

Ytterjärna, den 12 oktober 2019

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# 5G-Teknik & Riskhantering



Forskare, fil.dr Mikko Ahonen



# Bakgrund, Mikko Ahonen:

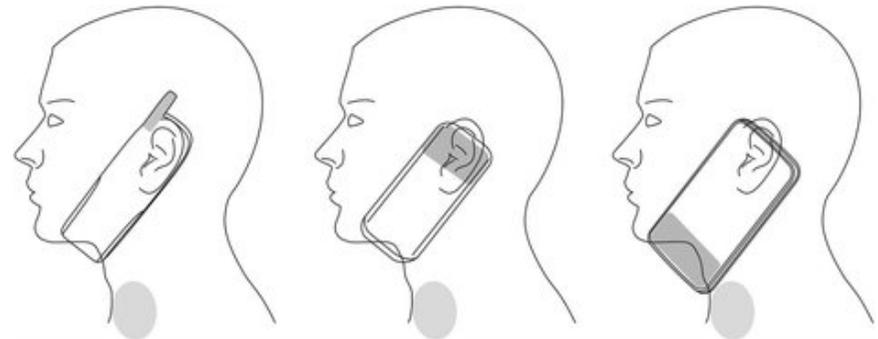
- Riskhantering & bioelectromagnetics forskning 2008-2019
- Tidigare: Forskare (PhD) i Tammerfors universitetet över 25 år. Också i TeliaSonera och i Mittuniversitetet. Bor i Sundsvall.
- Ansvarig för RF/ELF-mätningar & dosimetri



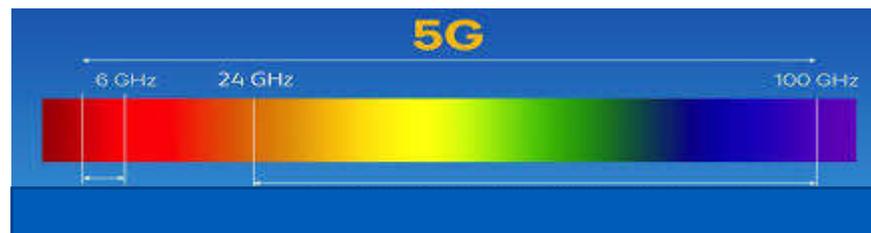
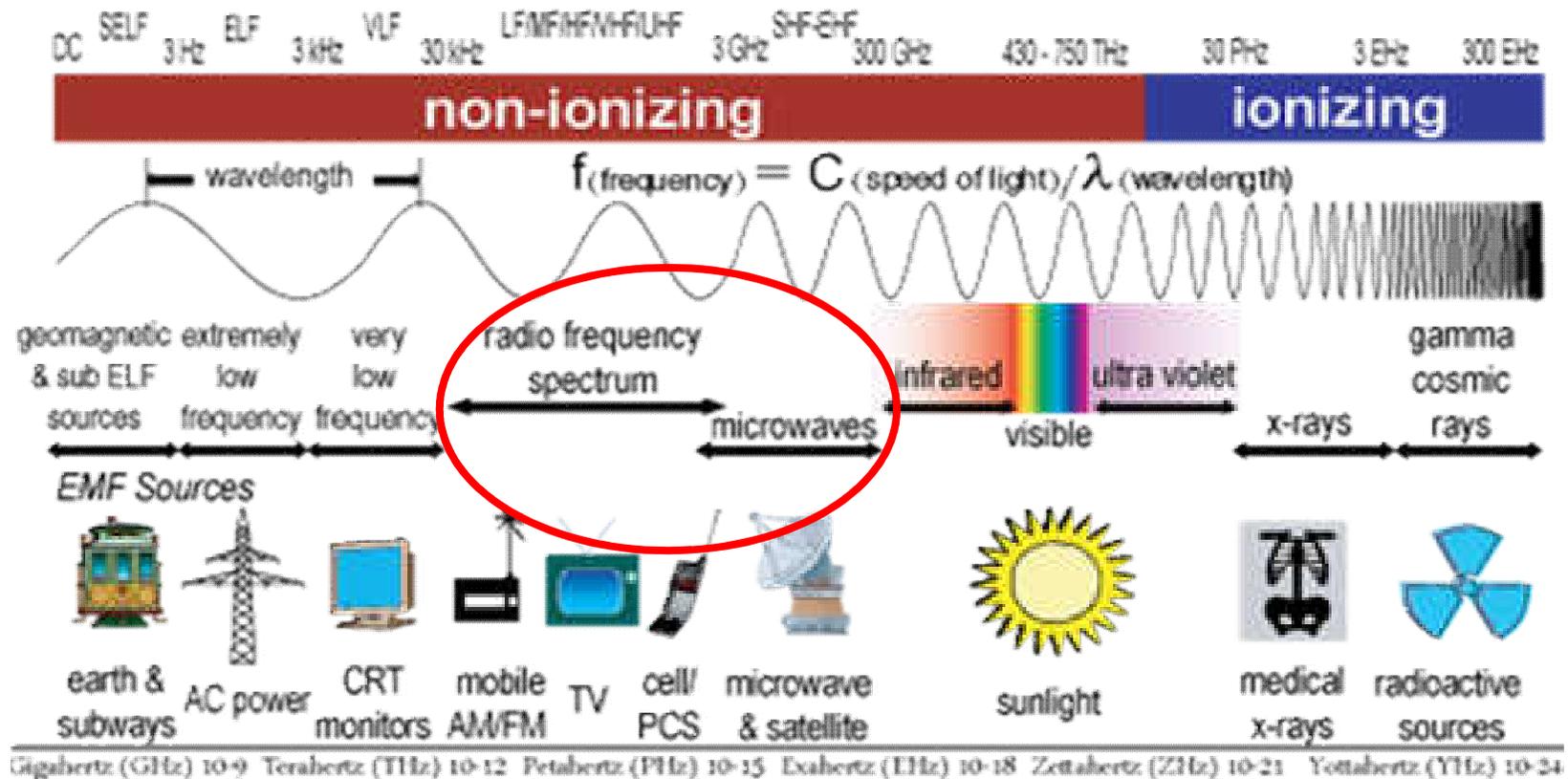
Hardell, L., Koppel, T., Carlberg, M., Ahonen, M., & Hedendahl, L. (2016). **Radiofrequency radiation at Stockholm Central Railway Station in Sweden and some medical aspects on public exposure to RF fields.** *International Journal of Oncology*, 49(4), 1315–1324.  
<https://www.ncbi.nlm.nih.gov/pubmed/27633090>

Carlberg, M., Hedendahl, L., Ahonen, M., Koppel, T., & Hardell, L. (2016). **Increasing incidence of thyroid cancer in the Nordic countries with main focus on Swedish data.** *BMC Cancer*, 16, 426.

<https://www.ncbi.nlm.nih.gov/pubmed/27388603>

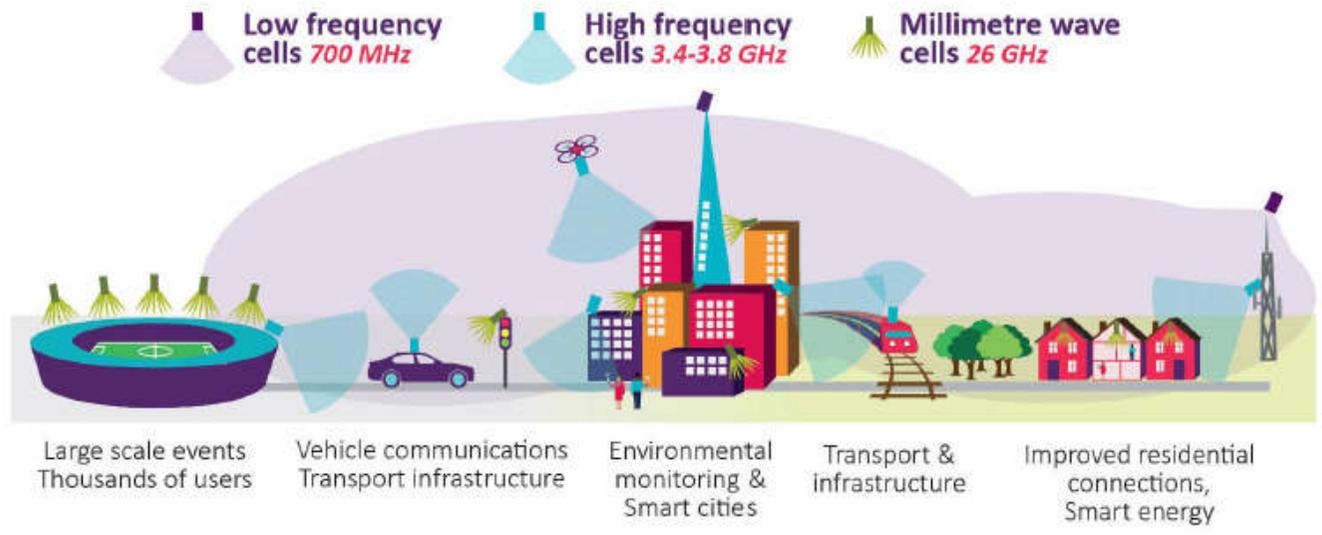


# THE ELECTROMAGNETIC SPECTRUM



# Radiovågor, frekvensdelning, Sverige

380 MHz	Raket (TETRA)
<b><u>700 MHz</u></b>	<b>5G</b>
800 MHz	4G
900 MHz	2G, 3G
1800 MHz	2G
1900 MHz	DECT. Bärbara telefoner
2100 MHz	3G
2600 MHz	4G
2450 + 5200 MHz	Wi-Fi
<b><u>3400-3600 MHz</u></b>	<b>5G, första installationer</b>
<b><u>26500-27500 MHz</u></b>	<b>5G (26,5-27,5 GHz, nästan millimetervågor)</b>



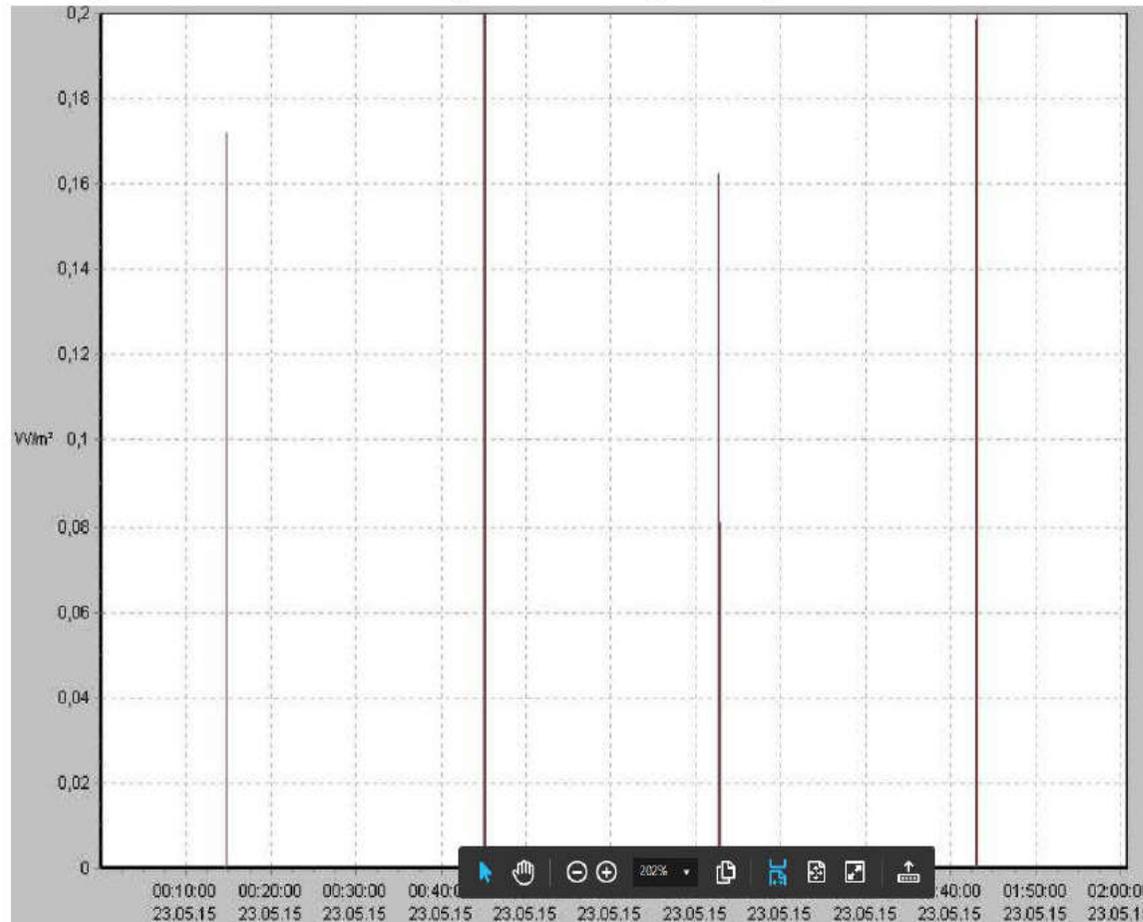
## **Först: Om era egna mobiltelefoner**

**- Demonstration med ljudanalys,  
en RF-strålningsmätare**

**( Mobildata , Wi-Fi , Bluetooth etc. )**

**Utan mobildata bara 1 gång per 30 minuter  
”berättar” mobiltelefonen läget till basstationen.**

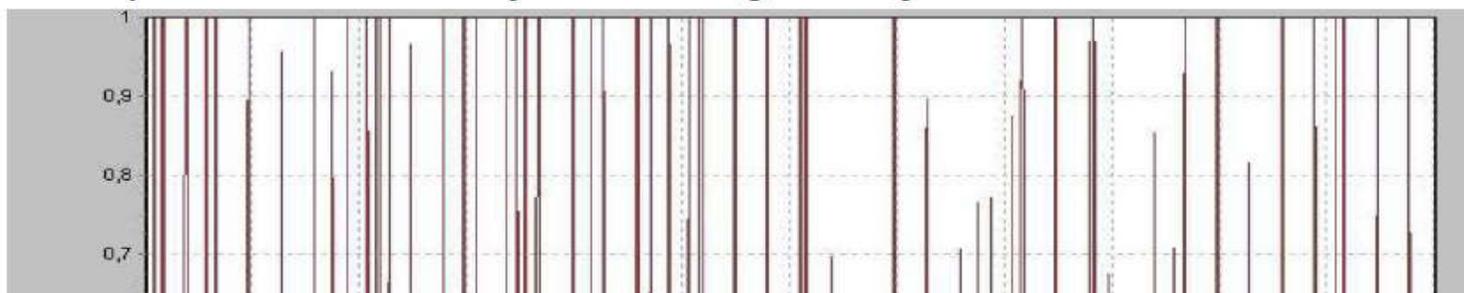
Smartphone - Mobildata Stängd/OFF → signal varje 30 minut



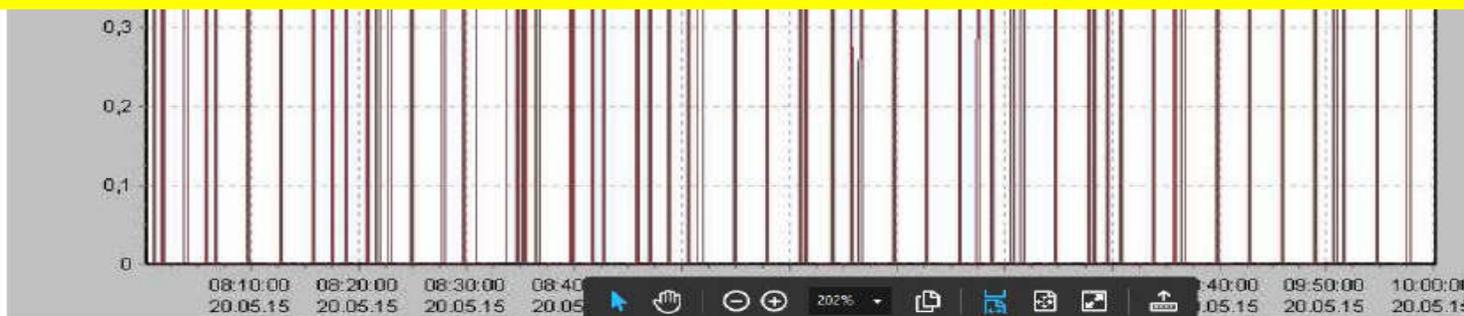
Mätningar: Ingenjör, doktor Dietrich Moldan, <http://www.drmoldan.de>

**Med mobildata + apps, belastningen (starka RF-spikar speciellt i 4G data) nästan varje sekund. Gäller också läsplattor.**

Smartphone - **Mobildata på/ON** → Signal varje 2 minut.



**Ärztchamber Wien / Wien Läkareförbund – 10 Råd :  
<https://www.aekwien.at/medizinische-handly-regeln>  
- Stäng av mobildata (&Wi-Fi)!**



**OBS! OM apps på (WhatsApp, Facebook osv), då signal nästan varje sekund!**

## Från mobiltelefons handbok:

iPhone's SAR measurement may exceed the FCC exposure guidelines for body-worn operation if positioned less than 15 mm (5/8 inch) from the body (e.g. when carrying iPhone in your pocket).

[http://www.mmfai.org/public/sarpdf/eng/3gs\\_sar.pdf](http://www.mmfai.org/public/sarpdf/eng/3gs_sar.pdf)

## Från läsplattans handbok:

always follow these instructions and precautions: Orient the device in portrait mode with the Home button at the bottom of the display, or in landscape mode with the cellular antenna (located under the black edge at the top of the device) away from your body or other objects.

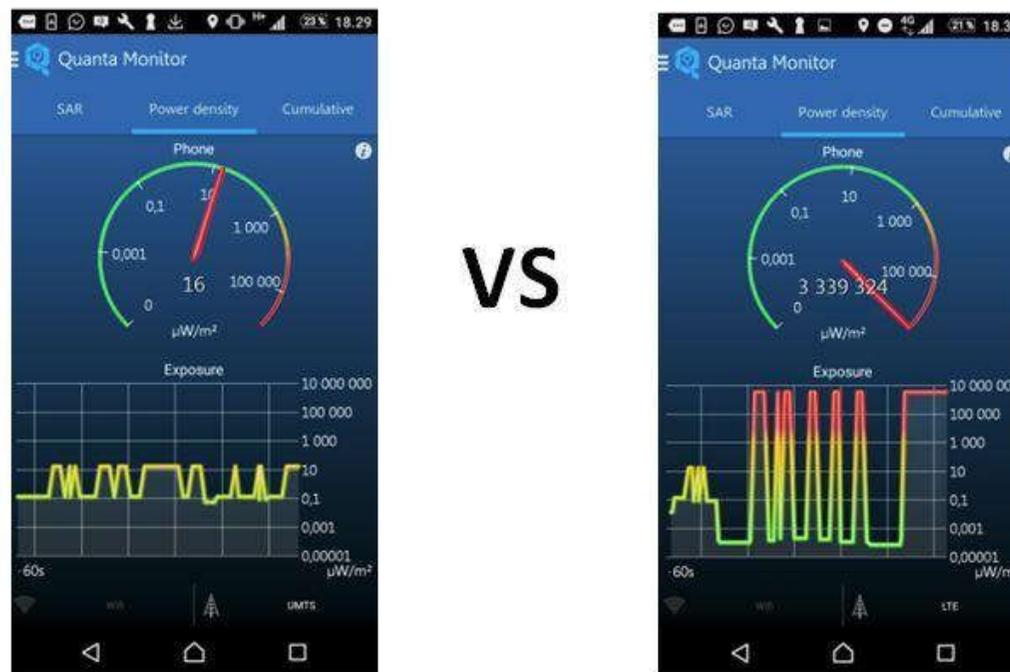
further limit your exposure by limiting the amount of time using iPad Wi-Fi + 3G in wireless mode, since time is a factor in how much exposure a person receives, and by placing more distance between your body and iPad Wi-Fi + 3G, since exposure level drops off dramatically with distance.

[http://manuals.info.apple.com/en\\_US/iPad\\_iOS4\\_Important\\_Product\\_Info.pdf](http://manuals.info.apple.com/en_US/iPad_iOS4_Important_Product_Info.pdf)

**Fortfarande har man bättre täckning med 3G (UMTS) +  
RF-strålningsnivåer är (mycket) lägre än med 4G (LTE)**

**(Gäller både mobiltelefoner och router !! )**

### **RADIATION 3G vs 4G**

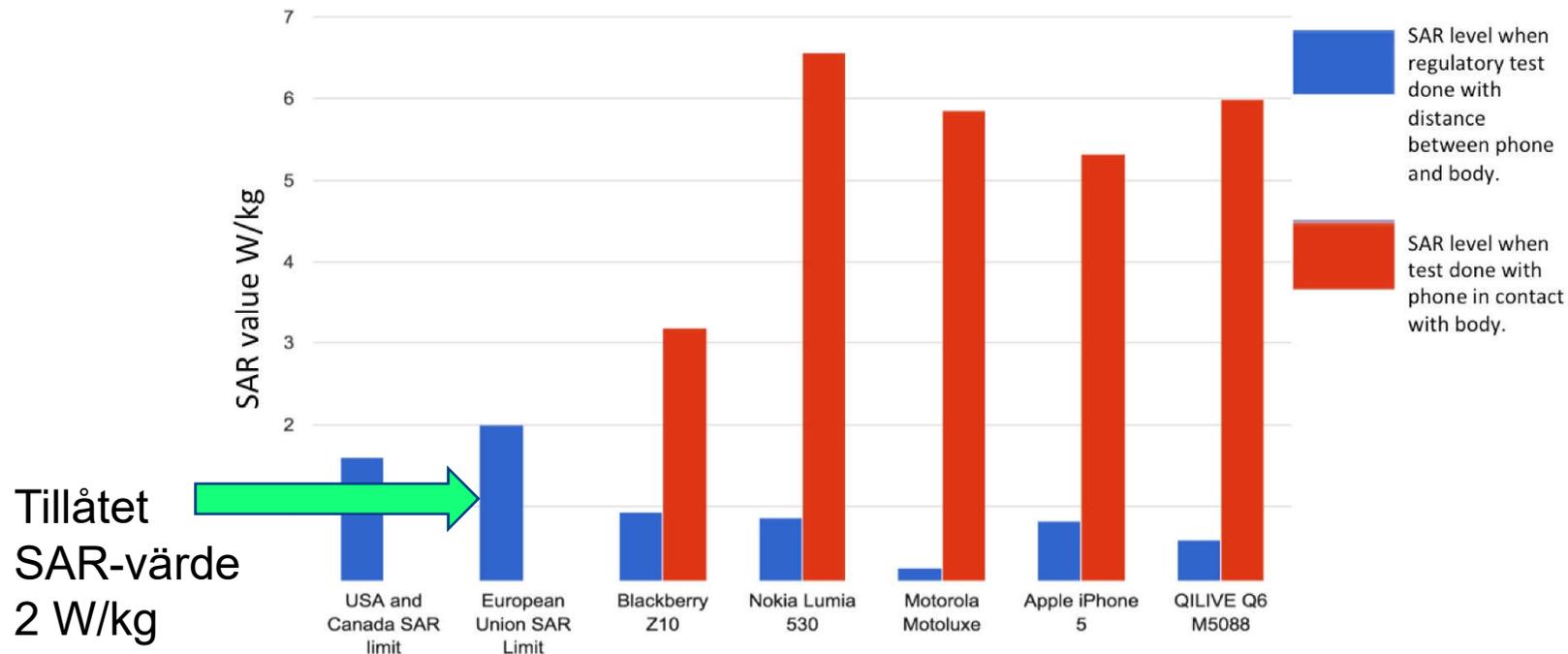


Källa: Cellraid - <http://www.cellraid.com>

# PHONEGATE – Mer allvarlig än VW DIESELGATE ?

## Cell Phone Radiation SAR Levels

Released by the French National Frequency Agency June 1, 2017



Regulatory Limits

Cell Phone Models Comparing Regulatory Compliance Tests With Tests In Direct Contact With Body

## GÄLLANDE PHONEGATE:

“Most cell phones will exceed the safety guidelines by factors of 1.6-3.7 times for the European/ICNIRP standard or **by factors as high as 11** if 1-g SAR values were to be measured as required by the U.S. FCC.

Make	MODEL	SAR at Mfr. Suggested Distance D	SAR (5mm)	SAR (0mm)	Percent increase in SAR for	
					From D to 0mm	From 5 to 0mm
POLAROID	PRO 881A	1.05 (15 mm)	3.63	7.42	13.90%	15.40%
HTC	ONE SV	0.366 (15 mm)	2.256	7.183	22.00%	26.10%
BLACKBERRY	Z 10	0.934 (15 mm)	3.18	6.8	14.20%	16.40%
MOTOROLA	MOTOLUXE	0.254 (25 mm)	2.96	5.86	13.40%	14.60%
ORANGE	NEVA 80 (ZTE BLADE V770)	1.39 (15 mm)	3.62	5.79	10.00%	9.90%
HUAWEI	P9 (EVA-L09)	1.32 (15 mm)	3.18	5.6	10.10%	12.00%
MOTOROLA	RAZR I	0.507 (25mm)	2.27	5.51	10.00%	19.30%
SONY	XPERIA S CITIZY LT26I	0.748 (15 mm)	2.253	5.45	14.20%	19.30%
APPLE	iPHONE 5	0.825 (10 mm)	1.453	5.321	20.50%	29.60%
SAMSUNG	GALAXY S 5 SM-G900 F	0.545 (15 mm)	1.55	3.55	13.30%	18.00%
ECHO	NOTE	1.35 (5 mm)	1.35	4.15	25.20%	25.20%
APPLE	iPHONE 5C	1.11 (5 mm)	1.11	3.11	22.90%	22.95%
SAMSUNG	GALAXY J7 (SM-J710FN)	1.29 (5 mm)	1.29	3.56	22.50%	22.50%

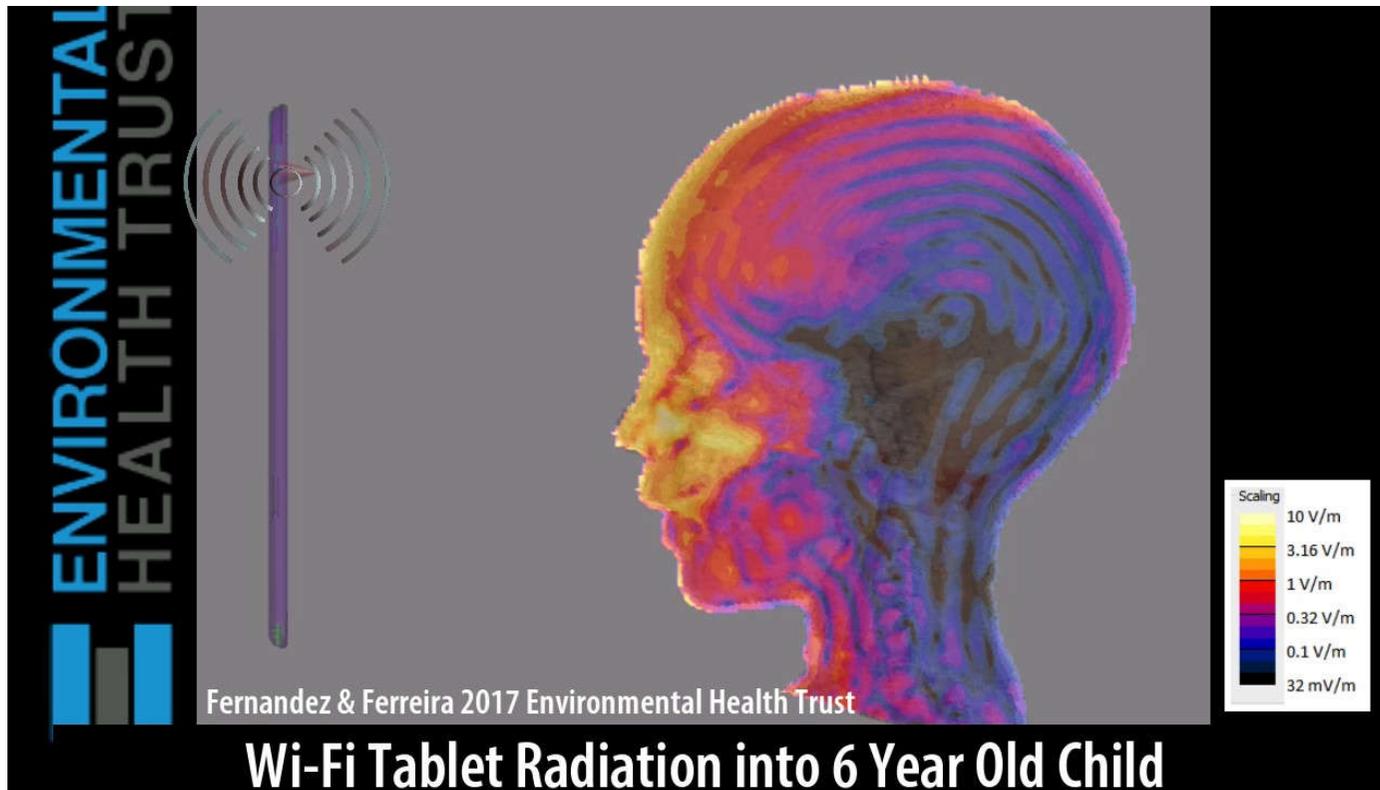
Gandhi, O. P. (2019). **Microwave Emissions From Cell Phones Exceed Safety Limits in Europe and the US When Touching the Body.** *IEEE Access*, 7, 47050–47052. <https://doi.org/10.1109/ACCESS.2019.2906017> --> **“Every millimeter counts”**



Steve Jobs och Apple Ipad

( Tack Kia & Co ! )

## Video: Tablet - Absorbering av mikrovågor (radiofrekvent strålning) till barns hufvud (& djupare till hjärnan via ögonen) → Case: Förskolor



Borges, F., de Salles, A. & Fernández-Rodríguez, C.

[“SAR simulations of EMF exposure due to tablet operation close to the user’s body.”](#)

*Microwave and Optoelectronics Conference (IMOC),  
2015 SBMO/IEEE MTT-S International. IEEE, 2015.*

Video: <https://www.youtube.com/watch?v=wMJsR79p2xg>

## IARC/WHO riskbedömning, 2011:

The WHO/International Agency for Research on Cancer (IARC) has classified radiofrequency (RF) electromagnetic fields as **possibly carcinogenic to humans (Group 2B)**, based on an increased risk for **glioma**, a malignant type of brain cancer, associated with **wireless phone use**.

[http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208\\_E.pdf](http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf)



*(Riskbedömning gäller alla RF-sändare. Samverkan? Total belastning?)*

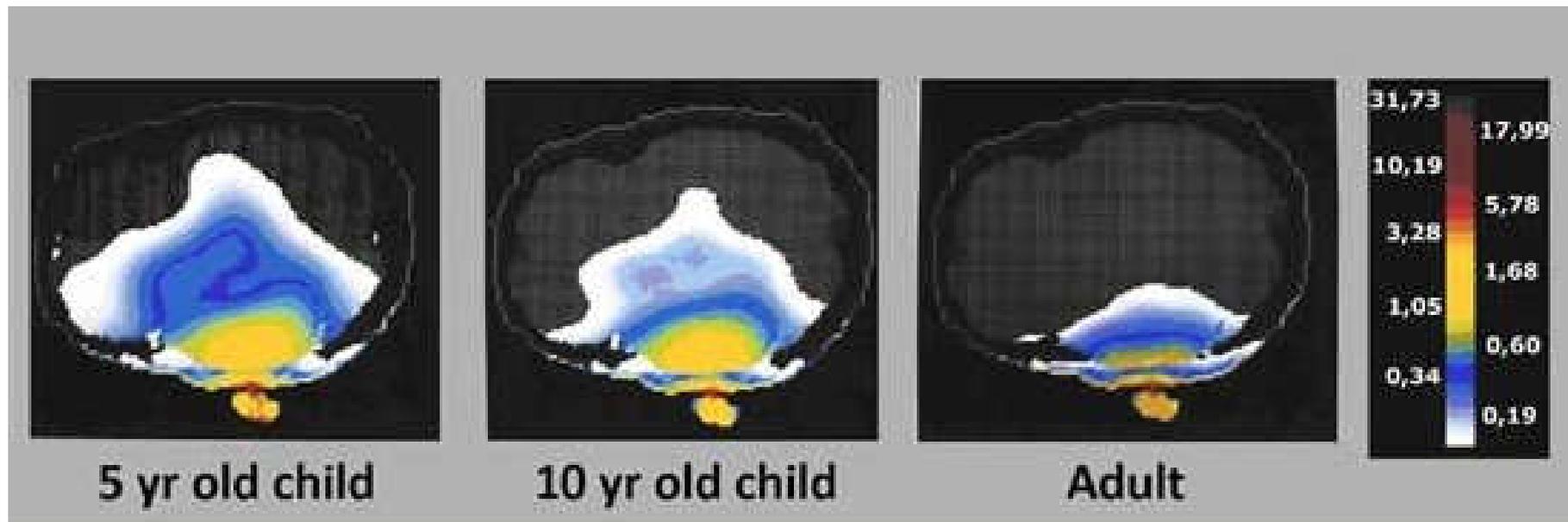
*Efter 2011 bevis att höja riskbedömning: <https://www.ncbi.nlm.nih.gov/pubmed/30196934,28401165>*



# Fysiologiska skillnader: Barn vs. Vuxen

## (Case: Hur mikrovågor absorberas i huvudet, 835 MHz)

Gandhi *et al.* (1996) , också Wiart *et al.* (2008), de Salles (2008)



I barns benmärg är mikrovågstrålningen 10-gånger starkare än i vuxens benmärg (Christ *et al.* (2010); Peyman & Gabriel (2010)) Om 5G vet vi inte (tillräckligt).

Svettkörtlar i huden möjligen riktar 5G-strålningen djupare ([Betzalel \*et al.\*](#),

Varför tillverkare rekommenderar i handboken  
att behålla mobiltelefonen cirka 2 cm avstånd från huvudet/kroppen?

<http://showthefineprint.org/>

# **Om 5G mobiltelefoner/apparater**

# Världens första 5G smartphone (mod/cover) - med hälsovarning (?) gällande millimetervågor (MMW) och 26 GHz antenn.

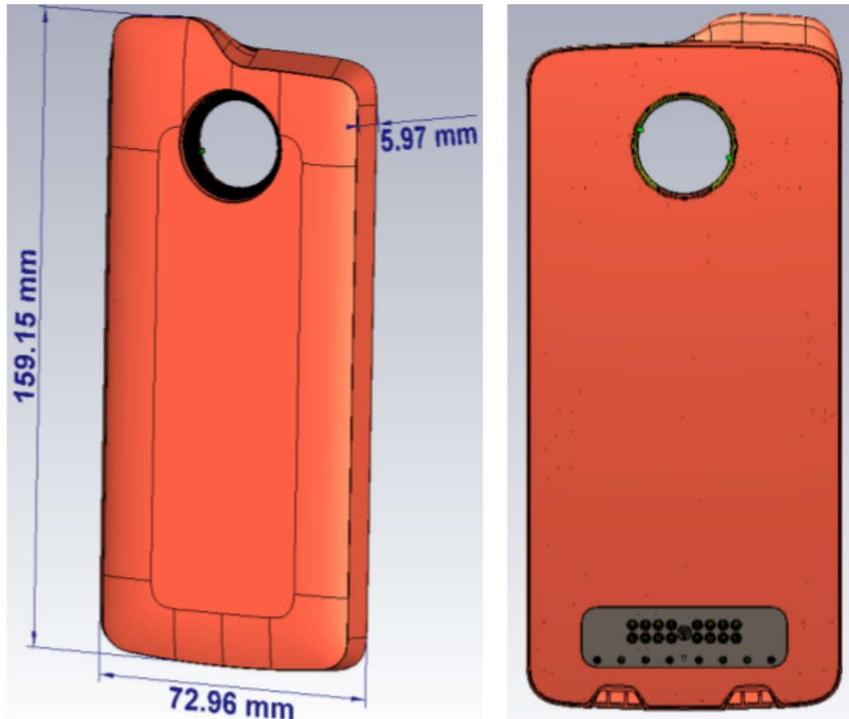


Figure 1: Exterior views of the 5G Mod

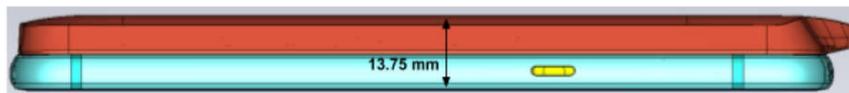


Figure 2: Edge view of the 5G Mod assembled to the host smartphone.

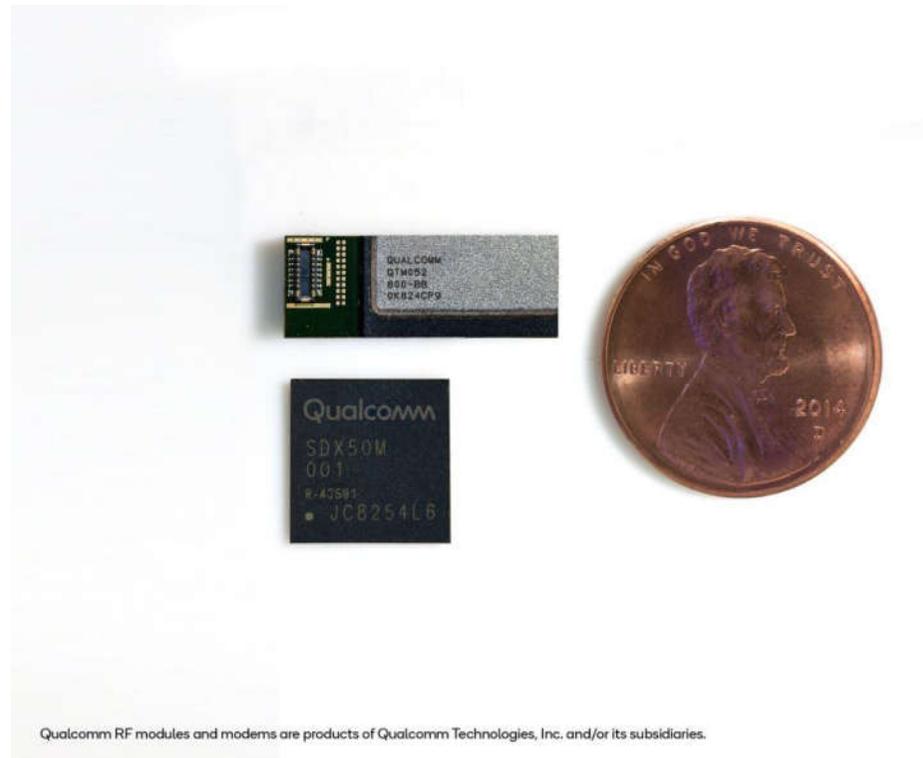
*“The control mechanism is a simple one in which, if **proximity detectors** indicate the potential presence of the user within a roughly conical region in front of the module where power density may approach the **MPE [Maximum Permissible Exposure] limit**, that module is disabled from use by the modem.*

*This terminates and prevents transmission from the module in question until the condition is cleared”*

→ Vad ska det hända, om ‘control mechanism’ inte fungerar ???

<https://www.androidauthority.com/5g-moto-mod-radiation-954955/>  
<https://fccid.io/IHDT56XL1/RF-Exposure-Info/PD-Simulation-report-0213-Appendices-4170292>

## Varje 5G mobiltelefon kommer att innehålla en stor mängd av (5G) antenn



Storlek av en "antenn array",  
mindre än en mynt

“Up to four of these modules can be integrated into a smartphone at once, giving each device a grand total of 16 antennas to work with”

## Många "antenna array" i bruk, med riktad stråle



Fig. 2. Architecture of the multi-user MIMO for 5G mobile communications.

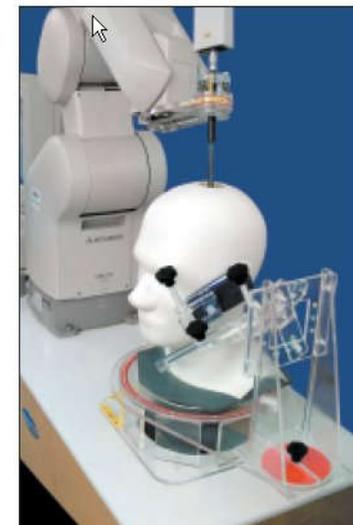
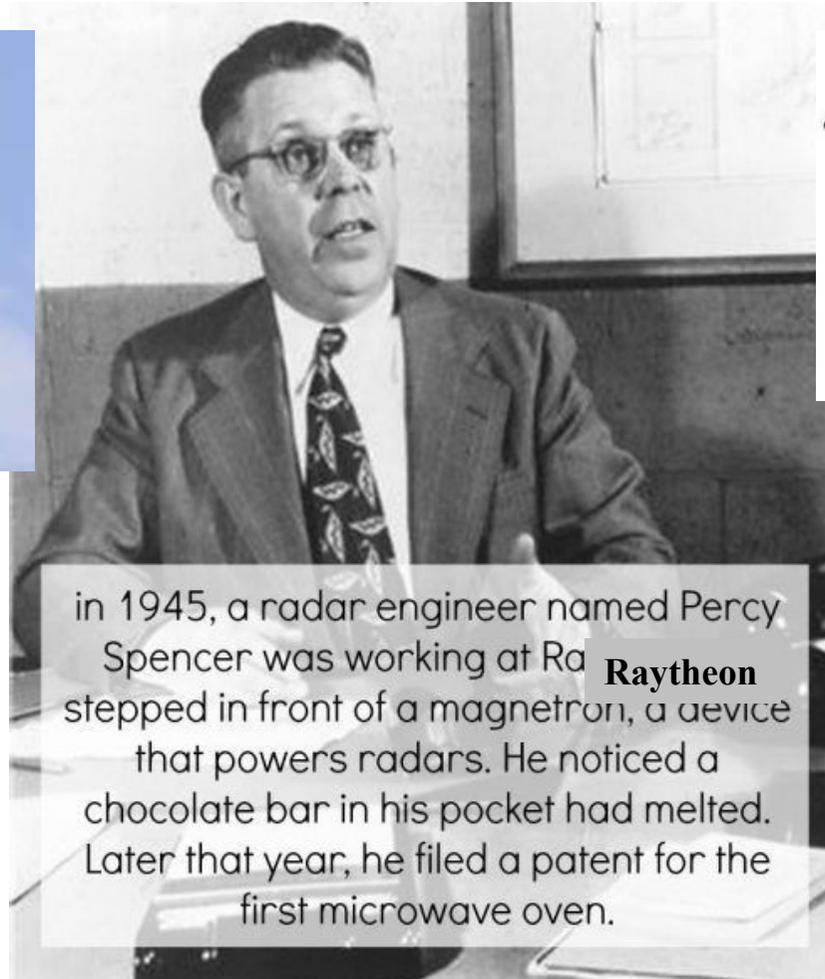
Ojaroudiparchin, N., Shen, M., & Pedersen, G. F. (2015). Multi-layer 5G mobile phone antenna for multi-user MIMO communications. *2015 23rd Telecommunications Forum Telfor (TELFOR)*, 559–562.

<https://doi.org/10.1109/telfor.2015.7377529>

# **Om radiofrekvent strålning och gränsvärde**

# Thermal dogma från 1950-talet

## - RF-Guidelines / riktlinjer baserade bara på akut uppvärming av vävnader



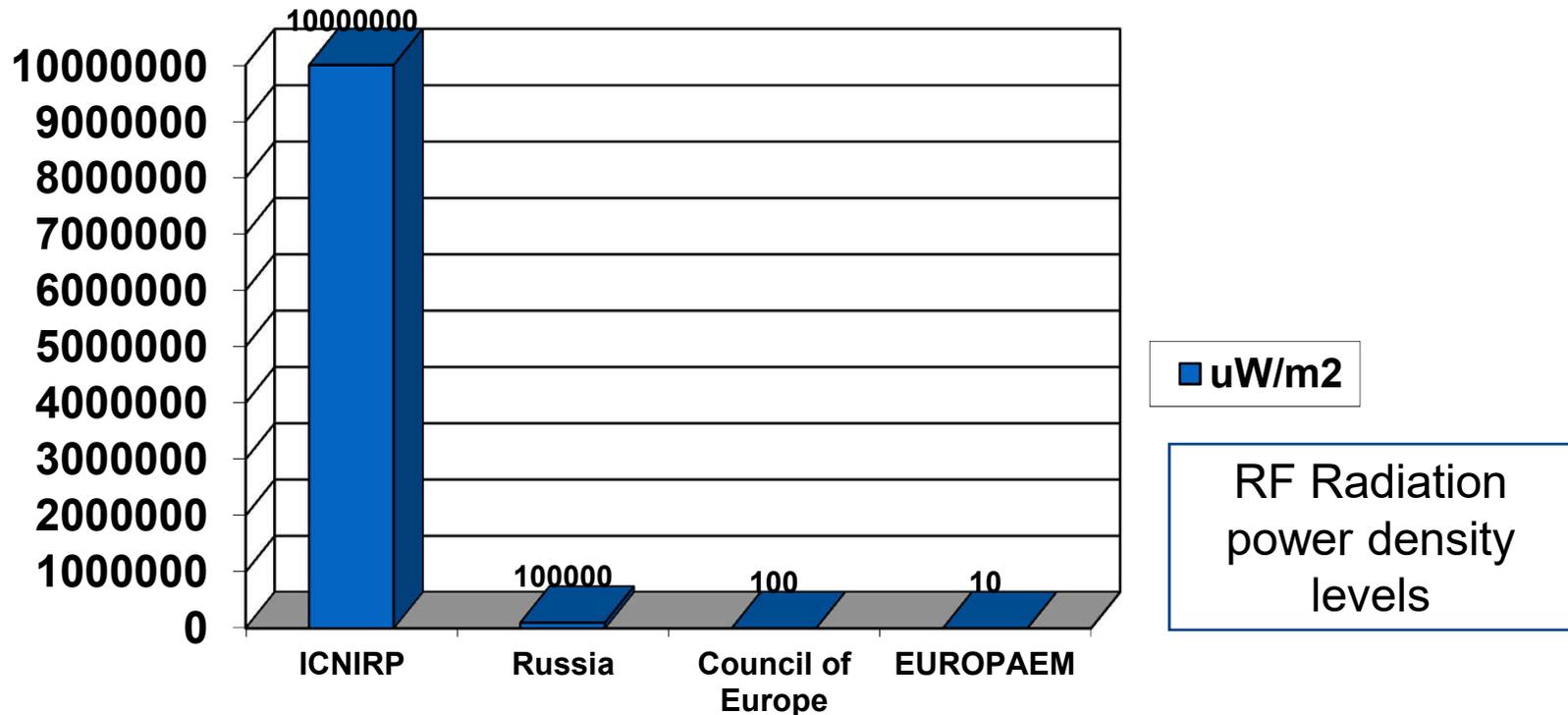
**Histori:** <https://www.slideshare.net/MAhonen/microwave-radiation-guidelines-and-debate-during-the-last-50-years>

+ Bok: **Nicholas C. Steneck – The Microwave Debate**

# Thermal-based acute (6 minutes) ICNIRP/SSM-guideline

vs.

# Biological, non-thermal 24/7 guidelines/recommendations



Please, note: ICNIRP-level is 100-1.000.000 times higher! <http://www.icnirp.de>

EMF Scientist Appeal. 200 researchers contact in 2015 the UN and require lower levels:

<http://www.emfscientist.org>

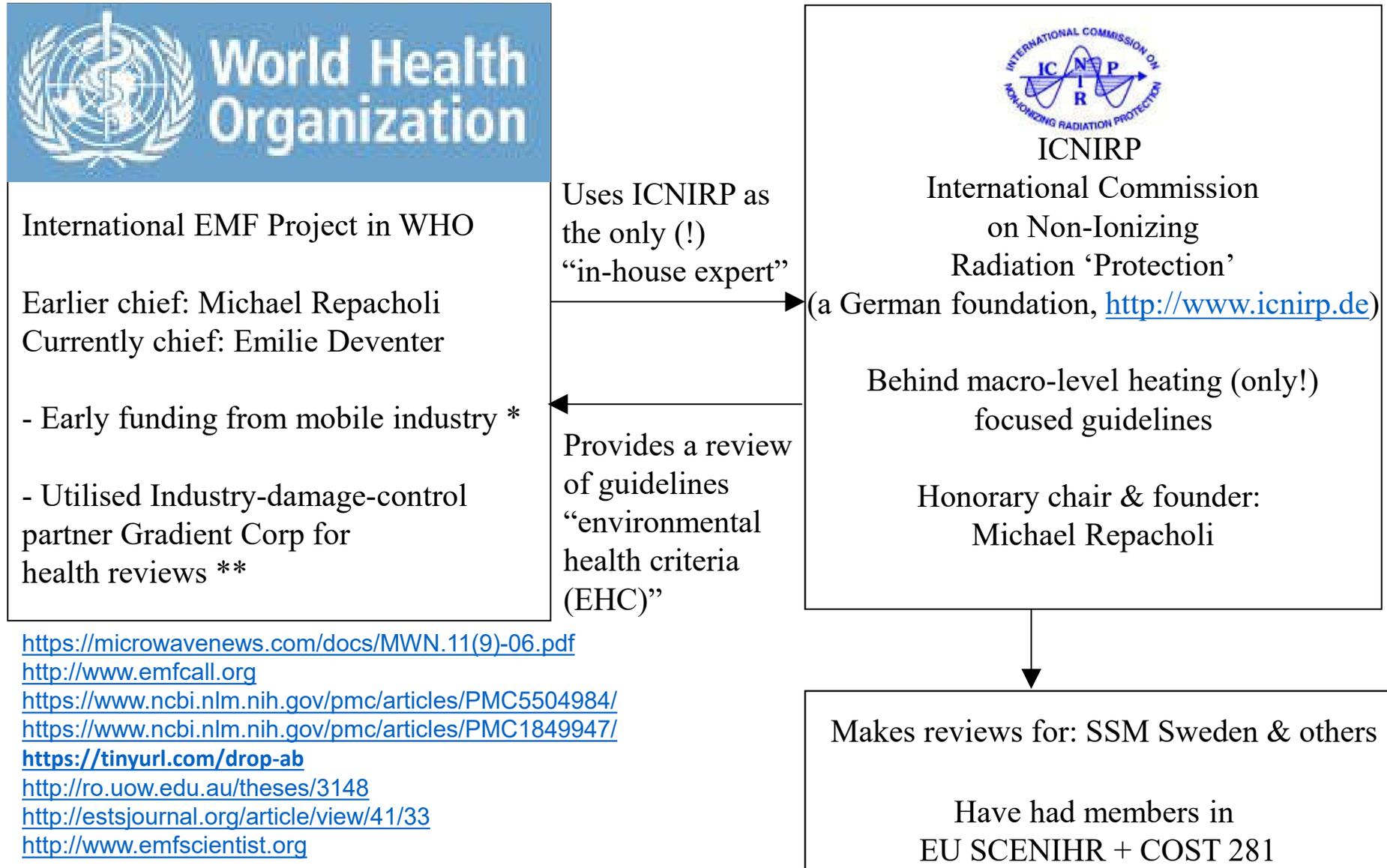
Comparison of guidelines: <http://tinyurl.com/RF-Guideline1>

European Academy of Environmental Medicine (EUROPAEM) & RF: <http://tinyurl.com/emf-europaem>

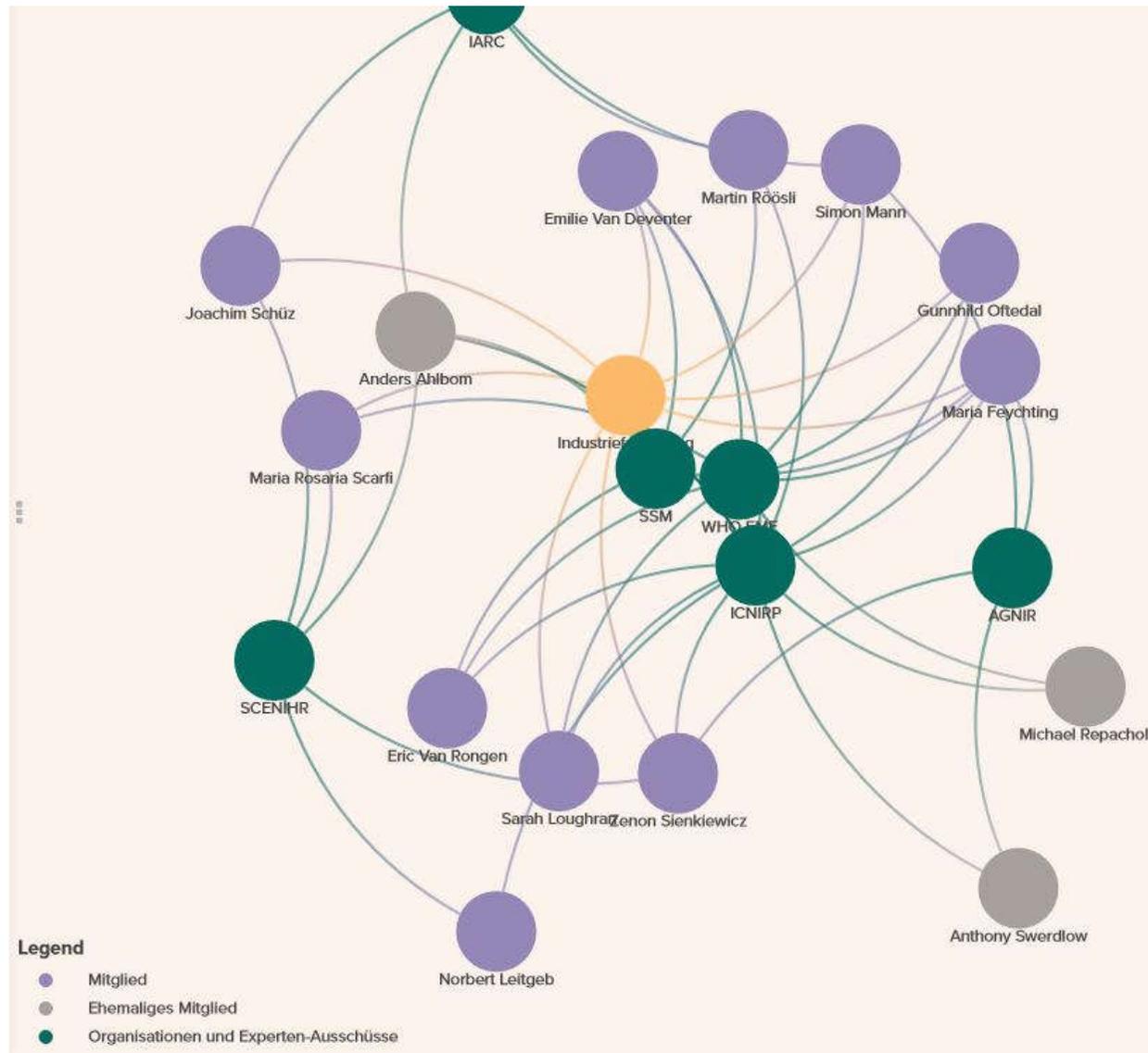
RF source Max Peak/ Peak Hold	Daytime exposure	Nighttime exposure	Sensitive populations <sup>1)</sup>
Radio broadcast (FM)	10,000 $\mu\text{W}/\text{m}^2$	1000 $\mu\text{W}/\text{m}^2$	100 $\mu\text{W}/\text{m}^2$
TETRA	1000 $\mu\text{W}/\text{m}^2$	100 $\mu\text{W}/\text{m}^2$	10 $\mu\text{W}/\text{m}^2$
DVBT	1000 $\mu\text{W}/\text{m}^2$	100 $\mu\text{W}/\text{m}^2$	10 $\mu\text{W}/\text{m}^2$
GSM (2G) 900/1800 MHz	100 $\mu\text{W}/\text{m}^2$	10 $\mu\text{W}/\text{m}^2$	1 $\mu\text{W}/\text{m}^2$
DECT (cordless phone)	100 $\mu\text{W}/\text{m}^2$	10 $\mu\text{W}/\text{m}^2$	1 $\mu\text{W}/\text{m}^2$
UMTS (3G)	100 $\mu\text{W}/\text{m}^2$	10 $\mu\text{W}/\text{m}^2$	1 $\mu\text{W}/\text{m}^2$
LTE (4G)	100 $\mu\text{W}/\text{m}^2$	10 $\mu\text{W}/\text{m}^2$	1 $\mu\text{W}/\text{m}^2$
GPRS (2.5G) with PTCCH' (8.33 Hz pulsing)	10 $\mu\text{W}/\text{m}^2$	1 $\mu\text{W}/\text{m}^2$	0.1 $\mu\text{W}/\text{m}^2$
DAB+ (10.4 Hz pulsing)	10 $\mu\text{W}/\text{m}^2$	1 $\mu\text{W}/\text{m}^2$	0.1 $\mu\text{W}/\text{m}^2$
Wi-Fi 2.4/5.6 GHz (10 Hz pulsing)	10 $\mu\text{W}/\text{m}^2$	1 $\mu\text{W}/\text{m}^2$	0.1 $\mu\text{W}/\text{m}^2$

Belyaev, I., Dean, A., Eger, H., Hubmann, G., Jandrisovits, R., Kern, M., ... Thill, R. (2016). EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. *Reviews on Environmental Health*. 31(3). 363–397. <https://doi.org/10.1515/reveh-2016-0011>

# Jävigare experter – nuvarande EMF-riktlinjer skyddar inte



## Granskande journalister av Investigate Europe kollade hurdan Kartell (deras uttalande) det finns inom gränsvärde och riktlinjer

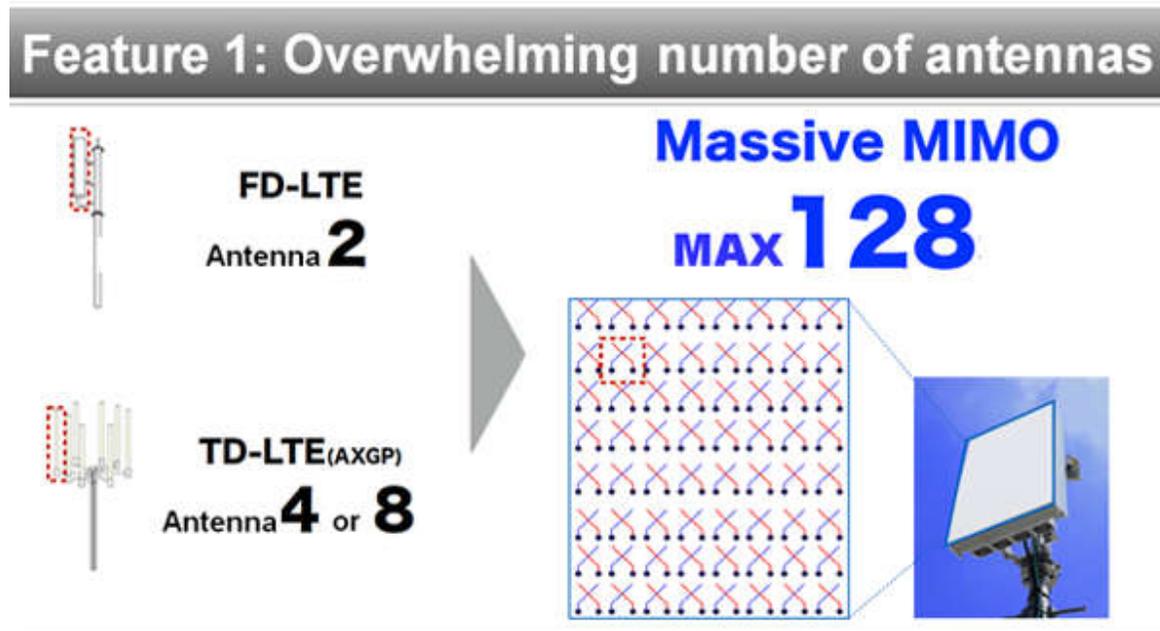


<http://investigate-europe.eu/publications/how-much-is-safe/>

# **Om basstationer - Från 4G till 5G**

# “Utveckling”

→ Från 4G(LTE) småningom till rejäl 5G



Källa: xgpforum.com

# Massive MIMO – Multiple Input Multiple Output

## Det kan vara hundratala antenn i varje basstation

*"Our simulation results suggest the downlink of a Fifth Generation Cellular Mobile Communications (5G) system can generate significantly higher power density (PD) and specific absorption rate (SAR) than the previous generations of wireless systems."*

Nasim, I., & Kim, S. (2019). **Mitigation of human EMF exposure in downlink of 5G**. *Annals of Telecommunications*, 74(1), 45–52.  
<https://doi.org/10.1007/s12243-018-0696-6>

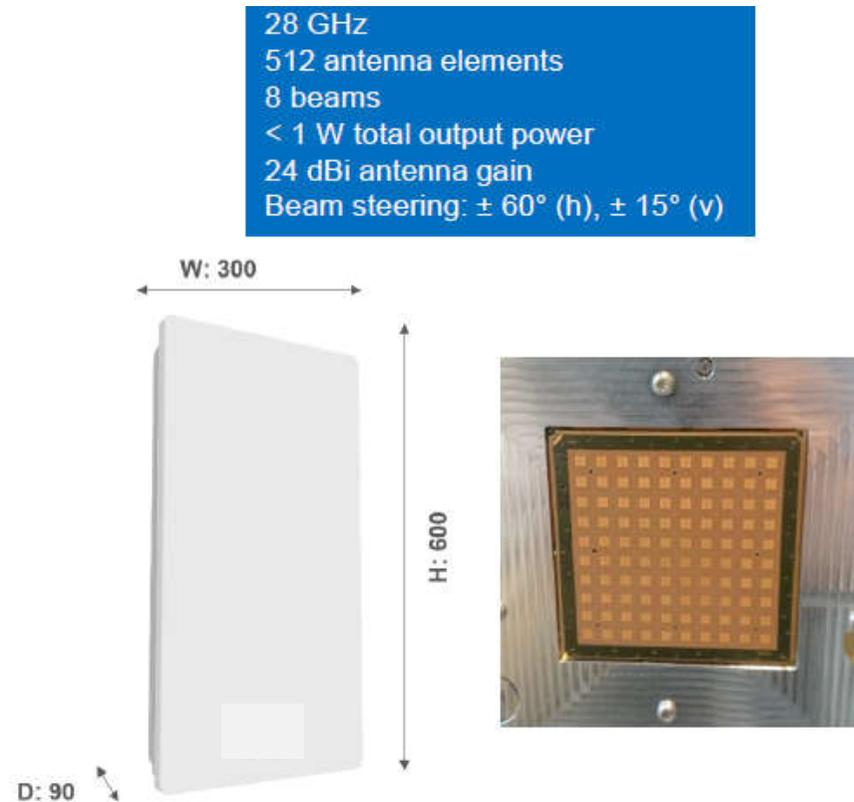
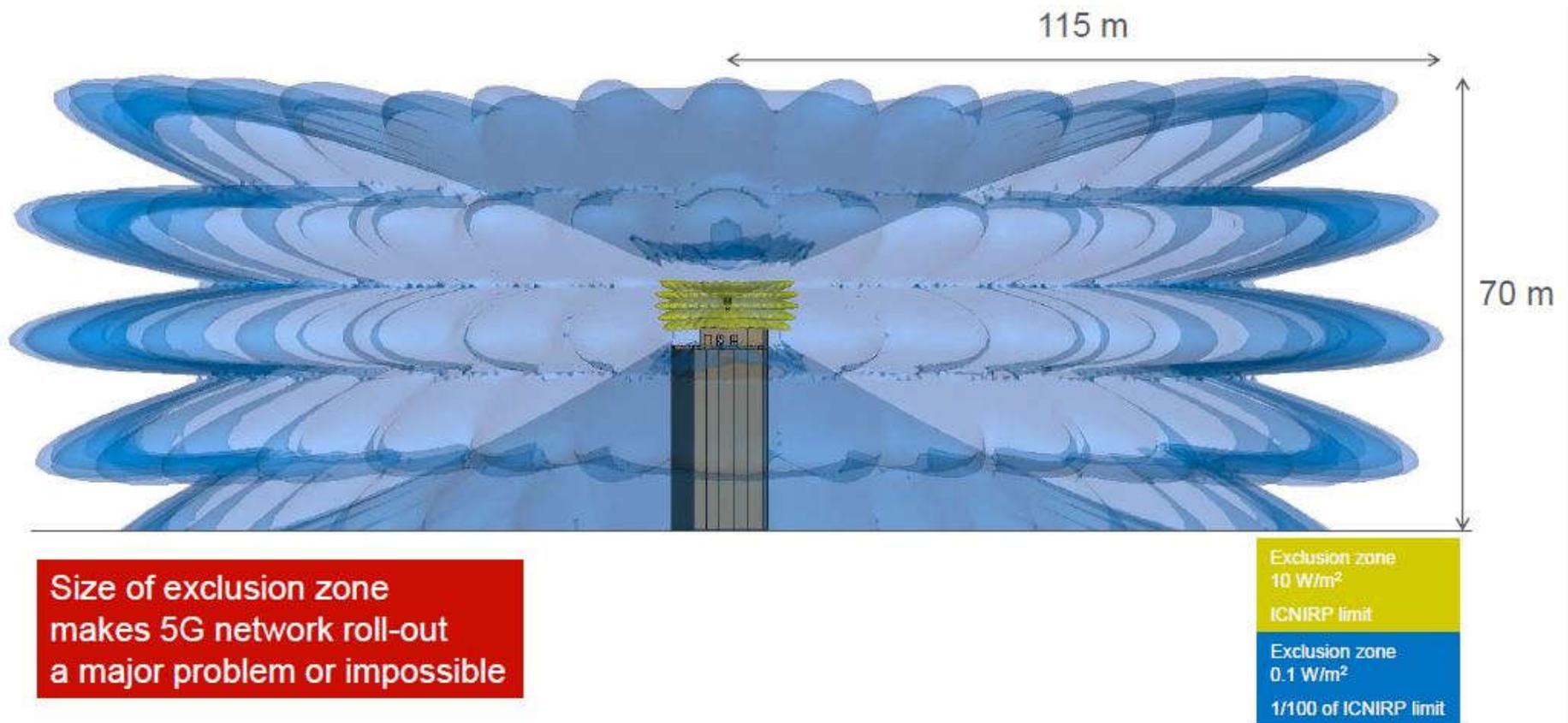


Bild: Törnevik, ITU 2017

**Stor antal av antenn gör det omöjligt att köra 5G i länder med lägre, skyddande gränsvärde → Skyddsområde 115 meter !!**



Källa: [https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20171205/Documents/S3\\_Christer\\_Tornevik.pdf](https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20171205/Documents/S3_Christer_Tornevik.pdf)

# Instituto Ramazzini – världens största djurstudie – hjärttumörer – Max 50 V/m - bara 1 antenn !



→ Falcioni et al. 2018:

<https://www.ncbi.nlm.nih.gov/pubmed/29530389>

**U.S. National Toxicology Program (NTP) studie →  
Classification: Clear evidence of heart tumors (2018).**

<https://www.niehs.nih.gov/news/newsroom/releases/2018/november1/index.cfm>



Bild: IEEE

## Beamforming – många antenn riktade till samma riktning



*"However, since the radiation is concentrated into selected portions of territory, there may be an increase of EMFs in these points".*

Chiaraviglio, L., Cacciapuoti, A. S., Martino, G. D., Fiore, M., Montesano, M., Trucchi, D., & Melazzi, N. B. (2018). Planning 5G Networks Under EMF Constraints: State of the Art and Vision. *IEEE Access*, 6, 51021–51037.  
<https://doi.org/10.1109/ACCESS.2018.2868347>

## Video om beamforming



<https://spectrum.ieee.org/video/telecom/wireless/5g-bytes-beamforming-explained>

## Med Beamforming och Massive MIMO belastning kan vara högre än nuvarande (ICNIRP) gränsvärde i nordiska länder

Neufeld, E., & Kuster, N. (2018). **Systematic Derivation of Safety Limits for Time-varying 5g Radiofrequency Exposure Based on Analytical Models and Thermal Dose.**

Health Physics, 115(6), 705–711. <https://www.ncbi.nlm.nih.gov/pubmed/30247338>



*“The results also show that the **peak-to-average ratio of 1,000 tolerated by the ICNIRP guidelines may lead to permanent tissue damage after even short exposures, highlighting the importance of revisiting existing exposure guidelines.**”*



## Epidemiologiska studier:

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### Radio & TV-sändare/master:

**Effekt:** Dolk *et al.* (1997a), Hocking & Gordon (2003), Ha *et al.* (2007), Mascarinec *et al.* (1994), Michelozzi *et al.* (2002), Morton & Phillips (1983), Park *et al.* (2004)  
[mer leukemi och lymfoma]

**Ingen effekt:** Dolk *et al.* (1997b), Mersenich *et al.* (2008)

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### Mobilbasstationer / mobilmaster:

**Effekt:** Abdel-Rassoul *et al.* (2007), Eger *et al.* (2004), Hutter *et al.* (2006), Gadzicka *et al.* (2004), Navarro *et al.* (2003), Santini *et al.* (2003), Wolf & Wolf (2004), Blettner *et al.* (2008), Eger & Jahn (2010), Dode *et al.* (2011) [adverse neurobehavioral problems + cancer]

**Ingen effect:** Meyer *et al.* (2006), Berg-Beckhoff *et al.* (2009)

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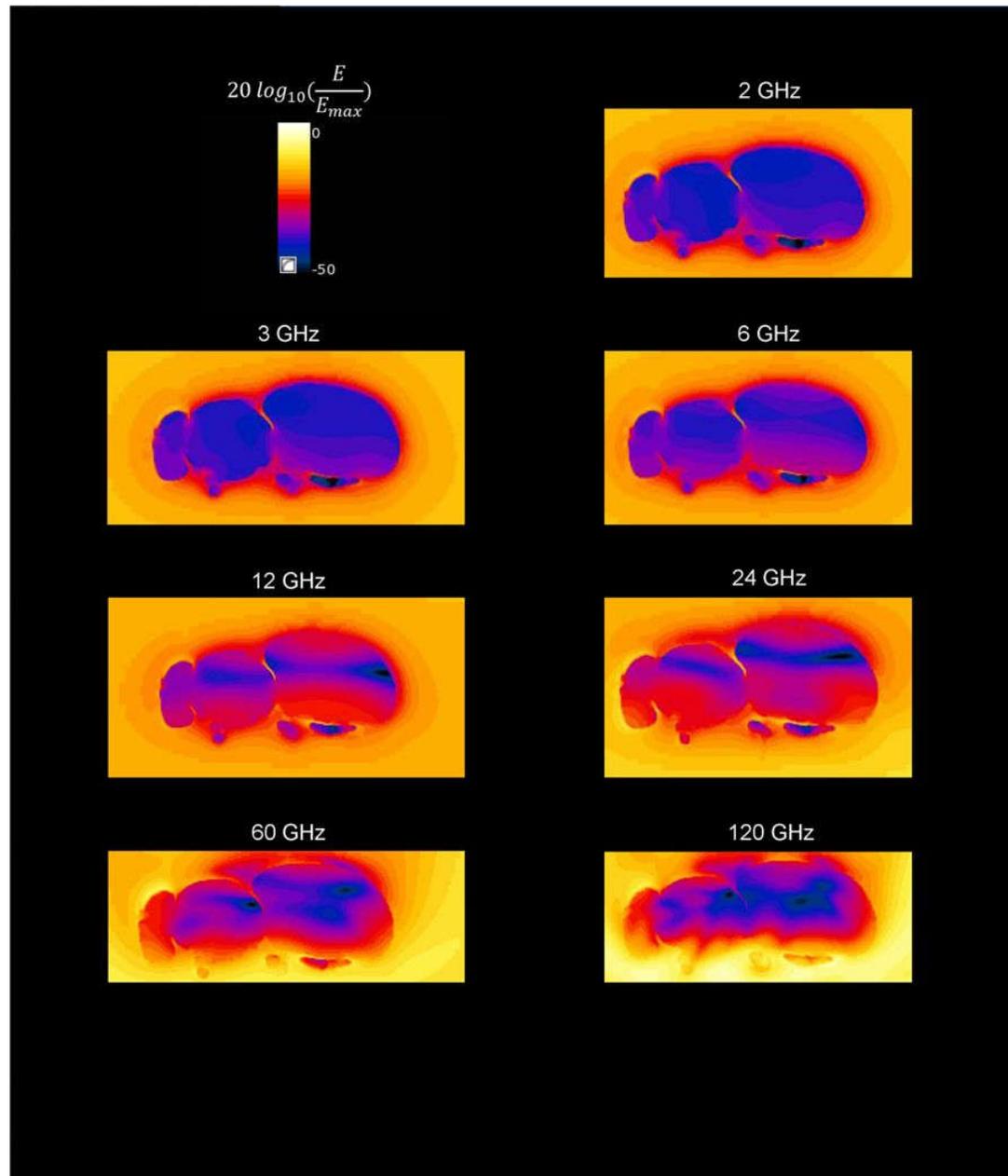
<https://www.ncbi.nlm.nih.gov/pubmed/20662418>  
<http://www.chronicexposure.org>

## Europaparlamentet 2.4.2009 :

- Maximal användning av fiber- och ethernet-infrastruktur
- Minska radiofrekvent strålning (mobilstrålning) nivåer i vår omgivning
- Undervisning om hälsosammare metoder att använda mobilteknologier.



<http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+IM-PRESS+20090401IPR53233+0+DOC+XML+V0//EN&language=EN>  
<http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2008-0410+0+DOC+XML+V0//EN>  
<http://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-en.asp?fileid=17994&lang=en>

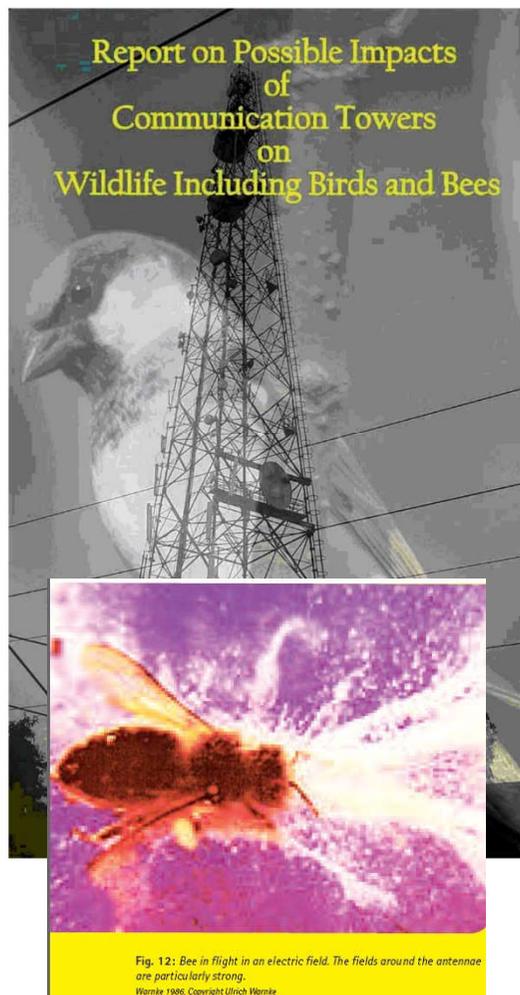


**" ... above 6 GHz would lead to an increase in absorbed power between 3–370%. ....This could lead to changes in insect behaviour, physiology, and morphology."**

**→ Starkaste absorbering nära 24 GHz (5G i 26 GHz)**

Picture: Thielens *et al.* (2018). Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz. *Scientific Reports*, 8(1), 3924. <https://doi.org/10.1038/s41598-018-22271-3>

# Effekt på bina, fåglar och växter - Radiofrekvent (RF) strålning



Redan 3 review-dokument visar skador:

Cucurachi *et al.* (2013).  
<http://www.ncbi.nlm.nih.gov/pubmed/23261519>

Balmori (2009):  
<http://www.ncbi.nlm.nih.gov/pubmed/19264463>

Sivani & Sudarsanam (2012).  
[http://www.biolmedonline.com/Articles/Vol4\\_4\\_2012/Vol4\\_4\\_202-216\\_BM-8.pdf](http://www.biolmedonline.com/Articles/Vol4_4_2012/Vol4_4_202-216_BM-8.pdf)

+ [http://www.indiaenvironmentportal.org.in/files/file/final\\_mobile\\_towers\\_report.pdf](http://www.indiaenvironmentportal.org.in/files/file/final_mobile_towers_report.pdf)

<http://www.ncbi.nlm.nih.gov/pubmed/23915130>

# The 5G Appeal – 200 forskare varnar:

**“We the undersigned, ..., recommend a moratorium on the roll-out of the fifth generation, 5G, for telecommunication until potential hazards for human health and the environment have been fully investigated by scientists independent from industry.**

**5G will substantially increase exposure to radiofrequency electromagnetic fields (RF-EMF) on top of the 2G, 3G, 4G, Wi-Fi, etc. for telecommunications already in place. RF-EMF has been proven to be harmful for humans and the environment. “**

**<http://www.5gappeal.eu>**



# **Om massiv energibruk – 5G**

# A Smart Phone Uses as Much Energy as a Refrigerator?

By Katherine Tweed

Posted 15 Aug 2013 | 17:44 GMT

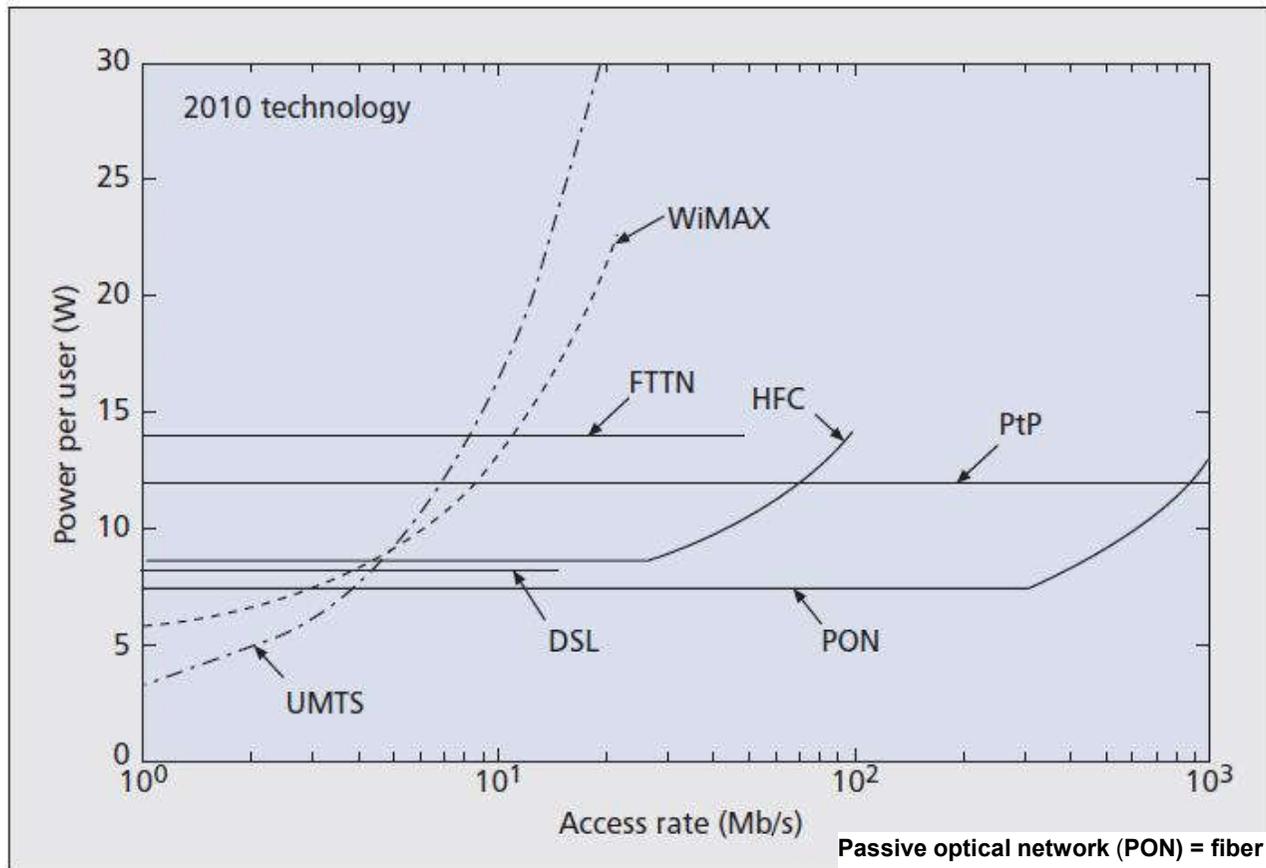
|  Email |  Print



Från IEEE Spectrum :

<http://spectrum.ieee.org/energywise/energy/environment/smart-phones-uses-as-much-energy-as-a-refrigerator>

## Ju snabbare hastighet, desto större energianvändning i mobilförbindelser



Baliga, J., Ayre, R., Hinton, K., & Tucker, R. S. (2011). Energy consumption in wired and wireless access networks. *IEEE Communications Magazine*, 49(6), 70–77.

→ **Fiber&ethernet-användning är miljövänligt !**

**"5G could increase total network energy consumption by almost 200 percent over the next several years"**

**<https://spectrum.ieee.org/telecom/wireless/5gs-waveform-is-a-battery-vampire>**

**<https://www.itopstimes.com/itops/report-5g-could-increase-total-network-energy-consumption-by-almost-200-percent-over-the-next-several-years/>**

# **Slutsatser gällande 5G:**

- Helt otestad teknologi. Borde inte lanseras nu.**
- Nuvarande SSM/ICNIRP-gränsvärdet skyddar inte människor eller djur**
- Borde minska RF-strålningsnivåer både från existerande mobilapparater och också från basstationer**
- Stort behov för: hälsosammare/lågstrålande skolor, bostäder, vistelseområden, fordon etc**

# Frågor och kommentarer välkomna!



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