smiths detection

Development of a Portable Mass Spectrometer for Explosives and Narcotics Detection

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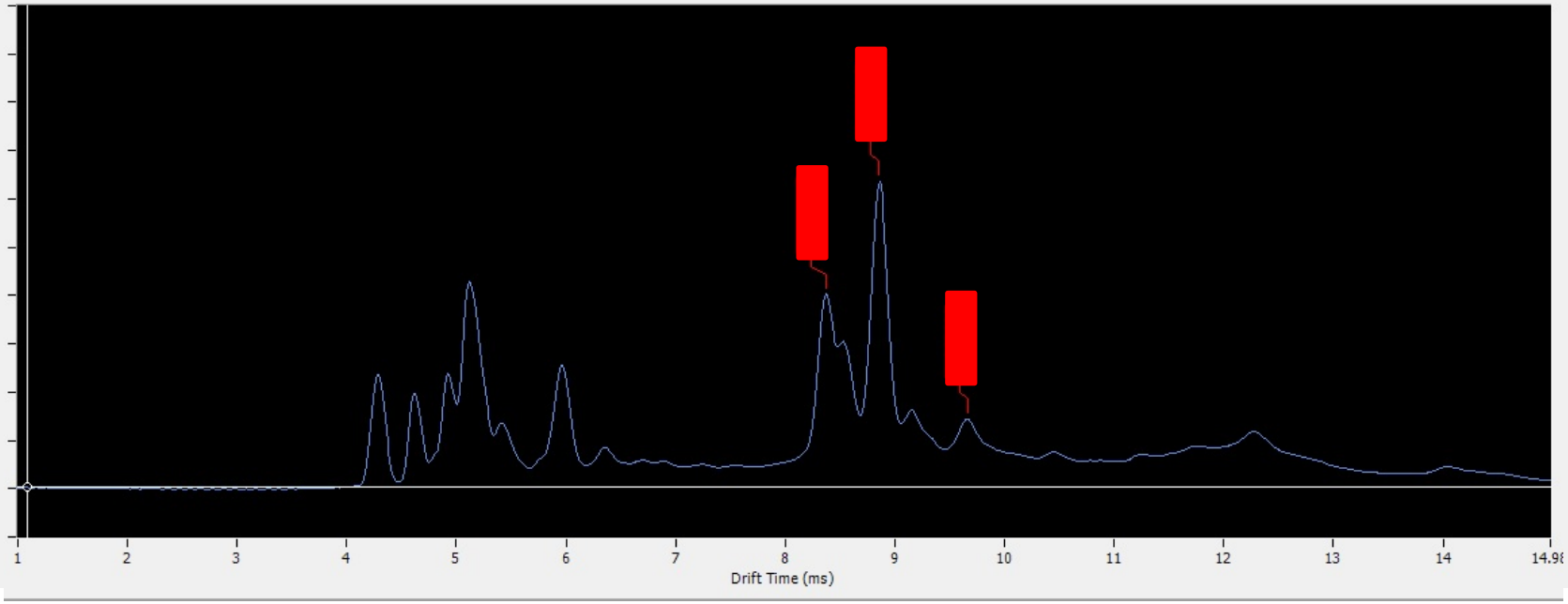
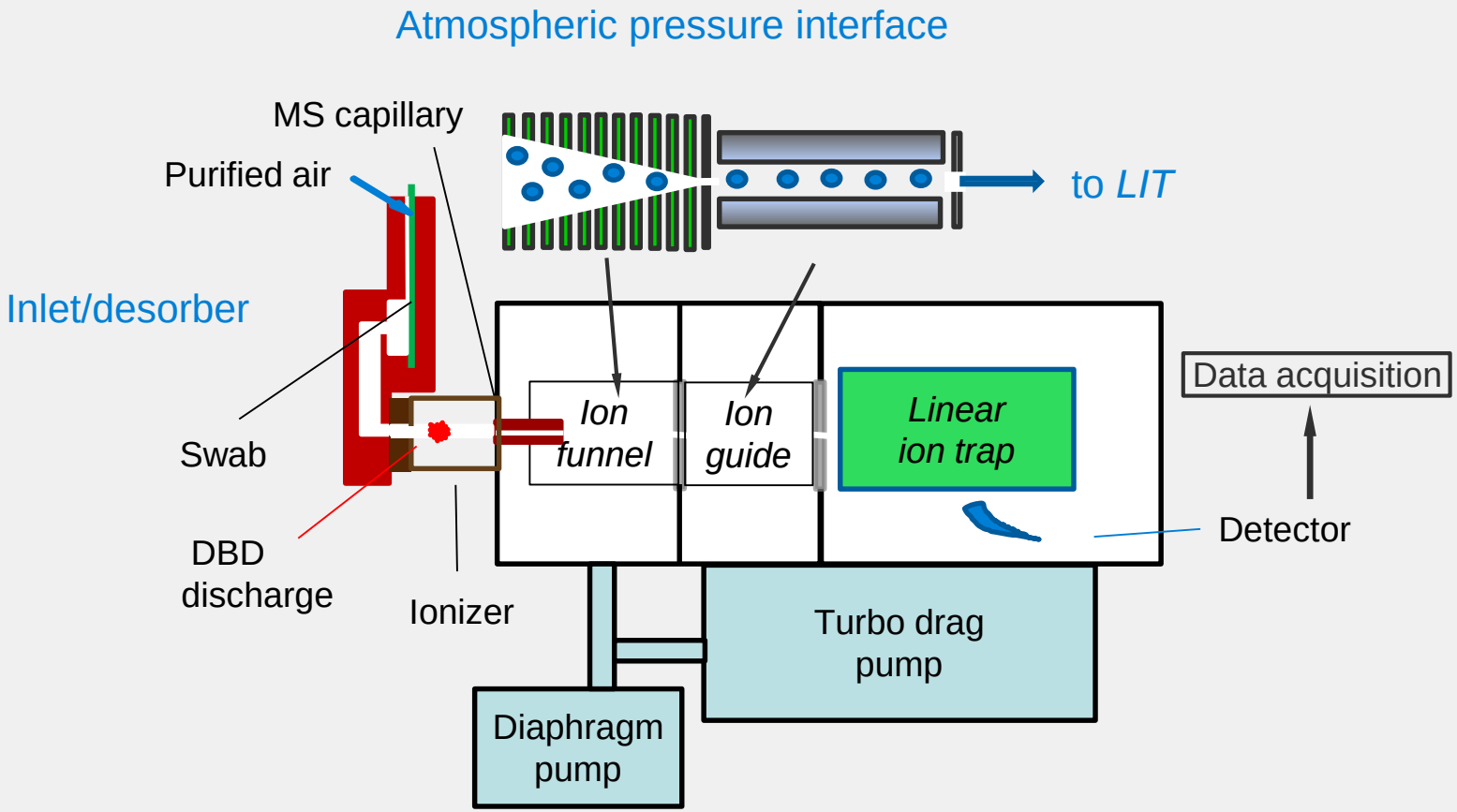
Role of Mass Spectrometry

- Need improved threat coverage for identifying an expanded list of
  - Explosives/HMEs
  - Emerging chemical & narcotic threats
- Solutions are needed which offer significantly reduced FAR and ability to resolve interferences

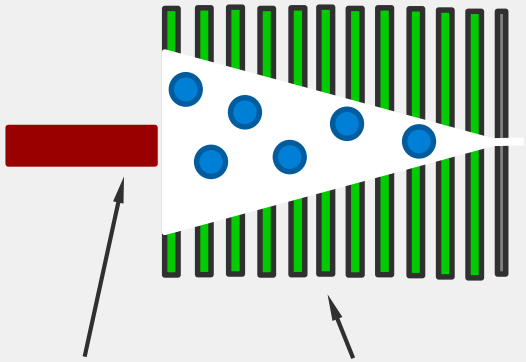
Ion mobility spectrum (thermal desorption from a swab)



System Diagram



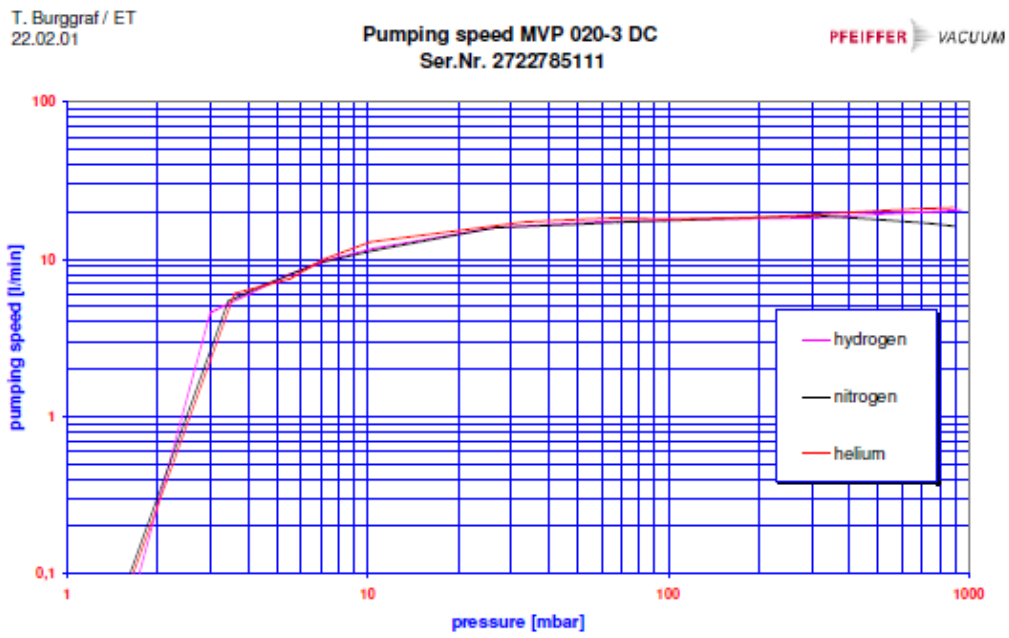
API interface design



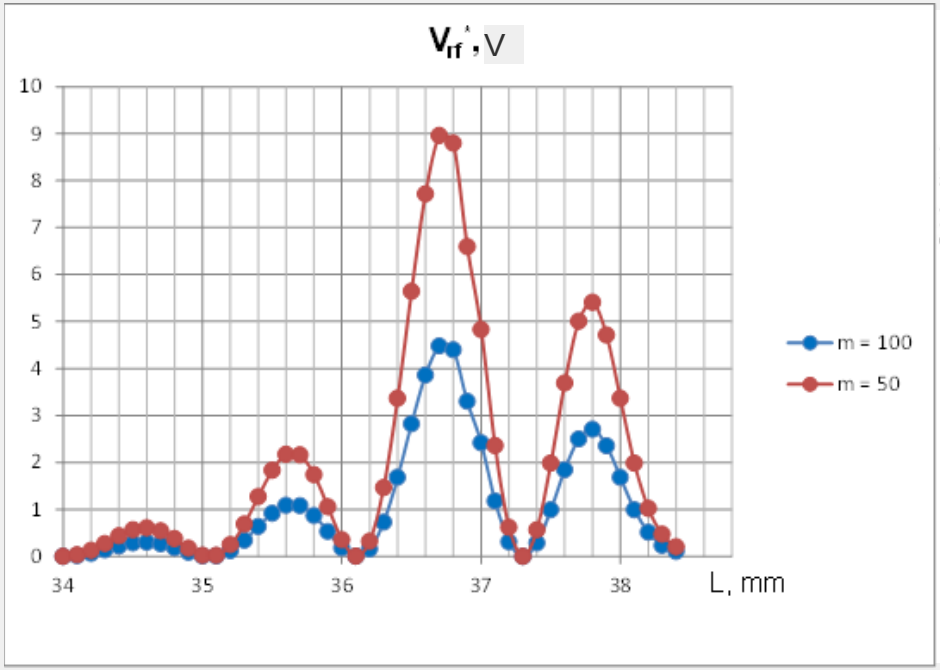
Ion funnel allows efficient ion transmission at elevated pressures

Pumping speed:

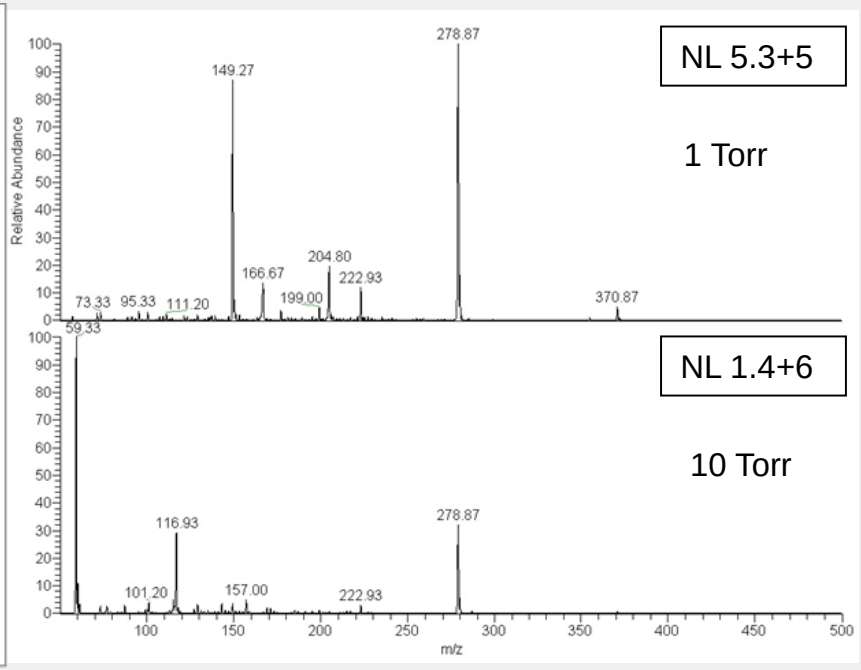
- 0.6 L/min at 1 Torr
- 12 L/min at 10 Torr



Ion funnel ion transmission for low *m/z*

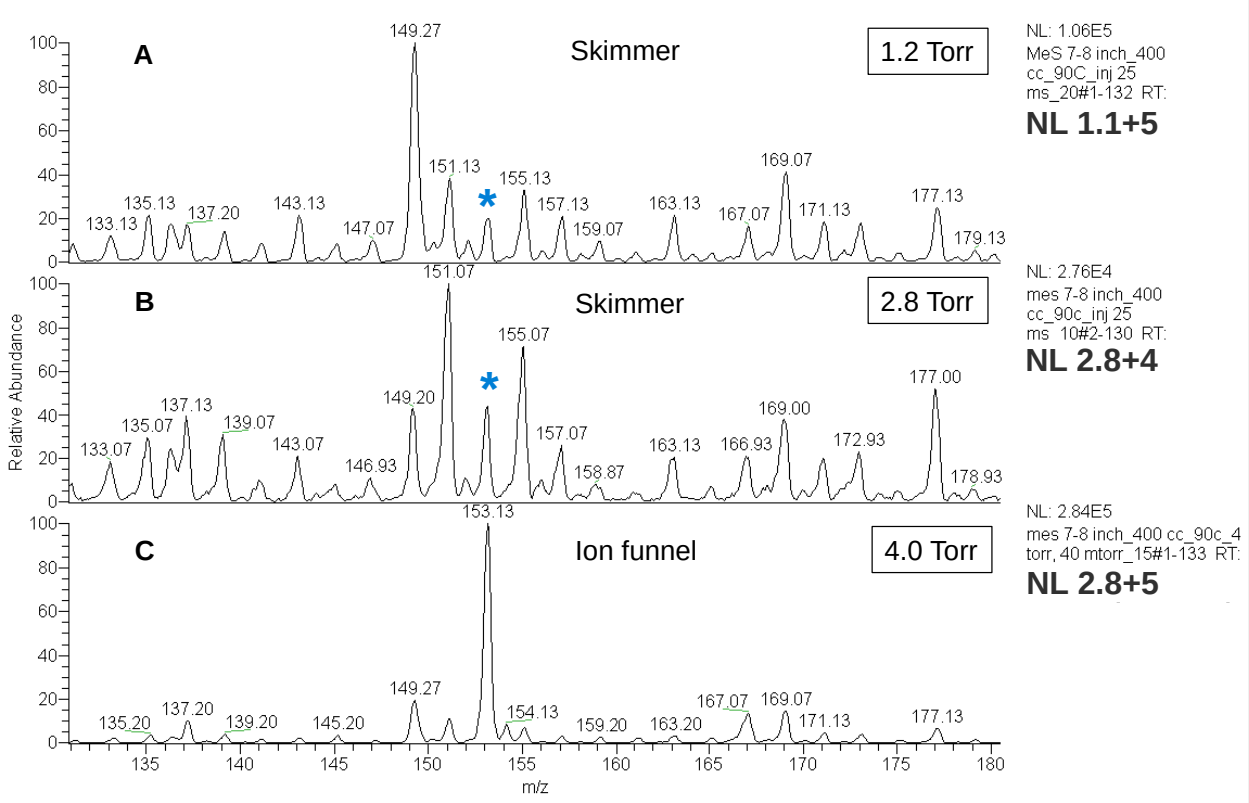


Effective rf potential on the ion funnel axis (SIMION modeling)



APCI ion source; API interface comprised of heated capillary and ion funnel on LCQ Deca XP

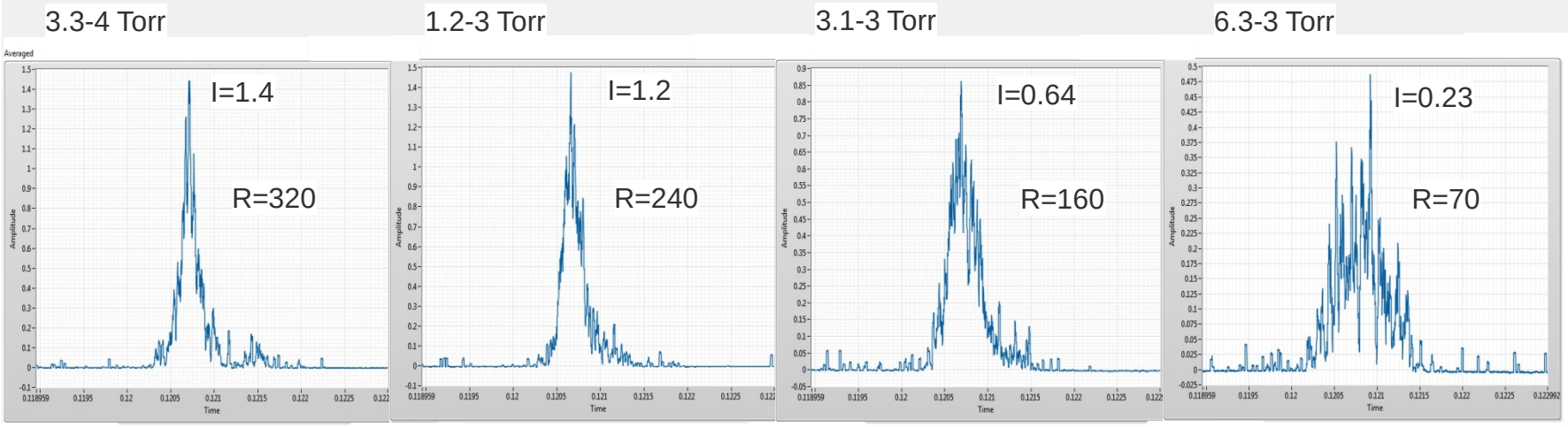
Ion funnel vs skimmer for ion transmission



- APCI ion source
- MeS permeation tube with dilution flow (~ 100 pptv)
- API interface comprised of heated capillary with a skimmer or ion funnel on an LCQ Deca XP (fixed injection time into the ion trap)

LIT performance at different pressures

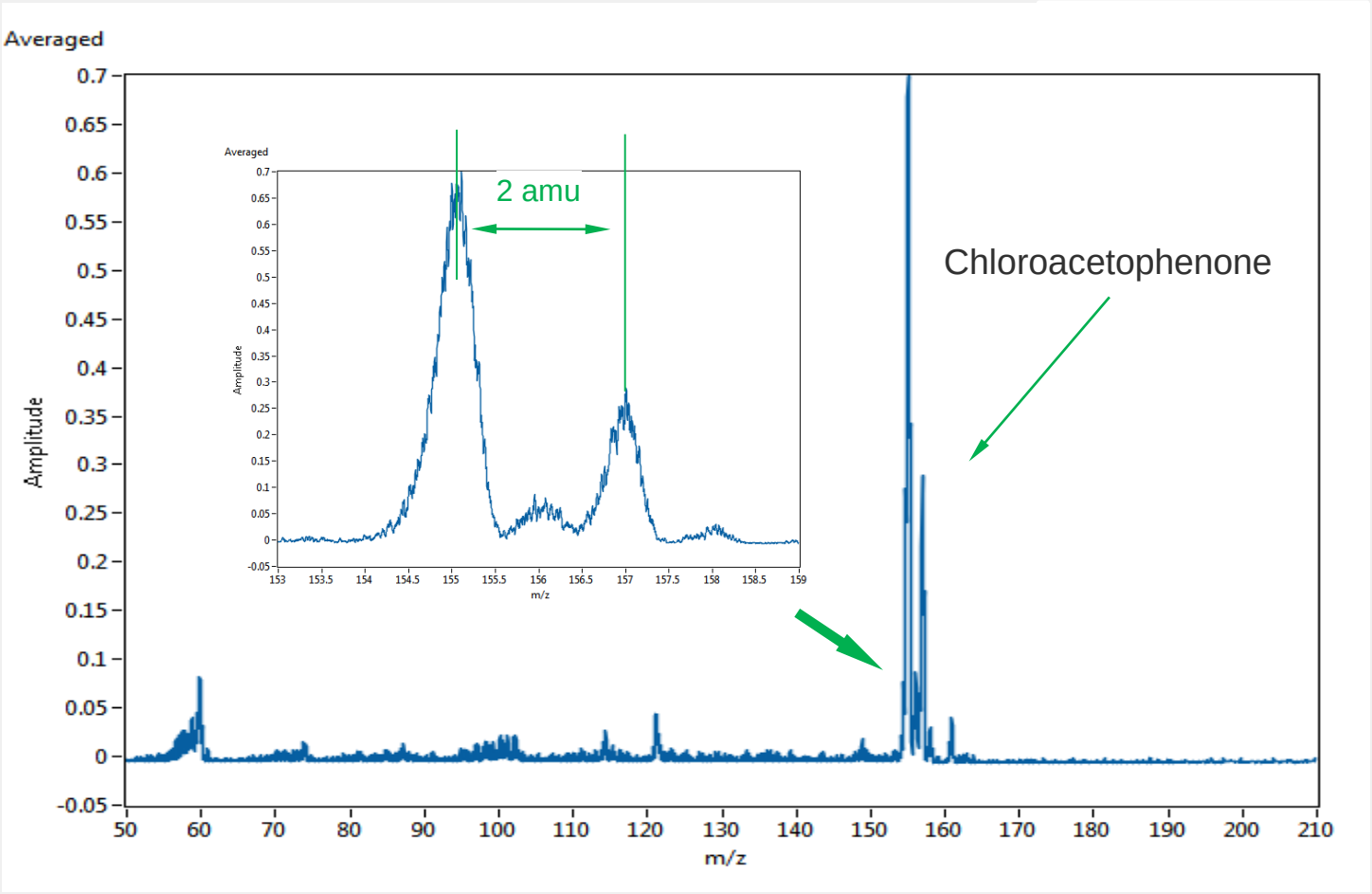
pressure



- APCI ion source
- MeS permeation tube (~ 300 pptv)
- API interface comprised of an ion funnel and ion guide with portable mass spectrometer
- N_2 supplied to high vacuum chamber through a capillary
- Hamamatsu hybrid detector

Mass resolution

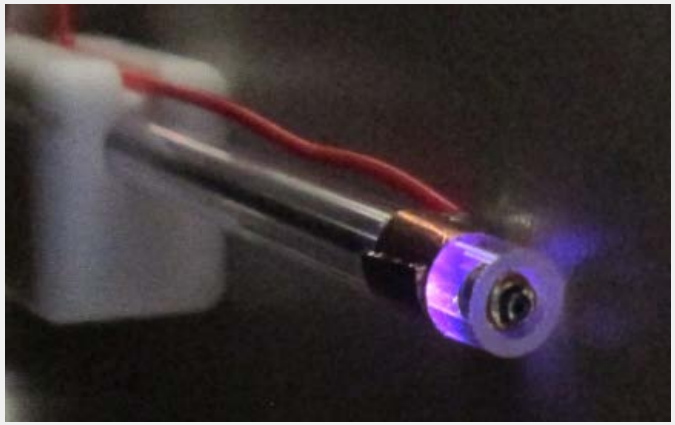
APCI ion source (positive ion mode), Chloroacetophenone vapors



Ionization source

Dielectric-barrier discharge (DBD):

- AC voltage: few kV, 5-50 kHz
- collapse of the local electric field caused by charges accumulated on the dielectric surface
- micro discharge ~ 20ns
- electron energy 1-10 eV
- ion energy ~ 0.03 eV, i.e. low-temperature plasma



Coaxial configuration of DBD

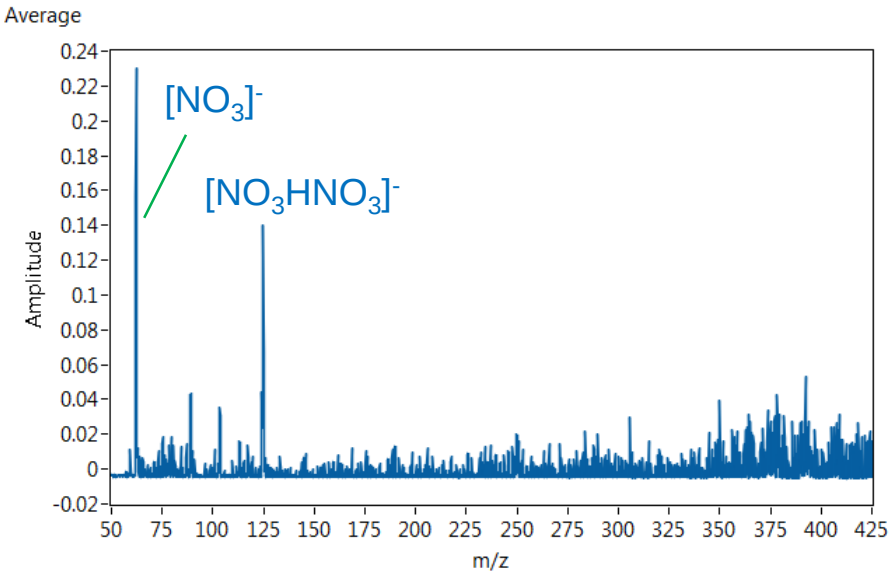
Major advantages:

- Produces ions of both polarities
- Robust: operational reliability
- Diffuse nature allows ionization in large volumes
- Can be used for direct ionization from various surfaces

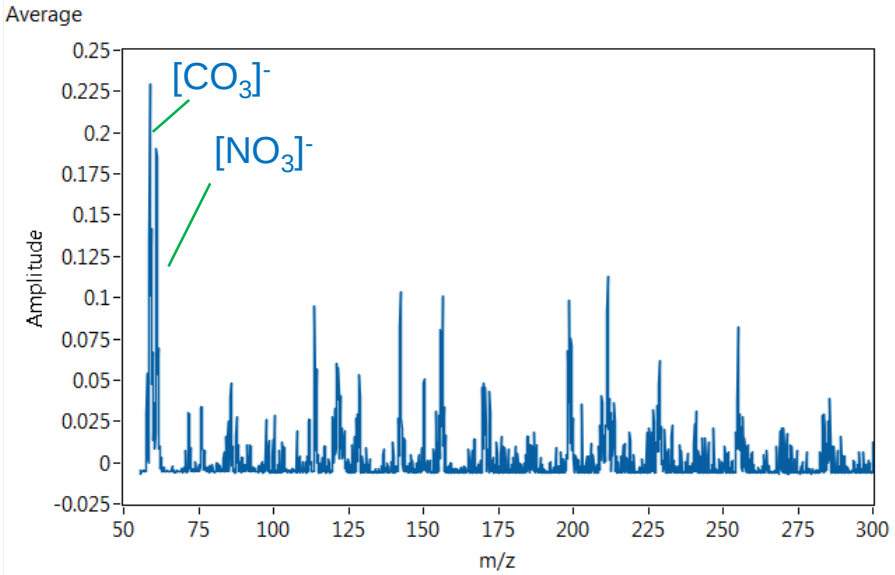
Effect of gas flow on ion chemistry

DBD 100 Hz, 1.46 kV_{p-p}, MS intake 180 cc/min, exhaust flow 400 cc/min

Inlet closed

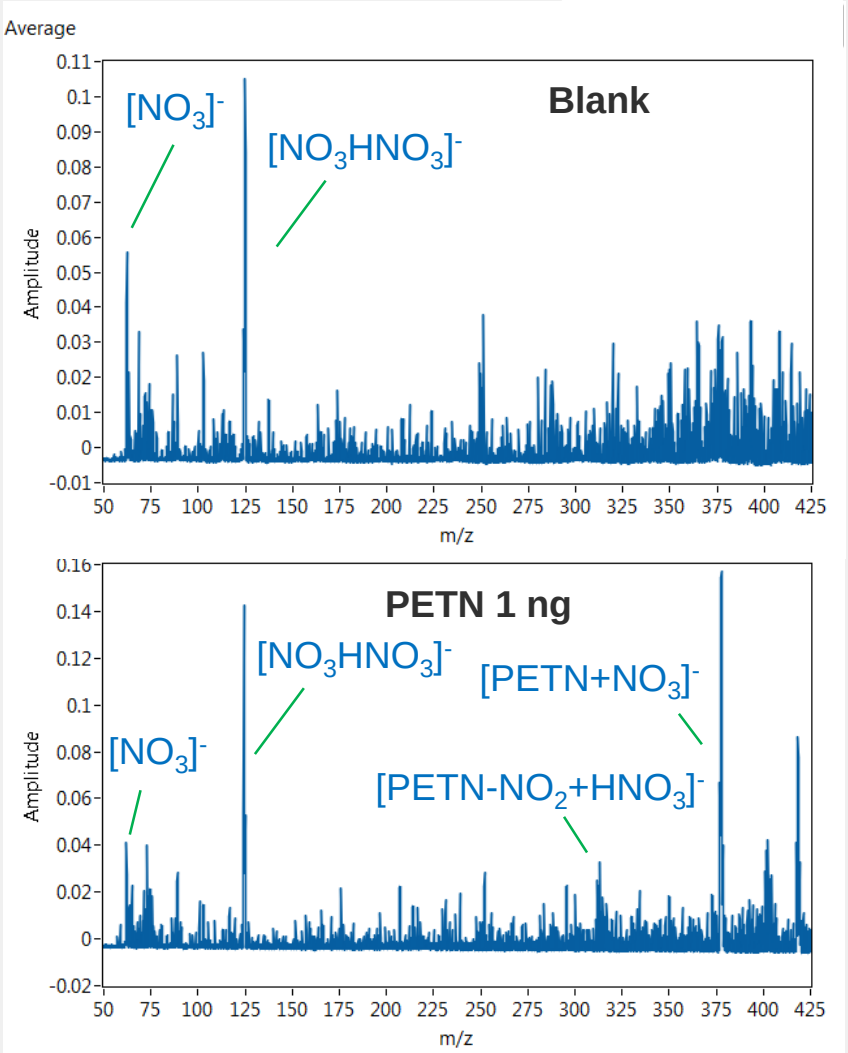


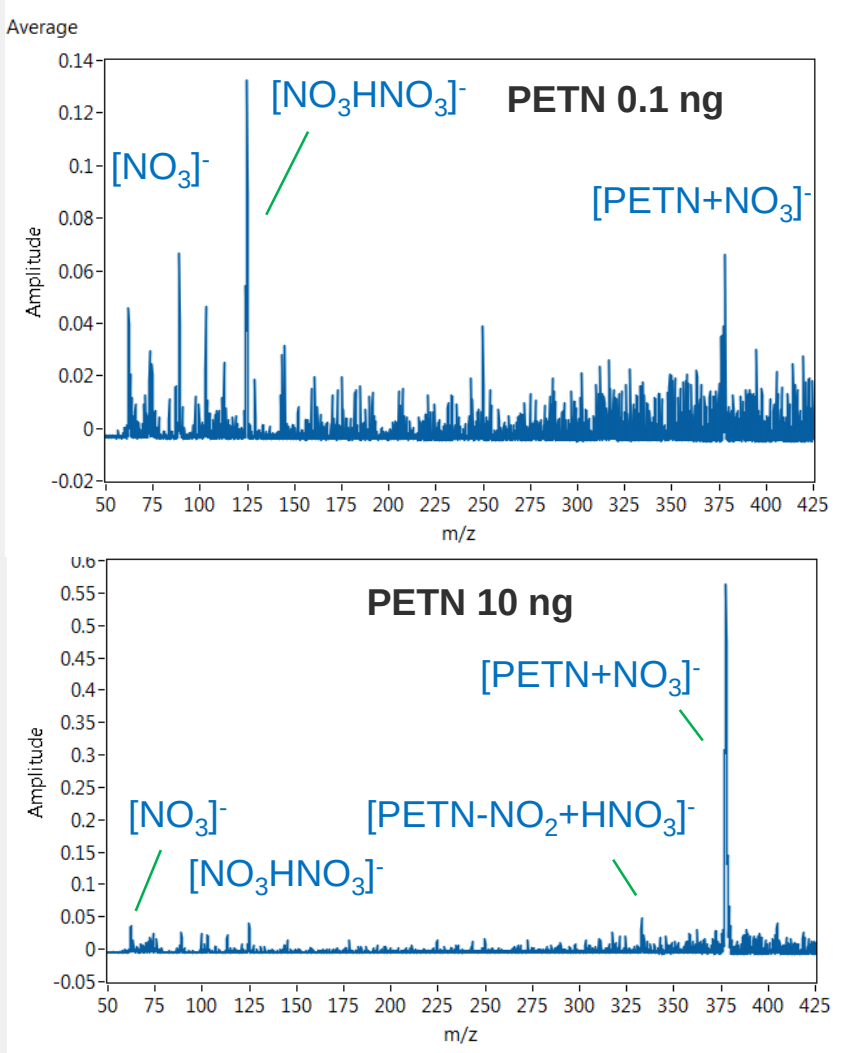
Inlet flow 400 cc/min



Representative spectra of PETN at different loading amounts

- Direct deposit on a swab, DBD 100 Hz, 1.46 kV_{p-p}10 scans averaged

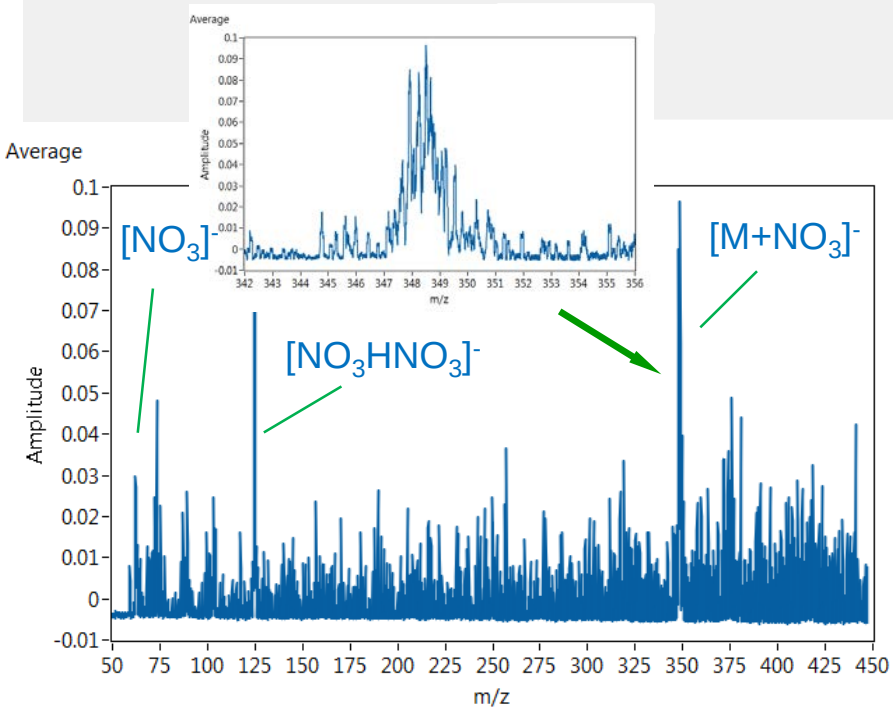




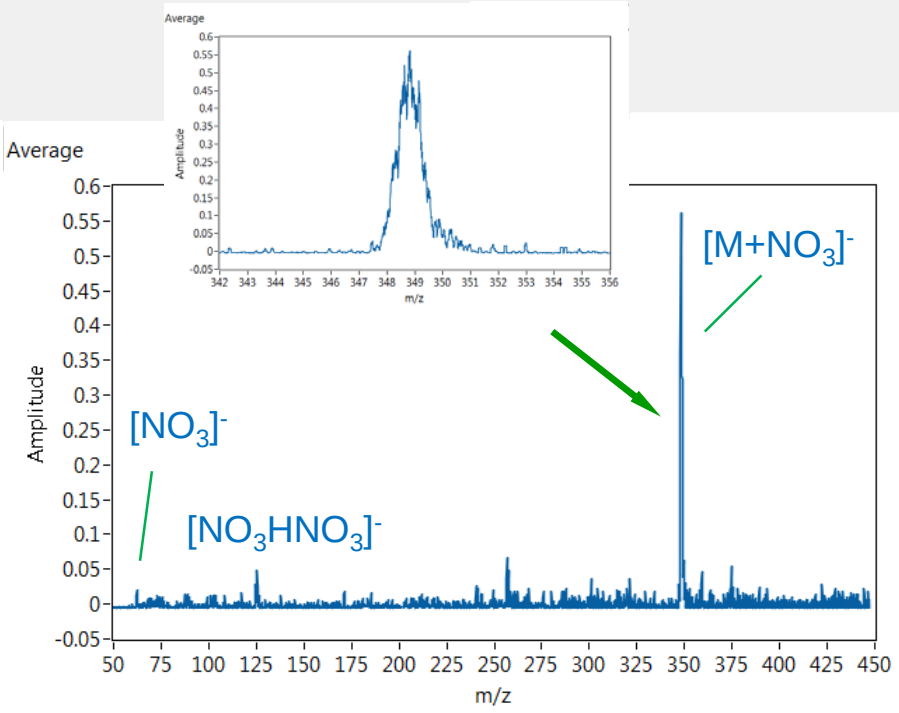
Representative spectra of Tetryl

Direct deposit on a swab, DBD 100 Hz, 1.46 kV_{p-p}, 10 scans averaged

Tetryl 1 ng



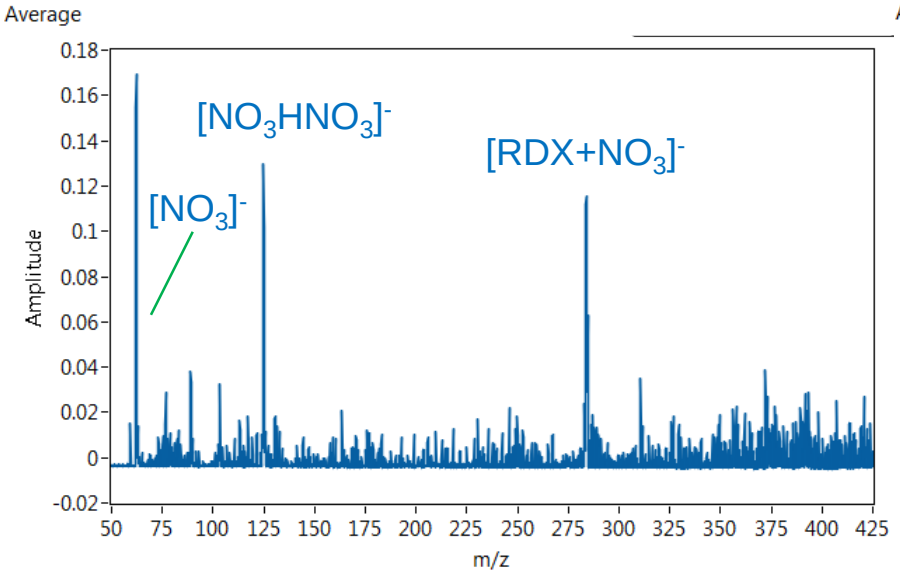
Tetryl 10 ng



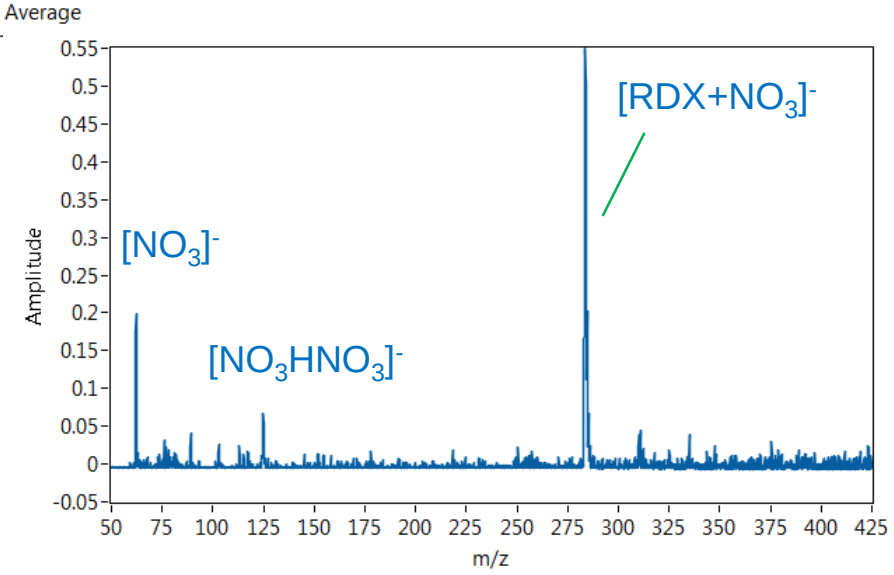
Representative spectra of RDX

Direct deposit on a swab, DBD 100 Hz, 1.46 kV_{p-p}, 10 scans averaged

RDX 1 ng



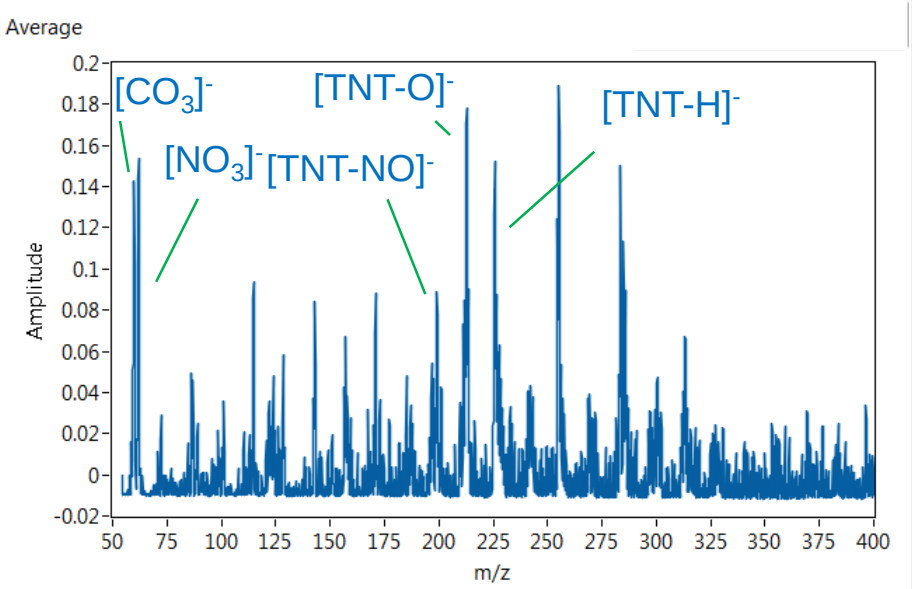
RDX 10 ng



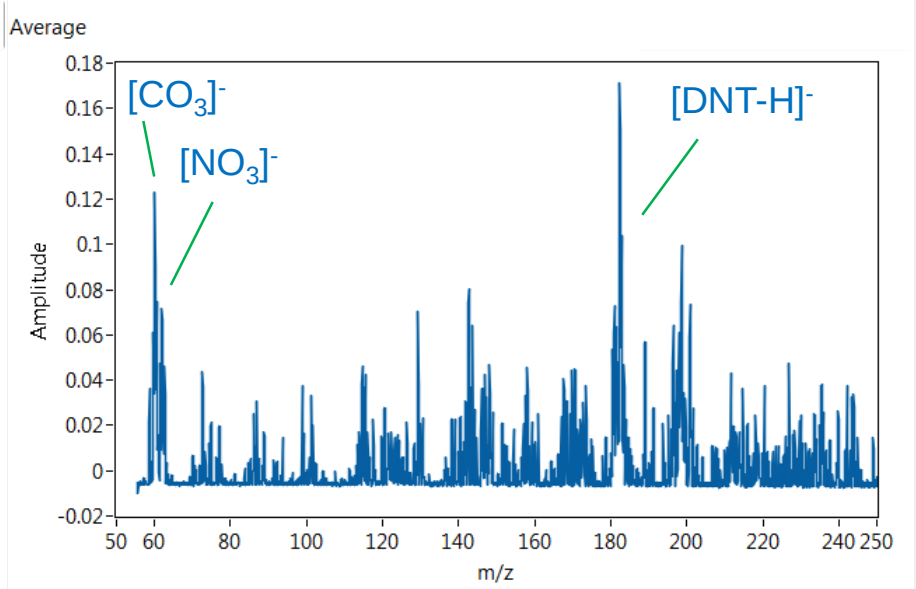
Representative spectra of TNT and 2,4 DNT

Direct deposit on a swab, DBD 100 Hz, 1.46 kV_{p-p}, 10 scans averaged

TNT 10 ng

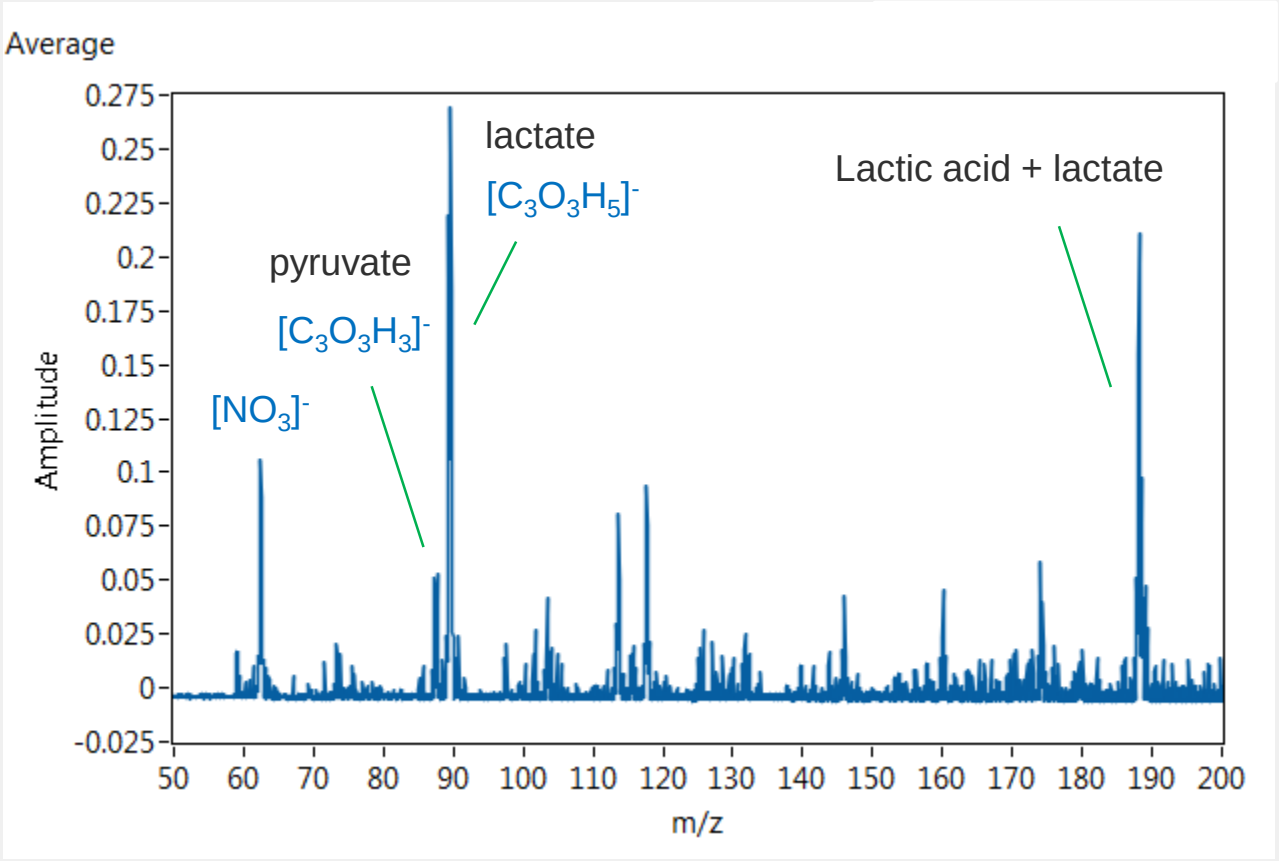


2,4 DNT 10 ng



Representative spectrum from human fingerprint oil

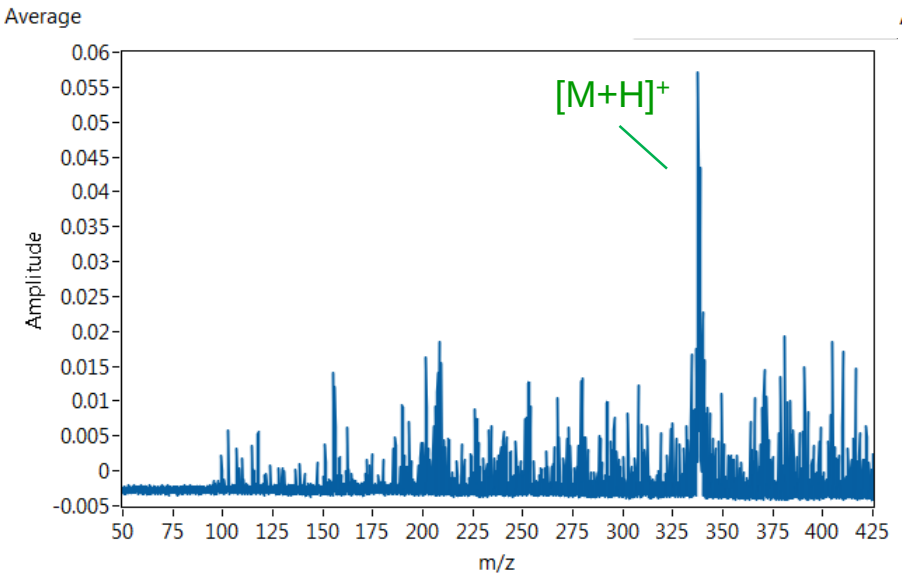
Fingerprint on a swab, DBD 100 Hz, 1.46 kV_{p-p}, 10 scans averaged



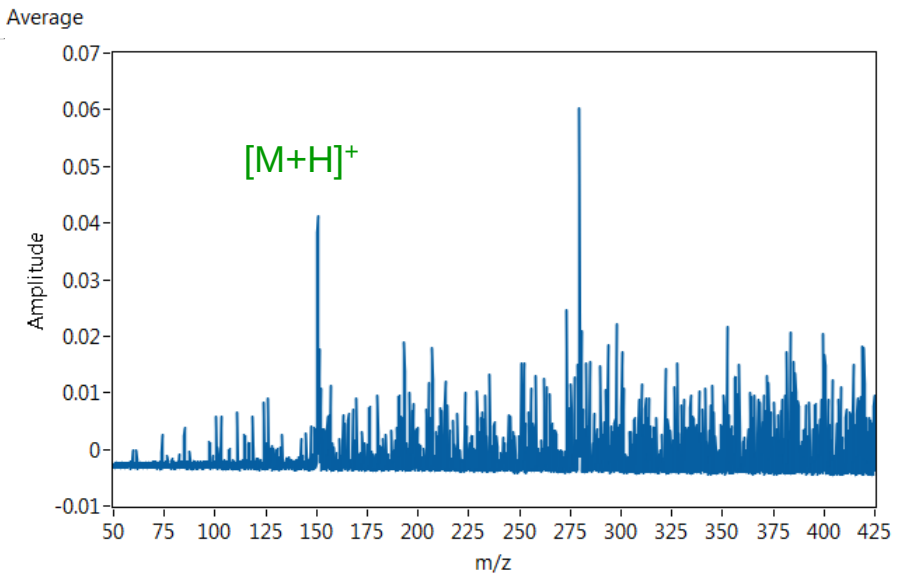
Representative spectra of Fentanyl and Methamphetamine

Direct deposit on a swab, DBD 100 Hz, 1.46 kV_{p-p}, 10 scans averaged

Fentanyl 1 ng



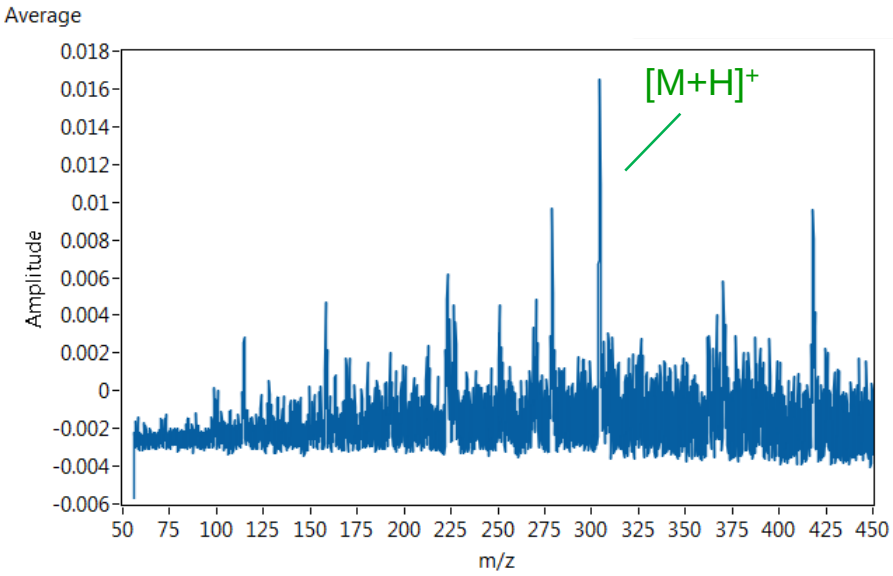
Methamphetamine 5 ng



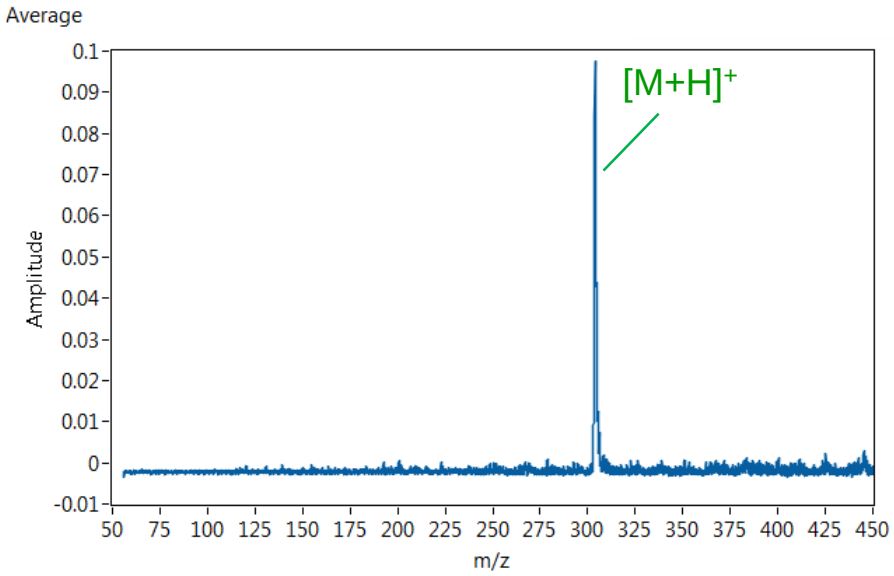
Representative spectra of Cocaine

Direct deposit on a swab, DBD 100 Hz, 1.46 kV_{p-p}, 10 scans averaged

Cocaine 1 ng



Cocaine 10 ng



Conclusions

- A portable linear ion trap mass spectrometer with a DBD ionization source was designed, built and tested
- High ion transmission efficiency from atmosphere into the vacuum of mass analyzer is achieved using a proprietary ion funnel design
- The system incorporates a thermal desorber for detection from a swab or similar sampler
- Initial results demonstrate trace level detection of explosives and high-priority narcotic substances

Acknowledgements

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