LA-UR-07-6857

High Precision Nondestructive Assay to Complement DA

H.O. Menlove, M.T. Swinhoe, and J.B. Marlow
Los Alamos National Laboratory

Action Sheet 53
DOE-JAEA Safeguards Cooperation

Los Alamos NATIONAL LABORATORY EST 1943

NNSA

Purpose of Development

- To reduce costs for inventory verification
- To improve timeliness of verification results
- To reduce waste generation
- To reduce DA reference material requirements
- To provide QC information

ENMC Function

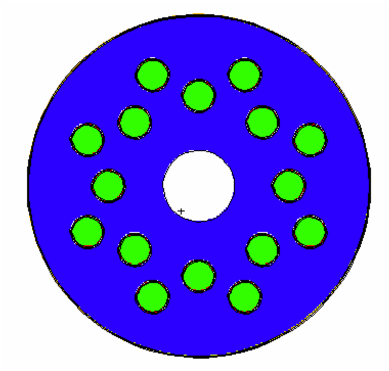
(Epi-thermal Neutron Multiplicity Counter)

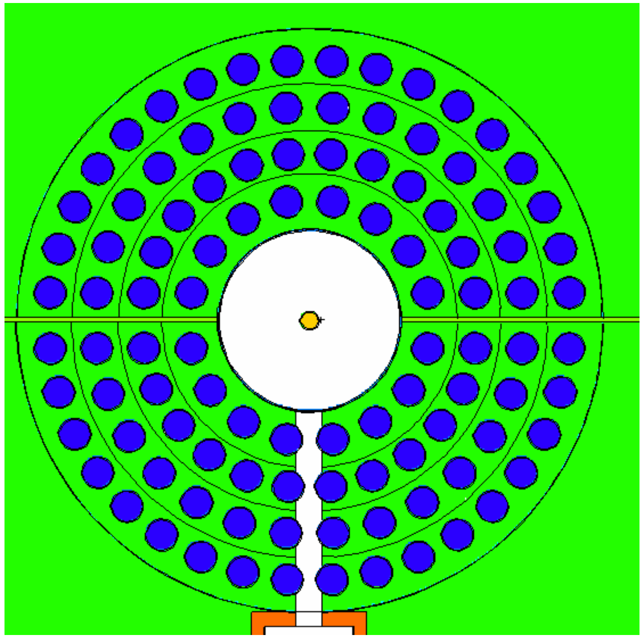
- Measure Pu-240 mass of separated Pu (isotopics via DA)
  - Oxides (impure)
  - Oxalates (impure)
  - Liquids (nitrates, etc.)
- Variable size sample cavity (62-68% efficiency)
- Opens for larger samples (split-halves)
- Detector ring ratios provides contamination information for Be, B, and F

INVS and ENMC Type Neutron Counters

ENMC

INVS

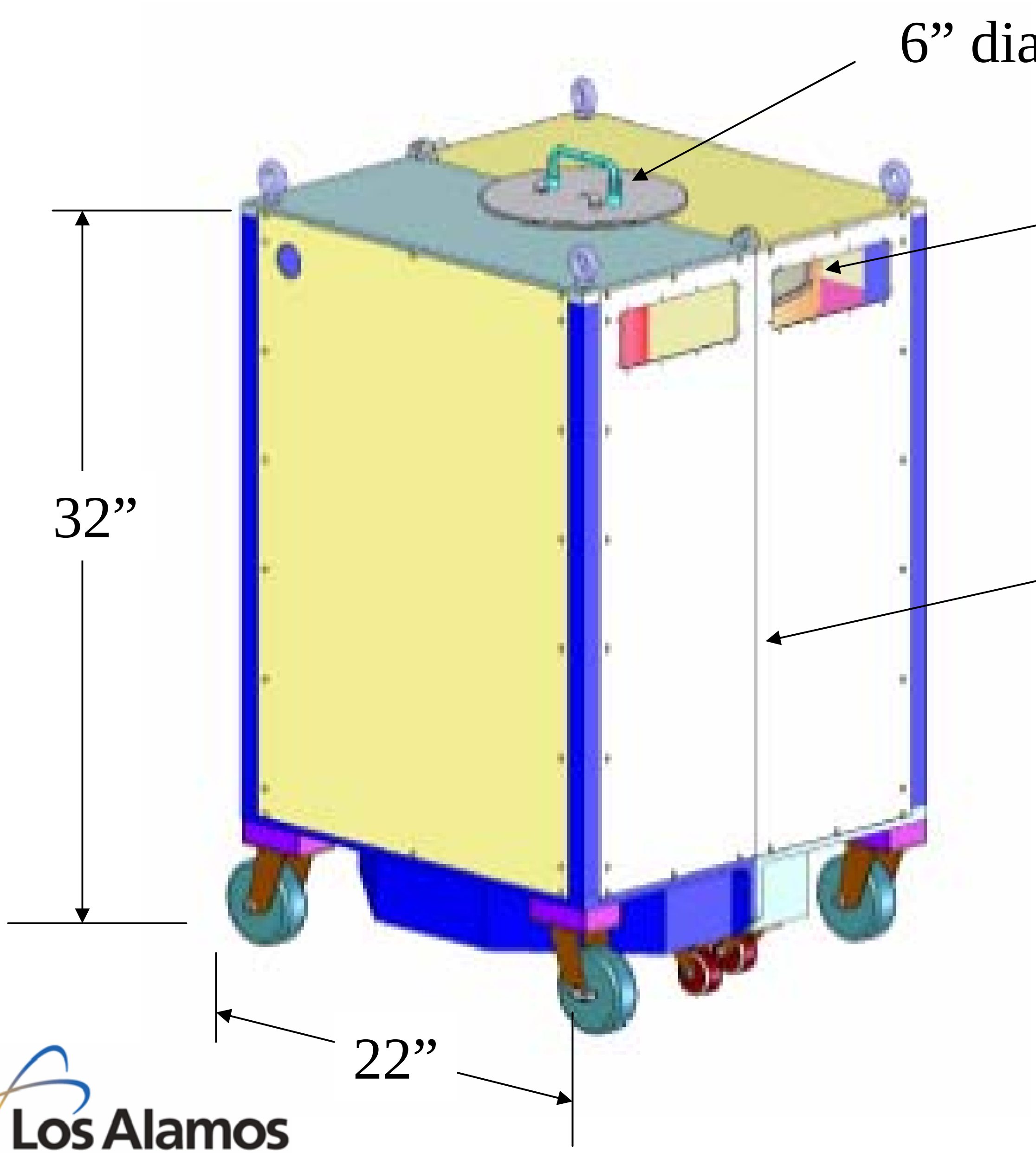




Los Alamos
NATIONAL LABORATORY
EST. 1943

NNSA

Mini-ENMC

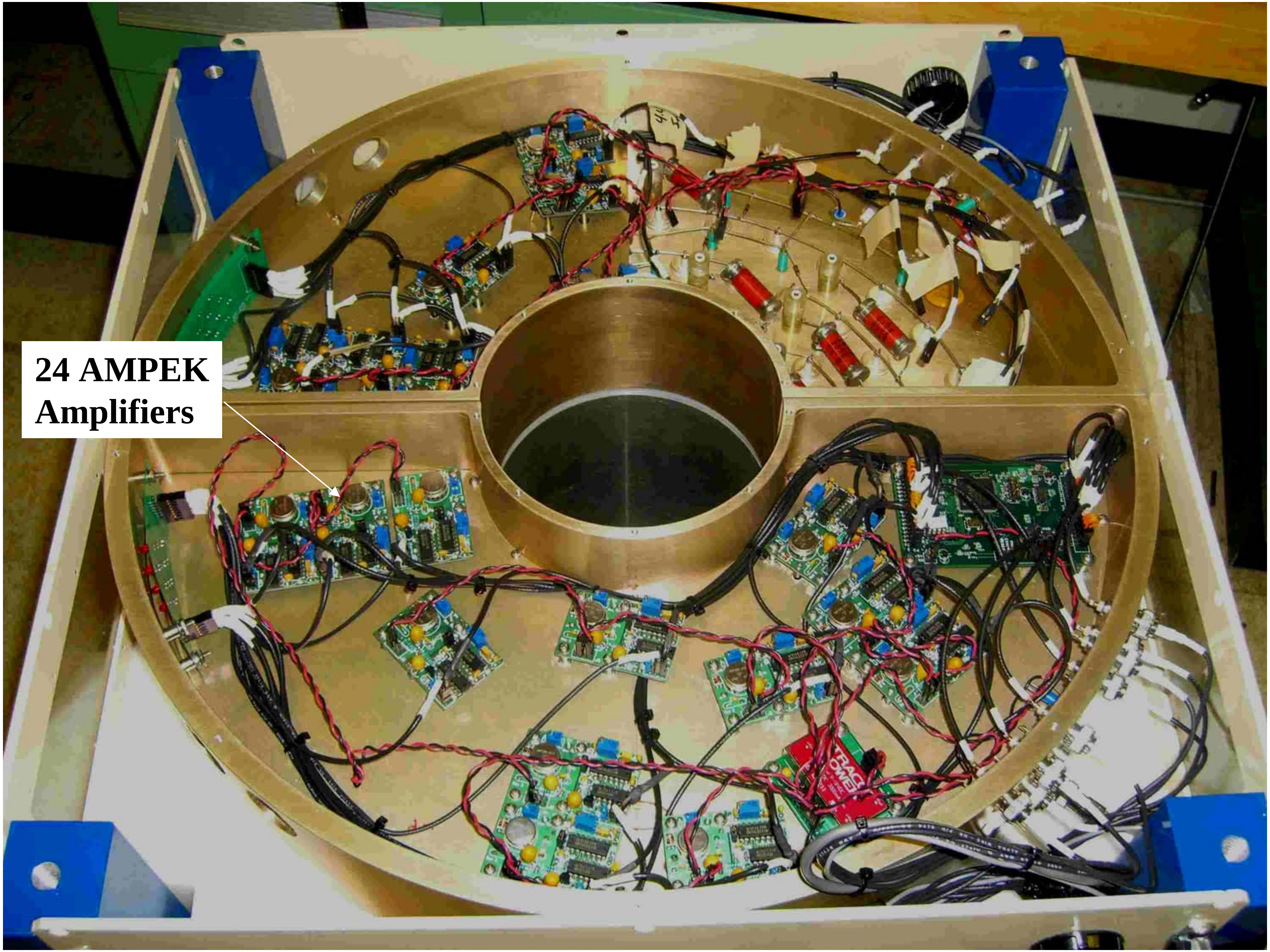


Los Alamos NATIONAL LABORATORY EST. 1943

NNSA

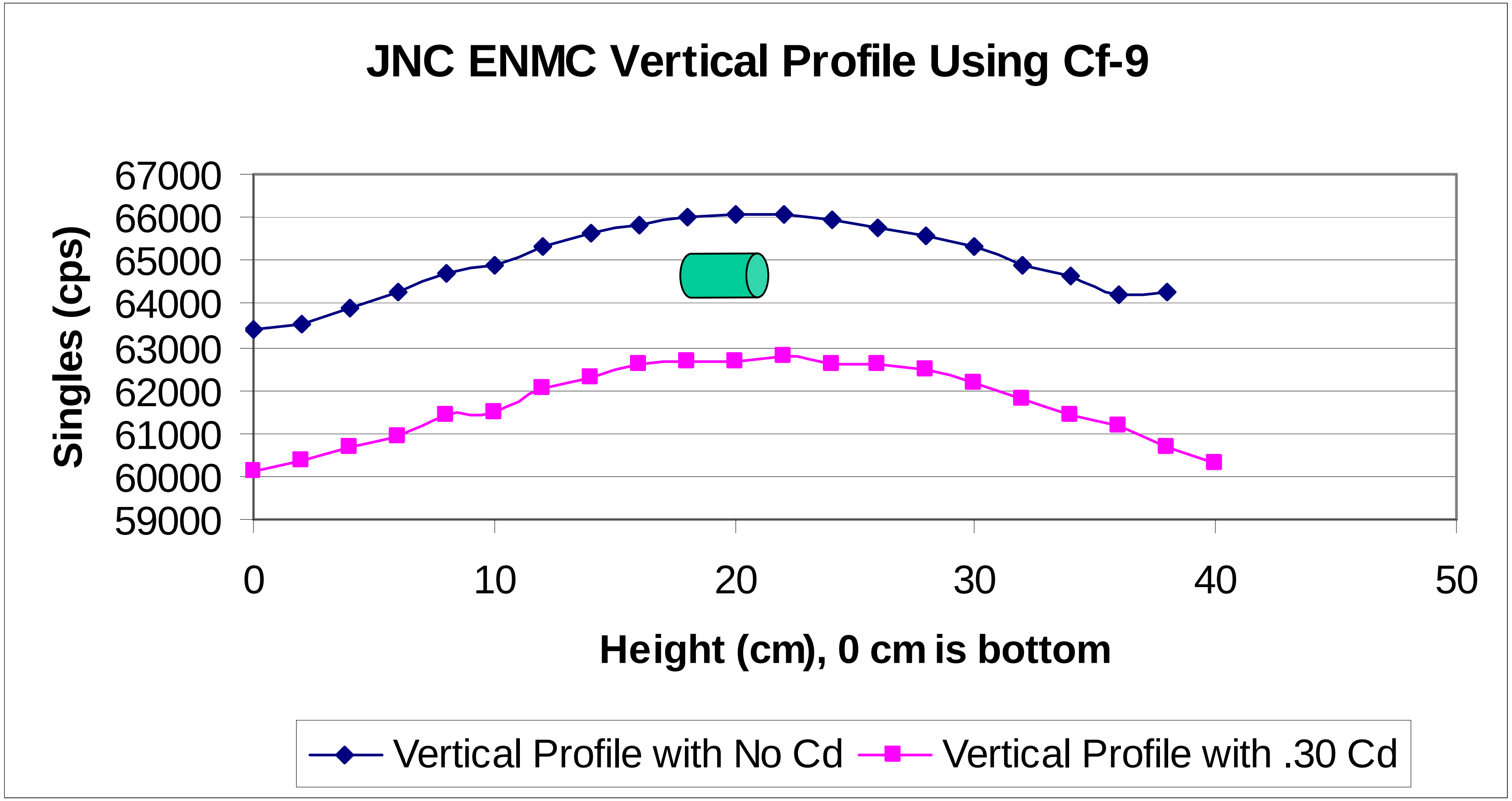
Los Alamos
NATIONAL LABORATORY
EST. 1943

NNSA

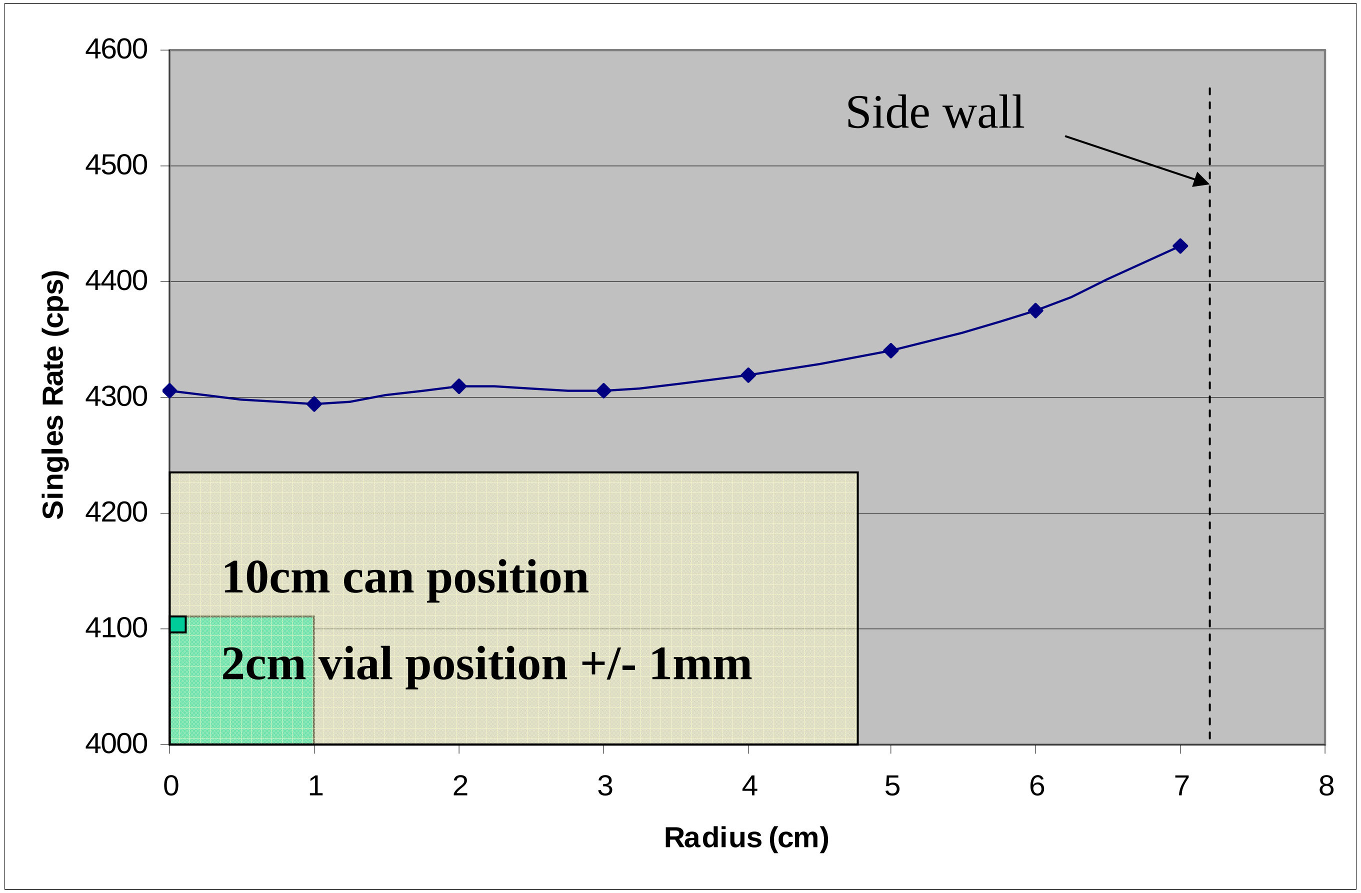

24 AMPEK
Amplifiers

Mini-ENMC
Opened with
Simulated sample


10 kΩ
1 Ω


JNC ENMC Vertical Profile Using Cf-9
Singles (cps)
67000
66000
65000
64000
63000
62000
61000
60000
59000
0
10
20
30
40
50
Height (cm), 0 cm is bottom
Vertical Profile with No Cd
Vertical Profile with .30 Cd

Mini-ENMC Radial Efficiency Profile



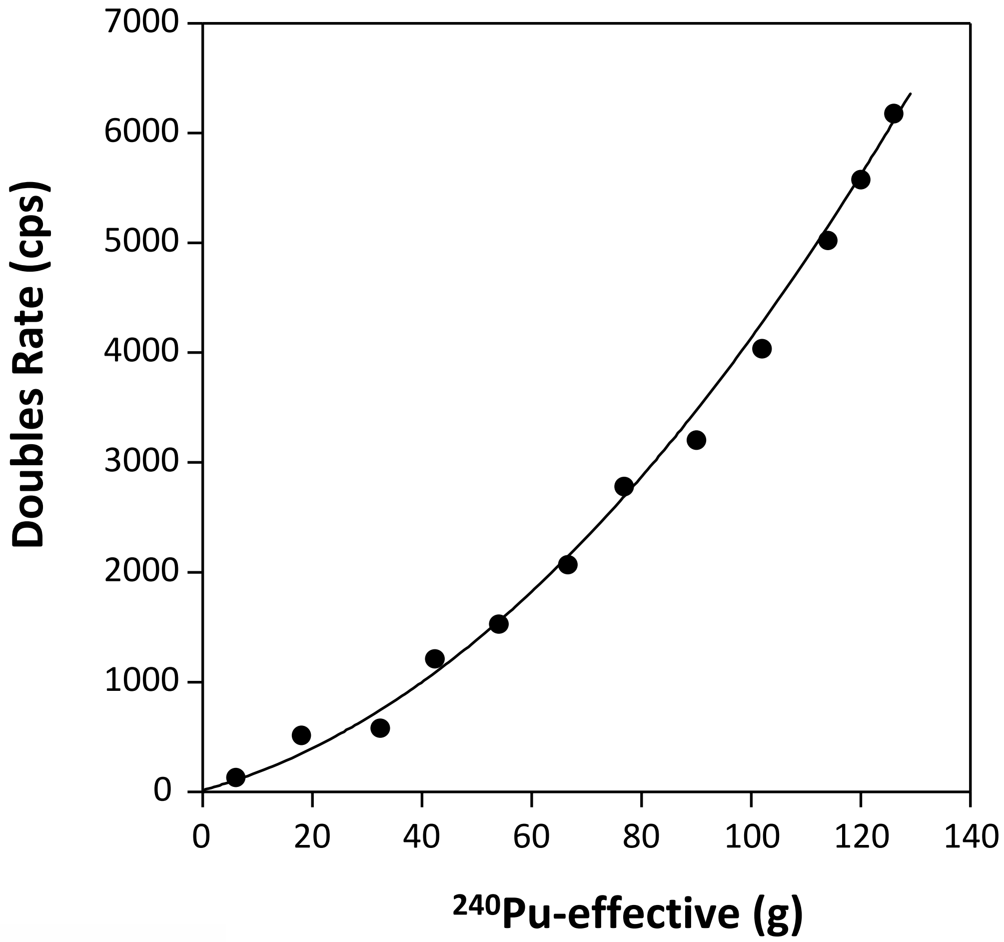
Neutron Analysis Methods

- Measured doubles versus Pu-240e mass (“passive calibration curve”)
  - Small samples (low multiplication)
  - Variable singles background
- “Known-Alpha” multiplication correction
  - Pure material
  - Isotopic ratios used to get alpha
  - Best precision
- Multiplicity Mode
  - Used for impure samples
  - Focus for this talk

Los Alamos NATIONAL LABORATORY EST.1943

NNSA

Calibration Curve Method



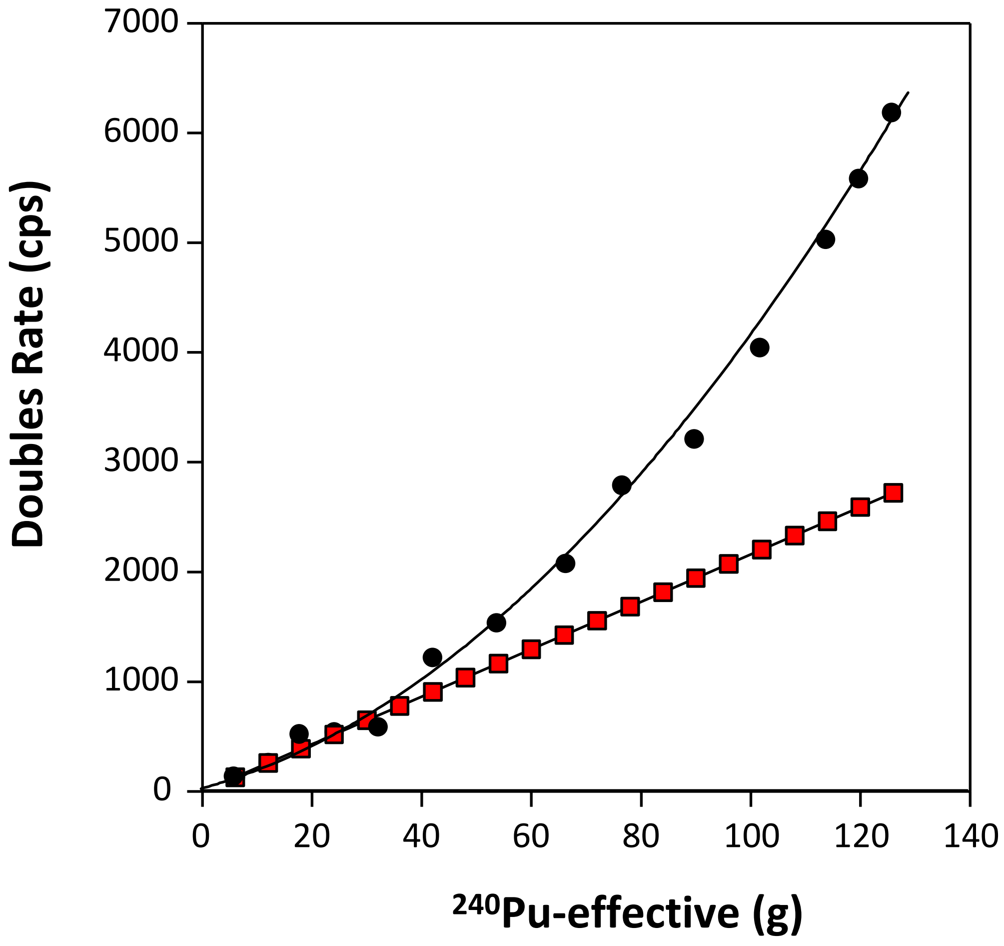
The calibration is dependent on:

- Material type
- Geometry
- Density
- Impurities (high M items)

Los Alamos NATIONAL LABORATORY EST.1943

NNSA

Known Alpha



Use singles and doubles to deduce a "multiplication" correction that linearizes the calibration. Works well for pure oxides, metals, and fluorides. Still need standards.

The calibration is dependent on:

- Known material type
- Isotopic values

This technique does not work for impure items.

Statistical Uncertainty Versus Analyses Methods

Table 1 Uncertainty from Counting Statistics on small Pu mass measurement (1 hour)

	Singles Cps	Doubles cps	Multiplication Corrected Doubles cps	Triples cps	Passive Calibration Curve Mass (g)	Known alpha mass (g)	Multiplicity Mass (g)
Mean value	2084	414	404	82.3	4.39	4.28	4.27
Rel error %	0.06 %	0.14%	0.07%	0.41%	0.14%	0.07 %	0.12%

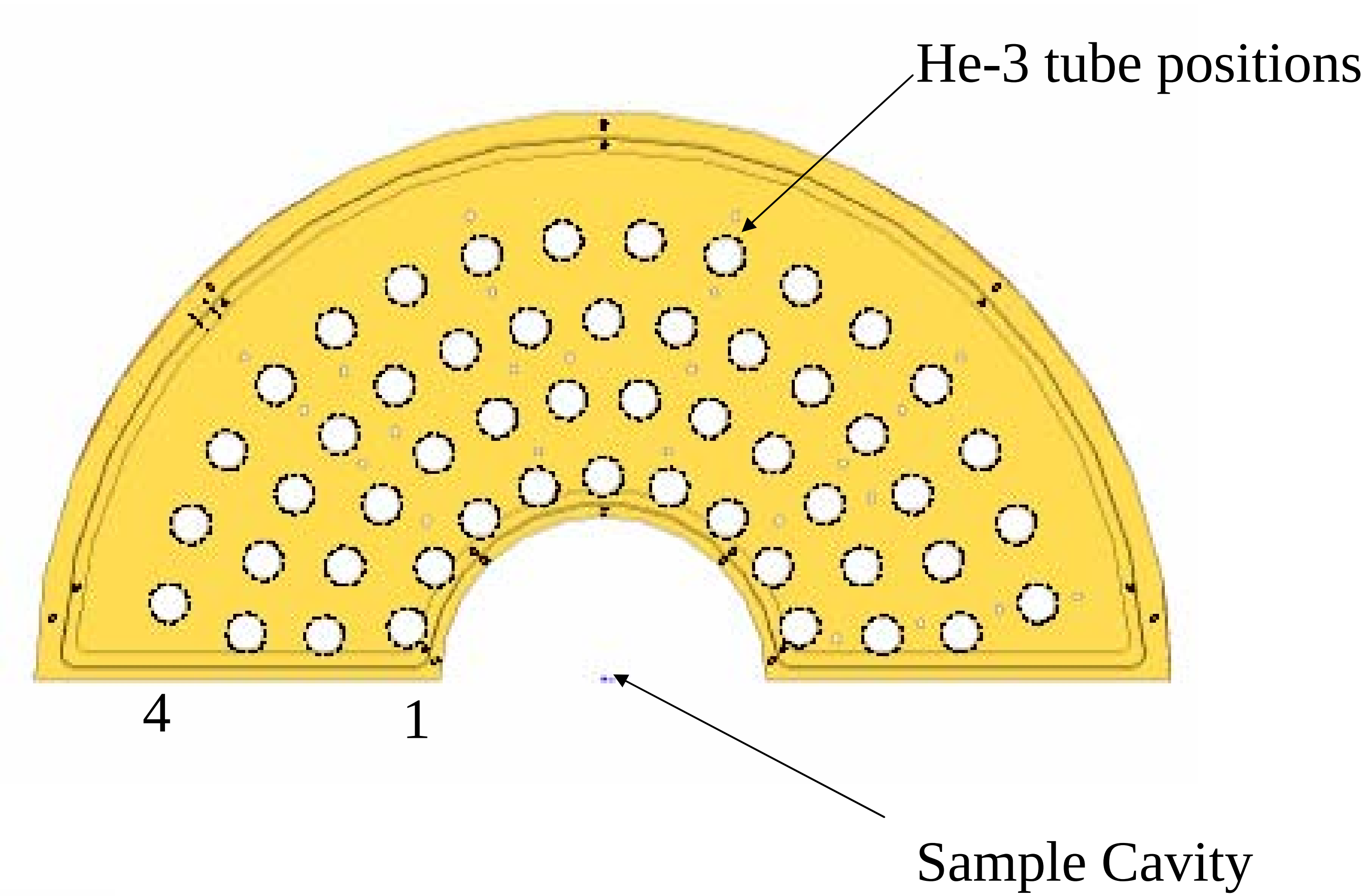
Los Alamos NATIONAL LABORATORY EST.1943

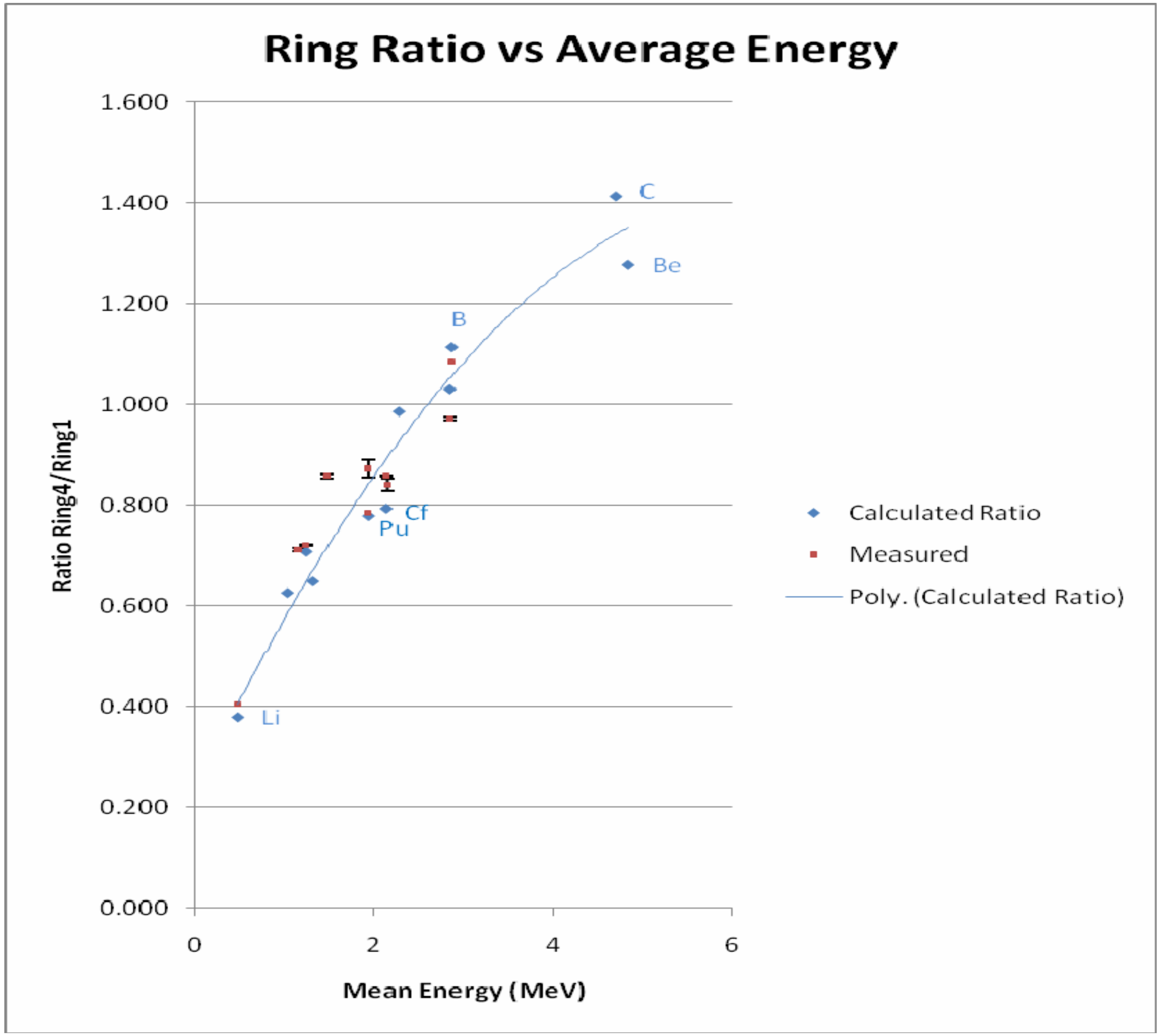
NNSA

Changes in Moisture or Density

Table 2 Uncertainty from Counting Statistics on small Pu mass measurement (1 hour)							
	Singles Cps	Doubles cps	Multiplication Corrected Doubles cps	Triples cps	Passive Calibration Curve Mass (g)	Known alpha mass (g)	Multiplicity Mass (g)
Change with 5% moisture	9.25%	0.72%	3.23%	1.33%	0.59%	3.23 %	0.29%
Change with 10% higher density	0.23%	1.45%	-0.02%	4.5%	1.44%	-0.02%	-0.20%

Mini-ENMC Top Half
Tube Ring Ratio 4/1





Los Alamos
NATIONAL LABORATORY
EST.1943

NNSA

Summary

- The ENMC provides a measurement time reduction of a factor of ~ 5 versus an INVS
- Pu-240e is measured and the isotopic ratios come from mass spectrometry
- DA standards with uncertainty of < 0.1% required
- Identical containers for standards and unknowns
- Random statistical counting error reduced to ~ 0.12%
- Counting electronic stability better than 0.01%
- Most systematic errors removed by having well matched standards for calibration
- TMU goal 0.2% for Pu-240
- Goal of significant reduction in DA analysis, but calibration standards from DA