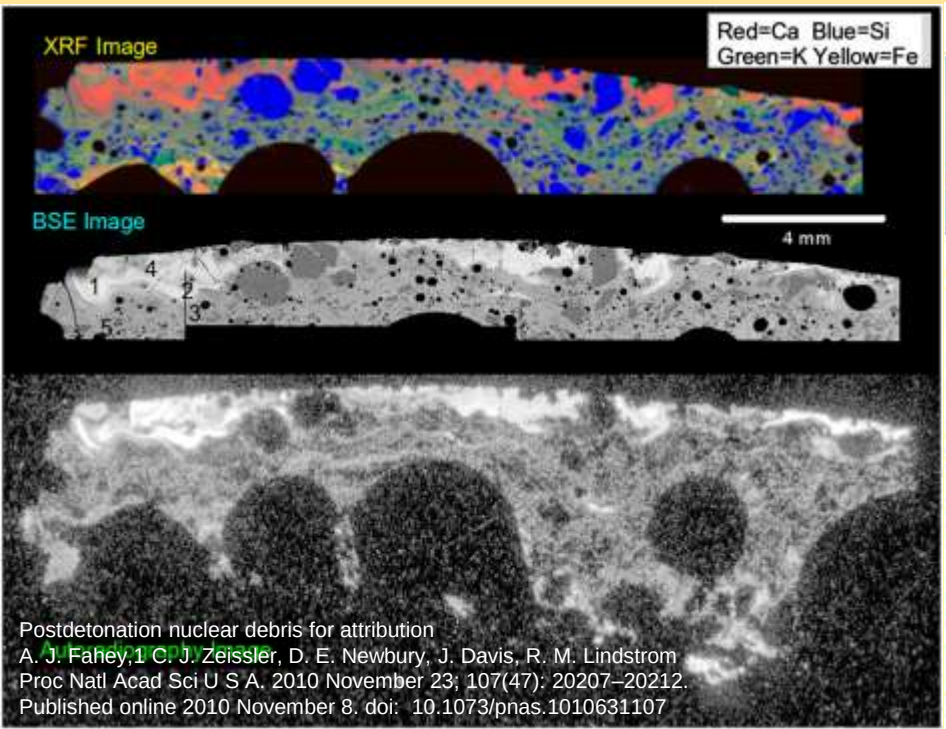
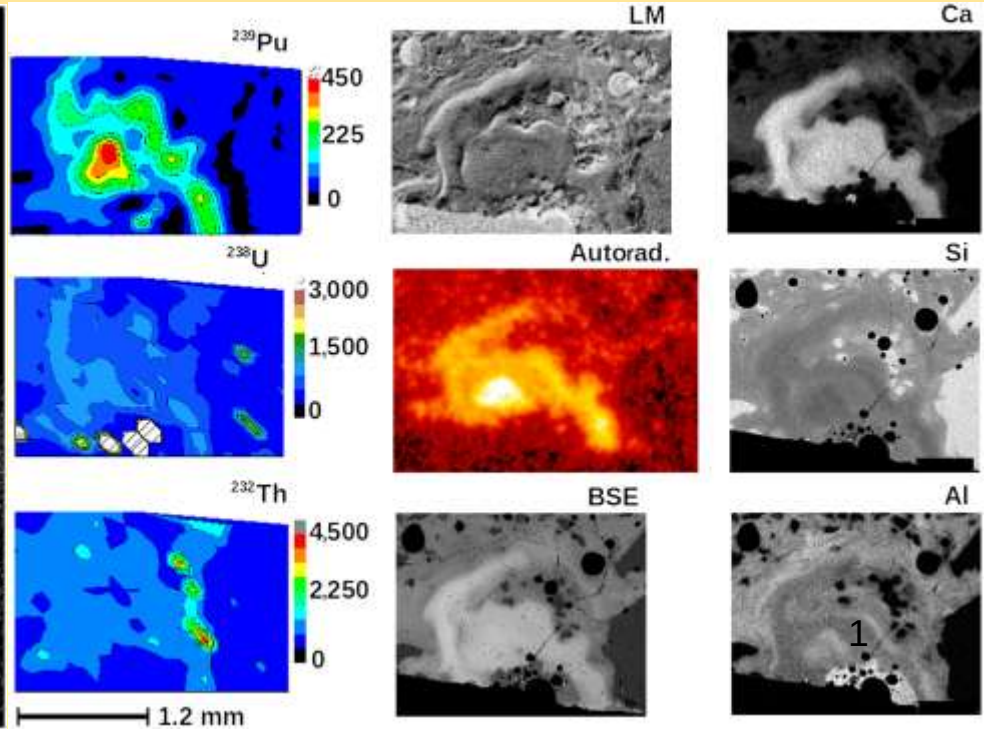
A Full Cup

Kenneth G.W. Inn





Postdetonation nuclear debris for attribution
A. J. Fahey,1 C. J. Zeissler, D. E. Newbury, J. Davis, R. M. Lindstrom
Proc Natl Acad Sci U S A. 2010 November 23; 107(47): 20207–20212.
Published online 2010 November 8. doi: 10.1073/pnas.1010631107

Caswell Award

Division Chief

Sabbatical

NBS NML

ORM

CIRMS

MPDs

Previous Awardees

2002 H. Thompson Heaton, II, FDA

2004 Anthony J. Berejka, Ionicorp

2006 Kenneth L. Swinth, Swinth Associates

2007 Bert M. Coursey, DHS

2008 Larry A. DeWerd, U Wisconsin

2009 Marshall R. Cleland, IBA Industrial, Inc

2010 Geoffrey S. Ibbott, UT MD Anderson Cancer Center

Acknowledgements

Low-level Radiochemistry Project Colleagues

Radioactivity Group Leaders

NIST [NBS]

National and International Colleagues

Interns

CIRMS Family

Dad, Mom, Estelle, Rachel, Jarrett, Juan, Maka Koa

Radionuclide Metrology Infrastructure Workshops

- **Environmental cleanup, occupational safety, ocean studies, food safety, nuclear forensics, radionuclide speciation, waste management, emergency response, measurement traceability testing**

- **Need metrology tools for:**
  - **Method development/validation**
  - **Quantitative measurement confidence for decision making**
  - **Measurement comparison over time/distance**
  - **Independent verification of measurement capability**

Agenda

Natural Matrix Radionuclide SRM

CIRMS MPDs

Traceability to NIST for Reference, Monitoring & Service Laboratories

Emergency Radiological Response Metrology

Sorption of Radioactive Elements in Contaminated Soils, Sediments and Urban Materials

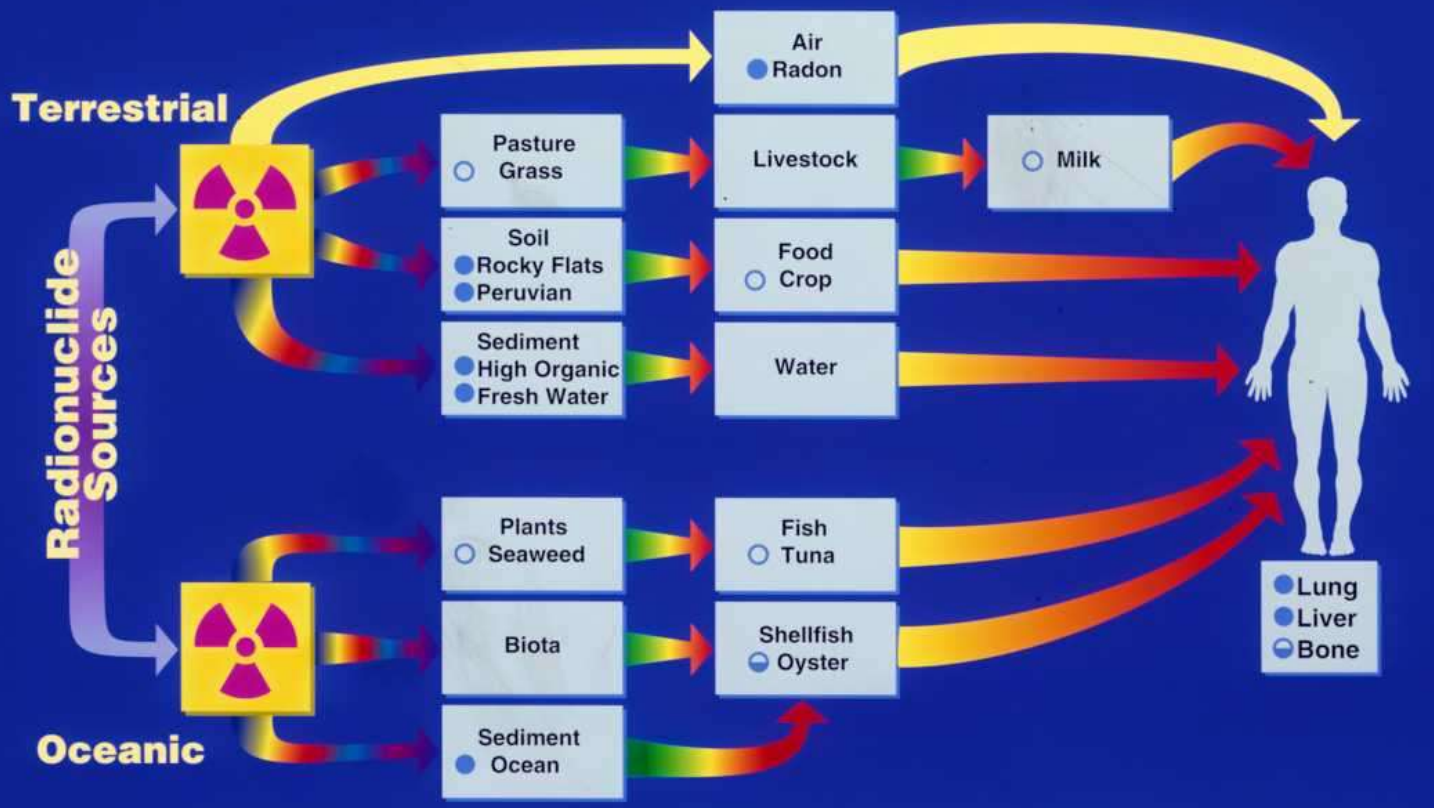
Improvements for In-vivo and In-vitro Radiobioassay

Atom-counting Measurement Techniques for Environmental and Radiobioassay

(Nuclear Forensics)

Natural Matrix Radionuclide SRMs

Standards for Environmental Radioactivity



Sources
- Reprocessing
- Fallout
- Catastrophes
- Spills
- Sewage
- Remediation
- D and D
- Ocean Dumpsites

Radionuclides
^{90}Sr, ^{129}I, ^{137}Cs, Rn, Pu, etc.

Molecular Species
(designated by line color)
- Exchangeables
- Carbonates
- Oxides
- Organics
- Silicates

SRMs
- Completed
- Under Development
- Planned

Matrix	Radionuclides	10-Yr Requirements
Soil: High Ca Low Ca	90Sr, 137Cs, 210Pb, Alpha Emitters	5,000 Aliquants (1 kg Samples)
Sediments: High Ca Low Ca Mill Tailings	Alpha- & Beta-Particle Photon Emitters	1,600 Aliquants (100 g Samples)
Water:	3H, 60Co, 90Sr, 106Ru, 134Cs, 137Cs, Natural Radionuclides, Alpha-Particle Emitters	Several 1000 Aliquants (50-100 mL Samples)
Biological: Lung Liver Bone Milk Sea Clam Sea Hare Seaweed	3H, 14C, Fission & Activation Products, Alpha-Particle Emitters	Several 100 Aliquants
Air: Filters	Natural Radionuclides	

Natural Matrix SRMs

for Environmental Radioactivity Measurement

- Rocky Flat Soil I
- River Sediment
- Peruvian Soil
- Human Lung
- Human Liver
- Lake Sediment
- Ocean Sediment
- Bone Ash
- Shell Fish

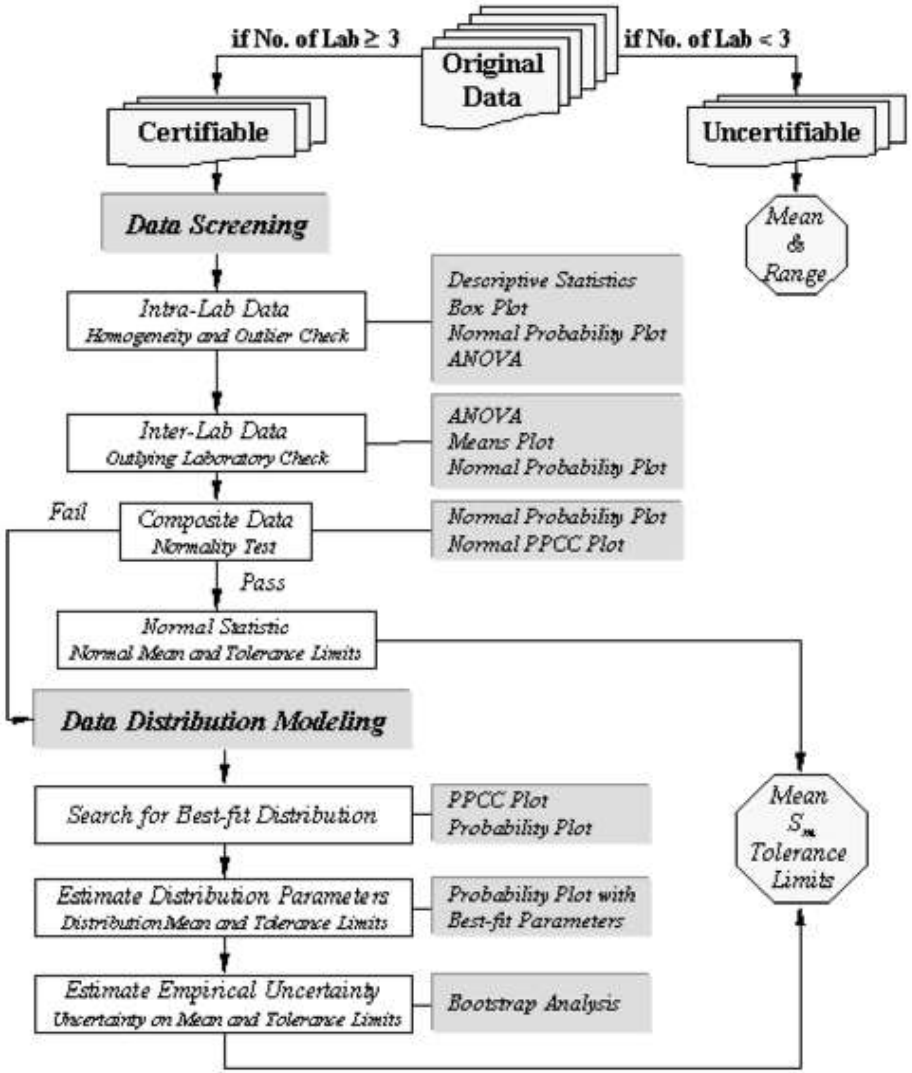

if No. of Lab ≥ 3
Original Data
if No. of Lab < 3
Certifiable
Uncertifiable
Data Screening
Mean & Range
Intra-Lab Data
Homogeneity and Outlier Check
Descriptive Statistics
Box Plot
Normal Probability Plot
ANOVA
Inter-Lab Data
Outlying Laboratory Check
ANOVA
Means Plot
Normal Probability Plot
Fail
Composite Data
Normality Test
Normal Probability Plot
Normal PPCC Plot
Pass
Normal Statistic
Normal Mean and Tolerance Limits
Data Distribution Modeling
Search for Best-fit Distribution
PPCC Plot
Probability Plot
Estimate Distribution Parameters
Distribution Mean and Tolerance Limits
Probability Plot with Best-fit Parameters
Estimate Empirical Uncertainty
Uncertainty on Mean and Tolerance Limits
Bootstrap Analysis
Mean
S_m
Tolerance Limits

Figure 1

Lessons Learned

- **Critically evaluated measurement results necessary to certify NMM SRMs**
- **Well characterized heterogeneous materials can be certified**
- **While a lab may excel in one measurement, may perform poorly in another**
- **Excellence from careful craftsmanship & vigilance, not only instrumentation**

Traceability to NIST for Reference, Monitoring & Service Laboratories

Emergency Radiological Response Metrology

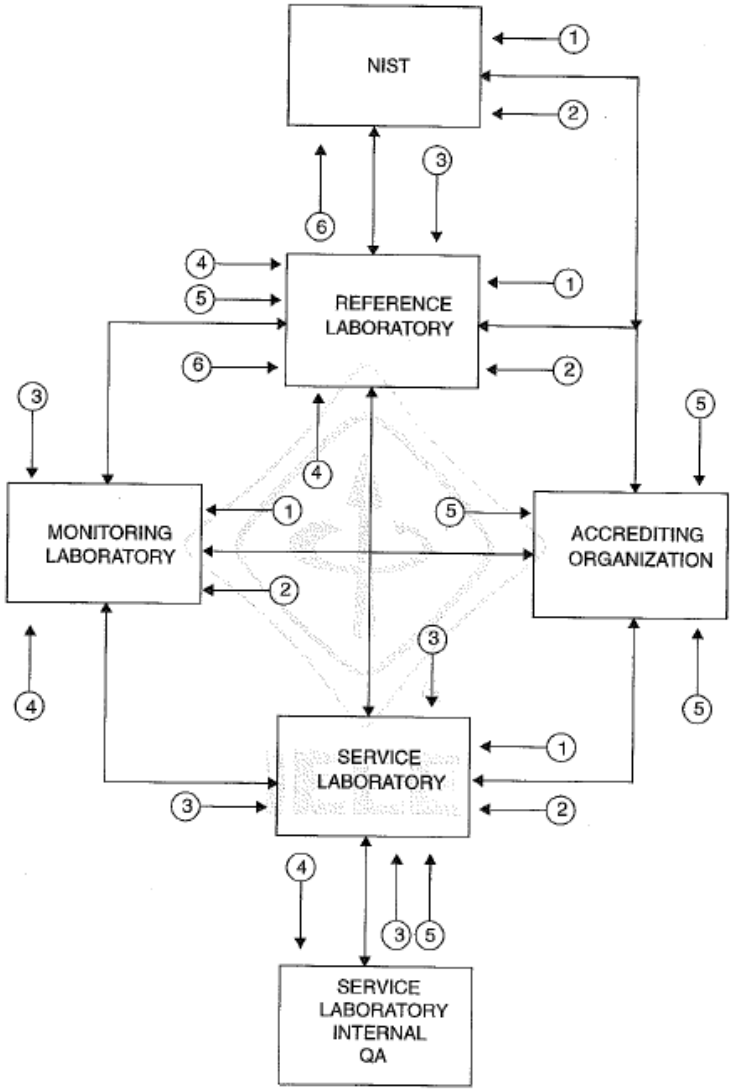
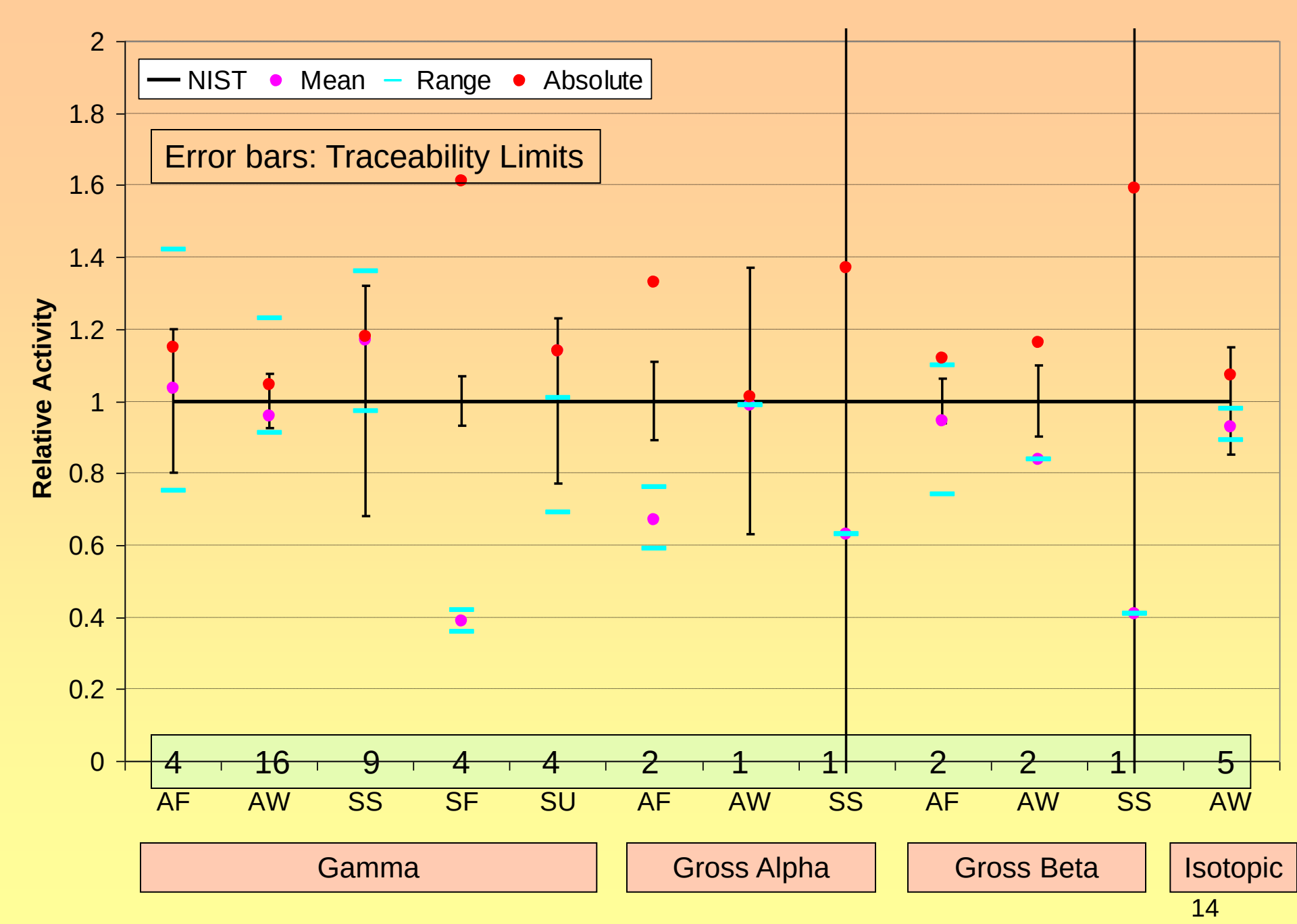


Figure 1—Conceptual diagram of the national performance testing program


NIST
Mean
Range
Absolute
Error bars: Traceability Limits
Relative Activity
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
4
16
9
4
4
2
1
1
2
2
1
5
AF
AW
SS
SF
SU
AF
AW
SS
AF
AW
SS
AW
Gamma
Gross Alpha
Gross Beta
Isotopic

Lessons Learned

- **Distribution of capabilities;**
  - **x ~ NIST**
  - **1s ~ 10%**
- **Labs get better with practice**

NRIP Emergency Preparedness Exercises

(8 hour turnaround)

Lessons Learned

- **Laboratories modified SOPs well to go faster**
- **Need realistic uncertainty estimates**
- **Laboratories can respond in 8 hours**
- **Traceable exercise samples are critical for study evaluation**
- **Report the Exercise evaluations to labs ASAP**
- **Lab management issues revealed, corrective action needed**
- **SRNL capability for rapid analysis of Fukushima samples**

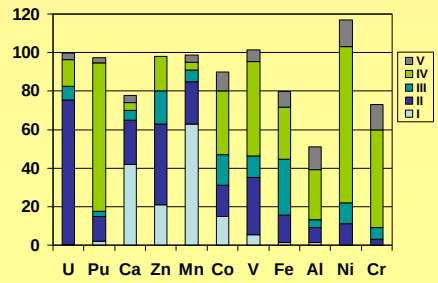
Sorption of Radioactive Elements in Contaminated Soils, Sediments and Urban Materials

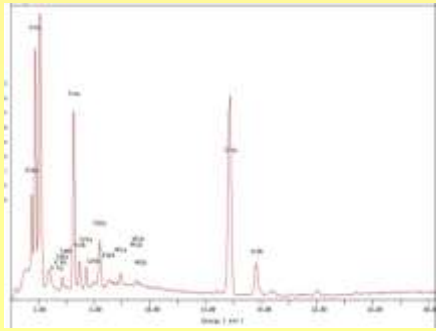
Optimized NIST Protocol Established

Nuclear Forensics Application being Evaluated

New NMM SRMs certified for radionuclide extraction

Potential Application for D&D





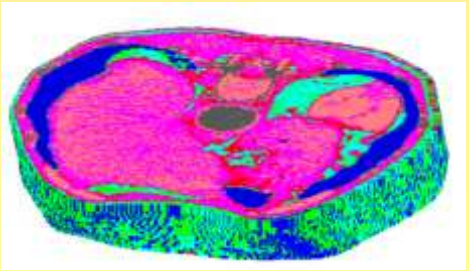
Lessons Learned

- **Developed robust reference sequential extraction method**
- **Zr containing trace acid resistant minerals contains about 15% of U/Th**
- **Resistates found in all 4 natural matrix SRMs from widely different collection sites – i.e. quantitative U/Th measurements must use total dissolution methods**

Improvements for In-Vivo and In-Vitro Radiobioassay

- **Radioiodine traceability testing of RESL**

- **Whole-body counting of phantoms & volunteers**



- **MCNP calibrations & R/D [RPI]**

Rapid Urine Screening Method for ^{90}Sr

Atom-counting Measurement Techniques for Environmental and Radiobioassay

Complements Radioassay

Environmental Monitoring
Food Safety
Population Screening
Occupational Safety
Geoscience
Ocean Studies
Cosmology
Nuclear Forensics

Evaluated AMS MDA
Marshall Island Resettlement
D&D Occupational Safety

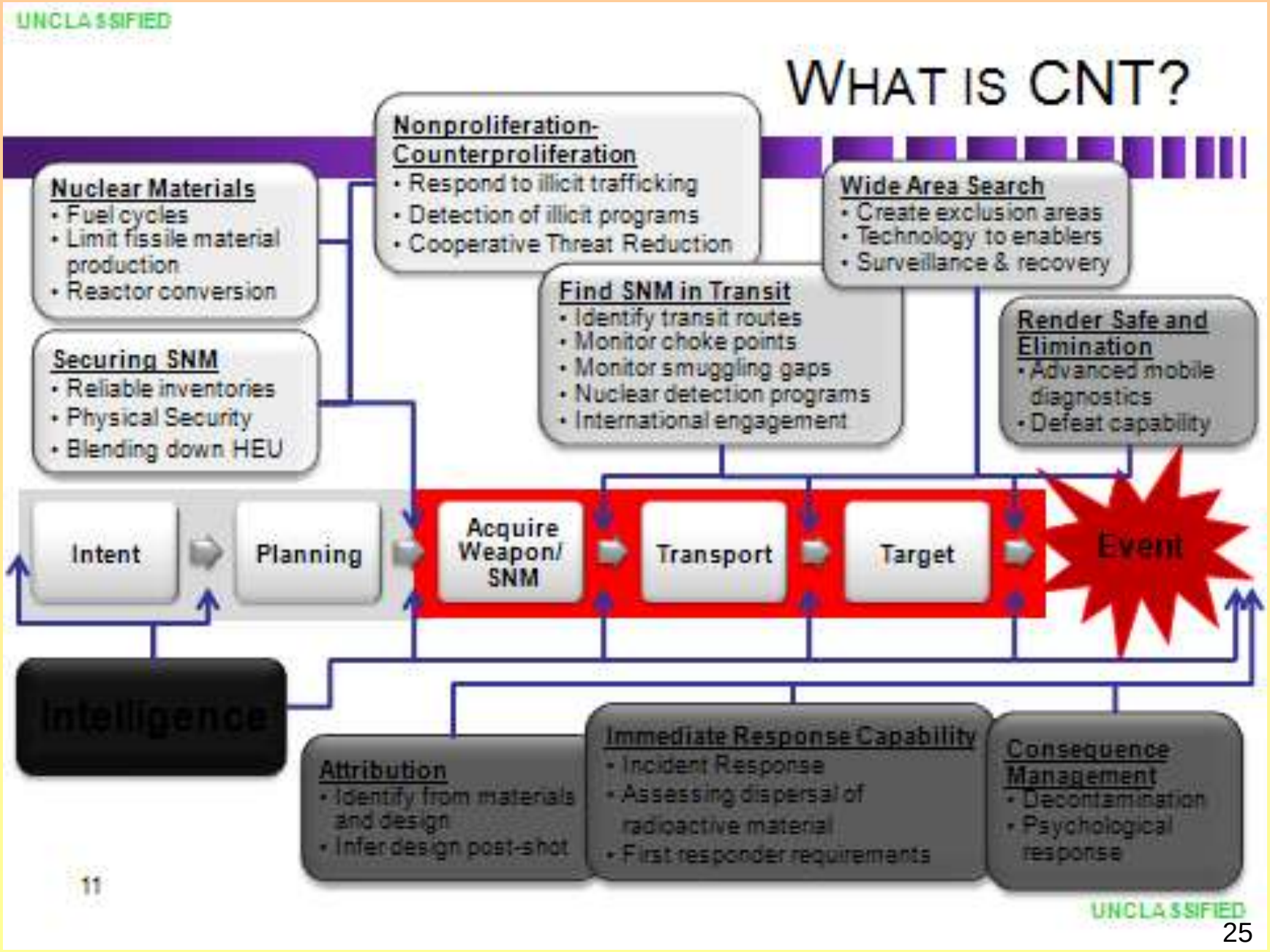
QC and PT RMs for Emergency Population Screening

Ultra-Low ^{239}Pu in Peruvian Soil

SRMs/CRMs Needed to Combat Nuclear Threats

Daubert v. Merrell Dow Pharmaceuticals [113 S. Ct. 2786 (1993)]

- **HAS THE TECHNIQUE BEEN VALIDATED?**
- **WERE THE CONDITIONS CONTROLLING THE TECHNIQUE'S OPERATION MAINTAINED?**
- **WERE THE RESULTS PEER REVIEWED?**
- **DOES, AND AT WHAT FREQUENCY, THE METHOD LEAD TO ANY ERRONEOUS RESULTS?**
  (FALSE POSITIVES AND/OR NEGATIVES)
- **HAS THE TECHNIQUE BEEN GENERALLY ACCEPTED IN THE SCIENTIFIC COMMUNITY?**


WHAT IS CNT?
Nonproliferation-Counterproliferation
• Respond to illicit trafficking
• Detection of illicit programs
• Cooperative Threat Reduction
Nuclear Materials
• Fuel cycles
• Limit fissile material production
• Reactor conversion
Wide Area Search
• Create exclusion areas
• Technology to enablers
• Surveillance & recovery
Find SNM in Transit
• Identify transit routes
• Monitor choke points
• Monitor smuggling gaps
• Nuclear detection programs
• International engagement
Render Safe and Elimination
• Advanced mobile diagnostics
• Defeat capability
Securing SNM
• Reliable inventories
• Physical Security
• Blending down HEU
Intent
Planning
Acquire Weapon/ SNM
Transport
Target
Event
Intelligence
Attribution
• Identify from materials and design
• Infer design post-shot
Immediate Response Capability
• Incident Response
• Assessing dispersal of radioactive material
• First responder requirements
Consequence Management
• Decontamination
• Psychological response
11

Blessed with a Full Cup

Making a Difference

Natural Matrix Radionuclide SRM

CIRMS MPDs

Traceability to NIST for Reference, Monitoring & Service Laboratories
Emergency Radiological Response Metrology
Sorption of Radioactive Elements in Contaminated Soils, Sediments and Urban Materials
Improvements for In-vivo and In-vitro Radiobioassay
Atom-counting Measurement Techniques for Environmental and Radiobioassay

Challenges: radionuclide speciation, nuclear waste Management, Nuclear Power D&D, Nuclear Forensics Traceability, High Quality Mass Spectrometry

Thank you