Molecular Plating of Mixed Alpha Radionuclides for Energy Calibration and Quality Assurance of CDC Alpha Spectrometer Instrument

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Division of Laboratory Science (DLS)

The background of Molecular Plating of Mixed Alpha Radionuclides Preparation for The CDC Bioassay Laboratory

The CDC Rapid Radionuclide Bioassay analytical compliance CLIA methods

- **Radiological and Nuclear Emergency Response**
  - High throughput and QA/QC requirement
  - Alpha Spec Lab Anal procedure: QA1-QC1-Patient Sample-QC2-QA2
  - CDC Alpha Spec : 128 detectors
  - 16 ESS of Eckert Ziegler Isotope Products (EZIP)
  - Long time QA issue forced the CDC Lab to create more ESS
    - CDC Molecular Plating Standard Source (CDC MPSS): 64
    - Same configuration between EZIP ESS and CDC MPSS
      - 1-inch in diameter
      - Mixed alpha radionuclides: U-238, U-234, Pu-239 and Am-241

ESS: Electroplated Standard Source
MPSS: Molecular Plating Standard Source
CLIA: Clinical Laboratory Improvement Amendments

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- **Molecular Plating (MP):**
  - Molecular plating is a widely used technique
  - Molecular plating: Preferred, higher efficiency (85%–100%).
  - Chemical Vapor Deposition (CVD) : inefficient (yields of ≤ 10%)
  - **Materials**: Stainless Steel, IPA and mixed of alpha sources in HNO_3
  - **Condition**: Potential of 800V, current density of 1-5 mA/cm2 for 15 minutes
  - **Quality**: The thickness of 2.5–7.5 ng/cm^2, good quality, acceptable uniformity
  - Comparison between EZIP ESS and CDC MPSS in Alpha Spec:
    - Very good agreement in determination of Detector efficiency
    - Consistent in Full Width at Half Maximum (FWHM), Energy Calibration

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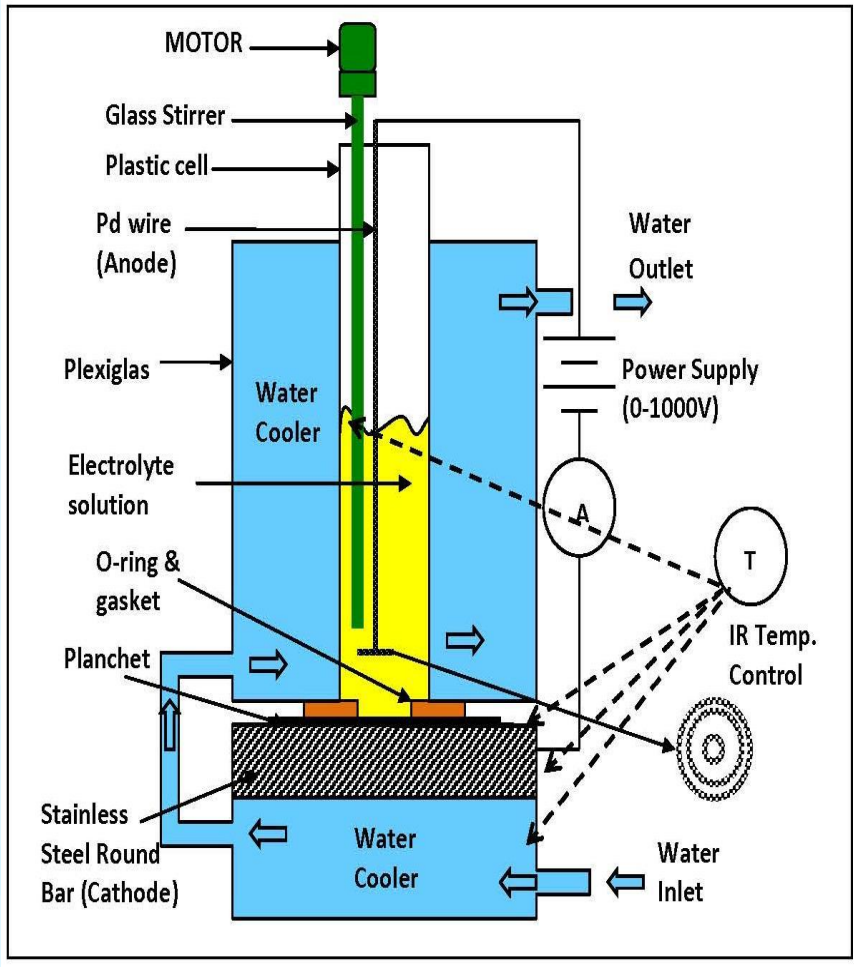
Molecular Plating Process



Sadi, S. (2012). Microstructure of Radiation Damage in the Uranium Film and its Backing Materials Irradiated with 136 MeV $^{136}Xe^{+36}$. [Doctoral dissertation, Oregon State University, Oregon]

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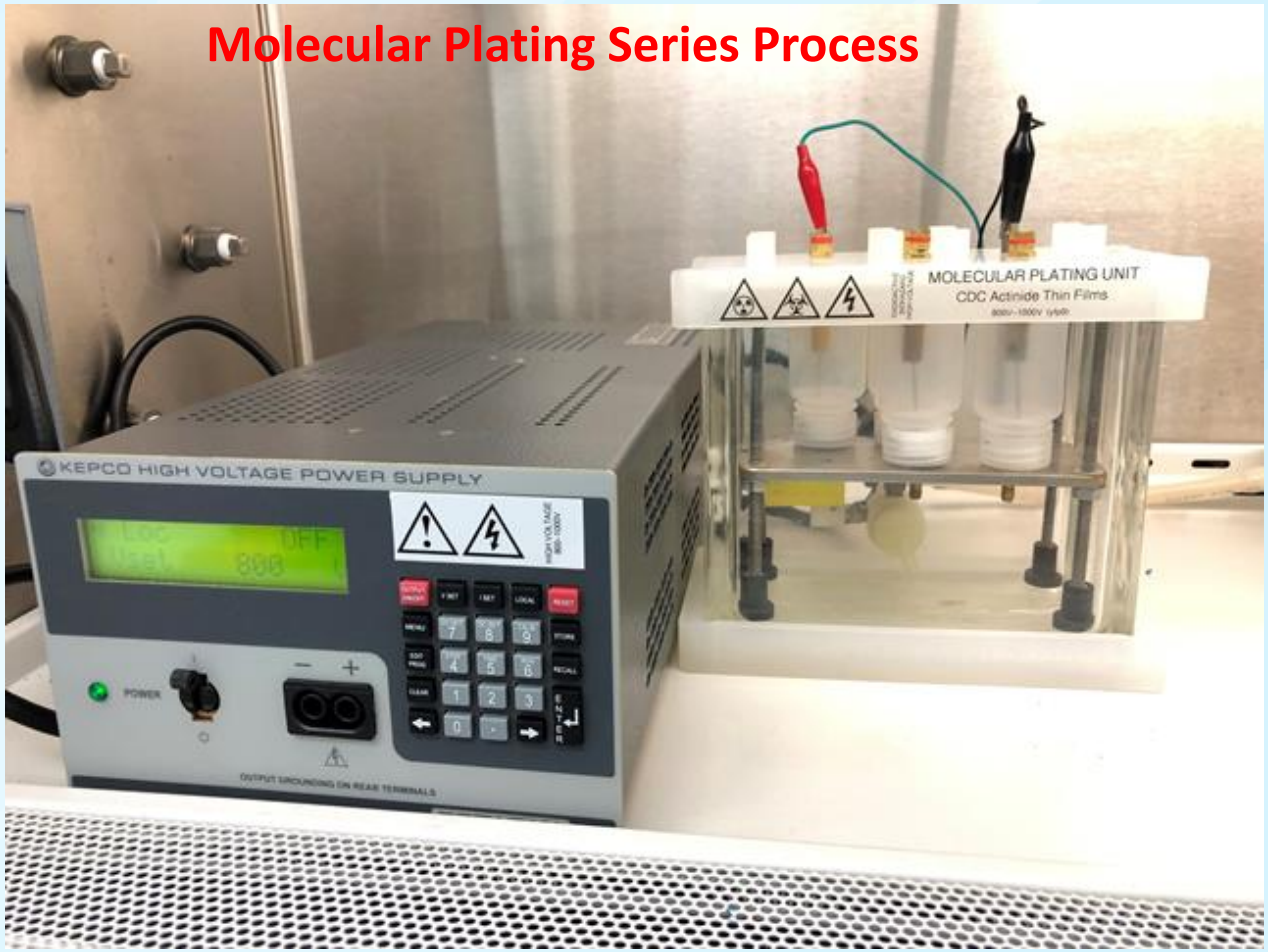

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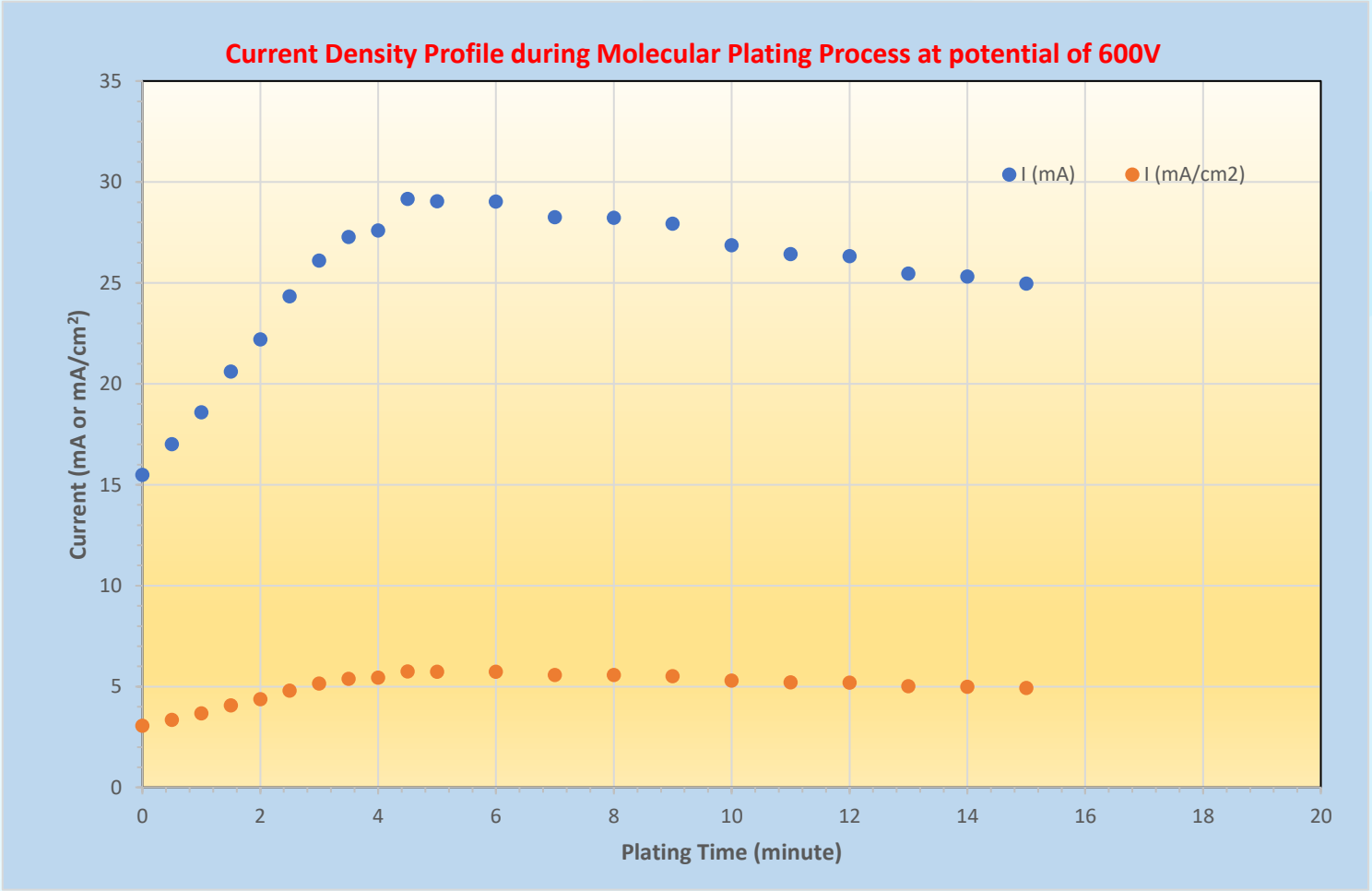

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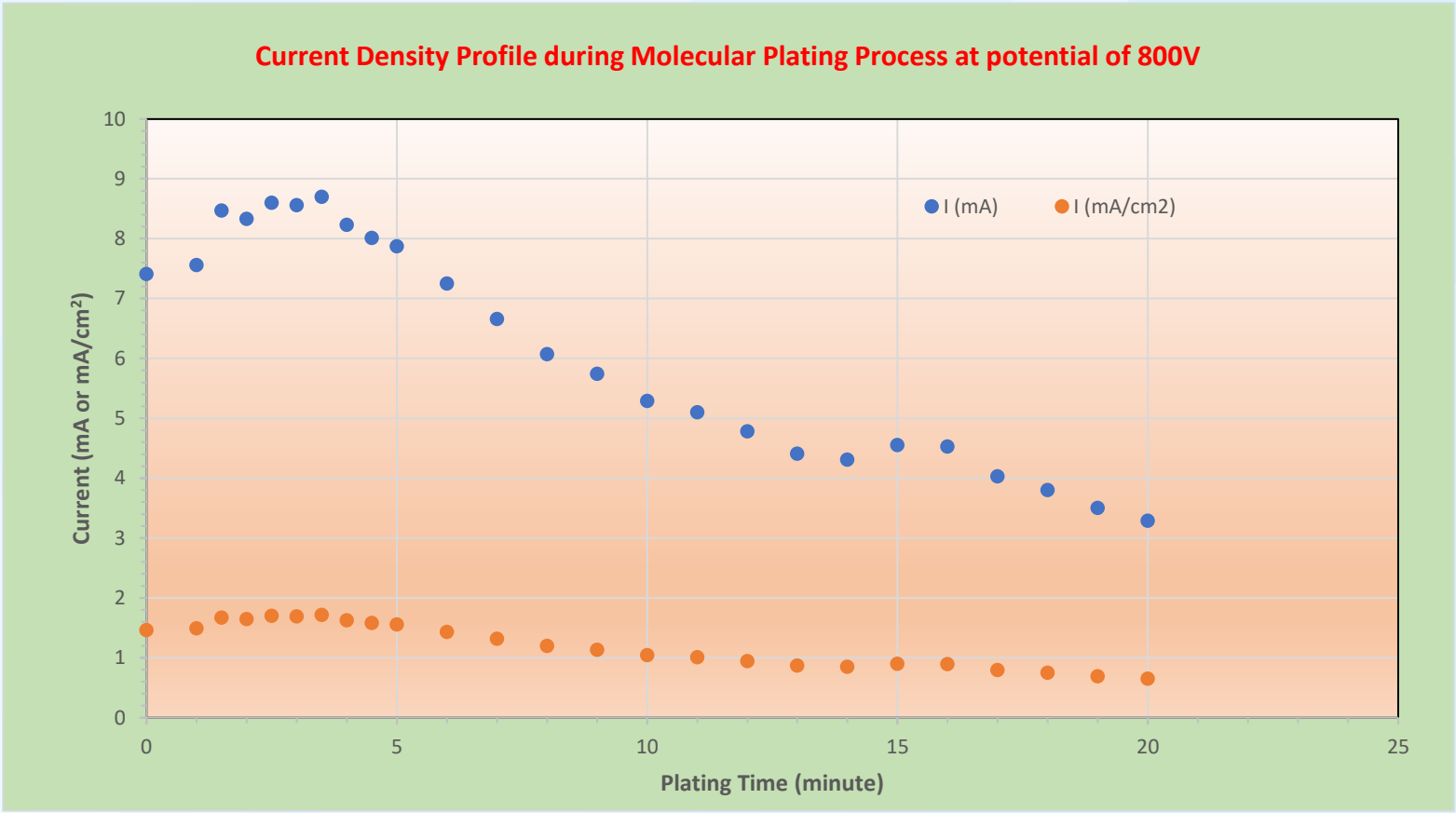

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1 Run EZIP ESS = 60 minutes; CDC MPSS = 30 minutes

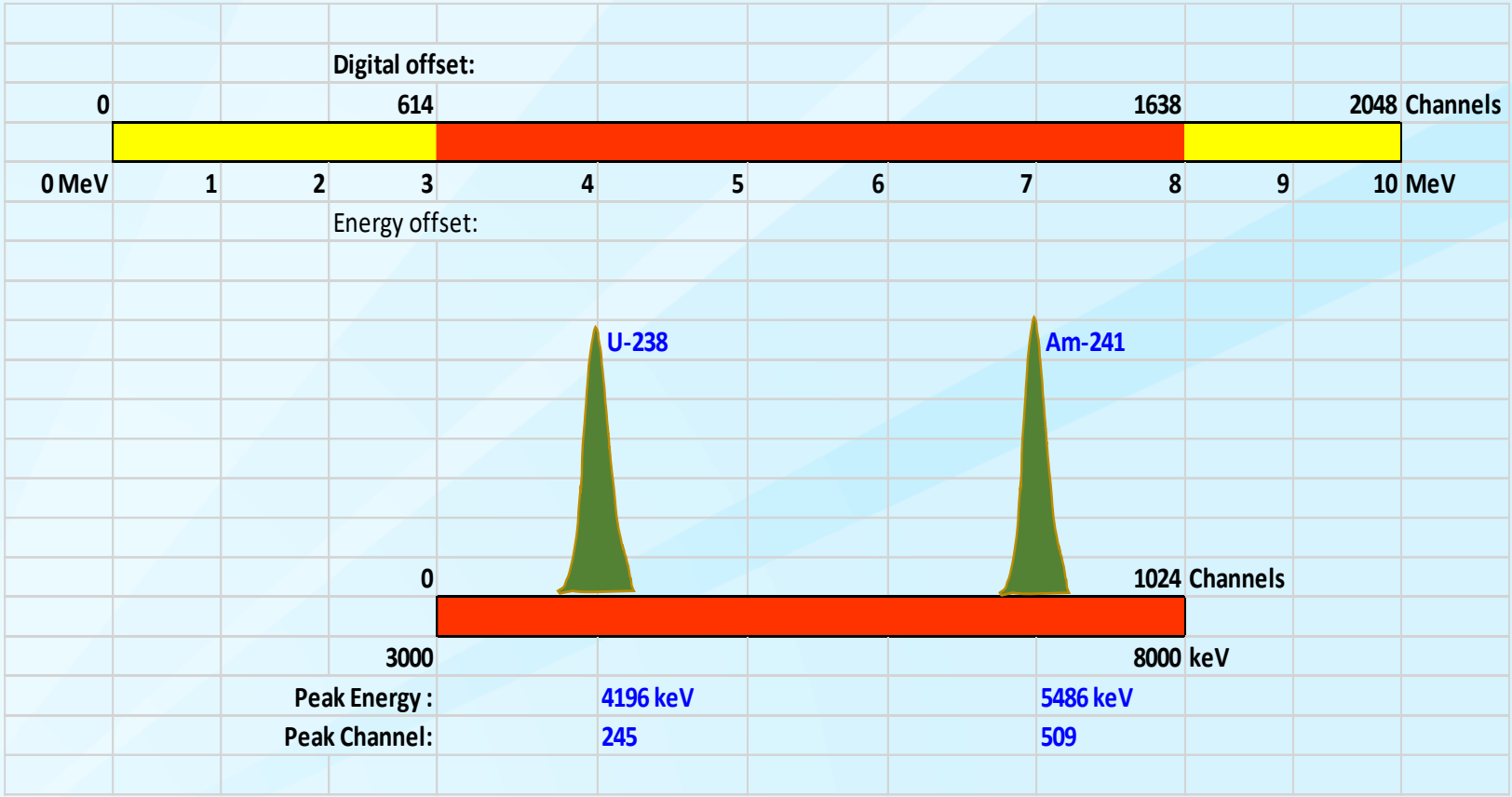
EZIP: QA for all detectors = 128/16 x 60 minutes x 2 = 16 hours

CDC: 128/64 x 30 minutes x 2= 2 hours

The CDC MP Standard Source (CDC MPSS) Results for Energy Calibration and Quality Assurance of CDC Alpha Spectrometer Instrument

The CDC Rapid Radionuclide Bioassay analytical compliance CLIA methods

Energy calibration and resolution



GAIN = 4.8828 keV/Ch; Display Channel = 1024

Energy offset = 3000 keV; Digital offset = 614s

The CDC Rapid Radionuclide Bioassay analytical compliance CLIA methods

Typical QA & Energy Calibration

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
Am-241	516	5,485.70	478	537	55.15	2,936.00	16.31
U-238	245	4,196.00	187	259	67.50	3,729.00	20.72
U-234	366	4,775.80	307	380	75.65	3,734.00	20.74
Pu-239	446	5,155.40	400	459	55.23	3,506.00	19.48

(EZIP ESS)

Nuclide Activity Summary

Nuclide	Peak Channel	Peak Energy keV	ROI Start Channel	ROI End Channel	Peak FWHM keV	Gross Counts	Net Count Rate (cpm)
U-238	245	4,196.00	202	257	86.99	6,824.00	37.91
U-234	368	4,775.80	326	380	87.22	6,989.00	38.83
Pu-239	448	5,155.40	408	460	67.28	6,904.00	38.36
Am-241	518	5,485.70	473	538	69.68	10,981.00	61.01

CDC MPSS

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Average Peak Channel and Energy of U-238, U-234, Pu-239 and Am-241 source

SOURCE:	CDC Molecular Plating Standard (CDC MPSS)				EZIP Electroplated Standard Source (EZIP ESS)			
CHANNEL	U-238	U-234	Pu-239	Am-241	U-238	U-234	Pu-239	Am-241
Peak Channel	247 ± 3	368 ± 3	448 ± 4	519 ± 5	246 ± 3	368 ± 4	448 ± 5	518 ± 6
Ideal Peak Channel	245	364	441	509	245	364	441	509
% RSD	1.12%	0.94%	0.98%	0.91%	1.16%	1.01%	1.05%	1.08%
BIAS	0.90%	1.18%	1.63%	1.93%	0.55%	0.98%	1.55%	1.81%
ENERGY	U-238	U-234	Pu-239	Am-241	U-238	U-234	Pu-239	Am-241
Peak Energy (keV)	4198 ± 2	4773 ± 4	5153 ± 3	5489 ± 3	4198 ± 2	4773 ± 3	5154 ± 3	5488 ± 2
Ideal Peak Energy (keV)	4196	4776	5155	5486	4196	4776	5155	5486
% RSD	0.05%	0.07%	0.07%	0.05%	0.04%	0.07%	0.05%	0.04%
BIAS	0.05%	-0.05%	-0.05%	0.05%	0.04%	-0.06%	-0.03%	0.04%
FWHM (keV)	76 + 9	79 + 8	62 + 7	64 + 7	74 ± 5	78 ± 4	60 ± 4	60 ± 4
Energy Resolution (%)	(1.80 ± 0.21)	(1.65 ± 0.16)	(1.21 ± 0.14)	(1.16 ± 0.12)	(1.77 ± 0.11)	(1.63 ± 0.08)	(1.17 ± 0.08)	(1.09 ± 0.07)
Detector Efficiency (%)	ε = (20.4 ± 2.31)%				ε = (20.9 ± 0.97)%			
Energy Calibration Eq.	E (keV) = 4.7511*Channel + 3023.6 (R^2 = 1)				E (keV) = 4.7573*Channel + 3028.9 (R^2 = 1)			

- **Both CDC MPSS and EZIP ESS gave the same detector efficiency (20-22%).**
- **There were no significant differences in the GAIN and ENERGY OFFSET from energy calibration equations**

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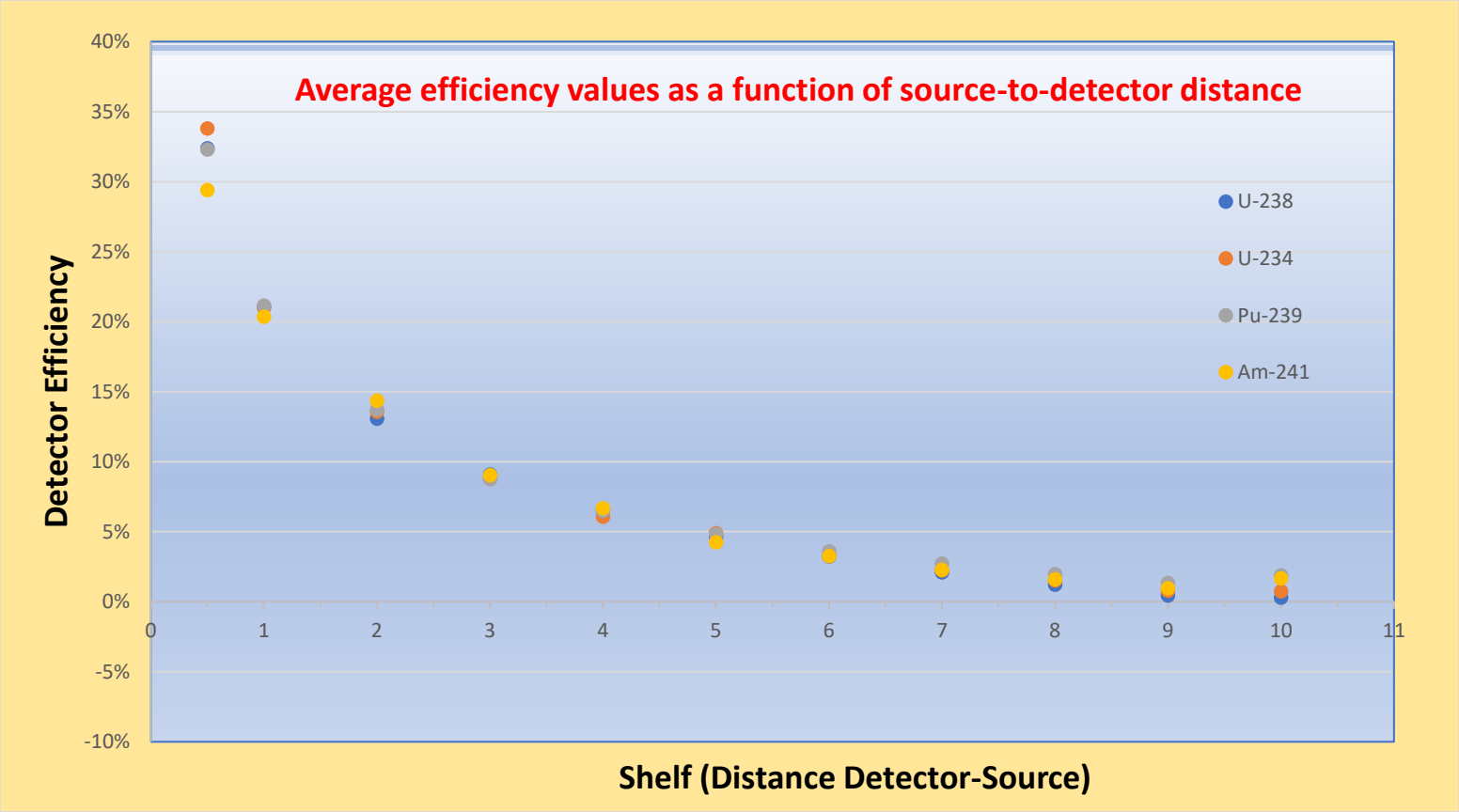

- Detector efficiencies decreased by increasing the shelf number
- The maximum detector efficiency can be reached at the closest distance between Detector &Source

Summary

- Radiation Laboratory Methods in nuclear emergency
  - Rapid analyses and high throughput
  - Rapidly QA checks (Before and after patient samples)
  - Critical step to evaluate and check our detectors

- The 64 CDC MPSS will reduce QA times from 16-hrs to 2-hrs

- The optimum plating condition for the deposition
  - Power: Potential of 800V
  - Current density of 1-5 mA/cm^2
  - Deposition Time: 15 minutes.

- The target thickness of 2.5–7.5 ng/cm^2 with a good quality and acceptable uniformity

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Questions and Discussion

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