The Pursuit of Excellence in Radiation Safety

Darrell R. Fisher
President, Health Physics Society

Home: Richland, Washington

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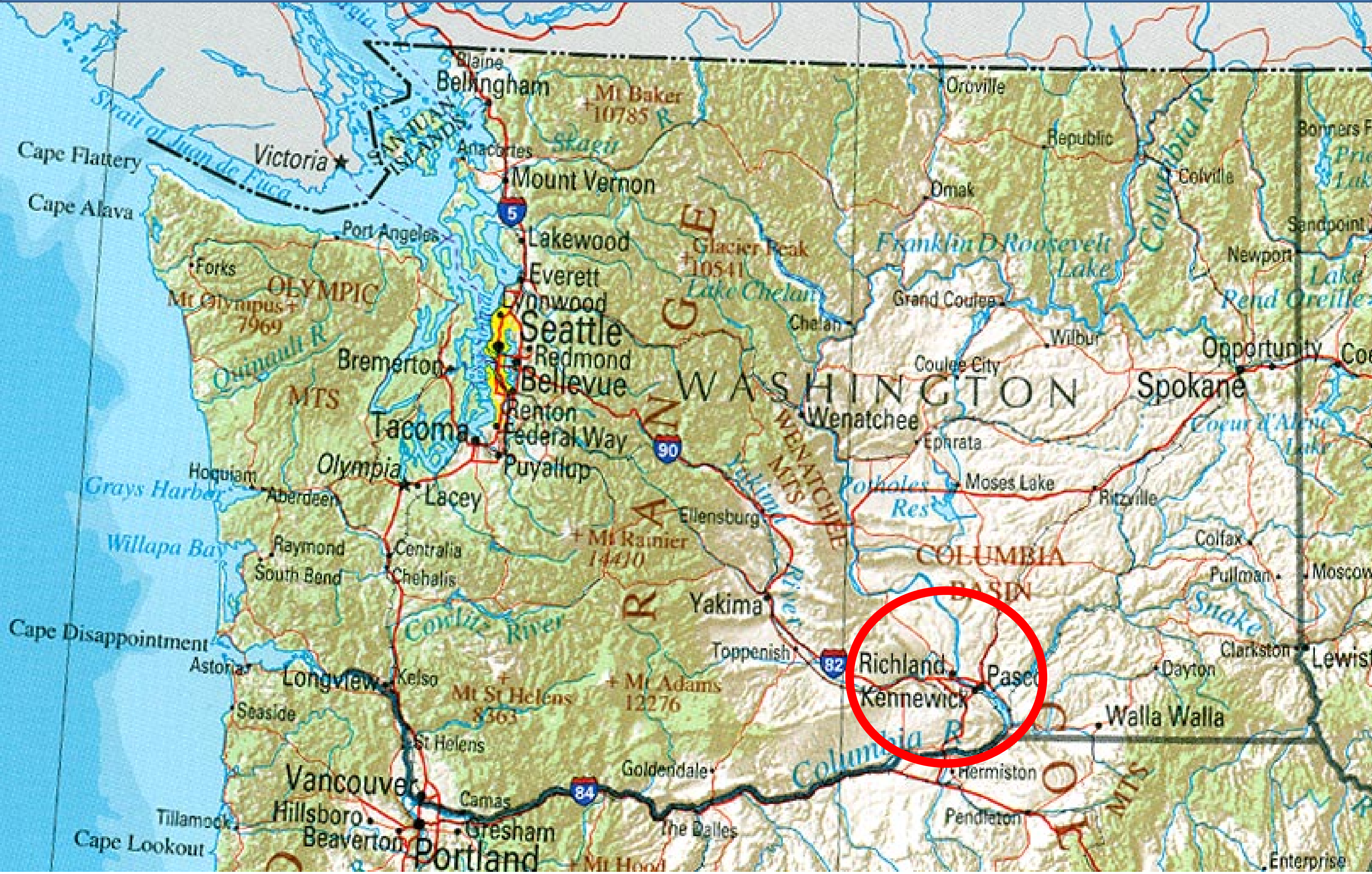
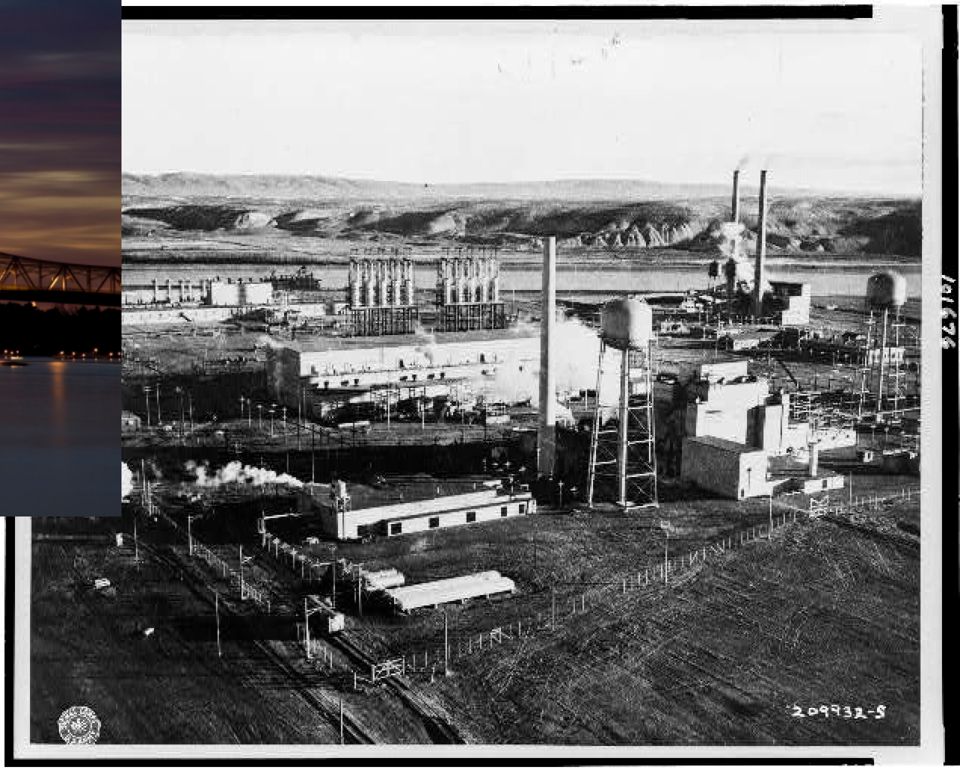


Home: Richland, Washington

- Population: 55,000
- Site of former Atomic Energy Hanford Works



Richland: Home to WNP2

Columbia Generating Station: 1,170 MWe
GE BWR-5 using a Mark II containment structure

An honorable profession

Dedicated to excellence in radiation safety

- ✓ Protecting the health and safety of the general public, radiation workers, and hospital patients
- ✓ Advancing standards for excellent practices
- ✓ Performing accurate radiation measurements
- ✓ Interpreting measurement data honestly
- ✓ Developing academic programs and helping students

Multidisciplinary scientists

Health physics combines excellence in multiple specialties:

- nuclear physics
- radiation biology
- medical radiology
- radiochemistry
- radiopharmaceutical sciences
- materials sciences
- mathematics and biostatistics
- nuclear engineering
- environmental sciences
- occupational hygiene
- electrical engineering and instrumentation

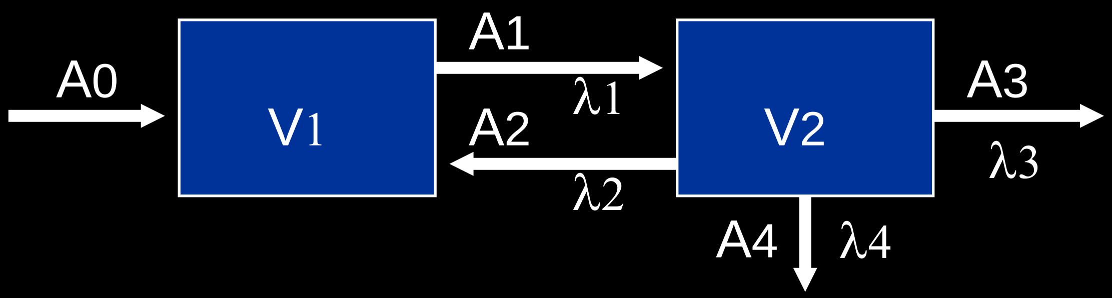
Addressing difficult challenges

- We deal with radiation emergencies
- Our broad science backgrounds and passion for technical accuracy:
  - help us put into proper perspective the relative magnitude of an incident,
  - provide us with methods for making correct radiation measurements and analyzing data, and
  - help us to determine engineered solutions for site recovery and waste management, containing and shielding radioactivity, packaging, transportation, and disposal.

We apply correct scientific principles to our work

Using correct measurements, models, and computer software

- Environmental transport of radioactive materials
- Internal and external radiation dosimetry



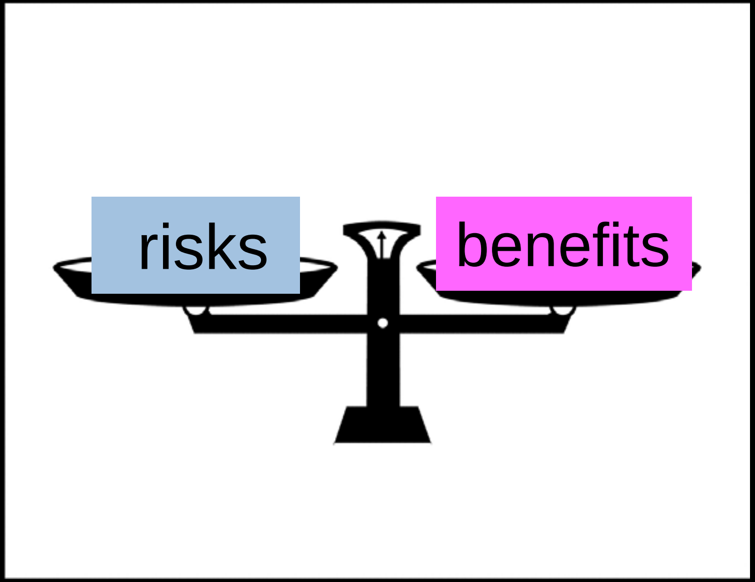
We encourage academic programs to educate and train the next generation

We support education in the radiation sciences

- ✓ Elementary, middle school, and high school studies
- ✓ College and university education

We balance our perspectives on radiation risks and benefits

Our scientific perspective of radiation risks and health detriment, judged against the societal benefits of nuclear technologies, engender credibility and facilitate effective communication when dealing with government officials, the news media, and the public



We learn to communicate effectively with the news media

We must be able to provide simple, yet highly credible answers to difficult questions from news reporters and TV and radio journalists

Pseudo-scientists and impostors

In the process of serving our respective communities, we encounter many imposters who compete for recognition and authority:

- the uncredentialed or pseudo-scientists
- critics and fault-finders
- activist organizations
- cross-overs from unrelated specialty fields in academia

Case study: Safecast™

Safecast™ is a global project to build a sensor network and map radiation levels

Safecast™ uses static and mobile sensors actively deployed near the Fukushima exclusion zone and elsewhere in Japan

Source: http://blog.safecast.org

Case study: Safecast™

Radiation detectors:

Inspector Alert (International Medcom); uses a 2-inch pancake sensor →

bGeigie: an *Inspector* connected to recording electronics that log counts tagged with GPS coordinates and saved to a memory card

Case study: Safecast™

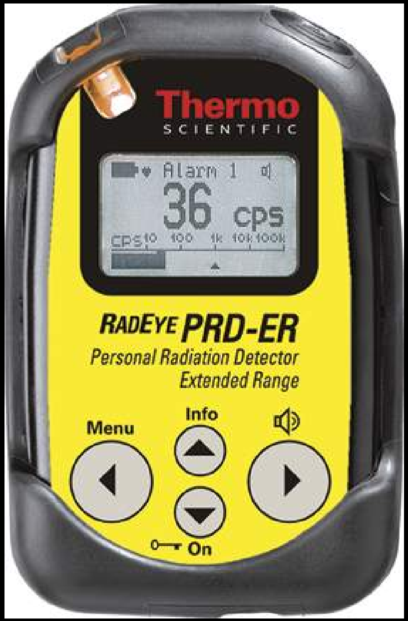
With pancake probe, this instrument was designed to detect spot contamination (cpm)

- Not good for environmental monitoring or for above-ground (1-2 meter) in-air gamma exposure rate monitoring
- From the manufacturer's Operating Manual: "The Inspector Alert's reading in mR/hr <u>may not be accurate</u>"

Case study: Safecast™

Radiation detectors:

Thermo Scientific RadEye™ PRD/PRD-ER Personal Radiation Detector



- Portable, detects and localizes radiation sources, but does not identify radionuclides or provide personnel dose-rate information;

- Not designed for general environmental monitoring

Personal viewpoint

1) the G-M counter with pancake probe is not right for measuring low-level environmental gamma radiation because it is highly insensitive (small detector) and does not provide accurate information about the ambient gamma dose rate

2) With so many excellent options available from radiation detector manufacturers, why didn't Safecast choose an appropriate measurement technology?

Preferred alternatives (environmental)

1. Large-volume, energy compensated Geiger-Muller detector with scaler and timer
2. High-pressure ion chamber with scaler and timer
3. Energy-compensated proportional counter with scaler and timer
4. Large-volume scintillation detector with scaler and timer

References: UK Health and Safety Executive, Information Sheet; Ionizing Radiation Protection Series #7; Knoll, Glenn F (1999), *Radiation Detection and Measurement* (3rd ed.). New York: Wiley.

Personal viewpoint

The Thermo Scientific™ Wide Range Gamma Detector (proportional counter) is well-suited for environmental monitoring

It uses a Natural Background Rejection method to discriminate between normal background gamma radiation and artificial gamma radiation

http://www.thermoscientific.com

The professional health physicist

- Educated and trained at an accredited college or university, with advanced degrees (M.S., Ph.D.)
- Certified in health physics
- Several years field experience
- Reads and understands the radiation protection literature
- Belongs to an IRPA-affiliated professional society
- Attends and participates in scientific meetings
- Understands radiation protection standards

Addressing technical problems

- All problems in radiation safety have solutions
- Radiation safety issues are best addressed by professional health physicists
- We have the responsibility to act with integrity, scientific accuracy, patience, and endurance

We Are Giving Ourselves Cancer
By RITA F. REDBERG and REBECCA SMITH-BINDMAN
New York Times, Jan. 30, 2014

"Increasingly, we and many other experts believe that an important culprit may be our own medical practices: We are silently irradiating ourselves to death. The use of medical imaging with high-dose radiation — CT scans in particular — has soared in the last 20 years…."

What are the risks?

- Is the news article true?
- What are the actual risks of medical diagnostic radiation?
- How do the risks compare with the medical benefits?
- How can we better communicate the risks to the public?

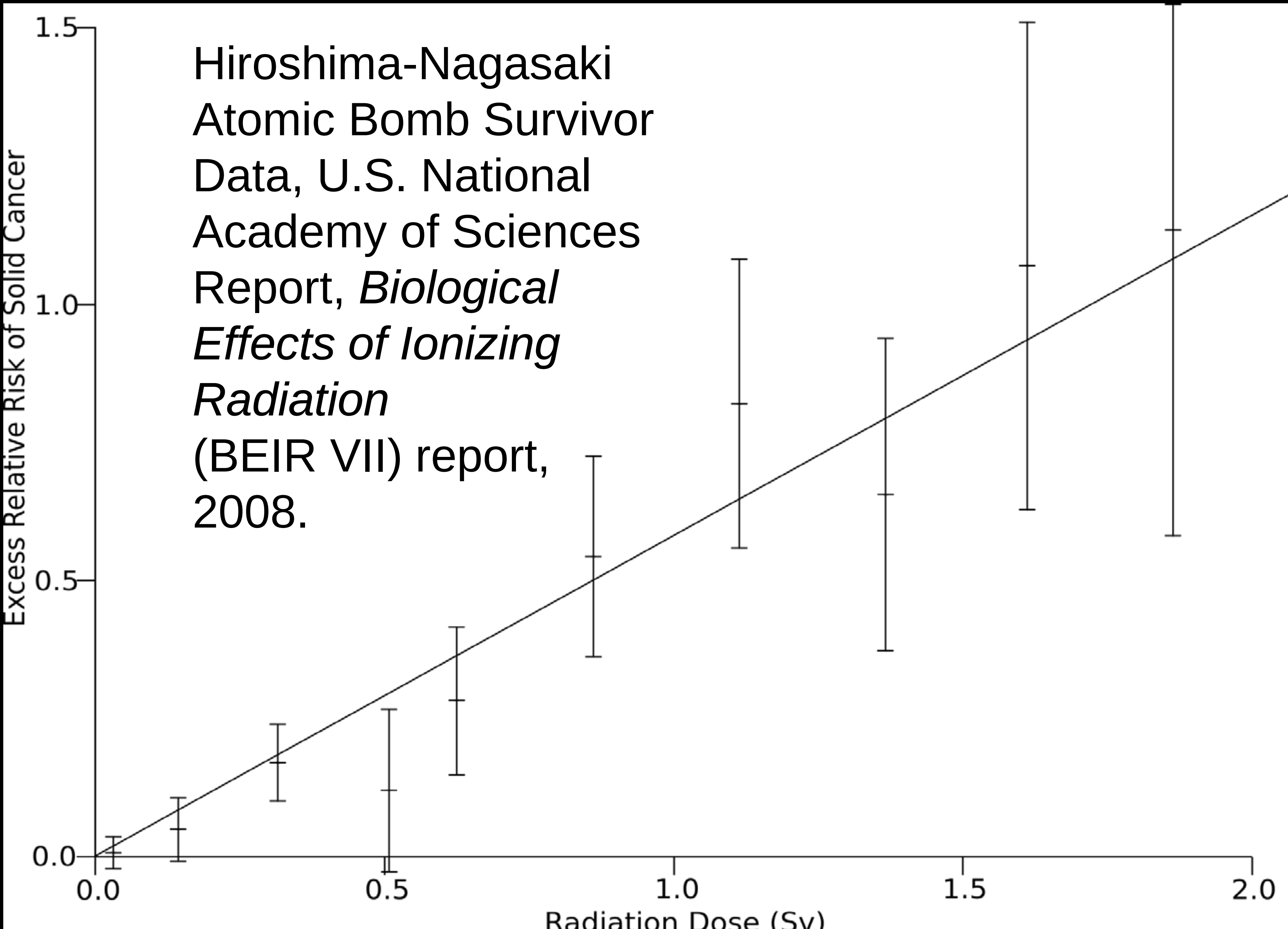
Only nine people out of 30,622 persons screened had Cs-137 levels greater than 50 Bq/kg

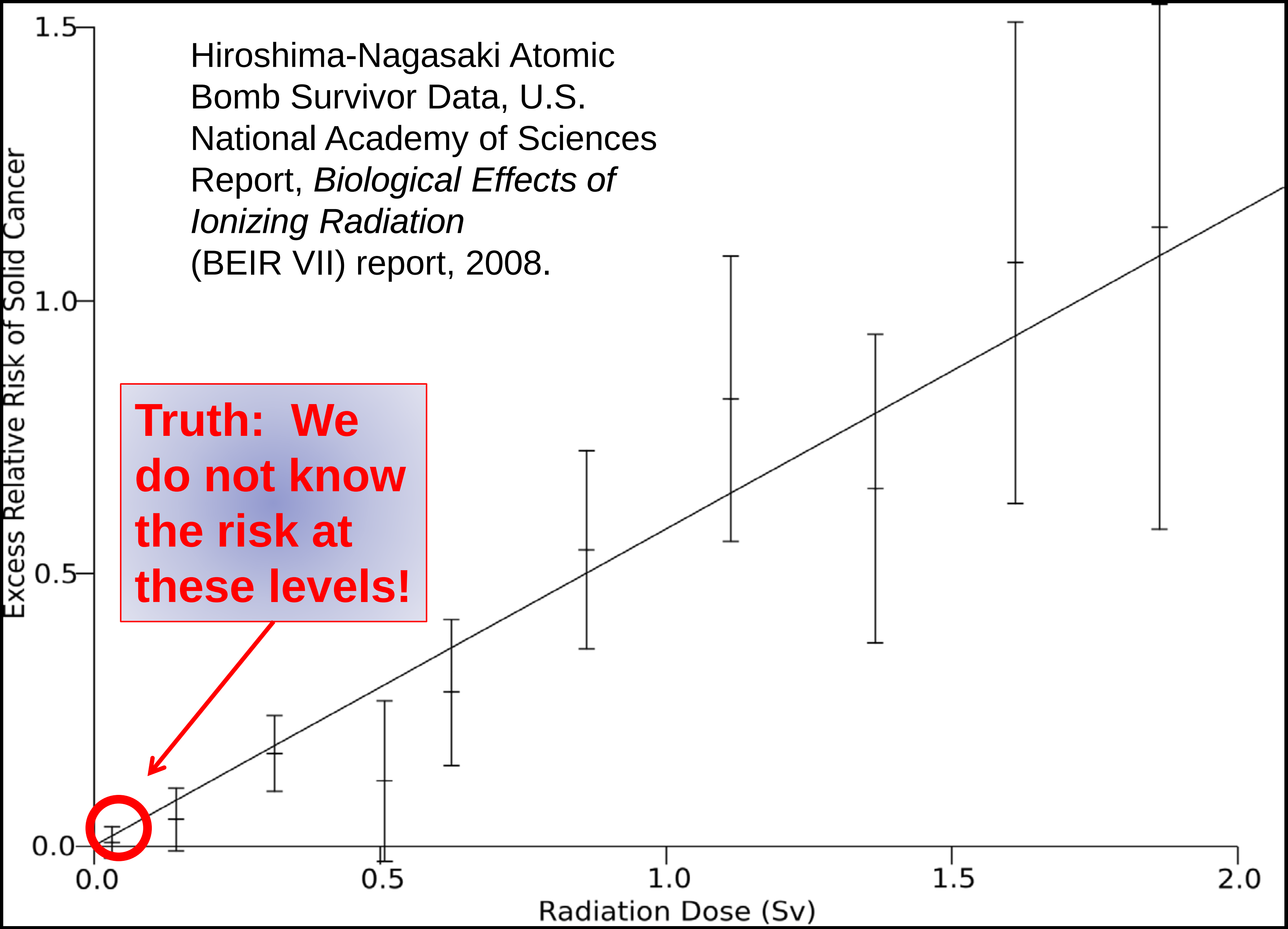
Unchecked Food Risky in Fukushima
By Mizuho Aoki
The Japan Times, International New York Times, June 17, 2014, Tokyo

“Cesium-137 levels among nine participants ranged from 3,230 to 15,918 becquerels per person, which corresponds to between 0.07 to 0.53 millisieverts per year . . .

“. . . cumulative exposure of 100 millisieverts would increase the chance of death by cancer by 0.5 percent….”

Hiroshima-Nagasaki Atomic Bomb Survivor Data, U.S. National Academy of Sciences Report, *Biological Effects of Ionizing Radiation* (BEIR VII) report, 2008.

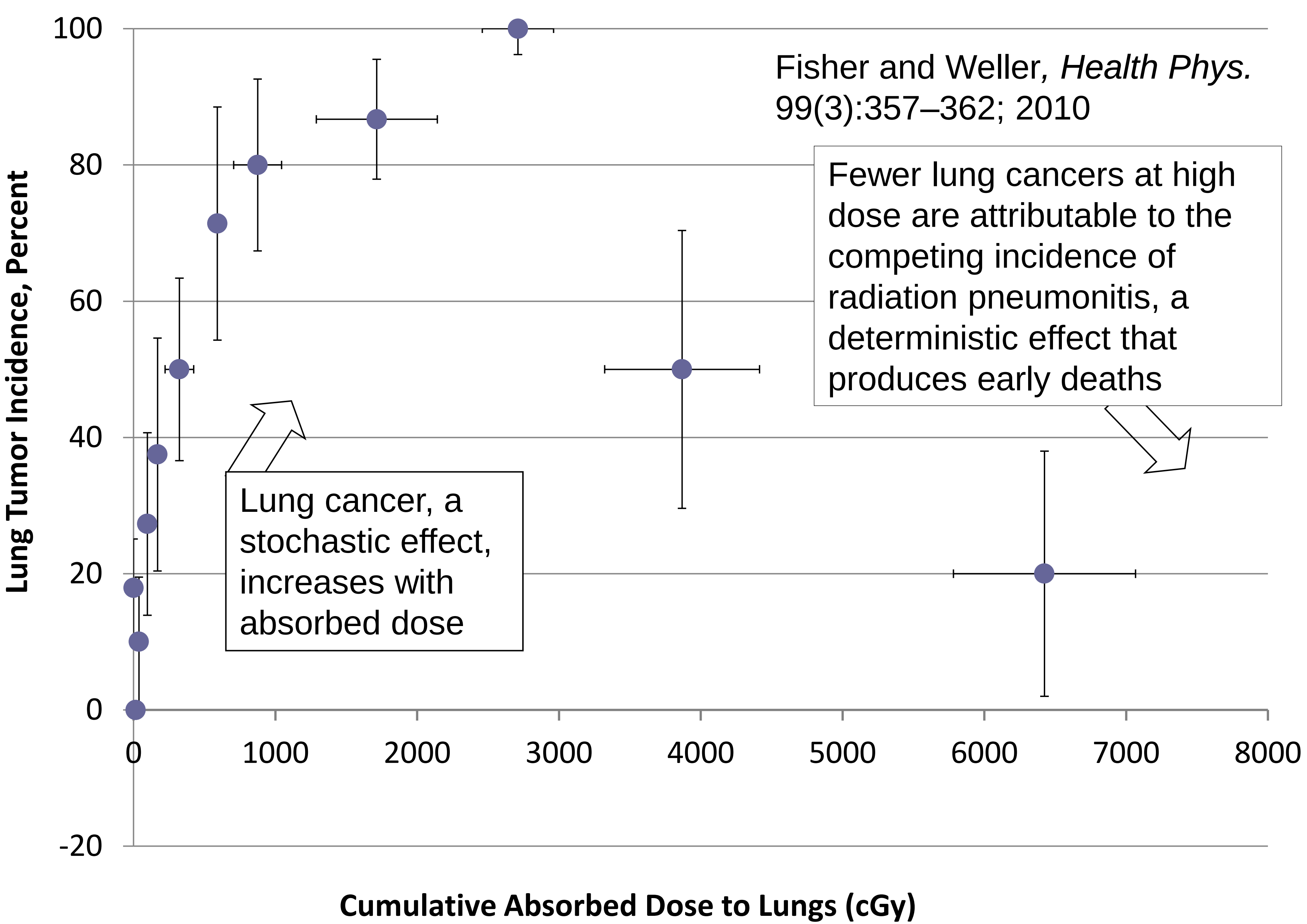



Hiroshima-Nagasaki Atomic Bomb Survivor Data, U.S. National Academy of Sciences Report, *Biological Effects of Ionizing Radiation* (BEIR VII) report, 2008.
Truth: We do not know the risk at these levels!
Excess Relative Risk of Solid Cancer
Radiation Dose (Sv)
0.0
0.5
1.0
1.5
2.0

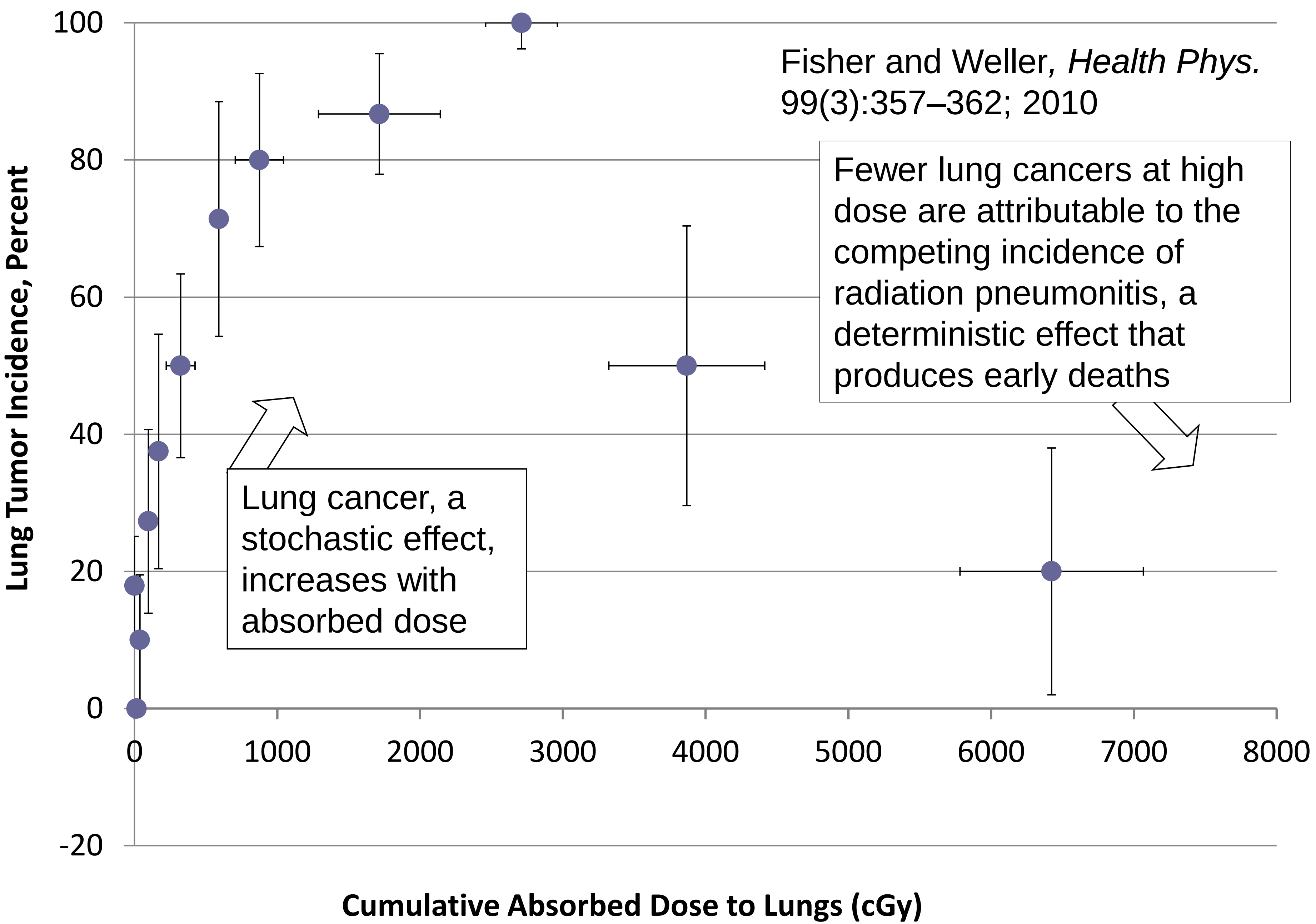
Dose-response relationships

- When we take a closer look, new forms of dose-response relationships may emerge from radiobiological data at very low dose
- Example: Large-scale, life-span studies (lung cancer) of inhaled plutonium-239 in beagle dogs

(Fisher and Weller, *Health Phys*. 99(3):357–362; 2010)



Fisher and Weller, *Health Phys.* 99(3):357–362; 2010
Fewer lung cancers at high dose are attributable to the competing incidence of radiation pneumonitis, a deterministic effect that produces early deaths
Lung cancer, a stochastic effect, increases with absorbed dose
Lung Tumor Incidence, Percent
100
80
60
40
20
0
-20
0
1000
2000
3000
4000
5000
6000
7000
8000
Cumulative Absorbed Dose to Lungs (cGy)



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Lung Tumor Incidence, Percent
100
80
60
40
20
0
-20
0
1000
2000
3000
4000
5000
6000
7000
8000
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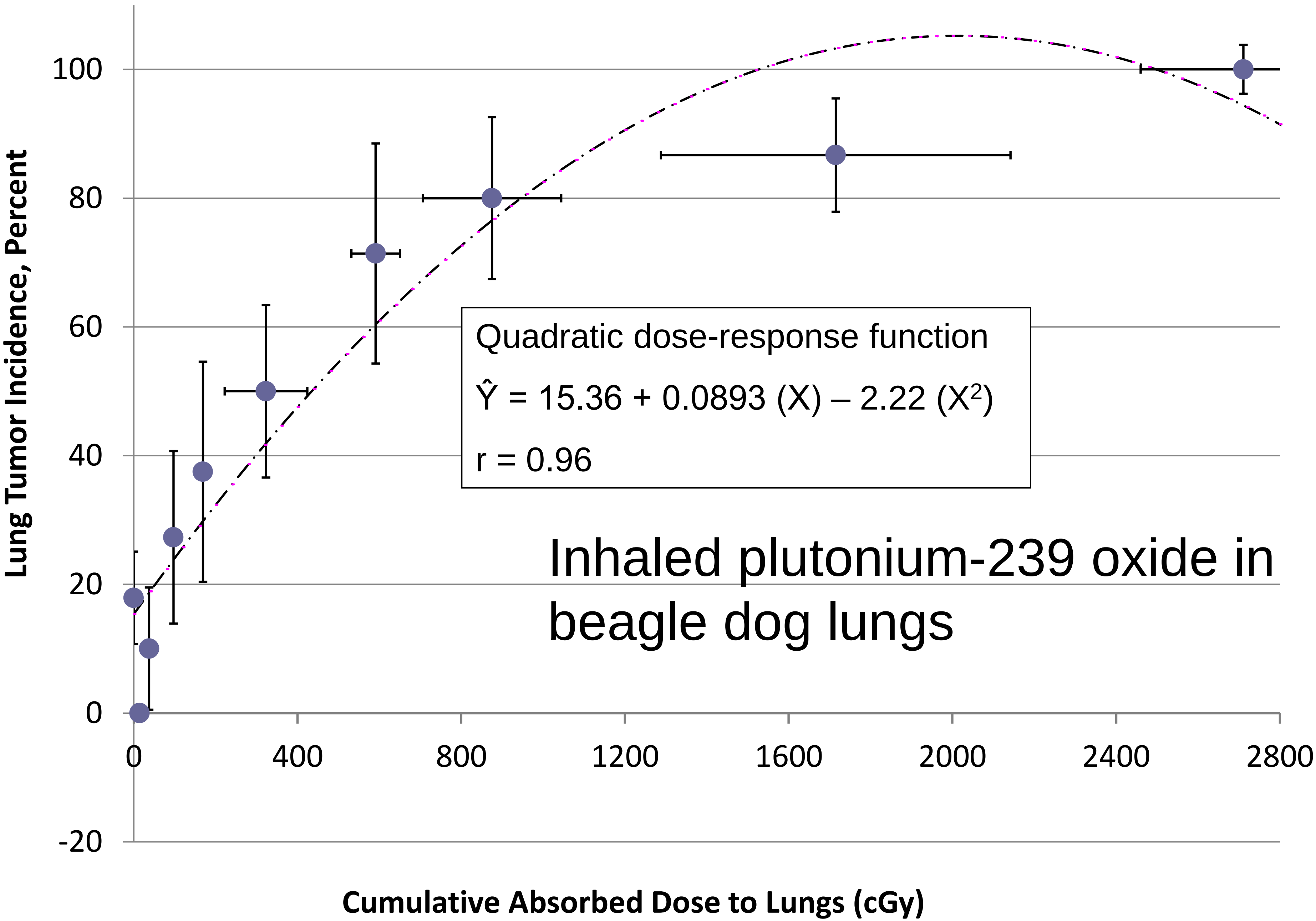
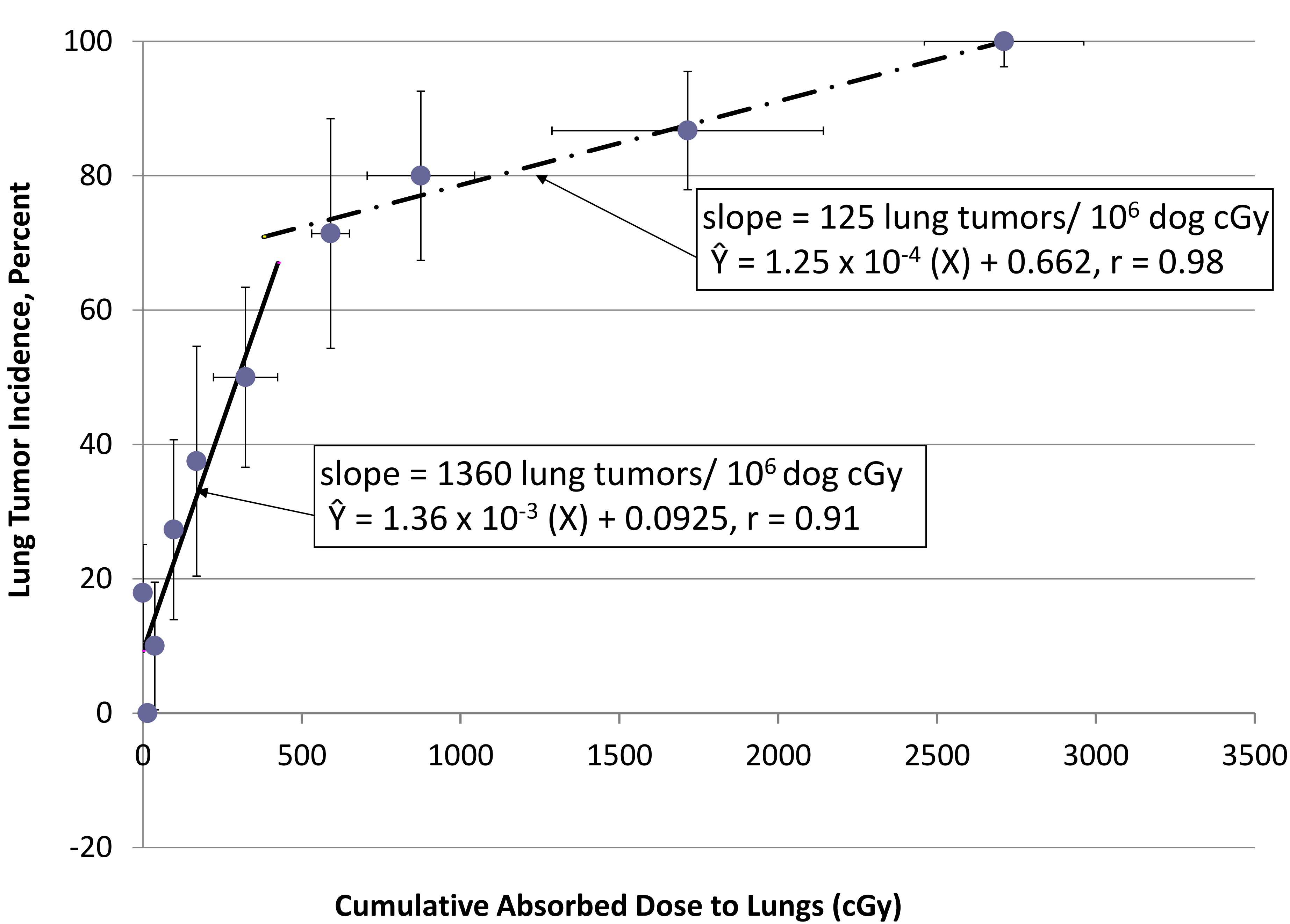
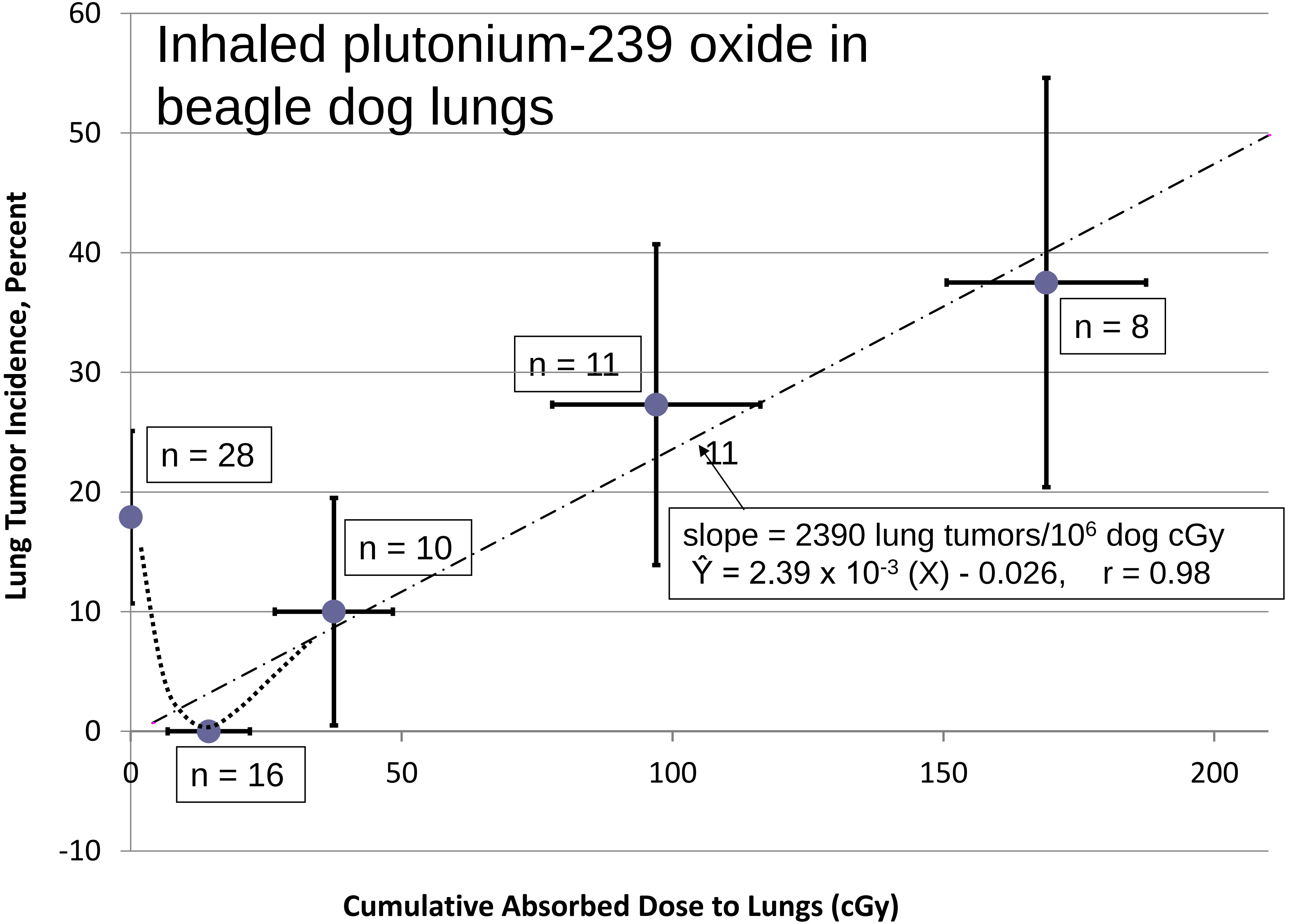


Quadratic dose-response function
Ŷ = 15.36 + 0.0893 (X) – 2.22 (X2)
r = 0.96
Inhaled plutonium-239 oxide in beagle dog lungs
Lung Tumor Incidence, Percent
Cumulative Absorbed Dose to Lungs (cGy)
100
80
60
40
20
0
-20
0
400
800
1200
1600
2000
2400
2800



Lung Tumor Incidence, Percent
100
80
60
40
20
0
-20
0
500
1000
1500
2000
2500
3000
3500
Cumulative Absorbed Dose to Lungs (cGy)
slope = 125 lung tumors/ 10^6 dog cGy
Ŷ = 1.25 x 10^-4 (X) + 0.662, r = 0.98
slope = 1360 lung tumors/ 10^6 dog cGy
Ŷ = 1.36 x 10^-3 (X) + 0.0925, r = 0.91



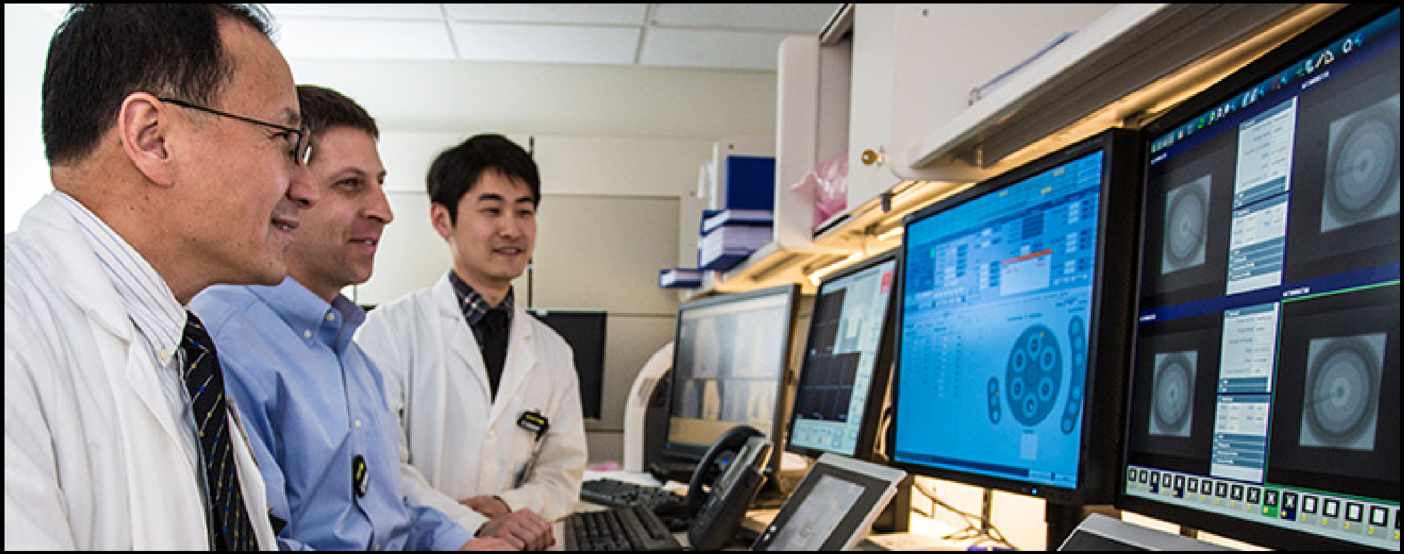
Inhaled plutonium-239 oxide in beagle dog lungs
Lung Tumor Incidence, Percent
Cumulative Absorbed Dose to Lungs (cGy)
60
50
40
30
20
10
0
-10
0
50
100
150
200
n = 28
n = 16
n = 10
n = 11
n = 8
11
slope = 2390 lung tumors/10^6 dog cGy
Ŷ = 2.39 x 10^-3 (X) - 0.026,   r = 0.98

Observations

- The linear no-threshold hypothesis may not hold for very low doses of radiation
- The risk coefficients have high uncertainty at very low doses
- We do not know the actual risks of cancer at very low doses

The pursuit of excellence

- In all that we do, we must strive for excellence in the science and practice of radiation safety
- Always learning, we strengthen our technical skills and expand our knowledge through study, research, publishing, and participation in scientific meetings



Personal qualities of excellent health physicists

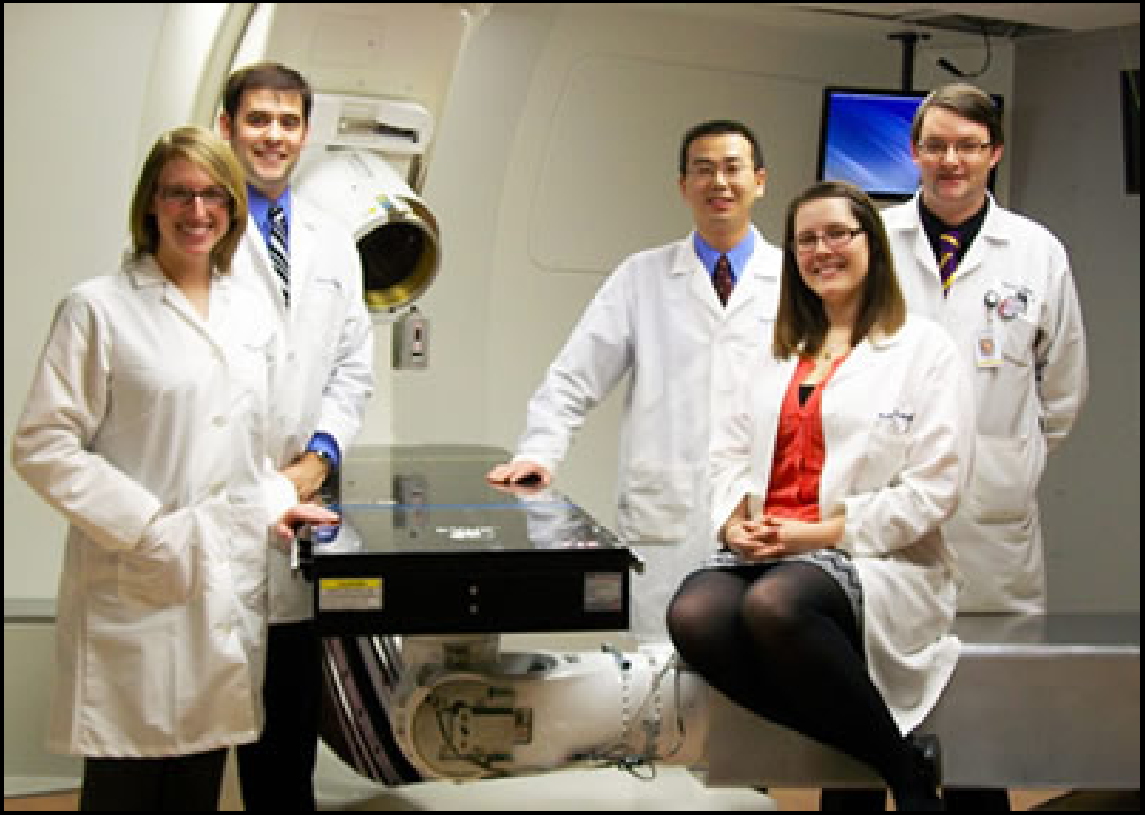
- Objectivity: following the scientific method
- Sound and rational decision-making: we act on our skills, education, knowledge, and experience
- Humility: we are still learning, and we are willing to learn
- Honesty: needed to gain and retain the trust of the general public and the government
- Compassionate: understanding the concerns of patients, pregnant women, citizens, children, and workers

Summary

- The professional health physicist strives for excellence
- Always cautious and careful to act, we must act with boldness, courage, and fortitude
- As we pursue excellence in our profession, we will find joy--and our labors will be rewarded with respect from our peers, the media, and society

Summary

Health physics is a noble and honorable profession



Thank you!

I have enjoyed visiting the Japan Health Physics Society in Ningyo-toge