4th ITU Green Standards Week

Minimization of EMF Exposures and Optimization of Safety Using EMF

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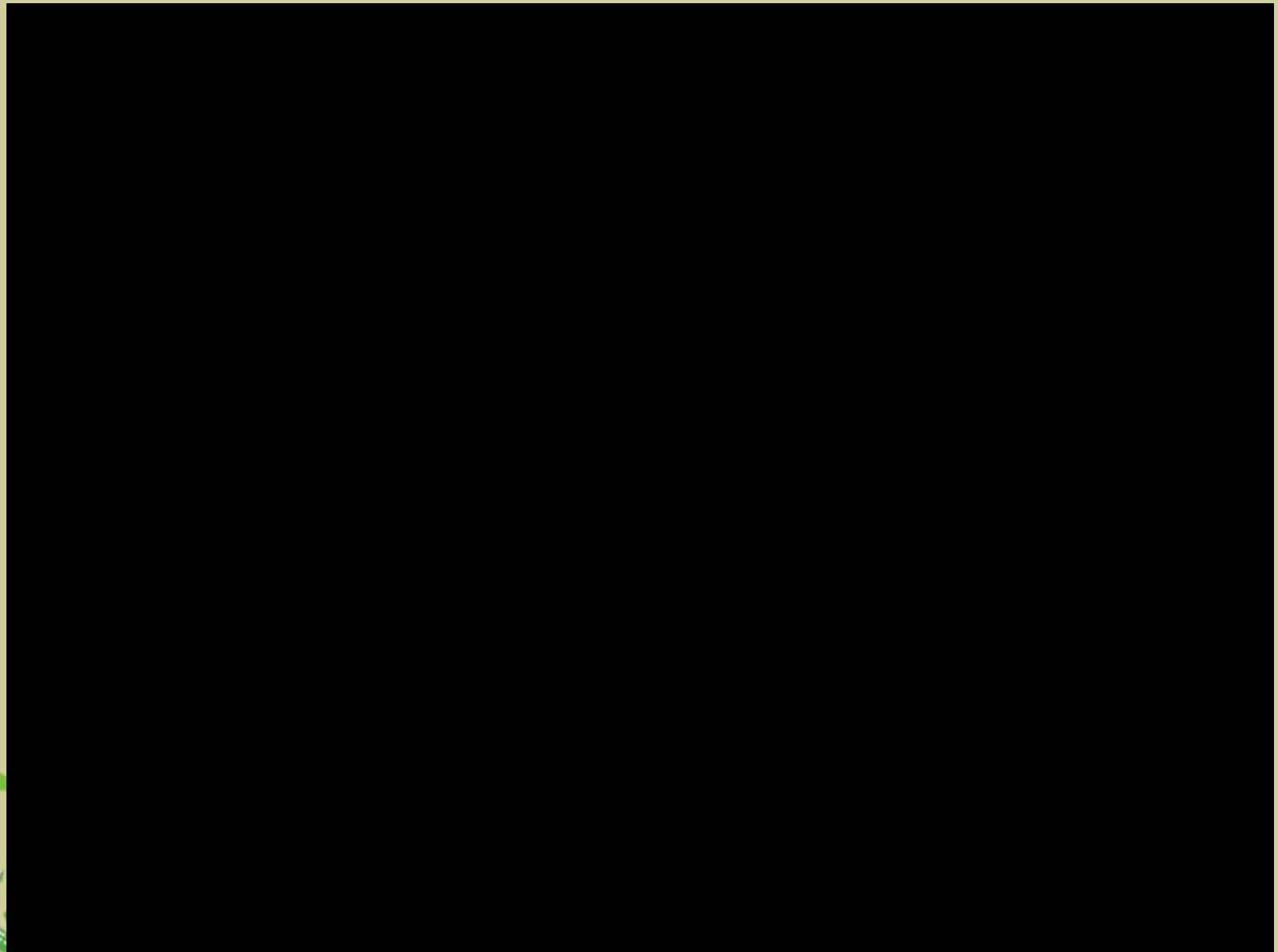


Content

- Exposure ranking of wireless RF sources
- Rules and measures for minimization of RF exposures
- Optimization of safety & energy using EMF
- Conclusions

Interaction Mechanism

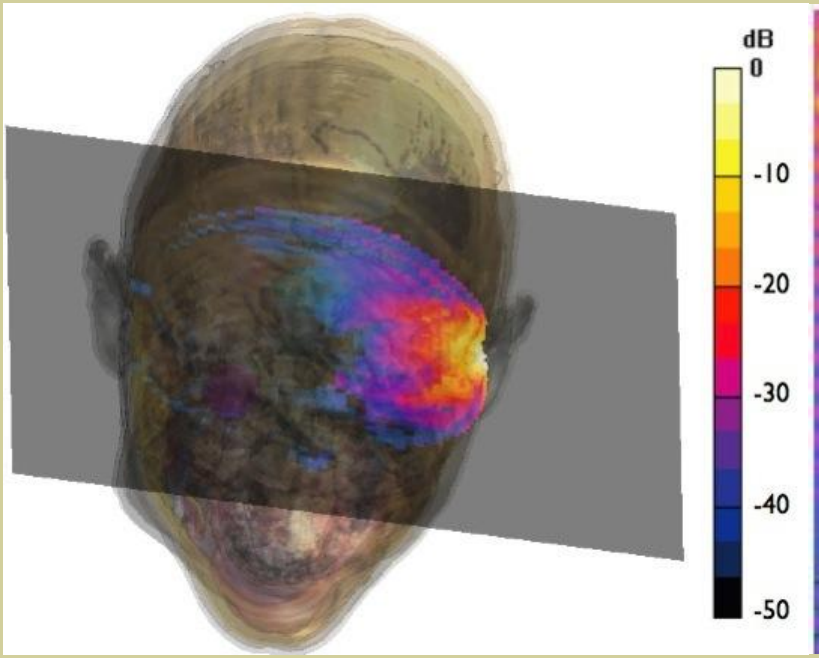
$$\mathrm{SAR} = \frac{\sigma}{\rho} \frac{\mu\omega}{\rho\sqrt{\sigma^2 + \varepsilon^2\omega^2}} (1 + c_{\mathrm{corr}}\gamma_{\mathrm{pw}})^2 H_{t_{\mathrm{inc}}}^2 \qquad (1)$$

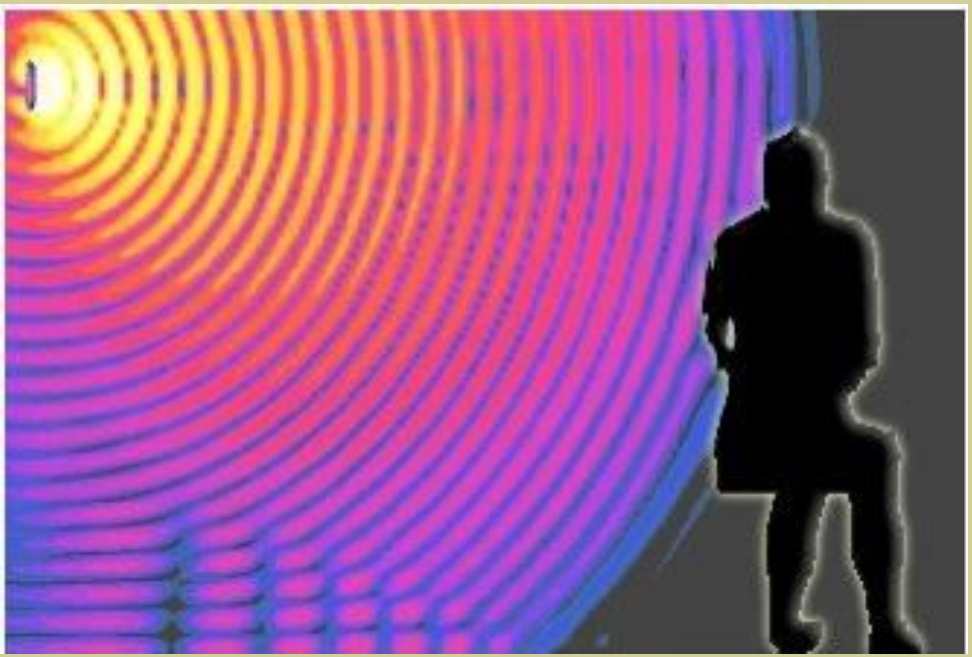
in which γ_{pw} is the plane-wave reflection coefficient for the H_t field

$$\gamma_{\mathrm{pw}} = \frac{2\left|\sqrt{\varepsilon'}\right|}{\left|\sqrt{\varepsilon'} + \sqrt{\varepsilon_0}\right|} - 1 \qquad (2)$$

- SAR ~ H^2(tangential to tissue)
- Far-field sources: SAR ~ H^2 ~ P_{rad}/d^2
- Near-field sources: SAR ~ H^2 ~ j^2/d^2 (design dependent)

Localized versus Whole-Body Exposure



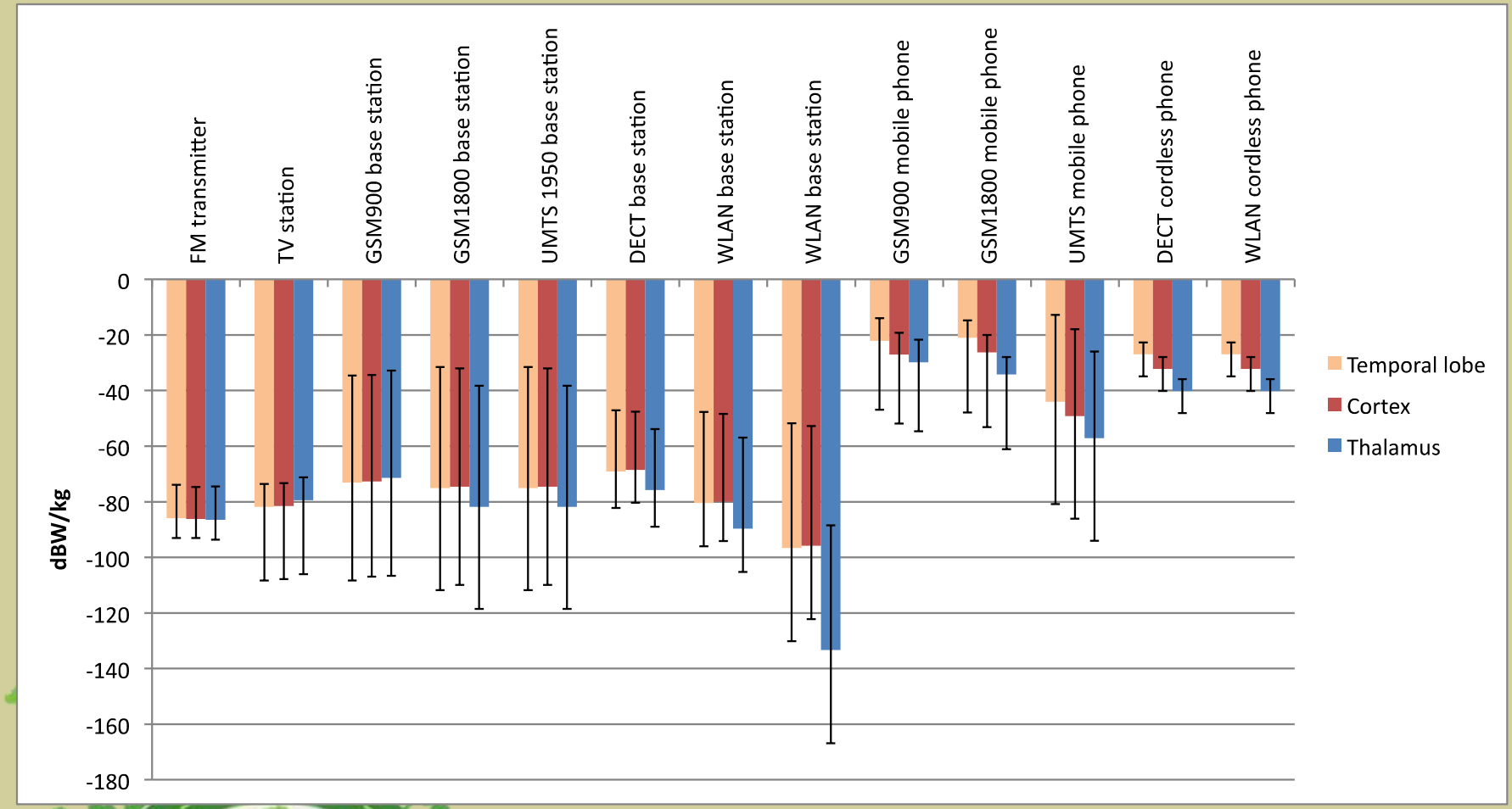


Power Required to Induce 2 W/kg (@1900 MHz)

- P = 0.075 W at 0.01m
- P > 600 W at 1m
- P > 6 MW at 100m

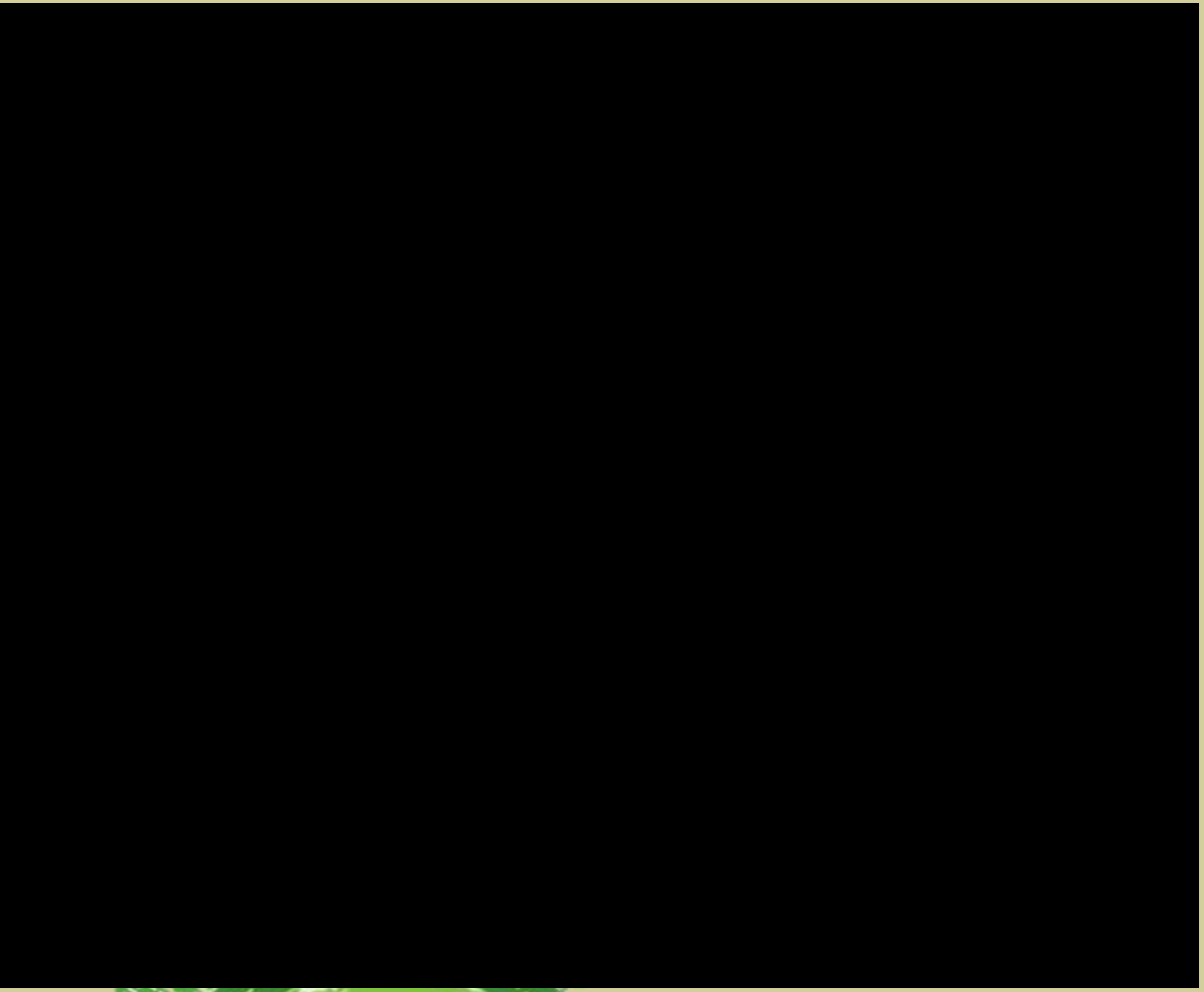
- Body mounted devices are the highest source of exposure
- Cumulative exposure:
  - $t * P_{avg} * SAR_{max} / P_{max}$
  - P_{avg} = f (power control)
- Power control level is system network and OTA performance dependent
  - P_{avg} / P_{max} (2G) ≈ 0.3
  - P_{avg} / P_{max} (3G/4G) ≈ 0.005

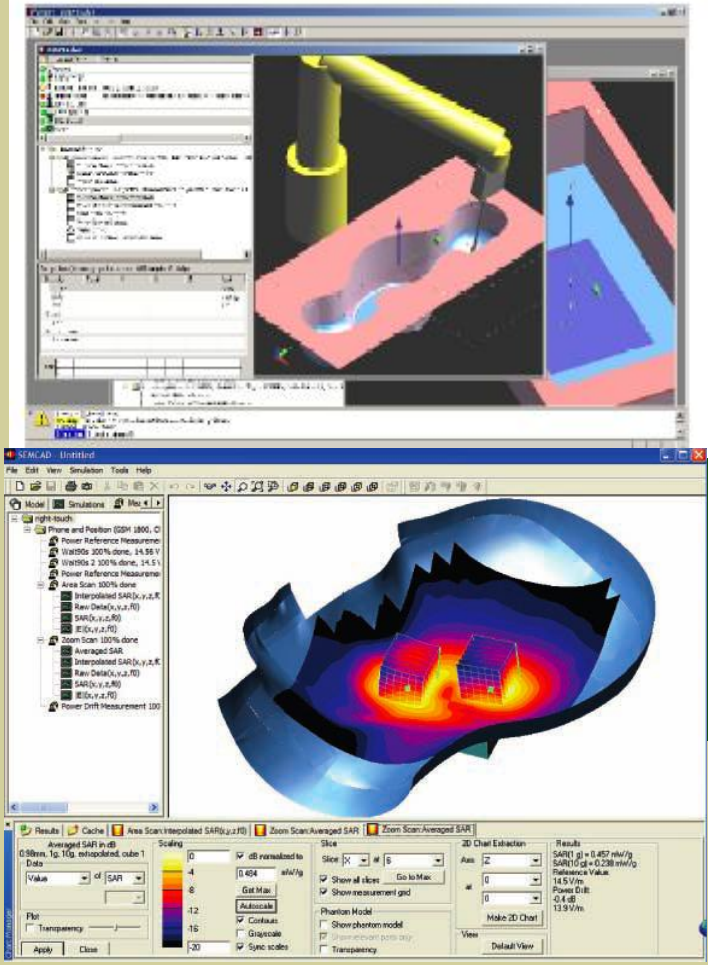
Cumulative CNS Exposure



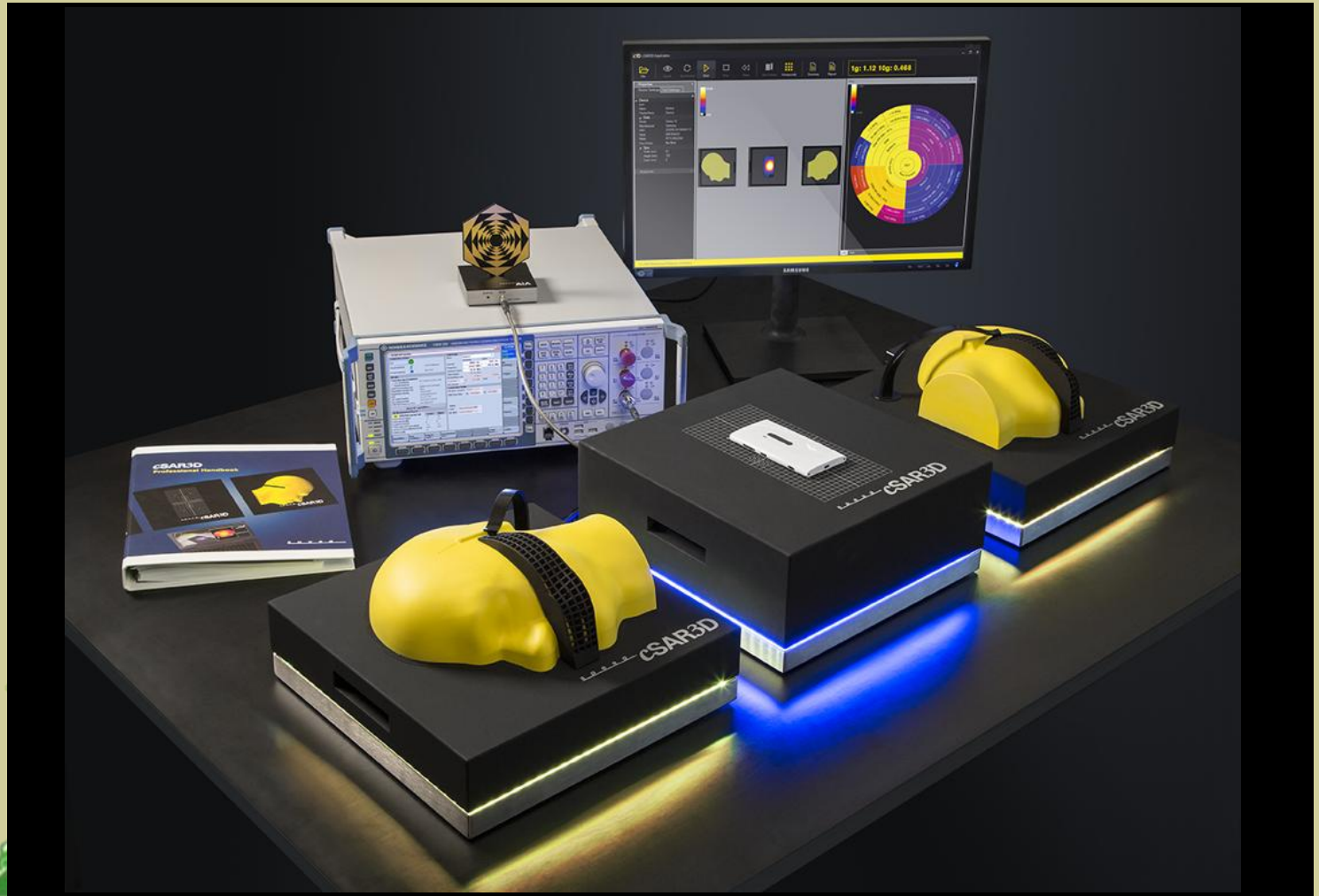
Optimization of SAR_{max} / P_{max}

Compliance Testing of SAR_{max} (Standard Technoloy)





Compliance Testing of SAR_{max} (Novel Technoloy)



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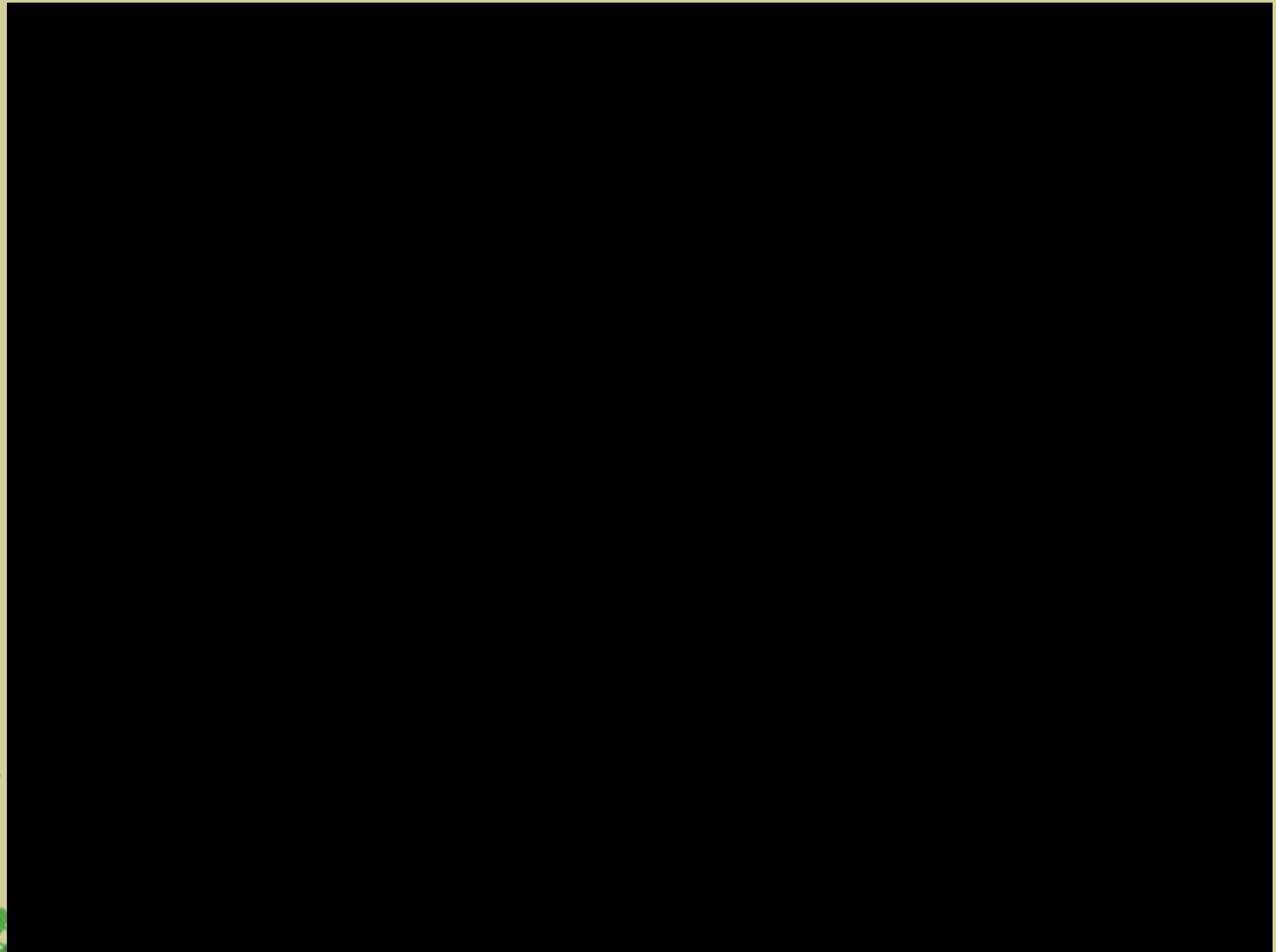


Design Measures to Minimize SAR_{max}

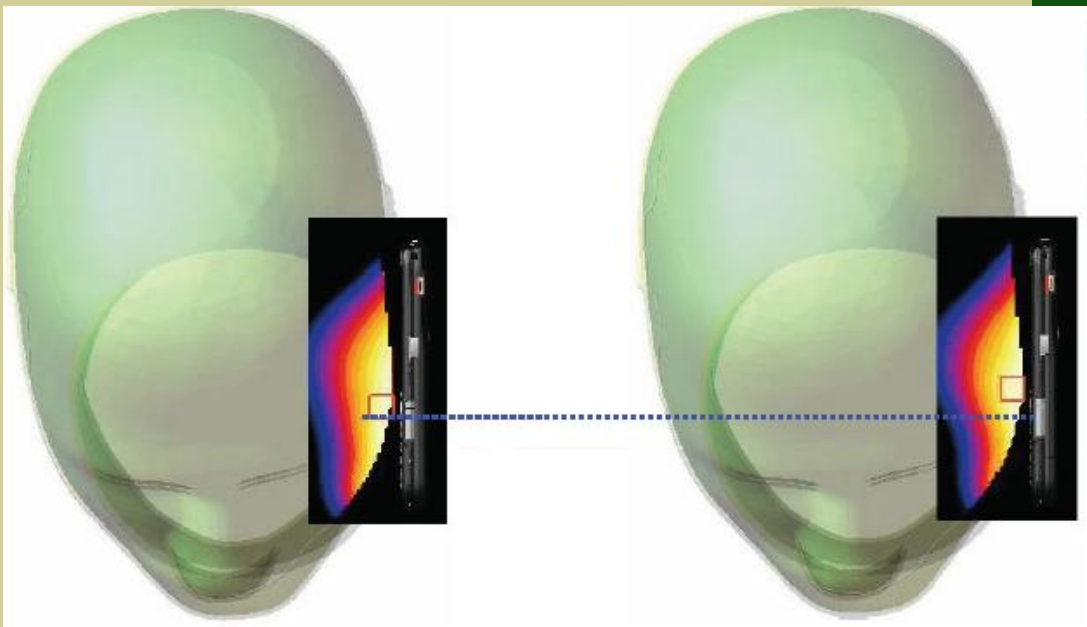
$$\mathrm{SAR} = \frac{\sigma}{\rho} \frac{\mu\omega}{\rho\sqrt{\sigma^2 + \varepsilon^2\omega^2}} (1 + c_{\mathrm{corr}}\gamma_{\mathrm{pw}})^2 H_{t_{\mathrm{inc}}}^2 \qquad (1)$$

in which γ_{pw} is the plane-wave reflection coefficient for the H_t field

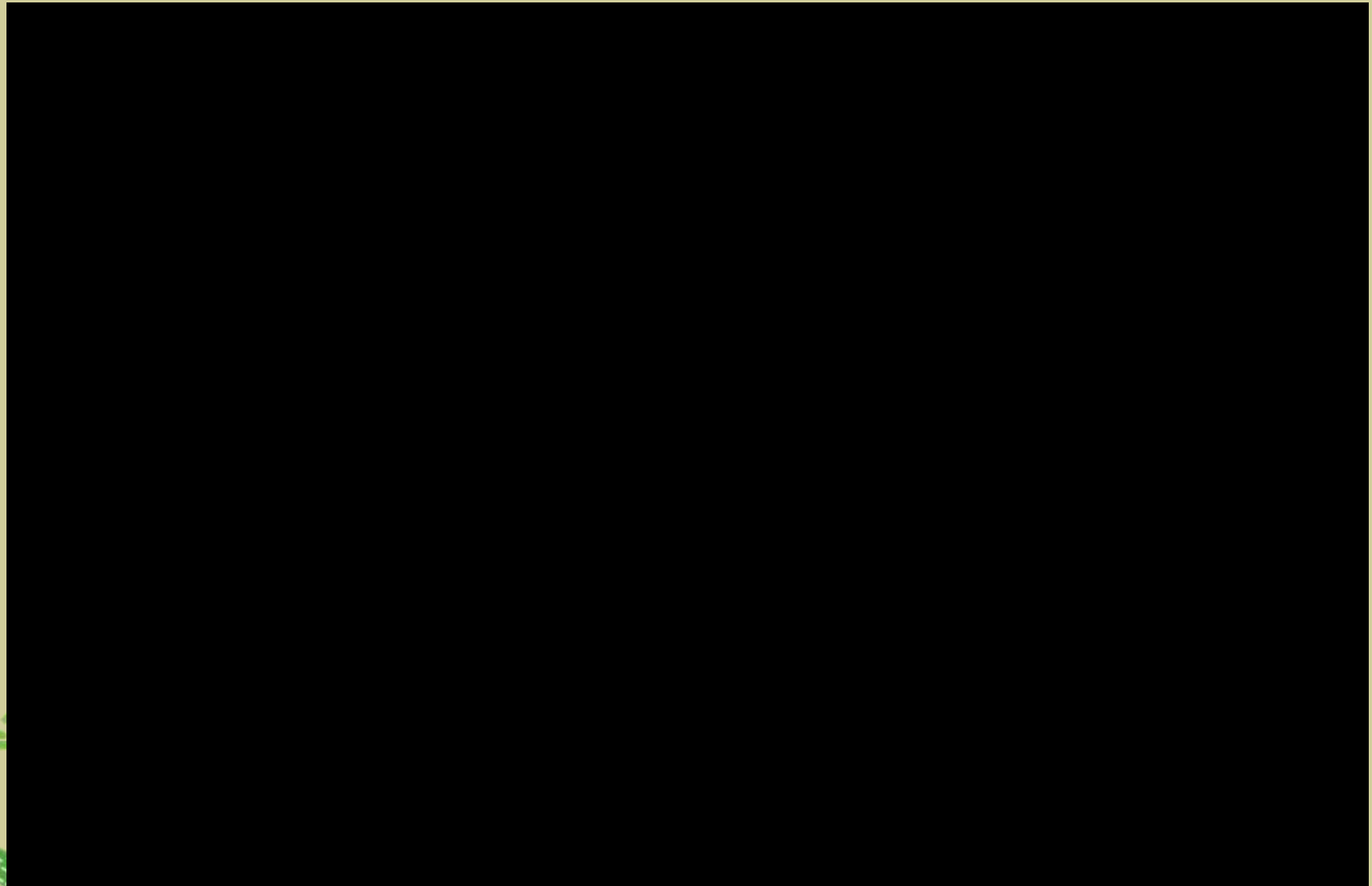
$$\gamma_{\mathrm{pw}} = \frac{2\left|\sqrt{\varepsilon'}\right|}{\left|\sqrt{\varepsilon'} + \sqrt{\varepsilon_0}\right|} - 1 \qquad (2)$$

- Near-field sources: SAR ~ j^2/d^2
  - larger distance between currents and tissue (e.g., new concepts)
  - uni-directional antennas (away from body)
  - high impedance antenna
- Exposure reduction: factor of 10

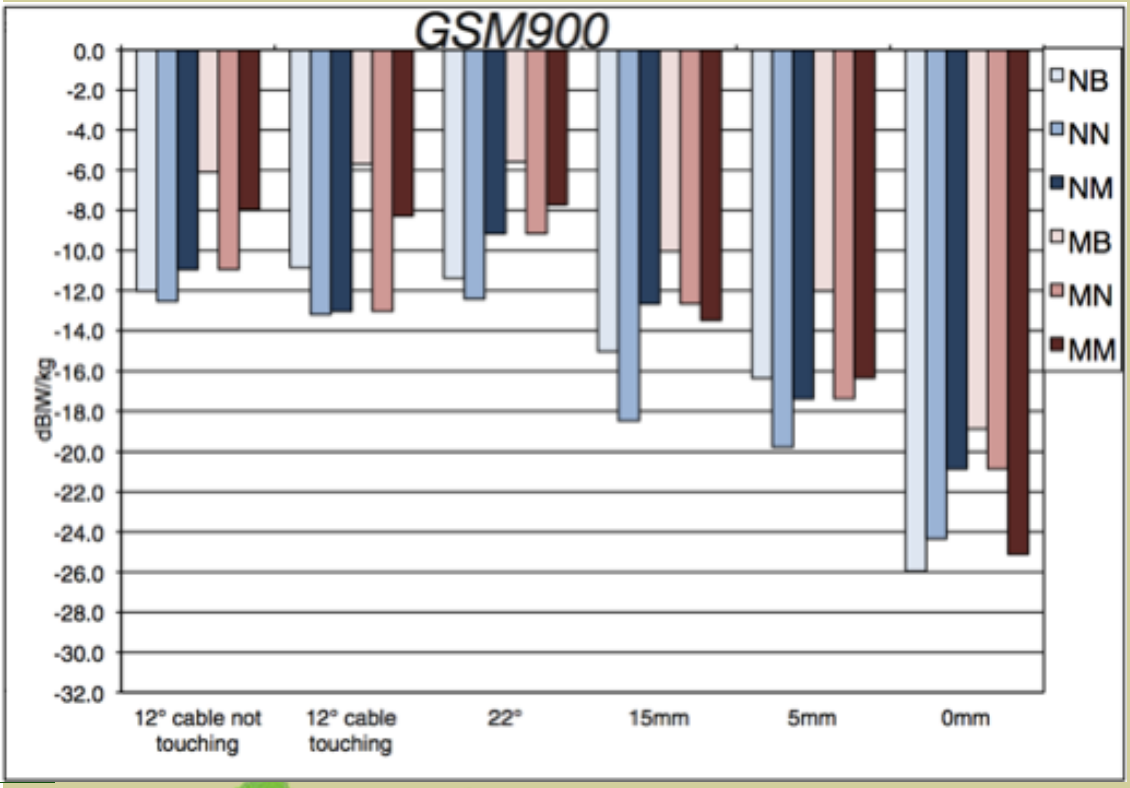
Consequences of Interaction Mechanism

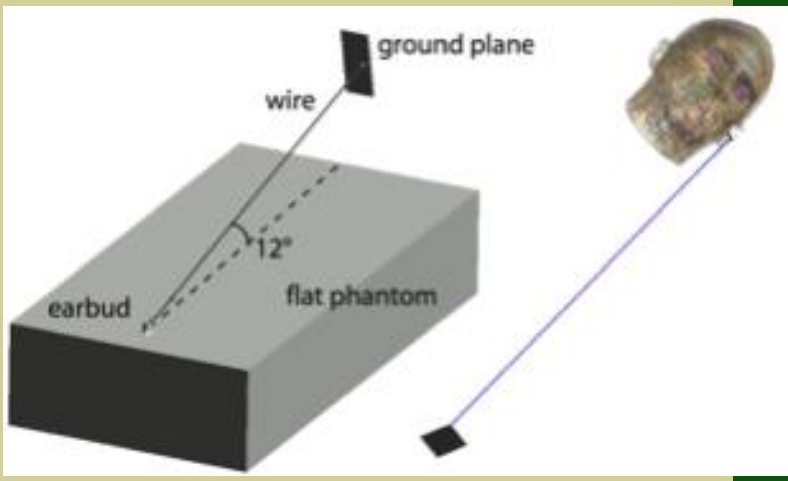


Adult vs Child Exposures



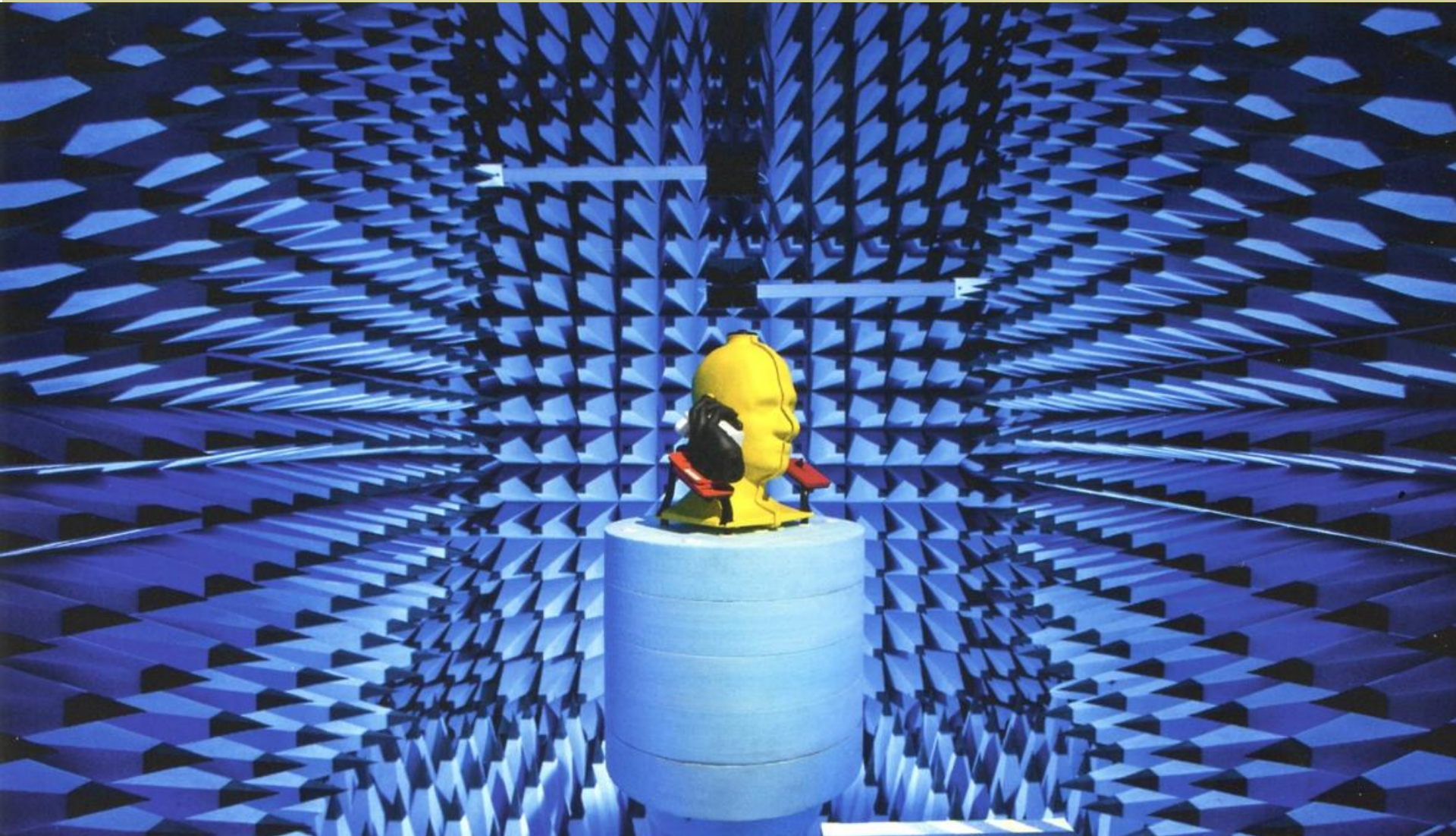
Other Measures: Hand Free Kit





Optimization of P_{avg}

Over-the-Air Performance

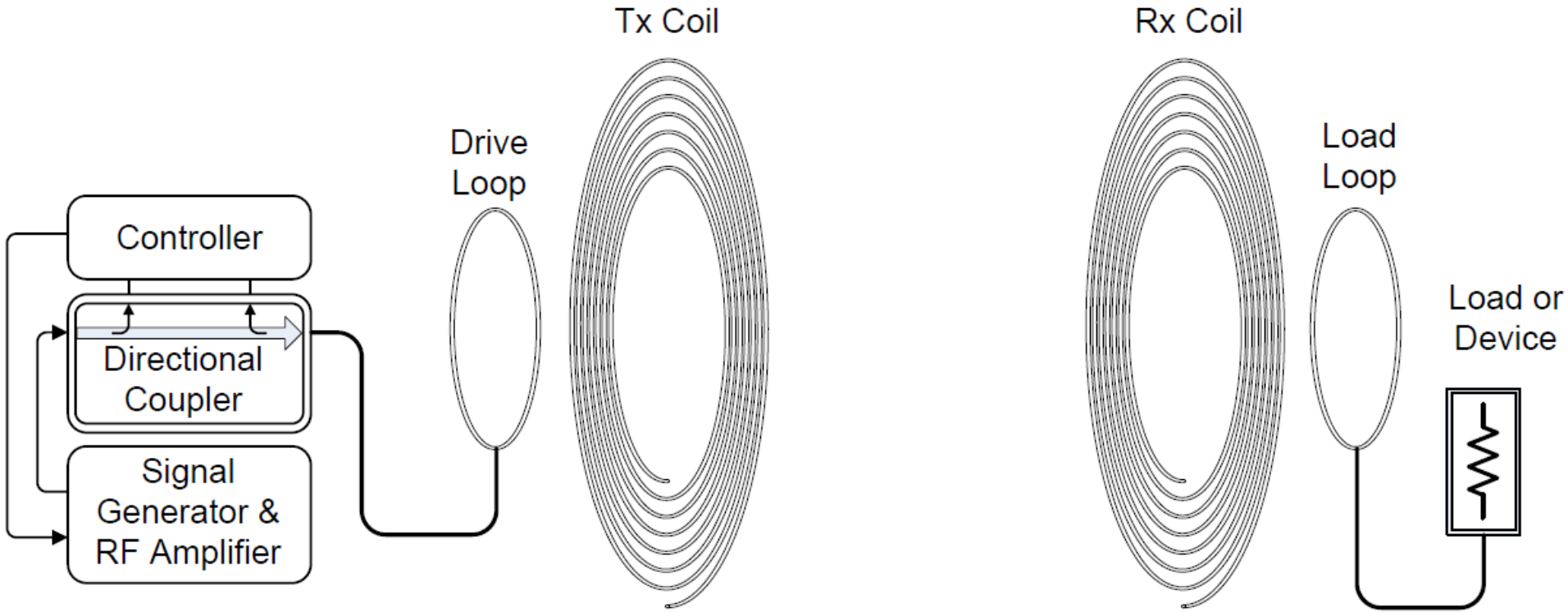


Optimization of P_{avg}

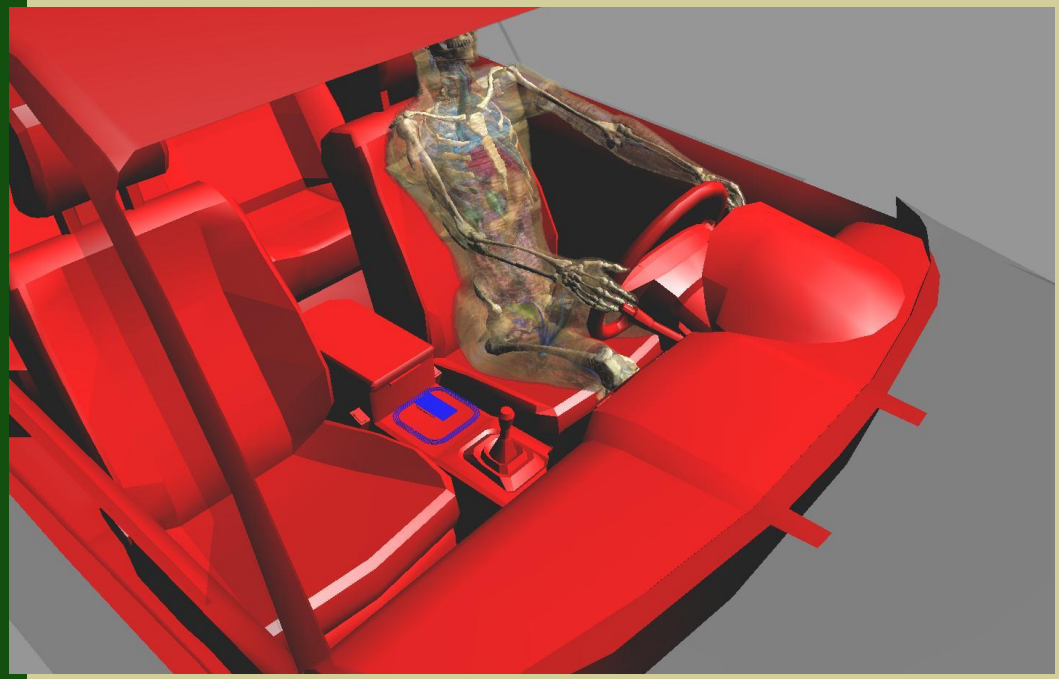
- System-specific
  - power per bit (2G: >4000 nJ; 3G: 650 nJ; 4G: 31 nJ)
  - effective handover (2G vs 3/4G)
- Base station-specific
  - distance to base station: ~ d^2
  - efficiency of base stations
- Device-specific
  - high over-the-air performance: P_{rad}/P_{abs}
- Optimization
  - dense base station network (micro cells)
  - modern effective communication systems
  - effective OTA performances of base stations and personal devices
- Exposure reduction: >>100

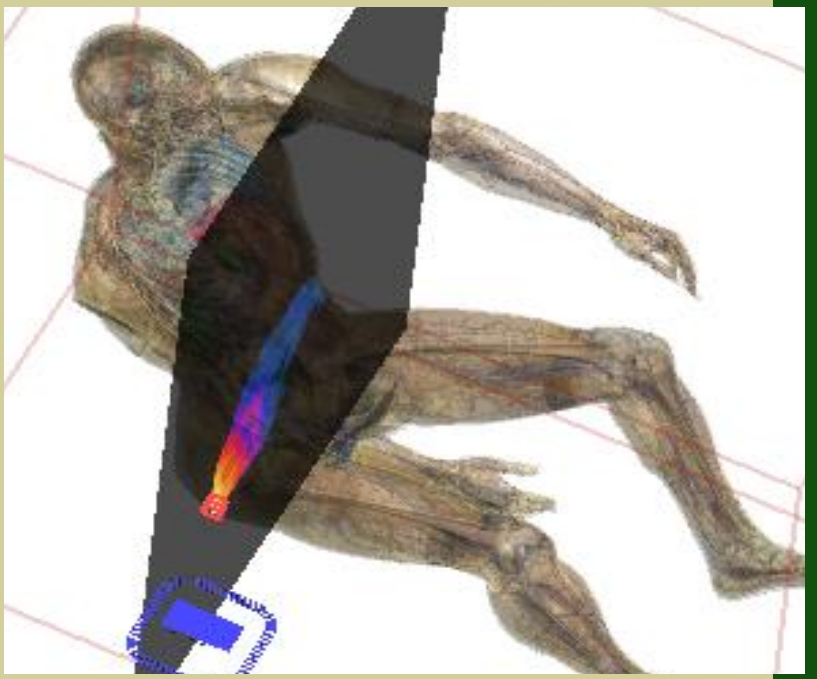
Other Source: Wireless Power Transfer

- f = 0.1 - 10 MHz



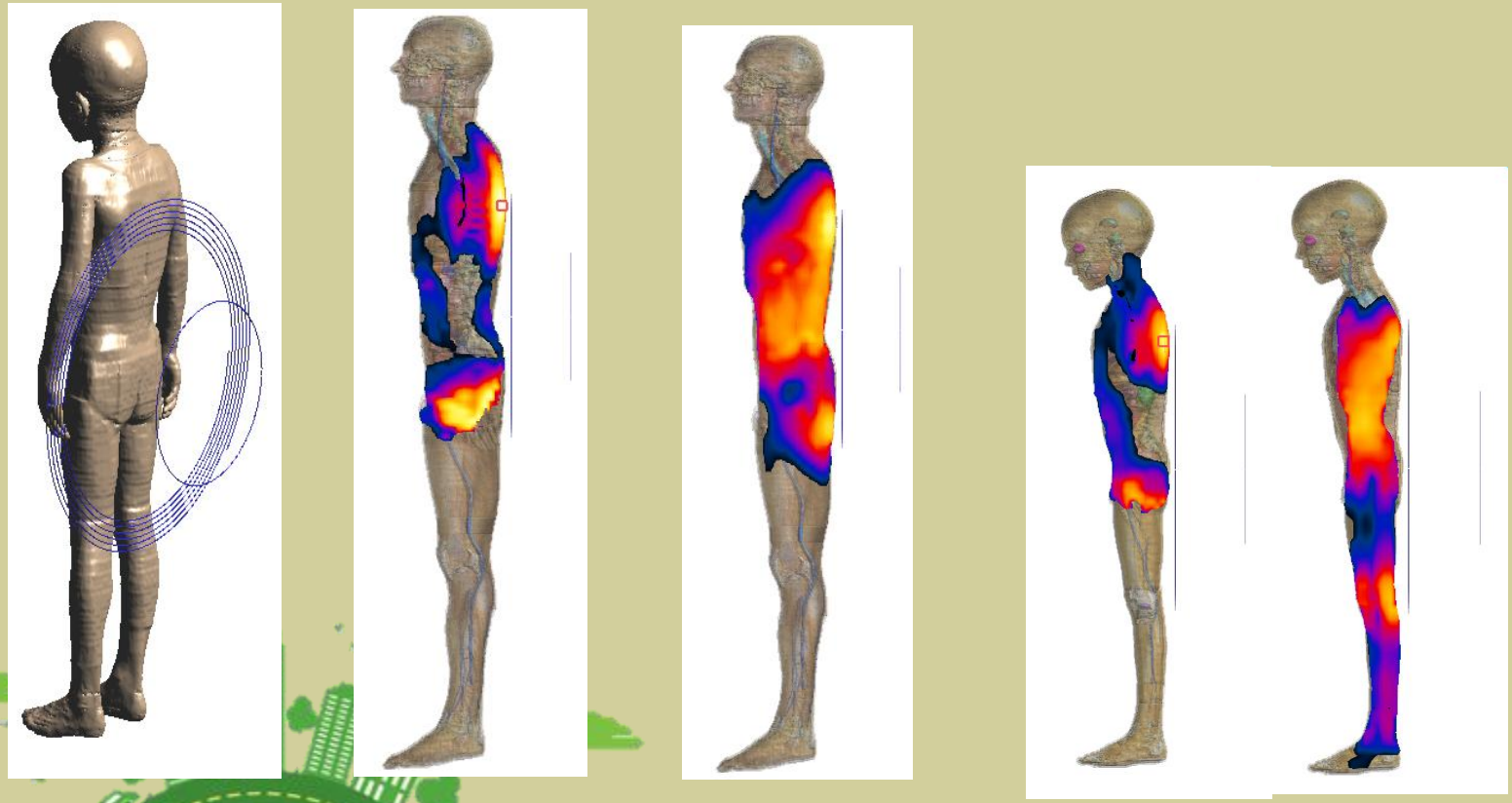
Tray Charging Systems





psSAR10g Distribution for Large Volume WPS

750mm off sagittal plane 750mm off



Exposure by Automotive WPS

- Highest exposures for children when close to the car
- Highest exposure when below the care, e.g., repair
- Exceed basic restrictions by >10dB

Exposure Minimization of WPS

- Switch off when not charging
- Switch off when human are within the strong reactive fields

Optimization of Safety & Energy

Optimization of Energy

- Broadcasting over a wide area is on old practice going back to the origin of cell telephony (antediluvian technology)
- Ideally, the RF link should be a narrow electromagnetic beam
- Needed a dense network of micro base stations
- Benefits: no interference, minimum power and exposure, no stealing of information off the air
- Feasible using 100's GHz bands (filled with current technology in sparsely populated environments)

Optimization of Energy

- RF energy is an excellent tool to increase road safety, increase vehicular energy efficiency and decrease air pollution due to traffic jams in and around cities
- Traffic jams are often caused by collision
- Vehicle-to-vehicle (V2V) communication can substantially decrease or eliminate front, side, rear-end and round corner collisions.
- Collision avoidance technology is currently planned or installed in high end vehicles which, however, is not able to avoid round the corner collisions.

Optimization of Energy

- A vehicle to infrastructure (V2I) communication system (smarter than the driver) can be used to redirect vehicles away from traffic hold ups
- Avoiding traffic jams will increase the efficiency of vehicles and decrease air pollution near and in the cities
- Driverless car is not too far into the future
- Benefits: fewer accidents and less air pollution, car sharing, fewer cars on the road

Solutions to Prevent Talking & Texting While Driving

- ~ 30% of road accidents attributed to usage of wireless communication devices
- Although banned in most countries, law enforcements could not prevent wide usage
- Need to be prevented by means of proper standards

Solutions to Prevent Talking & Texting While Driving

- Location of the phone within the car space can be detected by simple receiver technology or other means
- If car speed > 20 km/h is detected by base station and the phone is within the drivers space, call shall be rejected
- Requires appropriate standard by phone and car manufacturers

Energy Optimization

- Most charger technology have the transformer connected to the AC, even though the charging has been completed
- Switch the charger from the AC supply when charging is completed
- Most lights are still timed on the basis of expected traffic loads rather than real traffic present
- Usage of mobile devices locations to optimize traffic flow by light signaling (number, speed, etc.; similar to information available to google)

Conclusions

- EMF RF exposure is dominated by near-field sources
- Minimization of maximum exposure by optimization of near-field devices
  - increased distance to the body
  - reduced H-field close to the body (radiation outwards, high impedance antennas)
  - reduction potential: factor of 10
- Minimization of cumulative exposure by optimizing the network
  - micro cell network
  - communication technology offering lowest power per bit
  - effective handover
  - optimized over-the-air performance
  - reduction potential: >>100
- Overall optimization potential with appropriate standards: >>1000

Conclusions

- Reduction of exposure and energy consumption of charging systems
  - switch off the AC supply when not charging
  - switch off WPS when humans are within the reactive near-field WPS
  - development of specific standard
- Largely reduced casualties by preventing improper usage of wireless communication devices
  - automatic call rejection when used in driver site while the car moves >20km
  - development of specific standard and improved technology
- Reduced traffic pollution
  - control of traffic lights and signaling based on the location information of phones
  - development of specific standard

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Thank you