

Preview of the New Developments Underway in the Radiation Physics Division

Alan K. Thompson, Acting Chief, Radiation Physics Division

- Brief overview of 245 renovation project
 - Current status and path forward
- New facilities in H wing
 - Detector Testing
 - Low-energy Electron Beam (LEEB)
 - X-ray Calibrations
 - Transition-edge Sensors (TES) for True Becquerel project
- Thanks

Who am I? Why am I here?



- **Until this January, I was the Deputy Division Chief**
- **Jim Adams took a detail (or two) and is Acting Chief at the NIST Center for Neutron Research for at least the next few months**
- **So, here I am!**

The Building 245 Renovation Project

NIST



1 Detector Testing

Test survey instruments in a large facility with a variety of sources on a moving track. Often used for Homeland Security applications.

3 X-Ray Calibrations

Calibrations of ionization chambers. Positioning table allows calibration of an instrument on multiple anodes without realignment.

2 Low-energy Electron Beam (LEEB)

New program to develop dosimetric techniques for low-energy (100 kV to 300 kV) electron beams used for sterilization, materials processing, etc.

4 Transition-Edge Sensor (TES)

An Innovative Measurement Science (IMS) project to improve accuracy and decrease staff time for radioactivity measurements.

Renovations Project Overview

- **8½ task orders**
- **~\$330M funding**
- **Six years of construction**
- **5,500 square meters of new facilities**
- **.....soon to be paused as we wait for additional funding.**

1. Detector Testing

Detector Testing Facility - Purpose

Facility is being used for:

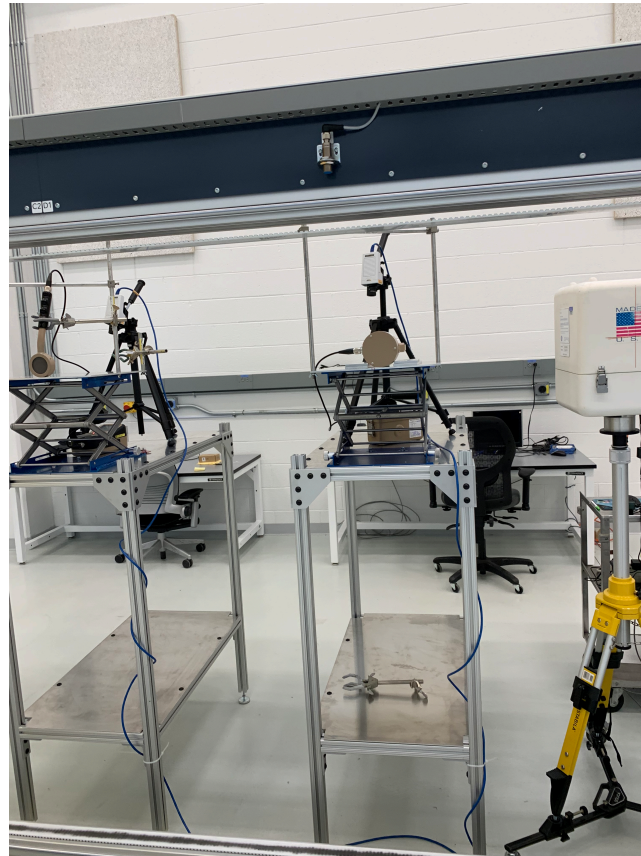
- Testing radiation detection instruments
- Validation measurements for development of consensus standards
- Instrument acceptance tests
- Characterization of instrument response

Users (current and expected):

- Government agencies
- Instrument manufacturers
- Instrument users

Linear Motion System

Allows testing of all kinds of instruments from Personal Radiation Detectors to Radiation Portal Monitors



Characterization Instrument Setup



Setup that allows the characterization of instruments that are used as reference instruments during test campaigns

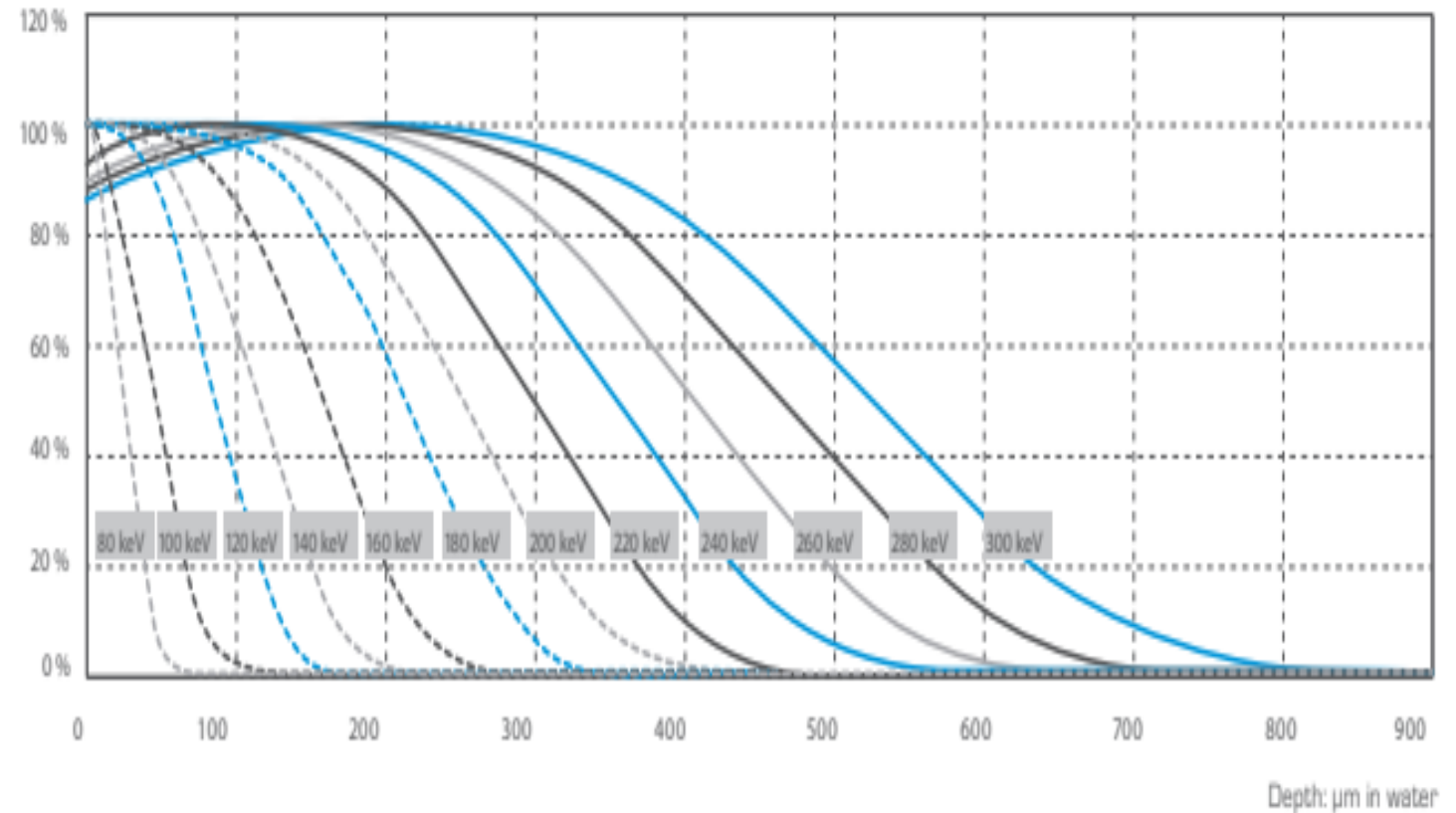
2. Low-energy Electron Beam (LEEB)

Features of LEEB dosimetry

- Low-energy electron beams have an extremely steep dose gradient
- Even at 300 keV, penetration depth in products and materials is less than 1 mm (unit density)
- This makes the quantification of dose extremely difficult

Electron penetration

Dose% of maximum dose

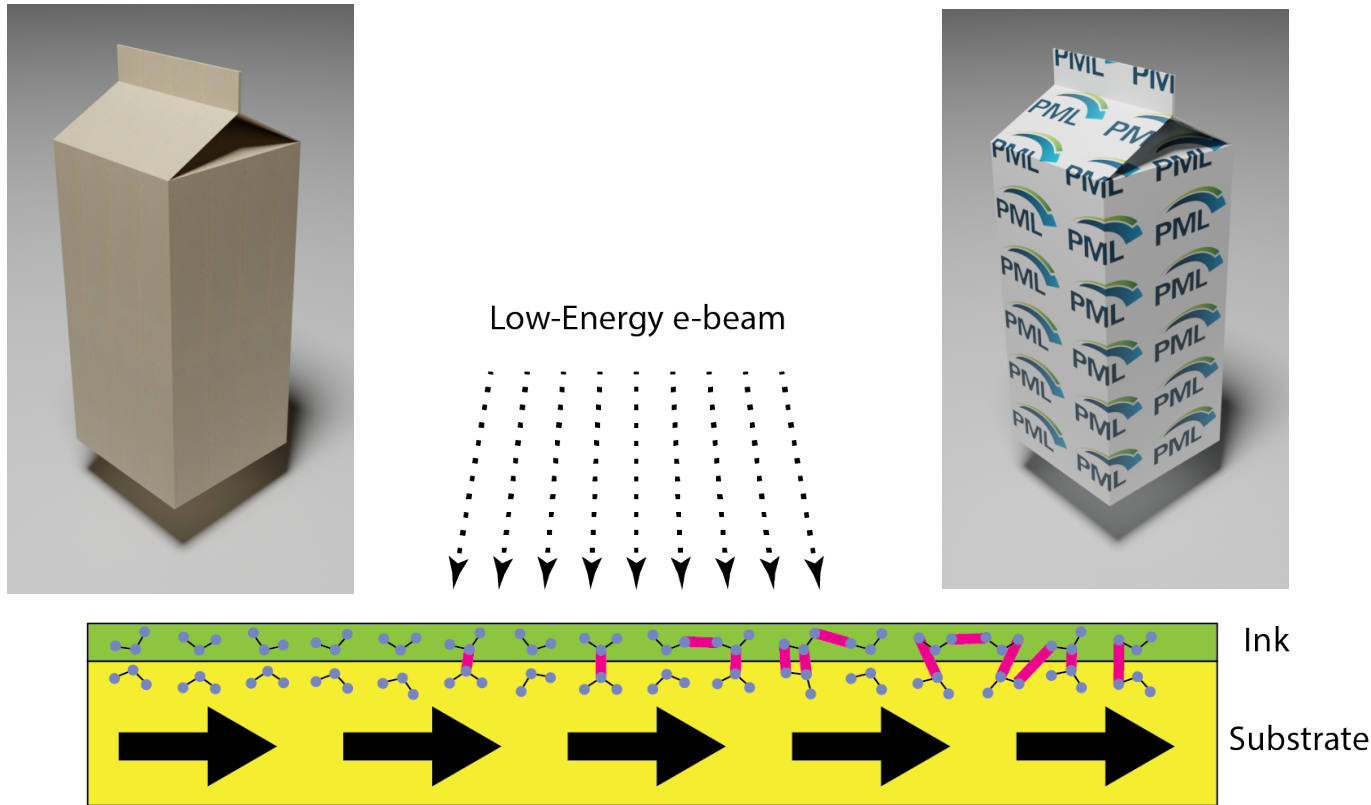


Comet EBLab-300 Laboratory Unit

- Self-shielded, self-contained electron beam unit
- Semi-custom design, extended energy range from 100 keV to 300 keV
 - Covers most LEEB radiation processing applications
- Additional shielding, R&D required during design and development
 - Extensive testing procedures
- Located in new laboratory space (H-wing) in Radiation Physics Building



LEEB Applications



- Sterilization
 - Surface sterilization of food and packaging materials
- Food-safe packaging (\$0.5T/year)
 - Curing of inks, crosslinking
- Materials Modification
 - Crosslinking
 - Radiation grafting
 - Protective coating for metal coils
 - Pressure-sensitive adhesives

Recent LEEB activities



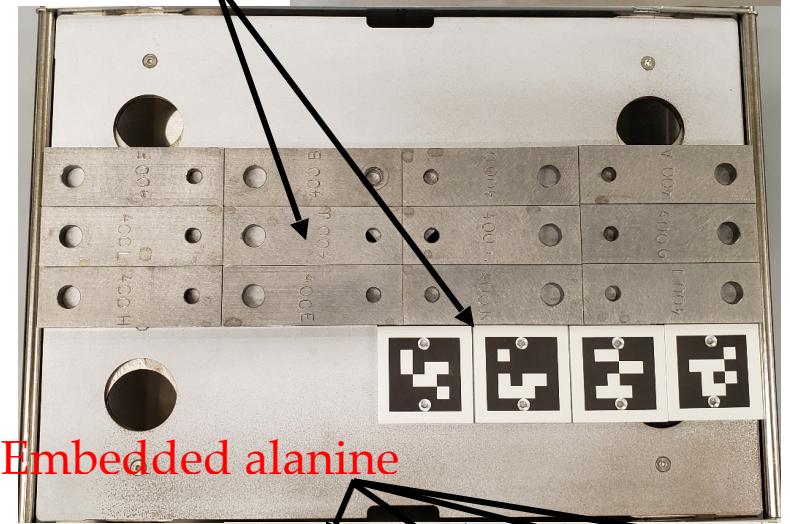
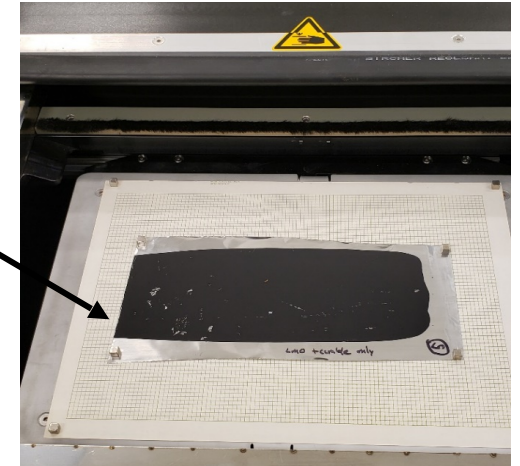
- Electron beam curing of water-based lithium ion battery electrodes for the Army Research Laboratory
- Radiation tolerance (up to 4 MGy) of Nickel-Teflon coatings used as a lubricant for space vehicles for Northrop Grumman Corporation
- Calibration of low-energy dosimeters for radiological event exposure
 - Dosimeters embedded in ID cards can provide rapid assessment of exposure (portable ESR sensor)*

* <https://www.nist.gov/noac/technology/radiation/emergency-dosimetry>

Polymer-coated graphite

Nickel-Teflon coated test

Embedded alanine



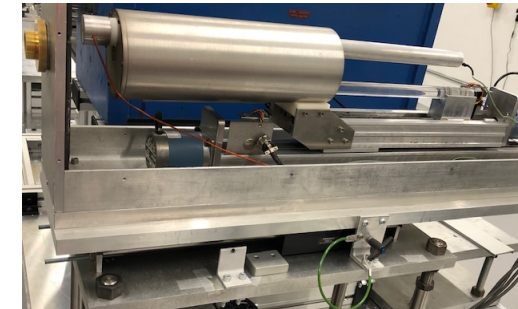
300 keV 20 kGy S *R1 *R4 #2 17.7ms	300 keV 20 kGy S *R1, *R2, *R3 #3 16.7ms	300 keV 20 kGy D *R1, *R2 #4 17.5ms	300 keV 20 kGy D *R1, *R2, *R3 #6 16.9ms
---	---	--	---

3. X-Ray Calibrations

Air-Kerma X-Ray Calibration Services

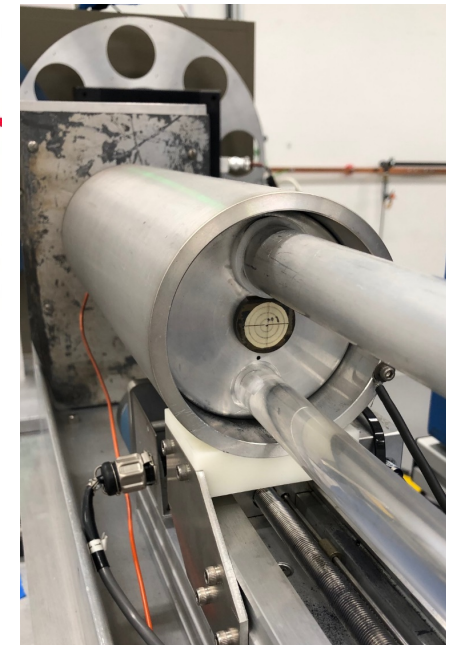
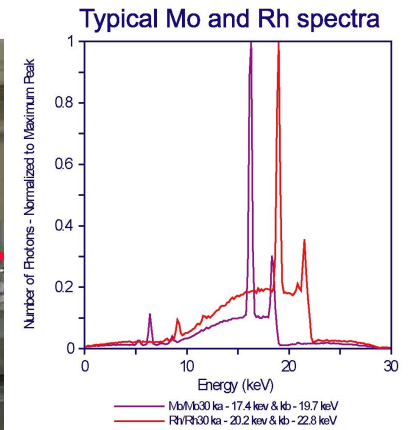
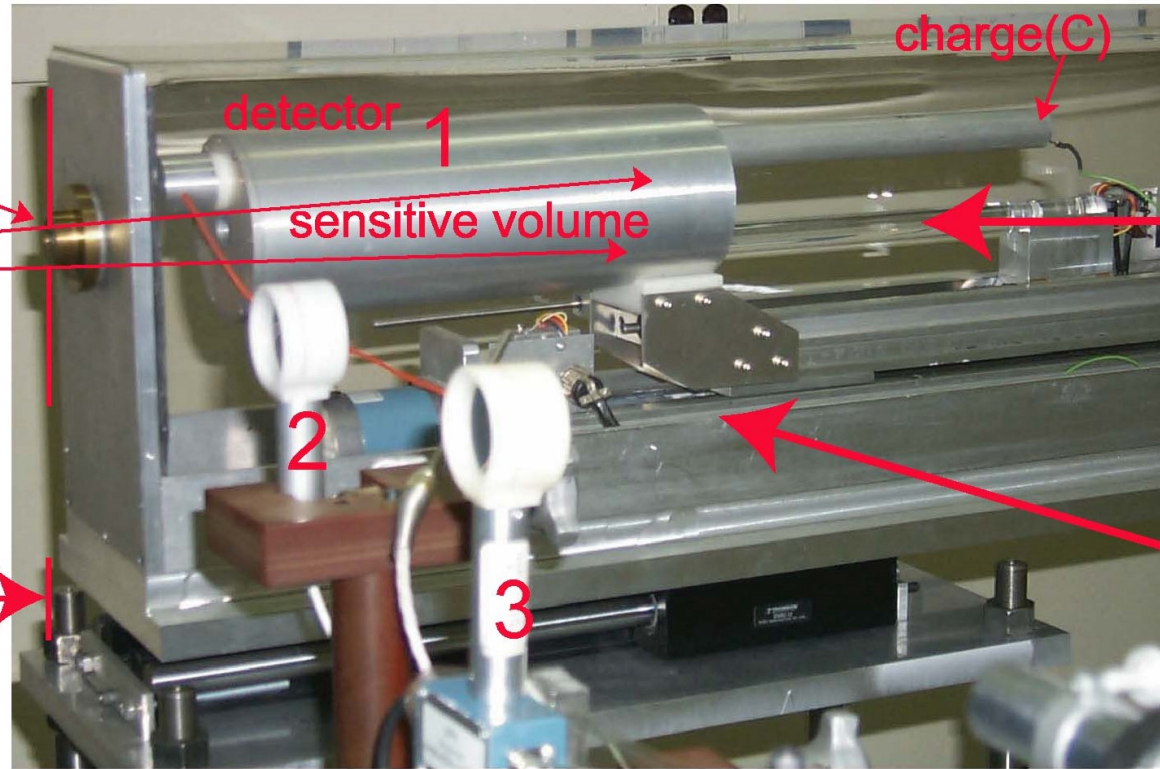
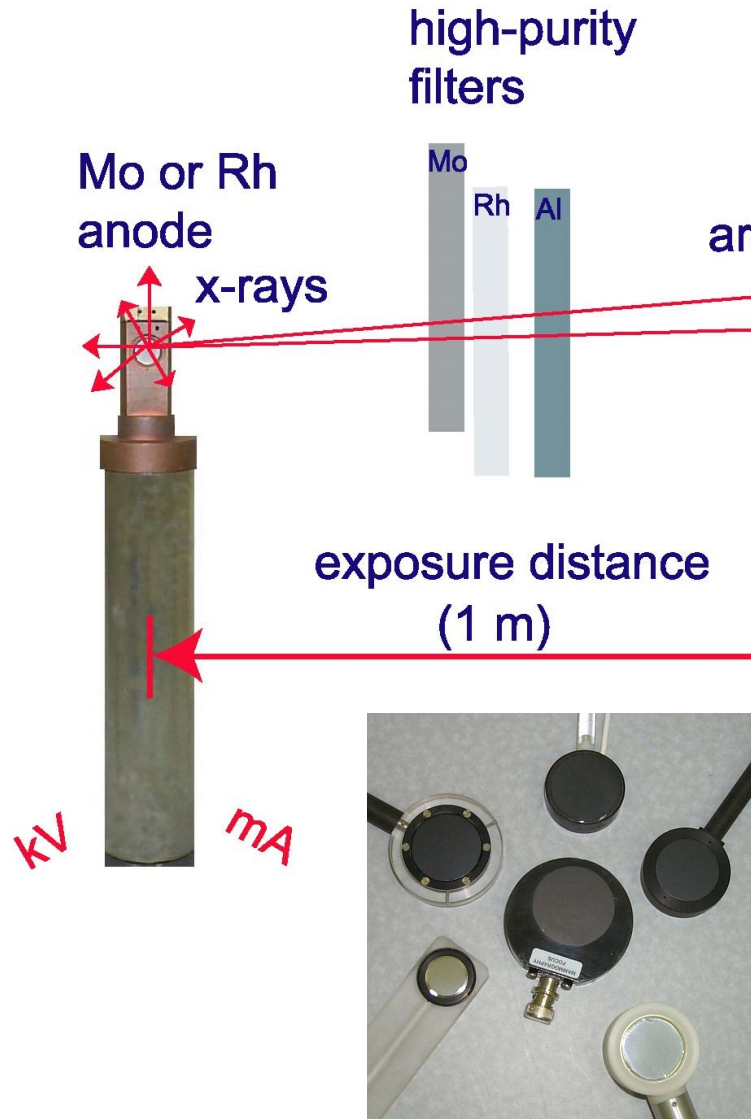


- Tungsten, Molybdenum and Rhodium anode tubes
- 10 kV to 300 kV
- Filters
- Reference Ionization Chambers:



Wyckoff-Attix 60 kV to 300 kV * Ritz 10 kV to 100 kV * Attix 10 kV to 50 kV
308 mm 127 mm 212 mm

Air-Kerma Measurement for Mammography **NIST**



Mammography Reference Beams

Beam code	Tube voltage (kV)	Filtration (mm)	Half-value layer (mm Al)
Mo Anode			
Mo/Mo23	23	0.032 Mo	0.288
Mo/Mo25	25	0.032 Mo	0.313
Mo/Mo28	28	0.032 Mo	0.346
Mo/Mo30	30	0.032 Mo	0.370
Mo/Mo35	35	0.032 Mo	0.404
Mo/Rh28	28	0.029 Rh	0.420
Mo/Rh32	32	0.029 Rh	0.453
Mo/Mo25x	25	0.030 Mo + 2.0 Al	0.551
Mo/Mo28x	28	0.030 Mo + 2.0 Al	0.589
Mo/Mo30x	30	0.030 Mo + 2.0 Al	0.633
Mo/Mo35x	35	0.030 Mo + 2.0 Al	0.715
Rh Anode			
Rh/Rh25	25	0.029 Rh	0.351
Rh/Rh30	30	0.029 Rh	0.438
Rh/Rh35	35	0.029 Rh	0.512
Rh/Rh40	40	0.029 Rh	0.559
Rh/Rh30x	30	0.029 Rh + 2.0 Al	0.814
Rh/Rh35x	35	0.029 Rh + 2.0 Al	0.898

NIST Tungsten Reference Beams

Beam code	Additional filtration				Half-value layer (HVL)	
	Al (mm)	Cu (mm)	Sn (mm)	Pb (mm)	Al (mm)	Cu (mm)
H10	0.105				0.051	
H15	0.5				0.16	
H20	1.01				0.36	
H30	4.50				1.2	
H40	4.53	0.26			2.93	
H50	4.0			0.1	4.16	0.14
H60	4.0	0.61			6.06	0.25
H100	4.0	5.2			13.51	1.15
H150	4.0	4.0	1.51		16.93	2.43
H200	4.0	0.6	4.16	0.77	19.72	4.1
H250	4.0	0.6	1.04	2.72	21.59	5.19
H300	4.1		3.0	5.0	23.55	6.19

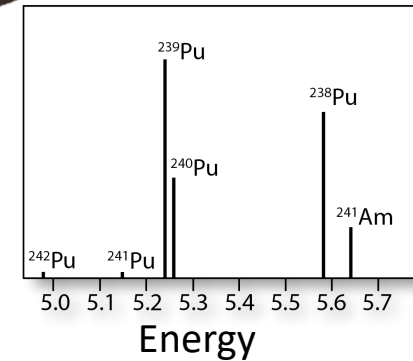
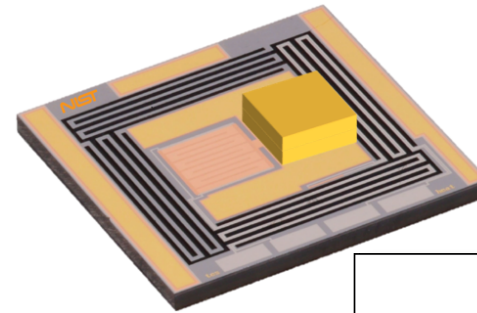
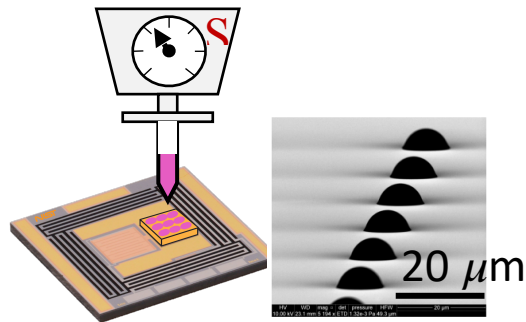
4. Transition-edge Sensors (TES) Facility for True Becquerel project

True Becquerel Overview

TRUE Bq

1. Dispense sample by mass

2. Measure decay-energy spectra



3. Automated quantification



$$^{238}\text{U} = (0.050 \pm 0.004) \text{ Bq/g}$$

$$^{238}\text{Pu} = (1.312 \pm 0.003) \text{ Bq/g}$$

True Becquerel Motivation

Realization of the Bq

- SI derived unit becquerel (Bq) = 1 decay per second
- Each of 100+ radionuclides needs a primary standard
- Primary methods often use 4π high-efficiency counting

Dissemination of the Bq

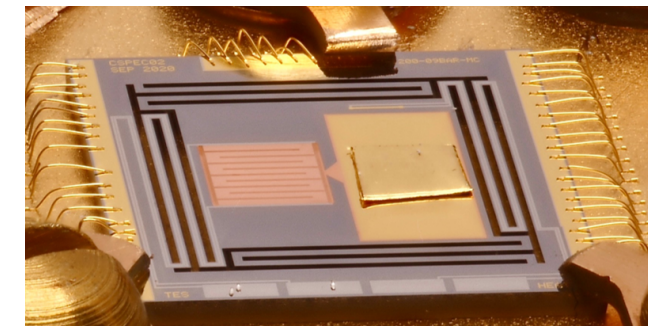
- Calibrations, SRMS, nuclear data, proficiency testing
- Customers need massic activity of solutions (Bq/g)

“Real world” challenges

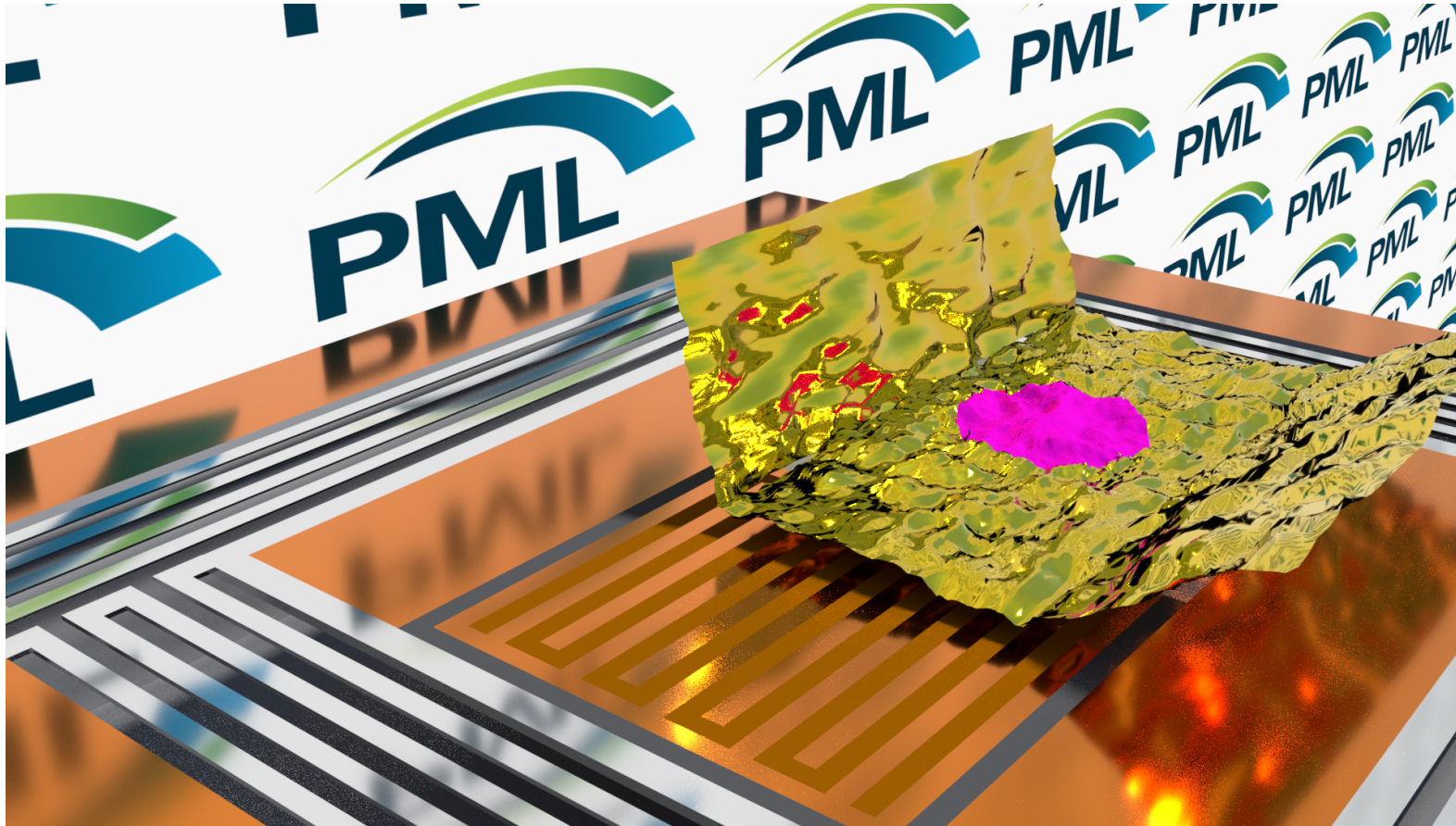
- Environment, waste, medicine, forensics contain radionuclide **mixtures**
- Large uncertainties from chemical separations and reliance on multiple methods

New paradigm: True Bq

- Leverage NIST quantum sensors to standardize multiple radionuclides in a sample
- Leverage redefinition of the kg to standardize mass of tiny liquid samples



Transition-edge Sensor



- Sensor cooled to superconducting transition temperature T_c
- Heat from decay raises temperature and resistance of the TEC
- The sharp transition between superconducting state and normal state yields sensitive thermometer
- Design thermal capacity for energy resolution

Recent progress in TES lab

February 2022

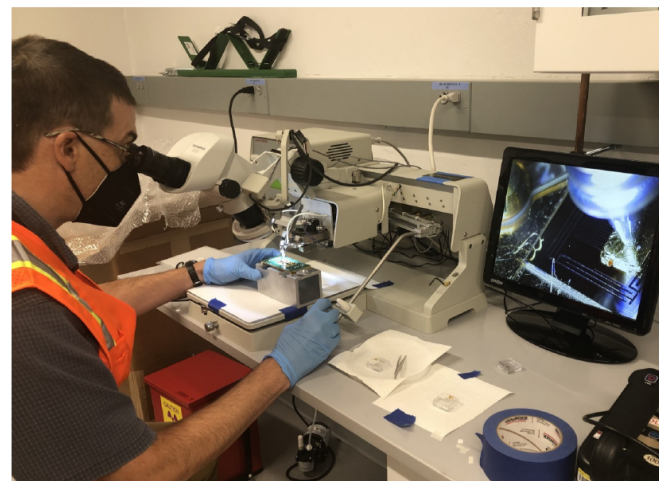


Galen O'Neil and Ryan Fitzgerald planning G'burg TES lab (245/B015)

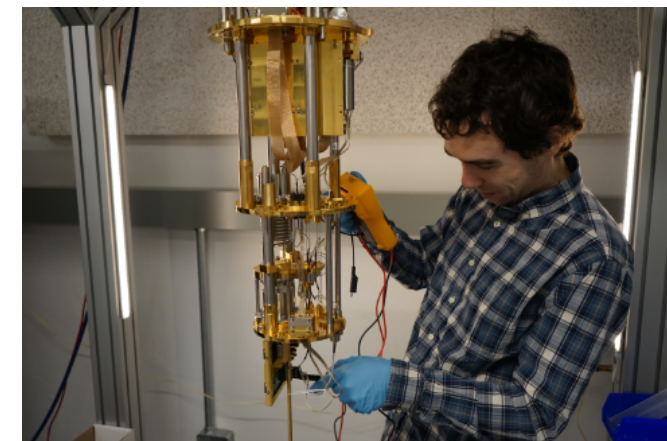
August 2022



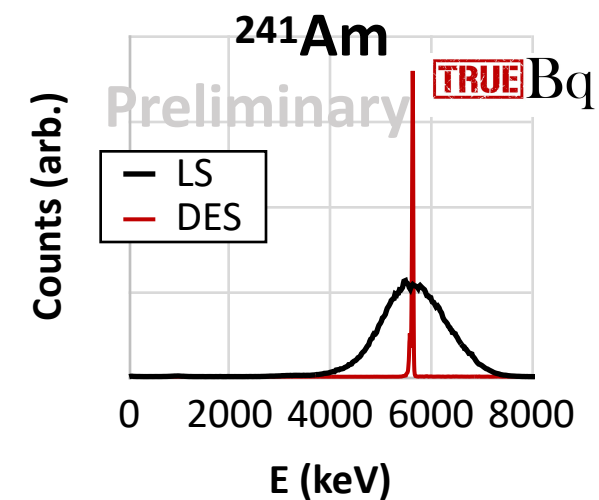
Dan Schmidt and Ryan Fitzgerald installing TES sensors and first quantitative alpha sources



January 2023



Max Carlson checking TES wiring in cryostat



Thanks for providing slides and guidance



Division Office

Jim Adams

Dosimetry

Fred Bateman

Mike Mitch

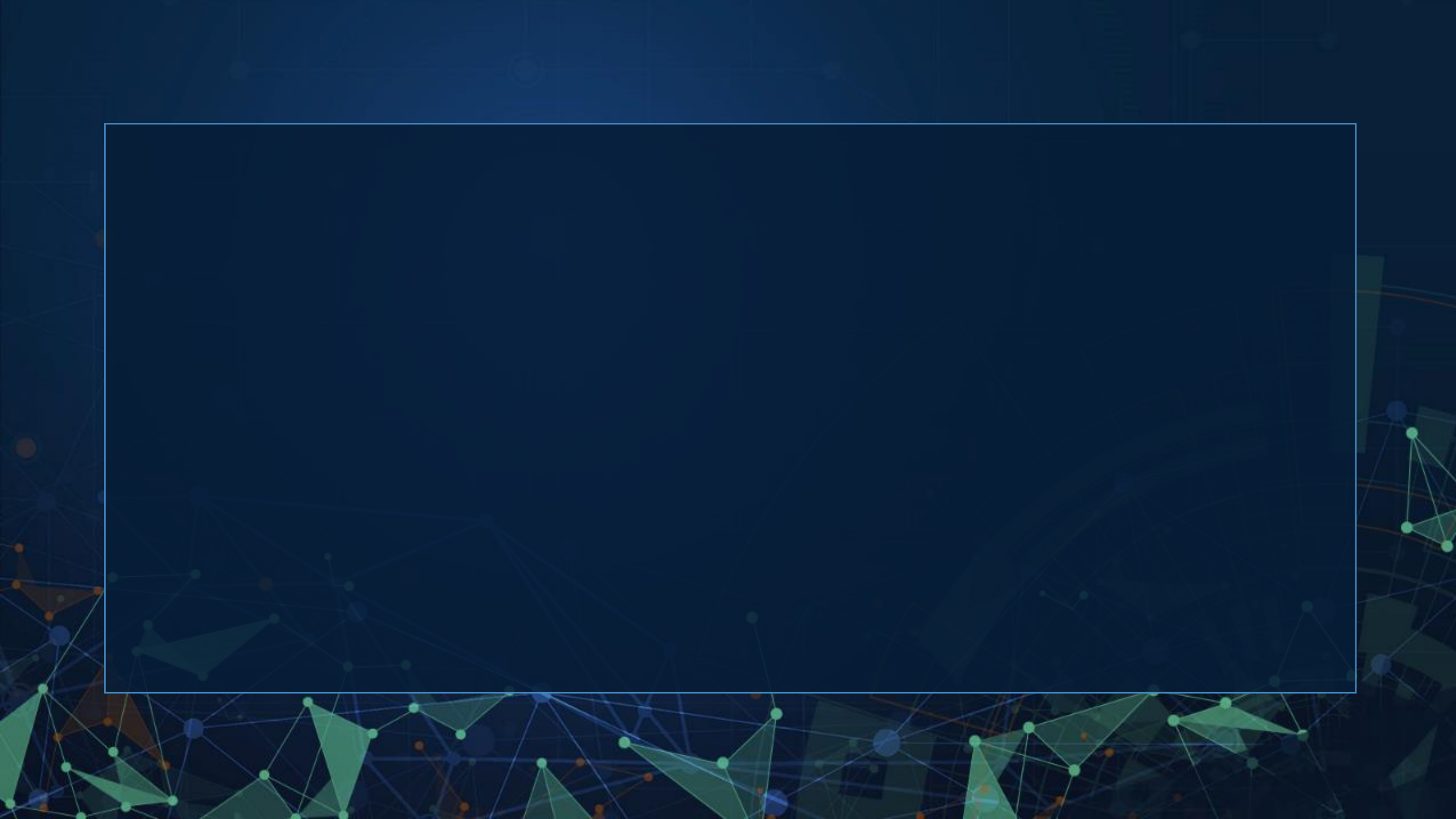
Michelle O'Brien

Radioactivity

Ryan Fitzgerald

Leticia Pibida

Brian Zimmerman



INSTRUCTIONS (16x9 aspect ratio)

1. Save the PowerPoint to your local drive and rename.
2. Fill text as desired per each slides. The font for the PowerPoint in Calibri. The font of text will adjust to the box size. Recommended font sizes are 44 for the title and 18 for body text.
3. To insert pictures, double click picture box and upload. OR select picture box frame, SHAPE FILL> PICTURE> then upload desired picture from file. Once inserted, do not stretch photo, the image crops to the picture frame size.
4. To replace icons, double click on the icon, select “change picture” or “insert picture” and select the one you want to use. There is also a slide of icons on the next page. Simply copy and paste if you would like to use these.
5. To add a new slide, selected the down arrow from the dropdown next to “New Slide” and select your desired slide design.
6. FIND NIST IMAGES : <https://www.nist.gov/image-gallery> contact PAO for assistance if needed.

Copy and paste icon to desired slide. To change color, double click on icon, select color from drop down. For consistency, please use colors in the template. Due to licensing restrictions, you can only use these icons for NIST PowerPoints.



Copy and paste icon to desired slide. To change color, double click on icon, select color from drop down. For consistency, please use colors in the template. Due to licensing restrictions, you can only use these icons for NIST PowerPoints.



NIST