TTI-P-G 158

Report

Dosimetric Assessment of the Sagem P52-2 According to the FCC Requirements

March 11, 2002

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Executive Summary

The P52-2 is a new mobile phone from Sagem operating in the 900 MHz and 1900 MHz frequency range. The device has a helix antenna. The system concepts used are the GSM 900 and PCS 1900 standards.

The objective of the measurements done by IMST was the dosimetric assessment of one device in the PCS 1900 standard. The examinations have been carried out with the dosimetric assessment system „DASY3“.

The measurements were made according to the Supplement C to OET Bulletin 65 of the Federal Communications Commission (FCC) Guidelines [FCC 2001] for evaluating compliance of mobile and portable devices with FCC limits for human exposure (general population) to radiofrequency emissions.

The Sagem P52-2 mobile phone is in compliance with the Federal Communications Commission (FCC) Guidelines [FCC 2001] for uncontrolled exposure. The phone was tested in the Body Worn configuration without any accessory with a distance of 1cm.

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Table of Contents

1 Subject of Investigation

The P52-2 is a new mobile phone from Sagem operating in the 900 MHz and 1900 MHz frequency range. The device has a helix antenna. The system concepts used are the GSM 900 and PCS 1900 standards.

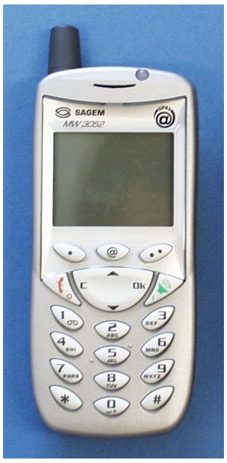

Fig. 1: Picture of the device under test.

The objective of the measurements done by IMST was the dosimetric assessment of one device in the PCS 1900 standard. The examinations have been carried out with the dosimetric assessment system „DASY3“ described below.

2 The IEEE Standard C95.1 and the FCC Exposure Criteria

In the USA the recent FCC exposure criteria [FCC 2001] are based upon the IEEE Standard C95.1 [IEEE 1999]. The IEEE standard C95.1 sets limits for human exposure to radio frequency electromagnetic fields in the frequency range 3 kHz to 300 GHz.

2.1 Distinction Between Exposed Population, Duration of Exposure and Frequencies

The American Standard [IEEE 1999] distinguishes between controlled and uncontrolled environment. Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces. For exposure in controlled environments higher field strengths are admissible. In addition the duration of exposure is considered.

Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the limits in general vary with frequency.

2.2 Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E^2}{\rho} = c \left. \frac{\partial T}{\partial t} \right|_{t \to 0+} \quad . \qquad (1)$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity c of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric E and magnetic field strength H and power density S, derived from the SAR limits. The limits for E, H and S have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

For the relevant frequency range the maximum permissible exposure may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding limits.

2.3 SAR Limit

In this report the comparison between the American exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

Having in mind a worst case consideration, the SAR limit is valid for uncontrolled environment and mobile respectively portable transmitters. According to Table 1 the SAR values have to be averaged over a mass of 1 g (SAR_{1g}) with the shape of a cube.

Standard	Status	SAR limit [W/kg]
IEEE C95.1	In force	1.6

Table 1: Relevant spatial peak SAR limit averaged over a mass of 1 g.

3 The FCC Measurement Procedure

The Federal Communications Commission (FCC) has published a report and order on the 1st of August 1996 [FCC 1996], which requires routine dosimetric assessment of mobile telecommunications devices, either by laboratory measurement techniques or by computational modeling, prior to equipment authorization or use. In 2001 the Commission's Office of Engineering and Technology has released Edition 01-01 of Supplement C to OET Bulletin 65. This revised edition, which replaces Edition 97-01, provides additional guidance and information for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions [FCC 2001].

3.1 General Requirements

The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity.

3.2 Device Operating Next to a Person's Ear

3.2.1 Phantom Requirements

The phantom is a simplified representation of the human anatomy and comprised of material with electrical properties similar to the corresponding tissues. The physical characteristics of the phantom model shall resemble the head and the neck of a user since the shape is a dominant parameter for exposure.

3.2.2 Test Positions

As it cannot be expected that the user will hold the mobile phone exactly in one well defined position, different operational conditions shall be tested. The Supplement C to OET Bulletin 65 requires two test positions. For an exact description helpful geometrical definitions are introduced and shown in Fig. 2 - 3.

There are two imaginary lines on the mobile, the vertical centerline and the horizontal line. The vertical centerline passes through two points on the front side of the handset: the midpoint of the width w_t of the handset at the level of the acoustic output (point A on Fig. 2), and the midpoint of the width w_b of the bottom of the handset (point B). The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output (see Fig. 2). The two lines intersect at point A.

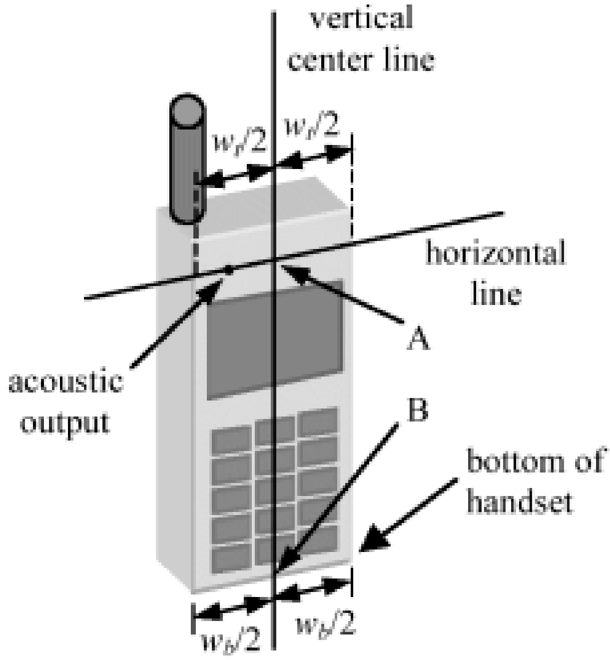

Fig. 2: Handset vertical and horizontal reference lines.

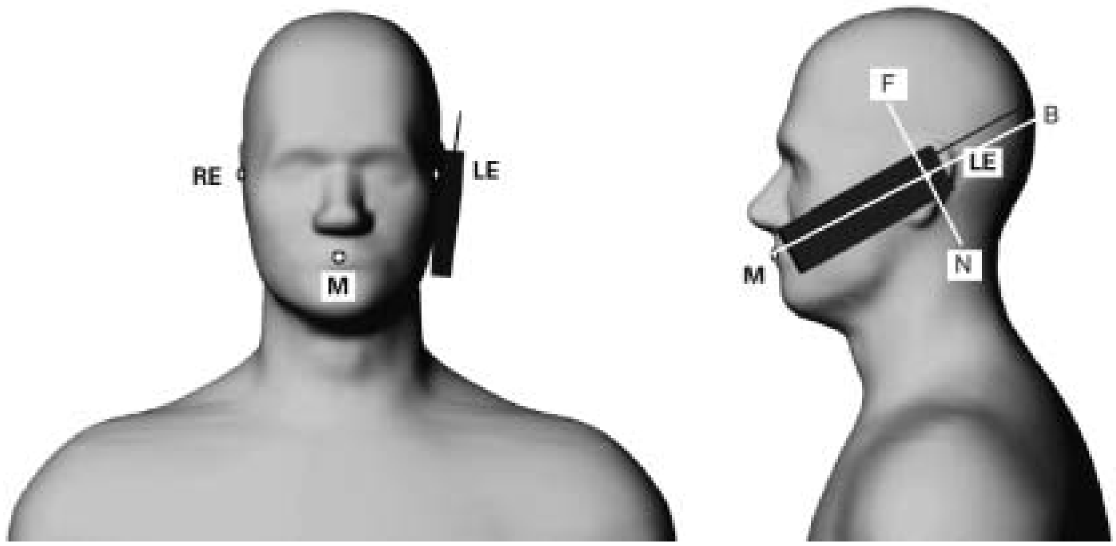

Fig. 3: Phantom reference points.

According to Fig. 3 the human head position is given by means of the following three reference points: auditory canal opening of both ears (RE and LE) and the center of the closed mouth (M). The ear reference points are 15-17 mm above the entrance to the ear canal along the BM line (back-mouth), as shown in Fig. 3. The plane passing through the two ear canals and M is defined as the reference plane. The line NF (Neck-Front) perpendicular to the reference plane and passing through the RE (or LE) is called the reference pivoting line. Line BM is perpendicular to the NF line. With this definitions the test positions are given by

- **Cheek position (see Fig. 4):**

Position the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Fig. 3), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom. Translate the handset towards the phantom along the line passing through RE and LE until the handset touches the ear. While maintaining the handset in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane). Rotate the phone around the vertical centerline until the phone (horizontal line) is symmetrical with respect to the line NF. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, rotate the handset about the line NF until any point on the handset is in contact with a phantom point below the ear.

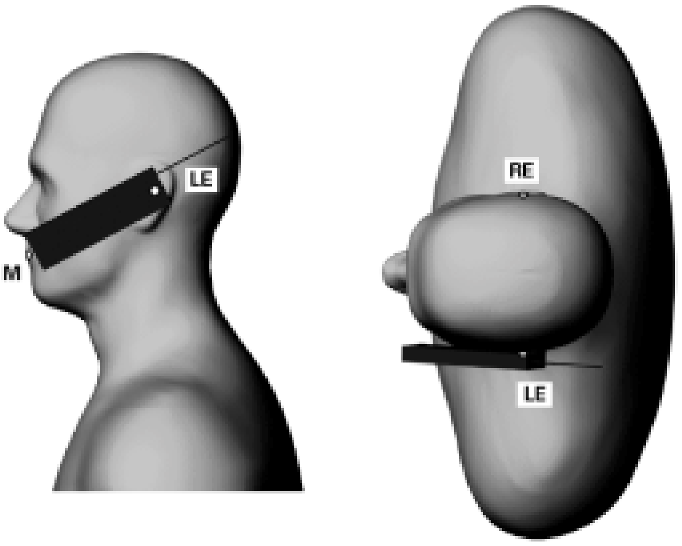

Fig. 4: The cheek position.

- **Tilted position (see Fig. 5):**

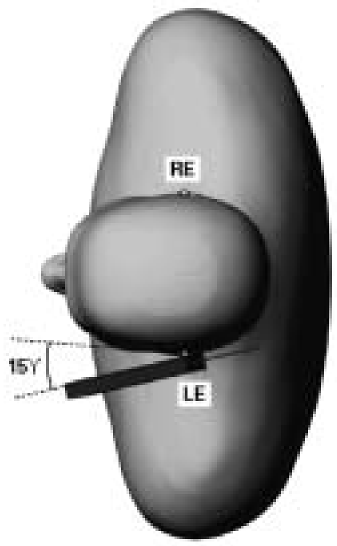

Fig. 5: The tilted position.

While maintaining the orientation of the phone retract the phone parallel to the reference plane far enough to enable a rotation of the phone by 15°. Rotate the phone around the horizontal line by 15°. While maintaining the orientation of the phone, move the phone parallel to the reference plane until any part of the phone touches the head. In this position, point A will be located on the line RE-LE.

3.2.3 Test to be Performed

The SAR test shall be performed with both phone positions described above, on the left and right side of the phantom. The device shall be measured for all modes operating when the device is next to the ear, even if the different modes operate in the same frequency band.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional.

3.3 Body-worn and Other Configurations

3.3.1 Phantom Requirements

For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

3.3.2 Test Position

The body-worn configurations shall be tested with the supplied accessories (belt-clips, holsters, etc.) attached to the device in normal use configuration. Devices with a headset output shall be tested with a connected headset.

3.3.3 Test to be Performed

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body.

For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested.

If the manufacturer provides none body-worn accessories a separation distance of 1.5 cm between the back of the device and the flat phantom is recommended. Other separation distances may be used, but they shall not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional.

4 The Measurement System

DASY is an abbreviation of „Dosimetric Assessment System“ and describes a system that is able to determine the SAR distribution inside a phantom of a human being according to different standards. It consists of a robot, several field probes calibrated for use in liquids, a shell phantom, tissue simulating liquid and software. The software controls the robot and processes the measured data to compare them with safety levels with respect to human exposure to radio frequency electromagnetic fields. Fig. 6 shows the equipment, similar to the installations in other laboratories [DASY 1995].

Fig. 6: The measurement set-up with two phantoms containing tissue simulating liquid.

The mobile phone operating at the maximum power level is placed by a non metallic device holder in the above described positions at a shell phantom of a human being. The distribution of the electric field strength *E* is measured in the tissue simulating liquid within the shell phantom. For this miniaturised field probes with high sensitivity and low field disturbance are used. Afterwards the corresponding SAR values are calculated with the known electrical conductivity σ and the mass density ρ of the tissue. The system software is able to determine the averaged SAR values (averaging region 1 g or 10 g) for compliance testing.

This is done by two scans: first a coarse scan determines the region of the maximum SAR, afterwards the 1 g or 10 g averaged SAR is measured in a second fine scan. The measurement time takes about 20 minutes.

For the measurements the Specific Anthropomorphic Mannequin (SAM) is used. The phantom is a fibreglass shell integrated in a wooden table. The thickness of the phantom amounts to 2 mm ± 0.1 mm. It enables the dosimetric evaluation of left and right hand phone usage and includes an additional flat phantom part. The phantom set-up includes a coverage (polyethylene), which prevents the evaporation of the liquid.

4.1 Measurement Procedure

The following steps are used for each test position:

- Measurement of the local SAR value at a fixed location (P1). This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with a grid spacing of 15 mm x 15 mm and a constant distance to the inner surface of the phantom. With interpolation of these values, the area of the maximum SAR is calculated.
- Around this point, a cube of 30 mm x 30 mm x 30 mm is assessed by measuring 7 x 7 x 7 points. With these data, the peak spatial-average SAR value is calculated.
- Repetition of the SAR measurement at the fixed location (P1) and repetition of the whole procedure if the two results differ by more than ± 5%.

4.2 Uncertainty Assessment

Table 2 includes the preliminary uncertainty budget suggested by the [IEEE 200x] and determined according to NIST TN1297 [NIST 1994]. The extended uncertainty (K=2) is assessed to be ± 24.1%. This uncertainty includes probe, calibration, positioning and evaluation errors as well as errors the correct dielectric parameters for the tissue simulating liquid, etc..

Error Sources	Uncertainty Value	Probability Distribution	c_i	Standard Uncertainty
Measurement System				
Probe calibration	± 2.6 %	Normal	1	± 2.6 %
Axial isotropy	± 2.3 %	Rectangular	0.7	± 0.9 %
Spherical isotropy	± 5.9 %	Rectangular	0.7	± 2.4 %
Spatial resolution	± 0.5 %	Rectangular	1	± 0.3 %
Boundary effect	± 11.0 %	Rectangular	1	± 6.4 %
Linearity	± 4.7 %	Rectangular	1	± 2.7 %
Detection limit	± 2.0 %	Rectangular	1	± 1.2 %
Readout electronics	± 1.0 %	Normal	1	± 1.0 %
RF ambient conditions	± 3.0 %	Rectangular	1	± 1.7 %
Mechanical robot constraints	± 0.4 %	Normal	1	± 0.4 %
Probe positioning	± 5.0 %	Rectangular	1	± 2.9 %
Extrapolation and integration	± 3.9 %	Rectangular	1	± 2.3 %
Test Sample Related				
Device positioning	± 6.0 %	Normal	1	± 6.0 %
Power drift	± 5.0 %	Rectangular	1	± 2.9 %
Phantom and Set-up				
Liquid conductivity (target)	± 5.0 %	Rectangular	0.6	± 1.7 %
Liquid conductivity (meas.)	± 10.0 %	Rectangular	0.6	± 3.5 %
Liquid permittivity (target)	± 5.0 %	Rectangular	0.6	± 1.7 %
Liquid permittivity (meas.)	± 5.0 %	Rectangular	0.6	± 1.7 %
Combined Uncertainties				± 12.05 %

Table 2: Uncertainty budget of DASY3.

5 SAR Results

The Tables below contain the measured SAR values averaged over a mass of 1 g.

Phantom Configuration	Test Position	SAR_{1g} [W/kg] (Drift[dB])		
		Channel 512 1850.20 MHz 29.9 dBm	Channel 661 1880.00 MHz 29.6 dBm	Channel 810 1909.80 MHz 29.6 dBm
Left Side of Head	Cheek		0.702* (-0.07)	
	Tilted		0.726 (-0.11)	
Right Side of Head	Cheek		0.771 (0.10)	
	Tilted	0.850 (-0.02)	0.818 (0.03)	0.741 (-0.02)

Table 3: Measured head phantom results for PCS 1900 for the Sagem P52-2 (*Cube 1).

Accessory	SAR_{1g} [W/kg] (Drift[dB])		
	Channel 512 1850.20 MHz 29.9 dBm	Channel 661 1880.00 MHz 29.6 dBm	Channel 810 1909.80 MHz 29.6 dBm
Body Worn Configuration, 1 cm under the phantom	0.661 (-0.19)	0.563 (0.0)	0.475 (-0.11)

Table 4: Measurement results in body-worn configuration for PCS 1900 for the Sagem P52-2.

The above mentioned power values are conducted measured values. The power output was measured and provided by the manufacture.

Evaluation

In Fig. 7 the head phantom SAR results for PCS 1900 given in Table 3 are summarized and compared to the limit. In Fig. 8 the SAR results in body-worn configuration for PCS 1900 given in Table 4 are summarized and compared to the limit.

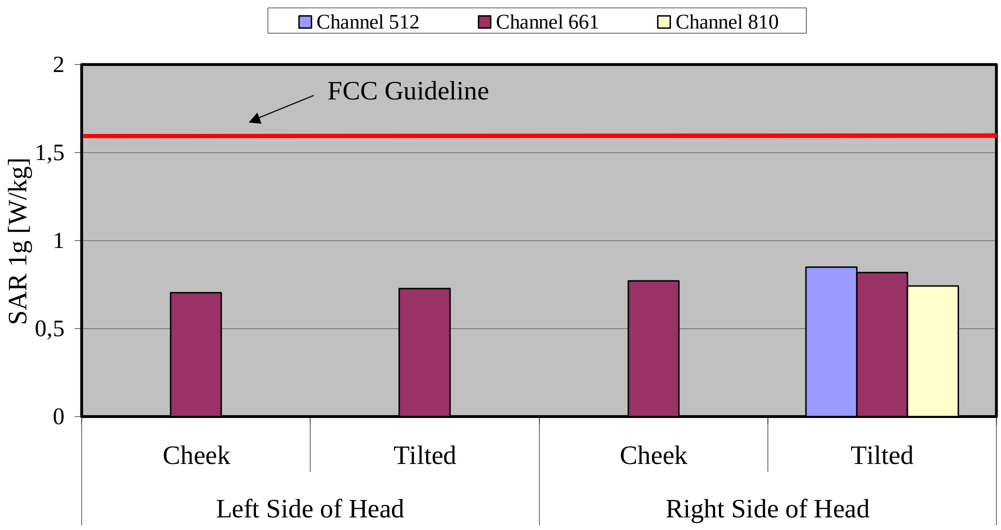

Fig. 7: The measured head phantom SAR values for the Sagem P52-2 for PCS 1900 in comparison to the FCC exposure limit.

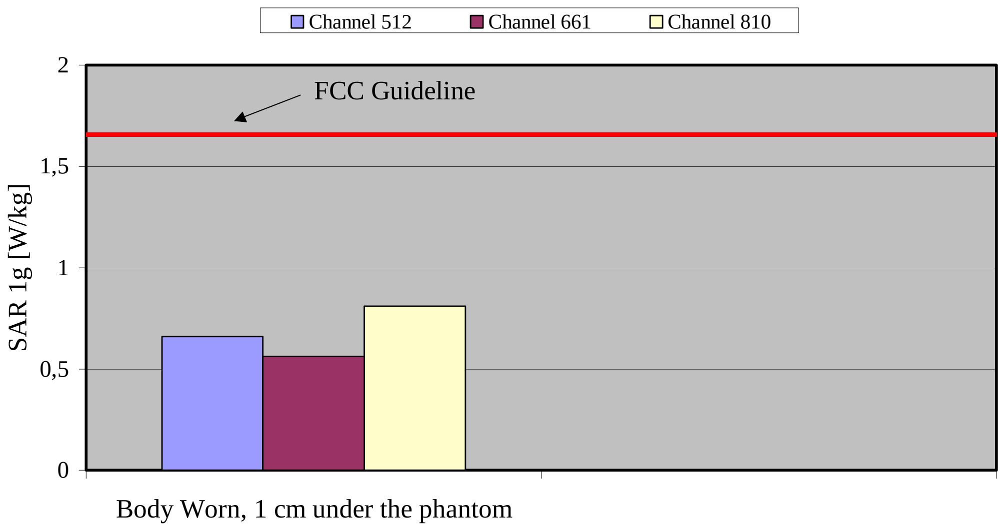

Fig. 8: The measured SAR values in body-worn configuration for the Sagem P52-2 for PCS 1900 in comparison to the FCC exposure limit.

The Sagem P52-2 mobile phone is in compliance with the Federal Communications Commission (FCC) Guidelines [FCC 2001] for uncontrolled exposure. The phone was tested in the Body Worn configuration without any accessory with a distance of 1cm.

Fig 9 - 13 shows the SAR distribution plots for PCS 1900.

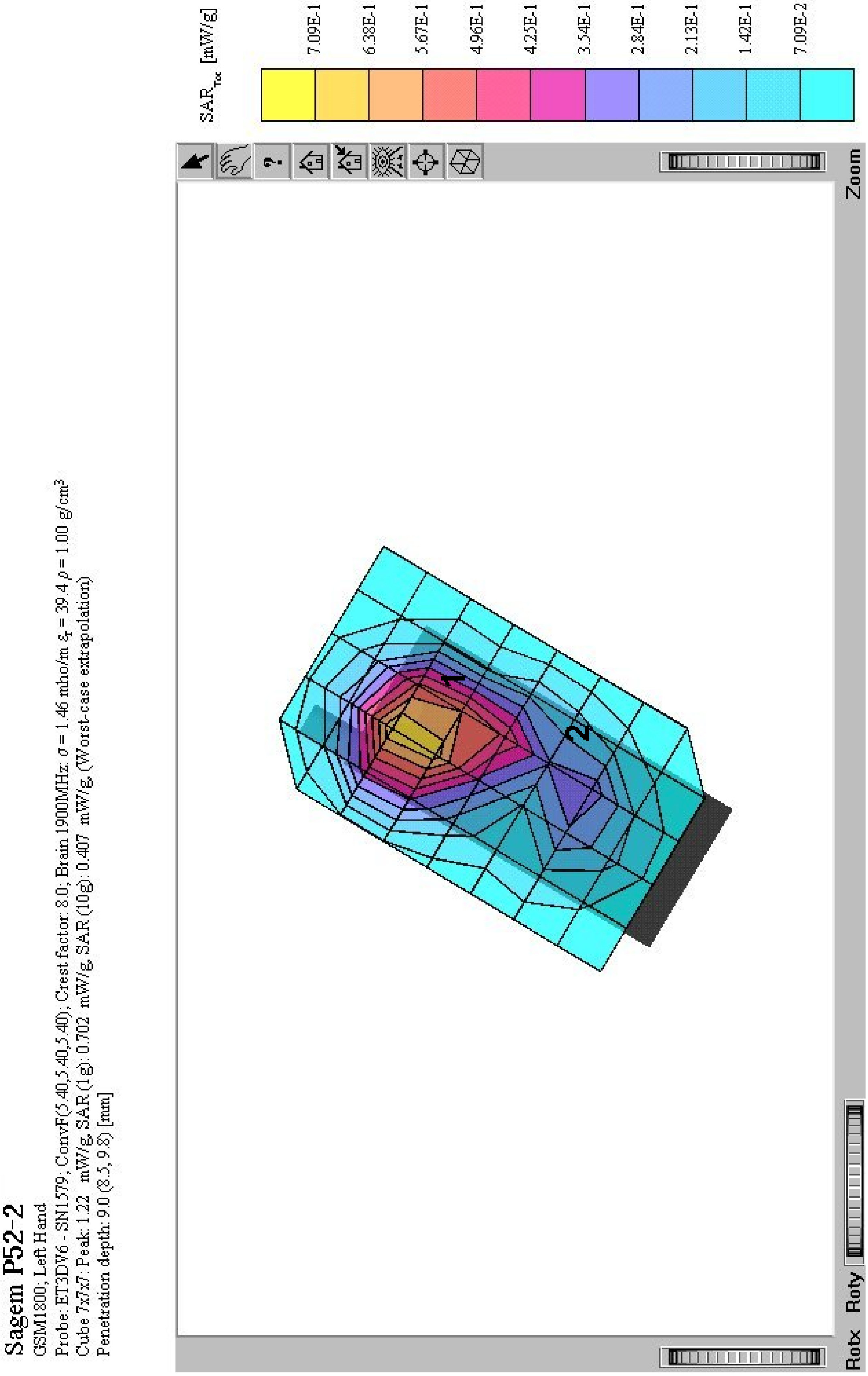

Fig. 9: SAR distribution plot for PCS 1900 for the SAGEM P52-2 (channel 661, cheek position, left side). Cube 2: 0.448 W/kg.

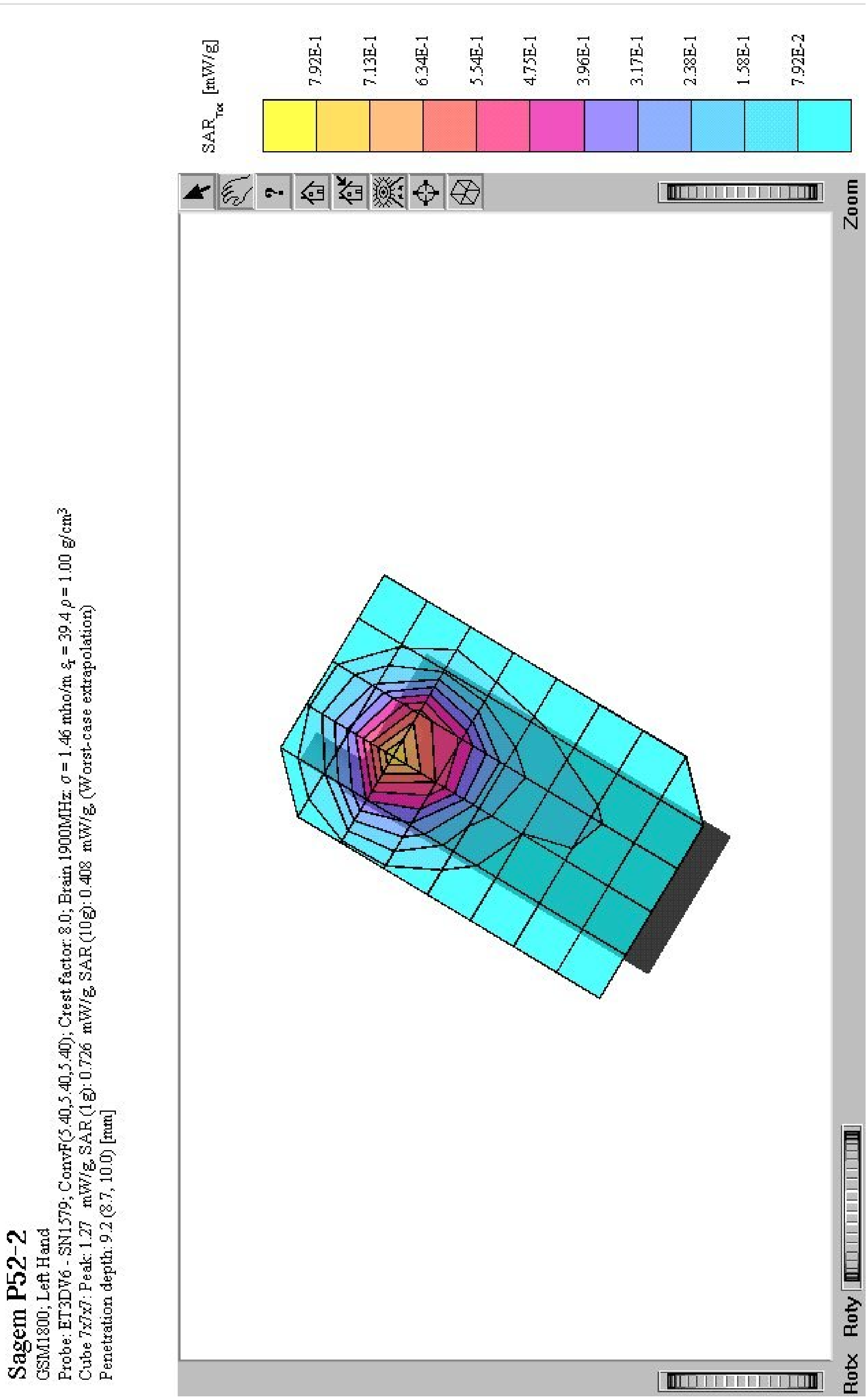

Fig. 10: SAR distribution plot for PCS 1900 for the SAGEM P52-2 (channel 661, tilted position, left side).

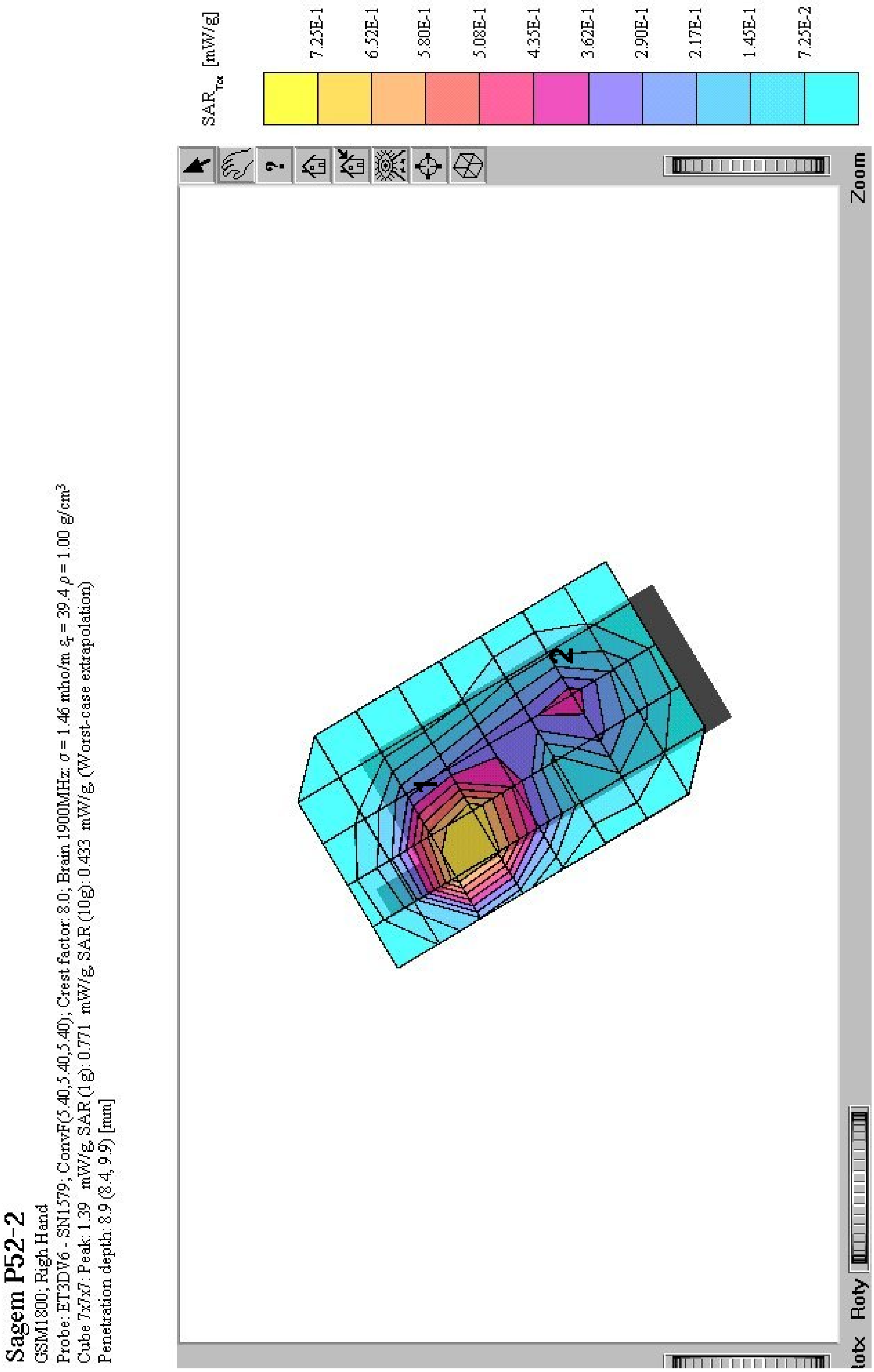

Fig. 11: SAR distribution plot for PCS 1900 for the SAGEM P52-2 (channel 661, cheek position, right side). Cube 2: 0.371 W/kg.

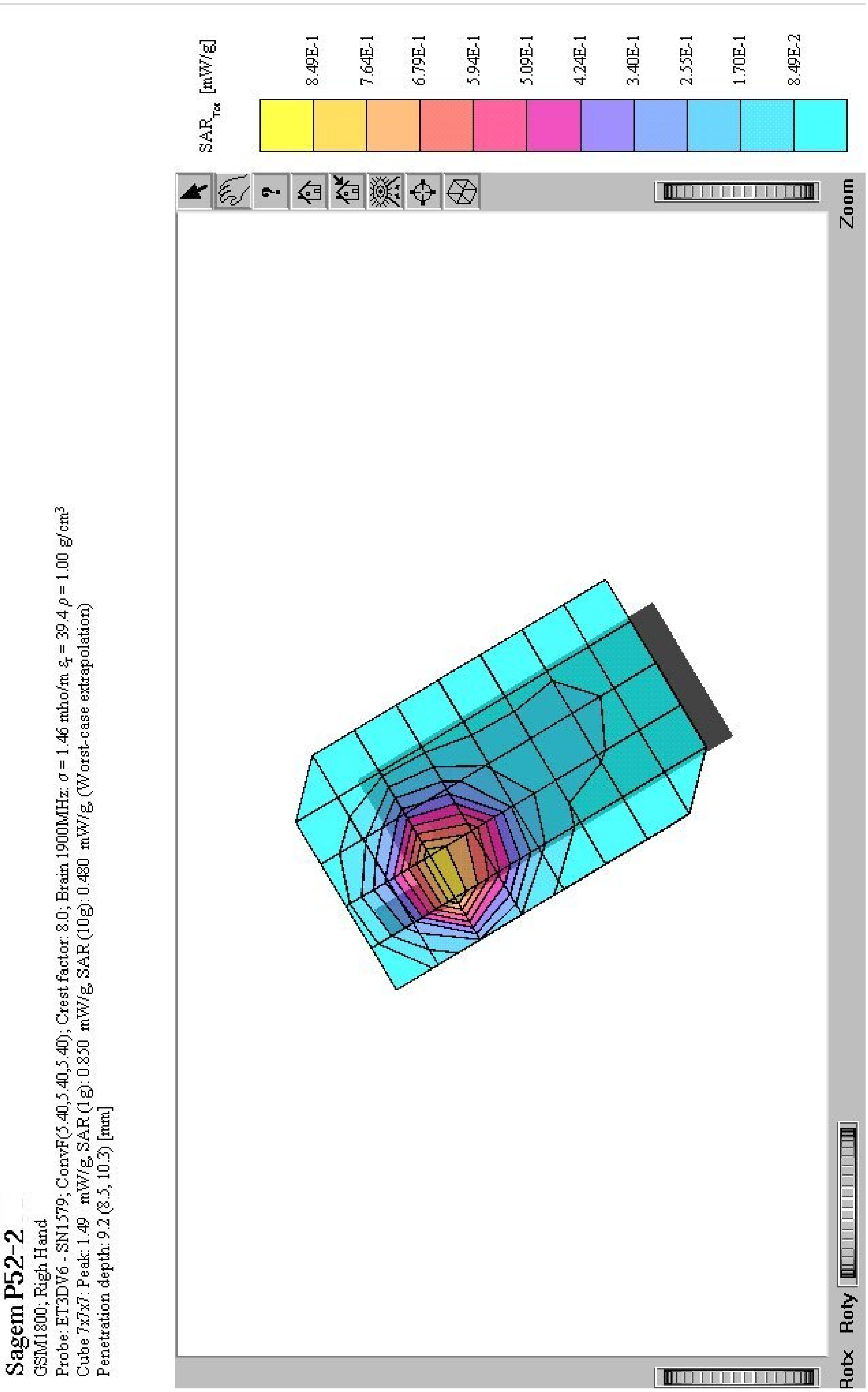

Fig. 12: Worst Case SAR distribution plot for PCS 1900 for the SAGEM P52-2 (channel 512, tilted position, right side).

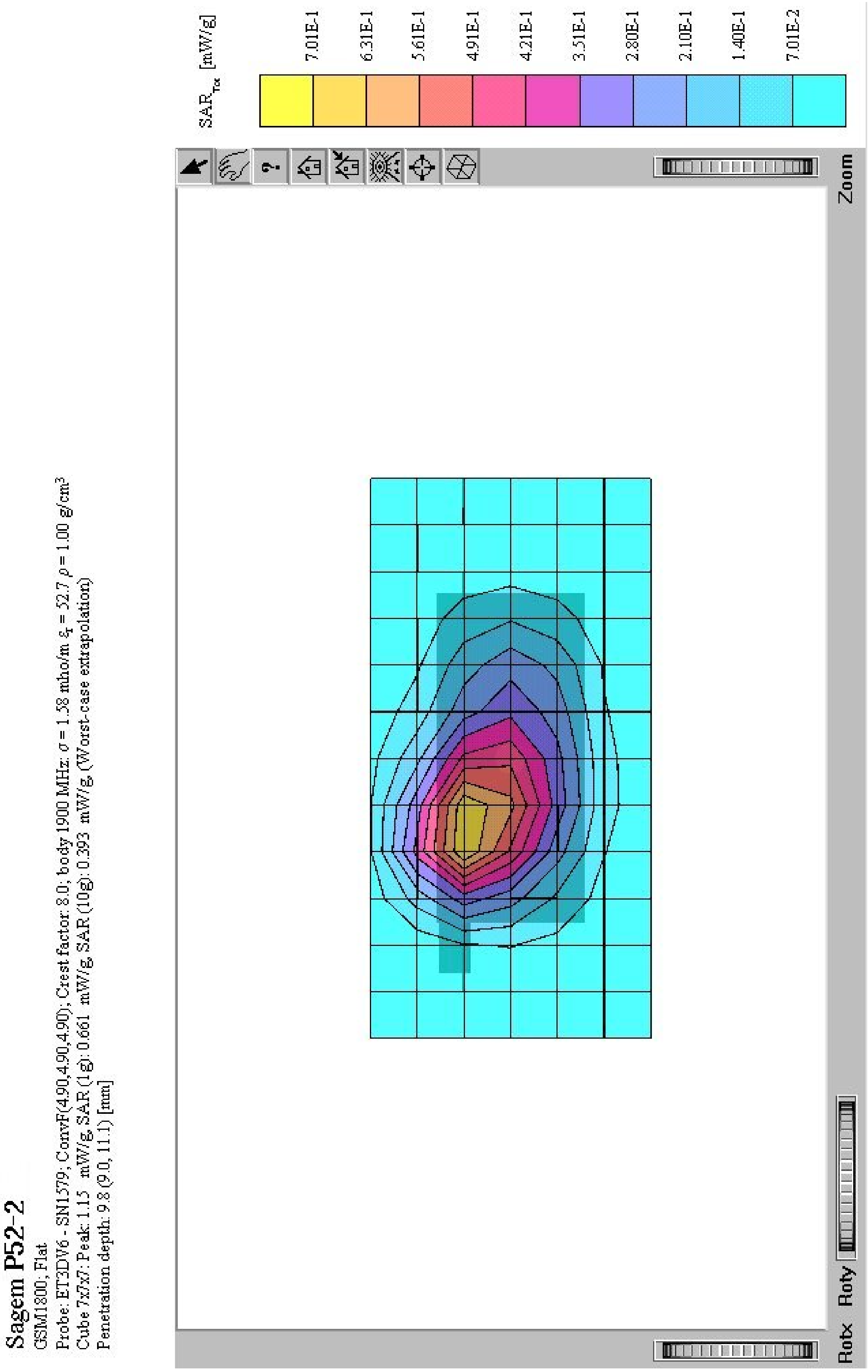

Fig. 13: Worst Case SAR distribution plot for PCS 1900 for the SAGEM P52-2 (channel 512, body worn configuration, 1cm under the phantom, display towards the ground).

6 Appendix

6.1 Administrative Data

Date of validation:	1900 MHz, Head: October 29, 2001
	1900 MHz, Body: November 06, 2001
Date of measurement:	PCS 1900, Head: October 29, 2001
	PCS 1900, Body: November 06, 2001
Data stored:	Sagem_6575_205

The phantom used for the 1900 MHz measurements is marked as GSM 1800.

6.2 Device under Test and Test Conditions

MTE:	Sagem P52-2, Production Line Unit
Date of receipt:	October 15, 2001
IMEI:	010043950005460
Device Category:	Mobile device
RF exposure environment:	General Population/Uncontrolled
Power supply:	Internal Battery (Other batteries not available)
Antenna:	Antenna Typ: Helix
Measured Standards:	PCS 1900 (Basestation Simualtor)
Modulation:	GMSK
Crest Factor:	PCS 1900: 8
TX range:	1850.2 MHz – 1909.8 MHz
RX range:	1930.2 MHz – 1989.8 MHz
Used TX Channels:	low: ch. 512, center: ch. 661, high: ch. 810

6.3 Tissue Recipes

The following recipes are provided in percentage by weight.

1900 MHz, Head:	45.65%	Diethylenglykol-monobutylether
	54.00%	De-Ionized Water
	0.35%	Salt
1900 MHz, Body:	29.68%	Diethylenglykol-monobutylether
	70.00%	De-Ionized Water
	0.32%	Salt

6.4 Material Parameters

Frequency		ε_r	σ [S/m]
1900 MHz (Head)	Recommended Value	40.0 ± 2.0	1.40 ± 0.07
	Measured Value	39.4 ± 2.0	1.46 ± 0.15
1900 MHz (Body)	Recommended Value	53.3 ± 2.7	1.52 ± 0.08
	Measured Value	52.7 ± 2.7	1.58 ± 0.16

Table 5: Parameters of the tissue simulating liquid, 1900 MHz.

6.5 Simplified Performance Checking

The simplified performance check was realized using the dipole validation kits. The input power of the dipole antennas were 250 mW and they were placed under the flat part of the SAM phantom. The results are listed in the Table 6 and shown in Fig. 14-15

Frequency		SAR_{1g} [W/kg]	ε_r	σ [S/m]
1900 MHz (Head)	Target Value	10.8	39.20	1.47
	Measured Value	10.9	39.40	1.46
1900 MHz (Body)	Target Value	10.2	53.50	1.46
	Measured Value	11.2	52.70	1.58

Table 6: Validation results, 1900 MHz.

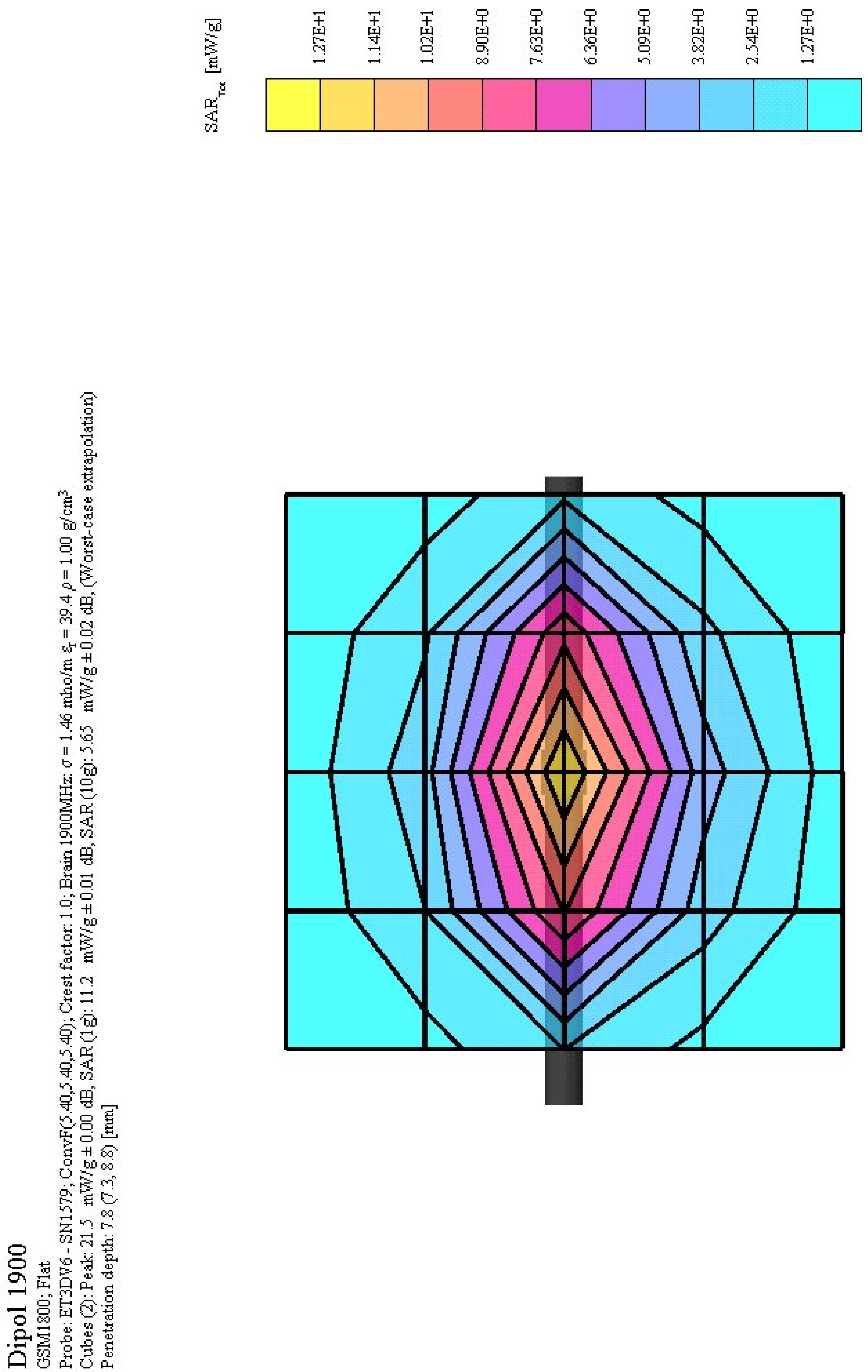

Fig. 14: Validation measurement 1900 MHz Head, coarse grid.

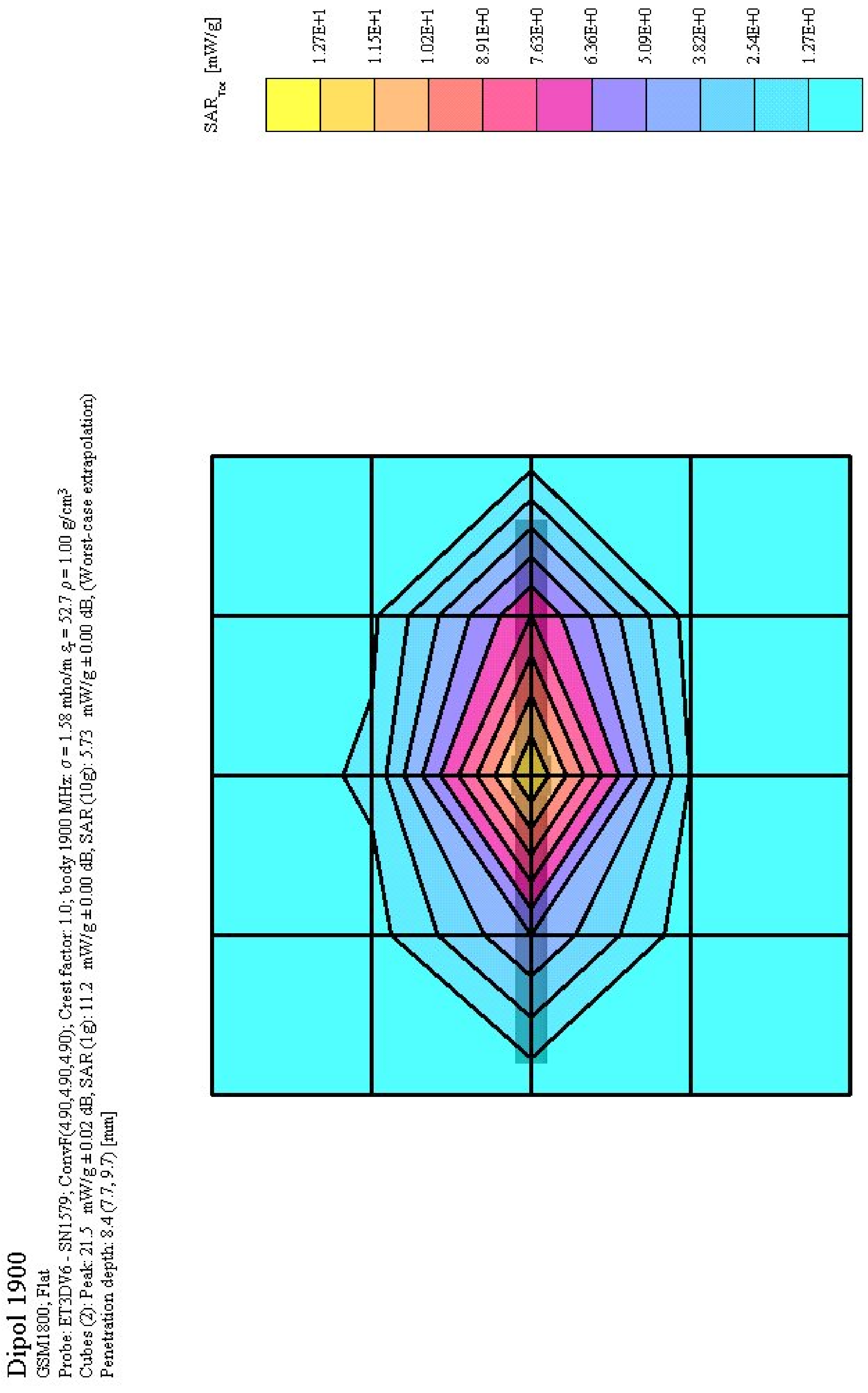

Fig. 15: Validation measurement 1900 Body, coarse grid.

6.6 Environment

Ambient temperature: 23 °C ± 1.0 °C
Liquid temperature: 22 °C ± 1.0 °C
Humidity: 50 % ± 5 %

6.7 Test Equipment

Test Equipment	Model	Serial Number	Calibration
DASY3 System			
Software Version	V3.1D	N/A	N/A
Dosimetric E-Field Probe	ET3DV6	1579	05/2001
Data Acquisition Electronics	DAE3 V1	410	01/2001
Phantom (marked as GSM 1800)	SAM	1073	N/A
Performance Checking			
System Validation Dipole, Head	D1900V2	535	04/2001
System Validation Dipole, Body	D1900V2	535	08/2001
Power Meter, Agilent	E4426A	GB41050414	06/2001
Power Sensor, Agilent	E9301H	U40010212	06/2001
Power Meter, Gigatronics	8541B	1830892	12/2000
Power Sensor, Gigatronics	80401A	1829437	12/2000
RF Source (Network Analyzer)	HP8753D	3410A06555	12/2000
RF Amplifier, Mini-Circuits	ZHL-42	D012296	N/A
Material Measurement			
Network Analyzer	HP8753D	3410A06555	12/2000
Dielectric Probe Kit	HP85070B	US33052263	N/A
General			
Base Station Simulator, Wavetek	4032	1388073	N/A

Table 7: Test equipment.

6.8 Pictures of the device under test

Fig. 16 – 17 show the device under test.

Fig. 16: Front and back view of the device.

Fig. 17: Side views of the device.

6.9 Test Positions for the Device under Test

Fig. 18 – Fig. 22 shown the test positions for the SAR measurements.

Fig. 18: Cheek position, left side.

Fig. 19: Tilted position, left side.

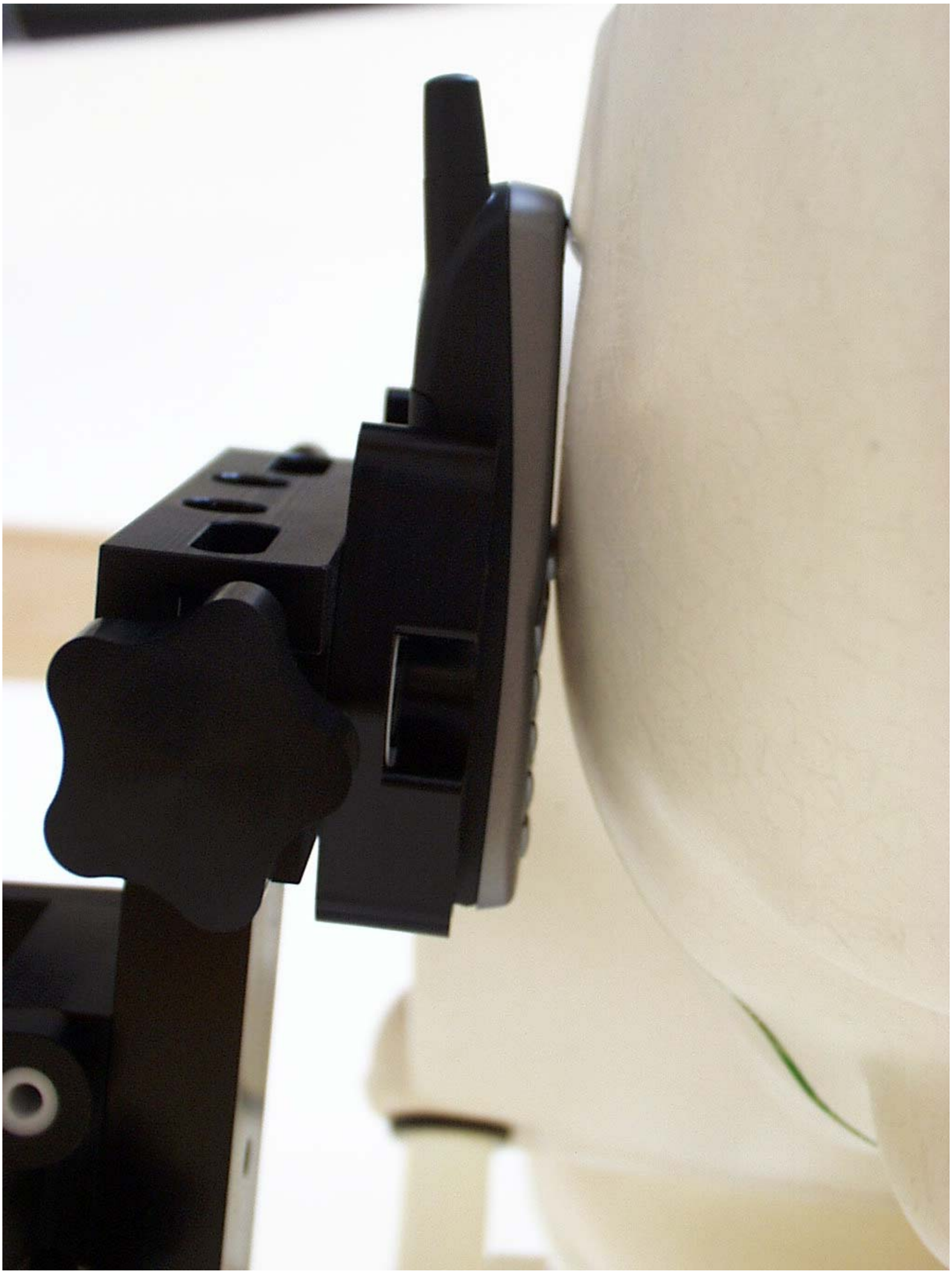

Fig. 20: Cheek position, right side.

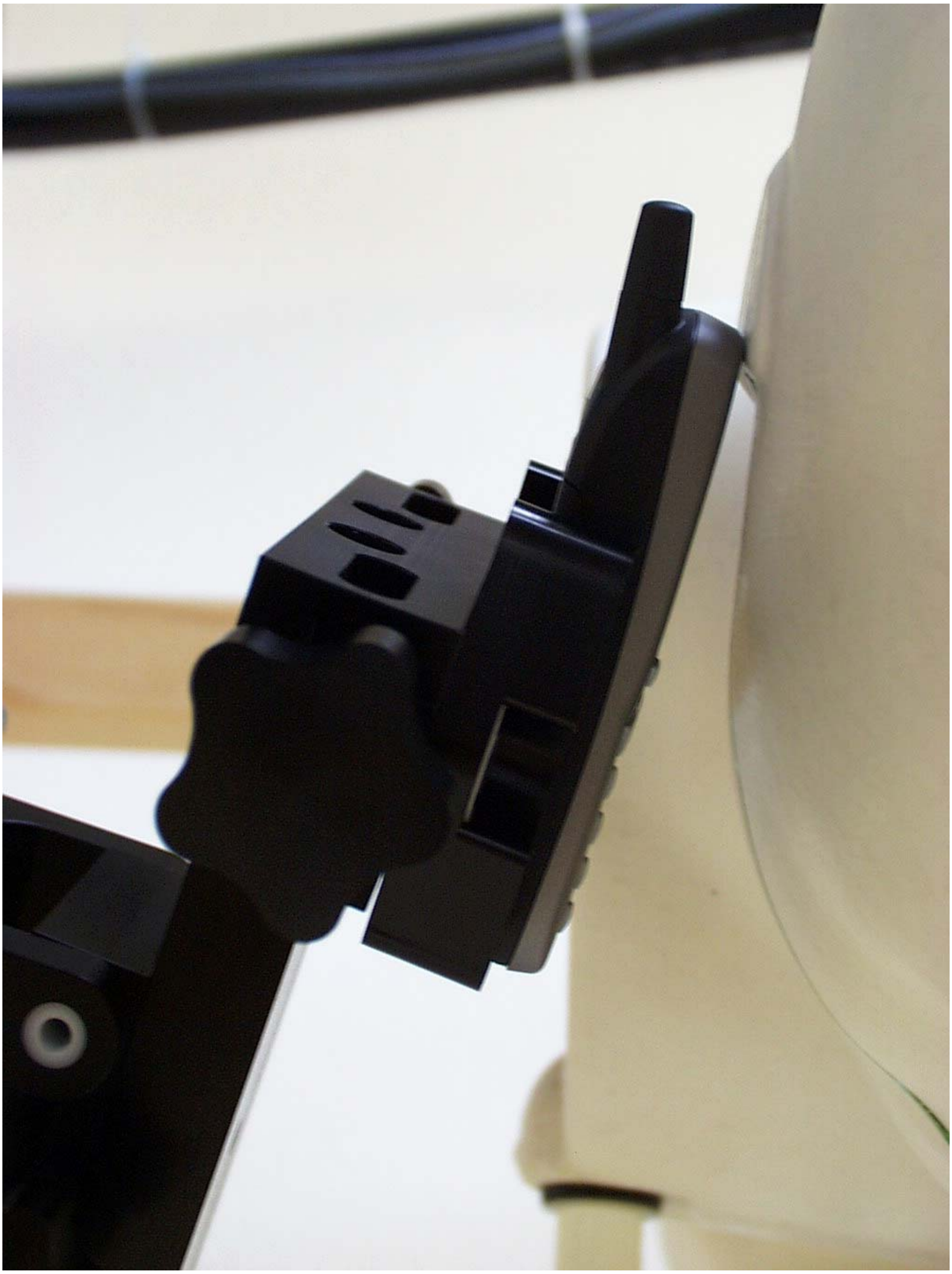

Fig. 21: Tilted position, right side.

Fig. 22: Body worn configuration.

7 References

[DASY 1995] Referenzliste des Herstellers, der Fa. Schmid & Partner Engineering AG, über installierte DASY-Systeme mit RX90 Robotern: Deutsche Telekom, Forschungs- und Technologiezentrum; Motorola Cellular - MRO; Motorola; Ericsson Mobile Communications AB; Nokia Mobile Phones LTD; IMST GmbH, 1995.

[FCC 2001] Federal Communications Commission: Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), FCC, 2001.

[IEEE 1999] IEEE Std C95.1-1999: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, Inst. of Electrical and Electronics Engineers, Inc., 1999.

[IEEE 200x] IEEE Std 1528-200x: DRAFT Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques. Draft 6.2, Inst. of Electrical and Electronics Engineers, Inc., 2000.

[NIST 1994] NIST: Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, Technical Note 1297 (TN1297), United States Department of Commerce Technology Administration, National Institute of Standards and Technology, 1994.