Università degli Studi di Perugia

UNIVERSITÀ degli STUDI di PERUGIA

Facoltà di Ingegneria

I corsi di Elettromagnetismo:

- *Campi Elettromagnetici*
- *Laboratorio di Elettromagnetismo*
- *Ingegneria delle RF*

- *Antenne*
- *Compatibilità Elettromagnetica*
- *Progetto di circuiti a microonde*
- *Sistemi wireless a microonde e rf*
- *Telerilevamento*

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Elettromagnetismo

1. scienza basata sulle “equazioni di Maxwell”, che studia i fenomeni elettrici, magnetici ed elettromagnetici;
2. la propagazione libera e guidata delle onde elettromagnetiche,
3. i metodi per generare, emettere, guidare, ricevere, elaborare i campi elettromagnetici

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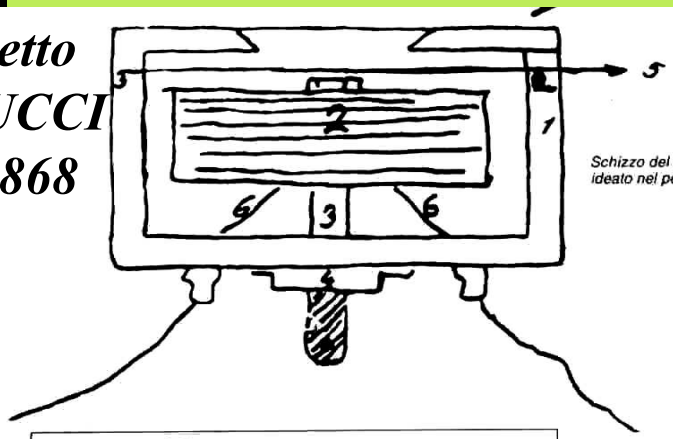
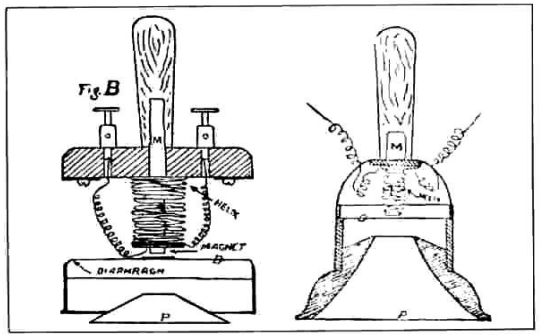
Richiami storici

- 1873: Maxwell pubblica "A Treatise on Electricity and Magnetism". L'introduzione della corrente di spostamento predice l'esistenza di onde elettromagnetiche e che la luce stessa è un fenomeno elettromagnetico
- 1879 Morte di Maxwell all'età di 48 anni. Helmholtz promuove un premio per chi confermerà sperimentalmente le predizioni di Maxwell
- 1886-88: H. Hertz, già allievo di Helmholtz, verifica sperimentalmente la correttezza delle equazioni di Maxwell, battendo sul tempo (1 mese) l'inglese O. Lodge.
- 1894: Hertz muore all'età di 36 anni, per setticemia da un dente infettato
- 1895: Marconi, utilizzando il trasmettitore di Hertz e adottando un altro tipo di rivelatore (il choerer), compie il primo esperimento di comunicazione senza fili (wireless) nella villa Griffone
- 1901: primo esperimento di cominicazione transatlantica
- 1937: Comincia lo sviluppo del radar in Inghilterra
- 1969: Primo telefono cellulare a 450 MHz, sul treno N.Y.-Washington

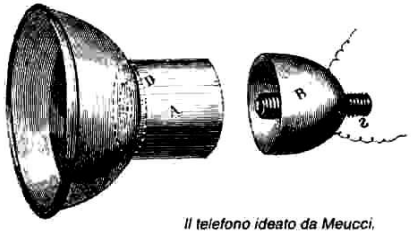
Brevetto MEUCCI del 1868



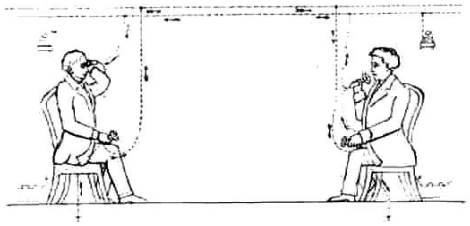
Schizzo del telefono Meucci come ideato nel periodo 1856/60.



Disegni del telefono ideato da Meucci uniti alla domanda depositata all'ufficio brevetti di Washington nel 1871.



Il telefono ideato da Meucci.



Prospetto e schema della trasmissione telefonica come prevista da Meucci.

Da un giornale di New York del 1868:

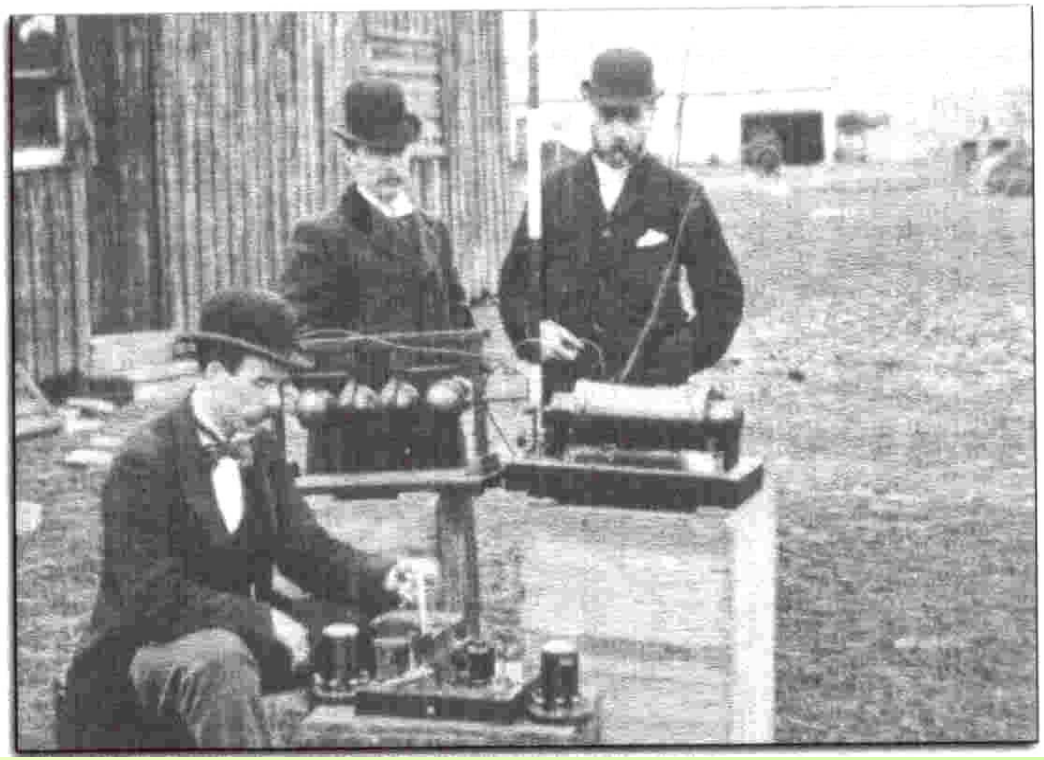
"Arrestato un individuo che cercava di estorcere denaro a persone superstiziose esibendo uno strumento che trasmetterebbe la voce umana a qualunque distanza per mezzo di cavi metallici……."

"L'uomo chiama questo strumento *telefono*. Le persone bene informate sanno che è impossibile trasmettere la voce umana attraverso cavi…."

La grande rivoluzione di Marconi del 1895

1895
MARCONI INVENTA LA RADIO E LA TELEGRAFIA "SENZA FILI"

Il mondo scopre i vantaggi del "wireless" e della trasmissione radio a grandissime distanze (onde corte)



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Elettromagnetismo

Scienza basata sulle "equazioni di Maxwell", che studia i fenomeni elettrici, magnetici ed elettromagnetici:

Notevole componente matematica

Propedeuticità: Analisi I e II, Fisica I e II

Elettromagnetismo

Studia la propagazione libera e guidata delle onde elettromagnetiche:

Propagazione nello spazio, nell'atmosfera

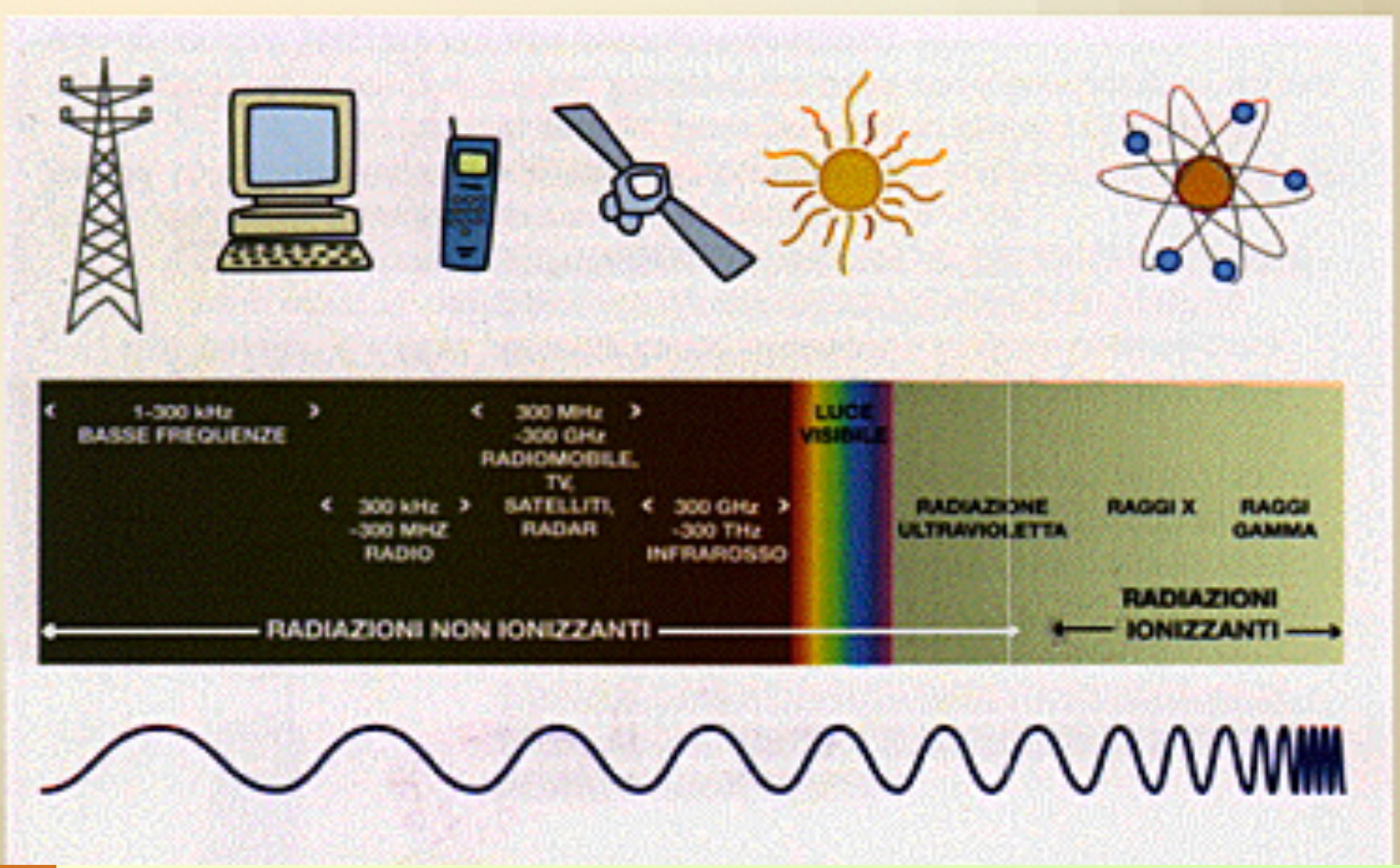
Linee di trasmissione, cavi coassiali, guide d'onda, fibre ottiche

Elettromagnetismo

Studia i metodi per generare, emettere, guidare, ricevere, elaborare i campi elettromagnetici :

Generatori, antenne, linee di trasmissione, dispositivi e componenti ad alta frequenza, dalle centinaia di KHz ai GHz (miliardi di Hz)…THz (migliaia di miliardi di Hz).

Campi elettromagnetici



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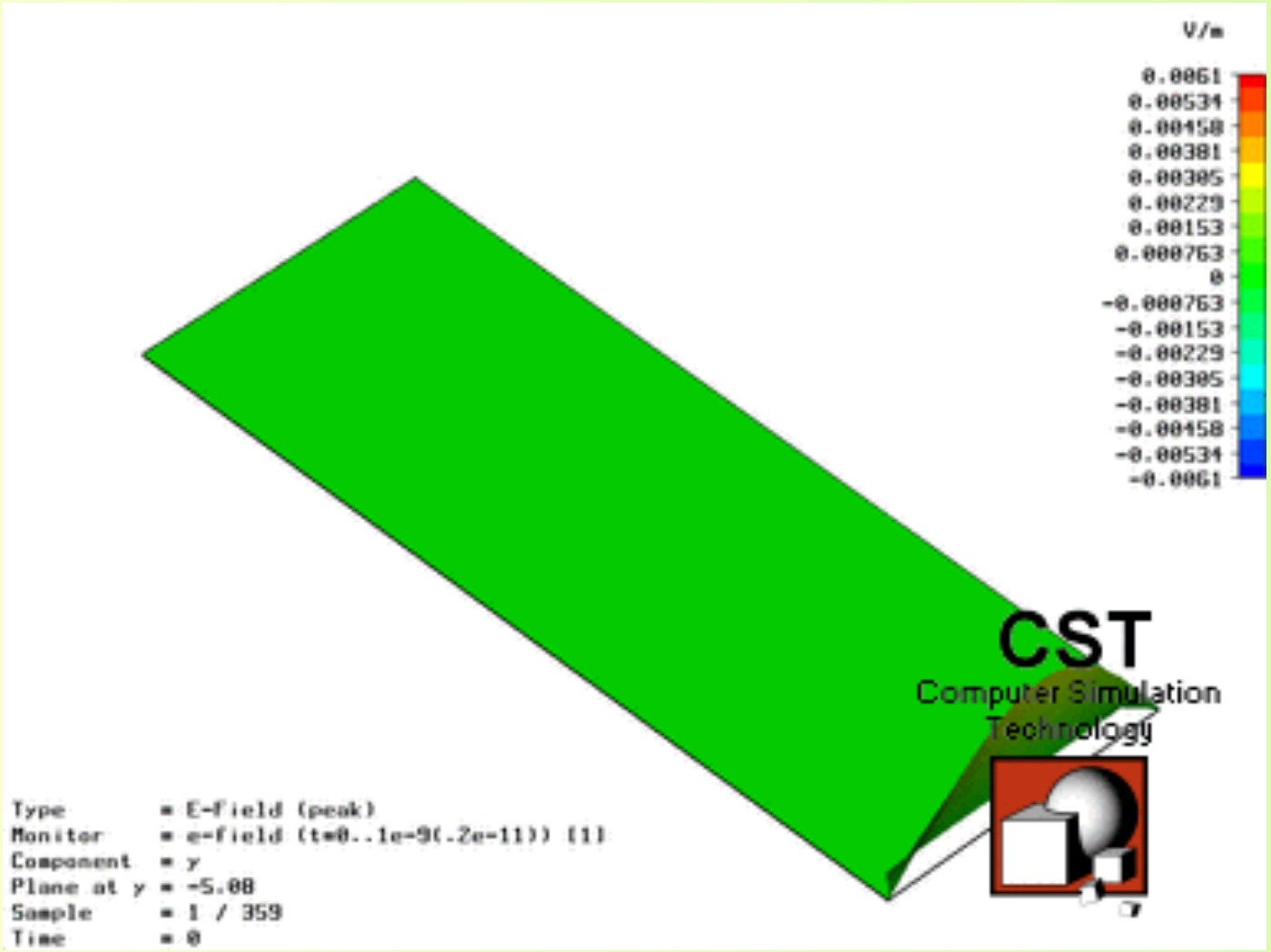
La propagazione delle onde
Onde progressive e stazionarie



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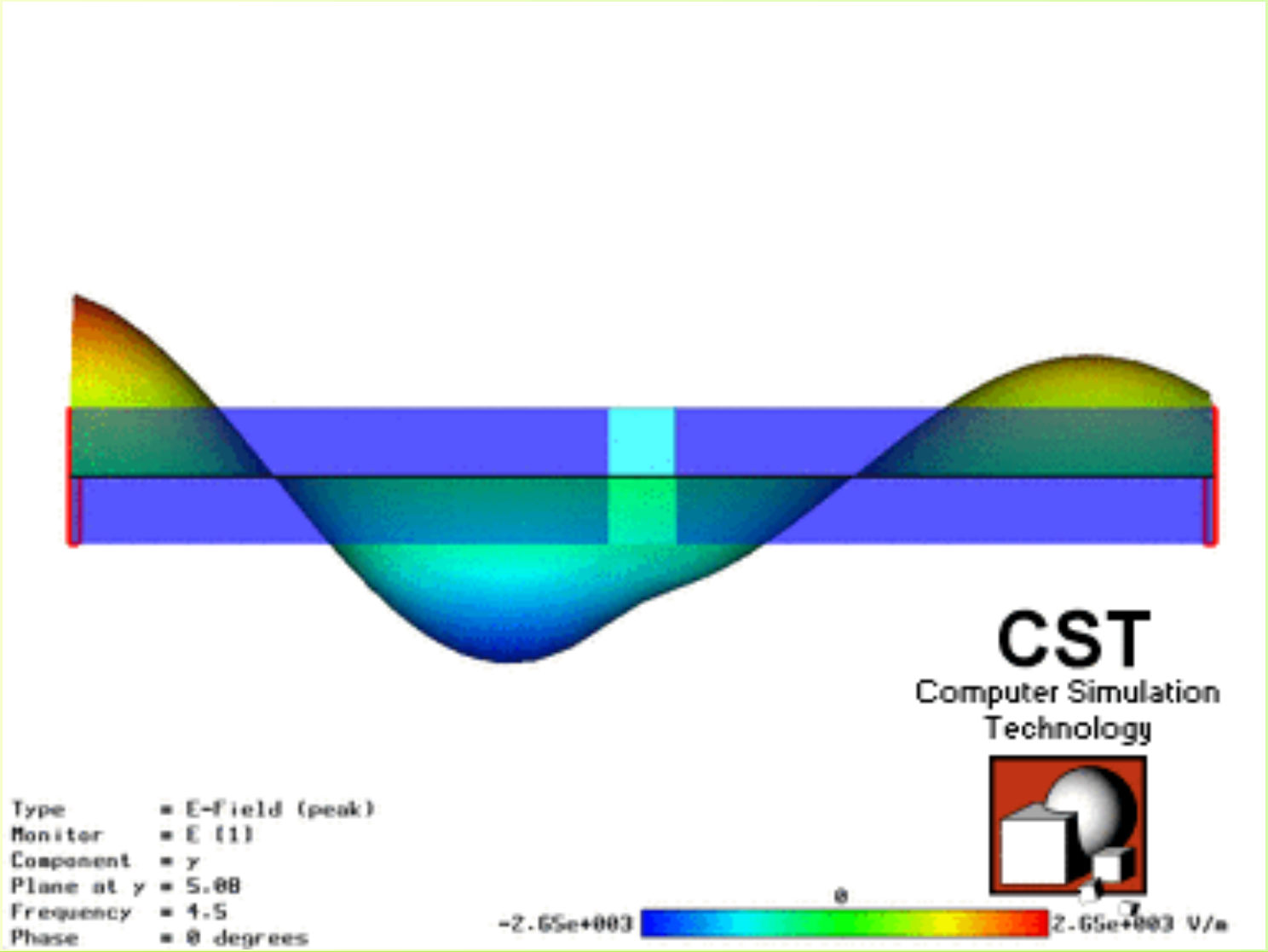
Effetto tunnel:
L'onda supera una barriera sottile



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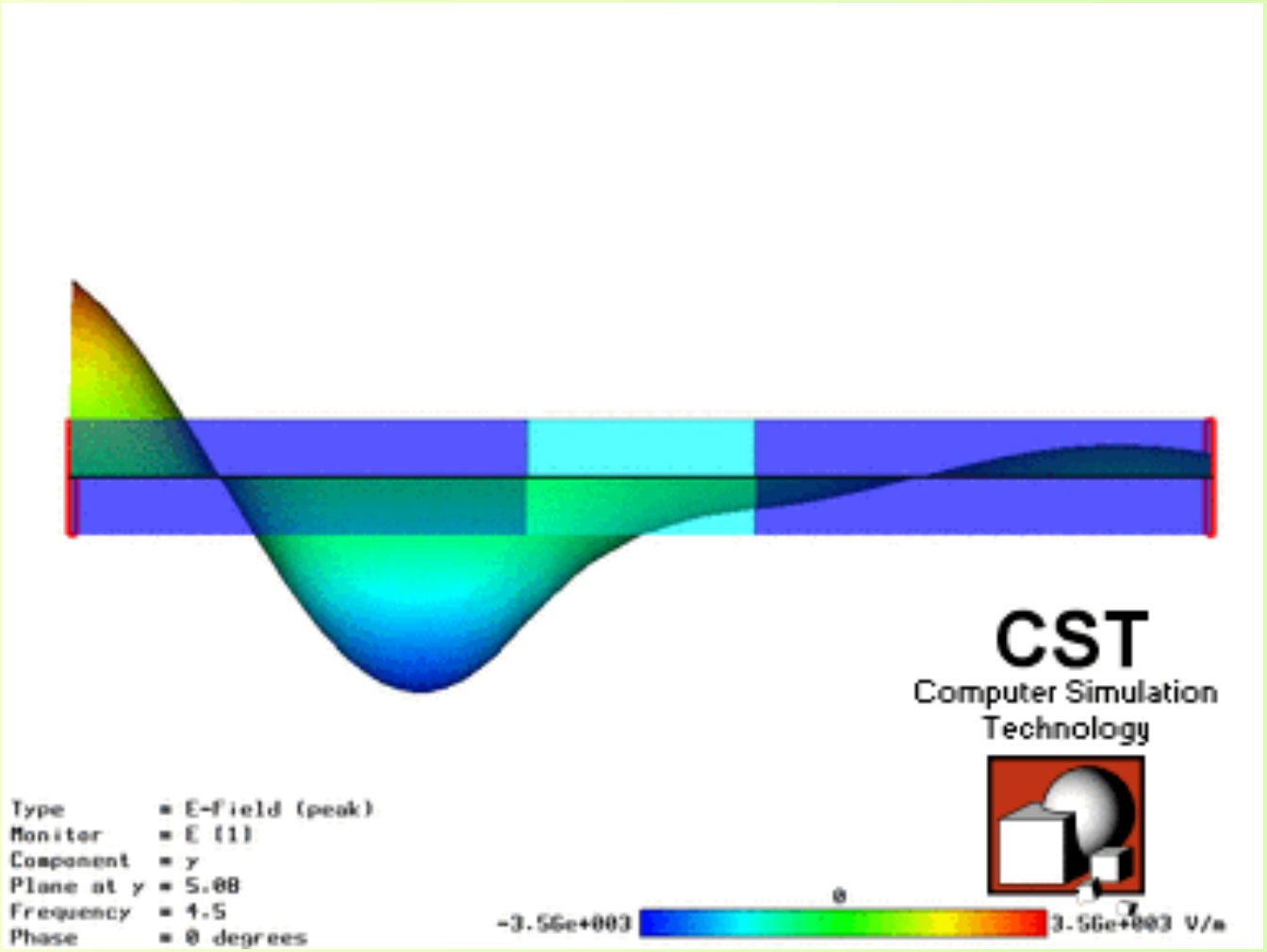
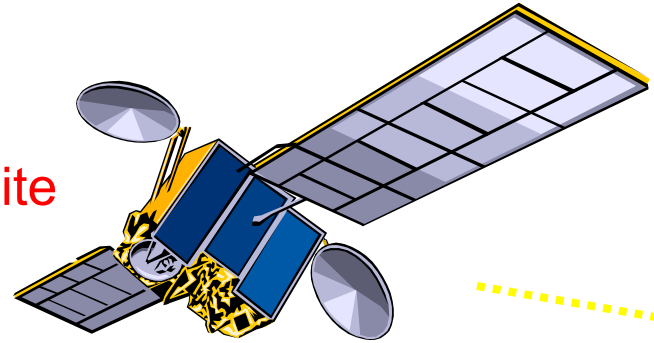
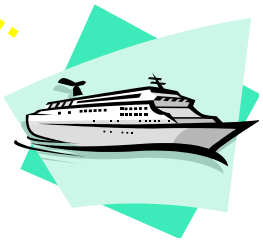
…ma non la barriera spessa

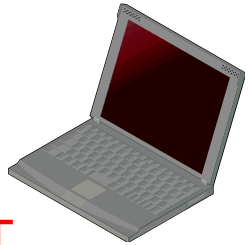


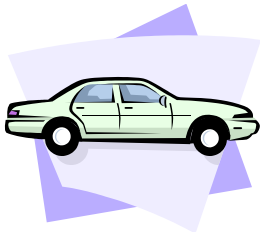
Alcune applicazioni

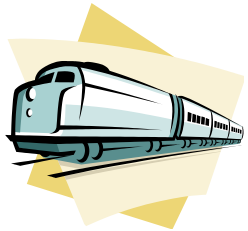
Servizi satellitari mobili







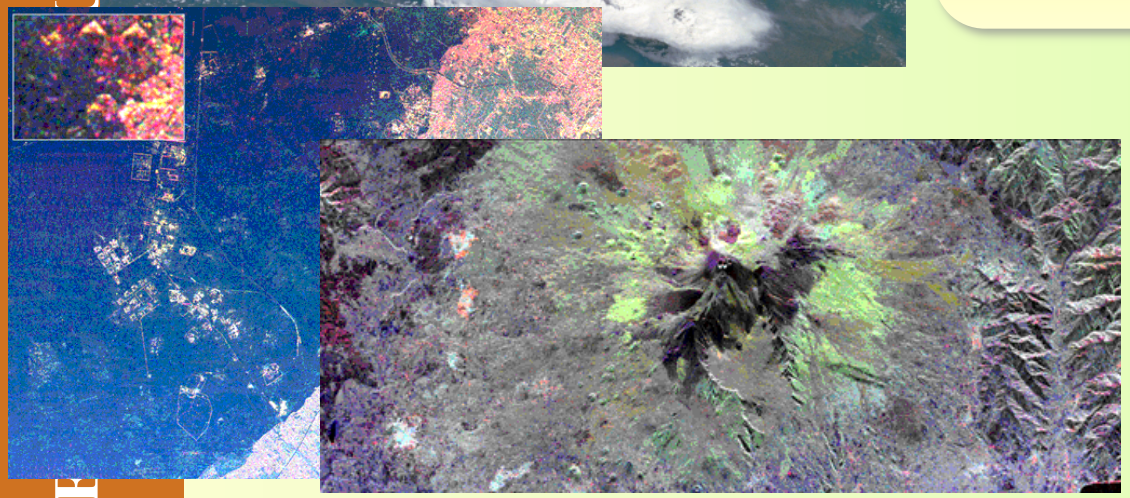




Sistemi di comunicazione wireless

SFIR → SDMA → SDMA/ MIMO

Synthetic Aperture Radar Applications



- Topographic imaging
- Oceanography
- Monitoring ice sheet and glaciers
- Hydrology
- Environmental monitoring
- Surveillance

Digital Beam Forming (DBF) SAR

UNIVERSITÀ KARLSRUHE (TH)

Telerilevamento

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Acquisizione di informazioni su un oggetto mediante un sensore non in contatto con esso

Campo di forze utilizzato: Campo elettromagnetico

Componenti del sistema di telerilevamento:

Oggetto (target) da studiare

Sorgente della radiazione

Percorso della radiazione

Piattaforma/sensori

Sistema trattamento/interpretazione dati

Applicazioni del telerilevamento

RUGIA

- **Contesto scientifico-sperimentale**
- **Contesto operativo**
- **Contesto commerciale**

- **Studio e monitoraggio delle variazioni del clima e della composizione atmosferica**
- **Previsioni meteorologiche**
- **Studio e monitoraggio delle superfici marine, del moto ondoso e dei ghiacci marini**
- **Monitoraggio delle zone costiere**
- **Monitoraggio del suolo, incluso l'inquinamento**
- **Monitoraggio della produttività vegetale e dei processi biologici superf.**
- **Monitoraggio e gestione delle risorse non rinnovabili**
- **Monitoraggio e riduzione delle conseguenze delle calamità naturali**

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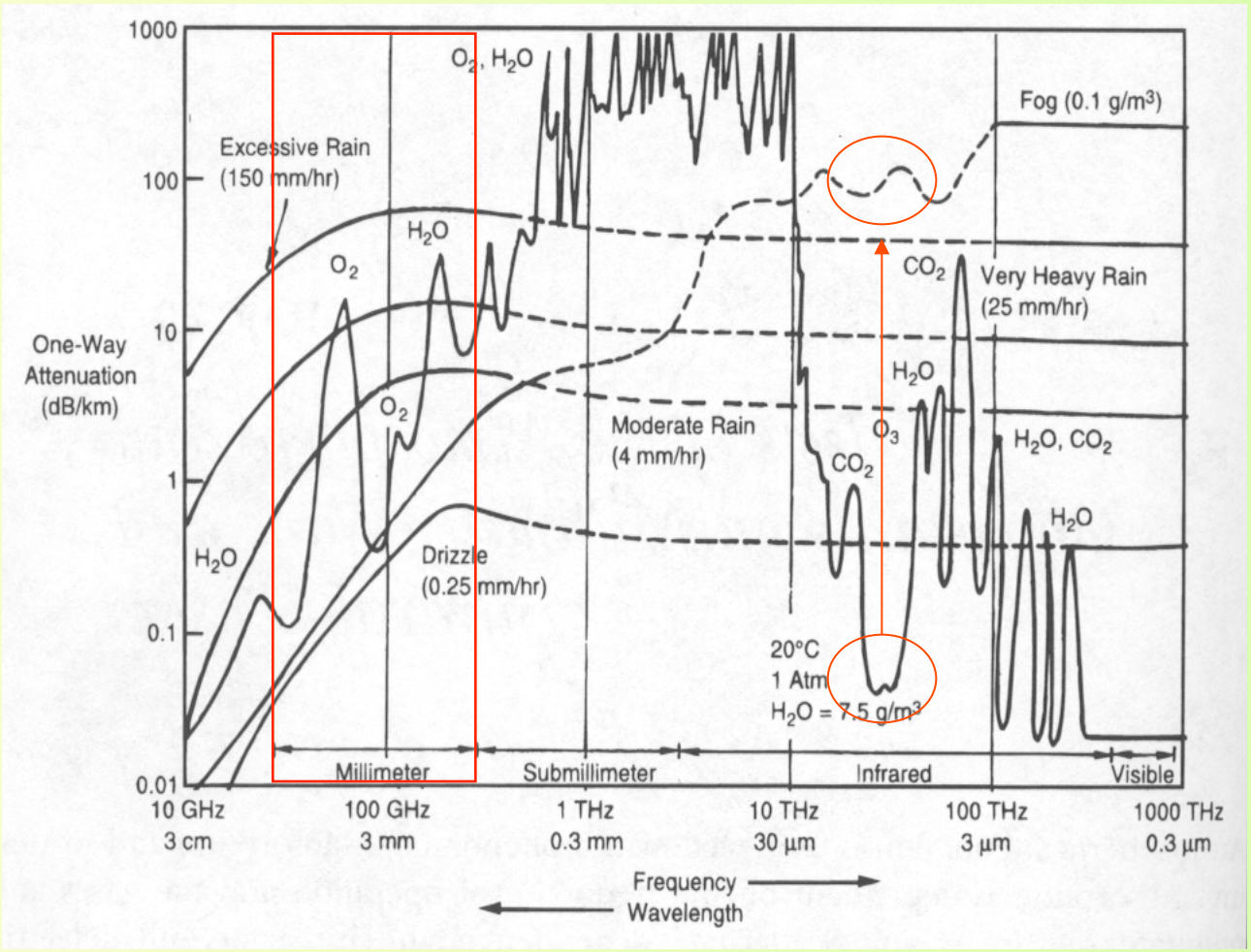
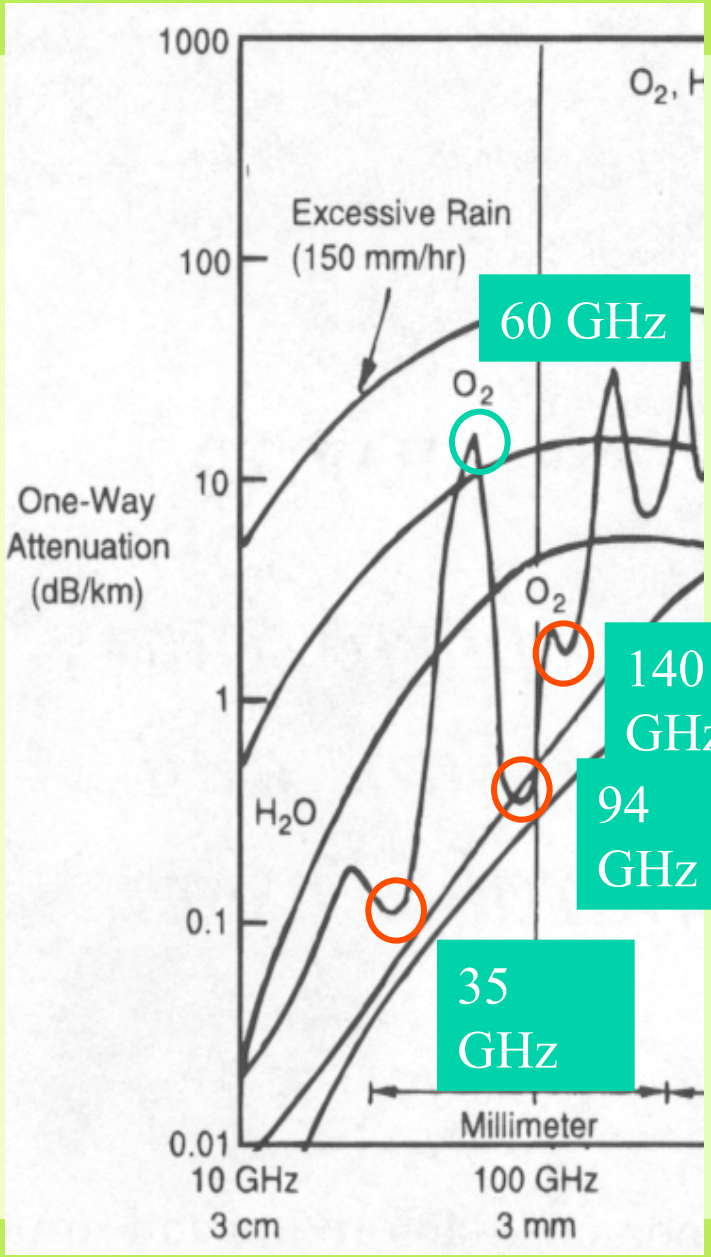
mm-waves 30 -300 GHz



Transmission attenuation



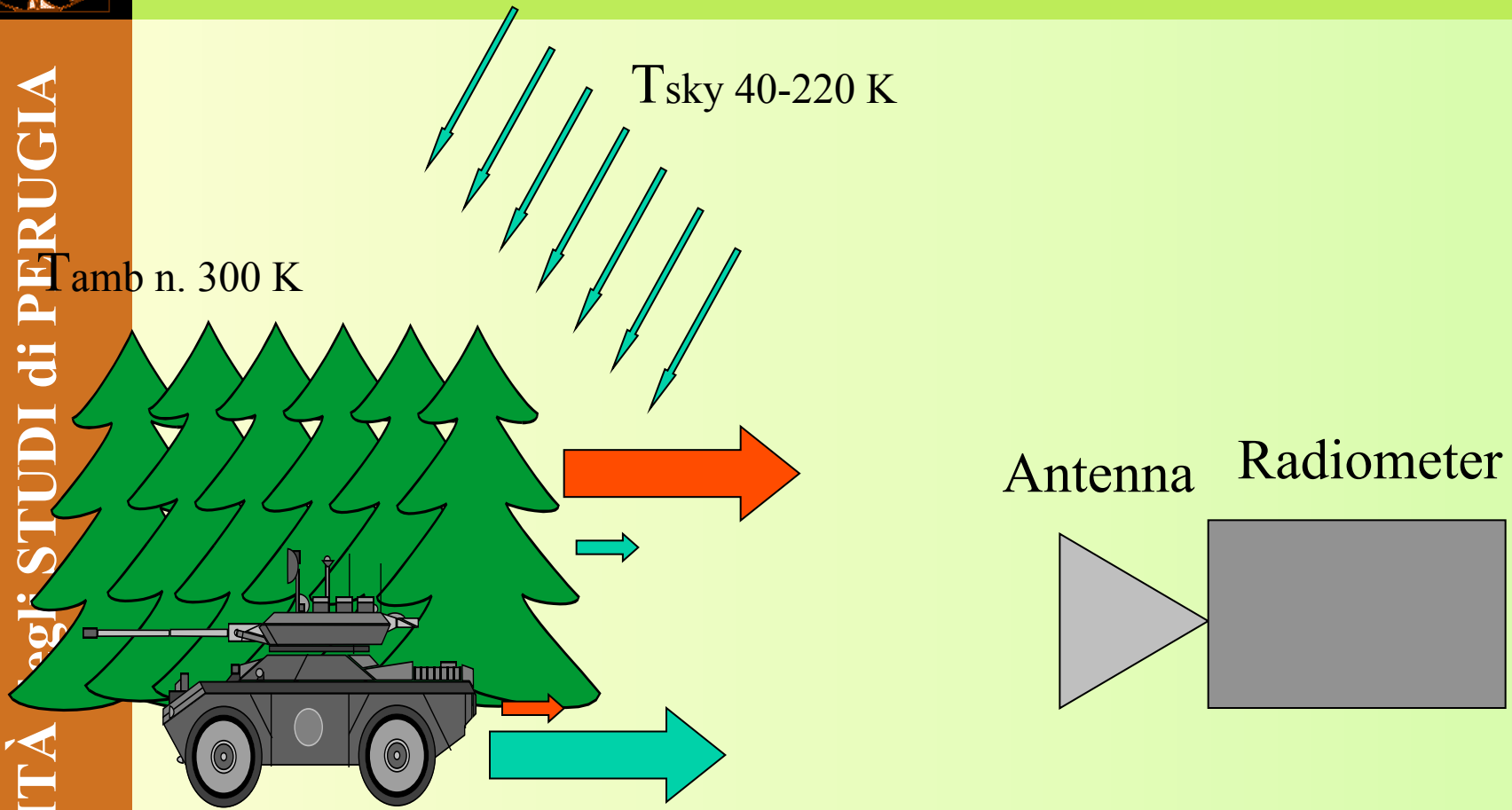
Minimi di attenuazione:

35, 94, 140 GHz

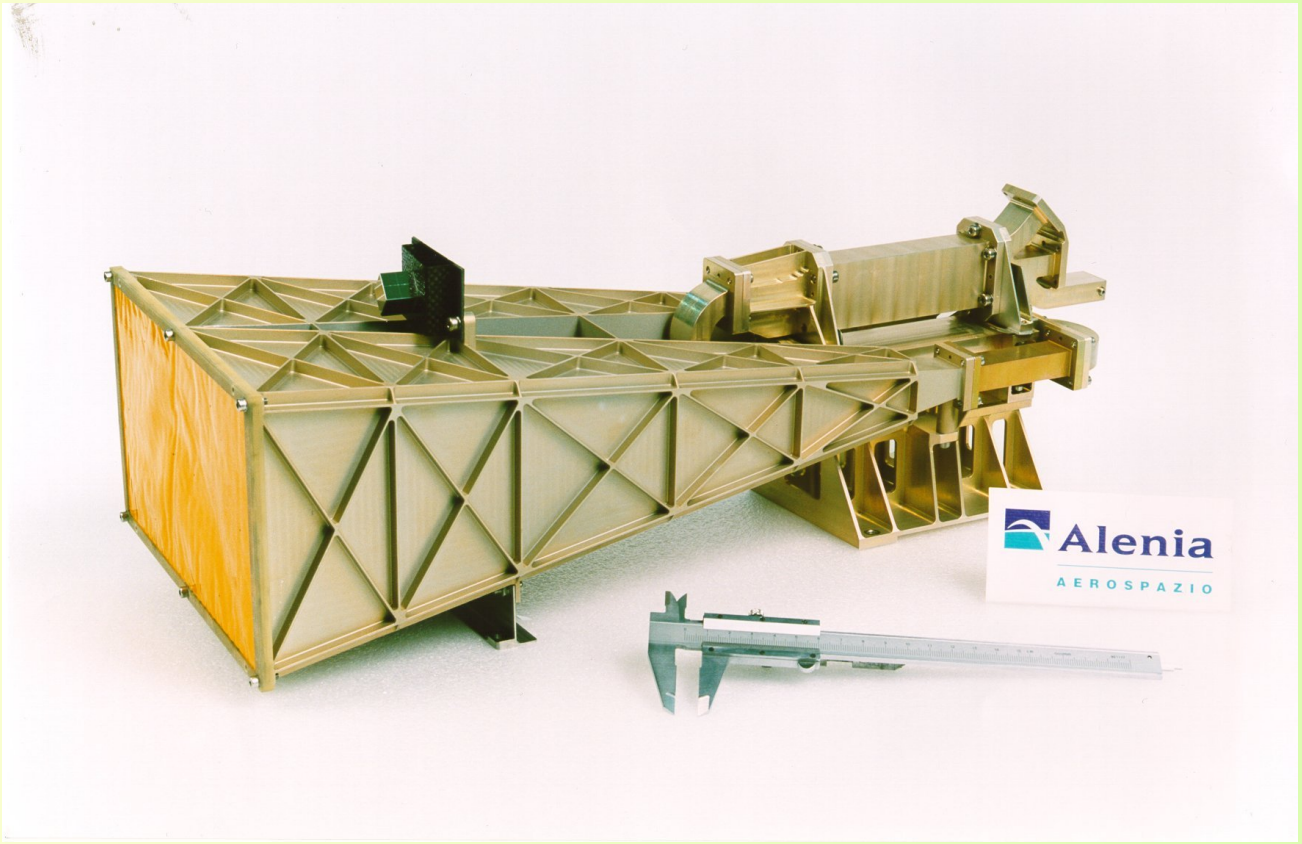
Massimo di attenuazione:

60 GHz

Passive Imaging

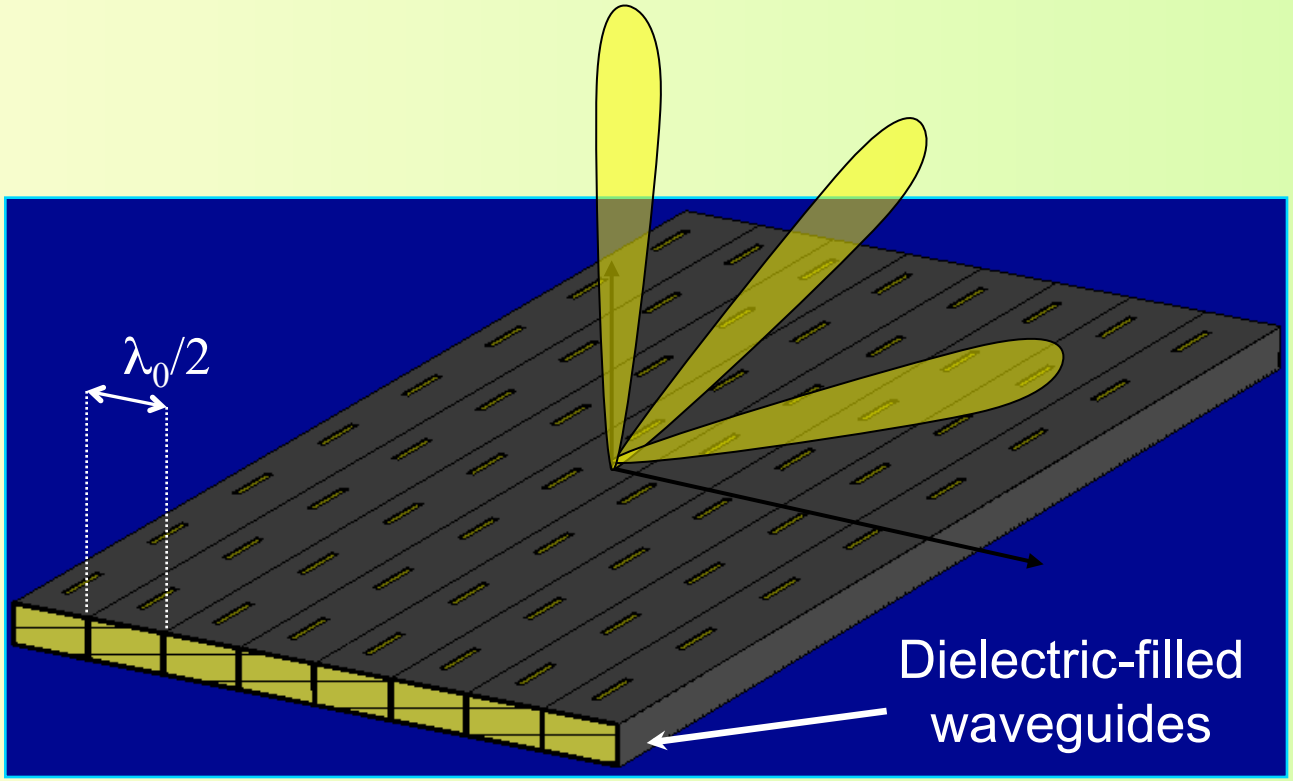


European Horn



Horns a larga Banda (10.95 - 14.50 GHz) dei satelliti Eutelsat W24. Opera su entrambe le polarizzazioni orizzontale(uso telemetria) e verticale(uso telecomunicazioni).

Un' antenna "a scansione"



Antenne “stampate”

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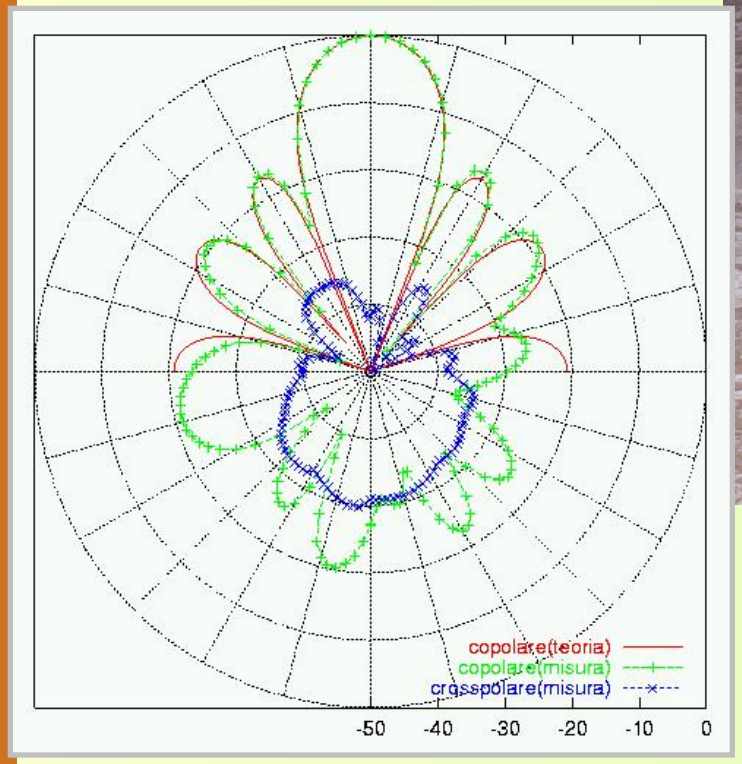
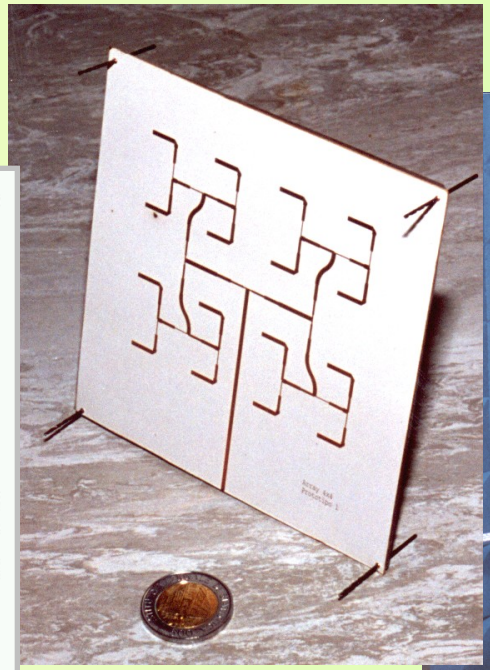
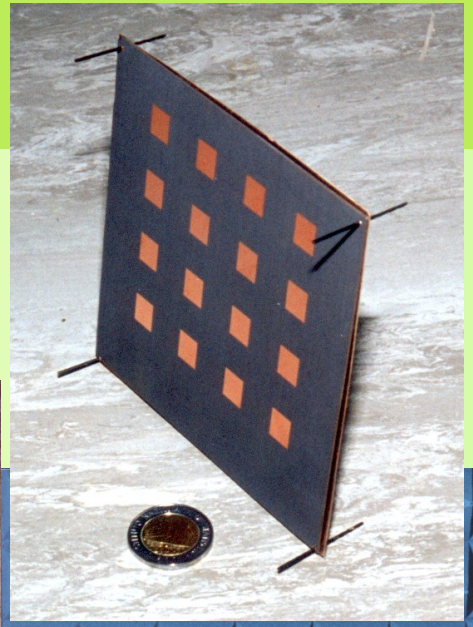
10 GHz patch array







Nuove Tecnologie per circuiti a RF: i MEMS

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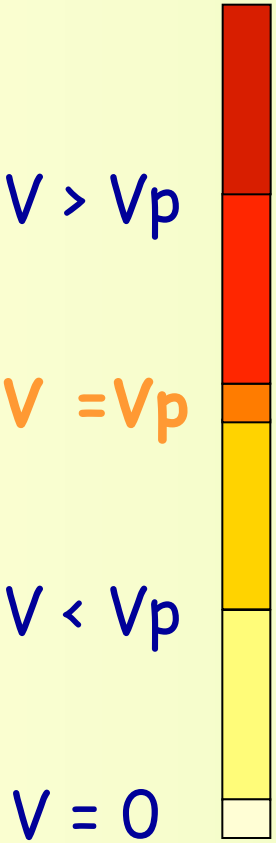

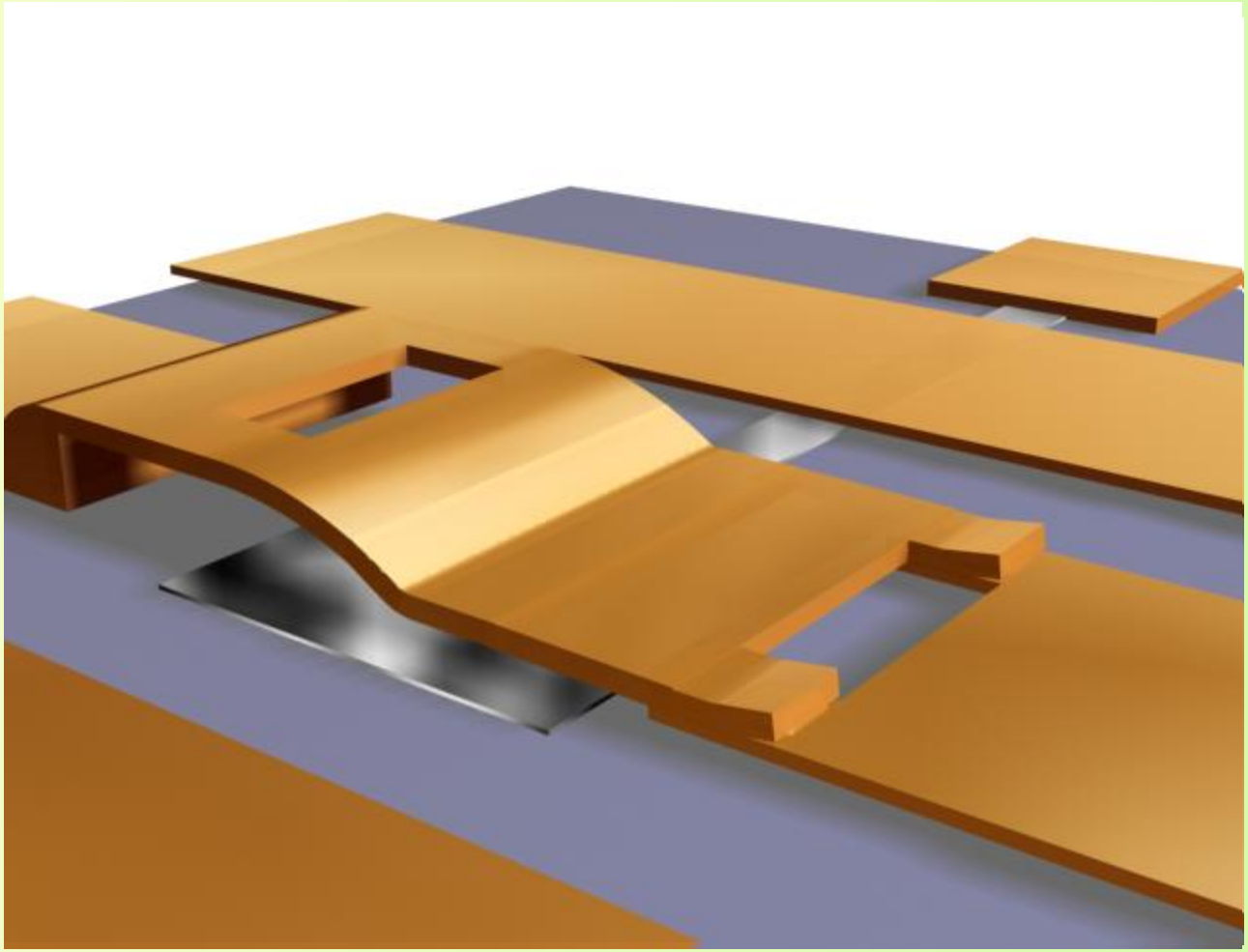

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Un "induttore" MEMS

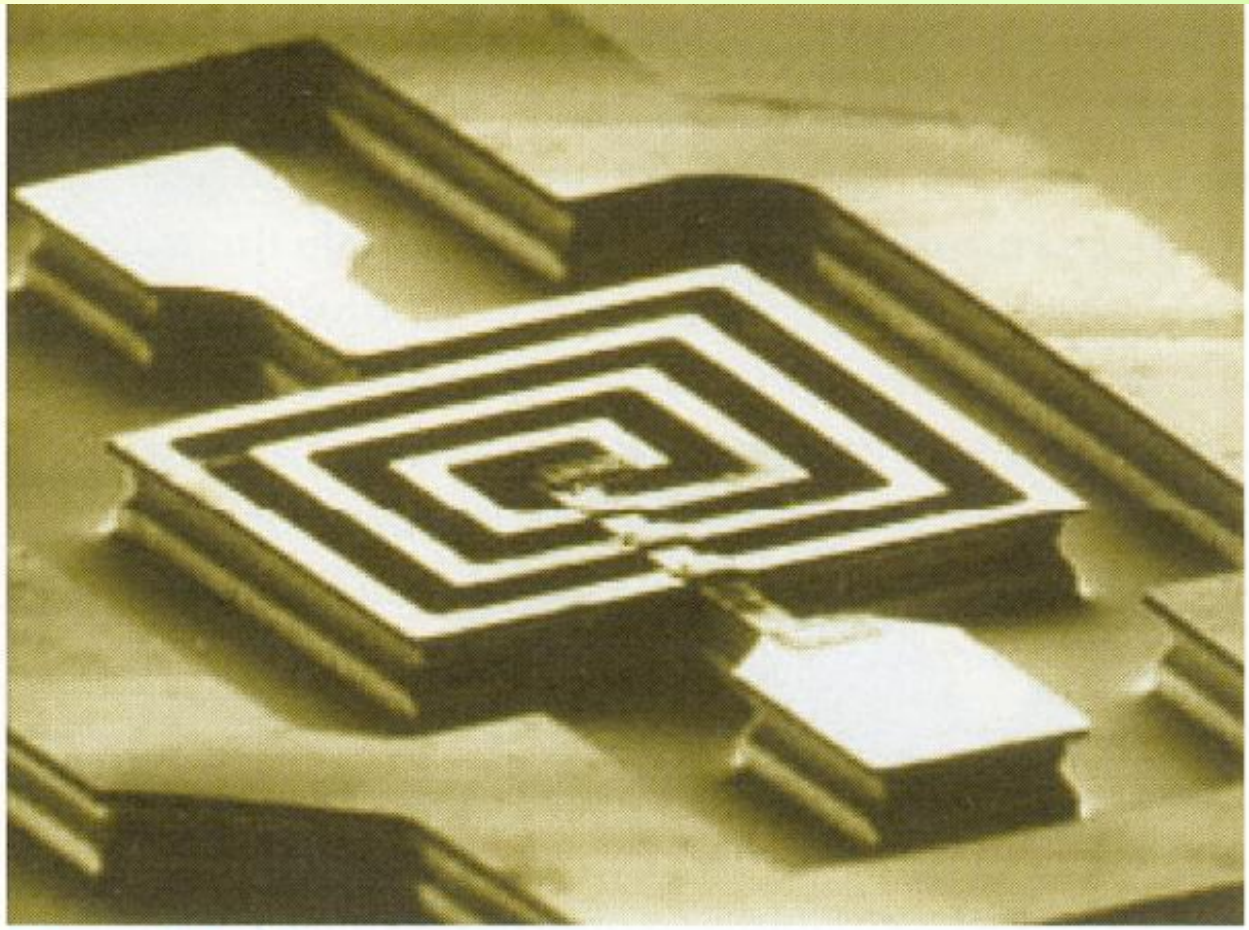

Figure 4. *Micromachined inductor.*

Sensori a microonde per la misura di umidità

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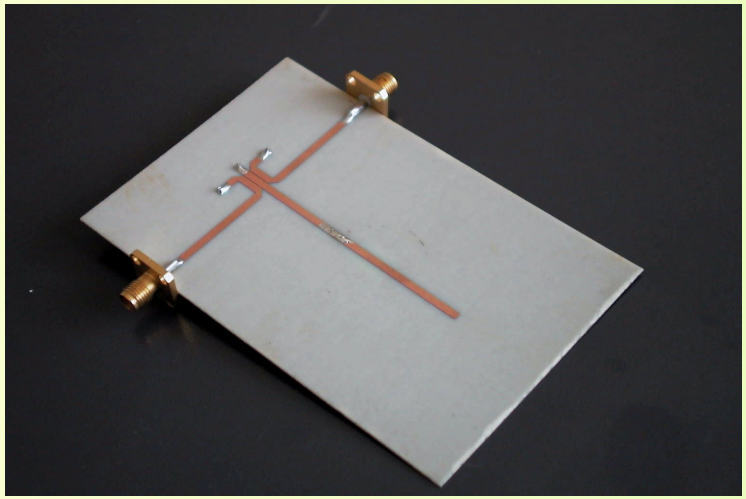
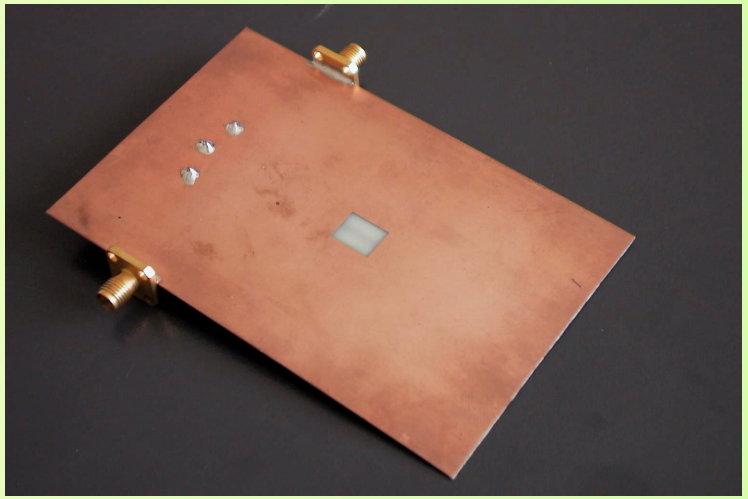
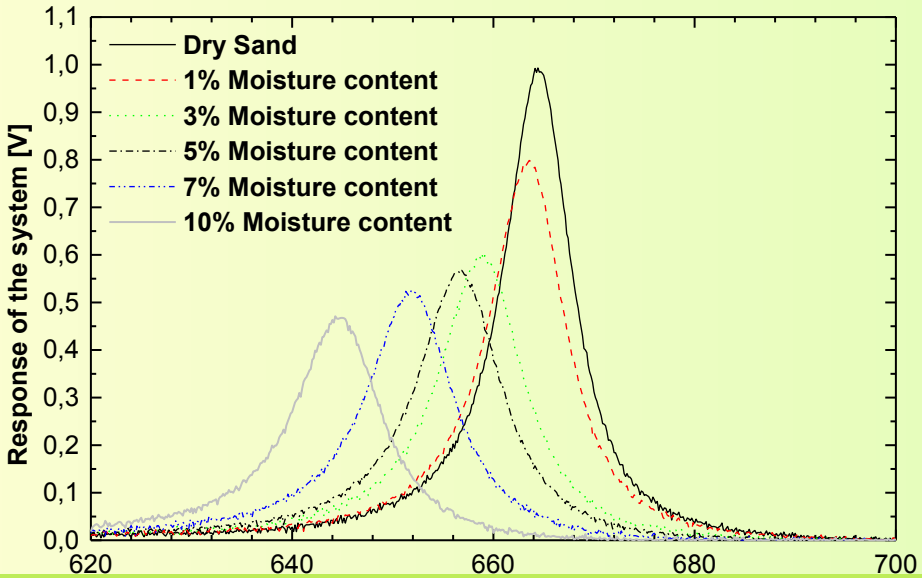
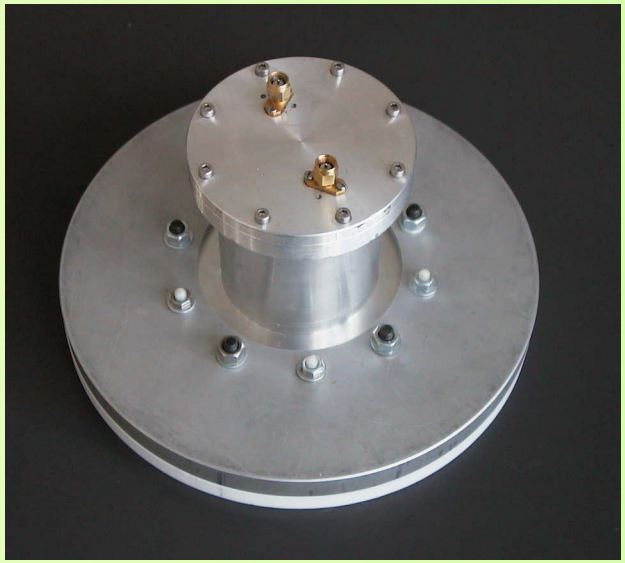


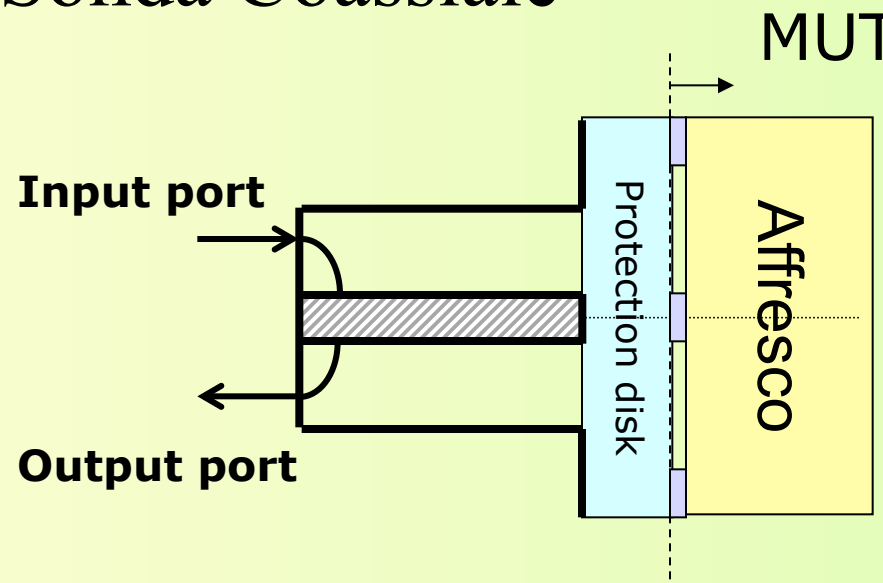


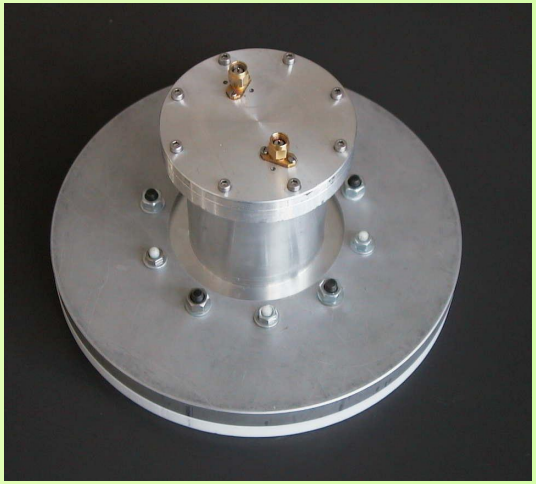




Pareti Affrescate

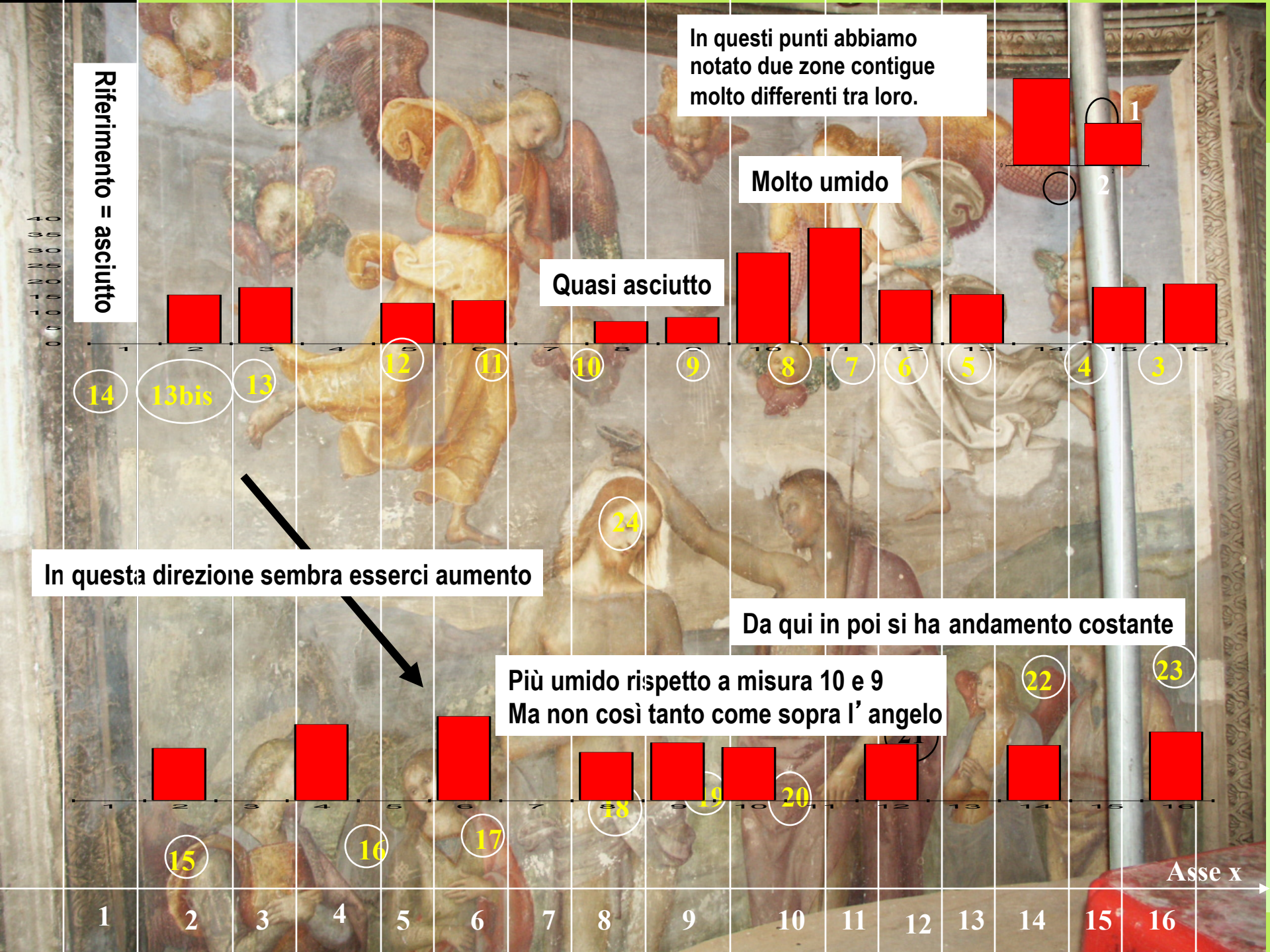
- Sonda Coassiale





Misura di frequenza e banda

'Mappatura' con scostamenti rispetto ad un valore di riferimento (dovuti in prima istanza a contenuto di umidità)


Riferimento = asciutto
In questi punti abbiamo notato due zone contigue molto differenti tra loro.
Molto umido
Quasi asciutto
In questa direzione sembra esserci aumento
Da qui in poi si ha andamento costante
Più umido rispetto a misura 10 e 9
Ma non così tanto come sopra l' angelo
Asse x
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
13bis

La “compatibilità” elettromagnetica

public health

Research intensifies as the public grows wary of one of its favorite communications tools

Are mobile phones safe?

A MOTORIST USING A wireless telephone might be worried about having an accident, even while being reassured that if one were to happen, he or she could call for help. Recently some scientists and lay people have expressed alarm at another possible danger—that the use of mobile phones itself may harm the user's health, perhaps even causing cancer.

There is good reason to be concerned. The widespread use of hand-held mobile phones means that many people routinely place radio frequency (RF) transmitters against their heads—in some European and Asian countries, a majority of the adult population does so. That fact alone would warrant examination of the safety of this form of radiant energy.

Concern about the possibility of mobile phone's ill effects on health took shape in mid-1992 in a U.S. court. A lawsuit filed in Florida by David Reynard alleged that the use of a cell phone had caused his wife's fatal brain cancer. The suit was dismissed by a Federal court in 1995 for lack of valid scientific evidence, and similar suits since have been no more successful. But they have raised questions for which no entirely satisfactory answers existed at the time they were filed.

KENNETH R. FOSTER
University of Pennsylvania
&
JOHN E. MOULDER
Medical College of Wisconsin

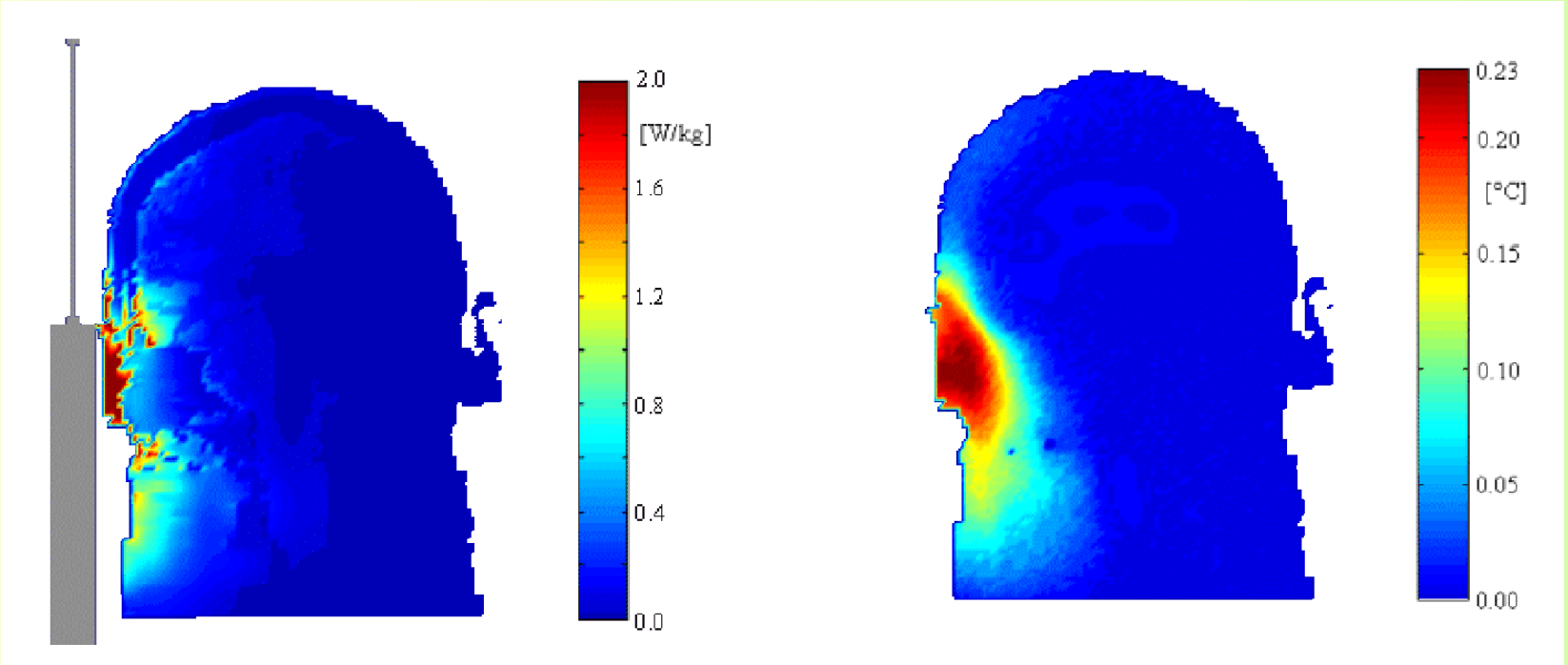
PHOTOGRAPH: ROBERT LEWIS

0018-9235/00/$10.00©2000 IEEE

Antenne per telefonia mobi

Esposizione al telefonino

SAR e riscaldamento indotto
f = 900 MHz, P_{rad} = 600 mW



In questo caso la sorgente è sicura se il SAR massimo prodotto è minore di 2 W/kg (valore medio su 10 grammi)

Monitoraggio delle sorgenti di campo elettromagnetico sul territorio

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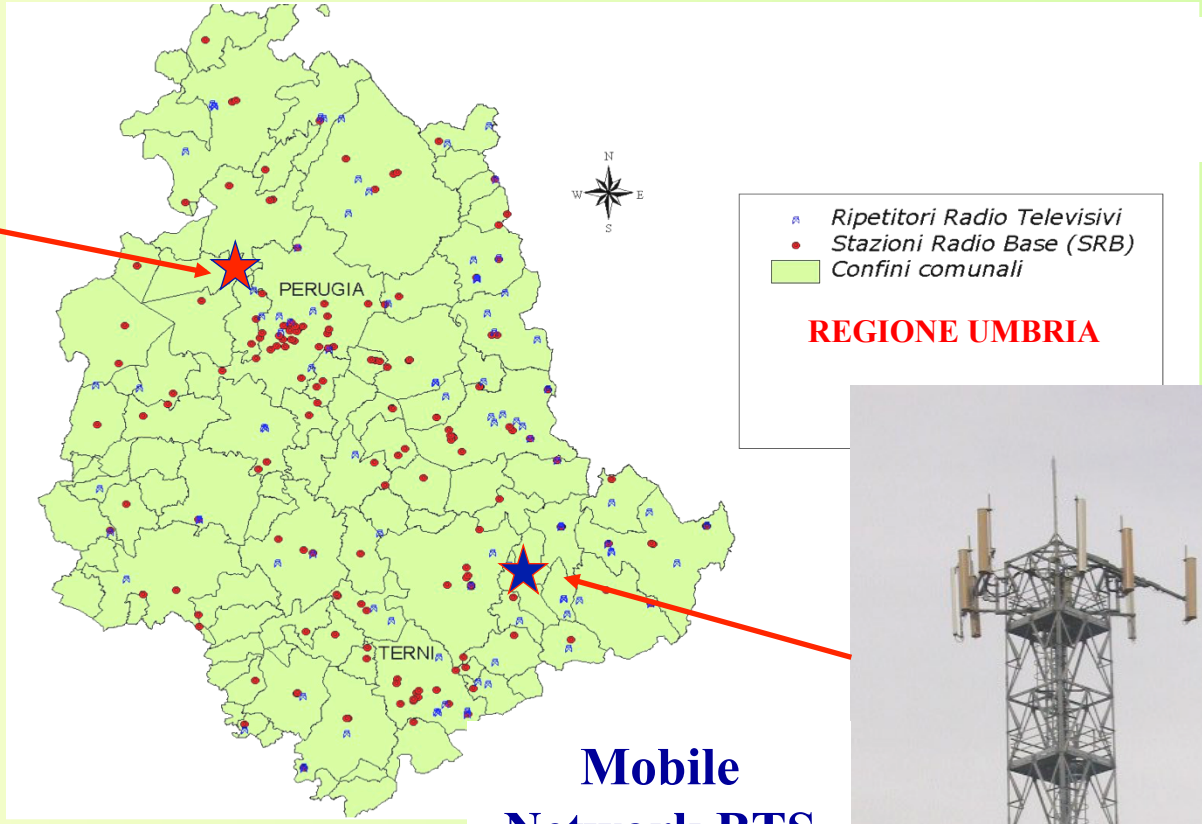
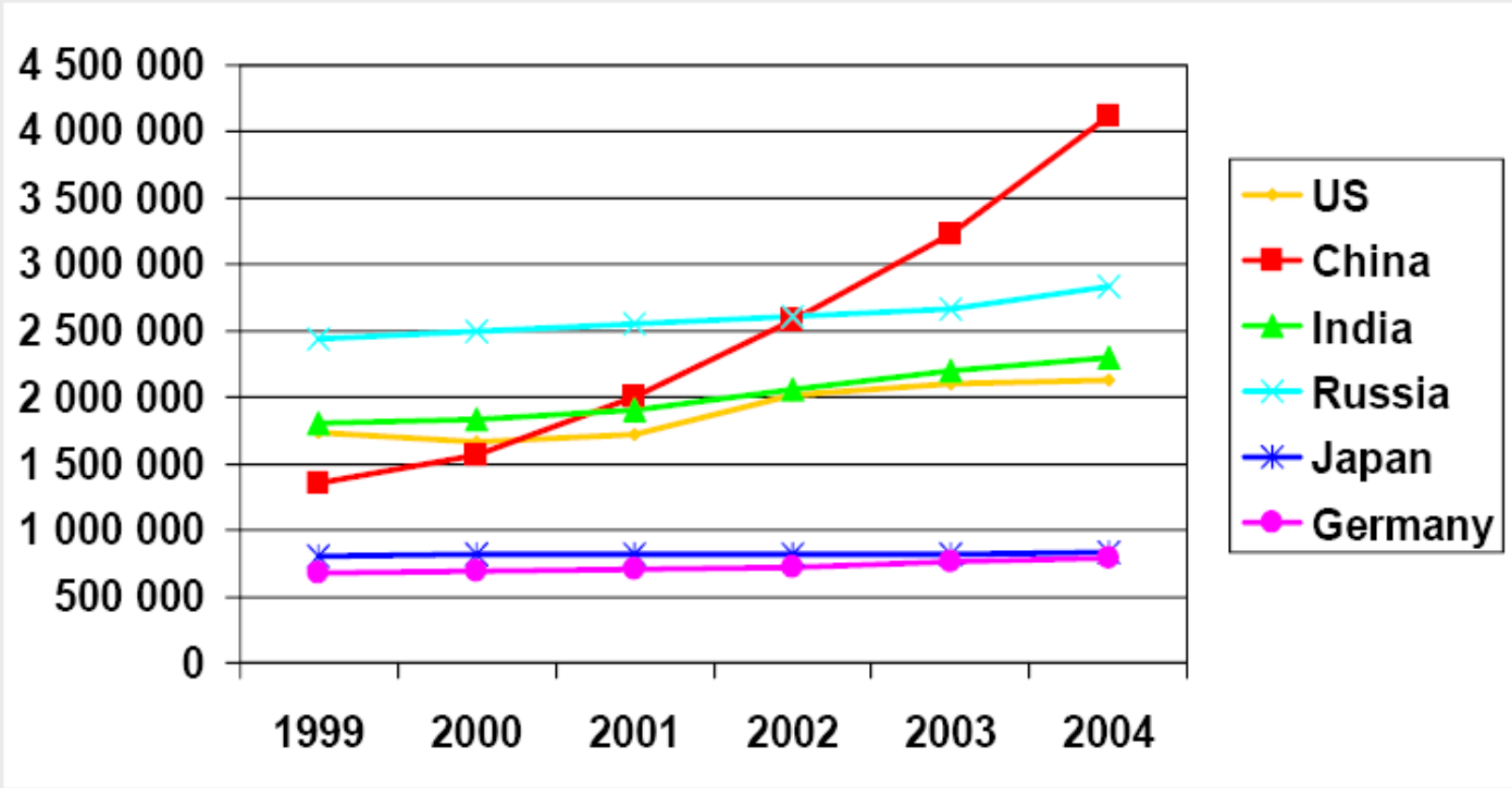
Radio – TV Network BTS



Mobile Network BTS

Applicazione ad un caso reale: area urbana di Foligno. Ottimizzazione di due SRB di un nuovo gestore

Number of students enrolled in technical oriented tertiary education



Source: Own calculations based on UNESCO and UNCTAD (2006)

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Wireless is intelligence!

- Wireless systems are usually complex
- Knowledge and competence are ***essential***
- Phy layer determines performance
- European engineers are excellent on complex systems

- Wireless fits well in the European technology landscape!

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Radio
a cornerstone in the modern society

Ulf Wahlberg
vice president, Industry and Research Relations
Ericsson

ERICSSON
TAKING YOU FORWARD

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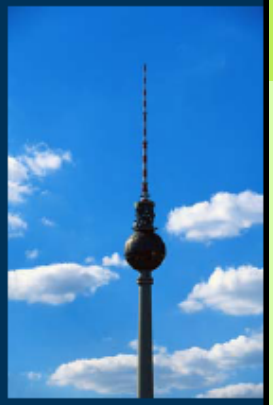
radio & microwave in our everyday life



- public mobile communications – GSM, WCDMA, …
- public broadcast – radio, TV
- short range communications – wLAN, cordless phones
- very short range – **rfid**, PAN, Bluetooth, UWB
- private mobile radio – TETRA, dispatch systems
- fixed links – telecom backbone networks
- radar – from defense to mass market
- sensor networks
- focused heating, as microwave ovens

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Mobile communications

- the success of mobile communications is well-known
- penetration in Europe is close to 100 %
- European wireless infrastructure OEM has more than 60% of world market
- European wireless handheld OEM has more than 50% of world market
- essential enablers for the European success were ***competence & knowledge*** and the European ***coordination in standards and research***

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use of radio & microwave will increase

- extended use of mobile communications
- Road Traffic Information, communication & management
- sensors, sensor networks
- health care
- RFID
- radar (automotive)
- …

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Multi-Access Terminal of the Future

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Europe radio & microwave environment

sustainable growth needs

- basic and applied research
  - which will attract new talented students
- education
- ➔ skilled engineers
- creative technology environment

Required Energy for Basestations in 2010 in Germany

- **3300 GWh in 2010**
- **This is 50% of the small Nuclear Power Plant Isar 1 (6200 GWh)**
- **This is 100% of the big Water Power Plants**
  - **Altenwörth (1970 GWh) and Greifenstein (1720 GWh)**

- Urgent need for Basestations with improved efficiency

GALLILEO

INMARSAT-4

SPACE

SAR-LUPE

METOP

SAAB

THz technology
Detection of hidden weapons

SAAB

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IC solutions and prospects for RF & microwave markets in Europe

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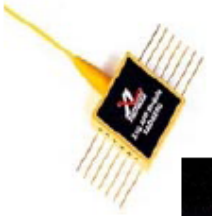
OMMIC, Paris, France

OMMIC : Europe's Independent III-V Foundry

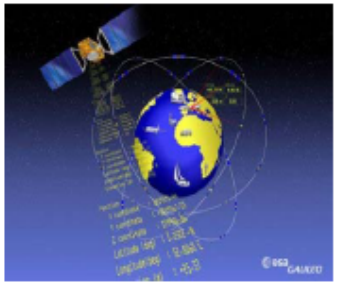
High added value RF and microwave markets requiring III/V technologies: linearity, NF, PAE, fmax

- **WIRELESS TELECOMMUNICATION INFRASTRUCTURE**
  - Cellular Base Stations : Very Low Noise Amplifiers
  - Millimetre Wave Links : LMDS - BWS

- **OPTICAL NETWORKS :**
  - 2.5 -10 - 40 Gb/s interfaces

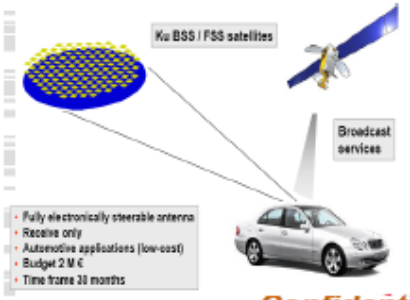


- **SPACE /DEFENSE :**
  - -Space payload and ground based
  - Wide band systems



- **SECURITY**
  - Microwave imaging

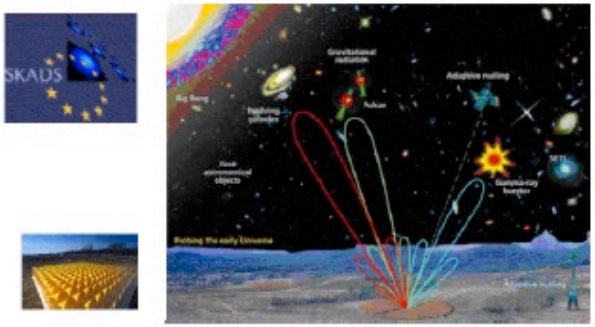
- **AUTOMOTIVE**
  - Mobile Internet



A case study : Electronically Steerable Antennas

Military Radars

Earth Observation



Radio Astronomy

Mobile Applications

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Synergy and conclusion

- Our goal is to be at the industrial state of the art
- We only need business focussed R&D projects
- We have to set up common R&D teams and avoid fragmented projects with internal competition
- We need to promote new generations of R&D engineers and researchers in the fields of microelectronics

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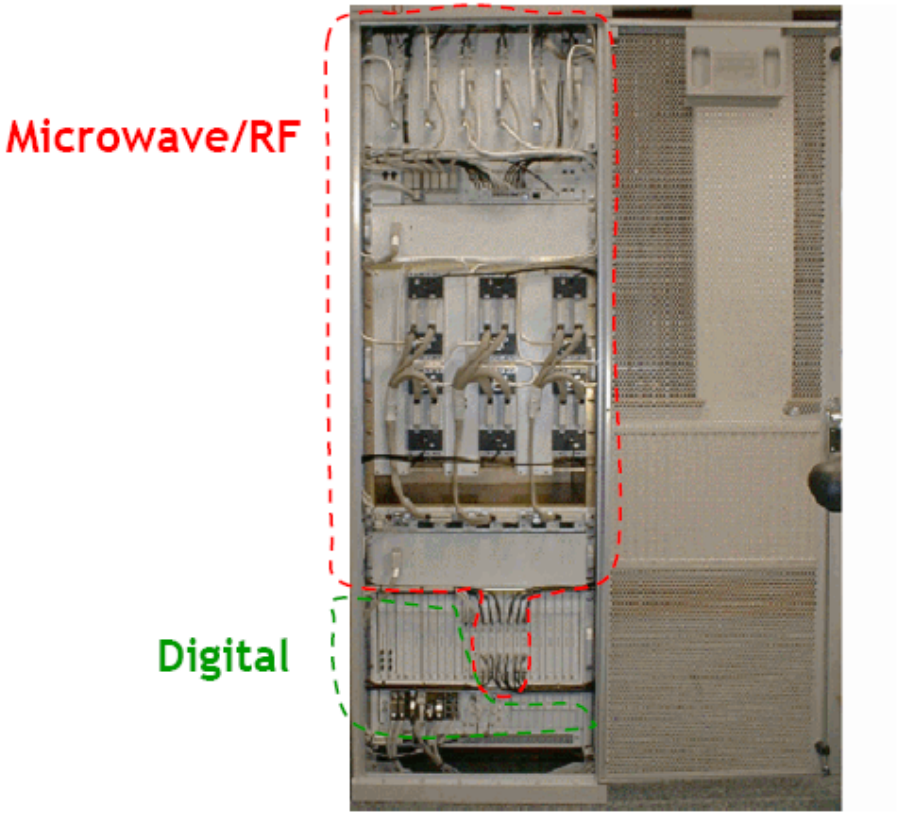
Future Challenges in R&D with respect to mobile communication basestations

European Microwave Interest Group

Dr. Georg Fischer, CMTS
Bell Labs Research, Europe
Brussels, January 2008

Microwave and mobile communication

Microwave dominates the basestation!



Microwave dominates the basestation – form factor and cost wise - not digital!

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What is our problem?

Cost structure of BS dominated by microwave

RF/Microwave

Moore's law

	Percentage of total MOC by functional block					
Detailed Category	1C	2C	3C	4C	5C	6C
Filters	21%	16%	13%	10%	9%	8%
Amplifier	20%	30%	37%	39%	43%	47%
RADIO & Digital Radio Signal Processing	53% 12%	55% 9%	58% 8%	61% 12%	63% 11%	64% 9%
Clock & Timing	5%	3%	3%	2%	2%	2%
Channel Element Processing	7%	10%	13%	13%	15%	16%
Call Processing + Controller	3%	2%	2%	3%	3%	2%
Network Interface	2%	1%	1%	1%	1%	1%
Power Converter	1%	1%	1%	1%	1%	1%
Physical Housing	9%	7%	6%	5%	4%	4%
Digital Module Interconnection	13%	10%	8%	7%	6%	5%
CABLES	3%	3%	2%	2%	2%	1%
Heat Disipation	3%	6%	5%	4%	4%	3%
MISC.	1%	1%	1%	1%	1%	1%
	100%	100%	100%	100%	100%	100%

Source: Steve Wilkus

Around 60% of basestation cost by RF/Microwave!

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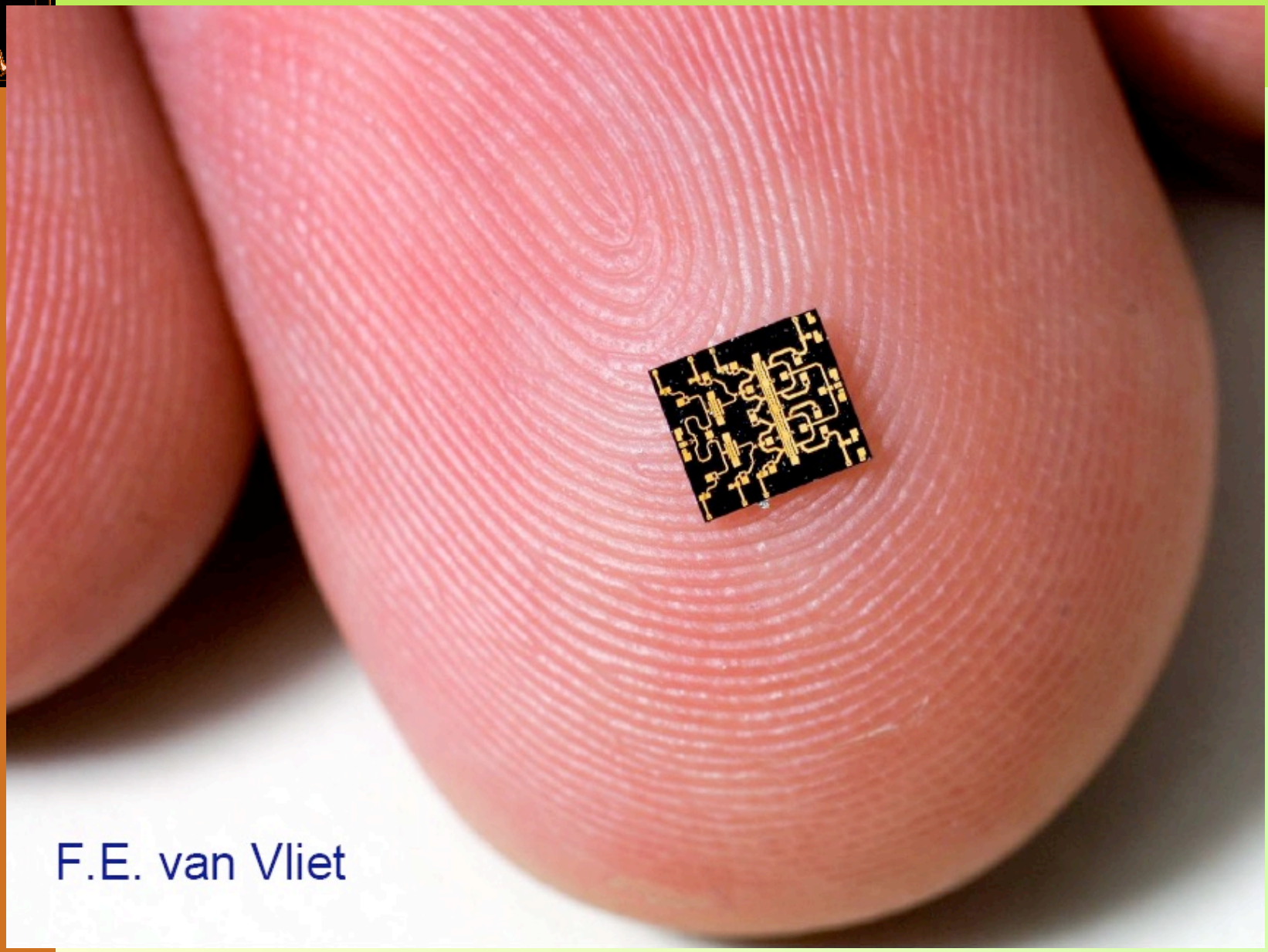
SWOT: Microwaves in Europe

- **Strengths**
  - Scientific strength at world level
  - Strong industrial track record (GSM...)
- **Weaknesses**
  - Academic/industry interface not functioning well
  - Low-levels of EU funding to support research
- **Opportunities**
  - Huge growth in wireless applications driven by demand for ubiquitous personal broadband
  - Mm-wave -> THz
- **Threats**
  - Decreasing number and quality of RF engineers
  - Loss of technical leadership in Europe
  - 'Big Science' dominating


F.E. van Vliet

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Microwaves in Europe - the status

Strengths

- Diverse, creative research environment, good EU-level networking
- More emphasis on civilian, globally marketable products (cf. to US)

Weaknesses

- University/public research significantly underfunded
- Political emphasis on funding topics with short-term appeal (BSE, bird flu, now global warming ..)

Opportunities

- Strong position in markets with high microwave technology demands: mobile communications, automotive, civilian aircraft

Threats

- Insufficient interest of European students in a career in microwave engineering
- The “microelectronics is something you buy in Taiwan” attitude
- East Asian countries are rapidly catching up (Taiwan, Korea - strong microwave IC programs)

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