



Technology Transition Workshop | *Patricia Guerra-Diaz, Ph.D.*

Introduction to Instrumental Detection Technology: IMS and DMS

Outline

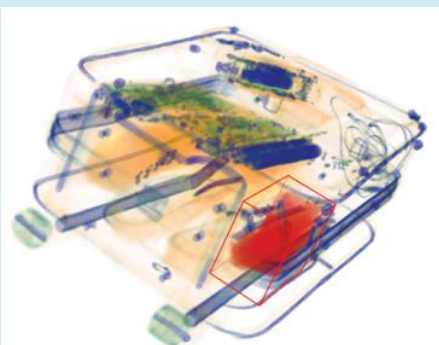
- **Trace vs. bulk detection**
- **Instrumental detection technologies**
 - **Ion Mobility Spectrometry (IMS)**
 - **Morpho Detection Itemiser[®] 3 Enhanced (3 e)**
 - **Morpho Detection MobileTrace[®]**
 - **Gas Chromatography-Differential Mobility Spectrometry (GC-DMS)**
 - **Thermo Scientific[®] EGIS[™] Defender**
 - **Operating conditions optimization**
- **Conclusions**

Bulk Detection

Metal Detectors



<http://michellemalkin.com/2005/04/24/airport-security-follies-seaworld-edition-2/>



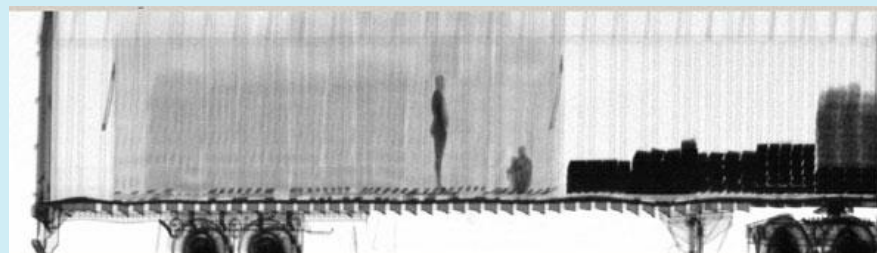
<http://www.analogic.com/Collateral/Images/English-US/products/bag.jpg>

Computer Tomography (CT) Scanners

X-ray Systems



http://205.130.201.42/ImageCache/cgov/content/newsroom/photogallery/newsphotos/2008/hi_5fres/xray_5ftruck_2.jpg/v1/xray_5ftruck.jpg



http://206.241.31.147/ImageCache/cgov/content/newsroom/press_5f_releases/2006/mar/03312006_2ectt/v1/image/1/scanb.jpg

Trace Detection

Trained K9 Teams



<http://www.flickr.com/photos/ironsoldiers/4502883580/sizes/m/in/photostream/>

Colorimetric Kits



http://fieldforensics.com/media/pdfs/08_EL100_Data_CR4.pdf

Ion Mobility Spectrometry



http://www.smithsdetection.com/SABRE_4000.php

Amplifying Fluorescent Polymers



<http://www.icxt.com/uploads/file/products/ brochures/Fido%20Technical%20Overview.pdf>

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Contraband Detection

Trace

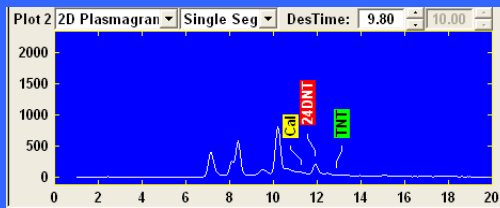
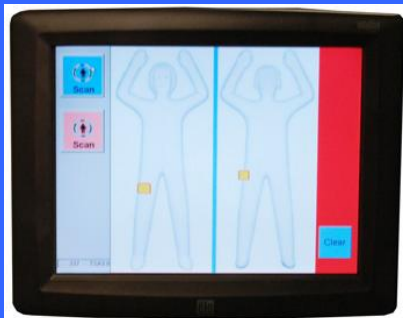


Image courtesy of Dr. Patricia Guerra-Diaz

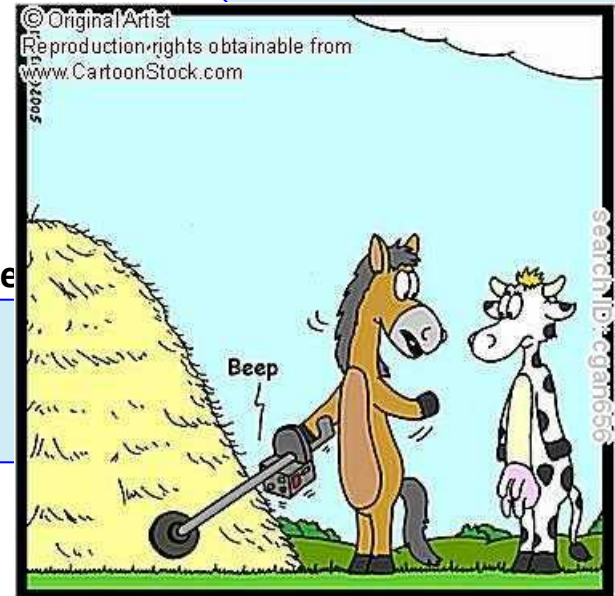
- Suggests handling of explosives or being in close proximity
- Microscopic
- Chemical sensors
- Higher specificity
- Sampling dependent
- Background may be an issue

Bulk



http://www.tsa.gov/approach/tech/ait/how_it_works.shtm

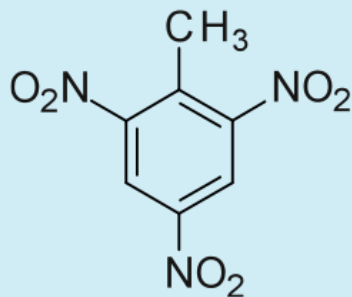
- Actual material
- Macroscopic
- Imaging and nuclear properties
- Higher equipment costs



You were right: There's a needle in this haystack...

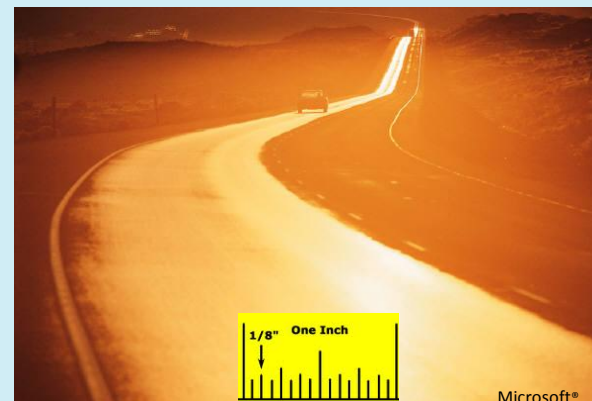
Trace Detection

CHEMICAL ANALYSIS OF MICROSCOPIC AMOUNT OF CONTRABAND MATERIAL COLLECTED



http://www.warhistory1944.co.uk/images/front_3_lg.jpg

Parts per million (ppm) =
1 inch in 16 mile road



Parts per billion (ppb) =
1 second in 32 years



Nanogram = 1 billionth of a gram



<http://routingbyrumor.wordpress.com/2008/05/22/whats-in-that-little-blue-packet-sweet-deception-from-domino-foods-inc/>

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Trace Detection Processes

Collect

- **Sample acquisition**
- **Pre-concentration (if applicable)**
- **Sample introduction**

Separate

- **Selectivity towards contraband**
- **Resolve multiple indicators of contraband**

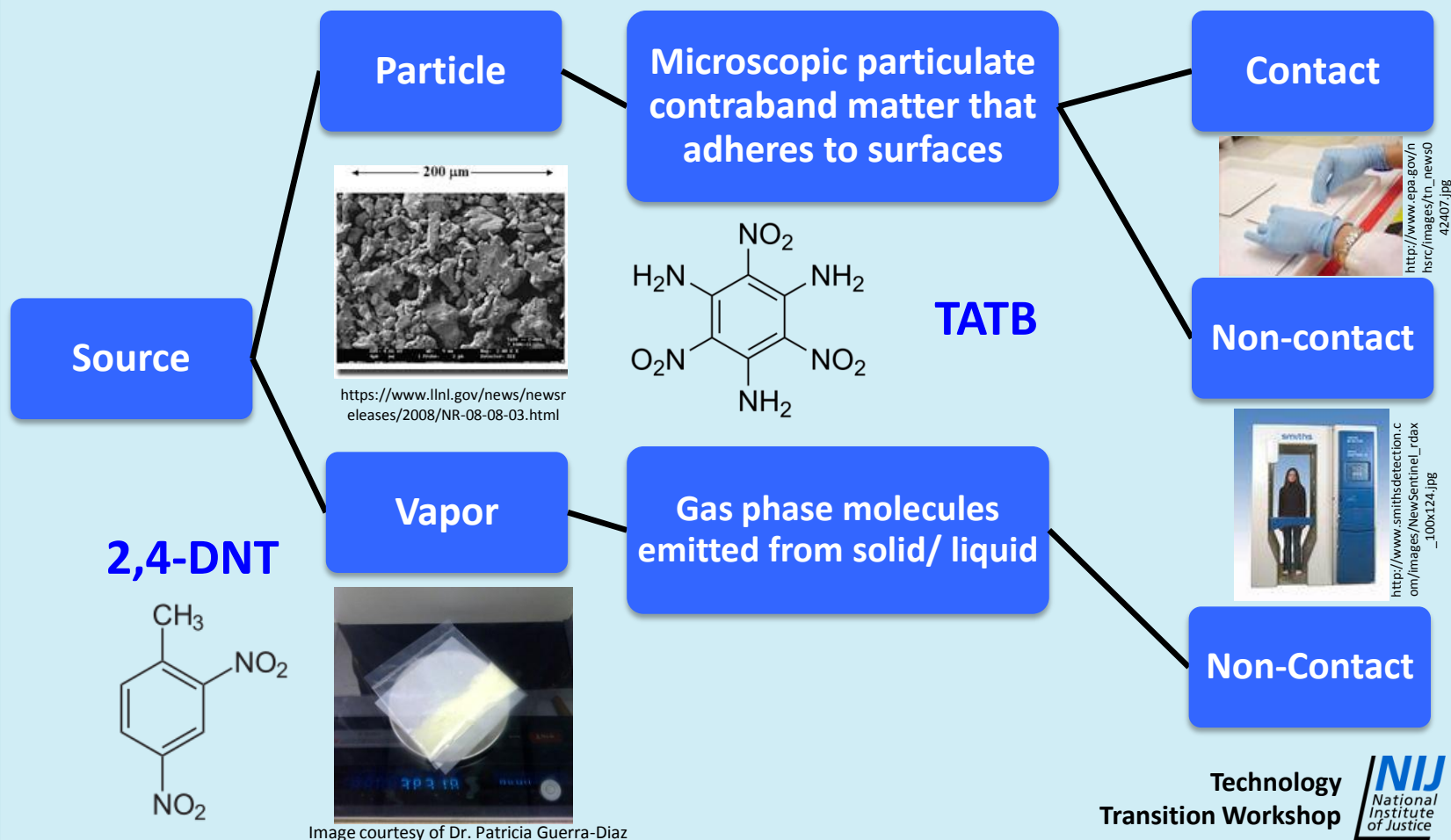
Analyze

- **Detection of contraband**
- **Detection limits and sensitivity**

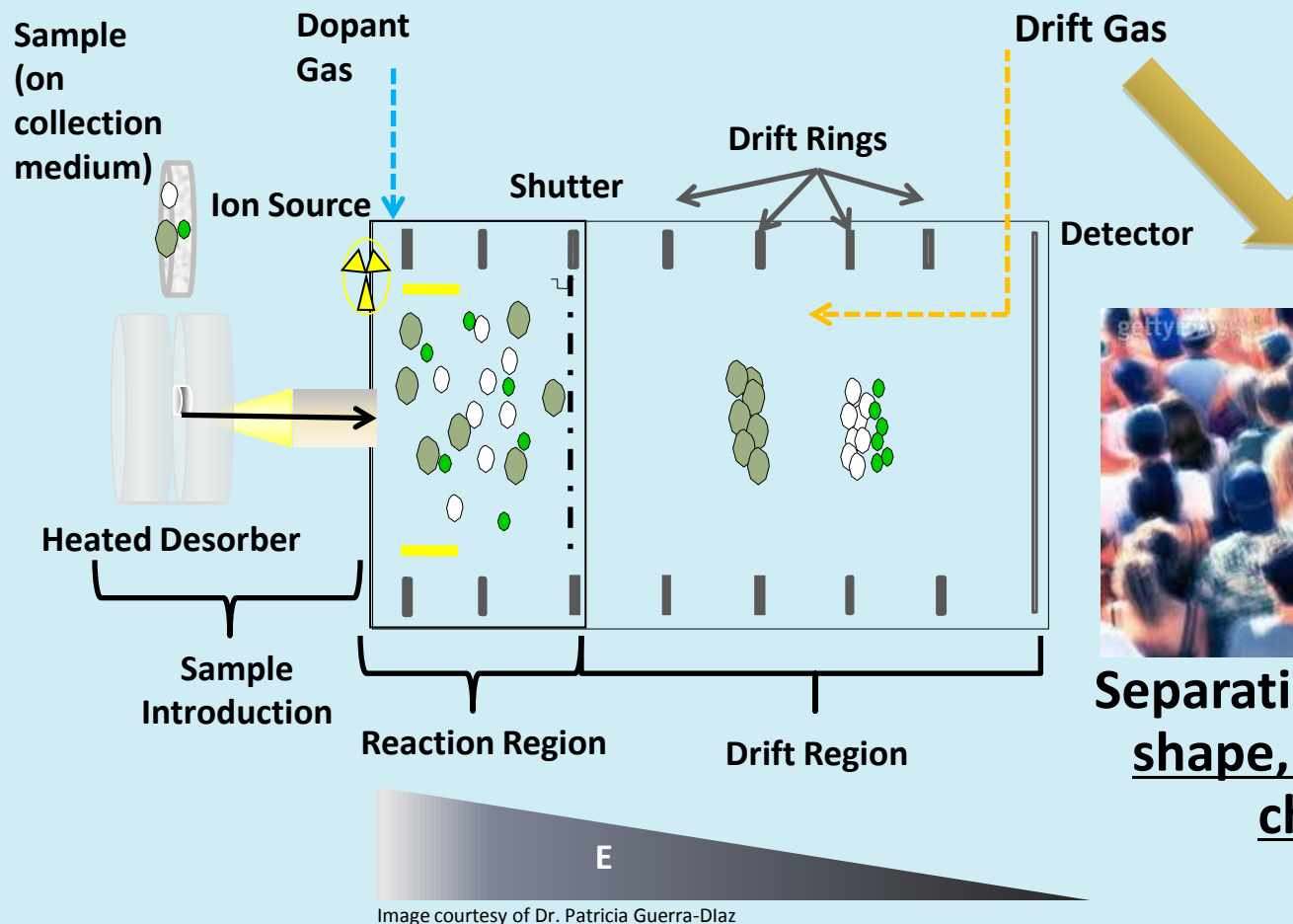
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Trace Samples for Instrumental Analysis



Ion Mobility Spectrometry



<http://www.gettyimages.ie/detail/BD1820-001/Stone>

Separation based on shape, mass, and charge

Image courtesy of Dr. Patricia Guerra-Dlaz

Ion Mobility Spectrometry



Advantages

- Analysis is low cost/easy to operate
- More than 15K instruments conducting over 10 M analyses/yr
- Portability/APCI
- High sensitivity: LODs (pg)
- **Explosives:** Stable negative product ions
- **Drugs:** Favorable response toward nitrogen containing compounds
- Dual mode analyzers

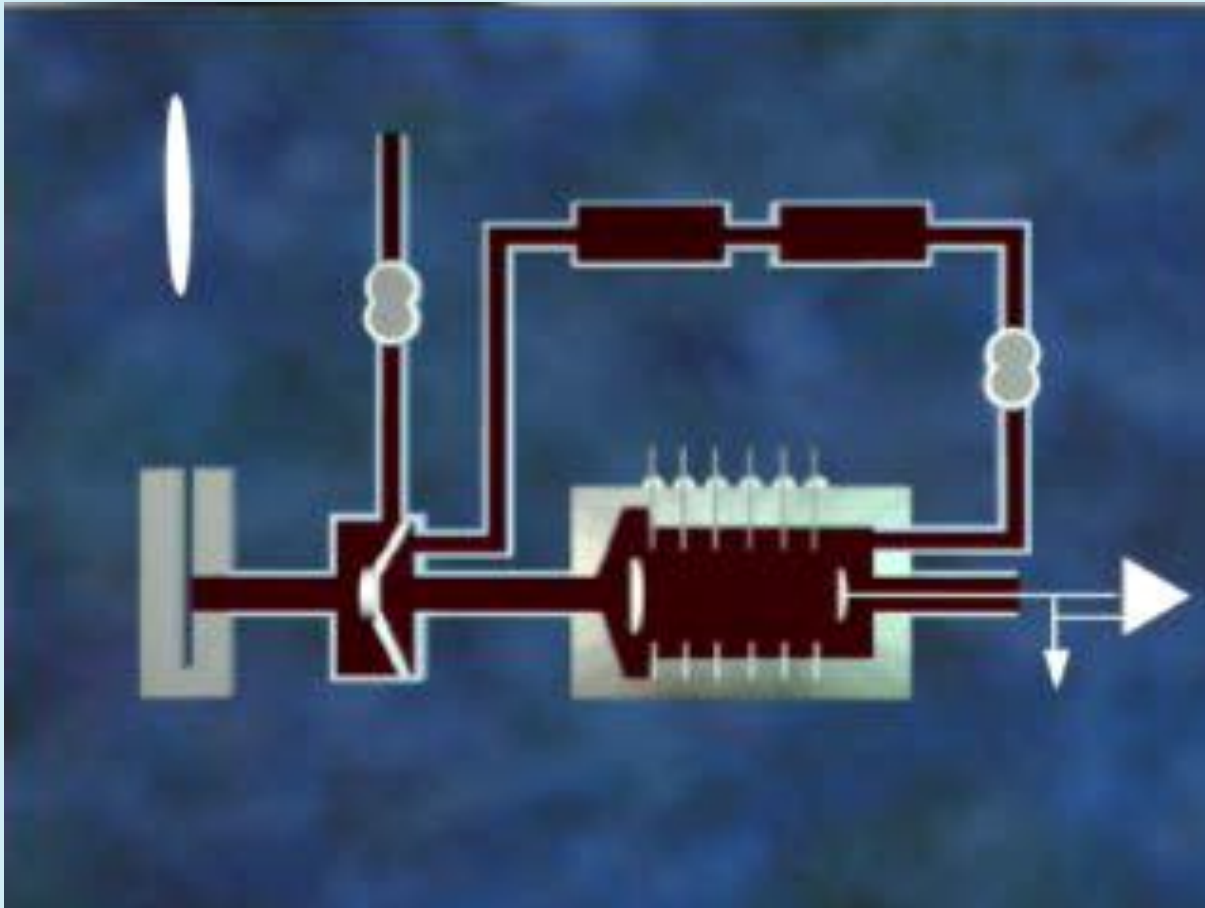
Disadvantages

- Radioactive source
- Detection channels
- Particle sampler, vapor sampler
- Lacks effective sample introduction



<http://www.youtube.com/watch?v=0A9cESqf6RQ>

Ion Trap Mobility Spectrometry



Video from GE Security, Inc..

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Itemiser[®] 3 e



Simultaneous
Drug and
Explosive
Detection

Analysis in 8 s

Wipe/Vacuum
Sampling

Easy to Use



Images from http://www.morpho.com/IMG/pdf/MDI_Itemiser_Enhanced_DAT.pdf

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MobileTrace[®]



Particles

Vapors

Handheld
9.4 lbs

Simultaneous
Dual Mode
Detection

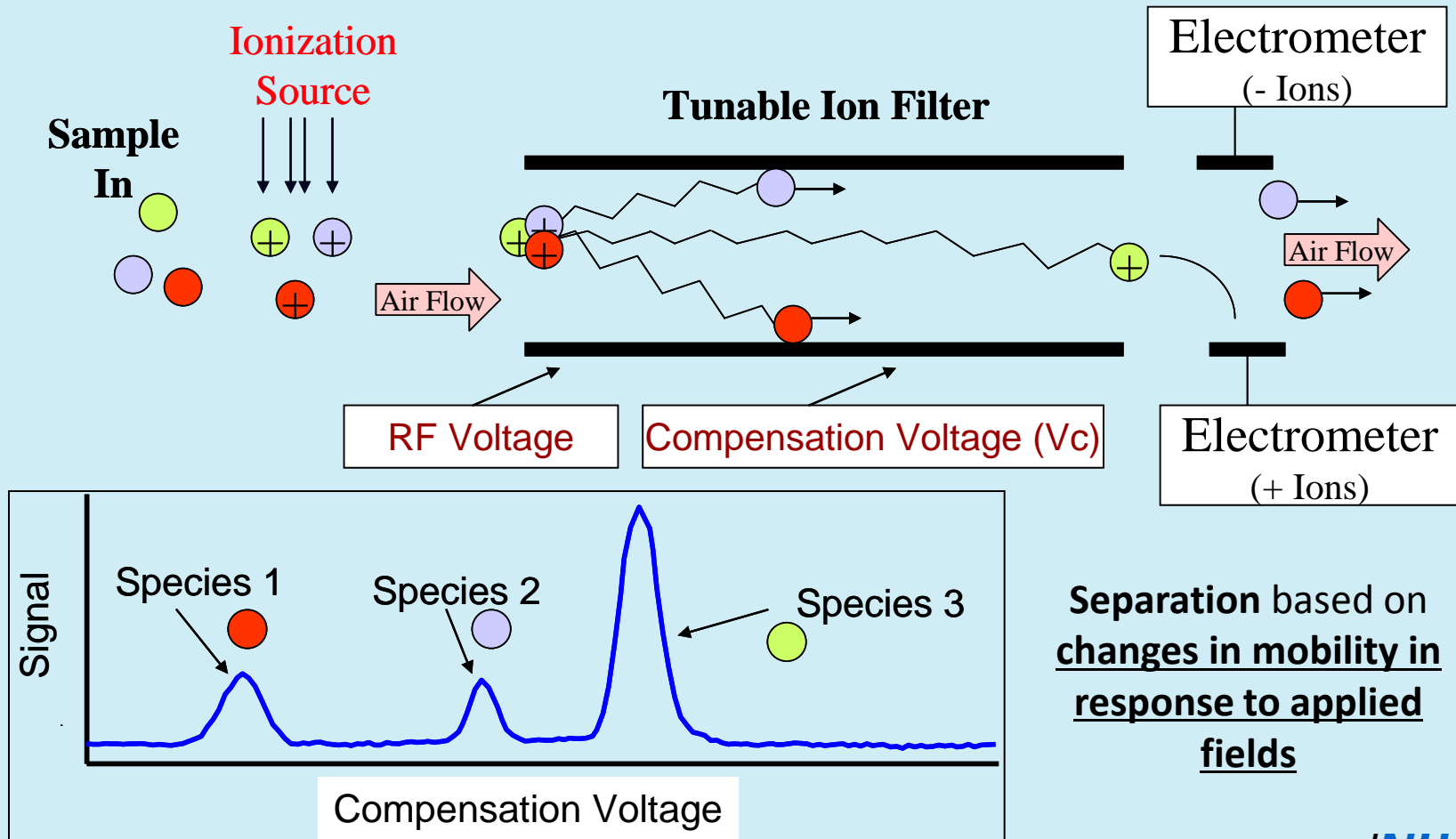
Analysis in
8 s

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<http://www.morpho.com/detection/see-all-products/trace-detection/mobiletrace-r/>

Differential Mobility Spectrometry



Separation based on changes in mobility in response to applied fields

Gas Chromatography-Differential Mobility Spectrometry

High Speed Gas Chromatography

Fast pre-separation



RESOLUTION OF MULTIPLE THREATS



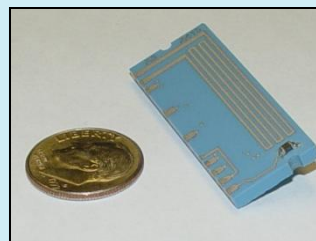
DMS
microDMX™



Thermo
EGIS®
Defender

Deployed at
over 170
airports

Simultaneous +/-
detection



More information in only 16 s
total analysis time



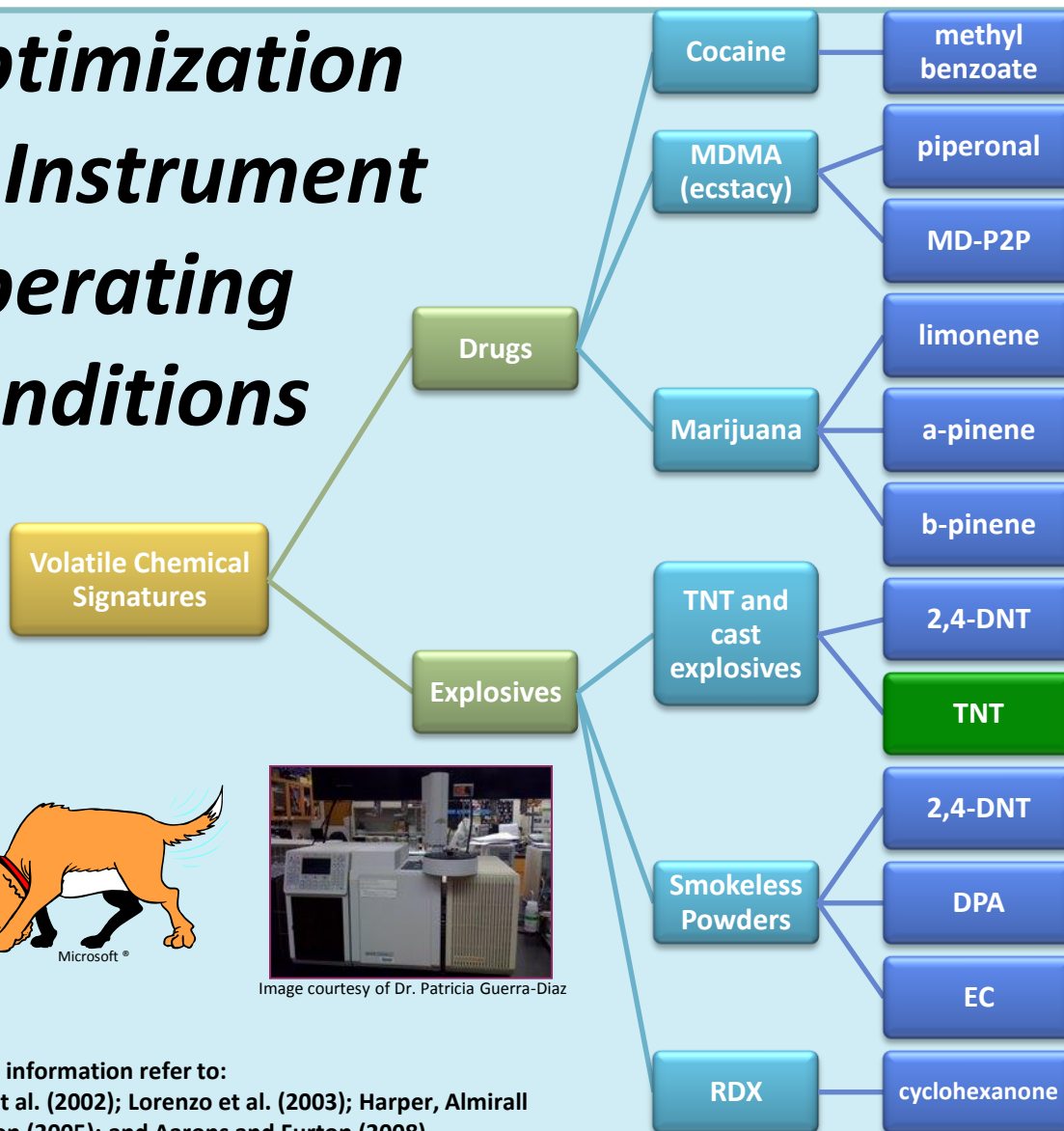
http://www.thermo.com/eThermo/CMA/PDFs/Product/productPDF_30772.pdf

DMA output and microDMX™ chip image from: <http://depts.washington.edu/cpac/Activities/Meetings/Satellite/2007/Tuesday/Raanan%20Miller%20-%20Micro-fabricated%20Differential%20Mobility%20Spectrometers.ppt>

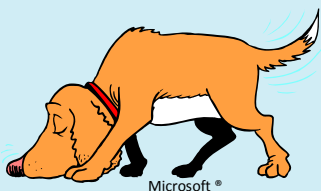
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Optimization of Instrument Operating Conditions



Commercial instruments are configured to detect the parent drug/explosive



Microsoft®

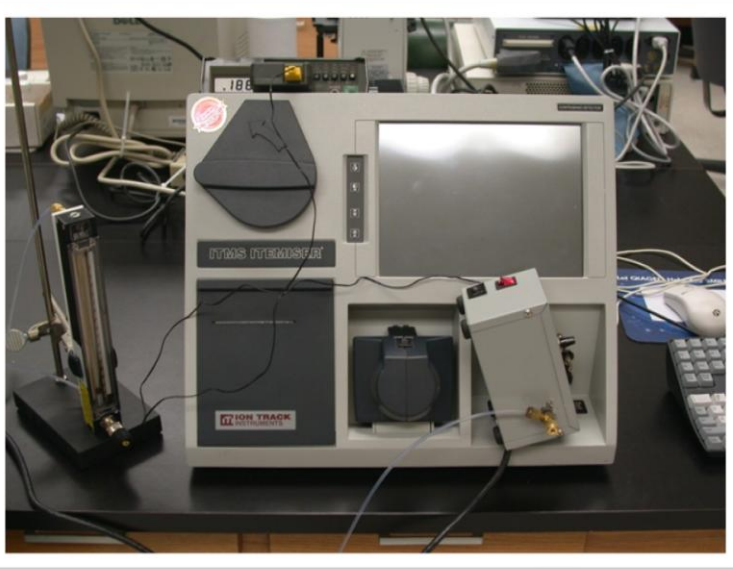


Image courtesy of Dr. Patricia Guerra-Diaz

For more information refer to:
 Furton, et al. (2002); Lorenzo et al. (2003); Harper, Almirall and Furton (2005); and Aarons and Furton (2008)

Optimization of Instrumental Operating Conditions

Image courtesy of Dr. Patricia Guerra-Diaz



Perr, Furton, and Almirall (2005)

Operating
Conditions

Dopant
Composition

Drift Tube
Temperature

Polarity

Drift Flow

Sample Flow

Lai, Guerra, Joshi, and Almirall (2008)

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Conclusions

- **Bulk and trace detection are complementary**
- **Trace detection involves particle and vapor sampling**
- **Detection of vapors emitted from parent drugs and explosives may require instrument operating conditions optimization**
- **Vapor detection using commercial trace detection instruments is improved with pre-concentration**

Cited Scientific References

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- Furton, K.G.; Hong, Y.; Hsu, Y.; Lue, T.; Rose, S.; Walton, J. Identification of Odor Signature Chemicals in Cocaine Using Solid-Phase Microextraction-Gas Chromatography and Detector-Dog Response to Isolated Compounds Spiked on U.S. Paper Currency. *Journal of Chromatographic Science* 2002, 40(3), 147-155.
- Harper, R.J.; Almirall, J.R.; Furton, K.G. Identification of Dominant Odor Chemicals Emanating from Explosives for Use in Developing Optimal Training Aid Combinations and Mimics for Canine Detection. *Talanta* 2005, 67(2), 313-327.
- Lai, H.; Guerra, P.; Joshi, M.; Almirall, J.R. Analysis of Volatile Components of Drugs and Explosives by Solid Phase Microextraction-Ion Mobility Spectrometry. *Journal of Separation Science* 2008, 31(2), 402-412.
- Lorenzo, N.; Wan, T.; Harper, R.J.; Hsu, Y.L.; Chow, M.; Rose, S.; Furton, K.G. Laboratory and Field Experiments Used to Identify *Canis lupus var. familiaris* Active Odor Signature Chemicals from Drugs, Explosives, and Humans. *Analytical and Bioanalytical Chemistry* 2003, 376(8), 1212-1224.
- Perr, J.M.; Furton, K.G.; Almirall, J.R. Solid Phase Microextraction Ion Mobility Spectrometer Interface for Explosive and Taggant Detection. *Journal of Separation Science* 2005, 28(2), 177-183.

Questions?

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