Environmental Monitoring for the Upper-Bound Radiation Dose Assessment Operation TOMODACHI Registry

Brief for: Veterans' Advisory Board on Dose Reconstruction

March 23, 2012

Briefer: Steven E. Rademacher, Ph.D., CHP

Air Force Safety Center, Weapons Safety Division

Acknowledgements

- Dr. Daniel Blumenthal, National Nuclear Security Administration, who shared DOE's radiological monitoring results,
- Dr. FURUTA Sadaaki, Japan Atomic Energy Agency, who provided information on the Japanese radiological monitoring stations,
- Veterans' Advisory Board on Dose Reconstruction, Subcommittee No. 1 members (Harold Beck, Paul Voilleque, and Gary Zeman), who provided peer-review,
- Dr. David Kocher of SENES Oak Ridge, Inc., who provided peer-review, and
- My co-authors: CDR Cassata, USN, Dr. Falo, LTJG Alleman, USN, LTC Rosser, USA, Mr. Dunavant, Dr. Case, & Dr. Blake.

Overview

Provide a brief summary of the environmental monitoring data used in determining Operation TOMODACHI upper-bound radiation doses for shore-based, DOD-affiliated population between 12 March and 11 May from four primary pathways.

Outline

- External Radiation Monitoring
- Air Monitoring
- Water Monitoring
- Soil Monitoring

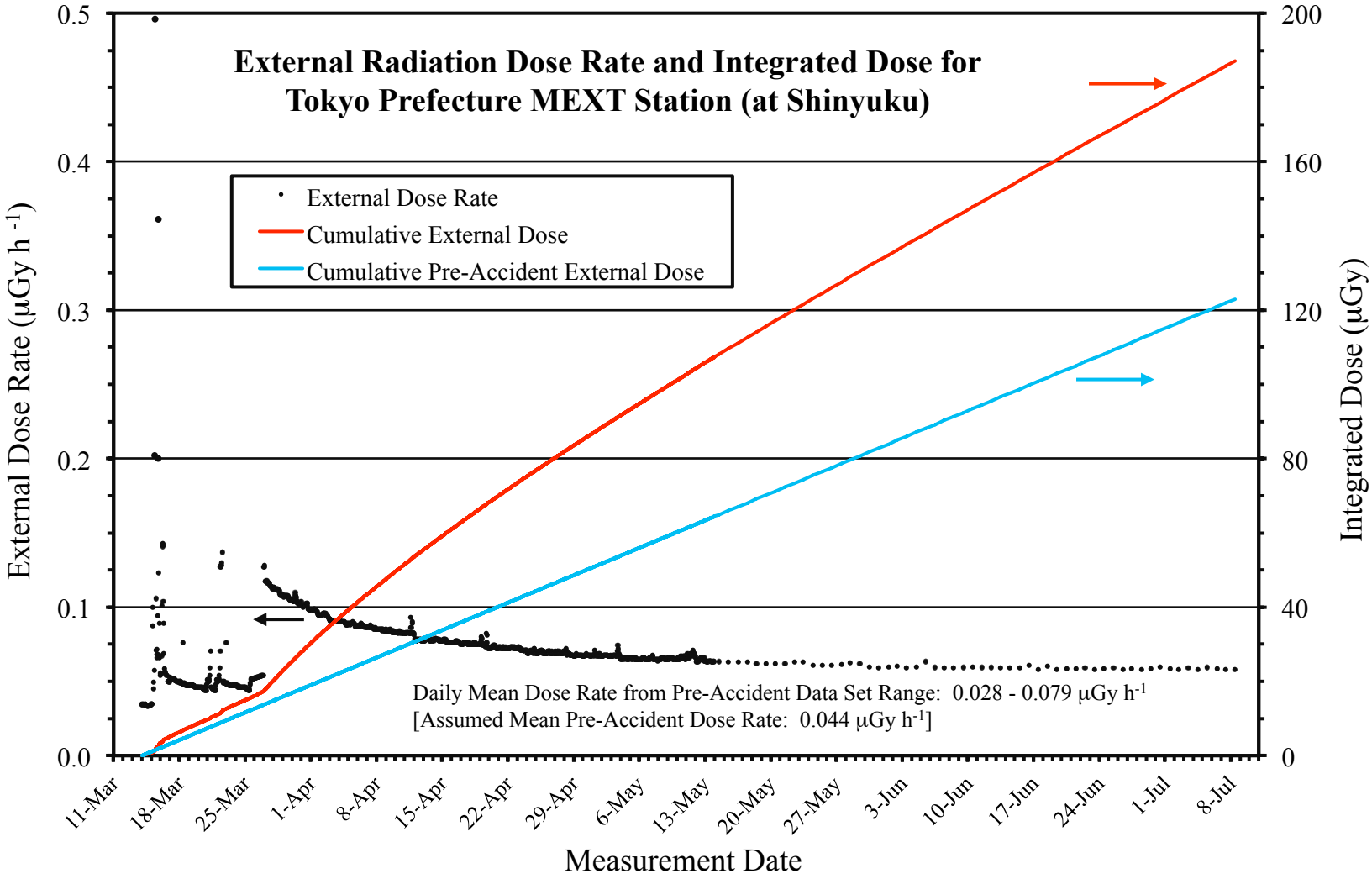
External Radiation Monitoring

- External dose measurements collected with portable instruments on US Forces Japan installations and Naval ships
- Numerous other measurements: Japan, US DOE
- Corroborate data to personal dosimetry measurements for individuals at specified locations
- Differences between Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT) and DOD/US DOE portable instrument measurements

External Radiation Monitoring

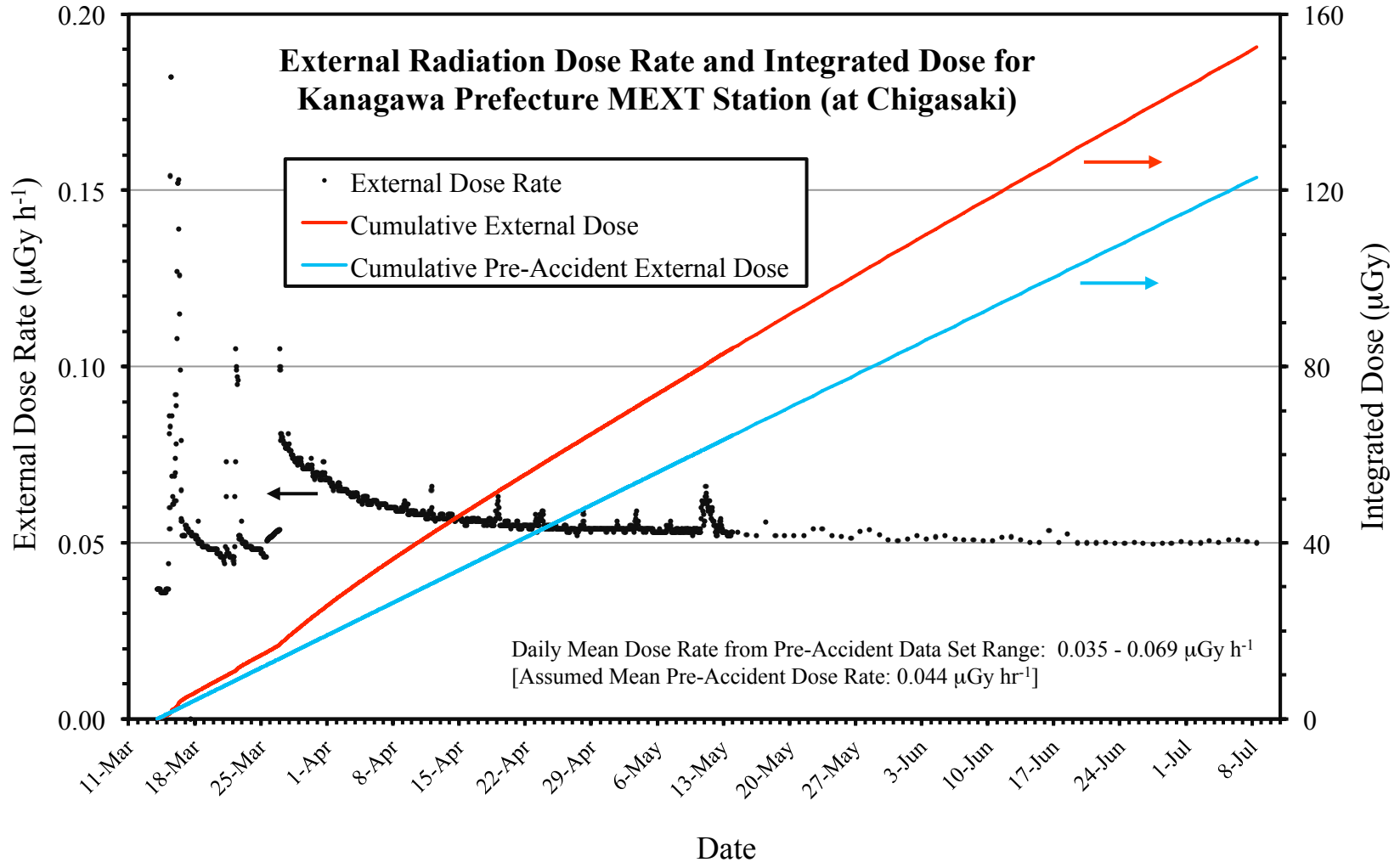
(MEXT Station Closest to US Embassy/Yokota AB)

External Radiation Monitoring
(MEXT Station Closest to US Embassy/Yokota AB)



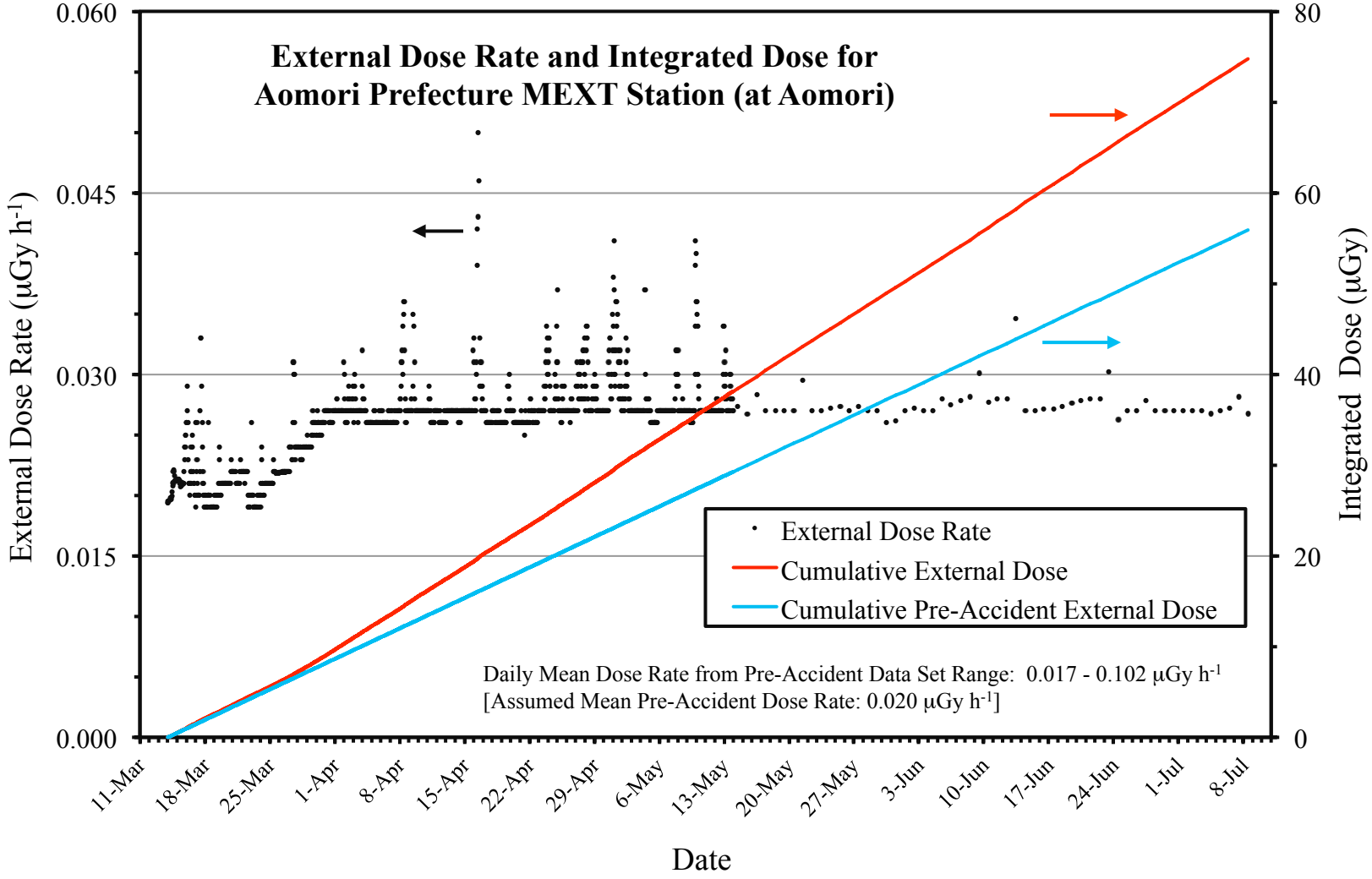
External Radiation Monitoring

(MEXT Station Closest to Yokosuka NB/Camp Zama)



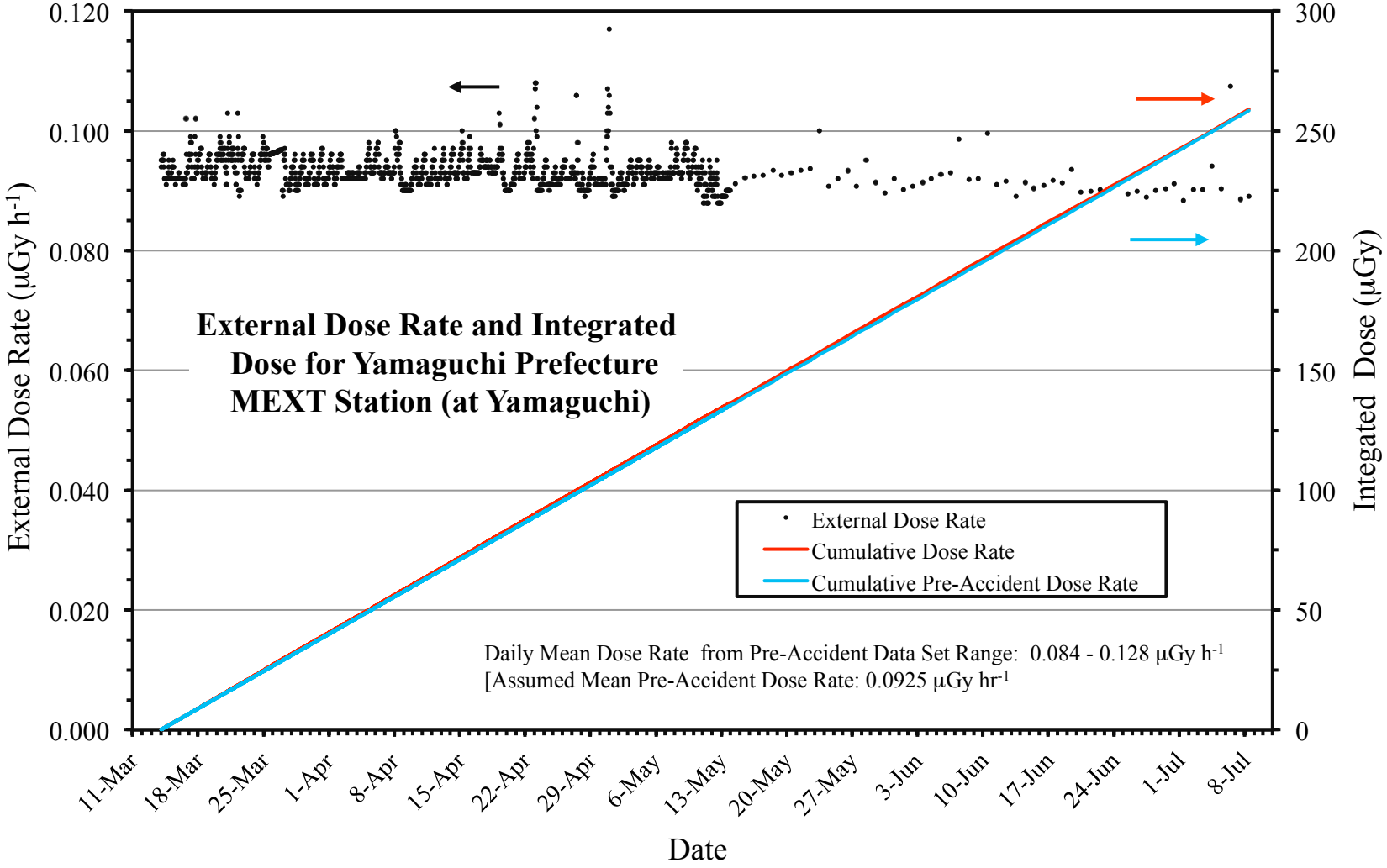
External Radiation Monitoring

(MEXT Station Closest to Misawa AB)



External Radiation Monitoring

(MEXT Station Closest to Iwakuni MCAS)



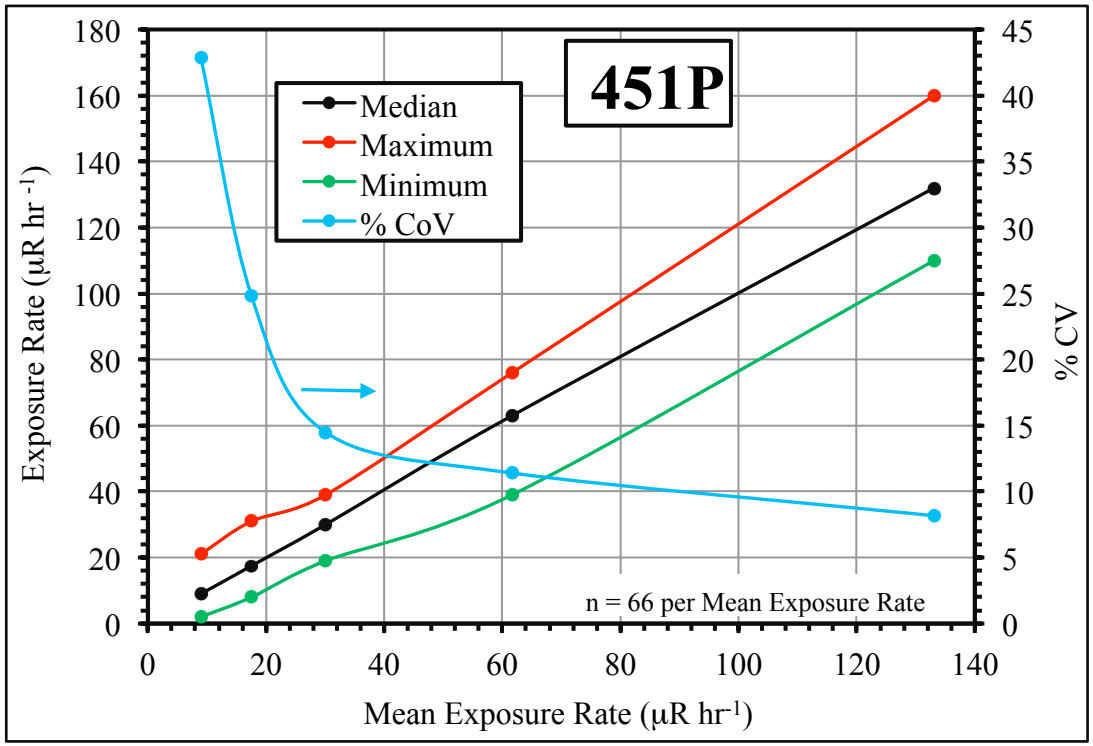
External Radiation Monitoring Differences

- MEXT external dose rates measurements lower than DOD/US DOE portable instrument data
  - Differences not consistent among DARWG location/ closest MEXT station
    - DOD/US DOE to MEXT ranged by factor of 1.9 to 5.12
  - MEXT detector placement vs. DOD/US DOE measurement locations believed to be a primary factor
  - Some DOD/US DOE portable instrument biased-high at low exposure rates, another primary factor
  - One DOD/US DOE portable instrument subject to user introduced high bias at low exposure rates

External Radiation Monitoring Differences (Detector Location)

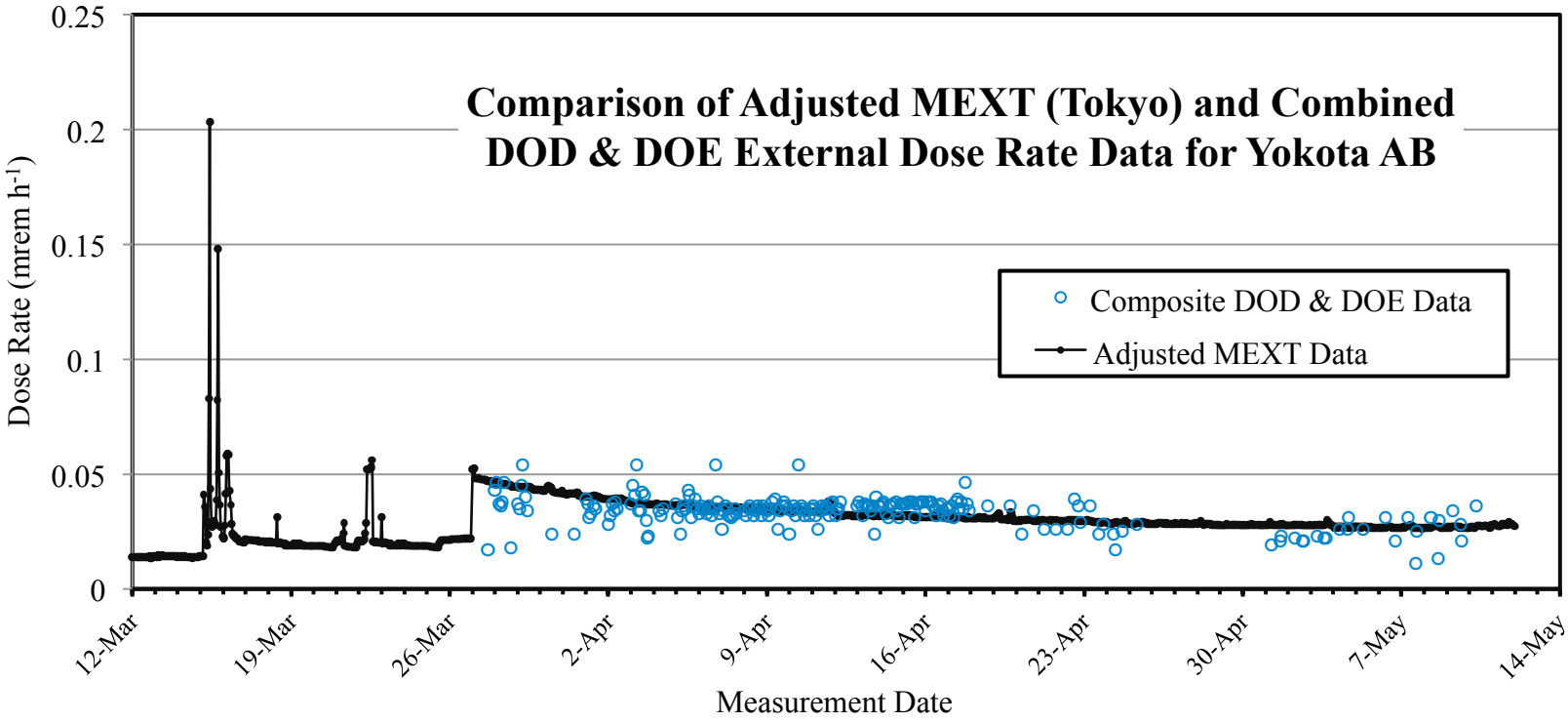
External Radiation Monitoring Discrepancies (DOD Portable Instruments)

- AF Safety Center conducted portable instrument study with ADM-300 & Fluke Biomedical 451P
  - ADM-300 (2)-hour integrated response ~ 2-fold higher than 451P
  - Army Institute of Public Health confirmation
  - 451P subject to user bias at low exposure rates



External Radiation Dose Rate
(MEXT Data Adjustments)

- External dose rates - DARWG Upper-Bound Doses
  - DOD/US DOE measurements used to adjust MEXT data
  - MEXT data vital for fine detail & early period dose rates



External Radiation Dose Rate
(MEXT Data Adjustments)

Shore Location (DARWG Loc. No.)	Closest MEXT Station (Prefecture)	Adjustment Factor	Detector Height (meters)
Misawa AB (D-1)	Aomori (P-2)	**5.12**	**1.8**
Camp Sendai (D-2)	Miyagi (P-4)	**4.30**	**80.3**
City of Ishinomaki (D-3)	Miyagi (P-4)	**2.83**	**80.3**
City of Yamagata (D-4)	Yamagata (P-6)	**4.70**	**20**
Hyakuri AB (D-6)	Ibaraki (P-8)	**2.00**	**3.45**
City of Oyama (D-7)	Tochigi (P-9)	**5.12**	**20**
Yokota AB (D-8)	Tokyo (P-13)	**4.10**	**18**
Atsugi NAF (D-10)	Kanagawa (P-14)	**4.78**	**4.9**
Yokosuka NB (D-11)	Kanagawa (P-14)	**3.74**	**4.9**
Camp Fuji (D-12)	Shizuoka (P-22)	**4.40**	**3.0**
Iwakuni MCAS (D-13)	Yamaguchi (P-35)	**1.90**	**1.5**
Sasebo NB (D-14)	Nagasaki (P-42)	**3.37**	**11**

Air Monitoring

- Conducted on multiple US Forces Japan Installations & US Naval ships
- Varied sampling equipment and methodology
  - Army: primarily Staplex high-flow rate for aerosols & Radēco medium flow rate sampling with in-line aerosol filter and charcoal canisters later
  - AF: Radēco medium flow rate sampling with in-line aerosol filter and charcoal canisters; high flow rate continuous monitoring at two locations (aerosols)
  - Navy: low volume air sampling on ships/installations; some later sampling with Radēco medium flow rate sampling systems

Air Sample Analysis

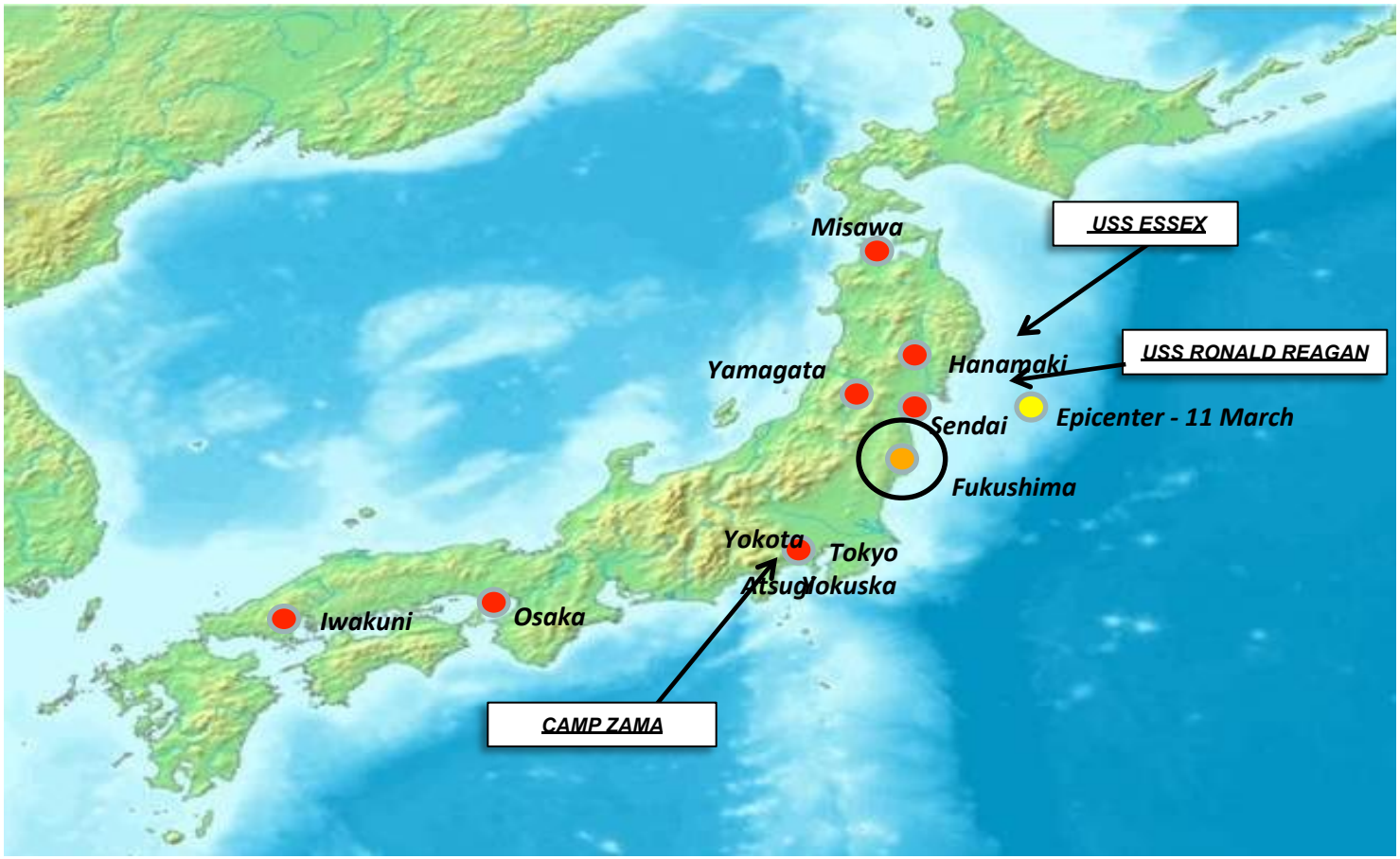
- Navy low volume samples
  - Portable instrument screening of filters
- Air Force
  - AF Radiation Assessment Team (AFRAT) high-resolution γ-spectroscopy field
  - CONUS high-resolution γ-spectroscopy
- Army
  - Portable instrument pre-screen
  - CONUS high-resolution γ-spectroscopy
  - Correlation between two allowed inferences on subsequent pre-screened samples

Air Monitoring Data Use

- Inhalation Exposure Pathway
  - Projected source of dose to individuals
- Comparative analyses:
  - In-vivo bioassay measurements performed on ~ 8,000 individual vs. predicted uptakes
    - Due to conservative assumptions, predicted should be > bioassay, barring sensitivity issues
  - Modeled atmospheric release/transport to air sampling data

Air Monitoring Example

- Fixed air sampling site at Yokota AB



Air Sampling Example

Start	Date =	16-Mar	**Yokota AB**
	Time =	1422Z	
Stop	Date =	17-Mar	
	Time =	1422Z	
Sampling Time (hr) =		24	

		Ground-Level Air Sample			
Nuclide	Halflife	FIELD DETECTOR		LABORATORY	
	yr	μBq m^{-3}	% Rel Err (1σ)	μBq m^{-3}	% Rel Err (1σ)
Ba-136m	1.00E-08				
Ba-140	0.035			3.08E+02	16.0
Cs-134	2.05	1.40E+04	7.8	7.30E+03	1.1
Cs-136	0.0375	3.44E+03	9.5	1.45E+03	1.7
Cs-137	30.0	1.98E+04	8.2	7.45E+03	1.7
I-130	0.0014				
I-131	0.022	7.59E+04	6.0	6.77E+04	1.1
I-132	0.00026	6.33E+04	8.3	3.28E+04	1.1
I-133	0.0023	1.66E+03	8.0		
La-140	0.11	1.38E+03	15.0	3.55E+02	6.6
Rb-86	0.051				
Rh-102	2.9				
Ru-106	1.01				
Mo-99	0.0076			4.85E+02	21.0
Tc-99m	0.00069				
Te-129	0.000131	1.39E+04	10.5		
Te-129m	0.093	2.42E+04	37.0		
Te-131m	0.00005				
Te-132	0.0089	8.86E+04	6.5	3.77E+04	5.0

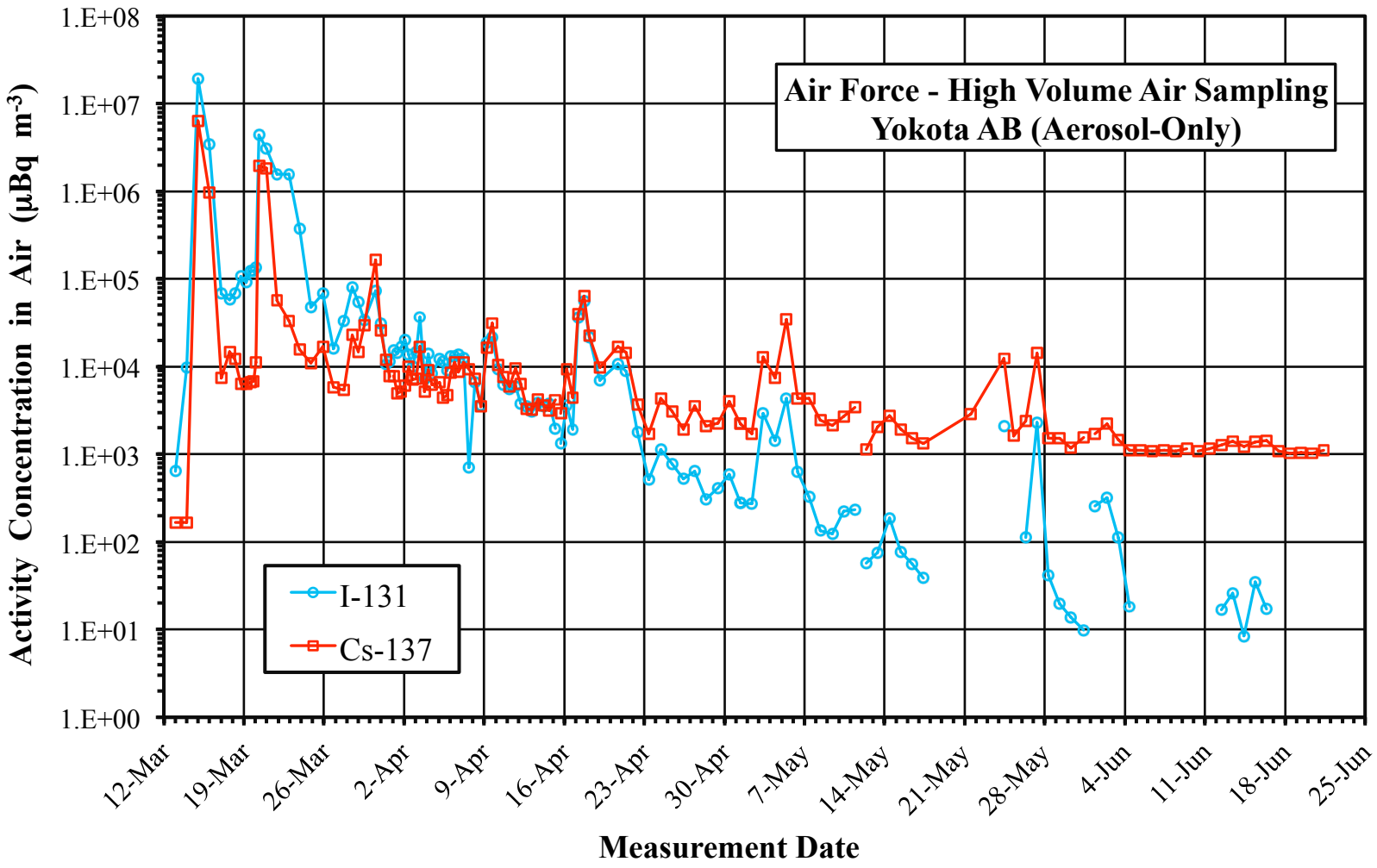
Ba-140 ($t_{1/2}$ - 12.8 d)

↓ β -

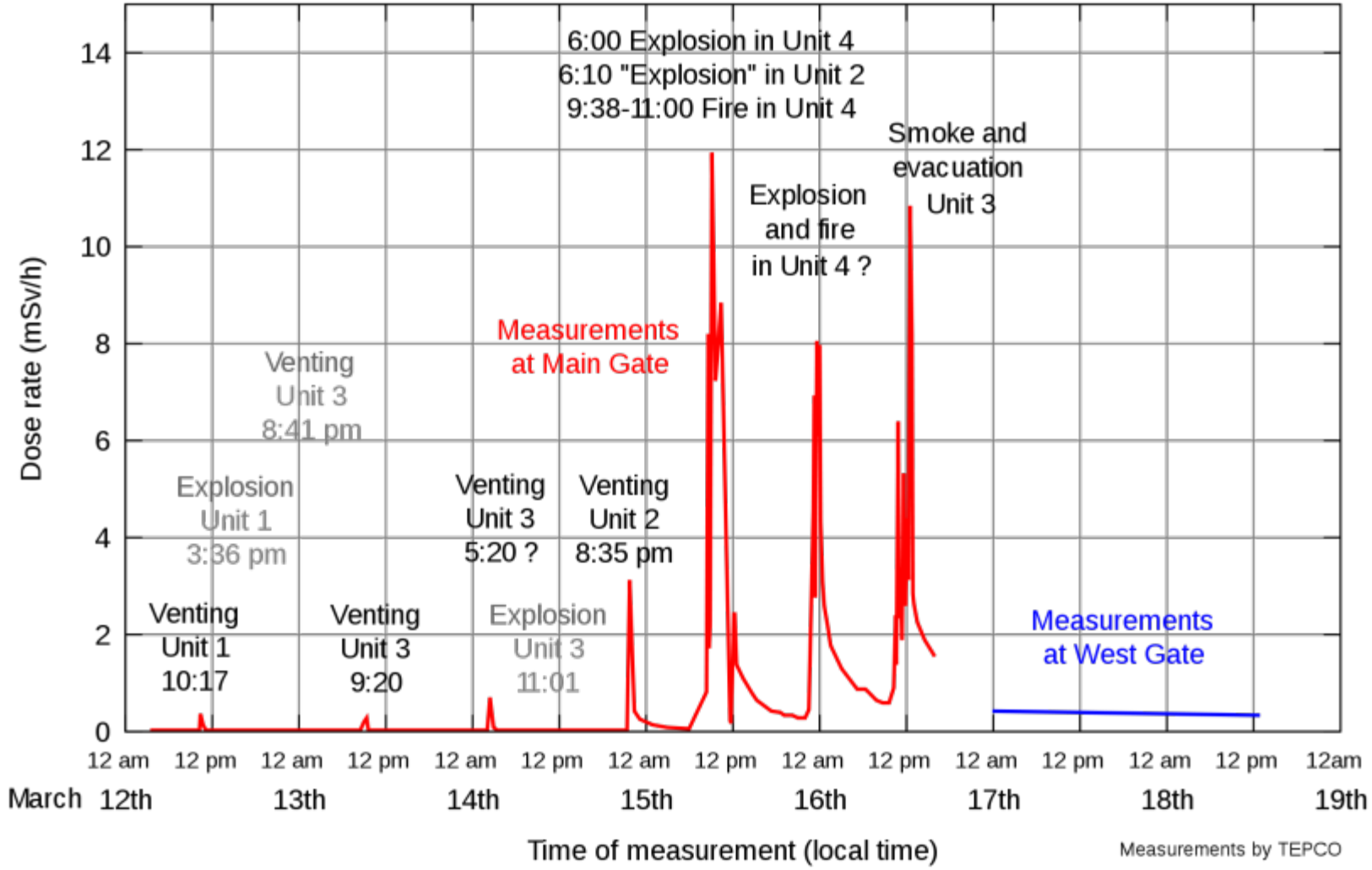
La-140 ($t_{1/2}$ – 40.8 d)

Nuclide	Key Photon Emissions	
	Energy (keV)	Frequency
Ba-140	163	0.06
	305	0.06
	438	0.05
	537	0.34
La-140	329	0.20
	487	0.40
	815	0.19
	923	0.10
	1,596	0.96

Air Sampling Example



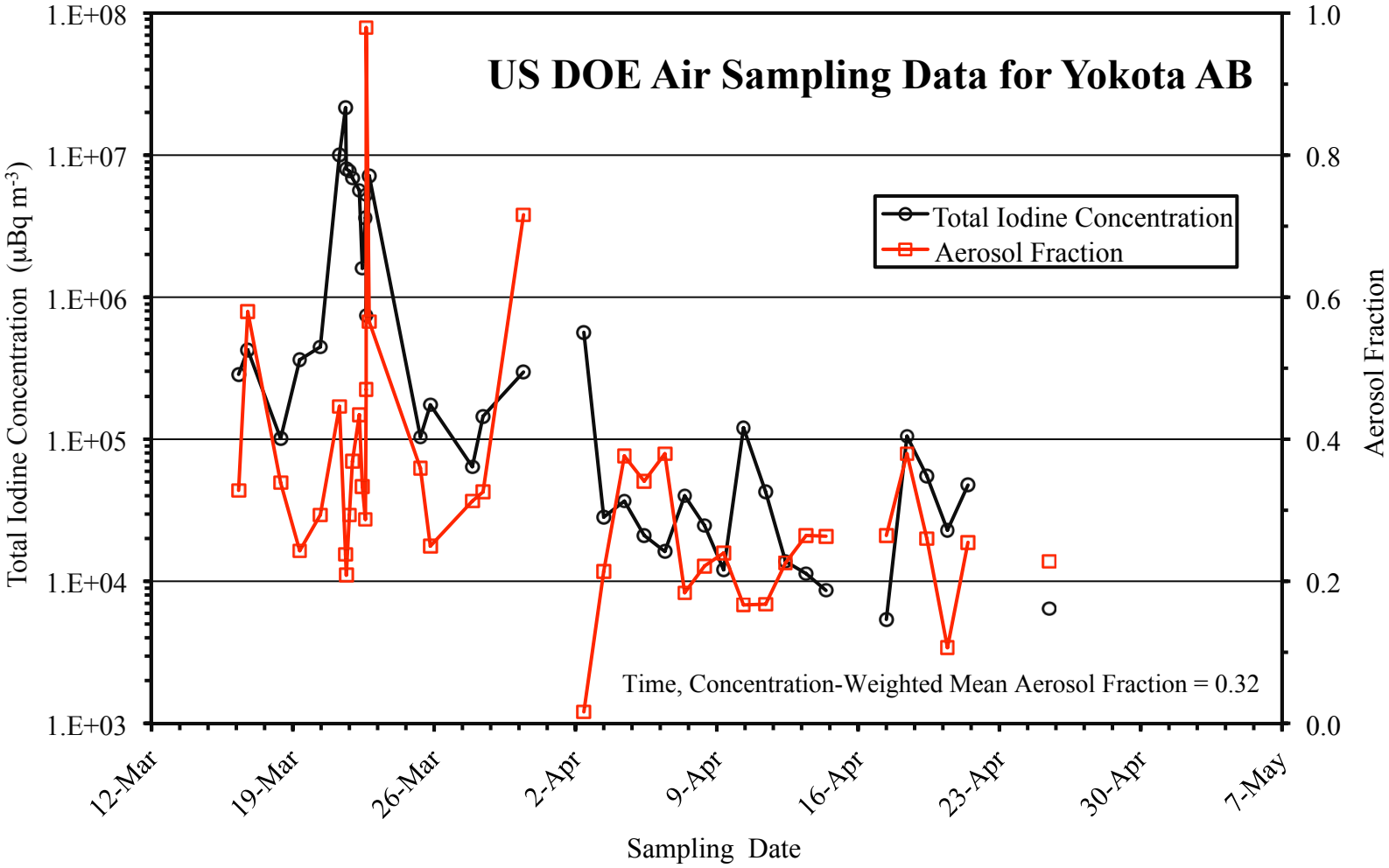
Air Sampling Example



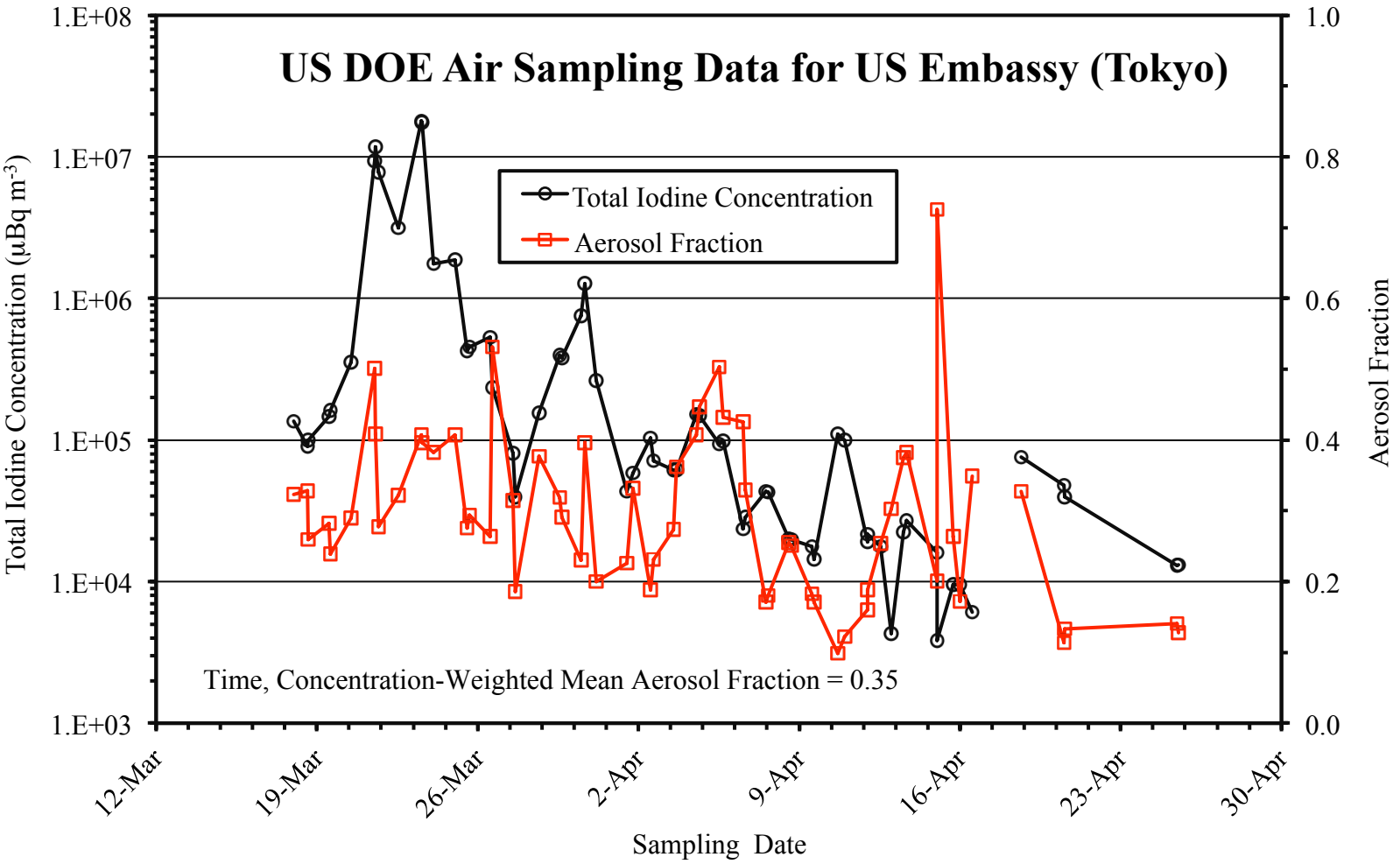
Air Sampling

- Limitations
  - High-flow rate sampling
    - Good sensitivity for multiple radionuclides
    - Inadequate in-itself for radioiodines due to potential for high gaseous-form content
  - Low-flow rate sampling
    - Allows aerosol/gas sampling in the same air sampling stream with filter/charcoal canister combination
    - Limited sensitivity for radionuclides other than Cs-134, Cs-137, and I-131

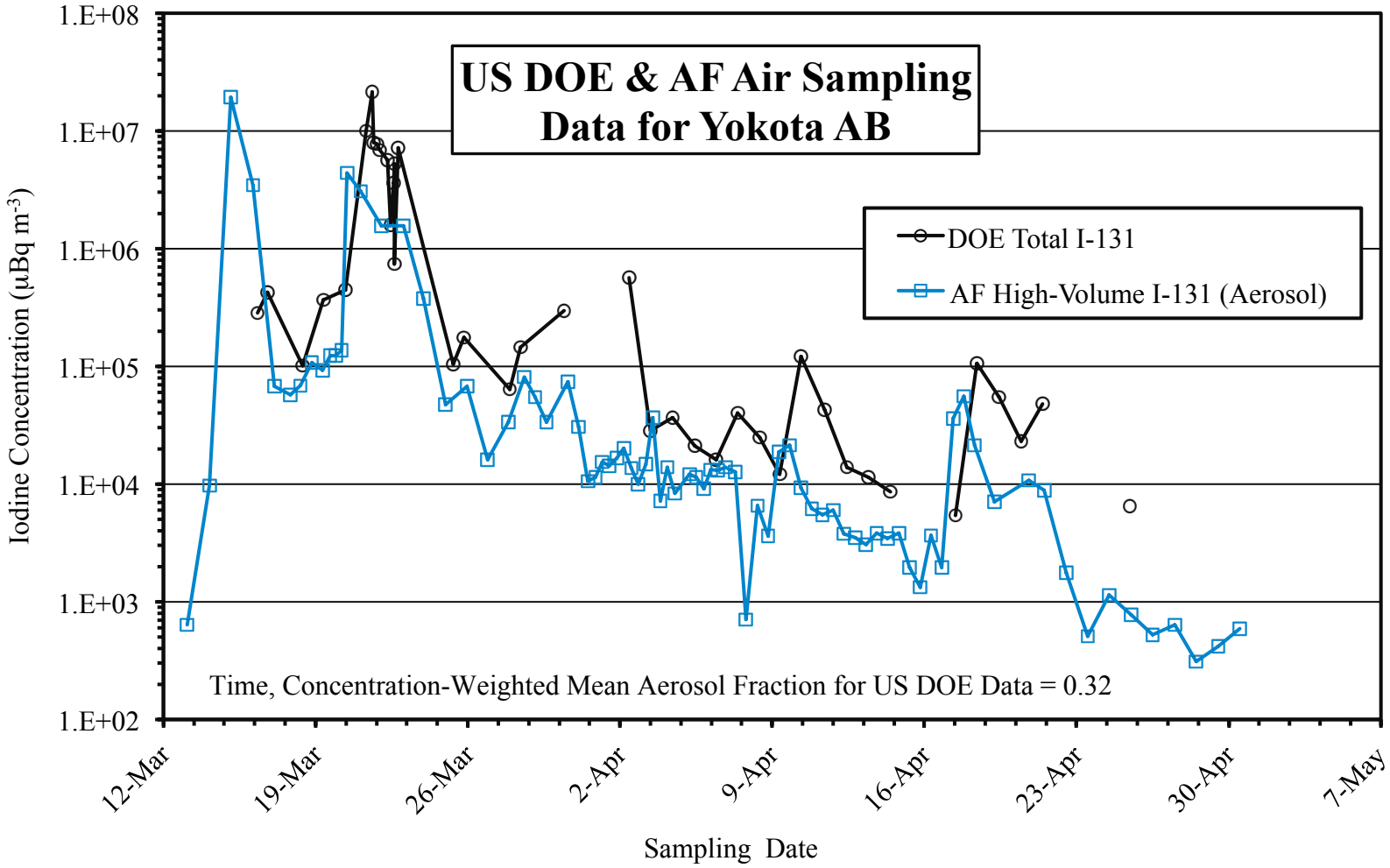
Air Sampling Example



Air Sampling Example



Air Sampling Example

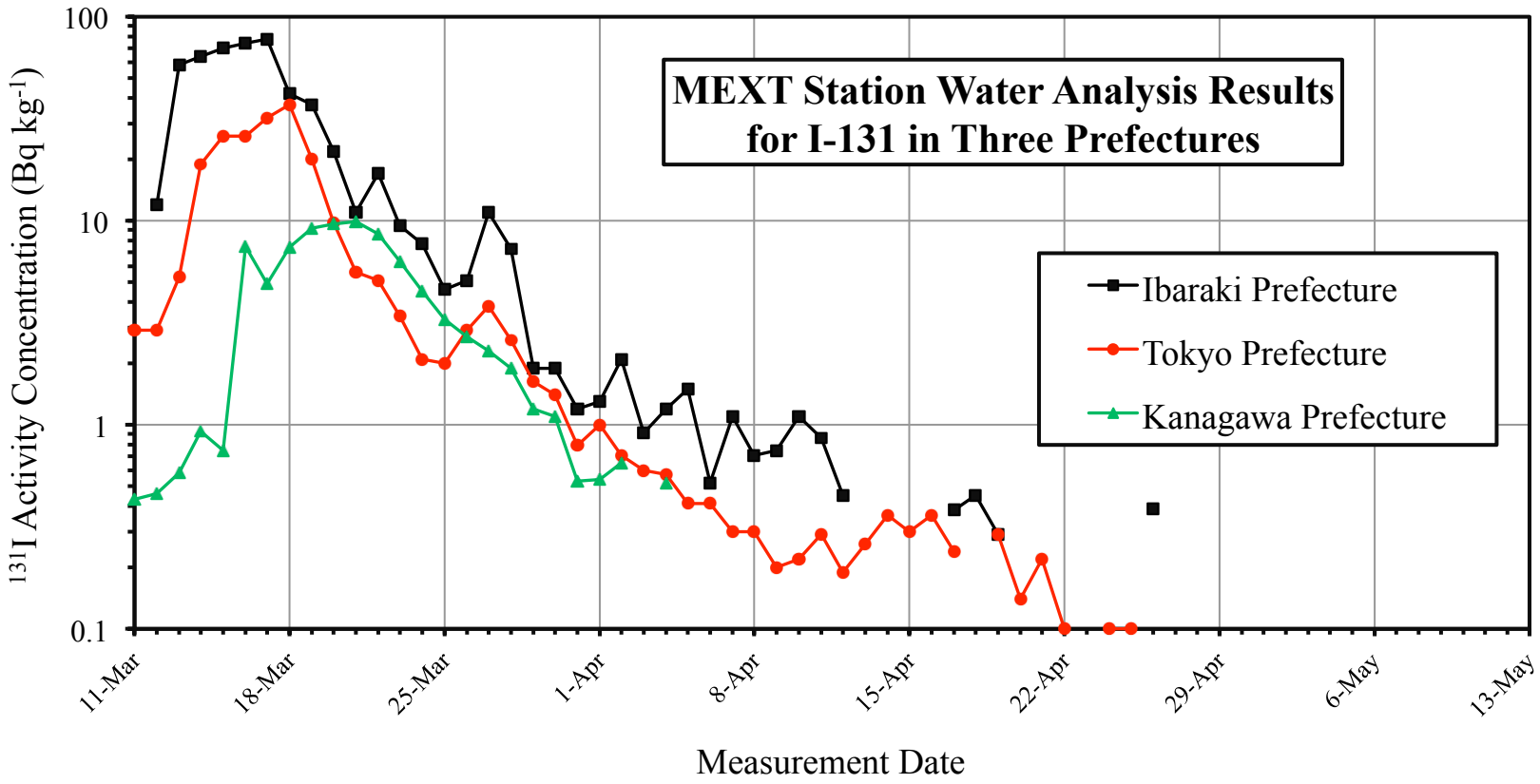


Water Monitoring

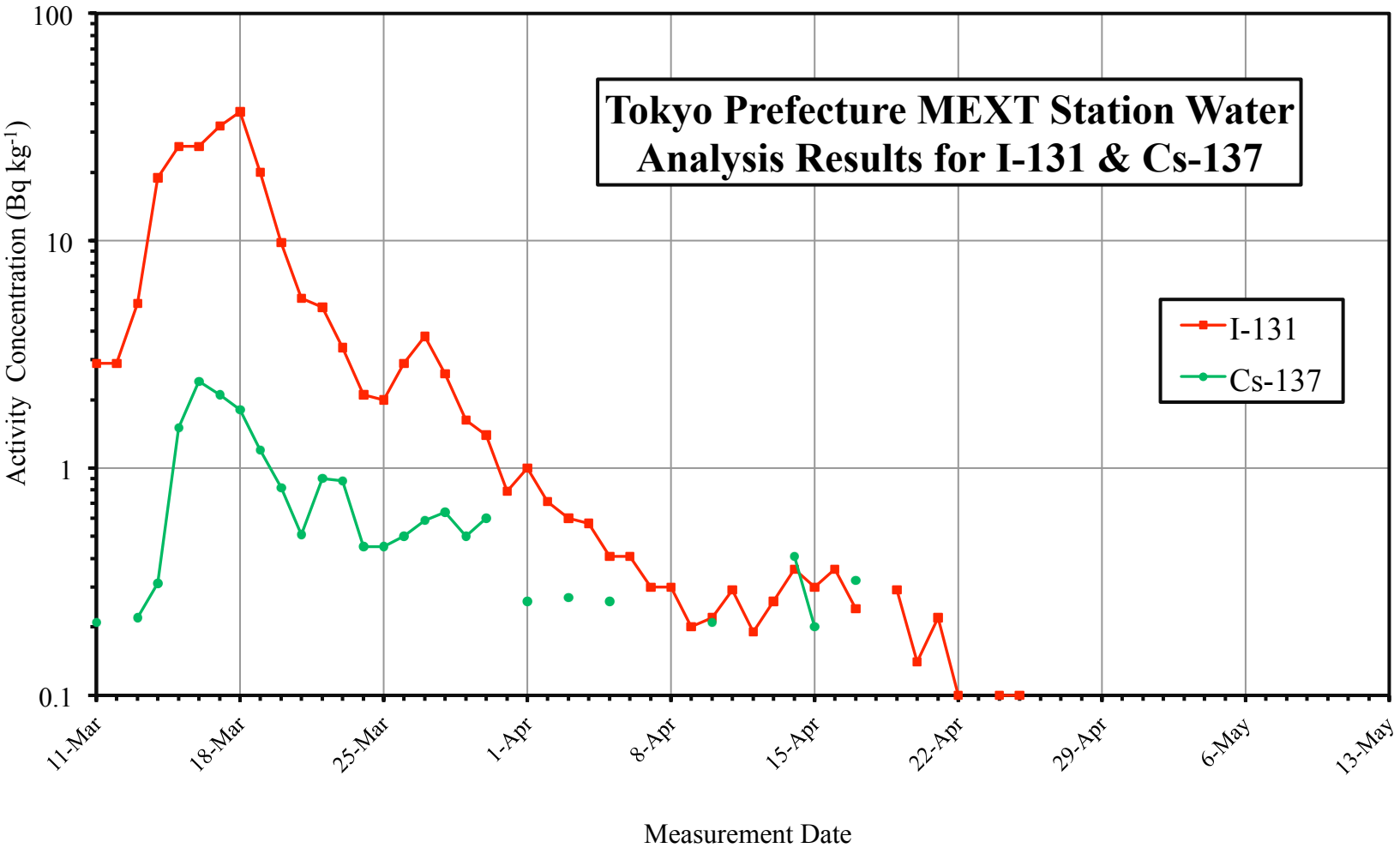
- Drinking water and surface water samples collected at US Forces Japan installations and by Japanese
- Drinking water radionuclide content predictive of intakes to individuals
  - Variables:
    - Multiple sources of drinking water
    - Differences in consumption volumes
- Expected to be a small contribution to individual doses

Water Monitoring

- Some USFJ installation had underground aquifer sources while others relied on municipal source



Water Monitoring



Water Monitoring

- USAFSAM Analysis Results for DOD Samples

Shore Location (DARWG Location Number)	Sampling Dates	Number of Samples	Maximum Concentration (Bq kg^{-1})		
			I-131	Cs-134	Cs-137
Misawa AB (D-1)	Mar 25 - Apr 28	33	< 0.28	< 0.013	< 0.013
Yokota AB (D-8)	Mar 25 - Apr 11	20	0.086	< 0.12	0.073
Yokosuka NB (D-11)	March 25 - May 2	96	8.2	0.32	0.31
Camp Fuji (D-12) & Miscellaneous in Kanagawa Prefecture (D-11)	March 27 - May 2	19	< 15.2	< 0.40	< 0.39
"<" annotates less than minimal detectable activity value					

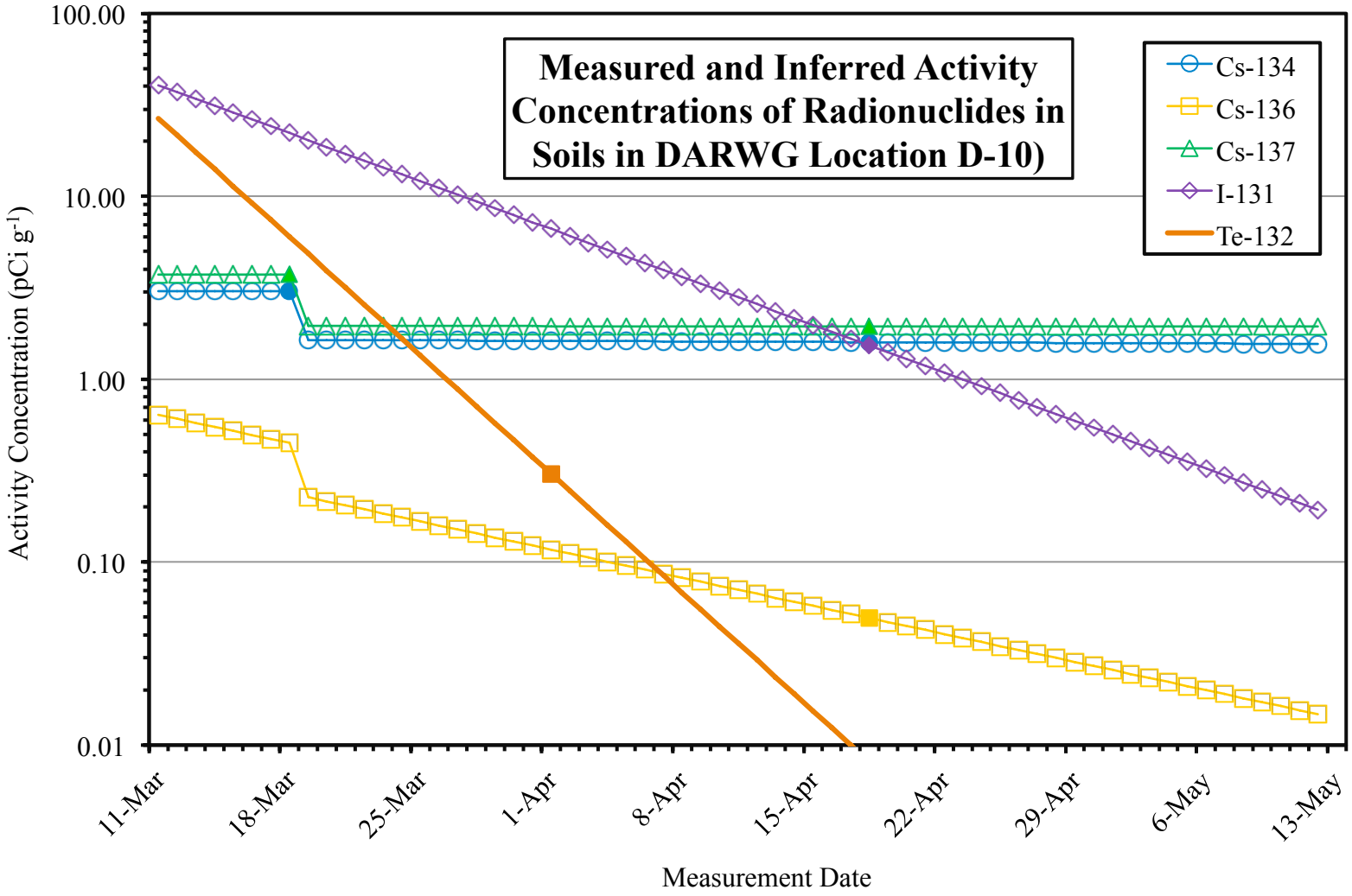
Soil Monitoring

- Surface soil sample collection on US Forces Japan installations
- Analysis
  - AFRAT high-resolution γ-spectroscopy field analysis of some samples
  - CONUS high-resolution γ-spectroscopy at AIPH and USAFSAM
- Radionuclide content of soils indicative of deposition and some relation to previously existing airborne concentrations
- Much smaller sample number than air sampling and external exposure measurements

Soil Monitoring
(Example: Camp Zama/Atsugi NAF)

Sampling Date	Activity Concentration (pCi g^{-1})					Notes
	Cs-134	Cs-136	Cs-137	I-131	Te-132	
18-Mar	3.025		3.75	2.04		AFRAT Collected, Sagama Depot
1-Apr	0.0407		0.0624	0.526	0.024	AFRAT Collected, Atsugi NAF
11-Apr	0.21		0.27	1.43		AFRAT Collected, Atsugi NAF
18-Apr	0.219		0.281	1.044		AFRAT Collected, Atsugi NAF
18-Apr	2.4		2.87	1.47		AFRAT Collected, Sagama Depot
18-Apr	0.953		0.9925	0.811		AFRAT Collected, Sagamihara
18-Apr	3.29		3.87	2.51		AFRAT Collected, Sagama Depot
18-Apr	1.14		1.18	0.92		AFRAT Collected, Sagamihara
18-Apr	0.647		0.9385	0.593		AFRAT Collected at Sagamihara Housing Area
18-Apr	1.07		1.25	1.075		AFRAT Collected at Camp Zama
18-Apr	1.66		1.825	4.38		AFRAT Collected at Camp Zama (High Traffic Area)
18-Apr	5.81	0.173	6.59	3.5		AFRAT Collected, Sagamihara
18-Apr	1.345		1.495	1.47		AFRAT Collected, Sagamihara
18-Apr	1.8		2.2	2.2		AIPH Collected, Camp Zama (High Elevation Area)
18-Apr	0.39		0.51	0.74		AIPH Collected, Camp Zama (High Traffic Area)
18-Apr	0.47		0.74	0.47		AIPH Collected, Camp Zama (Runoff Area)
18-Apr	1.1		1.3	1.5		AIPH Collected, Sagama (High Elevation Area)
18-Apr	0.71		1.4	0.43		AIPH Collected, Sagama (High Traffic Area)
18-Apr	2.3		3.2	2.1		AIPH Collected, Sagama (Runoff Area)
18-Apr	0.94		1.2	1.3		AIPH Collected, Sagamihara (High Elevation Area)
18-Apr	1.4		1.7	1		AIPH Collected, Sagamihara (High Traffic Area)
18-Apr	1.3		1.8	1.1		AIPH Collected, Sagamihara (Runoff Area)

Soil Monitoring
(Example: Atsugi NAF/Camp Zama)



Questions