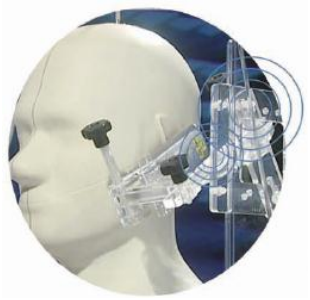
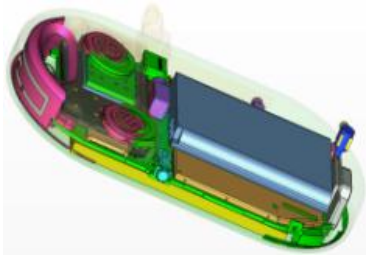
IEEE P1528.3 CAD interlaboratory comparison





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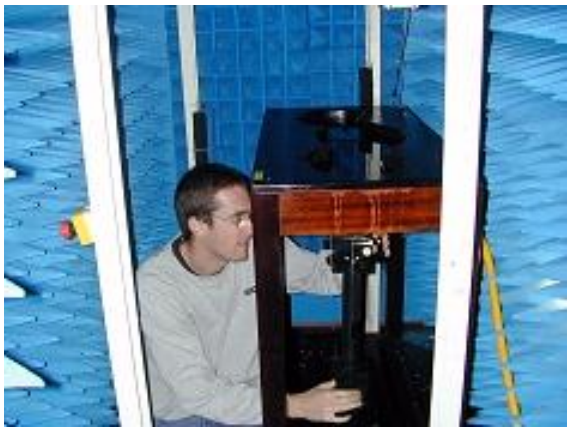
Tilmann Wittig (CST, Germany)

Experimental Dosimetry

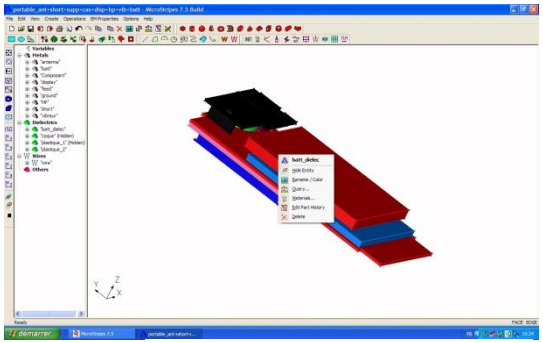


Standard specific absorption rate (SAR) measurement facilities :
XYZ-robot (left)
6-axis robot (right)

- ☺ CENELEC SAR standard applied since 2001
- ☹ SAR measurement uncertainty : up to 30%
- ☹ Mobile phone radiated power tolerance : 2 dB
- ☹ SAR measurement: time-consuming (one day for a dual-band mobile phone)
- ☹ Daily maintenance of the dosimetric facility
- ☹ Not practical for mobile phone antenna designers

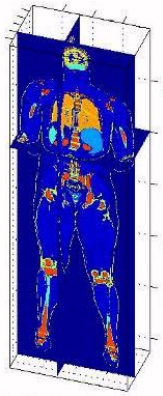
Numerical dosimetry

- **Essentially Time Domain Solvers**
  - **FDTD, FITD, TLM, …**
  - **Enhanced graphical user interfaces**

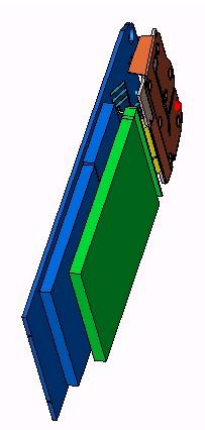


- **Computer resources (standard)**
  - **Workstation : multi-core processors with Gbytes RAM**
  - **Accelerator cards (e.g. TESLA)**
  - **Mesh volume : several millions voxels**

- ☺ **Human models**
  - **Morphing (reconstruct new head models)**
  - **Posing (assess whole-body exposure)**



- ☺ **Focus on realistic mobile phones**
  - **CAD models (if you work with manufacturers)**



IEEE1528 Framework

International Committee on Electromagnetic Safety (ICES)
Technical Committee 34: Wireless Handset SAR Certification (IEEE/ICES/TC34)

Chair: Dr. Wolfgang Kainz
Vice-Chair: Dr. Mark Douglas
ICES Chair: Ralf Bodemann
Sponsor Chair: Ron Petersen
IEEE-SA Liaison: Donal Heirman

http://grouper.ieee.org/groups/scc34/sc2/

IEEE Recommended Practice for Determining the Spatial Peak SAR in the Human Body Due to Wireless Communications Devices

Subcommittee 1: Experimental Techniques
Chair: Dr. Mark Douglas
Subcommittee 2: Computational Techniques
Chair: Dr. Wolfgang Kainz
WG1: Chair: Dr. Andreas Christ
WG2: Chair: Dr. Giorgi Bit-Babik
WG3: Chair: Dr. Vikass Monebhurrun →
WG4: Chair: Dr. Martin Vogel

Draft Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body from Wireless Communications Devices, 30 MHz - 6 GHz: Specific Requirements for Finite Difference Time Domain (FDTD) Modeling of Mobile Phones/Personal Wireless Devices

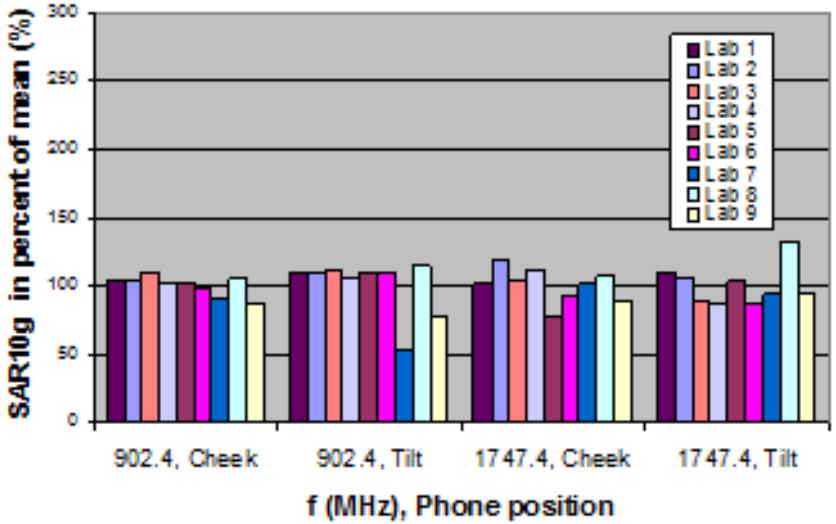
Previous interlaboratory comparison

M. Siegbahn, G. Bit-Babik, J. Keshvari, A. Christ, B. Derat, V. Monebhurrun, C. Penney, M. Vogel and T. Wittig, "An international interlaboratory comparison of mobile phone SAR calculation with CAD-based models," *IEEE Transactions on Electromagnetic Compatibility*, 52, 4, 2010, pp. 804-811.

Motorola c330

Nokia 8310

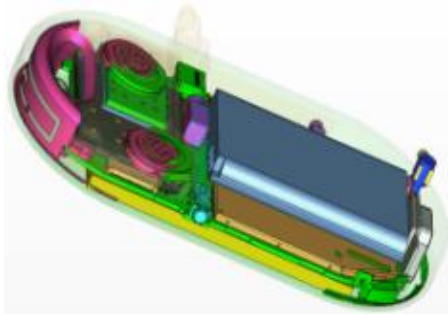
Sony Ericsson W810



Good overall agreement of the results (S11, SAR1g and SAR10g) but deviations were also observed.

Current interlaboratory comparison

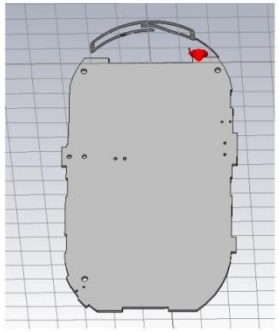
Main objective: step-by-step comparisons to track possible causes of errors (e.g. wrong dielectric properties, wrong positioning against head).
Also: provide a benchmark for 1528.3.
=> CAD model should be freely available for anyone who wants to run the benchmark.



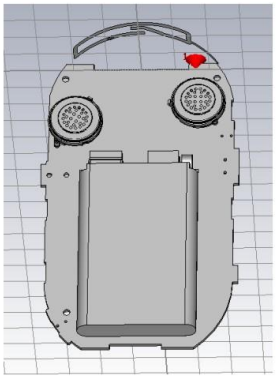
Neo_Free_Runner

- **Participating laboratories can download the CAD file from the Openmoko website: http://wiki.openmoko.org/wiki/Main_Page**
- **Antenna not present in this model (it was reconstructed based on geometrical measurements)**

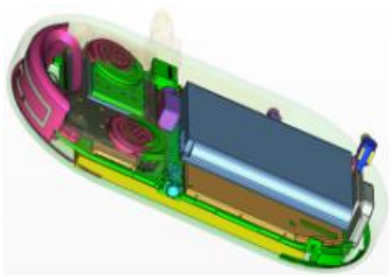
Elements of the CAD model

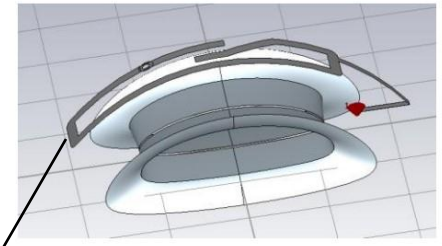


Antenne + PCB

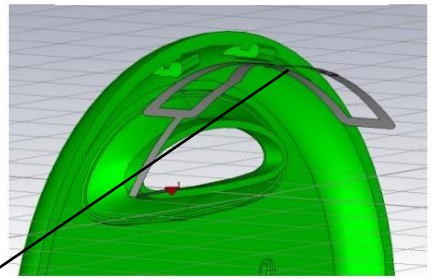


Antenne + PCB
+éléments métalliques



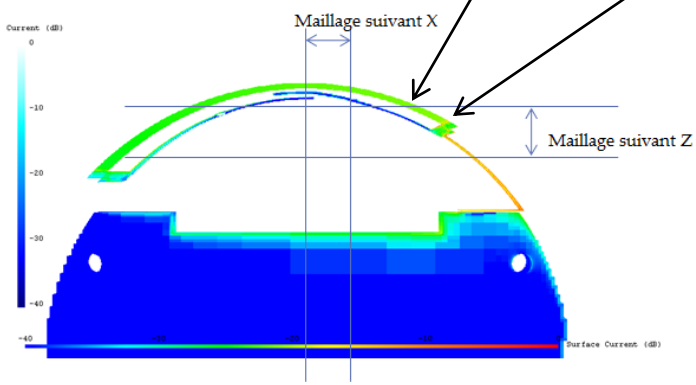


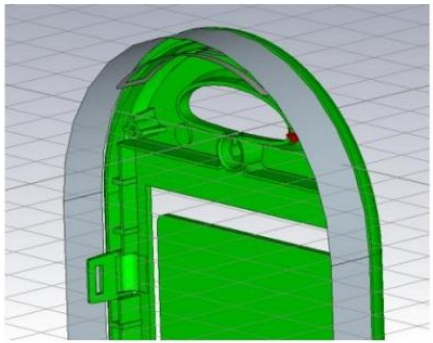
Diélectriques GTC 1, 2 et 5



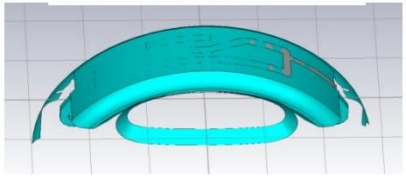
Diélectriques GTC 4

Antenna is curved
(requires careful handling)





Diélectriques GTC 10 + écran



Support de l'antenne

Dielectric properties of the materials are unknown (e.g. plastic, glass)
(values estimated from handbooks are used)

Softwares used for the intercomparison

- ANSYS HFSS: Finite Element Method (FEM)
- CST Microwave Studio: Finite Integral Time Domain (FIT)
- CST Microstripes: Transmission Line Matrix (TLM)
- Remcom XFDTD: Finite Difference Time Domain (FDTD)
- IMST EMPIRE: FDTD

Some participating laboratories could perform the numerical simulations using two different solvers (e.g. FIT and TLM)

Corresponds to the equivalent of 8 different participants

Step-by-step process to track errors

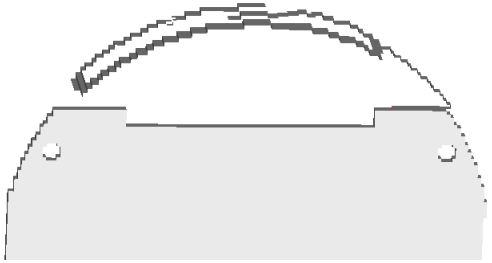
- Phase 1: preliminary investigations by SUPELEC (students)

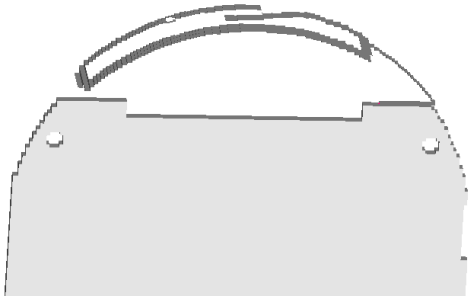
- Phase 2: participating laboratories perform **S11** simulations with the **mobile phone alone** (simplied model, intermediate and full models)

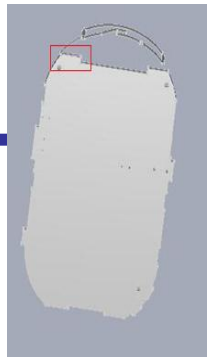
- Phase 3: participating laboratories perform **SAR** simulations with the **full model** and the SAM phantom

- Phase 4: investigation of the **uncertainty** of the numerical simulations

Phase 1: preliminary investigations

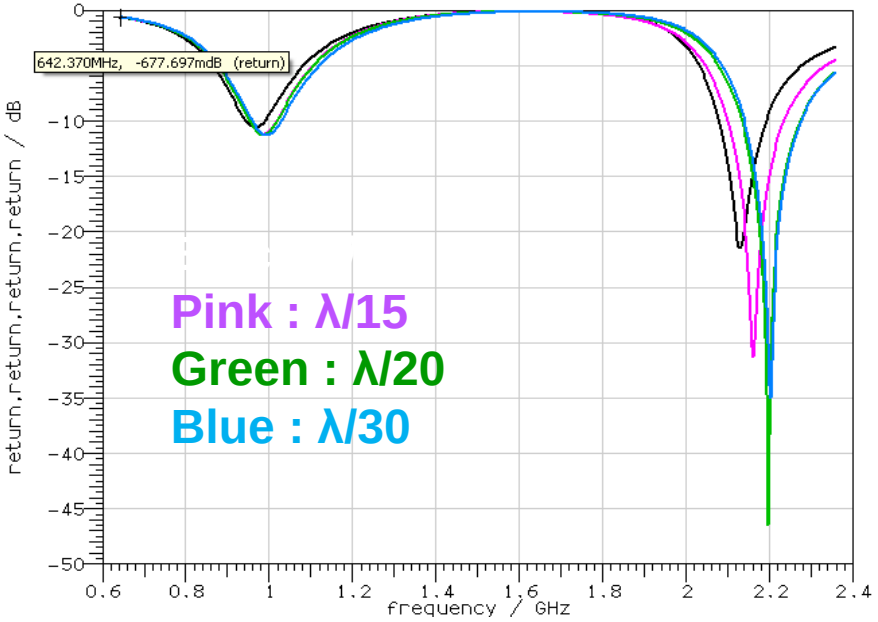


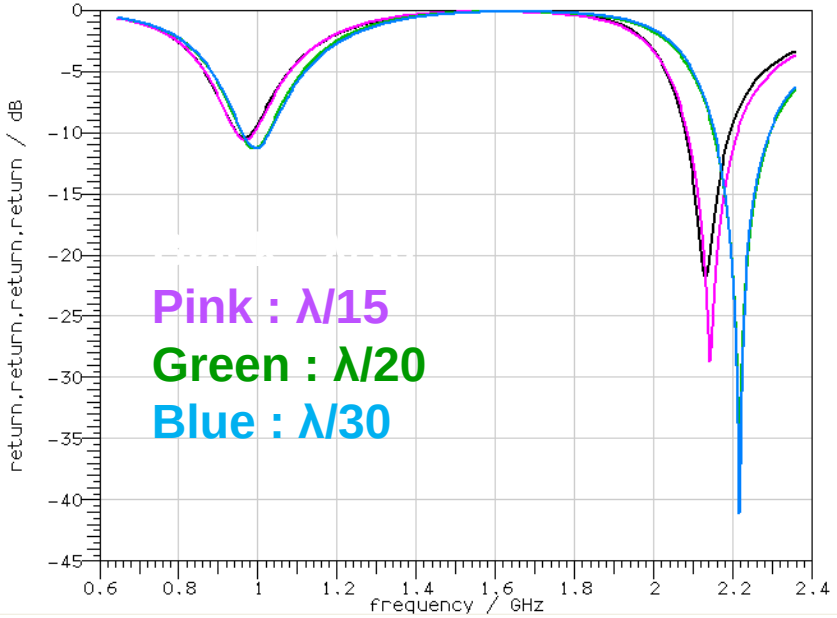




Automatic mesh generation

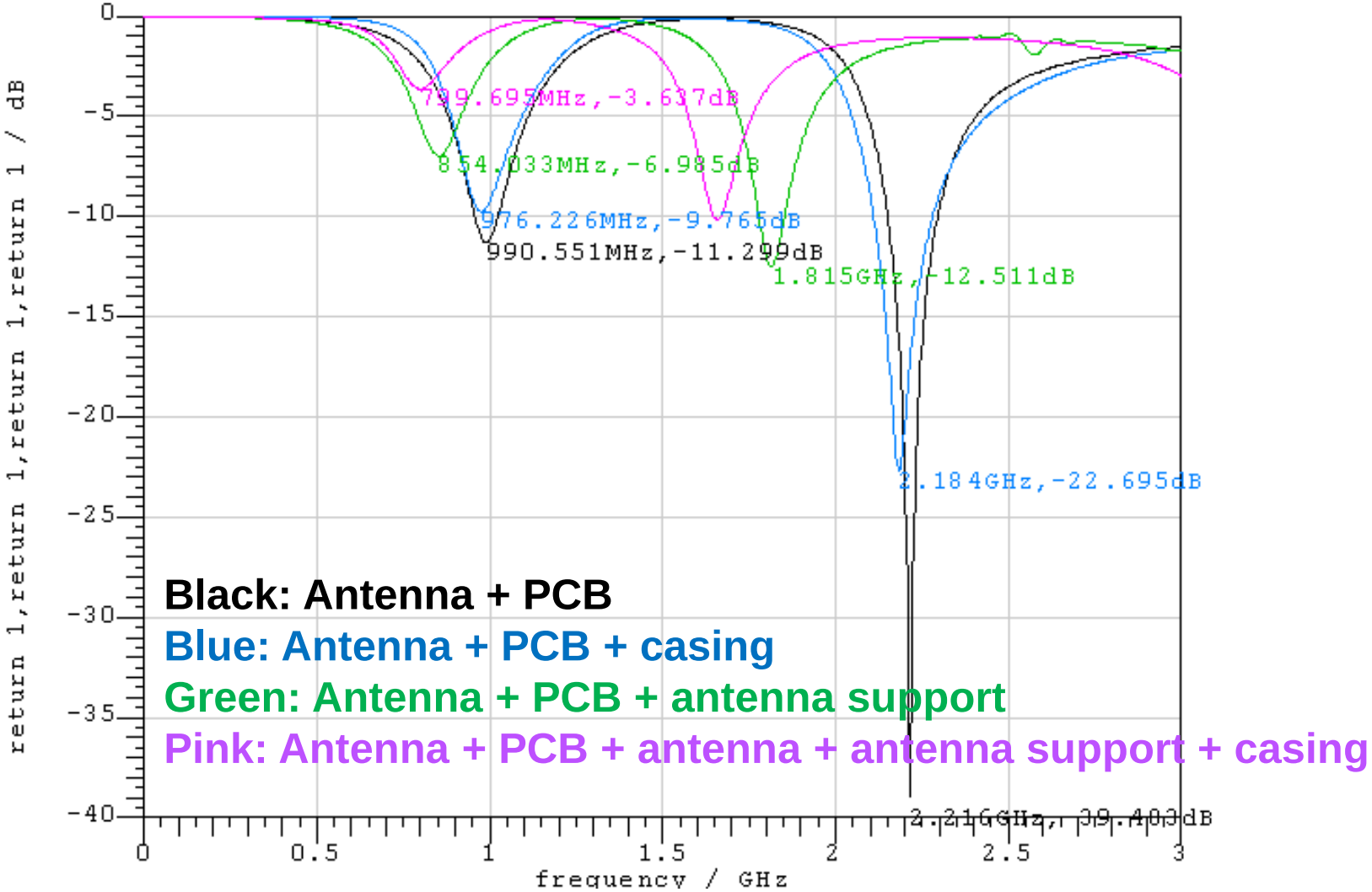
Automatic mesh generation
+ manual mesh for curved antenna





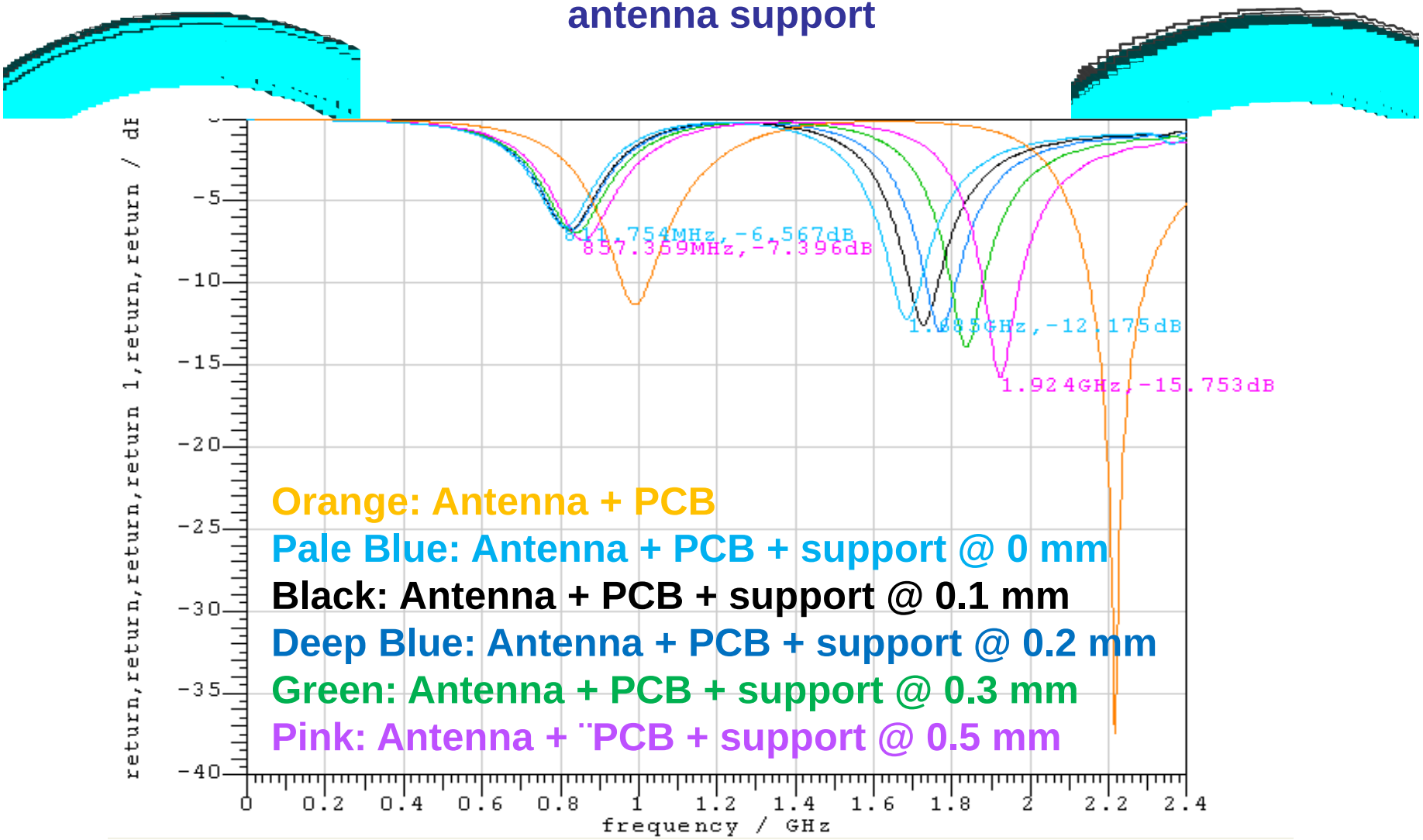
Phase 1: preliminary investigations

Investigation of the influence of some of the elements of the mobile phone on the return loss



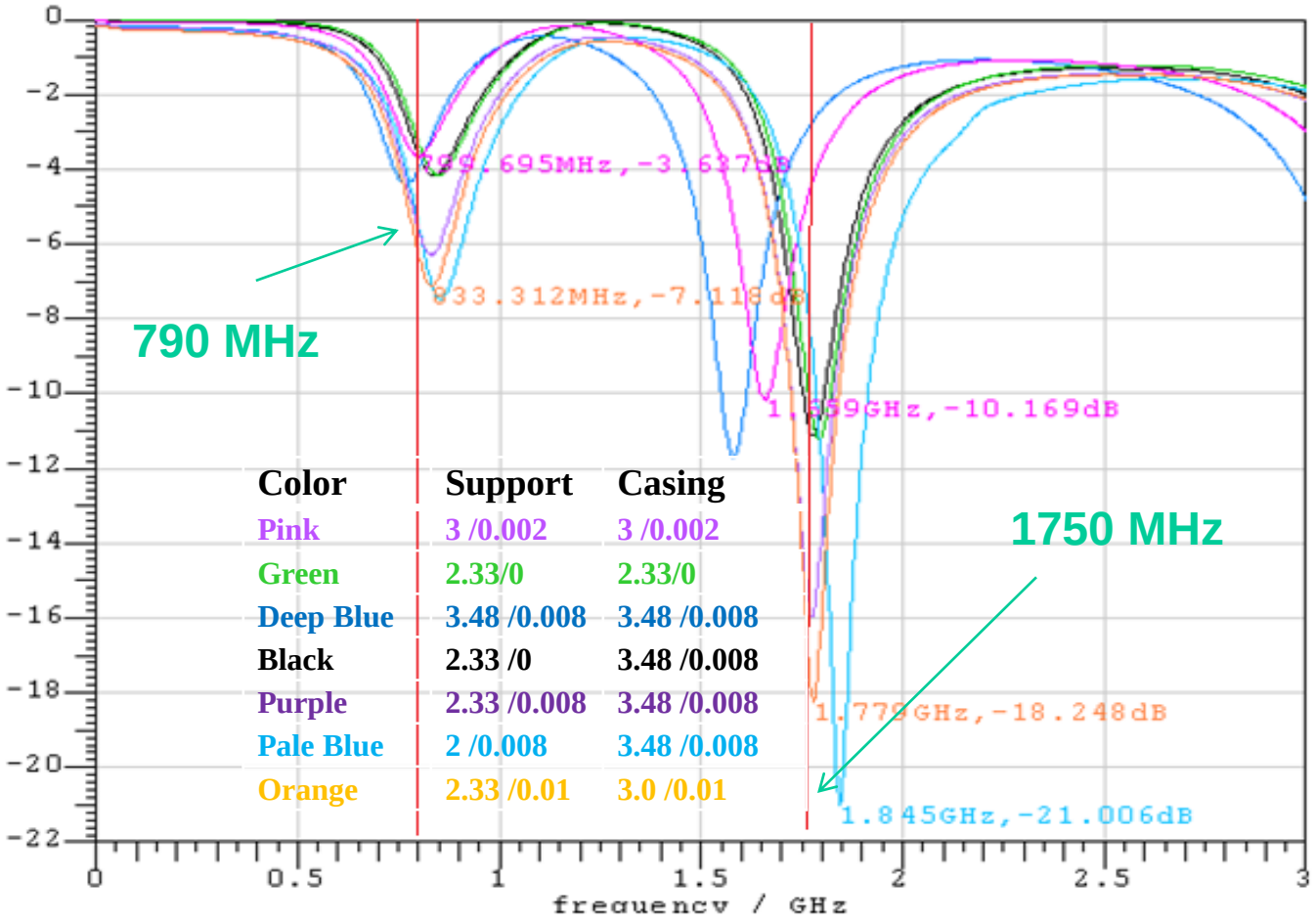
Phase 1: preliminary investigations

Investigation of the influence of distance between antenna and antenna support

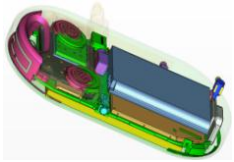


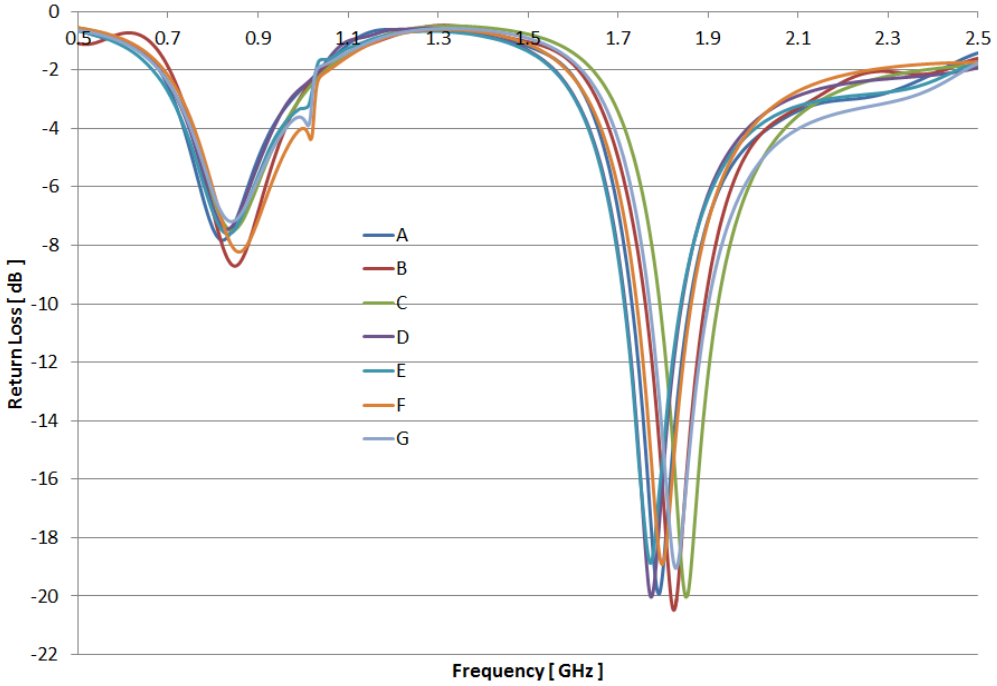
Phase 1: preliminary investigations

Numerical simulations performed to match as best as possible the measured S11 i.e. dielectric properties of the materials are varied using as reference typical values published for materials (plastic, glass, etc.)



Phase 2 : S11 Intercomparisons



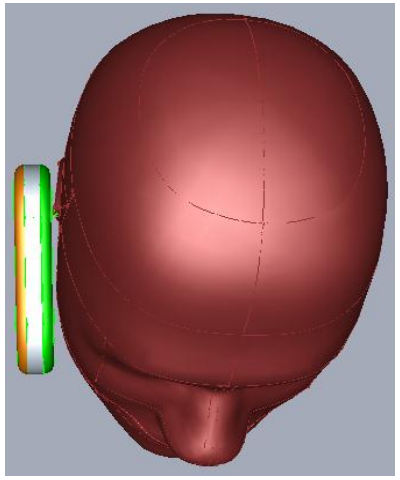


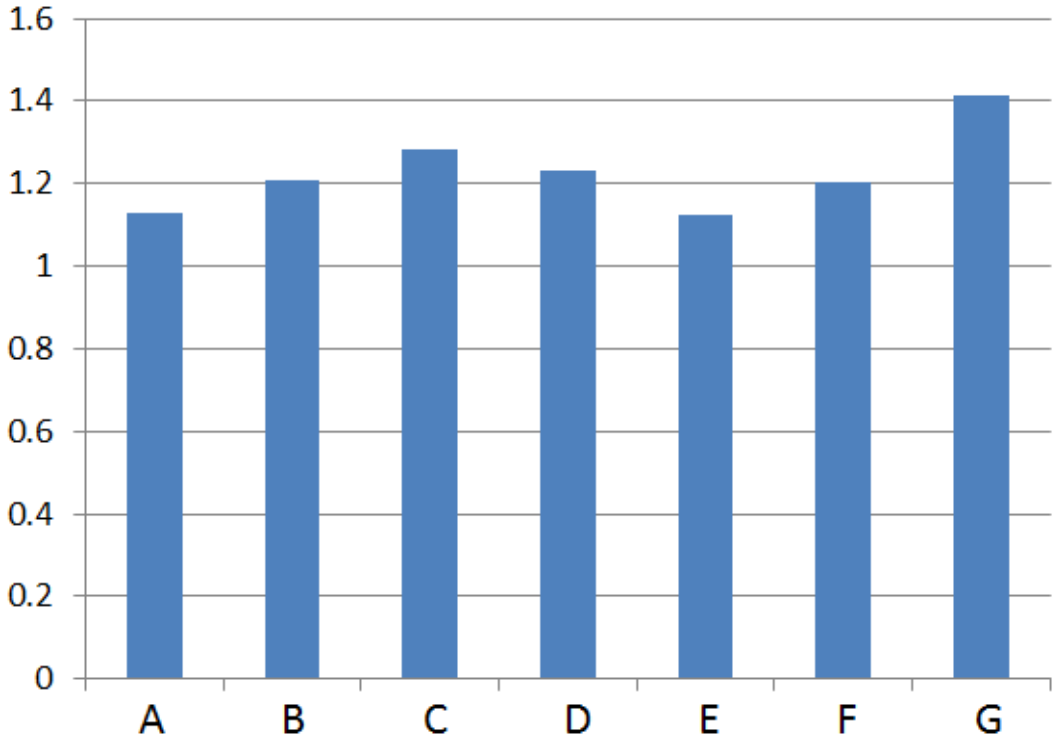
Good overall agreement (relatively higher deviations observed at 1750 MHz, most probably because the mesh densities applied by the participating laboratories are different)

Phase 3: SAR intercomparisons

Full SAR results not yet received from one participating laboratory
(issue regarding positioning of the phone against phantom also requires clarification)

RIGHT/CHEEK 890 MHz

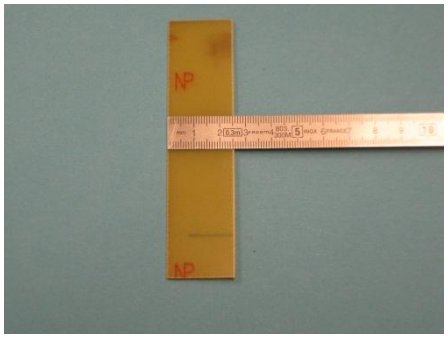




Phase 4: Uncertainty evaluation

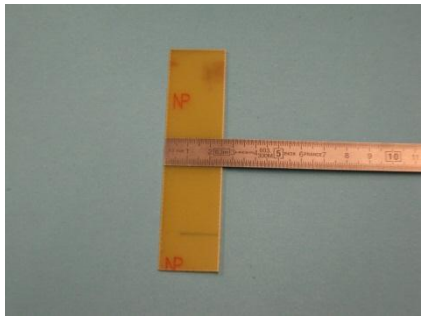
A simple example of uncertainty evaluation: measurement of the length (L) of an object

Case A: ruler
main graduations=1 mm
no subgraduation



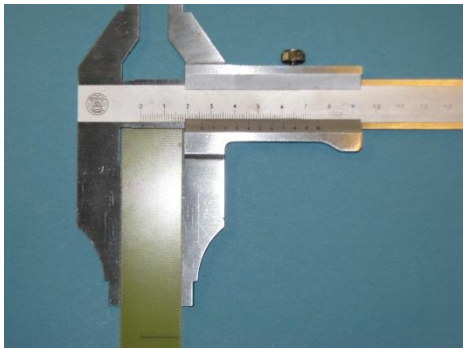
L= 25.5 ± 0.5 mm

Case B: ruler
main graduations=1 mm
subgraduations=0.5 mm



L= 25.75 ± 0.25 mm

Case C: Vernier calipers
main graduations=1 mm
subgraduations=0.02 mm



L= 25.92 ± 0.01 mm

Uncertainty associated with the tool: measurement=>ruler; numerical simulation=> mesh density, absorbing boundary conditions, excitation, etc.
Uncertainty associated with the object itself (e.g. the actual length may be sensitive to temperature): model uncertainty

Phase 4: Uncertainty evaluation

Analogy between SAR measurement and numerical simulation procedures

Measurement

Evaluate uncertainty of the measurement system (e.g. positioning of probe)

Perform system validation (e.g. measurement with a dipole antenna and a flat phantom and get target value)

Model uncertainty (e.g. is the measured sample representative of the family?)

Numerical simulation

Evaluate uncertainty of the numerical method (FDTD)
e.g. how does mesh density affect results?

Perform system validation (e.g. numerical simulations using a benchmark and get target value)

Model uncertainty (e.g. uncertainty of the dielectric properties of the phone)

Phase 4: Uncertainty evaluation

- Uncertainty due to FDTD modeling is being tackled in P1528.1

- Procedures to evaluate uncertainties: Monte Carlo Method (lots of simulations!), perturbation method (OK for small uncertainties <10%), moment equations (requires higher order moments which are not easy to derive), generalized Polynomial Chaos (efficient and increasingly being applied).

- P1528.3: uncertainties due to CAD model (how good is the numerical model compared to the real device?)

- On-going investigations on these issues …

Conclusion

- Development of standardized procedures for the calculation of SAR using CAD phone models and FDTD method (PIEEE1528.3)

- CAD Interlaboratory comparison using freely available model (you are welcome to join in the interlaboratory comparison)

- Overall good agreement between the participating laboratories (taking into account different solvers, users, applied mesh densities, etc.)

- Uncertainty evaluation is currently on-going …