



AI-Driven VOC Analysis for Early Detection of Wound Infection from Skin Emissions

Cristina Davis

Prof. Cristina E. Davis

Mechanical and Aerospace Engineering
Clinical and Translational Science Center
University of California, Davis
cedavis@ucdavis.edu



Conflict of Interest Disclosures

- Co-founder, scientific advisor, equity holder and board member of the start-up company SensIT Ventures, Inc. I do not and will not hold a C-level position with the company. I report on this COI annually to UC Davis and have permission from the provost for the activity.
- Patents #12,048,893 and #11,813,050 and #11,491,436 and #10,940,428 and #10,111,606 and #10,067,119 and #9,398,881 and PCT/US2017/063,018 and PCT/US2017/023908 are assigned to UC Davis and licensed to SensIT Ventures, Inc.
- Patent #9,824,870 is assigned to SensIT Ventures, Inc.
- Patents #7,968,842 and #7,576,319 and #7,470,898 and #7,388,195 and #7,355,170 and #7,057,168 and #7,241,989 are assigned to The Charles Stark Draper Laboratory. Some of these have been licensed to major chemical detection equipment manufacturers (e.g. Thermo Scientific, Varian/Agilent, AB Sciex, General Dynamics).
- Patent #9,824,870 is assigned to NASA and licensed to Datatecnics Corporation (UK) and Datatecnics Meditech.
- Without salary (WOS) appointments at:
 - Los Alamos National Laboratory
 - Veteran's Administration, VA Northern California Health Care System

The need for new technologies to screen battlefield wounds for infections



- Extremity trauma among most common battlefield injuries
- Infections occur in ~16% of soldiers with open wounds
- **Problem: Diagnosing infections requires lab testing**
 - Limited field use
 - Delays = worsened outcomes
 - Empiric antibiotics = antimicrobial resistance

Our solution: Portable AI-enabled skin sensor

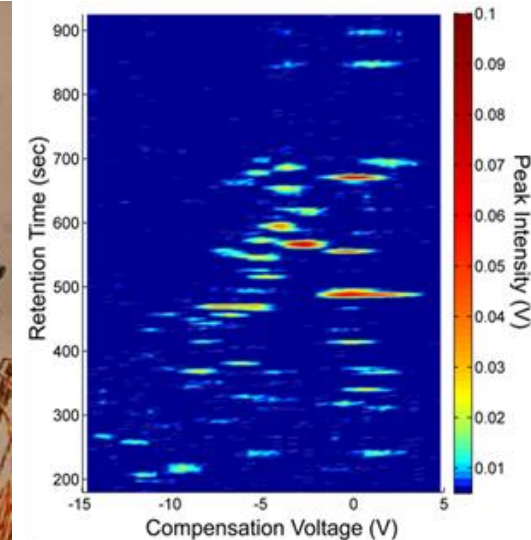


- **“Sniff” wounds for early infection detection**
- AI models utilize chemical (VOC) emissions from skin and infection pathogens
- Rapid assessment (15 mins)
- **Portable:** field, bedside, or point-of-care
- Improve clinical outcomes, reduce unnecessary antibiotic use

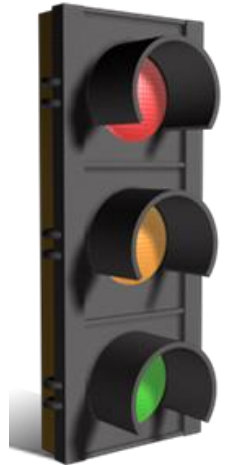
Portable skin sensor, “sniffs” wounds



Skin chemical emission data (differential mobility spectrometer)



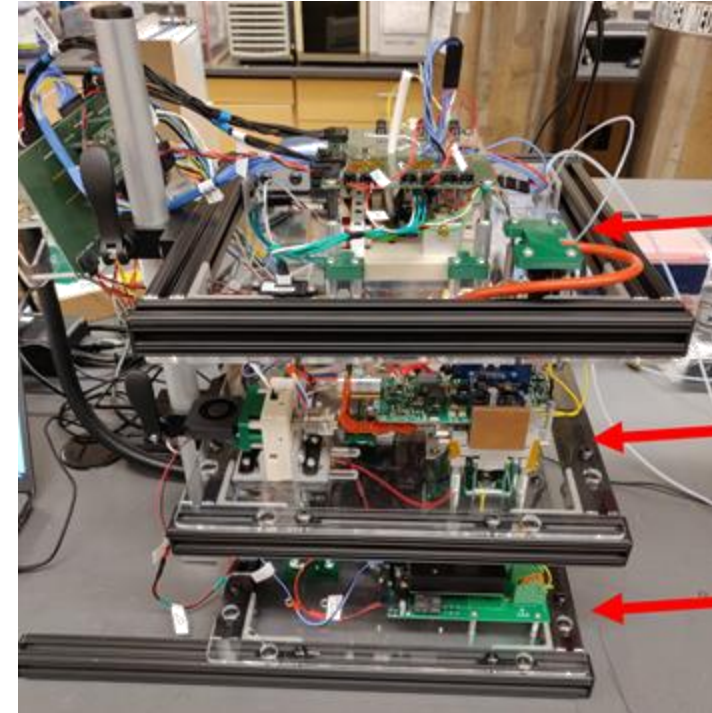
AI-enabled infection screening



Bedside μ PC-GC-DMS system for skin diagnostics

- NIH RADx-rad SCENT awards U18TR003795 and U01TR004083
- Portable, Quantitative results at point-of-sampling / point-of-need
- Uses differential mobility spectrometer (DMS)
 - Used by military for explosives, chemical warfare agent detection

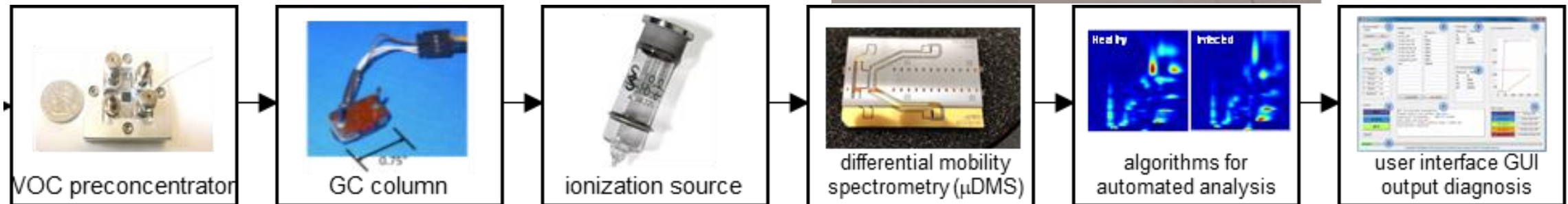
(Outer casing removed)



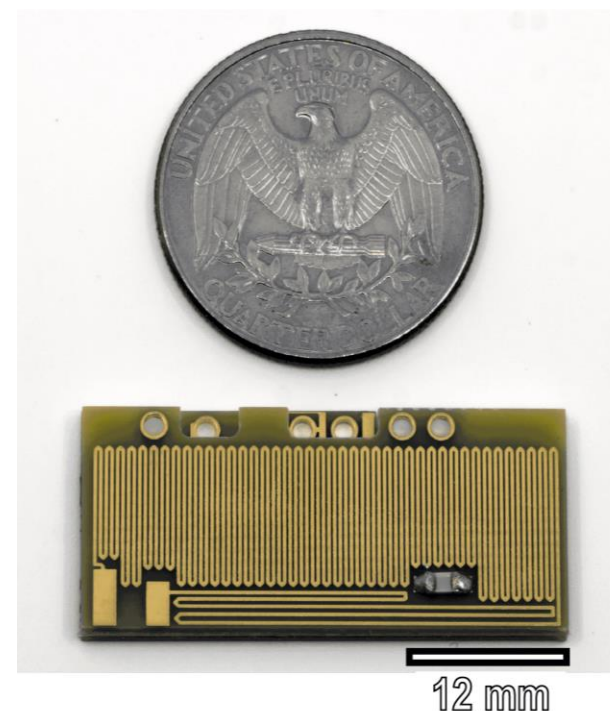
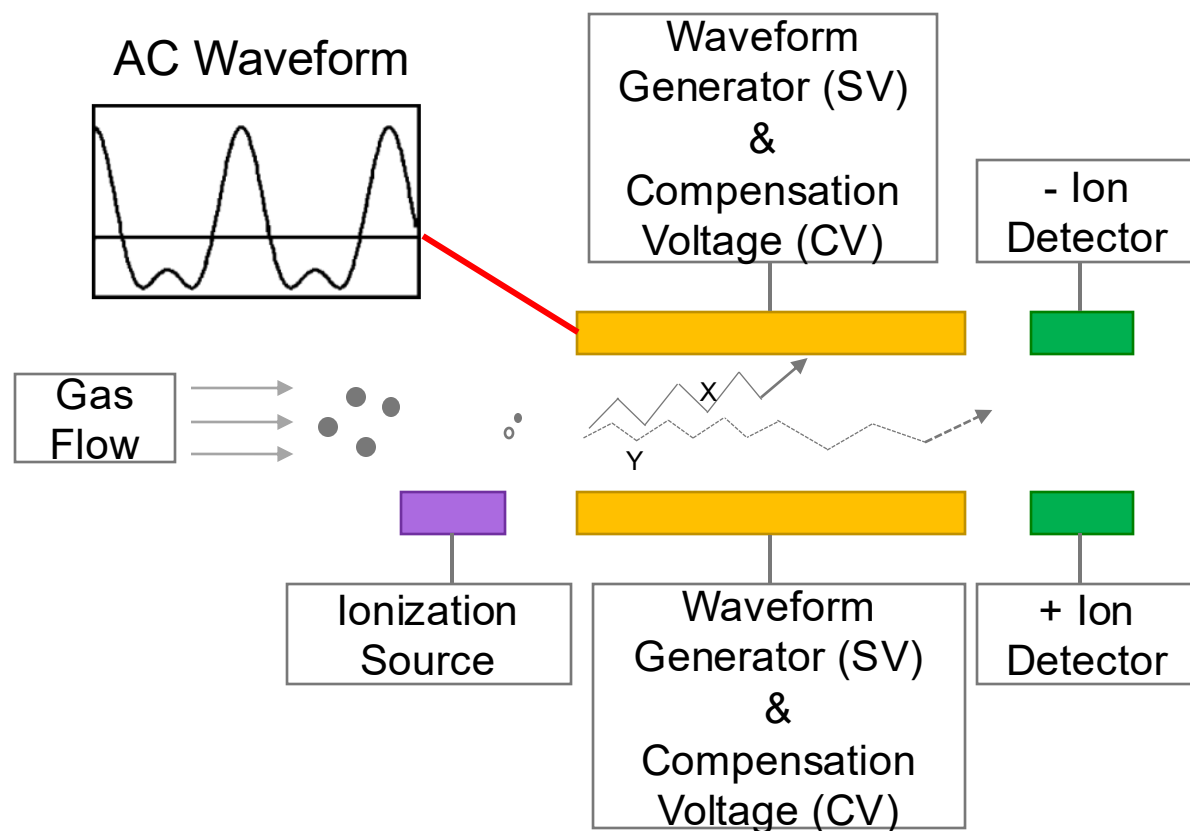
Level 3:
Flow System

Level 2:
Devices (μ PC, GC, DMS)

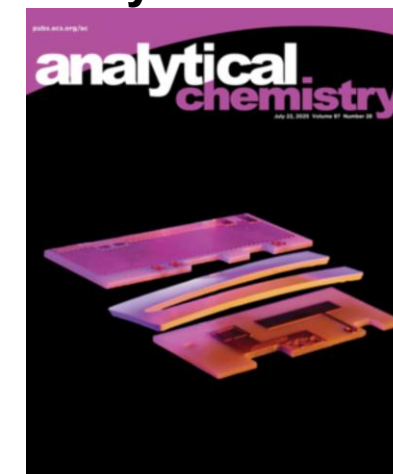
Level 1:
Power Electronics



Differential mobility spectrometer (DMS) chip: Highly selective, sensitive VOC detector



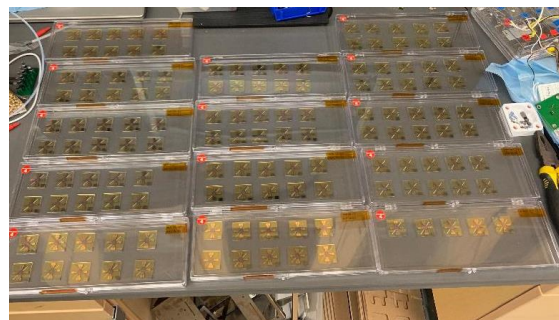
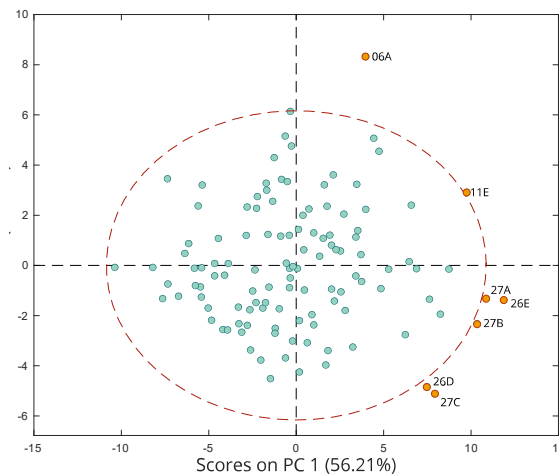
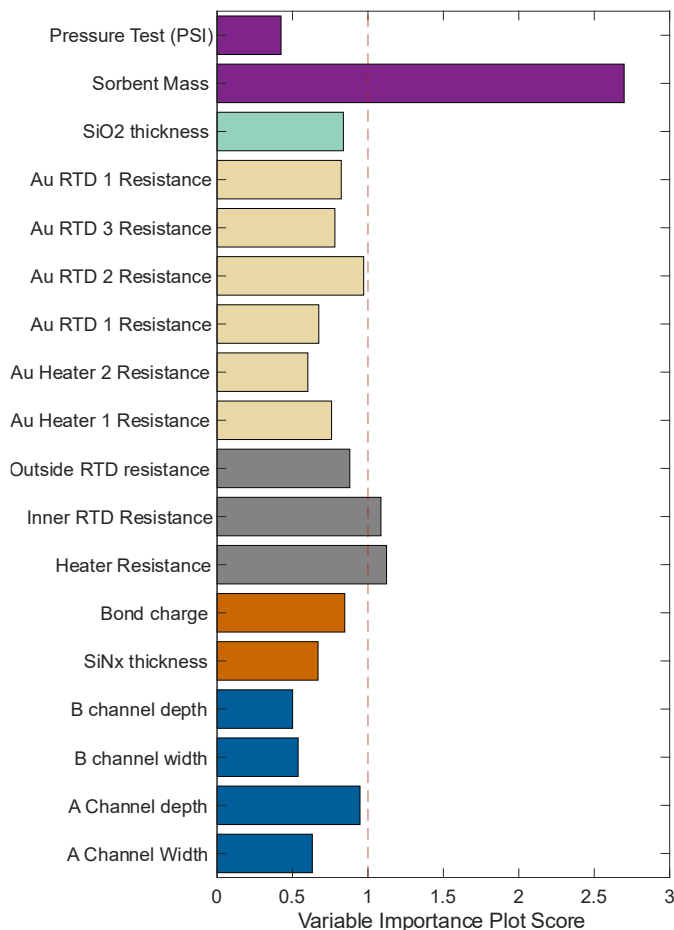
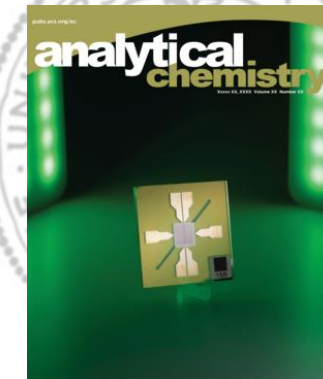
Led by PhD student
Dylan Koch



Made the cover!

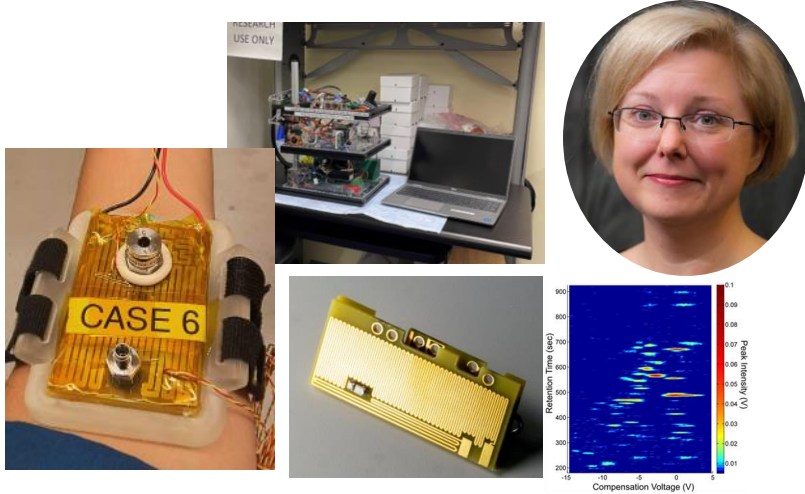
- Koch DT, Belous Y, Chew BS, Anderson G, Haun J, Gibson P, McCartney MM, Kenyon NJ, Davis CE*. (2025) OpenDMS: An Open-Source Approach to Differential Mobility Spectrometry. *Analytical Chemistry* 97(28): 14974-14982. DOI: [10.1021/acs.analchem.5c00361](https://doi.org/10.1021/acs.analchem.5c00361)

Translational efforts: first commercial foundry run



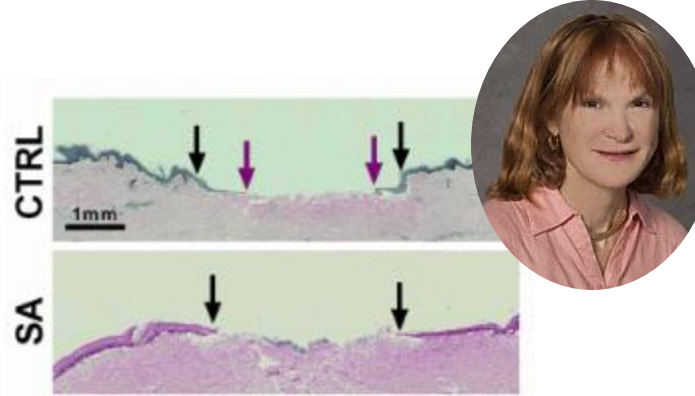
- Commercial partner Vitrion
- Vitrion etched flow channels, sorbent cavities
- Final production in UCD cleanroom
- 180 chips, QA/QCed with VOC standards from NIST
- Regression model determined most critical manufacturing parameters for optimal chemical performance

DARPA-funded pilot effort (2024-2025): “Sniffing” wounds for infection screening



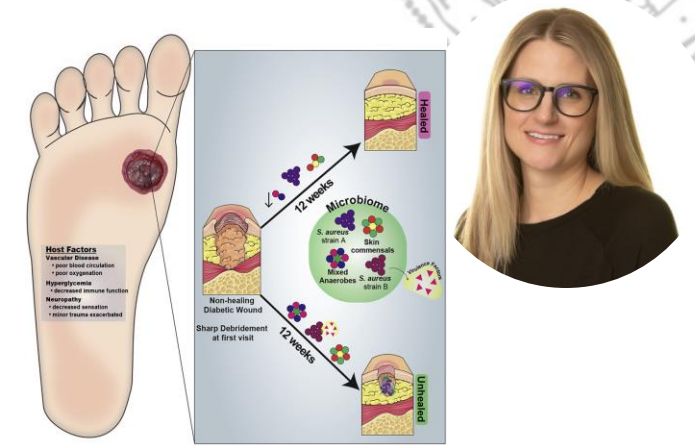
Cristina Davis (UC Davis, VA Northern California)

- Ongoing NIH NCATS project for skin-based diagnostics
- Developed skin emission sampling patch (patent pending)
- Developed point-of-care VOC detector platform
- Developed AI analysis software to analyze skin VOC data



Rivkah Isseroff (UCD, VA Northern California)

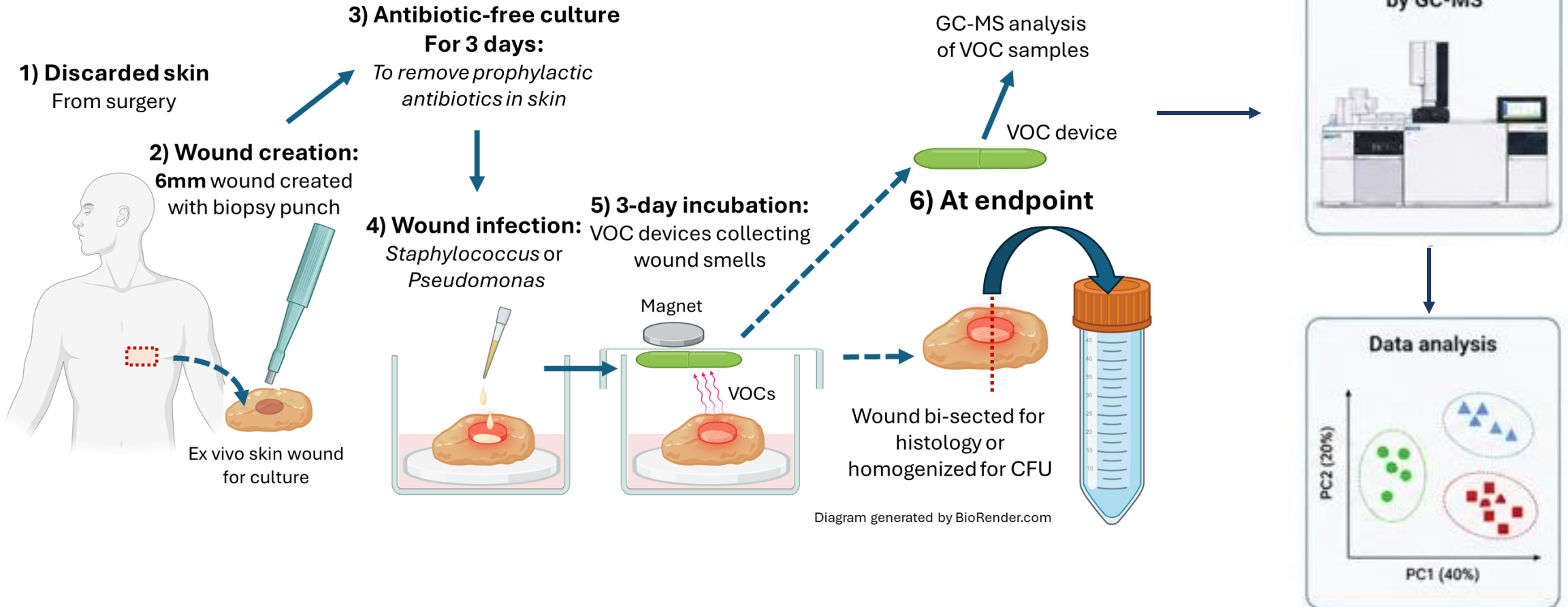
- Physician-scientist, expert in wound infections
- Developed *ex vivo* human wound infection model
- Chief of Dermatology at VA Northern California Hospital
- Ongoing trial on wound therapeutics



Lindsay Kalan (McMaster)

- Profiles skin wound microbiota
- Uses predictive AI to identify biomarkers of wound infection
- Ongoing NIH NIDDK award to translate biomarkers to clinic

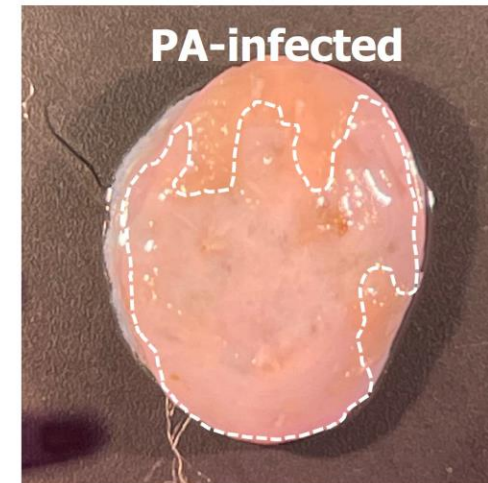
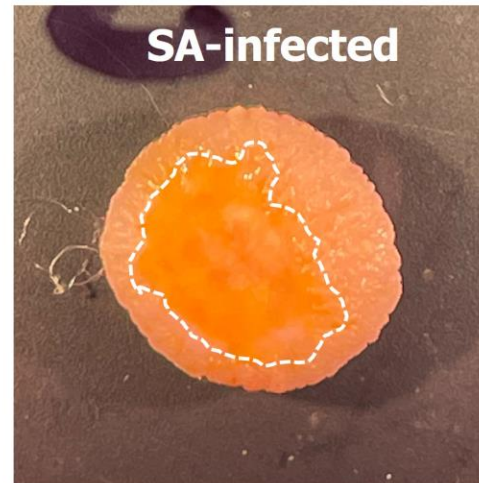
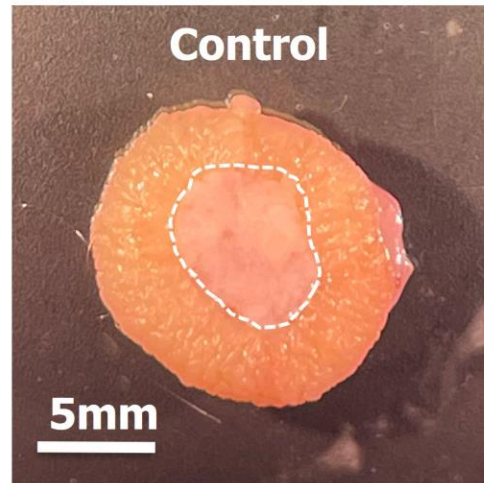
Ex vivo skin wound infection model and VOC collection



From inoculation to frank infection over 3 days

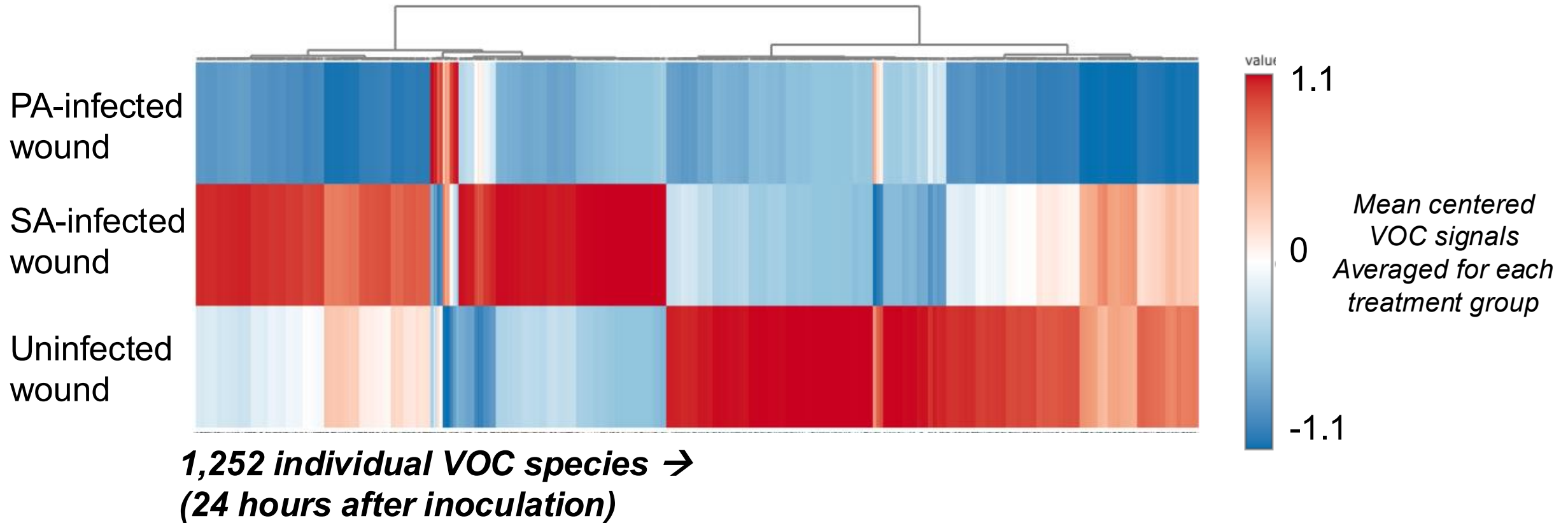


Day 3 wounds
edge outlined

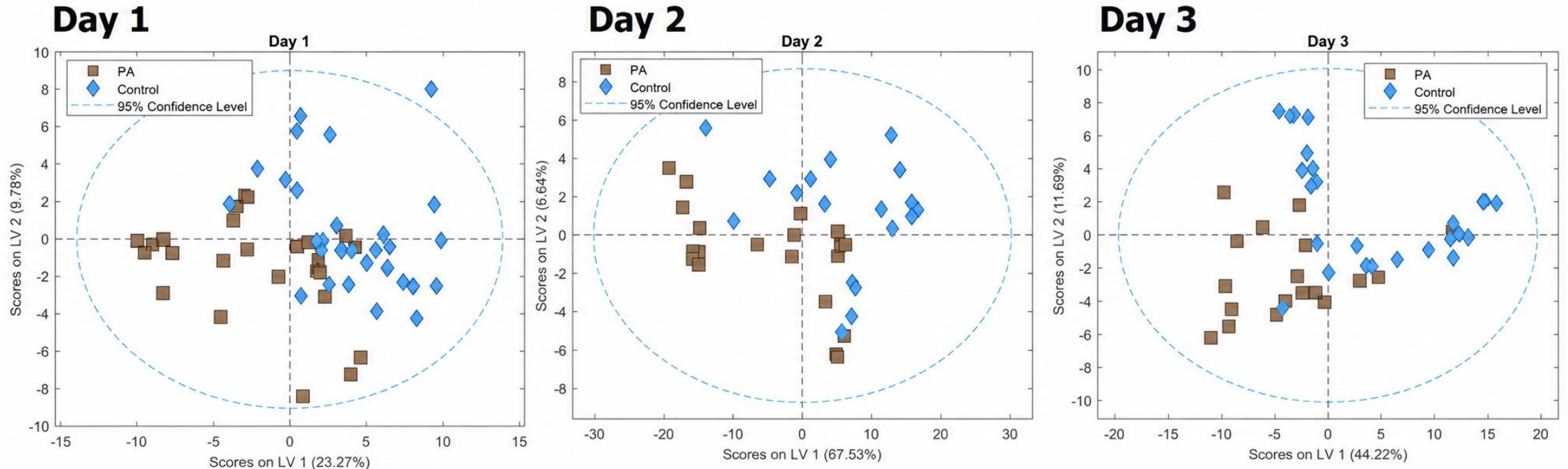


	Control	Staphylococcus aureus (SA)	Pseudomonas aeruginosa (PA)
Day 0 inoculum	none	60,000 / wound	4,533 / wound
Day 3 CFU count average $\pm$ stdev, n=3	1.30E+02 $\pm$ 2.26E+02	9.28E+10 $\pm$ 6.52E+10	3.39E+10 $\pm$ 2.78E+10

Strong VOC emission differences only 1 day after infection



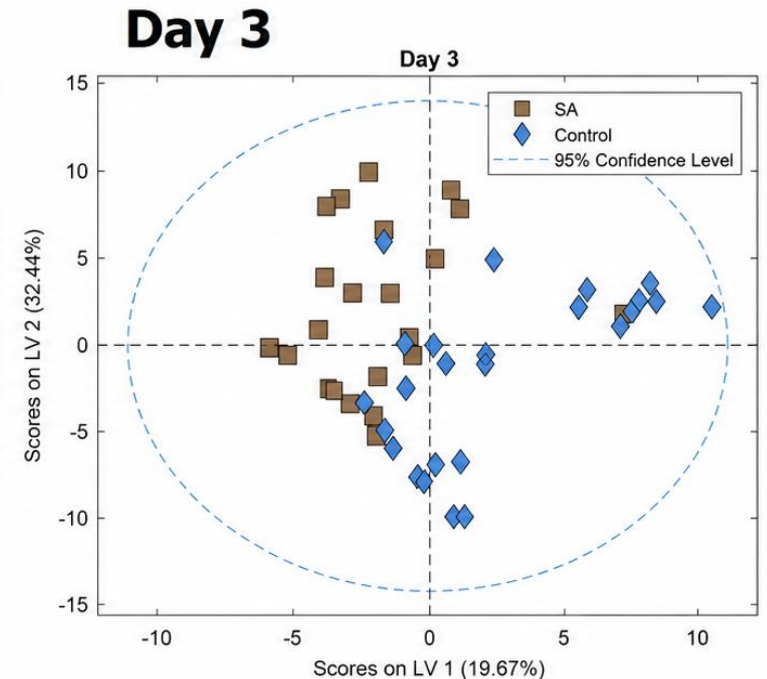
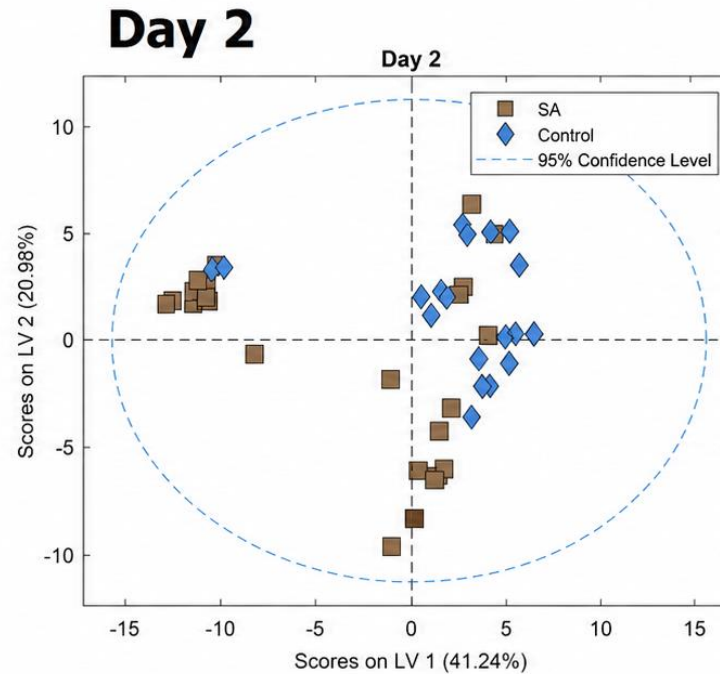
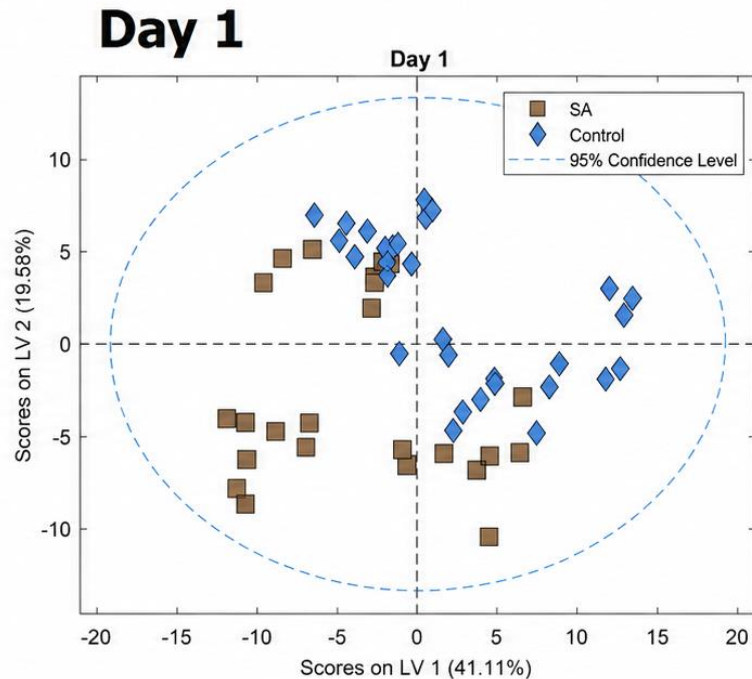
Pseudomonas-infected wounds



Pseudo. infected (squares) **non infected (diamonds)**

Days since infection	# samples calibration/validation	Accuracy (std)	Sensitivity (std)	Specificity (std)
1	34/21	0.78 (0.09)	0.67 (0.19)	0.67 (0.16)
2	26/14	0.81 (0.10)	0.63 (0.17)	0.66 (0.23)
3	24/19	0.77 (0.11)	0.70 (0.19)	0.68 (0.17)

Staphylococcus-infected and noninfected wound



Days since infection	# samples calibration/validation	Accuracy (std)	Sensitivity (std)	Specificity (std)
1	34/21	0.81 (0.10)	0.62 (0.17)	0.75 (0.15)
2	25/18	0.71 (0.10)	0.61 (0.16)	0.78 (0.19)
3	29/18	0.82 (0.11)	0.80 (0.16)	0.70 (0.16)

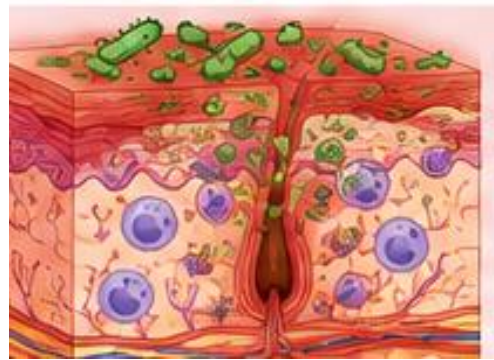
Can our technology distinguish colonization from infection?



Normal colonization



Frank infection

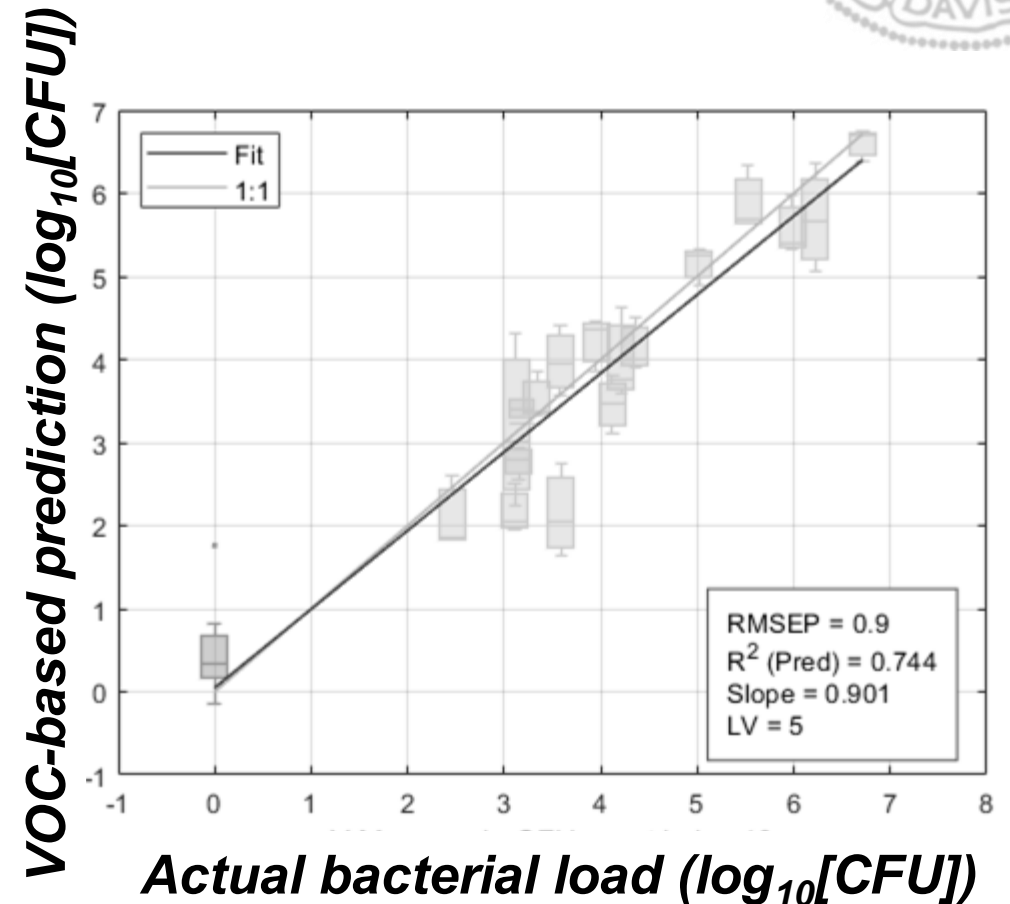


- Healthy wounds are naturally colonized by microorganisms
- As bacterial levels increase, colonization progresses into infection
- There is **no universally accepted clinical threshold** to distinguish colonization from infection
- For our study, we defined infection as $\geq 10,000$ bacteria (10^4 CFU)



VOC emissions can distinguish colonization from infection

- Measured VOC emissions from wounds spanning a range of bacterial loads (CFU)
- Trained AI models to correlate VOC signatures with bacterial burden
- Pilot study demonstrates VOC-based models can **predict bacterial load within one order of magnitude (10^1)**
- Results support feasibility of **non-invasive estimation of wound bacterial burden** using portable VOC sensor



VOC biomarkers as indicator of bacterial skin infection



CFU 0



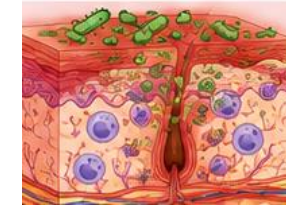
Uninfected skin

CFU 10^3



Initial bacterial infection

CFU 10^5



Established bacterial infection

Early Colonization Signature	
Compound	Biological Significance
Furfural	Carbohydrate degradation (microbial activity)
Indole	Tryptophan metabolism by skin bacteria (quorum sensing)
D-Limonene	Microbial transformation / environmental
N,N-Dimethylglycine	Amino acid metabolism (early host response)
Nonanoic acid	Lipase activity on sebum (short chain fatty acid)

Progression to Active Infection	
Compound	Biological Significance
n-Hexadecanoic acid	Strong lipase activity
Octadecanal	Lipid peroxidation / degradation product
Tridecane, 5-methyl-	Lipid metabolism
Pentadecane, 7-methyl-	Biofilm-associated branched alkanes
Dodecane, 2,6,11-trimethyl-	Bacterial membrane remodeling
Indole	Quorum sensing, biofilm maturation, virulence



Conclusions, future directions

- AI models can use skin VOC emissions to distinguish infected from colonized wounds, non-invasively
- Pilot results demonstrate feasibility of a rapid, point-of-care detection of wound infection

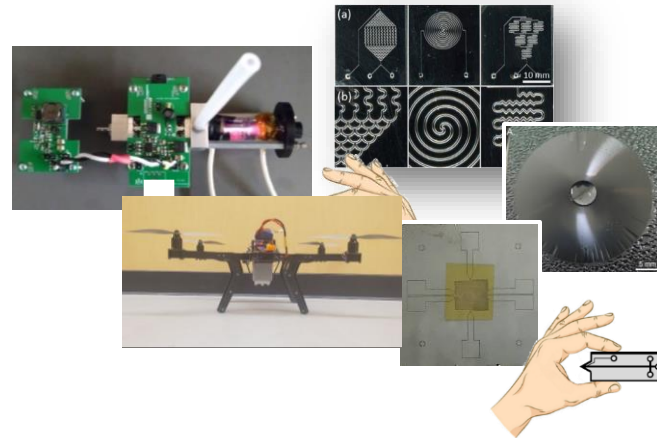
Next steps

- Continued model development (larger datasets, improved accuracy and robustness)
- Expand models to other wound pathogens, predict infection progression, guide targeted therapies
- **Long-term goal: portable, AI-enabled battlefield diagnostic technology**

BioMEMS Lab: portable chemical sensors

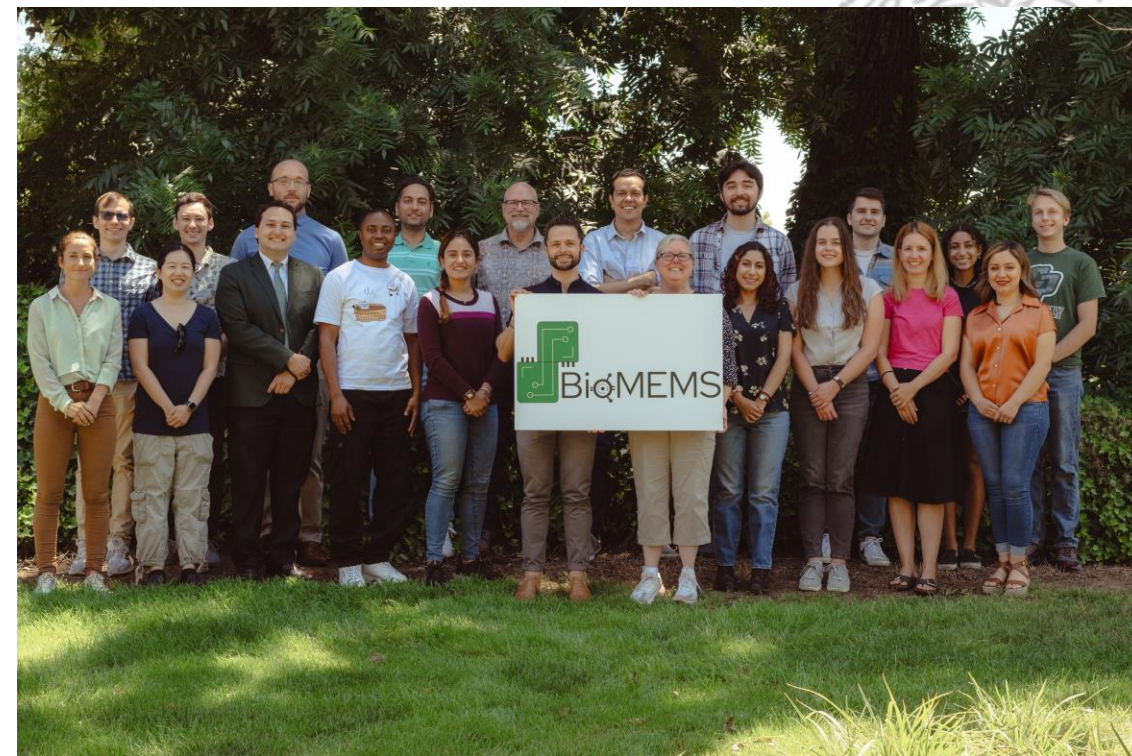
Chem Sensor team

- Microfabricated sensor development
- Software and AI/ML algorithm development



Metabolomics team

- Support sensor development
- Gold standard instrumentation for biomarker discovery (mass spec)
- Chemometrics, statistical analysis



Contributing researchers to this skin VOC work:

M. Razeeth Shait Mohammed
Hsin-ya Yang
Anthony Gallegos
Mitchell M McCartney
Eva Borrás
Lindsay Kalan
Rivkah Isseroff