG = \frac{1}{P}\sum_{i} tPROG, PAGEi$$

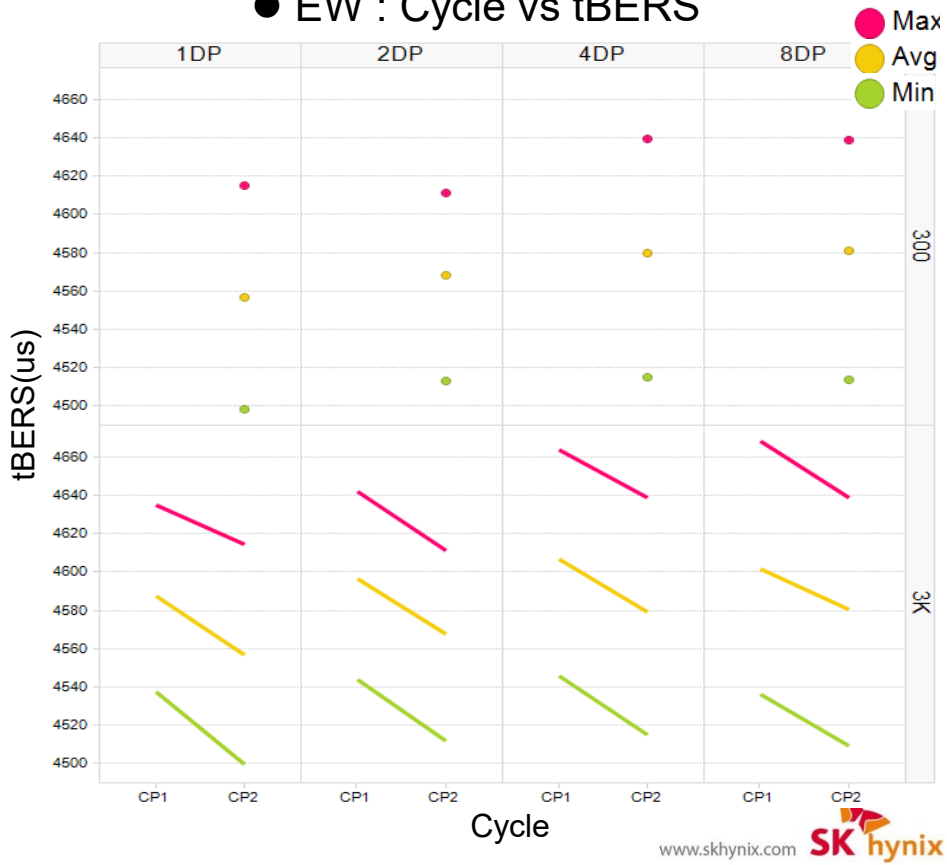
EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%

tPROG worst := Average_dies(Average_blocks(Average_pages(program time))) + 5*std_dies(Average_blocks(Average_pages(program time)))
tPROG average := Average_dies(Average_blocks(Average_pages(program time)))
tPROG max := Max_dies(Average_blocks(Average_pages(program time)))

● EW : Cycle vs tPROG



● EW : Cycle vs tBERS



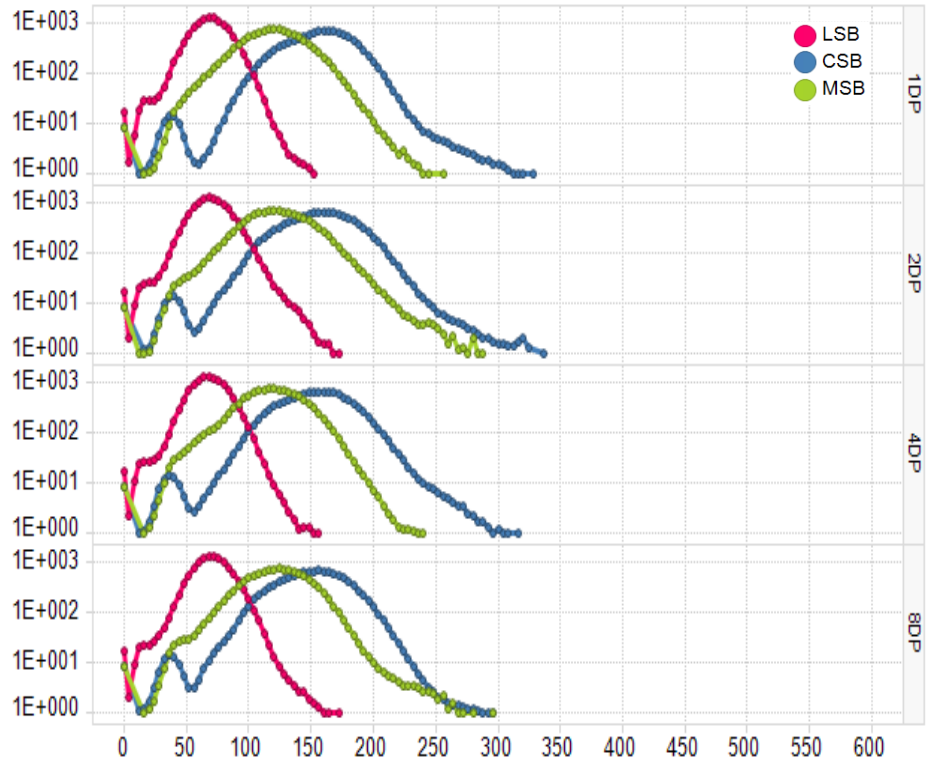
TLC (SOL HTDR) – CP2

☑ Reliability Check points satisfied with checkpoint 2.

● Result Summary

TLC Checkpoint 2 (Data Retention)			
Test Result			PASS
Correctness Fail Bit Level (Indepth DEF)			HTDR 2.5Y
			100%
1DP	EW 300	Max	328
		Median	108
2DP	EW 300	Max	336
		Median	108
4DP	EW 300	Max	316
		Median	100
8DP	EW 300	Max	296
		Median	104

● EW+ Bake 2.5yr

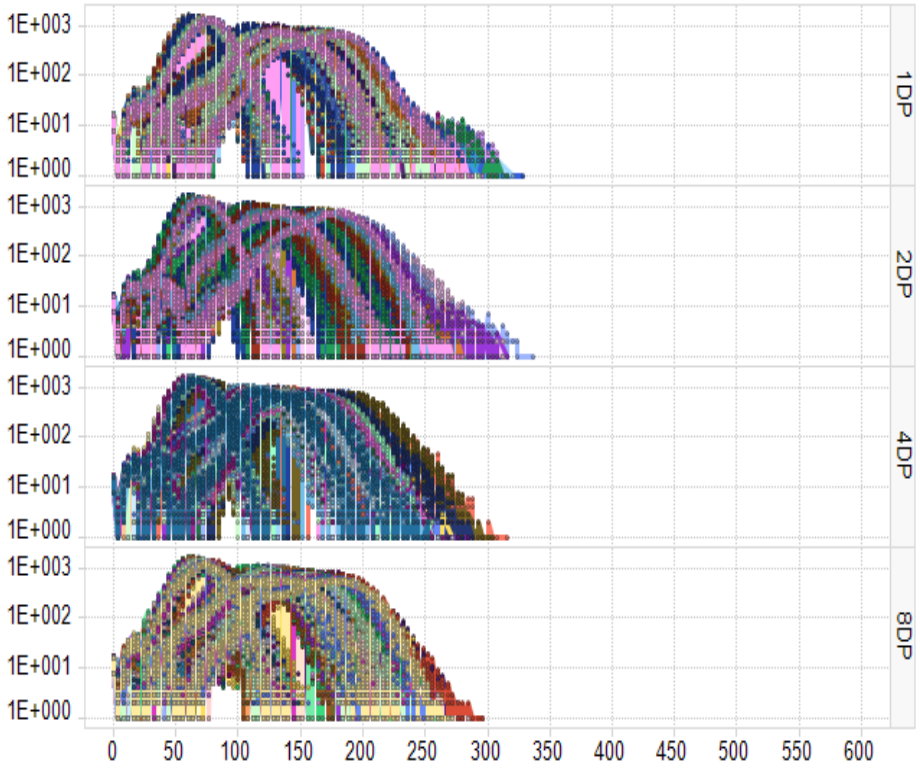


TLC (SOL HTDR) – CP2

☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
Bake 13hrs @ 125℃

- EW + Bake 2.5yr



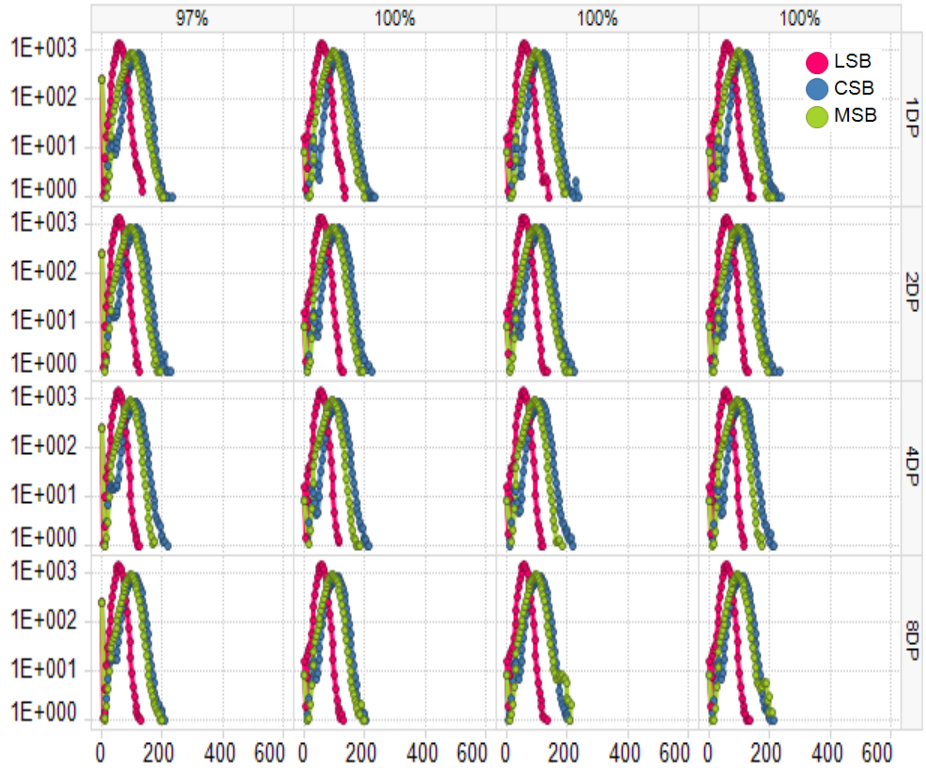
TLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3.

● Result Summary

TLC Checkpoint 3 (Data Retention)														
Test Result			PASS											
Correctness Fail Bit Level (Indepth DEF)			EW				HTDR 1Y				HTDR 1Y+2week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	72	64	64	68	232	232	236	236	256	268	260	260
		Med	20	20	20	20	84	84	84	84	92	96	96	100
2DP	EW 3K	Max	68	68	68	72	228	224	224	232	252	252	252	248
		Med	20	20	20	20	80	80	80	80	88	92	92	92
4DP	EW 3K	Max	64	64	60	64	216	212	216	212	252	260	256	248
		Med	20	20	20	20	80	76	76	76	84	88	88	88
8DP	EW 3K	Max	84	72	84	84	208	204	212	212	236	240	244	240
		Med	24	20	24	24	80	76	80	76	84	88	88	88

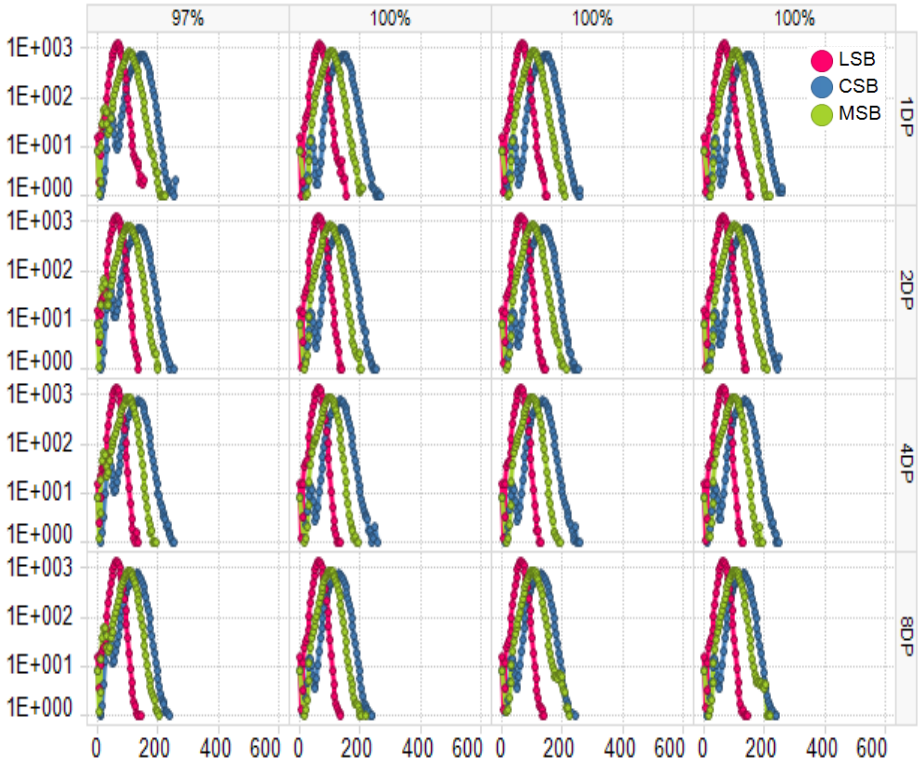
● EW+ HTDR 1Yr



TLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3.

- EW+ HTDR 1Yr+ 2Week

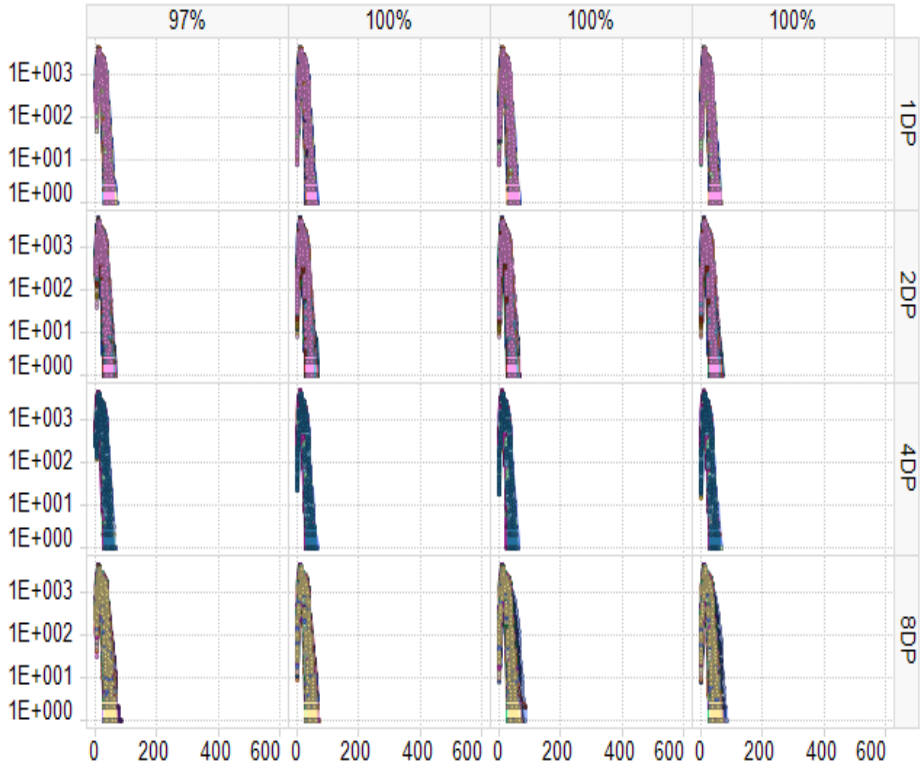


TLC (EOL HTDR) – CP3

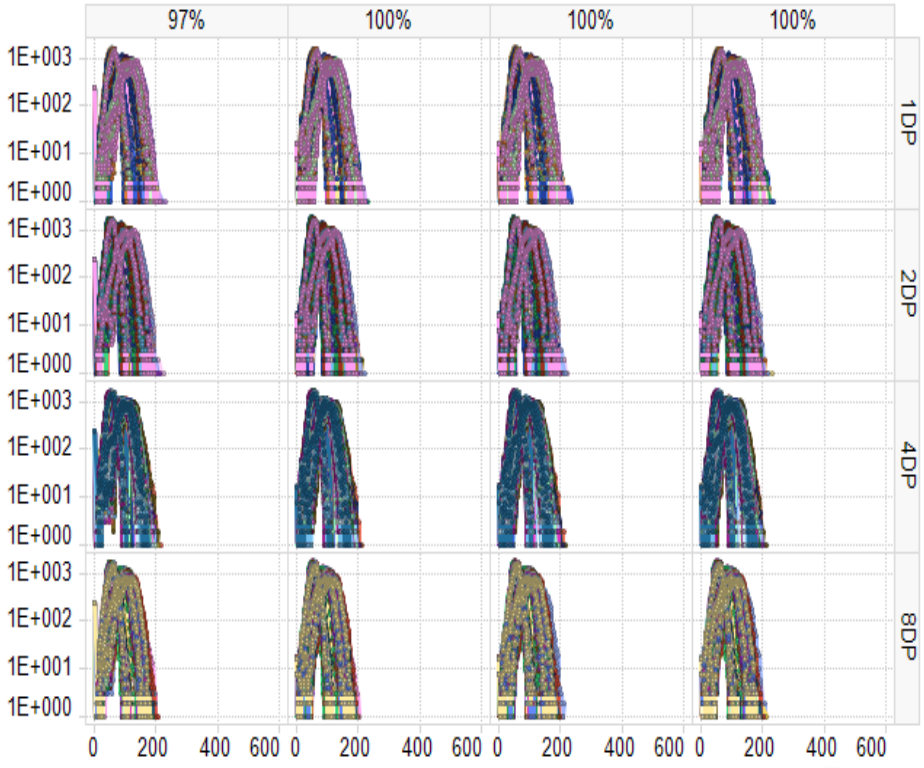
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
Bake 5.5Hr @ 125℃

● EW



● EW + HTDR 1Yr

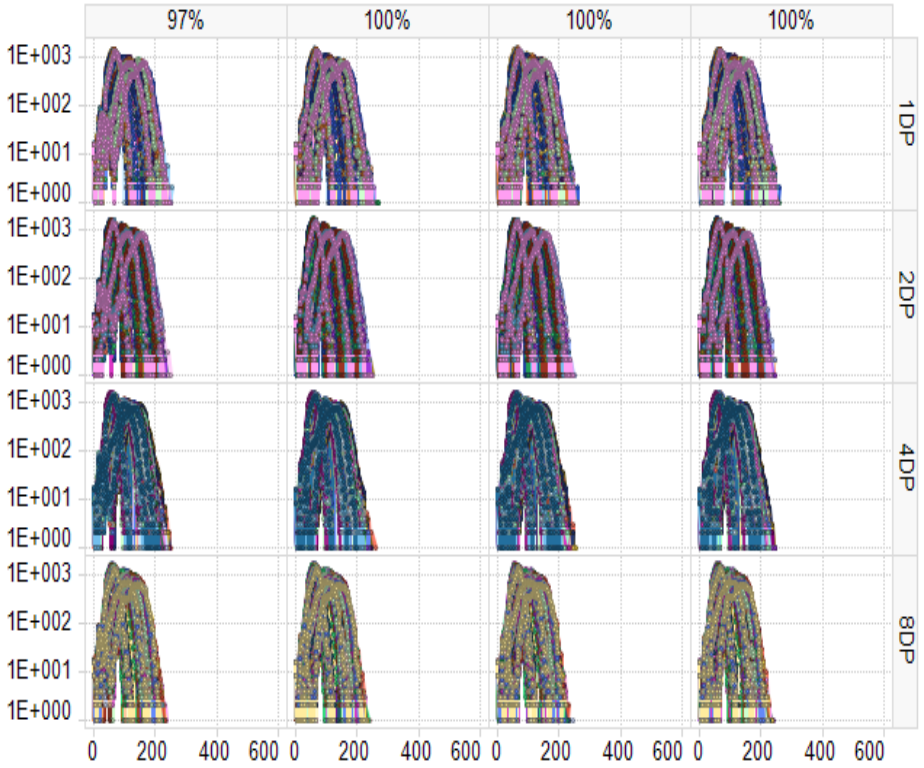


TLC (EOL HTDR) – CP3

☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
Bake 5.5Hr @ 125℃

- EW + HTDR 1Yr + 2Week



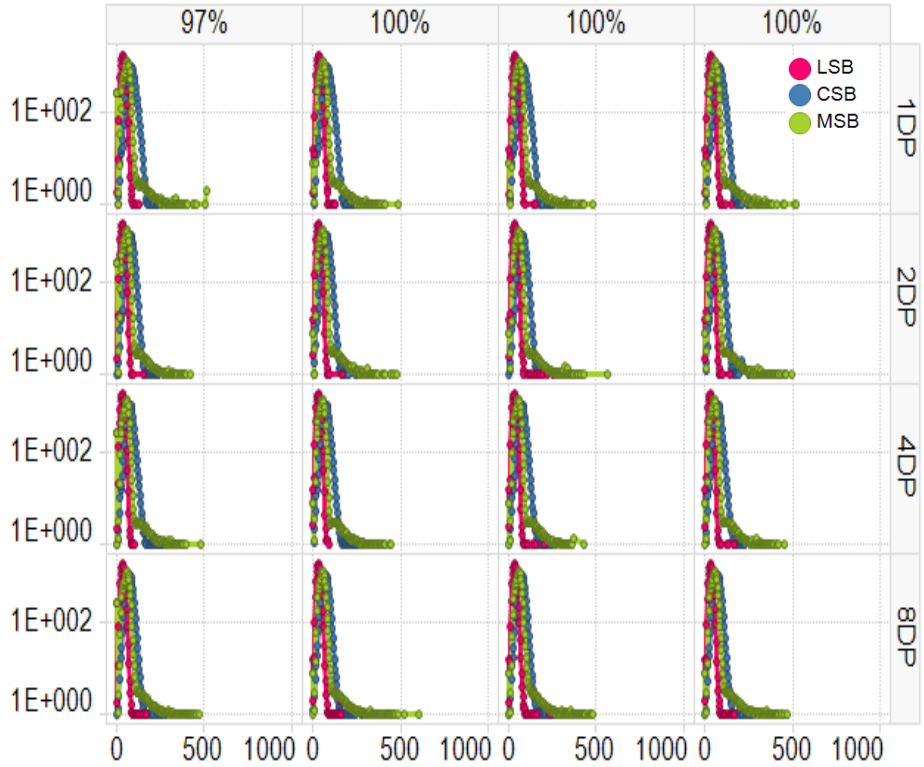
TLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3.

● Result Summary

TLC Checkpoint 3 (Data Retention)									
Test Result			PASS						
Correctness Fail Bit Level (Indepth ADSP)			HTDR 1Y				HTDR 1Y+2week			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	512	488	476	524	544	468	500	500
		Med	80	80	80	80	88	92	92	92
2DP	EW 3K	Max	416	480	560	496	436	464	544	484
		Med	76	76	76	76	84	84	84	84
4DP	EW 3K	Max	476	444	432	452	468	464	416	448
		Med	76	76	76	76	84	84	84	84
8DP	EW 3K	Max	468	608	480	468	492	552	520	576
		Med	76	76	76	76	80	84	84	84

● EW+ HTDR 1Yr (ADSP)

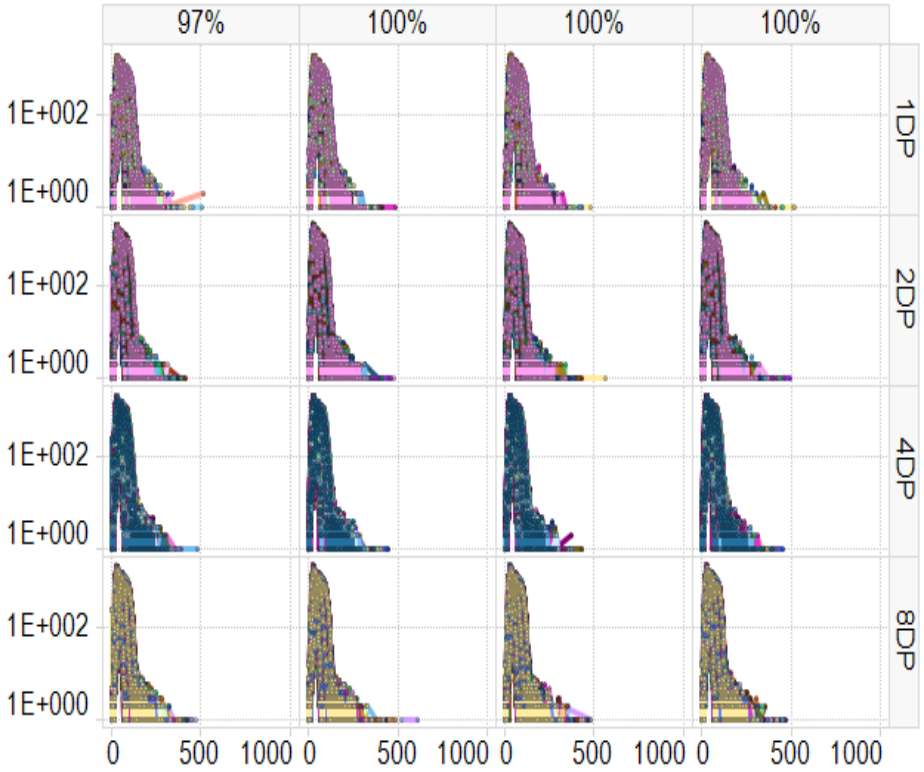


TLC (EOL HTDR) – CP3

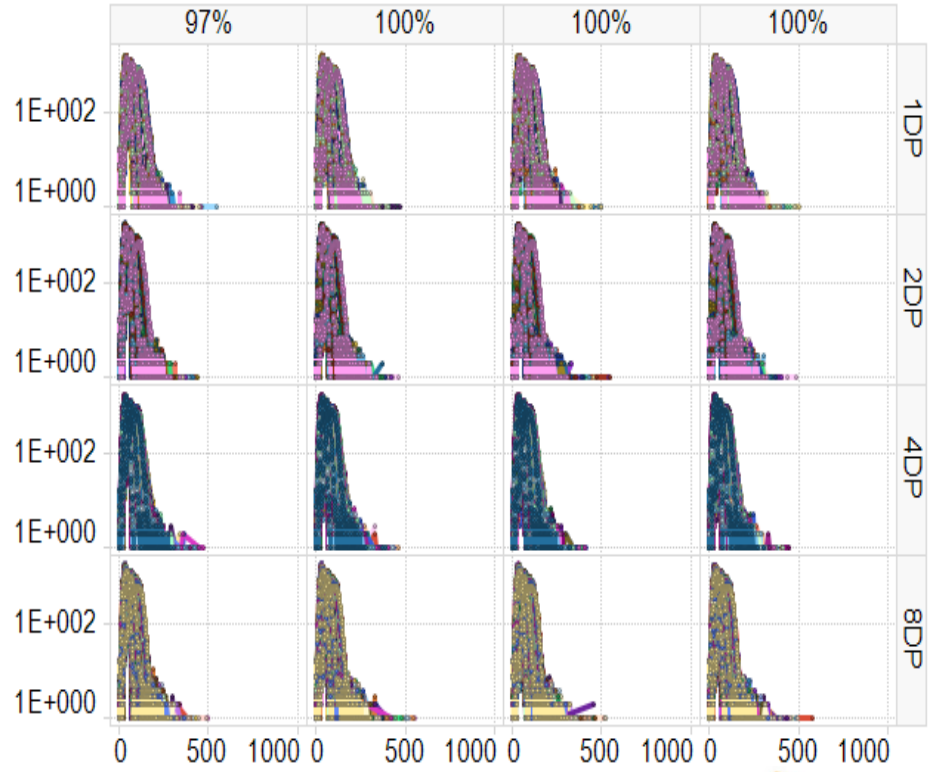
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
Bake 5.5Hr @ 125℃

- EW + HTDR 1Yr (ADSP)



- EW + HTDR 1Yr + 2Week(ADSP)



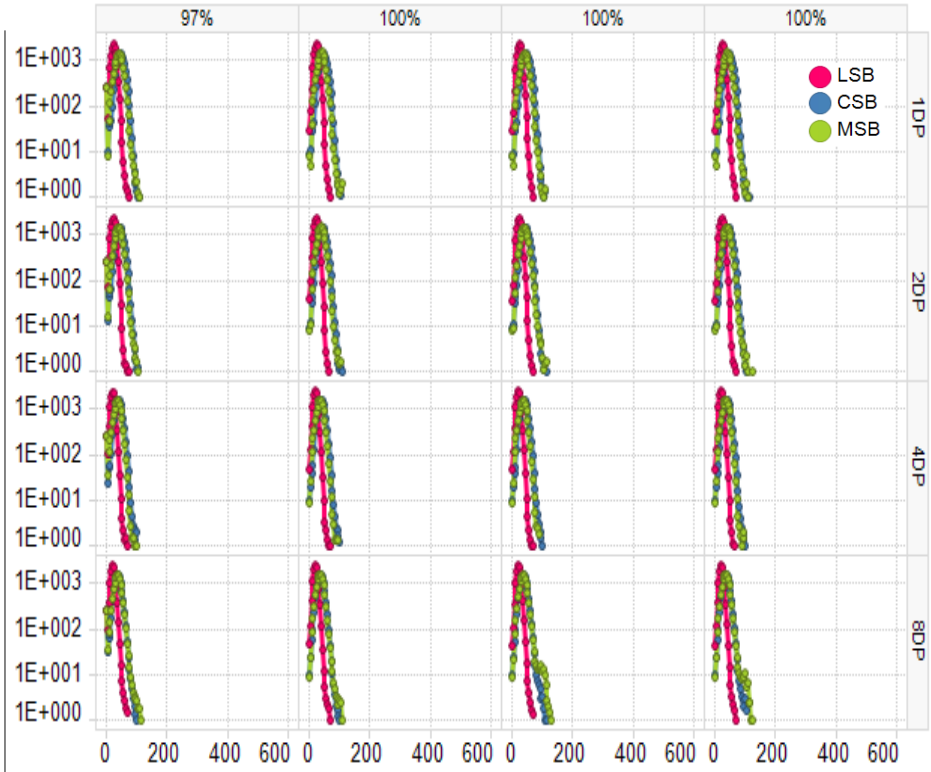
TLC (EOL Latency) – CP11

☑ Reliability Check points satisfied with checkpoint 11.

● Result Summary

TLC Checkpoint 3 (Data Retention)									
Test Result			PASS							
Correctness Fail Bit Level (Indepth DEF)			EW				1Month			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	72	64	64	68	108	108	108	112
		Median	20	20	20	20	40	40	40	40
2DP	EW 3K	Max	68	68	68	72	104	108	112	124
		Median	20	20	20	20	36	36	36	36
4DP	EW 3K	Max	64	64	60	64	100	100	100	100
		Median	20	20	20	20	36	36	36	36
8DP	EW 3K	Max	84	72	84	84	112	108	128	124
		Median	24	20	24	24	36	36	36	36

● EW+ 1Month



TLC (EOL Latency) – CP11

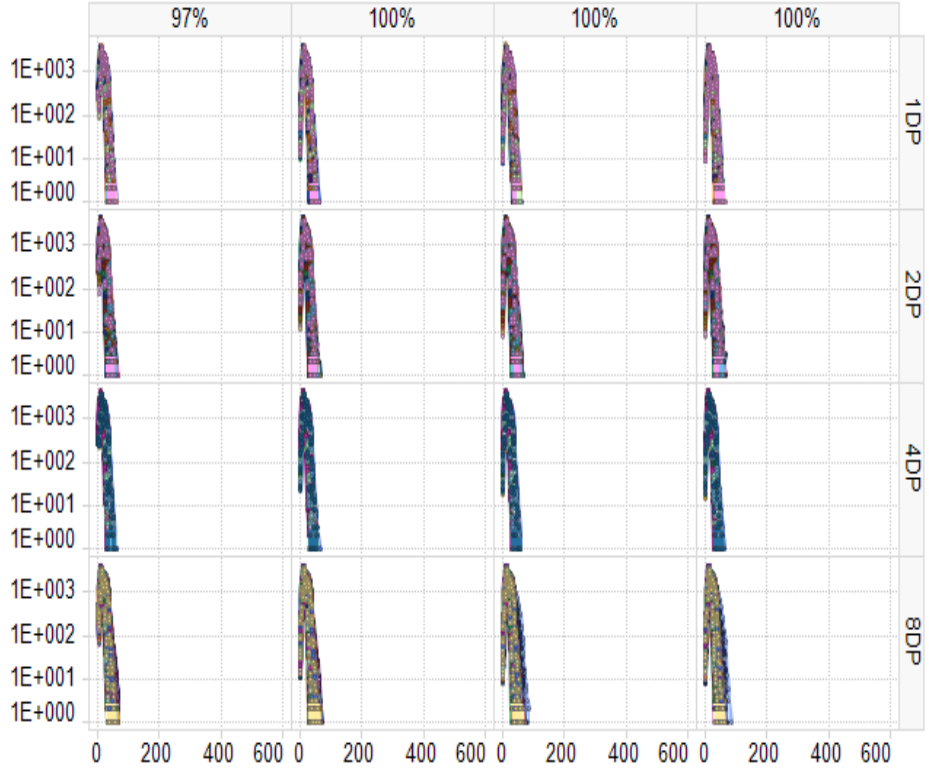
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

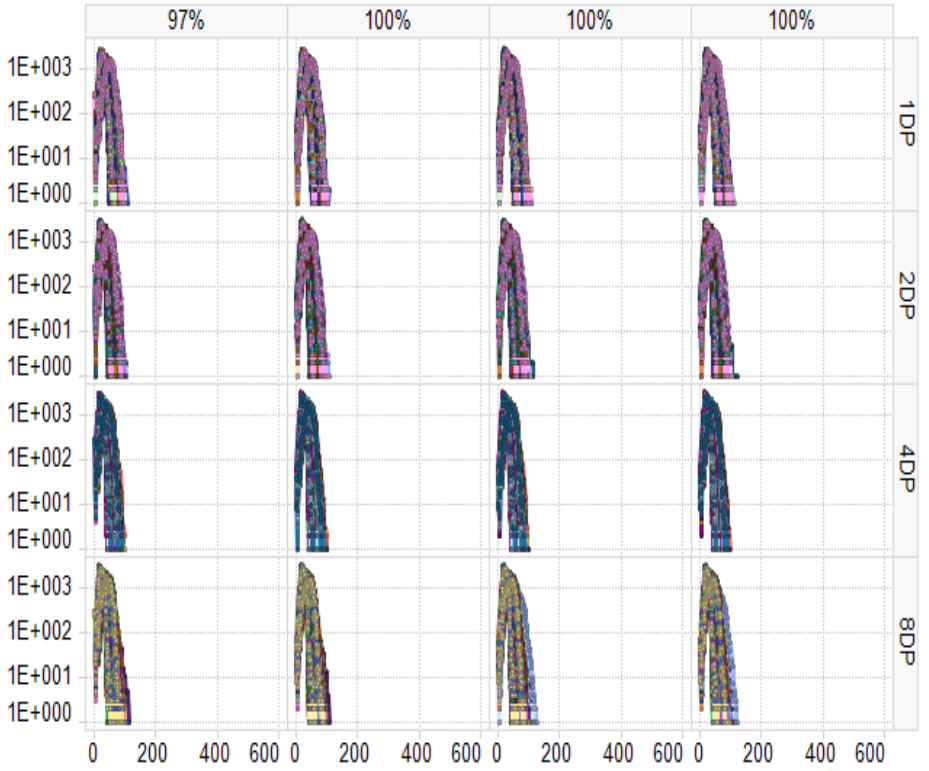
Back Pattern : Random pattern @ -5℃

1month@ 45℃ with cross temp 60 ℃

● EW



● EW + 1Month

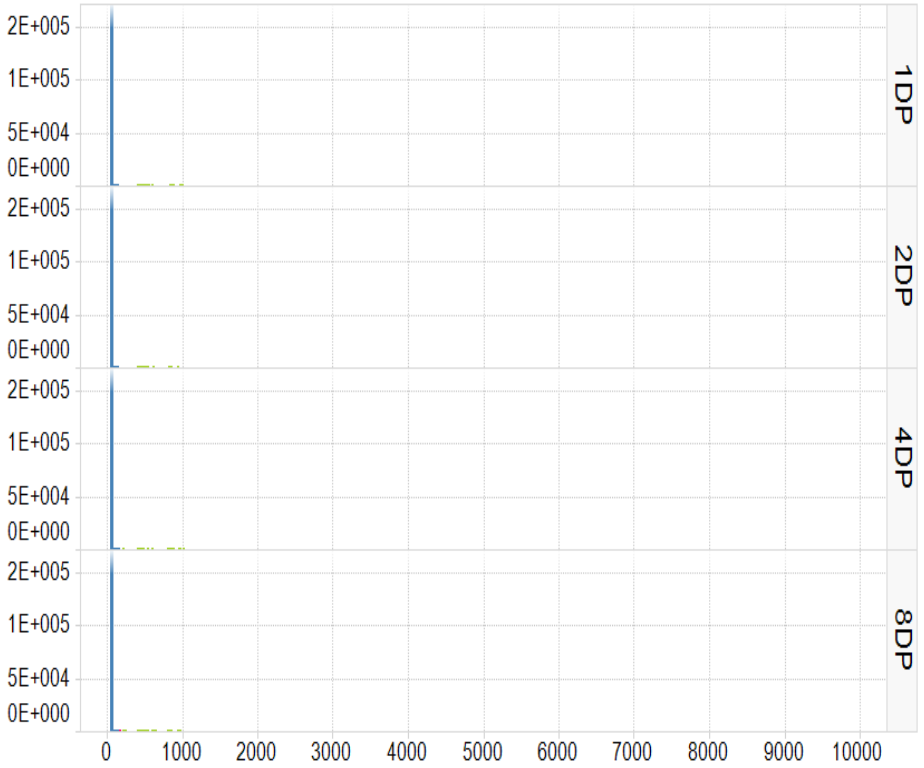


TLC (EOL Latency) – CP11

☑ Read Latency Distribution@ EW + RD 100K + 1month@ 45℃ with cross temp 60 ℃

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 60 ℃

● No. of Chunk vs. Read Latency
(EW + RD 100K + 1month)



TLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A.

● Result Summary

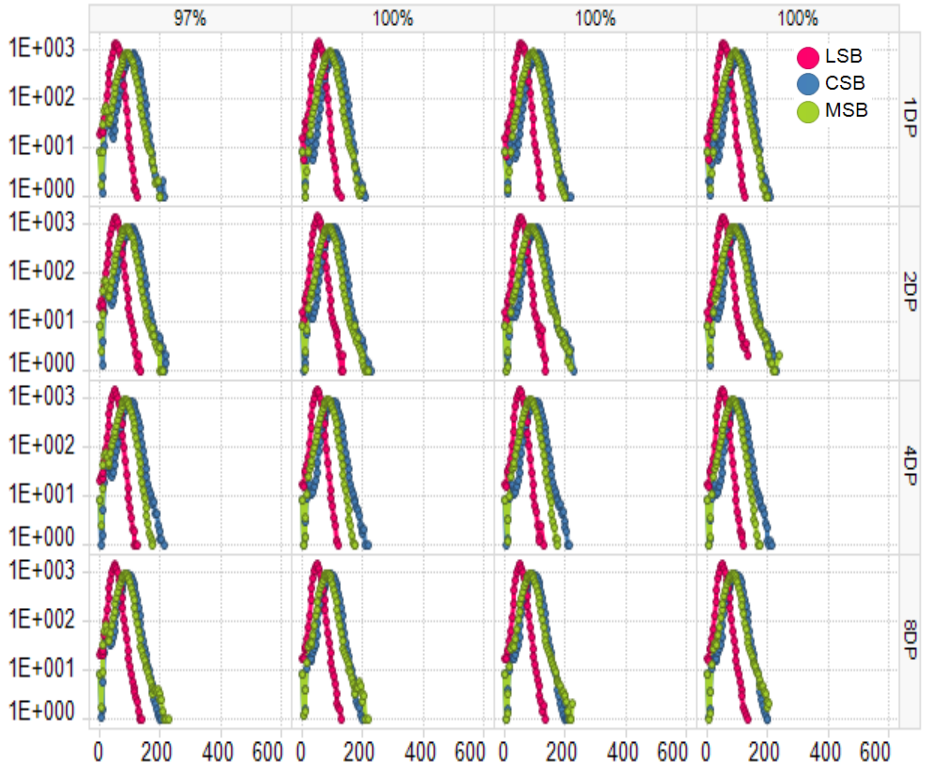
TLC Checkpoint 4A (X-Temp)														
Test Result			PASS											
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp				100℃ Cross Temp +2Week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 300	Max	72	64	64	68	196	196	192	192	212	208	216	208
		Med	20	20	20	20	72	72	72	72	76	76	76	76
2DP	EW 300	Max	68	68	68	72	204	212	220	216	220	228	228	236
		Med	20	20	20	20	68	68	68	68	72	76	76	76
4DP	EW 300	Max	64	64	60	64	184	184	196	188	212	216	212	212
		Med	20	20	20	20	64	64	64	64	68	72	72	72
8DP	EW 300	Max	84	72	84	84	212	208	228	220	228	216	224	204
		Med	24	20	24	24	64	64	68	64	68	68	72	72

● EW + 100℃ Cross Temp

TLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A.

- EW + 100℃ Cross Temp + 2Week

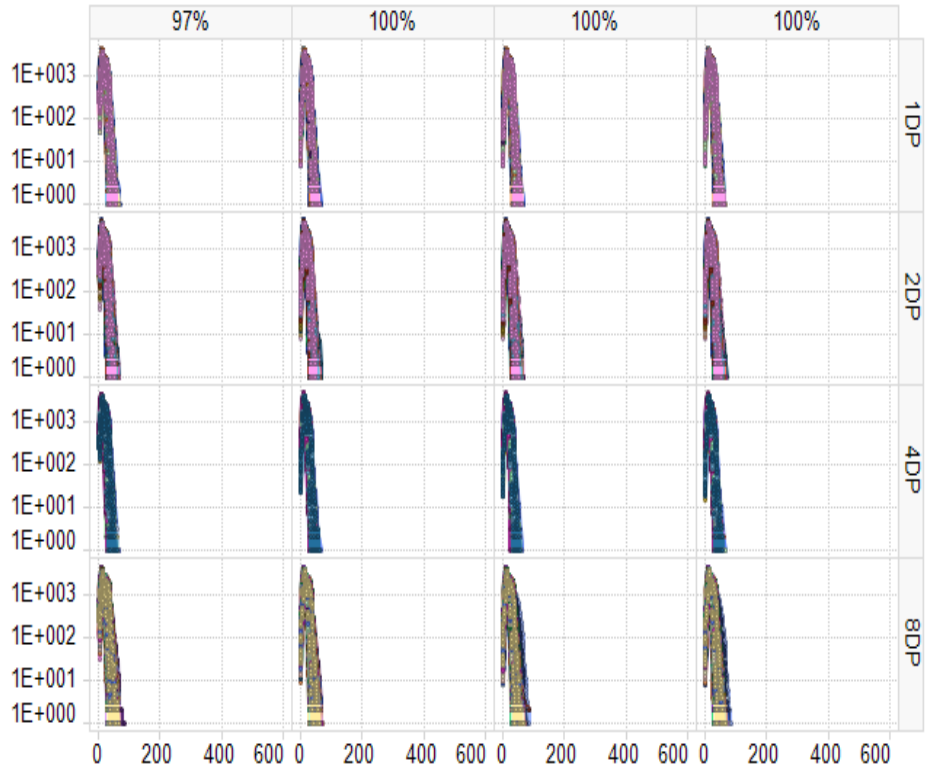


TLC (SOL X-Temp) – CP4A

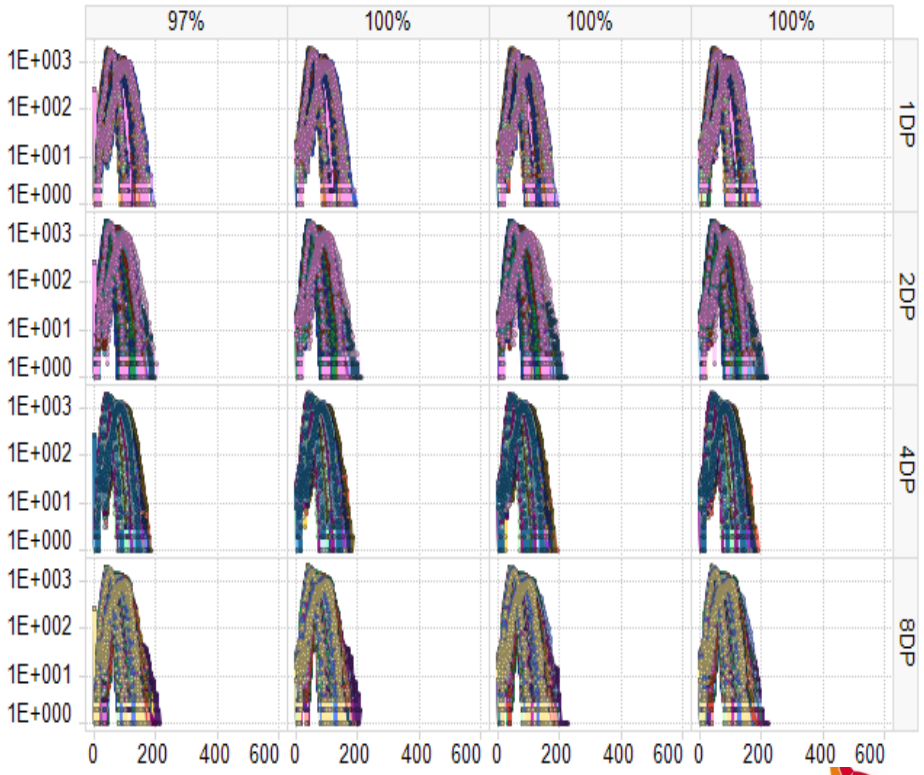
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -15℃
Cross Temp 100 ℃ @ 85 ℃

● EW



● EW + 100℃ Cross Temp

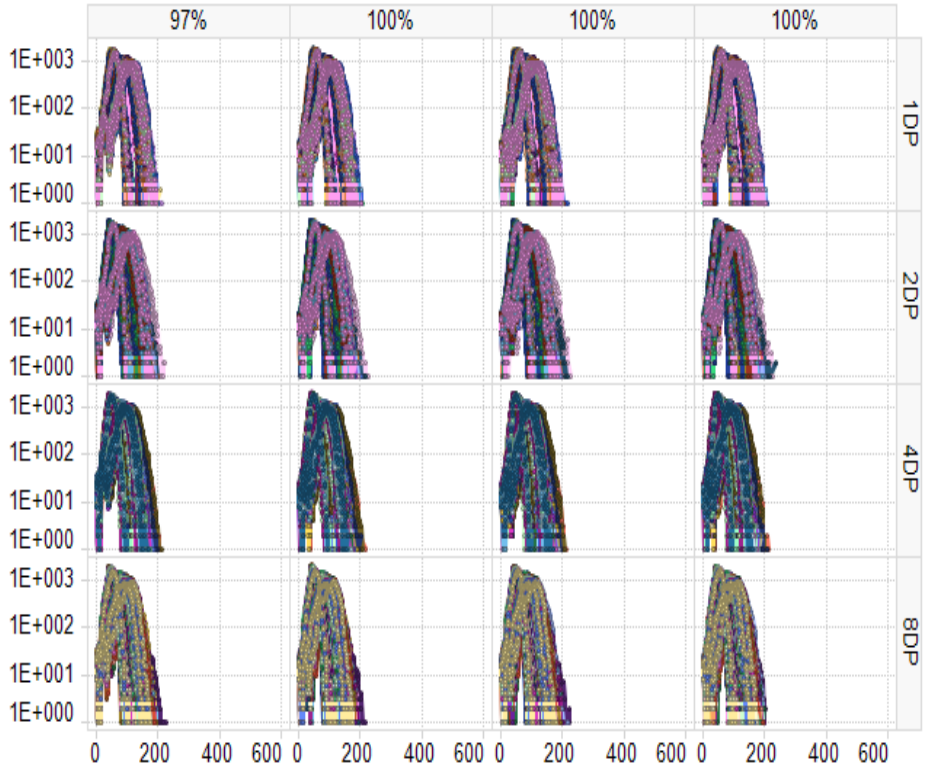


TLC (SOL X-Temp) – CP4A

☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -15℃
Cross Temp 100 ℃ @ 85 ℃

- EW + 100℃ Cross Temp + 2Week



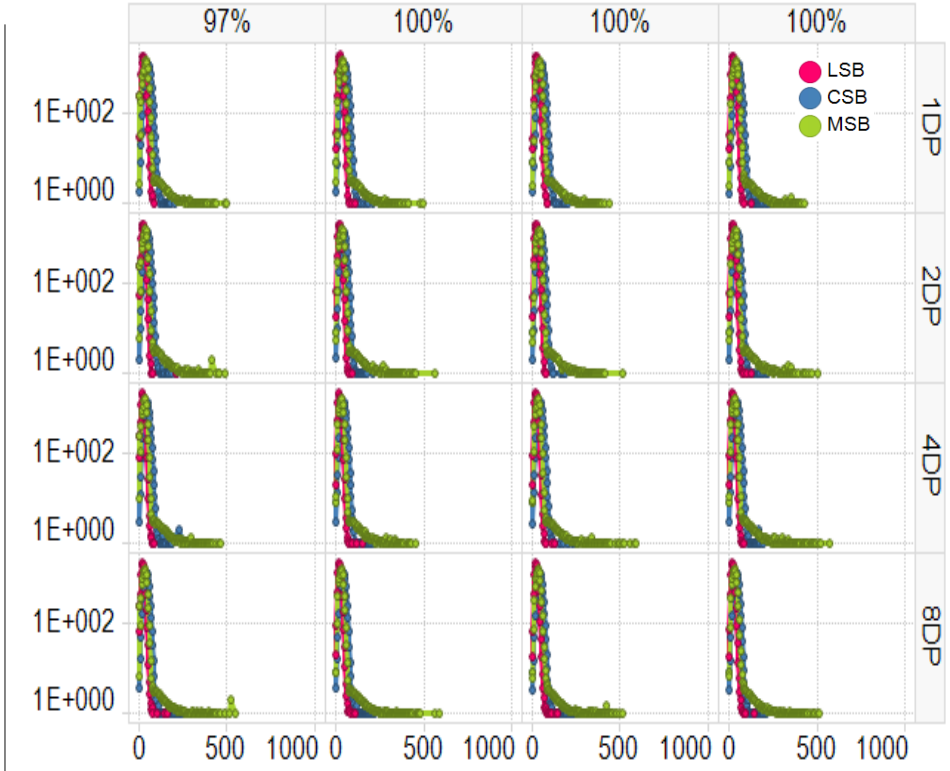
TLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A.

● Result Summary

TLC Checkpoint 4A (X-Temp)										
Test Result			PASS							
Correctness Fail Bit Level (Indepth ADSP)			100℃ Cross Temp				100℃ Cross Temp +2Week			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 300	Max	492	496	436	432	404	408	436	452
		Med	60	60	60	60	68	68	68	68
2DP	EW 300	Max	484	564	512	500	496	528	516	456
		Med	56	56	56	60	64	64	64	64
4DP	EW 300	Max	460	452	588	572	456	488	572	656
		Med	56	56	56	56	64	60	64	60
8DP	EW 300	Max	544	588	512	516	544	480	532	524
		Med	56	56	56	56	60	60	60	60

● EW + 100℃ Cross Temp(ADSP)

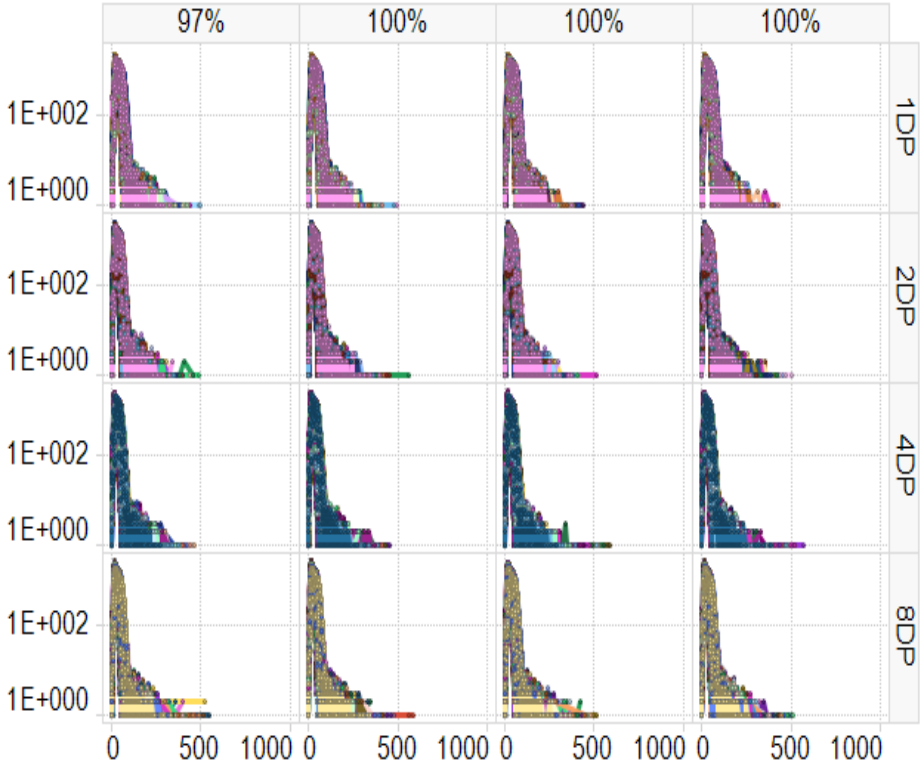


TLC (SOL X-Temp) – CP4A

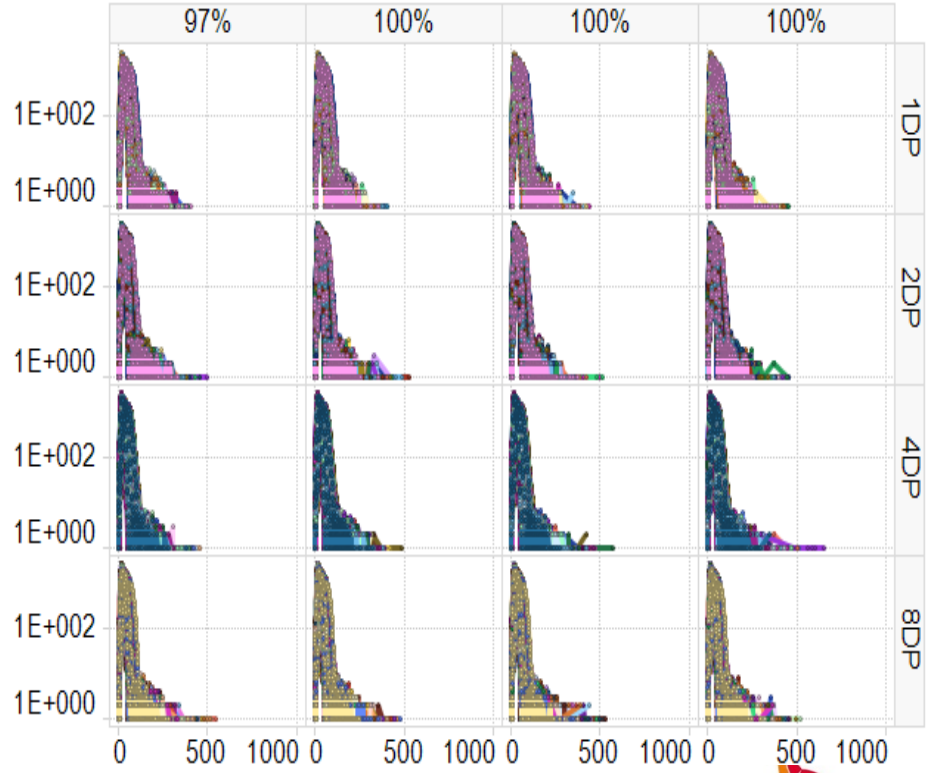
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -15℃
Cross Temp 100 ℃ @ 85 ℃

● EW + 100℃ Cross Temp(ADSP)



● EW + 100℃ Cross Temp + 2Week(ADSP)



TLC (EOL X-Temp) – CP4B

☑ Reliability Check points satisfied with checkpoint 4B.

● Result Summary

TLC Checkpoint 4B (X-Temp)									
Test Result			PASS							
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	72	64	64	68	100	104	100	100
		Median	20	20	20	20	36	32	36	36
2DP	EW 3K	Max	68	68	68	72	96	100	108	104
		Median	20	20	20	20	32	32	32	32
4DP	EW 3K	Max	64	64	60	64	96	88	92	92
		Median	20	20	20	20	32	32	32	32
8DP	EW 3K	Max	84	72	84	84	116	112	128	124
		Median	24	20	24	24	32	32	32	32

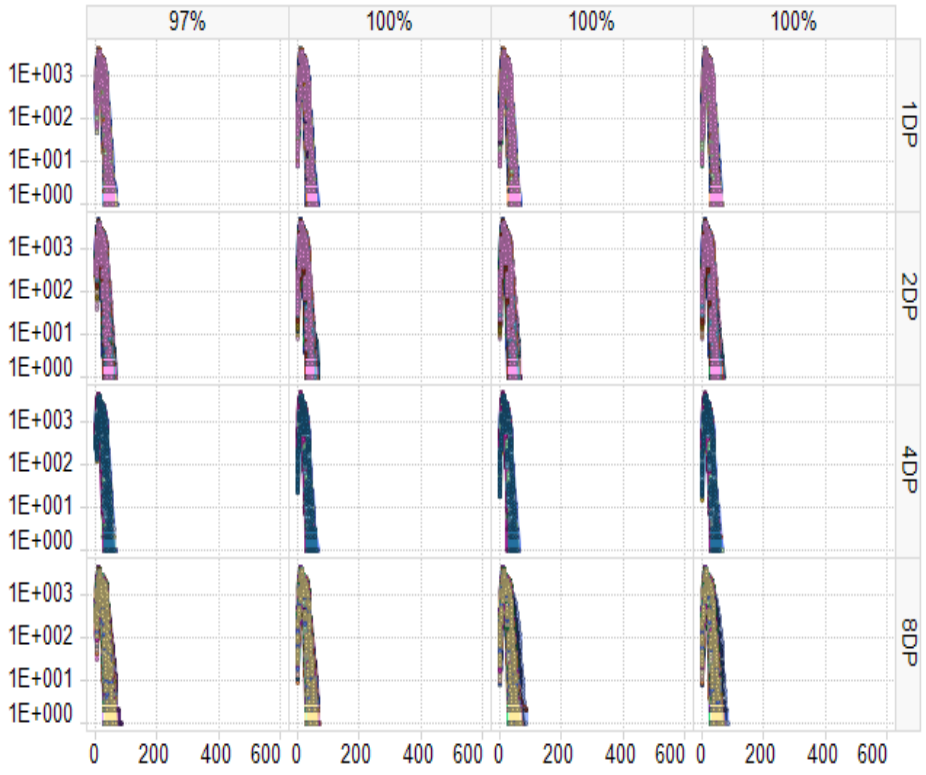
● EW + 100℃ Cross Temp

TLC (EOL X-Temp) – CP4B

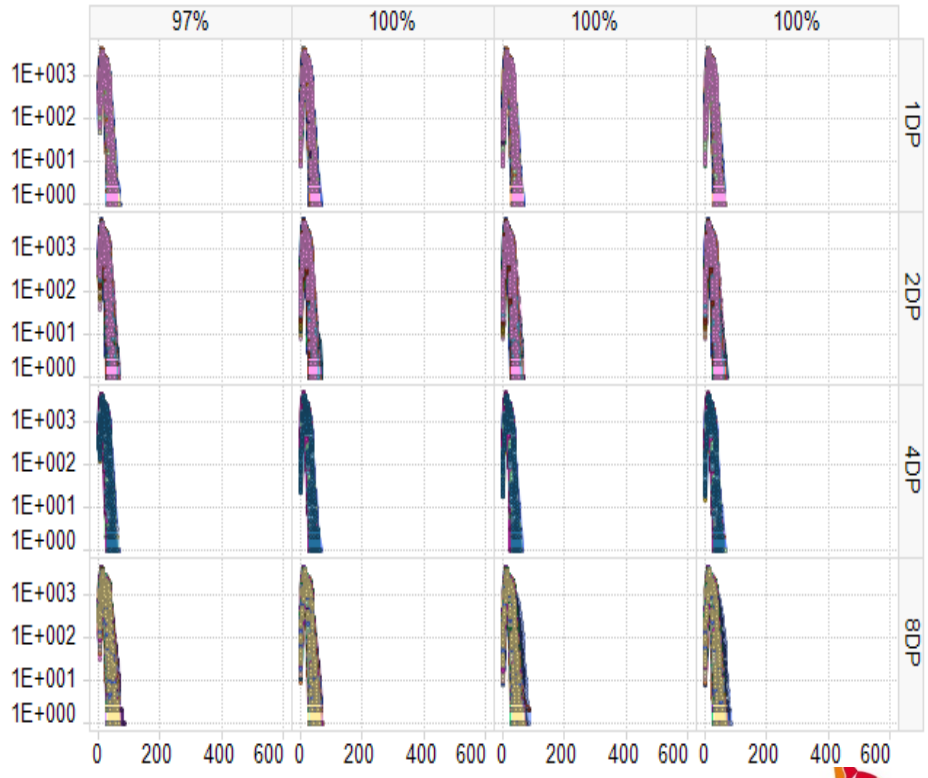
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -15℃
Cross Temp 100 ℃ @ 85 ℃

● EW



● EW + 100℃ Cross Temp



TLC (EOL X-Temp) – CP4C

☑ Reliability Check points satisfied with checkpoint 4C.

● Result Summary

TLC Checkpoint 4C (X-Temp)										
Test Result			PASS							
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp			
			97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 3K	Max	72	64	64	68	104	100	100	104
		Median	20	20	20	20	36	36	36	36
2DP	EW 3K	Max	68	68	68	72	104	108	108	108
		Median	20	20	20	20	36	36	36	36
4DP	EW 3K	Max	64	64	60	64	112	116	108	116
		Median	20	20	20	20	36	36	36	36
8DP	EW 3K	Max	84	72	84	84	136	136	140	132
		Median	24	20	24	24	40	40	40	40

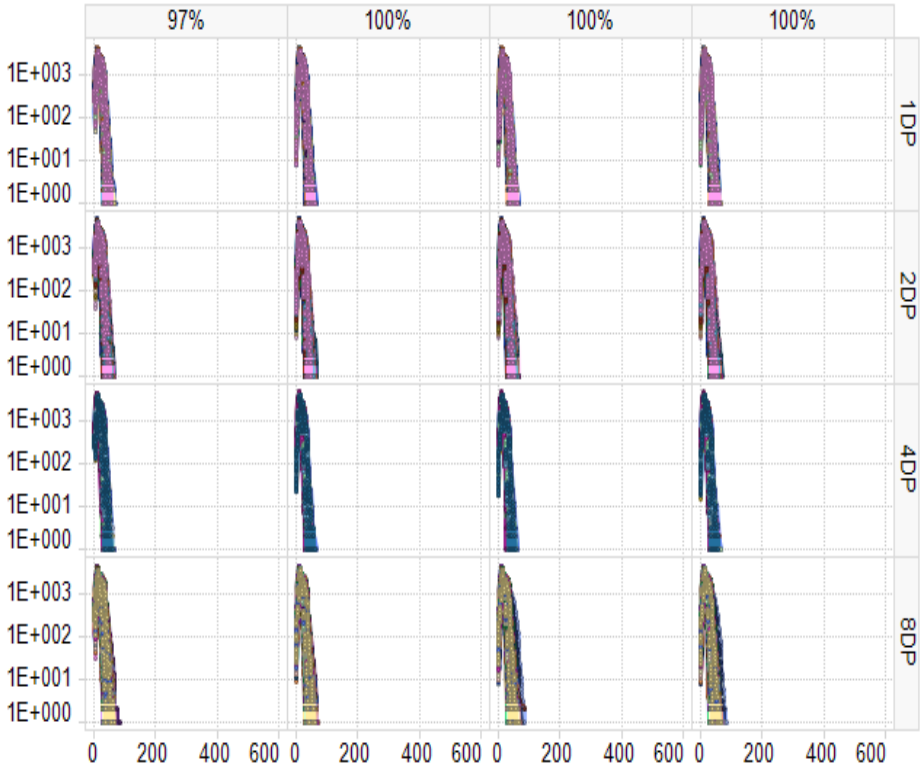
● EW + 100℃ Cross Temp

TLC (EOL X-Temp) – CP4C

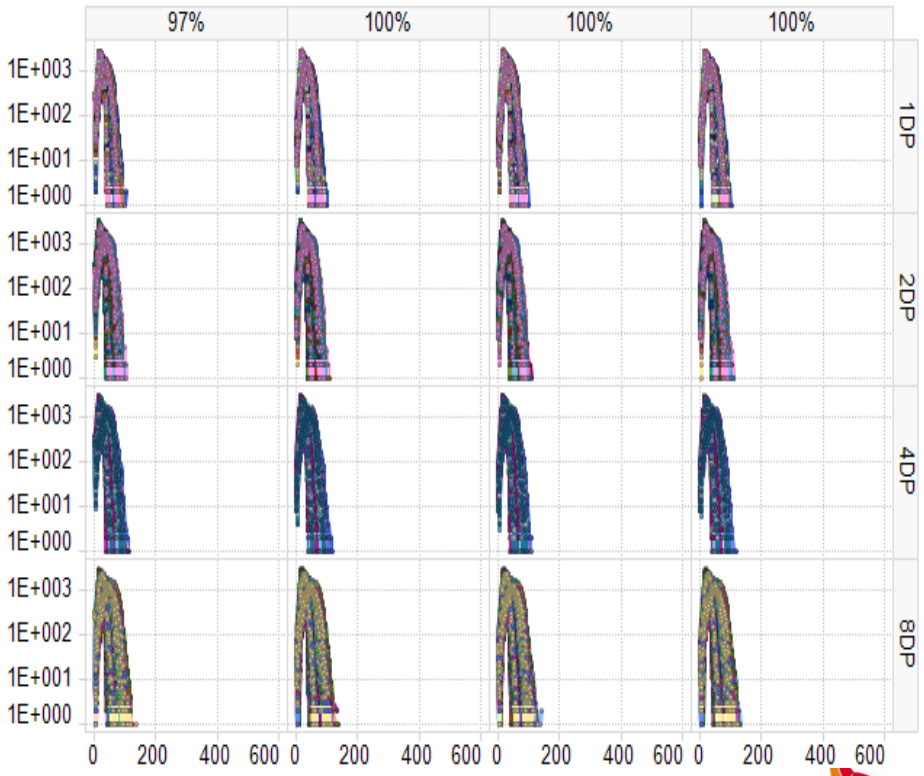
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 85℃
Cross Temp 100 ℃ @ -15 ℃

● EW



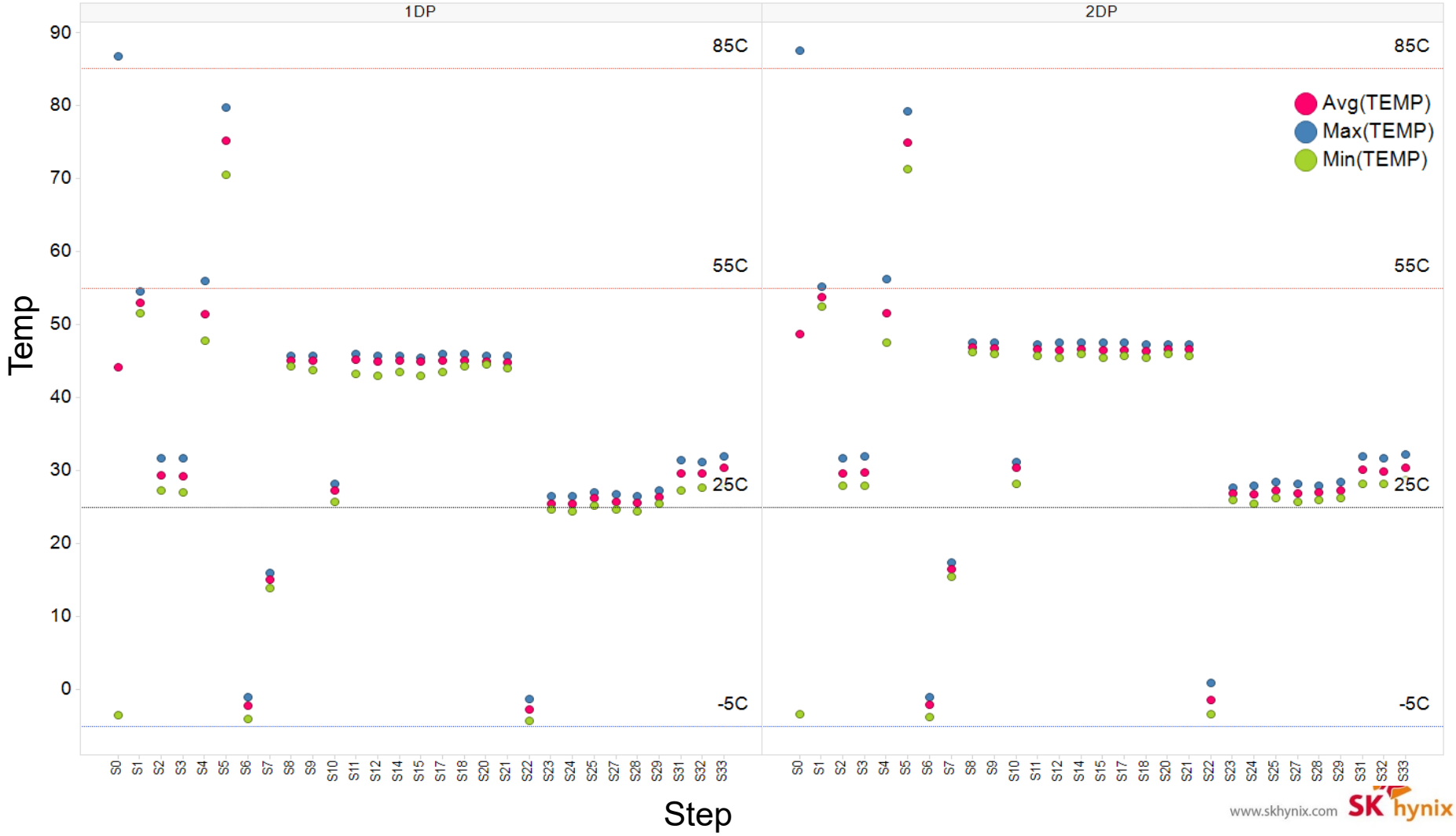
● EW + 100℃ Cross Temp



[QUAL10] TLC
Latency / Throughput

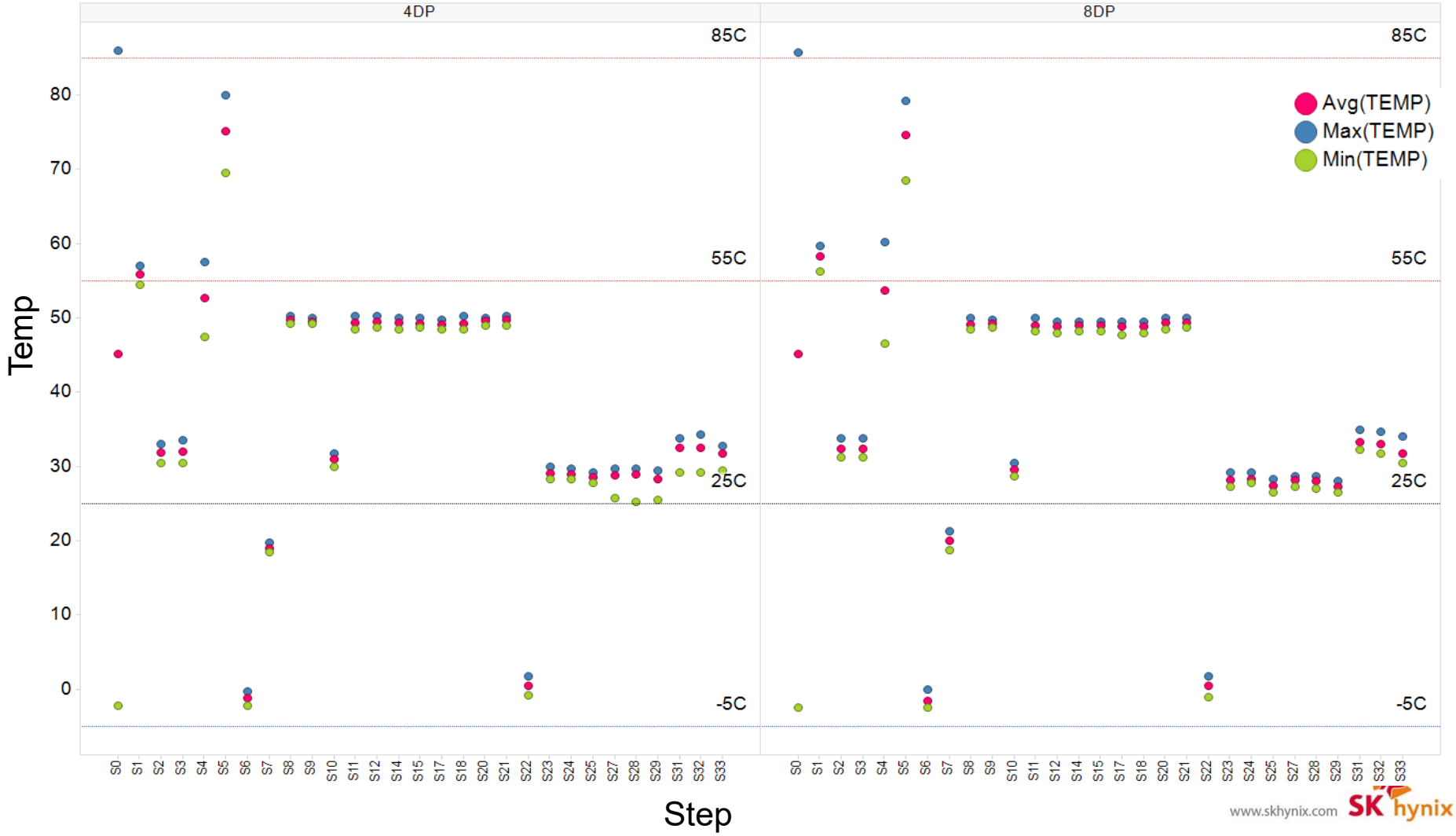
QUAL10 TLC Latency Temp Measurement

TLC Latency temp Sensor Measurement (1/2DP)



QUAL10 TLC Latency Temp Measurement

TLC Latency temp Sensor Measurement (4/8DP)

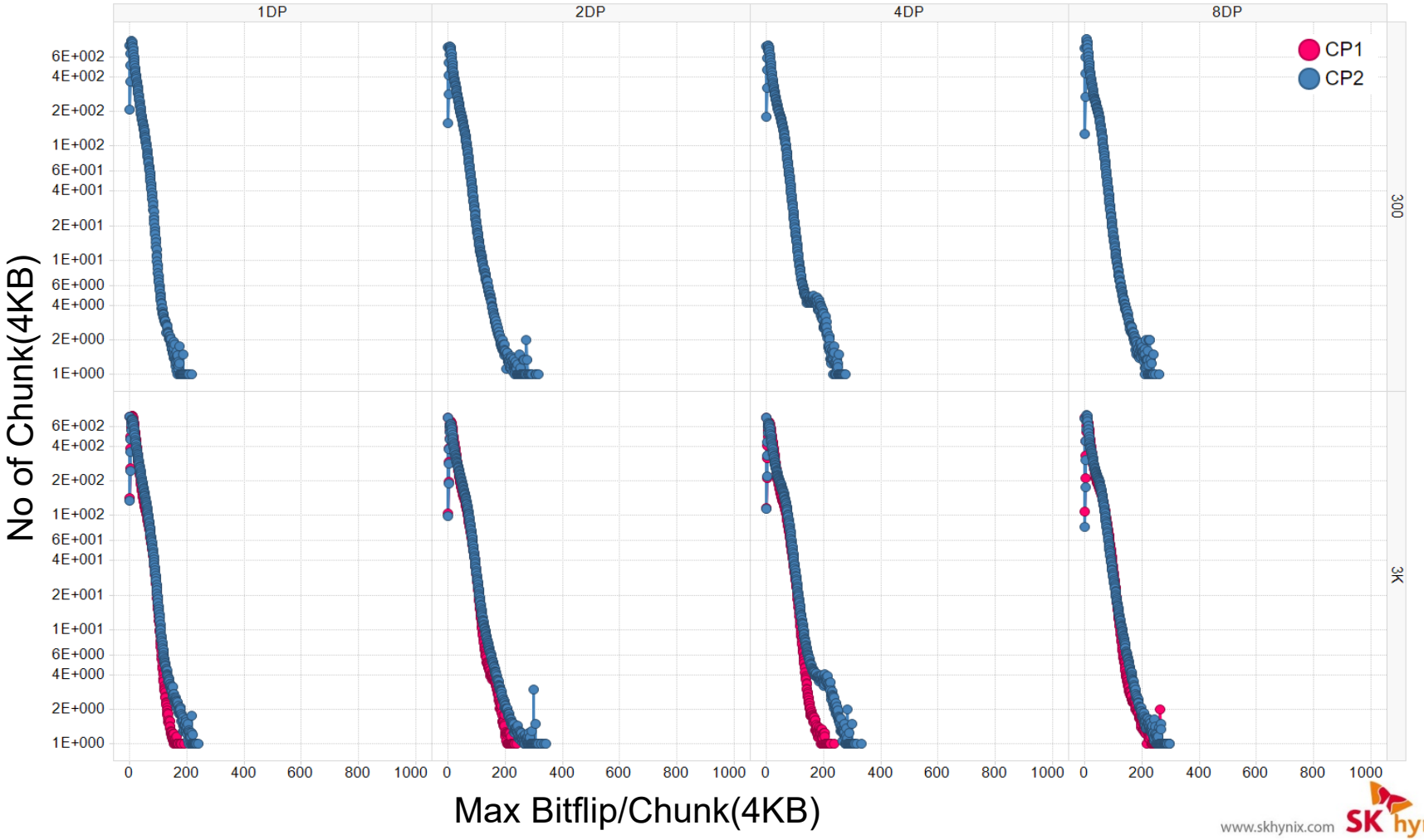


QUAL10 Latency Cycling Bitflips Measurement

☑ EW No. of Chunk vs. Bit Flips

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Bitflip Monitor 1Checkpoint @90%, 2Checkpoint @10%



QUAL10 Reliability tPROG/tBERS

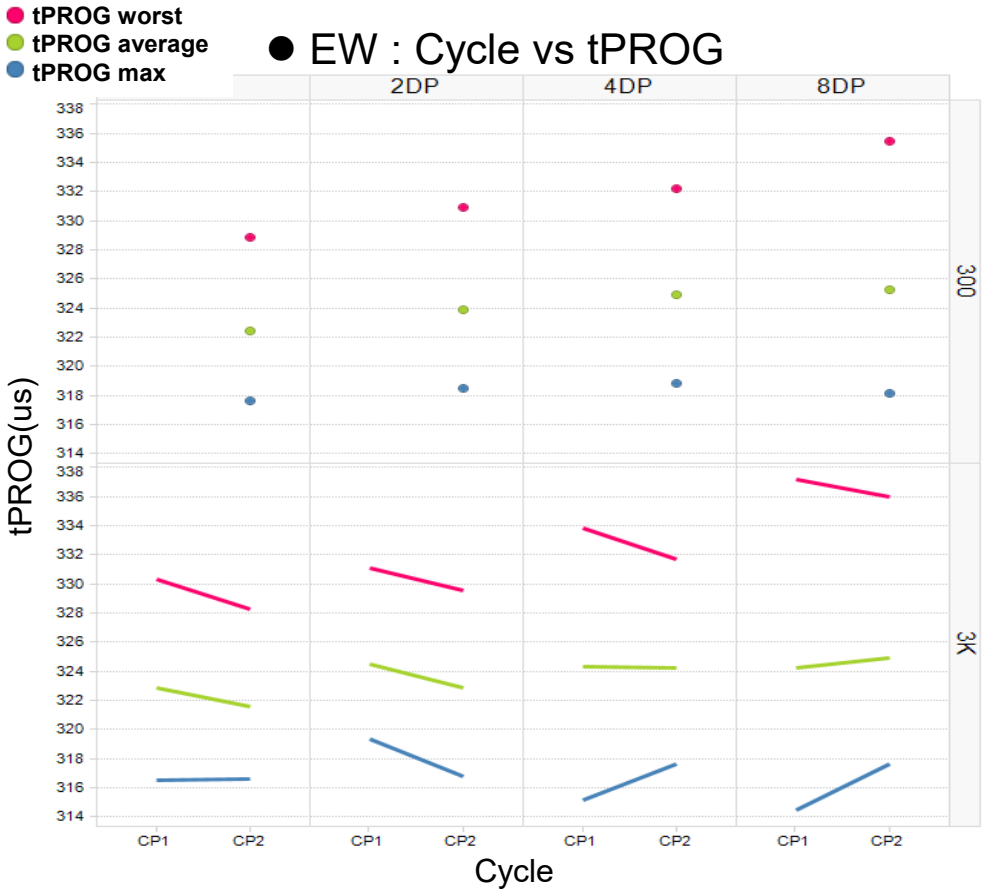
☑ EW tPROG/tBERS

$$tPROG = \frac{1}{P}\sum_{i} tPROG, PAGEi$$

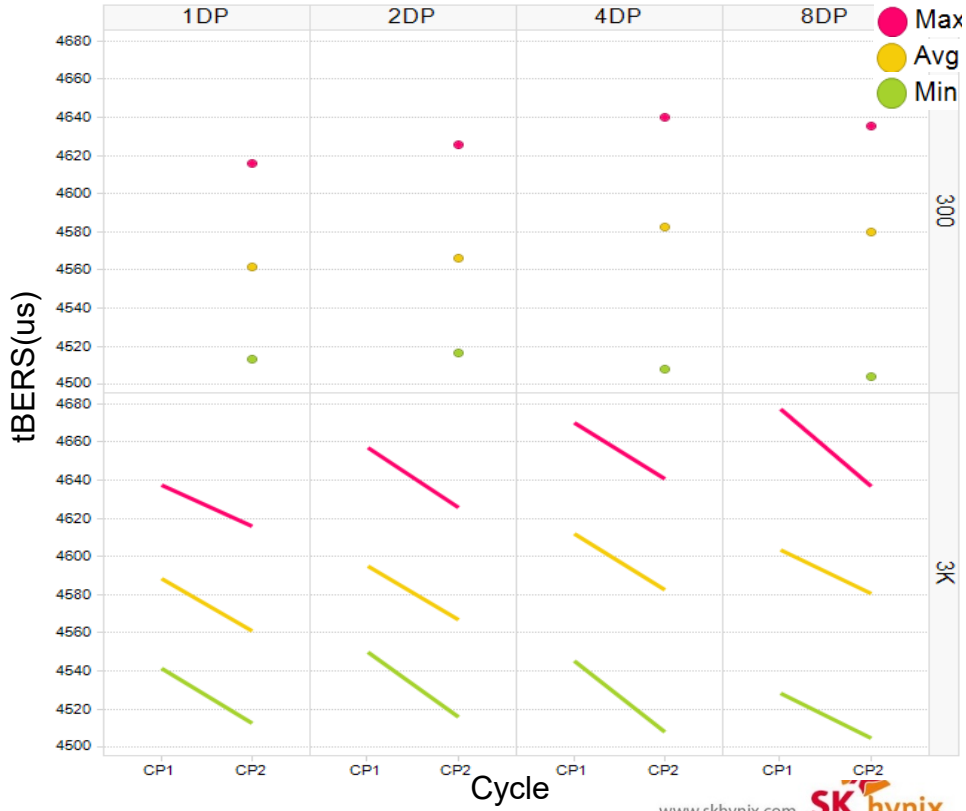
EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%

tPROG worst := Average_dies(Average_blocks(Average_pages(program time))) + 5*std_dies(Average_blocks(Average_pages(program time)))
tPROG average := Average_dies(Average_blocks(Average_pages(program time)))
tPROG max := Max_dies(Average_blocks(Average_pages(program time)))

● EW : Cycle vs tPROG



● EW : Cycle vs tBERS

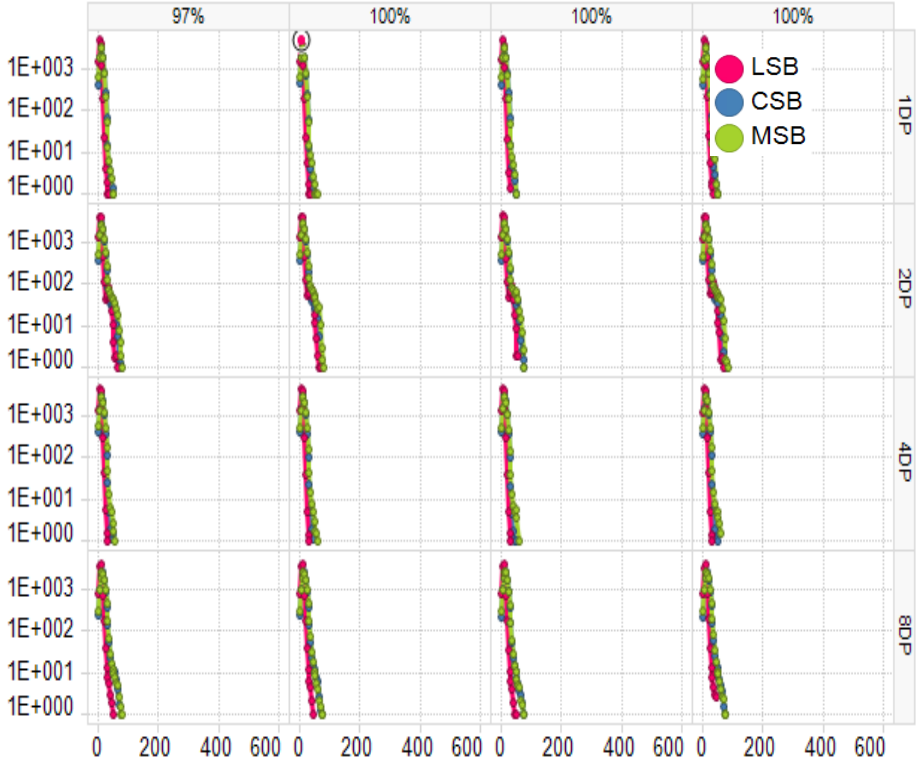


TLC (SOL Latency) – CP8

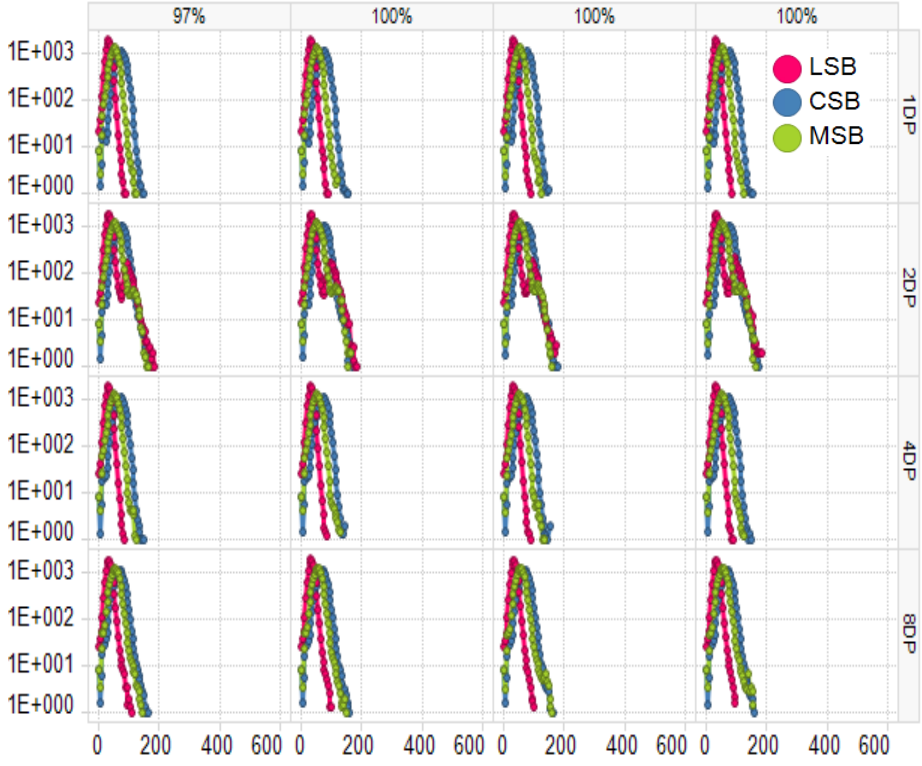
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● EW



● EW + RD 100K + 3Months

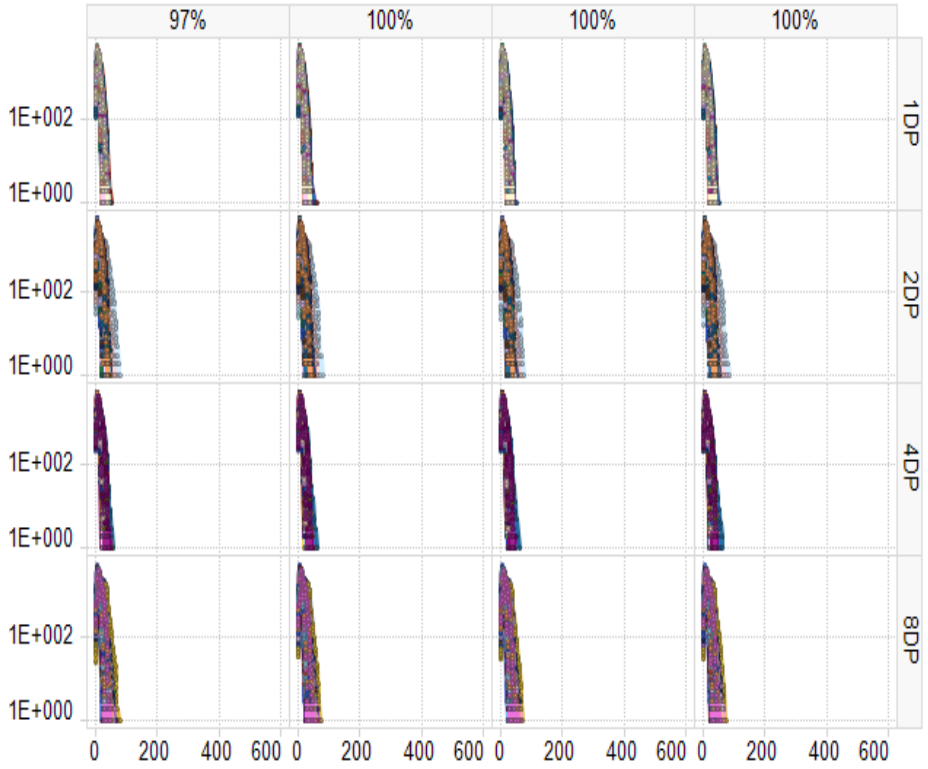


TLC (SOL Latency) – CP8

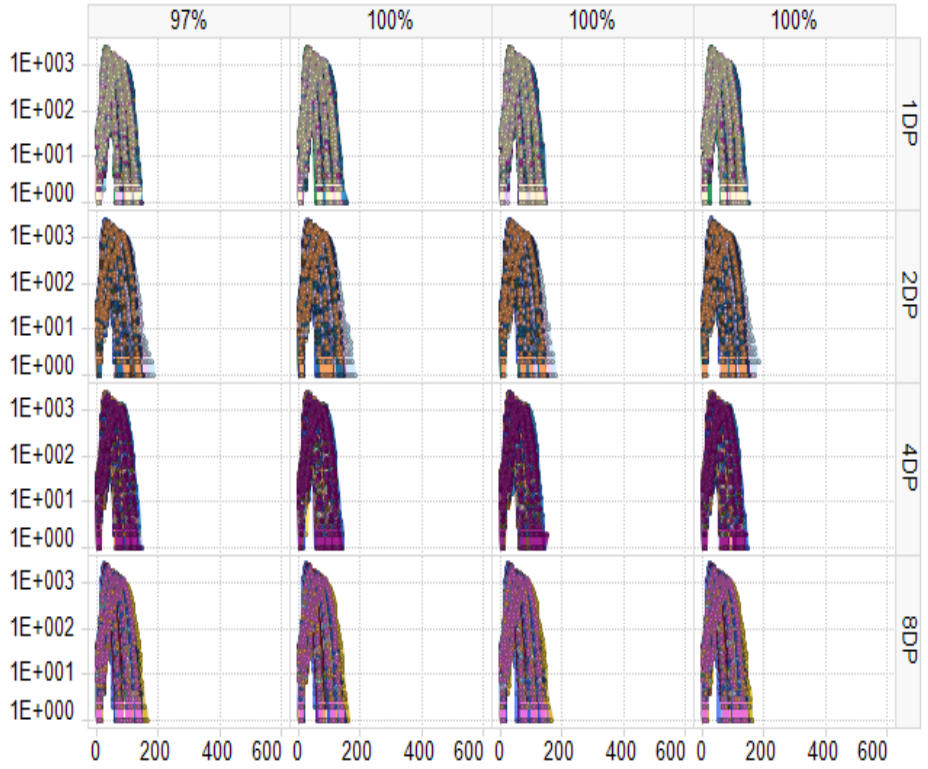
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● EW



● EW + RD 100K + 3Months

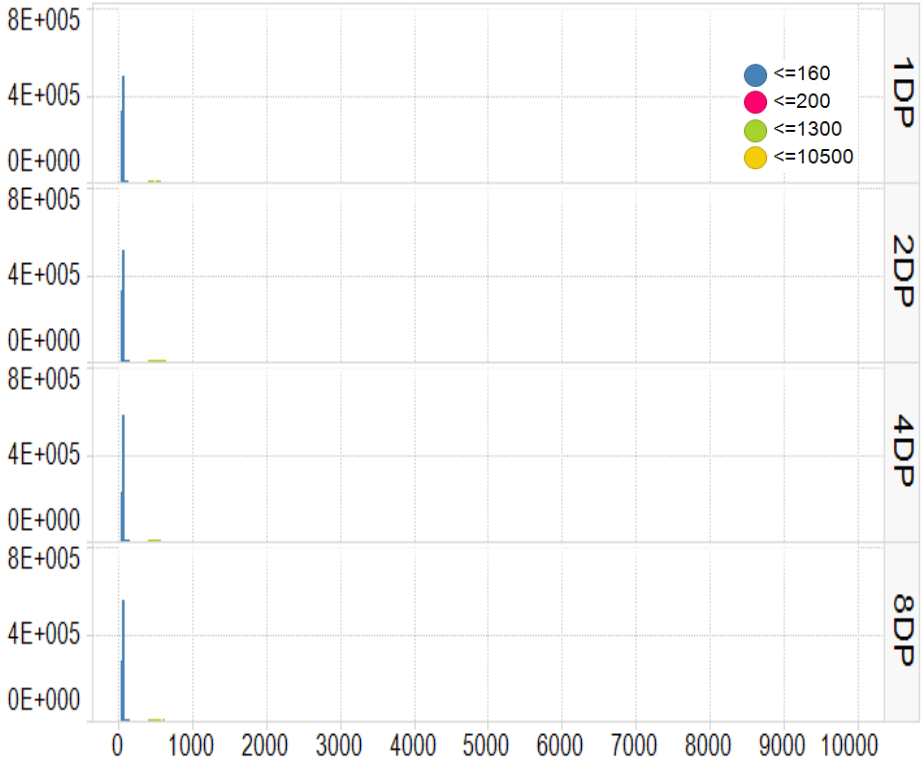


TLC (SOL Latency) – CP8

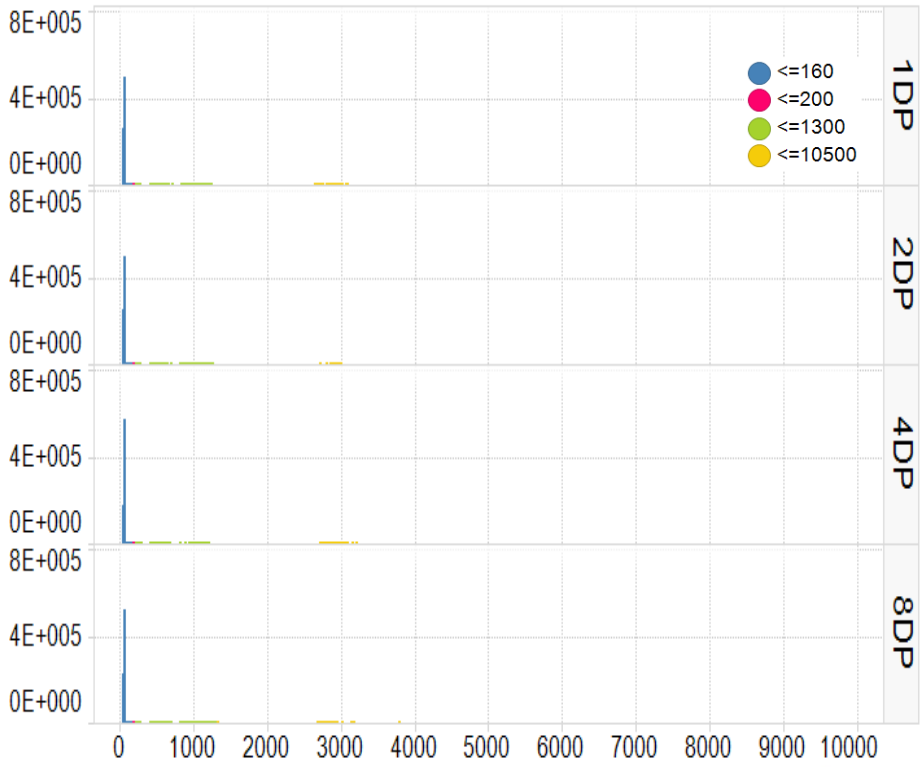
☑ Read Latency Distribution@ EW + RD 100K + 3months@ 45℃ with cross temp 30 ℃

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(EW)



● No. of Chunk vs. Read Latency
(EW + RD 100K + 3months)

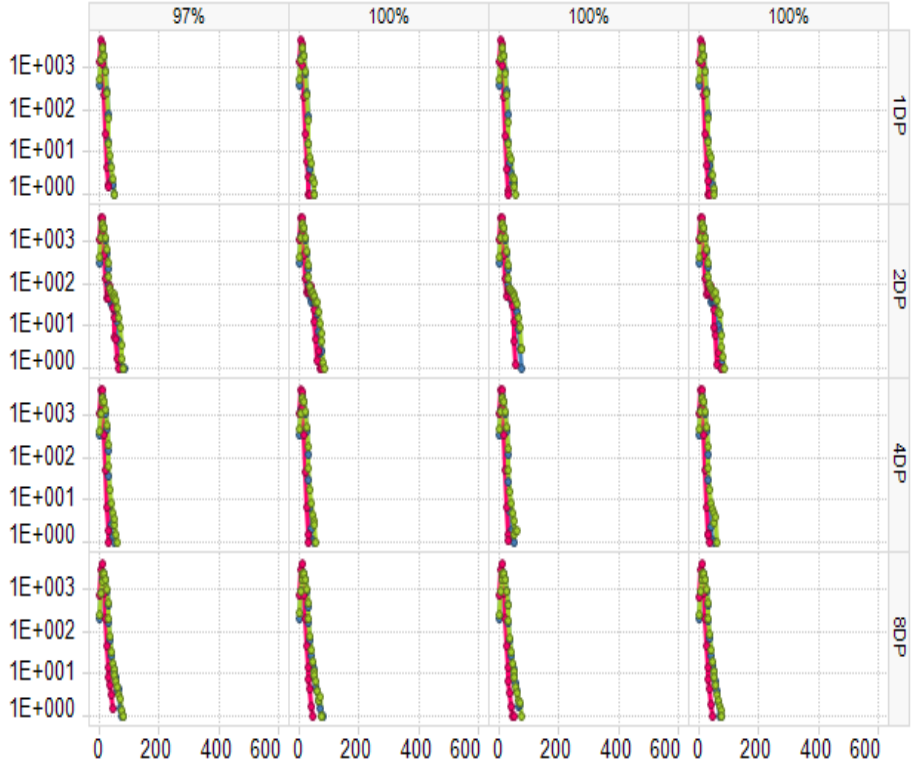


TLC (EOL Latency) – CP9A

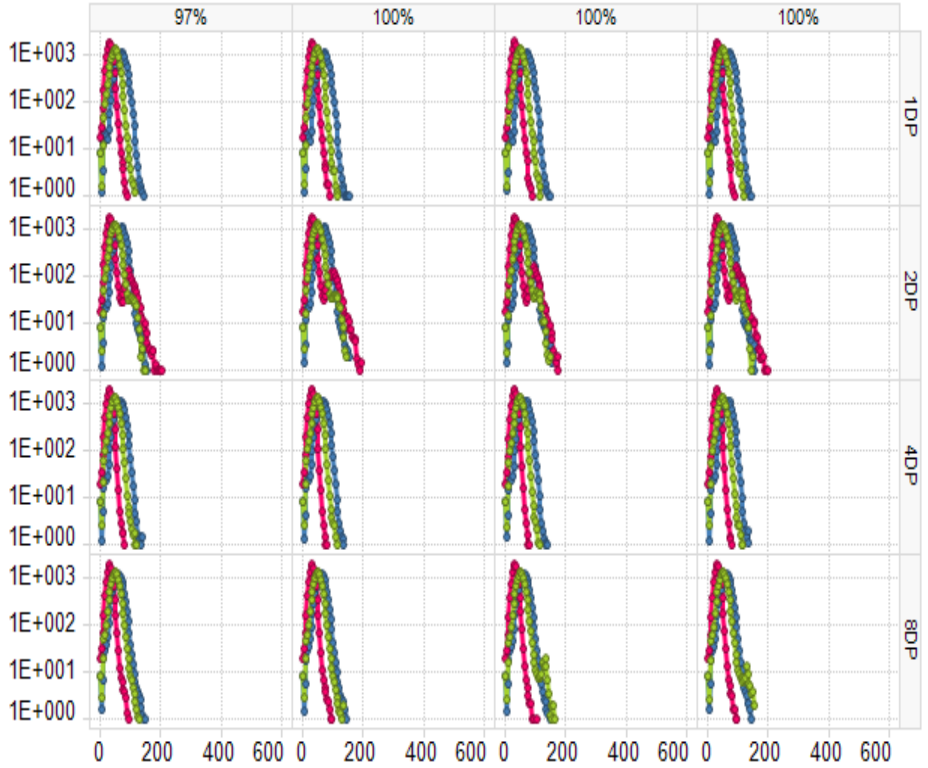
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 30 ℃

● EW



● EW + RD 100K + 1Month

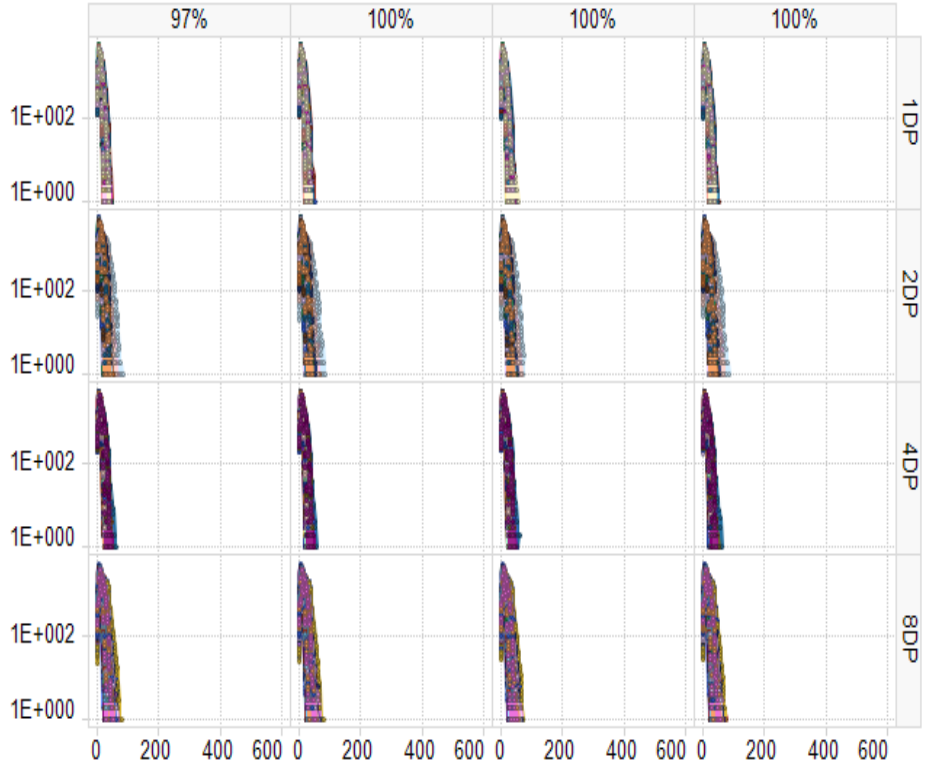


TLC (EOL Latency) – CP9A

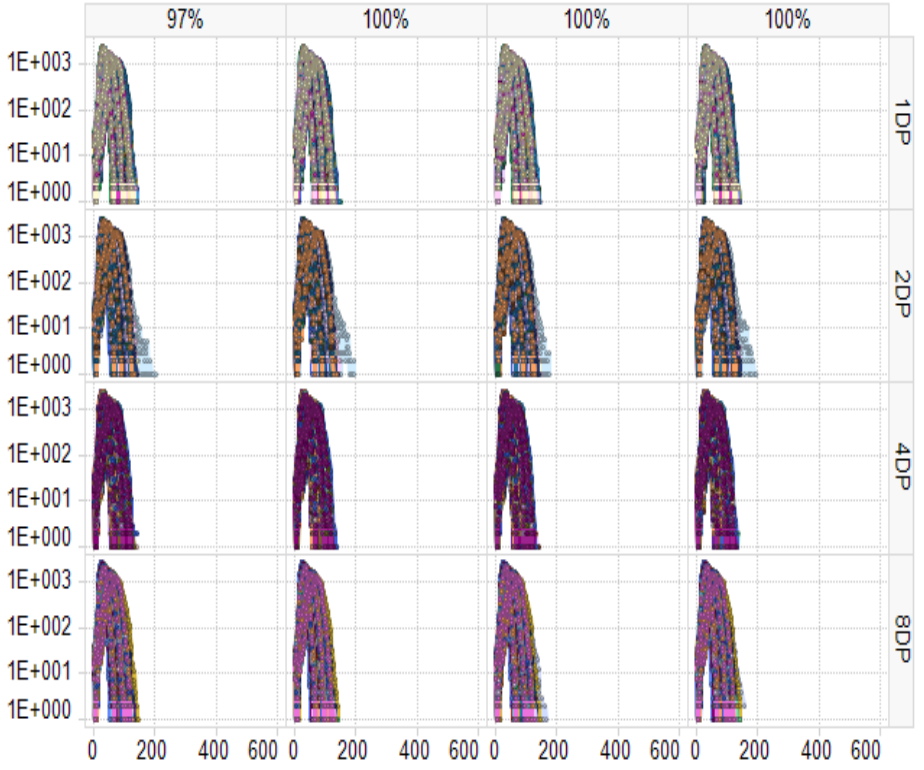
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 30 ℃

● EW



● EW + RD 100K + 1Month

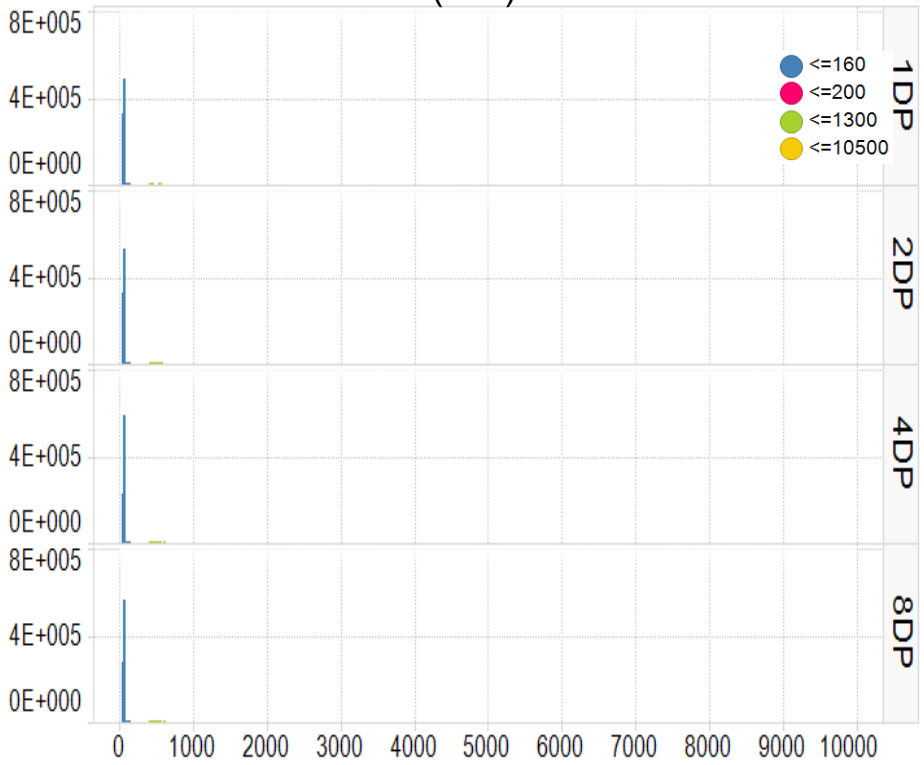


TLC (EOL Latency) – CP9A

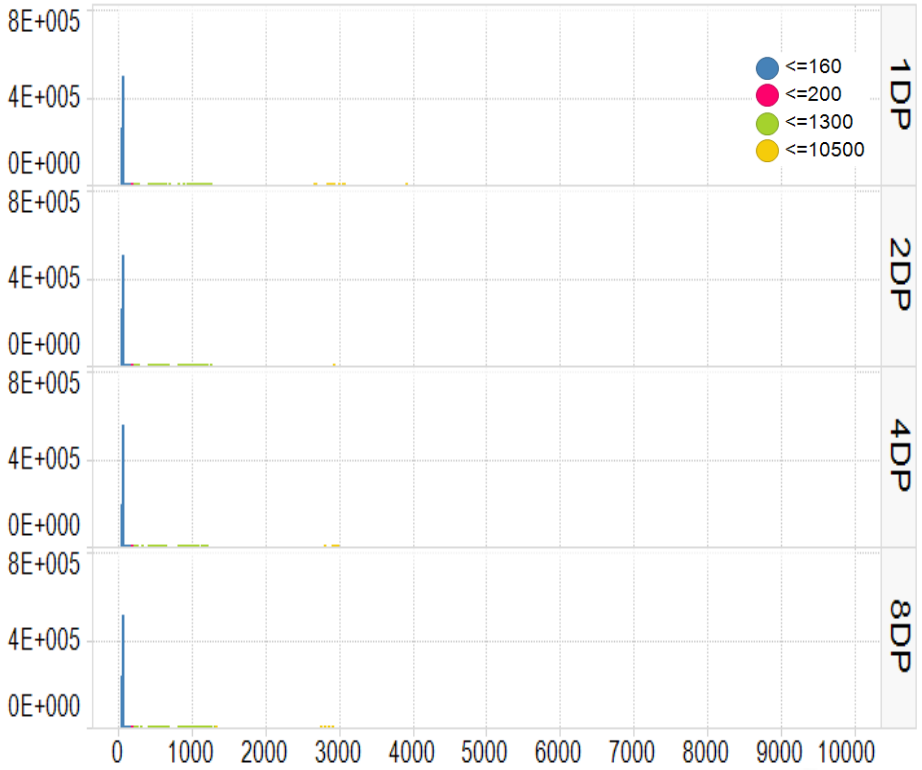
☑ Read Latency Distribution@ EW + RD 100K + 1month@ 45℃ with cross temp 30 ℃

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(EW)



● No. of Chunk vs. Read Latency
(EW + RD 100K + 1month)

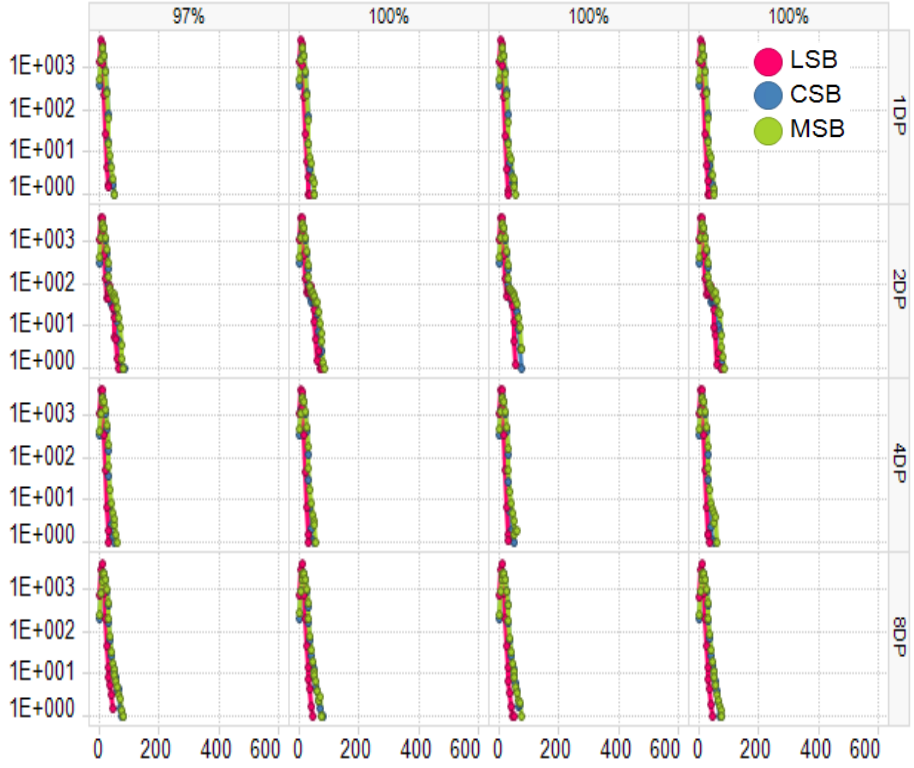


TLC (EOL Latency) – CP9C

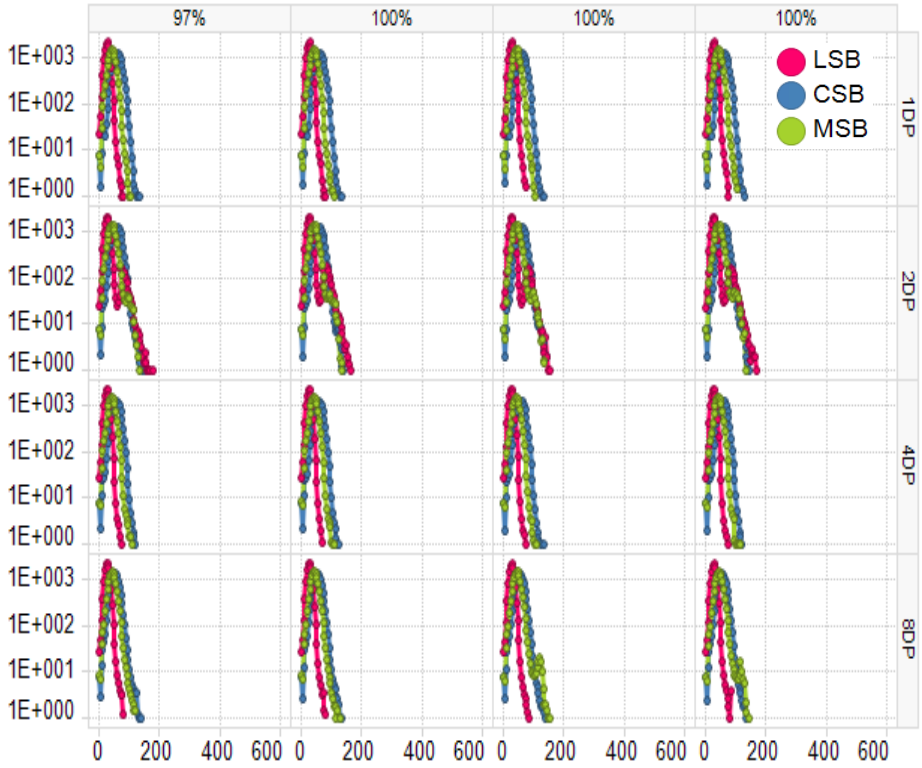
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃

● EW



● EW + RD 100K + 1Month

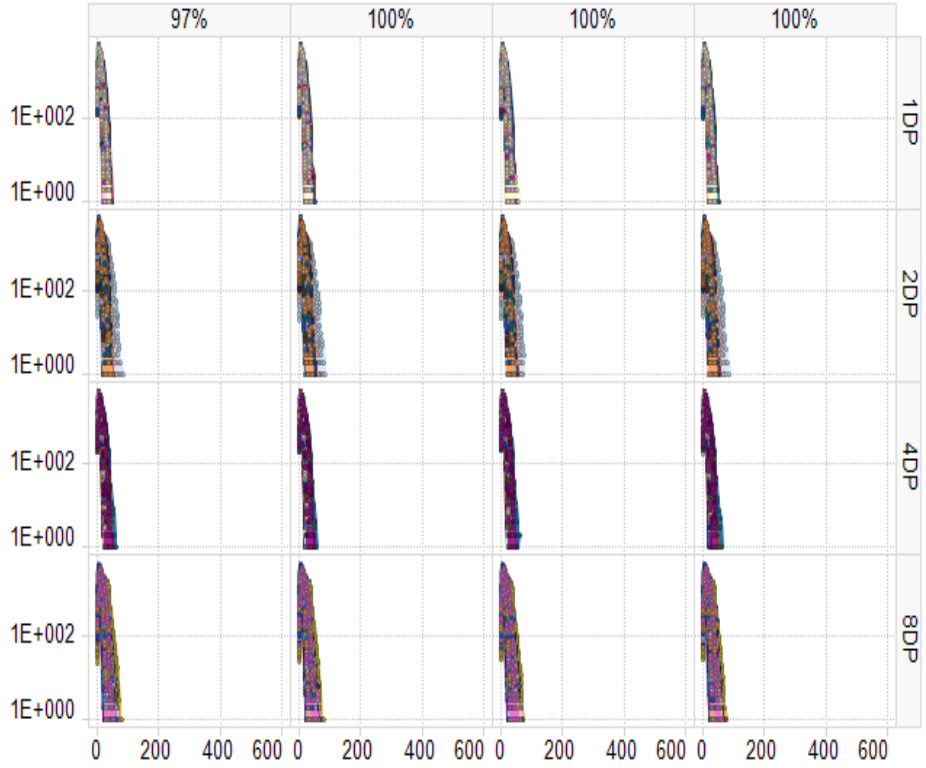


TLC (EOL Latency) – CP9C

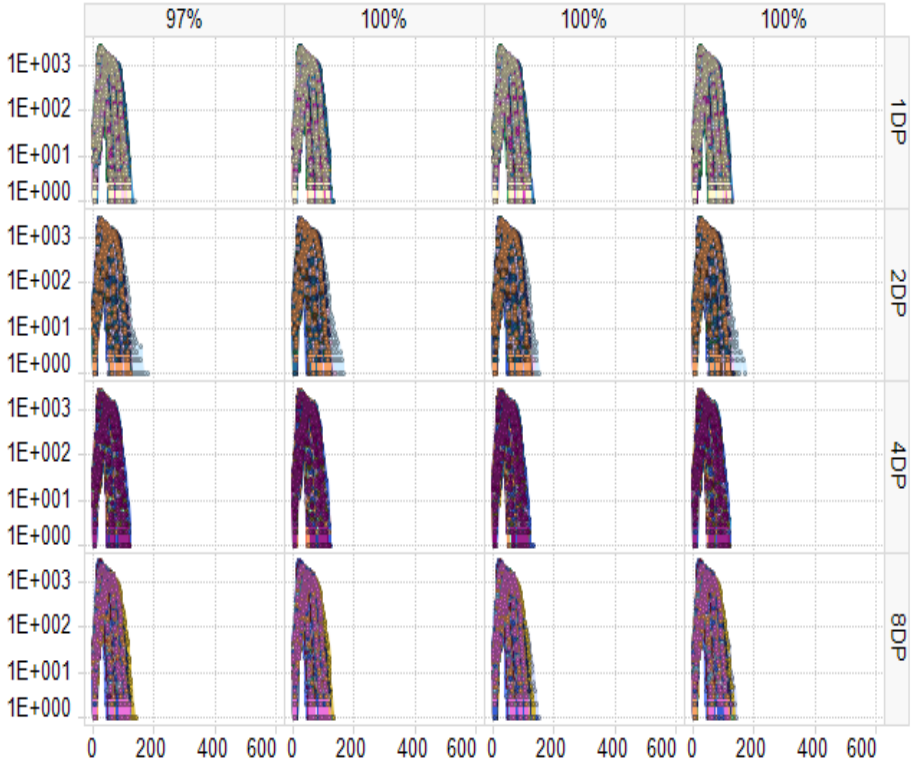
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1months@ 35℃ with cross temp 30 ℃

● EW



● EW + RD 100K + 1Month

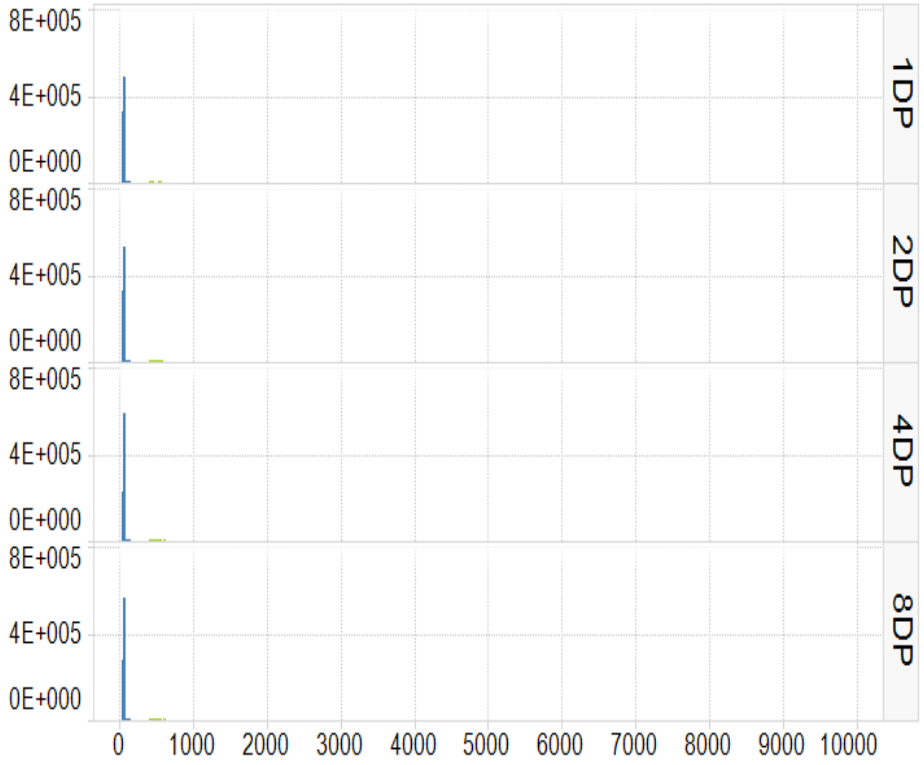


TLC (EOL Latency) – CP9C

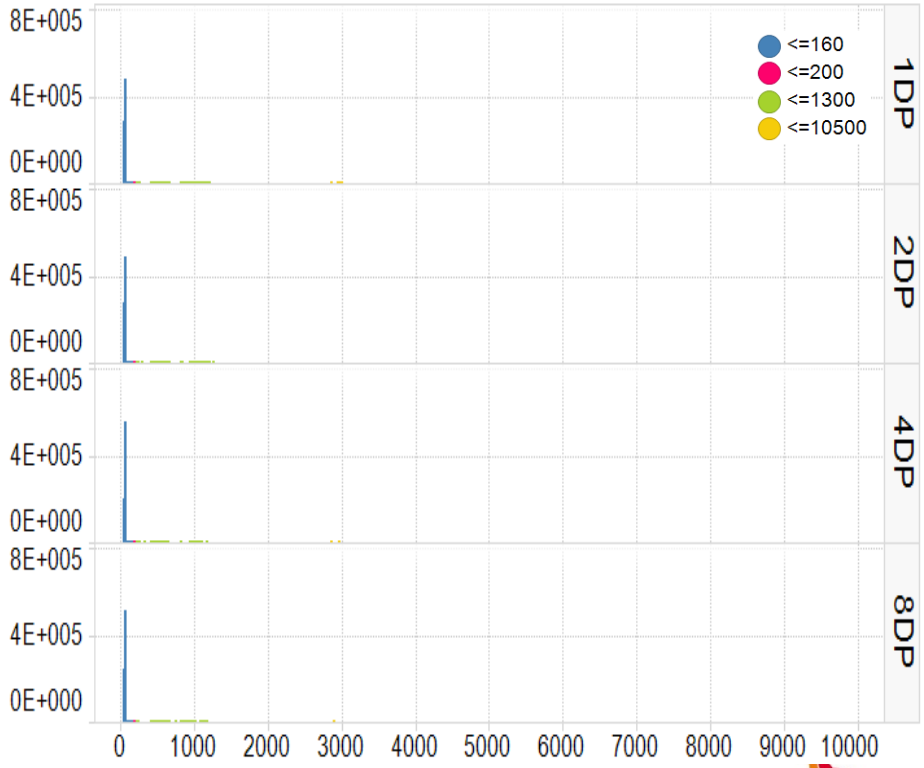
☑ Read Latency Distribution@ EW + RD 100K + 1month@ 35℃ with cross temp 30 ℃

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(EW)



● No. of Chunk vs. Read Latency
(EW + RD 100K + 1month)

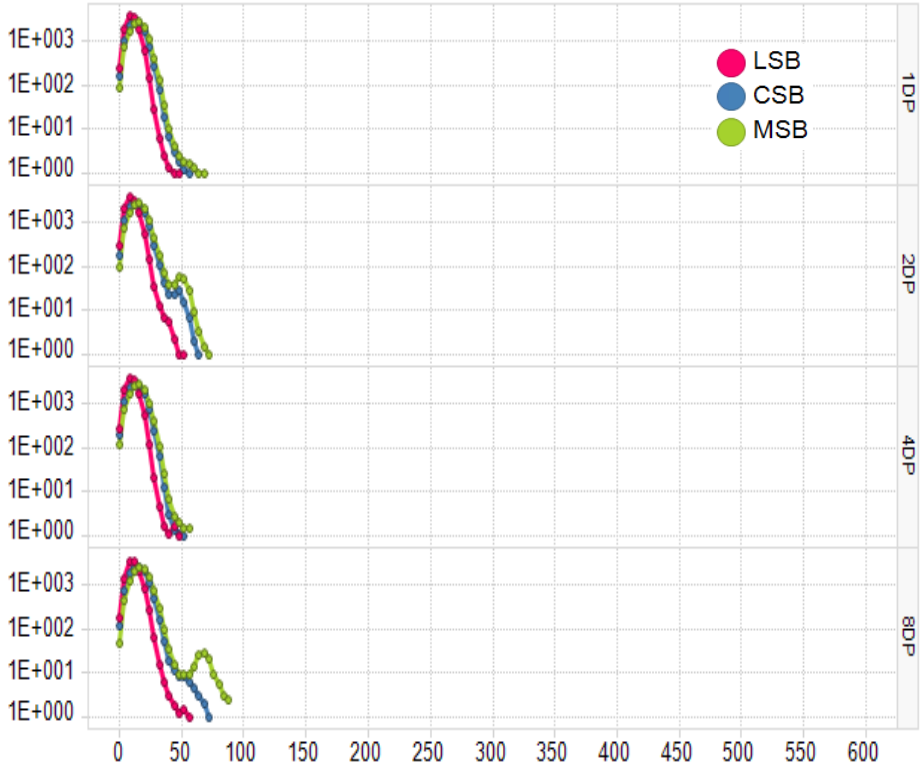


TLC (Erase Tolerance) – CP10

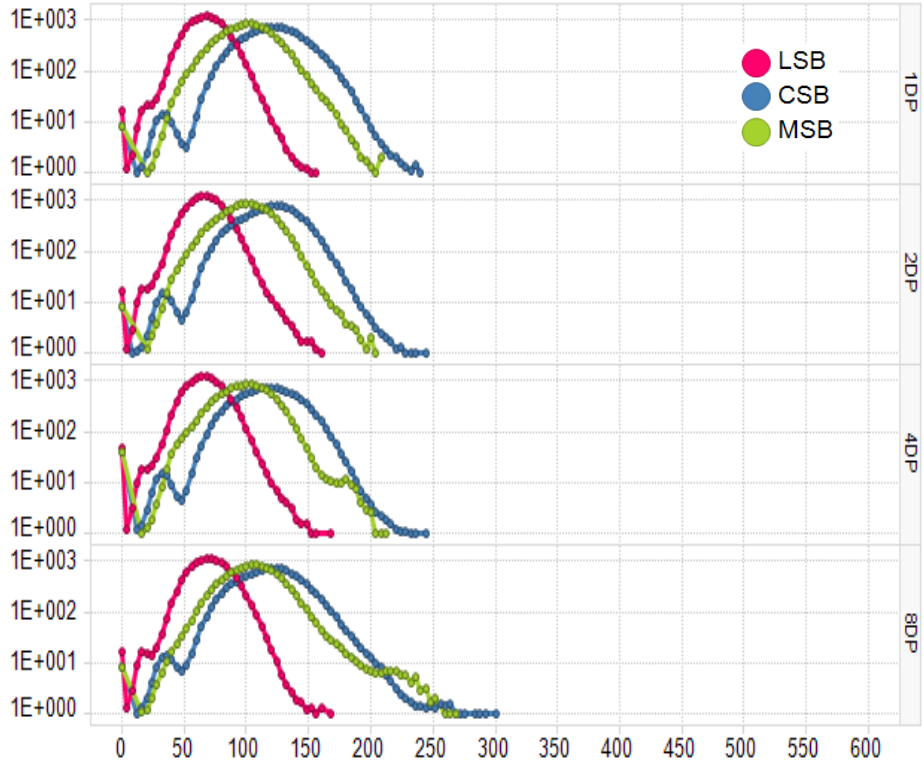
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● PGM



● PGM + 12Months+2week

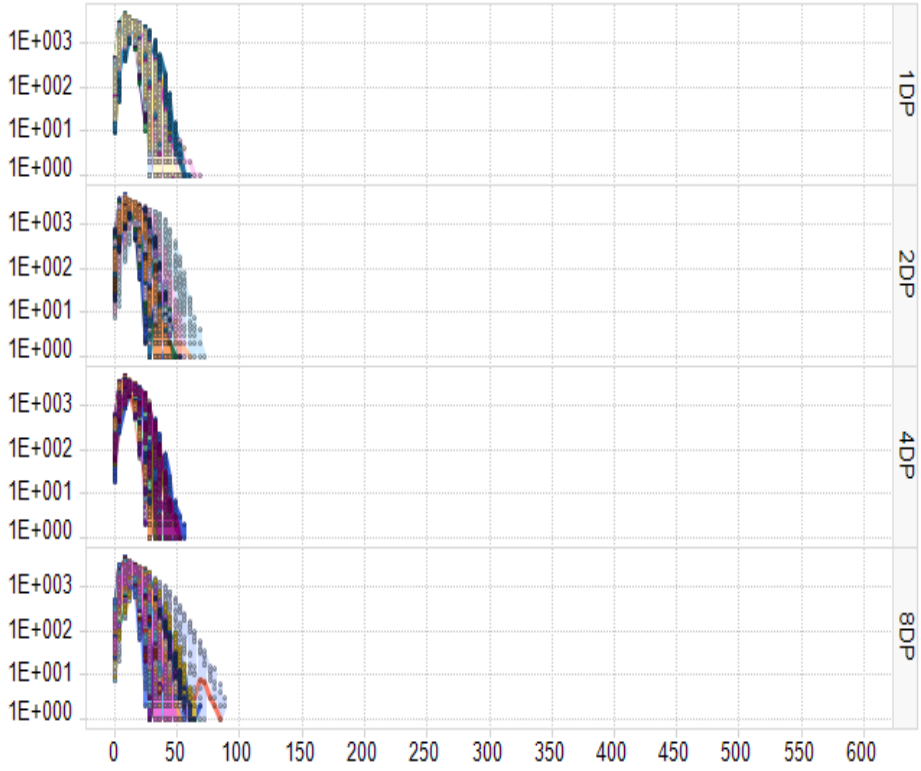


TLC (Erase Tolerance) – CP10

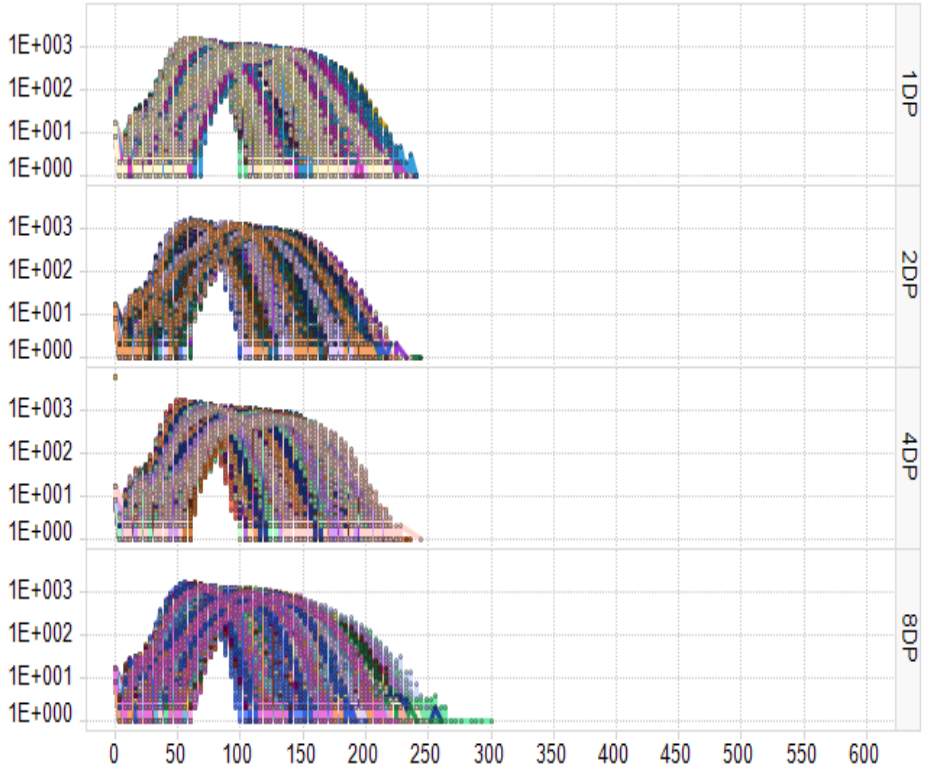
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● PGM



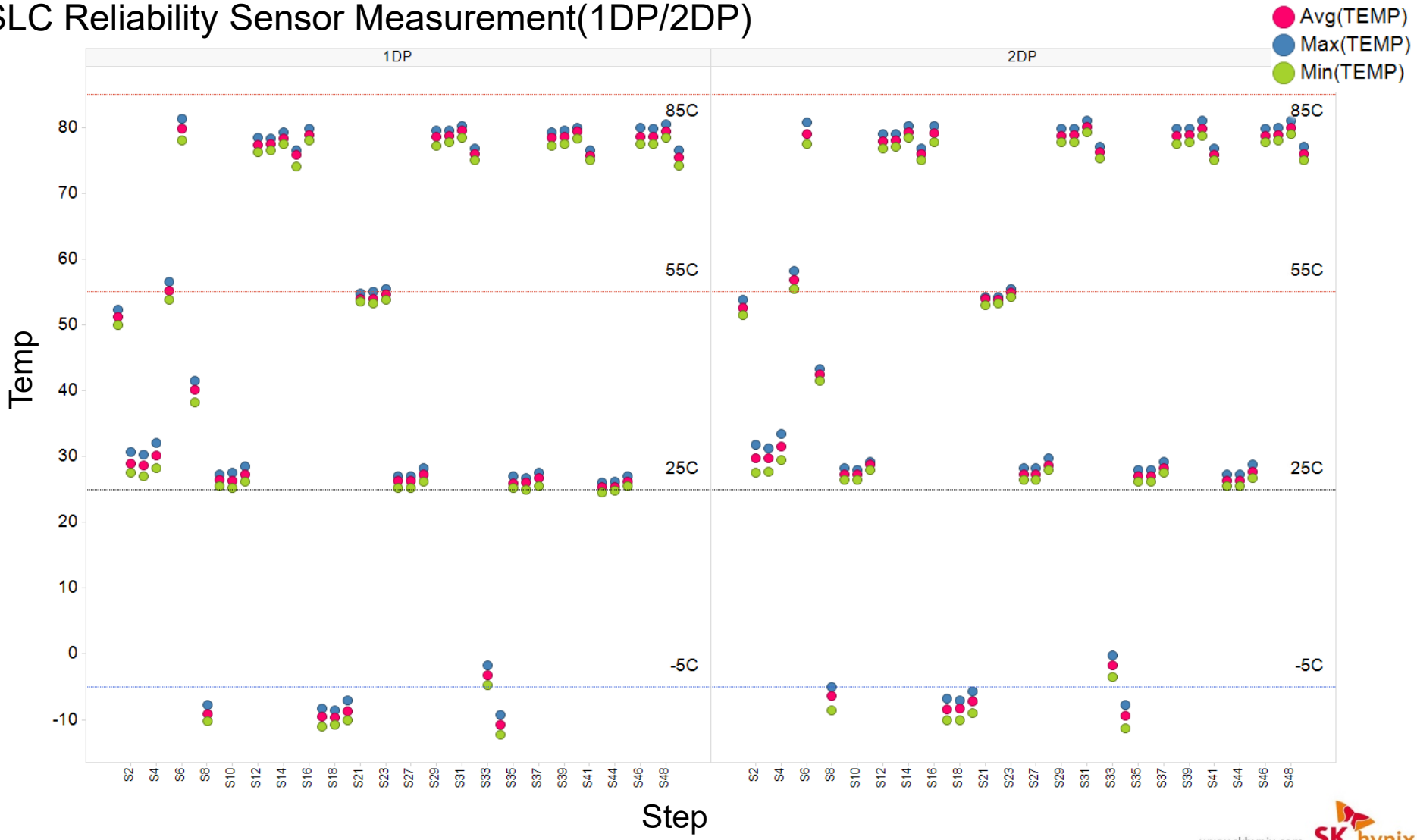
● PGM + 12Months+2week



[QUAL12] SLC Reliability

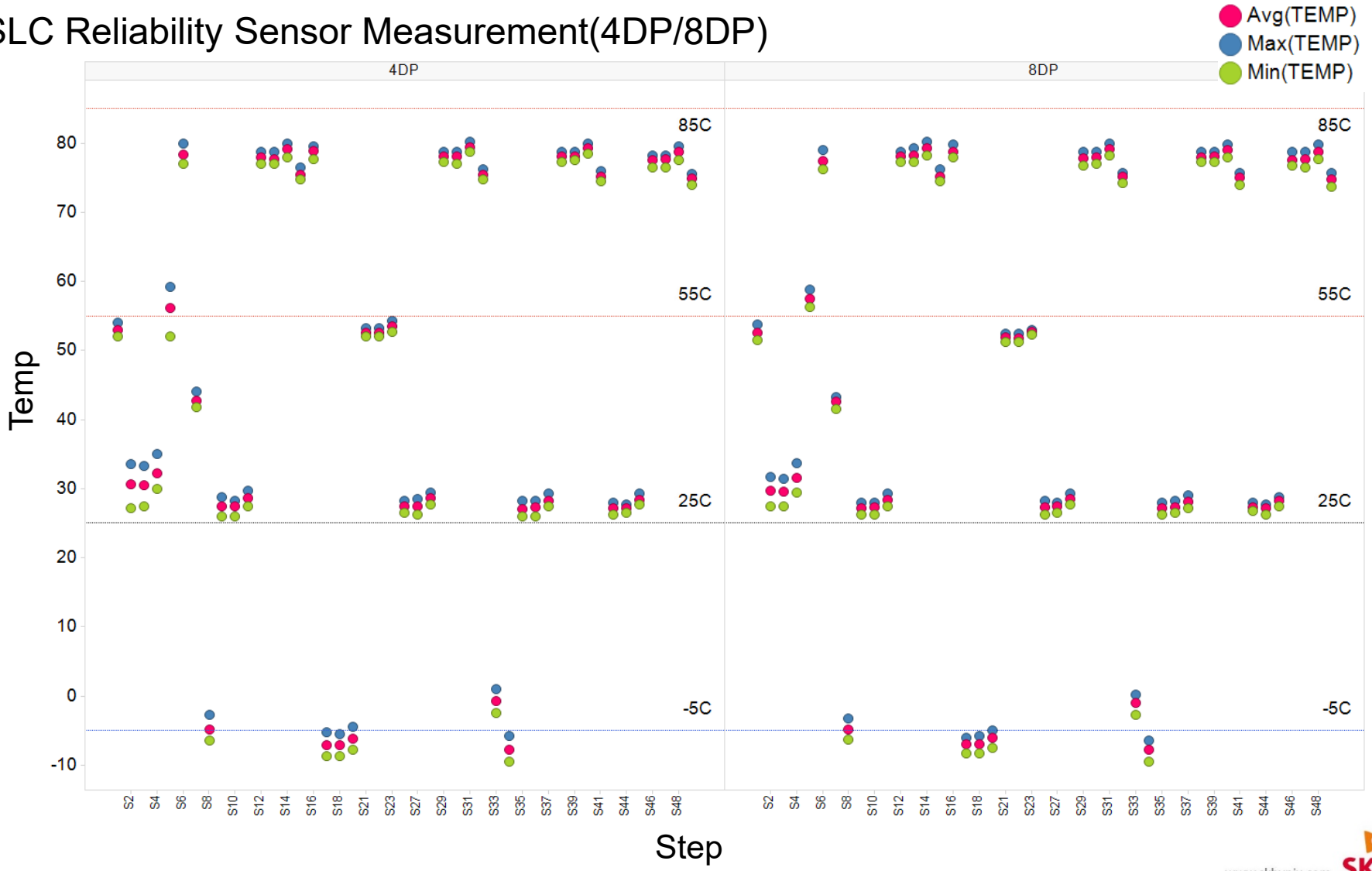
QUAL12 SLC Reliability Temp Measurement

SLC Reliability Sensor Measurement(1DP/2DP)



QUAL12 SLC Reliability Temp Measurement

SLC Reliability Sensor Measurement(4DP/8DP)

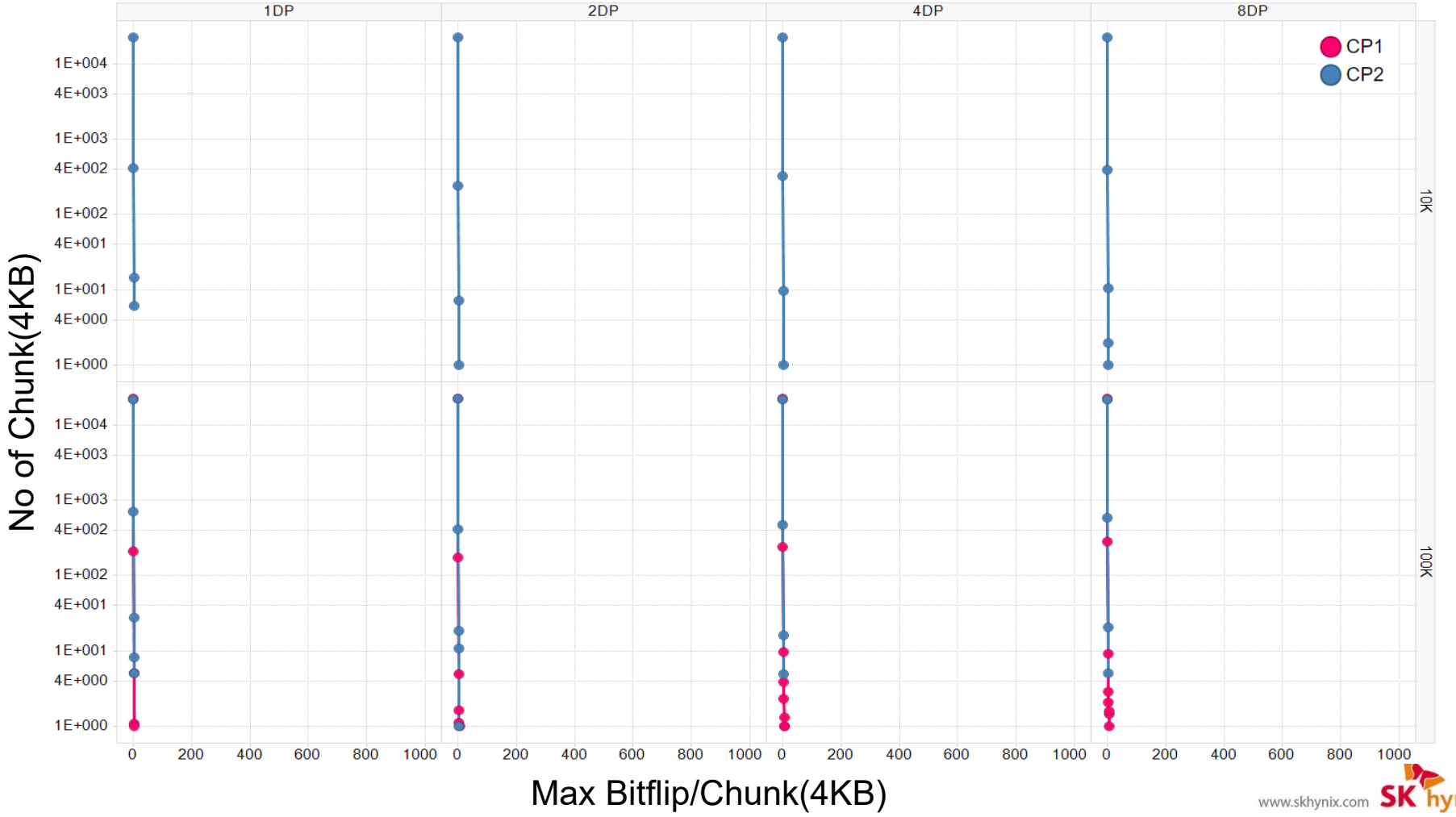


QUAL12 SLC Reliability Cycling Bitflips Measurement

☑ EW No. of Chunk vs. Bit Flips

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%



QUAL12 Reliability tPROG/tBERS

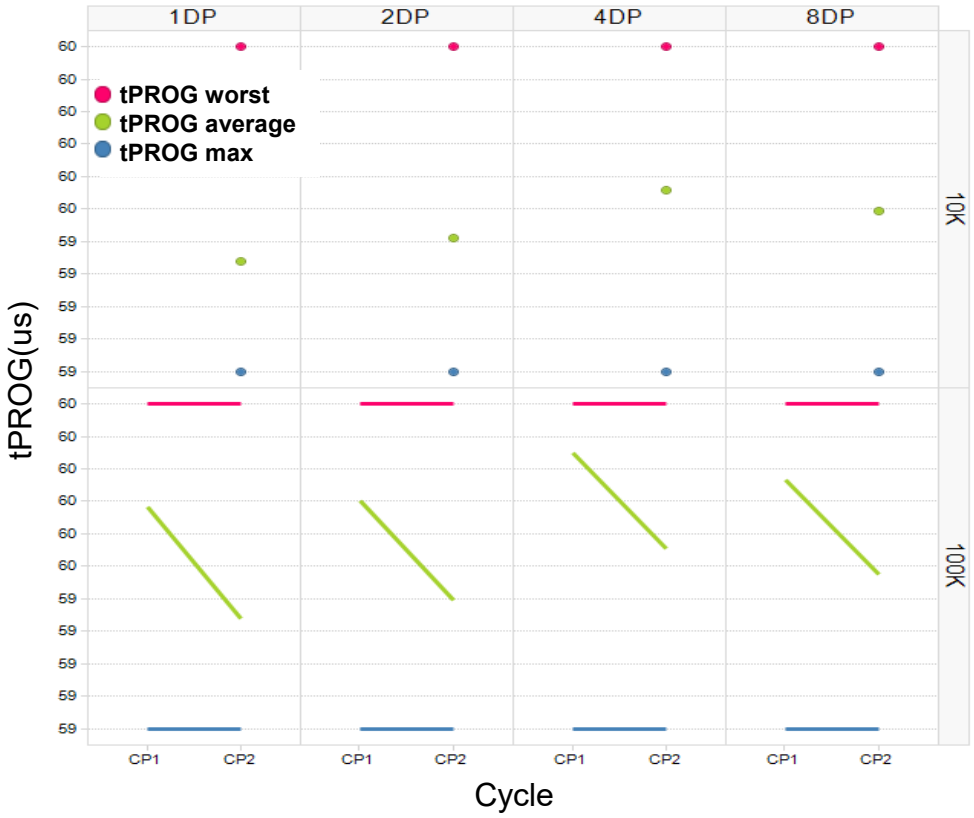
$$tPROG = \frac{1}{P}\sum_{i} tPROG, PAGEi$$

☑ EW tPROG/tBERS

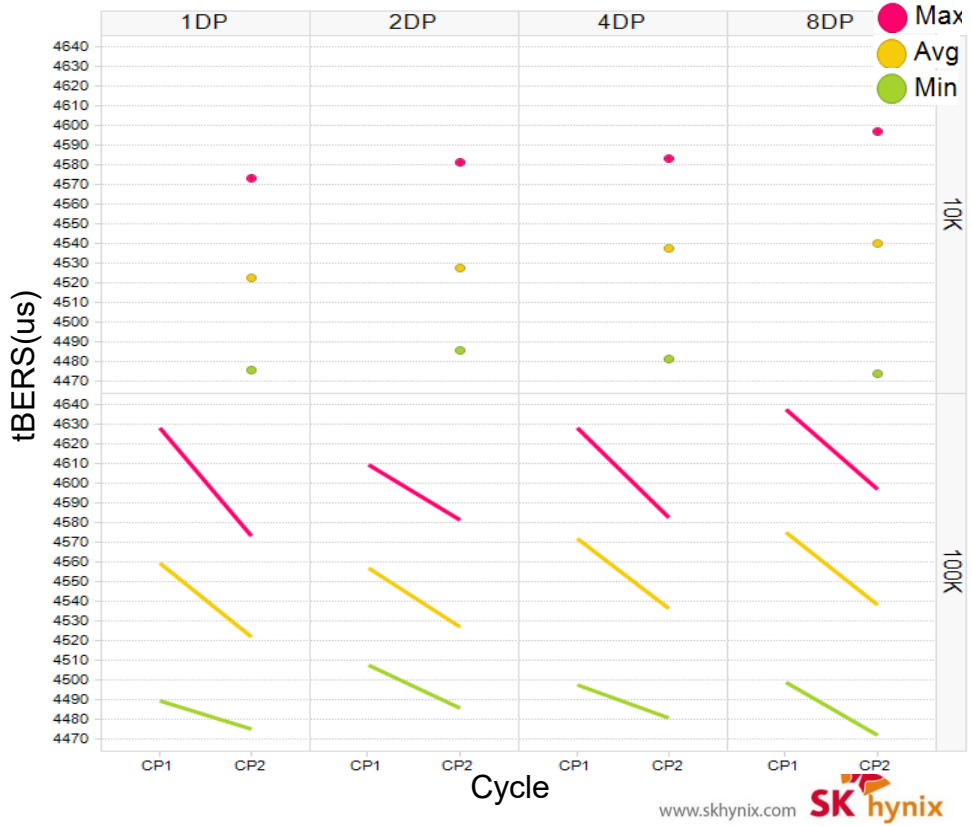
EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%

tPROG worst := Average_dies(Average_blocks(Average_pages(program time))) + 5*std_dies(Average_blocks(Average_pages(program time)))
tPROG average := Average_dies(Average_blocks(Average_pages(program time)))
tPROG max := Max_dies(Average_blocks(Average_pages(program time)))

● EW : Cycle vs tPROG



● EW : Cycle vs tBERS



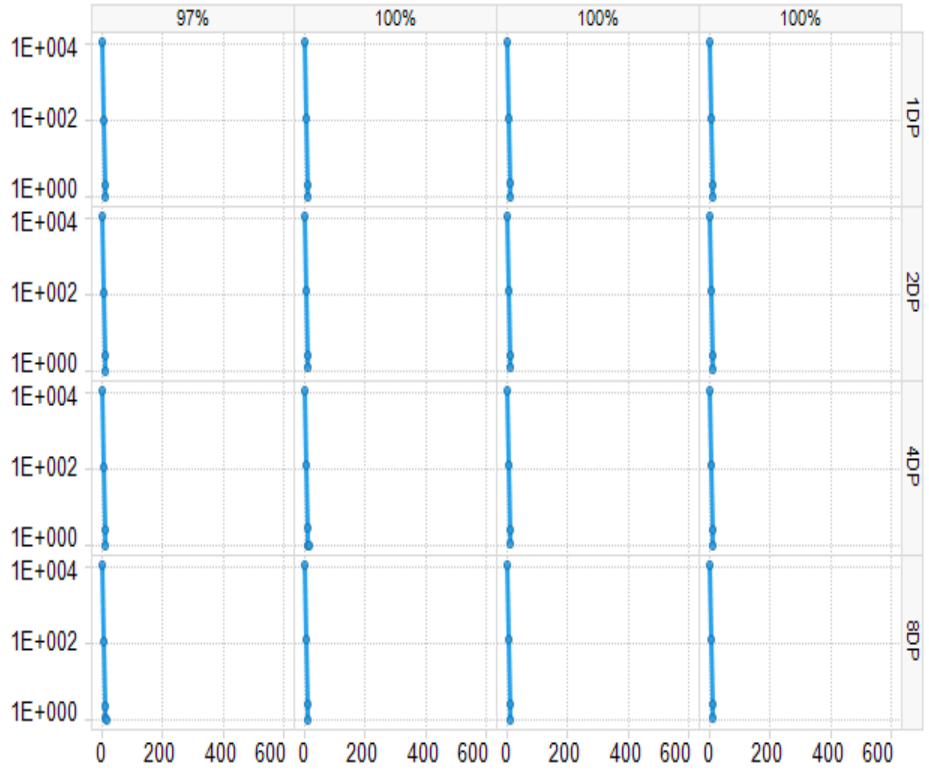
SLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3.

● Result Summary

SLC Checkpoint 3 (Data Retention)													
Test Result			PASS										
Correctness Fail Bit Level (Indepth DEF)			EW				HTDR 1Y				HTDR 1Y+2week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 100K	Max	20	16	20	16	12	12	12	12	12	12	12	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
2DP	EW 100K	Max	16	16	20	20	12	12	12	12	12	12	12	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
4DP	EW 100K	Max	20	16	16	16	12	16	12	12	12	12	16	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
8DP	EW 100K	Max	20	20	20	16	16	12	12	12	12	16	12	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4

● EW+ HTDR 1Yr

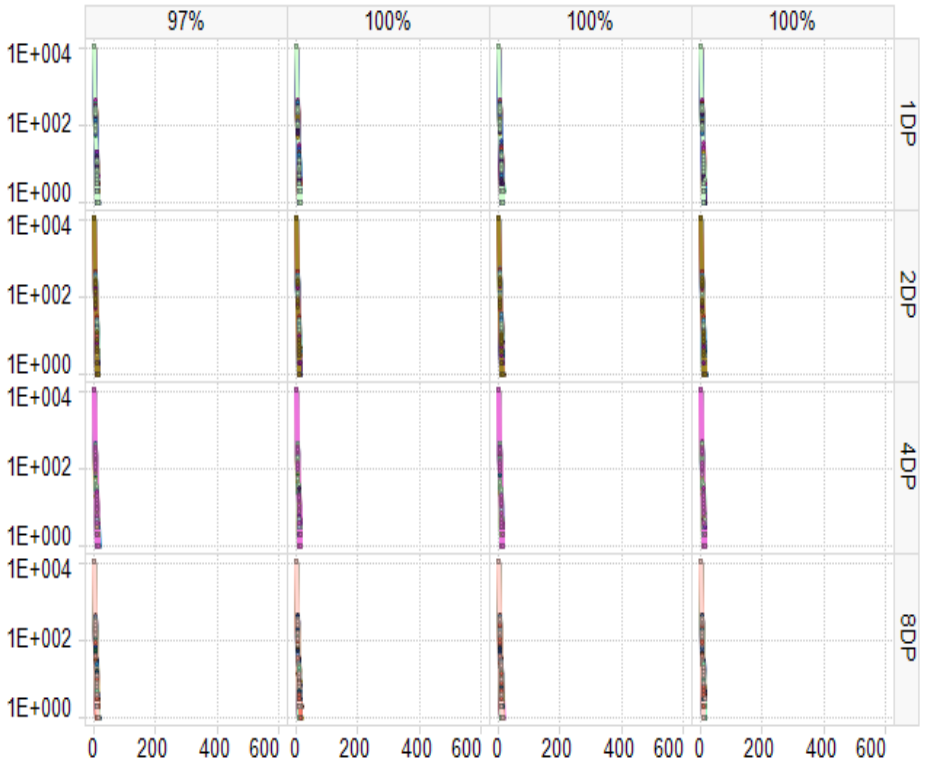


SLC (EOL HTDR) – CP3

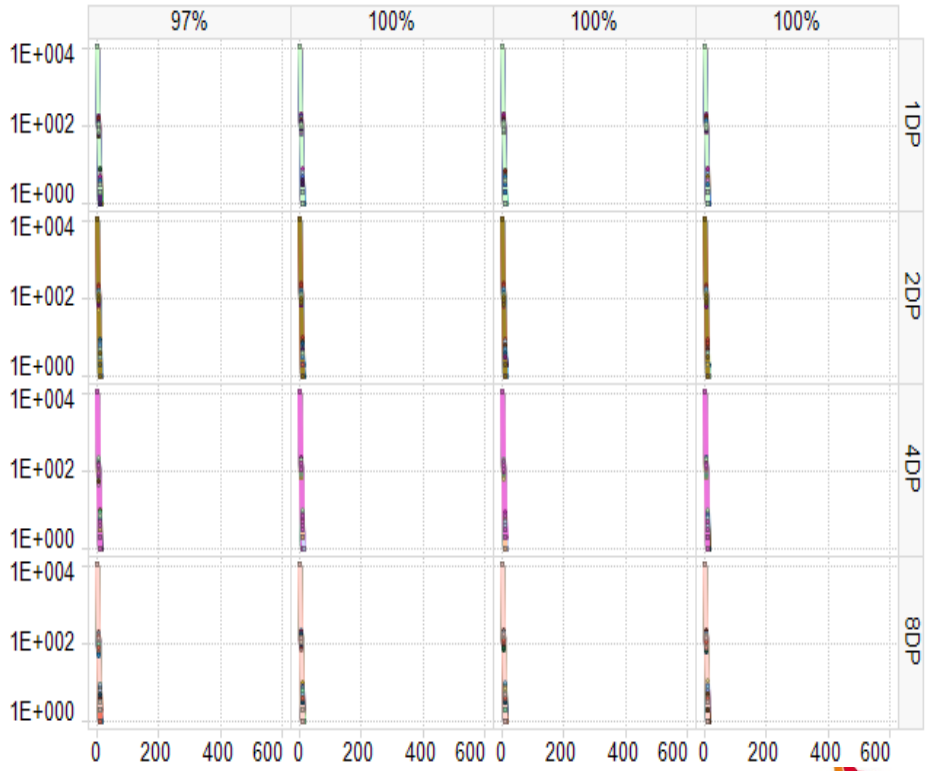
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
Bake 5.5Hr @ 125℃

● EW



● EW + HTDR 1Yr

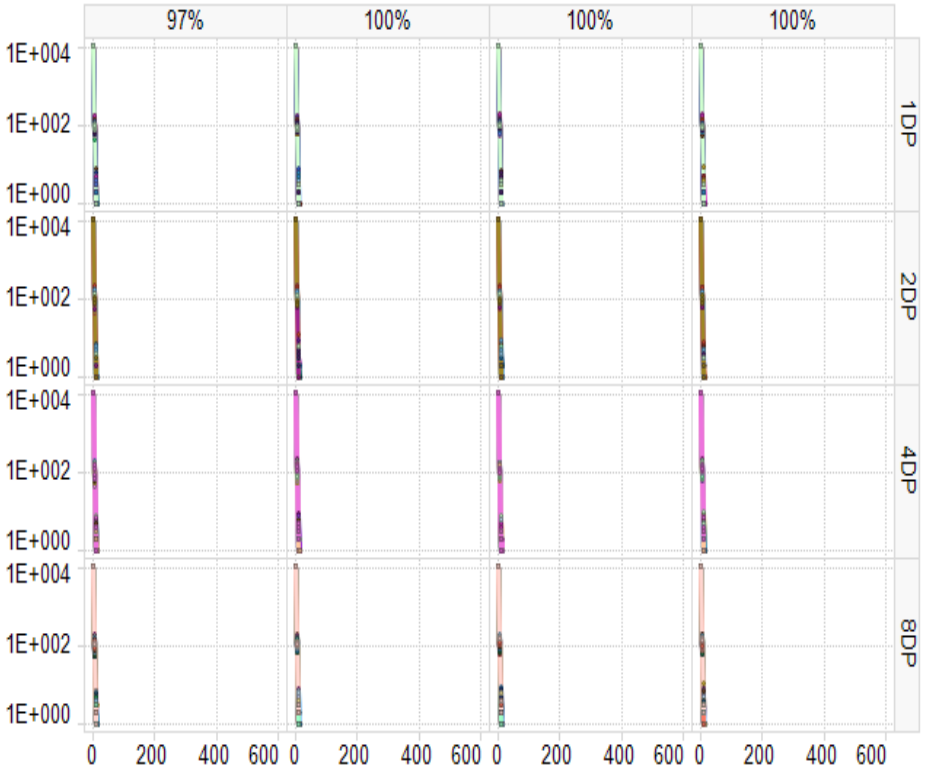


SLC (EOL HTDR) – CP3

☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
Bake 5.5Hr @ 125℃

- EW + HTDR 1Yr + 2week



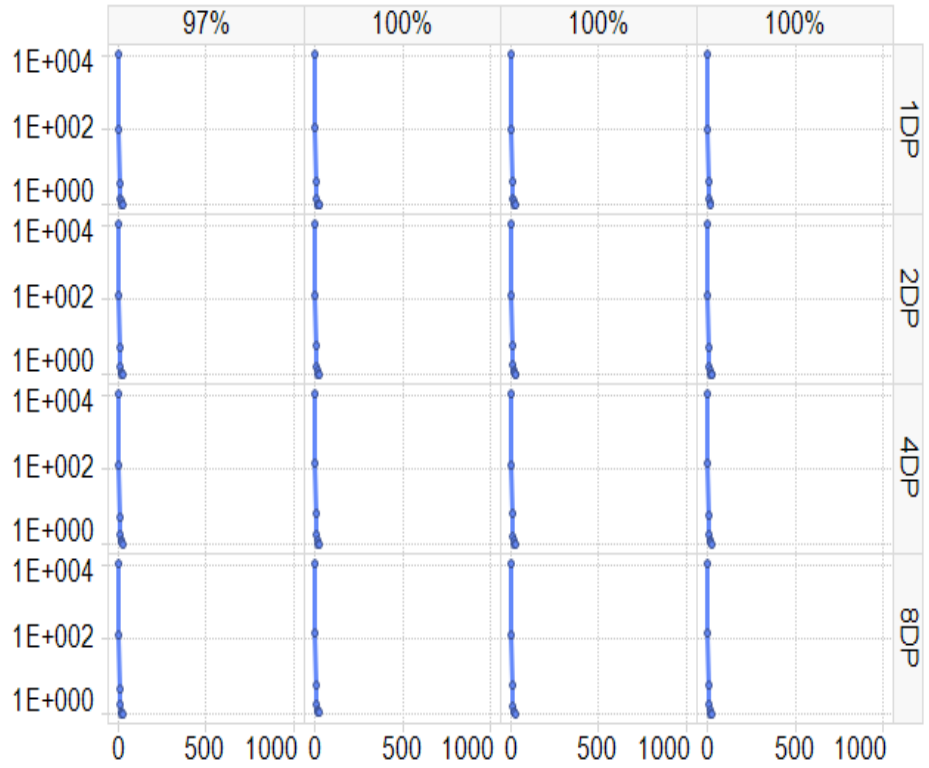
SLC (EOL HTDR) – CP3

☑ Reliability Check points satisfied with checkpoint 3.

● Result Summary

SLC Checkpoint 3 (Data Retention)							
Test Result				PASS			
Correctness Fail Bit Level				HTDR 1Y			
				97%	100%	100%	100%
SLC	1DP	EW 100K	Max	24	28	24	20
			Median	4	4	4	4
	2DP	EW 100K	Max	28	24	28	28
			Median	4	4	4	4
	4DP	EW 100K	Max	24	24	24	24
			Median	4	4	4	4
	8DP	EW 100K	Max	24	24	24	24
			Median	4	4	4	4

● EW+ HTDR 1Yr(ADSP)

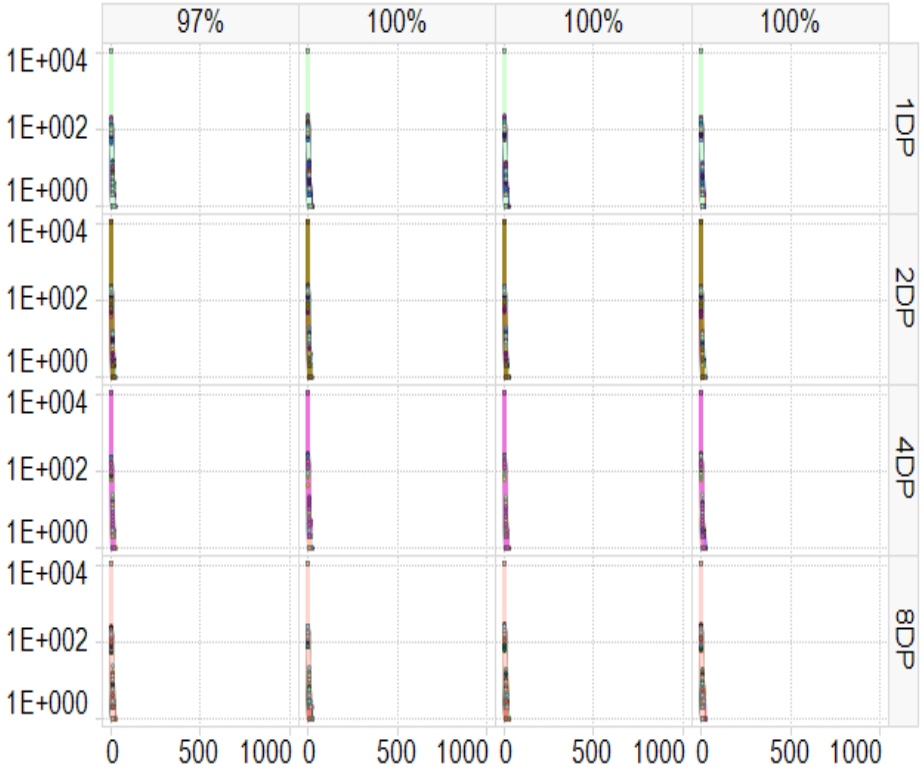


SLC (EOL HTDR) – CP3

☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
Bake 5.5Hr @ 125℃

- EW + HTDR 1Yr(ADSP)



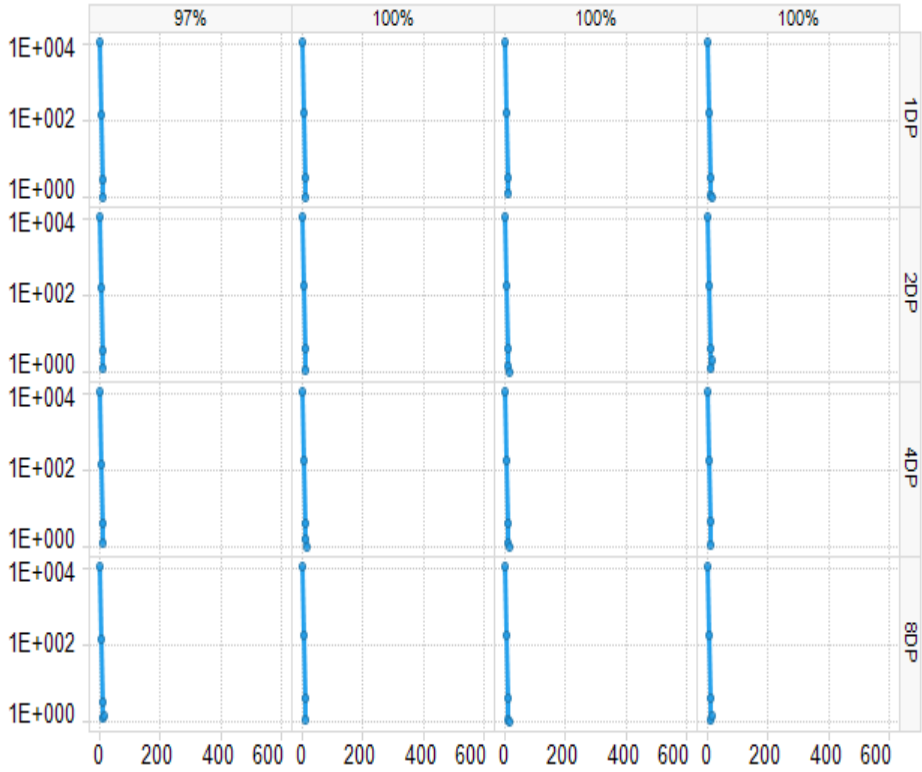
SLC (EOL Latency) – CP11

☑ Reliability Check points satisfied with checkpoint 11.

● Result Summary

SLC Checkpoint 5 (Latency)												
Test Result				PASS								
Correctness Fail Bit Level				EW				1Month				
				97%	100%	100%	100%	97%	100%	100%	100%	
SLC	1DP	EW 100K	Max	20	16	20	16	12	12	12	16	
			Median	4	4	4	4	4	4	4	4	
	2DP	EW 100K	Max	16	16	20	20	12	12	16	16	
			Median	4	4	4	4	4	4	4	4	
	4DP	EW 100K	Max	20	16	16	16	12	16	16	12	
			Median	4	4	4	4	4	4	4	4	
	8DP	EW 100K	Max	20	20	20	16	16	12	16	16	
			Median	4	4	4	4	4	4	4	4	

● EW+ 1Month

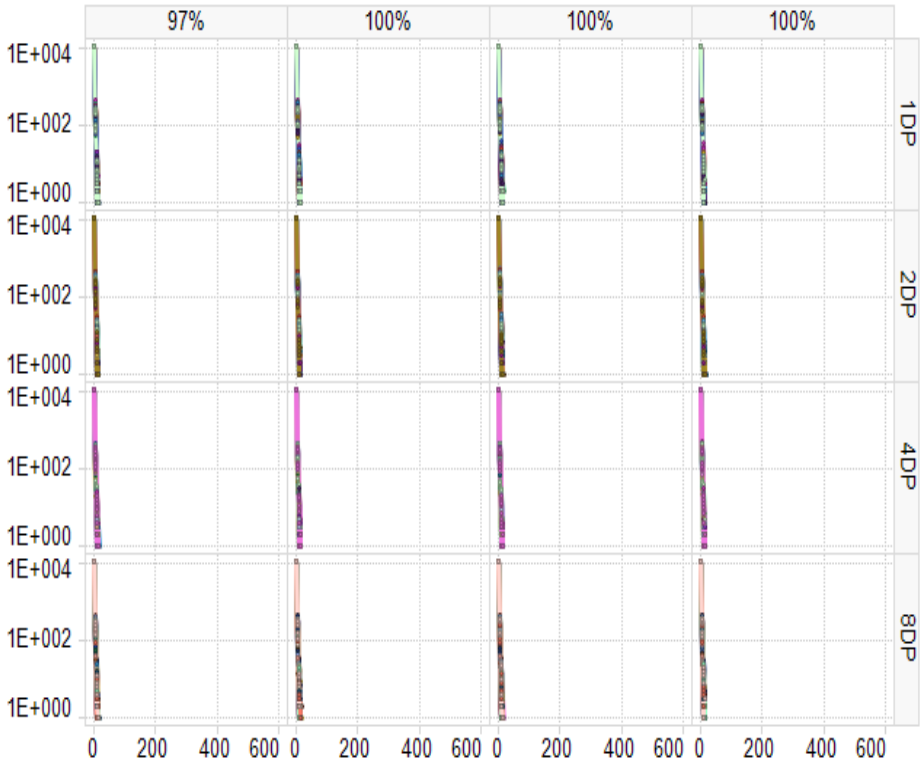


SLC (EOL Latency) – CP11

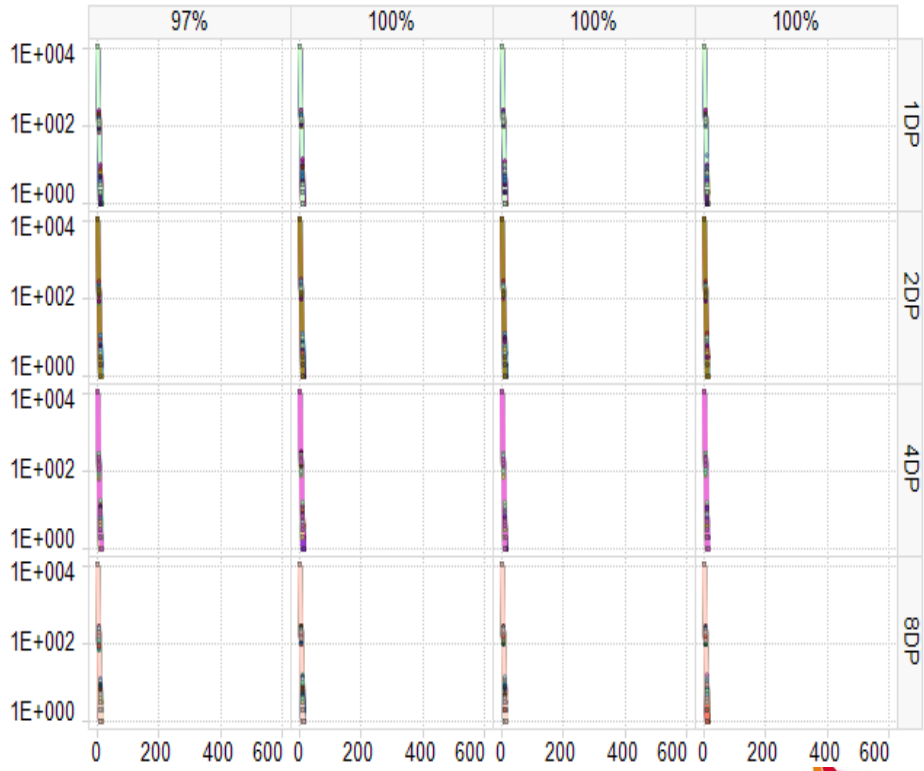
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ -5℃
1month@ 45℃ with cross temp 60 ℃

● EW



● EW + 1Month

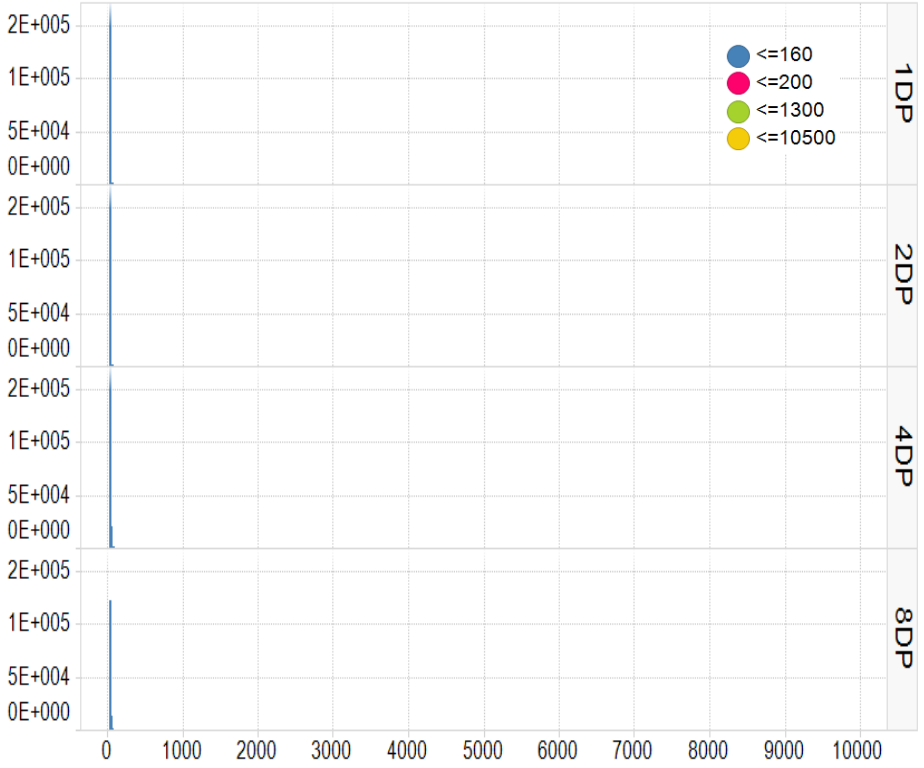


SLC (EOL Latency) – CP11

☑ Read Latency Distribution@ EW + RD 100K + 1month@ 45℃ with cross temp 60 ℃

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 60 ℃

● No. of Chunk vs. Read Latency
(EW + RD 100K + 1month)



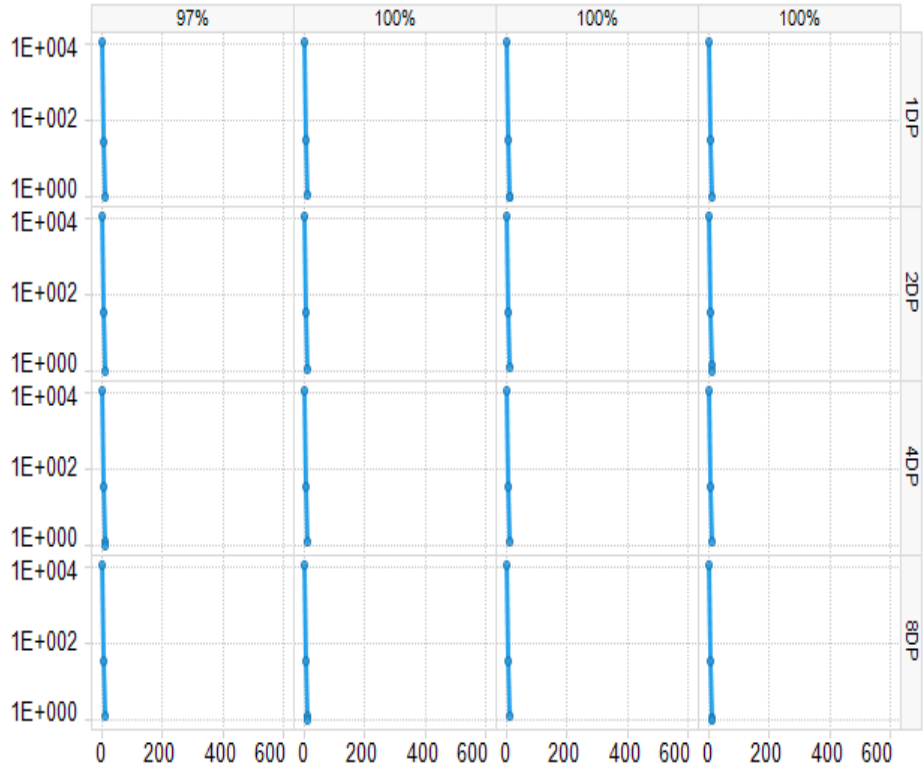
SLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A.

● Result Summary

SLC Checkpoint 4A (X-Temp)														
Test Result			PASS											
Correctness Fail Bit Level (Indepth DEF)			EW				100℃ Cross Temp				100℃ Cross Temp +2week			
			97%	100%	100%	100%	97%	100%	100%	100%	97%	100%	100%	100%
1DP	EW 10K	Max	20	16	20	16	8	8	12	8	8	8	8	8
		Med	4	4	4	4	4	4	4	4	4	4	4	4
2DP	EW 10K	Max	16	16	20	20	8	8	8	12	8	8	8	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
4DP	EW 10K	Max	20	16	16	16	12	8	8	8	12	12	8	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4
8DP	EW 10K	Max	20	20	20	16	8	12	8	12	8	12	8	12
		Med	4	4	4	4	4	4	4	4	4	4	4	4

● EW+ 100℃ Cross Temp



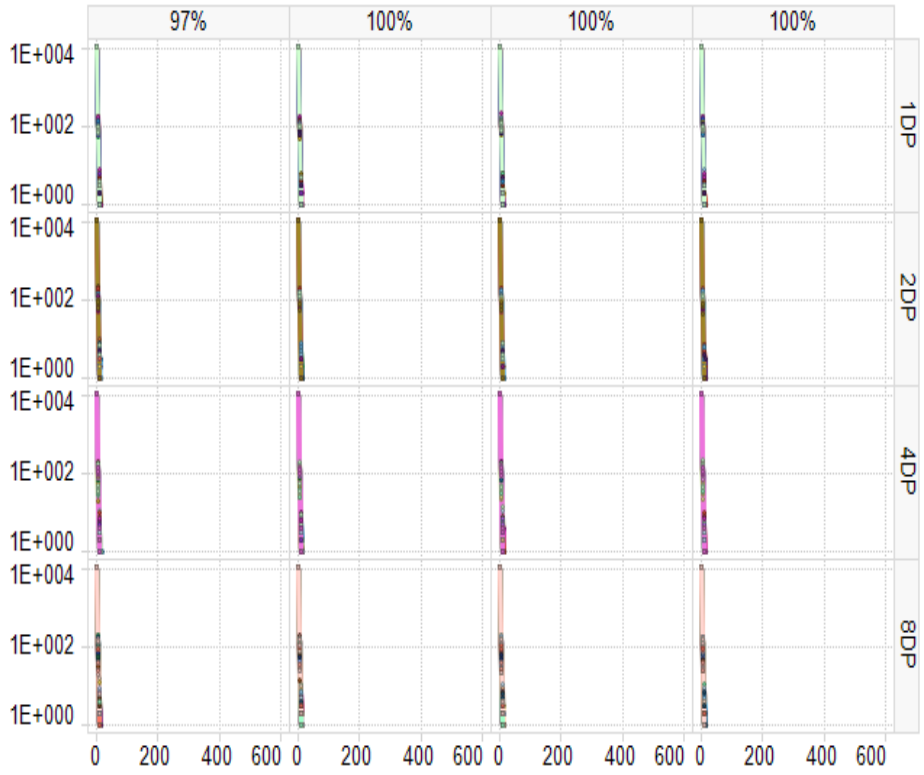
SLC (SOL X-Temp) – CP4A

☑ No. of Chunk vs. Correctness (By. Die)

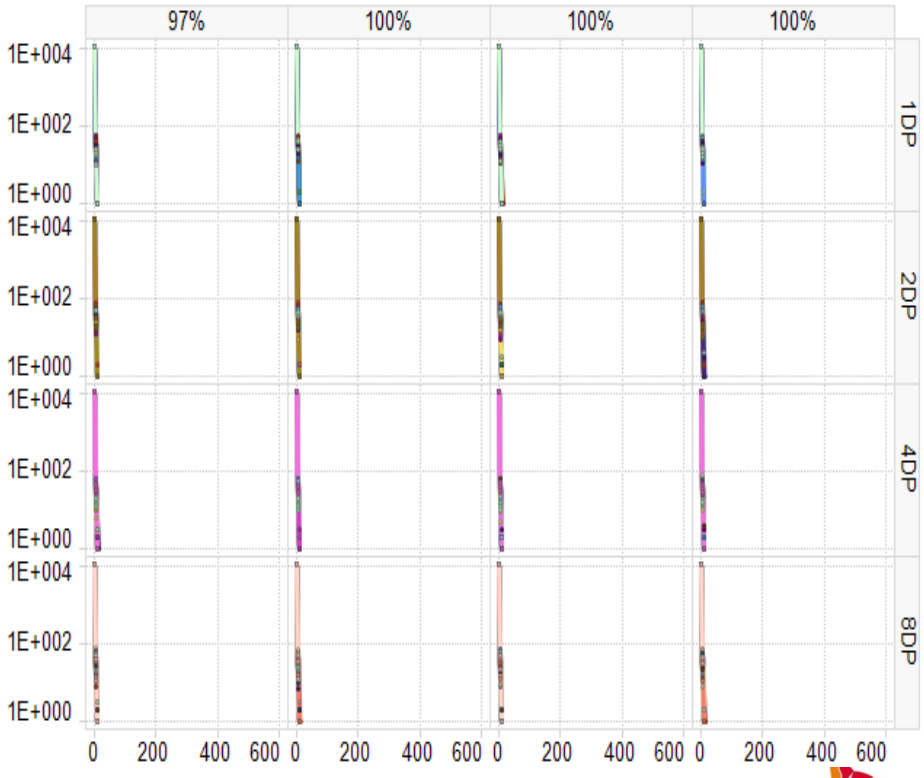
Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Cross Temp 100 ℃ @ 85 ℃

● EW



● EW +100℃ Cross Temp

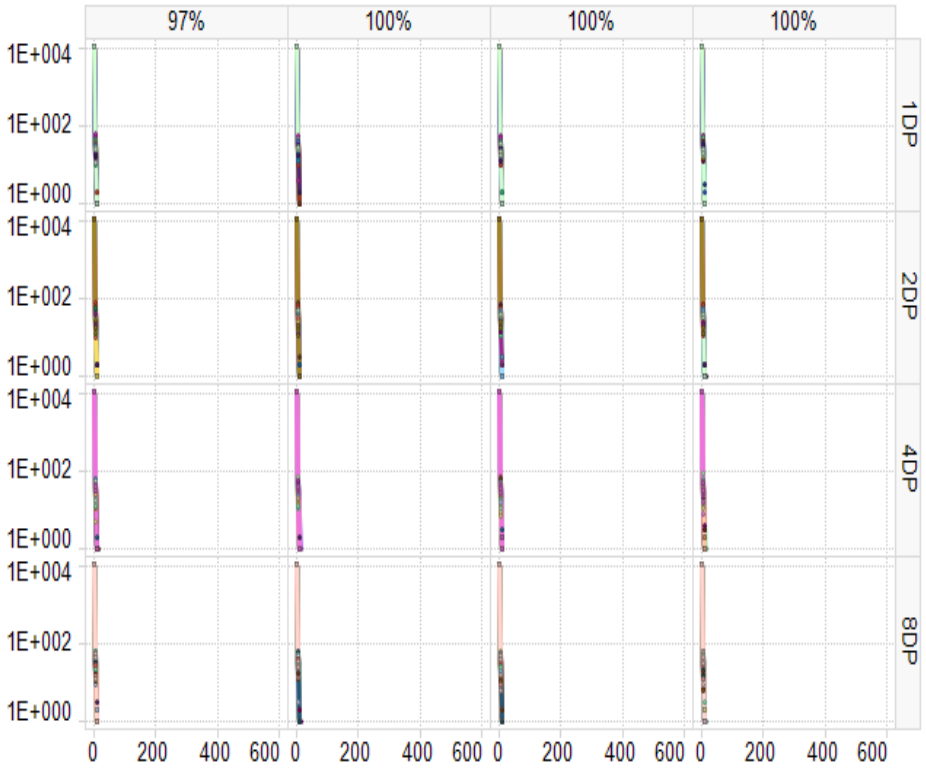


SLC (SOL X-Temp) – CP4A

☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Cross Temp 100 ℃ @ 85 ℃

- EW +100℃ Cross Temp + 2week



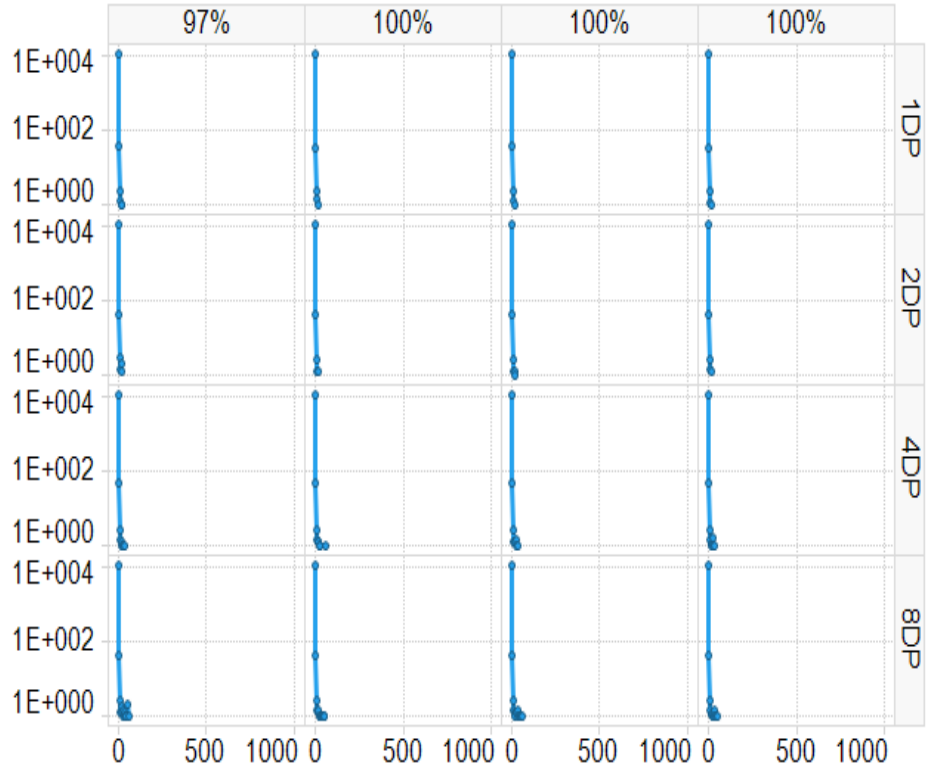
SLC (SOL X-Temp) – CP4A

☑ Reliability Check points satisfied with checkpoint 4A.

● Result Summary

SLC Checkpoint CP4A (X-Temp)							
Test Result				PASS			
Correctness Fail Bit Level				100℃ Cross Temp			
				97%	100%	100%	100%
SLC	1DP	EW 10K	Max	20	16	16	16
			Median	4	4	4	4
	2DP	EW 10K	Max	20	16	20	16
			Median	4	4	4	4
	4DP	EW 10K	Max	32	56	32	32
			Median	4	4	4	4
	8DP	EW 10K	Max	56	52	56	48
			Median	4	4	4	4

● EW+ 100℃ Cross Temp(ADSP)



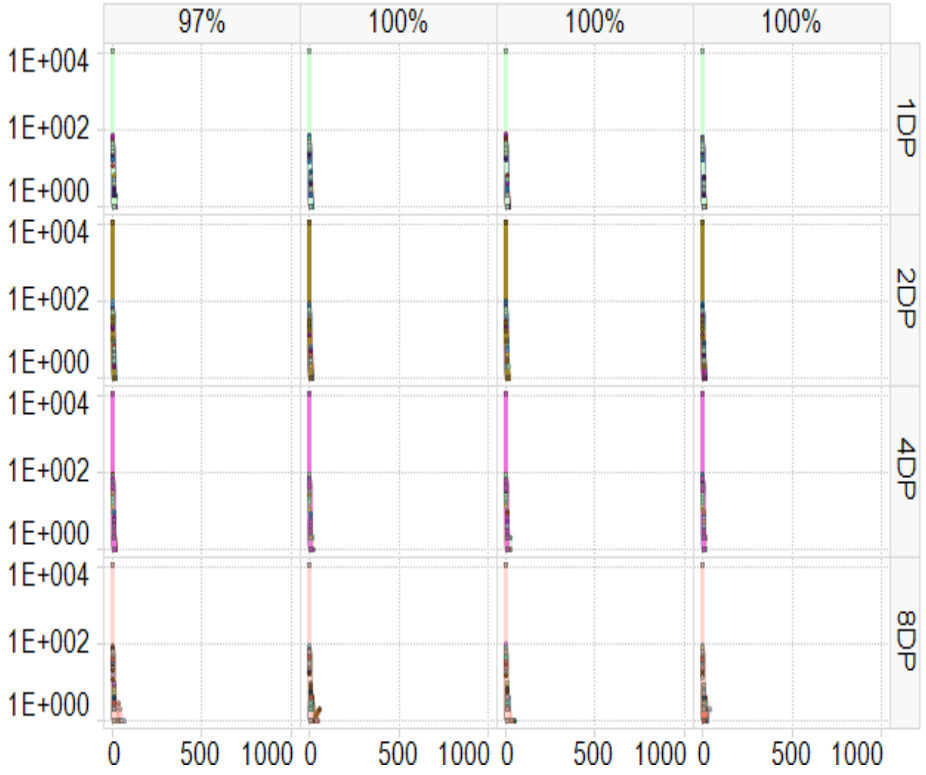
SLC (SOL X-Temp) – CP4A

☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Cross Temp 100 ℃ @ 85 ℃

- EW+100℃ Cross Temp(ADSP)



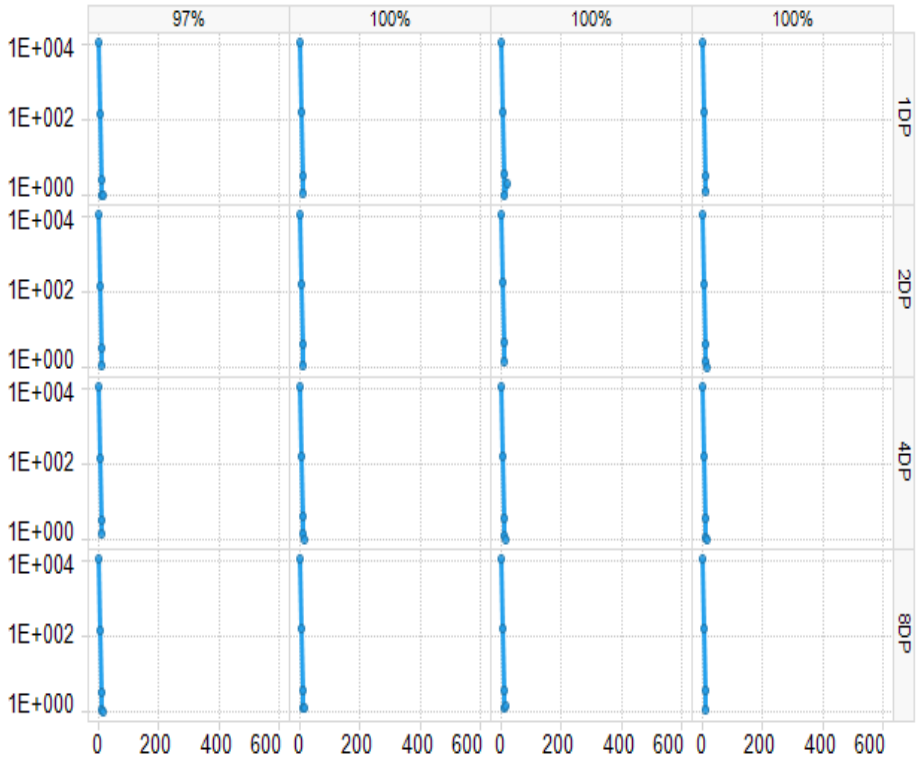
SLC (EOL X-Temp) – CP4B

☑ Reliability Check points satisfied with checkpoint 4B.

● Result Summary

SLC Checkpoint 4B (X-Temp)										
Test Result				PASS							
Correctness Fail Bit Level				EW				100℃ Cross Temp			
				97%	100%	100%	100%	97%	100%	100%	100%
SLC	1DP	EW 100K	Max	20	16	20	16	16	12	20	12
			Median	4	4	4	4	4	4	4	4
	2DP	EW 100K	Max	16	16	20	20	12	12	12	16
			Median	4	4	4	4	4	4	4	4
	4DP	EW 100K	Max	20	16	16	16	12	16	16	16
			Median	4	4	4	4	4	4	4	4
	8DP	EW 100K	Max	20	20	20	16	16	16	16	12
			Median	4	4	4	4	4	4	4	4

● EW+100℃ Cross Temp



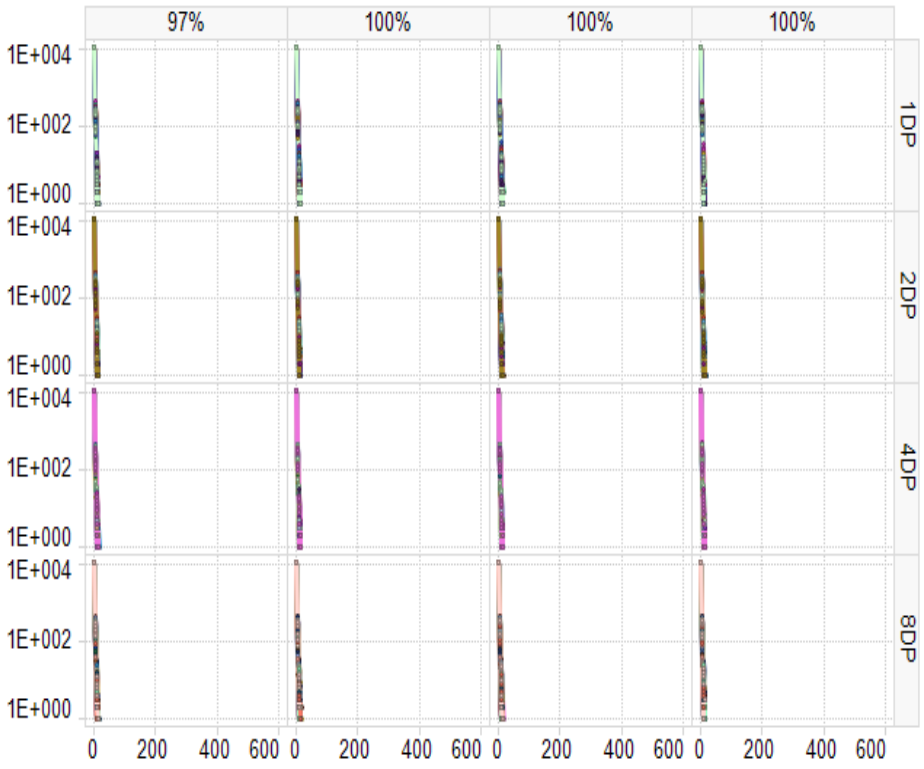
SLC (EOL X-Temp) – CP4B

☑ No. of Chunk vs. Correctness (By. Die)

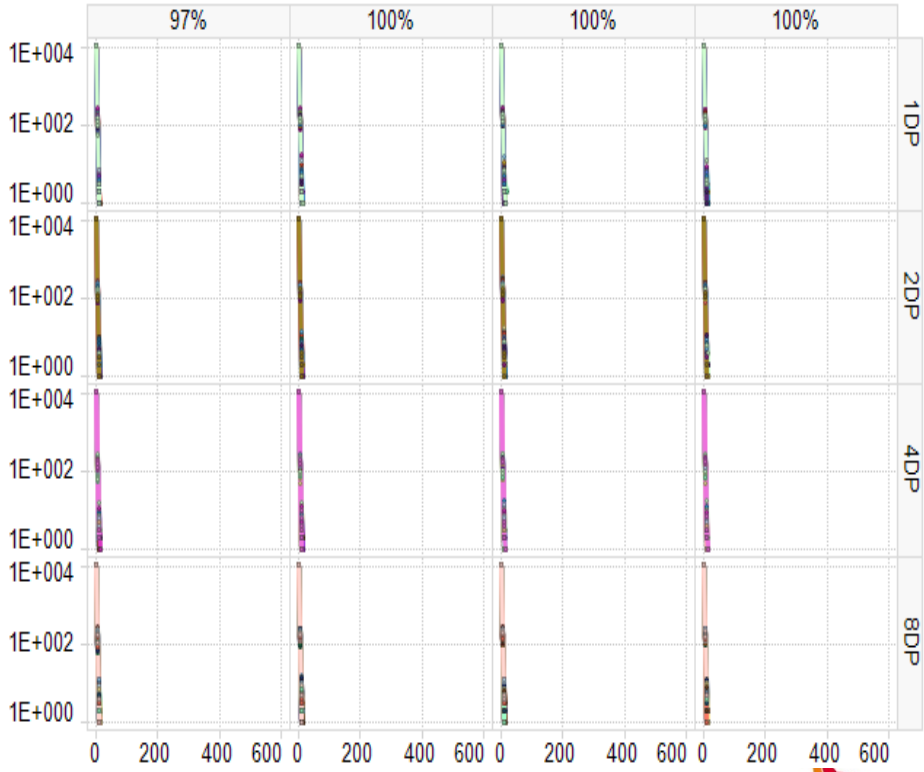
Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Cross Temp 100 ℃ @ 85 ℃

● EW



● EW+100℃ Cross Temp



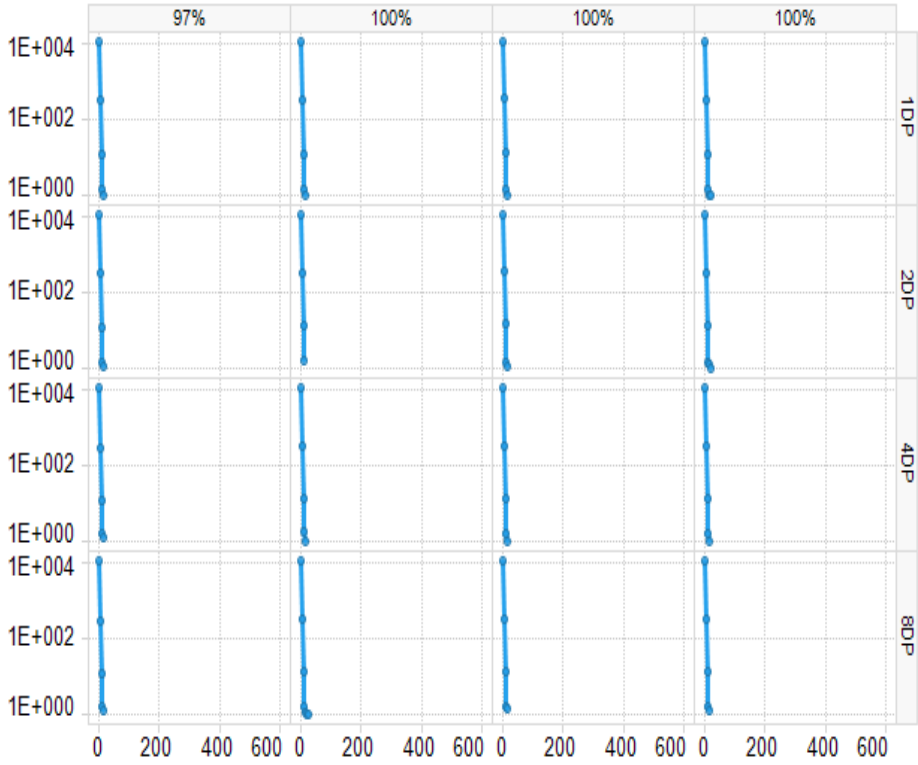
SLC (EOL X-Temp) – CP4C

☑ Reliability Check points satisfied with checkpoint 4C.

● Result Summary

SLC Checkpoint 4C (X-Temp)											
Test Result				PASS							
Correctness Fail Bit Level				EW				100℃ Cross Temp			
				97%	100%	100%	100%	97%	100%	100%	100%
SLC	1DP	EW 100K	Max	20	16	20	16	16	16	16	20
			Median	4	4	4	4	4	4	4	4
	2DP	EW 100K	Max	16	16	20	20	16	12	16	20
			Median	4	4	4	4	4	4	4	4
	4DP	EW 100K	Max	20	16	16	16	16	16	16	16
			Median	4	4	4	4	4	4	4	4
	8DP	EW 100K	Max	20	20	20	16	16	24	16	16
			Median	4	4	4	4	4	4	4	4

●EW+100℃ Cross Temp



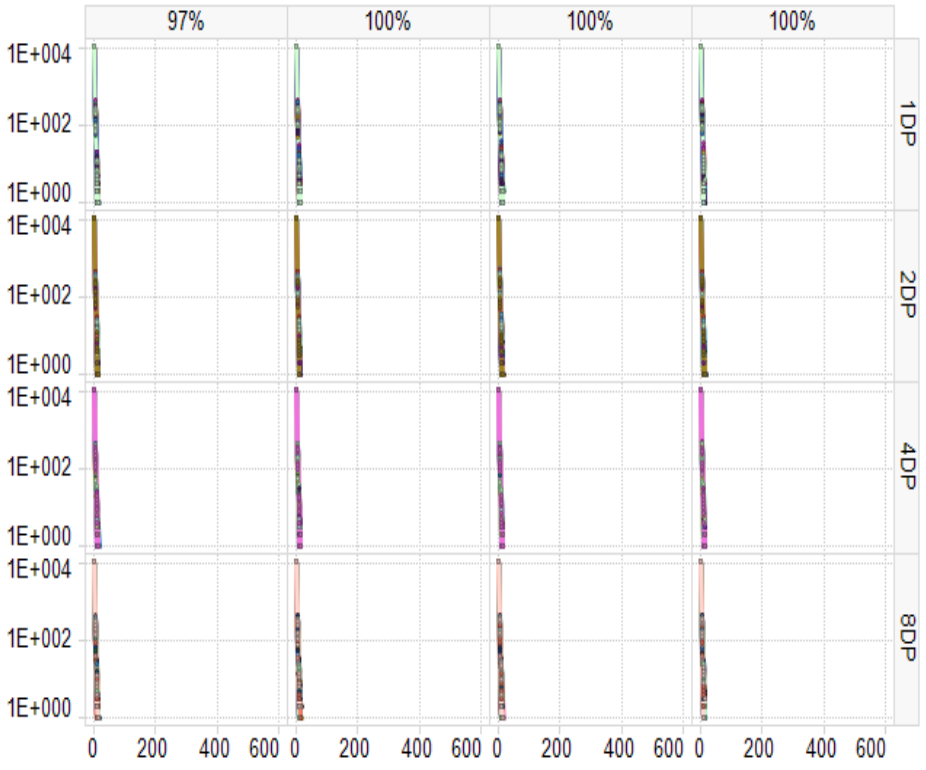
SLC (EOL X-Temp) – CP4C

☑ No. of Chunk vs. Correctness (By. Die)

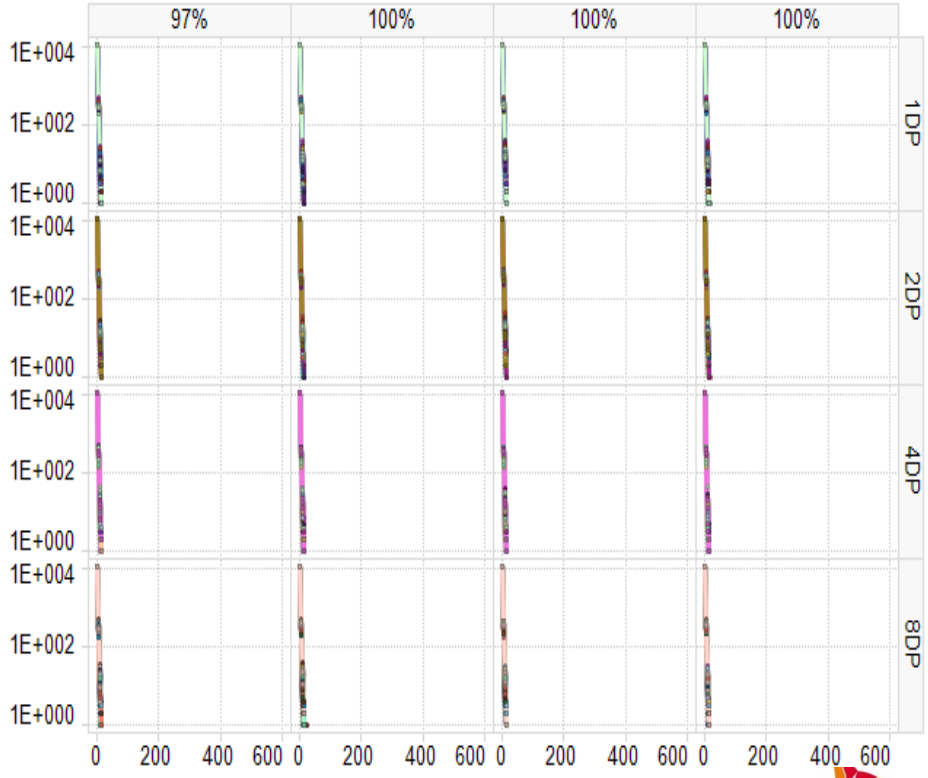
Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Cross Temp 100 ℃ @ 85 ℃

● EW



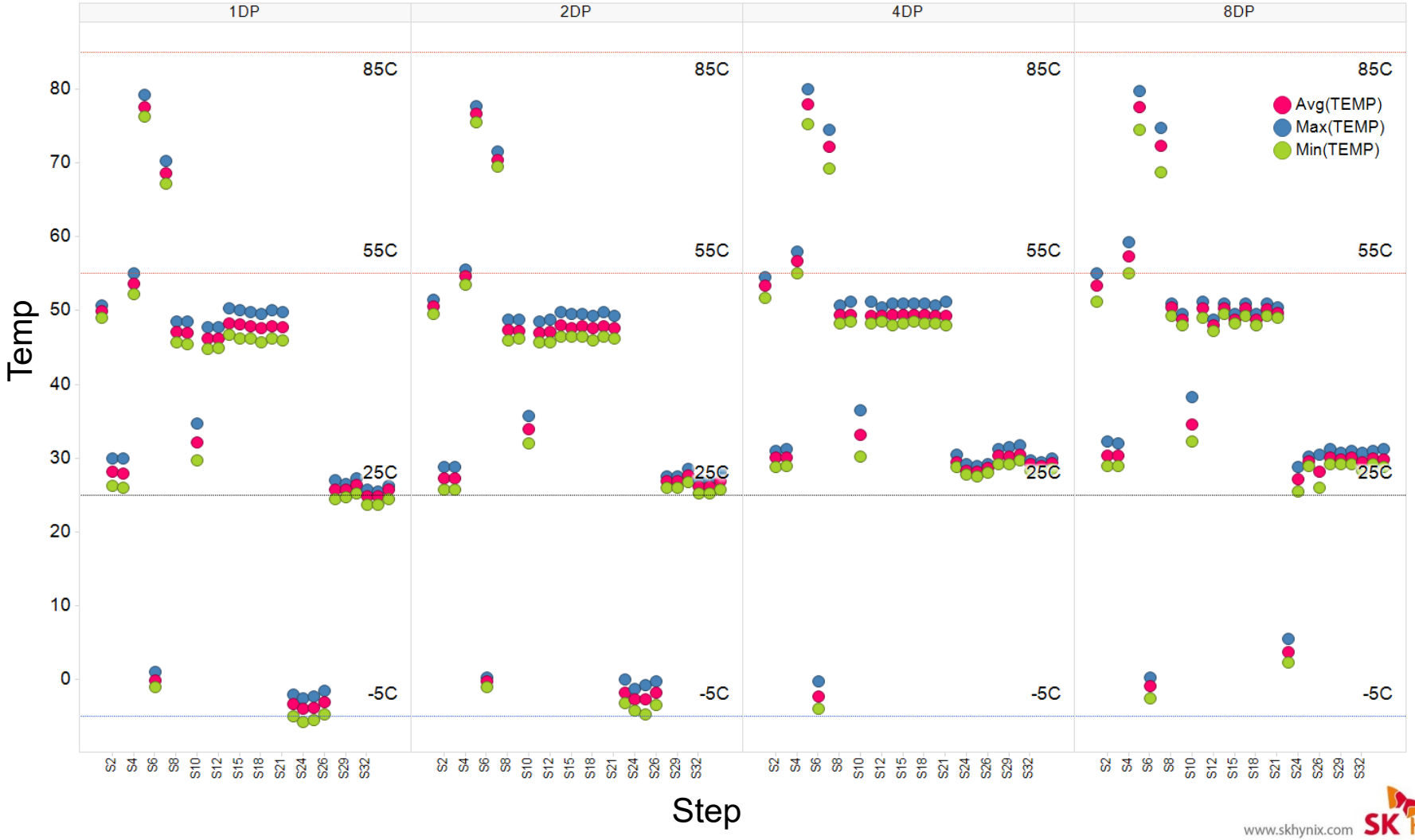
● EW+100℃ Cross Temp



[QUAL13]
SLC Latency / Throughput

QUAL13 SLC Latency Temp Measurement

SLC Latency temp Sensor Measurement

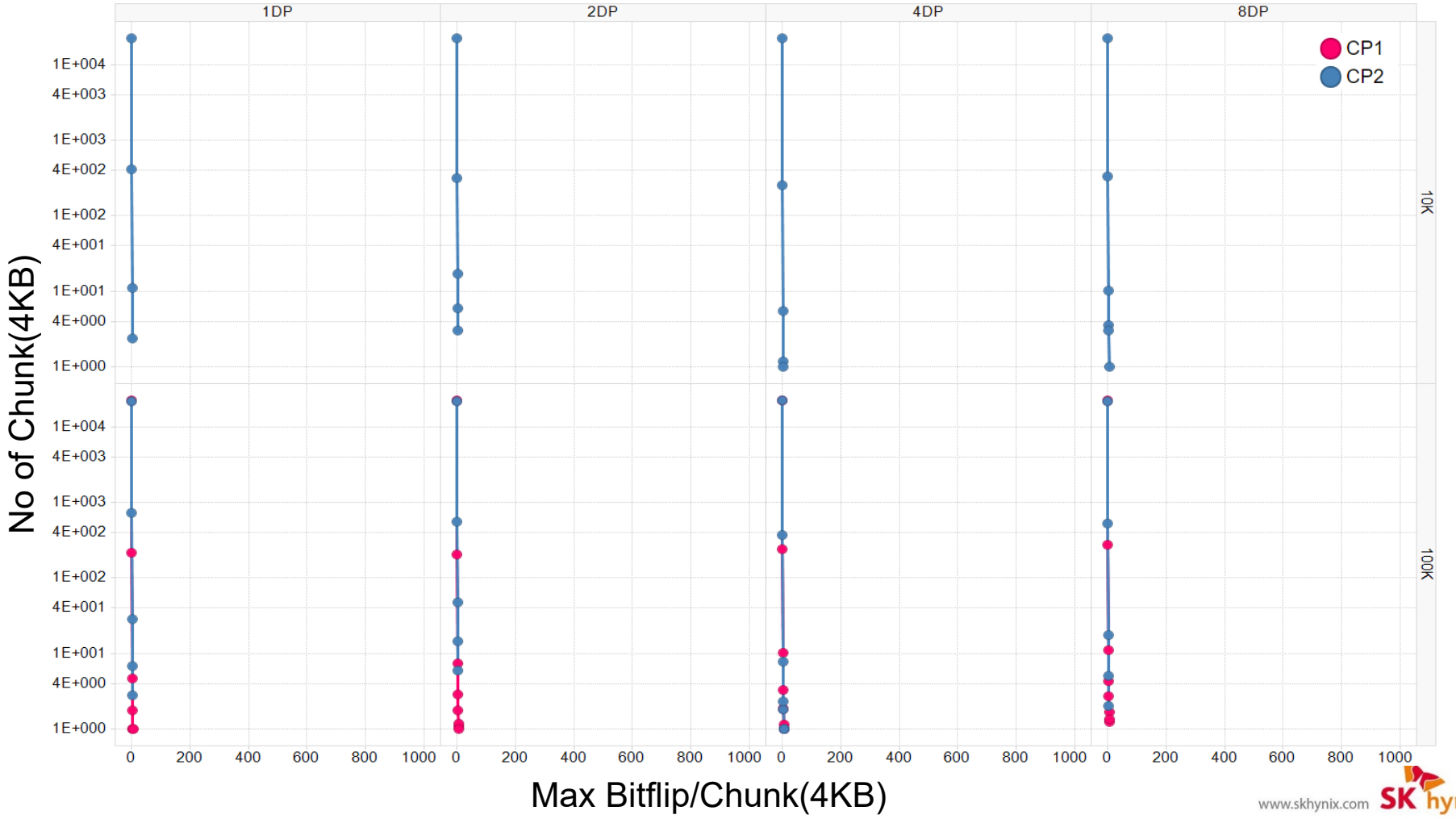


QUAL13 Reliability Cycling Bitflips Measurement

☑ EW No. of Chunk vs. Bit Flips

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)

Bitflip Monitor 1Checkpoint @90%, 2Checkpoint @10%



QUAL13 Reliability tPROG/tBERS

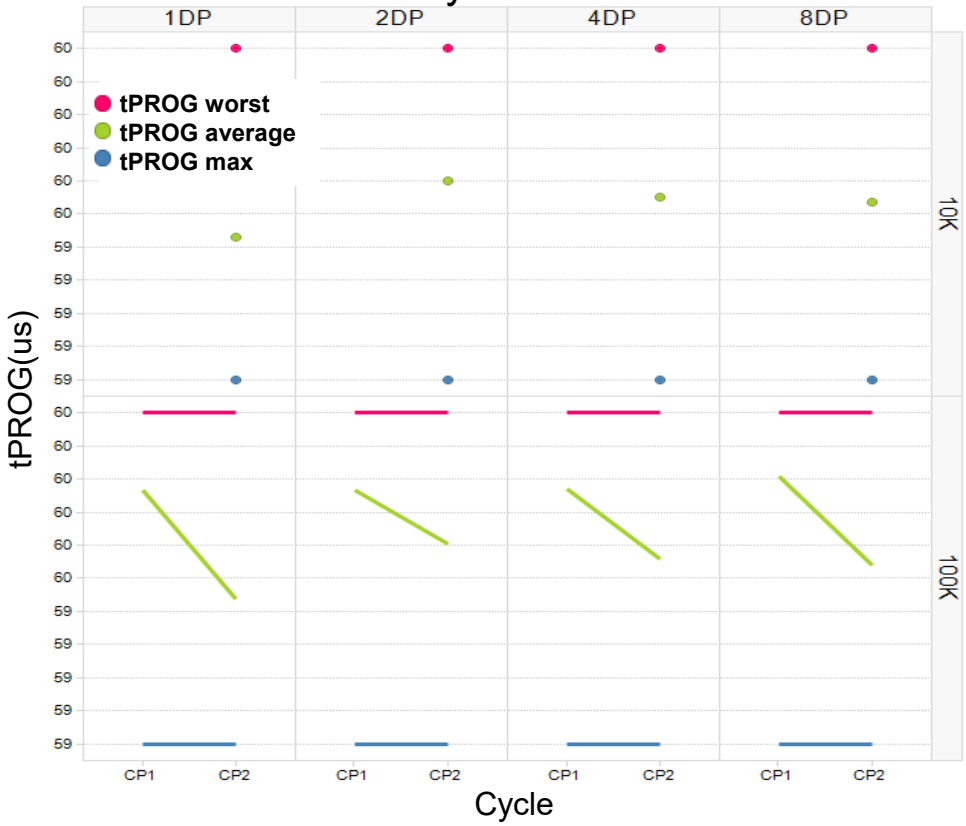
$$tPROG = \frac{1}{P}\sum_{i} tPROG, PAGEi$$

☑ EW tPROG/tBERS

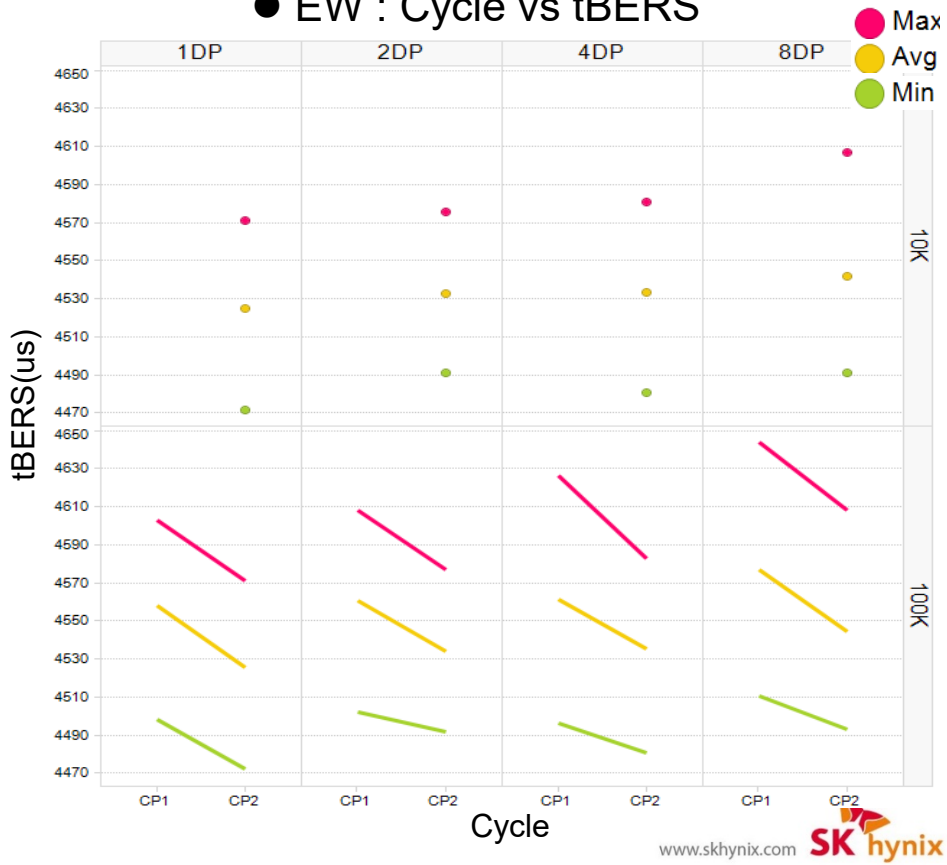
EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%

tPROG worst := Average_dies(Average_blocks(Average_pages(program time))) + 5*std_dies(Average_blocks(Average_pages(program time)))
tPROG average := Average_dies(Average_blocks(Average_pages(program time)))
tPROG max := Max_dies(Average_blocks(Average_pages(program time)))

● EW : Cycle vs tPROG



● EW : Cycle vs tBERS

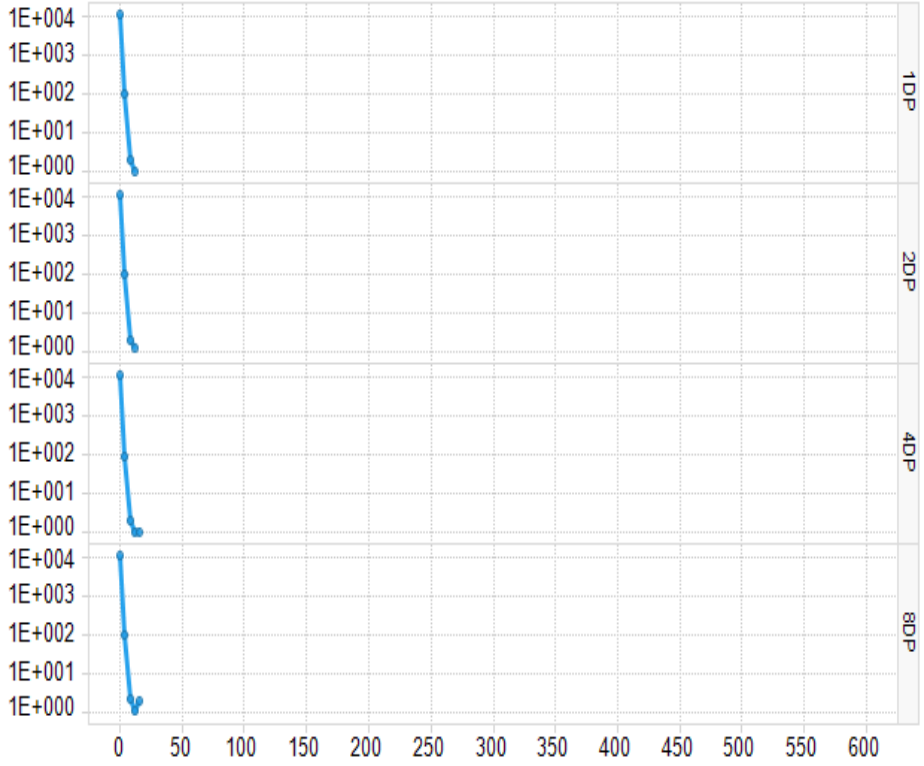


SLC(SOL Latency) – CP8

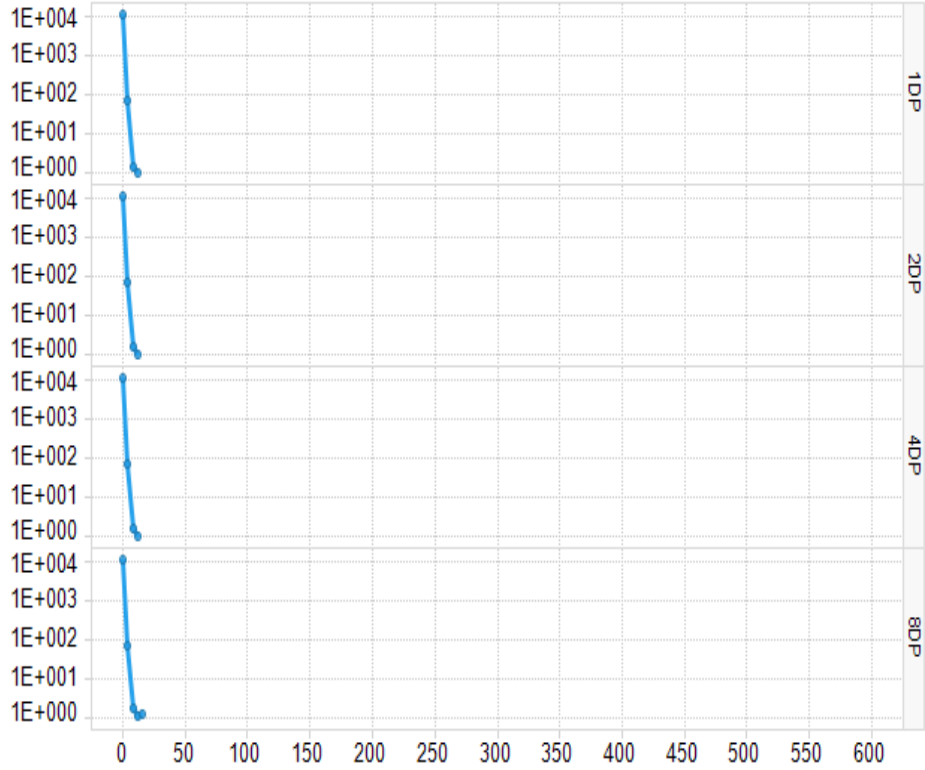
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● Pre EW



● Pre EW + RD 100K + 3Months

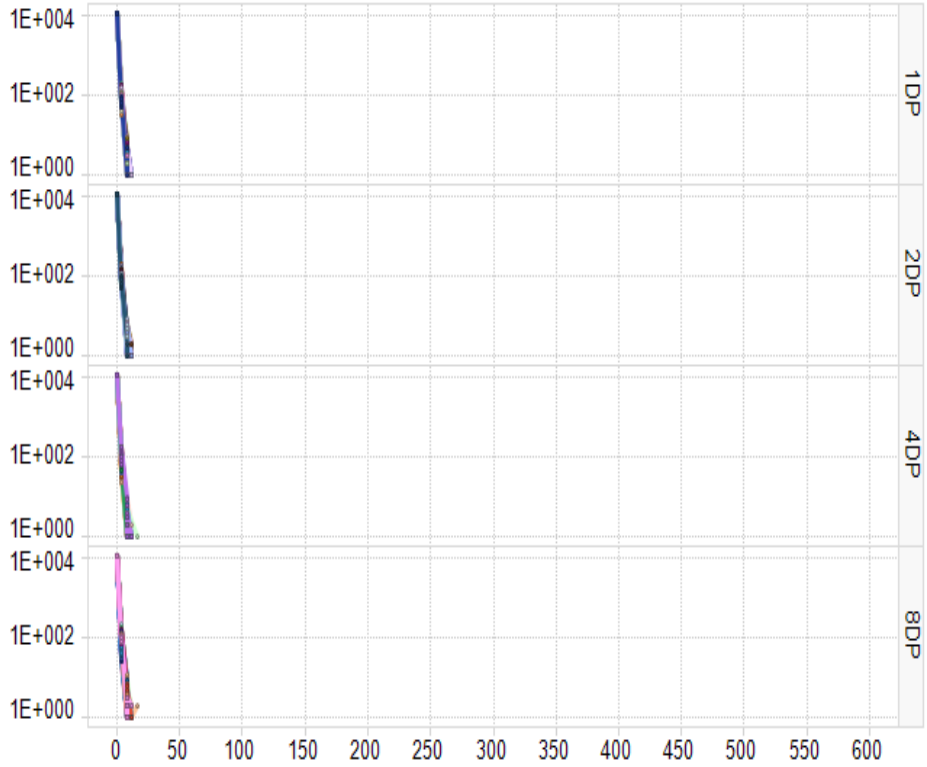


SLC(SOL Latency) – CP8

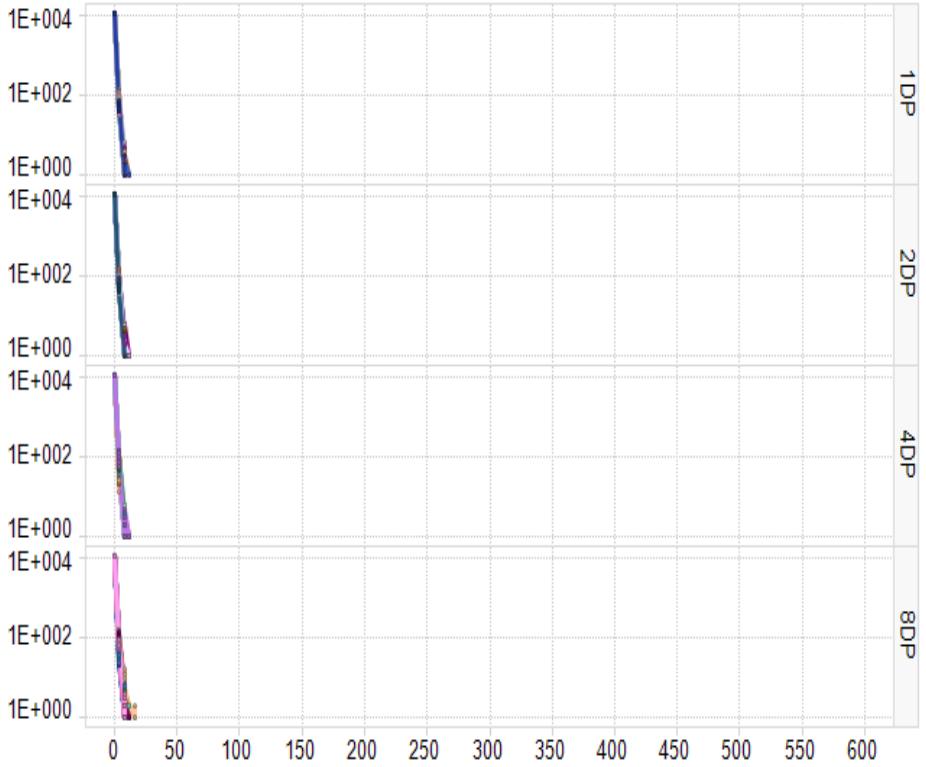
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● Pre EW



● Pre EW + RD 100K + 3Months

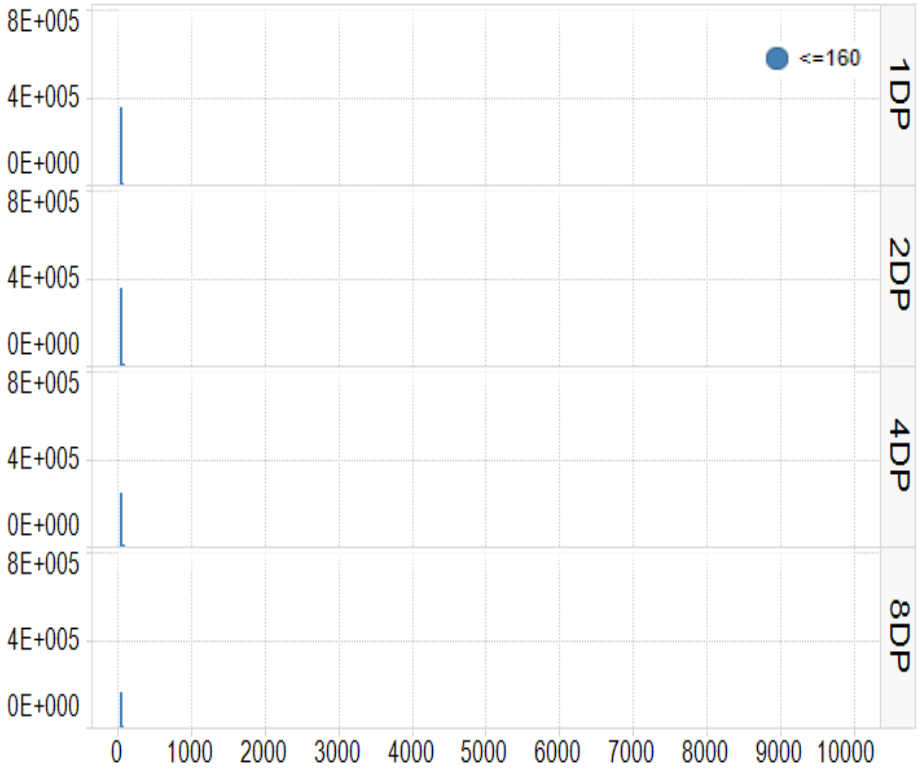


SLC(SOL Latency) – CP8

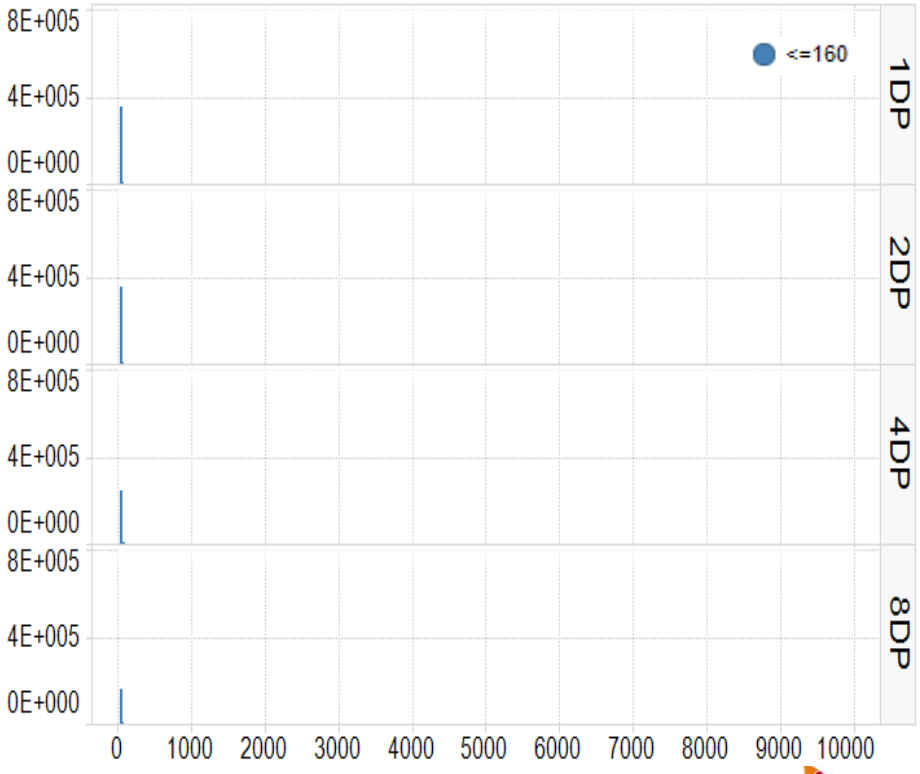
☑ Read Latency Distribution@ Pre EW + RD 100K + 3months@ 45℃ with cross temp 30 ℃

Pre-EW : Random pattern 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(Pre EW)



● No. of Chunk vs. Read Latency
(Pre EW + RD 100K + 3months)

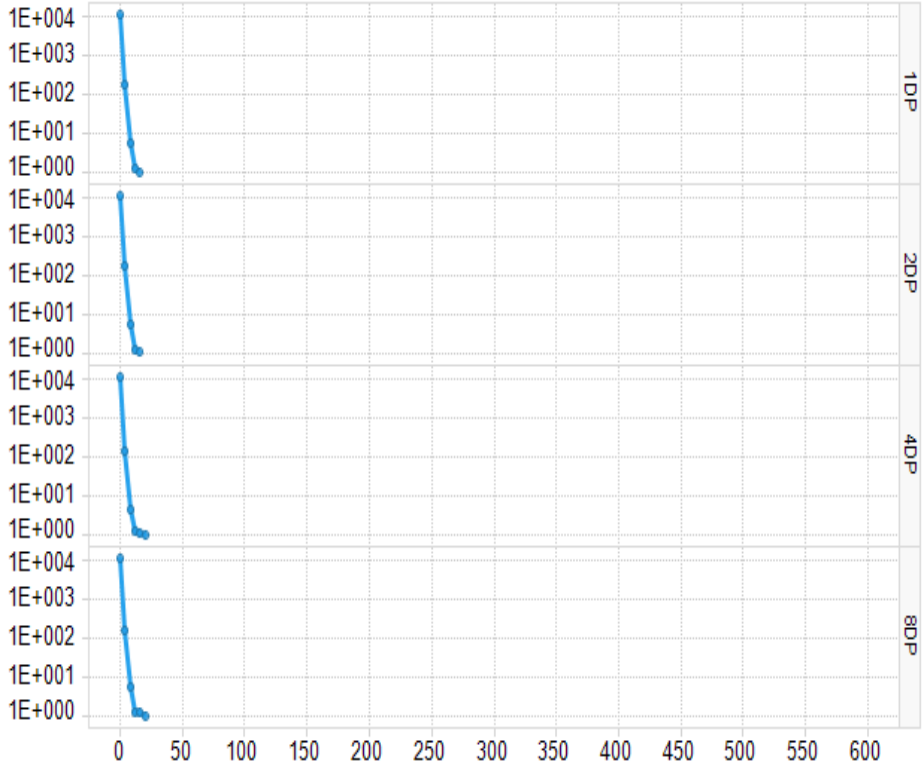


SLC(EOL Latency) – CP9A

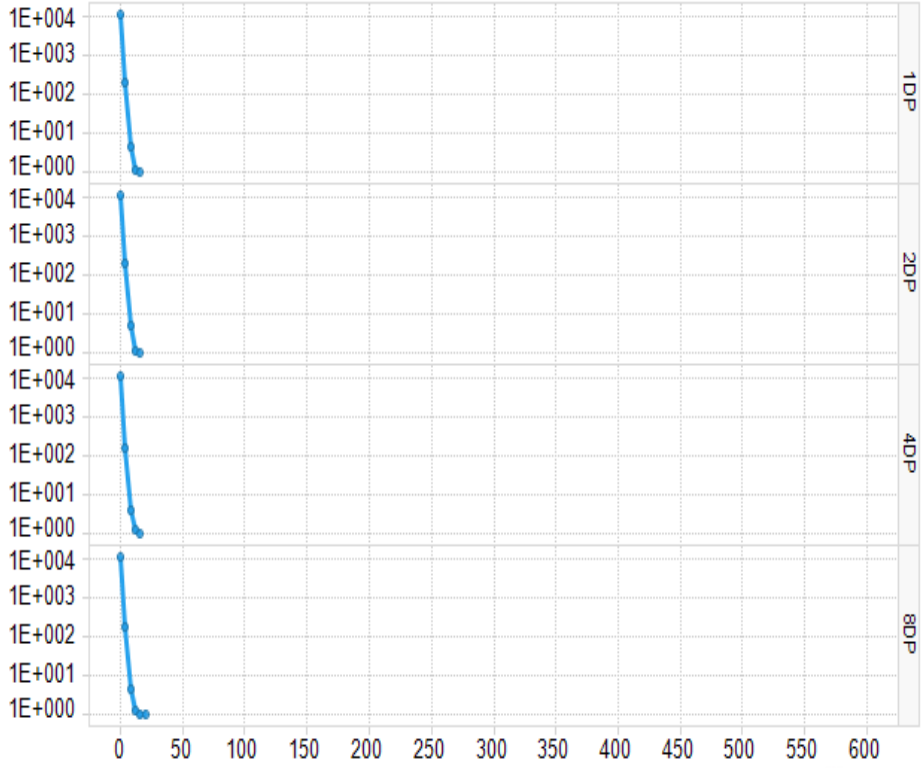
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 30 ℃

● Pre EW



● Pre EW + RD 100K + 1Month

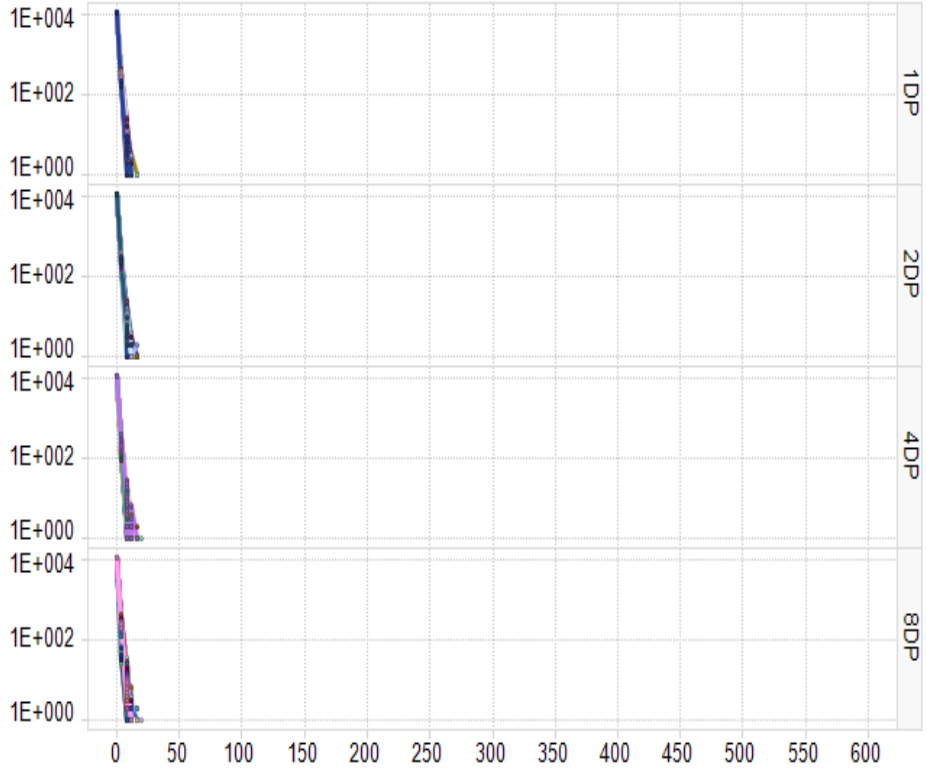


SLC(EOL Latency) – CP9A

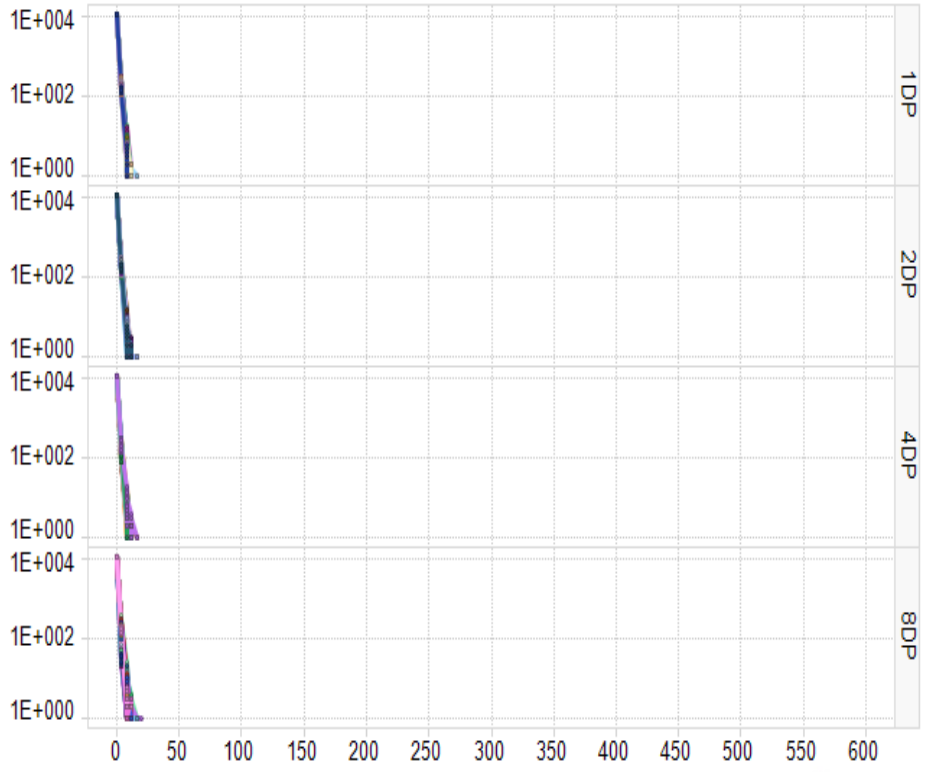
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 30 ℃

● Pre EW



● Pre EW + RD 100K + 1Month

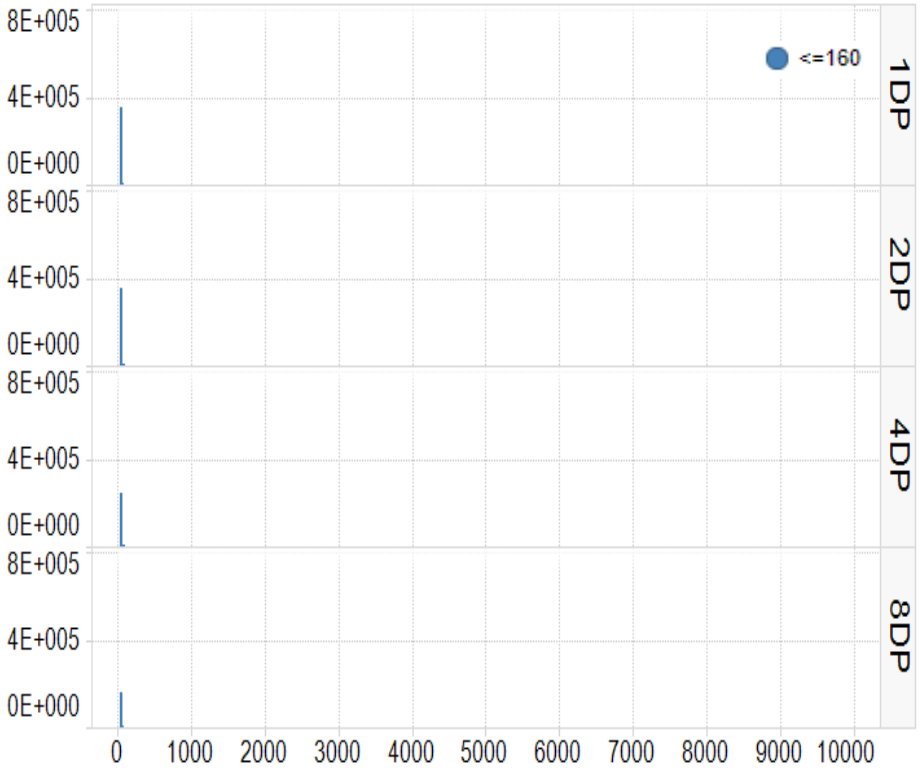


SLC(EOL Latency) – CP9A

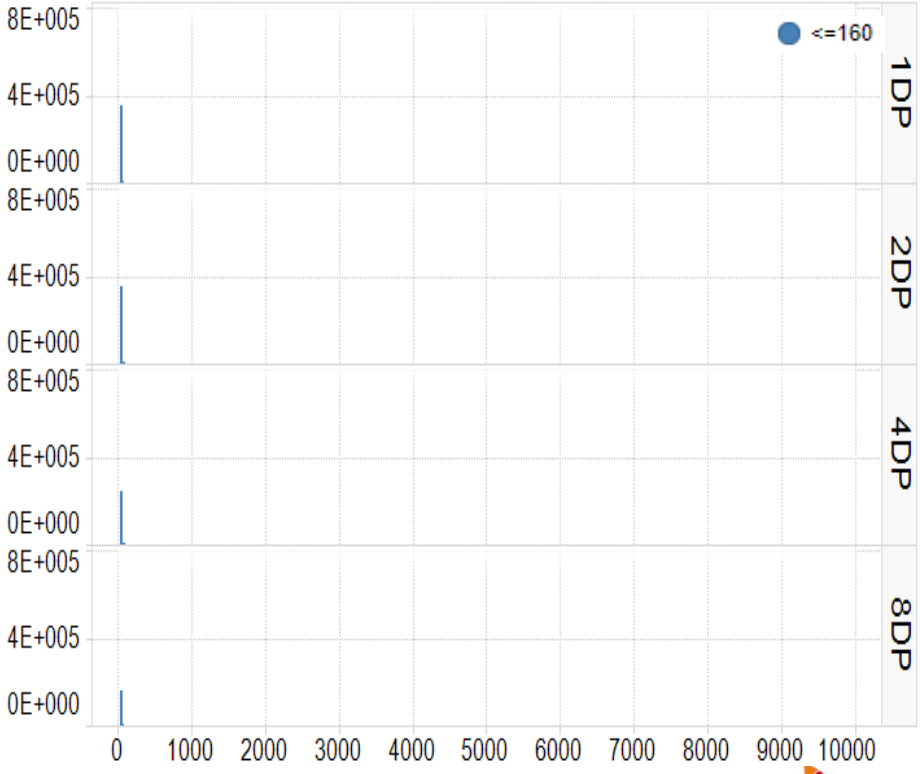
☑ Read Latency Distribution@ Pre EW + RD 100K + 1months@ 45℃ with cross temp 30 ℃

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(Pre EW)



● No. of Chunk vs. Read Latency
(EW + RD 100K + 1Month)

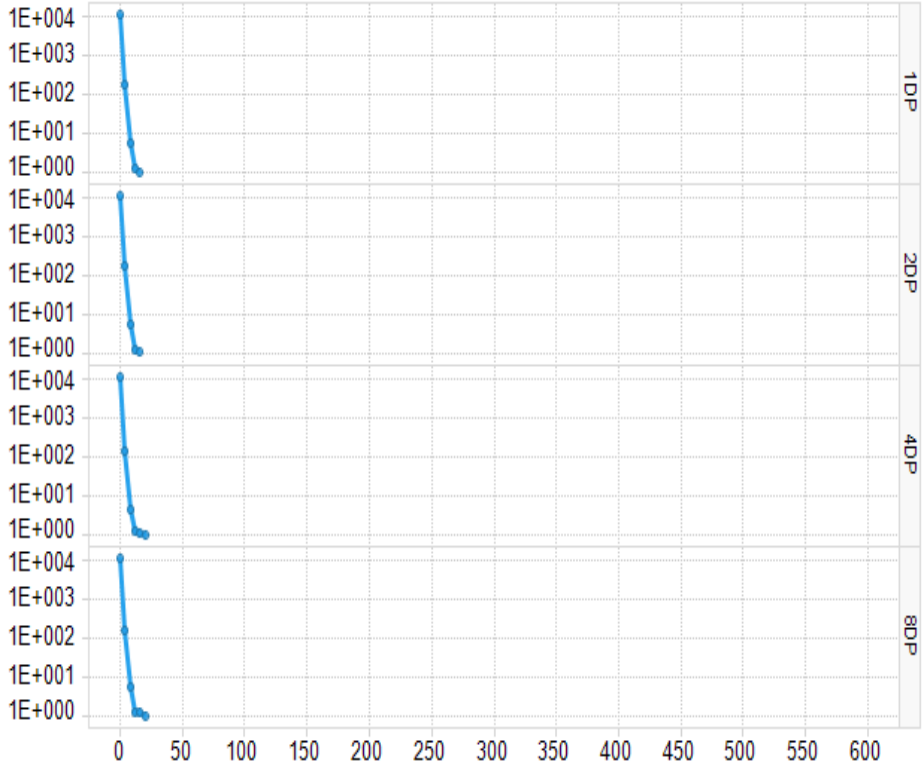


SLC(EOL Latency) – CP9C

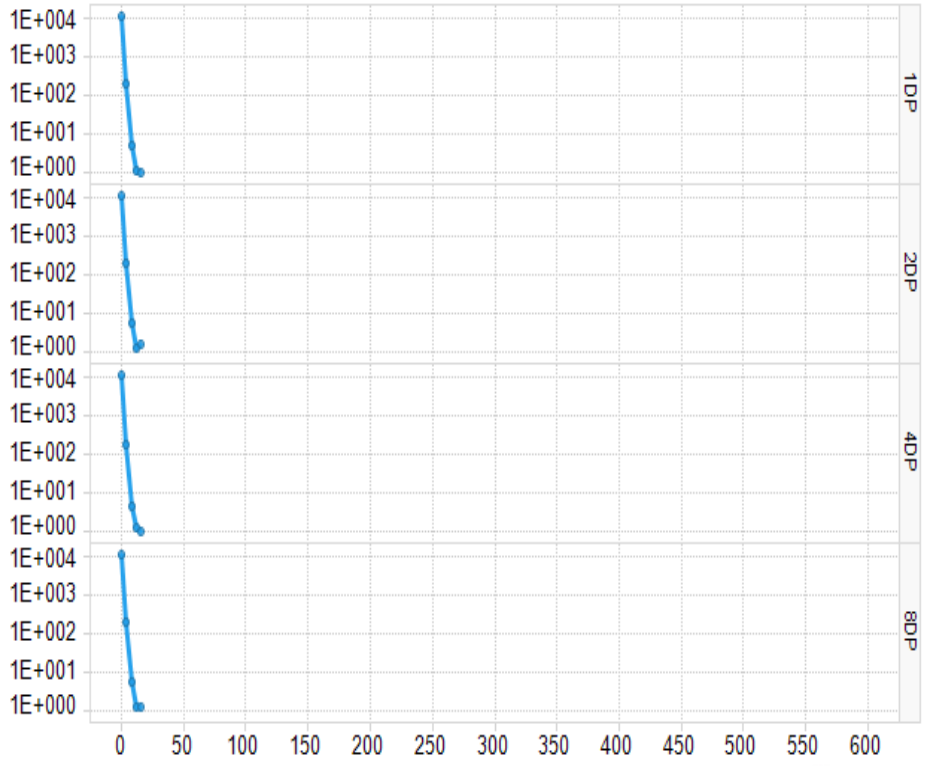
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃

● Pre EW



● Pre EW + RD 100K + 1Month

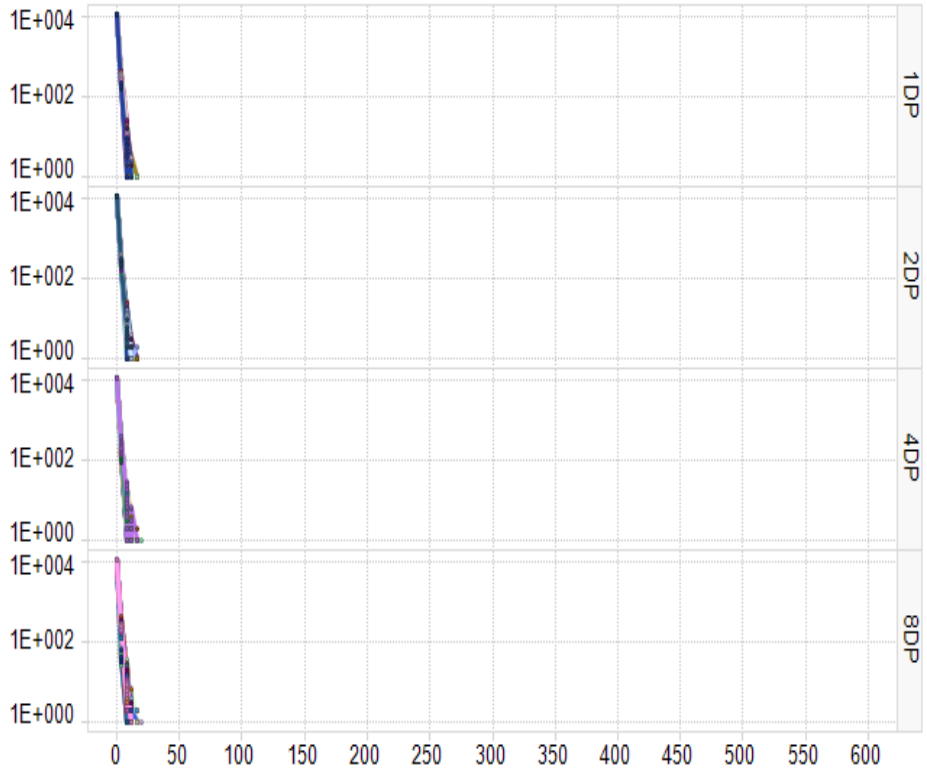


SLC(EOL Latency) – CP9C

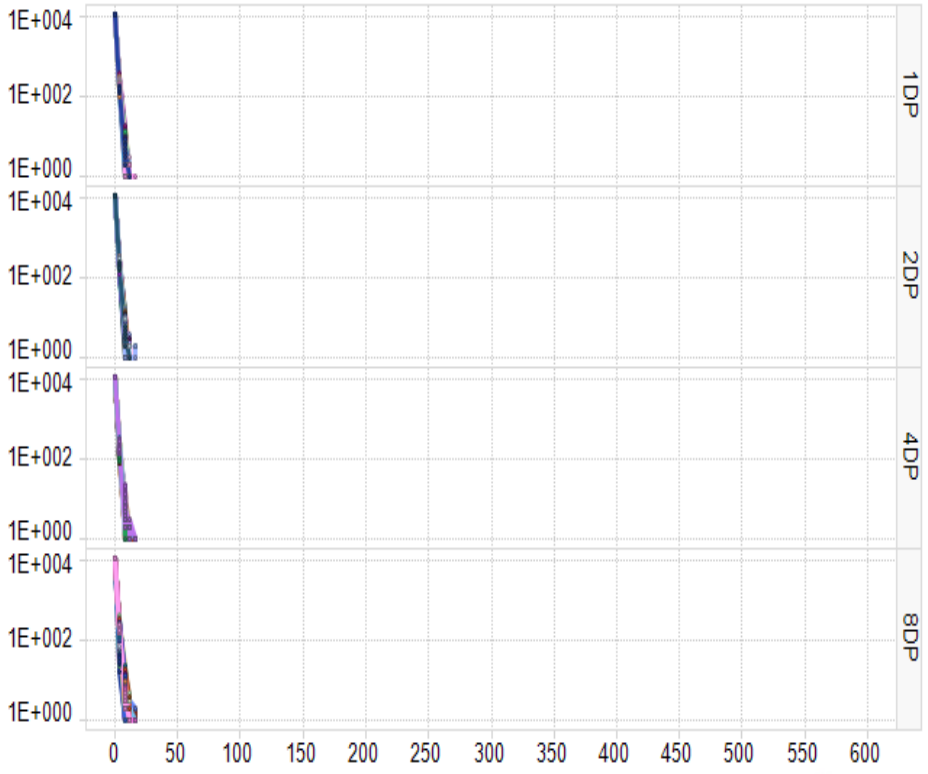
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃

● Pre EW



● Pre EW + RD 100K + 1Month

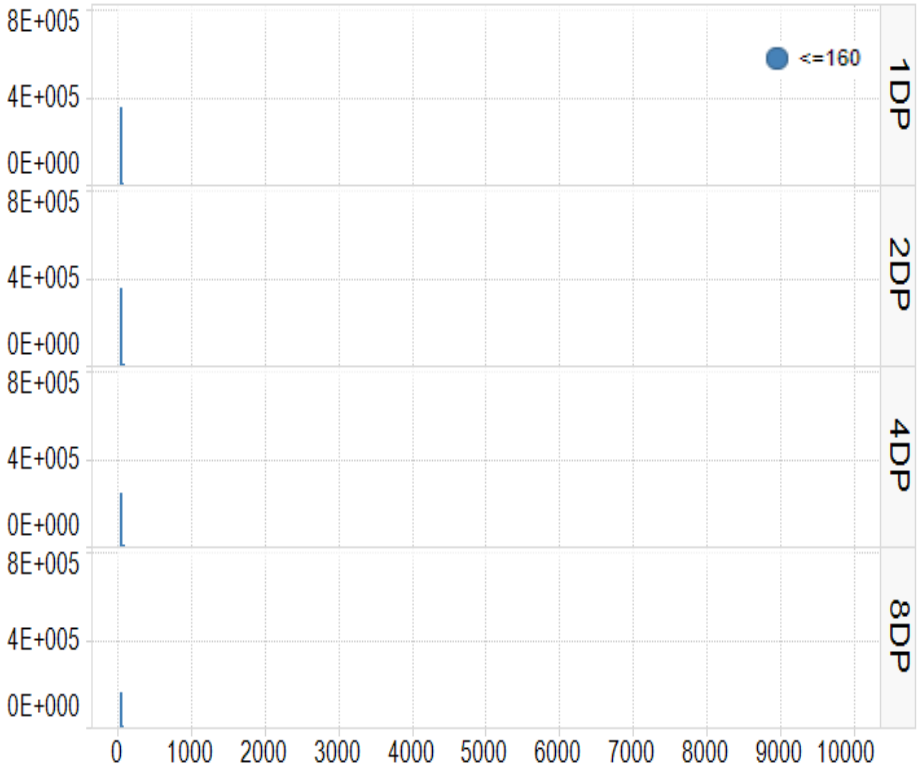


SLC(EOL Latency) – CP9C

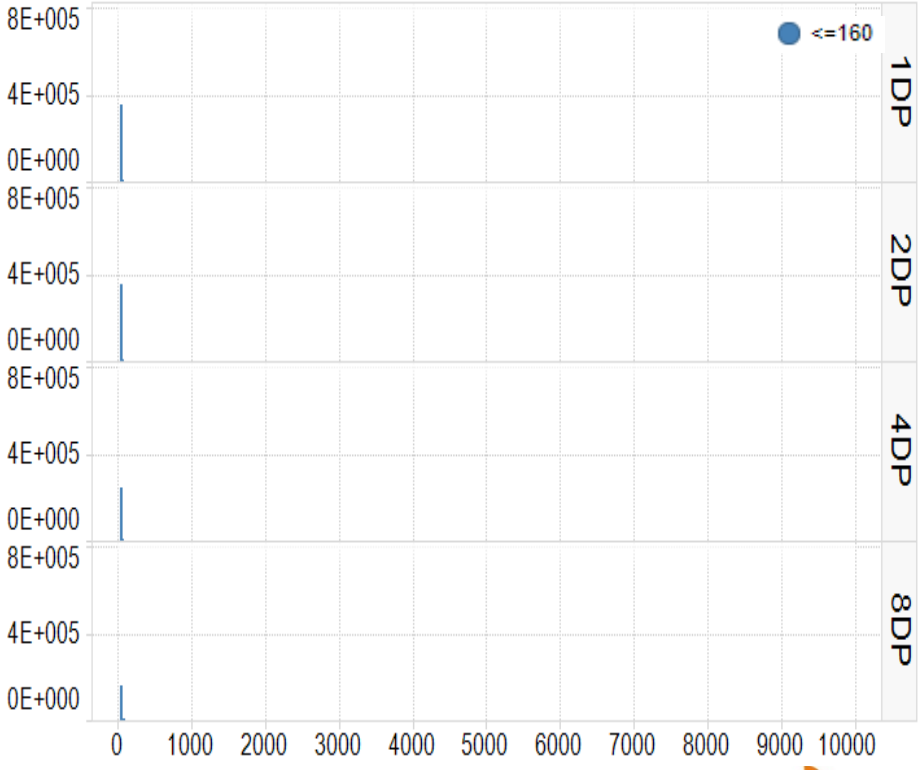
☑ Read Latency Distribution@ Pre EW + RD 100K + 1month@ 35℃ with cross temp 30 ℃

Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Back Pattern : Random pattern @ 10℃
Read disturb 100K @ 25℃
1months@ 35℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(Pre EW)



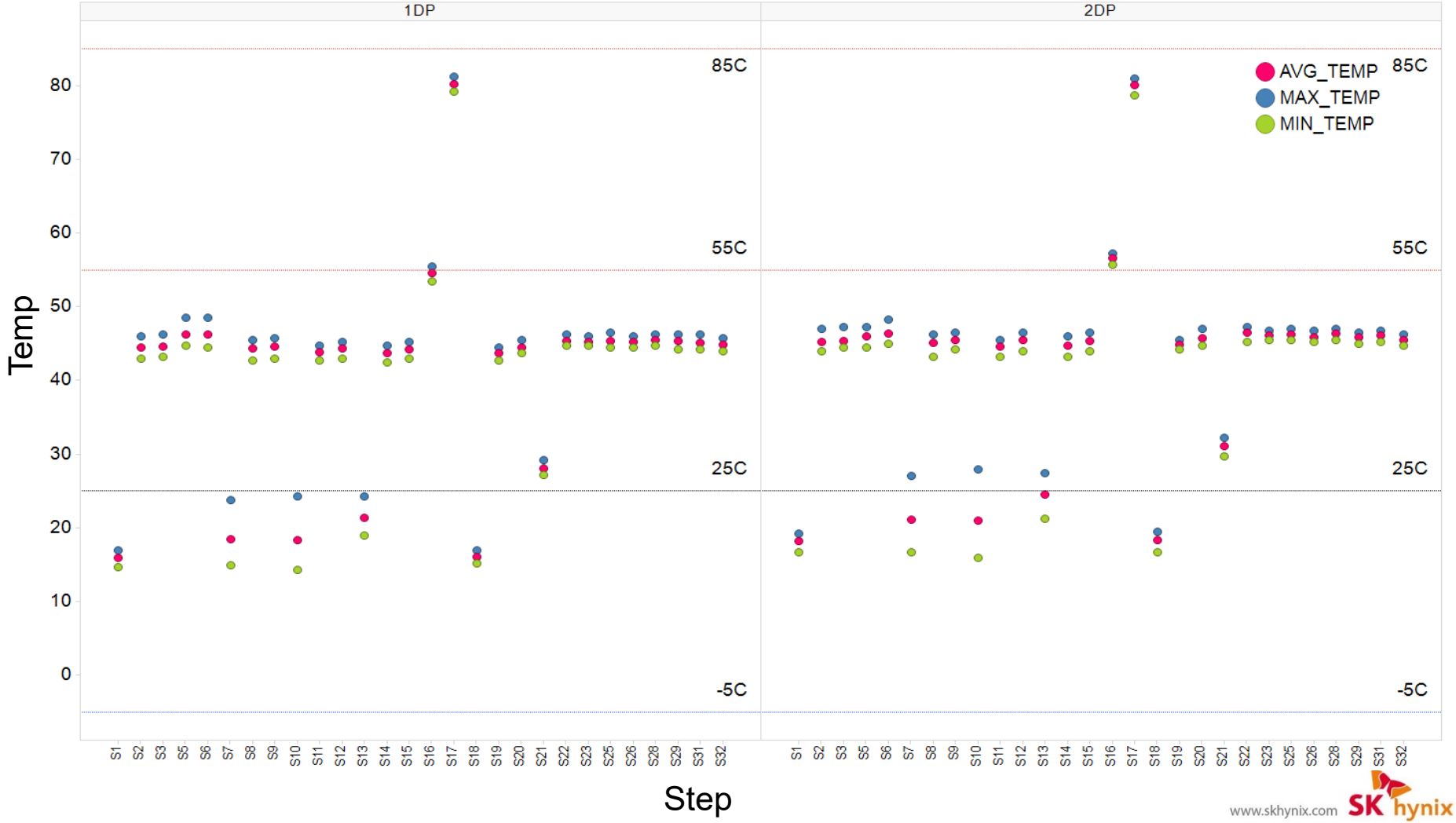
● No. of Chunk vs. Read Latency
(EW + RD 100K + 1month)



[X-Ray Tolerance]
Latency / Throughput

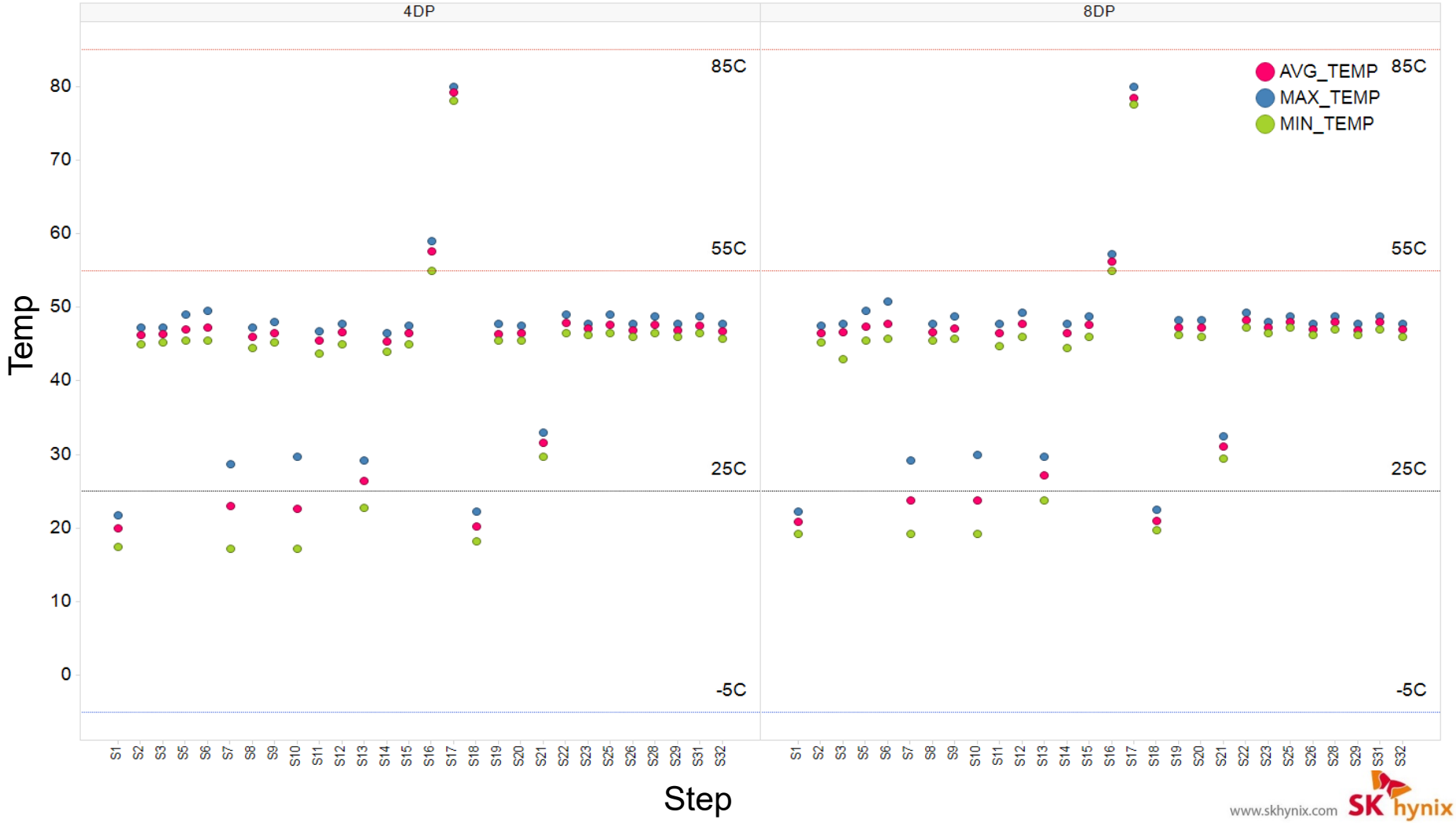
X-Ray Tolerance Temp Measurement

X-Ray Tolerance temp Sensor Measurement (1/2DP)



X-Ray Tolerance Temp Measurement

X-Ray Tolerance temp Sensor Measurement (4/8DP)

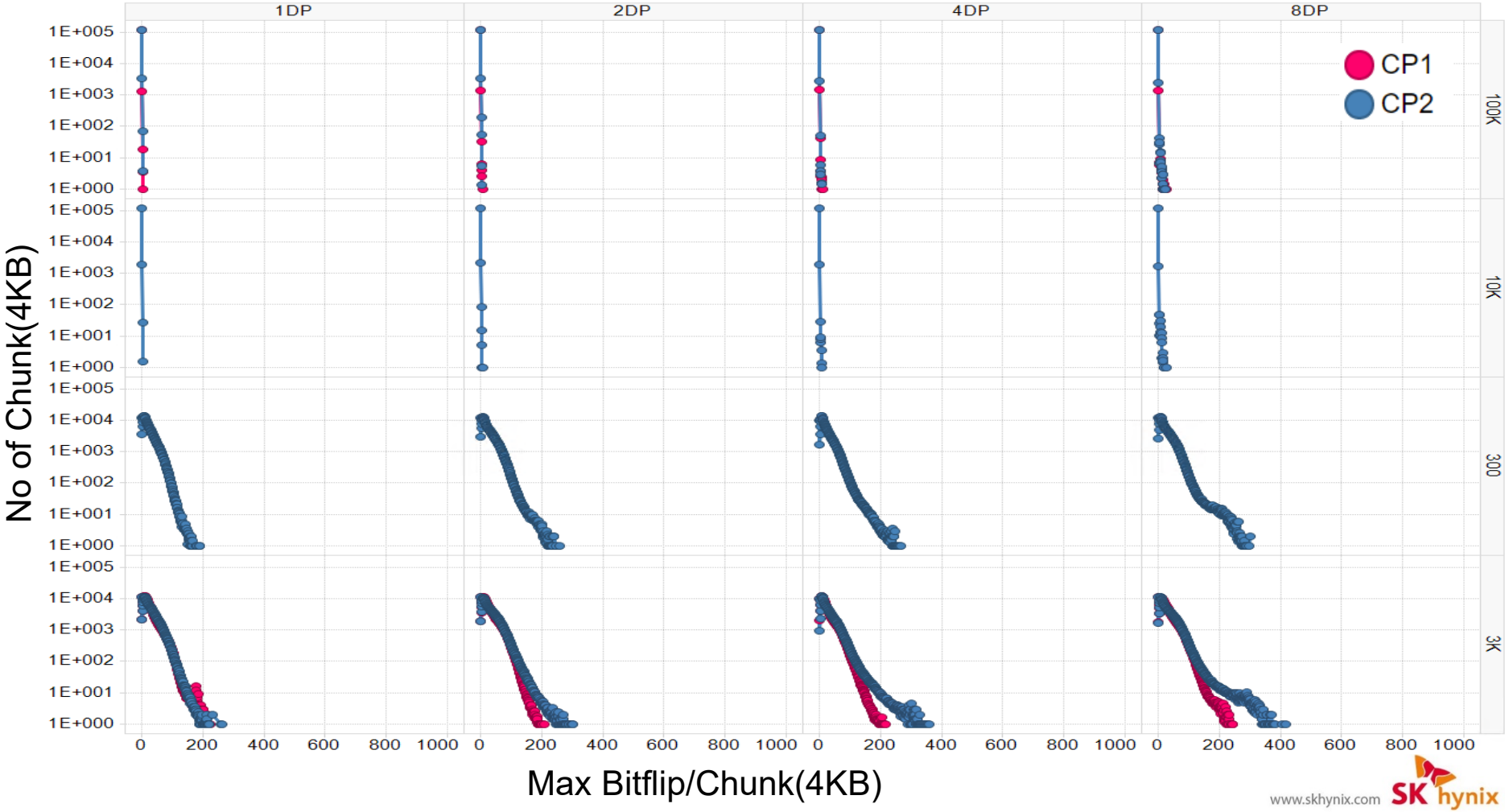


X-Ray Tolerance TLC Cycling Bitflips Measurement

☑ EW No. of Chunk vs. Bit Flips

Pre-EW : Random pattern 10% cycle(85℃)

Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%



X-Ray Tolerance TLC tPROG/tBERS (TLC)

☑ EW tPROG/tBERS

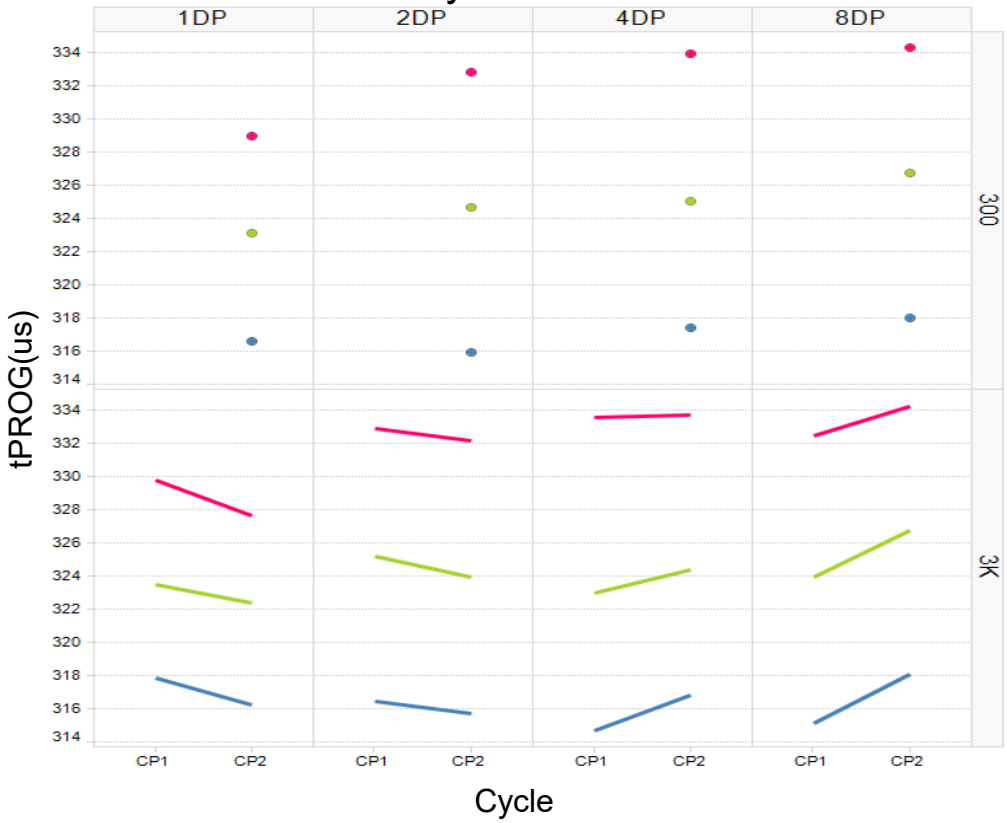
Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%

$$tPROG = \frac{1}{P}\sum_{i} tPROG, PAGEi$$

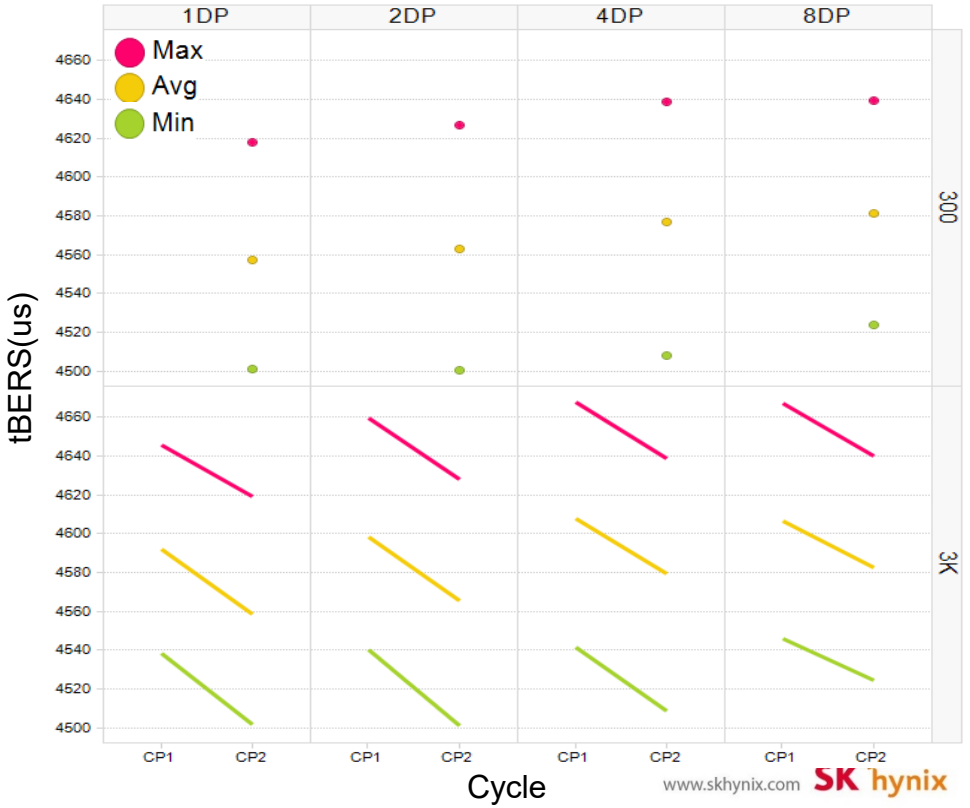
t-Prog worst := Average_dies(Average_blocks(Average_pages(program time))) + 5*std_dies(Average_blocks(Average_pages(program time)))
t-Prog average := Average_dies(Average_blocks(Average_pages(program time)))
t-Prog max := Max_dies(Average_blocks(Average_pages(program time)))

t-Prog worst
t-Prog average
t-Prog max

EW : Cycle vs tPROG



EW : Cycle vs tBERS



X-Ray Tolerance TLC tPROG/tBERS (SLC)

☑ EW tPROG/tBERS

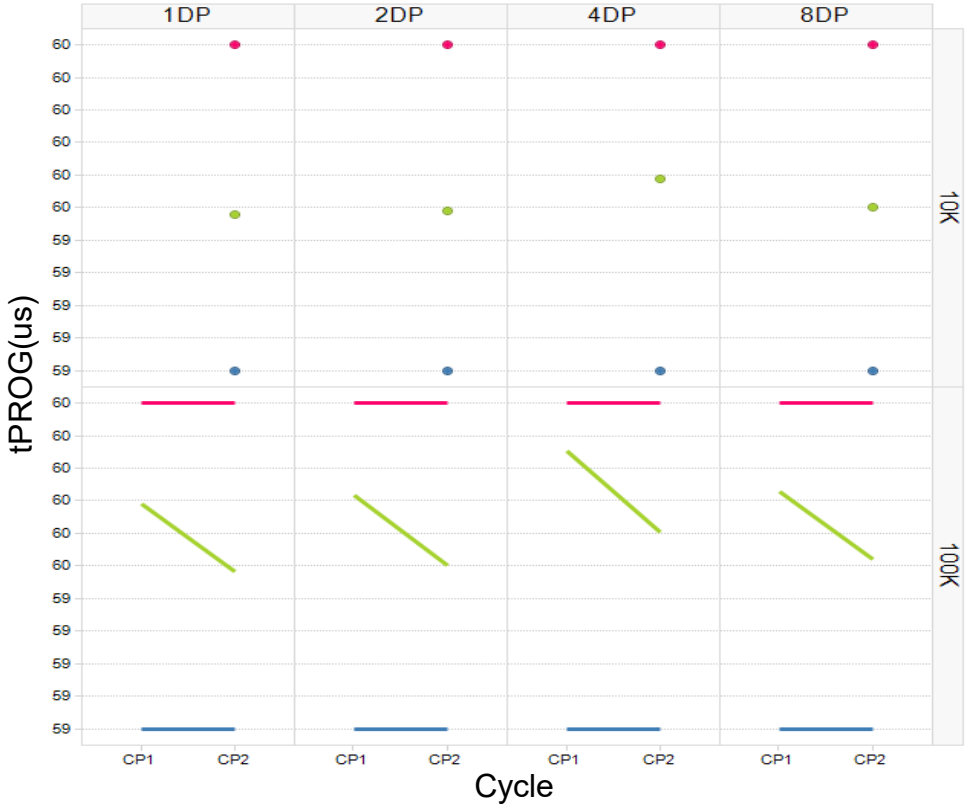
Pre-EW : Random pattern @ 90% Cycle (55℃) , 10% cycle(85℃)
Bitflip Monitor 1Checkpoint @90%, 1Checkpoint @10%

$$tPROG = \frac{1}{P}\sum_{i} tPROG, PAGEi$$

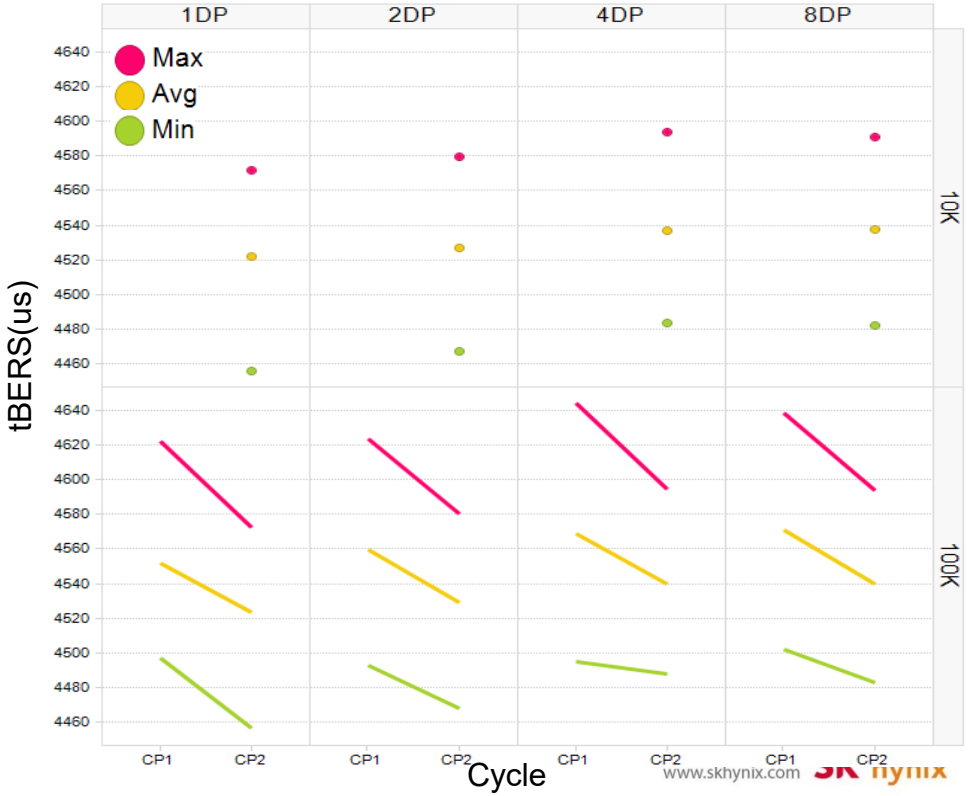
t-Prog worst := Average_dies(Average_blocks(Average_pages(program time))) + 5*std_dies(Average_blocks(Average_pages(program time)))
t-Prog average := Average_dies(Average_blocks(Average_pages(program time)))
t-Prog max := Max_dies(Average_blocks(Average_pages(program time)))

t-Prog worst
t-Prog average
t-Prog max

● EW : Cycle vs tPROG



● EW : Cycle vs tBERS

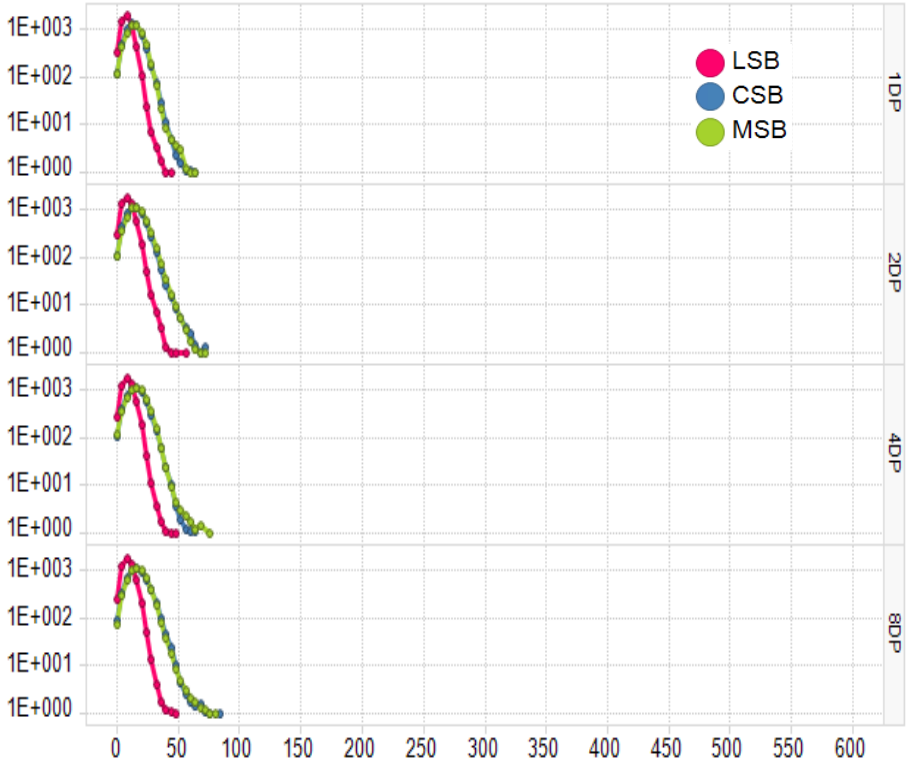


X-Ray Tolerance TLC Type 1

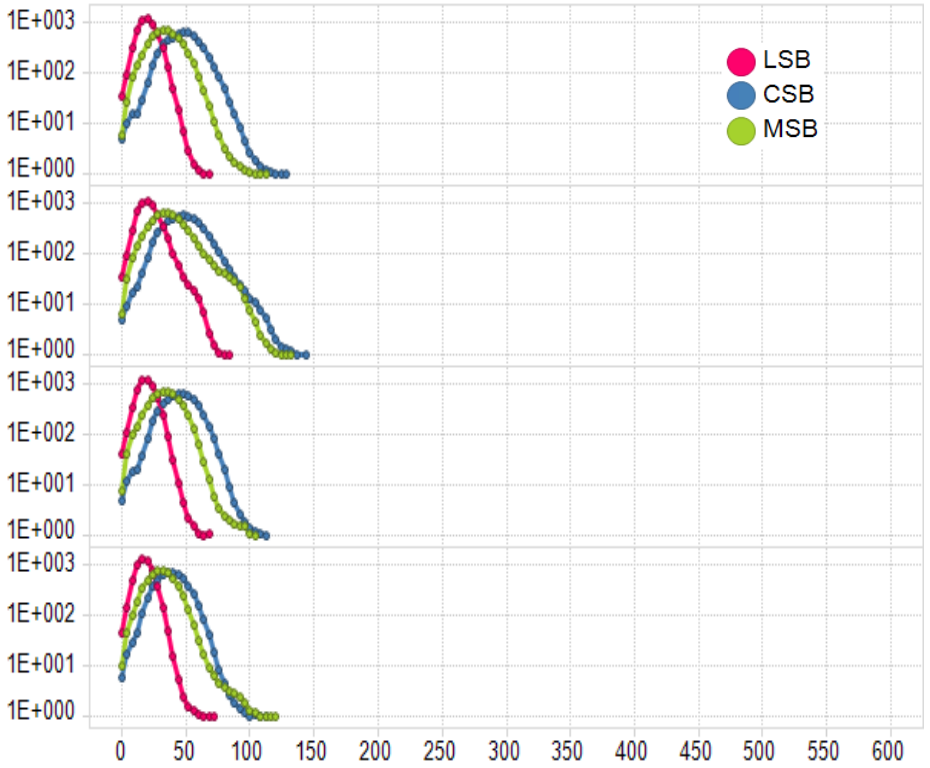
☑ No. of Chunk vs. Correctness

Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● Initial



● X-Ray + RD 100K + 3Months

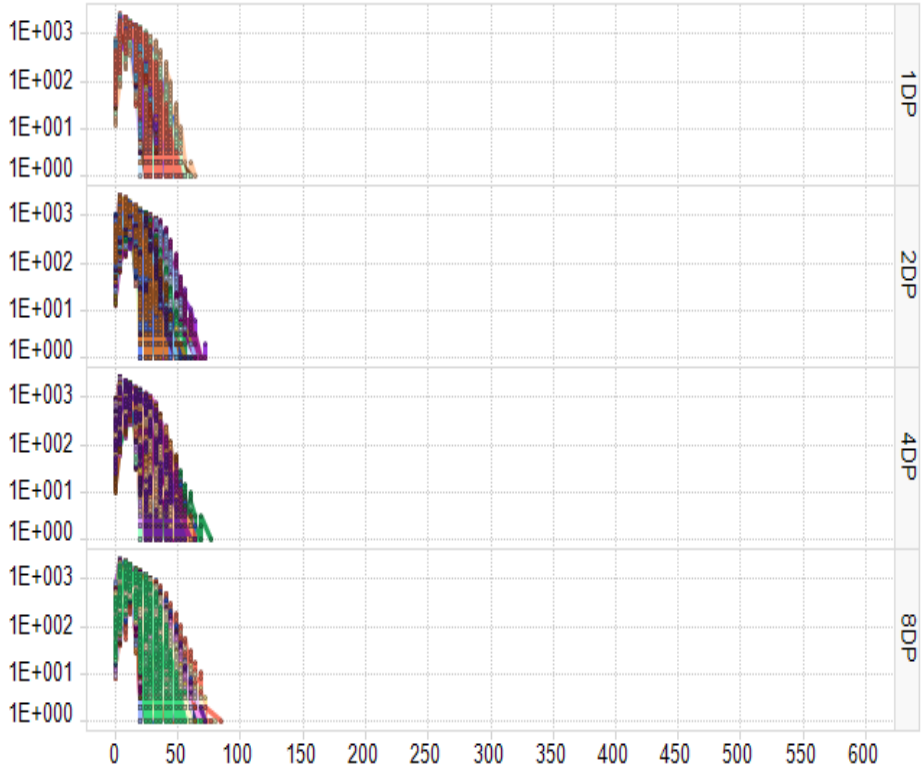


X-Ray Tolerance TLC Type 1

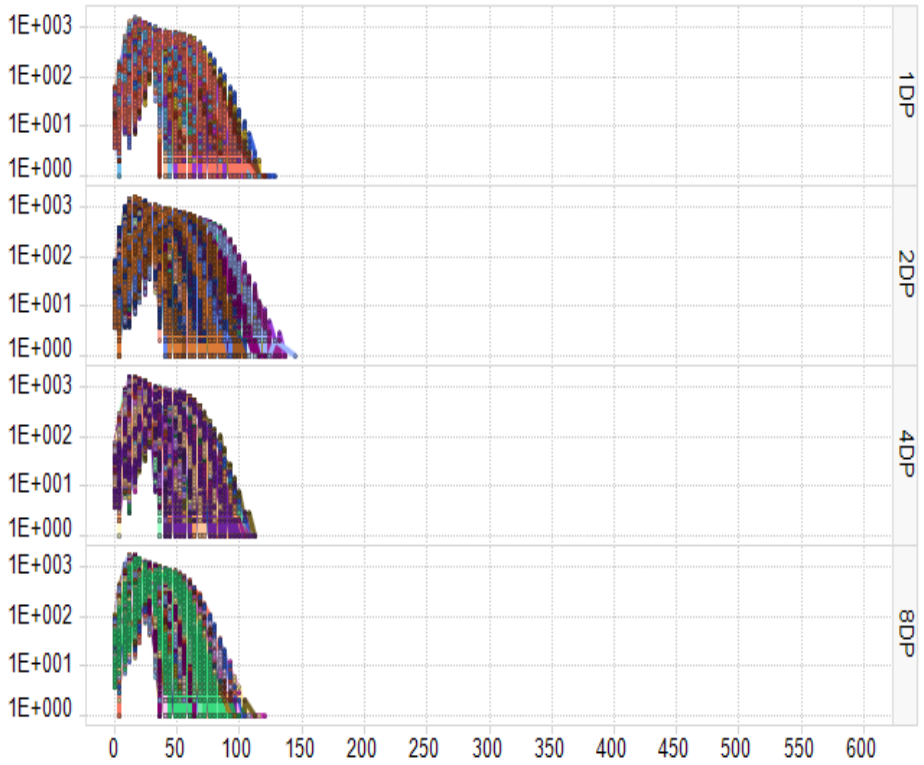
☑ No. of Chunk vs. Correctness (By. Die)

Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● Initial



● X-Ray + RD 100K + 3Months

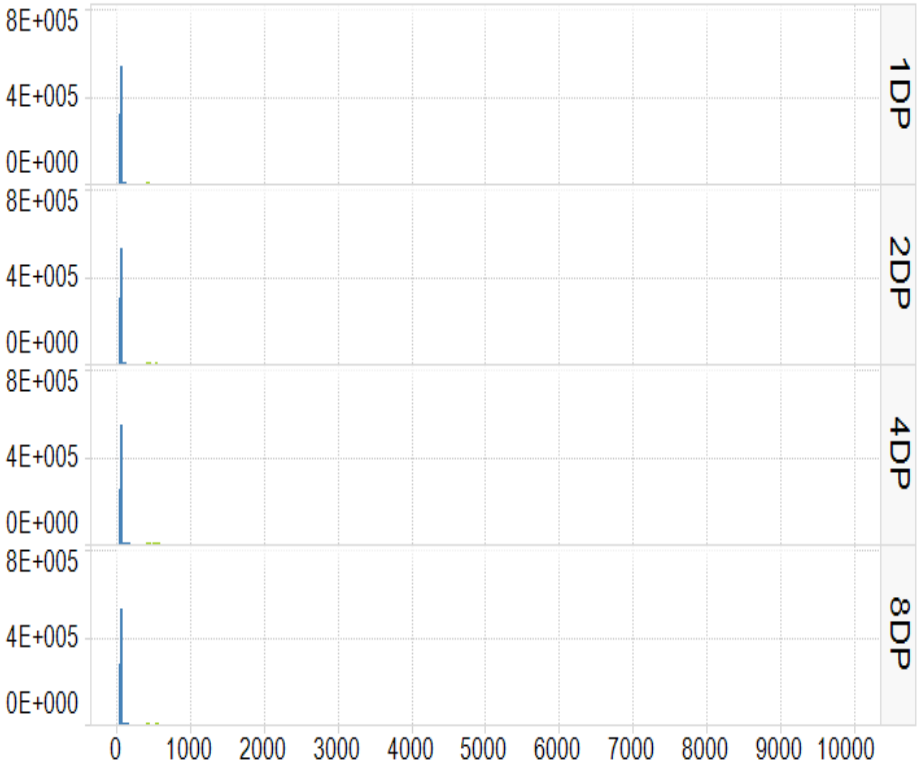


X-Ray Tolerance TLC Type 1

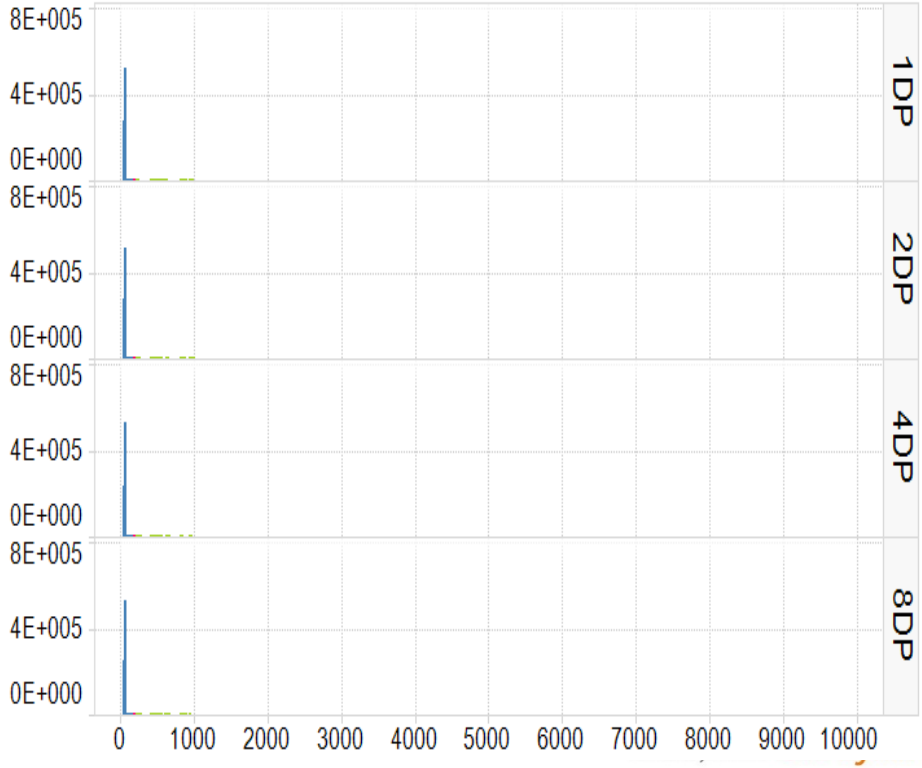
☑ Read Latency Distribution@ X-Ray 1Gr + RD 100K + 3months@ 40℃ with cross temp 30 ℃

Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(Initial)



● No. of Chunk vs. Read Latency
(X-Ray 1Gr + RD 100K + 3months)

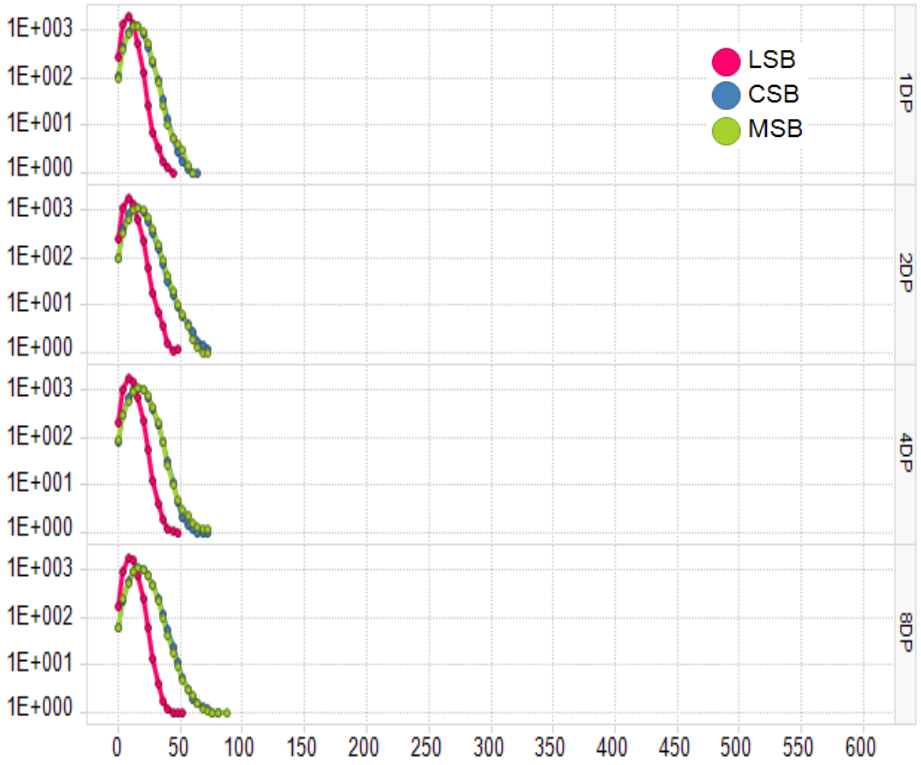


X-Ray Tolerance TLC Type 2

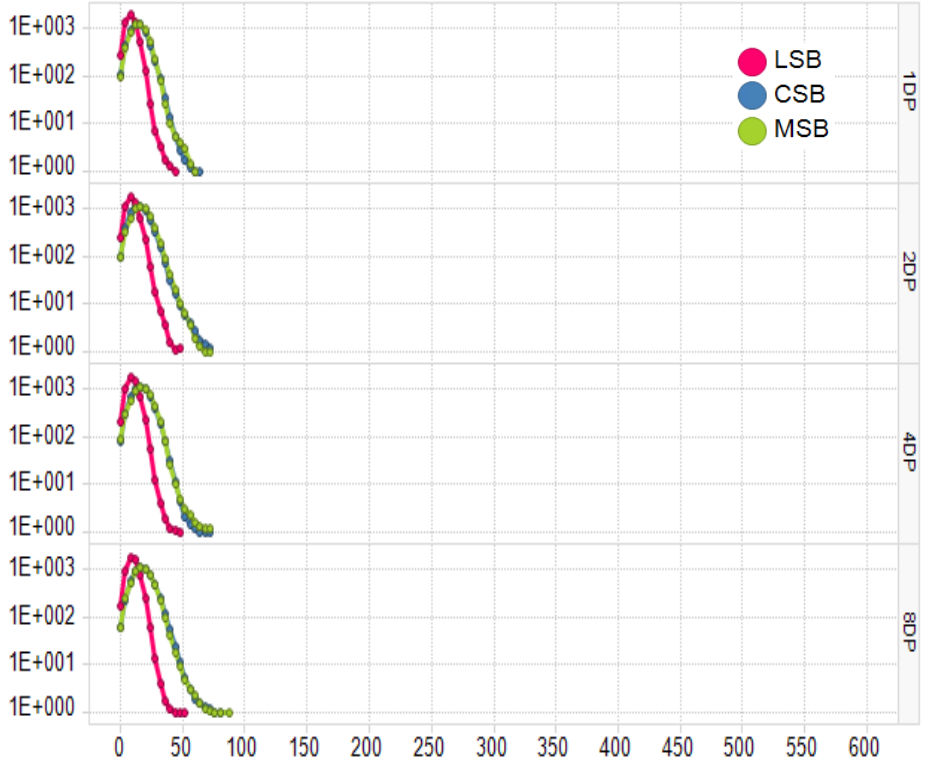
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 3Months

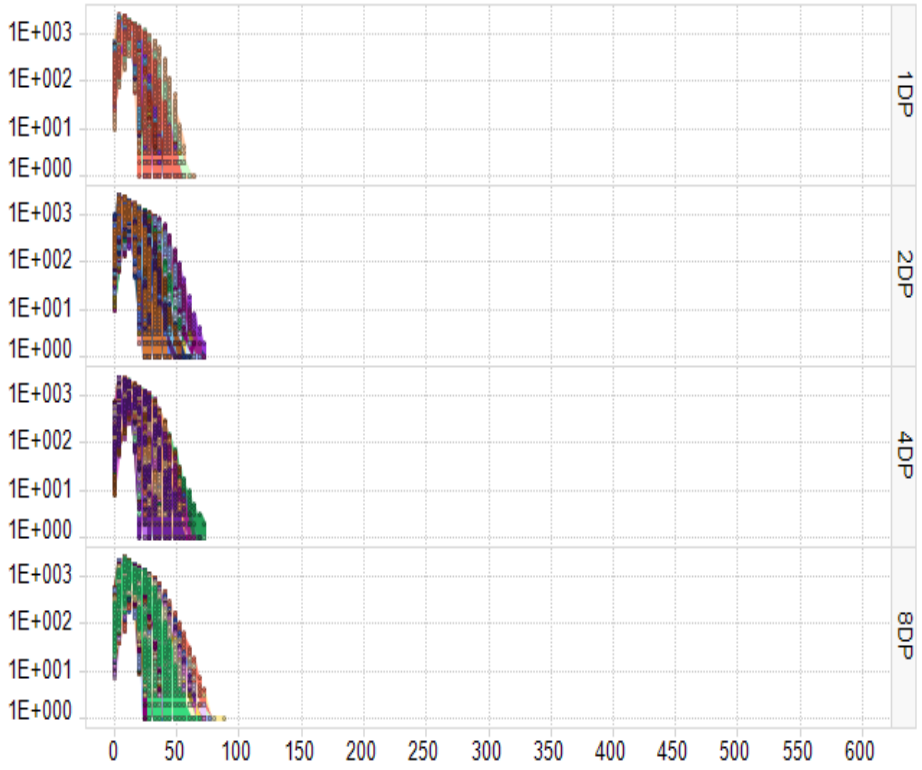


X-Ray Tolerance TLC Type 2

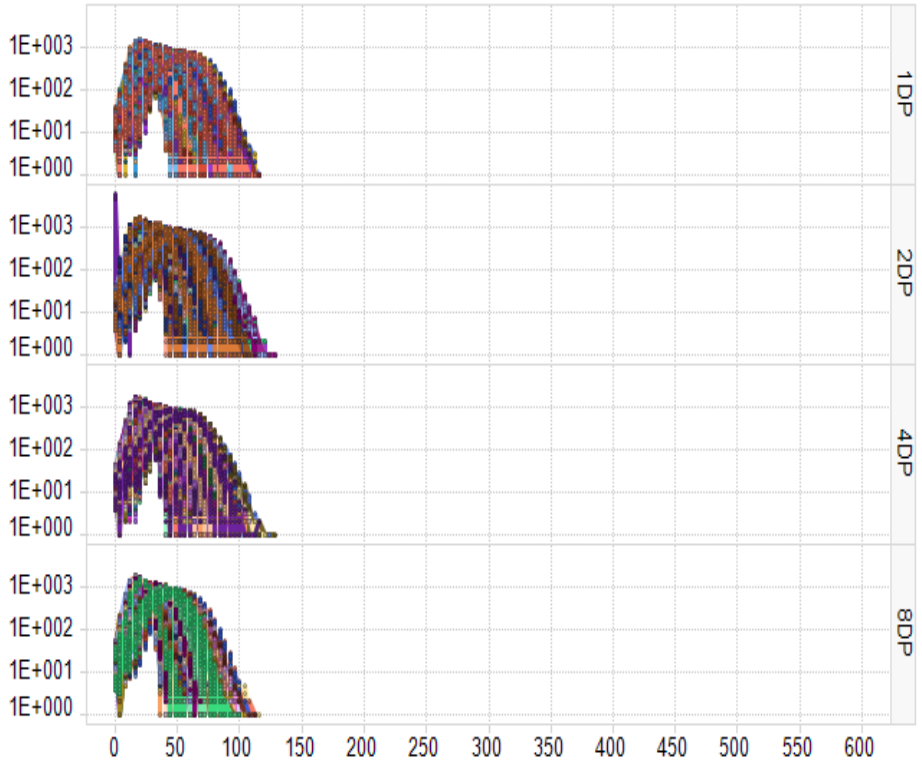
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 3Months

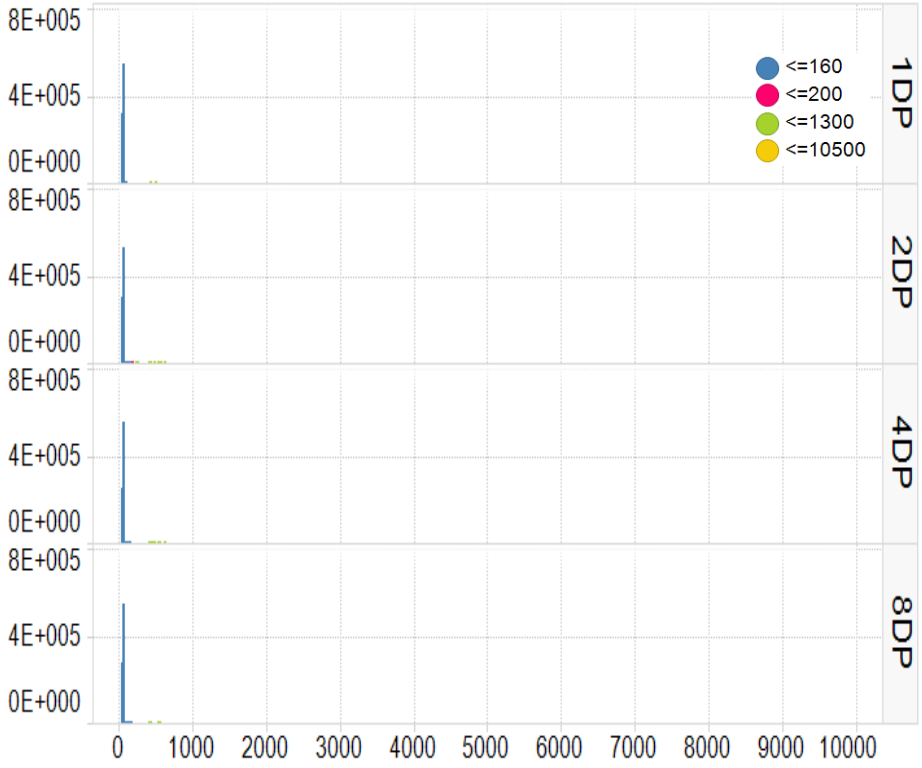


X-Ray Tolerance TLC Type 2

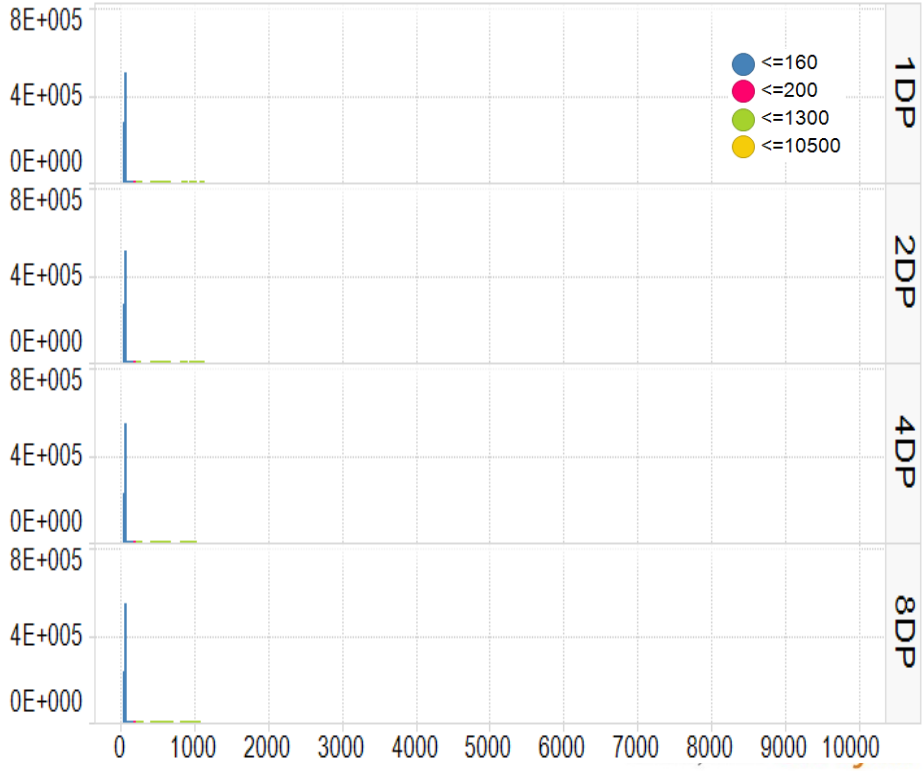
☑ Read Latency Distribution@ EW + RD 100K + 3months@ 45℃ with cross temp 30 ℃

Pre-EW : Random pattern @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(X-Ray + EW)



● No. of Chunk vs. Read Latency
(X-Ray + EW + RD 100K + 3months)

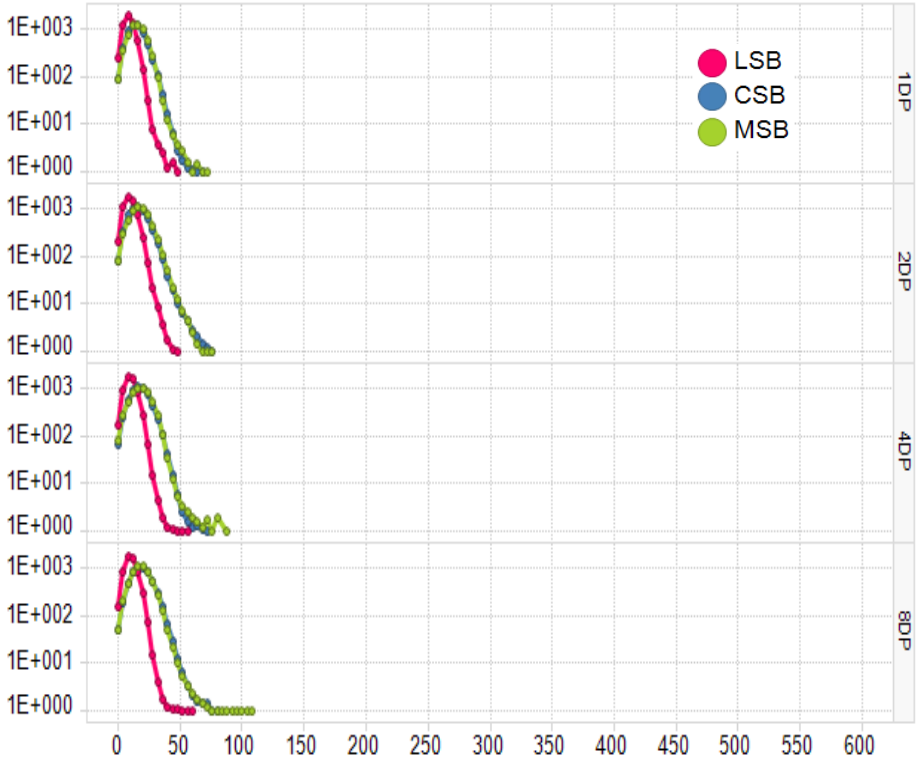


X-Ray Tolerance TLC Type 3 (1M)

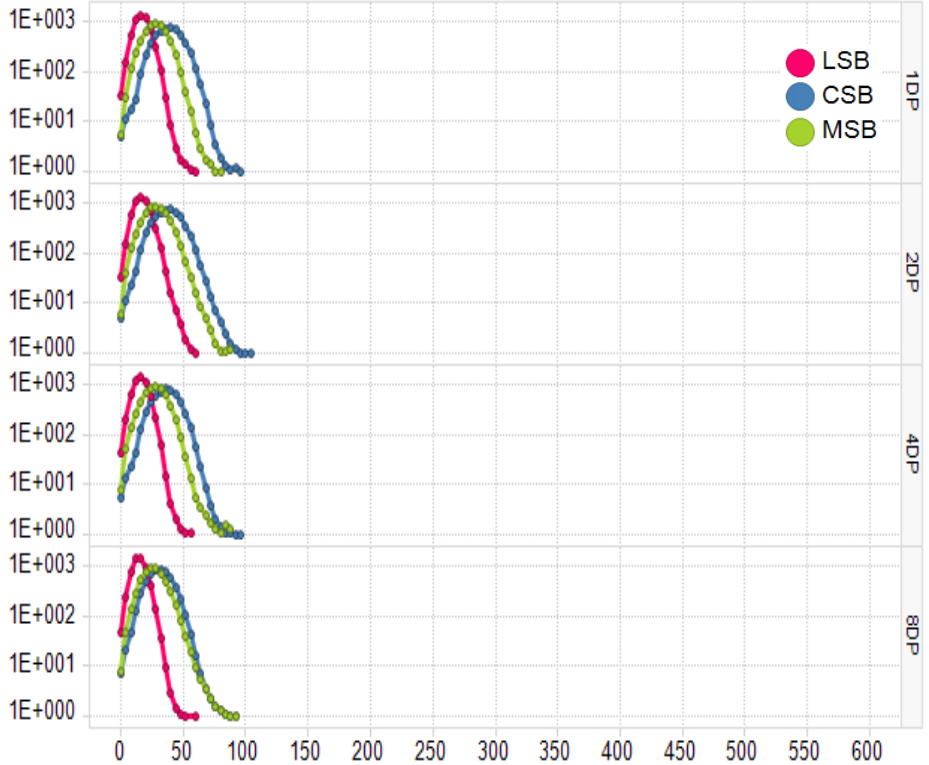
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 1Month

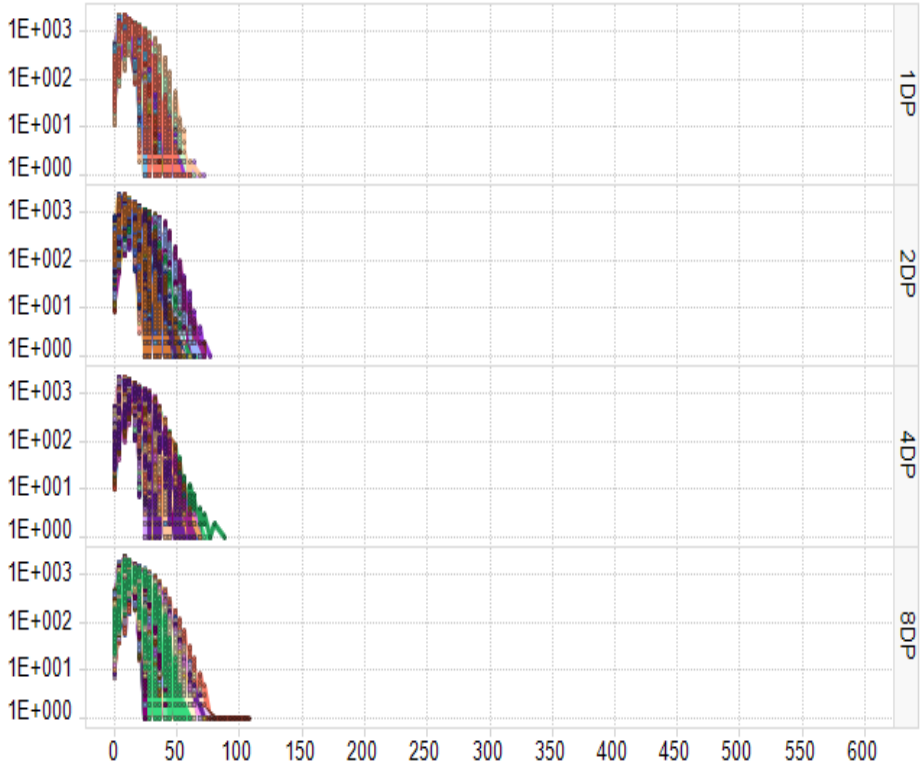


X-Ray Tolerance TLC Type 3 (1M)

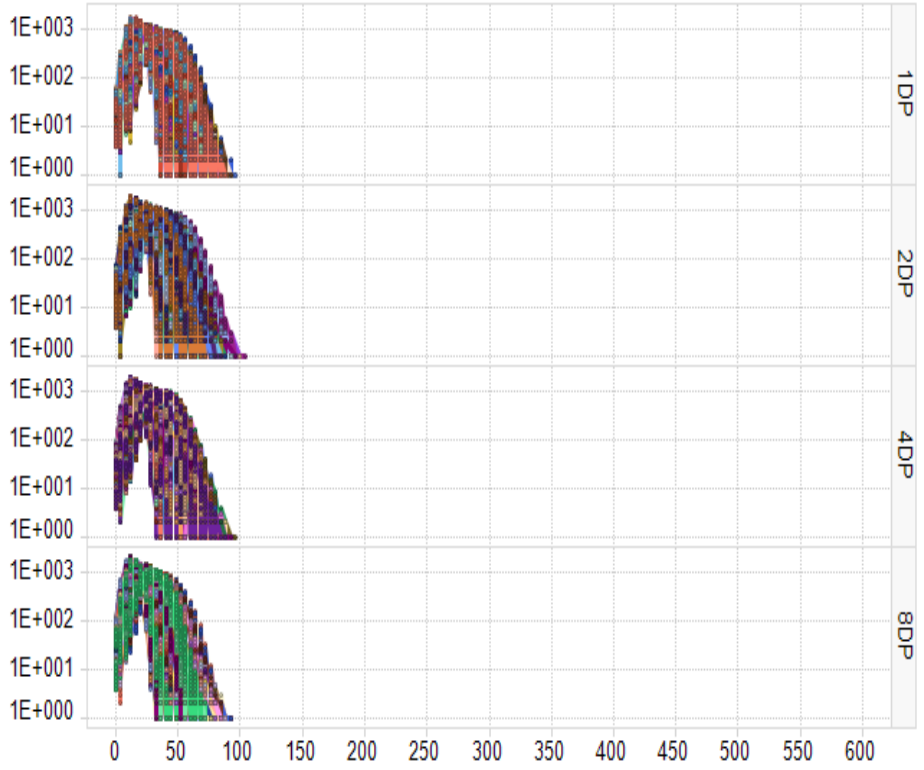
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 1Month

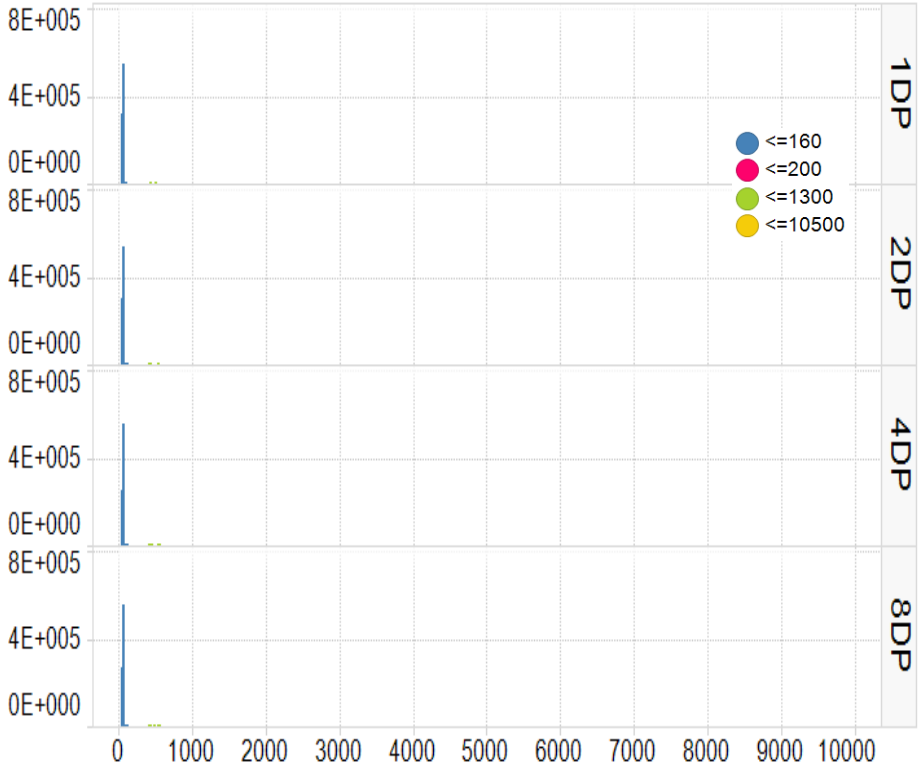


X-Ray Tolerance TLC Type 3 (1M)

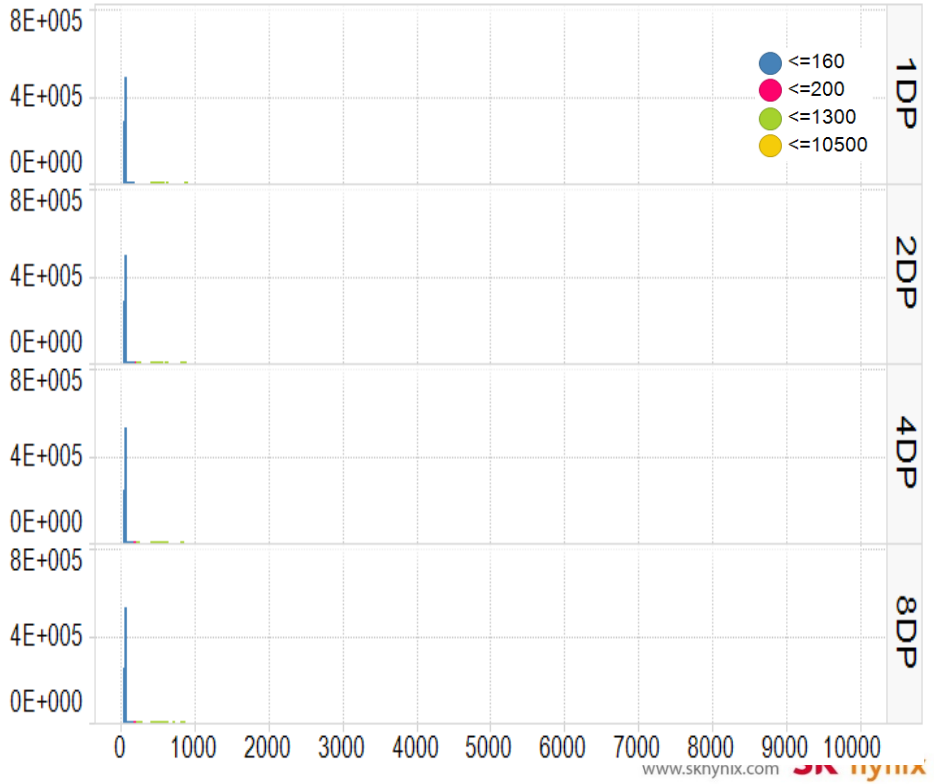
☑ Read Latency Distribution@ EW + RD 100K + 1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(X-Ray + EW)



● No. of Chunk vs. Read Latency
(X-Ray + EW + RD 100K + 1month)

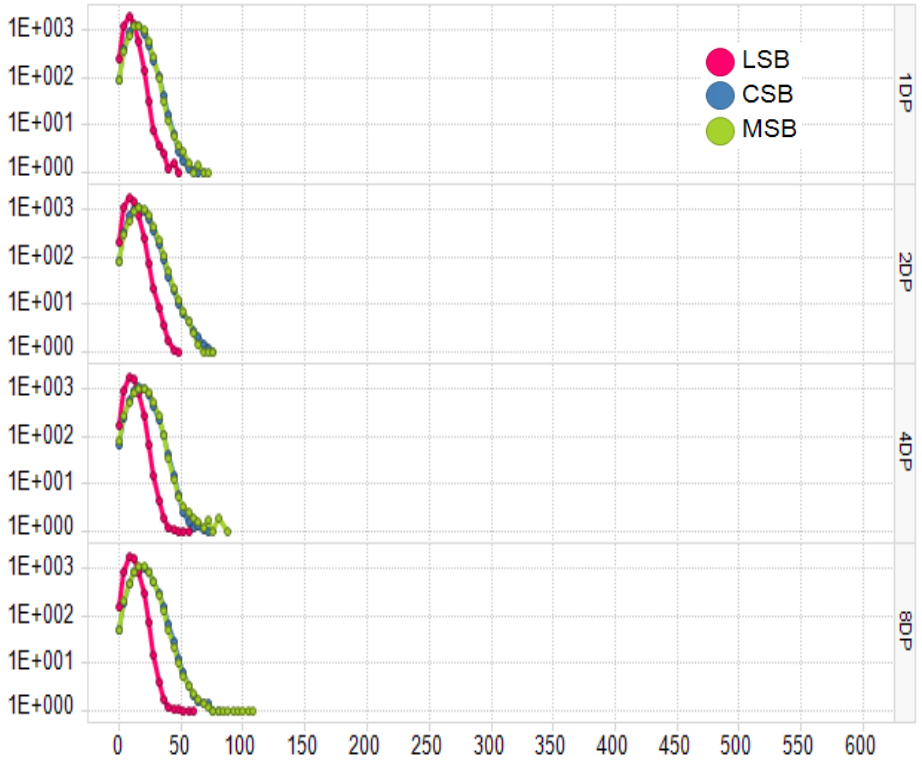


X-Ray Tolerance TLC Type 3 (3M)

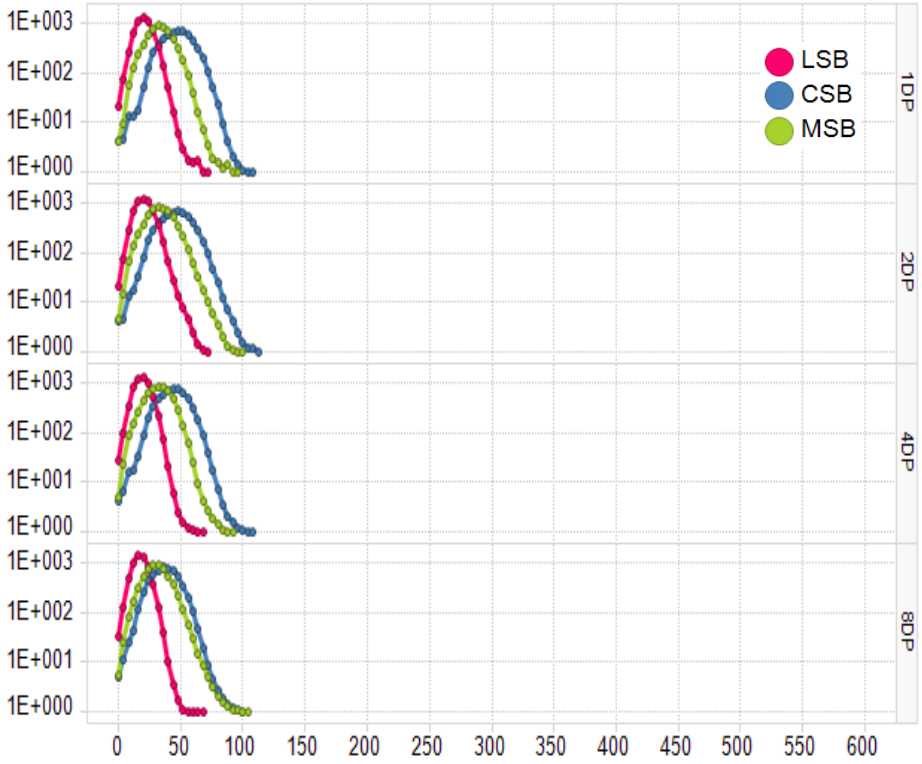
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 3Months

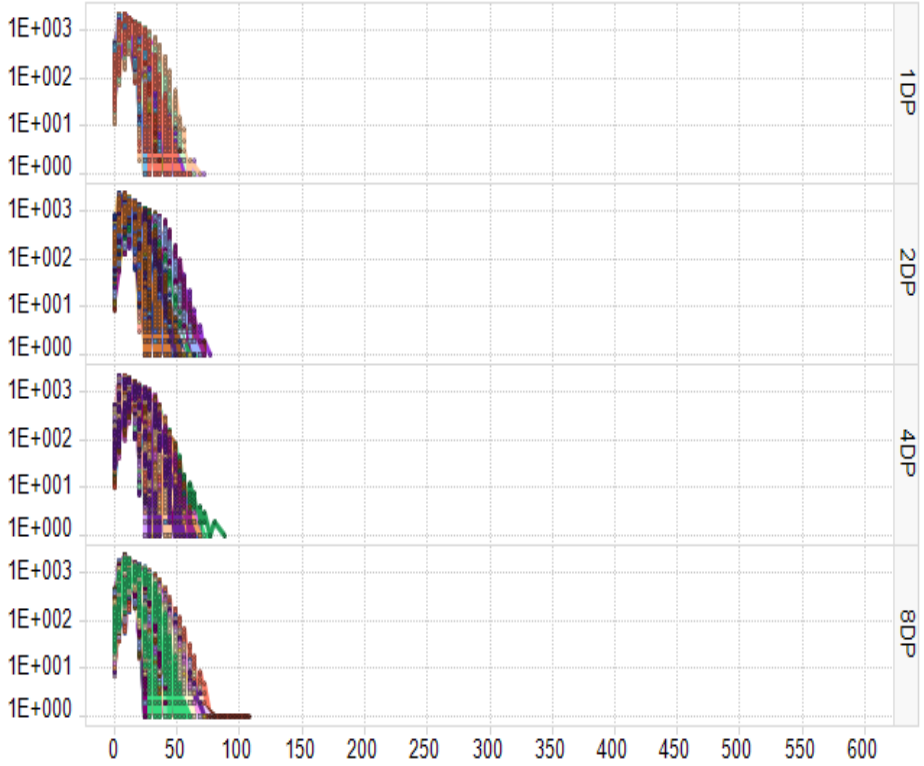


X-Ray Tolerance TLC Type 3 (3M)

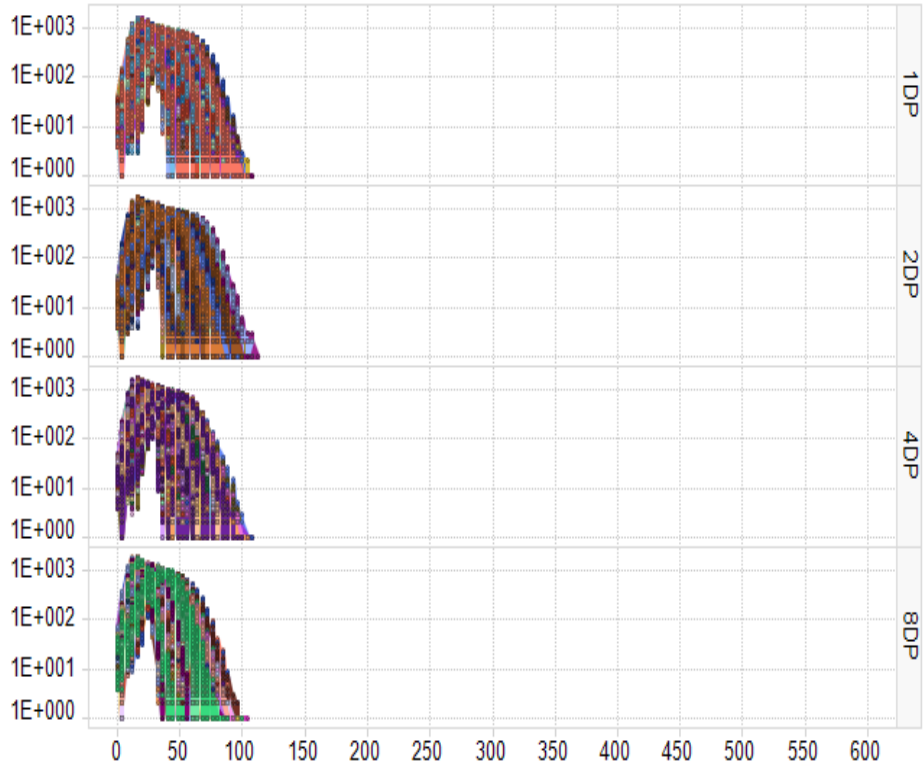
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 3Months

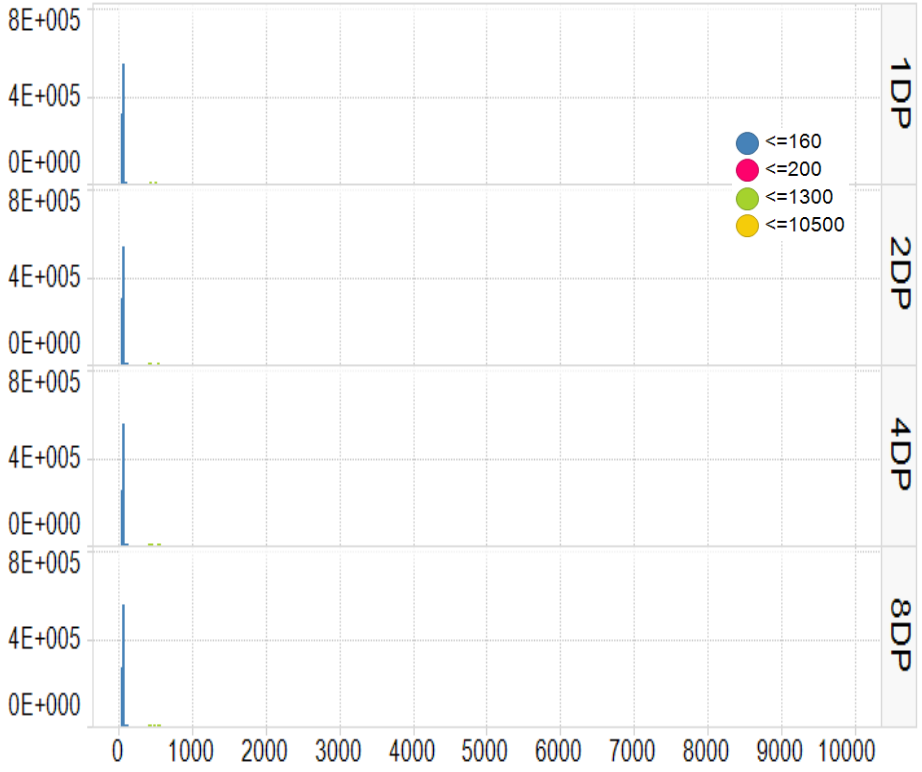


X-Ray Tolerance TLC Type 3 (3M)

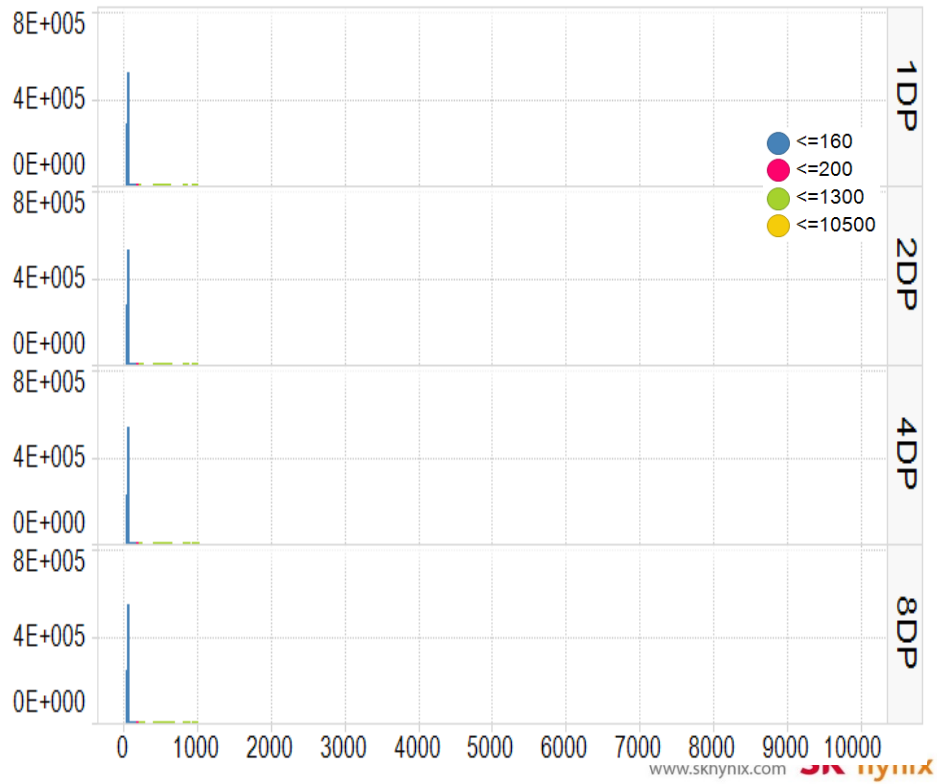
☑ Read Latency Distribution@ EW + RD 100K + 1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(X-Ray + EW)



● No. of Chunk vs. Read Latency
(X-Ray + EW + RD 100K + 3months)

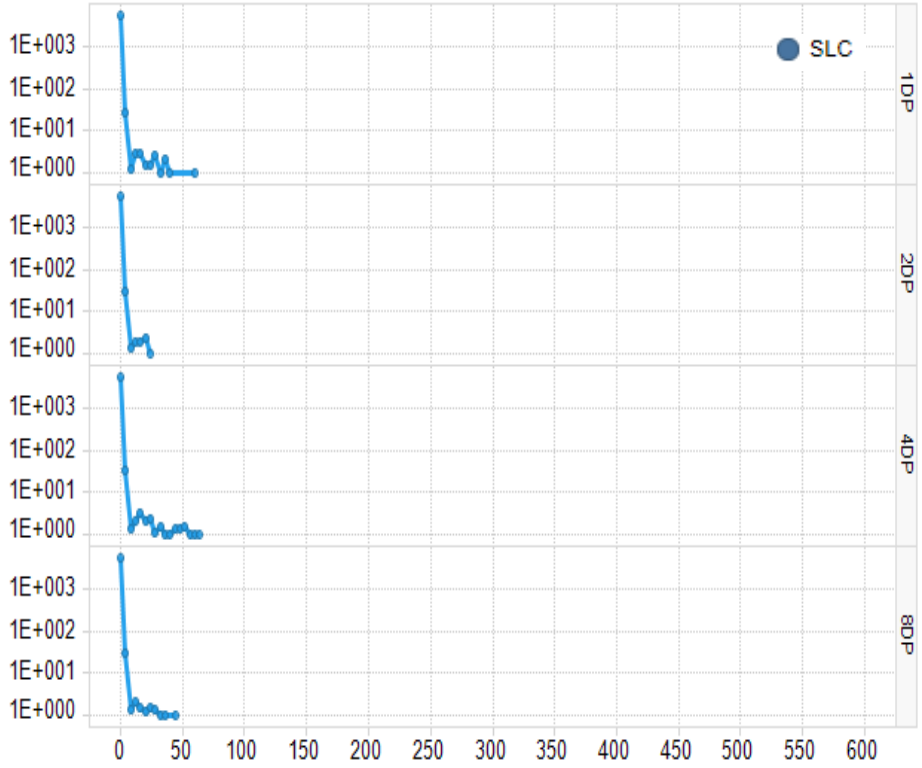


X-Ray Tolerance SLC Type 1

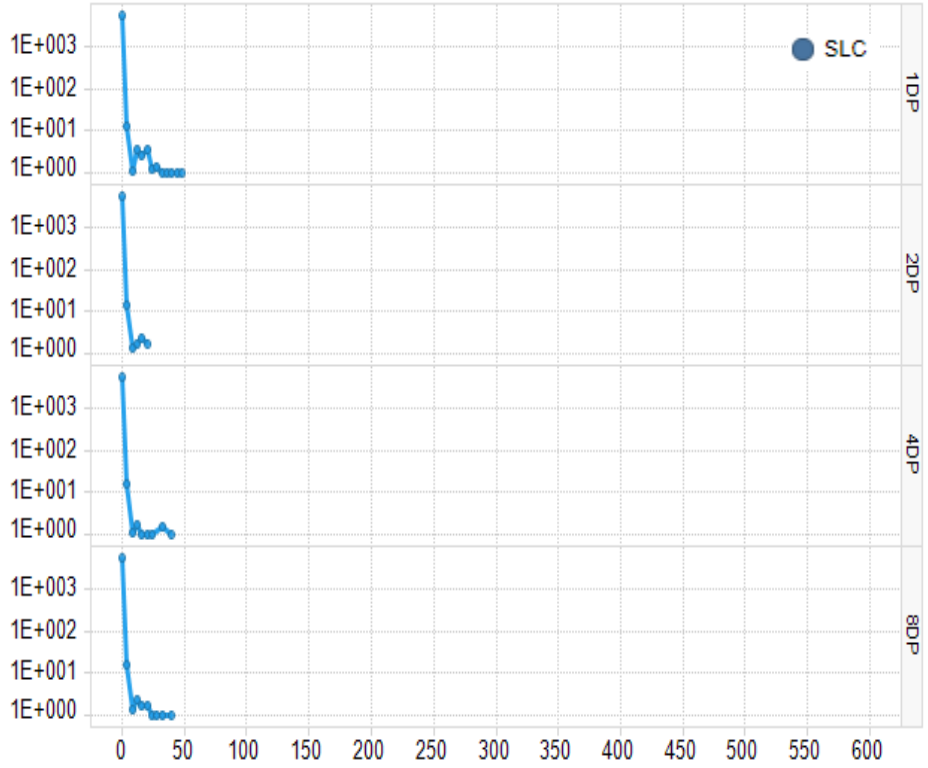
☑ No. of Chunk vs. Correctness

Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● Initial



● X-Ray + RD 100K + 3Months

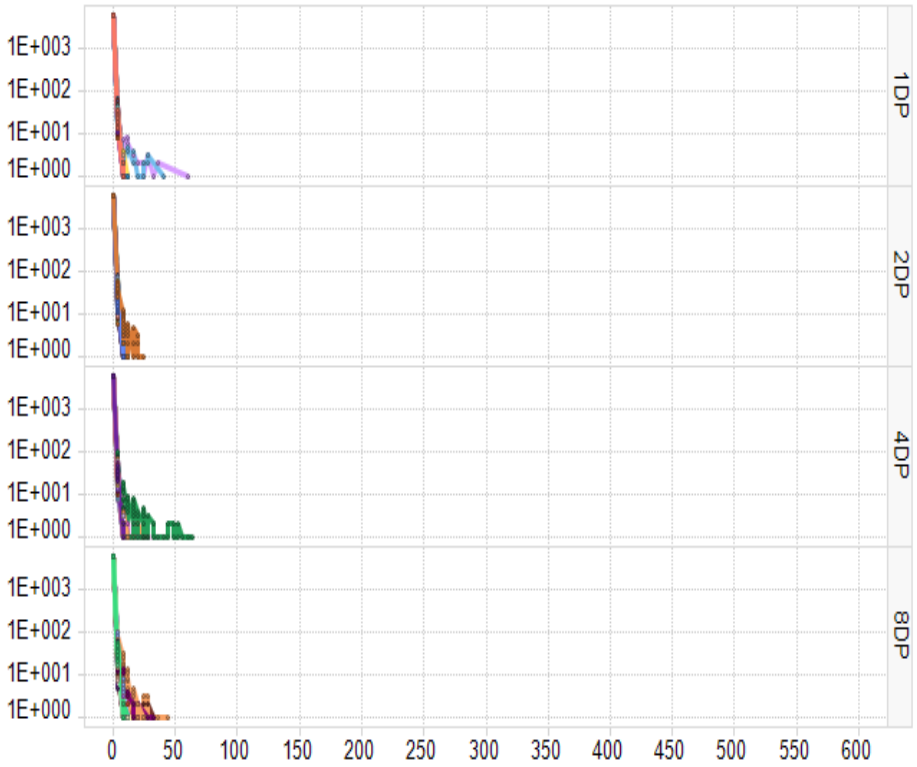


X-Ray Tolerance SLC Type 1

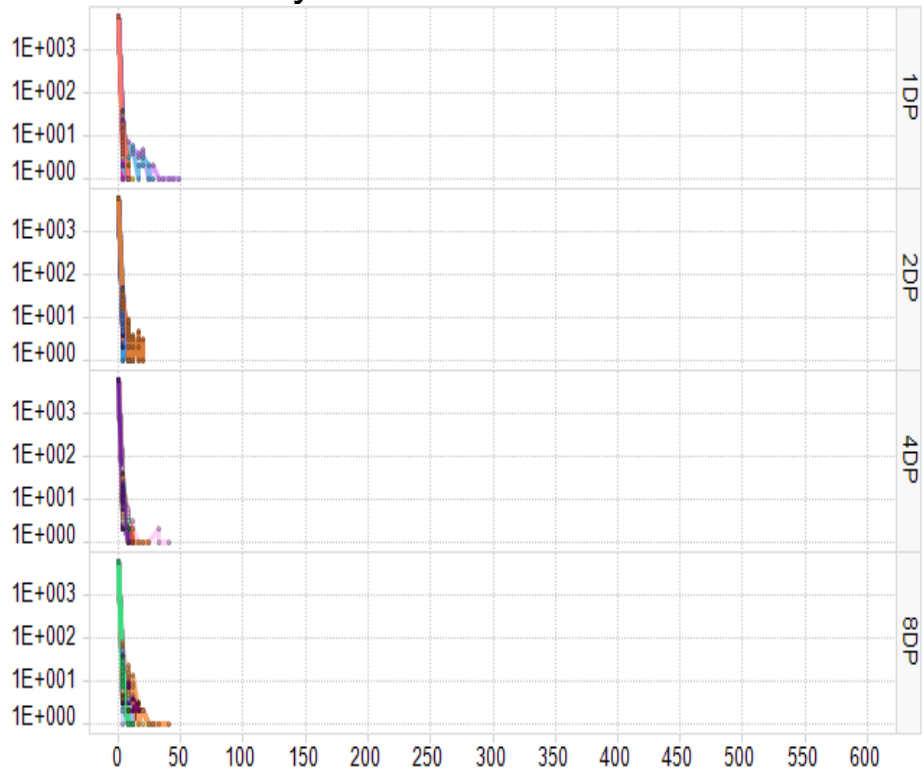
☑ No. of Chunk vs. Correctness (By. Die)

Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● Initial



● X-Ray + RD 100K + 3Months

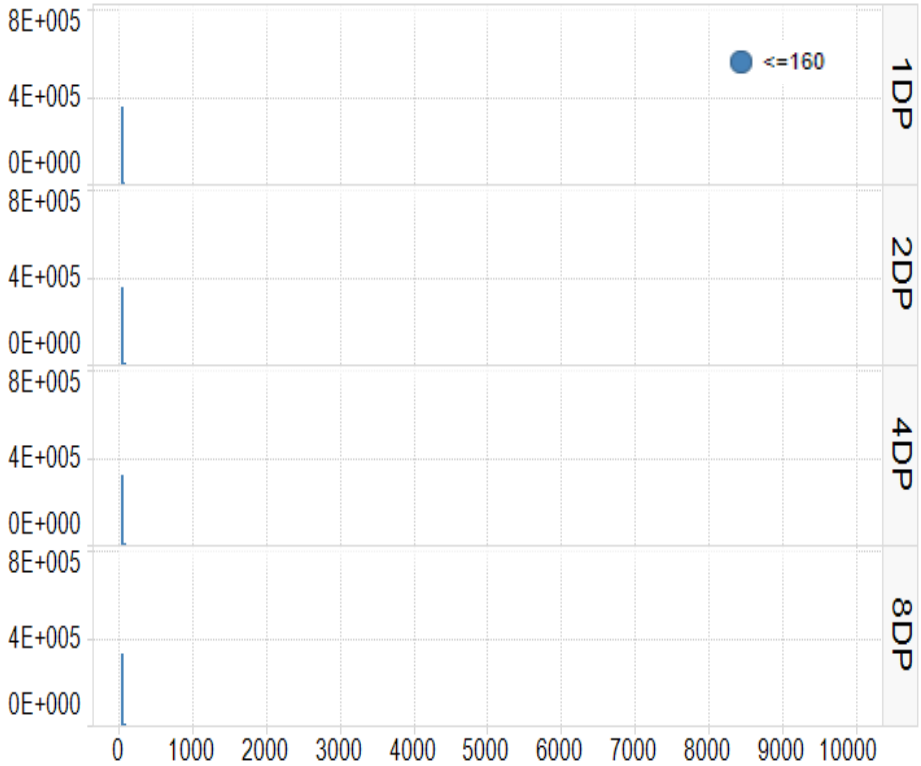


X-Ray Tolerance SLC Type 1

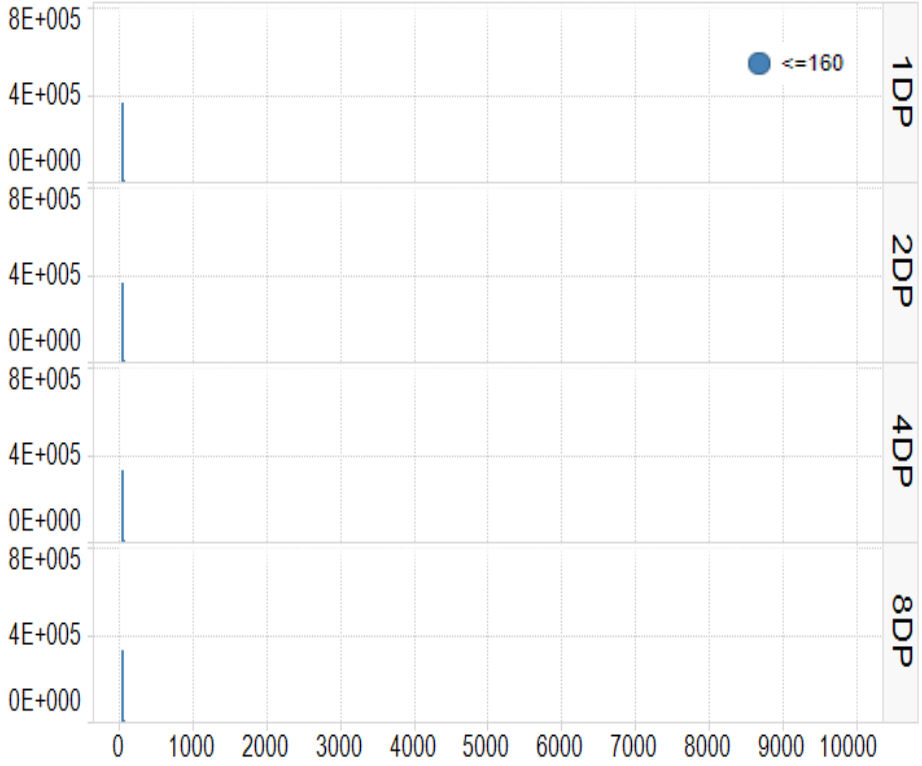
☑ Read Latency Distribution@ Pre EW + RD 100K + 3months@ 45℃ with cross temp 30 ℃

Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(Initial)



● No. of Chunk vs. Read Latency
(X-Ray + RD 100K + 3months)

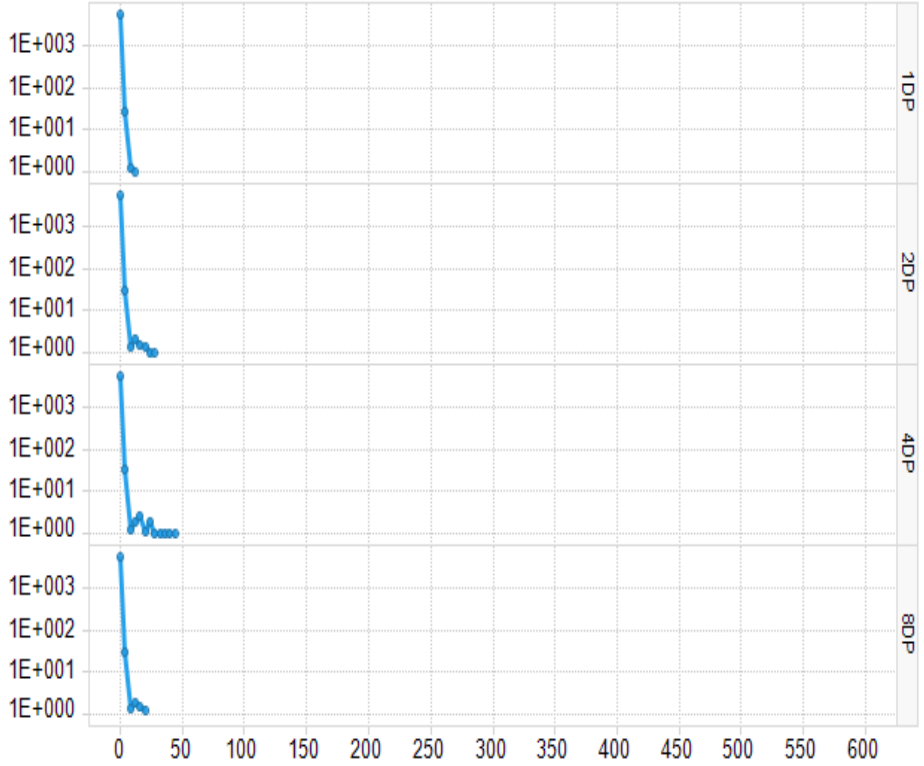


X-Ray Tolerance SLC Type 2

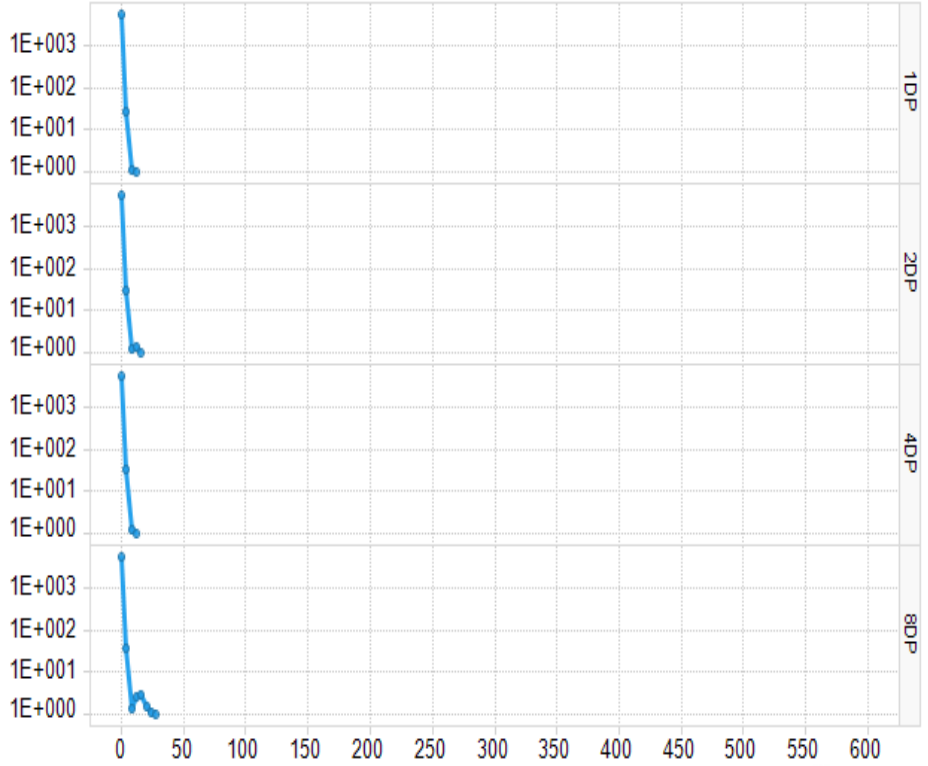
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 3Months

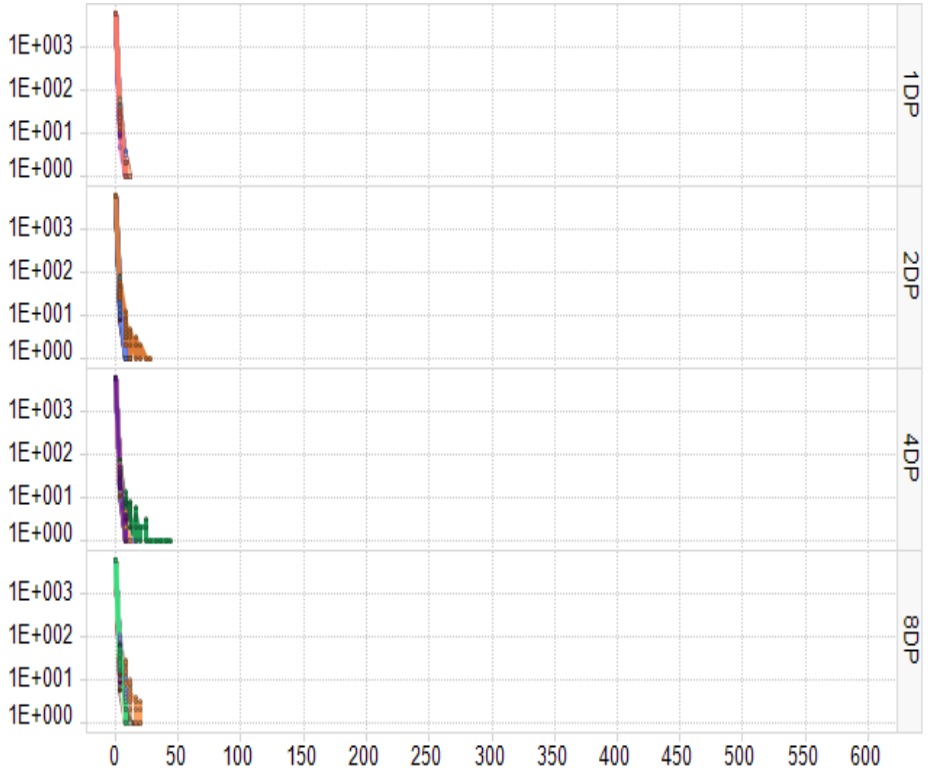


X-Ray Tolerance SLC Type 2

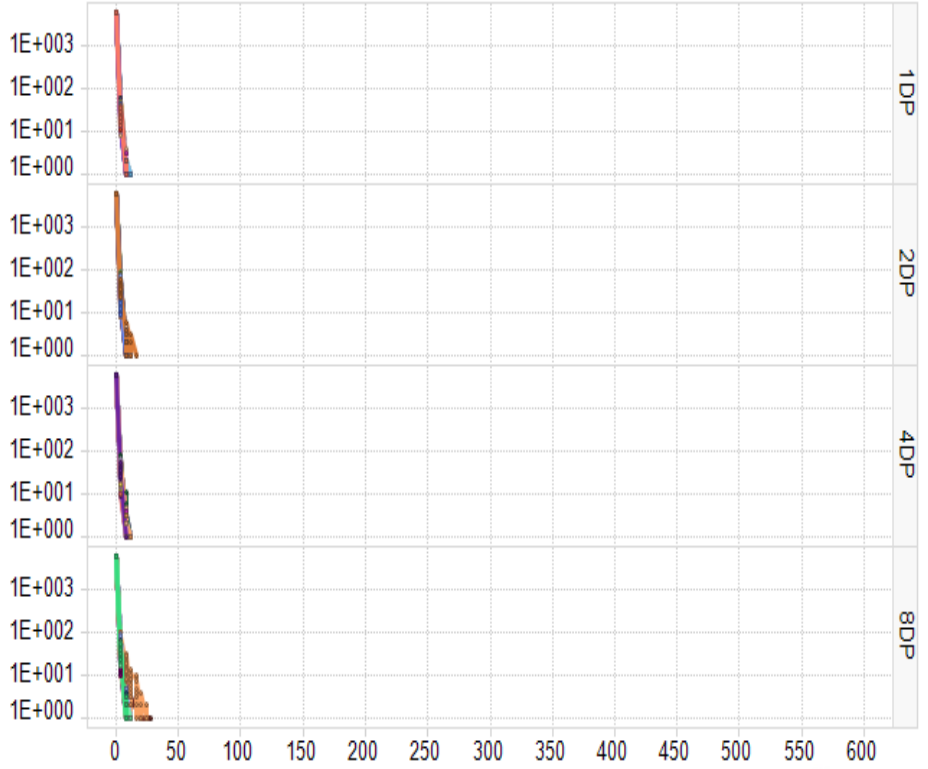
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 3Months

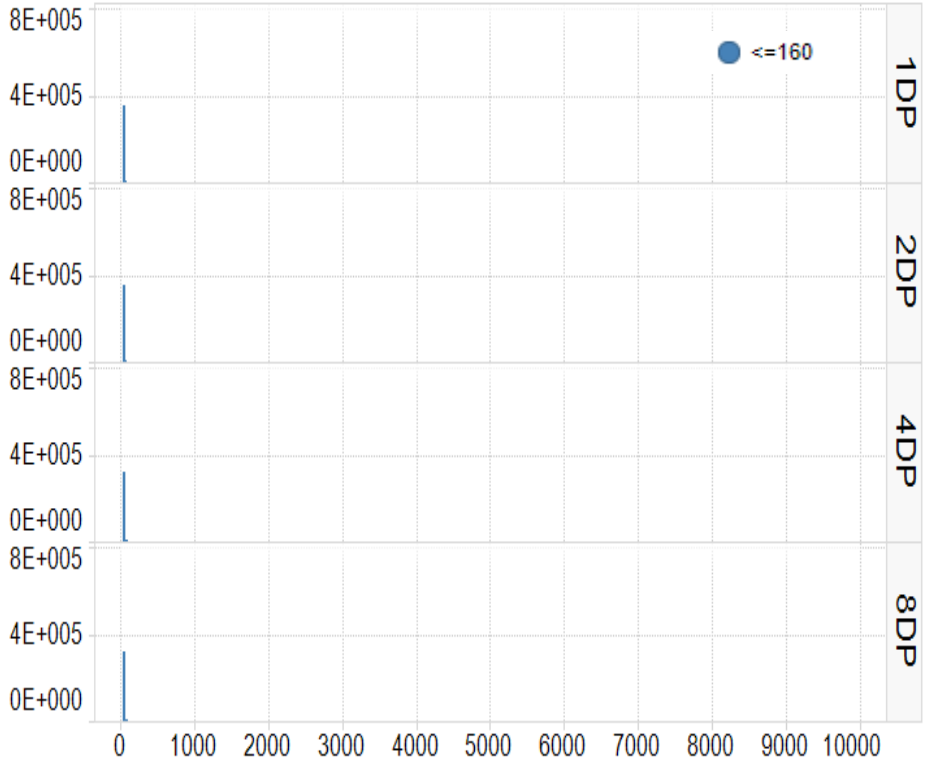


X-Ray Tolerance SLC Type 2

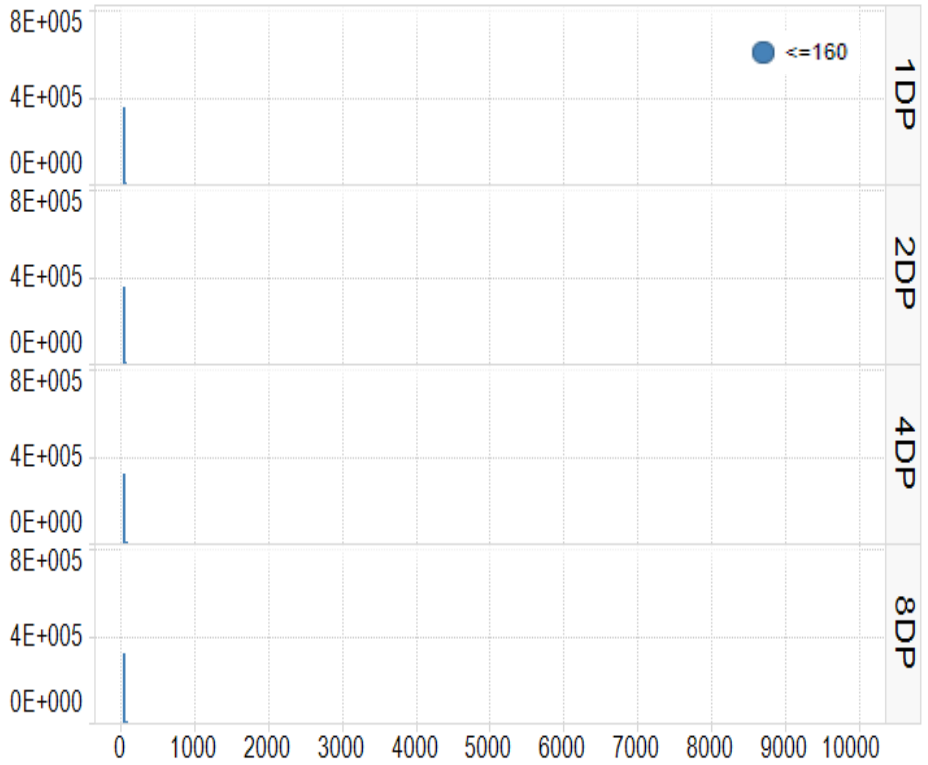
☑ Read Latency Distribution@ Pre EW + RD 100K + 3months@ 45℃ with cross temp 30 ℃

Pre-EW : Random pattern @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
3months@ 45℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(X-Ray + EW)



● No. of Chunk vs. Read Latency
(X-Ray + EW + RD 100K + 3months)

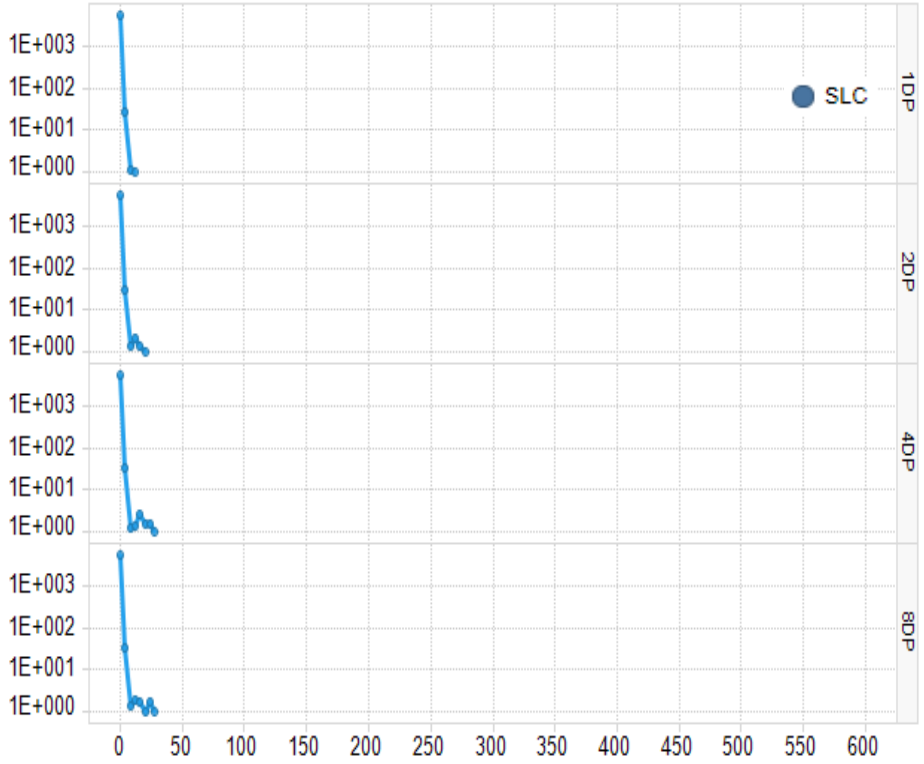


X-Ray Tolerance SLC Type 3 (1M)

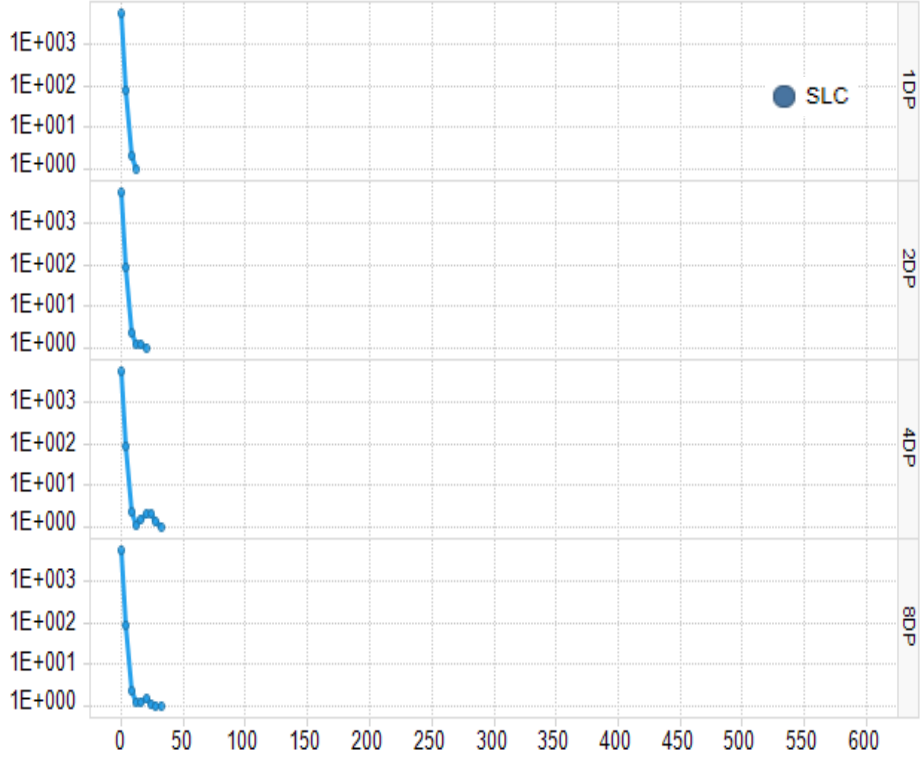
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@ 35℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 1Month

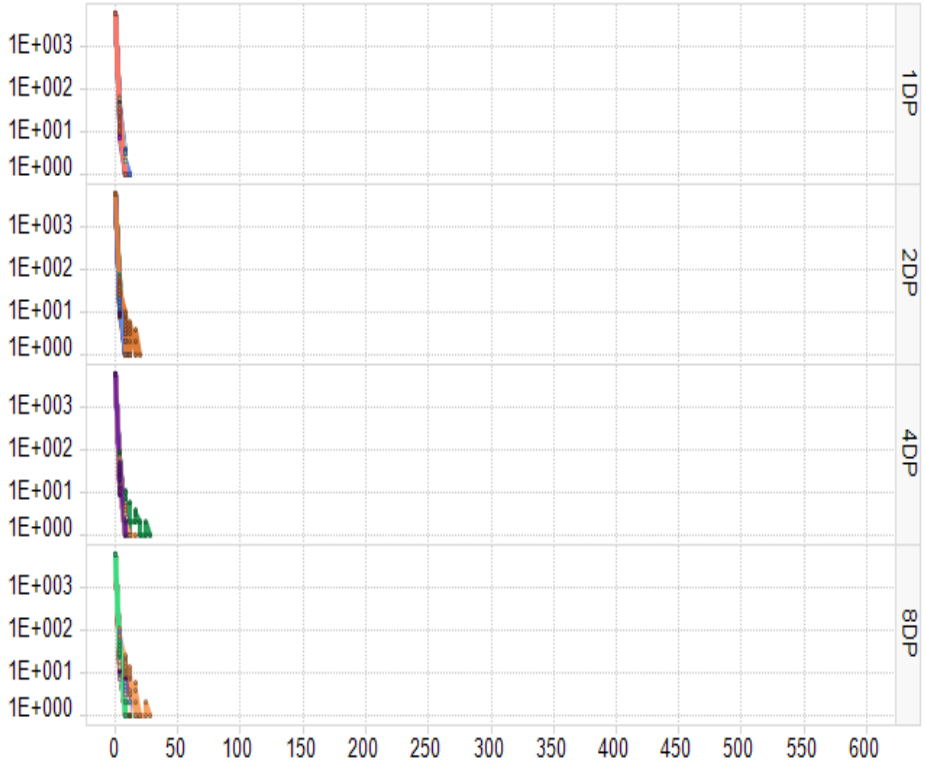


X-Ray Tolerance SLC Type 3 (1M)

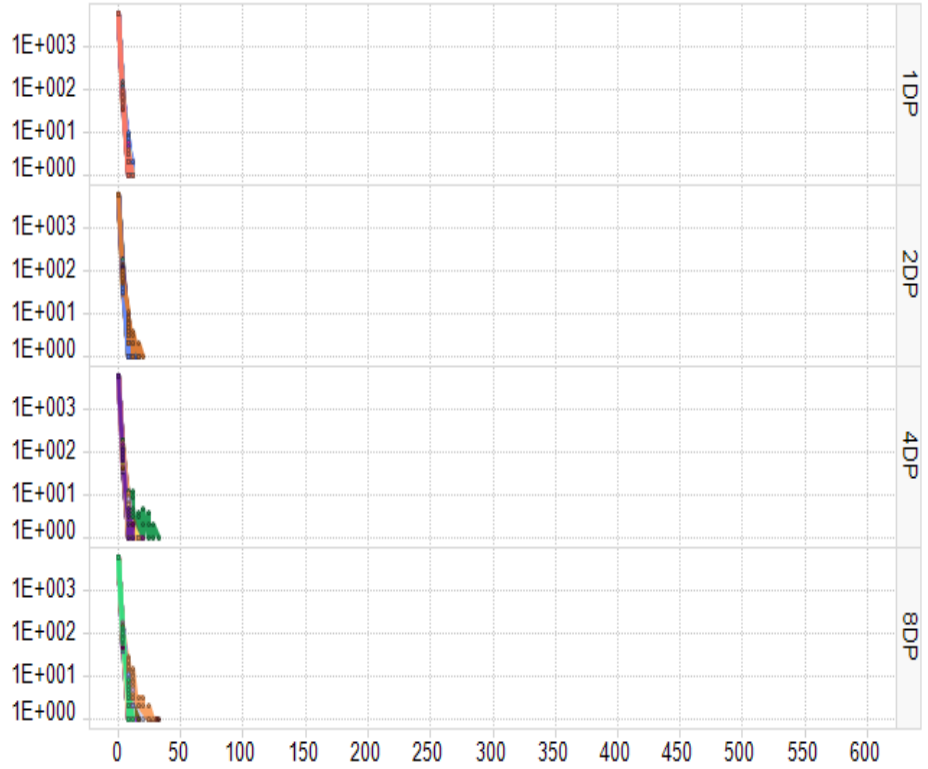
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● X-Ray + EW



●X-Ray + EW + RD 100K + 1Month

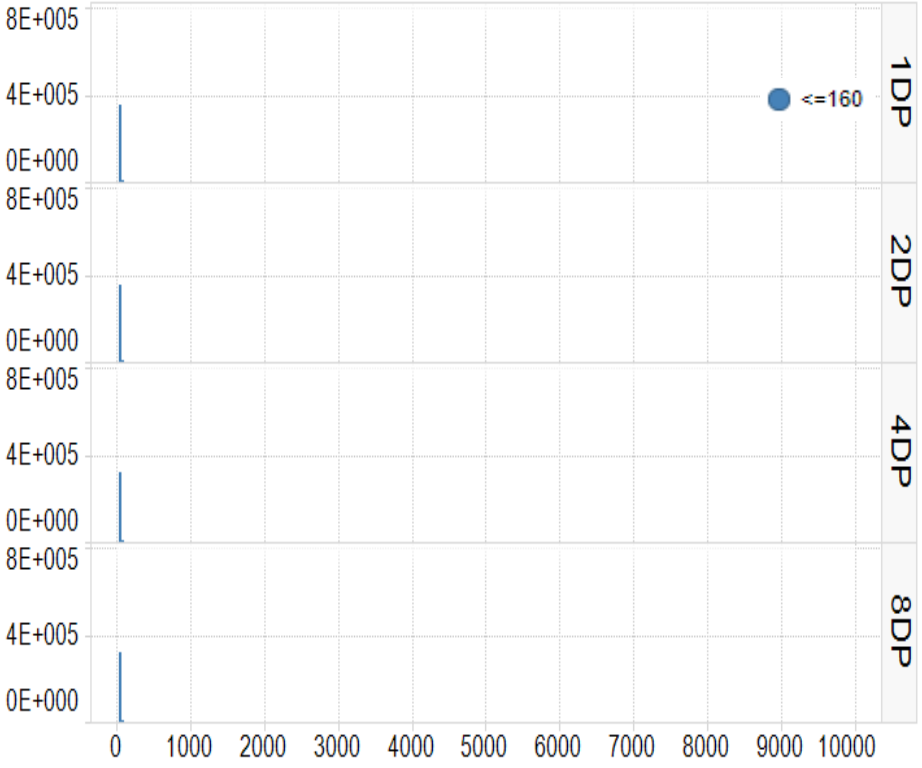


X-Ray Tolerance SLC Type 3 (1M)

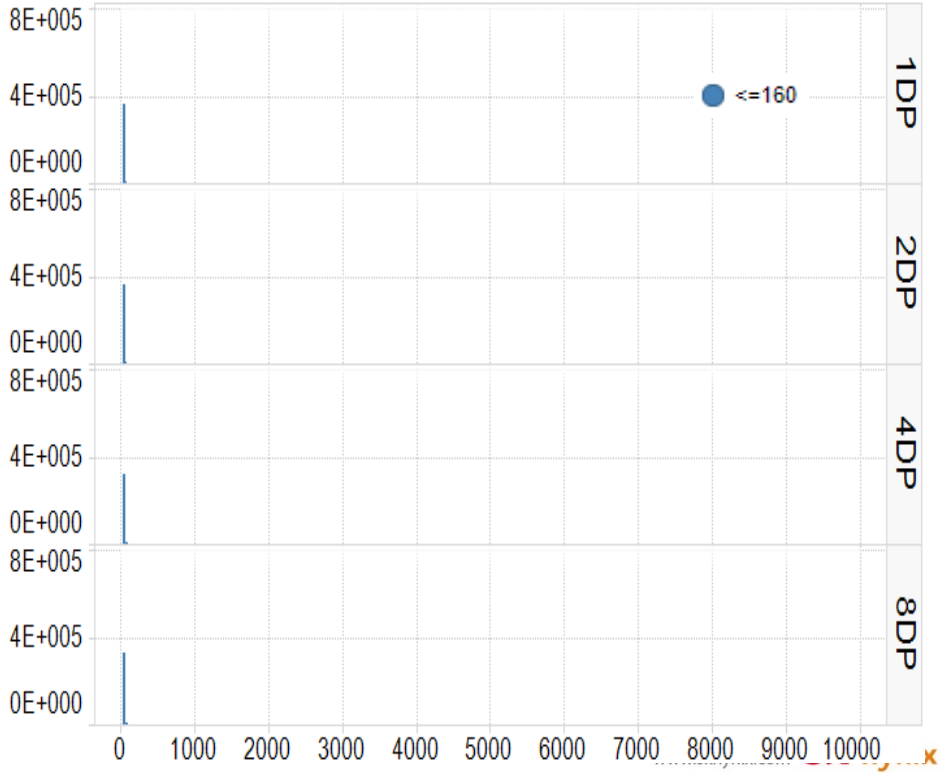
☑ Read Latency Distribution@ EW + RD 100K + 1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(X-Ray + EW)



● No. of Chunk vs. Read Latency
(X-Ray + EW + RD 100K + 1month)

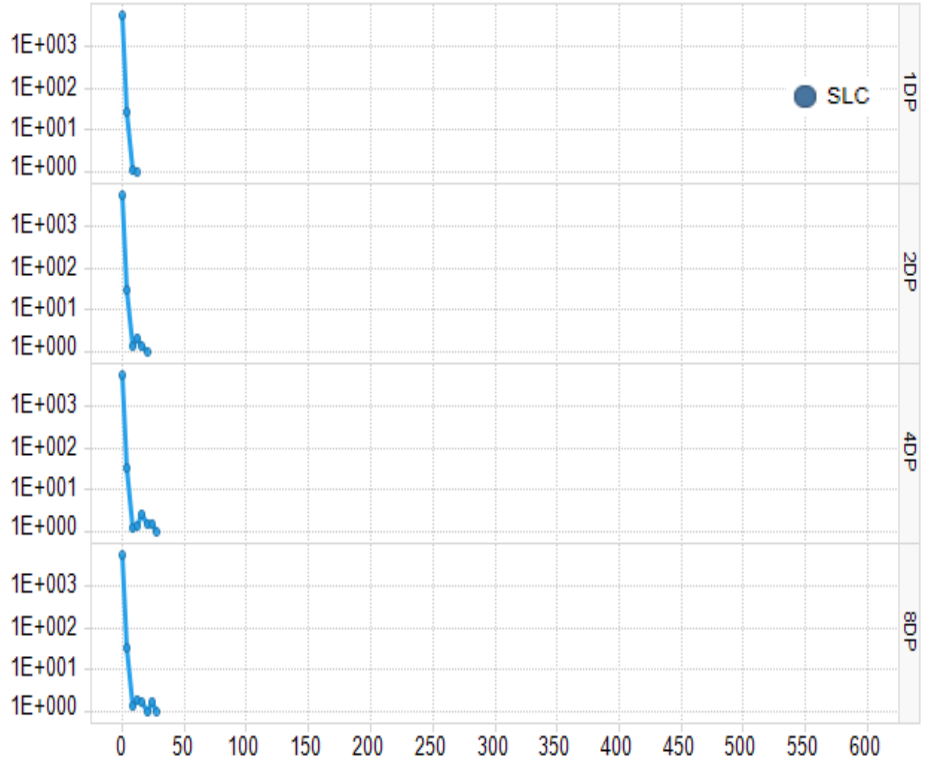


X-Ray Tolerance SLC Type 3 (3M)

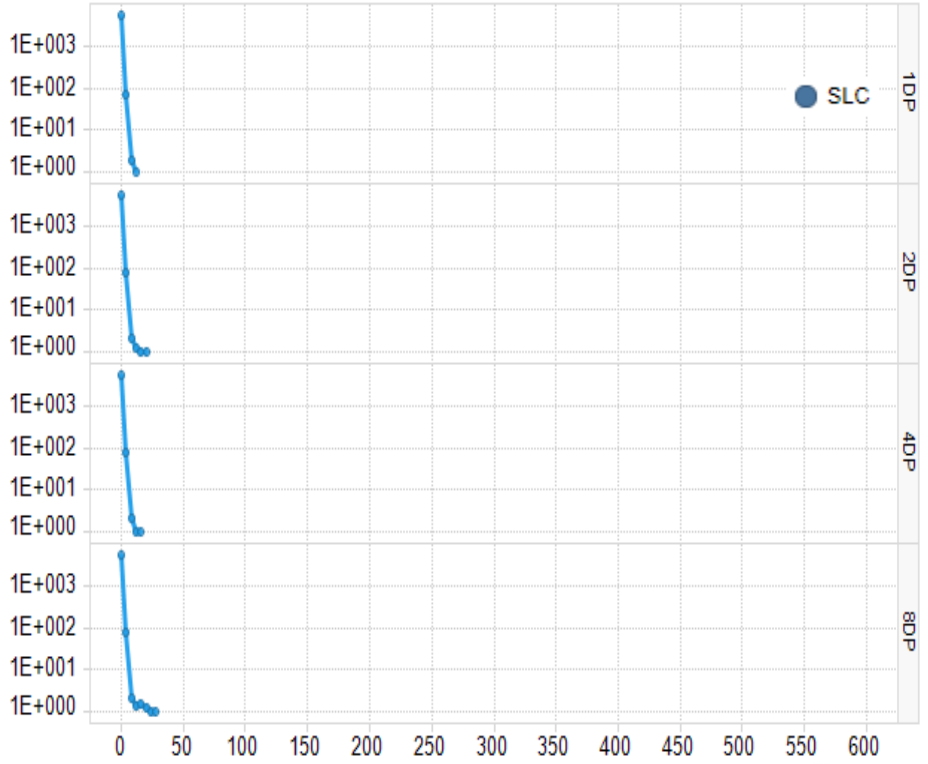
☑ No. of Chunk vs. Correctness

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@ 35℃ with cross temp 30 ℃

● X-Ray + EW



● X-Ray + EW + RD 100K + 3Months

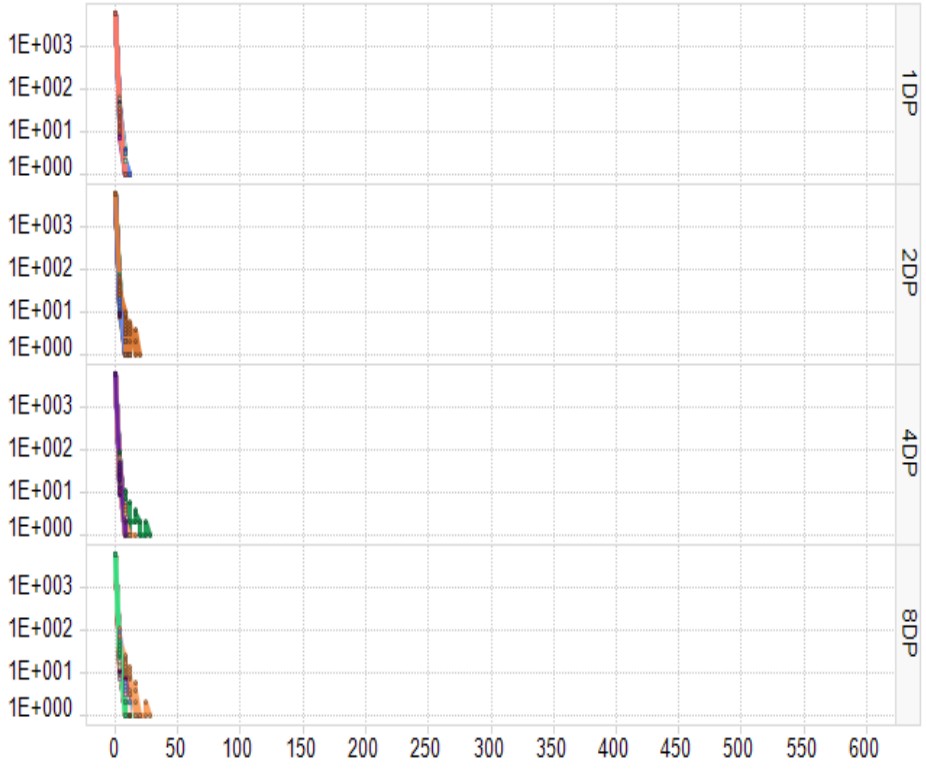


X-Ray Tolerance SLC Type 3 (3M)

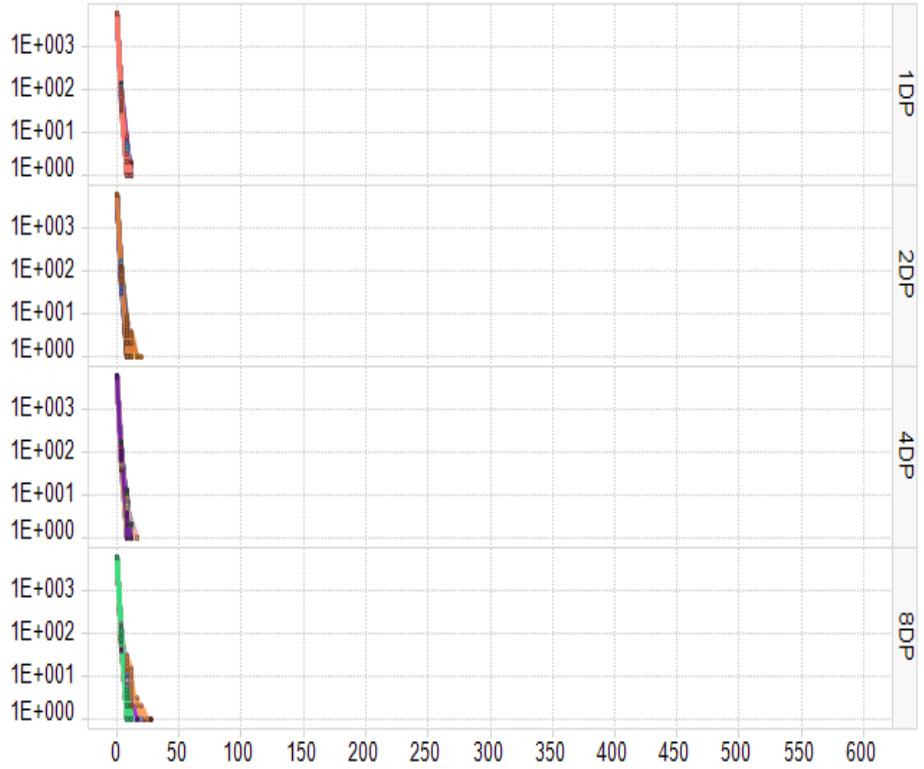
☑ No. of Chunk vs. Correctness (By. Die)

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● X-Ray + EW



●X-Ray + EW + RD 100K + 3Months

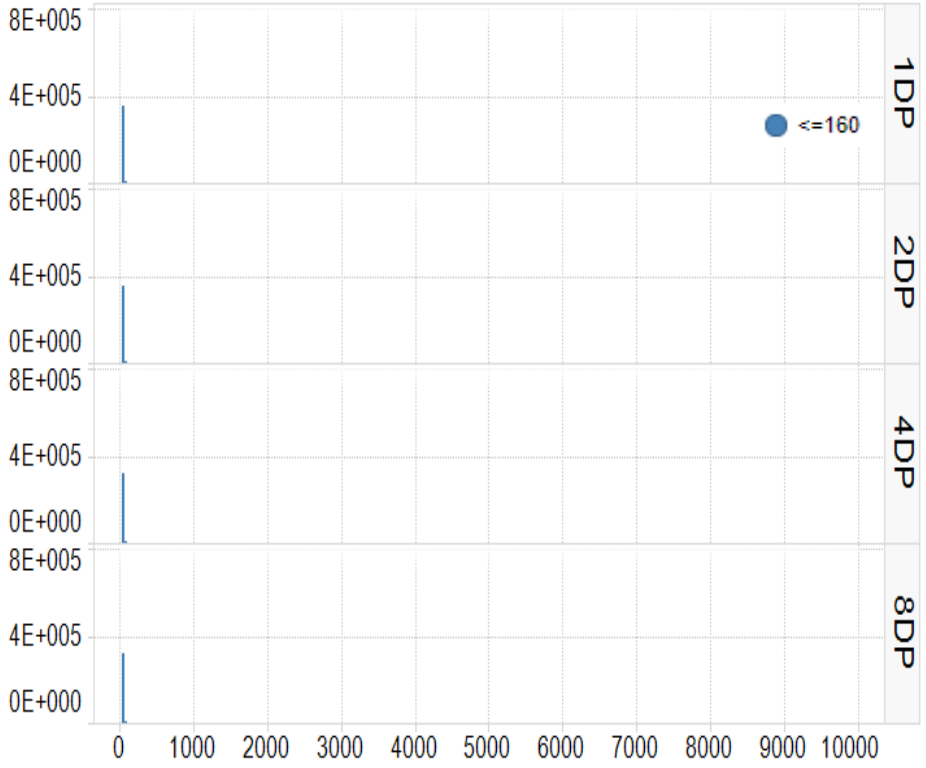


X-Ray Tolerance SLC Type 3 (3M)

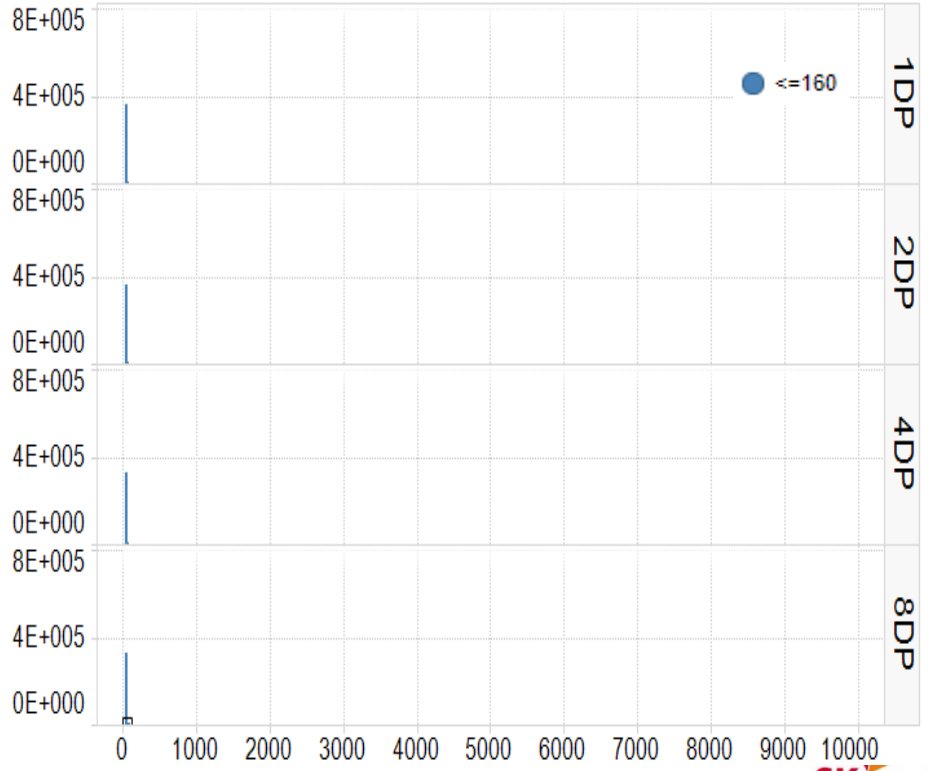
☑ Read Latency Distribution@ EW + RD 100K + 1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

Pre-EW : Random pattern 90% @55 ℃ / 10% @ 85℃
Back Pattern : Random pattern @ 10℃
X-Ray 1Gr
Read disturb 100K @ 25℃
1month@ 35℃ with cross temp 30 ℃ / 3months@35℃ with cross temp 30 ℃

● No. of Chunk vs. Read Latency
(X-Ray + EW)



● No. of Chunk vs. Read Latency
(X-Ray + EW + RD 100K + 3months)



Boot Qual. 1,2

Controller Block Result

- Fail Information
  - Boot Qual 1 : 0F / 60EA for each stack
  - Boot Qual 2 : 0F / 60EA for each stack

Fail Type	Result		Remark
	Boot Qual. 1 (1/2/4/8DP)	Boot Qual. 2 (1/2/4/8DP)	
Timeout expired for PCIe or ASI status register polling	0F	0F	
Over 1 GBB during controller block reliability test	0F	0F	
FW maintenance returns error	0F	0F	
Any unexpected timeout.	0F	0F	

Boot Block reliability – CP1

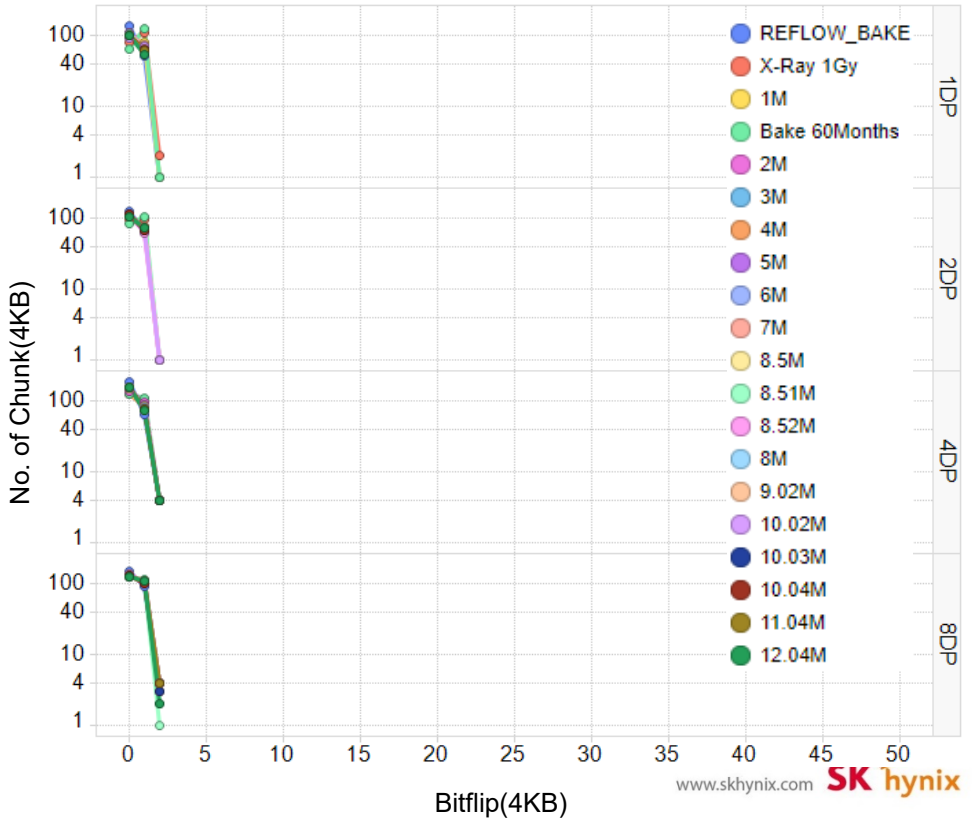
☑ Reliability Check points satisfied with checkpoint CP1.

● Result Summary

Controller Block Reliability(CP1)						
Test Result		PASS				
Bitflip Fail Bit Level		FW10 + Reflow 4Cycle	1Gray	1M Read Disturb	5Yrs Retention	11.04M Read Disturb
1DP	Max	2	2	2	2	1
	Median	0	0	0	0	0
2DP	Max	1	1	1	2	1
	Median	0	0	0	0	0
4DP	Max	2	2	2	2	2
	Median	0	0	0	0	0
8DP	Max	2	2	2	2	2
	Median	0	0	0	0	0

● Bitflip Histogram

Boot Qual CP1(10FW update + 4Reflow +1 Gy+ 1M + 5Yr + 12.04M)



Boot Block reliability – CP2

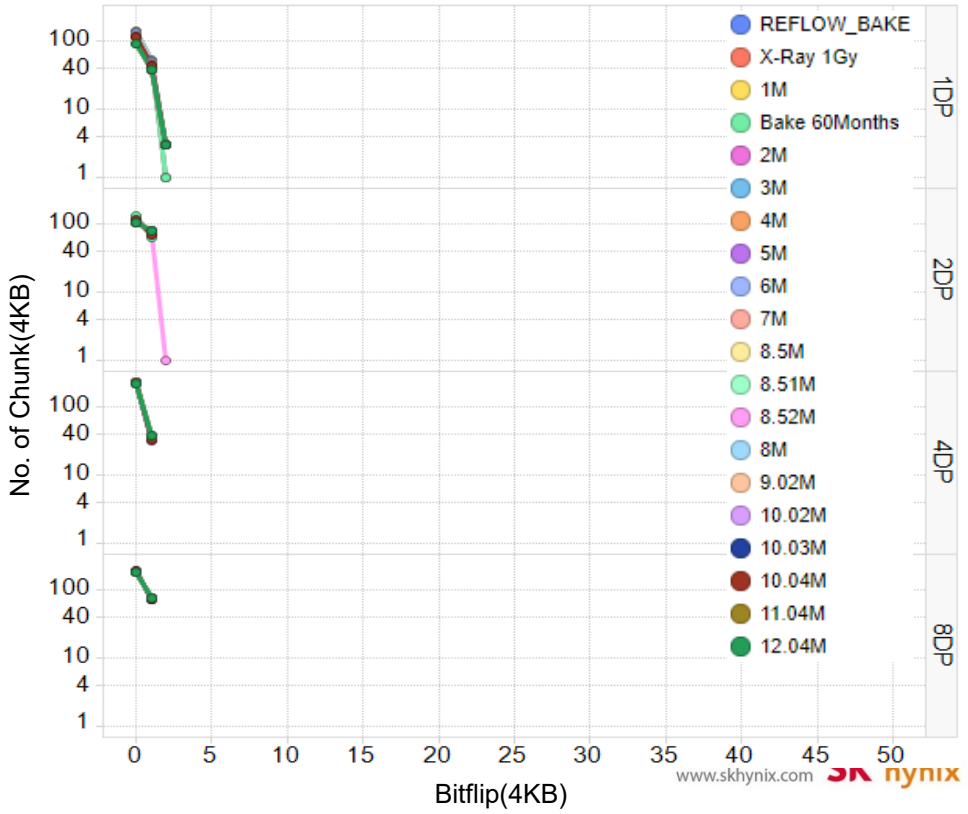
☑ Reliability Check points satisfied with checkpoint CP2.

● Result Summary

Controller Block Reliability(CP2)						
Test Result		PASS				
Bitflip Fail Bit Level		FW10 + Reflow 4Cycle (CP2 + FW100)	1Gray	1M Read Disturb	5Yrs Retention	11.04M Read Disturb
1DP	Max	2	2	2	2	2
	Median	0	0	0	0	0
2DP	Max	1	1	1	1	1
	Median	0	0	0	0	0
4DP	Max	1	1	1	1	1
	Median	0	0	0	0	0
8DP	Max	1	1	1	1	1
	Median	0	0	0	0	0

● Bitflip Histogram

Boot QualCP2
(10FW update+4Reflow+100FW Update+1 Gy+1M+5Yr+12.04M)



Thank You