Geometric Characterization Setup and Materials Database for DREAM End-Station Heated Gas Nozzle

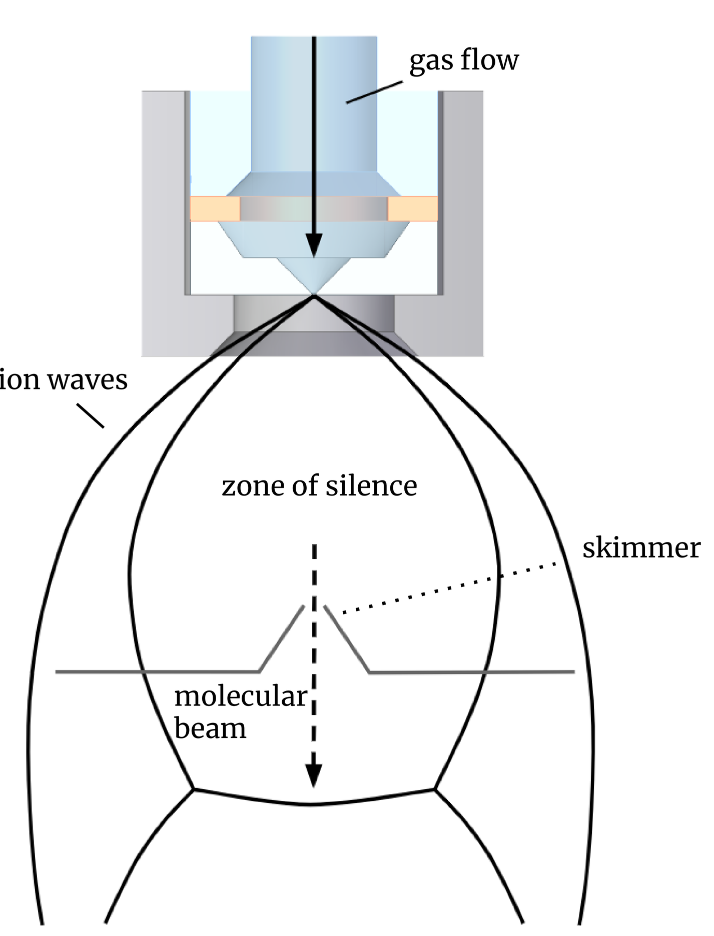
Desmond Rix[1,2], Mia Edmonson[1,3], Jim Runner[1], Justin James[1], Don Schafer[1], Razib Obaid[1]

[1] SLAC National Accelerator Laboratory, USA [3] University of California, Berkeley, USA
[2] San Jose State University, USA.

SLAC NATIONAL ACCELERATOR LABORATORY U.S. DEPARTMENT OF ENERGY Stanford University SPARTAN SPARK

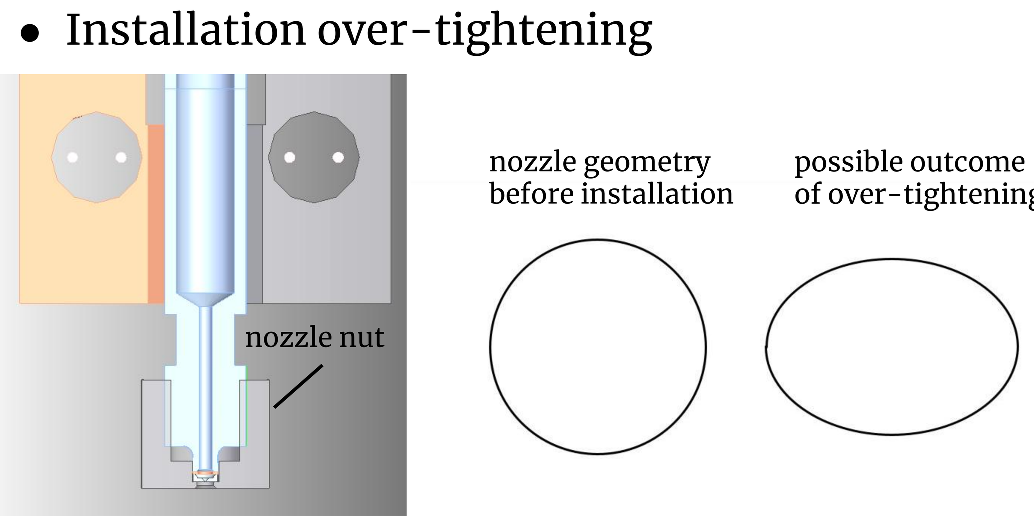
WHY DOES NOZZLE GEOMETRY MATTER?

In the Dynamic Reaction Microscope (DREAM) endstation, samples are injected into the reaction chamber through a nozzles and a series of collinear skimmers to isolate individual molecules in the reaction chamber.[1] Skimmers must be precisely placed to select the coldest part of the molecular beam. Prediction of this distance is possible using known models of supersonic gas expansion. If nozzle geometry is unknown, it is no longer possible to accurately predict and locate the coldest part of the beam.

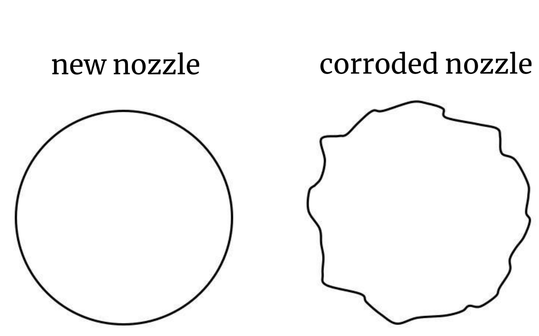


WHAT IMPACTS NOZZLE GEOMETRY?

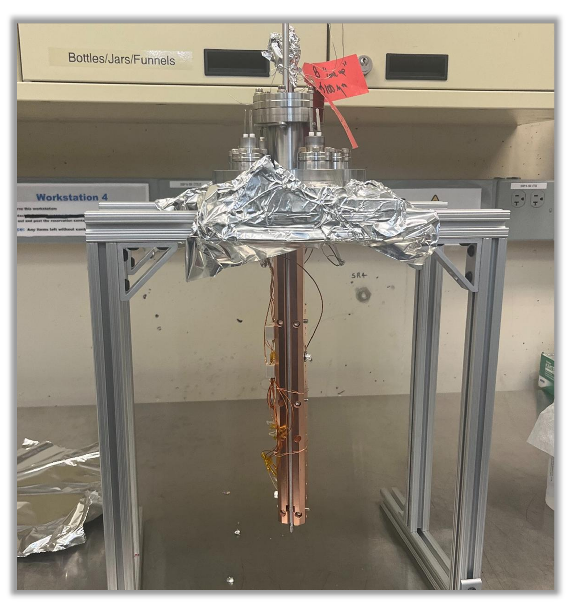
- Installation over-tightening



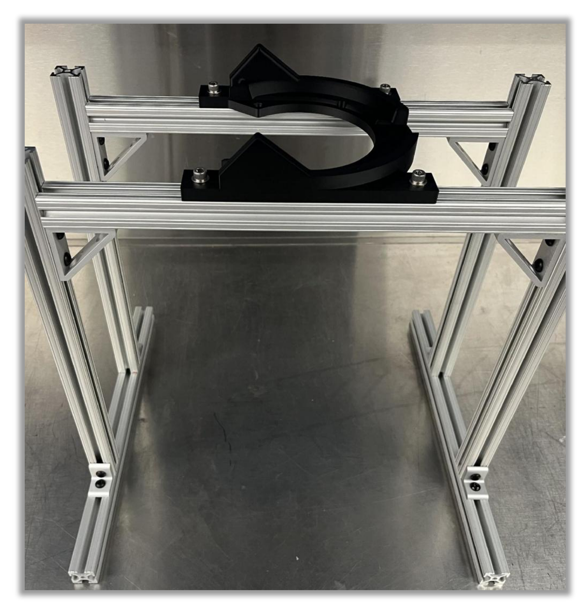
- Corrosion



INSPECTION SETUP

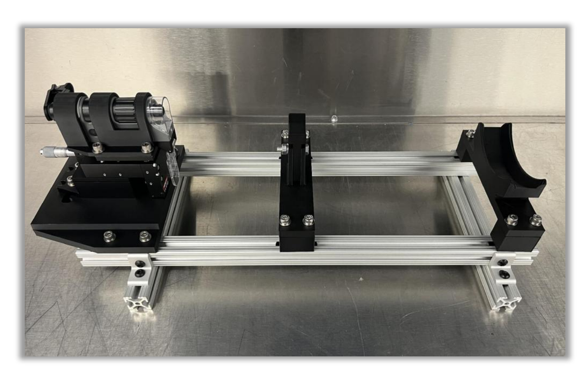


Vertical flow testing setup during initial testing. Findings were that the 3d modeled mounting ring worked but the overall height was too high.



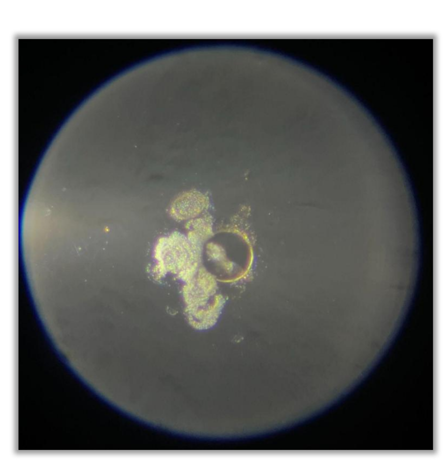
Final vertical setup for bubble testing with novel mounting ring system, optimized for ease of use and safety of the vacuum components.

Horizontal microscope inspection setup during initial testing. Findings were that the microscope mount sliders was clumsy and overly flexible, resulting in unstable clearance of the nozzles.

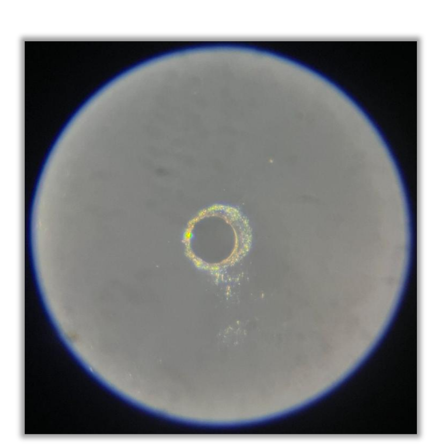


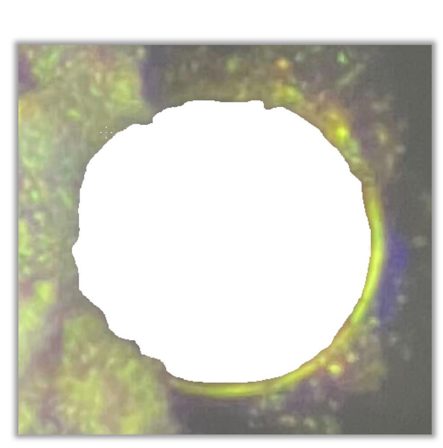
Final horizontal inspection setup. Microscope mount was redesigned for a 3-axis micrometer for careful focusing and wider base to provide greater stability.

RESULTING IMAGES & GEOMETRIC CHARACTERIZATION

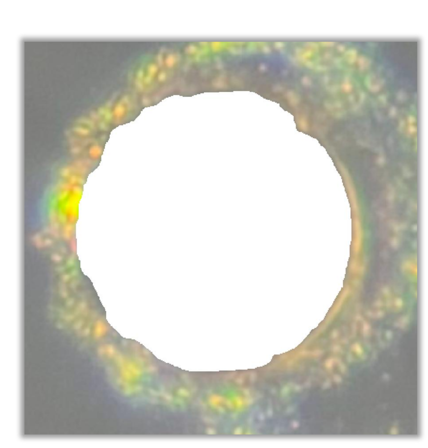


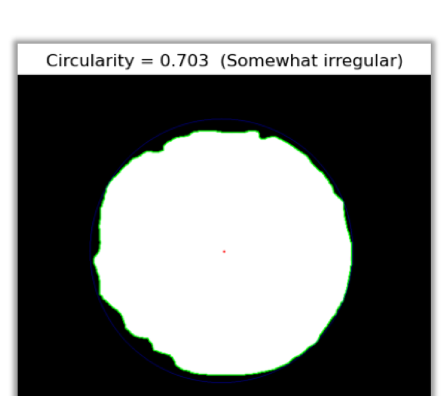
nozzle at 250x





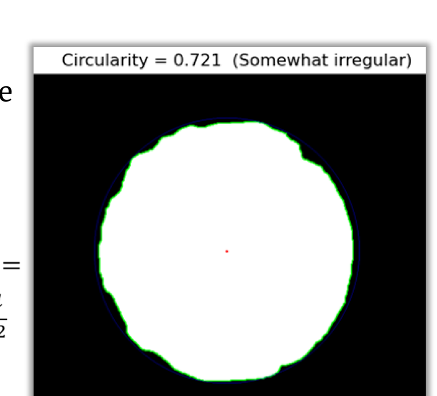
nozzle hole isolated





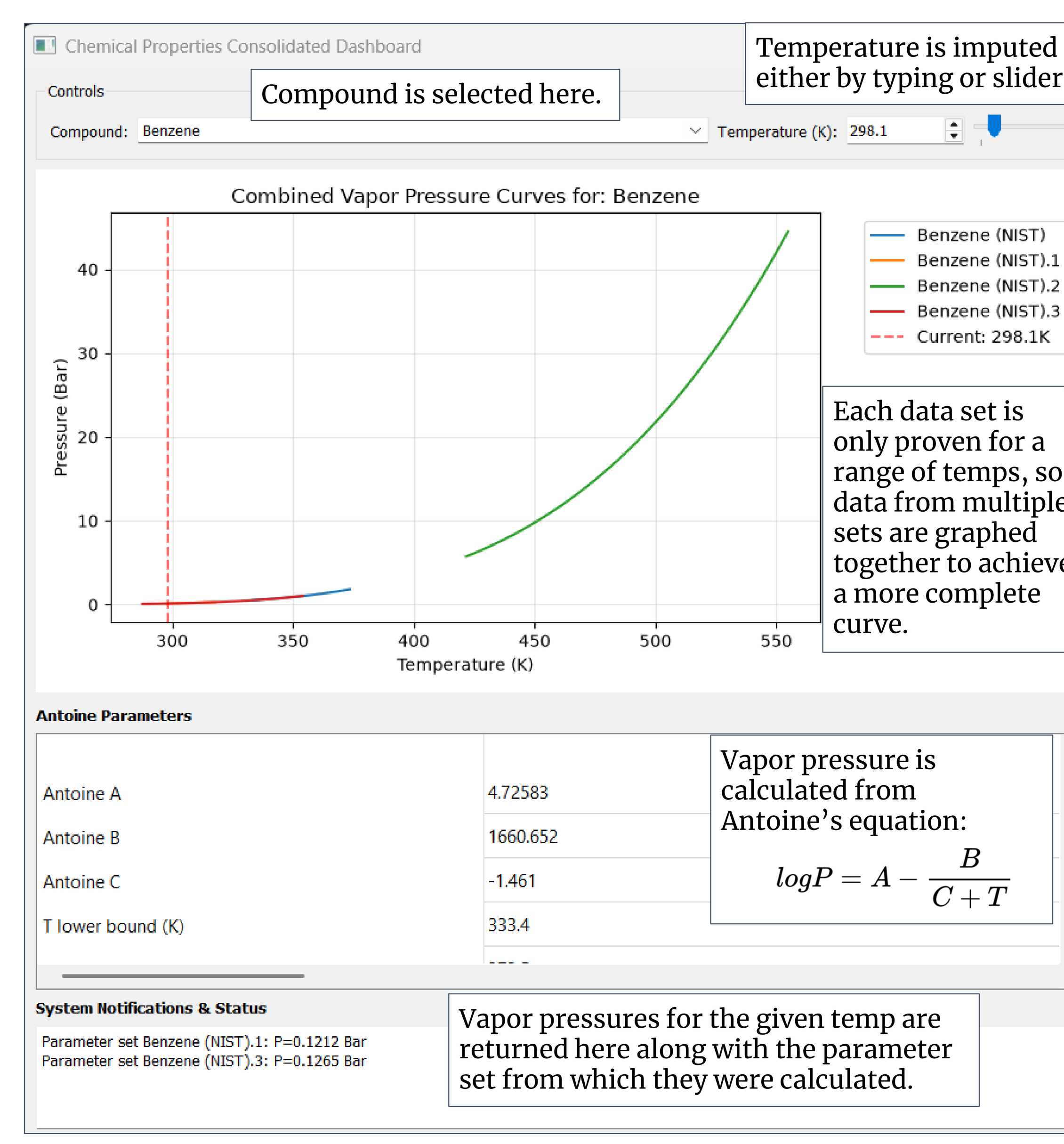
nozzle hole circularity calculated

$$Circularity = \frac{4\pi \times Area}{Perimeter^2}$$



VAPOR PRESSURE & NOZZLE COMPATIBILITY

A significant pool of samples used in DREAM endstation require change of phase from solid/liquid to gas for injection into the chamber. A ready-to-use database for temperature dependent phase change was developed along with the material compatibility with nozzle materials.[2,3,4,5]



By knowing the volume of the chamber, temperature, and vapor pressure of a compound given that temperature, we can predict the moles of vapor molecules present using the following equation:

$$n = \frac{(10^A)V}{10^{\frac{B}{C+T}}RT}$$

Where A,B, and C are the Antoine parameters for the compound, V is the vapor volume of the bubbler, R is the ideal gas constant, and T is the temperature.

Corrosion was graded with an AI model on a scale 'A', 'B', 'C', 'D', and 'F'. Grading methodology is available by scanning the QR code. Notable exceptions are 'R' for resistant and 'X' for fail when data was only available on a pass/fail basis. The making of this tool has directly influenced materials for the next iteration of DREAM, changing the standard nozzle from 95/5 PtIr to 80/20 PtIr.[6]

Corrosion Matrix Data

	Benzene
Platinum Iridium	R
Copper	A
Aluminum	R
Silver	B
Gold	R
Aluminum 6061-T6	nan
Beryllium	nan
Brass (general)	D
Bronze (general/architectural)	D
Calcium	nan
Carbon Steel / Mild Steel	nan
Cartridge Brass	nan
Cast Iron	nan
Chromium	nan
Gadolinium	A (Low Data)

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