Rapid Bioassay Detection Limits for Co-57, Co-60, Cs-137 and Ir-192 in HPGe Gamma Spectrometry

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NCEH LABORATORY

Biomonitoring : Radiological Bioassay

- Rapid assessment of radionuclides in populations exposed to nuclear/radiological incident
- Detection, identification and quantification of a number of radionuclides in urine specimens for evaluation of risk (dose estimation) and use in application of medical counter measures

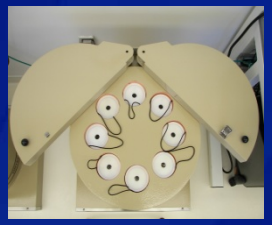
Biomonitoring Methods at NCEH Laboratories for Radionuclides

- Gamma Spectrometry
  - NaI(Tl) : Gross Gamma Screening
  - HPGe : Gamma emitting nuclide identification and quantification
- Liquid Scintillation : Screening and quantification of Gross Alpha /Beta emissions and quantification of some specific beta emitters
- Alpha Spectrometry : For polonium-210 and some actinide isotopes
- ICP/MS : For screening and quantification of some long half life actinides

CDC's Urine Radionuclide Screen

Urine Sample "Spot"

Gamma Radionuclide Screen

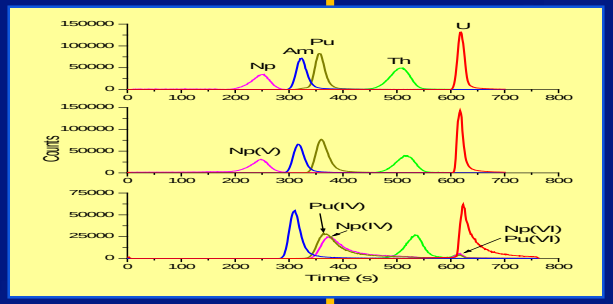


Gamma Radionuclide Quantification

Alpha/Beta Radionuclide Screen/Quantification

Alpha Spectroscopy Quantification

Alpha (Long Lived) ICP-MS Screen



Mass Spectroscopy Quantification

High Resolution Mass Spectroscopy Quantification

HPGe Urine Bioassay

- We have validated a HPGe Gamma Spectrometry method for detection, identification and quantification of:
  - Co-57
  - Co-60
  - Cs-137
  - Ir-192

Gamma Emmissions

Nuclide	Decay mode	Gamma Energy (keV)	Intensity(%)	Half life (Y)
Co-57	EC	122.1	85.6	0.7440
		136.5	10.7	
Co-60	Beta	1173.0	100	5.271
		1332.5	100	
Cs-137	Beta	661.6	84.6	30.08
Ir-193	Beta &EC	295.8	28.3	0.2021
		308.5	29.3	
		316.5	83.0	
		468.1	47.7	

This presentation is concerned with:

Determination and evaluation of Limits of Detection (LOD) for urine bioassay using HPGe detectors of different types procured by NCEH laboratories over a period of time with a view to maximizing sample throughput with minimal count time (900 S).

These method Limits of Detection (LOD) are for priority nuclides Co-57, Co-60, Cs-137 and Ir-192.

LOD

- A key characteristic of the bioassay method.
- LOD: The lowest concentration at which the radionuclide can be detected in the sample collected a few days or more post incident using minimum count time to maximize throughput.
- LOD has been determined for 10 mL and 50 mL counting geometries.

EXPERIMENTAL

1. Urine Specimens:	Anonymous donors. Solids removed, storage at < -20°C
2. Co-57, Co-60, Cs-137	NIST traceable commercially Ir-192 available standards
3. Specimen cups:	Polypropylene cups (120 mL) Polypropylene Falcon tubes (15 mL)
4. HPGE Detectors and MCA	Small coaxial (~80%) Big coaxial (~180%) Well type
5. Count time	900 seconds

Emergency Response Urine Containers: counting Geometry

HPGe Detectors used in LOD work

- Small co-axial detectors :~80% relative efficiency
- One large co-axial detector :~180% relative efficiency
- A well detector

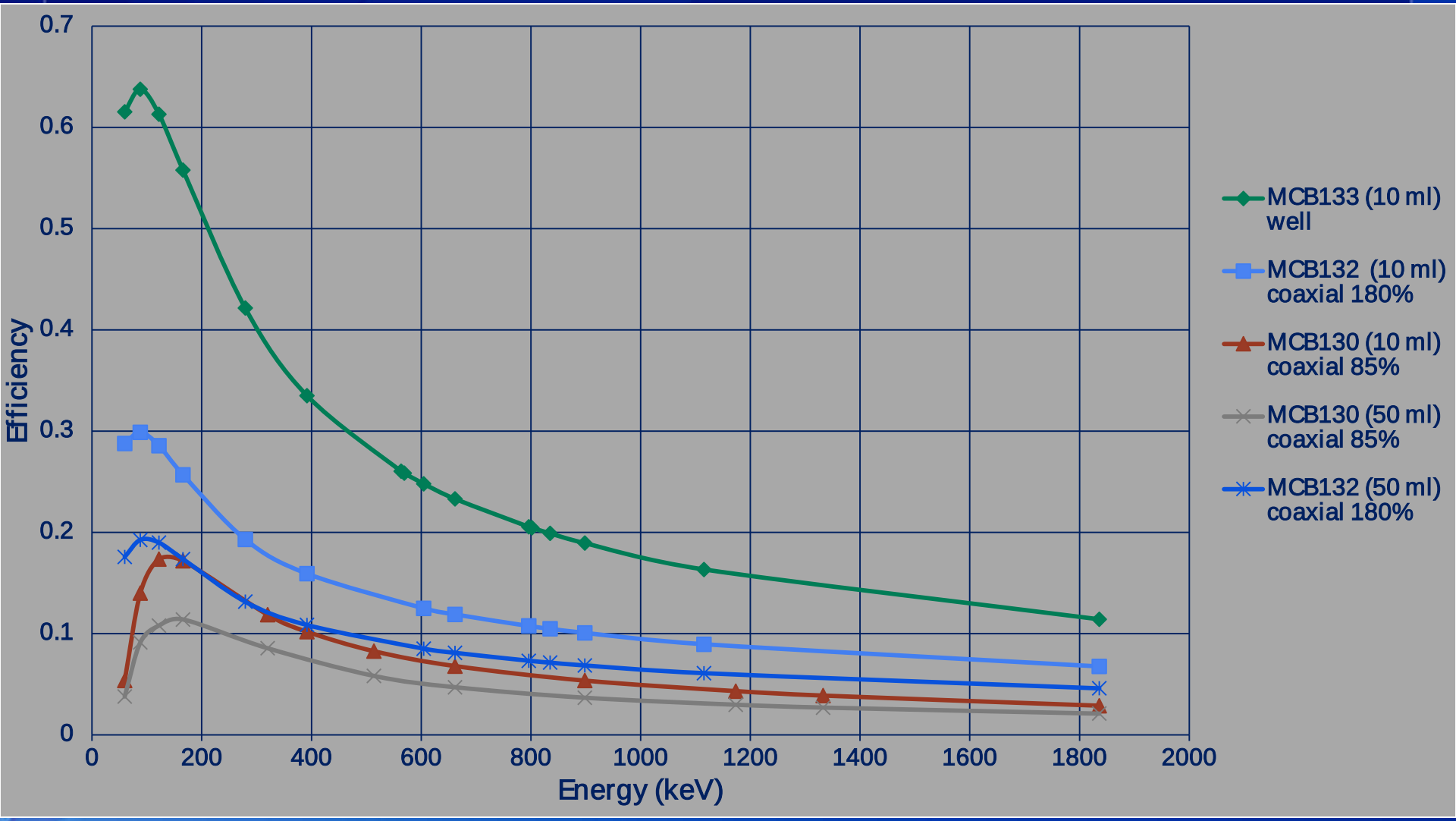
HPGe Detectors used for LOD Study

Det ID	Type	Dimensions (mm)	End cap	Resolution (keV)	Rel Efficiency (%)
MCB 129	Co-axial	79.4X67.7	1.5 mm Al	1.96	79.1
MCB 130	Co-axial	79.9X74.4	1.5 mm Mg	1.89	94.4
MCB 131	Co-axial	78,8X68.5	1.5 mm Cu	1.86	78.1
MCB 132	Co-axial	93.5X103.2	0.76 carbon fiber	2.14	171.7
MCB 133	Well	88.8X96.6	Carbon fiber		
		70 (well depth)		2.81	
		17(well inside dia)			
		520 cc (total active volume)			

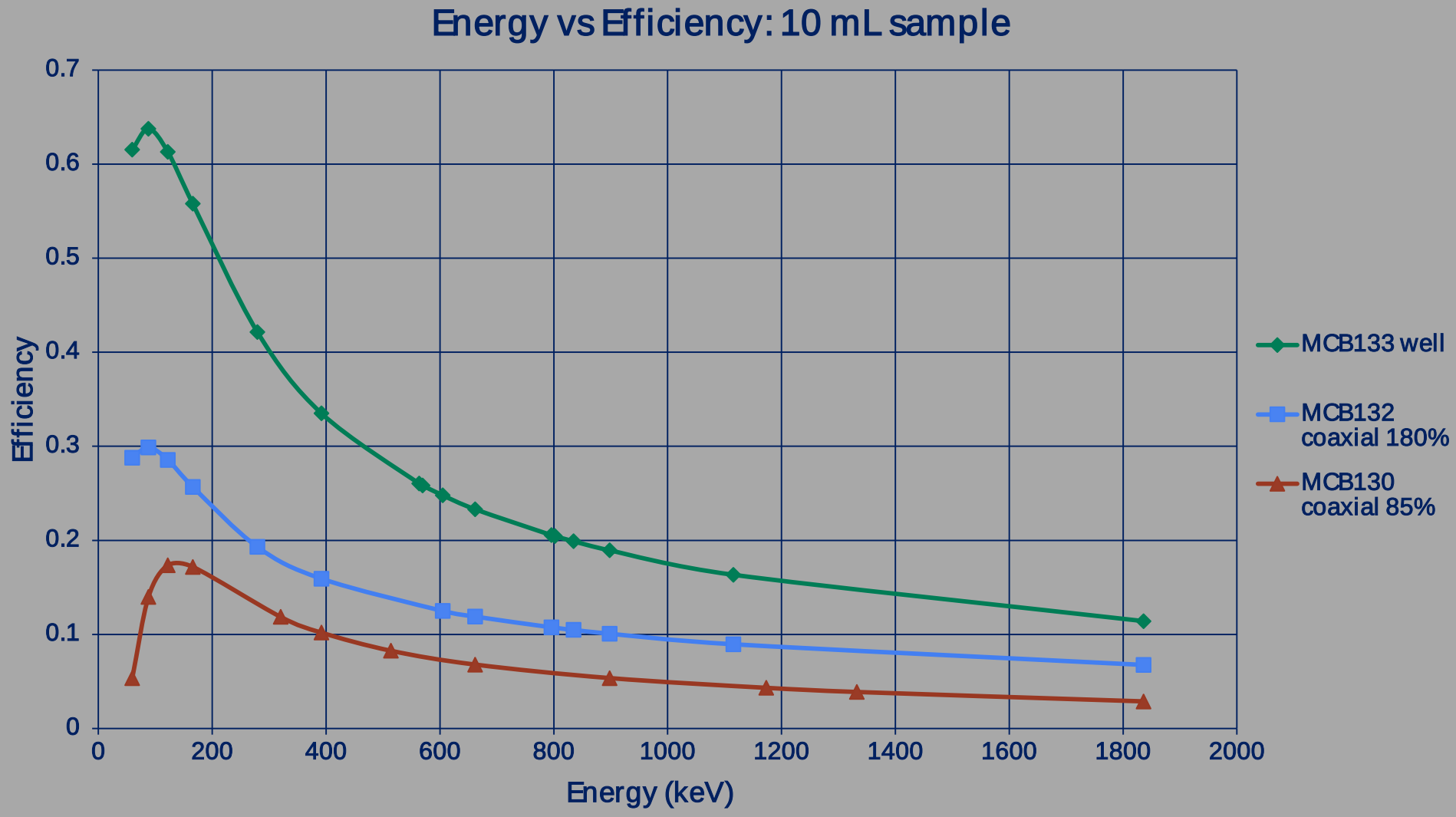
Factors that Affect LOD

- Detector Efficiency
- Sample size
- Counting time

Energy VS Efficiency (Different Volumes of sample)



Energy VS Efficiency: 10 mL sample



LOD CALCULATION

LOD is calculated by the formula:

LOD = 3* standard deviation

Standard deviation is calculated from 20 replicate analyses (one analysis per day) of the radionuclide spiked into urine at a **very low concentration.**

This concentration was derived from standard deviation of blank urine analysis (20 replicates).

Radionuclide Concentrations Spiked into Urine for LOD Determination

Nuclide	Standard used	Spiked concentration (Bq/L)
Co-57	Eckert & Ziegler 94607 dt. 9-11-13	38.92
Co-60	NIST ICLN # 11 dt. 12-31-07	34.92
Cs-137	NIST ICLN # 11 dt. 12-31-07	34.91
Ir-192	Eckert & Ziegler 1701-48 dt. 11-15-13	69.64

Accuracy of analysis was within 2-3 sigma uncertainty

Results of LOD Determination

			LOD (Bq/L)			
Detector type (rel eff)	Sample container	Sample volume (mL)	Co-57	Cs-137	Co-60	Ir-192
Small co-axial (85%)	120 mL specimen cup	10	34.2	19.2	22.9	31.1
Big co-axial (180%)	120 mL specimen cup	10	31.3	25.7	21.3	64.3
Well type	15 mL Falcon tube	10	25.5	17.8	27.9	57.8
Small co-axial (85%)	120 mL specimen cup	50	23.0	13.4	12.5	17.2
Big co-axial (180%)	120 mL specimen cup	50	13.4	11.6	8.6	25.9

Note: LODs were determined by analyzing the aliquot containing individual nuclide

Better LOD for sample volume of 50 mL with Big Co-axial detector

Number of determinations : N=20

Results of Different Detectors 10 mL Geometry

			LOD(Bq/L)			
Detector type (rel eff)	Sample container	Sample volume (mL)	Co-57	Cs-137	Co-60	Ir-192
Small co-axial (85%)	120 mL specimen cup	10	34.2	19.2	22.9	31.1
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Well type	15 mL Falcon tube	10	25.5	17.8	27.9	57.8

LOD determined by analyzing the aliquot containing individual nuclides

Well detector gives lower LOD
Number of determination: N=20

Clinical Decision Guide (CDG)

- Radionuclide concentration in urine (of a person who has internal contamination with these radionuclides) that indicates a need for medical intervention.

- Concentration levels of concern for these radionuclides in urine were derived from data in NCRP report 161 (2009)

Target Child/Pregnant Female CDG Urine Activity Levels(Bq/L): 5 days Post intake/incident

Nuclide	M-inhal	Ingest(sol)	S-inhal	F-inhal
Co-57	7.20E+04	9.21E+04	-	-
Co-60	8.26E+03	-	1.04E+03	-
Cs-137	-	2.96E+04	-	2.90E+04
Ir-192	1.80E+03	-	1.88E+02	-

LODs from the present study are well below these CDG levels.
(Data derived from NCRP Report # 161, 2009)

CONCLUSION

The limit of Detection (LOD) obtained in the present study for Co-57, Co-60, Cs-137 and Ir-192 are well below the concentrations in urine derived from Clinical Decision Guides (CDGs) for medical intervention found in NCRP Report # 161 (2009). Our target levels of interest are based on data taken from this report for the child or pregnant woman subpopulation at 5 days post event/intake.

CONCLUSION (continued)

This LOD information will be useful for potential radiobioassay laboratories in choosing the most efficient detector systems for population monitoring.

- Well type HPGe systems appear promising as they require smaller sample volumes (10 mL).
- In addition, sample aliquots that were used for gross gamma screen (Well type NaI(Tl)) can be used without additional sample preparation steps – saving considerable time in an emergency situation.

Questions - Discussions

For more information please contact Centers for Disease Control and Prevention

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