National Cancer Institute

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

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Improving Exposure Assessment Methods for Nuclear Detonations: A Study Involving the Most Highly Exposed U.S. Atomic Veterans

Presentation to Veterans Board on Dose Reconstruction

July 23, 2013

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Considerable national efforts are underway to develop strategies to prevent exposures and to mitigate the health effects / risks from a nuclear detonation on U.S. soil that could expose large numbers of the public.

This study is based on the concept that our understanding about the significance of nuclear threats can be improved by a better understanding of the exposures received by our veterans involved in nuclear testing and the consequences of those exposures.

The value of our Atomic Veterans to radiation health research and national security

Exposures of atomic veterans resulted from detonations of nuclear devices, the most feared scenario today in national security.

Too little effort, in my view, has been made to learn from the exposures received by veterans.

My goal is to involve atomic veterans in a scientific study so as to learn from the exposures they received.

This study potentially will improve our ability to estimate dose, as well as to better understand the nature and seriousness of future nuclear threats.

The specific goals of this study are :

1) Conduct and compare 3 independent means of assessing radiation doses to living atomic veterans.

2) Draw generalizations about the advantages of each of the dose assessment strategies studied.

3) Summarize the mortality and cancer experience of these two veteran groups.

4) Make the study findings available to participants, study sponsors, and professional community interested in nuclear threats and countermeasures.

How compatible are estimates of radiation doses resulting from nuclear detonations when assessed by these 3 different methods?

Historical film badge measurements

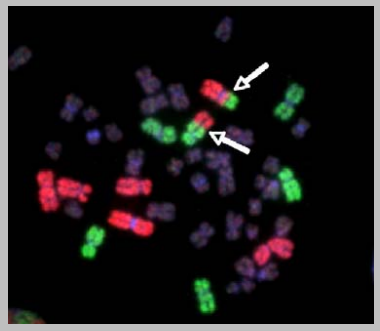
?
=

Environmental radioactivity measurements

+

Individual questionnaire responses

?
=



Biodosimetry via FISH

How compatible are estimates of radiation doses resulting from nuclear detonations when assessed by these 2 different methods?

Historical film badge measurements

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Individual questionnaire responses

?

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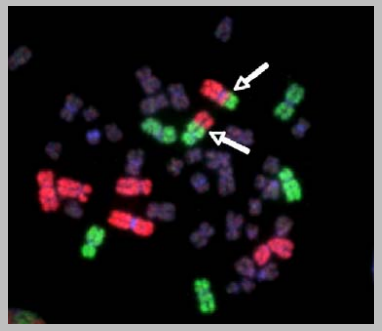


Biodosimetry via FISH

What is *FISH*?

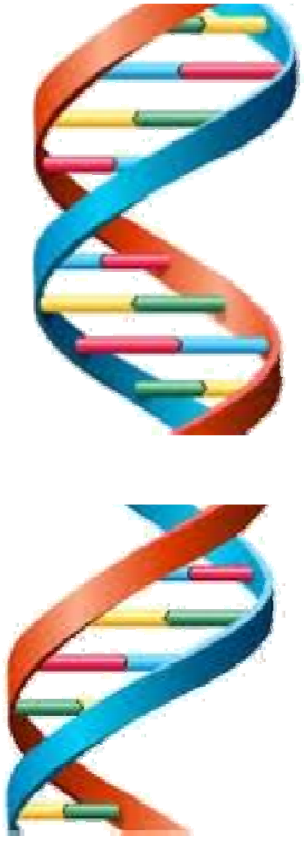
FISH is an acronym for a biochemical assay of aberratins in human chromosomes. It means ***Fluorescent In Situ Hybridization.***

The assay, conducted in the laboratory, is very technically difficult and expensive. However, it is considered to be the "gold standard" for assessing radiation doses many years after exposure.

How does it work?

All cells of the body have genetic material called DNA (below) and in human cells, it is stored in 23 pairs of chromo-somes.

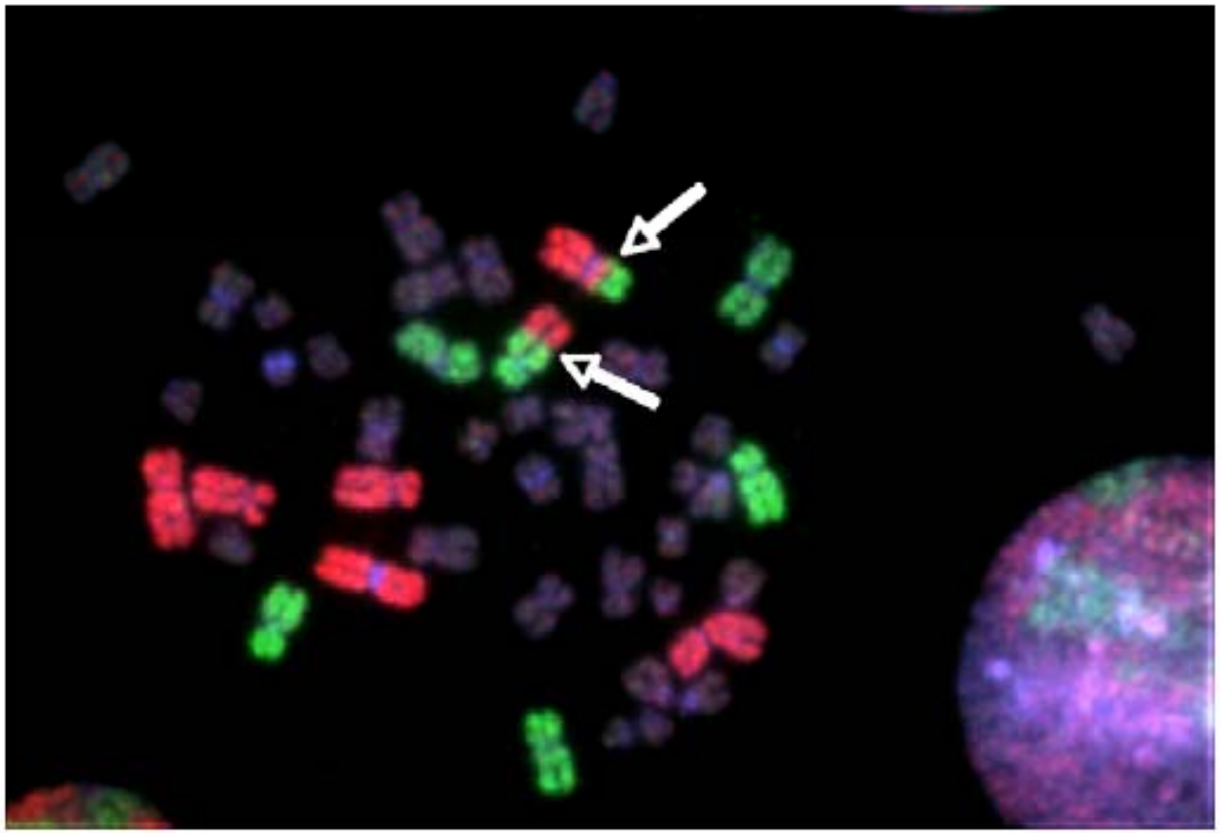
Radiation exposure can cause breaks in a chromosome (below).



After breakage, DNA can repair itself. Usually the repair is perfect (below).

Sometimes, however, the repair is not perfect and the wrong pieces reconnect.

FISH uses fluorescent dyes to stain the chromosomes. One can count (under a microscope), the number of misrepaired chromosome and relate the frequency of the misrepairs to the radiation dose received by the body.



Chromosome pairs # 1, 2, and 4 are painted red, and 3, 5, and 6 are painted green.

From which nuclear test site or accident site, should veteran groups should be studied?

Ranking of Radionuclide Releases from Nuclear Testing in Comparison to Nuclear Accidents

I-131 Released Relative to Chernobyl	Geographic Location	Year(s)
150	Marshall Islands, Pacific Ocean	1946-1958
20	Semipalatinsk Nuclear Test Site, Kazakhstan	1949-1962
3	Nevada Test Site, USA	1952-1970
1*	Chernobyl (Ukraine)	1986
0.10	Fukushima Daiichi Reactor Accident (Japan)	2011
0.03	A-bombs of Hiroshima and Nagasaki	1945
0.01	Hanford Reservation, WA, USA	1944-1972
0.001	Savannah River Site, SC, USA	1955-1990
0.0005	Oak Ridge National Laboratory, TN, USA	1944-1956
0.0004	Windscale, UK	1957
0.0000003	Three Mile Island, PA, USA	1979

***1,900 x 10^{15} Bq ^{131}I**

The veteran groups to be studied are:

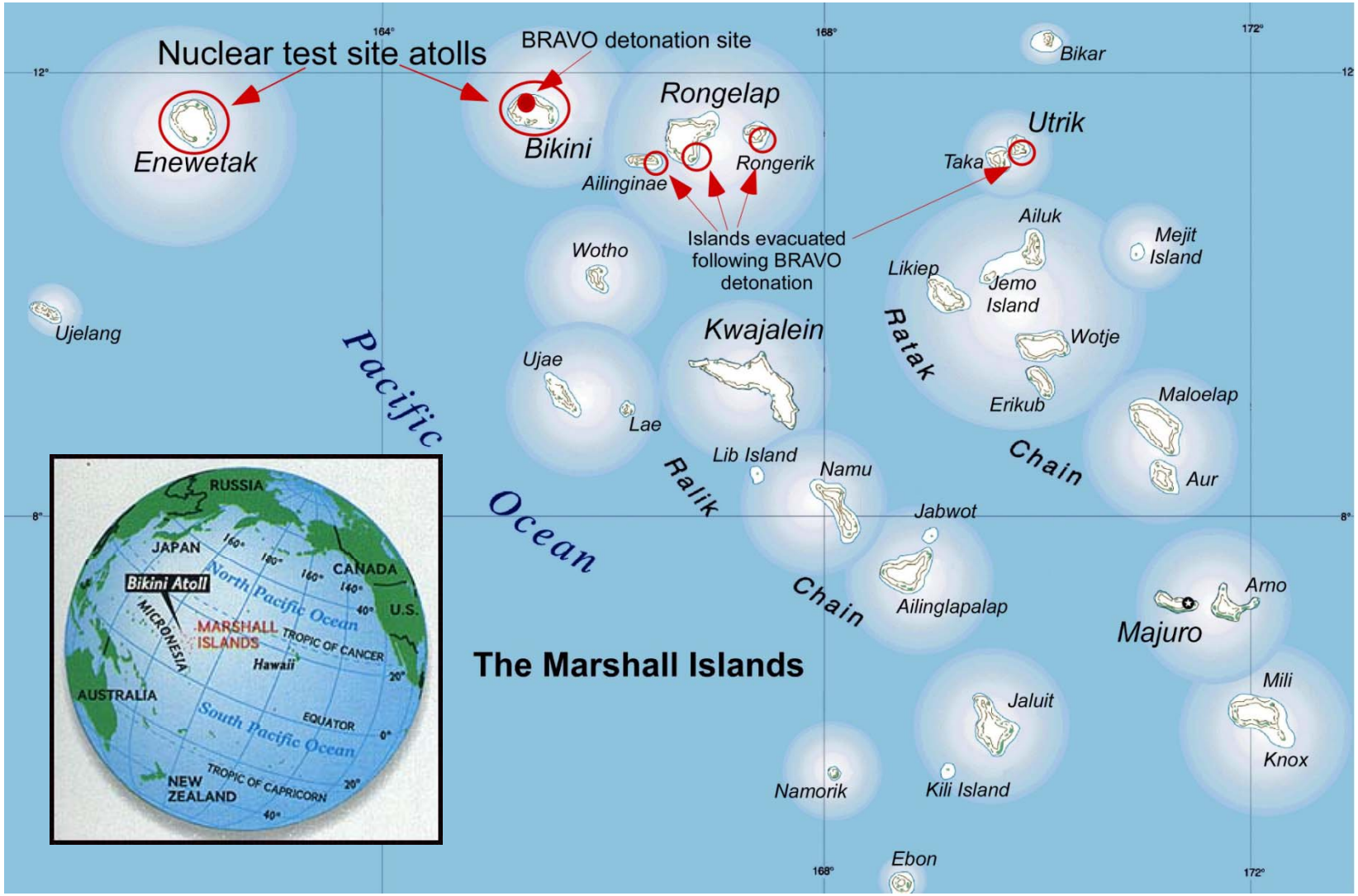
(i) The 9 living (of 27) military weather observers exposed on Rongerik Atoll in the Pacific in 1954 to fallout from the BRAVO nuclear test, and

(ii) The 7 highest-dose military personnel who were observers or participants of nuclear tests in 1951-1962 at the Nevada Test Site (and possibly in the Pacific).

A criteria for inclusion in the study group is that the subject should have received more than 250 mSv (i.e., 250 mGy whole-body) or more. DOD records indicate that only these 16 living veterans satisfy the criteria.

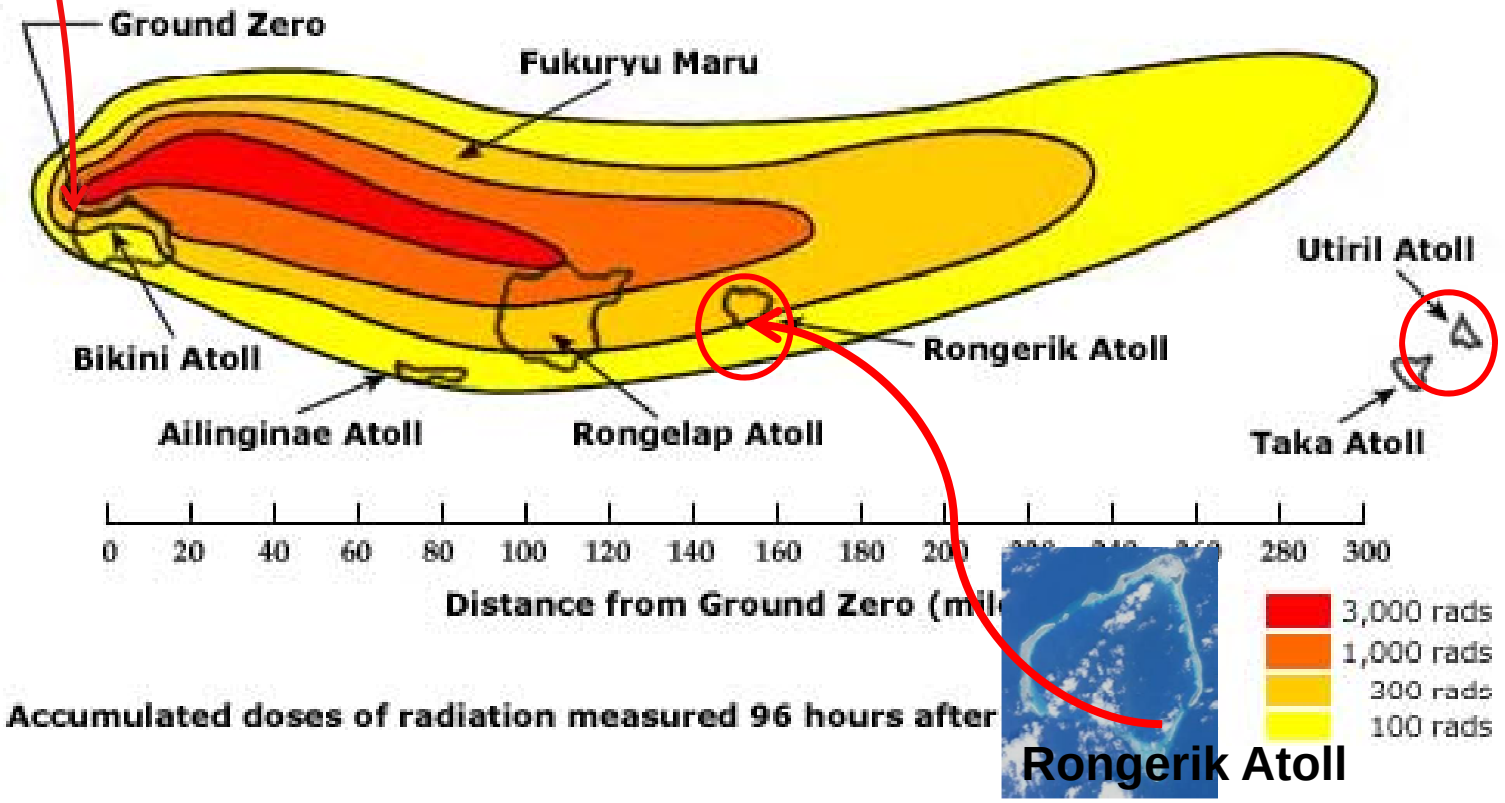
What were the circumstances of the Rongerik and NTS Veterans exposures?

Marshall Islands was site of nuclear testing 1946-1958

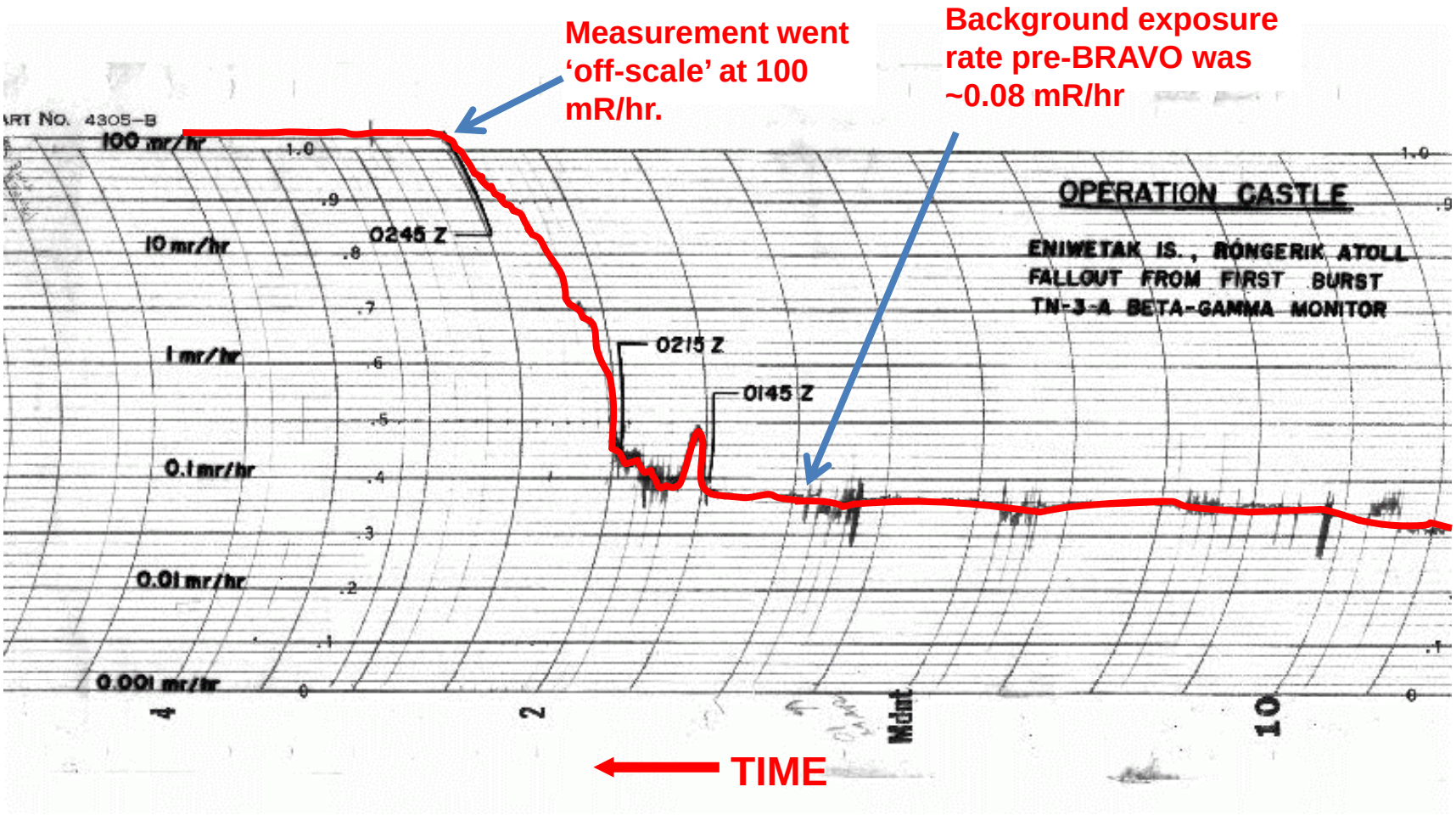


Locations of nuclear test sites and evacuated populations.

Fallout from the BRAVO nuclear test (March 1, 1954) moved without warning towards native and military inhabited islands.



How was the arrival of fallout on Rongerik recognized?



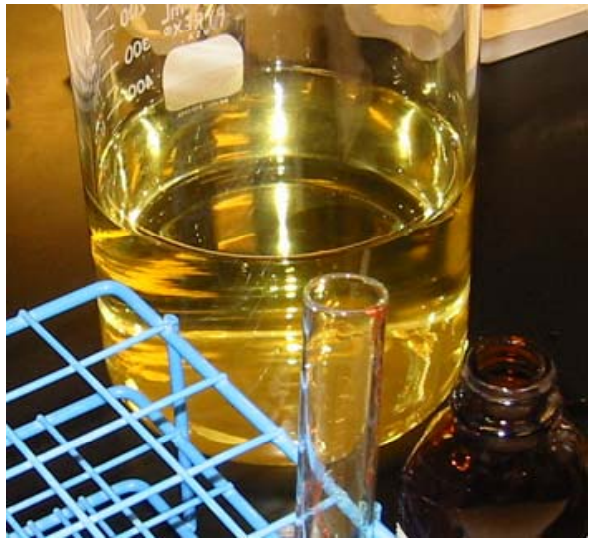
The Rongerik weather observers were exposed for a full day to fresh nuclear detonation fallout.

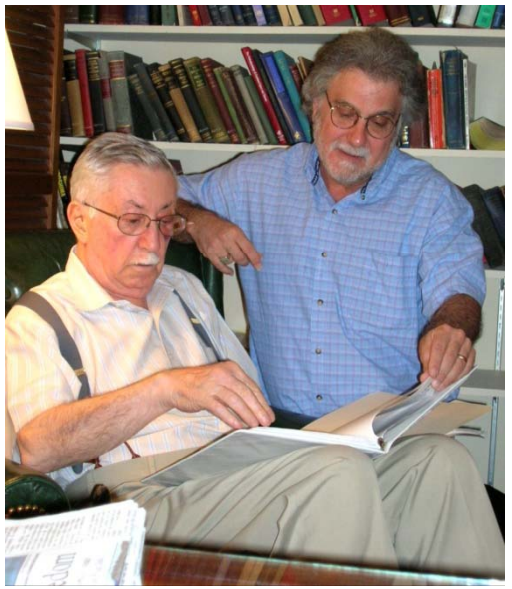
The first emergency evacuation of the nuclear age was the evacuation of Rongelap residents (native Marshall Islanders) exposed for about 48 hours,

and 28 military weather observers on Rongerik Atoll exposed for about 30 hours.

Internal doses for Rongerik weather observers were based on sampling of urine by Dr. Payne Harris and measurement of Iodine-131 at Los Alamos Scientific Laboratory.

Sampling was conducted on 9 of the military weather observers on March 18, 1954 - first use of bioassay under these conditions.





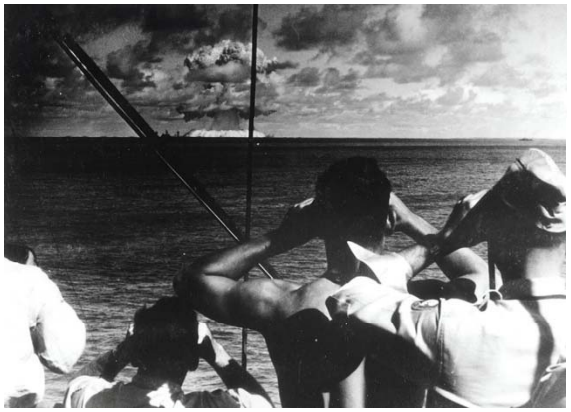
Dr. Payne Harris and Steve Simon in Santa Fe, NM in 2008.

Table 4. Estimates of external doses (mGy) received by adults from the Bravo test, the entire Castle (1954) test series, and from all tests (dose estimates rounded to two significant digits).

From Bouville et al. (2010)

Atoll or population group	Bravo	Castle series	All tests
Ailinginae[a]	460	470	470
Ailinglaplap	0.37	5.3	6.9
Ailuk	37	57	59
Arno	2.3	9.3	10
Aur	3.3	7.7	9.9
Bikini community[b]	1.1	5.0	14
Ebon	0.71	4.8	5.3
Enewetak community[a]	2.1	14	25
Jaluit	1.1	4.8	6.6
Kwajalein	1.0	15	22
Lae	1.6	7.8	10
Lib Island	0.7	11	12
Likiep	25	37	39
Majuro	2.2	8.7	9.8
Maloelap	5.1	11	12
Mejit Island	27	47	49
Mili	1.8	6.4	7.0
Namorik	0.70	4.4	5.5
Namu	0.73	9.0	11
Rongelap control group[c]	8.4	17	22
Rongelap Island community[a]	1,600	1,600	1,600
Rongerik[d]	940	—	—
Ujae	1.0	6.4	8.6
Utrik community[a]	110	130	130
Wotho	4.3	13	23
Wotje	17	30	31

The High-Exposure NTS soldiers were exposed via multiple activities at NTS and in the Pacific where they were involved in observations and military training activities.



How will this study be conducted?

METHODS:

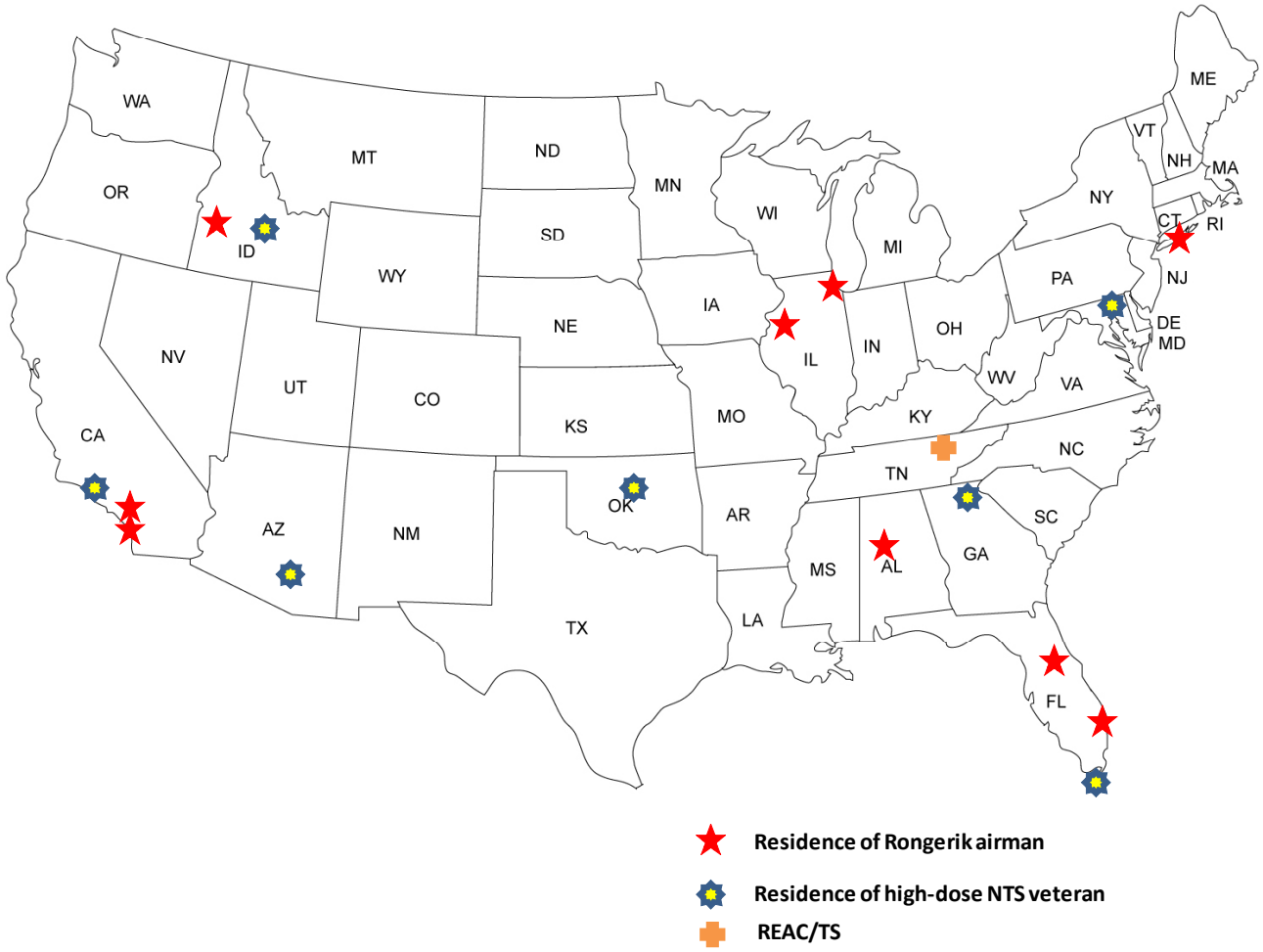
1) Human subjects approvals (NIH IRB).
2) Subject enrollment.
3) Obtain veterans identities and other personal data from AVES.
4) Conduct interviews with all 16 exposed study subjects.
5) Collect a 20 mL venous blood sample from each.
6) Collect a 20 mL venous blood sample from 16 additional “control” subjects.
7) FISH assay.
8) Analytical dose reconstruction using all available date.
9) Compare dose estimates from the 3 methods.
10) Prepare findings for communication to veterans, study sponsors and for publication.

Status of Study

Status (1 of 3)

- IRB approvals underway.
- Historical documents collected under NCI's previous research into Marshall Islands exposures.
- Consent forms / questionnaires have been designed.
- Collaborations have been established.
- Availability of environmental contamination data for Rongerik is ensured since I did the radiological monitoring myself (in 1993).
- Estimates of "air dose" for Rongerik group have already been completed (see Health Physics, 99(2), 2010) – only requires interview data on time spent in- and out-doors to complete external dose reconstruction.
- Estimation of NTS doses is presently underway by Atomic Veterans Epidemiology Study (PI: John Boice).

Status (2 of 3)



Present residence locations of 16 living veterans have been determined.
Interviews can be completed by a team of two over a 2-week period.

Status (3 of 3): Collaborations established

Management and Dose Reconstruction

Dr. Steve Simon (NCI, physicist): PI, oversight and management, dose reconstruction for Rongerik group.

AVES dosimetry team: Dose reconstruction for NTS veterans.

Administration / Financial

Abigail Ukwuani (NCI): administration.

Annelie Landgren (NCI): financial tracking.

Study Design / Analysis / Epidemiologic Considerations

Dr. Peter Inskip (NCI, epidemiologist): Oversight of design and analysis.

Dr. John Boice (NCRP, epidemiologist): Coordination with AVES and selection of control subjects for FISH analysis.

Interviews and Human Subjects Protection

Dr. Gordon Willis (NCI, cognitive psychologist): Interviews and human subjects protection issues.

Biodosimetry

Dr. Gordon Livingston (REAC/TS, cytogeneticist): Cell culturing and slide preparation

Dr. Joan Francesco Barquinero (IRSN, cytogeneticist): FISH assay

Contact with Veterans

Capt. Paul Blake (DTRA, Program Director): Assistance with contacting and enrolling veterans

What do I need to complete the study?

I am still seeking a commitment for funding – on the order of $125k to complete this study in FY 2014.

I also need assistance in recruiting the 16 exposed veterans plus controls subjects.

What will be the payoff?

1. **Findings can be used to inform future choices on optimal dose reconstruction strategies following nuclear events based on real exposures.**

2. **Findings will tell us about the health outcomes and their frequency, among the most highly exposed atomic veterans.**

3. **Findings will tell us the external doses received by our most highly exposed veterans, but confirmed by the "gold standard" FISH assay.**

Closing Comments

- While we are moving ahead, a funding commitment for this work is needed to complete the critical (and expensive) steps.

- There are few (if any) other available sources of real exposure data to conduct this same analysis. This is a unique opportunity.

- The time-window to complete this is very narrow. **Cohort attrition due to advanced age is the primary concern. We must act very quickly or lose this opportunity forever.**

If you or your agency has interest in this study:
in financially supporting it,
in assisting, or collaborating,
please see me afterwards or contact me at:

ssimon@mail.nih.gov

THANK YOU FOR YOUR ATTENTION.