



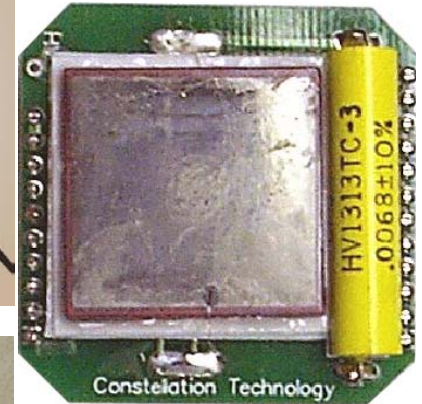
# **CT-1128 Portable GC-MS**

**HEMS Workshop 2005**

## Nuclear

- Mercuric Iodide Gamma Detectors
- GN-3 Handheld Spectrometer for SOCOM
- P3 Portable Radiation Portal

Portable Portal Personnel Monitor



## Biological

- Array BioSensor

## Chemical

- \* **CT-1128 Portable GC-MS**



In the late 1990's, the Forensic Science Center at the Lawrence Livermore National Laboratory (LLNL) designed a prototype portable GC-MS



In 2000, Constellation Technology Corporation teamed with LLNL to make the prototype GC-MS a commercial product



The CT-1128 GC-MS product utilizes a custom-built GC coupled to a custom vacuum manifold which houses an Agilent Technologies® 5973 Network MSD



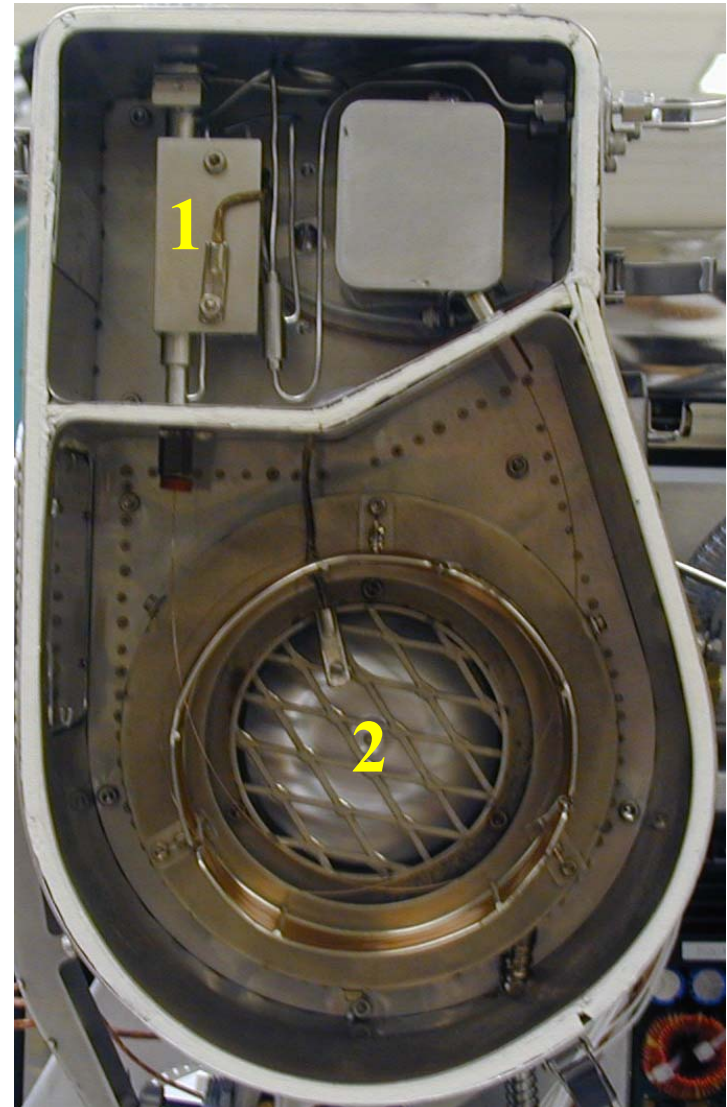
## GC Components

### 1. Injection Port

- Varian CP-1177 split/splitless injector
- Compatible with direct liquid injection or solid-phase microextraction (SPME) syringes

### 2. GC Oven

- Double-ramp capability from ambient to 325°C
- Variable ramp rates of up to 60°C/min.



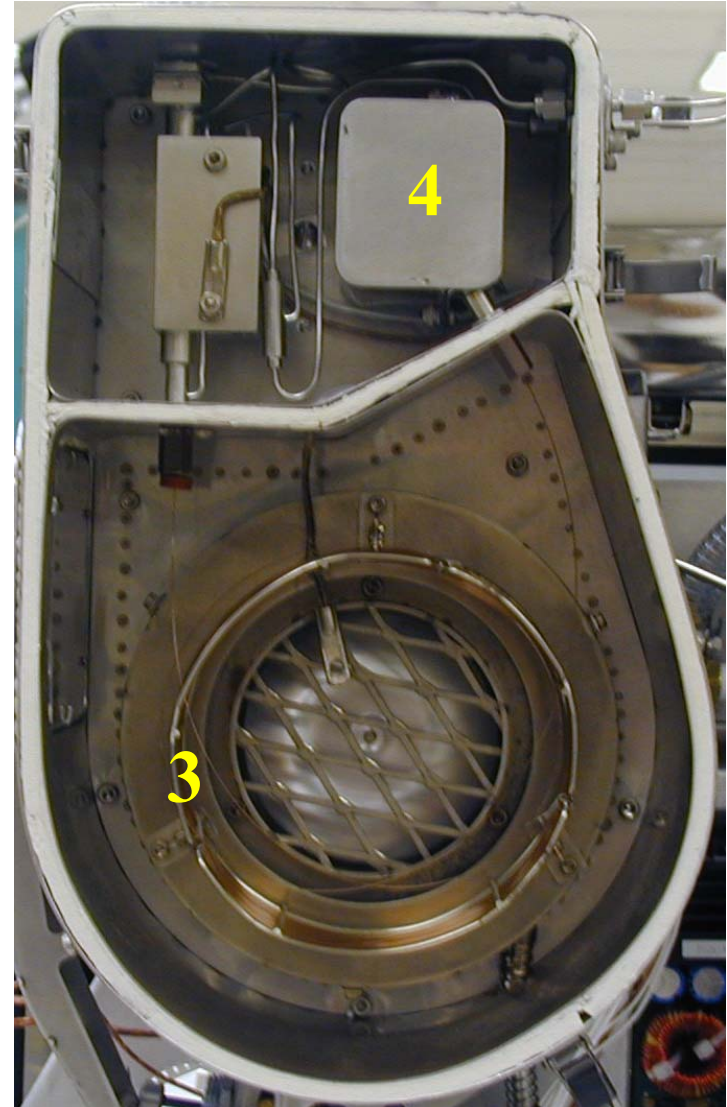
## GC Components

### 3. GC Capillary Column

- Quadrex 007-5MS (or equivalent) 30m x 0.25mm I.D. x 0.25 $\mu$ m film thickness; mounted on 4" diameter cage

### 4. MS Transfer Line

- Programmable temperature control up to 300 °C
- Rugged design allows shipment of instrument with column installed



## GC Components

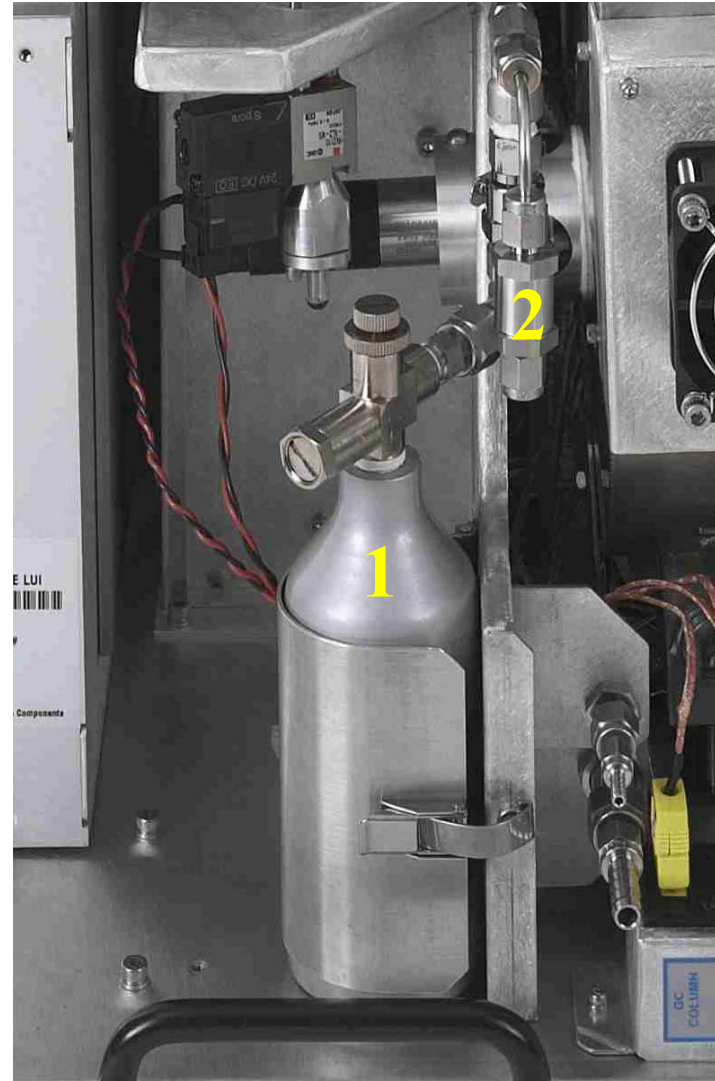
### 5. Oven Cooling Mechanism

- Automated door and fan activates upon completion of an analysis
- Hot air is removed more rapidly
- Oven recycling from 325°C to 50°C in ~10 minutes



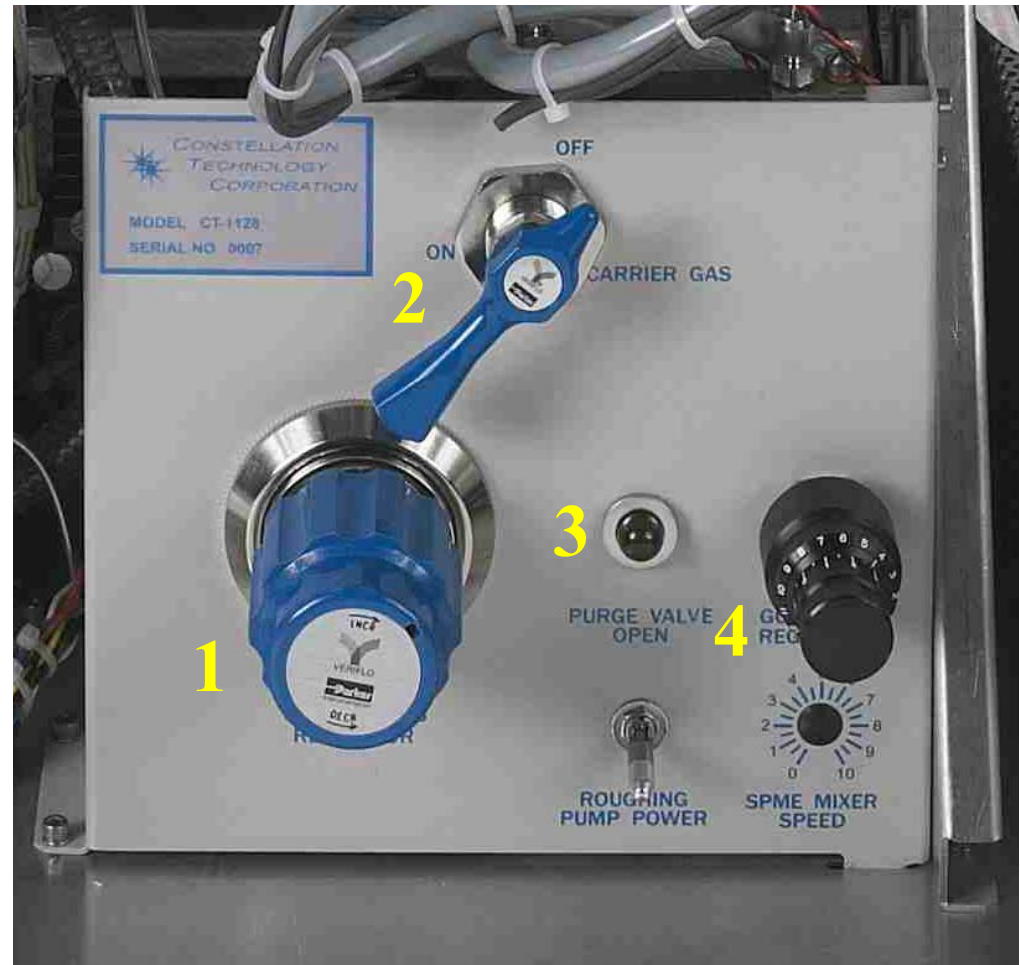
## Carrier Gas Supply

1. Onboard H<sub>2</sub> Bottle
  - Metal hydride provides several days of continuous operating time
2. Carrier Gas Option
  - External gas cylinder or gas generator may be connected



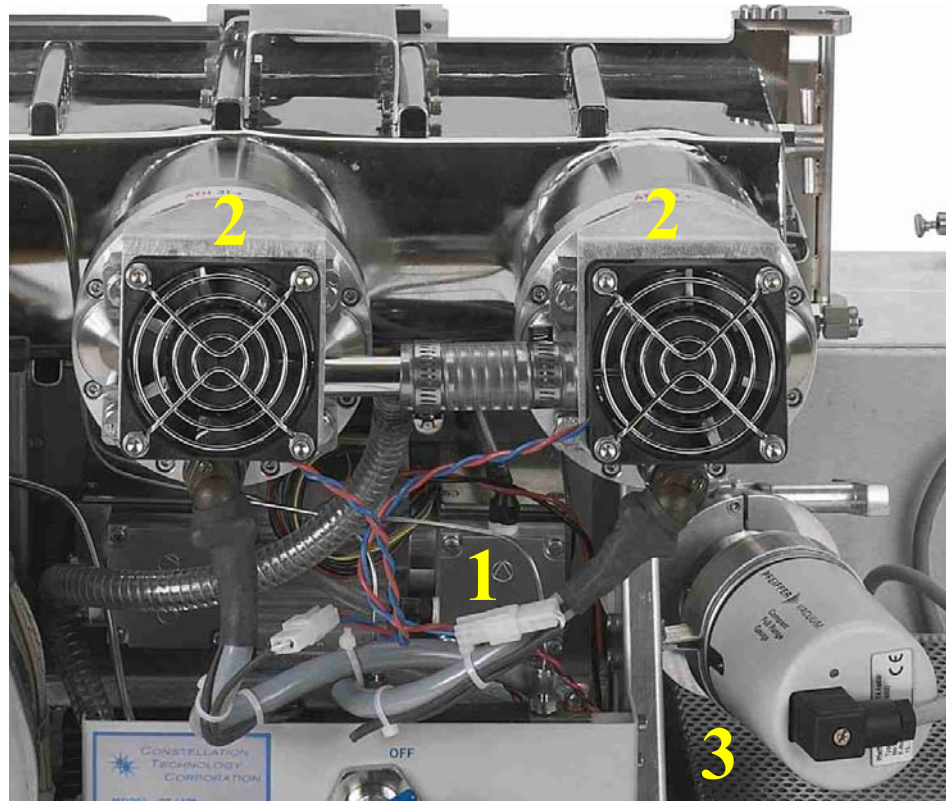
## Carrier Gas Control

1. Carrier Gas Pressure Regulator
2. Carrier Gas Valve
3. Injector Purge Indicator
4. Split-Splitless Flow Control Valve



## Vacuum System

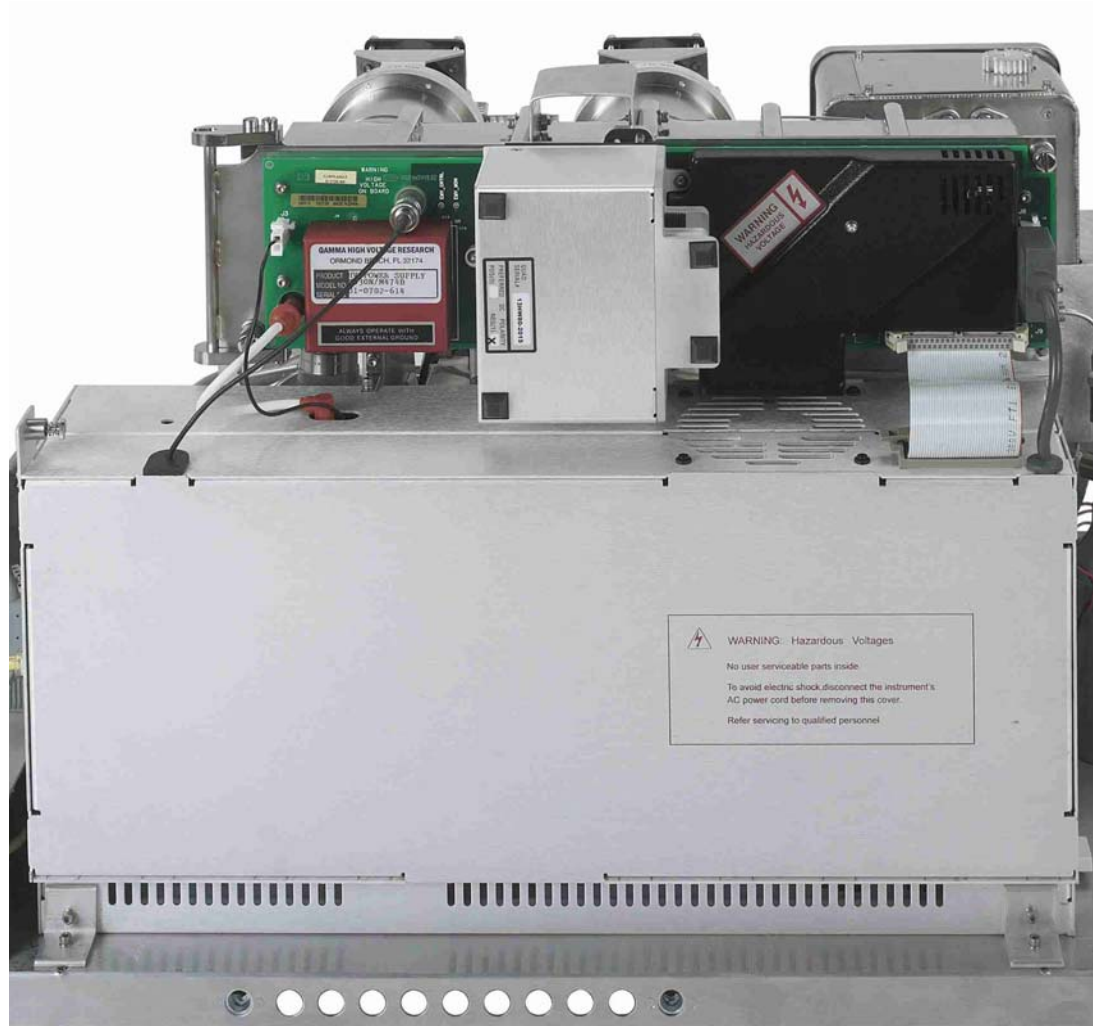
1. 4-Head Diaphragm Rough Pump (Neuberger)
2. Two Turbomolecular Pumps (Alcatel)
  - Air-cooled, 22 liters  $\text{He}_2/\text{sec}$  (15 liters  $\text{H}_2/\text{sec}$ ) pumping speed per pump
3. Full Range Vacuum Gauge (Pfeiffer)



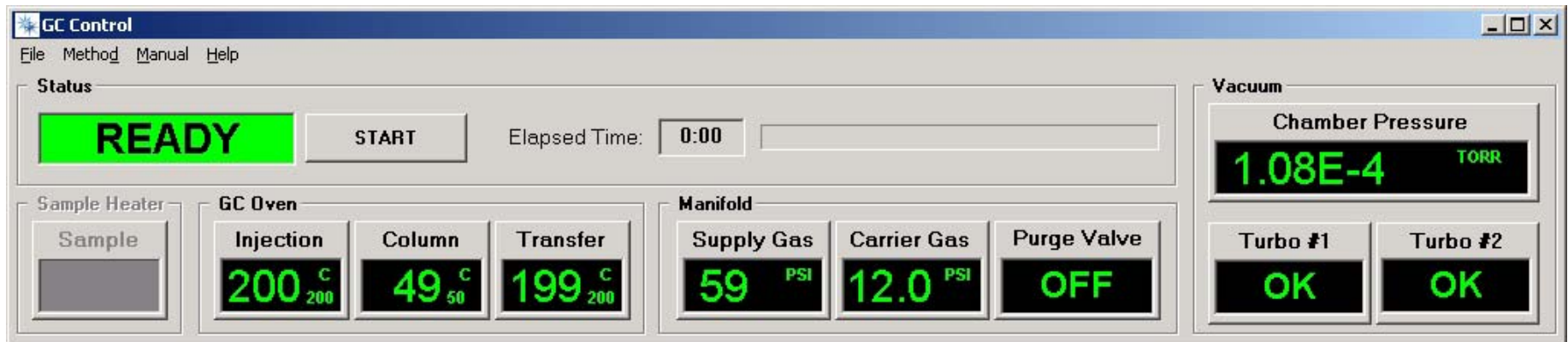
## MS Detector

### Agilent 5973N MSD

- Quadrupole mass spectrometer
- Electron Impact (EI) ion source
- 1.6 to 800 atomic mass unit (amu) scanning range
- Up to 10400 amu/sec scan speed



## *GC Control Software*



### GC Oven Control and Monitors

- GC actual temperatures
- GC heater set points

### Pressure Monitors

- H<sub>2</sub> bottle pressure
- Carrier Gas pressure
- Vacuum Pressure

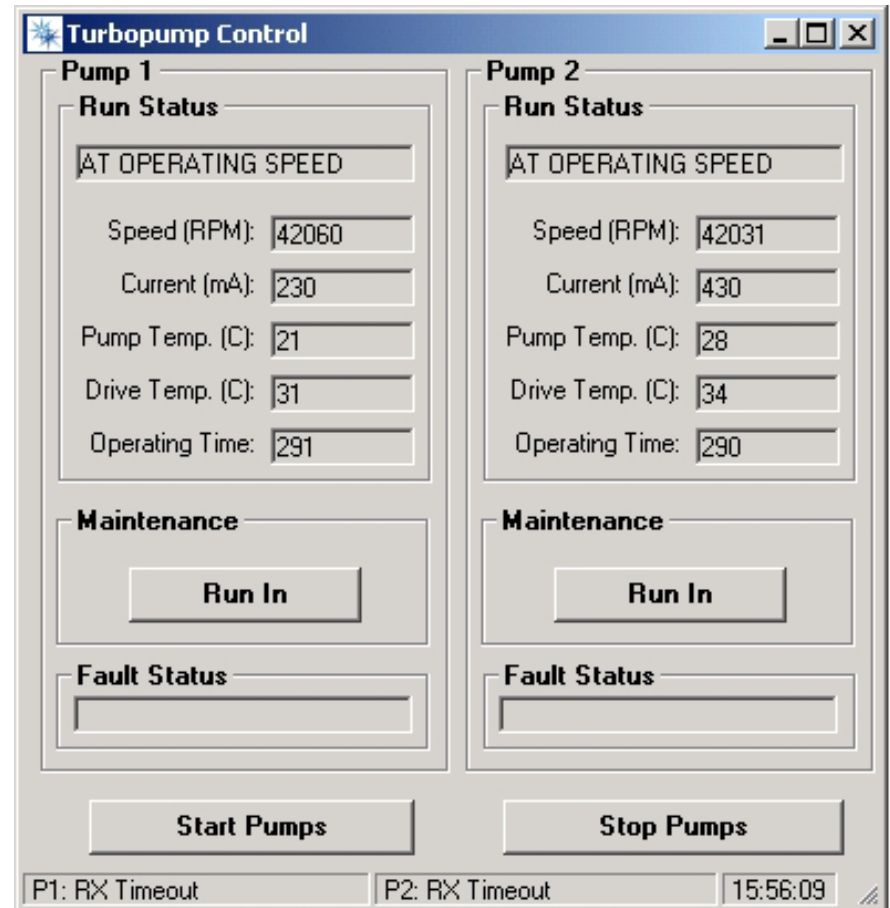
## *GC Control Software*

### Turbopump Control

- Start-up/Shutdown control

### Turbo pump telemetry

- Run status
- Pump speed
- Current draw
- Pump temperature



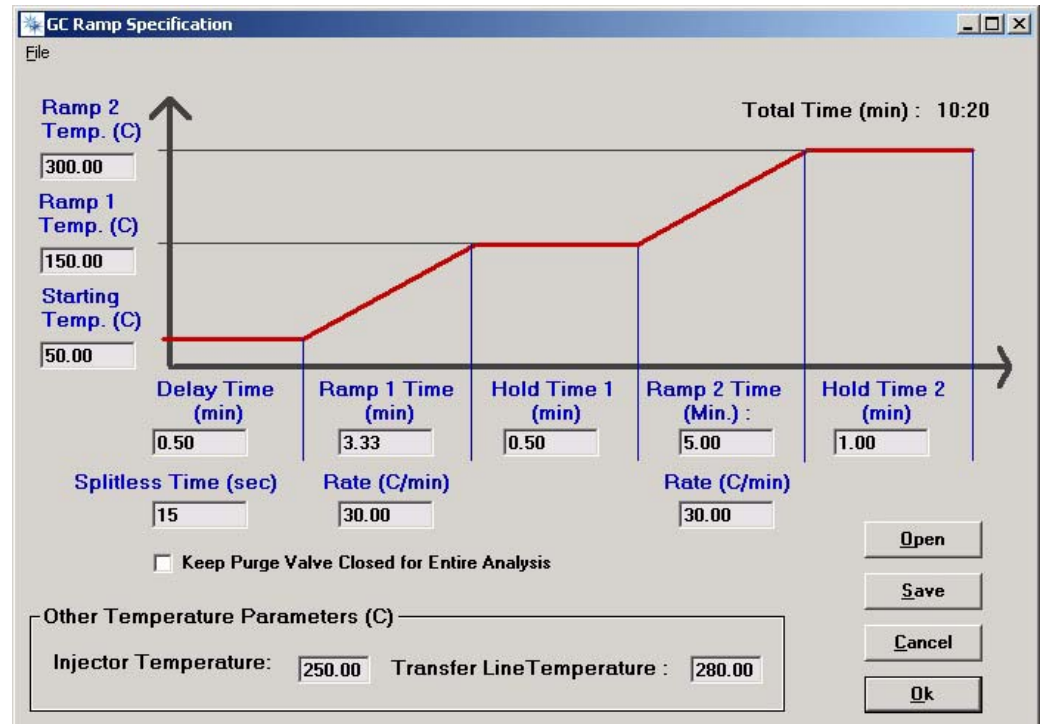
The screenshot shows the 'Turbopump Control' software window. It is divided into two main sections for Pump 1 and Pump 2. Each section has a 'Run Status' area with a text box showing 'AT OPERATING SPEED'. Below this are input fields for Speed (RPM), Current (mA), Pump Temp. (C), Drive Temp. (C), and Operating Time. For Pump 1, the values are 42060 RPM, 230 mA, 21 C, 31 C, and 291. For Pump 2, the values are 42031 RPM, 430 mA, 28 C, 34 C, and 290. Below the telemetry is a 'Maintenance' section with a 'Run In' button. At the bottom of each pump section is a 'Fault Status' text box. At the very bottom of the window are two large buttons: 'Start Pumps' and 'Stop Pumps'. The status bar at the bottom shows 'P1: RX Timeout', 'P2: RX Timeout', and the time '15:56:09'.

Parameter	Pump 1	Pump 2
Run Status	AT OPERATING SPEED	AT OPERATING SPEED
Speed (RPM)	42060	42031
Current (mA)	230	430
Pump Temp. (C)	21	28
Drive Temp. (C)	31	34
Operating Time	291	290

## GC Control Software

### GC Temperature Programming

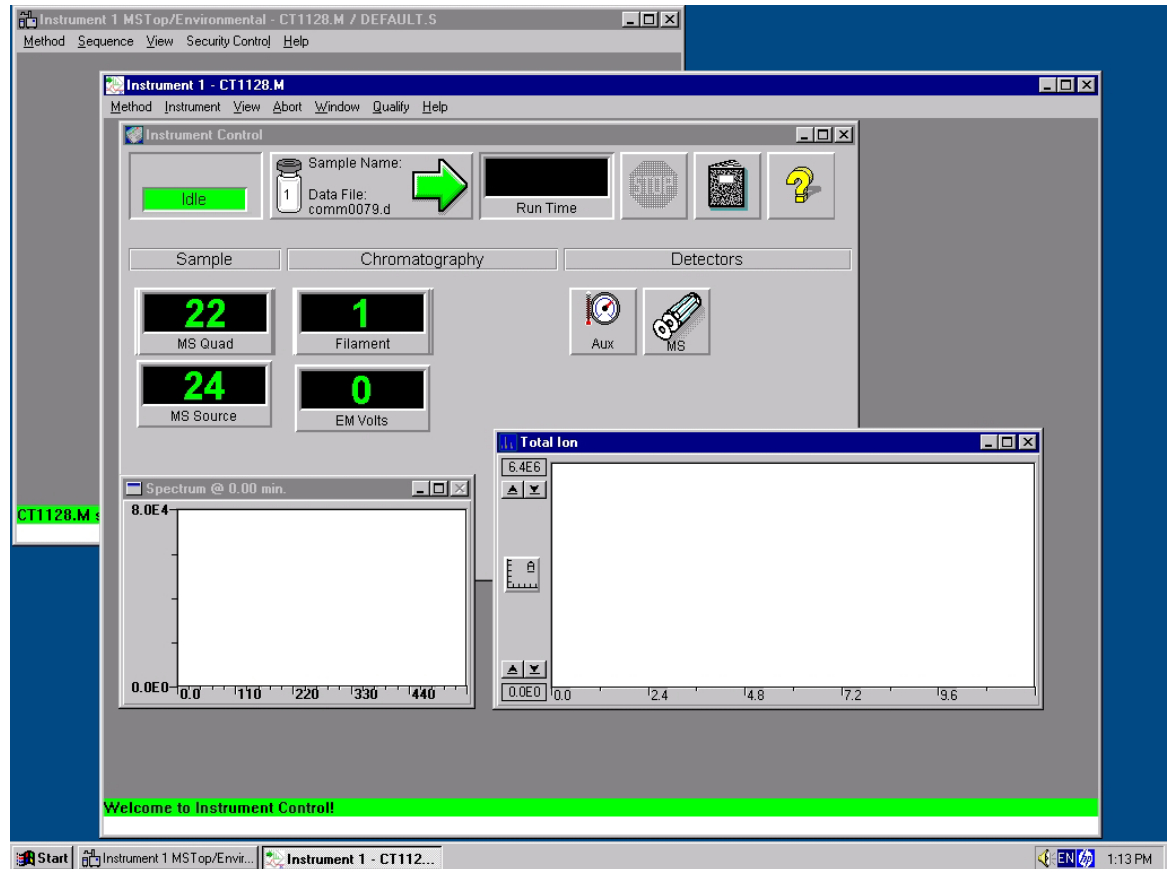
- Initial/Final temperatures
- Ramp rates
- Split/Splitless injection settings



## MSD Chemstation Software

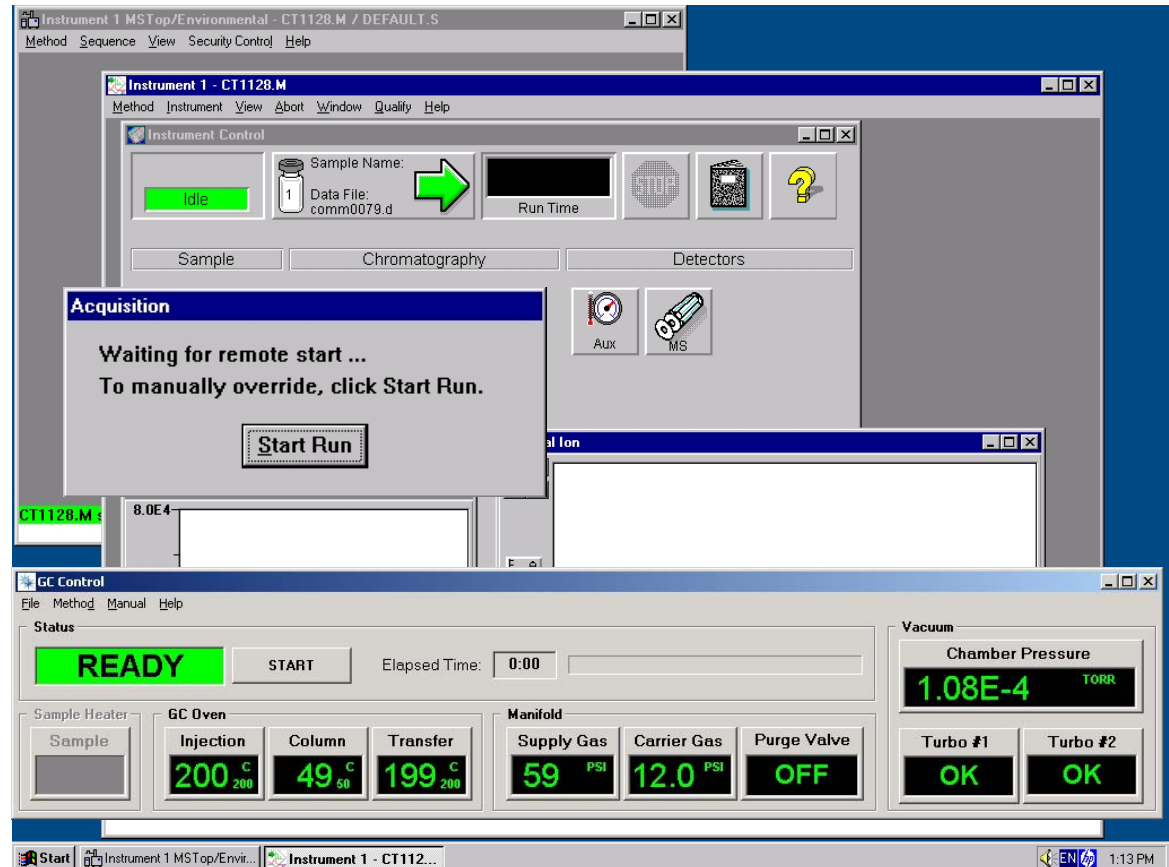
(Agilent Technologies)

- MS Controls
- MS Method Development
- Real-Time Data Analysis



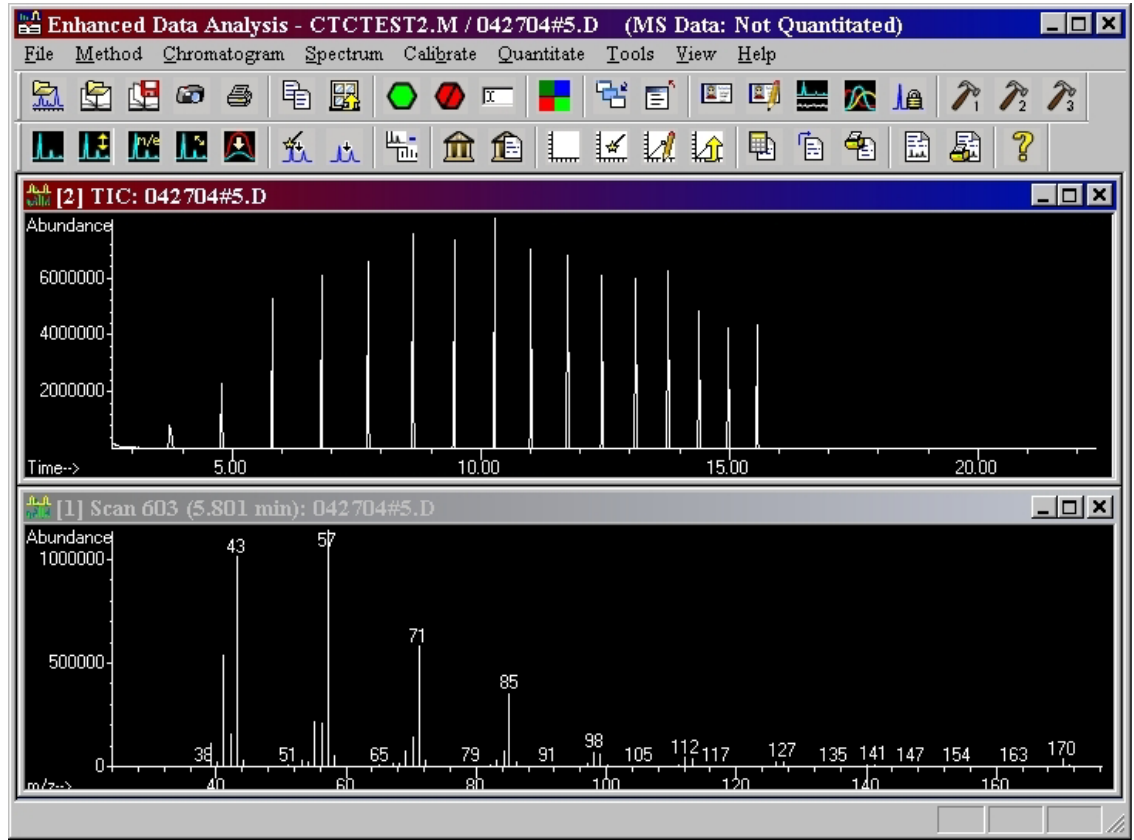
## GC-MS Software

- Synchronized start of analysis with a single 'click' or keystroke



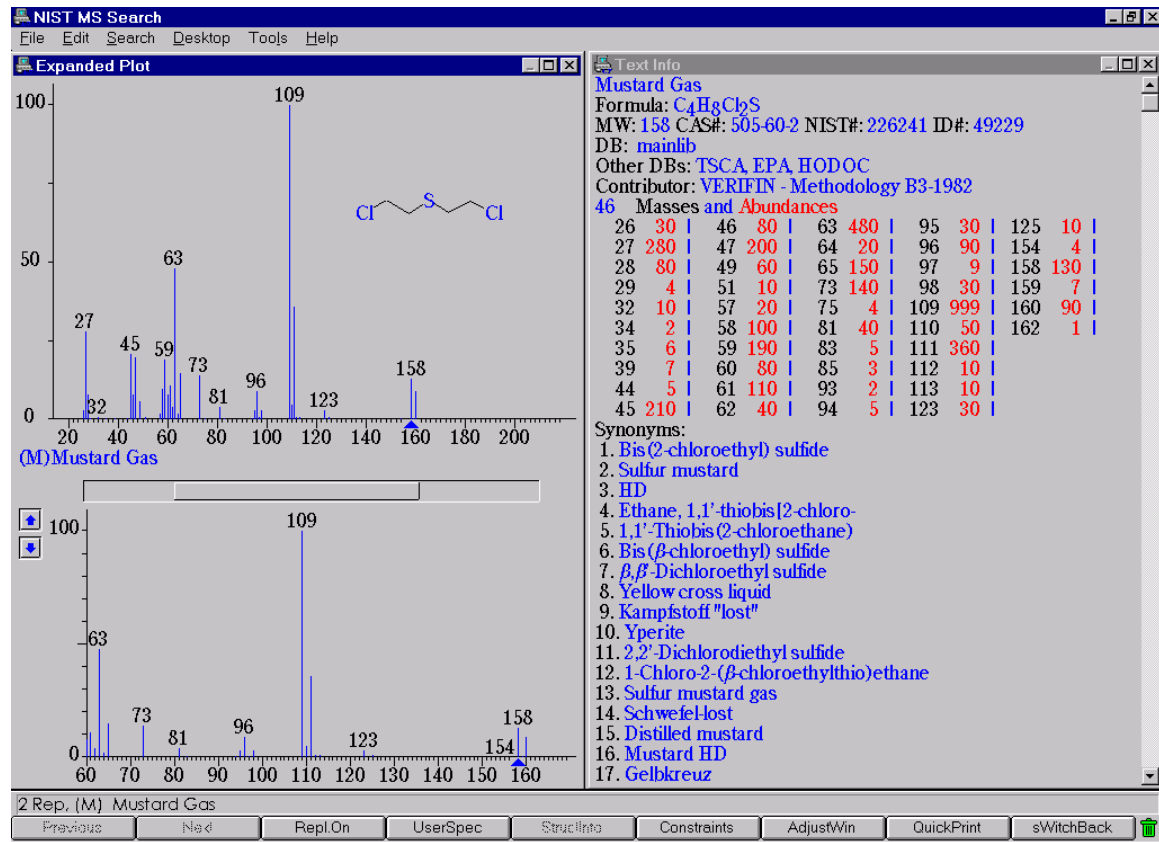
## MSD Chemstation Software (Agilent Technologies)

- Data Analysis



## NIST/EPA/NIH Comprehensive Library of Mass Spectra

- Unknown identification



## Specifications

### Instrument Parameter

### Specification

Dimensions

15in. x 23in. x 15in.

Weight

75 pounds

Power Requirements

120 volts A/C

Computer/Operating System

State-of-the-art laptop CPU with peripherals; Windows 2000; Reach-back capability with wireless aircard

## Shipping Case

- Allows safe transport anywhere via commercial freight carriers



## Field Deployment



## Application Fields

- Environmental field testing
- Environmental clean-up
- Industrial process monitoring
- HAZMAT/first responder site evaluation
- Military (chemical weapons/explosives detection)
- On-site forensic analyses (arson, clandestine drug labs)

## CT-1128 Users

- ⇒ Forensic Science Center at Lawrence Livermore National Laboratories (Lawrence, CA)
- ⇒ Kobe Steel, Ltd (Japan)
- ⇒ Defense Threat Reduction Agency, Department of Defense (U.S.)
- ⇒ Counter-Terrorism Unit of Los Angeles County Sheriff's Dept (Los Angeles, CA)
- ⇒ Civil Support Teams, Florida National Guard
- ⇒ Police Scientific Branch, Ministry of Defense (United Kingdom)

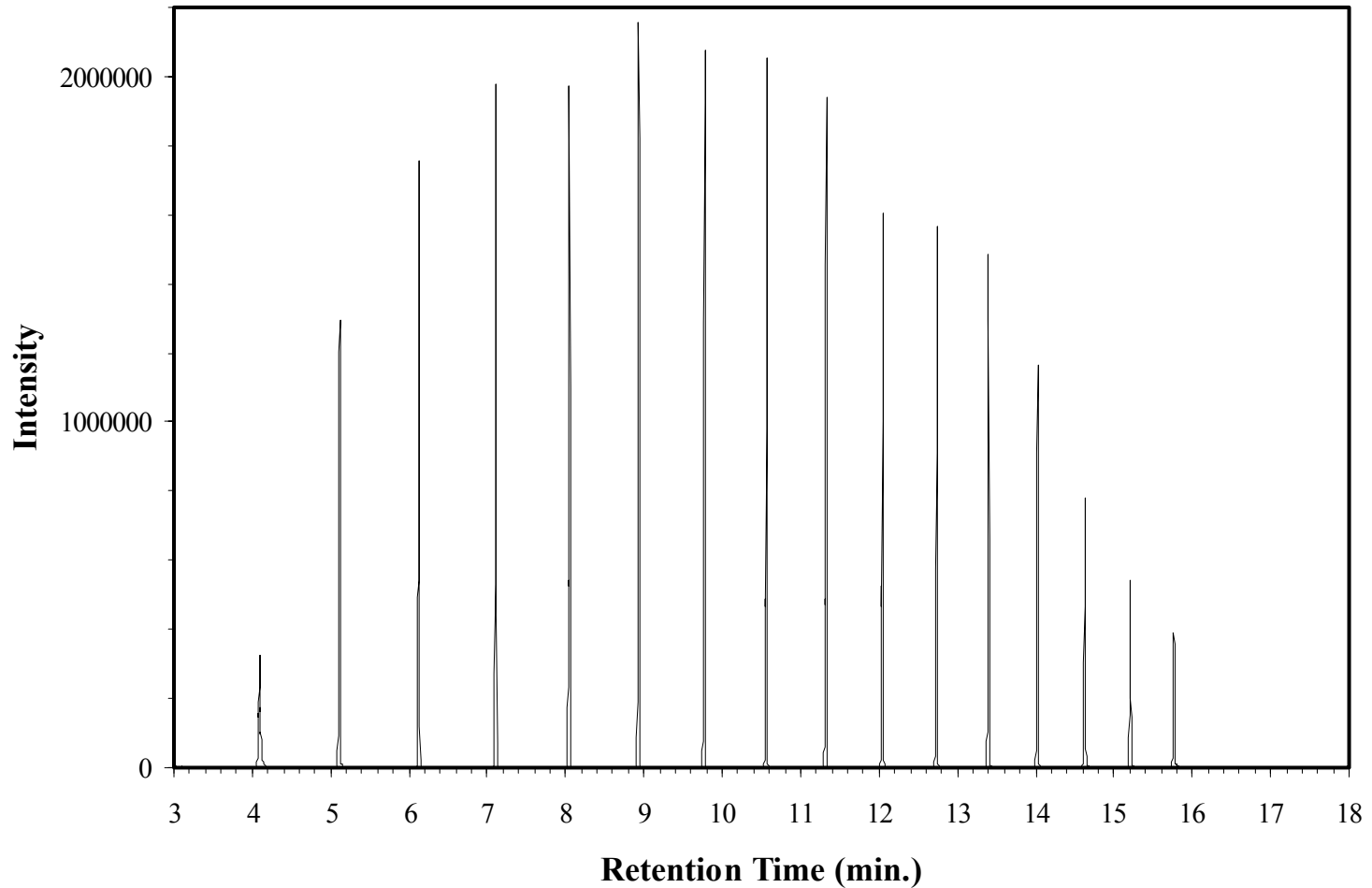
## GC Parameters

Column Type:	007-5MS (Quadrex)
Column Dimensions:	30m x 0.25mmID x 0.25 $\mu$ m film
Temperature Program:	50°C, hold 0.75min.; 15°C/min. to 300°C; optional hold
Injector/Detector Temperature:	250°C / 280 °C
Run Time:	10-30 minutes (application dependent)
Carrier Gas/Flow	Hydrogen or Helium / ~1mL/min.

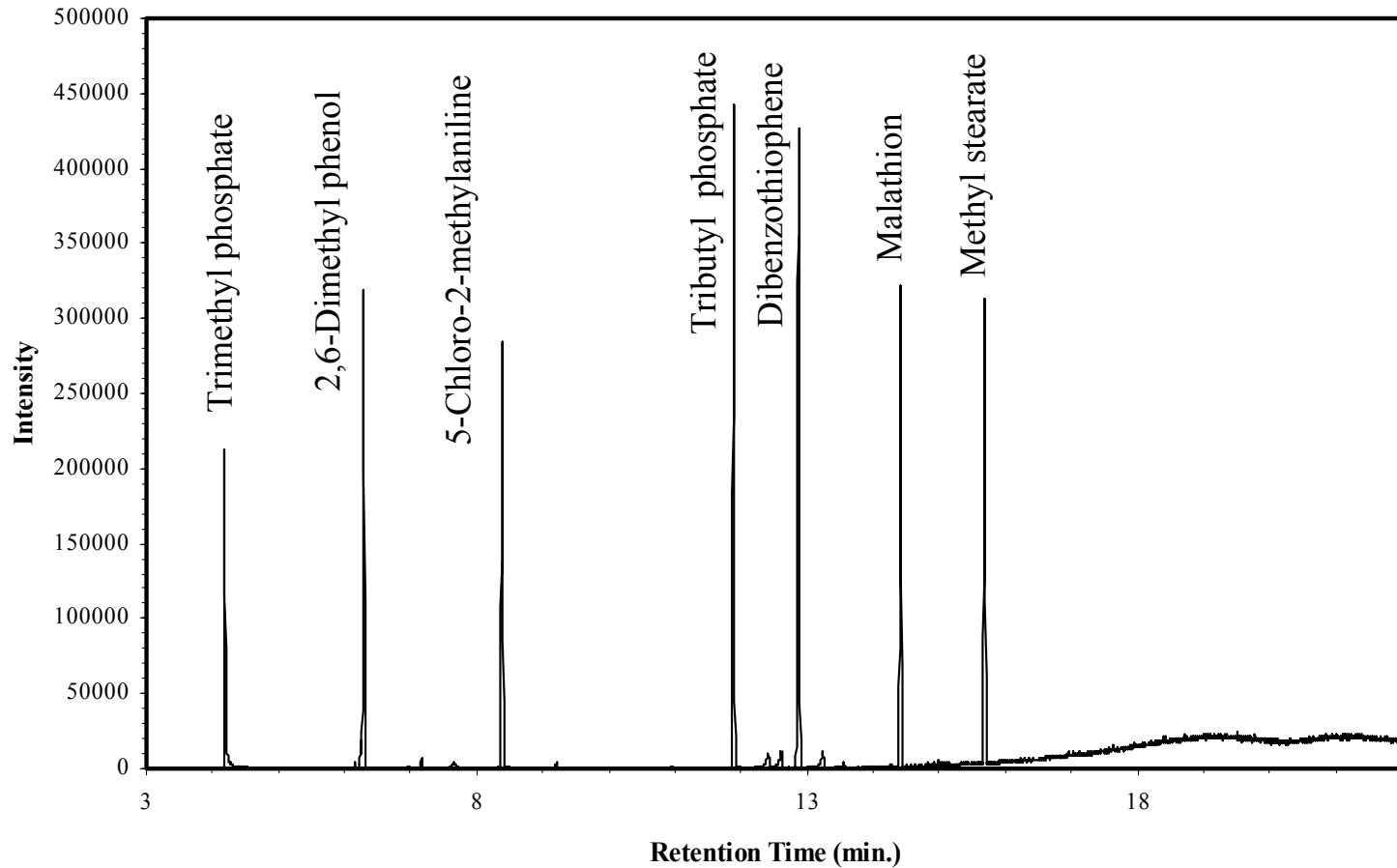
## MS Parameters

Solvent Delay:	1.5 - 3.0 minutes (carrier gas dependent)
Scan Range:	35 to 500 amu
Scan Rate:	~5 scans/sec.

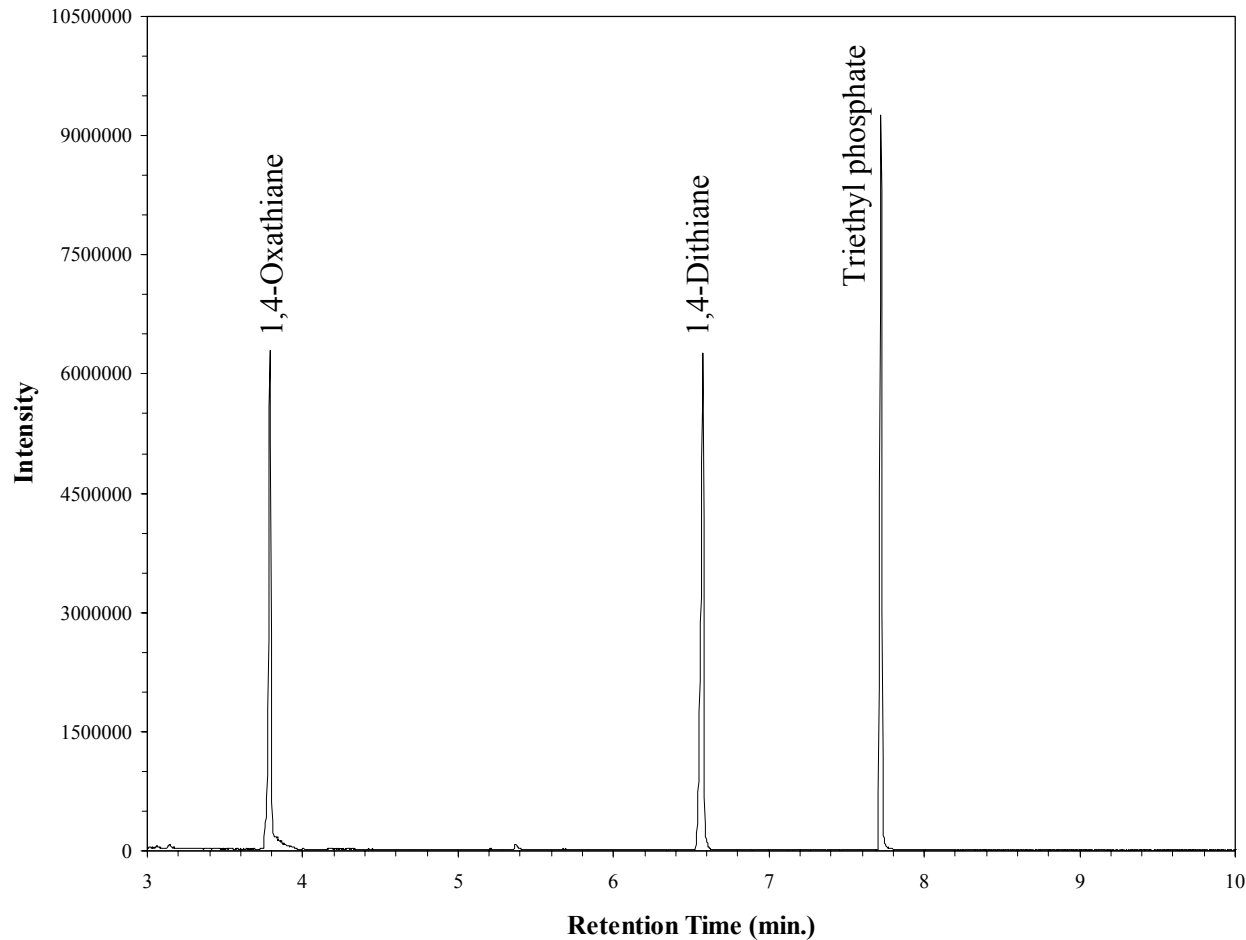
## Hydrocarbon Test Mix (C<sub>10</sub>-C<sub>25</sub>)



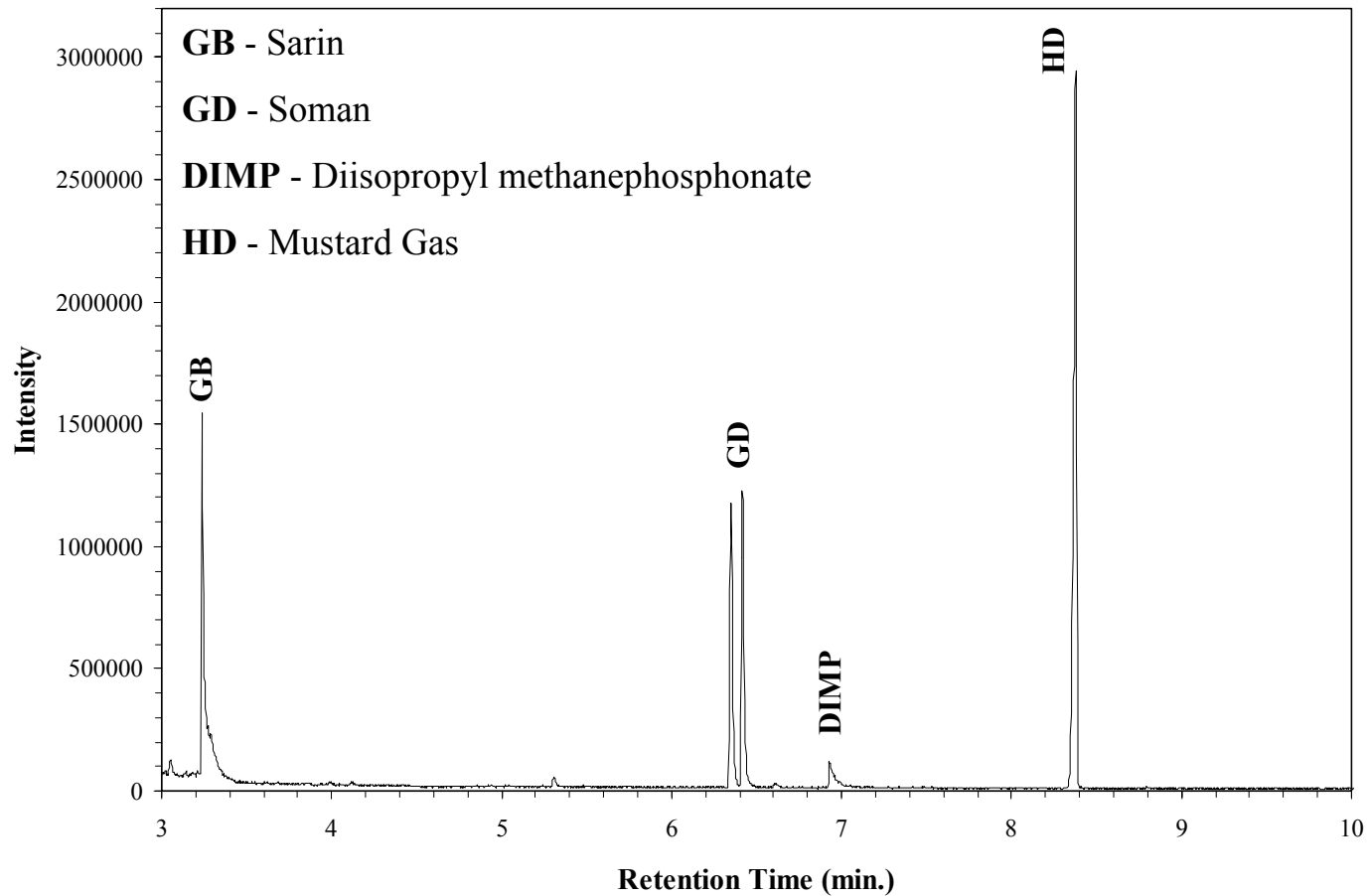
## CW Test Mix



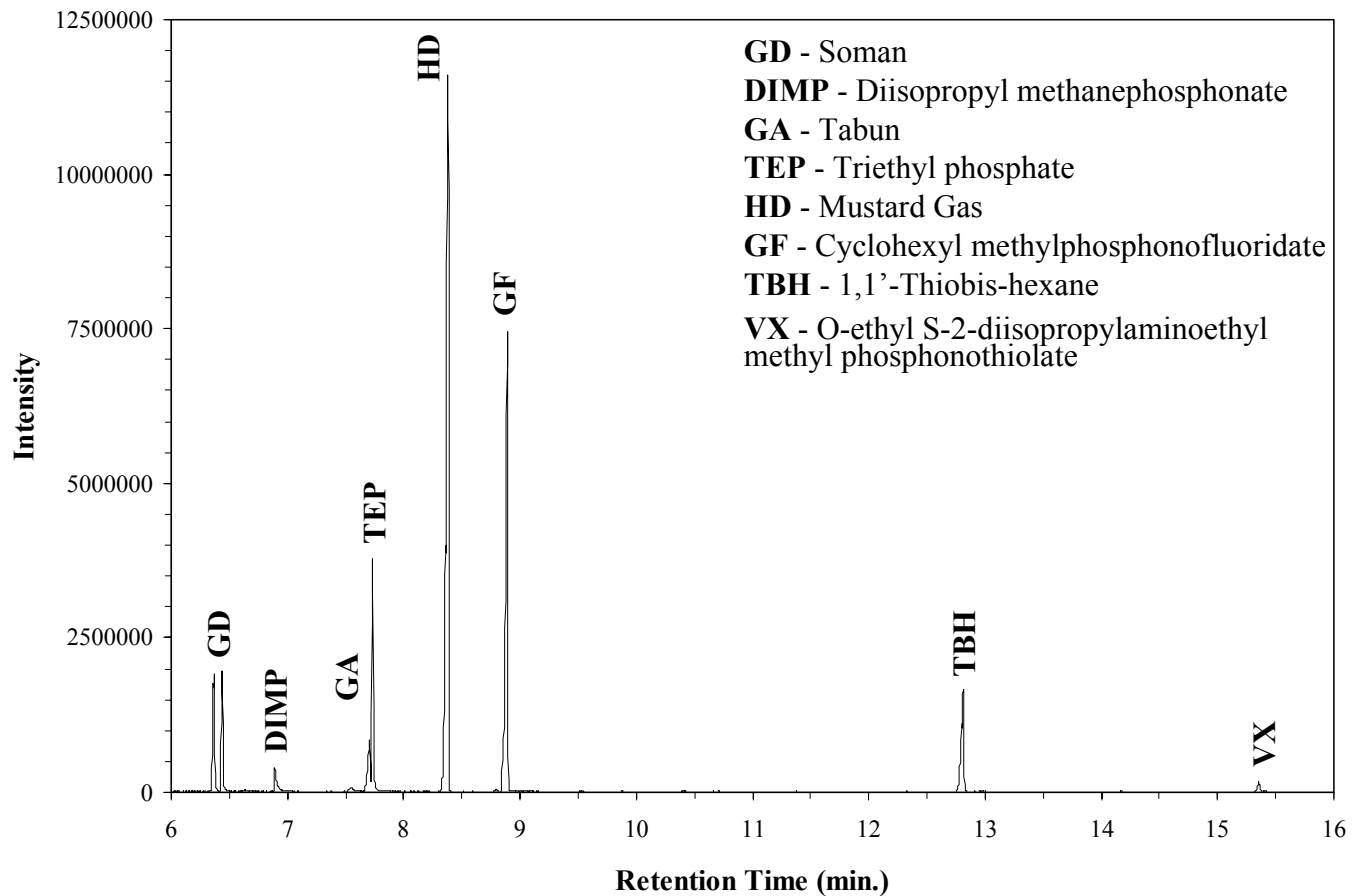
## CW Degradation Products



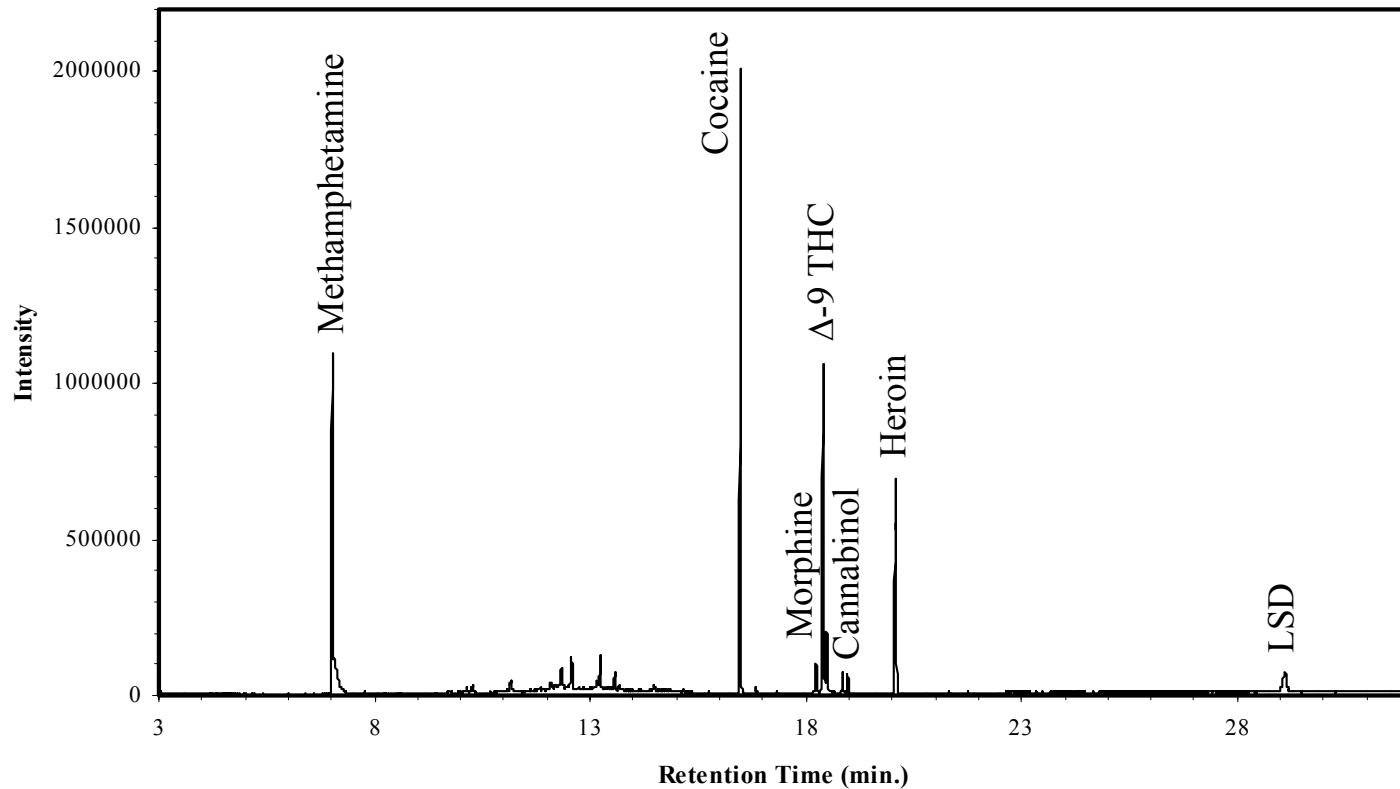
## CW Agents



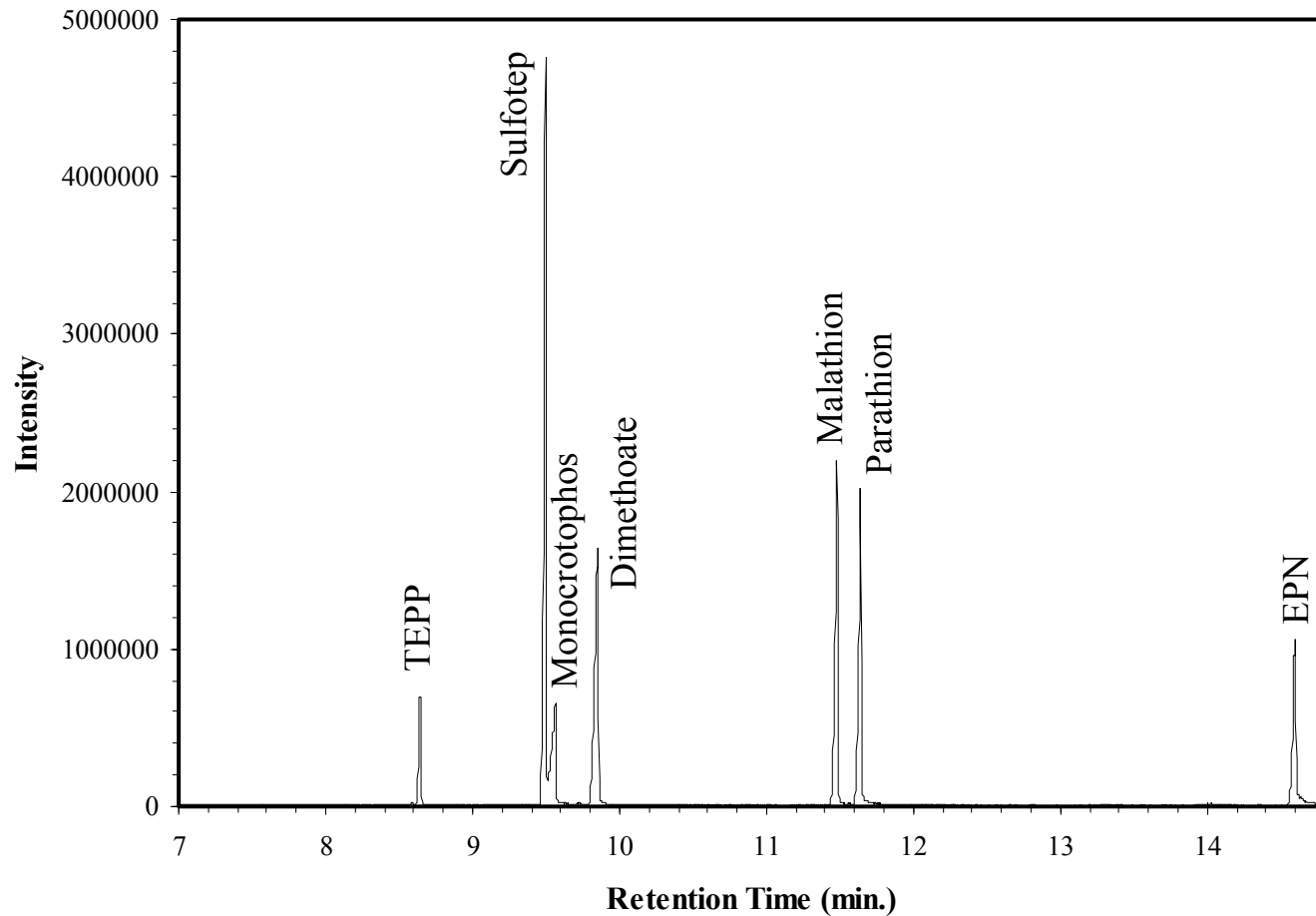
## CW Agents & Precursors



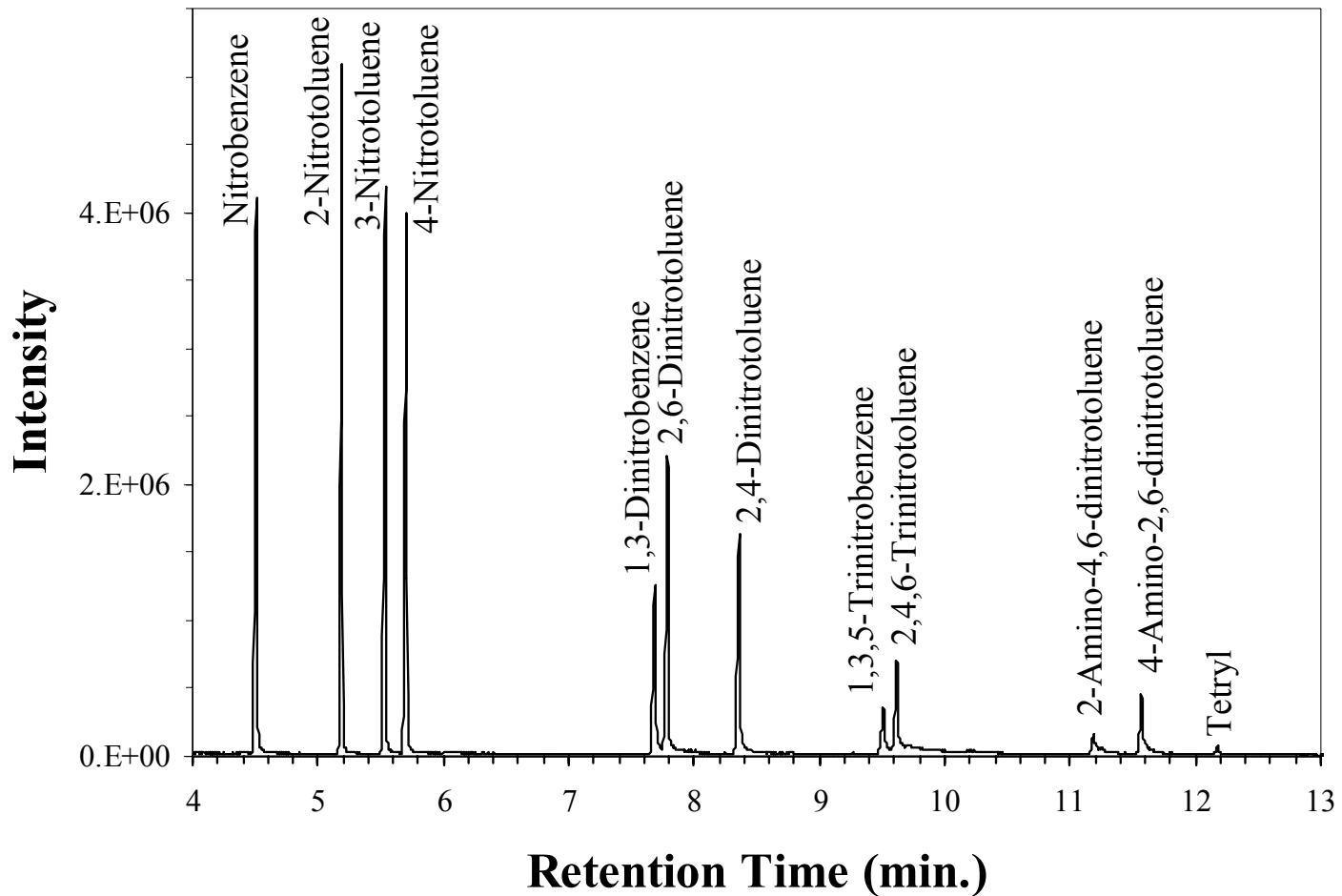
## Controlled Substances



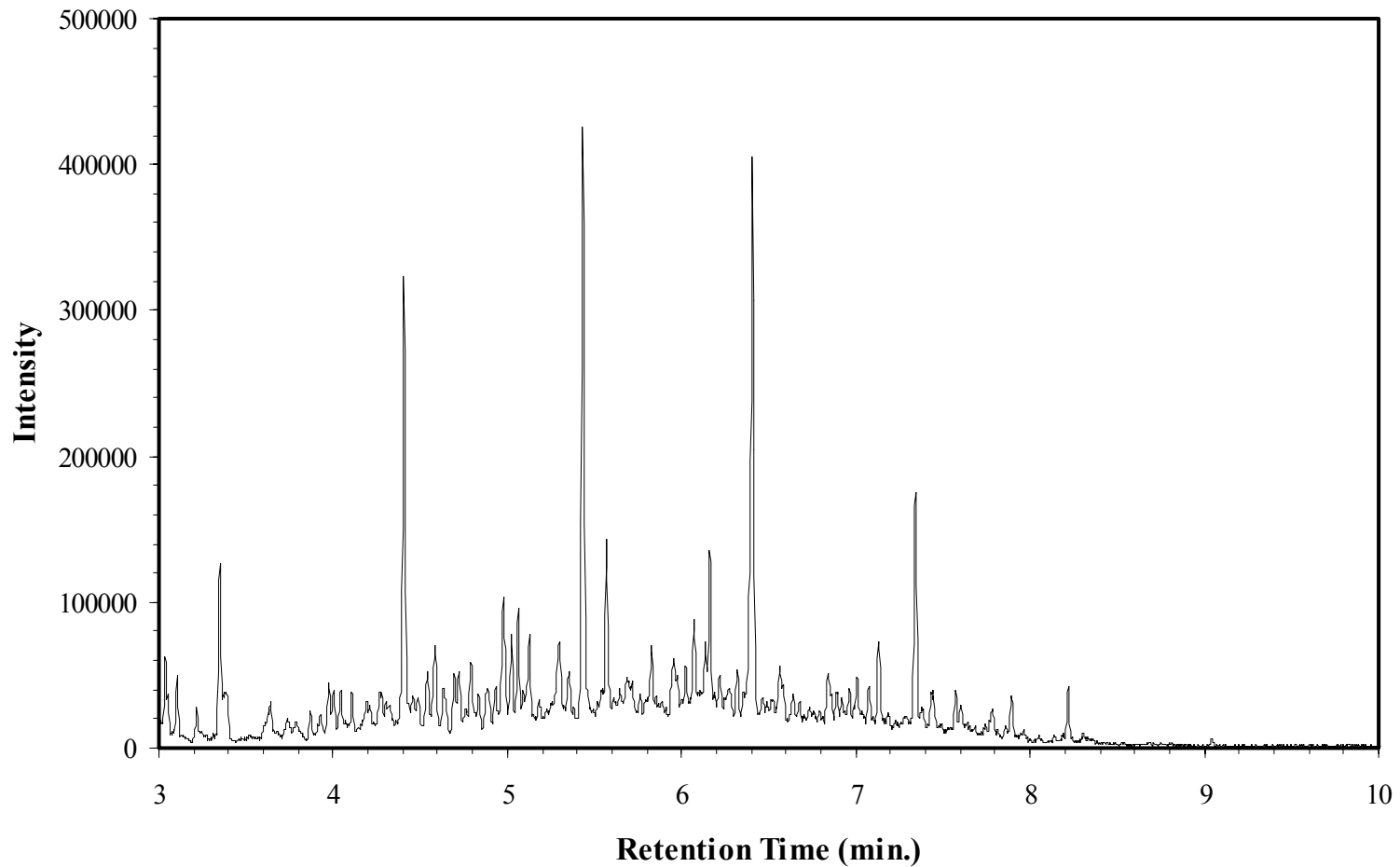
## Pesticides



## Explosives (Nitroaromatics)

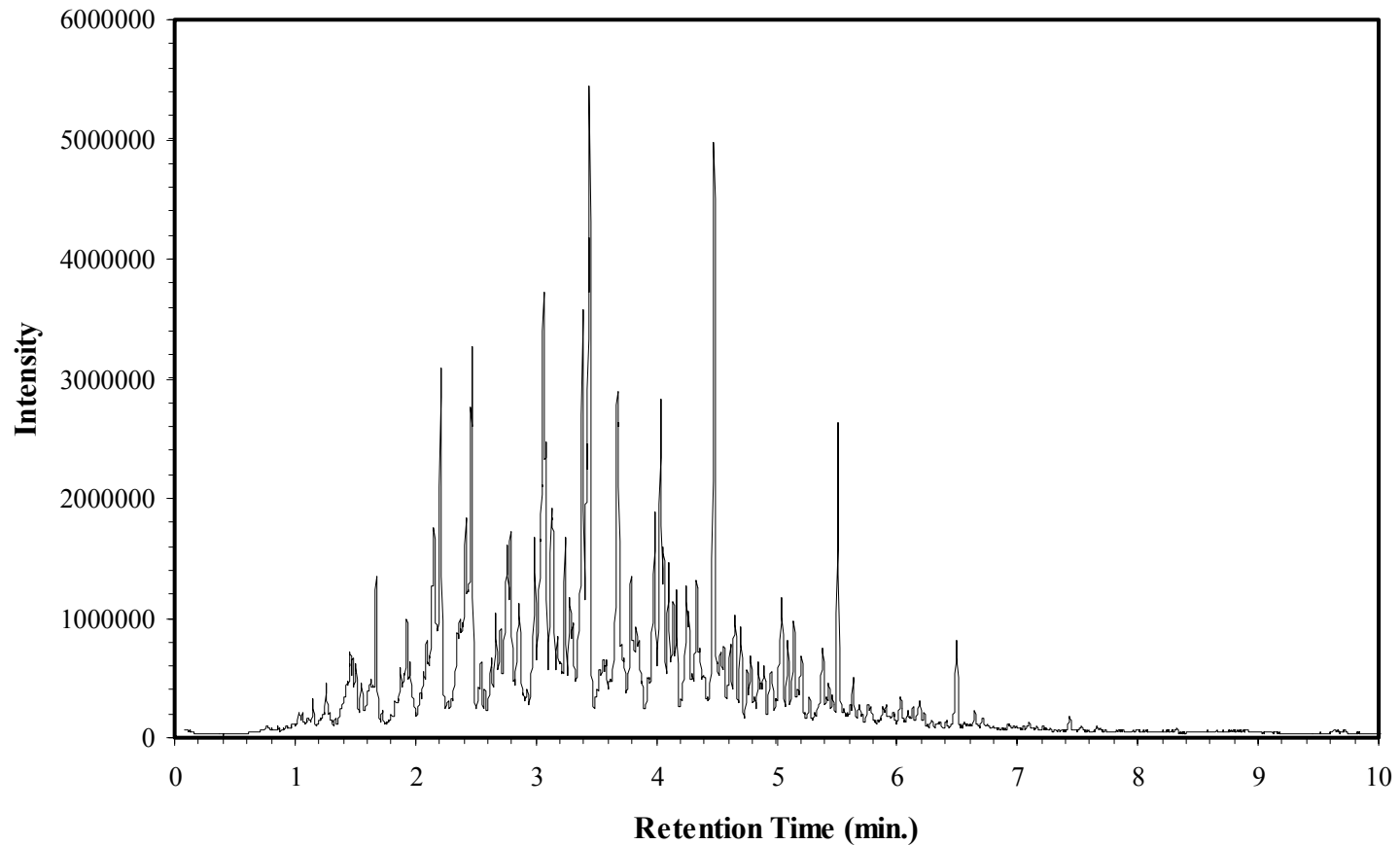


## JP-5 Fuel



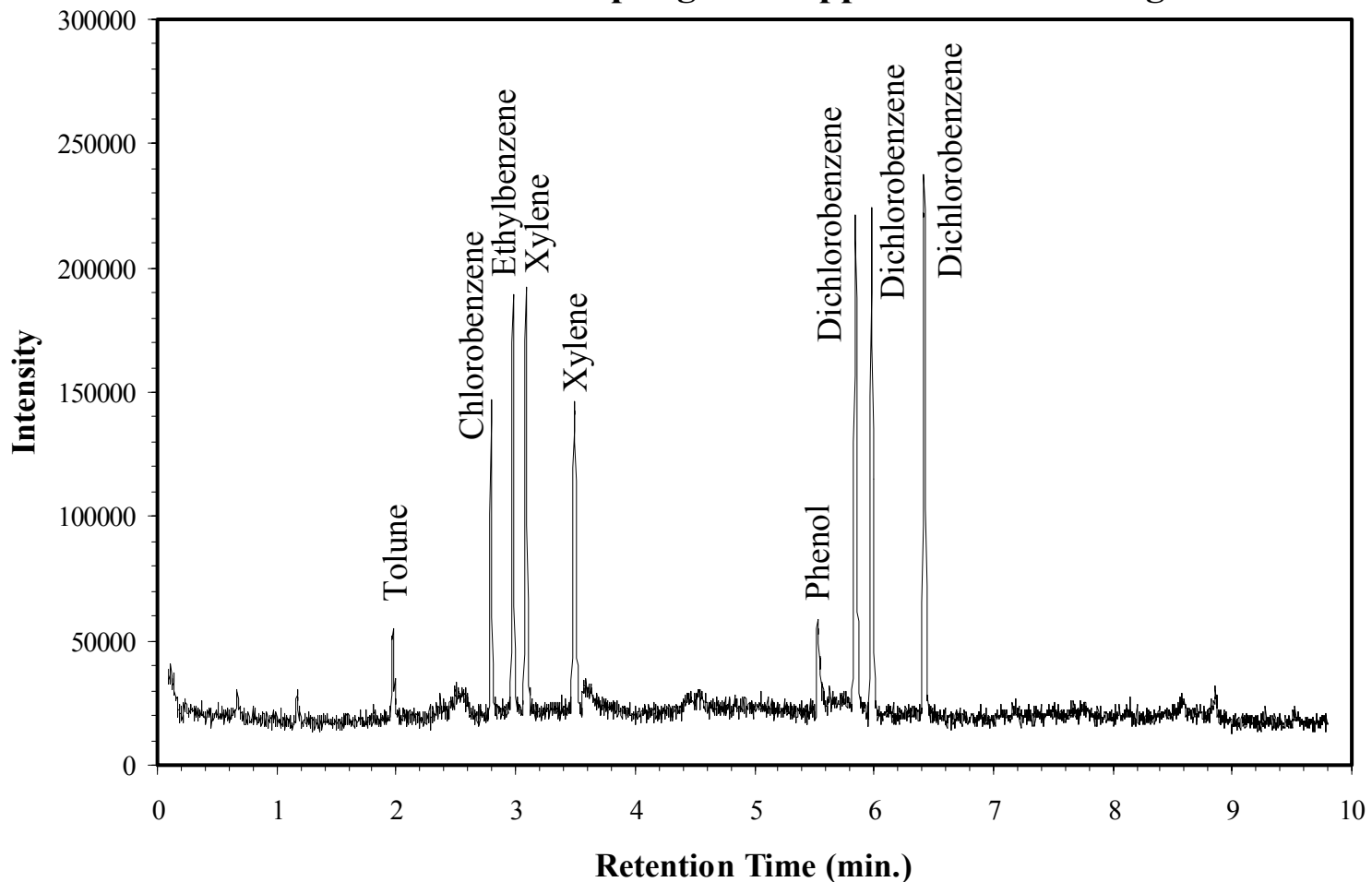
## JP-5 Fuel

\*SPME sampling from cotton swipe



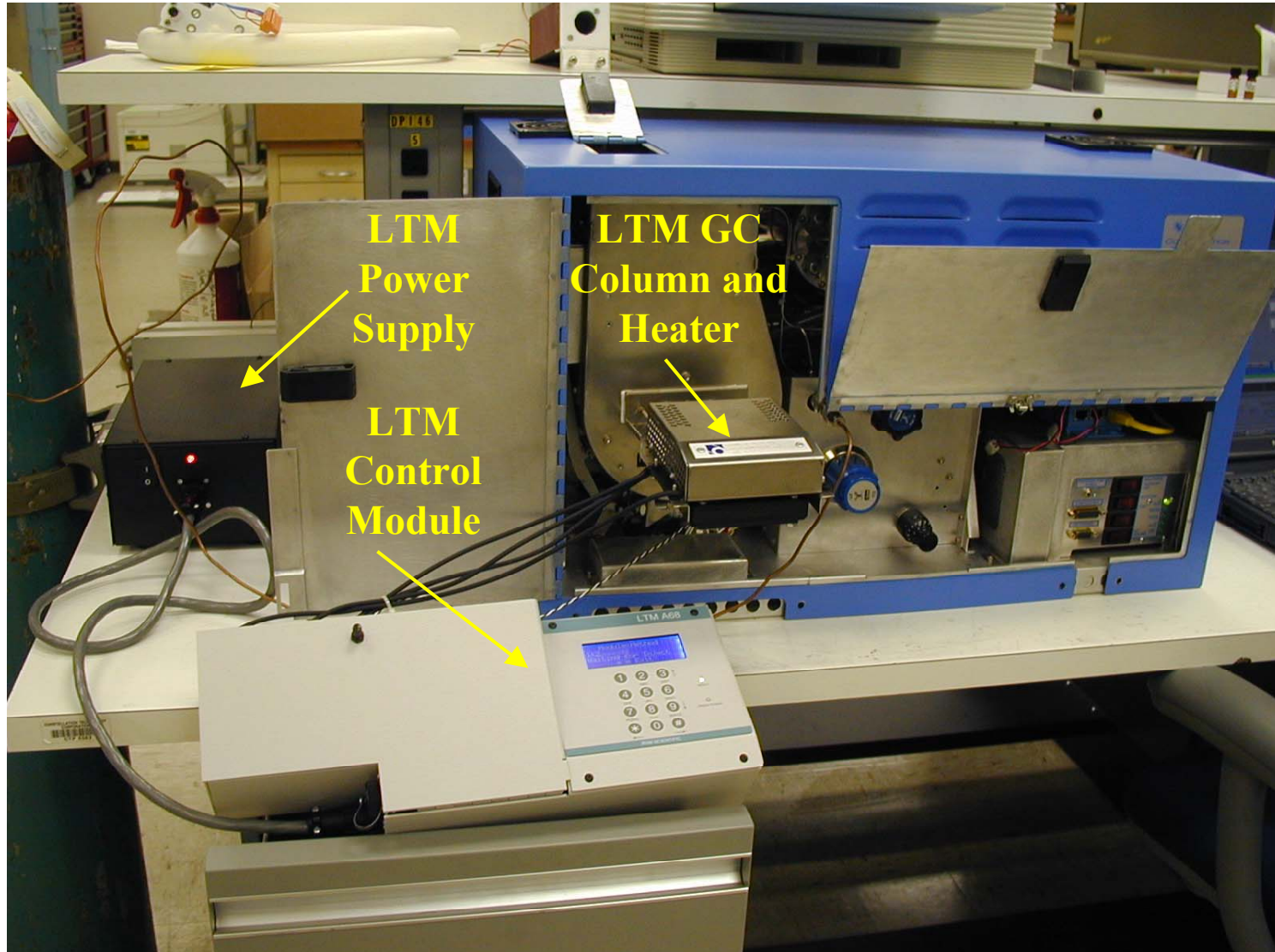
## Volatile Organics

\*SPME sampling from 1ppm VOA in air bag

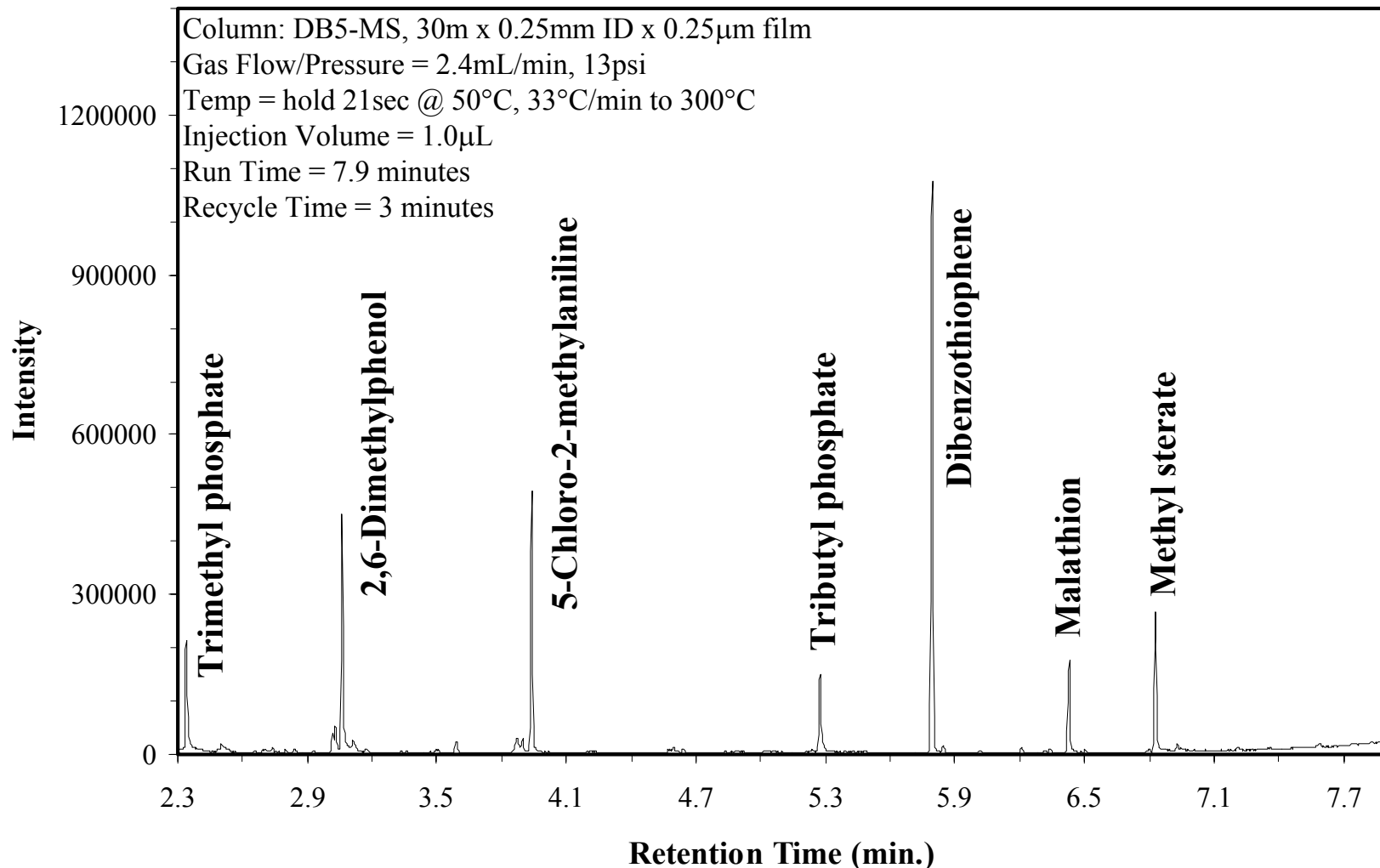


## **Received an SBIR award from Marine Corps Systems Command**

- Investigated hardware modifications that might improve the current CT-1128
- Purchased a Low Thermal Mass (LTM) module from RVM Scientific and fitted with the CT-1128 instrument as a proof-of-concept
- ❖ Will incorporate these improvements in future iterations of the CT-1128 GC-MS



## Standard GC Column and Accelerated Conditions

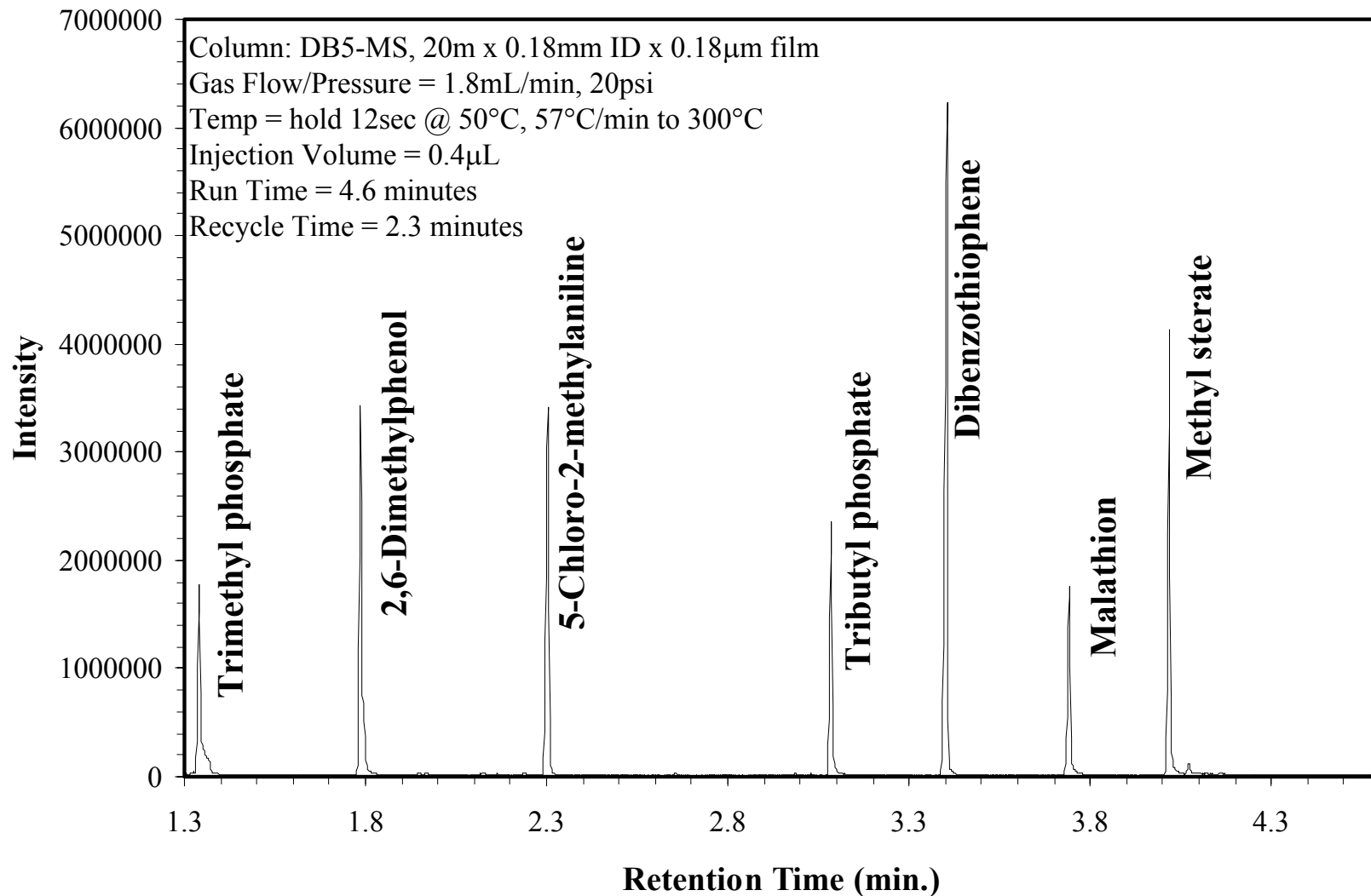


## Detection Limits: 30m Column

Compound Name	Selected Ion (m/z)	Detection Limit (ng/ $\mu$ L)	Detection Limit (pg)
<b>Decane (C10)</b>	57	0.5	500
<b>Pentadecane (C15)</b>	57	0.1	100
<b>Eicosane (C20)</b>	57	0.2	200
<b>Pentacosane (C25)</b>	57	0.2	200
<b>Trimethylphosphate</b>	110	0.1	7
<b>2,6-Dimethylphenol</b>	122	0.005	5
<b>5-Chloro-2-methylaniline</b>	106	0.1	100
<b>Tributylphosphate</b>	99	0.1	100
<b>Dibenzothiophene</b>	184	0.001	1
<b>Malathion</b>	125	0.5	500
<b>Methylstearate</b>	74	0.1	100

\*Detection Limit is defined as the concentration of analyte in solution (or weight of analyte) which produces a signal-to-noise ratio of 10:1 for the most abundant ion in the given analyte's mass spectrum. For cases where background noise is approximately zero, detection limit is defined as a signal intensity of 100 for the most abundant ion in the given analyte's mass spectrum.

## Smaller GC Column and Accelerated Conditions



## Detection Limits: 20m Column

Compound Name	Selected Ion (m/z)	Detection Limit (ng/ $\mu$ L)	Detection Limit (pg)
Decane (C10)	57	1	400
Pentadecane (C15)	57	0.1	40
Eicosane (C20)	57	0.2	80
Pentacosane (C25)	57	0.4	160
Trimethylphosphate	110	0.2	80
2,6-Dimethylphenol	122	0.4	160
5-Chloro-2-methylaniline	106	0.2	80
Tributylphosphate	99	0.3	120
Dibenzothiophene	184	0.03	12
Malathion	125	0.6	240
Methylstearate	74	0.3	120

\*Detection Limit is defined as the concentration of analyte in solution (or weight of analyte) which produces a signal-to-noise ratio of 10:1 for the most abundant ion in the given analyte's mass spectrum. For cases where background noise is approximately zero, detection limit is defined as a signal intensity of 100 for the most abundant ion in the given analyte's mass spectrum.