# Portable Gamma-ray Analysis System

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# Radiation Screening the Role of Gamma Radiation

- Alpha Emitting Radionuclides – Emitting high energy positive ions ($He^{+2}$) and often simultaneous gamma photons

- Beta Emitting Radionuclides – Emitting high energy electrons and often simultaneous gamma photons

- Other types of Radiation (including pure gamma) will result in gamma photons.

# Radio-analytical Challenges

- Limited radio-analytical capacity nationwide due to:
  1. Resources required for establishing and sustaining laboratory infrastructure and expertise
  2. Global shortage in radio-analytical expertise
- Traditional analytical methods require laboratory setting

Standard Laboratory
Gamma-ray detection system

# Project Objectives

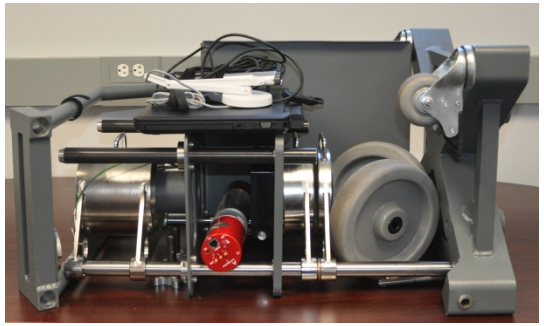
**Design Features**

- Light weight, modular, scalable, mobile
- Field user does not need radionuclide expertise
- Robust
- User-friendly
- Limit time and resources required in the field
- Meet data quality objectives
- Laboratory quality analytical data that is ISO 17025 compliant
- Real time in-situ high throughput sample data collections and analytical results potentially allowing follow-up action (i.e. sample release or increased sampling) in one visit.

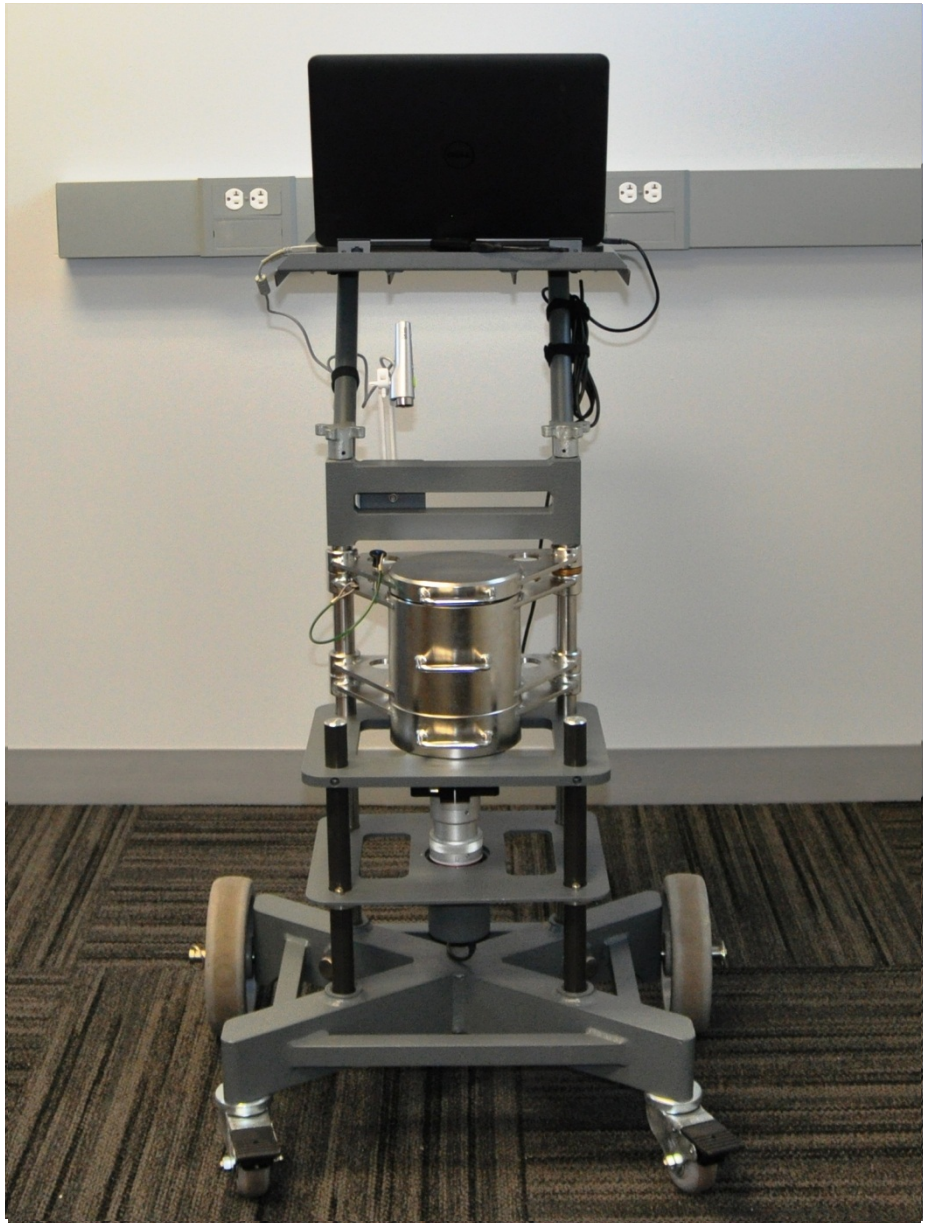
# Portable Gamma-ray Analysis System

# System Portability

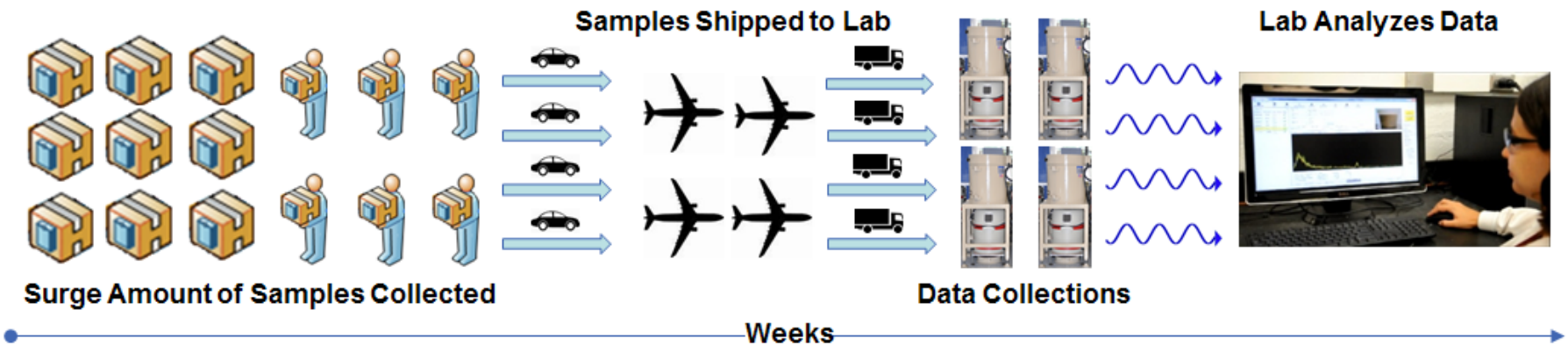
- The unit weighs ~110 lbs. fully assembled.
- The system can be disassembled and assembled in less than ten minutes.
- Each piece ways less than 20lbs
- Can be stored in a 31”x21”x16” area (less than a car trunk)

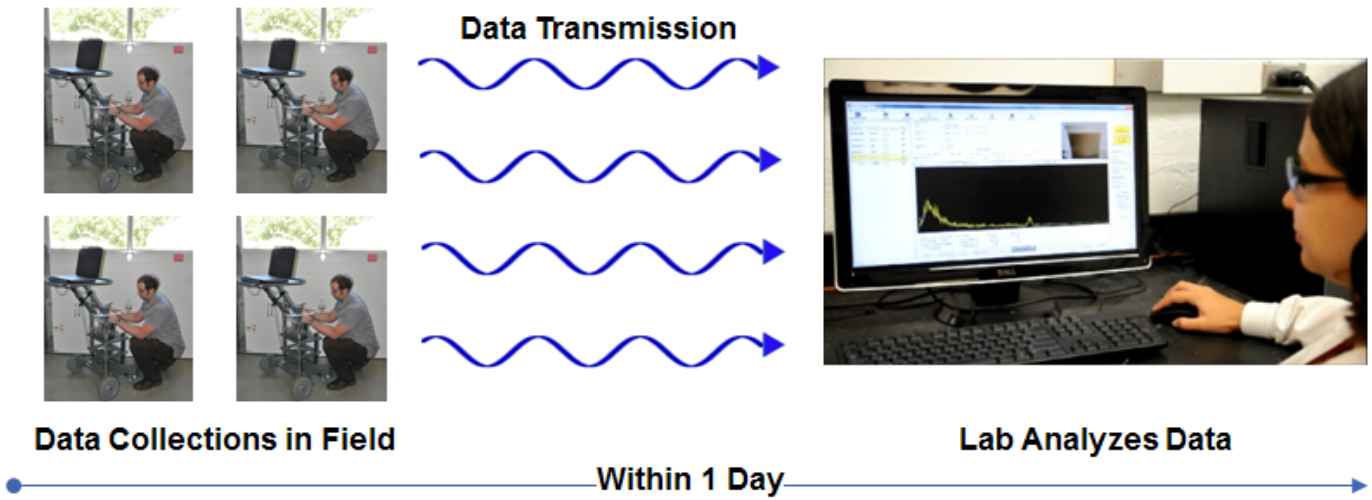


- Large back wheels provide easy mobility
- The temperature stabilized Cerium Bromide detector provides robust measurement capabilities without the need for cooling.
- The unit is battery powered by the laptop PC’s USB port.

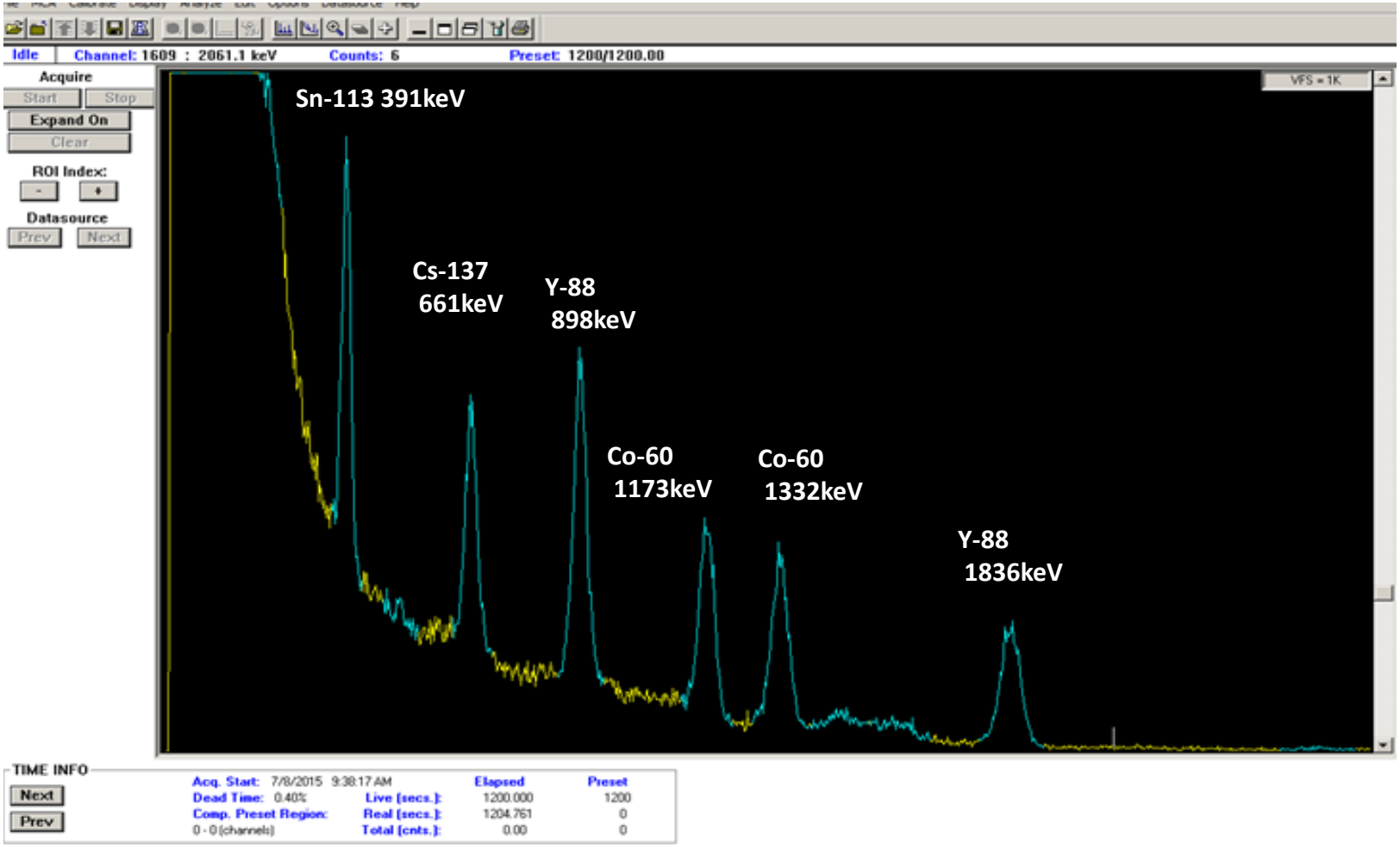


# Comparison of Data Collections

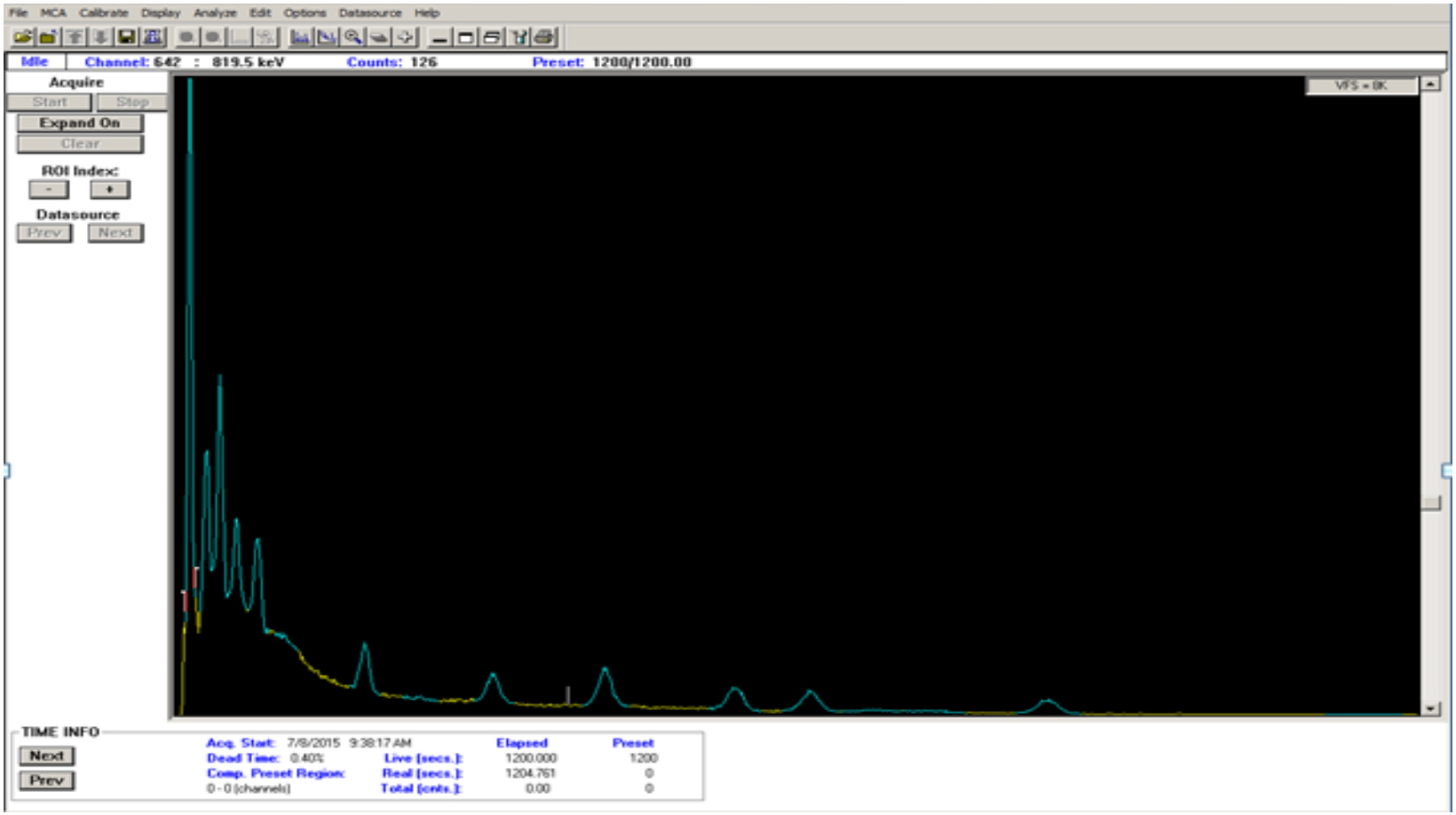


# Efficiency Calibration Spectrum



# Efficiency Calibration Spectrum (Cont.)



# Quality Control

- A 1 minute QC check with an exempt Eu-152 button source demonstrates energy calibration, stability of FWHM at low and high energies and activity constancy (with button source efficiency).
- A 20 minute background check verifies that the analytes are not present in the background environment.
- A 20 minute count of an epoxy standard with Ba-133, Cs-137 and Co-60 (exempt levels) serves as a laboratory control sample.
- All QC results are monitored centrally in the lab both against parameters from the same unit and other similar field units.

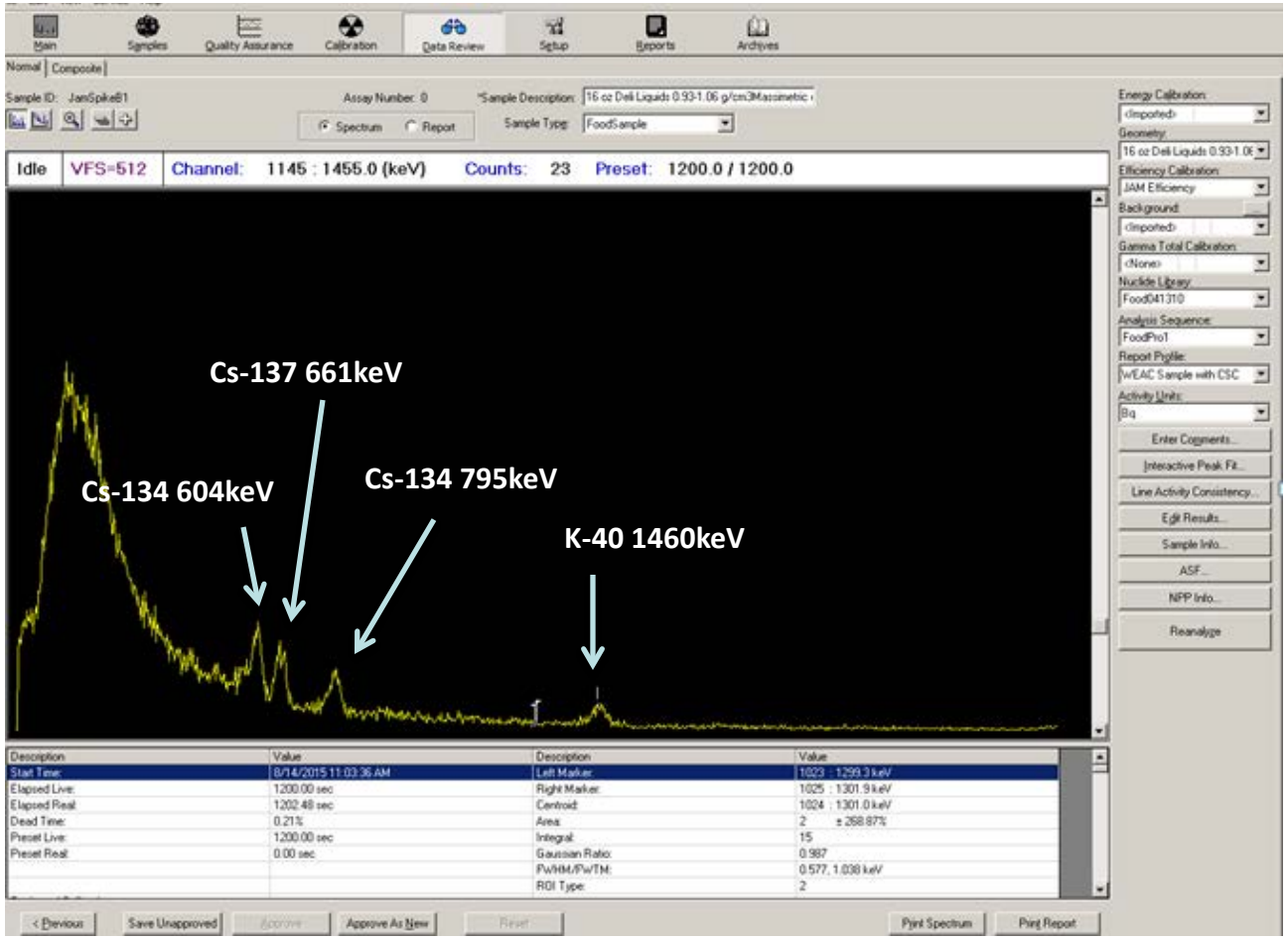
# Minimal Detectable Concentration using 20 min count time

| | Cs-134 | | Cs-137 | I-131 |
|---|---|---|---|---|
| FDA Recommended DIL | Combined total < 1200Bq/kg | | | 160Bq/kg |
| | 604keV | 795keV | 661keV | 364.49 |
| | MDC (Bq/kg) | MDC (Bq/kg) | MDC (Bq/kg) | MDC (Bq/kg) |
| Average of Water Measurements | 33.21 | 35.31 | 33.92 | 35.35 |
| Avg Low Densities (0.3-0.7 g/cc) | 48.84 | 52.30 | 51.72 | 51.59 |
| Avg Medium Densities (0.7-1.1 g/cc) | 32.19 | 35.06 | 33.42 | 34.71 |
| Avg High Densities (1.1-1.6g/cc) | 23.83 | 25.48 | 25.43 | 26.05 |
| **Average of Food Matrices** | **35.20** | **37.90** | **37.07** | **37.70** |

# Back of the Envelope MDC calculation for Soils

| | Cs-134 (Mn-54) | | Cs-137 |
|---|---|---|---|
| NRC 1757 Vol 2. Soils (Table H.2): | 5.7 (15) pCi/g | | 11 pCi/g |
| | 604keV | 795keV (835) | 661keV |
| | MDC (pCi/g) | MDC (pCi/g) | MDC (pCi/g) |
| Average of Water Measurements | 0.89 | 0.95 | 0.92 |
| Avg Low Densities (0.3-0.7 g/cc) | 1.32 | 1.41 | 1.40 |
| Avg Medium Densities (0.7-1.1 g/cc) | 0.87 | 0.95 | 0.90 |
| Avg High Densities (1.1-1.6g/cc) | 0.64 | 0.69 | 0.69 |
| **Average of Food Matrices** | **0.95** | **1.02** | **1.00** |

# Typical Spectrum with Both Cs-134 and Cs-137



# Summary for Accuracy and Precision

| | Radionuclide | Energy Line (keV) | % Accuracy | % Precision |
|---|---|---|---|---|
| | | | | |
| Low Denisty | Cs-134 | 604 | 8.8% | 14.3% |
| Range (0.3 - 0.7 g/cc) | Cs-134 | 795 | 1.3% | 14.6% |
| | Cs-137 | 661 | -3.4% | 14.1% |
| | | | | |
| Medium Density | Cs-134 | 604 | 17.1% | 13.9% |
| Range (0.7 - 1.1 g/cc) | Cs-134 | 795 | 0.3% | 12.6% |
| | Cs-137 | 661 | -5.8% | 14.4% |
| | | | | |
| High Density | Cs-134 | 604 | -5.5% | 13.2% |
| Range (1.1-1.4 g/cc) | Cs-134 | 795 | -9.9% | 13.3% |
| | Cs-137 | 661 | -18.1% | 13.9% |
| | | | | |
| **Average of All Foods** | **Cs-134** | **604** | **5.0%** | **13.7%** |
| **Range (0.3-1.4 g/cc)** | **Cs-134** | **795** | **-4.2%** | **13.4%** |
| | **Cs-137** | **661** | **-10.9%** | **14.1%** |

# Uncertainty at the LOQ Activity

| Analyte | Density | Approximate LOQ (Bq/kg) | Absolute Uncertainty (Bq/kg) | Relative Standard Uncertainty (1-sigma, %) | Expanded Uncertainty (2-sigma, %) |
|---|---|---|---|---|---|
| **I-131** | low | 172 | 31 | 18.0 | 36.0 |
| | medium | 134 | 17 | 12.7 | 25.4 |
| | high | 107 | 13 | 12.2 | 24.4 |
| **Cs-137** | low | 181 | 33 | 18.2 | 36.4 |
| | medium | 139 | 18 | 12.9 | 25.8 |
| | high | 110 | 14 | 12.7 | 25.4 |
| **Cs-134** | low | 147 | 27 | 18.4 | 36.8 |
| | medium | 110 | 14 | 12.7 | 25.4 |
| | high | 87 | 11 | 12.6 | 25.2 |

# Acknowledgement

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