

**Radiation Protection Computer Code Analysis and Maintenance Program (RAMP)  
User Group Virtual Meeting, Internal Dosimetry Session, October 28, 2020**

# **Internal Dosimetry for Radiation Emergency Response**

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Radiation Studies Section

Division of Environmental Health Science and Practice

**National Center for Environmental Health**

Restricted Use/Recipients Only



# Radiation Studies Section: Emergency Roles

- Member of the Federal Advisory Team for Environment, Food, and Health
- Support state and local health partners
  - Technical assistance on a range of public health issues
    - Population monitoring



# Nuclear/Radiological Incidents

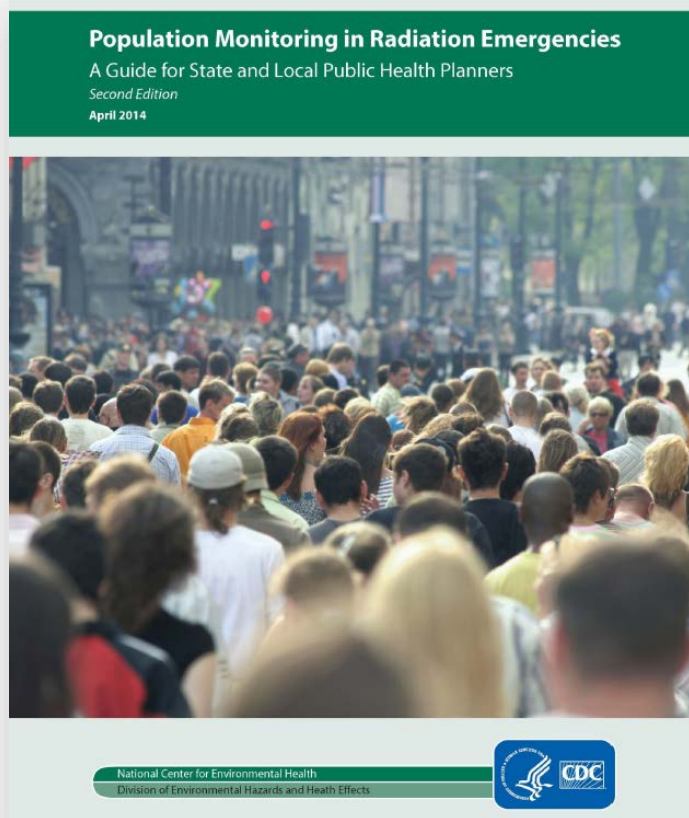
## Impact on People

- Fatality
- Injury
- Exposure to radiation
- Contamination with radioactive material
- Anxiety
- Displacement



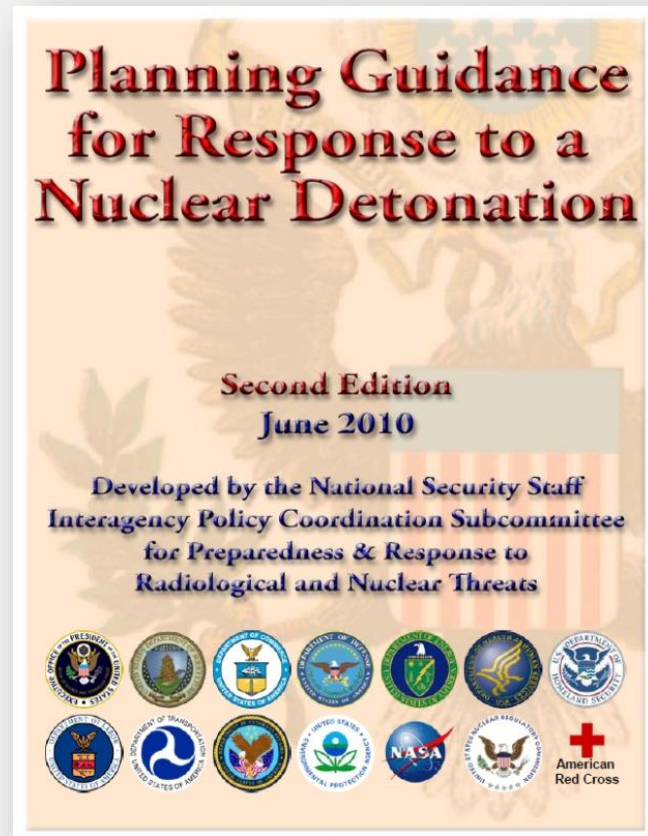
**Population  
Monitoring**

# Population Monitoring Guidance



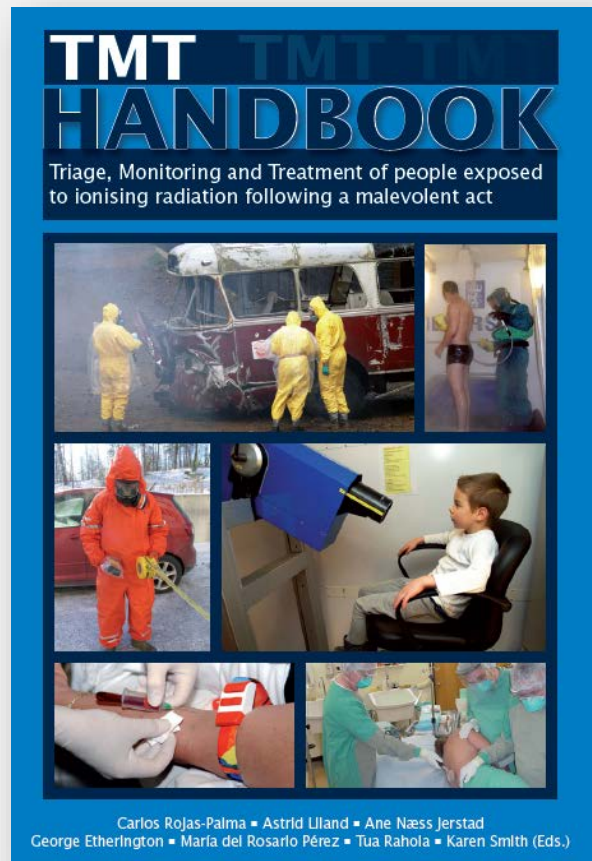
<http://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf>

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<http://www.remm.nlm.gov/PlanningGuidanceNuclearDetonation.pdf>

# Guidance



## IAEA Safety Standards

for protecting people and the environment

### Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency

Jointly sponsored by the  
FAO, IAEA, ILO, PAHO, WHO



IAEA

WHO

### General Safety Guide

No. GSG-2



**IAEA**

International Atomic Energy Agency

[www.tmthandbook.org/](http://www.tmthandbook.org/)

[www-pub.iaea.org/MTCD/publications/PDF/Pub1467\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/Pub1467_web.pdf)

# Guidance



## Commentary No. 19

Key Elements of Preparing  
Emergency Responders for Nuclear  
and Radiological Terrorism

## Report 165

Responding to a Radiological or  
Nuclear Terrorism Incident: A  
Guide for Decision Makers

## Report 161

**Management of Persons  
Contaminated With Radionuclides**

## Report 166

Population Monitoring and  
Radionuclide Decorporation  
Following a Radiological or  
Nuclear Incident

# Guidance Specifically for Nuclear Power Plants Off-site Response

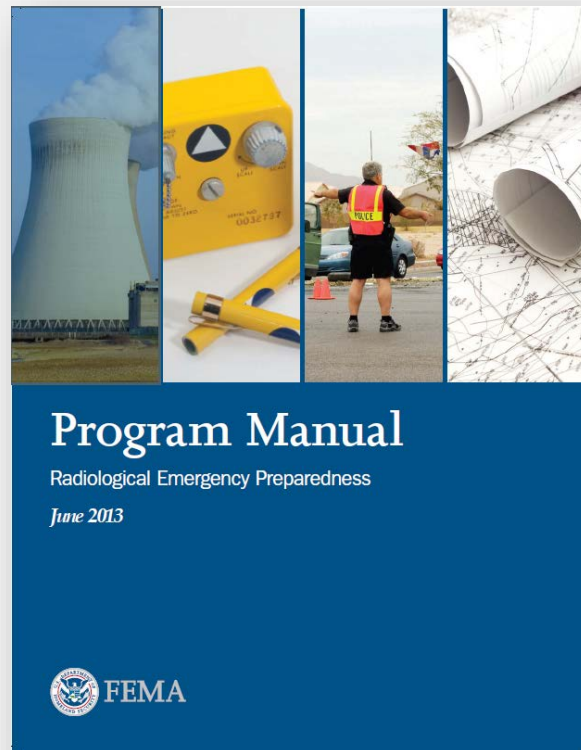
NUREG-0654  
FEMA-REP-1  
Rev. 1

## Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants

U.S. Nuclear Regulatory  
Commission



Federal Emergency Management  
Agency



[www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0654/](http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0654/)

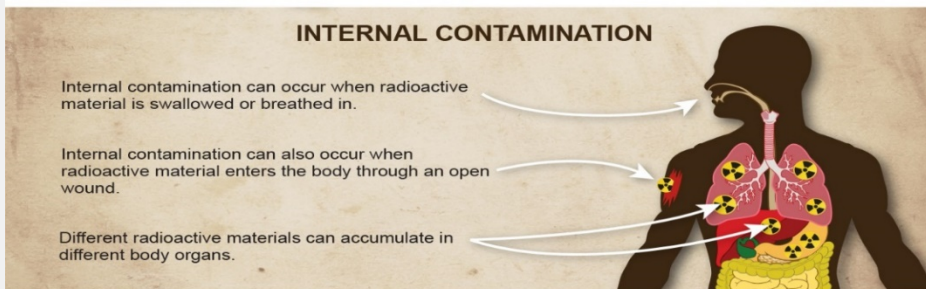


# RADIATION CONTAMINATION VERSUS EXPOSURE

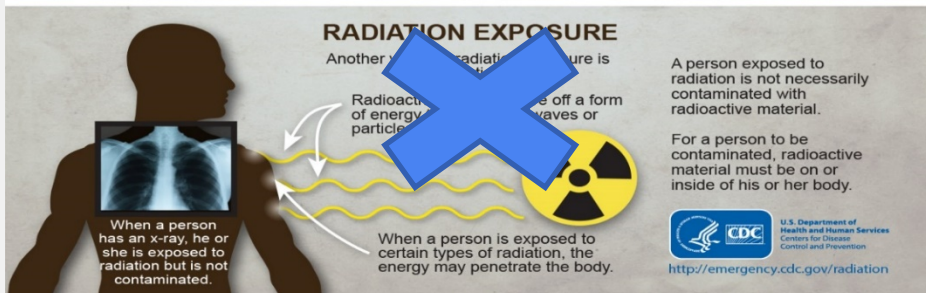
## EXTERNAL CONTAMINATION



## INTERNAL CONTAMINATION

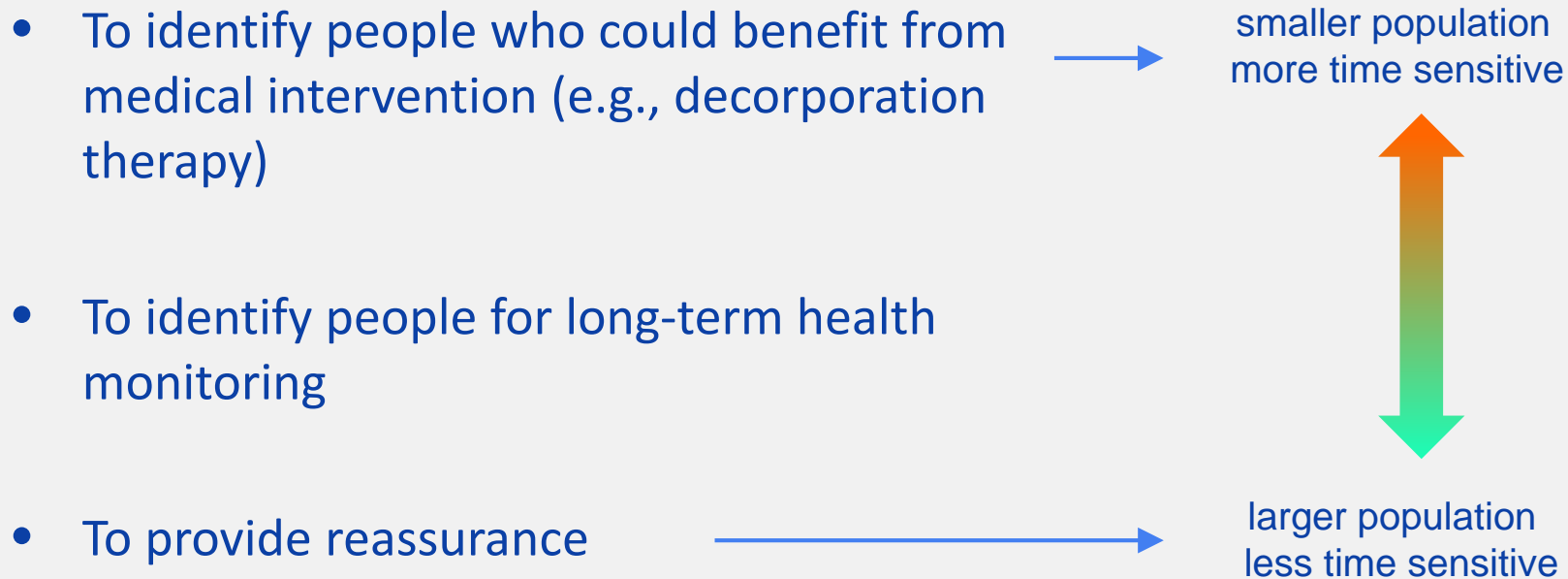


## RADIATION EXPOSURE





# Screening for Internal Contamination



# Clinical Decision Guide (CDG)



To help physicians make clinical decisions about individuals with internal contamination who may need treatment.

For Adults\* (use the most limiting value):

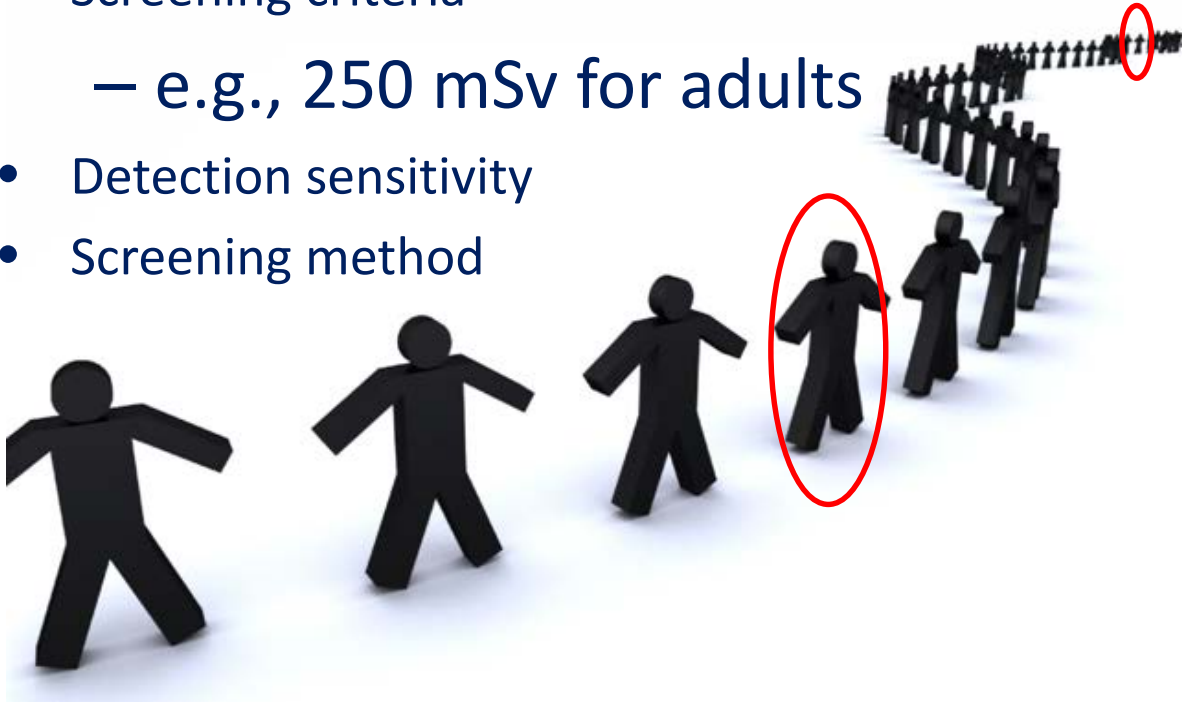
- **0.25 Sv (50-year effective dose) whole body**
- 0.25 Gy-Eq (30-day RBE-weighted absorbed dose) to the bone marrow
- 1 Gy-Eq (30-day RBE-weighted absorbed dose) to the lung

For children and pregnant/nursing women:  $1/5^{\text{th}}$  of the Adult CDG

\* Except for iodine

# Screening a Large Population

- Screening criteria
  - e.g., 250 mSv for adults
- Detection sensitivity
- Screening method



# Laboratory Analyses

- Conventional methodology
  - 24-hr urine sample (1-2 Liter sample)
  - 3-6 days turnaround time
  - 10-20 samples/day/lab
- Improved methodology (for population screening)
  - One 15-70 ml “spot” urine sample
  - < 24 hours turnaround time (multiple radionuclides)
  - 250-3000 samples/day
  - CLIA certified

**Field screening and prioritization important**

# Direct Bioassay

- Feasible only when contaminants are gamma emitters (with some exceptions)
- Detection sensitivity does NOT have to be as low as routine occupational bioassays
- Allows for rapid prioritization of individuals for further analysis
- Needs characterization of instrument response

# Examples of Instruments for Use in Direct Bioassay

- **Field Instruments**

- Portable Hand-held instruments
- Portal monitors



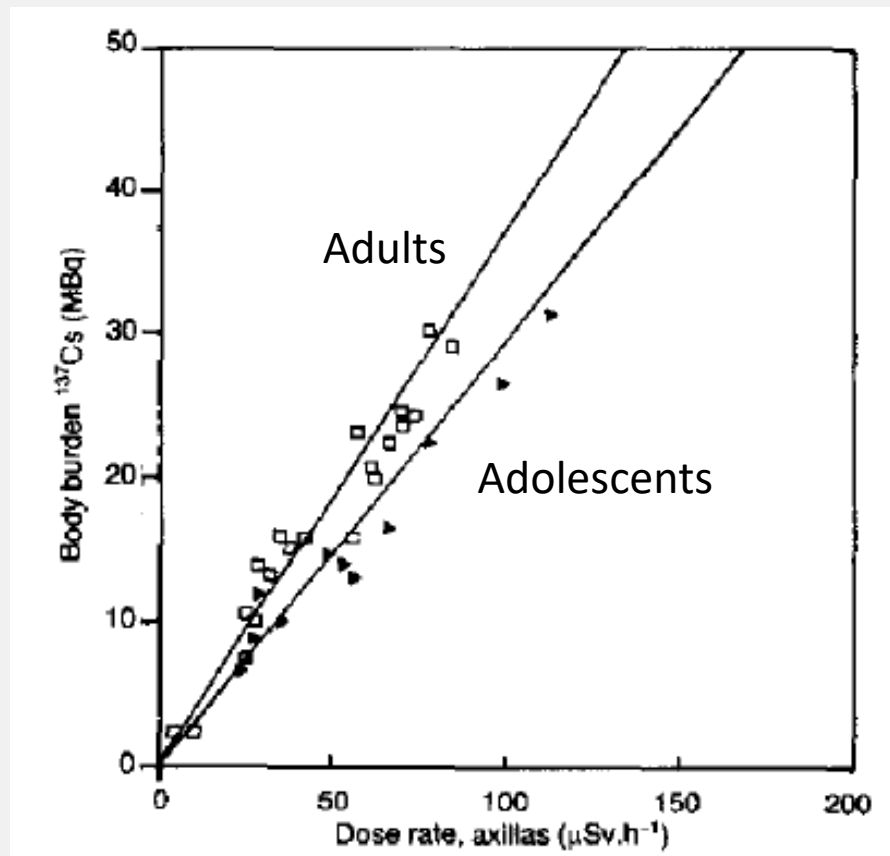
- **Hospital instruments**

- Thyroid Scanners
- Gamma Cameras



# Example of Direct Bioassay: Goiania Patients

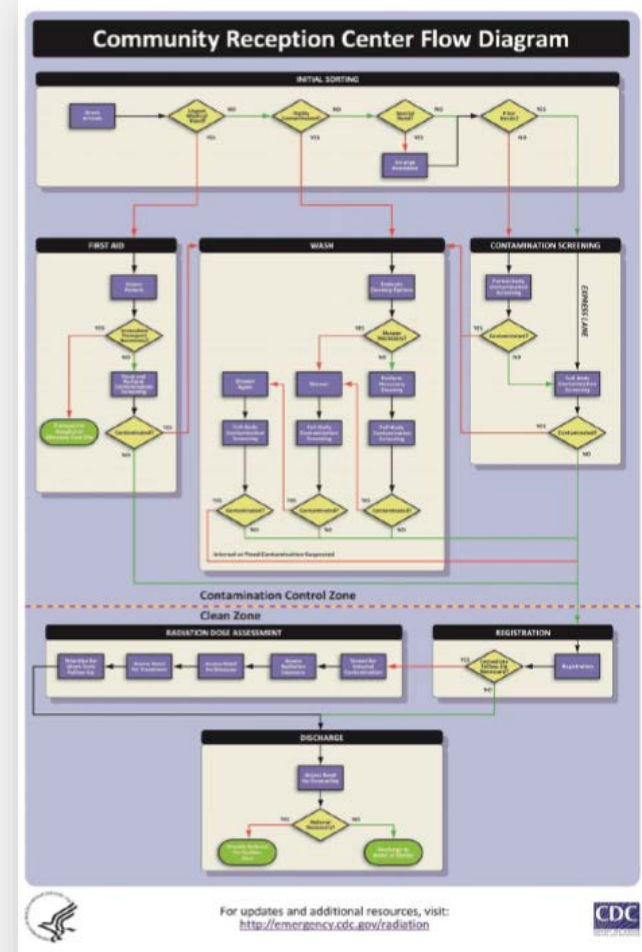
- Correlation for axilla measurements
- Adults
  - 20-60 years
  - 66 kg average weight
- Adolescents
  - 13-15 years
  - 41 kg average weight



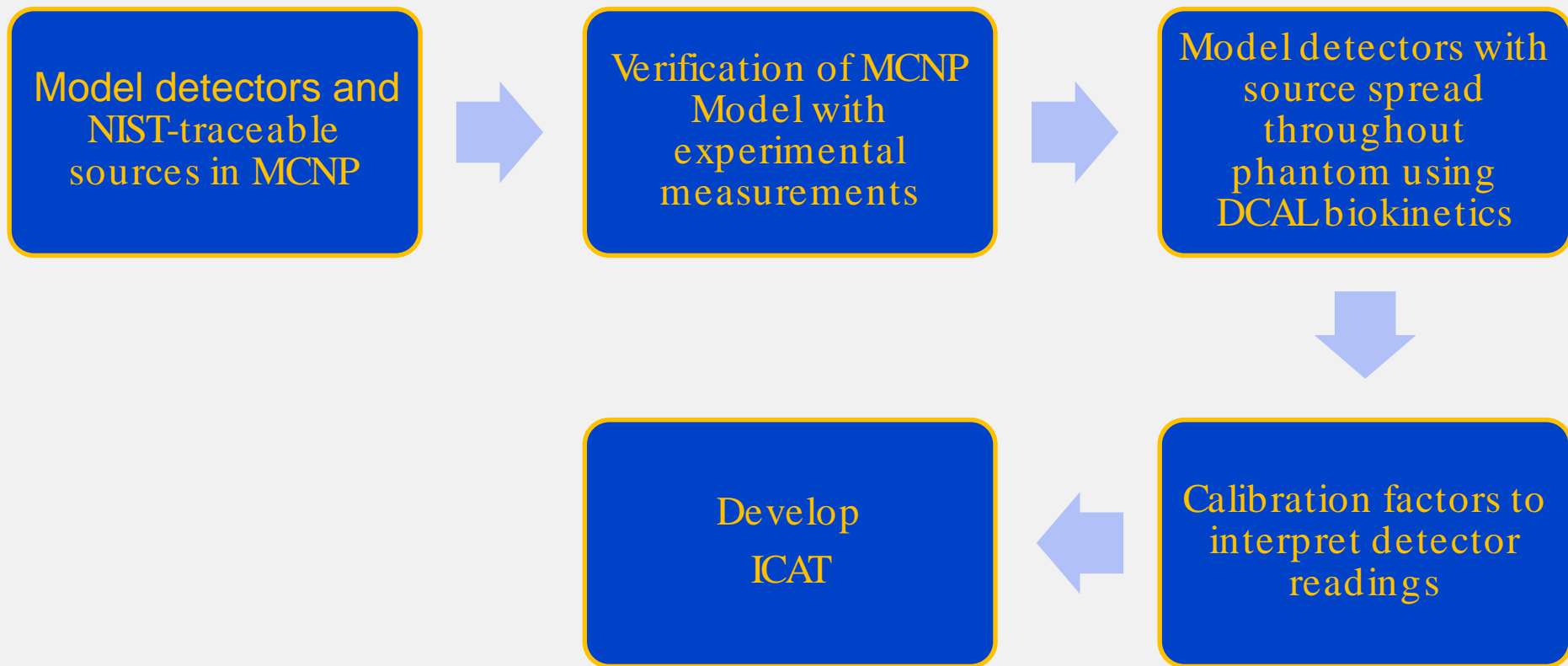


# Community Reception Center (CRC)

- Place where population is directed after a radiological incident to receive screening, decontamination, and other services
- Services include:
  - First Aid
  - Contamination screening
  - Wash (Decon)
  - Dose Assessment**
    - includes triage for internal contamination
  - Registration



## Overview of Methodology



## **Motivation for Developing ICAT (Internal Contamination Assessment Tool)**

- **Need for simple, readily available way for rapid triage and prioritization of individuals suspected of internal contamination using field deployable instruments**
- **Create software that incorporates instrumentation data for easy use by responders**
  - Only applicable for gamma-emitters
  - Not a substitute for laboratory bioassay

**USE OF TRANSPORTABLE RADIATION DETECTION INSTRUMENTS TO  
ASSESS INTERNAL CONTAMINATION FROM INTAKES OF RADIONUCLIDES  
PART I: FIELD TESTS AND MONTE CARLO SIMULATIONS**

Robert Anigstein,\* Michael C. Erdman,† and Armin Ansari‡

**USE OF TRANSPORTABLE RADIATION DETECTION INSTRUMENTS TO  
ASSESS INTERNAL CONTAMINATION FROM INTAKES OF RADIONUCLIDES  
PART II: CALIBRATION FACTORS AND **ICAT COMPUTER PROGRAM****

Robert Anigstein,\* Richard H. Olsher,† Donald A. Loomis,\* and Armin Ansari‡

**Abstract**—The detonation of a radiological dispersion device or other radiological incidents could result in widespread releases of radioactive materials and intakes of radionuclides by affected

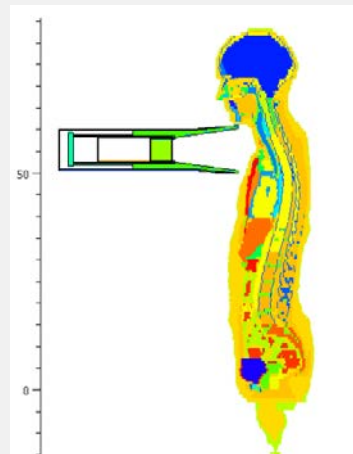
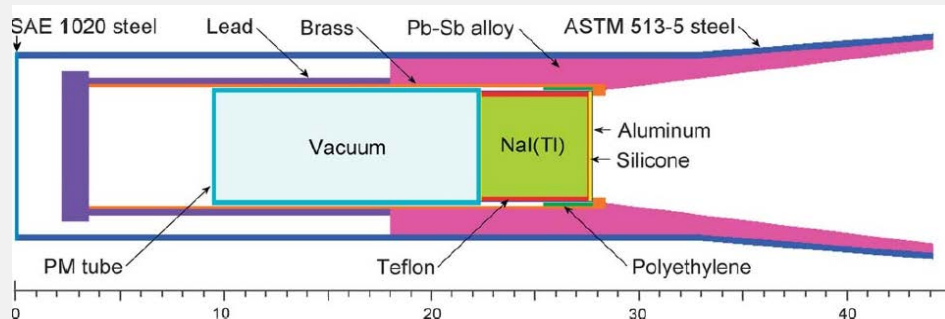
Health Phys. 111(6):542–558; 2016

**Key words:** biokinetics; detector, scintillation; intake, radionuclide; phantom mathematical

Anigstein, R, Erdman MC, Ansari A, Use of transportable radiation detection instruments to assess internal contamination from intakes of radionuclides Part I: field tests and Monte Carlo simulations. *Health Phys* 110 (6):612-22, 2016.

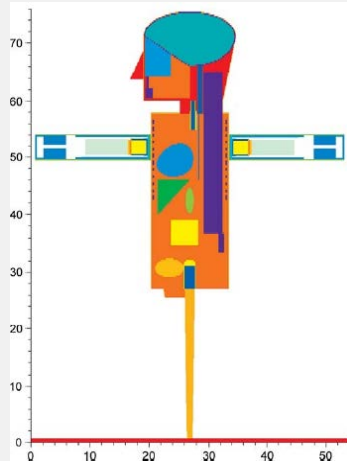
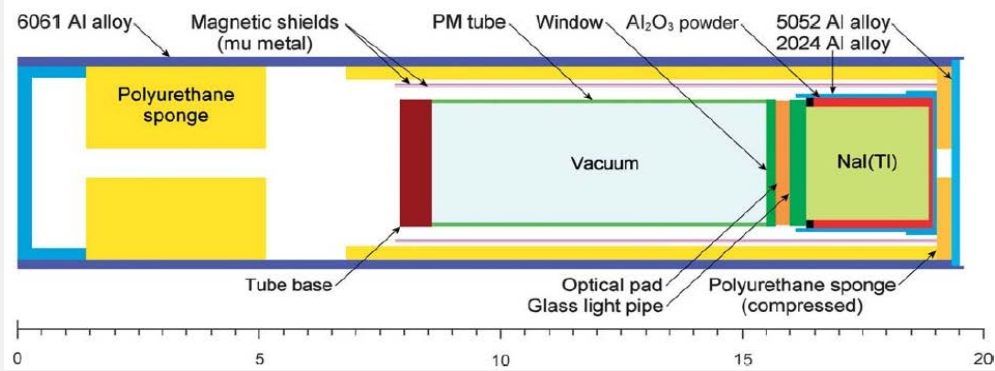
Anigstein, R, Olsher RH, Loomis DA, Ansari A, Use of transportable radiation detection instruments to assess internal contamination from intakes of radionuclides Part II: calibration factors and ICAT computer program. *Health Phys* 111 (6):542-558, 2016.

# CAPTUS 3000 Model



\*Capintec, Inc. Captus 3000 Uptake Thyroid System. 2015. <http://www.capintec.com/product/captus-3000-thyroid-uptake-system/>. Accessed 19 June 2017.

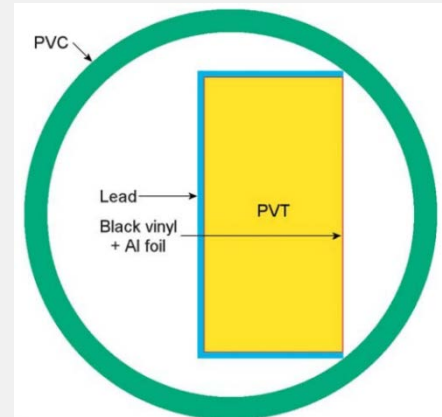
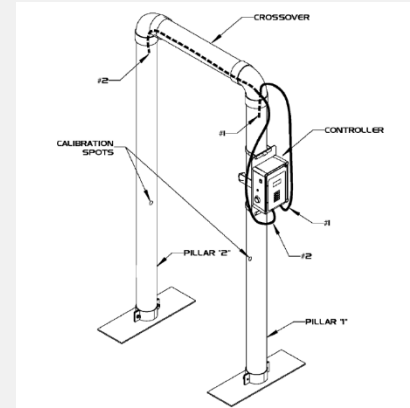
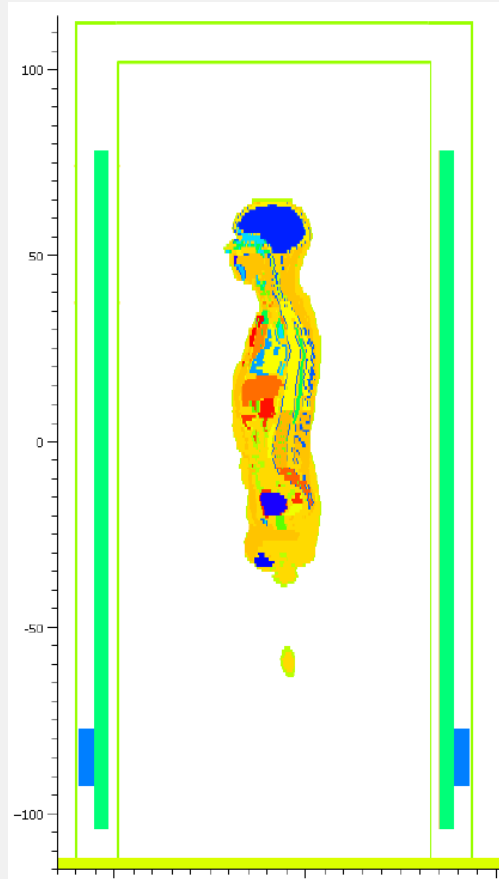
# Ludlum 44-2 Model



\*Ludlum Measurements, Inc. Ludlum Model 44-2 gamma scintillator[online]. 2014. [http://ludlums.com/images/stories/Product\\_manuals/M44-2.pdf](http://ludlums.com/images/stories/Product_manuals/M44-2.pdf).

Accessed 19 June 2017.

# TPM-903B Model






Last name Doe	First name John	
Age of client 20 Years Months	Sex of client <input checked="" type="radio"/> Male <input type="radio"/> Female	Weight of client  lb kg

Instrument Ludlum 44-2	
Date of measurement 3/13/2016	Time of measurement 7:20:00 PM
Location <input checked="" type="radio"/> Chest <input type="radio"/> Abdomen <input type="radio"/> Thyroid	Position <input checked="" type="radio"/> Anterior <input type="radio"/> Posterior
Distance to front of detector <input checked="" type="radio"/> 0 ft <input type="radio"/> Other <input type="text"/>	
Client Ludlum 44-2 Count time (min) 2000 cpm	
Background Ludlum 44-2 Count time (min) 1500 cpm	

Calculate Results	Print Results	Next Client
Results <input type="radio"/> Conventional units <input checked="" type="radio"/> SI		
Calculated intake 5.84E-02 MBq	Cumulative effective dose (to present time) 8.10E-03 mSv	Committed effective dose 0.27 mSv

Principal mode of intake <input checked="" type="radio"/> Inhalation <input type="radio"/> Ingestion	Clear Incident Data
Date client inhaled or ingested radioactive material 3/11/2016	Time 7:20:00 PM
Principal radionuclide <input type="radio"/> Co-60 <input type="radio"/> I-131 <input checked="" type="radio"/> Cs-137 <input type="radio"/> Ir-192	Lung absorption type <input checked="" type="radio"/> F - All compounds

Notes (optional)
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 ICAT

Client Energy Windows Quick Reference

Edit Energy Windows

Save Energy Windows

Restore Original

### Energy windows for TPM-903B

☐ Default

☒ Custom

☐ Alternate

	Lower level discriminator	Upper level discriminator	Lower level discriminator	Upper level discriminator	Lower level discriminator	Upper level discriminator
	V	V	V	V	V	V
Co-60	0.068	5.04	0.068	5.04	0.098	5.04
I-131	0.068	5.04	0.068	5.04	0.098	5.04
Cs-137	0.068	5.04	0.068	5.04	0.098	5.04
Ir-192	0.068	5.04	0.068	5.04	0.098	5.04

## Emergency Preparedness and Response

Information on Specific Types of Emergencies > Radiation Emergencies > Radiation Emergency Training, Education, and Tools



### 🏠 Radiation Emergencies

What Should I Do? +

Questions About Radiation (FAQ)

Radiation Dictionary

Radiation Emergencies & Your Health +

Types of Radiation Emergencies +

Information for Professionals +

Radiation Emergency Training, Education, and Tools -

Success Stories in Radiation  
Emergency Preparedness

Community Reception Center  
Electronic Data Collection Tool  
(CRC eTool)

## Use of Radiation Detection, Measuring, and Imaging Instruments to Assess Internal Contamination from Intakes of Radionuclides

1. [Instructions for Using Gamma Cameras to Assess Internal Contamination from Intakes of Radionuclides](#) 📄 (1.5 MB/37 pages)
2. [ASSESS, a Utility for Using Gamma Cameras to Assess Internal Contamination](#) 📄 (Zip File)
3. [Supporting Technical Documents](#) (Parts I – VI Support PDFs)

## Use of portable survey meters and portal monitors for initial screening and triage of internally contaminated people: Internal Contamination Assessment Tool (ICAT).

- [ICAT Software](#) 📄 (Zip File)
- [Quick Reference Guide for ICAT](#) 📄
- [Part I: Field Tests and Monte Carlo Simulations](#) 🔗
- [Part III: Supplementary Data](#) 📄
- [Part IV: Instructions for Users](#) 📄

<https://emergency.cdc.gov/radiation/clinicians/evaluation/index.asp>

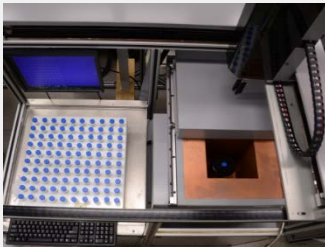
# CDC's Urine Radionuclide Screen

Urine "Spot" Sample

Gamma Radionuclide Screen



Gamma Spectroscopy  
Quantification



Alpha/Beta Radionuclide Screen/Quantification



Alpha Spectroscopy  
Quantification



Alpha (Long Lived) ICP-MS Screen



Mass Spectrometry  
Quantification



High Resolution Mass  
Spectrometry Quantification



# Internal Dose Calculation for Large Batch of Urine Bioassay Results

Sample Matrix	Matrix Qualifier	Sample Volume (ml)	Laboratory Sample ID	Local Sample ID	Analytical Result	Units	Creatinine Corrected Result	Creatinine Corrected Units	LOD (pCi/L)	Volume-Corrected units	First Name	Last Name	DOB MM/DD/YYYY	Age (years)	Gender	Height (cm)	Weight (Kg)
Urine	Spot	200	08-901-000001-4RA	CHE2018000001	3.39E+01	Bq/L	3.39E+01	Bq/gCr	4.20E+04	Bq/L				10	M		
Urine	Spot	200	08-901-000002-4RA	CHE2018000012	3.39E+01	Bq/L	3.39E+01	Bq/gCr	4.20E+04	Bq/L				10	M		
Urine	Spot	200	08-901-000003-4RA	CHE2018000022	3.54E+01	Bq/L	3.54E+01	Bq/gCr	4.20E+04	Bq/L				10	M		
Urine	Spot	200	08-901-000004-4RA	CHE2018000032	3.54E+01	Bq/L	3.54E+01	Bq/gCr	4.20E+04	Bq/L				10	M		
Urine	Spot	200	08-901-000005-4RA	CHE2018000042	3.39E+01	Bq/L	3.39E+01	Bq/gCr	4.20E+04	Bq/L				10	M		
Urine	Spot	200	08-901-000006-4RA	CHE2018000052	3.54E+01	Bq/L	3.54E+01	Bq/gCr	4.20E+04	Bq/L				10	M		

Laboratory Sample Id 08-901-000006-4RA  
BioDose - 8/8/2018 6:53:02 AM

## BioDose v4.2.1



Import Batch

Select Batch

View Bioassay Data

Set Dose Options

Calculate Doses

View Dose Results

Biokinetics

### Currently Selected Batch

Current Calculation Options

Samples

☒ all

☐ high CDG

☐ flagged

### Intake

Intake Date 7/8/2018 10:15:00 AM  
Route wound  
I131 activity 100%

### Person involved

Sex M  
Weight not given  
Height not given  
Age Group 10y (reported age 10 years)

### Bioassay Data

Sample Date 7/10/2018 10:15:00 AM  
Time from Intake 2 days  
Nuclide I131  
Type Spot Urine  
Reported Result 3.535E+01 Bq/L  
Result (Urine24H) 2.475E+01 Bq (see calculation details at end)  
CDG 5.020E+04 Bq (Model used=WIN)

### Definition of Dose

Type Equivalent Dose (H)  
Tissue Thyroid  
Time Period 60 years (21915 days) after intake

### Dose Result

Intake	Default dose (Sv)(model)	Min dose (Sv)(model)	Max dose (Sv)(model)
I131	5.471E-04 (WIN)	5.471E-04 (WIN)	5.471E-04 (WIN)

### Definitions in Calculation Section

IRF Intake retention fraction for bioassay type (from Biokinetic table)  
dose coefficient Coefficient from Biokinetic table for dose type, tissue and time period  
\* See end of Comments section (Biokinetic Tables Used) for values  
const extrapolate #days exceeds max days in table, use value for max days

### Detail Calculation

# Thank you!

**Armin Ansari**

**770-488-3654**

**AAnsari@cdc.gov**

For more information, contact NCEH

1-800-CDC-INFO (232-4636)

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