DIRECTED ENERGY BIOMETRICS AND REMOTE SENSING

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DEMRT DISCLOSURE

- USAF
- USAF Surgeon General (USAF SGR), Falls Church, VA
- Air Force Research Laboratory (AFRL), Wright-Patterson AFB, Dayton
- National Institute of Standards and Technology (NIST)
- American National Standards Institute (ANSI): Z136.ORG
- Z136 SSC-5: Lasers in Education Facilities
- Z136 SSC-8: Lasers in R&D and Testing
- Z136 TSC-1: Bio-effects
- FBI / NCIC, National Dental Image Repository (NDIR)
- American Dental Association (ADA), Council on Dental Practice (CDP)
- Association of State and Territorial Dental Directors (ASTDD)
- University of Illinois at Chicago Police Depart, State of Illinois Police

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DENTAL DISASTER PREPAREDNESS

What is a Dental Responder

2012 Illinois Public Acts 225, ILCS 25/54.2, "A dentist or dental hygienist who is a dental emergency responder is deemed to be acting within the bounds of his or her license when providing care during a declared local, state, or national emergency."

Dentists and dental hygienists can support national emergency, disaster, and forensic needs providing clinical care and infrastructure for: "walking well" care, pandemic vaccination support, biometric information, and forensic dentistry. The Illinois Oral Health Care community assists the State of Illinois by providing licensed dental personnel for surge support to major disasters, pandemics, for forensic identification, and other readiness planning needs, as determined by appropriate authorities.

ADA

astdd

Where oral health lives

Dental Emergency Responders (DER)

NIST

2006

Illinois Public Act 94-409: Dental Emergency Responder passes

2011

US House of Representatives: H.R. 570 Dental Emergency Responder (DER) passes full House

2013

US House of Representative H.R. 307 Passes: **Pandemic and All Hazards Preparedness Reauthorization ACT**

Colvard MD, et..al. The dental emergency responder: expanding the scope of dental practice. 2006, *JADA*, 137:468-473.

UIC-DEMRT OFFICE:

The UIC Dental Emergency Medicine Responder Training (DEMRT) Office assists various national and Illinois agencies through strategy and policy, curriculum and education, and research and development (R&D) support for disaster, pandemic, forensic, and other biometric and response needs.

DEMRT operates in association with the American Dental Association (ADA), Council on Dental Practice (CDP) the Association of State & Territorial Dental Directors (ASTDD), and other Department of Defense and Federal Agencies to support disaster response, pandemic, and forensic response needs.

2013 H.R. 307:

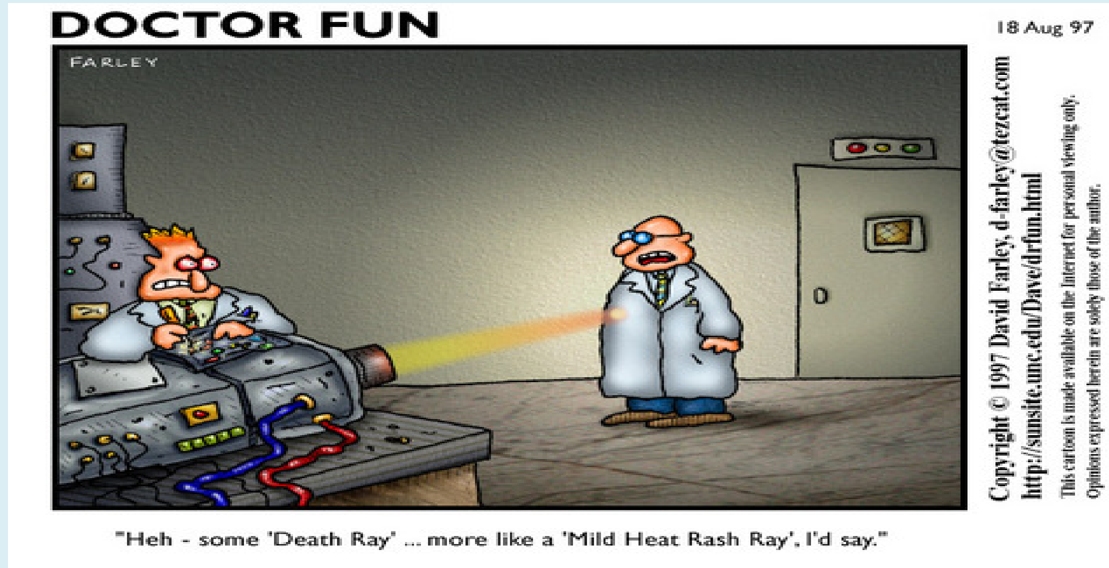
"Dental Assets"

"Dental Health Facilities"

"Dental Curricula & Training"

Z136.Org; SSC-8: Safe Use of Lasers in Research, Development, and Testing
Chair: Ken Barat

ANSI Z 136.8



- **New Hazard Evaluation Parameters**
- **Discussion of Alignment Eyewear**
- **Improved Robotics Section**
- **Information on Export Controls**
- **Full Color Signage and Diagrams**
- **New and Reorganized Appendices**
- **Sample Audit Forms**
- **And more**

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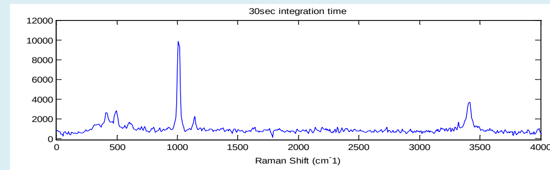
DIRECTED ENERGY REMOTE SENSING: Richard Preston, PhD, SSI

Personnel Protection Laser Sensor

Laser Geo-location Sensor

Active Sensor



Spectral Data

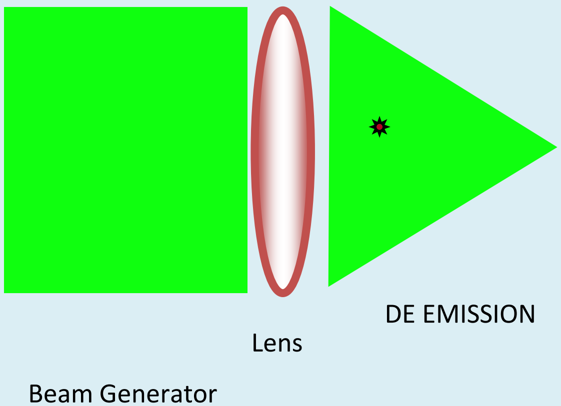
- **CW and Pulsed laser detection/warning**
- **Warns of laser events at <0.001×MPE (maximum permissible exposure)**
- **Incorporates eye protection filter**
- **Alerts if eye protection is effective**
- **Records amplitude, time, GPS, PRF of events (110º FOV, <1 lb)**

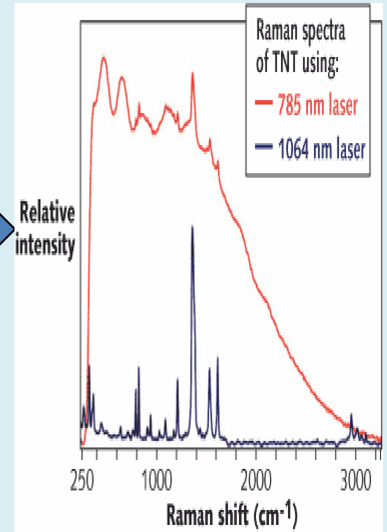
AP HILL TEST: Retro-reflection: 1 kilometer

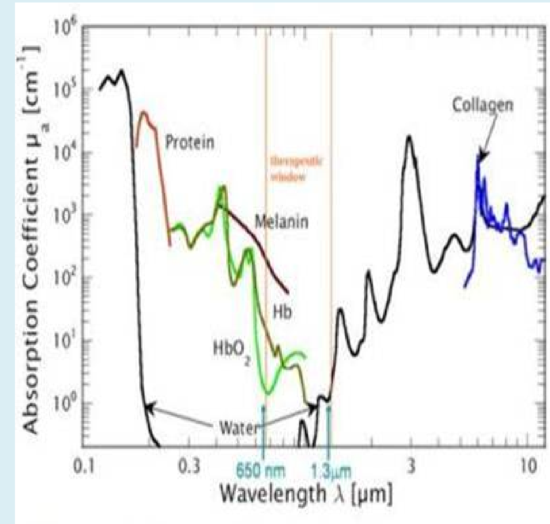
HAND-HELD, DIRECTED ENERGY SENSOR for CLINICAL APPS

OBJECTIVE: **Portable detectors of: 1) laser radiation, 2) human exposure, 3) BIOLOGICAL Biometrics**

LASER WAVELENGTH METER







Problem:	**Benefits:**
• Identify BIOLOGICAL SPECIMENS • Detect Clinical threats • Protect from exposure to DE radiation	Detect, Identify, Evaluate, Store, Transmit Hand-Held, Area Protection, UAV-portable Biometric, Remote sensing, Spectroscopic

GOAL: Hand-Held, Off-the-shelf, laser based, detection technology, ported to a PDA

APPLICATIONS: Anthropology, Dental Forensics, Botanical Discovery, Environmental, Medical, Occupational , Leverages future Hand-held, DE spectroscopy advancements for biological biometrics.

Colvard MD, Naiman M, Danziger L, Hanley L., Handheld directed energy sensor for environmental monitoring and clinician safety, *Aviat Space Environ Med*. 2010 Jun;81(6):602-4.

DE BIOMETRICS RESEARCH QUESTION

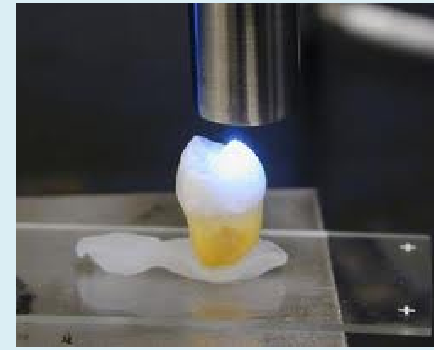
QUESTIONs: Can hand-held, DIRECTED ENERGY (DE), COTS, spectroscopic technology discriminate a biometric data continuum between well and poorly preserved archaeological and forensic bone, teeth, and plant specimens?

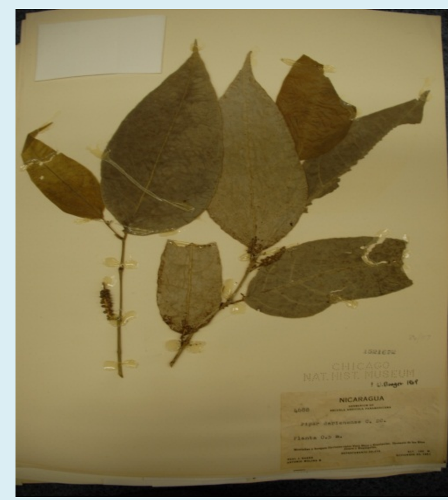
Can the biometric data/packet be NIST / DOD base lined, secured, and moved, without interference, and or modification?

CURRENT ART / UTILITY: Chemical, radiometric, and genetic assays predicated on sufficient amounts of unaltered collagen, hydroxyapatite, or alkaloids in specimens, analyses, destructive, costly, and time-consuming, → improving.

Difficult to accomplish non-destructive or minimally destructive assessments of field specimens, *in situ*, prior to export to Lab.

GOAL: Enable rapid field analysis and tissue sparing assessments, for ID, reduce *in situ* disruption.





Pestle, W.J., and M. Colvard. Bone Collagen Preservation in the Tropics: A Case Study from Ancient Puerto Rico. *Journal of Archaeological Science*. Vol 39, I ssue 7 (July, 2012), p. 2079-2090.

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DE METHODS AND MATERIALS

- **4 handheld COTS spectroscopy devices:**
  - BWTek 785nm Raman InnoRam
  - DeltaNu 785nm Raman PharmaID
  - Thermo Scientific First Defender FTIR
  - DeltaNu 1030nm Raman InspectoR
- **26 previously analyzed museum bone samples (100s-1000s of years old) and from a variety of geological settings:**
  - Ground bone
  - Extracted hydroxyapatite
  - Extracted collagen
- **3-5 scans per sample (depending on device/sample type) at automatically determined optimal acquisition time, multiple scans averaged.**

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SPECIMENS / RESULTS

Pestle and Colvard

Sample #	Taxon	Locality	Age (years before present)	Collagen yield (wt%)	Hydroxyapatite yield (wt%)
A-3	Odocoileus virginianus	SW Colorado	Modern	19.8%	62.0%
A-40	Homo sapiens	Puerto Rico	1255±45	8.2%	77.6%
A-47	Homo sapiens	Puerto Rico	1099±45	5.9%	79.3%
A-66	Homo sapiens	Puerto Rico	674±44	15.6%	65.5%
A-73	Homo sapiens	Puerto Rico	1358±48	4.0%	76.2%
A-80	Homo sapiens	Puerto Rico	1319±42	3.1%	81.2%
A-89	Homo sapiens	Puerto Rico	1253±52	11.3%	70.5%
A-91	Homo sapiens	Puerto Rico	1441±44	1.3%	81.5%
A-102	Homo sapiens	Puerto Rico	1347±45	6.6%	77.3%
A-105	Homo sapiens	Puerto Rico	1403±44	5.1%	80.2%
C-2	Homo sapiens	Puerto Rico	1413±64	2.0%	78.2%
C-8	Homo sapiens	Puerto Rico	1322±42	5.6%	77.9%
C-15	Homo sapiens	Puerto Rico	1271±45	4.7%	79.8%
C-36	Homo sapiens	Puerto Rico	1287±43	4.0%	76.7%
C-42	Homo sapiens	Puerto Rico	1055±41	9.1%	73.9%
C-45	Homo sapiens	Puerto Rico	1408±46	1.7%	85.0%
F-10	Homo sapiens	Puerto Rico	951±42	6.2%	77.8%
F-14	Homo sapiens	Puerto Rico	1053±42	14.1%	69.7%
F-23	Homo sapiens	Puerto Rico	1086±46	3.7%	81.8%
F-35	Homo sapiens	Puerto Rico	1070±45	7.1%	75.8%
F-61	Homo sapiens	Iraq	4000-5000	0.9%	85.5%
F-62	Homo sapiens	Iraq	4000-5000	0.4%	83.8%
F-71	Homo sapiens	Chile	2622±47	17.8%	60.3%
F-72	Homo sapiens	Chile	1805±38	25.6%	57.2%
F-73	Homo sapiens	Chile	1177±36	18.8%	50.4%
F-76	Homo sapiens	Chile	1827±37	21.7%	51.6%

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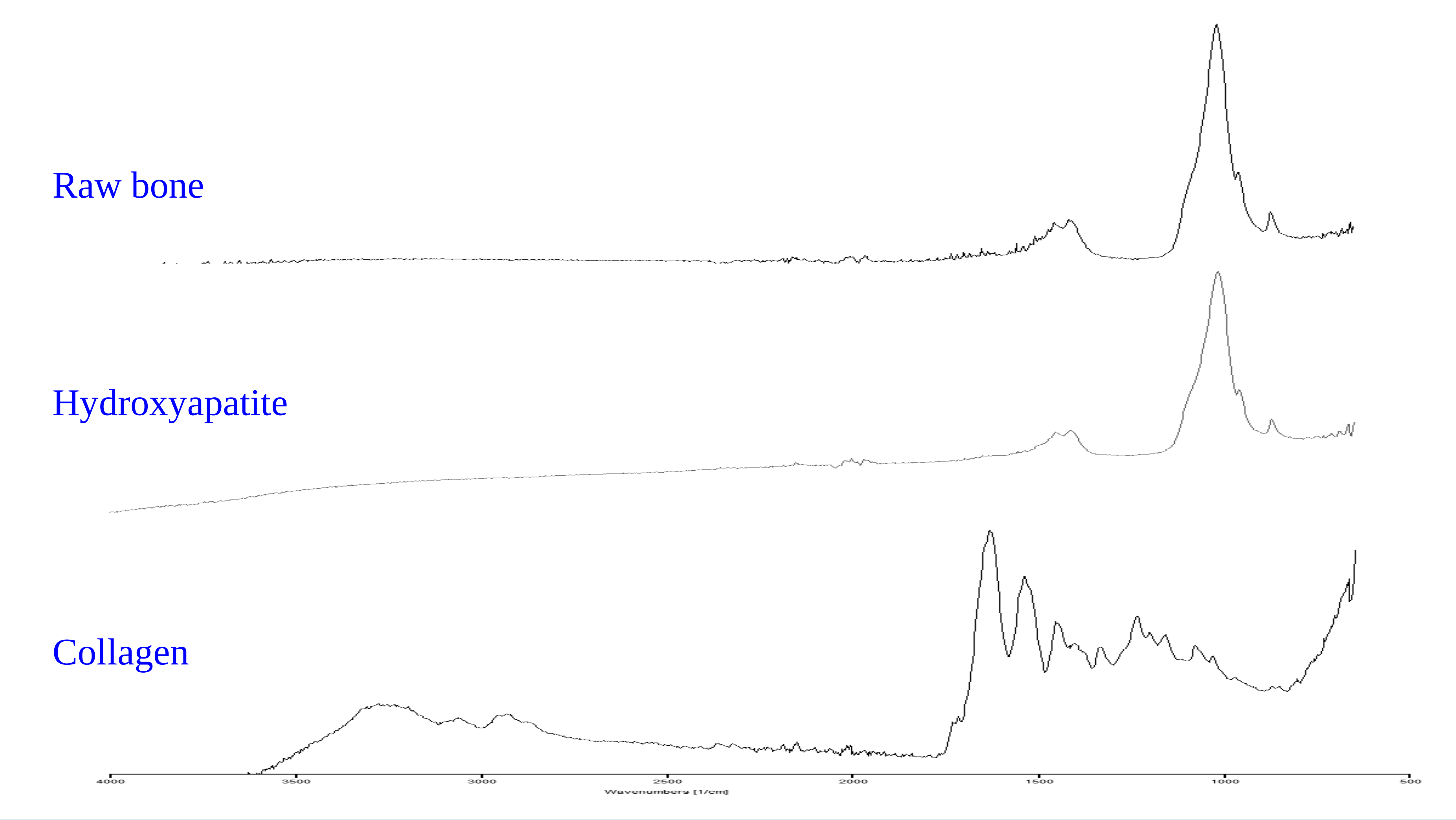
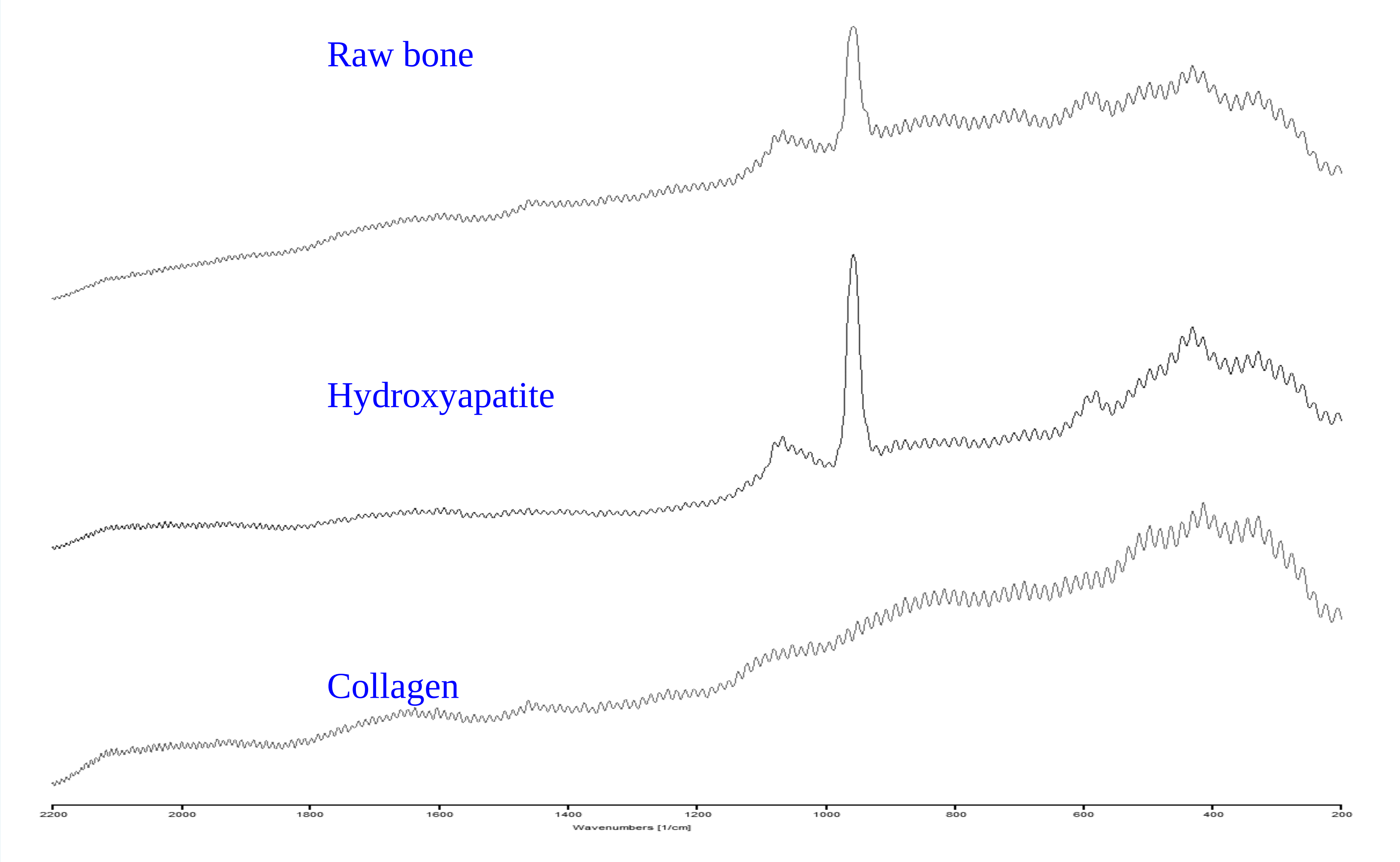
Thermo First Defender (Fourier Transform Infrared) **FTIR Spectroscopy Averages, all samples**



Thoughts on Thermo FTIR results

- Strong signal from both raw bone and hydroxyapatite samples, collagen has much lower signal intensity, but still has several notable peaks in pure form.
- Both raw bone and hydroxyapatite show strong absorbance peaks at 960 and 1015^{-1} (phosphate), and carbonate peaks at 870-875, 1415, and $1450cm^{-1}$
- Collagen samples show Amide I peak at $1625\text{-}1650cm^{-1}$, amide II at $1530\text{-}1540cm^{-1}$, and amide III at $1225\text{-}1235cm^{-1}$
- HOWEVER, the signal intensity (absorbance) of the collagen samples is sow low as to be absolutely swamped in raw bone, meaning that this device is not immediately useful for the purposes envisioned here

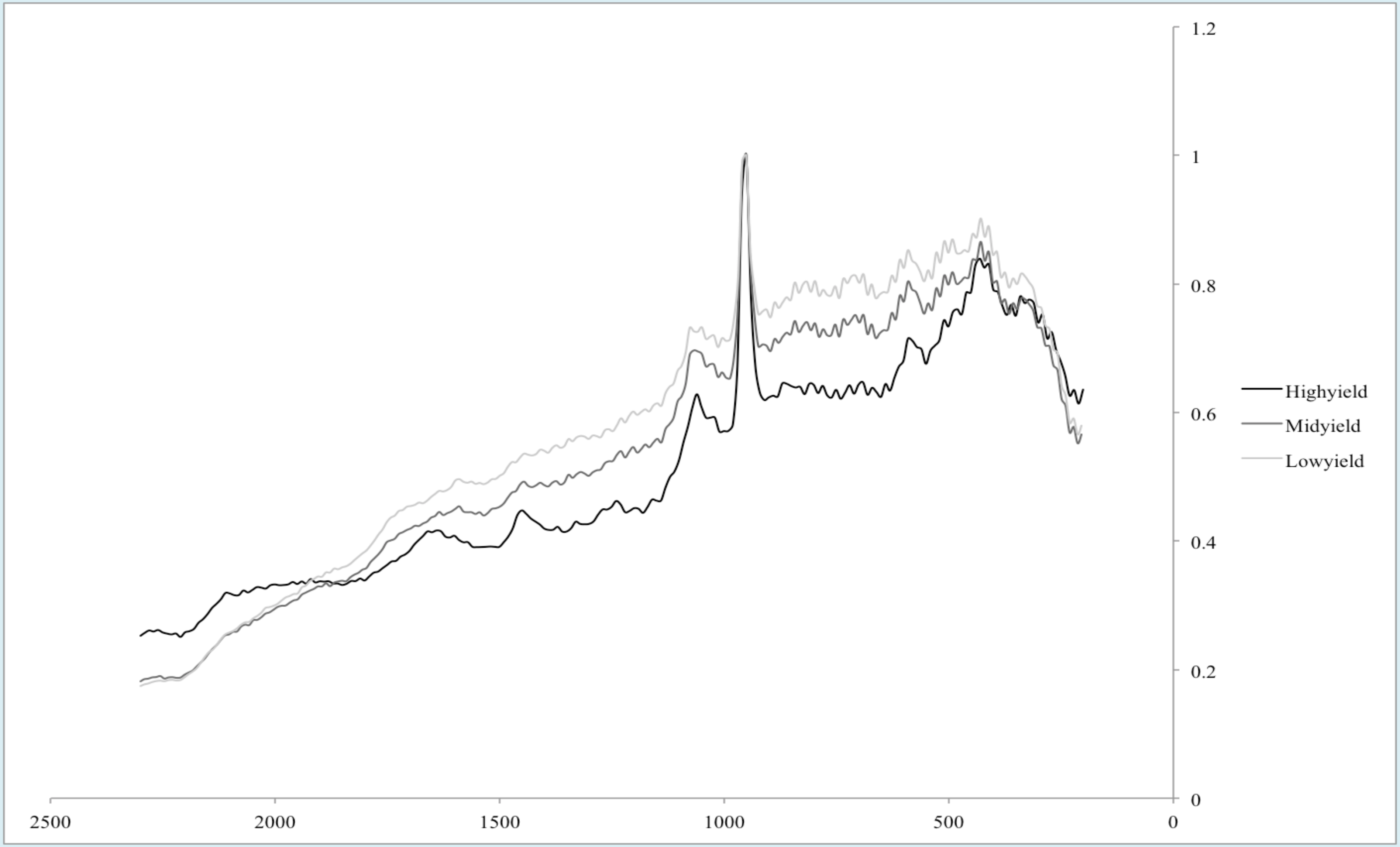
DeltaNu InspectoR 1030nm Raman Averages, all samples



Thoughts on DeltaNu 1030nm

- Lower fluorescence than with 785nm Raman devices
- 960cm^{-1} peak in raw bone and hydroxyapatite scans consistent with v_1 PO_4 symmetric stretching, plus a carbonate substitution peak at 1050-1100cm^{-1}
- Most importantly, however, for the present purposes, is a very weak peak in the average collagen spectrum at 1440-1450cm^{-1}, a location which is consistent with a CH_2 bend or deformation consistent with Type I collagen, this is developed in greater detail below…

DeltaNu InspectoR 1030nm Raman, raw bone by collagen yield



DeltaNu 1030nm collagen content discrimination

- Breaking the raw bone samples into 3 groups (high, medium, and low collagen yield) produces an intriguing result, as the 1440-1450cm^{-1} peak is evident in the high yield samples, less so in the medium yield samples, and not detectable in the lowest yielding bone.
- This finding would suggest that the 1030nm Raman unit may be a feasible means for discriminating between those bones that have sufficient collagen and are thus worthwhile to sample and analyze and those that are devoid of enough collagen for study and worthwhile analyzing.
- Next steps: Biometrics and Cyber-Security standards
- Next steps: Additional Anthropological and Dental Forensic Education
- Next steps: optimize Directed Energy frequency / emissions / secure data
- Next steps: optimize EMR data movement to ADA/NIST/DOD standards.

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