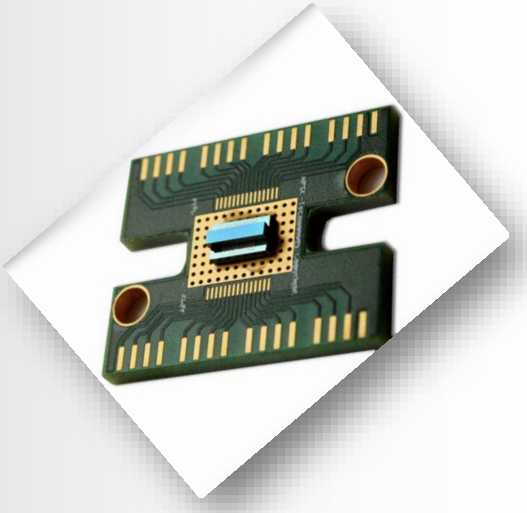
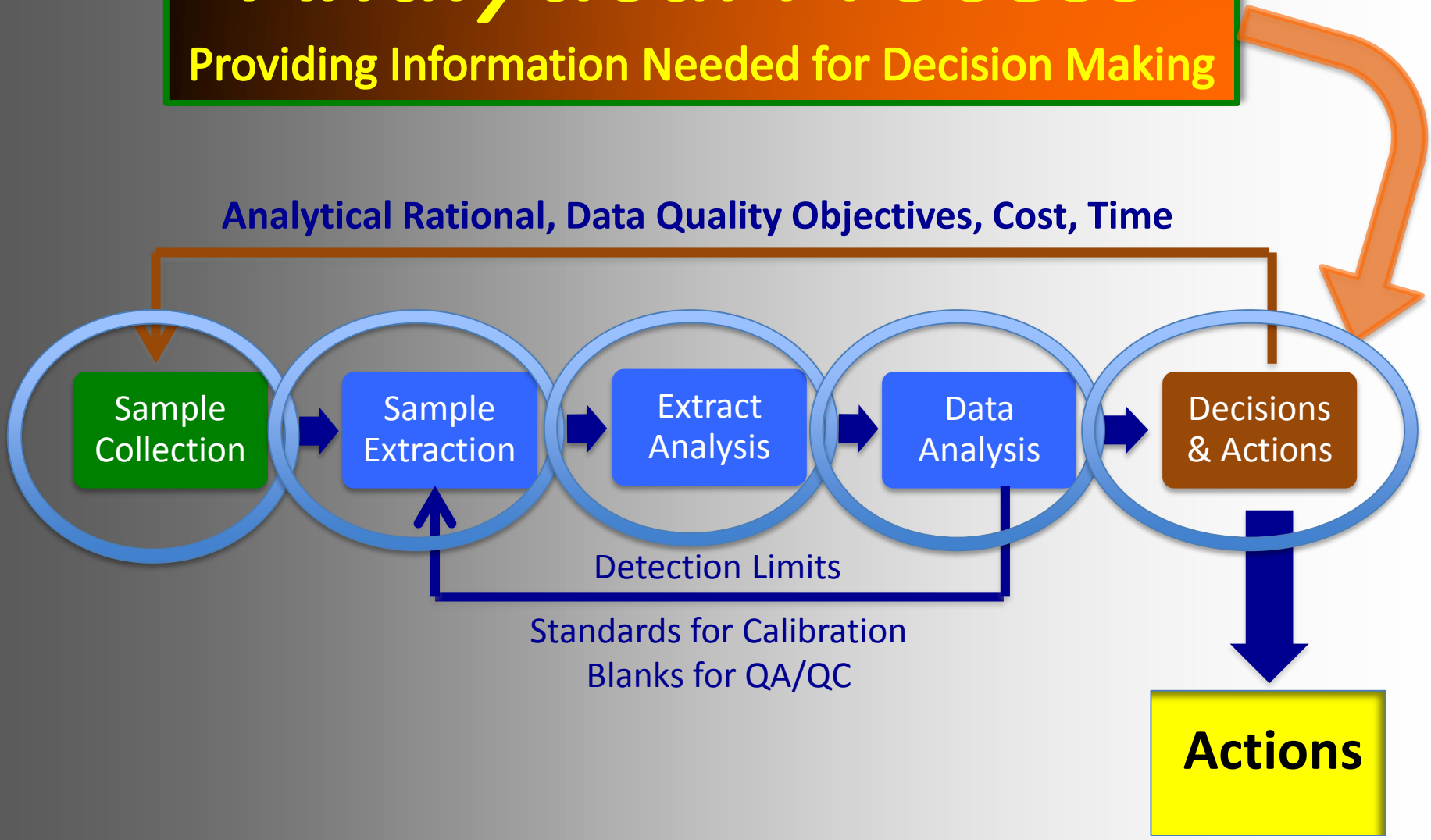


# Micro GCs: Current Capabilities and Future Trends


# *Analytical Process*

**Providing Information Needed for Decision Making**



# Types of Air Pollution

Criteria Pollutants

Acid Rain

Oxidized organics (TO15)

Industrial Pollutants

Ozone Precursors

Air Toxics (TO14)

Greenhouse Gases

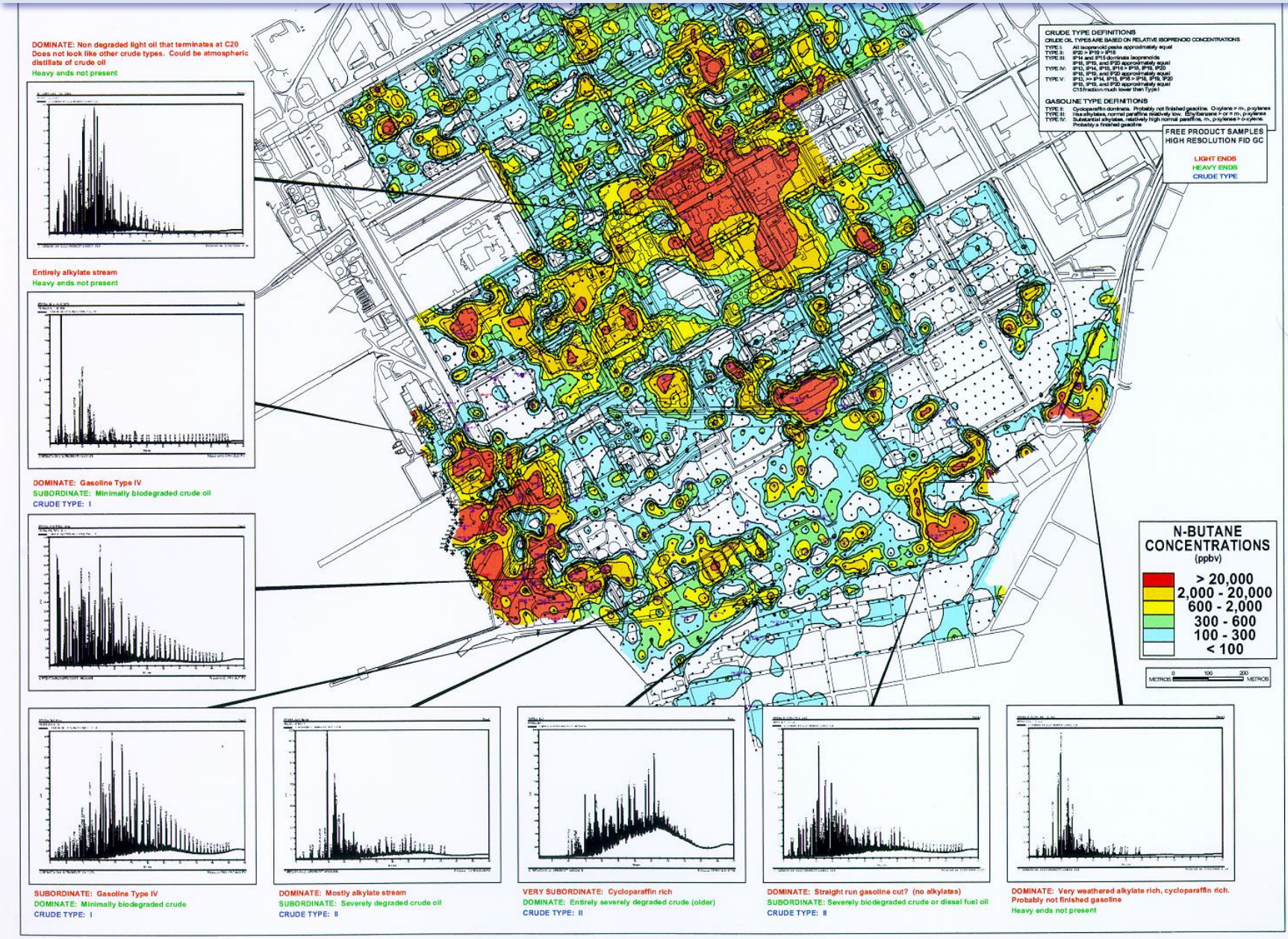
Indoor Air

# GCMS Chromatogram of Rural Air Sample collected in the middle of a field




## Biogenic Emissions

# Refinery Site: GC Analysis of Selected Free Product Samples and Airborne Butane Conc.



Vapor trail

Elephants also possess one of the most well developed senses of smell in the animal kingdom. This keen sense of smell is used not only to locate food and water sources but also for communication. Elephants detect and process many chemical signals in a wide variety of smells throughout their environment. Sources of odors used in chemical communication between elephants include urine, feces, saliva, and secretions from the temporal gland.

**TABLE 3. Distinctive volatiles in temporal gland emissions, breath, and urine of Asian elephants in the United States and India**

| | Acetone | Isoprene | Butanal | 2-Butanone | 2-Methyl-3-buten-2-ol | 2,3-Butanediol | Dimethyl disulfide | 4-Heptanone |
|---|---|---|---|---|---|---|---|---|
| PostM-TG | x | | | | | | | |
| PreM-TG | X | X | X | X | | | | |
| PreM-TG[a] | X | X | X | X | | | | |
| Skin-C | X | | | | | | | |
| PreM-B | x | X | X | X | X | | | |
| PreM-B[a] | x | X | X | X | x | | | |
| PostM-B | x | | | | | | | |
| PostM-B[a] | x | | | | | | | |
| Preg-B | x | X | | x | | X | | |
| Preg-B[a] | x | X | | x | | X | | |
| Preg-U | x | | | x | | | x | X |
| Preg-U[a] | x | | | x | | | x | X |
| Mahkna U | x | | | x | | | X | |

[a]Control samples, U.S. studies [Rasmussen and Perrin, 1999].
X, high concentration; x, lower concentration; M-TG, musth temporal gland secretions; C, control; M-B, musth breath; Preg, pregnant; B, breath; U, urine.

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**BreathLink rapid point-of-care breath test for breast cancer | Menssana Products**

**United States Patent** [19]

**Phillips**

[54] **BREATH TEST FOR DETECTION OF LUNG CANCER**

[76] Inventor: **Michael Phillips**, 1 Horizon Rd., Fort Lee, N.J. 07024

**Breathometer**


DIAGNOSTICS

## Point-of-care breath test for biomarkers of active pulmonary tuberculosis

Michael Phillips[a,b,*], Victoria Basa-Dalay[c], Jaime Blais[a], Graham Bothamley[d], Anirudh Chaturvedi[a], Kinjal D. Modi[h], Mauli Pandya[a], Maria Piedad R. Natividad[e], Urvish Patel[a], Nagsen N. Ramraje[f], Peter Schmitt[g], Zarir F. Udwadia[h]

[a] Menssana Research Inc., Breath Research Laboratory, EDC III, 211 Warren Street, Newark, NJ 07103, USA
[b] Department of Medicine, New York Medical College, Valhalla, NY, USA
[c] Center for Tuberculosis Research, Angelo King Medical Research Center, De La Salle Health Sciences Institute, Cavite, Philippines
[d] Department of Respiratory Medicine, Homerton University Hospital NHS Foundation Trust, London E9 6SR, UK
[e] Center for Respiratory Medicine, The University of Santo Tomas Hospital (USTH), Espana Boulevard, Manila 1008, Philippines
[f] Sir J.J. Group of Hospitals, Byculla, Mumbai 400008, India
[g] Schmitt & Associates, 211 Warren St, Newark, NJ 07103, USA
[h] P.D. Hinduja National Hospital and Research Center, Veer Savarkar Marg, Mahim, Mumbai 400016, India

## Prediction of breast cancer using volatile biomarkers in the breath

Michael Phillips[1,2], Renee N. Cataneo[1], Beth Ann Ditkoff[3], Peter Fisher[4], Joel Greenberg[1], Ratnasiri Gunawardena[5], C. Stephan Kwon[6], Olaf Tietje[7], and Cynthia Wong[2,5]

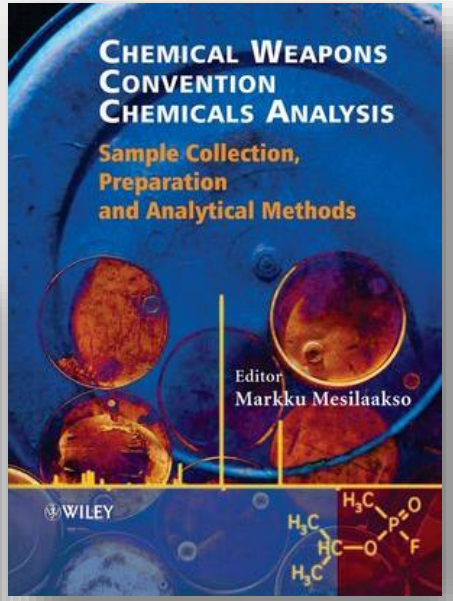
[1]*Menssana Research Inc., 1 Horizon Road, Suite 1415, Fort Lee, NJ 07024, USA;* [2]*Department of Medicine, New York Medical College, Valhalla, NY USA;* [3]*Department of Surgery, Columbia University Medical Center, New York, NY 10032, USA;* [4]*Department of Pathology, Columbia University Medical Center, New York, NY 10032, USA;* [5]*Department of Medicine, Saint Vincents Catholic Medical Centers of New York, Staten Island Region, New York USA;* [6]*Department of Laboratory Medicine, Saint Vincents Catholic Medical Centers of New York, Staten Island Region, New York USA;* [7]*SystAim GmbH, Pfingstweidstr. 31a, CH 8005, Zürich, Switzerland*

## Diagnostic Accuracy of Canine Scent Detection in Early- and Late-Stage Lung and Breast Cancers

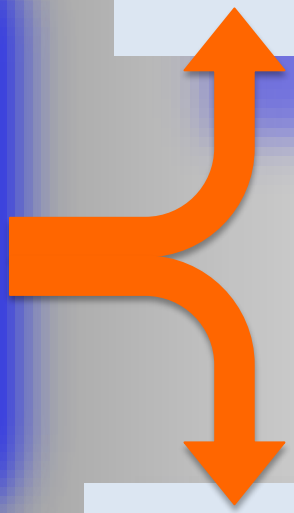
**Michael McCulloch, Tadeusz Jezierski, Michael Broffman, Alan Hubbard, Kirk Turner, and Teresa Janecki**


**Environmental monitoring**
**Emergency response**
**Chemical Weapons Convention**
**Chemical Warfare Agent Detection**
**Infectious Disease Detection**

# Mobile Labs



# Organic Compound Analysis



## Volatile Organic Compounds

## VOCs

**>3000 1 to ~0.1mm Hg VP**

**VC to DCB**

## Semi-volatile Organic Compounds

## SVOCs

**~01mm to 0.000001mm Hg VP**

GC Amenable Analyses

# Carbon Number Range (RI = Carbon # times 100)


## Molecular Weight Range (for Saturate Hydrocarbons)

Gases

>250mm VP

% to ppm

micropacked columns

loop injectors

Semivolatile Organic Compounds

0.1mm to 0.000001mm VP

ppm to high ppt

thin film capillary columns

sorbent traps or flash evaporators

VOCs

250mm to 0.1mm VP

ppm to ppb

thick film columns

sorbent traps

Pesticides, Industrial Pollutants

Fugitive Emissions

Oil Spill Chemicals, PAHs

Industrial Emmisions

TO-14 Compounds

Green House Gases

CWA Compounds

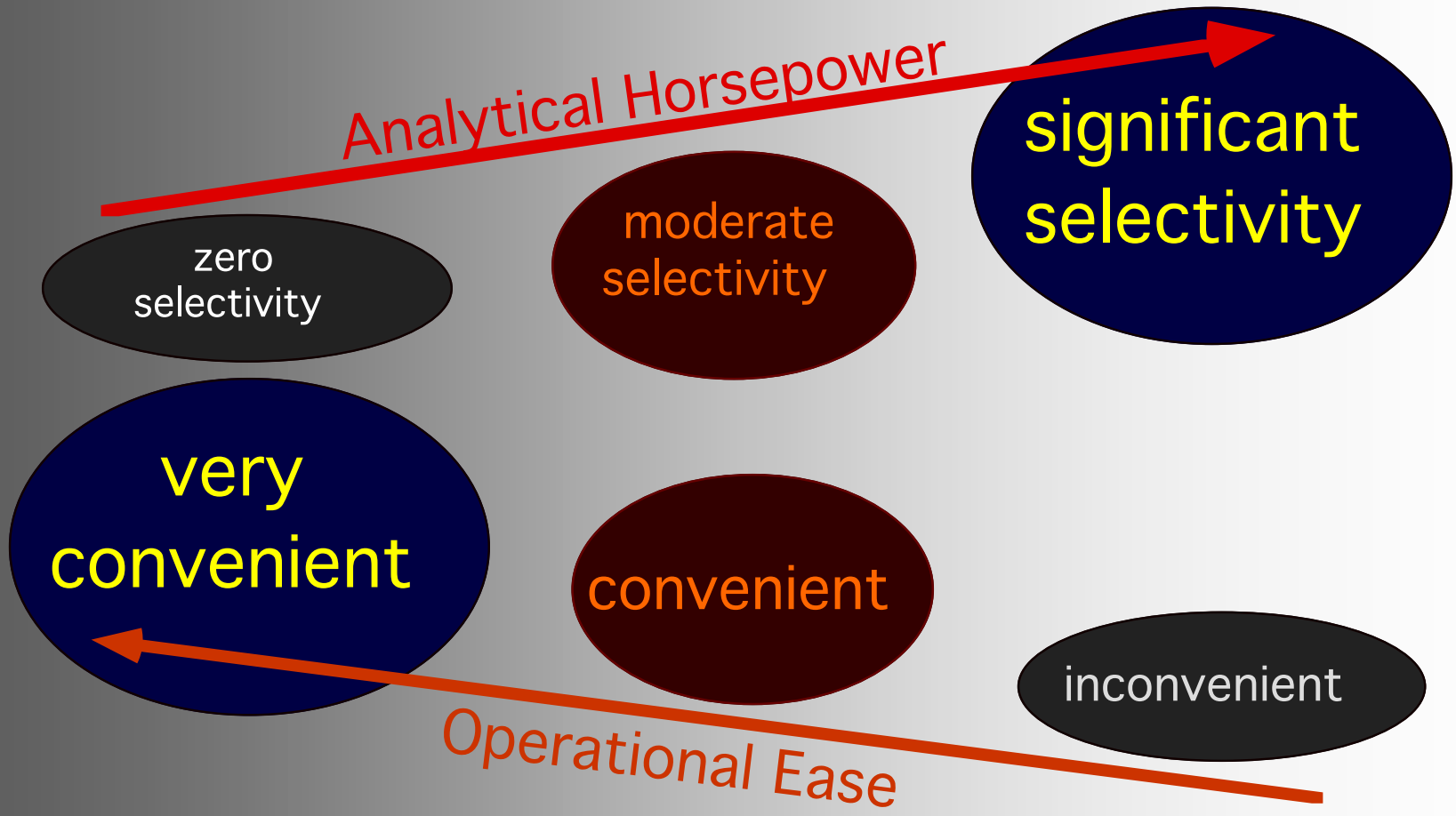
Ozone Precursors

Breath Diagnostic Compounds

Compound Specific Analysis
(tunably selective)
Portability
(transportable to portable)

= *Analytical Horsepower*

= *Operational Ease*




**Issues: false positives vs false negatives**

# Analytical Horsepower

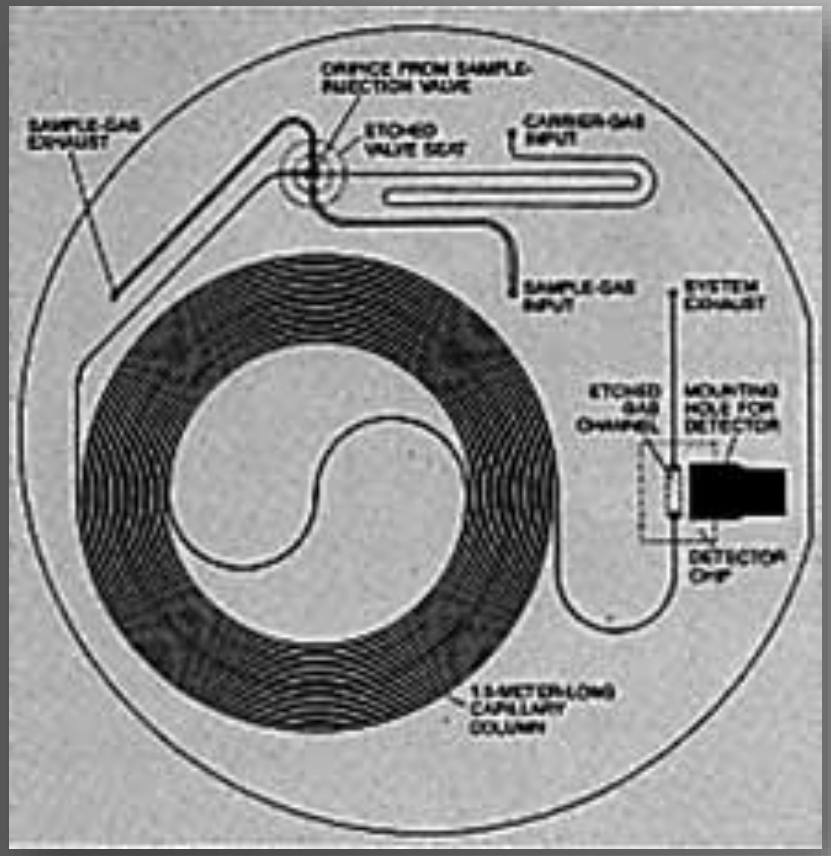


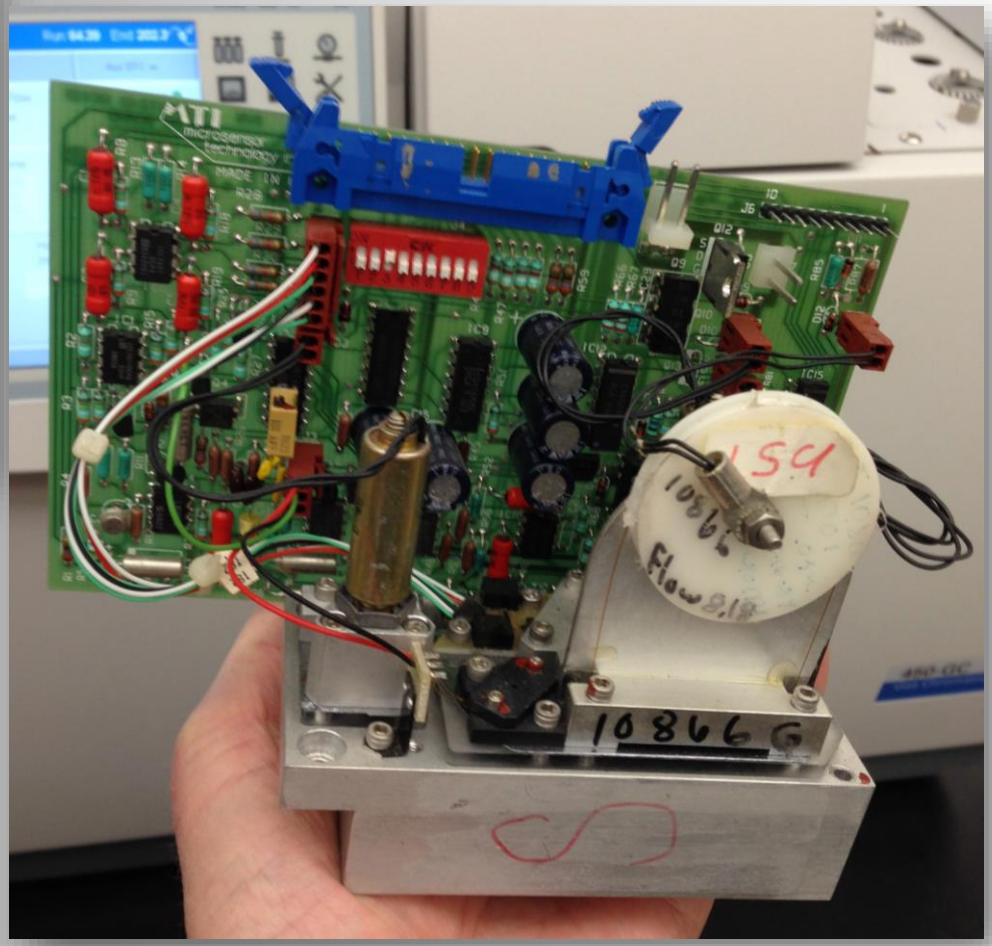

GC, IMS


GCMS

# Ease of Use, Cost

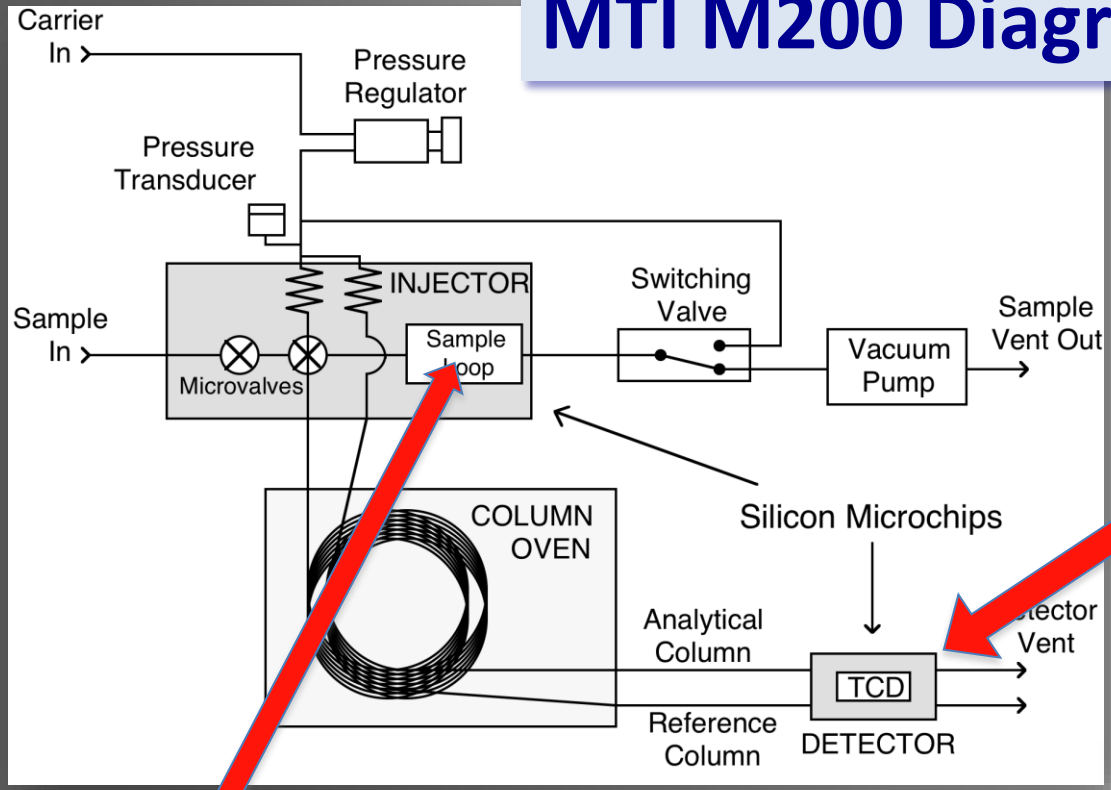
# Stanford “GC on a chip”



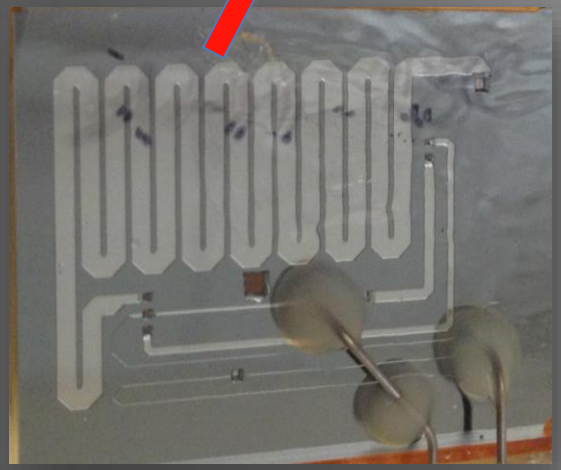




# Michromonitor 500

# MTI M200 Diagram



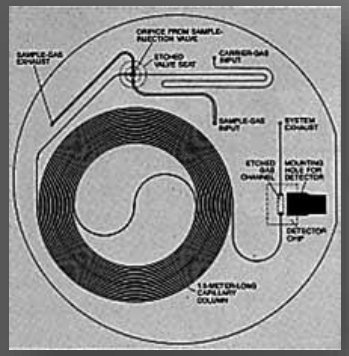

Silicon TCD



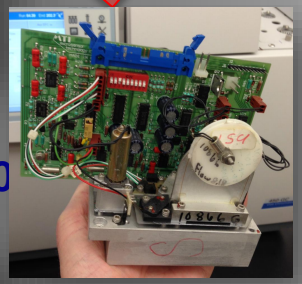
Acrylic encapsulated
Silicon injector chip

M200 GC module insulated

# Silicon micro GC Evolution
# Gas Only Analyzers



Stanford
Silicon GC



MTI
Michromonitor 500

Silicon Injector Chip

MTI Michromonitor 200

Inficon Fusion

Agilent 3000

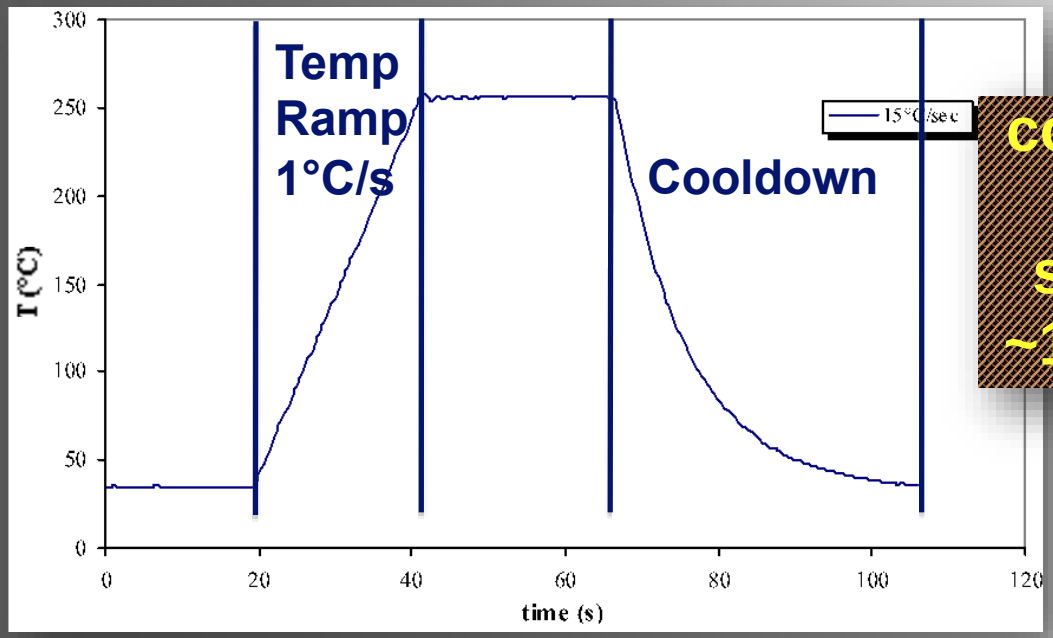
SLS µGC

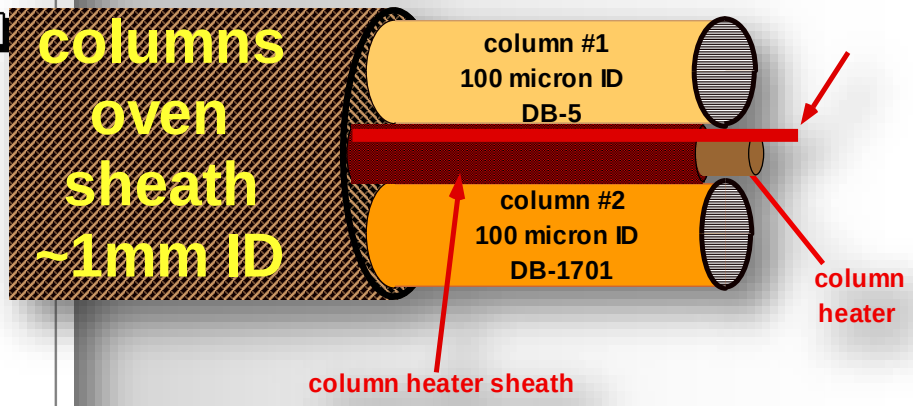
Agilent 490 PRO

C2V

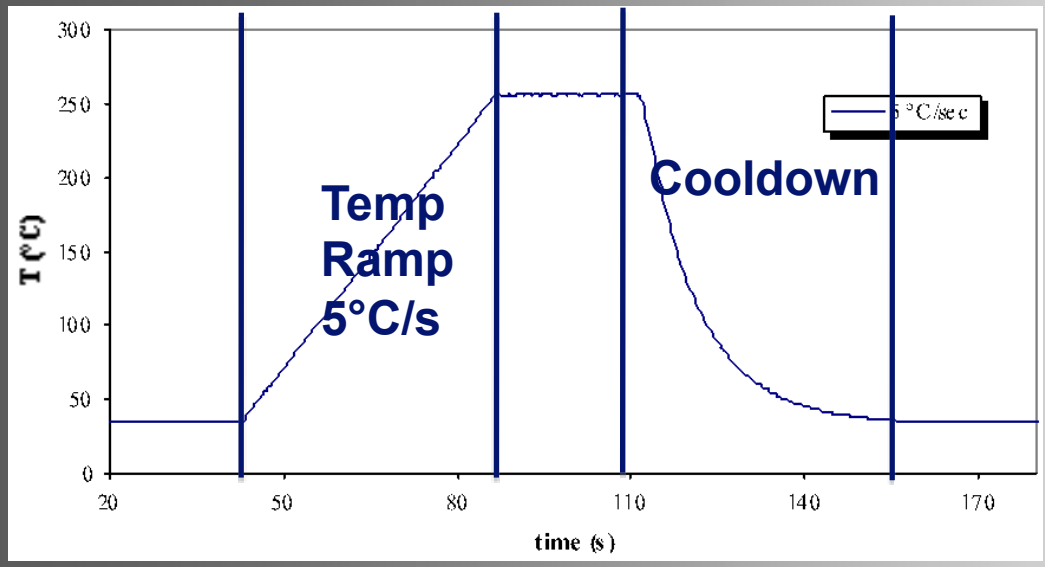

Chrompack
CP 2000

CP 3200
Varian

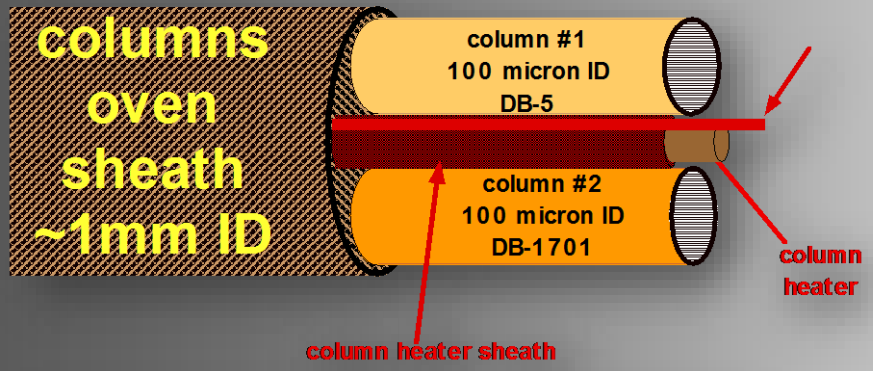


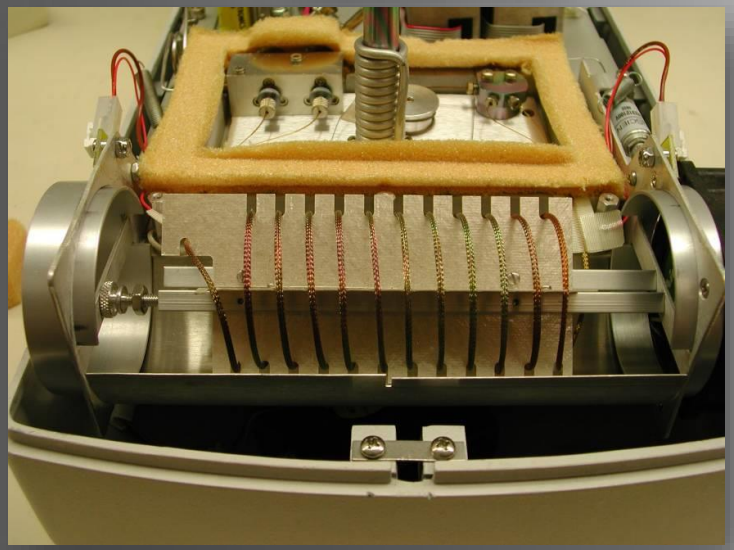




# The microFAST GC's Column Temperature vs. Heating Rates



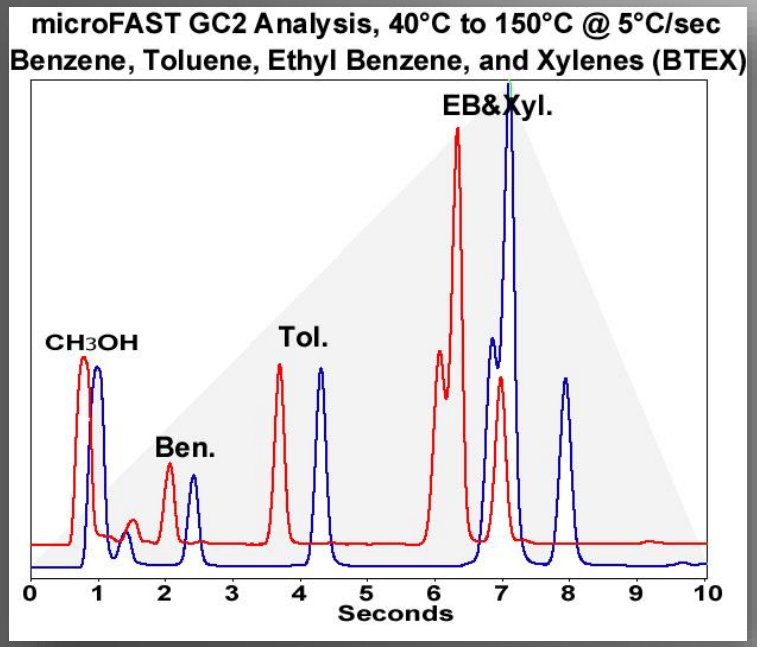

under research for the CWC sponsored by the DNA via a subcontract to General Research Corp,
Santa Barbara CA
Robert V Mustacich, PI

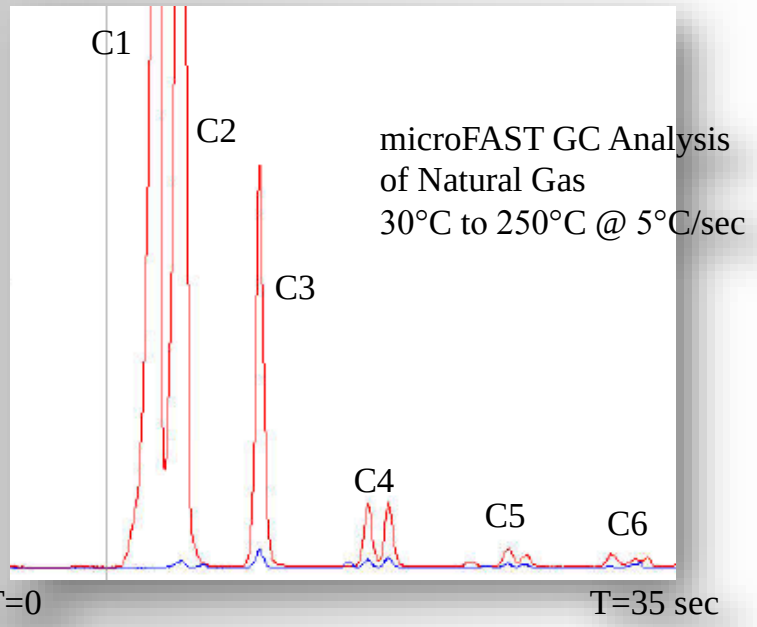


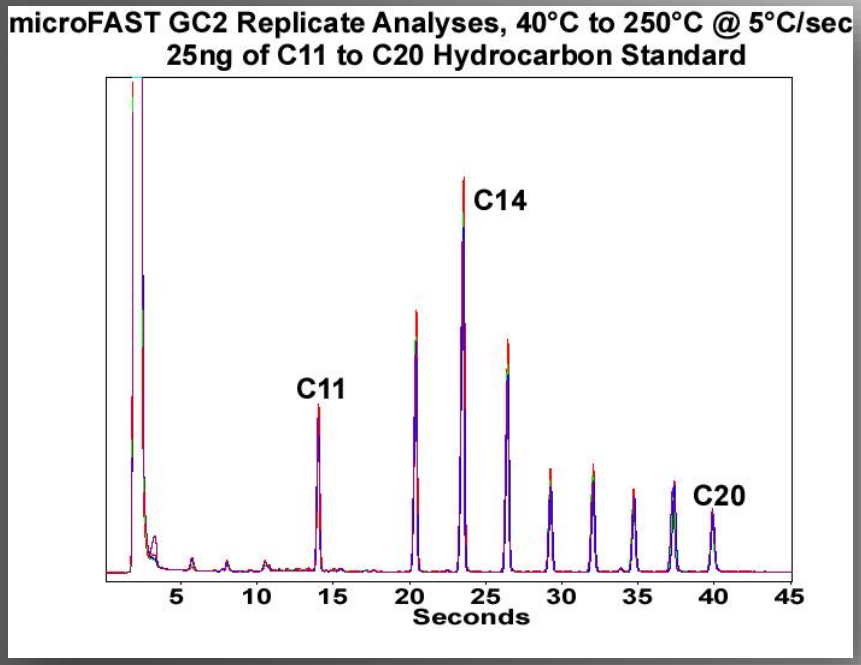
ultra fast temperature programming

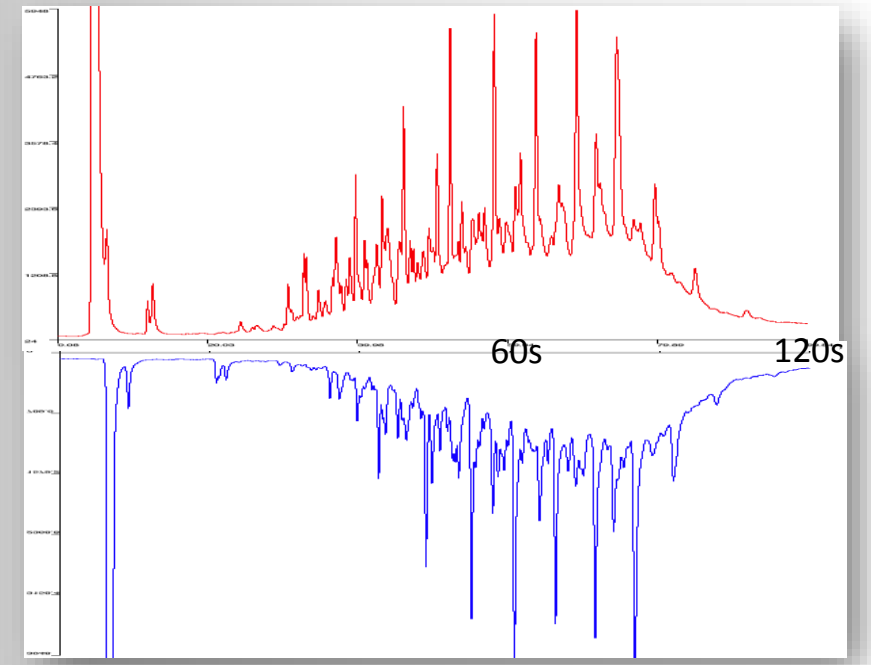
**the microFAST GC**

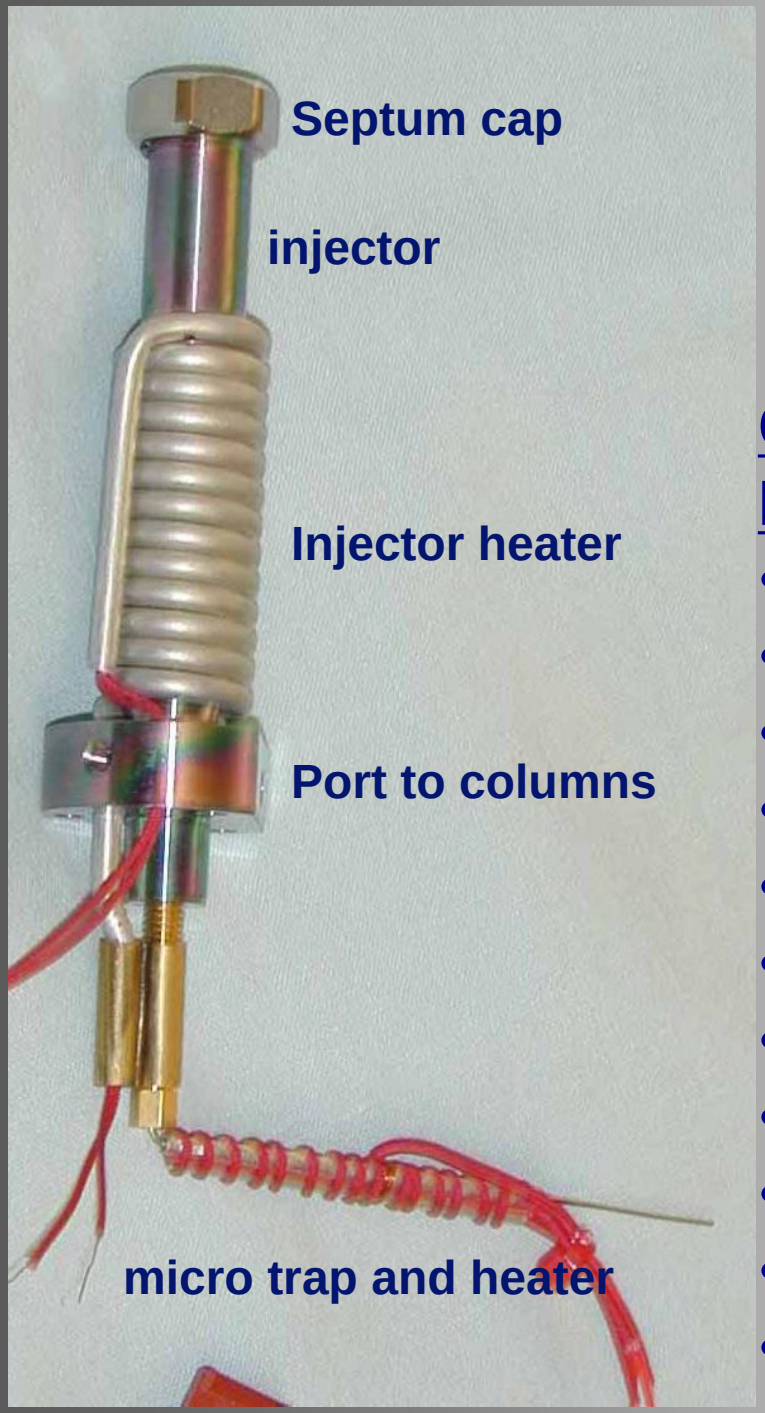



# Permanent Gases, Volatiles and Semivolatiles on a micro GC





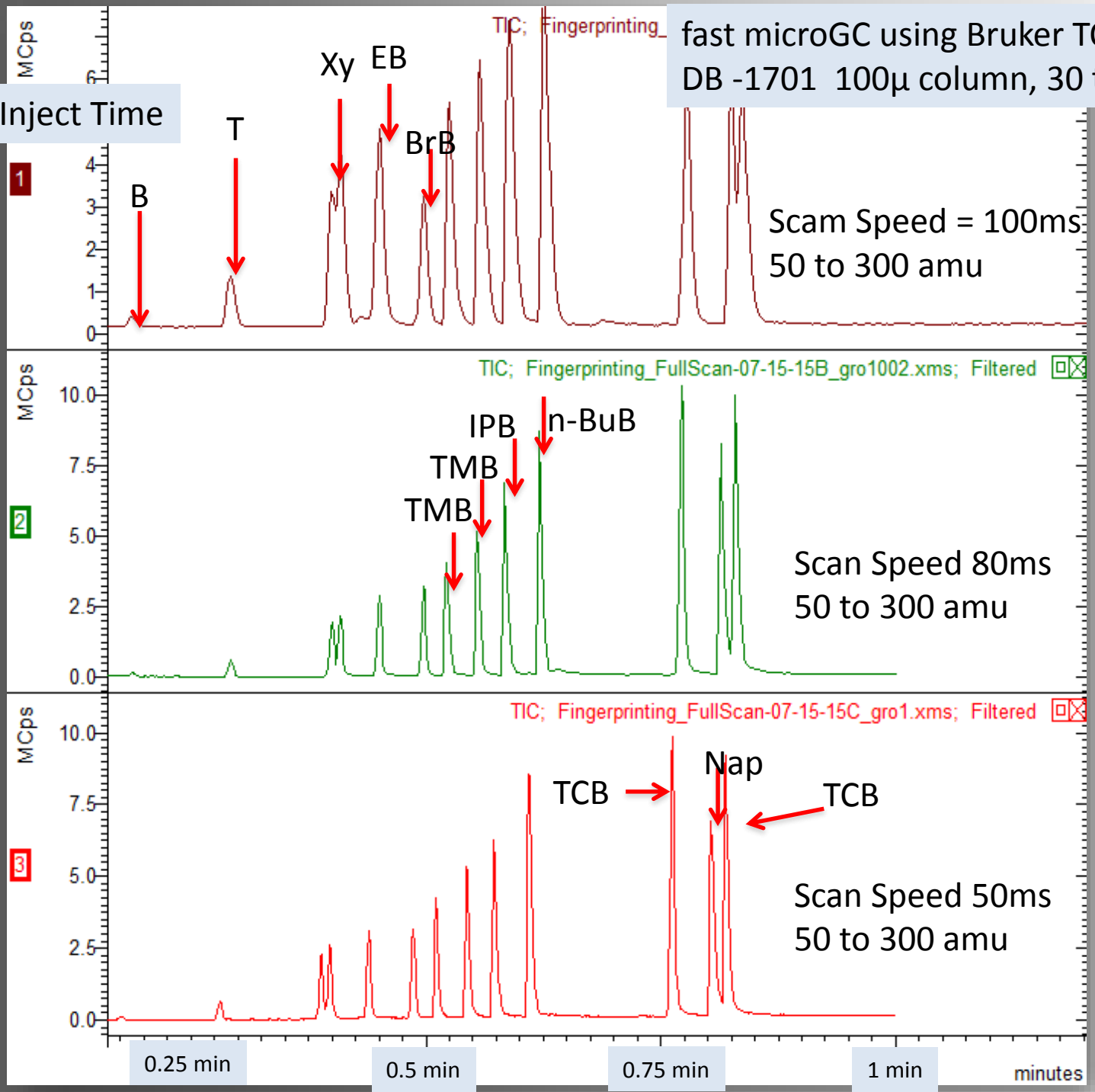


## Concentration Trap Injector Facilitates Multi Sampling Capacity:

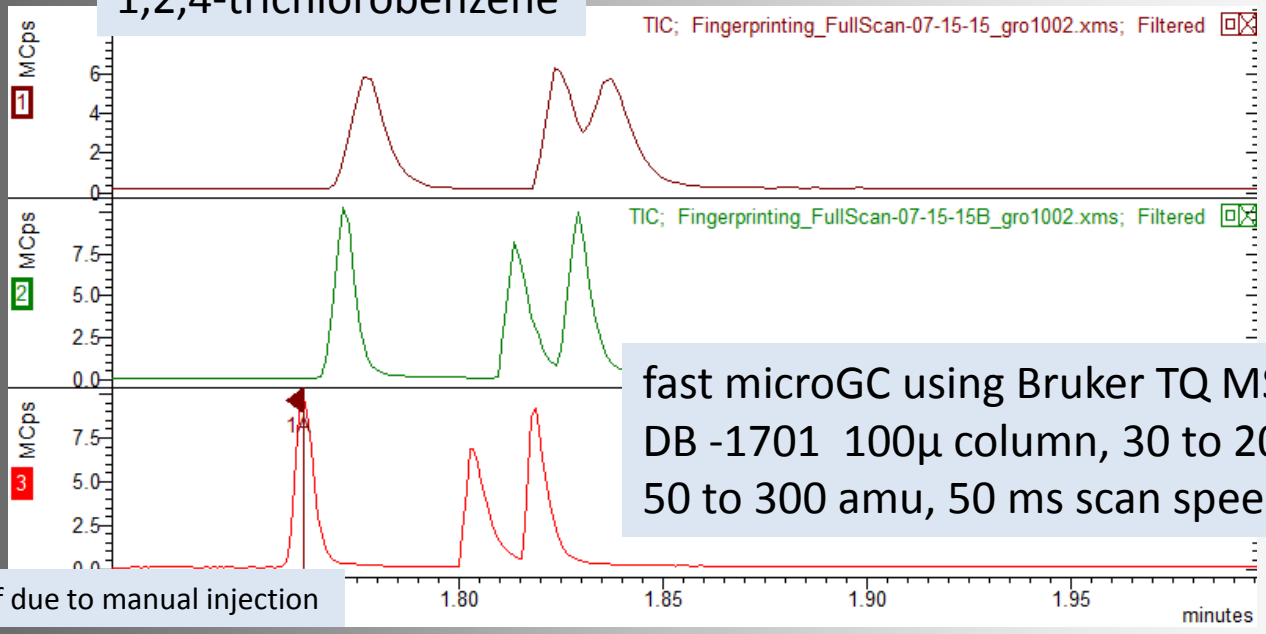
- Normal/large volume injections
- Gases, dilute gases (ppb level)
- Static and dynamic headspace
- SPME
- Membrane & external concentrators
- Purge and trap extracts
- Liquid organic solvent extracts
- Neat organic liquid mixtures
- Aqueous liquids
- Thermal desorption tubes
- Thermal and SCF extracts


# Fast microGC using Bruker Scion TQ as a fast scanning MS detector

50 µID deactivated fused silica capillary connected from the columns end directly into ion source

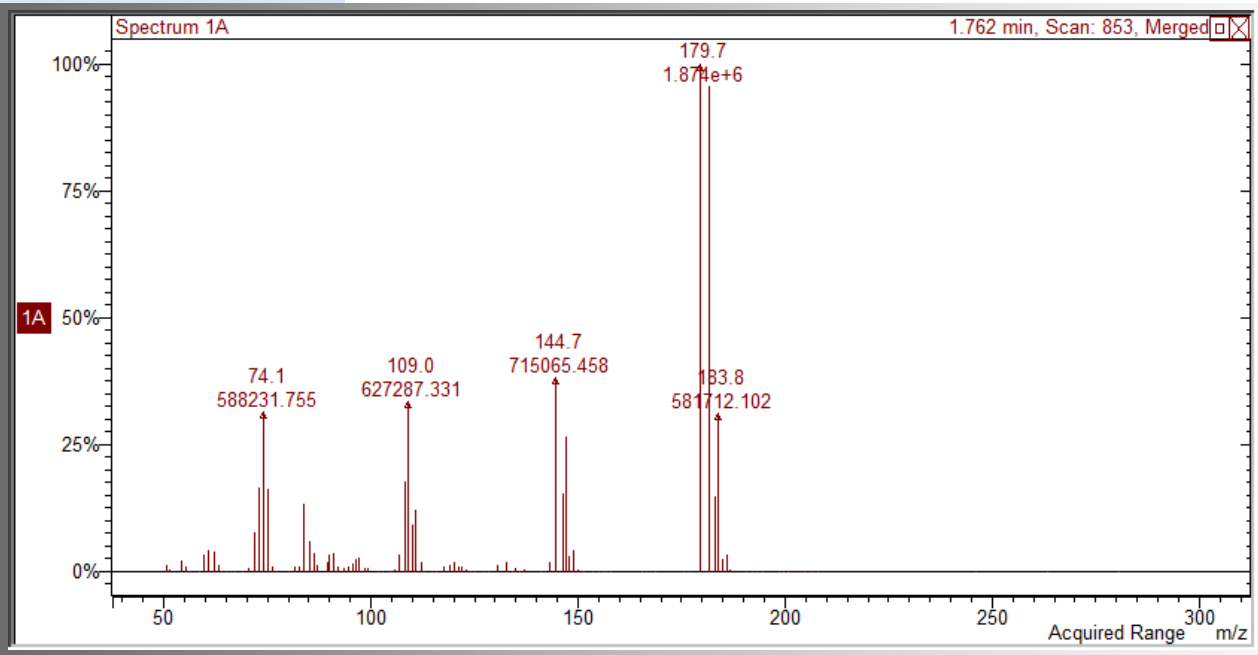

fast microGC using Bruker TQ MS Detector
DB -1701 100µ column, 30 to 200 C at 3° C/sec
Inject Time
TIC; Fingerprinting_
MCps
B
T
Xy
EB
BrB
Scam Speed = 100ms
50 to 300 amu
TIC; Fingerprinting_FullScan-07-15-15B_gro1002.xms; Filtered
IPB
n-BuB
TMB
TMB
Scan Speed 80ms
50 to 300 amu
TIC; Fingerprinting_FullScan-07-15-15C_gro1.xms; Filtered
TCB
Nap
TCB
Scan Speed 50ms
50 to 300 amu
0.25 min
0.5 min
0.75 min
1 min
minutes
B= benzene
T= tpulene
Xy= xylenes
EB= ethyl benzene
BrB= bromobenzene
TMB= trimethylbenzene
IPB= isopropylbenzene
N-BuB= butylbenzene
TCB=trichlorobenzene
Nap= naphthalene

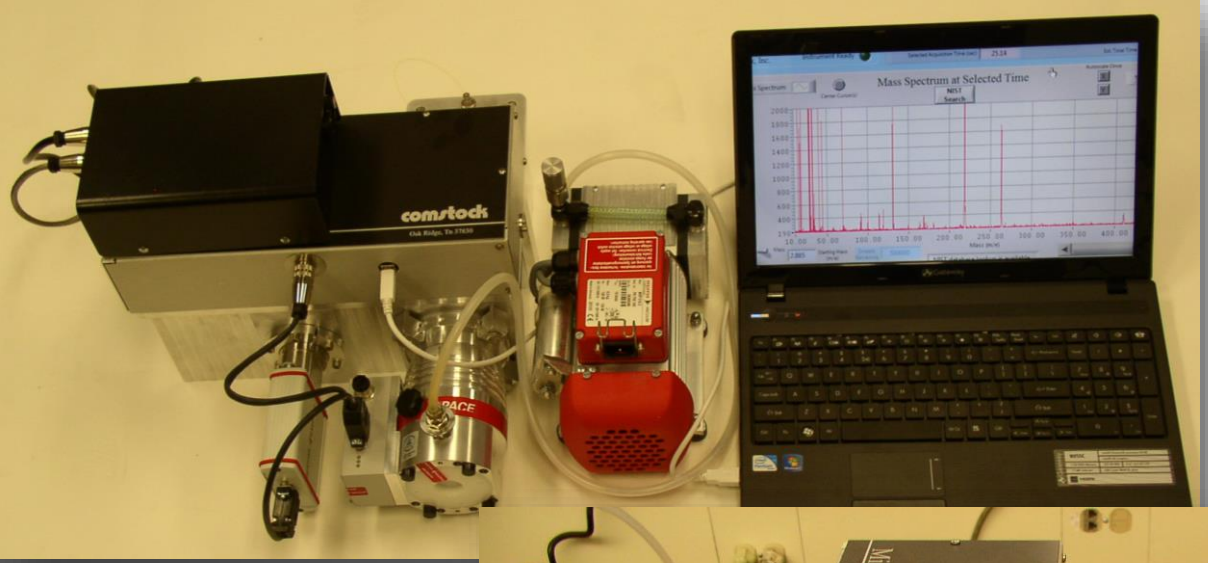
# 1,2,4-trichlorobenzene

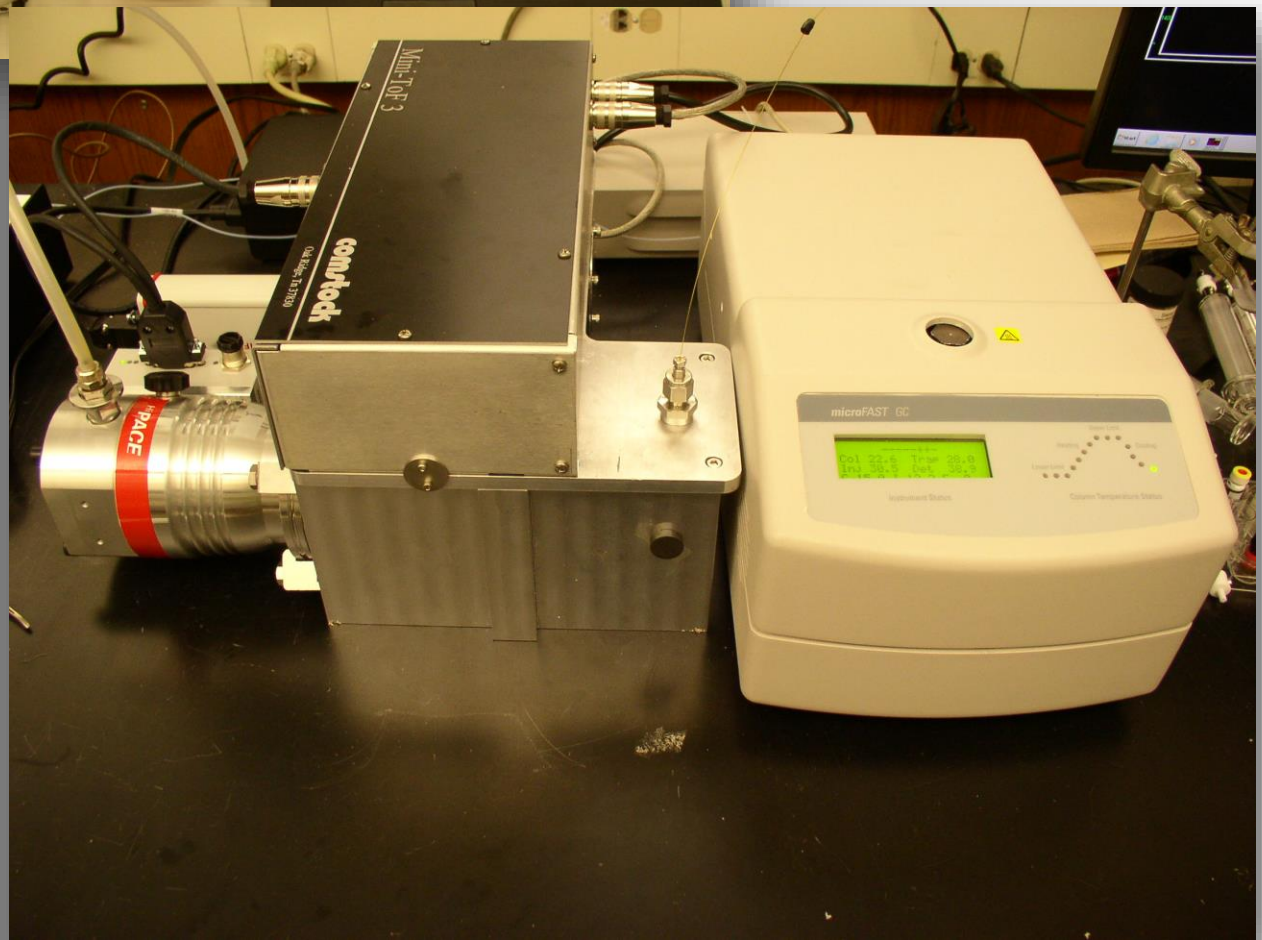


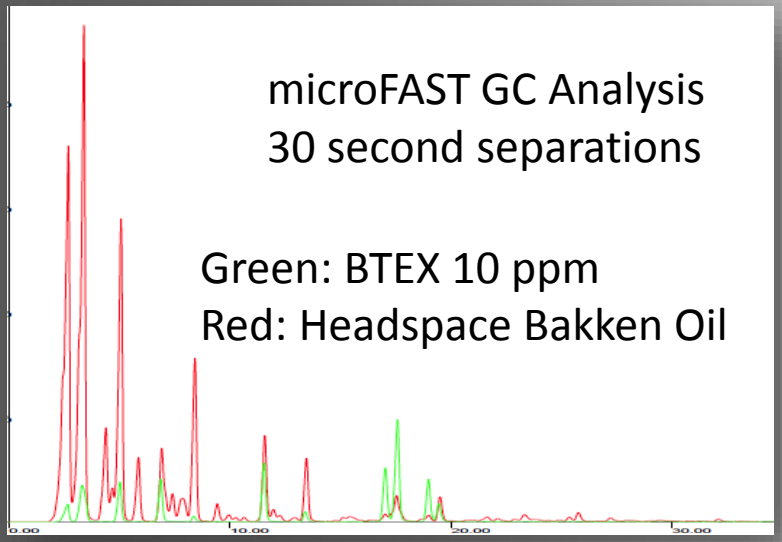

fast microGC using Bruker TQ MS Detector
DB -1701 100µ column, 30 to 200 C at 3° C/sec
50 to 300 amu, 50 ms scan speed

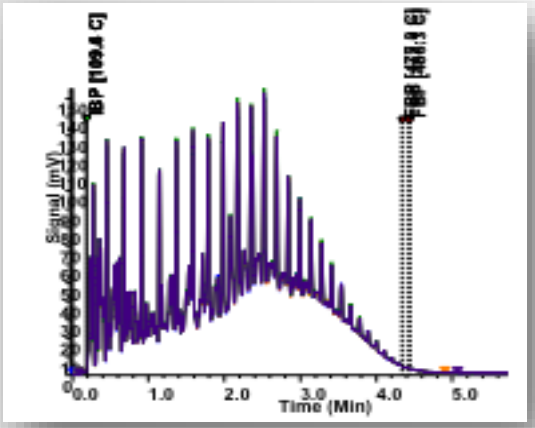
Retention times off due to manual injection




comstock
Mass Spectrum at Selected Time


Mini-ToF 3
comstock
microFAST GC




**Falcon Calidus 101HT µGC**

**microFAST GC**

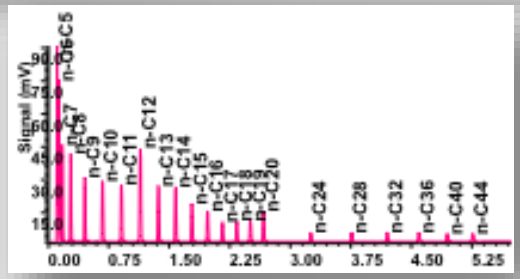
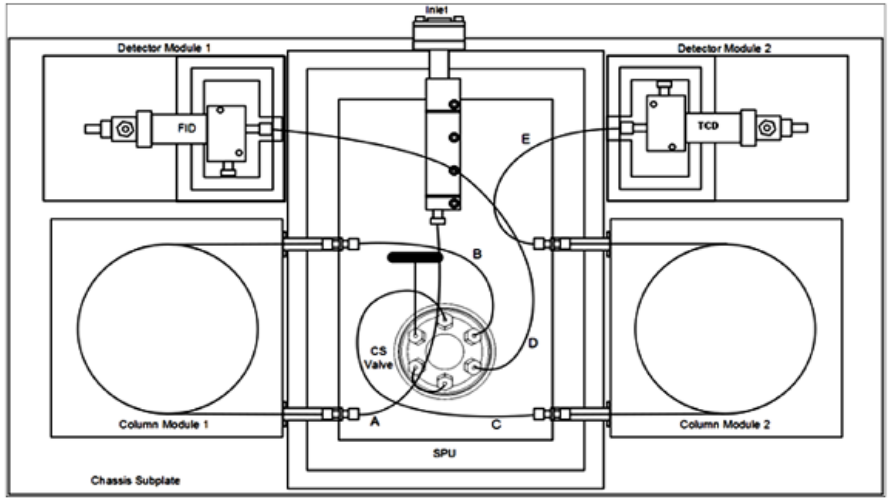
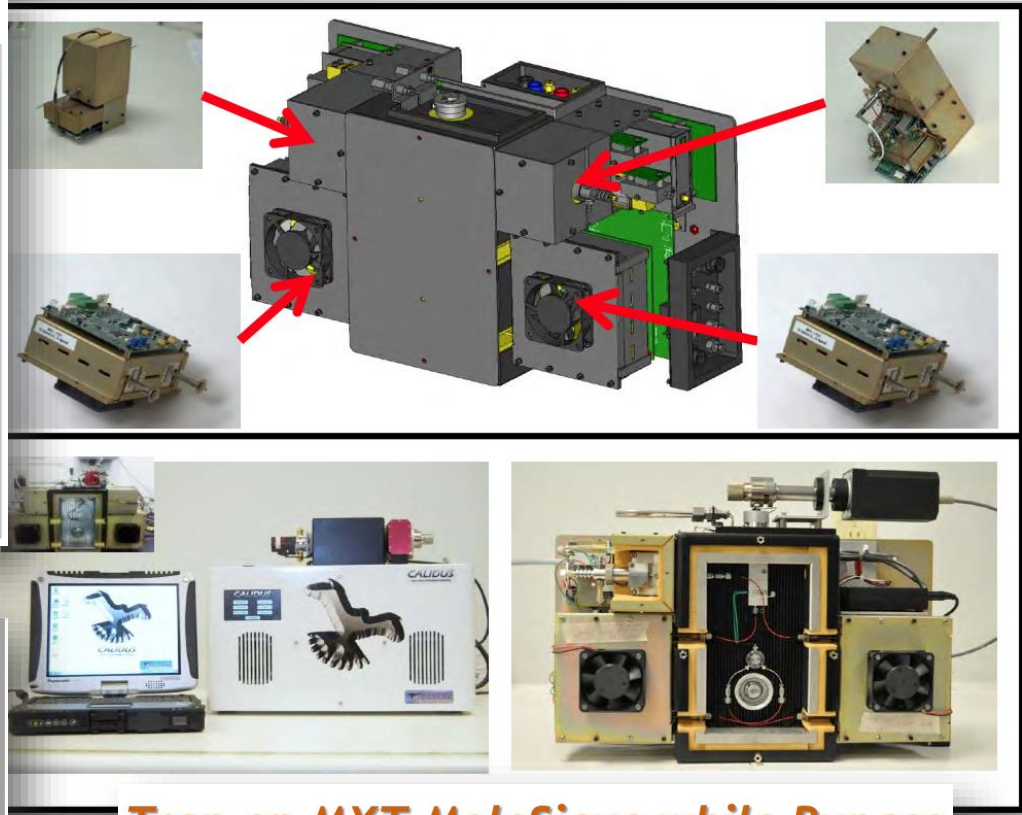
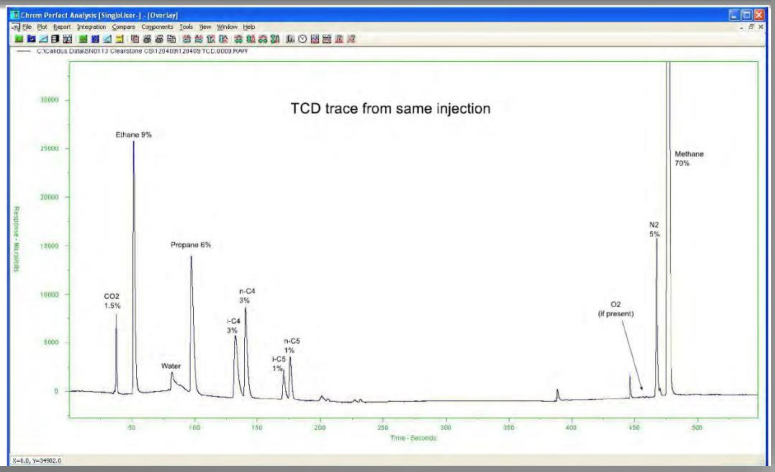



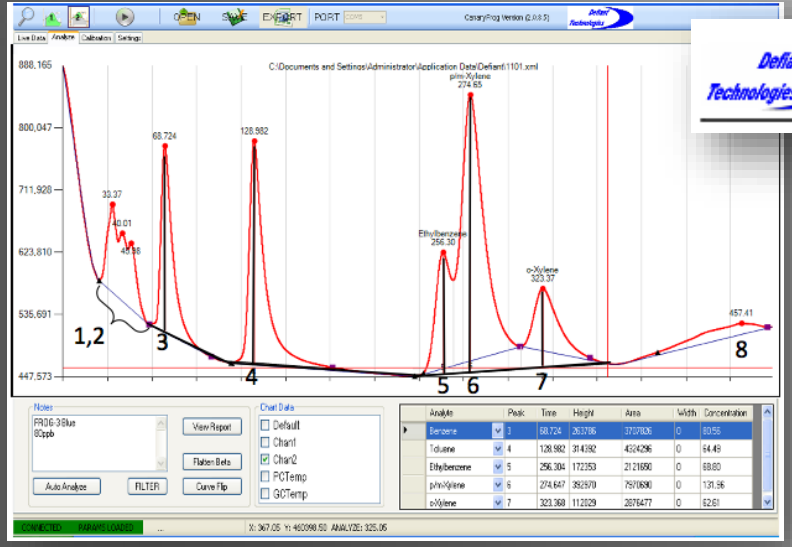
**Figure 1: CALIDUS Model CS Functional Diagram.**

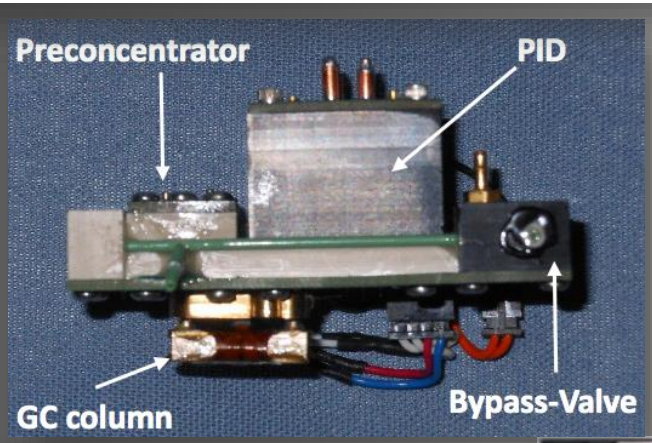


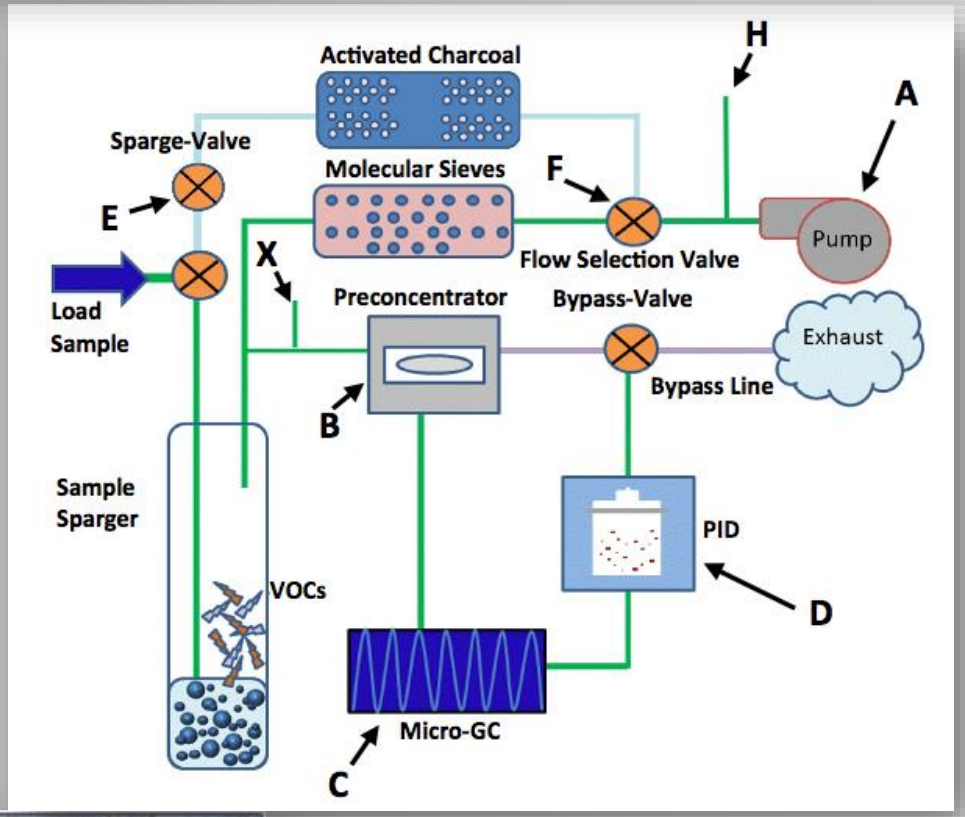




## *Trap on MXT MoleSieve while Bypass through MXT QBond to the TCD*




C:\Documents and Settings\Administrator\Application Data\Defiant\1101.xml
888,165
800,047
711,928
623,810
535,691
447,573
1,2
3
4
5
6
7
8
Benzene
Toluene
Ethylbenzene
p/m-Xylene
o-Xylene


Preconcentrator
PID
GC column
Bypass-Valve


Activated Charcoal
H
A
Sparge-Valve
Molecular Sieves
F
E
X
Flow Selection Valve
Pump
Load Sample
Preconcentrator
Bypass-Valve
Exhaust
Bypass Line
B
Sample Sparger
PID
VOCs
D
Micro-GC
C

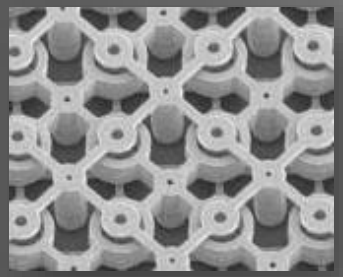

AIR


WATER


SOIL

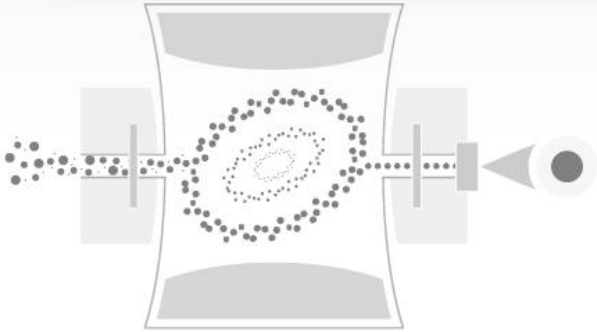

# 908 Devices

27 Drydock Ave., 8th Floor Boston, MA 02210



## Purpose-built

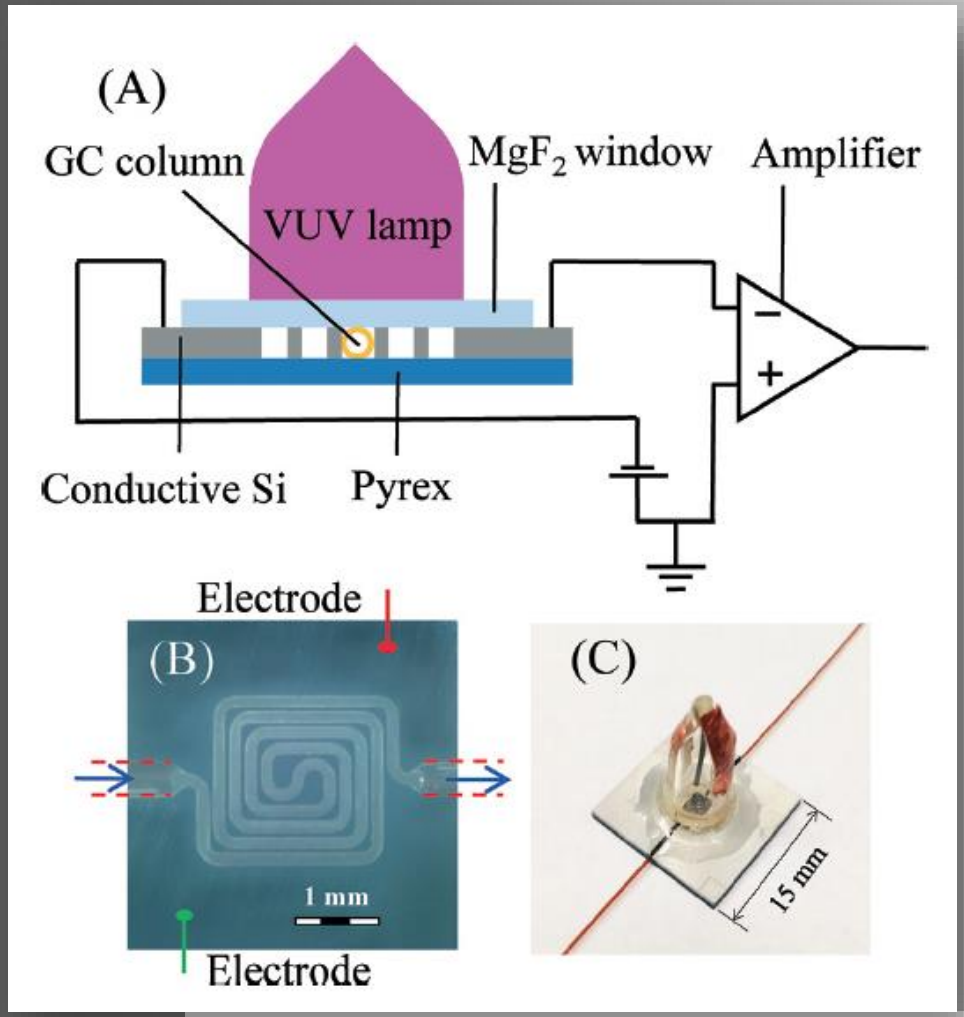
Many applications just don't require all the complexity these laboratory platforms incorporate. We are building ridiculously small, and elegantly simple purpose-built products based on remarkable mass spectrometry technology. These systems are designed for specific applications in security, biotechnology, diagnostics and others, bringing MS capability from the centralized lab to the point of need.



## near atmospheric pressure Ion Trap Mass Spectrometer

## Secret sauce

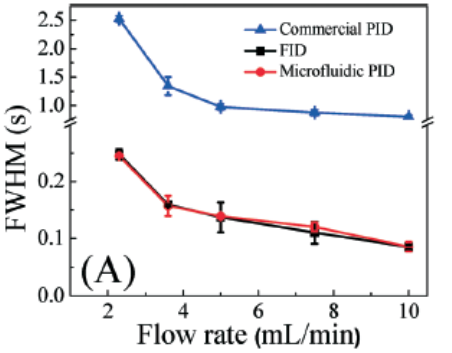
At the heart of our systems are molecular traps a thousand times smaller than those in conventional mass spectrometers. These diminutive traps can operate much closer to atmospheric pressures and enable us to use dramatically smaller pumps, ionizers, detectors and electronics than existing laboratory or luggable mass spectrometers. We call this breakthrough High Pressure Mass Spectrometry or HPMS™.

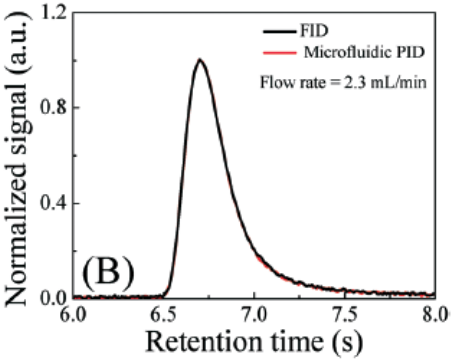


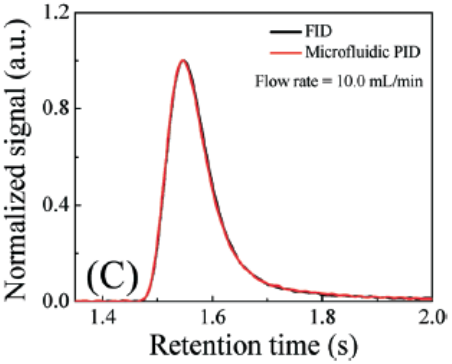

# Flow-through microfluidic photoionization detectors for rapid and highly sensitive vapor detection†

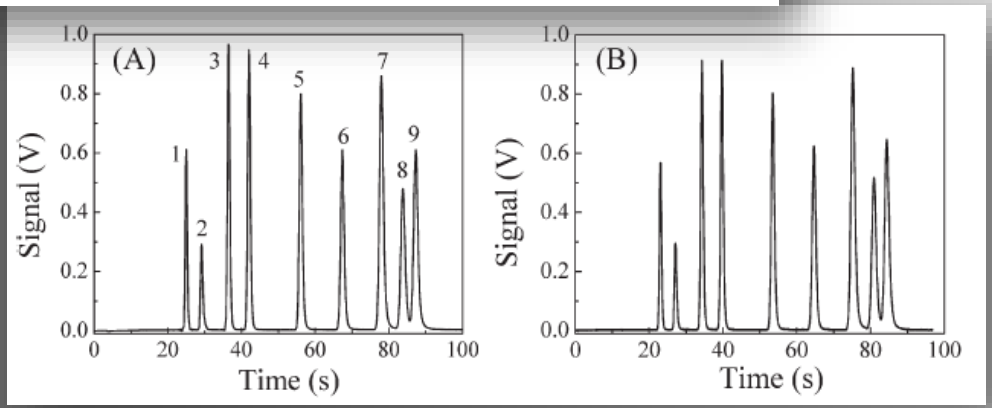
Hongbo Zhu,[a] Robert Nidetz,[b] Menglian Zhou,[a] Jiwon Lee,[a] Sanketh Buggaveeti,[b] Katsuo Kurabayashi[b] and Xudong Fan*[a]

*Lab Chip*, 2015, **15**, 3021



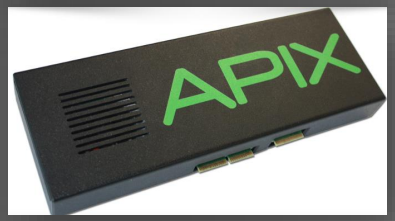



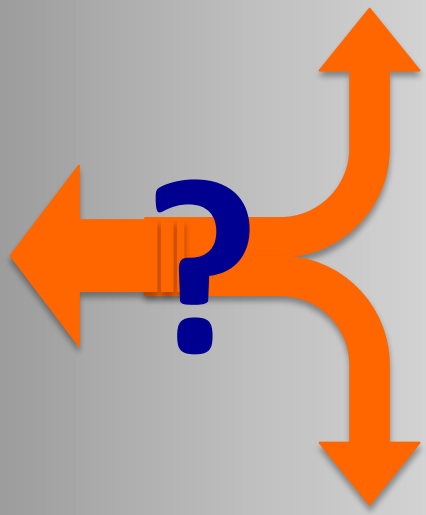
# Where do we go from here?

micro

small


small, fast in Conventional applications



small, fast <u>inexpensive</u> in nonconventional applications