



3GPP TSG-RAN WG4 Meeting NR ad-hoc #4
January 22nd – 26st, 2018
San Diego, CA, USA

Agenda Item: 4.3.2.1.5

R4-1800864

Preliminary results on mmW NR Coverage and Capacity: sensitivity to UE EIRP

Document in response to R4-1713849

Overview

Problem statement and goals

- R4-1713849 discussed the impact of UE EIRP to NR network performance considering throughput and coverage
 - Observations indicate a relative impact of UE EIRP in the scenario analyzed
- In the following we carry out a detailed analysis of throughput and coverage in the following scenarios:
 - Indoor deployment
 - Outdoor deployments
- Our conclusions based on the outcome of the analysis indicate a very large impact of max UE EIRP on mmW NR network performance

Indoor deployment



Simulation assumptions

TR 38.803 and more

- Indoor deployment as defined in TR 38.803
- Compared to TR 38.803, the following additional assumptions are considered
 - UE operating with 2 PC parameters to target 15dB and 22dB SNR
 - Simulation w/ and w/o blockage losses ($L_{BH} = N(\mu, \sigma) [dB]$)
$$\mu = 15.26 \text{ dB}; \sigma = 3.8 \text{ dB}$$
- Sensitivity to EIRP is analyzed considering the following three configurations (antenna configuration as in TR 38.803):
 - 34dBm
 - 26dBm
 - 18dBm

Summary of simulation results

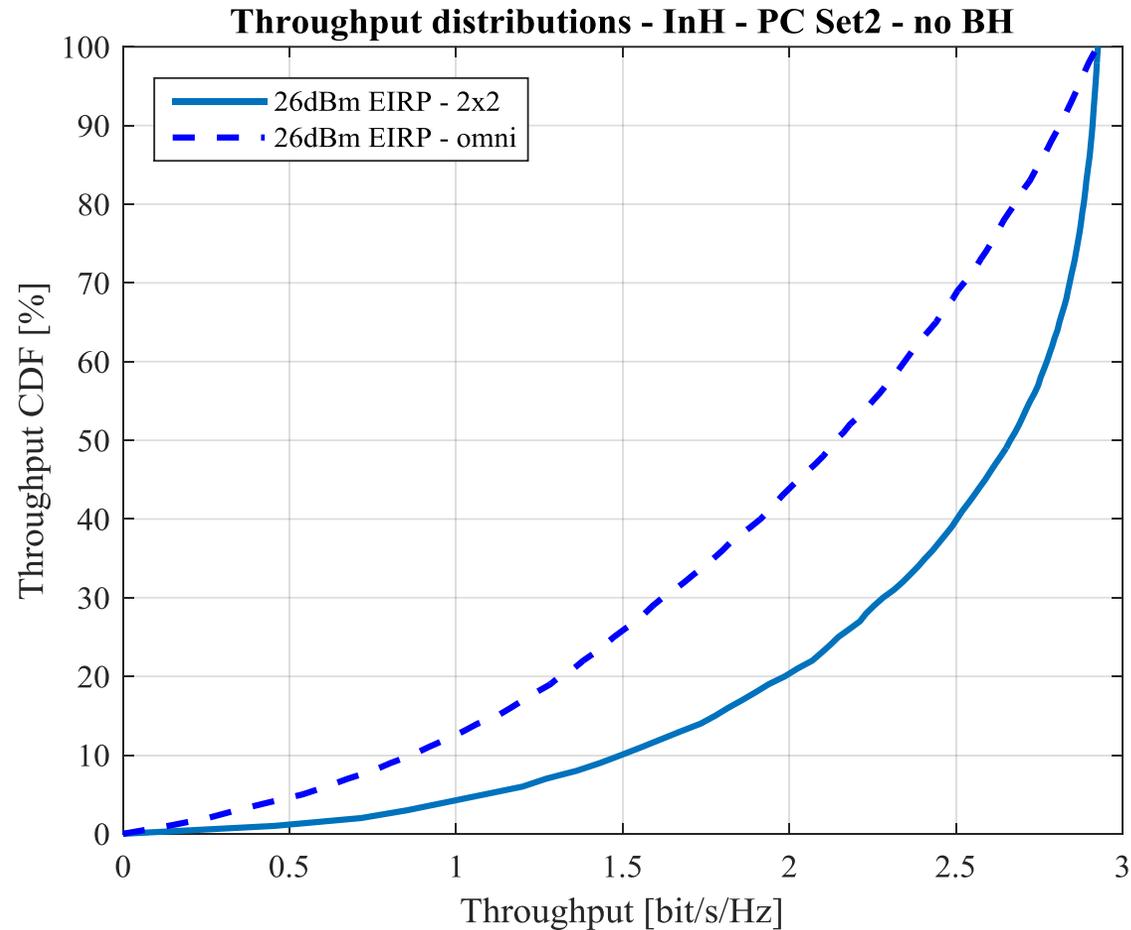
5%-tile and 50%-tile throughput loss

50%-tile throughput loss compared to 34dBm EIRP				
Max EIRP [dBm]	PC Set1 - No Body/Hand Losses	PC Set1- Body/Hand Losses	PC Set2 - No Body/Hand Losses	PC Set2 - Body/Hand Losses
26	0%	1%	0%	6%
18	0%	9%	1%	29%

5%-tile throughput loss compared to 34dBm EIRP				
Max EIRP [dBm]	PC Set1 - No Body/Hand Losses	PC Set1- Body/Hand Losses	PC Set2 - No Body/Hand Losses	PC Set2 - Body/Hand Losses
26	0%	12%	0%	20%
18	0%	59%	0%	64%

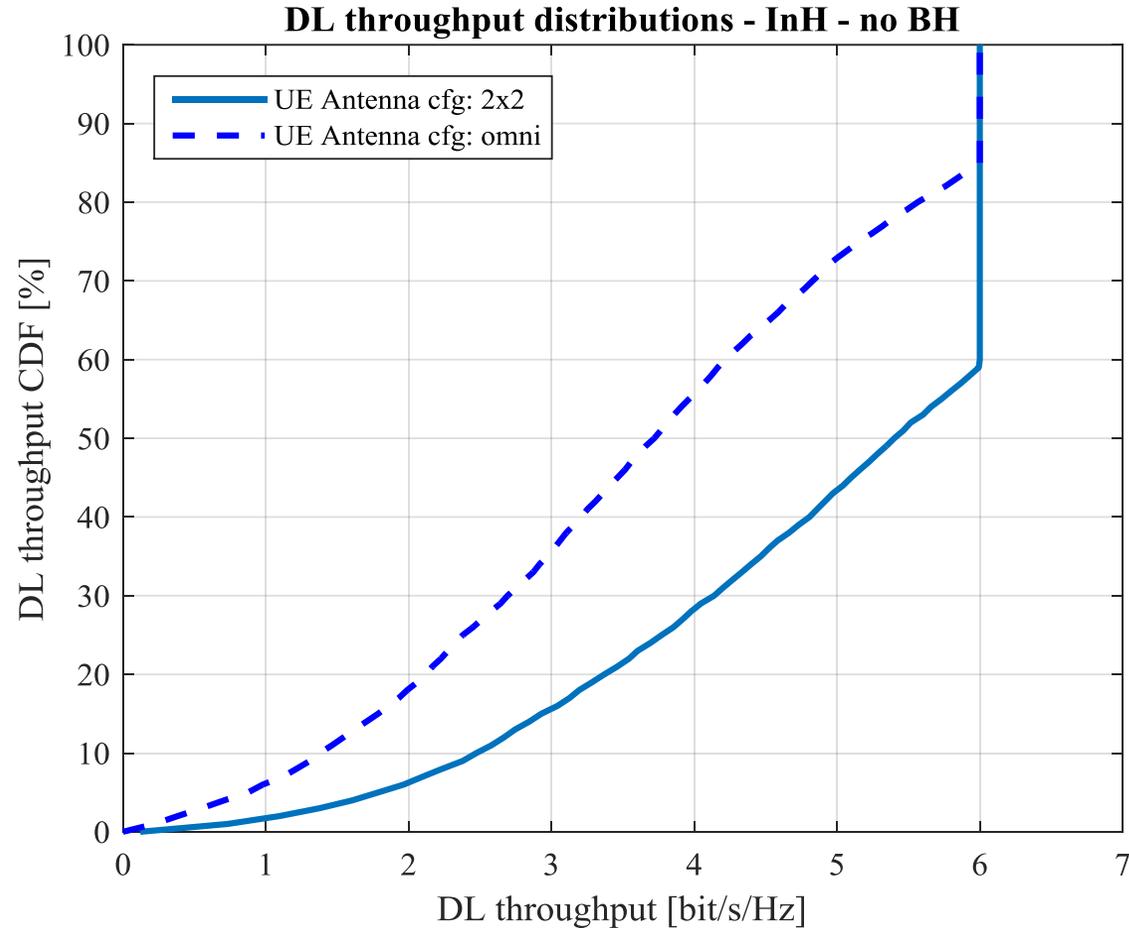
Impact of UE directivity – UL throughput

InH 26dBm – PC Set 2 – no Hand/Body losses – 2x2 vs omni



Impact of UE directivity – DL throughput

InH - Hand/Body losses – 2x2 vs omni



Impact of UE directivity - summary

Lower directivity implies higher co-channel and adjacent channel interference

- The impact of lower UE directivity was observed in previous slide is consistent with our observations made in R4-1703876, ~~i.e.~~
- Lower directivity implies higher co-channel and adjacent channel interference
 - 20% median throughput degradation is observed going from 2x2 to omni
- Lower UE directivity has also impact on DL performance due to the lower amount of rejection of other cells interference
 - 31% median throughput degradation is observed going from 2x2 to omni
- Both peak EIRP and directivity have impact on Indoor NR performance

Key takeaways

Achievable peak throughput is impacted by low EIRP

- Indoor scenario is generally interference limited
- In a realistic scenario in which blockage due to human body is present impact of interference becomes negligible (noise limited)
 - In this case, throughput loss due to low UE EIRP can be severe
 - 50%-tile degradation: with the blockage model analyzed 18dBm UE has up to 29% degradation compared to 34dBm UE
 - 5%-tile degradation: with the blockage model analyzed 18dBm has up to 64% degradation compared to 34dBm UE
- Even in Indoor deployment UE max EIRP and directivity have direct impact on network performance

Outdoor deployment



Simulation assumptions

Variable inter-site distance (ISD)

- BS antenna model corresponding to UMi/UMa environment (TR 38.803)
- Hexagonal layout is adopted with all UEs outdoor
- The following additional assumptions are considered
 - UE operating with 2 PC parameters to target 15dB and 22dB SNR
 - Simulation w/ and w/o blockage losses (same as in slide 4)
 - ISD = 100, 200, 300, 400, 500m
- Sensitivity to EIRP is analyzed considering the following three configurations (antenna configuration as in TR 38.803):
 - 34dBm, 26dBm, 18dBm

Summary of simulation results

PC Set1 – No Hand/Body losses - 5%-tile, 50%-tile throughput loss and outage

50%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	0%	0%	1%	14%	41%
18	0%	0%	22%	59%	80%

5%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	0%	24%	64%	77%	100%
18	1%	67%	92%	100%	100%

Outage					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
34	0%	0%	1%	1%	1%
26	0%	0%	1%	3%	8%
18	0%	1%	4%	14%	26%

Summary of simulation results

PC Set2 – No Hand/Body losses - 5%-tile, 50%-tile throughput loss and outage

50%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	0%	1%	13%	34%	46%
18	1%	16%	45%	68%	81%

5%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	0%	34%	65%	76%	100%
18	8%	71%	92%	100%	100%

Outage					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
34	0%	0%	1%	1%	1%
26	0%	1%	1%	3%	8%
18	0%	1%	4%	14%	26%

Summary of simulation results

PC Set1 – Hand/Body losses - 5%-tile, 50%-tile throughput loss and outage

50%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	0%	22%	54%	70%	78%
18	20%	66%	87%	100%	100%

5%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	32%	75%	100%	0%	0%
18	74%	100%	100%	0%	0%

Outage					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
34	0%	1%	4%	13%	25%
26	1%	3%	14%	30%	44%
18	1%	10%	31%	51%	64%

Summary of simulation results

PC Set2 – Hand/Body losses - 5%-tile, 50%-tile throughput loss and outage

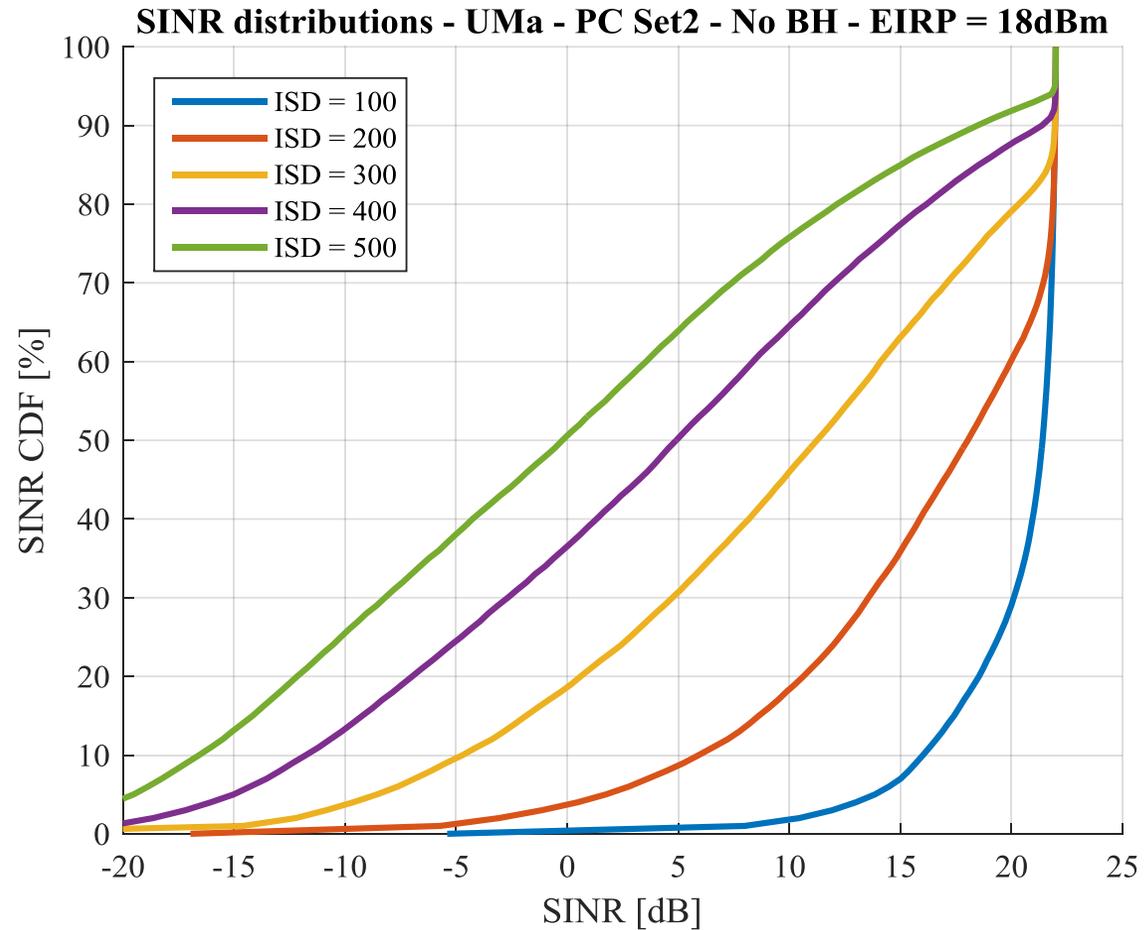
50%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	11%	38%	54%	70%	78%
18	44%	73%	87%	100%	100%

5%-tile throughput loss compared to 34dBm EIRP					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
26	40%	73%	100%	0%	0%
18	77%	100%	100%	0%	0%

Outage					
Max EIRP [dBm]	ISD = 100m	ISD = 200m	ISD = 300m	ISD = 400m	ISD = 500m
34	1%	1%	5%	13%	25%
26	1%	3%	14%	30%	44%
18	1%	10%	31%	51%	64%

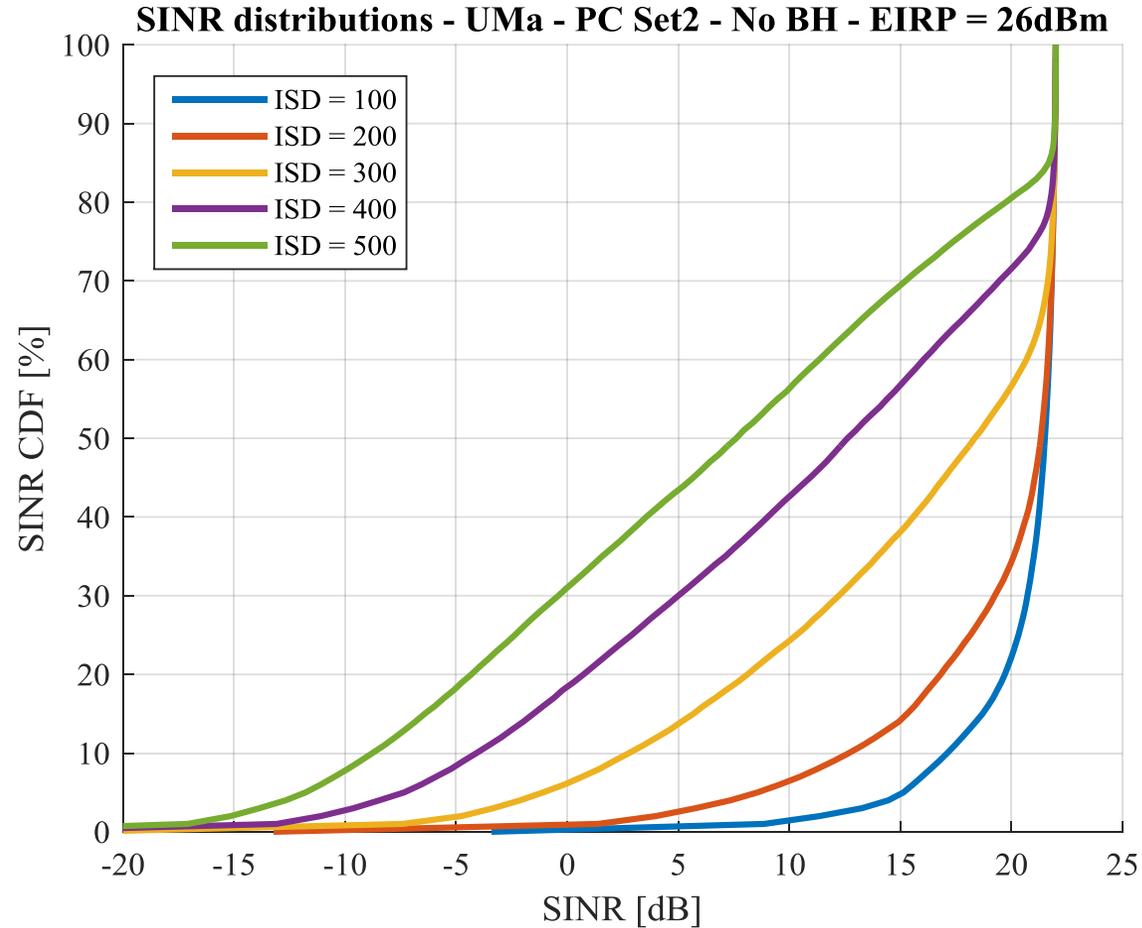
Summary of simulation results

UE EIRP vs ISD trade-off: PC Set2 – no Hand/Body losses – 18dBm EIRP



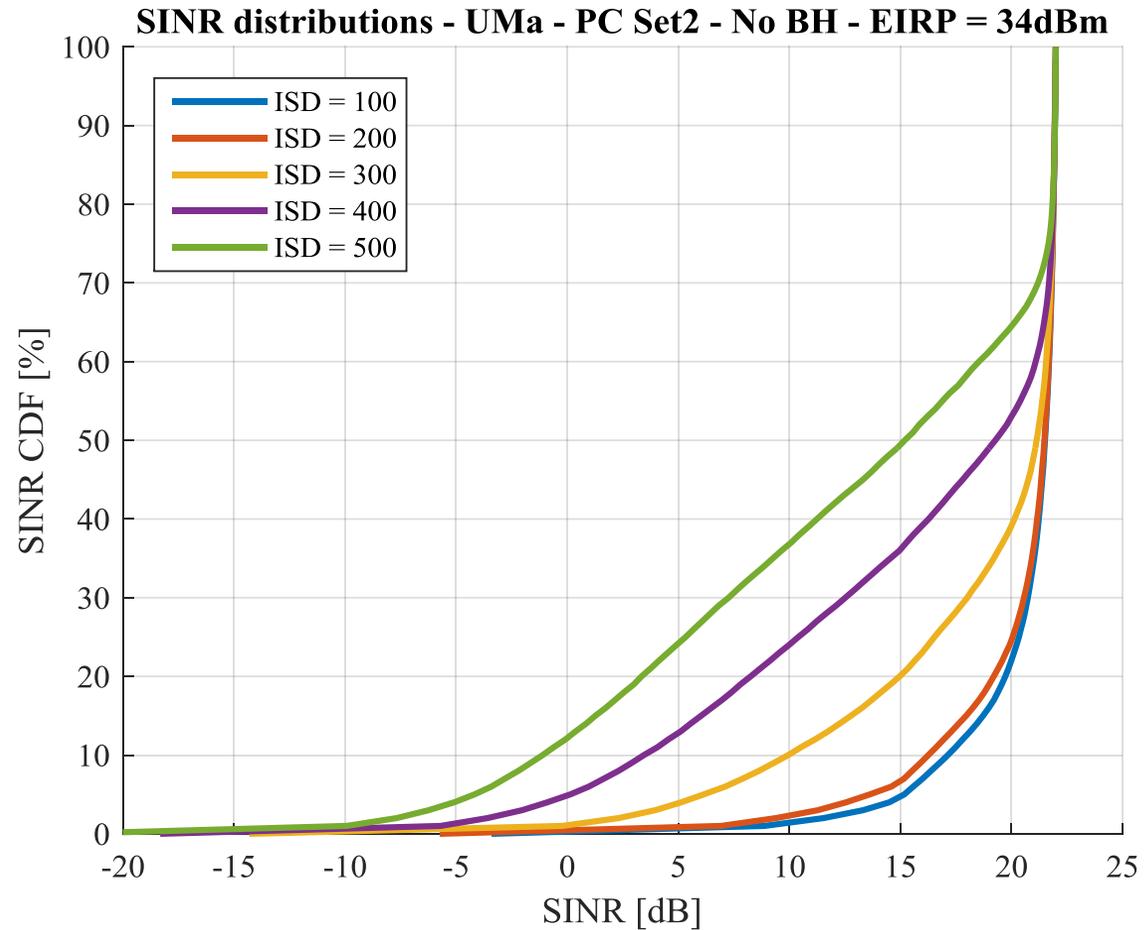
Summary of simulation results

UE EIRP vs ISD trade-off: PC Set2 – no Hand/Body losses – 26dBm EIRP



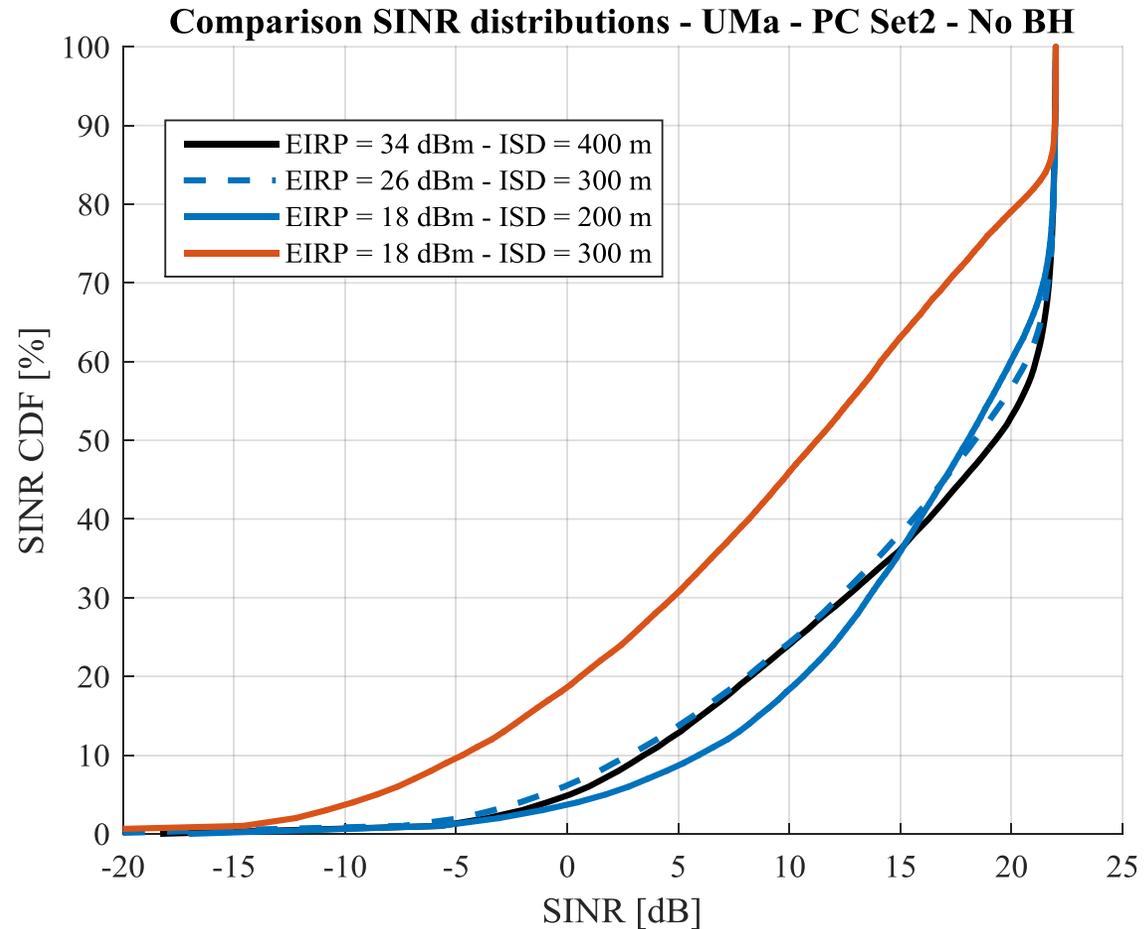
Summary of simulation results

UE EIRP vs ISD trade-off: PC Set2 – no Hand/Body losses – 34dBm EIRP



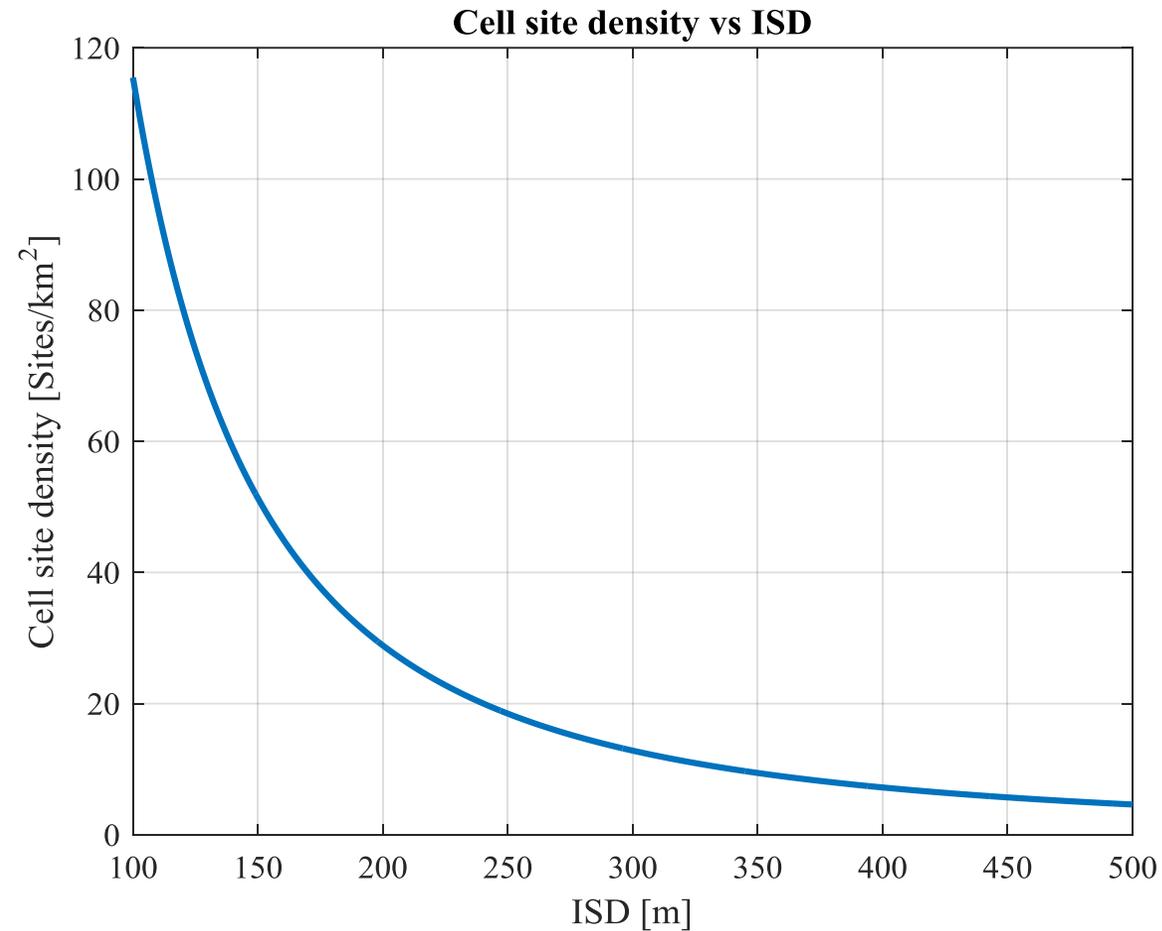
Summary of simulation results

To compensate 8dB UE EIRP decrease ISD needs to be decreased by 100m



Impact of ISD on number of sites

To compensate lower EIRP higher cell site density is needed



Key takeaways

Capacity and coverage are largely impacted by low EIRP

- Outdoor deployment is noise limited (even if no hand/body losses or other blockages are considered), this implies a large impact of peak EIRP
- Very large median and 5%-tile throughput degradation is observed with 26dBm and 18dBm UEs compared to 34dBm max EIRP UE
- Very large outage increases is observed with 26dBm and 18dBm UEs compared to 34dBm max EIRP UE
- To compensate for the lower EIRP, ISD can be decreased
 - We observed ~100m ISD decrease needed to compensate 8dB EIRP drop
 - In the ISD region of interest this is equivalent to double the density of cell sites
- Low UE EIRP does not allow mmW outdoor deployment

Final remarks



Observations and conclusions

Impact of EIRP and directivity

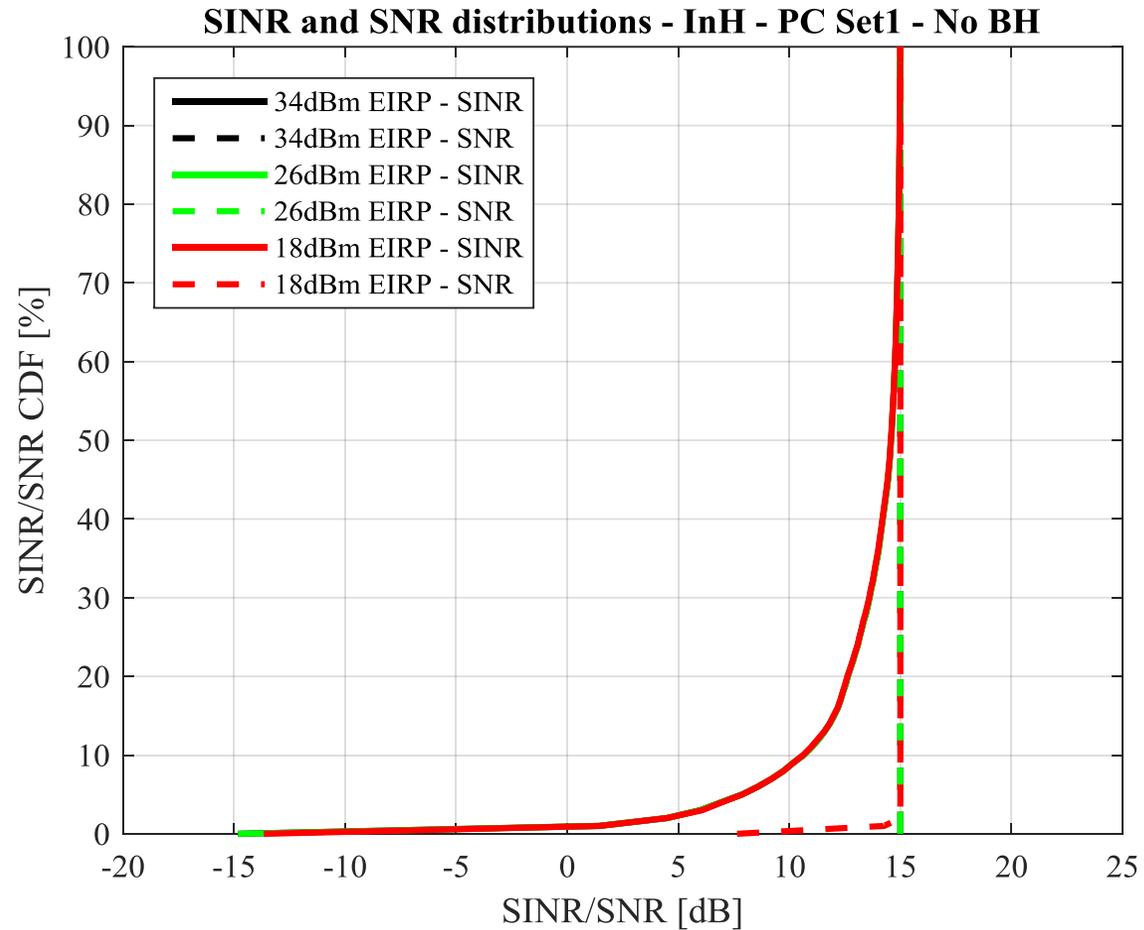
- UE directivity and maximum EIRP largely impact mmW NR performance:
 - In indoor deployment
 - ✓ If scenario is noise limited due to blockage, decreasing max EIRP causes throughput degradation and outage
 - ✓ If scenario is very dense and interference limited, decreasing directivity (i.e. number of antennas) causes throughput degradation due to larger inter-cell interference
 - In outdoor deployment
 - ✓ Since this scenario is noise limited, lower EIRP has very large impact on outage and throughput: to keep similar performance with 8dB lower EIRP it is necessary to double cell site density
- The conclusion of the study is that UE peak EIRP and directivity are fundamental to guarantee good NR system level performance

Appendix 1: indoor plots



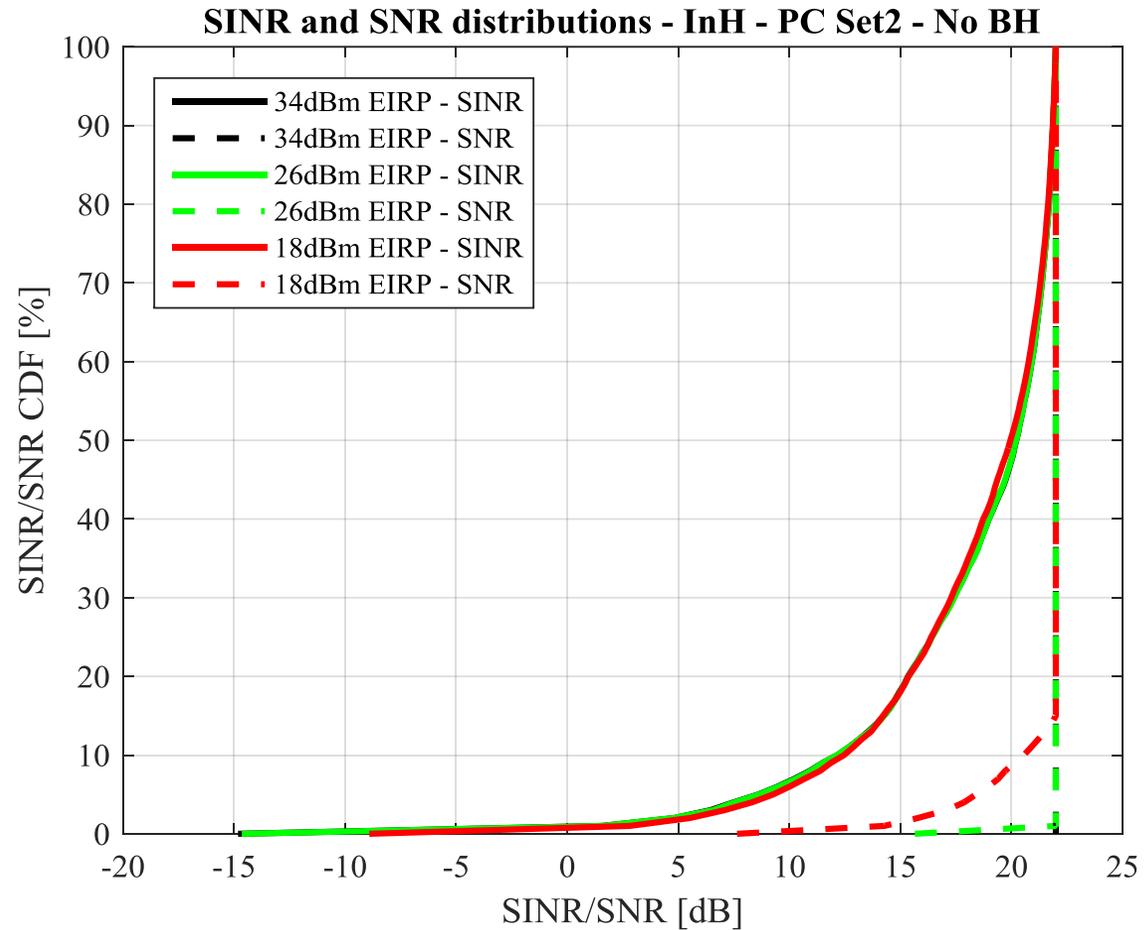
SINR/SNR distributions

PC Set 1 - no hand and body losses



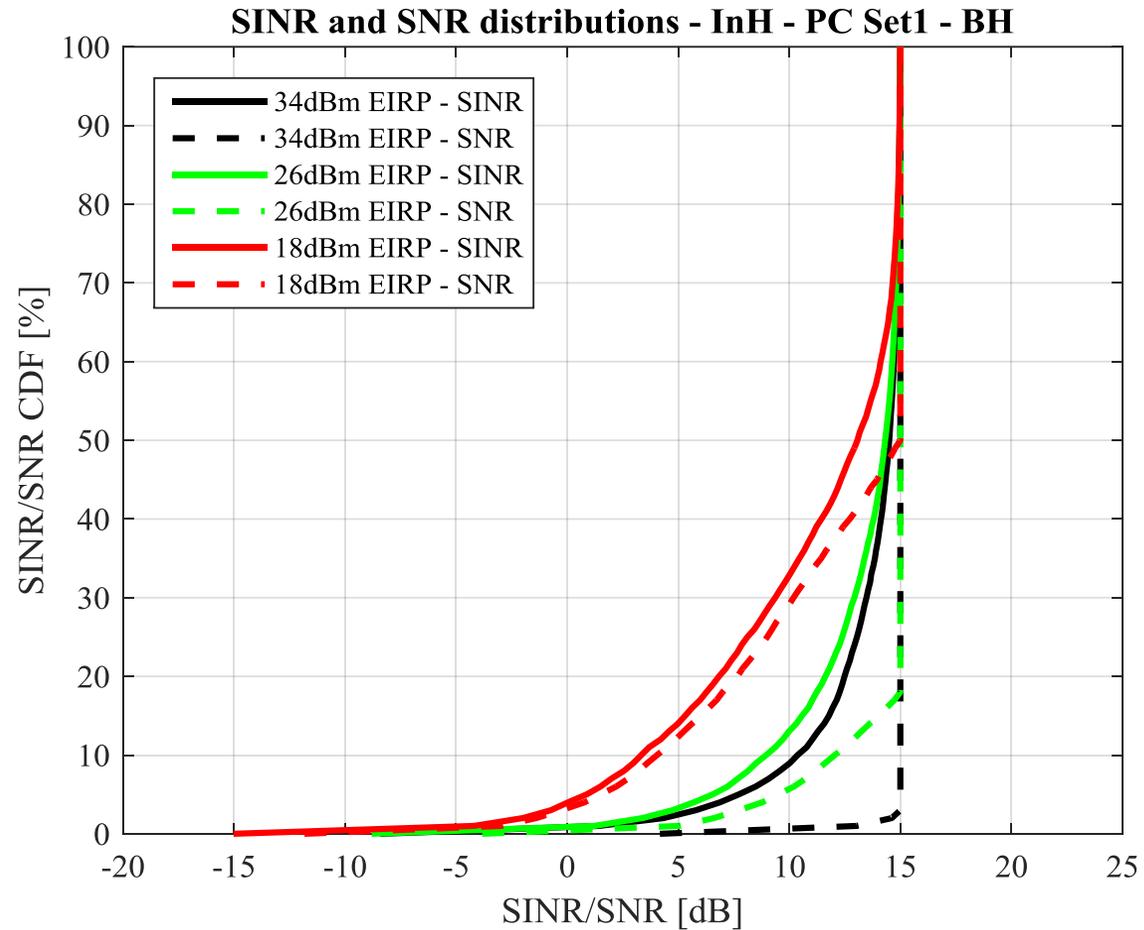
SINR/SNR distributions

PC Set2 - no hand and body losses



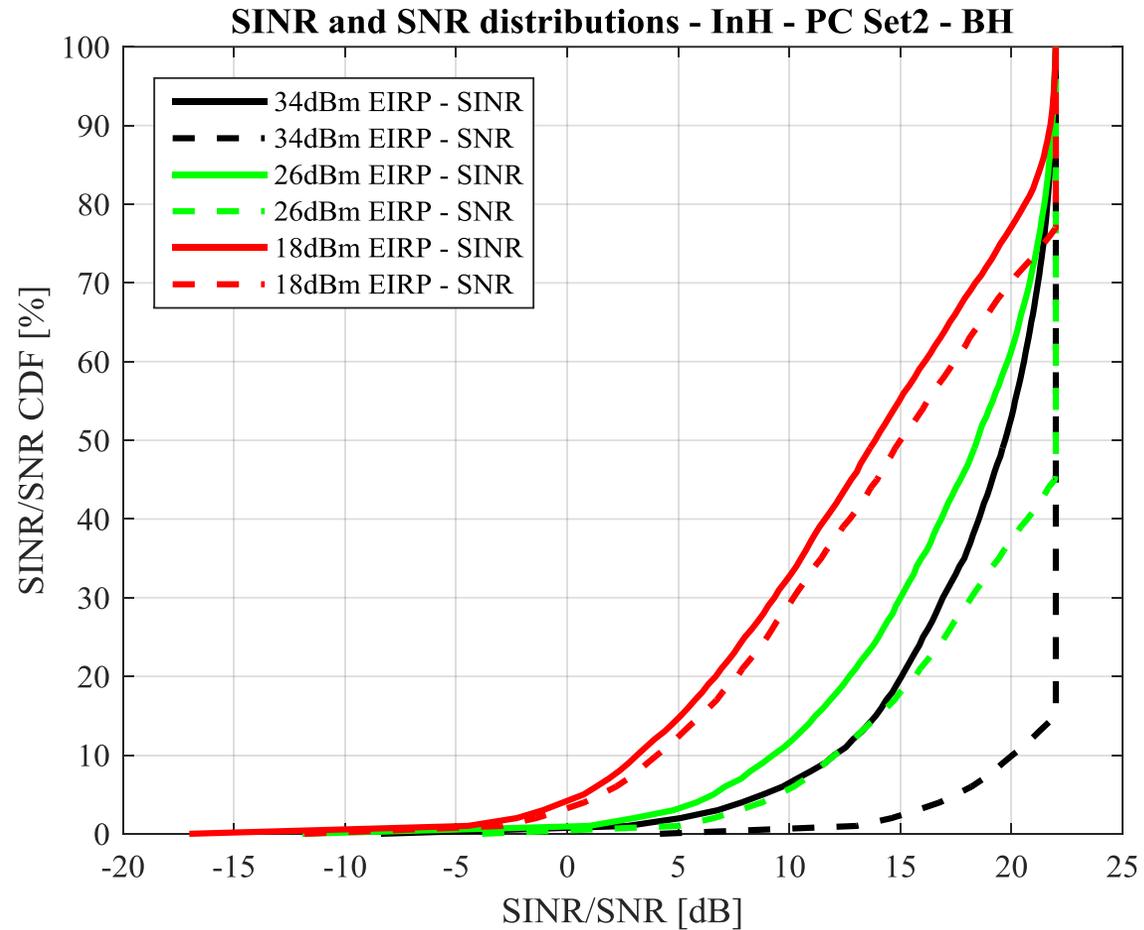
SINR/SNR distributions

PC Set1 - hand and body losses



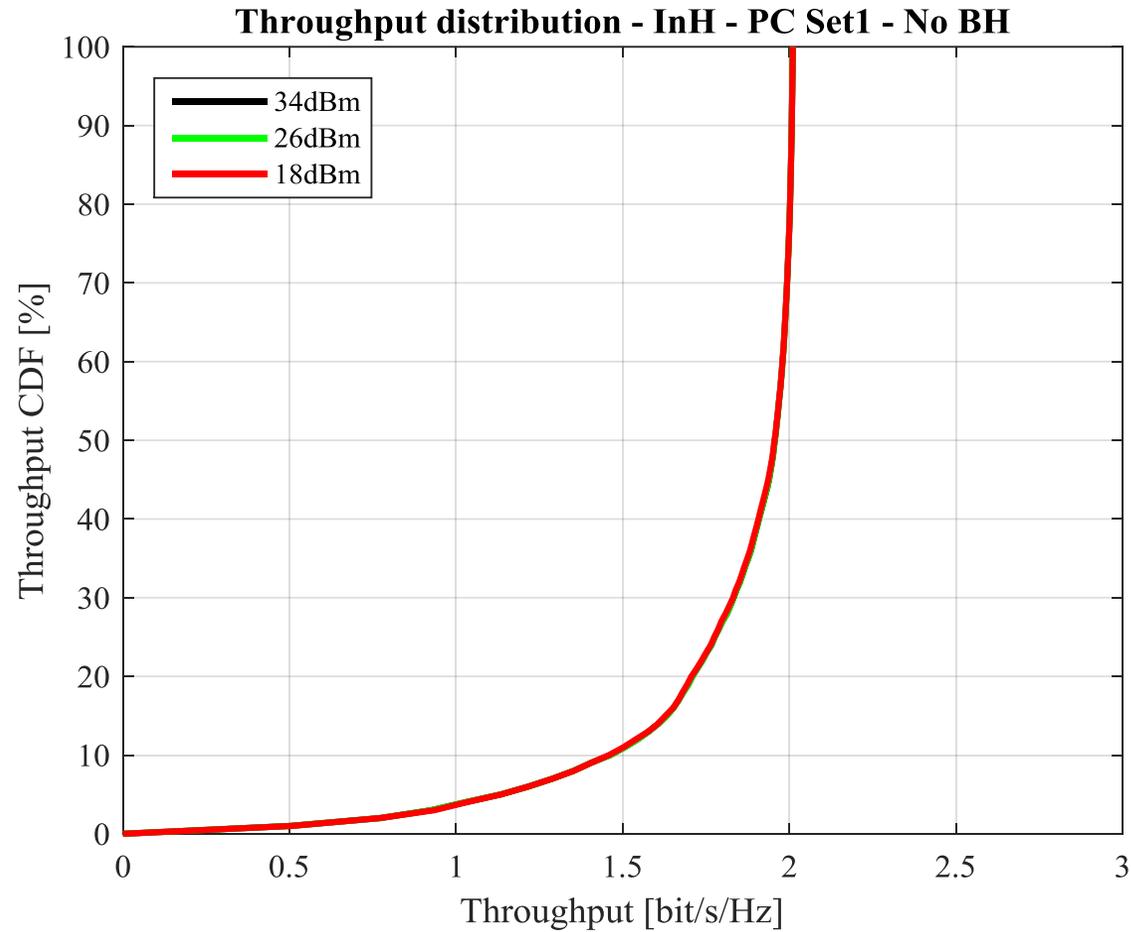
SINR/SNR distributions

PC Set2 - hand and body losses



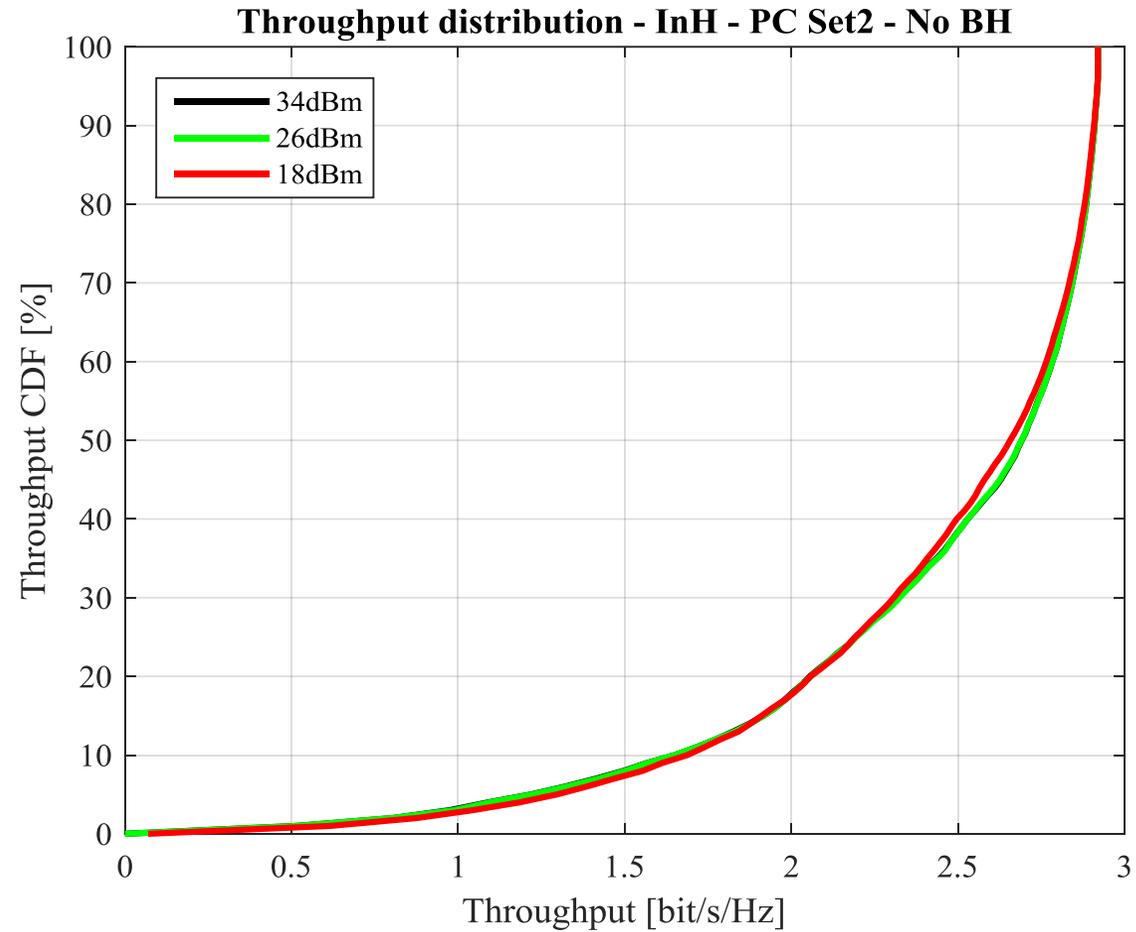
Throughput distribution

PC Set1 - no hand and body losses



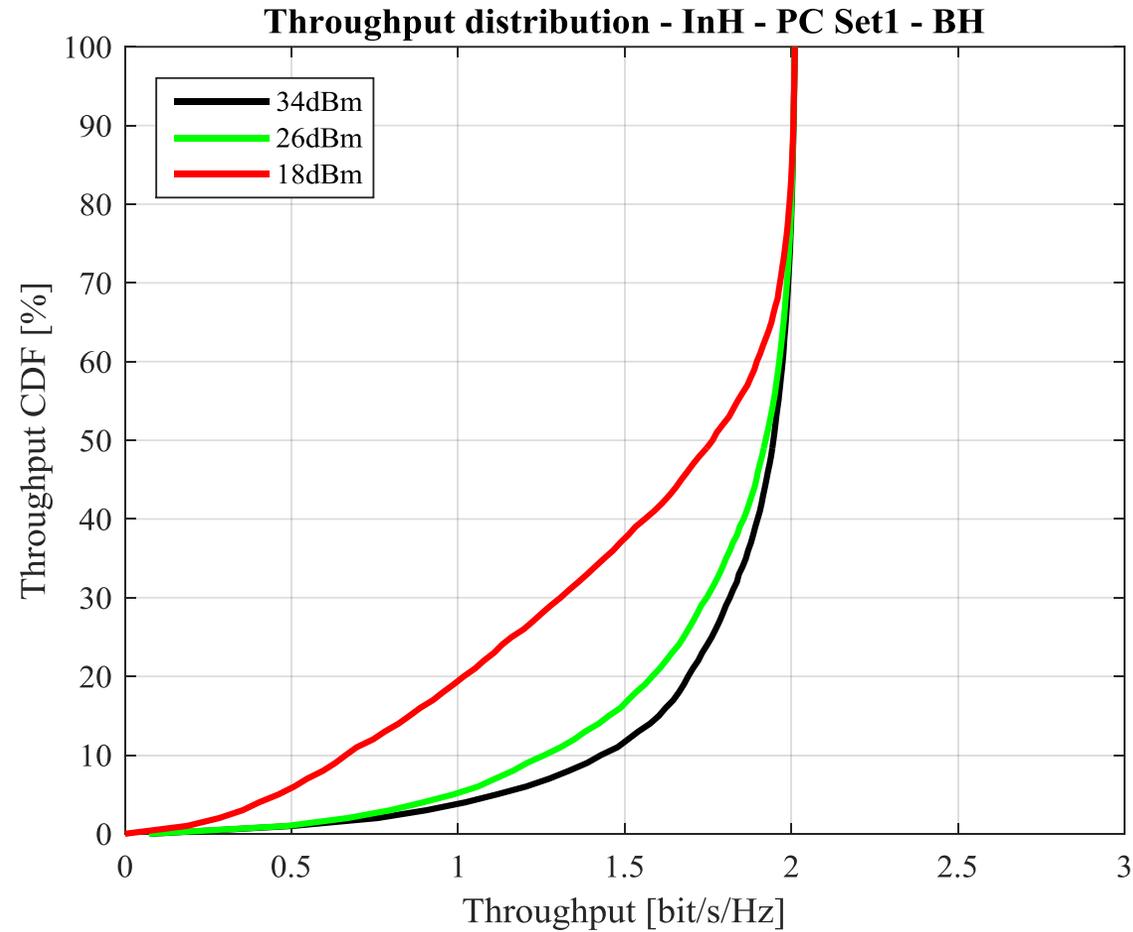
Throughput distributions

PC Set2 - no hand and body losses



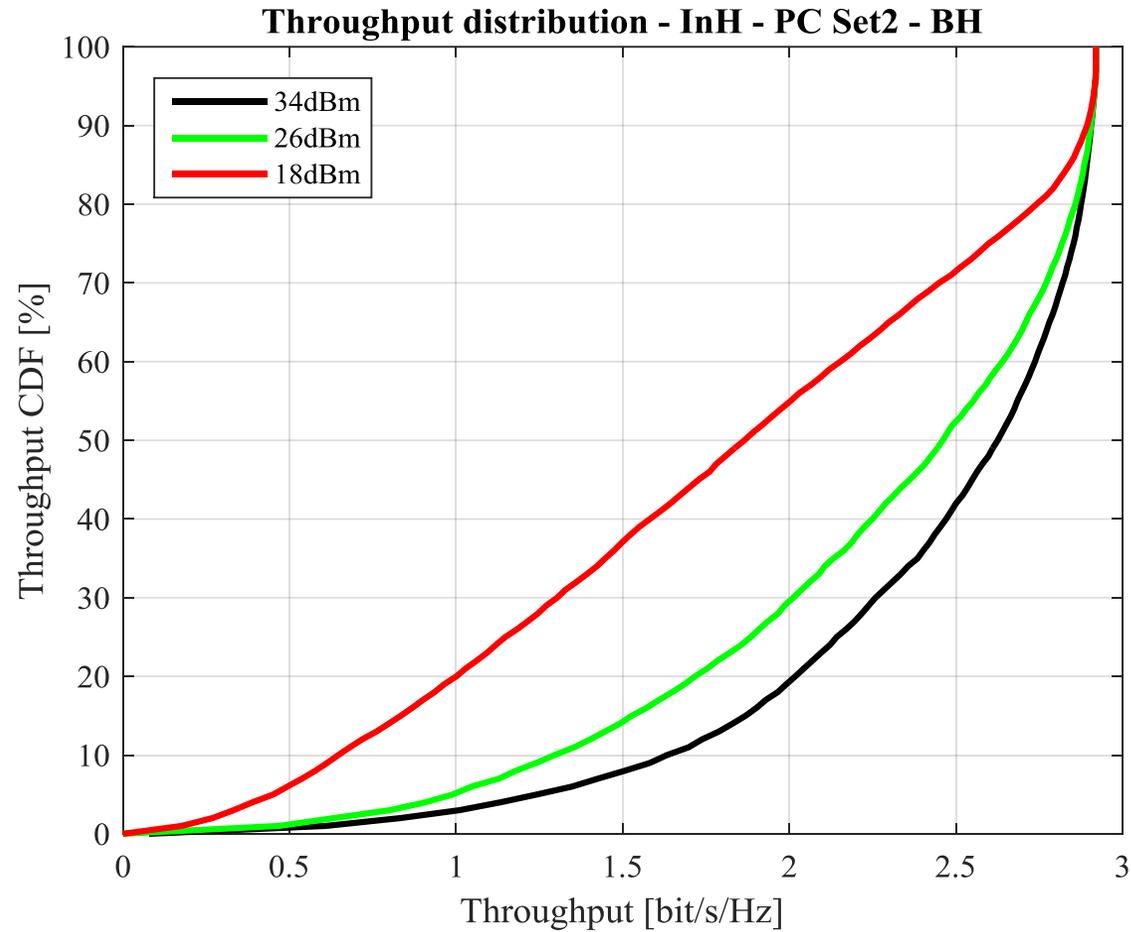
Throughput distributions

PC Set 1 - hand and body losses



Throughput distributions

PC Set2 - hand and body losses

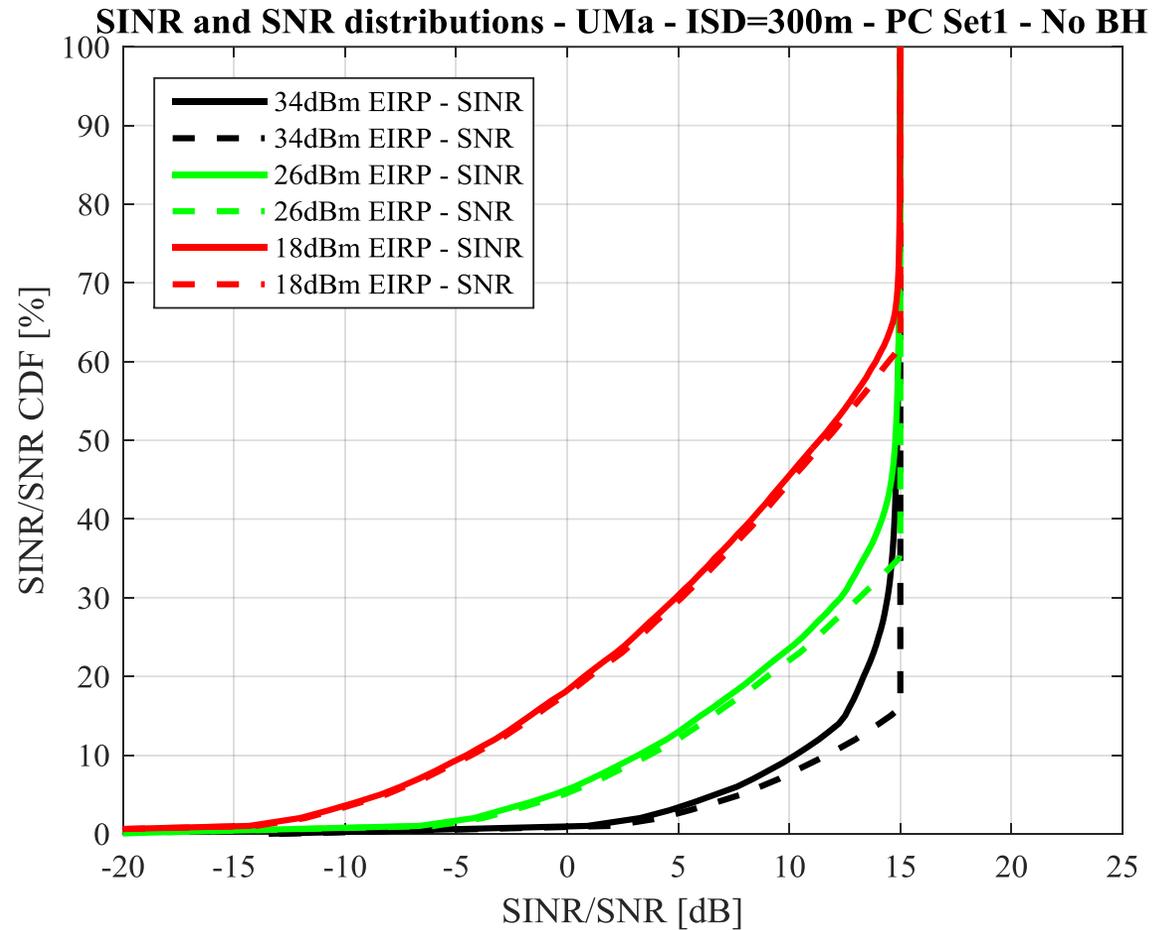


Appendix 2: outdoor plots



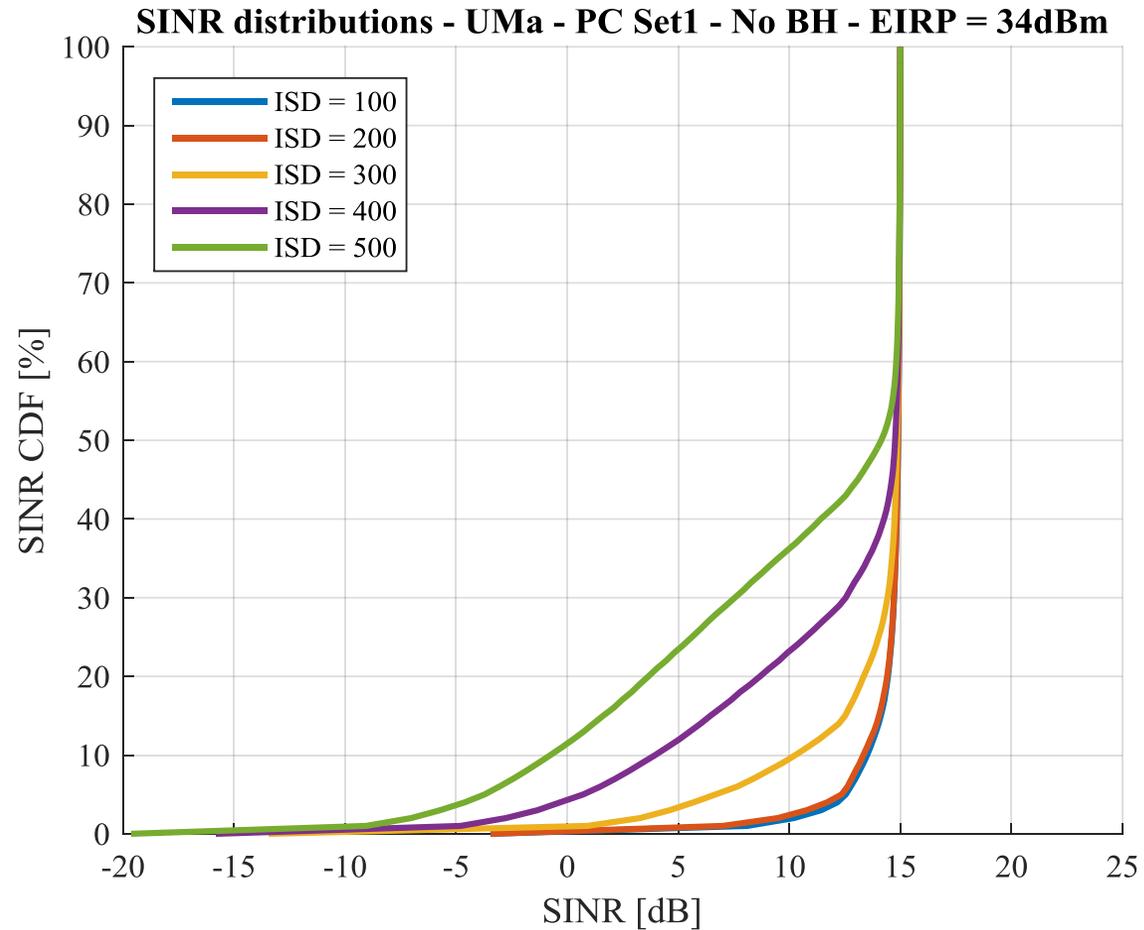
SINR/SNR distributions

PC Set1 - no hand and body losses – ISD = 300 m



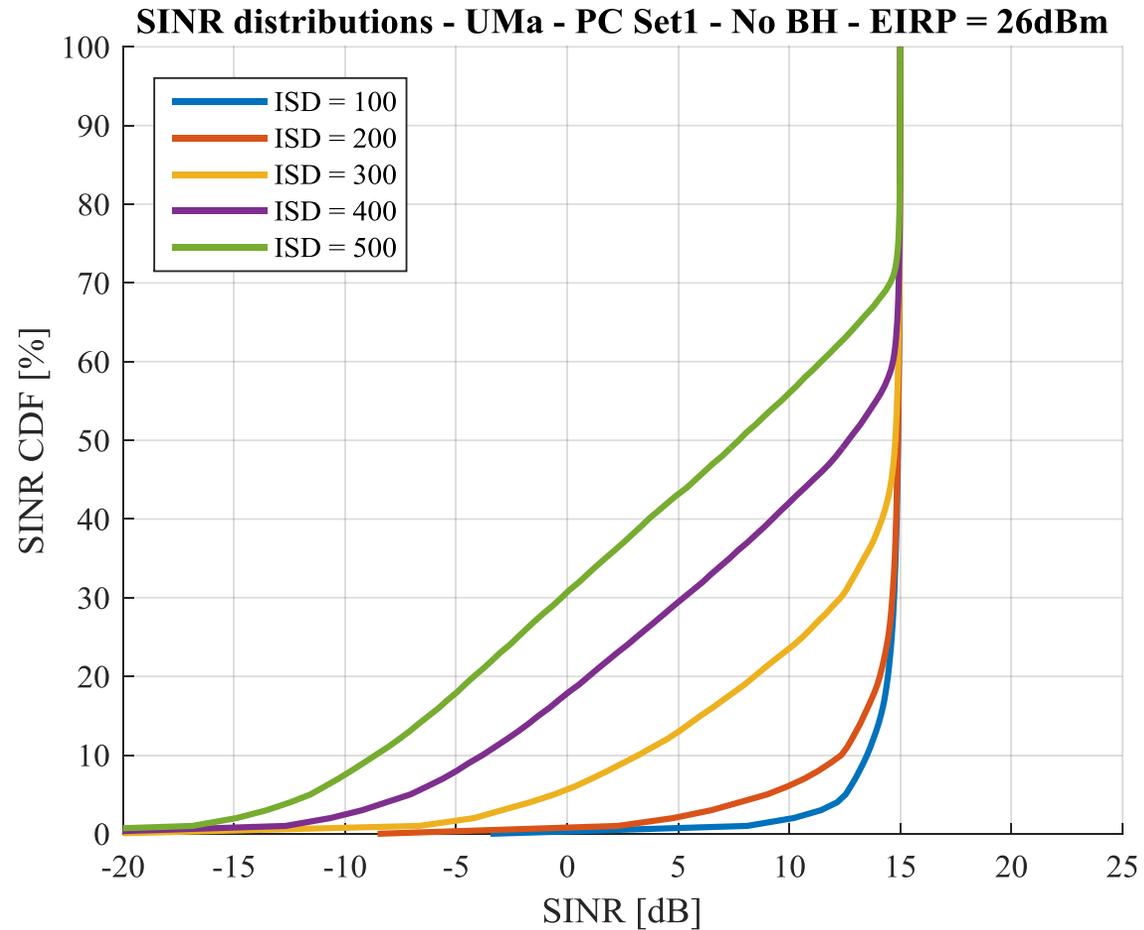
SINR distributions

PC Set1 - no hand and body losses – EIRP = 34 dBm – variable ISD



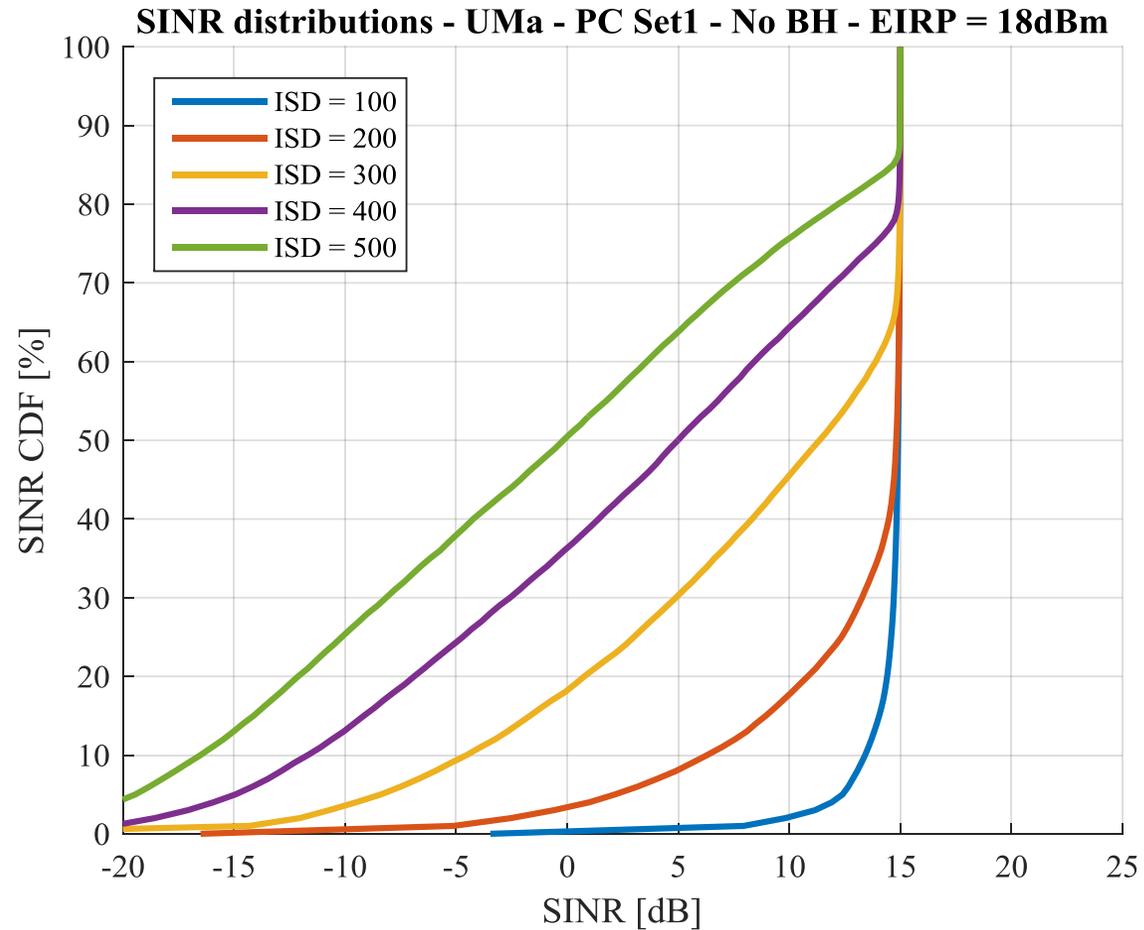
SINR distributions

PC Set1 - no hand and body losses – EIRP = 26 dBm – variable ISD



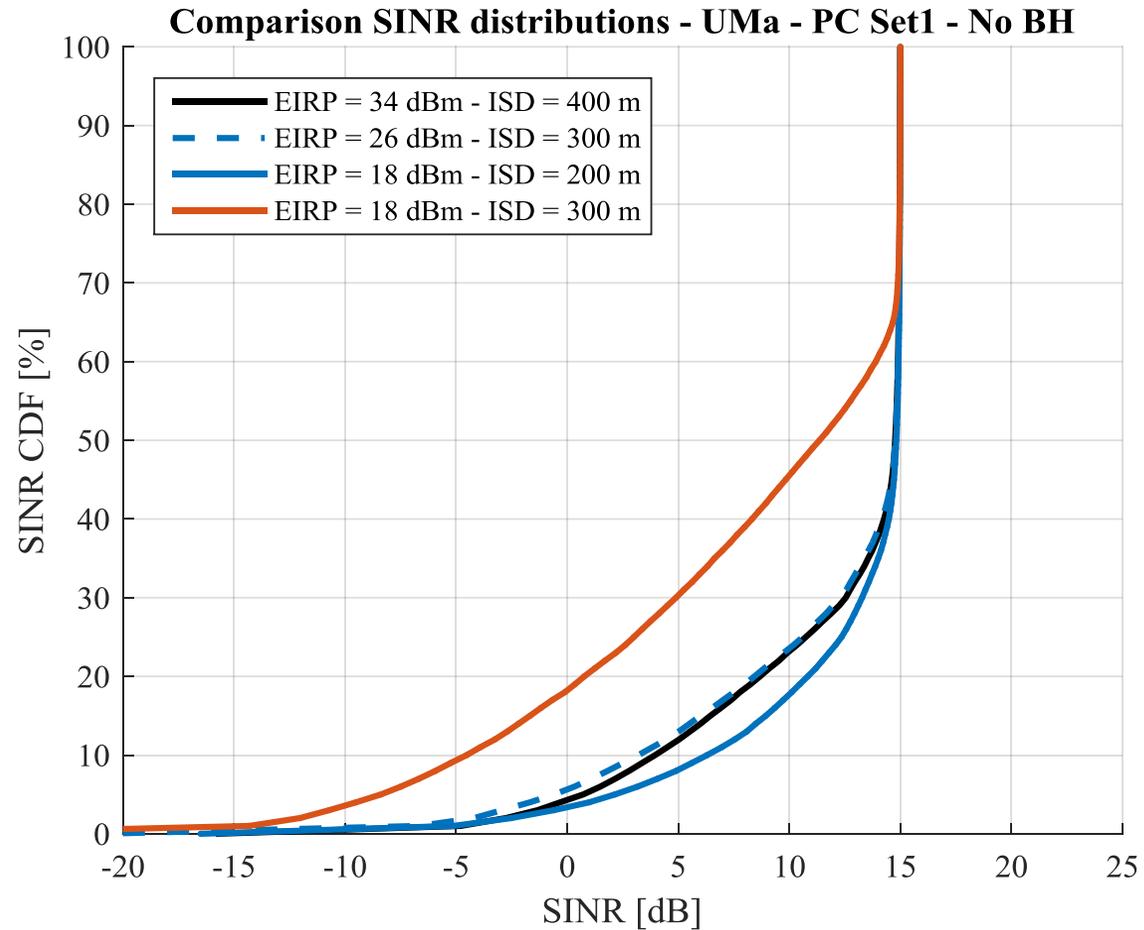
SINR distributions

PC Set1 - no hand and body losses – EIRP = 18 dBm



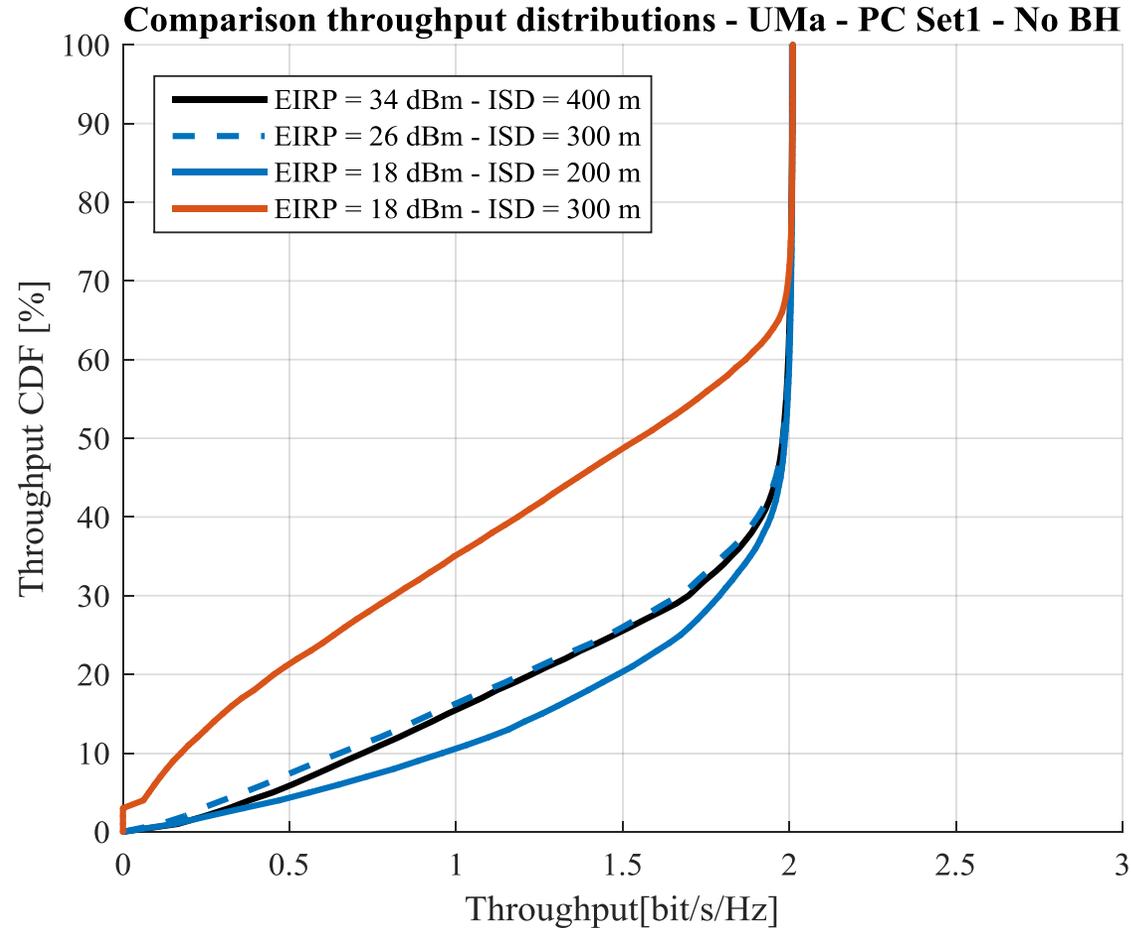
SINR comparison

PC Set1 – no hand and body losses



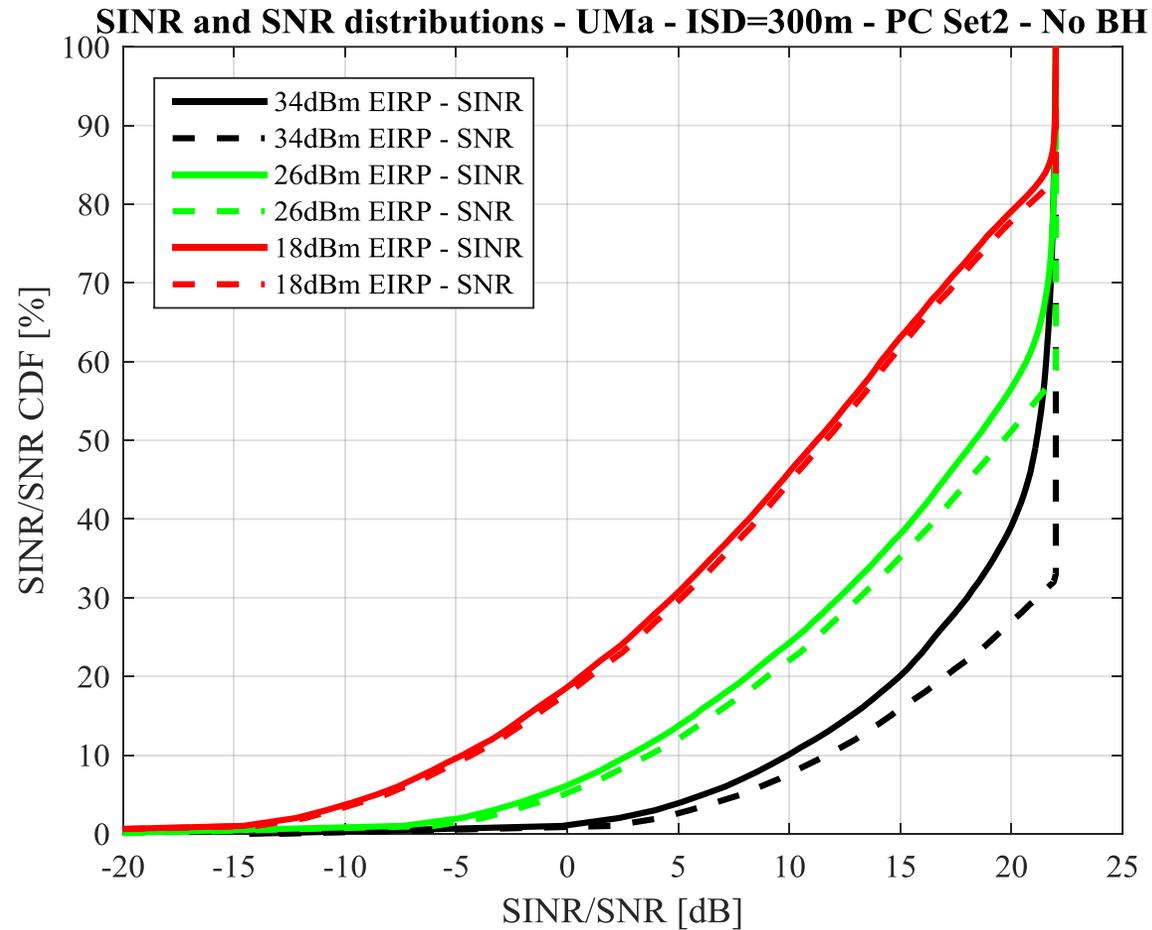
Throughput comparison

PC Set1 – no hand and body losses



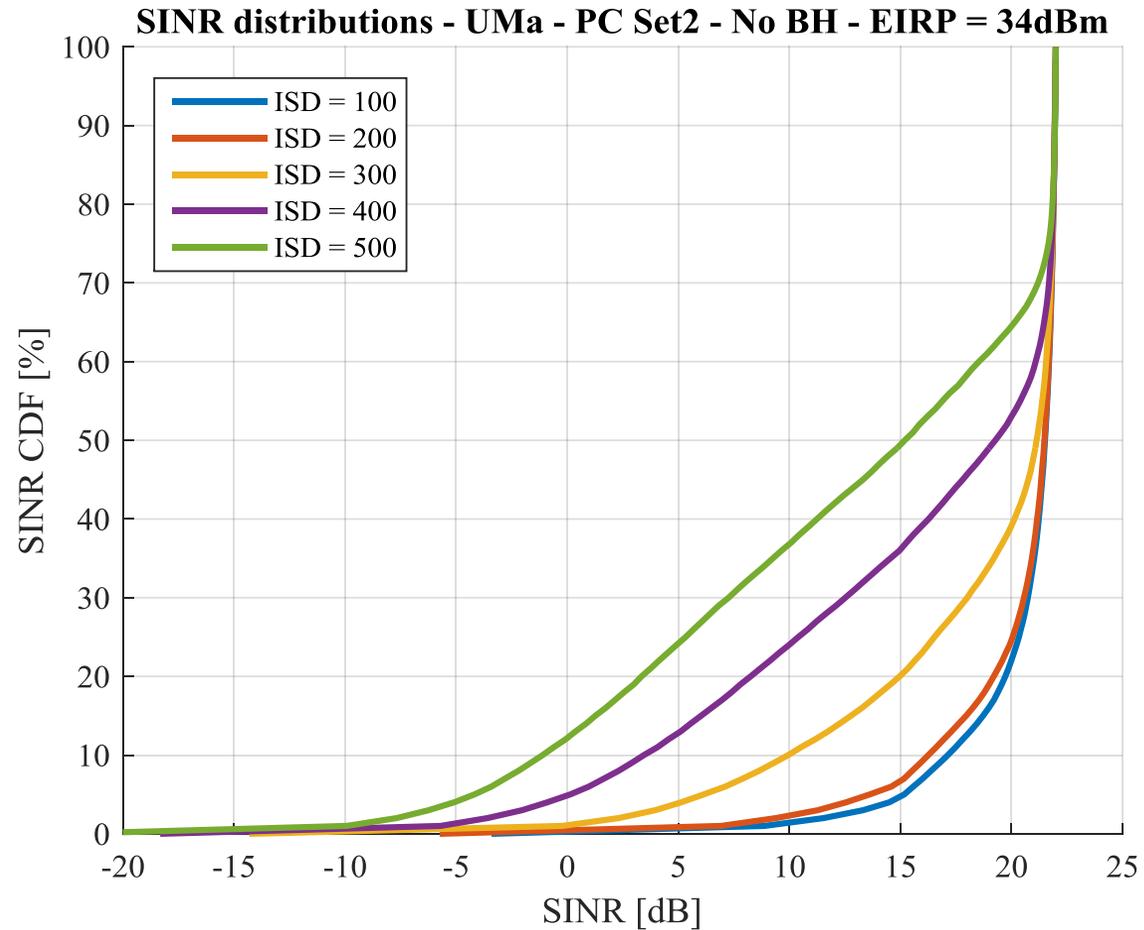
SINR/SNR distributions

PC Set2 - no hand and body losses – ISD = 300 m



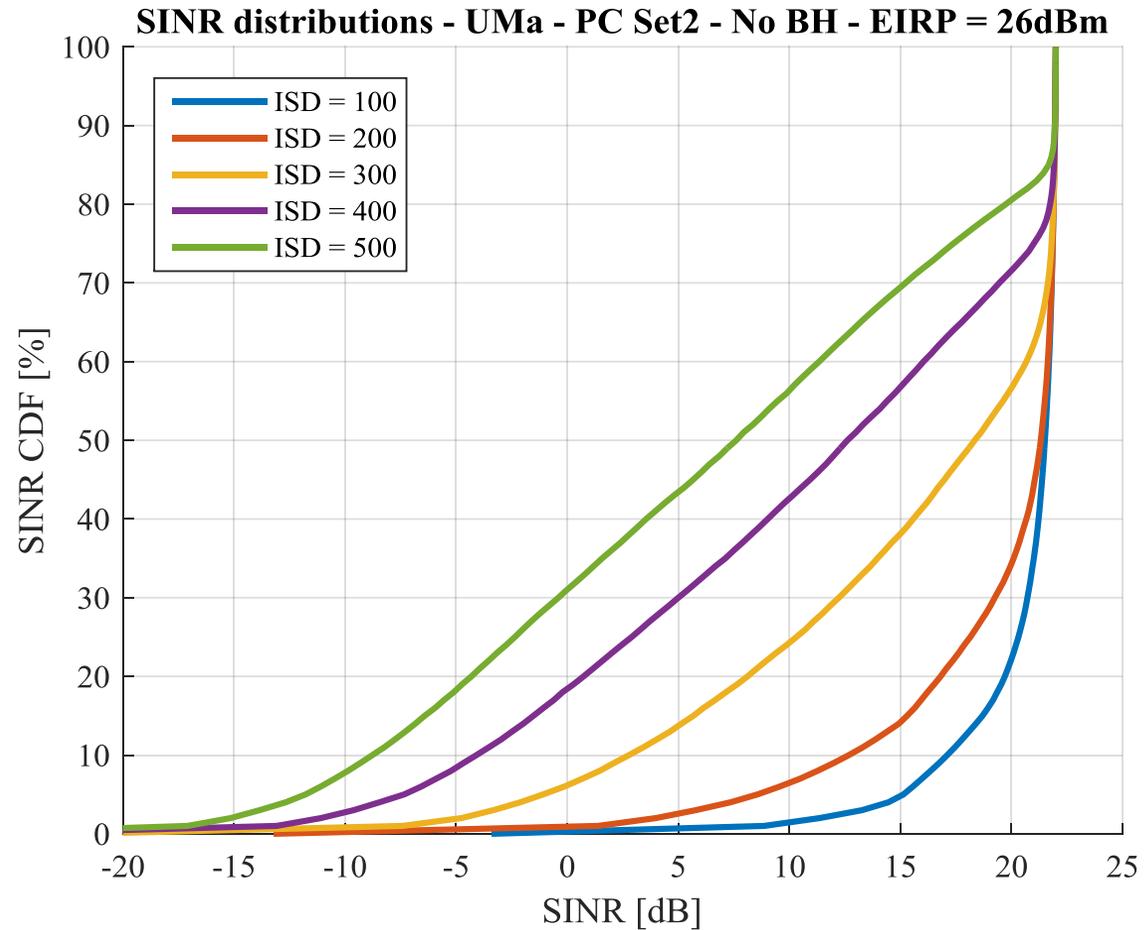
SINR distributions

PC Set2 - no hand and body losses – EIRP = 34 dBm – variable ISD



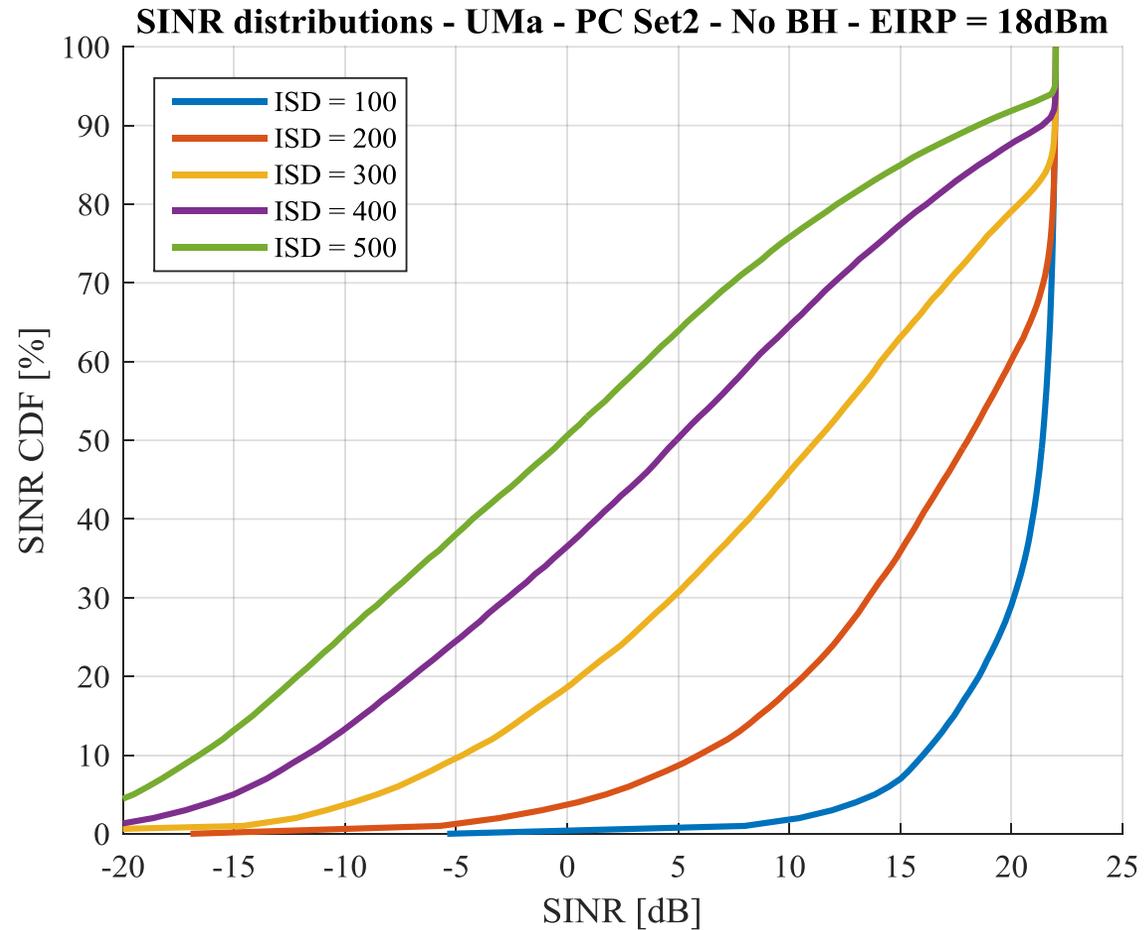
SINR distributions

PC Set2 - no hand and body losses – EIRP = 26 dBm – variable ISD



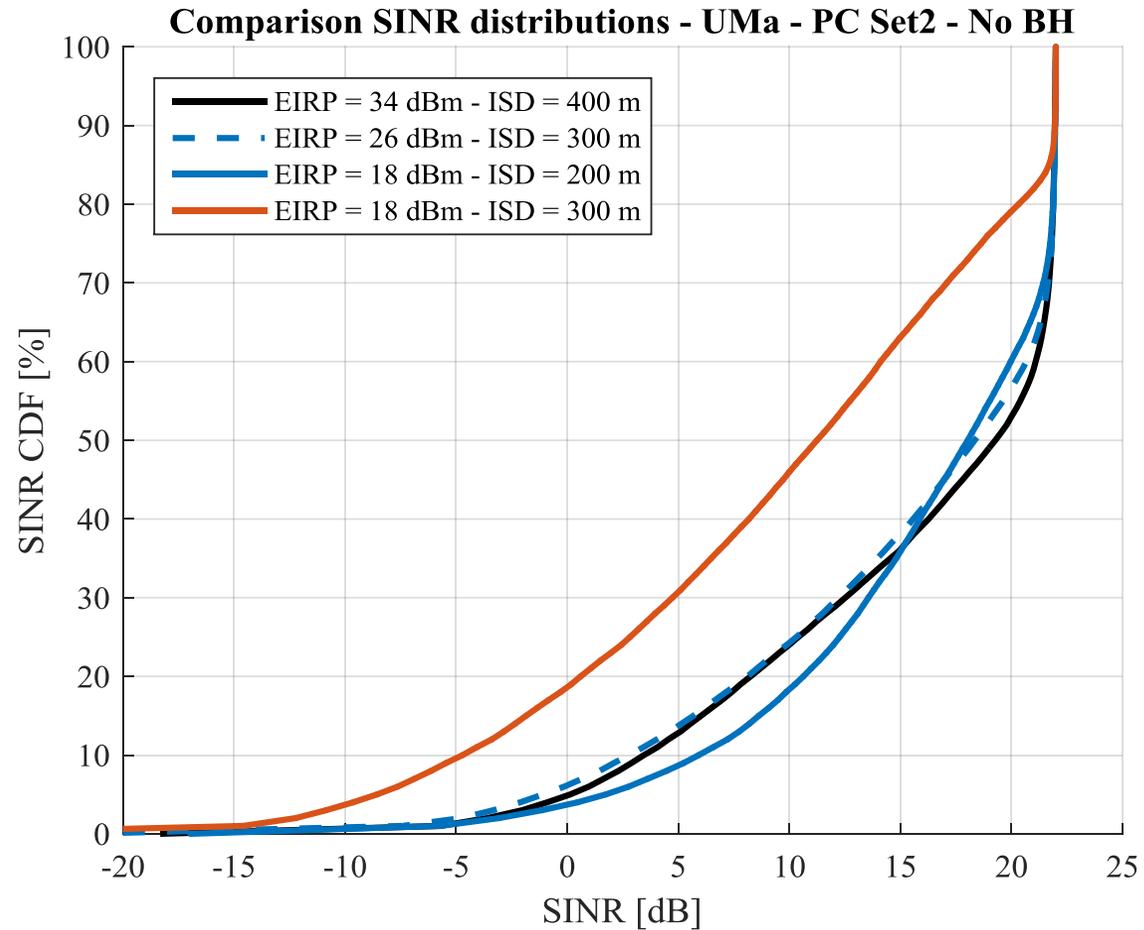
SINR distributions

PC Set2 - no hand and body losses – EIRP = 18 dBm



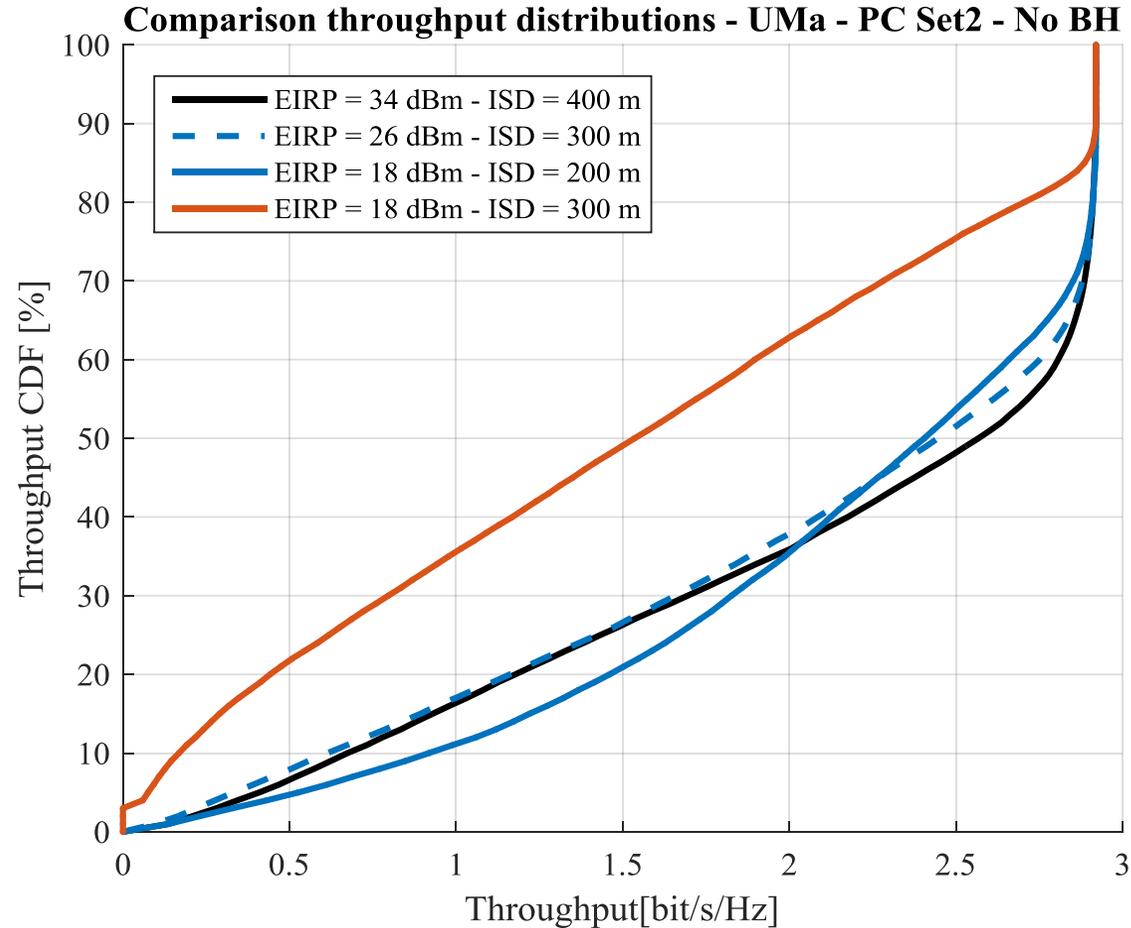
SINR comparison

PC Set2 – no hand and body losses



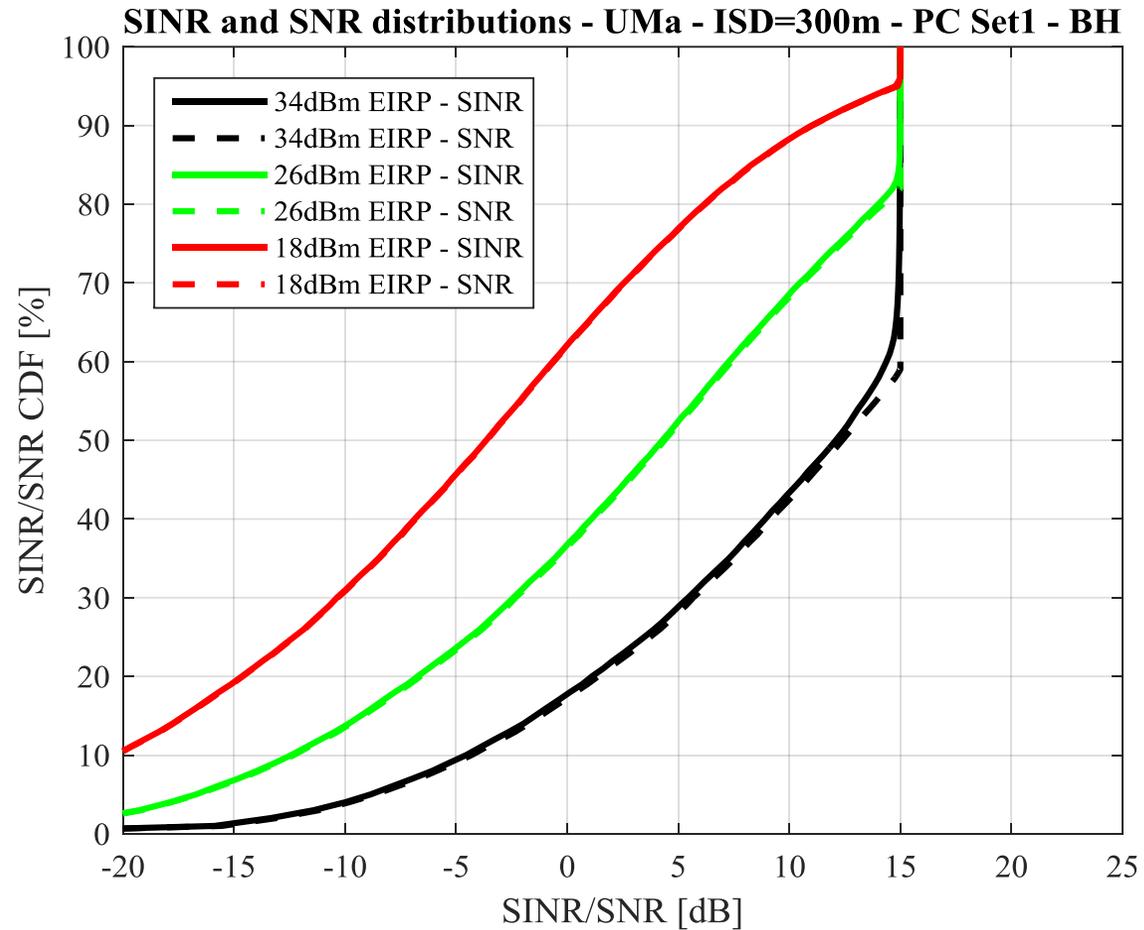
Throughput comparison

PC Set2 – no hand and body losses



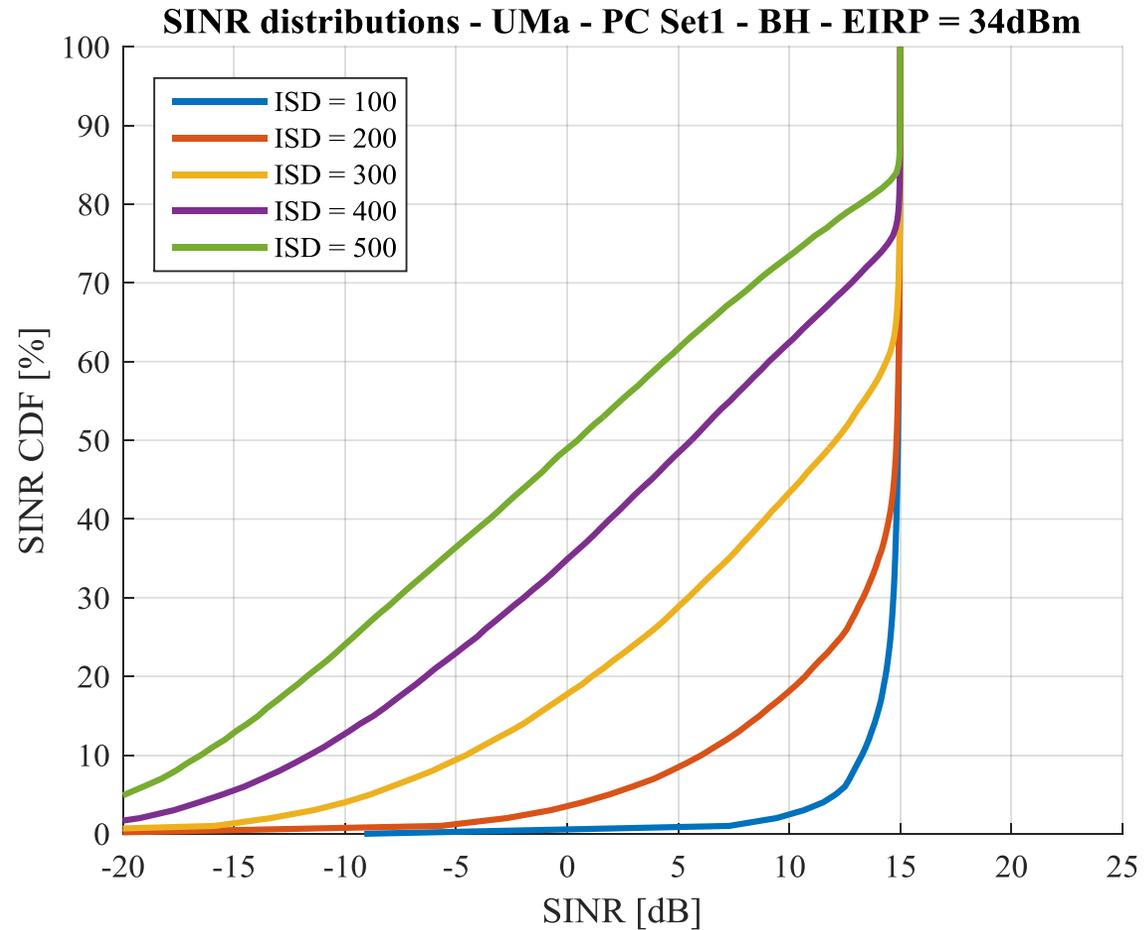
SINR/SNR distributions

PC Set1 - hand and body losses – ISD = 300 m



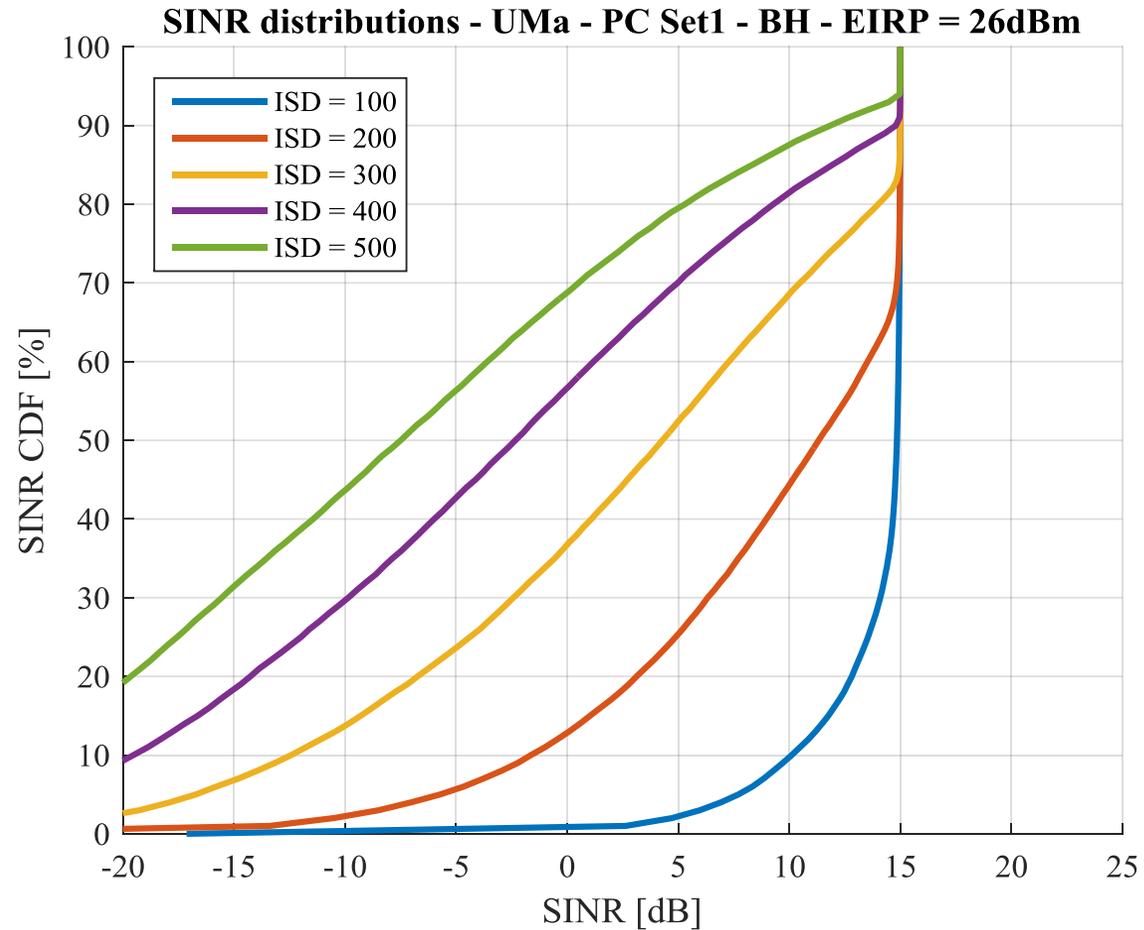
SINR distributions

PC Set1 - hand and body losses – EIRP = 34 dBm – variable ISD



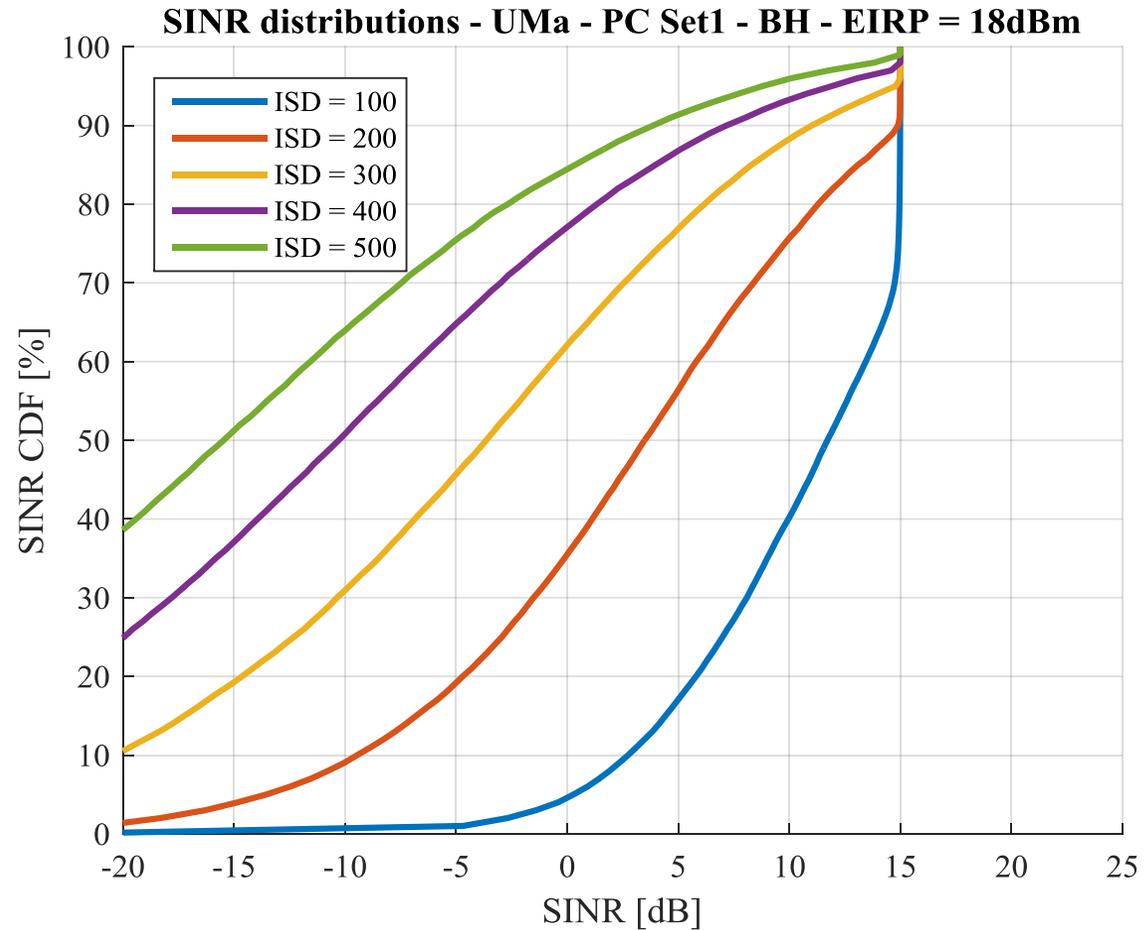
SINR distributions

PC Set1 - hand and body losses – EIRP = 26 dBm – variable ISD



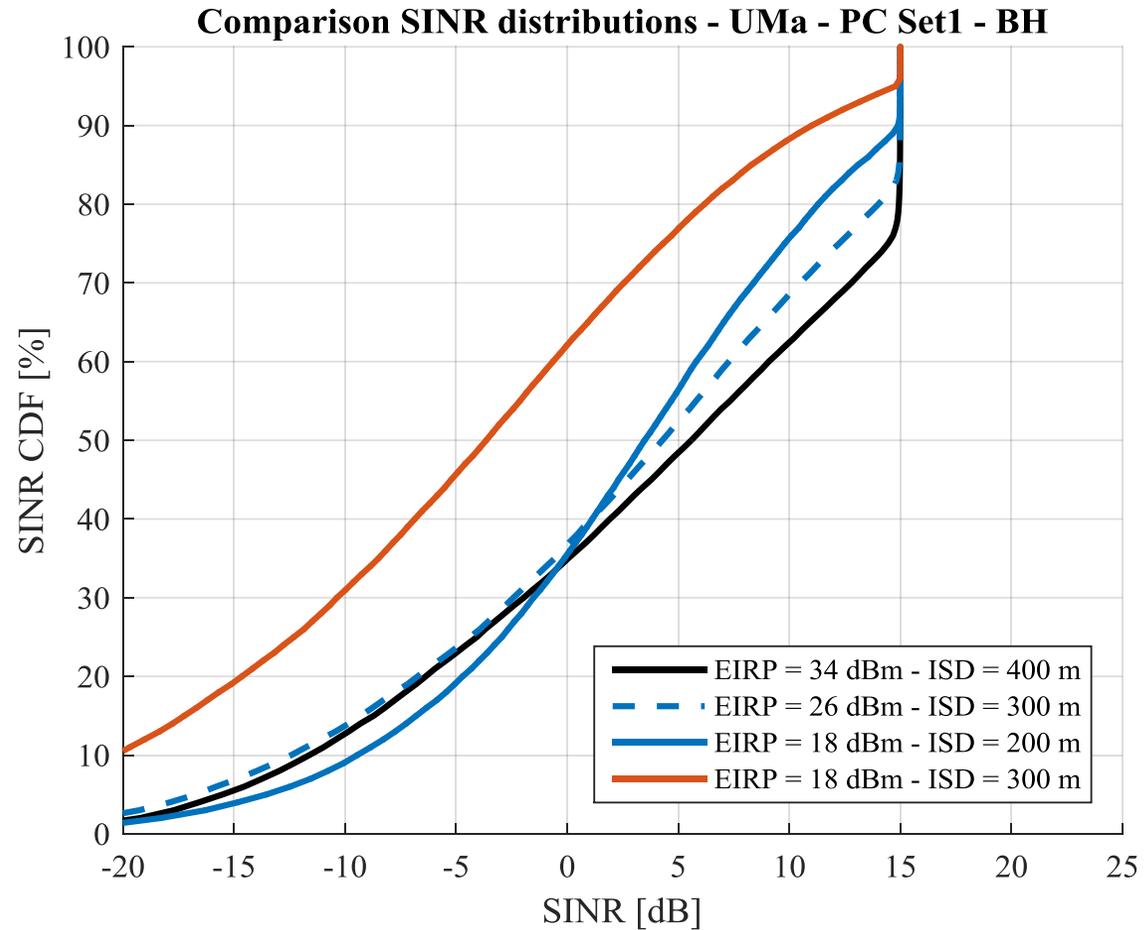
SINR distributions

PC Set1 - hand and body losses – EIRP = 18 dBm



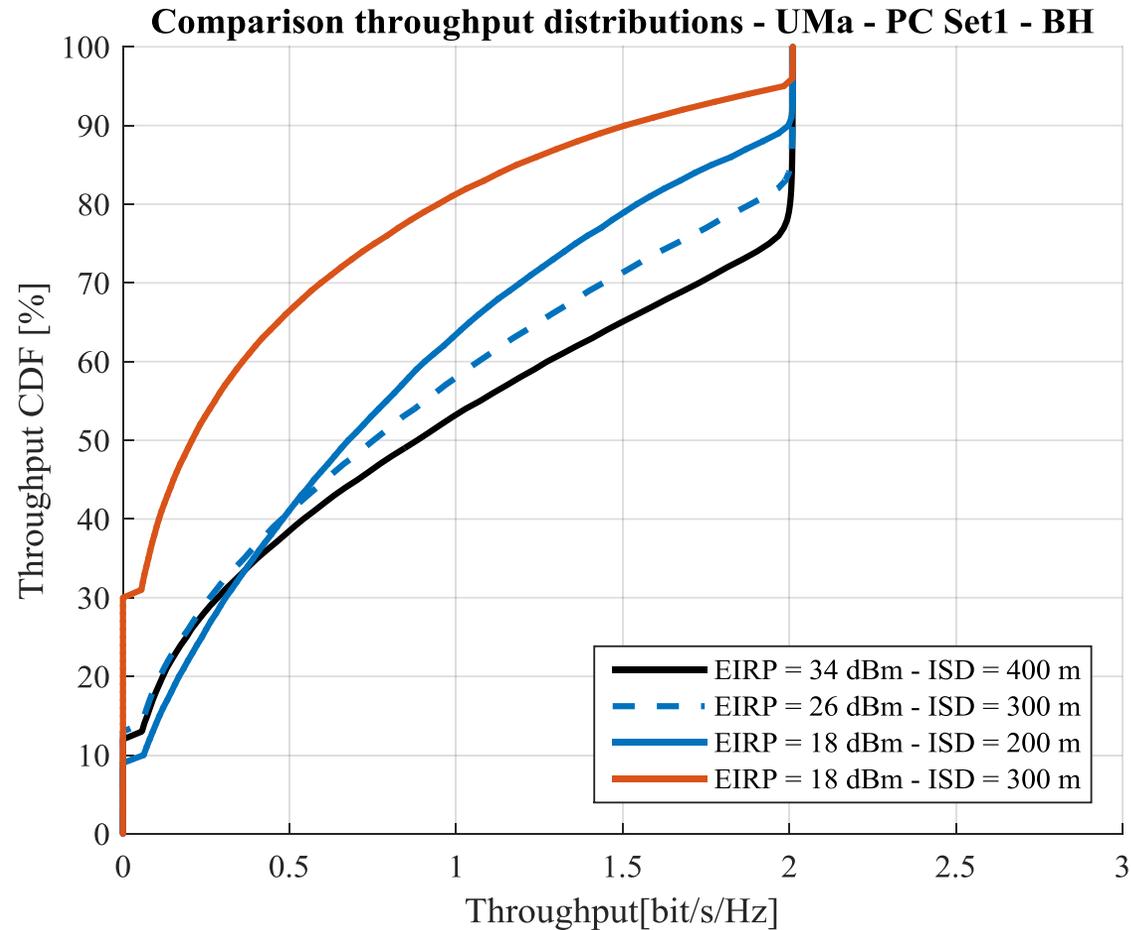
SINR comparison

PC Set1 – hand and body losses



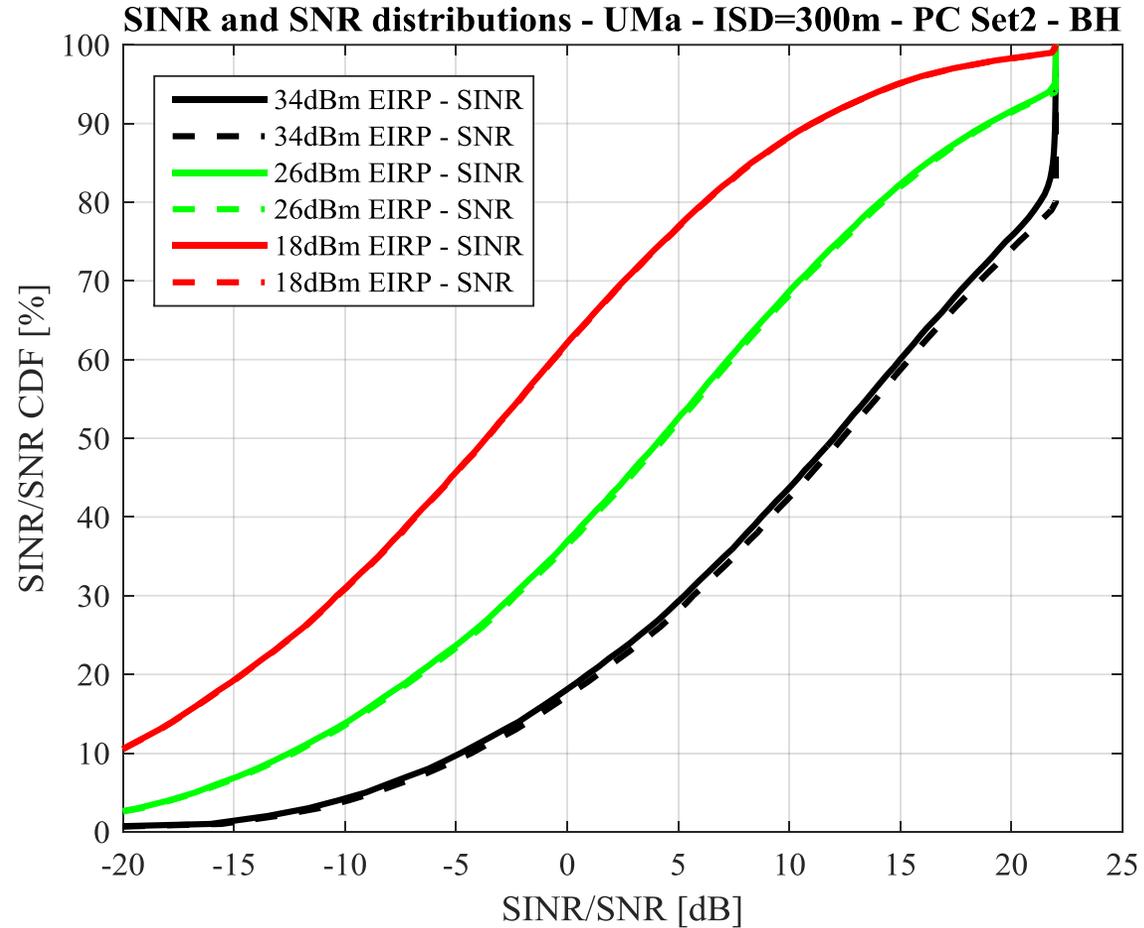
Throughput comparison

PC Set1 – hand and body losses



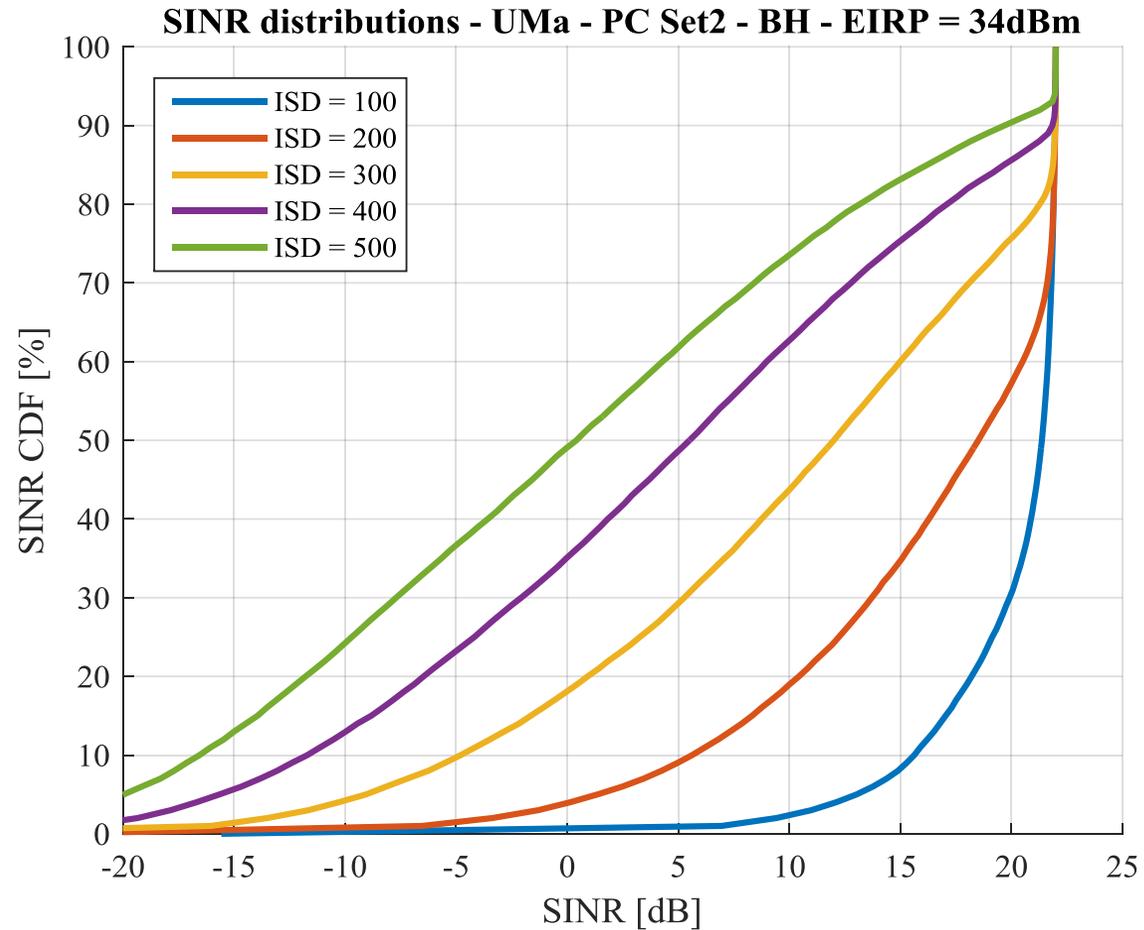
SINR/SNR distributions

PC Set2 - hand and body losses – ISD = 300 m



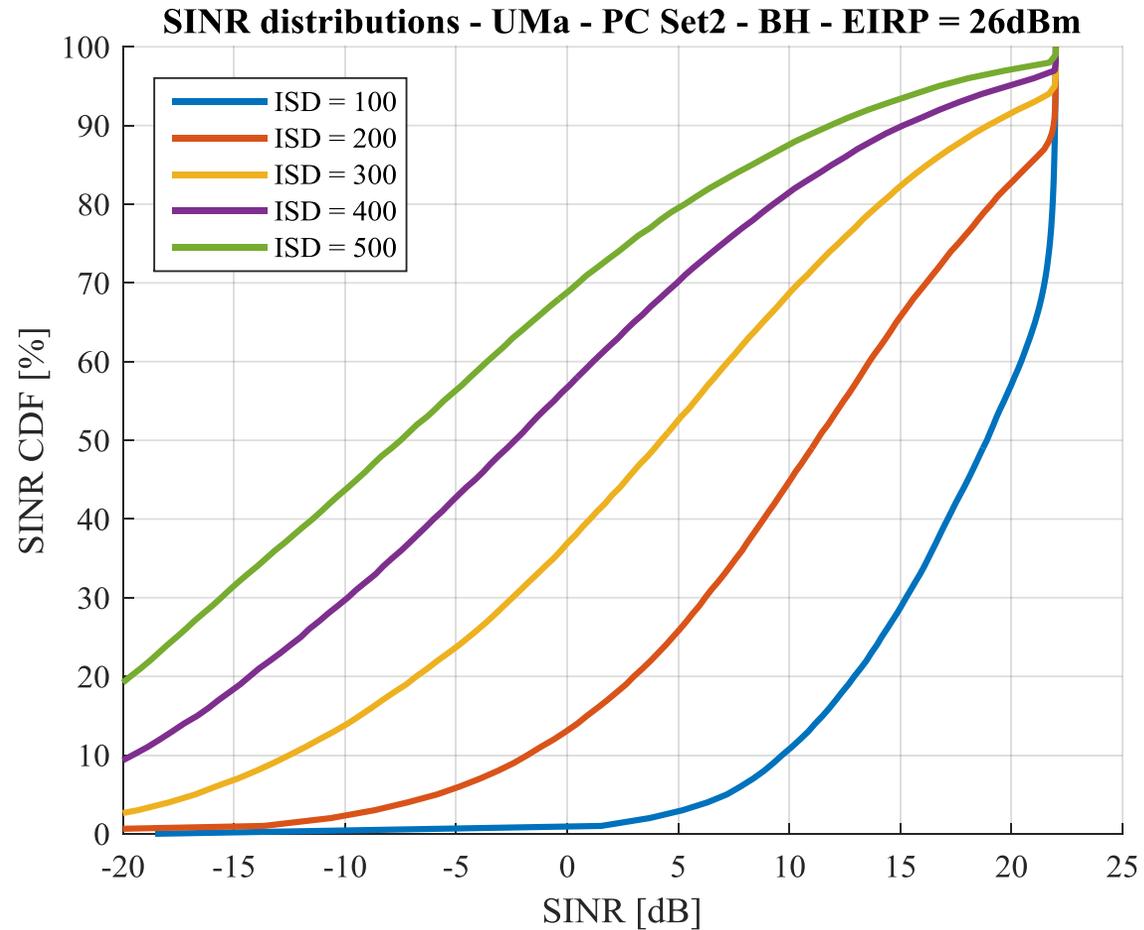
SINR distributions

PC Set2 - hand and body losses – EIRP = 34 dBm – variable ISD



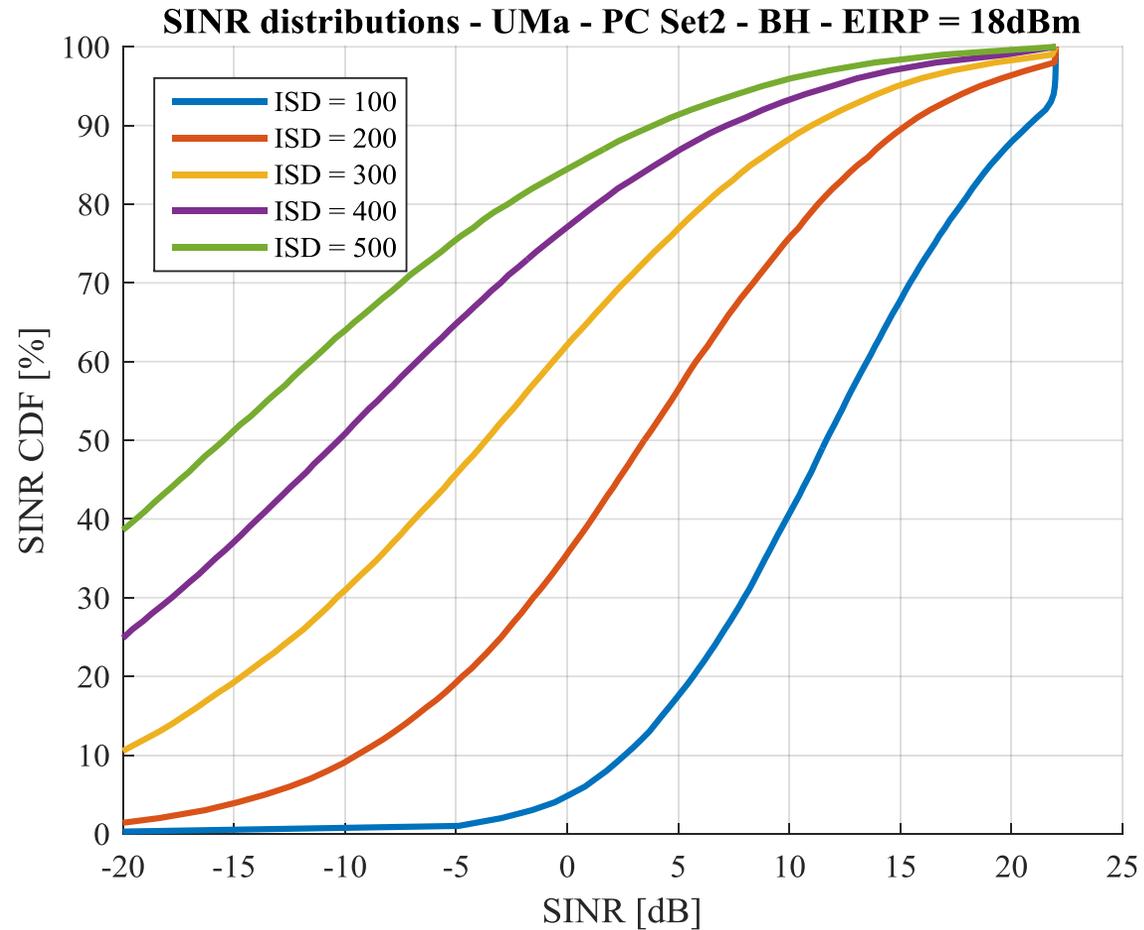
SINR distributions

PC Set2 - hand and body losses – EIRP = 26 dBm – variable ISD



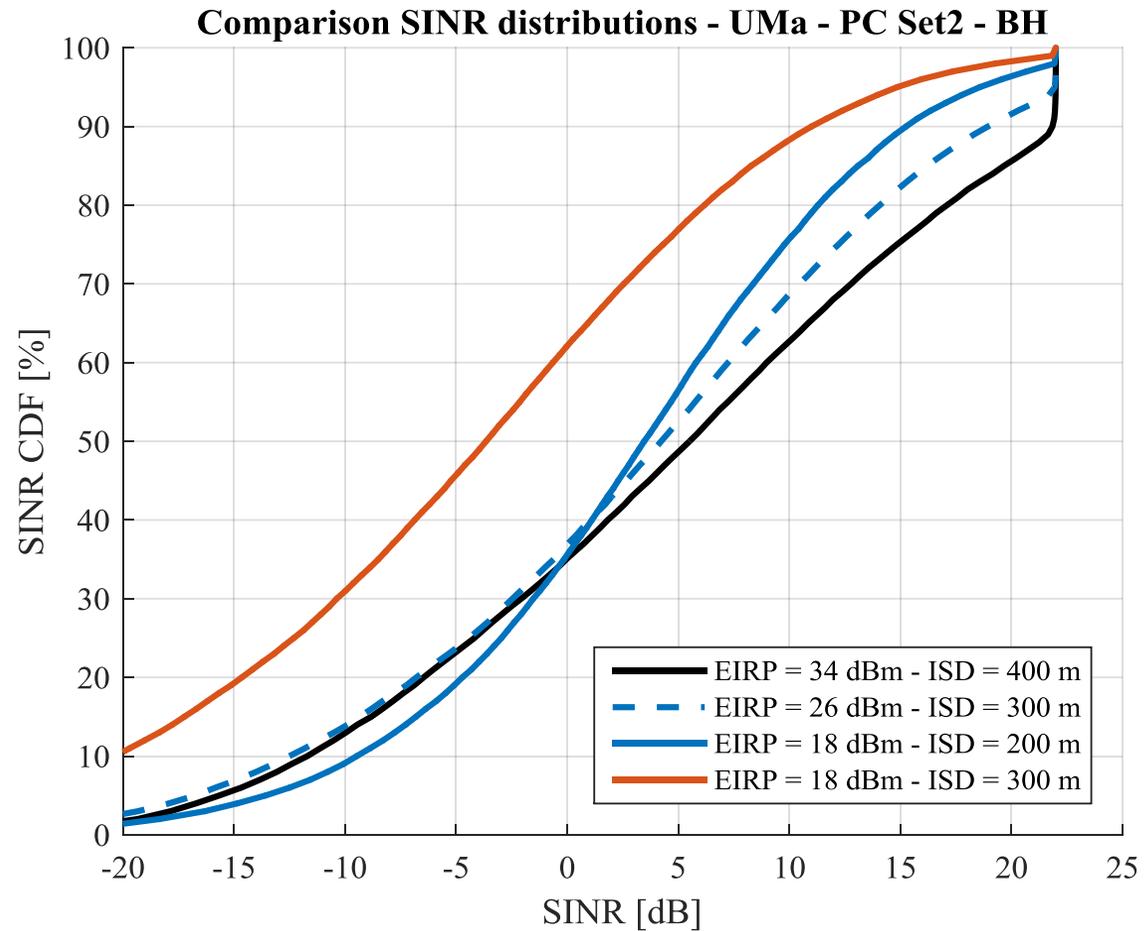
SINR distributions

PC Set2 - hand and body losses – EIRP = 18 dBm



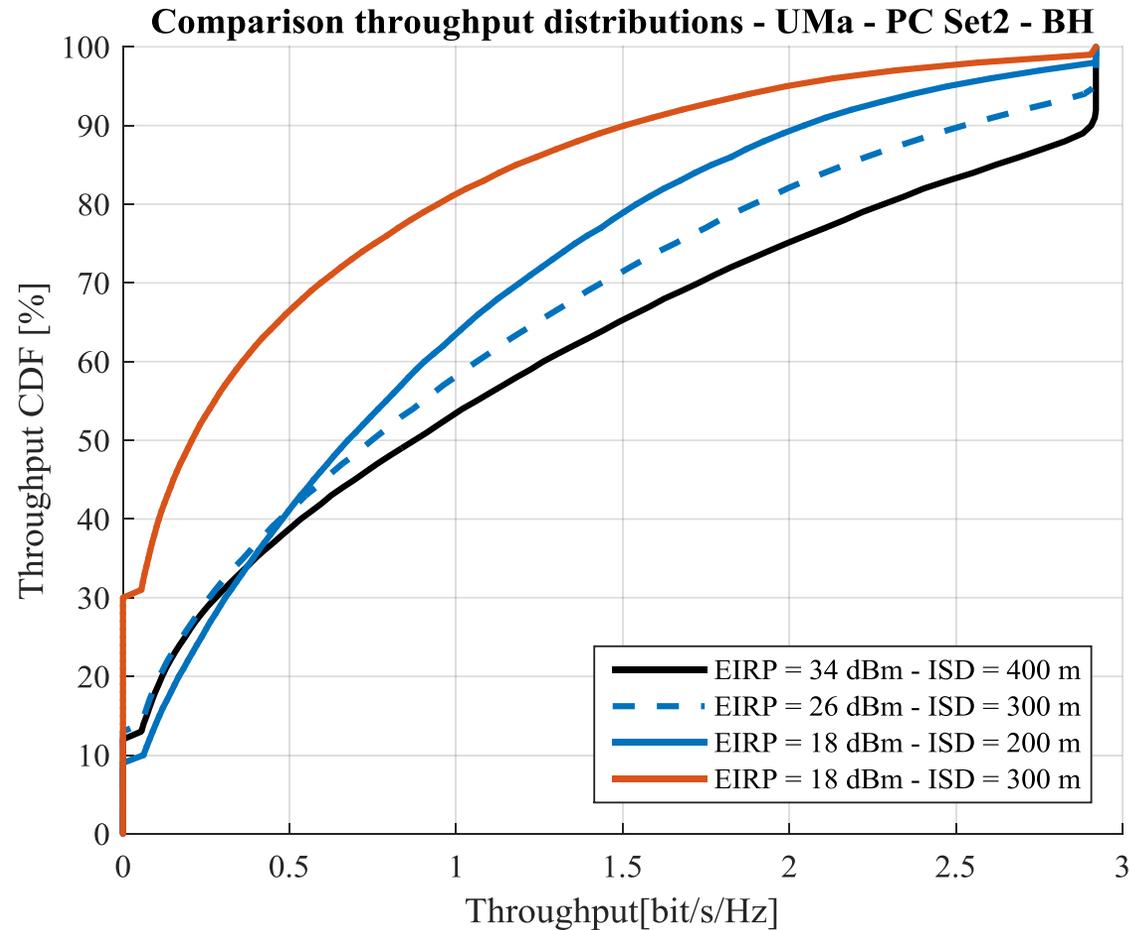
SINR comparison

PC Set2 – hand and body losses



Throughput comparison

PC Set2 – hand and body losses



Thank you



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