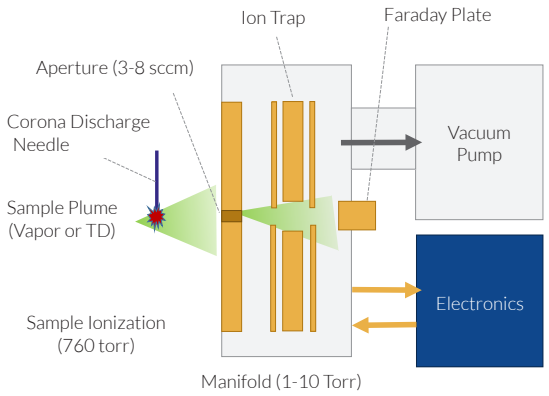
TECH NOTE 2.0

Multi-Mission Threat Detection with Handheld High Pressure Mass Spectrometry

Overview

Effective threat detection using chemical analysis requires an instrument that responds across a wide range of target materials, is able to distinguish those targets when present in complex real-world backgrounds, and is compatible with many different sample types. Additional system requirements include the need for high sample throughput, high confidence in the analysis result, and low limits of detection. The MX908™ handheld high pressure mass spectrometer represents a significant step forward toward meeting these requirements. The core of the MX908 is a high-pressure mass spectrometer™ (HPMS) coupled with a fast-switching dual-polarity ionization source that allows the instrument to screen a single sample multiple times for a wide range of explosives, CWAs, and drugs of abuse. Swappable front-end modules enable real-time vapor monitoring and alarming at low parts-per-billion levels or thermal desorption of solid and liquid samples at tens of nanograms with sample-to-result times of 30 seconds. The powerful on-board analytics streamline the data processing workflow to provide clear answers and easy instrument operation. Specialized mission modes offer optimized hardware and software configurations for enhanced operational performance under specified mission objectives.

MX908 Schematic

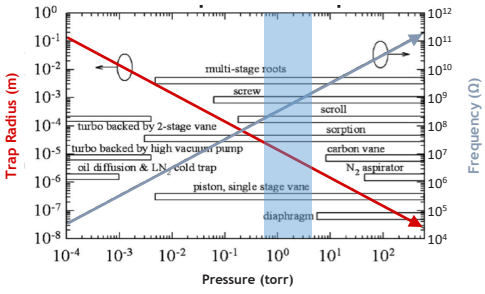


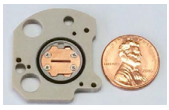
USPTO 8,878,127 Miniature charged particle trap

HPMS Theory

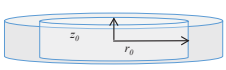
The high vacuum requirement intrinsic to most mass spectrometers is relaxed in ion trap-based instruments. By further reducing the dimensions of the ion trap to <1 mm, mass spectrometry (MS) at pressures as high as 10 Torr can be performed while simultaneously decreasing the total volume held under vacuum. This ability to operate at higher pressures (relative to other MS platforms) eliminates the need for expensive, large, power-hungry, and highly fragile turbo and rough vacuum pumps. Pressures of 1 torr can be readily achieved with low-power scroll pumps.

Ion-Trap Trade-Space





Ring Electrode Schematic



Ω Ion trap radio frequency (Hz)
V_{max} operating peak voltage
q_{max} 0.908

Mass Range

$$\left(\frac{m}{e}\right)_{max} = \frac{8V_{max}}{q_{max}\Omega^2(r_0^2 + 2z_0^2)}$$

Mass Resolution

$$\frac{\Delta m}{m} \propto \frac{2\sqrt{3}c}{\Omega}$$

The MX908 Commercial Product

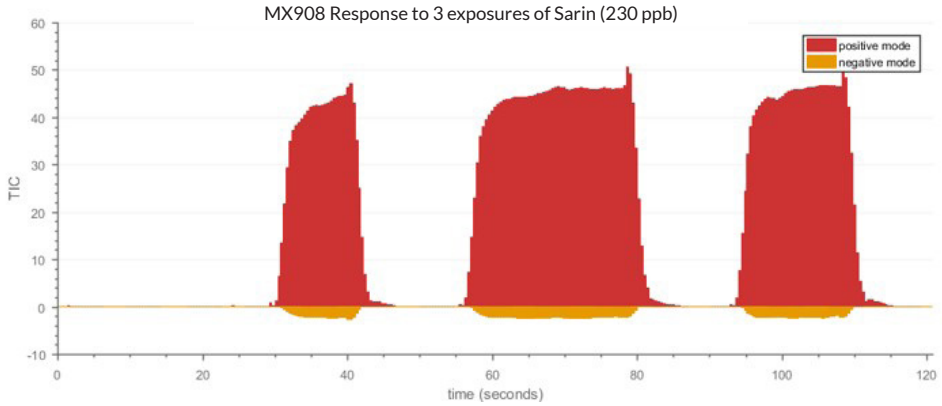
Top View (with Vapor Module)

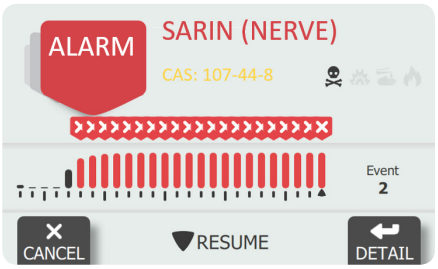
Front View (with Trace Module)

908devices

Example: Real-Time Vapor Detection – CWA

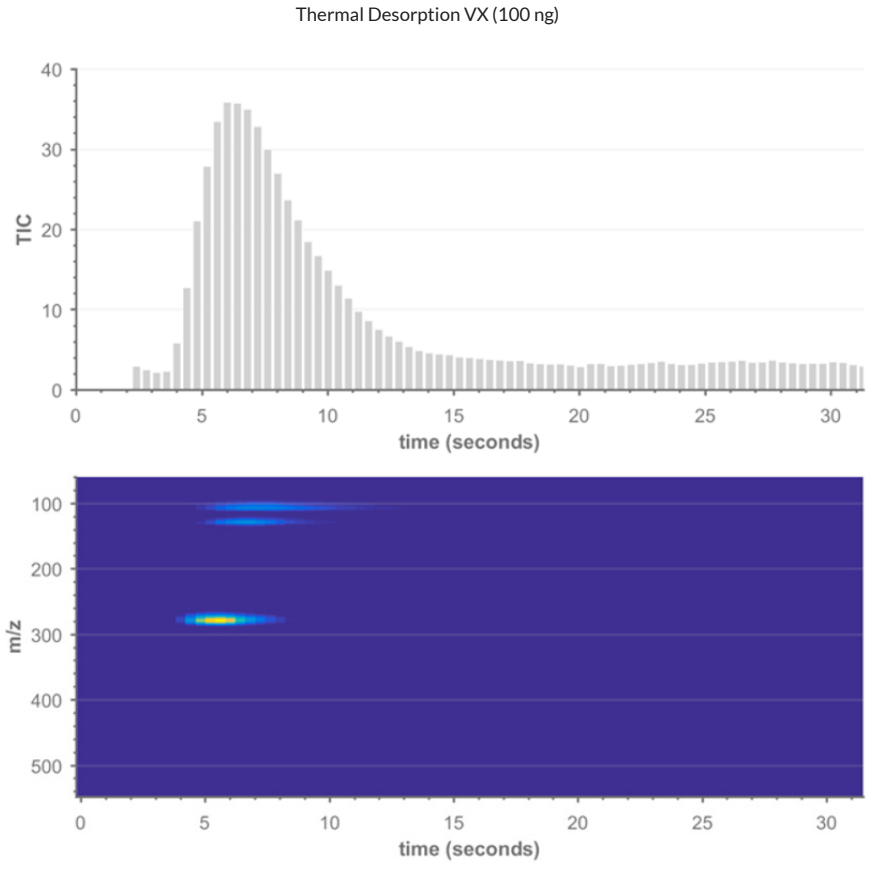
The data below demonstrate real-time vapor detection at low ppb levels. The response onset and recovery times of the MX908 are on the order of a few seconds for most threat vapors.

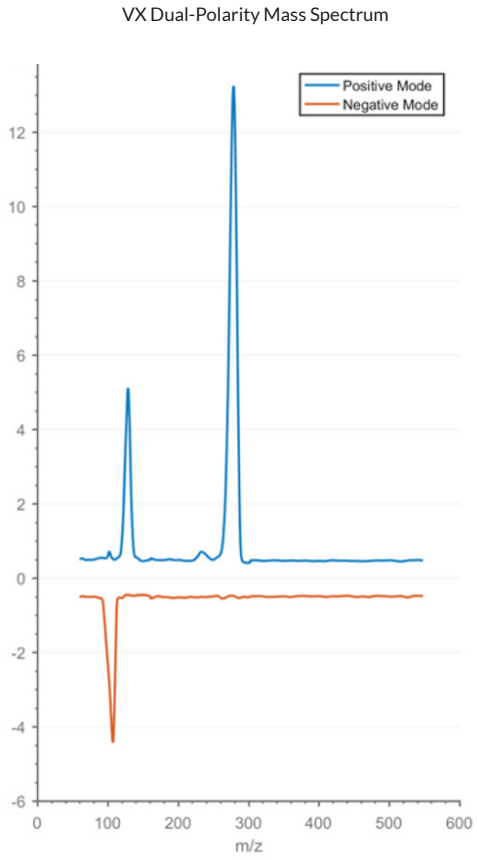




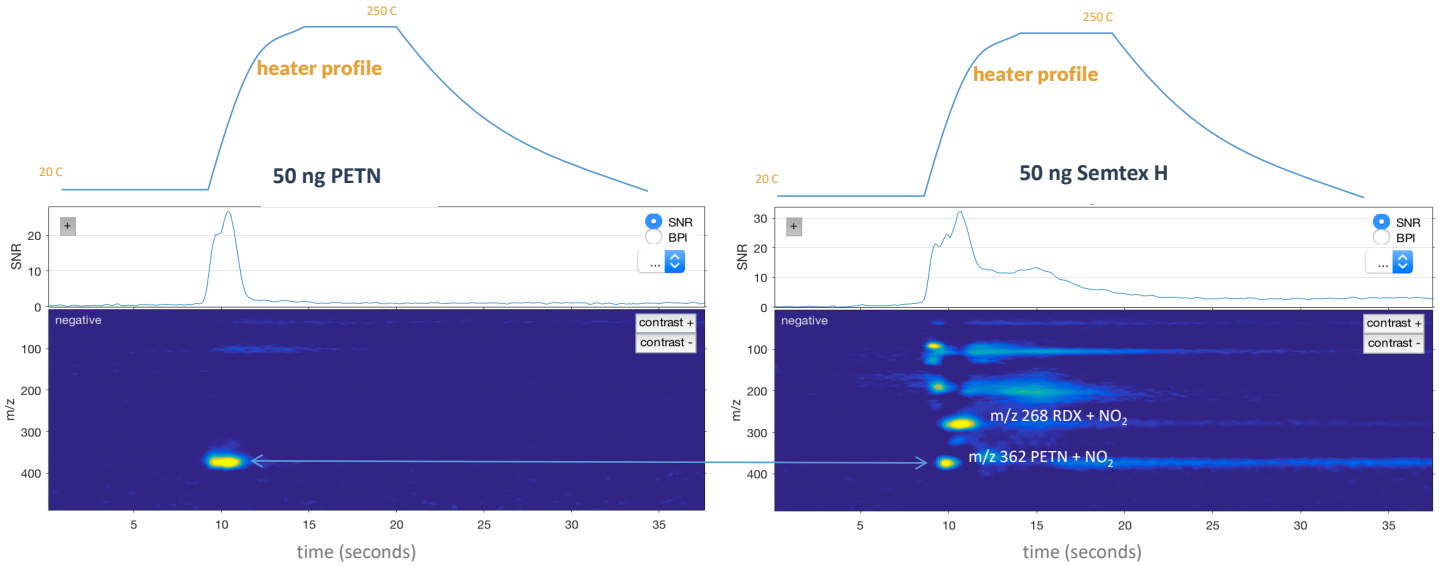
Example: TD-HPMS – CWA and Explosive Residues

An integrated thermal desorber provides controlled heating of a sample collected on a swab. This trace analysis module enables the detection of persistent threats on surfaces at low nanogram levels. The charts below demonstrate the response of the instrument to 100 ng of liquid VX.





Negative mode MS is particularly beneficial to the detection of several organonitrate and some inorganic explosive compounds. Trace (<500 ng) detection of pure PETN as well as detection of both PETN and RDX in a Semtex H formulation is shown below.



MX908 Mission Modes

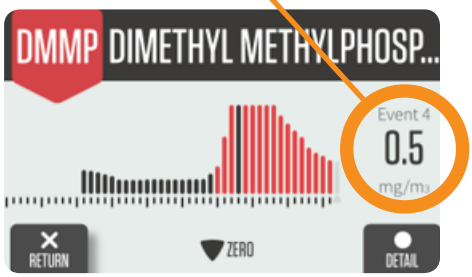
The MX908's Mission Modes are specialized hardware and software configurations for enhanced operational performance to meet specified mission objectives.

CW Hunter Mission Mode:

CW Hunter scans for CWAs and Simulants with a specific set of instrument settings that offer the highest possible sensitivity to this class of compounds. This Mission mode also provides the approximate vapor concentration detected by the instrument.

Agent	Lowest concentration with min SNR for alarm*	Estimated limit of ID	Response time to plateau
GB	13 ppb	20-50 ppb	2 seconds (@40 ppb)
GA	9.7 ppb	20-50 ppb	4 seconds (@100 ppb)
GD	16 ppb	20-50 ppb	Not Run
GF	21 ppb	20-50 ppb	10 seconds (@40 ppb)
HD	~500 ppb	500 ppb	Not Run
VX	10 ppb**	10 ppb**	Not Run

Real-time vapor quantification



* Reference concentrations for GA, GB, GD, GF, HD from calibrated MiniCAMS
** VX purity as delivered was very low, will require further analytical validation; reference information from GC-MS pending

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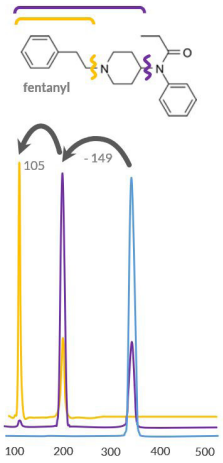
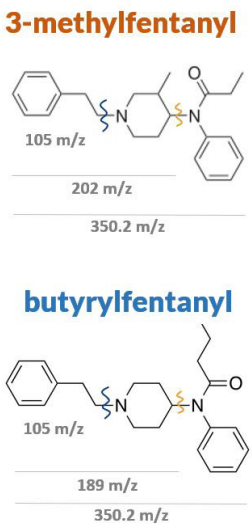
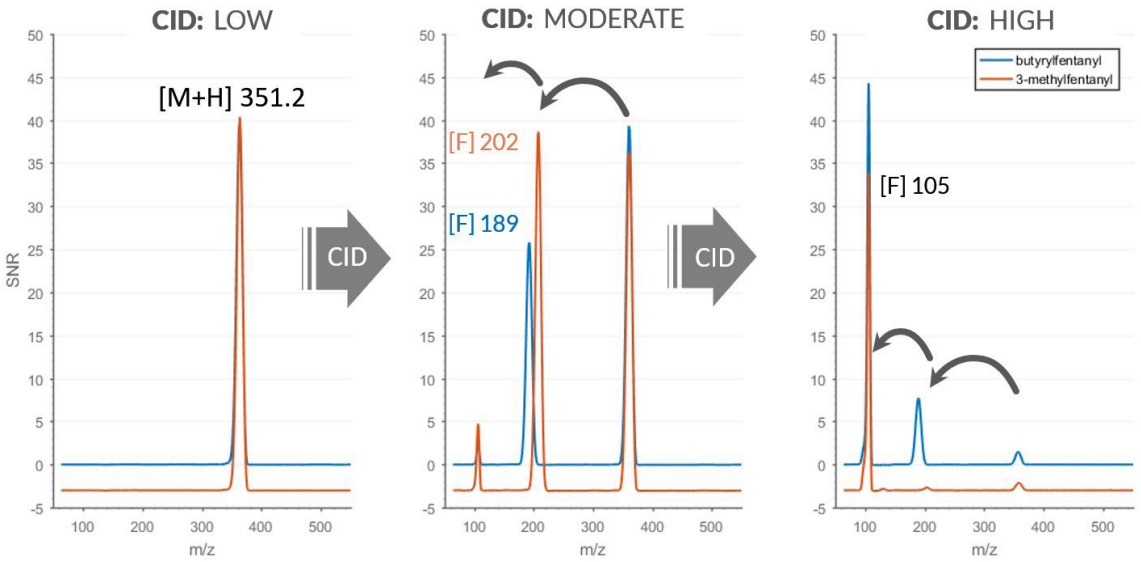
Drug Hunter Mission Mode:
Drug Hunter generates a series of mass spectral scans with progressive fragmentation voltages (collisionally induced dissociation) to selectively create & confirm the expected mass fragments of the drug targets of interest.

This process is automatic and occurs within milliseconds during operation in the Drug Hunter Mission.







CONCLUSIONS

The fast-switching dual-polarity MX908 offers true trace detection capabilities in both vapor (LODs in the 10s of ppbv) and thermal desorption (LODs ~10s of ng on swab) modes. This platform is a comprehensive multi-mission solution that scans the full range of explosives, drugs of abuse, chemical warfare agents (CWAs) and relevant precursors on a single sample. The MX908 HPMS platform is commercially available and continues to undergo rigorous field testing and algorithm refinement.

908 Devices
+1.857.254.1500 | info@908devices.com
www.908devices.com