# BEST PRACTICES FOR NUCLEAR PHARMACY

WENDY GALBRAITH

MIRION CONNECT 25 ORLANDO

JULY 31, 2025

WENDY-GALBRAITH@OUHSC.EDU

# OBJECTIVES

1. Describe qualitative imaging vs quantitative imaging
2. Explain the error rate in activity from various geometries
3. Review activity traceability using NIST sources
4. Evaluate the traceability of activity when no NIST source is available

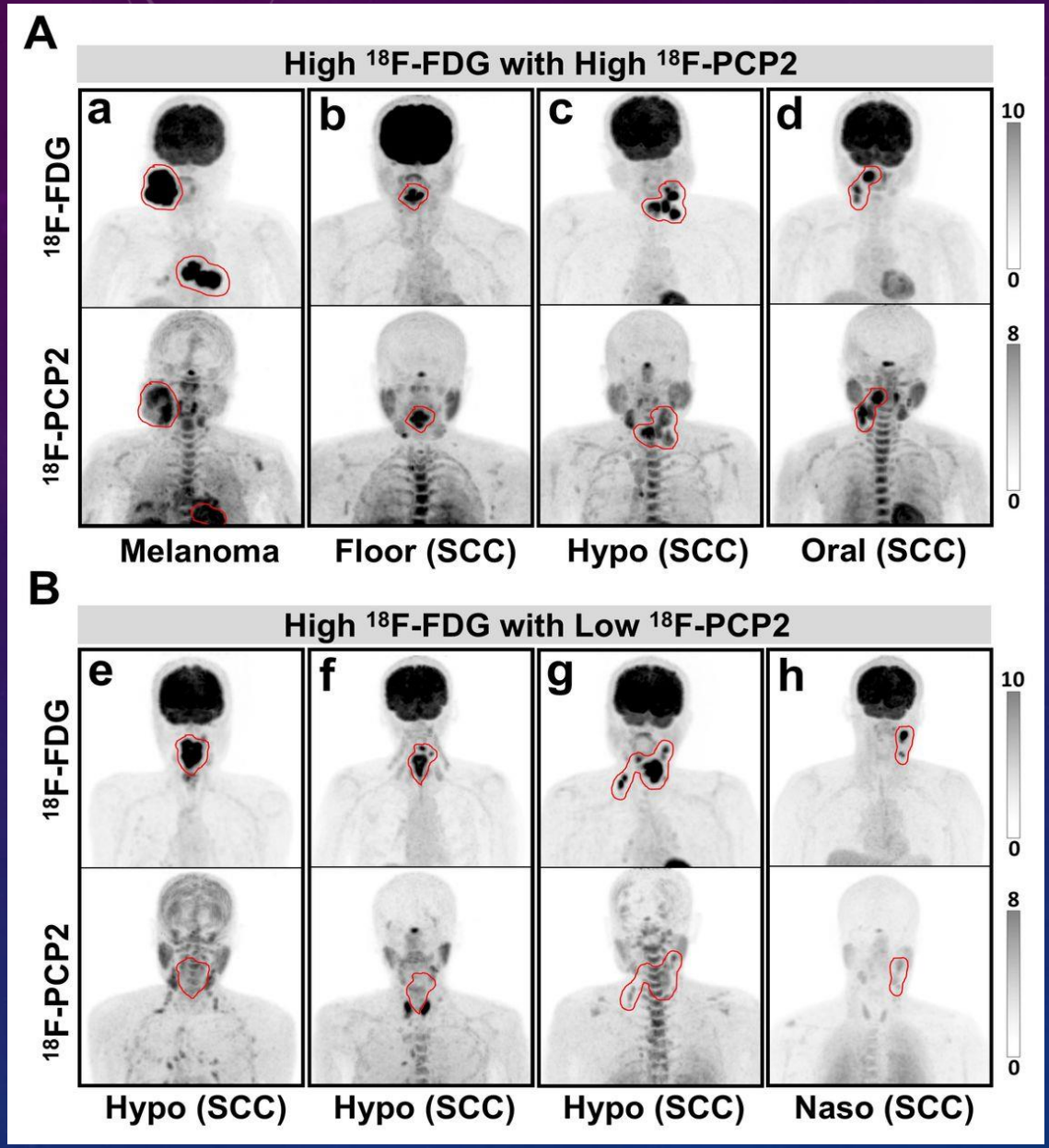
# SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

–

# IMAGE OF THE YEAR

**New Immuno-PET Tracer Superior to FDG PET in Predicting PD-L1 Expression in Head and Neck Cancer**

*PD-L1 expression* in head and neck cancer signifies the amount of the PD-L1 protein present, which is used as a biomarker for both potential immunotherapy response and, to some extent, prognosis




- Qualitative Imaging Agent
- Indicating a worse response if treated with a PD-1 inhibitor like Keytruda

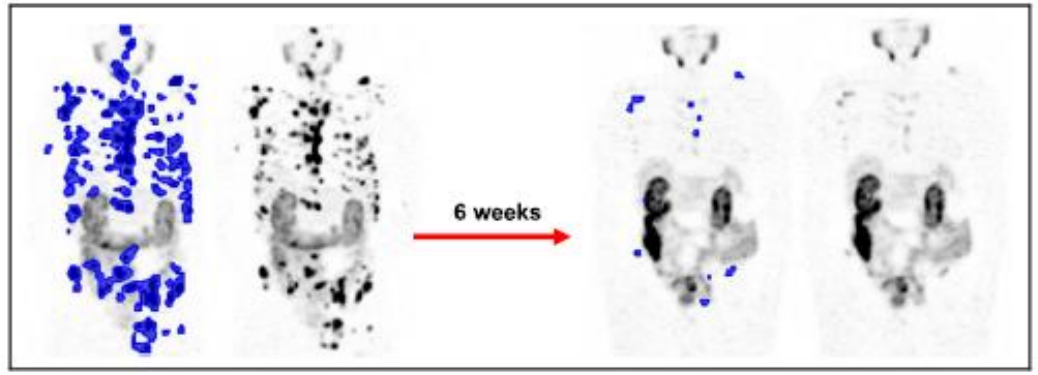
JNM The Journal of NUCLEAR MEDICINE

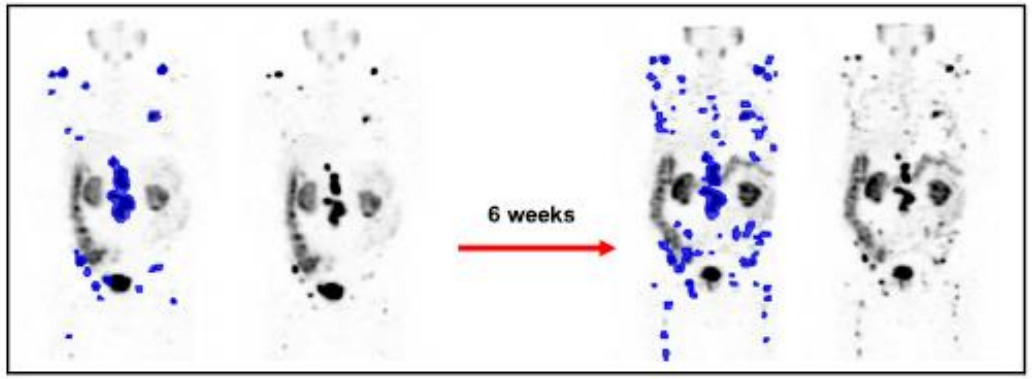
Yong Wang et al. J Nucl Med 2025;66:251095

QUALITATIVE IMAGING

TX WITH LU-177 LABELED PSMA

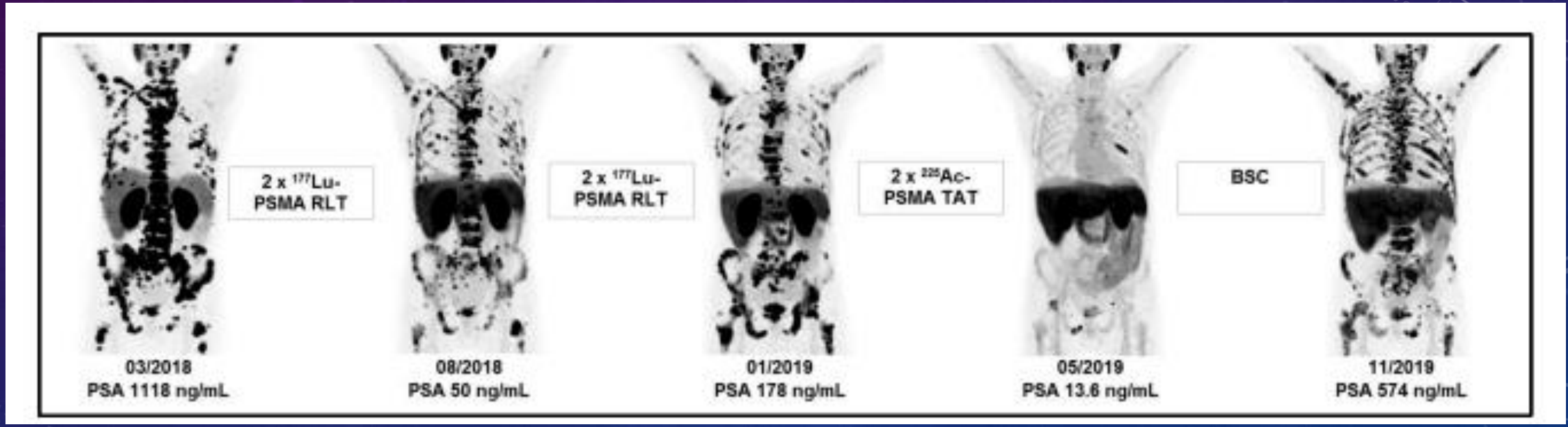
BOTH GIVEN THE SAME ACTIVITY



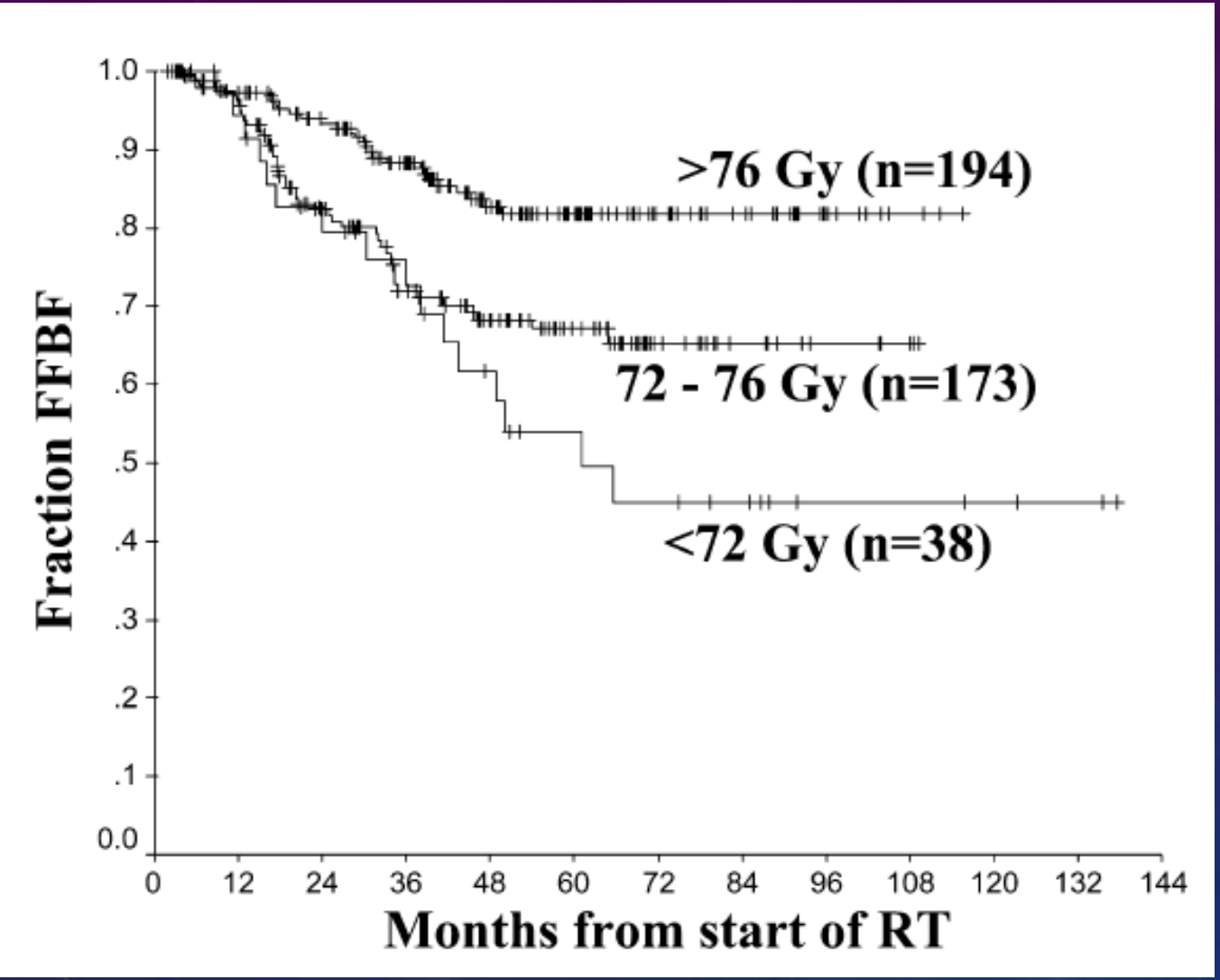




SPECT DESERVES RESPECT. JNM. 2025. Emmett

# First Clinical Results for PSMA-Targeted a-Therapy Using 225Ac-PSMA-I&T in Advanced-mCRPC Patients




225AC-PSMA-I&T TAT FOR MCRPC; Zacherl et al. JNM Vol. 62 No. 5 May 2021




# Prostate External Beam Radio Therapy

Freedom from biochemical failure at 5 years following therapy

**5.2% big difference in care**

Radiation therapy dose escalation for prostate cancer: a rationale for IMRT. World J Urol (2003) 21: 200–208

# QUANTITATIVE IMAGING – FOR DOSE-RESPONSE RELATIONSHIP

**TABLE 1**
Absorbed Doses for Tumors and Organs at Risk in $^{177}$Lu PRRT Studies

| Organ or lesion | No. of patients | Absorbed dose (Gy/GBq) Median | Range | Mean ± SD | Method | R |
|---|---|---|---|---|---|---|
| Red marrow | 6 | | | 0.07 ± 0.01 | Blood | |
| | 61 | | | 0.04 ± 0.02 | Blood | |
| | 15 | 0.02 | 0.01–0.13 | 0.034 ± 0.030 | Blood | *11* |
| | 12 | 0.03 | 0.02–0.06 | 0.04 ± 0.02 | Blood | *13* |
| | 200 | 0.02 | 0.01–0.05 | | Blood | *14* |
| | 7 | ≤0.07* (≤0.08†) | | | SPECT | *16* |
| | 10 | 0.04 | 0.02–0.06 | | Blood | *33* |
| Kidneys | 6 | | | 0.88 ± 0.19 | Planar | *9* |
| | 61 | | | 0.90 ± 0.30 | Planar | |
| | 16 | | | 0.97 ± 0.24 | Planar | |
| | 16 | | | 0.90 ± 0.21 | SPECT | |
| | 12 | 0.68 | 0.33–1.65 | 0.80 ± 0.35 | Planar | |
| | 200 | 0.61 | 0.27–1.35 | | SPECT | *14* |
| | 88 | | 0.36–0.78 | 0.57 ± 0.09 | Planar | |
| | 7 | 1.15* (0.68†) | 0.54–2.16* (0.34–1.82†) | 1.24 ± 0.49* (0.84 ± 0.49†) | SPECT | |
| | 10 | 0.62 | 0.45–17.74 | | Planar | |
| | 33 | | 0.33–2.4 | 0.8 ± 0.3 | Planar | |
| Tumors | 6 | | 3.9–37.9 | | Planar | *9* |
| | 61 | | | 9.7 ± 11.1 | Planar | *10* |
| | 16 | 6.7 | 0.1–20 | | SPECT | *12* |
| | 88 | | 1.3–4.8 | 3.41 ± 0.68 | Planar | |
| | 7 | | 2–11* (1–11†) | | SPECT | |
| | 10 | | 0.6–56 | | Planar | |
| | 24 | 6.8 | 1.4–23 | | SPECT | |

*Pretherapeutic.
†Posttherapeutic.



Red Marrow 0.01 Gy/GBq

Kidneys 0.27 Gy/GBq

Tumor Bed 3.9 – 37.9 Gy/GBq

Tumor Bed 0.6 Gy/GBq

Eberlein, JNM 2017; Individualized Dosimetry

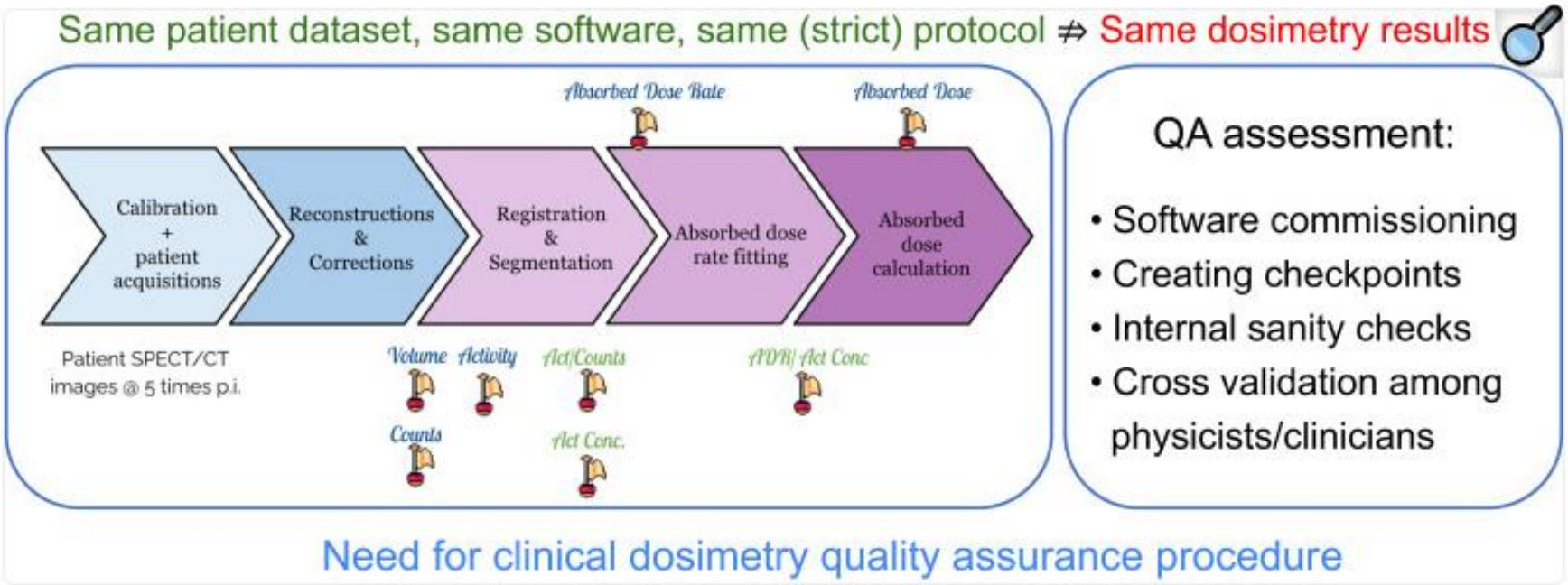
# QUANTITATIVE AND DOSIMETRIC EVALUATION OF LU-177 SPECT IMAGING ON STARGUIDE™ CZT-BASED SPECT CAMERA: A PHANTOM STUDY

- **Patient-specific dosimetry has the potential to significantly increase the therapeutic benefit of targeted radionuclides by delivering the maximum administered activity without exceeding normal tissue toxicity limits. Voxel-based dosimetry has the potential to provide patient-specific dose volume information**
- **Energy deposition (absorbed dose) is a function of how much activity is in a gram of tissue**
- **The quantitation begins with the Dose Calibrator**

Yazdan Salimi JNM June 2024, 65 (supplement 2) 241763

Stephen Graves, Ashok Tiwari, Yusuf Menda, Mark Madsen and John Sunderland. JNM 2019;S1

J Nucl Med. 2024 Jan;65(1):125–131. doi: 10.2967/jnumed.122.265340



# DOSE CALIBRATOR OR "ACTIVITY METER"

$^{40}$AR ARGON MASS 40 G ATOMIC NUMBER 18

IONIZATION ENERGY 15.760 EV

0.0017837 GRAMS PER CUBIC CENTIMETER

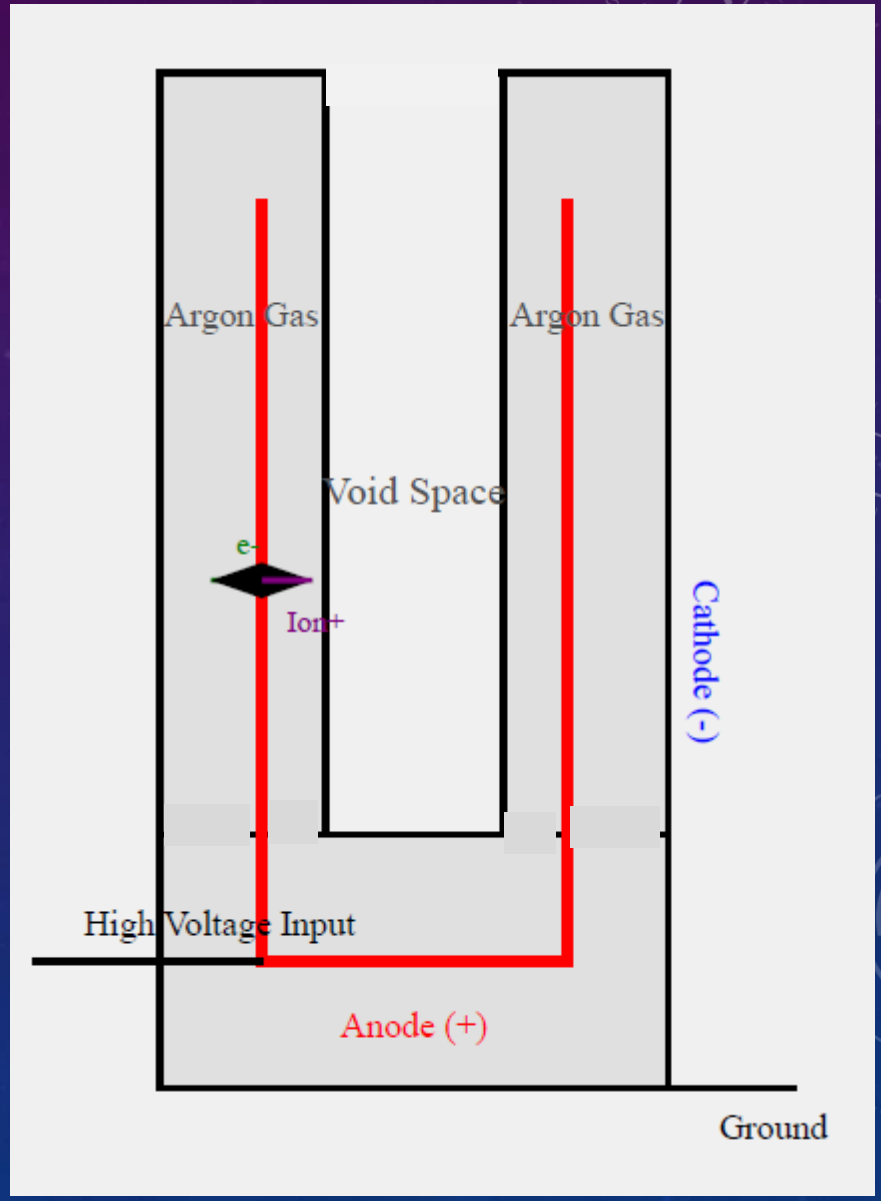
CAPINTEC CRC-15R DOSE CALIBRATOR HAS

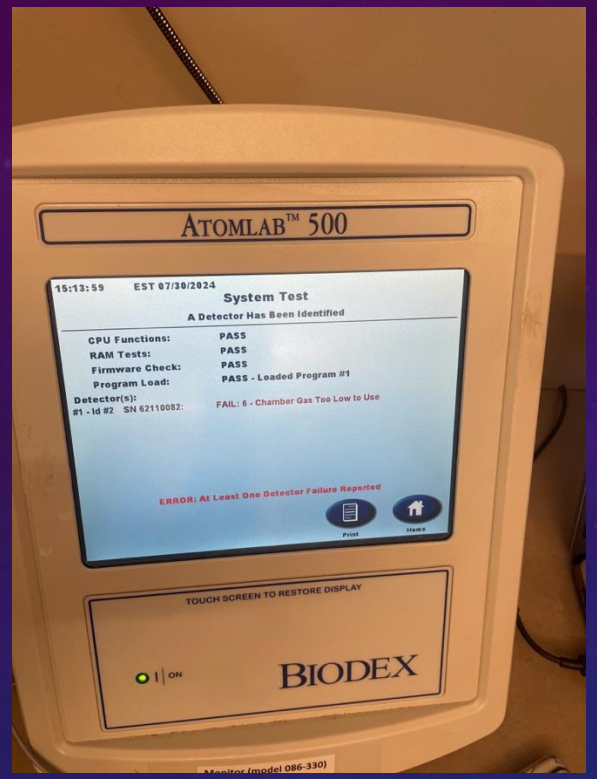
A WELL DEPTH AND DIAMETER OF 25.4 CM AND 6.1 CM

$Bq/cm^3$

Bq/mL

Bq/gram




ATOMLAB™ 500
15:13:59 EST 07/30/2024
System Test
A Detector Has Been Identified
CPU Functions: PASS
RAM Tests: PASS
Firmware Check: PASS
Program Load: PASS - Loaded Program #1
Detector(s):
#1 - Id #2 SN 62110082: FAIL: 6 - Chamber Gas Too Low to Use
ERROR: At Least One Detector Failure Reported
Print
Home
TOUCH SCREEN TO RESTORE DISPLAY
ON
BIODEX


086-838-M11
1190507


CAUTION
GLASS
DISPOSAL
VWR


CAUTION
GLASS
fisher

DEVIATION IN THE PREDEFINED CALIBRATION FACTORS OF THE DOSE CALIBRATORS AND THE ASSOCIATED INACCURACY IN THE RADIOACTIVITY MEASUREMENTS OF BETA-GAMMA EMITTERS; SARIKA SHARMA, BALJINDER SINGH, ASHWANI KOUL1, BHAGWANT RAI MITTAL

INDIAN JOURNAL OF NUCLEAR MEDICINE | VOL. 30: ISSUE 2 | APRIL-JUNE, 2015

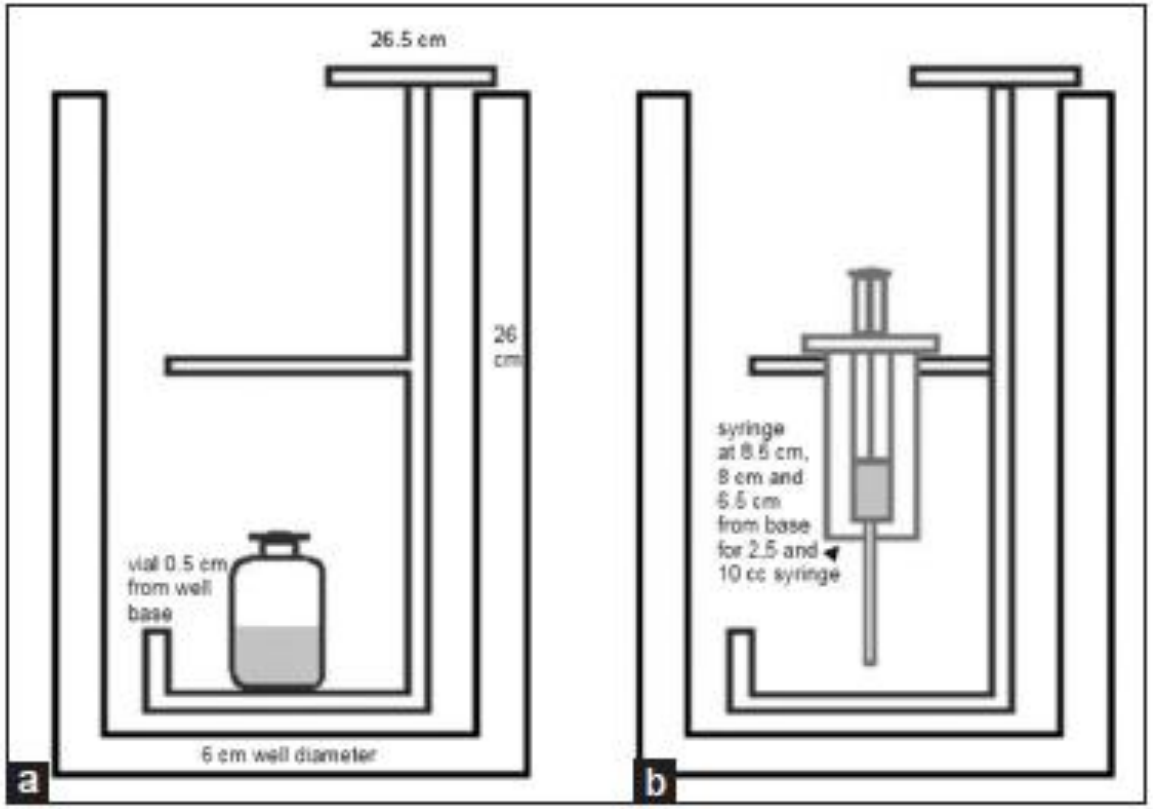



Figure 1: Block diagram of the dose calibrator with the source holder for (a) vial geometry and (b) syringe geometry

*different source geometries*

# HISTORY- FOR DIFFERENT SOURCE GEOMETRIES

- 2001 61 medical events – Sm-153 28 percent less activity over 4-years
- 2015 Ra223 dichloride (Xofigo) Change in NIST Standard Reference Material – 10% numerical increase in Bq/mL in the vial- new dial setting
- 1994 14 medical events – Sr-89 less activity
- 2007-2023 Y-90 Spheres 523 medical events - Pure beta Y-90 has a little spike of 511; but majority are x-ray breaking radiation – depending on geometry especially careful – draw out activity and then re-assay vial, but use a correction factor based on the volume displaced that you calculate from carefully doing the trial volume testing, you don't have to replace the volume after you have a correction factor

# NIST F-18 SYRINGE STANDARD (GE-68/GA68)

**Accuracy of F-18 calibration settings in commercial dose calibrators using a new traceable Ge-68 standard (2010) From 439 to 472 on some Capintec models**

- Clinical site establishing syringe F-18 dial setting with Ge68/Ga68 syringe geometry source
- Clinical site is filling F-18 phantom to perform PET normalization
- PET scanner converts F-18 normalization into calibration for OTHER ISOTOPES (Bq/mL)

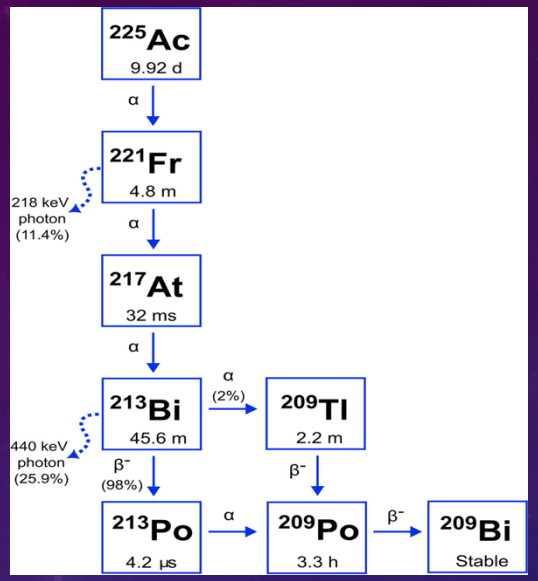
- Dose Calibrator assay of all ISOTOPES injected activity- input the absolute activity given to patient
- Quantitative PET SUV

Natasia O'Brien, Mike Zimmer, Nancy McDonald and Stewart Spies
Journal of Nuclear Medicine April 2010, 51 (supplement 2) 2112;

# GRAVES ET AL, 2021-SIR SPHERES 23% HIGHER GNESIN ET AL, 2022-THERASPHERES 20% LOWER

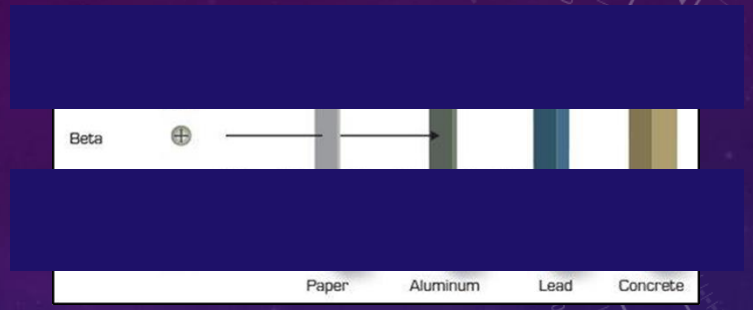
- These articles measured the true activity of the Y-90 spheres and the manufacturer was 20% wrong in the activity on the vial, and hence prescribed by the AUs and hence the DOSE (Gy) delivered to the patients.
- This was consistent with SIR Spheres all the way back to the trials
  - Resin microspheres are known to have a lower liver toxicity dose threshold – 52 Gy = 50% NTCP; implies 40 Gy = 15% NTCP
- It was inconsistent with Theraspheres
  - Glass spheres are known to have a higher liver toxicity – 70 Gy = 15% NTCP (normal tissue complication prob)

# ALPHA EMITTERS




- For an alpha emitter – decay chains can lead to measurements being made before equilibrium is reached – must rely on the MCA for timing
- Low energy x-rays can lead to significant geometry effects
- Administered activities are low, on the order of 50 to 200 microcuries - Measurement of the residual can be a larger fraction of the administered activity.
- A series of decays means you need to know when the RN was produced and when it's in equilibrium

# 5.4.2 BETA EMITTERS




- Beta emitters can be accurately measured in a radionuclide calibrator using the bremsstrahlung produced as the beta particles interact with surrounding materials
- most of the first bremsstrahlung interactions occur in the source (solution and container) followed by interactions with the chamber's aluminum wall
- Higher energy Beta's have direct ionization of the chamber volume and may significantly distort assay results. A beta emitter with an Emax greater than 2 MeV is considered a high-energy beta emitter
- The authors recommend that commercial nuclear pharmacies establish a Y-90–calibrated setting based on the NIST standard reference source so that each source supplied to a medical facility could be used as a secondary reference standard and each medical facility determine its own calibration setting based on the initial Y-90 activity received from the pharmacy

# GRAVES, SNMMI 2023

- **Based on UAB and IOWA the Lu177 Lutathera and Pluvicto are approximately -3.3% and +3.2% compared to Novartis activity specifications.**
- **This indicates that different dial settings should be used 20 cc in a glass vial and 10 cc in a glass vial is not the difference your seeing with only volume difference in the vial**

# 5.4 PROBLEM RADIONUCLIDES

## *5.4.1 LOW-ENERGY PHOTON EMITTERS (<100 KEV)*

- A number of commonly used radionuclides emit relatively abundant characteristic x-rays in addition to their principal photons
- The characteristic x-rays from these radionuclides have energies that fall within the peak and potentially contribute a large component to the ionization current
- If the source container is glass, the x-rays may be highly absorbed in the glass wall
- If the container is a capsule or plastic syringe, a significant number of the x-rays will penetrate to the sensitive volume of the chamber

AAPM TG-181

# Comecer data for container type

| ISOTOPE | CONTAINER CORRECTION | |
|---|---|---|
| | GLASS VIAL | PLASTIC SYRINGE |
| $^{241}$ Am | +5% | -5% |
| $^{123}$ I | +15% | -15% |
| $^{125}$ I | +25% | -25% |
| $^{111}$ In | +10% | -10% |
| $^{133}$ Xe | +10% | -10% |

Ionization current was 100% at 5-7 cm from the bottom of the chamber.

**TABLE I - NUCLEAR DECAY DATA FOR $^{111}In$ [1]**

| Radiation Type | Energy (keV) | Intensity (%) |
|---|---|---|
| X-ray L | 3.13 | 7.00 |
| X-ray $K_{\alpha 2}$ | 22.98 | 23.50 |
| X-ray $K_{\alpha 1}$ | 23.17 | 44.40 |
| X-ray $K_{\beta}$ | 26.00 | 14.50 |
| $\gamma$ 1 | 171.28 | 90.93 |
| $\gamma$ 2 | 245.39 | 94.00 |

**TABLE II - $^{111}In$ CORRECTION FACTORS FOR VARIOUS GEOMETRIES**

| DOSE CALIBRATOR MODEL # | | RAD CAL 4050 | ATOM LAB 100 | CAPINTEC CRC 12 |
|---|---|---|---|---|
| MANUFACTURER'S CALIBRATION FACTOR | | 1141 | 12.7 | 303 |
| | Volume in VIAL or SYRINGE | Correction Factor | Correction Factor | Correction Factor |
| 10 CC Molded Glass Vial | 1.0 to 6.0 mL | 1.154 | 1.213 | 1.136 |
| 1 CC SYRINGE | 1.0 mL | 0.770 | 0.812 | 0.797 |
| 3 to 10 CC SYRINGE | 1.0 mL | 0.786 | 0.828 | 0.812 |
| 3 to 10 CC SYRINGE | 3.0 mL | 0.798 | 0.843 | 0.821 |
| 6 to 10 CC SYRINGE | 6.0 mL | 0.815 | 0.859 | 0.835 |

**Example 1:** A Capintec Model CRC 12 is used to assay a 10 cc molded glass vial containing 1.1 mL of $^{111}InCl_3$. The obtained value is 5.28 mCi. The correction factor from Table II is 1.136. The actual activity contained in the vial is:

5.28 mCi x 1.136 = 6.00 mCi

# TECHNICAL BULLETIN BY MALLINCKRODT IN THE 80'S IN-111

# DIPPER AND SOURCE POSITION 1-3% DIFFERENCE DEPENDING ON WHERE THE SAMPLE IS PLACED IN THE DIPPER- EVEN WITH CORRECT DIAL SETTING AND GEOMETRY

# AAPM TG-181

# POST-ASSAY ERRORS

**Table 3.** Stages and Typical Uncertainties in Radiopharmaceutical Dosage Delivery

| | Source of Uncertainty | Uncertainty |
|---|---|---|
| Prescribed Dosage | | |
| ↓ | | |
| Dosage Prepared | Technique/Human Error | Unknown |
| ↓ | | |
| Assayed Dosage | Calibrator Accuracy | ±5%–10%* |
| | % of Prescribed Dosage | ±5%–10%* |
| ↓ | | |
| Time to Administration | E.g., Tc-99m | 0.2%/min |
| | E.g., F-18 | 0.6%/min |
| ↓ | | |
| Residual Activity | E.g., Syringe-Needle Dead Volume | (–) ~6% |
| ↓ | | |
| | E.g., Adsorption to Vessel Wall | (–) ~1%–30% |
| Administered Dosage | % of Prescribed Dosage | ±10%* |

*Recommended Maximum

# NRC REGS 15 YEARS AGO

- Geometry-at time of installation, repair, recalibration, or relocation ± 5%
- Accuracy-annually-two radionuclides ± 5%
- Constancy-Daily –reference source ± 5%
- Linearity-Quarterly –shielding or decay method ± 5%

# 10CFR35

- **§ 35.60 Possession, use, and calibration of instruments used to measure the activity of unsealed byproduct material**
- (a) For direct measurements performed in accordance with § 35.63, a licensee shall possess and use instrumentation to measure the activity of unsealed byproduct material before it is administered to each patient or human research subject.
- (b) A licensee shall calibrate the instrumentation required in paragraph (a) of this section in accordance with nationally recognized standards or the manufacturer's instructions.
- (c) A licensee shall retain a record of each instrument calibration required by this section in accordance with § 35.2060.
- § 35.63 Determination of dosages of unsealed byproduct material for medical use. (d) Unless otherwise directed by the authorized user, a licensee may not use a dosage if the dosage does not fall within the prescribed dosage range or if the dosage differs from the prescribed dosage by more than 20 percent.

## 10.4 Recommended Quality Control Programs

### *10.4.1 Test Frequencies*

| | Acceptance[a] | Daily[b] | Annually |
|---|---|---|---|
| Physical Inspection | X | X | X |
| System Electronic | X | X | X |
| Clock Accuracy | X | X | X |
| High Voltage | X | X | X |
| Zero Adjustment | X | X | X |
| Background | X | X | X |
| Check Source | X | X | X |
| Accuracy Test | X | | X |
| Reproducibility | X | | X |
| System Linearity | X | | X |
| Supplier Equivalence | X | | X |

[a] And after repair.

[b] At the beginning of each day-of-use. **Note:** The term "day-of-use" may lead to some confusion for facilities that offer after-hour services. For purposes of radionuclide calibrator quality control, "day-of-use" means a normal 24-hour day starting at 12:00 a.m.

# COMMERCIAL NUCLEAR PHARMACY & RADIOPHARMACEUTICAL MANUFACTURER (10CFR32)

Professional Guidelines:

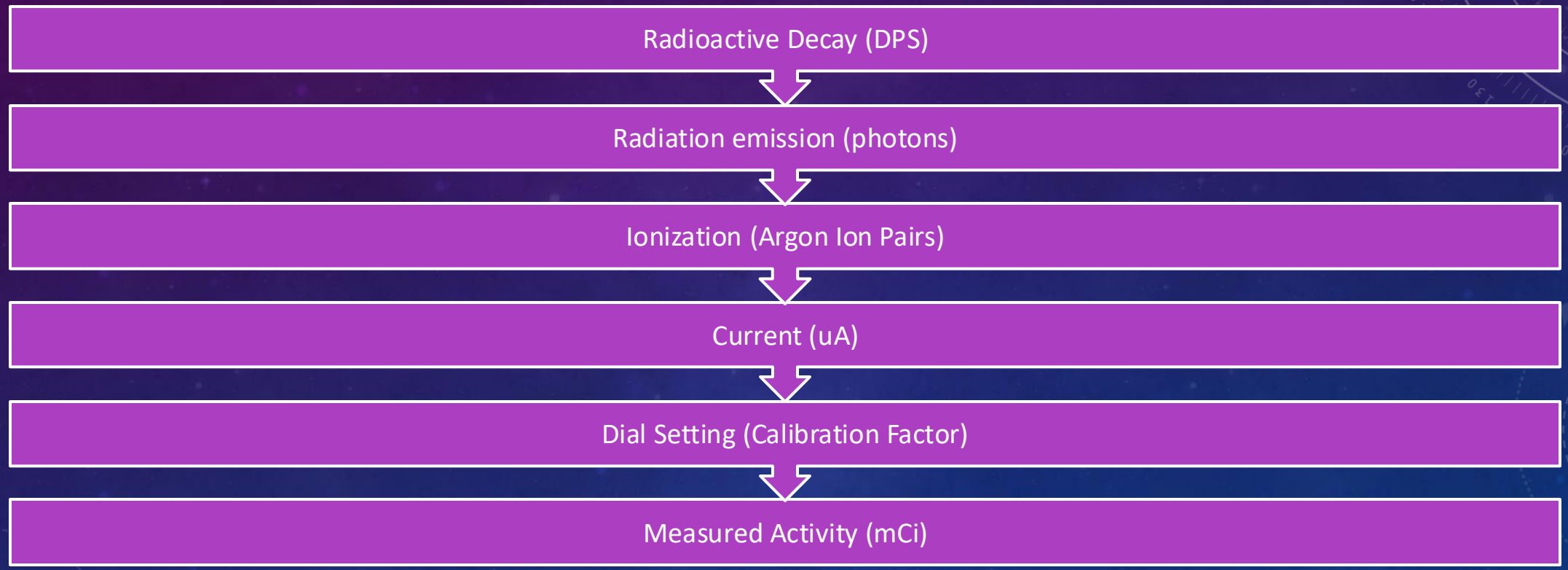
- AAPM TG-181 ± 2% FOR ANY ABSOLUTE ACTIVITY QUANTIFICATION
- NUREG 1556 VOLUME 13 REV 2 APPENDIX L ± 10%
- NUREG 1556 VOLUME 9 REV 3 APPENDIX G ± 10%

AAPM 181.

# ROLE OF STANDARDS IN QA/QC

- Regular checks should utilize traceable standards
- Sources should be traceable to NIST
- Acceptance criteria for various tests (e.g., accuracy, precision, linearity)
- Perform tests at different frequencies: daily, monthly, annually
- New calibration factors needed when a **source geometry change leads to activity change** > 5%

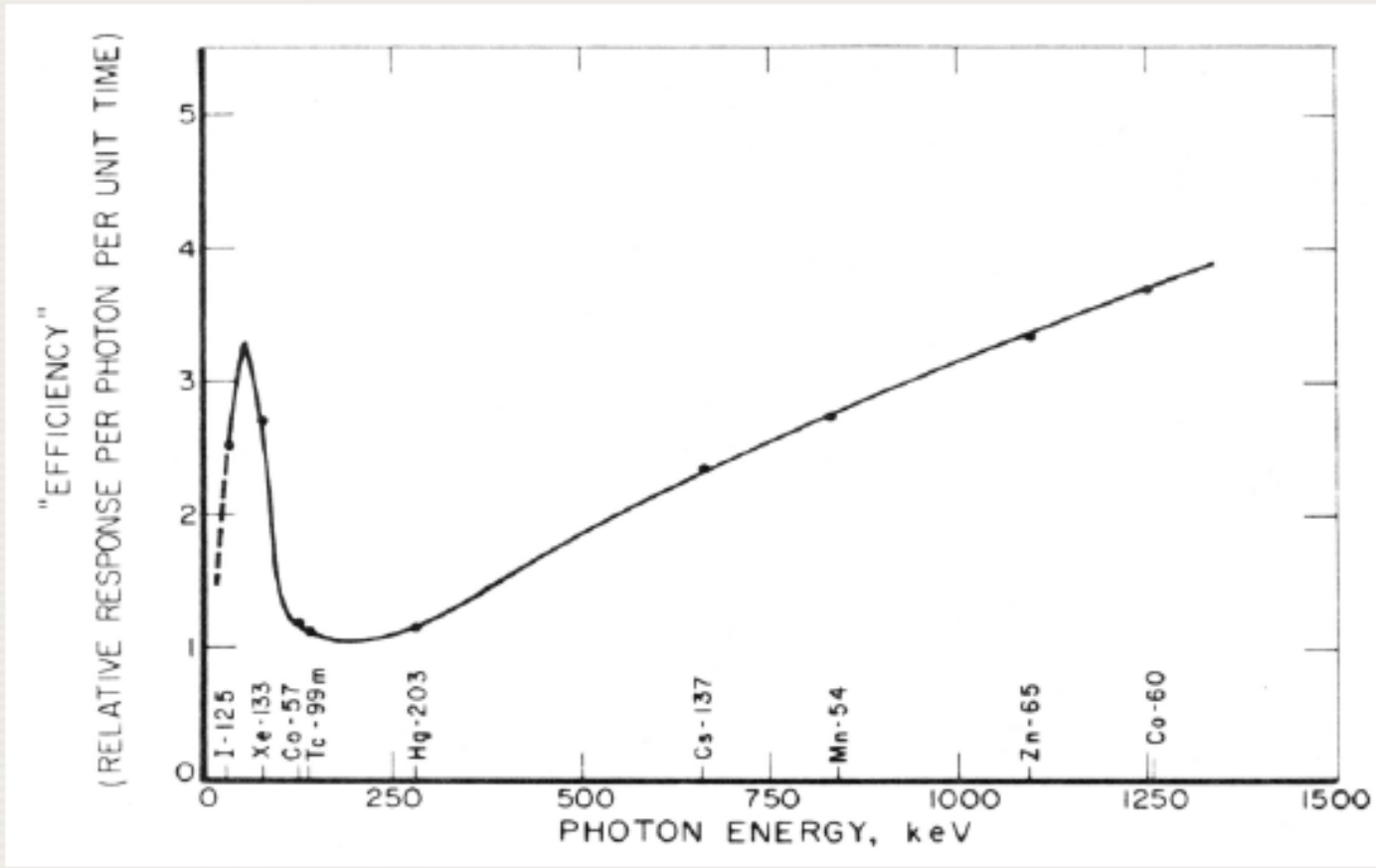
# HOW DO THE MANUFACTURERS CONVERT CURRENT TO ACTIVITY




Dr. Wayne The University of Iowa Hospitals and Clinics – Everything you need to know about the dose calibrator for quantitative data – 2023 SNMMI Annual Meeting

# CALIBRATOR MANUFACTURER

- Manufacturers are required to obtain an FDA (510K) approval for their calibrators
- The 510K requirements are satisfied differently by different calibrator manufacturers
- Manufacturers should provide traceable calibrations for common source geometries and qualify when the calibrations may or may not be used for other geometries
- This is not the case and the user should be aware of the qualifications placed on the use of the calibrations provided by the manufacturers
- The manufacturer suggests an acceptable error of ±10%
- The manufacturer provides a table with estimates of the errors associated with syringe assays. The errors range from 2% to 15% for common clinically used radionuclides.
- For high-energy pure beta emitters (e.g., Y-90), the manufacturer notes that the supplied calibration coefficients are for estimation only




Efficiency curve as a function of photon energy.

Commercially available radionuclide calibrators are initially calibrated by the manufacturers.
The calibration is typically for common radionuclides in a specific geometry.

$$R_A = \frac{\dfrac{\text{Detector Output Due to Sample A}}{\text{Activity of Sample A}}}{\dfrac{\text{Detector Output Due to } Co^{60}}{\text{Certified Activity of } Co^{60}}}$$

# RESPONSE-ENERGY CURVE RELATIVE TO CO-60

*Based on presentation by Brian E. Zimmerman, PhD, National Institute of Standards and Technology*

- Radionuclide calibrator manufacturers typically calibrate their instruments using a national standard vial (e.g., the NIST SRM borosilicate-glass ampoule) or a specific multi-dose vial.
- Ampoule dimensions shall be: o Height: (75 ± 1) mm o Straight length of body: (37 ± 1) mm o Diameter of body: (16.5 ± 0.1) mm o Wall thickness of body: (0.60 ± 0.05) mm o Neck diameters (as group), not critical at about 7 mm to 8 mm and 9 mm to 11.5 mm o Stem wall diameter at opening: (6.2 ± 0.5) mm, some minor flare can be present, o Stem wall thickness: (0.40 ± 0.05) mm

**205.5 - Radiopharmaceuticals (solution and gaseous forms)**

These SRMs are intended for the calibration of radioactivity-measuring instruments. They are calibrated in terms of activity per gram of solution (except SRM 4415, which is calibrated in terms of activity). Each SRM is contained in a 5 mL flame-sealed glass ampoule and, except for SRM 4415, consists of the radionuclide dissolved in an aqueous solution (usually acidic).These SRMs are produced in collaboration with the NRMAP, Inc. and, because of the short half lives, are available only at specific times.

When an import permit for radioactive material is required of a customer outside the U.S., NIST must have a copy to complete an order and facilitate shipment.

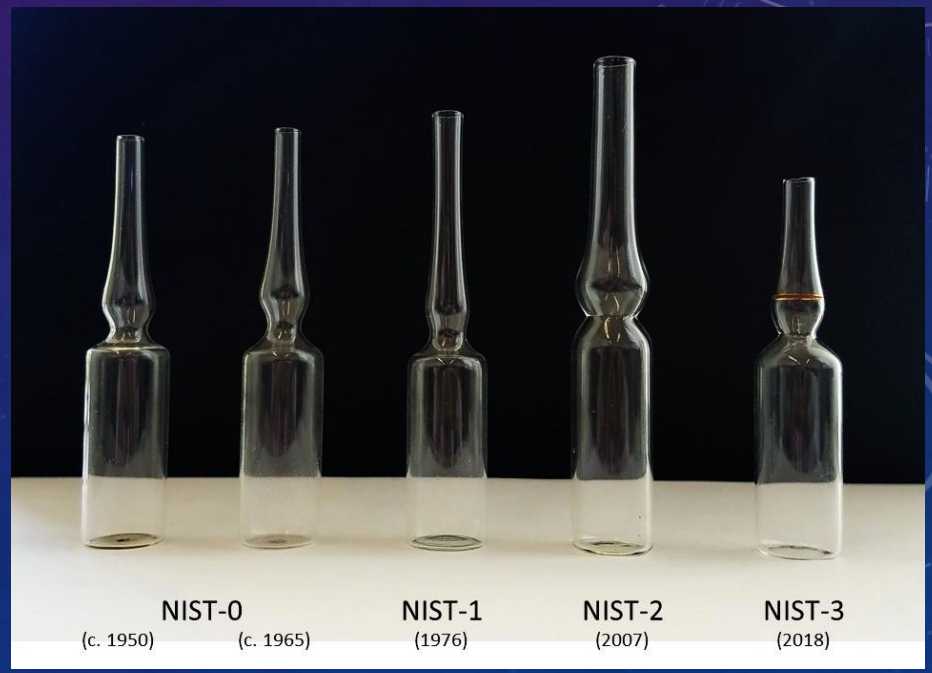
"Radionuclide Calibration Services"

"Radioactive SRM Purchasing Instructions & License Certification Form"

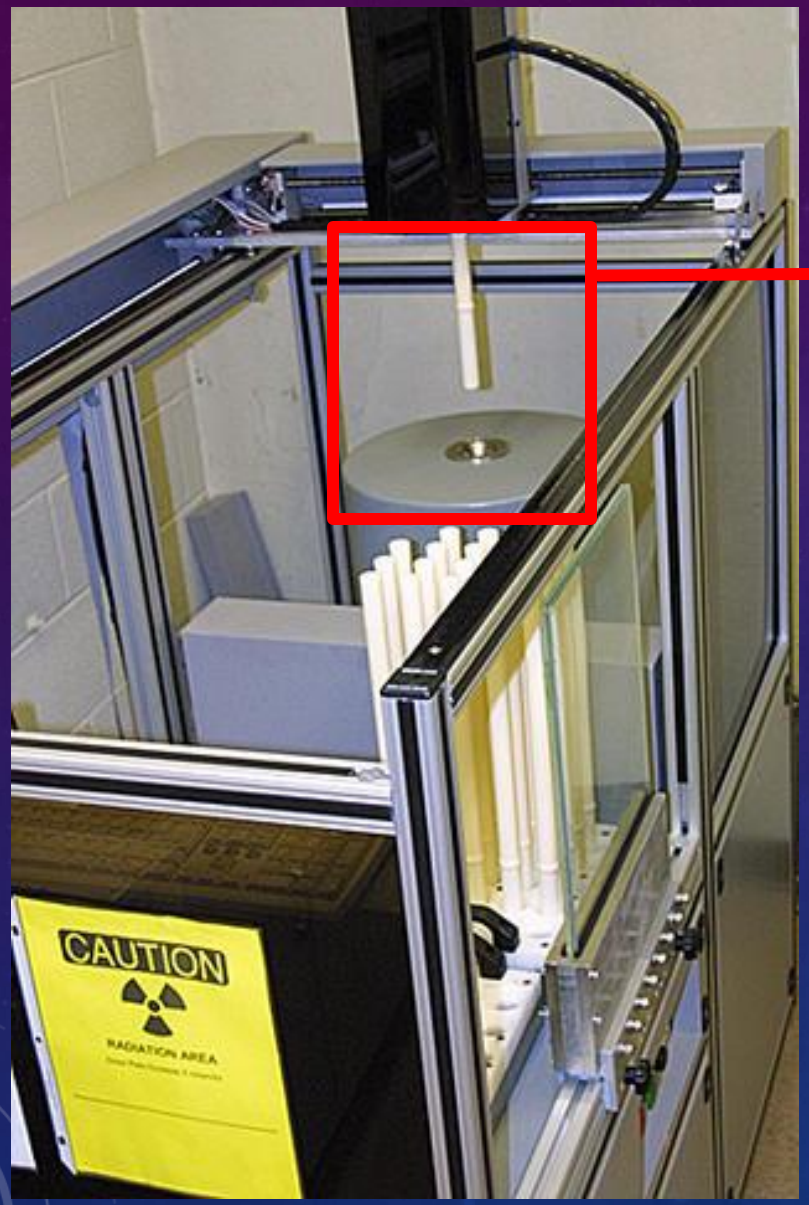
"Radioactive SRMs-General Info"

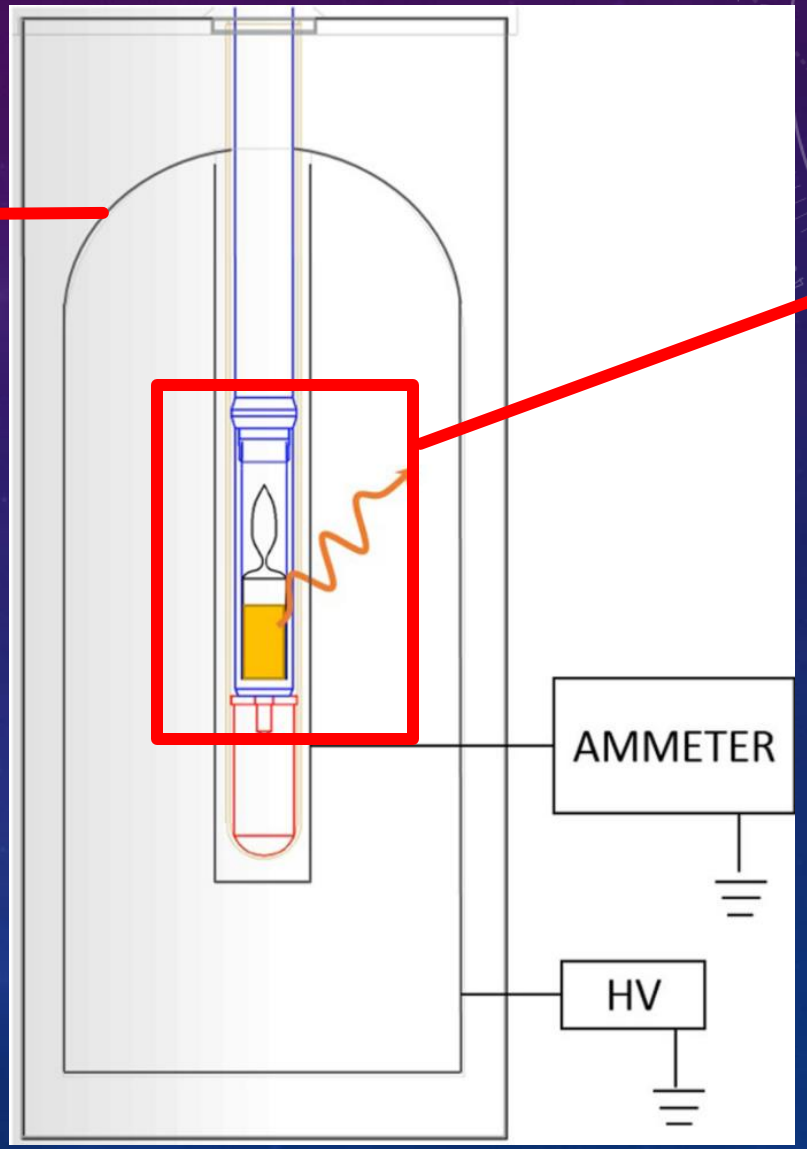
PLEASE NOTE: The tables are presented to facilitate comparisons among a family of materials to help customers select the best SRM for their needs. For specific values and uncertainties, the certificate is the only official source.

| SRM | Description | Unit of Issue | Half Life (days) | Month Produced ** | NRC License or Equivalent Required* |
|---|---|---|---|---|---|
| 4401L | Iodine-131 Radioactivity Standard | 5 mL | 8.0 | February | X |
| 4404L | Thallium-201 Radioactivity Standard | 5 mL | 3.0 | June | X |
| 4407L | Iodine-125 Radioactivity Standard | 5 mL | 59.4 | December | X |
| 4410H | Technetium-99m Radioactivity Standard | 5 mL | 0.3 | September | X |
| 4412L | Molybdenum-99 Radioactivity Standard | 5 mL | 2.74 | April | X |
| 4415L | Xenon-133 Radioactivity Standard | 5 mL | 5.243 | Sept | X |
| 4416L | Gallium-67 Radioactivity Standard | 5 mL | 3.3 | May | X |
| 4417L | Indium-111 Radioactivity Standard | 5 mL | 2.8 | August | X |
| 4427L | Yttrium-90 Radioactivity Standard | 5 mL | 64.0 hrs | October | X |



*Based on presentation by Brian E. Zimmerman, PhD, National Institute of Standards and Technology*




glass ampoule sitting in a sample holder (blue)

# PRIMARY AND SECONDARY STANDARDS

Primary standard: uncertainties that range typically from 0.5% to 1%

- Highest metrological quality
- Not calibrated by or subordinate to other standards
- Linked to fundamental physical units

Secondary Reference Standard (SRS) uncertainty 1-2%:

- Linked to a primary standard through comparisons or calibrations
- Larger uncertainty than primary standards
-Both require complete, documented uncertainty assessment

# AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE (AAPM) REPORT 181 (2012)

- AAPM Report 181 (5.1) Individuals in medical facilities or in commercial nuclear pharmacies who use radionuclide calibrators on a daily basis may not fully understand the calibrator's operating characteristics and may not have read and/or understood the operating manual.

- They are initially measured or calculated for a manufacturer's master or typical production system. The calibrations are then transferred to each field instrument using limited source measurements and an algorithm that relates dial settings to calibration factors.

- It is up to the user to either demonstrate that the change is not significant It is up to the user to either demonstrate that the change is not significant (<5%) or, if significant, new calibration settings, calibration coefficients, or correction factors need to be derived and applied.

# AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE (AAPM) REPORT 181 (2012)

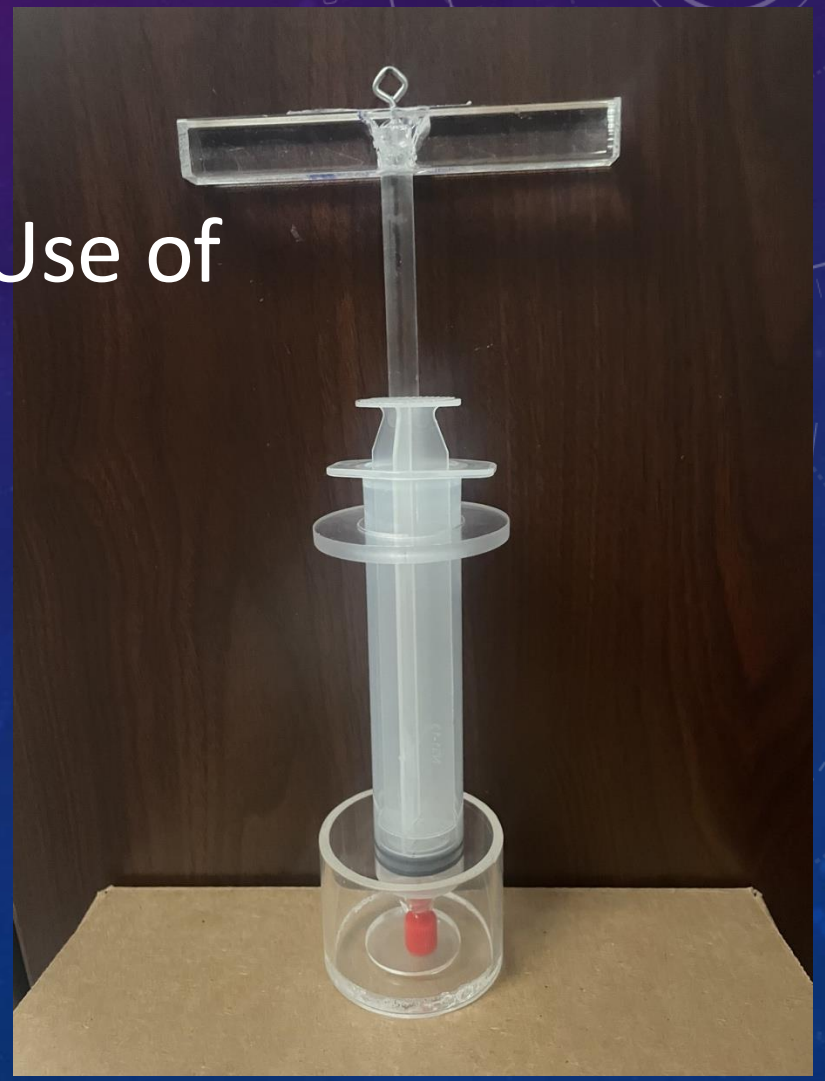
**Table 2.** Common Sources of Uncertainty in the Assay of Radionuclides with Ionization Chambers

1. Errors in calibration of standard reference sources
2. Errors in calibration by interpolation using "master" chamber response-energy curve and published decay schemes as extrapolated to "field" instruments
3. Variation in "field" instrument wall thickness and chamber gas pressure
4. Backscatter from chamber shielding
5. Inherent accuracy and linearity of electronics, including range changing errors (with and without with auto-ranging electrometers) and rounding or truncation errors
6. Ion pair recombination with high-activity sources
7. Variations in radiation background with low-activity sources
8. Differences between calibration containers and sample containers
9. Variation in attenuation due to variations in sample containers' wall thickness or material and sample volume
10. Sample position in the chamber (including changes in sample volume)
11. Solution density and homogeneity are potential problems but typically not significant. Non-homogeneity due to settling can be a problem with microsphere dosages

# PRACTICAL TIPS FOR ACTIVITY METERS IN NUCLEAR MEDICINE

- Setting Up New Radiopharmaceuticals: Use of Activity

  Meters for Radioactivity Measurement



# *7.4.2 SUBSIDIARY CALIBRATION*

- The ANSI standard requires that calibrators be calibrated with identified radionuclide sources of known activity and established purity. ANSI nomenclature and definitions for radioactive standard sources from are used in this document, as follows:

  1. **National radioactivity standard source.** A calibrated radioactive source prepared and distributed as a standard reference material by the U.S. National Institute of Standards and Technology.

  2. **Certified radioactivity standard source.** A calibrated radioactive source, with stated accuracy whose calibration is certified by the source supplier as traceable to the National Radioactivity Measurements System.

# HOW ACCURATE ARE OUR ACTIVITY MEASUREMENTS

- Generally we obtain a NIST-traceable source in a clinically relevant geometry to establish a clinical dial setting
- In practice, it's much more common to establish a "supplier equivalence" rather than NIST traceability
- It is NOT guaranteed that the manufacturer/supplier has established traceability - especially for phase I and II
- In the past there was a measurement assurance program-NIST eliminated 2018

# CALIBRATING ACTIVITY METERS

Two main methods:

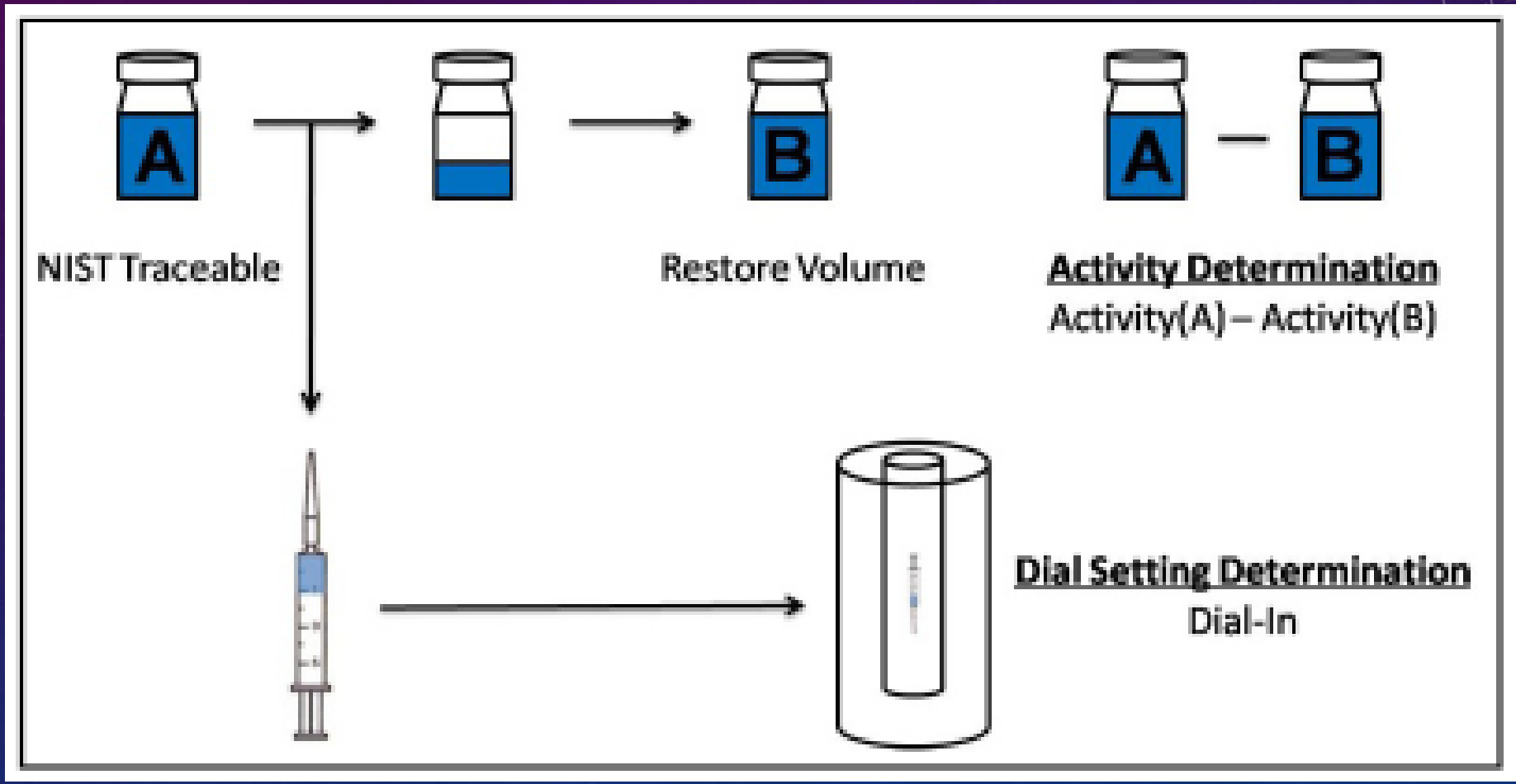
1. 'Dialing-in' (when activity is known):

- - Use traceable standard in correct geometry
- - Adjust dial setting until correct activity is displayed

2. Response curve (when activity is initially unknown):

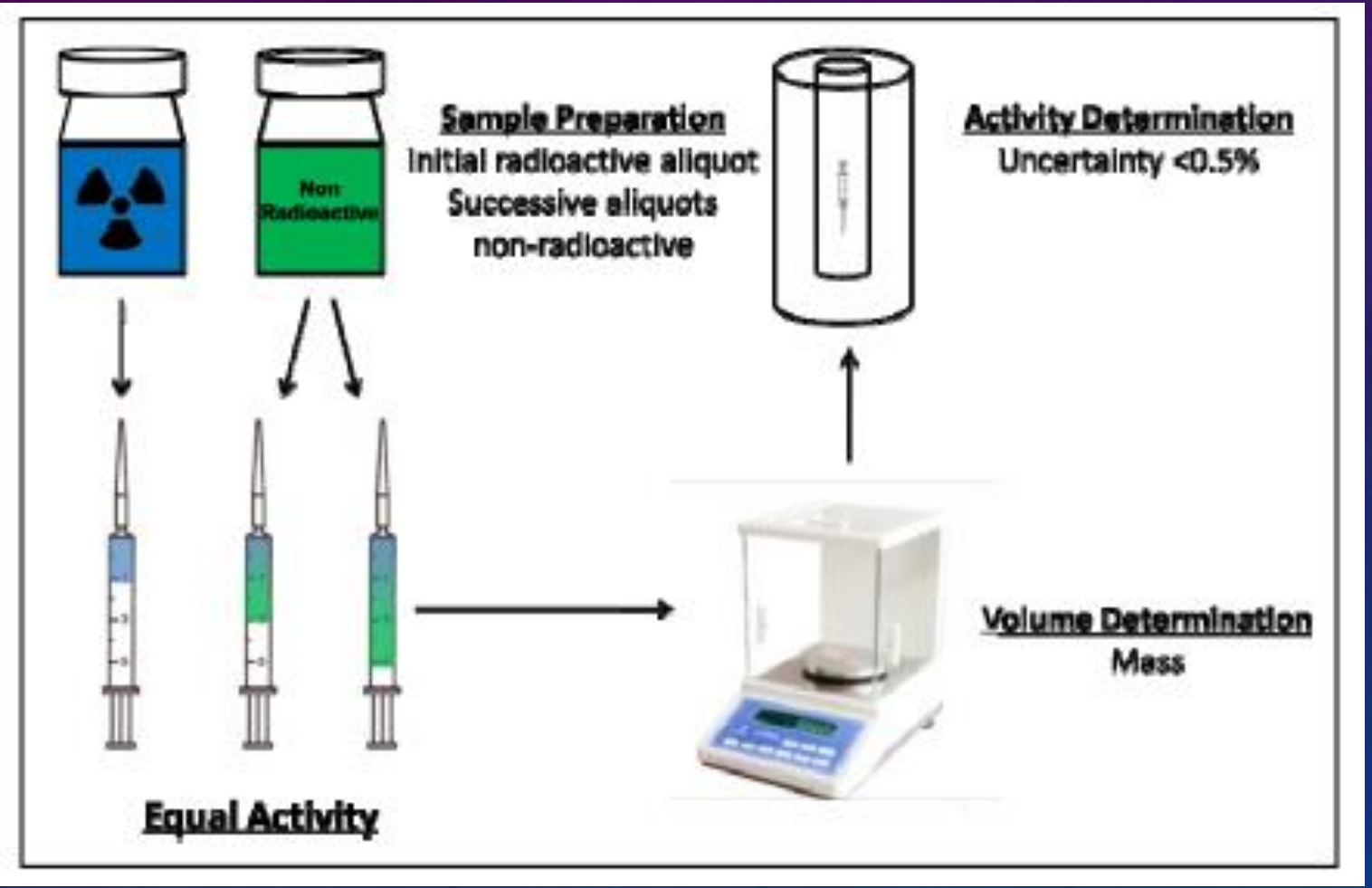
- - Measure response curve for specific geometry
- - Calculate dial setting from fit of response curve

# ACTIVITY DIFFERENCE METHOD




*Gabriel Candelaria and Daniel Irwin. UNM CE 2010. Vol 15. Science of Measurement: A Primer on Radioactivity Dose Calibrators*

# GRAVIMETRIC, CONSTANT ACTIVITY METHOD




*Gabriel Candelaria and Daniel Irwin. UNM CE 2010. Vol 15. Science of Measurement: A Primer on Radioactivity Dose Calibrators*

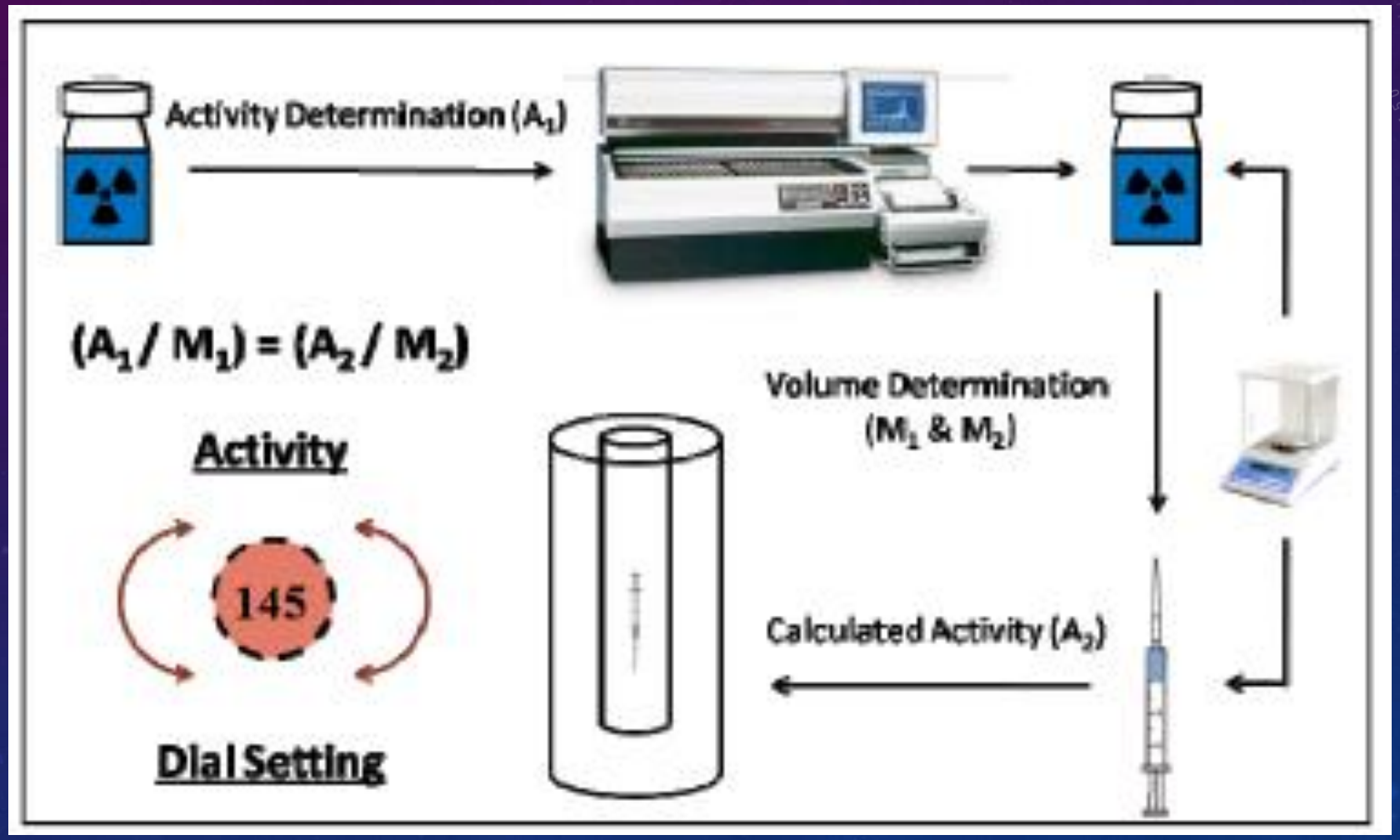
$$CF = A_R / A_m$$

$$A_T = A_m \times CF$$

| Volume (mL) | $A_m$ (mCi) | CF |
|---|---|---|
| 4 | 2.85 | 0.70 |
| 8 | 2.30 | 0.87 |
| 10 ($A_R$) | 2.00 | 1.00 |

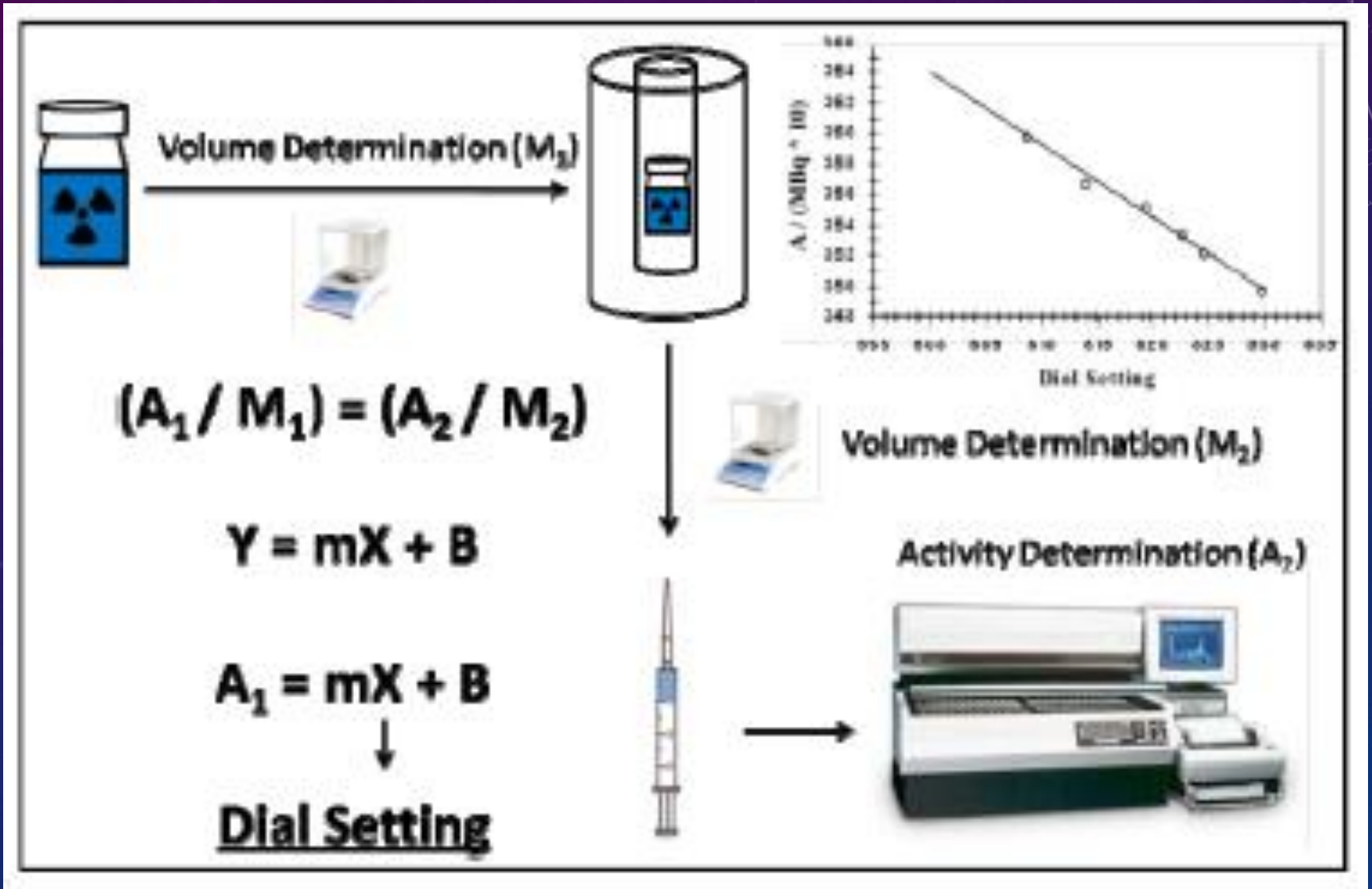
*Gabriel Candelaria and Daniel Irwin. UNM CE 2010. Vol 15. Science of Measurement: A Primer on Radioactivity Dose Calibrators*

# DIAL IN METHOD




*Gabriel Candelaria and Daniel Irwin. UNM CE 2010. Vol 15. Science of Measurement: A Primer on Radioactivity Dose Calibrators*

# CALIBRATION CURVE METHOD




*Gabriel Candelaria and Daniel Irwin. UNM CE 2010. Vol 15. Science of Measurement: A Primer on Radioactivity Dose Calibrators*

# CONCLUSION

- The activity meter is a highly pressurized gas filled ionization chamber which measures the amount of ionization generated by a radioactive source via the Compton scattering interaction.
- Individual nuclides will cause a different amount of ionization within the chamber due to the gamma constant associated with each radionuclide.
- The differing amount of ionization necessitates normalizing the response of the detector to a known source geometry with known activity.
- Quantification in any capacity necessitates a better understanding of errors to assaying and matching the manufacturers or NIST standard source or secondary reference standard to a maximum of 2% error.

# THANK YOU!!

## QUESTIONS?

Wendy-Galbraith@ouhsc.edu

BEST PRACTICES FOR NUCLEAR PHARMACY

WENDY GALBRAITH

MIRION CONNECT 25 ORLANDO

JULY 31, 2025