Overview

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


Picture courtesy of M.Rosker, DARPA
THz: Possible Applications

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

Pictures courtesy of M. Rosker, DARPA
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
• 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 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

This Period

shorter

Size of a wavelength

Common name of wave

RADIO WAVES

INFRARED

VISIBLE

ULTRAVIOLET

“HARD” X RAYS

“SOFT” X RAYS

GAMMA RAYS

Sources

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

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
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<tr>
<th>Name</th>
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<th>Role</th>
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Experiments

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

• \textit{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
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  – Characterization of the beam
  – Exposures of wet chamois, 2 phantoms

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

\[ \text{Irradiance (W/cm}^2\text{)} \]

\[ \text{Temperature Rise (°C)} \]

• TX151 never had positive score
• Laserman: 15 second exposure at 30.7 W/cm\(^2\)
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