RESEARCH & DEVELOPMENT

Creare®

# Electrostatic Precipitation System for Radionuclide Particle Collection

## DOE DNN R&D SBIR

**June 15, 2019**

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**Patrick Magari**



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## DISCLAIMER



## Acknowledgment

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## Disclaimer

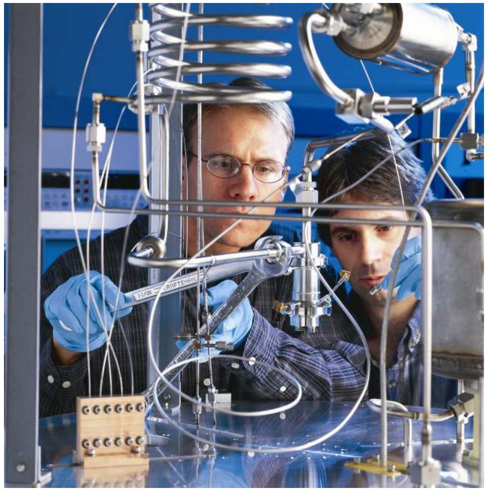
# About Creare

## Creare's Mission

- Creare means "*to create*"
- Creare engineers *create value* by:
  - Helping our clients solve their most difficult problems
  - Developing innovative new technologies
  - Applying new technologies to clients' products, systems, and processes
  - Commercializing new technologies and developing new products

## Core Expertise

- Thermal & Fluid Engineering
- Technology Innovation
- Cryogenics and Power Systems
- Innovative Fabrication and Manufacturing



## Our People

- Diverse technical expertise
- Over 70 engineers including mechanical, electrical, materials, aerospace, and software
- Highly skilled technicians, machinists, and designers

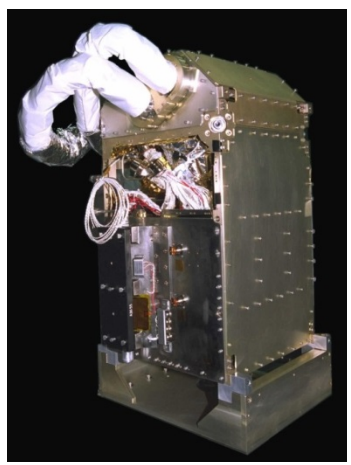
## Customers

- Federal: DOE, Navy, Air Force, Army, DTRA, NASA, and NIH
- Commercial: Large and small businesses, both domestic and international

# Creare Capabilities

- **Our Facilities**
  - 60,000 sq. ft. office/laboratory/shop, plus 20,000 sq. ft. shared with affiliate
  - Capabilities range from micromachining to running large outdoor experiments
  - Wide range of in-house fabrication facilities include precision machining, laser welding, vacuum brazing, EDM, and thin-film deposition
  - Electronics lab, clean room, environmental chambers, inspection lab, thermal vacuum systems
- **Established Record of Technology Transition**
  - Hubble Space Telescope Cryocooler
  - Mars Curiosity Rover Miniature Vacuum Pumps
  - Compact Swaging Machine for Aircraft Carriers
  - Multiple Spin-off Companies and Technology Licenses


*Miniature Vacuum Pumps on Mars Curiosity Rover*

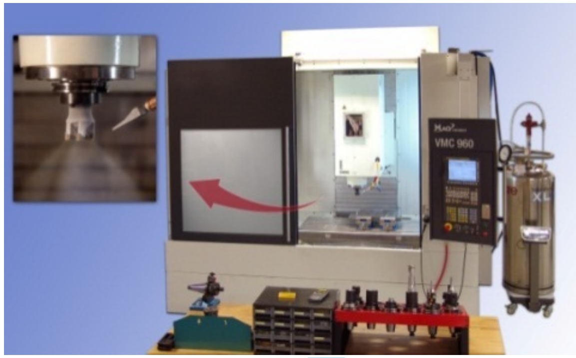


*NICMOS Cryocooler System on Hubble Space Telescope*


*Cryogenic Machining*

*Compact Swaging Machine*

# Technology Licensing




5ME

**Part of Over $1B in Commercialization Revenue From Creare SBIR Projects**

PHILLIPS SCREW COMPANY
INNOVATION IN FASTENER TECHNOLOGY

- **Anti-Corrosion Coverings**
  - Shield Technologies Corporation
- **Machine Tool Cooling Systems**
  - MAG Industrial Automation
- **Aerosol Drug Delivery Devices**
  - AerovectRx Corporation
  - NASA/NIH funding
- **MorTorq® Threaded Fasteners**
  - Phillips Screw Company
  - Used for Space Shuttle viewports, advanced gas turbine engines

# Radionuclide Aerosol Collection

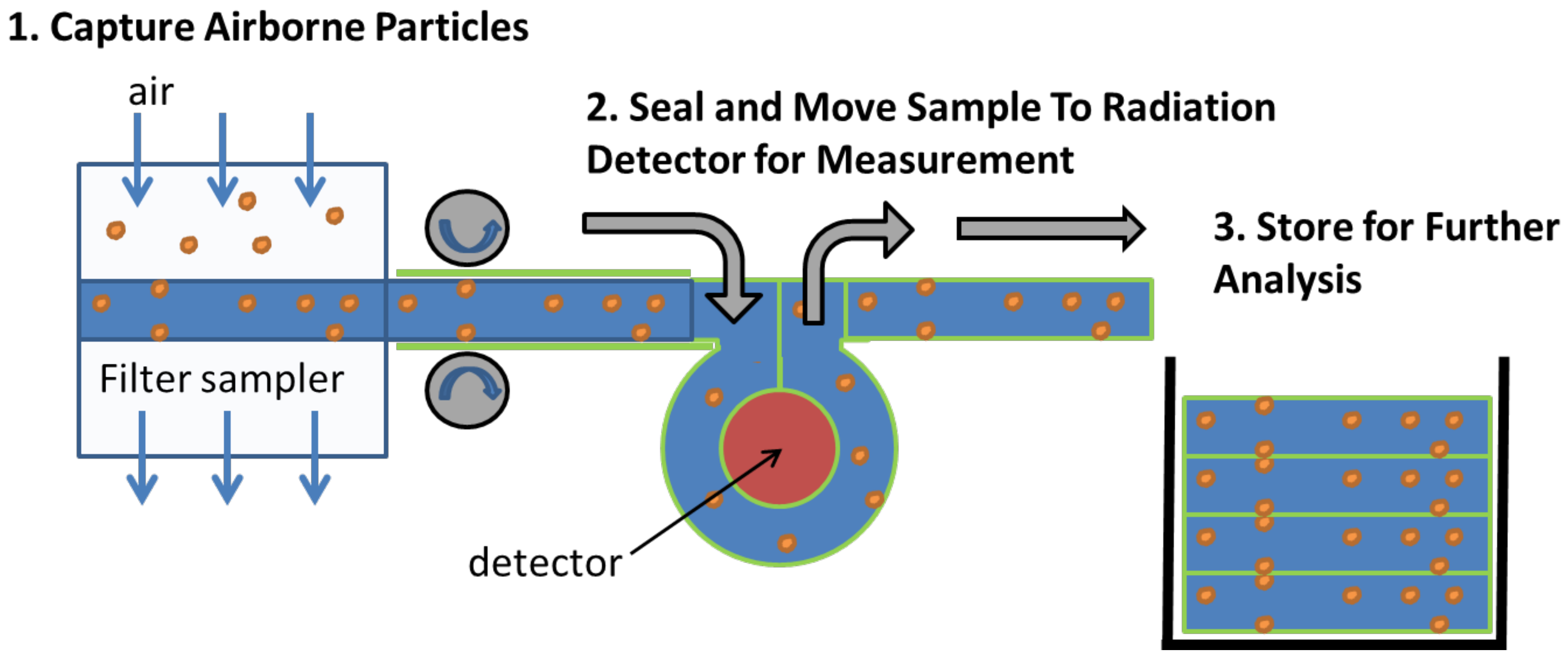
- **International Monitoring System Radionuclide Stations**
  - Each station includes Radionuclide Particulate Monitoring
  - Existing system is the Radionuclide Aerosol Sampler/Analyzer (RASA)
  - Samples captured in a filter-paper collector over 24-hour sample period (batch process)
  - Decay of fission isotopes are measured with gamma-ray spectrometry: provides positive proof of nuclear detonation
  - Samples are archived for physical analysis if desired

- **Challenges for Current Systems**
  - Power Consumption
    - Some sites are limited in power access
    - Filter based approach requires high blower power due to large ΔP across filter
  - Sensitivity
    - Blower power limits air flow rate and total sample quantity
    - Creating more compact samples will increase detection sensitivity
    - Environments with high background radiation limit detection– some locations operate barely above minimum detection sensitivity due to limited sample collection

Radionuclide Monitoring Station Locations- 63/80 certified.
https://www.ctbto.org/map/

# Radionuclide Aerosol Collection

- **Improvements Needed to Existing System:**
  - **Reduce Power (Existing System Uses 3 hp Blower)**
  - **Capture More Particles (Increase Detection Sensitivity)**
  - **Reduce Sample Size (Increase Detection Sensitivity)**
  - **Minimize Sample Cross-Contamination**



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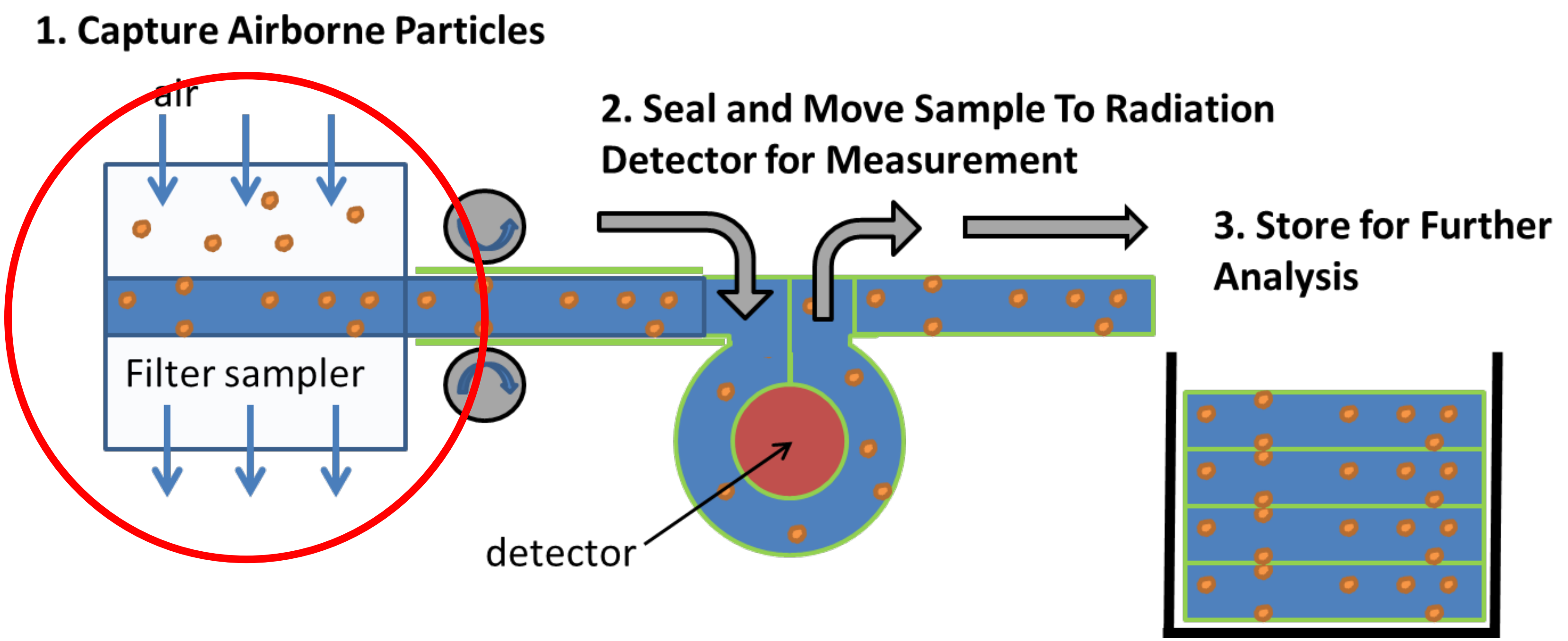

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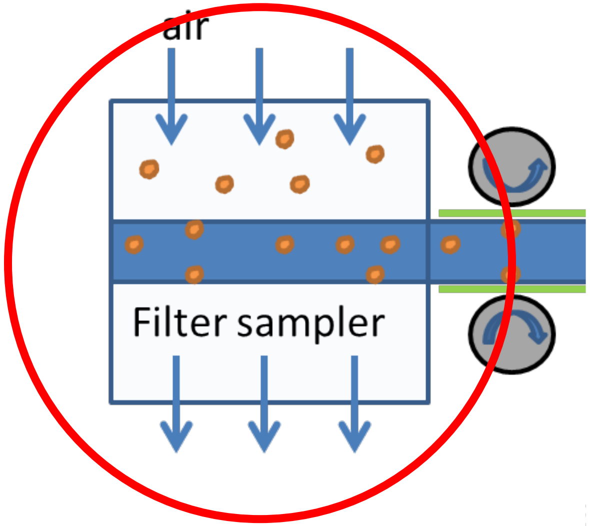
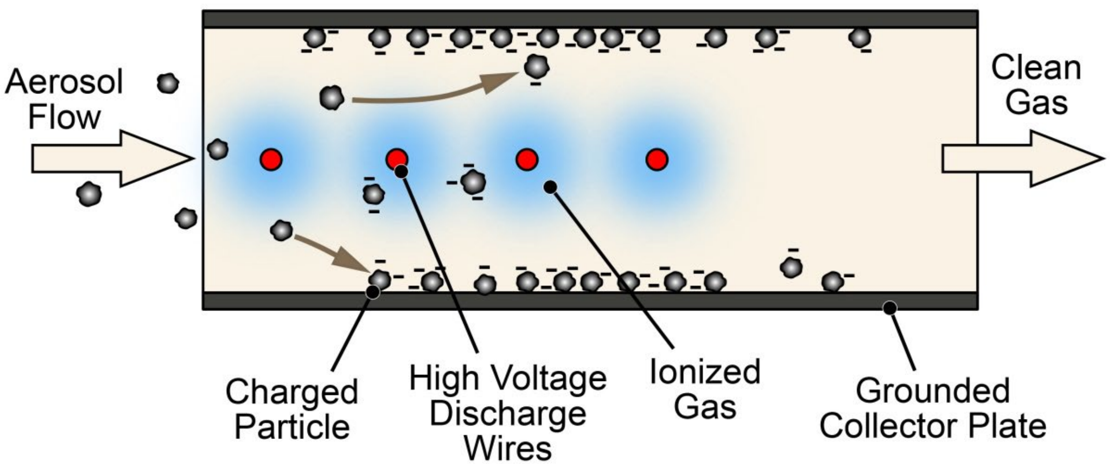
**1. Capture Airborne Particles**

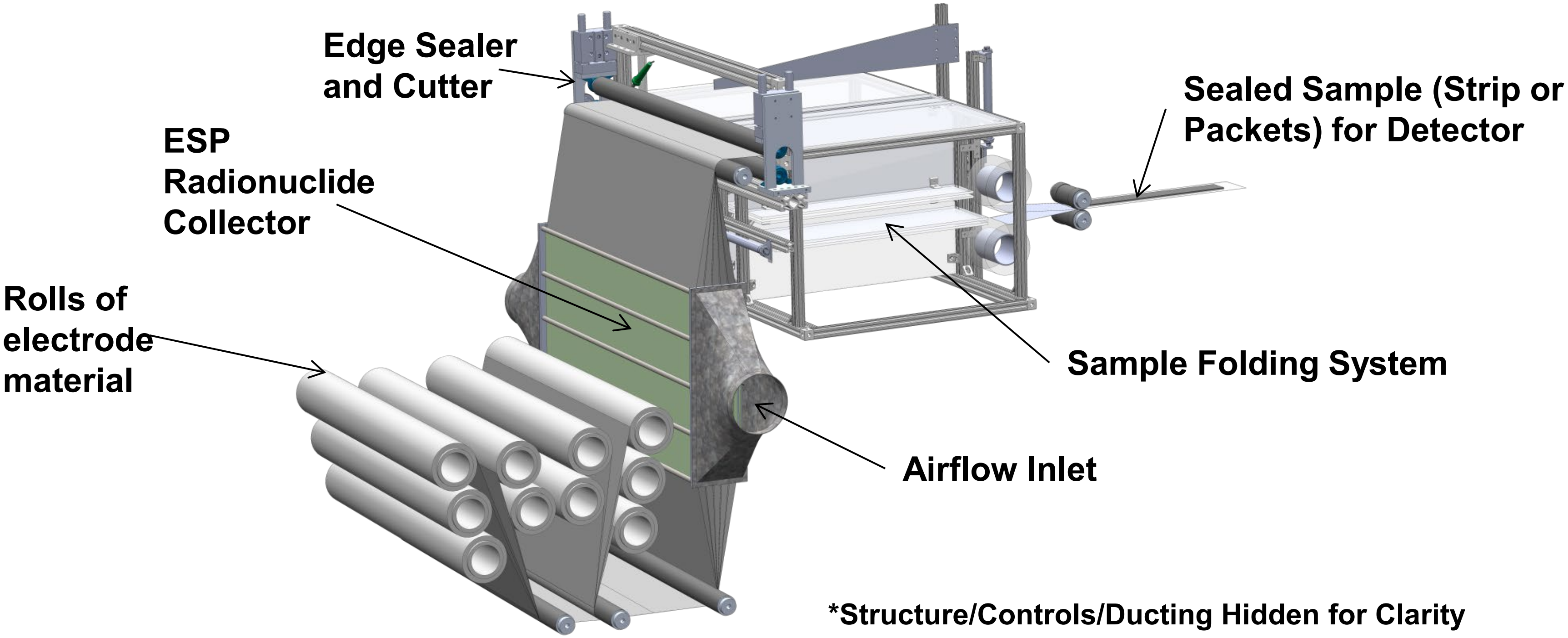



**Electrostatic Precipitator**



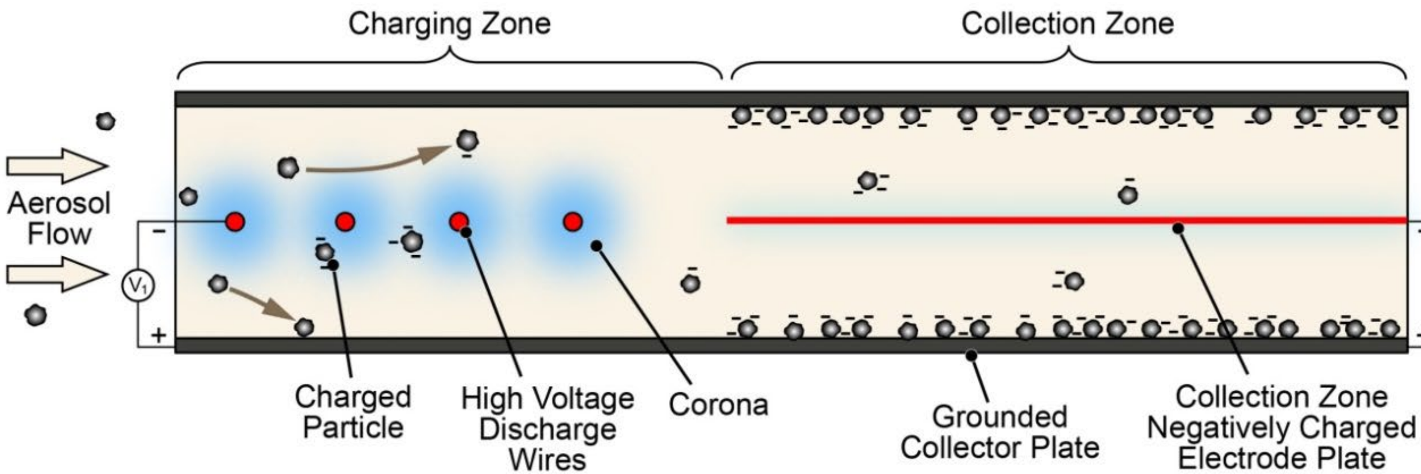
# Radionuclide Aerosol Collection

- **Creare's Radionuclide Sampling System*:**
  - Flexible Electrode Sheets Collect Particles in ESP
  - Roll-to-Roll Process Seals and Folds Sheets and Presents to Detector
  - Enables up to 10x Power Reduction
  - Increase in Instrument Sensitivity through 2x–3x More Sample Mass Collection and Smaller Sample Sizes
  - Flexible Design Configuration Allows Modification for Different Mission Requirements




*Structure/Controls/Ducting Hidden for Clarity

# Electrostatic Precipitation




**Two-Stage Electrostatic Precipitator Configuration**

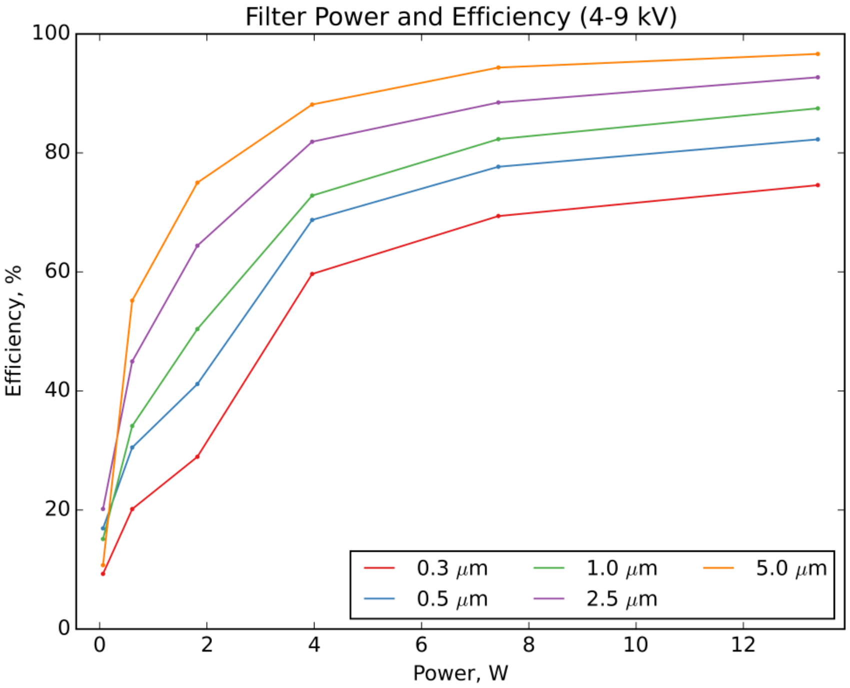

ESP systems can achieve very high collection efficiencies (>99.5%) across a wide range of particle sizes: 30 nm to >100 µm

# Phase II Progress: Subscale Testing

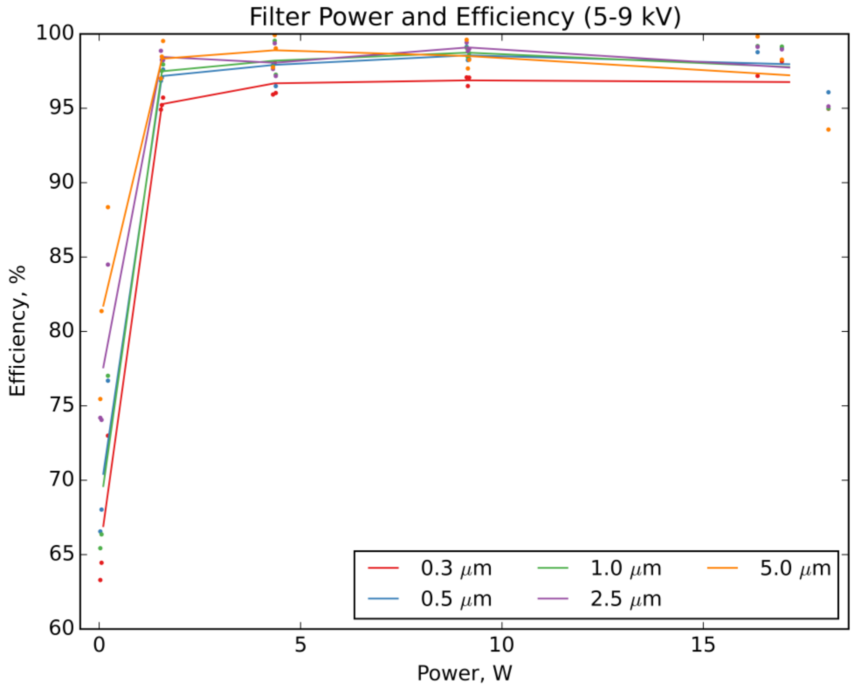
- **Goals:**
  - Obtain additional data for optimization of ESP performance
  - Determine long-term stability of ESP operation and sampling medium (ensure 24-hour sample time)
- **Recent Work:**
  - Finalized the charging wire configuration
  - Implemented two-stage configuration to increase particle collection efficiency while reducing ESP power
  - Finalized ESP channel geometry for full-scale prototype

# Phase II Progress: Subscale Testing

**4-Wire Configuration**



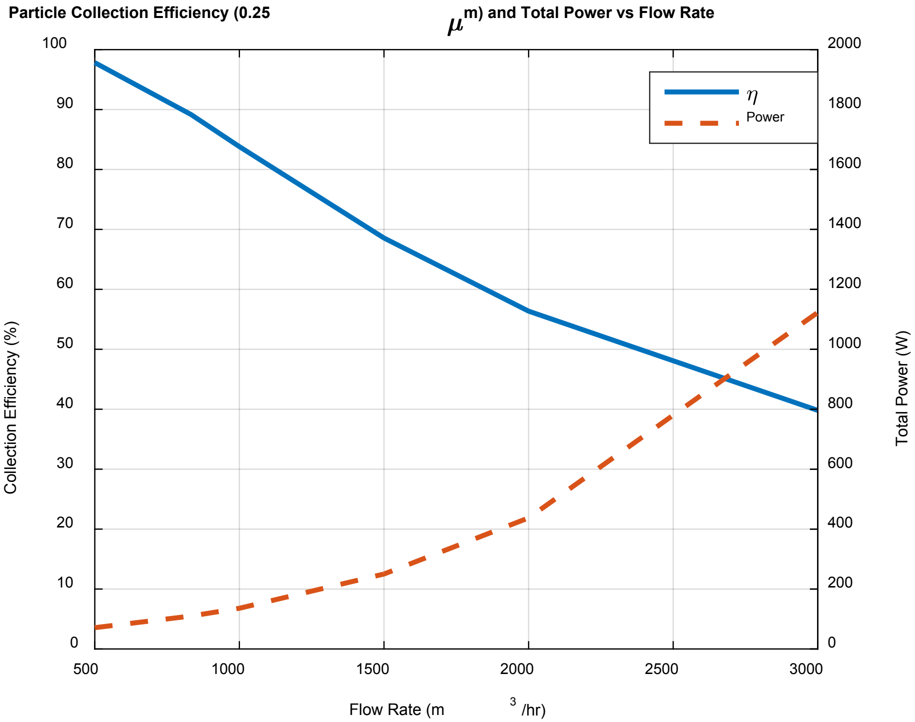

**12-Wire, Two-Stage Configuration**

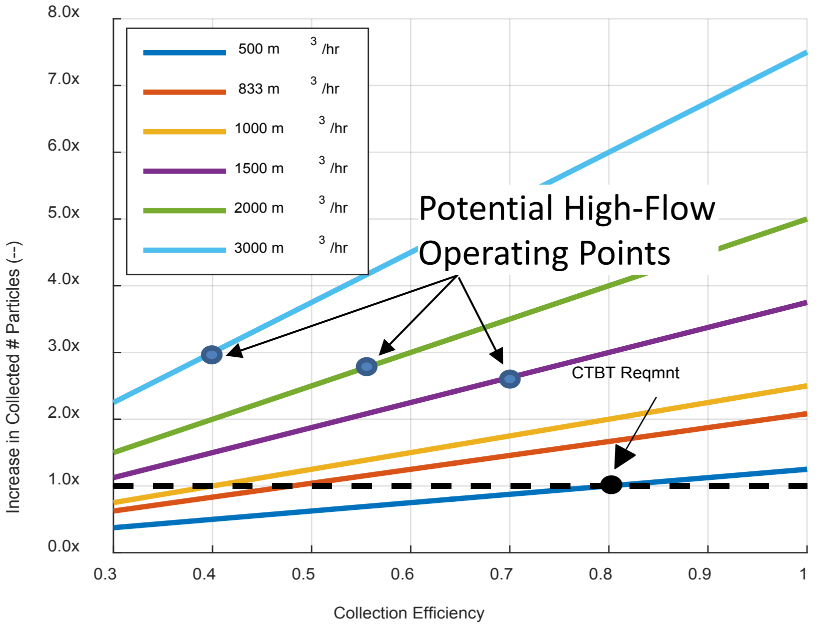



- **Significant improvement in particle collection efficiency for a given power**
- **Results have informed the full-scale sizing and operating parameters**
- **Subscale experimental results showing better collection performance than model predictions**

# Phase II Progress: Full-Scale Performance Prediction

- **Updated design model to include two-stage ESP configuration**
- **General trends useful for full-scale design:**
  - **Can achieve high collection efficiency at lower voltages on charging wires**
  - **Low overall predicted system power consumption (5x–10x less power than RASA system)**

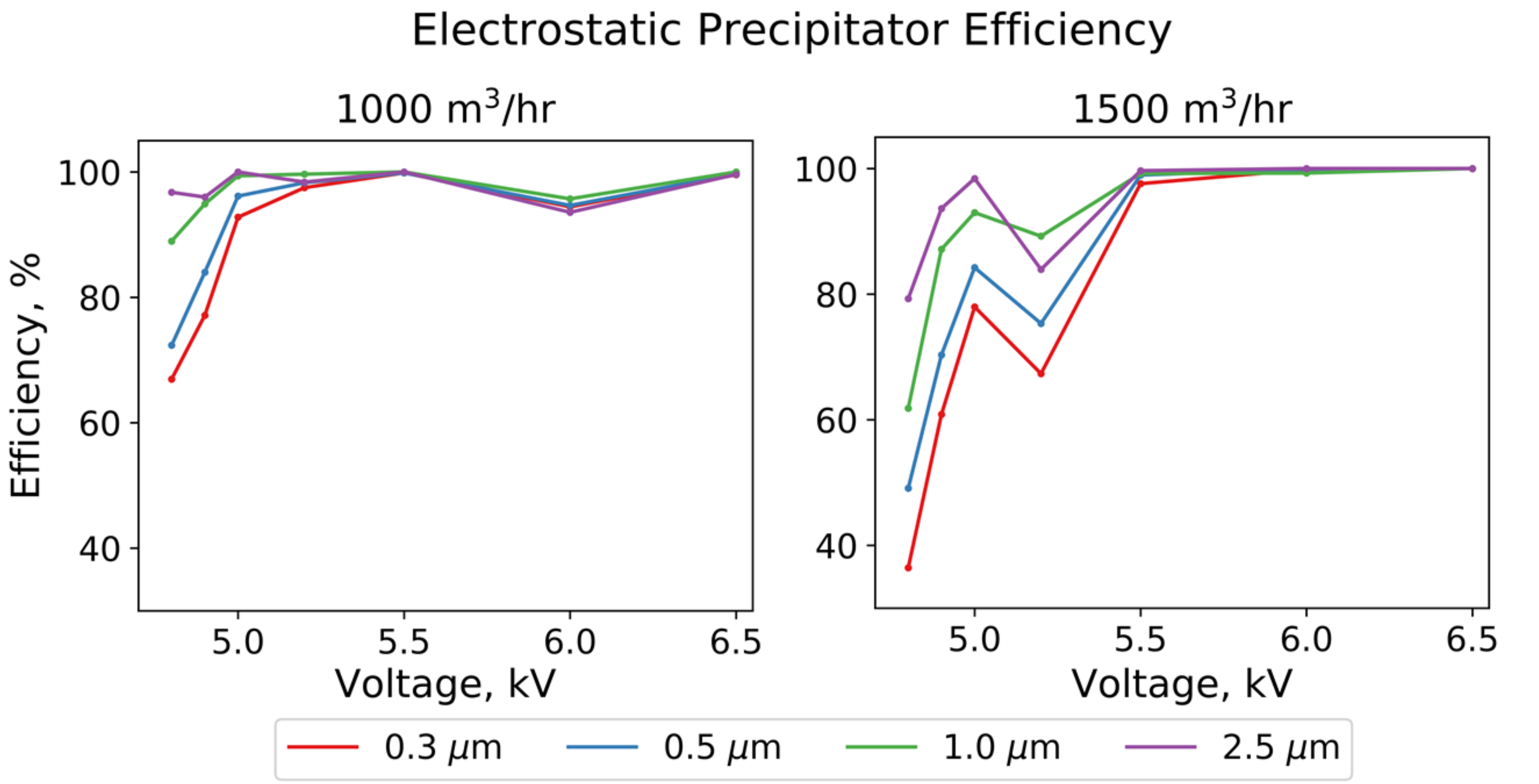



- **At higher flow rates, even if η drops to 50%–60%, still achieves significant gains in overall collected sample quantity: increase in sensitivity**

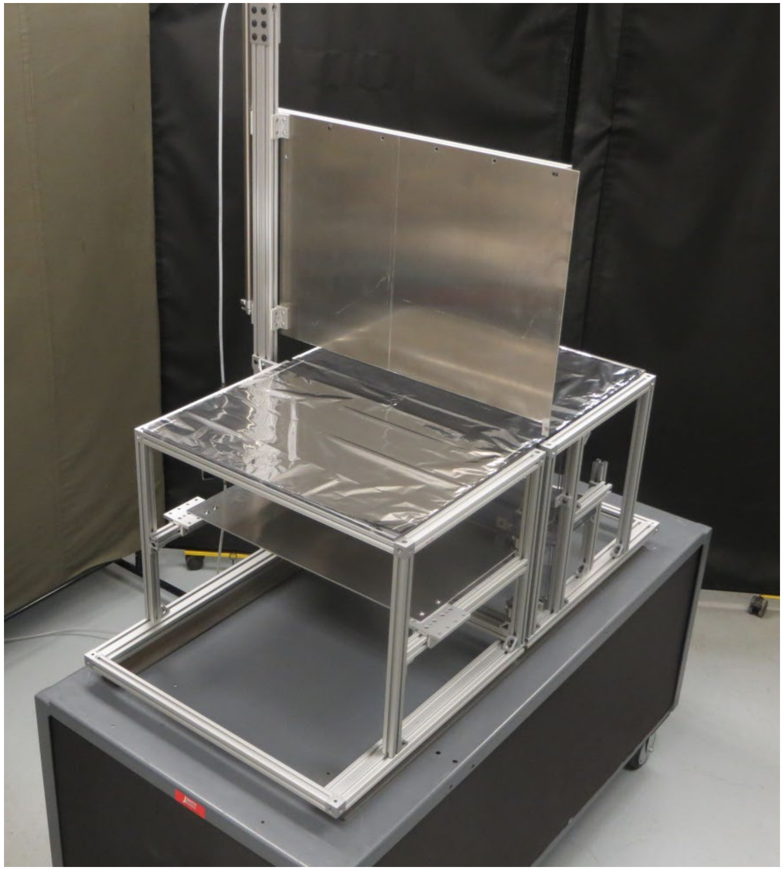
# Phase II Progress: Full-Scale Experimental Results

- **Initial Results from Full-Scale Prototype System**



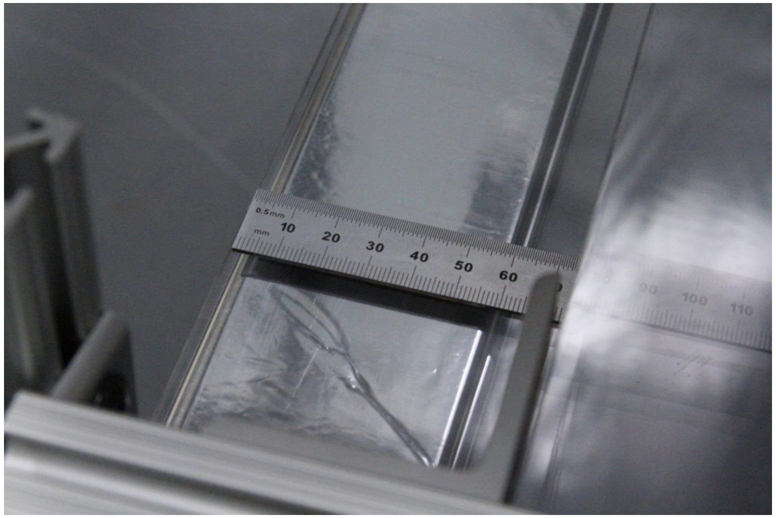
# Phase II Progress: Sample Handling System

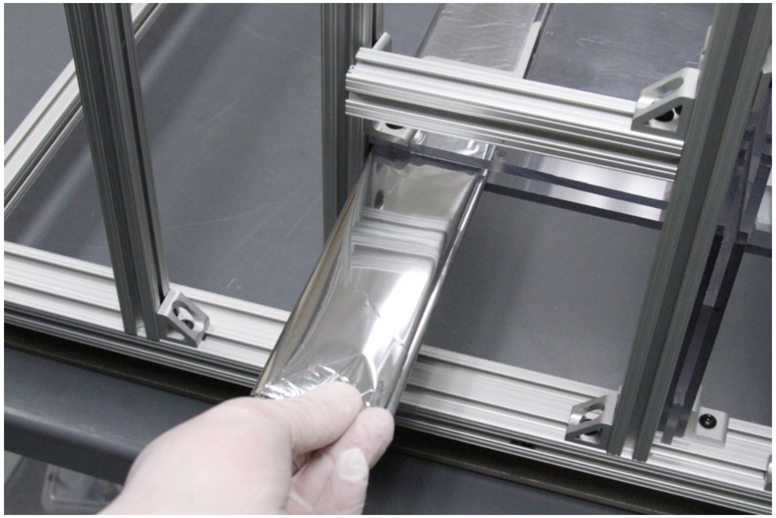
- **Goals:**
  - To seal and fold sample, integrate with detector, and spool to storage
  - Folding system must reduce sheets to strip <10 cm wide x 40 cm long (RASA Sample Size)



- **Recent Progress: Discrete Folding**
  - Cutting into discrete sample sections
  - Successive multiple folds of the sheet length to achieve ~5.6 cm x 40 cm strip
  - Adhesive seal samples to produce continuous web to wrap around the detector
  - Option to add additional folds to make a ~5.6 cm x 5 cm x 2 cm puck for alternative detector interface

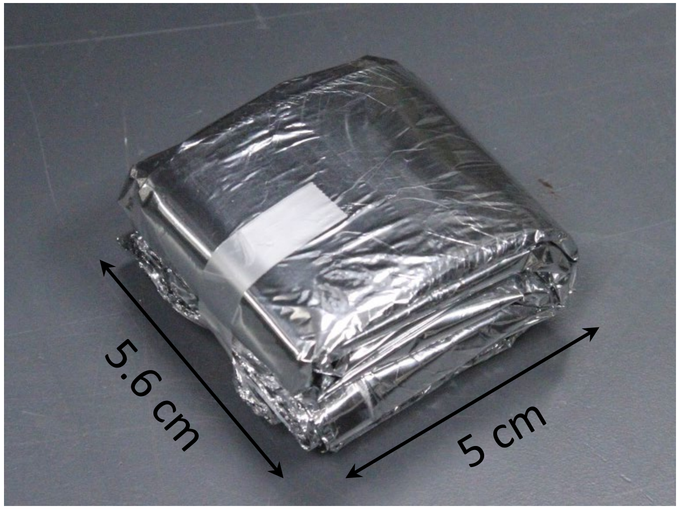
# Phase II Progress: Sample Handling System





Multiple Fold System Produces 5.6 cm x 40 cm Strip

Extra Folds Produce
5.6 cm x 5 cm x ~2cm tall puck



# Status Summary

- **Subscale Test Results Demonstrating High ESP Performance**
  - Performed Sweeps of Critical Operating Parameters
  - Answered Key Questions for Full-Scale Design
  - Demonstrated Two-Stage Configuration Maximizes Performance
  - Expect to exceed RASA particle collection for less power
- **Discrete-Sample Folding System**
  - Working Full-Scale Prototype
  - Flexible design offers options for final sample (strip or packet)
  - Enables smaller samples than existing RASA, leading to gains in instrument sensitivity
- **Full-Scale Prototype Design Almost Complete**
  - System can be optimized in future effort to minimize footprint
  - Key Mechanical, Electrical, and Flow Control Design Elements are Complete
  - Fabrication of Full-Scale Prototype Beginning in Feb

# System Benefits

- **Increased Sensitivity compared to the RASA system**
  - Smaller sample presented to the detector including sample height and thickness (potential ~1.3x improvement in detector efficiency)
  - Option for a puck design to be place on top of detector (~2x improvement)
- **Options for Interfacing with next generation detectors**
- **Flexible design for changing particle collection based on conditions**
  - Reduce the particle collection efficiency and increase the flow rate to collect more overall particles
  - Change collection efficiency if an ‘event’ occurs
  - Increase ESP power or flow rate to shorten sample times during events
- **More Power Efficient for a given particle collection efficiency**
  - Advantageous for remote locations

# Phase II Plan: Next Steps/Schedule

- **Complete sample handling (Jan 2019)**
  - Demonstrate integrated sample handling system (sealing, cutting, folding)
  - Pneumatic operation for each fold
  - Drive roller/conveyor integration of folder with ESP particle collector
- **Complete Full-Scale Integrated Prototype Design (Jan 2019)**
  - Detailed design of ESP assembly currently in-progress and near completion
- **Build and Test (Feb–June 2019)**
  - Demonstrate full-scale ESP performance for varying flow rates, particles, conditions (i.e., humidity)
  - Demonstrate collection efficiency
  - Demonstrate sample handling
  - Goal to collect 24-hour atmospheric sample to send to PNNL for analysis with detector

# Post Phase II

- **Phase II will end with end-to-end prototype and performance demonstration**
  - **80/20 Aluminum Frames, Non-Optimized System Packaging for Low Footprint**
  - **Uses Laboratory-Level Power Supplies, Data Acquisition, and Control, etc.**

- **Future Next Steps:**
  - **Fieldable Version:**
    - **Increase robustness of mechanical system**
    - **Optimize footprint/configuration**
    - **Incorporate controls and remote operation features**
  - **Longer Term Testing**
  - **Integration with a Detector**

# Questions/Discussion