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A small, portable electrostatic precipitation-based radio-aerosol monitor

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INTRODUCTION

METHODS/DATA

RESULTS

CONCLUSION

Atmospheric aerosol collection using electrostatic precipitation promises power consumption roughly one order of magnitude lower than filter-based collection methods

Two bench-top electrostatic precipitation-based (ESP) aerosol collectors built, the 2^{nd} including NaI(Tl) radiation detectors

START

Additional work is needed to improve upon the 32% collection efficiency achieved in a small form factor

Lessons learned are being incorporated into a portable, low-power radio-aerosol monitor

Mechanical design is complete; build of a portable ESP-based radio-aerosol monitor is in progress

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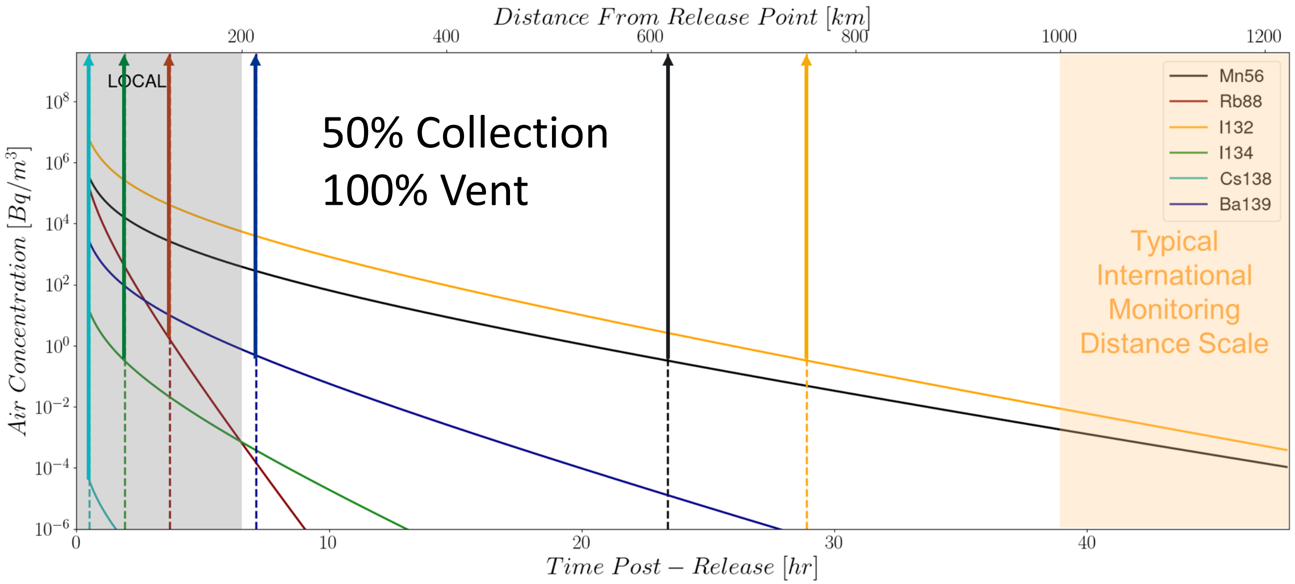
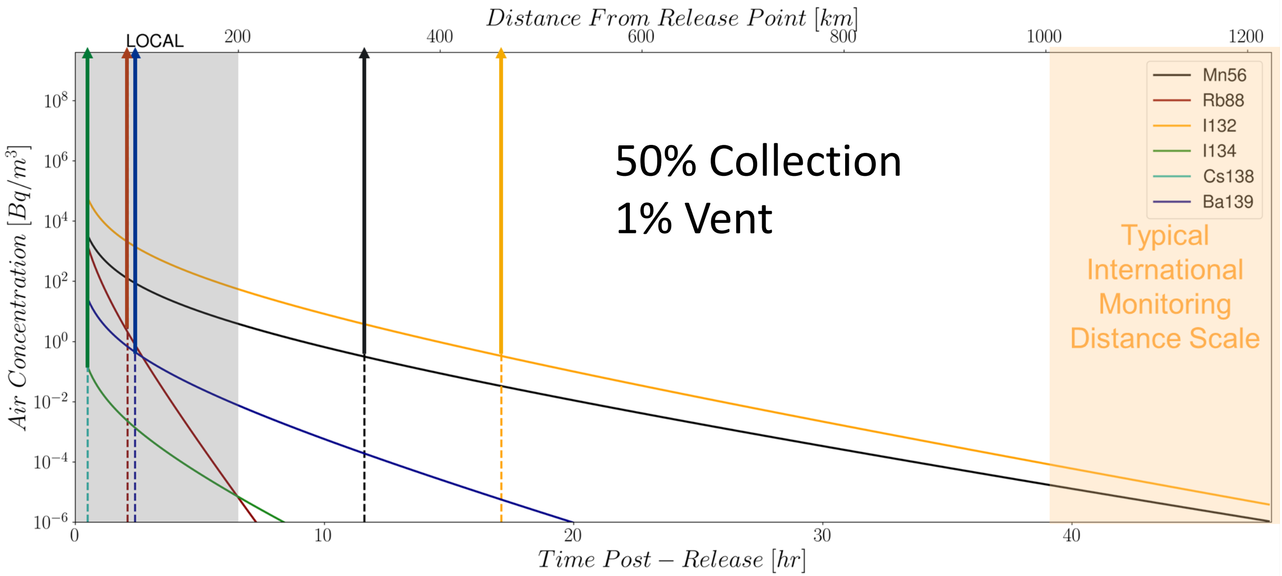
Detection of Short-Lived Isotopes at Local and Regional Scale

- Source term and atmospheric dilution
  - Perkins[1] and Eslinger[2] used to estimate atmospheric concentrations for 1 kT ^{239}Pu burst with 1-day venting delay
- The minimal detectable concentrations (MDCs) were estimated using:
  - A short 10 min collection & measurement
  - 1000 SCM/day flow rate (vs ~1000 SCM/hour in the IMS)
  - Isotope sensitivities based on MCNP calculations & experimental outdoor background at PNNL with 2x2 NaI(Tl)





Goals for a Portable Radio-Aerosol Monitor

- Build an aerosol collector based on electrostatic precipitation (ESP)
- On-board radiation measurement
- Develop a system easily emplaced by field operator, where recovery/return of samples is possible
  - This effort is focused on measurement in-place rather than sample preservation for lab measurement
- Minimal size, weight, and power
- Solar and battery powered
- Components should be capable of field use

<u>Current Targets</u>

Size < 24 × 24 × 11 in
Weight < 40 kg
Power < 100 watts
Automated

INTRODUCTION
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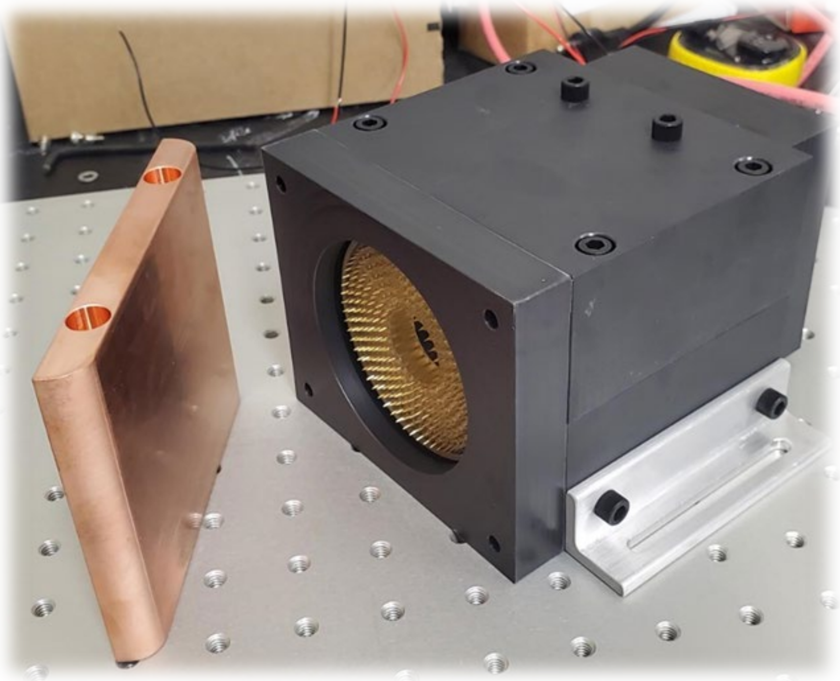
Electrostatic Precipitation (ESP)

An electrostatic precipitator is a device for removing fine aerosols from a gas by charging the particles with electrons from corona discharge and forcing them to a collector using an electric field.



Ground plate and ESP box

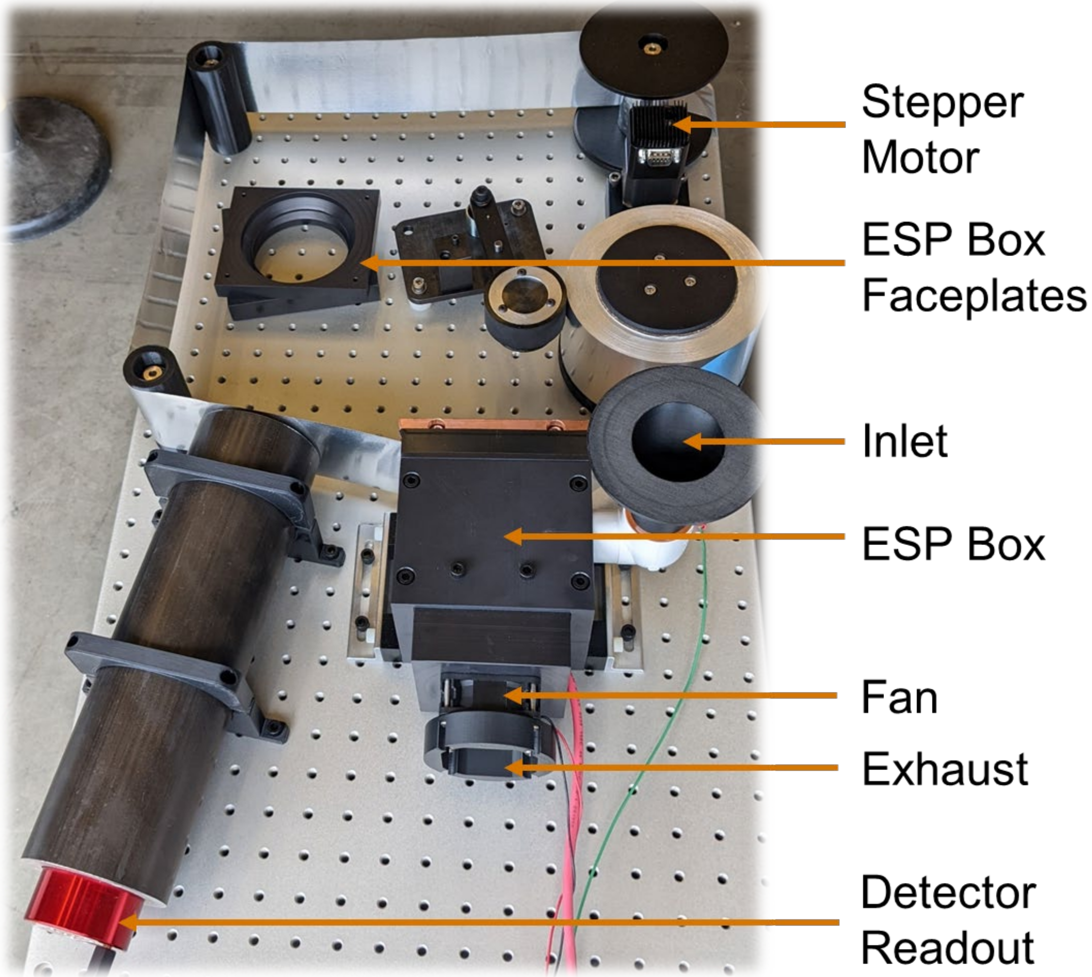
Pin Array

Corona discharge during collections

This ESP consists of a ground plate, an array of pins at high voltage, and a moving collection tape

Laboratory-based Prototype Testing

- Laboratory ESP prototype testing[3,4]
    - Aerosol collection
        - System uses a spool of collection media
        - Preliminary collection efficiency 32 ± 14%
            - Additional work needed to establish higher collection efficiency in small form factor
            - Working to refine collection efficiency measurement method
    - Radiation measurement testing based on collection of atmospheric radon daughter radioisotopes
    - Manual operation
- In Progress
    - Transition from manual lab-based system to portable, automated system

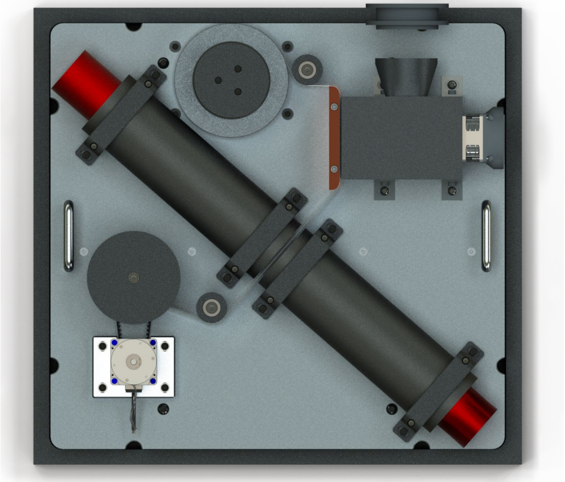


Lab-based prototype

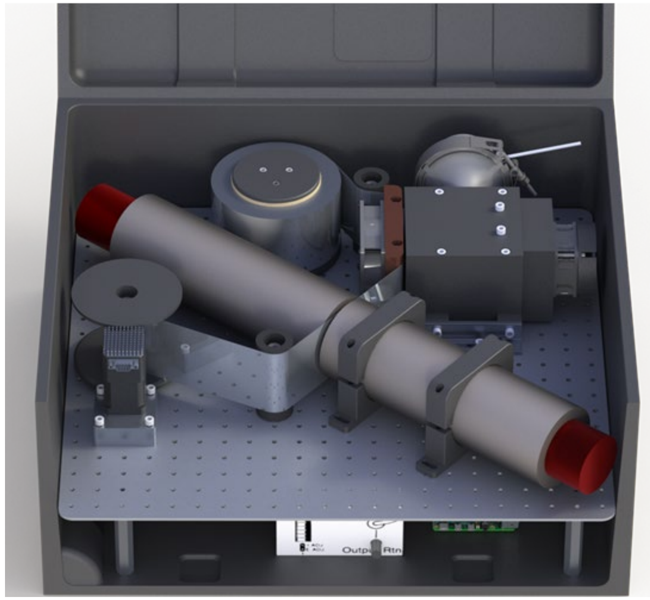
INTRODUCTION
OBJECTIVES
METHODS/DATA
RESULTS
CONCLUSION

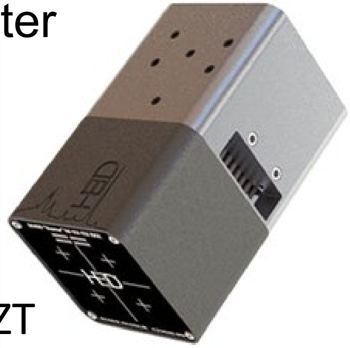
Progress on Portable Radio-Aerosol Monitor

- Mechanical design complete, system build in progress
  - Airflow up to ~2 standard cubic centimeters per minute
  - Optimization of power consumption and aerosol collection per unit time may recommend lower flow rate
- Control system being finalized
  - Based on prior work, e.g. Linux-based data acquisition for gamma spectra
  - Automated collection and gamma spectrum acquisition
- Parameter studies planned: bias voltage, airflow, collection media stand-off from ESP, gamma spectrometer performance (NaI(TI), CeBr, CZT)



Prototype system renders





H3D M400 CZT

INTRODUCTION
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METHODS/DATA
RESULTS
CONCLUSION

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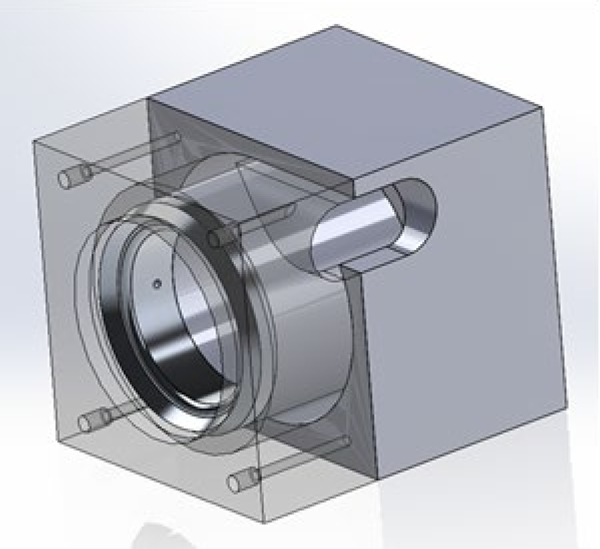
- A portable, low-power ESP-based monitor has the potential for solar/battery operation
- A portable monitor of this type would provide capability to measure radioactive plumes at closer proximity to the source
  - Also useful if plume track will take extended time period to reach fixed-site monitoring stations
- Lab-based prototypes provided valuable insights
  - Small form-factor resulted in lower than desired aerosol collection efficiency (atmospheric radon daughter particle size distribution)
  - Testing alternate designs for aerosol charging and collection field generation
- Portable prototype is in progress
  - Incorporating lessons-learned from lab prototypes



Modified design for electric field generation to be tested in portable version

References

1. Eslinger et. al. "Atmospheric plume progression as a function of time and distance from the release point for radioactive isotopes", JER 148 (2015) 123-129
2. Perkins and Jenquin, "Fission and Activation Products in Nuclear Reactor Fuels and Nuclear Explosion Debris", PNNL-11554 Rev. 1, April 1997
3. Moore, *et. al.* "Atmospheric radon progeny collection efficiency studies of an electrostatic precipitator, submitted to the Journal of Environmental Radioactivity (JER)

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