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In-situ, field gamma spectrometry in a radionuclide air sampler

Dr. Luke Lebel, Kyle Barlow,
Tony Clouthier

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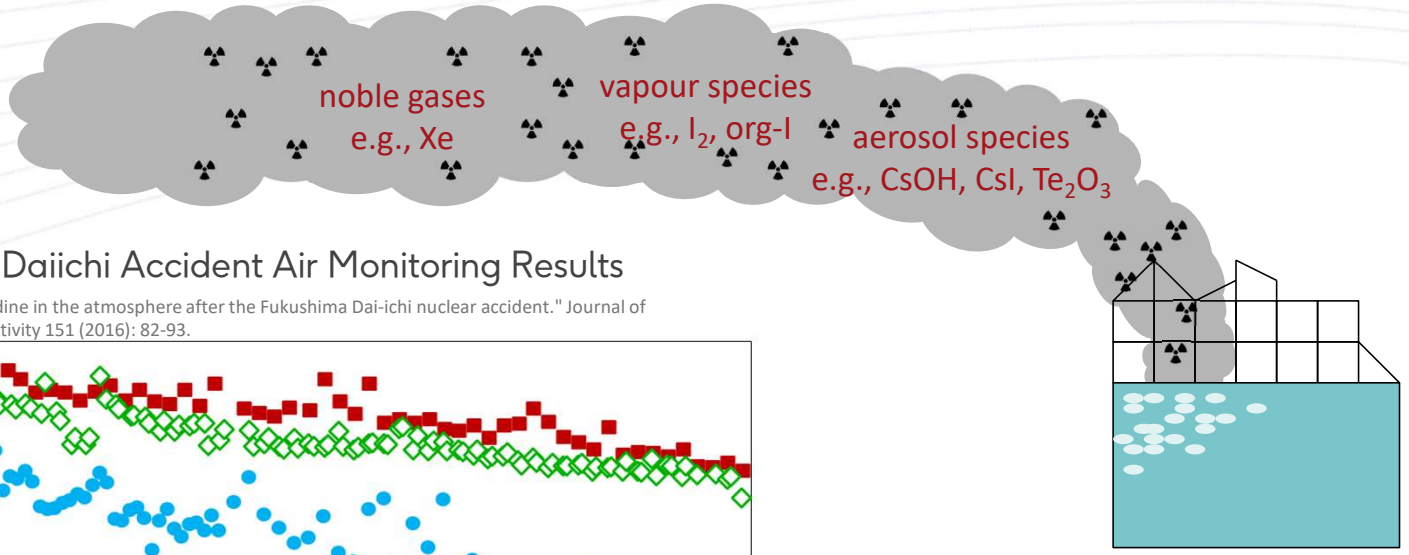
Outline

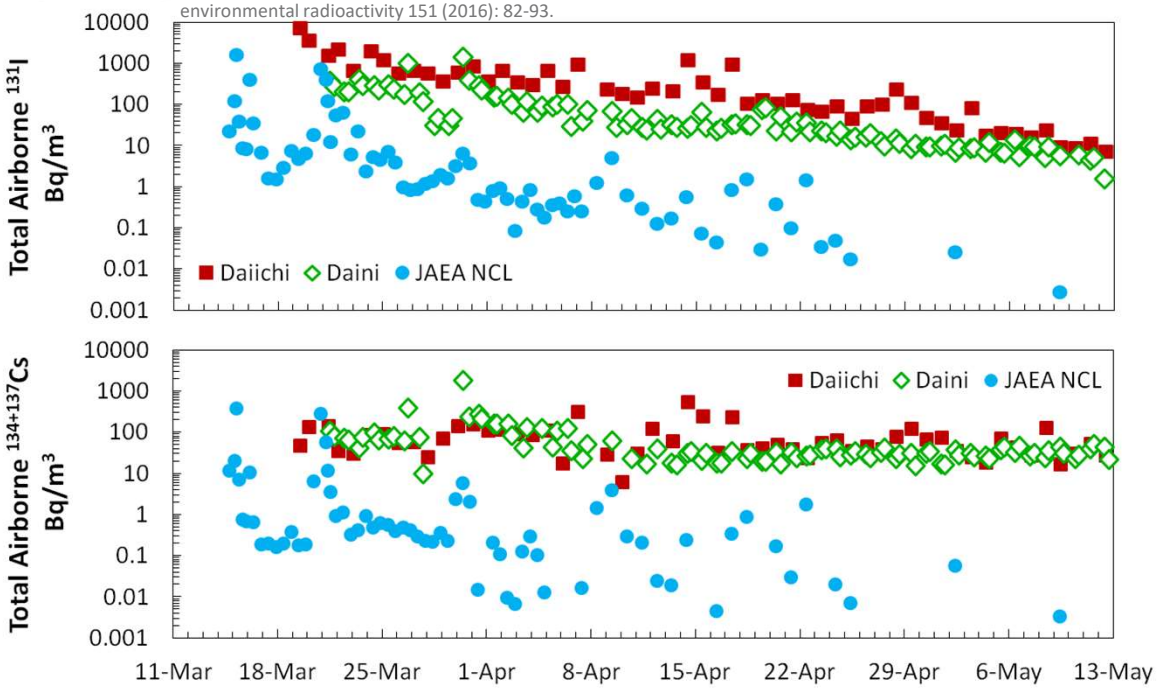
- Motivation
- Air sampler design
- Prototype development

Motivation.



Fukushima Daiichi Accident Air Monitoring Results

[1] Lebel at al., "Radioiodine in the atmosphere after the Fukushima Dai-ichi nuclear accident." Journal of environmental radioactivity 151 (2016): 82-93.



Challenges with Air Monitoring Systems:

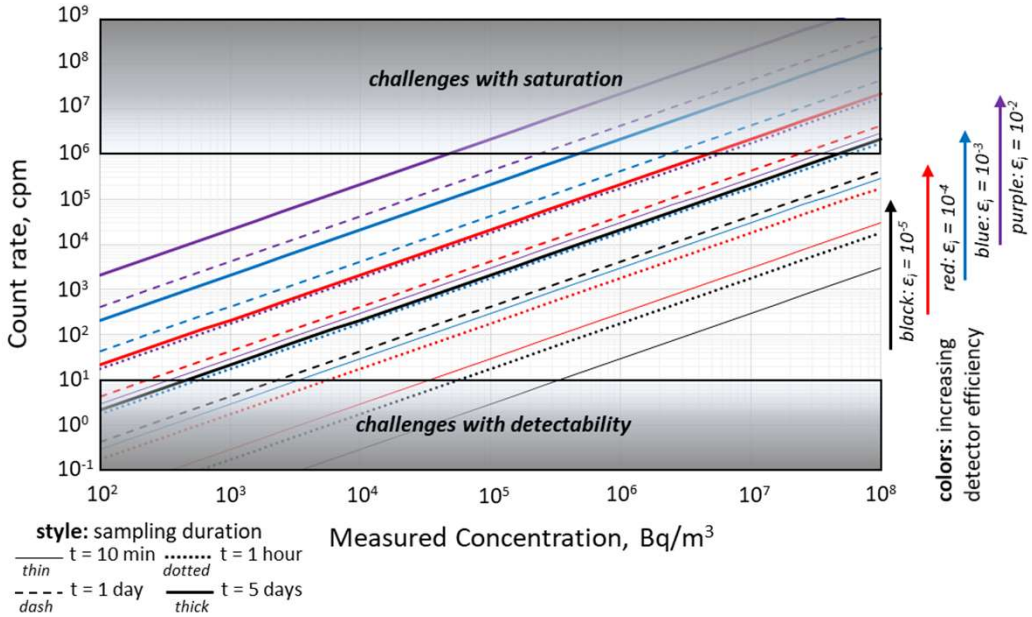
- @ Fukushima, deployment delayed
- Requires human intervention
- Filters analyzed via γ-spectrometry off-site
- No communication of real-time results

Value of Air Monitoring Systems

- Provide information on release compositions
- Dosimetric implications of radionuclide mix
- Indicators of state-of-the-accident

Air sampler design
(with in-situ gamma spectrometer).

Design requirements & operating envelope

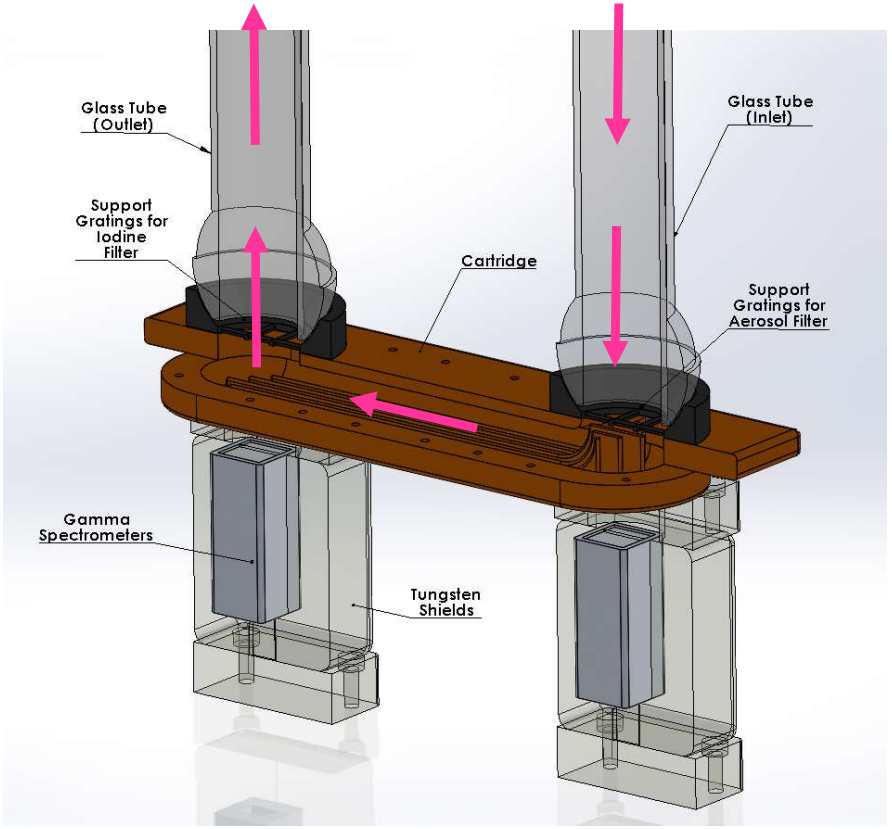


Count rate influenced by sampling flow rate, F, duration, t_f, detector efficiency, ε_i

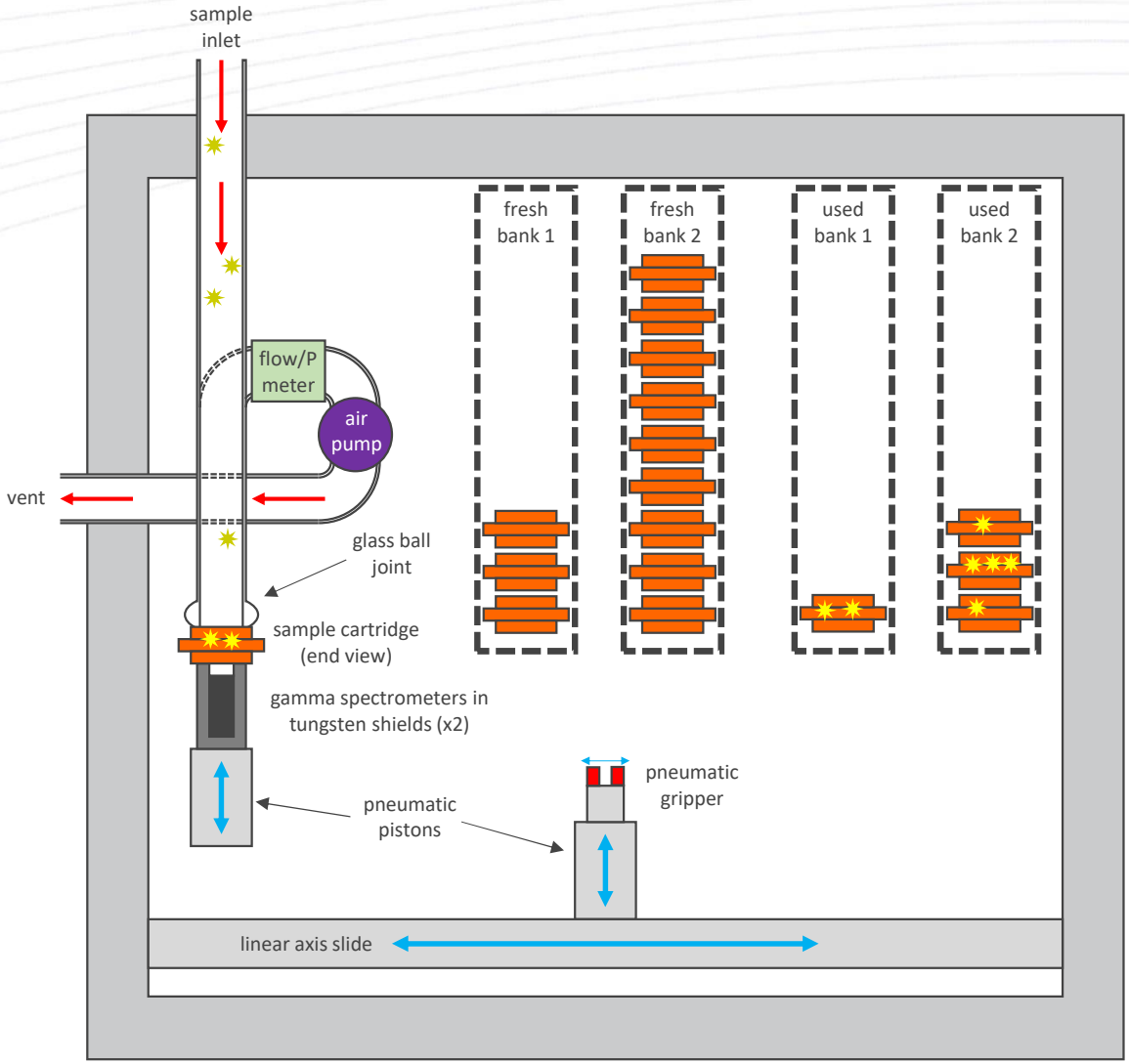
- System enabled by field-deployable, compact CZT γ-spectrometry technology
- Design of air sampling system around CZT spectrometers capable of:
  - In-situ γ-spectrometry of activity collected on filters, with maximized view factor
  - Live, on-line collection of results with capability to communicate back in near real-time
  - Capability to automatically change filters without human intervention, and dynamically adjust sampling duration
- Measure both aerosols + vapor-phase iodine
- Measure airborne activity in the range of 10^2 Bq/m^3 to 10^8 Bq/m^3

Spectrometer and filter cartridge design

- Swappable cartridges containing aerosol and iodine filters mates & seals with flow inlet and outlet
- U-shaped flow path, with internal flow channel in cartridge, with two filters in series
  - aim to maximize view factor of spectrometers
- Dual spectrometers (one each for aerosol & iodine filter) with tungsten shields & collimators

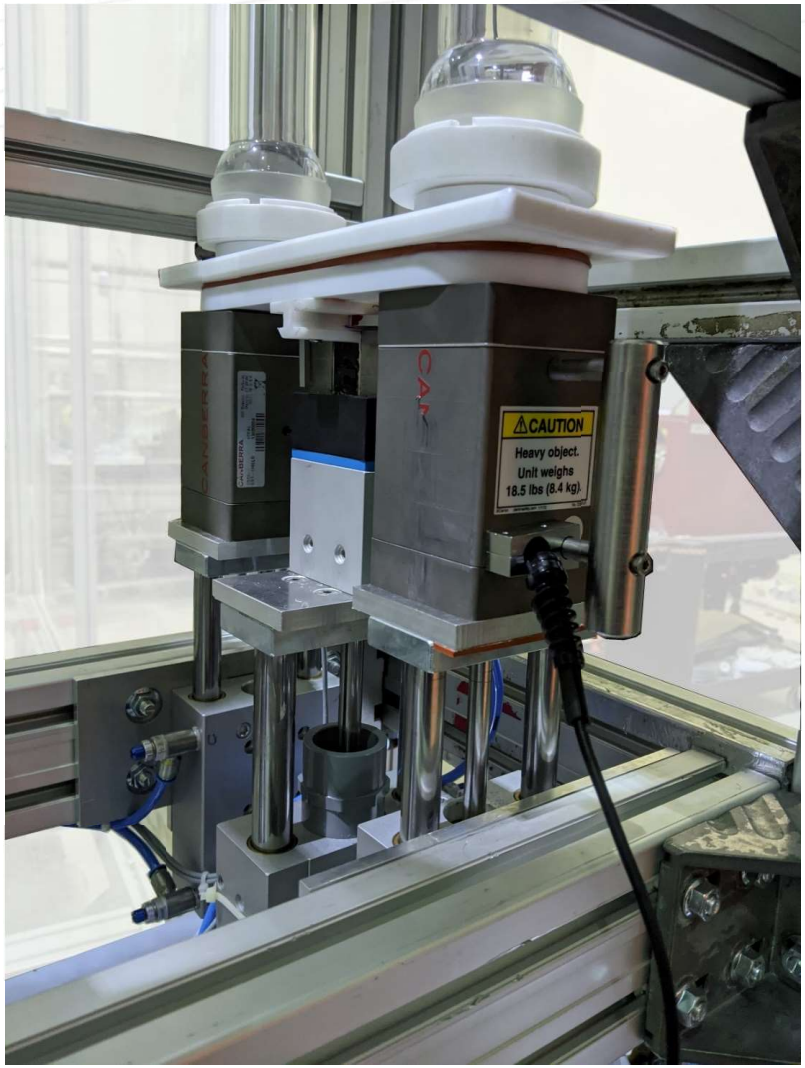


Overall system & automation

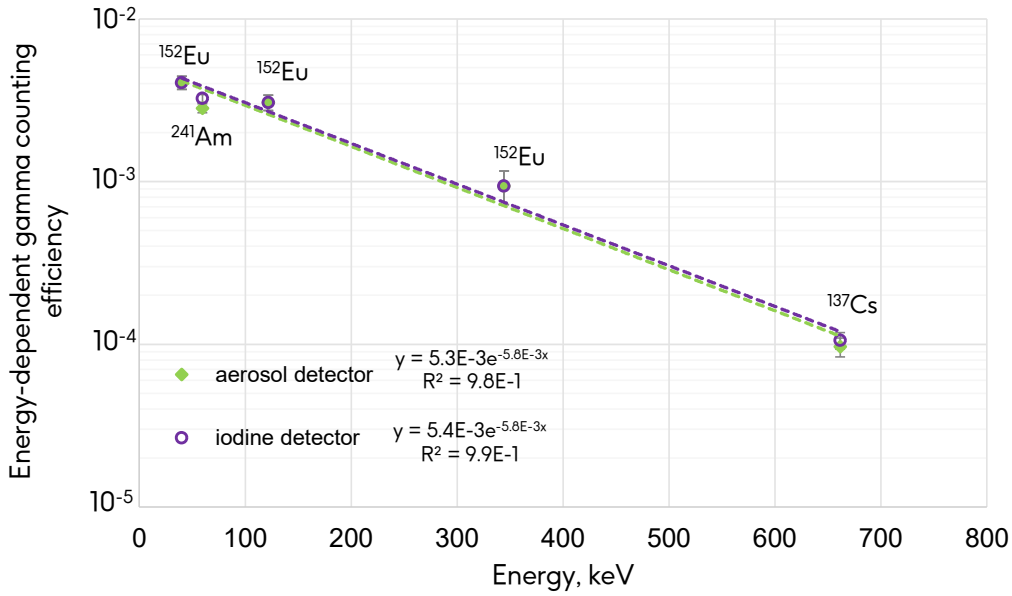


Prototype development.

Prototype system



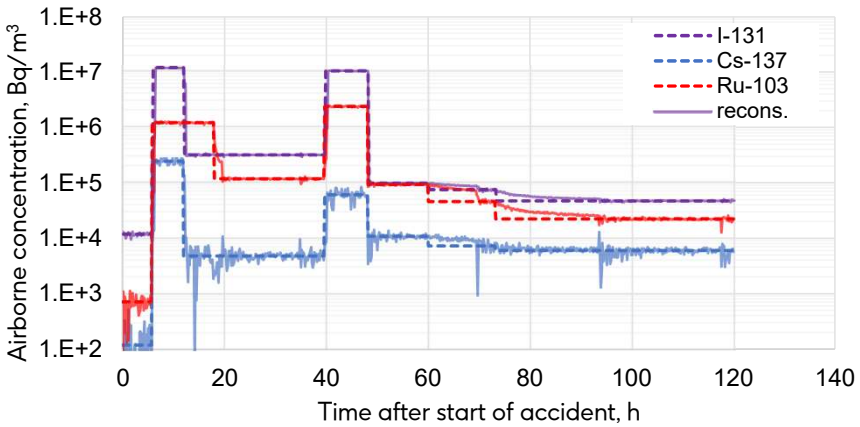
Testing with fixed sources

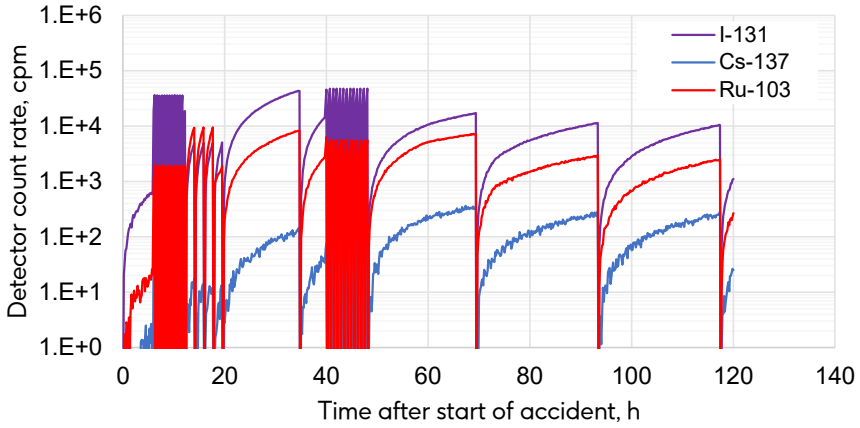


Projected performance during a nuclear emergency

- Simulated outdoor concentrations from a hypothetical accidental release of ^{131}I, ^{137}Cs, and ^{103}Ru
- Projected detector count rates (aerosol filter only) and reconstruction of simulated outdoor concentrations calculated
- Filters changed when sampling time-based criteria met

$$t_{f,max} = \min\left(24\ \text{h}, \frac{\dot{C}_{i,max}}{\dot{C}_i} t_f\right)$$





Conclusions & next steps

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- Significant benefits from air sampling with in-situ γ-spectrometry and live communication of results

- CNL development of design and initial prototype

- Future work:
  - further testing, e.g., live ^{131}I vapor capture demonstration, outdoor demonstration
  - further development of data processing & communication system
  - further development of sampling duration/cartridge changing decision protocols

Thank you

contact information:
Luke.Lebel@cnl.ca