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5G;
Measurements of Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) performance of User Equipment (UE) (3GPP TR 38.761 version 18.1.0 Release 18)

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Contents

Foreword

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  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

shall indicates a mandatory requirement to do something

shall not indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

should indicates a recommendation to do something

should not indicates a recommendation not to do something

may indicates permission to do something

need not indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

can indicates that something is possible

cannot indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

will indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

will not indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document is a Technique Report for Measurements of Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) performance of User Equipment (UE). It includes analysis and measurement results of MIMO OTA in Frequency Range 1 and Frequency Range 2, such as verification of channel models, lab alignment activities, etc..

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 38.151: “NR; Multiple Input Multiple Output (MIMO) Over-the-Air (OTA) performance requirements for NR UEs”.

[3] 3GPP TR 38.827: “Study on radiated metrics and test methodology for the verification of multi-antenna reception performance of NR User Equipment (UE)”.

[4] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone"

[5] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone"

[6] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios"

[7] 3GPP TS 38.101-4: "NR; User Equipment (UE) radio transmission and reception; Part 4: Performance requirements"

[8] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception"

[9] 3GPP TS 38.508-1: "5GS; User Equipment (UE) conformance specification; Part 1: Common test environment"

[10] 3GPP TR 38.901: "Study on channel model for frequencies from 0.5 to 100 GHz"

[11] F. Zhang, L. Hentilä, P. Kyösti and W. Fan, "Millimeter-wave New Radio Test Zone Validation for MIMO Over-the-air Testing," in IEEE Transactions on Antennas and Propagation, doi: 10.1109/TAP.2021.3111326.

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

FS: UE used in a free space configuration.

Handheld UE: A UE intended to be used in hand held scenario.

MIMO Average Spherical Coverage: An averaged sensitivity of best 18 FR2 MIMO OTA sensitivity values within the 3D sphere with constant-density points for PC3 device.

Primary mechanical mode: The mode that is most often used for a specific user scenario. Every terminal has at least one primary mechanical mode, if multiple modes are supported, different primary mechanical modes may be applicable for different user scenarios, e.g., different primary mechanical modes for Free Space and Hand phantom usage for the same UE.

PSP (PAS Similarity Percentage): The similarity of the PAS produced by the OTA system and the reference PAS, which is presented by the Total Variation Distance (TVD) of power angular spectrum (PAS). PSP is defined as (1-TVD)*100%. PSP=100% denotes full similarity and PSP=0% denotes full dissimilarity..

3.2 Symbols

For the purposes of the present document, the following symbols apply:

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

AOA	Azimuth angle Of Arrival
AOD	Azimuth angle Of Departure
BS	Base Station
CDL	Clustered Delay Line
CW	Continuous Wave
DML	Data Mode Landscape
DMP	Data Mode Portrait
DMSU	Data Mode Screen Up
DUT	Device Under Test
EUT	Equipment Under Test
FR1	Frequency Range 1
FR2	Frequency Range 2
FS	Free Space
MASC	MIMO Average Spherical Coverage
MIMO	Multiple Input Multiple Output
MPAC	Multi-Probe Anechoic Chamber
NR	New Radio
NSA	Non-Standalone, a mode of operation where operation of an other radio is assisted with an other radio
OTA	Over The Air
PAS	Power Angular Spectrum
PDP	Power Delay Profile
PSP	PAS Similarity Percentage
RS-EPRE	Reference Signal-Energy Per Resource Element
SS	System Simulator
SSS	Secondary Synchronization Signal
TRMS	Total Radiated Multi-antenna Sensitivity
UE	User Equipment
UMa	Urban Macro
UMi	Urban Micro
XPR	Cross-Polarization Ratio
ZOA	Zenith angle Of Arrival
ZOD	Zenith angle Of Departure
ZSA	Zenith angle Spread of Arrival

ZSD Zenith angle Spread of Departure

4 General

4.1 Device types

The present technical report covers the smartphone device type.

4.2 Testing configuration

The present technical report covers the free space (FS) testing configuration.

4.3 Testing Bands

The present technical report covers both FR1 and FR2 operating bands. FR1 operating bands are defined in TS 38.101-1 [4] and FR2 operating bands are defined in TS 38.101-2 [5]. NSA band combinations are defined in TS 38.101-3 [6]. E-UTRA is designed to operate in operating bands defined in TS 36.101 [8].

5 Measurement setup

5.1 General

The measurements in the present technical report are based on the test methodology defined in 3GPP TS 38.151 [2] and 3GPP TR 38.827 [3].

5.2 Measurement setup for FR1 MIMO OTA

The multi-probe anechoic chamber (MPAC) test method is the reference methodology for FR NR MIMO OTA testing, the measurement setup and test procedure are defined in TS 38.151 [2].

5.3 Measurement setup for FR2 MIMO OTA

The 3D MPAC test method is the reference methodology for FR2 NR MIMO OTA testing, the measurement setup and test procedure are defined in TS 38.151 [2].

6 Channel Model Validation

6.1 General

This clause describes the FR1 and FR2 MIMO OTA channel model validation measurements. The purpose of channel model validation is to ensure that the channel models are correctly implemented and hence capable of generating the propagation environment, as described by the model, within the test zone.

6.2 Verification of Channel Model implementation of FR1

6.2.1 Framework

This clause describes how to proceed Channel Model Validation for FR1 MIMO OTA with MPAC system.

- The channel model validation measurements shall be performed according to the procedures in Annex C.3 of TS 38.151, including:
  - Power Delay Profile (PDP)
  - Doppler/Temporal correlation
  - Spatial correlation
  - Cross-polarization
  - Power validation
- Channel model: FR1 UMa CDL-C and UMi CDL-C, as specified in Annex C.1 of TS 38.151
- Test frequency: as specified in Tables C.3.1-1 and C.3.1-2 of TS 38.151
- Pass/fail limits: as defined in Annex C.4 of TS 38.151

6.2.2 Channel Model Validation Results

This clause presents channel model validation results from different labs with different types of equipment and setup vendors. All the validation results are included for comparison. Table 6.2.2-1 lists equipment and setup vendors of different labs.

Table 6.2.2-1: Equipment and setup vendors of different labs

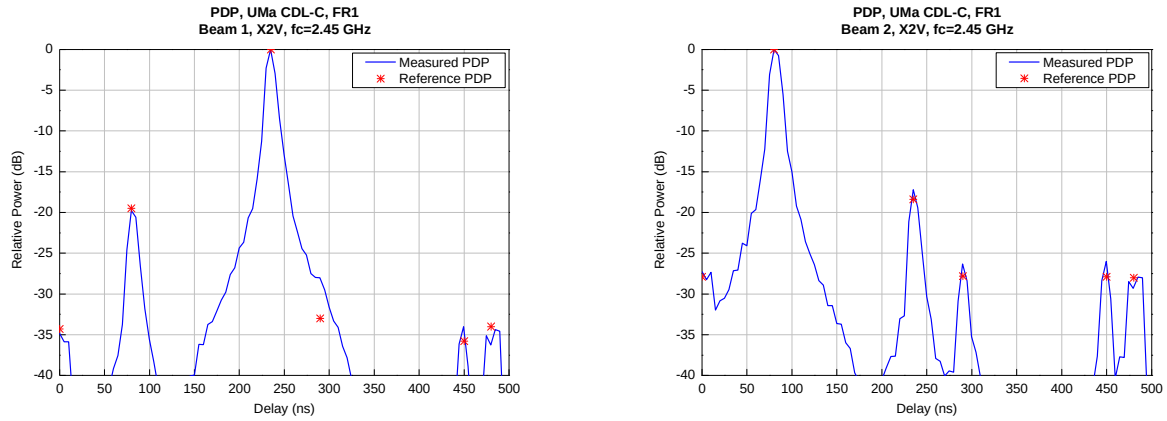
Labs	Channel Emulator	BS Emulator	System
Lab 1	Vendor A	Vendor I	Vendor 1
Lab 2	Vendor B (for bands n41, n78) Vendor A (for band n28)	Vendor II	Vendor 4
Lab 3	Vendor B	Vendor II	Vendor 1
Lab 4	Vendor A	Vendor II	Vendor 3
Lab 5	Vendor A	Vendor III	Vendor 3
Lab 6	Vendor B	Vendor I	Vendor 2
Lab 7	Vendor B	Vendor I	Vendor 1

6.2.2.1 Power Delay Profile (PDP)

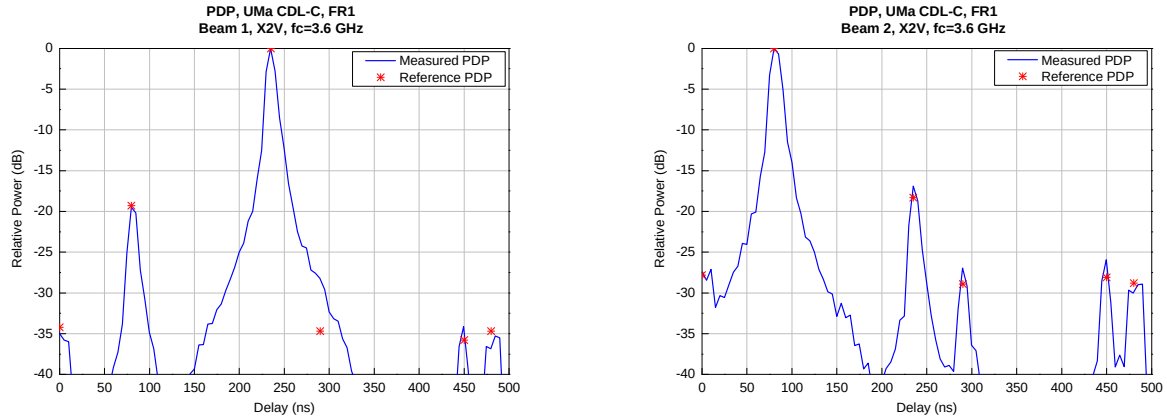
The PDP should be validated in a Beam-Specific manner. It is assumed that the beams are mapped to the inputs of the channel emulator as follows:

- Beam 1: Input 1 and Input 2
- Beam 2: Input 3 and Input 4 (CDL-C UMa only)

The PDP measurement results of UMa CDL-C for bands n41 and n78 are presented in Figures 6.2.2.1-1~5.

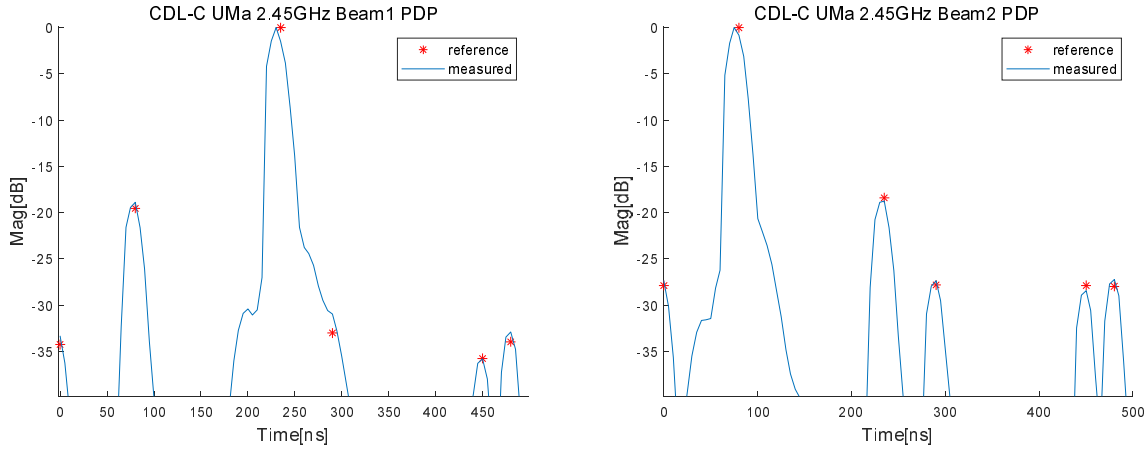


(a) Band n41

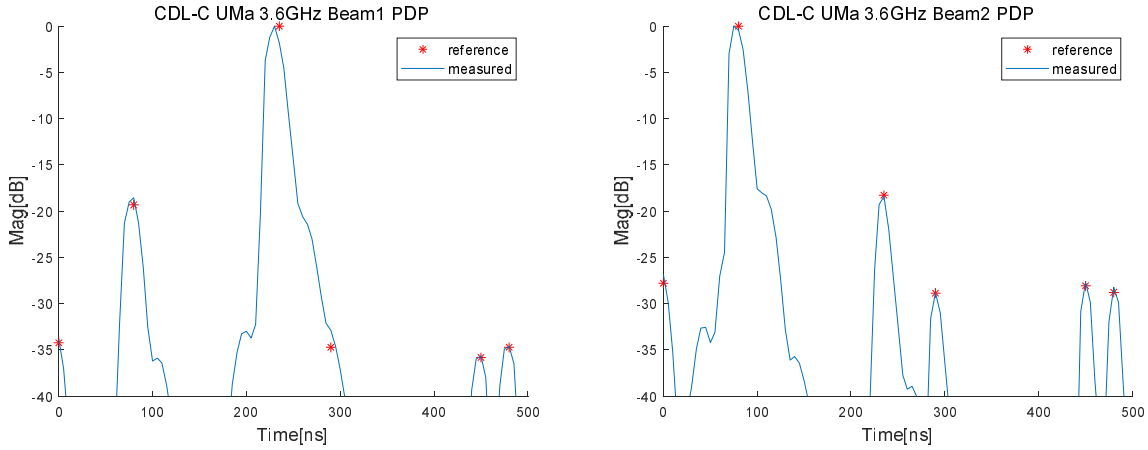


(b) Band n78

Figure 6.2.2.1-1: Lab 1: PDP measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2. CE bandwidth: 100MHz

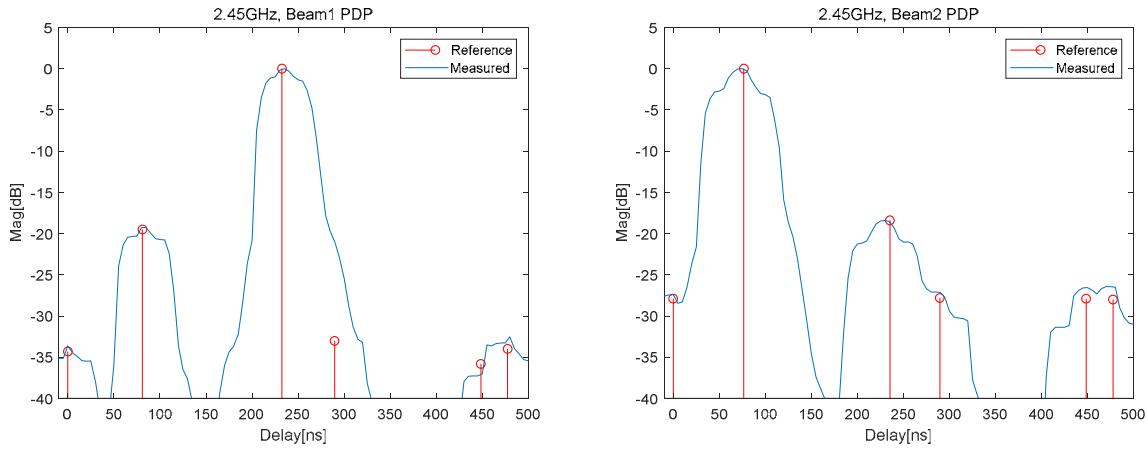


(a) Band n41

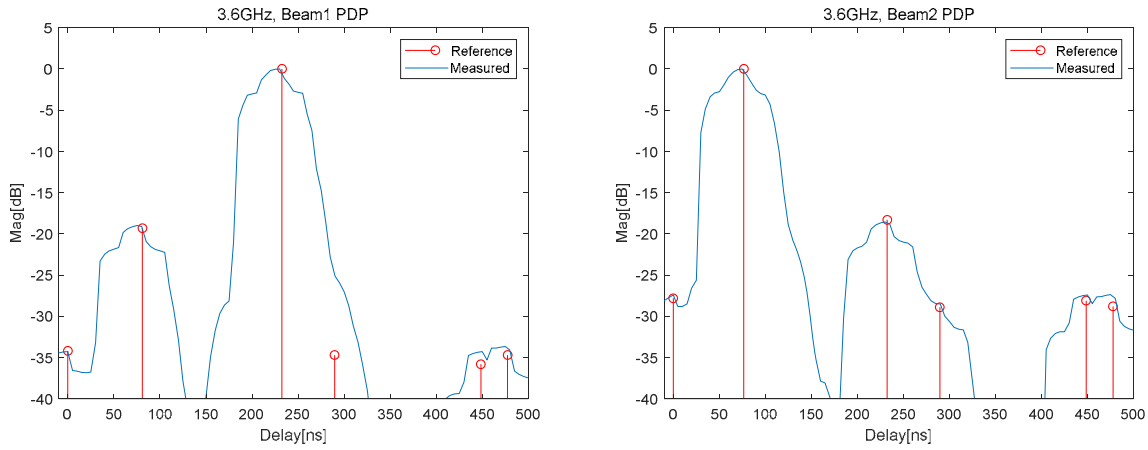


(b) Band n78

Figure 6.2.2.1-2: Lab 2: PDP measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2

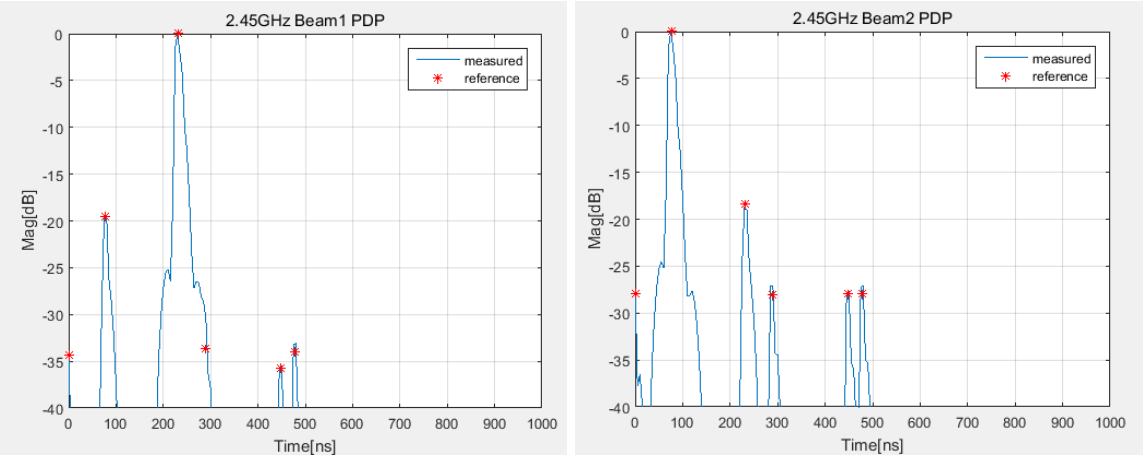


(a) Band n41

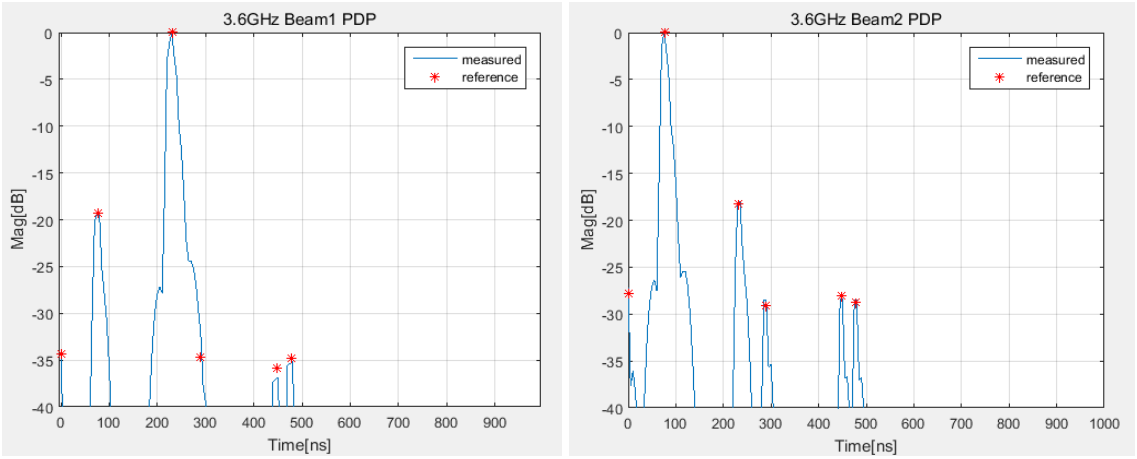


(b) Band n78

Figure 6.2.2.1-3: Lab 3: PDP measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2. CE bandwidth: 40MHz

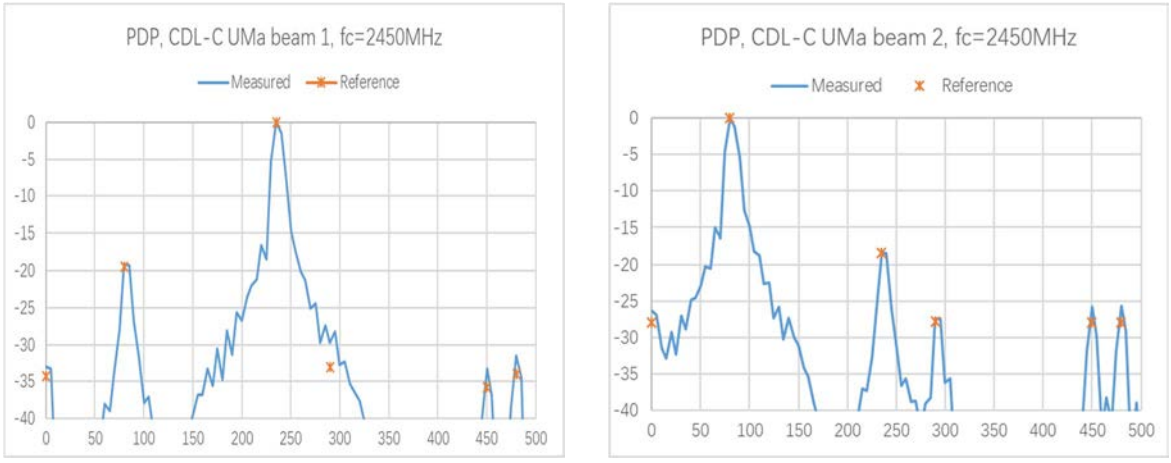


(a) Band n41

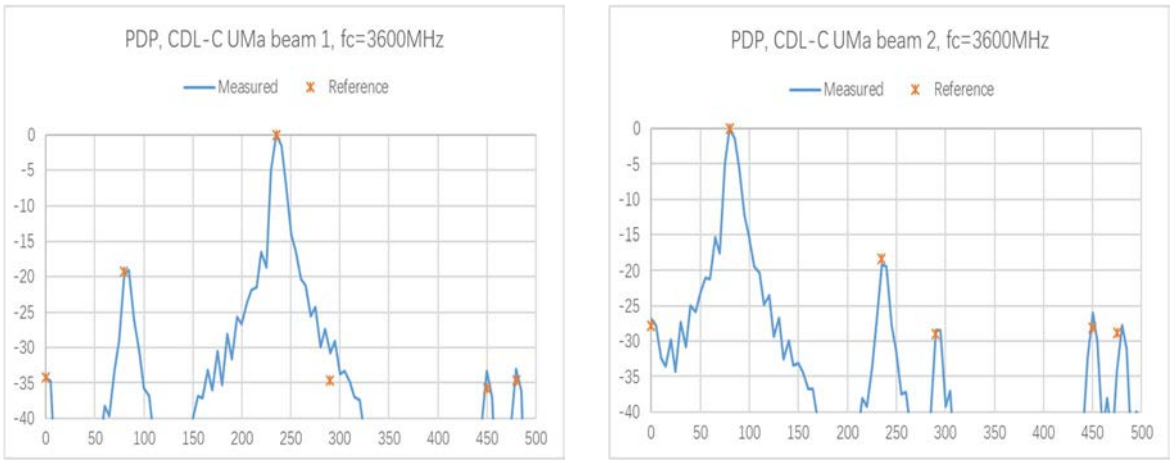


(b) Band n78

Figure 6.2.2.1-4: Lab 4: PDP measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2.

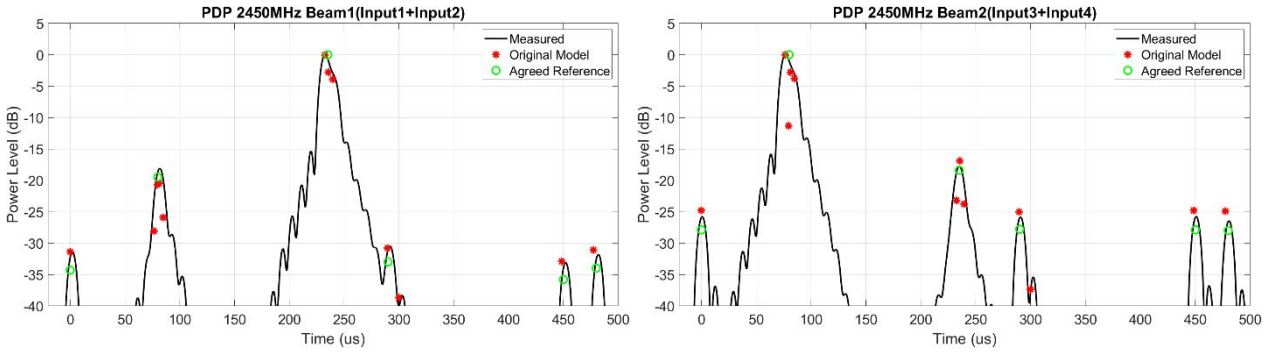


a. Band 41

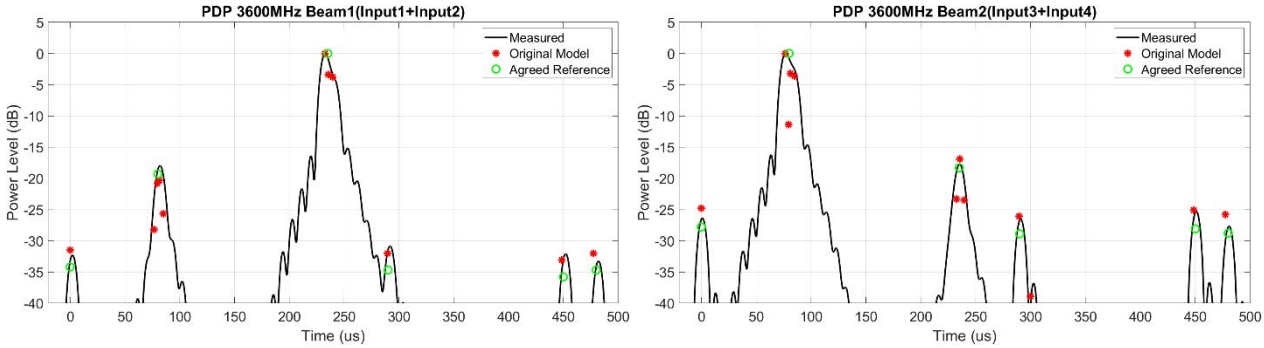


b. Band n78

Figure 6.2.2.1-5: Lab 5: PDP measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (c) Band n78, beam 1 and beam 2.



(a) Band n41



(b) Band n78

Figure 6.2.2.1-6: Lab 6: PDP measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2.

The PDP measurement results of UMi CDL-C for band n28 are presented in Figures 6.2.2.1-7~12.

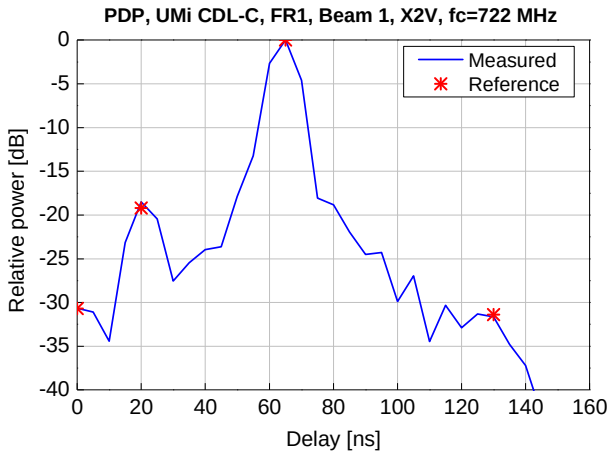


Figure 6.2.2.1-7: Lab 1: PDP measurement results for CDL-C UMi at Band n28, beam 1

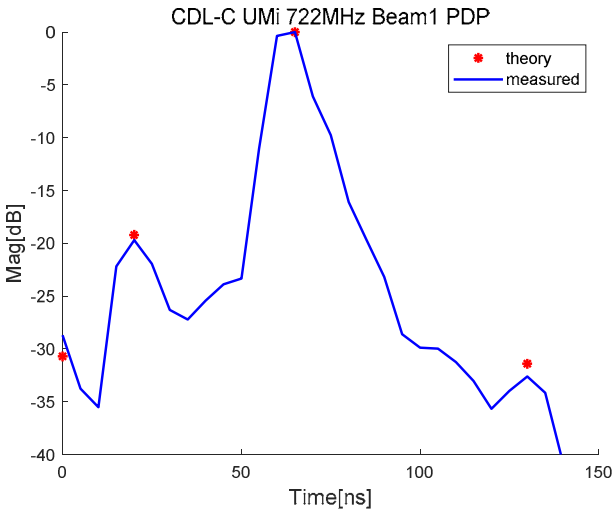


Figure 6.2.2.1-8: Lab 2: PDP measurement results for CDL-C UMi at Band n28, beam 1

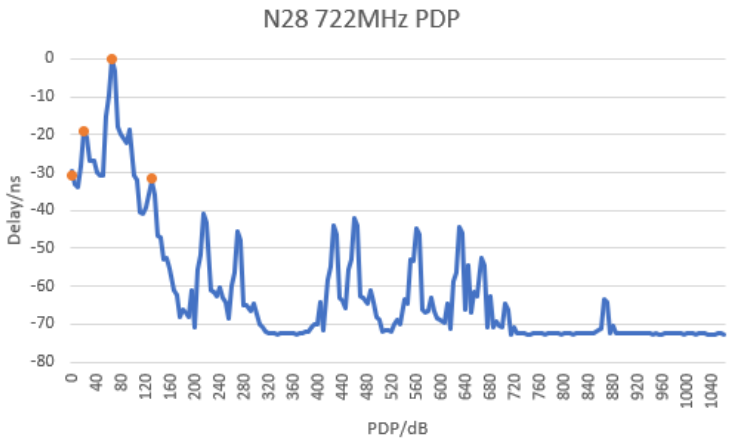


Figure 6.2.2.1-9: Lab 4: PDP measurement results for CDL-C UMi at Band n28, beam 1

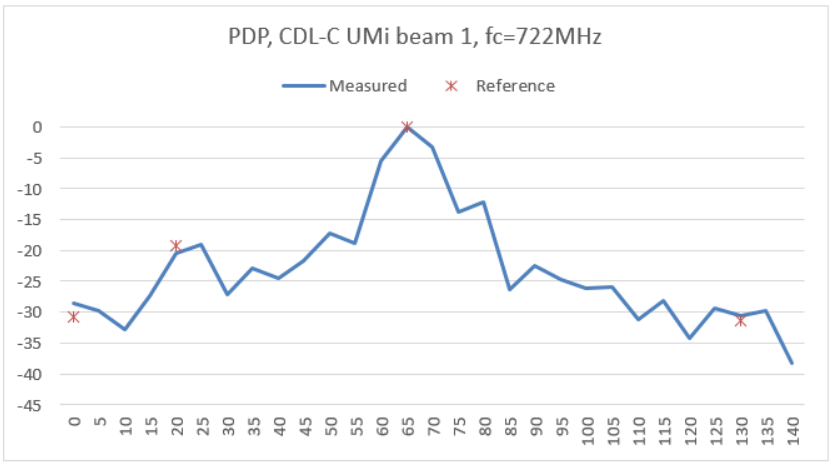


Figure 6.2.2.1-10: Lab 5: PDP measurement results for CDL-C UMi at Band n28, beam 1

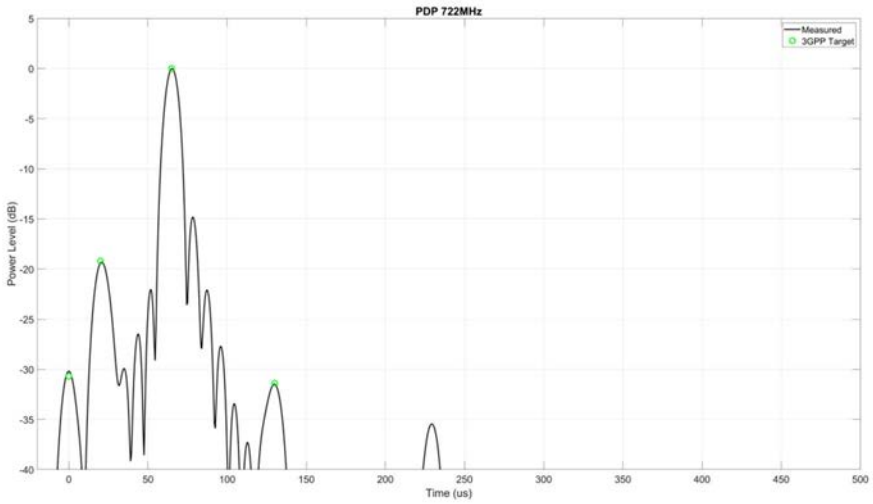


Figure 6.2.2.1-11: Lab 6: PDP measurement results for CDL-C UMi at Band n28, beam 1

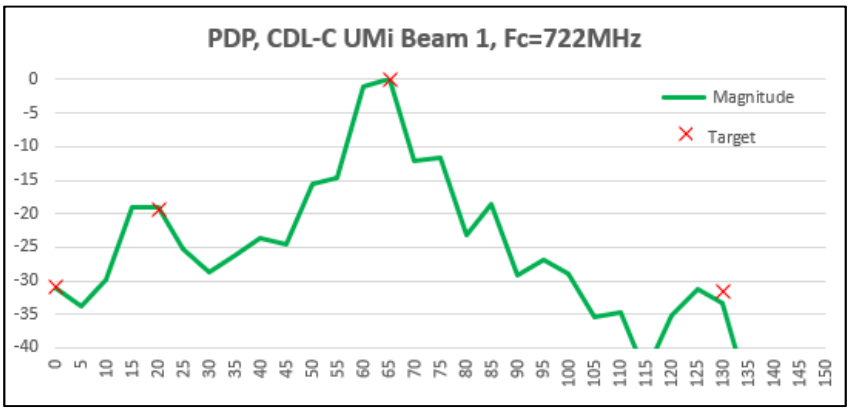


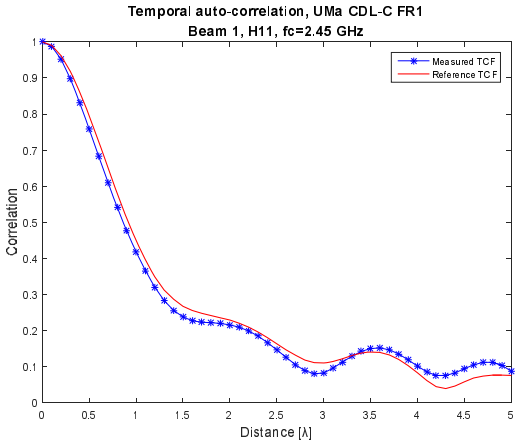
Figure 6.2.2.1-12: Lab 7: PDP measurement results for CDL-C UMi at Band n28, beam 1

6.2.2.2 Doppler/Temporal correlation

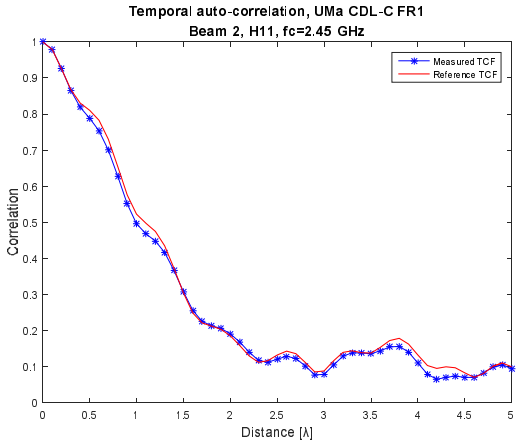
The Doppler should be validated in a Beam-Specific manner. It is assumed that the beams are mapped to the inputs of the channel emulator as follows:

- Beam 1: Input 1 and Input 2
- Beam 2: Input 3 and Input 4 (CDL-C UMa only)

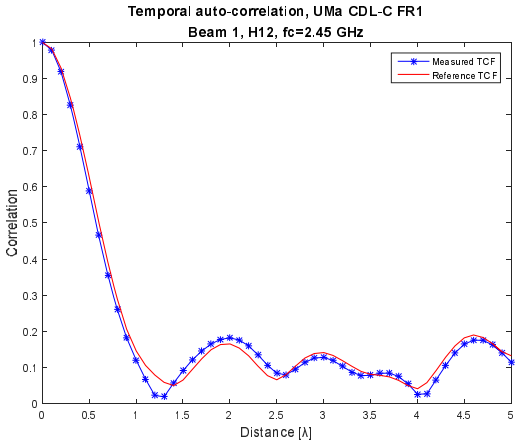
The Doppler measurement results of UMa CDL-C for bands n41 and n78 are presented in Figures 6.2.2.2-1~6.



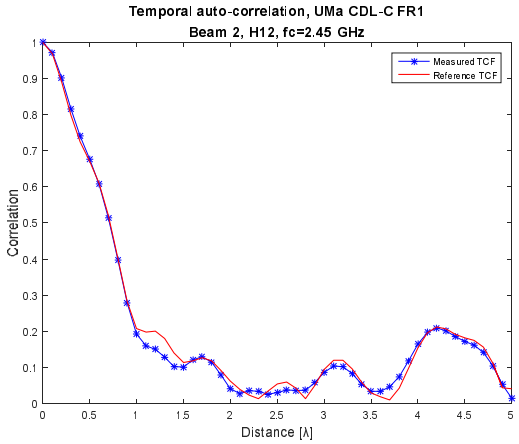
(a-1) Beam 1, H11



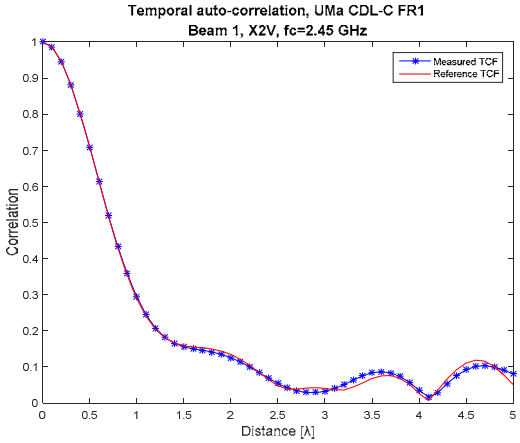
(a-2) Beam 2, H11



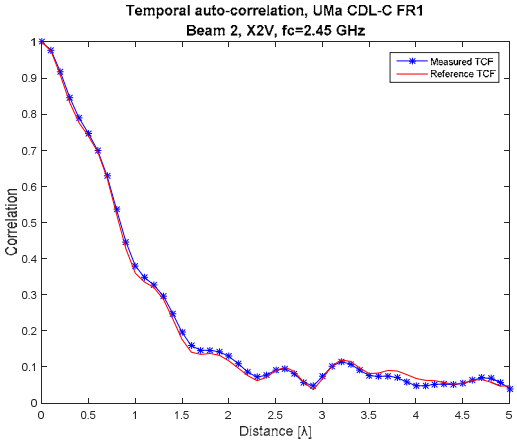
(a-3) Beam 1, H12



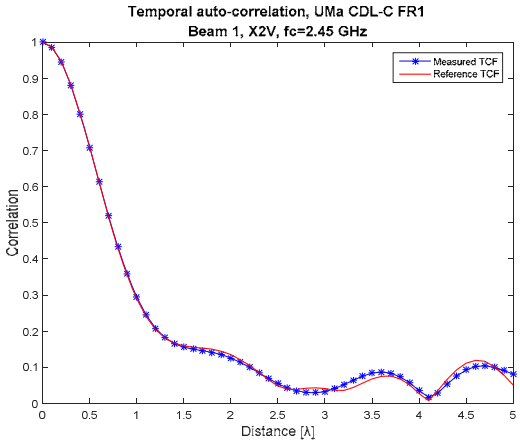
(a-4) Beam 2, H12



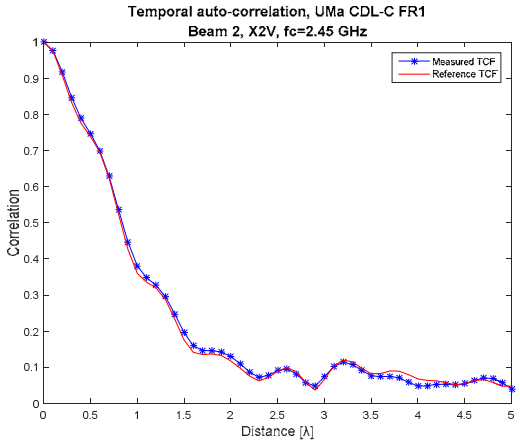
(a-5) Beam 1, H12



(a-6) Beam 2, H12

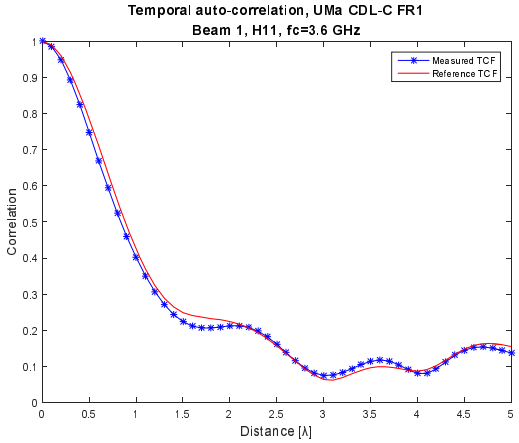


(a-7) Beam 1, X2V

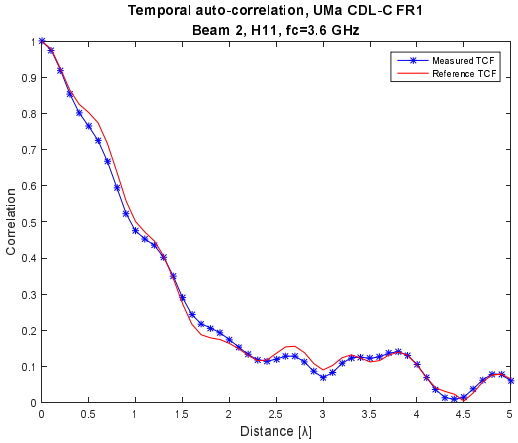


(a-8) Beam 2, X2V

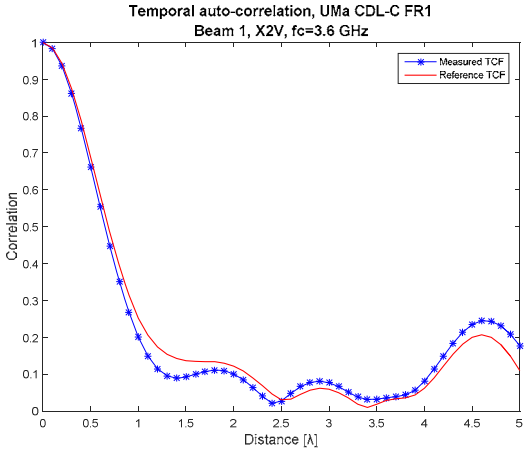
(a) Band n41



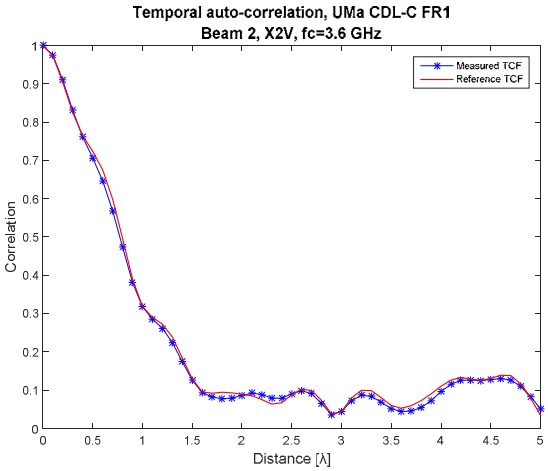
(b-1) Beam 1, H11



(b-2) Beam 2, H11



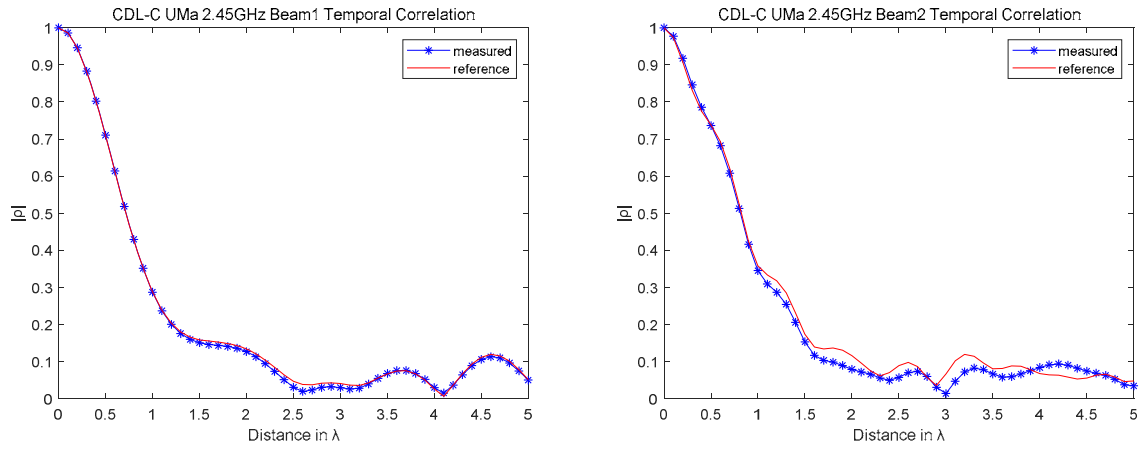
(b-3) Beam 1, X2V



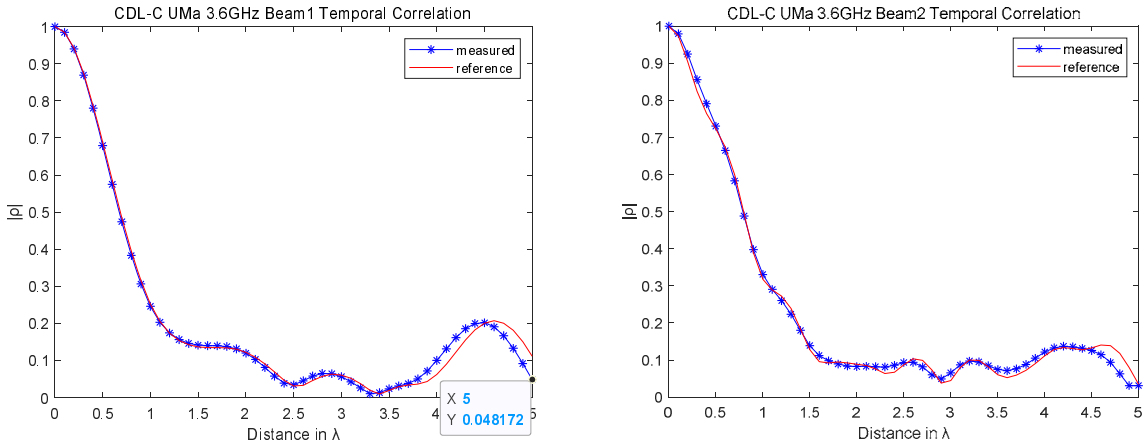
(b-4) Beam 2, X2V

(b) Band n78

Figure 6.2.2.2-1: Lab 1: Doppler measurement results for CDL-C UMa, (a) Band n41 with different beams and different polarizations; (b) Band n78 with different beams and different polarizations

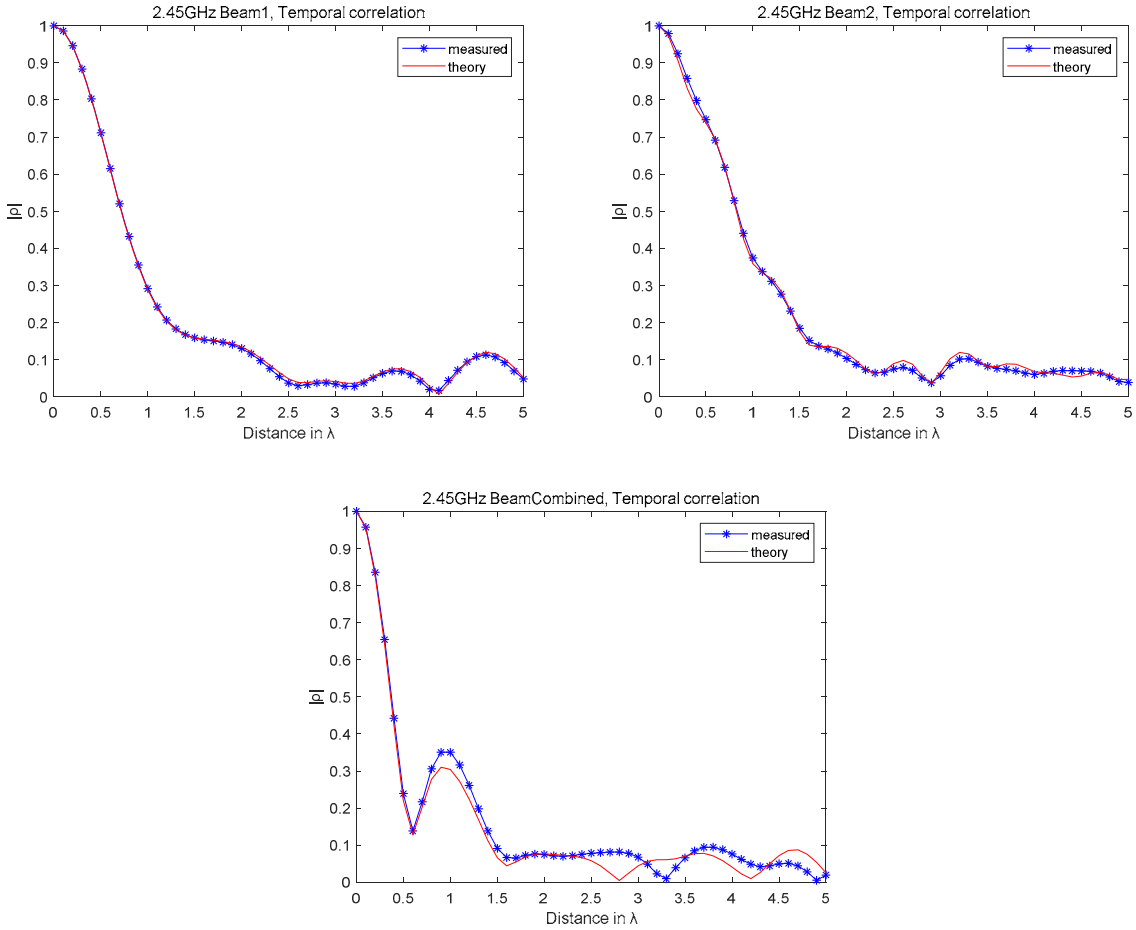


(a) Band n41

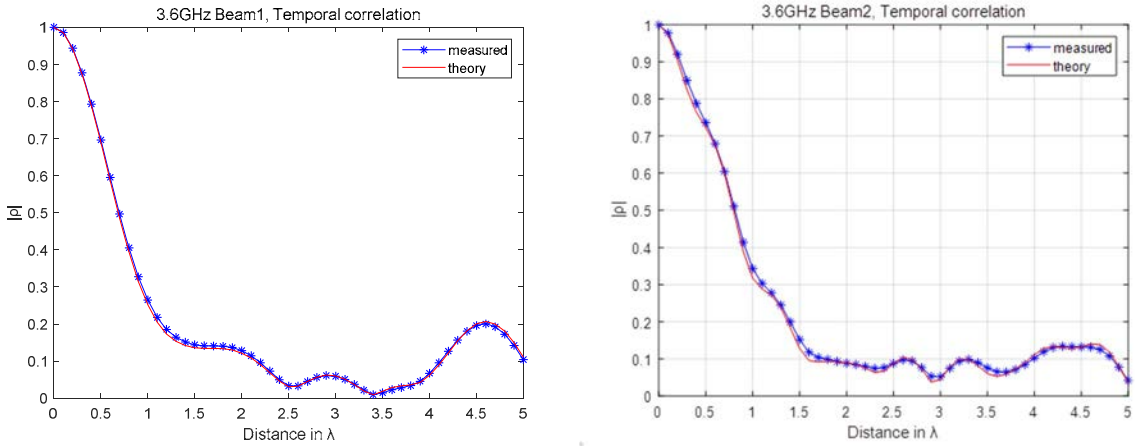


(b) Band n78

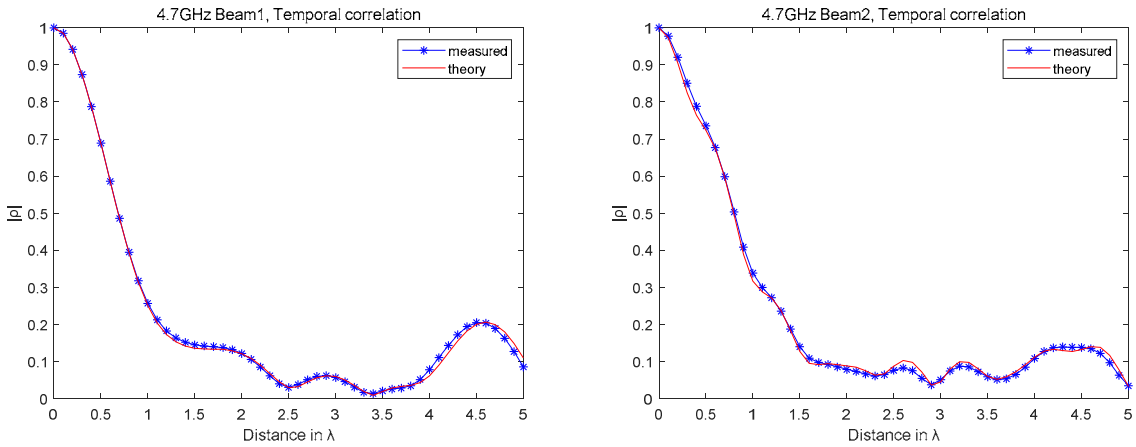
Figure 6.2.2.2-2: Lab 2: Doppler measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2



(a) Band n41

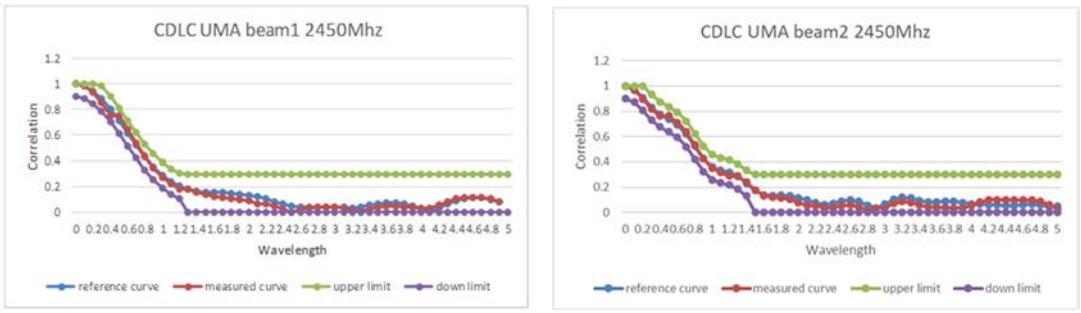


(b) Band n78

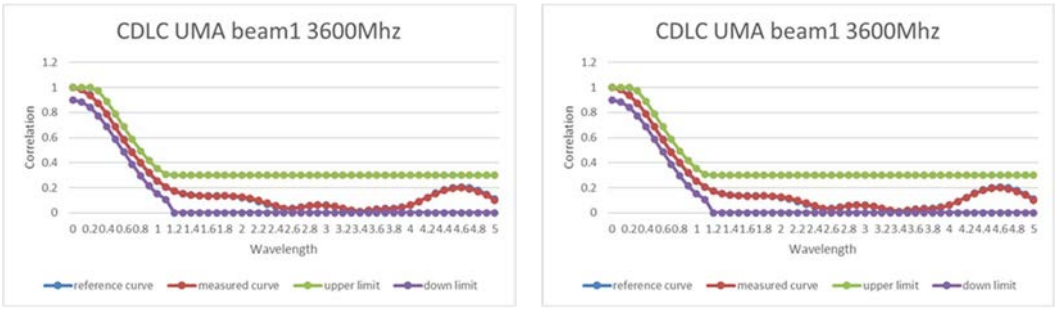


(c) Band n79

Figure 6.2.2.2-3: Lab 3: Doppler measurement results for CDL-C UMa, (a) Band n41, beam 1, beam 2, and combined beams; (b) Band n78, beam 1 and beam 2; (c) Band n79, beam 1 and beam 2

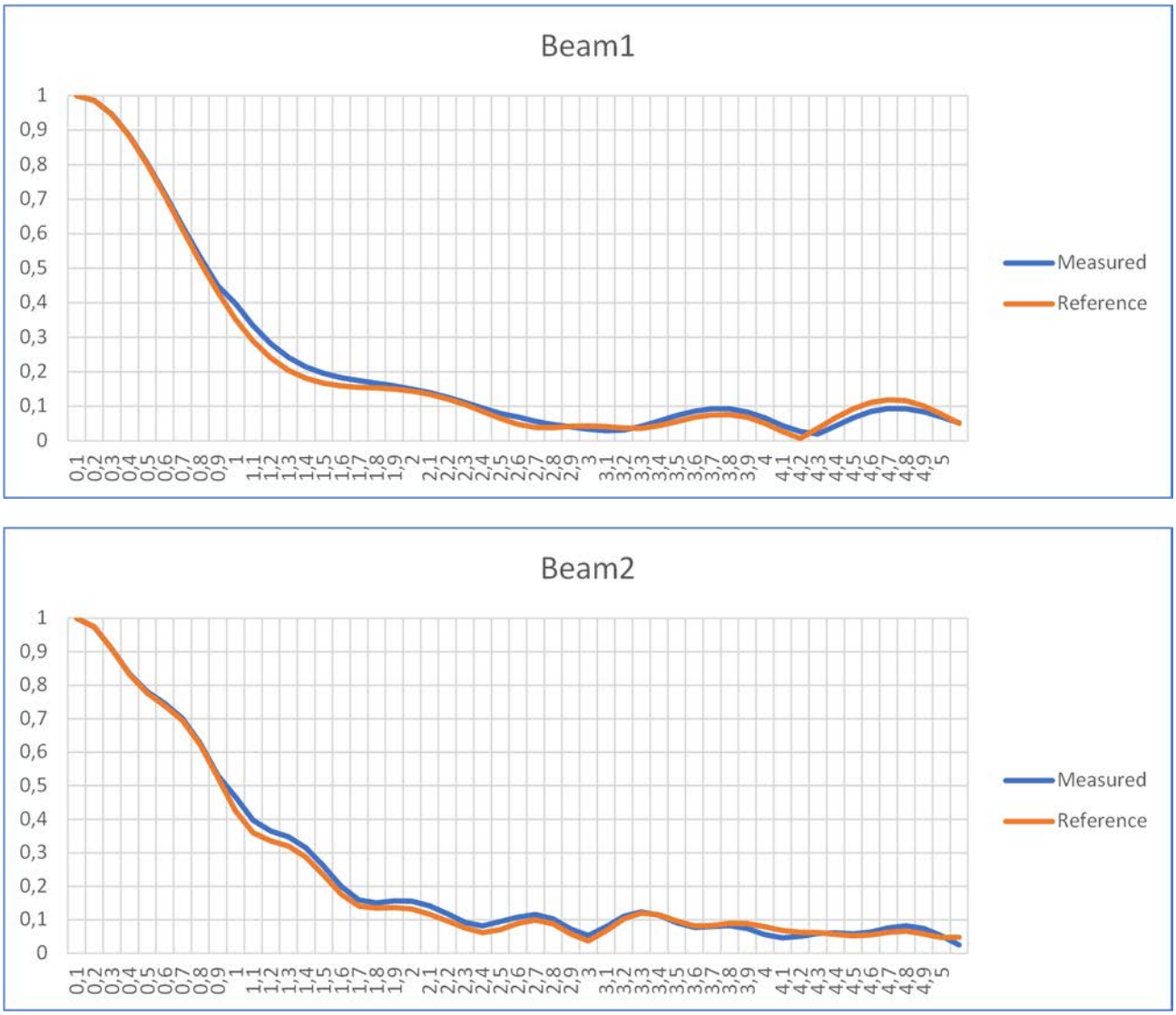


(a) Band n41

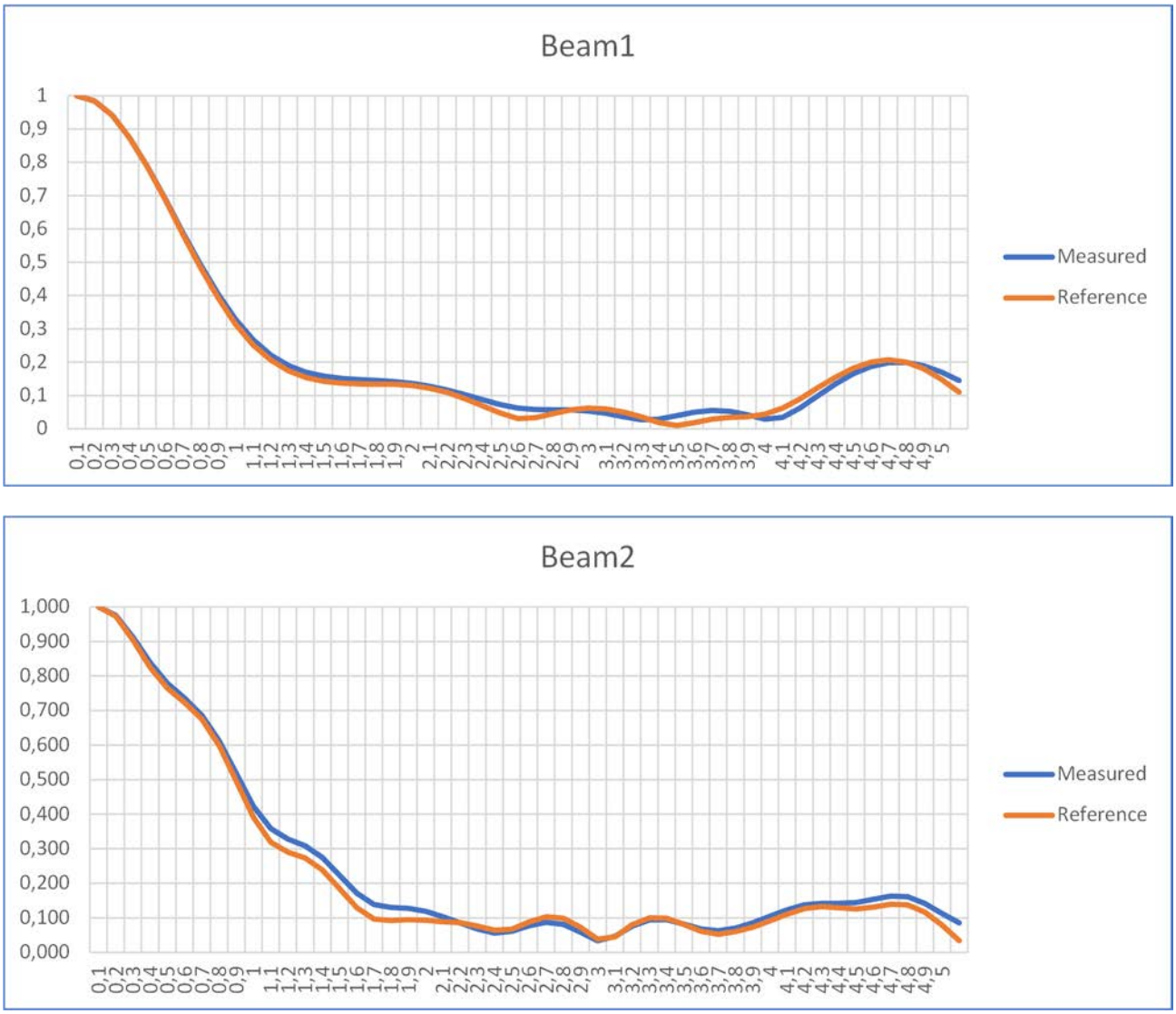


(b) Band n78

Figure 6.2.2.2-4: Lab 4: Doppler measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2

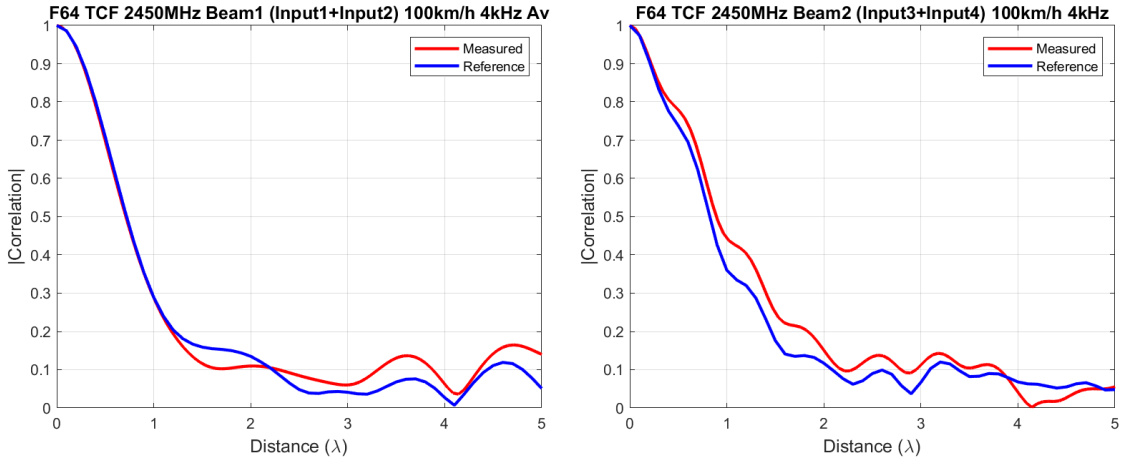

Beam1
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Measured
Reference
Beam2
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Measured
Reference

(a) Band n41

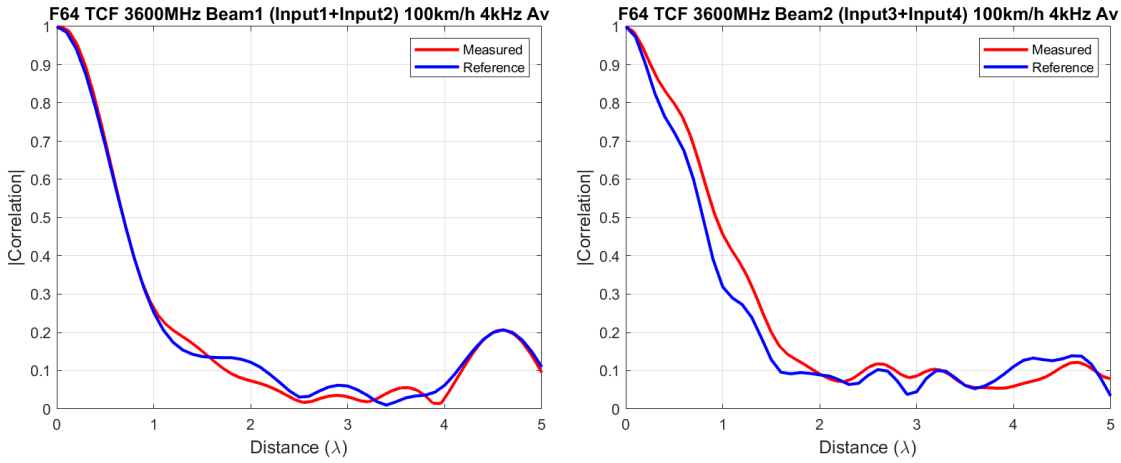


(b) Band n78

Figure 6.2.2.2-5: Lab 5: Doppler measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2



(a) Band n41



(b) Band n78

Figure 6.2.2.2-6: Lab 6: Doppler measurement results for CDL-C UMa, (a) Band n41, beam 1 and beam 2; (b) Band n78, beam 1 and beam 2

The Doppler measurement results of UMi CDL-C for band n28 are presented in Figures 6.2.2.2-7~12.

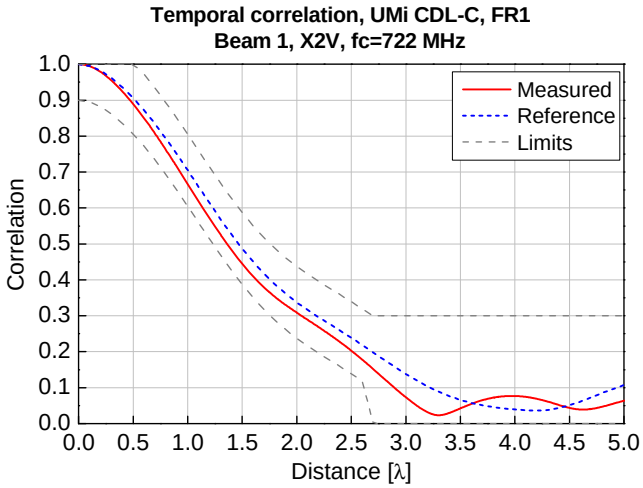


Figure 6.2.2.2-7: Lab 1: Doppler measurement results for CDL-C UMi at Band n28, beam 1

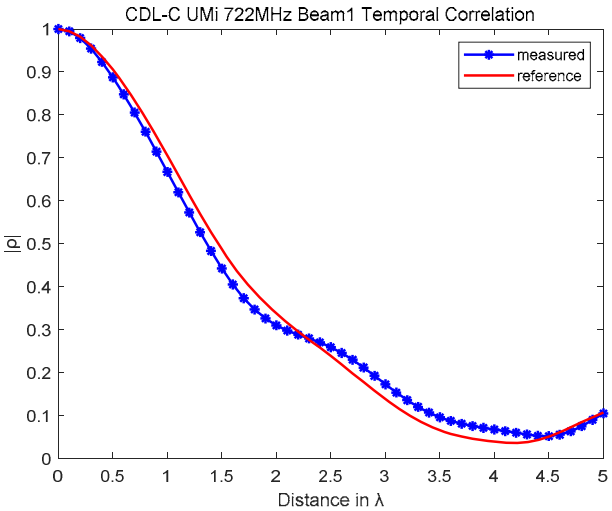


Figure 6.2.2.2-8: Lab 2: Doppler measurement results for CDL-C UMi at Band n28, beam 1

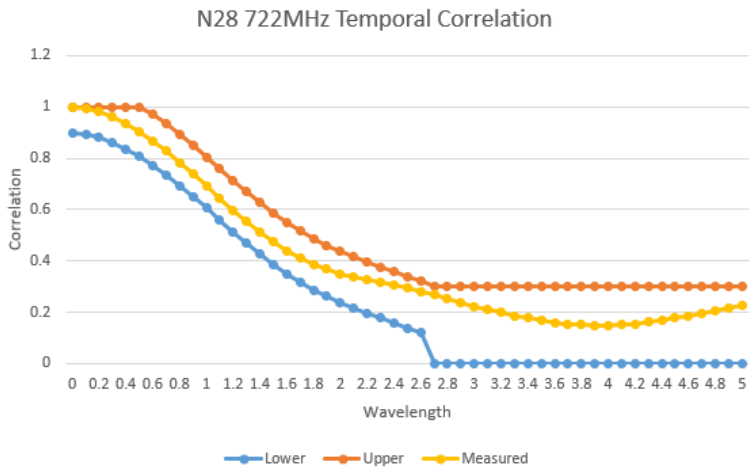


Figure 6.2.2.2-9: Lab 4: Doppler measurement results for CDL-C UMi at Band n28, beam 1

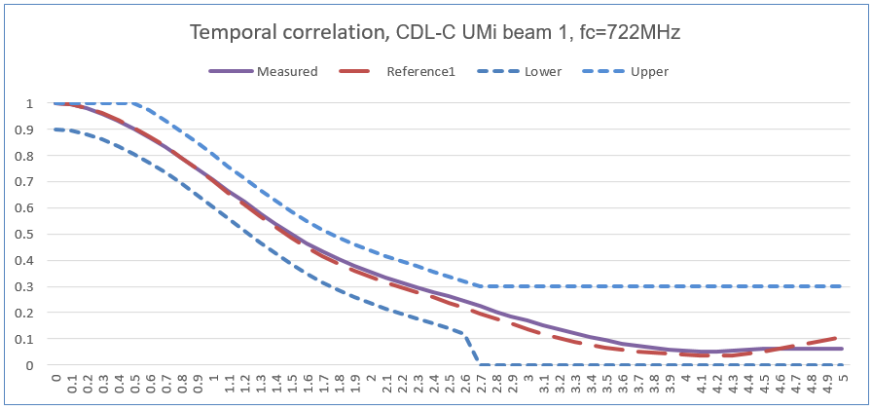


Figure 6.2.2.2-10: Lab 5: Doppler measurement results for CDL-C UMi at Band n28, beam 1

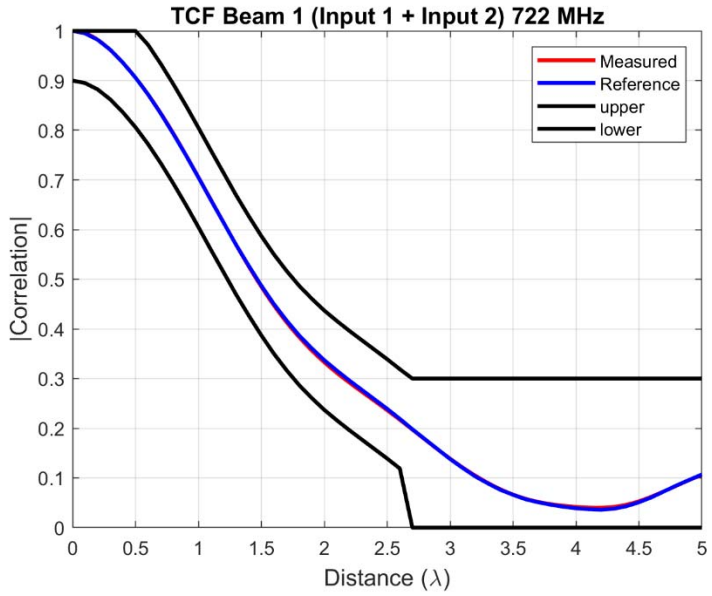


Figure 6.2.2.2-11: Lab 6: Doppler measurement results for CDL-C UMi at Band n28, beam 1

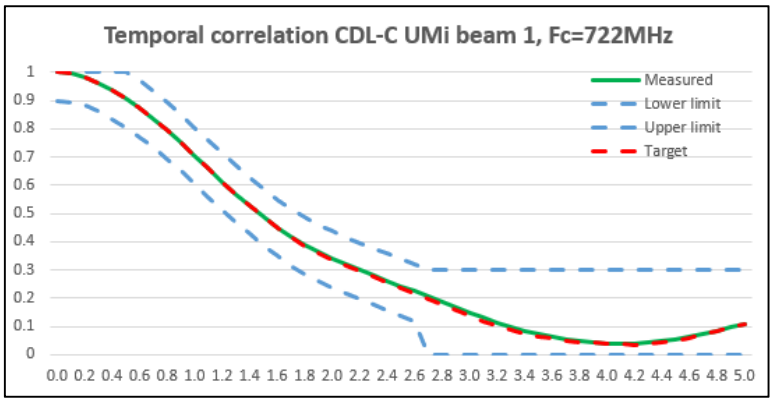


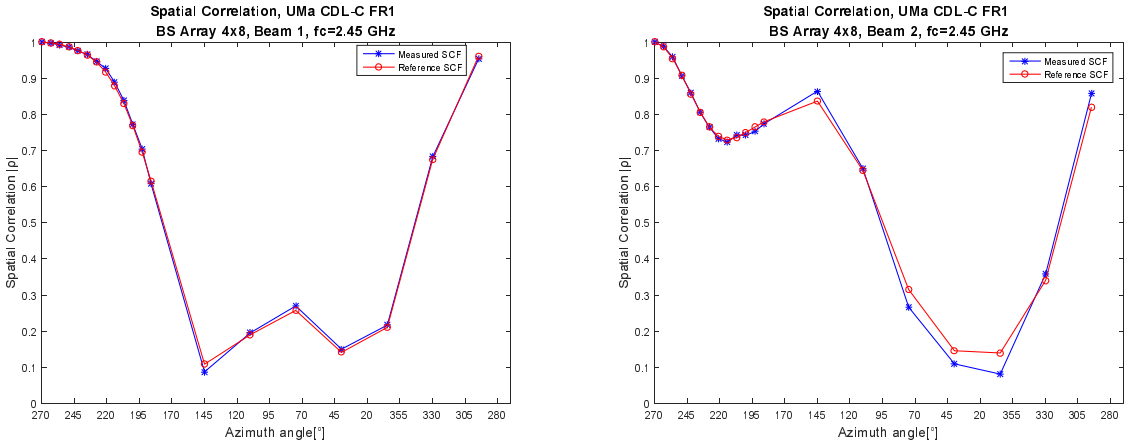
Figure 6.2.2.2-12: Lab 7: Doppler measurement results for CDL-C UMi at Band n28, beam 1

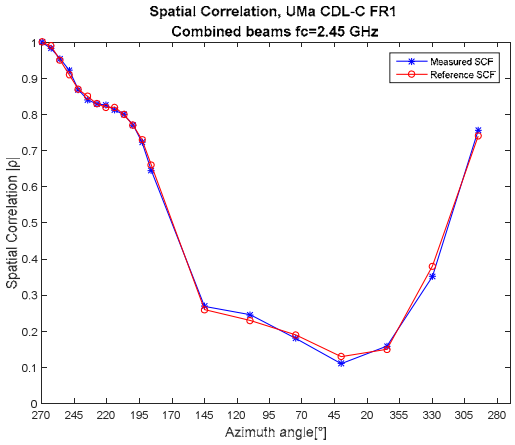
6.2.2.3 Spatial correlation

The Spatial correlation should be validated in a Beam-Combined manner. It is assumed that the beams are mapped to the inputs of the channel emulator as follows:

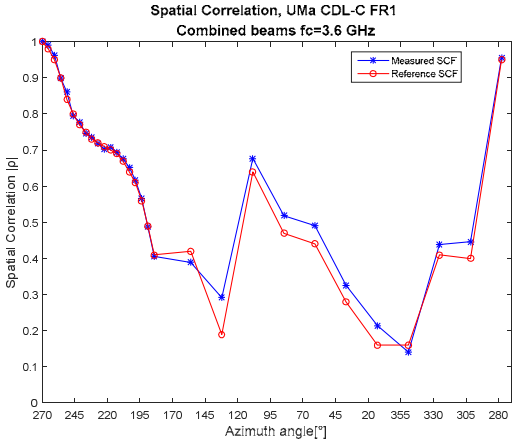
- Beam 1: Input 1 and Input 2
- Beam 2: Input 3 and Input 4 (CDL-C UMa only)
- Combined beam for CDL-C UMa: Input 1 + Input 2 + Input 3 + Input 4
- Combined beam for CDL-C UMi: Input 1 + Input 2

The Spatial correlation measurement results of UMa CDL-C for bands n41 and n78 are presented in Figures 6.2.2.3-1~6.



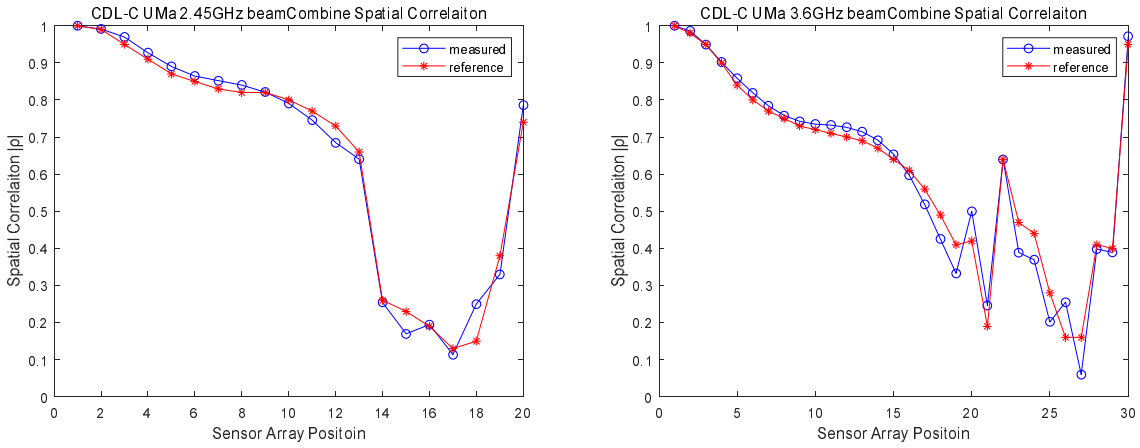


(a) Band n41



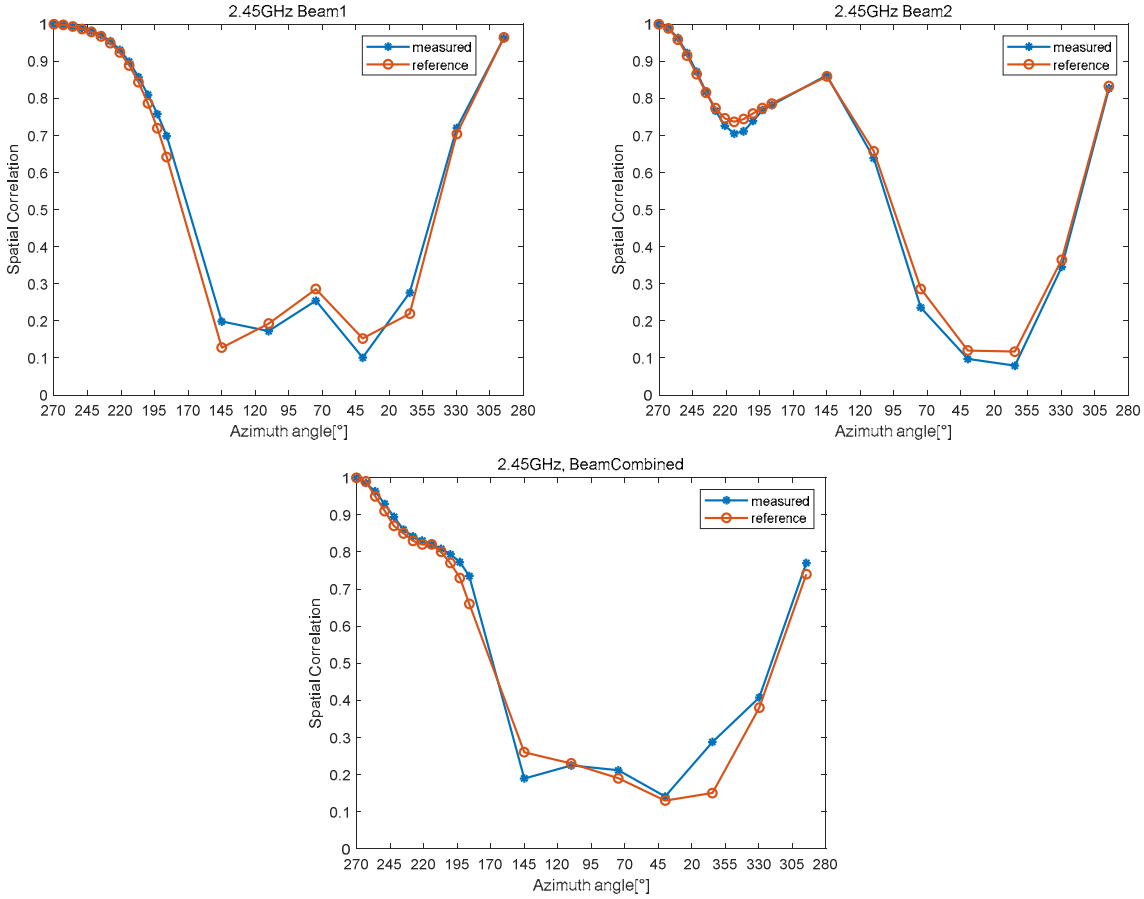
(b) Band n78

Figure 6.2.2.3-1: Lab 1: Spatial correlation measurement results for CDL-C UMa, (a) Band n41, beam 1, beam 2, and combined beams; (b) Band n78, combined beams

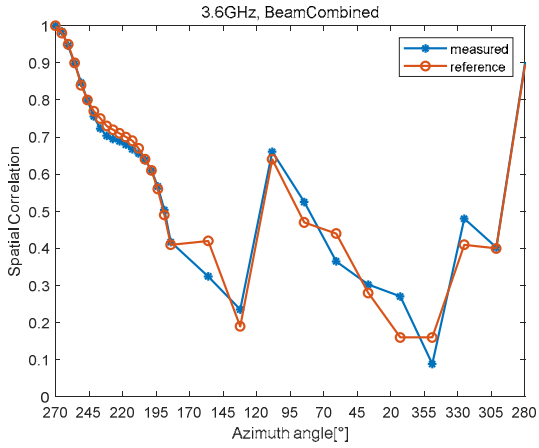


(a) Band n41 **(b) Band n78**

Figure 6.2.2.3-2: Lab 2: Spatial correlation measurement results for CDL-C UMa, (a) Band n41 with combined beams; (b) Band n78 with combined beams

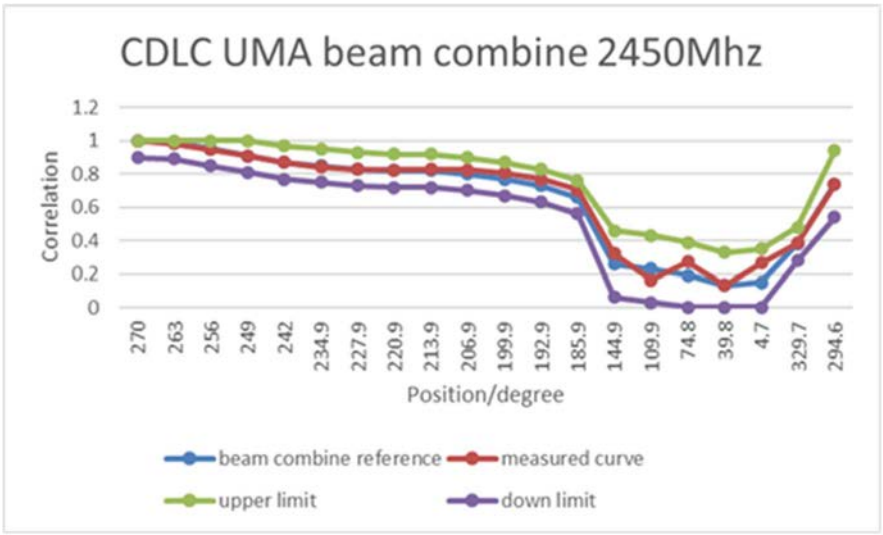


(a) Band n41

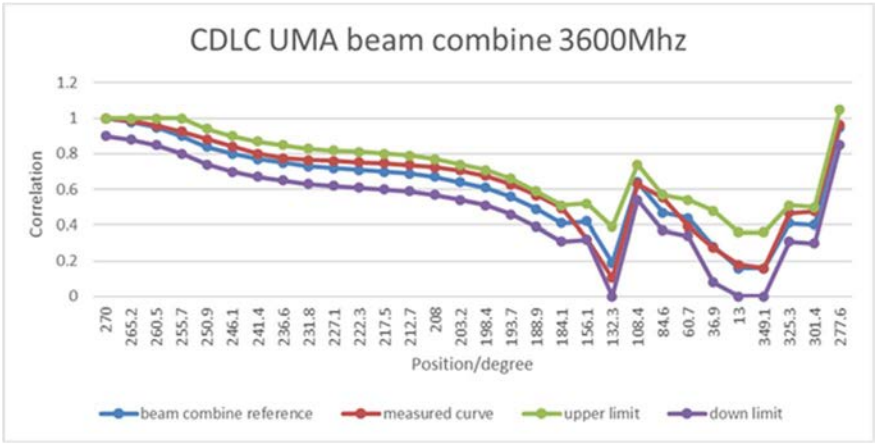


(b) Band n78

Figure 6.2.2.3-3: Lab 3: Spatial correlation measurement results for CDL-C UMa, (a) Band n41, beam 1, beam 2, and combined beams; (b) Band n78, combined beams

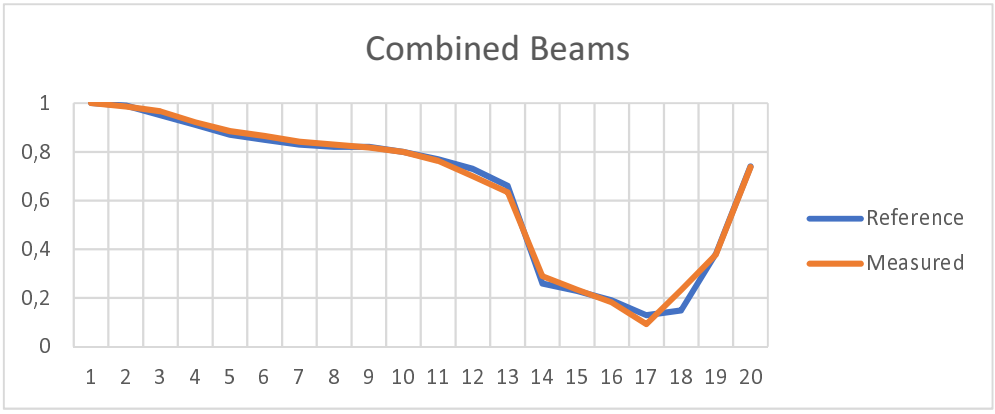


(a) Band n41

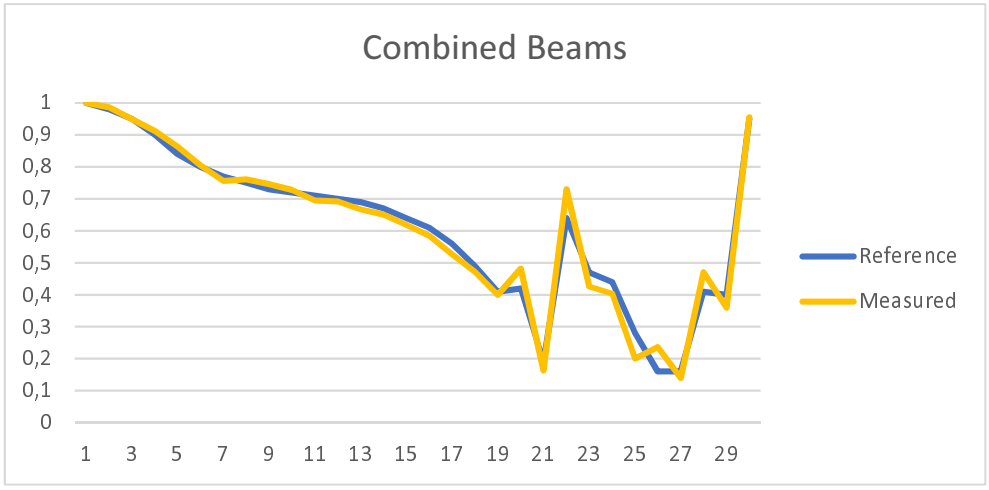


(b) Band n78

Figure 6.2.2.3-4: Lab 4: Spatial correlation measurement results for CDL-C UMa, (a) Band n41, combined beams; (b) Band n78, combined beams

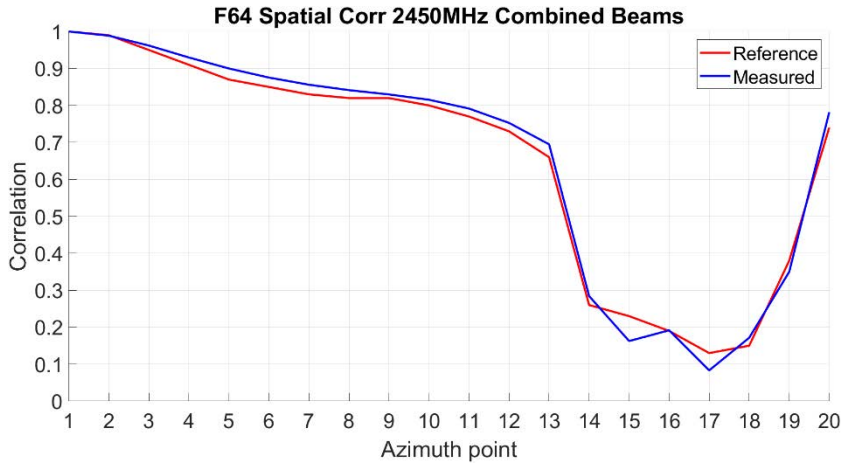


(a) Band n41

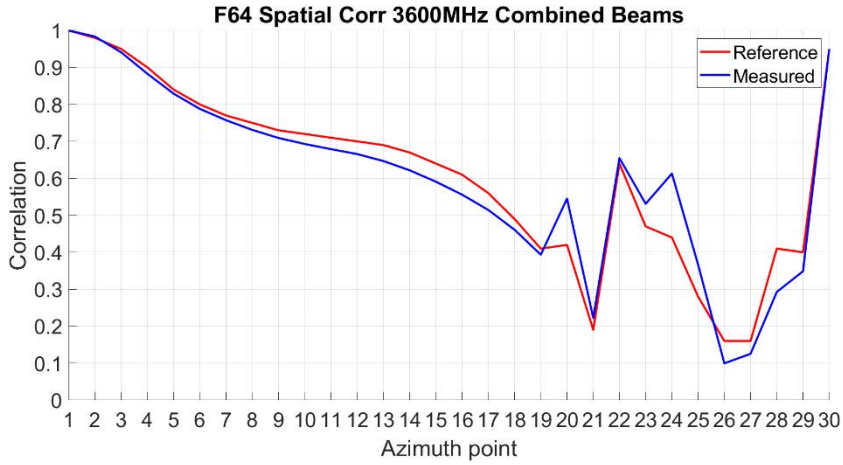


(b) Band n78

Figure 6.2.2.3-5: Lab 5: Spatial correlation measurement results for CDL-C UMa, (a) Band n41, combined beams; (b) Band n78, combined beams



(a) Band n41



(b) Band n78

Figure 6.2.2.3-6: Lab 6: Spatial correlation measurement results for CDL-C UMa, (a) Band n41, combined beams; (b) Band n78, combined beams

The Spatial correlation measurement results of UMi CDL-C for band n28 are presented in Figures 6.2.2.3-7~12.

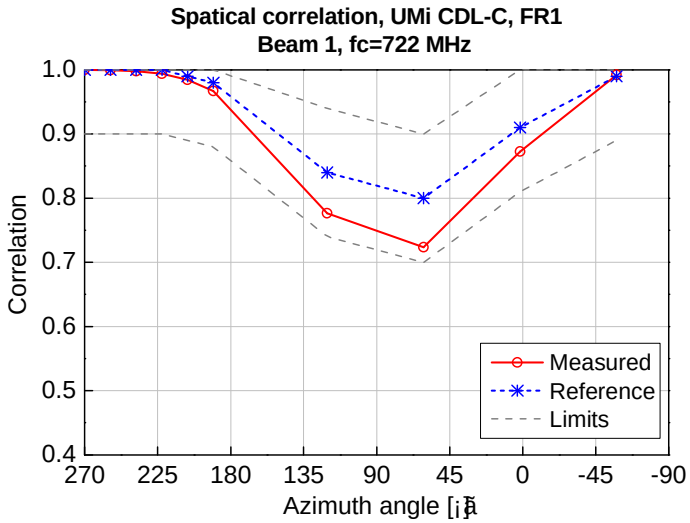


Figure 6.2.2.3-7: Lab 1: Spatial correlation measurement results for CDL-C UMi at Band n28, beam 1

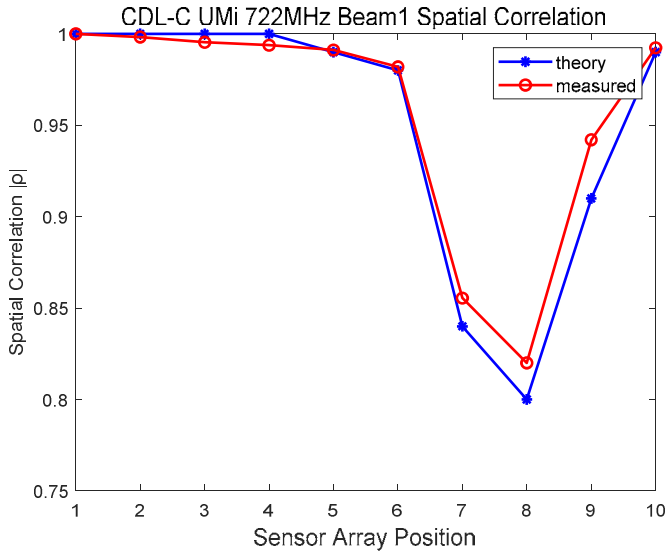


Figure 6.2.2.3-8: Lab 2: Spatial correlation measurement results for CDL-C UMi at Band n28, beam 1

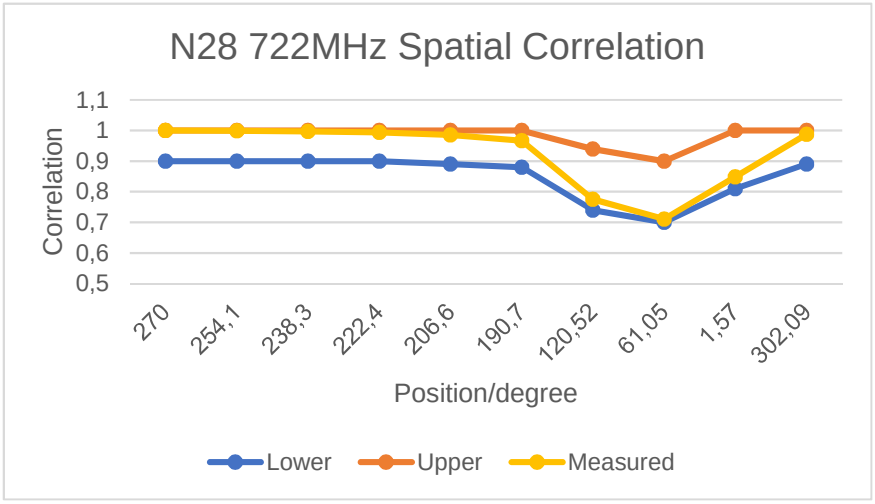


Figure 6.2.2.3-9: Lab 4: Spatial correlation measurement results for CDL-C UMi at Band n28, beam 1

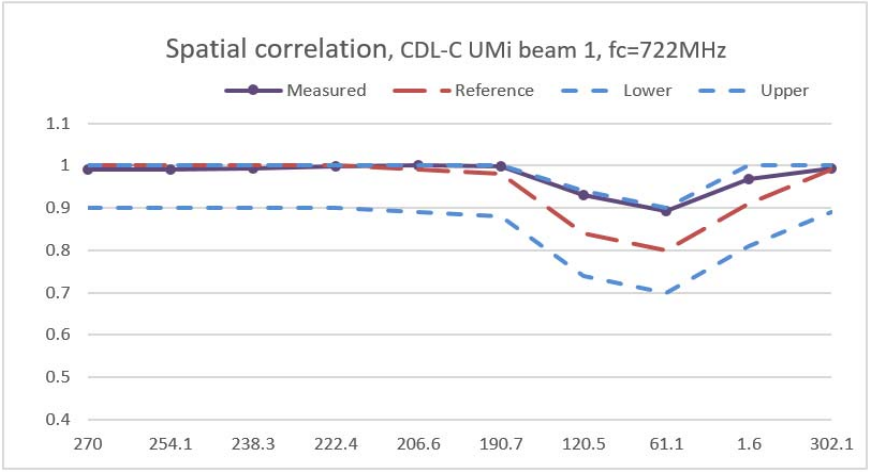


Figure 6.2.2.3-10: Lab 5: Spatial correlation measurement results for CDL-C UMi at Band n28, beam 1

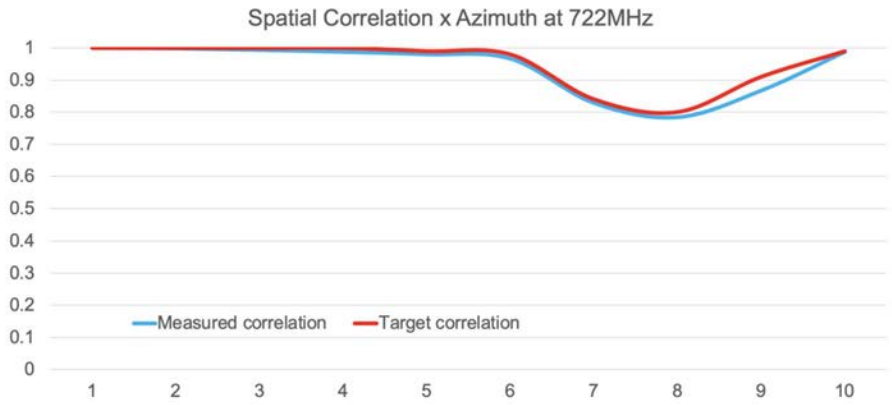


Figure 6.2.2.3-11: Lab 6: Spatial correlation measurement results for CDL-C UMi at Band n28, beam 1

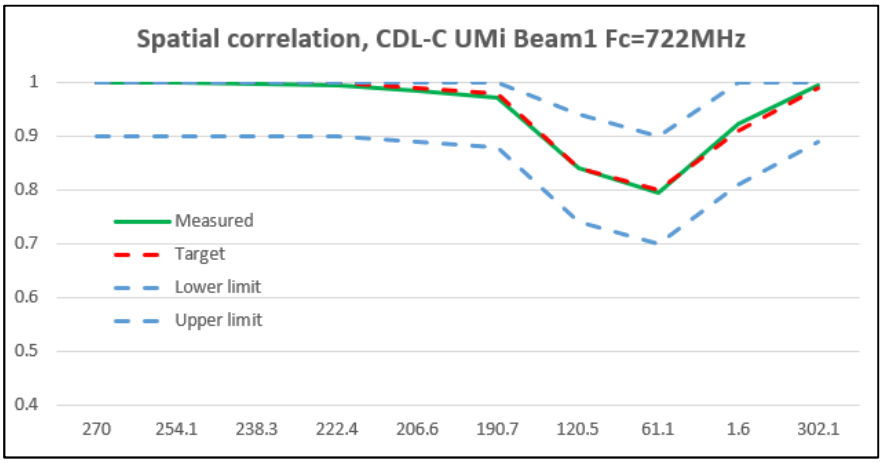


Figure 6.2.2.3-12: Lab 7: Spatial correlation measurement results for CDL-C UMi at Band n28, beam 1

6.2.2.4 Cross-polarization

The Cross-polarization should be validated in a Beam-Specific manner. It is assumed that the beams are mapped to the inputs of the channel emulator as follows:

- Beam 1: Input 1 and Input 2
- Beam 2: Input 3 and Input 4 (CDL-C UMa only)

The Cross-polarization measurement results of UMa CDL-C for bands n41 and n78 are presented in Table 6.2.2.4-1~6.

Table 6.2.2.4-1: Lab 1: Cross-polarization verification results for CDL-C UMa, bands n41 and n78

Frequency	Beam	Reference	Measurement result
fc ≤ 2.5 GHz (n41)	Beam 1	Input 1+2: V/H = 0 dB	0.44 dB
	Beam 2	Input 3+4: V/H = 0 dB	0.55 dB
fc > 2.5 GHz (n78)	Beam 1	Input 1+2: V/H = 0 dB	0.49 dB
	Beam 2	Input 3+4: V/H = 0 dB	0.58 dB

Table 6.2.2.4-2: Lab 2: Cross-polarization verification results for CDL-C UMa, bands n41 and n78

Frequency	Beam	Reference	Measurement result
fc ≤ 2.5 GHz (n41)	Beam 1	Input 1: V/H = -0.5 dB Input 2: V/H = 0.6 dB	Input 1: V/H = -0.96 dB Input 2: V/H = 0.94 dB
	Beam 2	Input 3: V/H = -0.6 dB Input 4: V/H = 0.7 dB	Input 3: V/H = -0.11 dB Input 4: V/H = 0.71 dB
fc > 2.5 GHz (n78)	Beam 1	Input 1: V/H = -0.6 dB Input 2: V/H = 0.7 dB	Input 1: V/H = -0.51 dB Input 2: V/H = 1.19 dB
	Beam 2	Input 3: V/H = -0.7 dB Input 4: V/H = 0.8 dB	Input 3: V/H = -0.41 dB Input 4: V/H = 0.47 dB

Table 6.2.2.4-3: Lab 3: Cross-polarization verification results for CDL-C UMa, bands n41 and n78

Frequency	Beam	Reference	Measurement result
fc ≤ 2.5 GHz (n41)	Beam 1	Input 1: V/H = -0.5 dB Input 2: V/H = 0.6 dB Input 1+ 2: V/H = 0 dB	Input 1: V/H = -0.98 dB Input 2: V/H = 0.63 dB Input 1+ 2: V/H = -0.21 dB
	Beam 2	Input 3: V/H = -0.6 dB Input 4: V/H = 0.7 dB Input 3+4: V/H = 0 dB	Input 3: V/H = -1.1dB Input 4: V/H = -0.07 dB Input 3+4: V/H = -0.60 dB
fc > 2.5 GHz (n78)	Beam 1	Input 1: V/H = -0.6 dB Input 2: V/H = 0.7 dB Input 1+ 2: V/H = 0 dB	Input 1: V/H = -0.45 Input 2: V/H = 1.32 dB Input 1+ 2: V/H = 0.39 dB
	Beam 2	Input 3: V/H = -0.7 dB Input 4: V/H = 0.8 dB Input 3+4: V/H = 0 dB	Input 3: V/H = 0.25 Input 4: V/H = 1.61 Input 3+4: V/H = 0.91 dB

Table 6.2.2.4-4: Lab 4: Cross-polarization verification results for CDL-C UMa, bands n41 and n78

Frequency	Beam	Reference	Measurement result
fc ≤ 2.5 GHz (n41)	Beam 1	Input 1: V/H = -0.5 dB Input 2: V/H = 0.6 dB Input 1+ 2: V/H = 0 dB	Input 1: V/H = -0.48 dB Input 2: V/H = 0.57 dB Input 1+ 2: V/H = 0.36 dB
	Beam 2	Input 3: V/H = -0.6 dB Input 4: V/H = 0.7 dB Input 3+4: V/H = 0 dB	Input 3: V/H = -0.69 dB Input 4: V/H = 0.71 dB Input 3+4: V/H = 0.52 dB
fc > 2.5 GHz (n78)	Beam 1	Input 1: V/H = -0.6 dB Input 2: V/H = 0.7 dB Input 1+ 2: V/H = 0 dB	Input 1: V/H = -0.48 Input 2: V/H = 0.99 dB Input 1+ 2: V/H = 0.47 dB
	Beam 2	Input 3: V/H = -0.7 dB Input 4: V/H = 0.8 dB Input 3+4: V/H = 0 dB	Input 3: V/H = -0.34 Input 4: V/H = 1.13 Input 3+4: V/H = 0.66 dB

Table 6.2.2.4-5: Lab 5: Cross-polarization verification results for CDL-C UMa, band n41 and n78

Frequency	Beam	Reference	Measurement result
fc ≤ 2.5 GHz (n41)	Beam 1	Input 1+2: V/H = 0 dB	0.38 dB
	Beam 2	Input 3+4: V/H = 0 dB	0.12 dB
fc > 2.5 GHz (n78)	Beam 1	Input 1+2: V/H = 0 dB	-0.25dB
	Beam 2	Input 3+4: V/H = 0 dB	0.34dB

Table 6.2.2.4-6: Lab 6: Cross-polarization verification results for CDL-C UMa, bands n41 and n78

Frequency	Beam	Reference	Measurement result
fc ≤ 2.5 GHz (n41)	Beam 1	Input 1+2: V/H = 0 dB	-0.6555 dB
	Beam 2	Input 3+4: V/H = 0 dB	-0.0676 dB
fc > 2.5 GHz (n78)	Beam 1	Input 1+2: V/H = 0 dB	0.5064 dB
	Beam 2	Input 3+4: V/H = 0 dB	0.6414 dB

The Cross-polarization measurement results of UMi CDL-C for band n428 are presented in Table 6.2.2.4-7~12.

Table 6.2.2.4-7: Lab 1: Cross-polarization verification results for CDL-C UMi, Band n28

Frequency	Beam	Reference	Measurement result	Pass/fail limit
fc = 722 MHz	Beam 1	Input 1+2: V/H = 0 dB	V/H = -0.08 dB	±1 dB

Table 6.2.2.4-8: Lab 2: Cross-polarization verification results for CDL-C UMi, Band n28

Frequency	Beam	Reference	Measurement result	Pass/fail limit
fc = 722 MHz	Beam 1	Input 1+2: V/H = 0 dB	V/H = 0.15 dB	±1 dB

Table 6.2.2.4-9: Lab 4: Cross-polarization verification results for CDL-C UMi, Band n28

Frequency	Beam	Reference	Measurement result	Pass/fail limit
fc = 722 MHz	Beam 1	Input 1+2: V/H = 0 dB	V/H = -0.14 dB	±1 dB

Table 6.2.2.4-10: Lab 5: Cross-polarization verification results for CDL-C UMi, Band n28

Frequency	Beam	Reference	Measurement result	Pass/fail limit
fc = 722 MHz	Beam 1	Input 1+2: V/H = 0 dB	V/H = -0.09 dB	±1 dB

Table 6.2.2.4-11: Lab 6: Cross-polarization verification results for CDL-C UMi, Band n28

Frequency	Beam	Reference	Measurement result	Pass/fail limit
fc = 722 MHz	Beam 1	Input 1+2: V/H = 0 dB	V/H = 0.59 dB	±1 dB

Table 6.2.2.4-12: Lab 7: Cross-polarization verification results for CDL-C UMi, Band n28

Frequency	Beam	Reference	Measurement result	Pass/fail limit
fc = 722 MHz	Beam 1	Input 1+2: V/H = 0 dB	V/H = -0.71 dB	±1 dB

6.2.2.5 Power validation

The Power validation results of UMa CDL-C for bands n41 and n78 are presented in Table 6.2.2.5-1~3.

Table 6.2.2.5-1: Lab 1: Power validation results for CDL-C UMa, bands n41 and n78 (Unit: dBm/30kHz)

CDL-C UMa, n41, 2592.99 MHz				
Measured V power	**Measured H power**	**Measured total power**	**Expected**	**Delta**
-79.6244	-79.5959	-76.5999	-77	0.4001
CDL-C UMa, n78, 3549.99 MHz				
Measured V power	**Measured H power**	**Measured total power**	**Expected**	**Delta**
-79.9988	-79.6618	-76.8168	-77	0.1832

Table 6.2.2.5-2: Lab 4: Power validation results for CDL-C UMa, bands n41 and n78 (Unit: dBm/30kHz)

Frequency	Measured power	Target power	Delta	Pass/fail limit
CDL-C UMa, n41 2592.99 MHz	-80.8630082	-80.6	-0.26	±1.5 dB
CDL-C UMa, n78 3549.99 MHz	-80.9320026	-80.6	-0.33	

Table 6.2.2.5-3: Lab 5: Power validation results for CDL-C UMa, bands n41 and n78 (Unit: dBm/30kHz)

Frequency	Measured power	Target power	Delta	Pass/fail limit
fc = 2593 MHz	-51.17	-50.22	-0.94dB	±1.5dB
fc = 3550 MHz	-51.76	-51.69	-0.07 dB	±1.5dB

Table 6.2.2.5-3 (a): Lab 6: Power validation results for CDL-C UMa, band n41 (Unit: dBm/30kHz)

V component [dBm]	-56.48
Interferer V component [dBm]	-84.73
H component [dBm]	-57.14
Interferer H component [dBm]	-85.16
V component compensated [dBm]	-52.55
Interferer V component comp [dBm]	-80.80
H component comp [dBm]	-52.71
Interferer H component comp [dBm]	-80.73
Target Power [dBm/20MHz]	-50.00
Measured Total Power [dBm/20MHz]	-49.62
Delta Power [dB]	0.38
Target SIR [dBm/20 MHz]	
Measured SIR [dB]	28.13
Delta SIR [dB]	28.13
Target V/H radio [dB]	0.00
Measured V/H [dB]	0.16
Delta V/H [dB]	0.16

Table 6.2.2.5-3 (b): Lab 6: Power validation results for CDL-C UMa, band n78 (Unit: dBm/30kHz)

V component [dBm]	-57.05
Interferer V component [dBm]	-85.51
H component [dBm]	-58.59
Interferer H component [dBm]	-86.36
V component compensated [dBm]	-53.31
Interferer V component comp [dBm]	-81.78
H component comp [dBm]	-53.85
Interferer H component comp [dBm]	-81.63
Target Power [dBm/20MHz]	-50.00
Measured Total Power [dBm/20MHz]	-50.56
Delta Power [dB]	-0.56
Target SIR [dBm/20 MHz]	
Measured SIR [dB]	28.13
Delta SIR [dB]	28.13
Target V/H radio [dB]	0.00
Measured V/H [dB]	0.54
Delta V/H [dB]	0.54

The Power validation results of UMi CDL-C for band n28 are presented in Table 6.2.2.5-4~9.

Table 6.2.2.5-4: Lab 1: Power validation results for CDL-C UMi, Band n28 (Unit: dBm/15kHz)

Frequency	Measured V power	Measured H power	Measured total power	Target power	Delta	Pass/fail limit
780.5 MHz	-83.1288	-82.9819	-80.0444	-80	-0.0444	±1.5 dB

Table 6.2.2.5-5: Lab 2: Power validation results for CDL-C UMi, Band n28 (Unit: dBm/15kHz)

Band	Setting Power	Measured Power V component	Measured Power H component	Measured Power	Delta	Pass/fail limit
n28	-80	-83.432	-83.036	-80.219	0.219	±1.5dB

Table 6.2.2.5-6: Lab 4: Power validation results for CDL-C UMi, Band n28 (Unit: dBm/15kHz)

Frequency	Measured power	Target power	Delta	Pass/fail limit
780.5 MHz	-70.6609811	-70.6	-0.06098109	±1.5 dB
	-80.5325084	-80.6	0.067491565	
	-90.116428	-90.6	0.483572032	

Table 6.2.2.5-7: Lab 5: Power validation results for CDL-C UMi, Band n28 (Unit: dBm/15kHz)

Frequency	Measured power	Target power	Delta	Pass/fail limit
780.5 MHz	-52.62	-52.12	0.5	-52.62

Table 6.2.2.5-8: Lab 6: Power validation results for CDL-C UMi, Band n28 (Unit: dBm/15kHz)

Frequency	Measured power	Target power	Delta	Pass/fail limit
780.5 MHz	-49.64	-50.00	0.36	±1.5 dB

Table 6.2.2.5-9: Lab 7: Power validation results for CDL-C UMi, Band n28 (Unit: dBm/15kHz)

Frequency	Measured power	Target power	Delta	Pass/fail limit
780.5 MHz	NA	NA	0.0002	±1.5 dB

6.3 Verification of Channel Model implementation of FR2

6.3.1 Framework

This clause describes how to proceed Channel Model Validation for FR2 MIMO OTA with 3D-MPAC system.

1. The channel model validation measurements shall be performed as described in Annex D.3 of TS 38.151, including:

- Power delay profile (PDP)
- Doppler/Temporal correlation
- PAS similarity percentage (PSP)
- Cross-polarization
- Power validation

2. Channel model: FR2 UMi CDL-C, as specified in Annex D.1 of TS 38.151
3. Test frequency: as specified in Tables D.3.1-1 of TS 38.151
4. Pass/fail limits: as defined in Annex D.2 of TS 38.151

6.3.2 Channel Model Validation Results

This clause presents channel model validation results from different labs with different types of equipment and setup vendors. All the validation results are included for comparison. Table 6.3.2-1 lists equipment and setup vendors of different labs.

Table 6.3.2-1: Equipment and setup vendors of different labs (FR2)

Labs	Channel Emulator	BS Simulator	System
Lab A	Vendor 1	Vendor A	Vendor I
Lab B	Vendor 2	TBA	Vendor II
Lab C	Vendor 1	TBA	Vendor III
Lab D	Vendor 2	TBA	Vendor II
Lab E	Vendor 1	TBA	Vendor III
Lab F	Vendor 1	TBA	Vendor IV

6.3.2.1 Power Delay Profile (PDP)

The PDP measurement results of UMi CDL-C for bands n261/28GHz are presented in Figures 6.3.2.1-1~6.

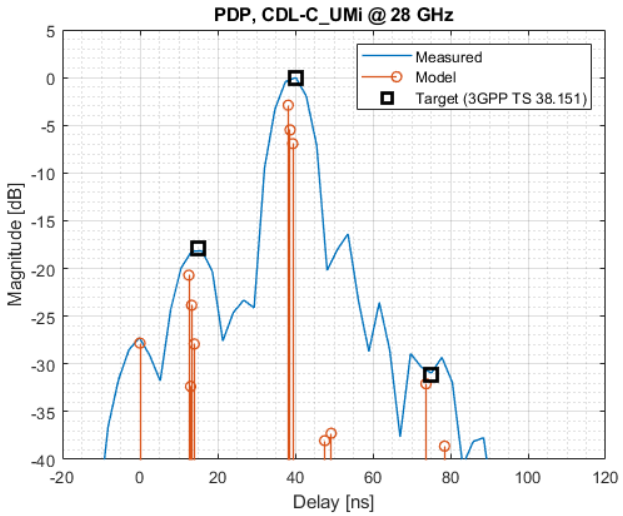


Figure 6.3.2.1-1: Lab A: PDP measurement results for CDL-C UMi at 28GHz

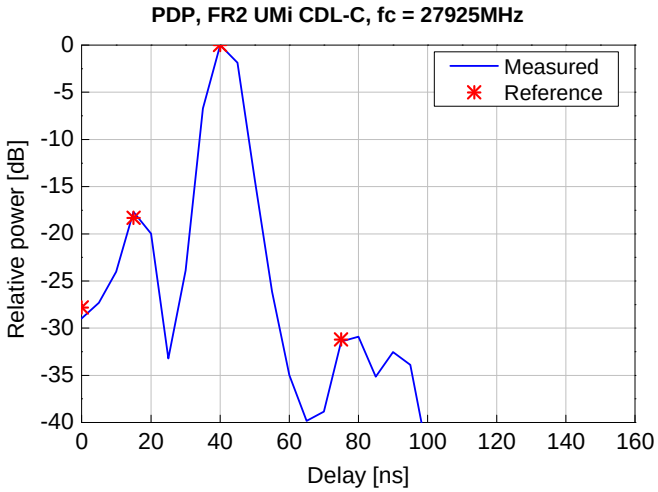


Figure 6.3.2.1-2: Lab B: PDP measurement results for CDL-C UMi at band n261

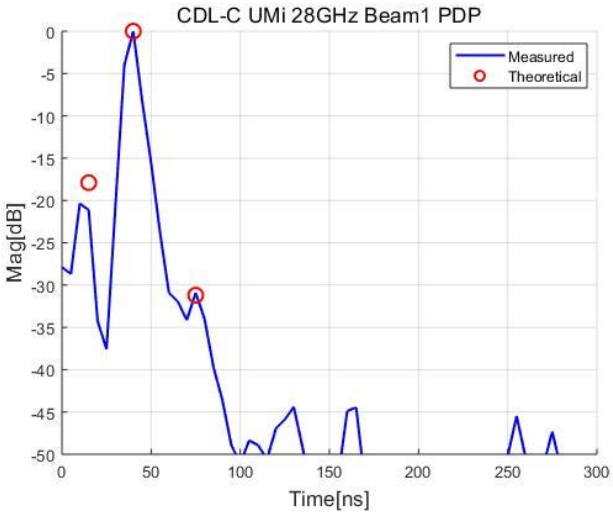


Figure 6.3.2.1-3: Lab C: PDP measurement results for CDL-C UMi at band n261

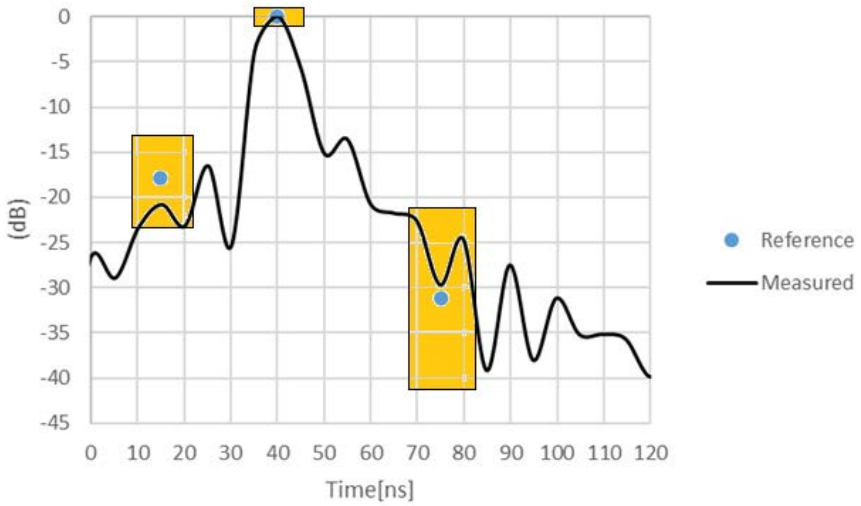


Figure 6.3.2.1-4: Lab D: PDP measurement results for CDL-C UMi at band n261

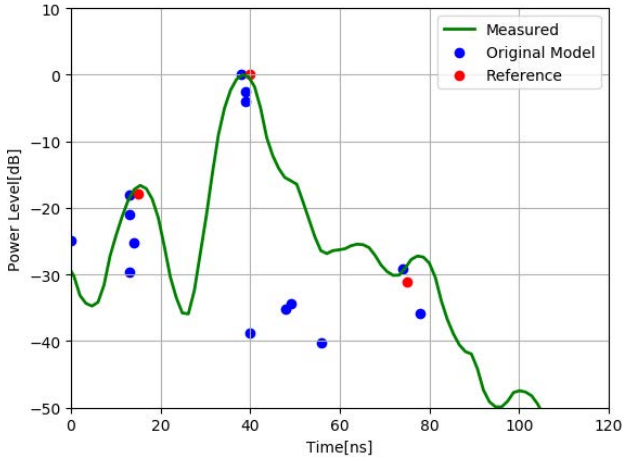


Figure 6.3.2.1-5 Lab E: PDP measurement results for CDL-C UMi at band n261

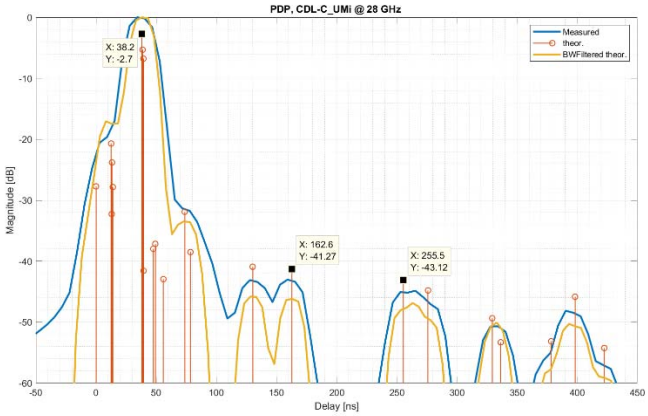


Figure 6.3.2.1-6 Lab F: PDP measurement results for CDL-C UMi at 28GHz

6.3.2.2 Doppler/Temporal correlation

The Doppler measurement results of UMi CDL-C for bands n261/28GHz are presented in Figures 6.3.2.2-1~6.

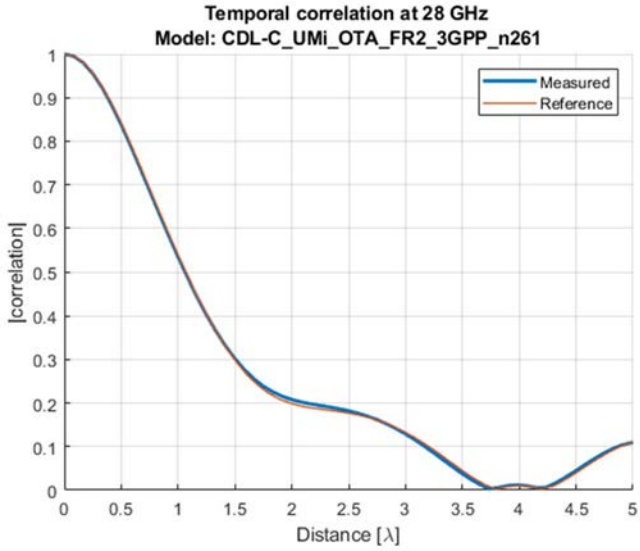


Figure 6.3.2.2-1: Lab A: Doppler measurement results for CDL-C UMi at band n261

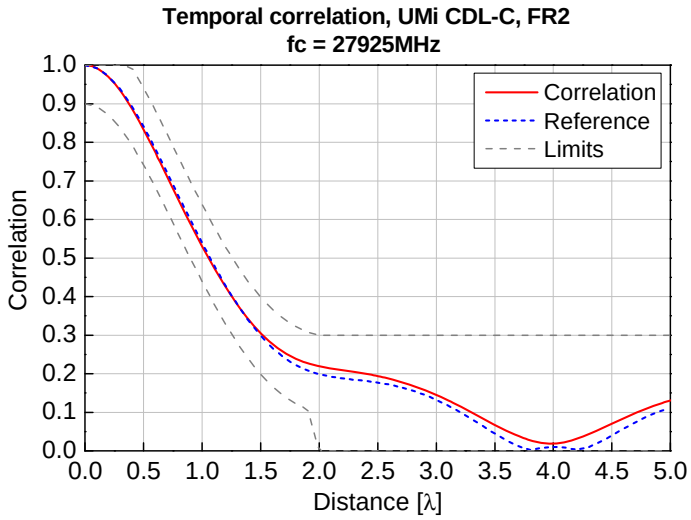


Figure 6.3.2.2-2: Lab B: Doppler measurement results for CDL-C UMi at band n261

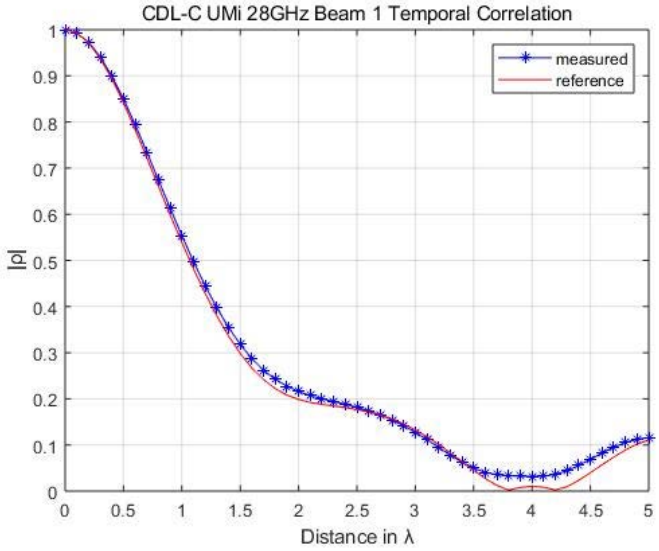


Figure 6.3.2.2-3: Lab C: Doppler measurement results for CDL-C UMi at 28GHz

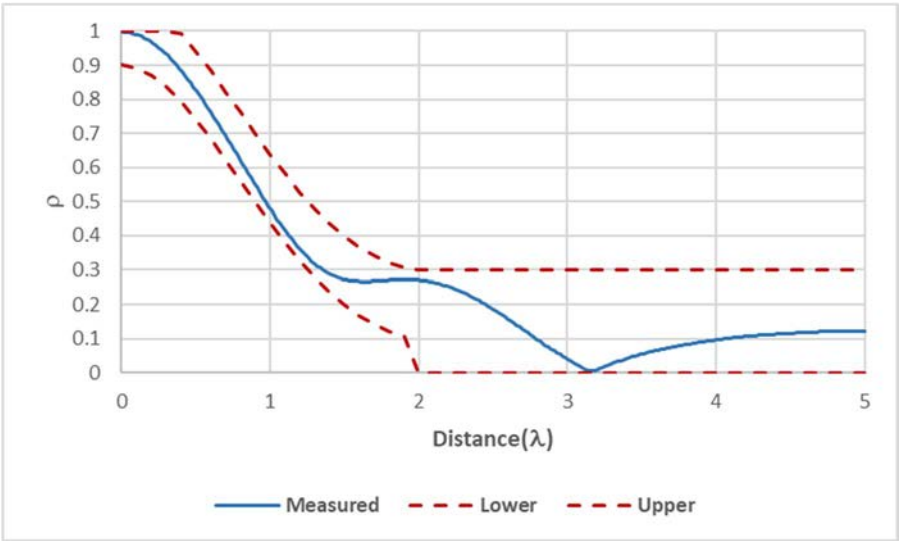


Figure 6.3.2.2-4: Lab D: Doppler measurement results for CDL-C UMi at band n261

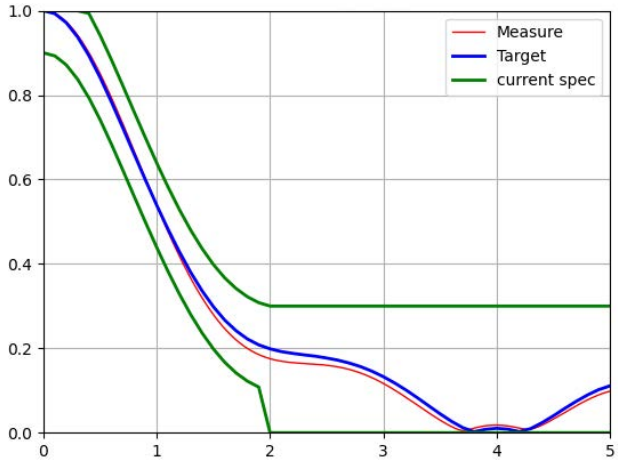


Figure 6.3.2.2-5: Lab E: Doppler measurement results for CDL-C UMi at band n261

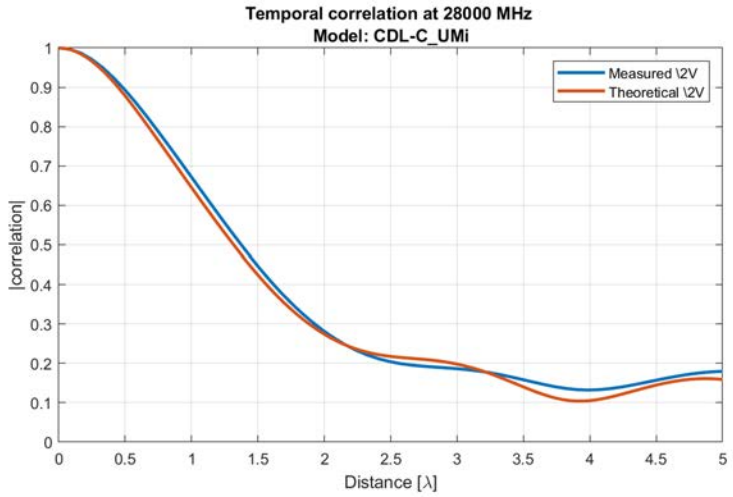


Figure 6.3.2.2-6: Lab F: Doppler measurement results for CDL-C UMi at 28GHz

6.3.2.3 PAS similarity percentage (PSP)

The PAS measurement results of UMi CDL-C for band n261/28GHz are presented in Figures 6.3.2.3-1~6. The corresponding PSP values are summarized in Table 6.3.2.3-1.

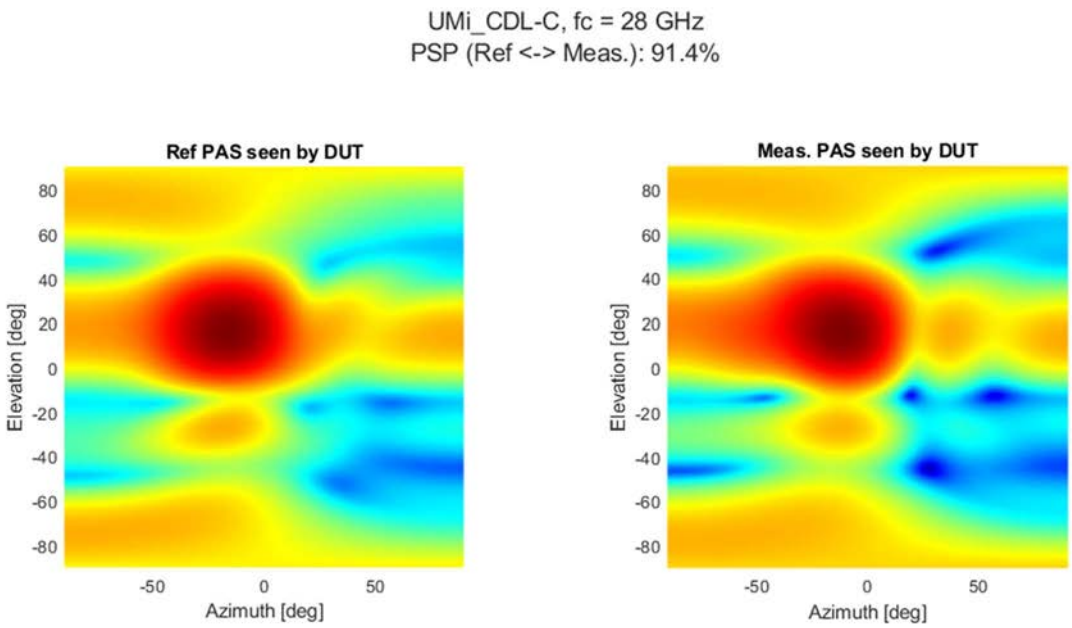
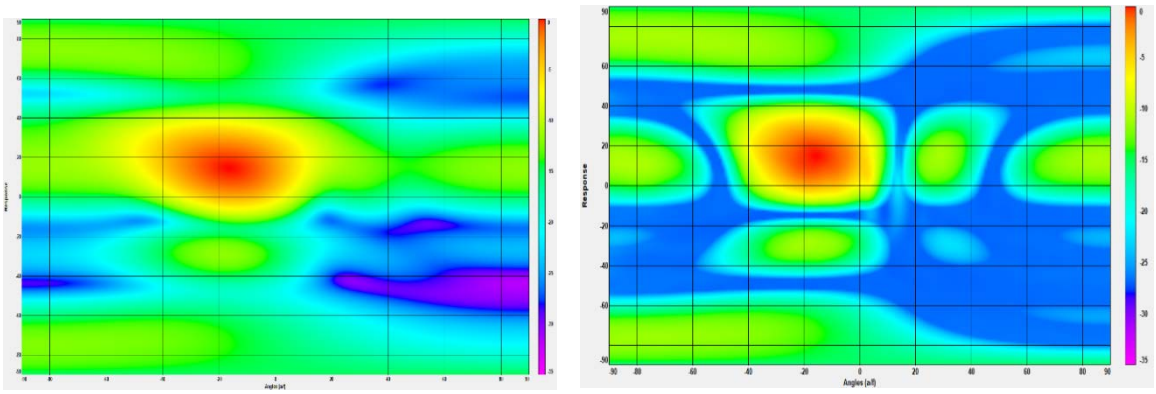


Figure 6.3.2.3-1: Lab A: PAS measurement results for CDL-C UMi at band n261



(a) Ref. PAS Seen by DUT **(b) Measured PAS Seen by DUT**

Figure 6.3.2.3-2: Lab B: PAS measurement results for CDL-C UMi at band n261

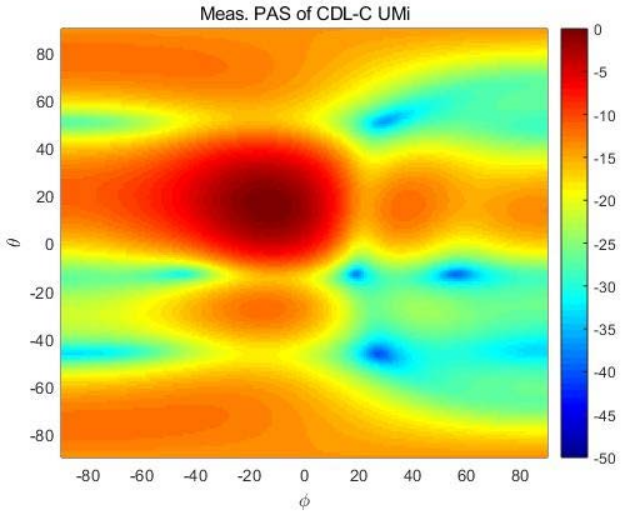
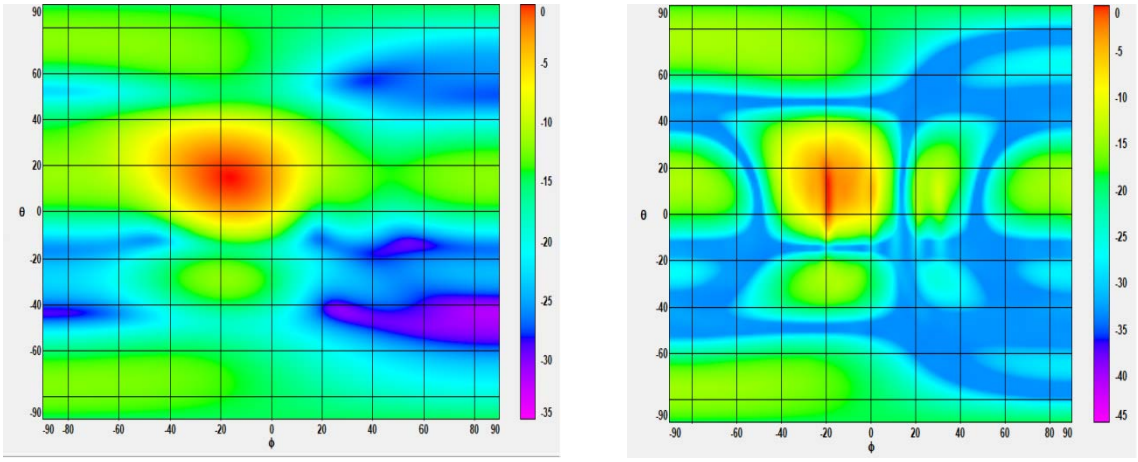


Figure 6.3.2.3-3: Lab C: PAS measurement results for CDL-C UMi at band n261



(a) Ref. PAS Seen by DUT (b) Measured PAS Seen by DUT

Figure 6.3.2.3-4: Lab D: PAS measurement results for CDL-C UMi at band n261

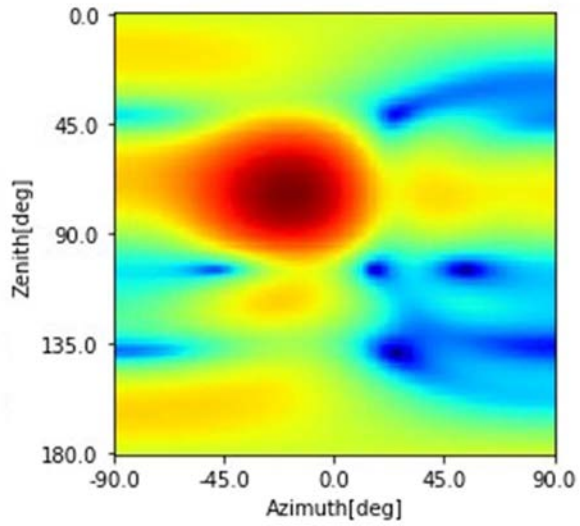


Figure 6.3.2.3-5: Lab E: PAS measurement results for CDL-C UMi at band n261

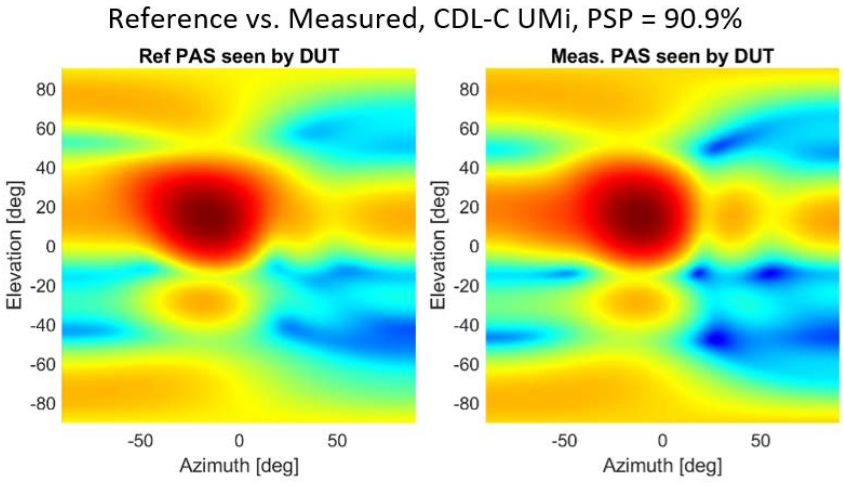


Figure 6.3.2.3-6: Lab F: PAS measurement results for CDL-C UMi at band n261

Table 6.3.2.3-1: PSP verification results for CDL-C UMi, band n261

Lab	PSP value	Pass/fail limit
Lab A	91.4%	84%
Lab B	89.7%	
Lab C	94%	
Lab D	86.2%	
Lab E	91.3%	
Lab F	90.9%	

6.3.2.4 Cross-polarization

The Cross-polarization measurement results of UMi CDL-C for bands n261/28GHz are presented in Table 6.3.2.4-1~5.

Table 6.3.2.4-1: Lab A: Cross-polarization verification results for CDL-C UMi, band n261

Beam	Reference	Measurement result	Delta	Pass/fail limit
Beam 1	Input 1: V/H = -0.45 dB	V/H = -0.38 dB	0.07 dB	±1.5 dB
	Input 2: V/H = 0.49 dB	V/H = 0.76 dB	0.27 dB	
	Input 1+2: V/H = 0 dB	V/H =0.44dB	0.44 dB	

Table 6.3.2.4-2: Lab B: Cross-polarization verification results for CDL-C UMi, band n261

Beam	Reference	Measurement result	Delta	Pass/fail limit
Beam 1	Input 1: V/H = -0.45 dB	V/H = -0.70 dB	-0.25 dB	±1.5 dB
	Input 2: V/H = 0.49 dB	V/H = 1.27 dB	0.78 dB	
	Input 1+2: V/H = 0 dB	V/H = -0.23dB	-0.23 dB	

Table 6.3.2.4-3: Lab C: Cross-polarization verification results for CDL-C UMi, band n261

Beam	Reference	Measurement result	Delta	Pass/fail limit
Beam 1	Input 1: V/H = -0.45 dB	V/H = 1.01 dB	1.46 dB	±1.5 dB
	Input 2: V/H = 0.49 dB	V/H = -0.51 dB	-1.00 dB	

Table 6.3.2.4-4: Lab D: Cross-polarization verification results for CDL-C UMi, band n261

Beam	Reference	Measurement result	Delta	Pass/fail limit
Beam 1	Input 1+2: V/H = 0 dB	V/H = -0.28dB	-0.28 dB	±1.5 dB

Table 6.3.2.4-5: Lab E: Cross-polarization verification results for CDL-C UMi, band n261

Beam	Reference	Measurement result	Delta	Pass/fail limit
Beam 1	Input 1: V/H = -0.45 dB	V/H = -0.80 dB	-0.35 dB	±1.5 dB
	Input 2: V/H = 0.49 dB	V/H = 1.01 dB	0.52 dB	
	Input 1+2: V/H = 0 dB	V/H = 0.76 dB	0.76 dB	

6.3.2.5 Power validation

The Power validation results of UMi CDL-C for bands n261 are presented in Table 6.3.2.5-1~4.

Table 6.3.2.5-1: Lab A: Power validation results for CDL-C UMi, band n261 (Unit: dBm/120kHz)

Band	Measured EPRE	Target EPRE	Delta	Pass/fail limit
n261	-74.3	-74	-0.3	±1.5 dB

Table 6.3.2.5-2: Lab B: Power validation results for CDL-C UMi, band n261 (Unit: dBm/120kHz)

Band	Measured V power	Measured H power	Measured total power	Target power	Delta	Pass/fail limit
n261	-110.314	-110.807	-107.543	-107	-0.543	±1.5 dB

Table 6.3.2.5-3: Lab C: Power validation results for CDL-C UMi, band n261 (Unit: dBm/120kHz)

Band	Measured power	Target power	Delta	Pass/fail limit
n261	-43.96	-43.18	-0.78	±1.5 dB

Table 6.3.2.5-4: Lab E: Power validation results for CDL-C UMi, band n261 (Unit: dBm/120kHz)

Band	Measured power	Target power	Delta	Pass/fail limit
n261	-42.16	-42.84	0.68	±1.5 dB

7 Lab alignment of FR1 MIMO OTA

7.1 General

To establish valid and trustable measurement data pools for defining FR1 MIMO OTA requirements, lab alignment campaigns are required before measurement campaign for ensuring there is no unexpected deviations among labs. 3GPP RAN4 performed a lab alignment campaign for bands > 1GHz during Rel-17, and a lab alignment campaign for bands < 1GHz during Rel-18.

7.2 Noise impact in MPAC on MIMO performance

This clause includes analysis and experimental measurement results of the impact of noise in MPAC on FR1 MIMO OTA performance.

During Rel-18, several companies studied the impact of noise in MPAC on FR1 MIMO OTA performance, conducted experiments, and obtained similar observations. It was found that by adding suitable attenuators after the amplifiers in MPAC system, the impact of noise can be eliminated and the MIMO OTA measurement results can be corrected, as shown in Figure 7.2-1.

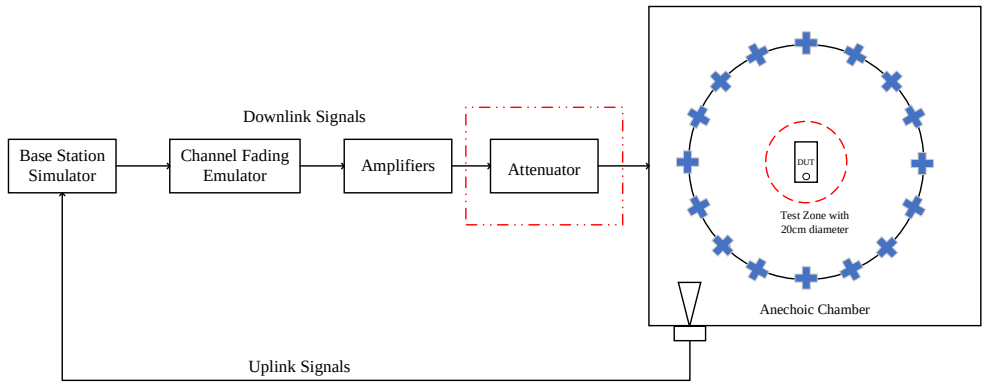
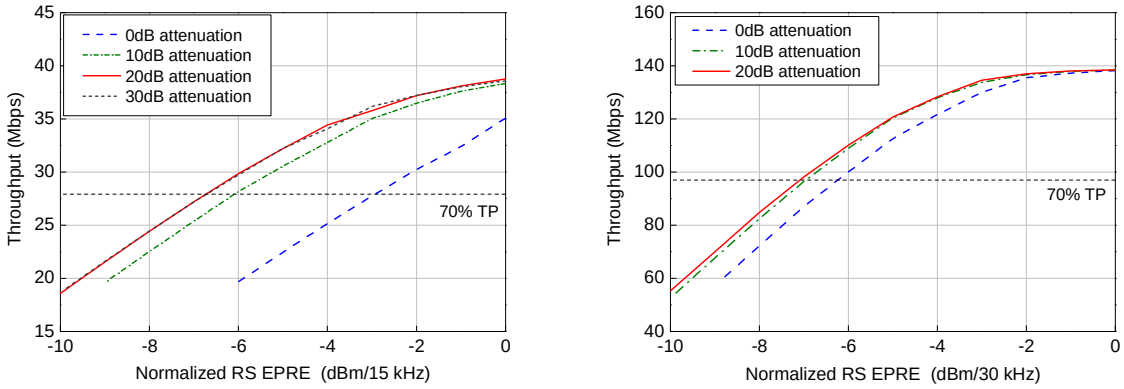


Figure 7.2-1: Measurement setup for correcting FR1 MIMO OTA test results with MPAC

The measurement results (12 orientations average in FS DMP mode) at bands n28 (780.5MHz) and n41 (2593MHz) obtained by Lab 1 are show in Figure 7.2-2. The same DUT were measured with different attenuation values. It can be observed that, as the attenuation value increases, the measurement results first get better and then become stable. At the lower frequency, the effect of the attenuation value is more obvious, and it requires a lager attenuation to make the measurement results stable. The reason is that at lower frequency, the path loss from the amplifier output to the chamber centre is smaller, and when the amplifier noise arrives at the chamber centre, it has higher power than that at higher frequency.

Adding attenuators after the amplifiers can reduce the noise and make it neglectable for FR1 MIMO OTA testing. A suitable attenuation value can be selected, e.g., for band n28, the measurement results with 20dB-attenuation and 30dB-attenuation are almost the same, but the measurement result with 10dB-attenuation is worse, which means 20dB-attenuation is enough for band n28 in Lab 1's MPAC system.



(a) Band n28 (780.5MHz) **(b) Band n41 (2593MHz)**

Figure 7.2-2: Measured MIMO OTA performance with different attenuation values (in Lab 1)

Figures 7.2-3 and 7.2-4 present the measurement results at band n28 (780.5MHz) from Lab 2 and Lab 4. Similar phenomenon can be observed.

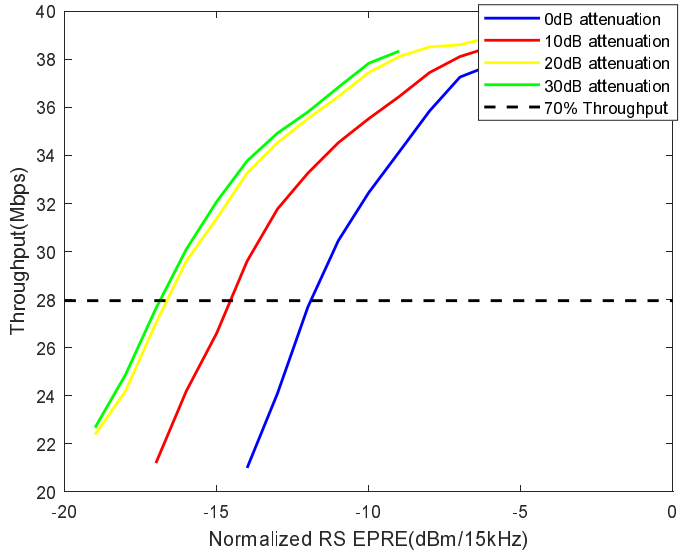


Figure 7.2-3: Measured MIMO OTA performance at band n28 (780.5MHz) with different attenuation values (in Lab 2)

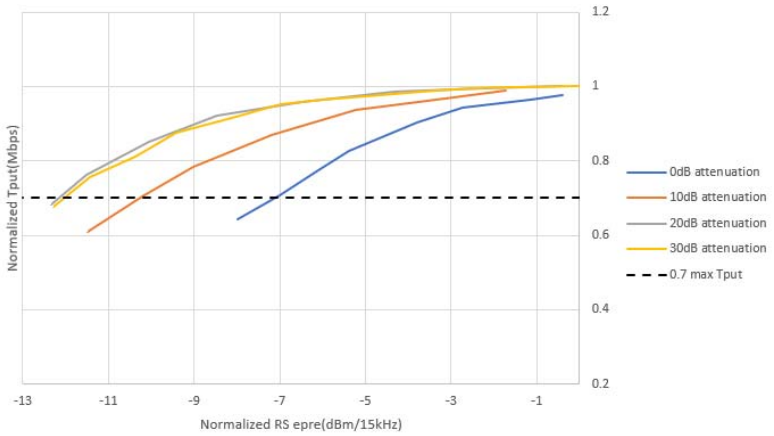


Figure 7.2-4: Measured MIMO OTA performance at band n28 (780.5MHz) with different attenuation values (in Lab 4)

Table 7.2-1 presents the measurement results at band n28 (780.5MHz) from Lab 6, RS EPRE difference between FR1 MIMO OTA system with and without 10dB attenuators are listed.

Table 7.2-1: Measured RS EPRE difference between FR1 MIMO OTA system with and without 10dB attenuators at band n28 (780.5MHz) in Lab 6

Percentile of max TP	RS EPRE Δ between FR1 MIMO OTA system with and without 10dB attenuators
@ 50% throughput	0.59 dB
@ 70% throughput	0.66 dB
@ 90% throughput	0.67 dB

Based on the observations, RAN4 reached the following agreements:

- Labs should first exclude the impact of noise before performing MIMO OTA measurements, especially for frequency bands <1GHz.
- Perform a low-band lab alignment activity at Band n28, to cross-validate the measurement results from different labs and ensure the validity of the data pool for requirements definition.

7.3 Lab alignment campaign for frequency bands > 1GHz

7.3.1 Framework

This clause defines the working procedure on how to proceed the lab alignment campaign for frequency bands > 1GHz.

Labs/companies volunteer to participate in the performance requirement part shall complete the lab alignment measurements and system validation measurements, results should be submitted to RAN4 for review.

Using the testing conditions as defined in TS38.151.

The test bands for lab alignment are n41 and n78. Three performance alignment devices (PADs) for each band should be tested to ensure the alignment of measurement results.

TRMS value in SA mode will be used for alignment comparison.

The reference value of each PAD should be the average of the PAD measurement results submitted on or before 12:00 UTC 30th April 2022, based on the condition at least 3 labs' results collected. Submission with measurement data after 12:00 UTC 30th April can be considered for lab alignment, but will not change the reference TRMS value.

The acceptance criteria for declaring alignment should be defined based on the preliminary MU value of MPAC system. The detailed criteria for accepting the outcome of the lab alignment activity are listed in Table 7.3.3-1.

Table 7.3.3-1: Requirements for lab alignment results (FR1 MIMO OTA)

Band	Case	Acceptance criteria
n41	PAD_1	The deviation between the measurement result and the reference value of each PAD shall be less than the pass/fail limit, i.e., $\lvert \mathrm{TRMS}_{\mathrm{average,70\_mea}} - \mathrm{TRMS}_{\mathrm{average,70\_ref}} \rvert \leqq$ pass/fail limit
	PAD_2	
	PAD_3	
n78	PAD_1	The deviation between the measurement result and the reference value of each PAD shall be less than the pass/fail limit, i.e., $\lvert \mathrm{TRMS}_{\mathrm{average,70\_mea}} - \mathrm{TRMS}_{\mathrm{average,70\_ref}} \rvert \leqq$ pass/fail limit
	PAD_2	
	PAD_3	

Note:

- The PAD measurement results shall NOT be shared to anyone before submitting to RAN4 meetings or sharing in the NR MIMO OTA reflector. Comparison and alignment analyses should only be done in RAN4 meetings.
- Three PADs for each band are selected. Labs should submit PAD measurements results in an anonymous approach, i.e., the PADs for each band should be marked as PAD_1, PAD_2, and PAD_3, respectively. The mapping between the codename PAD_n and the actual PAD shall only be known among the labs participated in the alignment activity, and shall NOT be disclosed to any other companies.

7.3.2 Measurement results

RAN4 carried out the lab alignment campaign for frequency bands > 1GHz during Rel-17. Considering the test burden and urgent timeline, RAN4 decided to select three smartphones (named as PADs, Performance Alignment Devices) as reference DUTs, and select two bands, n41 and n78, to perform FR1 MIMO OTA lab alignment activity for frequencies bands > 1GHz.

There are 6 test labs participated in the lab alignment campaign, the reference value of each PAD at each band is derived based on linear average (with dBm) of PAD measurement results submitted by all labs. The summary of the lab alignment results is shown in Table 7.3.2-1 and Figure 7.3.2-1. The TRMS offset between each measurement result and reference value of FR1 MIMO OTA lab alignment is shown in Table 7.3.2-2 and Figure 7.3.2-1.

Table 7.3.2-1: Summary of FR1 MIMO OTA lab alignment results for bands > 1GHz

Device	Band	TRMS measurement result [dBm/30kHz]						Average approach	Reference value	Max-Min deviation
		Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6			
PAD_n41_1	n41	-96.43	-97.61	-98.20	-97.45	-96.88	-99.10	Linear average	-97.61	2.67
PAD_n41_2	n41	-99.30	-97.80	-100.02	-99.96	-99.62	-101.43		-99.69	3.63
PAD_n41_3	n41	-96.31	-97.39	-97.81	-96.53	-96.74	-98.59		-97.23	2.28
PAD_n78_1	n78	-96.02	-96.54	-96.44	-96.10	-96.53	-98.38		-96.67	2.36
PAD_n78_2	n78	-95.42	-95.95	-96.11	-96.48	-96.66	-98.97		-96.60	3.55
PAD_n78_3	n78	-99.06	-97.42	-99.53	-99.08	-99.54	NA		-98.93	2.12

Table 7.3.2-2: FR1 MIMO OTA lab alignment outcome - TRMS offset (for bands > 1GHz)

Device	Band	TRMS offset from reference [dBm/30kHz]						Pass/fail limit
		Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	
PAD_n41_1	n41	1.18	0.00	-0.59	0.16	0.73	-1.49	+/- 0.75 MU, i.e., +/- 2.25 dB
PAD_n41_2	n41	0.39	1.89	-0.33	-0.27	0.07	-1.74	
PAD_n41_3	n41	0.92	-0.16	-0.58	0.70	0.49	-1.36	
PAD_n78_1	n78	0.65	0.13	0.22	0.57	0.14	-1.71	+/- 0.75 MU, i.e., +/- 2.55 dB
PAD_n78_2	n78	1.18	0.65	0.48	0.12	-0.06	-2.37	
PAD_n78_3	n78	-0.13	1.51	-0.60	-0.15	-0.61	NA	
Lab alignment conclusion		**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**	

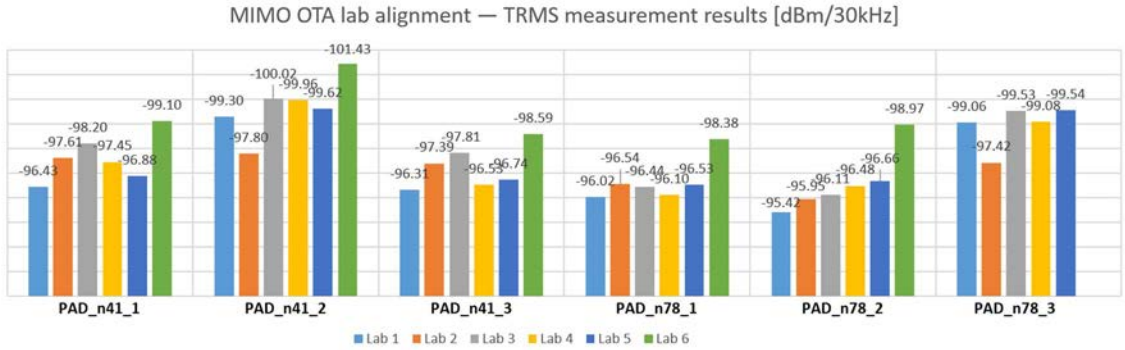


Figure 7.3.2-1: Measurement results of FR1 MIMO OTA lab alignment for bands > 1GHz

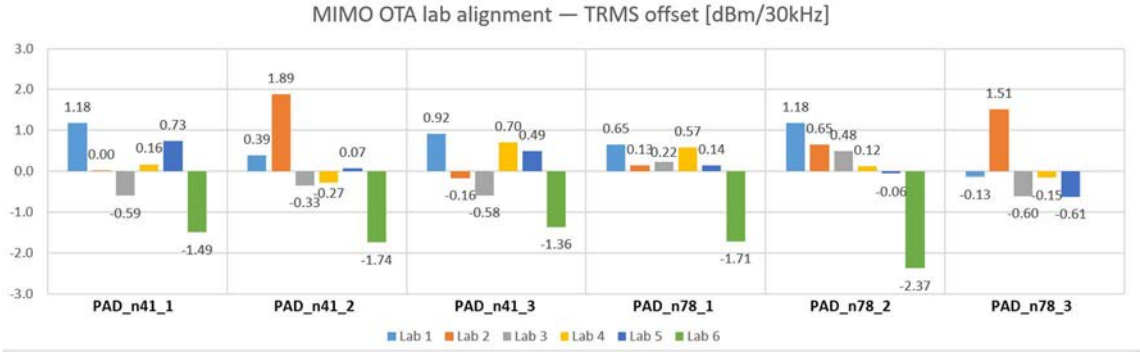


Figure 7.3.2-2: Deviation between each measurement result and reference value of FR1 MIMO OTA lab alignment for bands > 1GHz

7.3.3 Pass/fail limits

Based on the preliminary MU assessment of FR1 MPAC system in Annex A.2.5 of TS 38.151, and lab alignment measurement results in Clause 7.3.2, RAN4 decided the final pass/fail limits for FR1 MIMO OTA lab alignment activity for bands > 1GHz as 0.75* preliminary MU, i.e.,

- < 3GHz: 2.25 dB
- > 3GHz: 2.55 dB

7.3.4 Conclusion

RAN4 concluded the successful FR1 MIMO OTA lab alignment activity for bands > 1GHz, all the 6 test labs are aligned. FR1 MIMO OTA performance requirements for bands > 1GHz are specified based on the measurement results submitted by the above aligned test labs.

7.4 Lab alignment campaign for frequency bands < 1GHz

7.4.1 Framework

This clause defines the working procedure on how to proceed the lab alignment campaign for frequency bands < 1GHz.

1. Test labs are invited to participate in the lab alignment activity, the following conditions should be fulfilled:
   - At least 3 participating labs are required.
   - Participating labs shall complete channel model validation.
   - Participating labs should have sufficient test resource to provide on-time measurement results without delay.
   - Participating labs should first examine and exclude the impact of noise before submitting PAD measurement results.
2. Test methodology:
   - Test plan: 3GPP TS 38.151
   - Test system: MPAC
3. Test cases for Lab Alignment Activity:
   - Test band: n28
   - Number of test cases: 3 PADs
   - Operation mode: NR Standalone (SA)
   - Use scenario: Free space
4. Test results submission:
   - Use the same worksheet template in R4-2316308 to submit the measurement results
   - The measurement results should be submitted to RAN4 by anonymous approach (the UE model shall not be disclosed publicly)
   - Results shall not be shared between labs before submitting to RAN4 meetings or sharing in the RAN4 reflector. Comparison and lab alignment analysis should only be done in RAN4 meetings/discussions
5. Lab alignment criteria:
   - The pass/fail criteria are defined as the maximum deviation between the measurement result and the reference value

- The reference value will be derived based on the averaging approach (linear average in dBm) of lab alignment data pool from ≥ 3 labs
- Apparent outliers (if identified) will not be considered in the average process for reference value. The PAD measurement result deviates over 1.5*preliminary MU (i.e., 4.55dB) from all the other labs' results should be identified as apparent outlier.
- Pass/fail limit for lab alignment should be defined as X*preliminary MU (X is TBD) as baseline.

6. Volunteer lab procedures:
   - PAD delivery scheme: Decide PAD delivery scheme after all the volunteer labs and PADs information being confirmed.
   - PAD measurement time in each volunteer lab: finalize PAD measurement within [7] workdays, and deliver to the next lab ASAP with PAD delivery In/Out information shared in email-reflector.

7.4.2 Measurement results

<Editor's note: This clause includes the measurement results of the reference DUTs in the selected frequency bands (<1 GHz). This clause will be added when lab alignment campaign for frequency bands < 1GHz is completed.>

7.4.3 Pass/fail limits

<Editor's note: This clause defines the pass/fail limits of lab alignment campaign for frequency bands < 1GHz. This clause will be added when lab alignment campaign for frequency bands < 1GHz is completed.>

7.4.4 Conclusion

<Editor's note: This clause describes the conclusion of lab alignment campaign for frequency bands < 1GHz. This clause will be added when lab alignment campaign for frequency bands < 1GHz is completed.>

8 Lab alignment of FR2 MIMO OTA

8.1 Framework

This clause defines the working procedure on how to proceed the FR2 MIMO OTA lab alignment campaign. The purpose of lab alignment activity is to ensure there is no unexpected lab deviation and establish full trust and confidence on the measurement data pool for specifying FR2 MIMO OTA performance requirements.

1. Test labs are invited to participate in the lab alignment activity, the following conditions should be fulfilled:
   - At least 3 participating labs are required.
   - Participating labs shall complete channel model validation.
   - Participating labs should have sufficient test resource to provide on-time measurement results without delay.
   - Each lab should finalize PAD measurement within 10 workdays, and deliver to the next lab in the same country ASAP with PAD In/Out information shared via email-reflector; otherwise, labs in the same country should equally share the period for testing the PADs.
2. Test methodology:
   - Test plan: 3GPP TS 38.151
3. Test cases for Lab Alignment Activity:
   - Test band: n261 (for PADs that support n261), n257 (for the PAD that does not support n261)

- Number of test cases: 2~4 PADs per-band
- Operation mode: NR Non-Standalone (NSA) is preferred and SA is not precluded, and should be mapped with the measurement results submission.
- Power class: PC3

4. Test results submission:
   - Use the same worksheet template in R4-2308740 to submit the measurement results
   - The measurement results should be submitted to RAN4 by anonymous approach (the UE model shall not be disclosed publicly)
   - Results shall not be shared between labs before submitting to RAN4 meetings or sharing in the RAN4 reflector. Comparison and lab alignment analysis should only be done in RAN4 meetings/discussions
5. Lab alignment criteria:
   - The pass/fail criteria are defined as the maximum deviation between the MASC measurement result and the reference value
   - The reference value is derived based on the per-band averaging approach of lab alignment data pool from ≥ 3 labs, whether apparent outliers will be considered in averaging process, or not, is FFS
   - Pass/fail limit for lab alignment should be derived from the preliminary MU value. Adopt [0.5-1]*preliminary MU as starting point and further check after the FR2 MU is decided and some PAD measurement results are available.

8.2 Measurement results

<Editor's note: This clause includes the measurement results of the reference DUTs in the selected frequency band (FR2). This clause will be added when lab alignment campaign for FR2 MIMO OTA is completed.>

8.3 Pass/fail limits

<Editor's note: This clause defines the pass/fail limits of lab alignment campaign for FR2 MIMO OTA. This clause will be added when lab alignment campaign for FR2 MIMO OTA is completed.>

8.4 Conclusion

<Editor's note: This clause describes the conclusion of lab alignment campaign for FR2 MIMO OTA.This clause will be added when lab alignment campaign for FR2 MIMO OTA is completed.>

Annex A:
Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2023-10	R4#108bis	R4-2316704				Skeleton of TR38.761 on Measurement of NR MIMO OTA performance	0.0.1
2023-11	R4#109	R4-2319164				R4-2316946 TP to TR 38.761 on channel model validation for n41 n78 R4-2316968 TP to TR 38.761 on lab alignment for bands > 1GHz	0.1.0
2023-11	R4#109	R4-2320179				R4-2321107 TP to TR 38.761 on Lab 6 Power Validation R4-2320060 TP to TR 38.761 on General Aspects and Measurement Setup R4-2320062 TP to TR 38.761 on FR2 channel model validation R4-2318895 TP for TR 38.761 on channel model validation for n78 and n41 R4-2320061 TP to TR 38.761 on channel model validation for n28 R4-2321108 TP to TR 38.761 on FR1 noise impact R4-2320064 TP to TR 38.761 on Rel-18 lab alignment framework	0.2.0
2023-12	RAN#102	RP-23xxxxx				Presented to RAN for approval	1.0.0

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
2023-12	RAN#102					Approved by plenary – Rel-18 spec under change control	18.0.0
2024-03	RAN#103	RP-240593	0001	1	F	CR to TR 38.761 on FR1 MIMO OTA channel model validation results	18.1.0
2024-03	RAN#103	RP-240593	0002		F	Update to the FR1 channel model validation results	18.1.0
2024-03	RAN#103	RP-240608	0003		F	Update the lab 5 channel model validation for n28	18.1.0
2024-03	RAN#103	RP-240608	0004		F	On the remaining lab 5 channel model validation for n41 and n78	18.1.0

History

Document history		
V18.1.0	May 2024	Publication