ARNOLD AND MABEL BECKMAN FOUNDATION REQUEST FOR PROPOSALS:
BUILDING PORTABLE MASS SPECTROMETRY SYSTEMS FOR ATMOSPHERIC MONITORING

There is a critical need for advanced analytical tools that can be widely deployed to provide real-time information on the composition and concentration of pollutants in the air, at sensitivity levels that are equivalent to laboratory-based techniques. Mass spectrometers can provide the information needed for the detection of hazardous pollutants, but most systems are still too large and expensive, and require a trained operator with scientific expertise, to be effectively used for long-term monitoring. Having easily deployable instruments to perform these measurements is essential for collecting these data sets. The Arnold and Mabel Beckman Foundation sees this challenge as an exciting opportunity to inspire scientists and engineers to work in interdisciplinary teams to build prototype systems and address this real-world problem.

The Foundation's mission is to support leading edge research, in the fields of chemistry and life sciences, and particularly to foster the invention of methods, instruments, and materials that open new avenues of research and applications in these sciences and related disciplines. In addition, this program will follow the legacy of Dr. Arnold O. Beckman's work in environmental monitoring and understanding of physical processes in the air from his own efforts in combating smog in the Los Angeles basin that he continued to champion on the national stage at the Federal Air Quality Control board.

The Foundation is requesting proposals for a grant opportunity for the development of new instrument designs to bring the most advanced mass spectrometry detection capabilities and sensitivity levels into a lightweight, inexpensive, and easily operated system that could be portable or deployed on airborne platforms, in unattended monitoring stations, or operated by citizen scientists, for long-term analysis of the chemical composition of the atmosphere. The intent of this program is to support scientists, with a focus on undergraduates, to become inventors and innovators in this compelling area of research by building tools and instruments. Miniaturizing mass spectrometers has been an active area of research for many years, and it is timely to advance such prototype designs for broader applications for mobile monitoring. If successful, these prototype monitoring systems could have a lasting impact on informing policy decisions on sources of pollution, improving indoor and outdoor air quality, and furthering the democratization of access to clean air around the world.

The Foundation will provide support of up to $1 million per selected team over a 3-year development and testing program at awarded Institutions, which can be used flexibly to purchase materials for several prototype systems, consumables for testing, full-time support for undergraduate students to participate in the program, part-time support for other personnel, which could include research staff, graduate students and/or postdoctoral fellows, support for industry collaborations, and/or training courses or experiences for participating students. Applicant institutions must demonstrate their commitment for additional funding beyond the $1 million support from the Arnold and Mabel Beckman Foundation, if necessary, to complete the objectives of the program described below. The Foundation does not provide support for overhead or indirect costs. Additional information on the allowable program costs, budget format, and institutional support requirements can be found in the instructions in the online application portal.

PROGRAM OVERVIEW

We are requesting proposals to build novel mass spectrometer instruments with performance equivalent to current laboratory instruments that could operate on a wide range of ground-based and/or airborne platforms with minimal user expertise, as further detailed in Table 1 below. Program teams must be based within a university or non-profit research institution with the ability to engage

undergraduate students in research. The program team should include active participation from undergraduate students, with graduate students, postdoctoral fellows, and staff members from a mix of disciplines (e.g., chemistry, atmospheric sciences, engineering) as well as the technology transfer, commercialization, and administrative offices, as appropriate for the proposed program and institution's resources. A consortium among several institutions to form a program team is also acceptable.

Proposals should be centered around addressing the performance needs for a specific use case, for example, but not limited to, on an airborne sampling platform, or in a ground-based sensor suite, or in a citizen scientist field sampling kit. Table 1 below provides several performance parameters for mass spectrometry systems, with threshold and objective metrics that span a range of use cases. Proposals should justify the desired performance for each parameter depending on the specific selected use case. The proposal should include an initial design concept that would meet the desired form factor and performance of the final instrument, including the aerosol inlet and detection system with the required power and consumables, and an initial cost analysis of production costs of the system compared to similar commercially available laboratory equipment. Proposals should also include a program plan for a 3-year effort to iterate on the design concept through building prototypes, testing, and refining the designs. At the end of the program, the Foundation will provide an opportunity for the systems to be tested against simulated real-world challenges in a laboratory environment.

One faculty member or senior research scientist should be identified as the Program Lead. The inclusion of junior scientists is a high priority for the Foundation, and proposals must include a program team plan that clearly identifies how undergraduates will be incorporated in the development process in a meaningful way, as well as detail the other team member roles and responsibilities required for the project, such as graduate students, postdoctoral fellows, other faculty, and staff scientists to maintain continuity in the engineering program over the three-year effort. Incorporation of industrial partners at all program stages is encouraged, and will be required in later stages of the program, but is not required at the proposal stage. A training plan shall also be developed that specifically addresses how the undergraduate students participating in the program will benefit from new training opportunities, either within or beyond the individual institution.

PROGRAM DELIVERABLES

Table 1 below lists the range of performance goals for the mass spectrometry systems to address either particulate composition measurements or gas concentration measurements. Proposals could address one of these detection modalities, or a combined instrument to measure both particles and gas in a single system, depending on the targeted use case. These new mass spectrometers could be combined with other standard low-cost particulate matter counters or carbon monoxide and ozone sensors to create a measurement capability for atmospheric monitoring.

In addition to the instrument build itself, during the award term the selected awardee teams would also be required to submit for publication any advancements in mass spectrometer designs and test results to relevant analytical chemistry, engineering, or atmospheric science journals. Teams would also submit to the Foundation annually updated plans on how they will either commercialize, patent, or otherwise disseminate the design concept(s) of successful instruments with input from their technology transfer office and collaborations with industry partners. Updated plans and progress on the system build, technology transfer plans, and system cost analysis will be required for Foundation review in the Year 2 and Year 3 annual reports. Following review of the annual reports, the Foundation will provide funding for the next year of the award. At the end of Year 3, if the final prototype performance meets the threshold requirements for the proposed use case, the team will be invited to participate in a Beckman Foundation funded testing event in a laboratory against simulated real-world challenges. Details about the testing will be made available at the start of the second year of the program.

Table 1. Performance parameters for particle and gas measurement systems with threshold and objective metrics.

Parameter	Threshold	Objective
Physical Parameters		
Weight and Size	Lifted by two people and fit on a cart	Carried by one person while being operated (such as in a backpack or other portable configuration)
Power	Standard 120V	Battery for 24 hours of operation included in overall system
Robustness	6 months operation with field repair	6 months operation without repair
Operational Parameters		
Hours continuous autonomous operation	6 hours	7 days
Sampling frequency	10 minutes	1 minute
Consumables	Readily available consumables only (e.g., N_2, CO_2, O_2)	Battery power only
Operator Expertise	5-day training course	1-day training course
Detection Parameters - particulate		
Mass/Delta Mass Resolution	m/(Δm) ~ 500	m/(Δm) ~ 1,000
Accuracy	Quantify with +-25% accuracy for concentrations > 3 µg/m^3	
Target Particulates	Nitrate, sulfate, and organics	Threshold + ammonium, elemental carbon, sodium salts, dust
Particulate size	PM_{10}	$PM_{2.5}$
Detection Parameters - gas		
Mass/Delta Mass Resolution	m/(Δm) ~ 500	m/(Δm) ~ 1,000
Accuracy	Better than 30% for concentrations > 0.5 ppb	
Target Chemicals	Benzene, toluene, propene, butene (total), acetonitrile, hexanes (total), octanes (total), isoprene, monoterpenes (total)	

APPLICATION TIMELINE

Request for Proposals Announced: July 2022
Full Proposals Due: November 18, 2022 at 5PM Eastern Time
Award announcements anticipated in June 2023, with first year payments in Aug 2023

ELIGIBILITY CRITERIA

The Foundation will consider proposals from individual institutions or from consortia of institutions whose combined resources will address the program requirements. For any consortium application, there must be a "Lead Institution", defined as the institute that will accept the entire grant award on behalf of the consortium. The Lead Institution submitting the proposal must be a nonprofit US university or research institution.

APPLICATION SUBMISSION

Online submission portal: https://beckman-foundation.smapply.io/
One faculty member or senior research scientist must be identified as the Program Lead for the team to create an account on the submission portal and submit the Full Proposal on behalf of the full team. The submission portal allows for the addition of collaborators to access and upload documents into the account. Instructions for collaborators are provided in the submission portal.

Instructions for all proposal elements are listed in the online portal.

SELECTION & REVIEW PROCESS

Applications will be reviewed by a scientific review committee appointed by the Foundation. The Foundation reserves the right to use a review panel composed of internal and external reviewers, subject to a non-disclosure agreement and without conflicts of interest. For general information on our review processes and award terms, please visit: https://www.beckman-foundation.org/programs/general-award-processes-and-terms/

Due to the administrative requirements involved, the Arnold and Mabel Beckman Foundation is unable to provide critical commentary on unsuccessful proposals.

QUESTIONS

Please contact Anne Hultgren at instrumentgrants@beckman-foundation.org.