3GPP TSG-RAN WG4 Meeting #68 **R4-134154**
Barcelona, Spain August 19th – 23th , 2013

Source: Motorola Mobility LLC, ETS-Lindgren, Spirent Communications

Title: DUT Polarization discrimination, among MIMO OTA test methods

Agenda Item: 8.4 – Verification of Radiated multi-antenna reception performance of UEs in LTE/UMTS [HSPA_LTE_measRP_MIMO-Perf]

Document for: Discussion

1 Introduction

During RAN1 #73 in Fukuoka, Japan. RAN1 provided a response for [1] RAN4 LS R4-131988 "Proposal of Additional Channel Models for MIMO Performance Characterization". After deliberation RAN1 offered a brief summary of its discussion in this topic [2] including this statement:

"RAN1's understanding is that the isotropic and geometric models under consideration by RAN4 are different. There is no consensus in RAN1 on the questions raised. RAN1 understands that consideration of the questions is ongoing in RAN4 and therefore respectively suggests that RAN4 continue its investigations and ask RAN1 if questions within RAN1's expertise remain after RAN4's investigations are complete."

Despite the summarized answer, RAN1 had useful off-line discussions around this subject. In one of these discussions, a question regarding the capability of discriminate the EU MIMO antenna system polarization was raised. In this contribution, we will start to investigate how effectively different MIMO OTA test methodologies are capable to make such discrimination.

2 Proposal

In this first preliminary study, a simplified test setup based on anechoic multi-cluster boundary array and reverberation chamber is proposed. Three antennas based on the same CTIA MIMO 2x2 reference antennas RF enclosure and 1/2λ dipoles were built, one antenna system having cross-polarized antennas and 1/2λ apart Fig 2.1-1, both antennas vertically polarized and 1/2λ apart Fig 2.1-2, and finally a antenna system having two horizontally polarized antennas also 1/2λ apart Fig2.1-3.

The test setup adopted in the anechoic and reverberation chamber neasurements are defined in the table 2-1 bellow

Table 2-1 Anechoic and reverberation chamber test settings

Test settings	Anechoic chamber settings	Reverberation chamber settings
ID	AC Cross-Poll v1	RC Cross-Pol v1
Lab	ETS-Lindgren – Cedar Park	ETS-Lindgren – Cedar Park
Date	08/13/2013	08/13/2013
Methodology	Anechoic chamber Multi-cluster, 8DP	Reverberation chamber
eNodeB emul.	R&S CMW500	R&S CMW500
eNodeB emul. ver	Installed SW V 3.2.20	Installed SW V 3.2.20
eNodeB ant config	Sec 7.2 in 37.977	Sec 7.2 in 37.977
eNodeB PHY config	Sec 7.1 in 37.977	Sec 7.1 in 37.977
Band	13	13
DL channel	5230	5230
UL channel	23230	23230
RMC	R35	R35
Num subframes per SNR pt	5000	5000
Channel emul.	Spirent VR5	NA
Channel emul. ver	2.5.341.3	NA
Channel model config	Sec 8.2 in 37.977	NA
Channel model	SCME Umi, SCME Uma	NIST, 80 ns delay spread
Emul. veh. speed	30 km/h	NA
UE mfg	HTC	HTC
UE model	Rezound	Rezound
UE ID	IMEI: 990000327075422 - MOSG-RD-13-01	IMEI: 990000327075422 - MOSG-RD-13-01
Transmission Mode	TM3	TM3
Max theoretical throughput	35.424 Mb/s	35.424 Mb/s
Num theta pos.	Sec 9.3.1.3 in 37.977	NA
Theta pos.	Sec 9.3.1.3 in 37.977	NA
Num phi pos.	Sec 9.3.1.3 in 37.977	NA
Phi pos.	Sec 9.3.1.3 in 37.977	NA
Test plan version	Lab “E1” 001	Lab “E2” 001
Comments	Base station XPR = 0 and 9dB were evaluated	

2.1 Anechoic chamber setup, in each picture antenna 1 (left), antenna 2 (right) respectively

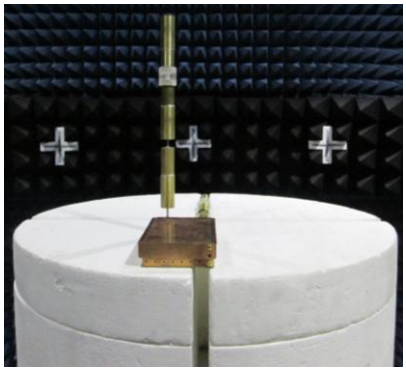

Fig 2.1-1. Cross-polarized

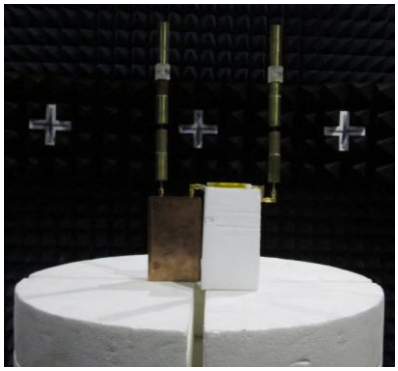

Fig 2.1-2 V Co-polarized

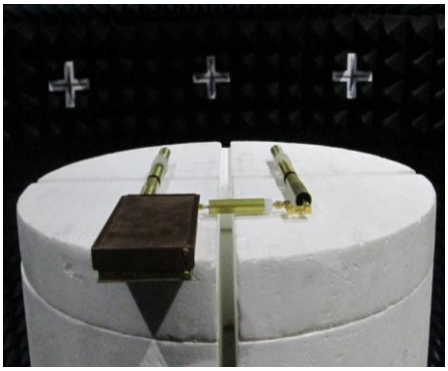

Fig 2.1-3. H Co-polarized

The OTA test system consisted of an ETS-Lindgren AMS-8700 boundary array with eight active dual polarized antennas at a radius of 1.95 meters driven by two Spirent VR5 8 output channel emulators for 16 total output channels used to generate the applied channel model and resulting signal levels within the test volume. Two ETS-Lindgren 8-channel power amplifiers were used to amplify the outputs of the channel emulators to produce the required signal levels within the test volume. The reported measurements were captured using a Rohde & Schwarz CMW-500 as the eNodeB emulator/communication tester. The two outputs were each split and fed into the two VR5s. A separate circularly polarized conical log spiral antenna was used to provide the uplink from the DUT. The uplink path was then fed through a pre-amplifier to provide additional downlink isolation prior to feeding the signal to the eNodeB input. Fig 2.1-4 contains a system schematic for the test setup, while Table 2.1-1-1 contains the detailed equipment list.

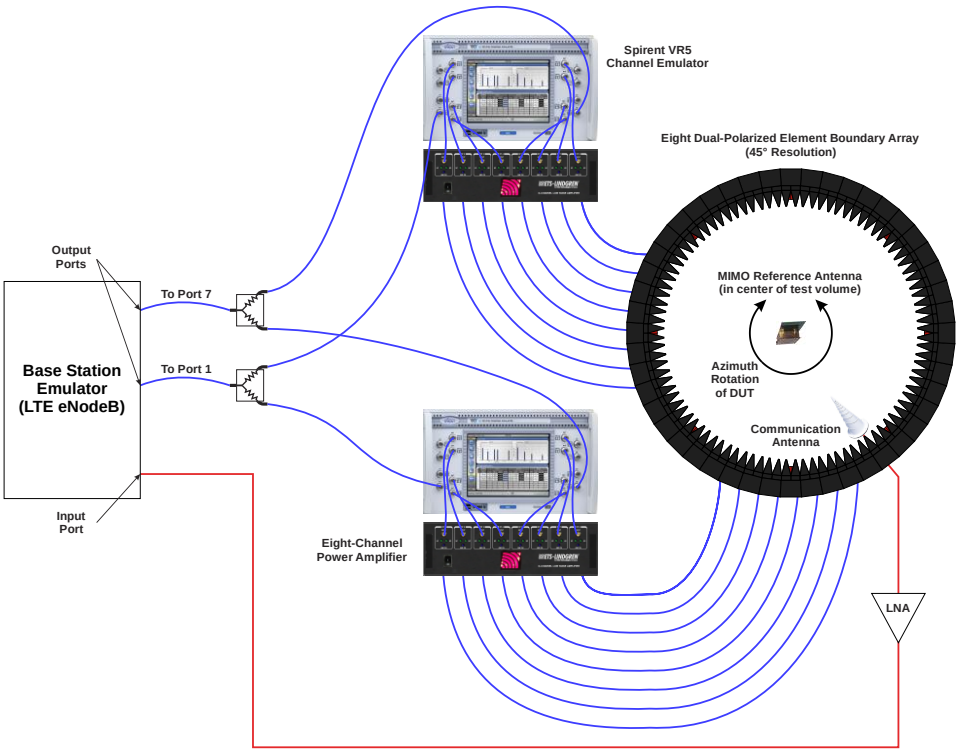

Fig 2.1-4 ETS-Lindgren AMS-8700 Boundary Array Schematic Diagram

Table 2.1-1 Test Equipment List

Equipment	Manufacturer	Model	Firmware Revision
MIMO Boundary Array System	ETS-Lindgren	AMS-8700	NA
Channel Emulator (2X)	Spirent	VR5	2.5.341.3
8-Channel Power Amplifier (2X)	ETS-Lindgren	P/N 117907	NA
eNodeB Emulator/ Communication Tester	Rohde & Schwarz	CMW-500	3.2.20
Power Splitters (2X)	Mini Circuits	ZFSC-2-2500-S+	NA
Uplink Preamp	ETS-Lindgren	NA	NA

2.2 Reverberation chamber setup

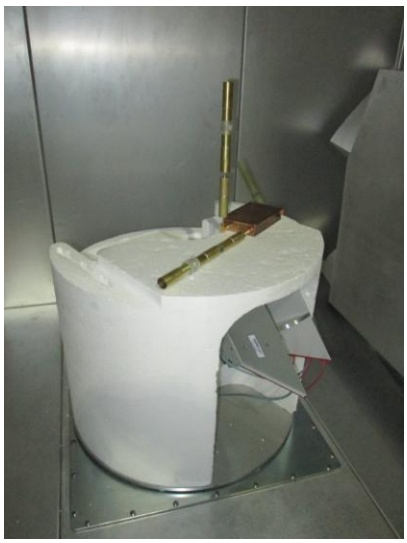

Fig 2.2-1. Cross-polarized

Fig 2.2-2 V Co-polarized

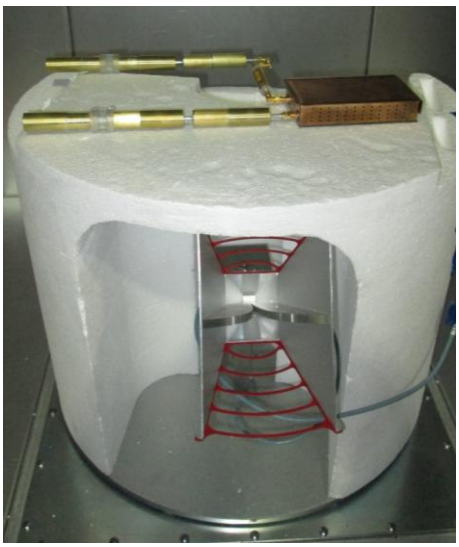

Fig 2.2-3. H Co-polarized

An ETS-Lindgren AMS-7000 wireless OTA reverb test system was used to perform the average isotropic (uniform probability distribution) testing. The system consists of a compact reverberation chamber (2.00 x 1.20 x 1.50 m) with two independent stirring paddles and a DUT turntable having a lowest operating frequency of ~700 MHz, connected to a Rohde & Schwarz CMW-500 as the eNodeB emulator/communication tester. The cell was selectively loaded to produce an RMS delay spread of 80 ns for the NIST model. Tests were performed using continuous stirring of all positioners for an integral number of rotations of all positioners at a fixed ratio and timed such that one long throughput measurement was performed per revolution of the slowest positioner, thus producing one average throughput measurement per power level.

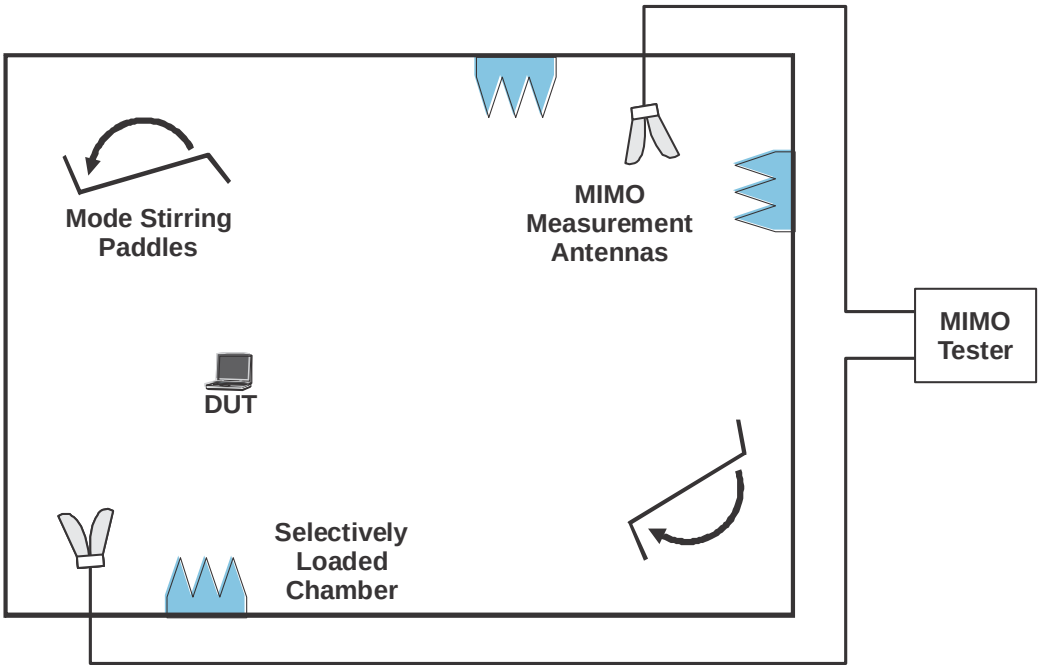

Fig 2.2-4 ETS-Lindgren Reverberation chamber schematic diagram

3 Measured data

3.1 Setup antennas FoM in uniform 3D environment.

Table 3.1-1, setup antennas (751MHz) FoM in uniform 3D environment

MIMO 2x2 antennas FoM based on 3D isotropic measurments					
MIMO 2x2 B13 antennas	ant. position	Total Efficiency (%)	Polarization Ratio V/H (dB)	Branch imbalance (dB)	envelope correlation coefficient
Cross-polarized	Antenna 1 (V)	90.68	21.89	0.450	0.0059
	Antenna 2 (H)	81.76	-4.86		
Vertical co-polarized	Antenna 1	86.1	22.79	0.003	0.0001
	Antenna 2	86.15	22.5		
Horizontal co-polarized	Antenna 1	87.76	-4.98	0.212	0.0017
	Antenna 2	83.58	-4.82		

3.1.1 Cross-polarized 3D radiation pattern

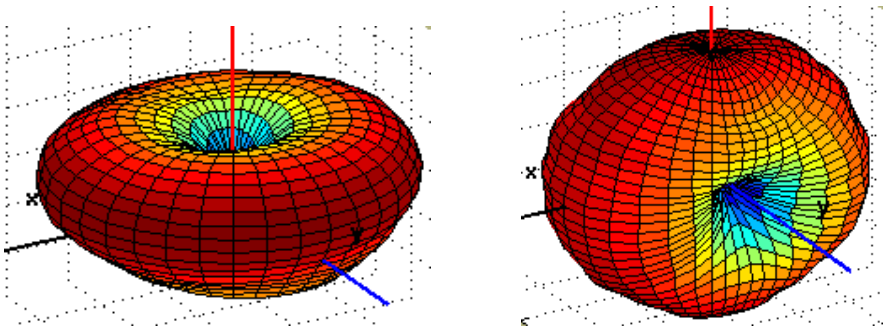

Fig 3.1.1-1, (a) Antenna 1 3D radiation pattern, (b) Antenna 2 3D radiation pattern

3.1.2 Vertical co-polarized 3D radiation pattern

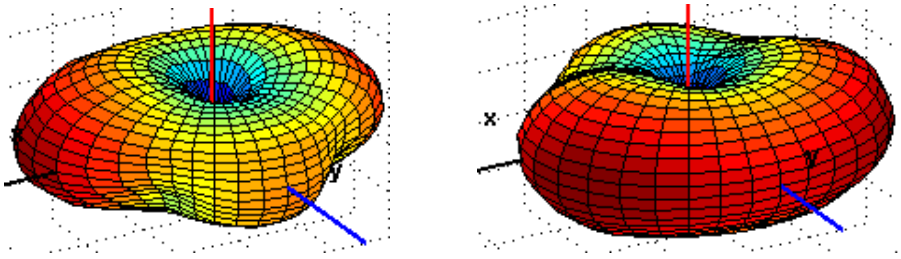

Fig 3.1.2-1, (a) Antenna 1 3D radiation pattern, (b) Antenna 2 3D radiation pattern

3.1.3 Horizontal co-polarized 3D radiation pattern

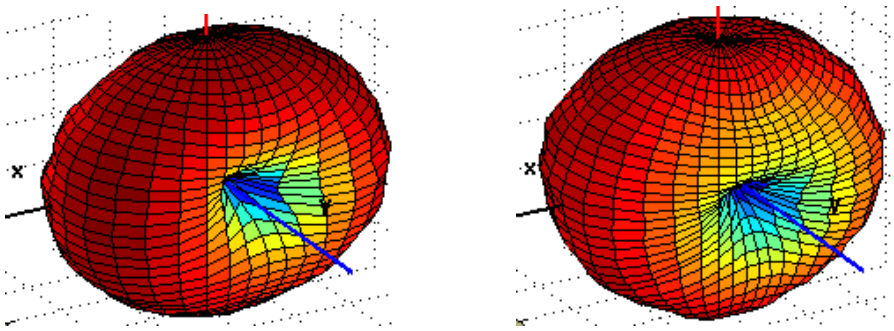

Fig 3.1.3-1, (a) Antenna 1 3D radiation pattern, (b) Antenna 2 3D radiation pattern

3.2 Anechoic chamber MIMO OTA absolute data throughput vs. RS EPRE

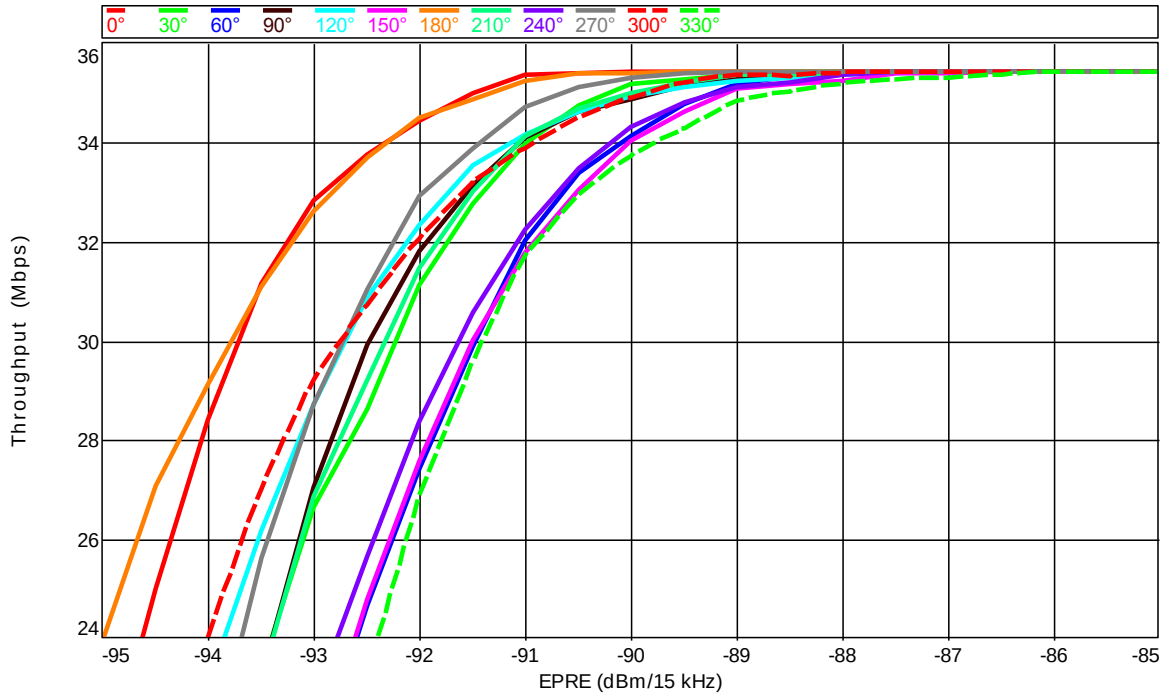

Fig 3.2-1, anechoic chamber boundary array with 8 DP antennas, SCME Umi, 30kph, XPR = 9dB, Horizontal co-polarized

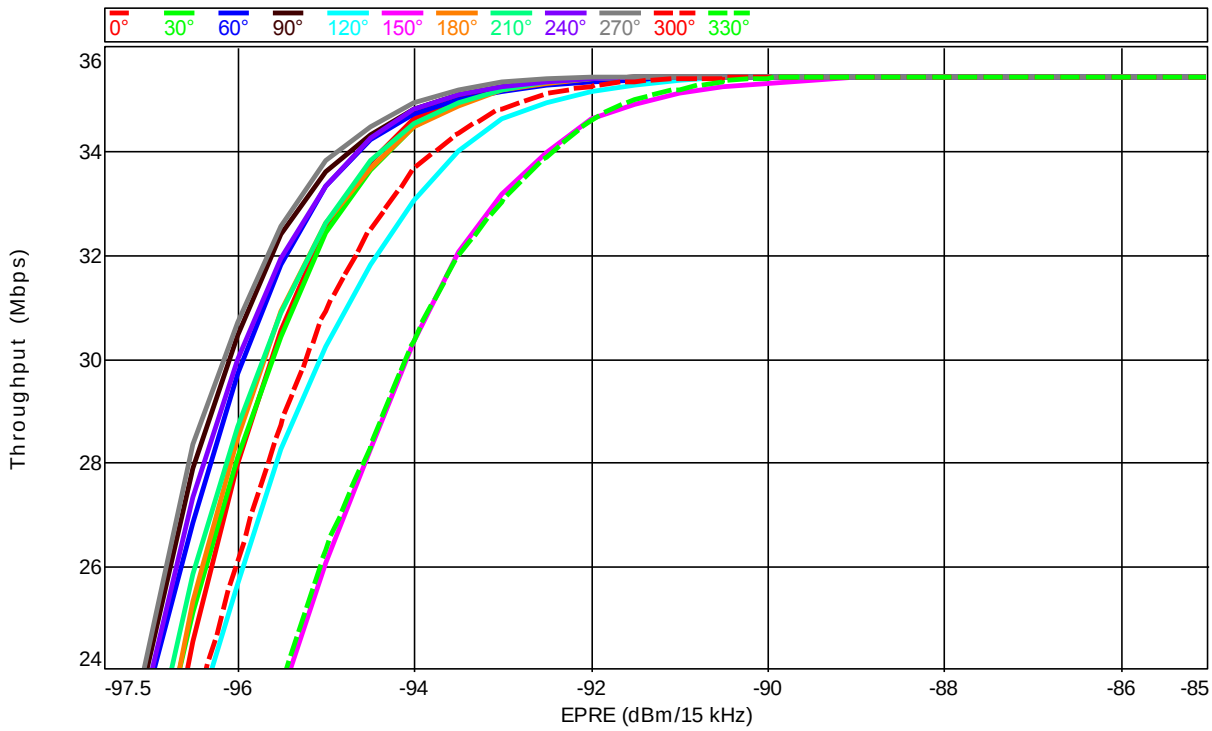

Fig 3.2-2, anechoic chamber boundary array with 8 DP antennas, SCME Umi, 30kph, XPR = 9dB, Vertical co-polarized

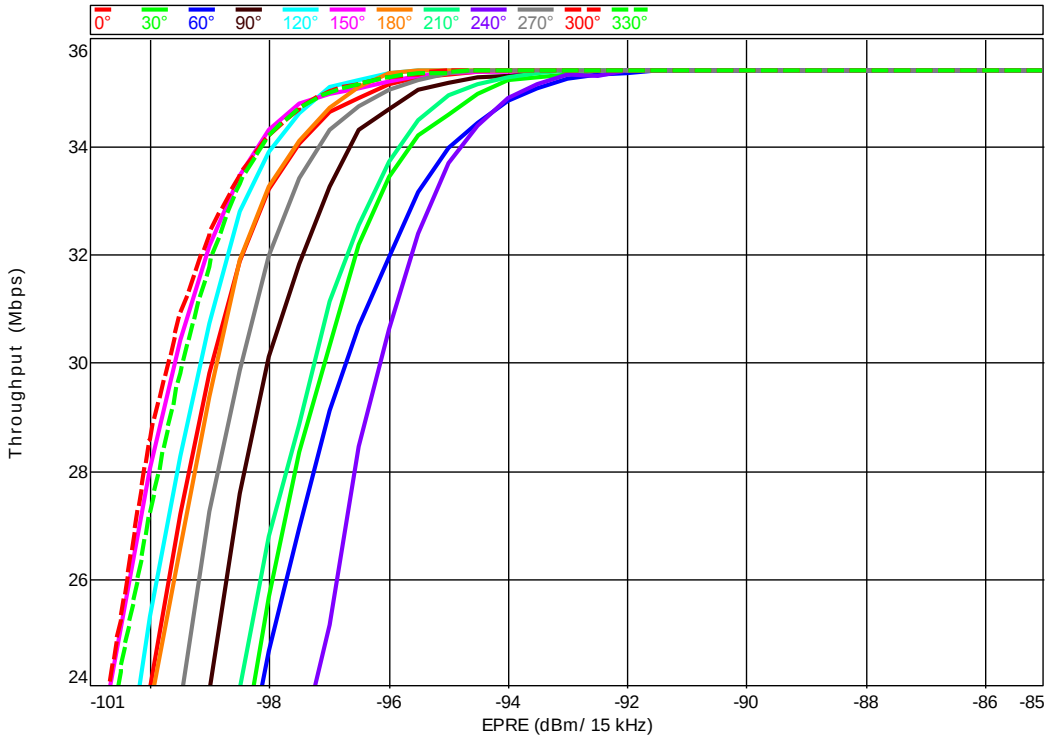

Fig 3.2-3, anechoic chamber boundary array with 8 DP antennas, SCME Umi, 30kph, XPR = 9dB, cross-polarized

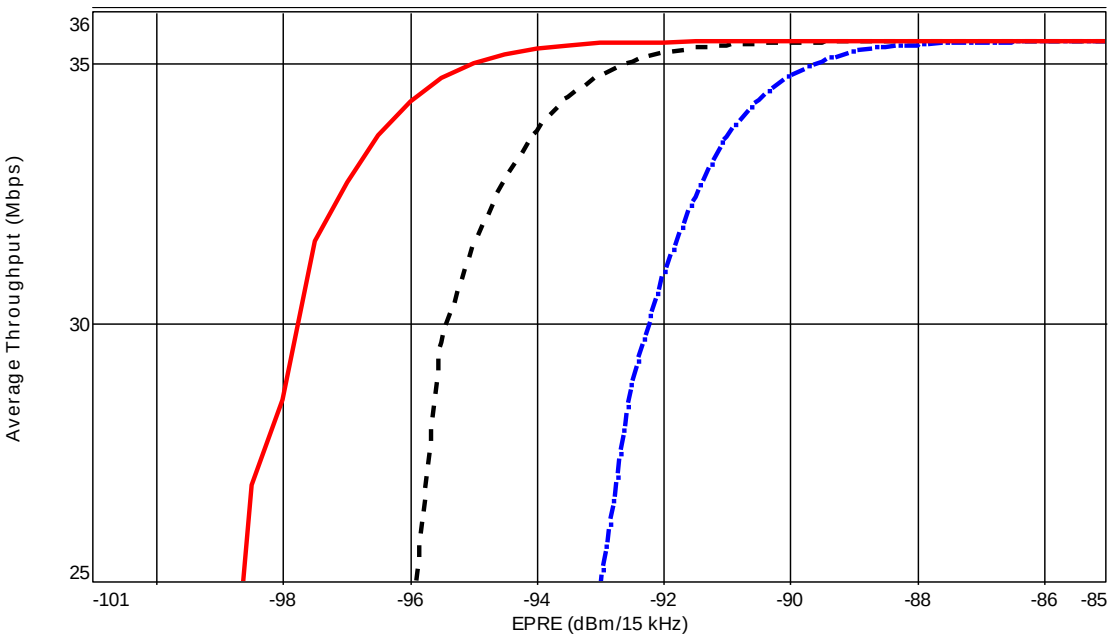

Fig 3.2-4, anechoic chamber boundary array with 8 DP antennas, SCME Umi, 30kph, XPR = 9dB, throughput average benchmark. Solid (red) cross-pol, dashed (black) V-pol, dash-trace (blue) H-pol.

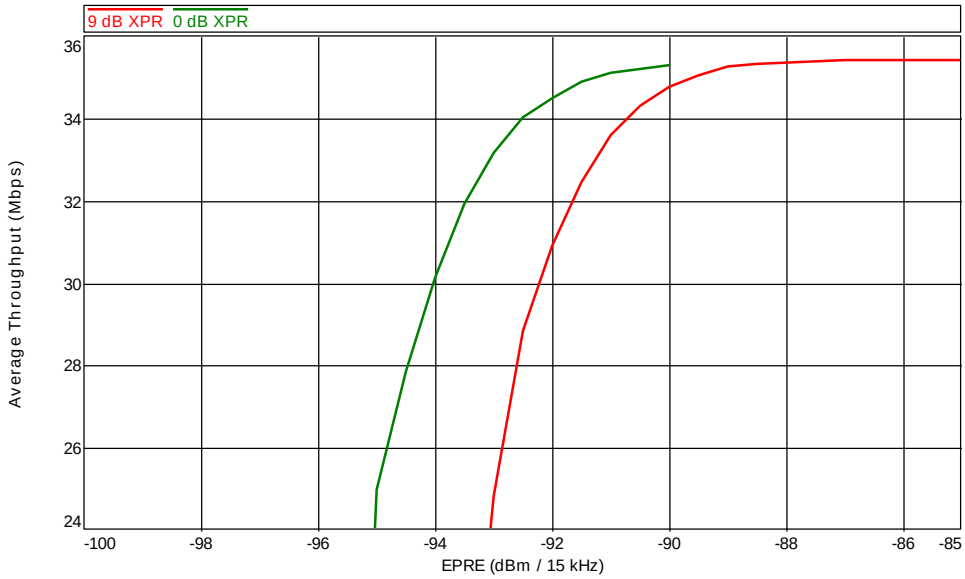

Fig 3.2-5, Horizontal co-polarized dipoles, SCME Umi, RS EPRE vs avg TP, benchmarking XPR 9 and 0 dB.

The BS X-pol correlation observed from the horizontal dipole has a similar behavior as the vertical dipole measured in the following plot, and the gap between the green and red curves is also similar. There is a shift in the absolute level by about 3~3.5 dB worse for the horizontal, which is due to the pattern shape of the horizontal dipole. The total average power of a horizontally oriented dipole receiving a horizontally polarized signal is -3.5dB compared to a vertically oriented dipole receiving a vertically polarized signal. (See figure A-1 and A-2, on the polar plot of the Horizontal dipole showing the pattern shape.)

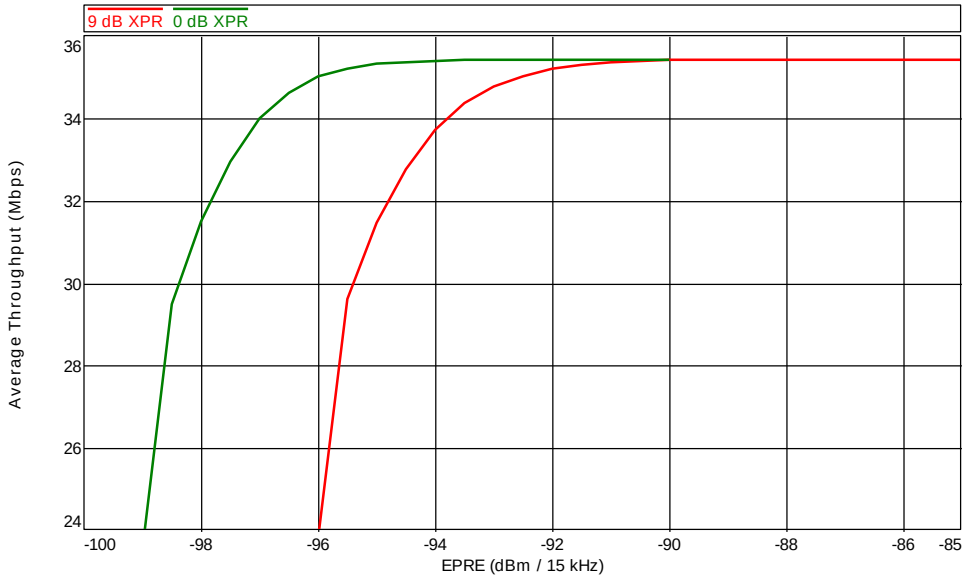

Fig 3.2-6, Vertical co-polarized dipoles, SCME Umi, RS EPRE vs avg TP, benchmarking XPR 9 and 0 dB.

As shown in [3] and Fig A-3, the effect of reducing XPR from 9dB to 0dB is a reduction in BS correlation, which is a function of AoD. For the UMi channel model, which has all of its AoDs < 50 degrees from boresight, the BS correlation drops significantly from about 70% to < 10%. This translates into an improvement in throughput for the case of XPR=0 dB compared to the higher 9dB standard value.

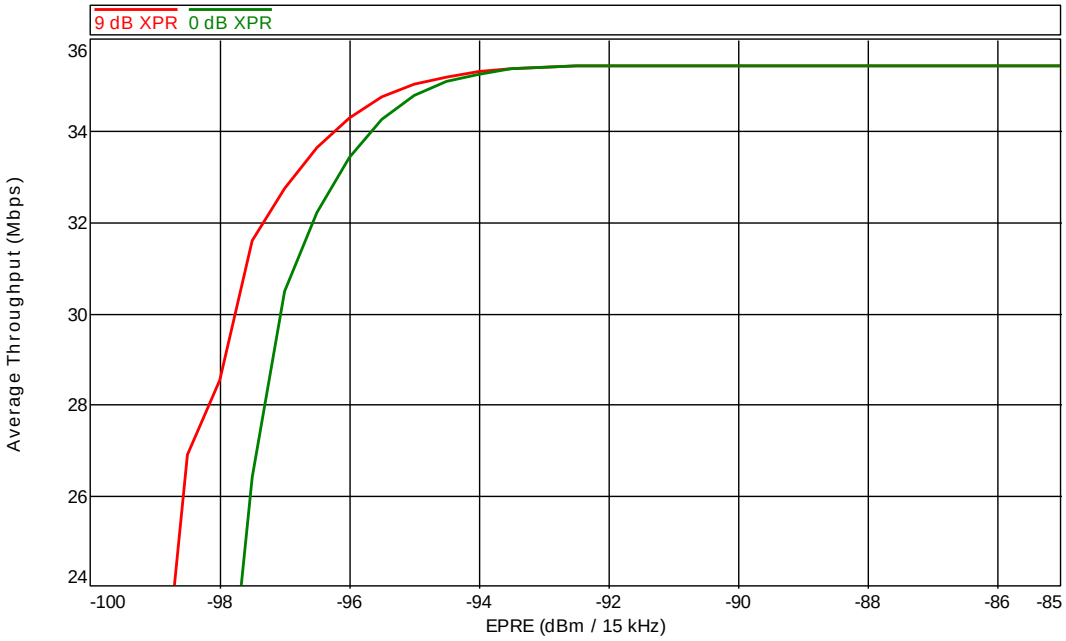

Fig 3.2-7, cross-polarized dipoles, SCME Umi, RS EPRE vs avg TP, benchmarking XPR 9 and 0 dB.

For the cross-polarized experiment, the antennas consist of one vertical and one horizontal dipole element in the test zone. UMi has a nearly balanced XPR, but there is a slight advantage to the Vertical by about 0.88 dB for the standard model with XPR=9dB. In this case, low correlation is achieved when the DuT received branches are orthogonal because the BS correlation observed on the Vertical is about +70% and the BS correlation observed on the Horizontal is about -70% resulting in a cancellation when observed between branches to produce a low correlation case.

A similar low BS correlation is observed for the case when XPR=0dB, because this parameter drives the correlation down for both the V & H components.

There is a slight advantage to the curve with XPR=9dB observed in the plot, probably due to the difference in power that is received. In this case, the vertical has slightly more power that the horizontal by 0.88 dB as defined by the channel model. Since the Horizontal dipole attenuates the average signal by 3.5dB, there is a slight power advantage to the curve with XPR=9dB compared to XPR=0dB.

3.3 Reverberation chamber

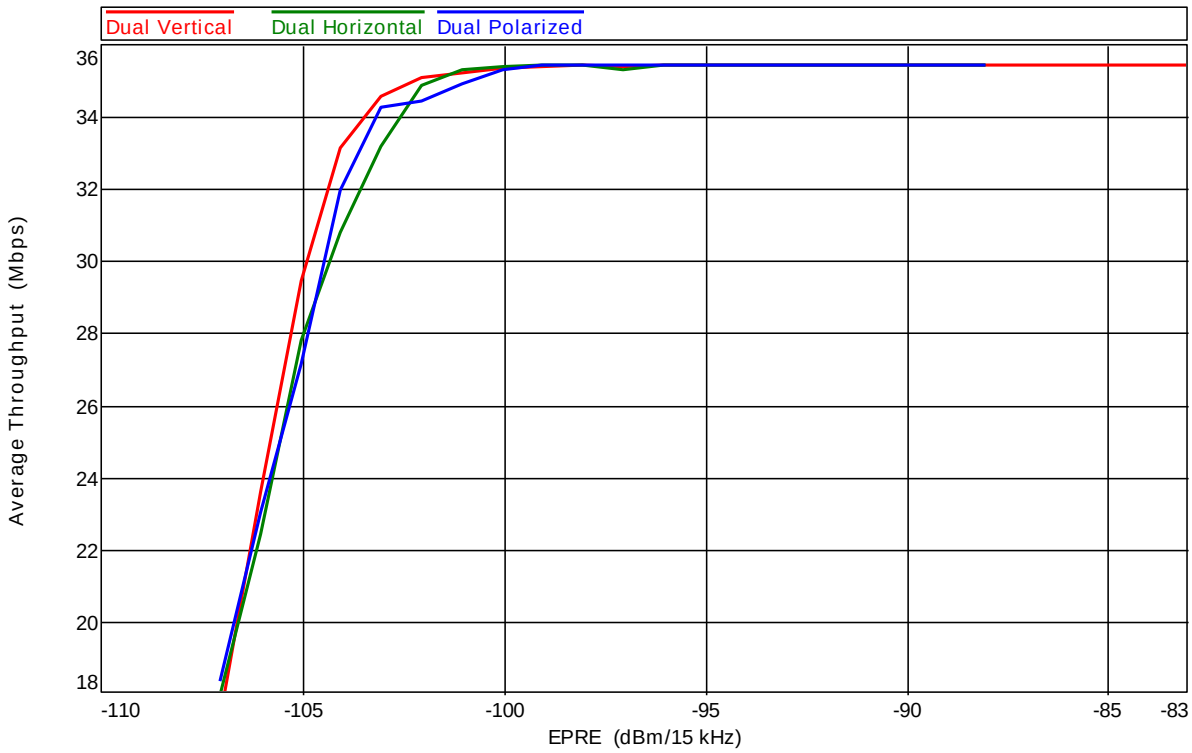

Fig 3.3-1, Antennas benchmark, NIST (80ηs RMS Delay Spread) Isotropic channel model

The three antennas described in session 2 (cross-pol, H co-pol and V co-pol), were measured in the MIMO OTA test method based on reverberation chamber. While same antennas could be discriminated by its unique polarization in anechoic chamber (up to 6dB). In the reverberation chamber, such discrimination could not be verified.

4 Conclusion

A new set of MIMO 2x2 antennas was presented, where the 3D fundamental FoM agreed, however with different polarization characteristics.

These antennas have different MIMO OTA radiated performance, when evaluated under the assumption of the agreed spatial channel models defined in the TR37.977 and different XPR values , however the same antennas can't be discriminated in the statistically uniform MIMO OTA test environment.

The measured performance of the presented antennas in this work, in conjunction with the currently adopted CTIA MIMO Reference antennas IL/IT results. Questioned the validity of relative "ranking" as pass/fail criteria for MIMO OTA. As it was demonstrated, the same MIMO antenna systems can have different results in different test methodologies due its fundamental limitations, i.e. lack of antenna polarization discrimination.

5 References

[1] R4-131988, Proposal of Additional Channel Models for MIMO Performance Characterization

[2] R1-132814, Reply LS on Proposal of Additional Channel Models for MIMO Performance Characterization

[3] R4- 66AH-0011, XPR effects in MIMO Channel Models

Appendix A

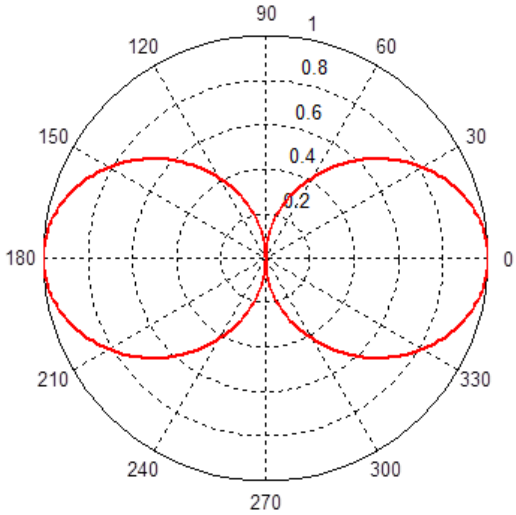

Fig A-1, Eϕ with Horizontally Oriented Dipole

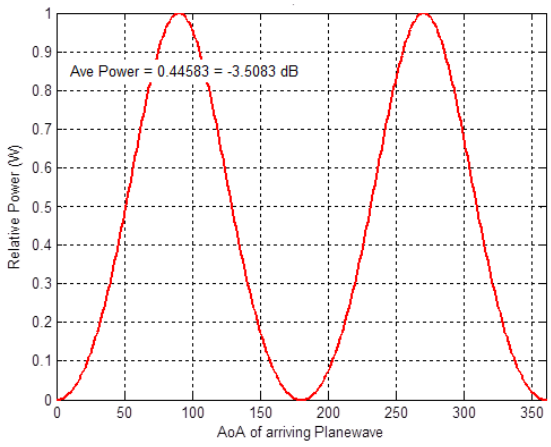

Fig A-2, Average power versus AoA for Eϕ, using Horizontally Oriented Dipole

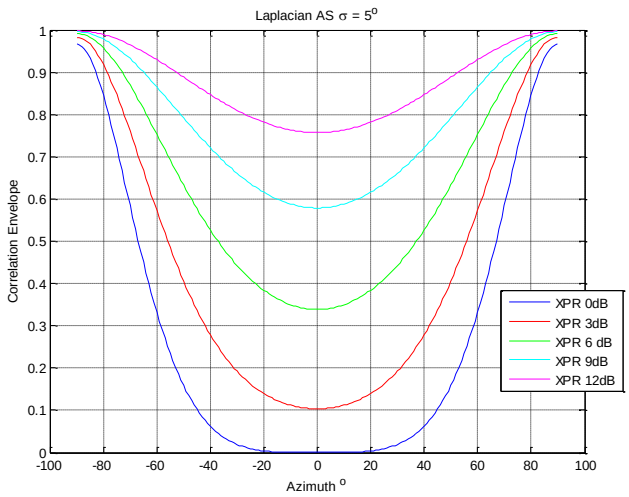

Figure A-3, Cross Polarized BS Correlation vs Azimuth