Overview

ATTACHMENT 12

- Potential Applications
- Current Exposure Standards
- AFRL/HED: THz Bioeffects Research
  - Modeling
  - Phantom experiment
  - *in vivo* experiments

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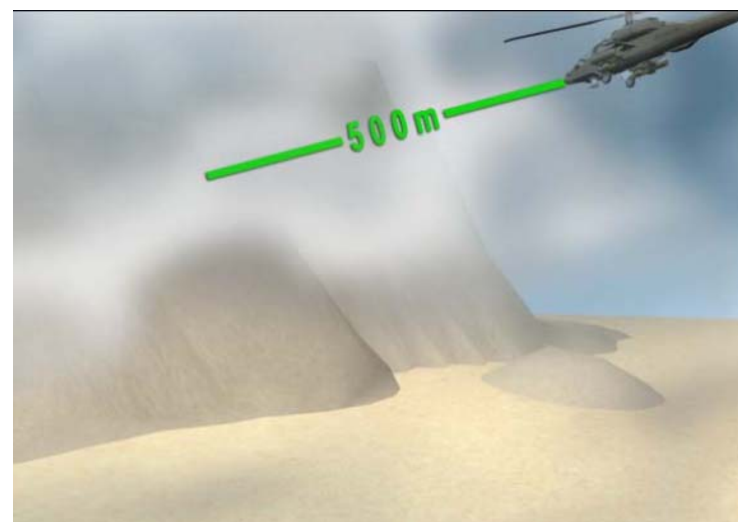
THz: Possible Applications

- **Imaging**
  - High spatial resolution
  - Through clothing, possibly walls
  - Recognition of non-metal materials
- **Communications**
  - Space
  - Plane to plane
  - High speed data links
- **All weather navigation**

Clery, Science **297** 763 (2002)



Picture courtesy of M.Rosker, DARPA

THz: Possible Applications

- Security
  - Standoff detection
  - Detection of land mines/IEDs

Pictures courtesy of M. Rosker, DARPA

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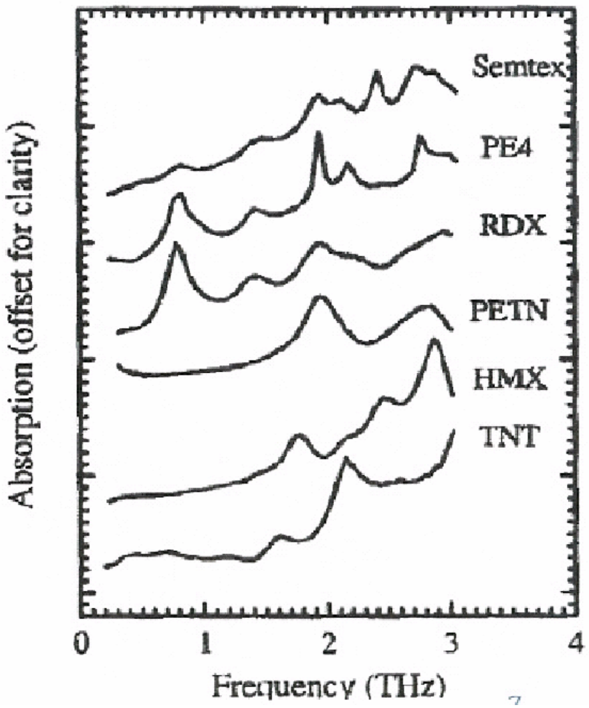
THz: Possible Applications

- **Security**
  - **Unique spectra of many materials allows for identification of substances**
    - **Chemical and biological agent identification**
    - **Explosives detection**



Kemp et al 2003, Proc SPIE 5070

THz Technology is Evolving

- Systems are being developed to use in these applications
- High power sources and detectors are being developed, expediting ability to field these systems
- Bioeffects of these high powered emissions need to be understood for the health and safety of personnel
- Bioeffects/standards efforts needs to catch up or even lead tech development to enable system fielding

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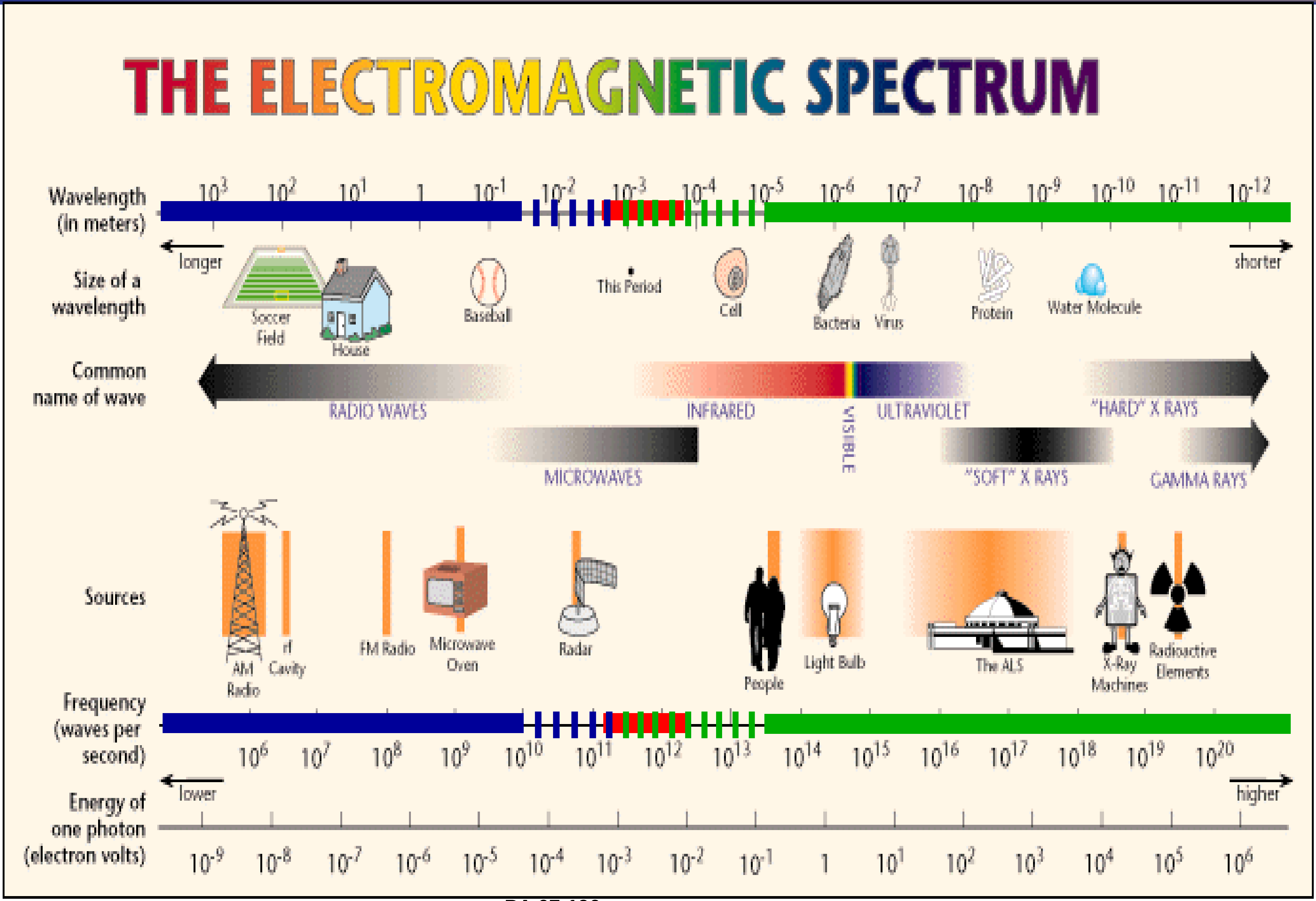
THz: Bioeffects and Standards

- Bioeffects data pertaining to the health effects of high-powered THz exposure are non-existent
- Terabridge, a consortium of European researchers, recently published an extensive report on the effects of low-powered THz emissions on biological samples
- Current human exposure standards are extrapolations from standards at other frequencies/wavelengths
- It is important to establish/validate exposure standards through empirical scientific testing
- Collecting bioeffects data to establish/validate exposure standards can take years to decades


THE ELECTROMAGNETIC SPECTRUM
Wavelength (in meters)
10^3 10^2 10^1 1 10^-1 10^-2 10^-3 10^-4 10^-5 10^-6 10^-7 10^-8 10^-9 10^-10 10^-11 10^-12
longer
shorter
Size of a wavelength
Soccer Field
House
Baseball
This Period
Cell
Bacteria
Virus
Protein
Water Molecule
Common name of wave
RADIO WAVES
INFRARED
VISIBLE
ULTRAVIOLET
"HARD" X RAYS
MICROWAVES
"SOFT" X RAYS
GAMMA RAYS
Sources
AM Radio
rf Cavity
FM Radio
Microwave Oven
Radar
People
Light Bulb
The ALS
X-Ray Machines
Radioactive Elements
Frequency (waves per second)
10^6 10^7 10^8 10^9 10^10 10^11 10^12 10^13 10^14 10^15 10^16 10^17 10^18 10^19 10^20
lower
higher
Energy of one photon (electron volts)
10^-9 10^-8 10^-7 10^-6 10^-5 10^-4 10^-3 10^-2 10^-1 1 10^1 10^2 10^3 10^4 10^5 10^6

Approach

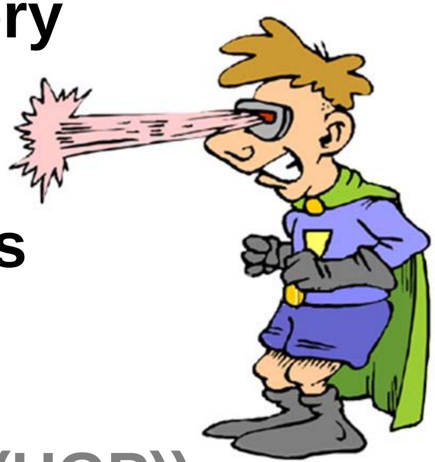
- Modeling and Simulation
  - Heat Transfer Models
  - SAR or Linear Absorption (by Layer) Source Terms
  - Single Rate-Process Model of Thermal Damage
- Experiments: Establish injury thresholds
  - Wet chamois/phantom experiment
  - *in-vivo* experiment

RHD Terahertz Team

Dr. Jill McQuade	RHDR	Physiologist: Project Lead
Dr. Bob Thomas	RHDO	Physicist: Modeling
Mr. Jason Payne	RHDR	Biomedical Scientist: Modeling
Ms. Nichole Jindra	RHDO	Biologist: Expt, GP pilot
Dr. Semih Kumru	RHDO	Physicist: Expt
Mr. Victor Villavicencio	RHDO-NG Cont	Physicist: Expt
Dr. Ron Seaman	RHDR–GD-AIES Cont	Physiologist: Expt, protocol
Mr. Alex Salazar	RHDR–GD-AIES Cont	Physiologist: Expt
Dr. Walter Hubert	RHDR	Molecular Biologist: Biotechnology

Experiments

- **Experimental Validation of models**
  - **To be performed at Jefferson Laboratory**
  - **Characterization of the beam**
  - **Exposures of wet chamois, 2 phantoms**



- ***in-vivo* Experiments (Hairless guinea pig (HGP))**
  - **Skin damage thresholds**
    - **Includes pilot study to determine histology of HGP skin**
  - **Plasma Proteomics**

Experiment #1

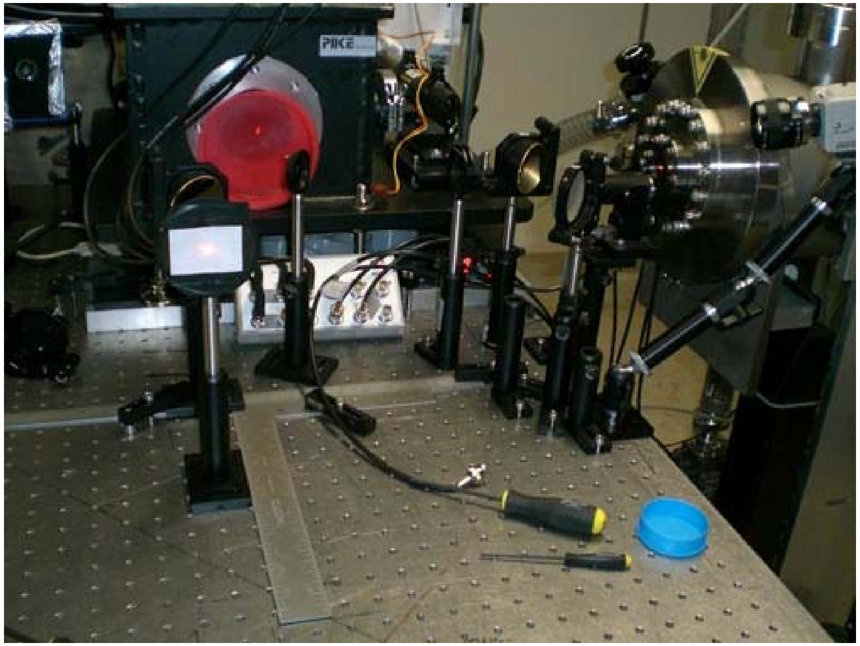
- Expose wet chamois and 2 tissue phantoms to high power THz energy
  - Phantom #1: Designed by HEDO to simulate laser effects on skin
  - Phantom #2: Specifically designed by Walker, et al to simulate THz effects on skin

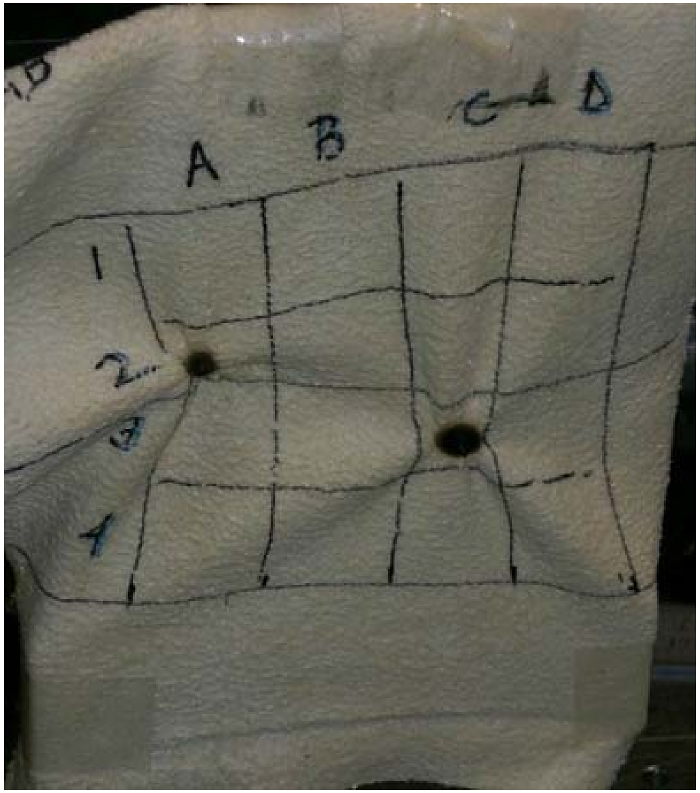
Upcoming Experiments

- Experimental Validation of models
  – To be performed at Jefferson Laboratory
  – Characterization of the beam
  – Exposures of wet chamois, 2 phantoms

- *in-vivo* Experiments (Hairless guinea pig (HGP))
  – Skin damage thresholds
    - Includes pilot study to determine histology of HGP skin
  – Plasma Proteomics

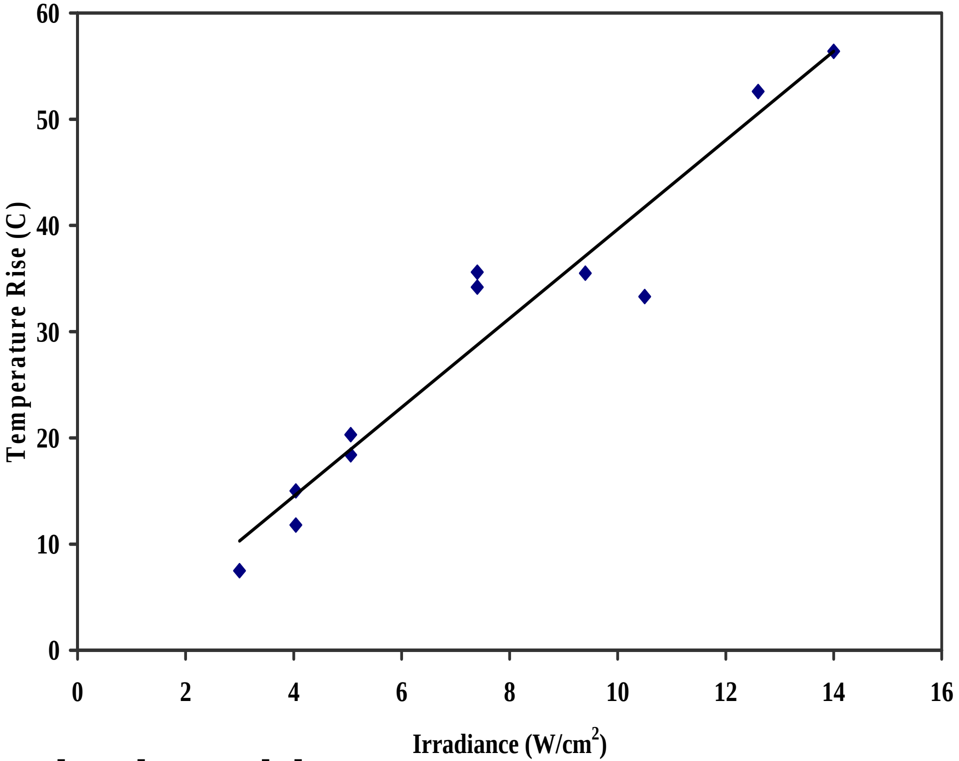
Experimental Setup





Pilot Results

- **ED_{50} (2 s exposure) chamois = 7.14 W/cm^2**
- **Model predicted 4-5 W/cm^2**



- **TX151 never had positive score**
- **Laserman: 15 second exposure at 30.7 W/cm^2**

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