

# **The Brain is not a Radio Receiver for Wireless Phone Signals: Human Tissue does not Demodulate a Modulated Radiofrequency Carrier**

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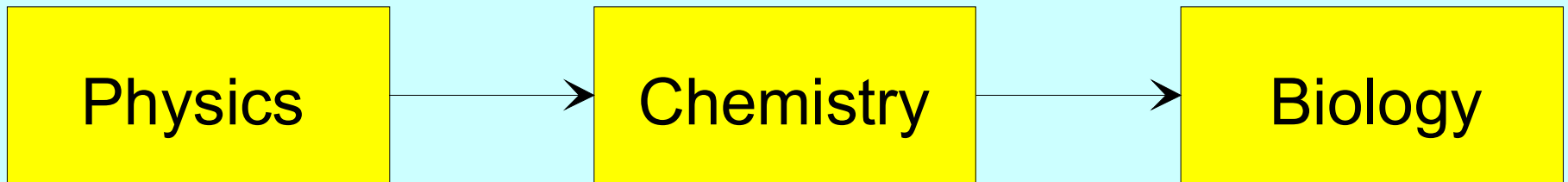


# SUMMARY

- If Radiofrequency radiation produces biological effects, there must be mechanisms – **Effects have Causes**
- RF and microwave exposure
  - Mechanisms
- Does your wireless phone heat your brain?
- Can tissue demodulate RF?
- The Q Experiment
- Conclusions



# The Interaction Sequence



You cannot get a biological effect without precursor chemistry and physical interaction

Jim Weaver, MIT



# WHAT ARE THE PHYSICAL INTERACTION MECHANISMS FOR RF INTERACTION WITH TISSUE?

- Heating, mostly from dipole relaxation, some ohmic heating
- Ion motion - ions have too much inertia to follow the rapidly oscillating RF field
  - At 1 GHz motion amplitude is smaller than an atomic nucleus
- Direct excitation of energy states - only possible for rotational energy states, which relax very quickly and provide only a heating effect
- Breakage of chemical bonds - not possible because the photon energies from RF radiation are too small. The weakest bonds are hydrogen bonds and their strength corresponds to about 1000 RF photons
- Low frequency electromagnetic fields can move ions around

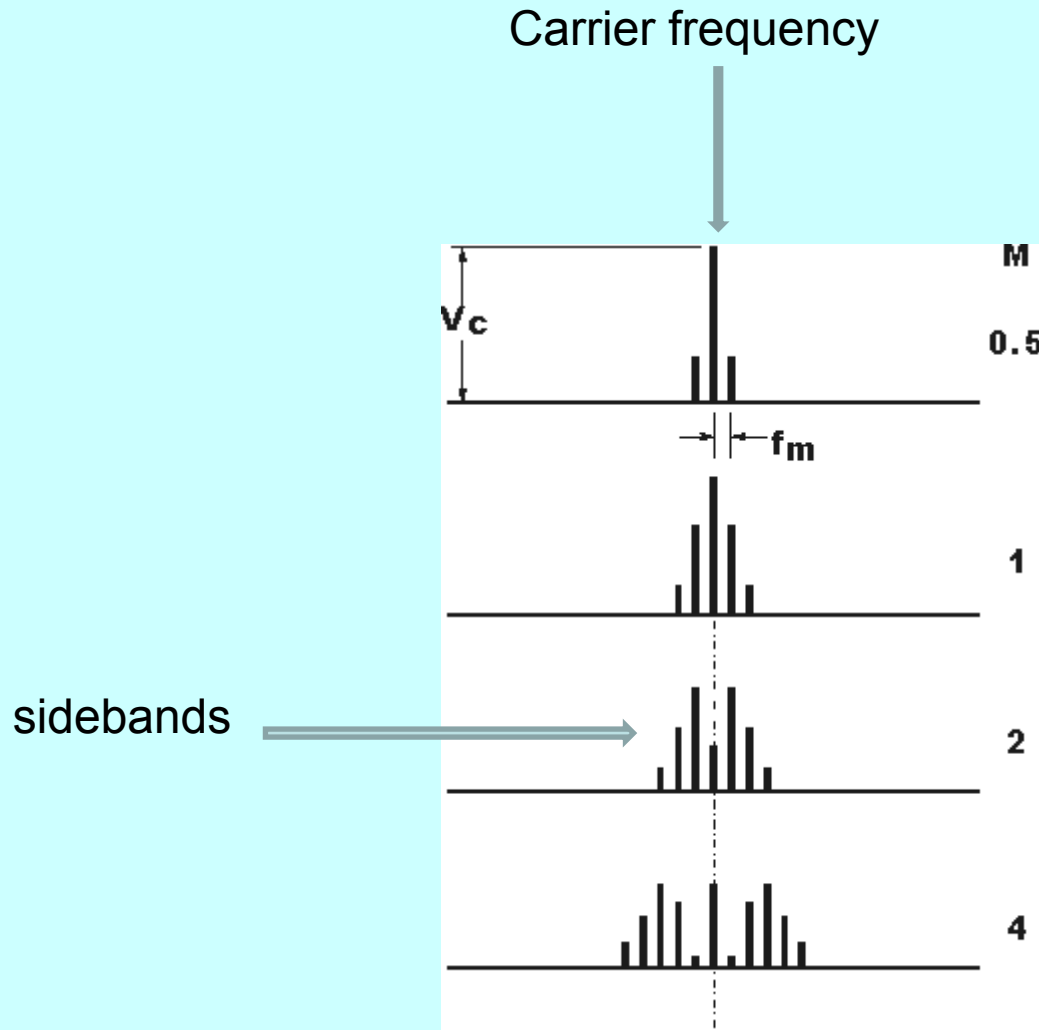


# SOME FREQUENCIES INVOLVED

- 825MHz-845 MHz UPLINKS (AMPS, TDMA, CDMA)
- 869-894 MHz DOWNLINKS
- 935-960 MHz GSM
- 1800-2000 MHz PCS, GSM

**Wireless phones antennas do not emit low frequencies, only an RF carrier with sidebands**

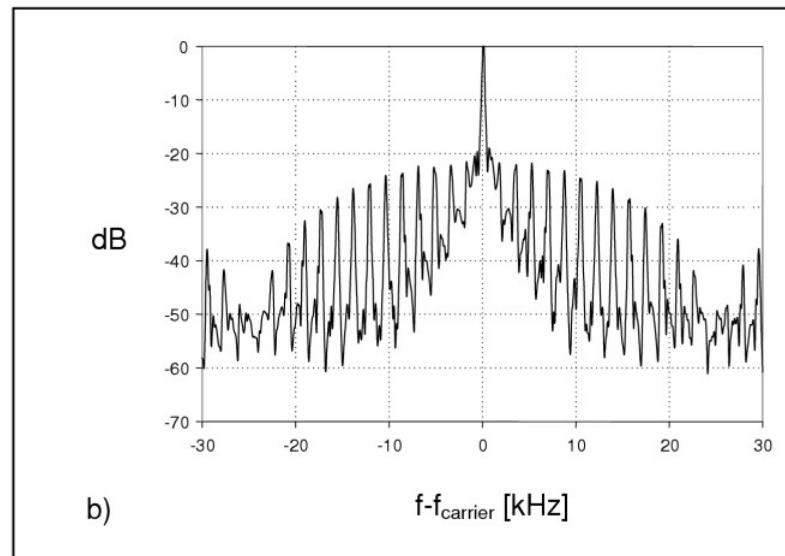
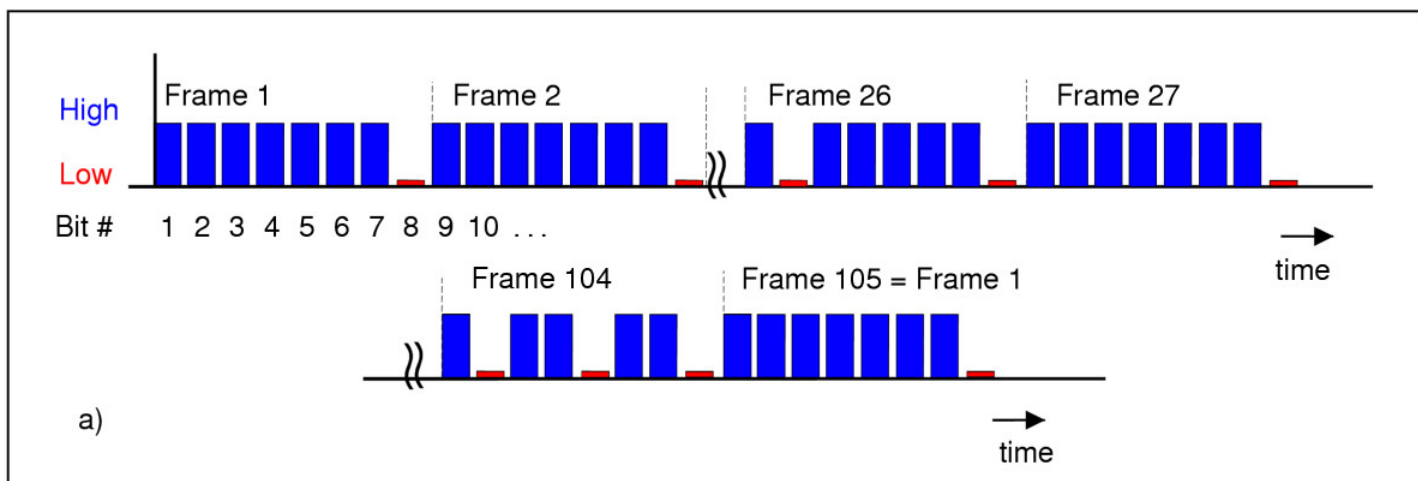
# FM Spectra at different modulation depths



For voice transmissions there are only RF signals separated from the carrier by voice frequencies

<http://www.radio-electronics.com/info/rf-technology-design/fm-frequency-modulation/fm-spectrum-02.gif>

# Spectrum of a GSM signal



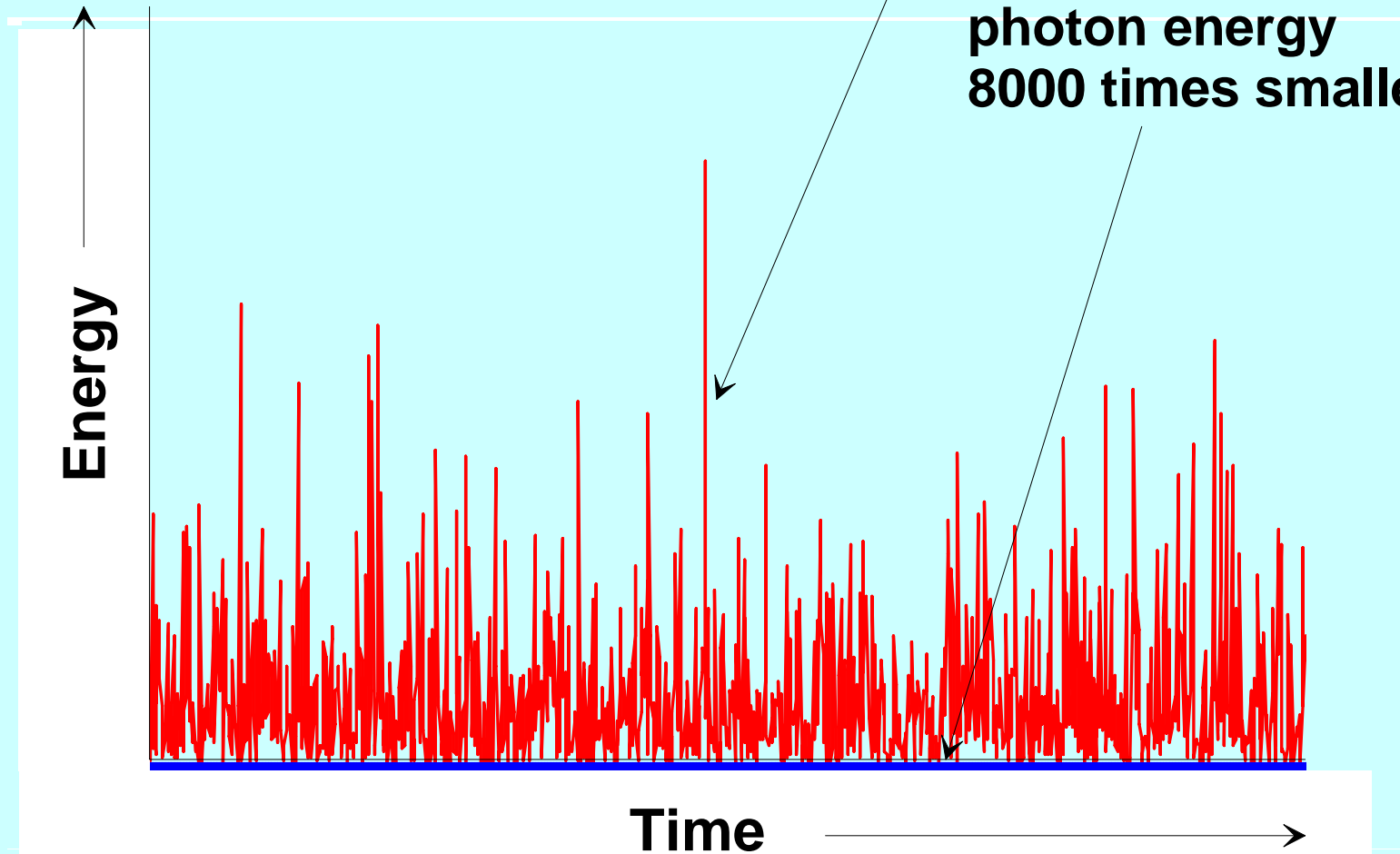




# RF photons have tiny energies

**Thermal energy  
fluctuations**

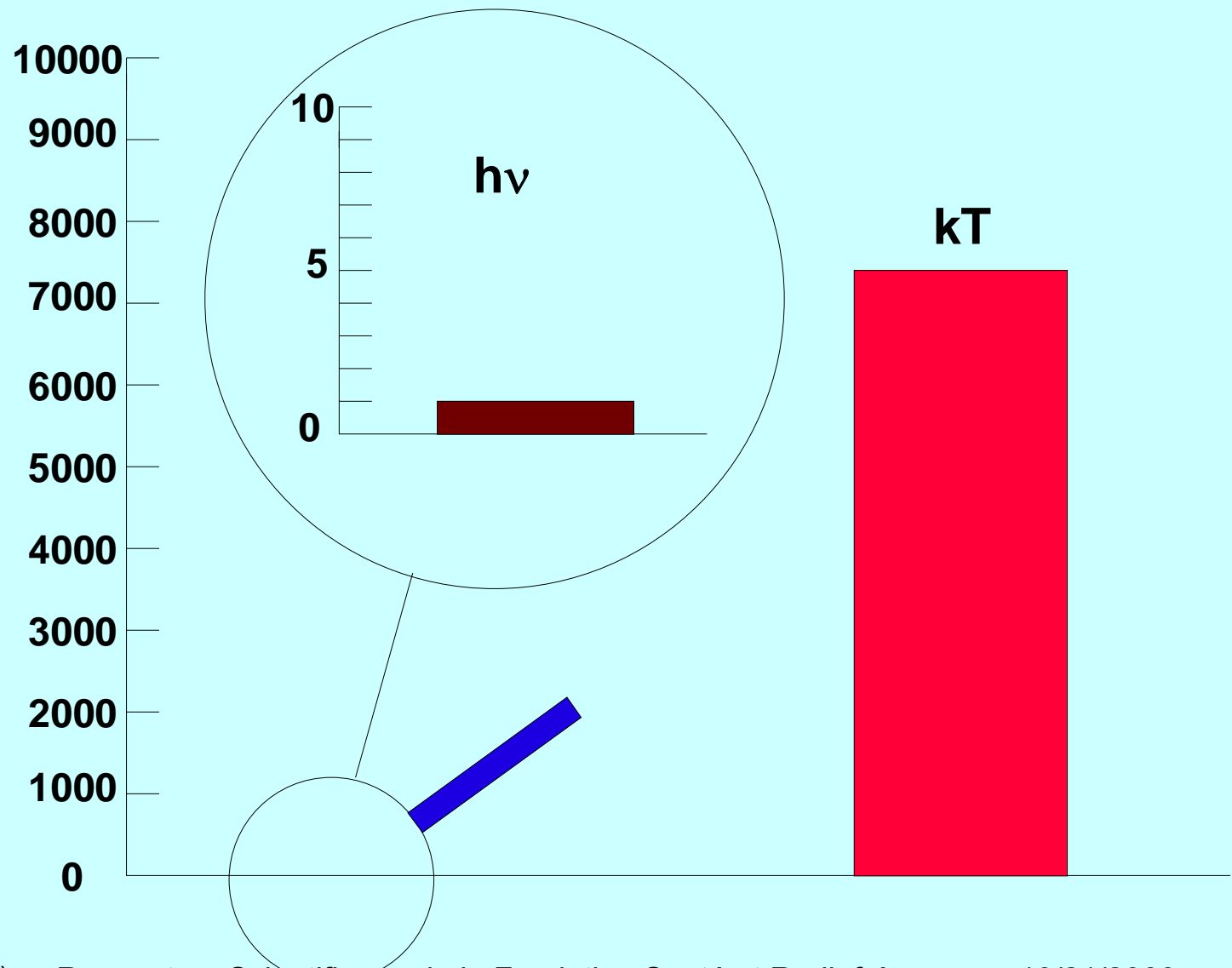
**Wireless phone  
photon energy  
8000 times smaller**





# Wireless Phone Photon Energy Relative to kT

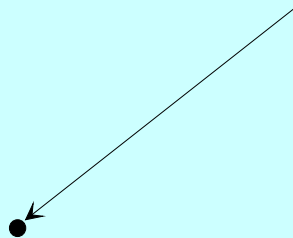
Energy relative to Wireless Phone Photon

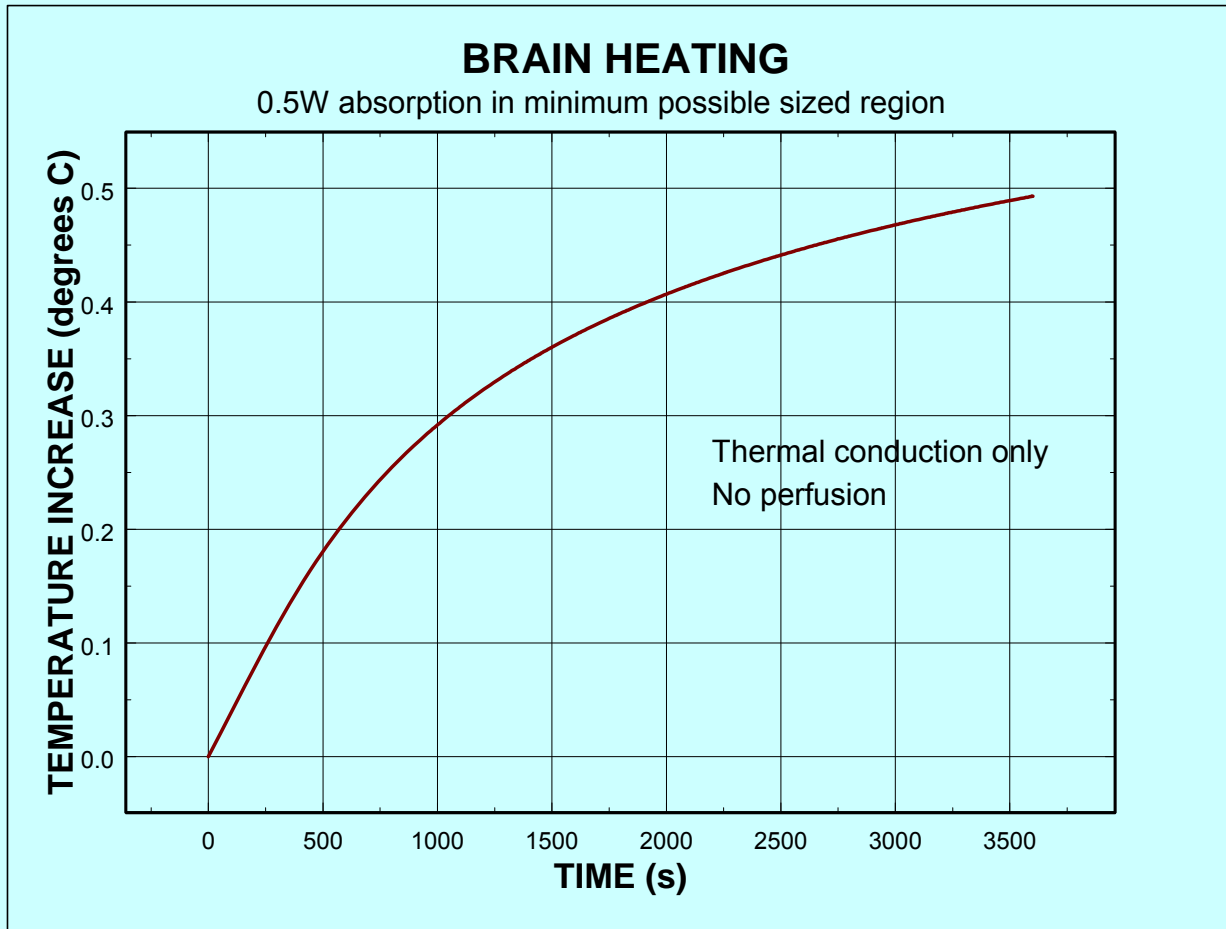


## Comparison of photon energies



Low energy  
photon from  
wireless phone





Calculated  
maximum  
increase in brain  
temperature at  
800 MHz w/o  
blood perfusion

Several theoretical studies suggest that with blood perfusion included the maximum temperature increase anywhere in the brain is  $\sim 0.1^{\circ}\text{C/W}$




# ATHERMAL MECHANISMS?

- Raised as an issue by those who want to explain supposed “bioeffects” for which there is no rational explanation
- Cannot be incorporated into safety standards because there is no accepted dose-response relationship
- What is “athermal”? Is it a process where temperature elevation is below 1°C? 0.1°C?



# A Possible Athermal Interaction Mechanism?

- Can tissue demodulate the low frequencies on an RF carrier?
  - low frequencies in tissues can be biologically active
- Would imply tissue nonlinearity – the tissue acts like a diode 
- If so the tissue should also generate the second harmonic



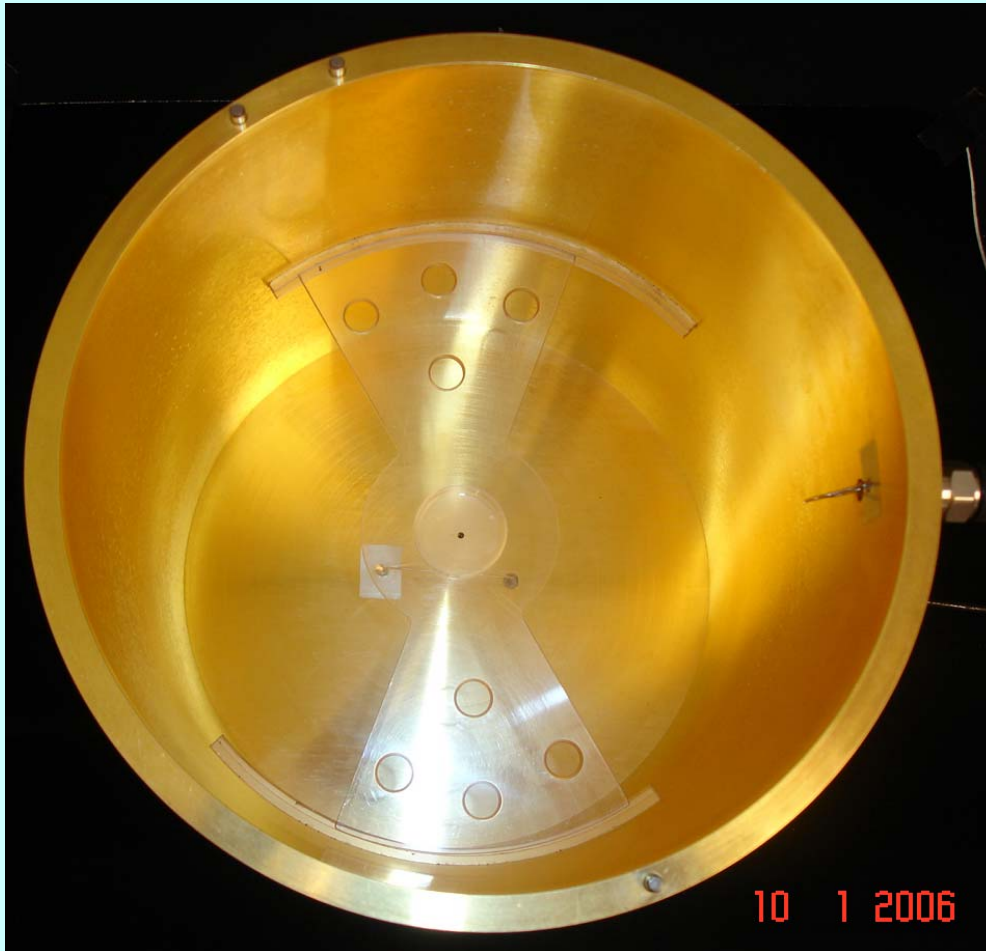
# The “Q” Experiment

- Implementation of Quirino Balzano’s (Q) Method
- Measurement of the demodulation response of biological cells exposed to a 900 MHz signal by observing the second harmonic at 1800 MHz.
- Expose a sample to the fundamental frequency energy in a cavity and use a spectrum analyzer to detect the second harmonic

Quirino Balzano, Vildana Hodzic, Robert W. Gammon, and Christopher C. Davis, "A Doubly Resonant Cavity for Detection of RF Demodulation by Living Cells," *Bioelectromagnetics*, 29, 81-91 (2008)



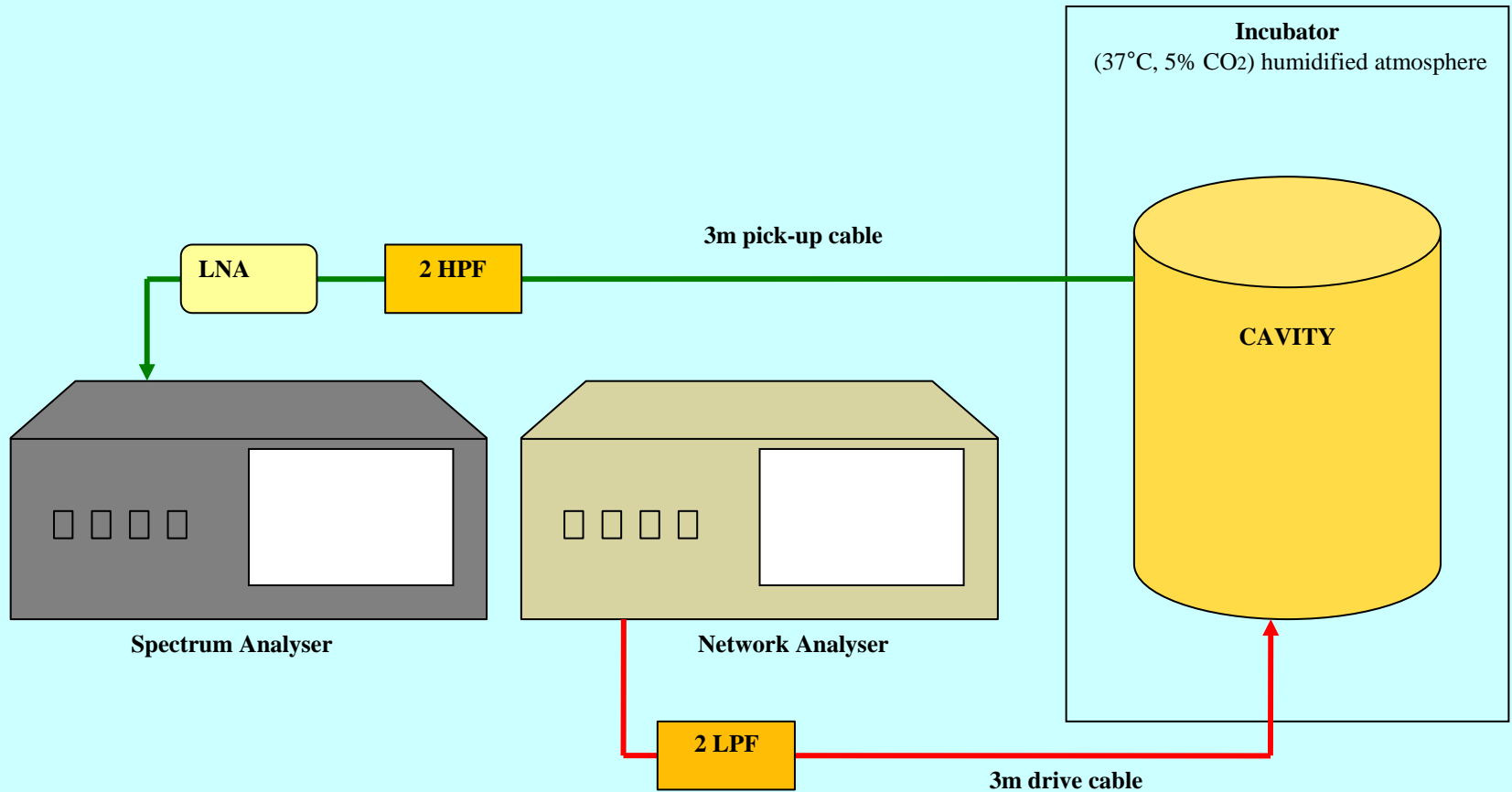
# Microwave Cavity to Search for Cell Nonlinearity



- One of two made at the University of Maryland.
- Radius = 12.35 cm
- Length = 27.22 cm
- Unloaded Q = 41000
- Dominant modes  
 $TE_{111} = 900\text{MHz}$ ,  
 $TE_{113} = 1800\text{ MHz}$



# Test Setup

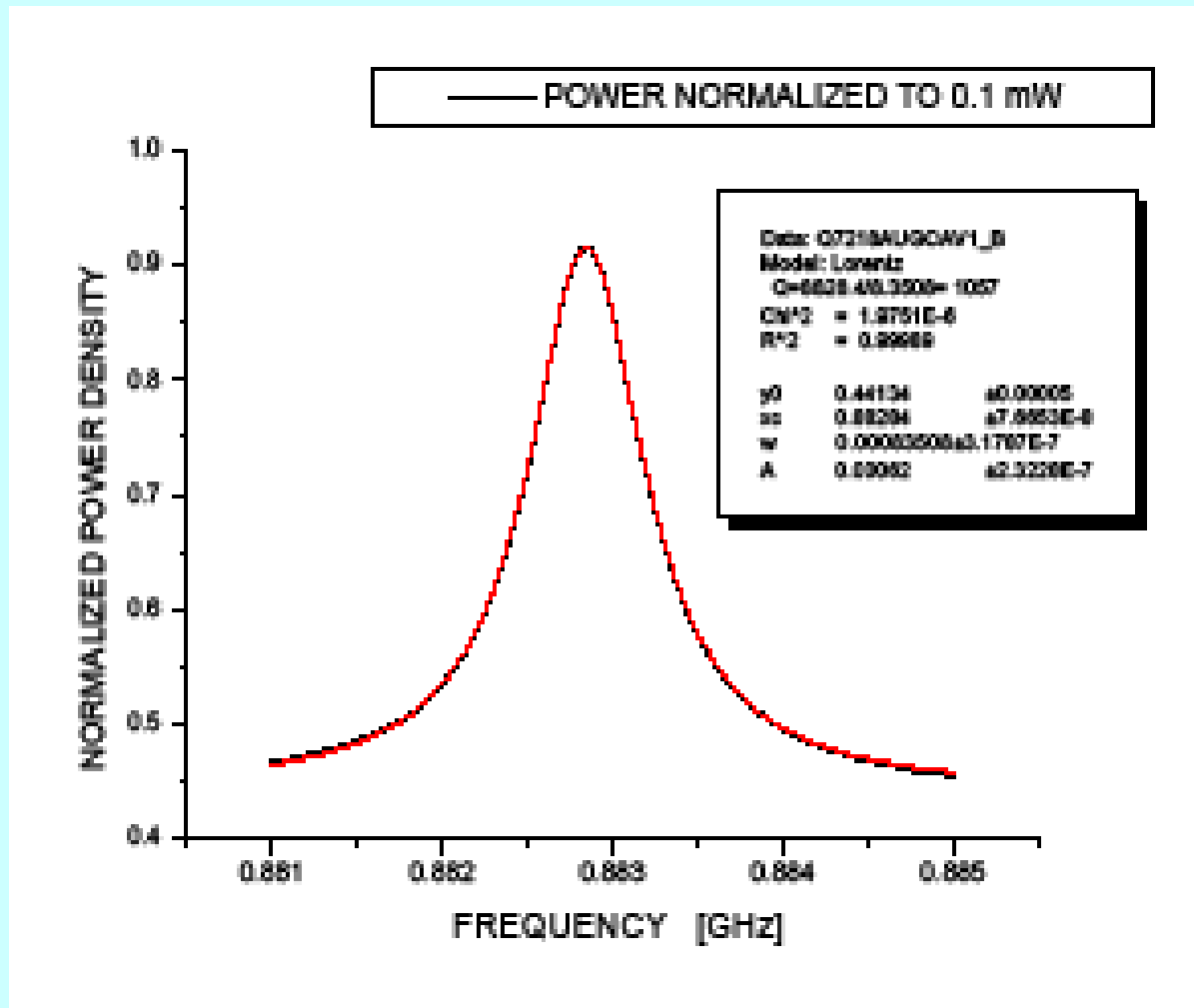




# Testing Procedure

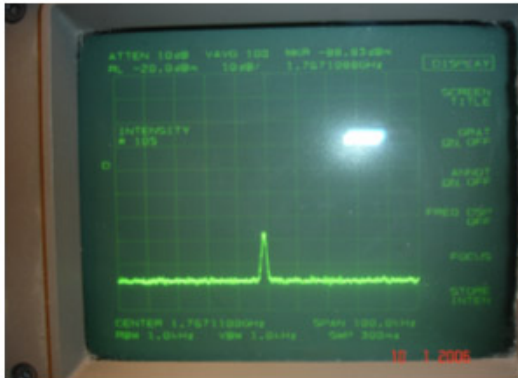
1. Test the resonance of the empty cavity
2. Test of the cavity with the empty sample holder placed within, followed by the addition of a Petri-dish
3. Control testing of non-biological liquids, e.g. nutrient solution
4. Testing of second harmonic generation using a Schottky diode
5. Testing of the cavity with the biological samples inserted

# Resonance Curve Lorentzian

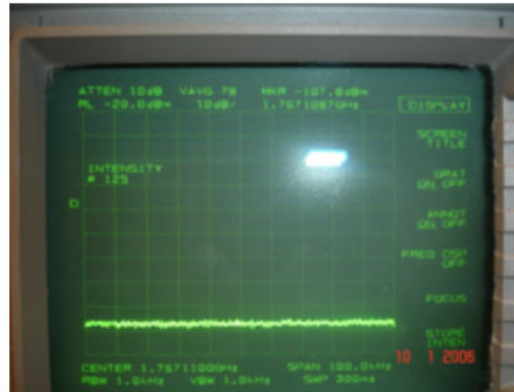




# Non-Linearity Test – Schottky Diode Measurements taken at the University of Maryland



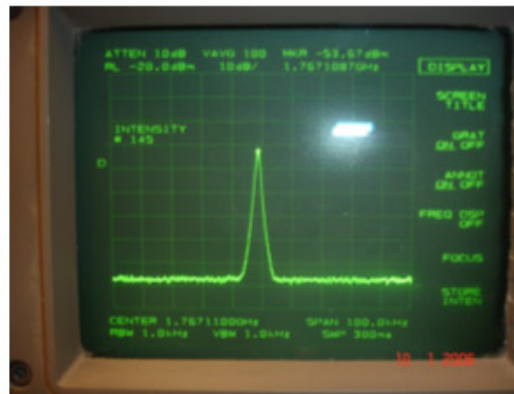
Second harmonic response of diode in normal configuration



Second harmonic response of diode at 90°



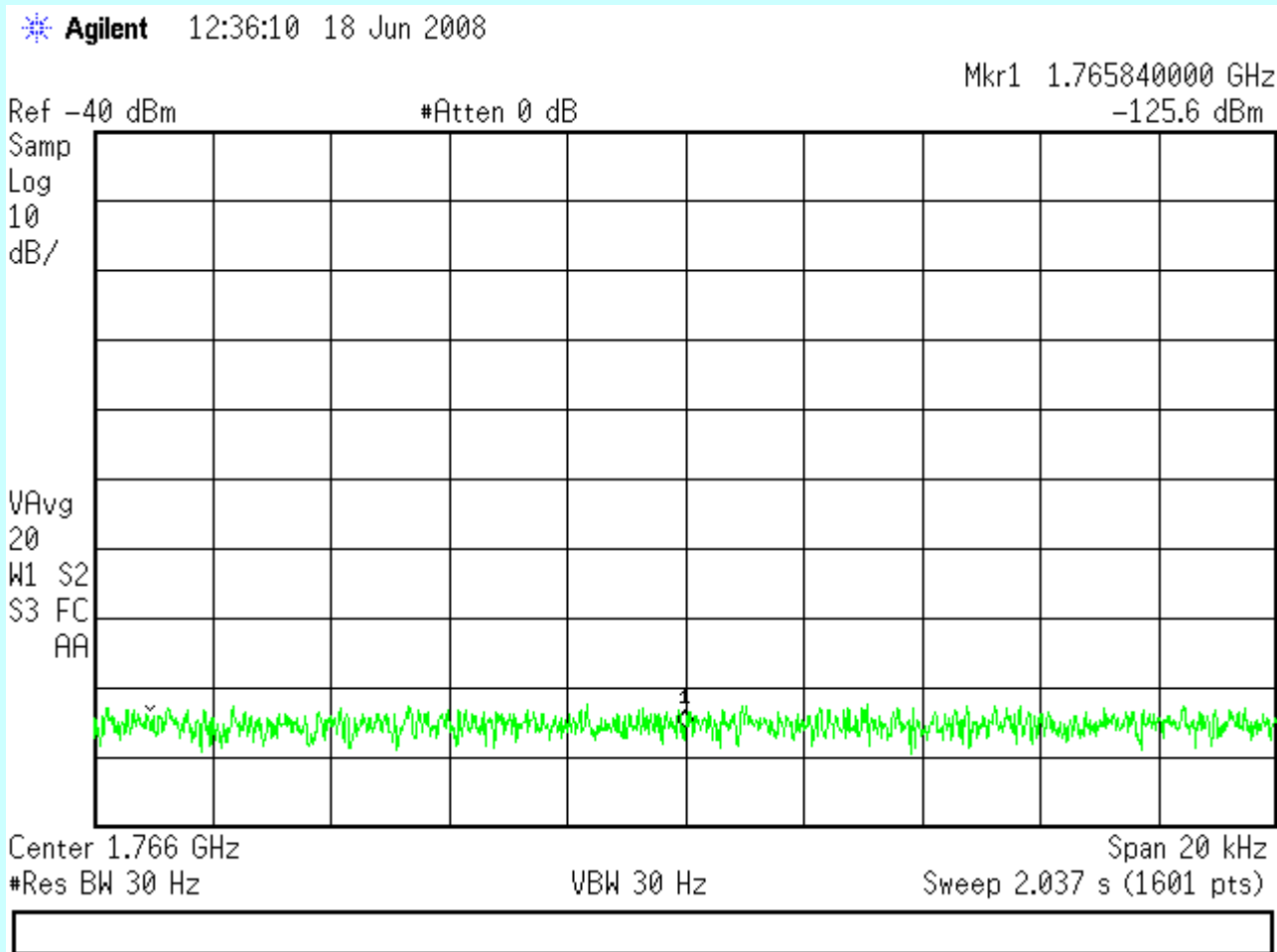
Second harmonic response of clipped diode with 0 length legs.



Second harmonic response of extended diode legs.

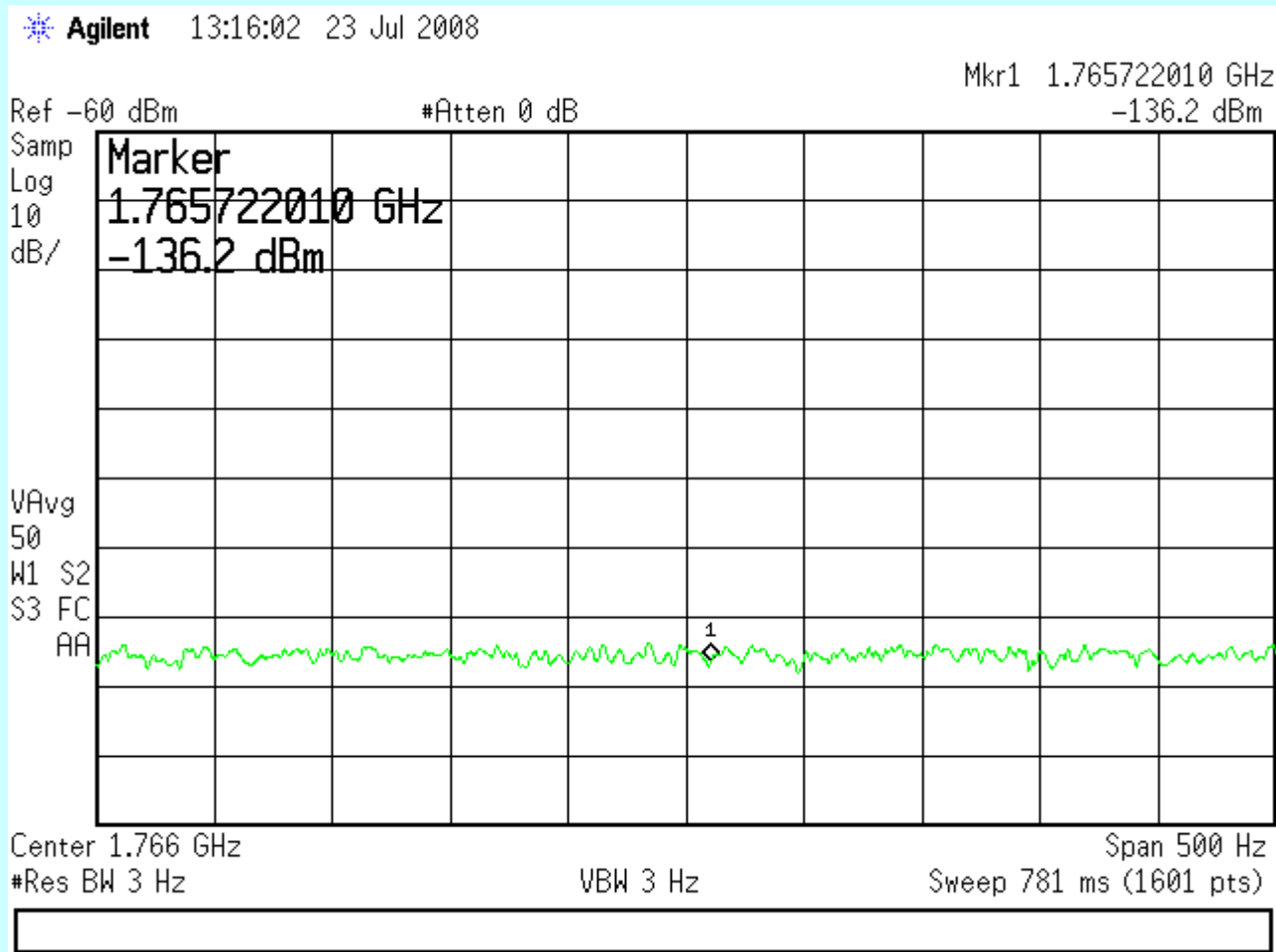


# Cell Response (1mW)





# Cell Response (0.1 mW)



# Cell testing – cavity inside incubator



- 1 million human fibroblast HF19 cells tested when placed within the cavity
- Cavity placed within incubator and heated to 37°C and CO<sub>2</sub> set to 5.0
- Other cells tested:
  - 0.5 million IMR-32 (undifferentiated human neuroblastoma with 25µl media)
  - 1 million IMR-32
  - 2 million IMR-32
- 1 million IMR-32 cells heated for 16 minutes to increase temperature to 80°C
- No second harmonic observed above the noise floor (-136dBm), for all samples



# SAMPLES STUDIED

- High density cell suspensions (human lymphocytes and mouse bone marrow cells)
- Semi-confluent mono-layers of adherent cells
  - IMR-32 human neuroblastoma
  - G361 human melanoma
  - HF-19 human fibroblasts
  - N2a murine neuroblastoma (differentiated and non-differentiated)
  - CHO cells
- Thin sections or slices of mouse tissues (brain, kidney, muscle, liver, spleen, testis, heart, and diaphragm).
- Viable and non-viable (heat killed or metabolically impaired) samples were tested.





# CONCLUSIONS

- We have detected no second harmonic generation from any cells or tissue at levels down to the noise floor of our system at about -136 dBm (0.025 femtowatt) with a fundamental drive power into the cavity of 0 dBm (1 mW)
- No significant coherent rectification of RF CW carriers by individual cells or aggregates of cells found in tests
- We have used specific energy absorption rate (SAR) values ranging between 3 and 15 W/kg



**THANK YOU**

# THE GOLDEN RULES

- “The person with the gold rules”
- “This area needs more study”
- “We haven’t found anything, but with more funding we might”

