

FUKUSHIMA FROM A DISTANCE

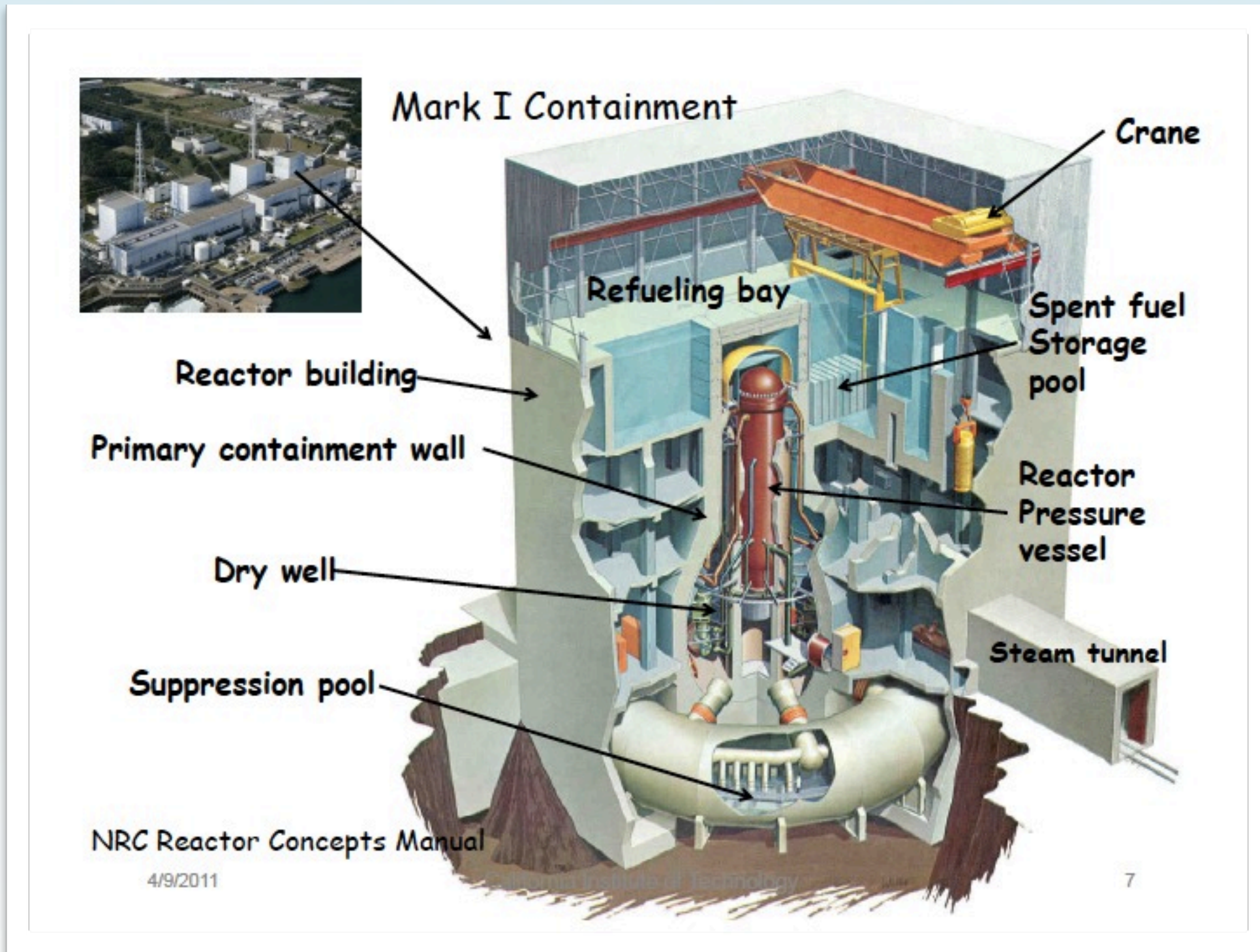
MIKE MILLER
UNIVERSITY OF WASHINGTON

UW REU
JUNE 27, 2011

DEVASTATION



CAUSE FOR CONCERN?



Many layers of redundancy

REDUNDANCY



Typical installation is
2 - 6 MWe per
generator set.

Usually at least 2
per reactor unit.

<http://www.nucleartourist.com/>

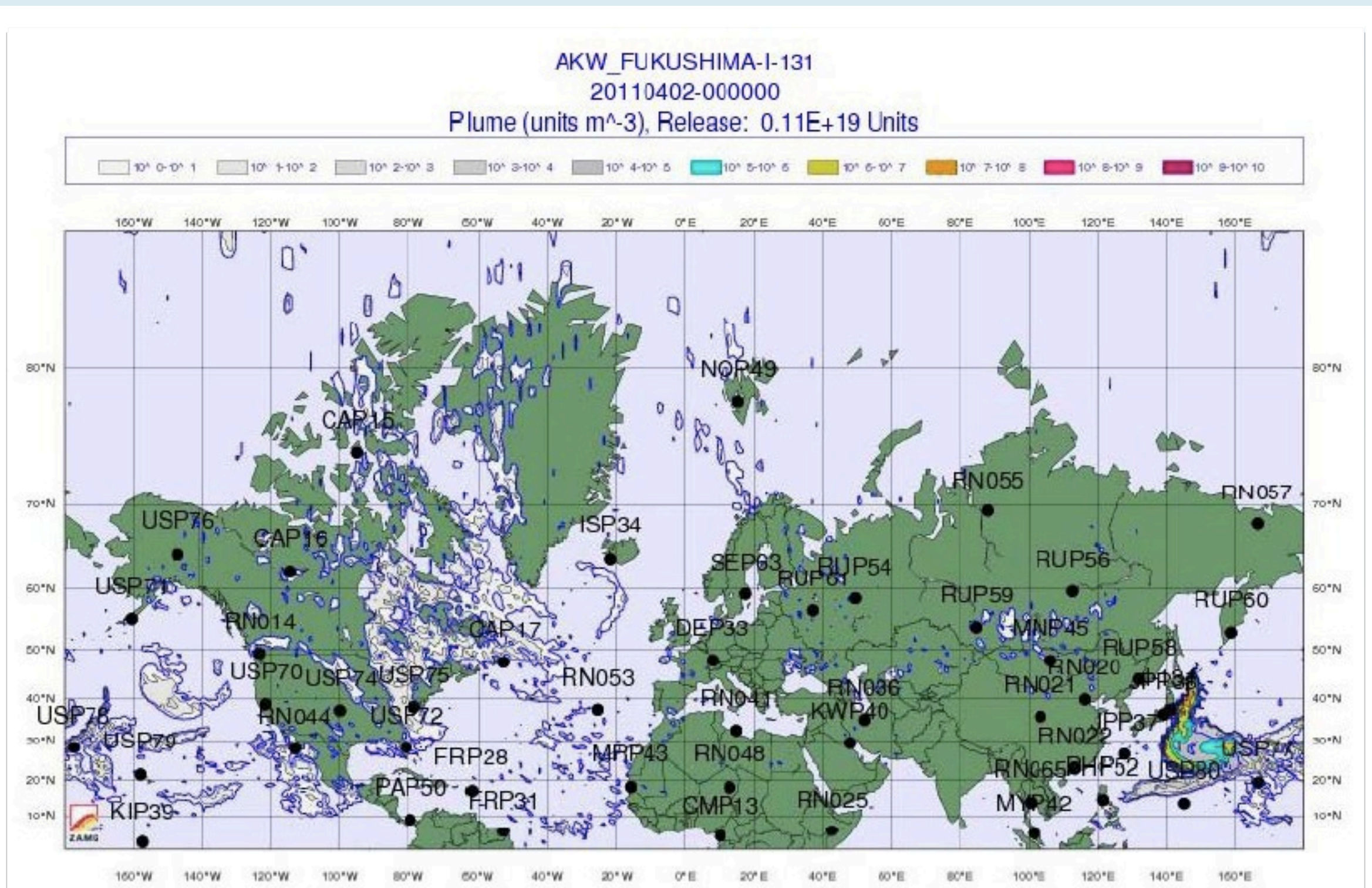


All 13 (!) destroyed

INCREASING ANGST



TRUSTED AUTHORITIES?



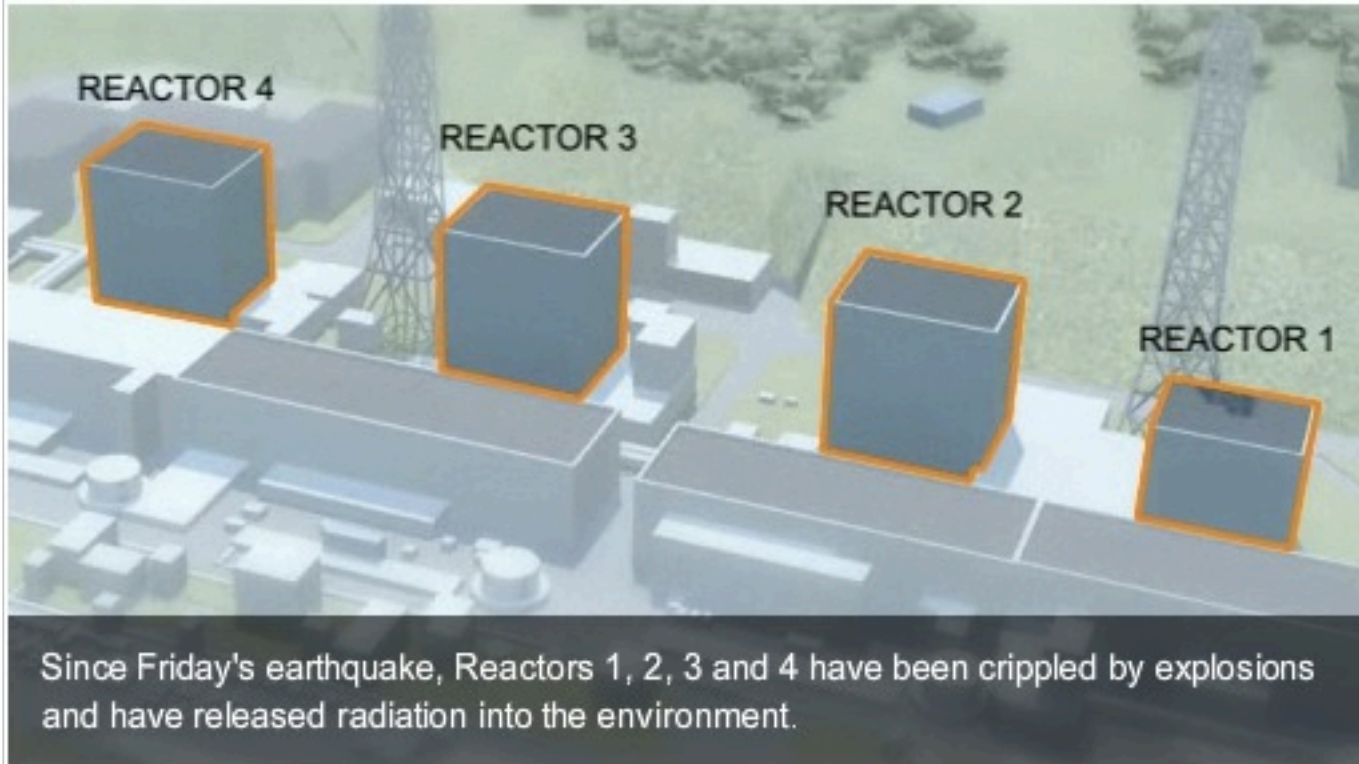
CTBTO Monitoring Stations

LOCAL HISTORY

Published: March 15, 2011

Accident at Fukushima Daiichi Nuclear Plant

The worst nuclear accident since the Chernobyl explosion in 1986 is unfolding in northern Japan at the Fukushima Daiichi power plant. Three reactors have been critically damaged and one caught fire.



UW NPL '86 Ann Rep

12.4 Detection of Radionuclides from the Chernobyl Incident

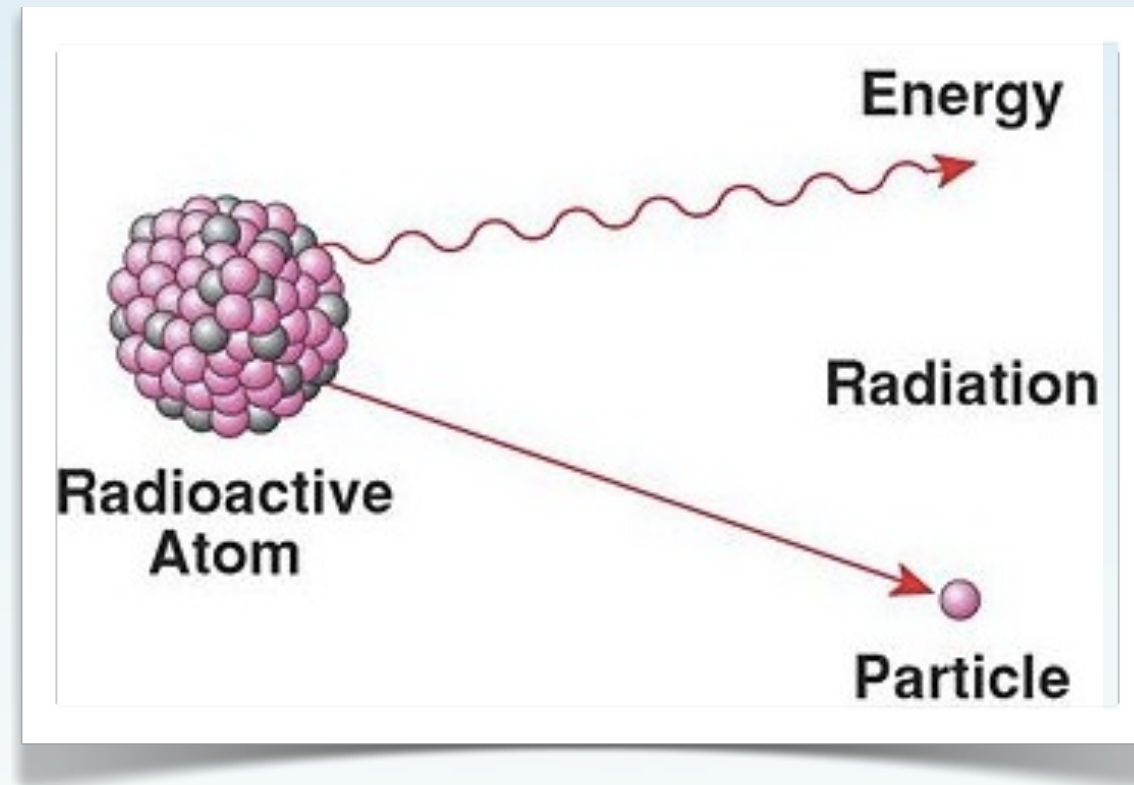
S.E. Kellogg, J.H. Gundlach, and C.W. Stubbs

An air sampling system set up at the University of Washington Nuclear Physics Laboratory was able to detect airborne radionuclides emanating from the reactor incident at Chernobyl, USSR. The measurements were made during the month of May by drawing air through a filter and then taking a spectrum of gamma ray emissions from the filter with a Ge(Li) detector. Comparison with background spectra allowed unambiguous detection of ^{99}Mo , ^{103}Ru , ^{106}Ru , ^{131}I , ^{129}Te , ^{132}Te , ^{134}Cs , ^{136}Cs , ^{137}Cs , ^{140}Ba and ^{141}Ce . These results are consistent with the isotopes observed in Europe, and we conclude that the Chernobyl event is the source of these shortlived airborne radioisotopes.

THREE MAIN QUESTIONS

- 1. How much radiation is in the air?**
- 2. What types of radiation?**
- 3. What is the impact for us in Seattle?**

RADIOACTIVITY



Every atom has unique “fingerprints”

We count decays per second (**Becquerel**)

RADIOACTIVITY

A **banana equivalent dose (BED)** is defined to be the absorbed dose of **radiation** due to eating one **banana**. The concept seeks to explain the risk of radiation exposure that results from human activity, such as the use of **nuclear power** or medical procedures, by comparing it with the risk associated with natural doses. BED is a **radiation dose equivalent** unit; the corresponding **SI unit** is the **sievert**. In the U.S., the **rem**, equal to 0.01 sieverts, is commonly used.

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History

[\[edit\]](#)

The BED calculation probably originated on a nuclear safety mailing list in 1995, where a value of 9.82×10^{-8} sieverts or about $0.1 \mu\text{Sv}$ was suggested.^[1] However, that calculation was subsequently recognised as erroneous.^[1] It had mistakenly ignored the effect of the stable isotope of potassium (^{39}K) also present in a banana.^[2] The stable isotope mitigates displacement of the potassium atoms already present long-term in the body, and permits the excess radioisotope to be quickly eliminated in homeostasis.



Bananas, like any other  organic material, are slightly radioactive.

Bananas are ~ 15 decays / sec $\Rightarrow 15$ Bq

1 banana = 1 cubic meter of air = 15 grams of granite

BACK TO FUKUSHIMA

METHOD

- **Sample air. A lot of air**
~150,000 m³/day
- **Filter**
60% (80%) efficient at 2 um (5 um)
- **Package**
- **Count**
- **Calculate**

Mike,

The "usual suspects":

3/15/11

137Cs 661.65 keV

131I 364.48 keV

284.298 keV

140Ba 537.27 keV

13.85 keV

29.97 keV

140La 2348 keV

815.8 keV

328.77 keV

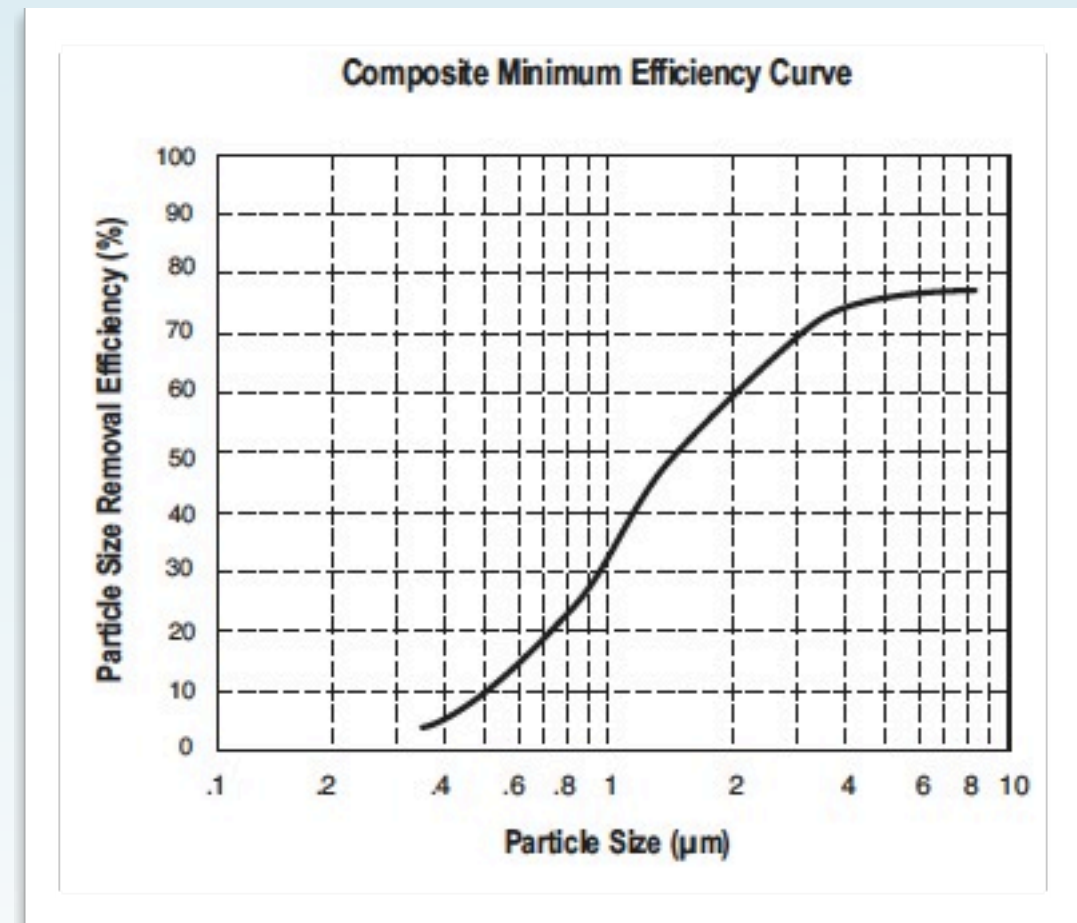
751.83 keV

99Mo 140.508 keV

All these isotopes have lots of weaker lines. Also, I don't think it's worth extending the range just to catch the 2348 keV line from 140La. Everything shows up below 1 MeV one way or another.

Hamish

AIR COLLECTION



- **Two different filter types used, nearly identical specs**
- **D. Jaffee (UW): “likely carried by 0.2-0.6 um dust”**

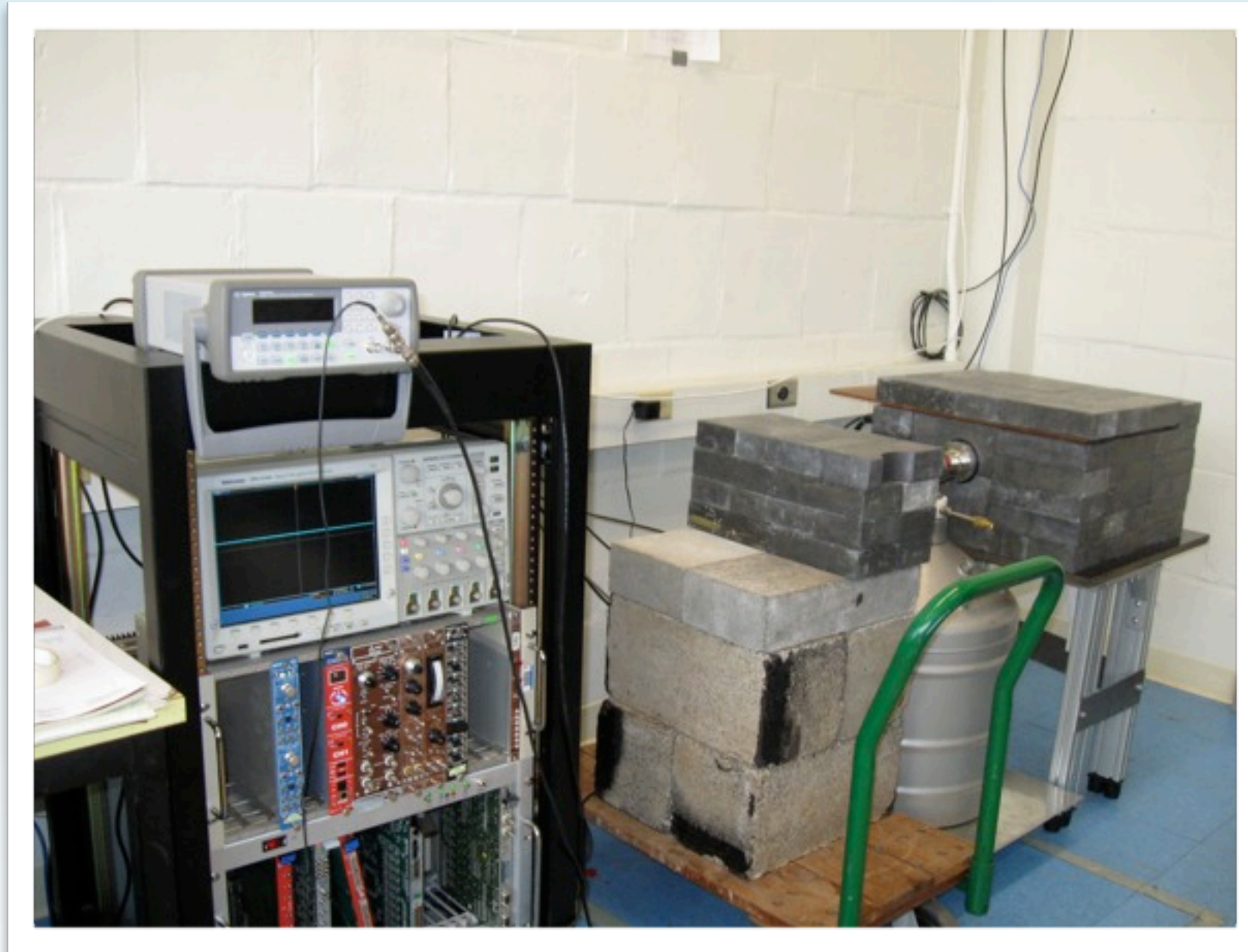
PACKAGE FOR COUNTING



- **Hardest part:**

24" x 24" x 2". Paper on wire mesh, cardboard supports
Press, fold, zip-tie tie, repeat

COUNT



- **Germanium Detector in Lead Shield**

GERMANIUM DETECTORS

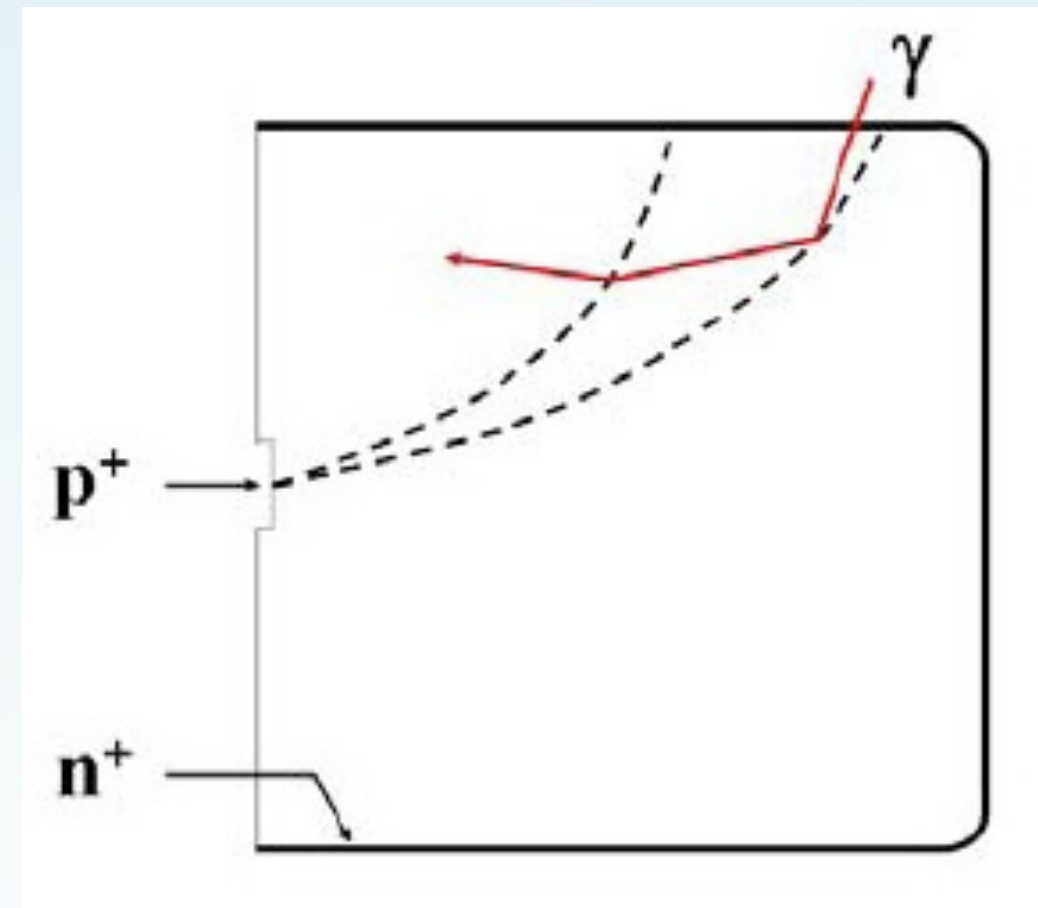
- **Fission products yield unique signature**

photons of a very specific energy
count photons, find peaks, lookup in
online databases

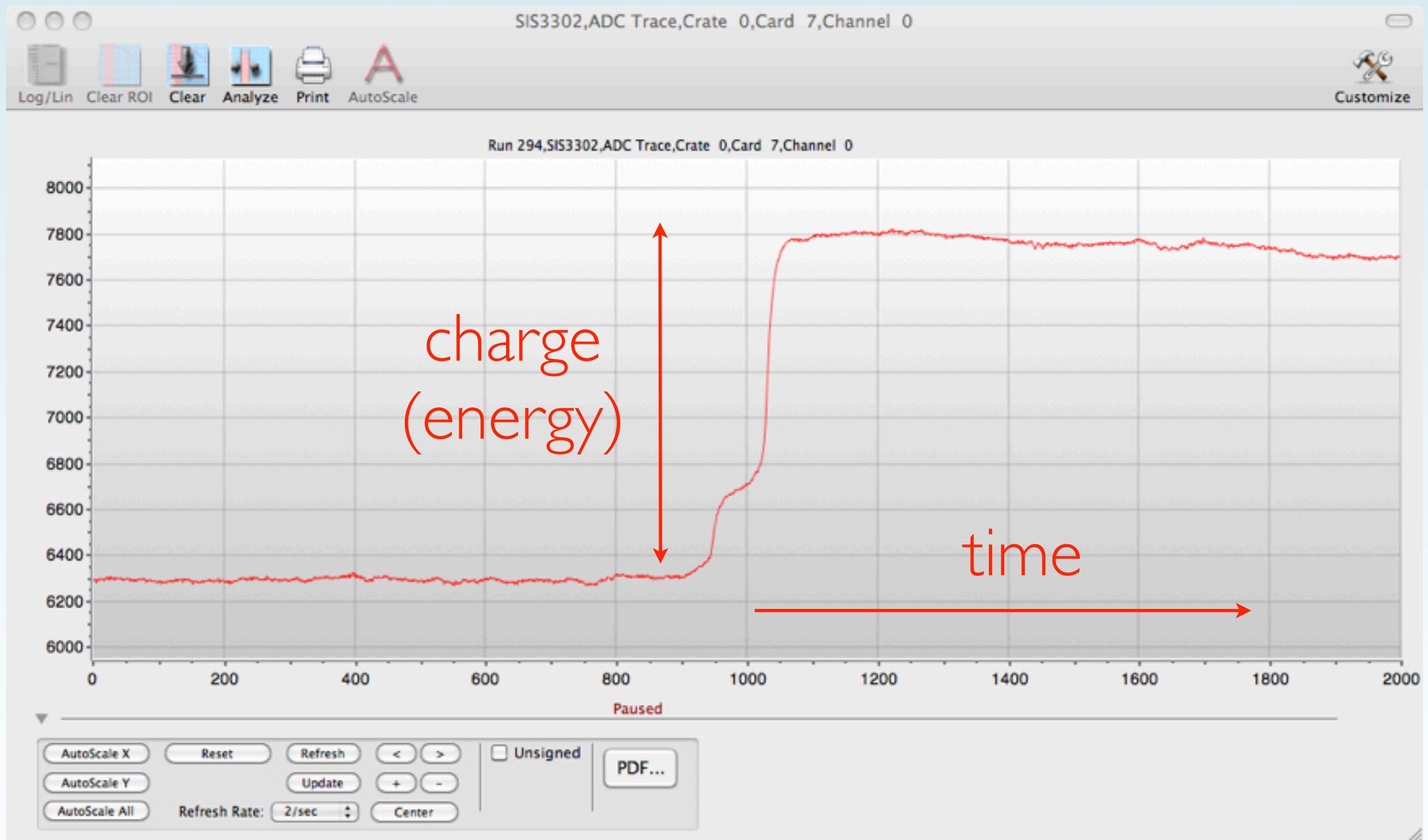
- **Fingerprint!**

- **Germanium detector**

1 pixel digital camera with perfect color
photon creates electron/hole pair.
collected charge ~ energy of photon

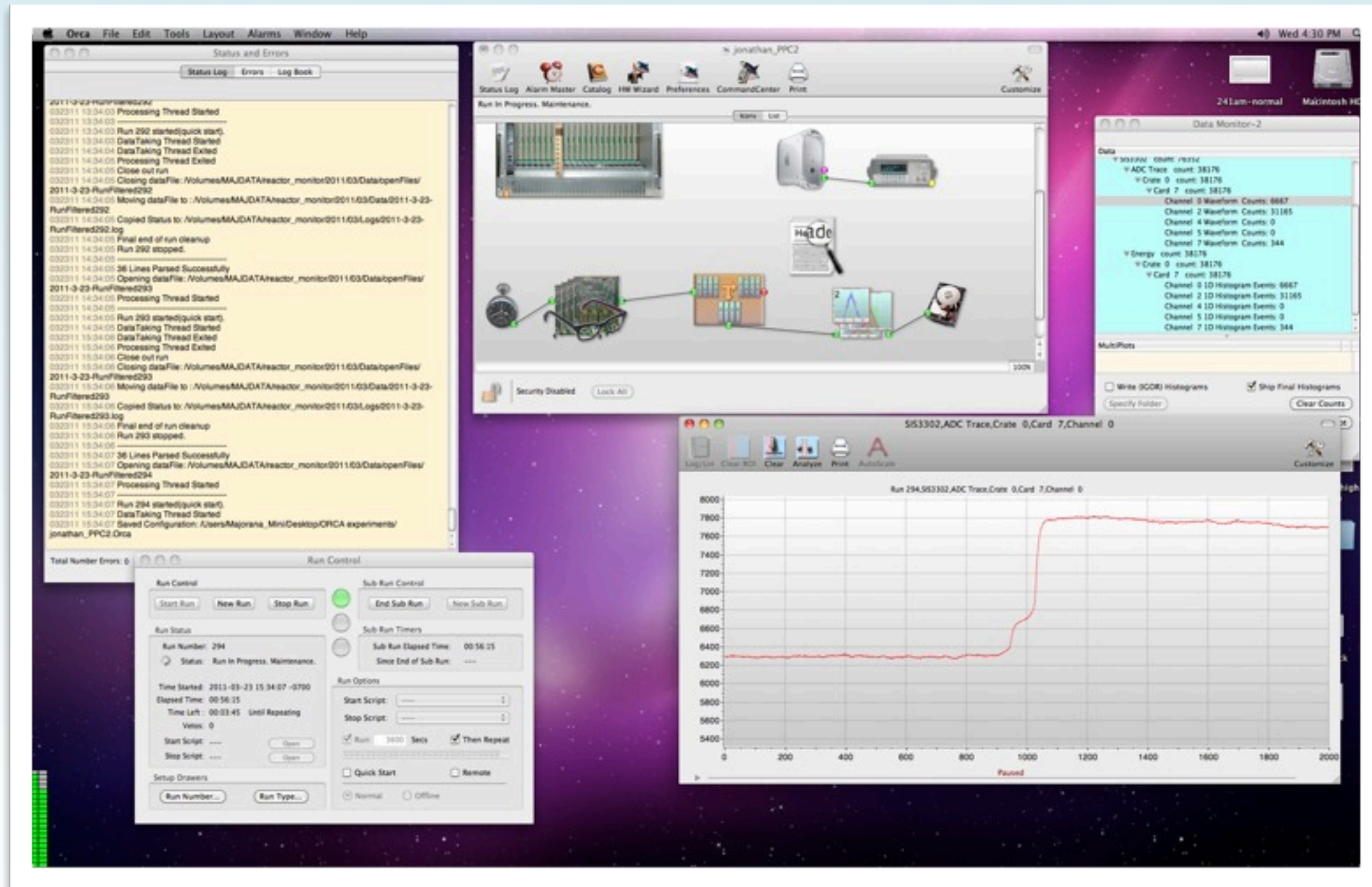


GERMANIUM DETECTORS



Digital Signal Processing \Rightarrow Pulse Height \Rightarrow Energy

DATA ACQUISITION (ORCA)



detector

Digitizer

SBC

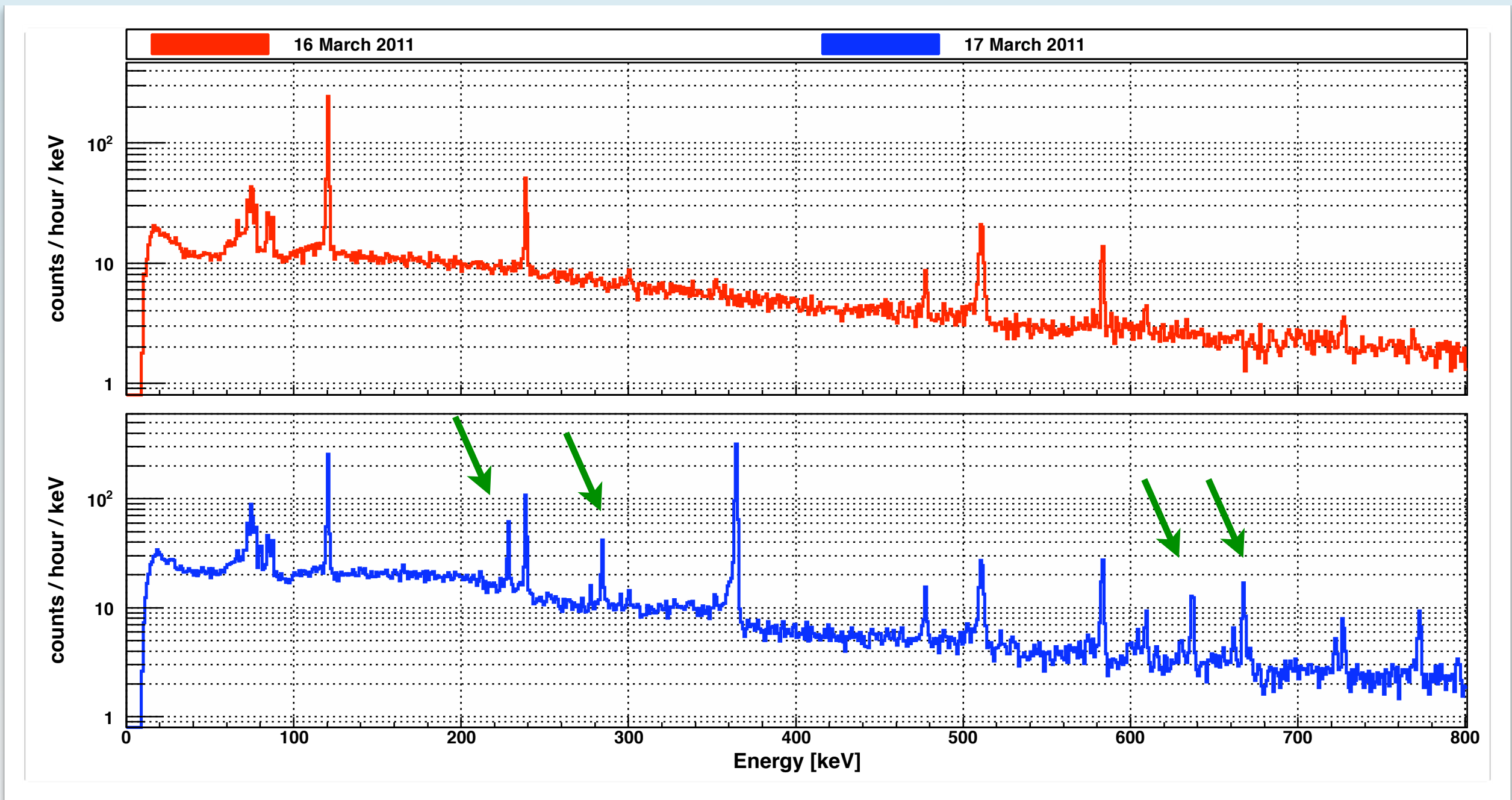
Mac Mini

FIRST RESULTS

Sample 2: 3/17-3/18

3 pm Friday: insert Sample 2 for counting...

FIRST RESULTS



- Clear lines from ^{131}I , ^{132}I , ^{134}Cs , ^{137}Cs , ^{132}Te
- Only 1 unidentified feature in spectrum

WHAT'S THE NUMBER?!



11:30 pm Friday night
2011 Data: 0.004 Bq/m³
EPA Limits: ~ 4 Bq/m³

AND THE HARD PART



“Hey now, nobody said the word plume!”

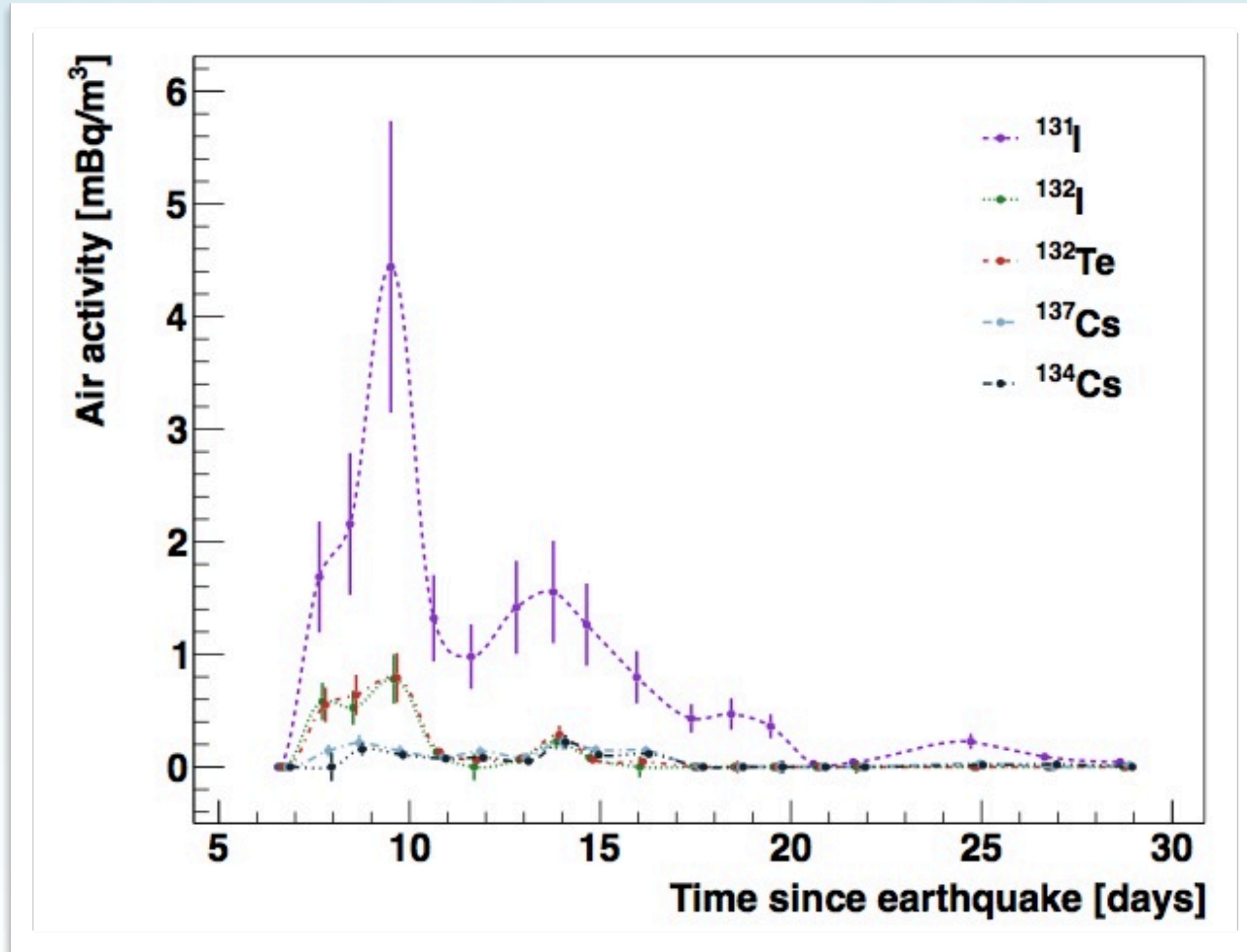
WHAT DOES IT MEAN?

- **We are safe... here (1000x below EPA limit for air)**
but... eat local
- **Reactor was shutdown automatically with the earthquake**
- **Reactors were burning ^{235}U**
- **No clear evidence for spent fuel emission**

- **Significantly higher than we expected**
Chernobyl was operating, and had a complete meltdown
CTBTO estimates* 25% (^{131}I) to 50% (^{137}Cs) of the Chernobyl yield on site

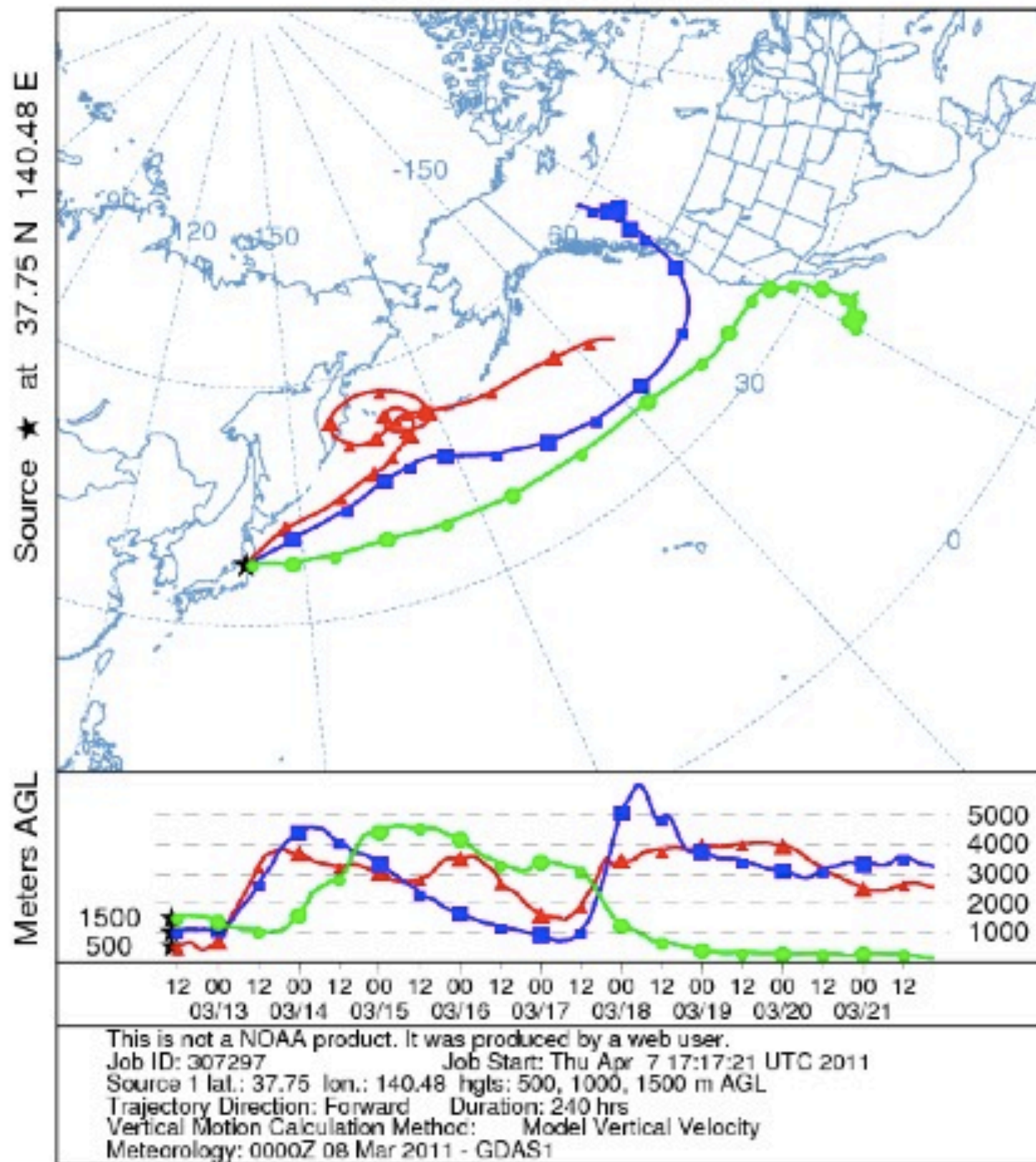
*http://www.zamg.ac.at/docs/aktuell/Japan2011-03-22_1500_E.pdf

FINAL RESULTS



By Friday, April 8, no longer detectable

NOAA HYSPLIT MODEL
 Forward trajectories starting at 1000 UTC 12 Mar 11
 GDAS Meteorological Data



COMPARISON

| Species | Fukushima Dai-ichi | Chernobyl Unit 4 | Aboveground nuclear testing |
|---------|---------------------------------|----------------------|-----------------------------|
| I-131 | 10^{16} to 7×10^{17} | 1.8×10^{18} | 9×10^{20} |
| Cs-134 | ? | 5.0×10^{16} | - |
| Cs-137 | 10^{15} to 7×10^{16} | 8.5×10^{16} | 1.3×10^{18} |
| Total | $> 7.7 \times 10^{17}$ | 9.4×10^{18} | |
| | ZAMG 30 March 2011 | UNSCEAR 2000 | UNSCEAR 1982 |

A very serious incident

WHAT ABOUT FOOD?

- **Food cycle => bio-accumulators**

Rain brings pollutants to ground / plants

cows eat grass, milk

=> concentration

- **CDC limits** (http://www.atsdr.cdc.gov/csem/iodine/standards_regulations.html)

Water: 0.1 Bq / Liter

Food: 170 Bq / Liter

- **So far very safe, but watch DOH for data as it appears**

OFF THE RECORD

MORE INFORMATION

- **UW: <http://www.npl.washington.edu/monitoring/>**
- **Cal: <http://www.nuc.berkeley.edu/UCBAirSampling>**
- **WADOH: <http://www.doh.wa.gov/Topics/japan/iodine.htm>**
- **Seattle Times:**
http://seattletimes.nwsourc.com/html/localnews/2014693490_nukemonitors06m.html