# CDC'S Rapid Radionuclide Screen – Improvements, New Methods, and Plans for the Future

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National Center for Environmental Health
Division of Laboratory Sciences

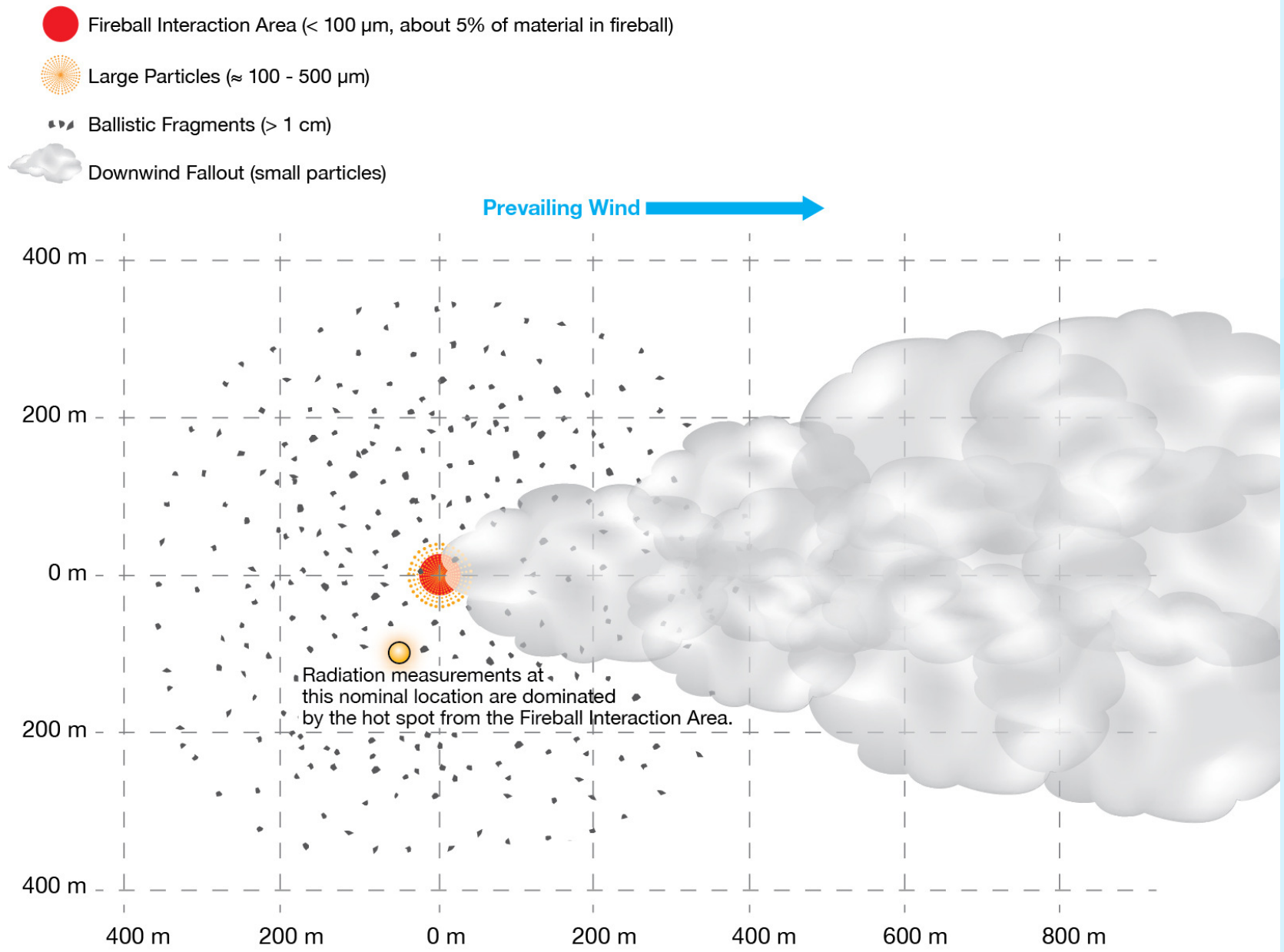
# The Boston Marathon 2013

## What if,

## It had been an RDD

## ("Dirty Bomb")?

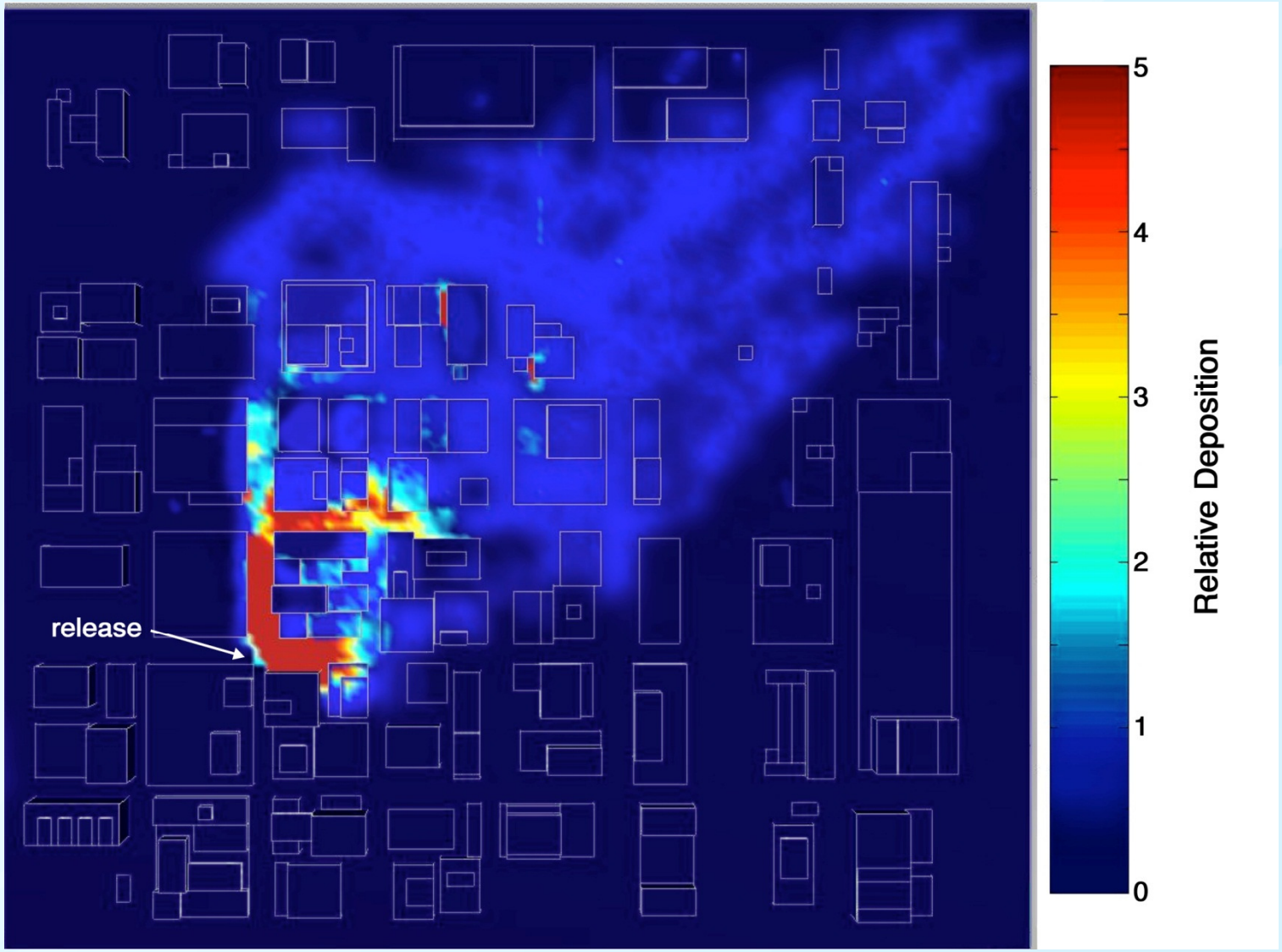
## Dispersal Pattern




Musolino, et.al., Health Physics, 2013, Volume 105, pages 65-73.

**Michael Brown, LANL**

# Was it a Widespread Dispersal?

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# Examples of Mass Screening Radiation Specific

- 1986 Chernobyl, Incident – **>300,000** screened
- 1987 Goiania, Incident - ~**112,000** screened
- 1999 Japan, Tokaimura Incident – >**74,600** screened
- 2011 Japan, Fukushima incident – >**244,000** screened

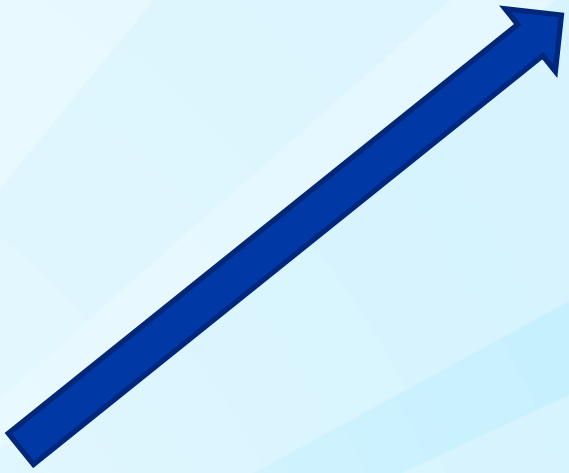
# Examples of Radiation Poisonings (Micro RDD)

- 1957 Frankfurt, Germany Thallium-204
- 1990 Canada, Tritium (H-)3
- 1994-1995 Taiwan, Phosphorus-32
- 1995 NIH, Phosphorus-32
- 1995 MIT, Phosphorus-32
- 1996 Long Island, NY, Radium-226
- 1999 U. of CA, Phosphorus-32
- 2009 India, Tritium (H-3)
- 2006 London, Polonium-210

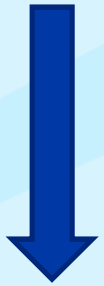
# Examples of Contamination Triage Testing for Alpha Emitters

External Testing:
**Alpha/Beta/Gamma Emitters**
Pre-Decon

External
(**Alpha/Beta/Gamma**)
Internal
(**Gamma only**)
Testing:
Post-Decon

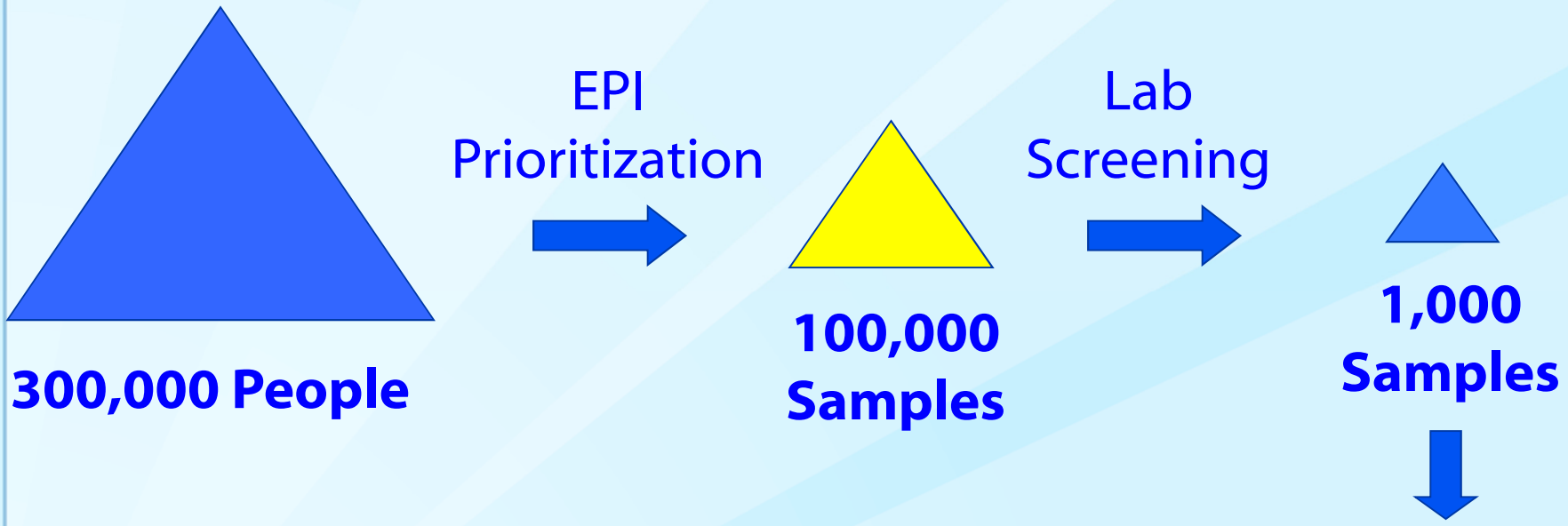


External
(**Alpha/Beta/Gamma**)
Testing



Internal
(**Gamma only**)
Testing

# Rapid Response: Epidemiologic, Laboratory and Health Physics Coordination



# Rapid Radionuclide Bioassay analytical methods: traditional versus new methods

| | "Traditional" Radionuclide methods | New "Rapid" methods: CDC |
|---|---|---|
| Time to first analytical results for 40 samples | About 3-6 ***days*** | Less than **24 *hours*** |
| Sample Requirements | ***24 hour*** collection | "***spot***" collection |
| Sample Size Requirement | 1 -2 **L** | 70 **mL** |
| Number of radionuclides with validated clinical methods | Limited to contract with Bioassay lab | 22 + "fission products" (14 current) |
| Sample throughput | **10-20** samples per day | **250 -3000 samples** per day |
| CLIA Certified Methods | no | yes |
| Scalable for "Surge Capacity" | minimal | yes |

# The Clinical Decision Guide (CDG),

The Clinical Decision Guide (CDG), a new operational quantity, is defined here to provide a measure that **physicians can use** when considering the need for **medical treatment** for **internally-deposited radionuclides or** as **a screening level indicating the need for a more detailed investigation** of tissue-specific absorbed doses over different time periods. For radionuclides **other than isotopes of iodin**e, the CDG is the maximum, **once-in-a lifetime** intake of a radionuclide that represents:

NCRP Report 161: Management of Persons Contaminated with Radionuclides: Handbook

# Clinical Decision Guide (Adult)

| Nuclide | Route | Class /chem | AMAD | ALI (Bq) | CDG (Bq) | (Bq/d) | (Bq/ml) | (Bq/L) |
|---|---|---|---|---|---|---|---|---|
| Co-60 | Inhalation | M | 1 um | 7.40E+06 | | 1.23E+05 | 8.54E+01 | 8.54E+04 |
| Co-60 | Inhalation | M | 5 um | | 3.50E+07 | 7.00E+05 | 4.86E+02 | 4.86E+05 |
| Sr-90 | Inhalation | F | 1 um | 1.48E+05 | | 3.41E+03 | 2.37E+00 | 2.37E+03 |
| Sr-90 | Inhalation | F | 5 um | | 8.30E+06 | 5.64E+05 | 3.92E+02 | 3.92E+05 |
| Sr-90 | Ingestion | n/a | n/a | 1.11E+06 | | 4.96E+04 | 3.45E+01 | 3.45E+04 |
| Sr-90 | Ingestion | n/a | n/a | | 8.90E+06 | 4.98E+05 | 3.46E+02 | 3.46E+05 |
| Cs-137 | Inhalation | F | 1 um | 7.40E+06 | | 4.21E+04 | 2.92E+01 | 2.92E+04 |
| Cs-137 | Inhalation | F | 5 um | | 5.80E+07 | 1.28E+06 | 8.86E+02 | 8.86E+05 |
| Cs-137 | Ingestion | n/a | n/a | 3.70E+06 | | 8.35E+04 | 5.80E+01 | 5.80E+04 |
| Cs-137 | Ingestion | n/a | n/a | | 2.80E+07 | 1.26E+06 | 8.78E+02 | 8.78E+05 |
| Pu-239 | Inhalation | M | 1 um | 2.22E+02 | | 3.61E-02 | 2.51E-05 | 2.51E-02 |
| Pu-239 | Inhalation | M | 5 um | | 7.60E+03 | 1.60E+00 | 1.11E-03 | 1.11E+00 |

**Adult, 1 day Post exposure**

# Bioassay: Key Issue
# Detection of Internal Contamination

| Radionuclides | Urine bioassay detection | Primary radiation detection |
|---|---|---|
| Uranium ($^{235}U$, $^{238}U$), Thorium | yes | alpha and beta |
| Strontium, Plutonium ($^{238}Pu$, $^{239}Pu$) | yes | |
| Americium, Californium, Neptunium, | yes | |
| Phosphorus, Curium, Polonium | yes | |
| | | |
| Cesium, Cobalt ($^{57}Co$, $^{60}Co$), Radium | yes | Gamma rays |
| Iodine ($^{125}I$, $^{131}I$), Technetium-99m | yes | |
| Selenium, Molybdenum, Iridium | yes | |

Internal radiation screening via hand held detectors or portals is only applicable for gamma emitting radionuclides.

Radionuclides of concern can be found at:
www-pub.iaea.org/MTCD/publications/PDF/Pub1309_web.pdf
www.energy.gov/media/RDDRPTF14MAYa.pdfc

The "Grand Rounds" presentation and slides can be found at:
www.cdc.gov/about/grand-rounds/archives/2010/03-March.htm

# CDC's - Bioassay Testing

- **Capability**: Rapid **screening**, **identification** and **quantitative** assessment of **internal** incorporation of radionuclides to quantify exposure or dose ("health risk")
- **Capacity**: ID and Quantify approximately 300 samples per day
- **Dose Range**:
  - 0.0001 to >2 Sieverts (Sv) - analytical sensitivity
  - Medical Treatment Threshold –
    - 0.05 Sv Children and Pregnant Women,
    - 0.2 Sv for the general population (**CDG**)
- Provide initial identification of a possible poisoning (e.g. $^{210}$Po)
- Assist with the EPI investigation

**CDG = Clinical Decision Guide**

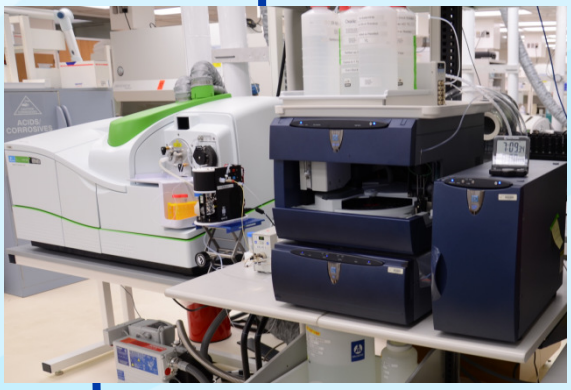
# CDC's Urine Radionuclide Screen

**Urine "Spot" Sample**

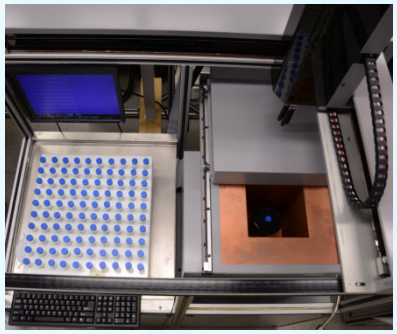
**Gamma Radionuclide Screen**

**Alpha/Beta Radionuclide Screen/Quantification**

**Alpha (Long Lived) ICP-MS Screen**

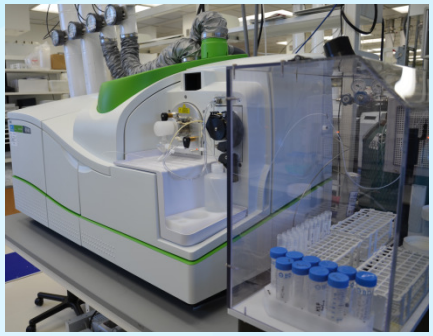


**Gamma Spectrometry Quantification**



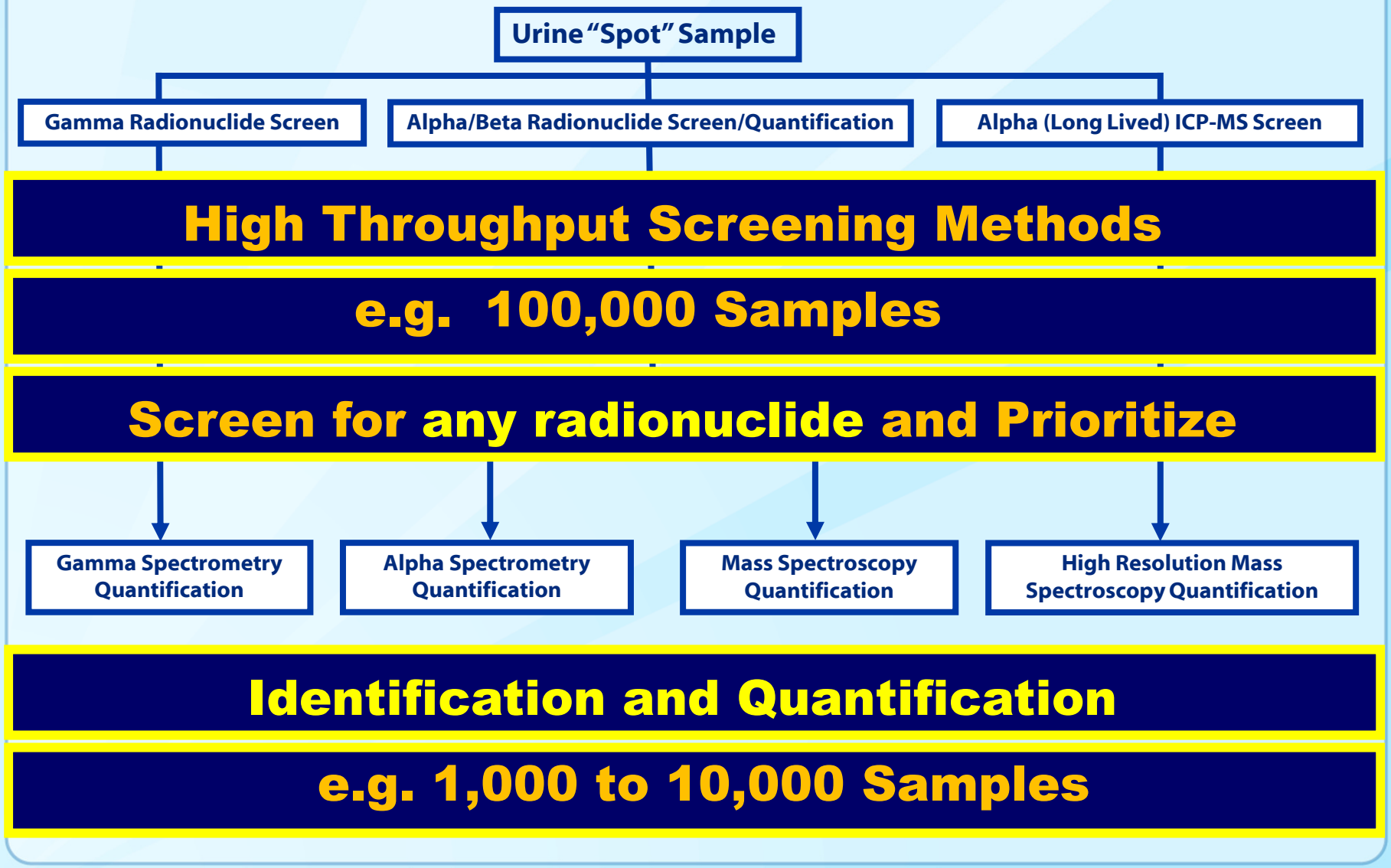
**Alpha Spectrometry Quantification**

**Mass Spectroscopy Quantification**



**High Resolution Mass Spectroscopy Quantification**

# CDC's Urine Radionuclide Screen



# CDC Radiation Lab Updates

- Analytical methods for 14 of the 22 Priority radionuclides have been developed
- Refining and enhancing current methods
  - (e.g. Sr-90, Pu-239)
- Additional methods being developed for:
  - Np-237 via HR-ICP-MS and Q-ICP-MS
  - Ra-226 via ICP-MS-QQQ
  - Se-75, I-131 & I-125 via Gamma Spec. (HPGe)
  - Po-210, Cf-252 & Cm-242 via Alpha Spec.

# Radiological Incident Impact

- Loss of life
- Acute radiation exposure
- Potential future cancer risk
- Psychosocial issues
- Economic impact, including area denial (due to contamination)
- Increased anxiety among citizens

# Summary

- Radiation Laboratory Methods (bioassay): rapidly identify and quantify specific radionuclides in people potentially contaminated in a radiological or nuclear event.
- Provides timely and critical information for effective medical management of individuals by assessing risk for medical management and follow-up.
- Provides information for population monitoring (populations and population sub-groups) by determining the level of internal contamination/exposure.
- Provides "negative" results for people, who think that they may be contaminated but are not truly contaminated, thereby relieving the stress on the public health system and medical infrastructure (e.g. limited SNS resources).

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# Questions

# and

# Discussions

# Thank you

**For more information please contact**

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# Backup Slides

# Radiation Diagnostics

- Radiation **Exposure**: A person is "exposed" to radioactive materials through
  - gamma irritation (external only e.g. IND blast)
  - "exposure" to alpha, beta or gamma radiation from external or internal contamination (RDD or IND fallout).

- Radiation **Contamination**: A person is "contaminated" **internally** with **radioactive materials** via inhalation or ingestion.

Both "exposure" and "contamination" results in an exposure dose.

# Radiation Diagnostics Tool Effectiveness vs. Type of

| Type of Incident | Exposure (Biodosimetry) | Contamination (Bioassay) |
|---|---|---|
| Improvised Nuclear Device (IND) | **Effective** (shine) | **Effective** (fallout) |
| Nuclear Power Plant (NPP) | Limited | **Effective** (fallout) |
| Radiation Dispersal Device (RDD) | Limited | **Effective** |
| Radiation Exposure Device (RED) | **Effective** | Not useful |

**Biodosimetry** determines a "past" radiation dose from an "exposure" incident. (HHS/BARDA Diagnostic test Development)

**Bioassay** determines "past, current and future" radiation doses from a "contamination" incident. (CDC Diagnostic test Development)

# Examples of Mass Screening/Analysis

- 1987 Goiania – $^{137}Cs$ - **112,000** tests in **~ 3 Months**
- 1995-1996 U.S. Methyl parathion – **16,000** tests
- 2001-2002 U.S. Anthrax (clinical) - **250,000** tests
- 2001-2002 U.S. Anthrax (environmental) – **1,000,000**
- 2005 NV Mercury exposure – **280** tested
- 2006 London - $^{210}Po$ - **800** tested in **~ 6 weeks**

# Concerned Citizen Multiplier

- 1987 Goiania – $^{137}Cs$ – 50 treated / 112,000 screened = **2240 "concerned citizen multiplier" (CCM)**
- 1995-1996 U.S. Methyl parathion – **16,000 CCM**
- 2001-2002 U.S. Anthrax (clinical) – 30 casualties or infected / 250,000 tests = **8,500 CCM**
- 2005 NV Mercury exposure – 1 contaminated /280 tested = **280 CCM**
- 2006 London - $^{210}Po$ –1 casualty / 800 tested = **800 CCM**