Appendix I. SPLSR criteria

SAR to Peak Location Separation Ratio (SPLSR)

KDB 447498 D01 General RF Exposure Guidance explains how to calculate the SAR to Peak Location Ratio (SPLSR) between pairs of simultaneously transmitting antennas:

$$SPLSR = (SAR_1 + SAR_2)^{1.5} / Ri$$

Where:

SAR_1 is the highest reported or estimated SAR for the first of a pair of simultaneous transmitting antennas, in a specific test operating mode and exposure condition

SAR_2 is the highest reported or estimated SAR for the second of a pair of simultaneous transmitting antennas, in the same test operating mode and exposure condition as the first

Ri is the separation distance between the pair of simultaneous transmitting antennas. When the SAR is measured, for both antennas in the pair, it is determined by the actual x, y and z coordinates in the 1-g SAR for each SAR peak location, based on the extrapolated and interpolated result in the zoom scan measurement, using the formula of

square root of $[(x_1-x_2)_2 + (y_1-y_2)_2 + (z_1-z_2)_2]$

In order for a pair of simultaneous transmitting antennas with the sum of 1-g SAR > 1.6 W/kg to qualify for exemption from Simultaneous Transmission SAR measurements, it has to satisfy the condition of:

$$(SAR_1 + SAR_2)^{1.5} / Ri \leq 0.04$$

When an individual antenna transmits at on two bands simultaneously, the sum of the highest *reported* SAR for the frequency bands should be used to determine SAR_1.or SAR_2. When SPLSR is necessary, the smallest distance between the peak SAR locations for the antenna pair with respect to the peaks from each antenna should be used.

The antennas in all antenna pairs that do not qualify for simultaneous transmission SAR test exclusion must be tested for SAR compliance, according to the enlarged zoom scan and volume scan post-processing procedures in KDB Publication 865664 D01

The antennas for the unlicensed transmitters are closely situated. As a result, the associated SAR hotspots are also closely situated. Some of the sum of SAR calculations yielded results over 1.6 W/kg. The SPSLR calculations for these situations were performed by treating the unlicensed SAR values as a single transmitter. The most conservative distance between all the unlicensed hotspots to the licensed hotspot was used for the value of *d* in the SPSLR calculation.

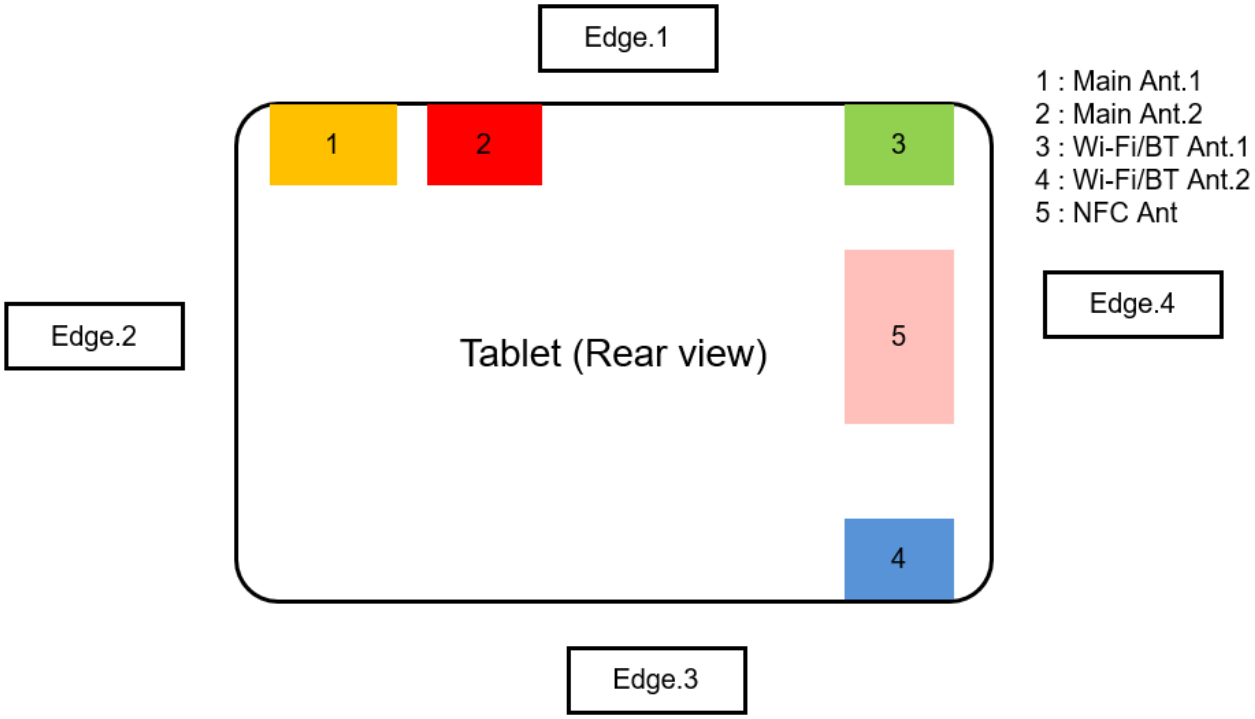
Sum to Peak Location Separation Ratio

According to TCB workshop note, Instead of doing a small volume scan over a co-located antenna pair (Hybrid SPLSR guide), Simultaneous transmission SAR test exclusion may algebraically sum the SAR values of the co-located pair and use that value in SPLSR calculation;

-In the calculation Separation distance must use the minimum distance between the spatially separated antenna and the closest antenna of the co-located antenna pair to be conservative.

1. Peak SAR location in each WWAN & WLAN & BT & NFC in Rear position

According to Antenna location of Rear side, WWAN and “WLAN & BT & NFC” are far enough apart. So First SPLSR criteria performed for each pair combination of “WLAN & BT & NFC” according to simultaneous transmission scenarios, and then SPLSR criteria performed at the closet distance between WWAN and one of “WWAN & WLAN & BT & NFC. If each pair has meet SPLSR criteria, Volume scan test is not required.



Note(s):

Each Ant & Bands’ SAR distribution & Peak location are refer to Figures.

1.1 SPLSR criteria of WLAN & BT& NFC according to Simultaneous transmission scenarios

WLAN & BT & NFC Reported SAR & Peak SAR location

1	DTS Ant.2		Figure	2	DTS MIMO		Figure	3	UNII Ant.2		Figure	4	UNII MIMO		Figure	5	BT Ant.1		Figure	6	BT Ant.2		Figure	7	NFC		Figure
Reported SAR (W/kg)	SAR location (mm)			Reported SAR (W/kg)	SAR location (mm)			Reported SAR (W/kg)	SAR location (mm)			Reported SAR (W/kg)	SAR location (mm)			Reported SAR (W/kg)	SAR location (mm)			Reported SAR (W/kg)	SAR location (mm)			Reported SAR (W/kg)	SAR location (mm)		
	X-axis	Y-axis			X-axis	Y-axis			X-axis	Y-axis			X-axis	Y-axis			X-axis	Y-axis			X-axis	Y-axis			X-axis	Y-axis	
0.660	82.0	90.4	1	0.751	80.8	95.2	2	0.772	76.0	93.0	3	0.822	-74.0	89.0	4	0.741	-69.8	88.0	5	0.528	83.6	84.4	6	0.051	6.1	106.6	7

4 + 5	UNII MIMO + BT Ant.1		Figure
Sum SAR (W/kg)	SAR location (mm)		
	X-axis	Y-axis	
1.563	-69.8	88.0	8

SPLSR criteria of Simultaneous transmission scenarios

Simultaneous transmission scenarios		Sum of SAR (W/kg)	Calculated Distance (mm)	1-g SPLSR (=<0.04) or 10-g SPSLR (=<0.10)	Volume Scan (Yes/No)	Note.	Figure
Case.1	(1+4+5+7) (4+5+7)	2.274				1	9
	1+(4+5)	2.223	151.8	0.02	No		
	1+7	0.711	77.6	0.01	No		
	(4+5)+7	1.614	78.1	0.03	No		
Case.2	(1+5+7) (5+7)	1.452					10
	1+5	1.401	151.8	0.01	No		
	1+7	0.711	77.6	0.01	No		
	5+7	0.792	78.1	0.01	No		
Case.3	4+6+7 (4+7) (6+7)	1.401					11
	4+6	1.350	157.7	0.01	No		
	4+7	0.873	82.0	0.01	No		
	6+7	0.579	80.6	0.01	No		
Case.4	2+4+7 (2+7)	1.624					12
	2+4	1.573	154.9	0.01	No		
	2+7	0.802	75.6	0.01	No		
	4+7	0.873	82.0	0.01	No		
Case.5	3+7	0.823	71.2	0.01	No		13

Note(s):

1. For UNII MIMO + BT Ant.1, Both Peak SAR are located close to each other. So SUM-SPLSR procedure apply to this scenario.
2. Some Simultaneous transmission scenarios are subset of other Simultaneous transmission scenarios.
3. According to SPLSR results of each pair, WWAN & BT & NFC combination are meet SPLSR criteria.

1.2 SPLSR criteria of WWAN and one of "WLAN & BT& NFC" according to Simultaneous transmission scenarios

According to Peak SAR location results, BT Ant.1 is closet distance with WWAN Antennas. So The location was used for SPLSR criteria of Main bands. And For conservative SPLSR criteria, the highest Reported SAR value among "WLAN & BT & NFC" were used.

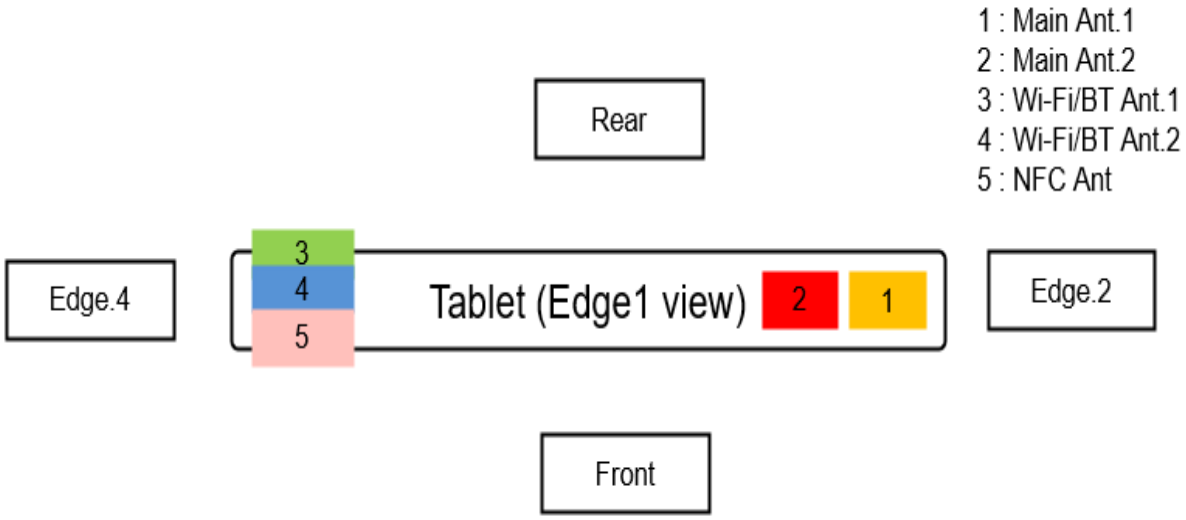
WWAN Bands	Antenna	Reported SAR (W/kg)	SAR location (mm)		Figure	WLAN/BT/NFC Combinations	Closet Antenna	Reported SAR (W/kg)	SAR location (mm)		SUM of SAR (W/kg)	Calculated Distance (mm)	1-g SPLSR (=<0.04) or 10-g SPSLR (=<0.10)	Volume Scan (Yes/No)
			X-axis	Y-axis					X-axis	Y-axis				
GSM 850	Main Ant.1	0.426	-57.5	-87.0	14	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	1.989	175.4	0.02	No
GSM 1900	Main Ant.1	1.118	-80.5	-85.5	15	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.681	173.8	0.03	No
WCDMA Band II	Main Ant.1	1.055	-80.5	-84.0	16	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.618	172.3	0.02	No
WCDMA Band IV	Main Ant.1	1.001	-83.5	-88.5	17	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.564	177.0	0.02	No
WCDMA Band V	Main Ant.1	0.497	-57.5	-90.0	18	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.060	178.4	0.02	No
LTE Band 5	Main Ant.1	0.436	-68.5	-99.0	19	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	1.999	187.0	0.02	No
LTE Band 12/17	Main Ant.1	0.471	-78.0	-85.5	20	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.034	173.7	0.02	No
LTE Band 13	Main Ant.1	0.348	-56.0	-87.0	21	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	1.911	175.5	0.02	No
LTE Band 25	Main Ant.1	0.920	-83.0	-85.5	22	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.483	174.0	0.02	No
LTE Band 26	Main Ant.1	0.700	-64.0	-109.0	23	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.263	197.1	0.02	No
LTE Band 41	Main Ant.2	0.927	-71.8	-51.0	24	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.490	139.0	0.03	No
LTE Band 66	Main Ant.1	1.120	-83.0	-81.0	25	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.683	169.5	0.03	No
NR Band n5	Main Ant.1	0.537	-68.5	-97.5	26	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.100	185.5	0.02	No
NR Band n66	Main Ant.1	1.020	-84.0	-88.0	27	UNII MIMO + BT Ant.1	BT Ant.1	1.563	-69.8	88.0	2.583	176.6	0.02	No

Note(s):

1. The highest Reported SAR value among "WLAN & BT & NFC" is 1.563 W/kg (UNII MIMO+BT Ant.1 combination).
2. According to SPLSR results of each pair, WWAN and "WLAN & BT & NFC" combination are meet SPLSR criteria.

2. Peak SAR location in each WWAN & WLAN & BT & NFC in Edge 1 position

According to Antenna location of Edge 1 side, WWAN and “WLAN & BT & NFC” are far enough apart. So Firstly SPLSR criteria perform for each pair combination of “WLAN & BT & NFC” according to simultaneous transmission scenarios, But Wi-Fi/BT Ant.1 & WiFi/BT Ant.2 & NFC are located close to each other in Edge.1 side. Therefore, Sum to Peak Location Separation Ratio procedure is apply to “WLAN & BT & NFC” according to simultaneous transmission scenarios. and then SPLSR criteria performed at the closet distance between WWAN and one of “WWAN & WLAN & BT & NFC. If each pair has meet SPLSR criteria, Volume scan test is not required.



Note(s):

Each Ant & Bands’ SAR distribution & Peak location are refer to Figures.

2.1 WWAN band's peak SAR locations & WLAN & BT & NFC's peak SAR locations

WWAN bands

Antenna	WWAN Bands	Reported SAR (W/kg)	SAR location (mm)		Figure	Highest Reported SAR (W/kg)	mimimum SAR location (mm)	
			X-axis	Y-axis			X-axis	Y-axis
Main Ant.1	GSM 1900	1.091	3.0	84.5	28	1.091	-4.5	82.5
	WCDMA Band II	0.956	-4.5	82.5	29			
	WCDMA Band IV	0.886	-3.0	85.5	30			
	LTE Band 25	1.043	-4.5	84.0	31			
	LTE Band 66	0.769	-3.0	85.5	32			
	NR Band n66	0.662	-1.5	87.0	33			
Main Ant.2	LTE Band 41	0.432	1.2	32.4	34	0.432	1.2	32.4

WLAN & BT & NFC

WLAN/BT/NFC Standalone	Reported SAR (W/kg)	SAR location (mm)		Figure
		X-axis	Y-axis	
DTS Ant.2	0.001	-1.2	-106.0	35
DTS MIMO	0.140	-1.2	-106.0	36
UNII MIMO	1.018	-4.0	-87.0	37
BT Ant.1	0.211	-2.4	-93.6	38
BT Ant.2	0.001	-8.4	-123.0	39
NFC	0.000	N/A	N/A	

WLAN/BT/NFC combinations	SUM SAR (W/kg)	Mimimum SAR location (mm)		Figure
		X-axis	Y-axis	
DTS MIMO + NFC	0.140	-1.2	-106.0	36
UNII MIMO + NFC	1.018	-4.0	-87.0	37
BT Ant.1 + NFC	0.211	-2.4	-93.6	38
BT Ant.2 + NFC	0.001	-8.4	-123.0	39
DTS Ant.2 + BT Ant.1 + NFC	0.212	-2.4	-93.6	40
UNII MIMO + BT Ant.1 + NFC	1.229	-4.0	-87.0	41
UNII MIMO + BT Ant.2 + NFC	1.019	-4.0	-87.0	42
DTS MIMO + UNII MIMO + NFC	1.158	-4.0	-87.0	43
DTS Ant.2 + UNII MIMO + BT Ant.1 + NFC	1.230	-4.0	-87.0	44

Note(s):

For Minimum SAR location, The smallest distance between "WWAN" and "WLAN&BT&NFC" was applied, respectively.

2.2 SPLSR criteria of WWAN and one of "WLAN & BT& NFC" according to Simultaneous transmission scenarios

For SPLSR criteria of both WWAN and "WLAN & BT & NFC" according to simultaneous transmission scenarios, The highest Reported SAR value and the minimum distance were determined from the reported SAR values and locations of the supported bands of each Main 1 Ant and Main 2 Ant respectively, and then SPLSR criteria performed.

Antenna	Highest Reported SAR (W/kg)	Minimum SAR location (mm)		WLAN/BT/NFC combinations	SUM SAR (W/kg)	Minimum SAR location (mm)		SUM of SAR (W/kg)	Calculated Distance (mm)	1-g SPLSR (=<0.04) or 10-g SPSLR (=<0.10)	Volume Scan (Yes/No)
		X-axis	Y-axis			X-axis	Y-axis				
Main Ant.1	1.091	-4.5	82.5	UNII MIMO + NFC	1.018	-4.0	-87.0	2.109	169.5	0.02	No
Main Ant.1	1.091	-4.5	82.5	UNII MIMO + BT Ant.1 + NFC	1.229	-4.0	-87.0	2.320	169.5	0.02	No
Main Ant.1	1.091	-4.5	82.5	UNII MIMO + BT Ant.2 + NFC	1.019	-4.0	-87.0	2.110	169.5	0.02	No
Main Ant.1	1.091	-4.5	82.5	DTS MIMO + UNII MIMO + NFC	1.158	-4.0	-87.0	2.249	169.5	0.02	No
Main Ant.1	1.091	-4.5	82.5	DTS Ant.2 + UNII MIMO + BT Ant.1 + NFC	1.230	-4.0	-87.0	2.321	169.5	0.02	No
Main Ant.2	0.432	1.2	32.4	UNII MIMO + NFC	1.018	-4.0	-87.0	1.450	119.5	0.01	No
Main Ant.2	0.432	1.2	32.4	UNII MIMO + BT Ant.1 + NFC	1.229	-4.0	-87.0	1.661	119.5	0.02	No
Main Ant.2	0.432	1.2	32.4	UNII MIMO + BT Ant.2 + NFC	1.019	-4.0	-87.0	1.451	119.5	0.01	No
Main Ant.2	0.432	1.2	32.4	DTS MIMO + UNII MIMO + NFC	1.158	-4.0	-87.0	1.590	119.5	0.02	No
Main Ant.2	0.432	1.2	32.4	DTS Ant.2 + UNII MIMO + BT Ant.1 + NFC	1.230	-4.0	-87.0	1.662	119.5	0.02	No

Note(s):

According to SPLSR results of each pair, WWAN and "WLAN & BT & NFC" combination are meet SPLSR criteria.

Conclusion:

Simultaneous Transmission SAR analysis results is satisfied the FCC Limit requirement according to follow procedures with "SPLSR or "Sum-Peak Location Separation Ratio"

Figure (1)

Reported SAR (W/kg)	0.660	Peak SAR location (mm)	
		X-axis	Y-axis
		82.0	90.4

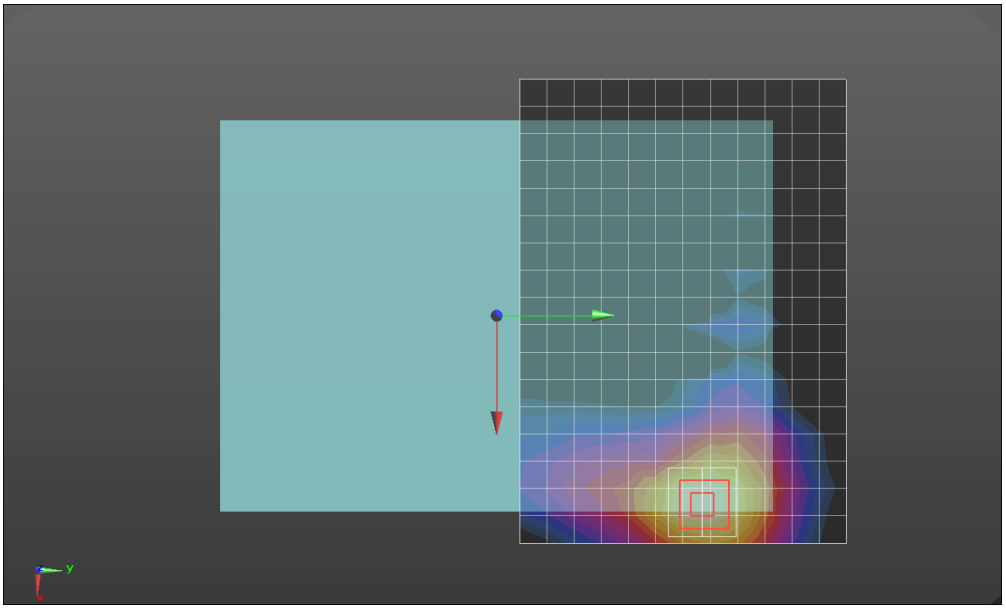


Figure (2)

Reported SAR (W/kg)	0.751	Peak SAR location (mm)	
		X-axis	Y-axis
		80.8	95.2

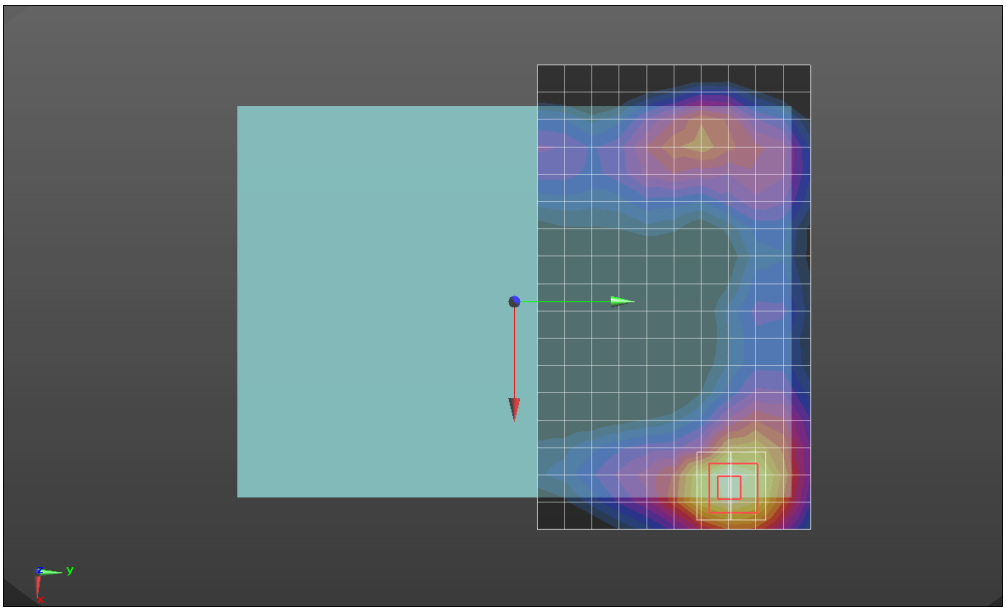


Figure (3)

Reported SAR (W/kg)	0.772	Peak SAR location (mm)	
		X-axis	Y-axis
		76.0	93.0

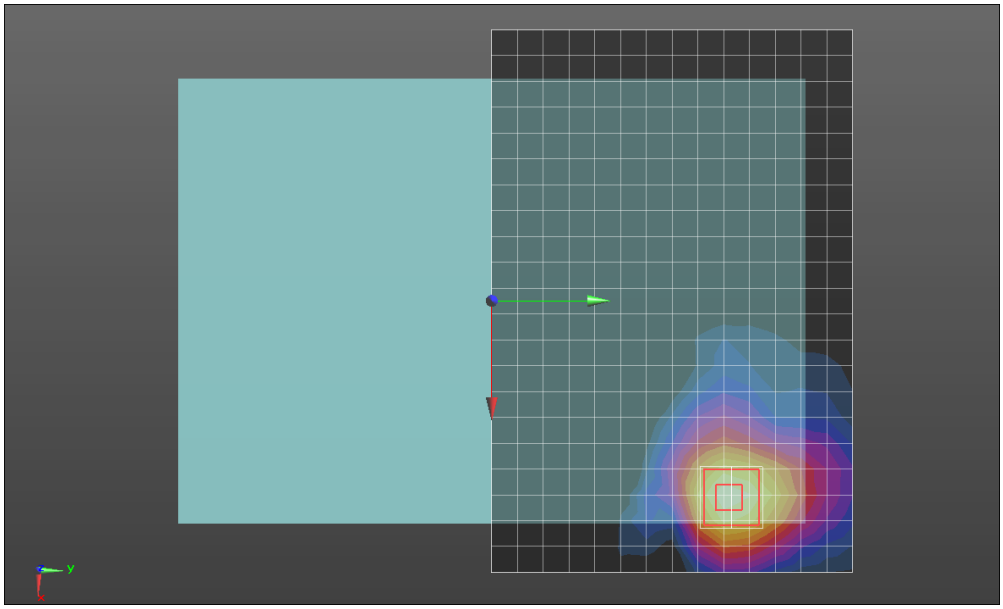


Figure (4)

Reported SAR (W/kg)	0.822	Peak SAR location (mm)	
		X-axis	Y-axis
		-74.0	89.0

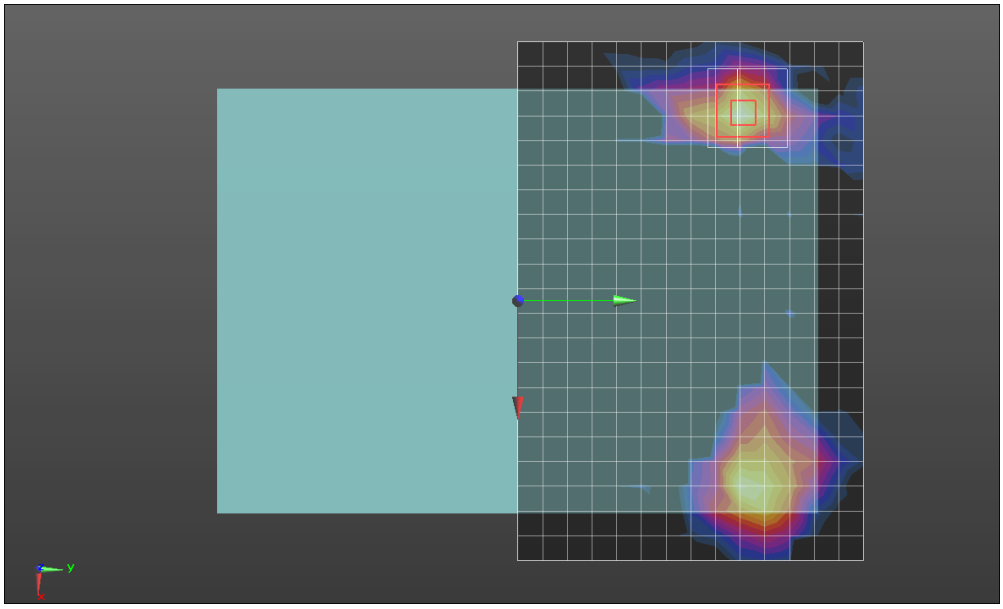


Figure (5)

Reported SAR (W/kg)	0.741	Peak SAR location (mm)	
		X-axis	Y-axis
		-69.8	88.0

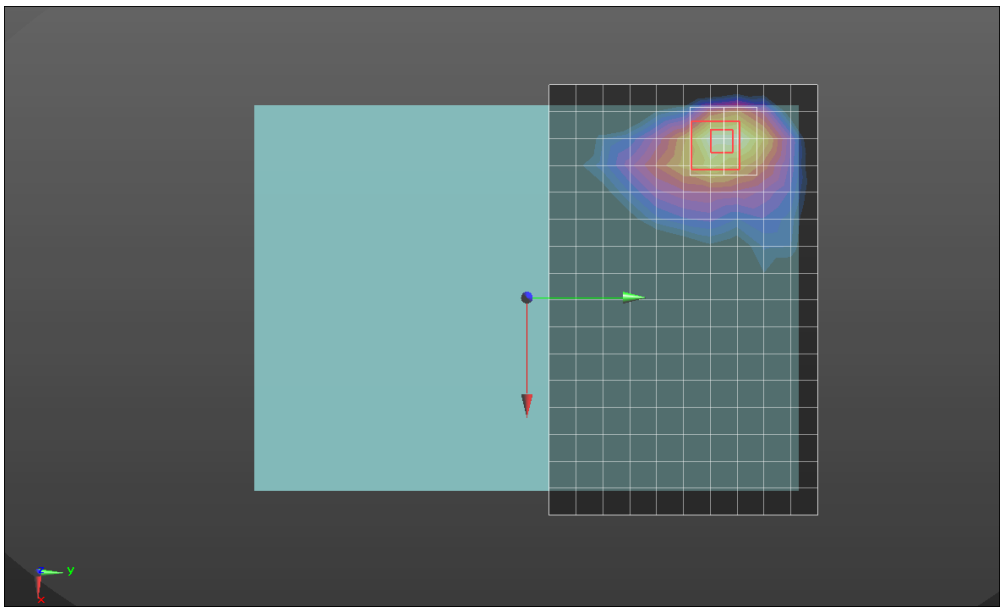


Figure (6)

Reported SAR (W/kg)	0.528	Peak SAR location (mm)	
		X-axis	Y-axis
		83.6	84.4

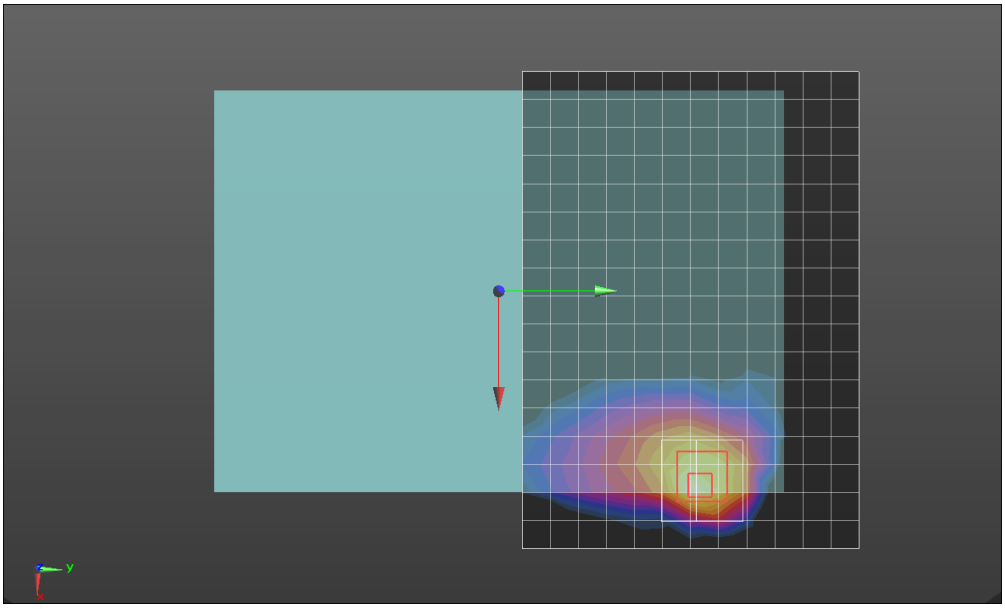


Figure (7)

Reported SAR (W/kg)	0.051	Peak SAR location (mm)	
		X-axis	Y-axis
		6.1	106.6

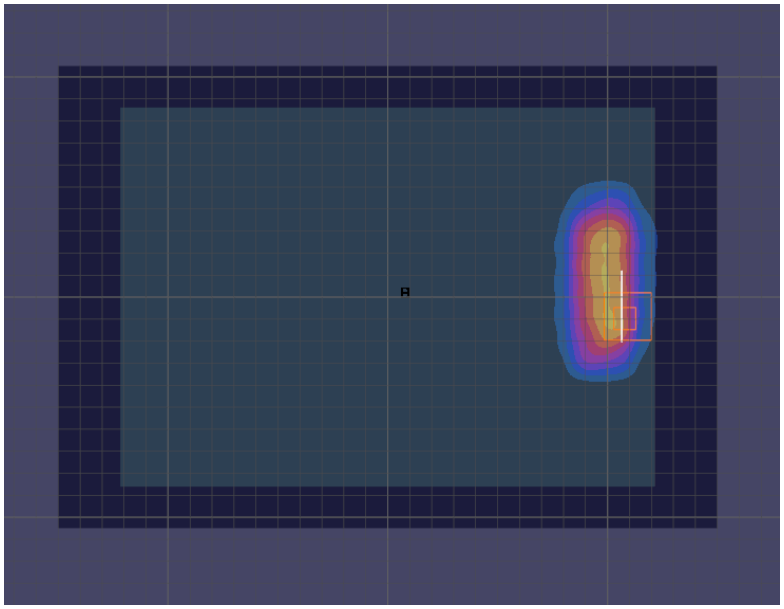


Figure (8)

SUM SAR (W/kg)	1.563	UNII MIMO		BT Ant.1	
		0.822		0.741	
		Peak SAR location (mm)			
		X-axis	Y-axis	X-axis	Y-axis
		-74.0	89.0	-69.8	88.0

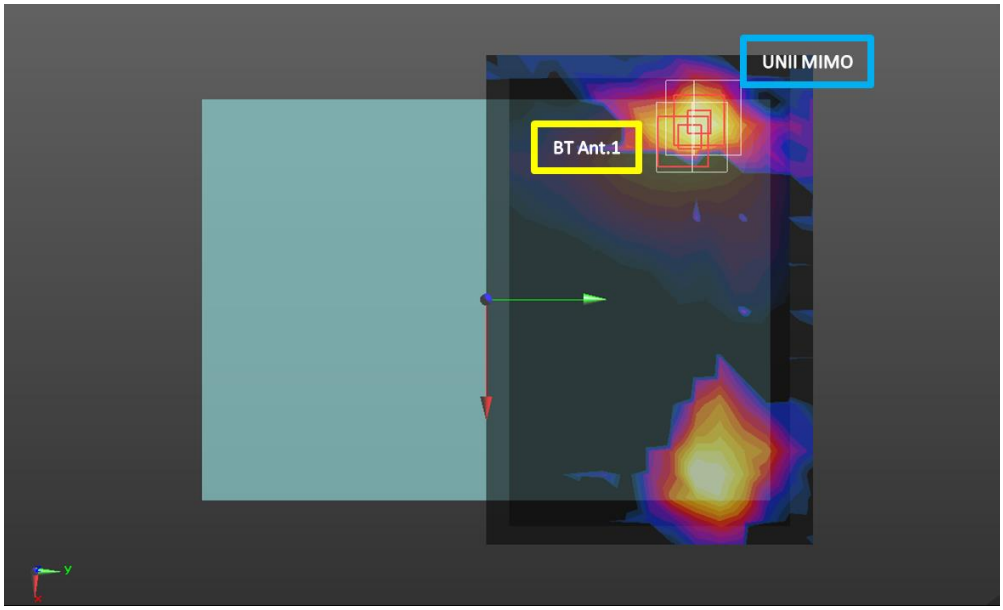


Figure (9)

SUM SAR (W/kg)	2.274	DTS Ant.2		UNII MIMO + BT Ant.1		NFC	
		0.660		1.563		0.051	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		82.0	90.4	-69.8	88.0	6.1	106.6

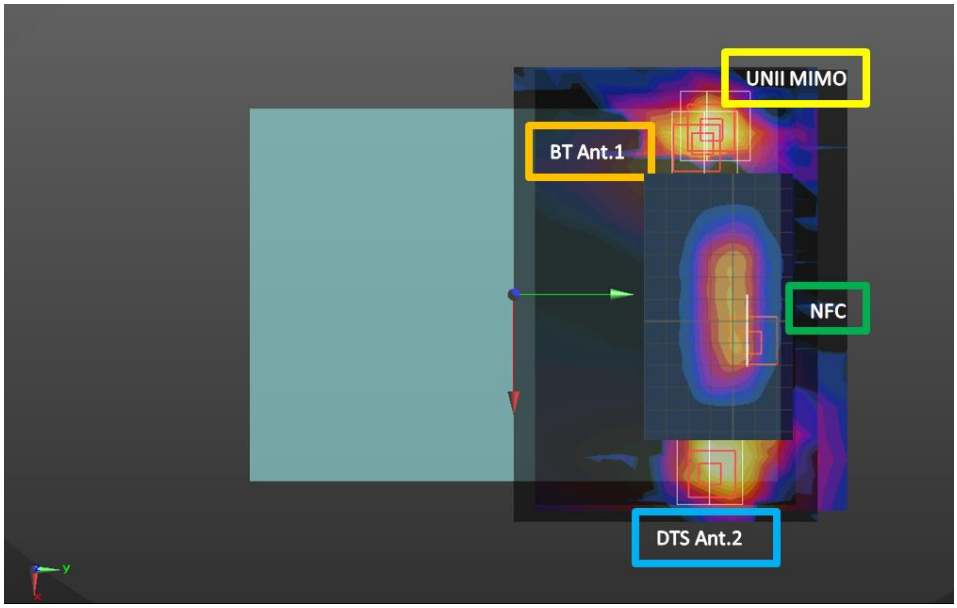


Figure (10)

SUM SAR (W/kg)	1.452	DTS Ant.2		BT Ant.1		NFC	
		0.660		0.741		0.051	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		82.0	90.4	-69.8	88.0	6.1	106.6

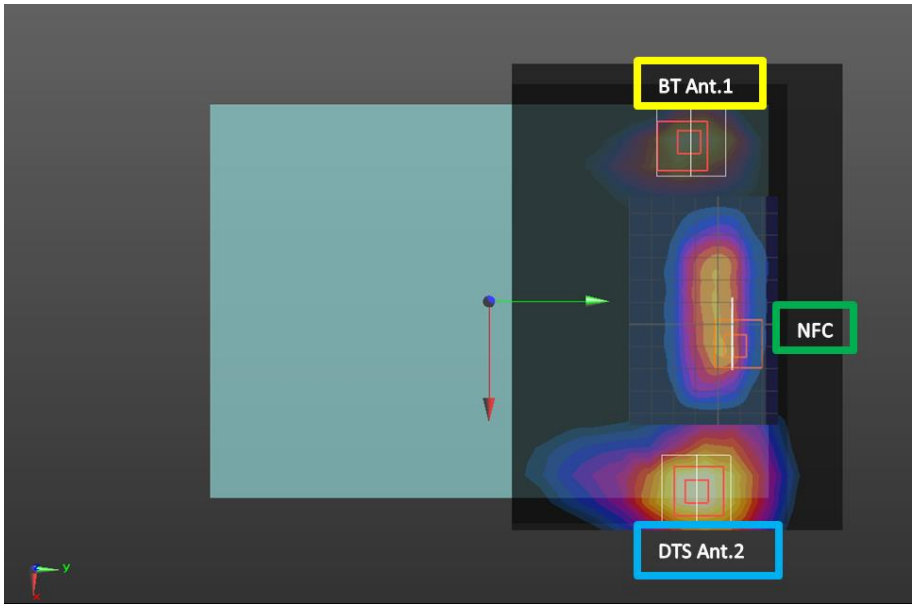


Figure (11)

SUM SAR (W/kg)	1.401	BT Ant.2		UNII MIMO		NFC	
		0.528		0.822		0.051	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		82.0	90.4	-74.0	89.0	6.1	106.6

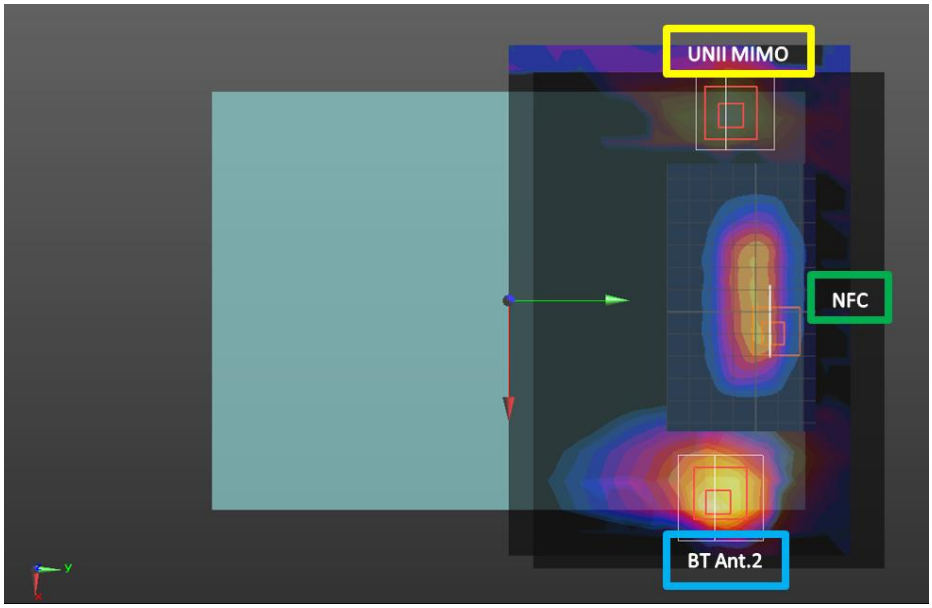


Figure (12)

SUM SAR (W/kg)	1.624	DTS MIMO		UNII MIMO		NFC	
		0.751		0.822		0.051	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		80.8	95.2	-74.0	89.0	6.1	106.6

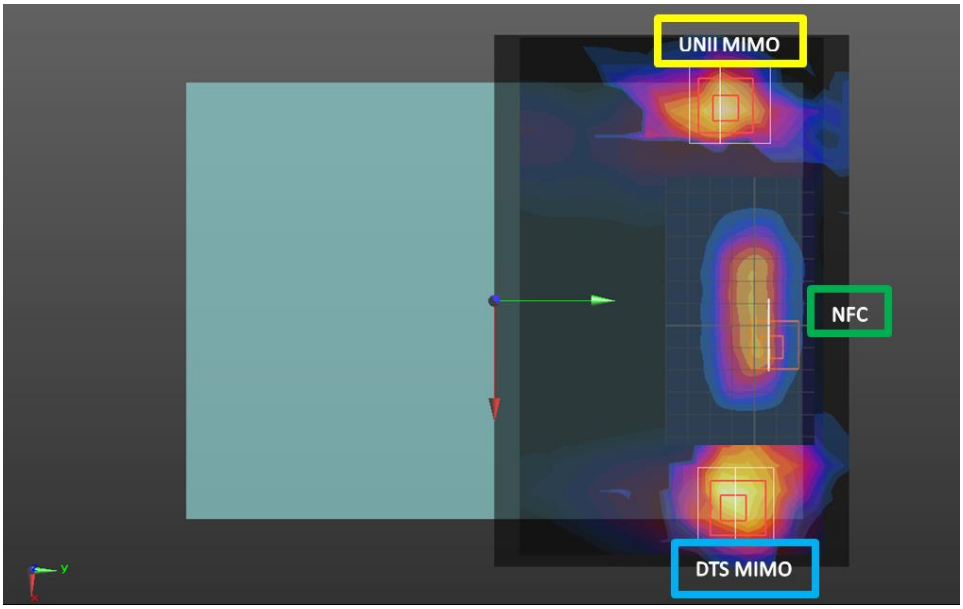


Figure (13)

SUM SAR (W/kg)	0.823	UNII Ant.2		NFC	
		0.772		0.051	
		Peak SAR location (mm)			
		X-axis	Y-axis	X-axis	Y-axis
		76.0	93.0	6.1	106.6

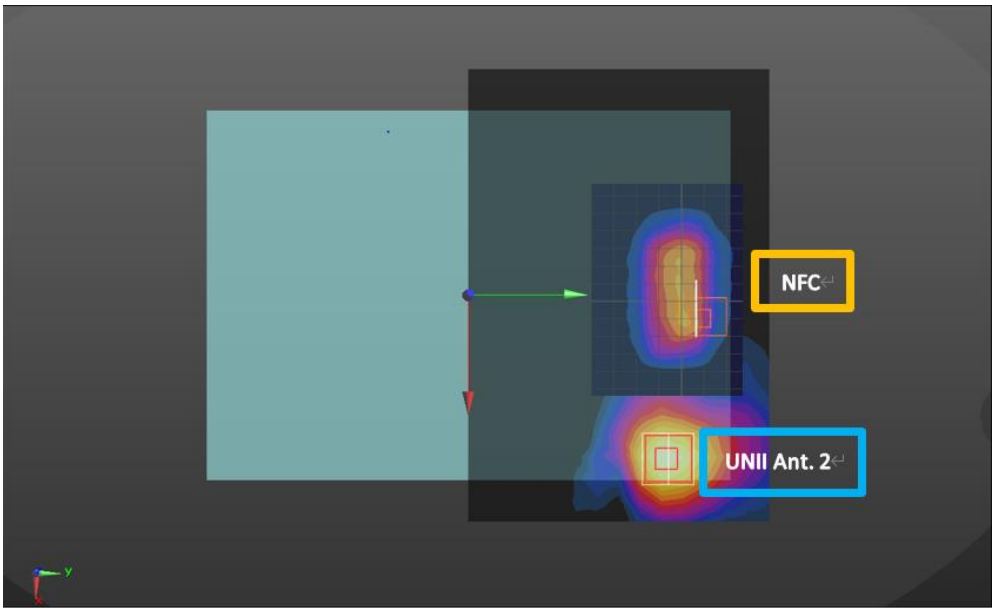


Figure (14)

Reported SAR (W/kg)	0.426	Peak SAR location (mm)	
		X-axis	Y-axis
		-57.5	-87.0

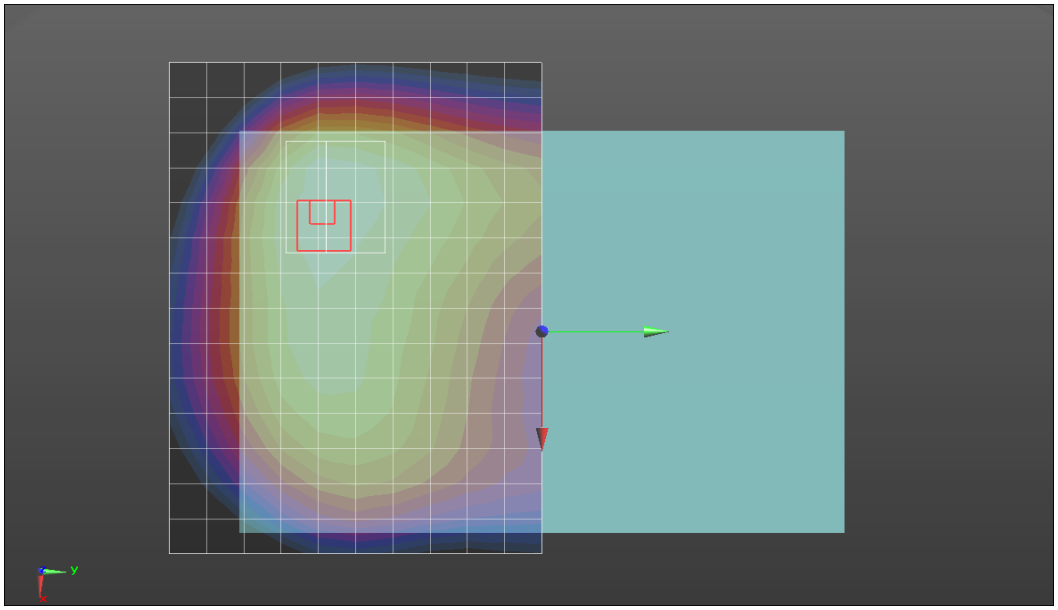


Figure (15)

Reported SAR (W/kg)	1.118	Peak SAR location (mm)	
		X-axis	Y-axis
		-80.5	-85.5

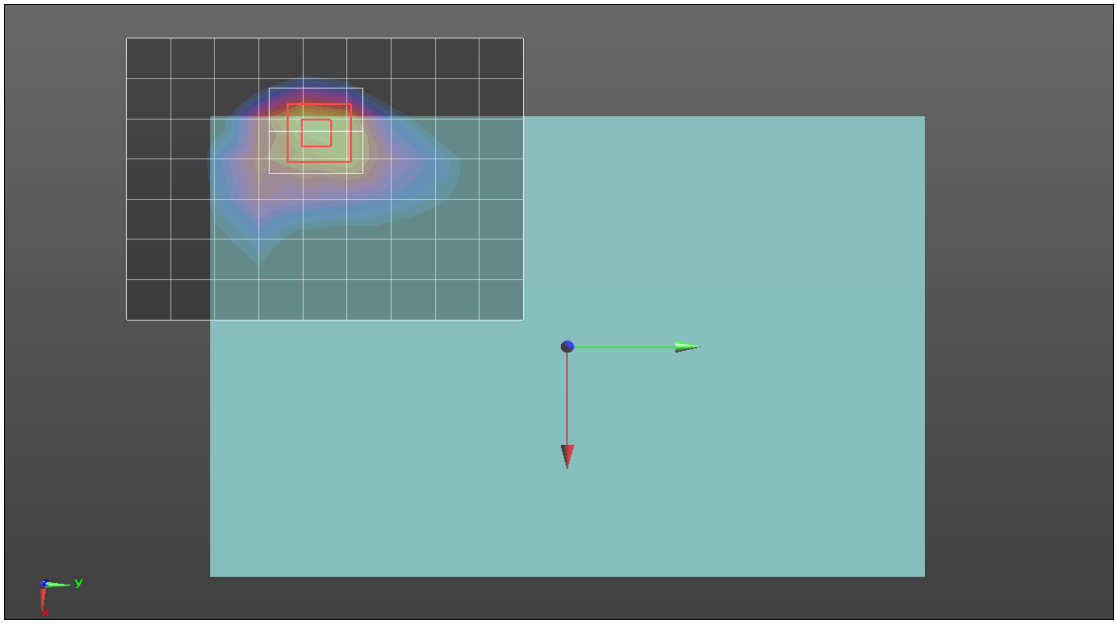


Figure (16)

Reported SAR (W/kg)	1.055	Peak SAR location (mm)	
		X-axis	Y-axis
		-80.5	-84.0

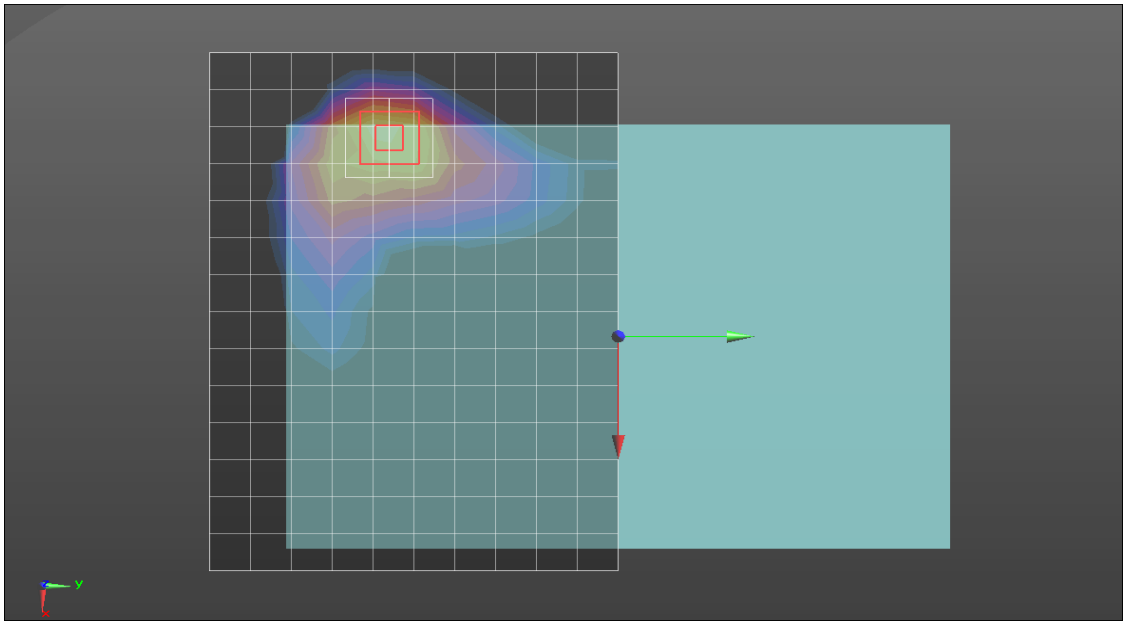


Figure (17)

Reported SAR (W/kg)	1.001	Peak SAR location (mm)	
		X-axis	Y-axis
		-83.5	-88.5

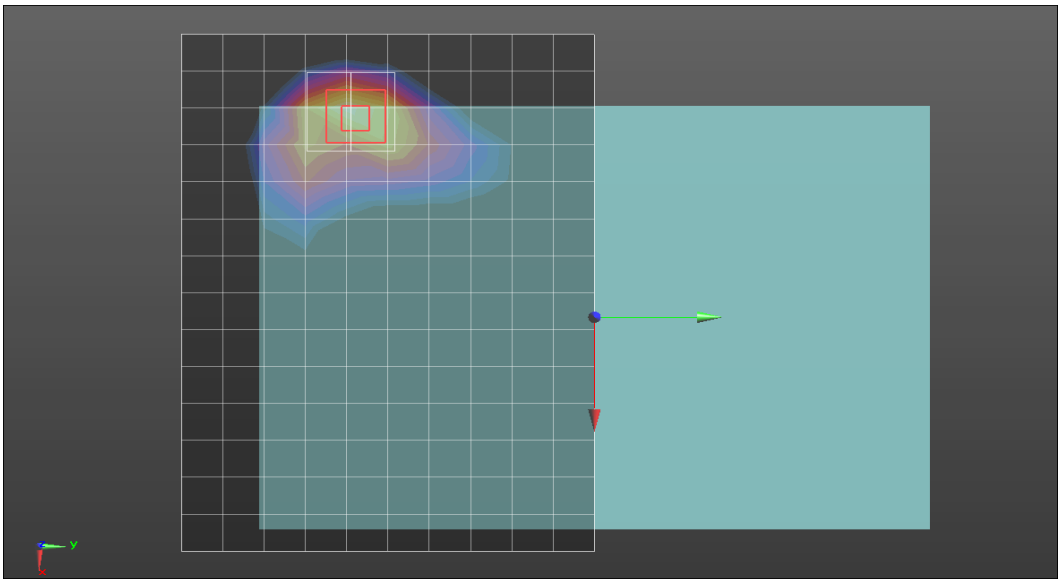


Figure (18)

Reported SAR (W/kg)	0.497	Peak SAR location (mm)	
		X-axis	Y-axis
		-57.5	-90.0

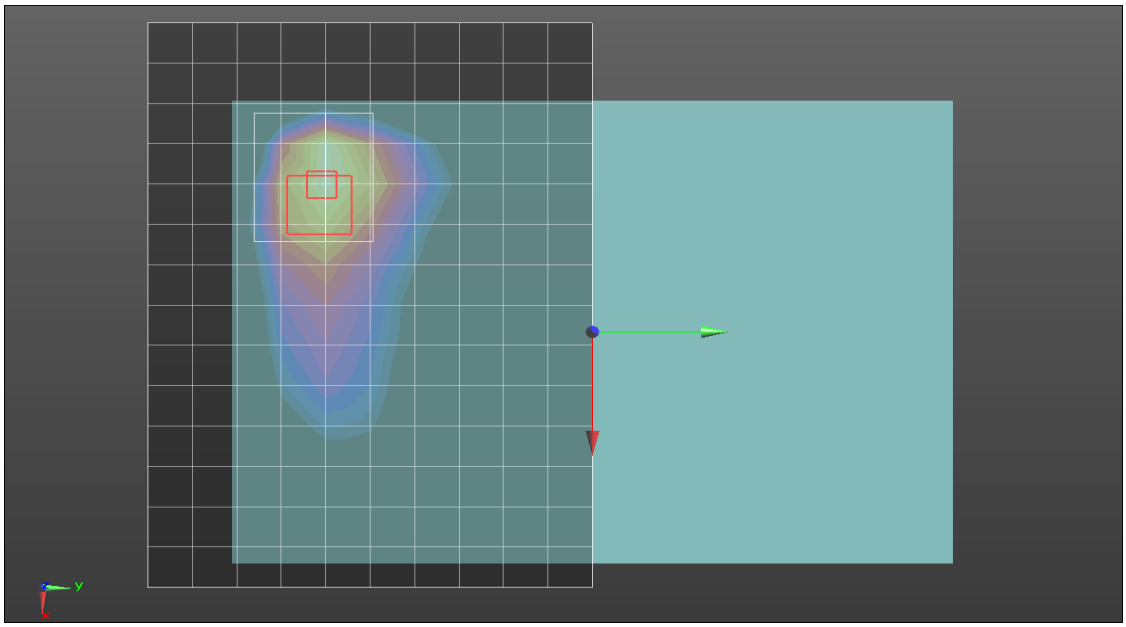


Figure (19)

Reported SAR (W/kg)	0.436	Peak SAR location (mm)	
		X-axis	Y-axis
		-68.5	-99.0

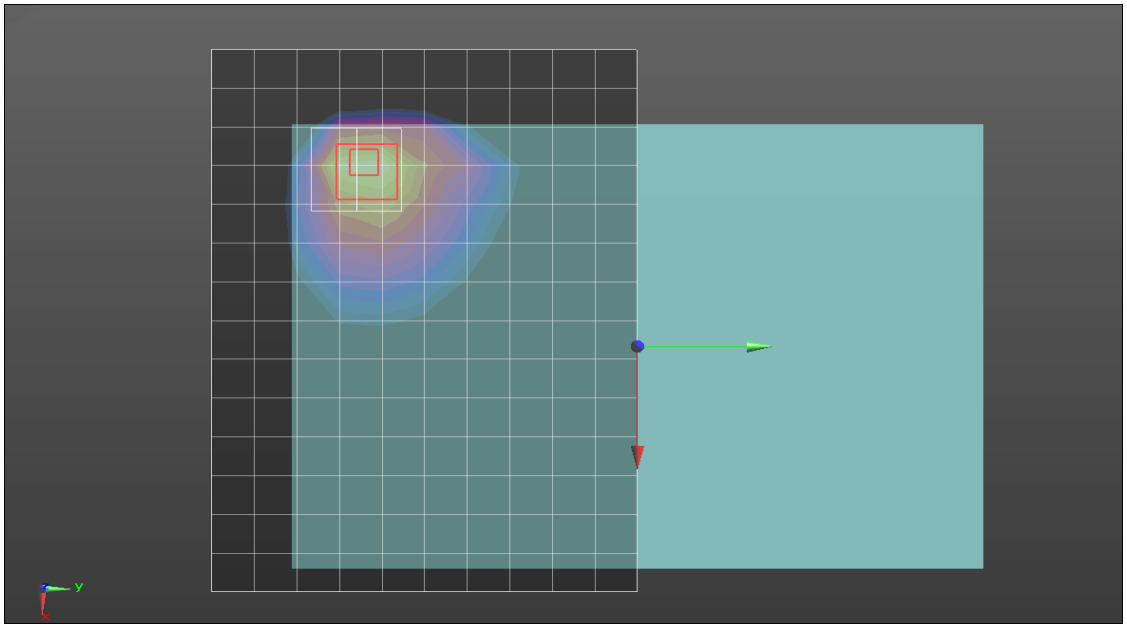


Figure (20)

Reported SAR (W/kg)	0.471	Peak SAR location (mm)	
		X-axis	Y-axis
		-78.0	-85.5

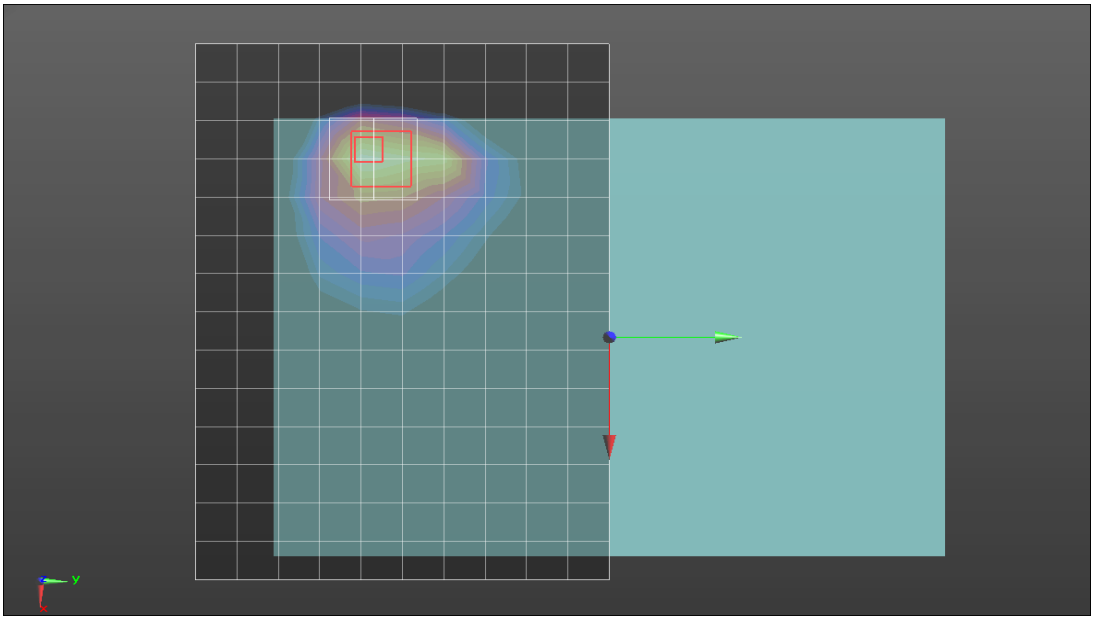


Figure (21)

Reported SAR (W/kg)	0.348	Peak SAR location (mm)	
		X-axis	Y-axis
		-56.0	-87.0

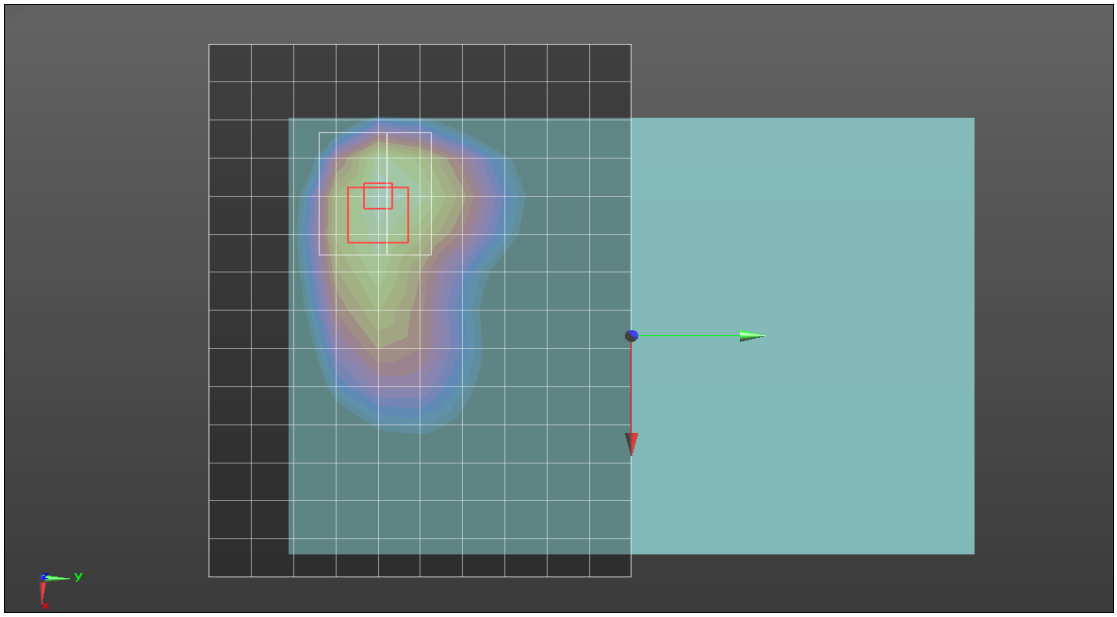


Figure (22)

Reported SAR (W/kg)	0.920	Peak SAR location (mm)	
		X-axis	Y-axis
		-83.0	-85.5

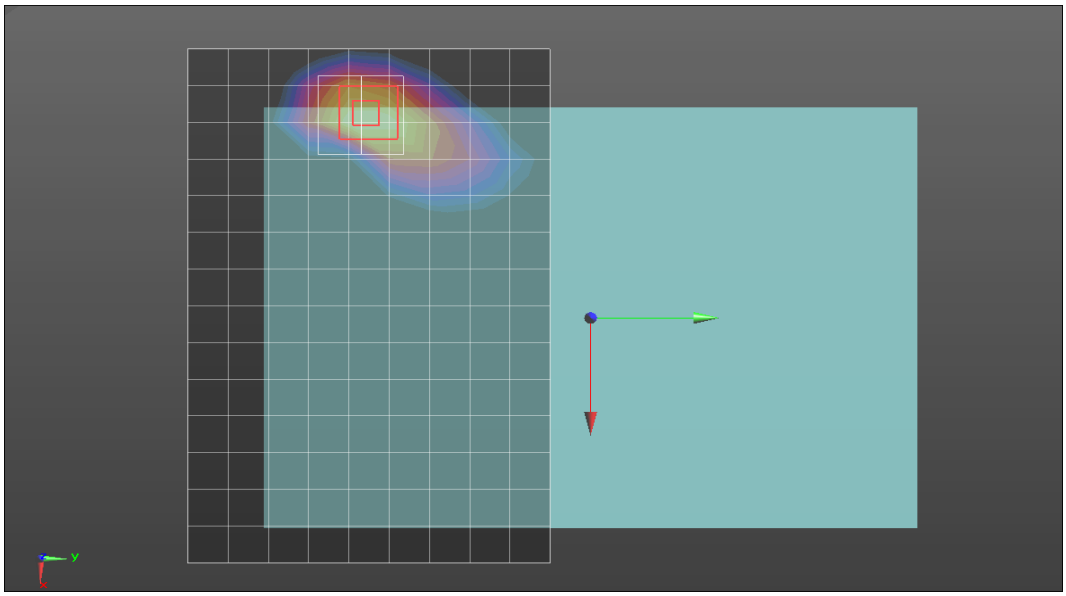


Figure (23)

Reported SAR (W/kg)	0.700	Peak SAR location (mm)	
		X-axis	Y-axis
		-64.0	-109.0

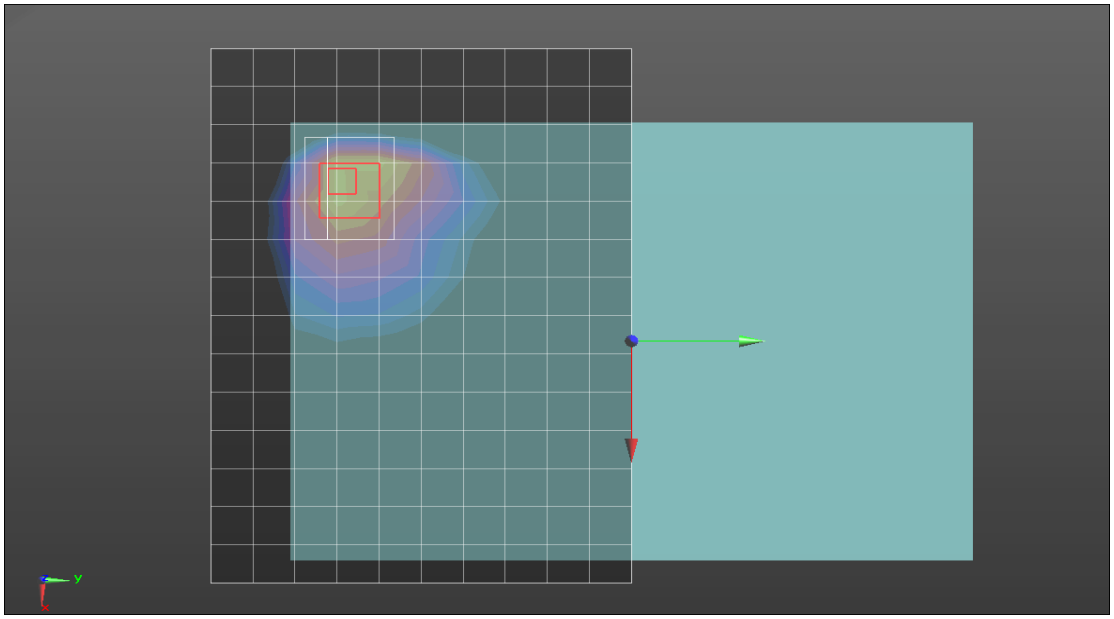


Figure (24)

Reported SAR (W/kg)	0.927	Peak SAR location (mm)	
		X-axis	Y-axis
		-71.8	-51.0

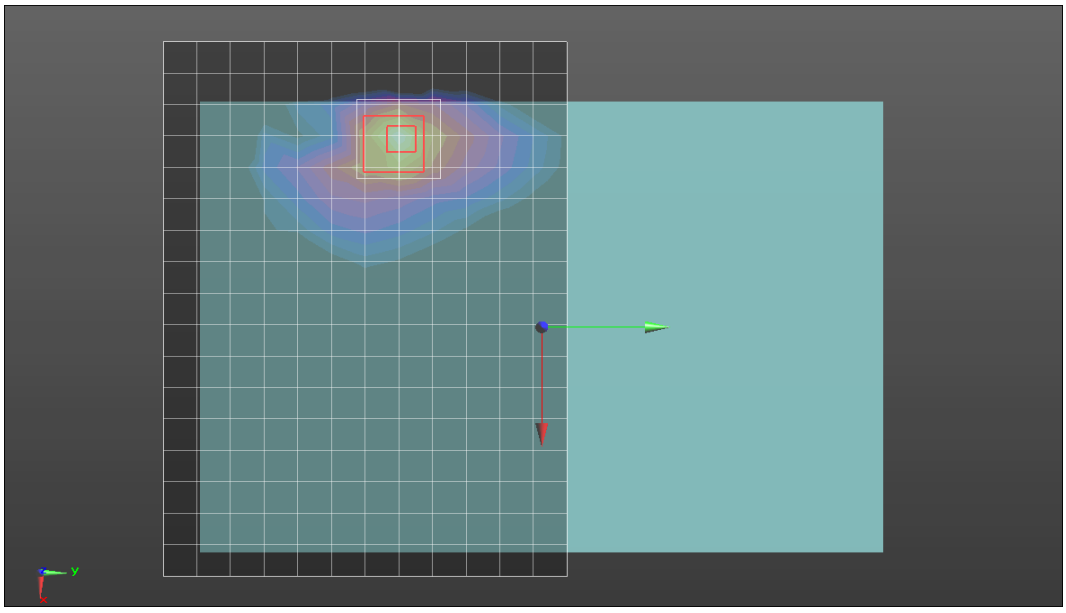


Figure (25)

Reported SAR (W/kg)	1.120	Peak SAR location (mm)	
		X-axis	Y-axis
		-83.0	-81.0

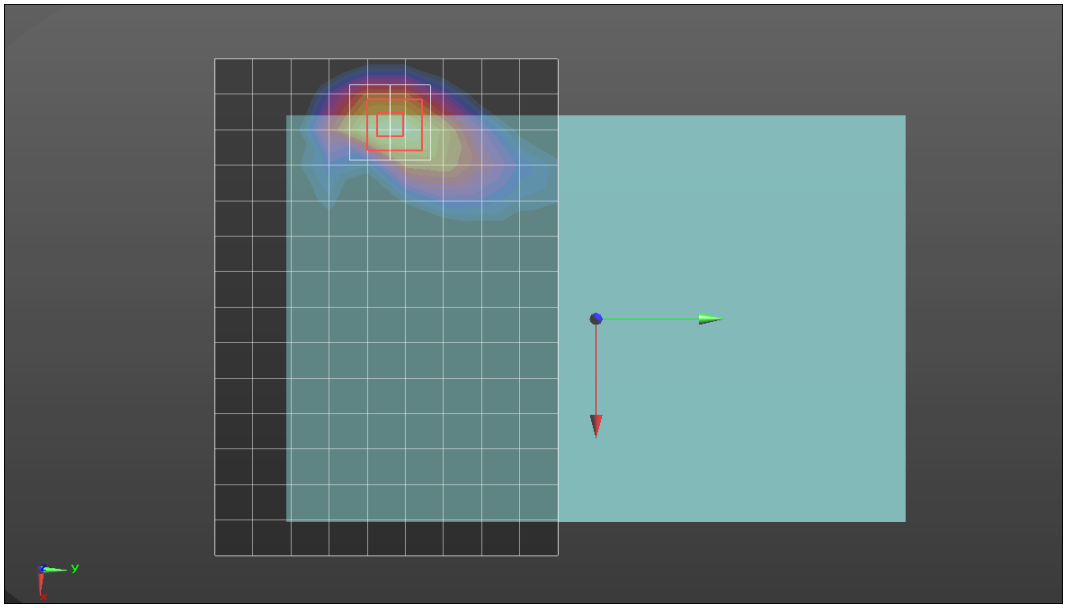


Figure (26)

Reported SAR (W/kg)	0.537	Peak SAR location (mm)	
		X-axis	Y-axis
		-68.5	-97.5

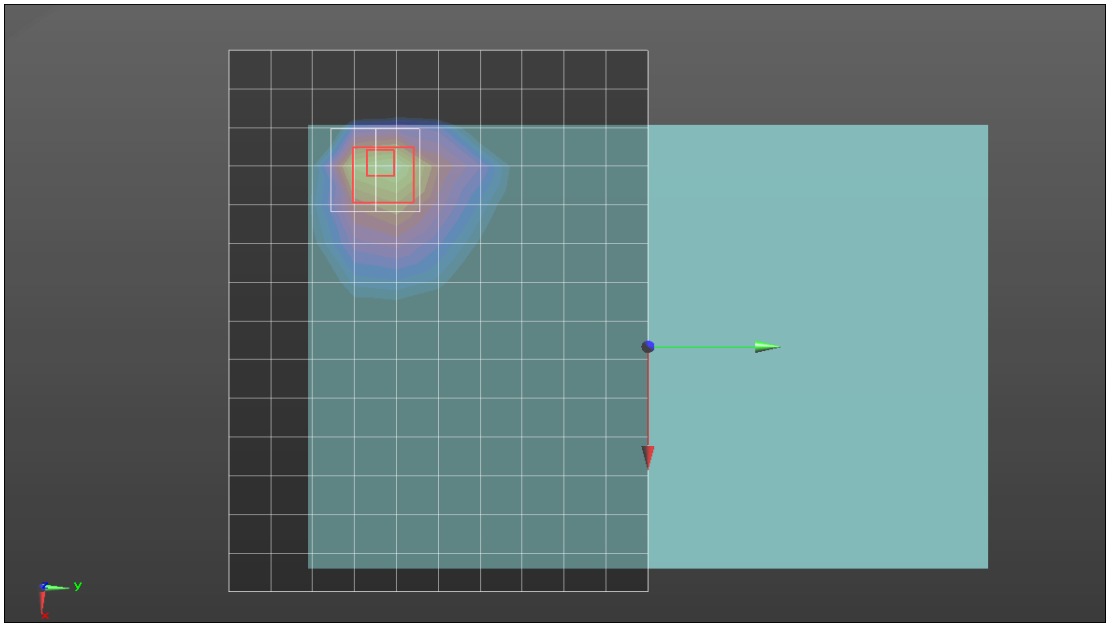


Figure (27)

Reported SAR (W/kg)	1.020	Peak SAR location (mm)	
		X-axis	Y-axis
		-84.0	-88.0

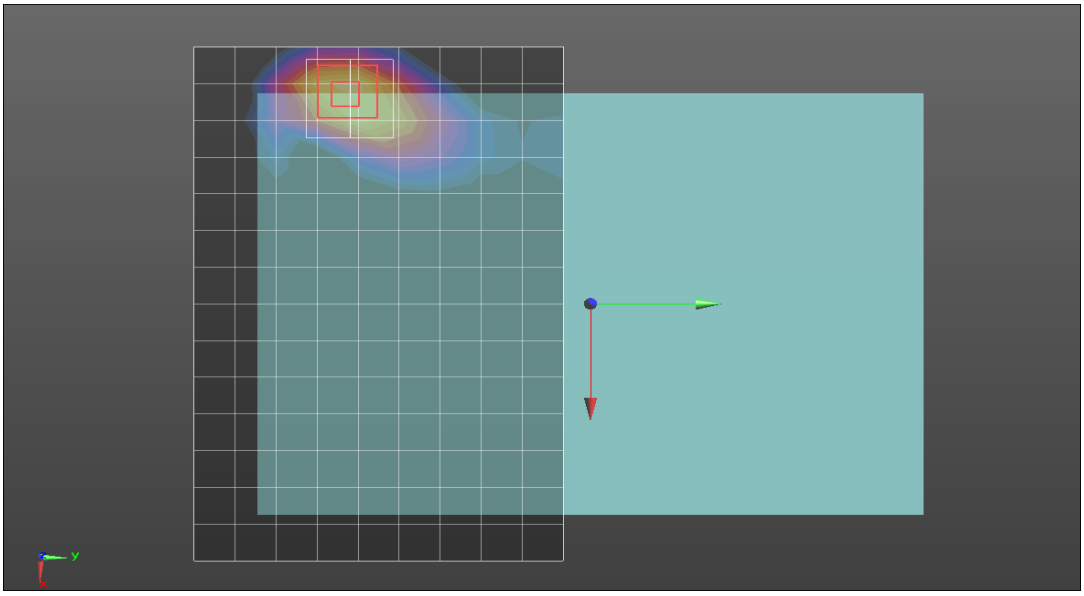


Figure (28)

Reported SAR (W/kg)	1.091	Peak SAR location (mm)	
		X-axis	Y-axis
		3.0	84.5

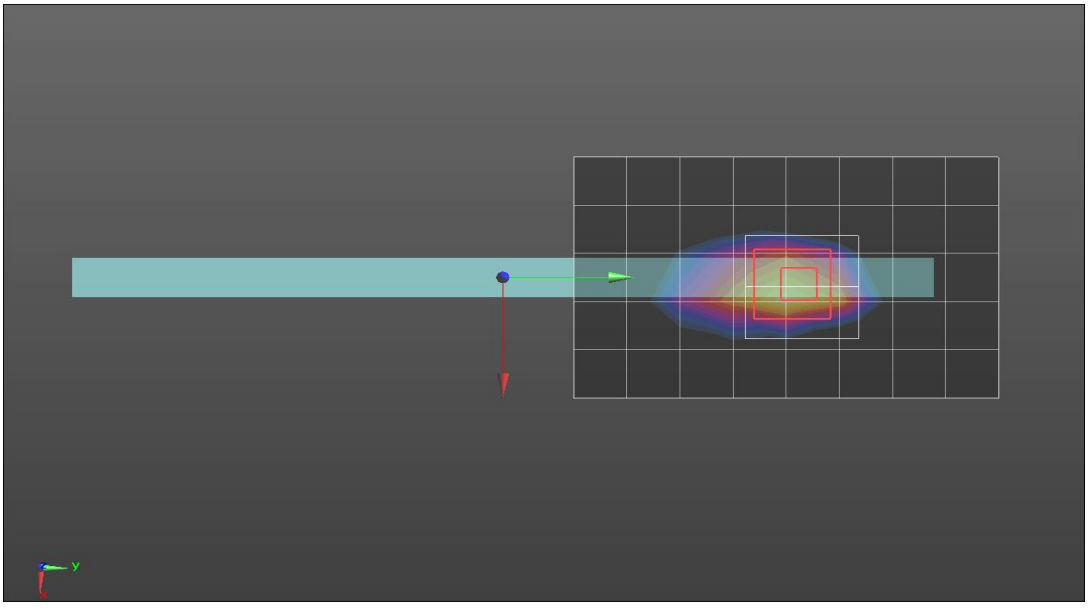


Figure (29)

Reported SAR (W/kg)	0.956	Peak SAR location (mm)	
		X-axis	Y-axis
		-4.5	82.5

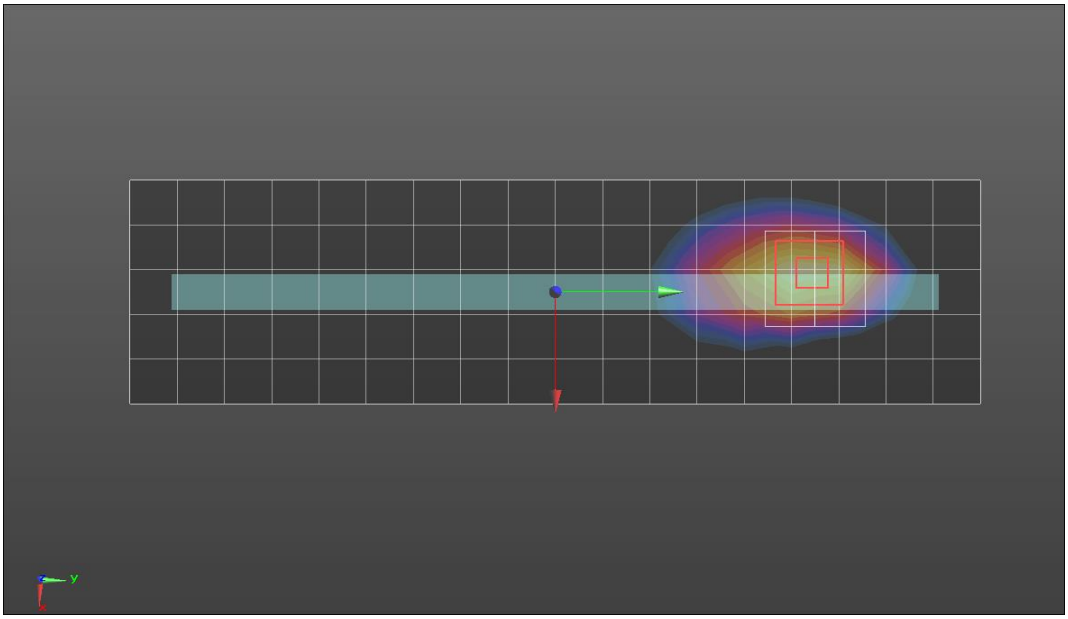


Figure (30)

Reported SAR (W/kg)	0.886	Peak SAR location (mm)	
		X-axis	Y-axis
		-3.0	85.5

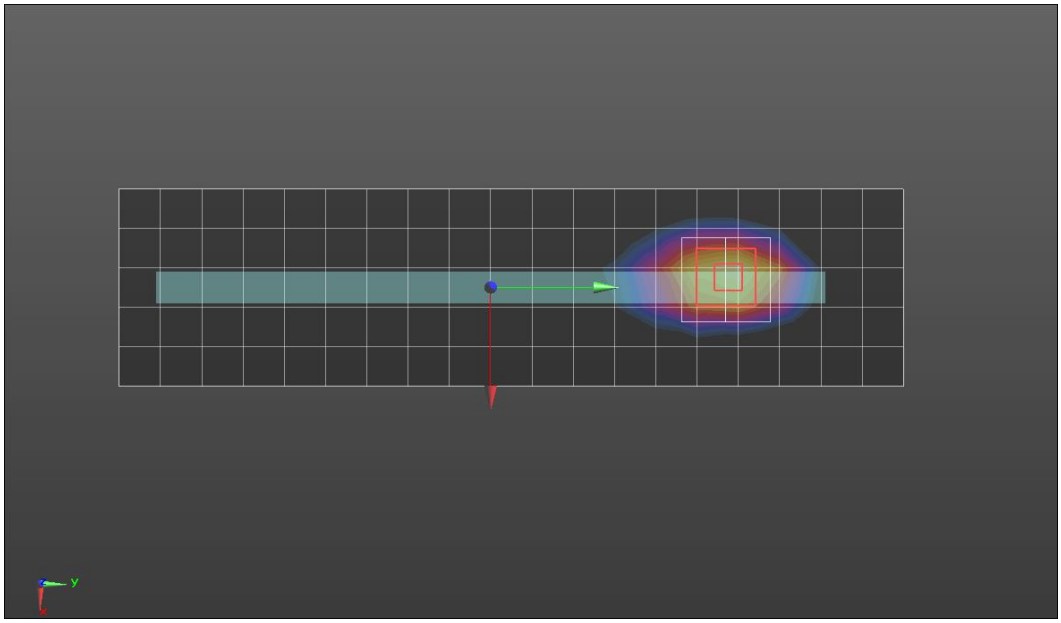


Figure (31)

Reported SAR (W/kg)	1.043	Peak SAR location (mm)	
		X-axis	Y-axis
		-4.5	84.0

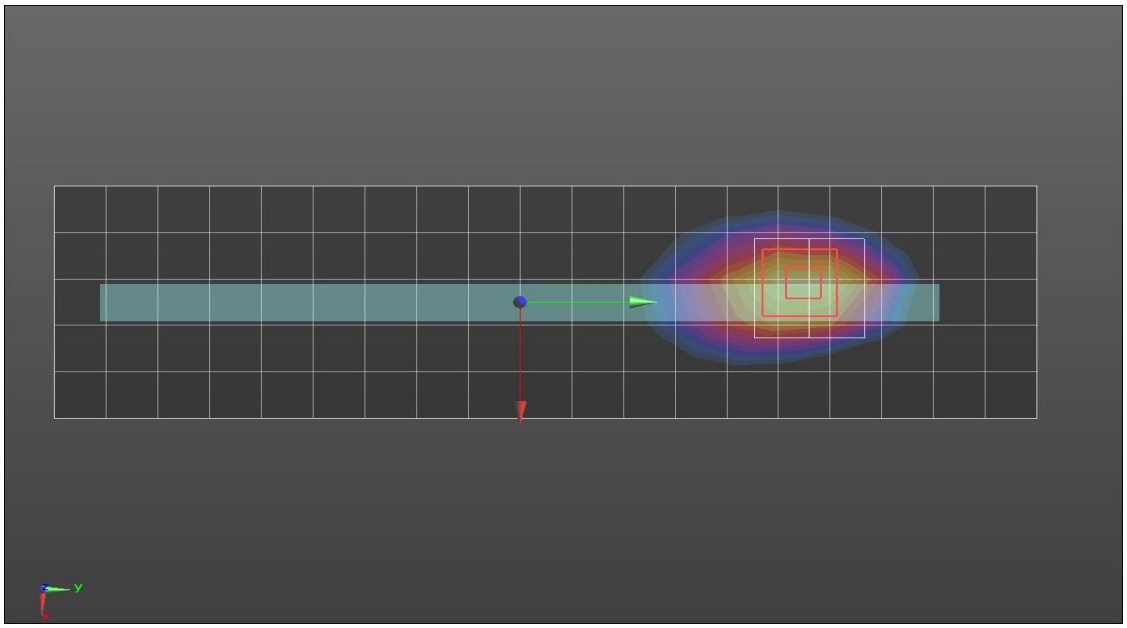


Figure (32)

Reported SAR (W/kg)	0.769	Peak SAR location (mm)	
		X-axis	Y-axis
		-3.0	85.5

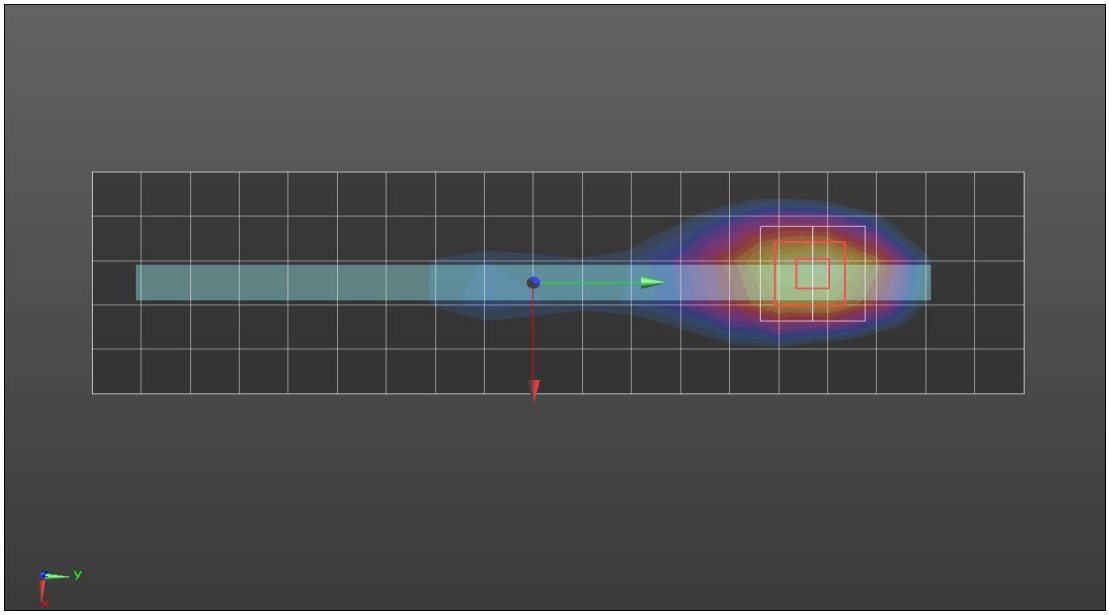


Figure (33)

Reported SAR (W/kg)	0.662	Peak SAR location (mm)	
		X-axis	Y-axis
		-1.5	87.0

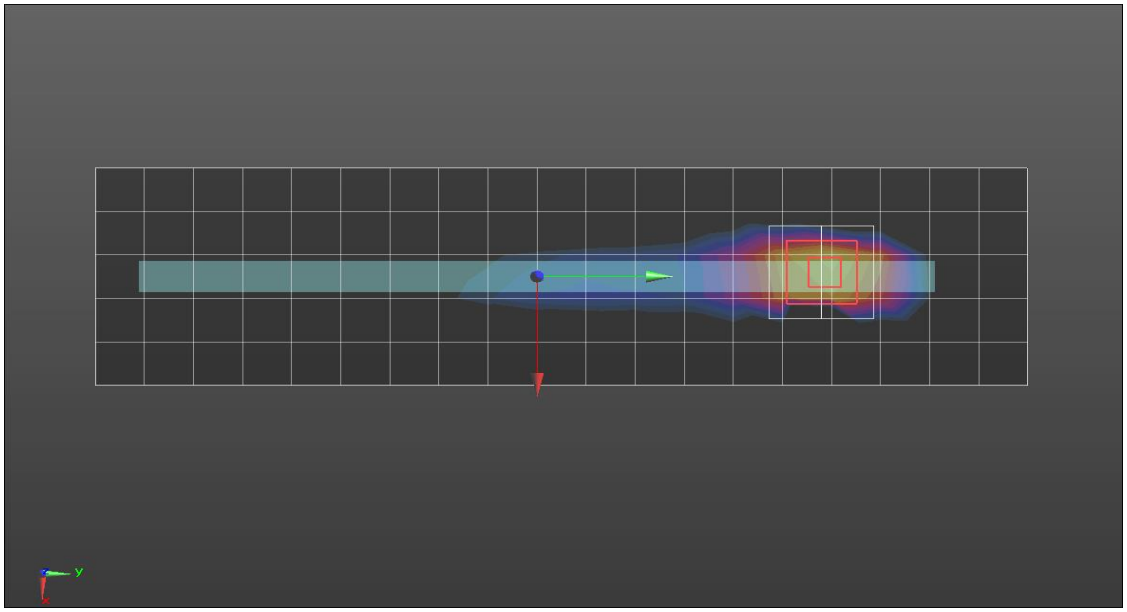


Figure (34)

Reported SAR (W/kg)	0.432	Peak SAR location (mm)	
		X-axis	Y-axis
		1.2	32.4

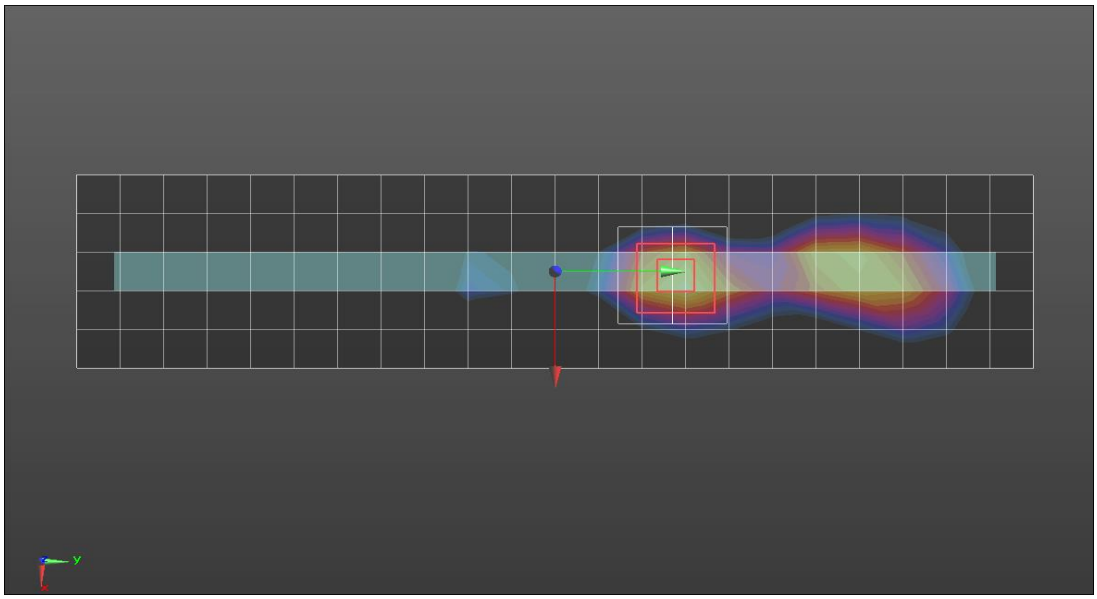


Figure (35)

Reported SAR (W/kg)	0.001	Peak SAR location (mm)	
		X-axis	Y-axis
		-1.2	-106.0

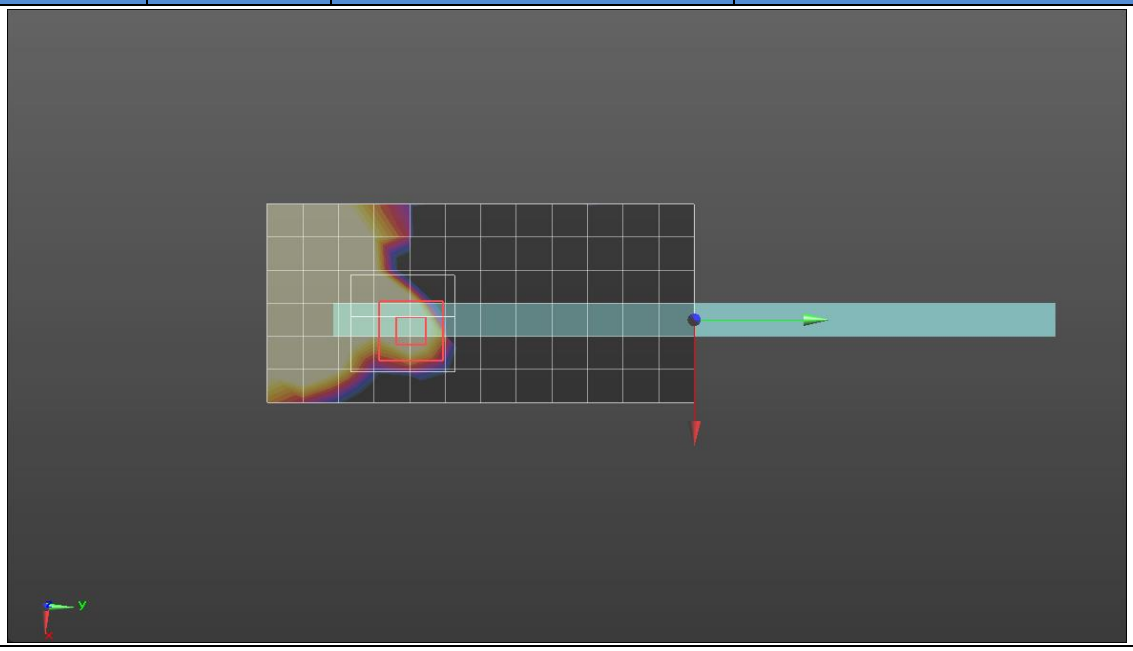


Figure (36)

Reported SAR (W/kg)	0.140	Peak SAR location (mm)	
		X-axis	Y-axis
		-1.2	-106.0

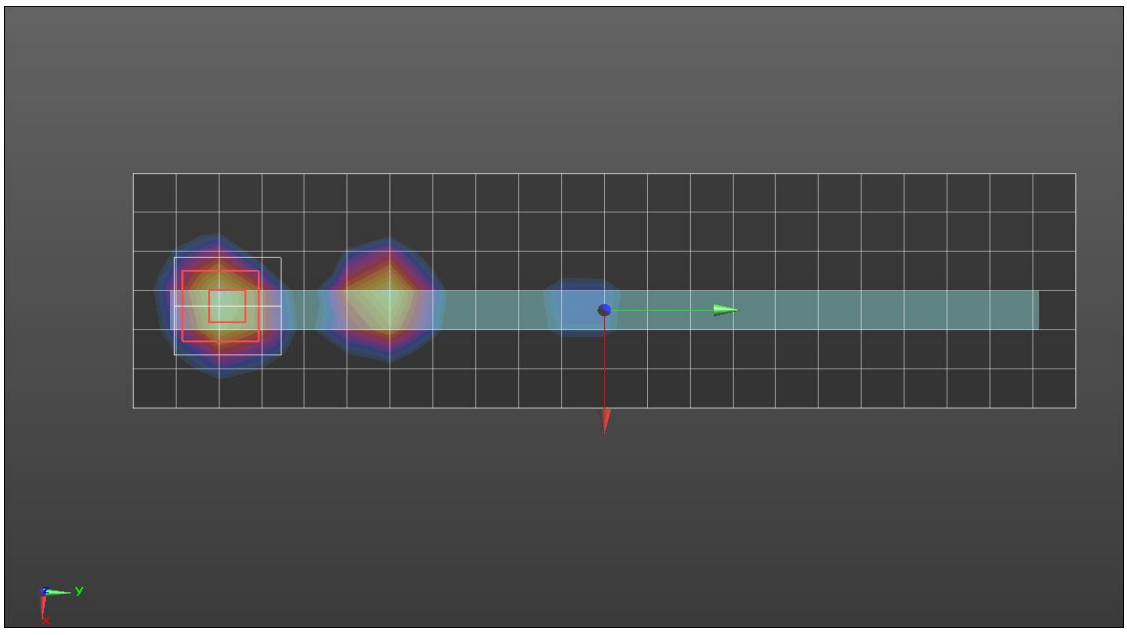


Figure (37)

Reported SAR (W/kg)	1.018	Peak SAR location (mm)	
		X-axis	Y-axis
		-4.0	-87.0

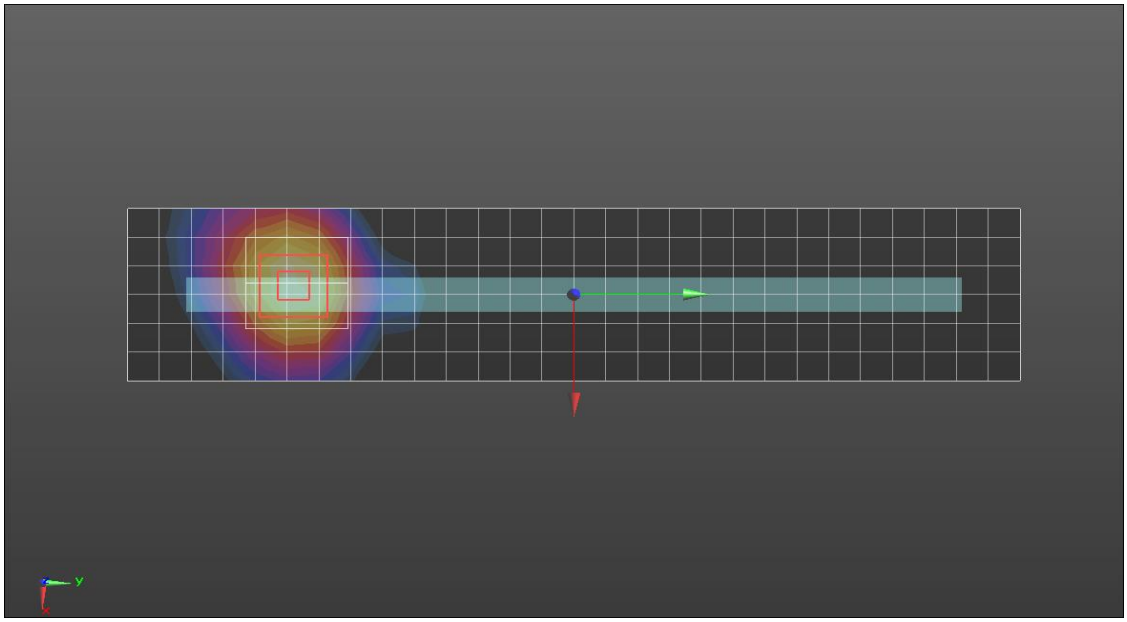


Figure (38)

Reported SAR (W/kg)	0.211	Peak SAR location (mm)	
		X-axis	Y-axis
		-2.4	-93.6

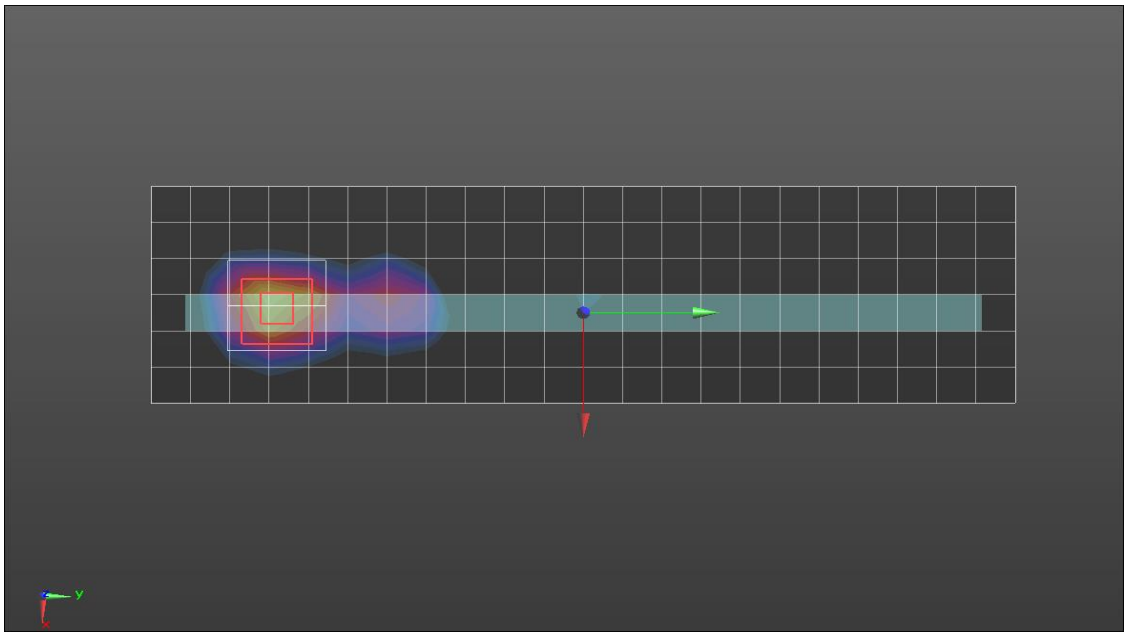


Figure (39)

Reported SAR (W/kg)	0.001	Peak SAR location (mm)	
		X-axis	Y-axis
		-8.4	-123.0

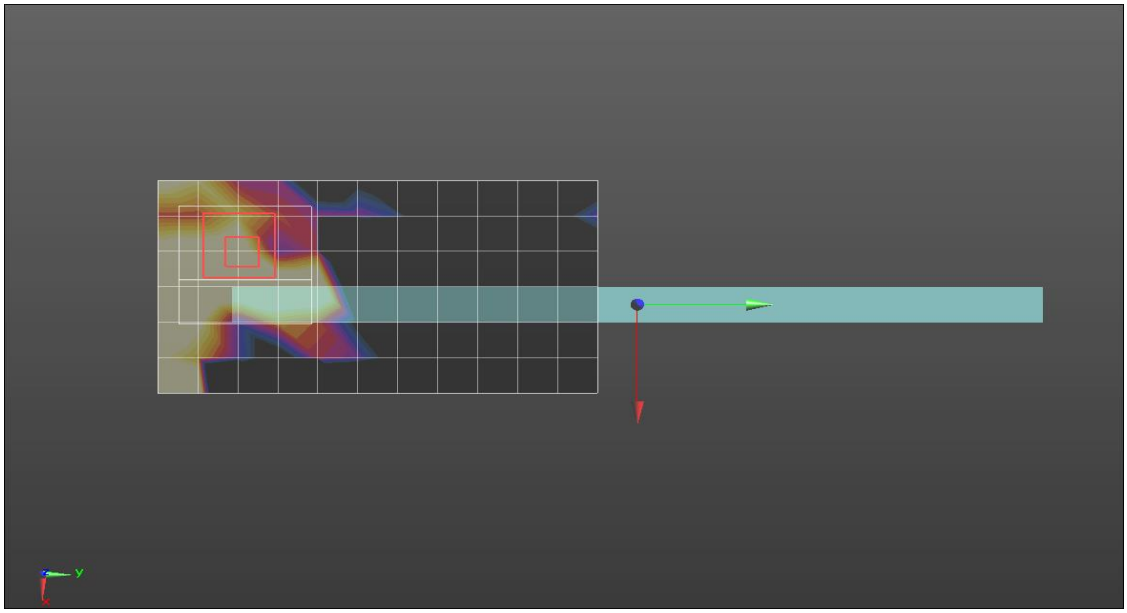


Figure (40)

SUM SAR (W/kg)	0.212	DTS Ant.2		BT Ant.1		NFC	
		0.001		0.211		0.000	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		-1.2	-106.0	-2.4	-93.6	N/A	N/A

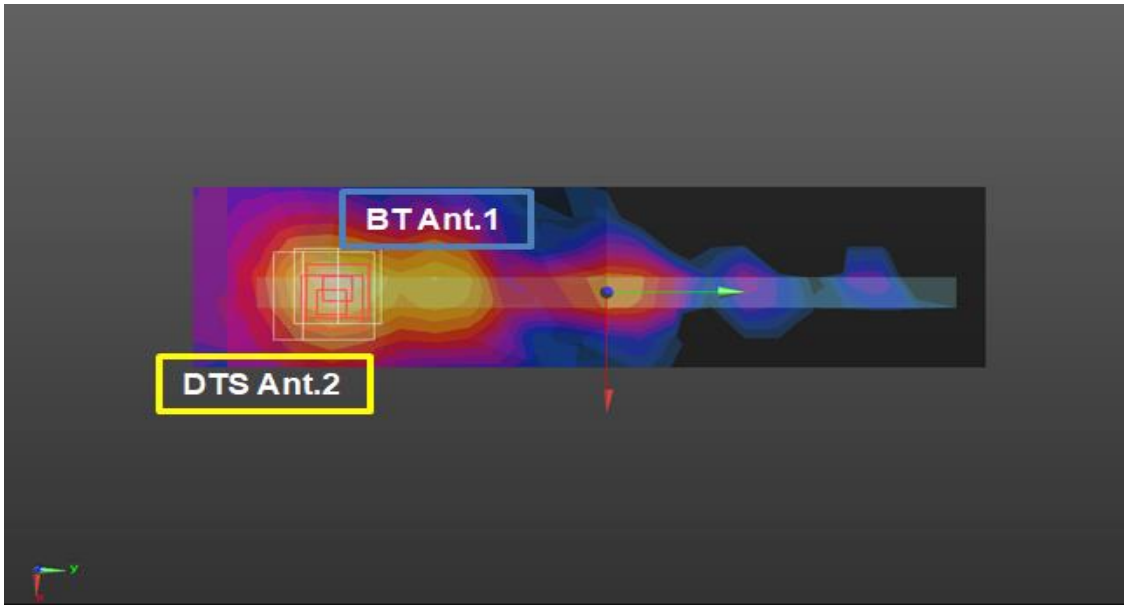


Figure (41)

SUM SAR (W/kg)	1.229	UNII MIMO		BT Ant.1		NFC	
		1.018		0.211		0.000	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		-4.0	-87.0	-2.4	-93.6	N/A	N/A

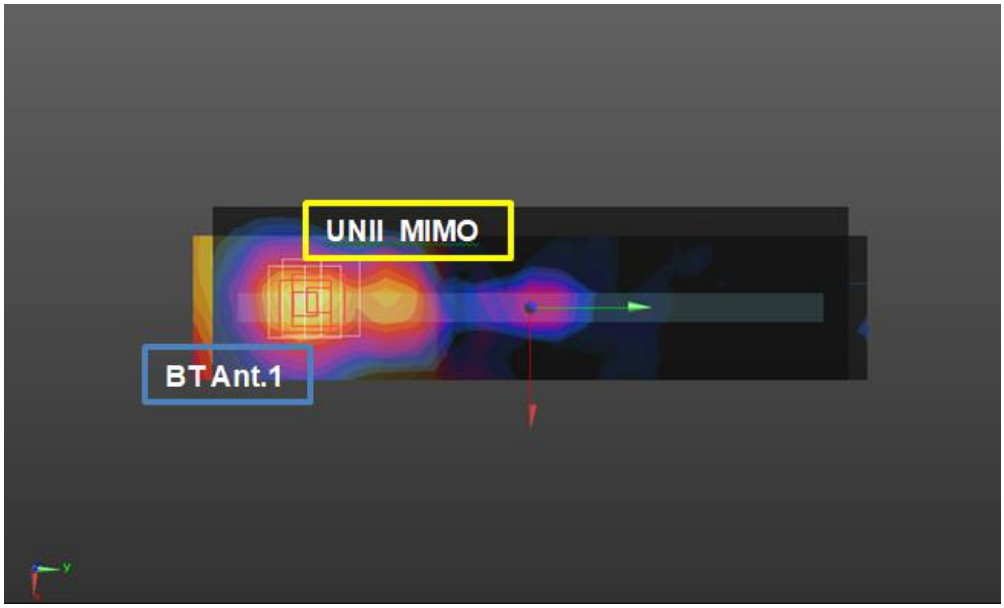


Figure (42)

SUM SAR (W/kg)	1.019	UNII MIMO		BT Ant.2		NFC	
		1.018		0.001		0.000	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		-4.0	-87.0	-8.4	-123.0	N/A	N/A

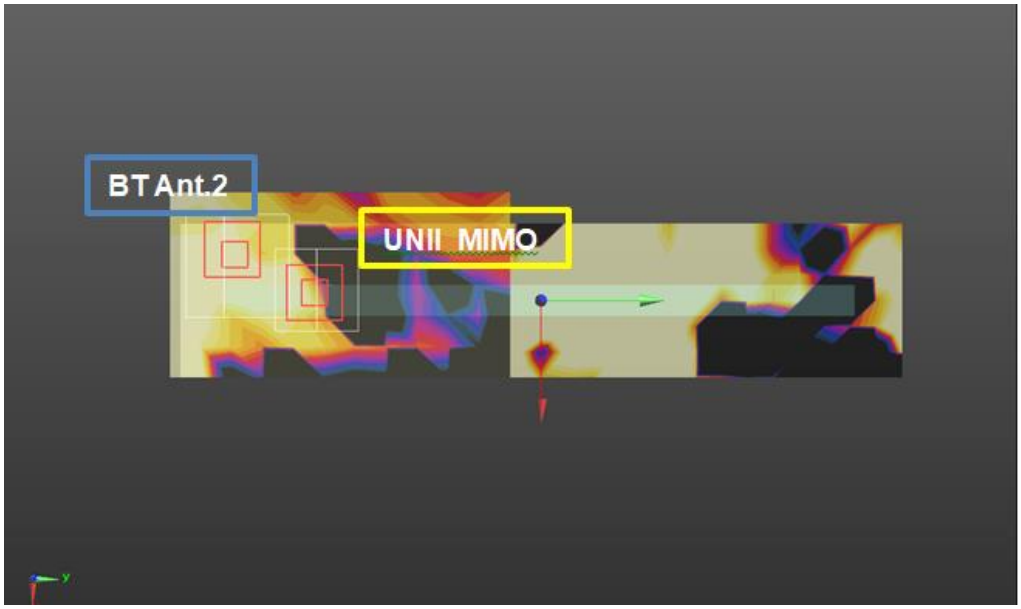


Figure (43)

SUM SAR (W/kg)	1.158	UNII MIMO		DTS MIMO		NFC	
		1.018		0.140		0.000	
		Peak SAR location (mm)					
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		-4.0	-87.0	-1.2	-106.0	N/A	N/A

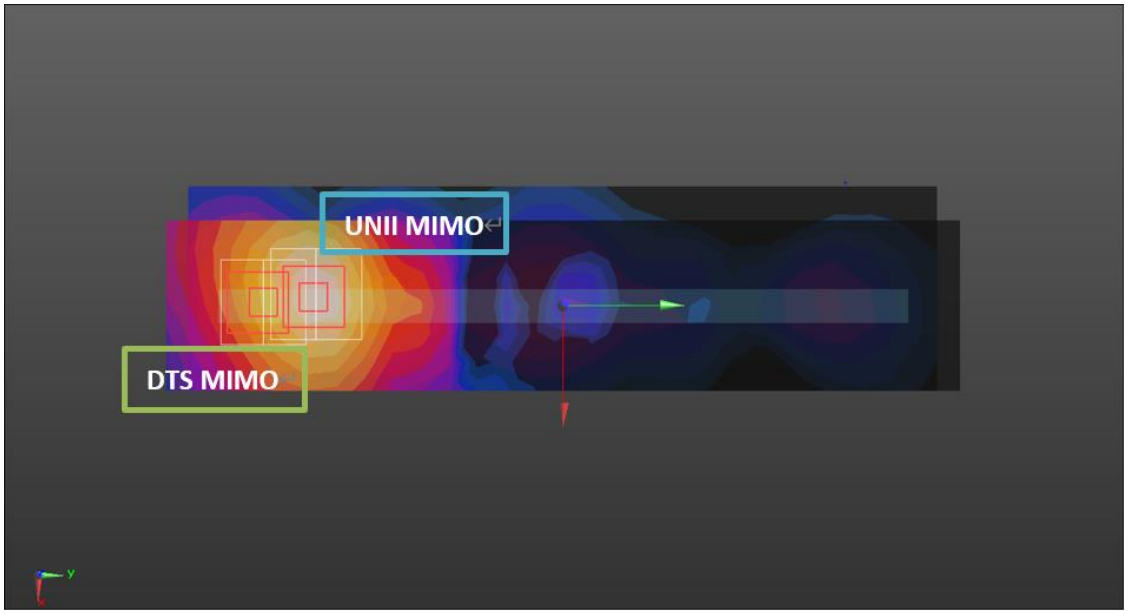
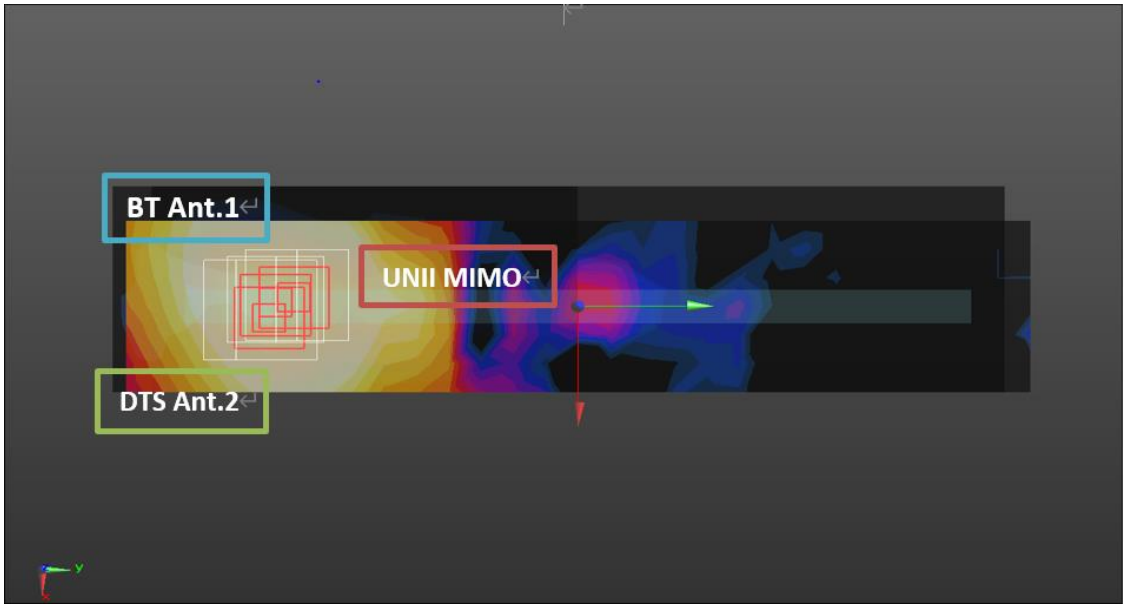


Figure (44)

SUM SAR (W/kg)	1.230	DTS Ant.2		UNII MIMO		BT Ant.1		NFC	
		0.001		1.018		0.211		0.000	
		Peak SAR location (mm)							
		X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
		-1.2	-106.0	-4.0	-87.0	-2.4	-93.6	N/A	N/A



-End-