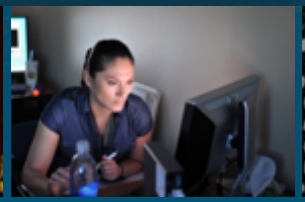
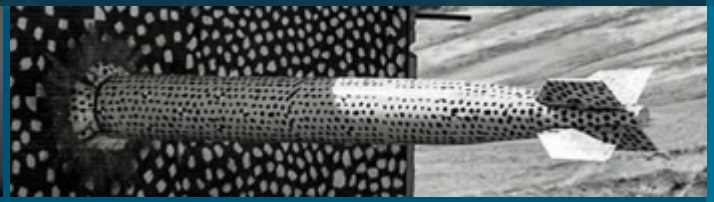
SAND2021-7882PE

Sandia National Laboratories

A Journey in Radiation Imaging





PRESENTED BY

Dr. Edward Jimenez

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Overview

1. Brief Introduction
    1. Early Education/Inspiration
    2. Undergraduate Serendipity
    3. Graduate School Slog

2. Sandia National Labs
    1. Career Overview
    2. On the relationship between E. Coli growth and computer memory…

3. Research
    1. Color X-ray Imaging and Computed Tomography: Transforming an ancient technology
    2. TSA/DHS: The journey from finding the bomb to finding the teddy bear
    3. Save the Rhinos!

4. Parting words, thoughts, rantings, and pontifications

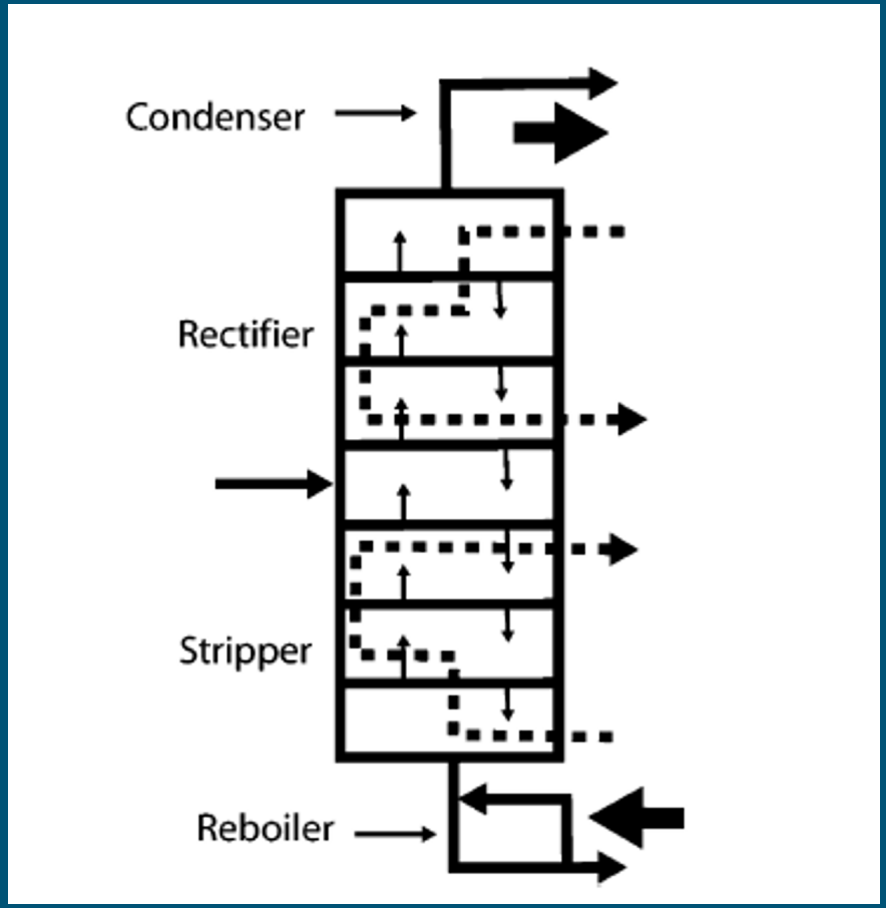
Early Education

Case courtesy of Dr Piotr Gołofit, Radiopaedia.org, rID: 46128

- Disadvantaged student growing up
- Always fascinated by science
  - Bill Nye
  - Carl Sagan
  - Bob Ross
- Picture it: El Centro CA 1987
  - Playing in the playground…
  - …then disaster strikes!

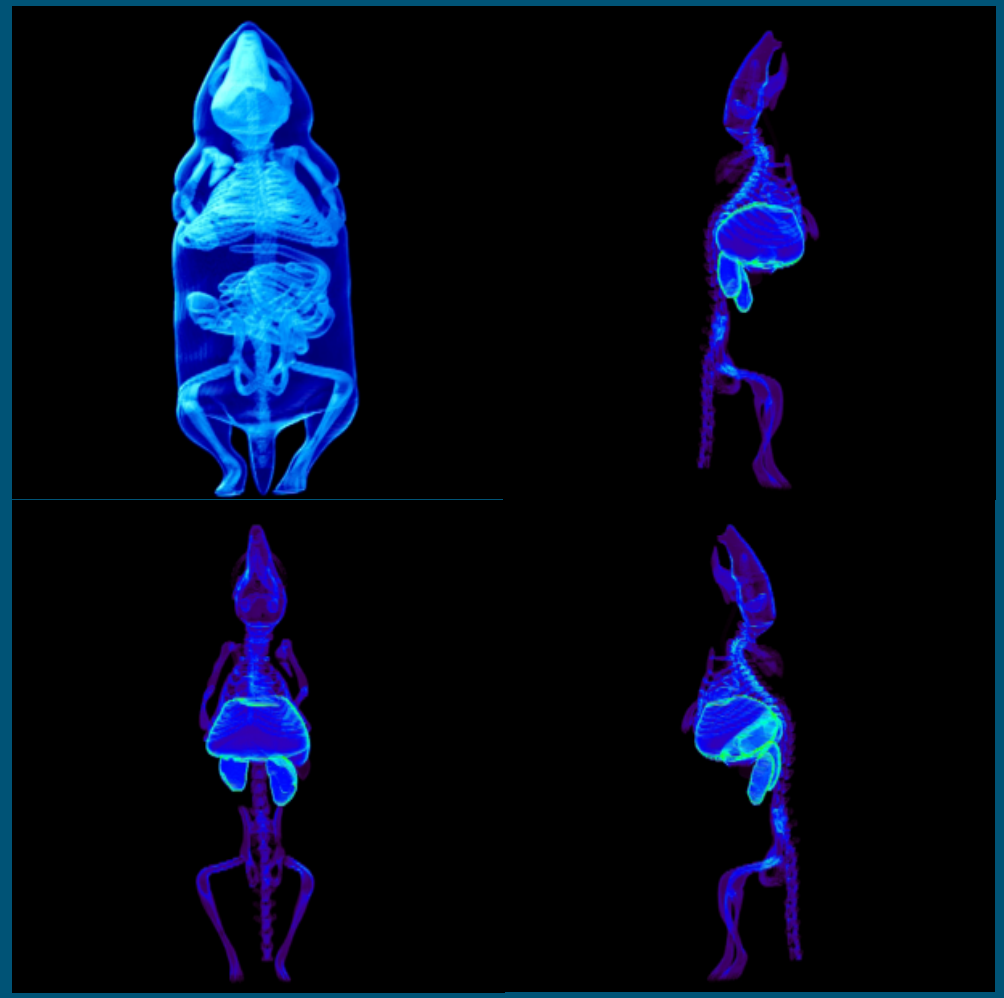
Undergraduate Serendipity… wait, you're telling me I have potential?

- Most of junior high and Freshman year of high school digging myself into a hole
  - Rapid change in attitude afterwards
- Got into college
  - First in my family to do so
  - New mentality: "C's get degrees!"
- A free calculator spiraled into a PhD
  - MESA, McNair, MARC, MEP, MSP
  - First mentor: Dr. Peter Salamon
  - International research in petroleum distillation



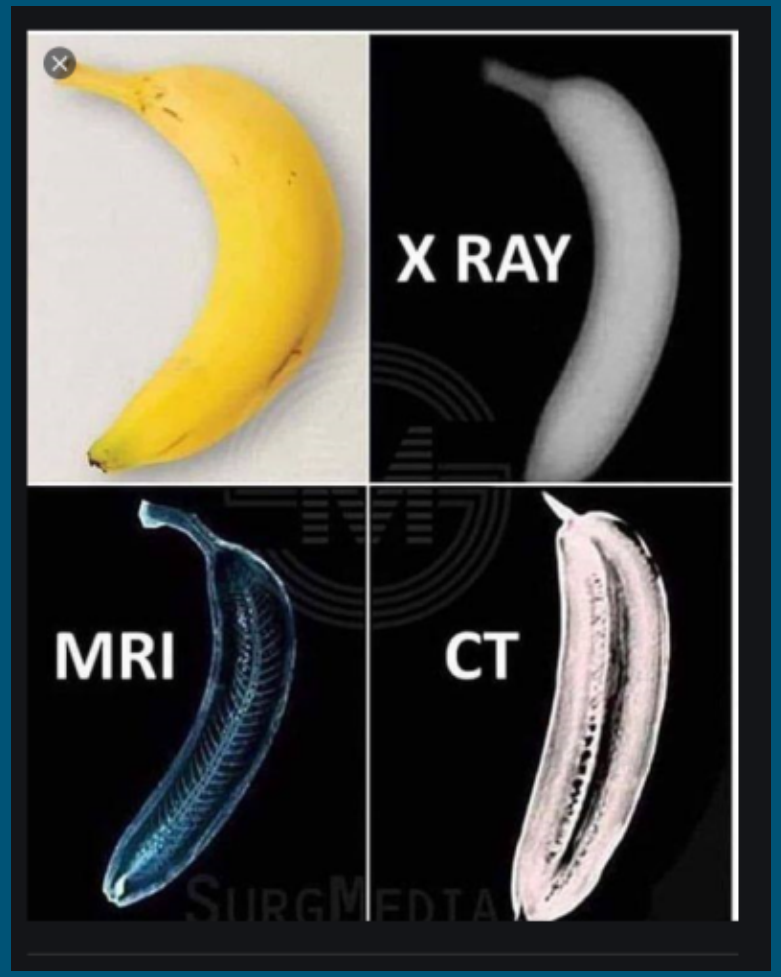
The Graduate School Slog

- SHELL SHOCK
  - Grad school is hard!
  - Too stubborn to quit
- Tragedy strikes again…
- Imaging has a mathematical formulation?
  - Memories of 1987
  - Inspiration to counter the new tragedy
- Dissertation in Cancer Research



Sandia National Laboratories

- **Goal: Novel X-ray CT Capability**
  - **Achieved by applying technologies in novel ways and inventing new methods.**
- **Revolutionize Industrial and Security-based Non-Destructive Evaluation**
- **Started as an intern in 2007 during grad school**
- **Started full-time two weeks after dissertation defense**
- **Never do the same thing twice!**



What is Hyperspectral CT?

Traditional X-ray image

Traditional X-ray CT

- Traditional X-ray Image –Single Gray-scale Image per Scan
- X-ray imaging is defined by a nonlinear mathematical operator!

Data– Traditional vs. Spectral X-ray Input Data

Bin 0 – 2 keV

Bin 63 – 150 keV

Bin 127 – 300 keV

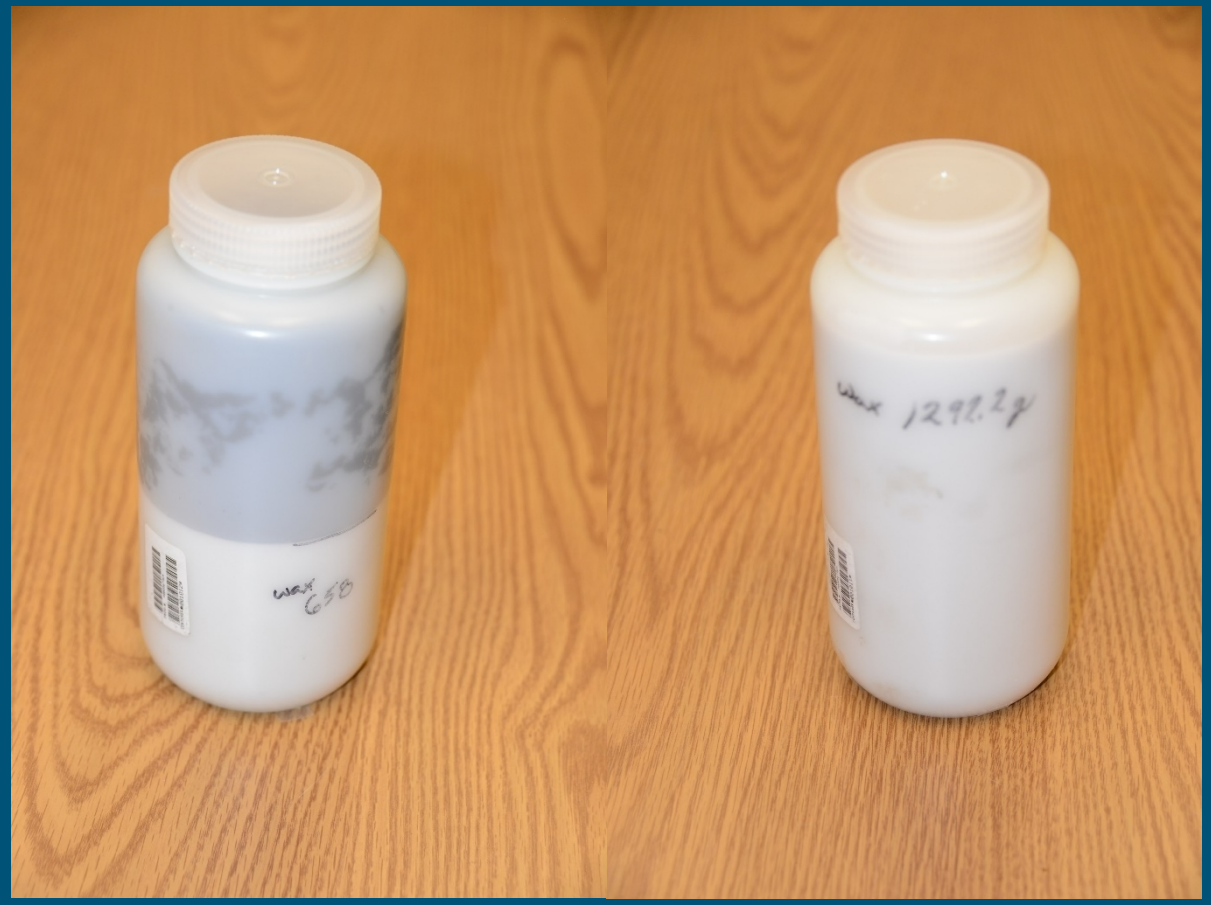
…

…

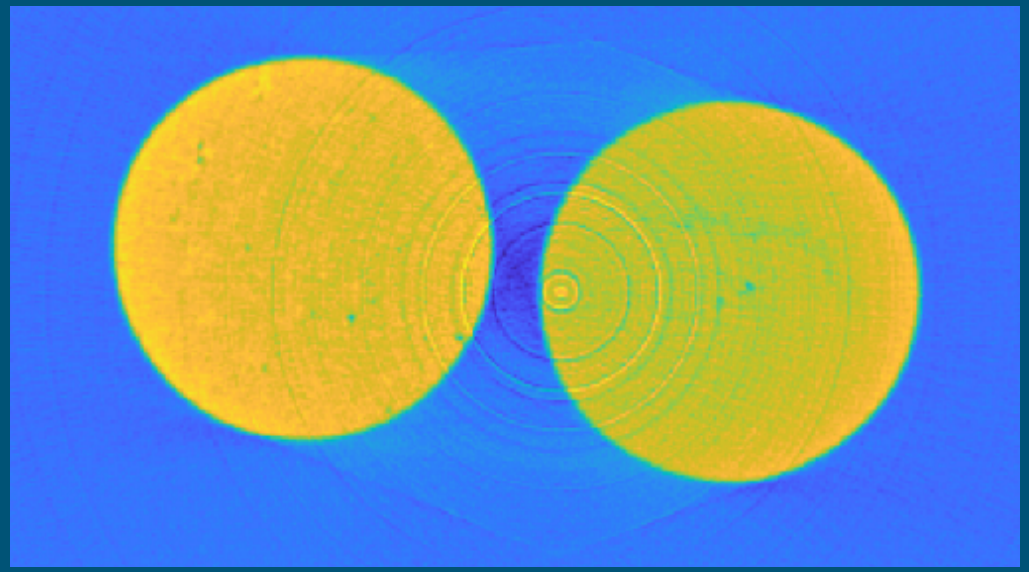
Spectral X-ray Images – 128 Images per Scan

Advantages of Hyperspectral CT

- Single-Channel for Effective Bandpass filter
- Linearizes the imaging system
- Improved Reconstruction Quality through artifact reduction

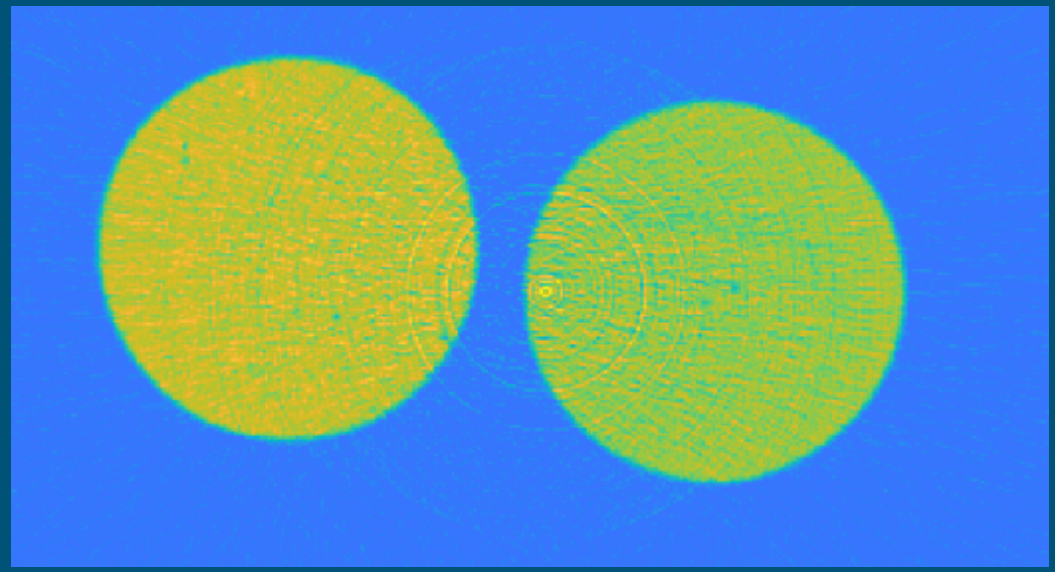


Reconstruction - Even Simple Objects have Artifacts!



Traditional Reconstruction

- Summed bin data
- Streaking emanating from objects
- Beam hardening

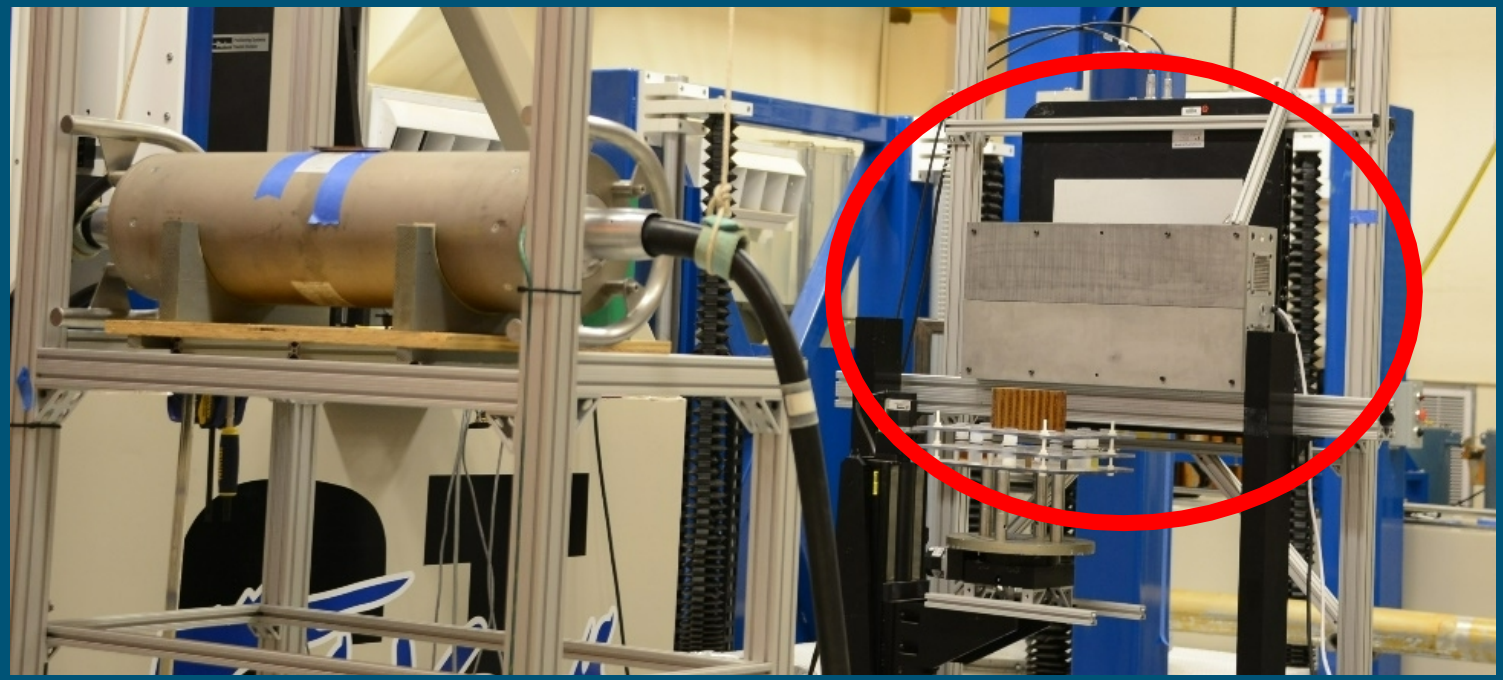


Single Bin Reconstruction

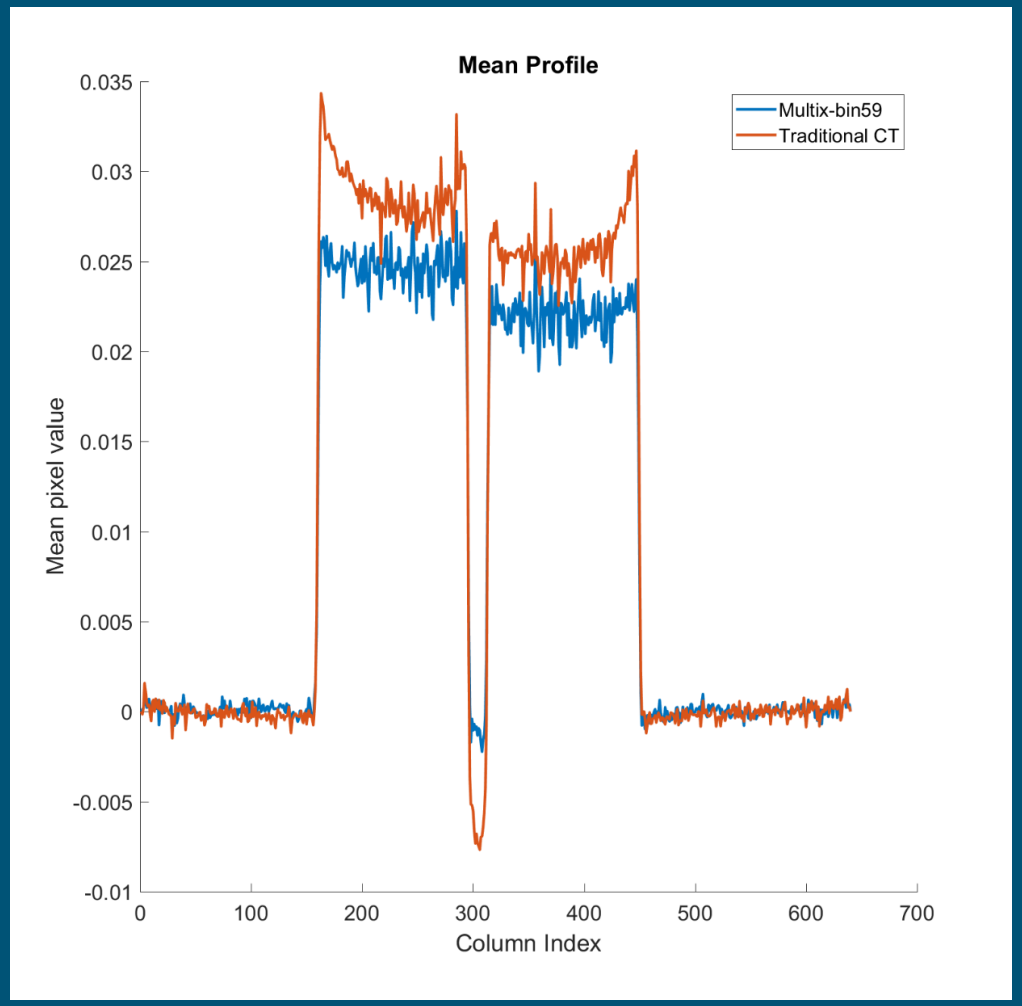
- Identical Reconstruction Algorithm
- Reduced Artifacts
- Uniform Sample Value

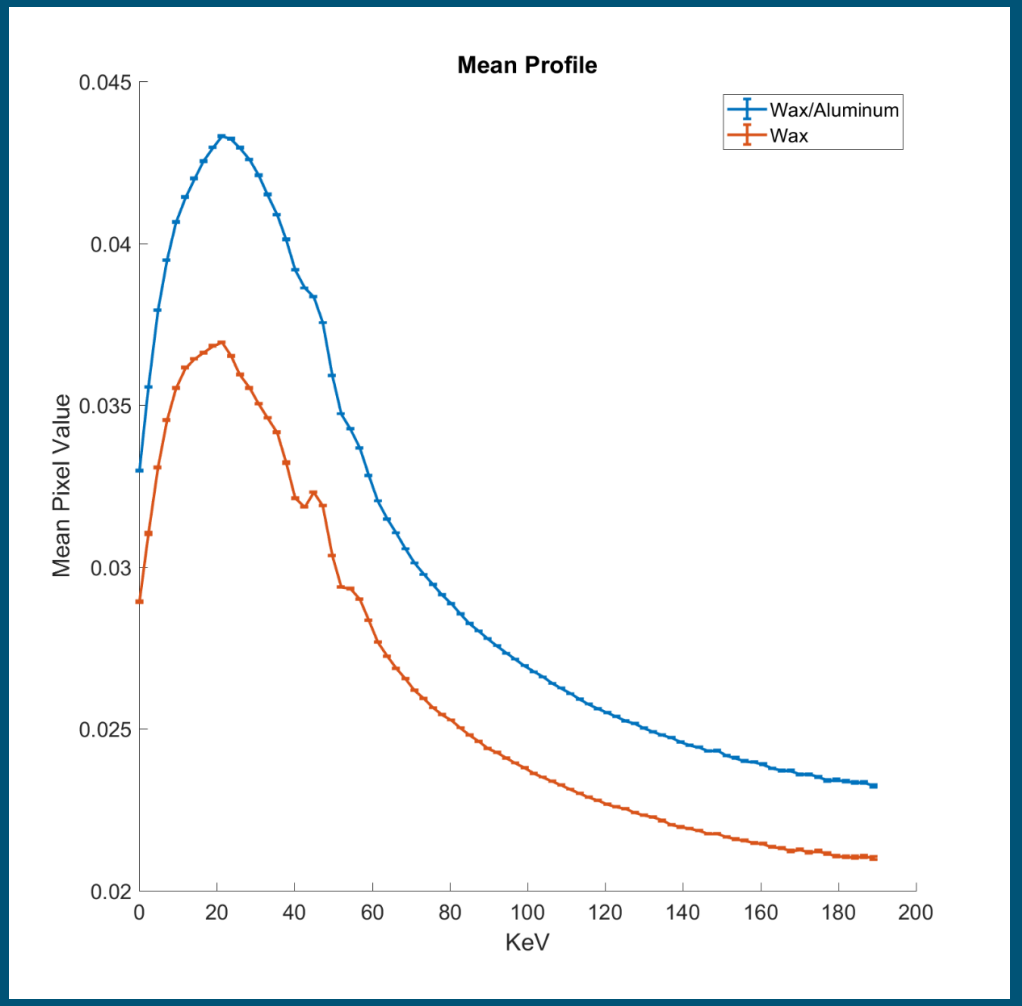
Hyperspectral CT at Sandia National Laboratories

- Hyperspectral Detector.
  - Calibrated for 300keV
  - 640 pixels wide
  - 0.8 mm pixel pitch
  - 128 Channels
- 4 axis motion control
  - 3 axis object manipulator
  - 1 axis detector stage
- FOV up to half meter wide
  - 9 feet tall!
- In use for data acquisition as of May 2017

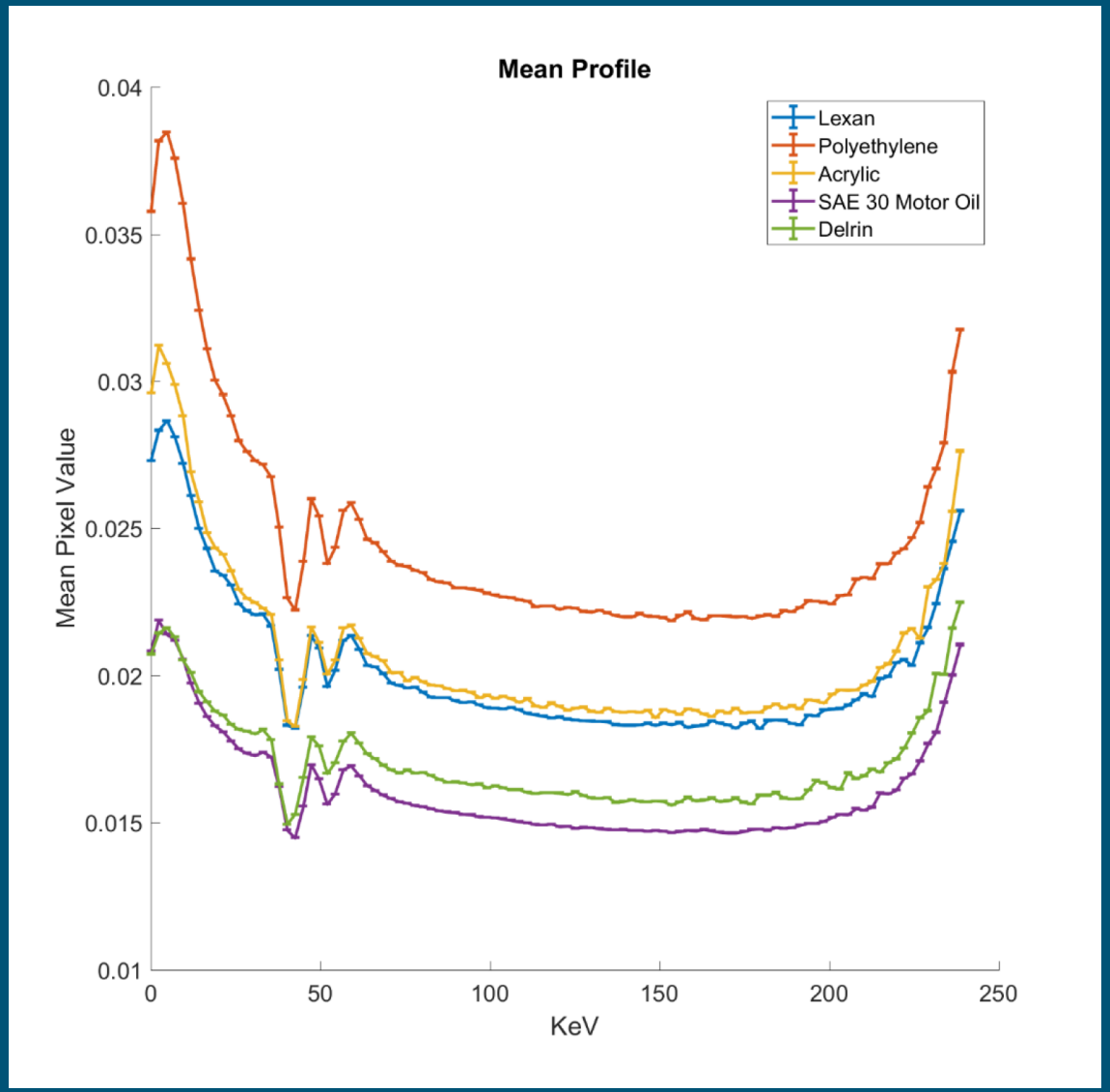


“Huh…well that’s interesting…”

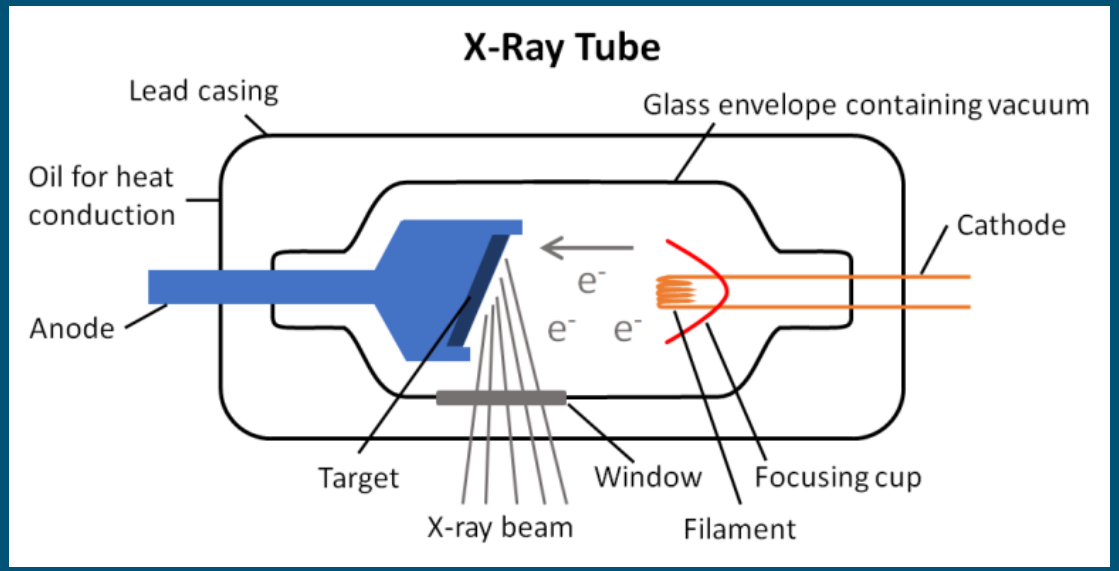




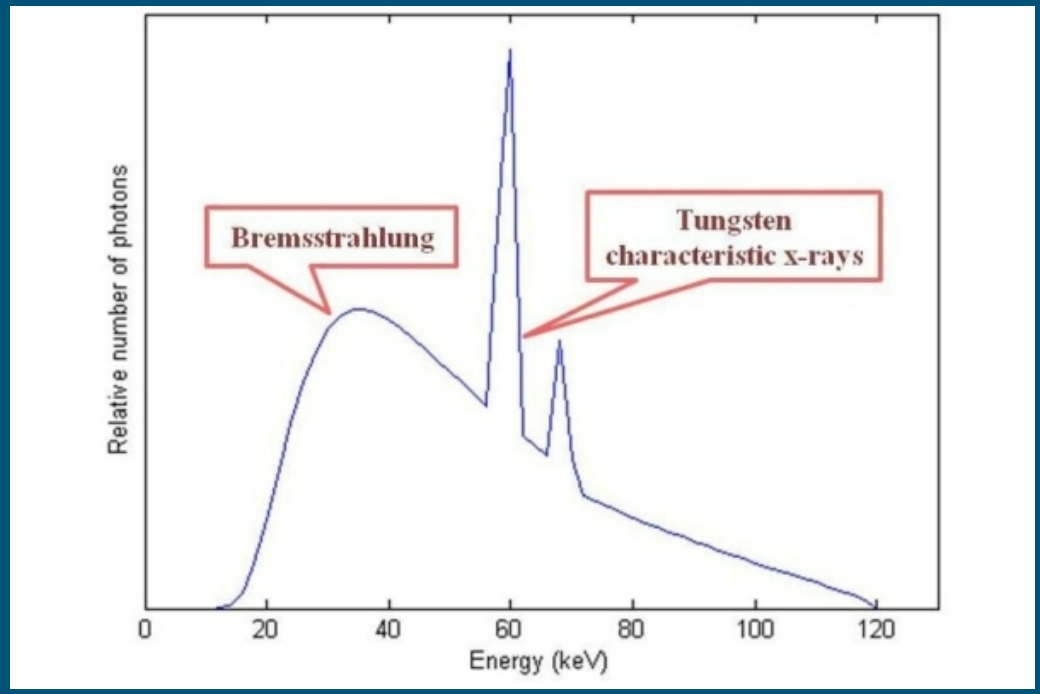
“Curiouser and curiouser…”



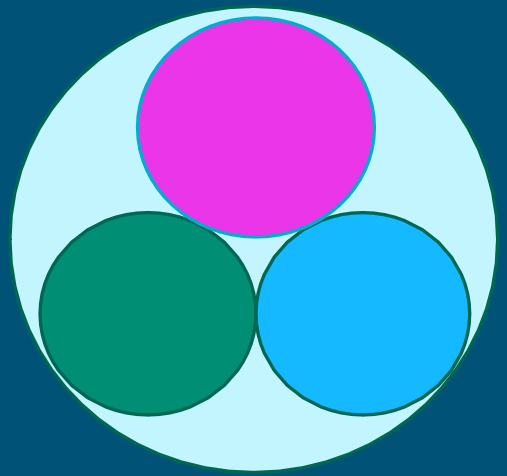
Current Work – “Colorize” the X-ray Source!

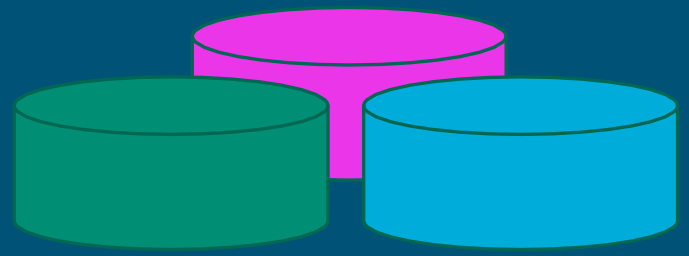


https://sites.google.com/site/frcrphysicsnotes/production-of-x-rays



https://www.researchgate.net/figure/shows-the-calculated-x-ray-spectrum-of-120-kV-tube-voltage-having-18mm-Al-filteration_fig4_257029228

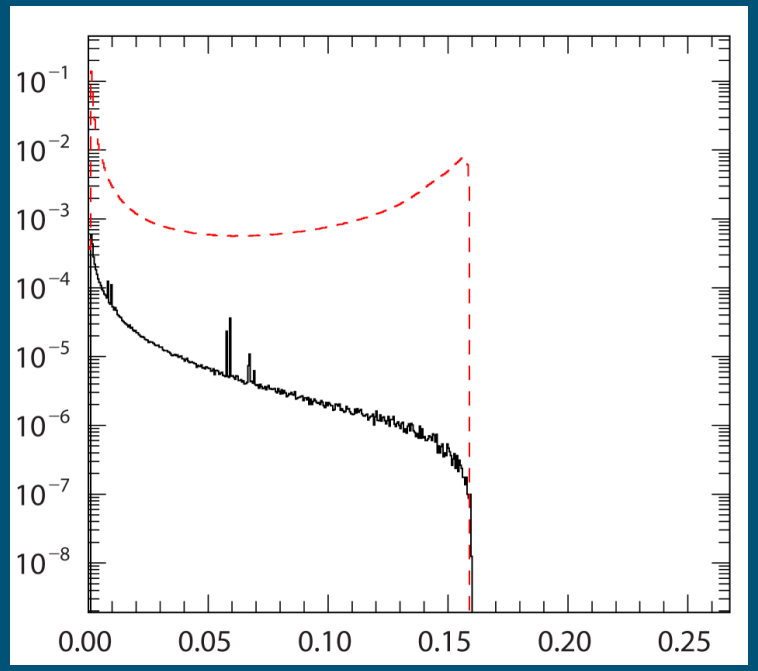




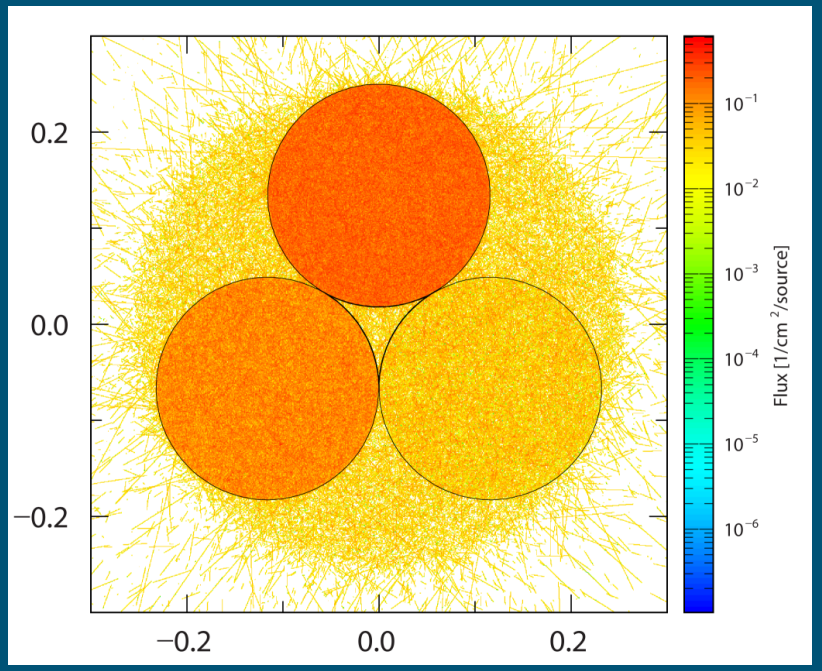
Spicy Light…

- Left Figure: K-lines for Tungsten (~59keV), Silver (~22keV), and Molybdenum (~17keV) are visible in unfiltered spectrum.
- Center figure: Fluorescence is mainly concentrated in the metals, very little activity from substrate material.
- Right figure: Electrons are efficiently blocked by the substrate for the given thickness.

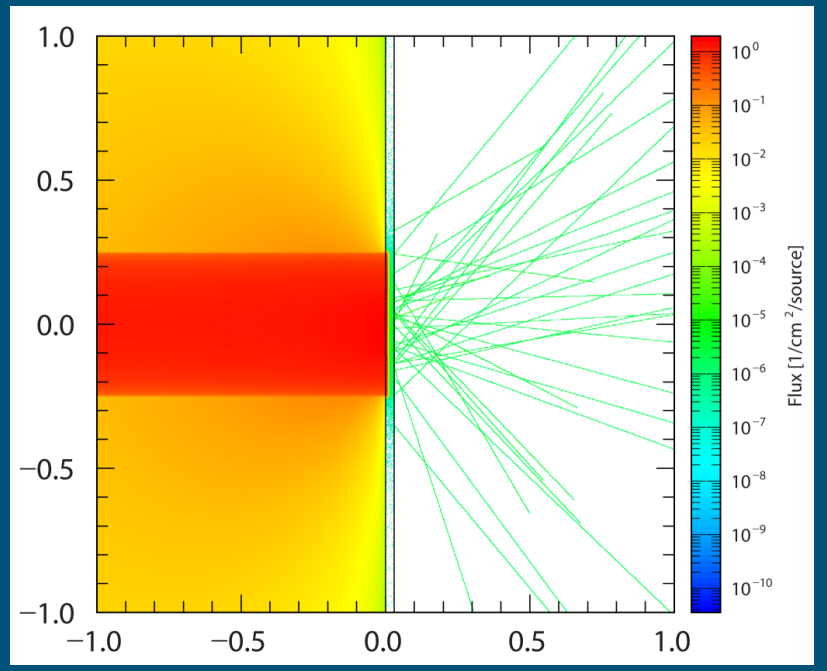
Multi-Metal Anode Spectrum



Multi-Metal Anode Fluorescence

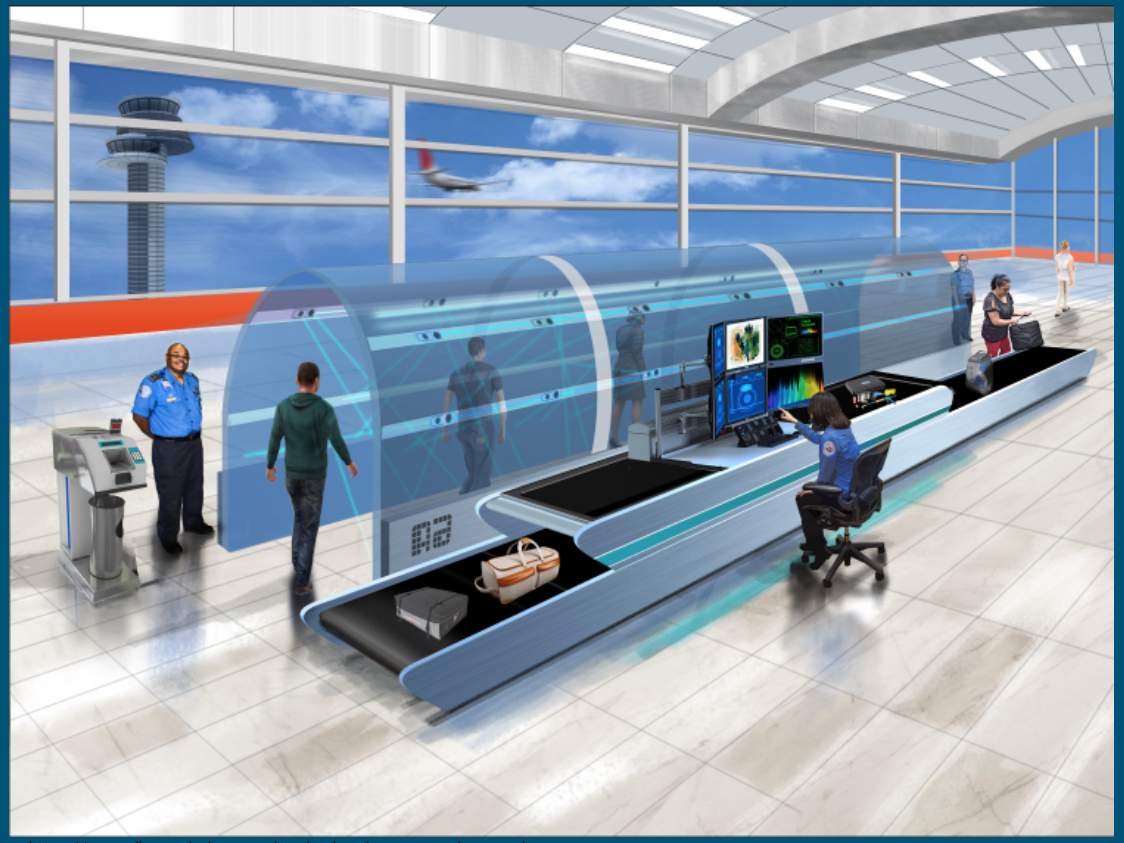


Electron Activity

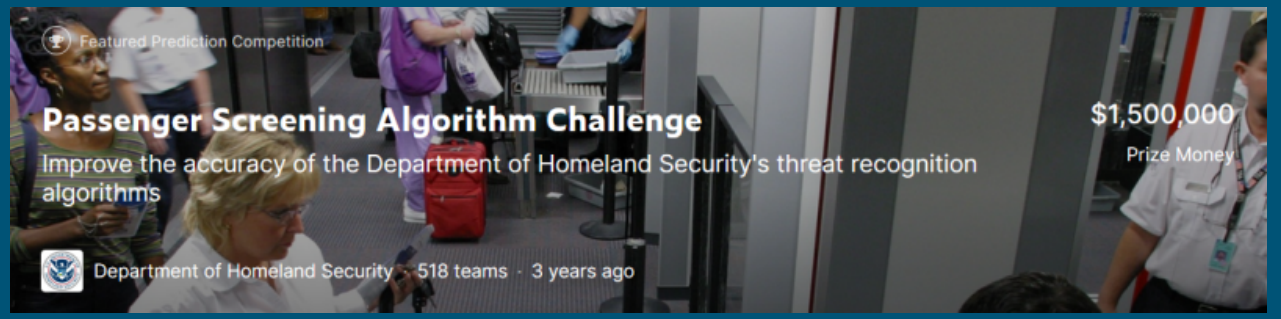


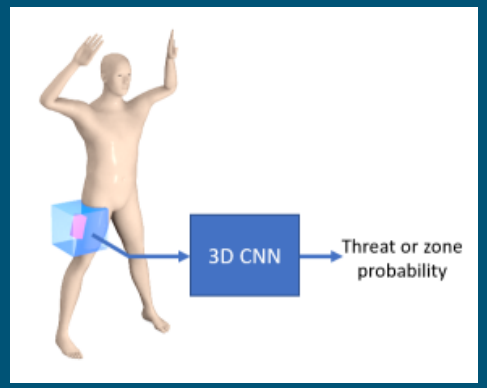
Transportation Security Agency and Department of Homeland Security

- Transform how all inspections are done in airports
  - Increase Security
  - Increase throughput
  - Reduce passenger divestiture, wait times, and other constraints

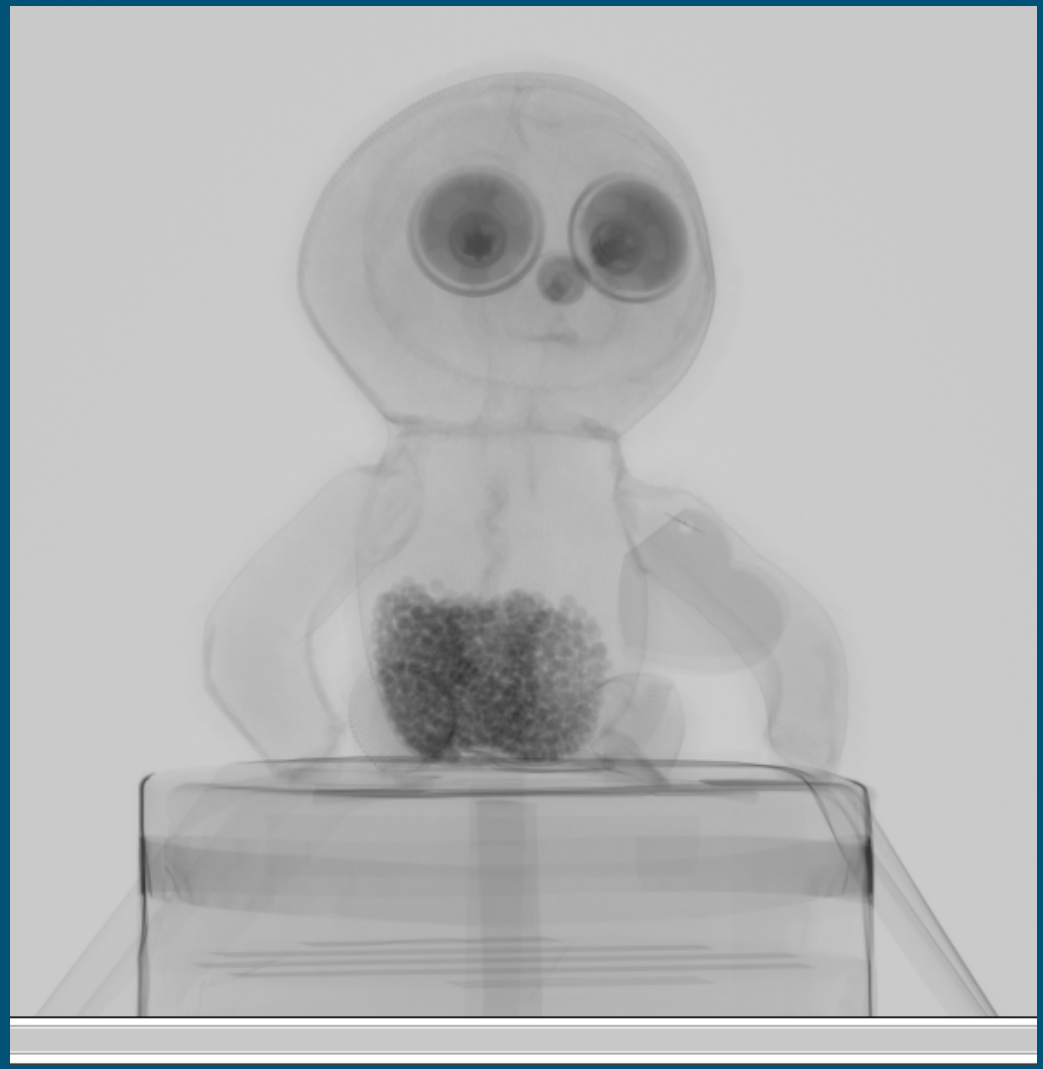


https://www.dhs.gov/science-and-technology/apex-screening-speed





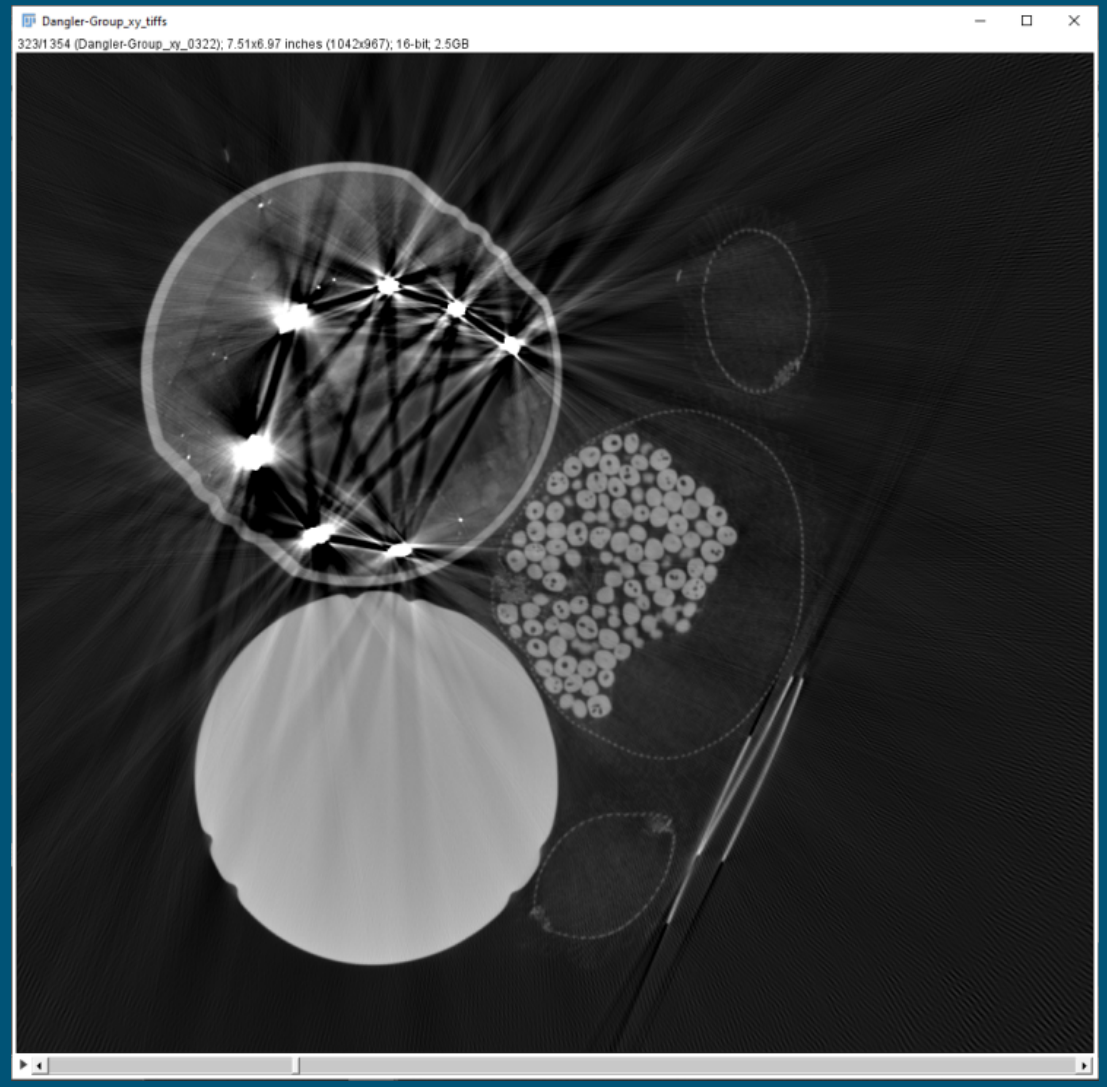
The greatest threat of all…



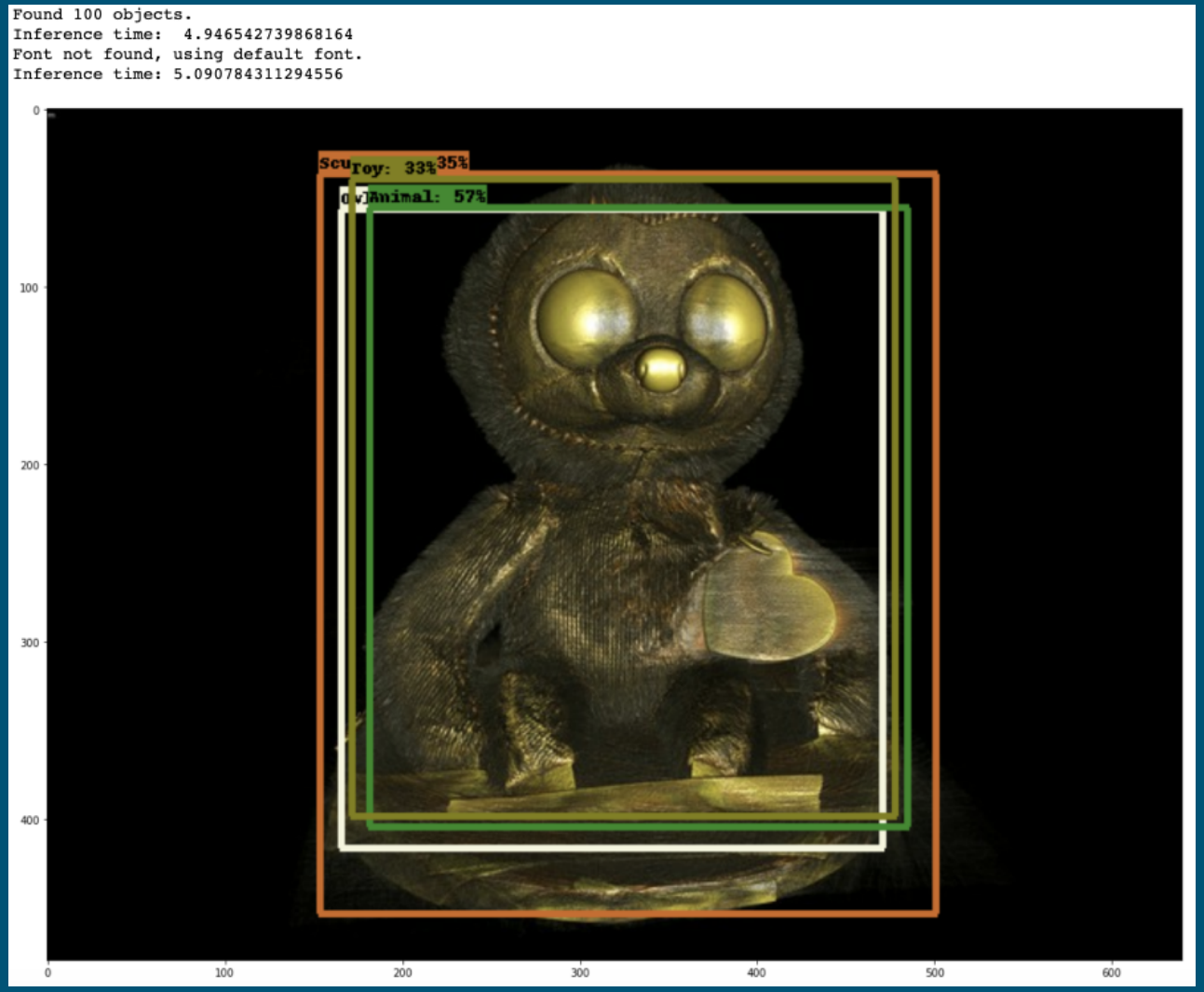
Find the Teddy Bear (Teddy Sloth?)

X-ray

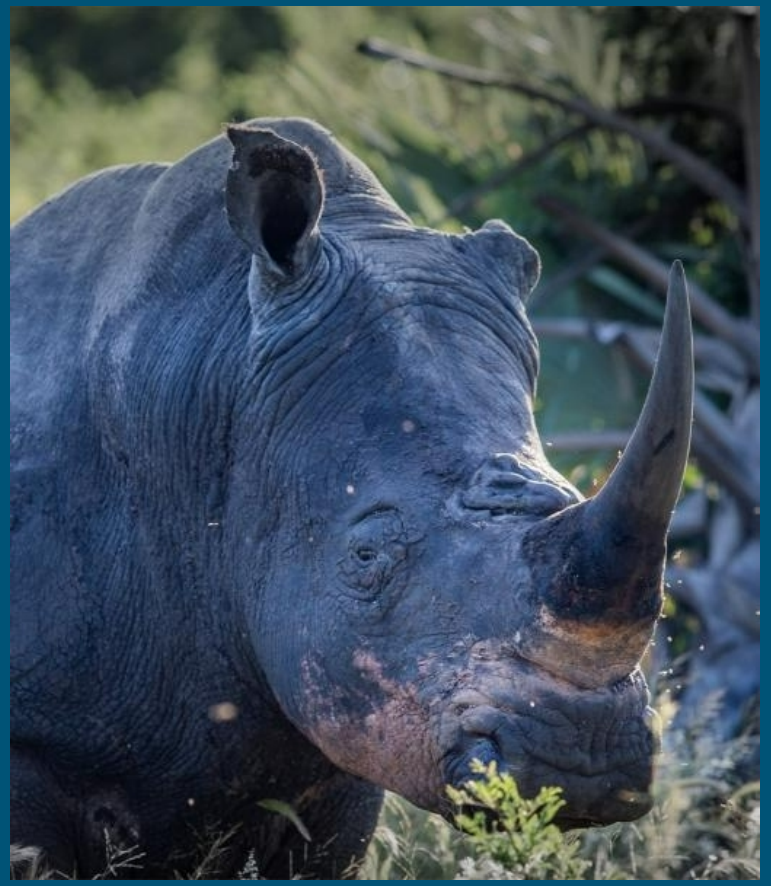
X-ray Computed Tomography



Find the Teddy Bear!



Save the Rhinos!



Images from: https://www.awf.org/wildlife-conservation/rhinoceros

Parting words, thoughts, rantings, and pontifications

- Get mentors…lots of them
- You've earned your seat at the table, don't be afraid to have an opinion.
- Your sanity is just as important as your GPA
- **If we knew what we were doing, it wouldn't be called "Research"!**