

Calibration Laboratory of

Schmid & Partner

Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Federal Office of Metrology and Accreditation
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis

Calibration is Performed According to the Following Standards:

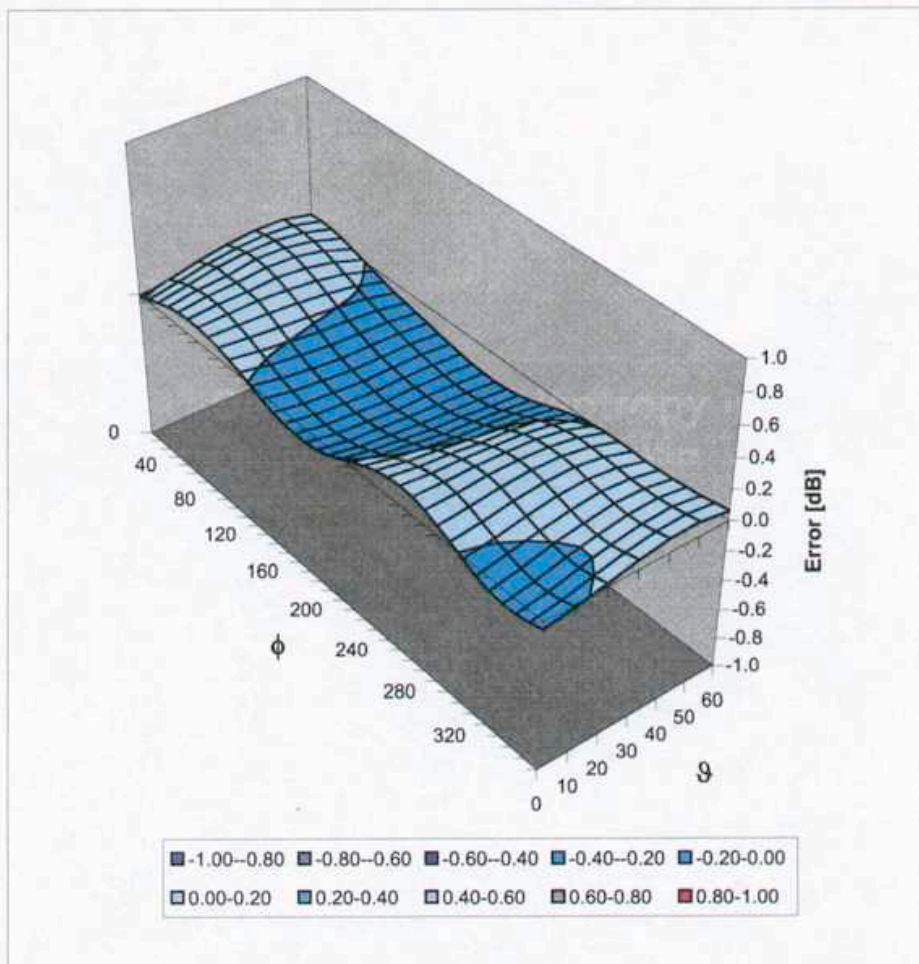
- IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- CENELEC EN 50361, "Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz - 3 GHz), July 2001

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E²-field uncertainty inside TSL (see below *ConvF*).
- NORM(f)_{x,y,z}** = NORM_{x,y,z} * *frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * *ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

Deviation from Isotropy in HSL

Error (ϕ , θ), $f = 900$ MHz



Uncertainty of Spherical Isotropy Assessment: $\pm 2.6\%$ ($k=2$)



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Accreditation No.: **SCS 108**

Client **IMST**

Certificate No: **ET3-1669_Jan05**

CALIBRATION CERTIFICATE

Object **ET3DV6R - SN:1669**

Calibration procedure(s) **QA CAL-01.v5**
Calibration procedure for dosimetric E-field probes

Calibration date: **January 13, 2005**

Condition of the calibrated item **In Tolerance**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
 The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	5-May-04 (METAS, No. 251-00388)	May-05
Power sensor E4412A	MY41495277	5-May-04 (METAS, No. 251-00388)	May-05
Reference 3 dB Attenuator	SN: S5054 (3c)	10-Aug-04 (METAS, No. 251-00403)	Aug-05
Reference 20 dB Attenuator	SN: S5086 (20b)	3-May-04 (METAS, No. 251-00389)	May-05
Reference 30 dB Attenuator	SN: S5129 (30b)	10-Aug-04 (METAS, No. 251-00404)	Aug-05
Reference Probe ES3DV2	SN: 3013	7-Jan-05 (SPEAG, No. ES3-3013_Jan05)	Jan-06
DAE4	SN: 617	29-Sep-04 (SPEAG, No. DAE4-617_Sep04)	Sep-05

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092180	18-Sep-02 (SPEAG, in house check Oct-03)	In house check: Oct 05
RF generator HP 8648C	US3642U01700	4-Aug-99 (SPEAG, in house check Dec-03)	In house check: Dec-05
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Nov-04)	In house check: Nov 05

	Name	Function	Signature
Calibrated by:	Nico Vetterli	Laboratory Technician	

Approved by:	Katja Pokovic	Technical Manager	
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Issued: January 13, 2005

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



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Accreditation No.: **SCS 108**

Glossary:

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- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
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- ConvF and Boundary Effect Parameters:** Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * *ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy):** in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset:** The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

ET3DV6R SN:1669

January 13, 2005

Probe ET3DV6R

SN:1669

Manufactured:	February 8, 2002
Last calibrated:	March 18, 2004
Remake to V6R:	January 4, 2005
Recalibrated:	January 13, 2005

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

DASY - Parameters of Probe: ET3DV6R SN:1669

Sensitivity in Free Space^A

NormX	1.73 ± 10.1%	$\mu\text{V}/(\text{V}/\text{m})^2$
NormY	1.88 ± 10.1%	$\mu\text{V}/(\text{V}/\text{m})^2$
NormZ	1.75 ± 10.1%	$\mu\text{V}/(\text{V}/\text{m})^2$

Diode Compression^B

DCP X	95 mV
DCP Y	95 mV
DCP Z	95 mV

Sensitivity in Tissue Simulating Liquid (Conversion Factors)

Please see Page 8.

Boundary Effect

TSL 900 MHz Typical SAR gradient: 5 % per mm

Sensor Center to Phantom Surface Distance		3.7 mm	4.7 mm
SAR _{be} [%]	Without Correction Algorithm	8.3	4.4
SAR _{be} [%]	With Correction Algorithm	0.1	0.2

TSL 1750 MHz Typical SAR gradient: 10 % per mm

Sensor Center to Phantom Surface Distance		3.7 mm	4.7 mm
SAR _{be} [%]	Without Correction Algorithm	13.4	9.3
SAR _{be} [%]	With Correction Algorithm	0.6	0.2

Sensor Offset

Probe Tip to Sensor Center 2.7 mm

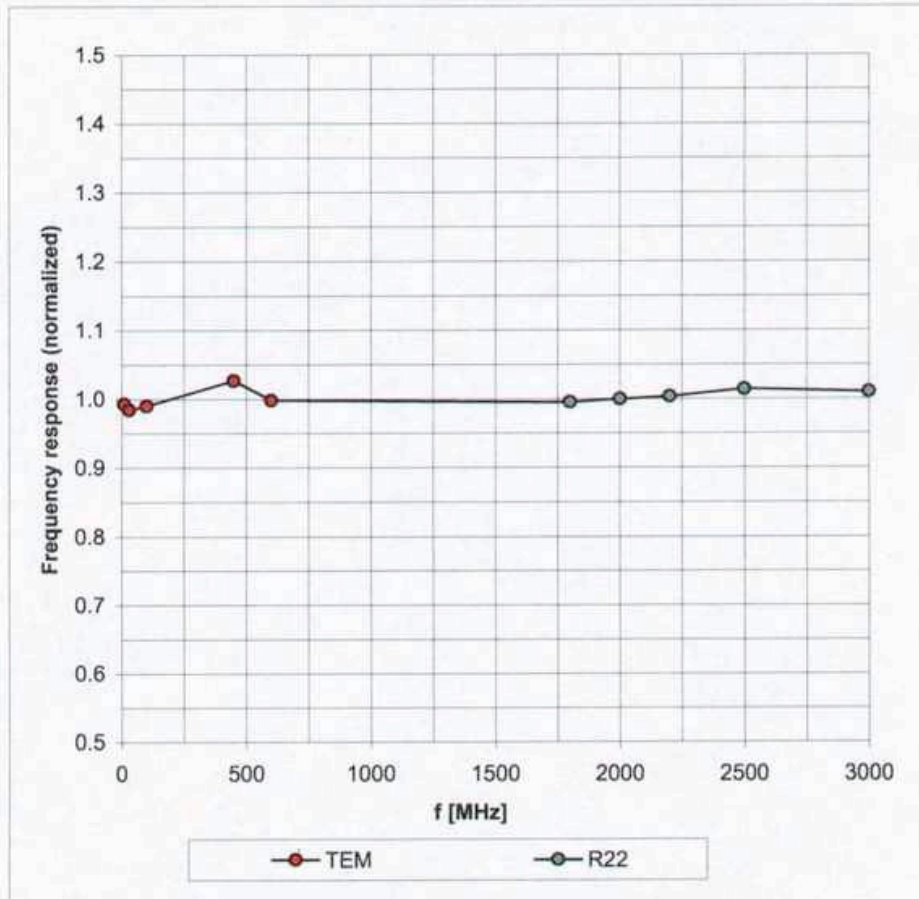
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^A The uncertainties of NormX,Y,Z do not affect the E²-field uncertainty inside TSL (see Page 8).

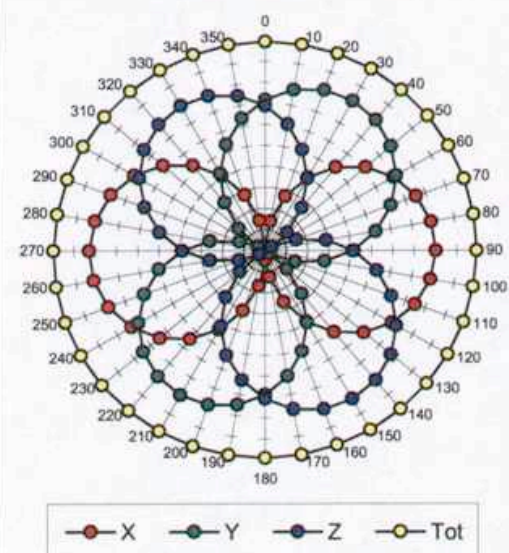
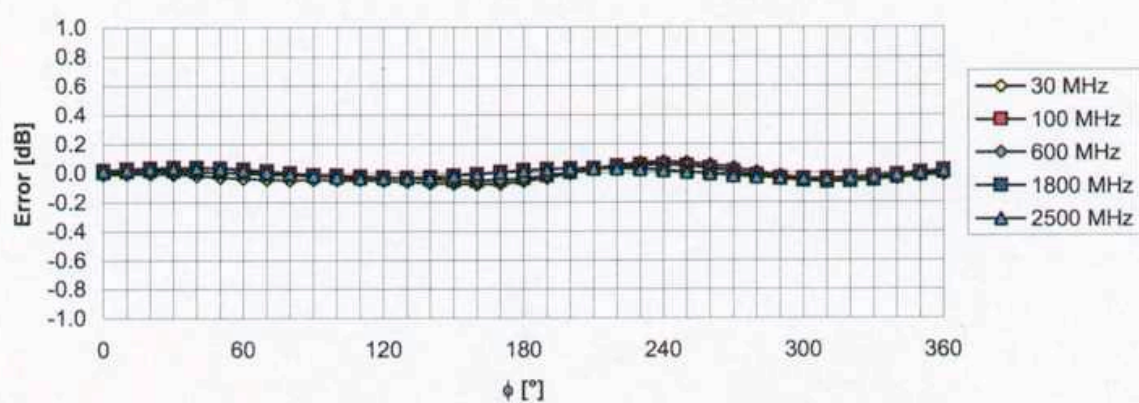
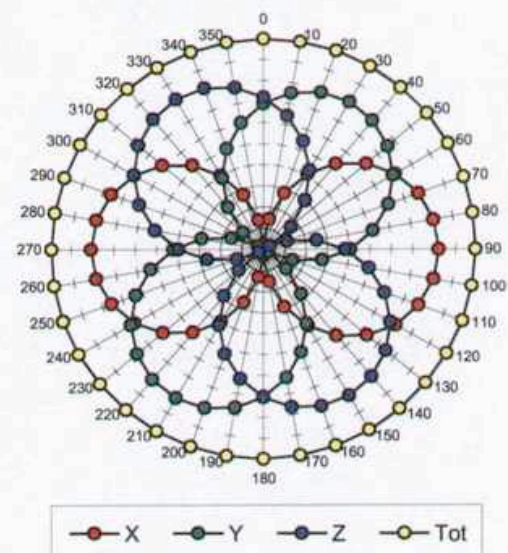
^B Numerical linearization parameter: uncertainty not required.

Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide: R22)

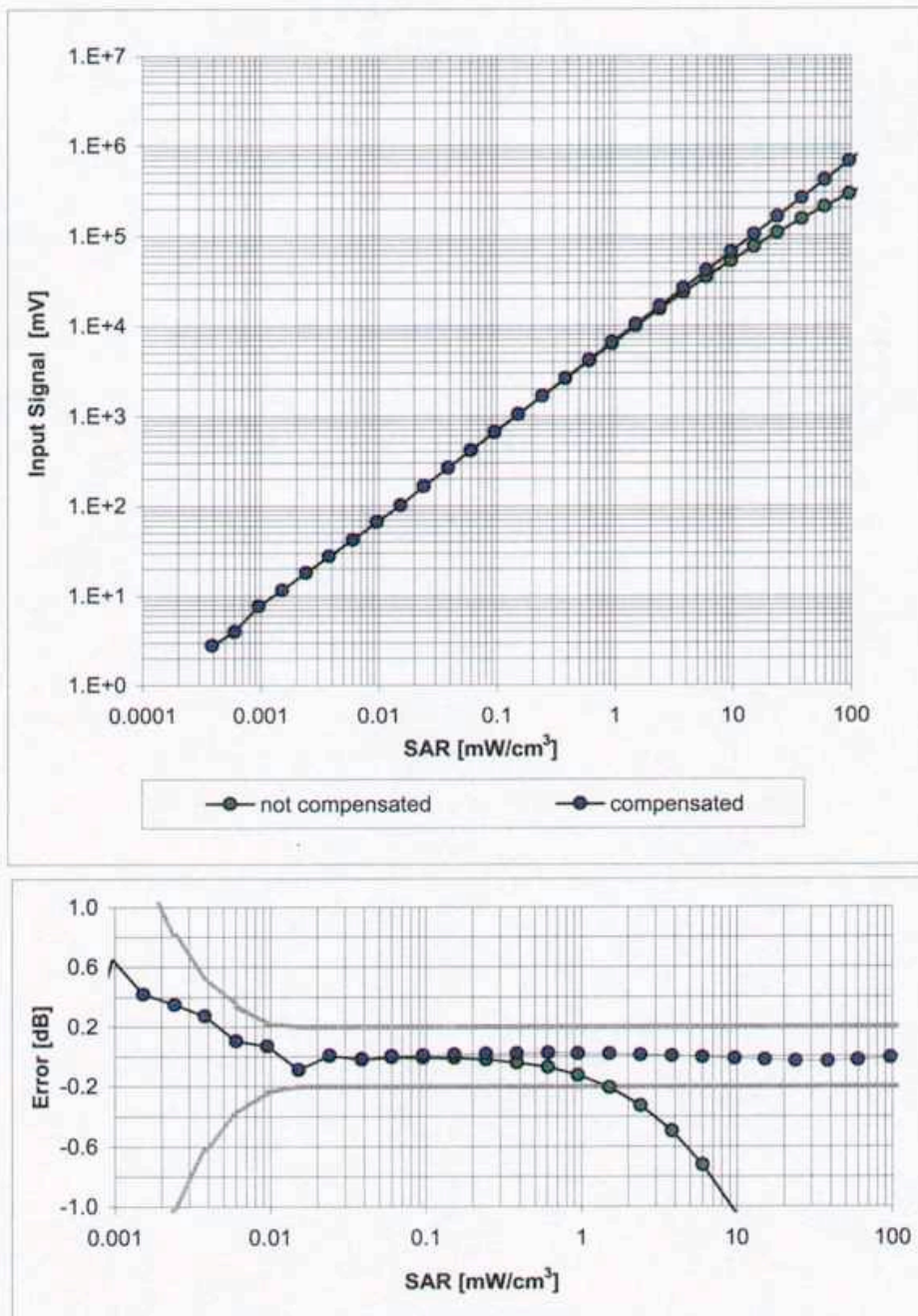


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

Receiving Pattern (ϕ), $\theta = 0^\circ$ $f = 600 \text{ MHz}$, TEM ifi110EXX $f = 1800 \text{ MHz}$, WG R22Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

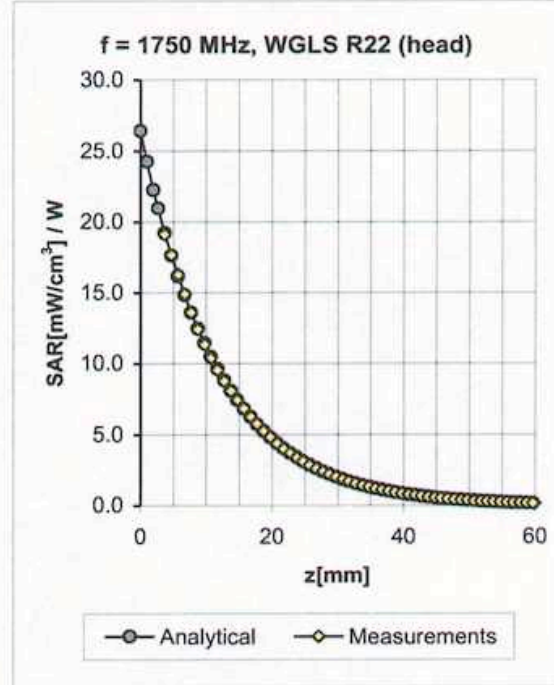
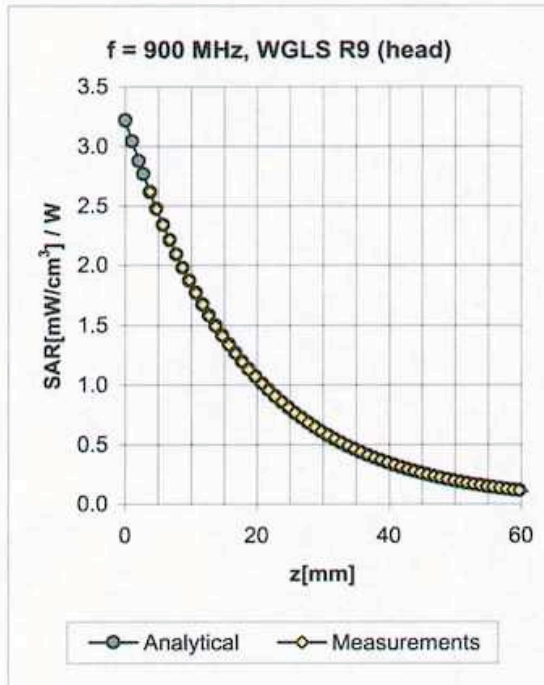
Dynamic Range $f(\text{SAR}_{\text{head}})$

(Waveguide R22, $f = 1800$ MHz)



Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment

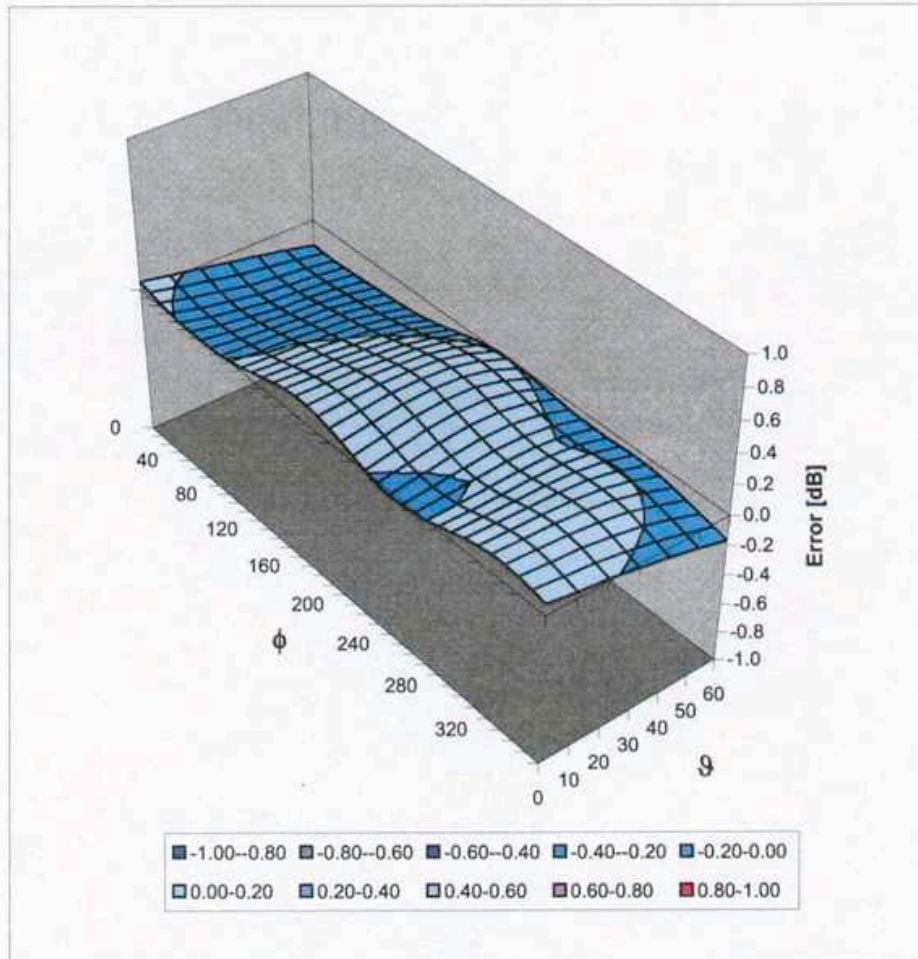


f [MHz]	Validity [MHz] ^c	TSL	Permittivity	Conductivity	Alpha	Depth	ConvF Uncertainty
835	± 50 / ± 100	Head	41.5 ± 5%	0.90 ± 5%	0.57	1.85	6.61 ± 11.0% (k=2)
900	± 50 / ± 100	Head	41.5 ± 5%	0.97 ± 5%	0.56	1.85	6.49 ± 11.0% (k=2)
1750	± 50 / ± 100	Head	40.1 ± 5%	1.37 ± 5%	0.56	2.38	5.36 ± 11.0% (k=2)
1900	± 50 / ± 100	Head	40.0 ± 5%	1.40 ± 5%	0.53	2.53	5.11 ± 11.0% (k=2)
1950	± 50 / ± 100	Head	40.0 ± 5%	1.40 ± 5%	0.51	2.71	4.75 ± 11.0% (k=2)
835	± 50 / ± 100	Body	55.2 ± 5%	0.97 ± 5%	0.49	2.09	6.39 ± 11.0% (k=2)
900	± 50 / ± 100	Body	55.0 ± 5%	1.05 ± 5%	0.50	2.09	6.11 ± 11.0% (k=2)
1750	± 50 / ± 100	Body	53.4 ± 5%	1.49 ± 5%	0.50	2.89	4.67 ± 11.0% (k=2)
1900	± 50 / ± 100	Body	53.3 ± 5%	1.52 ± 5%	0.51	3.01	4.52 ± 11.0% (k=2)
1950	± 50 / ± 100	Body	53.3 ± 5%	1.52 ± 5%	0.55	2.63	4.40 ± 11.0% (k=2)

^c The validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2). The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.

Deviation from Isotropy in HSL

Error (ϕ , ϑ), $f = 900$ MHz



Uncertainty of Spherical Isotropy Assessment: $\pm 2.6\%$ ($k=2$)

Client **IMST**

CALIBRATION CERTIFICATE

Object(s) **EX3DV4- SN:3536**

Calibration procedure(s) **QA CAL-01.v2**
Calibration procedure for dosimetric field probes

Calibration date: **August 27, 2004**

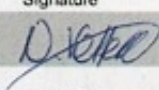
Condition of the calibrated item **In Tolerance (according to the specific calibration document)**

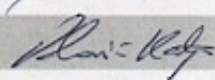
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
 The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature 22 ± 2 degrees Celsius and humidity $< 75\%$.

Calibration Equipment used (M&TE critical for calibration)

Model Type	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter EPM E4419B	GB41293874	5-May-04 (METAS, No 251-00388)	May-05
Power sensor E4412A	MY41495277	5-May-04 (METAS, No 251-00388)	May-05
Reference 20 dB Attenuator	SN: 5086 (20b)	3-May-04 (METAS, No 251-00389)	May-05
Fluke Process Calibrator Type 702	SN: 6295803	8-Sep-03 (Sintrel SCS No. 6030020)	Sep-04
Power sensor HP 8481A	MY41092180	18-Sep-02 (SPEAG, in house check Oct03)	In house check: Oct 05
RF generator HP 8684C	US3642U01700	4-Aug-99 (SPEAG, in house check Aug02)	In house check: Aug05
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Oct03)	In house check: Oct 05

	Name	Function	Signature
Calibrated by:	Nico Vetterli	Technician	

Approved by:	Katja Pokovic	Laboratory Director	
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Date issued: August 31, 2004

This calibration certificate is issued as an intermediate solution until the accreditation process (based on ISO/IEC 17025 International Standard) for Calibration Laboratory of Schmid & Partner Engineering AG is completed.

Probe EX3DV4

SN:3536

Manufactured:	April 30, 2004
Last calibrated:	August 27, 2004

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

DASY - Parameters of Probe: EX3DV4 SN:3536

Sensitivity in Free Space

Diode Compression^A

NormX	0.42 $\mu\text{V}/(\text{V}/\text{m})^2$
NormY	0.45 $\mu\text{V}/(\text{V}/\text{m})^2$
NormZ	0.38 $\mu\text{V}/(\text{V}/\text{m})^2$

DCP X	93	mV
DCP Y	93	mV
DCP Z	93	mV

Sensitivity in Tissue Simulating Liquid (Conversion Factors)

Please see Page 7.

Boundary Effect

Head 900 MHz Typical SAR gradient: 5 % per mm

Sensor Center to Phantom Surface Distance		2.0 mm	3.0 mm
SAR _{be} [%]	Without Correction Algorithm	4.2	1.7
SAR _{be} [%]	With Correction Algorithm	0.0	0.0

Head 1750 MHz Typical SAR gradient: 10 % per mm

Sensor Center to Phantom Surface Distance		2.0 mm	3.0 mm
SAR _{be} [%]	Without Correction Algorithm	5.2	2.7
SAR _{be} [%]	With Correction Algorithm	0.2	0.6

Sensor Offset

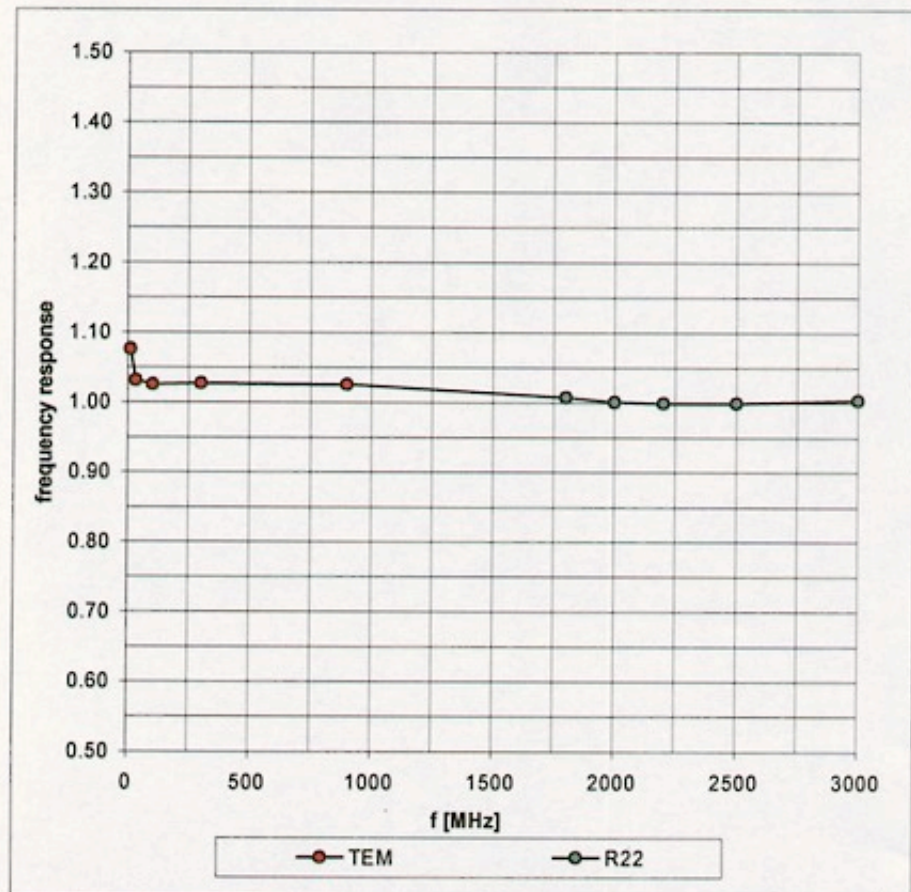
Probe Tip to Sensor Center **1.0** mm

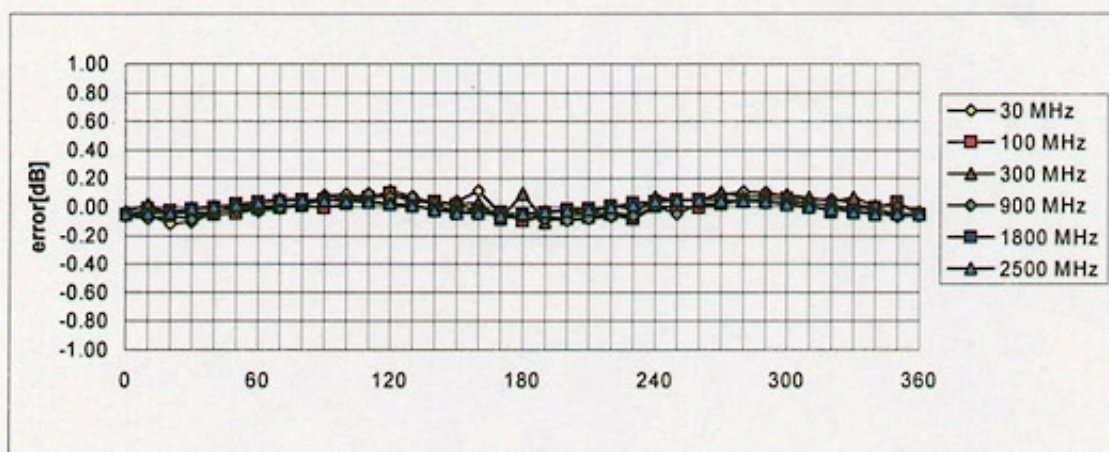
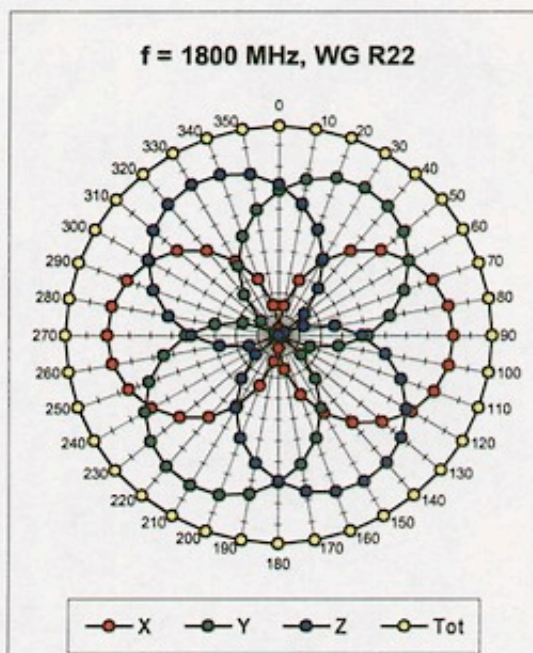
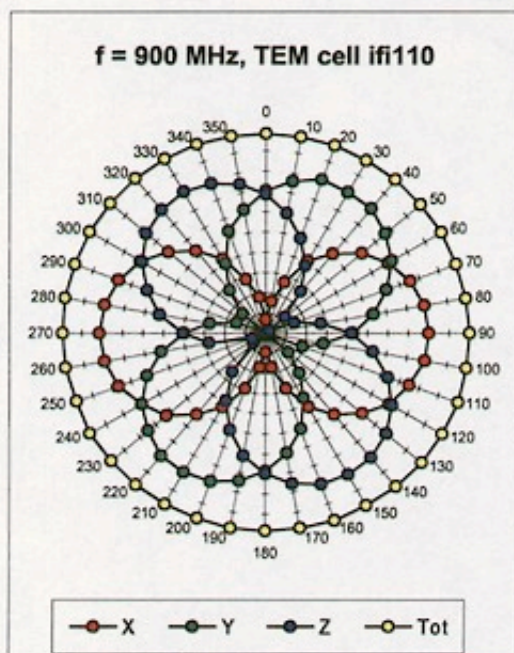
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^A numerical linearization parameter: uncertainty not required

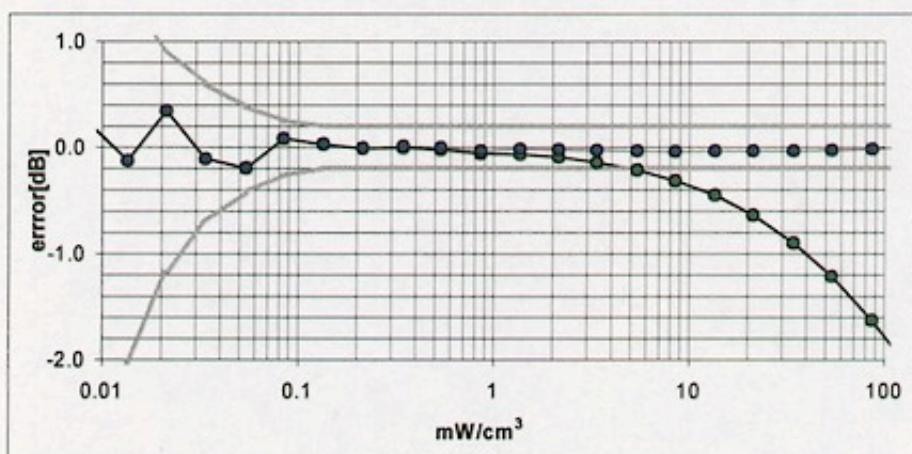
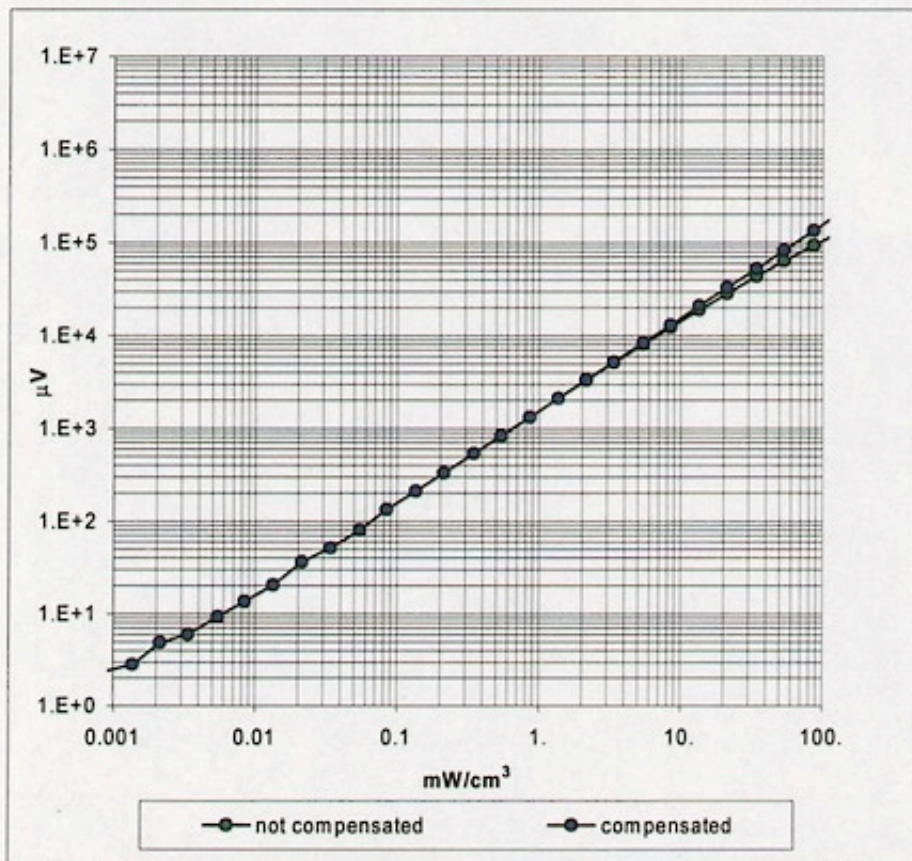
Frequency Response of E-Field

(TEM-Cell:ifi110, Waveguide R22)



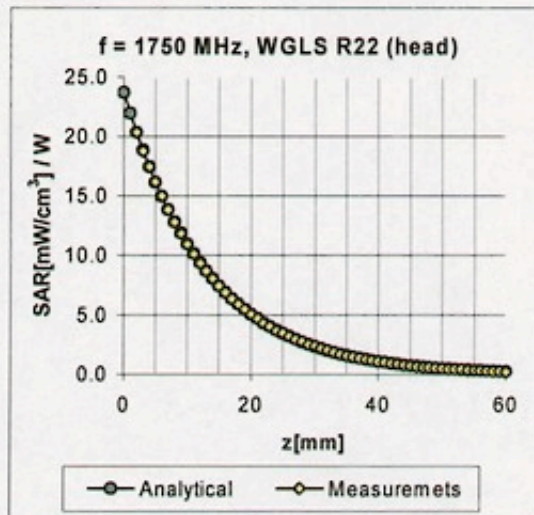
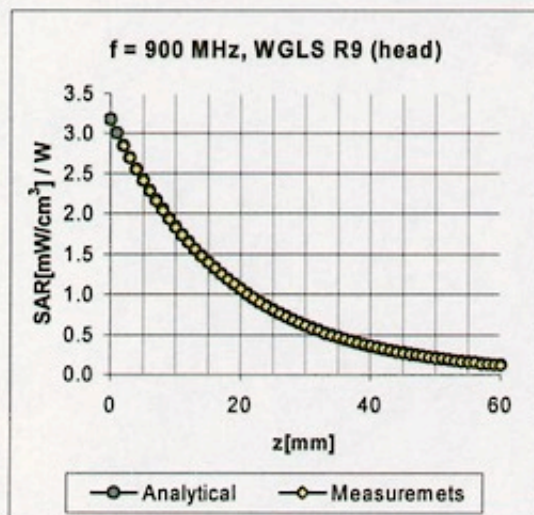
Receiving Pattern (ϕ), $\theta = 0^\circ$ Axial Isotropy Error $< \pm 0.2$ dB

Dynamic Range $f(\text{SAR}_{\text{head}})$ (Waveguide R22)



Probe Linearity Error $< \pm 0.2 \text{ dB}$

Conversion Factor Assessment

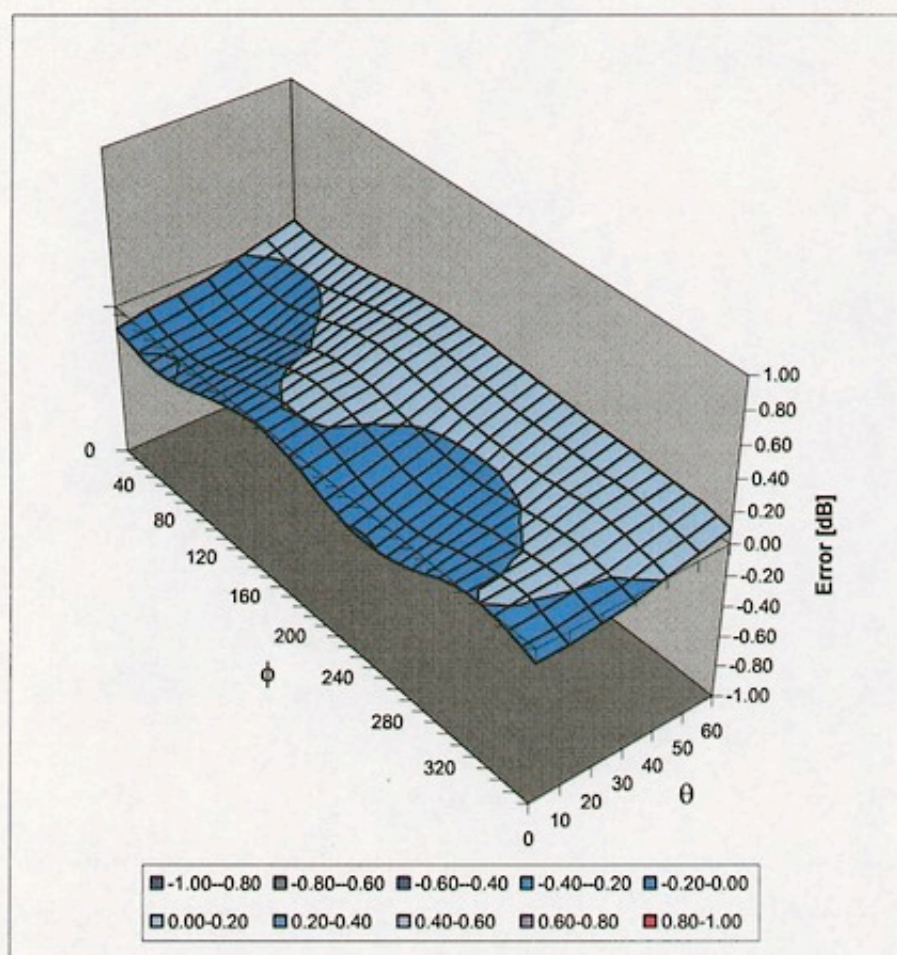


f [MHz]	Validity [MHz] ^B	Tissue	Permittivity	Conductivity	Alpha	Depth	ConvF Uncertainty
450	400-500	Head	43.5 ± 5%	0.87 ± 5%	0.10	1.84	9.77 ± 15.5% (k=2)
835	785-885	Head	41.5 ± 5%	0.90 ± 5%	0.63	0.67	9.88 ± 9.7% (k=2)
900	850-950	Head	41.5 ± 5%	0.97 ± 5%	0.26	1.07	9.49 ± 9.7% (k=2)
1750	1700-1800	Head	40.0 ± 5%	1.40 ± 5%	0.11	2.50	8.29 ± 9.7% (k=2)
1900	1850-1950	Head	40.0 ± 5%	1.40 ± 5%	0.11	2.50	8.19 ± 9.7% (k=2)
1950	1900-2000	Head	40.0 ± 5%	1.40 ± 5%	0.11	2.76	7.90 ± 9.7% (k=2)
2000	1950-2050	Head	40.0 ± 5%	1.40 ± 5%	0.11	3.98	7.55 ± 9.7% (k=2)
2450	2400-2500	Head	39.2 ± 5%	1.80 ± 5%	0.19	1.40	7.49 ± 9.7% (k=2)
5200	5150-5250	Head	36.0 ± 5%	4.66 ± 5%	0.49	1.80	5.27 ± 13.6% (k=2)
450	400-500	Body	56.7 ± 5%	0.94 ± 5%	0.11	1.79	9.31 ± 15.5% (k=2)
835	785-885	Body	55.2 ± 5%	0.97 ± 5%	0.24	1.29	9.78 ± 9.7% (k=2)
900	850-950	Body	55.0 ± 5%	1.05 ± 5%	0.28	1.08	9.42 ± 9.7% (k=2)
1750	1700-1800	Body	53.3 ± 5%	1.52 ± 5%	0.11	4.04	7.89 ± 9.7% (k=2)
1900	1850-1950	Body	53.3 ± 5%	1.52 ± 5%	0.12	4.63	7.54 ± 9.7% (k=2)
1950	1900-2000	Body	53.3 ± 5%	1.52 ± 5%	0.13	3.96	7.59 ± 9.7% (k=2)
2000	1950-2050	Body	53.3 ± 5%	1.52 ± 5%	0.14	4.10	7.26 ± 9.7% (k=2)
2450	2400-2500	Body	52.7 ± 5%	1.95 ± 5%	0.31	0.99	7.70 ± 9.7% (k=2)
5200	5150-5250	Body	49.0 ± 5%	5.30 ± 5%	0.50	1.90	4.84 ± 13.6% (k=2)

^B The total standard uncertainty is calculated as root-sum-square of standard uncertainty of the Conversion Factor at calibration frequency and the standard uncertainty for the indicated frequency band.

Deviation from Isotropy in HSL

Error (θ, ϕ), $f = 900$ MHz



Spherical Isotropy Error $< \pm 0.4$ dB